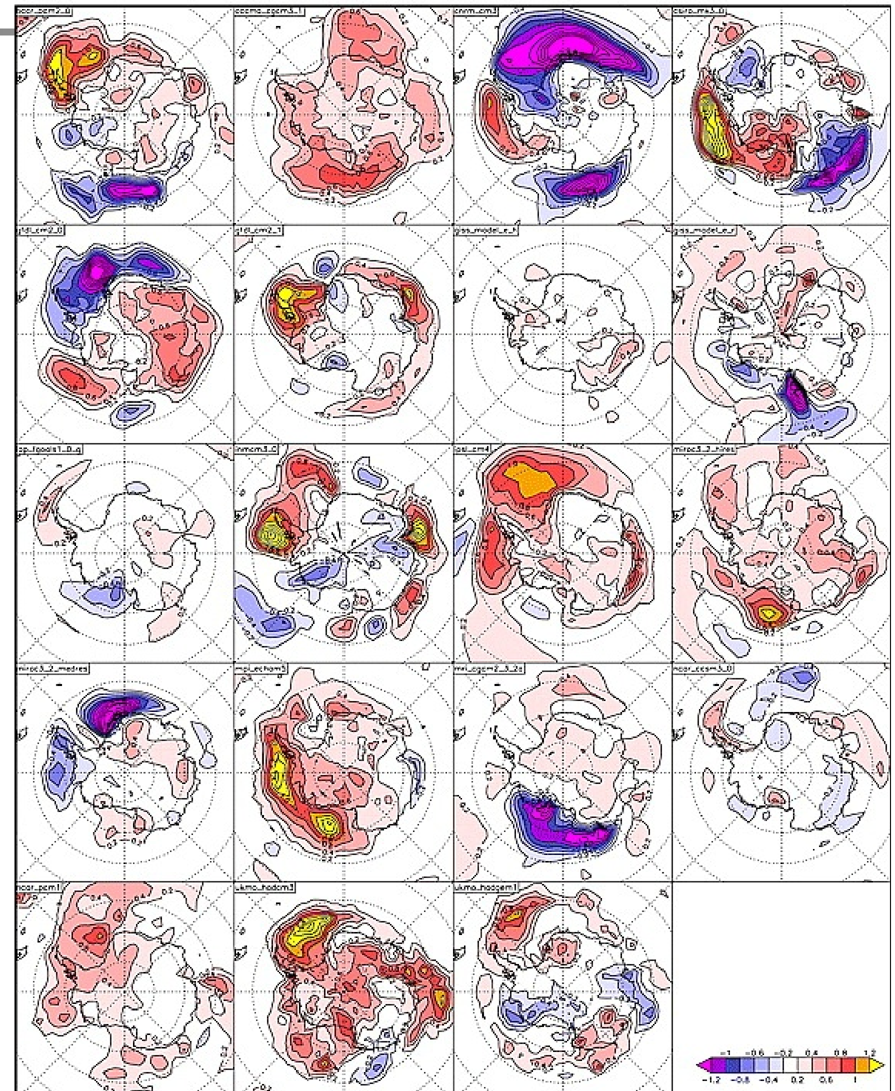
CONCORDIASI plans for the evaluation of climate and weather simulations over Antarctica

David Parsons
Mark and Kandi McCasland Chair
Director, School of Meteorology
University of Oklahoma

Motivation:

Temperature trends in °C/decade from 1960–2000 for winter (JJA) for individual models. (From Connolley and Bracegridle (2007))

19 coupled models from the IPCC 4th assessment report archive and found that trends in surface temperature, sea ice and continental mass were typically not simulated well and often showed a wide variation between model performance.



Average temperature trends from IPCC models

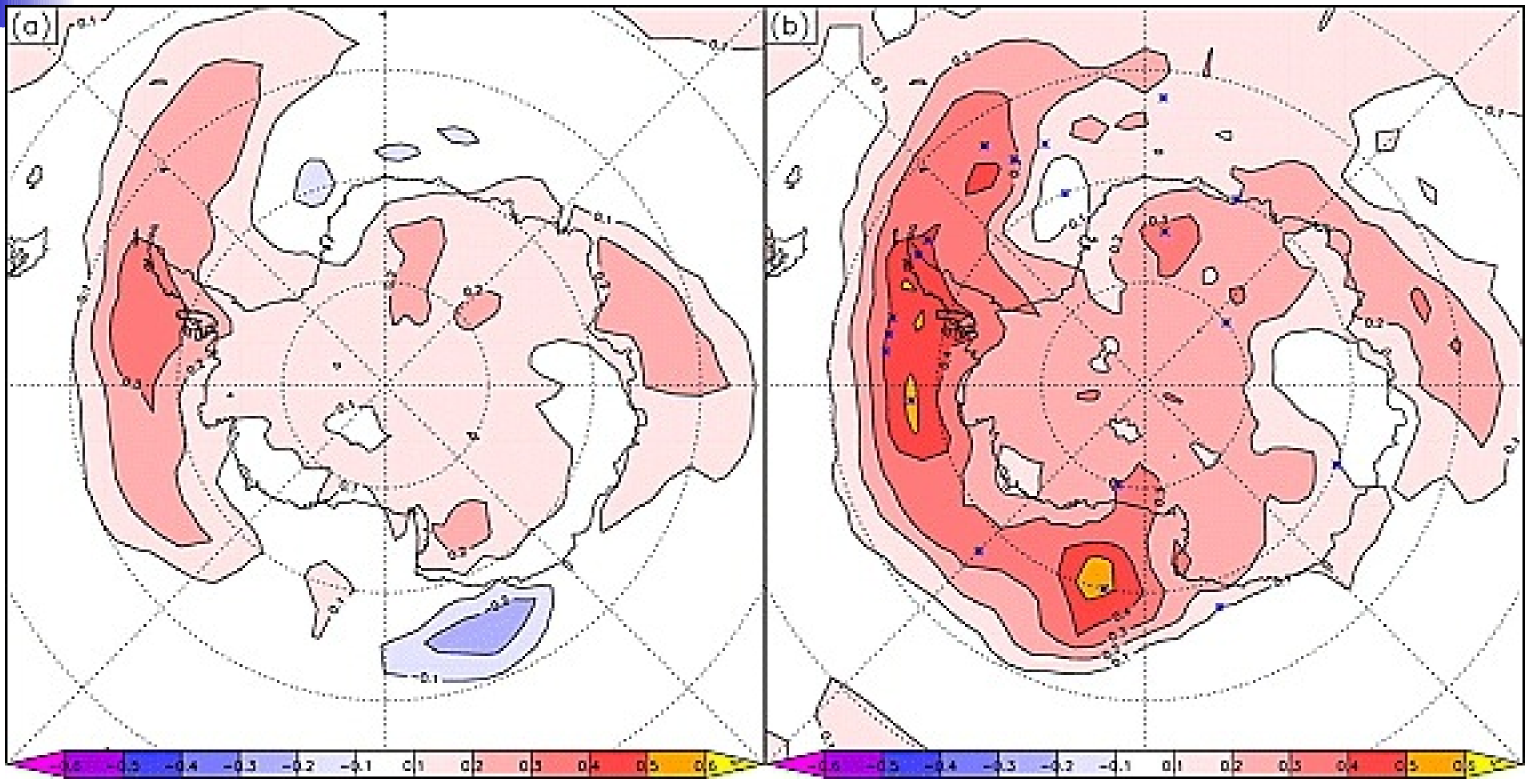
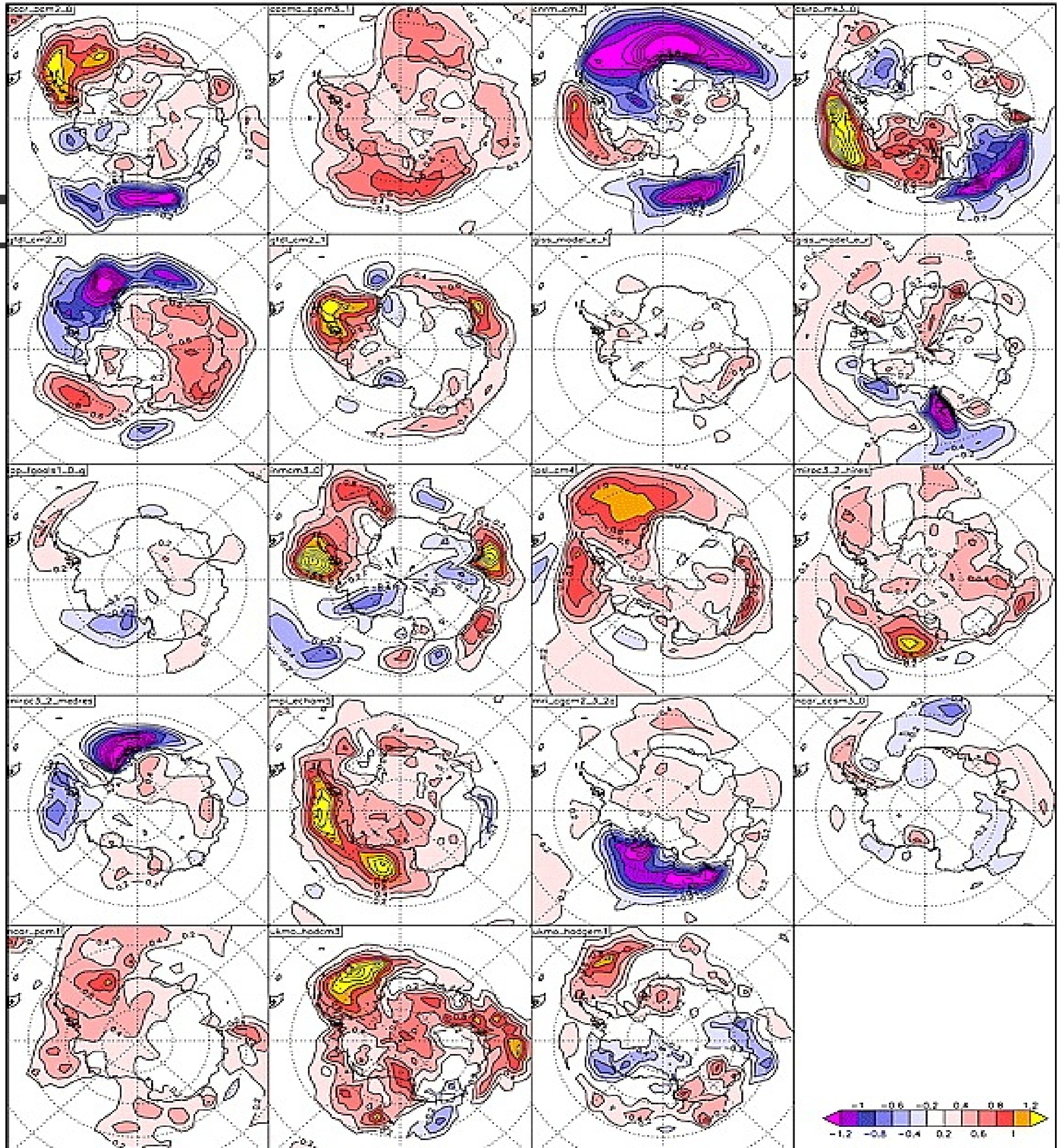


Figure 1. Temperature trends in °C/decade from 1960–2000 for winter (JJA). (a) Unweighted average of 19 models. (b) Weighted average. Also plotted on Figure 1b are the locations of the maximum trends from the individual models. Also from, Connelly and Bracegirdle (2007)


-1 -0.6 -0.2 0.4 0.8 1.2
-1.2 -0.8 -0.4 0.2 0.6 1

Why mostly just plans?

- Awaiting funding decision on analysis phase of effort from NSF's Office of Polar Programs (submission date in early summer 2011)
- Awaiting arrival of co-PI and his computing cluster
- Some work has started and is planned after the arrival of the co-PI

Introducing my Co-PI Steven Cavallo

- Joins OU faculty from NCAR on 1 November 2011

- PhD from U Washington in 2009.

- Expertise is in polar meteorology (more later)

- He is the smart guy on the team (already has two publication awards, four fellowship awards, one university-wide tutoring award)

Plans

1. Advance knowledge of the paths to improved treatment of Antarctic physical and dynamic processes in the NCAR Community Earth System Model (CESM)

- Will compare CONCORDIASI observations against CESM simulations initialized with NCAR's DART (ensemble Kalman filter) assimilation system
  - Will follow technique of Kay et al. (2011) (a series of 1-day forecasts to obtain monthly means) and/or Transpose-AMIPS project (climate models in numerical weather prediction mode, e.g., Martin et al. 2010)
  - Through collaboration with Anderson and others at NCAR, daily global analysis fields using DART have already been completed
  - First step is to use CONCORDIASI data to test the quality of these analyses

Plans(cont)

2. Advance knowledge of the errors, especially biases, in the initial conditions and in the predictions produced by AMPS (Antarctic Mesosale Prediction System) in order to improve data assimilation and the treatment of physical and dynamical processes over Antarctica.

(AMPS = Antarctic Mesoscale Prediction System)

- High-resolution, short-range simulations for US logistical and scientific operations over Antarctica

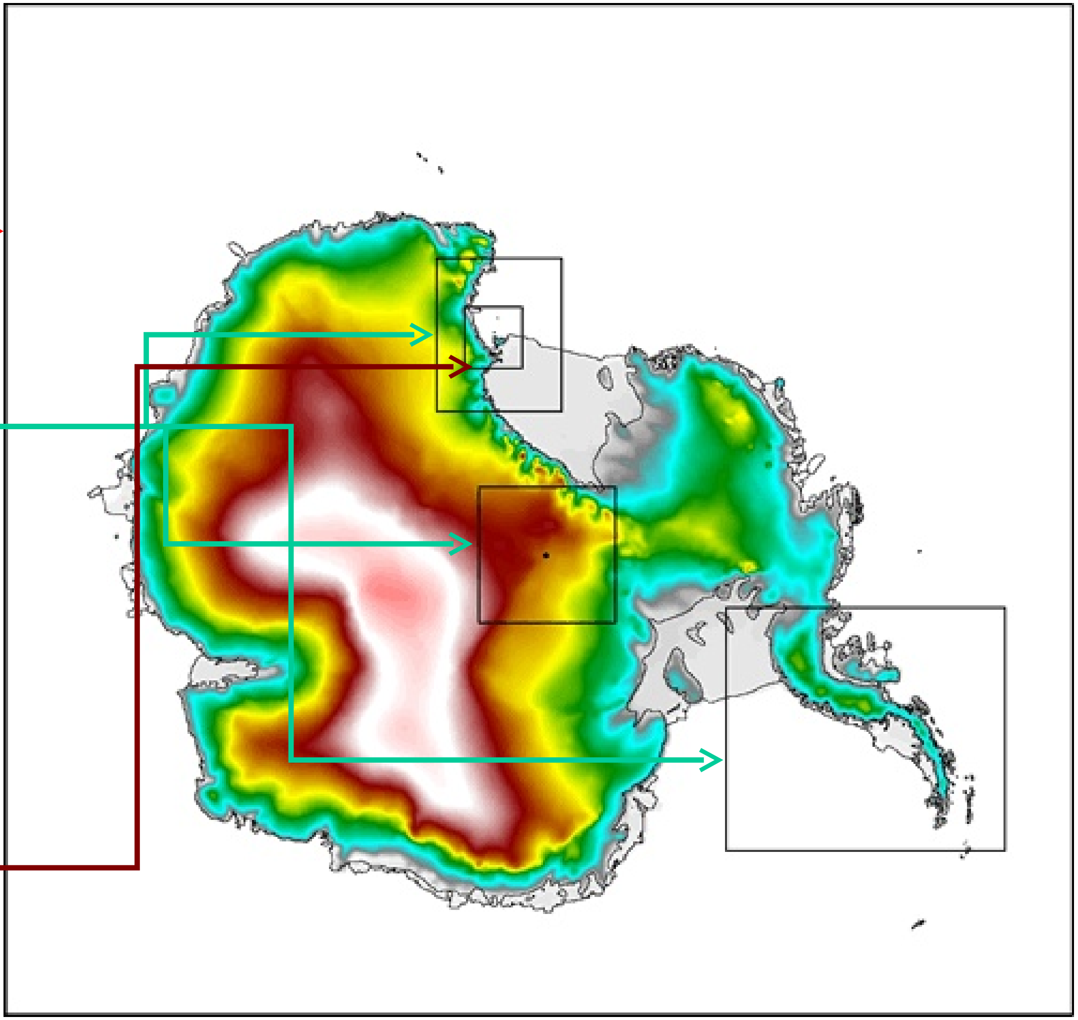
- AMPS is a collaboration of the National Center for Atmospheric Research and the Byrd Polar Research Center of The Ohio State University

- Application of WRF-Var, a **variational** data assimilation system built within the software framework of the Weather Research and Forecasting (WRF) model, used for application in both research and **real-time** environments….

- Uses all types of observations
  - Conventional: Surface ,Upper air
  - Remotely sensed retrievals
  - Radiances

NCAR-OSU AMPS

- 15 km -- outer mesh
- 5 km – inner mesh
- 1.67 km – Ross Island



Plans (cont.)

2. Advance knowledge of the errors, especially biases, in the initial conditions and in the predictions produced by AMPS (Antarctic Mesosale Prediction System) in order to improve data assimilation and the treatment of physical and dynamical processes over Antarctica.

- Will compare CONCORDIASI observations against AMPS simulations and initial fields (parallel to the climate model)

- AMPS simulations readily available and collaborative links established

- Will also undertake initializations with DART and compare relative quality of the two analysis and subsequent simulations to the operational AMPS (possible having ensemble techniques replace the AMPS 3-d Var)

Plans (cont.)

3. Further understanding of the benefits and possible added complexities of representing critical Antarctic processes with higher-resolution modeling over the Antarctic region.

- Orography, clouds, sea ice and treatment of polar cyclones should benefit from higher resolution. For example, recently Yoshimura and Kanamitsu (2008) demonstrated the value of dynamical downscaling over the Antarctic region in a global model.

- Our work will investigate the relative behavior of the high resolution AMPS and the CESM with both models initialized with the DART system.

Challenges

Understanding and diagnosing problems in physical parameterization is difficult, but PIs have experience in the area of diagnosing model errors

- Guichard et al. (2003) – significant errors in MM5 treatment of longwave radiation in moist environments with clouds and short comings in treatment in cirrus fallspeeds and small cumulus clouds

- Cavallo et al. 2011 – problems in the treatment of long-wave radiation in polar environments in WRF

- Redelsperger et al. 2002 – Sensitivity of tropical convection to variations in middle level water vapors

Challenges

Understanding and diagnosing problems in physical parameterization is difficult, but Cavallo has experience in the treatment of physical processes in polar regions

- Cavallo and Hakim (2008, 2009) --- on dynamics of polar cyclones

- Cavallo, S. M., 2012: Sensitivity of tropopause polar cyclone intensification to changes in sea ice. Mon. Wea. Rev. (submitted

- Cavallo, S. M., J. J. Cassano, and A. J. Monaghan, 2012: Changes in the Arctic atmosphere in response to reductions in sea ice. (submitted

- Cavallo, S. M. and J. Dudhia, 2012: Spatially, time-varying ozone in the Weather Research and Forecasting (WRF) Model. Mon. Wea. Rev. (to be submitted)

Challenges

Water vapor is a key issue for portions of our work (so we look to EOL for any paths to an improved data set, realizing that any improvements are limited). For example,

Cavallo and Hakim (2008; 2009) reveal that the intensity of the systems depends on the vertical distribution of water vapor through the long-wave radiation

Vertical gradients in water vapor impact the vertical gradients in radiative transfers that impact temperature that impact dynamics

Surprise --- open ocean can weaken these systems through decreasing the gradient of water vapor