Cloud resolving simulation of a local heavy rainfall event on 26 August 2011 observed by the Tokyo Metropolitan Area Convection Study (TOMACS)

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On 26 August 2011, a local heavy rainfall event occurred in the Tokyo metropolitan area. In Tokyo and Kanagawa prefectures, very intense rains more than 90 mm hr-1 were observed (Fig. 2a) and several houses were inundated. This heavy rainfall event was caused by a mesoscale convective system (MCS) which was triggered by low level convergence, and its characteristics were captured by a dense observation network deployed by the Tokyo Metropolitan Area Convection Study (TOMACS; Nakatani et al., 2013). The merging of two misocyclones were studied by Saito et al. (2013) using data from a high-density ground weather observation network of TOMACS and the Doppler radar for the airport weather system of JMA. A rapid scan special observation was conducted by the Meteorological Satellite Center of JMA for this event. Figure 1a shows a visible satellite image at 1210 JST of 26 August 2011 taken by the rapid scan observation. Sea breeze fronts from the east coast of the Kanto Plain and the Bay of Tokyo intruded inland in the morning, and collision of the two fronts triggered an MCS. These behaviors of sea breezes were also confirmed by the dense surface observation network of JMA and the Atmospheric Environmental Regional Observation System (AEROS; for their characteristics as surface observation, see Nishi et al. (2014)) of the Japanese Ministry of Environment (Fig. 1b).

Despite its relatively larger spatial scale as a local rainfall in Japan and existence of low level convergence by a synoptic front, the operational mesoscale model (MSM) of JMA failed to predict this intense rainfall event (Fig. 2b). Studies on model physics, predictability, and data assimilation should be conducted to improve the forecast.

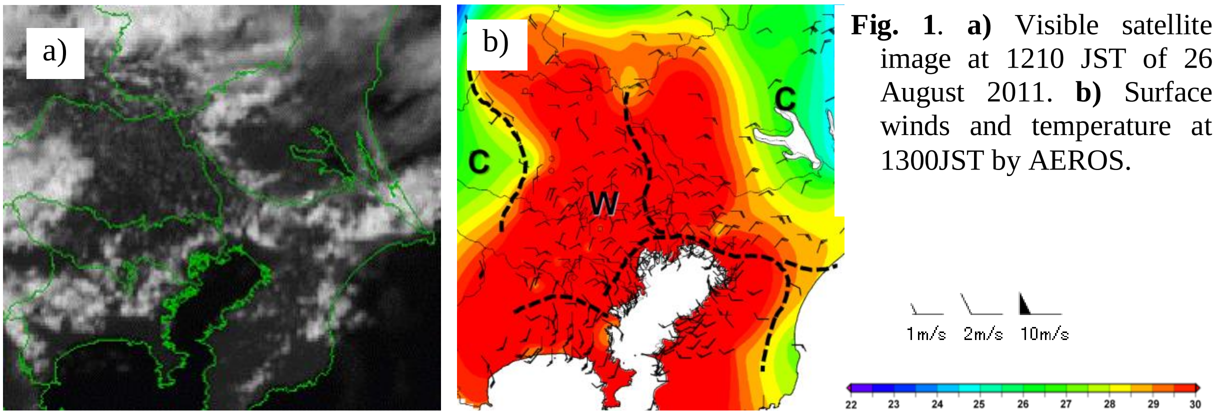

Fig. 1. **a)** Visible satellite image at 1210 JST of 26 August 2011. **b)** Surface winds and temperature at 1300JST by AEROS.

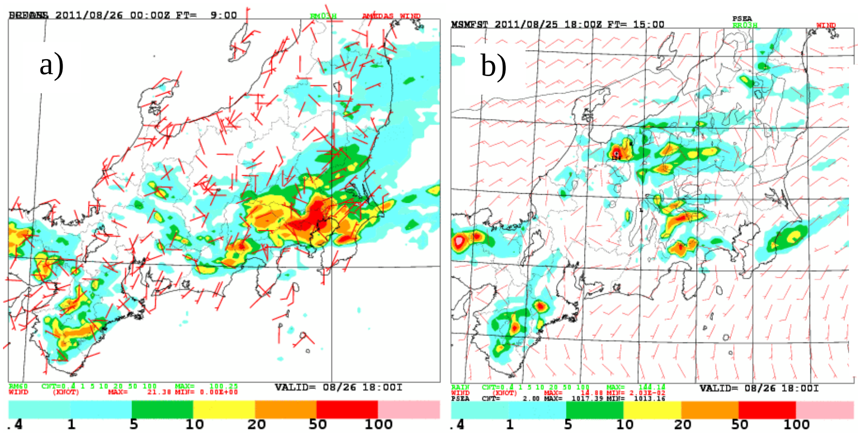

Fig. 2. a) Observed precipitation for 15-18 JST, 26 August 2011. **b)** Three-hour accumulated precipitation for 1500-1800 JST by MSM. Initial condition is 1800 UTC 25 August 2011 (FT=15).

Numerical experiments for this event have been performed. As a first trial, a simple downscale experiment from the operational mesoscale 4D-VAR analysis of JMA was conducted using the JMA nonhydrostatic model (NHM; Saito, 2012) with horizontal resolutions of 10 km and 2 km. Figure 3a shows three-hour accumulated precipitation for 1500-1800 JST by the 2 km NHM initiated at 1800 UTC 25 (0300 JST 26) August. Initial and boundary conditions were supplied from the 10 km NHM whose initial time was 1200 UTC (2100 JST) 25 August. The intense rainfalls appeared, but its position was in southwestern part of the Kanto Plain. A mesoscale ensemble forecast was also conducted using perturbations derived from the JMA one-week global ensemble prediction system (WEP) at 1200 UTC 25 August. However, only a few members intensified the rainfall around Tokyo and some fake precipitations appeared in the north of the Kanto Plain (figure not shown).

In NHM, the model cloud amount to compute radiation processes is evaluated from relative humidity considering subgrid scale partial condensation. Magnitude of the subgrid fluctuation is determined by the MYNN3 turbulent closure model. Recently, JMA has changed the lower limit of the fluctuation in their operational local model (LFM) to ameliorate an overestimation tendency of the cloud amount. When the lower limit was changed, surface temperatures increases about 1 C in southern part of the Kanto Plain, and it modified the position of low level convergence which triggered the MCS (figure not shown).

An additional experiment was conducted using an initial value perturbation by the mesoscale singular vector method (MSV; Kunii, 2010) based on the tangent linear and adjoint models of NHM. Figure 3b is the corresponding precipitation by the 2 km NHM for 1500-1800 JST, where perturbations from member ‘P04’ by MSV were added to the initial condition of the outer 10 km NHM. Fake precipitations in the north of the Kanto Plain were reduced, and the 2 km NHM captured the heavy precipitation in Tokyo and an associated cyclonic circulation around MCS. Figure 3c shows horizontal convergence at 1000 hPa and surface winds at 1500 JST by the simulation. Intrusion and collision of the two sea breeze fronts from the east coast of the Kanto Plain and the Bay of Tokyo were well reproduced.

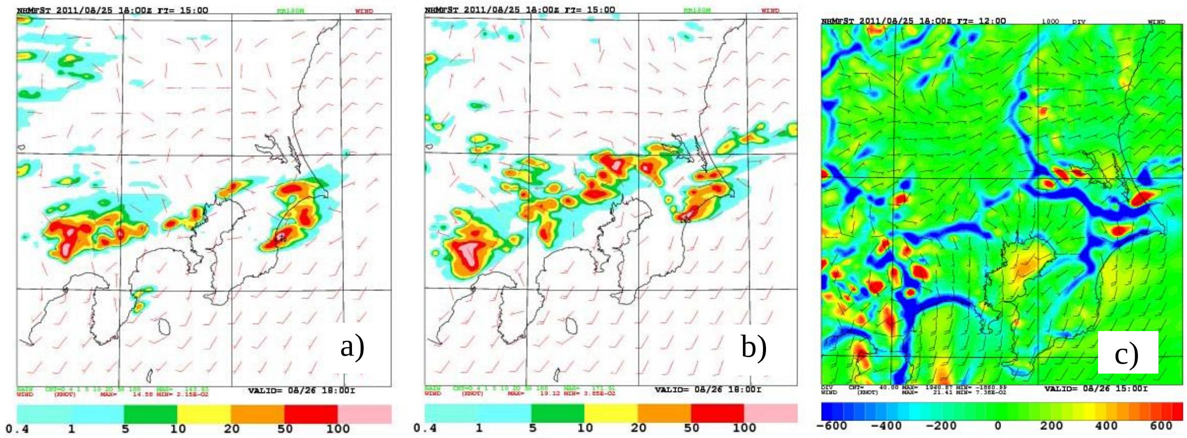

Fig. 3. a) Three-hour accumulated precipitation for 1500-1800 JST by the 2 km NHM (FT=15). **b)** Same as in a) but the limit of subgrid fluctuation of partial condensation in NHM was reduced, and by ensemble member P04 with the MSV method. **c)** Horizontal convergence at 1000 hPa and surface winds at 1500 JST by the simulation.

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