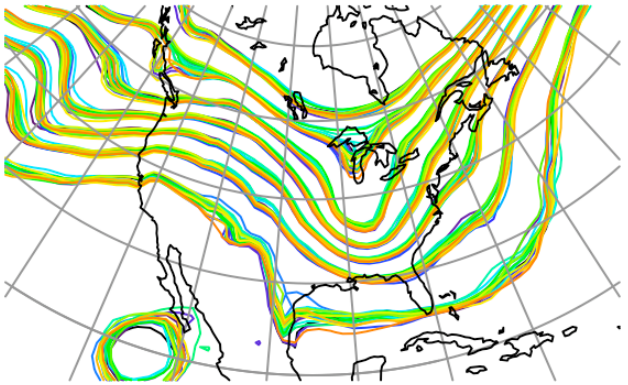
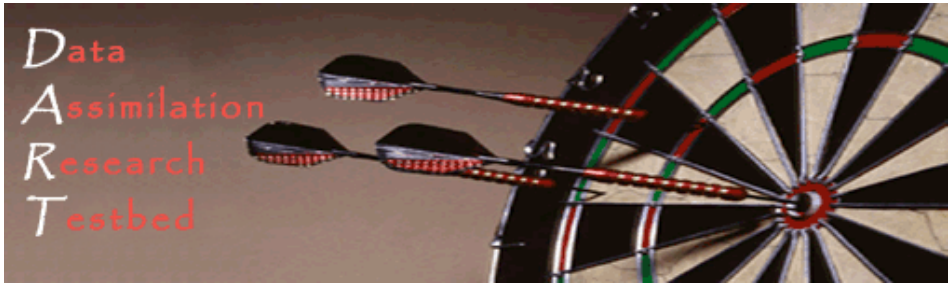


The Data Assimilation Research Section
DAReS



The National Center for Atmospheric Research is sponsored by the National Science Foundation.

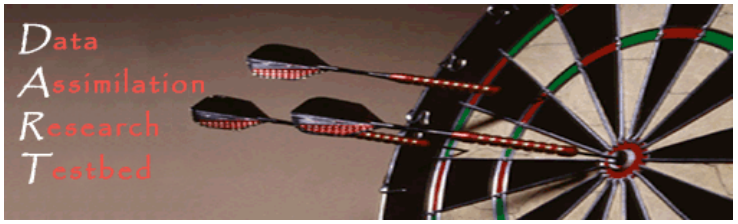
DAReS Team

- Jeff Anderson: Ensemble DA
- Nancy Collins: Software engineering
- Tim Hoar: Diagnostics, development
- Hui Liu: COSMIC GPS assimilation
- Doug Nychka (1/6): Statistics
- Kevin Raeder: DART/CAM interface
- Chris Snyder (1/6): WRF, Ensemble DA
- Joe Tribbia (1/6): Ensemble prediction
- New hire (1/2): DART/WRF interface

About 4 FTEs NCAR base; 2 FTEs assorted soft money

DAReS Imperative

- Develop and support the Data Assimilation Research Testbed (DART)



DART is:

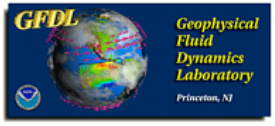
- Public domain software for Data Assimilation
  - Well-tested, portable, extensible, free!
- Models
  - Toy to HUGE
- Observations
  - Real, synthetic, novel
- An extensive Tutorial
  - With examples, exercises, explanations
- People: The DAReS Team

used at -

UNIVERSITY OF WASHINGTON

CIRES

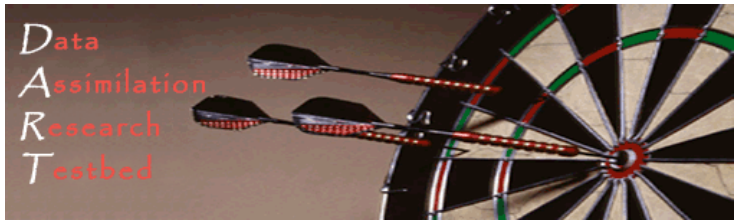
THE UNIVERSITY OF UTAH



PENNSTATE

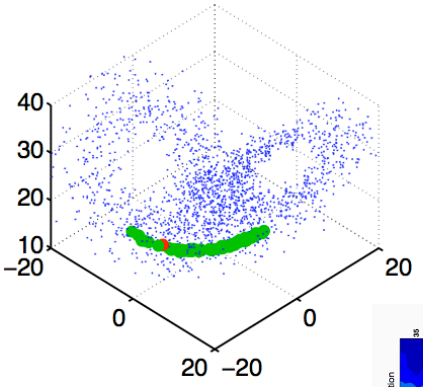
JPL
Jet Propulsion Laboratory
California Institute of Technology

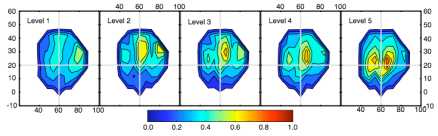
and many more …

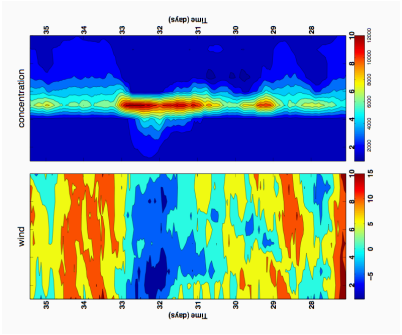


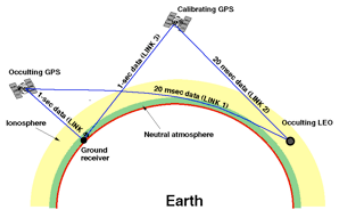
DART is:

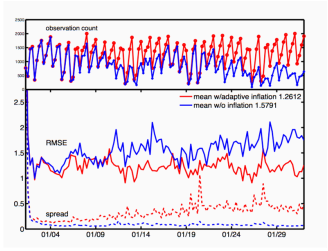
- Education
- Exploration
- Research
- Operations

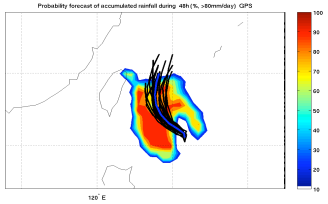


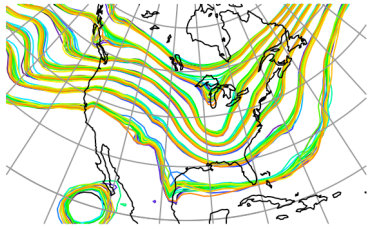


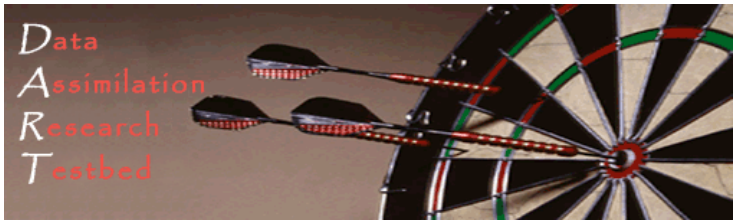




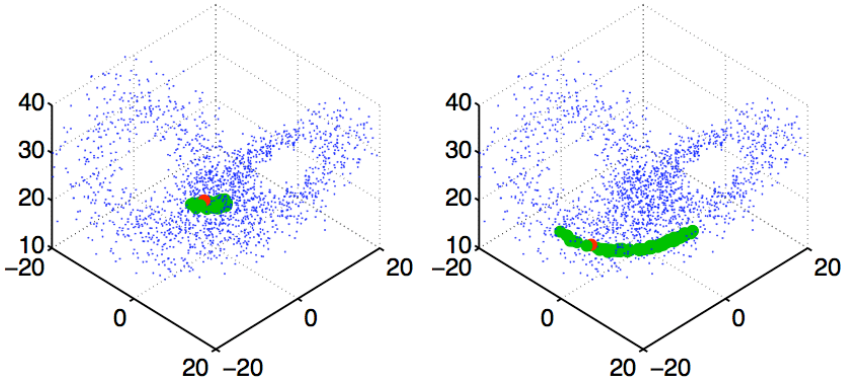




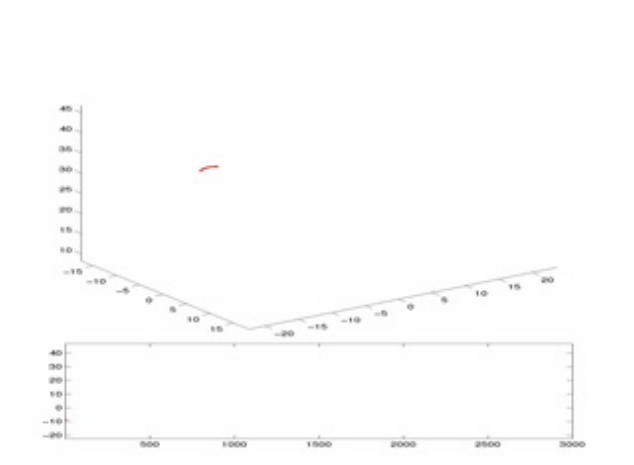


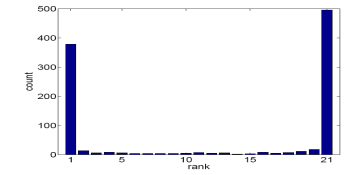


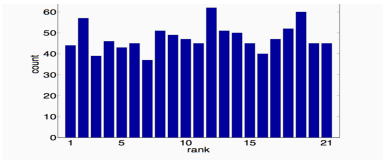
Education

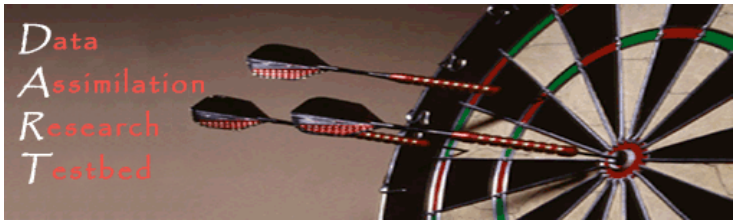


Tutorial



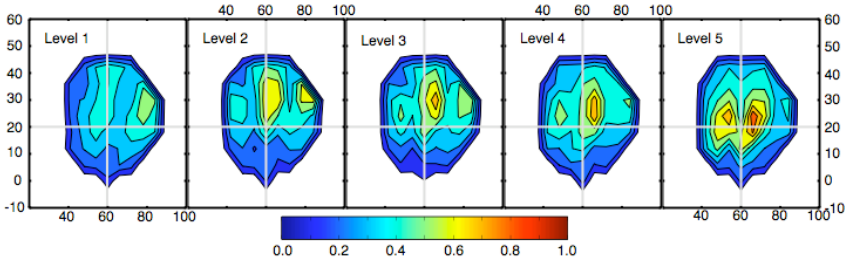




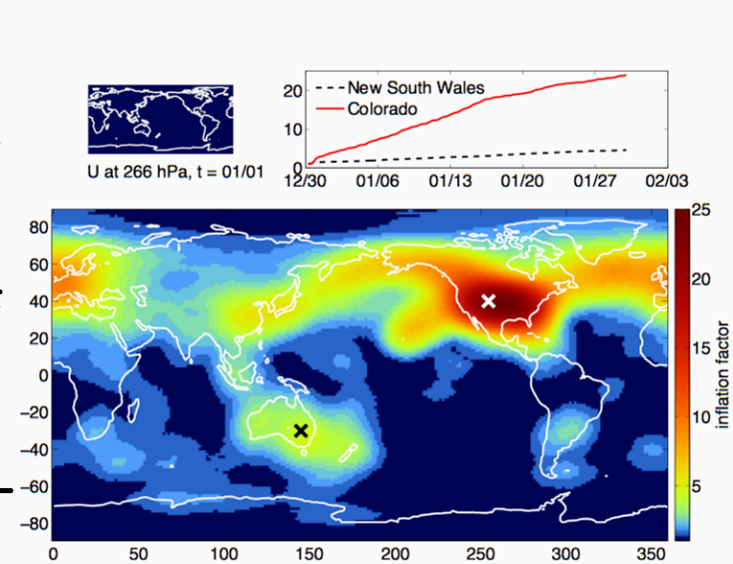


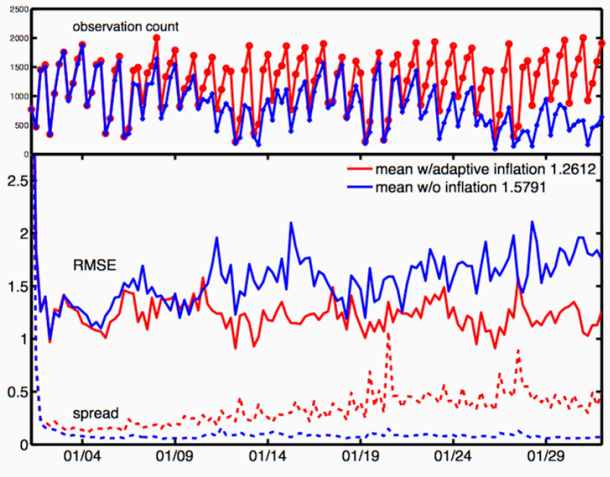
Exploration

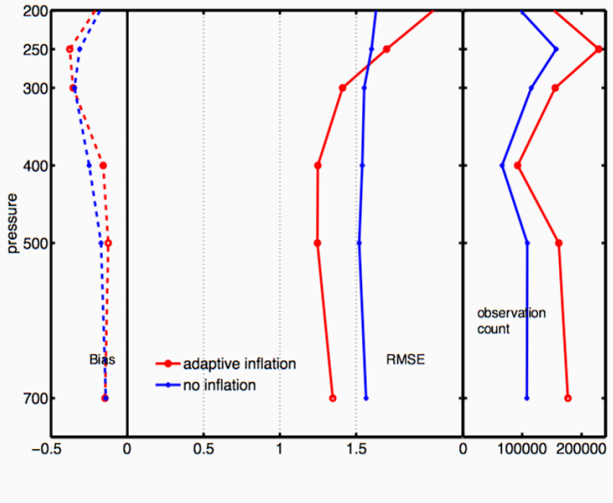
Impact of PS obs on V wind

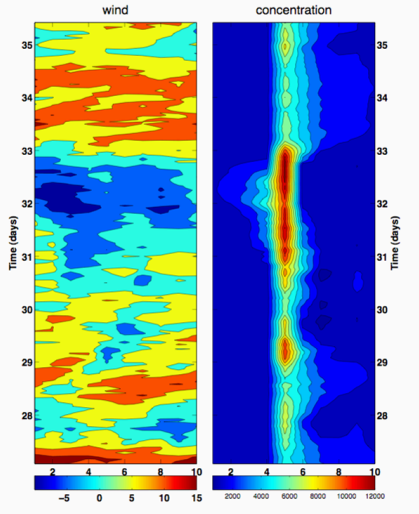


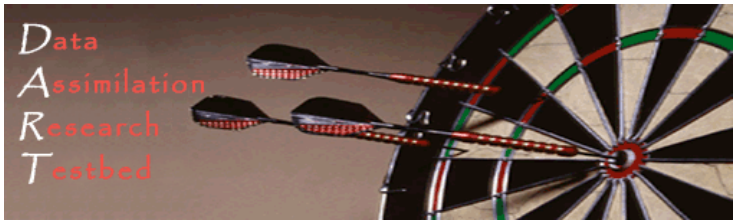
Adaptive Inflation





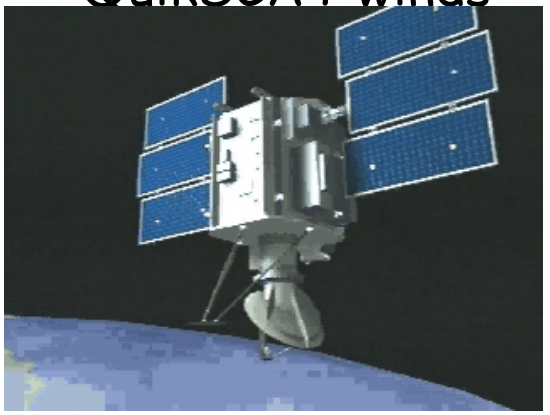


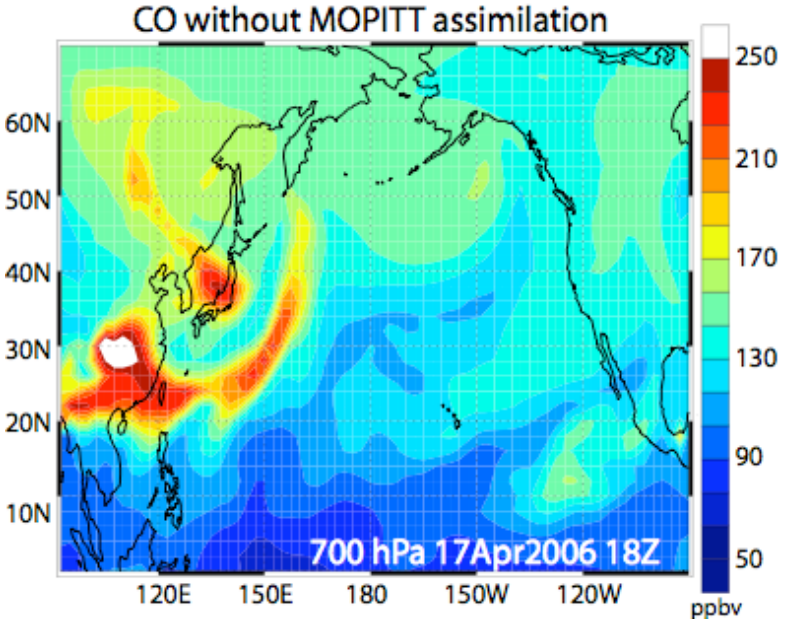


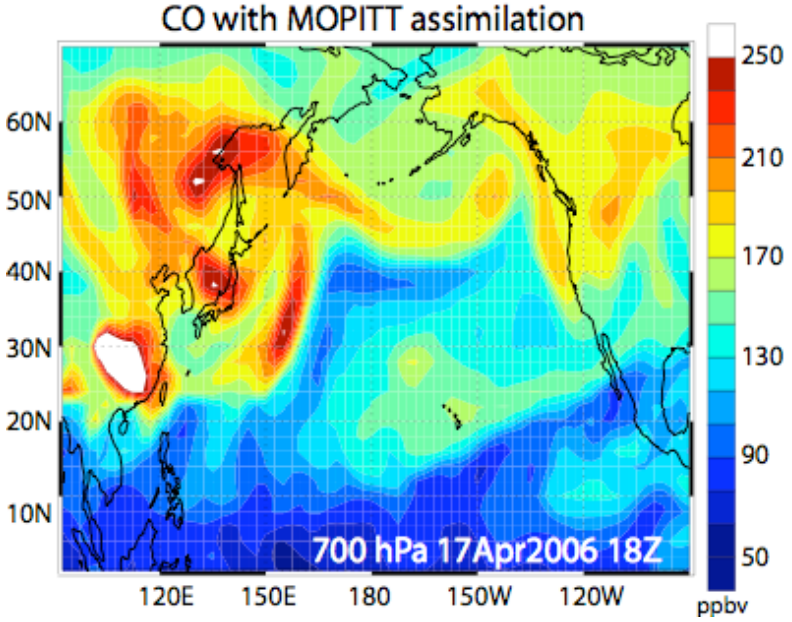


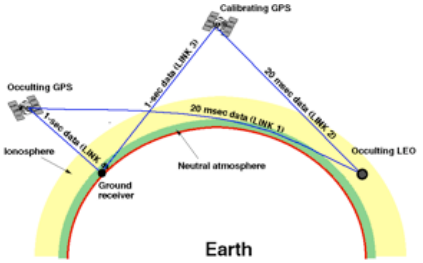
Research

QuikSCAT winds

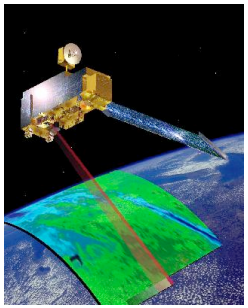


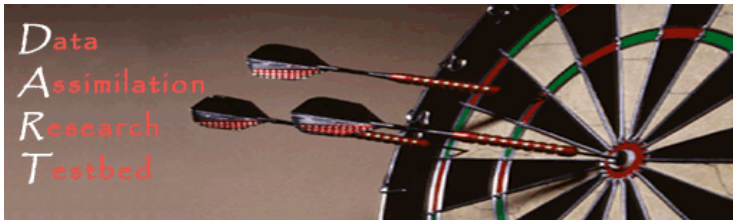






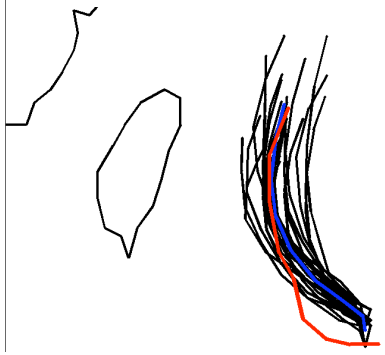
GPS occultations





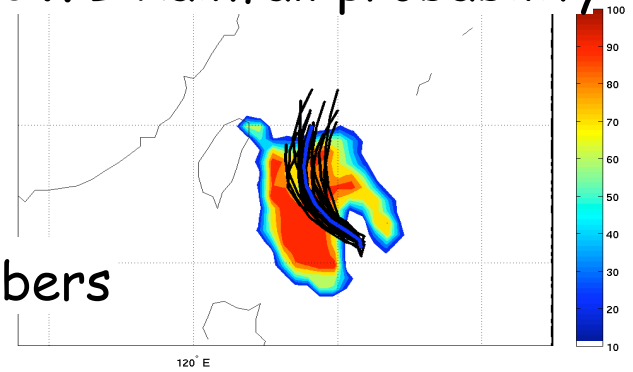
Operations

48h track forecast

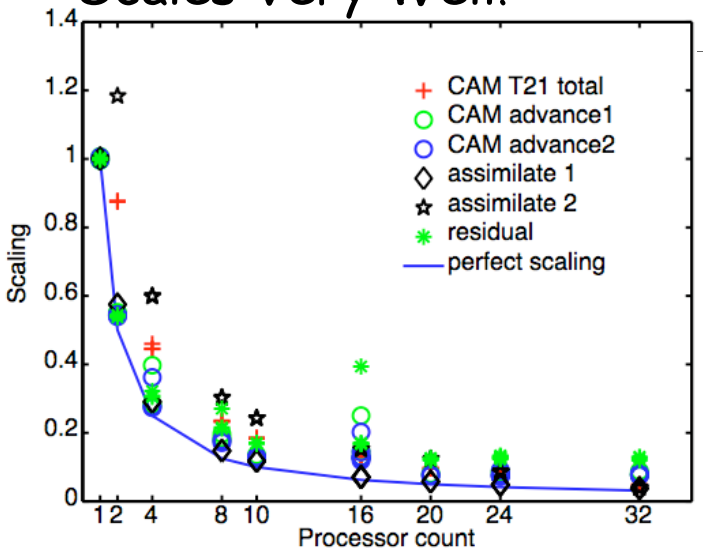


32 members

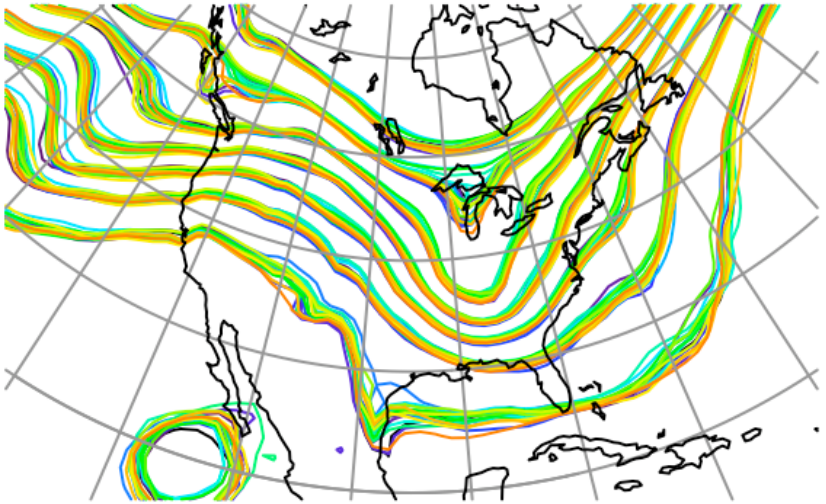
CWB Rainfall probability



Scales Very Well!



CAM T85 - 80 members



Major DART compliant models

- CAM spectral and FV, CAM/CHEM
- WRF, WRF/CHEM, WRF/MARS
- GFDL AM2
- NCEP GFS
- CMAQ (EPA dispersion model)
- MIT ocean GCM
- COAMPS
- ROSE (upper atmosphere model)

Recently Added Models

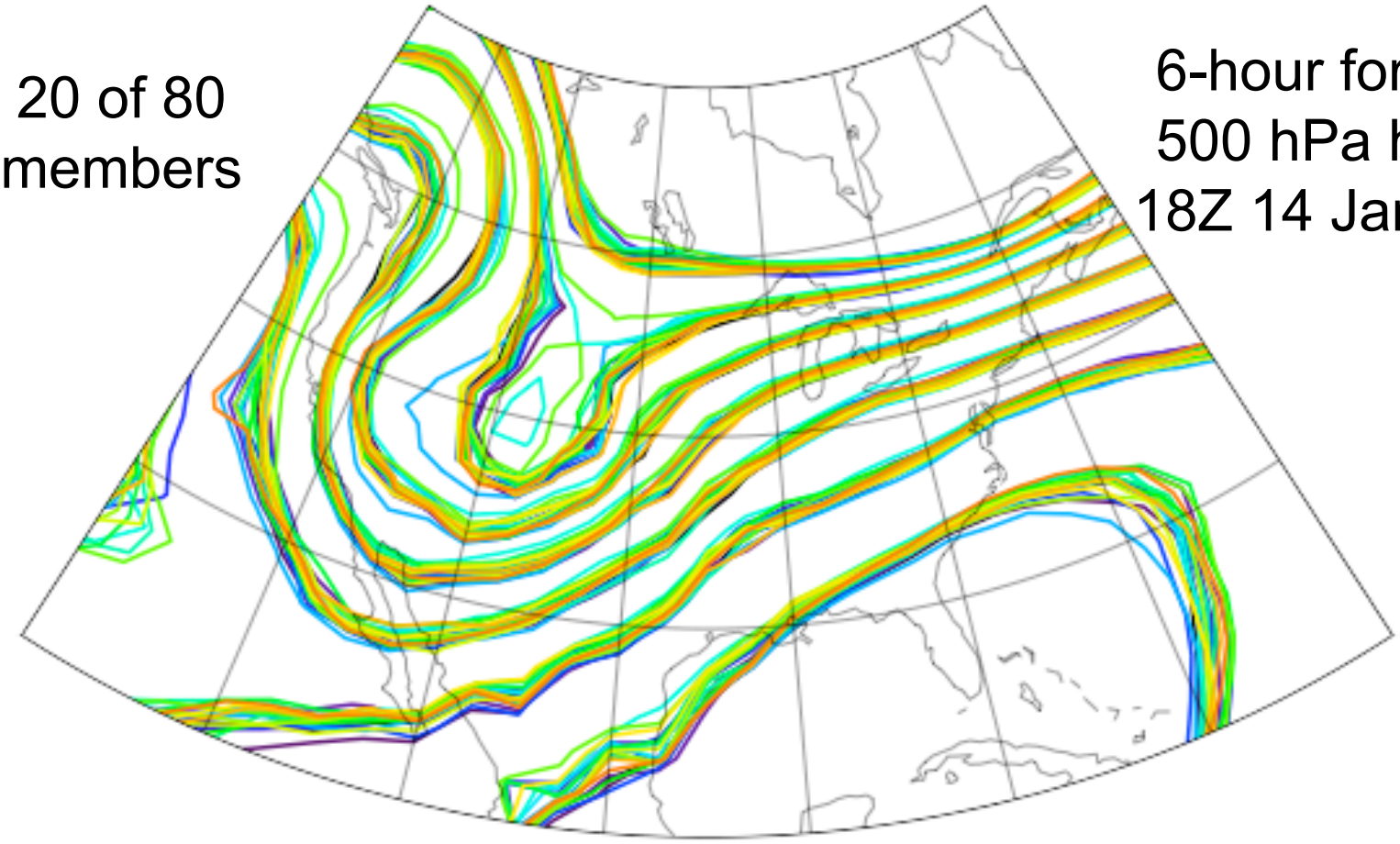
- MIT Ocean GCM, Gulf of Mexico
  - Collaboration with I. Hoteit at Scripps
  - Nancy, Tim and Jeff hosted 1-week visit
  - Supported 2-month development remotely

- COAMPS^{tm}
  - Done nearly independently by external modelers
  - Limited questions answered by email

Basic Capability: Ensemble Analyses and Forecasts in Large Geophysical Models

20 of 80 members

6-hour forecast
500 hPa height
18Z 14 Jan 2007



contours from 5400 to 5880 by 80

Forecast from CAM (Community Atmosphere Model)

Examples of Research using DART

Diagnosis of Noise in the CAM Finite Volume core using DART

Kevin Raeder*

Jeff Anderson*

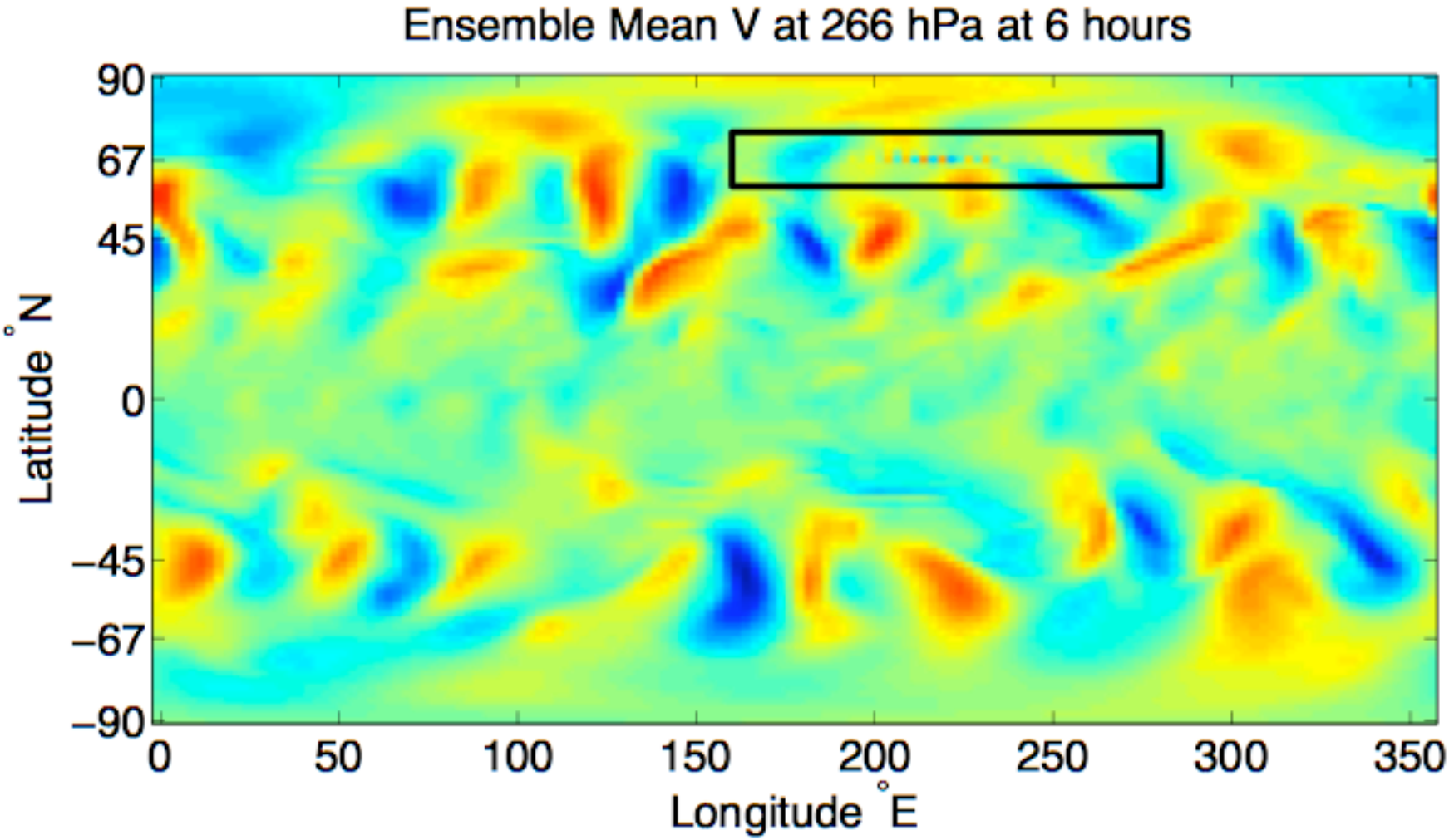
Peter Lauritzen+

Tim Hoar*

*NCAR/CISL/IMAGe/DAReS
+NCAR/ESSL/CGD/AMPS

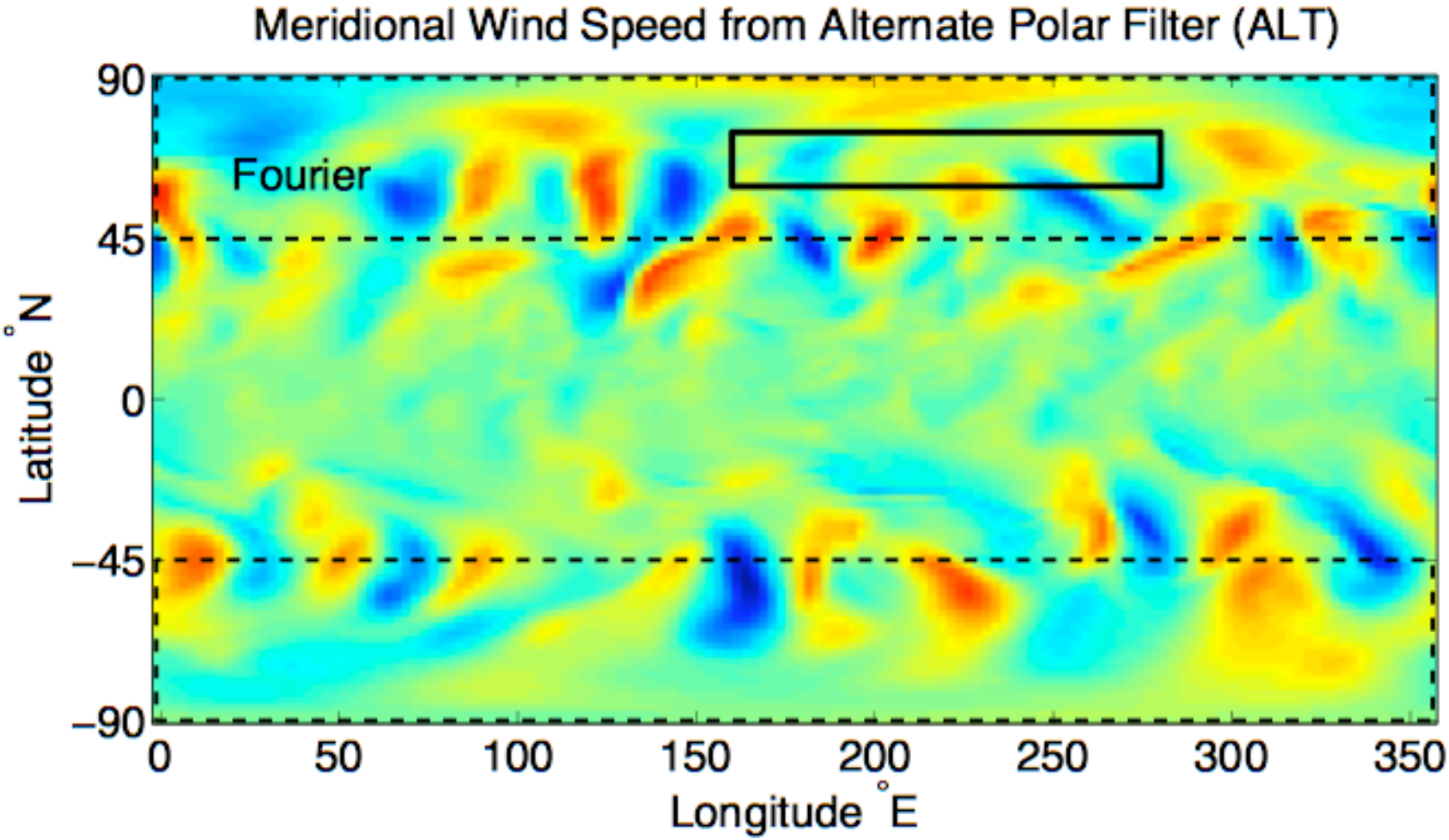
The National Center for Atmospheric Research is sponsored by the National Science Foundation.

“Houston, we have a Problem.”



CAM FV core - 80 member mean - 00Z 25 September 2006

Using a continuous polar filter (alt-pft) does not show this effect.



Ensemble Mean V @ 266hPa - 00Z 25 Sep 2006 - CAM FV core

Notes and Conclusions

The noise here may seem small and transient,
but since it had not been recognized by any of the labs which are using this FV core, the effects on climate runs had not been explored.

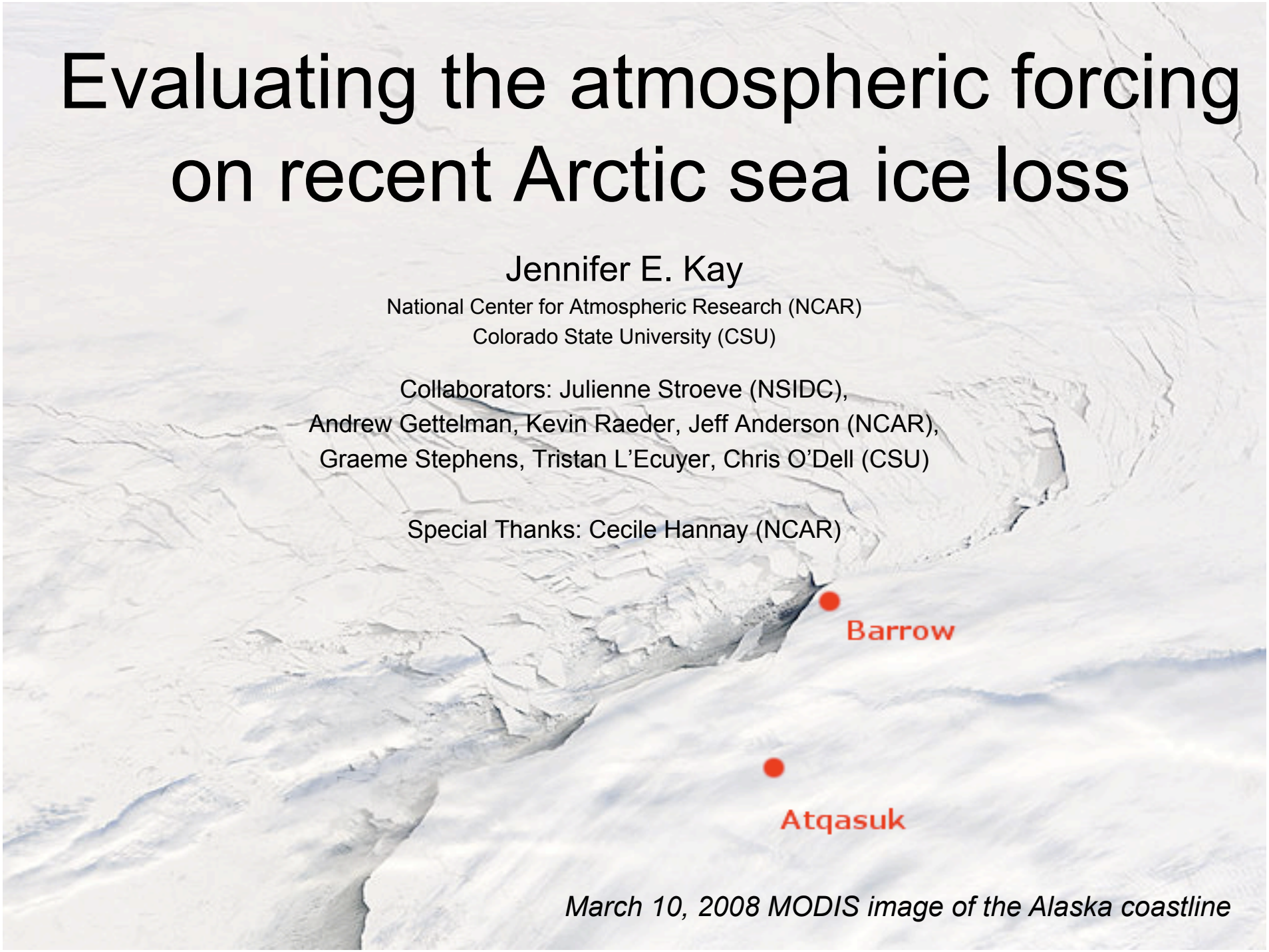
- Spurious mixing is happening.
- Parameterizations may have been mistuned.
- More time may need to be spent fixing the remaining noise and looking at other unexamined pieces of the code.

Evaluating the atmospheric forcing on recent Arctic sea ice loss

Jennifer E. Kay
National Center for Atmospheric Research (NCAR)
Colorado State University (CSU)

Collaborators: Julienne Stroeve (NSIDC),
Andrew Gettelman, Kevin Raeder, Jeff Anderson (NCAR),
Graeme Stephens, Tristan L'Ecuyer, Chris O'Dell (CSU)

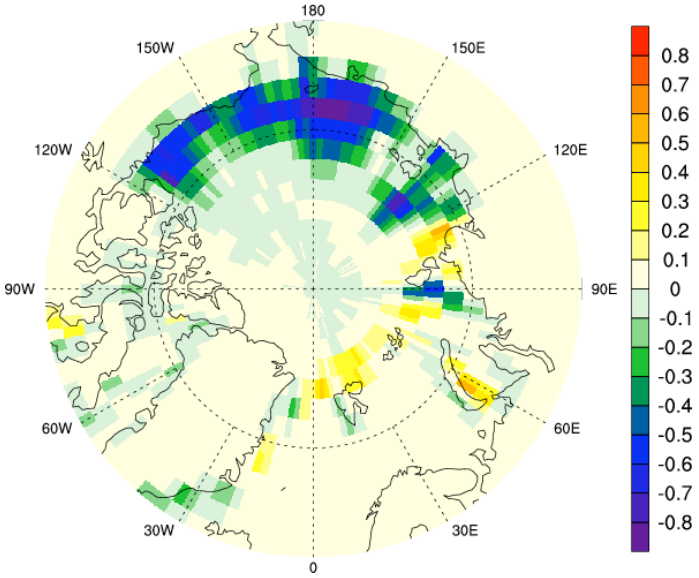
Special Thanks: Cecile Hannay (NCAR)



March 10, 2008 MODIS image of the Alaska coastline

DART-CAM Assimilations

July 2007 minus July 2006
Sea Ice Fraction

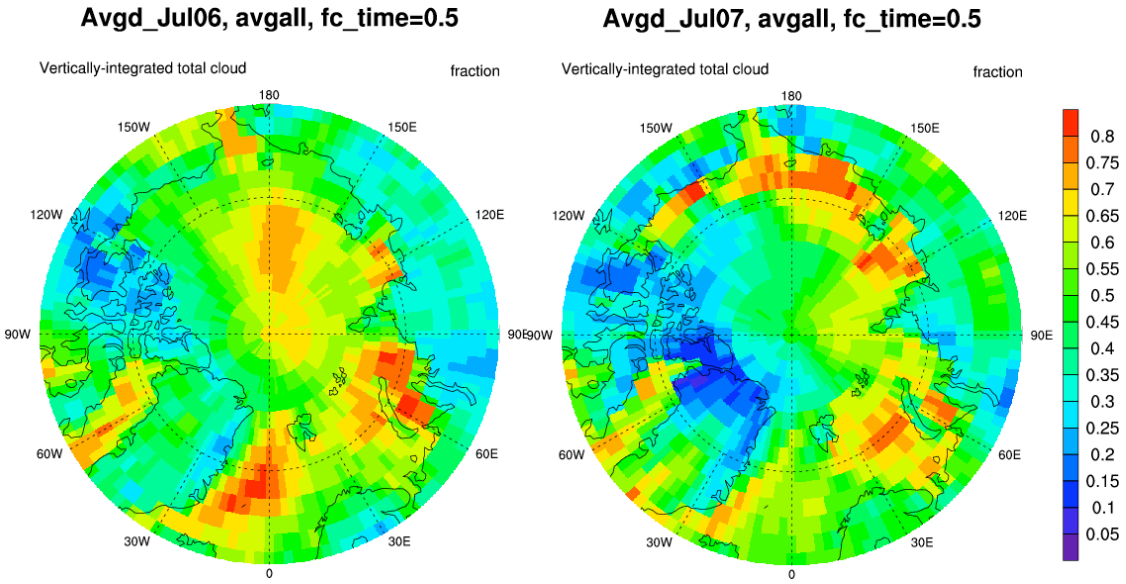


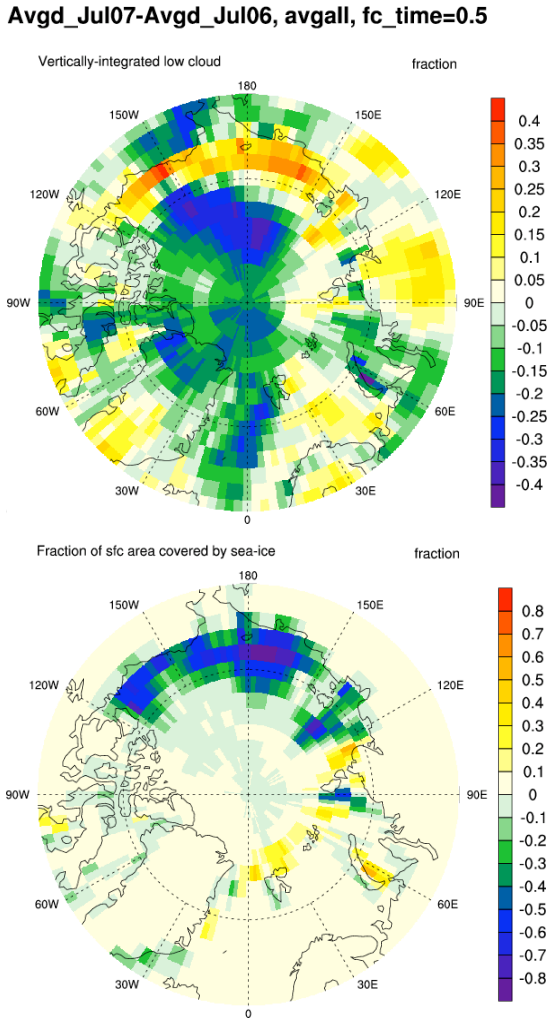
Month	Surface boundary condition
July 2006	observed (Hurrell et al., 2008)
July 2007	observed (Hurrell et al., 2008)

Research Questions:

- Does CAM capture changes in atmospheric forcing important for sea ice loss?
- Does the surface affect the atmospheric forcing on sea ice loss in CAM?

CAM-forecasted clouds

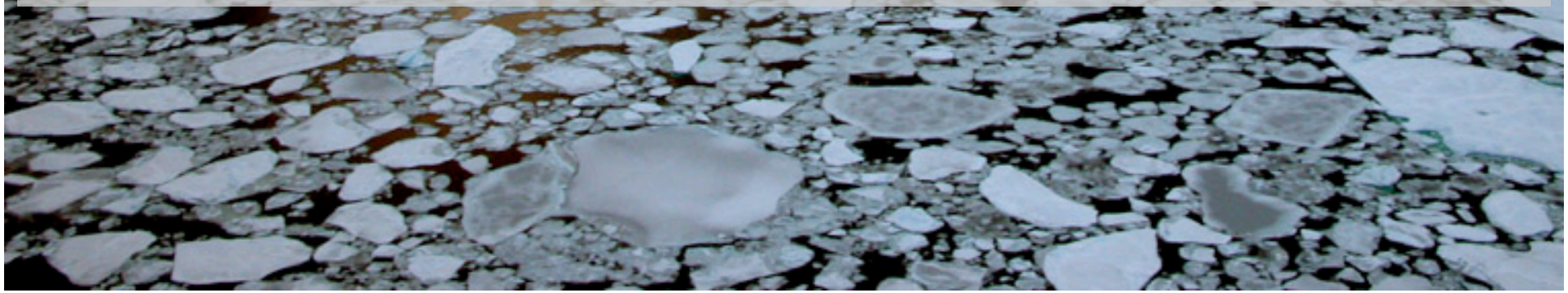




July 2007 had cloud decreases under high SLP, but cloud increases over the ice-free ocean.

Summary

- New satellite data and model-observation comparison tools are improving our understanding of atmospheric processes.
- While 2007 was a ‘perfect storm’ for ice loss, 2008 had the 2nd lowest ice extent with relatively ‘normal’ atmospheric forcing.
- The timing of ice loss matters, and can be used to understand ice loss forcing mechanisms.
- Comparing CAM forecasts from July 2006 and July 2007 revealed ubiquitous low cloud increases over open water. This negative feedback on sea ice loss was not seen in observations.



Application of Radio Occultation Data in Analyses and Forecasts of Tropical Cyclones Using an Ensemble Assimilation System

Hui Liu, Jeff Anderson, and Bill Kuo

Joint Statistical Meeting

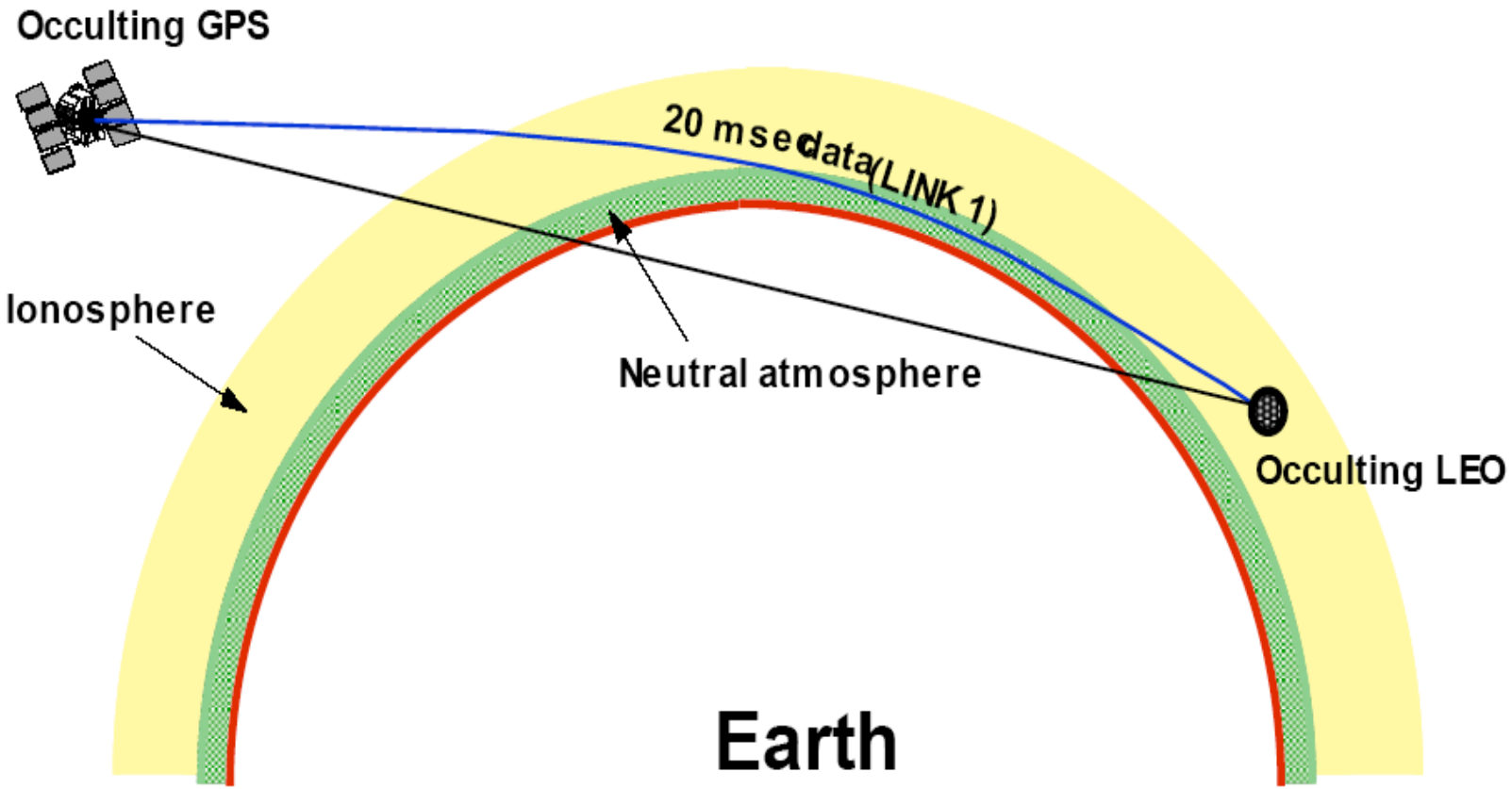
August 2008

An Example of using assimilation to evaluate the impact of novel observations.

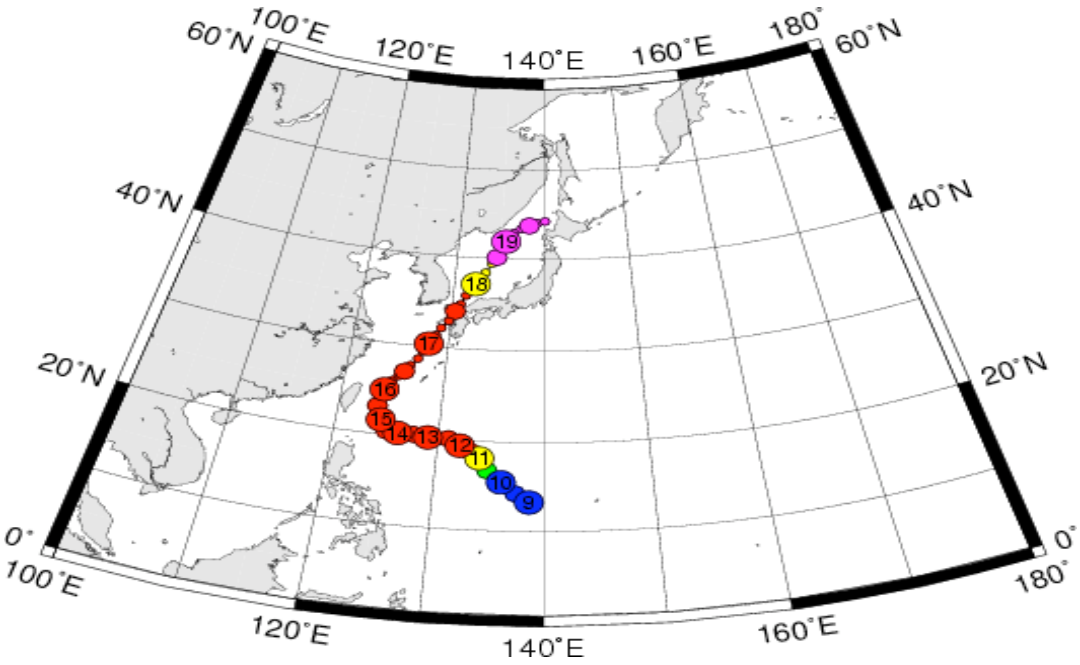
GPS Radio Occultation (RO)

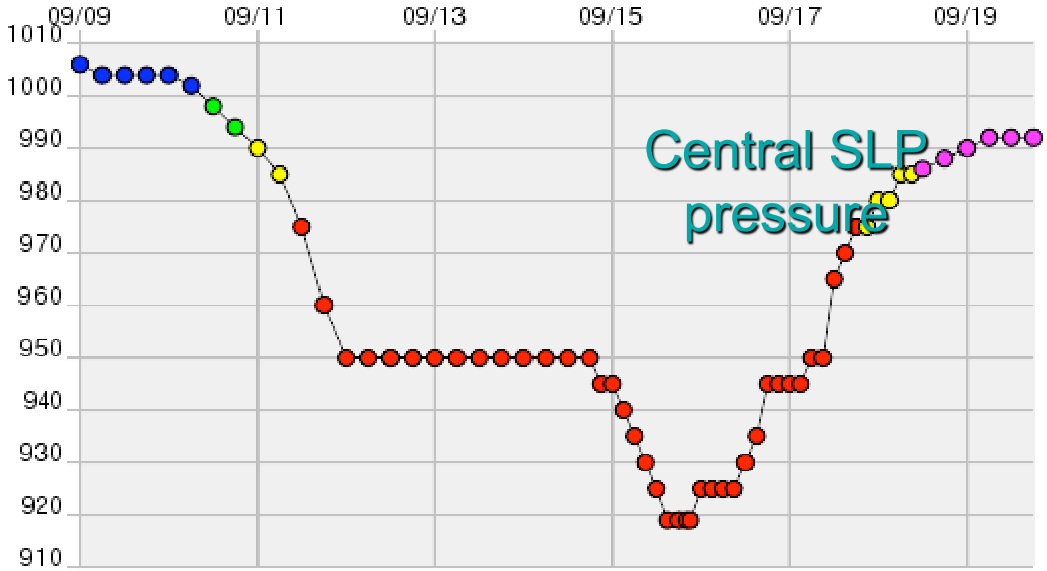
Basic measurement principle:

Deduce atmospheric water vapor and temperature based on measurement of GPS signal phase delay.



Typhoon Shanshan (Sept 10-17, 2006)

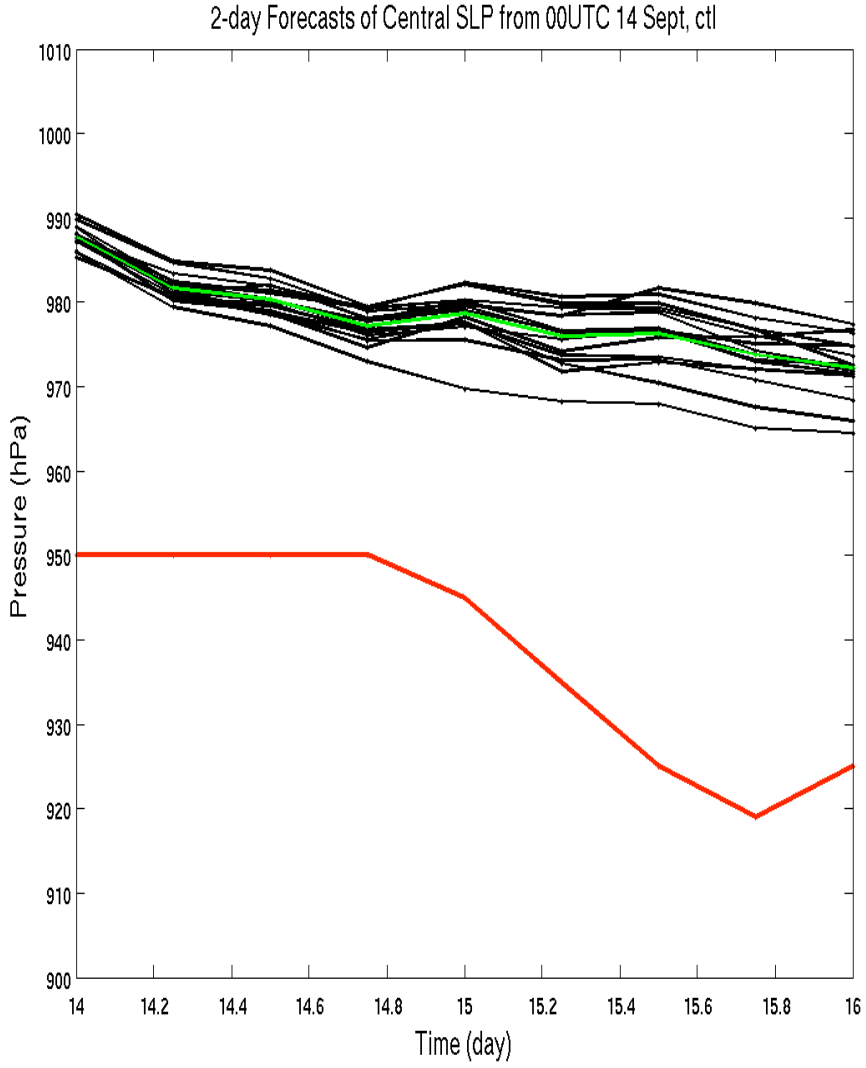




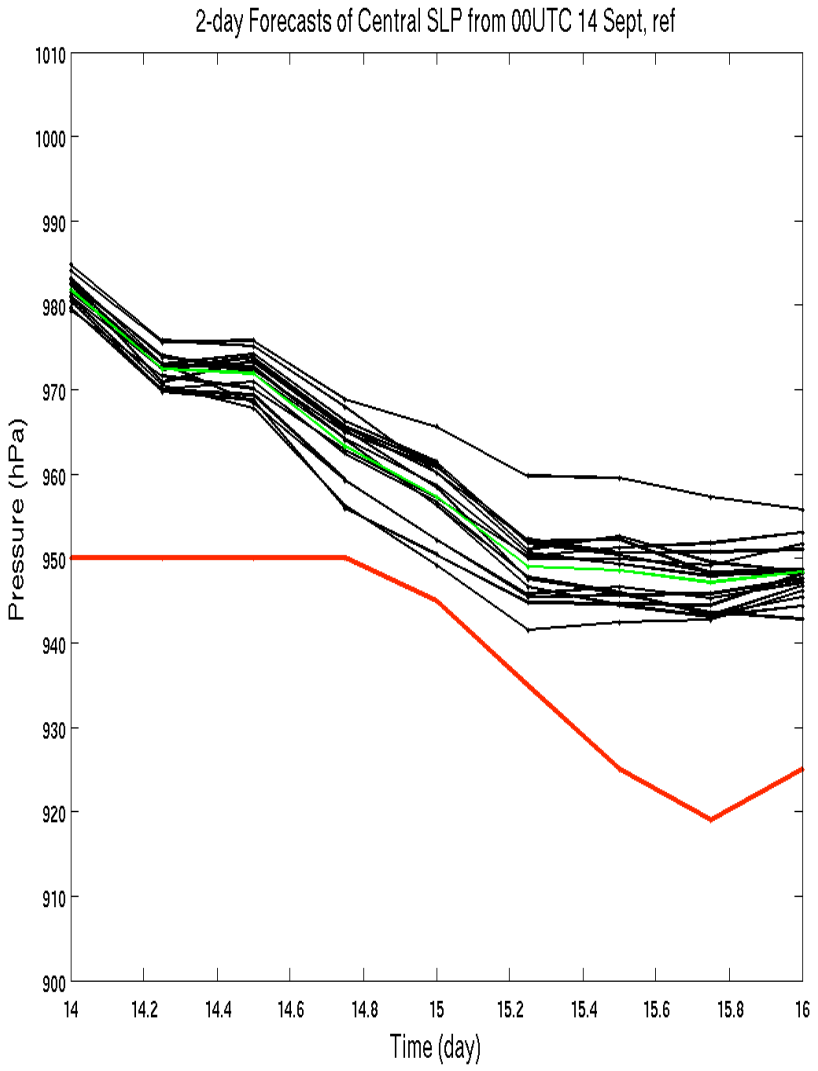
Operational forecasts using variational assimilation failed to predict the curving of the typhoon.

Ensemble Forecasts of Minimum Sea Level Pressure

NoGPS



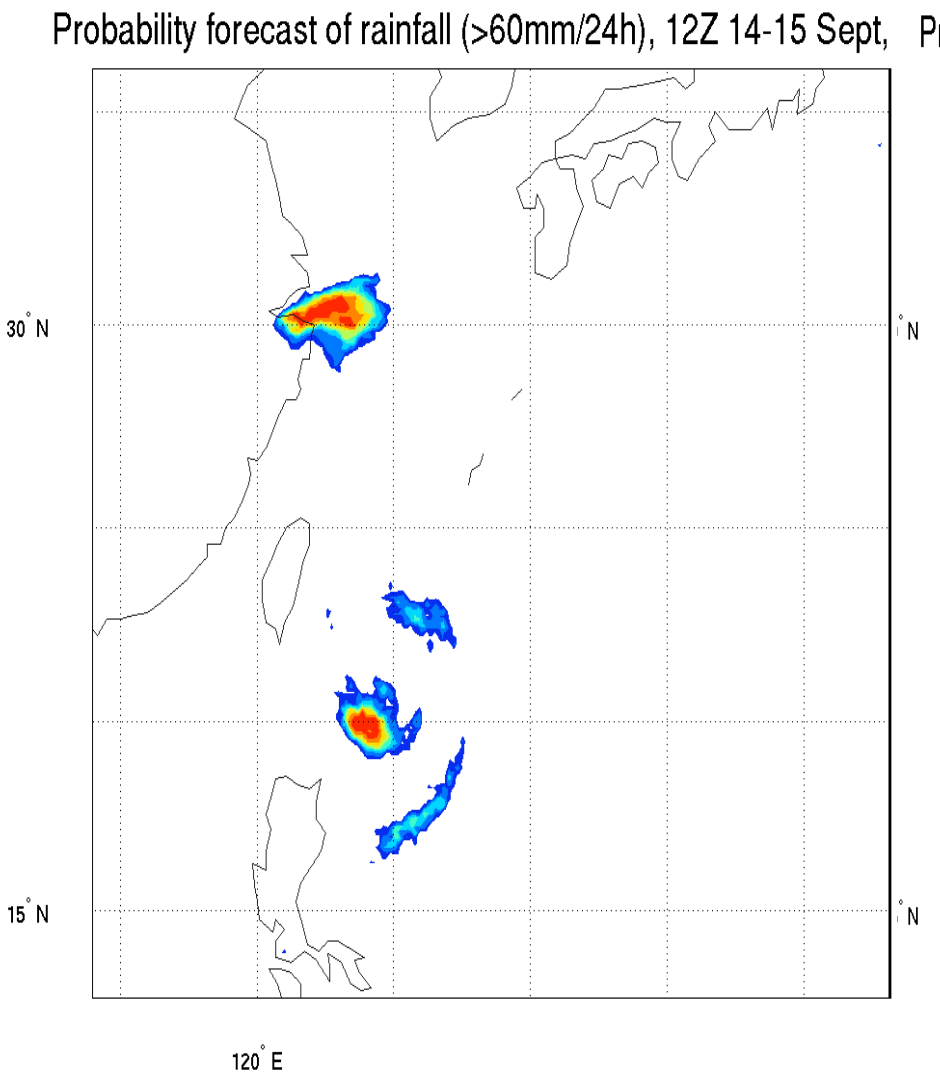
GPS



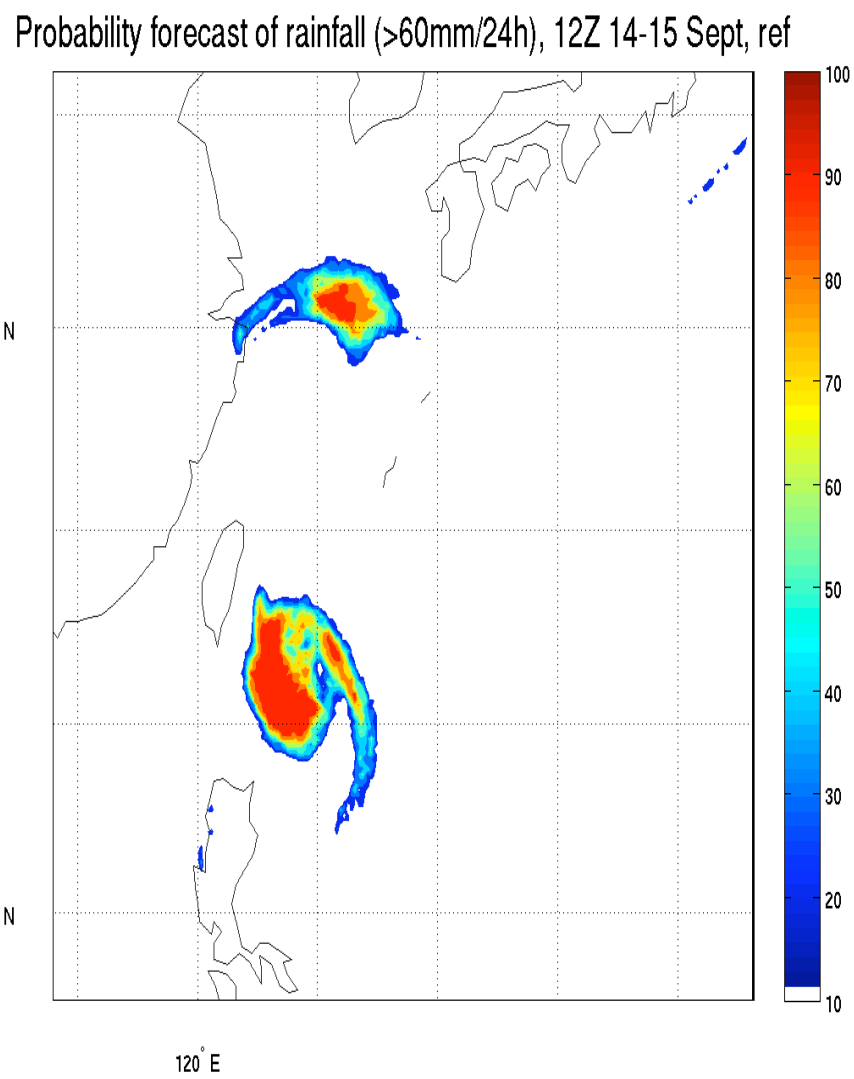
Intensity of the typhoon is significantly increased with RO data.

Forecast Probability of Rainfall >60mm/24h, 12Z 14-15 Sept.

NoGPS



GPS



Rainfall probability is increased with RO data

Summary

- Forecasts of the typhoon intensity and rainfall probability are improved by using RO refractivity observations with the WRF/ DART ensemble system.
- The curving path of the typhoon is well predicted.

Mesoscale WRF Surface-Data Assimilation: Spring 2007 Experiments at the National Severe Storms Laboratory

David Dowell
NCAR, Boulder, CO

David Stensrud
NSSL, Norman, OK

Nusrat Yussouf
CIMMS, Norman, OK

Mike Coniglio
NSSL, Norman, OK

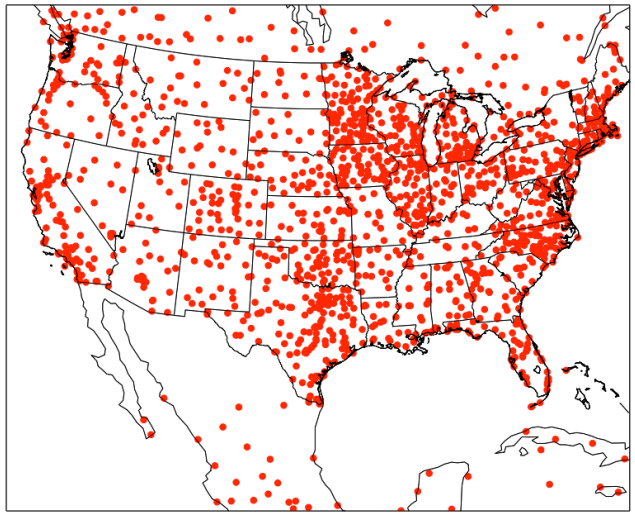
Jeff Anderson
NCAR, Boulder, CO

Chris Snyder
NCAR, Boulder, CO

Acknowledgments: Nancy Collins, Tim Hoar, Greg Carbin

Observations

- Hourly observations from approximately 1500 sites over USA, Mexico, and Canada



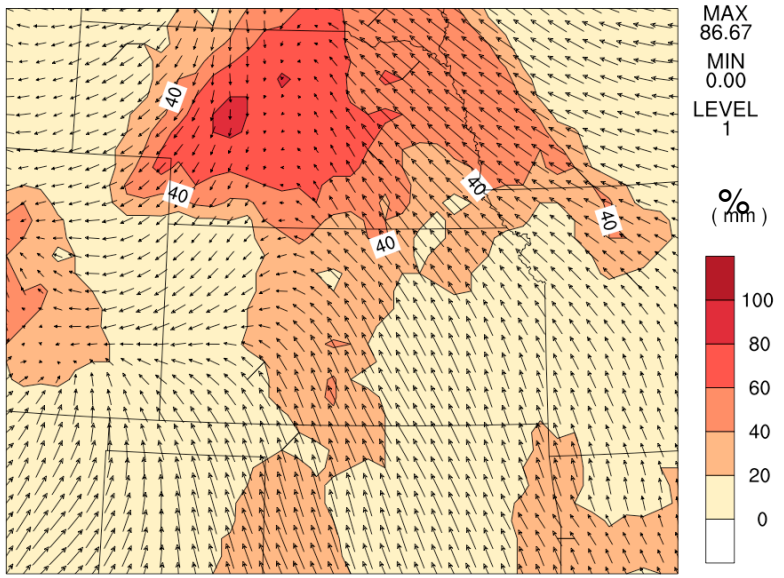
- Horizontal wind components (*u* and *v*) at 10 m AGL (2.0 m s^{-1} error)
- Potential temp. (θ) and dewpoint (T_d) at 2 m AGL (2.0 K error)

- All model state variables updated
  - 300-km (20-level) localization radius around each observation

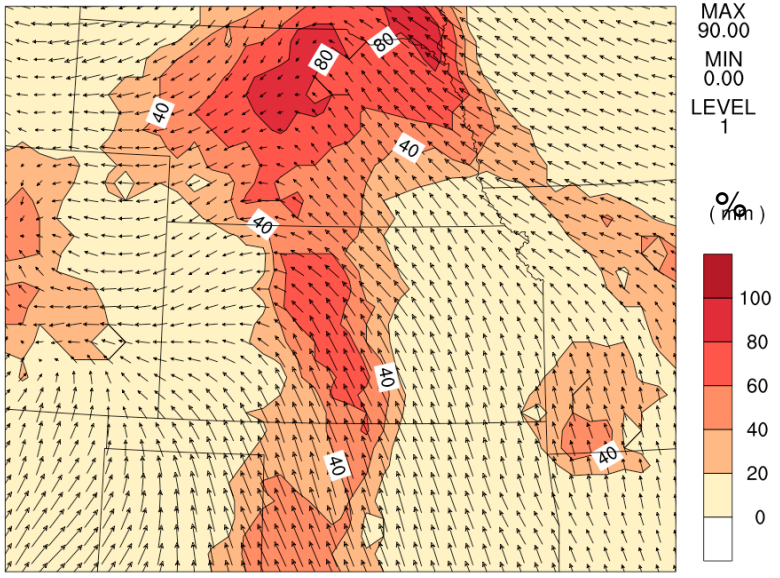
- Observations in model diagnosed through PBL and surface-layer schemes ("U10", "V10", "T2", "Q2")

Probability (1-hr convective precip. > 1 mm)

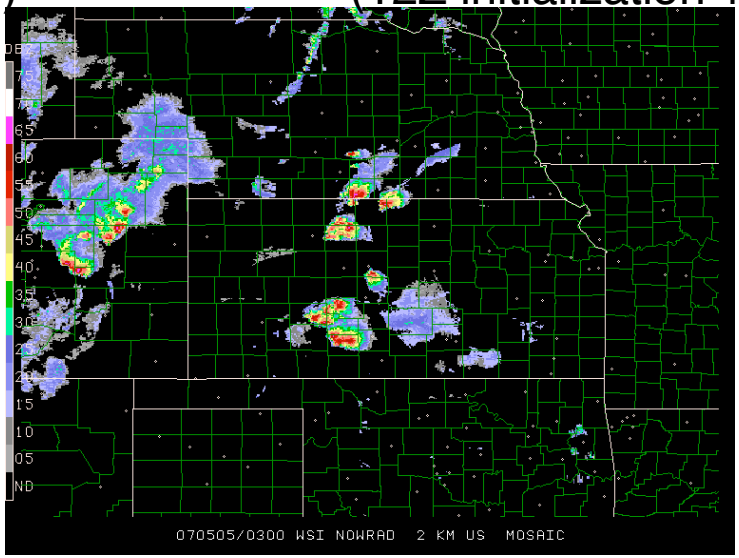
0300 UTC 5 May 2007



9-hr forecast without assimilation
(18Z initialization)

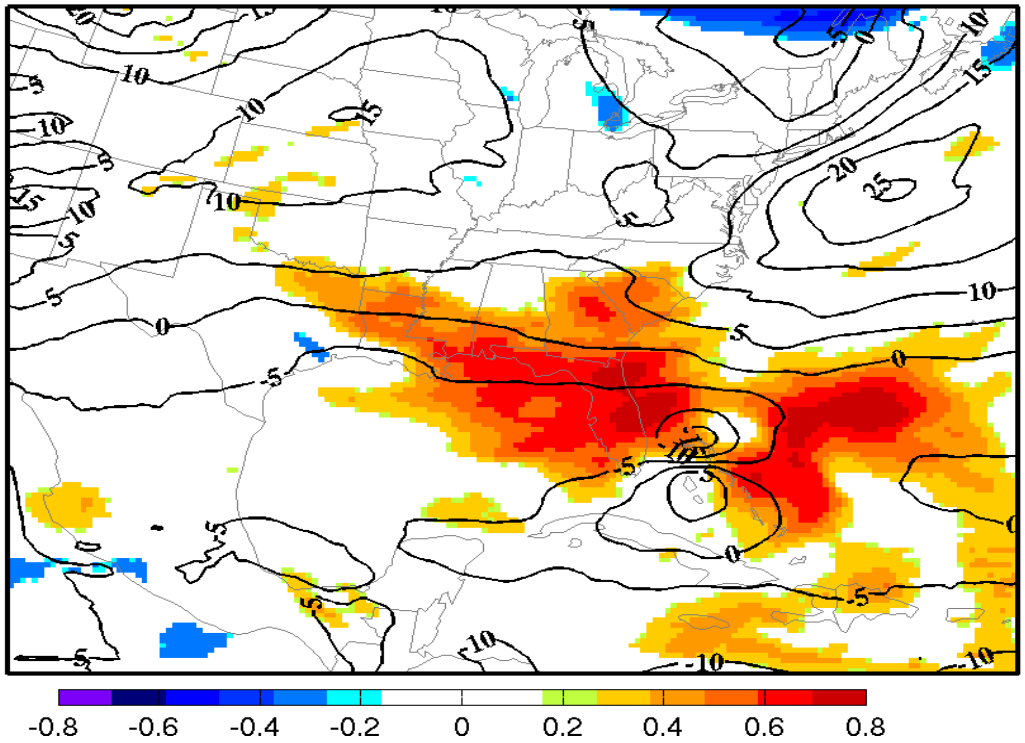


9-hr forecast with assimilation
(12Z initialization + 6 hr assimilation)



Projects making use of ensemble statistics…

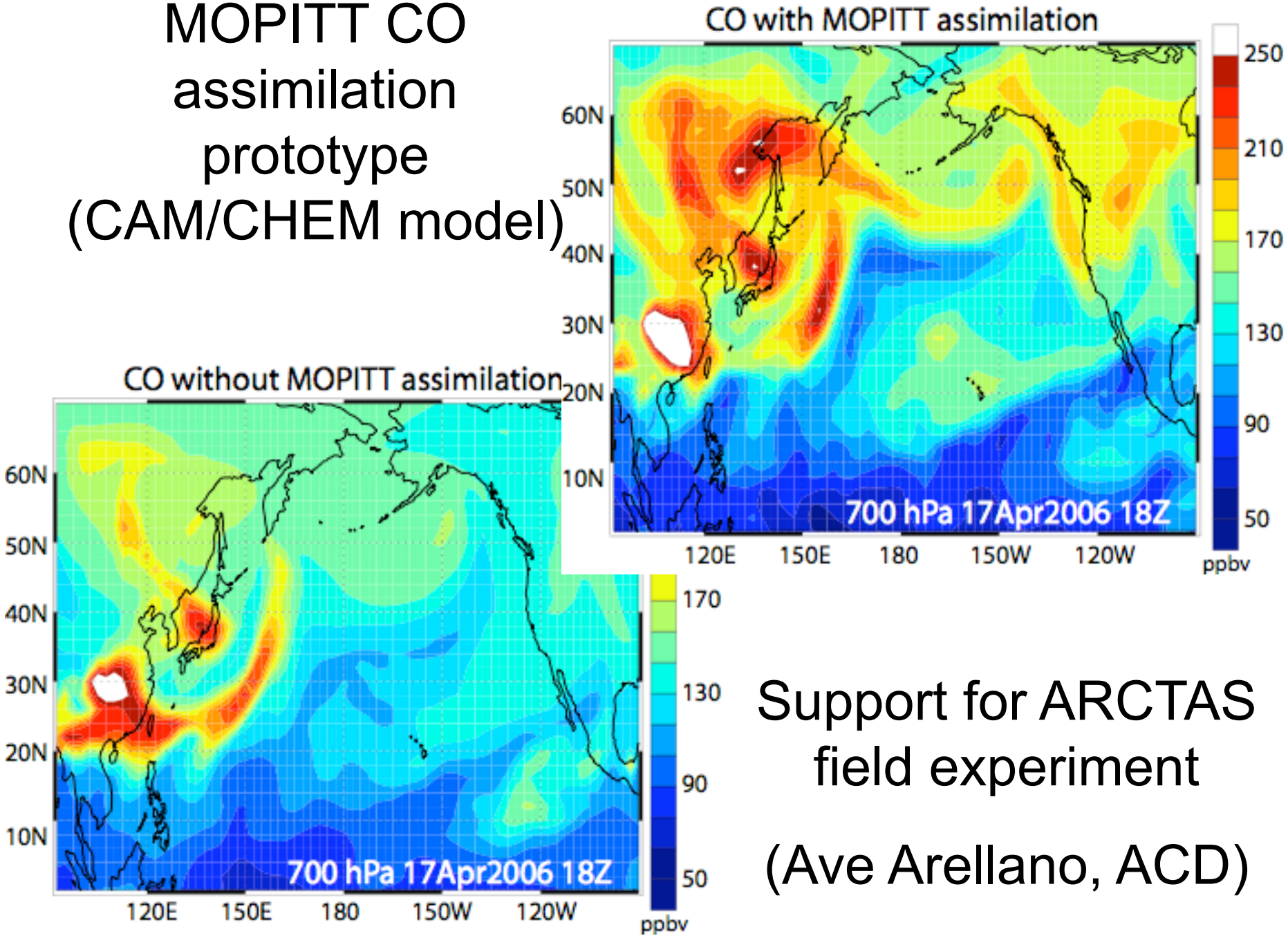
Hurricane Katrina Sensitivity Analysis
Ryan Torn, SUNY Albany



Contours are ensemble mean 48h forecast of deep-layer mean wind.

Color indicates change in the longitude of Katrina.

MOPITT CO assimilation prototype (CAM/CHEM model)



Support for ARCTAS field experiment

(Ave Arellano, ACD)

Other ongoing projects

- Doppler radial velocity assimilation
- Radar reflectivity assimilation
- WRF column model for boundary layer using ARM intensive obs.
- Mesoscale reanalysis for T-Parc typhoons
- Prediction with AM2, GFS

Other ongoing projects

- OSSEs for chemical remote sensing in CAM/chem and WRF/chem
- Assimilation of cloud -moisture, -ice, -fraction
- Gulf of Mexico mesoscale eddies with MIT ocean GCM
- Quasi-operational ensemble prediction for Taiwan

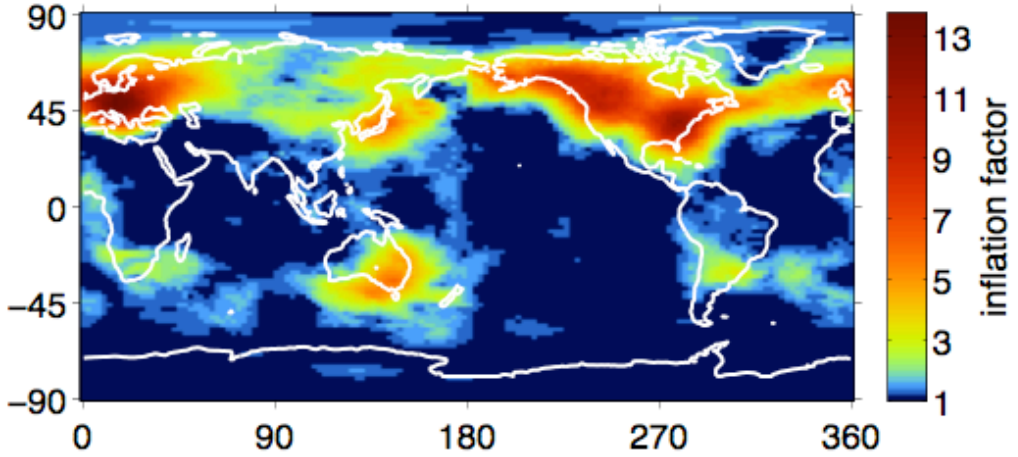
Other ongoing projects

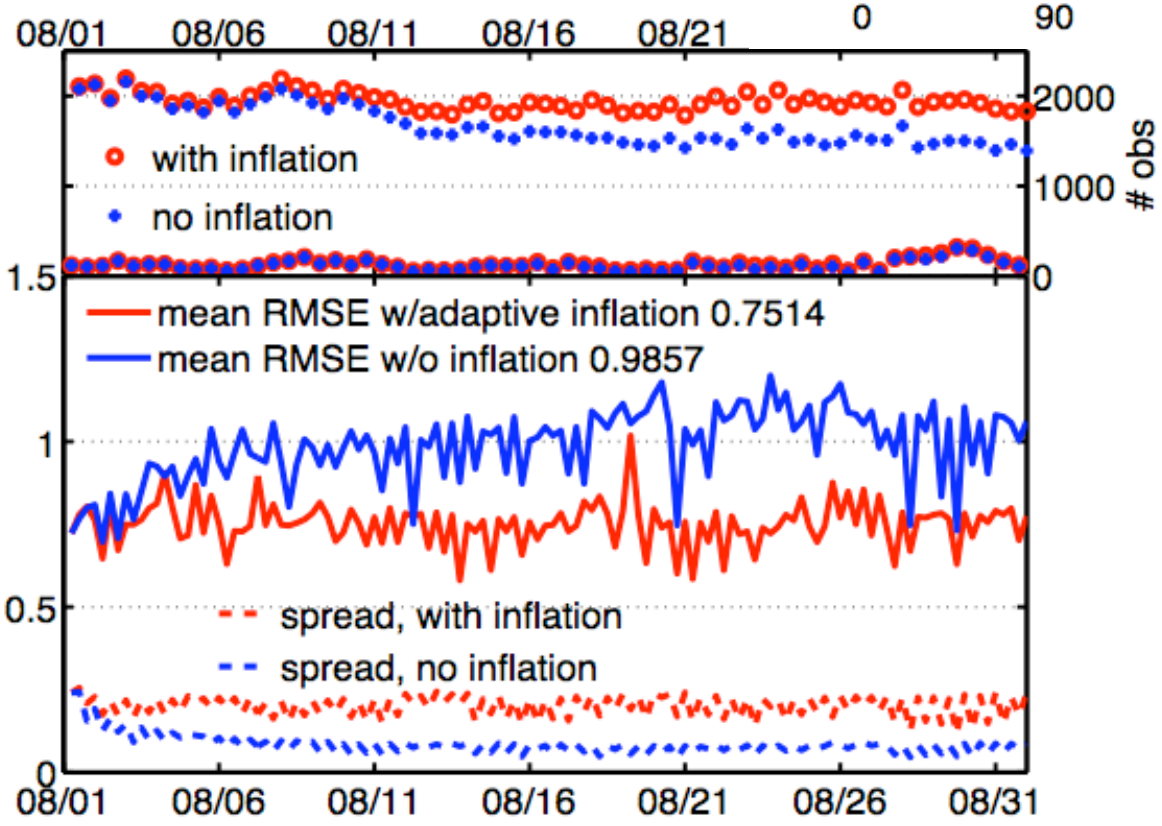
- Space weather, ionosphere, magnetosphere prediction
- Solar cycle prediction using helioseismology
- Martian OSSEs and assimilation with WRF/ MARS

Advanced Ensemble DA Algorithms

Maintaining Ensemble Diversity

Adaptive Inflation in DART can nearly eliminate tuning!





Other DA Advances

- Hierarchical filter for advice on localization
- Non-gaussian ensemble filters
  - Improved assimilation of bounded quantities
  - Improved assimilation of radar reflectivity

Frontiers

- Enhanced parallelism
  - Current DART algorithm widely adopted
  - Scales to O(100) processors
  - Can improve in current framework to O(1000)
  - New non-linear ensemble filters being explored
  - Might scale to O(10000+)

Frontiers

- Earth System DA
  - Atmosphere under control
  - Initial ocean projects completed
  - Exploring collaboration with Los Alamos on POP
  - Land surface, biosphere still mostly unexplored
- Space weather, solar prediction
  - Initial collaborations dormant
  - DAReS people attend space weather meetings

Challenges

- Collaboration, consumption, or exploitation?
  - DA was mentioned as part of every science strategic plan at NCAR
  - Generally no plan to pay for this
  - Limited help from MMM and RAL
  - Rest of NCAR projects are funded by DAReS
  - ESSL funds many other DA activities
  - We can’t sustain the envisioned level of activity

Challenges

- Balancing our activities
  - Algorithmic development
  - New models and observations
  - Supporting existing models and observations
  - Collaborative research using DART
  - Education / outreach / advertising

Challenges

- Staffing
  - Core funding slowly eroding
  - Soft money dilutes focus
  - Seriously over-extended
  - Need another software engineer and scientist?