53-year downscaling over Japan at 5km coupled with the ECMWF Reanalysis data

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Background Objective:

To evaluate the influence of weather and climate change on electric power facilities, a 53-year downscaling was conducted over Japan. These data-set will apply to make plans for fatigue damage measures and maintenance programs for electric power facilities.
Model description and calculation environment

Base Model: WRF-ARW3.2.1

Forcing: ECMWF ERA-40
- ECMWF ERA-Interim
  (6 hourly, 100km horizontal resolution)

- ERA-Interim Jan. 1 1987 – Dec. 31 2010

Output File: Domain01 3 hour,
/ Domain02 1 hour

Domain: domain01 (15km: nx150×ny160),
domain02 (5km: nx361×ny391)
Vertical: 35 layers, model top=50hPa

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<th>Cumulus parameterization</th>
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The reproducions of using ERA-40 and ERA-Interim were parallel executed.

The ground level variables were updated from 1 year reproduction pre-runs (2 times).

Improvement of the setting methods of the sea ice distributing and the lake temperature estimation model, etc.
The effect of Lateral Boundary Conditions (LBCs)

\[ \text{RMSE} = \sqrt{\sum \sum (\text{Model}(i, j) - \text{Analysis}(i, j))^2 / (nx*ny)} \]

⇒ The geopotential height error in the model did not accumulate.
Monthly averaged Geopotential Height at 500hPa (Domain01)

ERA-Interim (1989～2010)

Red line: Forcing data (ECMWF Re-analysis), Blue line: Regional climate model (WRF-ARW)
The land surface model evaluation at long-term simulation

Karuizawa Observation Site
The east foot hills of Mt. Asama in Japan (Height 1,380m)

(a) Snow Depth

(b) Soil Temperature (°C: Centigrade)

Fig. Comparison of Snow Depth and Soil Temperature at Karuizawa Observation Site.

⇒ A land surface model well reproduced the seasonal variations.
Evaluating reproduction’s accuracies using weather observation stations data

Fig. JMA’s surface weather observation stations including Domain02 (Total 143points)

Comparison of annual mean and accumulated bias in all areas (1991-2010)

- Temperature at 2m; 0.4deg (-0.2 ~ 0.7deg)
- Precipitation; 82mm (-227 ~ 396mm)
- Wind speed at 10m; 0.8m/s (0.4 ~ 1.2m/s)

All observation are divided into 10 regions
Comparison of temperature, precipitation and wind speed at Fukuoka weather observation station (1958-2008)

Average annual temperature

Annual accumulated precipitation

Average annual wind speed

Change Cup type anemometer (4cup ⇒ 3cup)

Change Propeller type anemometer
Comparison of one year accumulated precipitation

(a) Analyzed precipitation by Observations
(b) Calculated precipitation by WRF
Fig. Comparison of one year accumulated precipitation in 2004.

⇒ The result of Observation and WRF was corresponding well.
Conclusions

・We conducted 53-year runs over Japan with 5km resolution coupled with the ECMWF reanalysis data from 1958 to 2010.

・The effect of lateral boundary conditions was discussed using GPH at 200 and 500hPa, and it showed that the error in the model did not accumulate.

・The reproduction runs were evaluated using weather observation stations, and the model results were in good agreement with observations.

・WRF well reproduced the accumulated precipitation for one year.

・The WRF has the capability to reproduce weather and climate with high accuracy.
Thank you!

I will stay at NCAR from Sep. 2013 to Sep. 2014. I am looking forward to seeing you in September.
Computing Environment

SGI-IceX (Intel Xeon E5-2670 8core 2.6GHz)
4,032CPU / 3,256core (670.9TFlops)

Calculation time
128CPU: 20min/day, 5.1日/year
256CPU: 14min/day, 3.7日/year
512CPU: 11min/day, 2.8日/year

File size:
Domain1  74MB / 1file
Domain2  434MB / 1file

Total: (53year) : 210TB
(History interval: Domain1 180min,
Domain2 60min)
Soil Moisture distribution (Layer=4, 100-200cm)

Start date (1957-09-01)

1 time:
Start date (1958-09-01)

2 time:
Start date (1958-09-01)
Geopotential Height at 500hPa (Domain01)

Relative Humidity at 700hPa (Domain01)

ERA40 (1558〜1988)
Red line: Forcing data (ECMWF Re-analysis), Blue line: Regional climate model (NuWFAS-RCM)

ERA-Interim (1989〜2010)
Impact of cumulus parameterization at 5km horizontal resolution

Comparison of 24 hour accumulated precipitation around at Baiu (seasonal rain) frontal zone

(a) Radar Analyzed
(b) RCM (Domain02: non-cumulus)
(c) RCM (Domain02: cumulus)

Fig. The local heavy precipitation at the northern part of Kyusyu district in July 2009. ⇒ WRF well reproduced the accumulated precipitation such as extreme climate events, therefore we selected no cumulus at Domain02.
Comparison of one year accumulated precipitation

(a) Observation
(b) RCM
   (Domain02: non-cumulus)
(c) RCM
   (Domain02: cumulus)
Comparison of one year accumulated precipitation using Scatter Diagram (Oct. 2008 – Sep. 2009.)

(a) WRF-RCM
( Domain02: non-cumulus)
APHRODITE: Analyzed precipitation by observations

(b) WRF-RCM
( Domain02: cumulus)
Comparison of Daily Maximum Rainfall distribution
(Period: 2008/10 – 2009/09)

(a) Observation
(b) RCM (Domain02: non-cumulus)
(c) RCM (Domain02: cumulus)
Comparison of one year accumulated precipitation using Scatter Diagram (Oct. 2008 – Sep. 2009.)

(a) 第2領域積雲あり
(a) 第2領域積雲なし
Comparison of one year accumulated precipitation (ERA-Interim, 2003)

(a) RCM
(Domain02: non-cumulus)

(b) RCM
(Domain02: cumulus)