SMHI

UERRA
Uncertainties in Ensemble of Regional ReAnalyses

Seventh International WMO Symposium on Data Assimilation

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The UERRA Cloud Cover Analysis Study: An Extension

S

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Structure of the talk

1. How this has started ...

2. Space-scale dependent decomposition

3. Brand Ensemble

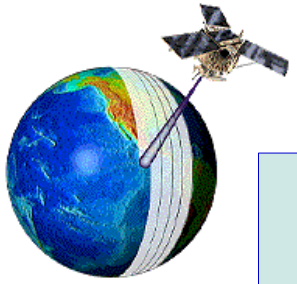
4. Why Low Clouds Cover in Summer Afternoon?

5. Scales of variability in high-resolution ensemble

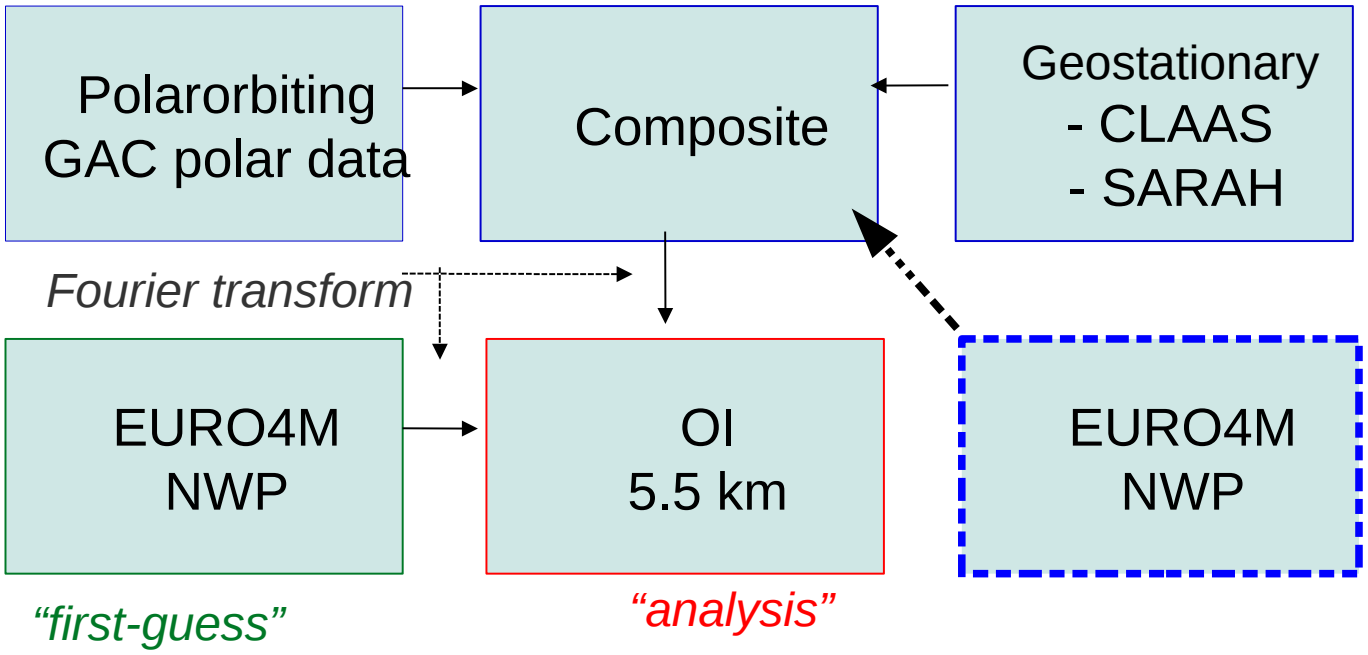
6. Lessons learned from this study

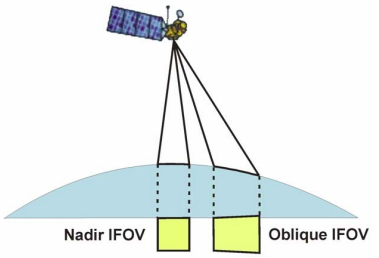
How this have started

UERRA : cloud cover fraction analysis



"super-observations" (so)





Horizontal resolution: 5.5km

Time resolution: every hour (1982-2013)

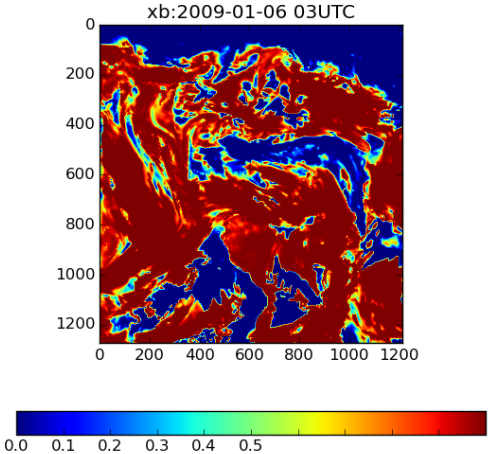
$$CCF = \frac{\sum w_i \, CM_i}{\sum w_i}$$

Observations: superobservations of cloud mask/cloud probability from AVHRR and SEVIRI

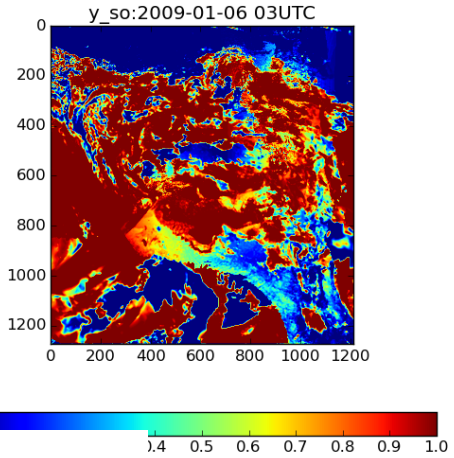
First guess: HIRLAM CCF reanalysis 22 km

"The kitchen"

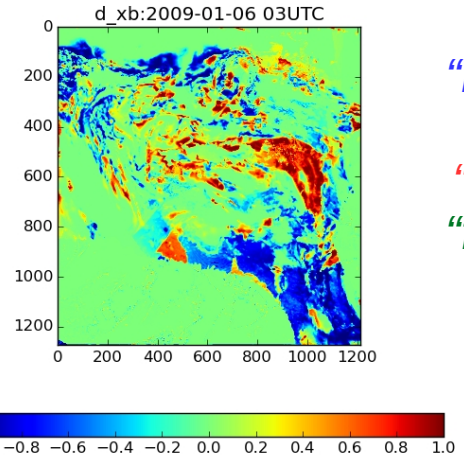
"first-guess"



"observations"



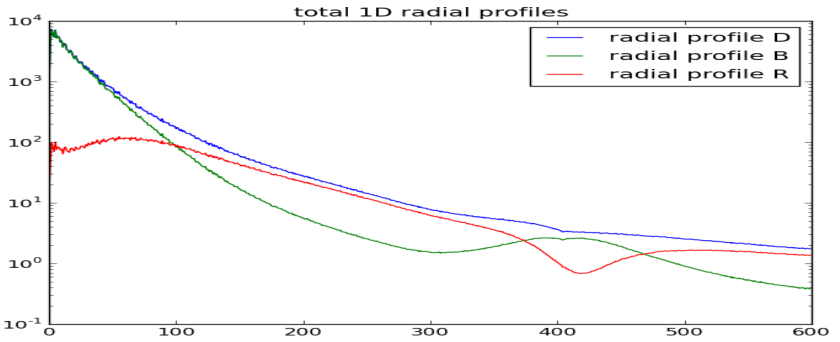
"innovations"



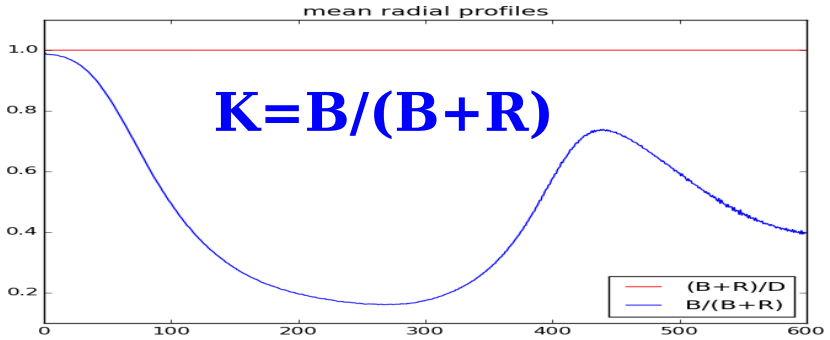
"innovations" =

"observations" - "first-guess"

Spectral Density



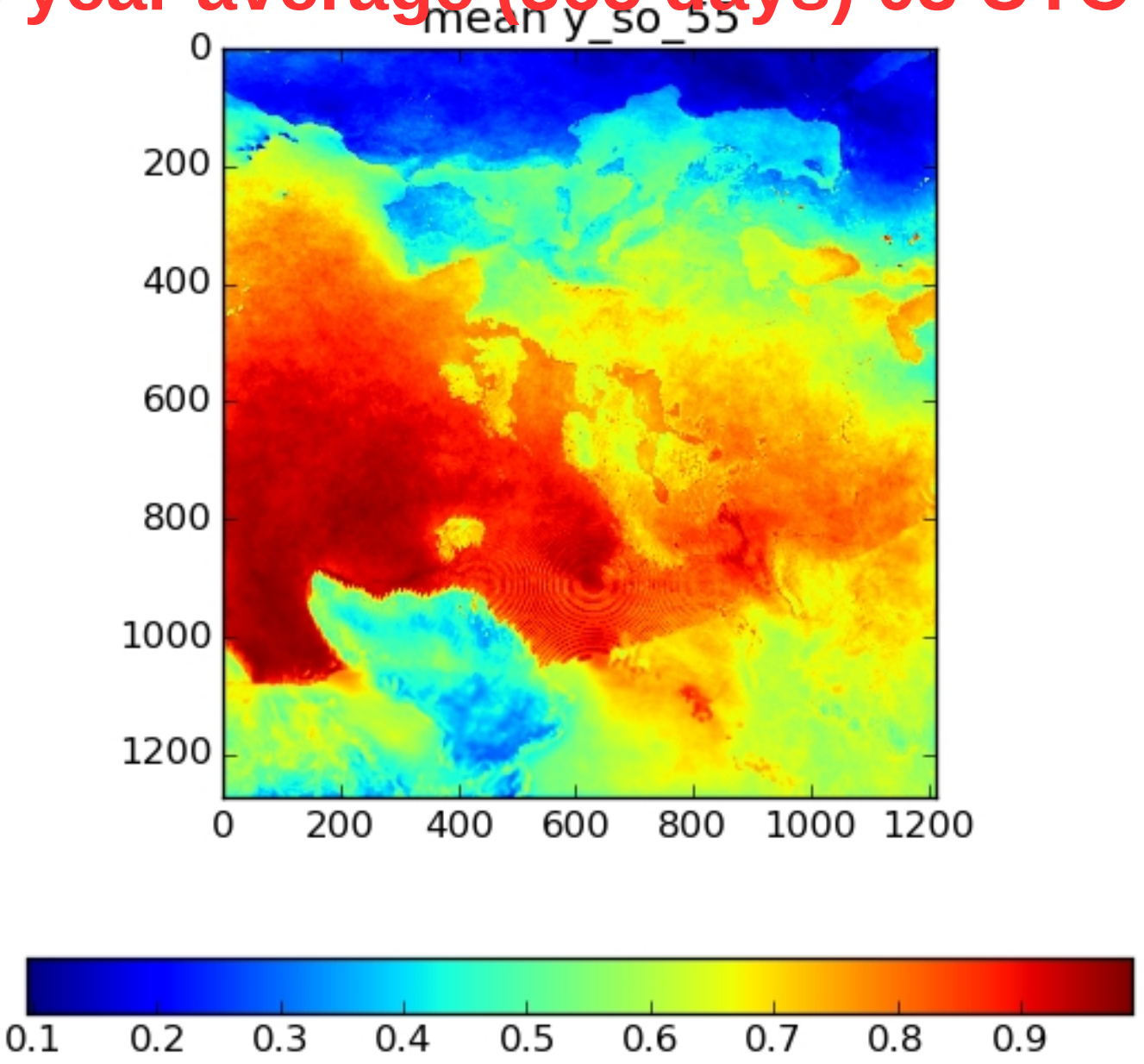
$D=d^{so}_{b}{}^{T}d^{so}_{b}, R=d^{so}_{a}{}^{T}d^{so}_{b}, B=d^{a}_{b}{}^{T}d^{so}_{b}$



Kalman Gain

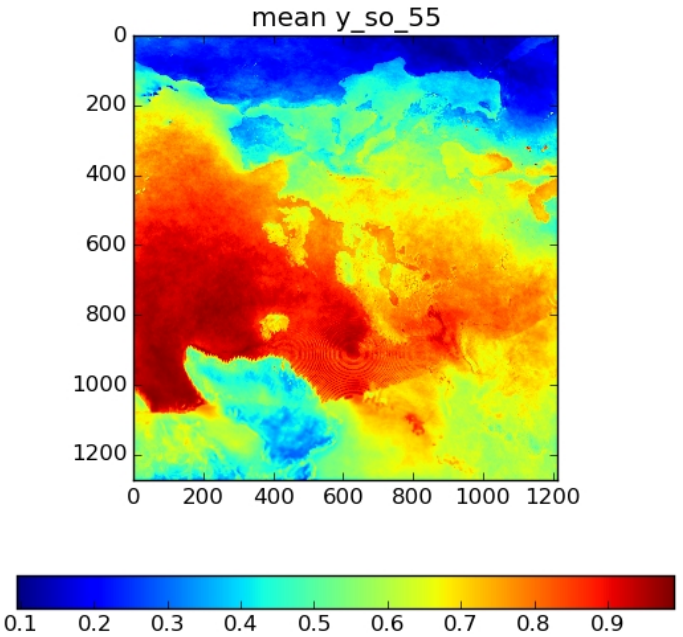
$x_a = x_b + dx_a;\ dx_a = \mathbf{K}(y_{so} - x_b) = Kd^{so}_{b}$

One year average (365 days) 03 UTC

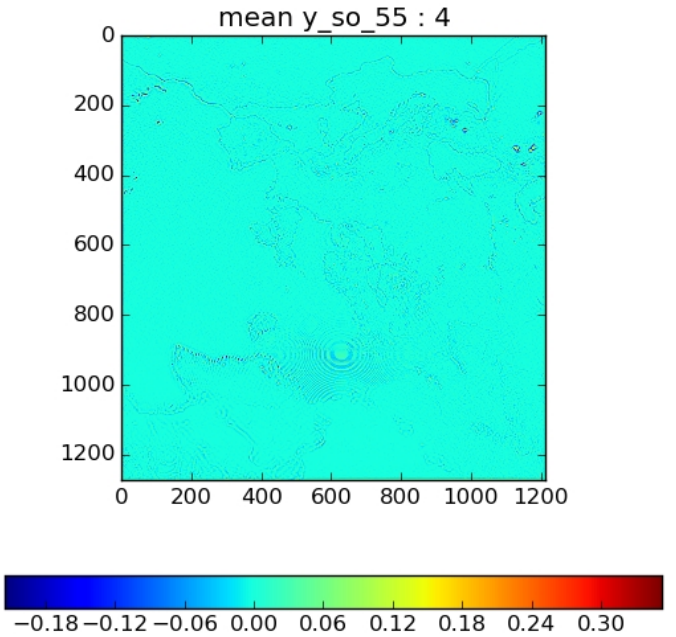


Cloud Cover Mask 2009

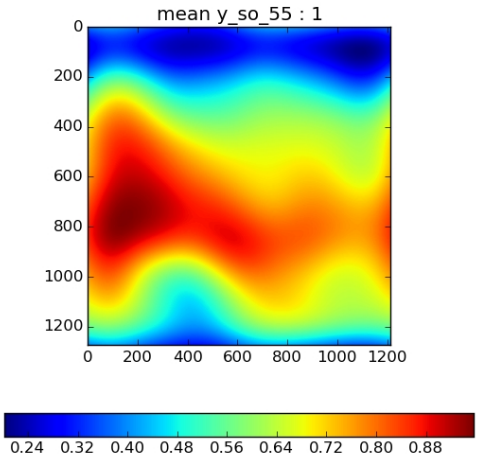
Space-Scale Decomposition



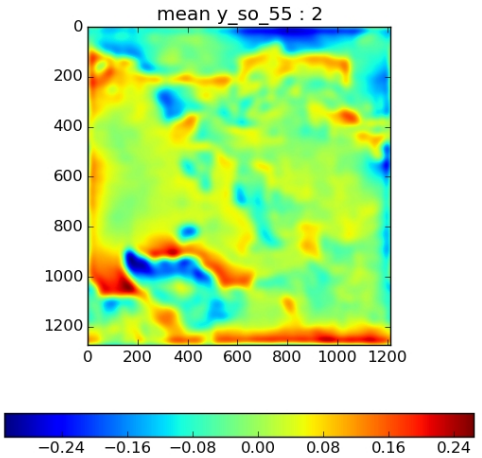
Cloud Cover Mask



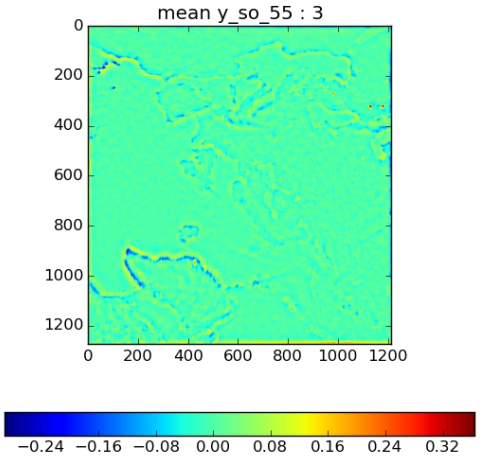
Scale 4



Scale 1



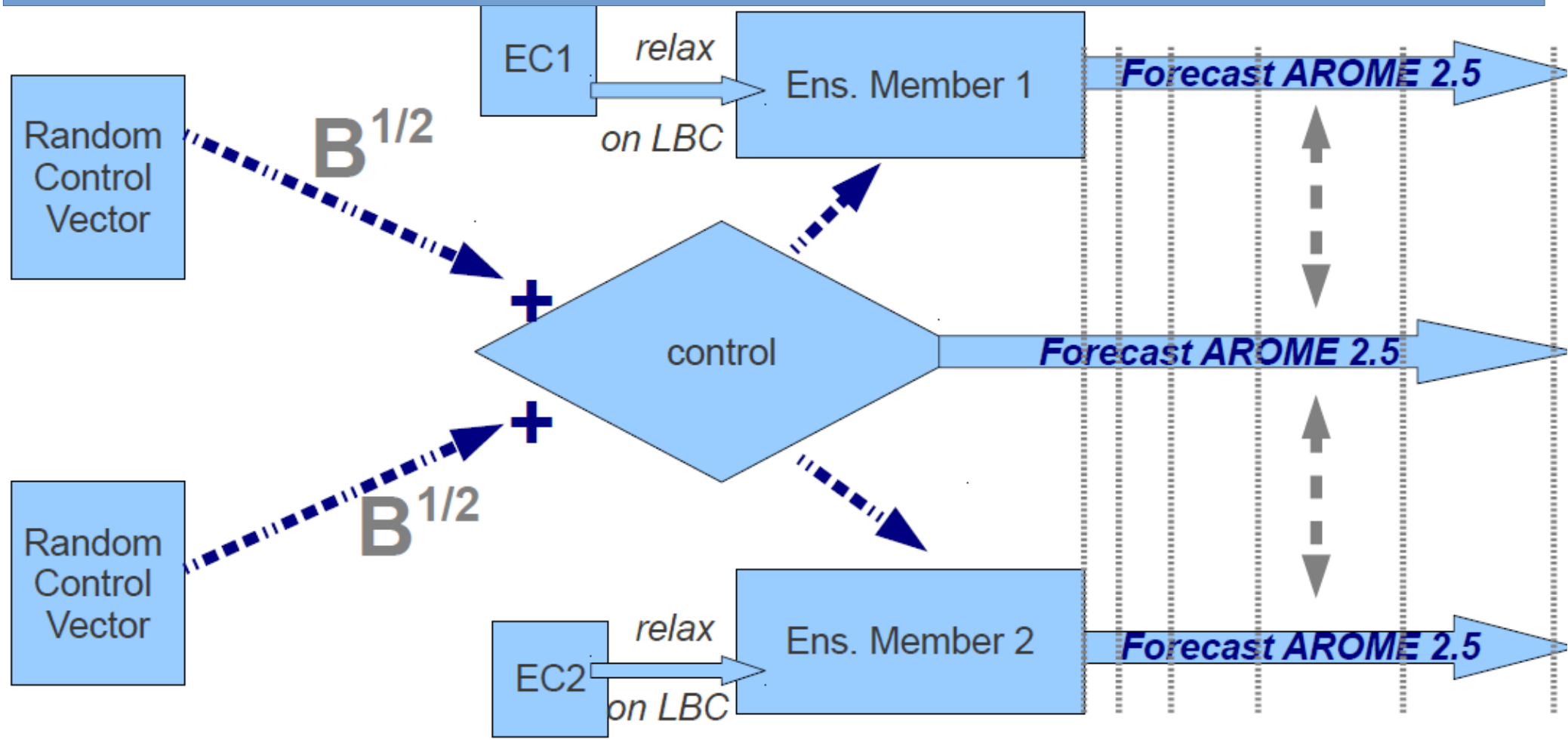
Scale 2



Scale 3

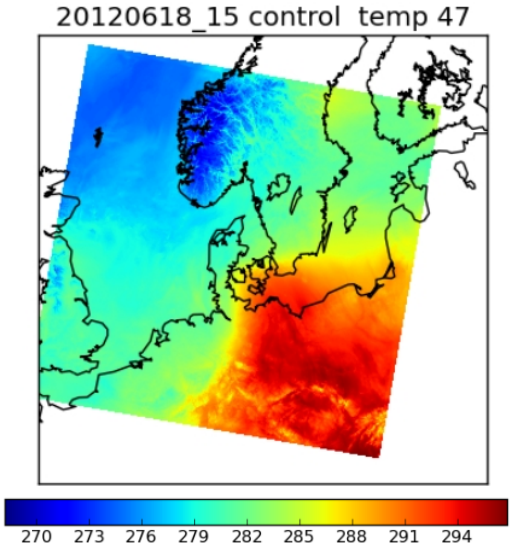
“Brand” perturbations

10 members+control (2012061203 - 2012062718)

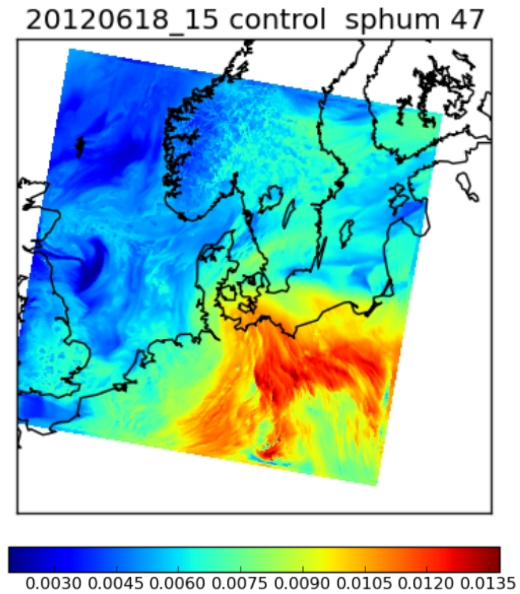


The Scheme: generation of perturbations with the structure of B-matrix covariance.

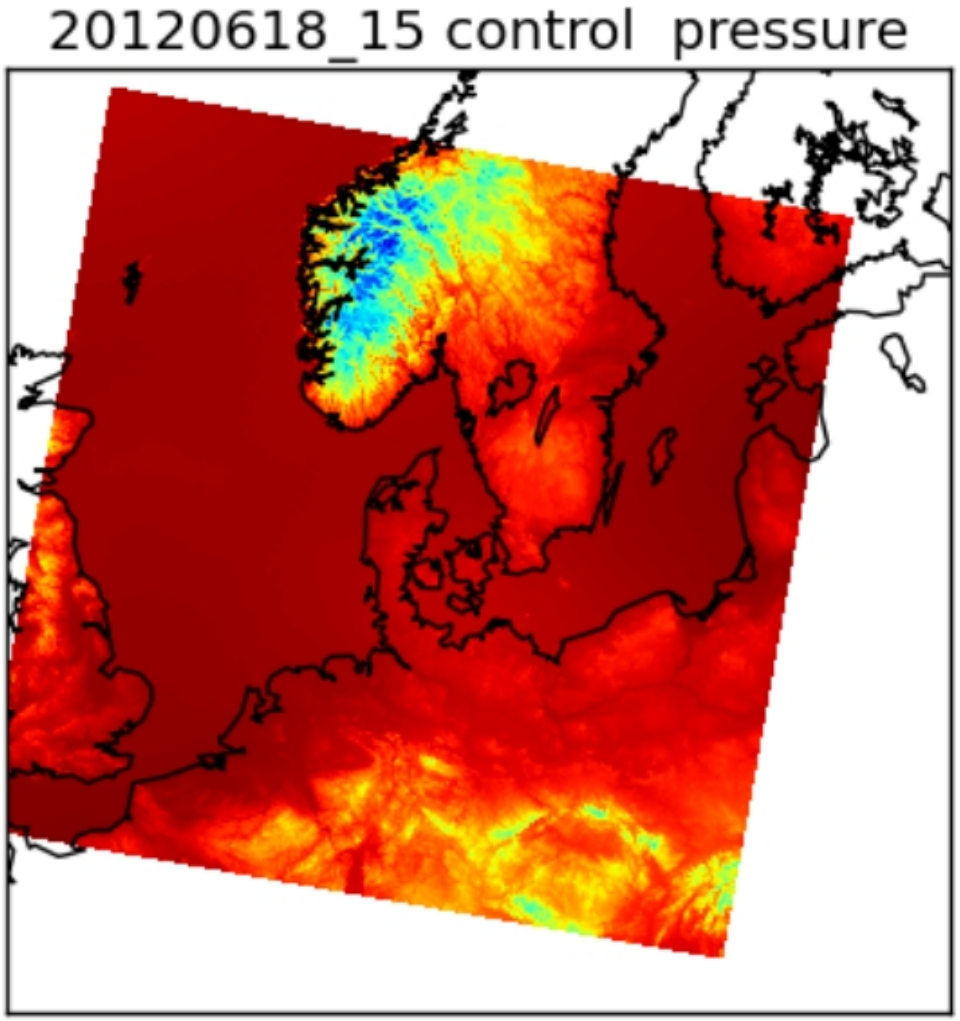
Domain and Flow situation



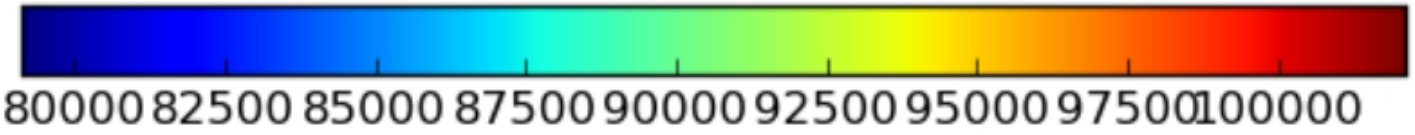
Temperature 850hPa



Specific humidity 850hPa

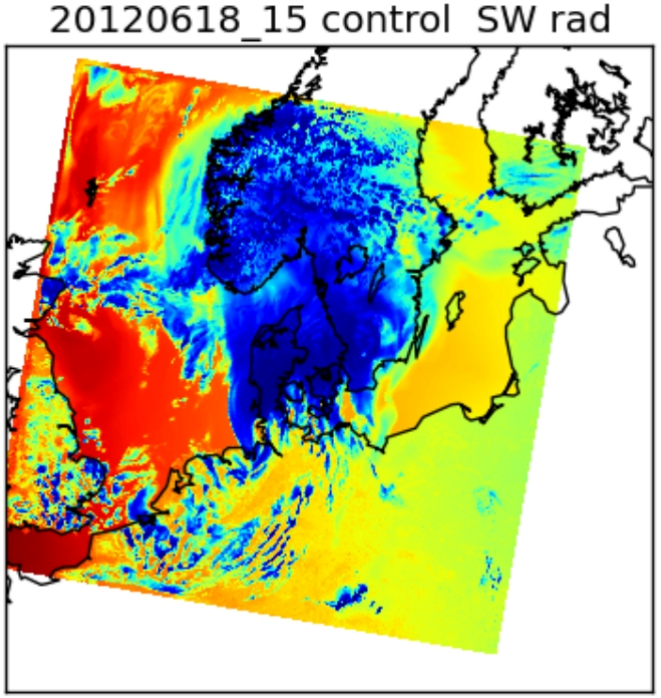


Surface pressure

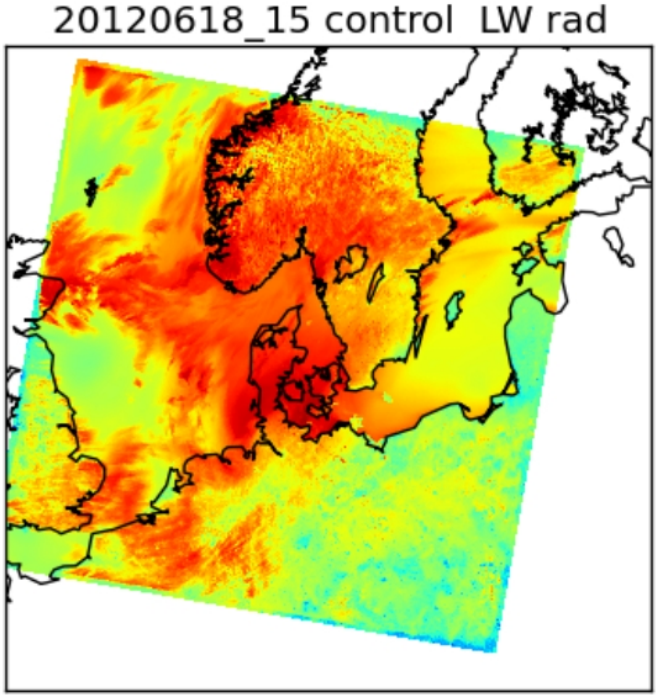


Why Cloud Cover ?

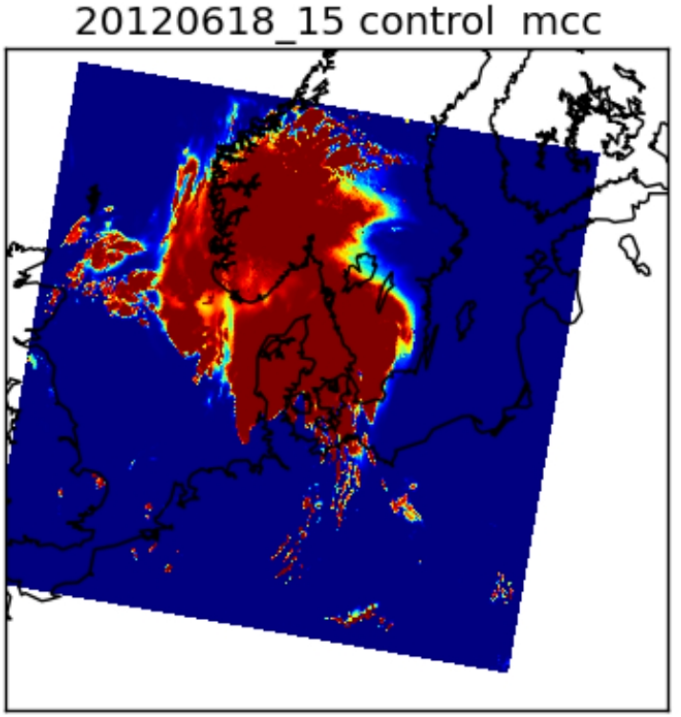
Short waves radiation flux



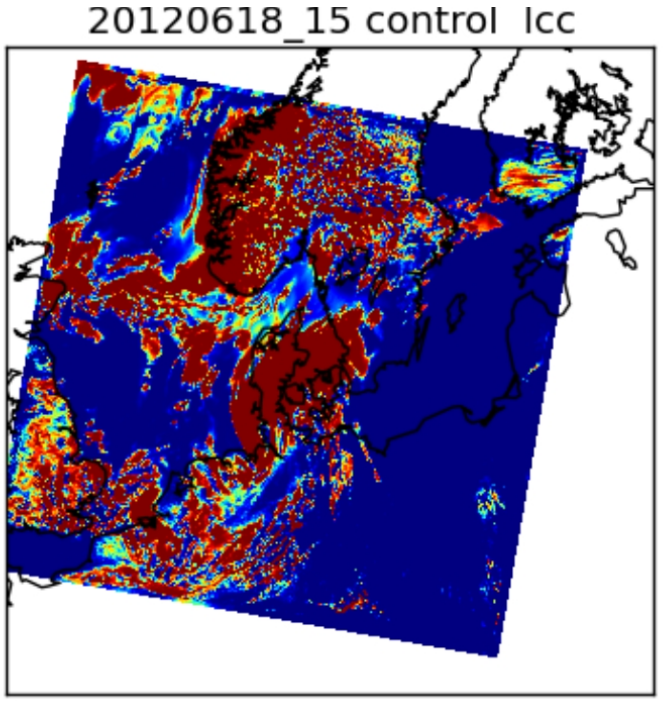
Long waves radiation flux



Parameterization



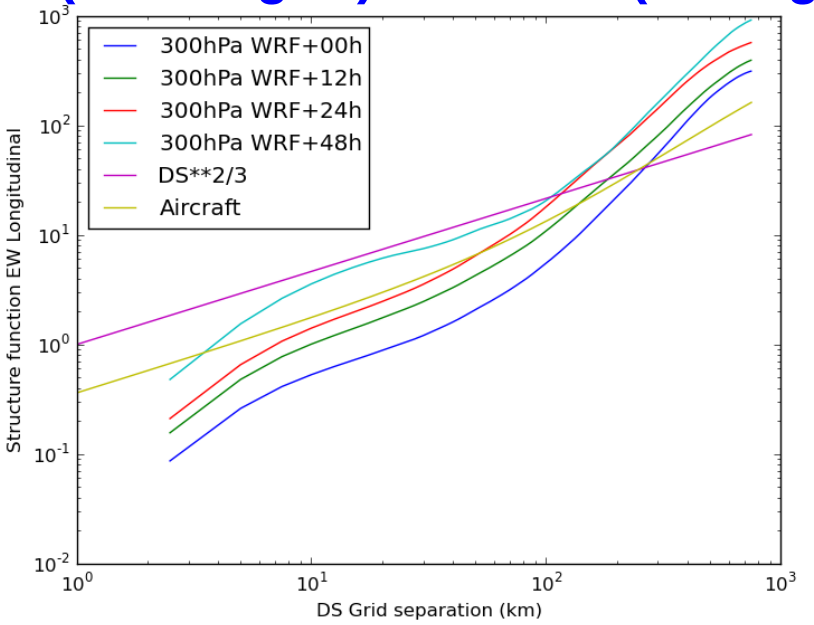
Medium Cloud Cover

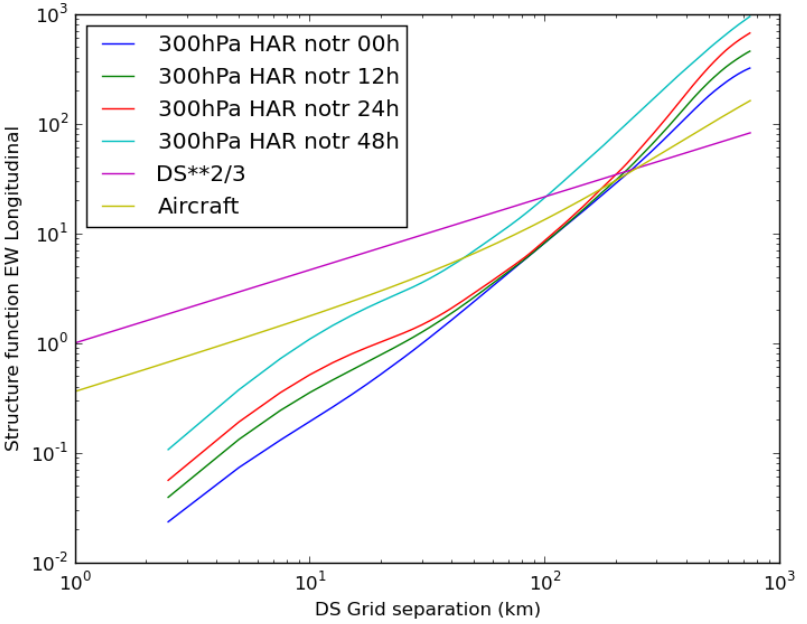


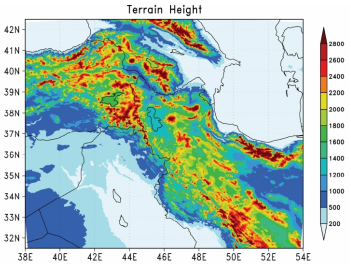
Low Cloud Cover

Why Low Clouds Cover In Summer Afternoon?

Structure functions ("KE spectra") of WRF and HARMONIE (2.5 km grid) over Iran (average of 2 cases)

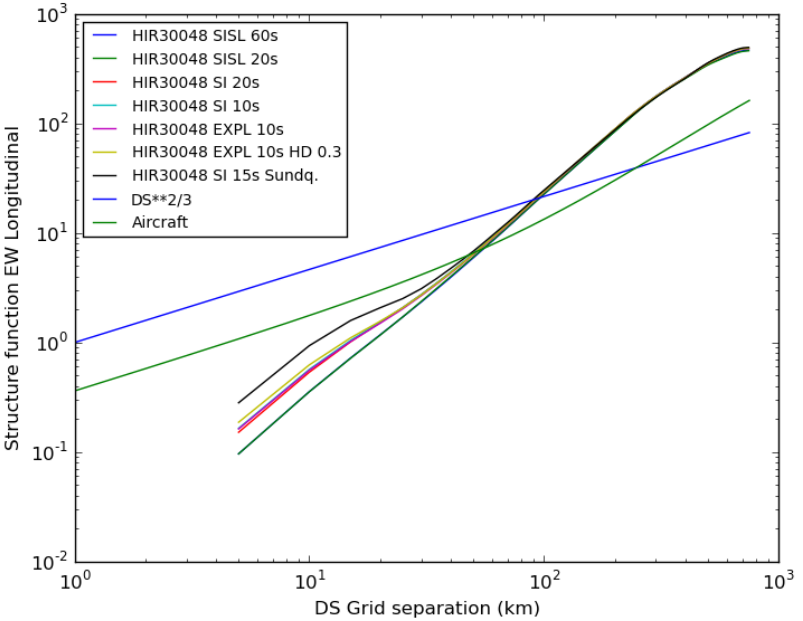




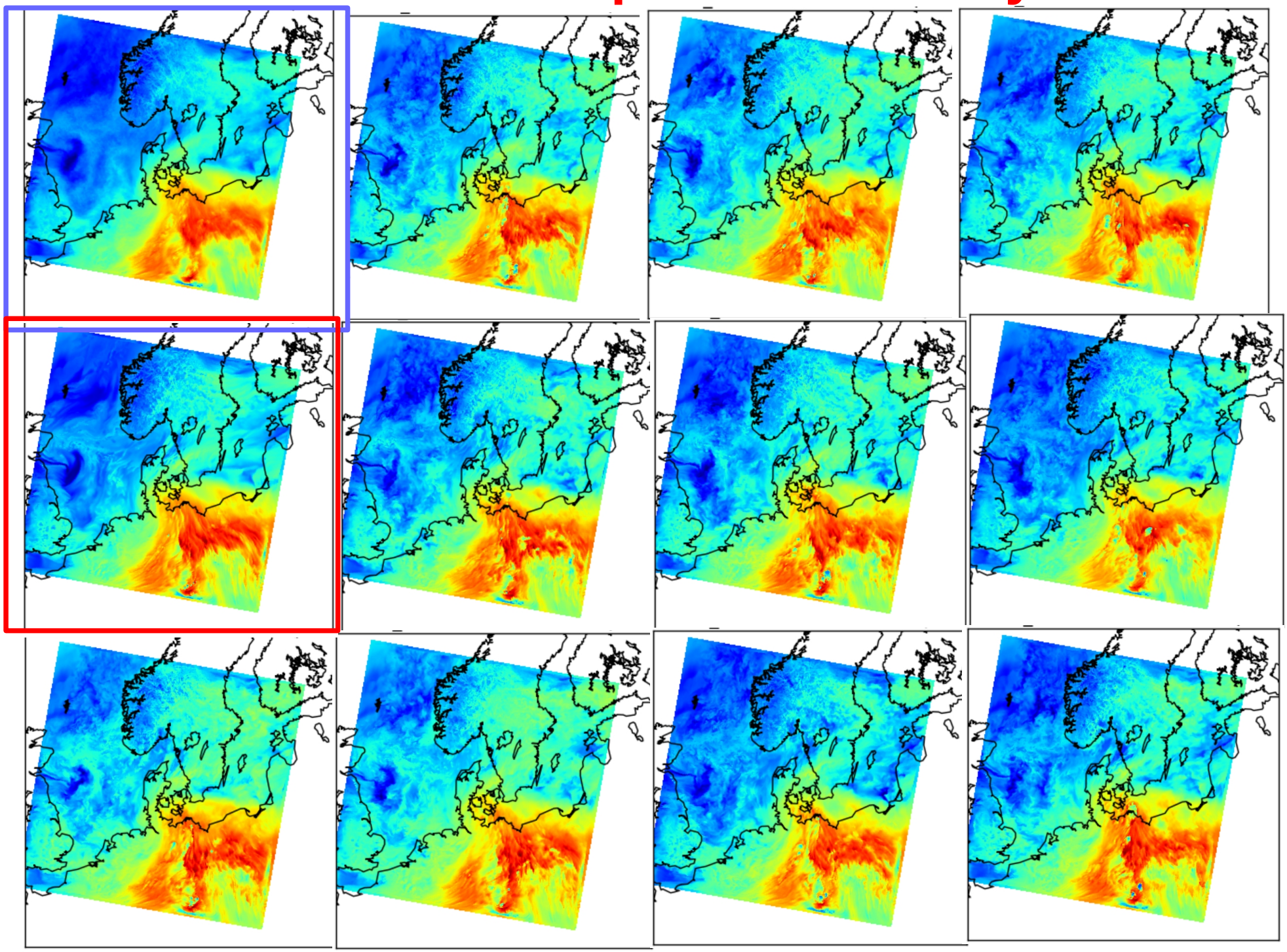


Sensitivity experiments with HIRLAM over the same domain (5 km grid) – single case:

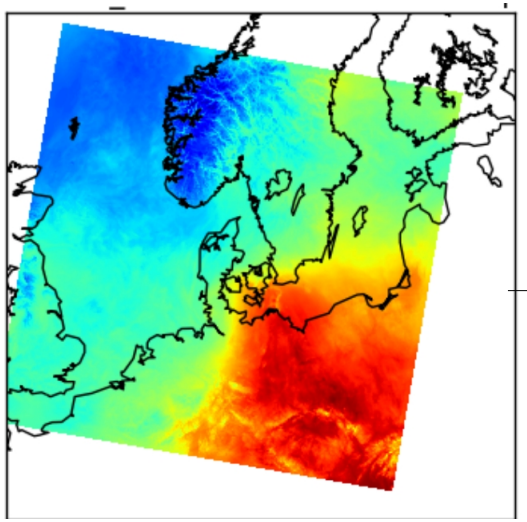
SISL (Semi-Implicit Semi-Langrangian) 60s
SISL 20s
SI 20s quadratic grid
SI 10s quadratic grid
Explicit 10s quadratic grid
Explicit 10s quadratic grid; reduced HD (0.1)
SI 15s quadratic grid Sundquist scheme



Ensemble of specific humidity 850 hPa

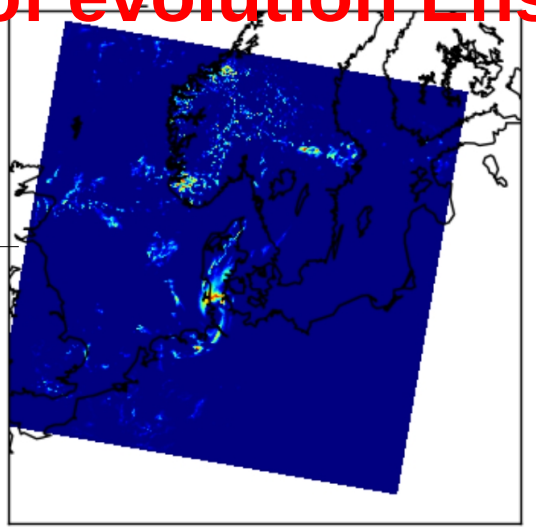


Dynamical consistency of evolution Ensemble member 4



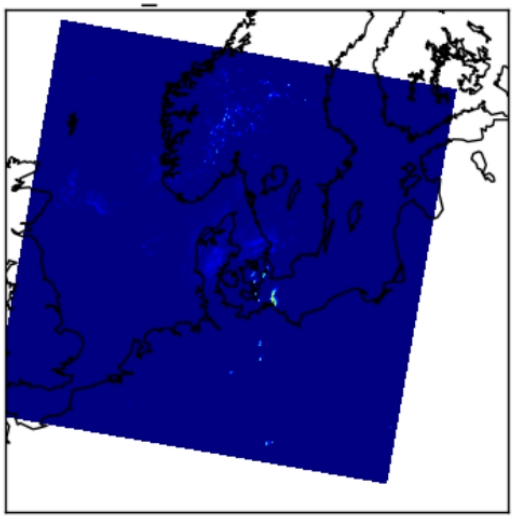
272 276 280 284 288 292 296

Temperature 850hPa



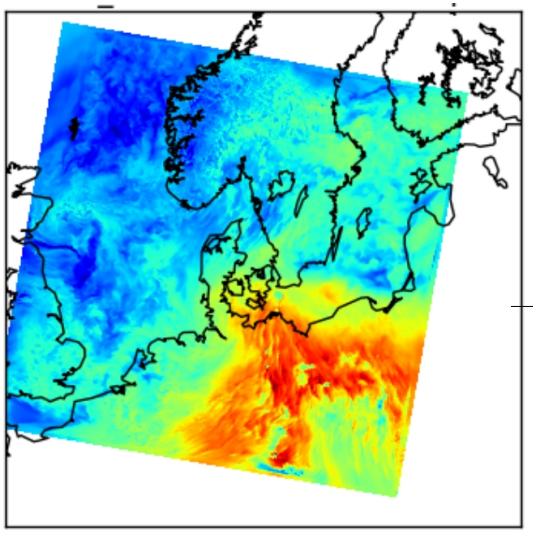
0.0000 0.0001 0.0002 0.0003 0.0004 0.0005 0.0006 0.0007 0.0008 0.0009

Cloud water 850hPa



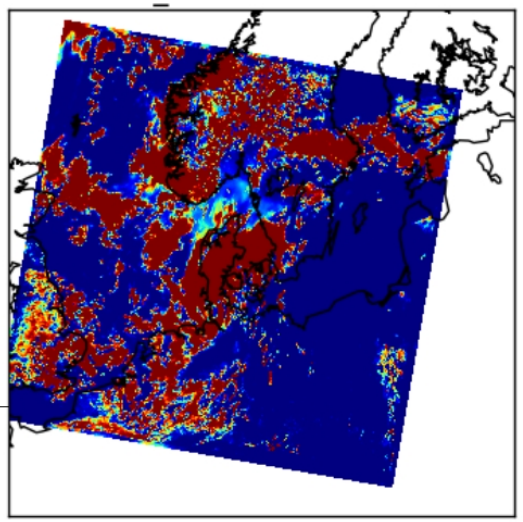
0.0000 0.0025 0.0050 0.0075 0.0100 0.0125 0.0150 0.0175 0.0200

3h accumulated precipitation



0.0015 0.0030 0.0045 0.0060 0.0075 0.0090 0.0105 0.0120 0.0135

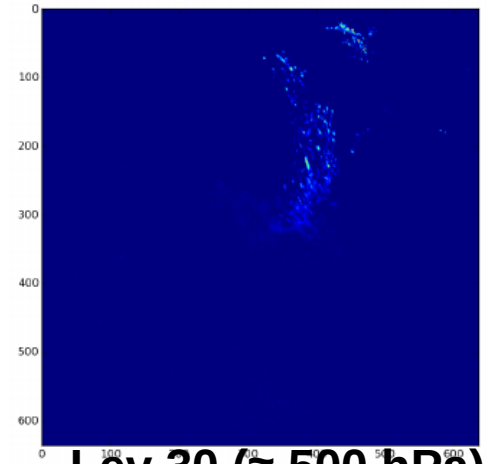
Specific Humidity 850hPa



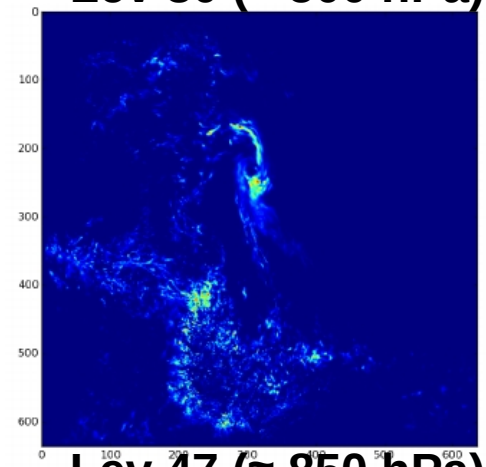
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Low Cloud Cover

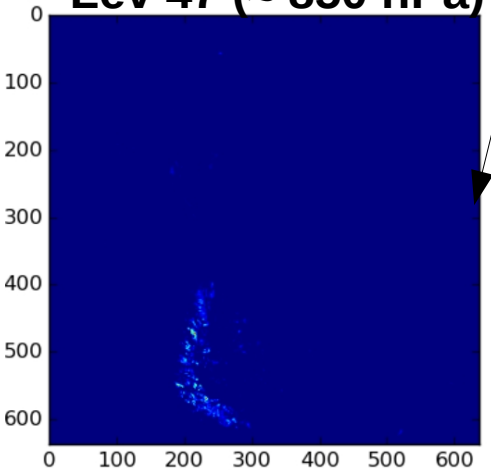
Advantages and Limitations



Lev 30 (≈ 500 hPa)



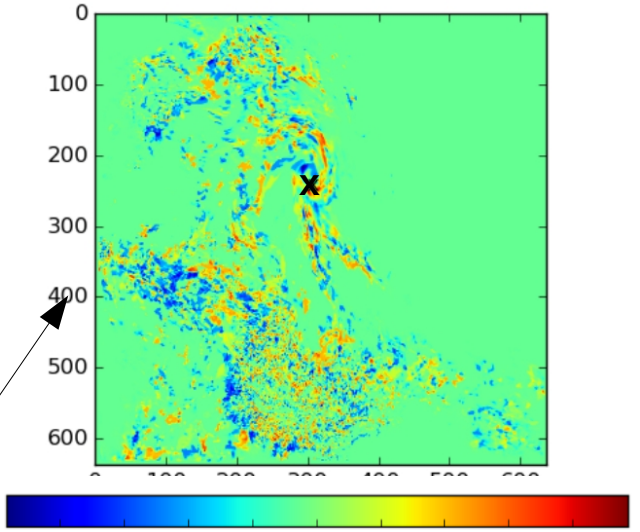
Lev 47 (≈ 850 hPa)



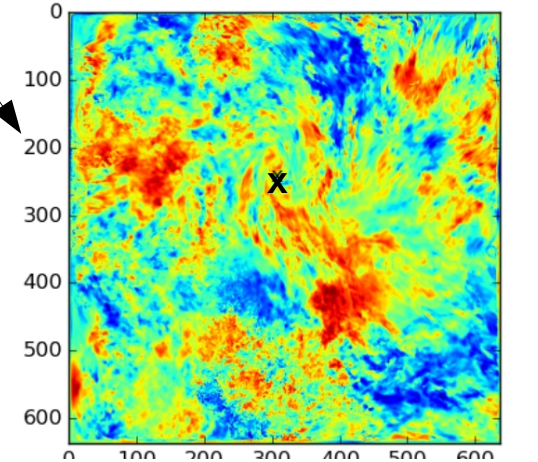
Lev 60 (≈ 900 hPa)

Variance of Cloud Water

Correlations of Cloud Water at Lev 47 (≈850 hPa) "x" location



...with CW Lev 47



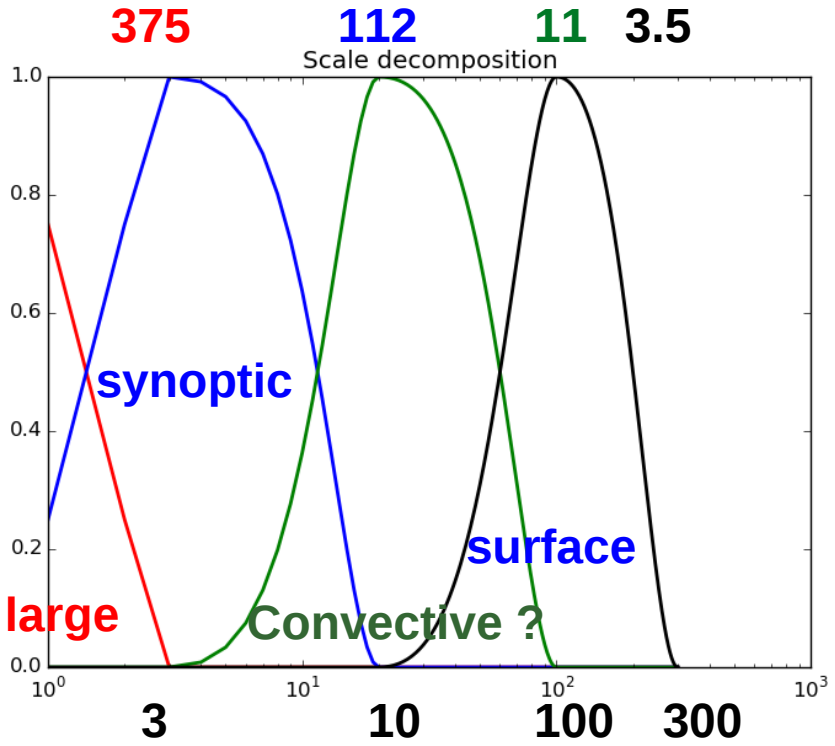
...with T Lev 47

+ Physically meaningful structures

- Sampling noise in particular for correlations with control variables

(Upside-down projection ...)

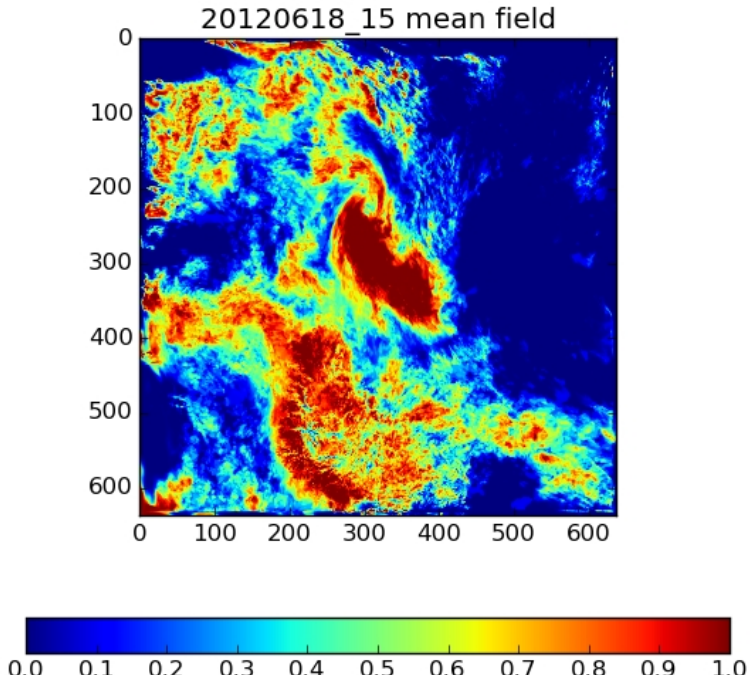
Ensemble characteristics



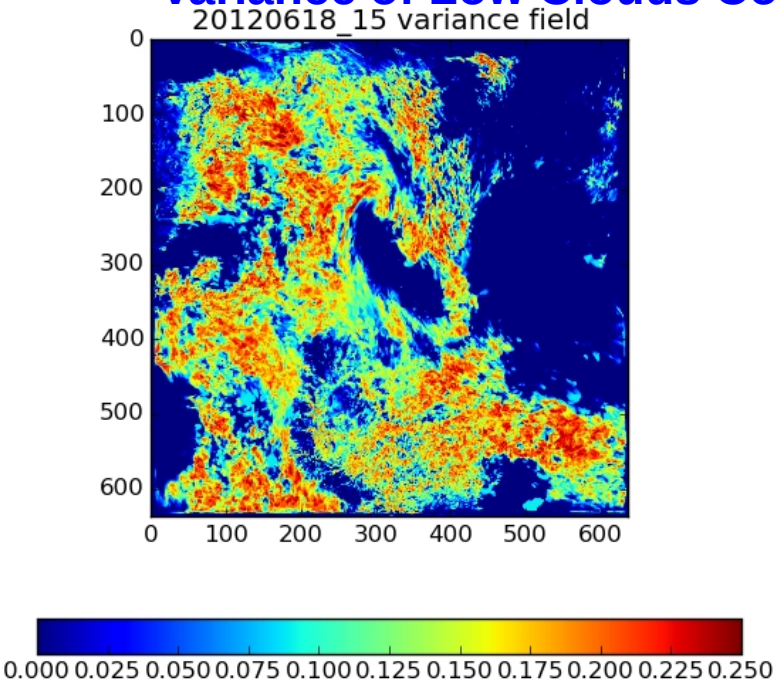
Space-Scale Dependent Decomposition

Domain: 637x637 grid-points@2.5km

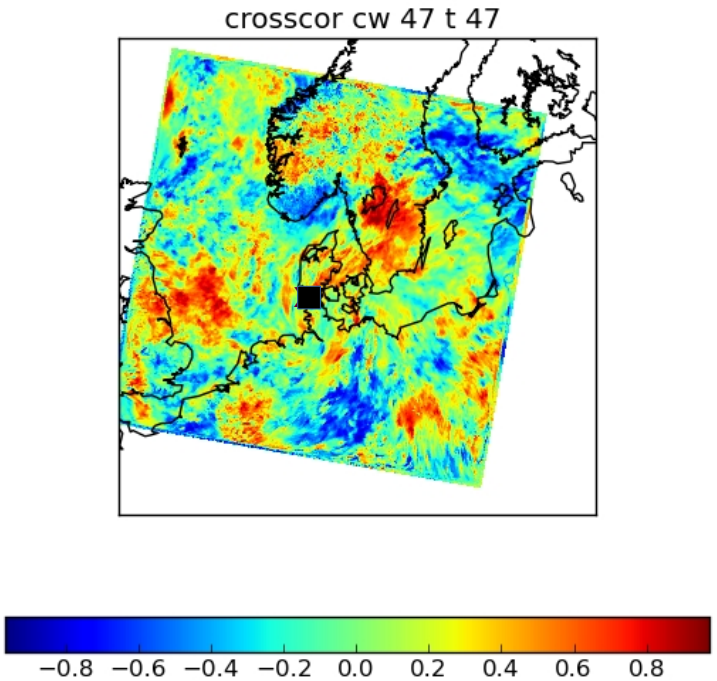
Mean Low Clouds Cover

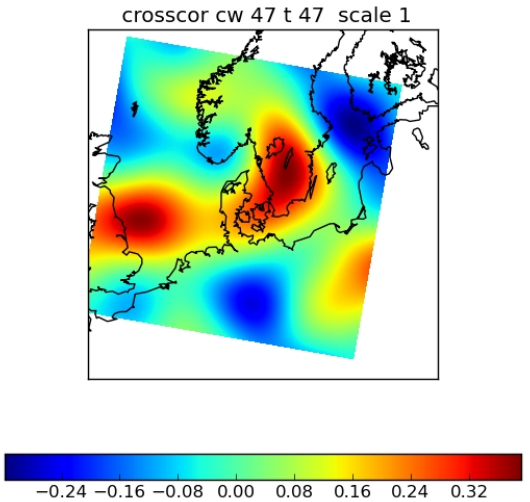


Variance of Low Clouds Cover

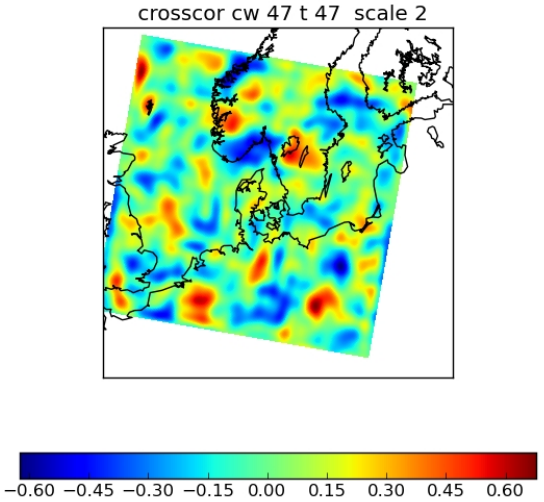


Space-scale dependent decomposition I



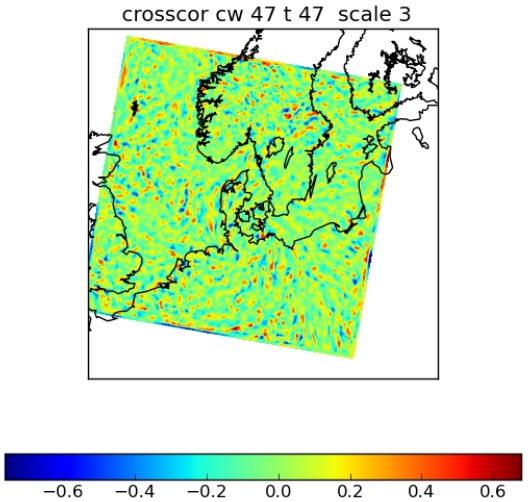


Scale 1

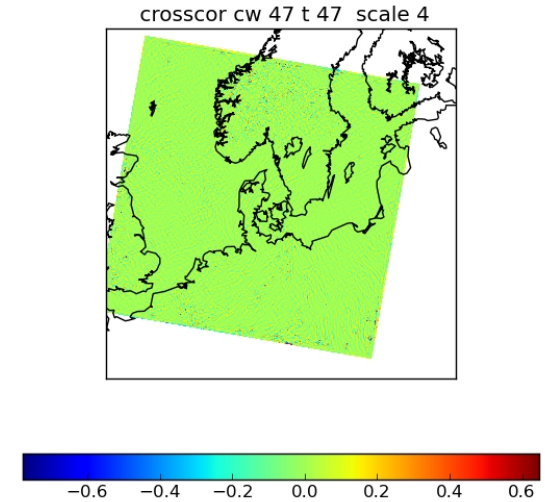


Scale 2

Cross-correlation between Cloud Water (“black box”) and Temperature field (Model Level 47) ≈ 850 hPa

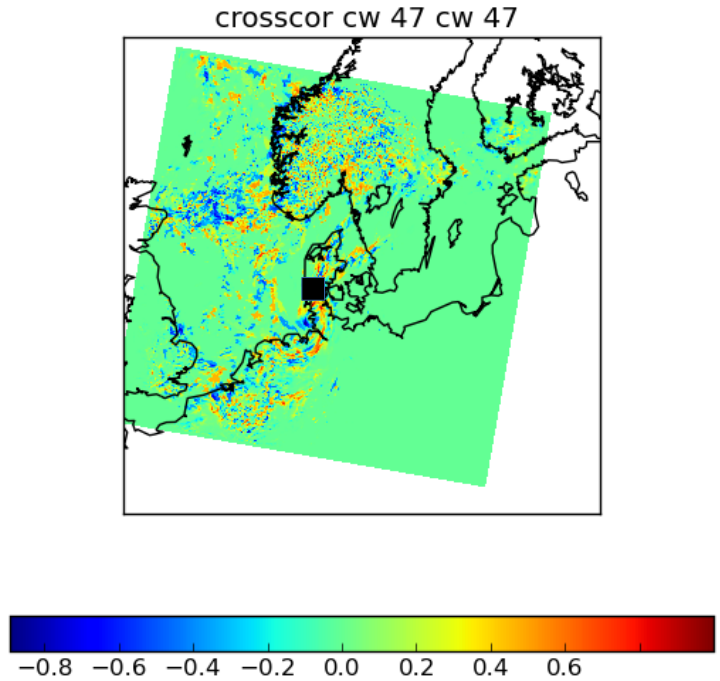


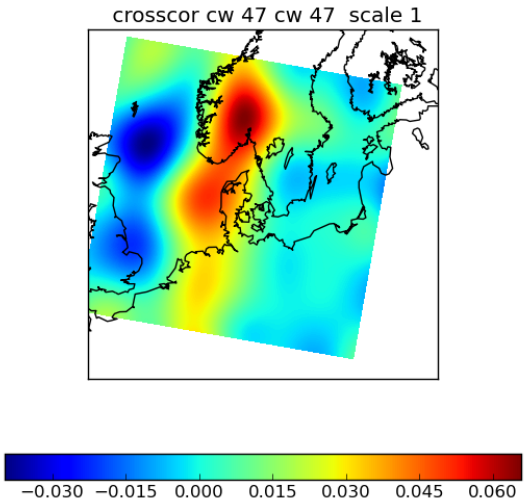
Scale 3



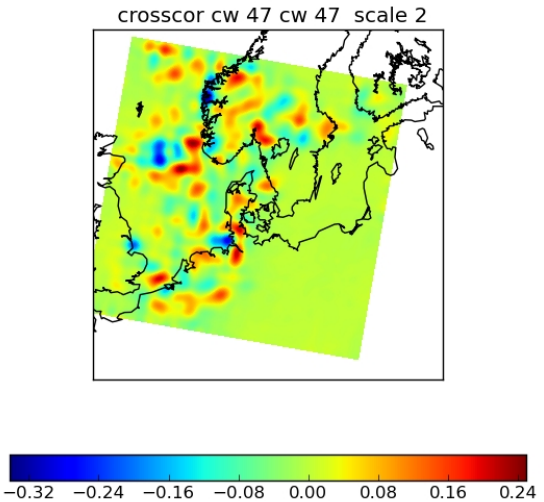
Scale 4

Space-scale dependent decomposition II



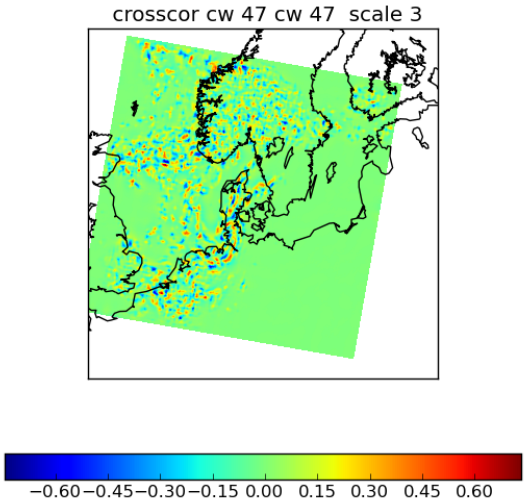


Scale 1

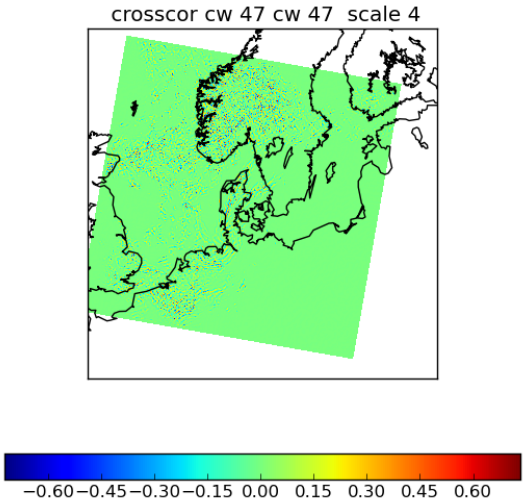


Scale 2

Auto-correlation
between Cloud Water
(“black box”)
and Cloud Water field
(Model Level 47)
≈ 850 hPa



Scale 3



Scale 4

Lessons learned ....

- Space-scale decomposition is a powerful technique to extract different scales of variablity => Guidance from the nature of the variability can be used to define the decomposition.

- HARMONIE AROME model is not able to create the meso-scale spectra in the free atmosphere above 500hPa => Despite of this the model is capable to spin-up cloud related processes relatively quickly in the lower atmosphere.

- The sampling error is a challenge when one is restricted to a small ensemble size=> one possible way to progress is to improve sampling strategy (deterministic sampling approach)

- This is a challenge to extract a proper signal from the ensemble estimate of correlation when variables with different scales of variability are involved!

- Sampling error affect scales of low predictability => The small scales are not necessary related to a low predictability, in parcular if processes are orography driven


Everything will be
okay in the end.
If it's not okay,
it's not the end!