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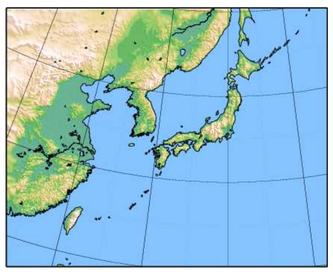
Development of Limited-Area NWP Systems at JMA

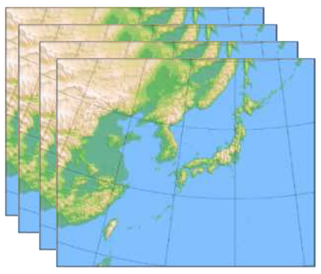
Aranami Kohei*, Sawada Masahiro, Matsubayashi Kengo, Kusabiraki Hiroshi, Anzai Taro, Ogihara Hirotaka, Nishimoto Shusuke, Tanoshita Junichi, Yamasaki Yukihiro, Okugawa Ryosuke, Kimura Tsubasa, Ishida Ryoga
Numerical Prediction Division, Japan Meteorological Agency
* aranami@met.kishou.go.jp

1. Regional operational NWP systems at JMA



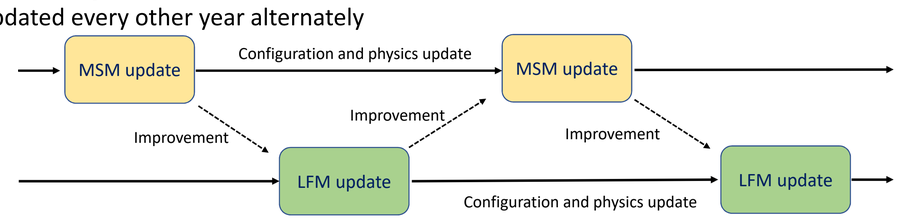
Meso-Scale Model (MSM):
Horizontal resolution: 5km
Vertical levels / top: 96 / 37.5km
Forecast hours (initial times):
78 hours (00, 12 UTC)
39 hours (03, 06, 09, 15, 18, 21 UTC)
Initial conditions: Meso-scale analysis (MA) (4D-Var)

Local Forecast Model (LFM):
Horizontal resolution: 2km
Vertical levels / top: 76 / 21.8km
Forecast hours (initial times):
10 hours (00–23 UTC hourly)
Initial conditions: Local analysis (LA) (hybrid 3D-Var)



Meso-Scale Ensemble Prediction System (MEPS):
Horizontal resolution: 5km
Vertical levels / top: 96 / 37.5km
Forecast hours (initial times):
39 hours (00, 06, 12, 18 UTC)
Initial conditions: Meso-scale analysis with ensemble perturbations (SV)
Ensemble members: 21 (Control = MSM)

Update Cycle of MSM and LFM
Updated every other year alternately



2. Update of Local Forecast Model (LFM2303)

Mar. 2023

Highlights:
- Improvement on cloud microphysics scheme
- Update of the elevation dataset
- Introduction of a turbulent orographic form drag (TOFD) scheme
- Modification of scale length in the MYNN3 scheme

Improvement on cloud microphysics scheme
- Introduction of the cloud microphysics scheme (Ikuta et al. 2021) used in the MSM, with modifications for 2km resolution model
  - Consideration of the non-uniform distribution within a grid by introducing the partial cloud
  - Modifications of the M-D and V-D relationship
  - RHc adjusted to 80 – 99 % for the 2km model, while 75 – 90 % for the 5km model.

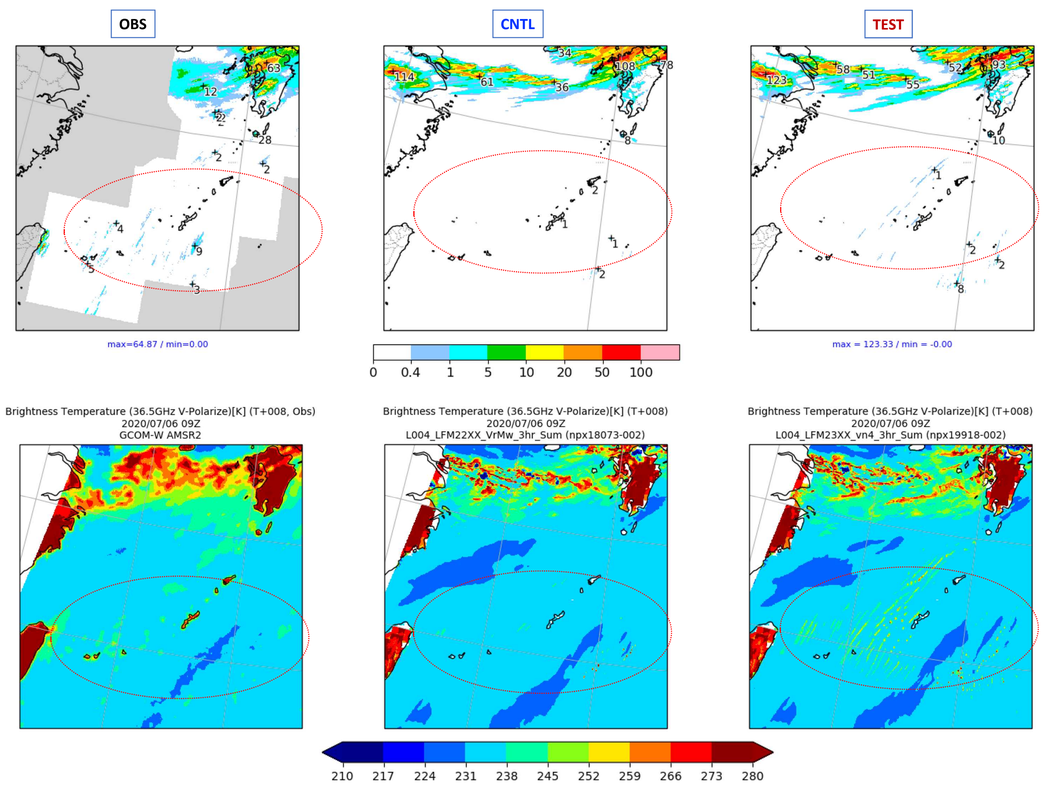


Fig.1 Precipitation distribution (top) and AMSR2 36.5V brightness temperature (bottom) of the observation (left), original (middle) and LFM2303 (right) configurations.

Update of the elevation dataset
- Changed the elevation dataset from GTOPO30 to MERIT-DEM (Yamazaki et al. 2017)
  - MERIT-DEM: 3” resolution, GTOPO30: 30” resolution

Introduction of a turbulent orographic form drag (TOFD) scheme
- Introduction of Beljaars et al. (2004)
  - TOFD scheme integrates over the spectral orography to represent all the relevant scales.

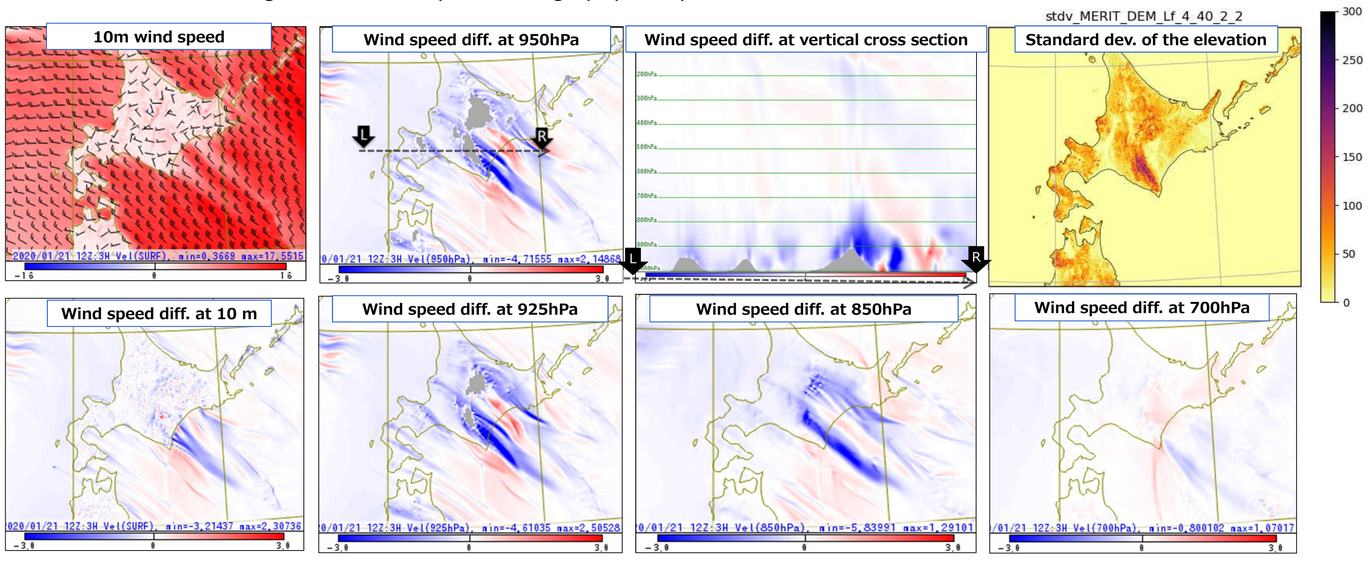


Fig.2 A case study : Wind speed differences (TEST-CNTL) at various levels and cross section at the forecast lead time of 3 hours (T=3) with the standard deviation of the elevation (top-right). Wind stream is reduced in the areas where the standard deviation of the elevation is large and downstream side the area.

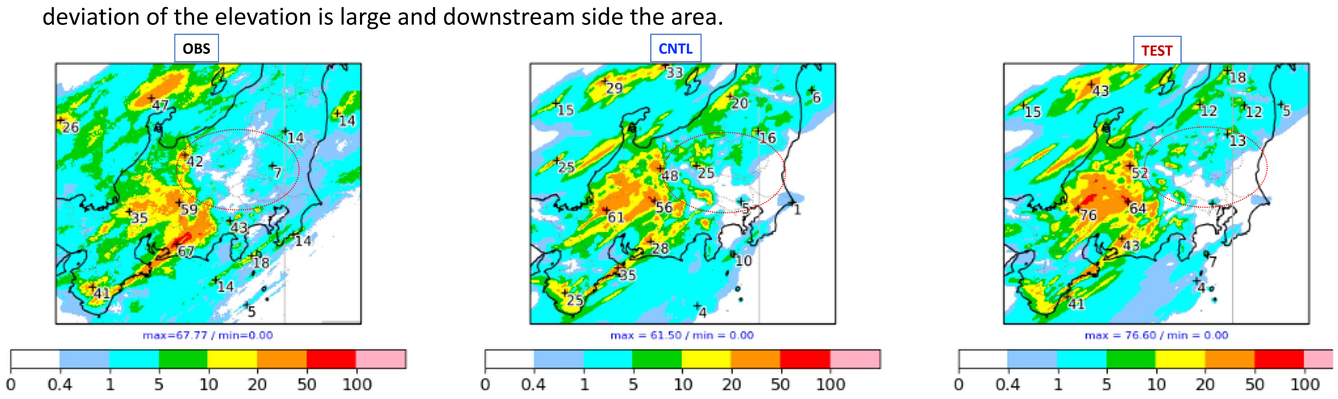


Fig.3 A precipitation forecast result for LFM2303 (right) and previous configuration (center) compared with the observation (left). Excessive precipitation in the downstream side of the Japanese Alps has been reduced.

Modification of the length scale in the MYNN3 (Nakanishi and Niino 2009) scheme
- Change the formula of the three equations to determine the master length.
  - Fixed the issue that the extremely large length scale in the boundary layer.

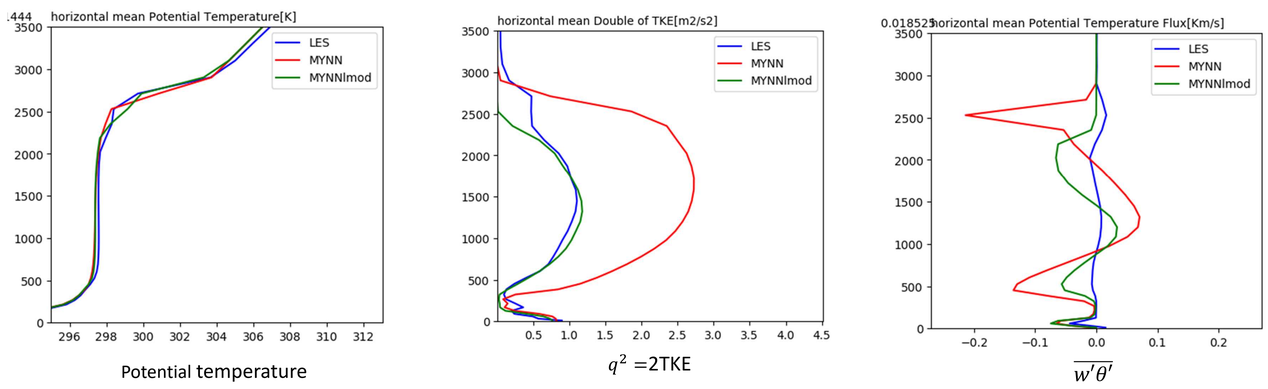


Fig.4 Impact of the modification for the GABLS3 test case compared with the LES result.

Score card

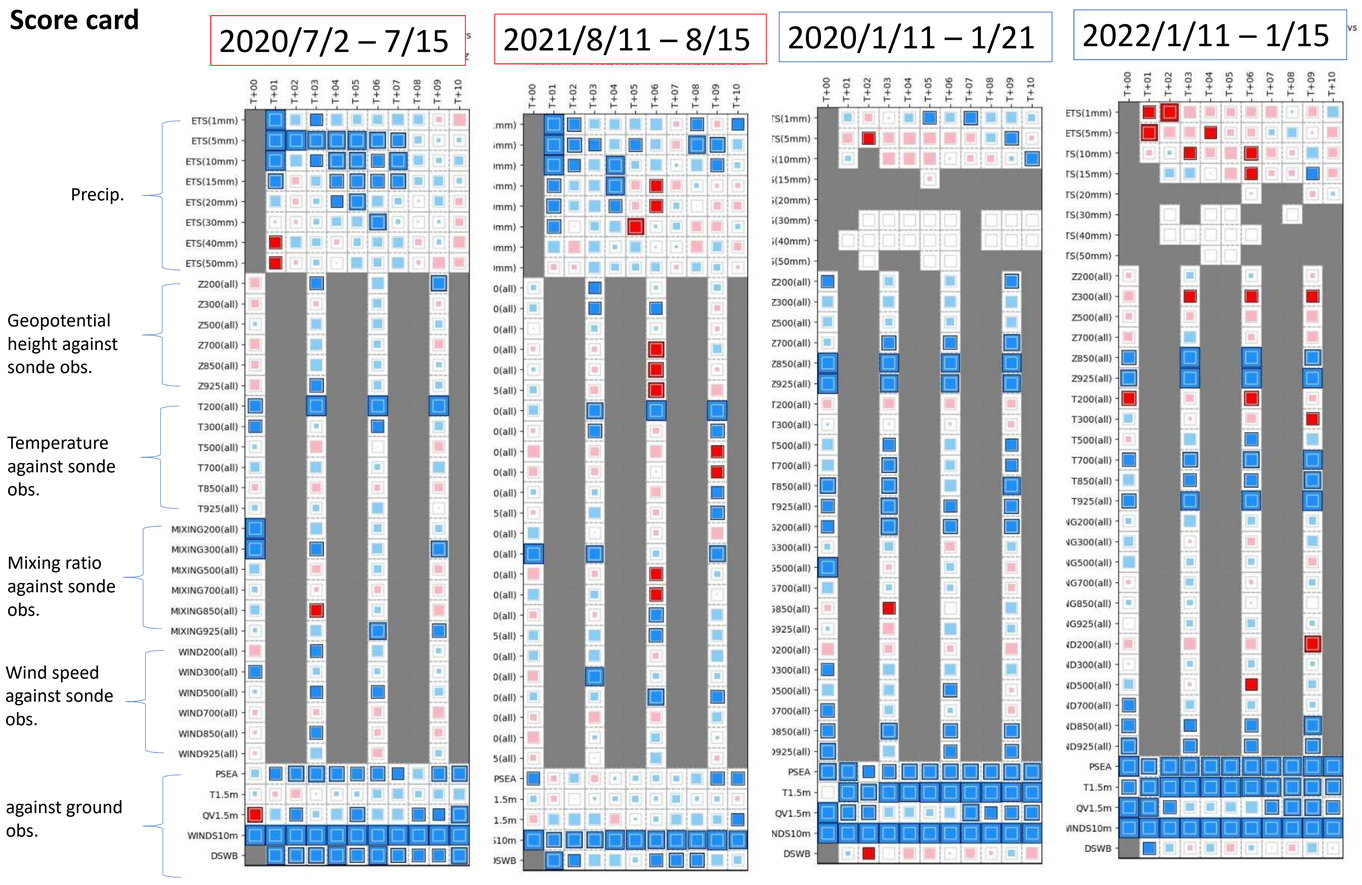


Fig.5 Score card for the LFM2303 configuration experiment compared with the previous configuration. Color panel indicates the improved (blue) and worsened (red).

References:

- Beljaars, A. C. M., Brown, A. R., & Wood, N. (2004). A new parametrization of turbulent orographic form drag. Quart. J. Royal Meteor. Soc., 130(599), 1327–1.
- Ikuta, Y., Satoh, M., Sawada, M., Kusabiraki, H., & Kubota, T. (2021). Improvement of the cloud microphysics scheme of the mesoscale model at the Japan Meteorological Agency using spaceborne radar and microwave imager of the global precipitation measurement as reference. Monthly Weather Review, 149(11), 3803–38.
- Nakanishi, M. and H. Niino, 2009: Development of an Improved Turbulence Closure Model for the Atmospheric Boundary Layer. J. Meteor. Soc. Japan, 87, 895–912.
- Yamazaki, D., D. Ikeshima, R. Tawatari, T. Yamaguchi, F. O'Loughlin, J. C. Neal, C. C. Sampson, S. Kanae and P. D. Bates, 2017: A high-accuracy map of global terrain elevations. Geophysical Research Letters, 44, 5844–5853.