Ensemble Prediction System at Japan Meteorological Agency

Wednesday afternoon session
10th THORPEX GIFS-TIGGE Working Group meeting
Boulder, NCAR and NOAA/ESRL
25 – 27 June, 2012

KYOUDA Masayuki,
UJIIE Masashi, YAMAGUCHI Haruki,
and TOKUHIRO Takayuki
Contents

• Outline of JMA operational EPSs
  – One-week EPS, Typhoon EPS, and One-month EPS
• Future plan of JMA EPS
  – Next generation: Integrated EPS
• Research and development for the next-generation EPS
  – Scale-dependent error and spread
  – Daily verification up to two weeks
  – Daily effect on removing systematic error
  – Impact on increase of ensemble size
• Conclusions
Outline of JMA Operational EPSs
The scale of phenomena varies in space and time.

- precipitation, baroclinic instability, quasi-stationary Rossby waves, MJO

JMA launched its operational EPSs for One-month Forecasts, One-week Forecasts, and 5-day tropical cyclone track forecasts in March of 1996, 2001, and 2008, respectively.
JMA operational EPS (2)

- At present, 11, 51, and 50 initial conditions are integrated by using a low-resolution version of the JMA global NWP model for producing an ensemble of **132-hour forecasts in the Typhoon EPS**, **9-day forecasts in the One-week EPS**, and **17/34-day forecasts in the One-month EPS**.

  - to assess uncertainties of the forecast targeted on specified phenomena.

<table>
<thead>
<tr>
<th>Week1</th>
<th>Week2</th>
<th>Week3</th>
<th>Week4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typhoon EPS up to 5.5 days</td>
<td>One-week EPS up to 9 days</td>
<td>One-month EPS up to 17 days</td>
<td>One-month EPS up to 34 days</td>
</tr>
</tbody>
</table>
## Specification of medium-range EPS at JMA

<table>
<thead>
<tr>
<th>EPS model and its integration</th>
<th>One-week EPS</th>
<th>Typhoon EPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objectives</strong></td>
<td>One-week forecast</td>
<td>Typhoon forecast</td>
</tr>
<tr>
<td>Forecast Domain</td>
<td>The whole Globe by using JMA’s AGCM, “GSM”</td>
<td></td>
</tr>
<tr>
<td>Horizontal Resolution</td>
<td>$T_L319$ (~55km)</td>
<td></td>
</tr>
<tr>
<td>Vertical Levels</td>
<td>60 levels, up to 0.1 hPa</td>
<td></td>
</tr>
<tr>
<td>Forecast Hours</td>
<td>216 hours (12UTC)</td>
<td>132 hours (00, 06, 12, 18) only when Tropical Cyclones of TS/STS/TY intensity are present or are expected to appear in the RSMC Tokyo – Typhoon Centre’s area of responsibility</td>
</tr>
<tr>
<td>Member</td>
<td>1 control run and 50 perturbed runs</td>
<td>1 control run and 10 perturbed runs</td>
</tr>
<tr>
<td>Initial perturbation</td>
<td>SV method, Three target areas (NH, TR, SH)</td>
<td>SV method, RSMC target (Fixed) and Max. 3 Typhoon Target (Movable)</td>
</tr>
<tr>
<td>Model ensemble</td>
<td>Stochastic Physics</td>
<td></td>
</tr>
</tbody>
</table>

More detailed information is available at the JMA part of the latest “WMO Technical Progress Report on GDPSF and NWP Research” and the standardized EPS documentation in Excel spreadsheet format at [http://tigge.ecmwf.int/models.html](http://tigge.ecmwf.int/models.html)
## Specification of extended-range EPS at JMA

<table>
<thead>
<tr>
<th>Objective</th>
<th>One-month EPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objectives</strong></td>
<td>Early warning information on extreme events</td>
</tr>
<tr>
<td><strong>Forecast Domain</strong></td>
<td>The whole Globe by using JMA’s AGCM, “GSM”</td>
</tr>
<tr>
<td><strong>Horizontal Resolution</strong></td>
<td>$T_L 159$ (≈110km)</td>
</tr>
<tr>
<td><strong>Vertical Levels</strong></td>
<td>60 levels, up to 0.1 hPa</td>
</tr>
<tr>
<td><strong>Forecast Hours</strong></td>
<td>17 days; every Wednesday and Thursday</td>
</tr>
<tr>
<td><strong>Ensemble Settings</strong></td>
<td>34 days; every Sunday and Monday</td>
</tr>
<tr>
<td><strong>Member</strong></td>
<td>1 control run and 24 perturbed runs</td>
</tr>
<tr>
<td><strong>Initial perturbation</strong></td>
<td>$x$ 2 days (LAF) = 50 (1 dataset) per week produced</td>
</tr>
<tr>
<td><strong>Model ensemble</strong></td>
<td>BGM method, two target areas (NH and TR)</td>
</tr>
<tr>
<td><strong>Hindcast</strong></td>
<td>Not considered</td>
</tr>
<tr>
<td><strong>Member</strong></td>
<td>1 control run and 4 perturbed runs</td>
</tr>
<tr>
<td><strong>Sampling size</strong></td>
<td>3 initials per month $x$ 12 months (the $10^{th}$, $20^{th}$ and end of every month) $x$ 31 years (1979 to 2009)</td>
</tr>
</tbody>
</table>
Future Plan of JMA EPS
Plan for an integrated EPS

- Verification results of the One-week EPS show the notable steady increase in ensemble forecast skill after it became operational.
  - Presently, the anomaly correlation coefficient of 9-day 500hPa geopotential height forecast for the extratropical Northern Hemisphere reaches 0.6.
- The One-month EPS is also operated for two-week forecasting.
  - But two-week forecasting is influenced by initial condition problems. The targeted phenomena and uncertainties are similar between the two EPSs.
- It is more efficient to unify the two EPSs for development costs.
- Consistent (in quality) EPS products are needed for one- and two-week forecasting operation.
Tasks to integrate three EPSs

- Unifying and verifying specifications of these EPSs
- Introducing hindcast (reforecast) system to One-week EPS

<table>
<thead>
<tr>
<th>Week1</th>
<th>Week2</th>
<th>Week3</th>
<th>Week4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Te(TL479L96)</td>
<td>We(TL479L96)</td>
<td>K2(TL319L96)</td>
<td>K1(TL319L96)</td>
</tr>
</tbody>
</table>

Te: Typhoon EPS
We: One-week EPS
K2,K1: One-month EPS

Next Plan

Extended We
Te(TL479L96)

Hindcast

K1(TL319L96)
Development and Research for the next-generation EPS
Scale-dependent error and spread

All scale score of the One-week EPS

Planetary scale: zonal wave-numbers 0 to 3

Synoptic scale: zonal wave-numbers 4 to 14

Small scale: zonal wave-numbers 15 to 63

Planetary- and synoptic-scale spreads are insufficient especially for longer lead time.

Synoptic-scale spread is overestimated in short-range forecasting.

4-type time evolutions of ensemble-mean's error (red lines) and ensemble spread (orange lines) up to 9 days, derived from the One-week EPS, for 500hPa geopotential height for the extratropical Northern Hemisphere.
Daily verification up to two weeks

Time evolution of root-mean-square error of ensemble-mean (green line) and its control (red line), derived from the current hindcast-experiment for the One-month EPS, for 500hPa geopotential height for the extratropical Northern Hemisphere.

- Verified month is January.
- Verified forecasts are initiated at three initials per month from 1979 to 2009 with five members.
Daily effect on removing systematic error

Time evolution of root-mean-square error of \textit{raw ensemble-mean (red lines) and daily bias-removed one (green lines)}, derived from the One-week EPS with the current hindcast-experiment for the One-month EPS, for mean sea level pressure for the extratropical Northern Hemisphere (left panel) and 850 hPa temperature for the Tropics (right panel).

- Verified period is January 2010.
- Daily systematic errors are calculated by using the hindcast-dataset for 1979-2000.
Impact on increase of ensemble size

- **Operational EPS (11 members)**
- **Experiment (25 members)**

Ensemble TC tracks of Typhoon “Talas” up to 120 hours derived from the Typhoon EPS (left panel) and an experimental EPS (right panel).

- Initial time is 12UTC 28th August 2011.
- Black lines and color lines indicate the best track and the forecast tracks, respectively.
Conclusions

• JMA has been developing and operating a suite of EPSs.
  • One-week EPS, One-month EPS, Typhoon EPS
• JMA plans to build up a global high-resolution EPS, which seamlessly covers a wide range of forecast periods from early medium-range up to one month in five years.
  • On the basis of the One-week EPS
  • With aim at development and unification of these three operational EPSs
• Presently, research and development for the next-generation EPS are conducted.
  • Daily validation up to two weeks
Thank you for your kind attention.