Sensitivity of coastal front simulation to thermal diffusivity in the PBL scheme

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Abstract

1. Introduction

"A coastal front is defined as a local front between warm air associated with an onshore wind and colder air trapped inland." "Coastal fronts are often formed over Kanto plain, an exposed region to southerly onshore winds during late autumn to winter season." [1] The forecasting of such phenomena is challenging at times. Furthermore, the numerical simulation of coastal front location over Kanto plain is frequently biased northward (inland) [2]. To our current knowledge, the cause of such bias is unknown. It could be due to grid size, physics parameterizations or other factors and needs further investigation. In this experiment, we focus on Planetary Boundary Layer (PBL) process under stable conditions. We conducted a case study on the sensitivity of coastal front simulation to thermal diffusivity.

2. Overview of Case Study

This case study is based during an extratropical cyclone (ex-TC) event that took place on 8th and 9th of March, 2018. An ex-TC passed over Sea of Japan while a coastal front was formed due to a warm southerly onshore wind interacting with colder air mass from the mountainous region.

3. Model configuration

We used JMA-NHM (Saito, et.al 2006) in this experiment. We conducted 250m grid scale simulation (including Kanto region) and used Deardorff [3][4] in the PBL scheme. Under stable condition ($d\theta_l/dz > 7K/km$), we applied the following; (1) constant thermal diffusivity (Ctl-Experiment), (2) thermal diffusivity reduced by a factor of 10 (S-Experiment) and (3) thermal diffusivity increased by a factor of 10 (L-Experiment).

4. Result

In figure 1 (middle), Ctl-Experiment shows that coastal front was formed

over Kanto region, however, it was biased inland as compared to real observation. In figure 1 (right), the coastal front moved slightly south-eastward in S-Experiment. It is also observed that the coastal front moved slightly north-westward in L-experiment. This indicates that the thermal diffusivity affects vertical heat transport, which in turn affects the strength of cold air mass trapped inland. Nevertheless, the displacement of coastal front is relatively small compared to the bias between observation and Ctl-Experiment.

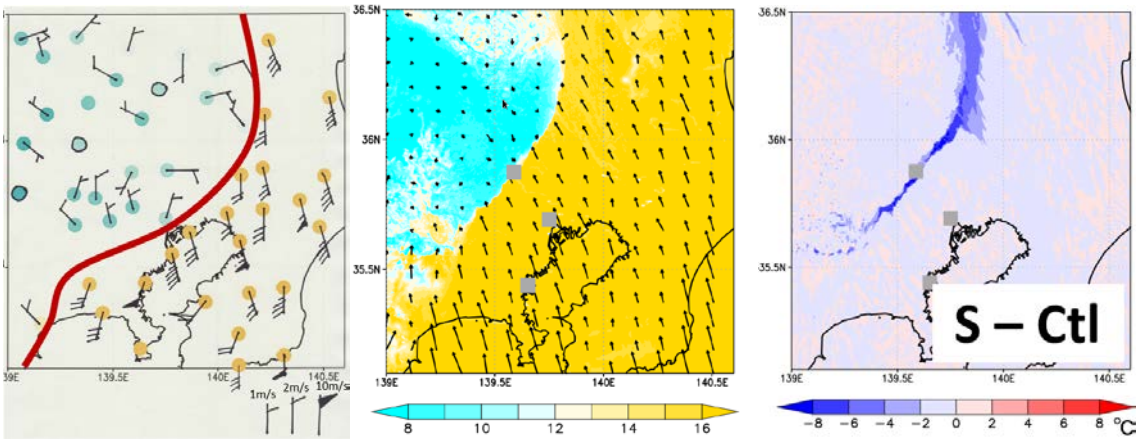

Figure 1. (left) Observed surface temperature and wind, (middle) simulated surface temperature and wind of Ctl-experiment, (right) simulated surface temperature anomaly between Ctl and S-experiment. Every figure is at 3:00, 9th March, 2018

5. Conclusion

The location of coastal front is not sensitive to thermal diffusivity as per this case study. It is insufficient to suggest that the bias in coastal front location is caused by the initial condition error or systematic error in the model. However, sensitivity to the thermal diffusivity may have relation with grid size, thus, future work is needed.

[References]

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