C09

WRF Study on Wind Characteristics of High Latitude Terrain

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1. Introduction

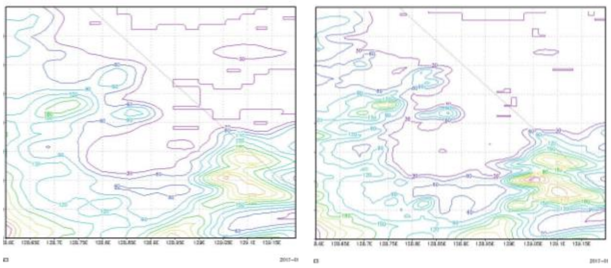
The growing human activities in Arctic region, inland Siberia and Antarctica have drawn attention to the study of wind characteristics in high latitude terrain. The Advanced Research core of Weather Research and Forecasting model (ARW-WRF) is a fully compressible conservative-form non-hydrostatic atmospheric model suitable for synoptic and mesoscale weather research. (Skamarock and Klemp, 2008) Practices of WRF in high latitude regions, e.g. (Cassano et al., 2011), have produced reasonable results in month-long synoptic-scale simulations. However, mesoscale study of surface wind by WRF in this region is still not fully discussed.

In this study, surface wind and pressure results from 4-day WRF simulations of a high-latitude complex terrain near Laptev Sea is compared with observation data. The accuracy and shortcomings of present simulations are discussed.

2. Methods

Hydrometeorological Observatory of Tiksi is located at 71.6N 128.9E, with the Laptev Sea in its east and a NW-SE ridge in west and south. Surface wind and pressure data are collected from a flux tower mounted on a tundra terrain (covered by snow).

Two sets of grids are tested in WRF. CASE1: two-way-nested domains d01, d02 and d03 are utilized, where the horizontal grid interval in the smallest domain d03 is Δx = 1km and the gird number is 90*90 for each domain; 30 arc-second elevation data is applied in d03. CASE2: we use a 4-domain grid system (also two-way nested), which has a same grid number of 90*90 for each domain; for the smallest domain d04, Δx = 0.5km and ASTER-GDEMV2 is converted and utilized. Fig. 1 has shown that more details in topography is introduced in CASE2.



(a) d03 in CASE1 (b) d04 in CASE2

Fig. 1 Isoheight around Tiksi station.

For both cases, a terrain following vertical coordinate system with 58 vertical levels is applied, among which the normalized hydrostatic pressure of first layer is η = 0.999. Monin-Obukhov surface layer scheme and Eta TKE PBL scheme are chosen for surface schemes while WSM6 microphysics scheme and Noah Land Surface Model are used to better simulate effects of snow, ice and frozen earth. Simulation time is from Oct 27, 00:00 to Oct 31, 00:00 in 2016, and another 24h simulation is performed prior to that. For initialization we use NCEP data.

3. Results

Fig. 2 compares surface pressure near Tiksi station. Obviously, WRF has proved its accuracy in pressure simulation, since error is quite small in CASE2; but in CASE1, a constant bias from observation is observed, which is likely to be caused by a discrepancy between model elevation and the real height.

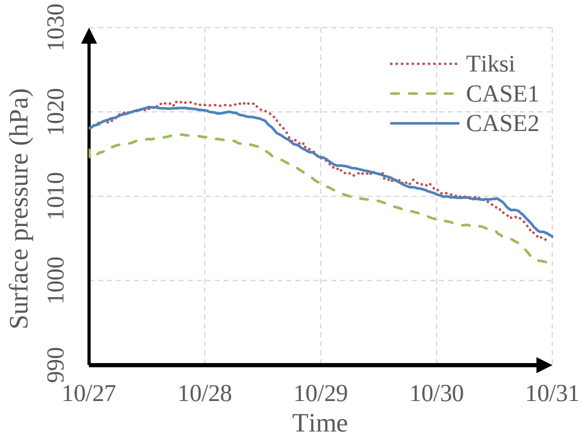
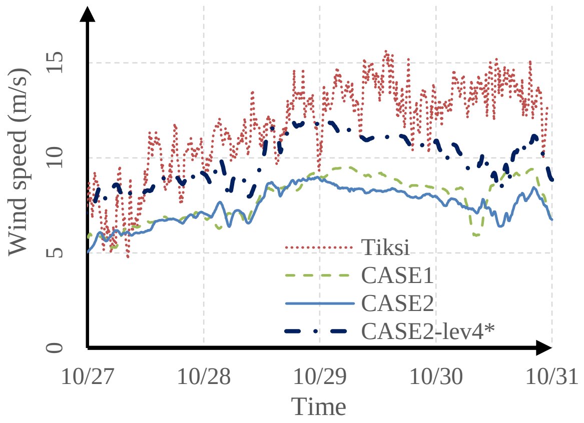
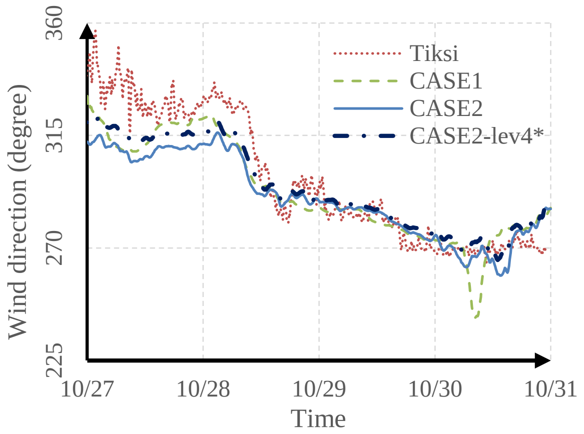


Fig. 2 Surface pressure history.



(a) 10m (except *) wind speed.



(b) 10m (except *) wind direction.

Fig. 3 Surface wind speed and direction history.

In Fig. 3, surface wind speed and direction are presented. Firstly, we notice that in both CASE1 and CASE2, the wind direction simulation is generally good, with relative large error in the first 1.5 days. However, for wind speed the deviation can not be ignored and a higher geographic resolution is not helpful. (Jim énez and Dudhia, 2012) clearly discussed the reason of difficulty in reproducing surface wind in WRF: the unresolved topographic effects is not considerd in WRF thus the local wind profile shape is incorrect. By lifting from 10m to about 47m from ground, as is shown in CASE2-lev4 in Fig. 3, the wind speed error decreases a lot; also the wind direction history is slightly better than CASE2. However, we are not sure if the difference in wind speed profile is generated by surface drag force error or is the characteristic of high-lattitude boundary layer. We will focus on this in our further research.

4. Conclusion

Two WRF cases considering various elevation resolutions are performed for a high-latitude complex region. Results show that WRF is good at reproducing surface pressure and wind direction, while great bias in wind speed is probably caused by an incorrect local wind profile shape. Higher geographic resolution improves accuracy of pressure simulation but is not very helpful for surface wind.

References

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