Workshop on Seasonal Climate Forecasts Mechanism in the Region
SAARC Disaster Management Center (IU), Gandhinagar, Gujarat, India

Global Source of Climate Monitoring and Climate Prediction Products

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भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Outline

Climate Monitoring Products:

- ENSO
- IOD
- MJO

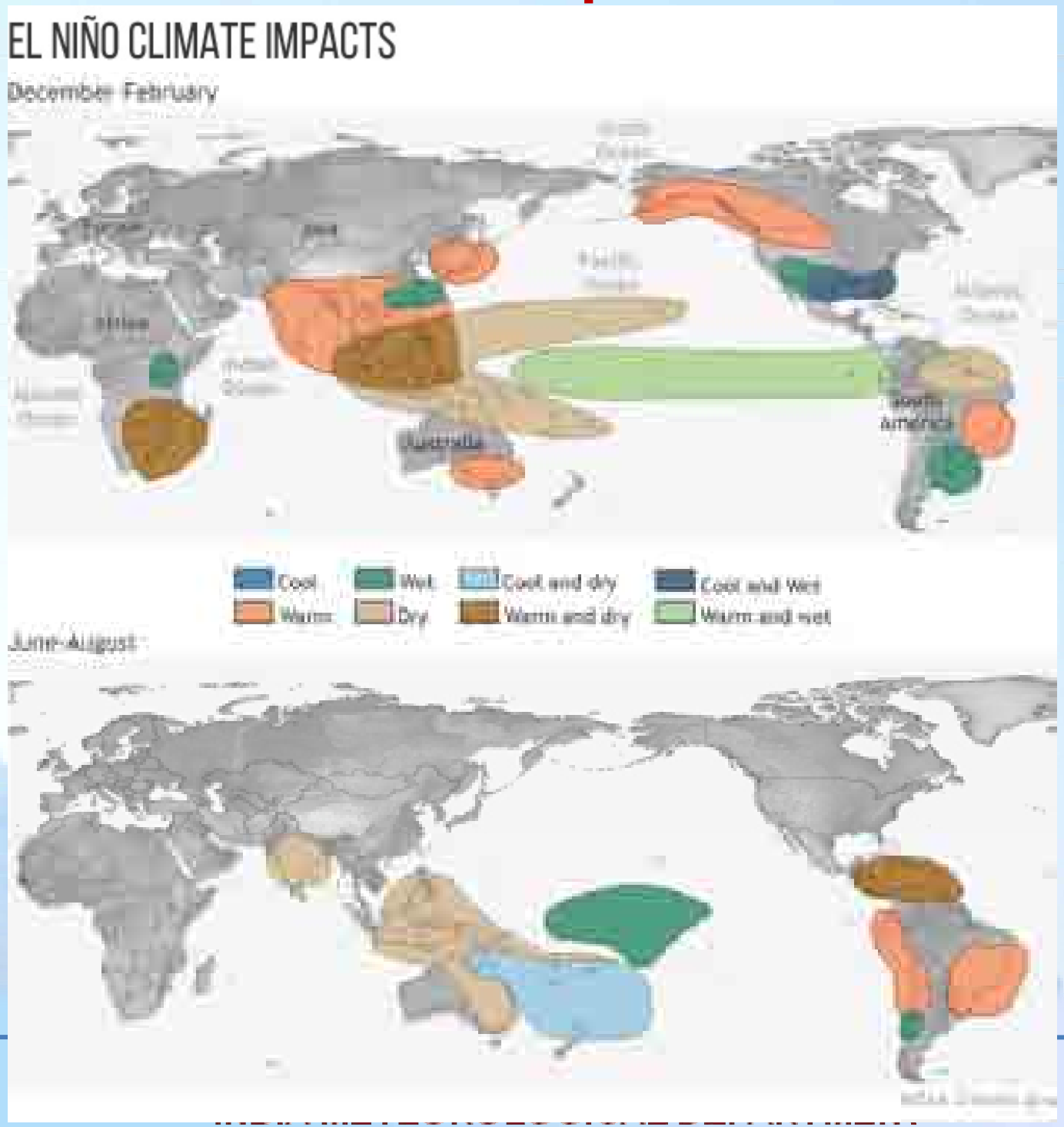
Climate Prediction Products:

- Elnino Forecast
- IOD Forecast
- Monthly & Seasonal Forecast

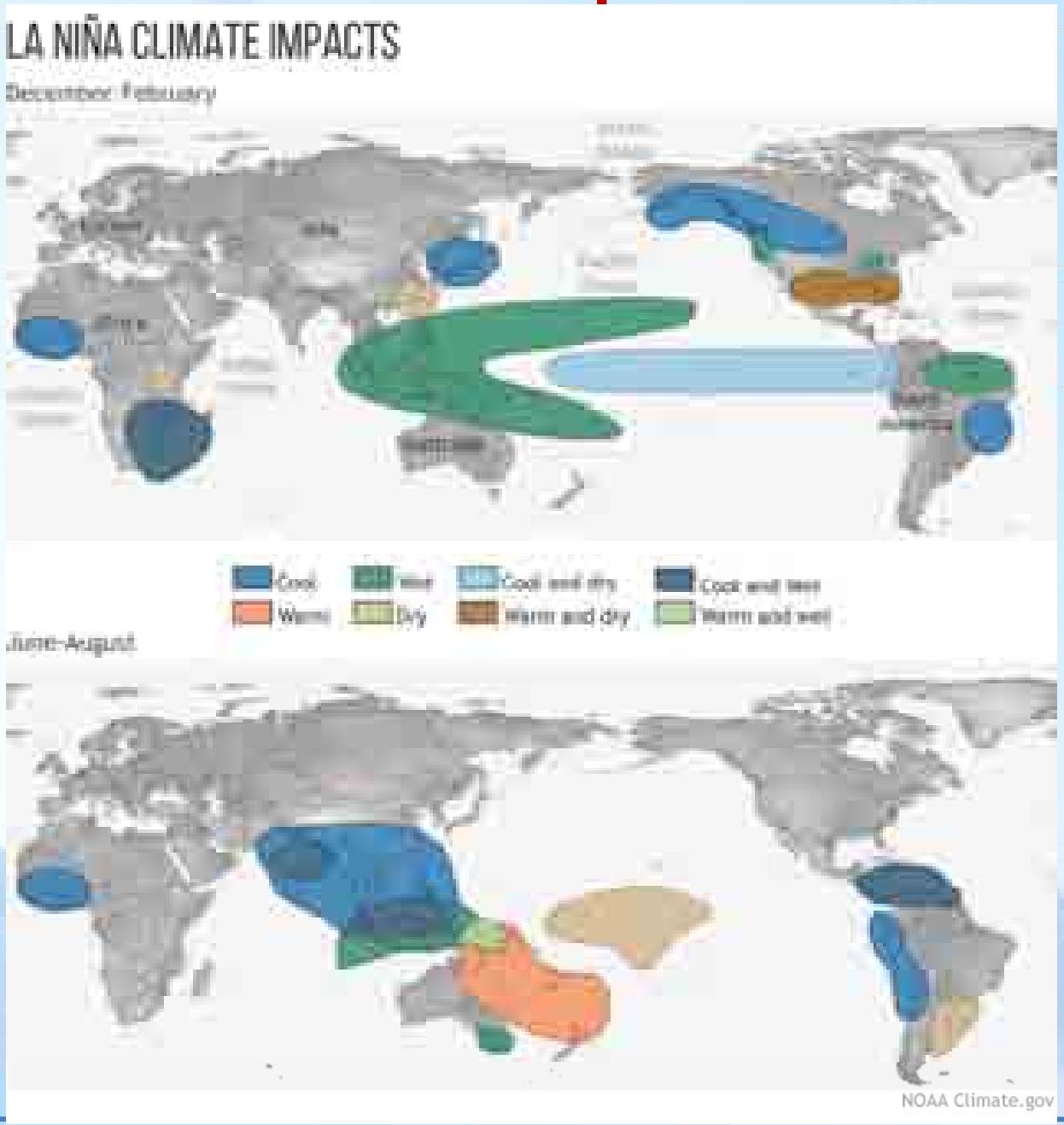
Online Data source & customising tools:

- Climate Data Library, CLIK,Climate Prediction Tool

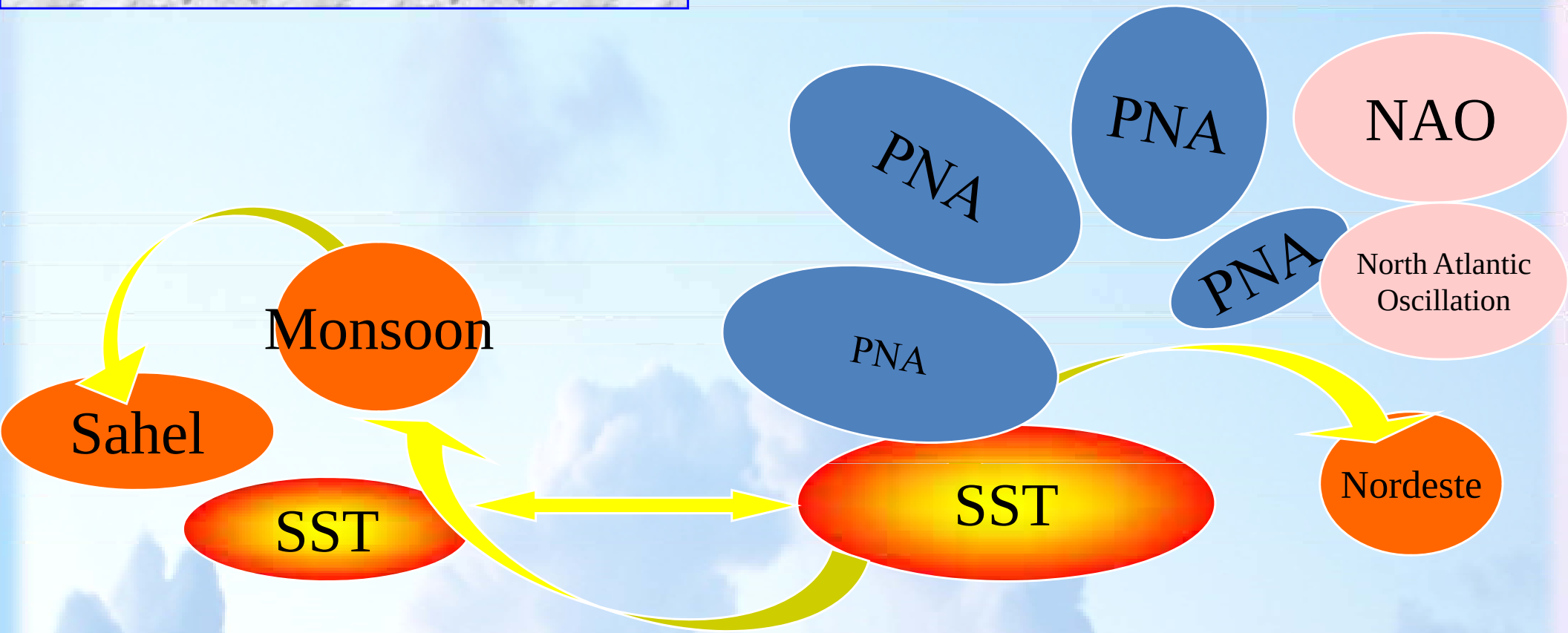
El Niño impact



La Niña impact

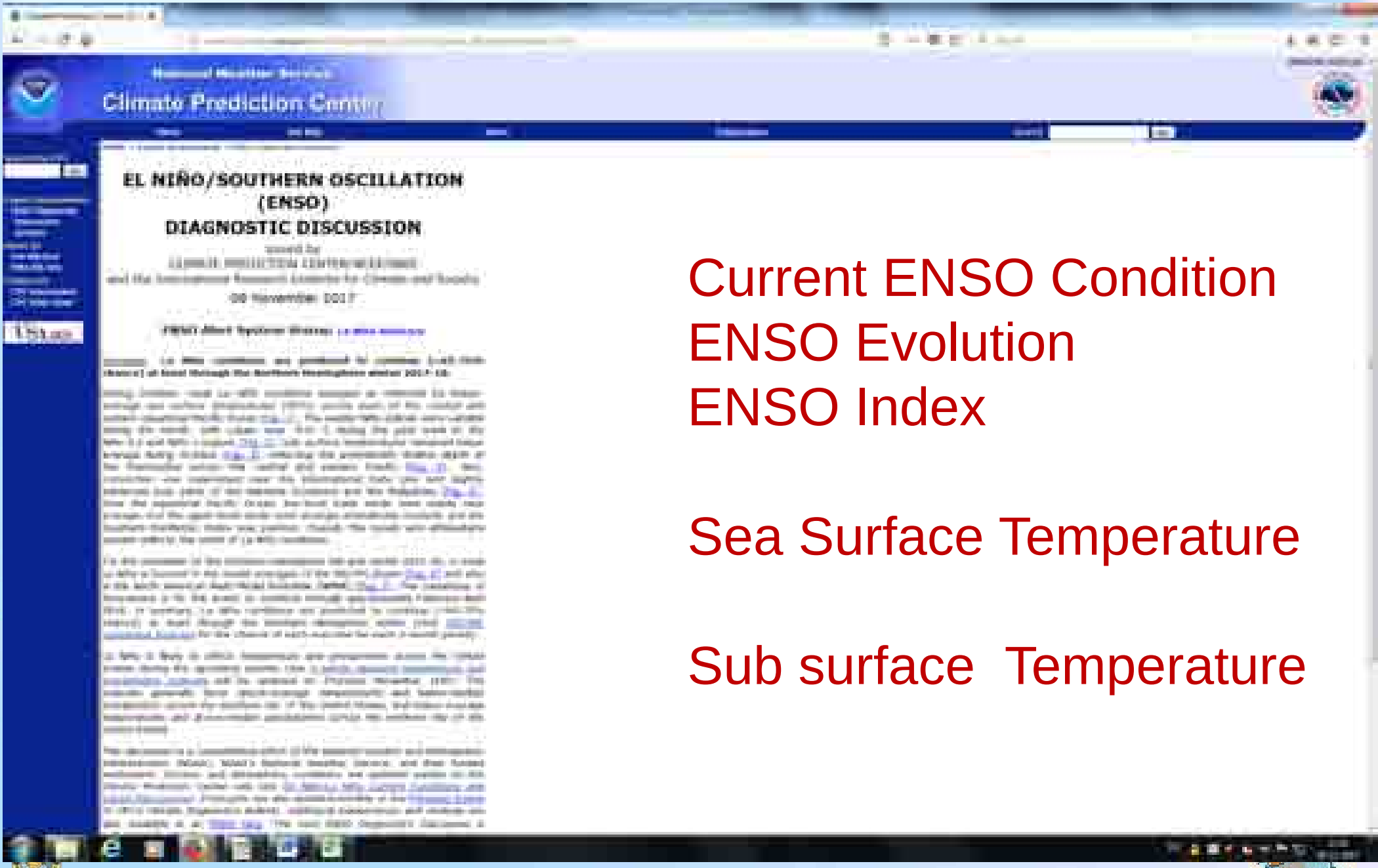


Teleconnections



The interactions between atmosphere and oceans in the tropics dominate the variability at interannual scales. The main player is the variability in the equatorial Pacific. Wavetrains of anomaly stem from the region into the mid-latitudes, as the Pacific North American Pattern (PNA). The tropics are connected through the Pacific SST influence on the Indian Ocean SST and the monsoon, Sahel and Nordeste precipitation. It has been proposed that in certain years the circle is closed and and a full chain of teleconnections goes all around the tropics. Also shown is the North Atlantic Oscillation a major mode of variability in the Euro_atlantic sector whose coupled nature is still under investigation.

ENSO Diagnostic Discussion



Current ENSO Condition
ENSO Evolution
ENSO Index

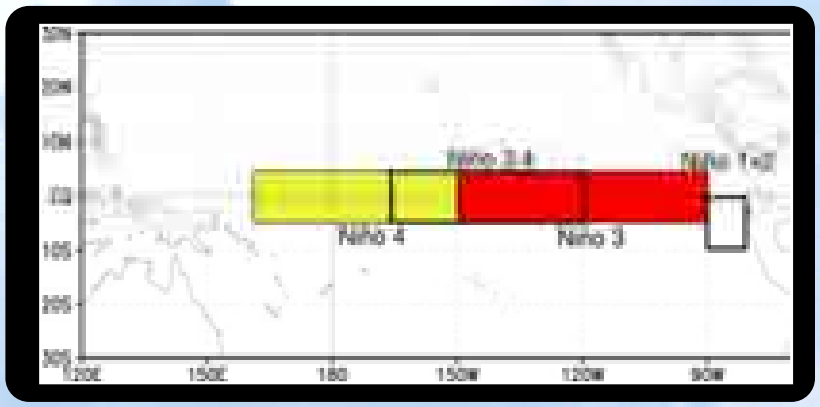
Sea Surface Temperature

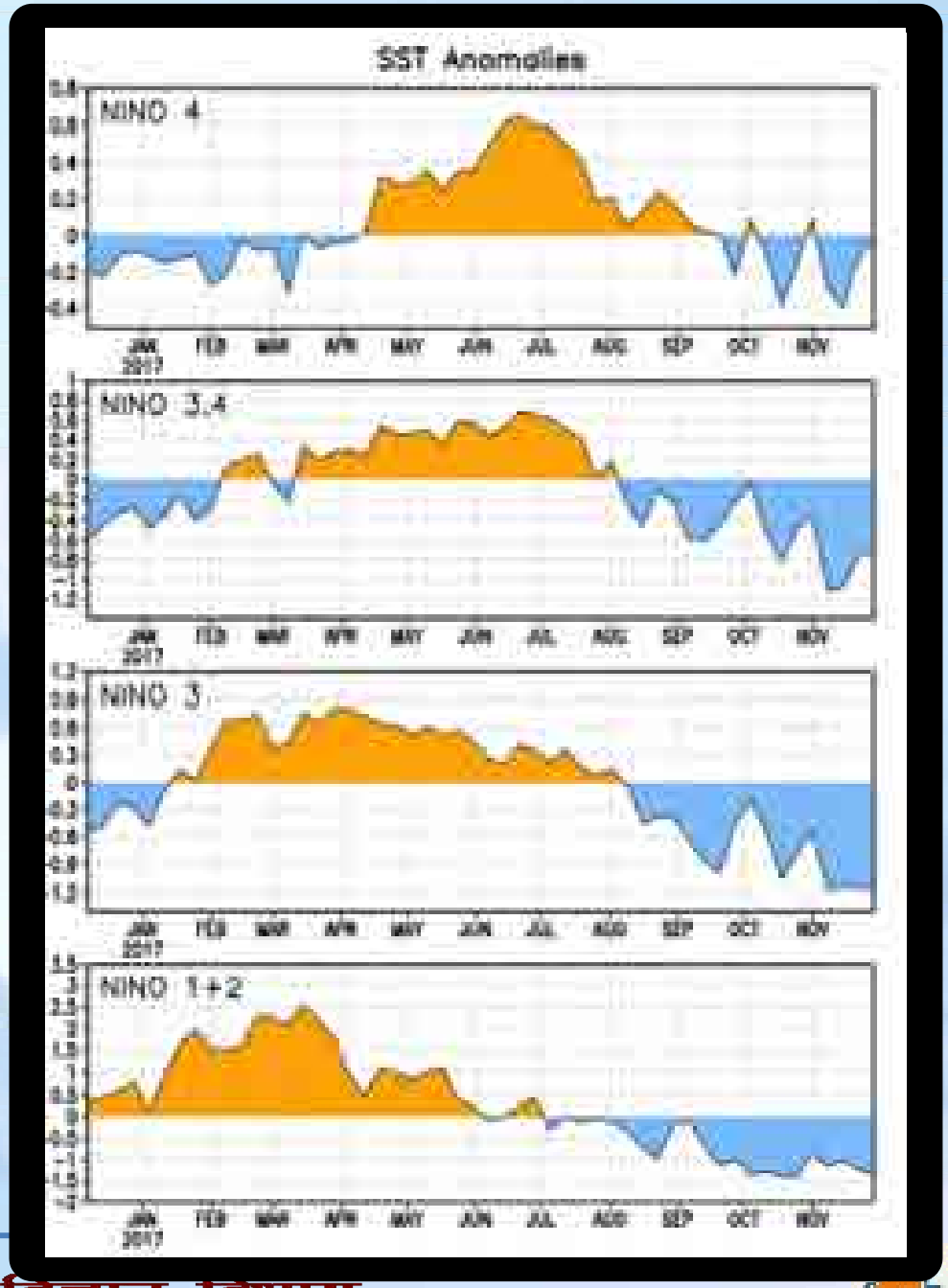
Sub surface Temperature

Niño Region SST Departures (ºC) Recent Evolution

The latest weekly SST departures are:

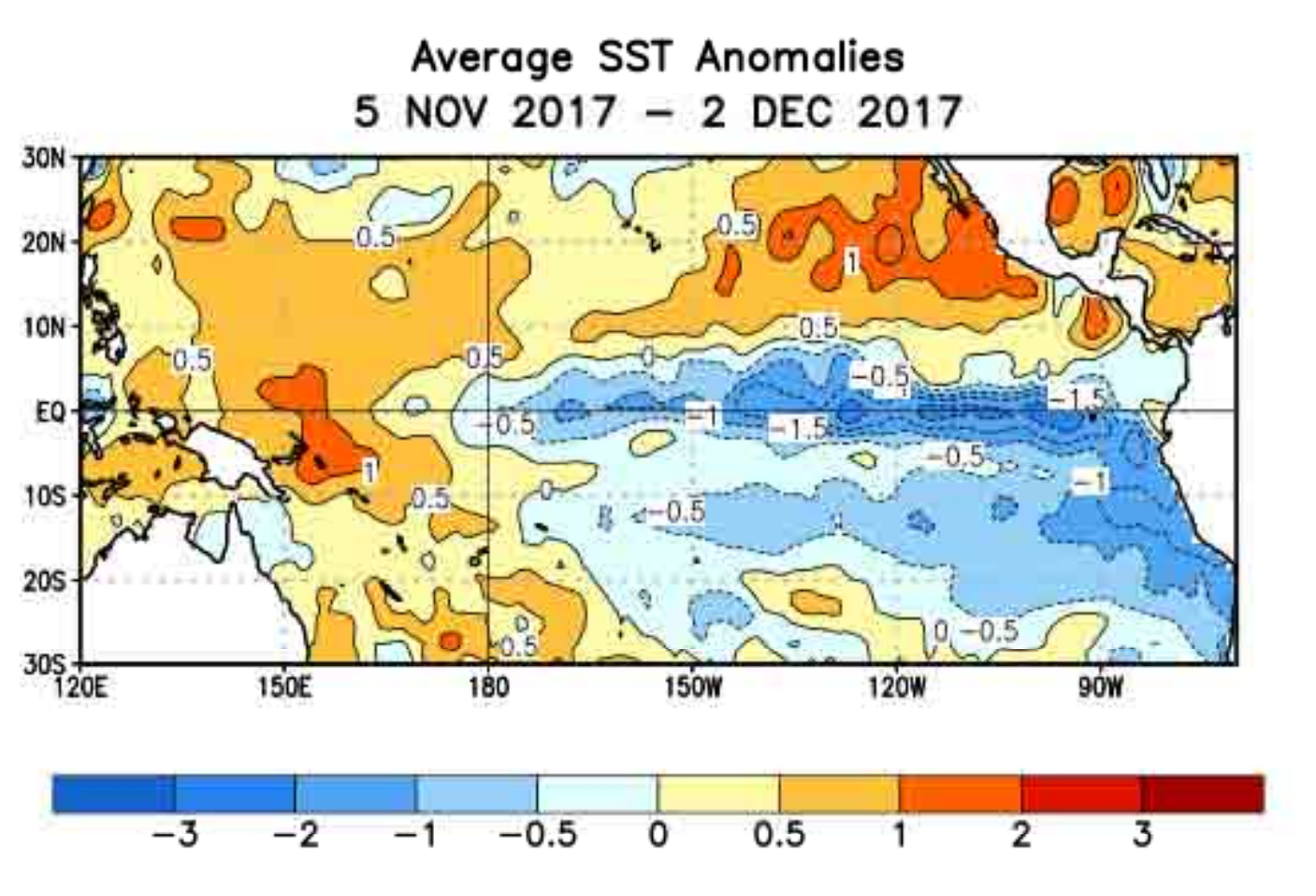
Niño 4	**0.0ºC**
Niño 3.4	**-0.7ºC**
Niño 3	**-1.1ºC**
Niño 1+2	**-1.3ºC**





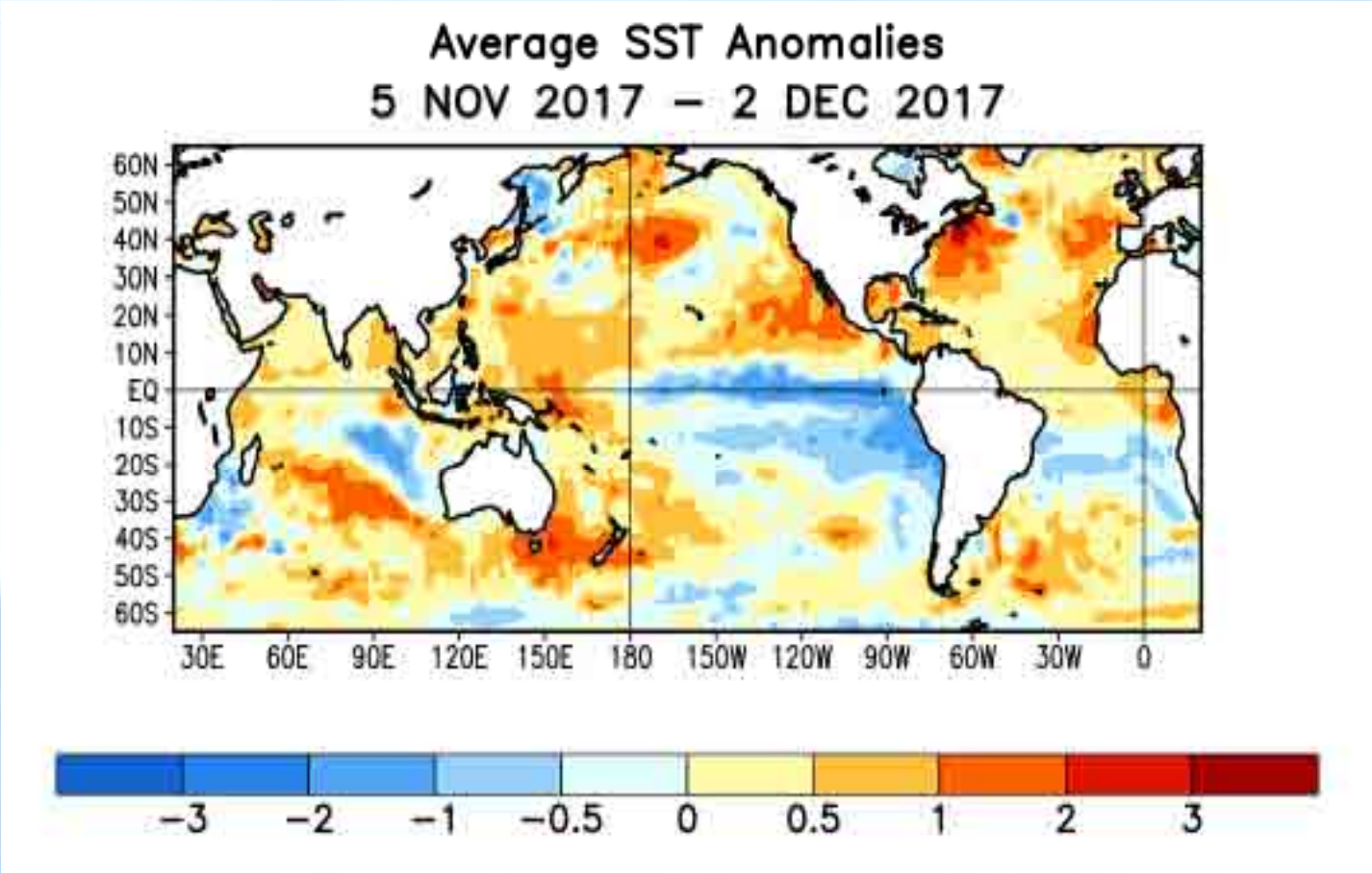
SST Departures (°C) in the Tropical Pacific During the Last Four Weeks

During the last four weeks, equatorial SSTs were below average across the central and eastern Pacific Ocean, and above average in the far western Pacific.



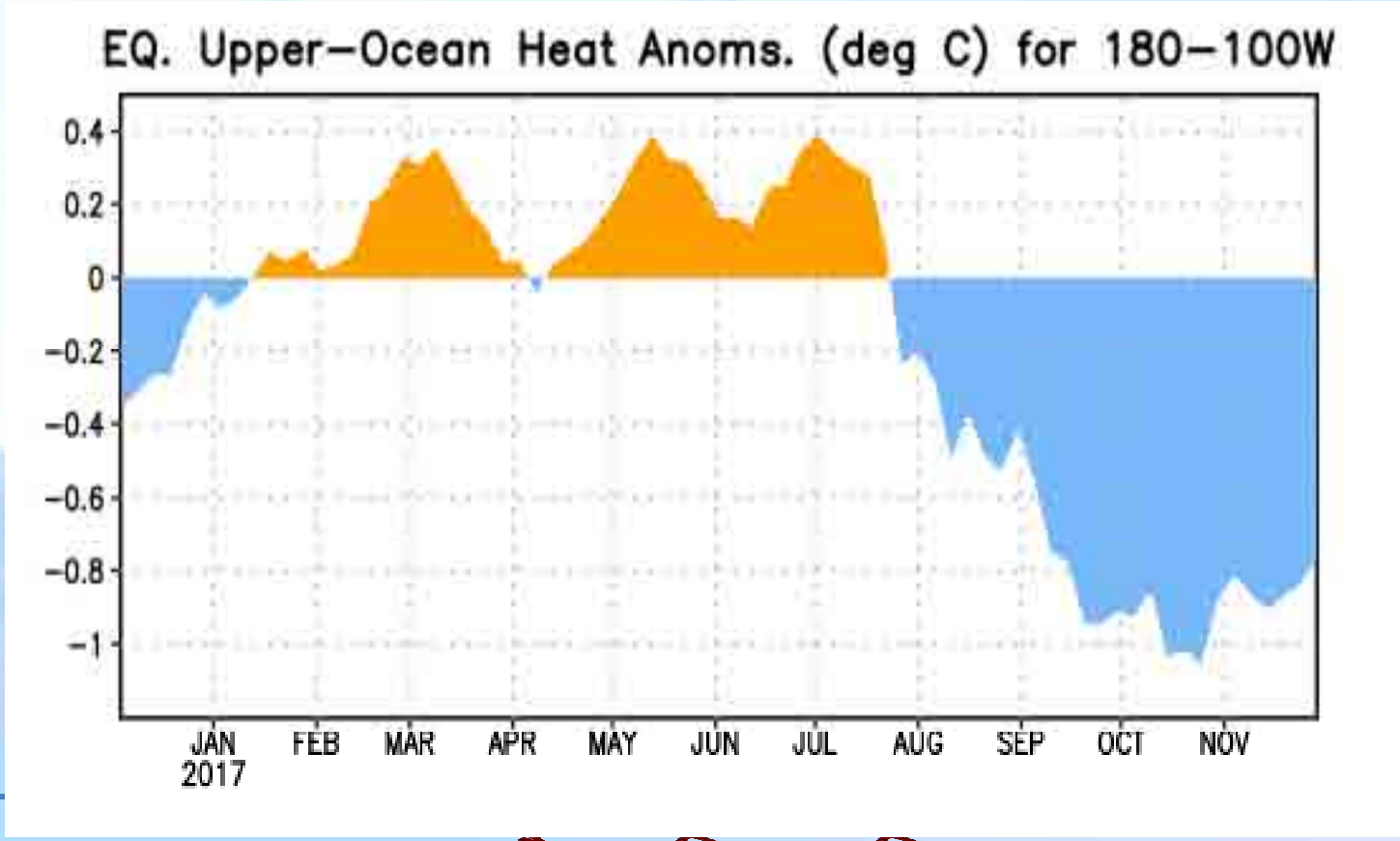
Global SST Departures (ºC) During the Last Four Weeks

During the last four weeks, equatorial SSTs were above average in the far western Pacific, eastern Atlantic, and eastern Indian Oceans. SSTs were below average in the central and eastern Pacific Ocean.



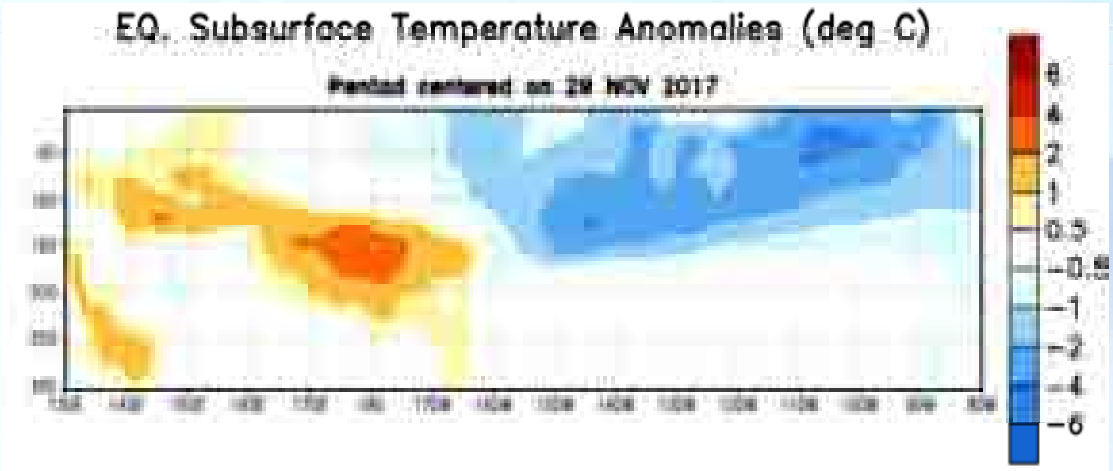
Central and Eastern Pacific Upper-Ocean (0-300 m) Weekly Average Temperature Anomalies

Negative subsurface temperature anomalies were present through December 2016. Positive anomalies with large fluctuations in amplitude were present from mid-January through mid-July 2017. Since mid-July, anomalies decreased and have remained negative.

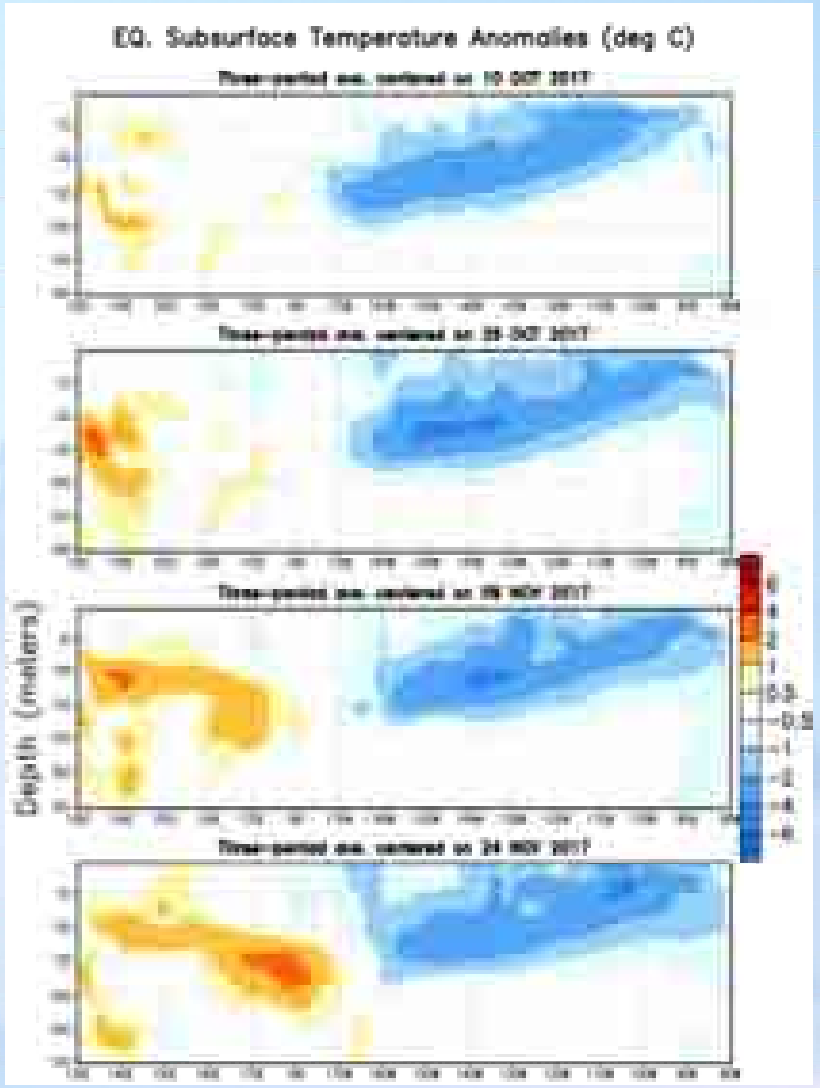


Sub-Surface Temperature Departures in the Equatorial Pacific

In the last two months, negative subsurface temperature anomalies have persisted across the central and eastern Pacific Ocean.



Most recent pentad analysis



Also, positive anomalies have increased in the western Pacific Ocean.

Recently, the strongest negative anomalies are between 160°W-80°W.

Historical El Niño and La Niña Episodes Based on the ONI computed using ERSST.v5

Recent Pacific warm (red) and cold (blue) periods based on a threshold of +/- 0.5 ºC for the Oceanic Nino Index (ONI) [3 month running mean of ERSST.v5 SST anomalies in the Nino 3.4 region (5N-5S, 120-170W)]. For historical purposes, periods of below and above normal SSTs are colored in blue and red when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

The ONI is one measure of the El Niño-Southern Oscillation, and other indices can confirm whether features consistent with a coupled ocean-atmosphere phenomenon accompanied these periods. The complete table going back to DJF 1950 can be found here.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2005	0.6	0.6	0.4	0.4	0.3	0.1	-0.1	-0.1	-0.1	-0.3	-0.6	-0.8
2006	-0.8	-0.7	-0.5	-0.3	0.0	0.0	0.1	0.3	0.5	0.7	0.9	0.9
2007	0.7	0.3	0.0	-0.2	-0.3	-0.4	-0.5	-0.8	-1.1	-1.4	-1.5	-1.6
2008	-1.6	-1.4	-1.2	-0.9	-0.8	-0.5	-0.4	-0.3	-0.3	-0.4	-0.6	-0.7
2009	-0.8	-0.7	-0.5	-0.2	0.1	0.4	0.5	0.5	0.7	1.0	1.3	1.6
2010	1.5	1.3	0.9	0.4	-0.1	-0.6	-1.0	-1.4	-1.6	-1.7	-1.7	-1.6
2011	-1.4	-1.1	-0.8	-0.6	-0.5	-0.4	-0.5	-0.7	-0.9	-1.1	-1.1	-1.0
2012	-0.8	-0.6	-0.5	-0.4	-0.2	0.1	0.3	0.3	0.3	0.2	0.0	-0.2
2013	-0.4	-0.3	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.3	-0.2	-0.2	-0.3
2014	-0.4	-0.4	-0.2	0.1	0.3	0.2	0.1	0.0	0.2	0.4	0.6	0.7
2015	0.6	0.6	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.5	2.6
2016	2.5	2.2	1.7	1.0	0.5	0.0	-0.3	-0.6	-0.7	-0.7	-0.7	-0.6
2017	-0.3	-0.1	0.1	0.3	0.4	0.4	0.1	-0.2	-0.4	-0.7		

ENSO Forecast : IRI

ENSO Forecast

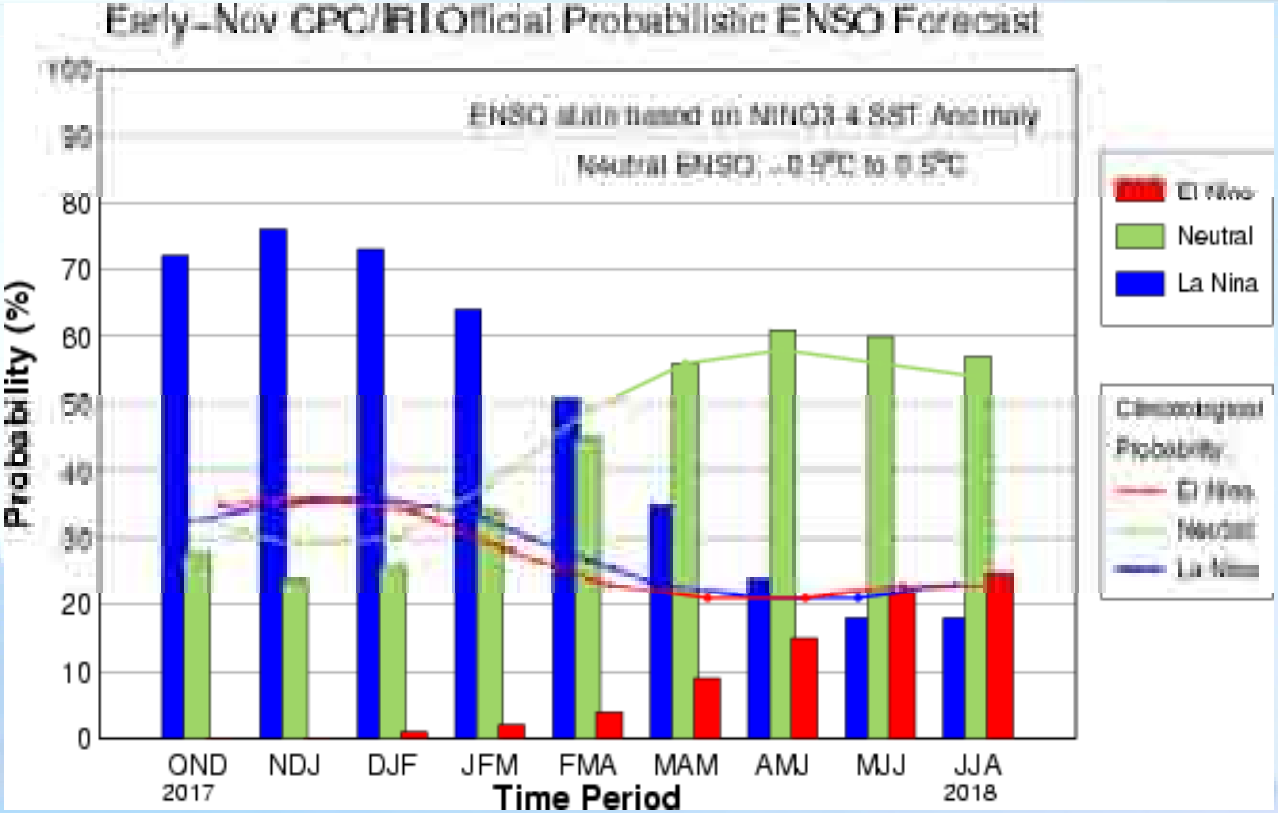
Consensus Outlook

SST Forecast from Various Models

CPC/IRI Probabilistic ENSO Outlook

Updated: 9 November 2017

La Niña conditions are predicted to continue (~65%-75% chance) at least through the Northern Hemisphere winter 2017-18, with a 51% chance of continuation through February-April 2018.



IRI/CPC Pacific Niño 3.4 SST Model Outlook

The multi-model averages predict La Niña to persist into early 2018.

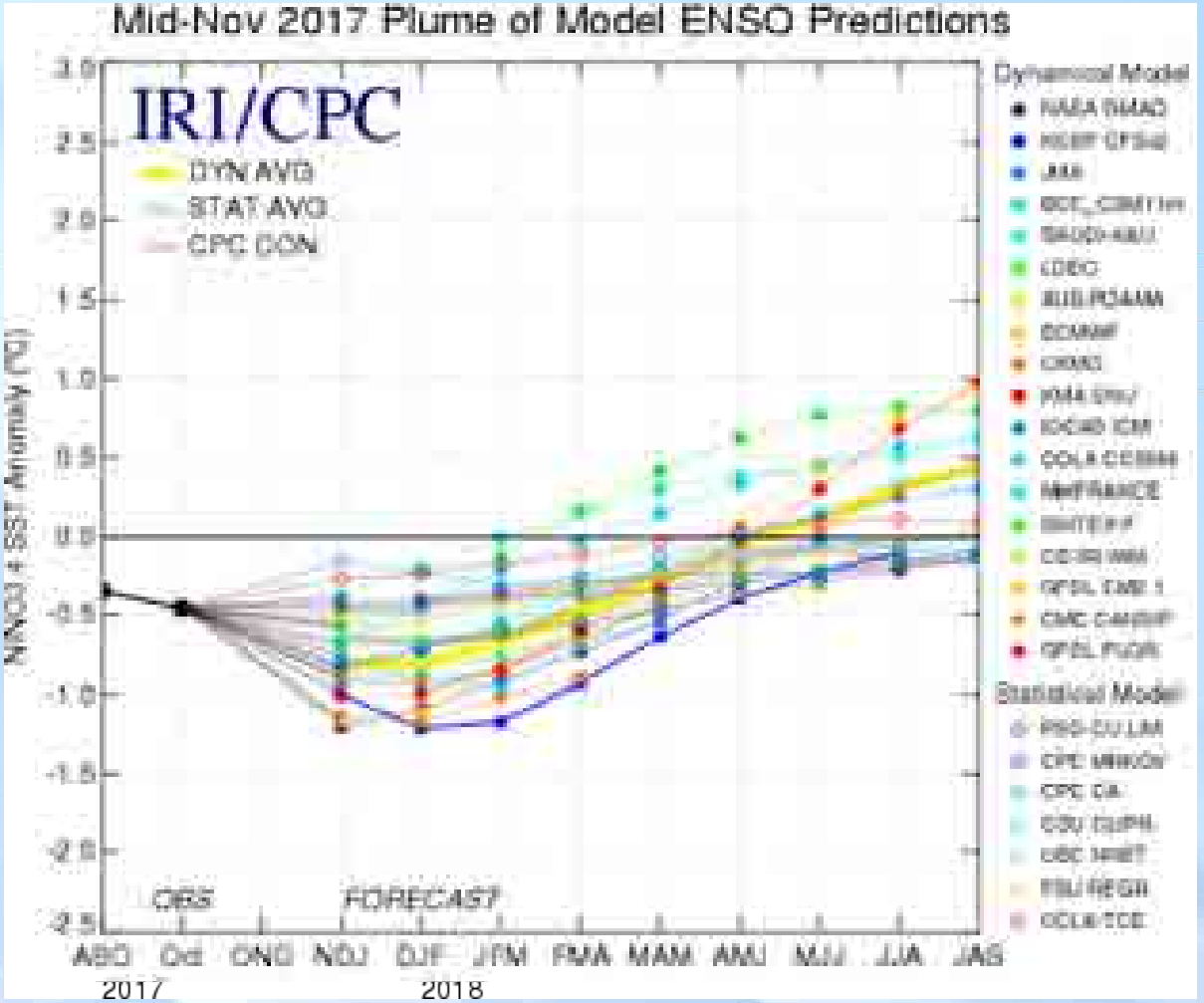


Figure provided by the International Research Institute (IRI) for Climate and Society (updated 17 November 2017).

ENSO Wrap-Up

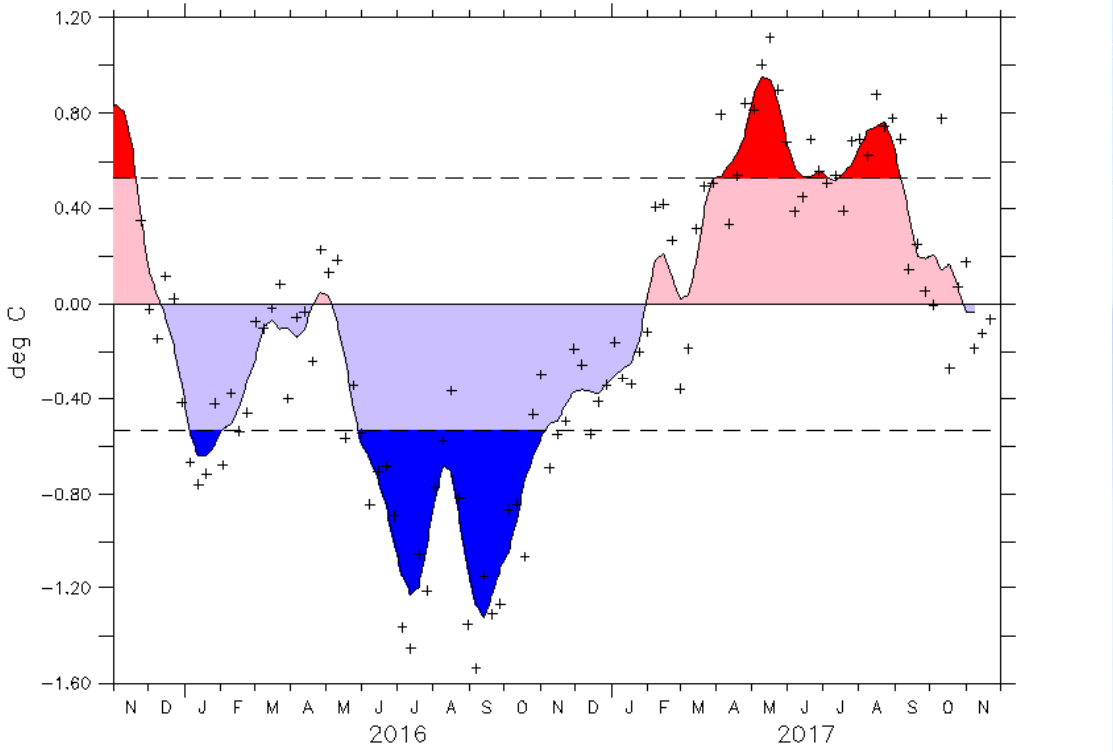
ENSO & IOD Forecast

Sea Surface Temperature

MJO

SOI

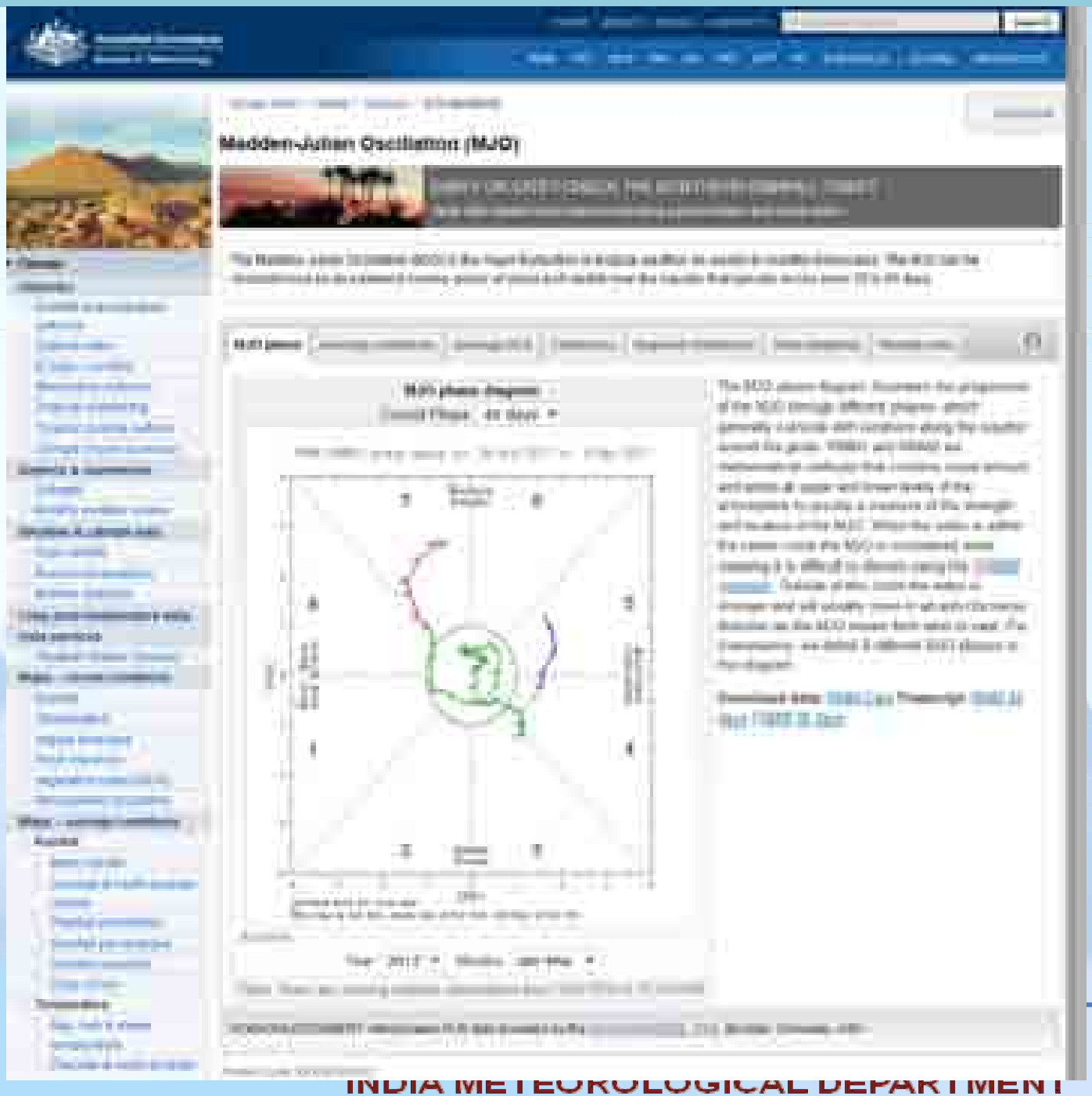
Indian Ocean Dipole



MJO Monitoring NCEP

Current status of MJO
MJO Prediction

MJO Monitoring Bureau of Meteorology Australia



Current status Prediction

Various Approaches used in Seasonal Prediction

- **Empirical/ Statistical model**
  - Multiple Regression
  - Canonical Correlation Analysis
  - Artificial Neural Network
  - Discriminant Analysis
  - Ex: IMD Operational LRF
- **Dynamical/ Numerical Model**
  - SST Forced Atmospheric General Circulation models (AGCMs)
  - Ex: IMD SFM
  - Coupled General Circulation Models (CGCMs)
  - Ex: MMCFS
- **Hybrid Model (Statistical + Dynamical)**
  - Statistical rescaling of dynamical model simulations

– based on historical observed data for the predictand (e.g. rainfall, temperature) and for relevant predictors (e.g. SST, atmospheric pressure

– using prognostic physical equations

2-tiered systems (first predict SST, then climate).

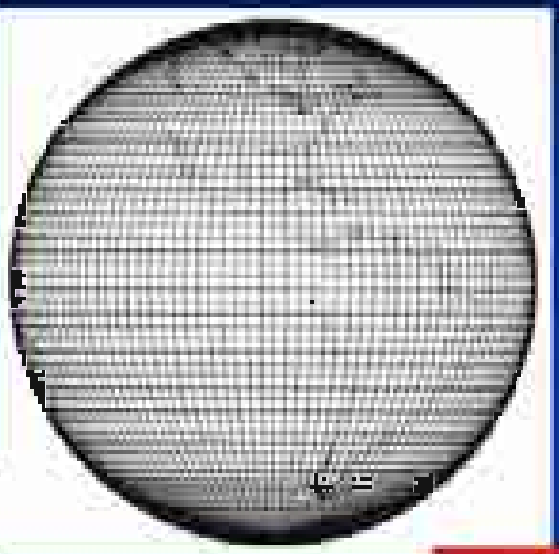
1-tiered systems (predict ocean and atmosphere together)

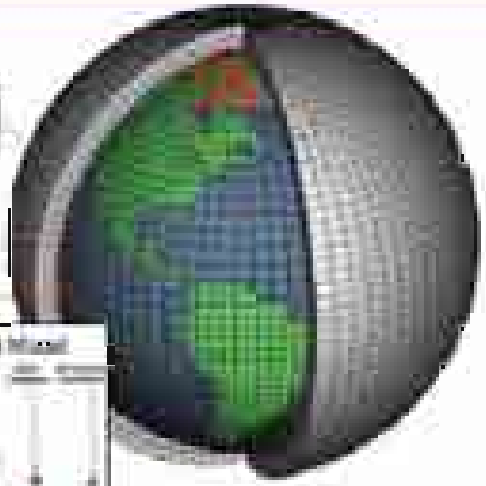
Basis of a weather / climate model

Representation of atmosphere (temperature, wind, moisture, pressure on a grid

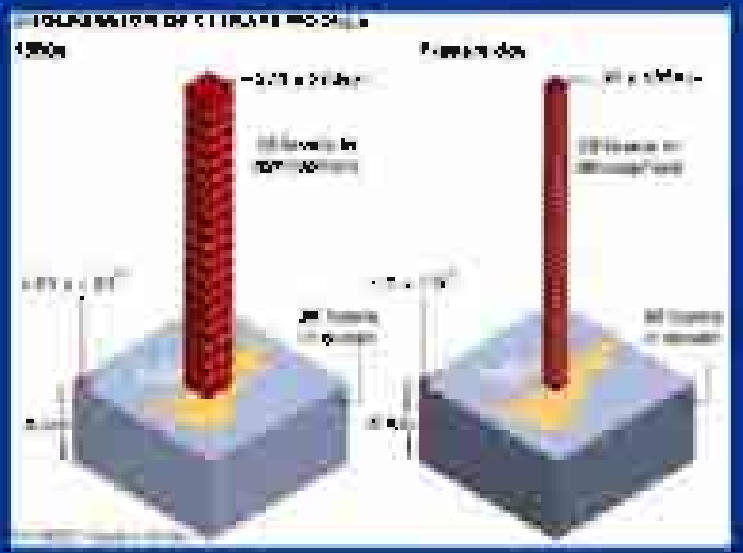
Equations of motions and laws of thermodynamics to predict rate of change of *T, P, V, q, etc.*

10 Million equations
100,000 Points × 100 Levels × 10 variables
Time step ~ 10 minutes





Courtesy Kamal Puri



What should be parameterized ?

Model Physics include:

- **Radiation transfer.**
- **Surface processes.**
- **Vertical turbulent processes.**
- **Clouds and large-scale condensation.**
- **Cumulus convection.**
- **Gravity wave drag.**

16 major physical processes in climate system. (from http://www.meted.ucar.edu/nwp/pcu1/ic4/frameset.htm)

Probabilistic-Ensemble NWP

- There are several ways to produce probabilistic information but the most viable and popular is ensemble prediction.
- Instead of running one forecast, run a collection (ensemble) of forecasts, each starting from a different initial state or with different physics.
- The variations in the resulting forecasts can be used to estimate the uncertainty of the prediction.
- The ensemble mean is on average more skillful than any individual member.

MoES AADITYA (790 TF)

WMO Global Producing Centers

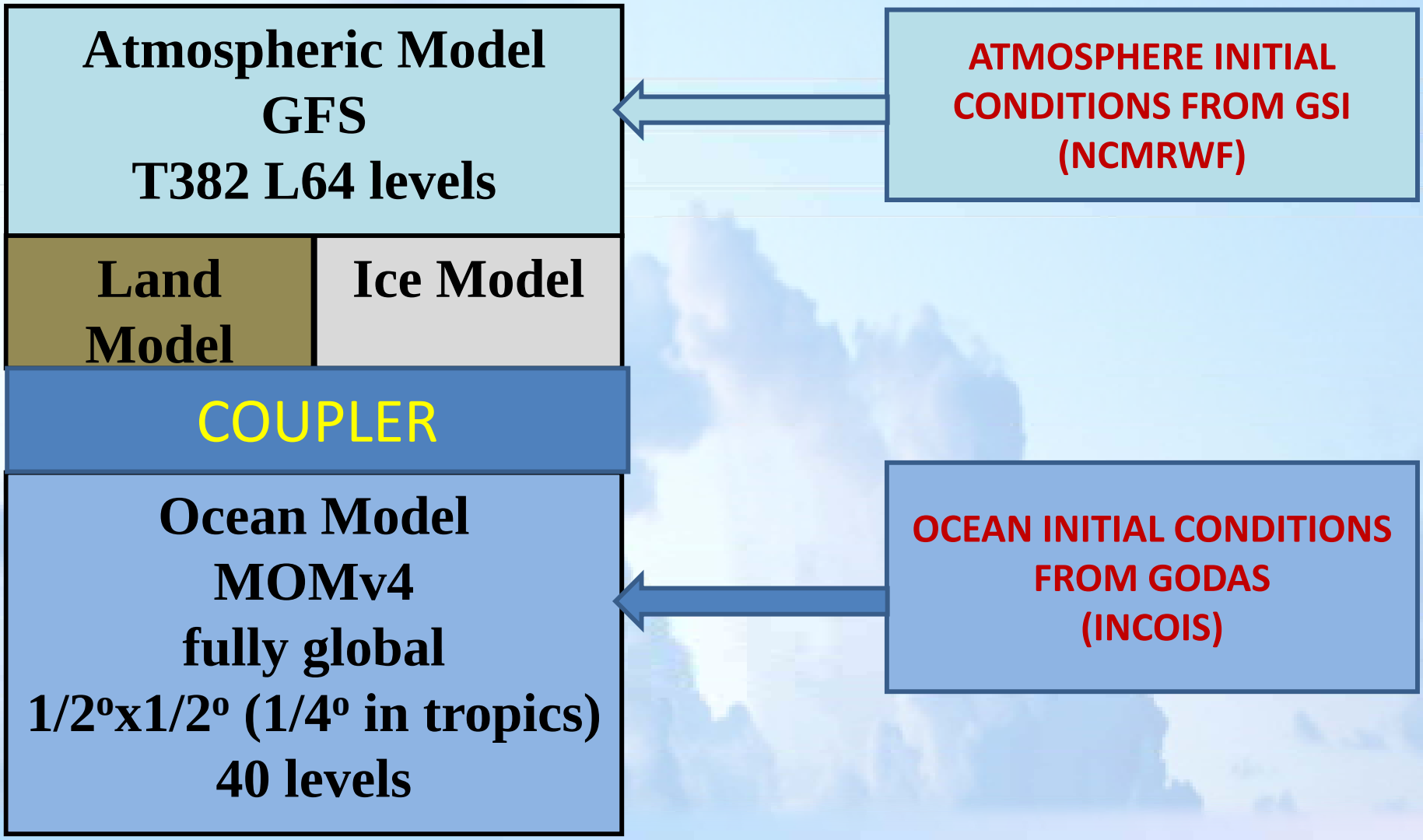
- Melbourne: Bureau of Meteorology (BoM), Australia
- Beijing: China Meteorological Administration (CMA)/ Bejing Climate Center (BCC)
- Washington: Climate Prediction Center (CPC), NOAA, United States of America
- ECMWF: European Centre for Medium-Range Weather Forecasts
- Tokyo: Japan Meteorological Agency (JMA)/ Tokyo Climate Centre (TCC)
- Seoul: Korea Meteorological Administration (KMA)
- Toulouse: Meteo-France
- Exeter: Met Office, United Kingdom
- Montreal: Meteorological Service of Canada (MSC)
- Pretoria: South African Weather Services (SAWS)
- Moscow: Hydrometeorological Centre of Russia
- CPTEC: Center for weather forecasts and climate studies/ National institute for space research (INPE)

Regional Climate Centres

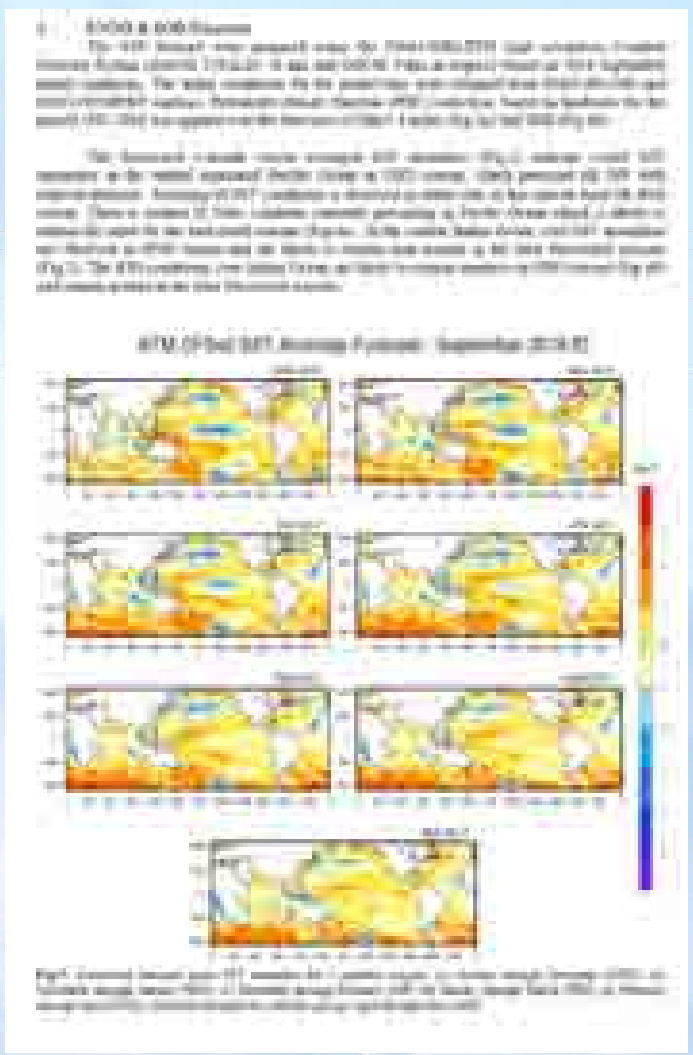
- **WMO RCCs are Centres of Excellence intended to perform regional-scale climate functions**
- **Established at the request of the Members of the Regional Associations**
- **Official accreditation given by WMO after a successful 2- 4 yr demonstration phase**
- **Primary users are the National Meteorological and Hydrological Services (NMHS)**
- **RCCs are complementary to and supportive of NMHSs, who will deliver all warnings and national-scale products in the appropriate language.**

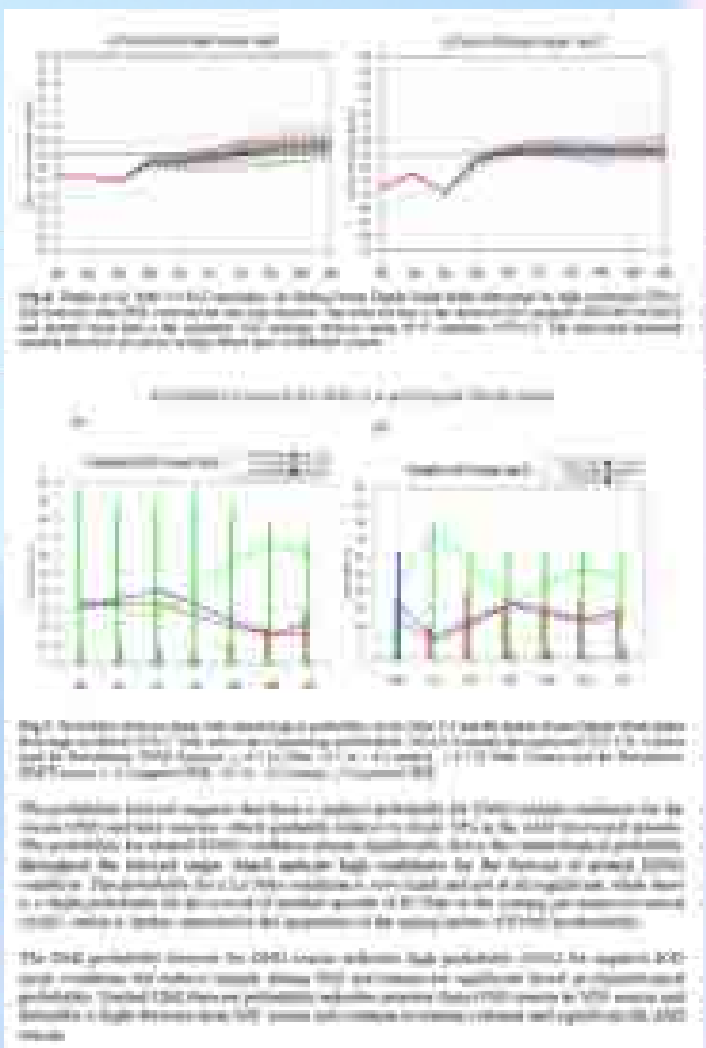
Regional Climate Centre (IMD, Pune)

Monsoon Mission CFS Model:



ENSO & IOD Forecast Bulletin (Every month)

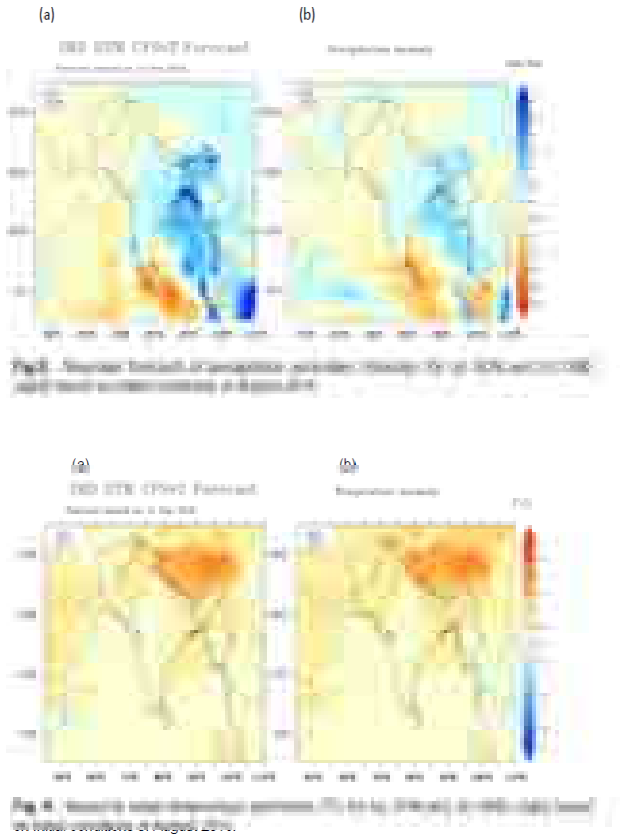


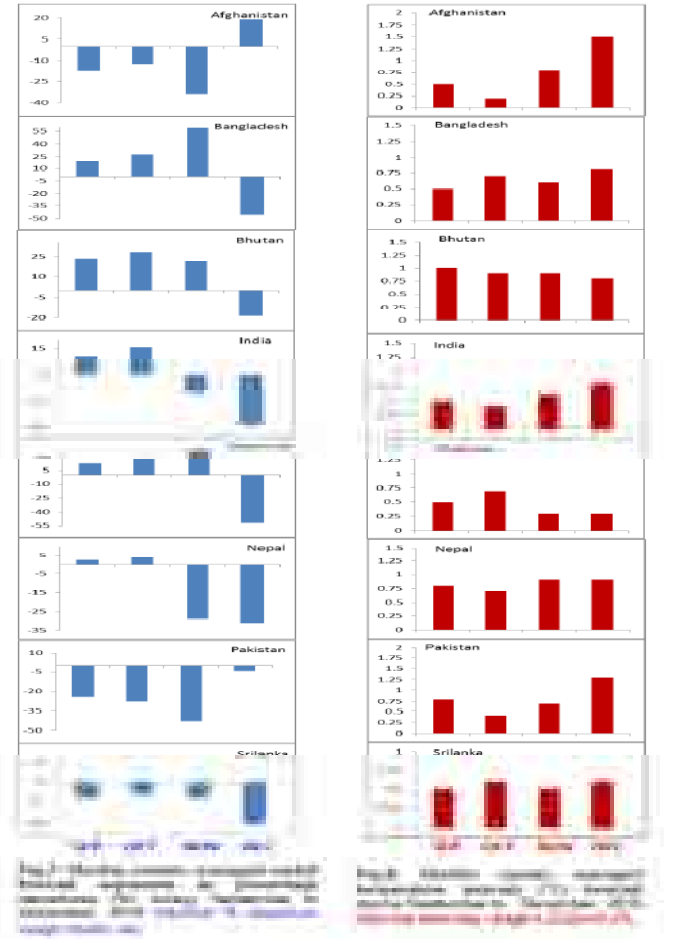


Seasonal Climate Outlook for South Asia

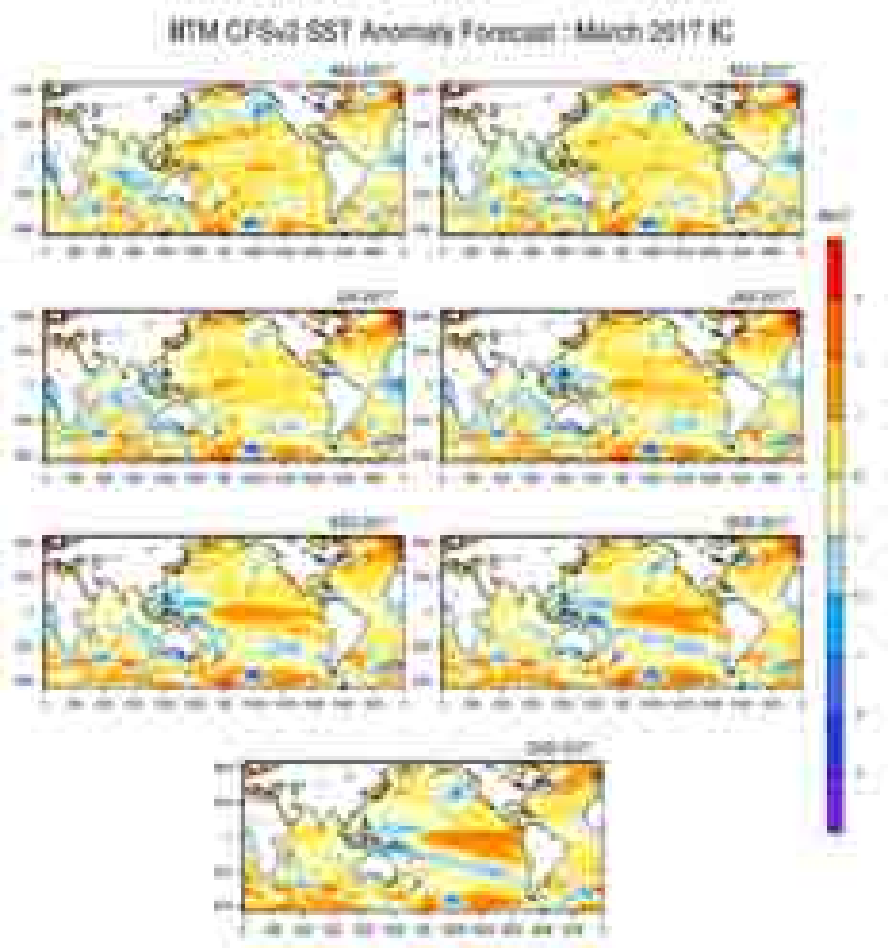
India Meteorological Department

(September to December 2019)

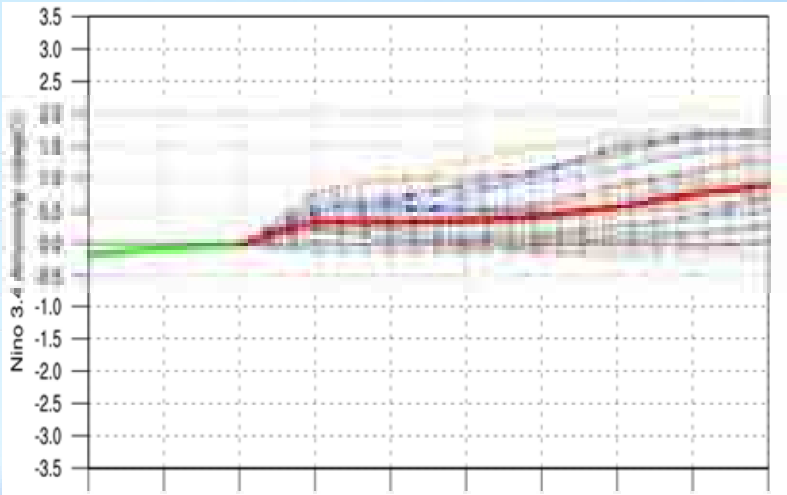


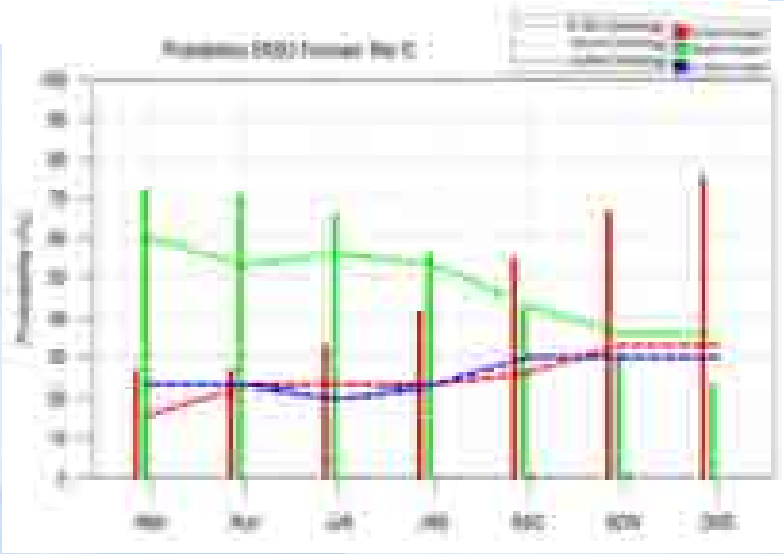


ENSO Forecast - MMCFS: March IC



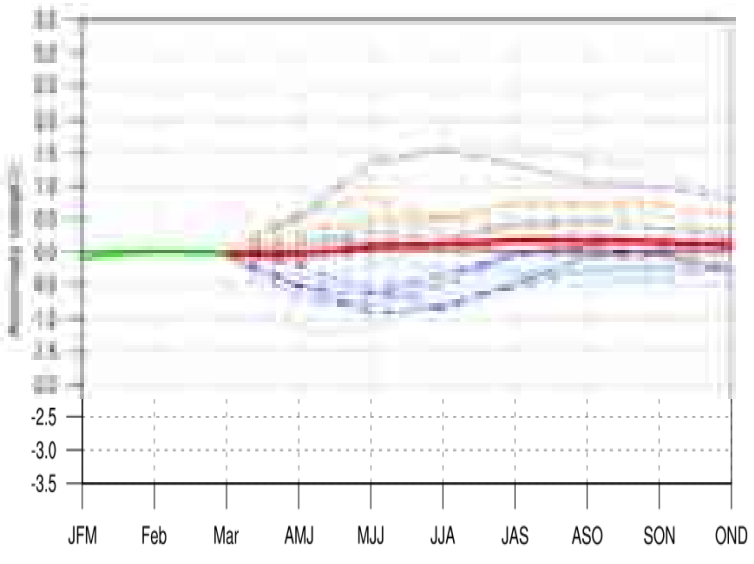
Plume of Nino 3.4 PDF Corrected Model Forecast – Mar IC

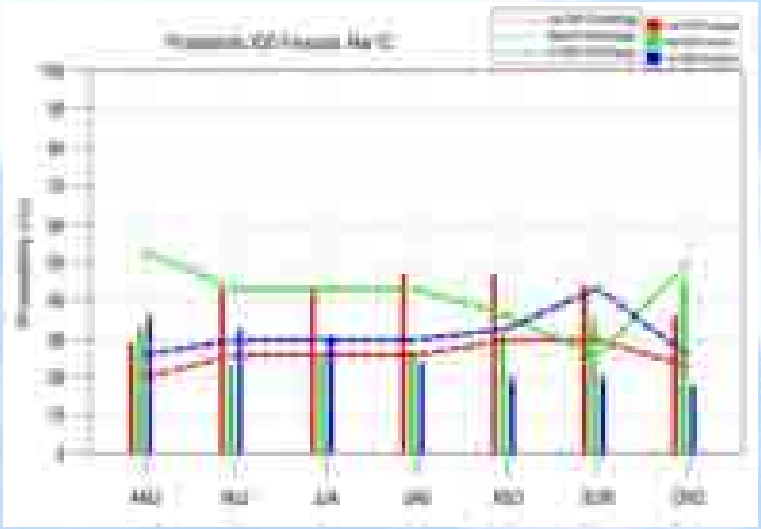




Enso Neutral conditions are likely till mid -2017 with increased probability (>50%) for the development of El Nino from ASO onwards

Indian Ocean Dipole: IMD-IITM CFS

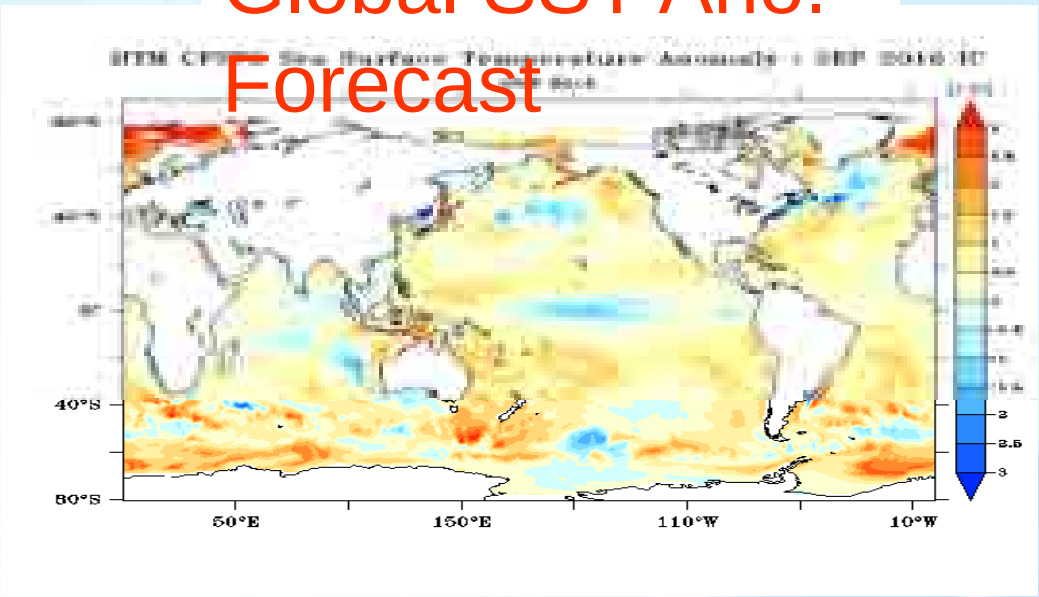




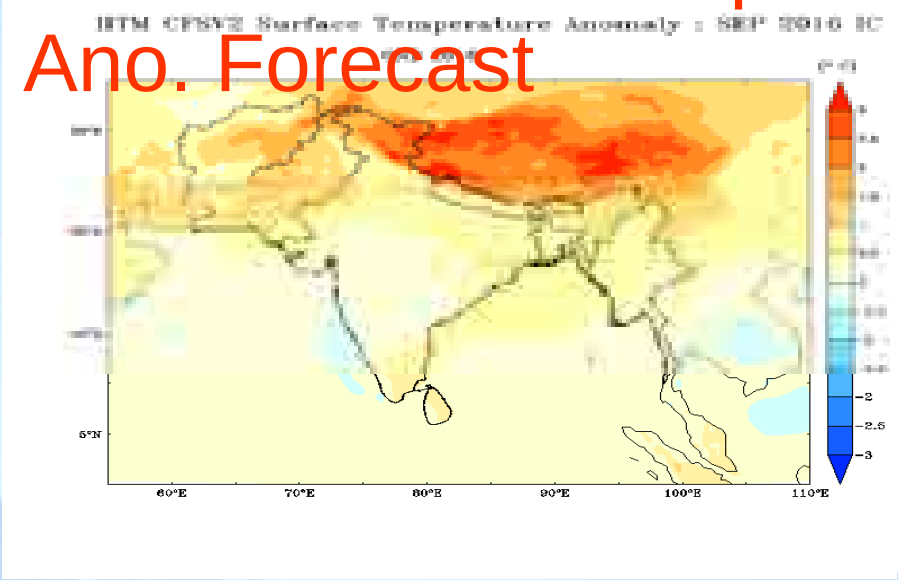
IOD forecast: The current neutral conditions are likely to turn to positive IOD conditions during the later part of the monsoon season.

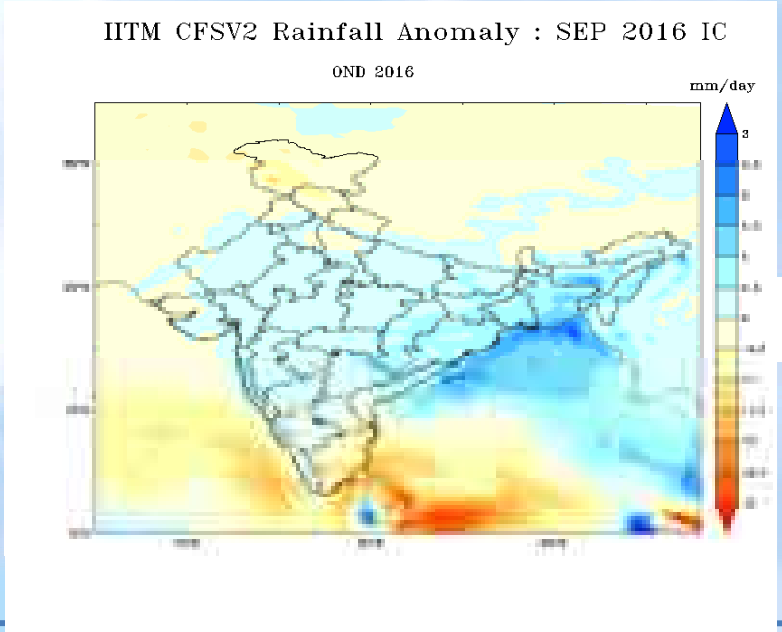
Products based on CFS: LRF Maps

Global SST Ano. Forecast



South Asia 2m Temp. Ano. Forecast

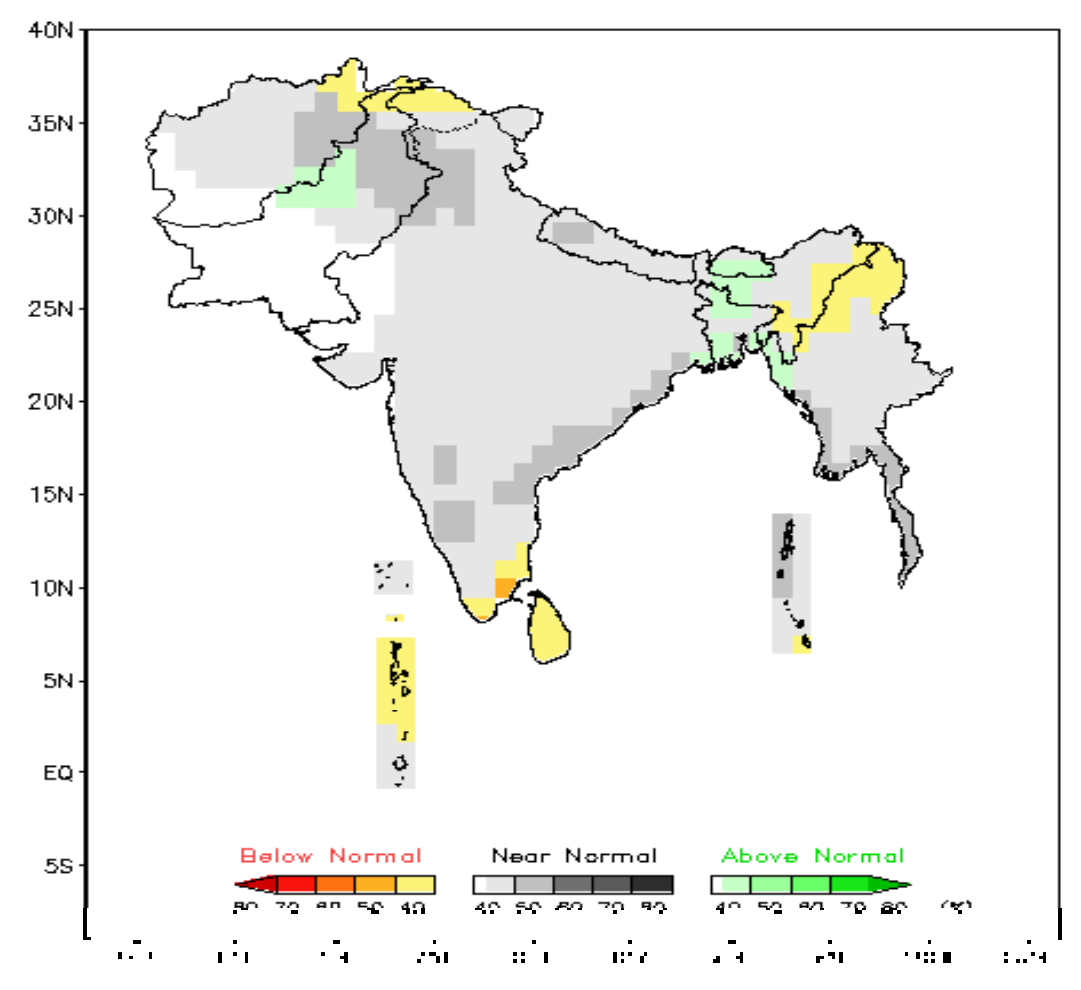




India Rainfall Ano. Forecast

Consensus Forecast Map: 2016 Northeast Monsoon Season (OND)

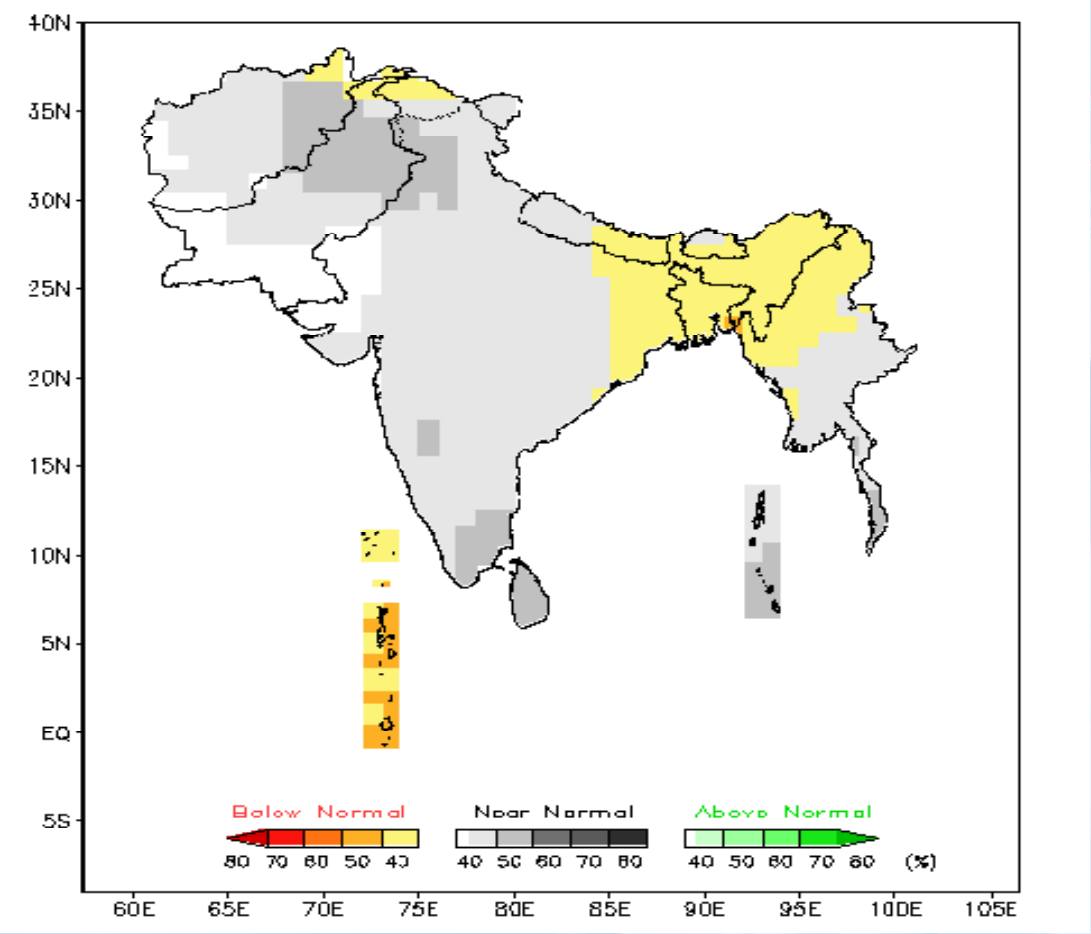
OND



Normal rainfall is most likely over most parts of south Asia during the 2016 Northeast monsoon season (October – December). However, below normal rainfall is likely over some areas of southeast peninsular India, Sri Lanka and Maldives. Below normal rainfall is also likely over some areas of north and eastern parts of the region. Above normal rainfall is likely over western and northwestern parts of Pakistan and some northeastern parts of the region.

During the season, normal to slightly above normal temperatures are likely, over most parts of the region.

Consensus outlook for DJF 2016/2017 over South Asia



Below normal precipitation is likely during the Winter Season (December 2016 to February 2017) over northern most parts of the south Asia, Maldives & neighboring Lakshadweep, and northeastern parts of South Asia including northeast India, east Nepal, Bhutan, and northern parts of Myanmar. Normal precipitation is likely over the remaining parts of the region.

During the season, normal to above normal temperatures are likely, over most parts of the region.

Beijing Climate Center (BCC)

Beijing Climate Center

FOCRAII 2017 Successfully Convened

Tokyo Climate Center (TCC)

WMO Lead Center for LRFMME

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

List of GPCs : system configuration information

	Beijing (BCC)	CPTEC (CPTEC)	ECMWF (ECMWF)	EXETER (EXETER)	Melbourne (POAMA)	Montreal (MSC)	Moscow (HMC)	Pretoria (SAWS)	Seoul (GDAPS)	Tokyo (TCC)	Toulouse (Toulouse)	Washington (NCEP)
Model Res.	T63/L16	T62/L28	T255/L91	0.83ºl x 0.56º /L85	T47L17	T63	1.125ºx 1.40625º /L28	T42/L19	T106/L21	1.875º x1.875º /L40	T63L91	T126/L64
Forecast												
Forecasting range	5 months	6 months	6 months	5 months	8 months	11 months	3 months	4 months	5 months	6 months	6 months	8 months
Data	Mean, Climate	Mean, Climate	Anomaly	Mean	Mean, Anomaly	Mean, Climate	Mean	Anomaly	Mean, Climate	Mean, Anomaly	Mean, Anomaly	Anomaly
Members	48	15	41	42	30	20 (2model x 10)	20	6	20	51	41	40
Hindcast												
Hindcast Period	1983~2004	1979~2001	1981~2010	1996-2009	1960~2010	1981~2010	1981~2010	1981~2001	1979~2012	1979~2010	1979~2007	1981~2010
Data	O	O	X	O	O	O	O	X	O	O	X	O
Members	48	10	15	12	10	20 (2model x 10)	10	6	20	10	11	20

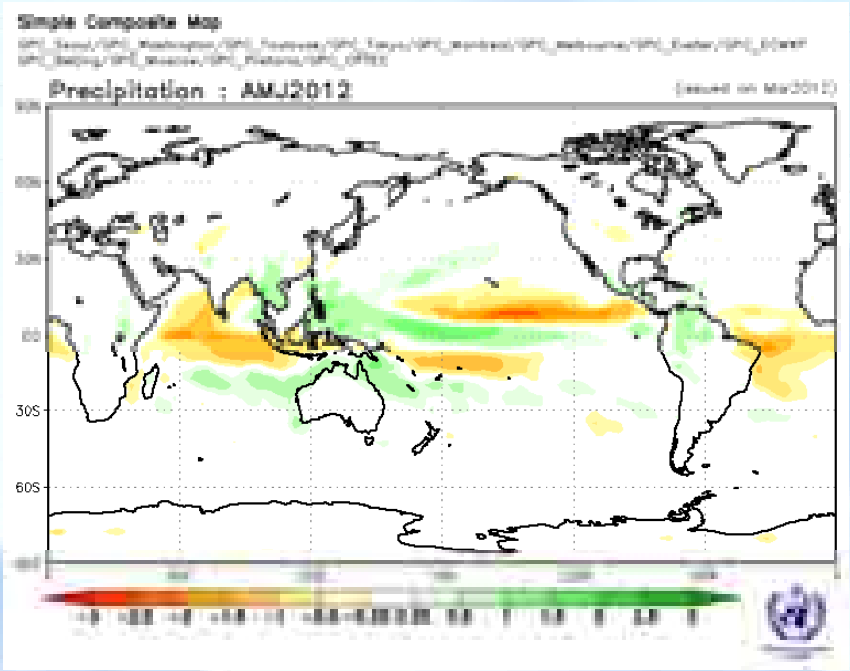
- Variable: T2m, SST, PREC, MSLP, T850, Z500
- Resolution: 2.5^{o} x 2.5^{o} (144 x73 grids)

: 2-Tier GCM

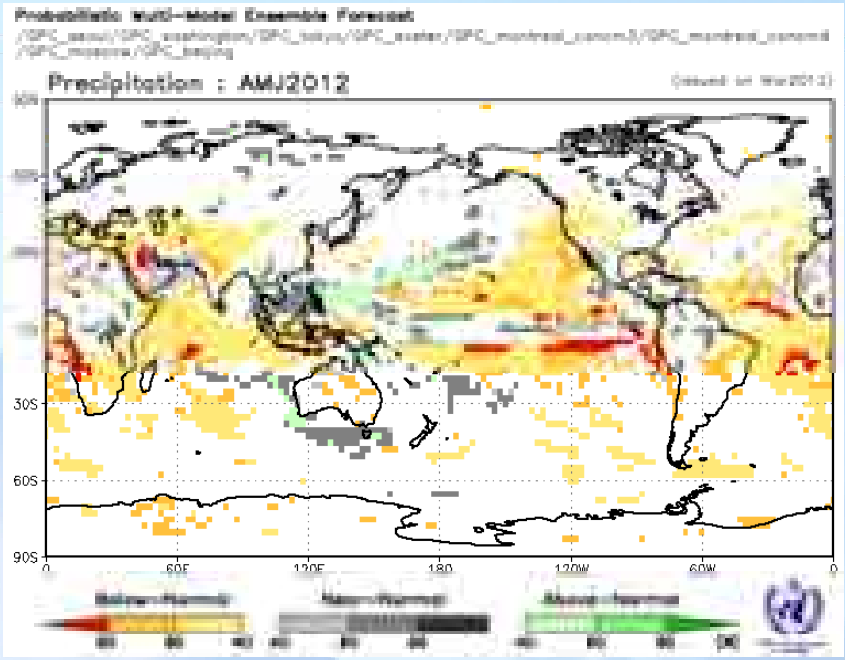
: 1-Tier GCM (coupled)

Graphical products WMOLRF-MME

Deterministic MME



Probabilistic MME



Seasonal Forecast : IRI

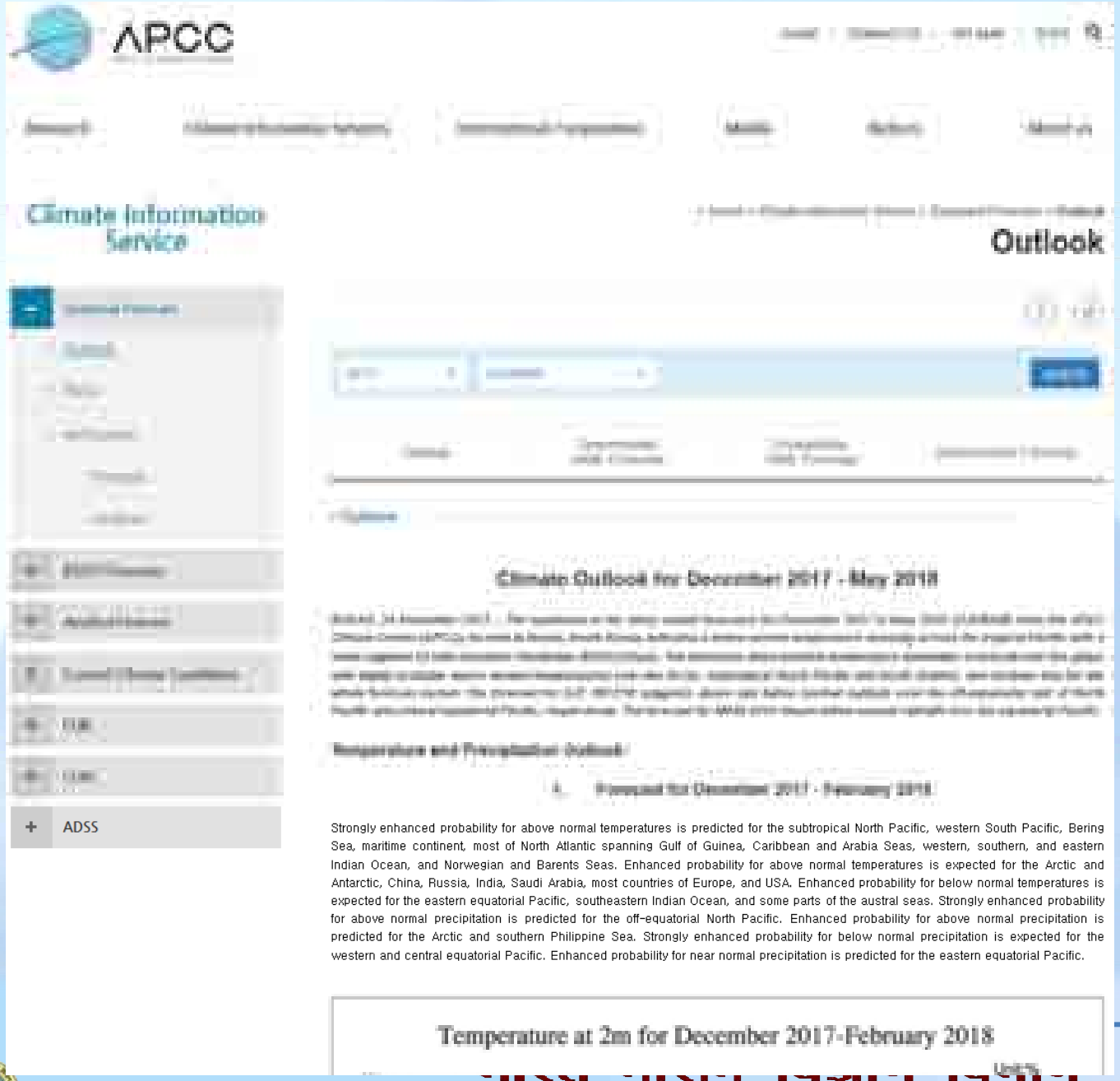
Seasonal Forecast

Precipitation

Temperature

Global & Regional

APEC Climate Center : Seasonal Forecast



Seasonal Forecast

Precipitation

Temperature

Global & Regional

Decision-making across timescales

- Begin planning and monitoring of forecasts
- Update contingency plans
- Sensitize communities
- Enable early-warning systems

- Continue monitoring
- Adjust plans
- Warn communities
- Local preparation activities

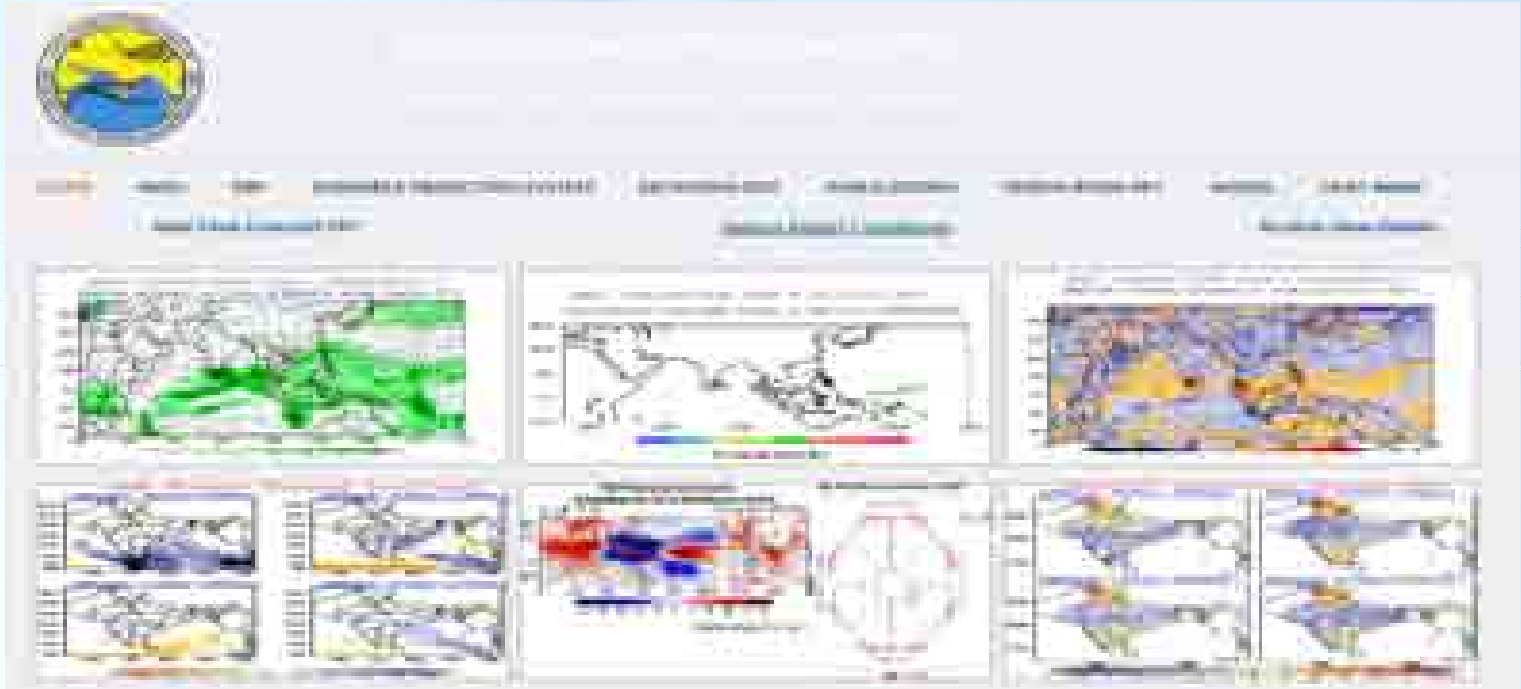
- Activate response
- Instruction to communities to evacuate, if needed

Prediction systems for other time scales

Extended range dynamical forecasting systems (four weeks)

Short range dynamical systems (5 days)

Extended Range Prediction IITM



Forecast for:
Rainfall

Temperature

Wind

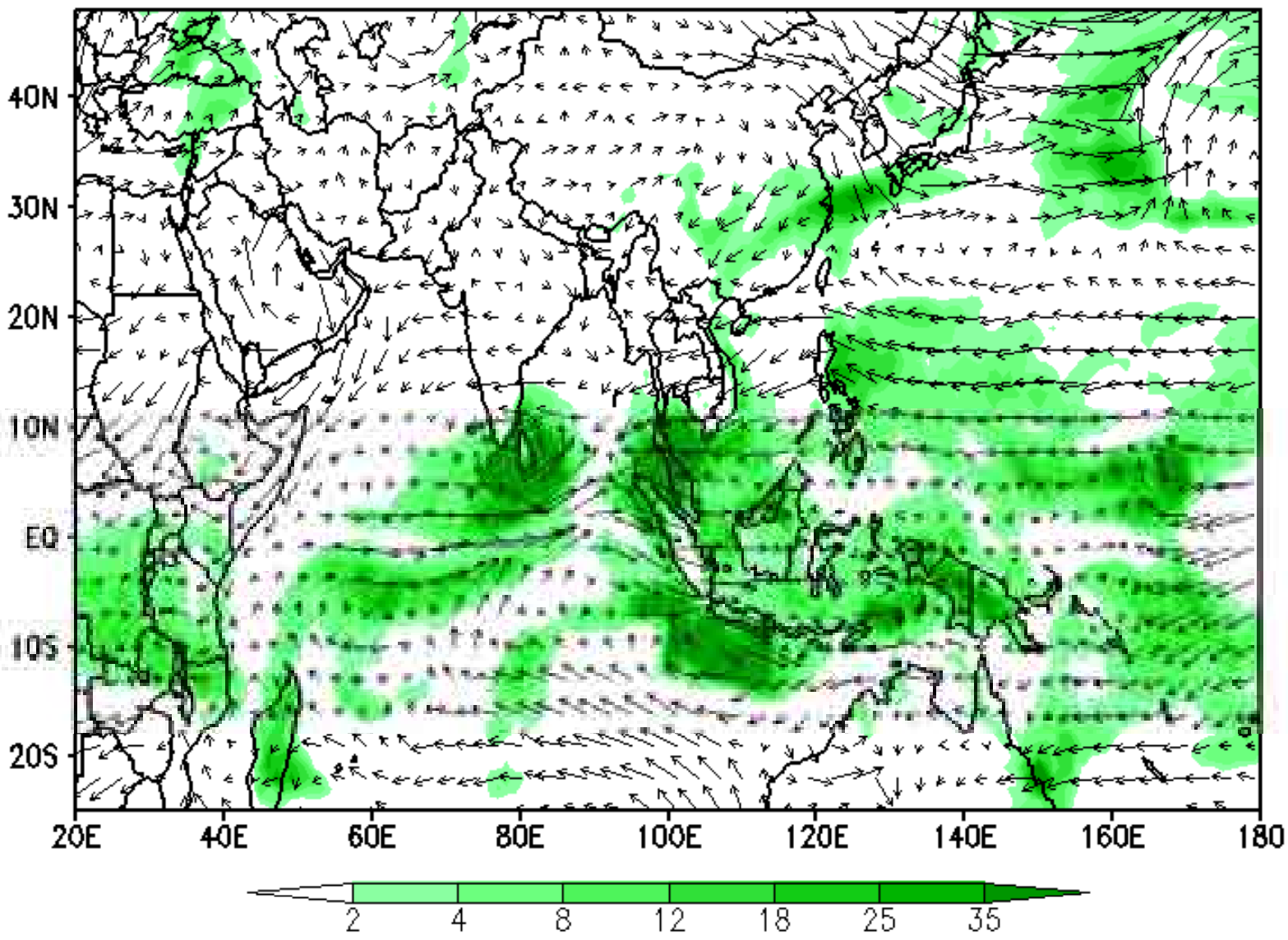
Soil Moisture

Cyclogenesis Potential
MJO

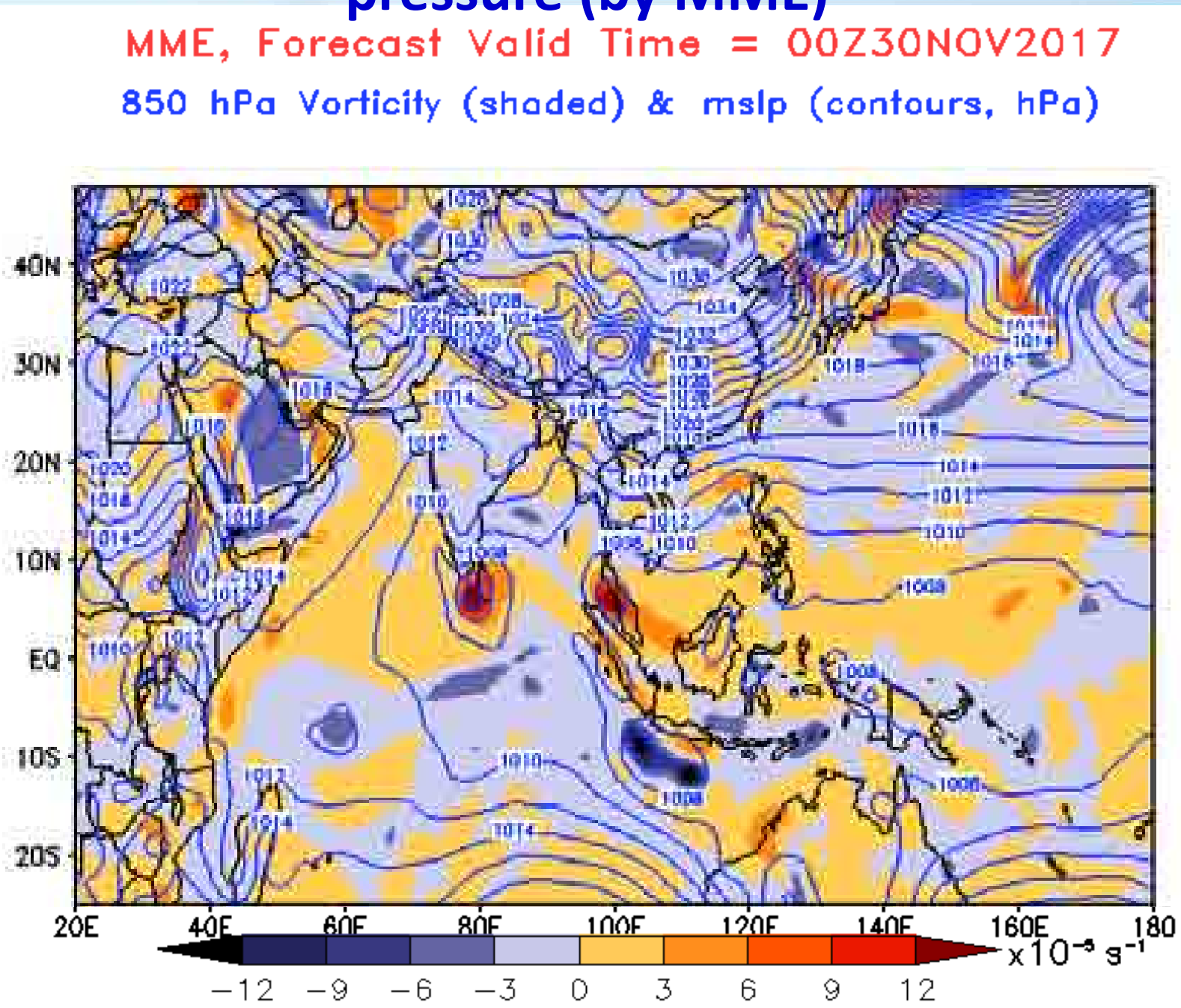
Extended Range Prediction IMD

Forecast for:
Rainfall
Temperature
Wind

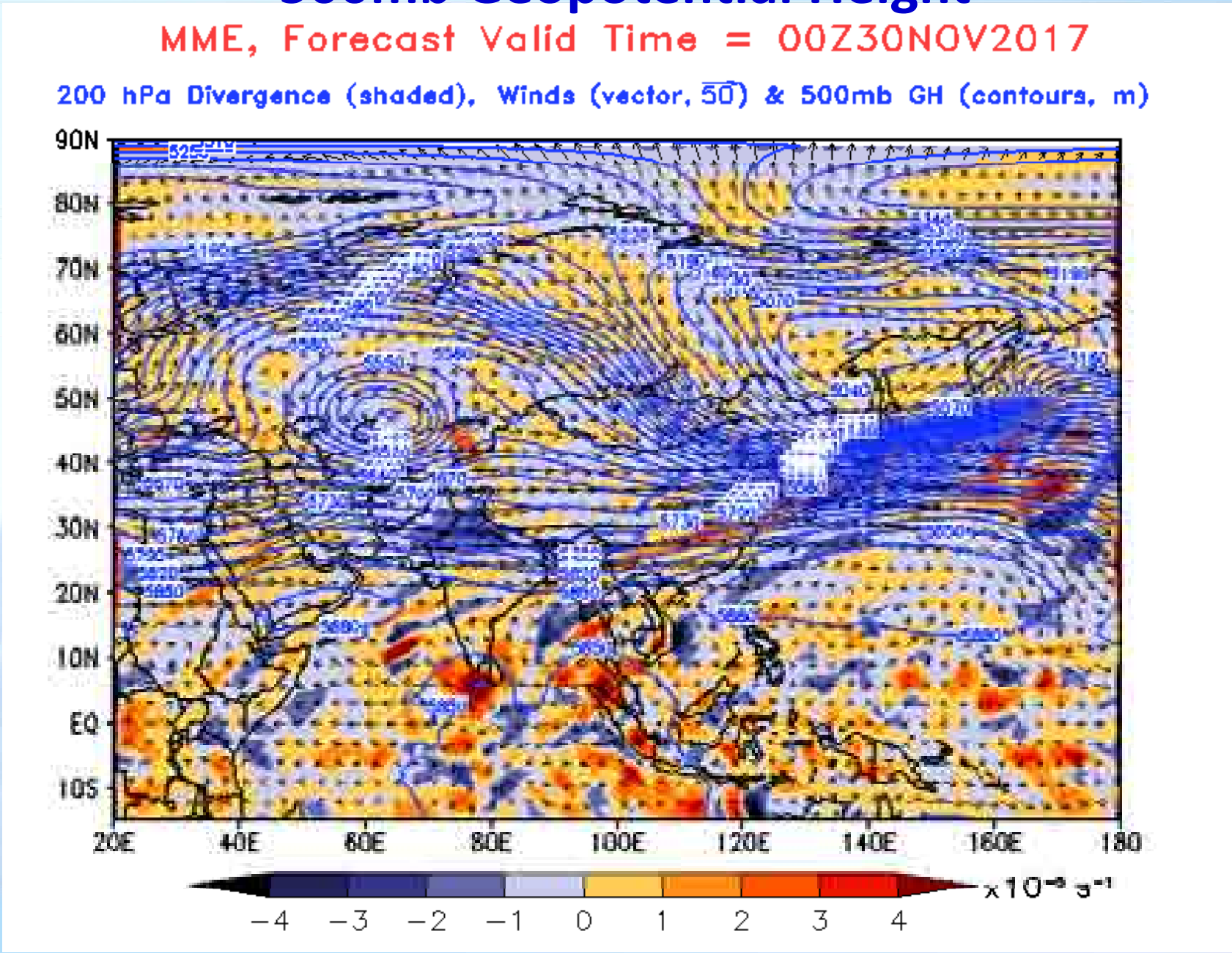
Daily evolution of rainfall and wind at 850hPa (by MME)



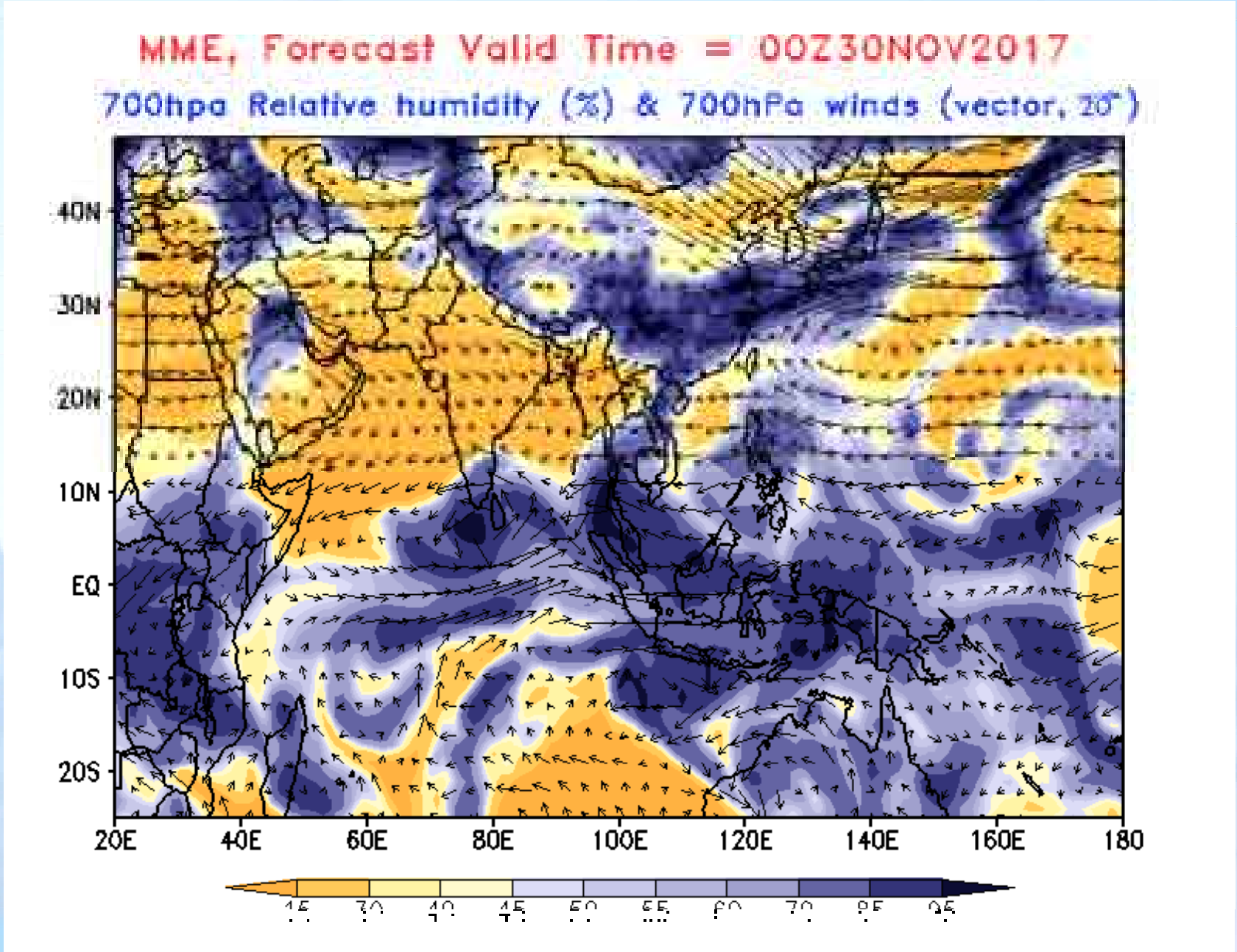
Daily evolution of vorticity at 850hPa and mean sea level pressure (by MME)



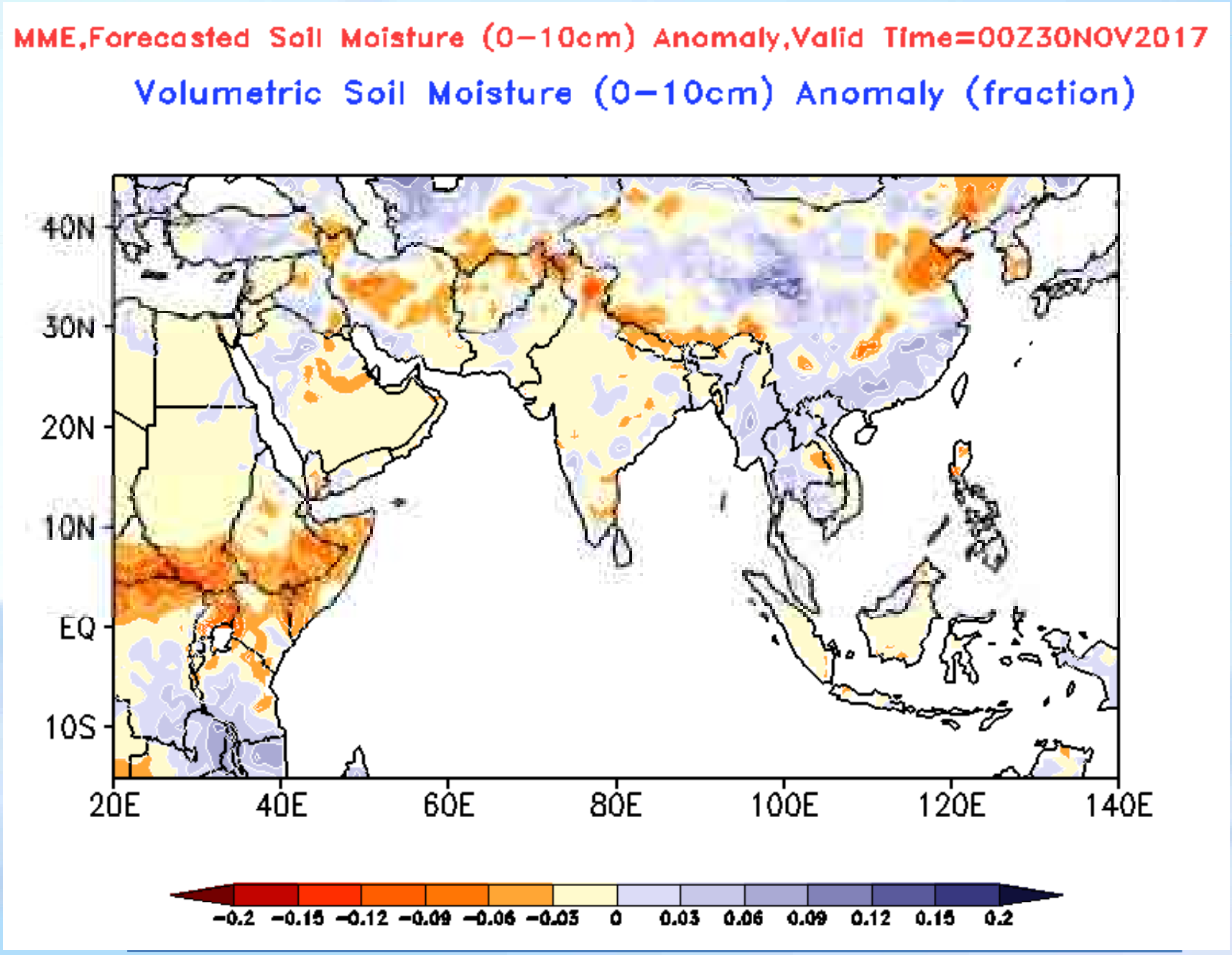
Daily evolution of divergence and winds at 200hPa and 500mb Geopotential Height



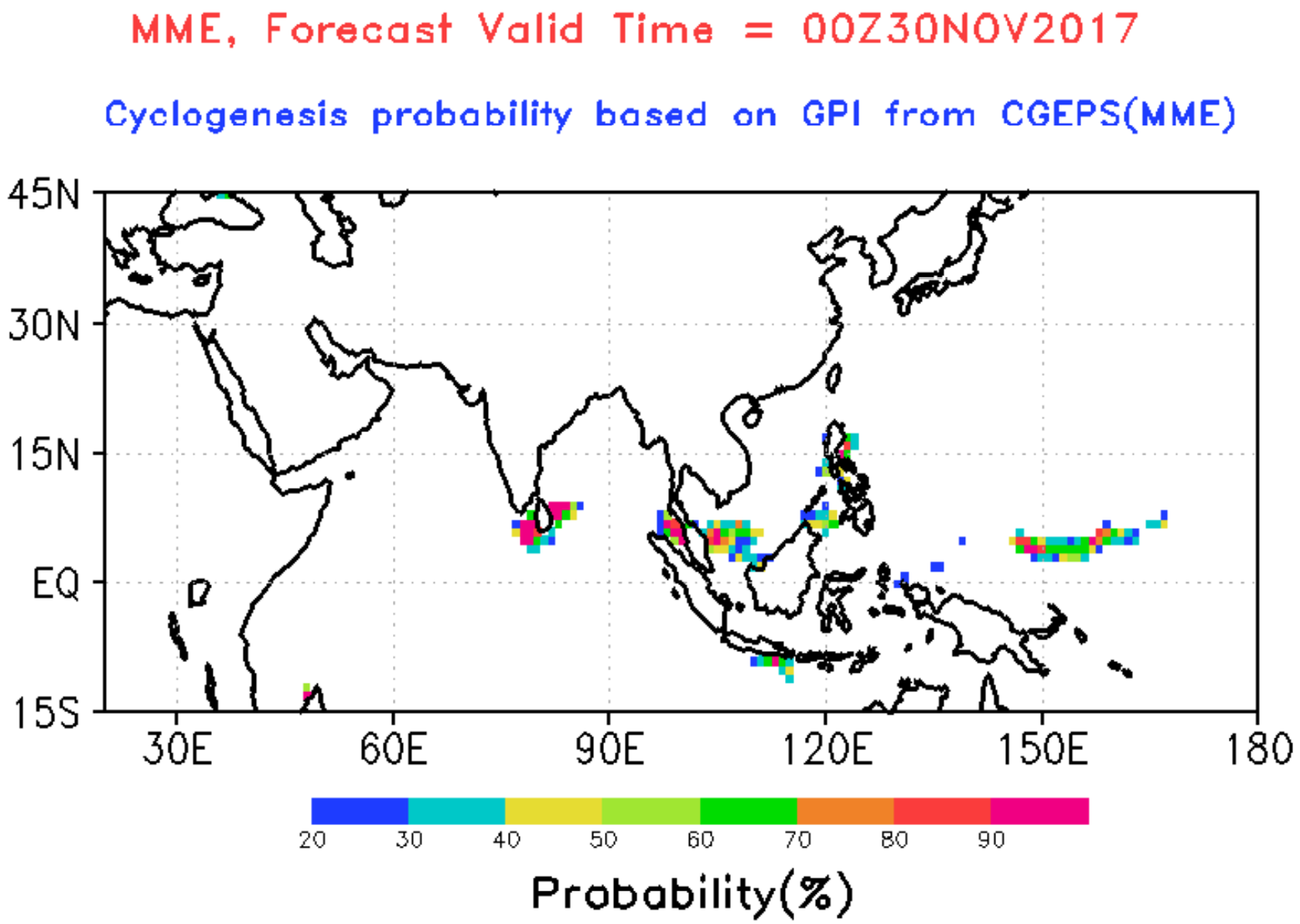
Daily evolution of RH and winds at 700hPa (by MME)



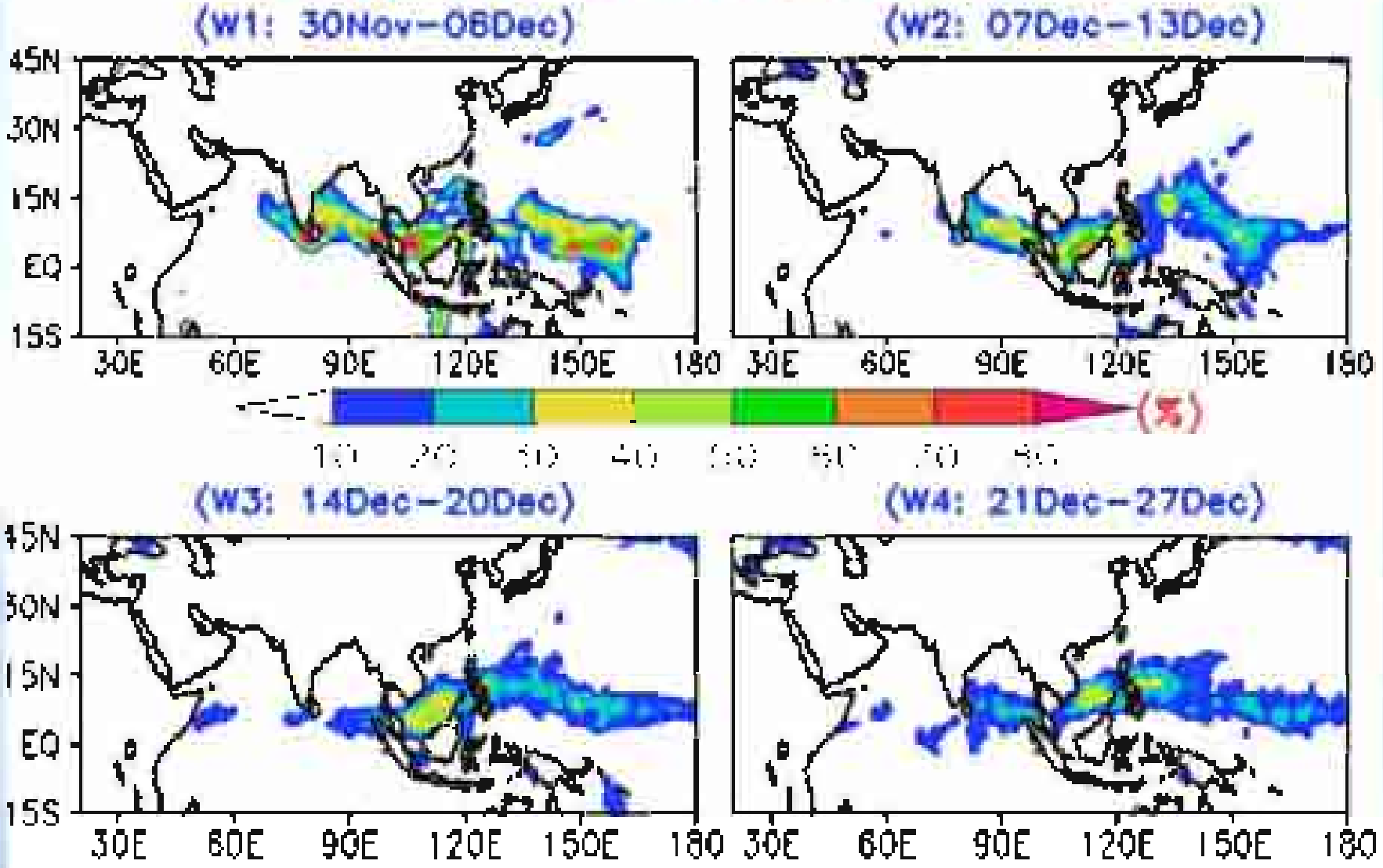
aily evolution of Soil Moisture (top 10cm) Anomaly (by MME



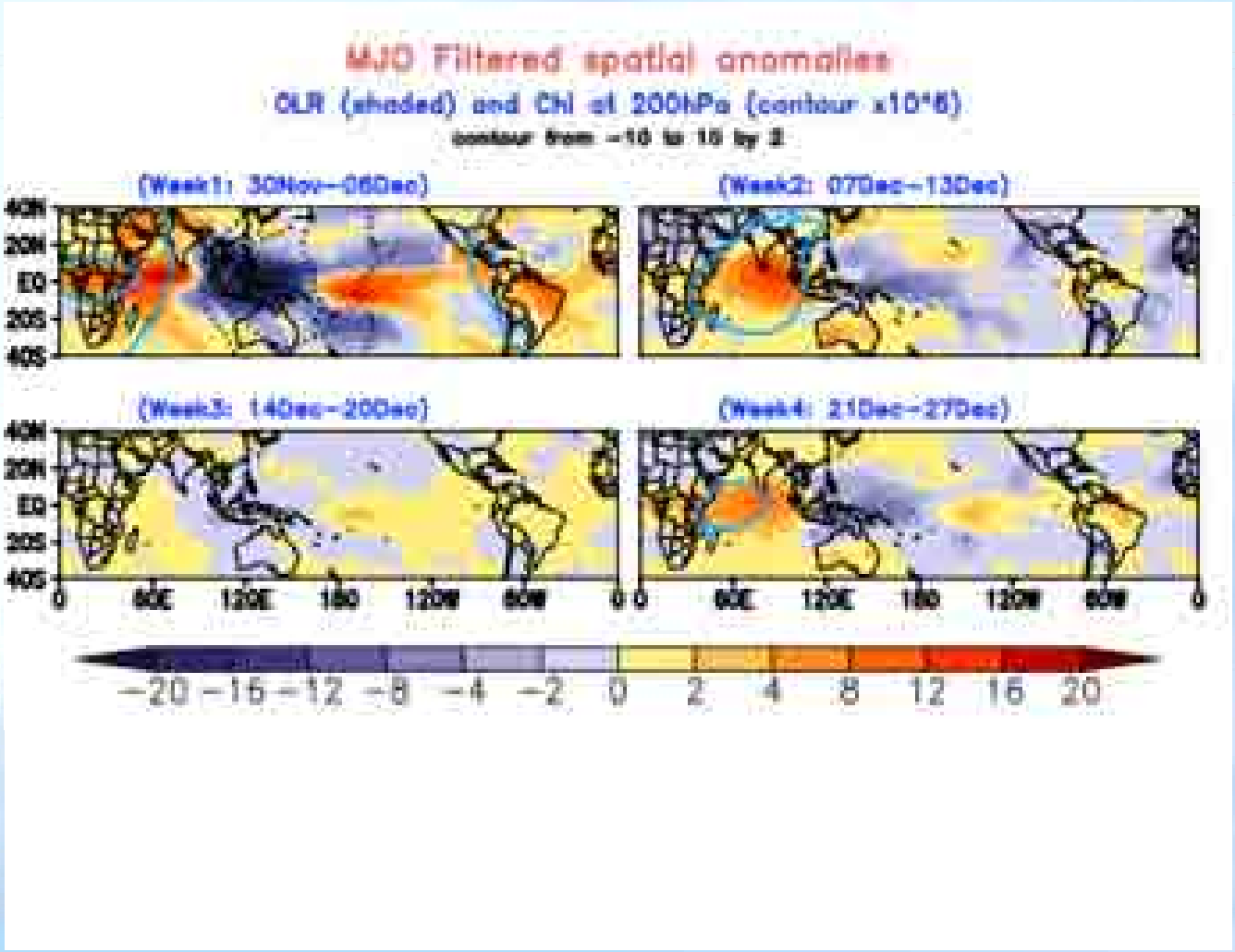
Forecast of Cyclogenesis probability based on GPI from

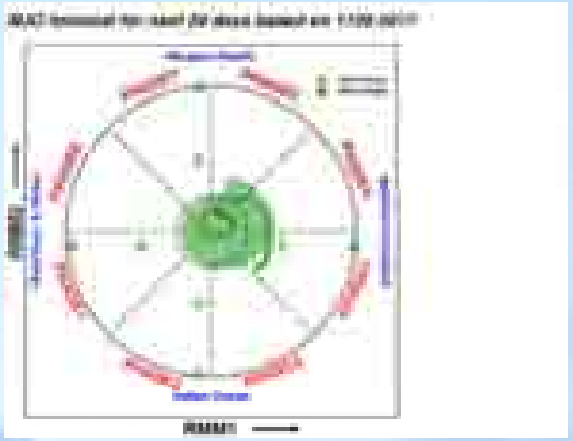


Cyclogenesis Probability (%) from MME



MJO Forecast

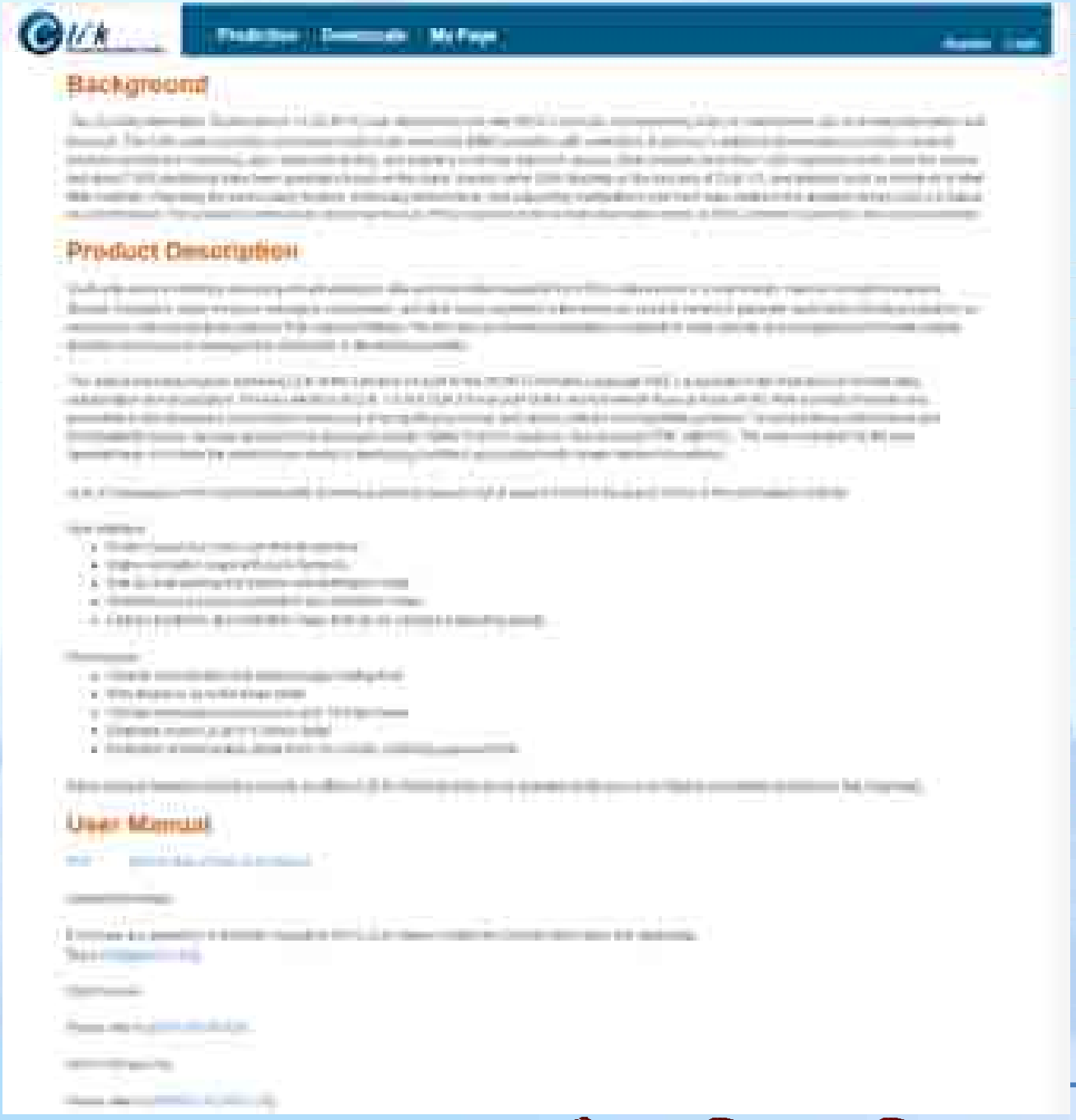




Climate Data Library: IRI

Climate Explorer: KNMI

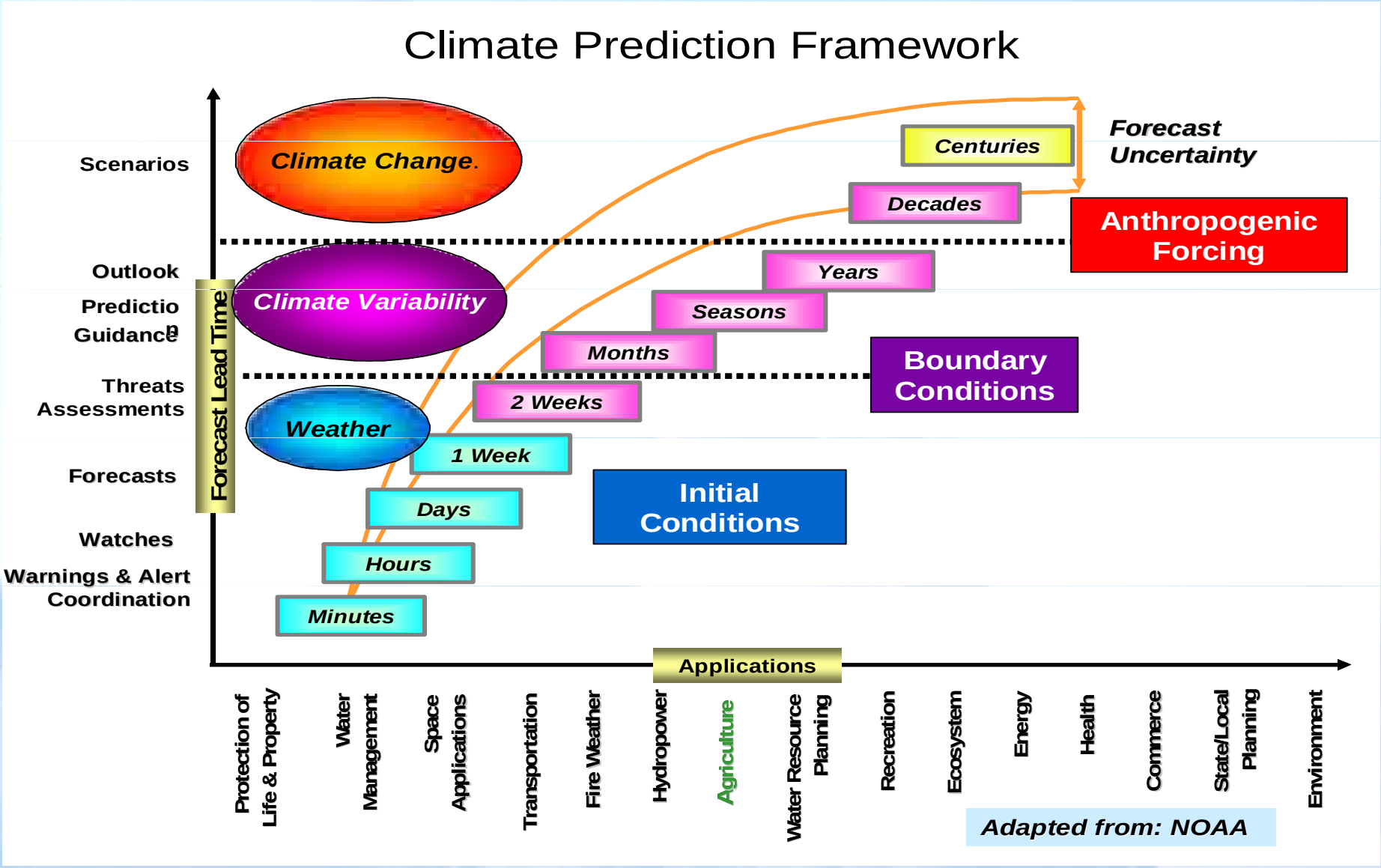
APEC Climate Centre: CLIK



Climate Predictability Tool (IRI): CPT

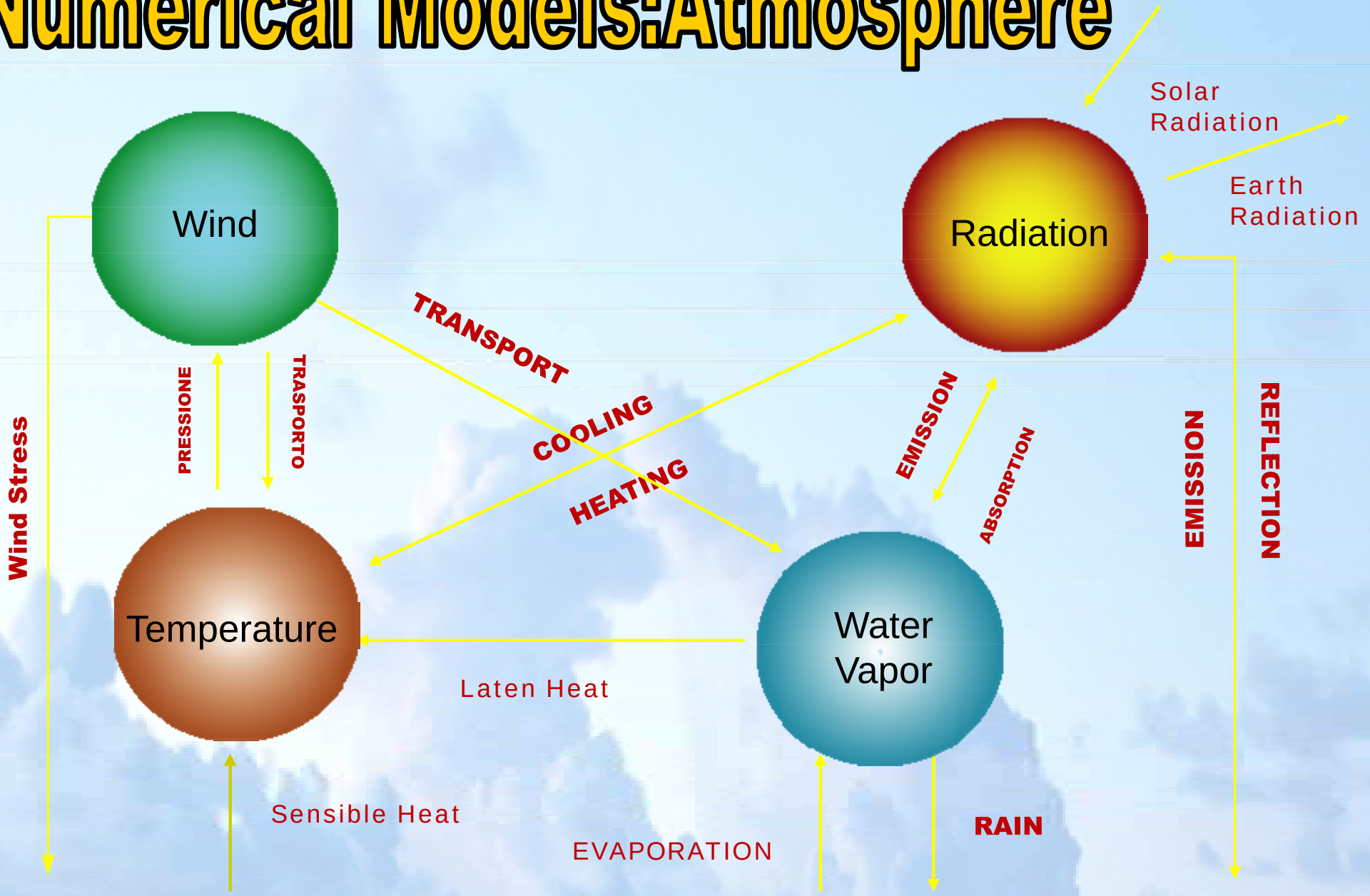
Thank You All

What are key elements to Climate Sevices?

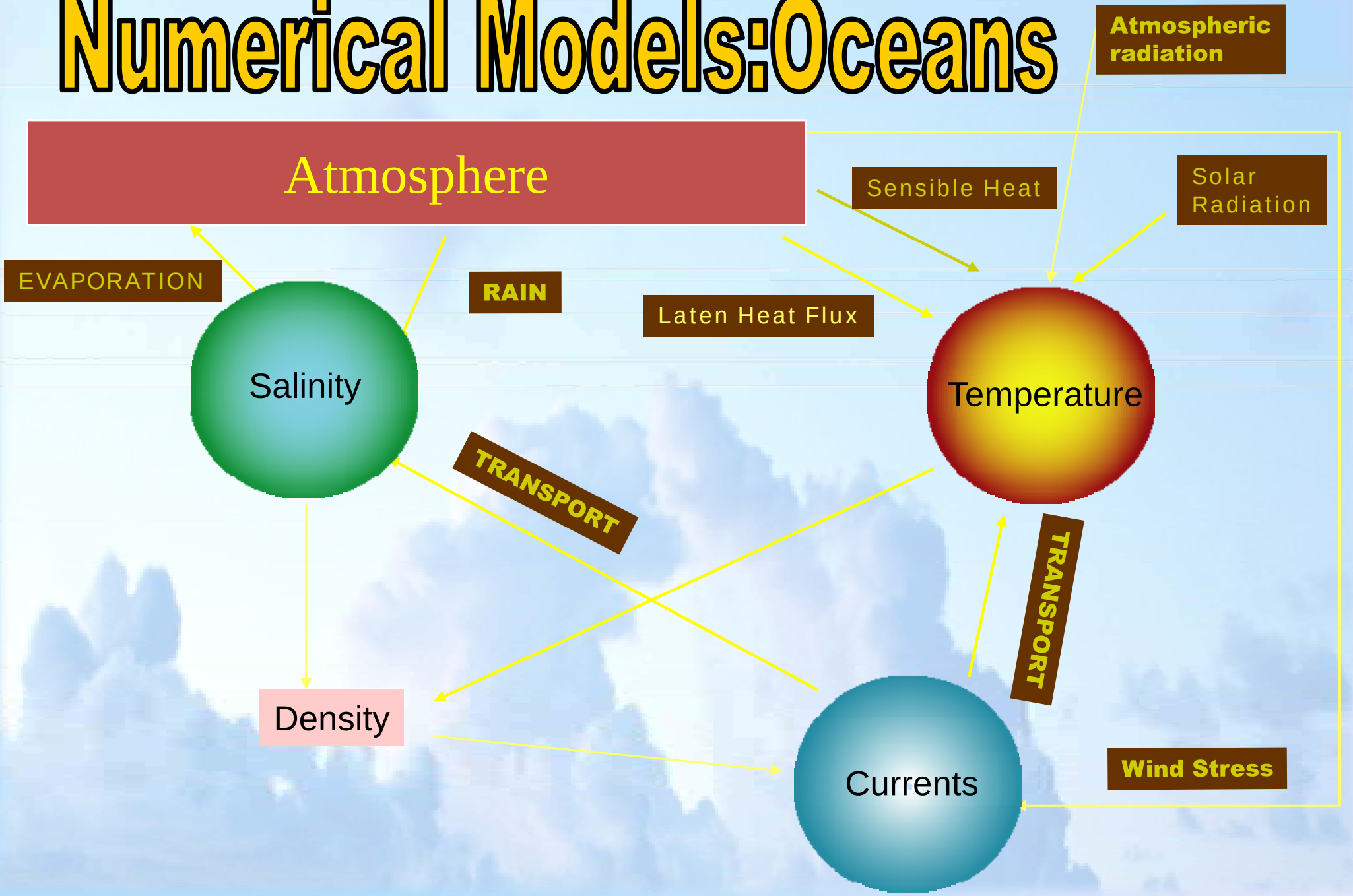


Seamless climate services

Numerical Models:Atmosphere



Numerical Models:Oceans



Numerical Models:Coupling

Atmosphere

Wind Stress

Precipitation

Solar Radiation

Atmospheric Radiation

Air Temperature

Surface Temperature

COUPLER:
(1) Interpolate from the atmospheric grid to the ocean grid and viceversa.
(2) Compute fluxes

Wind Stress

Fresh Water Flux

Sensible Heat Flux

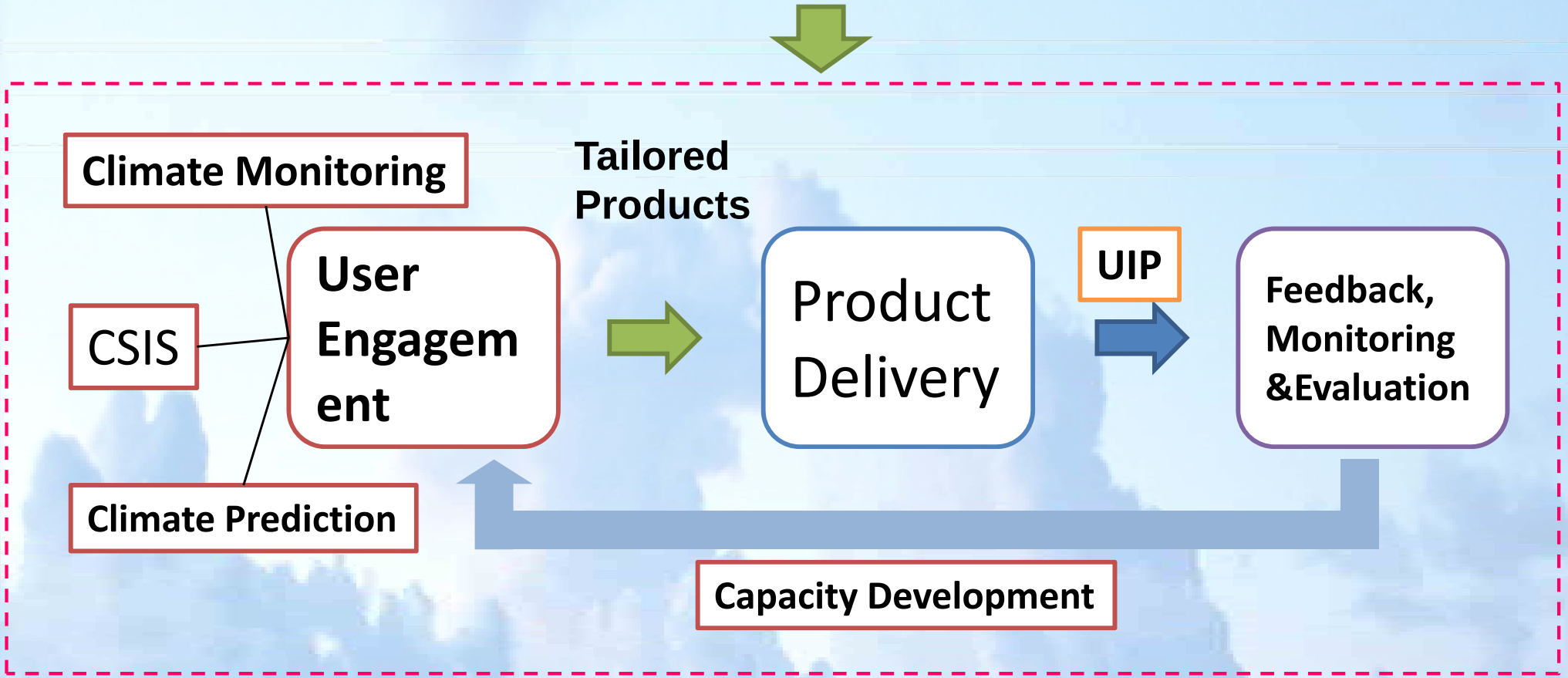
Latent Heat Flux

Sea Surface Temperature

Oceans -- Sea Ice

Method to Transfer from Climate to Sevices

Understanding the benefits of climate services



Process of developing climate services

Services are developed through ongoing engagement between providers and users.

Dynamical Predictions (Tier-2 or Tier-1?)

- **Tier-Two Models: Atmospheric General Circulation Models**
  - **Integration with prescribed SST boundary conditions**
  - **Atmospheric Initial Conditions**
- **Tier-One Models: Coupled Ocean-Land-Atmosphere Models**