Tokyo Climate Center’s Activity in Long-range Forecasting Development

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Tokyo Climate Center (TCC)
Japan Meteorological Agency (JMA)
Tokyo Climate Center (TCC)

- Established in April 2002 at JMA to support climate services in the Asia-Pacific region.
- Designated as a GPC in 2007 and an RCC (RAII) in 2009.
- Major activities:
  - providing climate data and products to NMHSs through the website,
  - assisting with capacity building at NMHSs.
## JMA’s long-range forecast products

<table>
<thead>
<tr>
<th>Forecast products</th>
<th>Date of issue</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>One-month Ensemble Prediction System (EPS) with Atmospheric Global Circulation Model (AGCM)</strong></td>
<td></td>
</tr>
<tr>
<td>One-month forecast</td>
<td>Every Friday</td>
</tr>
<tr>
<td><strong>Seasonal Ensemble Prediction System (EPS) with Coupled Global Circulation Model (CGCM)</strong></td>
<td></td>
</tr>
<tr>
<td>Three-month forecast</td>
<td>Around 20th every month</td>
</tr>
<tr>
<td>Cold (DJF) / warm (JJA) season forecast</td>
<td>Around 20th of Feb., Mar. and Apr. (for JJA)</td>
</tr>
<tr>
<td></td>
<td>Around 20th of Sep. and Oct. (for DJF)</td>
</tr>
<tr>
<td>El Niño Outlook</td>
<td>Around 15th every month</td>
</tr>
</tbody>
</table>

These products are provided at TCC website: [http://ds.data.jma.go.jp/tcc/tcc/products/model/index.html](http://ds.data.jma.go.jp/tcc/tcc/products/model/index.html)
JMA’s Seasonal Prediction System

- Ensemble size: 51 members
- Ensemble method: BGM and LAF

**Observation**

**Atmospheric initial perturbation (BGM)**

**Atmospheric analysis (JCDAS)**

**Oceanic analysis MOVE/MRI.COM-G**

**CGCM**

**AGCM (JMA-GSM)**

**OGCM (MRI.COM)**

(Perturbation in the lower atmosphere in the tropics)

(Forcing)

Perturbed initial condition for Ocean

Atmospheric initial condition

Atmospheric initial perturbation

Coupling

NEACOF-5, October 29 - November 1, 2013
<table>
<thead>
<tr>
<th>Coupled Global Circulation Model (CGCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AGCM</strong></td>
</tr>
<tr>
<td>JMA/MRI Unified AGCM</td>
</tr>
<tr>
<td>- $T_L95L40$ (horizontal resolution ~ 180km)</td>
</tr>
<tr>
<td><strong>OGCM</strong></td>
</tr>
<tr>
<td>MRI.COM</td>
</tr>
<tr>
<td>Ishikawa et al. (2005)</td>
</tr>
<tr>
<td>- 75S-75N, 0-360E</td>
</tr>
<tr>
<td>(normal sea-ice conditions in the polar regions)</td>
</tr>
<tr>
<td>- Horizontal resolution (lon: 1 deg, lat: 0.3-1 deg)</td>
</tr>
<tr>
<td>- Vertical resolution : 50 levels (23 levels in the upper 200m)</td>
</tr>
<tr>
<td><strong>Coupler</strong></td>
</tr>
<tr>
<td>- Coupling interval : 1 hour</td>
</tr>
<tr>
<td>- Flux adjustment for heat and momentum flux</td>
</tr>
</tbody>
</table>
Prediction skill of CGCM (NINO3.4-SST)

- Verification by Barnston et al. 2012, BAMS, 93, 631-651.
- The time period for the verification: 2002-2011 (operational forecasts)

Correlation by Lead Time (all seasons)
Verification (SVSLRF website)

- Lead Centre for the Long-Range Forecast Verification System
  - Australian Bureau of Meteorology (BOM)
  - Meteorological Service of Canada (MSC)


- Model: JMA

**Level 1. Region scores**

- Exp.: ROC curves
- Parameter: T2m
- Season: DJF
- Lead time: 1 month
- Area: Tropics

**ROC scores**
TCC website


World climate

El Niño monitoring

Climate system monitoring

NWP model prediction (prediction maps, verification maps, GPV data)

Training module

Climate in Japan

Global warming

TCC News (newsletter)
Latest Products: forecast maps, probabilistic prediction maps, verification maps.

One-month prediction

Three-month prediction

Warm/cold season prediction

Download gridded data (including hindcast)

Model Descriptions (Model outline)
Forecast maps (Ensemble mean)

- **CHI200**
- **PSI200**
- **PSI850**
- **SLP**
- **SST**

**RAIN**
- Ensemble mean forecast
- Ensemble mean forecast (mask [miss < 0]
- Data: October 29 - November 1, 2013

**Z500**
- Ensemble mean forecast
- Contour interval

**Tsurf**
- Ensemble mean forecast
- Contour interval

**NDJ 2013/2014 (initial: October 2013)**
Probabilistic prediction maps

• These maps show the probability of most likely category (tercile).

### Precipitation

JMA Seasonal Forecast (Forecast Initial date is 13 10 2013)
Most likely category of Precipitation for NDJ 2013

### Surface temperature

JMA Seasonal Forecast (Forecast Initial date is 13 10 2013)
Most likely category of Surface Temperature for NDJ 2013

NDJ 2013/2014 (initial: October 2013)
Verification maps

Verification map of the north flow forecast error for NEACOF-5, October 29 - November 1, 2013
Future plan

The next version of CGCM are being developed to put it into operation in two years.

• Next version of CGCM
  – AGCM:
    • Higher resolution (TL95L40 -> TL159L60)
    • Improvement of model physics
    • Introduction of stochastic parameterization to improve perturbation for ensemble forecasting
  – OGCM:
    • Widening of target area (75N-75S -> the whole globe)
    • Improvement of model physics
    • Introduction of sea-ice model
Thank you!
Supplements
(seasonal forecast system)
### Operational global NWP models at JMA

<table>
<thead>
<tr>
<th>Prediction model and system</th>
<th>Main target</th>
<th>Horizontal resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Spectral Model (GSM)</td>
<td>• Short-range forecasting</td>
<td>20km Global</td>
</tr>
<tr>
<td>Typhoon EPS (TEPS)</td>
<td>• Typhoon forecasting</td>
<td>55km Global</td>
</tr>
<tr>
<td>One-week EPS (WEPS)</td>
<td>• One-week forecasting</td>
<td>60km Global</td>
</tr>
<tr>
<td>One-month Ensemble Prediction System (EPS) with Atmospheric Global Circulation Model (AGCM)</td>
<td>• Early warning Information on extreme events  • One-month forecasting</td>
<td>110km Global</td>
</tr>
<tr>
<td>Seasonal EPS with Coupled Global Circulation Model (CGCM)</td>
<td>• Seasonal forecasting  • El Niño outlook</td>
<td>180km Global</td>
</tr>
</tbody>
</table>
Ensemble prediction system (EPS) for seasonal forecasts

<table>
<thead>
<tr>
<th></th>
<th>One-month EPS</th>
<th>Seasonal EPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td>AGCM</td>
<td>CGCM</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>Horizontal: approx. 110 km (TL159) Vertical: 60 levels (~0.1 hPa)</td>
<td>* Atmospheric component Horizontal: approx. 180 km (TL95) Vertical: 40 levels (~0.4 hPa) * Oceanic component Horizontal: 1.0° longitude, 0.3–1.0° latitude (75°S – 75°N) Vertical: 50 levels</td>
</tr>
<tr>
<td><strong>Forecast range</strong></td>
<td>Up to 34 days</td>
<td>7-month (initial month of Sep., Oct., Feb., Mar., Apr) 4 months (other initial month)</td>
</tr>
<tr>
<td><strong>SST</strong></td>
<td>Persisted anomaly</td>
<td>Prognostic variable of CGCM</td>
</tr>
<tr>
<td><strong>Sea ice</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ensemble method</strong></td>
<td>Combination of Breeding of Growing Modes (BGM) and Lagged Forecast (LAF)</td>
<td>Growing Modes (BGM) and Lagged Forecast (LAF)</td>
</tr>
<tr>
<td><strong>Ensemble size</strong></td>
<td>50 (25 BGMs &amp; 2 days with 1-day LAF)</td>
<td>51 (9 BGMs &amp; 6 days with 5-day LAF)</td>
</tr>
<tr>
<td><strong>Frequency of operation</strong></td>
<td>Every Wednesday and Thursday</td>
<td>Every 5 days</td>
</tr>
<tr>
<td><strong>Frequency of model product creation</strong></td>
<td>Once a week Every Friday</td>
<td>Once a month Around the 20th of every month</td>
</tr>
</tbody>
</table>
Schema of aggregation for the ensemble members in the EPS for long-range forecasting of JMA

EPS adopts combination of the initial perturbation method and the Lagged Average Forecasting (LAF) method.
– to disperse computing resources
– to get ensemble spread

EPS adopts combination of the initial perturbation method and the Lagged Average Forecasting (LAF) method.
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Basetime for ensemble
forecast target period

-25 -20 -15 -10 -5 0 [day]
51 members

NEACOF-5, October 29 - November 1, 2013
Prediction skill of CGCM (N.H. winter circulation)

Anomaly Correlation Coefficient (ACC) between hindcast (1-month lead) and observation

ACC: -0.04

ACC: 0.37

NEACOF-5, October 29 - November 1, 2013
History of JMA’s models for seasonal and El Niño outlook

El-Niño prediction system

Current system
1-tiered system

JMA/MRI-CGCM
A:TL95L40
O:1.0x(0.3-1.0)
M51(9mem,LAF)
Feb.2010

2-tiered system

JMA-CGCM
A:T42L21
O:2.5x(0.5-2.0)
M6(LAF)
Aug.1999

JMA-CGCM02
A:T42L40
O:2.5x(0.5-2.0)
M6(LAF)
Jul.2003

JMA/MRI-CGCM
A:TL95L40
O:1.0x(0.3-1.0)
M12(LAF)
Feb.2008

JMA/MRI-CGCM
A:TL95L40
O:1.0x(0.3-1.0)
M30(5mem,LAF)
Feb.2009

AGCM
T63L40M31
Mar.2003

AGCM
TL95L40M31
Mar.2006

AGCM
TL95L40M51
Sep.2007

SST

Long range prediction system

◆ In 2010, the long range prediction system and the El Niño prediction system (2-tiered system) were combined into the 1-tierd system, and the upgraded CGCM was introduced for Seasonal forecast and El Niño outlook.
Improvement of prediction skill by introduction of CGCM

Anomaly Correlation Coefficient (ACC), JJA forecast (initial: February)

AGCM

CGCM

SLP

850hPa stream function

 Improvement over Asian monsoon region and around SPCZ

NEACOF-5, October 29 - November 1, 2013
Supplements
(prediction products on TCC website)
El Niño Monitoring & Outlook

JMA operates the Ocean Data Assimilation System and the El Niño Prediction System (an ocean-atmosphere coupled model) for monitoring and prediction of El Niño-Southern Oscillation (ENSO).

Monthly diagnosis reports, ENSO monitoring products, ENSO indices and El Niño outlooks are available on TCC website.

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### El Niño Outlook

(October 2013 - April 2014)

Last Updated: 10 October 2013

- ENSO neutral conditions continued in the equatorial Pacific.
- It is likely that ENSO neutral conditions will continue in the northern hemisphere autumn and winter.

[El Niño / La Niña]

In September 2013, the NINO 3 SST was near normal with a deviation of -0.2°C (Table and Fig.1). SSTs were above normal in the western equatorial Pacific (Fig.2 and Fig.4). Subsurface temperatures were above normal in the western equatorial Pacific (Fig.3 and Fig.5). Easterly winds in the lower troposphere were stronger than normal in the central part (Fig.7 and Fig.8). On the other hand, in the central and eastern equatorial Pacific, deviations from normals of SSTs and subsurface ocean temperatures were small. This means that conditions in the northern hemisphere summer, which were similar to those observed during the past La Niña events, became unclear, and ENSO neutral conditions continued in the equatorial Pacific.

The JMA’s El Niño prediction model predicts that the NINO 3 SST will be near normal during the prediction period (Fig.9). Since subsurface ocean temperature anomalies in the central and eastern equatorial Pacific were small, it is considered that SSTs in the eastern part will not be affected significantly in the months ahead by the subsurface ocean conditions. In conclusion, it is likely that ENSO neutral conditions will continue in the northern hemisphere autumn and winter.

[Western Pacific and Indian Ocean]

The area-averaged SST in the tropical western Pacific (NINO WEST) region was above normal in September (Fig.1). It is likely that the NINO WEST SST will come closer to normal in the months ahead, and will be near normal during the northern hemisphere winter (Fig.10).

The area-averaged SST in the tropical Indian Ocean (IOBW) region was near normal in September (Fig.1). It is likely that the IOBW SST will be near normal or below normal during the northern hemisphere autumn and winter (Fig.11).
El Niño Monitoring & Outlook
(2) El Niño Monitoring Indices

- NINO.3
- SOI
- NINO.WEST
- IOBW

NEACOF-5, October 29 - November 1, 2013
(3) Model forecast of SST anomalies for Niño regions
Products available on TCC website

• **Maps**
  - Ensemble mean forecast map
  - Probabilistic forecast map
  - Verification (near real-time, hindcast)

• **Gridded data (binary)**
  - Operational run
  - Hindcast
    • Ensemble statistics
    • All ensemble members

(Only registered NMHSs can access.)

If you have any questions about ID and/or password, please e-mail to:

tcc@met.kishou.go.jp
Verification of hindcast

Verification of hindcast based on WMO Standard Verification System (SVS)

Verification of deterministic forecasts

- Mean Square Skill Score
  - RAIN | T2m | PSEA | Z500 | T850
  - Dependence of MSSS on Initial date

- 3 by 3 contingency tables (in Japan)
  - (Category: Below Normal, Near Normal, Above Normal)
  - RAIN | T2m | PSEA | Z500 | T850

Verification of Probabilistic forecasts

- Reliability diagrams (Aggregated verification)
  - (Anomaly > 0, Below Normal, Near Normal, Above Normal)
  - RAIN | T2m | PSEA | Z500 | T850

- Relative Operating Characteristics
  - ROC curves, ROC areas (Aggregated verification)
    - (Anomaly > 0, Below Normal, Near Normal, Above Normal)
    - RAIN | T2m | PSEA | Z500 | T850
    - Dependence of ROC areas on Initial date

  - ROC areas (Grid point verification)
    - (Anomaly > 0, Below Normal, Near Normal, Above Normal)
    - RAIN | T2m | PSEA | Z500 | T850
Animation of one-month prediction

TCC provides animation of JMA one-month prediction on an experimental basis.

http://ds.data.jma.go.jp/tcc/tcc/gpv/model/Anime.1mE.experiment/anime.e.php

(Only registered NMHSs can access.)

If you have any questions about ID and/or password, please e-mail to:
tcc@met.kishou.go.jp

http://ds.data.jma.go.jp/tcc/tcc/gpv/model/Anime.1mE.experiment/anime.e.php
Binary gridded data (GPV) (GPV: Grid Point Value)

Each files are available to download on your computer.

(Need to register)

### GPV data of 3-month forecast

| Parameters       | ● Ensemble mean: U200, V200, Z500, U850, V850, T850, mean sea level pressure, precipitation, 2m temperature  
|                 | ● SST used as boundary conditions |
| Temporal resolution | 1-month and 3-month mean |
| Spatial coverage and resolution | global, 2.5° × 2.5° |
| Lead time        | ● Monthly mean forecast: about 0.5, 1.5, and 2.5 months  
|                 | ● Three-month mean forecast: about 0.5 month |
| Issuance day     | Around 20th of every month |
| Data format      | GRIB2 |
| Calibration      | Model normals based on hindcast from 1984 to 2005 |
## GPV data of Cold/warm season forecast

| Parameters                  | Ensemble mean: U200, V200, Z500, U850, V850, T850, mean sea level pressure, precipitation, 2m temperature  
|                            | Ensemble members: Z100, Z200, U200, V200, T200, Z300, Z500, U500, V500, T500, Z850, U850, V850, T850, RH850, Q850, mean sea level pressure, precipitation, 2m temperature  
|                            | SST used as boundary conditions |
| Temporal resolution        | Ensemble mean: 1-month and 3-month mean  
|                            | Ensemble members: 1-month mean |
| Spatial coverage and resolution | global, 2.5º × 2.5º |
| Lead time                  | Ensemble mean: between about 1.5 and 3.5 months  
|                            | Ensemble members: between about 0.5 and 5.5 months |
| Data format                | GRIB2 |
| Calibration                | Model normals based on hindcast from 1984 to 2005 |