High Resolution Limited Area Model

Hirlam

Challenges of mesoscale data assimilation

Questions to be asked by you!

Answers required from you!

The complexities of mesoscale data assimilation

Different types of challenge:

- To some we have answers (we think)
- For others we have tentative suggestions for a solution
- And for some we just have to experiment to see what happens…

Questions and challenges

- Is mesoscale data assimilation worth the effort? Or: when is it worthwhile?
- Which observations are to be assimilated? Do we have enough of them? Do we have the right kind of observations? Do we make sufficient use of them?
- Which model variables to assimilate? Which assimilation method to apply?
- Do we need to make a separation of scales?
- How to handle non-linearities of mesoscale processes in the assimilation?
- What to do for the nowcasting time scale?
- What should be the relation between atmospheric and surface data assimilation?
- How to distinguish noise and spinup effects from real unbalances?
- ...???

More questions:

- ...?

Is mesoscale data assimilation worth the effort?

- To what extent are mesoscale phenomena forced by the larger scale circulation?
- Are we caught between the time that spinup effects last and the time when lateral boundary conditions will dominate in small integration areas?
- Are there enough high-resolution, high-frequency observations of mesoscale phenomena for a mesoscale analysis to have added value over a synoptic scale system?

Observation challenges

- Which observations to assimilate? Do we have sufficient and sufficiently frequent observations available?
- What is important information to capture particular mesoscale phenomena like convection in a mesoscale analysis? Surface? Water vapor? Winds/dynamics?
- Do we need new/better pre-processing tools? Super-obbing? Retrievals or direct assiilation of observed quantities? More extensive quality control needed because of more complex error structures?
- How to handle complicated error structures?
- Modelling of processes that affect observations (e.g. backscattering from clouds): adequate or to be improved?

Observations of potential interest

- Radar reflectivity and radar/profiler wind (quality control!!)
- Clear and cloudy radiances from new high-res. satellites
- GPS (slant) delays
- Surface observations, incl SST and sea ice, vegetation, snow, lakes, …
- Satellite wind observations, e.g. MODIS winds, DWL
- …?

Which model control variables in the assimilation?

Priorities of variables in adjustment processes?

-Is it meaningful to assimilate water vapor if wind and dry mass are wrong?

-Is it meaningful to assimilate cloud variables if water vapor is wrong?

-Is it meaningful to assimilate surface if clouds are wrong?

Can we apply meaningful balance constraints involving moisture?

Do we need to make a separation of scales?

• How to optimally merge the larger scales from synoptic scale systems with high-resolution mesoscale phenomena?

- Handle all scales in the mesoscale assimilation, as well as in the synoptic scale assimilation?

- Only add mesoscale features in mesoscale assimilation, and use large-scale analysis from synoptic model?

- Apply explicit large scale constraints in mesoscale D.A.?

- Mesoscale flow dependency coupled to the large scales?

How to handle non-linearities of mesoscale processes in the data assimilation?

Within 4D-Var:

- Is it meaningful to try tangent linear physics on the mesoscale?

- Convergence problems in the D.A. process?

Can Ensemble Kalman filters handle non-linearities in a (more) proper way?

-Ensemble is based on non-linear model runs

-Estimations still are based on linearity (Gaussian) assumption

The assimilation method

- Simple, complex or something in between?
- In case of 3/4D-VAR: Apply mesoscale balance constraints, in particular involving moisture? Use analytical or statistical constraints?
- How to handle inhomogeneities and anisotropy in structure functions?
- Flow-dependent structure functions? 4D-Var, ensemble techniques or synthesis?
- Mesoscale processes often inherently stochastic ➔ combination of data assimilation and ensemble techniques? Assimilation techniques for probabilistic forecasting of extreme events?
- How to handle model errors?

Operational requirements for nowcasting

- For nowcasting, rapid update cycling is essential:
  - Update frequency of (ground-based) RS seems high enough for this
  - Indications that 4D-VAR is better suited for analysis of e.g. radar data, but too computationally expensive?
  - So rapid update cycling using simple assimilation scheme, or less frequent 4D-VAR, or some combination ?
  - Do we need a more stringent initialization process (to reduce spinup time)?

Surface data assimilation:

- Surface initialization likely to be of increasing importance at mesoscale
- Present surface assimilation systems: usually simple (OI) and using limited number of types of observation; tuned to optimize T2m, RH2m
- Developments:
  - SAF's provide new observational products
  - Recommendations for more sophisticated surface d.a. and algorithms available from e.g. ELDAS
  - More realistic surface models to feed observations into, and that need to be fed by (new types of) observations

So:

- Which observations to assimilate in new generation of surface models?
- How to ensure that the surface model can handle this information correctly?
- How to optimize and validate the end result?
- Do we expect benefit from more sophisticated assimilation methods? With what priority?