Technical aspects of RCC Operations: Overview of Mandatory and Highly Recommended Functions and Related Aspects: Long Range Forecasting

WMO INTERNATIONAL WORKSHOP ON GLOBAL
REVIEW OF REGIONAL CLIMATE CENTRE OPERATIONS
12-14 November 2018
Pune, India

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भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Background: WMO Centers of Long Range Forecasting: GPC-LRFs, LCs, RCCs

At present, there is a three-tier arrangement under WMO operational infrastructure for generating long-range forecasting:

Global Level:

- **Global Producing Centres for Long-Range Forecasts (GPC-LRFs) responsible for producing and disseminating long-range forecasts and associated verification with global coverage;**

A Lead Centre (LC) for Long-Range Forecast Multi-Model Ensembles (LC-LRFMME): responsible for collecting GPC forecasts, displaying the forecast information, generating multi-model products, and more recently generating verification information for GPC-LRFs delegating score computation to the LC

A Lead Centre for Standardised Verification of Long-Range Forecasts (LC-SVSLRF): responsible for providing documentation on verification scores, software and datasets for long-range forecast verification

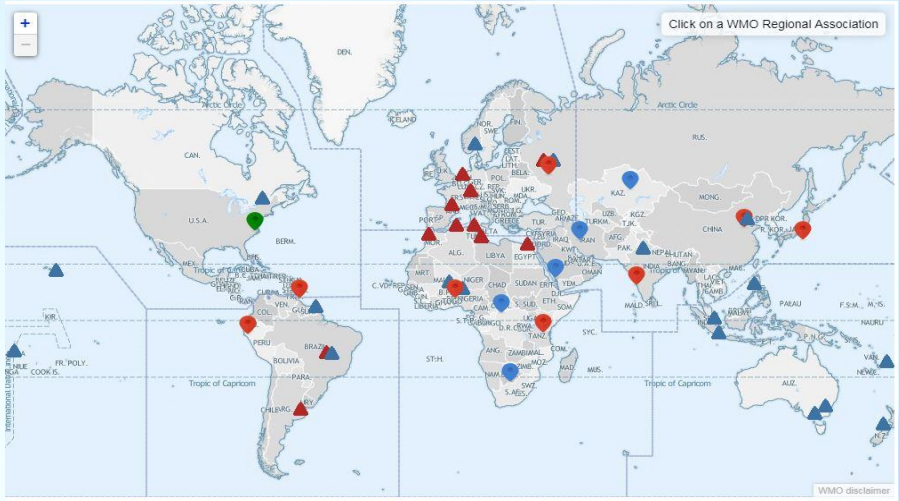
Regional Level:

- **Regional Climate Centres (RCCs) and RCC Networks. RCCs also plays lead role in the co-ordination of the Regional Climate Outlook Forums (RCOFs).**

National Level:

- **National Met. and Hydrological Serv. (NMHSs) has the central role which includes coordination National Climate Outlook Forums (NCOFs)**

Regional Climate Centres (RCCs)



http://www.wmo.int/pages/prog/wcp/wcasp/rcc/rcc.php

designated RCC | RCC in demonstration phase | RCC proposed
designated RCC-Network | RCC-Network in demonstation phase | RCC-Network proposed

- **ET-RCC -**
  - Establish global standards for mandatory RCC products and services and their delivery, as well as standards for verifying forecasts and reporting of results; monitor performance of RCCs and propose improvements as required;
  - Promote the use of GPC and RCC forecast products at regional and national levels and development of consensus-based forecasts, especially through mechanisms such as RCOFs;

- **RCCs provide regional climate products in support of regional and national climate activities**
- **Mandatory Functions:**
- **Conduct operational activities for long-range forecasting, both dynamical and statistical, within the range of a one-month to two-year timescale, based on regional needs:**
  - **Operational Activities for Climate Monitoring**
  - **Operational Data Services, to support operational LRF and climate monitoring**
  - **Training in the use of operational RCC products and services**
- **Highly Recommended Functions:**
  - **Climate prediction and projection**
  - **Non-operational data services**
  - **Coordination functions**
  - **Training and capacity building**
  - **Research and development**
- **Two modes of Implementation: fully self-contained RCCs or distributed-function RCC-Networks**

RCC Mandatory LRF Functions

Activities	Criteria
Interpret and assess relevant LRF products from GPCs, make use of the Lead Centre(s) for SVSLRF, distribute relevant information to RCC users, and provide feedback to GPCs (see Attachment 2.2.2)	Product: Assessment of the reliability and outcomes of GPCs or Lead Centre(s) for LRFMME products, including the reasoning (make use of the Lead Centre(s) for SVSLRF), for the region of interest, in the form of texts, tables, figures, etc. Element: 2-m mean temperature, total precipitation Update frequency: Monthly or at least quarterly

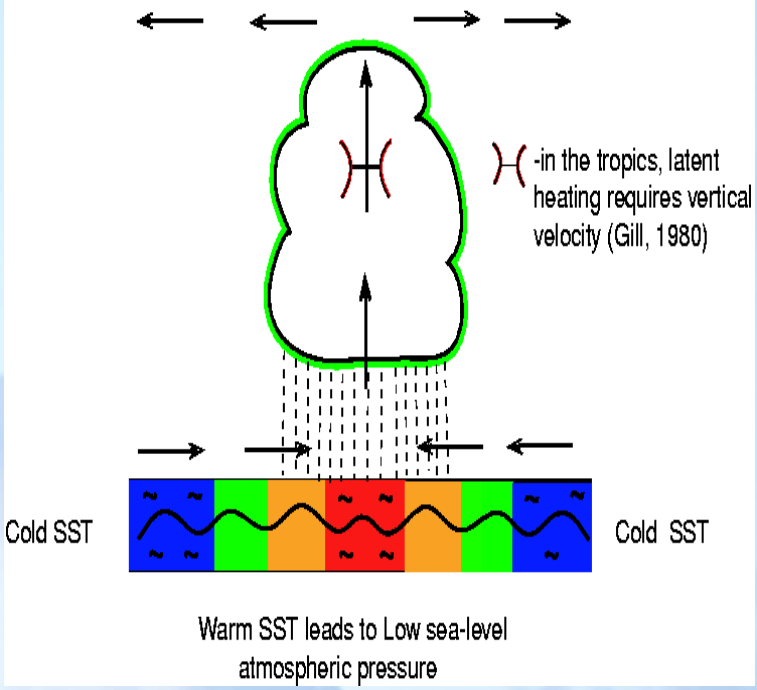
Important points

- There are some issues related to predictability (lack of predictability over large areas of the globe).
- Model predictabilities are very low for smaller countries and smaller time scales.
- More research is needed on predictability
- RCCs have been established to address specific regional needs and may require particular kinds of information and procedures. Excessive standardization should be avoided as it may affect mechanisms of cooperation among RCCs, NMHSs and users. Therefore, the delivery of products and services should be according to the regional context.
- There is a need for good communication between RCCs and NMHSs to avoid conflicts of information.

Potential Seasonal Predictability
(The upper limit of forecast skill)

- The seasonal to interannual variations are caused by the internal dynamical process of the coupled climate system. They are;
  - the fast atmospheric variations associated with the day to day weather; (climate noise)
  - slowly varying changes in sea surface temperature (SST), soil wetness, snow cover and sea ice at the earth's surface. The later acts as slowly varying boundary conditions for the fast weather variations. (climate signal)
- The evolution of slowly varying boundary forcings is often predictable. This gives a slow memory to the mean atmosphere; the evolution of the latter becoming partly predictable.
- Thus if it were possible to predict the boundary conditions themselves, it would be possible to predict the atmospheric circulation and rainfall.

SST influence on Tropical atmosphere



Potential predictability = $R = \frac{V(x_s)}{V(x)}$

$V(x_s)$: variance of signal

$V(x_n)$: variance of noise

Modifications of **boundary conditions** (SST, Land surface) can influence weather characteristics (amplitude of an event, its persistence etc.,)

Thus the characteristics of the season

Some issues Related to conducting of Mandatory Functions:
Potential Seasonal Predictability

The fraction of predictable variance of precipitation

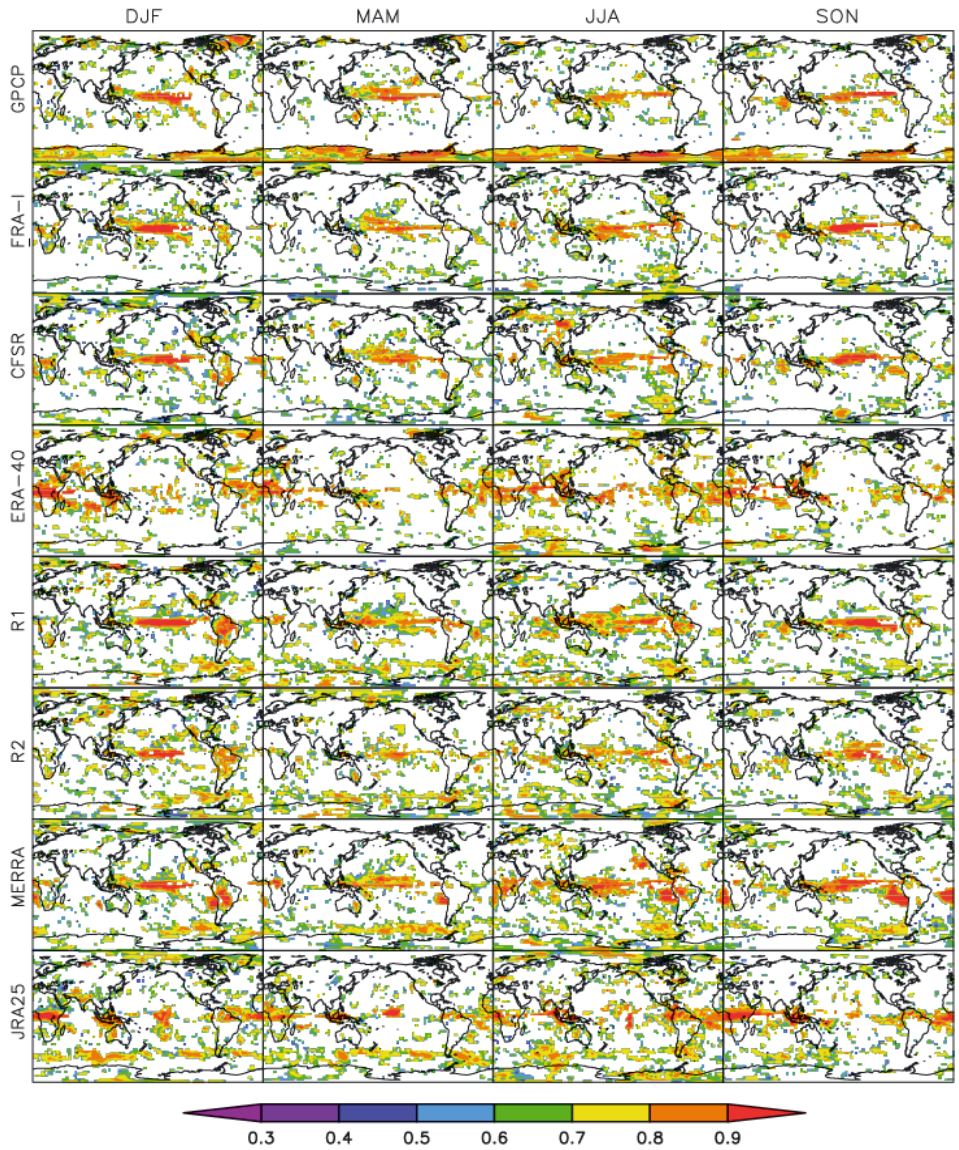


Figure 1. The fraction of predictable variance of precipitation estimated from GPCP, ERA-I, CFSR, ERA-40, R1, R2, MERRA and JRA25 in DJF, MAM, JJA and SON (left to right) over 1979 to 2012. The regions in which null hypothesis of no potential predictability is insignificant at the 5% level are masked out.

Xia Feng* and Paul Houser

ATMOSPHERIC SCIENCE LETTERS
Atmos. Sci. Let. **15**: 266–274 (2014)

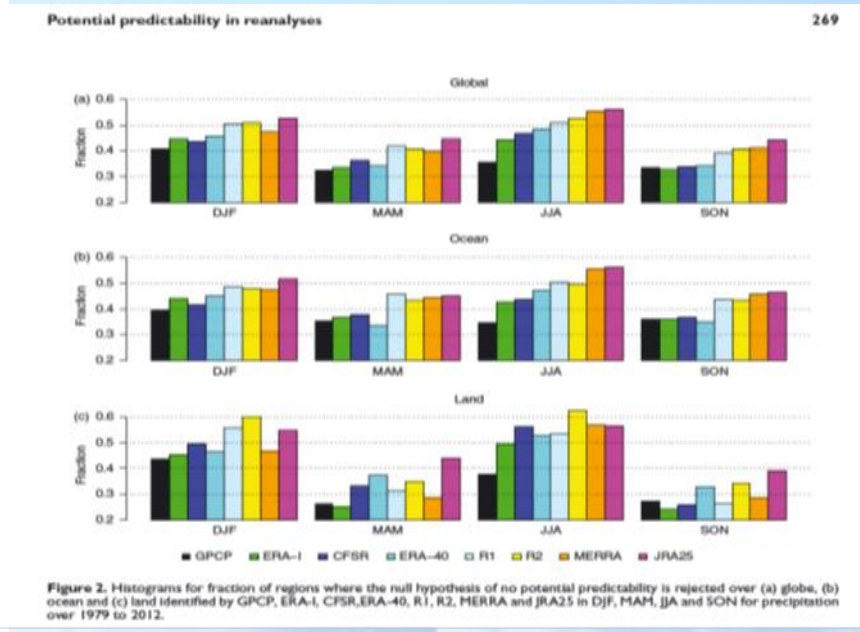
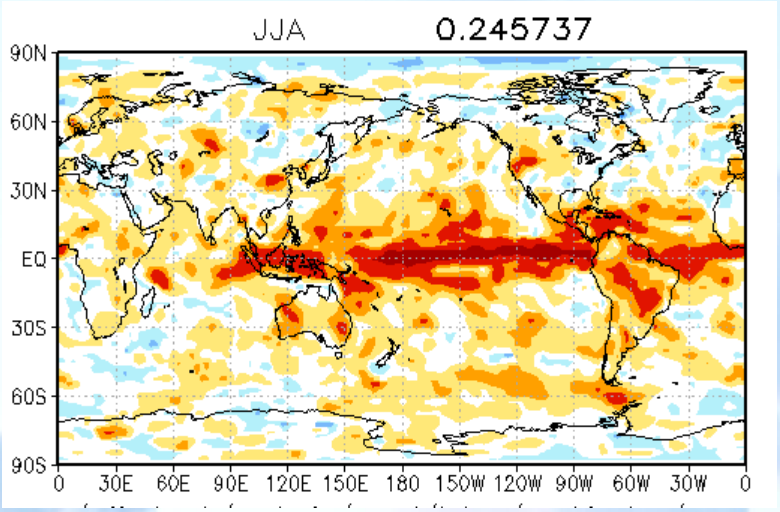
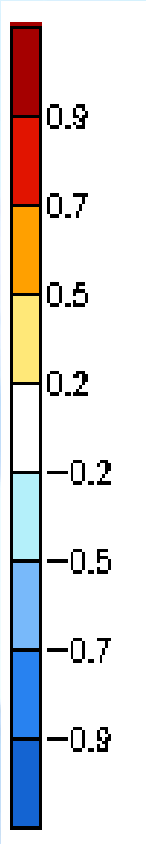


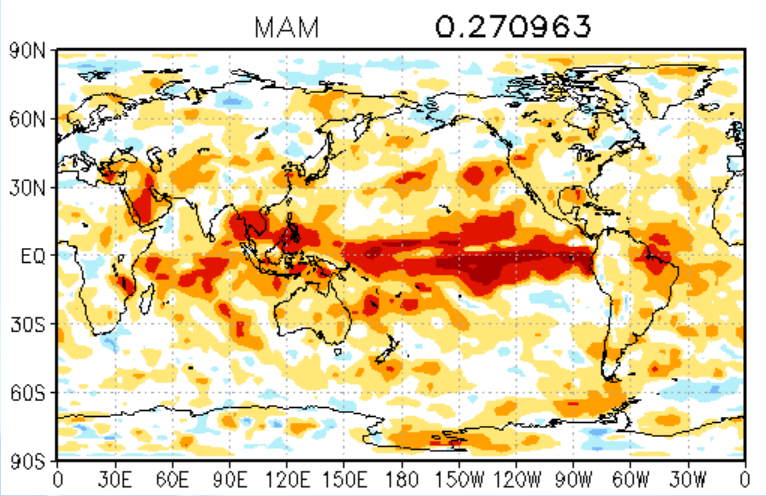
Figure 2. Histograms for fraction of regions where the null hypothesis of no potential predictability is rejected over (a) globe, (b) ocean and (c) land identified by GPCP, ERA-I, CFSR,ERA-40, R1, R2, MERRA and JRA25 in DJF, MAM, JJA and SON for precipitation over 1979 to 2012.

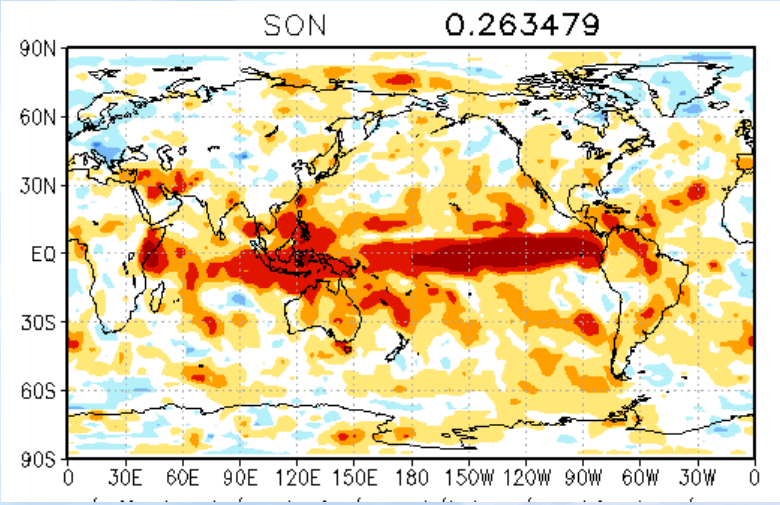
- Potential predictability is greatest in the tropics, smallest in the extra-tropics, and undergoes a strong seasonal variation.
- Predictability is higher in DJF and JJA than in MAM and SON, and more persistent over ocean than over land.

LRF MME Skill (ACC) of Deterministic Precipitation Forecast: Source (LC- LRF MME)









Areas of higher ACC values nearly coincides with the areas of potential predictability

Performance of Dynamical Model for forecasting ISMR over the country as a whole at '0' lead time

Model	Hindcast period	Forecast Period	Forecast Season	CC Between Actual & forecast/ Hindcast	RMSE (% of LPA of model hindcast)
GPC Beijing	1983-2007	2008-2012	JJA	-0.17	11.78
			JAS	0.22	8.19
GPC Melbourne	1981-2006	2009-2012	JJA	0.25	9.82
			JAS	0.19	9.23
GPC Moscow	1979-2004	2008-2012	JJA	-0.34	12.19
			JAS	-0.10	9.95
GPC Seoul	1981-2007	2008-2012	JJA	-0.11	10.05
			JAS	-0.19	8.97
GPC Tokyo	1979-2008	2010-2012	JJA	0.28	9.54
			JAS	0.28	7.66
GPC Washington	1981-2003	2008-2012	JJA	0.16	9.70
			JAS	0.10	7.84
NCEP CFS-2	1982 - 2010	2011-2012	JJAS	0.49	7.40

Forecasts from 6 Global Producing Centers (GPCs) of LRF for the two 3 month periods (JJA & JAS) and that from NCEP CFS-2 for the JJAS were used. GPCs generally produce forecast at moving 3 months periods. Forecasts at '0' lead time are considered.

Skill (C.C) for the Prediction of JJAS all India Rainfall

IC pertaining to the month of	IMD Monsoon Mission CFS Model Skill (C.C)				
	June	July	August	Sept.	JJAS
Jan	-0.02	0.25	0.21	0.29	0.33
Feb	0.05	0.44	0.11	0.19	0.46
Mar	0.12	0.54	0.14	0.61	0.45
Apr	0.06	0.27	0.04	0.29	0.35
May	0.43	0.17	-0.27	0.35	0.23

IC pertaining to the month of	NCEP CFSv2 Model Skill (C.C)				
	June	July	August	Sept.	JJAS
Jan	0.15	0.24	0.03	0.53	0.29
Feb	-0.1	0.38	0.1	0.35	0.41
Mar	0.24	0.43	0.14	0.53	0.51
Apr	-0.07	0.39	0.18	0.43	0.32
May	0.17	0.43	0.09	0.49	0.49

From Preethi et al, Climate Dynamics, 2010) & Rajeevan et al. Climate Dynamics, 2011

MODEL	Period	Correlation Coefficient
DEMETER	1960-2001	0.28
ENSEMBLES	1960-2005	0.49
	1984-2005	0.31
CFS V2	1984-2005	0.41

Seasonal prediction of south Asian monsoon region with the most modern dynamical coupled models such as those that contributed in DEMETER Project (Kang and Shukla 2006, Preethi et al. 2010) remains too low to be of practical use, even at the shortest lead times. However, encourging improvement was seen in the prediction skill of the Asian monsoon in recent models such as in ENSEMBLES Project (Rajeevan et al. 2011)

Skill (1982-2008) of MMCFS over Smaller South Asian Countries

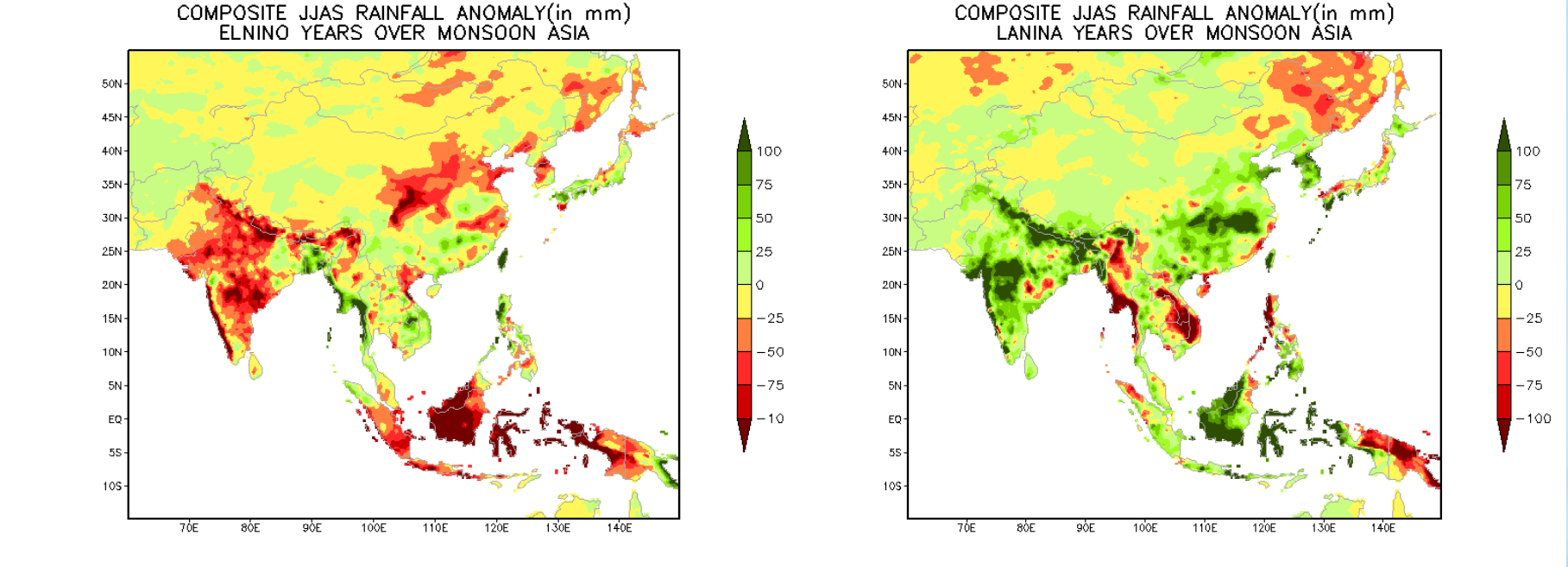
IITM	AFG		BAN		BHU		MYN		NEP		PAK		SRI	
IC	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE
January	-0.12	60	0.12	18	0.33	20	0.38	6	0.32	7	0.10	5	0.15	6
February	-0.30	61	-0.05	16	0.16	15	0.27	6	0.37	5	-0.06	5	0.31	7
March	0.30	62	0.14	19	0.19	21	0.51	5	0.45	5	0.30	5	0.39	6
April	0.07	67	0.02	15	0.17	18	0.03	5	0.30	4	-0.05	4	0.20	7
May	0.19	72	0.04	13	0.10	29	0.17	6	0.46	5	0.01	4	0.36	9

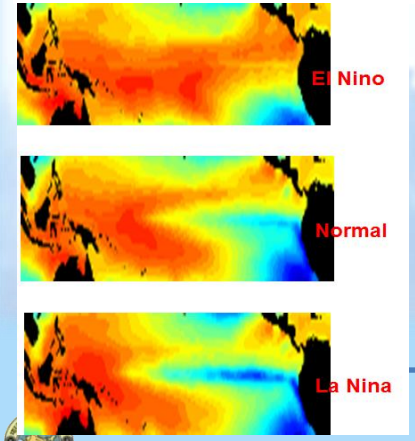
Skill (1982-2008) : of NCEP CFSV2 over Other South Asian Countries

CFSV2	AFG		BAN		BHU		MYN		NEP		PAK		SRI	
	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE	C.C	RMSE
January	0.32	61	0.05	19	-0.13	30	0.16	4	0.53	8	0.05	5	0.10	4
February	-0.08	7	0.14	17	0.05	19	0.11	3	0.41	11	-0.28	5	0.21	3
March	0.08	11	0.24	14	0.11	21	0.30	4	0.26	14	-0.12	4	0.38	3
April	0.35	3	-0.04	8	0.01	24	0.25	12	0.11	24	-0.02	4	0.32	2
May	0.38	4	-0.14	12	-0.44	35	-0.37	22	0.13	37	0.28	3	0.26	3

Even the latest state of art coupled models show low forecast skill. This is much lower for smaller regions and for smaller time periods

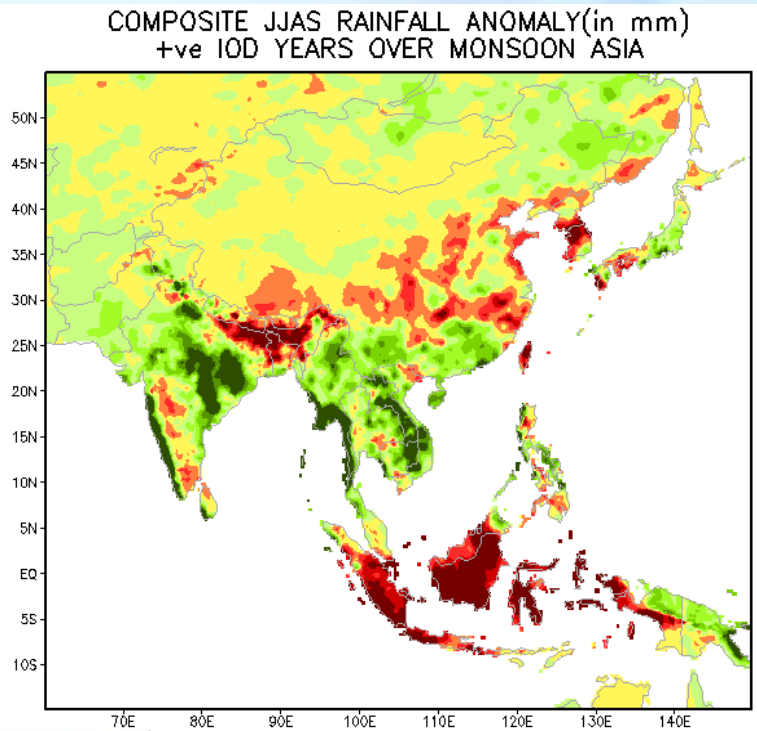
Importance of Understanding the Teleconnections: Composite Rainfall Anomaly Over Monsoon Asia: El Nino Vs La Nina

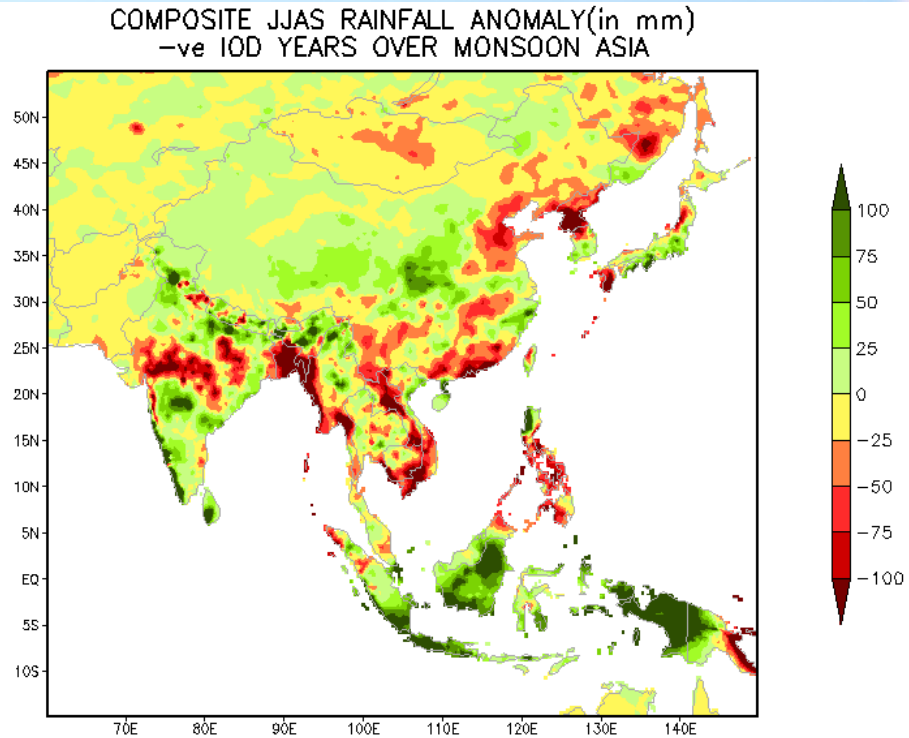


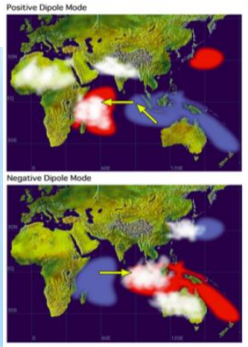


During El Nino (La Nina) years, in general, most parts of the South Asia except Some Northeastern parts of the region receive below (above) normal rainfall anomalies.

Composite Rainfall Anomaly Over Monsoon Asia: Positive IOD Vs Negative IOD







During positive (negative) IOD years, in general, monsoon trough region of India and eastern part of the south Asia receive above (below) normal rainfall and areas along the Himalayas receive below (above) normal rainfall..

Need to conduct specific research into understanding the regional variability and predictability for each RCC region. Back up observed teleconnections with theoretical or modelling evidence. The variability and teleconnections information can be used to modify the model output if the effect is not already represented by the model in question.

RCC Mandatory LRF Functions

Generate regional and subregional tailored products, relevant to RCC user needs, including seasonal outlooks	**Product: Probabilities for tercile (or appropriate quantile) categories for the region or subregion** **Element: 2-m mean temperature, total precipitation** **Output type: Rendered images (maps, charts), text, tables, digital data** **Forecast period: one month up to six months** **Update frequency: Ten days to one month**
Perform verification of RCC quantitative LRF products, including the exchange of basic forecasts and hindcast data	Products: Verification datasets (e.g., SVSLRF scores, Brier skill score; relative operating characteristic (ROC); hit rate skill score) Element: 2-m mean temperature, total precipitation

Important points

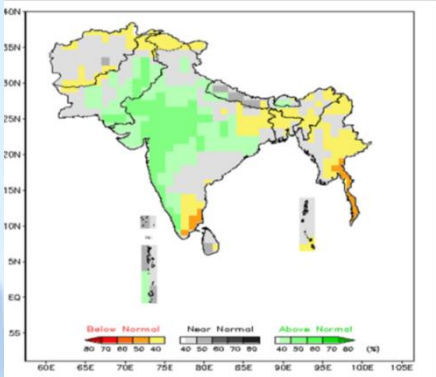
- Need to work with application communities to develop tailored downscaled products;
- Need clear idea about the scale to which one can expect to down scale the large scale information, and how to get the best compromise between the limits of seasonal predictability and the needs for applications
- Needs to move beyond the traditional tercile categories as per the regional user requirement.
- Model output should be recalibrated based on historical model performance. But lack of long time series of climate data over some regions do not help.
- Different product cycle used by different centers does not allow update the products at higher frequency.

RCC Mandatory LRF Functions

Generate consensus* statement on regional or subregional forecasts* A collaborative process involves discussion with experts in the region (e.g., through Regional Climate Outlook Forums (RCOFs) and teleconferencing). Consensus is both the agreed process and its joint conclusion, and the consensus can be that there is limited skill in the prediction for a region or subregion	**Product: Consensus statement on regional or subregional forecast Element: 2-m mean temperature, total precipitation Output type: Report Forecast period: A climatologically significant period (from one month to one year) Update frequency: At least once per year (to be defined by the region)**

Important points

- Needs to focus on the development of the objective methodology for generating the consensus forecast outlook (EC-69).
- Move from consensus regional outlook preparation to consensus objective approach for regional prediction (e.g., reference periods, variables, model identification/MME, calibration tools, presentation formats, verification, etc.); rule-based consensus – replicable, traceable, verifiable
- For moving towards objective seasonal forecast outlooks in RCOFs, RCCs should use of both digital hindcast and real time forecast datasets disseminated either directly by GPCLRFs or via the WMO LC-LRFMME to produce an objectively consolidated forecast product combining information of various GPCs-LRF, which may be used as a first estimate for RCOF discussions. This will also help in the verification of RCOF products.
- Should play a significant role on resource mobilization for RCOFs. Also needs to Build mechanisms at RCOF sessions to propose improving RCC activities to address RCOFs needs.



EC-69 Decision 4.5/2 (May 2017)
Sub-Seasonal and Seasonal Forecasting Systems

Recognizing:

- That current use of dynamical forecasts in the process of developing seasonal climate outlooks at RCOFs is mainly subjective and depends on confirming or challenging the statistical results, and the blending of individual national forecasts into a spatially coherent regional outlook on the basis of expert assessment,
- The limitations of subjective consensus-based approaches for the usability of forecasts, particularly at the national level, as well as the challenges they pose for evaluation of forecast skill,
- That, at the same time, the expert assessment taking into account many aspects, such as current climate conditions, past statistical relationships as well as the characteristics and limitations of the models used, are also still required to formulate sub-seasonal to seasonal forecasts with better forecast skill,
- That the longstanding RCOF process involves seasonal outlook preparation through consensus building of expert assessment, and that it is not merely a mechanical blending of the various forecast inputs,
- The rapid advances in dynamical modelling for sub-seasonal and seasonal forecasting, operational availability of such forecasts with greater space-time resolutions, and the need to optimize their use in the operationalization of regional forecasting systems,
- That further progress on operational seasonal forecasting, and the routine development of associated tailored products for decision support, will entail more widespread adoption of objective seasonal forecasting schemes that readily facilitate the tailoring of forecast products to support specific end uses,

Decides to consider the adoption of objective sub-seasonal and seasonal forecasts as an overarching technical strategy, particularly at regional and national levels, promoted through RCOFs, by adopting suitable operational practices and capacity development efforts, to be facilitated by a global RCOF review;

RCC Mandatory LRF Functions

Provide online access to RCC products and services to RCC users	**Product: An online data/information portal**
Assess use of RCC products and services through feedback from RCC users	Product: Analysis of feedback (which is made available using a template) Update frequency: Annually, as part of a regular reporting of RCCs to WMO RAs

Important points

- Feed back mechanisms needs to improved
- RCOFs is right forum for this purpose
- A standard questionnaire for feed backs from NMSs and User sectors is needed.

ADDITIONAL HIGHLY RECOMMENDED REGIONAL CLIMATE CENTRE FUNCTIONS

Climate prediction and climate projection:

- Assist RCC users in the access and use of World Climate Research Programme Coupled Model Intercomparison Project climate model simulations;
- Perform downscaling of climate-change scenarios;
- Provide information to RCC users for use in development of climate adaptation strategies;
- Generate, along with warnings of caution on uncertainty, seasonal forecasts for specific parameters where relevant, such as:
- Onset, intensity and cessation of rainy season;
- Tropical cyclone frequency and intensity;
- Perform verification on consensus statements for forecasts;
- Perform assessment of other GPC products such as SSTs and winds.

Important Points:

- Need to implement as per the priorities of regional users
- Supplement subseasonal forecasts to seasonal forecasts
- Additional information such as tropical cyclone frequency and intensity helps in better interpretation of first level seasonal forecasts

Thank you