Tropical Intra-Seasonal Oscillations in the DEMETER Multi-Model System

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European Centre for Medium-Range Weather Forecasts (ECMWF)
Outline

- Introduction to DEMETER
- Multi-model ensemble: a way to sample model uncertainty to increase seasonal skill
- Multi-model ensemble: a tool to diagnose model performance, the ISO case
- Summary
The idea behind DEMETER

- Growing demand for reliable seasonal forecasts
- Two main sources of uncertainty
  - Error in initial conditions
  - Error in model formulation
- Install a multi-model ensemble system
- Evaluate the skill and potential utility
Multi-model ensemble system

- DEMETER system: 7 coupled global circulation models

<table>
<thead>
<tr>
<th>Partner</th>
<th>Atmosphere</th>
<th>Ocean</th>
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<tbody>
<tr>
<td>ECMWF</td>
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<tr>
<td>UKMO</td>
<td>HadCM3</td>
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- 4 start dates per year
- 6 months hindcasts
- 9 member ensembles
- 3 ocean analyses, 4 ±SST pert
- ERA-40: ocean forcing and atmospheric initial conditions
Verification

• Bias
• Indices
• Deterministic Scores
• Probabilistic Scores
• Single vs. multi-model
• 54-single vs. multi-model
• Ocean diagnostics

http://www.ecmwf.int/research/demeter/verification
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Multi-model forecast skill

Niño-3.4 SST, 2-4 month seasonal hindcasts

<table>
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Intraseasonal SD OLR (May to Oct.)

Unfiltered data

Météo-France

Met Office

ECMWF
IS SD OLR (Nov. to April)
Unfiltered data

Météo-France

Met Office

ECMWF
IS SD OLR (May to Oct.)

ERA40

Difference wrt ERA40 ↓

Météo-France

Met Office

ECMWF
IS SD U 10m (May to Oct.)

Difference wrt ERA40

Météo-France

Met Office

ECMWF

Workshop on ISO Simulation and Prediction 5 November 2003
Coupling (U 10m May to Oct.)

Difference wrt ERA40 ↓

LODYC (IFS+OPA)

ECMWF (IFS+HOPE)

Met Office (coupled)

Met Office (persisted SSTs)
SST-precip. feedback (May to Oct.)

SST leading precip by 1 month

Precip leading SST by 1 month

Met Office (coupled)

Met Office (persisted SSTs)
**k-ω spectra (May to Oct.)**
Two-sided spectrum for OLR (15°N-15°S)

- **Raw spectrum**
- **Background spectrum**

Symmetric component

Westward

Eastward
**k-ω spectra (May to Oct.)**

Two-sided relative spectrum for OLR (15°N-15°S)

- Equatorial Rossby waves
- Symmetric component
- Kelvin waves
- MJO
Comparison OLR ERA40-NOAA

Two-sided spectra for OLR (5°N-5°S)

Frequency

Raw spectrum

Relative spectrum

Courtesy from Oscar Alves (BMRC)
$k-\omega$ spectra (May to Oct.)
Two-sided relative spectrum for OLR (15ºN-15ºS)

Symmetric component
**k-ω spectra (May to Oct.)**

Two-sided relative spectrum for OLR (15°N-15°S)

**Symmetric component**

ERA40

Météo-France

Met Office

ECMWF
k-$\omega$ spectra (May to Oct.)
Two-sided relative spectrum for $U_{10m}$ (15°N-15°S)

Symmetric component
**k-ω spectra (May to Oct.)**

Two-sided relative spectrum for $U_{10m}$ (15°N-15°S)

Symmetric component
EOFs U 10m (May to Oct.)
20-90 day filtered data (20ºN-20ºS)
EOFs U 10m (May to Oct.)
20-90 day filtered data (20ºN-20ºS)

ERA40 EOF1

ERA40 EOF2

ECMWF EOF1

ECMWF EOF2
Local mode analysis

- Complex principal component analysis of a 20-90 bandpass filtered field over a region on a 90-day running time window (a new analysis every 5 days)
- Separate analysis for each year and ensemble member
- Provides, for each member and year, an estimate of the IS signal features (date, spatial pattern, activity,...) as part of the most coherent patterns in a spatio-temporal sense
- Collaboration with J. Ph. Duvel (LMD, Paris); preliminary results for OLR during boreal winter
Local mode analysis (Nov. to April)
Percentage of the variance captured by the LM
(results without ERA40 influence in the filtering)
Average for all members and years

Lack of organization of the modes

NOAA

Météo-France

Met Office

ECMWF
Local mode analysis (Nov. to April)
Example of Météo-France hindcast

Mode in the NOAA dataset

Mode in ensemble member 5

Mode in ensemble member 9
Local mode analysis (Nov. to April)
Results for Météo-France (Indian Basin)

90-day window filtered variance

First mode variance

Workshop on ISO Simulation and Prediction  5 November 2003
Predictability (Nov. to April)
Correlation of the variance (ensemble mean)
Météo-France

Correlation for the filtered variance

Correlation for the mode activity

Correlation between ERA40 and NOAA

Met Office

ECMWF
Summary

• Different biases in the intraseasonal variability:
  - ECMWF and MetOffice tend to underestimate
  - Météo-France tends to overestimate
• MJO amplitude and frequency are misrepresented, especially by ECMWF and MetOffice and for OLR
• Beneficial impact of the coupling: increase of variability, representation of feedbacks
• Weak spatial coherence of the large-scale perturbations; link to mean state and variability errors
• No clear signs of long-range predictability of the IS activity (excess of ensemble spread)
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Retrieve NetCDF