Current status and prospects of Extended range prediction of Indian summer monsoon using CFS model

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Background and Motivation

Seasonal rainfall anomalies are nearly homogeneous over the Indian region during extreme monsoon years (droughts/floods). But, mostly (~70%) monsoon years are normal and during normal years the rainfall anomalies are inhomogeneous over the country, contributing to a large degree of spatial variability.

Adding to this is the variability of rainfall on temporal scales...

### Spatial Variability

- **Drought (2002)**
- **Flood (1961)**

### Temporal Variability

**Seasonal JJAS rainfall anomaly** during drought years may not be useful for agricultural planning. Therefore, in addition to the seasonal mean All-India rainfall, we need to predict some aspects of monsoon 3-4 weeks in advance on a relatively smaller spatial scale that will be useful for farmers.

But, mostly (~70%) monsoon years are normal and rainfall anomalies are inhomogeneous over the large degree of spatial variability.

Hence, under the “National Monsoon Mission” Project of Govt. of India, IITM has adopted Climate Forecast System (CFS) coupled model from NCEP for seasonal and extended range prediction of Indian summer monsoon on Indo-US collaborative mode.
As useful skill of daily rainfall forecast drops by 7-9 days, daily forecasts are no longer valid beyond 9 days lead. Some kind of averaging is required to remove the high frequency weather noise, prediction on pentad scale extends the skill.

ACTIVE ( > 40 %), NORMAL ( - 40 % to + 40 %), BREAK ( < 40 %)

Abhilash et al., 2014
Abhilash et al., 2013a

Development, Testing, tuning and reliability of Ensemble Prediction System (EPS)

- It has the potential to generate infinite number of ensembles.
- Amplitude of perturbation can be adjusted by changing the tuning factor.
- Sensitivity of perturbing each individual variables can be evaluated.

Spread-Error relationship

Reliability of the EPS

Lead-dependant climatology

SNR and Predictability

Abhilash et al., 2013a
Background

SST Bias from Long Simulation

SST Bias

20 day Lead

Abhilash et al., 2013c

Northward propagation of ISO

Sahal et al (2013)
Current Sciences
## Optimization of the EPS and Strategy for real-time prediction

1. **Does bias correction in forecasted SST improves the ERP skill?**
2. **How important is model resolution in ERP?**

<table>
<thead>
<tr>
<th>Model</th>
<th>Resolution</th>
<th>Forecast Lead</th>
<th>Hindcast period</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFSv2</td>
<td>T126~100km</td>
<td>45 days</td>
<td>2001-2012 (28 Start dates in one year during monsoon season)</td>
</tr>
<tr>
<td>CFSv2</td>
<td>T382~35km</td>
<td>45 days</td>
<td>-do-</td>
</tr>
<tr>
<td>GFSv2bc (Forced by Bias corrected CFSv2 SST)</td>
<td>T126</td>
<td>25 days</td>
<td>-do-</td>
</tr>
</tbody>
</table>
GFSv2bc Seasonal (JJAS) Climatology is better than CFS126

Spatial pattern of T382 seasonal climatology has further improved

Abhilash et al., 2013b
Sahai et al., 2013, Submitted
Model evaluation is done for both Actual Pentad mean rainfall averaged over 5 Homogeneous region as well as for large scale MISO Skill Statistics: CC at different pentad lead over MZI, CEI, NWI, NEI, SPI

T382 skill is better over NEI

Does better Seasonal Mean Simulation Guarantee Better ERP ????????
AUC over MZI
For AN, NN, BN categories

ROC over MZI
For AN, NN, BN categories

Borah et al, 2013
Skill in predicting MISO Indices

Correlations between the MISO1 and MISO2 index and the MISO amplitude as a function of lead-time.

Eight Phase evolution of MISO

Optimization of Low frequency component over Indian region

RMM------------→ BSISO------------→ MISO--- (Suhas et al., 2013, Goswami et al., 2013)
Bias Correction as well as High Resolution

- The dry bias over the Indian land region slightly reduced in all lead pentads in the bias corrected GFSv2 compared to CFSv2T126. While T382 run exhibit large reduction in climatological biases ... But no significant operational usefulness of CFST382 forecast over T126 forecast of MISO.

- The pentad lead prediction skill of ensemble mean deterministic and probabilistic forecasts from GFSv2bc is significantly higher than CFSv2, both T126 and T382, for all lead pentads.

- GFSv2 is superior to CFSv2 in predicting large-scale low-frequency components of MISO and is clearly an artifact of correcting the SST bias. Biases are similar in T126 and T382 resolutions.

- The real-time dissemination of extended range (~3 weeks) forecast in the high resolution NCEP CFSv2 framework could be a challenging task for the operational forecasters, owing to time constraints and computational management.
Model has been integrated for 45 days for each 11 ICs at five day intervals starting from 16th May (Eg: 16May, 21May, 26May, 31May, 05Jun........etc) at CFS T126 resolution and bias corrected SST from CFSv2 has been used to force GFSv2bc.

Forecast & Verification

- **Monsoon Onset over Kerala (MOK)** was predicted well from 16 May initial conditions (29 May 2013).
- **Rapid advancement of 2013 monsoon** and the incidence of Uttarakhand heavy rainfall event was predicted well in advance by the models from 05 June initial conditions.
- **Prediction of reduced rainfall activity in the end of August** helped Pune Municipal Corporation in planning their road-repairing works.
- **The revival of monsoon** was well predicted from 08 September initial conditions, which helped IMD in declaring the withdrawal of monsoon.
- **The extended range forecasts** were widely utilized by Agromet Division of IMD to prepare the fortnightly agromet advisory bulletins.
Forecast of Monsoon Onset over Kerala
Based on 16 May 2013: 29 May 2013
Onset declared by IMD: 1st June 2013

Y axis on each panel is in mm/day for rainfall (bars) and m/s for 850hPa wind (green line). Red circle is the onset date and also written at the top of each panel.

Onset date forecasts are obtained from each 11 member of CFSv2 45 day forecast. Then ensemble mean is given as the final forecasted onset date.

Onset date: 29 May
SD: +/- 1
NCEP/TRMM Analysis
Wind (850hPa) and R/F

Verification

F/C from 16May IC

CFSv2
Rapid advancement of monsoon was well-predicted from 5 Jun IC
Observed and Predicted percentage anomalies are shown for 2013 over Monsoon Zone.
Monitoring of MISO and verification

0710 2013
CFS  GFS  OBS

0730 2013
CFS  GFS  OBS

MISO1 →

MISO2

PHASE1  PHASE2  PHASE3  PHASE4  PHASE5  PHASE6  PHASE7  PHASE8

SIO and Indian Ocean
Foot Hills and SIO
Central India
North and Central India
CL and Peninsula
IO and Southern tip
South tip and Peninsular
NI and Foot hills
Revival of 2013 monsoon in the mid September was well-predicted from 08 Sept IC.

Daily evolution of rainfall and wind at 850hPa