Report on the Joint SRNWP workshop on DA-EPS Bologna, 22-24 March

Nils Gustafsson
Alex Deckmyn

http://www.smr.arpa.emr.it/srnwp/

Purpose of the workshop

On the one hand, data assimilation techniques require accurate estimates of forecast uncertainty in order to blend optimally the prior forecast with the new observations. On the other hand, ensemble forecasts are designed to estimate the flow-dependent uncertainty of the forecast, therefore a good representation of the analysis uncertainty is crucial, especially for short-range EPS.

→Bring together both communities.

Workshop agenda

- Preliminary LAM-EPS meeting (22-23 March)
- Presentations (6 sessions)
- Discussions: a list of questions was proposed. These were then discussed first in 2 groups (DA and EPS), in the last session the outcome of both groups was presented and further discussed together.

Preliminary LAM-EPS meeting

- Overview of LAM-EPS systems
    - Most notable: several high resolution ensembles.
    - DWD: 2.8 km Nested inside 7 km LAM-EPS
    - MetOffice: plan to nest 1.5 km MOGREPS directly into 16km global
    - Perturbations from different global models
    - Arome ensemble (MeteoFrance)

Preliminary LAM-EPS meeting

- Ensemble LBC discussion
  - LBC'sfor LAM-EPS at 06 and 18 UTC
  - A: 50+1 members at T639 (=EPS)
  - B: 24+1 at T799
  - Both based on same EDA perturbations from 6h earlier.
  - M.Leutbecher did some first tests and found very similar skill (higher resolution vs more members)
  - Option C: T1279 in first 2 days, then continued at T639 up to +144h.
  - M.Leutbecher will explore feasability & prepare test data. Consortia should experiment and come to common conclusion by spring 2012.
  - Cost...

Status of art: Where are we? (1)

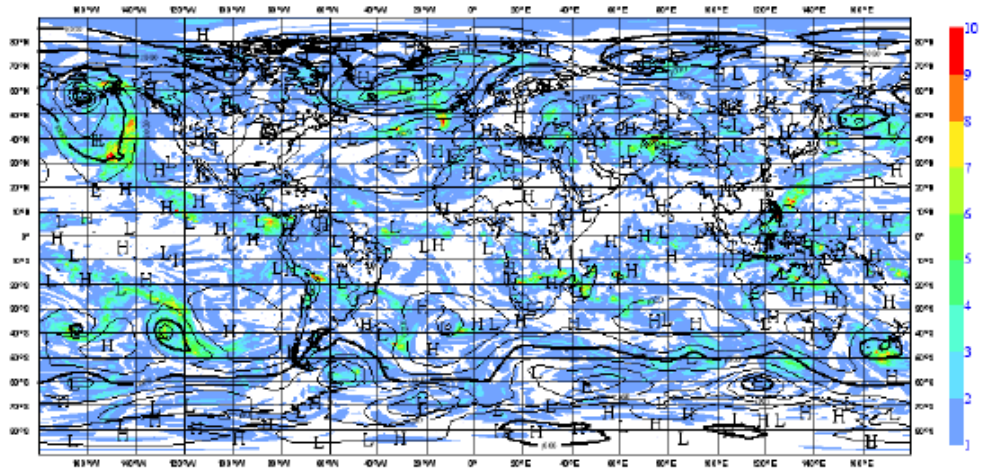
ECMWF:

- Ensemble of Data Assimilations (EnDA) based on observation perturbations and 4D-Var, Filtering of ensemble variances for use in 4D-Var (talk by Bonavita)
- EPS based on EnDA perturbations and singular vectors, Stochastically Perturbed Parameterisation Tendencies (SPPT) on three different scales, Stochastic Kinetic Energy Backscatter (SKEB) (talk by Leutbecher).
- Experimental EnsKF (Hamrud)

UK Met Office:

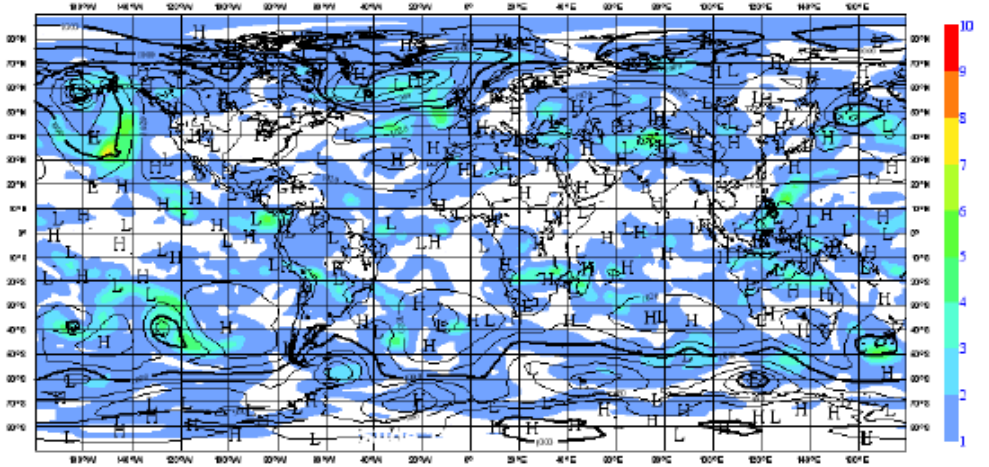
- 1.5 km model ETKF rescaling, problems with discontinuities along LBCs solved by scale-selective ETKF (talk by Caron)
- Variational Ensemble Hybrid at convective scales?
- Re-thinking on Ensemble data assimilation methods (talk by Bowler)

What type of errors affect EDA sample stats.?



Raw Ensemble StDev
VO ml64

Filtered Ensemble
StDev, VO ml64



From Bonavita (2011)

Status of art – Where are we? (2)

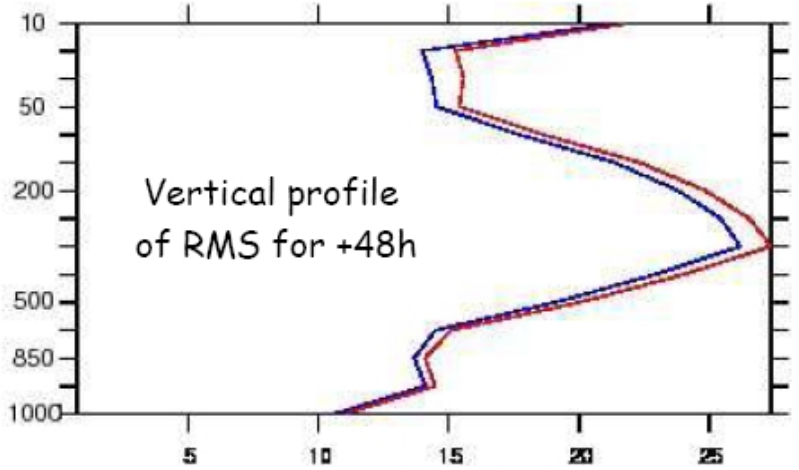
ALADIN including Meteo-France-ARPEGE:

- EnDA, Ensemble of Data Assimilations, 4D-Var + perturbed observations, spatial filtering of ensemble variances and wavelet filtering of correlations for use in 4D-Var (talk by Berre)
- Trials to model the model error variance (diagonal of Q) for EPS => multiplicative and additive inflations (talks by Boisserie, Raynaud)
- AROME ensemble: Selection of global members, downscaling (talk by Nuissier)
- Comparison ETKF <-> EnDA covariances (talk by Adamcsek)

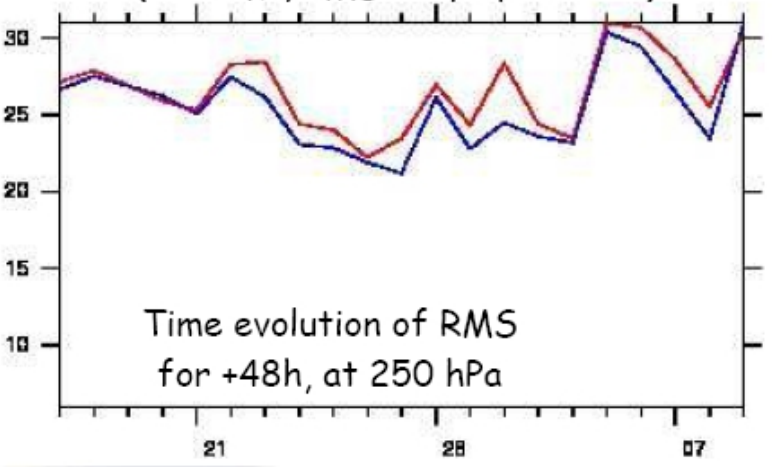
HIRLAM:

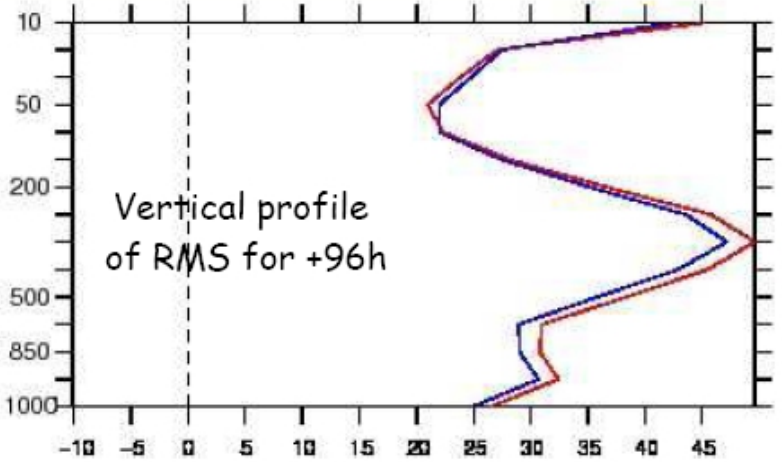
- ETKF rescaling including multiplicative and additive inflations, use of raw ensemble covariances + Schur product filtering (localization) in 3D-Var (talks by Bojarova and Johansson)

Impact of wavelet flow-dependent correlations against spectral static correlations (Varella et al 2011b)

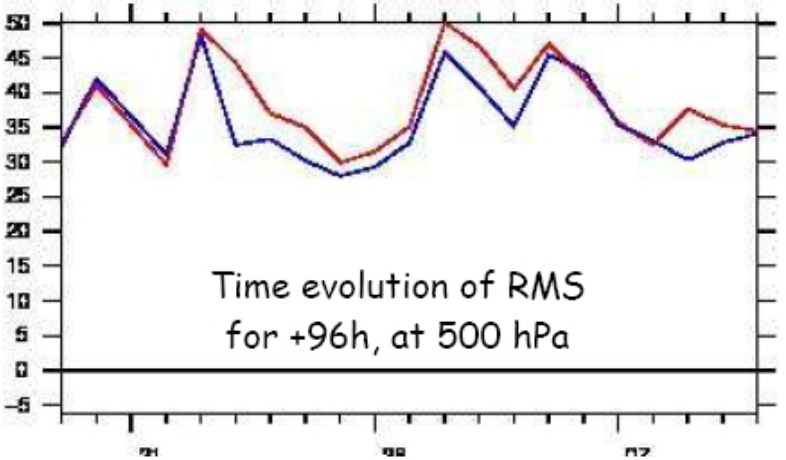


SOUTHERN HEMISPHERE
(3 weeks, RMS of geopotential)





EUROPE AND N. ATLANTIC
(3 weeks, RMS of geopotential)



From Berre (2011)

COSMO:

- KENDA – LETKF for the COSMO mode, multiplicative and additive inflations, hydrostatic balancing of increments (talks by Schraff and Reich)
- Study of model error – mixed multiplicative and additive ME term (talk by Tsyrulnikov)
- LETK with outer loop iterations (talk by Torrisi)
- SIR Sequential Importance Re-sampling (talks by Milan, Wursch)

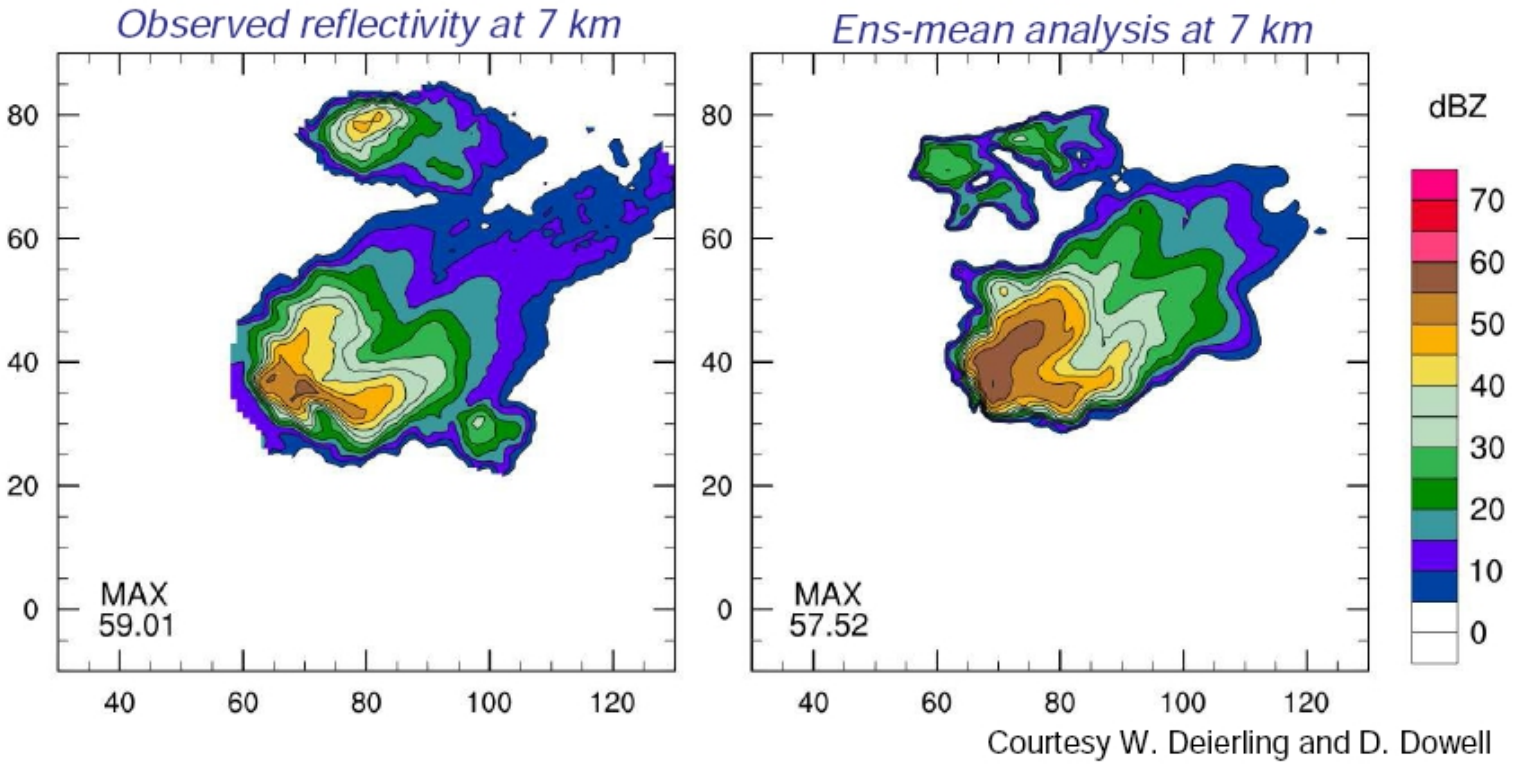
Others:

- NCAR: Use of EnKF (DART) for tropical cyclone forecasting, for convective scale assimilation and for assimilation of surface observations. (Talk by Snyder)
- JMA: Comparison of LETKF and 4D-Var for meso-scale model. Importance of lateral boundary perturbations in LETKF. (talk by Saito)

Radar Assimilation for Convective Storms (cont.)

Example: 5 July 2000 supercell

- Assimilate only radial velocity; reflectivity is independent observation.



Courtesy W. Deierling and D. Dowell

From Snyder (2011)

EPS Discussion

Multi-model, multi-physics

– Temporary solution?

- Yes, but will not be easily abandonned
- How strong is the requirement for a single-model ensemble from DA? (KENDA, Met Office, …)
- Can multi-physics be useful, even if it produces non-Gaussian distributions? Can DA live with non-Gaussian distributions?

- Fixes based on physics of the problem.

EPS Discussion

- **What should be the aim for representing model error in ensemble? Stochastic physics?**

– Additive inflation, statistical methods – is this a more objective method?

  - These are not flow-dependent. Is this a good thing?

- **Are the aims of ensemble prediction and DA in representing errors the same?**

EPS Discussion

- **How to best select a small number of members?**
  - COSMO-LEPS does better than a random choice (?)
  - Precip is difficult
  - Prefer fewer members for short-range ensemble, since resolution is more critical
- **We should rely on a global ensemble which is aimed at the short-range, for LBCs for a convective scale ensemble**

EPS Discussion

- **IC perturbations for a convective-scale model**
  - – Breeding, EDA, scale-selective ETKF – these are a good start, but we need more work
- **Bringing EPS and DA together**
  - – General agreement that this is a good idea
    - Redefine ensemble with DA aims
    - Try ensemble in DA, and adapt as necessary
- **Are there any things we should not perturb (such as the orography) ?**
  - – In principle happy with the idea of perturbing orography (multi-model ensembles)

DA Discussion: Treatment of model errors

- We need to consider variances as well as correlations of model errors
- We need to consider both errors associated with individual model processes and the integrated model error
  - Use of data assimilation techniques to diagnose the integrated model error
  - Use of field experiments to tune stochastic physics
- Do not forget model errors associated with numerics
- First thing to do is to diagnose which model errors we really have
- Find out which model errors really matters by sensitivity experiments
- For some physical processes we are well aware of the errors – these can be parametrized

Discussion:
Covariance filtering

- Two approaches : (1) Use raw covariances + Schur product filtering or (2) Spatial filtering of variances and , possibly, wavelet filtering of correlations
  - Approach (1) generally requires larger ensembles while (2) can live with smaller ensembles
  - Approach (1) may have advantages when it comes to the cloud resolving scale and complicated relations involving micro-physiscs (no consensus was reached) – which relations are important?
- Always remember that ensemble information has a low dimensionality

Discussion: Localization

- Localization length scales should be large enough to include structures of interest
  - Easy in specialized systems for e.g. convective scale
  - More difficult in general purpose NWP
- Adaptive estimation of localization length scale (Jeff Anderson is using sub-ensembles)
- Localization length scale related to observation density?
- Vertical localization and problems in the use of vertically integrated information (radiances)
- Use of dense observations and modelling of observation error correlations is a more fundamental problem
- Is Schur product fundamentally wrong??

Discussion:
Enforcing the large scales from the host model

The deterministic LBC problem:

- The numerical problem (we have tried hard with well posed solutions, but we still stick to ad hoc methods)
- Age of boundaries
- Miss-match of resolutions

Additional problems with ensembles:

- ETKF – use same linear combinations as for IC

Discussion:
Non-Gaussianity and non-linearities

- No complete consensus on the need of outer loops to treat weak non-linearities
- Examples of fixes to treat non-Gaussianity : 1. humidity transforms 2. Scatterormeter winds (pre-selection in EnsKF, during iterations in 4D-Var)
- Outer loops in EnsKF (Kalnay proposal) => use of observations twice without proper treatment. No concensus on degree of importance of thís problem.
- Simple smoothers using space-time correlations is another issue – They would also need outer loops to treat non-linearities
- Why does different deterministic filters treat outliers differently in strongly non-linear cases?
- Use of Stappers/Barkmeijer improved linearization?

Discussion:
Should EPS mimic DA system?

Almost consensus on ONE joint system.

- Special tuning for special phenomena?
- Not ready to skip singular vectors yet!

Discussion:
Choice of data assimilation method.

- The question is still open on the ultimate solution: VAR – EnsKF – hybrids
- How to optimize the hybrid? (Optimize the use of all information in the ensemble and get rid of the noise)

Thank you.

Open Issues

-Model error

– Temporary solution: additive inflation, multi-physics
– Aim: stochastic physics
– Objective techniques for model error estimation

• Covariance filtering

– Spatial filtering of variance
– Wavelet filtering of correlation and balances
– Is it enough hybrid incremetal formulation?

• Localisation

– What determines the proper lenght scale
– Problem with ETKF?

Open Issues

- Enforcing large scale from host model
  - surface
  - IC&LBC how to do together in appropriate way
- Non-gaussianity and non-linearity
  - Of obs operator
  - Fixes based on physics of the problem
  - Outer loop
- The ensemble system should mimic the DA system