Development and Validation of Polar WRF

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Outline

- **Lessons from Polar MM5 work**
- **WRF development simulations for Greenland**
  - **Test vs. AWS and Polar MM5**
  - **December 2002 (winter)**
  - **June 2001 (summer)**

  - **Temperature**
  - **Wind Speed**
  - **Specific Humidity**
  - **Surface Pressure**
  - **Wind Direction**
  - **Shortwave Radiation**
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- **Summary**

Lessons from Polar MM5

1. The Pennsylvania State University/National Center for Atmospheric Research Fifth-generation Mesoscale Model (PSU/NCAR MM5) was adapted for polar applications
   - (1) Real-time forecasting for Antarctica (AMPS)
   - (2) Forecasting for the Arctic Rivers (RIMS) Project
   - (3) Contemporary climate studies (ENSO)
   - (4) Paleoclimate studies (Last Glacial Maximum)
2. **Polar Optimizations to MM5**
   - (1) Revised cloud / radiation interaction
   - (2) Modified explicit ice phase microphysics
   - (3) Optimized turbulence (boundary layer) parameterization
   - (4) Implementation of a sea ice surface type
   - (5) Improved treatment of heat transfer through snow/ice surfaces
   - (6) Improved upper boundary treatment
3. Test for at least 3 different polar surface types.
   - (1) Ice Sheets (Antarctica and Greenland)
   - (2) Oceans and Sea Ice
   - (3) Arctic Land

Polar WRF Simulations for Greenland

110x100 Grid, 40 km horizontal grid spacing, 28 sigma levels

Modify surface energy balance of Noah LSM for snow cover

Try the YSU and Eta PBL schemes, the Noah and RUC land surface models, the 5-class WSM (WRF single-moment) and Hall-Thompson 2-moment cloud microphysics

Run for December 2002 (winter) and June 2001 (summer)

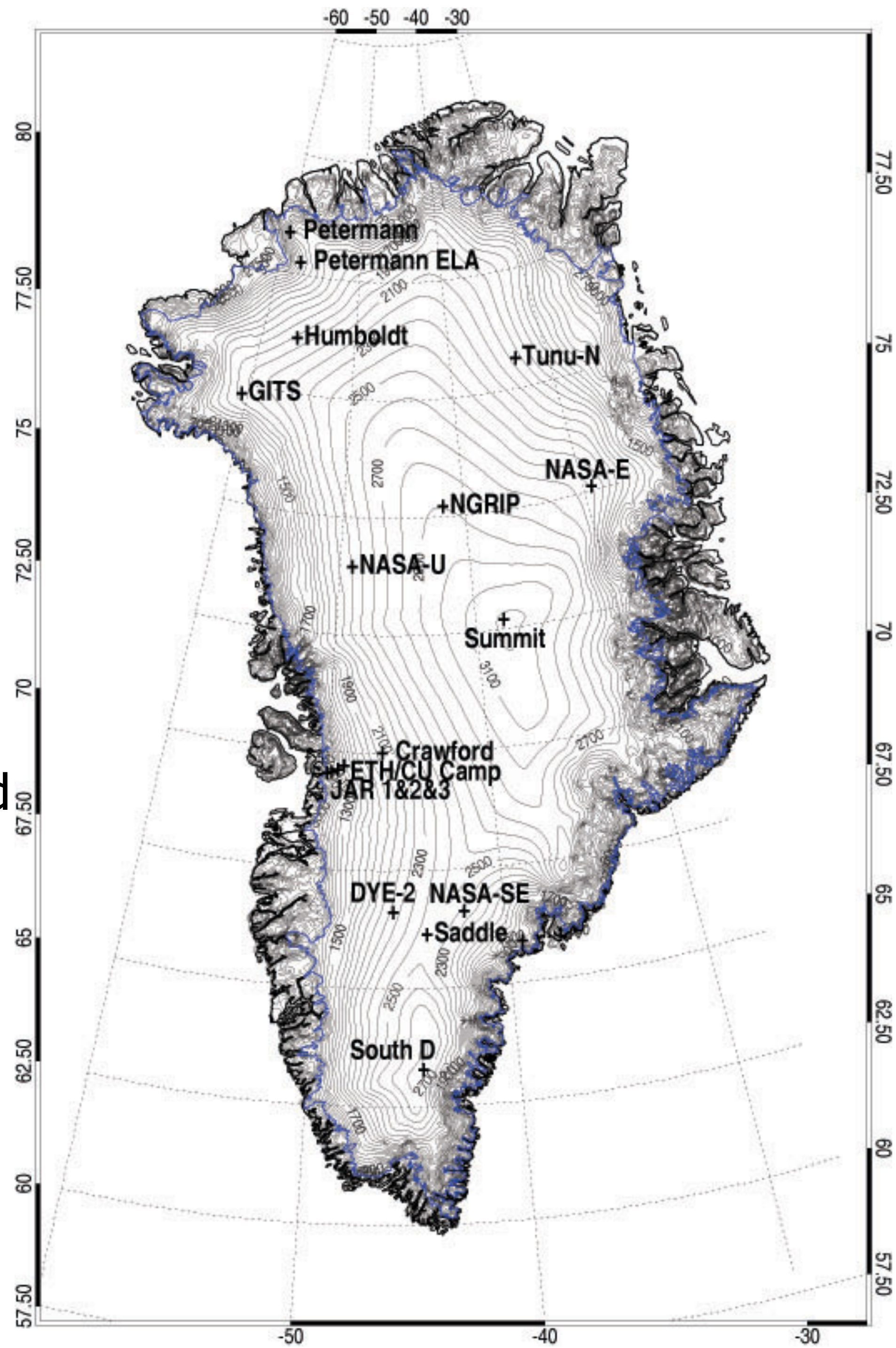
Compare 48-hour WRF simulations with AWS observations from the Greenland Climate Network, 30-hour Polar MM5 simulations (121x103 nested grid with 24-km horizontal resolution and 28 vertical levels), and radiation observations at Summit

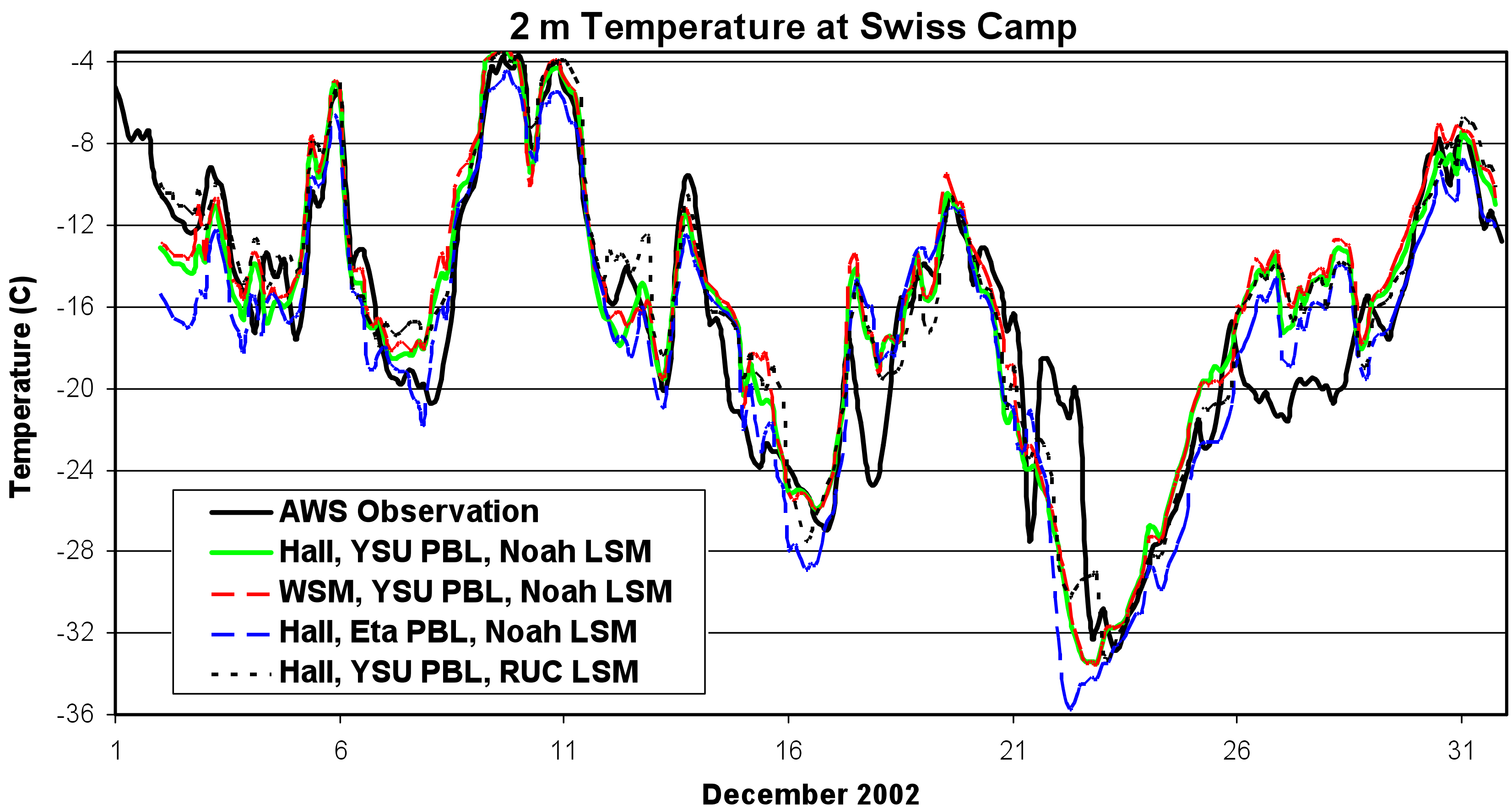
Greenland Climate Network Automatic Weather Stations (AWS)

(Konrad Steffen & Jason Box)

Up to 16 stations are active for June 2001 and December 2002

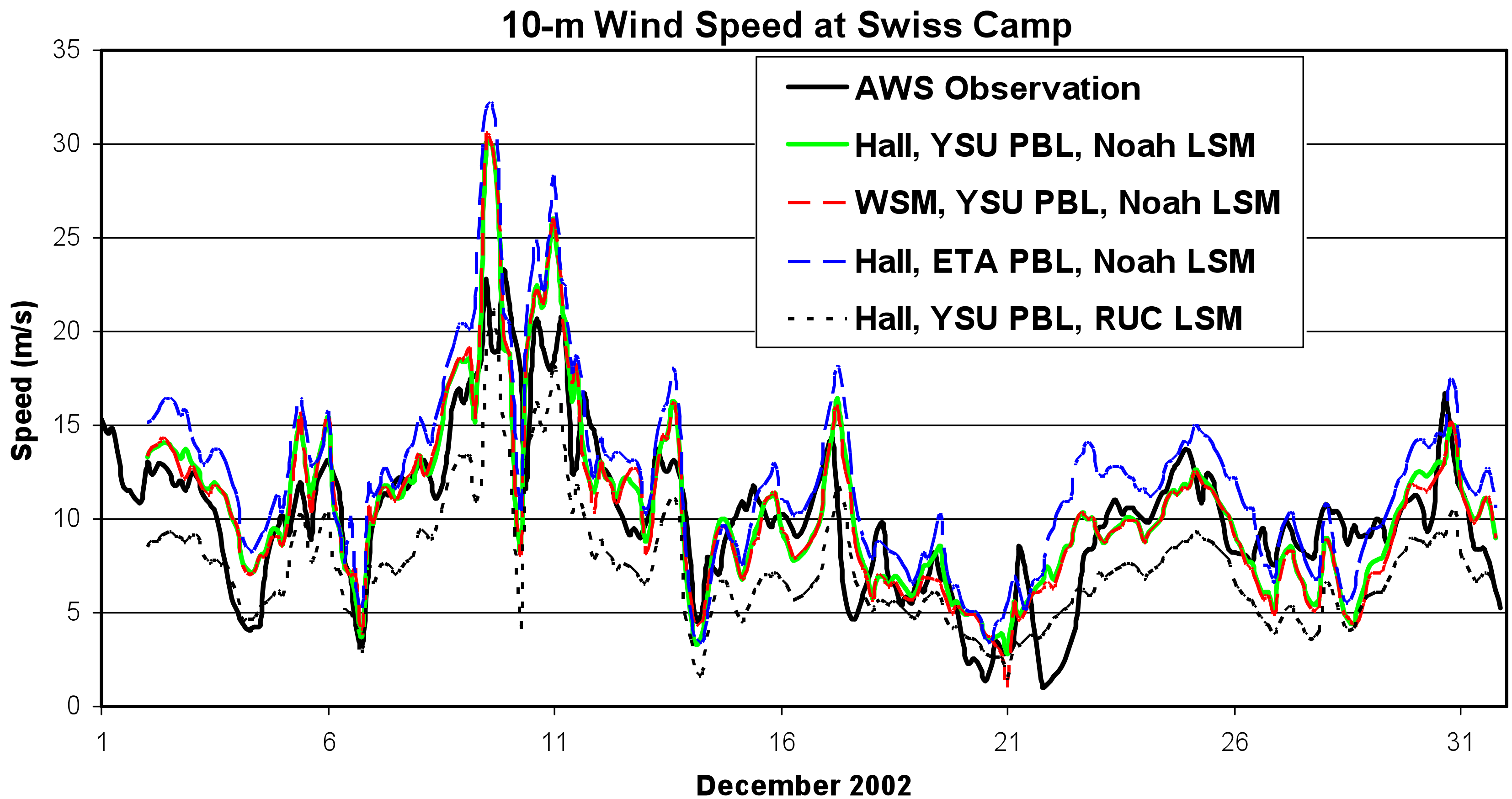
Interpolate WRF and MM5 output to these sites



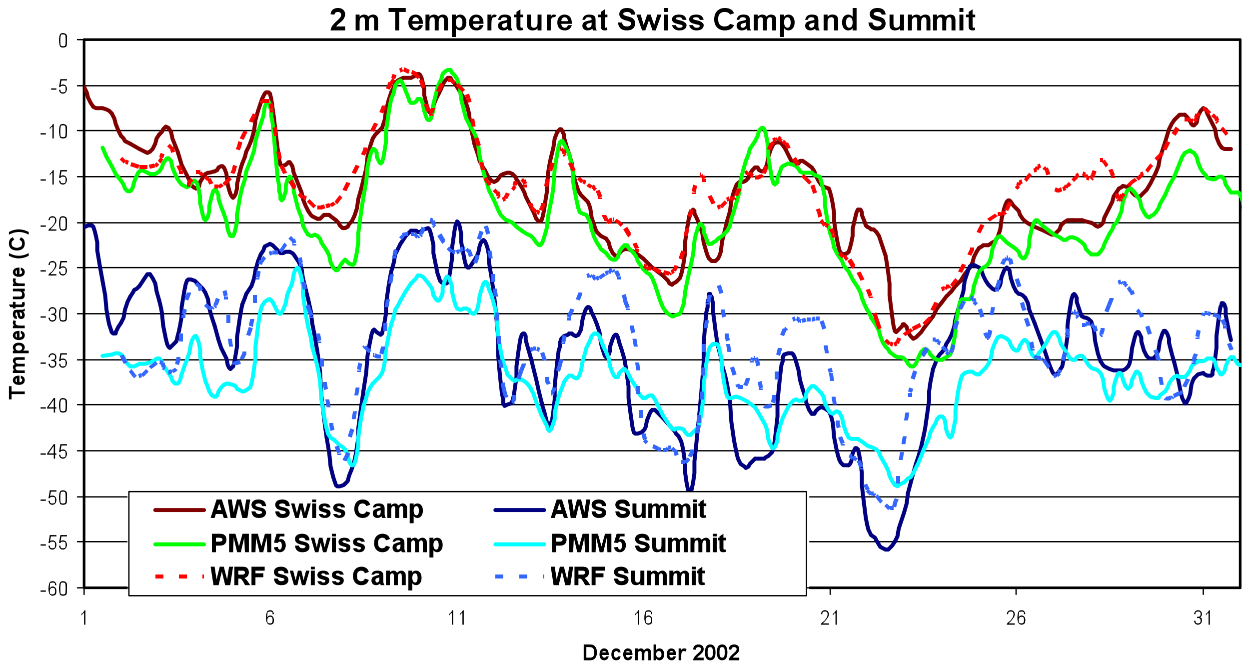


Run	Correlation	Bias
Hall, YSU, Noah	0.907	0.47
WSM, YSU, Noah	0.907	0.84
Hall, **Eta**, Noah	0.894	-0.78
Hall, YSU, **RUC**	0.904	0.80
Polar MM5	0.938	-2.56

WRF simulations with Dudhia shortwave radiation, RRTM longwave radiation, and initial and boundary conditions from the AVN Model

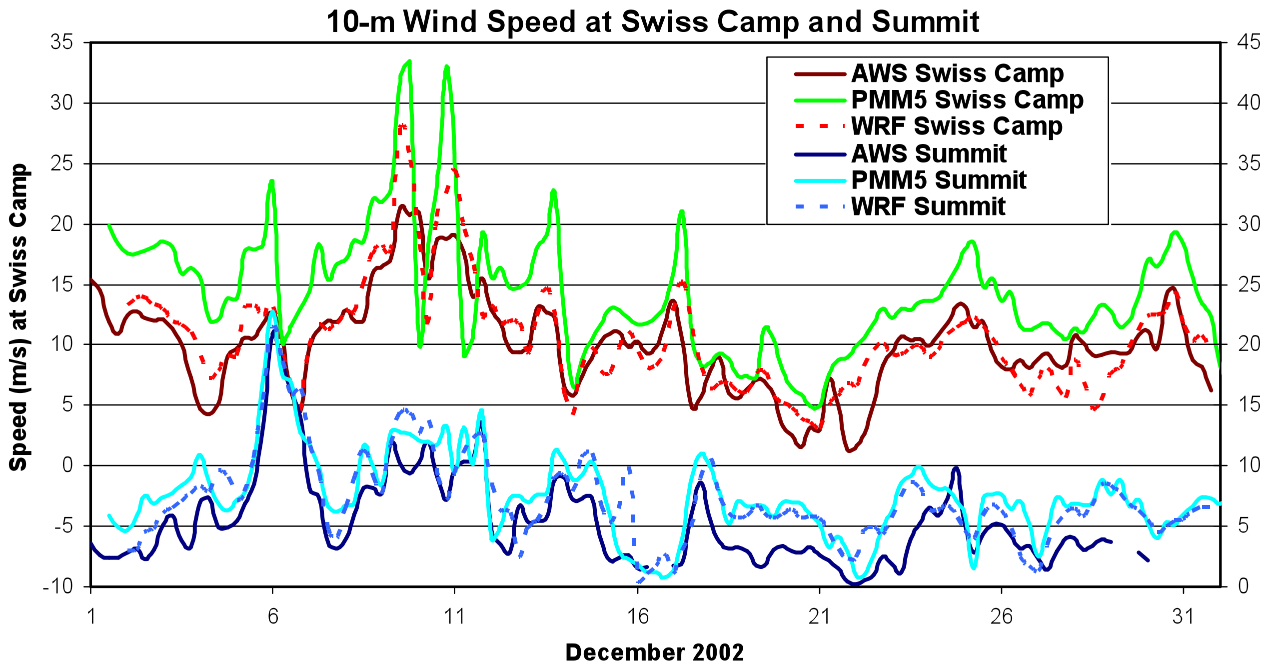


Run	Correlation	Bias
Hall, YSU, Noah	0.865	0.47
WSM, YSU, Noah	0.864	0.31
Hall, **Eta**, Noah	0.859	2.08
Hall, YSU, **RUC**	0.881	-2.72
Polar MM5	0.763	4.32



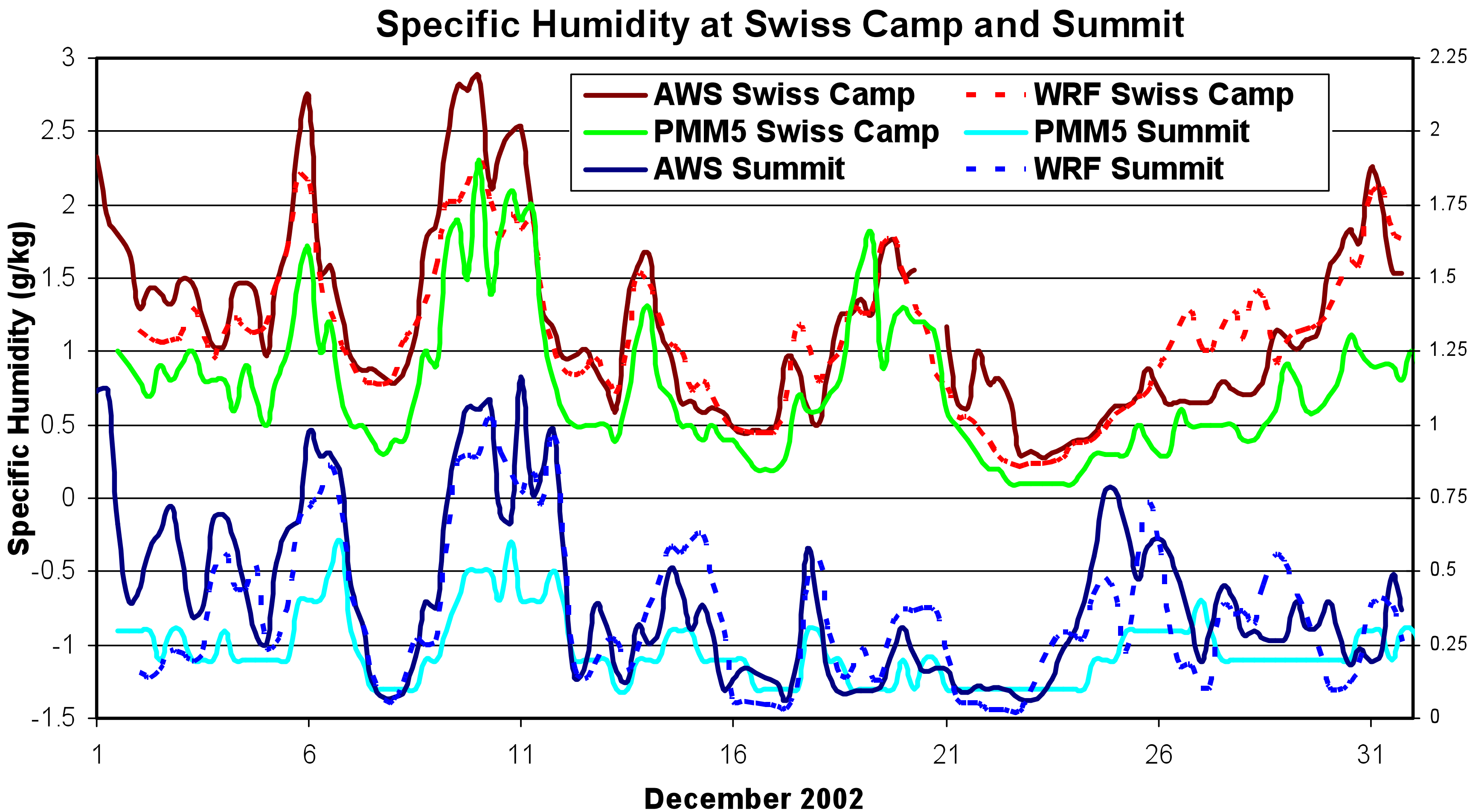
Run	Correlation	Bias
WRF - Swiss Camp	0.907	0.47
MM5 – Swiss Camp	0.938	-2.56
WRF - Summit	0.846	1.35
MM5 – Summit	0.853	-2.34

WRF simulations with Hall-Thompson microphysics, YSU PBL, Noah LSM, Dudhia shortwave and RRTM longwave radiation, and AVN-driven boundary conditions
MM5 simulations with Eta PBL, Reisner microphysics and ECMWF-driven boundary conditions

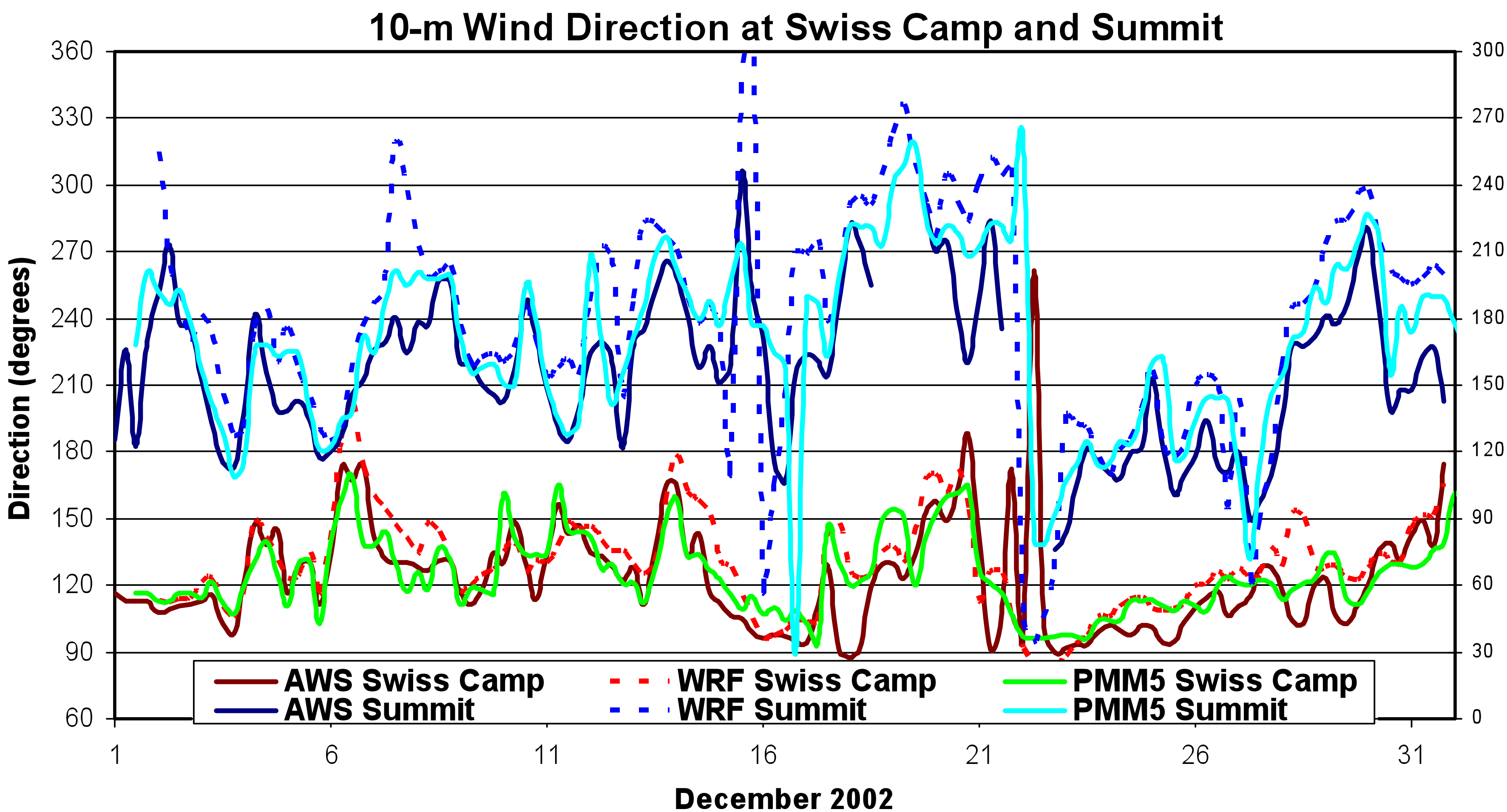


Run	Correlation	Bias
WRF - Swiss Camp	0.865	0.47
MM5 – Swiss Camp	0.938	4.32
WRF - Summit	0.863	1.83
MM5 – Summit	0.896	2.34

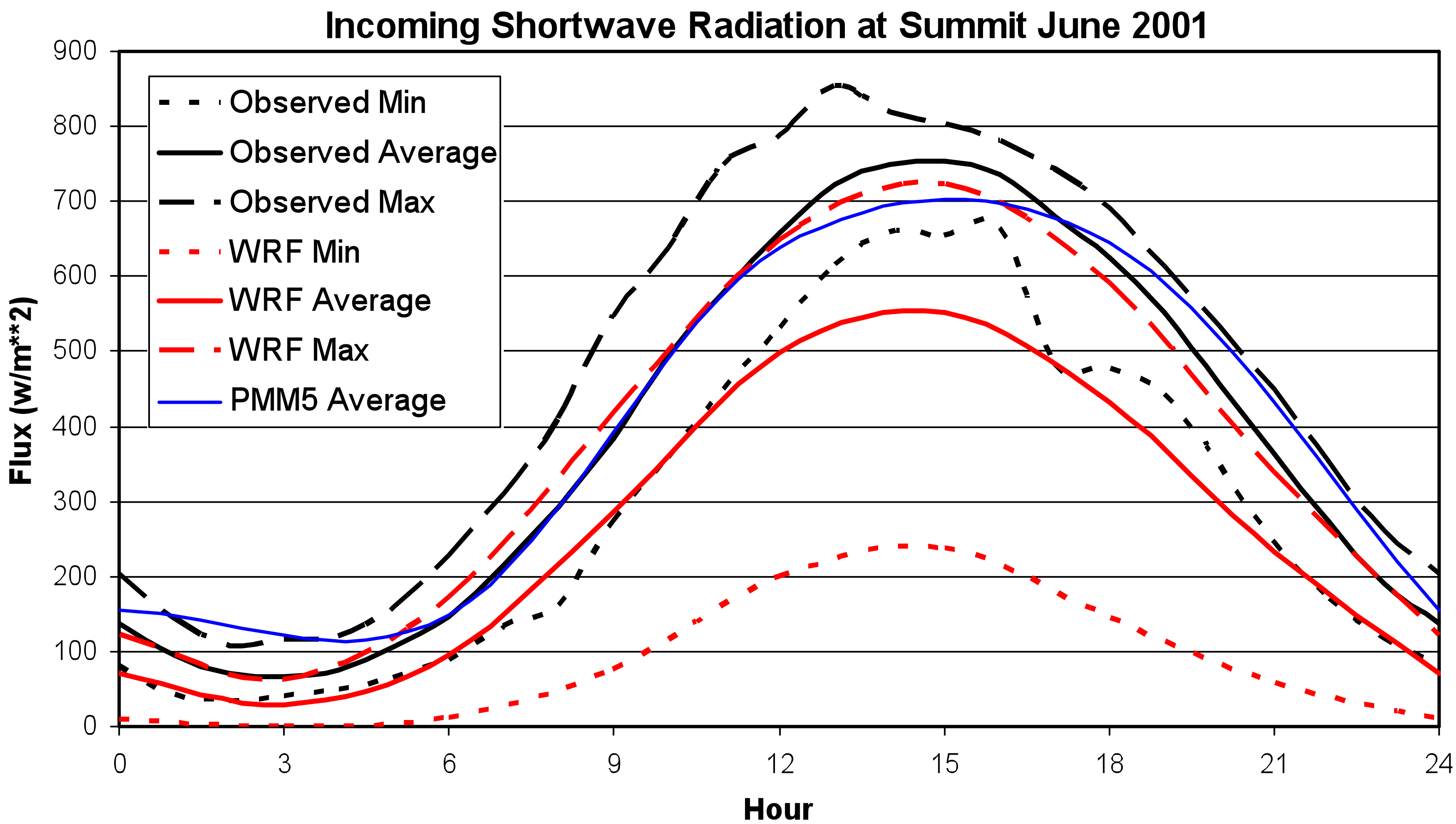
Wind Speed: MM5 shows a higher correlation. WRF has a smaller bias



Run	Correlation	Bias
WRF - Swiss Camp	0.888	-0.04
MM5 – Swiss Camp	0.895	-0.37
WRF - Summit	0.787	-0.04
MM5 – Summit	0.794	-0.15

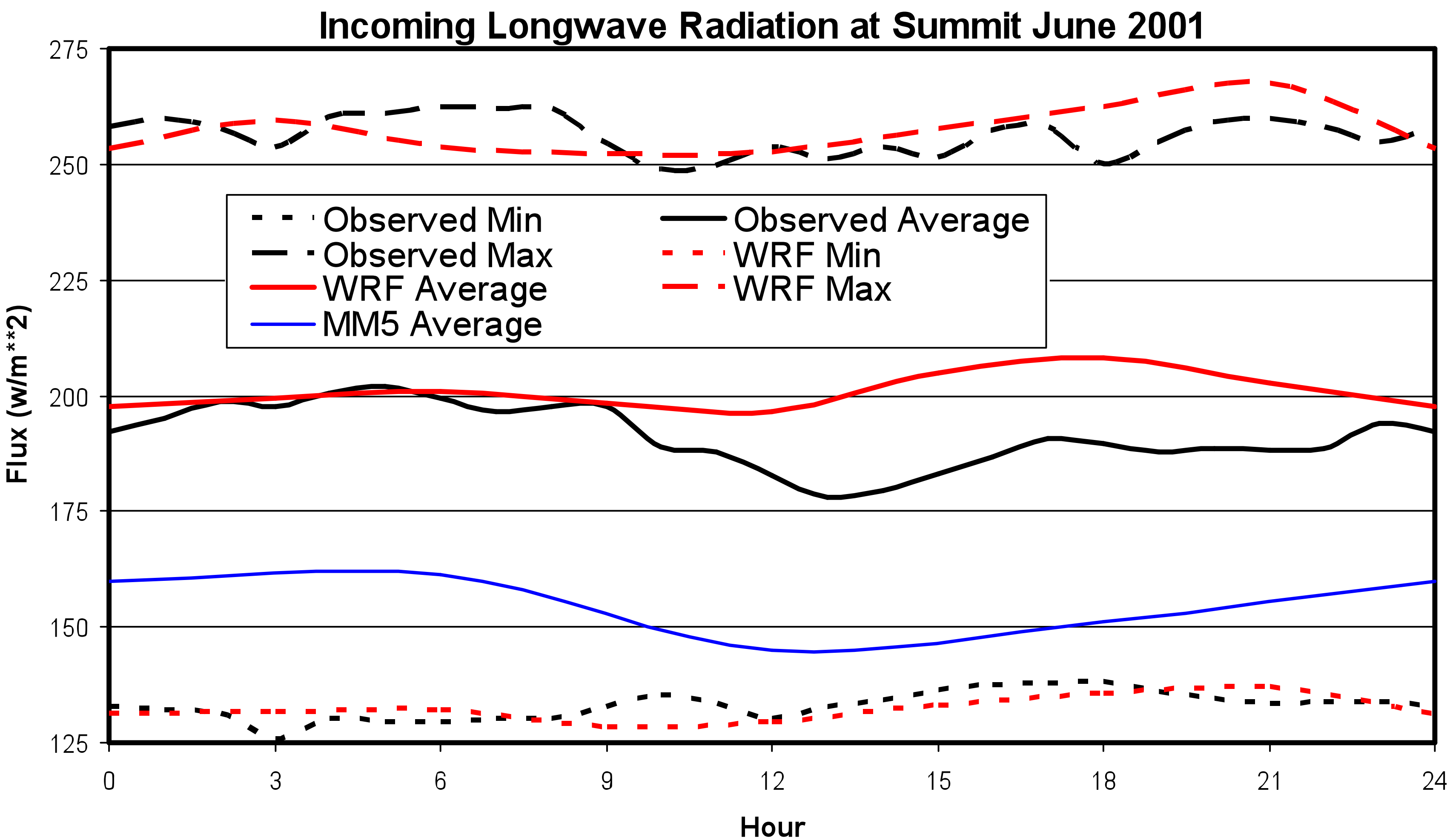


10-m Wind Direction at Swiss Camp and Summit
Direction (degrees)
360
330
300
270
240
210
180
150
120
90
60
300
270
240
210
180
150
120
90
60
30
0
1
6
11
16
21
26
31
December 2002
AWS Swiss Camp
AWS Summit
WRF Swiss Camp
WRF Summit
PMM5 Swiss Camp
PMM5 Summit

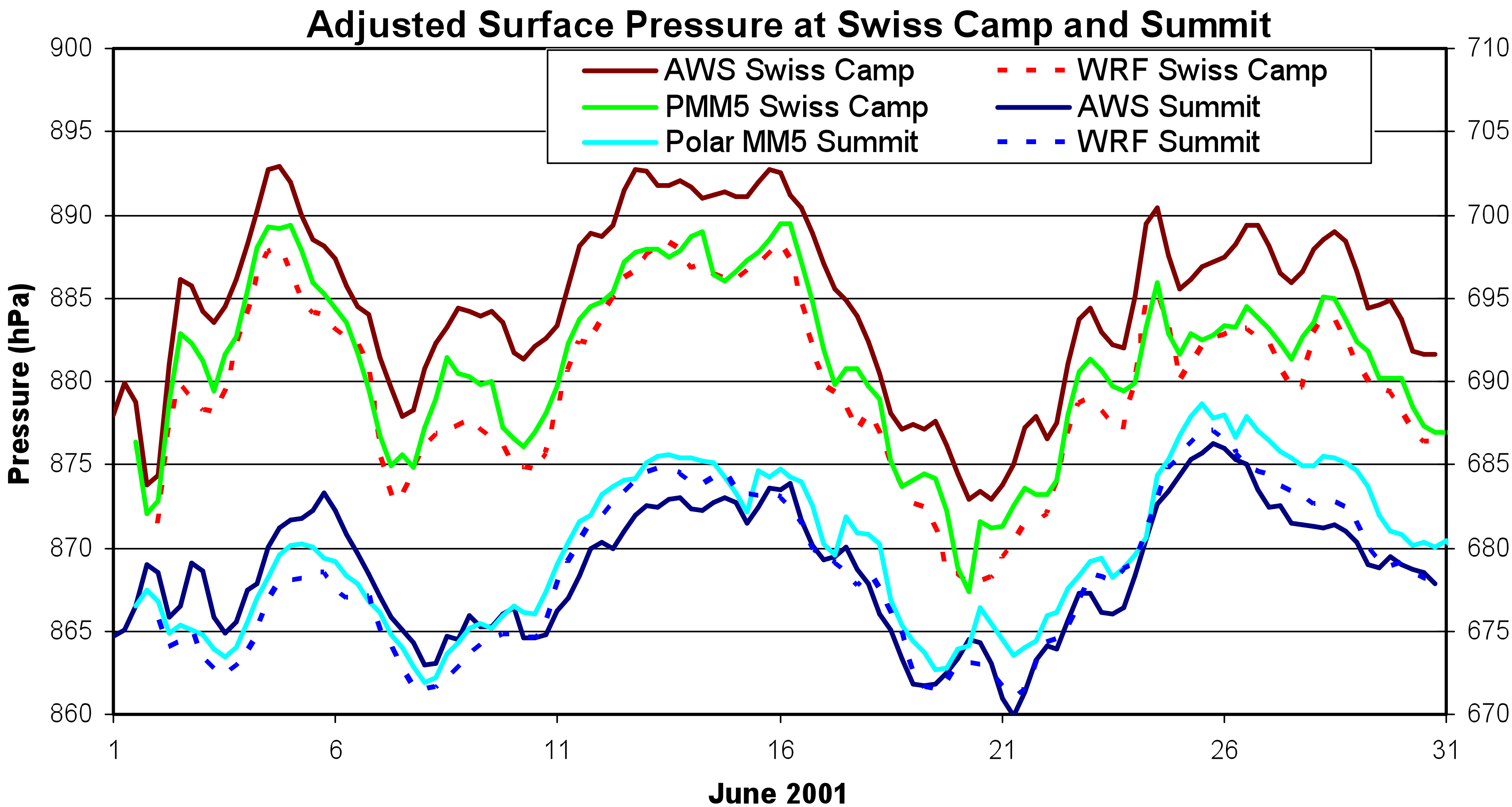


WRF simulations with Dudhia shortwave radiation show a large negative bias in downward shortwave at Summit.

MM5 simulations produce reasonable downward shortwave.



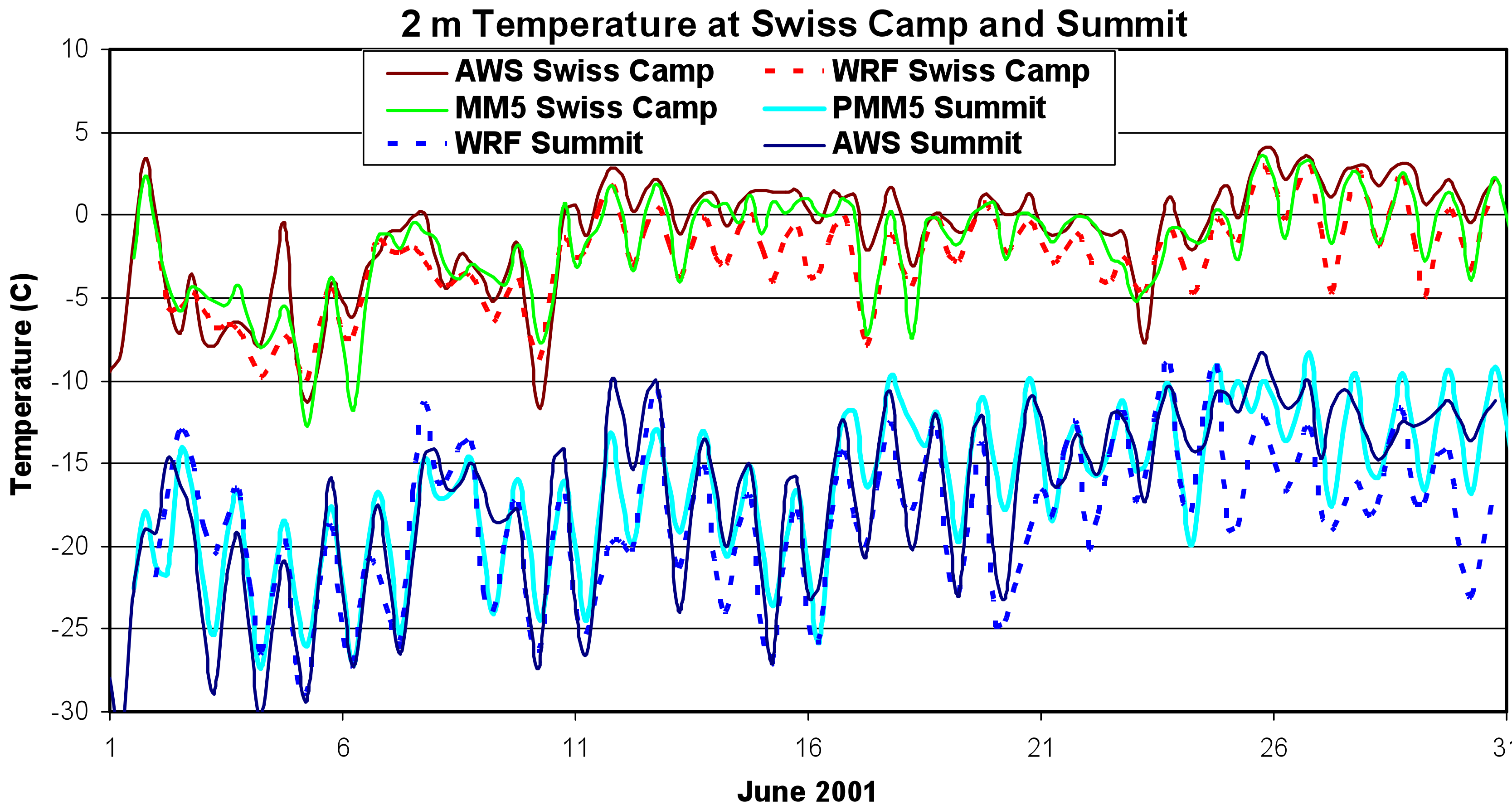
WRF simulations with RRTM longwave radiation reasonably produce the mean and range of downward longwave at Summit.
MM5 simulations show a large deficit in downward longwave.



Run	Correlation	Bias
WRF - Swiss Camp	0.978	-5.21
MM5 – Swiss Camp	0.979	-3.76
WRF - Summit	0.916	-0.24
MM5 – Summit	0.899	1.21

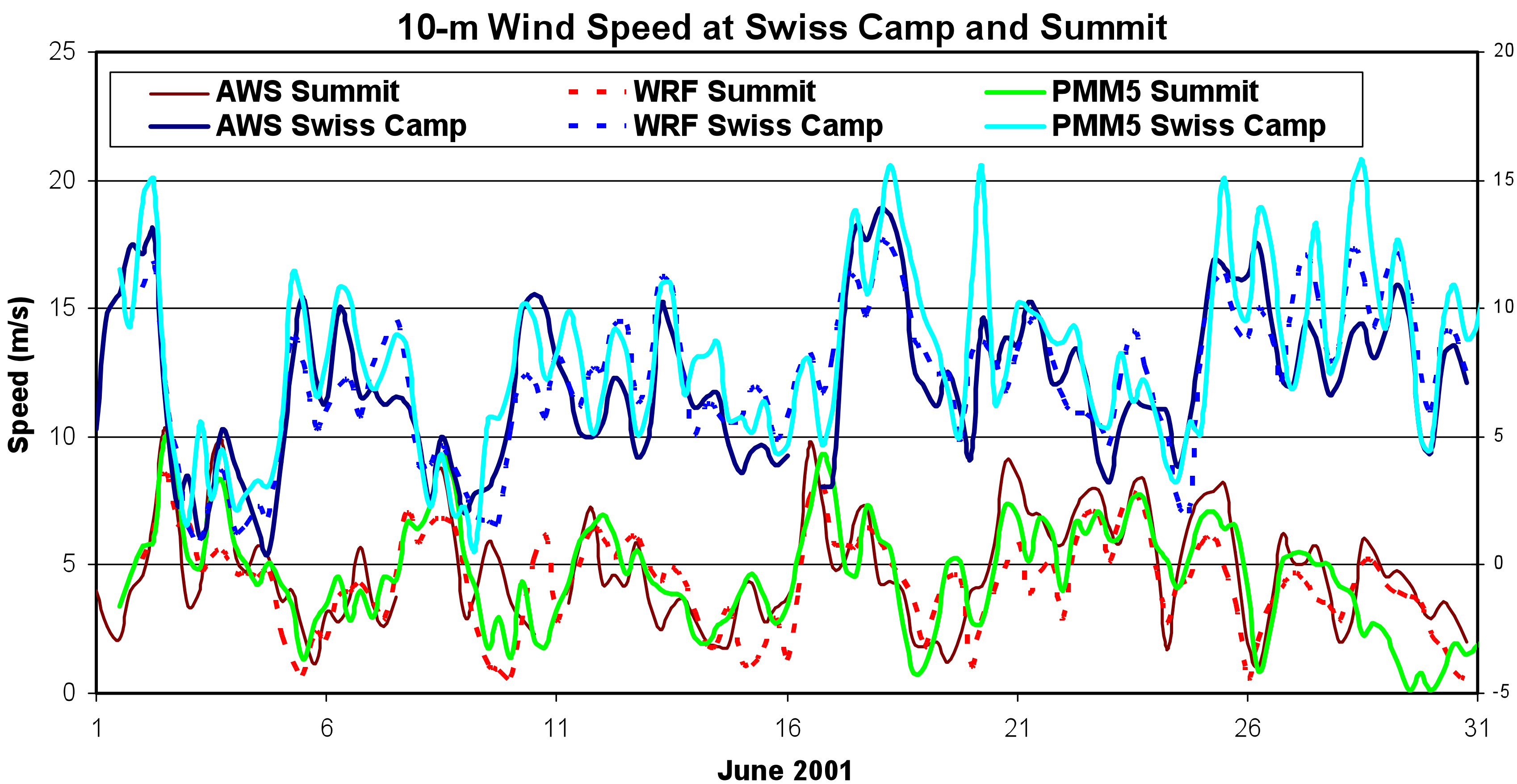
WRF simulations with Hall-Thompson microphysics, YSU PBL, Noah LSM, Dudhia shortwave and RRTM longwave radiation, and AVN-driven boundary conditions

MM5 simulations with Eta PBL, Reisner microphysics and ECMWF-driven boundary conditions

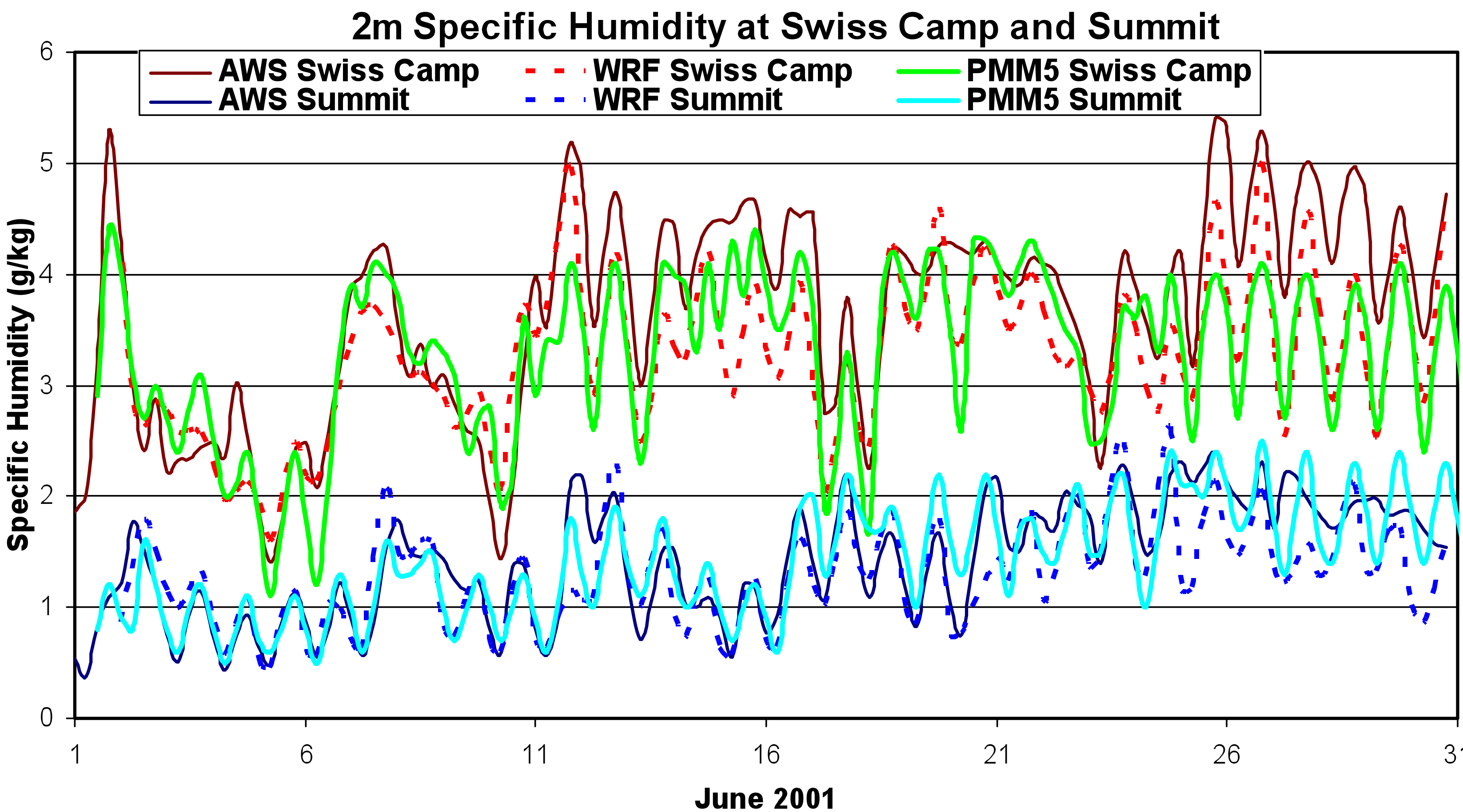


Run	Correlation	Bias
WRF - Swiss Camp	0.867	-1.75
MM5 – Swiss Camp	0.866	-0.78
WRF - Summit	0.770	-1.91
MM5 – Summit	0.854	0.27

WRF simulation shows a cold bias for late June. Both WRF and MM5 exaggerate the diurnal cycle for late June. Analysis suggests that slow spin-up of the subsurface temperatures contributes to the cold bias.



Run	Correlation	Bias
WRF - Swiss Camp	0.816	0.15
MM5 – Swiss Camp	0.847	1.01
WRF - Summit	0.668	-0.64
MM5 – Summit	0.725	-0.19



Run	Correlation	Bias
WRF - Swiss Camp	0.769	-0.52
MM5 – Swiss Camp	0.785	-0.33
WRF - Summit	0.689	-0.19
MM5 – Summit	0.853	-0.04

MM5 shows higher correlations and smaller bias for June.

Summary

- Following the path of development for Polar MM5, WRF is being optimized for polar applications.
- Polar WRF shows similar synoptic skill to Polar MM5 for Greenland simulations.
- Polar WRF is at least as successful as Polar MM5 for simulations of the Greenland winter boundary layer.
- Polar MM5 simulations of the Greenland summer boundary layer are superior to those of Polar WRF.
- Polar WRF well represents the longwave radiation at Summit, however, the downward shortwave radiation is under-simulated.
- Testing of WRF continues for the North Slope of Alaska (NSA) [Arctic land] and SHEBA [Polar Ocean] sites.

Arctic System Reanalysis (ASR)

1. Rapid climate change appears to be happening in the Arctic. A more comprehensive picture of the coupled atmosphere/ land surface/ ocean interactions is needed.

2. Global reanalyses encounter many problems at high latitudes. The ASR would use the best available description for Arctic processes and would enhance the existing database of Arctic observations. The ASR will be produced at improved temporal resolution and much higher spatial resolution.

3. The ASR would provide fields for which direct observation are sparse or problematic (precipitation, radiation, cloud, ...) at higher resolution than from existing reanalyses.

4. The system-oriented approach would provide a community focus including the atmosphere, land surface and sea ice communities.

5. The ASR would provide a convenient synthesis of Arctic field programs (SHEBA, LAII/ATLAS, ARM, ...)