Challenges of mesoscale data assimilation and HIRLAM plans

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Outline

- Many different types of challenge:
  - To some we have answers (we think)
  - For others we have tentative suggestions for an answer
  - And for some we just have to experiment to see what happens…

- Approach chosen in the HIRLAM plans

Questions and challenges

- Is mesoscale data assimilation worth the effort?
- Do we need to make a separation of scales?
- How to handle non-linearities of mesoscale processes in the assimilation?
- Which observations to be assimilated? Do we have enough of them?
- Which model variables to assimilate? Which assimilation method to apply?
- 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?
- How to achieve convergence between the HIRLAM and ALADIN systems?

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 of spinup effects and the time when lateral boundary conditions will dominate in small integration areas?
- Are there enough high-resolution, high-frequency observations for a mesoscale analysis to have added value over a synoptic scale system?

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?

- Only add mesoscale features in mesoscale assimilation?

- Explicit large scale constraints

- 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 TL physics on the mesoscale?

-Should we trust more outer loops with NL models? Convergence problems?

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

-Ensemble is based on NL model runs

-Estimations still are based on linearity (Gaussian) assumption

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?

Can we apply meaningful balance constraints involving moisture?

Observation challenges

- Which observations to assimilate?

 - What is important for particular phenomena like convection? Surface? Water vapor? Winds?

- Do we need pre-processing tools? Super-obbing? 1D-Var retrievals? More extensive quality control needed because of more complex error structures?

- Handling of complicated error structures? (e.g. to avoid data thinning)

- Modelling of processes that affect observations (e.g. backscattering from clouds)

The assimilation method

- Mesoscale balance constraints, in particular involving moisture? Analytical or statistical constraint?
- How to handle inhomogeneities and anisotropy?
- 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 RUC using simple assimilation scheme, or less frequent 4D-VAR, or some combination ?
  - Do we need a more stringent initialization process (to reduce spinup time)?

Approach to data assimilation method:

- start with 3D-VAR/FGAT as reference option, see how far you get
- In mean time, continue improving 4D-VAR in synoptic model and port proven concepts to mesoscale
- Experiment with combinations of frequent 3D-VAR, less often 4D-VAR
- Use of statistical balance seems the best choice
- Experiment with sizes of integration domains and types of constraints
- Areas for improvement: quality control of observations and reduction of spinup times

Observations in HIRLAM and ALADIN plans

- Radar reflectivity and radar wind
- Clear and cloudy radiances
- GPS slant delays
- Surface observations
- Satellite wind observations, e.g. MODIS winds

Surface data assimilation:

- Surface data assimilation likely to be of increasing importance at mesoscale
- Present system in both HIRLAM and ALADIN:
  - based on OI and on limited number of types of observation
- Developments:
  - SAF's provide new observational products to be assimilated
  - Recommendations for surface d.a. and algorithms available from ELDAS
  - More realistic surface models to feed observations into
- Approach:
  - Planning meeting of surface modelling and data assimilation
  - Start with externalized AROME surface data assimilation (OI) and model scheme, test on mesoscale
  - Test impact of ELDAS 2D-VAR assimilation algorithms first on synoptic scale
  - Test impact of SAF products as they become available (starting with LAND-SAF). Rely primarily on SAF's to create these products.

Transition phase challenges

- ALADIN system of observation preprocessing based on ODB, HIRVDA on CMA
- Start on convergence of obs.operator formulations
- Integration of HIRVDA concepts into ALADIN VAR-code:
  - Need to gain experience with ALADIN VAR system first
  - Which ideas to port?
- How to minimize “double work” on synoptic and mesoscale data assimilation systems when both are still under intense development?