Update of NOAA (NCEP, Climate Test Bed) Seasonal Forecast Activities

Stephen J. Lord
Director
NCEP Environmental Modeling Center

NCEP: “where America’s climate, weather, and ocean services begin”
Overview

• Science results
  – Ocean data assimilation
  – Land surface model

• Multi-model Ensembles (MME) for S/I prediction
  – Reforecast requirements
  – CFS performance

• CFS Reanalysis planning
Seasonal to Interannual Prediction at NCEP

Ocean Model
MOMv3
quasi-global
1°x1° (1/3° in tropics)
40 levels

Climate Forecast System (CFS)

Atmospheric Model
GFS (2003)
T62
64 levels

GODAS
3DVAR
XBT
TAO etc
Argo
Salinity (syn.)
(TOPEX/Jason-1)

Reanalysis-2
3DVAR
T62L28
update of the
NCEP-NCAR R1

D. Behringer
Standard vs. Deep assimilation

Two long (1980-2005) experiments

Standard or operational GODAS

- Temperature profiles from Argo, XBTs, TAO moorings
- Depth of assimilation is 750 m.

Deep GODAS-X

- Temperature profiles from Argo (2200), XBTs (750), TAO (500) moorings
- Depth of assimilation is 2200 m. Shallow profiles (XBT, TAO) are augmented with climatology.
Independent WOCE CTD section completed in 1988 & 1989 …

Standard vs. Deep assimilation

...and repeated in 2003 & 2005 by PMEL.

Shallow assimilation has a strong cold bias of 1-3°C below 750 m.

Deep assimilation eliminates the cold bias.
Assimilating Argo Salinity

Two 2005 experiments

Standard or operational GODAS

- Temperature profiles from Argo, XBTs, TAO moorings
- Salinity profiles are 100% synthetic (via TS-relationship)

Argo salinity in GODAS-A/S

- Temperature profiles from Argo and XBTs only
- Salinity profiles are 75% observed (Argo) and 25% synthetic (XBTs)
In the west, assimilating Argo salinity corrects the bias at the surface and the depth of the undercurrent core and captures the complex structure at 165°E.

In the east, assimilating Argo salinity reduces the bias at the surface and sharpens the profile below the thermocline at 110°W.

**Assimilating Argo Salinity**

Comparison with independent ADCP currents.
LAND-SURFACE IMPROVEMENTS FOR CFS

• NCEP LSM models
  – OSU model (1990’s)
    • Current LSM in CFS
  – Noah (supported by NOAA Climate Office CPPA)
    • Tested in operational regional model (North American Model)
    • Applied to Global Forecast System (2005)
      – Improved global precipitation and surface fluxes
    • Tested for seasonal prediction (2006)

• Future
  – NASA Land Information System
    • Includes 4 LSMs
      – Noah
      – VIC (Princeton, U. Washington)
      – MOSAIC (NASA)
      – Sacramento (NWS/OHD)
    • ESMF compliant component
  – Run offline with observed forcing to determine land surface states
  – Noah run as forecast module

K. Mitchell
Impact of Noah LSM implementation in GFS: example of warm season forecasts

Noah LSM changes reduce longstanding high bias in GFS surface evaporation over east half of CONUS

Operational GFS

09-25 May 2005

17-day mean surface
Latent heat flux

Parallel GFS test using improved Noah LSM

Noah LSM implemented in NCEP GFS in late May 05
July OBSERVED PRECIPITATION

1999-versus-2000 Interannual Variability of North American Monsoon:
Note 3 regions of opposite sign of precip anomaly from 1999 to 2000

July 1999

moist

July 2000

dry

Monthly observed precipitation accumulation based on 0.25 deg lat/lon gridded analysis of daily total gage-only data (Higgins, R.W., W. Shi and E. Yarosh, 2000: Improved United States Precipitation Quality Control System and Analysis. NCEP/Climate Prediction Center ATLAS No. 7, 40 pp).
July Precipitation Difference (mm)
10-member CFS Ensemble Mean Forecast initialized from mid-late June

T126 CFS / **Noah / GLDAS**

T126 CFS / **OSU / GR2**

Correct sign of interannual difference
Wrong sign of interannual difference

CFS/Noah/GLDAS is superior to CFS/OSU/GR2

Improving CFS prediction skill for summer season precipitation over CONUS via CPPA-sponsored improvements in land surface physics and land data assimilation.
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MME Strategy and Research

• **NCEP, NOAA Climate Test Bed activity**
  - Anchored by the CFS
  - IMME
    - CFS + International Systems
      - Operational centers
      - Required hindcast data sets
      - UKMO,
      - Meteo-France
      - ECMWF
      - BMRC
      - Beijing Climate Center
  - NMME: national research centers
    - GFDL
    - NASA
    - NCAR (through COLA)

• **Applied research**
  - Preliminary skill evaluation of IMME and NMME members
  - Assembly of full reforecast data sets from NMME contributors
  - Prototype products
    - Consolidate the IMME and NMME contributions
    - Single operational MME Prediction System

Saha, Vandendool, Higgins
Number of times IMME improves upon DEM-3:
out of 20 cases (4 IC’s x 5 leads):

<table>
<thead>
<tr>
<th>Region</th>
<th>EUROPE</th>
<th>EUROPE</th>
<th>USA</th>
<th>USA</th>
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<tbody>
<tr>
<td>Variable</td>
<td>T2m</td>
<td>Prate</td>
<td>T2m</td>
<td>Prate</td>
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<tr>
<td>Anomaly Correlation</td>
<td>9</td>
<td>14</td>
<td>14</td>
<td>14</td>
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<tr>
<td>Brier Score</td>
<td>16</td>
<td>18.5</td>
<td>19</td>
<td>20</td>
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<td>RPS</td>
<td>14</td>
<td>15</td>
<td>19.5</td>
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“The bottom line”
Frequency of being the best model in 20 cases in terms of Brier Score of the PDF

<table>
<thead>
<tr>
<th></th>
<th>CFS</th>
<th>European Models</th>
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<tr>
<td>T2m USA</td>
<td>11</td>
<td>2</td>
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<td>T2m EUROPE</td>
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<td>3</td>
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<tr>
<td>Prate USA</td>
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<tr>
<td>Prate EUROPE</td>
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“Another bottom line”
## Explained Variance (%)

February 1981-2001; lead 3 (Nov starts); monthly T2m (US, CD data)

<table>
<thead>
<tr>
<th>MODEL</th>
<th>CFS</th>
<th>MME8 (EW) ALL MODELS</th>
<th>MME3 (EW) CFS+ 2 EU</th>
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<tbody>
<tr>
<td>SEC</td>
<td></td>
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<tr>
<td>SEC0 (NO SE)</td>
<td>2.1</td>
<td>1.2 0.0 0.0 0.0 0.4 0.2 0.0 0.2 0.9</td>
<td>0.2</td>
</tr>
<tr>
<td>SEC8 (last 8 years)</td>
<td>4.3</td>
<td>7.1 1.4 1.4 7.5 1.4 0.4 2.2 3.8 8.6</td>
<td></td>
</tr>
<tr>
<td>SEC21 (all 21 years)</td>
<td>11.2 (0.33 cor)</td>
<td>8.0 0.4 0.4 8.6 0.6 0.1 0.5 2.0 17.0</td>
<td></td>
</tr>
</tbody>
</table>

**European Models**

Explained Variance = Square of Anom Correlation

**SEC**: Systematic Error Correction; **EW**: Equal Weights
CONCLUSIONS

• Without SEC there is no skill by any method (for presumably the best month: Feb)

• With SEC (1\textsuperscript{st} moment only), there is skill by only a few models (5 out of 8 do not add skill)

• MME not good when quality of models varies too much

• MME3 works well, when using just three good models
CONCLUSIONS (cont)

- CFS
  - Improves the most from extensive hindcasts
  - 21 years noticeably better than 8
  - Has the most skill.
  - Other models have less skill with all years included.

- Cross validation (CV) is problematic (leave 3 years out when doing 8 year based SEC?)

- Need more years to determine the SEC where/when the inter annual standard deviation is large

- With lower skill models
  - Consolidation of forecasts reduces the chance that this model will be included in the IMME
  - Based on a-priori skill estimates from hindcasts
  - May lead to improvements in IMME skill compared to equal weighting
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Current CFS

• Operational August 2004
• Frozen system
• Reforecast data base
• Twice daily runs (60/month)
Next Generation CFS

- Coupled atmosphere-ocean-land surface-cryosphere system
  - Improvements to
    - ODA (MOM3 → MOM4)
    - Land surface
    - Atmospheric model
      - Sigma-pressure hybrid model
      - Upgrades to microphysics, radiation,…
    - Atmospheric data assimilation (GSI)
      - ESMF-based coupling and model structure
- Reanalysis (1979-present)
- Reforecast for
  - Weather & Week2 (1-14 days)
  - Monthly (2 weeks to 2 months)
  - S/I (2-12 months)
- Estimated completion January 2010
Proposed Time Line

- **April 2007**: Implementation of the GSI scheme for GFS.
- **Aug 2007**: Pilot studies for fully coupled reanalysis (GFS, GODAS & GLDAS)
- **Jan 2008**: Production and Evaluation of CFS Reanalysis for 1979 to present
- **Jul 2008**: Prepare CFS Retrospective Forecasts (2 initial months: October and April)
- **Jan 2009**: Complete CFS Retrospective Forecasts (remaining 10 months)
- **Nov 2009**: Compute calibration statistics for CFS daily, monthly and seasonal forecasts.
  
  Prepare CFS Reanalysis & Retrospective Fcst data for public dissemination.
- **Jan 2010**: Operational implementation of the next CFS monthly & seasonal forecast suite.