Diagnostic tool for ALADIN lateral coupling

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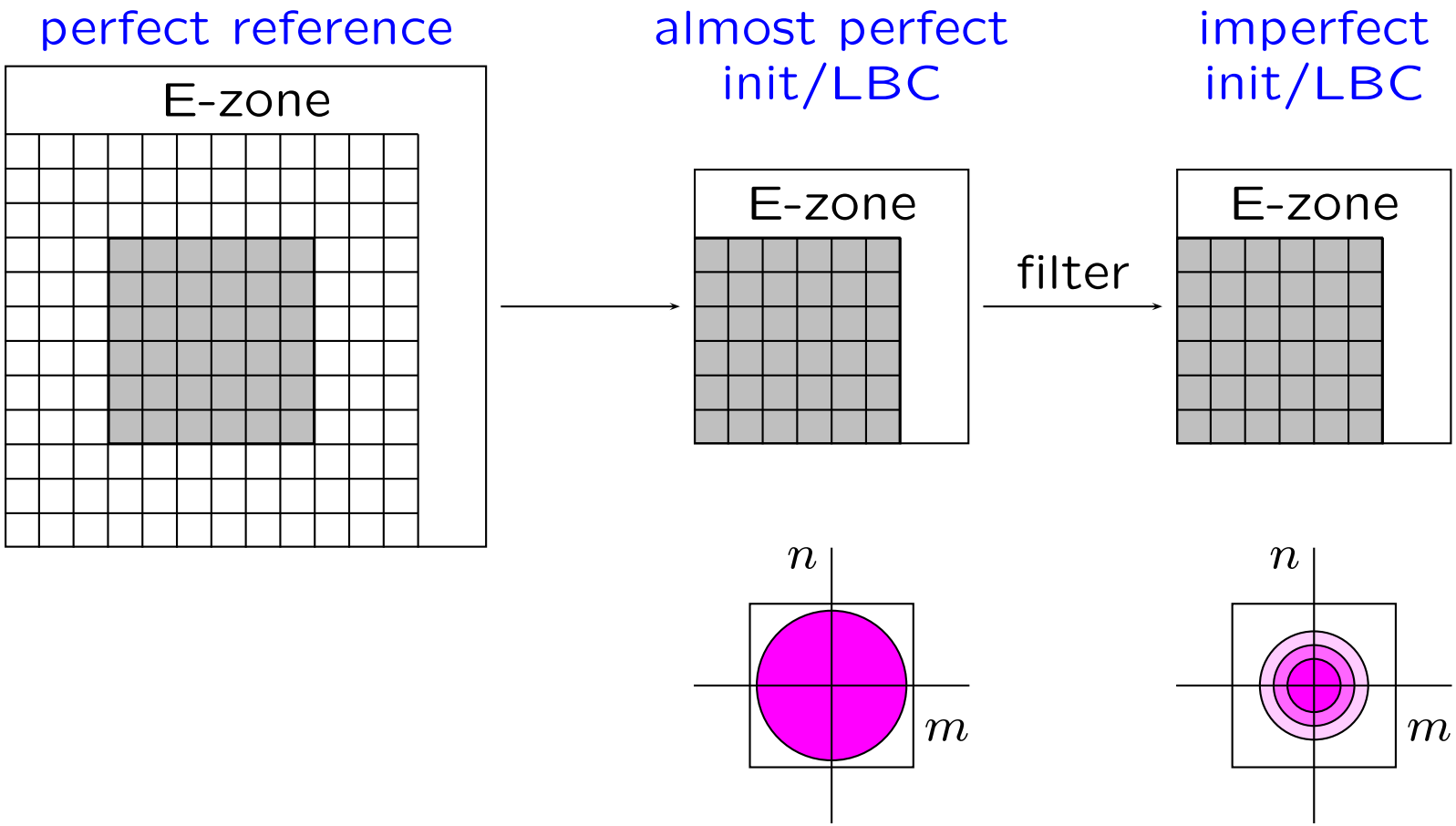
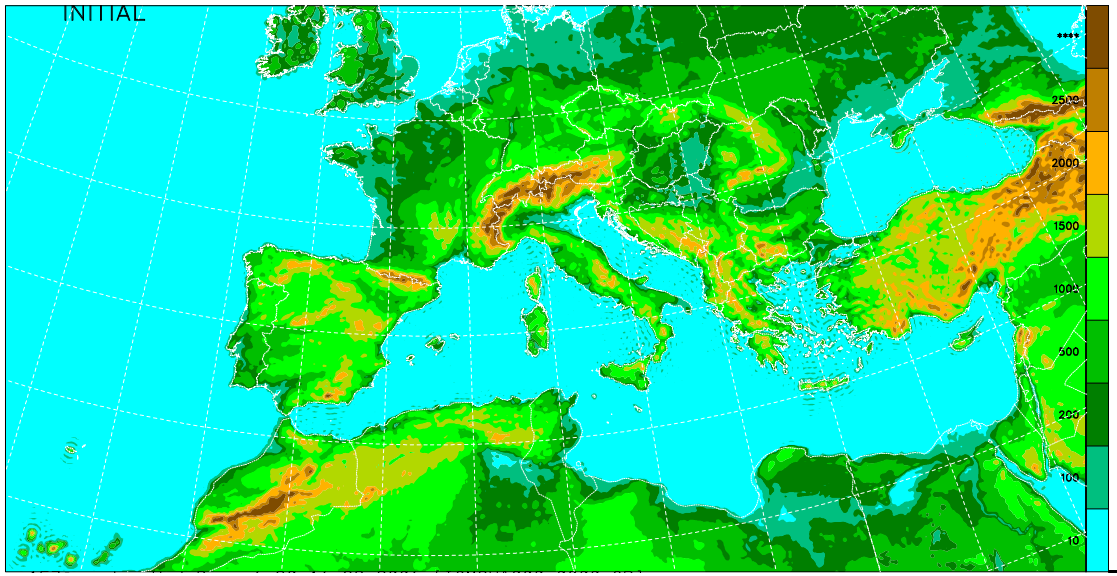
Motivation

- LAM integration is initial-boundary value problem
- shift towards kilometric resolutions and sophisticated physical packages together with limited computing resources implies use of small LAM domains
- in small domains, solution becomes dominated by LBC quite early $\Rightarrow$ lateral boundary treatment becomes key issue
- subjective evaluation of coupling performance in 3D real cases can be problematic $\Rightarrow$ diagnostic tool is needed
- once ready, tool can be used to evaluate alternative coupling strategies (Davies relaxation scheme being golden standard)

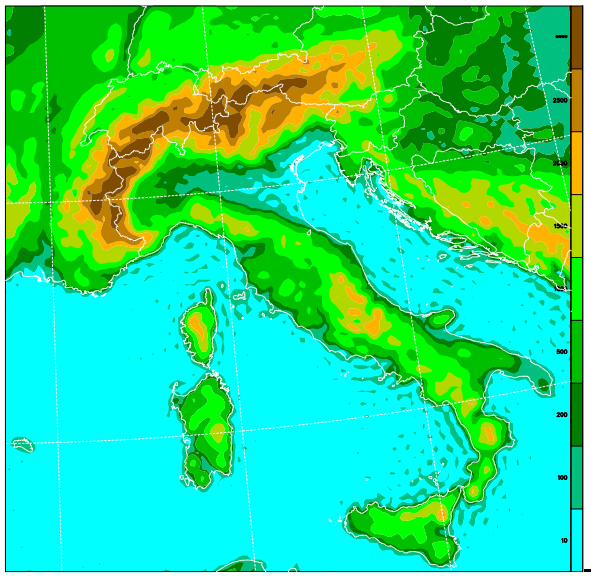
Perfect model approach (after Elía, Laprise and Denis, MWR 2002)



LAM domains



MFST (reference LAM)



DOM1 (nested LAM)

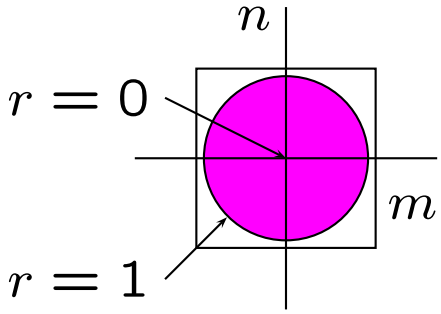
$\Delta x = \Delta y = 9.5\,\text{km}$, 37 levels
8 point wide relaxation zone (I-zone)
SL2TL SI scheme with $\Delta t = 400\,\text{s}$

domain	C + I	C + I + E	truncation
MFST	589×309	600×320	299×159
DOM1	139×139	150×150	74×74

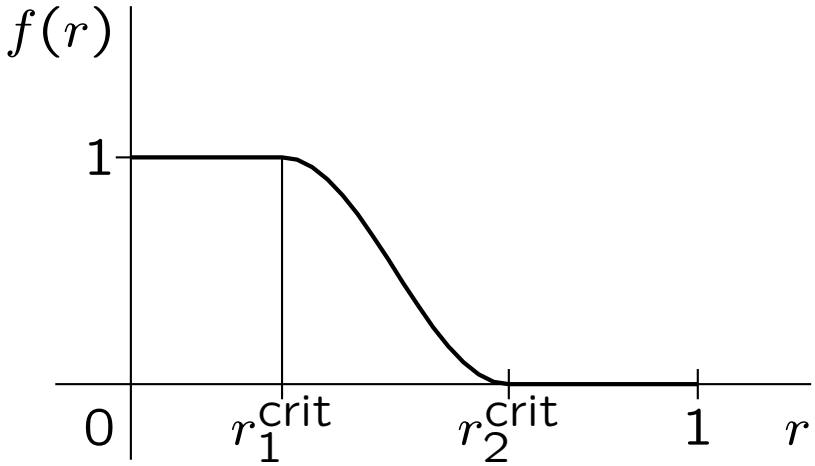
LBC filtering for nested LAM

$$c^{\text{filt}}_{m,n} = c_{m,n} \cdot f(r_{m,n})$$

$$f(r) = \begin{cases} 1 & ; \quad r \le r_1^{\text{crit}} \\ \frac{1}{2} + \frac{1}{2}\cos\left[\pi \dfrac{r - r_1^{\text{crit}}}{r_2^{\text{crit}} - r_1^{\text{crit}}}\right] & ; \quad r_1^{\text{crit}} < r \le r_2^{\text{crit}} \\ 0 & ; \quad r > r_2^{\text{crit}} \end{cases}$$



$$r_{m,n} = \sqrt{\left(\frac{m}{M}\right)^2 + \left(\frac{n}{N}\right)^2} = \frac{k}{k_{\text{max}}}$$



jump in resolution 3 was simulated using values $r_1^{\text{crit}} = 0$, $r_2^{\text{crit}} = \frac{1}{3}$

(all waves shorter than $6\Delta x$ removed)

Choice of parameter and scores

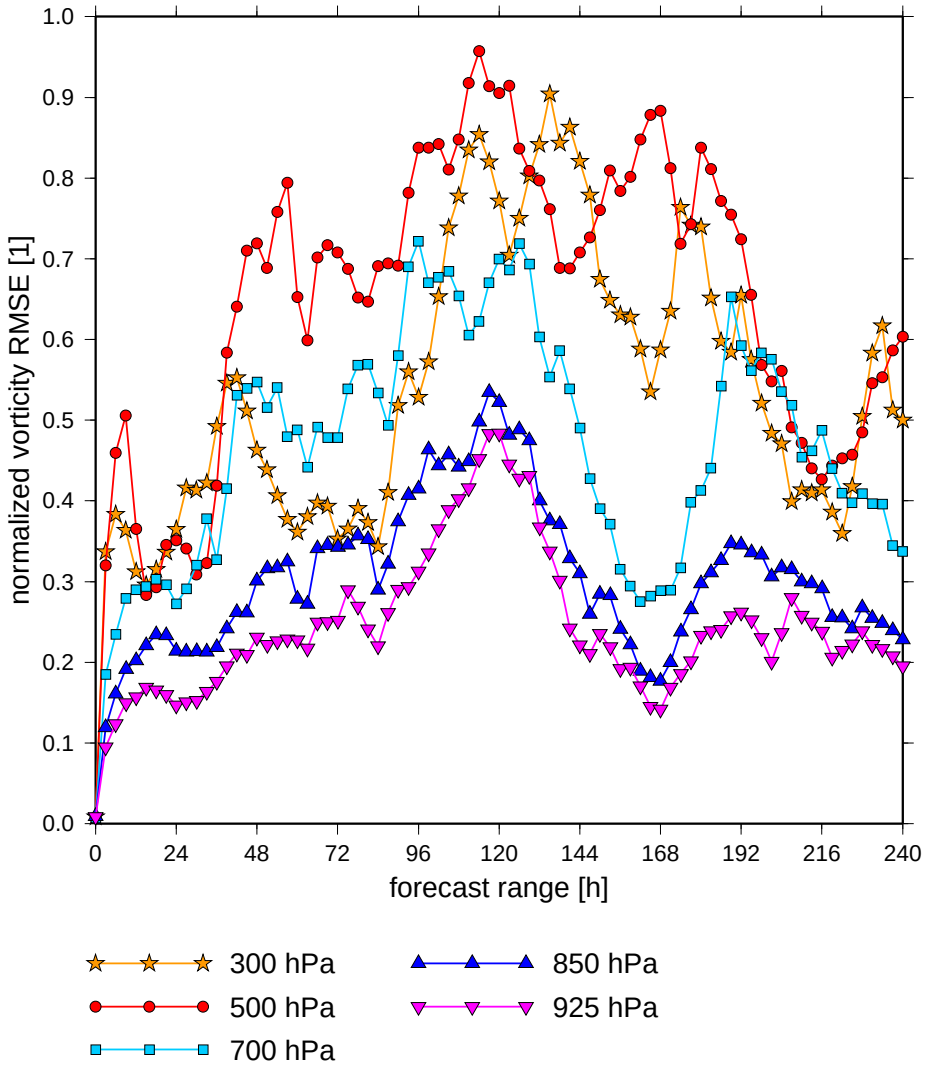
parameter:

– vorticity ξ at 500 hPa level

scores:

– normalized SDEV $\frac{\sigma(\xi)}{\sigma(\xi_{\text{ref}})}$

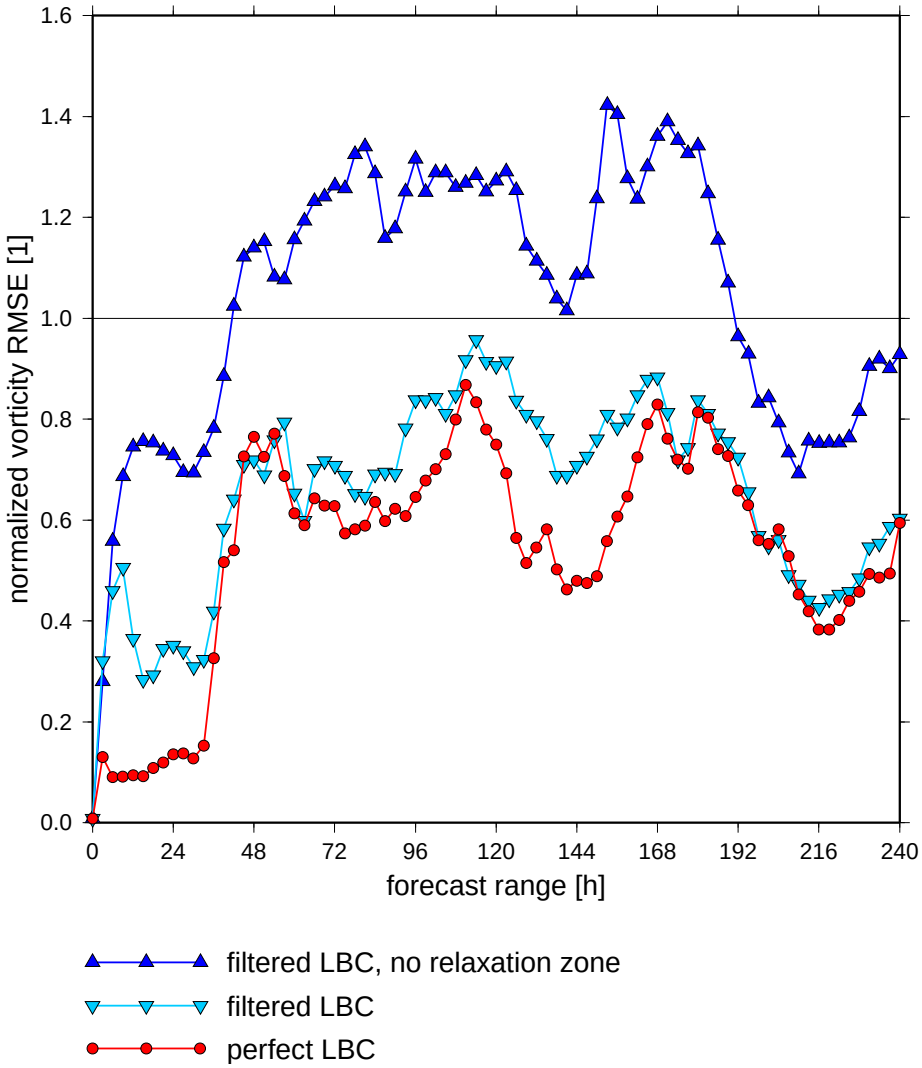
– normalized RMSE $\frac{\sqrt{\overline{(\xi-\xi_{\text{ref}})^2}}}{\sigma(\xi_{\text{ref}})}$



Sensitivity to LBC treatment

normalized vorticity RMSE
(at 500 hPa level)

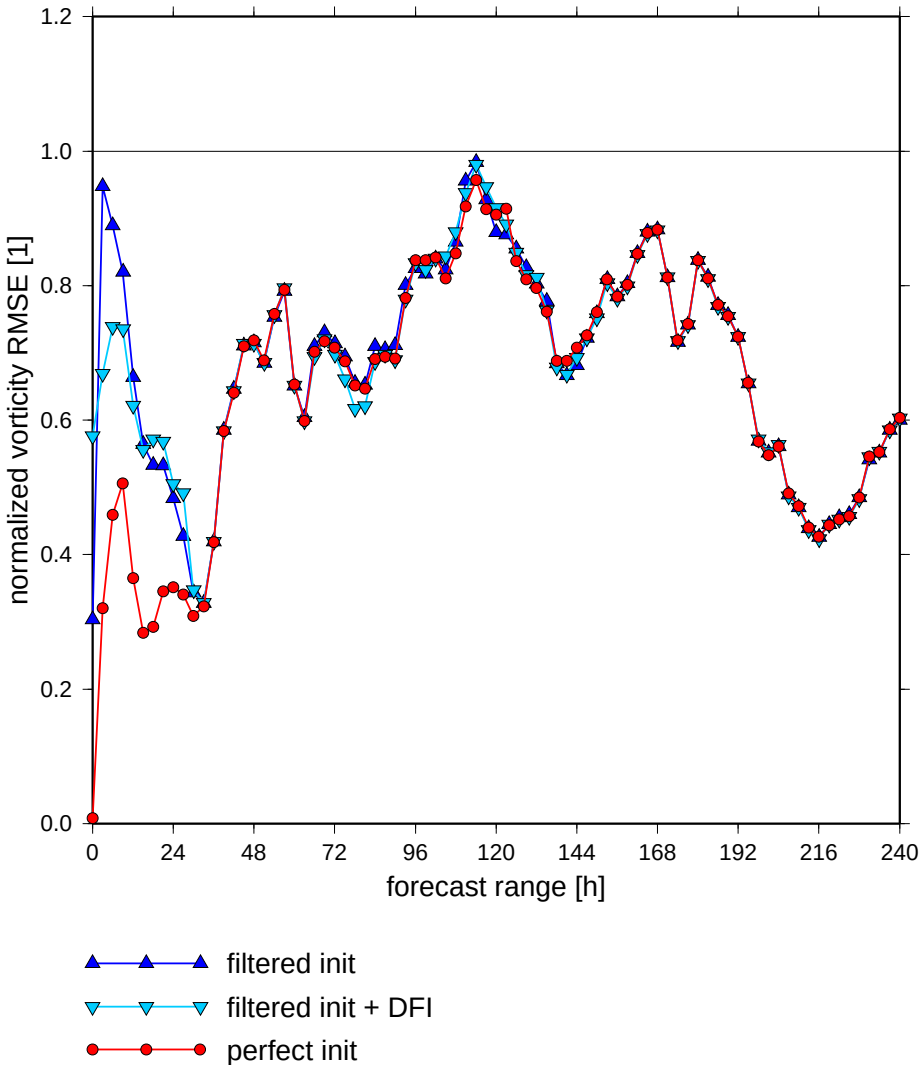
– perfect init
– coupling frequency 3 h



Sensitivity to initial state

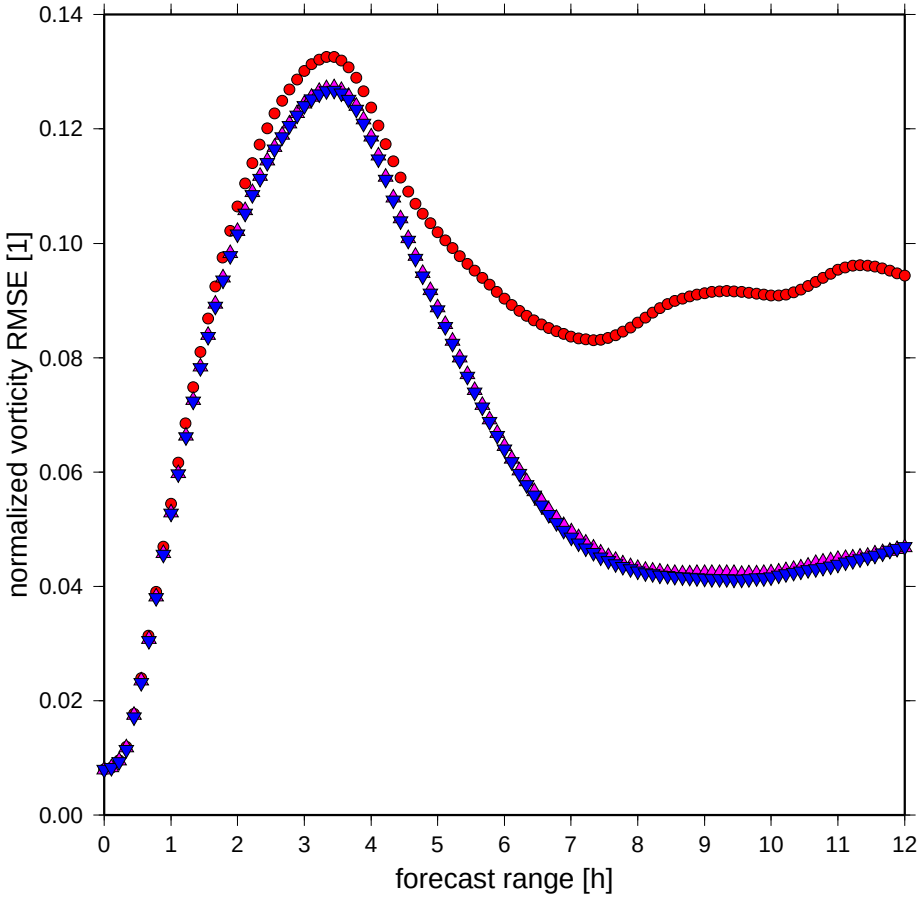
normalized vorticity RMSE
(at 500 hPa level)

– filtered LBC
– coupling frequency 3 h



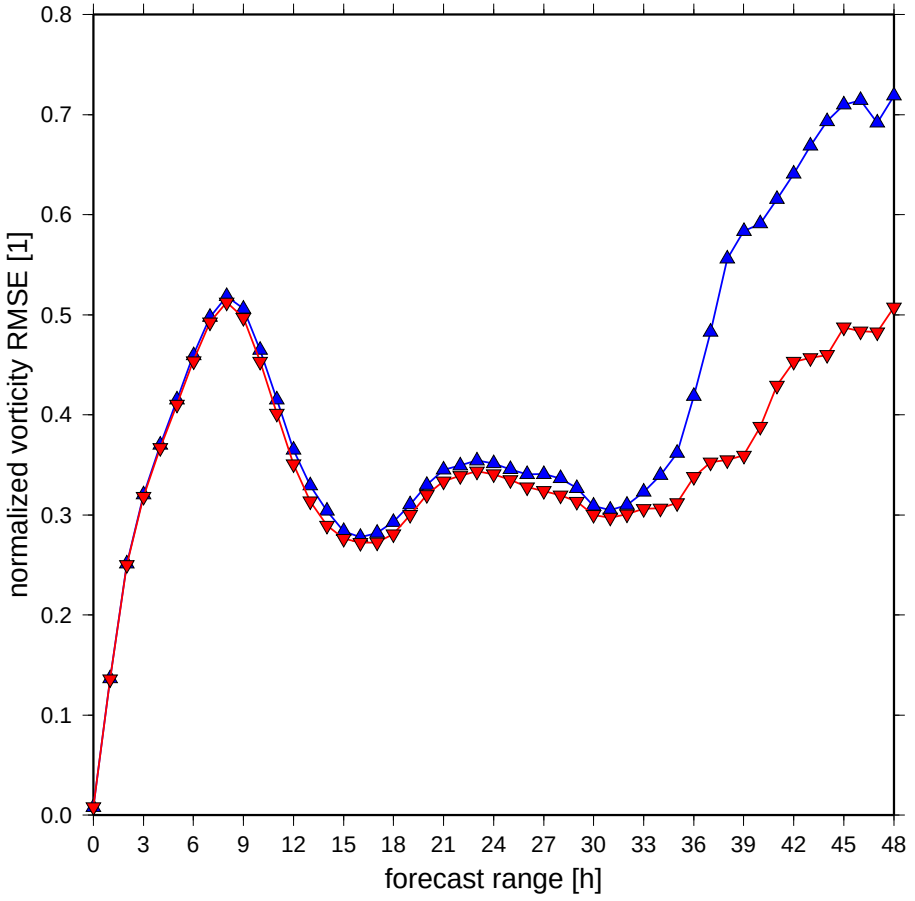
Sensitivity to coupling frequency

perfect init, perfect LBC



coupling frequency 3 h
coupling frequency 1 h
coupling frequency 1 timestep

perfect init, filtered LBC

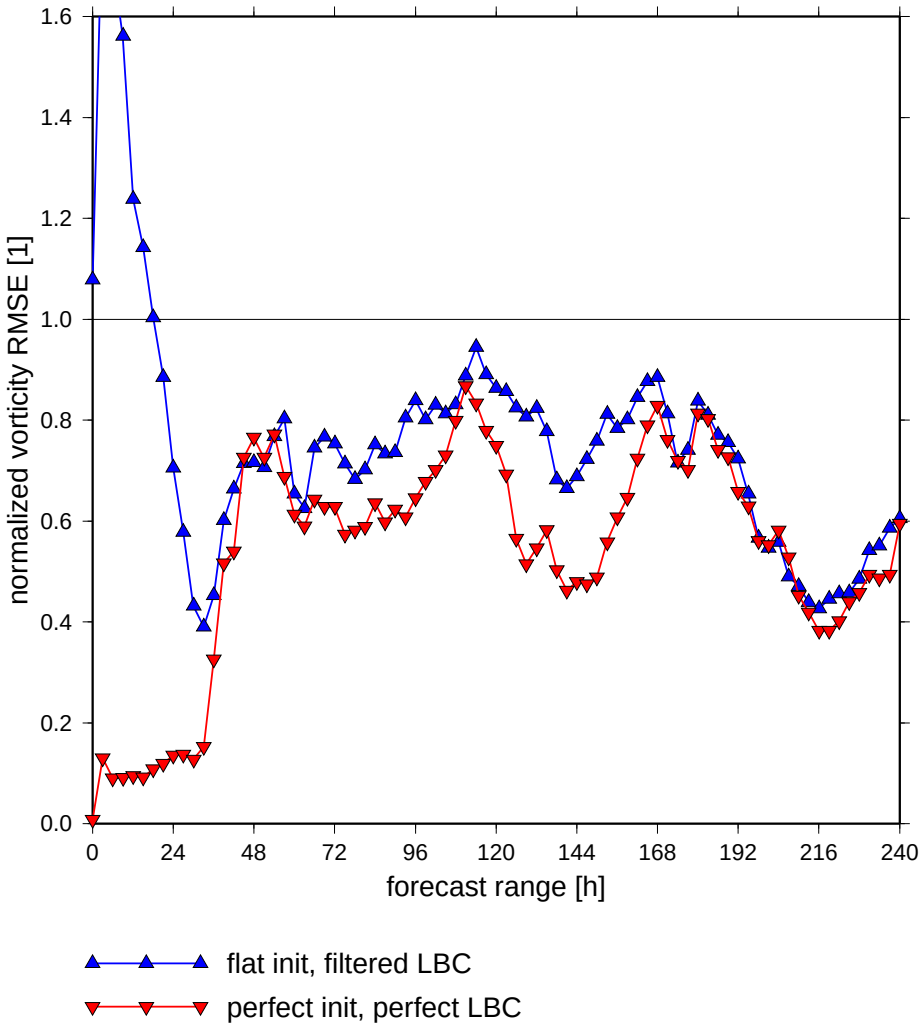


coupling frequency 3 h
coupling frequency 1 h

Two extreme cases – evolution of vorticity RMSE

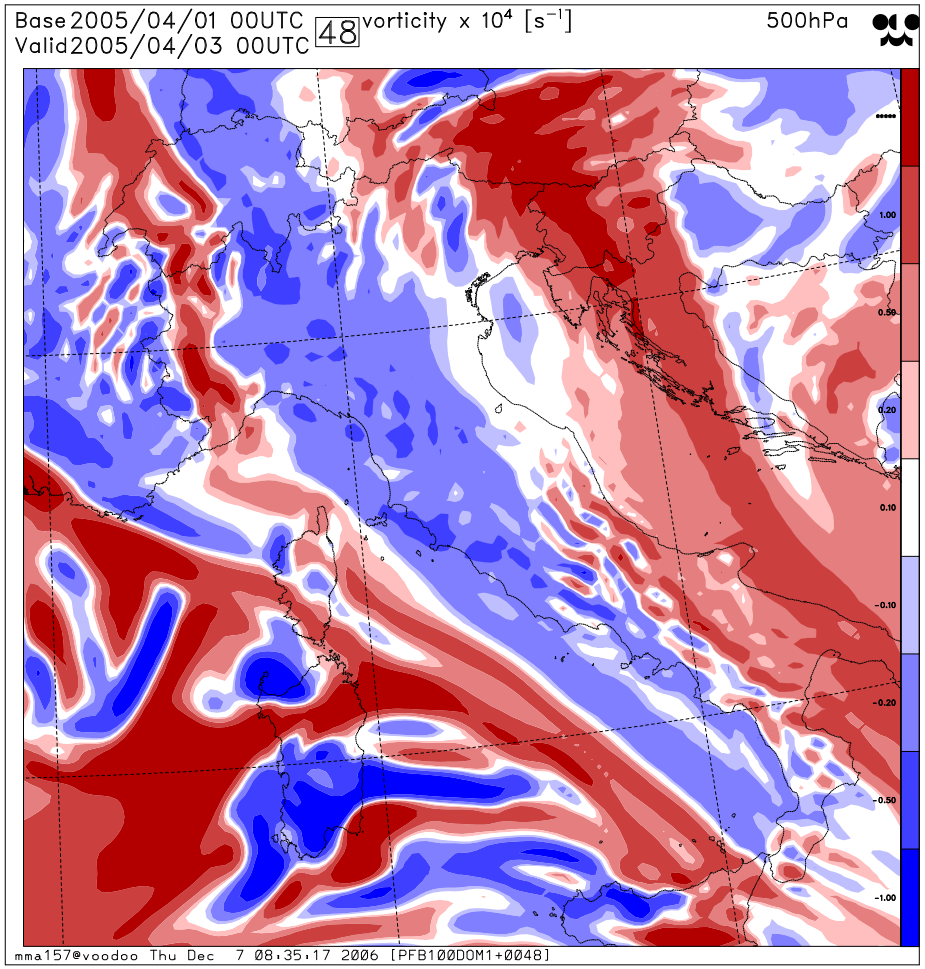
1) perfect init, perfect LBC (▼)

2) flat init, filtered LBC (▲)

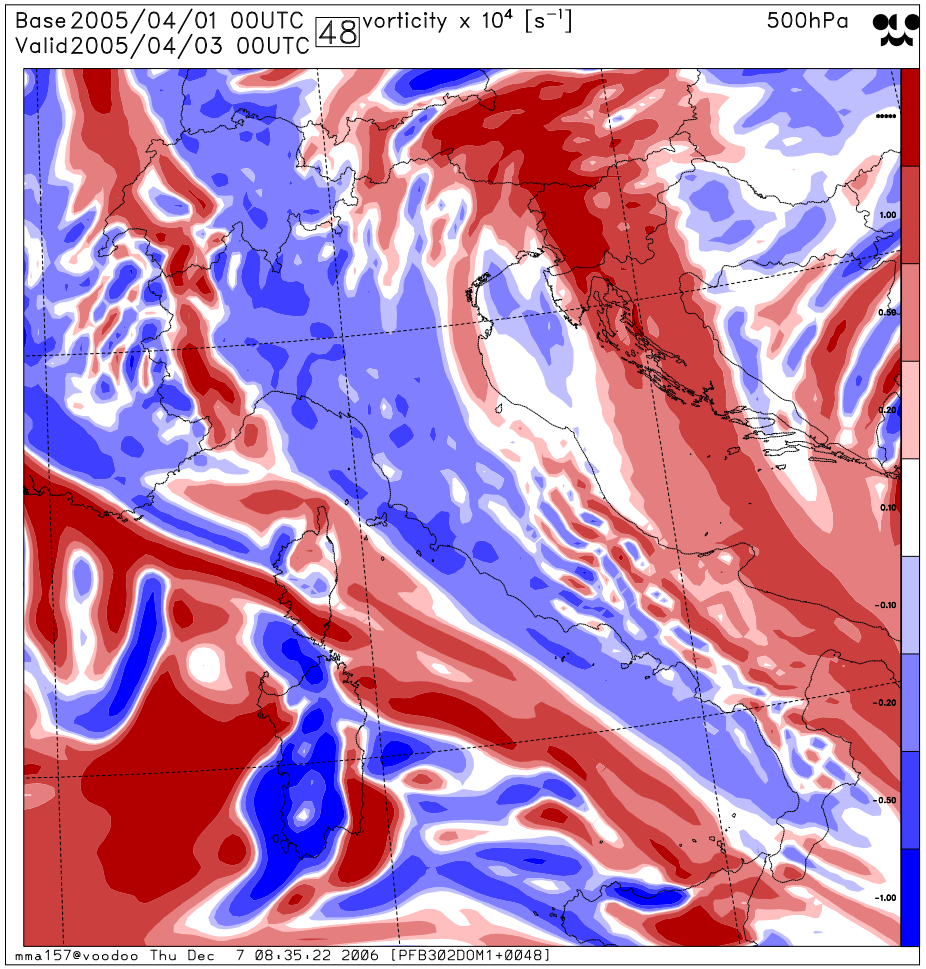


Two extreme cases – vorticity field after 48 hours

perfect init, perfect LBC



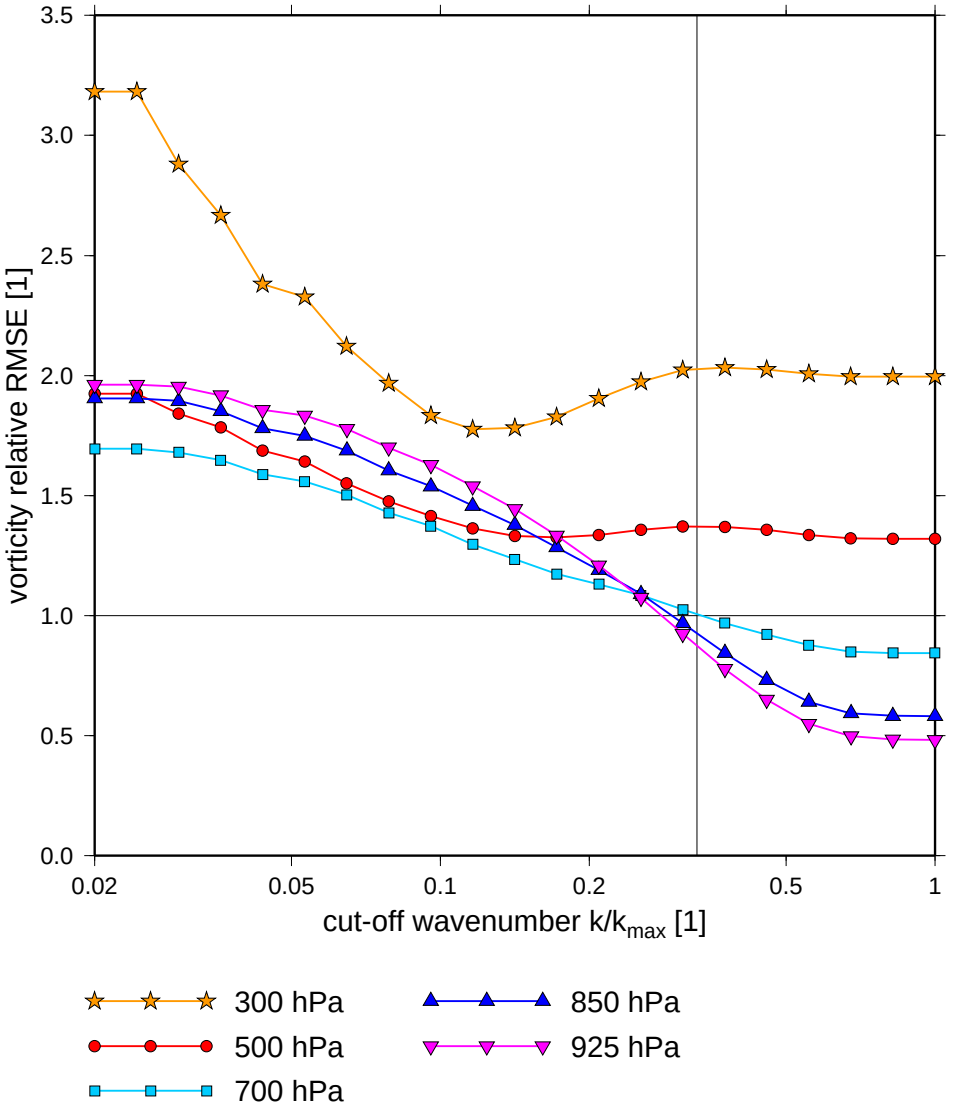
flat init, filtered LBC



Spectral composition of RMSE

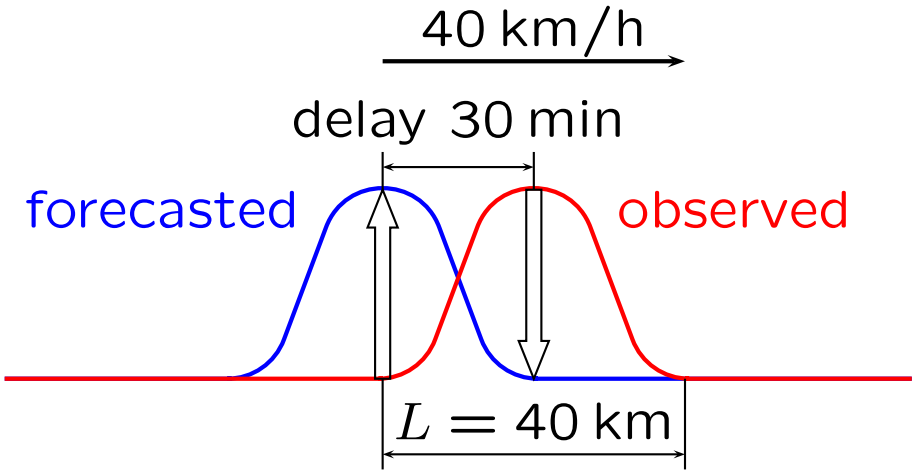
RMSE over forecast days 3-10
(relative to filtered LBC)

– perfect init
– filtered LBC
– coupling frequency 3 h



Note on forecast skill

- due to double penalty, RMSE is too strict measure of forecast skill
- on the plot below, mesoscale system resolved at $\Delta x = 10\,\text{km}$ and delayed by 30 min causes strong deterioration of RMSE score, but the forecast can be assumed almost perfect



- point interpretation of high resolution forecasts is problematic, still there can be useful information contained in short scales
- going to $\Delta x = 1\,\text{km}$, one does not expect accuracy in time 3 min!

Conclusions

- diagnostic tool for ALADIN lateral coupling is ready
- perfect model approach enables to isolate error caused by coupling scheme from other errors
- basic tests of Davies coupling in spectral LAM were carried out, illustrating most important limiting factors for LAM approach:
  - lack of predictive skill at higher levels, when measured by RMSE (long forecast lead times)
  - quality of initial state (short forecast lead times)
  - coupling frequency
- these results are not so interesting per se, since no competing scheme was evaluated
- field for testing new ideas is opened