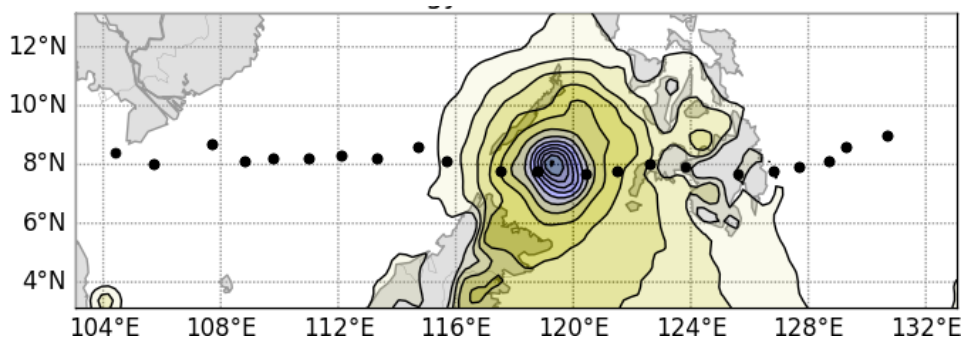
Hybrid background error for Numerical weather Prediction and its sensitivity to resolution

S. Massart

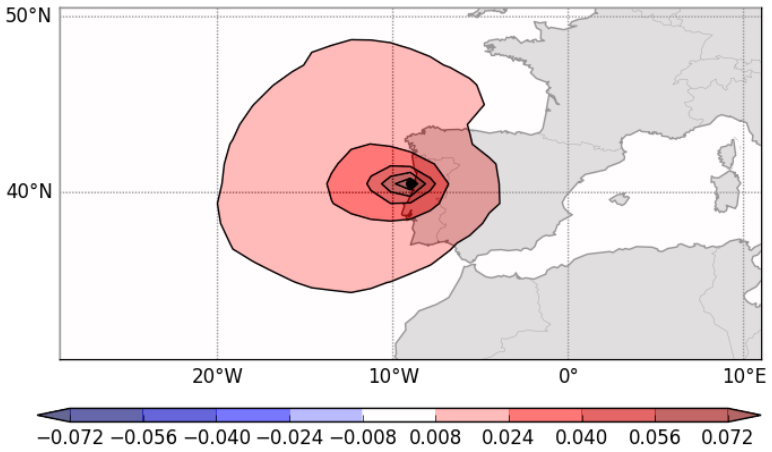
Workshop on Sensitivity Analysis and Data Assimilation
in Meteorology and Oceanography
July 2018



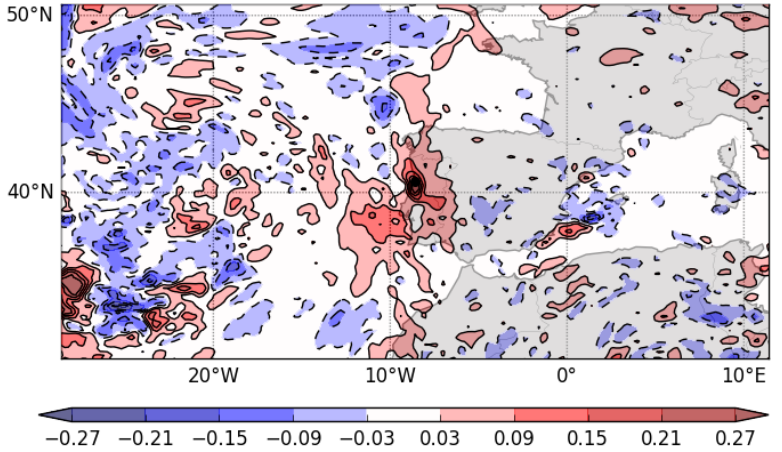
ECMWF

Examples of background error covariances

- Climatology $\mathbf{B}^s$



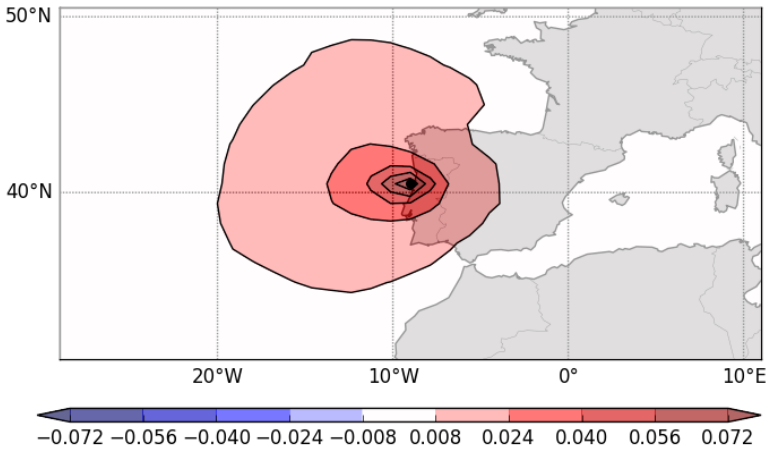
- From the ens. of the day $\mathbf{B}^e$



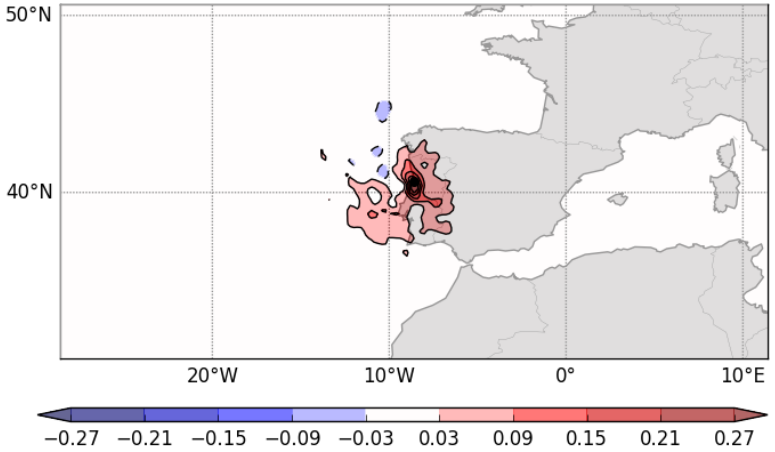
Temperature background error covariance (in K^2) for Aveiro at $\approx$ 850 hPa

Examples of background error covariances

- Climatology $\mathbf{B}^s$



- $\mathbf{B}^e$ + localisation (300 km)



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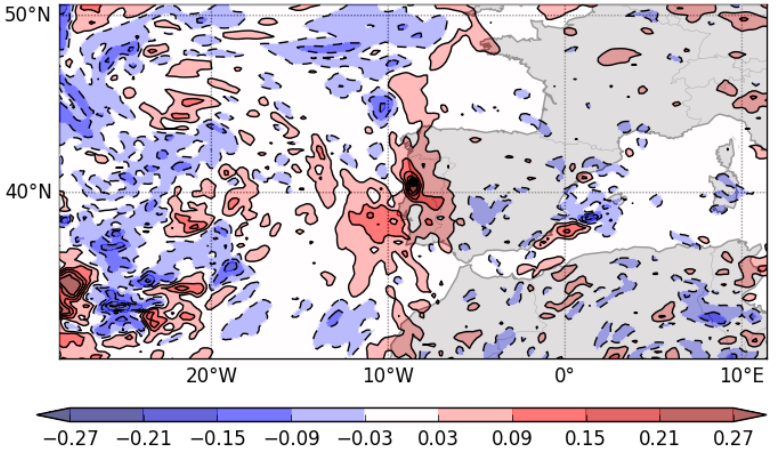

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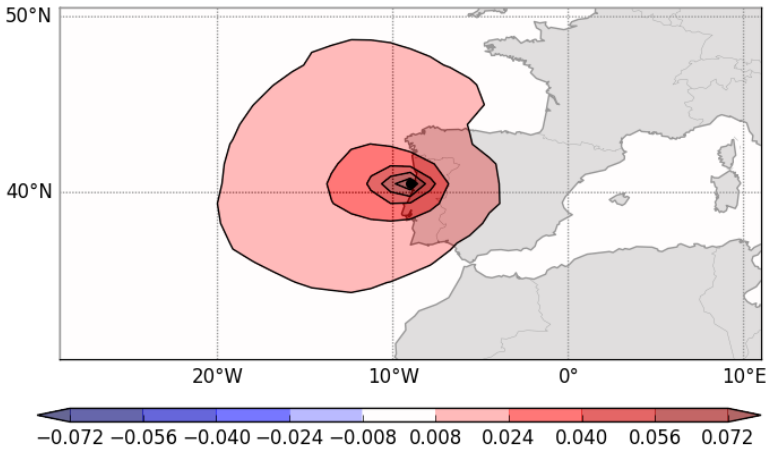
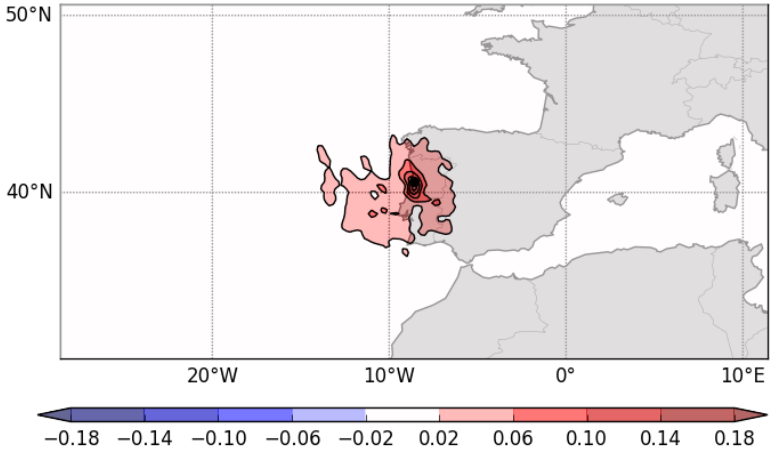


- $50\%\,\mathbf{B}^s + 50\%\,\mathbf{B}^e$ (w/ loc.)



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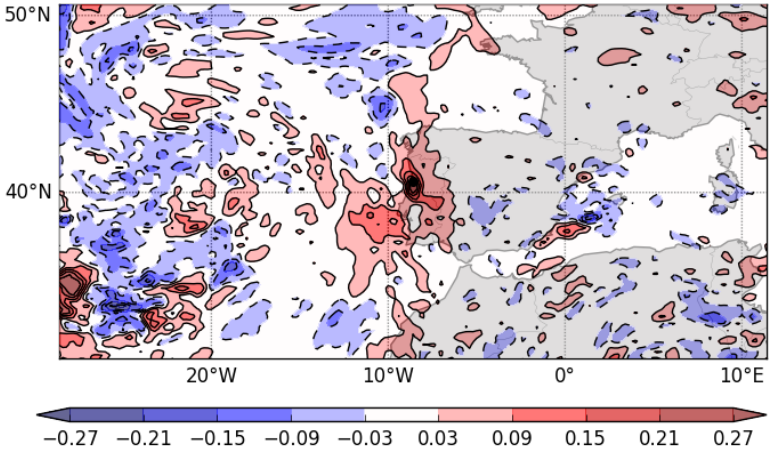
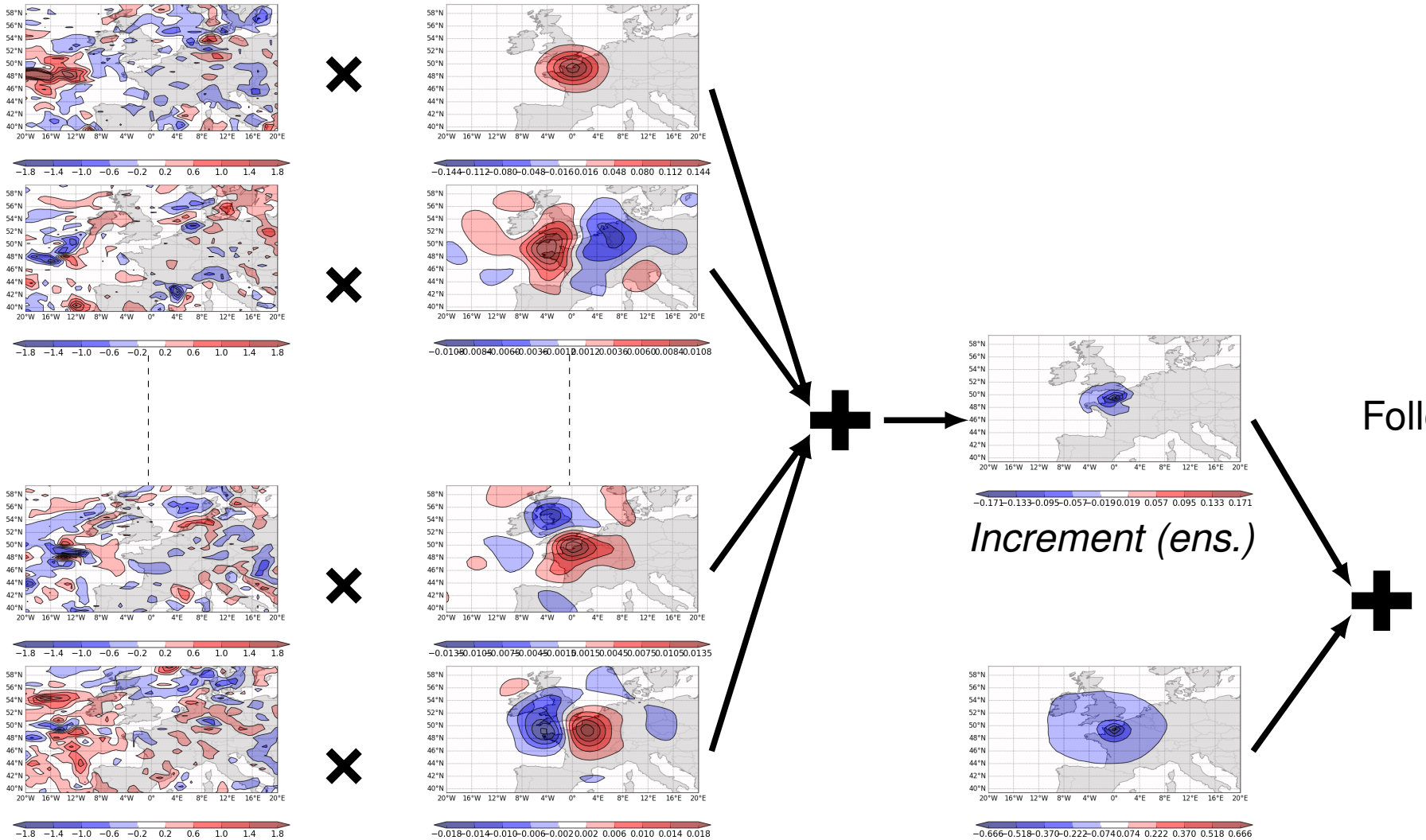


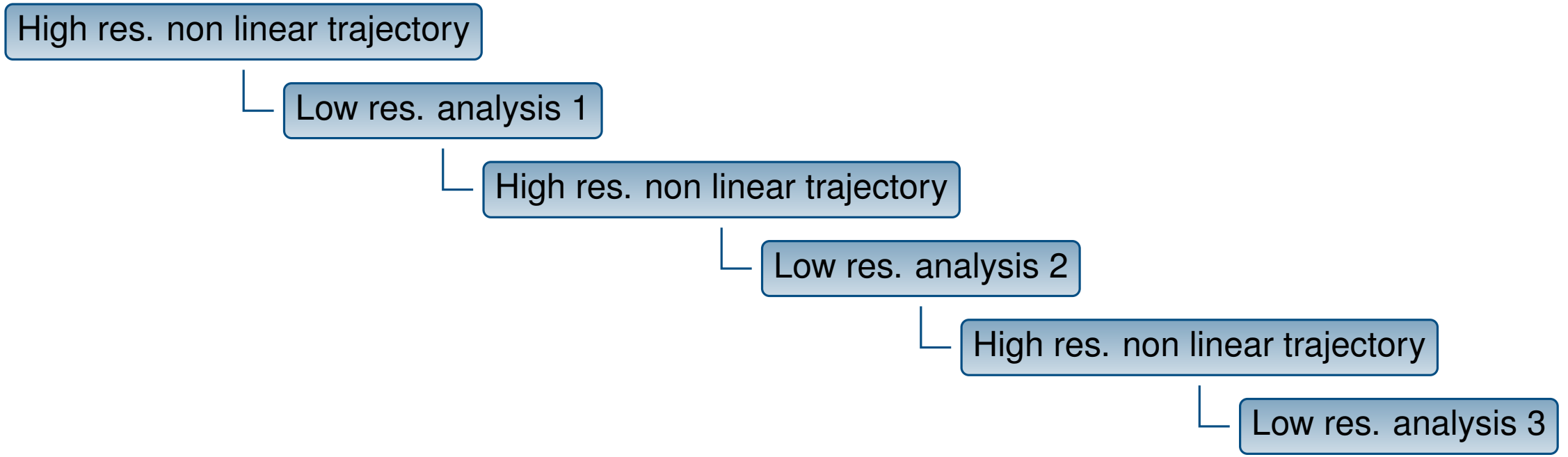
Temperature background error covariance (in K^2) for Aveiro at $\approx 850\,hPa$

Hybrid covariances: alpha control variable

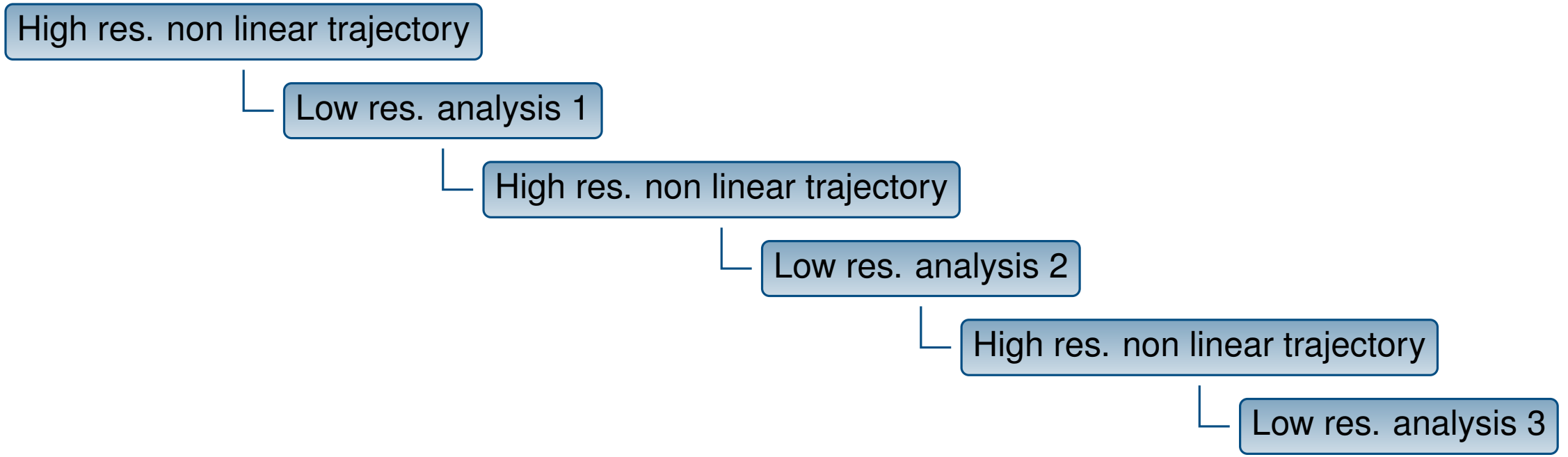


Following Desroziers *et al.*
QJRMS, 2014

ECMWF incremental 4D-Var approach



ECMWF incremental 4D-Var approach

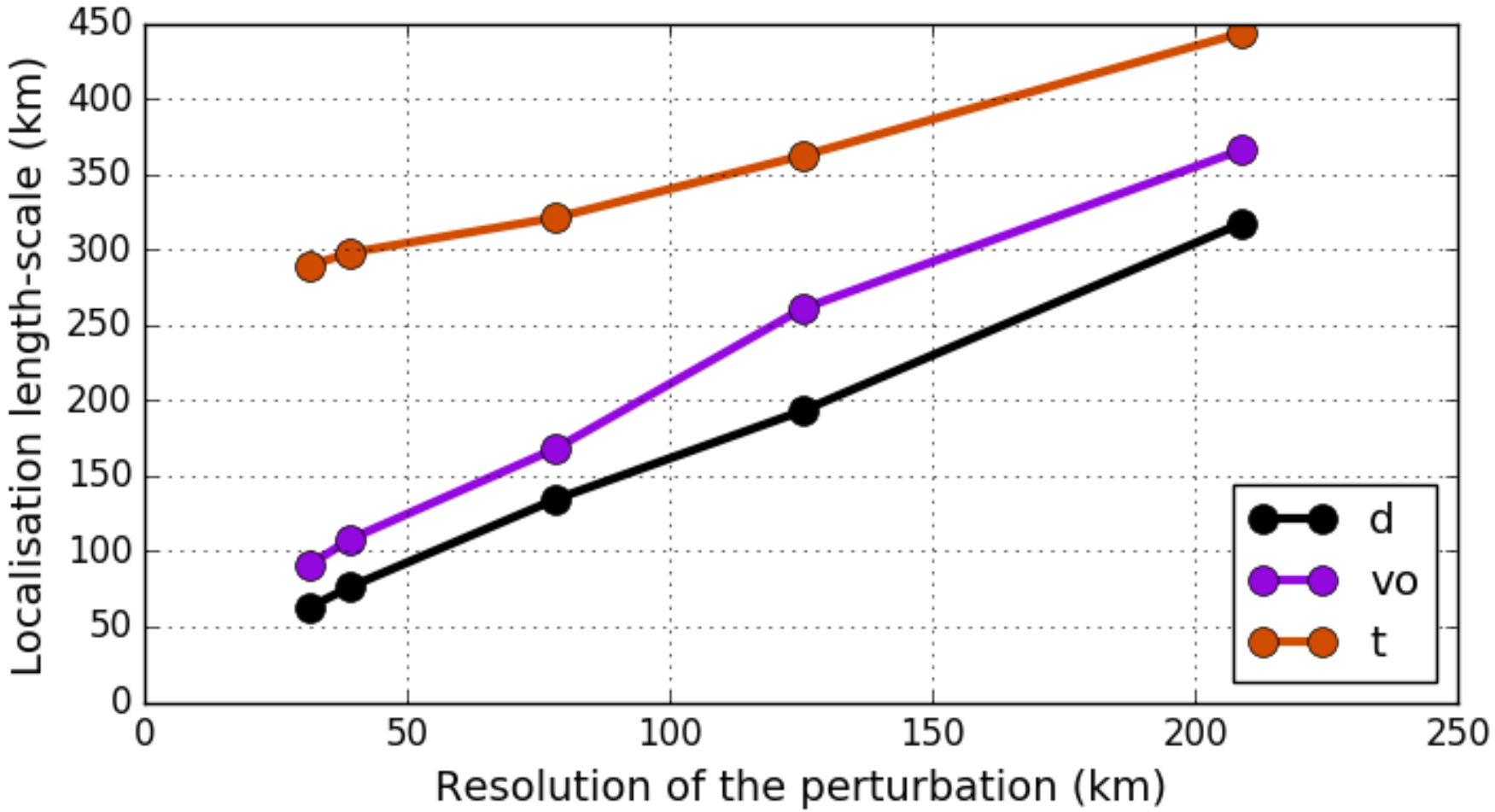


Strategy for each low resolution analysis

1. What resolution for the ensemble perturbation?
2. Which localisation?

Influence of the resolution on the localisation length-scale

Mean localisation length-scale between the surface and 100 hPa

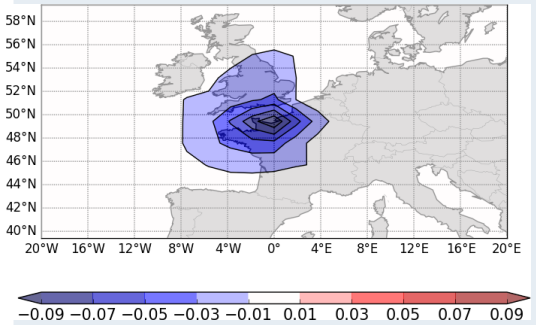


From Hybrid Diag (Ménétrier and Auligné, 2015)

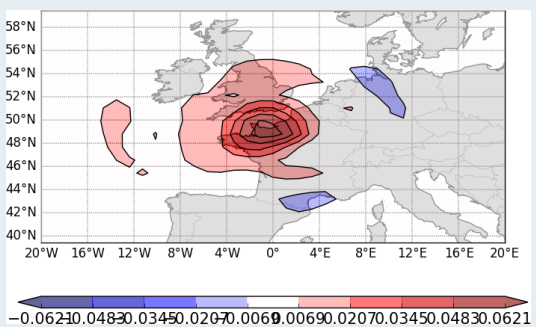
Sensitivity of the localisation length-scale in the inner loop

Fixed localisation (300 km)

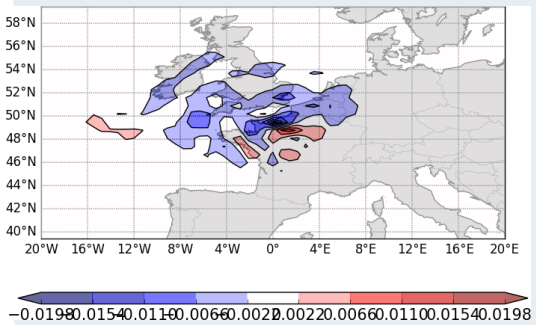
✘ Loop 1



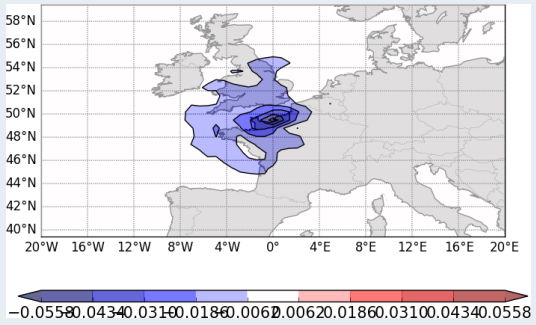
✘ Loop 2



✘ Loop 3

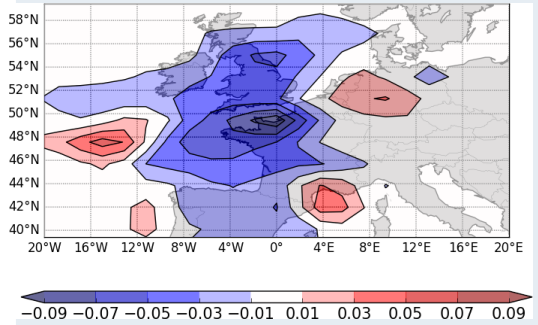


✘ Total

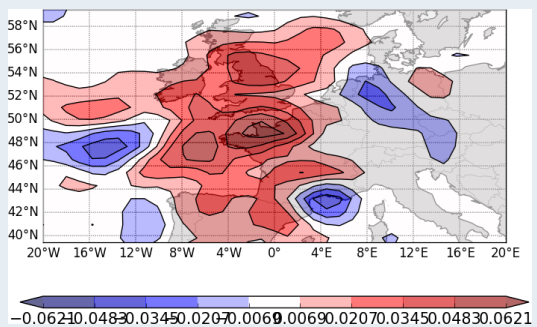


Varying localisation

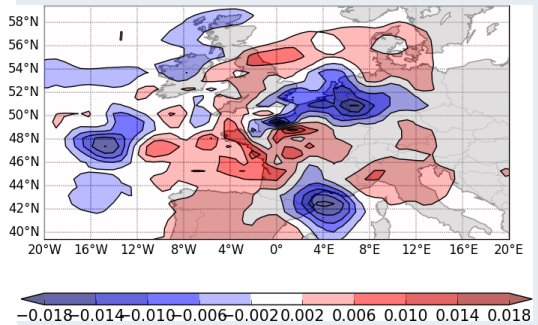
✘ Loop 1 - $L = 800\,km$



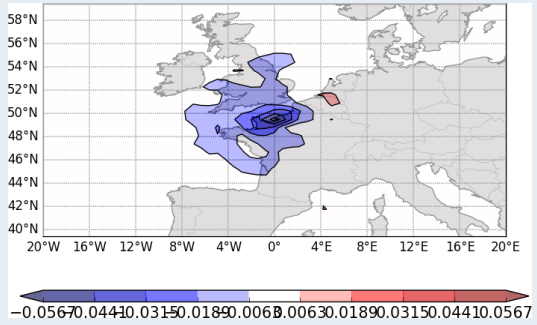
✘ Loop 2 - $L = 480\,km$



✘ Loop 3 - $L = 300\,km$



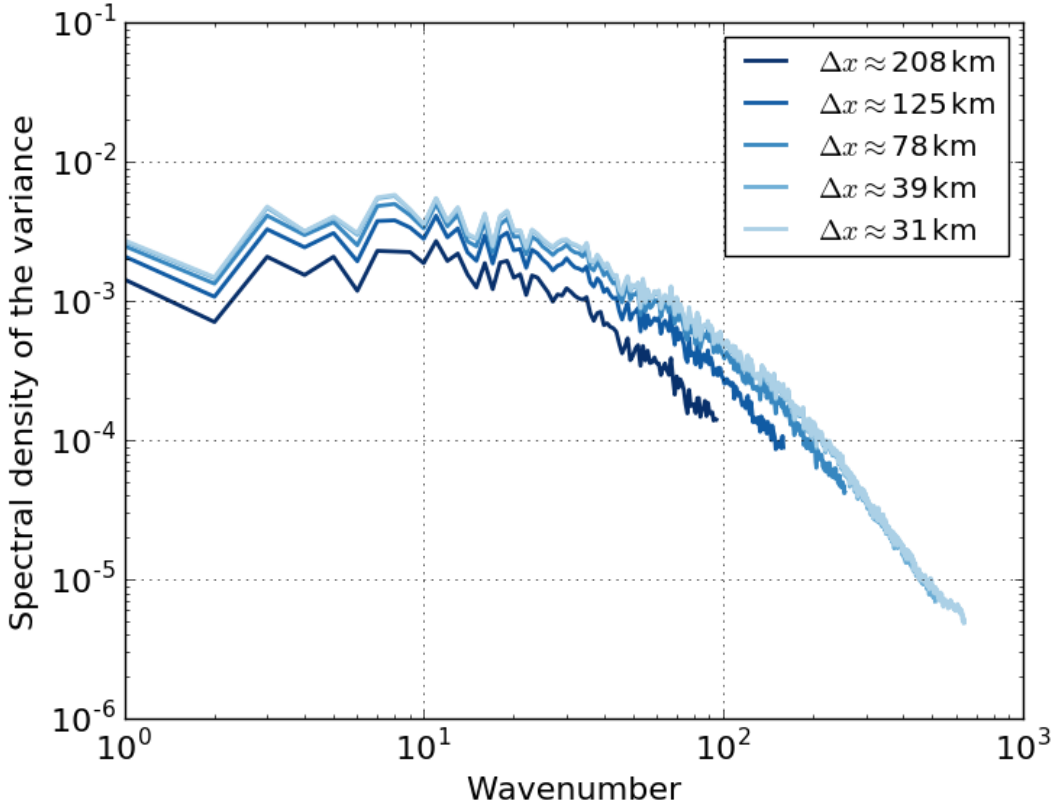
✘ Total



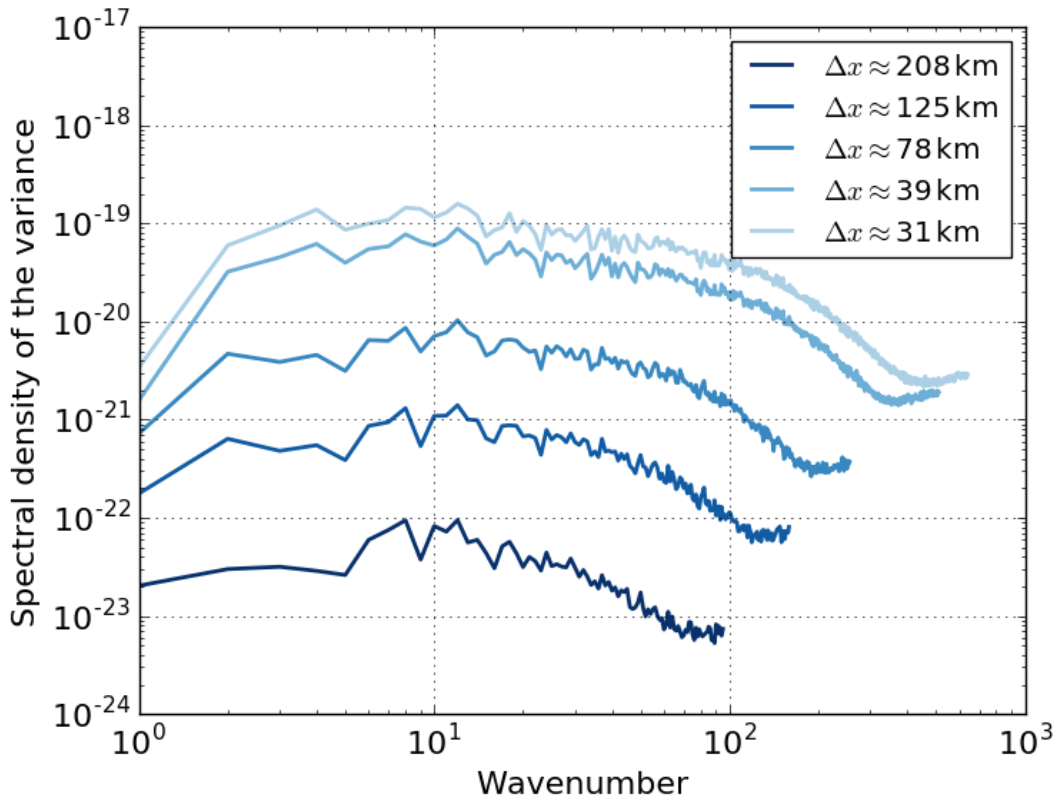
Example of temperature increments (in K)
obtained from the assimilation of a single temperature observation.
Analyses resolution: 1) $\Delta x \approx 200\,km$, 2) $\Delta x \approx 125\,km$, 3) $\Delta x \approx 80\,km$

Influence of the resolution on the variance

- Temperature



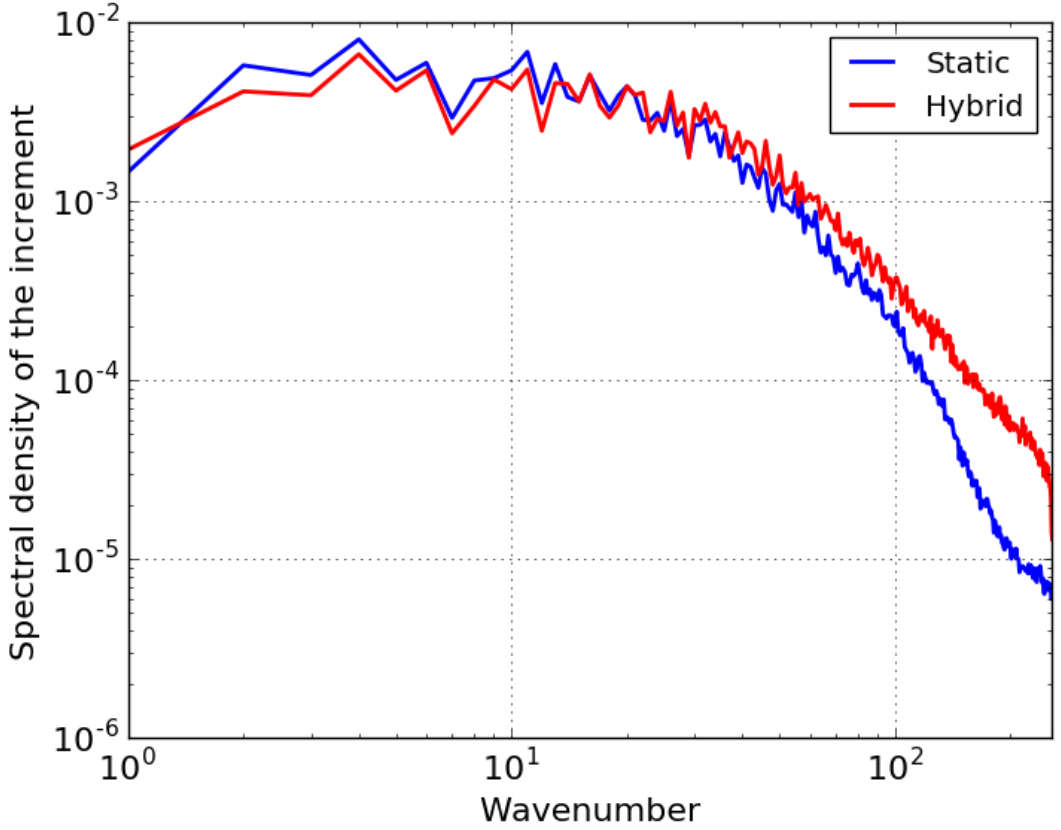
- Vorticity



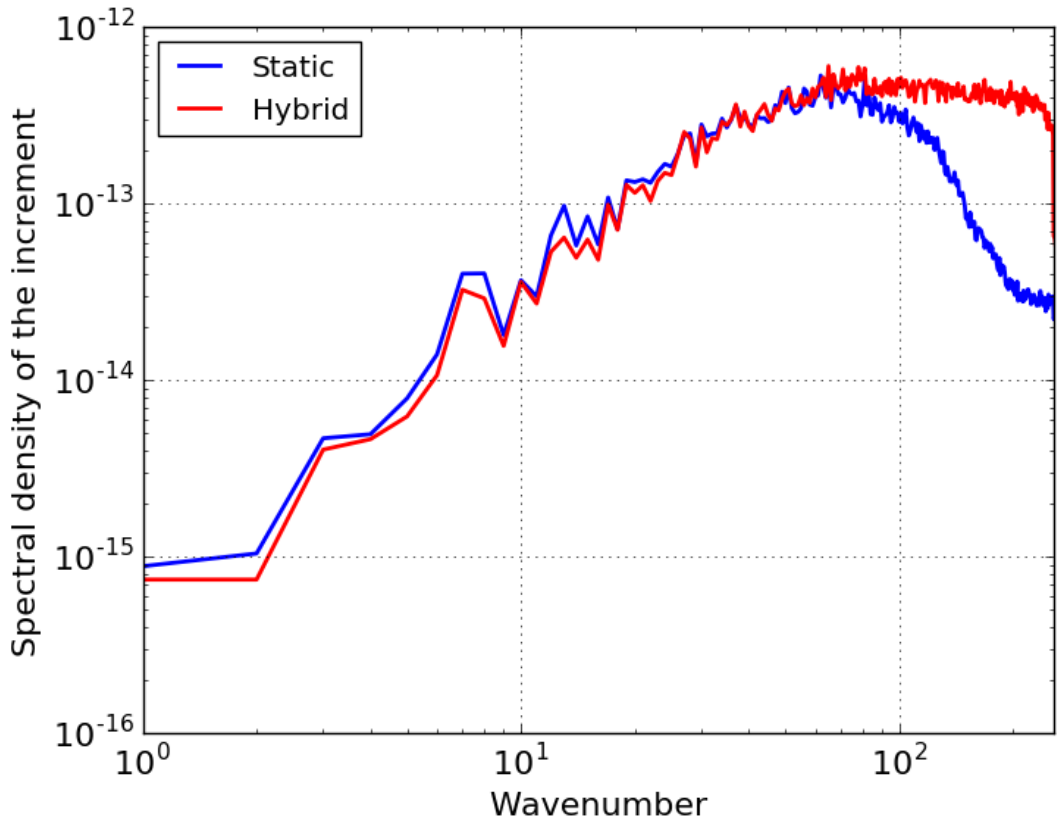
Background error variance at $\approx 900\,hPa$

Influence of the hybrid **B** on the increment

- Temperature



- Vorticity



Increment at $\approx$ 900 *hPa*

Influence of the hybrid **B** on the increment

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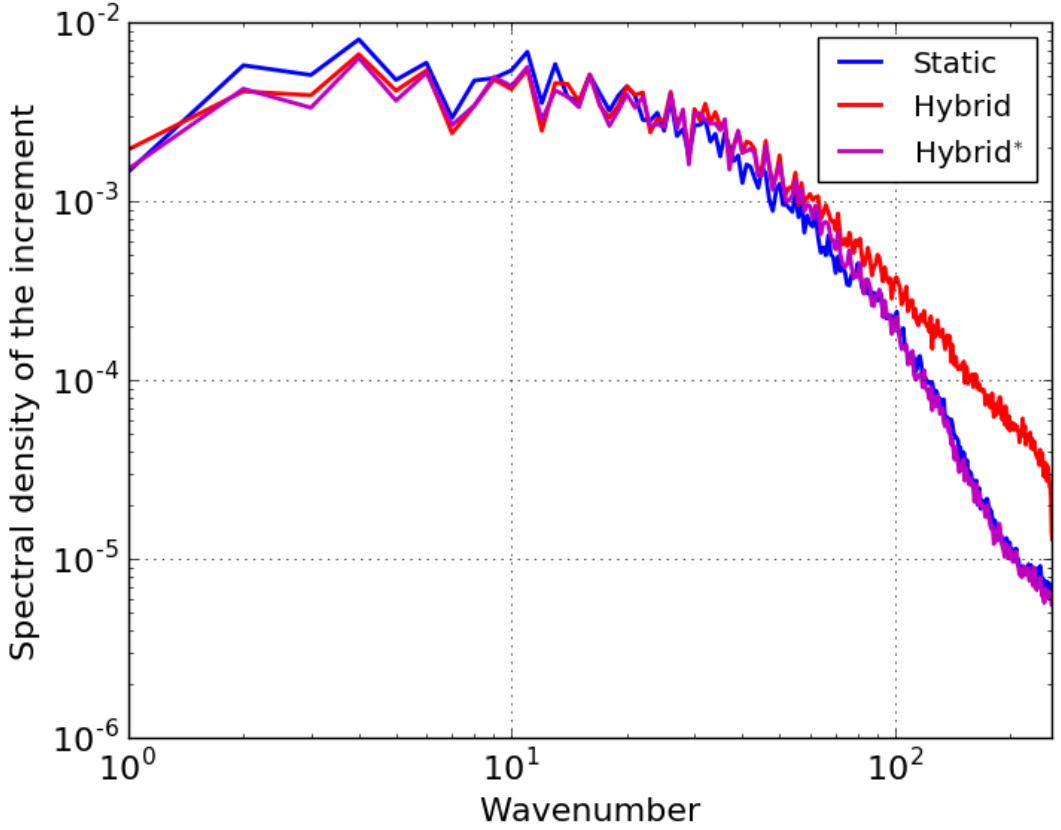
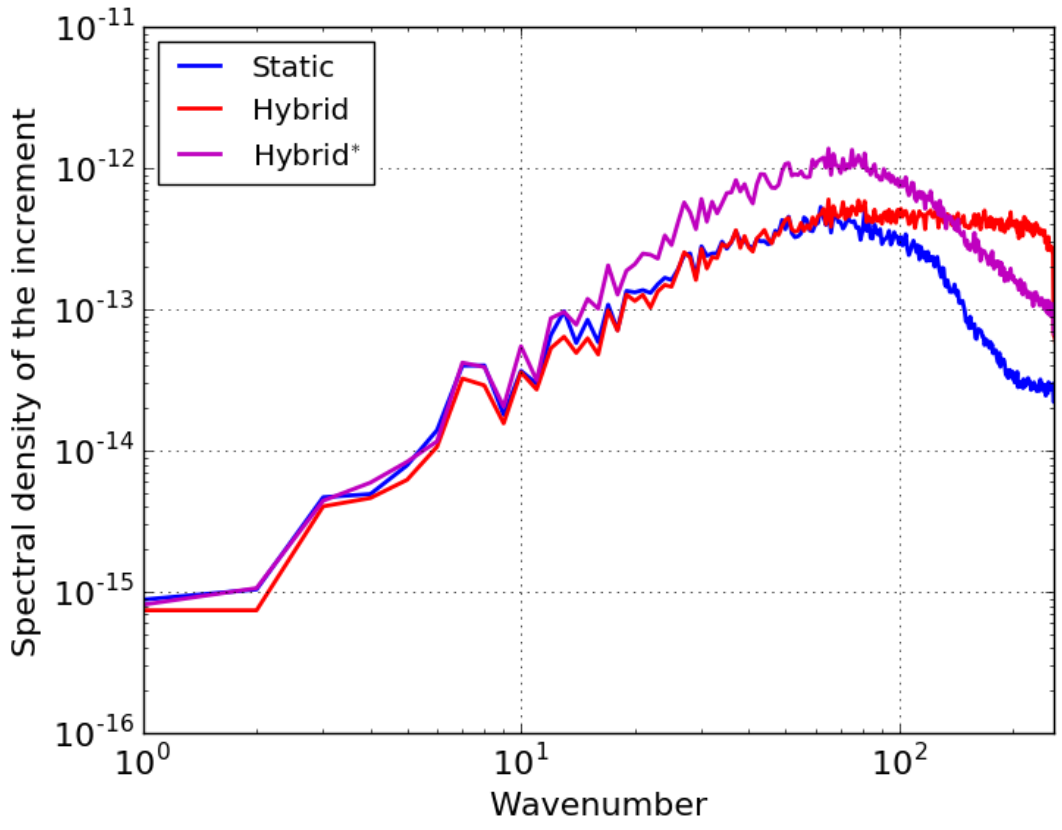


- Vorticity

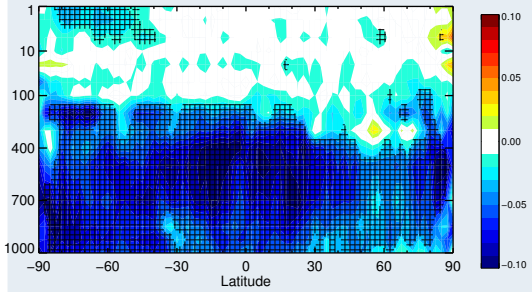


Increment at $\approx$ 900 *hPa*

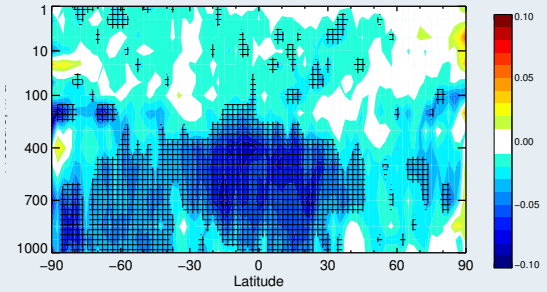
Impact of the perturbation filtering on the NWP scores

Hybrib **B** - reference

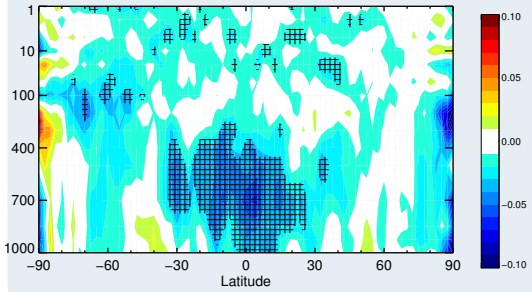
✘ T+12 h



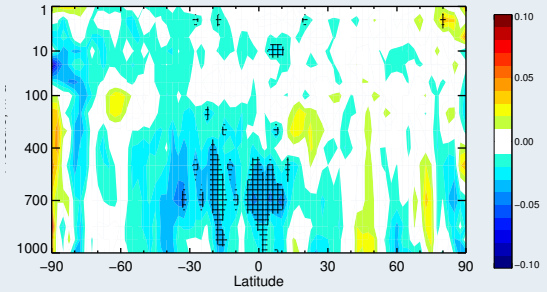
✘ T+24 h



✘ T+72 h

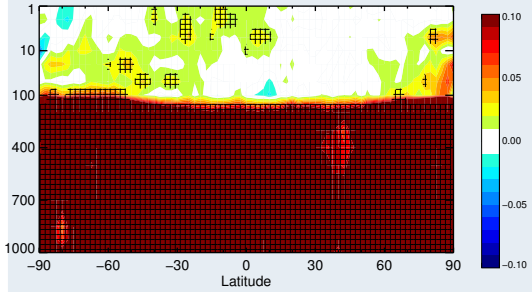


✘ T+120 h



Hybrib **B** - Filtering

✘ T+12 h



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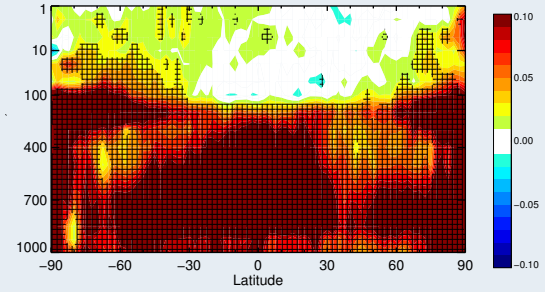

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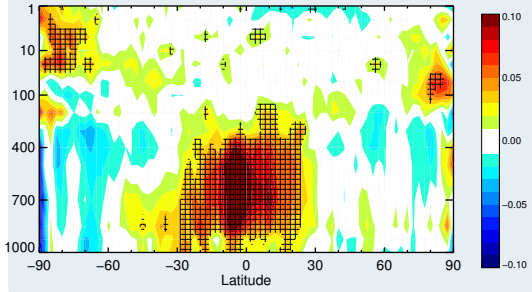

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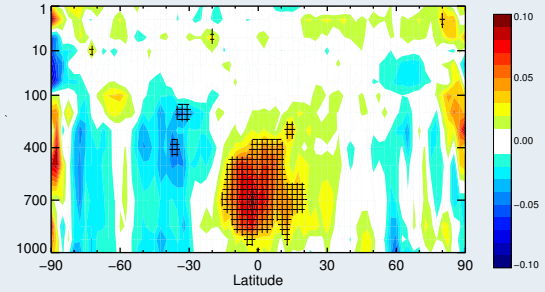

Change in error in wind (Hybrid - Static)

Bluish: 🙂, Reddish: ☹

Period: November 2016 – Verified against own analysis

Impact of the perturbation filtering on the NWP scores

Hybrib **B** - reference

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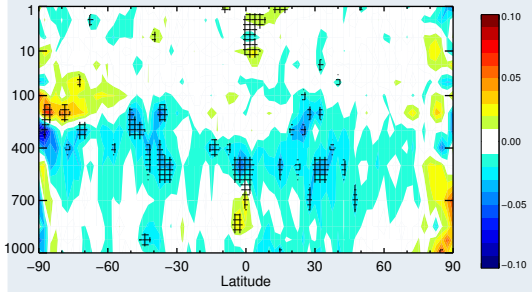

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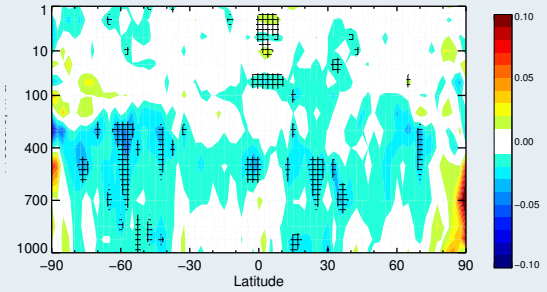

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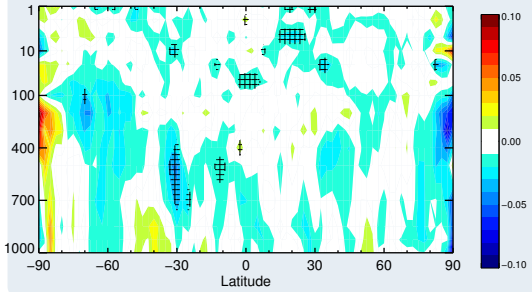

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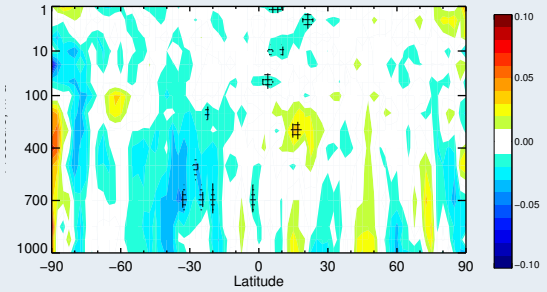
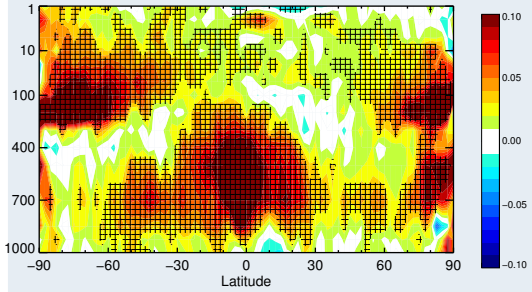


Hybrib **B** - Filtering

✘ T+12 h



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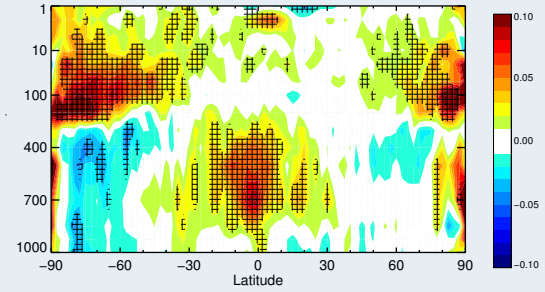

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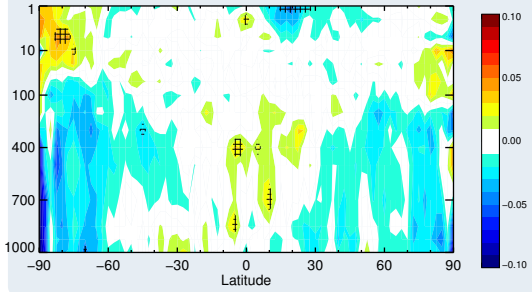

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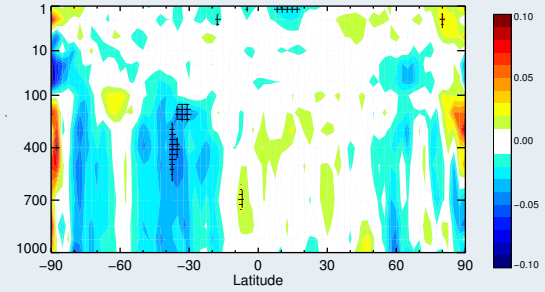


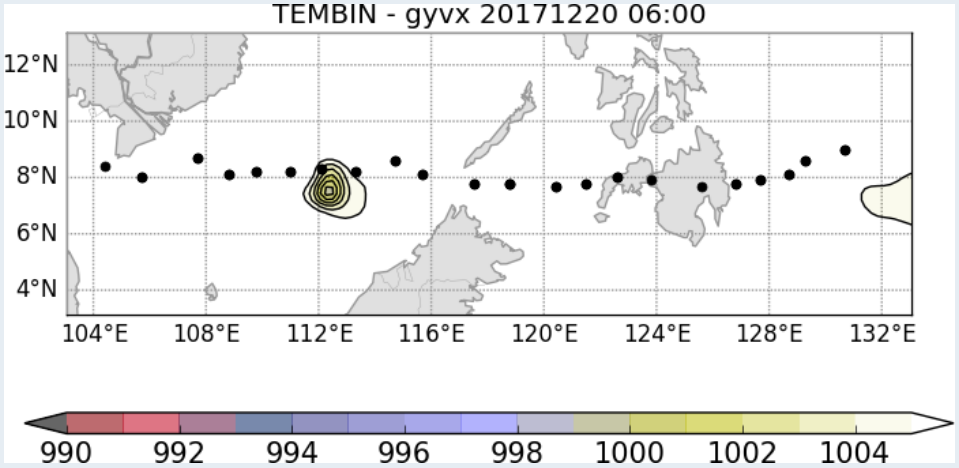
Change in error in wind (Hybrid - Static)

Bluish: 🙂, Reddish: ☹

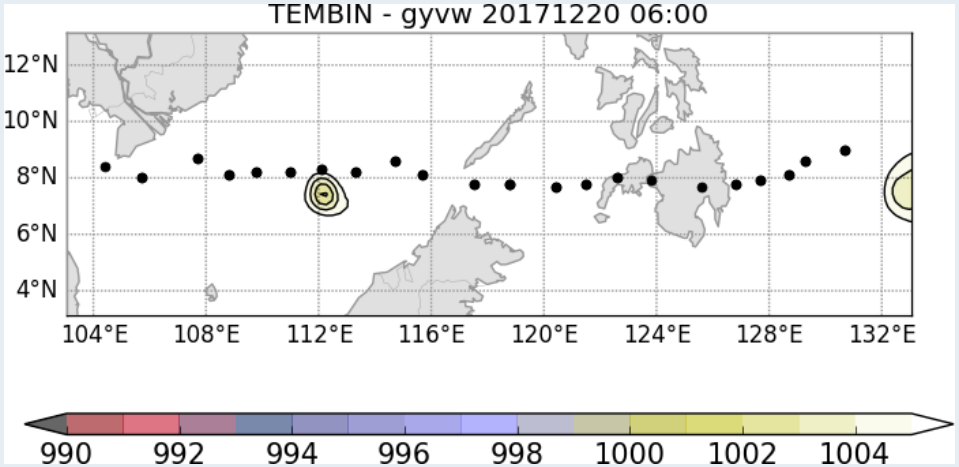
Period: November 2016 – Verified against operations

Case study

Analysis – Static **B**

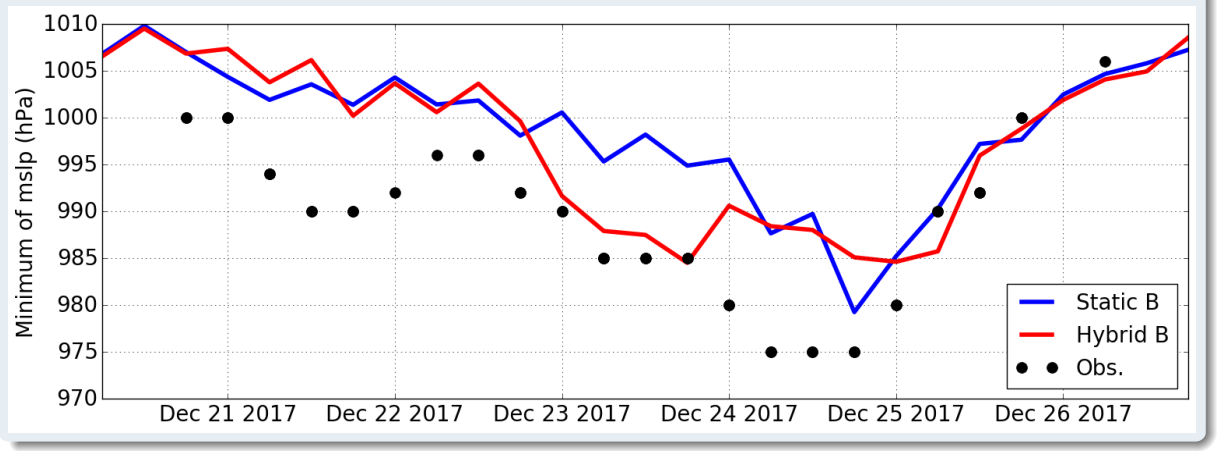


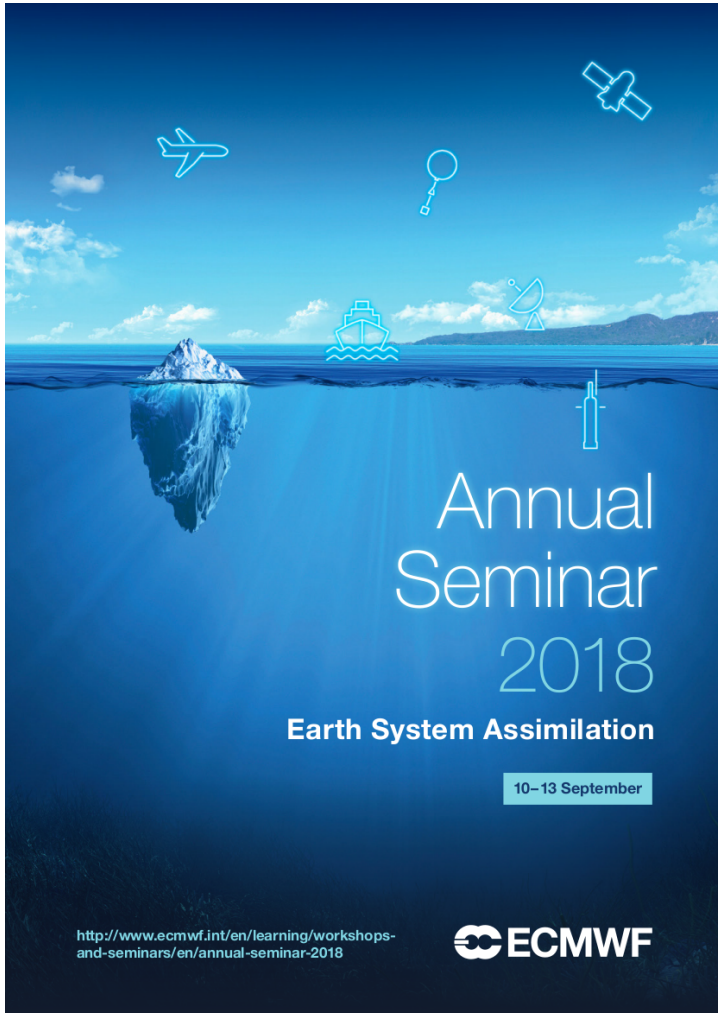
Analysis – Hybrid **B** (50/50)



Mean sea level pressure (mslp, in hPa)
for the tropical cyclone Tembin
December 2017

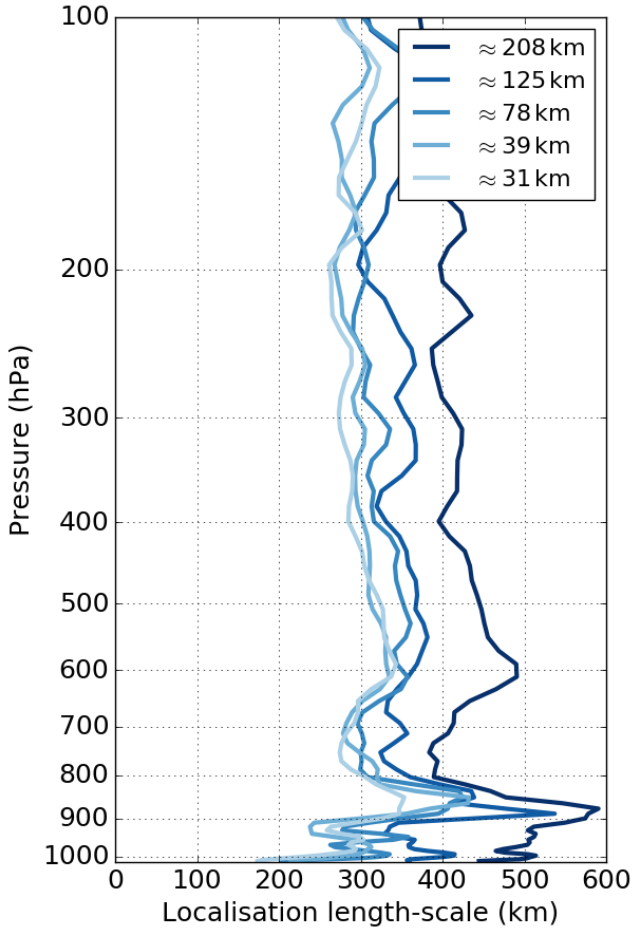
mslp minimum – Forecast day 3



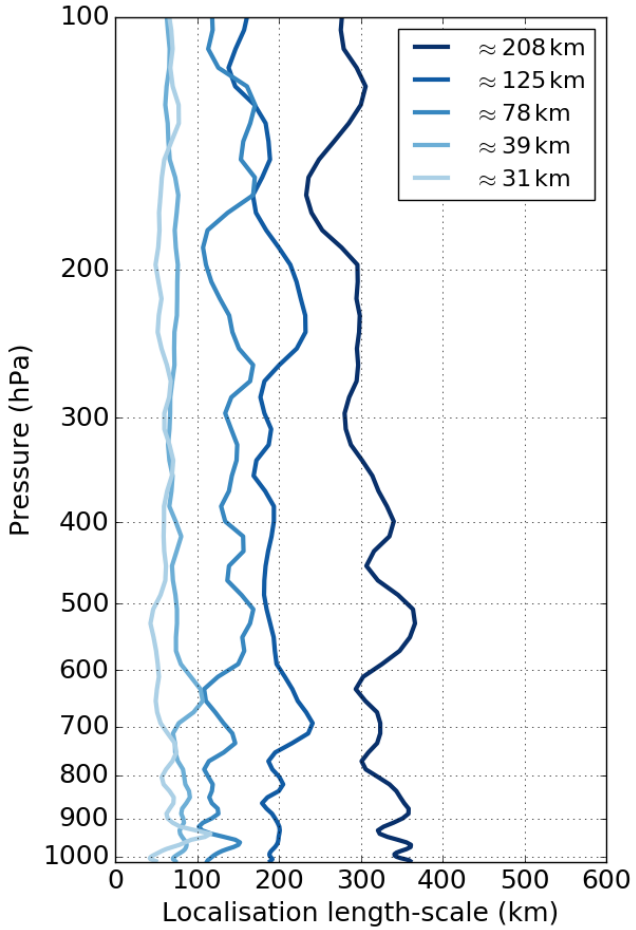

Annual
Seminar
2018
Earth System Assimilation
10–13 September
http://www.ecmwf.int/en/learning/workshops-and-seminars/en/annual-seminar-2018
ECMWF

Influence of the resolution on the localisation length-scale

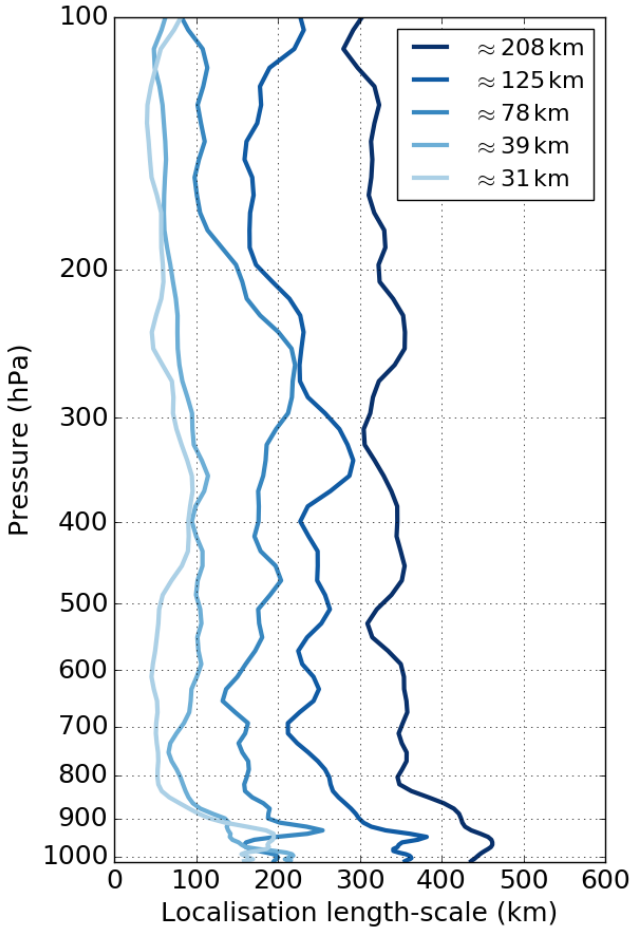
✘ Temperature



✘ Divergence



✘ Vorticity

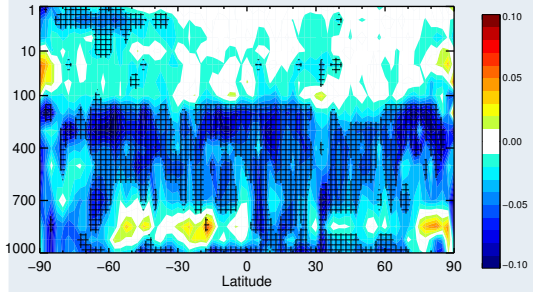


From Hybrid Diag (Ménétrier and Auligné, 2015)

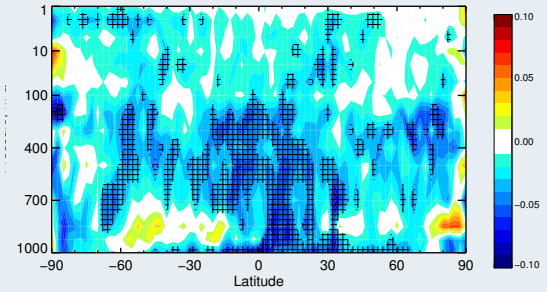
Impact of the perturbation filtering on the NWP scores

Hybrib **B** - reference

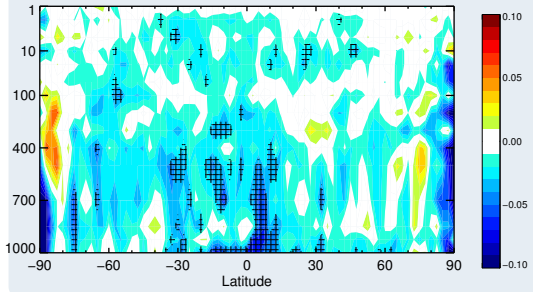
✘ T+12 h



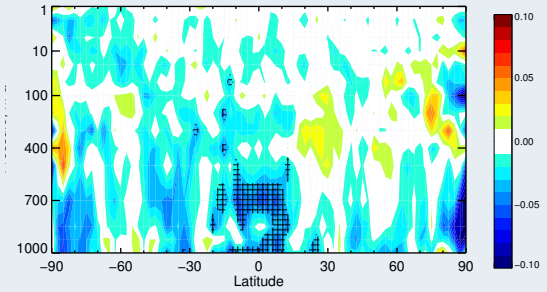
✘ T+24 h



✘ T+72 h

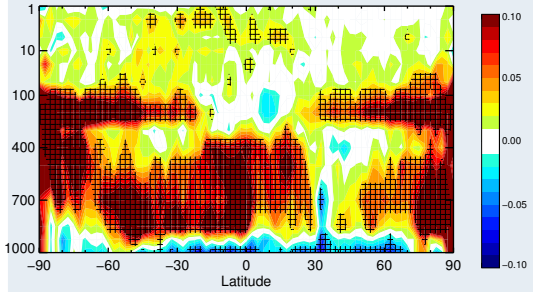


✘ T+120 h

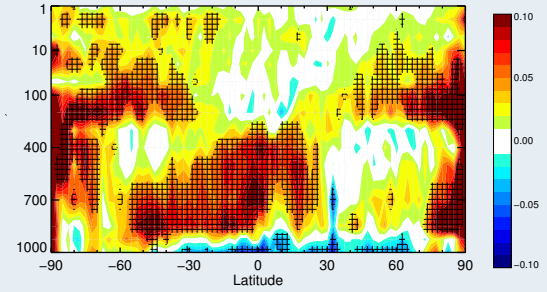


Hybrib **B** - Filtering

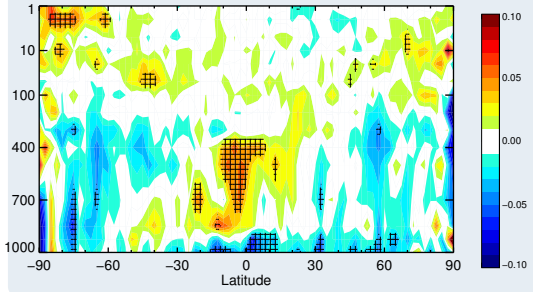
✘ T+12 h



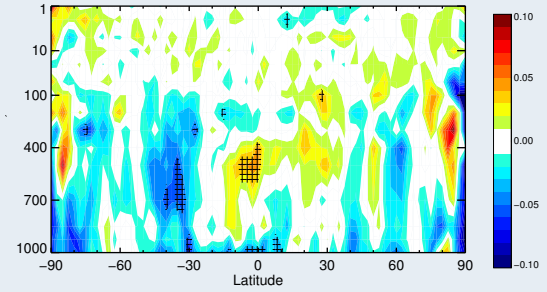
✘ T+24 h



✘ T+72 h



✘ T+120 h



Change in error in temperature (Hybrid - Static)

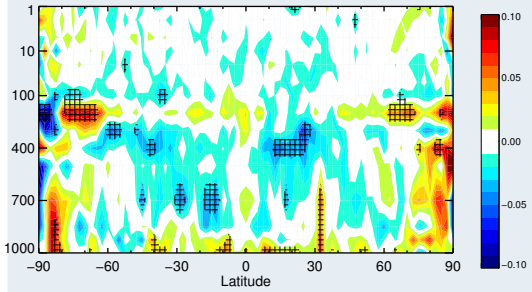
Bluish: 🙂, Reddish: ☹

Period: November 2016 – Verified against own analysis

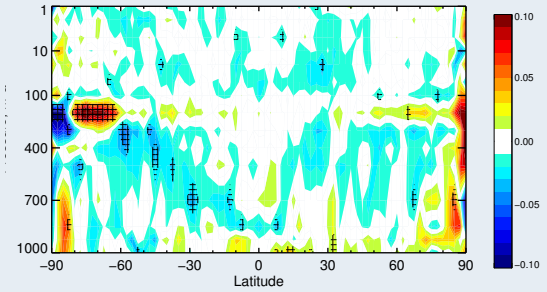
Impact of the perturbation filtering on the NWP scores

Hybrib **B** - reference

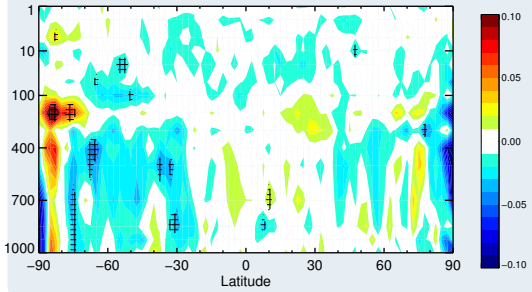
✘ T+12 h



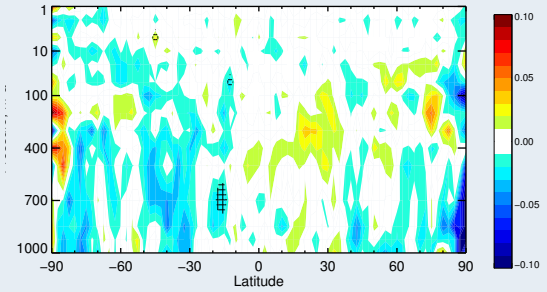
✘ T+24 h



✘ T+72 h

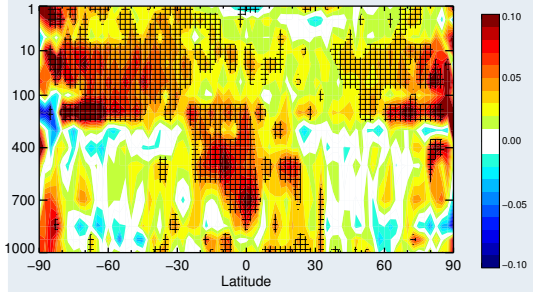


✘ T+120 h

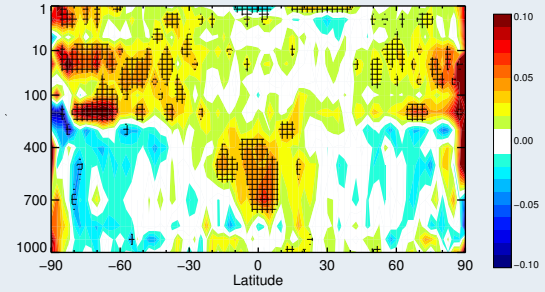


Hybrib **B** - Filtering

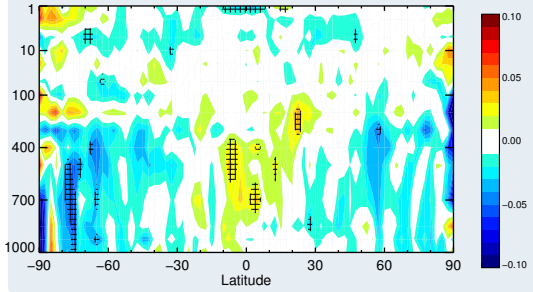
✘ T+12 h



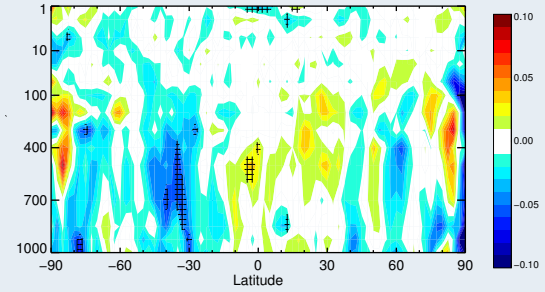
✘ T+24 h



✘ T+72 h



✘ T+120 h



Change in error in temperature (Hybrid - Static)

Bluish: 🙂, Reddish: ☹

Period: November 2016 – Verified against operations