Applications of Seasonal Climate Forecast to Crop Yield: International & Domestic Collaborations

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Outline

- Brief overview on climate predictability activities using SINTEX-F1 coupled model.

- On agricultural collaborations.

- A new attempt of developing high performance bias correction scheme for short term climate predictions.
EU-Japan Collaboration

Schematic view of the present version of the SINTEX-F CGCM

First successful prediction of IOD

Ocean - OPA8.2

Atmosphere – ECHAM4.6

Coupler- OASIS4.2

North Pole is replaced by two land points

Earth Simulator

SST Forecast plumes

Observed data

Ensemble mean forecast

E10 SSTA (90–110E, 10S–0) forecast

2006 IOD
Extreme Weather Conditions Associated with 2006 IOD

East African Flood (more than 1 million have been uprooted in Kenya)

Indonesian Forest Fire

Australian Drought
Rain hopes fading

Drought tip from box trees

By SIMONE DALTON

AS AUSTRALIA’s dry season warms up, country-dwelling Victorians are hankering after rain to make their crops grow and their livestock survive.

Scores of box trees have been savaged by stock, but a corner of Victoria is blessed with green fields and crops.

"It’s a recession," said the owner of the farm, "but the weather is on our side, and the crops are doing well."

"We’ve been saving up for the rain, and we’re hoping it will come soon," he said.

Sydney’s drought has been on everyone’s minds, but the rainfall in Victoria has been much better.

"We’ve had a great deal of rain, and we’re hoping it will continue," he said.

The rainfall has been a welcome relief for the farmers, and the crops are doing well.

"The crops are looking good, and we’re hoping for a good harvest," he said.

Cattle hold the line

As the drought persists, the cattle market has been affected.

"The cattle are in a bad state, and we’re hoping for some rain to help," he said.

The cattle are under stress, and the farmers are hoping for some relief.

"The cattle are in a bad state, and we’re hoping for some relief," he said.

JAMSTECによる2008年4月からの予測結果

2008年4月23日にThe Weekly Timesに掲載

日本の新聞にも掲載
CCARA approach (IRRI)

1. Development of a seasonal (weather) prediction model (JAMSTEC and IRRI)

2. Development of rice genotypes suitable for growing in abiotic stress conditions caused by climate change (IRRI, NAFRI, AIAT, and IAERI)

3. Development of fertilizer management technologies to mitigate stresses caused by climate change (IRRI, NAFRI, IAERI)

4. Development of an integrated decision support system (IRRI, NAFRI, IAERI)
CCARA design
Information process and delivery

Earth Simulator
JAMSTEC

IRRI server in Linux

Seasonal (Weather) Prediction Model
ORYZA2000 vr3.0
Nutrient manager

Internal collaboration

RA with JAMSTEC

Local CB
Implications for crop prediction

Table 1. RPS skill scores, % [Eq. (2)], for the IRI temperature forecasts.

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<thead>
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<tr>
<td>Global</td>
<td>8.9</td>
<td>4.2</td>
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<tr>
<td>Low latitudes ($</td>
<td>\phi</td>
<td>&lt; 30^\circ$)</td>
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<tr>
<td>High latitudes ($</td>
<td>\phi</td>
<td>&gt; 30^\circ$)</td>
</tr>
<tr>
<td>Africa</td>
<td>25.6</td>
<td>9.1</td>
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<tr>
<td>Asia</td>
<td>1.1</td>
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<td>North America</td>
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<tr>
<td>South America</td>
<td>5.9</td>
<td>7.0</td>
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Table 2. RPS skill scores, % [Eq. (2)], for the IRI precipitation forecasts.

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<thead>
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<tbody>
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<td>Global</td>
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<tr>
<td>Low latitudes ($</td>
<td>\phi</td>
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<td>-0.7</td>
</tr>
<tr>
<td>South America</td>
<td>4.8</td>
<td>2.5</td>
</tr>
</tbody>
</table>

\[
SS_{RPS} = \frac{RPS - RPS_{clim}}{0 - RPS_{clim}} \times 100%.
\]

Wilks & Godfrey (2002) *J Clim*

Nemani et al. (1997) *Science*

lizumi et al. (in preparation)
ENSO prediction skill of 10 top models
Correlation b/w 3-month mean values of JRA25 reanalysis and SINTEX-F forecast at various lead times (sample size 28: 1983-2010).

$T_{ave} - JJA$

a) 0-month lead

b) 1-month lead

c) 2-month lead
d) 3-month lead

e) 6-month lead

f) 9-month lead
New attempt of bias correction (1)

- Miscellany of several methods, some of them are based on our subjective judgments.
  \[ \Rightarrow \text{Generic method without ad hoc assumptions.} \]

- The basic idea of prevailing methods is called quantile(Q)-matching:

  \[
  \begin{array}{ccc}
  \text{Observational data} & \text{Model Output} \\
  \text{PDF}(o) \Rightarrow \text{CDF}(o) & \text{PDF}(m) \Rightarrow \text{CDF}(m) \\
  \end{array}
  \]

  There exists

  \[
  \text{CDF}(o) \leftarrow \text{(one to one correspondence)} \rightarrow \text{CDF}(m)
  \]

  since CDF is a monotonous function.
New attempt in bias correction (2)

- Conventional Q-matching is purely statistical approach in which the picture of time evolution of events is totally missing, while it is important in short-term climate variability prediction.

- This motivates us to look into the time dependent bias time series defined as the difference between observational value and model output with the same spatio-temporal mean.
New attempt in bias correction (3)

Y(i): Obs.; X(i): Model outputs (hindcast & prediction)

Time dependent model bias:

\[ Z(-i) = Y(-i) - X(-i) \]
New attempt in bias correction (4)

- Mathematically, we cannot determine power spectrum of a given data with finite length.
- Maximum Entropy Method provides a measure to cope with the lack of information.
- A numerically improved code of MEM is now available.
  i) High resolution analysis is justified beyond Akaike Information type criteria valid for AR process but not necessarily so for MEM.
  ii) Code satisfies Parseval’s theorem within allowable limits of numerical error.
BEFORE YEAR 2000
(OBS - SINTEX)^2/OBS^2 = 0.693^2
(OBS_FITTING)^2/OBS^2 = 0.560^2

AFTER YEAR 2000
0.646^2
0.626^2

1 year

Fig. 3
Summary

- A high-performance bias correction method exclusively for short-term seasonal climate prediction has been developed.

- Next challenge is bias correction for sub-seasonal or shorter time scale phenomena important for agricultural applications.