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Krakow

Large Scale Error Constraint
In The
HIRLAM Data-Assimilation System

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Motivation

- Constraints in data-assimilation:
  - The model's internal balances J_b
  - Observations J_o

- Regional models:
  - Coupled to a global model: boundaries
  - Global model information not taken into account during assimilation

- Global models: high quality analysis!

- HIRLAM
  - Large Scale Mixing, LSM
    Reruns from ECMWF analysis, updating first guess

- Instead: Include ECMWF information in assimilation!

- Related work done with ALADIN at Météo-France

Constrain Vorticity

- Begin as "simple" as possible:
  - Vorticity only
  - Univariate

$$J(\boldsymbol{x}) = J_b + J_o + J_k$$

$$J_k = \frac{1}{2}\left(\zeta - \zeta_{ls}\right)^T \boldsymbol{B}_{ls}^{-1}\left(\zeta - \zeta_{ls}\right)$$

NMC statistics from ECMWF forecasts, interpolated to HIRLAM RCR geometry

Vorticity, model state

Short forecast, ECMWF

Vorticity and Statistical Balance

J is a function of a control-vector, χ !

Model state

$$\delta\hat{\boldsymbol{x}} = \begin{pmatrix} \delta\hat{\boldsymbol{u}} \\ \delta\hat{\boldsymbol{v}} \\ \delta\hat{\boldsymbol{T}} \\ \delta\hat{\boldsymbol{q}} \\ \delta ln\hat{\boldsymbol{p}}_s \end{pmatrix}$$

Statistical balance

$$\xleftarrow[U^{-1}]{}$$

Control-vector

$$\chi = \begin{pmatrix} \hat{\zeta} \\ \hat{\boldsymbol{\eta}}_u \\ \hat{\boldsymbol{T}}_u \\ \hat{\boldsymbol{q}}_u \\ ln\hat{\boldsymbol{p}}_{su} \end{pmatrix}$$

Variables statistically independent

Error statistics from HIRLAM and ECMWF used to express J_k as a function of Control-vector ζ directly

Projections Affecting Vorticity

These are needed from both HIRLAM and ECMWF

Model state

$$\delta\hat{\varsigma} = \underbrace{\boxed{\sigma^{1/2}\ \lambda^{1/2}\ V\ \gamma^{1/2}}}_{U^{-1}}\hat{\varsigma}$$

Control-vector

σ= Error variances. 1 value per vertical level

λ= Horizontal spectral density. Diagonal matrix

V = Vertical eigenvectors

γ = Vertical eigenvalues. Diagonal matrix.

σ from ECMWF: Scalefactor applied – Tune J_k weight

V from ECMWF: Project onto first 6 modes

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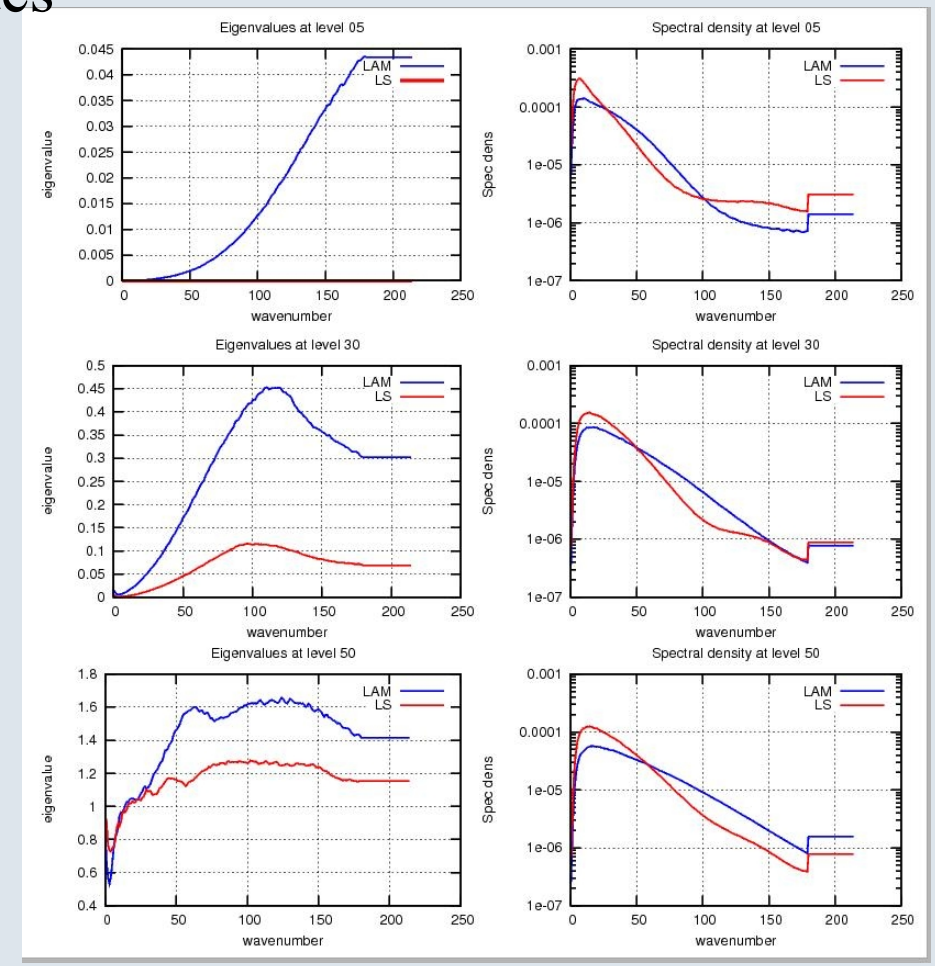
Some Error Statistics

γ
Vertical eigenvalues

λ
Horizontal spectral density



Functionality Test, 3DVAR

- Cost-function: $J = J_b + J_k$
- RCR (reference) HIRLAM domain
- Three fields:
  - x_b HIRLAM 1:st guess +06h forecast
  - x_a The resulting analysis
  - x_{ls} +06h forecast from ECMWF
- Calculate differences:
  - RMS(x_b-x_{ls})
  - RMS(x_a-x_{ls})
- ζ, u, v, T, q

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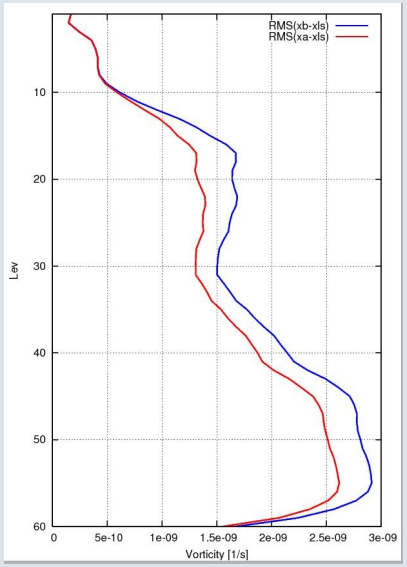
Functionality Test, 3DVAR

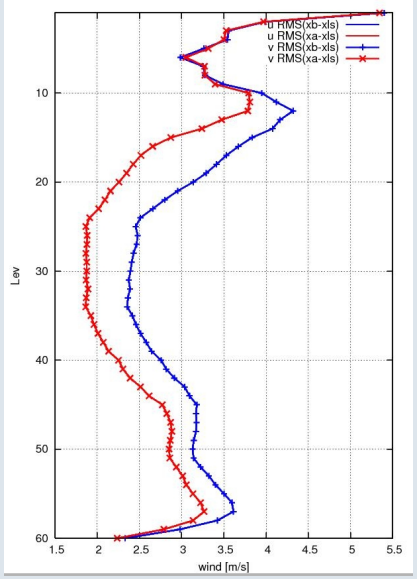
RMS Differences

$RMS(x_b-x_{ls})$ $RMS(x_a-x_{ls})$

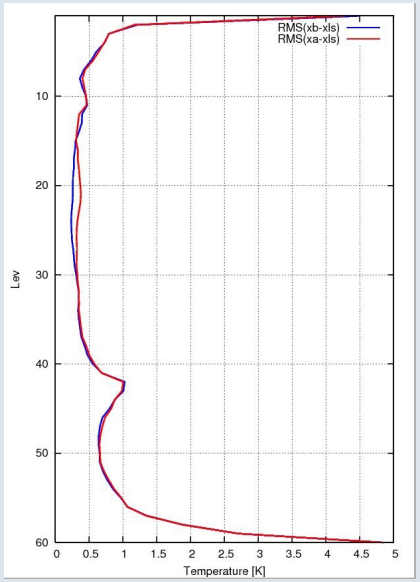
vorticity



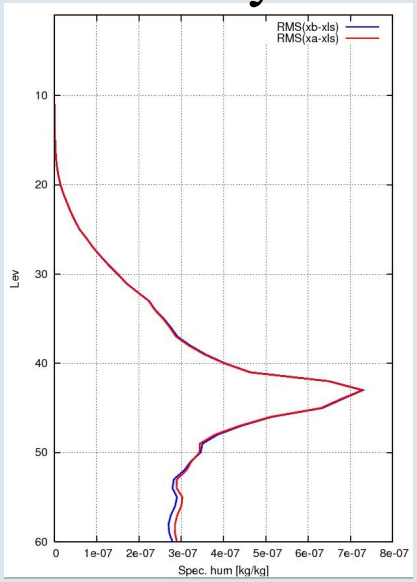
Wind



Temperature



Specific humidity



Forecast Impact
4DVAR, With Observations

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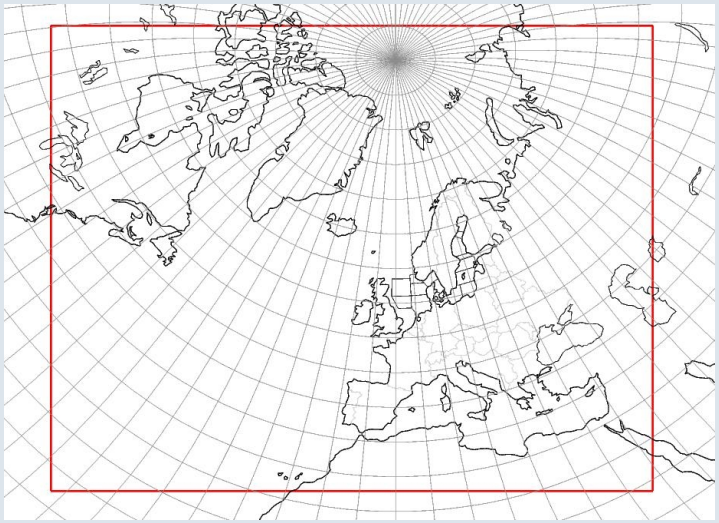
- 33 days: 24:th jan 2009 to 25:th feb 2009



- RCR (reference) HIRLAM domain
- 15km horizontal resolution
- 60 vertical levels
- 2 outer loops
  - 90km resolution in 1:st loop (ILRES=6)
  - 45km resolution in 2:nd loop (ILRES=3)
- Conventional observations only

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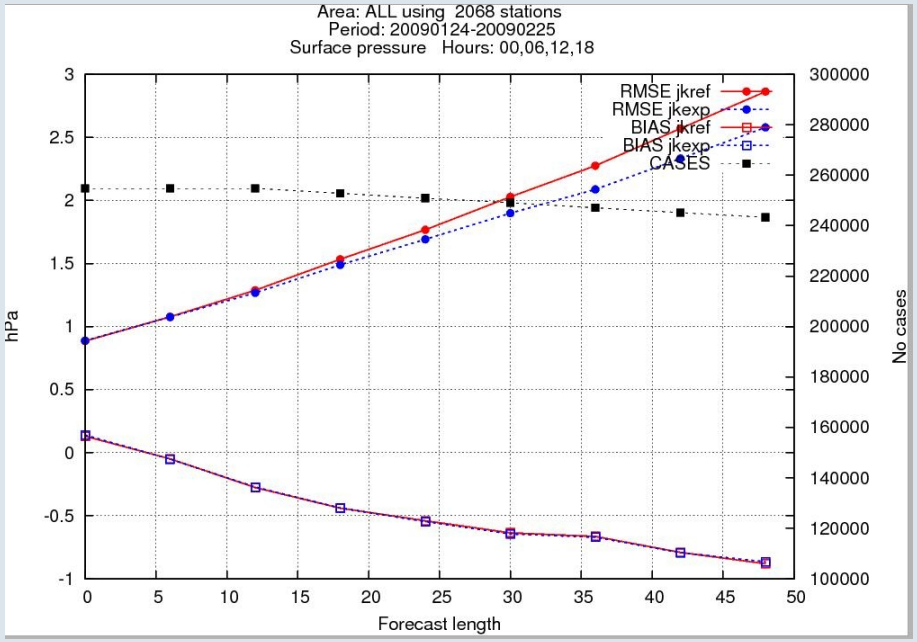
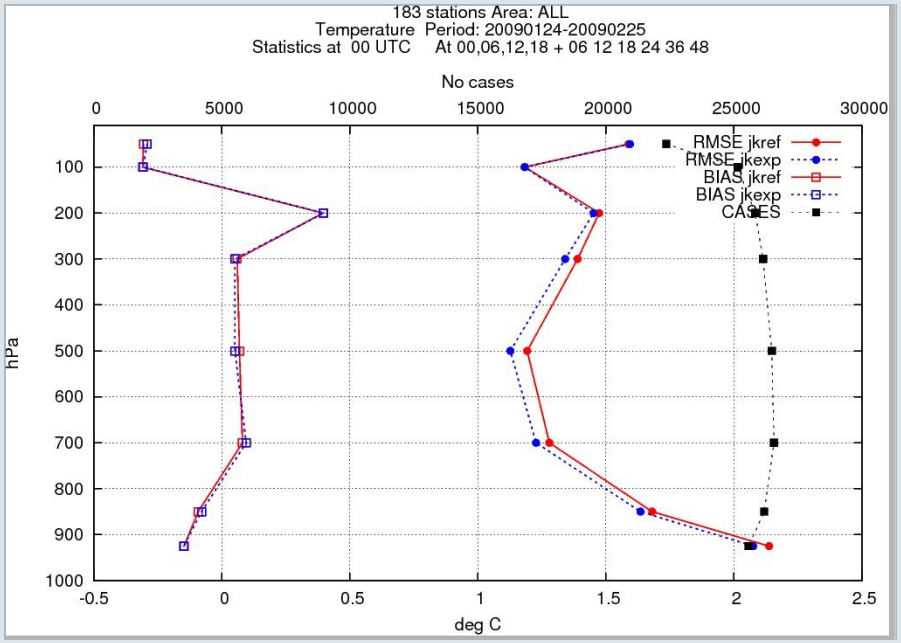
Forecast Impact
Verification Against Observations

- Upper air, MSLP: Very good
- Surface parameters: Unchanged

MSLP



Temperature



End Slide
Some Pros and Cons

- Difficult to tune Jk weight, scalefactor

  Need to run analyses and look at the behaviour

- Jk weight changes with resolution

  Need a horizontal truncation also

+ Good impact on forecasts

+ Good idea with great potential

  Pick the features you are interested in from the coupled model