Addressing the Livelihood Crisis of Farmers

Weather & Climate Services

WMO

Short, Medium and Extended Range Forecasting

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INDIA METEOROLOGICAL DEPARTMENT
Overview

- **Relevance of Weather prediction to agriculture**
- **Spatial and Temporal Scales of weather phenomena**
- **Predictability**
- **Conventional methods of forecast**
- **Global and Regional NWP Models**
- **Climate models**
- **Integrated Agro advisory services**
Relevance to the Livelihood Issue

Realization of the promise

Ideal Yield

Natural Technology Agromet

Yield aided by agro-meteorology

Yield aided by technology

Yield without technology

Intrinsic Variability
A View From Space -
hierarchical structure of planetary weather
Spatial Scales of Motion

JUNE

MAY

Distribution of atmospheric moisture
seasonal transition

2 May
Smaller spatial scales

Cumulonimbus clouds can coalesce to form a huge continuous cloud cell, as seen in this meteosat image of the Balkans.

View of an incoming storm low approaching the coast of California taken by SeaWIFS instrument on the OrbView-2 satellite.
Mix of fog and smog in northern India seen by MODIS

View of an "anvil cloud". from the International Space Station
Weather Systems: Temporal-Spatial Scales

- Dust Devil
- Tornado
- Thunderstorm
- Off-shore vortex
- Meso-cyclone
- Tropical Cyclone
- Extra-tropical Cyclone
- Monsoon depression
- Monsoon circulation

Horizontal scale: 10 m/10min

Life Time: 10,000 km/100 days
<table>
<thead>
<tr>
<th>Phenomena</th>
<th>Geographical occurrence</th>
<th>Temporal /Spatial scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madden Julian Oscillation</td>
<td>Tropical</td>
<td>30 – 40 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wave Number 2-4</td>
</tr>
<tr>
<td>Planetary waves</td>
<td>Mid latitudes</td>
<td>10 – 20 days</td>
</tr>
<tr>
<td>Baroclinic waves</td>
<td>Midlatitudes, subtropics</td>
<td>- 3 days</td>
</tr>
<tr>
<td>Tropical Cyclones</td>
<td>Tropical</td>
<td>- 7 days</td>
</tr>
<tr>
<td>Easterly waves</td>
<td>Tropical</td>
<td>- 7 days</td>
</tr>
<tr>
<td>Thunderstorms</td>
<td></td>
<td>- 5 hrs</td>
</tr>
<tr>
<td>Fog</td>
<td></td>
<td>hrs - days</td>
</tr>
<tr>
<td>Droughts</td>
<td>Any where</td>
<td>Days – Months - years</td>
</tr>
<tr>
<td>Heat / cold waves</td>
<td>Except Equatorial regions</td>
<td>Days - weeks</td>
</tr>
</tbody>
</table>
Very Limited Skill in Extended range time scale
(10 days to one month)
Predictability & Forecasting Range

**Lorenz system with slight different initials**

Predictability of the First Kind

**Lorenz system with a forcing**

Predictability of the Second Kind

Time Series of Solution

- **predictable**
- **unpredictable**

LRF targets this signal

Major forcing is boundary conditions
<table>
<thead>
<tr>
<th><strong>Range</strong></th>
<th><strong>Time</strong></th>
<th><strong>Methods</strong></th>
<th><strong>Phenomena</strong></th>
<th><strong>Utility</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nowcasting</td>
<td>- 6hrs</td>
<td>Radars etc</td>
<td>Hailstorms, Squalls with high accuracy</td>
<td>Severe Weather Warnings (~ 500 m)</td>
</tr>
<tr>
<td>Short Range</td>
<td>2-3 days</td>
<td>Nested Atmospheric Models</td>
<td>Synoptic scale weather systems</td>
<td>Conventional Forecasting resolution (3-25 km)</td>
</tr>
<tr>
<td>Medium Range</td>
<td>7-10 days</td>
<td>Global Atmospheric Models</td>
<td>Synoptic scale weather systems</td>
<td>Conventional Forecasting resolution (25 – 50 km)</td>
</tr>
<tr>
<td>Extended Range</td>
<td>10–30 days</td>
<td>Coupled Atmospheric Models</td>
<td>Persistent systems • Blocking Highs • MJO • ITCZ</td>
<td>Droughts and Heat / Cold Waves</td>
</tr>
</tbody>
</table>

**Resolution vs Lead time**
Forecasting by Synoptic Charts
Short-range Forecasting Strategy

- Triple nested model forecast
  27, 9 and 3 km
- Cycling
  4 times a day
ARPS & ADAS –

- Advance Regional Prediction System Model (ARPS) - has been used.
- ADAS has been used to assimilate & interpolate, radar data file generated by 88D2ARPS & background and boundary file generated by EXT2ARPS, onto the ARPS grid using GFS Forecast.
- Following Diagram is showing ½ hourly assimilation cycle (first 3 hours) & then 21 hours ARPS Model forecast -

**9-km assimilation:** For Cyclone Case

<table>
<thead>
<tr>
<th>Time (Z)</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000Z</td>
<td>ADAS</td>
</tr>
<tr>
<td>0030Z</td>
<td>ADAS</td>
</tr>
<tr>
<td>0100Z</td>
<td>ADAS</td>
</tr>
<tr>
<td>0130Z</td>
<td>ADAS</td>
</tr>
<tr>
<td>0200Z</td>
<td>ADAS</td>
</tr>
<tr>
<td>0230Z</td>
<td>ADAS</td>
</tr>
<tr>
<td>0300Z</td>
<td>ADAS</td>
</tr>
<tr>
<td>0000Z</td>
<td>Forecast (21 hrs)</td>
</tr>
</tbody>
</table>

GFS model provide background and boundary conditions

IMDS.20081127.0000 IMDS.20081127.0300
Generation of Multi-model Forecasts

\[ \text{Forecast (F)} = \sum W_i F_i \]

\[ W_{i,j,k} = \frac{C_{i,j,k}}{\sum_{k=1}^{5} C_{i,j,k}} \quad , \quad i = 1, 2, \ldots, 161; \quad j = 1, 2, \ldots, 161 \]
IMD Multi-model Ensemble (MME) based District level (50 x 50 km) Forecasts

Parameters:
- Rainfall
- Max and Min temperature
- Total cloud cover
- Surface Relative humidity
- Surface Wind
MAP SHOWING DISTRICT BOUNDARY
PEST TYPE: pink boll worm

SELECT STATE
MAHARASTRA

SELECT PEST TYPE
pink boll worm

SHOW MAP
SHOW MAP
Model Performance

Spatial Distribution
  - Rainfall
  - Root Mean Square Errors
  - Mean Errors

Categorical Skill scores
  - POD
  - TS
  - BS
Inter-comparison: Day-5 forecast of Cum. Rainfall (cm)
Inter-comparison of day-5 forecast of Cum. Rainfall (cm)
RMSE 2009 : Day-5
Inter-comparison of model performance: RMSE 2009

RMSE ERROR

RAINFALL (mm/day)

GFS
ECMF
JMA
T254
UKM
MME
ENSM

DAY-1  DAY-2  DAY-3  DAY-4  DAY-5

INDIA METEOROLOGICAL DEPARTMENT
TS : All India : Day-5

Rainfall Threshold in mm

Hit Rate : All India : Day-5

Rainfall Threshold in mm
The active/break cycles -manifestations of sub-seasonal fluctuations of the northward propagating ITCZ.

Since the time scale is sufficiently long so that much of the memory of the atmospheric initial conditions is lost, and it is probably too short so that the variability of the ocean is not large enough, which makes it difficult to beat persistence.

However, an important source of predictability at this time range is the Madden–Julian oscillation (MJO).
Madden-Julian Oscillation (MJO)

- Intraseasonal Time Scale: ~40-60 days
- Planetary-Scale: Zonal Wavenumbers 1-3
- Baroclinic Wind Structure
- Eastward Propagation
  - E. Hem: ~5 m/s, Surf.+Conv.+Circ. Interactions
  - W. Hem: ~ > 10 m/s, ~Free Tropospheric Wave
- Tendency to be Equatorially Trapped
- Strong Seasonal Dependence:
  - NH Winter: Eastward Propagation
  - NH Summer: ~Northeast Propagation
- Significant Interannual Variability
- Potential Role of Ocean/SST Feedback
- Convection Has Multi-Scale Structure
- Significant Remote and Extra-Tropical Impacts

Typical Variables Used for MJO Analysis

Cloudy Low OLR
Clear High OLR

Rainfall

U200

U850
1) **Real-time Multivariate MJO Index** – for 15 days Based on the first two Empirical Orthogonal Functions (EOFs) of the combined fields of near-equatorially-averaged 850 hPa zonal wind, 200 hPa zonal wind, and satellite-observed outgoing longwave radiation (OLR) data. *Wheeler and Hendon (2004)*.

2) **US CLIVAR MJO Forecast Project** - Available through Climate Prediction Centre, CPC).

3) **MJO forecast in the form of OLR anomalies**
   (a) Xavier and Goswami (1997) – Uses the analog method for the forecasting of OLR pentad anomalies at lead time period of 1 pentad to 4 pentads
   (b) Jones et al., (2004) - The model uses principal components (PC’s) of empirical orthogonal function analysis of 20-90 days anomalies of OLR. *(Jones et al. 2004 J. Climate)*.

4) **Self Organising Map** - Developed by IITM is based on a non-linear pattern recognition technique known as Self Organising Map (SOM), which predicts rainfall using dynamical indices. Currently upgraded and used real time rainfall as input in the forecasting of probability of rainfall anomaly over central India. *(IMD and IITM presently working together)*
1) ECMWF Monthly forecast 51 ensembles - (days 5 to days 32) – Forecast in four weekly averages. (Runs once a week)

2) JMA/Tokyo Climate Center 51 ensembles – (day 2 to day 29) - Forecast in two weekly averages and one fortnightly averaged. (Runs once a week).

3) NCEP CFS 4 ensembles - Forecast as daily averages (Runs daily).

   Model runs every day with 4 ensemble members with 2 days lag of Ocean initial condition

4) Experimental Multi-model forecast system for India: For two weeks after bias correction, based on ECMWF and NCEP coupled model
ECMWF forecast for Dry spell of September, 2009

Valid for 14-20 Sep

Valid for 21-27 Sep

Lag Week 1

Lag Week 2

Lag Week 3
Experimental Monthly Probability Forecast Based on Real time NCEP coupled model outputs

Total 60 forecast ensemble members
4 Ensembles/day
with 15 days of the Month (0)

Model Hindcast Climatology from 25 years (1981-2005)

Probability forecast (in %) for month 1
(i) Above Normal
(ii) Below Normal
Forecast (Tmax & Tmin) For March 2010 Based on February ICs

Observed Tmax anomaly, Mar 2010
Doppler Weather Radars

... Means of Nowcasting and very short range forecasting

- Wind information
- Water content in clouds in different phases
- Digital output

Increases forecast accuracy dramatically over the next few hours and appreciably over 24 HRS
24 HR forecast using DWR data
Regions likely to experience Stem borer incidence on Rice crop.
Districts likely to be affected by the incidence of tikka disease on Groundnut
Irrigation Requirement at different districts
Postpone fertilizer application at Gurdaspur and Patiala due to excess rainfall.

Farmers are advised to apply fertilizers in the remaining districts of the state due to light rainfall or no rain in these areas.
In Bhatinda and Patiala, wind speed is greater than 20 knots and in Jalandhar and Ropar, wind speed is greater than 34 knots, avoid applying fertilizer to the crop in these districts.

Apply the necessary fertilizer in the remaining districts of the state as wind is calm.
Apply light irrigation in Jalander and Ludhiana where temperature reaches more than 28°C.
Grape is grown in areas where the maximum temperature range is from 15-40°C.

High temperatures above 40°C during the fruit growth and development reduce fruit set and consequently the berry size.

Minimum temperature >10°C is good for grapes
When normal maximum temperature of a station is less than or equal to 40°C:

- Apply frequent irrigations to the crops.
- Apply mulches to maintain high moisture status in the soil.

When normal maximum temperature of a station is more than 40°C:

- Apply frequent irrigations to the crops.
- Apply mulches to maintain high moisture status in the soil.
In *rabi* season the most appropriate time of sowing for wheat crop is when the daily ambient temperature drops to 20-22°C.

In Amritsar, Firozpur, Faridkot, Bathinda and Muktsar the temperature range is between 20 to 22°C in the third week of November. In these districts, farmers can start sowing wheat. In the other districts, they can wait for sowing.
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For Kharif season

- Monsoon arrived in Punjab in the first week of July.
- In Firozpur, Amritsar, Faridkot, Muktsar districts as P/PET > 0.5, farmers may start for land preparation and sowing.
- In Nawashahar, Sangrur, Patiala, Fatehgarh sahib and Ropar districts as P/PET < 0.5, Starts for land preparation. Wait for proper sowing period.
Hail storm likely in the districts of Himachal Pradesh (through Doppler Radar Observations)
Thank You