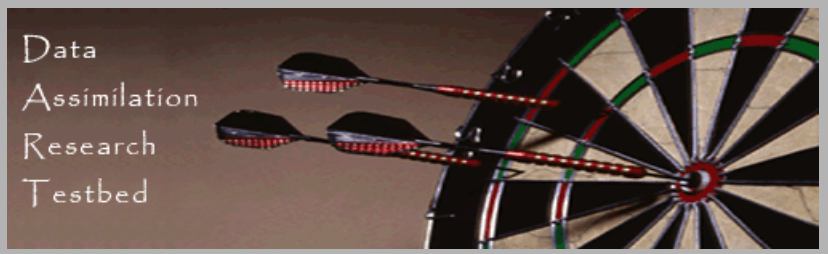
NCAR's Data Assimilation Research Testbed: DART

Tim Hoar, Data Assimilation Research Section
National Center for Atmospheric Research
6 August 2008

'Plug and Play' Ensemble Data Assimilation.



Financially supported by the U.S. National Science Foundation ATM

Roadmap to the talk

Overview of DART	$\sim$ 2 minutes
Novel DART Results	$\sim$ 4 minutes
Overview of Ensemble DA	$\sim$ 4 minutes
DART DA Tutorial,Algorithms	$\sim$ 6 years . . .
Questions	$\sim$ closing

In this talk, a 'model' is a numerical representation of a physical process - NOT a statistical model.

Data Assimilation Research Testbed – DART

- is an ensemble-based data assimilation facility,
- allows combinations of assimilation algorithms, models, and observation sets, without being an exercise in software engineering,
- can exploit parallel machines ("real-world" problems),
- has a suite of diagnostic tools for observations and model output,
- supports DA R&D for NCAR, external partners,
- has an extensive 'hands-on' tutorial,
- is available for download at

www.image.ucar.edu/DAReS/DART

Data Assimilation Research Testbed – DART

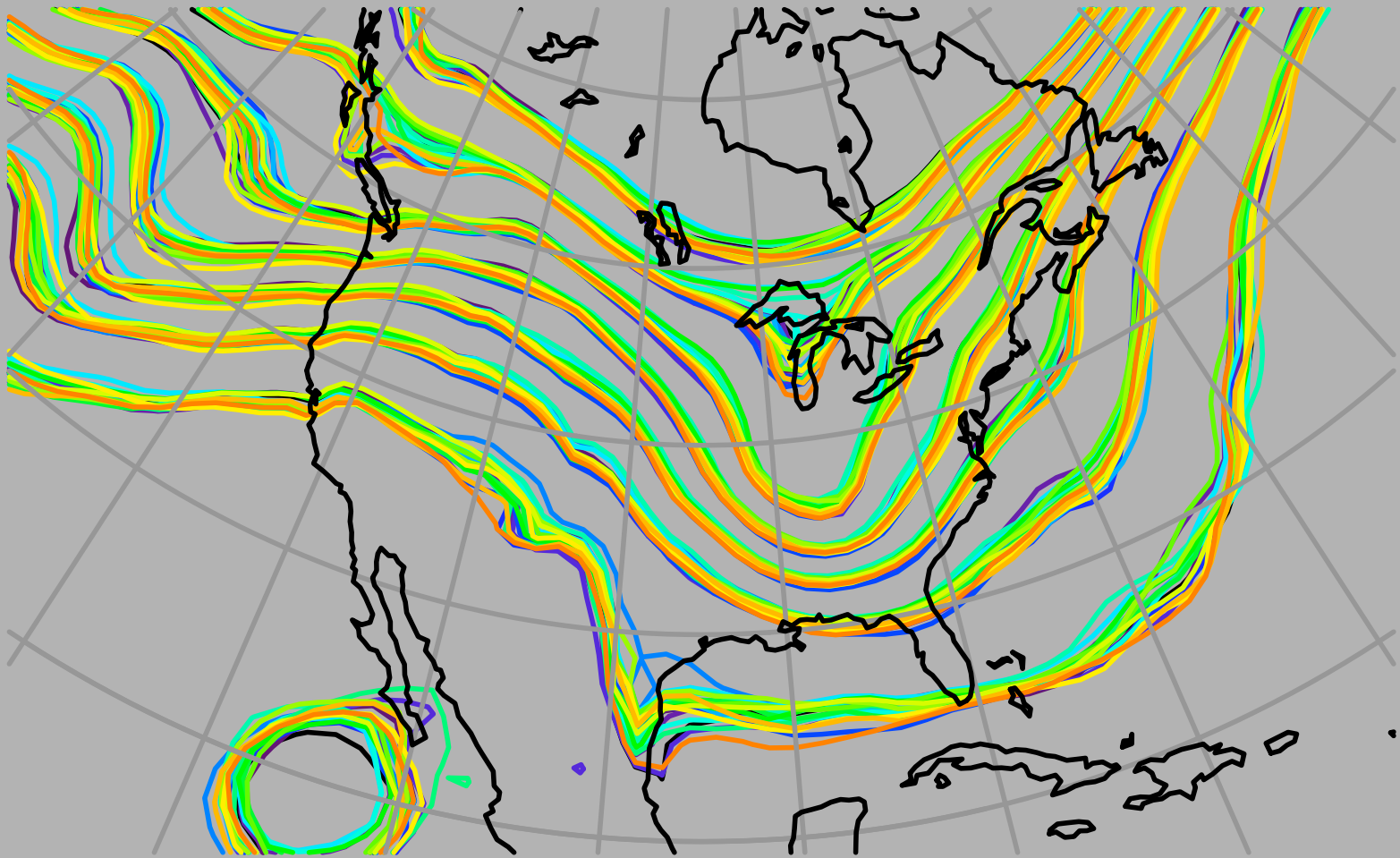
A subset of the models in use:

- L63, 9var, L96, ikeda, a simple advection model, ...
- GFDL: FMS B-grid, AM2 (atmosphere-only GCM)
- NCAR's CAM (used for IPCC)
- WRF (regional/global) Hurricanes, Mars
- MIT ocean model, ...

Forward Operators and Datasets

- linear, non-linear forward operators for simple models
- U,V,T,Ps,Q for realistic models
- Radar reflectivity, GPS refractivity
- Observations from BUFR files
- Can create 'perfect model' observations for all

DART/CAM T85 GPH@500hPa

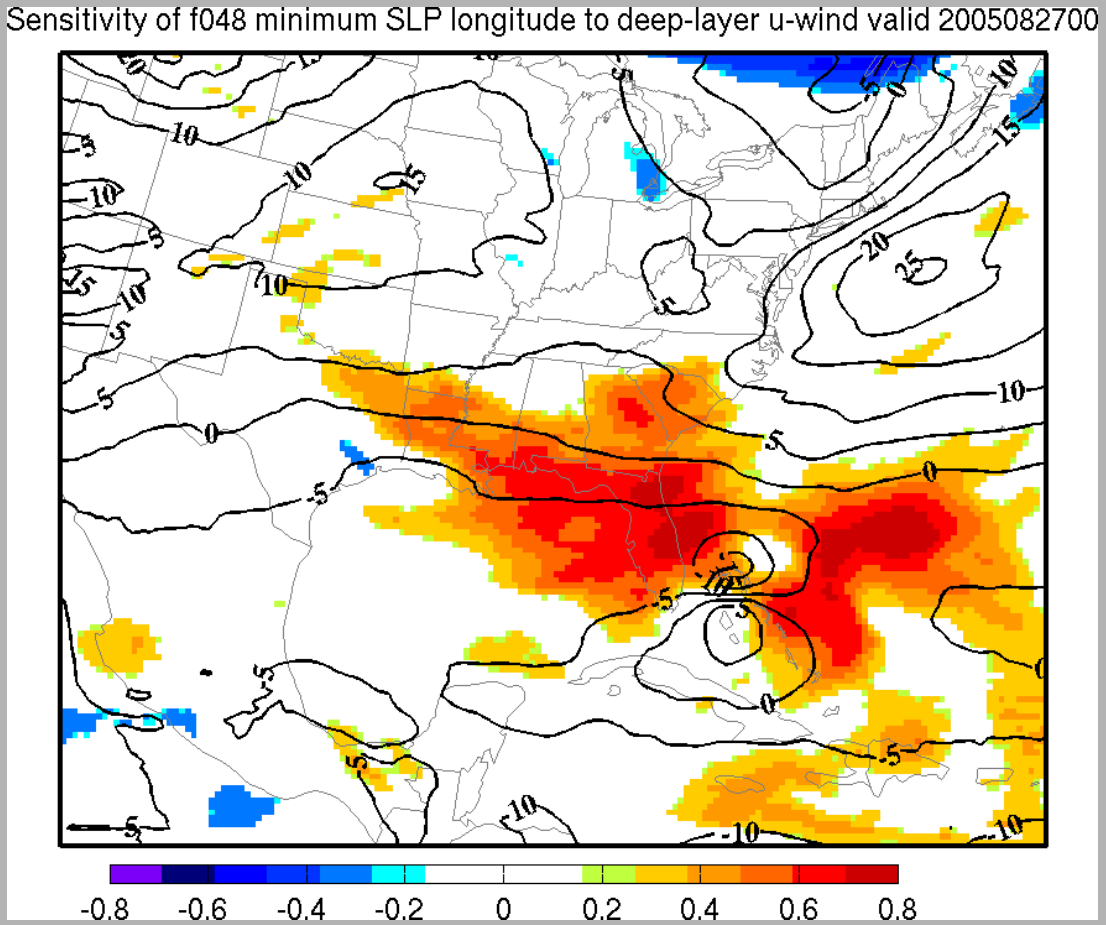


00Z 1 Feb 2003

contours 5320 to 5800 by 80

Hurricane Katrina Sensitivity Analysis - WRF

The colors illustrate how a one standard deviation change in the E-W wind will change the TC longitude.

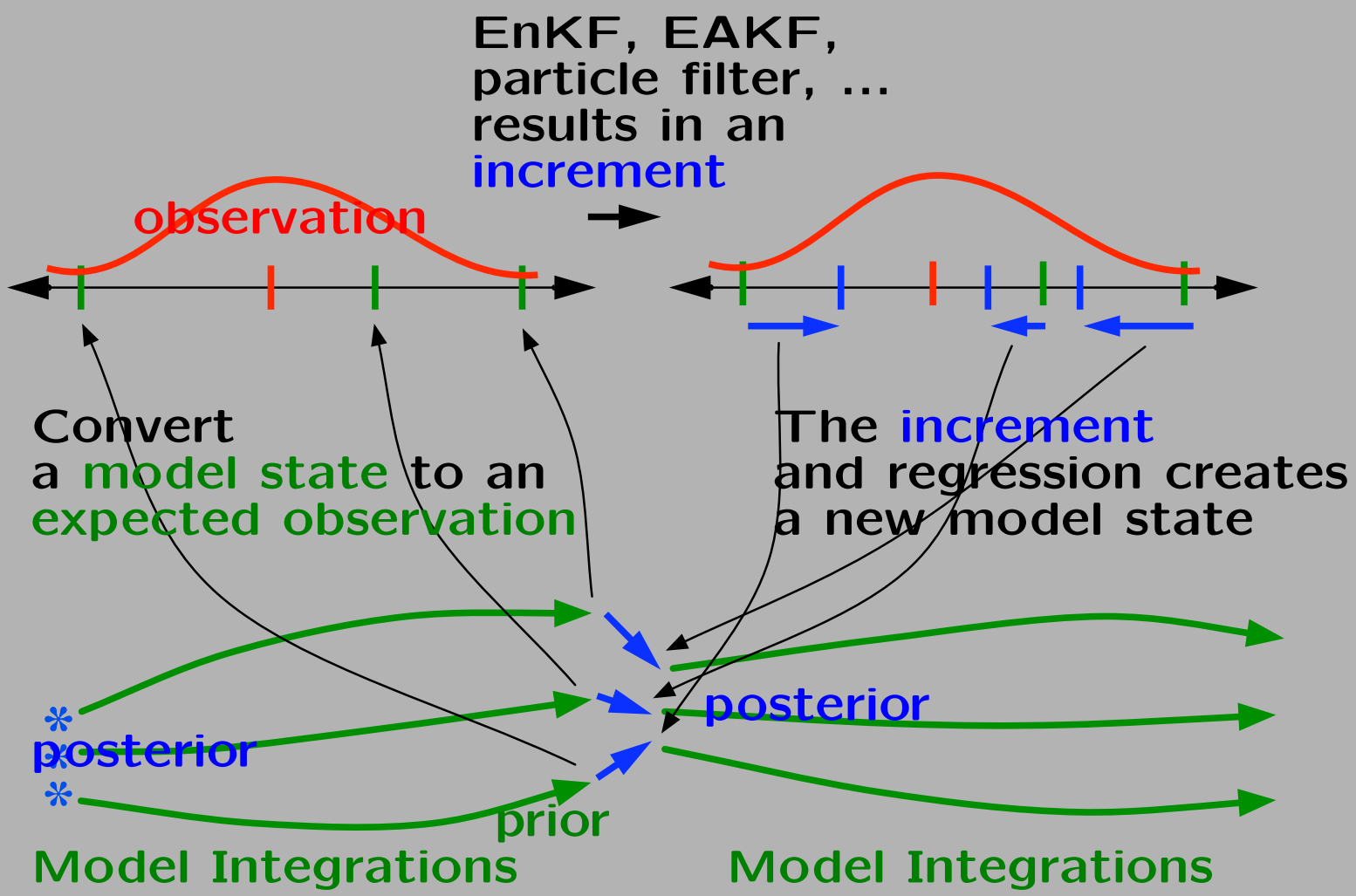


contours are ensemble mean 48h forecast

southerly jet shifts TC east

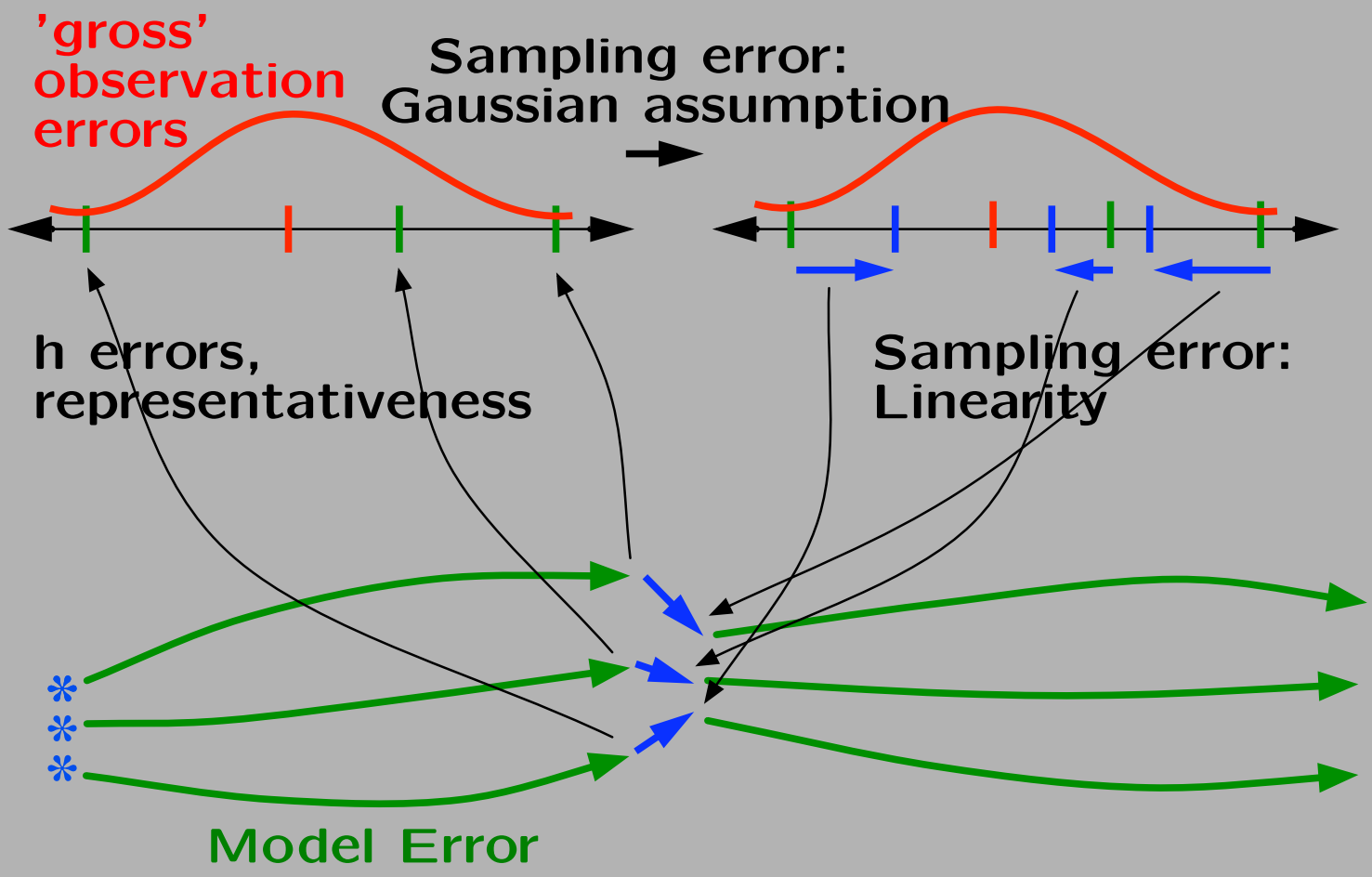
credit to Ryan Torn

Schematic of Ensemble Data Assimilation



Ensemble Data Assimilation Error Sources

errors $\Rightarrow$ systematic loss of variance in the prior



Combating the loss of variance

M-dimensional state vector x, ensemble size of N

Traditional (covariance) inflation:

$$x^{inf}_{m,n} = \sqrt{\lambda}\,(x_{m,n} - \bar{x}_m) + \bar{x}_m$$

- λ is 'one-size fits all', obtained by trial-and-error

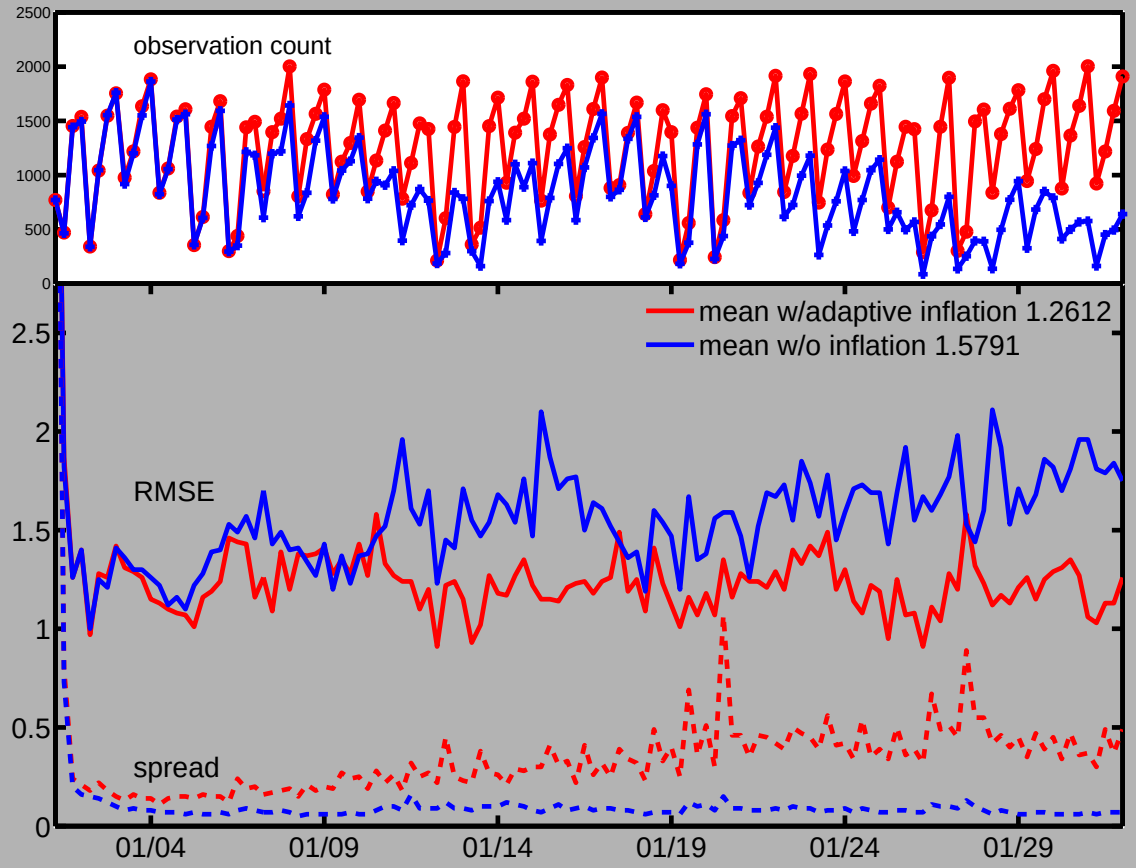
Adaptive inflation:

$$x^{inf}_{m,n} = \sqrt{\lambda_m}\,(x_{m,n} - \bar{x}_m) + \bar{x}_m$$

- λ_m is improved by Bayes theorem, observations
- more on this later . . .

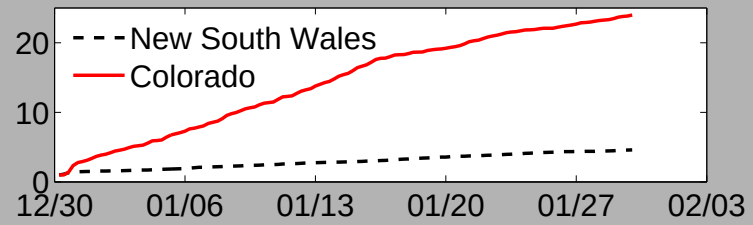
observations more effective

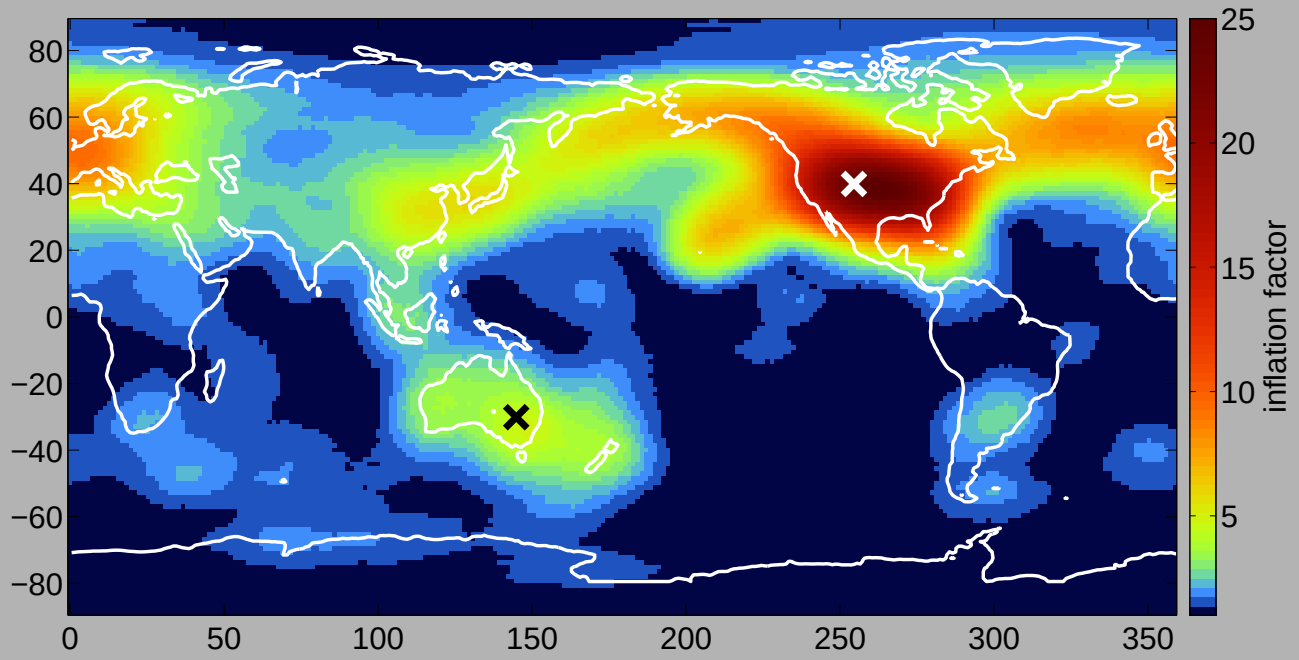
Adaptive Inflation in CAM: NA 500 hPa T
Observation-Space Prior RMS, Spread



Adaptive Inflation in CAM after 1 month of assimilation: 266hPa U wind

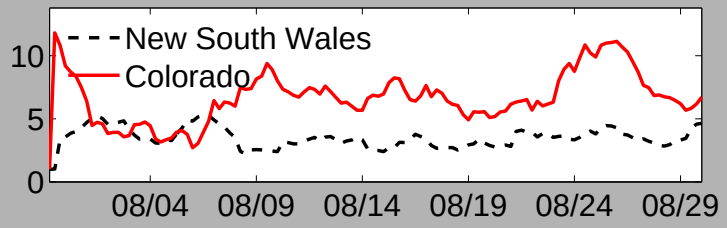
U at 266 hPa, t = 01/01

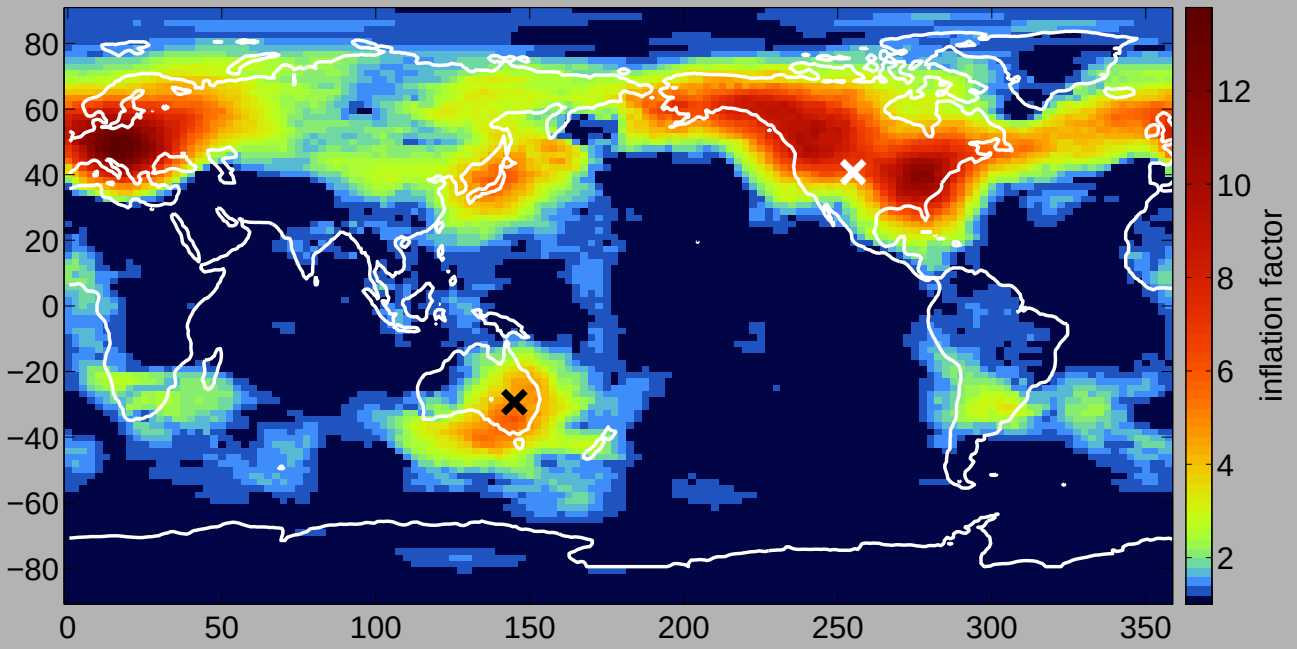




Damped Adaptive Inflation in CAM after 1 month of assimilation: 266hPa U wind

U at 266 hPa, t = 08/01





DART tutorial

This is a 'hands-on' tutorial.

The tutorial is distributed with DART; the best approach is to download DART, read the tutorial and follow along! Barring that, the tutorial is available at:

www.image.ucar.edu/DAReS/DART/doc/tutorial

(*browse tutorial section* 12 *for PROOF*)

Statistical rigor would be appreciated.

Ensemble Data Assimilation has Bayesian roots. It is now time to get the application-driven portion of the community back together with the theory-driven portion of the community.

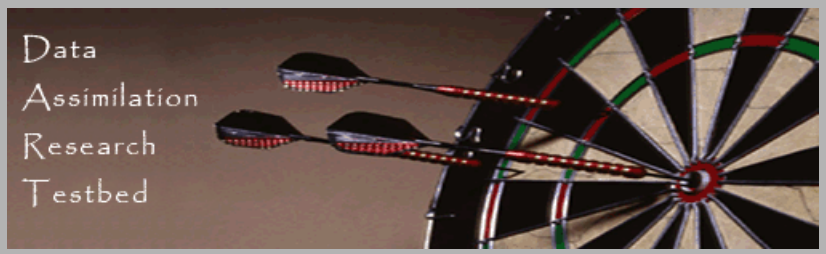
DART uses pragmatic algorithms that work.

Statistical properties are not fully known.

Acknowledgements

Thanks to:
Jeff Anderson, Nancy Collins, Kevin Raeder, Hui Liu, and Ryan Torn; all from the National Center for Atmospheric Research

www.image.ucar.edu/DAReS



DART is

funded by the U.S. National Science Foundation DMS