Initialization Scheme for Water Substances in the operational NHM

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The Japan Meteorological Agency (JMA) started the operational run of a nonhydrostatic model (NHM) on 1 September 2004 in place of the MSM (the former operational mesoscale model of JMA). NHM was developed based on the Meteorological Research Institute/Numerical Prediction Division unified nonhydrostatic model (Saito et al., 2001).

The bulk cloud microphysics used in NHM contains prognostic variables for the mixing ratios of water vapor, cloud water, rain, cloud ice, snow, and graupel. The JMA Meso 4D-VAR (Ishikawa and Koizumi, 2002) which gives the initial fields of NHM does not produce the initial fields for these water substances except the water vapor. Since the initial values of these water substances were set to zero at the early stage of development of NHM, a spin-up problem had been clearly seen where the precipitation is underestimated at initial time (Ishida and Narita, 2003). We have developed a new initialization scheme for the water substances.

Since the operational NHM is run four times a day, a 6-hourly forecast-forecast cycle system is employed for the water substances. The mixing ratios of cloud water, rain, cloud ice, snow, and graupel from output of the preceding (6 hours before) forecast are used as first guess values. These guess values are set to zero at the grid point where the relative humidity given by the Meso 4D-VAR analysis is less than 90 per cent in consideration of the consistency with the analysis field.

Figure 1 shows the one hour precipitation of the first three hours initialized at 06 UTC 30 October 2004. The left column indicates the observation by the Radar-AMeDAS analysis. The middle and right columns show the forecasts by NHM without and with initialization of water substances, respectively. It is clear that precipitation of NHM without initialization is much less than that of observation. Figure 2 shows the time sequence of numbers of grid points exceeding threshold values of precipitation by the Radar-AMeDAS analysis (red), by NHM with initialization (green), and by NHM without initialization (blue). The grid points over land and over sea within 100 km from the coast are counted (the area is wider than that of Fig. 1). The underestimation of precipitation in NHM without initialization is significant at the first one hour, and continues until three or four hours for weak rain (threshold: 0.5mm/hr) and six hours for moderate rain (threshold: 2mm/hr). The initialization scheme significantly improves this underestimation. Figure 3 shows the bias and threat scores of NHM with and without initialization and MSM for eight cases from 18 July to 19 July 2003. The bias scores of NHM with initialization are quite improved and the threat scores are also increased. The scores for longer periods and detailed validation of the operational NHM are described in Saito et al. (2005).

The initialization scheme of NHM for water substances has improved the precipitation forecast at the beginning of the forecast. Although the goal of initialization of water substances is a 4D-VAR analysis using bulk cloud microphysics, this scheme has been adopted into the operational NHM because of its effectiveness and simplicity. Since the current scheme does not consider the observational data of rainfall, a new additional treatment for initialization using observed rainfall is under development.

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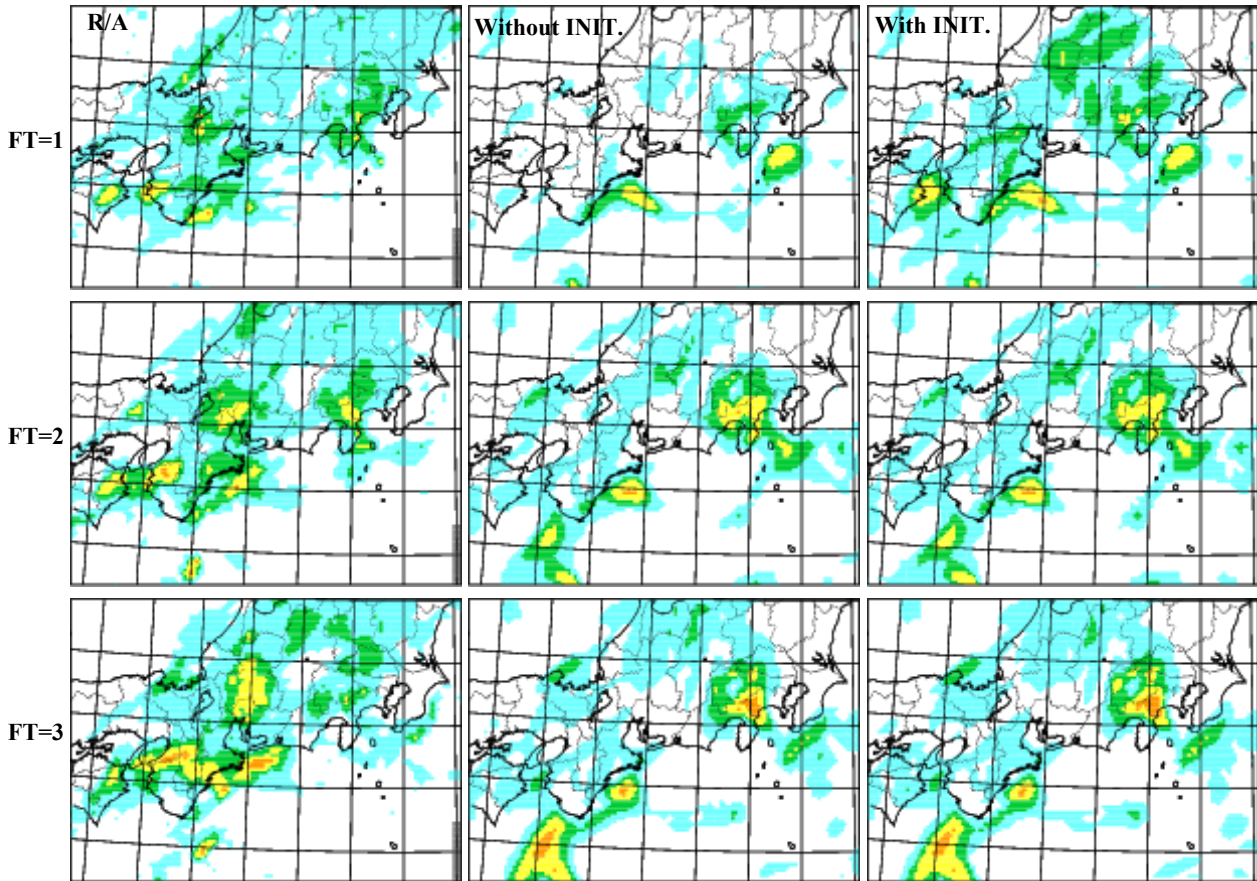
Fig.1. One hour precipitation. Left: observed by Radar-AMeDAS analysis. Center: forecasted by NHM without initialization. Right: forecasted by NHM with initialization. The initial time of NHM is 0600 UTC 30 October 2004.
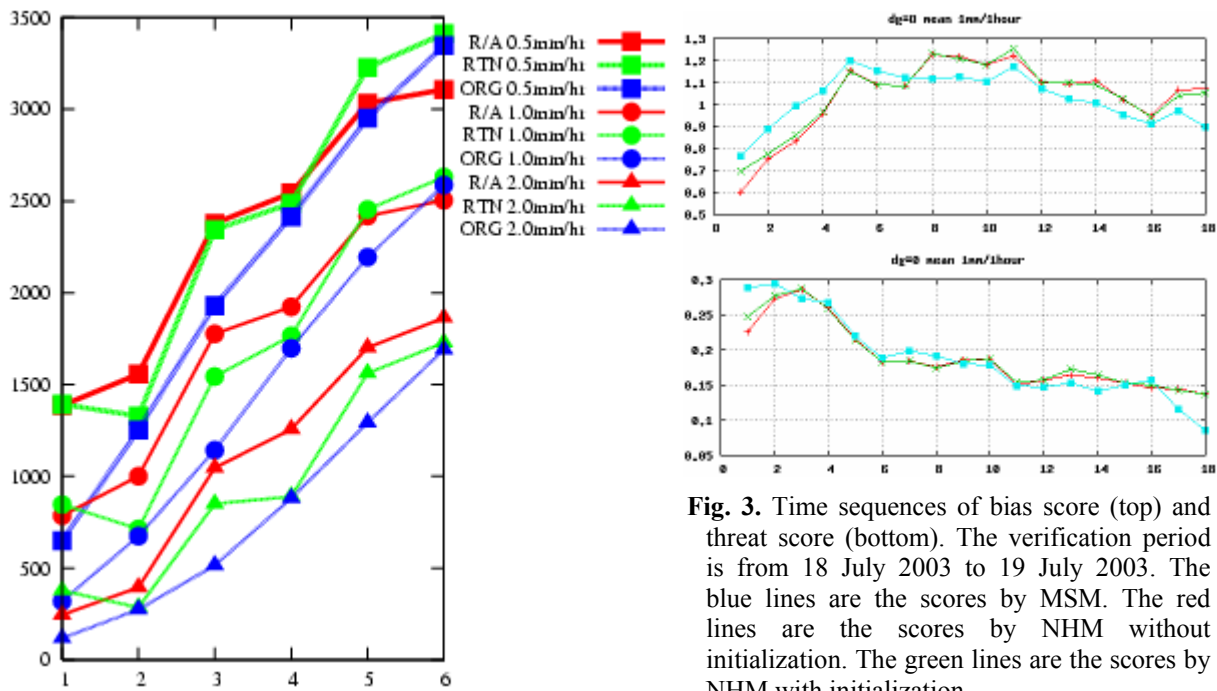

Fig. 2. Time sequence of numbers of grid points exceeding threshold values of precipitation. Red: Radar-AMeDAS analysis. Green: NHM with initialization. Blue: NHM without initialization.
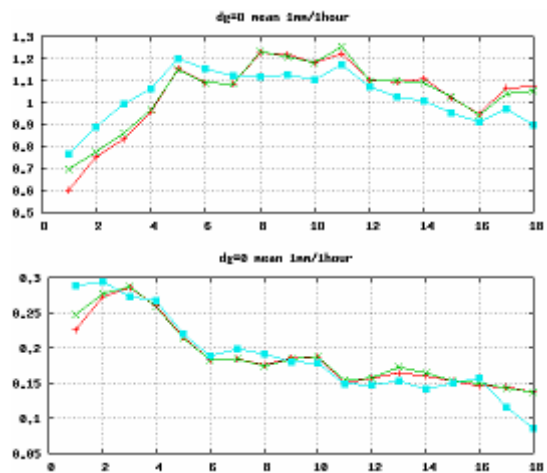

Fig. 3. Time sequences of bias score (top) and threat score (bottom). The verification period is from 18 July 2003 to 19 July 2003. The blue lines are the scores by MSM. The red lines are the scores by NHM without initialization. The green lines are the scores by NHM with initialization.