A Numerical Simulation of Strong Wind Event at King Sejong Station, Antarctica

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ABSTRACT

Despite the recent significant climatic changes observed over West Antarctica, adequate validation of regional simulations of extreme weather events is rare for this region. To address this gap, simulation results from a recent version of the Polar Weather Research and Forecasting model (Polar WRF) covering Antarctic Peninsula at a high horizontal resolution of 3 km are validated against near-surface meteorological observations. We selected a case of high wind speed event on 7 January 2013 recorded at Automatic Meteorological Observation Station (AMOS) in King Sejong station, Antarctica. It is revealed by in situ observations, numerical weather prediction, and reanalysis fields that the synoptic and mesoscale environment of the strong wind event was due to the passage of a strong mesoscale polar low of center pressure 950hPa. Verifying model results from 3 km grid resolution simulation against AMOS observation showed that high skill in simulating wind speed and surface pressure with a bias of -1.1m/s and -1.2hPa, respectively. Our evaluation suggests that the Polar WRF can be used as a useful dynamic downscaling tool for the simulation of Antarctic weather systems and the near-surface meteorological instruments installed in King Sejong station can provide invaluable data for polar low studies over West Antarctica.

Climatological characteristics of surface variables at KSJ station

- **Seasonal and interannual variability** (data period: jan. 1994 ~ dec. 2015)

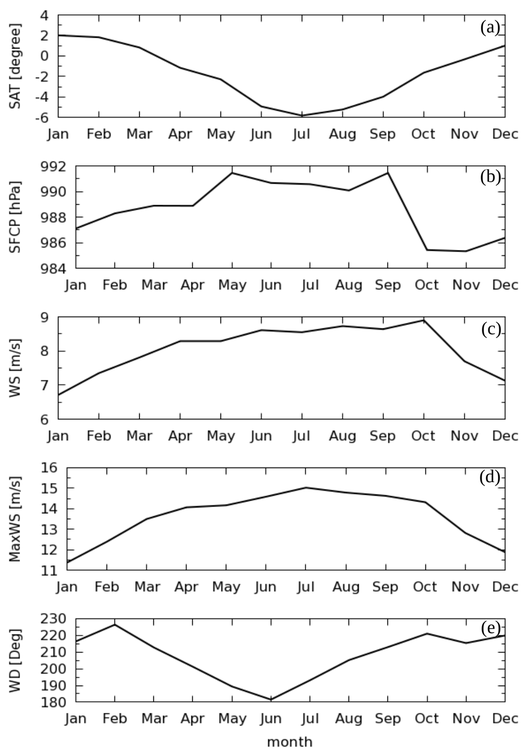

Figure 1. Monthly mean of (a) 2m temperature, (b) surface pressure, (c) wind speed, (d) daily maximum wind speed and (e) wind direction from AWS observation.

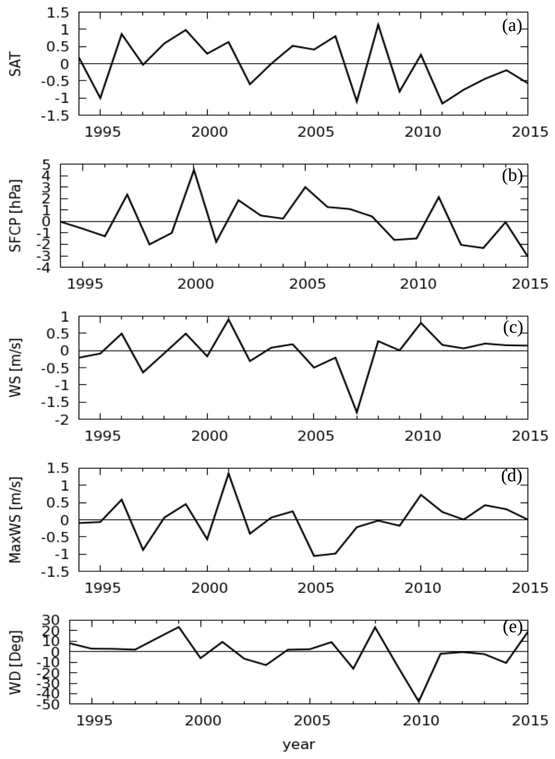

Figure 2. Annual mean anomaly of (a) 2m temperature, (b) surface pressure, (c) wind speed, (d) daily maximum wind speed and (e) wind direction from AWS observation.

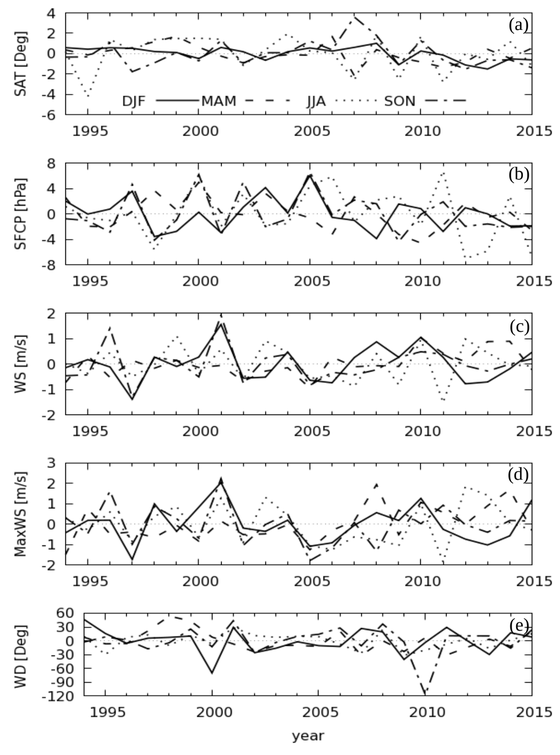

Figure 3. Seasonal mean anomaly time series of (a) 2m temperature, (b) surface pressure, (c) wind speed, (d) daily maximum wind speed and (e) wind direction from AWS observation for DJF, MAM, JJA and SON.

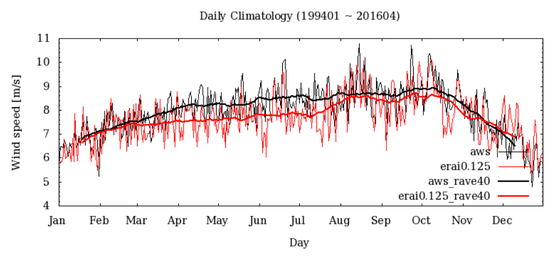

Figure 4. Daily climatology of wind speed from AWS (black thin line) and reanalysis (red thin line) at King Sejong station. The bold black and red lines indicate the moving average value of daily climatology of wind speed from AWS and reanalysis data, respectively.

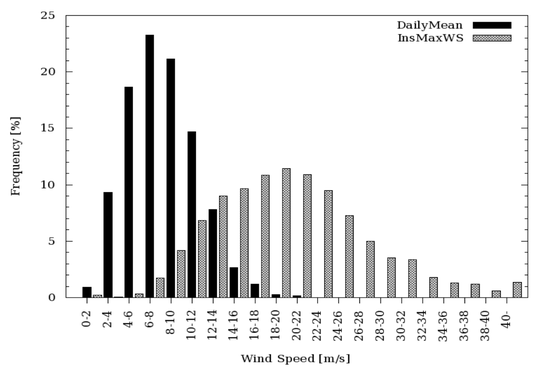

Figure 5. Frequency distribution of daily averaged 10 m wind speed and daily maximum instantaneous 10 m wind speed.

CASE DESCRIPTION

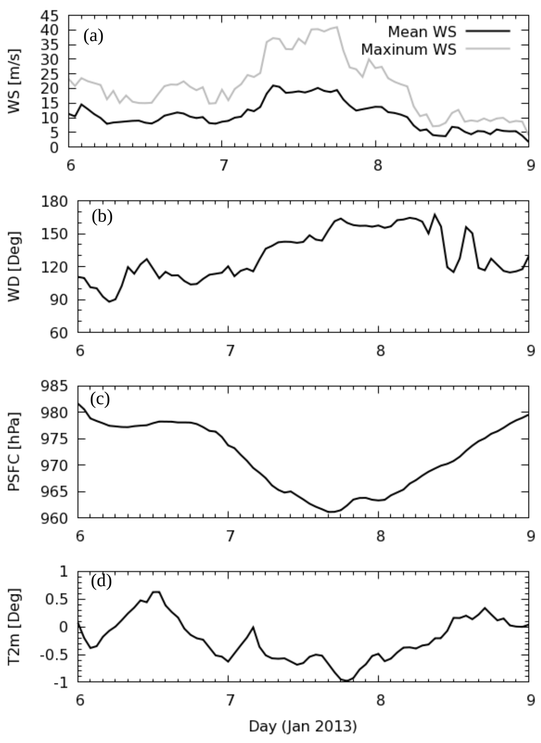

Figure 6. (left) Time series of (a) hourly averaged 10-m wind speed (m/s) (black line) and maximum 10-m wind speed (gray line) and (b) wind direction (degree), (c) hourly averaged surface pressure (hPa), and (d) 2m temperature (degree) at KSJ station for 6~9, January 2013.

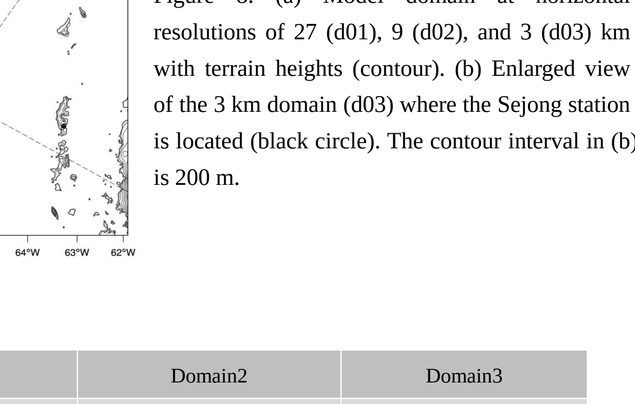

Figure 7. Surface weather map at 00 (a) and 18 UTC (b) on 6, and 18 UTC on 7 (c) and 8 (d) January 2013 obtained from Chilean Meteorological Office. Sea level pressure (solod and black line) is shown with 4 hPa. The warm (red) and cold (blue) fronts are also shown. Red triangle indicates King Sejong station in the King Jorge Island.

POLAR WRF CONFIGURATION

- **Polar WRF domain**

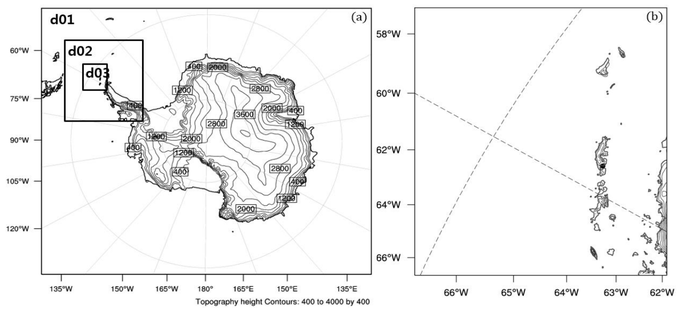

Figure 8. (a) Model domain at horizontal resolutions of 27 (d01), 9 (d02), and 3 (d03) km with terrain heights (contour). (b) Enlarged view of the 3 km domain (d03) where the Sejong station is located (black circle). The contour interval in (b) is 200 m.

- **Summary of model configuration**

	Domain1	Domain2	Domain3
Horizontal grid	281 × 242	202 × 220	187 × 205
Resoution	27 km	9 km	3 km
Vertical layers	44 Layers (model top: 10 hPa)		
Geog data resolution	10m′	30s′	30s′
Initial, lateral boundary condition	ERA-Interim (6-hour intervals with a spatial resolution of 0.75° × 0.75°)		
Time period	5 ~ 10 Jan 2013		
Integration	48h forecast from global analysis (first 24 h used for model spin up)		
Base state temperature	273.16 K		
Relaxation zone	4 grid point (Default)		

SIMULATION RESULTS

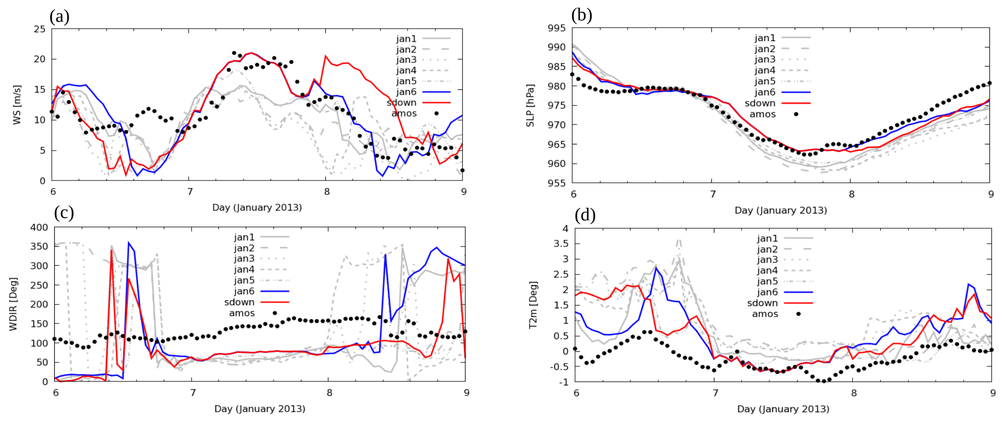

Figure 9. Time-series of hourly (a) 10 m wind speed (m/s), (b) sea level pressure (hPa), (c) wind direction and (d) 2m temperature from AMOS (black) and polar WRF (gray) simulations with different initialization time obtained from the nearest grid point.

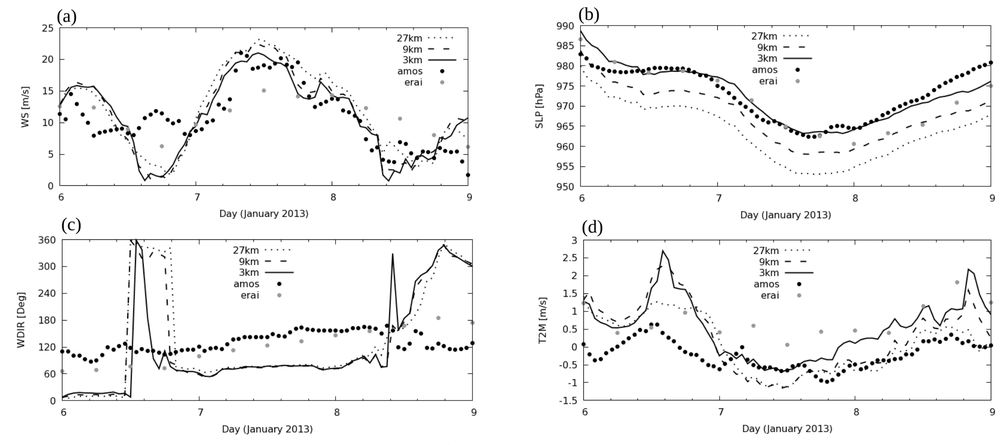

Figure 10. Same as in Fig. 9, except for time series from ERA-interim reanalysis (~ 80 km horizontal resolution, filled gray circle) and polar WRF simulation results with 27, 9, 3 km grid resolutions.

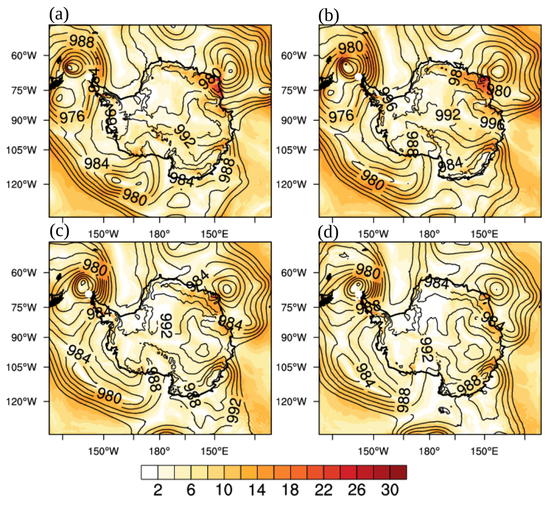

Figure 11. Sea-level pressure and wind speed at a) 00, b) 06, c) 12, and d) 18 UTC 07 January 2013 (the day of strong wind event occurance) in domain 1 (27 km) from Polar WRF simulation.

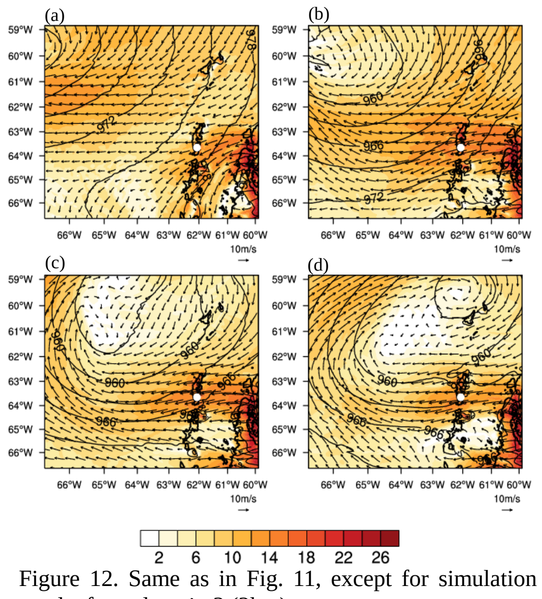

Figure 12. Same as in Fig. 11, except for simulation results from domain 3 (3km).