Proposal for the Revised M.Tech Programme

in

Atmospheric-Oceanic Science and Technology

Centre for Atmospheric Sciences

Indian Institute of Technology Delhi

Hauz Khas, New Delhi-110016

February 2015

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Preamble

The M.Tech programme in “Atmospheric-Oceanic Science and Technology” started at CAS in the academic year 2008-09. The goal of the programme is to develop manpower capable of conducting independent research in weather and climate and cater to the operational needs of national agencies. This programme has been running successfully for almost 7 years. The curriculum of the M.Tech programme is now revamped in view of the institute-wide M.Tech curriculum review on the basis of gained experience, feedback from various stake-holders including students, and suggestions made by the Internal Review Committee in March 2014.

As a part of the curriculum revision, we have modified the structure of the M.Tech programme and all 700 – 800 level courses. A summary of changes in all 700 – 800 level courses is given in Appendix I.

Eligibility criteria (shown in the Appendix II) remain unchanged.

CREDIT REQUIREMENT & PROGRAMME STRUCTURE

Total	:	54 Credits (including 6 credits as bridge courses)
Core Courses	:	33 Credits
Electives	:	21 Credits

CORE COURSES

Course No.	Course Name	(L-T-P)	Credits
ASL730	Introduction to Weather, Climate and Air Pollution	(1-0-0)	1 Credit *
ASP731	Data Analysis Methods for Atmospheric and Oceanic Sciences	(0-0-4)	2 Credits *
ASL732	Mathematical and Computational Methods for Atmospheric and Oceanic Sciences	(2-0-2)	3 Credits *
ASL733	Physics of the Atmosphere	(3-0-0)	3 Credits
ASL734	Dynamics of the Atmosphere	(3-0-0)	3 Credits
ASL735	Atmospheric Chemistry and Air Pollution	(3-0-0)	3 Credits
ASL736	Science of Climate Change	(3-0-0)	3 Credits
ASL737	Physical and Dynamical Oceanography	(3-0-0)	3 Credits
ASL738	Numerical Modeling of the Atmosphere and Ocean	(2-0-2)	3 Credits
ASP820	Advanced Data Analysis for Weather and Climate	(1-0-4)	3 Credits
ASD881	Project-I	(0-0-12)	6 Credits

* Bridge Course

ELECTIVE COURSES

Course No.	Course Name	(L-T-P)	Credits
ASL750	Boundary Layer Meteorology	(3-0-0)	3 Credits
ASL751	Dispersion of Air Pollutants	(3-0-0)	3 Credits
ASL752	Mesoscale Meteorology	(3-0-0)	3 Credits
ASL753	Atmospheric Aerosols	(3-0-0)	3 Credits
ASL754	Cloud Physics	(3-0-0)	3 Credits
ASL755	Remote Sensing of the Atmosphere and Ocean	(3-0-0)	3 Credits
ASL756	Synoptic Meteorology	(3-0-0)	3 Credits
ASL757	Tropical Weather and Climate	(3-0-0)	3 Credits
ASL758	General Circulation of the Atmosphere	(3-0-0)	3 Credits
ASL759	Land-Atmosphere Interactions	(3-0-0)	3 Credits
ASL760	Renewable Energy Meteorology	(3-0-0)	3 Credits
ASL761	Earth System Modeling	(3-0-0)	3 Credits
ASL762	Air-Sea Interaction	(3-0-0)	3 Credits
ASL763	Coastal Ocean and Estuarine Processes	(3-0-0)	3 Credits
ASS800	Independent Study	(0-3-0)	3 Credits
ASL821	Advanced Dynamic Meteorology	(3-0-0)	3 Credits
ASL822	Climate Variability	(3-0-0)	3 Credits
ASL823	Geophysical Fluid Dynamics	(3-0-0)	3 Credits
ASL824	Parameterization of Physical Processes	(3-0-0)	3 Credits
ASP825	Mesoscale Modeling	(0-0-6)	3 Credits
ASL826	Ocean Modeling	(2-0-2)	3 Credits
ASL827	Advanced Dynamic Oceanography	(3-0-0)	3 Credits
ASL851	Special Topics in Climate	(3-0-0)	3 Credits
ASL852	Special Topics in Oceans	(3-0-0)	3 Credits
ASL853	Special Topics in Atmosphere	(3-0-0)	3 Credits
ASL854	Special Topics in Air Pollution Studies	(3-0-0)	3 Credits

Course No.	Course Name	(L-T-P)	Credits
ASP855	Special Topics in Atmosphere and Ocean	(1-0-4)	3 Credits
ASL856	Special Topics in Atmospheric and Oceanic Observations	(2-0-2)	3 Credits
ASV862	Special Module in Climate	(1-0-0)	1 Credit
ASV863	Special Module in Oceans	(1-0-0)	1 Credit
ASV864	Special Module in Atmosphere	(1-0-0)	1 Credit
ASV865	Special Module in Air Pollution Studies	(1-0-0)	1 Credit
ASV866	Special Module in Atmosphere and Ocean	(1-0-0)	1 Credit
ASP867	Special Module in Weather Forecasting	(0-0-2)	1 Credit
ASP868	Special Module in Atmospheric and Oceanic Observations	(0-0-2)	1 Credit
ASC869	Atmospheric and Oceanic Science Colloquium	(0-1-0)	1 Credit
ASD882	Project-II	(0-0-24)	12 Credits

M.Tech. Full-time (2 Years)

(a) I Semester

S.No.	Course No.	Course Name	Credits
1.	ASL730	Introduction to Weather, Climate and Air Pollution	1 (1-0-0) *
2.	ASL731	Data Analysis Methods for Atmospheric and Oceanic Sciences	2 (0-0-4) *
3.	ASL732	Mathematical and Computational Methods for Atmospheric and Oceanic Sciences	3 (2-0-2) *
4.	ASL733	Physics of the Atmosphere	3 (3-0-0)
5.	ASL734	Dynamics of the Atmosphere	3 (3-0-0)
6	ASL735	Atmospheric Chemistry and Air Pollution	3 (3-0-0)
		Total Credits	**15 Credits**

* Bridge Course

(b) II Semester

S.No.	Course No.	Course Name	Credits
1.	ASL736	Science of Climate Change	3 (3-0-0)
3.	ASL737	Physical and Dynamical Oceanography	3 (3-0-0)
4.	ASL738	Numerical Modeling of the Atmosphere and Ocean	3 (2-0-2)
2.	ASP820	Advanced Data Analysis for Weather and Climate	3 (1-0-4)
5.		Elective I	3 (3-0-0)
		Total Credits	**15 Credits**

(c) III Semester

S.No.	Course No.	Course Name	Credits
1.	ASD881	Project-I (core)	6 (0-0-12)
2.		Elective II	3 (3-0-0)
3.		Elective III	3 (3-0-0)
		Total Credits	**12 Credits**

(d) IV Semester

S.No.	Course No.	Course Name	Credits
1.		Project-II (elective) or Electives IV-VII	12 Credits
		Total Credits	**12 Credits**

		Grand Total of Credits (Semester I - IV)	**54 Credits**

Summary (M.Tech. Full-time)

S.N.	Category	I-Sem	II-Sem	III-Sem	IV-Sem	Credits
1.	Core Courses	15	12	6	-	33
2.	Electives	-	3	6	12	21
	Total Credits	**15**	**15**	**12**	**12**	**54**

M.Tech. Part-time (3 Years)

(a) I Semester : Part-Time

S.No.	Course No.	Course Name	Credits
1.	ASL730	Introduction to Weather, Climate and Air Pollution	1 (1-0-0)*
2.	ASL731	Data Analysis Methods for Atmospheric and Oceanic Sciences	2 (0-0-4)*
3.	ASL732	Mathematical and Computational Methods for Atmospheric and Oceanic Sciences	3 (2-0-2)*
4.	ASL733	Physics of the Atmosphere	3 (3-0-0)
		Total Credits	**9 Credits**

* Bridge Course

(b) II Semester : Part-Time

S.No.	Course No.	Course Name	Credits
1.	ASL736	Science of Climate Change	3 (3-0-0)
2.	ASP820	Advanced Data Analysis for Weather and Climate	3 (1-0-4)
3.		Elective I	3 (3-0-0)
		Total Credits	**9 Credits**

(c) III Semester: Part-Time

S.No.	Course No.	Course Name	Credits
1.	ASL734	Dynamics of the Atmosphere	3 (3-0-0)
2.	ASL735	Atmospheric Chemistry and Air Pollution	3 (3-0-0)
3.		Elective II	3 (3-0-0)
		Total Credits	**9 Credits**

(d) IV Semester: Part Time

S.No.	Course No.	Course Name	Credits
1.	ASL737	Physical and Dynamical Oceanography	3 (3-0-0)
2.	ASL738	Numerical Modeling of the Atmosphere and Ocean	3 (2-0-2)
		Total Credits	**6 Credits**

(e) V Semester : Part-Time

S.No.	Course No.	Course Name	Credits
1.	ASD881	Project-I (core)	6 (0-0-12)
2.		Elective III	3 (3-0-0)
		Total Credits	**9 Credits**

(f) VI Semester : Part-Time

S.No.	Course No.	Course Name	Credits
1.		Project-II (elective) or Electives IV-VII	12 (0-0-24)
		Total Credits	**12 Credits**

		Grand Total of Credits (Semester I - VI)	**54 Credits**

Summary (M.Tech. Part-Time (3 Years))

S.N.	Category	I-Sem	II-Sem	III-Sem	IV-Sem	V-Sem	VI-Sem	Credits
1.	Core Courses	9	6	6	6	6	-	33
4.	Electives	-	3	3	-	3	12	21
	Total Credits	**9**	**9**	**9**	**6**	**9**	**12**	**54**

CORE COURSES

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** *(< 45 characters)*	**Introduction to Weather, Climate and Air Pollution**
3.	**L-T-P structure**	**1-0-0**
4.	**Credits**	**1**
5.	**Course number**	**ASL730**
6.	**Status** (*category* for *program*)	**Bridge course (Core)**

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem☐1stsem☐2ndsem☒**Either sem**

11.	**Faculty who will teach the course** All CAS faculty

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** This is a bridge course for students in the first-semester of the Atmospheric and Oceanic Science and Technology M.Tech program. This course will introduce students to the basic concepts of the science of weather, climate and air pollution to facilitate their transition into a new discipline.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Overview of the discipline, history and landmarks, career options, weather vs climate, online resources; composition of the atmosphere, Greenhouse Effect, Ozone Hole, vertical structure of the atmosphere and oceans; energy in the atmosphere, mechanisms of radiative transfer; water in the atmosphere, origin and types of clouds and precipitation; atmospheric and oceanic motion, forces, major wind patterns and ocean currents, monsoons, local circulations, scales of motion; climate and climate change, IPCC; air pollution, pollutants, acid rain, plumes, effects of wind and stability, episodes; observation tools including AWS, radar, satellite; weather and climate models, NWP, chaos theory; field trip to IMD and Hindon AFB to see meteorological instruments in operation.

15. Lecture Outline*(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Overview	2
2	Composition and vertical structure of the atmosphere and oceans	2
3	Energy in the atmosphere	1
4	Moisture in the atmosphere	1
5	Atmospheric and oceanic motion	2
6	Climate change	1
7	Air pollution	1
8	Observation tools	2
9	Weather and climate models	2
COURSE TOTAL *(14 times 'L')*		**14**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Explore weather/climate data using web-based tools	3
2	Read Ahrens Chapter 1	1
3	Read Ahrens Chapters 2-3 selected portions	1
4	Read Ahrens Chapter 4-7 selected portions	2
5	Read Ahrens Chapter 8-11 selected portions	2
6	Read Ahrens Chapter 17-18 selected portions; Read IPCC AR5 Technical summary and Summary for Policymakers	3
7	Read Ahrens Chapter 19 selected portions	1
9	Read Ahrens Chapter 13 selected portions	1
	COURSE TOTAL *(14 times 'L')*	**14**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Ahrens, C. D., Meteorology Today, 11th editions, Cengage, 2015

20. Resources required for the course *(itemized & student access requirements, if any)*

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Public domain images and animations
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	PowerPoint projection equipment, black/white board
20.7	Site visits	Transportation
20.8	Others (please specify)	None

21. Design content of the course*(Percent of student time with examples, if possible)*

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** *(< 45 characters)*	**Data Analysis Methods for Atmospheric and Oceanic Sciences**
3.	**L-T-P structure**	**0-0-4**
4.	**Credits**	**2**
5.	**Course number**	**ASP731**
6.	**Status** (*category* for *program*)	**Bridge course (Core)**

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒**Either sem**

11.	**Faculty who will teach the course** S. Baidya Roy, DilipGanguly, Krishna AchutaRao, Vimlesh Pant, SagnikDey

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** This is a bridge course for students in the first-semester of the Atmospheric and Oceanic Science and Technology M.Tech program. This course will introduce students to the computational tools that are required for the courses in the Atmospheric-Oceanic Science and Technology M.Tech program.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Introduction to UNIX/LINUX, basic commands, file management; introduction to MATLAB, using Mathworks resources; MATLAB I/O with NetCDF, HDF and GRIB2; plotting 1, 2 and 3 dimensional weather/climate data and animations with MATLAB; Univariate & bivariate statistics, mean/median/mode, variance/standard deviation, correlation, errors, regression; probability and distributions, how to frame and test a hypothesis, principles of statistical significance, using MATLAB functions to test hypotheses and estimate statistical significance; working with spatial weather/climate data, regridding meteorological station data, interpolation, map overlays; working with time-series, interpolation, estimating trend in weather/climate variables.

15. Lecture Outline*(with topics and number of lectures)*

Module no.	Topic	No. of hours

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Introduction to UNIX/LINUX	4
2	Programming with MATLAB	8
3	MATLAB I/O with common data formats	8
4	Data visualization	8
5	Basic statistical analysis	4
6	Introduction to probability, distributions and statistical significance	8
7	Spatial data analysis	8
8	Time-series analysis	8
COURSE TOTAL *(14 times 'L')*		**56**

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1-2	Read Trauth Chapter 2, practice + homework assignments	4
3	Practice + homework assignments	2
4	Read selected chapters of Trauth and Sillman, Practice + homework assignments	4
5	Read Trauth Chapters 3-4, practice + homework assignments	6
6	Read von Storch Chapter 6, Wilks Chapter 2, practice + homework assignments	4
7	Read Trauth Chapter 5, practice + homework assignments	4
8	Read Trauth Chapter 7, practice + homework assignments	4
COURSE TOTAL		**28**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- RudraPratap, Getting started with MATLAB, 1st Edition, Oxford, 2010.
- Trauth, M., MATLAB Recipes for Earth Sciences, 3rd Edition, Springer 2010
- Trauth, M. and E. Sillman, MATLAB and Design Recipes for Earth Sciences, 1st Edition, Springer, 2012
- von Storch, H. and F.W. Zwiers, Statistical Analysis in Climate Research,1st Edition, Cambridge,2003
- Wilks D.S., Statistical Methods in the Atmospheric Sciences. 3rd edition, Academic, 2010.

20. Resources required for the course *(itemized & student access requirements, if any)*

20.1	Software	UNIX/LINUX, MATLAB with toolboxes
20.2	Hardware	Desktop PC with LINUX or LINUX partition
20.3	Teaching aides (videos, etc.)	Public domain images and animations
20.4	Laboratory	Computing lab
20.5	Equipment	None
20.6	Classroom infrastructure	PowerPoint projection equipment, black/white board
20.7	Site visits	None
20.8	Others (please specify)	None

21. Design content of the course*(Percent of student time with examples, if possible)*

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	100%
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** *(< 45 characters)*	**Mathematical and Computational Methods for Atmospheric and Oceanic Sciences**
3.	**L-T-P structure**	**2-0-2**
4.	**Credits**	**3**
5.	**Course number**	**ASL732**
6.	**Status** (*category* for *program*)	**Bridge course (core)**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supersedes any existing course	

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	***Frequency of offering***	☐Every sem ☐ 1stsem ☐2ndsem ☒Either sem -

11.	**Faculty who will teach the course** Maithili Sharan, H.C. Upadhyaya, P. Goyal, A.D. Rao

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** *(about 50 words)***:** This is a bridge course for the students of the Atmospheric and Oceanic Science and Technology M.Tech program. This course will introduce students to the Mathematical & computational tools that are required for the courses in the Atmospheric and Oceanic Science and Technology M.Tech program.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Elements of FORTRAN programming; Initial and boundary value problems; second order ordinary differential equations, variation of parameters, orthogonal functions; Partial differential equations and their classification, method of separation of variables; Euler and RungeKutta methods for ODE; Spatial and temporal finite differencing schemes of various orders, comparison with exact solutions, accuracy and numerical stability, limitation of finite difference methods; Numerical solution of linear advection equation, advection-diffusion equation, and shallow water equation.

15. Lecture Outline*(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Elements of FORTRAN programming with an emphasis on iterations and decision structure.	5
2	Initial and boundary value problems, ordinary differential equations,	5
3	Partial differential equations and their classifications. Solution using separation of variables	5
4	Spatial and temporal finite differencing schemes of various orders, accuracy and numerical stability, limitation of finite difference methods.	7
5	Numerical solution of linear advection equation, advection-diffusion equation, and shallow water equations	6
COURSE TOTAL *(14 times 'L')*		**28**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Writing programs for simple problems such as averaging, sorting & ordering the sequence of numbers, Trapezoidal rule etc	10
2	Ordinary differential equations: Euler /RungeKutta and comparison with exact solutions	10
3	Program for the solution to advection-diffusion equation using temporal and spatial finite difference schemes	8
COURSE TOTAL (14 times 'P')		**28**

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Practice assignments using FORTRAN , Read selected chapters from Rajaraman.	10
2-3	Review on ordinary and partial differential equations (first and second order), Read selected parts of chapters 1,2, and 12 from Kreyszeig.	20
4-5	Methods for numerical integration, Read Chapters 1-3 of Mesinger and Arakawa, Chapter 21 from Kreyszeig.	12
		42

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Kreyszig, E.; Advanced Engineering Mathematics, Seventh Edition, John Wiley 1993.
- Press, W.H., Flannery, B.P., Teukolsky, S.A. and Vetterling W.E.; Numerical Recipes: The Art of Scientific Computing, Cambridge Univ Press.
- Boyce, W.E. &DiPrima R.C.; Elementary Differential Equations and Boundary Value Problems, John Wiley 2001.
- Carnahan, B., Lither, H.A & Wilkes, J.O.; Applied Numerical Methods, Wiley, New York 1969.
- Rajaraman, V.; Computer Programming in Fortran 90 and 95, PHI 1997.
- Mesinger, F. and A. Arakawa; Numerical Methods used in Atmospheric Models. Vol 1, Garp Publications Series No. 17.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Yes
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	Yes
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	Nil
20.8	Others (please specify)	Nil

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	50%
21.3	Project-type activity	
21.4	Open-ended laboratory work	50%
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Physics of the Atmosphere**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL733**
6.	**Status** (category for program)	**Program Core**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	ASL 703

9.	**Not allowed for** (indicate program names)	Nil

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** M. Mohan, SagnikDey, DilipGanguly, PramilaGoyal

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To teach students essential concepts on physics of the atmosphere covering mostly the thermodynamics, radiation and boundary layer and their application relevant for studies pertaining to various disciplines of atmospheric sciences.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Structure of the atmosphere; Hydrostatic equilibrium, Geopotential, Hypsometric equation and scale height, Altimetry; Adiabatic processes, Lapse rates, Static stability, dynamic stability; Atmospheric Boundary Layer Structure and evolution, turbulence etc. Atmospheric Thermodynamics: Thermodynamic laws; Thermodynamics of water vapour and moist air: Moisture parameters, Saturated adiabatic and Pseudoadiabatic processes, Conditional and convective instability, Free and forced convection; Thermodynamic diagrams; Phase change and Clausius-Clapeyron equation; Clouds: Formation and classification, Precipitation; Atmospheric visibility: Dew, Frost and fog, smog etc.

	The fundamental physics of radiation:solar and terrestrial radiation, radiation laws; absorption, emission and scattering in the atmosphere, Schwarzchild's equation; Radiation in the earth-atmosphere system: Geographical and seasonal distribution, Radiative heating and cooling of the atmosphere, Surface energy budget, The mean annual heat balance.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Structure of the atmosphere	3
2	Hydrostatic equilibrium and applications	3
3	Adiabatic processes and atmospheric stabilities	4
4	Atmospheric boundary layer	3
5	Thermodynamic laws, Thermodynamics of water vapour and moist air	7
6	Thermodynamic diagrams, Phase change and Clausius-Clapeyron equation	5
7	Clouds and Precipitation, Atmospheric visibility	5
8	The fundamental physics of radiation:solar and terrestrial radiation, radiation laws; absorption, emission and scattering in the atmosphere, Schwarzchild's equation, Greenhouse effect	8
9	Radiation in the Earth-Atmosphere System	4
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Read text material on structure of the atmosphere, meteorological conventions.	3
2	Hydrostatic equilibrium and applications: Read text material, Exposure to web based data resources	3
3	Adiabatic processes and atmospheric stabilities: Read text material, Home assignment	4
4	Atmospheric boundary layer: Read text material and study current research material on the subject	3
5	Thermodynamic laws, Thermodynamics of water vapour and moist air: Read text material and home assignment	7
6	Thermodynamic diagrams, Phase change and Clausius-Clapeyron equation: Read text material, web based thermodynamic diagrams and home assignment	5
7	Clouds and Precipitation, Atmospheric visibility: Read text material, practice cloud identification and home assignment	5
8	The fundamental physics of radiation:solar and terrestrial radiation, radiation laws; absorption, emission and scattering in the atmosphere, Schwarzchild's equation, Greenhouse effect: Read text material, research papers and home assignment	8
9	The heat balance in the Earth-Atmosphere System : Read text material and home assignment	4
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Wallace, J. M. and P. V. Hobbs, Atmospheric Science - An Introductory Survey, Academic Press, 2006.
- Stull, R.B., Meteorology for Scientists and Engineers, Brooks/Cole, 2000.
- Buyers, H.R., General Meteorology, McGraw Hill Book Company, 1977.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes (projection facility)
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	yes
20.7	Site visits	No
20.8	Others (please specify)	No

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Dynamics of the Atmosphere**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL734**
6.	**Status** (category for program)	**Program Core**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	**ASL701**

9.	**Not allowed for** (indicate program names)	Nil

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Maithili Sharan, S.K. Dash, H.C Upadhyaya, P. Goyal

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To teach students the fundamental principles of atmospheric dynamics to understand various atmospheric circulations/phenomena.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Fundamental forces; basic laws of conservation; hydrodynamic equations in rotating frame of reference; dimensional analysis; geostrophic and hydrostatic approximations; Atmospheric stability; Isobaric coordinate system; Gradient wind approximation; thermal wind; vertical motion; barotropic and baroclinic atmospheres; Circulation and vorticity; vorticity equation; potential vorticity conservation. Boussinesq approximation; Reynolds averaging; mixing length hypothesis; Ekman layer; Acoustic, gravity, Poincare, Rossby and Kelvin waves. Atmospheric general circulation.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Fundamental forces and basic laws of conservation in rotating frame of reference	7
2	Dimensional analysis; geostrophic and hydrostatic approximations	5
3	Isobaric coordinate system; Gradient wind approximation & thermal wind	6
4	Vertical motion	3
5	Circulation and vorticity; vorticity equation & potential vorticity conservation	6
6	Boussinesq approximation	3
7	Reynolds averaging; mixing length hypothesis & Ekman layer	5
8	Atmospheric waves: Acoustic, gravity, Poincare, Rossby and Kelvin waves	5
9	Atmospheric general circulation	2
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1-2	Various coordinate systems: rectangular, spherical, natural and isobaric; Assignments from chapters 1-2 of Holton's book	10
3-4	Derivations and assignments from chapter 3 of Holton's book, Baroclinic and barotropic atmosphere, atmospheric stability	10
5-6	Physical implications of vorticity, Assignments on the chapter 4 "Circulation and vorticity" from Holton's book	10
7	Structure of the boundary layer, derivations and assignments from the chapter 5 of Holton's book	5
8-9	Review and derivations based on the chapter 7 from Holton's book	7
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Vallis G.K., Atmospheric and Oceanic Fluid Dynamics, Cambridge Univ. Press, 2006
- Pedlosky J., Geophysical Fluid Dynamics, Springer-Verlag, 1979
- Holton J.R., An Introduction to Dynamic Meteorology, Academic Press, 1992
- Jacobson M. Z., Fundamental of Atmospheric Modeling, Cambridge University Press, 1999.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	yes
20.4	Laboratory	Nil
20.5	Equipment	Nil
20.6	Classroom infrastructure	yes
20.7	Site visits	Nil
20.8	Others (please specify)	Nil

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Atmospheric Chemistry and Air Pollution**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL735**
6.	**Status** (category for program)	**Program Core**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	**ASL808**

9.	**Not allowed for** (indicate program names)	Nil

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** M. Mohan, D. Ganguly, P. Agarwal, SagnikDey, P. Goyal

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** This course objective is to cover fundamentals of atmospheric chemical processes that potentially impacts atmospheric air pollution, weather and climate. Fundamental concepts on air pollution meteorology and atmospheric dispersion modeling are also introduced.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Atmospheric Composition and air pollutants, Geochemical cycles: Evolution of the atmosphere and geochemical cycling of elements, Atmospheric photochemistry; Chemistry of the troposphere: Basic photochemical cycle, atmospheric chemistry dealing with various pollutant species and photochemical smog; Oxidising power of the troposphere and the Hydroxyl radical, global budgets of precursor species; Stratospheric Chemistry and Ozone: Overview, Chapman mechanism, reservoir species and catalytic cycles, Ozone hole and polar stratospheric clouds, Arctic Ozone loss, Ozone depletion potential; Aqueous phase atmospheric chemistry and acid rain; Atmospheric Aerosols: sources and characteristics, radiative effects and perturbation to climate; Atmospheric air pollutants: sources, impacts and standards; Air Pollution Meteorology: sources of air pollutants, classification and air quality standards, stability conditions, wind velocity profile, turbulence, mixing depth, characteristics of stack plumes; Dispersion of pollutants in the atmosphere: A Gaussian dispersion model, dispersion parameters and effective stack height.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Atmospheric composition and air pollutants	3
2	Geochemical cycles	5
3	Atmospheric photochemistry	2
4	Chemistry of the troposphere	7
5	Oxidising power of the troposphere and the Hydroxyl radical	3
6	Stratospheric Chemistry and Ozone	6
7	Aqueous phase atmospheric chemistry and acid rain	4
8	Atmospheric Aerosols	3
9	Air Pollution Meteorology	4
10	Dispersion of pollutants in the atmosphere	5
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Self study and assignment on mixing ratio, number density and related quantities	3
2-3	Self study on Assignment on geochemical cycles and Atmospheric Photochemistry, Assignment	5
4	Self study on Chemistry of the troposphere, Assignment	5
5	Self study on Oxidising power of the troposphere and the Hydroxyl radical, Assignment	3
6	Self study on Stratospheric Chemistry and Ozone, Assignment	4
7	Self study on Aqueous phase atmospheric chemistry and acid rain, Assignment	3
8	Self study on Atmospheric aerosols, Assignment	3
9	Self study on Air Pollution Meteorology, Assignment	8
10	Self study on Dispersion of pollutants in the atmosphere, Assignment	8
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Sonntag, R. E., C. Borgnakke, and G. J.VanWylen, Fundamentals of Thermodynamics, 5th Ed., John Wiley, 2000.
- Seinfeld, J.H., and S.N. Pandis, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, John Wiley and Sons, 1998.
- Jacob, D.J., Introduction to Atmospheric Chemistry, Princeton University Press, 1999.
- Wark Kenneth, and Cecil F. Warner, Air Pollution: Its origin and Control, Harper and Row Publishers, 1976.
- Arya, S.P., Introduction to Micrometeorology, Academic Press, 2006.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	yes
20.7	Site visits	No
20.8	Others (please specify)	No

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Science of Climate Change**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL736**
6.	**Status** (category for program)	**Program Core**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	**ASL715**

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Krishna AchutaRao, Saroj K. Mishra, DilipGanguly, Manju Mohan

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** This course is intended to give an overview of the science of climate change. The course should give students a good understanding of how the climate system works and a scientific background to the problem of climate change - both natural and that resulting from human activity and prepare them to think of its impacts and possible solutions.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Description of the climate system (General circulation, hydrological cycle, carbon cycle). Natural greenhouse effect and the effect of trace gases and aerosols. Forcings (natural & anthropogenic), Fast and Slow Feedbacks, Equilibrium Climate Sensitivity, Transient Climate Response. Climates of the past (ice ages, proxy records, abrupt climate change, instrumental record of climate). Climate variability and time-scales; MJO, ENSO, PDO, Milankovic cycles. Modeling climate: Simple EBMs, Coupled Climate Models. Natural and Anthropogenic climate change. Future climate projections.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Energy balance, equilibrium climate	4
2	Description of the climate system	6
3	Role of Oceans and cryosphere in climate	5
4	Greenhouse gases, aerosols & short-lived climate forcers, tropospheric & stratospheric ozone, Carbon & Nitrogen cycles	6
5	Forcings and feedbacks	7
6	Variability on different time-scales	4
7	Climate models (EBMs to Coupled-GCMs)	4
8	Observed climate change, Natural & Anthropogenic climate change, Future climate projections.	6
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N.A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	N.A	

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Self study& problem solving from • Marshall, J., and Plumb, R.A., Atmosphere, Ocean, and Climate Dynamics: An Introductory Text, (Chapters 1-2)	4
2	Self study of description from • J. David Neelin, Climate Change and Climate Modeling, Cambridge University Press, 2011" (Chapter 2) Problem solving from • Marshall, J., and Plumb, R.A., Atmosphere, Ocean, and Climate Dynamics: An Introductory Text, (Chapters 3-4)	6
3	Self study& problem solving from • Marshall, J., and Plumb, R.A., Atmosphere, Ocean, and Climate Dynamics: An Introductory Text, (Chapters 9-11)	5
4	• Get familiar with online data sources for atmospheric composition (e.g. Mauna Loa CO_2 data, NOAA etc.) • Self study Chapter 3 of "Graedel, T. E., and Crutzen, P. J., Atmosphere, Climate and Change"	4
5	Read & Discuss Classical Papers on • Cloud Radiative Forcing by Ramanathan et al., "Cloud-Radiative Forcing and Climate: Results from the Earth Radiation Budget Experiment" • Climate Sensitivity by Hansen et al., "How Sensitive is the World's Climate?"	7
6	• Self study Chapter 4: "Climates of the Past" from "Graedel, T. E., and Crutzen, P. J., Atmosphere, Climate and Change"	4

7	Self study& problem solving from • Marshall, J., and Plumb, R.A., Atmosphere, Ocean, and Climate Dynamics: An Introductory Text, (Chapters 6-7) • Study and implement a one dimensional "Budyko" EBM with poleward heat transport. • Use EdGCM to run simple climate change simulations with an AGCM coupled to a slab model.	8
8	• Self study: IPCC Fifth Assessment Report Technical Summary	4

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Suggested Texts:

- Dennis L. Hartmann, Global Physical Climatology
- Marshall, J., and Plumb, R.A., Atmosphere, Ocean, and Climate Dynamics: An Introductory Text, Academic Press, 2007
- Peixoto, J. P., and Oort, A. H., Physics of Climate, Springer, 1992
- Graedel, T. E., and Crutzen, P. J., Atmosphere, Climate and Change, 1995.
- Neelin, J. D., Climate Change and Climate Modeling, Cambridge University Press, 2011.

References:

- Imbrie, J., and Imbrie, K. P., Ice Ages: Solving the Mystery, Harvard University Press, 2005
- Washington, W. M., and Parkinson, C. L., An Introduction to Three-Dimensional Climate Modeling, 2nd Edition, University Science Books, 2005
- Climate Change 2013 - The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC (Climate Change 2013), Cambridge University Press, 2013
- Weart, S. R., The Discovery of Global Warming, Harvard University Press, 2003

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Projector
20.4	Laboratory	No
20.5	Equipment	None
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	None

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Physical and Dynamical Oceanography**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL737**
6.	**Status** (category for program)	**Program Core**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** A. D. Rao, Vimlesh Pant

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The course intends to educate students about the basic physical properties of oceans and dynamics of the oceanic processes. Students will learn fundamentals of physical oceanography and application of fluid dynamics in governing oceanic motions.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Properties of sea water; temperature and salinity distributions; stratification and stability of oceanic water column; equation of state of sea water; oceanic mixed layer processes; governing equations for oceanic motions; inertial and geostrophic currents; wind-driven circulation; thermohaline circulation; Barotropic and baroclinic transports; western boundary intensification; gyres and meso-scale eddies; gyre systems, major currents in world oceans; Indian ocean circulation; physics and dynamics of ocean wind waves, internal waves and tides; coastal ocean processes; upwelling and downwelling in coastal and equatorial oceans; Rossby and Kelvin waves, biological productivity of oceans; heat and salt budget of oceans; observational methods in oceans; storm surges, ENSO and IOD phenomenon.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Properties of sea water and distributions of temperature, salinity, and density	4
2	Stratification and stability of oceanic water column, oceanic mixed layer.	3
3	Governing equations of oceanic motions	4
4	Wind-driven circulation and thermohaline circulation	4
5	Barotropic and baroclinic transports; western boundary intensification	4
6	Major currents in world oceans; Indian ocean circulation	3
7	Wind waves, internal waves and tides, storm surges	6
8	Coastal ocean processes; upwelling phenomenon, Ekman pumping	5
9	Heat and salt budgets of oceans	3
10	Observational methods in oceans	2
11	ENSO and IOD phenomenon	4
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Review on spatio-temporal variability of temperature, salinity of world oceans	4
2	Review on variability of mixed layer depth in the Indian Ocean	3
3	Understanding of equations of motion in the rotating and non-rotating frame of reference.	4
4-5	Read text material on theory of oceanic transport.	8
6	Read text material on Indian ocean circulation with reference to global ocean circulation.	3
7	Assignment on surface and sub-surface waves in the ocean. Analysis of Tidal data along the Indian coasts.	6
8	Assignment on differences between shallow and deep water ocean dynamics.	5
9	Assignment on computation of heat and salt fluxes over the Indian Ocean.	3
10	Term paper on measuring physical oceanic parameters.	2
11	Assignment on influence of ENSO and IOD on Indian summer monsoon.	4
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Book:

- Talley, L.D., G.L. Pickard, W.J. Emery, J. H. Swift, Descriptive Physical Oceanography, sixth edition, Elsevier, 2011.
- Pond, S., G.L. Pickard, Introductory Dynamic Oceanography, Butterworth-Heinemann, 1983

References:

- Stewart, R. H., Introduction to Physical Oceanography, 2008.
- Huang, R.X., Ocean Circulation, Cambridge, 2010.
- Trujillo, A. P., H.V. Thurman, Essentials of Oceanography, eleventh edition, Pearson, 2014.
- Olbers, D.J., J. Willebrand, C. Eden, Ocean Dynamics, First edition, Springer, 2012.
- C.A. Brebbia, G. Benassai, G.R. Rodriguez, Coastal Processes, WIT Press, 2009

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Numerical Modeling of the Atmosphere and Ocean**
3.	**L-T-P structure**	**2-0-2**
4.	**Credits**	**3**
5.	**Course number**	**ASL738**
6.	**Status** (category for program)	**Program Core**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	Any programme other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** S. K. Dash, D. Ganguly, S. K. Mishra, Somnath B. Roy, Maithili Sharan, Vimlesh Pant

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The objective of this course is to make the students aware of how numerical models of weather and climate are formulated from governing physical principles and how they are used for weather forecasting and climate prediction purposes.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Introduction to weather and climate models, Numerical Modeling Vs. Other Modeling Approaches, Examples of atmospheric and oceanic simulations, Model Hierarchy (Simple, Intermediate, Complex); Governing equations in Cartesian, Isobaric and sigma coordinate systems; Numerical discretization (finite difference, finite volume, spectral) and integration, stability, CFL criterion, unconditionally stable numerical scheme; model components, dynamical core, physical parameterization, tracers, coupling of components; global and regional models used in weather forecasting and climate simulations.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction to weather and climate models	5
2	Governing Equations and coordinate systems	3
3	Numerical discretization and integration	9
4	Model Components	6
5	Application of global and regional models for weather forecasting and climate prediction.	5
COURSE TOTAL (14 times 'L')		**28**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N/A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Survey of freely available state-of-the-art GCM and RCM codes along with necessary initial and boundary conditions data on the web such as CESM, WRF, RegCM, etc.	2
2	Going through the tutorials and making test runs.	2
3	Design a set of sensitivity experiments (eg. by changing model resolution, slightly modifying a physical parameterization, using a new physical parameterization, changing/modifying atmospheric chemistry, changing/modifying the initial and boundary conditions, etc.) using a suitable model in consultation with the course coordinator.	6
4	Conducting sensitivity experiment in the context of Indian weather and climate.	10
5	Analysis of model output.	8
	Total	**28**

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Read lectures notes and selected book chapters, assignments	12
2	Revise material on atmospheric dynamics, assignments on transformation of various coordinate system	12
3	Study various discretization schemes	6
4-5	Read model documentation, assignments.	12
COURSE TOTAL		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Jean Coiffier, Fundamentals of Numerical Weather Prediction, Cambridge University Press, 2011.
- Krishnamurti, T. N. and L. Bounoua, An Introduction to Numerical Weather Prediction Techniques, CRC Press, 1995.
- Ehrendorfer, Martin, Spectral Numerical Weather Prediction Models, SIAM, 2012.
- Holton, J. R. and G. J. Hakim, An Introduction to Dynamic Meteorology, Academic Press, 2012.
- Haltiner, G. J. and R. T. Williams, Numerical prediction and dynamic meteorology, Wiley, 1983
- Salby, M. L., Fundamentals of atmospheric Physics, Academic Press, 1996.
- Washington, M. and C. L. Parkinson, Introduction to three dimensional climate modeling, University Science Books, 2005.
- Kantha, L.H. and C.A. Clayson, Numerical Models of Oceans and Oceanic Processes, Academic Press, 2000.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Yes
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	Yes
20.5	Equipment	Workstation with Linux OS
20.6	Classroom infrastructure	PowerPoint projection equipment, black/white board
20.7	Site visits	No
20.8	Others (please specify)	Nil

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	30%
21.3	Project-type activity	
21.4	Open-ended laboratory work	70%
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Advanced Data Analysis for Weather and Climate**
3.	**L-T-P structure**	**1-0-4**
4.	**Credits**	**3**
5.	**Course number**	**ASP820**
6.	**Status** (category for program)	**Core**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Krishna AchutaRao, DilipGanguly, H.C. Upadhyaya, O.P. Sharma

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The course will provide concepts in statistical analysis for interpreting atmospheric and oceanic phenomena that are characterized by spatial and temporal patterns.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Weather Forecast Evaluation: Jet stream analysis, standard diagnostics and skill scores, Extreme events analysis. Using correlation to explore the relationships between large-scale atmospheric conditions, and local weather. Analyzing trends in climate data, and determining if they are statistically significant (regression, Mann-Kendall test etc). Regression based approaches, simple linear & multiple. Using indexes, Compositing patterns, Isolating patterns using EOF/PC analysis; Analysis of Time Series, Autocorrelation and Spectra.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Review of Statistics	1
2	Composites, index based analysis	2
3	Regressions and Correlation based approaches	2
4	Patterns in data: EOF/PC Analysis	4
5	Time series, Autocorrelation, Periodogram and Spectra	4
6	Data filtering and filter design	1
	COURSE TOTAL (14 times 'L')	**14**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N.A	0

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Skill scores for forecast verification, Extreme events diagnosis, use of ensembles, Jet stream analysis etc.	8
2	Index and composite based analysis of Monsoons, ENSO, PDO, NAO, etc.	8
3	Use of regression and correlation (spatial and temporal), ANOVA, Taylor diagrams	8
4	EOF and PC time-series use in understanding weather and climate modes using examples of MJO, ENSO and MISO.	16
5	Power spectra exercises using indices, Wave number/frequency power spectra analysis (Wheeler-Kiladis diagrams)	12
6	Filter design & implementation for weather/intra-seasonal/climate modes (high/band /low-pass)	4
	Total	**56**

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Refresh MATLAB skills. Gain familiarity with online data sources for weather and climate	8
2	WGNE standard diagnostics and weather skill scores survey	8
3	Linear Regression (including multiple) theory from Wilks	6
4	EOF theory self study from Wilks / Von Storch&Zweirs /Preisendorfer	12
5-6	Spectral analysis theory from Wilks / Von Storch&Zweirs/Jenkins & Watts	8
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Trauth, M., et al., MATLAB Recipes for Earth Sciences, 3rd Edition, Springer 2010
- Daniel S. Wilks, “Statistical Methods in the Atmospheric Sciences” Academic Press Inc; 3rd Revised edition (4 July 2011)
- Hans von Storch, Francis W. Zwiers, “Statistical Analysis in Climate Research”, Cambridge University Press (March 4, 2002)
- Gwilym Jenkins, Donald Watts, “Spectral Analysis and Its Applications”, Emerson-Adams Press (December 2000) - REFERENCE
- Rudolph W. Preisendorfer. “Principal Component Analysis in Meteorology and Oceanography”, Elsevier Science Ltd (December 1988) - REFERENCE

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Linux/Unix, MATLAB
20.2	Hardware	Desktop PC with LINUX or UNIX partition
20.3	Teaching aides (videos, etc.)	
20.4	Laboratory	Computing Lab
20.5	Equipment	
20.6	Classroom infrastructure	Powerpoint projection equipment, black/white board
20.7	Site visits	
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	100%
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Project-I**
3.	**L-T-P structure**	**0-0-12**
4.	**Credits**	**6**
5.	**Course number**	**ASD881**
6.	**Status** (category for program)	**Program Core**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	**ASD891**

9.	**Not allowed for** (indicate program names)	Any program other than AST

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** A problem of practical and theoretical interest will be explored by the students. The problem will be defined, relevant literature survey and preliminary research will be carried out and a report will be submitted by the student. Progress of the student will be evaluated as per the CRC/Institute guidelines.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Yes
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	No
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	100%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

ELECTIVE COURSES

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Boundary Layer Meteorology**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL750**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	**ASL705**

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒**Either sem**

11.	**Faculty who will teach the course** SomnathBaidya Roy, Manju Mohan, Maithili Sharan

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** In this course, students will develop a thorough quantitative understanding of the atmospheric boundary layer, learn the governing equations with emphasis on turbulence, and how these equations apply to boundary layer phenomena like thermals, cumulus clouds, fog, nocturnal jets and sea breeze.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Introduction to the boundary layer, definition and qualitative description of temporal evolution and vertical structure; Fourier series and turbulence spectra, Reynold's averaging, interpreting variance/covariance as turbulent kinetic energy and fluxes, tensors and Einstein summation notation; Prognostic equations for mean variables in a turbulent flow, simplifications; Prognostic equations for turbulent fluxes and variances; TKE equation, static and dynamic instability, Reynold's number, Richardson number, Obukhov length, stability parameter relationships, closure problem in turbulent flow, first-order local closure; surface boundary conditions, surface momentum, energy and moisture budgets, fluxes at surface and entrainment zone, drag and Bowen ratio methods; surface layer Similarity Theory, Buckingham Pi method, applications to wind profiles; Stable and convective mixed layer phenomena including nocturnal jets, thermals, dust devils; boundary layer clouds, fair-weather cumulus, fog; geographically generated local circulations like slope and valley winds, sea/lake breeze, geographically modified flow, fetch, internal boundary layer.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Mean boundary layer characteristics	2
2	Mathematical/statistical concepts and their physical interpretation	3
3	Governing equations of boundary layer flow	6
4	Prognostic equations for turbulent fluxes and variances	6
5	Turbulence Kinetic Energy, Stability and Scaling, Turbulence closure	8
6	Surface boundary conditions	6
7	Surface layer Similarity Theory	3
8	Boundary layer phenomena	3
9	Boundary layer clouds	2
10	Geographic effects	3
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Read Stull Chapter 1, Garratt Chapter 1	3
2	Explore sample boundary layer data , Plot time-series and vertical profiles, Assignment	6
3	Read Stull Chapter 3, Practice derivations	4
4	Read Stull chapter 4, Practice derivations, Assignment	6
5	Read Stull Chapter 5-6 and Garratt Chapter 8, Practice derivations	7
6	Read Stull Chapter 7 and Garratt Chapter 5 & 8, Assignment	6
7	Read Stull Chapter 9	2
8	Read Stull Chapter 11-12, Assignment	4
9	Read Stull Chapter 13	2
10	Read Stull Chapter 14	2
COURSE TOTAL		42

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Stull, R. B., Boundary Layer Meteorology, 1st Ed, Kluwer Academic, 1999.
- Garratt, J. R., The Atmospheric Boundary Layer, 1st Edition, Cambridge University Press, 1994.
- Kaimal, J.C. and J. J. Finnigan, Atmospheric Boundary Layer Flows, 1st Edition, Oxford, 1994

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	MATLAB
20.2	Hardware	Desktop PC
20.3	Teaching aides (videos, etc.)	Public domain animations
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	PowerPoint projection equipment, black/white board
20.7	Site visits	No
20.8	Others (please specify)	No

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Dispersion of Air Pollutants**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL751**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	**ASL724**

9.	**Not allowed for** (indicate program names)	Nil

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem: yes ☒Either sem

11.	**Faculty who will teach the course:** Manju Mohan, Maithili Sharan, PramilaGoyal and P. Aggarwal

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To provide in- depth knowledge on the concepts of atmospheric dispersion of air pollutants

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Air Pollution , Various types, sources and effects of pollutants in the atmospheric environment; Particulate matter and atmospheric visibility; Atmospheric diffusion theories and types of dispersion models; Lapse rates and various types of stability classification, Wind-profile ,Wind rose, Mixing Depth, General characteristics of the stack plumes; Dispersion of pollutants in the atmosphere and solution of advection diffusion equation with Gaussian distribution for point, line and area sources, plume rise, dispersion parameters and various methods of their evaluation; Atmospheric Removal processes and residence time; Effect of buildings and topography on dispersion; Similarity theory and profiles in the surface layer; Air Quality and Emission standards, their measurements and statistics; Introduction of air quality models for regulatory applications

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Air Pollution, Various types, sources and effects of pollutants in the atmospheric environment	3
2	Particulate matter and atmospheric visibility	3
3	Atmospheric diffusion theories and types of dispersion models	3
4	Lapse rates and various types of stability classification, Wind-profile ,Wind rose, Mixing Depth, General characteristics of the stack plumes	5
5	Similarity theory and profiles in the surface layer	4
6	Dispersion of pollutants in the atmosphere and solution of advection-diffusion equation with Gaussian distribution for point, line and area sources plume rise, dispersion parameters and various methods of their evaluation	8
7	Introduction of air quality models for regulatory applications	4
8	Air Quality and Emission standards, their measurements and statistics	4
9	Atmospheric Removal processes and residence time; Effect of buildings and topography on dispersion	4
10	Air Quality and Emission standards, their measurements and statistics	4
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities: NA

Module no.	Description	No. of hours

17. Brief description of laboratory activities: NA

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Self-study from web based resources on General characteristics of Air Pollution and its impact on human health and welfare	2
2	Assignment on atmospheric visibility	2
3	Self-study from web based resources along with text books included here on Atmospheric diffusion theories and types of dispersion models	3
4	Assignment on Lapse rates and various types of stability classification, Wind-profile ,Wind rose, Mixing Depth	4
5	Similarity theory and profiles in the surface layer	4
6	Assignment on Gaussian Dispersion Model	4
7	Exercises on regulatory air quality models from web based resources	15
8	Assignment on Air Quality statistics	4
9	Atmospheric Removal processes and residence time; Effect of buildings and topography on dispersion	4
	COURSE TOTAL (14 times 'L')	42

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Textbook:

- Wark K., C. F. Warner and W. T. Davis, Air Pollution, Its Origin and Control, Prentice Hall, 1997.
- S. Pal Arya, Air Pollution Meteorology and Dispersion, Oxford University press, Inc., 1999.

Reference:

- Pasquill F. and Smith F. B., Atmospheric Diffusion, Ellis Horwood Limited. 1983.
- Rao M. N. and Rao H. V. N., Air Pollution, Tata McGraw-Hill Publishing Company Limited, 1989.
- Seinfield J. H and S.N. Pandis: Atmospheric Chemistry and Physics of Air Pollution,John Wiley and Sons, 2006.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	No

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	-
21.2	Open-ended problems	100%
21.3	Project-type activity	-
21.4	Open-ended laboratory work	-
21.5	Others (please specify)	-

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Mesoscale Meteorology**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL752**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	**ASL817**

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** S K Dash, S Baidya Roy

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** This course will help students understand the dynamic and thermodynamic processes of mesoscale phenomena with spatial scale of one to hundreds of km commonly observed in India such as tornadoes, thunderstorms, etc.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Overview of mesoscale phenomena relevant to India including tornadoes, thunderstorms, cloud bursts, fog, extreme rain events, lightning, etc; Circulation systems related to orography, mountain drag, mountain waves, valley winds, valley air pollution; Adiabatic mesoscale perturbations in a straight atmospheric flow; Theory of linear gravity waves, orographic gravity-wave drag; Parameterization of mesoscale phenomena in general circulation models; Mesoscale models and their application in India.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Overview of mesoscale phenomena relevant to India	10
2	Circulation systems related to orography	10
3	Adiabatic mesoscale perturbations in a straight atmospheric flow	4
4	Theory of linear gravity waves, orographic gravity-wave drag	4
5	Parameterization of mesoscale phenomena in general circulation models	6
6	Mesoscale models and their application in India.	8
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Lilly Chapter 1; parts of Ray Chapters 15-20	10
2	Lin Chapter 5, 11; Ray Chapter 20-21	10
3	Lin Chapter 1-2	4
4	Lin Chapter 3-4; Lilly Chapter 5	4
5-6	Lin Chapter 12-14; Pielke Chapter 7-8, 13	14
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Ray, P. S., Mesoscale Meteorology and Forecasting, AMS, 1986
- Lilly, D. K. and T. G. Chen, Mesoscale Meteorology - Theories, Observations and Models, Springer, 1983
- Lin, Y., Mesoscale Dynamics, 2nd Edition, Cambridge University Press, 2010
- Pielke, R. A., Mesoscale Meteorological Modeling, 3rd Edition, Academic Press, 2013

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	No

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Atmospheric Aerosols**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL753**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒**Either sem**

11.	**Faculty who will teach the course** SagnikDey, DilipGanguly, Maithili Sharan

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The course is intended to provide a comprehensive understanding about the physical and chemical properties of aerosols, their life cycle in the atmosphere, interaction with radiation, role in cloud formation, and aerosol effects on air quality, human health, and climate.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Introduction to atmospheric aerosols; Characterization of Aerosols; Physical and Optical properties of aerosols, size distribution, refractive indices of aerosols, absorption and scattering of radiation by aerosols; single scattering albedo, aerosol optical depth, aerosol phase function, hygroscopic growth; mixing state, vertical distribution in the atmosphere; Aerosol Chemical Composition; mixing state of aerosols; New particle formation; volatile chemical compounds and gas-to-particle conversion processes; Observations and Measurements of aerosols; Climatology of Tropospheric Aerosols; Stratospheric aerosols; Dynamics of single aerosol particle and aerosol population; Transport and transformation of aerosols; Removal of aerosols; Thermodynamics of aerosols; Role in Nucleation; Role in Cloud Physics; Interaction of aerosols with radiation; Direct, indirect, and semi-direct effects of aerosols and their influence on Climate; Aerosol effects on human health and air quality; Aerosols in chemistry transport models; Aerosols in climate models; Latest trends in aerosol research and future directions.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction to atmospheric aerosols and their characterization	2
2	Physical and optical properties of aerosols	5
3	Aerosol chemistry, new particle formation, volatile chemical compounds, gas-to-particle conversion processes	4
4	Observations and Measurements of aerosols; climatology of Tropospheric and Stratospheric aerosols	4
5	Dynamics of single aerosol particle and aerosol population; Transport and transformation of aerosols	4
6	Thermodynamics of aerosols; Role in Nucleation; Role in Cloud Physics	6
7	Interaction of aerosols with radiation; Aerosol radiative forcing; Direct, indirect, and semi-direct effects of aerosols and their influence on Climate	6
8	Aerosol effects on air quality and human health	4
9	Aerosols in chemistry transport models; Aerosols in climate models	5
10	Latest trends in aerosol research and future directions	2
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N/A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	N/A	

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1 & 2	Explore the OPAC (Optical properties of aerosols and cloud) model and use it to compute the scattering, absorption, and extinction coefficients of various mixtures of aerosols; Read selected chapters from Seinfeld and Pandis	7
3 & 4	Utilization of AERONET data (freely available) to understand the space-time variation of aerosol properties across the globe; Read selected chapters from Seinfeld and Pandis, and Boucher	8
5	Explore the HYSPLIT model (online tool) to identify the possible source regions and transport pathways of aerosols in the atmosphere.	5
6 & 7	Assignment on aerosol radiative forcing estimation using SBDART model (freely available); Read selected chapters from Seinfeld and Pandis, and Hobbs	12
8	Read research articles on 'Aerosol effects on human health and air quality'	4
9 & 10	Read selected chapters from reference materials and research articles.	6
COURSE TOTAL		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Textbook:

- Seinfeld, J. H. and S. N. Pandis, Atmospheric chemistry and physics: from air pollution to climate change, Wiley, 2006.

Reference materials

- Jacob, D., Introduction to Atmospheric chemistry, Princeton University Press, 1999.
- Bohren, C. F., and D. R. Huffman, Absorption and Scattering of Light by Small Particles, Wiley, 1983.
- Kondratyev, K. Y., and L. S. Ivlev, Atmospheric Aerosol Properties: Formation, Processes and Impacts, Springer Praxis Books, 2005.
- Hobbs, P. V., Aerosol-Cloud-Climate Interactions, Academic Press Inc., 1993
- Kondratyev, K. Y., Climatic Effects of Aerosols and Clouds, Springer; 1999.
- Boucher, O., Atmospheric Aerosols: Properties and Climate Impacts, Springer; 2015
- Jacobson, M. Z., Fundamentals of Atmospheric Modeling, Cambridge University press, 2005.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Yes
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	PowerPoint projection equipment, black/white board
20.7	Site visits	No
20.8	Others (please specify)	Nil

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Cloud Physics**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL754**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	New

9.	**Not allowed for** (indicate program names)	None

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒**Either sem**

11.	**Faculty who will teach the course** SagnikDey,DilipGanguly

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** This course is intended to give the students an overview of cloud dynamics and microphysics and how these influence the weather and climate. Students will acquire the required fundamental background to work on the scientific problems, like aerosol-cloud-precipitation interaction, cloud radiative feedback, cloud-resolving models.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Cloud types; cloud formation; cloud dynamics: entrainment, detrainment and downdraft initiation in cumuli, large scale convergence, mesoscale convective system; Kohler theory; CCN and IN; homogeneous and heterogeneous nucleation; fundamental equations governing cloud processes; warm cloud microphysics: diffusional growth, droplet population, collision-coalescence, radiative cooling; ice cloud microphysics: nucleation, ice multiplication, growth of ice particles by accretion and ice particle melting; hydrometeor; impact of microphysical processes on dynamics; cloud chemistry; aerosol-cloud interaction: direct, indirect and semi-direct effects; clouds in numerical models: parameterization of cloud microphysics; cloud-climate interaction

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Cloud characteristics	3
2	Cloud dynamics	7
3	CCN, formation of cloud droplets, Kohler theory	6
4	Microphysics of warm clouds	9
5	Microphysics of cold clouds	5
6	Cloud chemistry	3
7	Aerosol-cloud-climate interaction	4
8	Clouds in numerical models	5
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N/A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	N/A	

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Read classic papers on selected chapters from text and reference books on Cloud radiative forcing and feedback	5
2	Read selected chapters on hydrodynamics of cloud and rain drops; assignment	5
3	Read selected chapters on Cloud size spectra; assignment	4
4 & 5	Familiarity and interpretation of cloud microphysical data (airborne and satellite); assignment	10
6	Read selected chapters on Scavenging mechanisms and rainwater chemistry; assignment	5
7	Review of basic aerosol characteristics; Read review articles and research papers	7
8	Read documents on Cloud feedback model intercomparison project (CFMIP); Assignment	6
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Suggested textbook:

- Pruppacher, H. R. and Klett, J. D., Microphysics of clouds and precipitation, Kluwer Academic Publications, 2000.
- Rogers, R. R. and M. K. Yau, A short course in cloud physics, 3rd Edition, 1996.

Suggested reference:

- Lamb, D., and Verlinde, J., Physics and chemistry of clouds, Cambridge Press, 2011
- Wang, P. K., Physics and dynamics of clouds and precipitation, Cambridge Press, 2013

- Starka, J. M., Cloud and precipitation microphysics, Cambridge Press, 2009
- Cotton, W. R., Bryan, G. H. and Heever, S. C. van D., Strom and Cloud Dynamics, Academic press, 2011
- Khvorostyanov, V. I. and J. A. Curry, Thermodynamics, Kinetics and Microphysics of Clouds, Cambridge Press, 2014.
- Seinfeld, J. H. and S. N. Pandis, Atmospheric chemistry and physics: from Air Pollution to Climate Change, Wiley, 2006.
- Houze, R. A., Cloud dynamics, 2nd edition, 2014

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Yes
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Remote Sensing of the Atmosphere and Ocean**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL755**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	**ASL720**

9.	**Not allowed for** (indicate program names)	None

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒**Either sem**

11.	**Faculty who will teach the course** SagnikDey,DilipGanguly

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The course will teach the students about various passive and active remote sensing sensors and techniques used today for observing the weather and climate system. The lectures will focus on the fundamentals of retrievals of various geophysical parameters and interpretation of remote sensing data.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Basics of satellite remote sensing: satellite orbits, sensor characteristics, view angle, passive and active remote sensing; atmospheric radiative transfer application in retrievals of geophysical parameters; aerosol remote sensing using ground-based (passive radiometer and lidar) and satellite platforms, retrieval algorithm, vertical distribution, application of aerosol products in climate studies; cloud remote sensing, cloud detection using multi-spectral technique, issues in cloud-masking, CO2 slice technique; trace gas retrievals; ocean colour remote sensing, SST retrieval, wind scatterometry, altimetry; microwave remote sensing: soil moisture retrieval, passive (brightness temperature) and active (radar) microwave remote sensing for precipitation, sounding, remote sensing of cryosphere; satellite meteorology for extreme weather events (e.g. cyclone, thunderstorms etc.); land-use/land-cover change; hydrological application using gravity anomaly from satellites.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Basics of Remote Sensing	3
2	Atmospheric Radiative Transfer for Retrieval of Geophysical Parameters	6
3	Aerosol Remote Sensing	5
4	Cloud Remote Sensing	6
5	Remote sensing of Trace gases	3
6	Remote sensing of the Ocean (SST, ocean colour, salinity, wind scatterometry, altimeter)	5
7	Application of microwave remote sensing (soil moisture, snow cover, sounding)	5
8	Remote sensing of Precipitation and extreme weather events	5
9	Land-use/land-cover change and hydrological application	4
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Meteorological satellite missions; critical review of articles	5
2	IPCC WG I assessment report (in the context of radiative forcing and uncertainty)	4
3	Algorithm theoretical basis documents of various passive and active sensors; Assignment on analysis of aerosol products from various passive and active sensors	6
4	Read selected chapters; GEWEX cloud system study - inter-comparison of various satellite dataset	6
5	Hyper-spectral techniques for trace gas measurements	3
6	Familiarization with various satellite products for ocean studies; Assignment on inter-comparison of multi-sensor data	5
7	Read selected chapters; Assignment on utilization of various satellite data products of passive and active microwave sensors	6
8	Doppler radar and its applications	4
9	Read research articles on utilization of gravity anomaly data for hydrological application	3
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

There is not a single text book covering all the topics. Reference materials consist of the following books and research articles.

- Kiddr, S. Q. and T. H. VonderHaar, Satellite Meteorology: An Introduction, Academic Press, 1995
- Coakley, J. and P. Yang, Atmospheric Radiation, Wiley-tech,2014
- Purkis, S., and V. klemas, Remote sensing and Global Environmental Change, Wiley-Blackwell, 2011.
- Liang, S., X. Li and J. Wang, Advanced Remote Sensing, Academic Press, 2012.
- Remer, L. and D. Tanre, Aerosol Remote Sensing, Springer, 2013
- Martin, S., An Introduction to Ocean Remote Sensing, Cambridge University press, 2nd edition, 2014
- Fukao, S., amd K. Hamazu, Radar for Meteorological and Atmospheric observations, Springer, 2014.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	MATLAB
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Synoptic Meteorology**
3.	**L-T-P structure**	**2-0-2**
4.	**Credits**	**3**
5.	**Course number**	**ASL756**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	**ASL860**

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** S. K. Dash, O. P. Sharma, S. Baidya Roy

12.	**Will the course require any visiting faculty? (yes/no)**	Yes

13.	**Course objectives** (about 50 words)**:** In this course, students will learn the fundamentals atmospheric processes that govern synoptic scale weather phenomena especially those that occur over tropical regions like India. The course will familiarize students with synoptic charts depicting meteorological information that are used for weather forecasting.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Different scales of atmospheric motion; Different types of air masses and tropical weather systems; Western disturbances and monsoonal cyclonic systems, Meteorological charts and diagrams, map projections, plotting of synoptic maps; Analysis of sea level pressure patterns, pressure tendency, surface temperature and dew point, stream lines and wind patterns, temperature patterns and isotach; Analysis of the vertical structure of the atmosphere.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Different scales of atmospheric motion	3
2	Synoptic weather systems	7
3	Meteorological charts and diagrams	3
4	Map projections and plotting of synoptic maps	3
5	Sea level pressure patterns and pressure tendency	3
6	Surface temperature and dew point	3
7	Streamlines, wind and temperature patterns, and isotachs	3
8	Vertical structure of the atmosphere	3
	COURSE TOTAL (14 times 'L')	**28**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Getting acquainted with map projections	2
2	Plotting of synoptic maps	6
3	Analysis of pressure patterns	3
4	Analysis of wind patterns	3
5	Analysis of temperature patterns	4
6	Analysis of vertical structure of atmosphere	4
7	Real time synoptic case studies	6
	Total	**28**

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1-2	Practice assignment with synoptic maps of India	14
3-6	Read selected chapters from texts, Assignments	12
7	Read selected chapters from texts, practice preparing weather briefing	16
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Lijlequist , G. H., Weather and Weather Maps: A Volume Dedicated to the Memory of Tor Bergeron (15.8.1891-13.6.1977**),** 1st Edition,Springer Basel, 1981.
- Bluestein, H. B., Synoptic-Dynamic Meteorology in Midlatitudes: Volume I: Principles of Kinematics and Dynamics, 1st Edition, Oxford University Press, 1993
- Krishnamurti, T. N., L. Stefanova, and V. Mishra, Tropical Meteorology, 1st Edition, Springer, 2013

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	No

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Tropical Weather and Climate**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL757**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒**Either sem**

11.	**Faculty who will teach the course** S. K. Mishra, D. Ganguly

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The objective of this course is to understand the fundamental concepts of tropical weather and climate and describe the role of tropics in the global climate system using theory and modeling approaches.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Overview; Structure of the tropical atmosphere; Role of the Tropics in the Global Mass, Momentum, and Energy Balance; Tropical Circulation & Mean Precipitation Distribution; ITCZ (Inter-tropical Convergence Zone); Tropical Waves and Tropical Variability (Intra-seasonal: MJO (Madden-Julian Oscillation), CCEWs (Convectively Coupled Equatorial Waves), Inter-annual: ENSO (El Niño Southern Oscillation), QBO (Quasi-biennial oscillation), Decadal: PDO (Pacific Decadal Oscillation), AMO (Atlantic Multi-decadal Oscillation), NAO (North Atlantic Oscillation)); Monsoons (Mean and variability); Tropical Cyclones; Modeling of the Tropical Climate & Weather.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Overview of Tropical Climate	2
2	Structure of the tropical atmosphere	3
3	Role of the Tropics in the Global Mass, Momentum, and Energy Balance	5
4	Tropical Circulation & Mean Precipitation Distribution	4
5	ITCZ	4
6	Tropical Waves and variability	9
7	Monsoons	6
8	Tropical Cyclones	5
9	Modeling of the Tropical Climate & Weather	4
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N/A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Read chapter 1 of the book "Krishnamurti et. al"	2
2	Read chapters 1 &2 of the book "Saha" and refereed papers	3
3	Read refereed papers, assignments	5
4	Read chapter 2 of the book "Krishnamurti et. al"	4
5	Read chapter 3 of the book "Krishnamurti et. al"	4
6	Read refereed papers, assignments	9
7	Read chapter 5 of the book "Krishnamurti et. al", assignments	6
8	Read chapters 15 & 16 of the book "Krishnamurti et. al"	5
9	Read refereed papers, assignments	4
COURSE TOTAL		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Saha, K., Tropical Circulation Systems and Monsoons, Springer, 2009.
- Krishnamurti, T.N., L. Stefanova, V. Misra, Tropical Meteorology: An Introduction, Springer, 2013.
- Review papers (Madden Julian, 1971; Philander, 1990; Schneider and Sobel, 2007; etc.)

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	Nil

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**General Circulation of the Atmosphere**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL758**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** DilipGanguly, S. K. Mishra

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The objective of this course is to develop a broad understanding of the large-scale circulation features of the Earth's atmosphere including the monsoon systems. Students will also learn simple theories that explain various observed circulation features and their representation in General circulation models (GCMs).

14.	**Course contents (about 100 words) (Include laboratory/design activities):** General Principles of Atmospheric Motion (Simplifications of Force Balances Important to Large-scale Motions, Large-scale Structures in the Atmosphere , Simplifications for Large-scale Vertical Structure, Scale Analysis of the Tropics), General Circulation of the Atmosphere (Historical Evolution of Global Circulation Conceptual Models, Axisymmetric Hadley Cell: Theories and Assumptions, A Road Map to the Tropics and Subtropics, Walker circulation, Comparing the Tropics and Midlatitudes, Stratospheric Circulations), Surface ocean circulation, Atmospheric response to Equatorial Heating, Monsoons (Defining the Monsoon, A Conceptual Model of Monsoon Evolution, Evolution of the South Asian Monsoon System, Other Monsoons Around the World, Australian-Maritime Continent Monsoon, West African Monsoon, Monsoons in the Americas), General Circulation Modeling (Basics of an atmospheric general circulation model, Representation of physical processes in GCMs, analysis of GCM simulations and comparison with observations, challenges for improving GCM simulations).

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	General Principles of Atmospheric Motion	6
2	General Circulation of the Atmosphere	9
3	Atmospheric response to equatorial heating	5
4	Monsoons	12
5	General Circulation Modeling	10
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N/A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Read book chapters 1-3 from Randall (2015), assignments	6
2	Read book chapter 5 from Randall (2015) and chapters 11-12 from Vallis (2006), assignments	9
3	Read book chapter 16 from Vallis (2006) and chapters 3-4 from James (1995), assignments	5
4	Read book chapter 11 from Randall (2015) and chapters 1-2 from Saha (2009), assignments	12
5	Read book chapters 5 from Neelin (2010), assignments	10
COURSE TOTAL		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Randall, D., Introduction to the General Circulation of the Atmosphere, Princeton University Press, 2015.
- James, I. N., Introduction to Circulating Atmospheres, Cambridge, 1995.
- Satoh, M., Atmospheric circulation dynamics and general circulation models, Springer, 2004.
- Vallis, G. K., Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-scale Circulation, Cambridge, 2006.
- Schneider, T. and A. H. Sobel, Global Circulation of the Atmosphere, Princeton University Press, 2007.
- Saha, K., Tropical Circulation Systems and Monsoons, Springer, 2009.
- Neelin, D. J., Climate Change and Climate Modeling, Cambridge University Press, 2010.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	Nil

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Land-Atmosphere Interactions**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL759**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒**Either sem**

11.	**Faculty who will teach the course** SomnathBaidya Roy

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** In this course, students will develop a thorough quantitative understanding of how the biotic and abiotic components of the land surface influences weather and climate processes at all scales.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Introduction: components of the Earth System, energy, hydrologic and biogeochemical cycles; Weather and climate processes including atmospheric boundary layer, convection, clouds and precipitation, surface energy and moisture fluxes, climate, climate variability; Canopy-air interactions: canopy processes, observations, big leaf models, canopy models; Terrestrial hydrology: watershed hydrology, river routing models; Soil: soil physics, soil moisture, soil biogeochemistry, soil models; Carbon cycle: photosynthesis, vegetation dynamics, global biogeography, carbon cycle models; Terrestrial forcings: landscape heterogeneity, landscape induced and modified flow, feedbacks, land models, coupled Earth System models; Land-use/land-cover change: Deforestation, agriculture, urbanization, forest fires, effects on weather and climate.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction	2
2	Weather and climate processes	4
3	Canopy-air interactions	6
4	Terrestrial hydrology	3
5	Soil	6
6	Carbon cycle	6
7	Terrestrial forcings	9
8	Land-use/land-cover change	6
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Read selected parts of ShuttleworthCh 1&Bonan, Ch 1-3.	2
2	Read selected parts of ShuttleworthCh 2-3, 9-12, 15-20 &BonanCh 5-7, 13-15; Assignment	6
3	Read ShuttleworthCh 11-12, 21; BonanCh 8	4
4	Read BonanCh 11-12; Assignment	6
5	Read BonanCh 9-10	4
6	Read selected parts of BonanCh 16-24; Assignment	6
7	Read BonanCh 25-29 &ShuttleworthCh 24-25	8
8	Read BonanCh 27, 30 &ShuttleworthCh 25; Assignment	6
COURSE TOTAL		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Bonan, G., Ecological Climatology: Concepts and Applications, 2nd Edition, Cambridge, 2008
- Shuttleworh, W. J., Terrestrial Hydrometeorology, 1st Edition, John Wiley & Sons.,2012

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	No

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Renewable Energy Meteorology**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL760**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	None

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒**Either sem**

11.	**Faculty who will teach the course** SomnathBaidya Roy

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** This course will introduce students to the meteorological concepts that are applied to solar and wind energy.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Introduction to the atmosphere: weather and climate processes; Solar radiation and surface energy balance: Solar constant, solar geometry, atmospheric radiative transfer, clouds and aerosols, surface energy budget, urban energy use, sensors and observations; Meteorological considerations for solar power: solar resource assessment, solar forecasting for different timescales, uncertainty estimation, types of solar systems; Wind in the atmospheric boundary layer: boundary layer structure and evolution, surface layer, stability, log and power laws, flow over complex terrain, low-level jets, offshore winds, sensors and observations; Meteorological considerations for wind power: wind resource assessment, wind forecasting for different timescales using statistical and numerical methods, uncertainty estimation, types of turbines, turbine wakes, wake interactions in wind farms, turbine and wake models, LES and mesoscale models of wind farms; Solar-wind coupling: resource variability, power demand, optimization.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction	2
2	Solar radiation and surface energy balance	6
3	Meteorological considerations for solar power	8
4	Wind in the atmospheric boundary layer	8
5	Meteorological considerations for wind power	16
6	Solar-wind coupling	2
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Selected parts of Ahrens	2
2	Stull Chapter 7; Explore MNRE data online	8
3	Kalogirou Chapter 3-4, 9-10, 12; Explore SAM model	6
4	Stull Chapter 1, 2, 5, 9-12	4
5	Emeis Chapter 5-6; journal articles; Explore WAsP model	20
6	Handouts and journal articles	2
COURSE TOTAL		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Ahrens, D., Meteorology Today, 11th Edition, Cengage, 2015
- Emeis, S., Wind Energy Meteorology, 1st Edition, Springer, 2013
- Garratt, J. R., The Atmospheric Boundary Layer, 1st Edition, Cambridge University Press, 1994.
- Kaimal, J.C. and J. J. Finnigan, Atmospheric Boundary Layer Flows, 1st Edition, Oxford, 1994
- Kalogirou, S., Solar Energy Engineering, 1st Edition, Elsevier, 2009
- Stull, R., Introduction to Boundary Layer Meteorology, 1st Ed, Kluwer Academic, 1999.
- Stull, R., Meteorology for Scientists and Engineers, 2nd Edition, Cengage, 1999.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	WAsP model, SAM model
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	No

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Earth System Modeling**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL761**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** DilipGanguly, S. K. Mishra, Krishna AchutaRao

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The objective of this course is to make students aware of how the fundamental physical principles determining the climate of the earth can be understood using an Earth System model and also teach how this tool can be used for understanding and attributing not just the observed changes, but also for predicting the future climate change.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Basics of Earth System Science (Earth system components, Physical phenomena in the Earth system, Globally averaged energy budget, Energy transports by atmosphere and ocean, concepts of radiative forcing, feedbacks and climate change), Physical Processes in the Earth System and governing principles (Equation of state, Continuity equation, Conservation of momentum, Temperature equation, Moisture equation and salinity equation, Moist processes, Wave processes in the atmosphere and ocean), Representation of Physical processes in Earth System Models (Treatment of sub-grid scale processes such as dry convection, moist convection, land surface, snow, ice and vegetation; Radiation, greenhouse gases, aerosols and other climate forcings), Biogeochemical and Biophysical Processes, coupling between physics packages, Dynamics in Earth System Models (Dynamical core, Grid scale processes, Numerical representation of the grid scale processes, Grids, Resolution,

	Accuracy, Efficiency, and Scalability), Earth system model simulations (Climate simulations and climate drift, Verification and Validation of simulations with observations, Emission Scenarios &forcings, Global-average response to greenhouse warming scenarios, Transient climate change versus equilibrium response experiments, Trends & natural variability, scale dependency of simulations, Multi-model simulations & ensemble averages, Simulation examples from Coupled Model Inter-comparison Project)

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Basics of Earth System Science	5
2	Physical Processes in the Earth System and governing principles	7
3	Representation of Physical processes in Earth System Models	9
4	Dynamics in Earth System Models	6
5	Earth system model simulations	15
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N/A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Read book chapters 1, 2 from Neelin (2010), assignments	5
2	Read book chapters 3 from Neelin (2010), assignments	7
3	Read book chapters 5 from Neelin (2010), assignments	9
4	Read book chapters 1-3 from Lauritzen (2011), assignments	6
5	Case studies	15
COURSE TOTAL		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Neelin, D. J., Climate Change and Climate Modeling, Cambridge University Press, 2010
- Lauritzen, P. H. et al., Numerical Techniques for Global Atmospheric Models, Springer, 2011.
- Washington, M. W. and C. L. Parkinson, An Introduction to three-dimensional climate modeling, University Science Books, 2005.
- Trenberth, K. E., Climate System Modeling, Cambridge University Press, 2010.
- Mote, P. and A. O'Neill Numerical Modeling of the Global Atmosphere in the Climate System, Kluwer, 2000.
- Puri, K., R. Redler, and R. Budich, Earth System Modeling - Volume 1: Recent Developments and Projects, Springer, 2013.
- Drake, J. B., Climate Modeling for Scientists and Engineers, Society for Industrial and Applied Mathematics, 2014

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	Nil

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Air-Sea Interaction**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL762**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	**ASL712**

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** A. D. Rao, Vimlesh Pant

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The course intends to provide knowledge of air-sea interaction processes, such as fluxes at the air-sea interface, transfer properties between atmosphere and ocean.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** State of matter near the air-sea interface, marine boundary layer, transfer properties between atmosphere and ocean, solar and terrestrial radiation, sea surface radiation budget, surface wind waves, air-sea interaction processes using examples of ENSO, hurricane, Indian monsoon, turbulent transfer near the interface, bubbles and spray, transport of trace gases across the interface; latent, sensible, and momentum fluxes in the surface boundary layer over the sea, bulk parameterizations, large-scale forcing by sea surface buoyancy fluxes, spatio-temporal variability of ocean surface fluxes with reference to Indian ocean.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	State of matter near the air-sea interface, Marine boundary layer	5
2	Transfer properties between atmosphere and ocean	5
3	Sea surface radiation budget	4
4	Surface wind waves and wave breaking	4
5	Air-sea interaction processes	5
6	Turbulent transfer near the interface, bubbles and spray, transport of trace gases across the interface	5
7	Heat, salt, and momentum fluxes in the surface boundary layer	5
8	Large-scale forcing by sea surface buoyancy fluxes	4
9	Spatio-temporal variability of ocean surface fluxes	5
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Assignment on how the ocean-atmosphere system is driven	5
2	Review on balance of hydrological cycle.	5
3	Self-study on computation of surface radiation budget	4
4	Review on wave hydrodynamics over the shelf region	4
5	Assignment on air-sea interaction processes during southwest monsoon period, ENSO and tropical cyclone.	8
6	Review on transfer of gases and particles across the air-sea interface.	5
7-9	Computation of heat, salt, and momentum fluxes over the Indian ocean and review on their spatiotemporal variability.	11
Total		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Gill, A. E., Atmosphere-Ocean Dynamics, Academic Press, 1982.
- Roll, H.U., Physics of the Marine Atmosphere, Academic Press, 1965.
- Kraus, E.B., J.A. Businger, Atmosphere-Ocean Interaction, Oxford University Press, 1994.
- Liss, P. S., M.T. Johnson, Ocean-Atmosphere Interaction of Gases and Particles, Springer, 2014.
- Csanady, G. T., Air-Sea Interaction: Laws and Mechanisms, Cambridge University Press, 2001.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Coastal Ocean and Estuarine Processes**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL763**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** A. D. Rao, Vimlesh Pant

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The course intends to familiarize students with the coastal ocean processes and their interaction with the estuarine circulation. Waves in the coastal waters and sediment transport mechanisms to be covered in detail.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Wave generating and restoring forces, shallow water waves, coastally trapped long waves, influence of sea-bed friction, Wave spectra, Refraction and shoaling of waves, Seiches, waves-current interaction, wave transformation in shallow waters, Tsunamis, Breaking waves, Phenomenon of wave reflection, refraction, and diffraction, Surf zone hydrodynamics, shoreline setup, Swash and runup heights, wave generated alongshore currents, Rip currents, Storm surges, theory of tides, Tides in rivers and coastal lagoons, General characteristics of estuaries, Classification of estuaries, stratification, estuarine circulation and mixing, Shear instability at an interface, Entrainment and sedimentation in estuaries, Dispersion processes: Advective and turbulent diffusion, River-estuary-near-shore systems, Sediment characteristics, Sediment transport mechanisms: bedform dynamics, suspended particles in wave flows and vortices, Morpho-dynamics: Beach profiles, Tide range influence on beach morphology, Lee side erosion, Beach realignment due to climate change, Interaction of an estuary with the near-shore bay.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Wave generating forces and shallow water waves	4
2	Wave spectra, wave transformation in shallow waters	3
3	Seiches, Tsunamis, storm surges	3
4	Phenomenon of wave reflection, refraction, and diffraction, waves-current interaction.	8
5	Surf zone hydrodynamics, shoreline setup	4
6	wave generated alongshore currents, Rip currents	3
7	Theory of tides, Tides in rivers and coastal lagoons	5
8	General characteristics and classification of estuaries, estuarine circulation and mixing	5
9	Interaction of an estuary with the near-shore bay.	3
10	Suspended sediment transport mechanisms, Bedform dynamics, Morpho-dynamics, Beach profiles	4
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Term paper on forces acting on the ocean surface and its response	4
2	Assignment on computation of spectral energy of waves	3
3	Term paper on Seiches in closed water bodies and Tsunamis in the Indian ocean.	3
4	Term paper on Superposition of linear waves and wave modifications by currents.	8
5-6	Assignment on near-shore hydrodynamics and computation of alongshore currents.	7
7	Seminar on Tides in the Indian ocean, formation of tropical cyclones in the Bay of Bengal and Arabian Sea.	5
8-9	Term paper on density driven circulation in the estuaries, intrusion of tide through the river system	8
10	Assignment on Sediment Transport and bedload in the Ganges-Brahmaputra river system.	4
Total		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Holthuijsen, L.H., Waves in Oceanic and Coastal Waters, Cambridge, 2009.
- Svendsen, I.A., Introduction to Nearshore Hydrodynamics, World Scientific, 2006.
- Janssen, P., The Interaction of Ocean Waves and Wind, Cambridge, 2009.
- Mani, J.S., Coastal Hydrodynamics, PHI, 2012.
- Dean, G.R. and R.A. Dalrymple, Coastal Processes with Engineering Applications, Cambridge, 2002.
- Nielsen, P., Coastal and Estuarine Processes, World Scientific, 2009.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Independent Study**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASS800**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	No
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Advanced Dynamic Meteorology**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL821**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	**Dynamics of the Atmosphere**

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	**ASL816**

9.	**Not allowed for** (indicate program names)	UG

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** O.P. Sharma, Maithili Sharan, S.K. Dash, H.C. Upadhyaya, S.B. Roy

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To impart in-depth understanding and analysis of atmospheric motions that forms the basis of present day numerical models for weather prediction.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Quasi-geostrophic motions in the atmosphere: circulation and vorticity; Ertel-Rossby invariants; Ertel's potential vorticity conservation theorem; Kelvin and Bjerknesbaroclinic circulation theorem; quasi-geostrophic turbulence. Instabilities in the atmosphere: barotropic and baroclinic instability; symmetric instabilities. Quasi-geostrophic motions in equatorial region, heat-induced tropical circulations: monsoons, El Nino and Madden-Julian Oscillation. Waves in the atmosphere: Kelvin, Rossby and Poincaré waves, Lamb wave, internal gravity waves, vertically propagating waves, Rossby adjustment theory. Middle atmosphere dynamics: sudden atmospheric warming, QBO. General circulation of the atmosphere: analysis of surface pressure and associated wind circulation, upper-tropospheric (200hPa) circulation; scale analysis, formulation of the governing set of equations for a weather prediction model.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Quasi-geostrophic motions in the atmosphere	7
2	Instabilities in the atmosphere	7
3	Quasi-geostrophic motions in equatorial region	7
4	Waves in the atmosphere	7
5	Middle atmosphere dynamics	7
6	General circulation of the atmosphere	7
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Review selected chapters from text; practice quantitative problems and derivations	10
2	Read selected chapters from texts, analyze meteorological charts; Assignment	8
3	Read selected chapters from text; practice derivations; Assignments	12
4	Identification of waves in the atmosphere based on frequency and wave number.	4
5	Read selected chapters from text; Assignment	2
6	Read selected chapters from text; Assignment	6
TOTAL		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Holton J.R., Introduction to Dynamic Meteorology, Academic Press, 2004
- Haltiner G.J. and R.T. Williams, Numerical Prediction & Dynamic Meteorology, Wiley, 1980
- Dutton J.A., Dynamics of Atmospheric Motion, Dover Publication, 1995
- Gill A.E., Atmosphere-Ocean Dynamics, Academic Press, 1982
- Zdunowski W. & A. Bott, Dynamics of Atmospheric Motion, Cambridge Univ. Press, 2003
- Riegel C.A., Fundamentals of Atmospheric Dynamics and Thermodynamics, World Scientific, 1992
- Lighthill M.J. & R.P. Pearce, Monsoon Dynamics, Cambridge Univ. Press,1980
- Palmen E. & C.W. Newton, Atmospheric Circulation System, Academic Press, 1969
- Schneider T. and A. Sobel (eds.), The Global Circulation of the Atmosphere, Princeton Univ. Press, 2007
- Pierrehumbert R.T., Principles of Planetary Climate, Cambridge Univ. Press, 2007

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	MET software
20.2	Hardware	Computers with Linux, Fotran compiler and graphics software
20.3	Teaching aides (videos, etc.)	Public domain animations
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	80%
21.3	Project-type activity	20%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Climate Variability**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL822**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	**ASL813**

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Krishna AchutaRao, S. K. Mishra

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** This course aims to provide students with a practical and critical understanding of the variability in the Earth's climate system and our ability to predict it. It deals with processes related to large-scale climate variability (atmospheric circulation, tropical-extratropical coupling, ocean-atmosphere coupling, external forcings) as well as their importance in climate history of the past 500-1000 years with a focus on the tropics

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Major modes or patterns of climate variability on intraseasonal to interannual and decadal time scales. Well-known modes including Madden-Julian Oscillation, El Nino-Southern Oscillation, Pacific Decadal Oscillation, Atlantic Multidecadal Oscillation, Indian Ocean Dipole, Monsoon, North Atlantic Oscillation, and Annular Modes (Arctic and Antarctic Oscillation) and their impacts on extreme weather and climate. The course will review climate mode/pattern dynamics, their teleconnection mechanisms and impacts on weather/climate such as droughts etc. Temporal behavior –including how these modes have changed in the past, and how anthropogenic climate change may affect future mode behavior). Discussion of predictability of climate modes/patterns on seasonal to interannual time scales. Detection and attribution of climate change.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Forced and unforced variability	6
2	Dynamics and physical mechanisms of tropical variability modes such as El Nino / La Nina, Madden Julian Oscillation (MJO) and IOD.	16
3	PDO, AMO, NAO and the Annular modes – known mechanisms and impacts	6
4	Relevance of climate variability phenomena and processes in climate predictions.	4
5	Detection and attribution of climate change	10
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	N.A	

17. Brief description of laboratory activities

Module no.	Description	No. of hours
	N.A	

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Review of statistical techniques such as EOF/PC analysis & composites. Self study of external forcing mechanisms in climate.	3
2	Reading assigned papers on El Nino / La Nina, Madden Julian Oscillation (MJO) and IOD.	20
3	Reading assigned papers on PDO, AMO, NAO and the Annular modes	7
4	Survey of current climate prediction state-of-art practices.	2
5	Reading assigned literature on Detection and attribution of climate change	10
Total		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

There are no textbooks on the subject. The course will be taught using classical papers published in books and journals.

- Clara Deser, Michael A. Alexander, Shang-Ping Xie, and Adam S. Phillips, Sea Surface Temperature Variability: Patterns and Mechanisms, Annual Review of Marine Science, Vol. 2: 115-143 (January 2010) DOI: 10.1146/annurev-marine-120408-151453
- D. R. Easterling, J. L. Evans, P. YaGroisman, T. R. Karl, K. E. Kunkel, and P. Ambenje, 2000: Observed Variability and Trends in Extreme Climate Events: A Brief Review*. Bull. Amer. Meteor. Soc., 81, 417–425.
- William K.-M. Lau, Duane E. Waliser, Intraseasonal Variability in the Atmosphere-Ocean Climate System, Springer-Praxis, 2012
- Roland A. Madden and Paul R. Julian, 1971: Detection of a 40–50 Day Oscillation in the Zonal Wind in the Tropical Pacific. J. Atmos. Sci., 28, 702–708.
- Roland A. Madden and Paul R. Julian, 1994: Observations of the 40–50-Day Tropical Oscillation—A Review. Mon. Wea. Rev., 122, 814–837.
- Zhang, C. (2005), Madden-Julian Oscillation, Rev. Geophys., 43, RG2003, doi:10.1029/2004RG000158.
- Battisti, D. S., and E. S. Sarachik (1995), Understanding and predicting ENSO, Rev. Geophys., 33(S2), 1367–1376, doi:10.1029/95RG00933.

- Wang, C. and Picaut, J. (2004) Understanding Enso Physics—A Review, in Earth's Climate (eds C. Wang, S.P. Xie and J.A. Carton), American Geophysical Union, Washington, D. C..doi: 10.1029/147GM02
- Webster, P. J. and Yang, S. (1992), Monsoon and Enso: Selectively Interactive Systems. Q.J.R. Meteorol. Soc., 118: 877–926. doi: 10.1002/qj.49711850705
- Gadgil, S., The Indian Monsoon And Its Variability, Annual Review of Earth and Planetary Sciences, Vol. 31: 429-467 (May 2003), DOI: 10.1146/annurev.earth.31.100901.141251
- Nathan J. Mantua, Steven R. Hare, The Pacific Decadal Oscillation, Journal of Oceanography, 02-2002, Volume 58, Issue 1, pp 35-44, 2002
- James W. Hurrell, YochananKushnir, GeirOttersen and Martin Visbeck, "An Overview of the North Atlantic Oscillation" DOI: 10.1029/134GM01, American Geophysical Union. 2013
- Marshall, J., Kushnir, Y., Battisti, D., Chang, P., Czaja, A., Dickson, R., Hurrell, J., McCartney, M., Saravanan, R. and Visbeck, M. (2001), North Atlantic climate variability: phenomena, impacts and mechanisms. Int. J. Climatol., 21: 1863–1898. doi: 10.1002/joc.693
- David W. J. Thompson and John M. Wallace, 2000: Annular Modes in the Extratropical Circulation. Part I: Month-to-Month Variability*. J. Climate, 13, 1000–1016.
- David W. J. Thompson, John M. Wallace, and Gabriele C. Hegerl, 2000: Annular Modes in the Extratropical Circulation. Part II: Trends. J. Climate, 13, 1018–1036.
- Palmer, T. N. and Anderson, D. L. T. (1994), The prospects for seasonal forecasting—A review paper. Q.J.R. Meteorol. Soc., 120: 755–793. doi: 10.1002/qj.49712051802
- Santer, B. D., K. E. Taylor, T. M. L. Wigley, J. E. Penner, P. D. Jones, and U. Cubasch. 1995. Towards the detection and attribution of an anthropogenic effect on climate. Climate Dynamics, 12, 77-100.
- Allen, M. R., and P. A. Stott. 2003. Estimating signal amplitudes in optical fingerprinting, part I: theory. Climate Dynamics, 21, 477-491.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Geophysical Fluid Dynamics**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL823**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Yes

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem☐1st sem☐2nd sem☒Either sem

11.	**Faculty who will teach the course** O.P. Sharma, Maithili Sharan, S.K. Dash, H.C. Upadhyaya, S.B. Roy

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To impart in-depth knowledge of naturally occurring fluid motions in earth's atmosphere and oceans. The course will provide a systematic exposure to fluid dynamical concepts common to atmosphere and ocean. The concepts could easily be extended to atmospheres of other planets.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** (i) Fundamental concepts in geophysical fluid dynamics: equations of motions on a rotating planet, vorticity and circulation, conservation of potential vorticity, thermal wind, Taylor-Proudman theorem; Ertel-Rossby invariants; Ertel's potential vorticity conservation theorem; consequences of geostrophic and hydrostatic approximation. (ii) Shallow-water theory: derivation of shallow-water equations; derivation of vorticity equation; linearized form of shallow-water equations; plane waves in a layer of constant depth; dispersion diagrams of Kelvin and Poincaré waves. (iii) Rossby wave theory: mechanism of Rossby wave generation; inertial boundary currents; derivation of potential vorticity on beta-plane; quasigeostrophic scaling; Rossby waves in a zonal current; method of multiple scales for linear potential vorticity equation; reflection and radiation of Rossby waves; generation of Rossby waves by an initial disturbance; Quasigeostrophic normal modes in a closed basin; resonant interaction; energy

	and enstrophy conservation; upscale energy transfer. (iv) Friction effects in geophysical flows: Turbulent Reynolds stresses; Ekman layers in a homogeneous, incompressible rotating fluid; Ekman layer on a sloping surface; quasigeostrophic potential vorticity with friction and topography. (v) Instability theory: linear stability; normal modes; growth rates; baroclinic instability; Eady model and Charney model; instability in a two-layer model.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Fundamental concepts	4
2	Shallow-water theory	12
3	Rossby wave theory	12
4	Friction effects in geophysical flows	8
5	Instability theory	6
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Complete equations of motions on a rotating planet, vorticity and circulation, conservation of potential vorticity, derivation of potential vorticity on beta-plane	8
2	Derivation of shallow-water equations; linearized form of shallow-water equations	5
3	Physical mechanism of Rossby wave generation	6
4	Turbulent Reynolds stresses, Ekman layers in a homogeneous, incompressible rotating fluid	8
5	Linear stability; normal modes; growth rates	8
6	Research papers reading, assignments	7
Total		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Pedlosky J., Geophysical Fluid Dynamics, Springer, 1987
- Holton J.R. and G. Hakim, Introduction to Dynamic Meteorology, Academic Press, 2012
- Cushman, B. and J. M. Beckers, Introduction to GFD, Academic press, 2011
- Dutton J.A., Dynamics of Atmospheric Motion, Dover Publication, 1995
- Gill A.E., Atmosphere-Ocean Dynamics, Academic Press, 1982
- Pierrehumbert R.T., Principles of Planetary Climate, Cambridge Univ. Press, 2007

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Model Evaluation Tools (MET)
20.2	Hardware	Computers with Linux, gfortran compiler and graphics software
20.3	Teaching aides (videos, etc.)	Yes, public domain images/videos
20.4	Laboratory	Yes
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	Meteorological data

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Parameterization of Physical Processes**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL824**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	**Any one of the following courses:ASL733, ASL734**

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	**ASL706**

9.	**Not allowed for** (indicate program names)	UG

10.	**Frequency of offering**	☐Every sem☐1st sem☐2nd sem☒Either sem

11.	**Faculty who will teach the course** O.P. Sharma, H.C. Upadhyaya, D. Ganguly

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** Introduce students to mathematical representations of subgrid-scale processes, parameterizations of clouds, radiation, and surface processes in numerical and analytical models of atmosphere.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** A simple model of atmosphere with Rayleigh friction and Newtonian cooling: Gill's analytical solutions for heat-induced tropical circulations (especially El Niño and monsoon circulation); horizontal diffusion in NWP models: prevention of accumulation of small scale noise, inverse cascade. Aerodynamic formulae for surface turbulent fluxes, vertical turbulent diffusion: one-dimensional PBL model. Parameterization of orographic drag. Dry and moist processes in the atmosphere: a simple model of convection, dry adiabatic adjustment, large-scale condensation, and parameterization of deep and shallow convection. Simple and complex radiative transfer in the atmosphere; absorption of radiation by ozone, carbon dioxide and water vapour; shortwave and longwave radiation computation; radiative heating in the atmosphere.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Heat-induced tropical circulations: simple solutions with Newtonian cooling and Rayleigh friction; horizontal diffusion in NWP models	10
2	One dimensional PBL model	5
3	Parameterization of orographic drag	3
4	Atmospheric convection and clouds	12
5	Radiative transfer in the atmosphere	12
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Identification and heuristic understanding of model equations.	8
2	Code development for one-dimensional PBL model.	5
3	Orographic drag: computation of mean orography, design of land/sea mask.	5
4	A simple cloud model, mass-flux scheme for deep convection	16
5	Long wave and short wave parameterization	8
	Total	**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Stull R.B., An Introduction to Boundary Layer Meteorology, Springer, 2009
- Rogers R.R. and M.K. Yau, A Short Course on Cloud Physics, Butterworth-Heinemann Publication, 1996
- Emanuel K.E., Atmospheric Convection, Oxford Univ. Press, 1994
- Liou K.N., An Introduction to Atmospheric Radiation, Academic Press, 2002
- Gill A.E., Atmosphere-Ocean Dynamics, Academic Press , 1982
- Wallace J.M. and P.V. Hobbs, Atmospheric Science, Elsevier/Academic Press, 2006
- Stensrud, D. J., Parameterization Schemes, Cambridge, 2009

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Open-source models, Fortran compiler and graphics software
20.2	Hardware	Computers with Linux
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	Nil
20.5	Equipment	No
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	Meteorological data

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	50%
21.3	Project-type activity	50%
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Mesoscale Modeling**
3.	**L-T-P structure**	**0-0-6**
4.	**Credits**	**3**
5.	**Course number**	**ASP825**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supersedes any existing course	None

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒**Either sem**-

11.	**Faculty who will teach the course** SomnathBaidya Roy

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** In this course students will learn how to design and conduct mesoscale numerical experiments with the Weather Research and Forecasting (WRF) model with particular emphasis on the ability to understand and modify the model code.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Introduction to the Weather Research and Forecasting (WRF) model and parallel computing; Install WRF, NCL and associated libraries; Conduct test simulations for 2-d idealized cases such as flow over a hill, sea-breeze, etc., configure and conduct test simulations for a full 3-d real case, conduct numerical experiments by changing initial & boundary conditions and namelist parameters/flags; Understand WRF code structure and registry by adding new variables into different modules; Introduction to parameterizations in WRF, explore the science and the codes of a land surface scheme and a cumulus scheme, make simple modifications to the schemes, conduct numerical experiments with modified schemes.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Introduction	6
2	Installation	12
3	Test simulations and numerical experiments	24
4	Adding new variables	18
5	Modifying selected parameterizations	24
	Total	**84**

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Read Pielke Chapter 1; Read WRF documentation; recap LINUX and FORTRAN	4
2	Read documentations of WRF, NCL; complete installation of WRF, NCL and associated libraries	6
3-4	Read WRF documentation	8
5	Read Pielke Chapters 7-9; Stensrud 2-3, 6; selected papers	24
COURSE TOTAL		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- NCL documentation
- Pielke, R., Mesoscale Meteorological Modeling, 3rd Edition, Academic, 2013
- Stensrud, D. J., Parameterization schemes, 1st Edition, Cambridge, 2009
- WRF documentation

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	WRF, NCL codes
20.2	Hardware	LINUX workstation
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	Yes
20.5	Equipment	No
20.6	Classroom infrastructure	Powerpoint projection equipment, black/white board
20.7	Site visits	No
20.8	Others (please specify)	No

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	100%
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Ocean Modeling**
3.	**L-T-P structure**	**2-0-2**
4.	**Credits**	**3**
5.	**Course number**	**ASL826**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem -

11.	**Faculty who will teach the course** A. D. Rao, Vimlesh Pant

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The course objective is to provide in-depth knowledge to students about modelling of oceanic circulation and processes with hands-on-training on 1-D, 2-D, and 3-D ocean circulation models, and wave models.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Introduction to ocean dynamics, governing equations of oceanic motions, numerical methods in ocean modelling, hydrostatic and non-hydrostatic phenomenon, barotropic and baroclinic processes, lateral and open boundary conditions, parameterization of sub-grid scale processes, large scale ocean circulation, modelling of shelf circulation, tides and storm surge modelling, regional and coastal ocean models, shallow water models, multi-level basin scale and global ocean models, ocean wave modelling, introduction to data assimilation techniques.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Governing equations of oceanic motions	3
2	Numerical methods in ocean modeling: Hydrostatic and non-hydrostatic approach	4
3	Lateral and open boundary conditions	2
4	Barotropic and baroclinic processes	2
5	Shelf dynamics and large scale ocean circulation	3
6	Tides and storm surge modelling	3
7	Ocean wave modelling	3
8	Shallow water models: Regional and coastal ocean models	6
9	Introduction to data assimilation techniques	2
COURSE TOTAL (14 times 'L')		**28**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours
1	Model installation and test runs using simple 1-D river flow models	3
2	Simulations using 2-D model for estuarine density controlled circulation	4
3	Generation of tides using 2-D barotropic model	6
4	Simulation of storm surges using basic 2-D ocean model, some examples using 3-D ocean model	8
5	Simulation of wave characteristics using state-of-the-art wave models	7
Total		**28**

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Review on basics of geophysical fluid dynamics along with forces acting on the fluid system.	4
2	Review on explicit and implicit methods, various temporal and spatial schemes used in the ocean models.	4
3	Applications of hydrostatic and non-hydrostatic approach for various oceanic processes.	3
4	Review on barotropic and baroclinic transports over topography.	3
5-6	Review on the effect of lateral and open boundary conditions on large scale circulation.	7
7	Assignment on tides and storm surges in the Bay of Bengal	5
8-9	Review on types, advantages and limitations of various ocean models.	9
10	Intercomparison of different wave models in terms of parameterization schemes used.	5
11	Term paper on data assimilation schemes used in ocean models	2
Total		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Kantha, L.H. and C.A. Clayson, Numerical Models of Oceans and Oceanic Processes, Academic Press, 2000.
- Kampf, J, Ocean Modelling for Beginners, Springer, 2009.
- Kampf, J, Advanced Ocean Modelling, Springer, 2010.
- Glover, D.M., W.J. Jenkins, S.C. Doney, Modeling Methods for Marine Science, Cambridge, 2011.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Yes
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	Yes
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	50%
21.3	Project-type activity	
21.4	Open-ended laboratory work	50%
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Advanced Dynamic Oceanography**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL827**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	**Either ASL734 or ASL737**

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	**ASL803**

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** A. D. Rao, Vimlesh Pant

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** The course aims to provide in-depth knowledge of dynamic oceanography to students. It will cover details of theories of oceanic transport, circulation at different spatial and temporal scales, wave-current interactions, and sediment transport mechanisms.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** Conservation laws for moving fluids, Ekman and Sverdrup theories, coastal upwelling and fronts, Western boundary intensification, barotropic currents, baroclinic transport over topography, thermohaline circulation, Mesoscale eddies and variability. Indian ocean circulation, wave theory, ocean wave spectra, wave energy equation, breaking waves, reflection and dissipation, theory of tides, tidal currents, tidal processes in embayment and estuaries, wind and buoyancy driven currents, near-shore circulation, alongshore currents, wave-current interaction, sediment transport, coastal ocean response to extreme wind forcing, storm surges, Planetary and equatorial waves, coastally trapped Kelvin waves.

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Conservation laws for moving fluids, Ekman and Sverdrup theories	5
2	Western boundary intensification, barotropic currents and transport	4
3	Thermohaline circulation	3
4	Mesoscale eddies and variability	3
5	Indian ocean circulation	3
6	Ocean wave theory and wave spectra	4
7	Theory of tides, tidal currents	5
8	Wind and buoyancy driven currents, near-shore circulation	4
9	Wave-current interaction	3
10	Coastal ocean response to extreme wind forcing, Storm surge, Sediment transport	5
11	Planetary and equatorial ocean waves, coastally trapped Kelvin waves	3
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours
1	Review of shallow water equations	5
2	Role of Coriolis force on western boundary intensification	4
3-5	Mesoscale eddies and its role in the mixing process in the Indian Ocean.	9
6-7	Characteristics of short and long waves and interaction with estuaries.	9
8-9	Surface and sub-surface circulation in the Indian ocean and influence of currents on the waves.	7
10	Computation of alongshore current and its effect on sediment transport.	2
11	Computation of storm surge due to an idealized cyclone.	3
12	Effects of Rossby and Kelvin ocean waves on the Indian ocean circulation	3
Total		**42**

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Pond, S., G.L. Pickard, Introductory Dynamic Oceanography, Butterworth-Heinemann, 1983
- Kantha, L.H., Clayson, C. A., Numerical Models of Oceans and Oceanic Processes, Academic Press, 2000.
- Dijkstra, H.A., Dynamical Oceanography, Springer, 2008.
- Pedlosky, J., Ocean Circulation Theory, 1998.
- Olbers, D.J., J. Willebrand, C. Eden, Ocean Dynamics, Springer, 2012.
- Holthuijsen, L.H., Waves in Oceanic and Coastal Waters, Cambridge, 2009.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Topics in Climate**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL851**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	no

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Topics in Oceans**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL852**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Topics in Atmosphere**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL853**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	**Topic**	**No. of hours**
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Topics in Air Pollution Studies**
3.	**L-T-P structure**	**3-0-0**
4.	**Credits**	**3**
5.	**Course number**	**ASL854**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Topics in Atmosphere and Ocean**
3.	**L-T-P structure**	**1-0-4**
4.	**Credits**	**3**
5.	**Course number**	**ASP855**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	Yes
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	25%
21.3	Project-type activity	
21.4	Open-ended laboratory work	75%
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Topics in Atmospheric and Oceanic Observations**
3.	**L-T-P structure**	**2-0-2**
4.	**Credits**	**3**
5.	**Course number**	**ASL856**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
COURSE TOTAL (14 times 'L')		**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	Yes
20.5	Equipment	Yes
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	50%
21.3	Project-type activity	
21.4	Open-ended laboratory work	50%
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Module in Climate**
3.	**L-T-P structure**	**1-0-0**
4.	**Credits**	**1**
5.	**Course number**	**ASV862**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Module in Oceans**
3.	**L-T-P structure**	**1-0-0**
4.	**Credits**	**1**
5.	**Course number**	**ASV863**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Module in Atmosphere**
3.	**L-T-P structure**	**1-0-0**
4.	**Credits**	**1**
5.	**Course number**	**ASV864**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Module in Air Pollution Studies**
3.	**L-T-P structure**	**1-0-0**
4.	**Credits**	**1**
5.	**Course number**	**ASV865**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	no

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Module in Atmosphere and Ocean**
3.	**L-T-P structure**	**1-0-0**
4.	**Credits**	**1**
5.	**Course number**	**ASV866**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Module in Weather Forecasting**
3.	**L-T-P structure**	**0-0-2**
4.	**Credits**	**1**
5.	**Course number**	**ASP867**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Yes
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	Yes
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	100%
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Special Module in Atmospheric and Oceanic Observations**
3.	**L-T-P structure**	**0-0-2**
4.	**Credits**	**1**
5.	**Course number**	**ASP868**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	No

13.	**Course objectives** (about 50 words)**:** To make the students understand the fundamental principles of a special topic requested by students to a faculty or to a visiting faculty to the Institute.

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	Yes
20.5	Equipment	Nil
20.6	Classroom infrastructure	Yes
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	100%
21.5	Others (please specify)	

Date: 13.02.2015 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	**Centre for Atmospheric Sciences**
2.	**Course Title** (< 45 characters)	**Atmospheric and Oceanic Science Colloquium**
3.	**L-T-P structure**	**0-1-0**
4.	**Credits**	**1**
5.	**Course number**	**ASC869**
6.	**Status** (category for program)	**Elective**

7.	**Pre-requisites** (course no./title)	Nil

8.	**Status vis-à-vis other courses** (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	Nil

9.	**Not allowed for** (indicate program names)	Any program other than AST and ASZ

10.	**Frequency of offering**	☐Every sem ☐1stsem ☐2ndsem ☒Either sem

11.	**Faculty who will teach the course** Any faculty from the Centre

12.	**Will the course require any visiting faculty? (yes/no)**	no

13.	**Course objectives** (about 50 words)**:** Students give and attend weekly seminar on the topic in ocean and atmospheric sciences

14.	**Course contents (about 100 words) (Include laboratory/design activities):** To be given by the interested faculty

15. **Lecture Outline**(with topics and number of lectures)

Module no.	Topic	No. of hours
	COURSE TOTAL (14 times 'L')	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

17. Brief description of laboratory activities

Module no.	Description	No. of hours

18. Brief description of module-wise activities pertaining to self-study component (mandatory for 700 / 800 level courses)

Module no.	Description	No. of hours

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

20. Resources required for the course (itemized & student access requirements, if any)

20.1	Software	Nil
20.2	Hardware	Nil
20.3	Teaching aides (videos, etc.)	No
20.4	Laboratory	No
20.5	Equipment	Nil
20.6	Classroom infrastructure	Nil
20.7	Site visits	No
20.8	Others (please specify)	

21. Design content of the course(Percent of student time with examples, if possible)

21.1	Design-type problems	
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	100%

Date: 13.02.2015 (Signature of the Head of the Department)

APPENDICES

Appendix-I

Summary of Changes in PG Courses

Table-1: List of courses to be Deleted AFTER AY2015-16			
Course Number	**Course Title**	**L-T-P**	**Credits**
ASL701	Dynamics of Atmosphere and Ocean	3-0-0	3
ASL703	Physics of Atmosphere and Ocean	3-0-0	3
ASL705	Boundary Layer Meteorology and Air Pollution	3-0-0	3
ASL706	Parameterization of Physical Processes	3-0-0	3
ASL707	Mathematical and Statistical Methods in Atmospheric Sciences	3-0-0	3
ASL710	Atmospheric Physics	3-0-0	3
ASL712	Air-Sea Interaction	3-0-0	3
ASL715	Science of Climate Change	3-0-2	4
ASL718	Tropical Meteorology	3-0-0	3
ASL720	Satellite Meteorology and Remote Sensing	3-0-0	3
ASL722	Biological Oceanography	3-0-0	3
ASL724	Atmospheric Diffusion and Air Pollution	3-0-0	3
ASP751	Simulation L- I: Weather Analysis & Forecasting	0-0-4	2
ASP752	Simulation L- II: Obj. Analysis & Data Assimilation	0-0-6	3
ASL803	Advanced Dynamic Oceanography	3-0-0	3
ASL804	Air Pollution Monitoring and Health Risk Assessment	2-0-2	3
ASL808	Atmospheric Chemistry & Aerosols	3-0-0	3
ASL813	Climate Variability	3-0-0	3
ASL814	Modelling of Dynamic Processes of Oceans and Atmosphere	3-0-0	3
ASL815	Marine Pollution and Coastal Zone Management	3-0-0	3
ASL816	Advanced Dynamic Meteorology	3-0-0	3

ASL817	Mesoscale Meteorology	3-0-0	3
ASL819	High Performance Computing in Atmospheric Sciences	2-0-2	3
ASL830	General Meteorology	3-0-0	3
ASL831	Introduction to Micro-Meteorology	3-0-0	3
ASL832	An Advanced Course in Micro-Meteorology and Risk Assessment Techniques	3-0-0	3
ASL840	Dynamic Meteorology	3-0-0	3
ASL850	Numerical Modelling of Atmosphere	3-0-0	3
ASL860	Synoptic Meteorology	3-0-0	3
ASC861	Atmospheric Science Colloquium	0-1-0	1
ASL870	Physical Oceanography	3-0-0	3
ASL871	Special Topics on Storm Surges	3-0-0	3
ASL875	Special Topics in Air Pollution	3-0-0	3
ASL877	Special Topics in Marine and Water Pollution	3-0-0	3
ASL879	Special Topics in Remote Sensing	3-0-0	3
ASL880	Dynamic Oceanography	3-0-0	3
ASL881	Special Topics in Objective Analysis	3-0-0	3
ASL883	Special Topics in Clouds and Aerosols	3-0-0	3
ASL885	Special Topics in Lake Circulation Modelling	3-0-0	3
ASL888	Special Topics in Atmospheric Sciences	3-0-0	3
ASL890	Special Topics in Geophysical Fluid Dynamics	3-0-0	3
ASP801	Simulation Lab-III:Ocean-Atmosphere Forecast Methodology	0-1-4	3
ASV872	Special Module on Storm Surges	1-0-0	1
ASV873	Special Module in Indian Ocean Studies and its Relevance to the Monsoons	1-0-0	1
ASV874	Special Module in Disaster Management	1-0-0	1

ASV875	Quantifying Uncertainty	1-0-0	1
ASV876	Special Module in Air Pollution	1-0-0	1
ASV878	Special Module in Marine and Water Pollution	1-0-0	1
ASV879	Atmospheric Radiation	1-0-0	1
ASV880	Special Module in Remote Sensing	1-0-0	1
ASV882	Special Module in Objective Analysis	1-0-0	1
ASV884	Special Module in Clouds and Aerosols	1-0-0	1
ASV886	Special Module in Lake Circulation Modelling	1-0-0	1
ASV887	Special Module in Numerical Weather Prediction	1-0-0	1
ASD891	Major Project Part – 1	0-0-12	6
ASD892	Major Project Part – 2	0-0-24	12

Table-2: List of New Courses to be Added FROM AY2015-16			
Course Number	**Course Title**	**L-T-P**	**Credits**
ASL730	Introduction to Weather, Climate and Air Pollution	1-0-0	1
ASP731	Data Analysis Methods for Atmospheric and Oceanic Sciences	0-0-4	2
ASL732	Mathematical and Computational Methods for Atmospheric and Oceanic Sciences	2-0-2	3
ASL733	Physics of the Atmosphere	3-0-0	3
ASL734	Dynamics of the Atmosphere	3-0-0	3
ASL735	Atmospheric Chemistry and Air Pollution	3-0-0	3
ASL736	Science of Climate Change	3-0-0	3
ASL737	Physical and Dynamical Oceanography	3-0-0	3
ASL738	Numerical Modeling of the Atmosphere and Ocean	2-0-2	3
ASL750	Boundary Layer Meteorology	3-0-0	3
ASL751	Dispersion of Air Pollutants	3-0-0	3
ASL752	Mesoscale Meteorology	3-0-0	3
ASL753	Atmospheric Aerosols	3-0-0	3
ASL754	Cloud Physics	3-0-0	3
ASL755	Remote Sensing of the Atmosphere and Ocean	3-0-0	3
ASL756	Synoptic Meteorology	3-0-0	3
ASL757	Tropical Weather and Climate	3-0-0	3
ASL758	General Circulation of the Atmosphere	3-0-0	3
ASL759	Land-Atmosphere Interactions	3-0-0	3
ASL760	Renewable Energy Meteorology	3-0-0	3
ASL761	Earth Systems Modeling	3-0-0	3
ASL762	Air-Sea Interaction	3-0-0	3
ASL763	Coastal Ocean and Estuarine Processes	3-0-0	3
ASP820	Advanced Data Analysis for Weather and Climate	1-0-4	3

Course Number	Course Title	L-T-P	Credits
ASL821	Advanced Dynamic Meteorology	3-0-0	3
ASL822	Climate Variability	3-0-0	3
ASL823	Geophysical Fluid Dynamics	3-0-0	3
ASL824	Parameterization of Physical Processes	3-0-0	3
ASP825	Mesoscale Modeling	0-0-6	3
ASL826	Ocean Modeling	2-0-2	3
ASL827	Advanced Dynamic Oceanography	3-0-0	3
ASL851	Special Topics in Climate	3-0-0	3
ASL852	Special Topics in Oceans	3-0-0	3
ASL853	Special Topics in Atmosphere	3-0-0	3
ASL854	Special Topics in Air Pollution Studies	3-0-0	3
ASP855	Special Topics in Atmosphere and Ocean	1-0-4	3
ASL856	Special Topics in Atmospheric and Oceanic Observations	2-0-2	3
ASV862	Special Module in Climate	1-0-0	1
ASV863	Special Module in Oceans	1-0-0	1
ASV864	Special Module in Atmosphere	1-0-0	1
ASV865	Special Module in Air Pollution Studies	1-0-0	1
ASV866	Special Module in Atmosphere and Ocean	1-0-0	1
ASV867	Special Module in Weather Forecasting	1-0-0	1
ASV868	Special Module in Atmospheric and Oceanic Observations	0-0-2	1
ASC869	Atmospheric and Oceanic Science Colloquium	0-1-0	1
ASD881	Project-I	0-0-12	6
ASD882	Project-II	0-0-24	12

Table-3: List of Courses Retained			
Course Number	**Course Title**	**L-T-P**	**Credits**
ASS800	Independent Study	3-0-0	3

Appendix-II

Eligibility Criteria (Unchanged)

Marks and CGPA in qualifying degree (M.Sc. or B.Tech./ B.E. or equivalent) as determined by IIT Delhi with BE/ B.Tech Agricultural Engineering, Chemical Engineering, Civil Engineering, Environmental Engineering, Mechanical Engineering; M.Sc. Meteorology/Atmospheric Sciences/Oceanography, M.Sc. Physics/Geo-Physics/ Marine Engineering/ Statistics/ Chemistry; M.A./ M.Sc. Maths (with physics at undergraduate level), MCA (with maths and physics at B.Sc. level), M.Sc. Environmental/Agricultural Sciences (with maths and physics at B.Sc. level), M.Sc. Geo-Information/Remote sensing (with maths and physics at B.Sc. level).

Candidates having B.Tech./B.E. in other branches of engineering will be considered only if they have appropriate experience in related areas of atmospheric and oceanic sciences, meteorology, remote sensing, etc.

GATE requirements and other conditions are as per the norms of the Institute for admission to M.Tech Programme in Atmospheric-Oceanic Science and Technology.

Total intake	:	Maximum 25
Duration of the Programme (full-time)	:	Two years
Duration of the Programme (part-time)	:	Three years