RMI

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The implementation of Boyd's proposal in the HARMONIE system
(and other E-zone business)

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Context and content

- A spectral Limited Area Model requires
  - boundary conditions
  - periodization of the fields for the spectral transforms
- Currently, these issues are tackled with engineering solutions
- Boyd (2005) made a proposal to deal with these issues in a more rational way

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- Current solution
- Boyd's proposal
- Impact on operational scores
- Impact for Lothar storm
- Implementation in cy38

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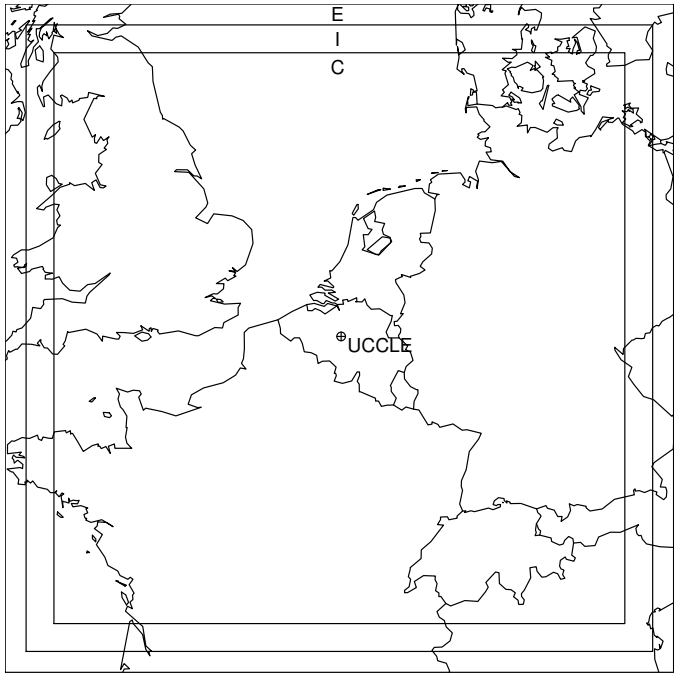
- Implementation in cy38
- Bonus: running without the E-zone

Current solution

- Domain organization: $C + I + E$



- Relaxation in I with power function

$$\alpha(z) = (p+1)z^p - pz^{p+1}$$

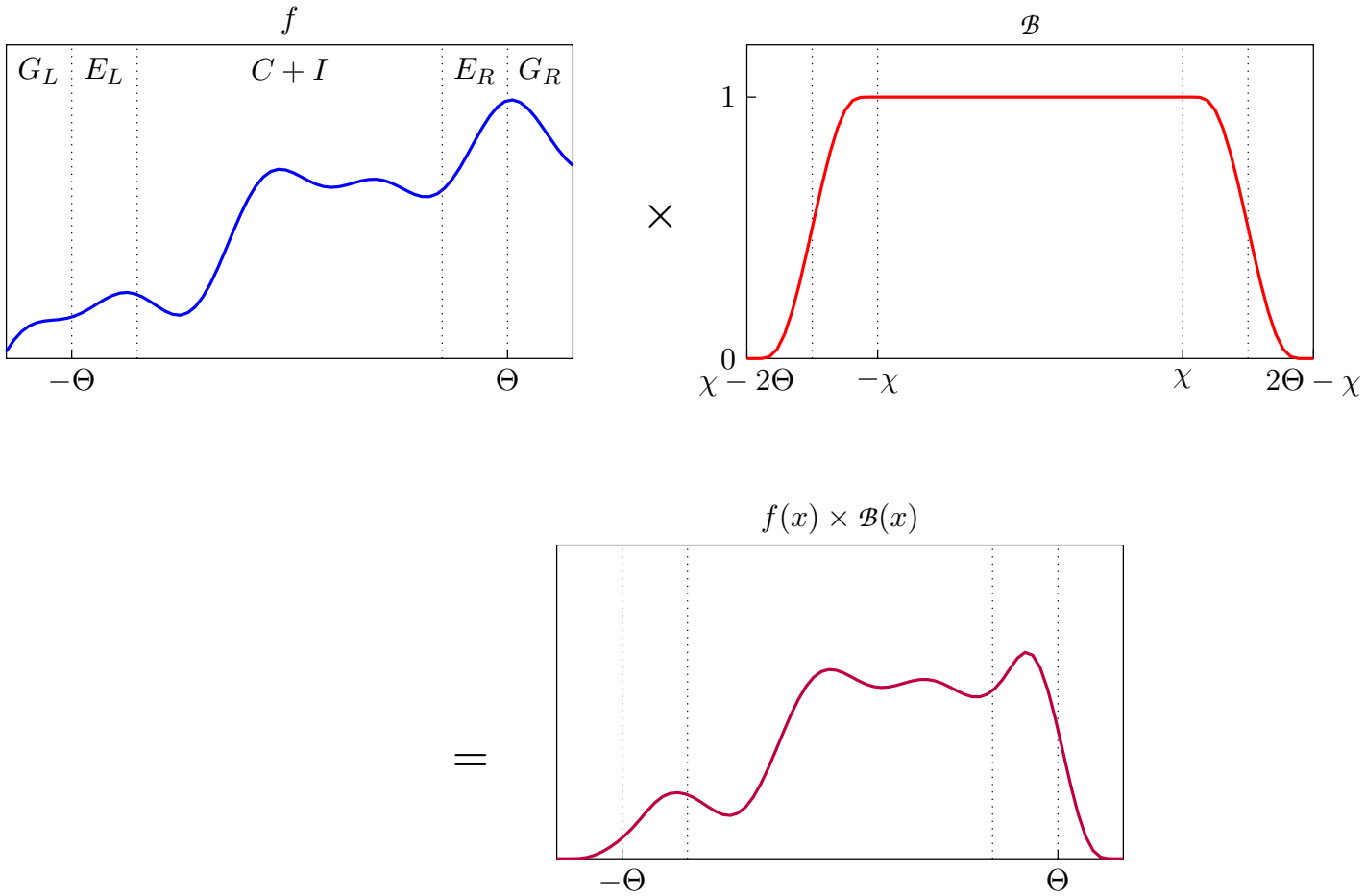
with p a tunable parameter

- Periodization in E with cubic splines + transversal smoothing

Boyd's proposal: periodization

Two-step procedure

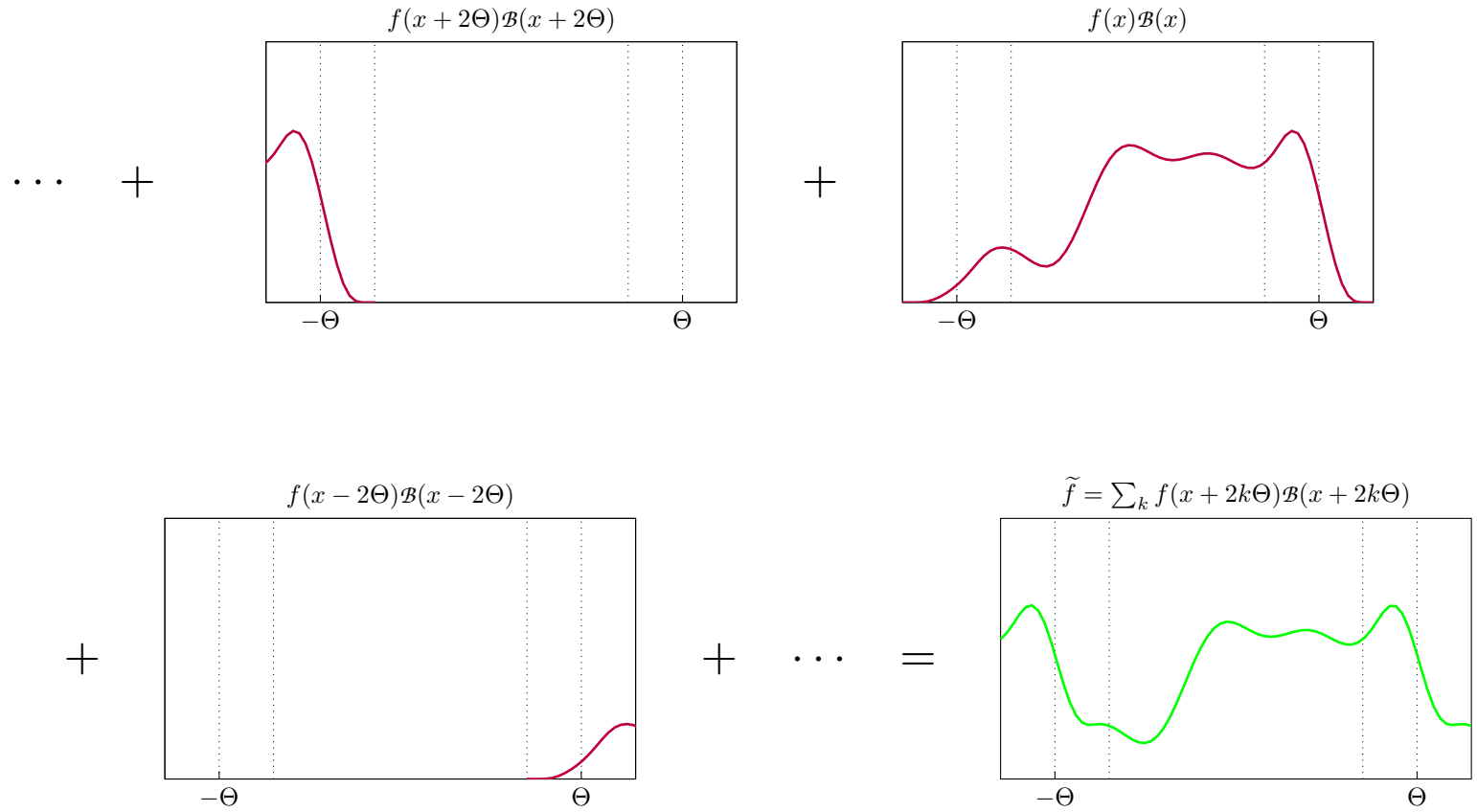
1. Multiply with a bell window



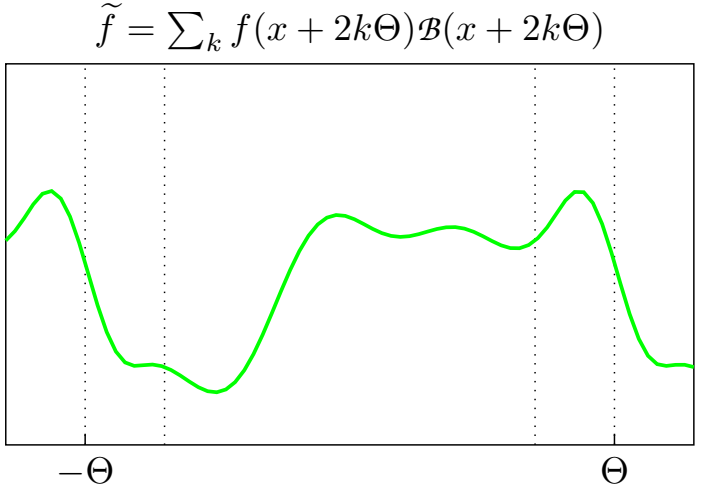
Boyd's proposal: periodization

Two-step procedure

1. Multiply with a bell window
2. Summation of series of shifted products



Boyd's proposal: periodization



Remarks:

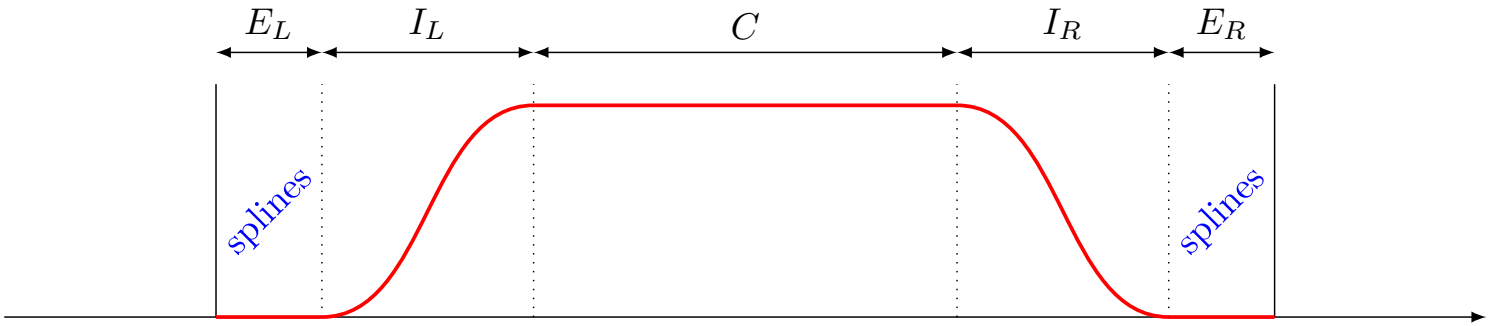
- Boyd's method requires data from outside the periodization interval, but this is no problem since we couple to a *global* model
- The bell window is "infinitely smooth":

$$\mathcal{B}(z) = \frac{1}{2} + \frac{1}{2}\mathrm{erf}\left(\frac{Lz}{\sqrt{1-z^2}}\right), \qquad \text{with } z \in (-1,1) \text{ inside the } E\text{-zone}$$

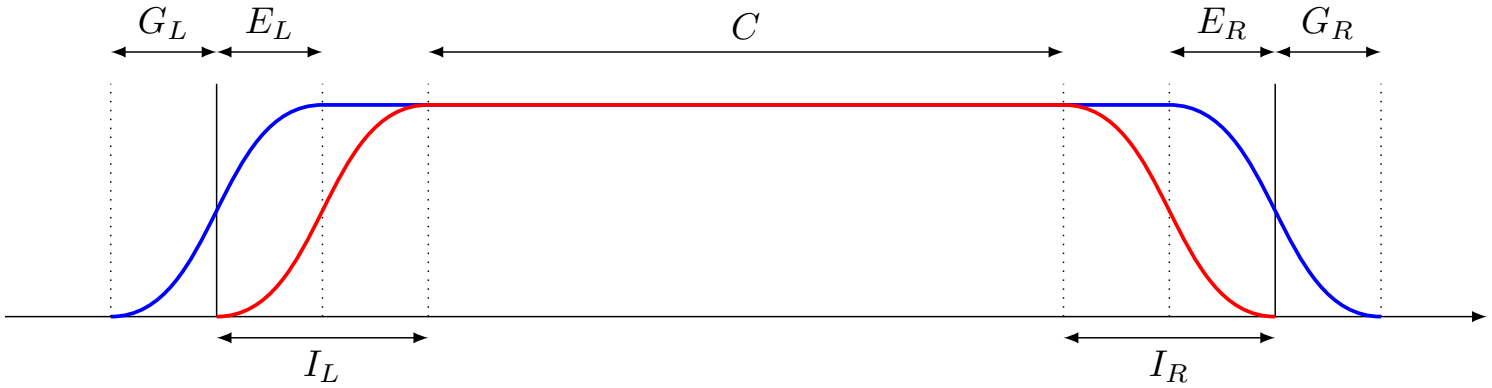
- This should lead to a faster decay of the Fourier spectrum
- The use of physical information near the boundaries should improve the semi-Lagrangian trajectories

Boyd's proposal: relaxation

- Relaxation with the same erf-based bell window
- Domain organization with overlap between E-zone and I-zone:



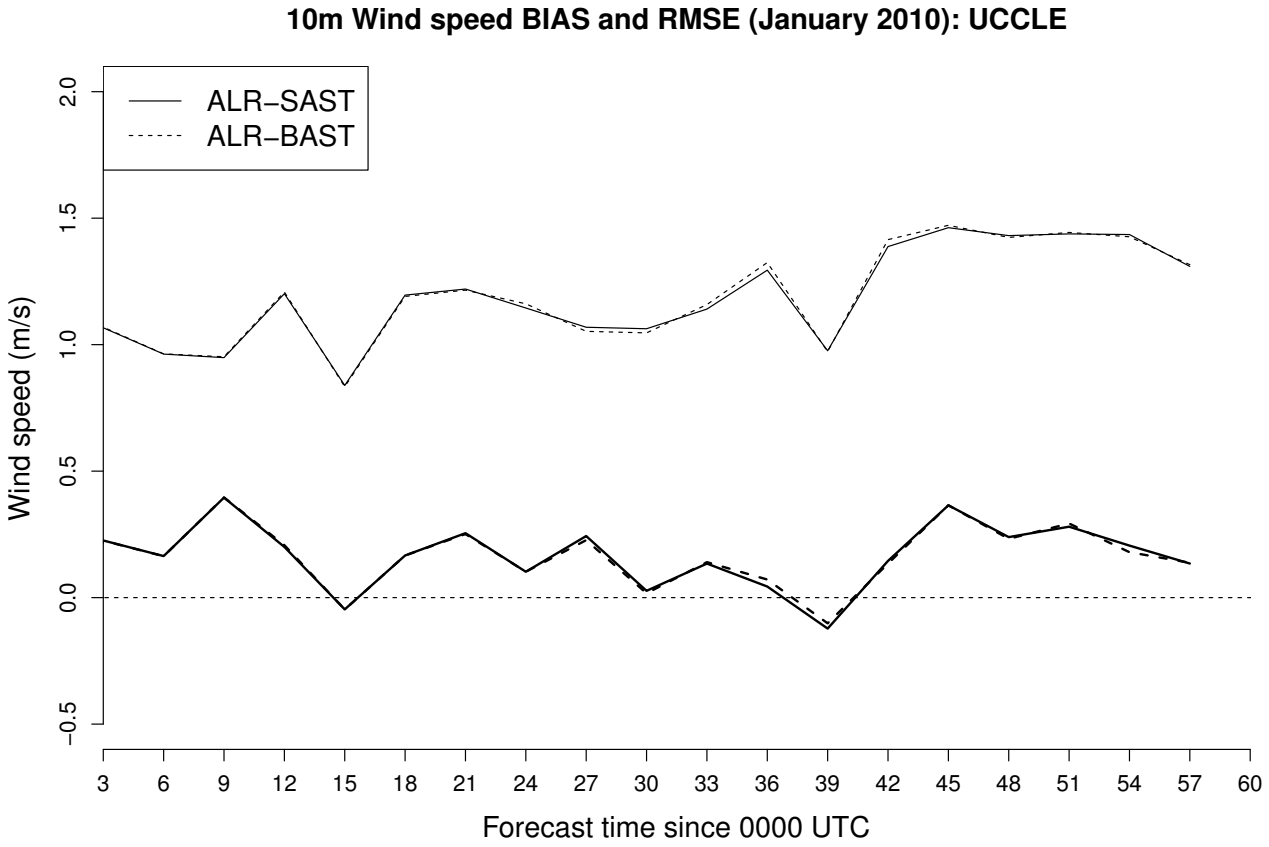
Current ALADIN domain



Boyd's proposal

Operational scores

Verification over Belgium for January 2010, ALARO physics:



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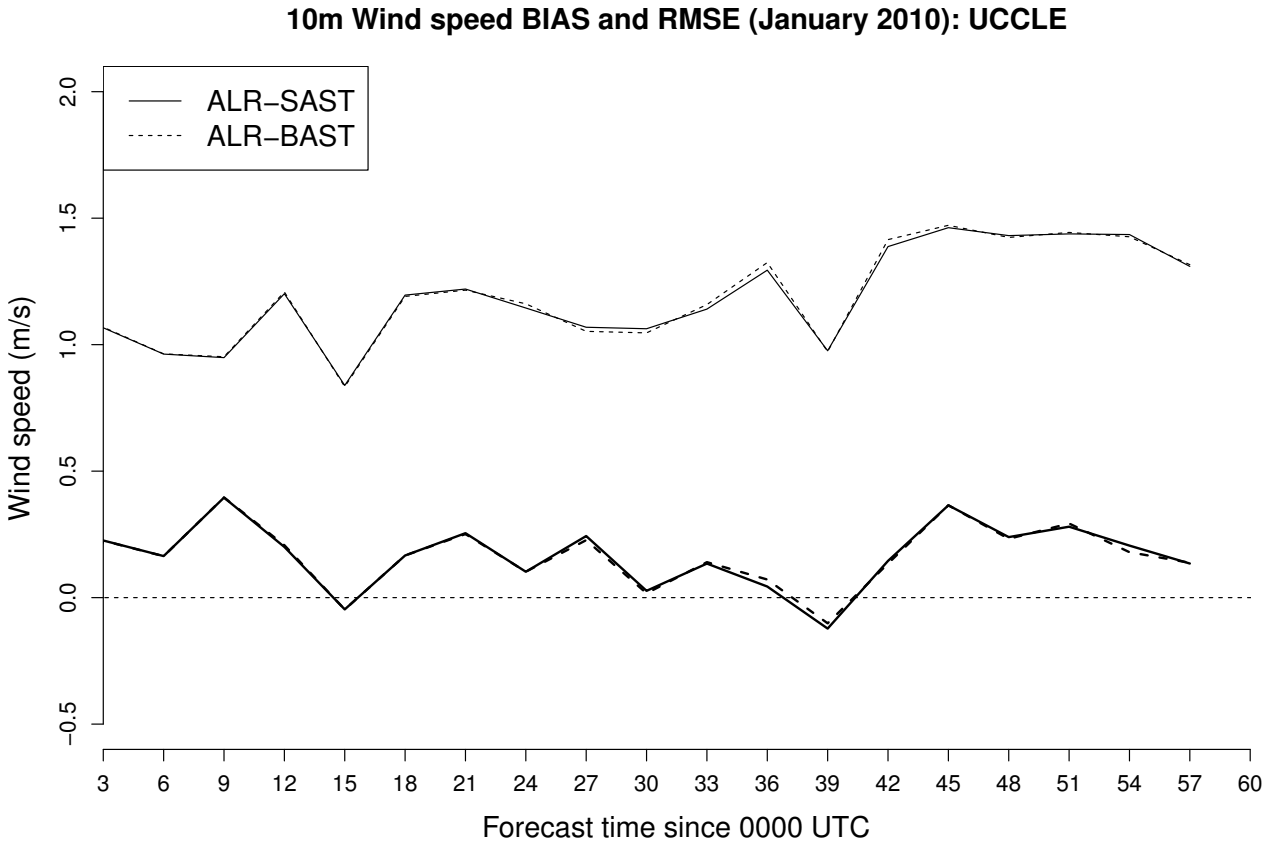
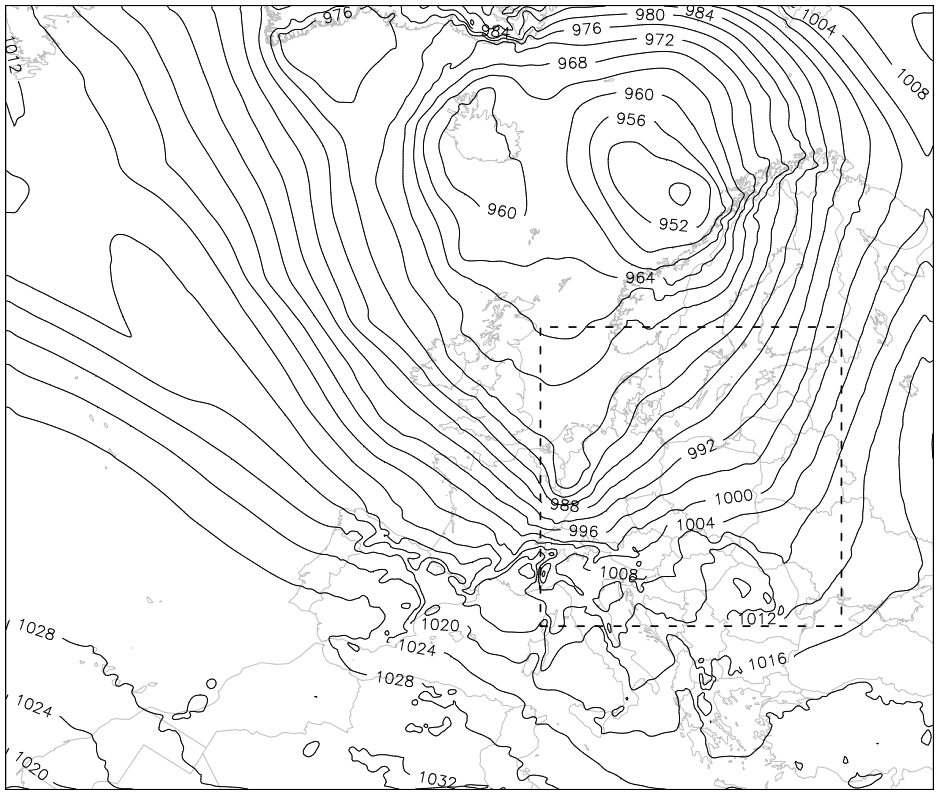


Also for other verification periods and other variables, the difference is minimal, *despite the theoretical superiority of Boyd's proposal*

Lothar storm case: experiment setup

We performed a 'perfect model' experiment for the Lothar storm case (1999/12/26):

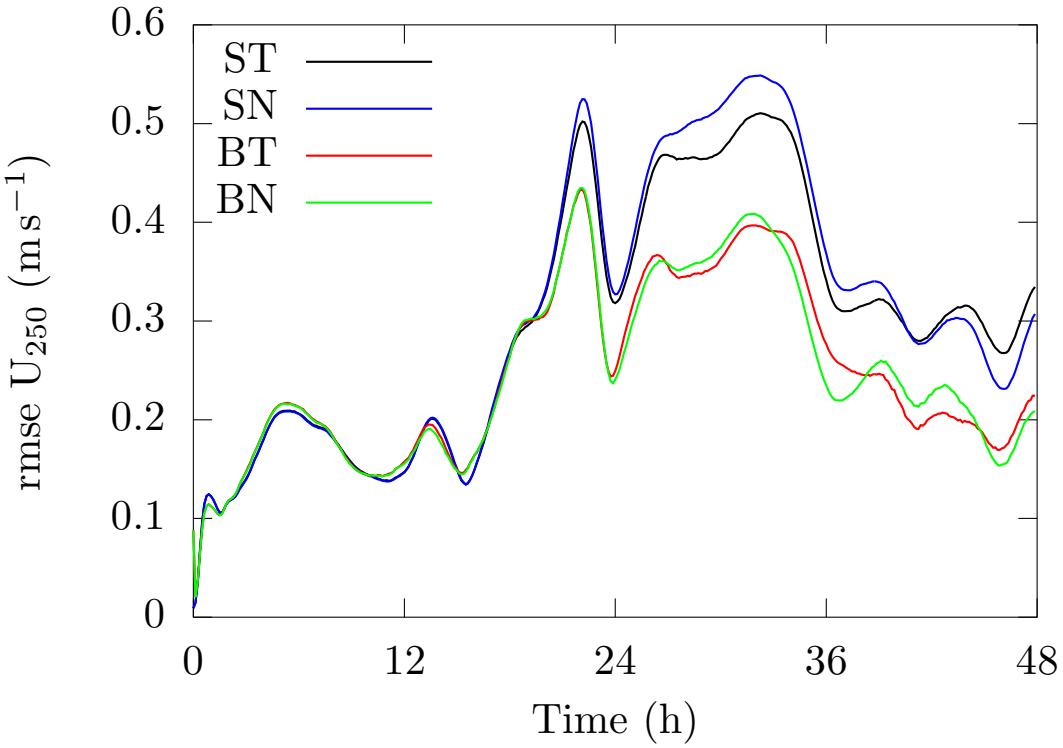
- Host run at 10km
- Guest run on subgrid of host run
- Same timesteps, dynamics, physics for both runs
- Coupling every timestep



Hence all differences between guest and host are due to periodization and relaxation.

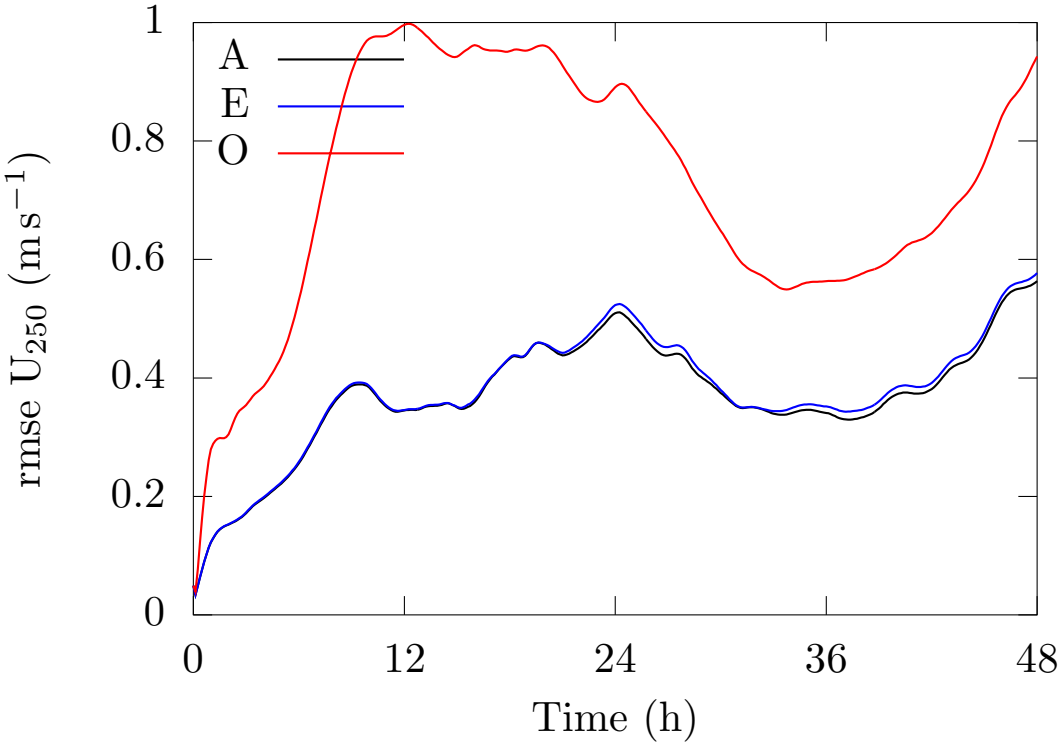
Lothar storm case: results

- Periodization: **S**plines/**B**oyd; **T**runcated/**N**on-truncated SL trajectories



Lothar storm case: results

- Periodization: **S**plines/**B**oyd; **T**runcated/**N**on-truncated SL trajectories
- Relaxation: **A**ladin/**E**rf/**O**verlapped



Lothar storm case: results

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So:

- In case of a strong forcing, Boyd's method outperforms spline periodization.
- Truncation of semi-Lagrangian trajectories is not necessary when using Boyd's method.
- The tuned relaxation function of Aladin is quite good.
- Overlapping is not such a good idea for our semi-Lagrangian model.

Implementation

- Boyd periodization is phased in cy38t1
- Specification during e(e)927:

```
&YOMFPC
  LFPBOYD=.TRUE.,
/
&YOMFPD
  NFPBWX=11,
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- The final domain will be a bit smaller than the one specified with `NFPLUX/NFPGUX`

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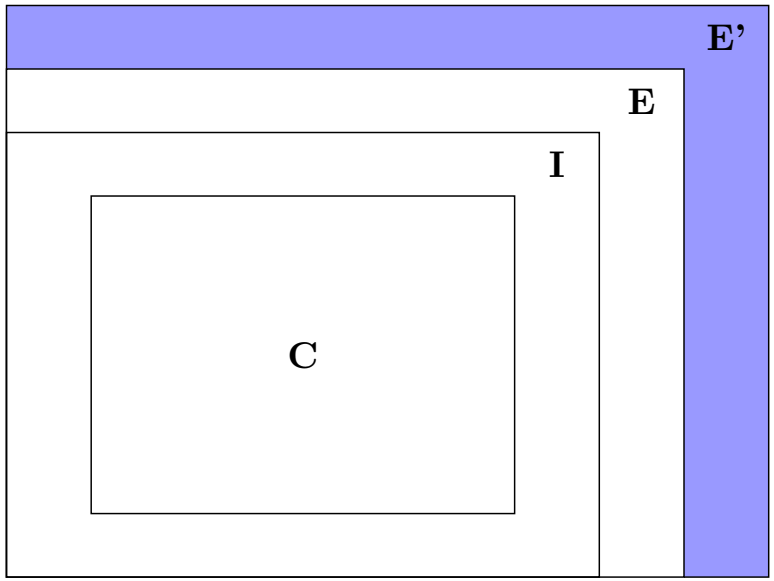
So there is no reason to do badly what can be done well !

Running without the E-zone

- Currently, gridpoint calculations are carried out unnecessarily in the E-zone
- Mariano Hortal made a proposal to avoid this, by doing the periodizations (with splines) *during the run, as a part of the spectral transforms*
- In order not to break functionality, Ryad El Khatib proposed to put this feature in a separate E'-zone, which is invisible to the gridpoint part of the model.

  The domain organization now looks like



where in practice, either $E = 0$ or $E' = 0$.

Running without the E-zone

- Implementation in cy38t1:

```
&NAMFPD                    &NEMDIM
  NFPNOEXTZL=11,             NNOEXTZL=11,
  NFPNOEXTZG=11,             NNOEXTZG=11,
/                          /
```

Running without the E-zone

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/                          /
```
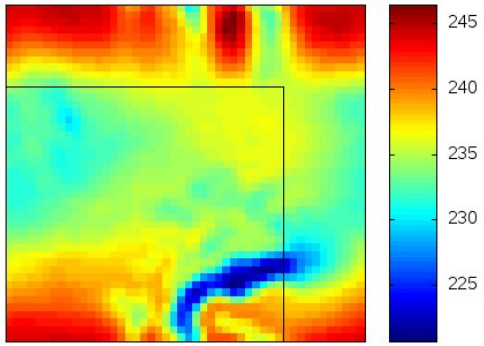
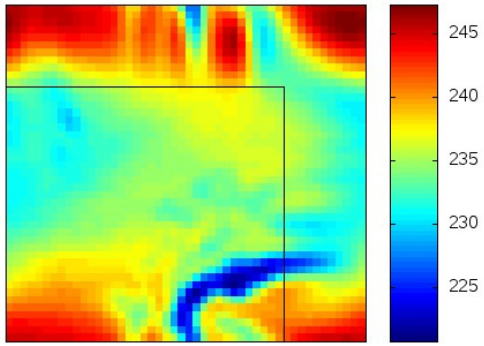
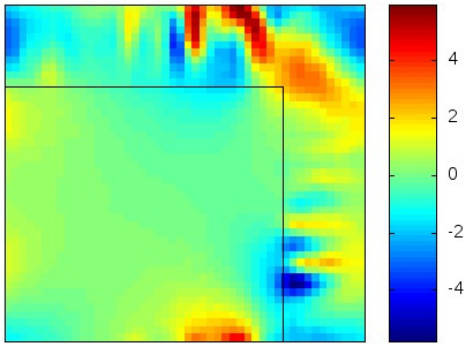

- Preliminar results: temperature difference between run with E and run with E' after one timestep:



E-zone



E'-zone



difference

These large (!) differences are due to

- Recalculation of splines for every transform
- Lacking of transversal smoothing

Running without the E-zone

Possible solutions:

- Coupling to vorticity and divergence instead of to wind speeds.
- Coupling in spectral space

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... to be continued ...

Thank you !