Diagnostic tool for 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

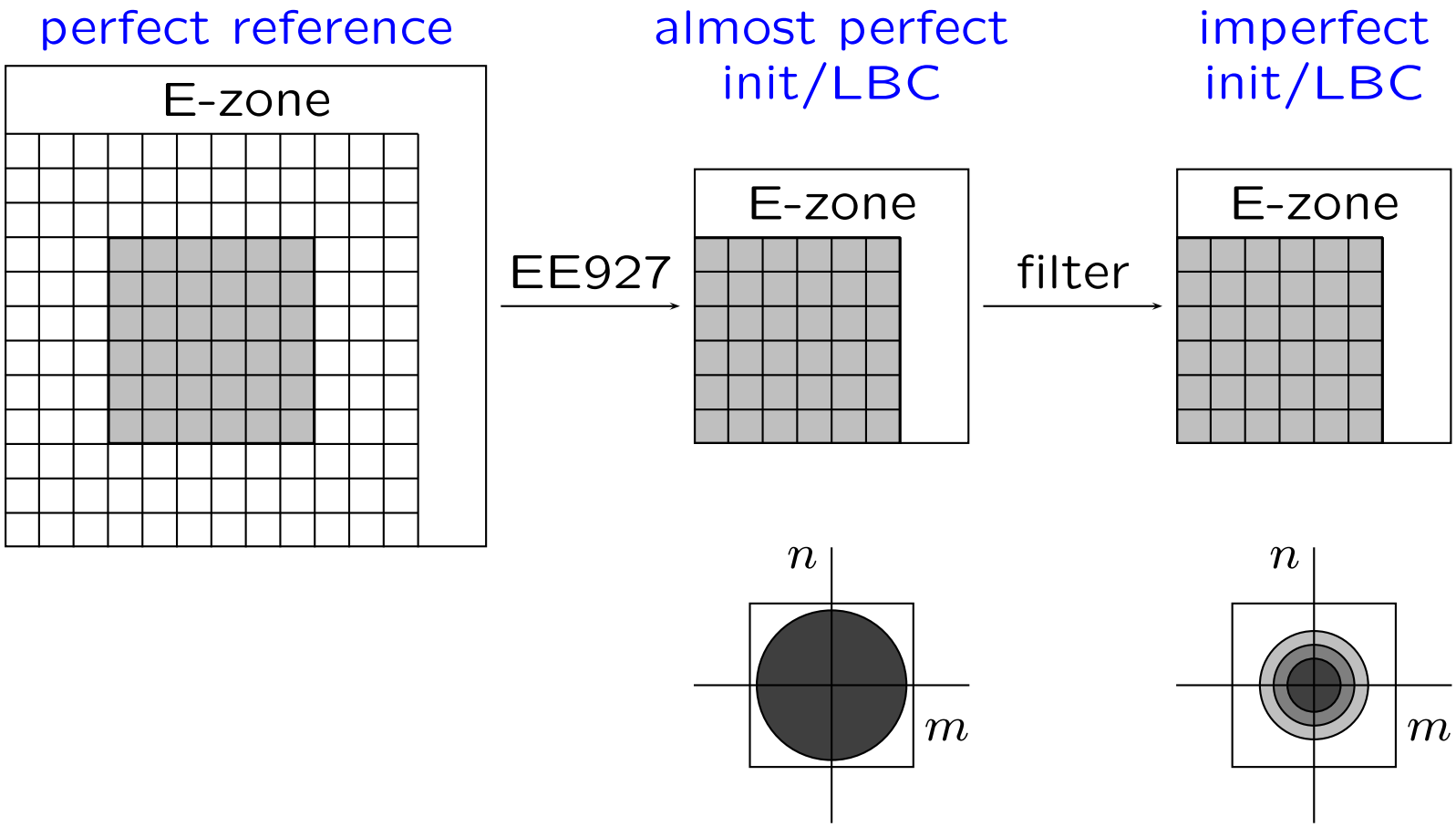
Underlying question

Can we beat Davies*?

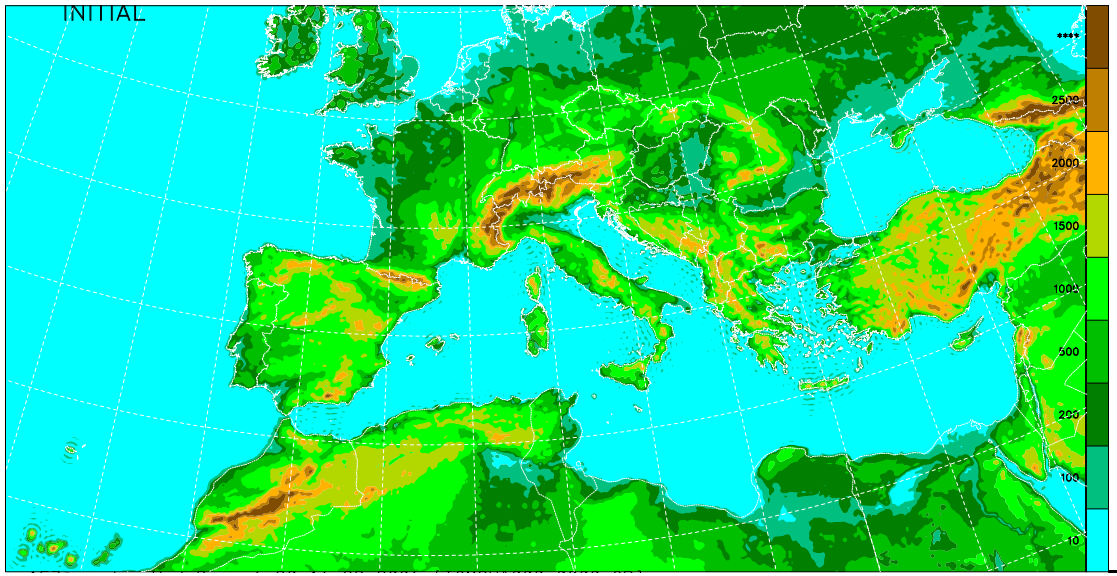
* Not Mr. Davies personally, but his miraculous coupling scheme.

Part I – design of diagnostic tool

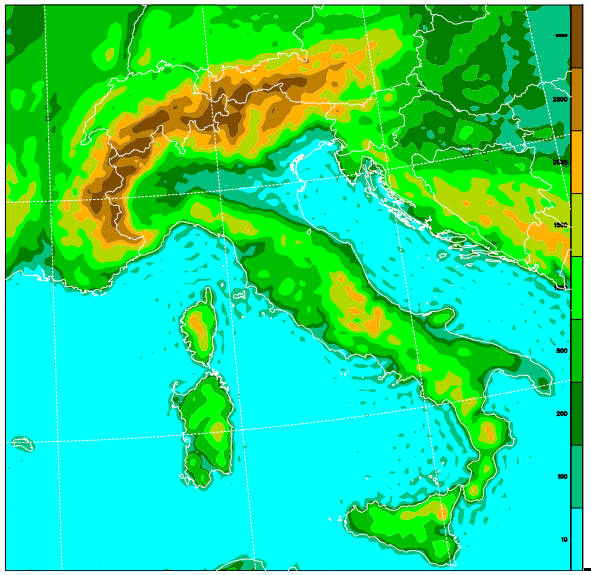
Perfect model approach



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 $\Delta t = 400\,\text{s}$

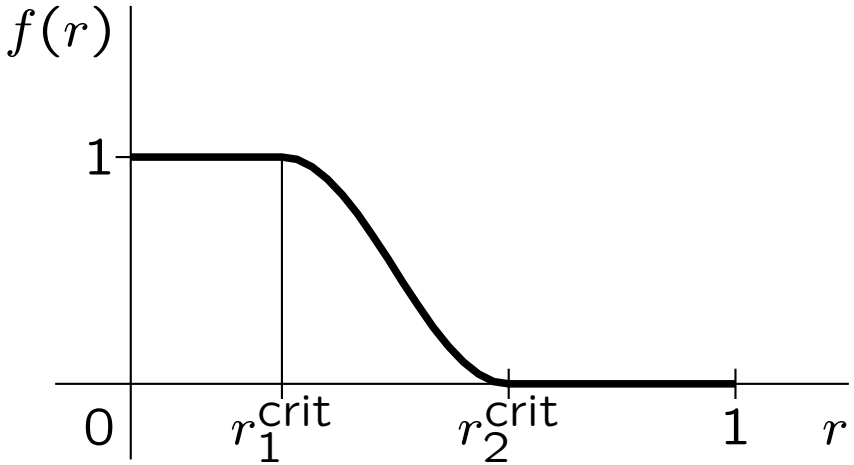
domain	C + I	C + I + E	truncation
MFST	589×309	600×320	299×159
DOM1	139×139	150×150	74×74

LBC filtering for nested LAM

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

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

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



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

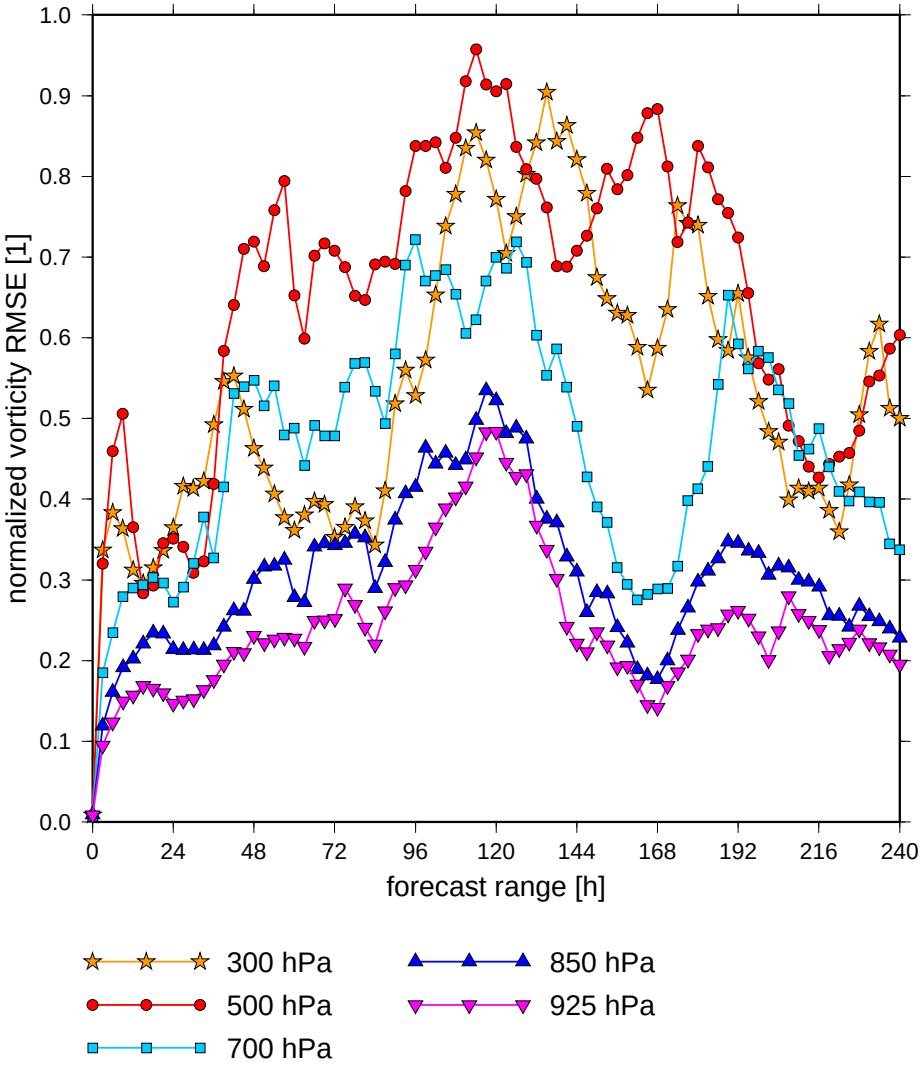
parameter:

vorticity ξ at 500 hPa level

scores:

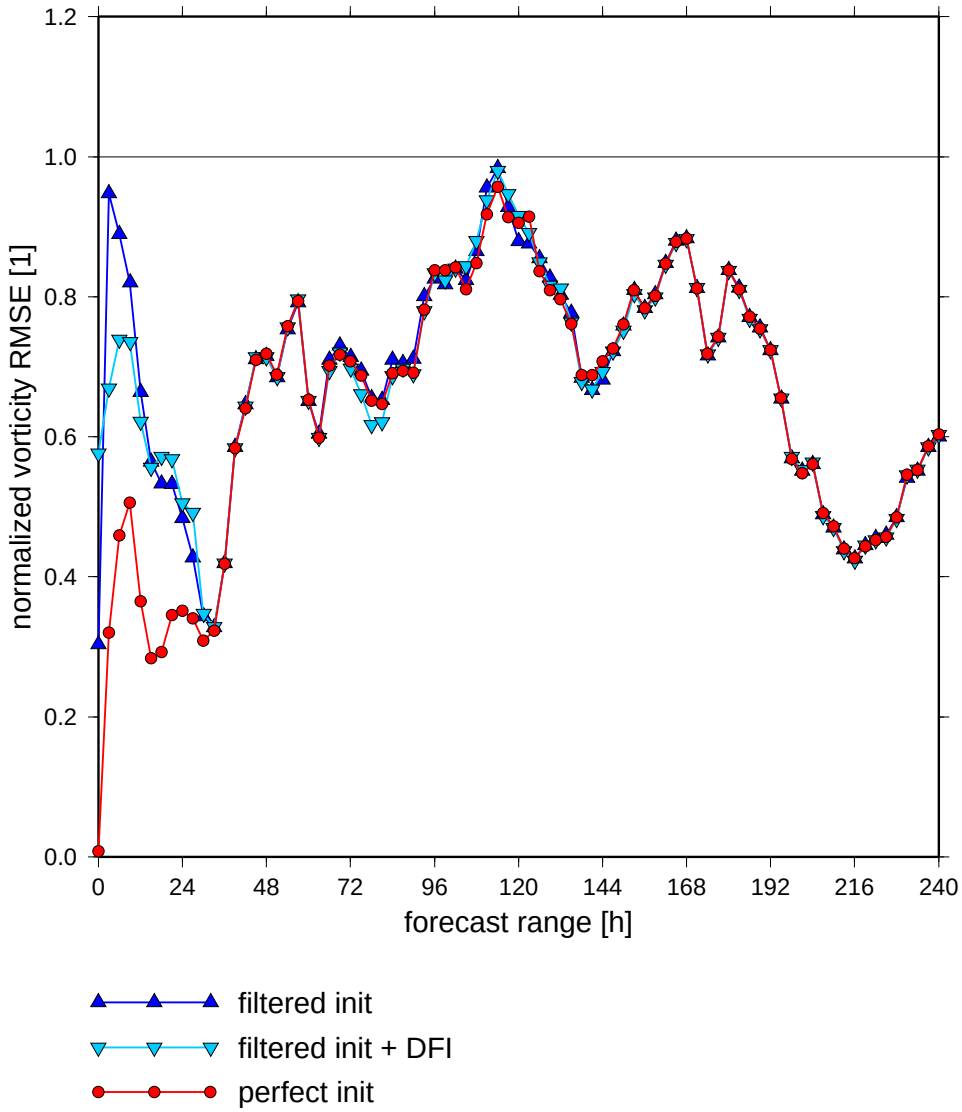
1) normalized SDEV $\frac{\sigma(\xi)}{\sigma(\xi_{\text{ref}})}$

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

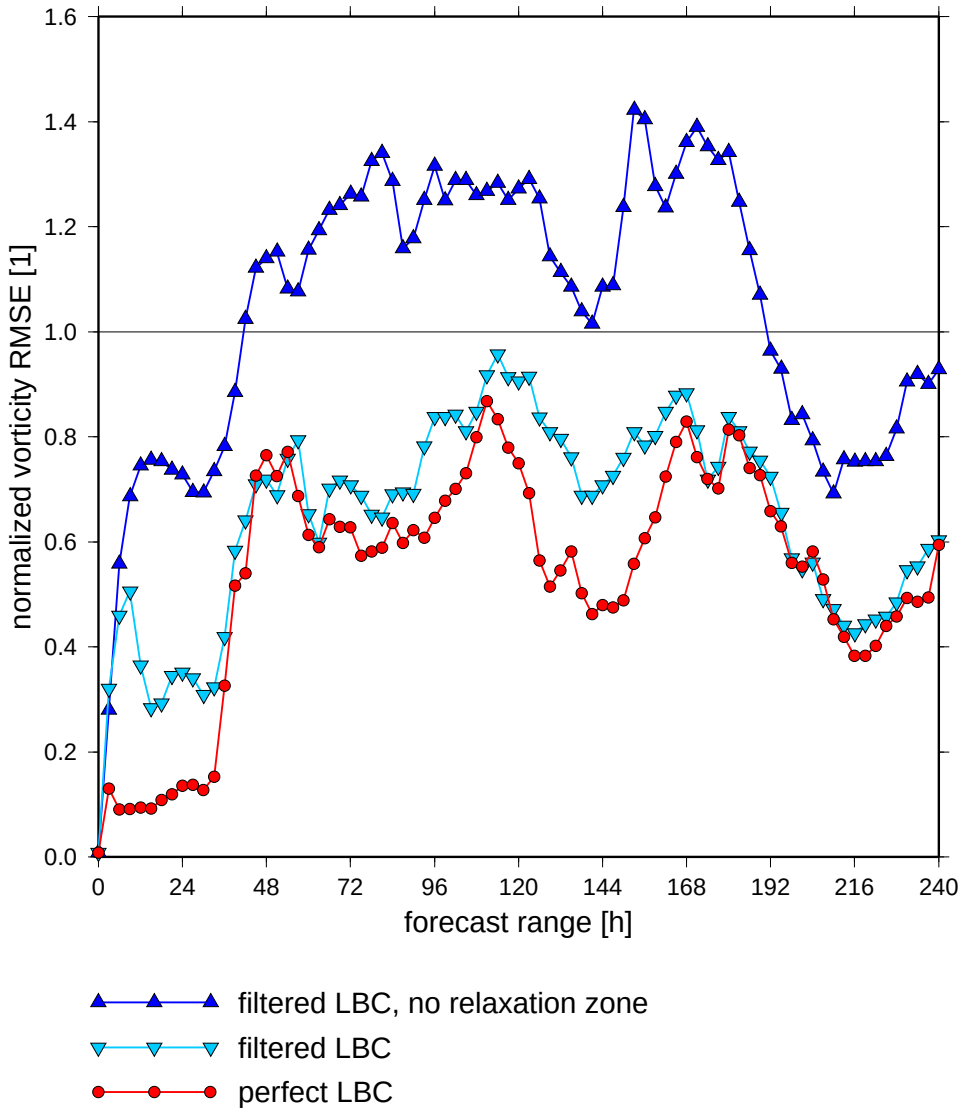


Part II – basic tests of Davies coupling

Sensitivity to initial state

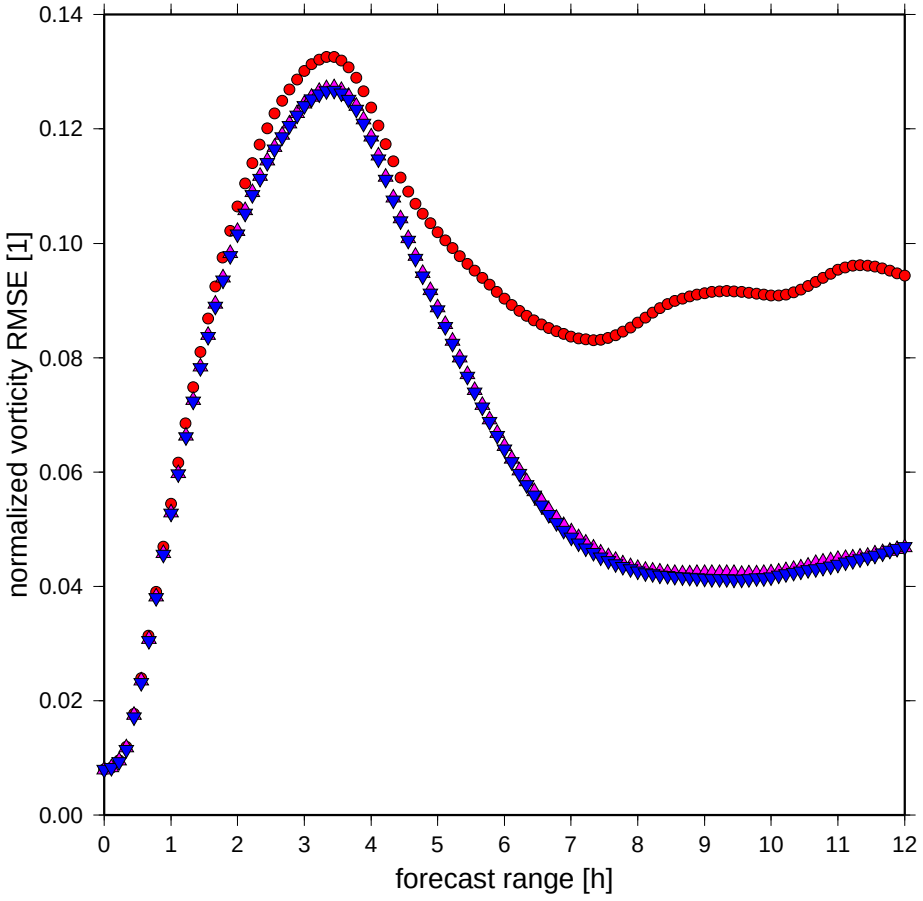


Sensitivity to LBC treatment



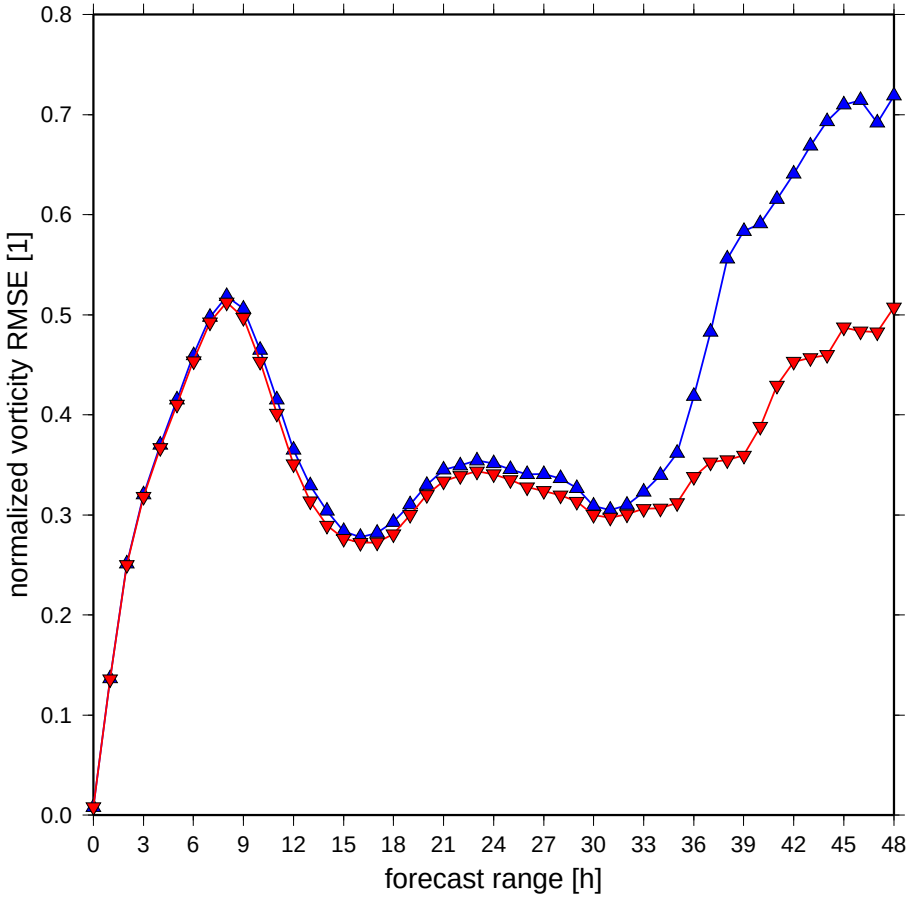
Sensitivity to coupling frequency

perfect LBC



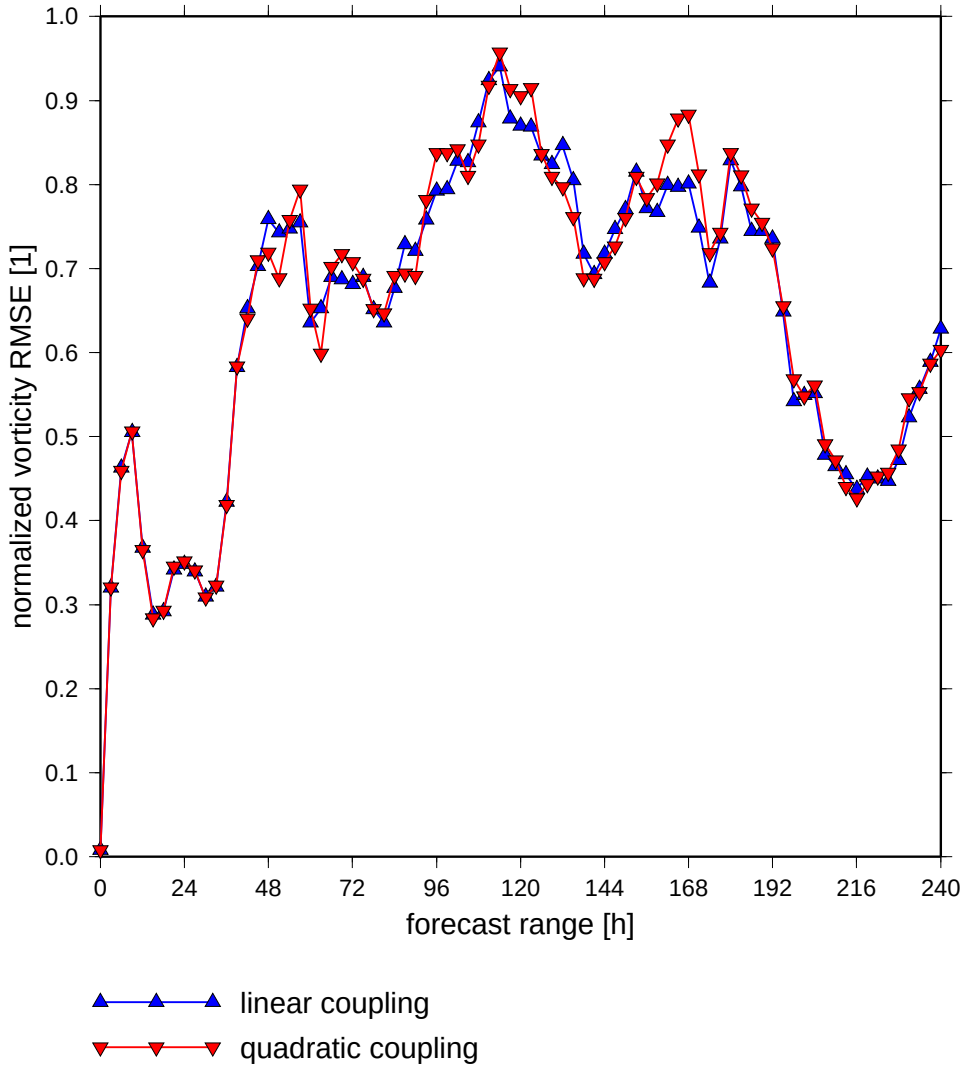
coupling frequency 3 h
coupling frequency 1 h
coupling frequency 1 timestep

filtered LBC



coupling frequency 3 h
coupling frequency 1 h

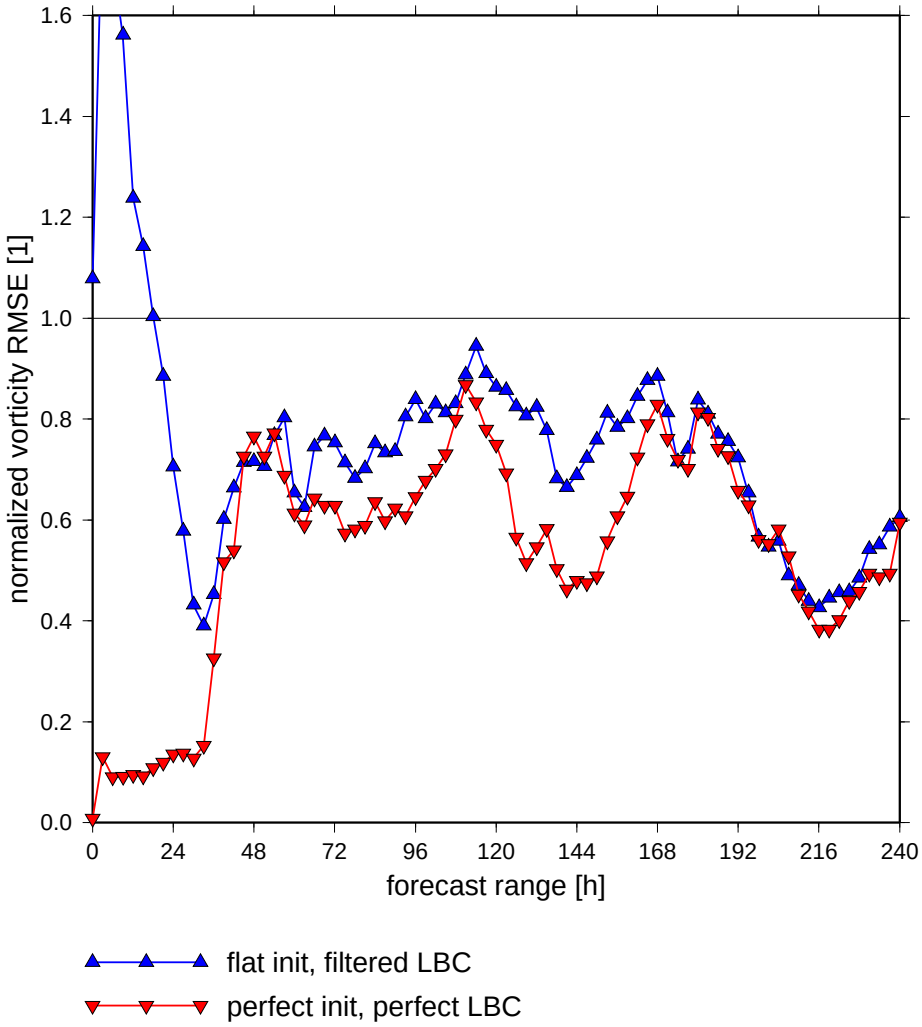
Quadratic versus linear interpolations in time



Two extreme cases – evolution of RMSE

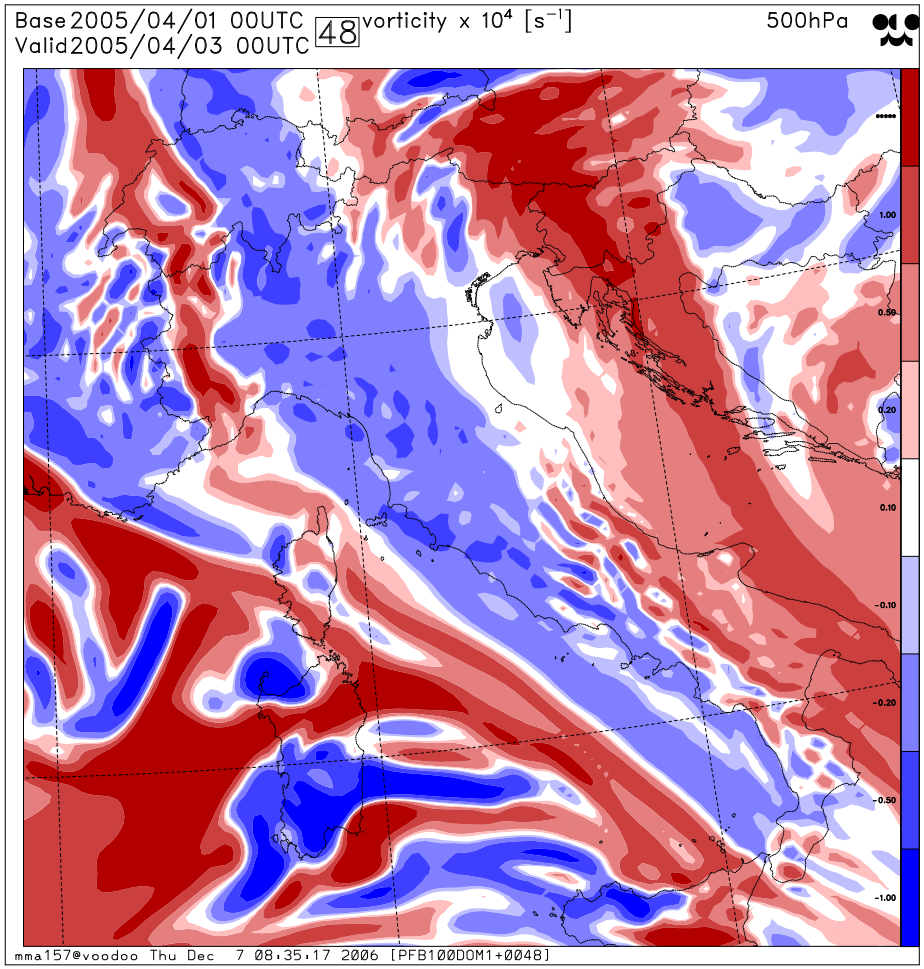
1) perfect init, perfect LBC

2) flat init, filtered LBC

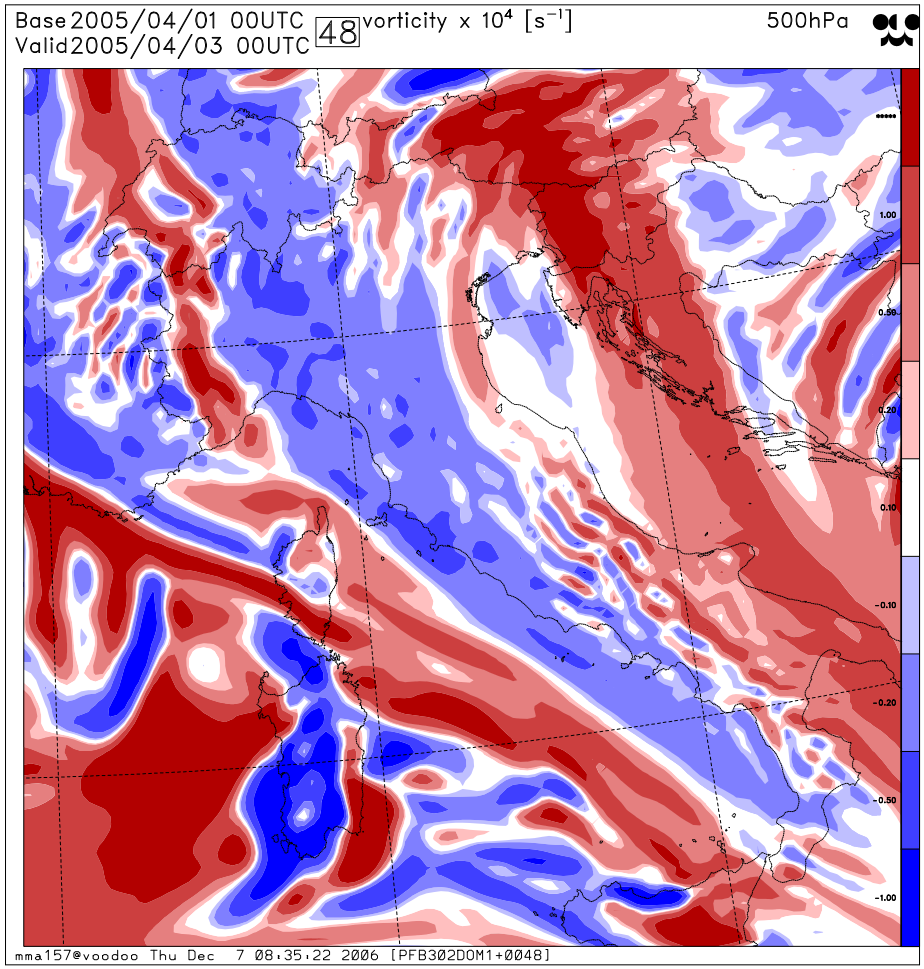


Two extreme cases – vorticity field after 48 hours

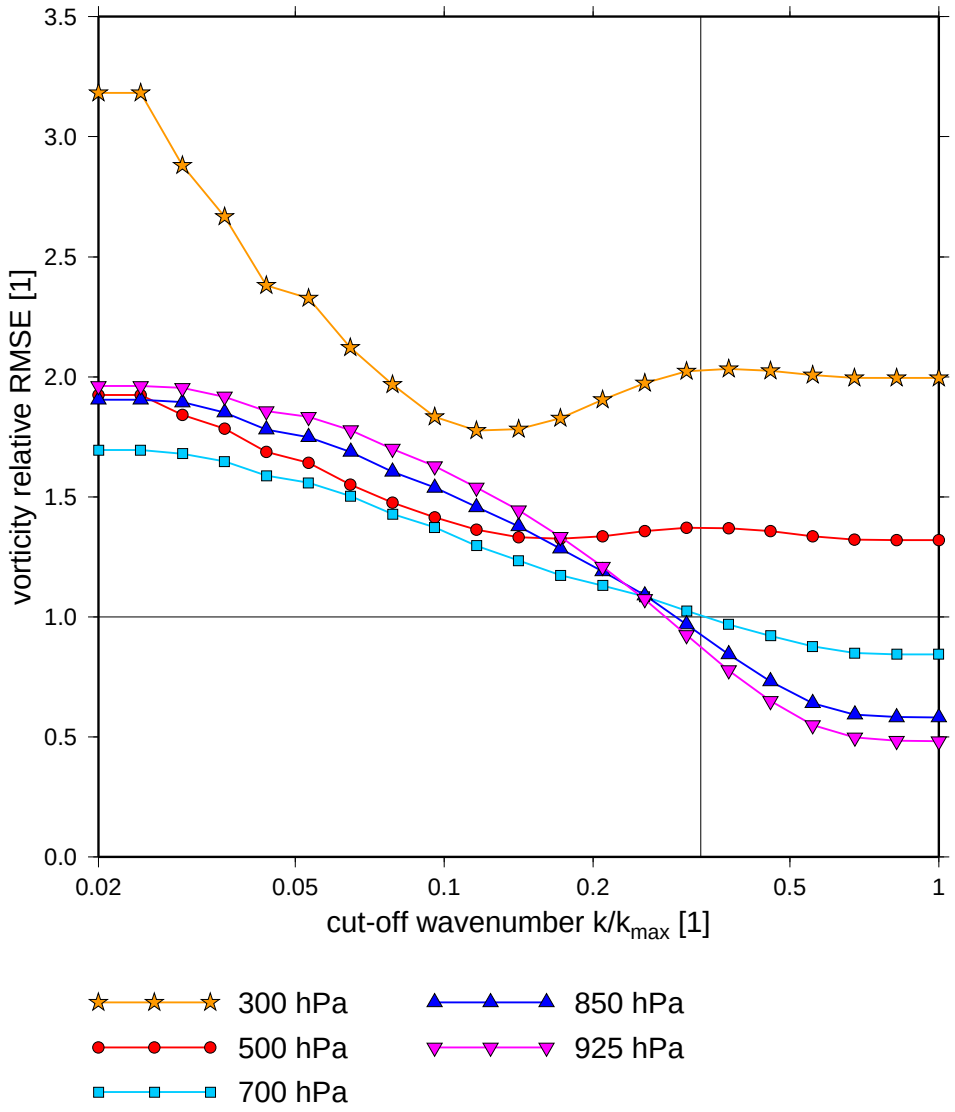
perfect init, perfect LBC



flat init, filtered LBC



Spectral composition of RMSE



Conclusions

- diagnostic tool for 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 (long forecast lead times)
  - coupling frequency
  - quality of initial state (short forecast lead times)
- these results are not so interesting per se, since no competing scheme was evaluated
- field for testing new ideas is opened

Additional info

More details can be found in stay report on RC LACE web page:

www.rclace.eu
→ Research areas
→ Dynamics and Coupling
→ Reports
→ 2006