Super-High-Resolution Modelling based on Down-Scaling Simulation System (DS^3): Configuration and Verification

Guixing Chen[1], Masahiro Sawada[1], Weiming Sha[1], Toshiki Iwasaki[1],
Hironori Iwai[2], Hiromu Seko[3], and Kazuo Saito[3]

1. Department of Geophysics, Tohoku University, Sendai, Japan.
2. National Institute of Information and Communications Technology, Tokyo, Japan.
3. Meteorological Research Institute, Tsukuba, Japan.

1. Introduction

A majority of population are living in large cities. Super-high-resolution forecast of urban weather becomes a demanding task. This challenge calls for a high-precision forecast of mesoscale events to give reliable weather conditions and a model to capture the weather-dependent effects of complex surfaces/building in the cities.

2. System configuration

We realize the super-high-resolution modelling through building a Down-Scaling Simulation System (DS^3). In this system, the operational non-hydrostatic model (JMA-NHM) is used to offer mesoscale forecast (*Saito et al.* 2007). It is incorporated with Local Ensemble Transform Kalman Filter (LETKF) to perform data assimilation, based on a nesting LETKF system (*Seko et al.* 2011). Using assimilated data, we make an extended forecast with high precision at 100-m mesh. These forecast fields are then applied to drive the building-resolving CFD model (SIMPLERgo) over a domain of 10*10 km^2 with a super high resolution of 10 m (*Sha* 2008).

3. Results and verification

The experiments are conducted on a sea breeze event and its associated fine-scale structures of horizontal convective rolls (HCRs) on 19 June 2007. Figure 1 shows the cooling of sea breeze invasion at the coast of Sendai Bay can be well captured by the DS^3 assimilated data (Figs. 1a-b). As a comparison, the experiments without data assimilation tend to underestimate the cooling because of an underestimation of sea breeze intensity (Fig. 1c). Data assimilation also helps to improve the reproduction of the vertical profile of horizontal winds over the airport (Figure omitted).

On super high resolution, DS^3 captures the sea-breeze HCRs over Sendai airport (Fig. 2a). The HCRs form on land with a distance of ~1.5 km to coast. They are most evident over airport, arising from inhomogeneous surface heating. Their wavelength increases with the distance inland (Fig. 2b), which is consistent with an estimate of lidar observations (*Iwai et al.* 2008). The CFD modelling also captures well the near-surface streaks of low wind speed that collocate with the HCRs axis of rising motion (Fig. 2c-d). These results highlight a first successful modelling of HCRs on super high resolution. The further efforts will promote the understanding of sea breeze structures.

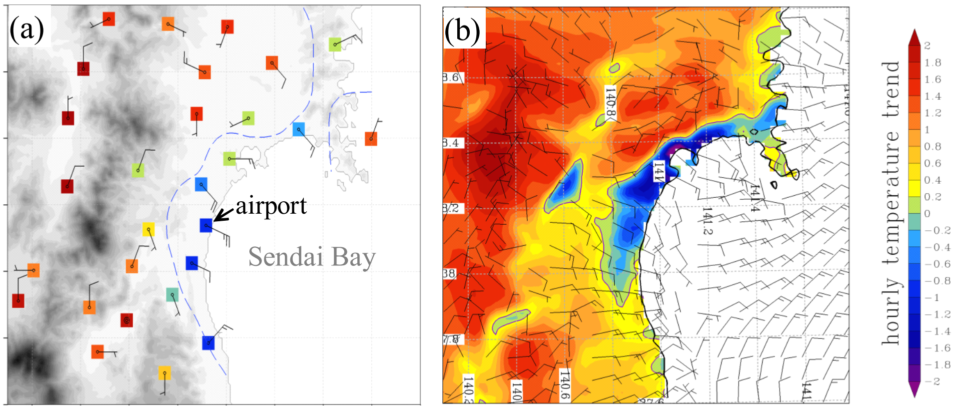
References:

Iwai, H., et al. (2008), Dual-Doppler lidar observation of horizontal convective rolls and near-surface streaks, Geophys. Res. Lett., 35, L14808, doi:10.1029/2008GL034571.

Saito, K., et al. (2007), Nonhydrostatic Atmospheric Models and Operational Development at JMA. Journal of the Meteorological Society of Japan 85B, 271–304.

Seko, H., et al. (2011), Data assimilation experiments of precipitable water vapour using the LETKF system: intense rainfall event over Japan 28 July 2008, Tellus, 63A, 402-414.

Sha W. (2008), 複雑地形と直線直角座標の LES 気象領域モデル開発, 気象ノート, 219, 21－26.



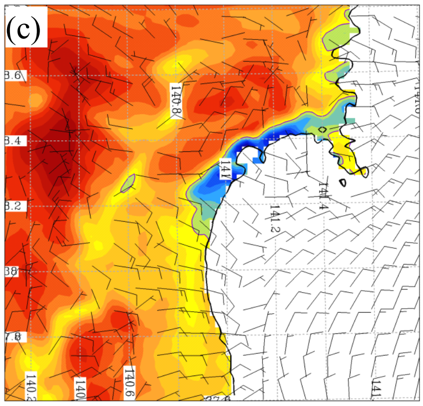


Figure 1. Surface wind and temperature trend at 10 JST, 19 June, 2007. (a) AMeDAS, (b) DS^3 with data assimilation, (b) DS^3 without data assimilation. The temperature trend is estimated as a difference between 10 JST and 11 JST. A full scale of wind barb is 2 m/s. In (a), the sea breeze head is marked by the dash line. In (b) and (c), a contour of 0.2 ^{o}C/h sketches the sea breeze head.

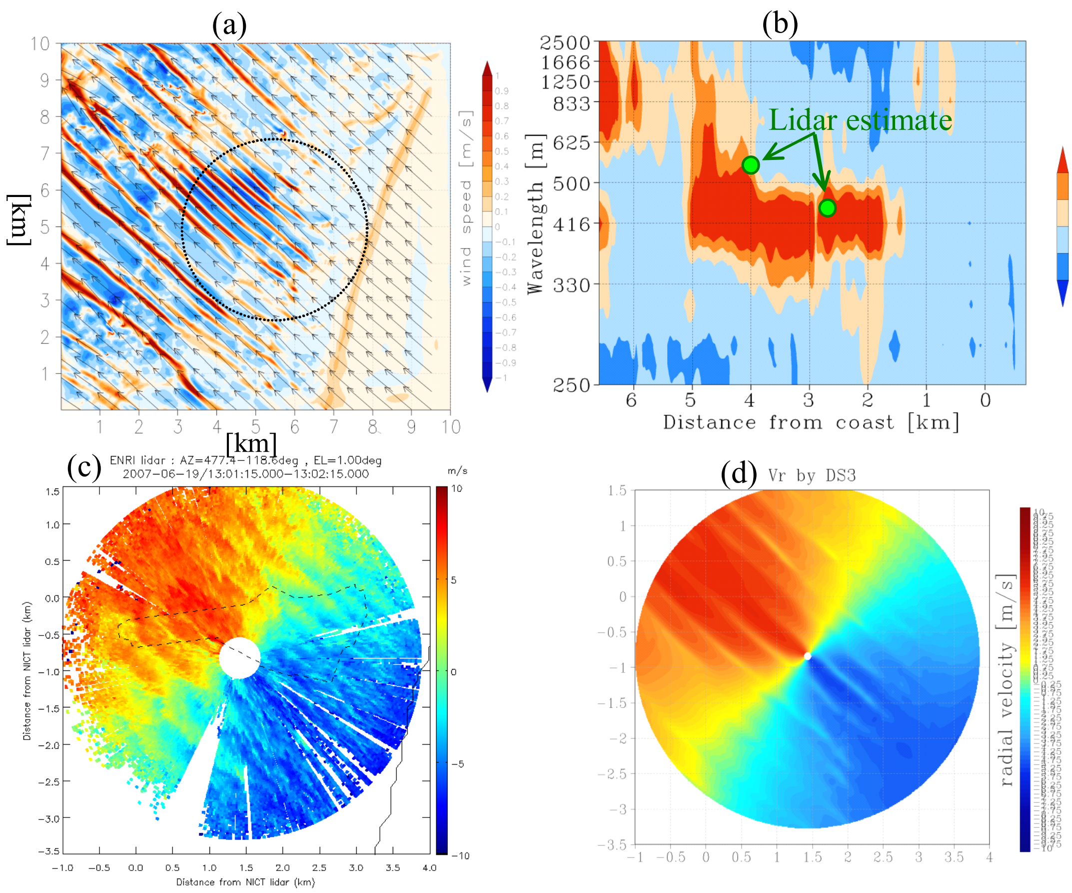


Figure 2. Horizontal convective rolls over Sendai airport. (a) DS^3 simulated vertical velocity and horizontal winds at 70 m AGL, (b) power spectral density normalized by the value of significance level of 95%, (c) radial velocity of lidar observation at the low elevation angle, (d) the same as (c), but for DS3 simulation.