Benchmarking Polar WRF in the Antarctic*

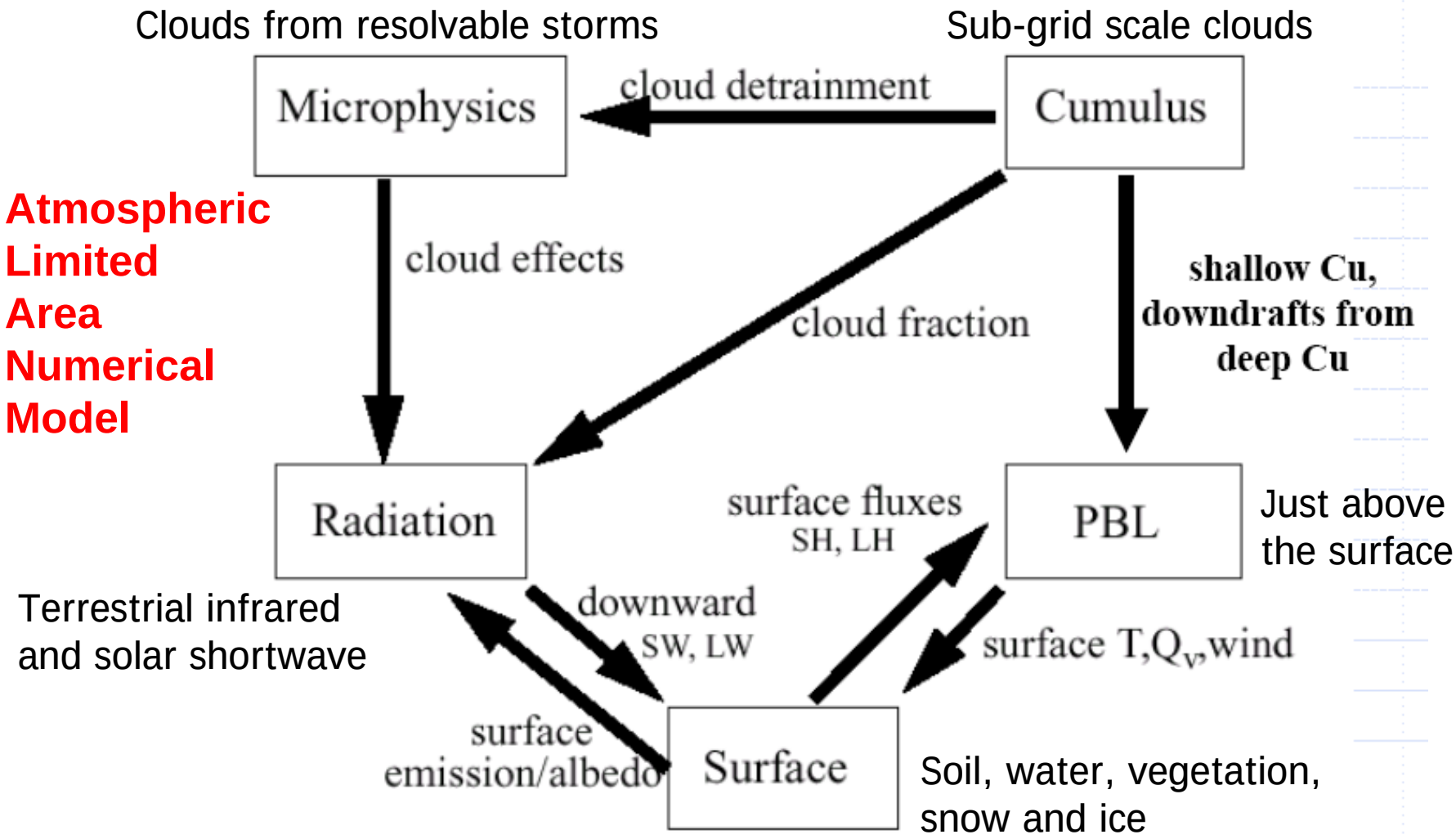
David H. Bromwich[1,2], Elad Shilo[1,3], and Keith M. Hines[1]

[1]Polar Meteorology Group, Byrd Polar Research Center
The Ohio State University, Columbus, Ohio, USA
[2]Atmospheric Sciences Program, Department of Geography
The Ohio State University, Columbus, Ohio, USA
[3]Department of Soil and Water Sciences,
Hebrew University of Jerusalem, Rehovot, Israel

***Supported by NSF, NOAA, NASA, and DOE**

Weather Research and Forecasting Model (WRF)

Direct Interactions of Parameterizations



BPRC Polar WRF

Polar Optimization:

Fractional sea ice (ice and water within the same grid box)

Morrison microphysics (2-moment for both ice and liquid)

Noah LSM modifications

- Heat transfer for snow and ice based upon Antarctic snow firn
- Surface energy balance
  - emissivity, snow/ice albedo
  - skin temperature equation

Testing of Polar WRF

1. **Permanent ice sheets**

   Started with Greenland (Follow Polar MM5 path)

   January 2002 (winter) and June 2001 (summer)

   Hines and Bromwich (June 2008, MWR)

   Also Antarctic AMPS forecasts (NCAR MMM Division)

   Antarctic climate simulations (Elad Shilo at BPRC)

2. **Polar pack ice**

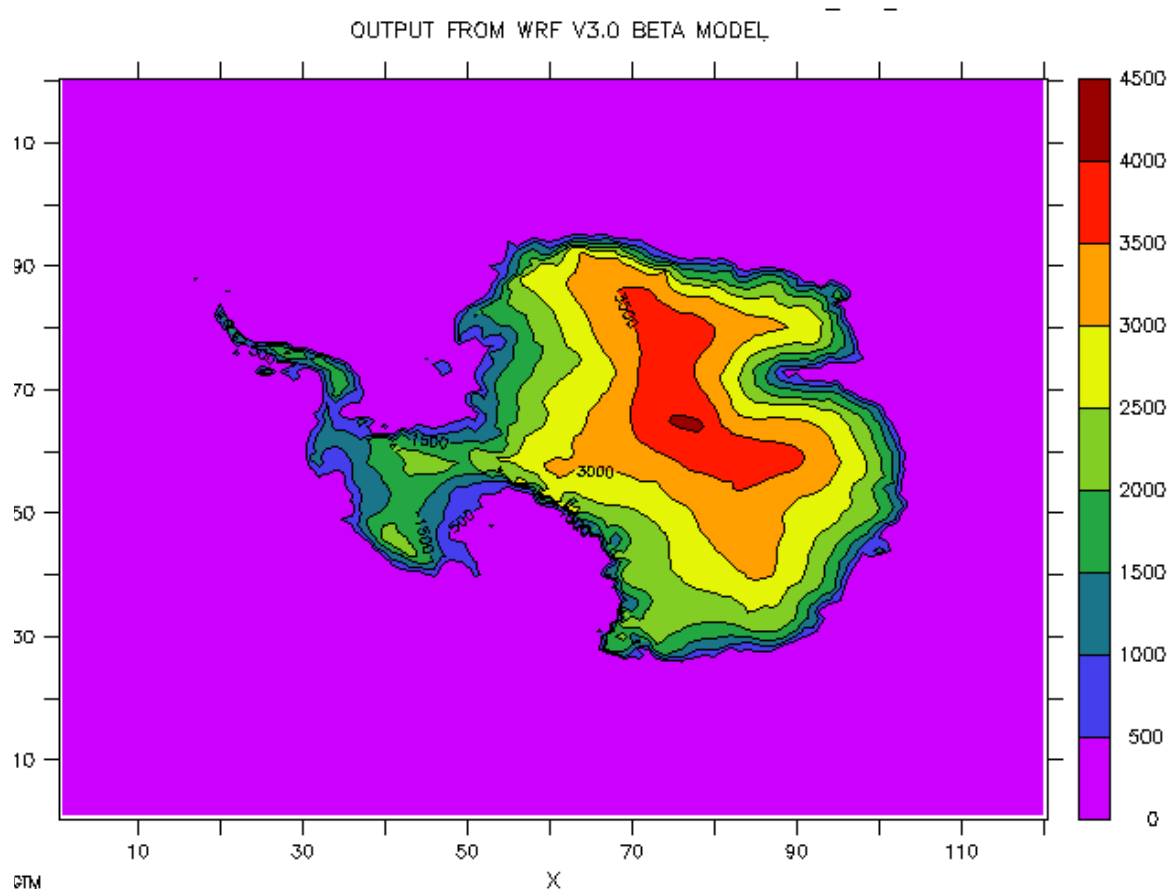
   Use 1997/1998 Surface Heat Budget of the Arctic (SHEBA) observations on drifting sea ice

   Bromwich, Hines, and Bai (2008, J. Geophys. Res.)

3. **Arctic land**

   Underway

Testing Polar WRF with Antarctic studies



121 x 121 grid 60 km spacing
28 levels

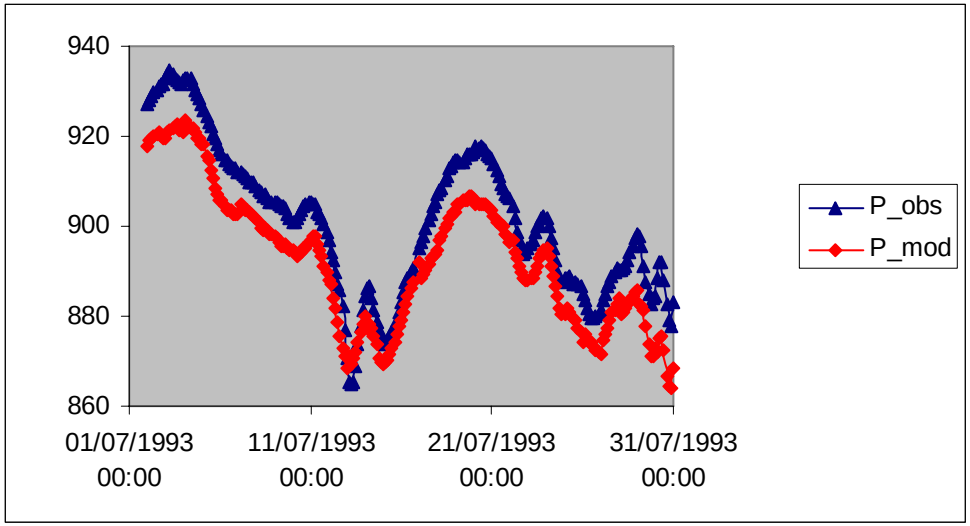
Modifications to Noah LSM for WRF Version3.0 Antarctic simulations

1. Snow/ice emissivity set at 0.98
2. Antarctic albedo set at 0.8
3. RAMP DEM 1 km resolution terrain data
4. If the snowpack depth > 0.05 m treat as snow within the prognostic “soil” layers of Noah
5. Direct summation of surface energy balance terms in diagnostic calculation of surface temperature for snow/ice
6. Snow firn heat capacity and heat conductance from Polar MM5 used for Antarctic snow firn
7. Treatment of fractional sea-ice.

Antarctic Case Study for Polar WRF

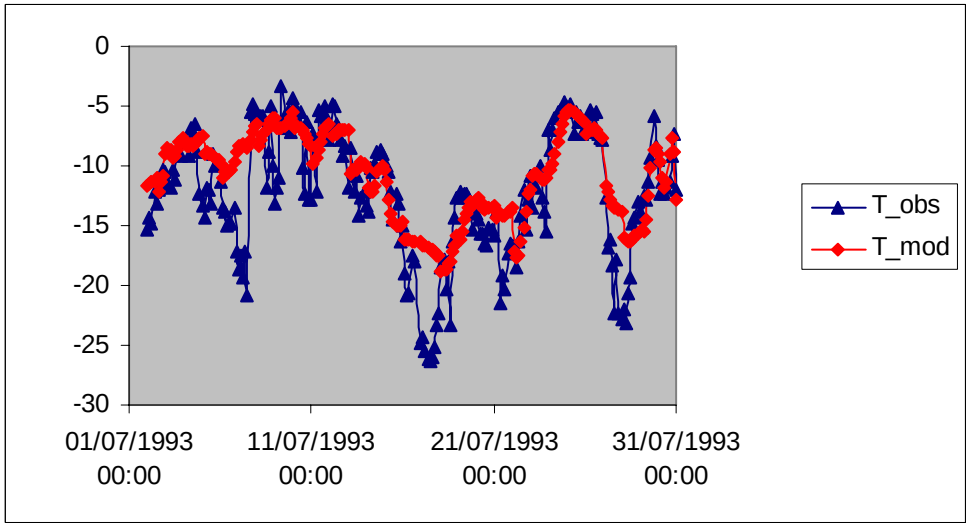
1. A series of 48 hr simulations for **July 1993**
2. Initial and Boundary conditions: ERA-40 data
3. Sea-Ice data concentration from Comiso Bootstrap algorithm Obtained from NSIDC
4. Horizontal grid spacing = 60 km
5. 121 x 121 points in the horizontal
6. 28 vertical sigma levels starting ~ 13 m AGL
7. MYJ boundary layer scheme
8. Modified Noah LSM
9. RRTM long wave radiation
10. Goddard short wave radiation

Uranus Glacier 71°S,69°W



Surface Pressure (hPa)

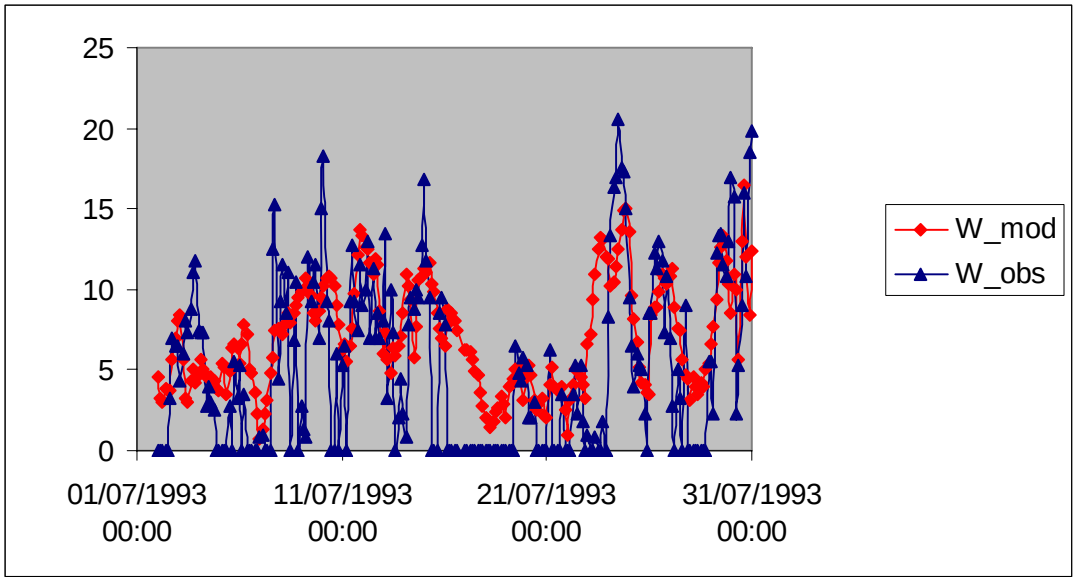
Correlation	0.99
Bias	-8.55
RMSE	8.72



T at 2m (°C)

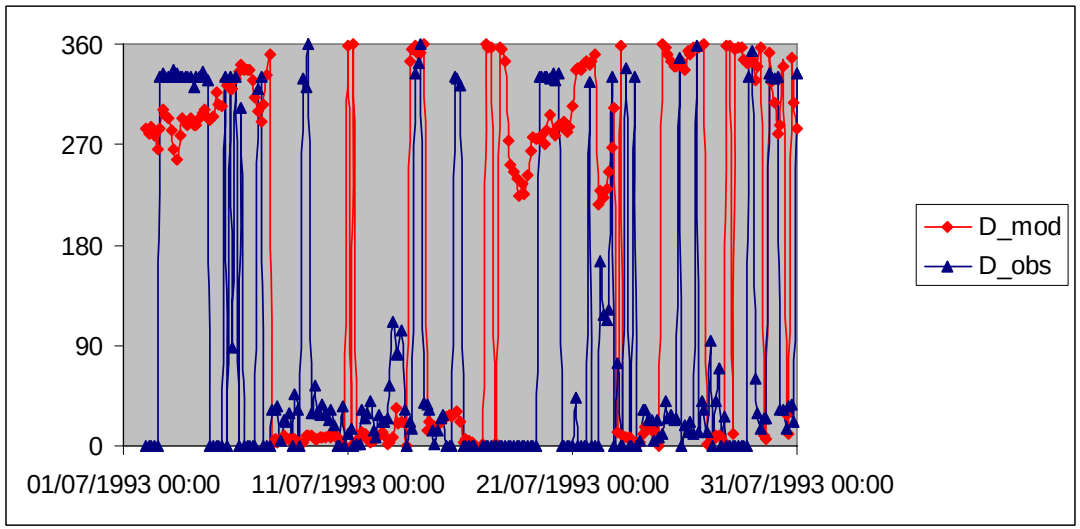
Correlation	0.88
Bias	1.34
RMSE	2.59

Uranus Glacier 71°S,69°W



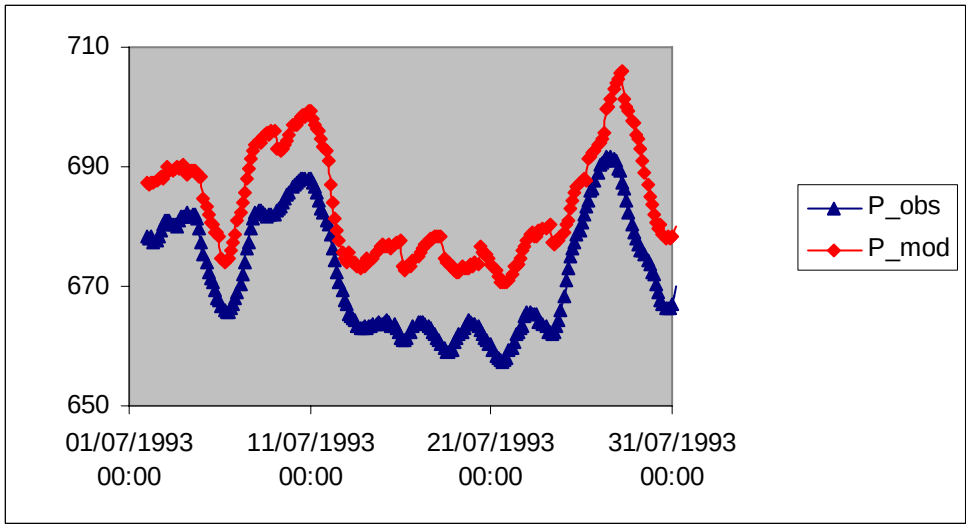
Wind speed (m/s)

Correlation	0.58
Bias	1.89
RMSE	3.8



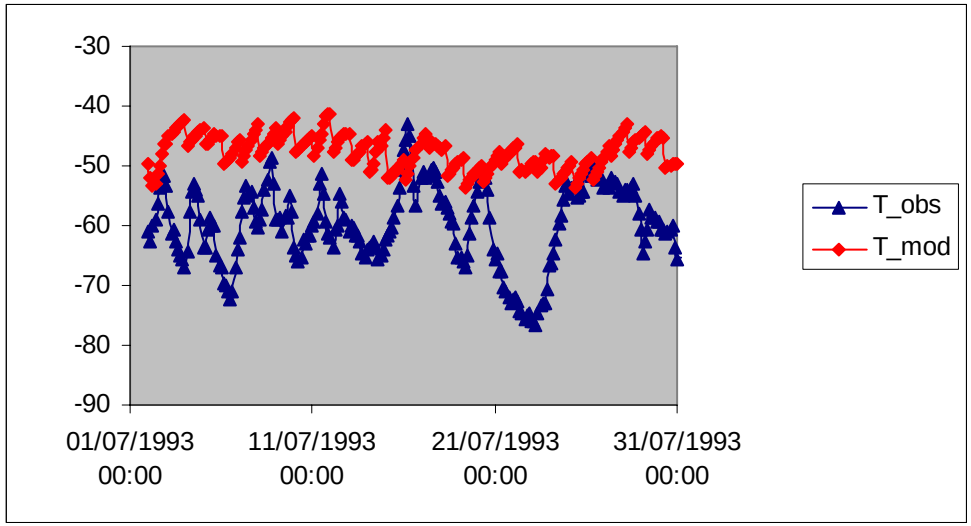
Wind direction

South Pole



Surface pressure (hPa)

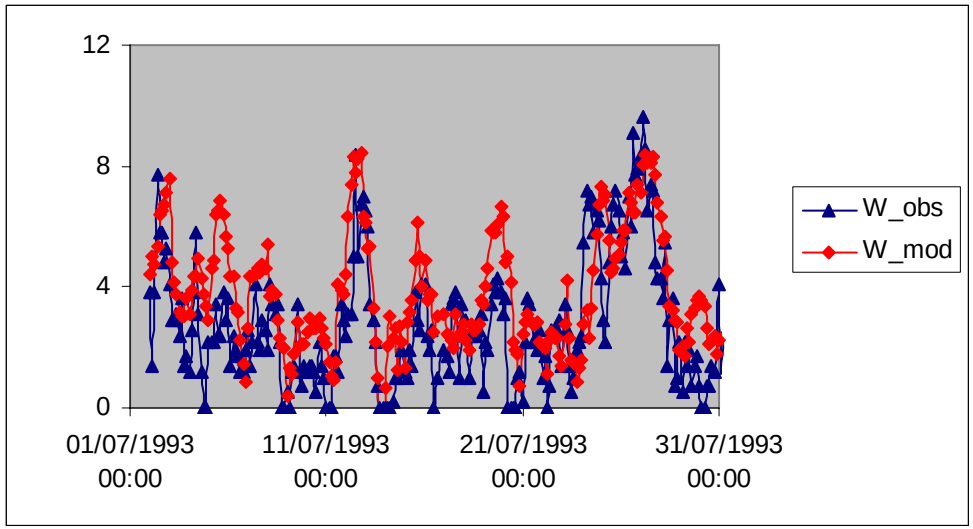
Correlation	0.97
Bias	11.22
RMSE	11.22



T at 2m (°C)

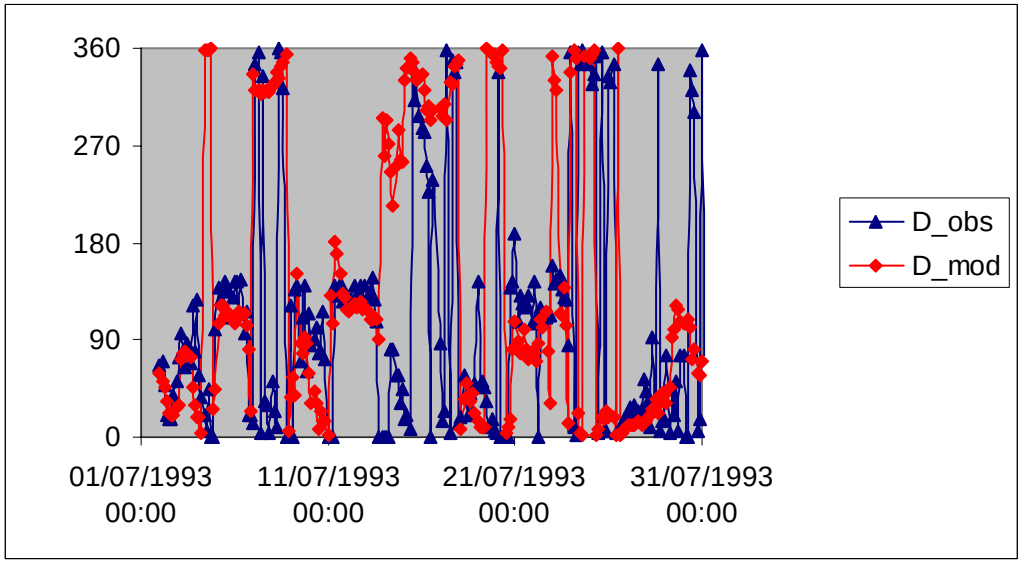
Correlation	0.17
Bias	12.1
RMSE	12.39

South Pole



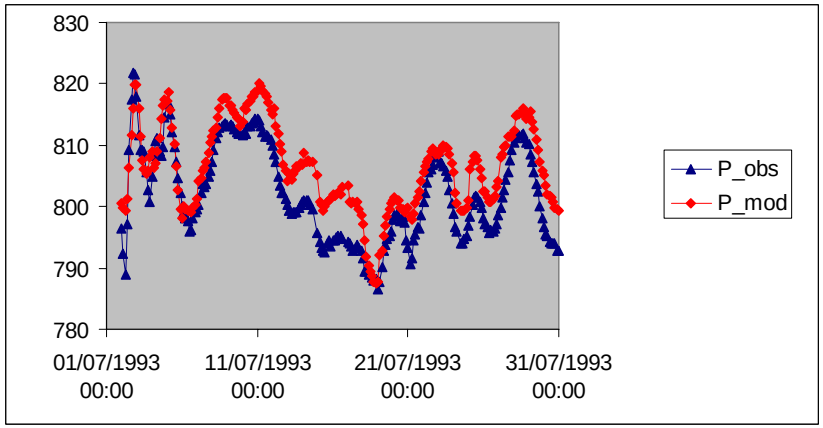
Wind speed (m/s)

Correlation	0.83
Bias	0.99
RMSE	1.5



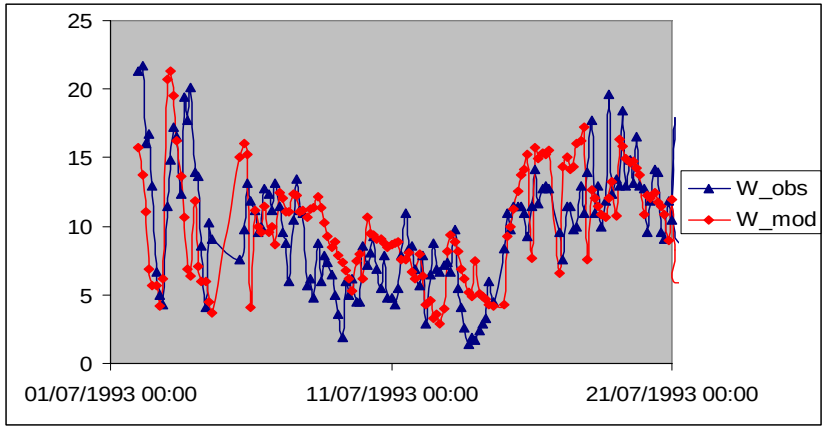
Wind direction

BYRD 80°S,120°W



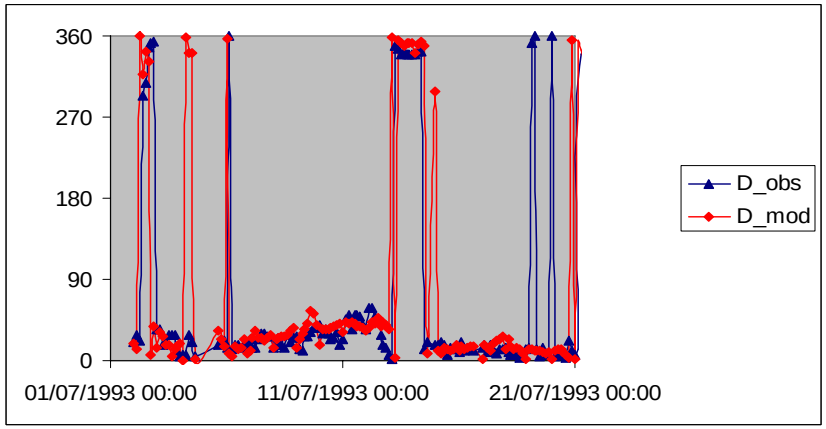
Surface pressure (hPa)

Correlation	0.96
Bias	4.26
RMSE	4.59



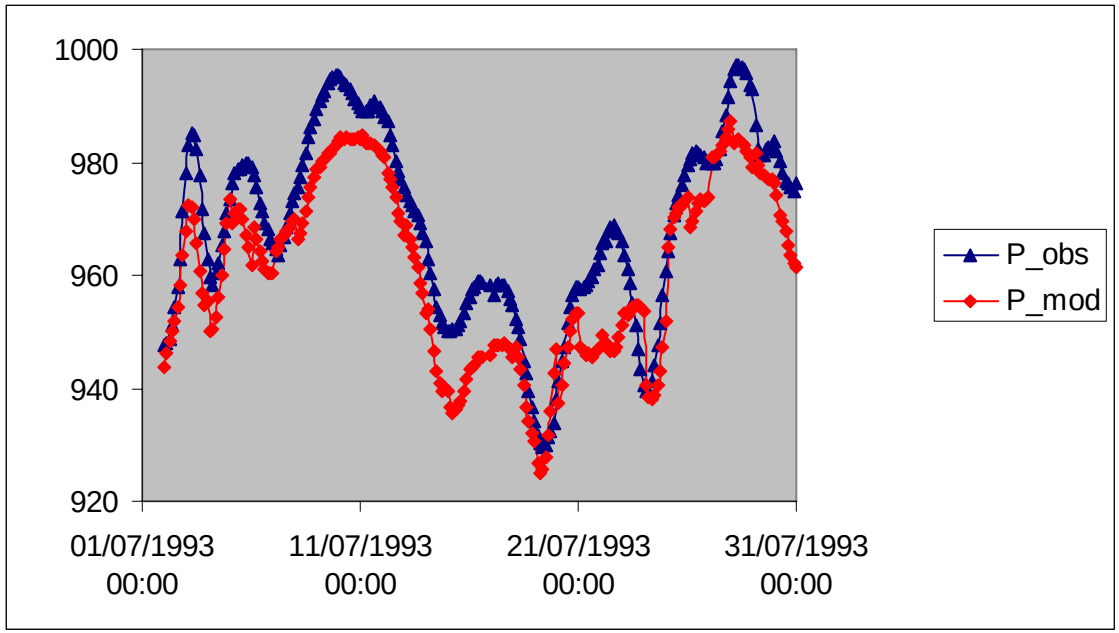
Wind speed (m/s)

Correlation	0.69
Bias	-0.25
RMSE	3.7



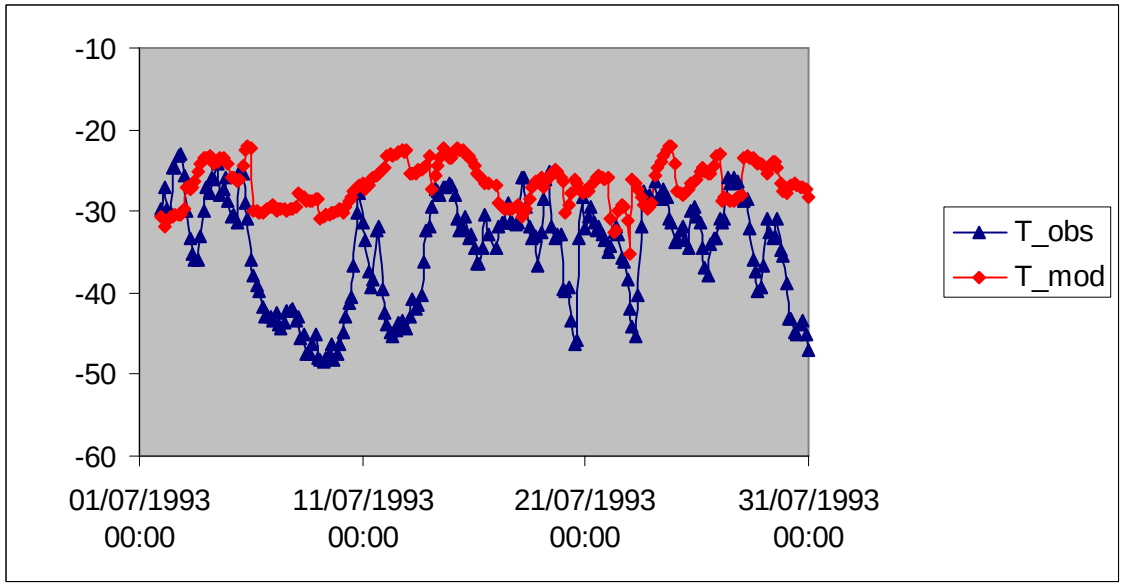
Wind direction

GILL 80°S,179°W



Surface pressure (hPa)

Correlation	0.943
Bias	-7.8
RMSE	8.4



T at 2m (°C)

Correlation	0.44
Bias	8.17
RMSE	8.76

Monthly mean surface fluxes simulated during July 1993

Station	GLW (w m^{-2})	HFX (w m^{-2})	GRDFLX (w m^{-2})	Lat	Lon
BYRD	214.20	-13.93	-9.97	80S	120W
DOME_C	141.62	-4.09	-9.96	74.5S	123E
CLEAN_AIR	152.40	-4.40	-14.72	90S	
LYNN	174.84	-12.73	-7.73	74.21S	160.39E
LINDSAY	157.52	-3.26	-13.51	89S	89.85W
GILL	208.69	-7.94	-8.24	80.03S	178.63E
NICO	153.09	-5.21	-17.50	89.01S	90.13E
URANUS-GLACIER	256.54	-12.56	-8.97	71.43S	68.93W

Negative = downward directed

South Pole Observations:

Downward longwave (GLW) ~ 105 w m^{-2} (monthly mean 1987).

http://stratus.ssec.wisc.edu/products

Flux to surface from snowpack (GRDFLX) = 2.35, Sensible Heat Flux upward (HFX) = -11.24 w m^{-2} (supplied by John King).

Past Observations (Rusin, N.P. 1961):

Monthly mean downward longwave radiation (w m $^{-2}$)

	Observed	Modeled
MIRNY (66.55S, 93.02E)	137.3357	226
Pionerskaya (69.73S, 9	74.91039	161

Preliminary Conclusions

Polar WRF has been run on an Antarctic domain for July 1993.

- Very good agreement between observed and simulated surface pressure, wind speed and wind direction.

- A significant modeled warm 2-m temperature bias is found in this initial austral winter experiment.

- Excessive modeled downward longwave radiation is present.

Future work

1. Investigate causes for excessive downward longwave radiation.

Appears to be the microphysics scheme.

2. Run additional sensitivity analyses

3. Run different periods (summer, annual)

4. Comparisons between Polar WRF and Polar MM5