Adjoint observation impact for a limited area model

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For global systems:
- \( e_g > e_f \)
- Reduction in error due to assimilation of obs

For limited area model:
- Error not necessarily reduced
- Lateral boundaries vary

**COAMPS** — US Navy mesoscale model, nonhydrostatic, relocatable

**NAVDAS** — 3D-Var, conventional obs, satellite winds + retrievals

Langland and Baker (2004)
COAMPS Observation Impact

Adjoint of forecast model and DAS quantify value of each observation in reducing short term forecast error.

- Error only calculated over part of domain
- Analysis grid is larger than model grid
Lateral Boundary / Trajectory Considerations

\[ \Delta e^f_g = \left< x_f - x_g, \left( \frac{\partial J_f}{\partial x_f} + \frac{\partial J_g}{\partial x_g} \right) \right> \]

Nonlinear Error

\[ \delta e^f_g = \left< x_a - x_b, \left( \frac{\partial J_f}{\partial x_a} + \frac{\partial J_g}{\partial x_b} \right) \right> \]

Model Space Estimate of Nonlinear Error

Lateral Boundary

- Estimate is ~90% of actual value, similar to NOGAPS
- Error box to the east
- Outer 7 pts removed
- All points

Gradient information propagates through lateral boundaries.

Trajectory

- Dry Trajectory
- No Ice Physics
- All Physics

Ice processes degrade trajectory for dry adjoint model integration.
1 wk 12/24-12/31/2010 COAMPS forecasts over US
60 km horizontal grid spacing – 30 vertical levels

For COAMPS (limited area model), error information is more variable than global systems

From Gelaro et al. 2010 – Comparison of NRL NOGAPS, GMAO GEOS-5, and EC GDPS Systems
Impacts for different domains
12/24-31 2010

Value of observations depends on area where error is calculated
Horizontal Grid Spacing

COAMPS 12 hr impacts 05/21-28 2011

45 km

20 km

Per Observation

35% of 20 km COAMPS adjoint runs failed

Similar results for successful cases
UAV Observations

COAMPS forecasts over W. Atlantic (Δx=45 km – 30 levels)
08/19 12Z - 08/22 00Z 2009. ~ 500 UAV Observations

Importance of UAV observation increases when radiosondes are not available
High Density Hurricane Hunter Observations

30 sec flight level data in vicinity of storm (includes moisture)
Tropical Cyclones – Synthetics vs High Density Obs

COAMPS Ob Impacts 12 hr forecasts 08/28/00Z- 09/04/12Z (TC Earl 2010)
Future Considerations

• Consistent “Truth”
• Different metrics
• Impacts for tactical scales (space and time)
Error Estimate

Difference in error can be estimated from observation or model grid point sensitivity

\[ \Delta e^f_g = \left\langle \left( x_f - x_g \right), \left( \frac{\partial J_f}{\partial x_f} + \frac{\partial J_g}{\partial x_g} \right) \right\rangle \]

Quantification of Error at Verification Time

\[ \delta e^f_g = \left\langle \left( x_a - x_b \right), \left( \frac{\partial J_f}{\partial x_a} + \frac{\partial J_g}{\partial x_b} \right) \right\rangle \]

Model Space Estimate

\[ \delta e^f_g = \left\langle \left( y - Hx_b \right), \frac{\partial J_g}{\partial y} \right\rangle \]

Observation Space Estimate