WRF Model Experiments on the Antarctic Atmosphere in Winter

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Antarctic modelling

- Antarctica is a demanding domain for any NWP system
  - intensive radiative cooling over the snow and ice surfaces covering most of the continent
- stable atmospheric boundary layer
  - one of the severest problems in the field of numerical weather prediction

Objectives of the study

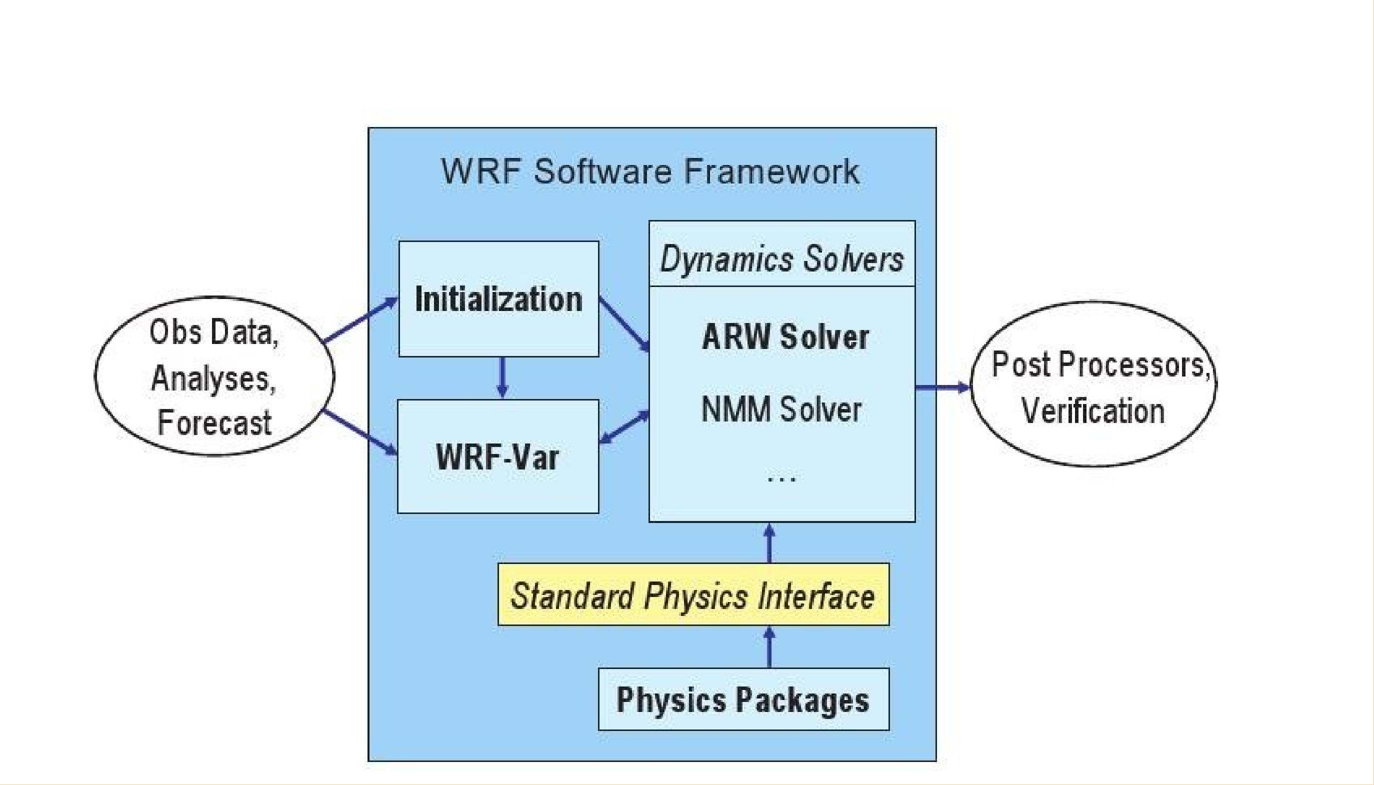
- sensitivity of the Weather Research and Forecasting model to land surface parameterizations
- comparison between the results produced by the standard version of the WRF and its Polar modification

WRF - model

- **W**eather **R**esearch and **F**orecasting
- numerical weather prediction system for both research and operational forecasting purposes
- main developers include: NCAR, NOAA and AFWA

- Applicability (e.g.)
  - air-quality modelling
  - storm-scale research
  - hurricane prediction
  - wildfire simulations
- scales ranging from meters to thousands of kilometers

WRF software framework



picture: Skamarock et al. (2007)

Polar WRF

- WRF for polar applications
- most changes included in Noah Land Surface Model
  - use of latent heat of sublimation over ice surfaces
  - adjustment of thermal diffusivity and snow heat capacity for the sub-surface layer
  - increase in snow albedo
- takes into account fractional sea-ice coverage
- applied in the Antarctic Mesoscale Prediction System which is an important basis for operational forecasts

Parameterization of the Land Surface

- Land Surface Model uses:
  - atmospheric information from the surface layer scheme
  - radiative forcing from the radiation scheme
  - precipitation forcing from the microphysics scheme

- Land Surface Model calculates heat and moisture fluxes over land and sea-ice points
  - these fluxes provide a lower boundary condition for the vertical transport done in the boundary layer

Land Surface Models in the WRF

LSM	vegetation processes	soil variables (layers)	snow scheme
5-layer thermal diffusion	no	Temperature (5)	none
Noah	yes	Temperature, Moisture (4)	1-layer, fractional

Simulations

- WRF-ARW 3.1.1 released in July 2009
- domain centered at the South Pole
- grid size 100 km
- 30 vertical levels, 10 of which below 500 m
- model initialization by ERA-40
- lateral boundary conditions by ERA-40 every 6 hours

- horizontal dimensions

  5900 km x 5400 km

- two different land surface models:

  - 5-layer thermal diffusion
  - Noah

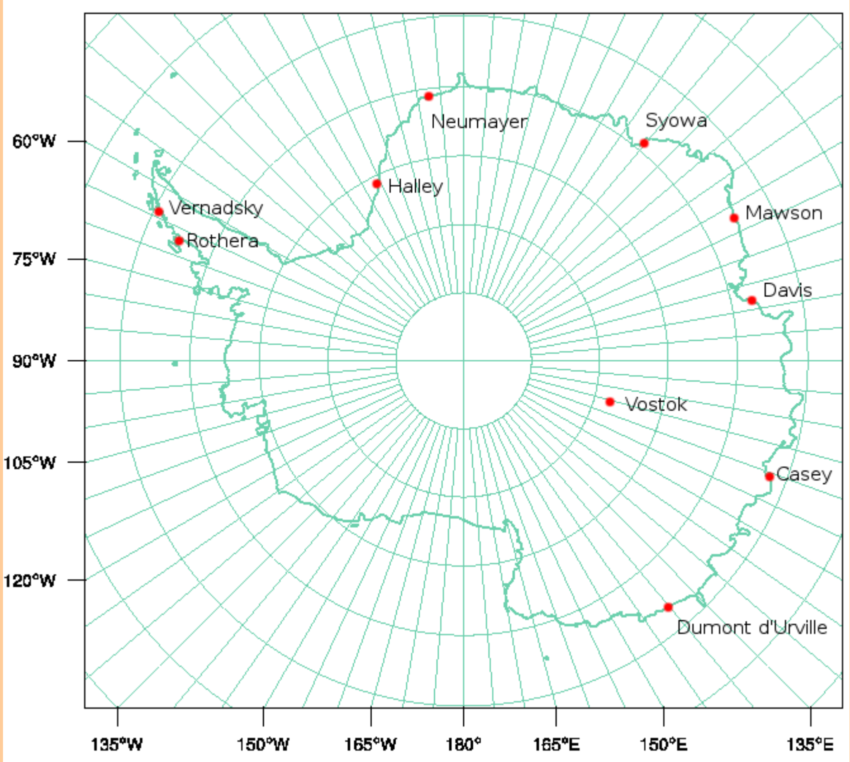
Simulations (cont.)

- three nine-day experiments:
  1. standard WRF (5-Diff)
  2. standard WRF (Noah)
  3. Polar WRF

  - initialization only in the beginning of the experiment
- three 30-day experiments:
  4. standard WRF (5-Diff)
  5. standard WRF (Noah)
  6. Polar WRF

  - initialization every 24 hours

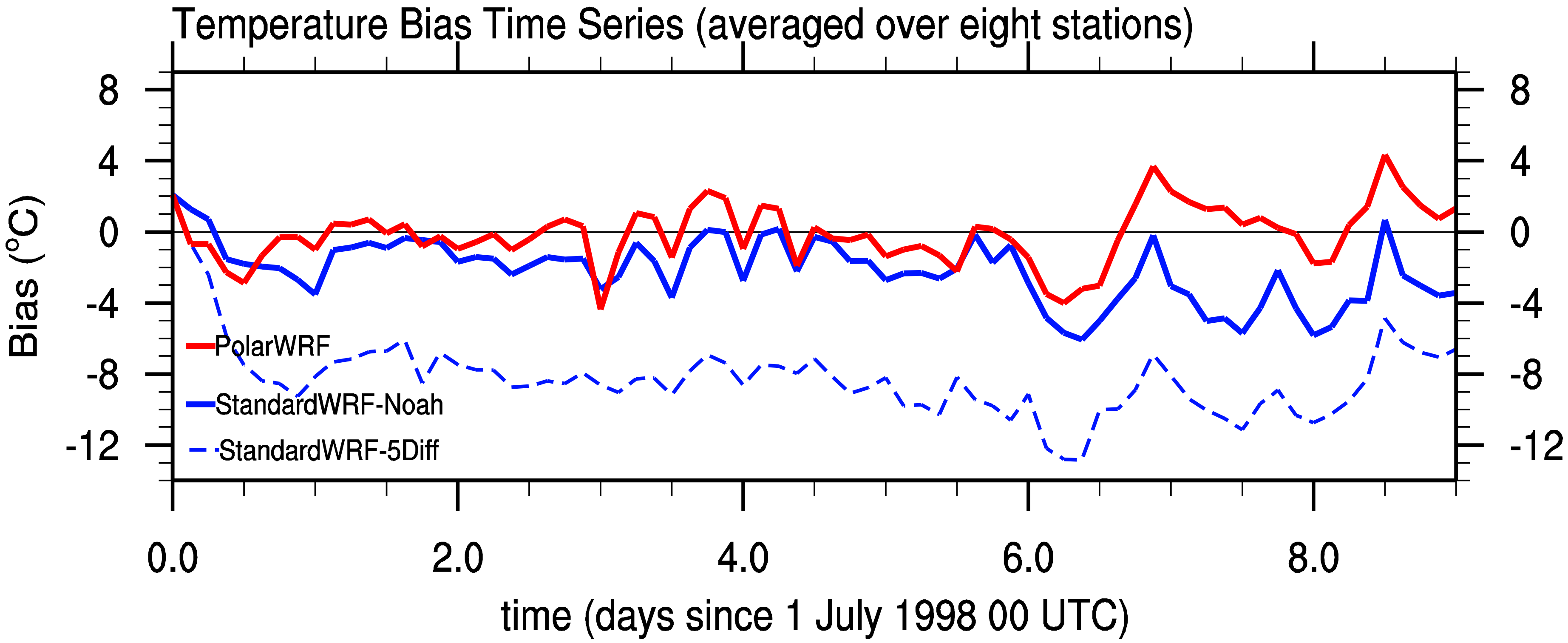
Domain



- time period for simulation July 1998
- observed weather data from ten stations
- considered quantities:

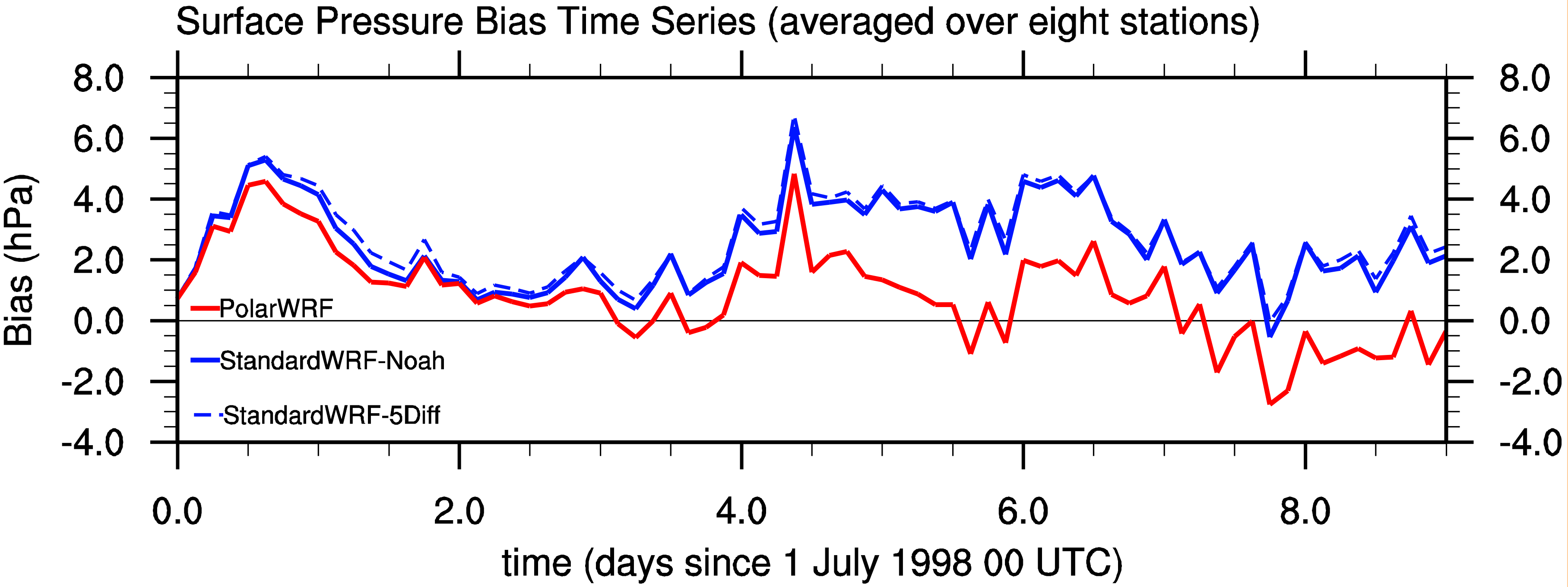
  2-m temperature and surface pressure

Experiments 1,2, and 3: temperature bias time series



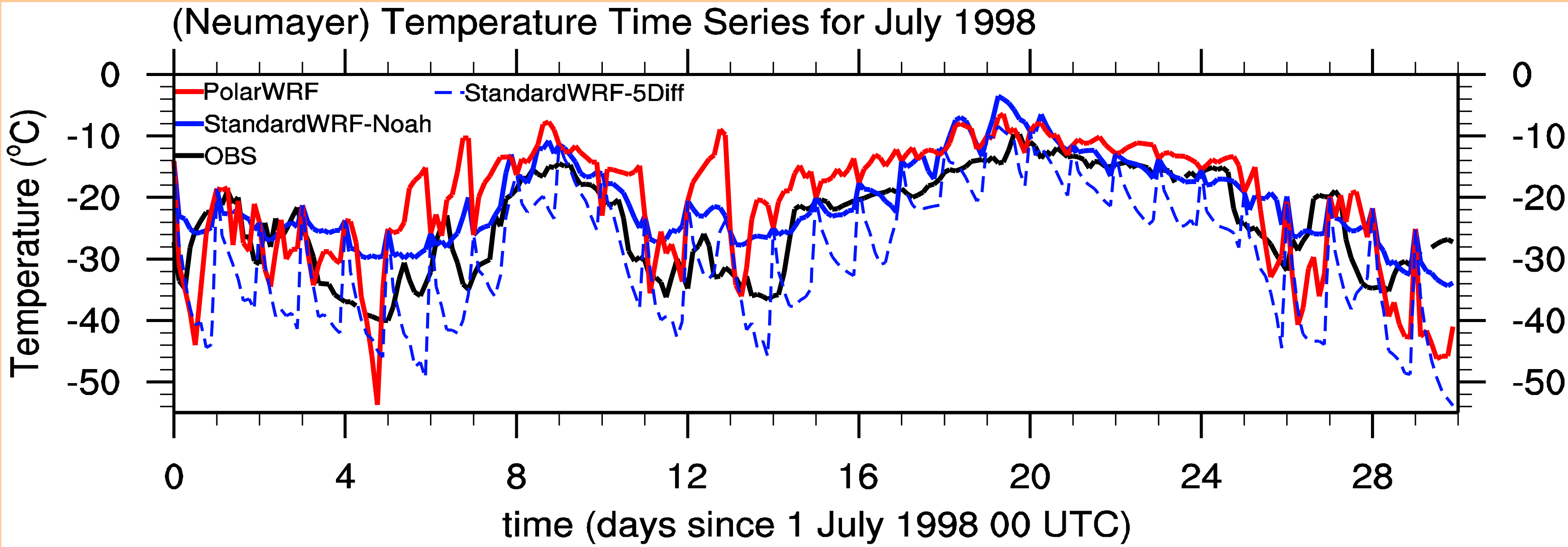
- Standard WRF (5-Diff) quickly develops a considerable temperature bias
- Standard WRF (Noah) and the Polar WRF give quite similar biases up to day six
- Standard WRF (Noah) gives more negatively biased temperatures overall but during the first 24 hours the Polar WRF is more negatively biased

Experiments 1, 2, and 3: surface pressure bias time series



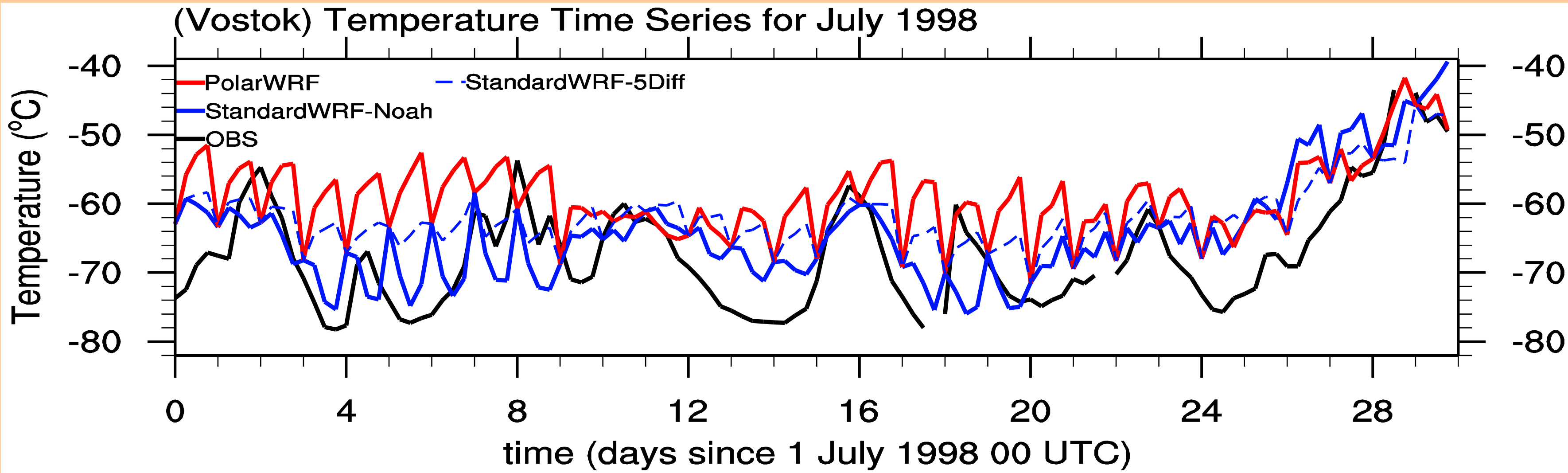
- The WRF does not show sensitivity to the choice of land surface parameterization in the case of the surface pressure
- The Polar WRF gives less positively biased surface pressure values than the standard WRF, especially after day four

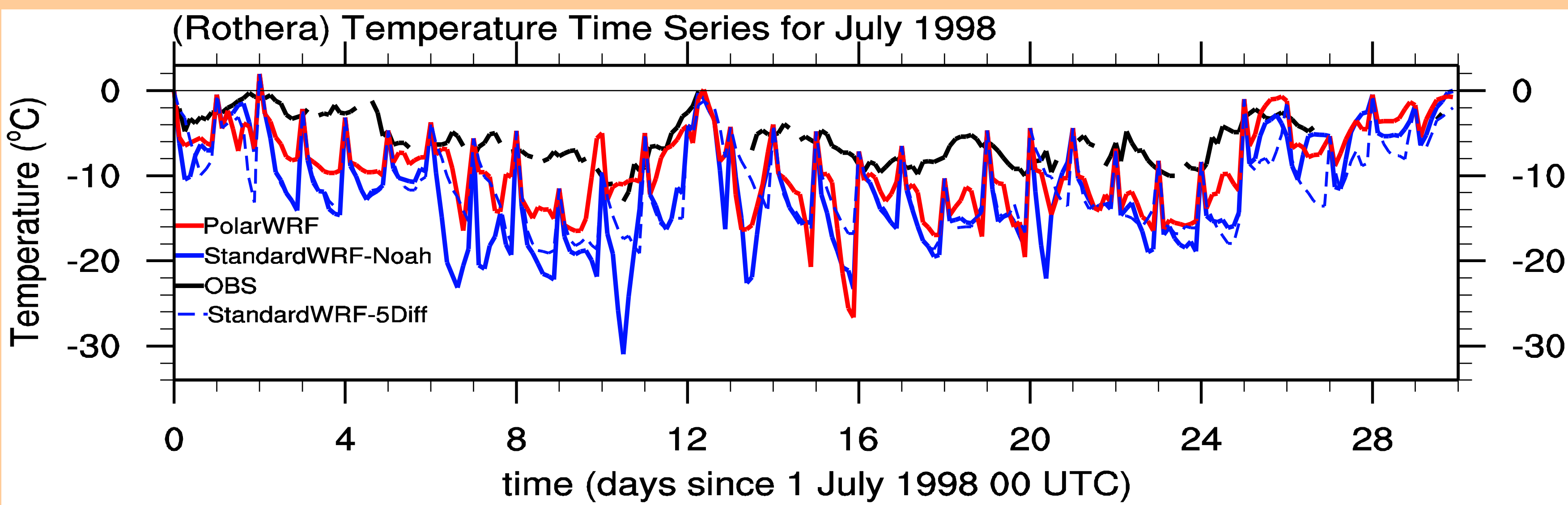
Experiments 4, 5, and 6: 30-day time series of 2-m temperature



	avg 2-m T RMSE (deg C)	avg 2-m T bias (deg C)
Standard WRF:5-Diff	6.7	-2.9
Standard WRF:Noah	4.7	0.2
Polar WRF	5.1	0.5

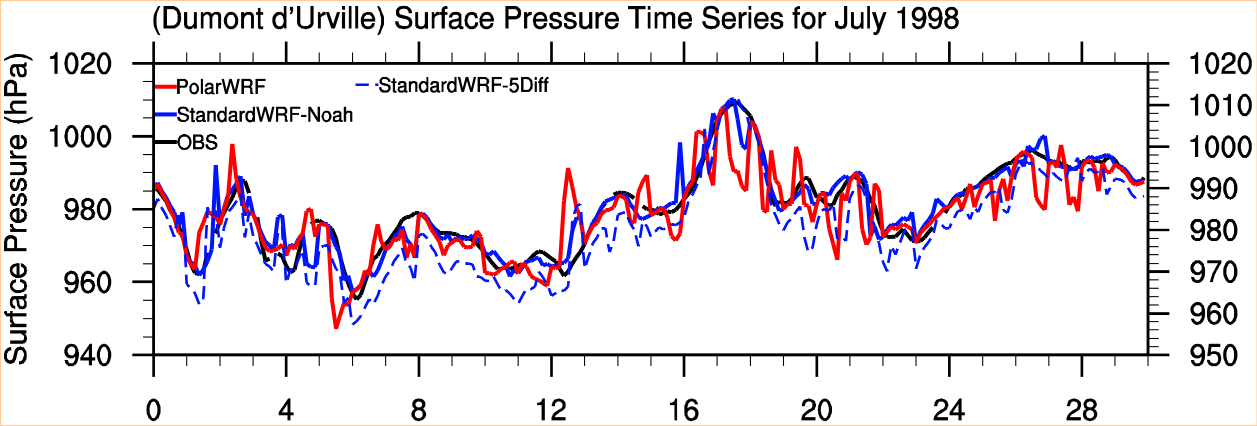
Experiments 4, 5, and 6: 30-day time series of 2-m temperature



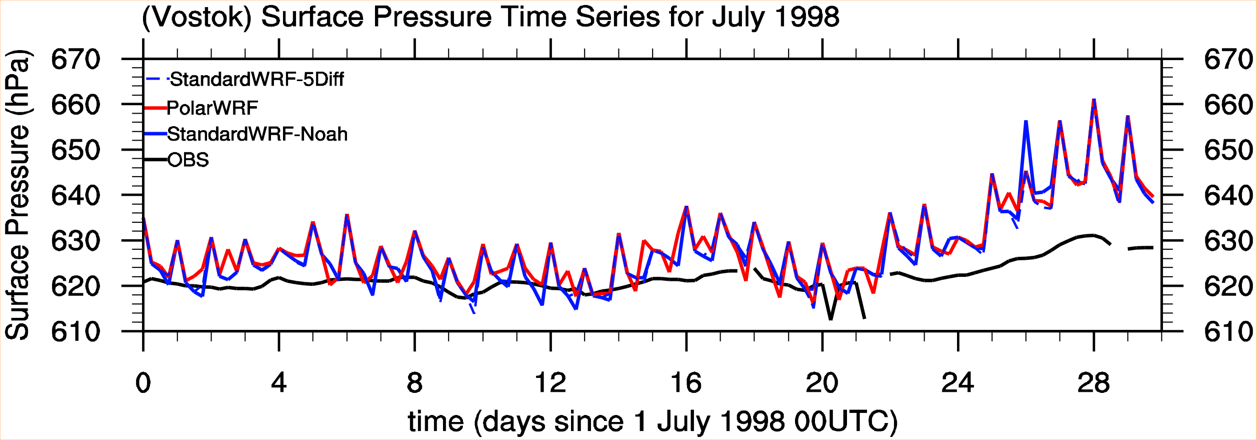


Experiments 4, 5, and 6: 30-day time series of surface pressure

	avg SFCP bias (hPa)
standard WRF: 5-Diff	2.3
standard WRF: Noah	1.9
Polar WRF	1.0



	avg SFCP correlation coefficient
standard WRF: 5-Diff	0.84
standard WRF: Noah	0.89
Polar WRF	0.75



Conclusions

2-m temperature:

- no drastic differences between the error growths of the standard WRF (Noah) and the Polar WRF
- the standard WRF shows great sensitivity to the choice of LSM
- when using the 5-layer thermal diffusion scheme a considerable negative bias is a problem
- with Noah LSM the standard version gives better results than the Polar WRF for the reference stations
- on the coldest station (Vostok), the standard version succeeds better than the Polar version

Surface pressure:

- The standard WRF not sensitive to the choice of LSM
- though Polar WRF gives a better bias than the standard WRF in the pressure simulation, the correlation is worse