Verification and Application of High-resolution AGCMs for Climatology

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Contents

• High-resolution AGCMs for Risk Assessment

• New 20km MRI-AGCM and Its Performance

• On-going Japanese Research Program for Risk Information on Climate Change (SOUSEI-C)
High Resolution AGCMs are helpful in Assessment of Risk due to Global Warming
Advantages of High Resolution AGCMs

- **Realistic Present Climatology**
  (Observed SST is specified)

- Fine geography

- **Realistic Extreme Events such as Typhoons**

- Experiments can be controlled well.
- SST and Model Ensembles are easily made.
Typhoon Prediction and Model Resolutions (20km and 60km)

Track Prediction

36-hour Prediction

OBS 20km AGCM 60km AGCM

Minimum Sea Level Pressure

Maximum Wind Speed

(Murakami et al., 2008)
KAKUSHIN-3 Time-Slice Future Projection
(FY2007-FY2011)

Kitoh et al., 2009, HRL

CMIP3 AOGCMs

20km AGCM

Regional Climate Model

5km NHM
Nested in the 20km AGCM

2km, 1km NHM
Nested in the 5km NHM

AGCM

SST

Lower Boundary
Projected SST

OGCM

SST

1979 ~ 2003
1979 ~ 2003
2015 ~ 2039
2075 ~ 2099

Present
Near Term
Future

Observed SST (AMIP-type)
Obs + Projected SST change

Regional Climate Model

5km NHM
Nested in the 20km AGCM

2km, 1km NHM
Nested in the 5km NHM
A Result: Future Change of Tropical Cyclones

90% significance for Increase Decrease

Murakami et al., 2012, J.Climate

95% Significance

Murakami et al., 2011, J.Climate
New 20km AGCM (MRI-AGCM3.2S) was developed by Mizuta et al (2012)
## MRI-AGCM 3.1 vs 3.2

### Previous version
(contributed to IPCC AR4)

<table>
<thead>
<tr>
<th>MRI-AGCM 3.1</th>
<th>MRI-AGCM 3.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Mizuta et al., 2006, <em>JMSJ</em>)</td>
<td>(Mizuta et al., 2012, <em>JMSJ</em>)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Horizontal resolution</th>
<th>TL959 (20km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical resolution</td>
<td>60 levels (top at 0.1hPa) 64 levels (top at 0.01hPa)</td>
</tr>
<tr>
<td>Time integration</td>
<td>Semi-Lagrangian</td>
</tr>
<tr>
<td>Time step</td>
<td>6minutes 10minutes</td>
</tr>
<tr>
<td>Cumulus convection</td>
<td>Prognostic Arakawa-Schubert</td>
</tr>
<tr>
<td>Cloud</td>
<td>Smith (1990)</td>
</tr>
<tr>
<td>GWD</td>
<td>Iwasaki et al. (1989)</td>
</tr>
<tr>
<td>Land surface</td>
<td>SiB ver0109(Hirai et al.2007)</td>
</tr>
<tr>
<td>Boundary layer</td>
<td>MellorYamada Level2</td>
</tr>
<tr>
<td>Aerosol (direct)</td>
<td>Sulfate aerosol 5 species</td>
</tr>
<tr>
<td>Aerosol (indirect)</td>
<td>No</td>
</tr>
</tbody>
</table>

### New version
(for IPCC AR5)
New Cumulus Scheme

In Previous AGCM → In New AGCM

(Mizuta et al., 2012)
Precipitation by Tropical Cyclones

Previous AGCM

AS-type

New AGCM

Yoshimura (2011)

Murakami et al., 2012, J.Climate
Tropical Cyclones ( Weak -> Strong )

Observation

(a) Observations (1979–2003)

(b) AGCM20 3.1 (1979–2003)

(c) AGCM20 3.2 (1979–2003)

Murakami et al., 2012, J.Climate

TL959L60
Previous AGCM

TL959L64
New AGCM
Model Verification by Numerical Metrics

Metrics (60-150E, EQ-30N)

<table>
<thead>
<tr>
<th>Element (July)</th>
<th>OBS</th>
<th>Previous</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation TRMM</td>
<td>0.3886</td>
<td>0.497</td>
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<tr>
<td>Precipitation CMAP</td>
<td>0.4523</td>
<td>0.5616</td>
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<tr>
<td>Precipitation GPCP</td>
<td>0.3441</td>
<td>0.4088</td>
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</tr>
<tr>
<td>500hPa Height JRA25</td>
<td>0.7266</td>
<td>0.7813</td>
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<tr>
<td>Sea Level Pressure JRA25</td>
<td>0.7894</td>
<td>0.8836</td>
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<tr>
<td>850hPa Temperature JRA25</td>
<td>0.9195</td>
<td>0.9776</td>
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<tr>
<td>850hPa Zonal Wind JRA25</td>
<td>0.8395</td>
<td>0.8547</td>
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<tr>
<td>200hPa Zonal Wind JRA25</td>
<td>0.8866</td>
<td>0.9641</td>
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</tr>
<tr>
<td>200hPa Meridional Wind JRA25</td>
<td>0.7945</td>
<td>0.7923</td>
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<tr>
<td>500hPa Height Wave JRA25</td>
<td>0.8161</td>
<td>0.868</td>
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<tr>
<td>SLP Wave JRA25</td>
<td>0.8185</td>
<td>0.902</td>
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<tr>
<td>850hPa T Wave JRA25</td>
<td>0.8785</td>
<td>0.936</td>
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</tr>
<tr>
<td>850hPa Zonal Wind Wave JRA25</td>
<td>0.8393</td>
<td>0.8833</td>
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<tr>
<td>200hPa Zonal Wind Wave JRA25</td>
<td>0.7995</td>
<td>0.9217</td>
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</tr>
</tbody>
</table>

(Mizuta et al., 2012)
Jun-> Sep East Asia (Precipitation, Sea Level Pressure, 200hPa Jet)

OBS (JRA25+CMAP)

New AGCM

Previous AGCM

(Mizuta et al., 2012)
New 20km AGCM is comparable with TRMM Observation

(Endo et al., 2012)
Precipitation Details (AGCM and NHRCM)

* All values are interpolated at 20km mesh grids

(Kanada et al. 2010)
New Japanese Program (SOUSEI-C)
Development of Basic Technology for Risk Information on Climate Change
by Izuru Takayabu (MRI/JMA)

(ii) Producing a standard climate scenario of Future projection by using super high resolution models

20km AGCM → Projection Output → Boundary data for downscaling over any regions in the world → downscaling around Japan → 5~2km NHRCM
SST Change Ensemble for Future Projection
Based on Cluster Analysis of CMIP5-RCP8.5 Scenario Projections

(by Mizuta (2012_SOUSEI Report))
AGCM Coupling with SST-Restored Ocean

Precipitation & SLP

SST Change from 5 days before
Summary

• High-resolution AGCMs have advantages in simulating realistic climatology for Regional downscaling and realistic Extreme-events such as Tropical cyclones, as compared with CGCMs.

• 20km MRI-AGCM is improved so as to simulate climatology and tropical cyclones further realistically by introducing a new cumulus scheme.

• New Japanese research program for Risk Information on Climate Change (J-MEXT SOUSEI-C) started. The 20km-mesh AGCM ensemble prediction outputs for regional downscaling over any regions will be available as well as the outputs for analysis.
Acknowledgements

This work was conducted under the framework of the “Development of Basic Technology for Risk Information on Climate Change” supported by the SOUSEI Program of the Ministry of Education, Culture, Sports, Science, and Technology.


• Kanada, S., M. Nakano, and T. Kato, 2010: Climatological characteristics of daily precipitation over Japan in the Kakushin regional climate experiments using a non-hydrostatic 5-km-mesh model: Comparison with an outer global 20-km-mesh atmospheric climate model. SOLA, 6, 117-120.


