Polar Meteorology Group, Byrd Polar and Climate Research Center, The Ohio State University, Columbus, Ohio

Antarctic Clouds simulated by Polar WRF and AMPS

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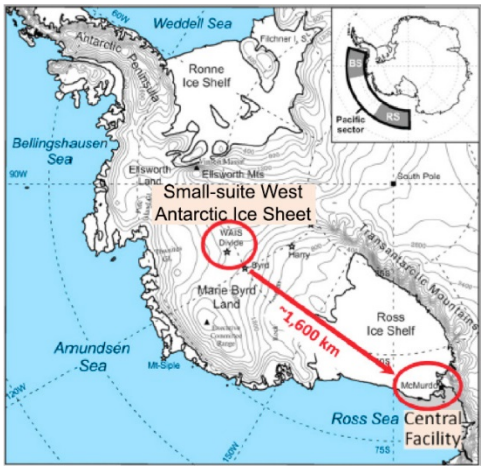

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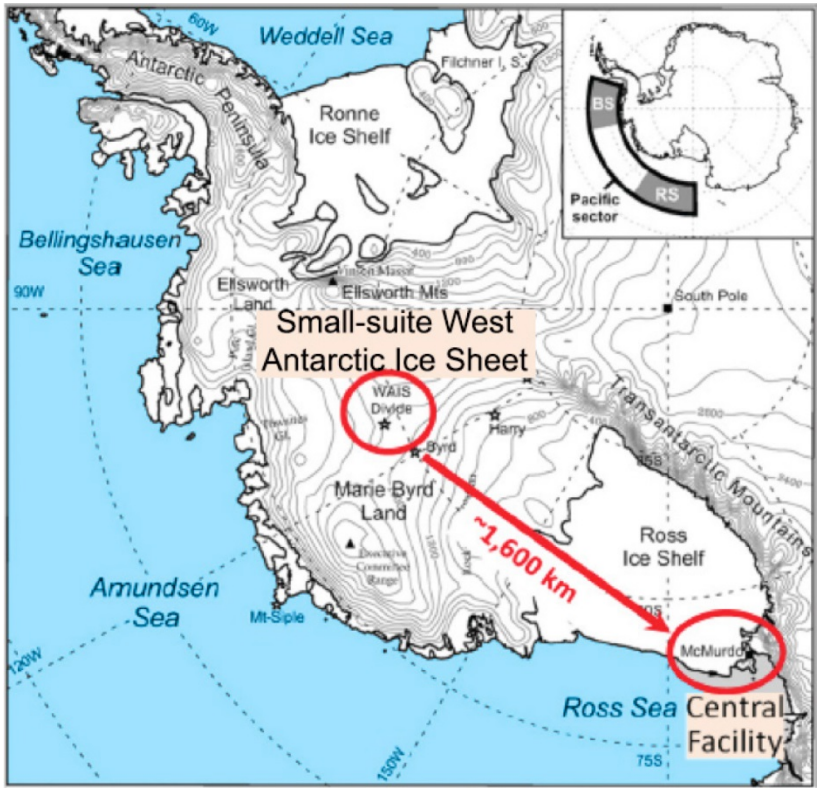
https://youtu.be/723763A24Fw

ARM West Antarctic Radiation Experiment (AWARE)

OBSERVATIONS: 23 NOVEMBER 2015 - 5 JANUARY 2017

Observations at West Antarctic Divide (WAIS) and McMurdo

West Antarctic warming during January 2016



AWARE aims to gain insight into the factors behind recent climate change in West Antarctica by quantifying the role of changing air masses on the surface energy balance. The field campaign use some of the most advanced atmospheric research instrumentation to conduct cloud, radiative, and aerosol observations.

Important for AWARE and WRF

Does our knowledge of Arctic clouds carry over to high southern latitudes?

Polar cloud observations (and modeling studies) much more extensive in Arctic than Antarctic

Antarctica is colder, has less vapor and is more pristine than the Arctic

AWARE McMurdo observations suggest Antarctic clouds are less extensive than over the Arctic Ocean, however McMurdo shows topographically-forced vertical motions

Cloud water at very low atmospheric temperature

Vertical cloud distribution is different

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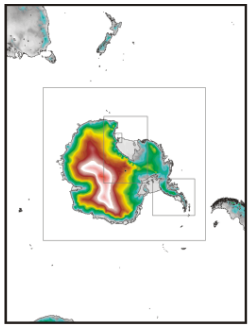
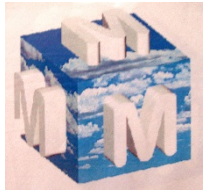
The Antarctic Mesoscale Prediction System (AMPS)



- **Adapted numerical weather prediction system for Antarctica**
  - **Polar WRF (Weather Research and Forecasting Model)**
  - **Variable resolution now to 0.9 km**

- **Priority Mission: U.S. Antarctic Program (USAP) Weather Support (clouds important for aircraft!)**

- **Collaborators: NCAR and OSU BPCRC**



- **Powers et al. (2012) A decade of Antarctic science through AMPS. BAMS, 93, 1699-1712.**
- **http://www.mmm.ucar.edu/rt/amps**

NCAR

National Science Foundation

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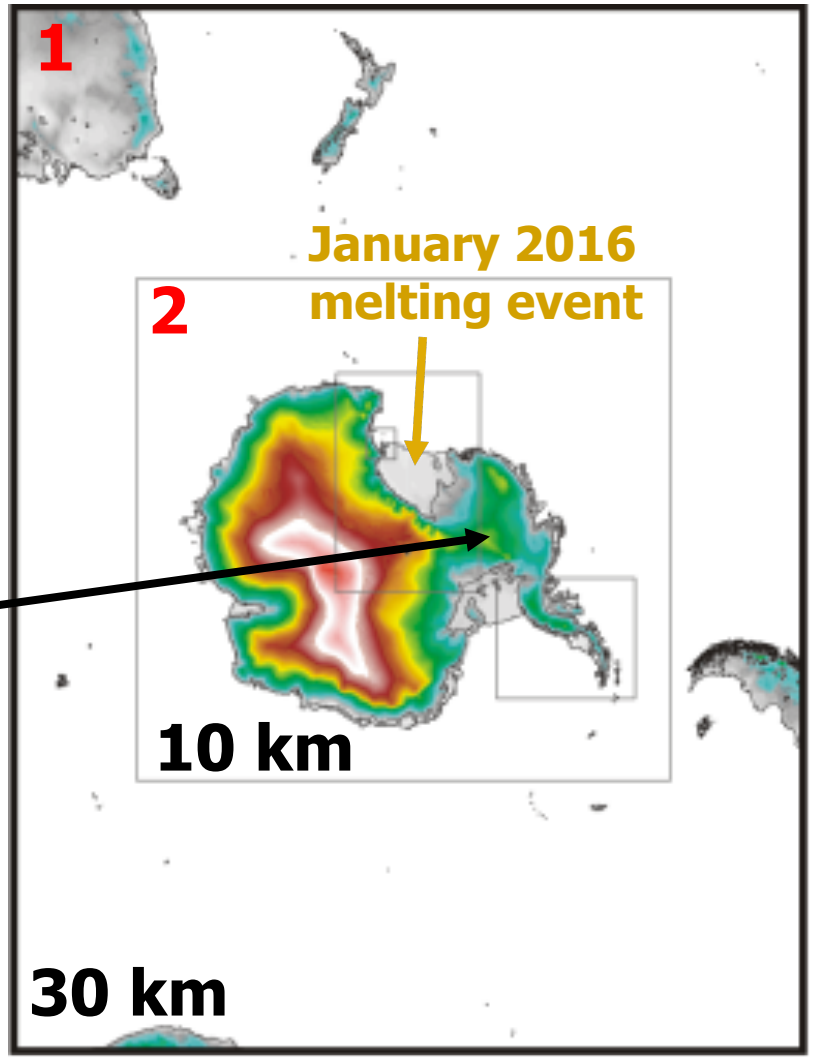
AMPS GRIDS

NCAR



Use AMPS grid 2 for WAIS evaluation

Use December 2015 and January 2016 AMPS forecasts and WAIS observations

National Science Foundation

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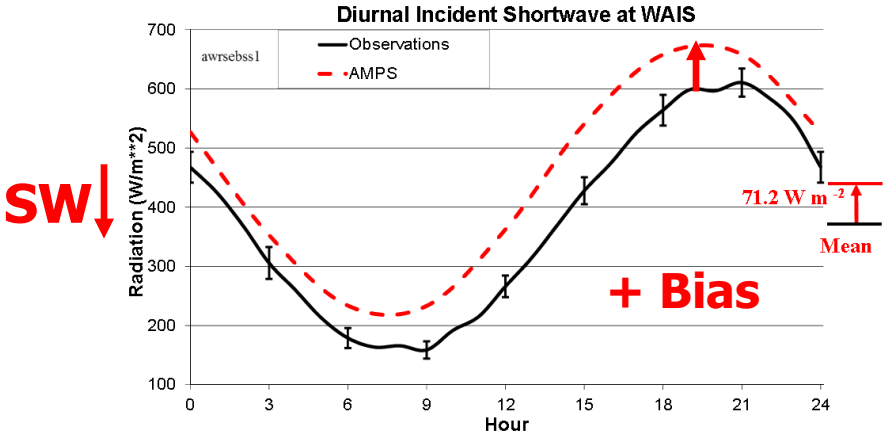
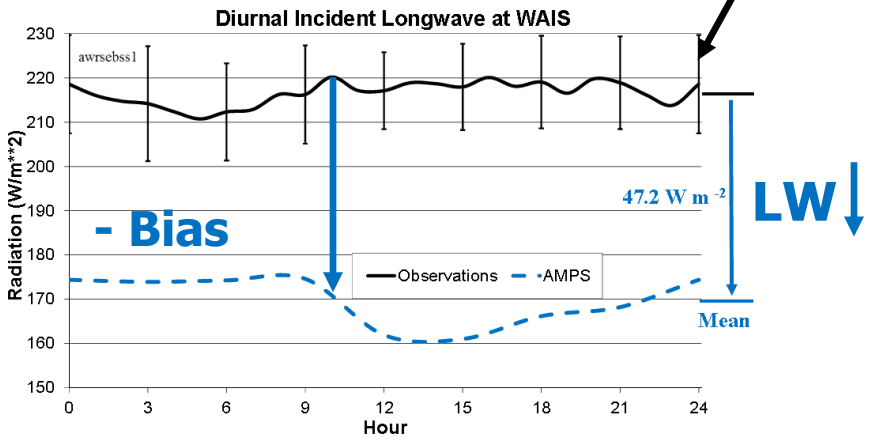
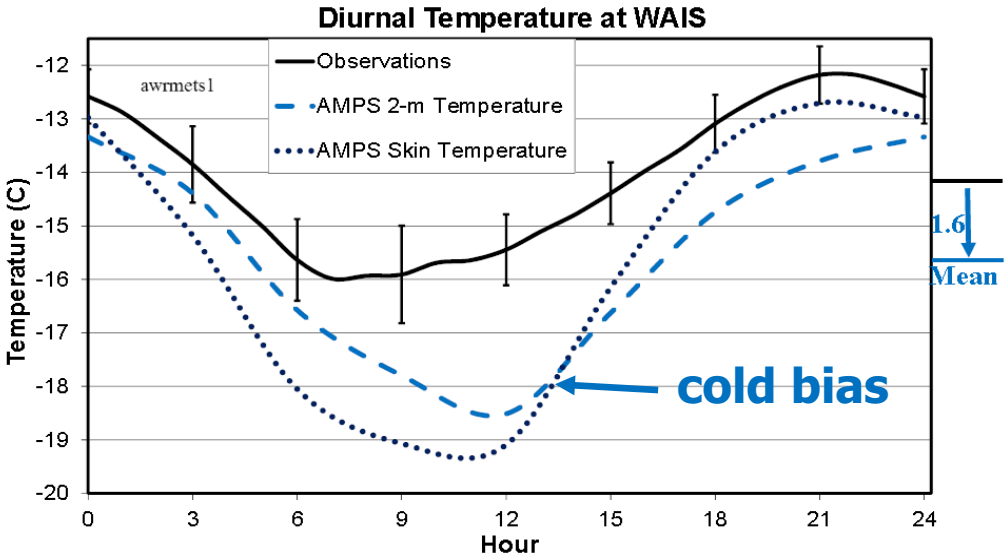
Test West Antarctic Summer Results for AMPS with WAIS Observations

Surface Energy Balance: Excess shortwave and deficit in longwave → Cloud deficit?

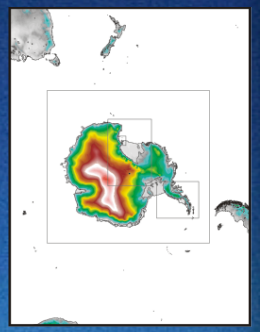




AMPS shows biases suggesting a better Antarctic cloud simulation is needed



Test WRF Microphysics Schemes vs. AWARE WAIS Observations



PWRF 3.9.1 on AMPS Grid 2 (10 km) with ERA-I I.C. + B.C. (AMPS uses GFS)

WRF Single-Moment 5-Class (same as AMPS)

Morrison 2-Moment (slight polar modifications)

Thompson-Eidhammer Aerosol Aware

Morrison-Milbrandt P3 (avoids arbitrary cloud and precipitation categorization)

Note: New daily PWRF 3.9.1 runs use 12-35 hr output
Two-times daily AMPS output with 12-21 hr fields

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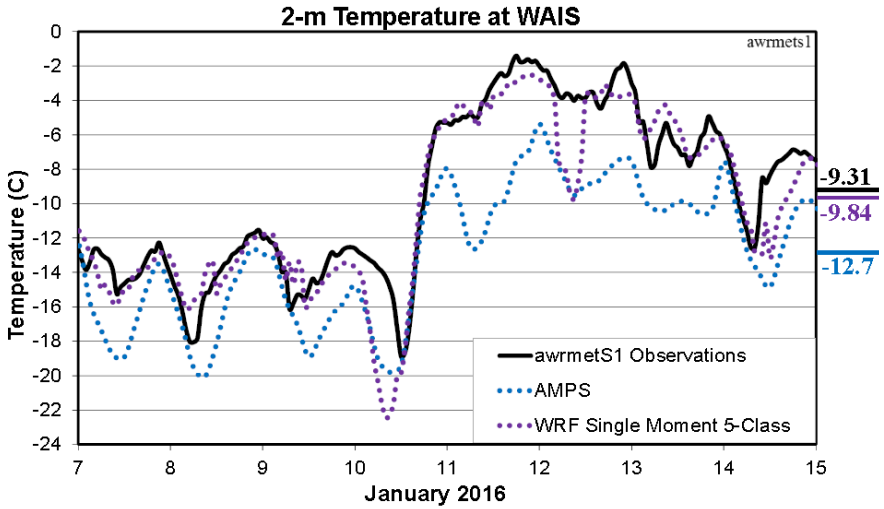
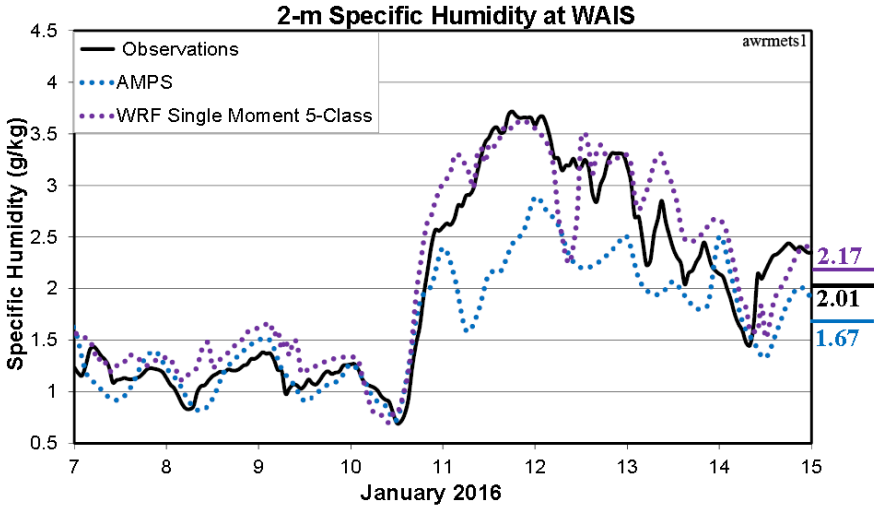
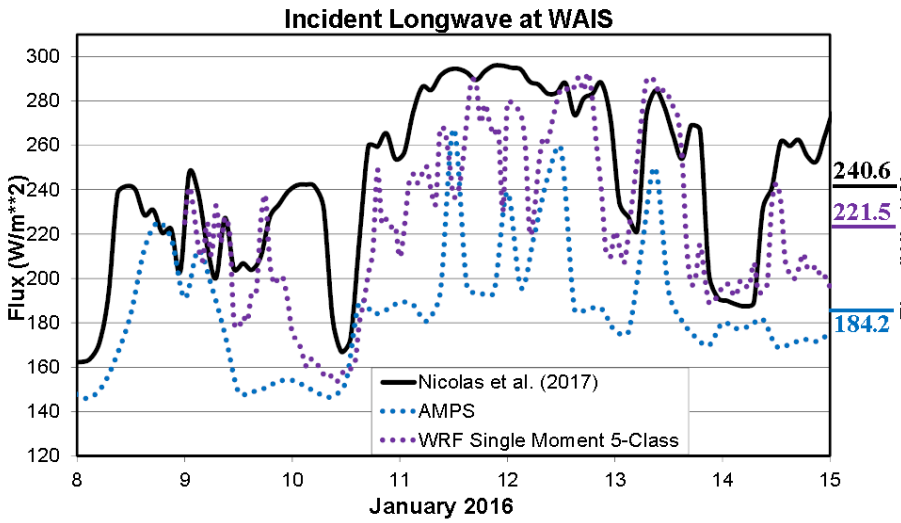
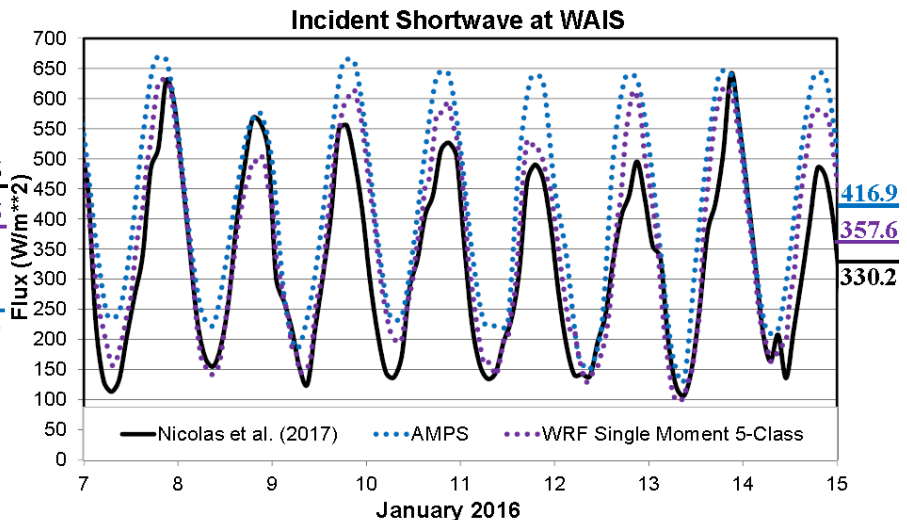
Near Surface Fields at WAIS 7 – 15 January 2016



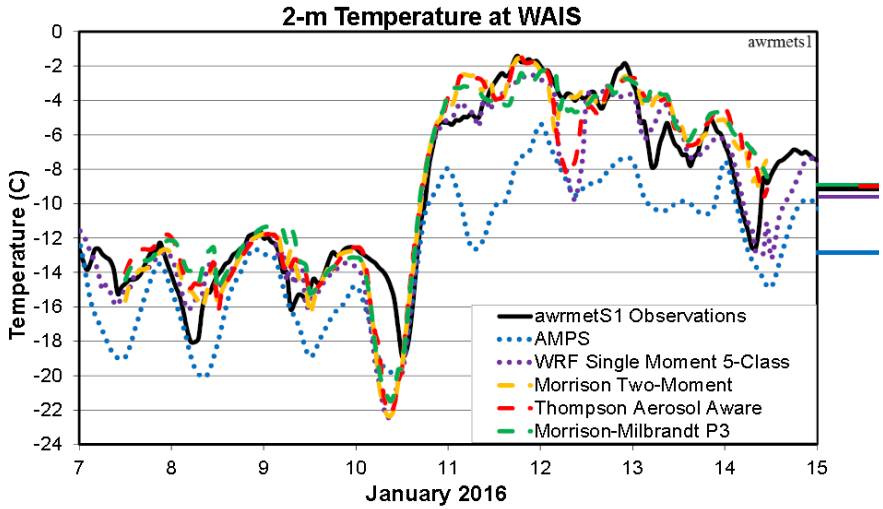


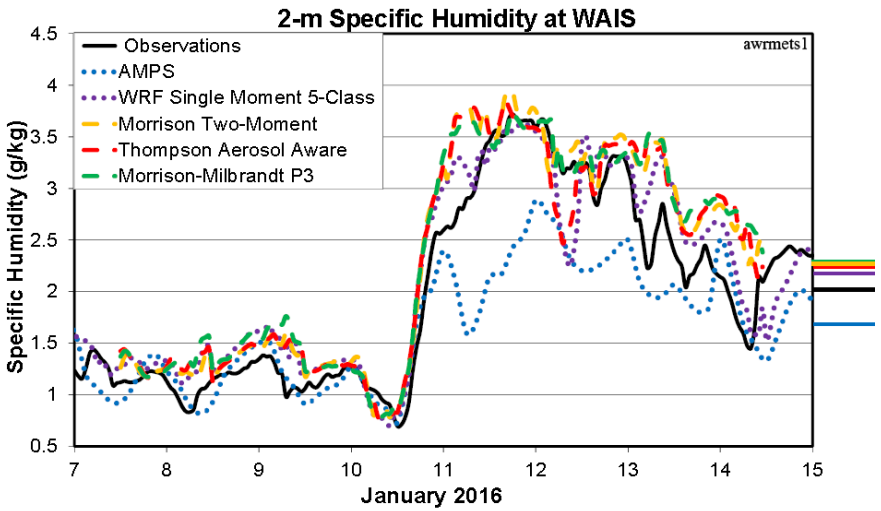


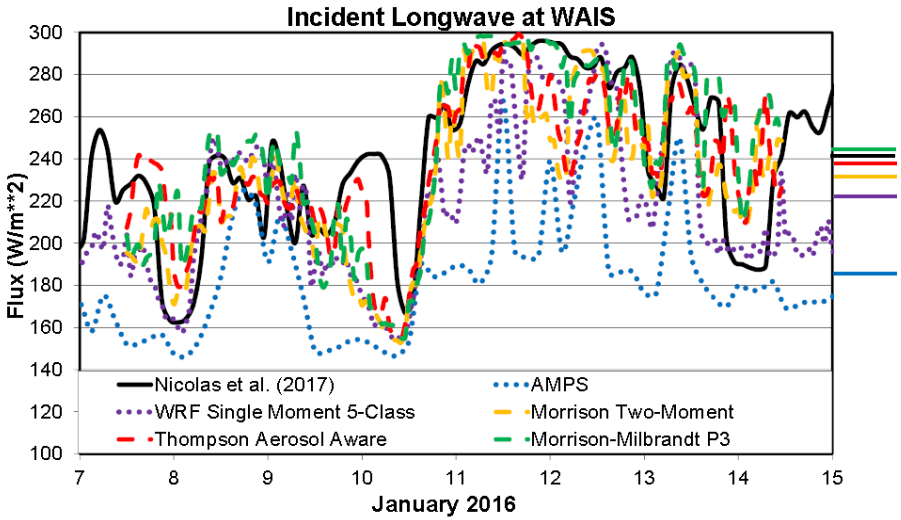


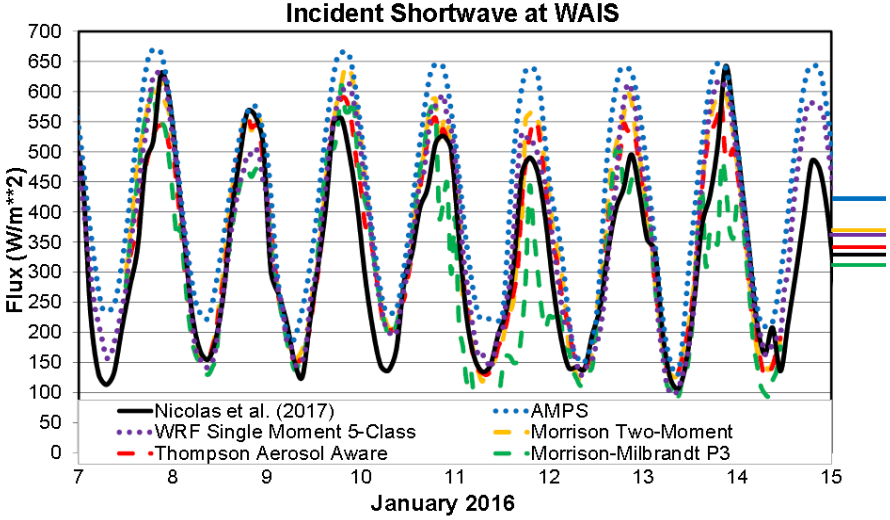
PWRF 3.9.1: SW and LW biases remain with ERA-I I.C. & B.C. , but are reduced in magnitude. Temperature and humidity biases are largely removed. Can use PWRF 3.9.1 to explore Antarctic cloud biases.

Near Surface Fields at WAIS 7 – 15 January 2016









Run with more advanced microphysics schemes: Warm bias in 2-m T?
Schemes increase LW and reduce SW radiation – positive result!

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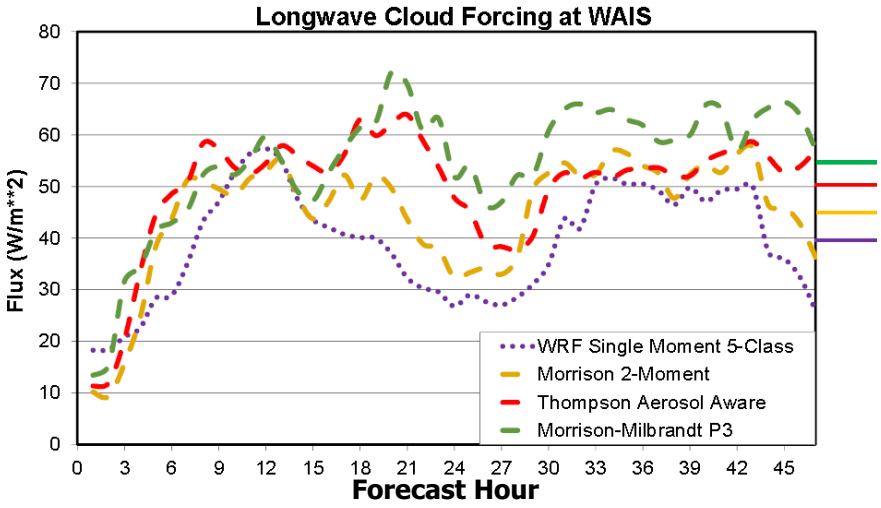
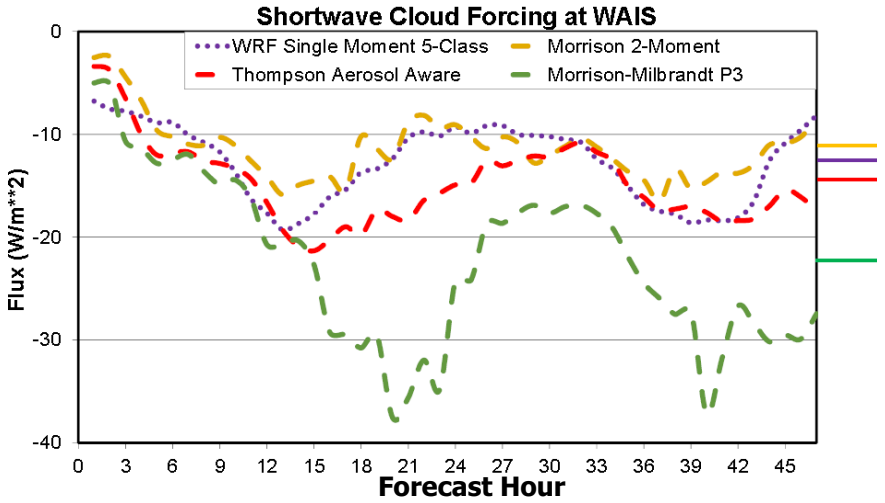
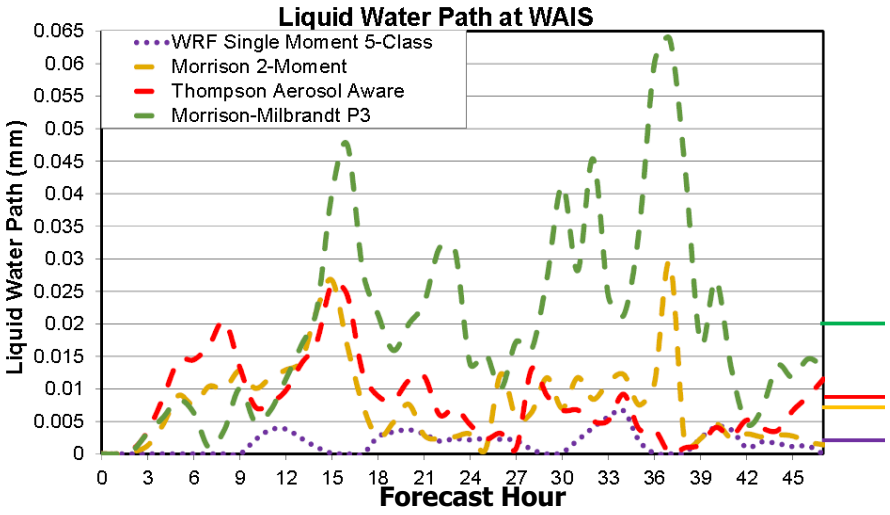
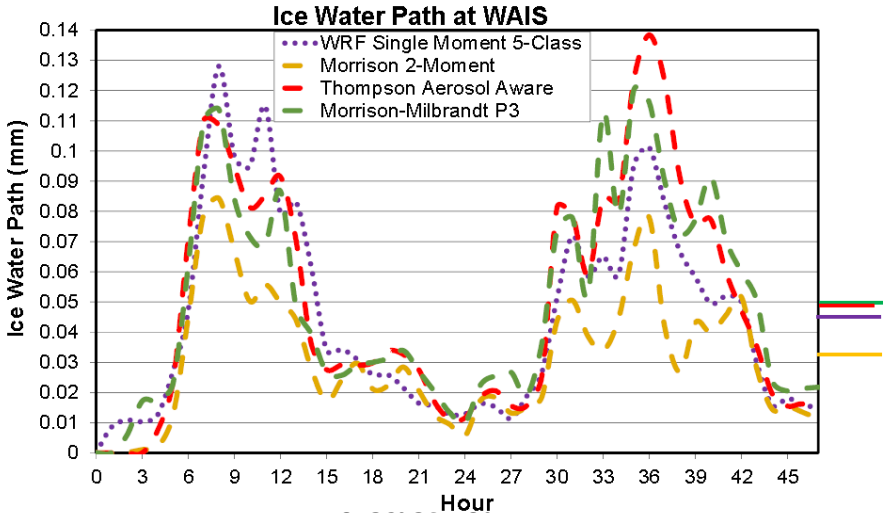
Average PWRF 3.9.1 Forecasts

Cloud Forcing at WAIS 7 – 15 January2016





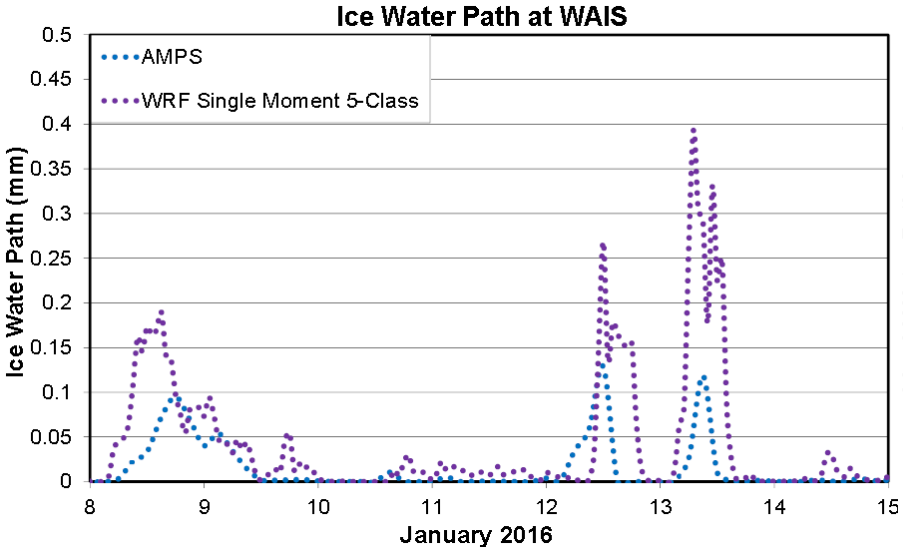


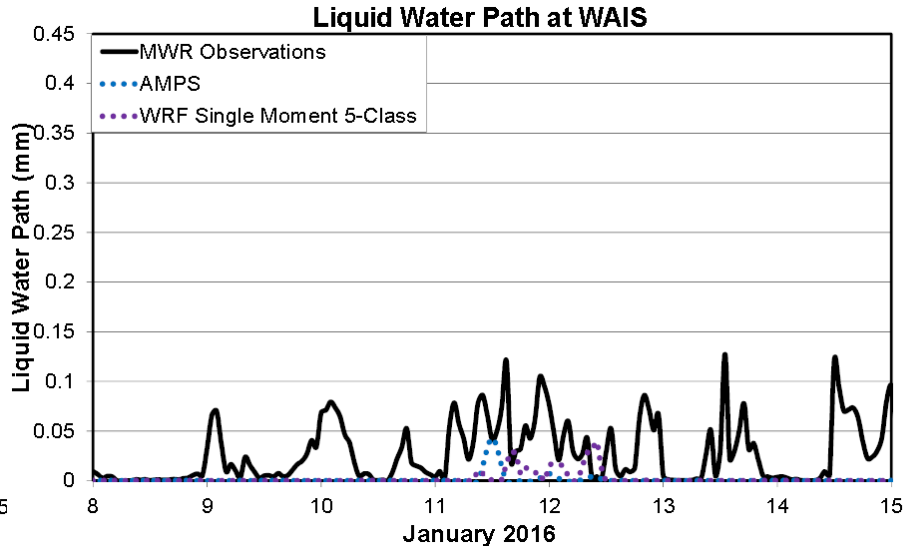


WSM5C has smallest LWP and slow spin-up of longwave cloud forcing.
M-M P3 scheme has largest LWP and stronger SWCF.
Microphysics schemes impact cloud radiative effects for Antarctica!

Cloud Condensate Path at WAIS 8 – 15 January 2016

AMPS and PWRF 3.9.1 with WRF Single-Moment 5-Class (WSM5C)





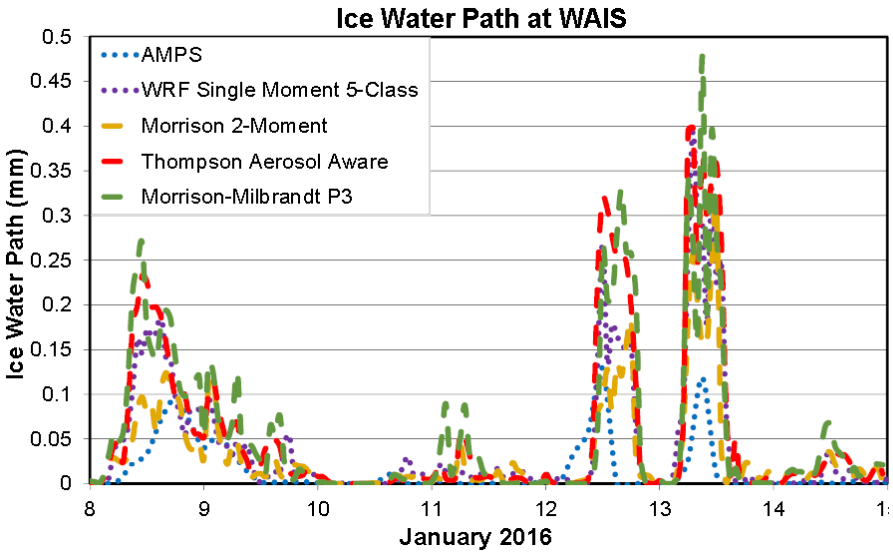
AMPS and PWRF 3.9.1 with WSM5C microphysics show much more ice water path than liquid water path.

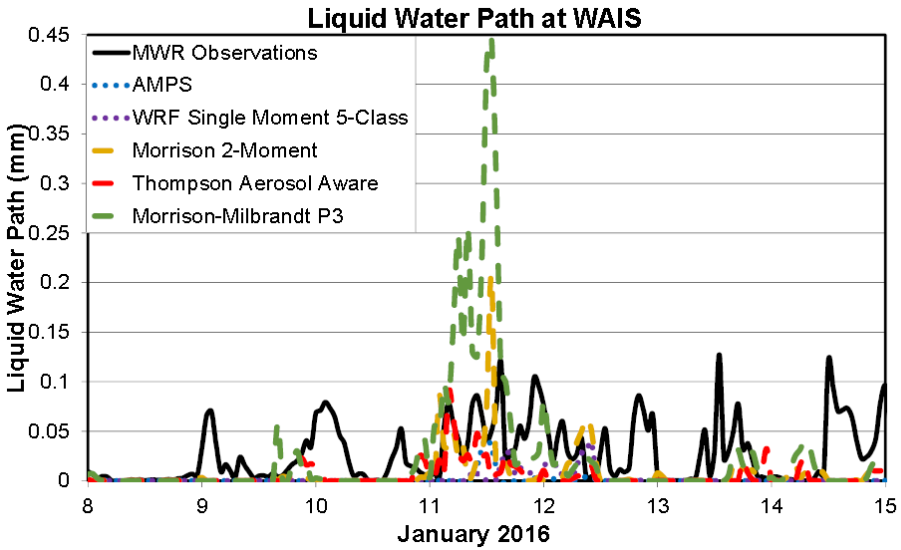
Simulated LWP is much less than values measured by the microwave radiometer (MWR).

Liquid has greater impact on radiation than ice.

Antarctic observations show liquid at very low air temperature.

Cloud Condensate Path at WAIS 8 – 15 January 2016





More advanced microphysics schemes increase ice water path and greatly increase liquid water path.

Morrison-Milbrandt P3 scheme shows a spike in liquid water on 11 January.

Day-to-day match of simulated and observed LWP is poor.

Simulating cloud water on cold days needs research.

Summary of AMPS and PWRF Findings with the AWARE Project

Liquid water deficit in AMPS clouds

Cloud radiative effect of AMPS clouds is too small

More advanced microphysics schemes increase the simulated liquid water and increase the cloud radiative effect

Which microphysics scheme is best? – not certain yet

Need to work on simulating cloud water at colder temperatures.

Clouds are critical for improving AMPS