WRFDA Tutorial

Wrap up discussion

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Recall what we have covered in this Tutorial

- **Important concepts/principal** for data assimilation
  - Background, observations and their error covariance B and R.
  - Correlation in B matrix is extremely important
  - Innovation, Observation operator, adjoint operator (transpose of matrix)
  - least square cost function J, gradient of J, Gaussian PDF
  - Vector/Matrix notation
  - Analysis error covariance A and precision (A^{-1}), Hessian of cost function

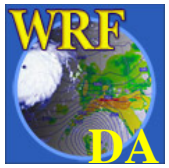
- Introduction to WRFDA **software** and how to **compile** it

Recall what we have covered in this Tutorial

- **DA Algorithms**: 3DVAR, FGAT, 4DVAR, hybrid-3DVAR, B matrix modeling/estimation
  - GEN_BE, Incremental formulation, outer loop, control variable transform, WRFPlus (TL/AD), time window/slots, flow-dependent B, cycling DA, ensemble

- **Observations**: conventional and others, satellite radiances, radar
  - OBSPROC, obs formats, obs types. Radiative transfer model, VarBC, reflectivity/radial-velocity, quality control

- Use WRFDA as a **tool** for other purposes
  - Forecast verification, Forecast Sensitivity to Obs, obs error estimation/tuning



Philosophy about our tutorial design

- Balance between “practice” and “theory”
  - Hopefully some mathematical materials can help you for future data assimilation studies/applications in depth
  - Not expect you to fully understand all theory, which will need at least two-week summer school.

- We will send you a survey afterward to have your feedback about Tutorial
  - Hope to improve tutorial design in the future

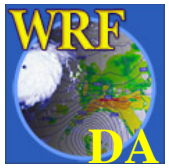
Advice when using WRFDA

- What we provided in the package should allow you to produce reasonable results even if you use it as a black-box

- But for better performance, you'd better understand what is within the box.
  - Know observations you are assimilating
  - Limitation/advantage of different DA methods, assumptions made behind various DA methods

We have NOT covered in this Tutorial

- **Minimization algorithms**
  - "Solver" of variational/hybrid data assimilation algorithms
- **Ensemble data assimilation**: ETKF included in WRFDA
  - More advanced ensemble DA under development within WRFDA
- **Cloudy radiance data assimilation**
  - Basic capability there, figure it out yourself or collaborate with us
- **Guidance for developers or your own studies**
  - How to add/assimilate your own observations?
  - Observing System Simulation Experiment (OSSE) for future obs
  - We plan to add this aspect next year!

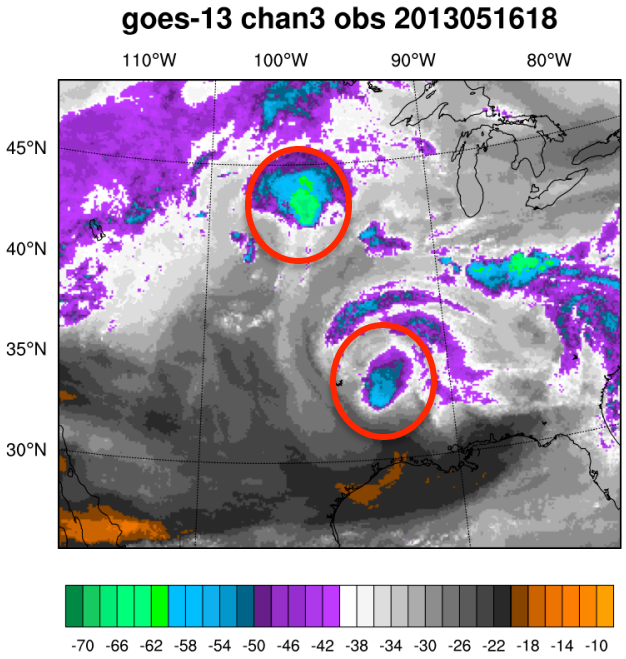


Ongoing developments

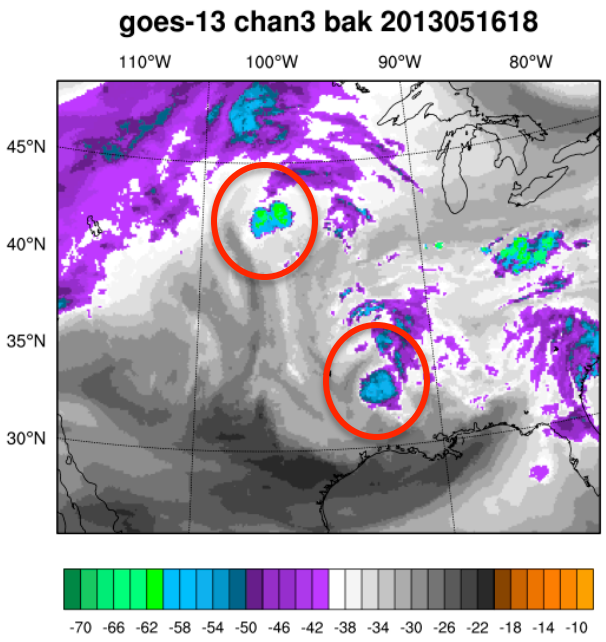
- DA Algorithms
  - Multiple-Incremental 4DVAR for speed up
  - Hybrid-4DVAR, hybrid 4D-Ensemble-Var
  - Ensemble DA within variational framework

- Observations
  - More radiances (e.g., AMSR2, GOES-Imager, …)
  - Improvement of radar, surface, precipitation DA
  - Cloudy radiance DA

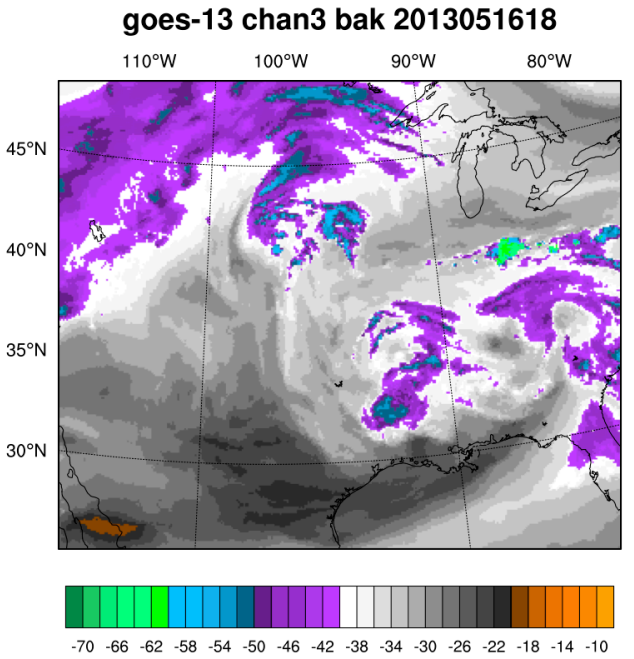
New radiance data assimilation: GOES-Imager



GOES-13 WV Obs



WRF 24-h Forecast with assimilation of GOES-13 clear-sky WV Obs



WRF 24-h Forecast w/o assim. of GOES-13 WV Obs

WRF configured at 3-km with hourly cycling 3DVAR assimilation

Aerosol DA for WRF/Chem

Liu, Z., Q. Liu, H.-C. Lin, C. S. Schwartz, Y.-H. Lee, and T. Wang, 2011: Three-dimensional variatio nal assimilation of MODIS aerosol optical depth: Implementation and application to a dust storm ov er East Asia. J. Geophys. Res., 116 , D23206, doi:10.1029/2011JD016159.

Schwartz, C. S., Z. Liu, H.-C. Lin, and S. McKeen, 2012: Simultaneous three-dimensional variation al assimilation of surface fine par ticulate matter and MODIS aerosol optical depth. J. Geophys. Res. , 117 , D13202, doi:10.1029/2011JD017383

Jiang, Z., Z. Liu, T. Wang, C. S. Schwartz, H.-C. Lin, and F. Jiang, 2013: Probing into the impact of 3DVAR assimilation of surface PM10 observations over China using process analysis. J. Geophys. Res. Atmos. , 118, 6738-6749.

Schwartz, C. S., Z. Liu, H.-C. Lin, and J.D. Cetola, 2014: Assimilating aerosol observations with a " hybrid" variational-ensemble data assimilation system. J. Geophys. Res. Atmos., , 119, 4043-4069.

Chen, D., Z. Liu, Schwartz, C. S., H.-C. Lin, J. D. Cetola, Y. Gu, and L. Xue, 2014: The impact of ae rosol optical depth assimilation on aerosol forecasts and radiative effects during a wild fire event ove r the United States. Geosci. Model Dev., 7, 2709-2715.

http://www2.mmm.ucar.edu/people/liuz/publications/publications.html