

Boyd's periodisation and relaxation for spectral LAMs

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and Piet Termonia



Outline talk

The idea of Boyd

3D perfect model tests

What now? Conclusion

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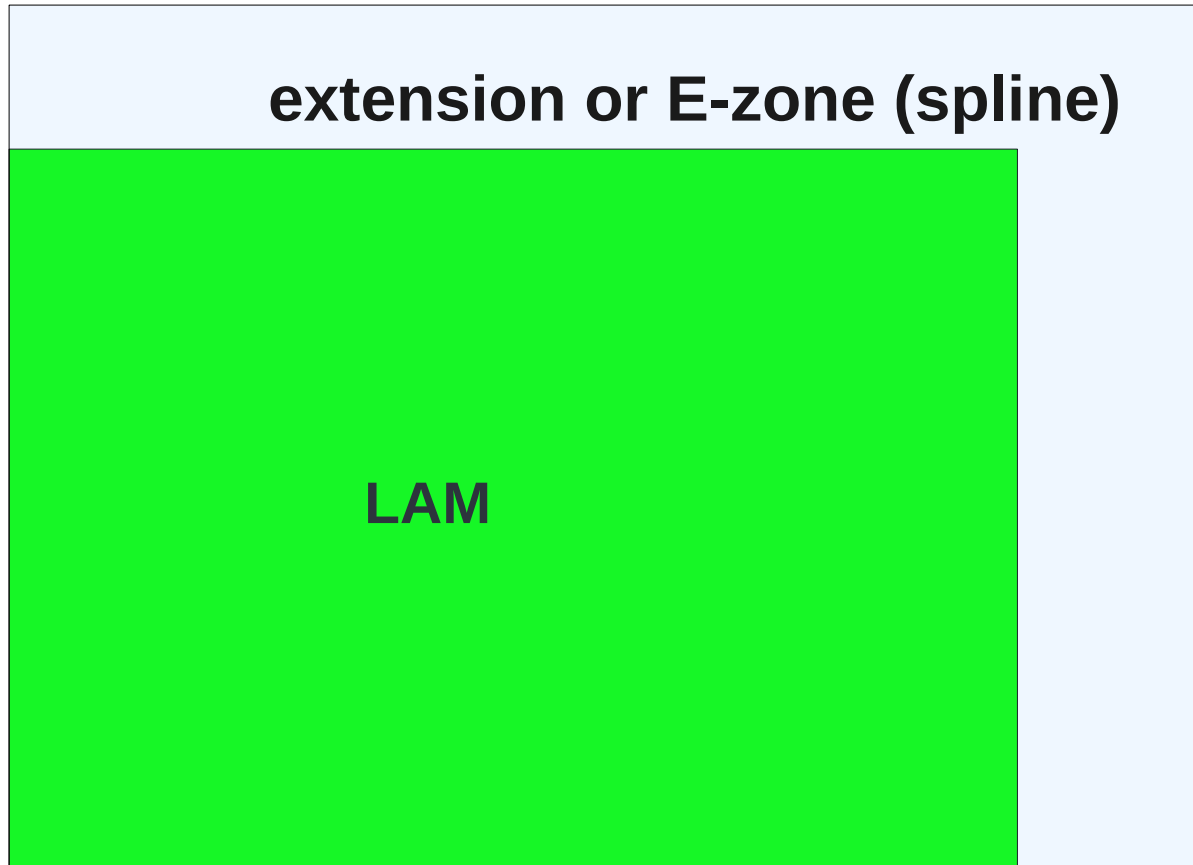


Traditional method: spline biperiodisation and Davies relaxation

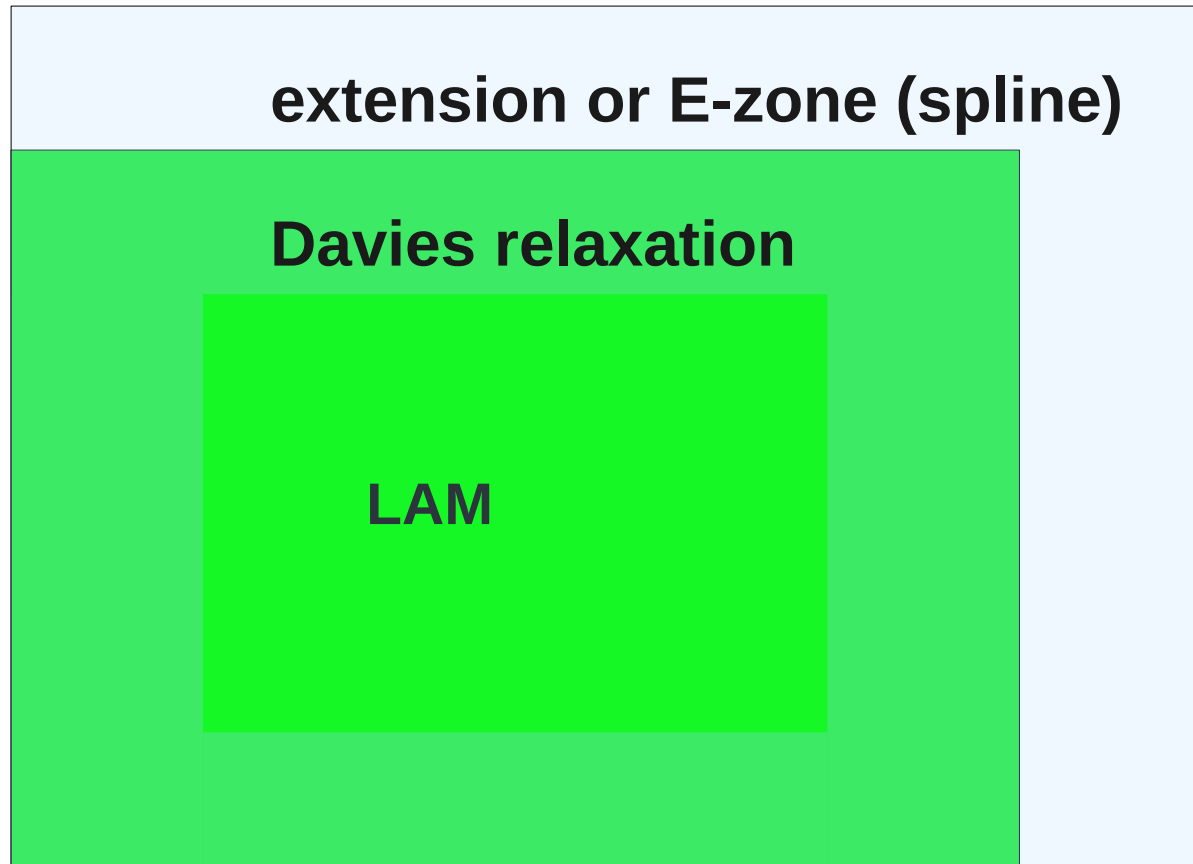


LAM

Traditional method: spline biperiodisation and Davies relaxation

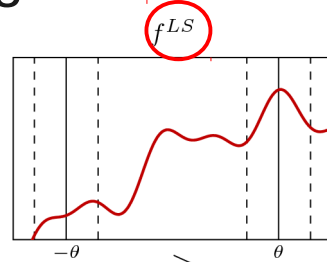


Traditional method: spline biperiodisation and Davies relaxation

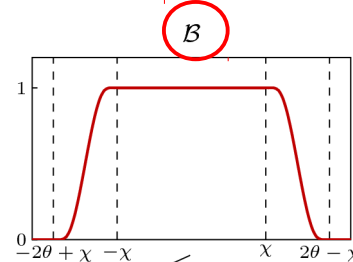


Boyd's idea: periodisation

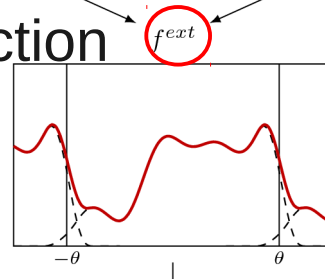
large-scale function



Bell function



extended function

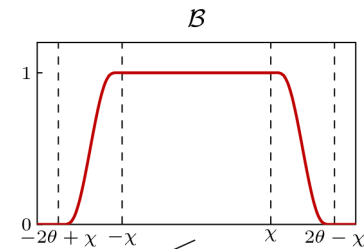
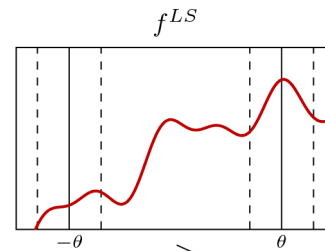


$$f^{ext}(x) = \mathcal{B}(x + 2\theta)f^{LS}(x + 2\theta) + \mathcal{B}(x)f^{LS}(x) + \mathcal{B}(x - 2\theta)f^{LS}(x - 2\theta)$$

$$\mathcal{B}(x) = \begin{cases} 0 & \text{for } |x| \geq 2\theta - \chi \\ \frac{1}{2} + \frac{1}{2} \operatorname{erf} \left[\frac{L}{2} \frac{(2\theta - \chi - |x|) - (|x| - \chi)}{\sqrt{(2\theta - \chi - |x|)(|x| - \chi)}} \right] & \text{for } \chi < |x| < 2\theta - \chi \\ 1 & \text{for } |x| \leq \chi \end{cases}$$

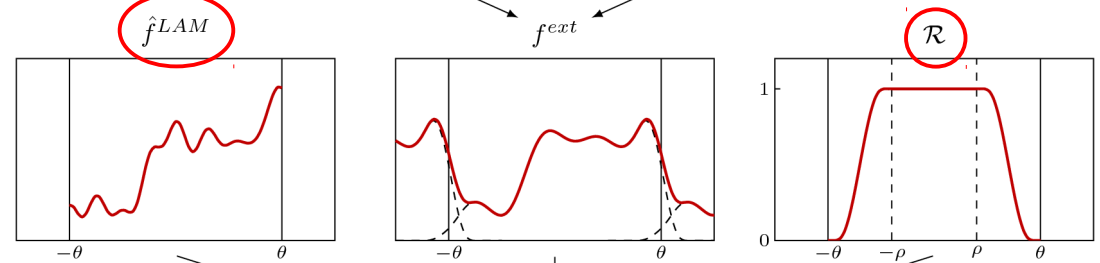
Boyd's idea: relaxation

$$f^{LAM}(x) = [1 - \mathcal{R}(x)]f^{ext}(x) + \mathcal{R}(x)\hat{f}^{LAM}(x)$$

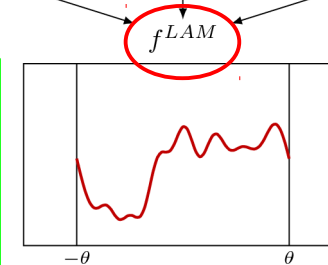


LAM function

relaxation function



$$\mathcal{R}(x) = \begin{cases} 0 & \text{for } |x| \geq \theta \\ \frac{1}{2} + \frac{1}{2}\text{erf}\left[\frac{L}{2} \frac{(\theta - |x|) - (|x| - \rho)}{\sqrt{(\theta - |x|)(|x| - \rho)}}\right] & \text{for } \rho < |x| < \theta \\ 1 & \text{for } |x| \leq \rho \end{cases}$$



relaxed LAM function

What are the advantages of Boyd's idea?

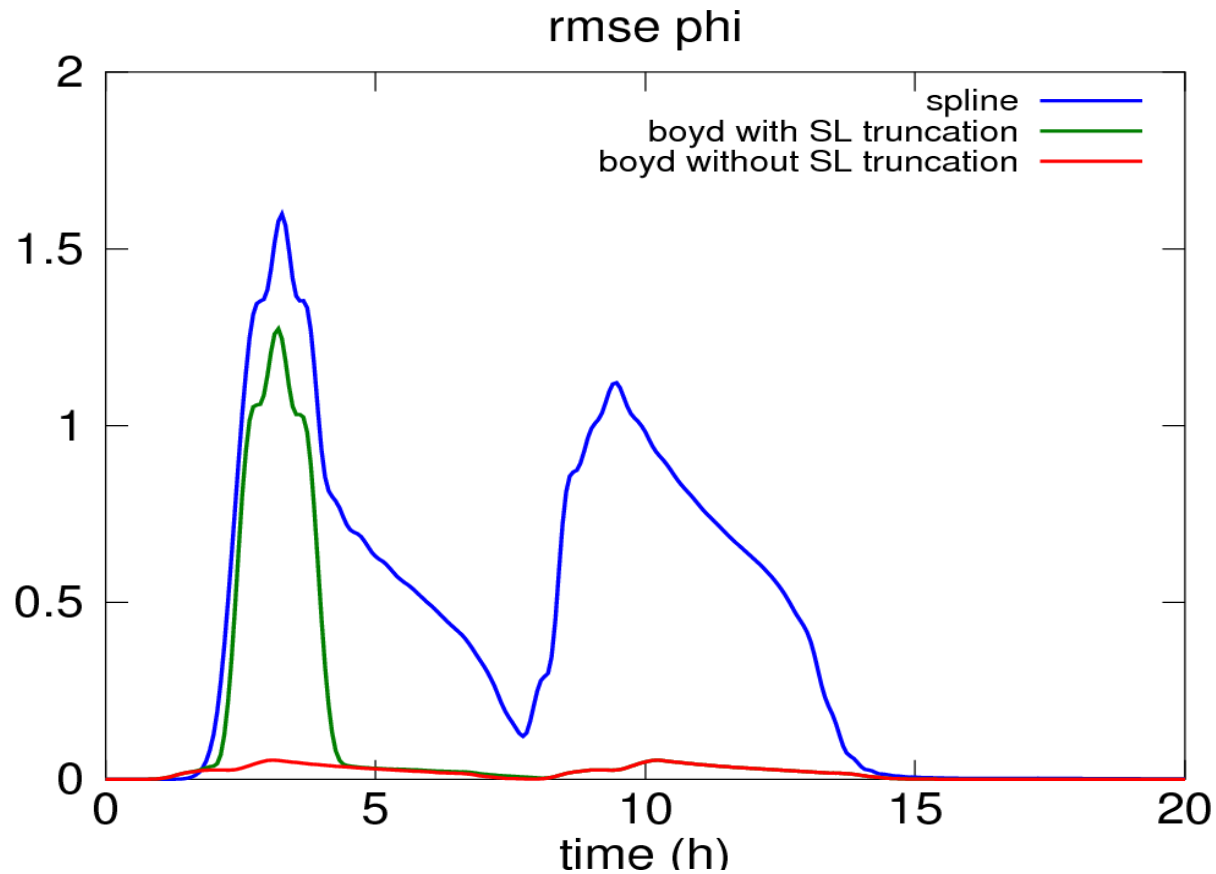
Faster spectral convergence of Boyd's method with respect to splines

—————▶ Spectral truncation makes **smaller errors**

Physically meaningful values used for periodisation

—————▶ **Better results possible without SL-truncation** at the boundaries

1D shallow water equation model test of Boyd



confirmation of the better results with Boyd...

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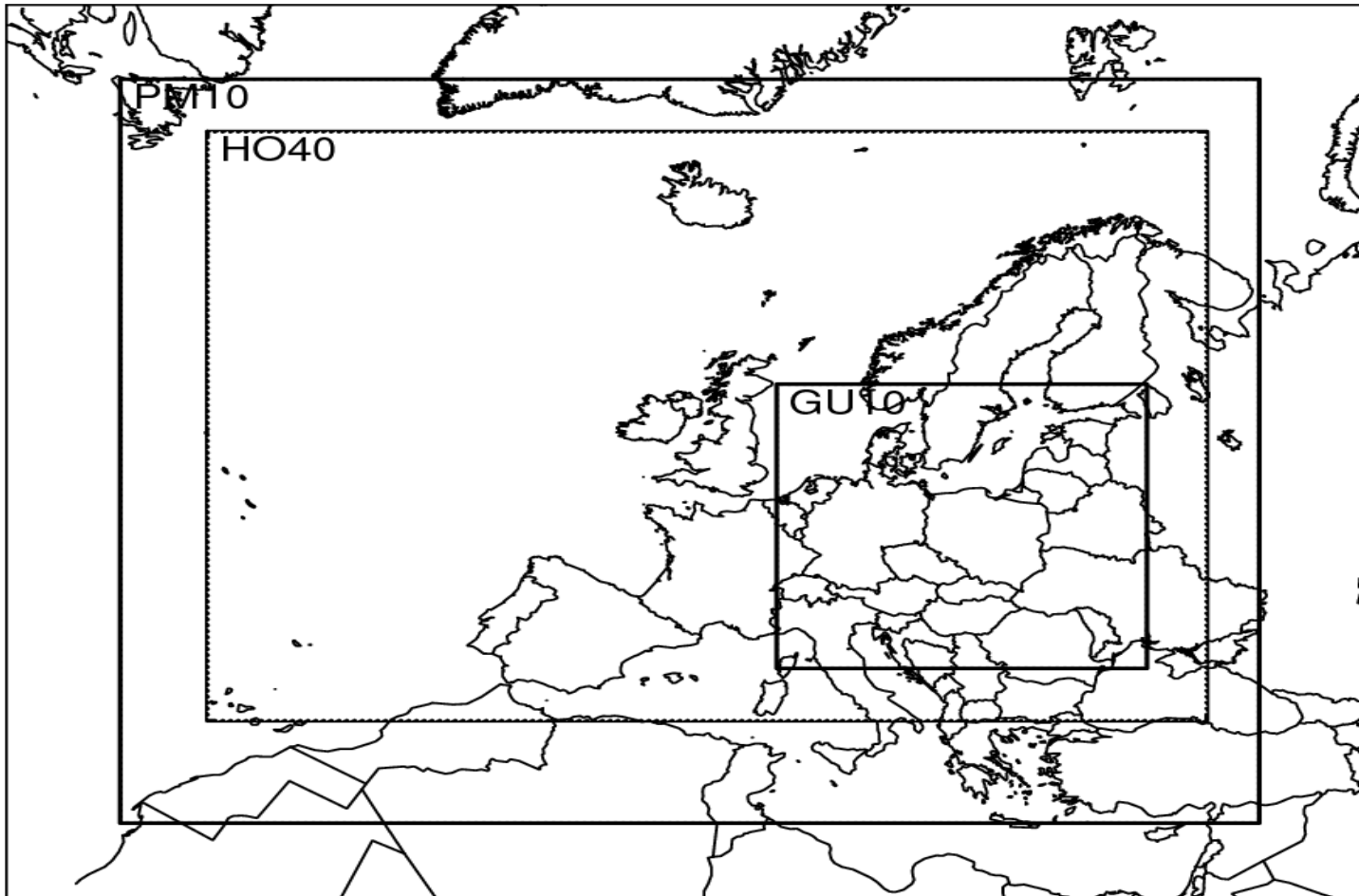
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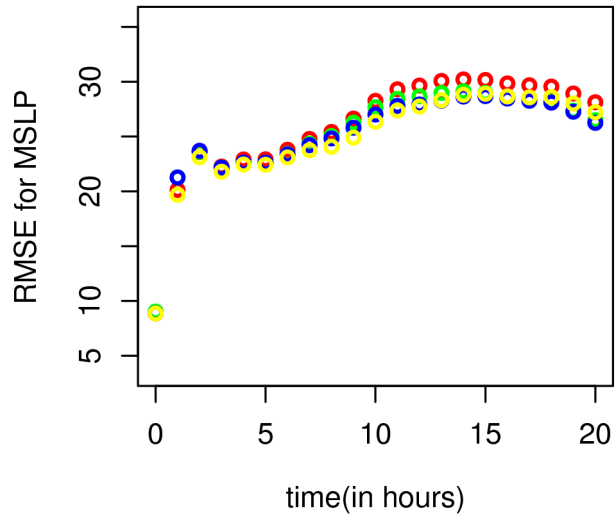


3D testing of Boyd with perfect model for Lothar storm

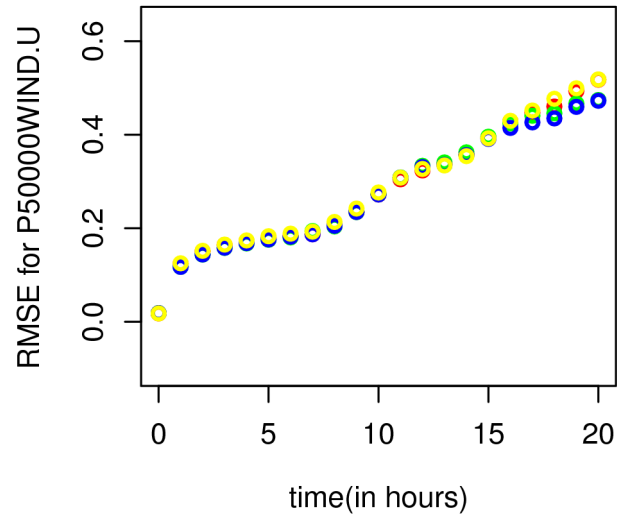


Overview of some results with physics

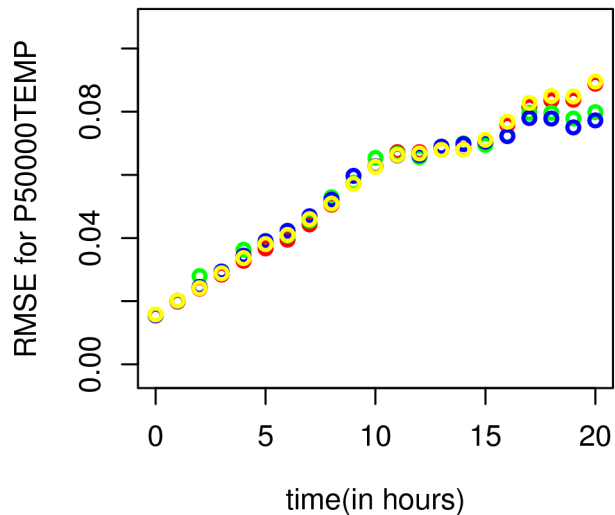
r=s , g=b, y =s_notr , b=b_notr



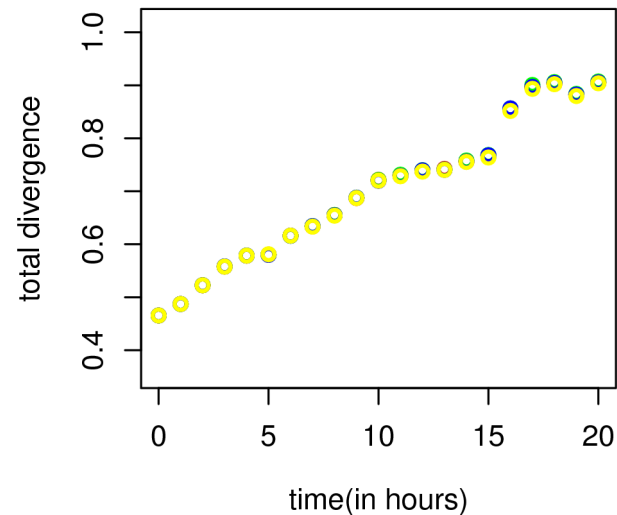
r=s , g=b, y =s_notr , b=b_notr



r=s , g=b, y =s_notr , b=b_notr



r=s , g=b, y =s_notr , b=b_notr



red =spline

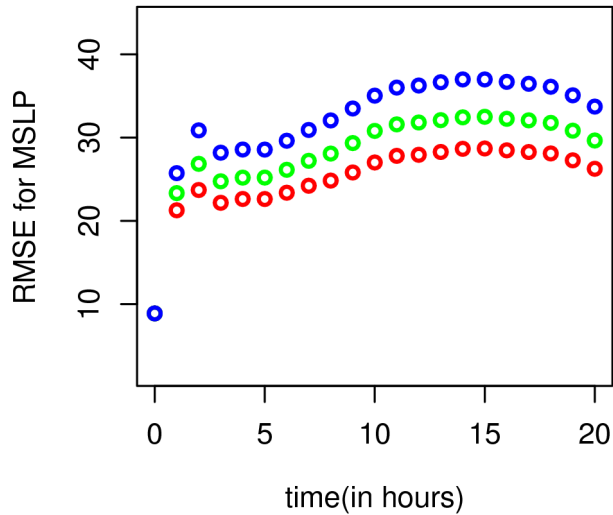
green=boyd

yellow=spline without SL-trunc

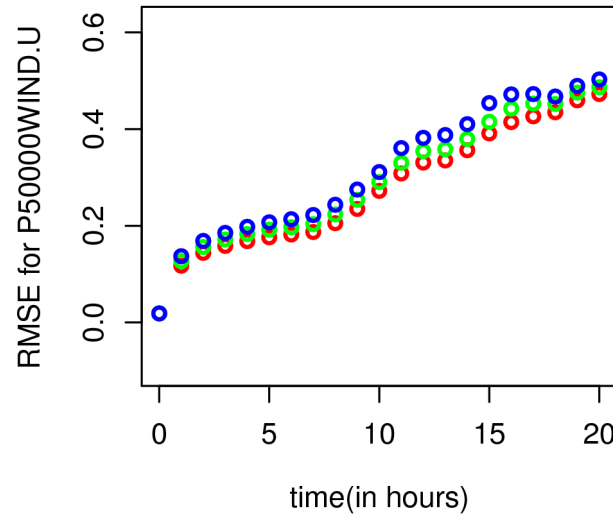
blue=boyd without SL-trunc

Effect of overlap on results.

r = no ov, g = 1GP ov, b = 2GP ov



r = no ov, g = 1GP ov, b = 2GP ov

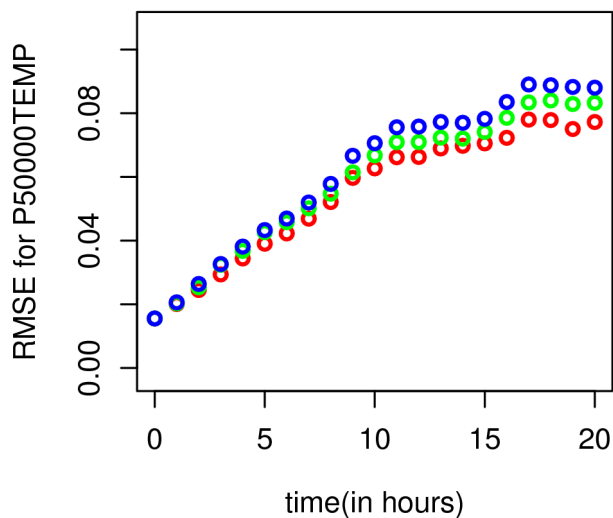


red = no overlap

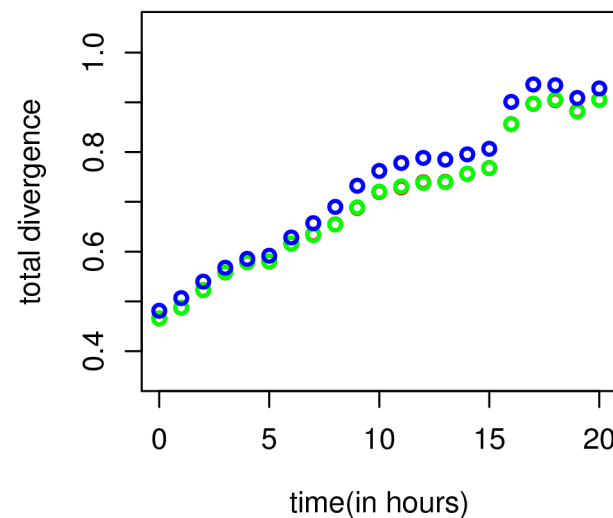
green= 1 GP overlap

blue= 2 GP overlap

r = no ov, g = 1GP ov, b = 2GP ov

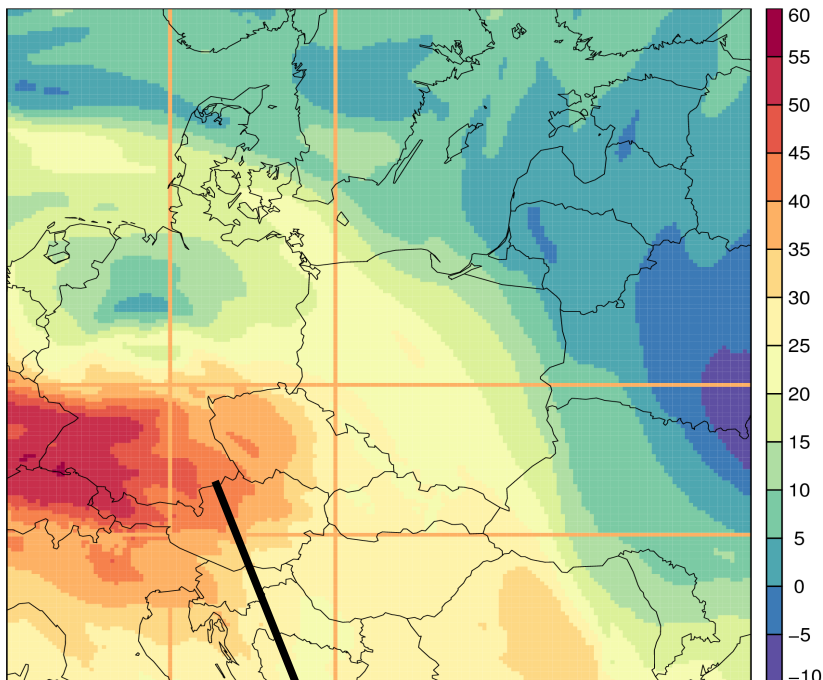


r = no ov, g=1GP ov, b=2GP ov



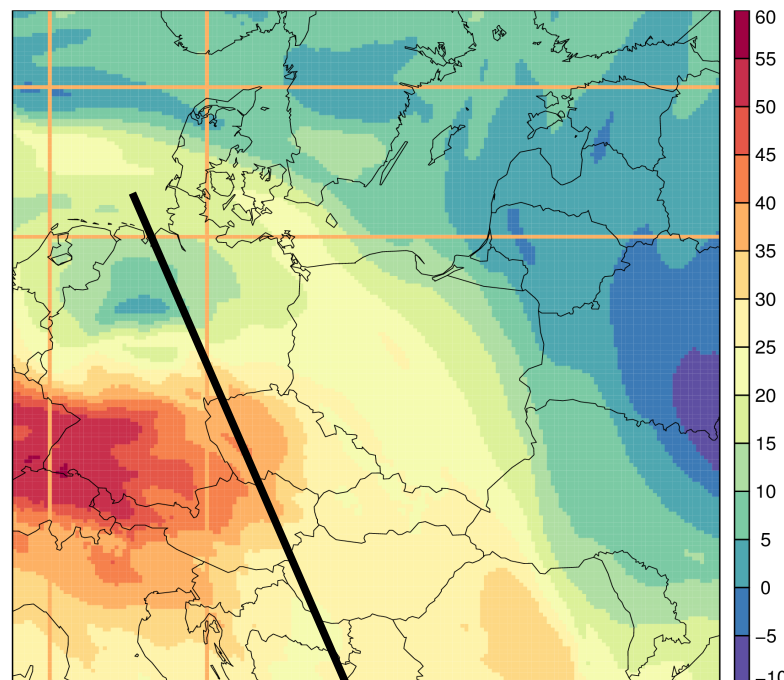
What is happening around the storm?

P50000WIND.U.PHY
1999/12/26 z0:0 +12h



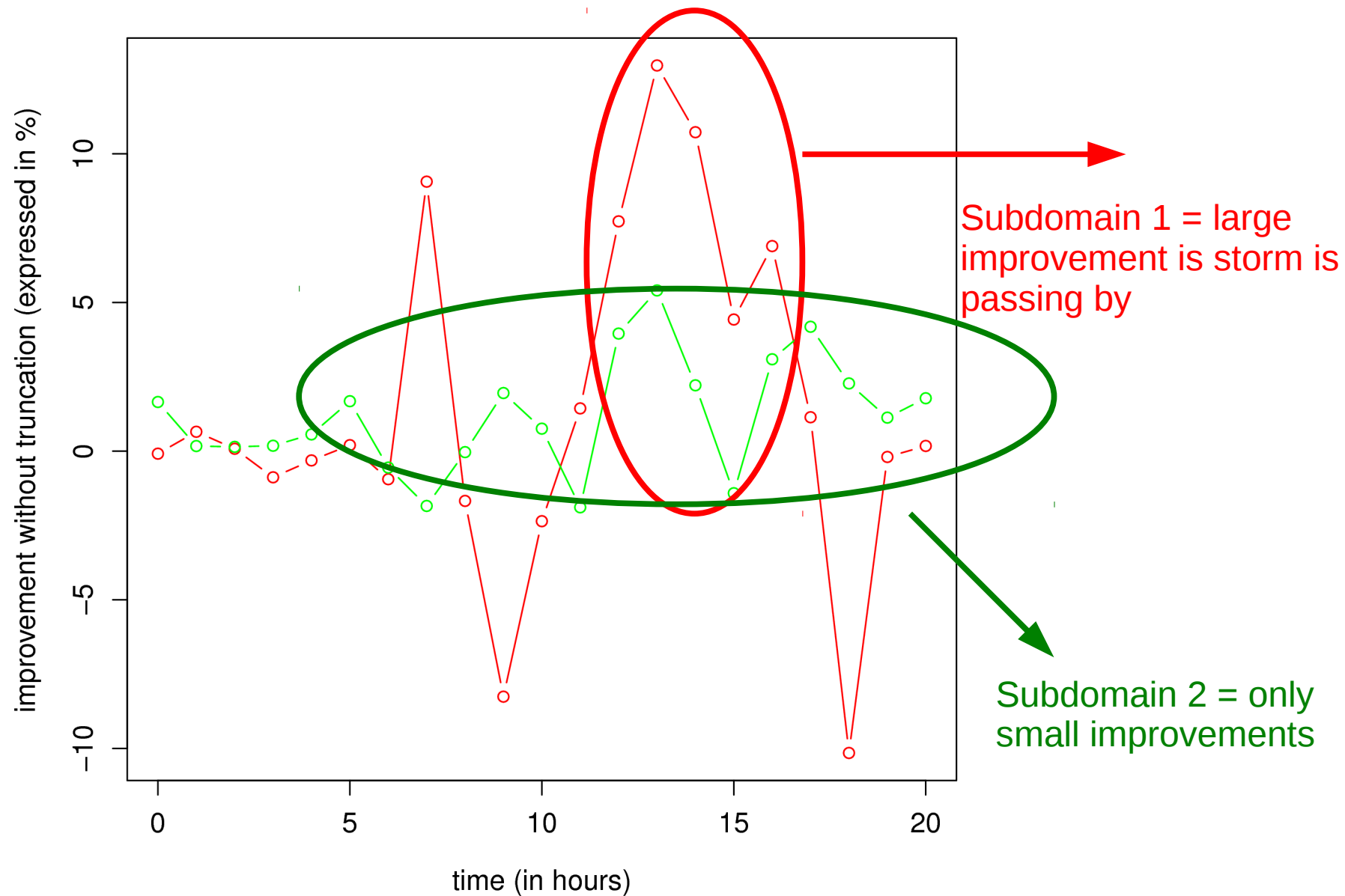
**Subdomain 1 on path
of the storm**

P50000WIND.U.PHY
1999/12/26 z0:0 +12h

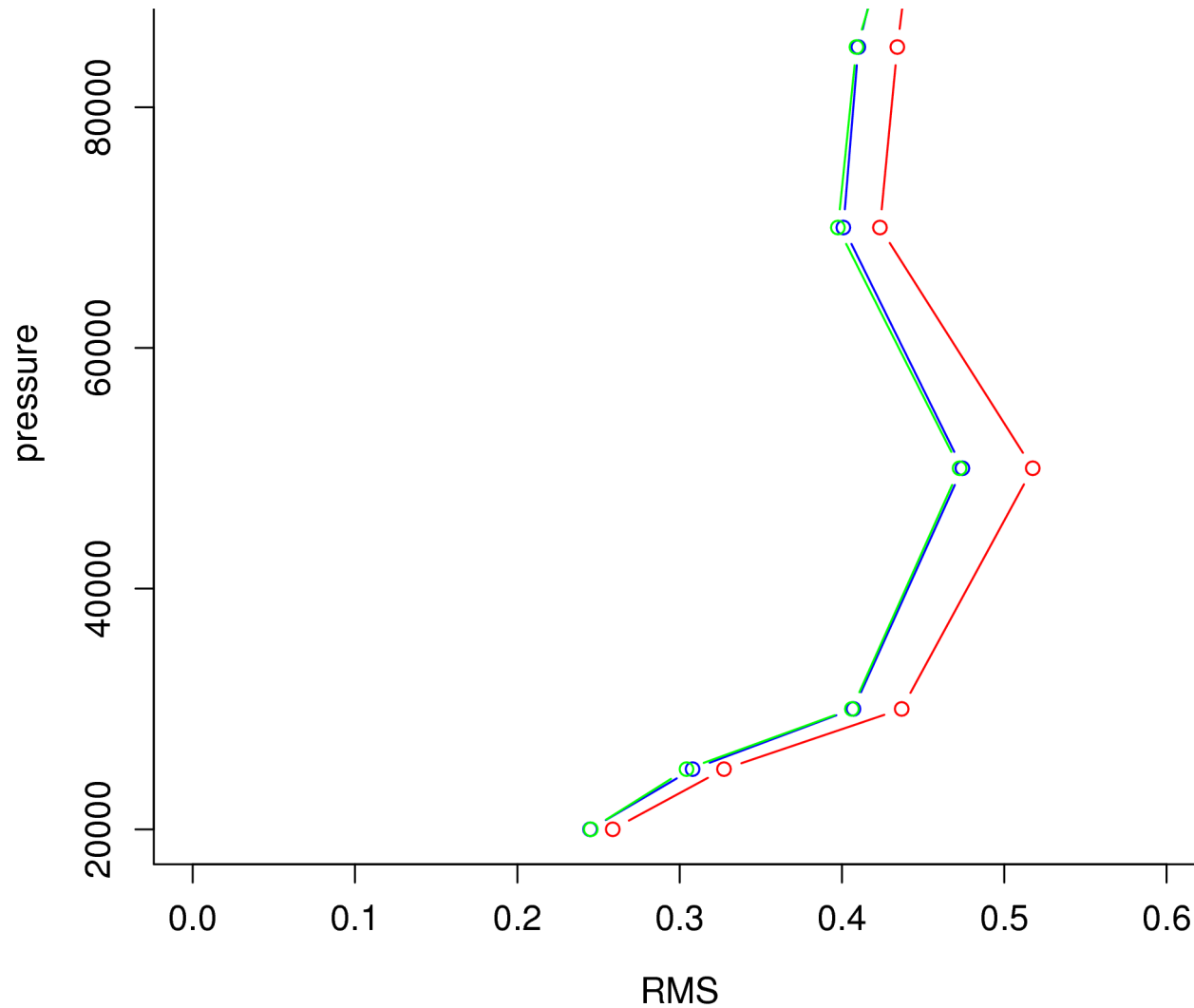


**Subdomain 2: quiet,
nothing special**

What is happening around the storm?



Result in the vertical direction: WIND.U (after 20 hours)

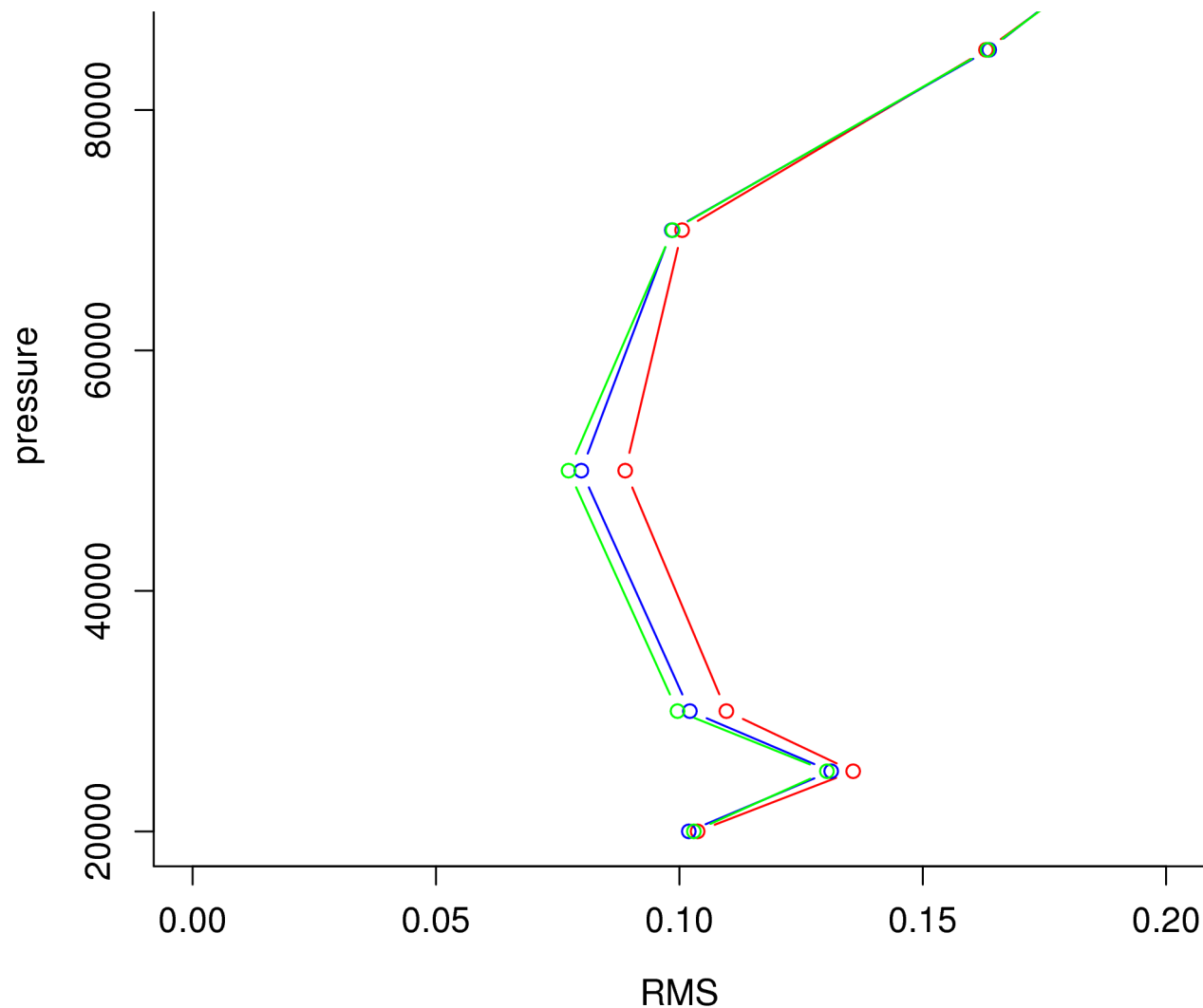


red = splines without SL trunc

blue = boyd with SL trunc

green = boyd without SL trunc

Result in the vertical direction: TEMP (after 20 hours)



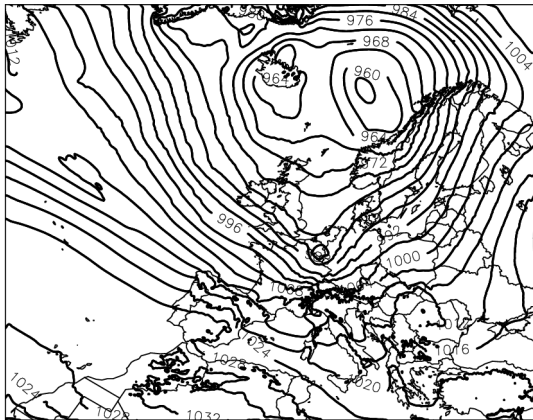
red = splines without SL trunc

blue = boyd with SL trunc

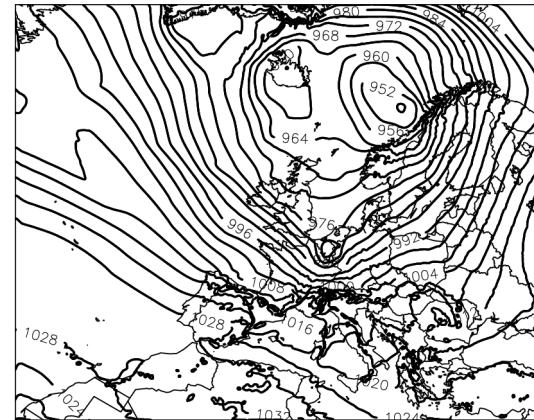
green = boyd without SL trunc

Can we see larger differences in adiabatic test cases?

WITH PHYSICS



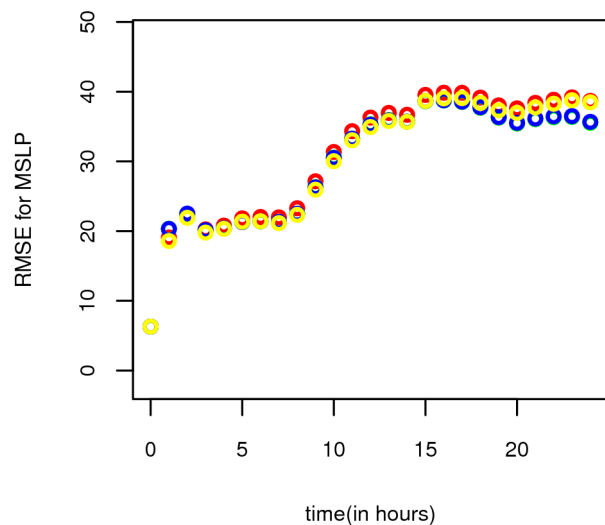
ADIABATIC



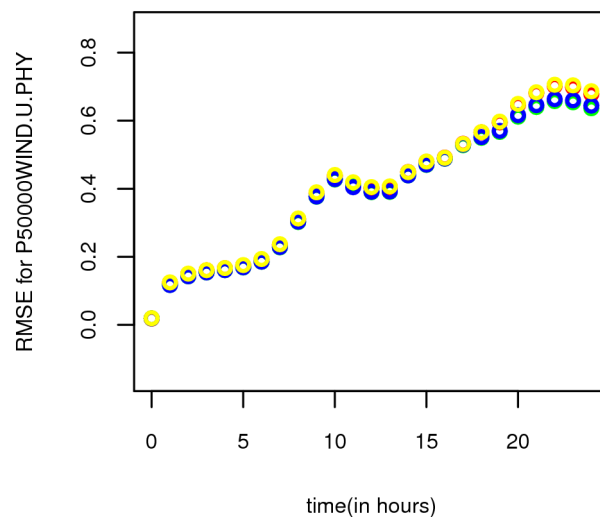
Storm is still in perfect model output.

Overview of some fields in adiabatic run.

r=s, g=b, y=s_notr, b=b_notr



r=s, g=b, y=s_notr, b=b_notr



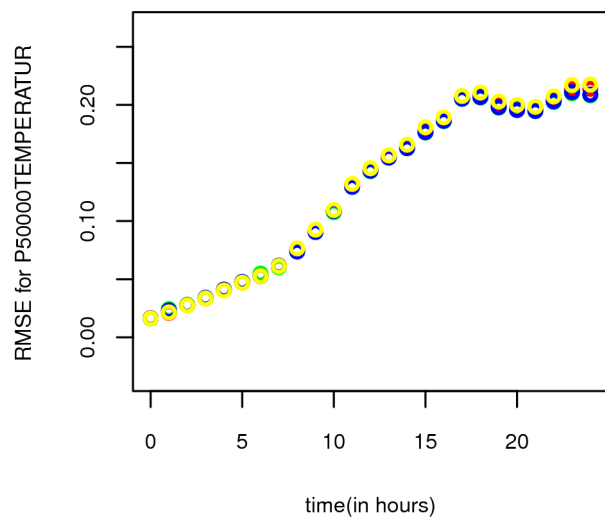
red =spline

green=boyd

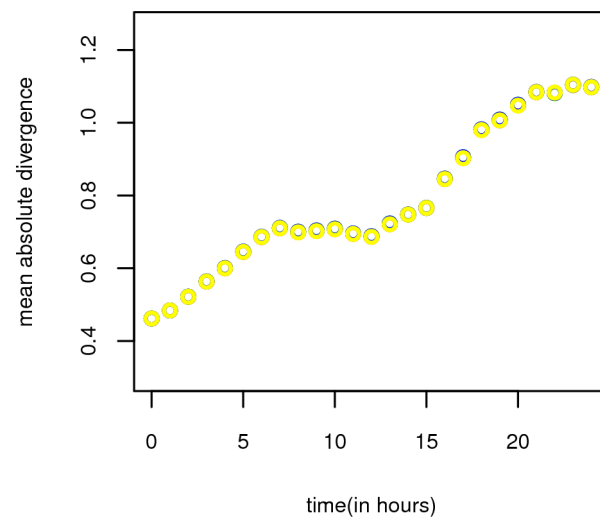
yellow=spline without SL-trunc

blue=boyd without SL-trunc

r=s, g=b, y=s_notr, b=b_notr



r=s, g=b, y=s_notr, b=b_notr

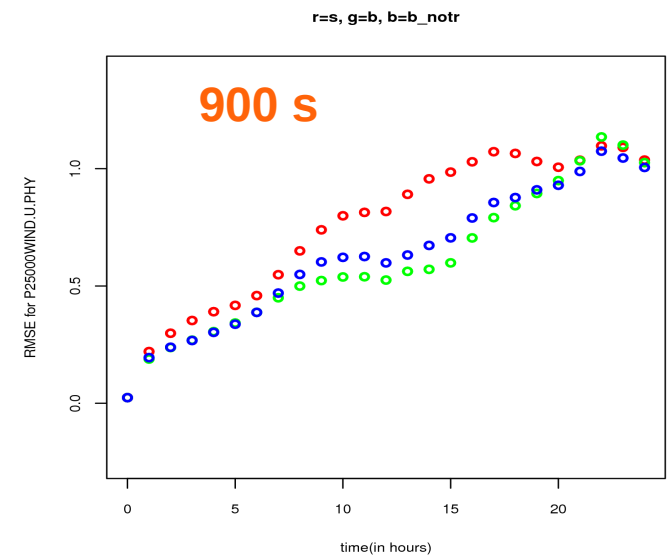
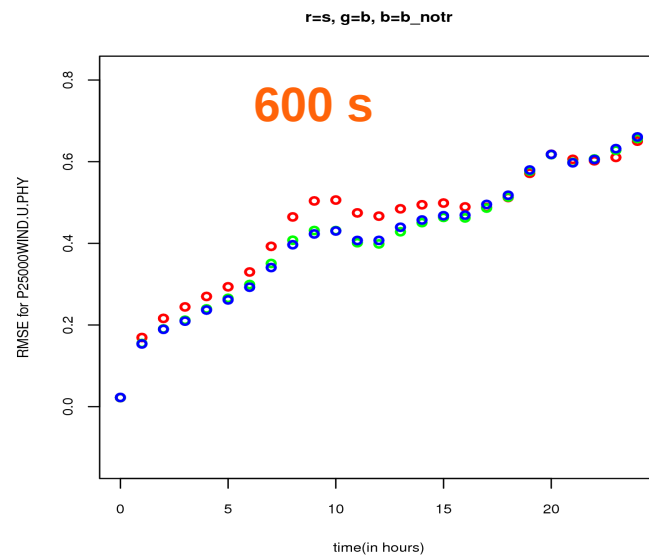
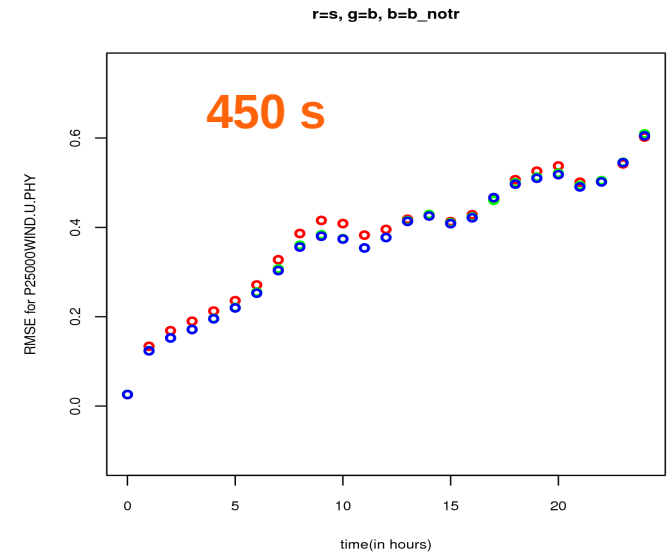
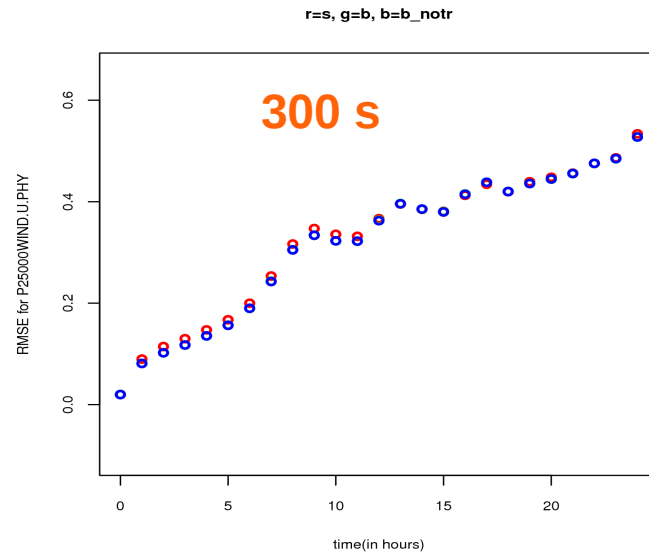


Effect of timestep on results.

red =spline

green=boyd

blue=boyd without
SL-trunc



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Boyd's method can be used operationally.

Boyd's periodisation method is performing better than splines.

Depending on the timestep, no SL-truncation can do better than Boyd's method with SL-truncation.

Effect of overlap on results.

