

Boyd's periodisation and relaxation for spectral LAMs

Steven Caluwaerts, Daan Degrauwe, Fabrice Voitus
and Piet Termonia



Outline talk

The idea of Boyd

3D perfect model tests

What now? Conclusion

Outline talk

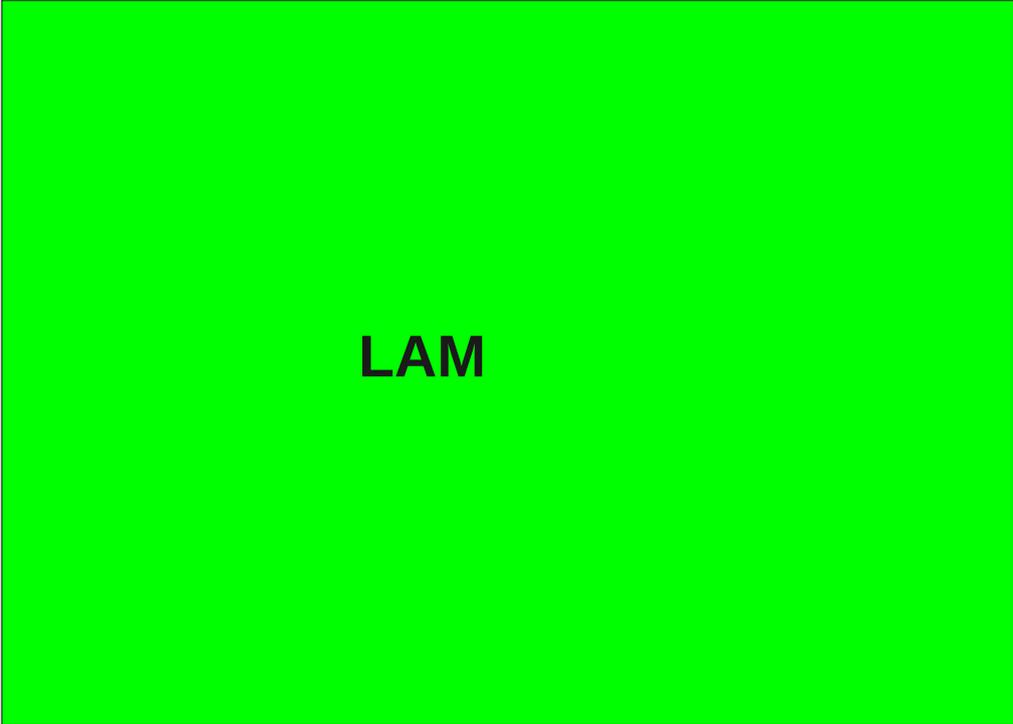
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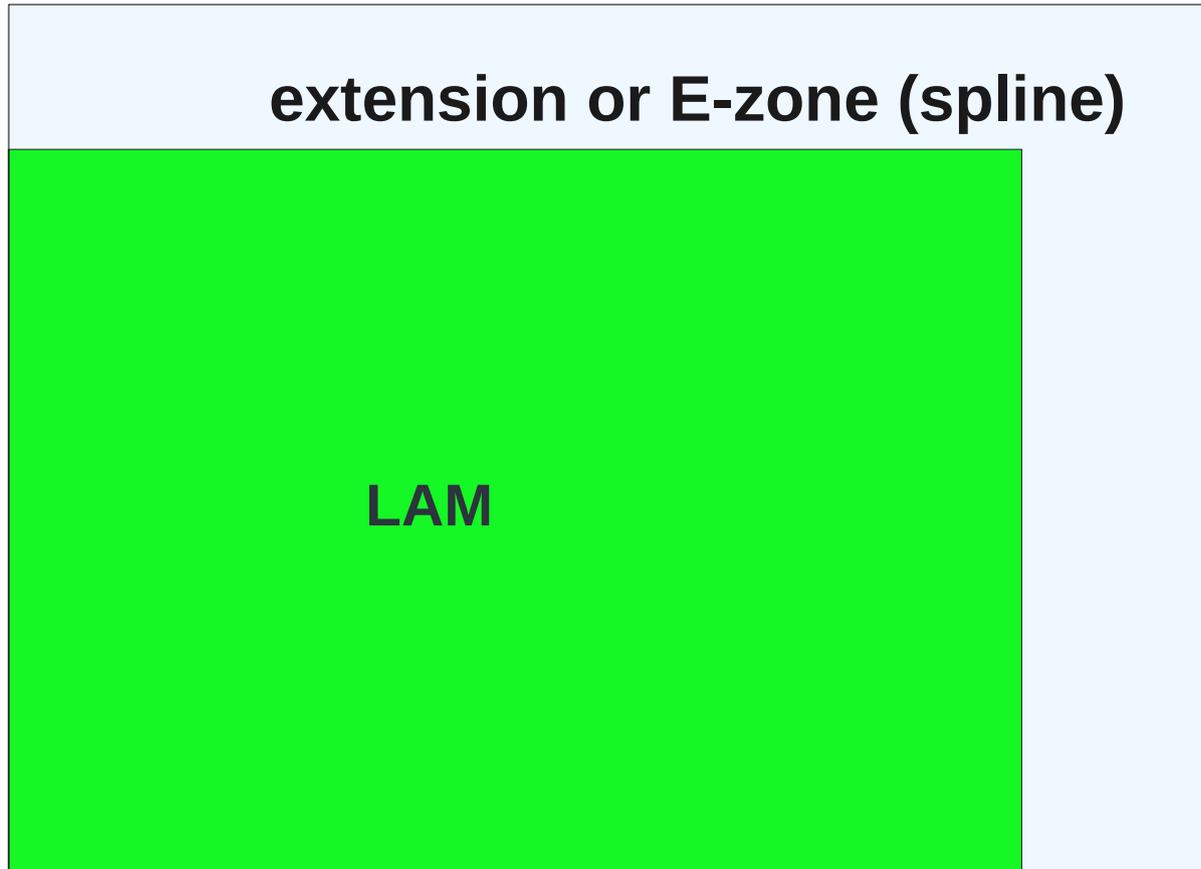


Traditional method: spline biperiodisation and Davies relaxation

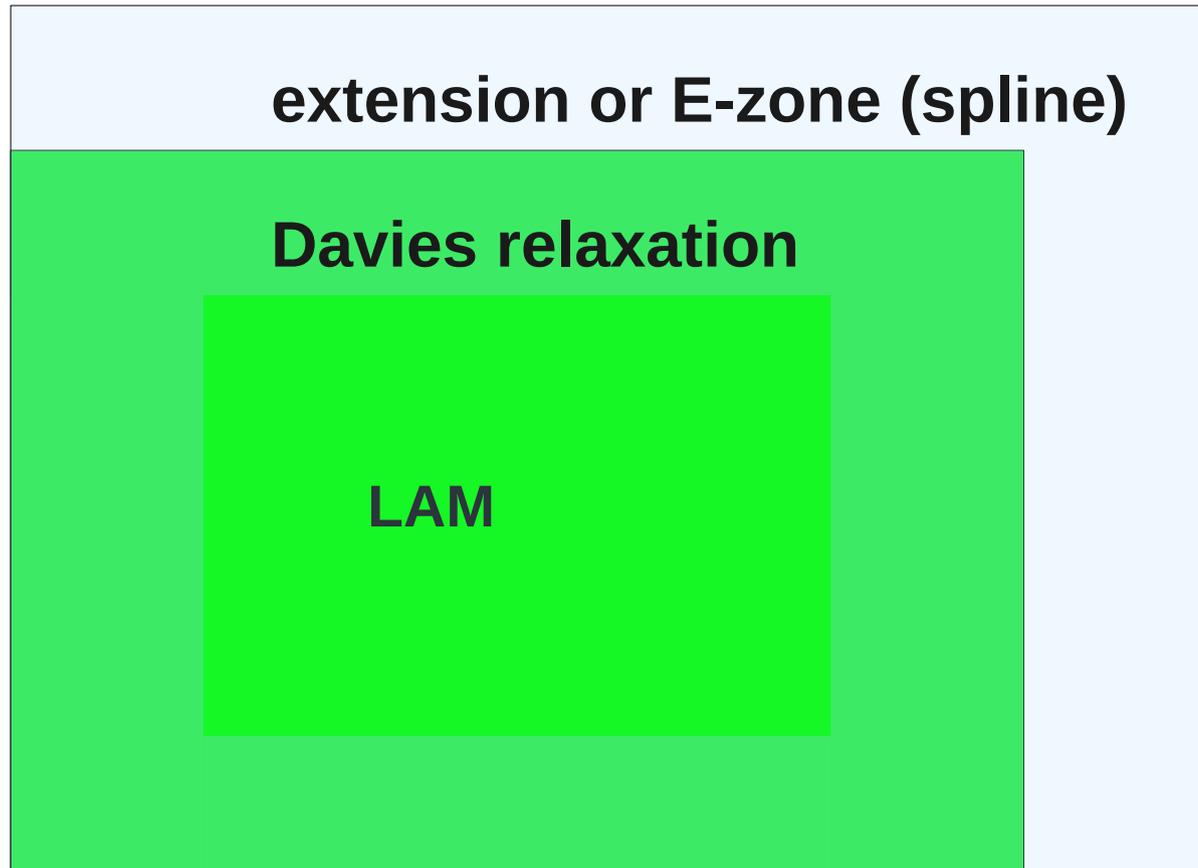


LAM

Traditional method: spline biperiodisation and Davies relaxation

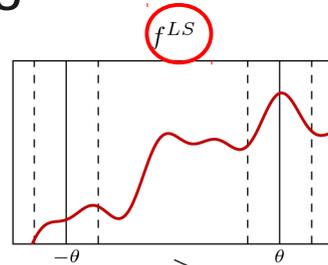


Traditional method: spline biperiodisation and Davies relaxation

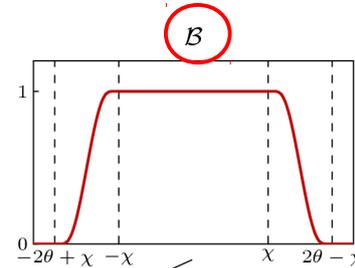


Boyd's idea: periodisation

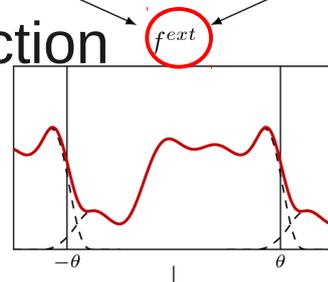
large-scale function



Bell function



extended function

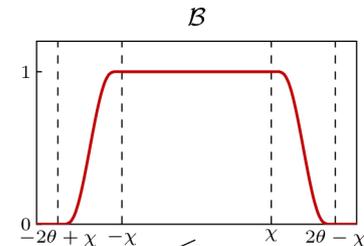
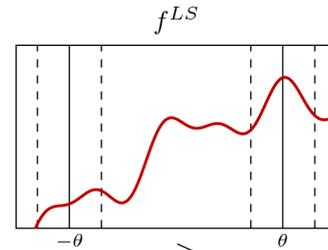


$$f^{ext}(x) = \mathcal{B}(x + 2\theta)f^{LS}(x + 2\theta) + \mathcal{B}(x)f^{LS}(x) + \mathcal{B}(x - 2\theta)f^{LS}(x - 2\theta)$$

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

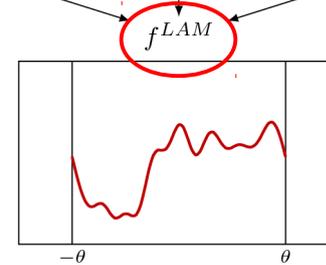
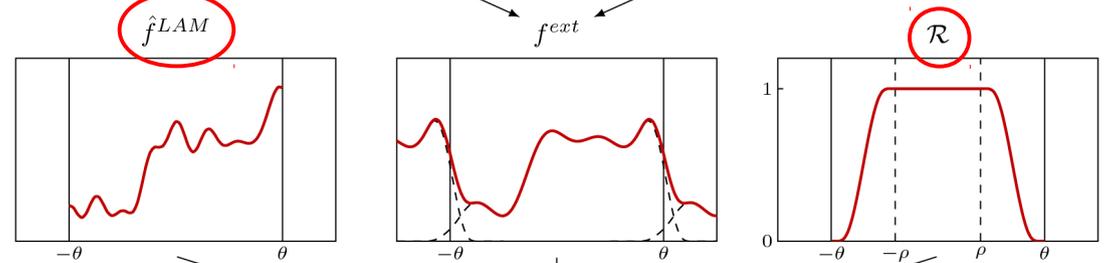
Boyd's idea: relaxation

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



LAM function

relaxation function



relaxed LAM function

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

What are the advantages of Boyd's idea?

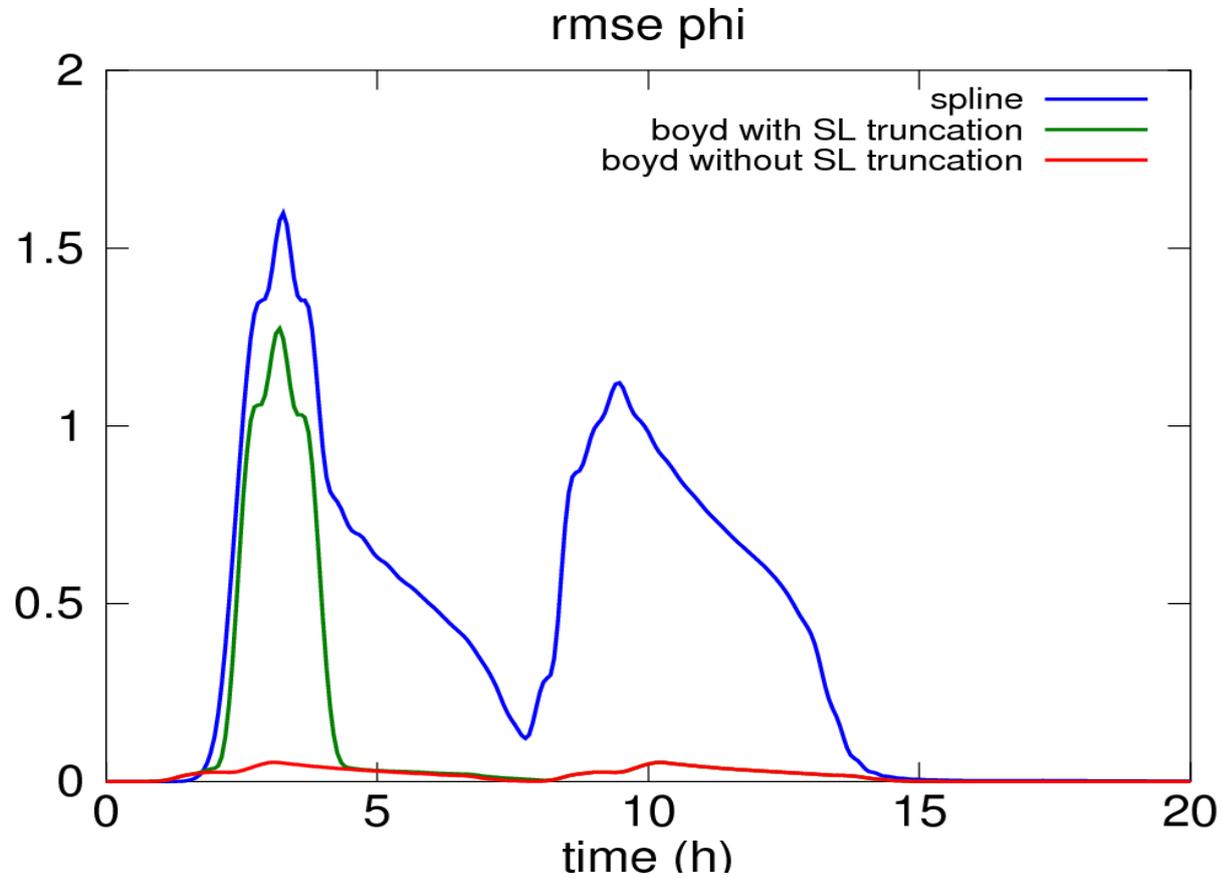
Faster spectral convergence of Boyd's method with respect to splines

—————▶ 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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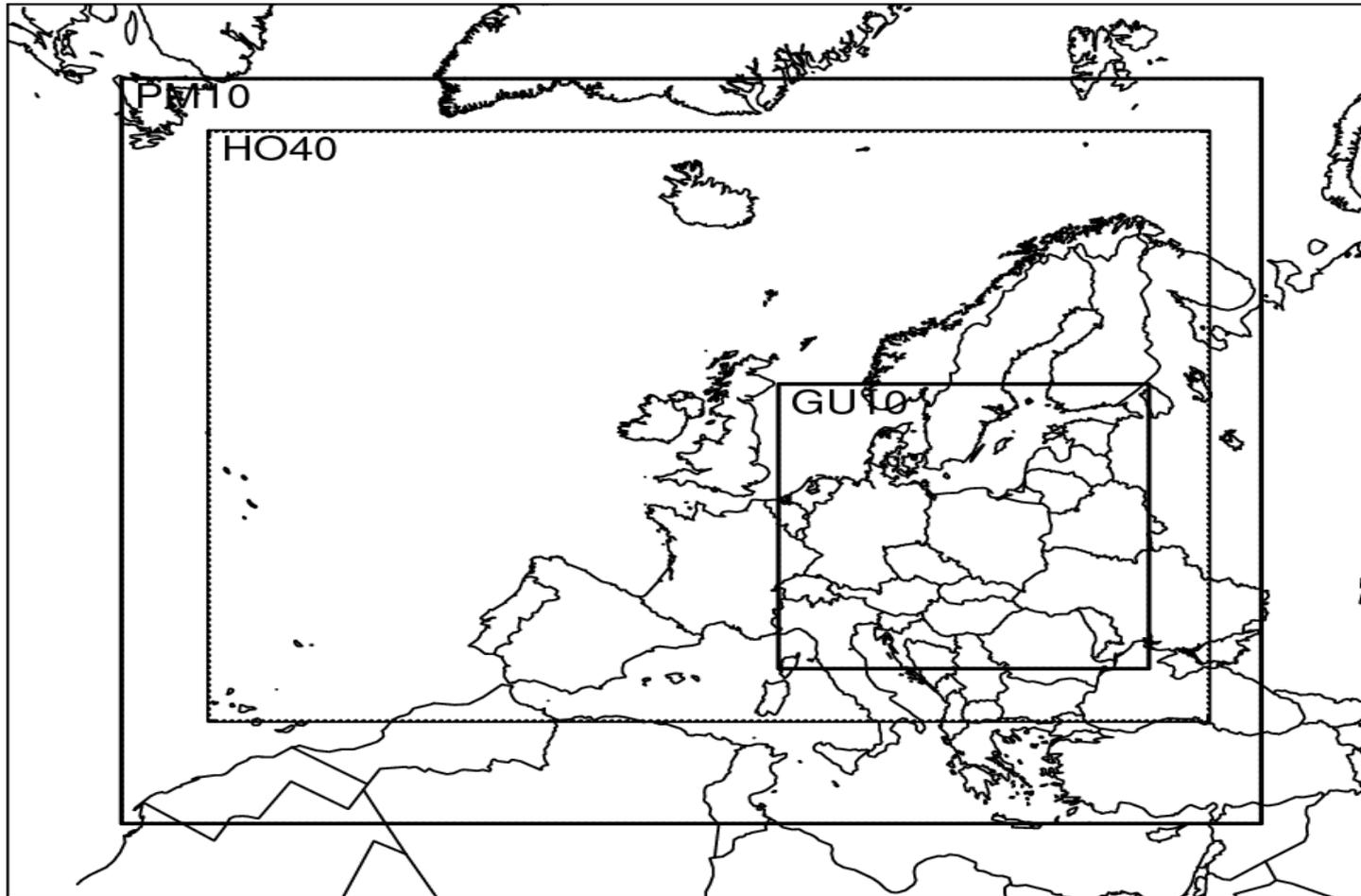
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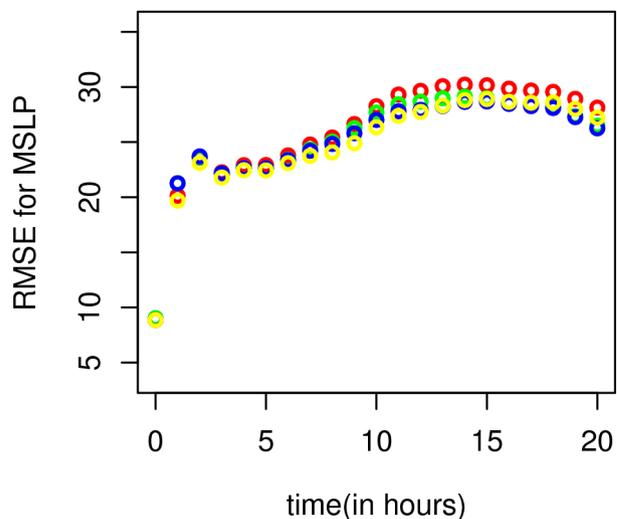


3D testing of Boyd with perfect model for Lothar storm

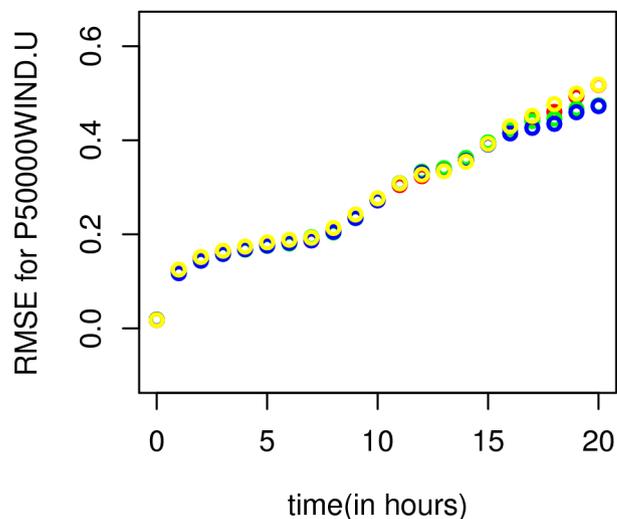


Overview of some results with physics

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



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



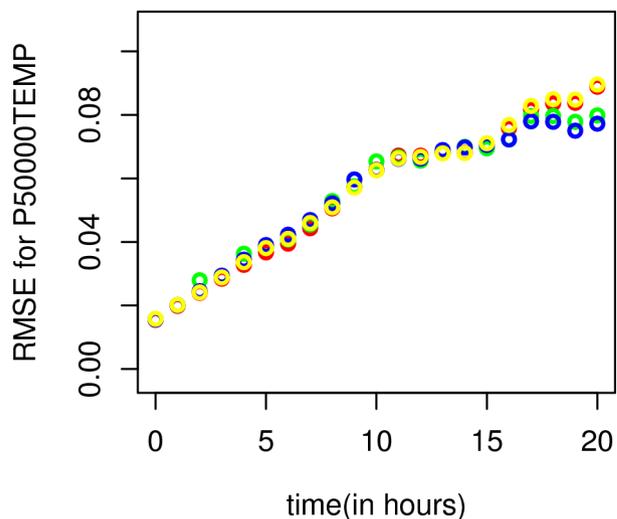
red =spline

green=boyd

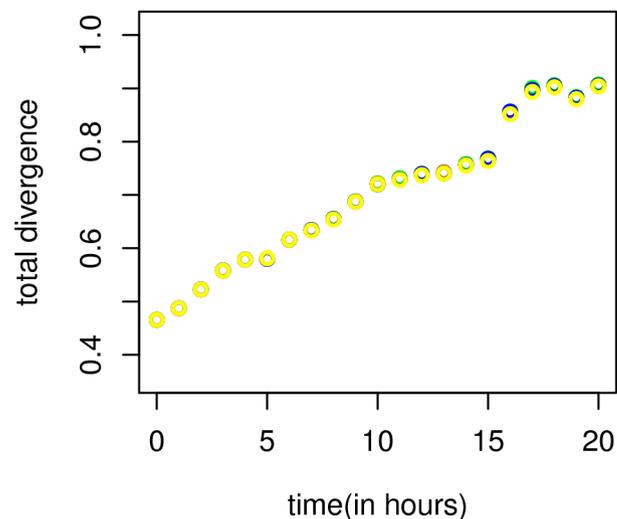
yellow=spline without SL-trunc

blue=boyd without SL-trunc

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

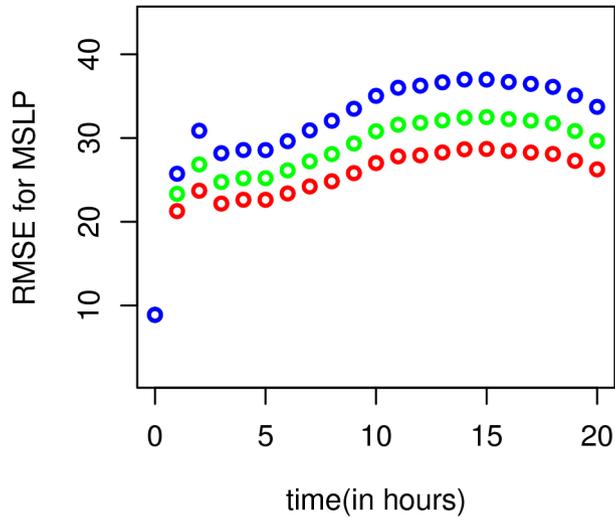


r=s , g=b, y =s_notr , b=b_notr

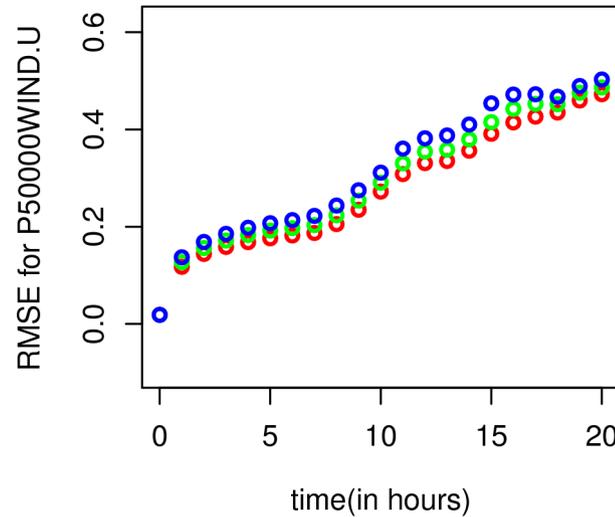


Effect of overlap on results.

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



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

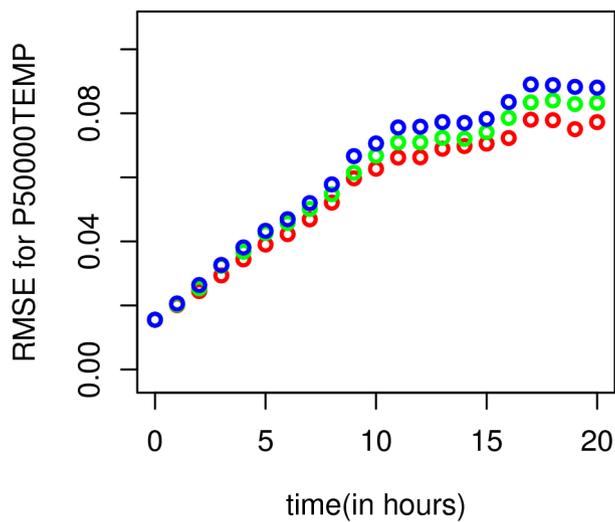


red = no overlap

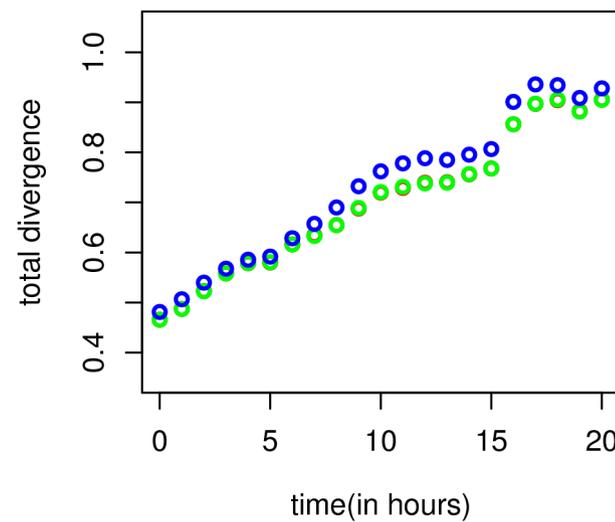
green = 1 GP overlap

blue = 2 GP overlap

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

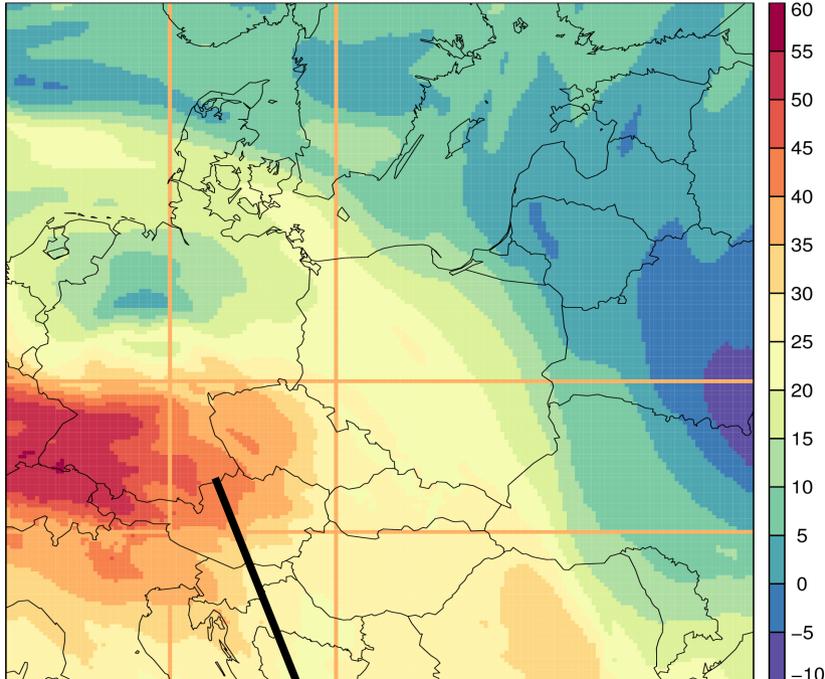


r = no ov, g=1GP ov, b=2GP ov



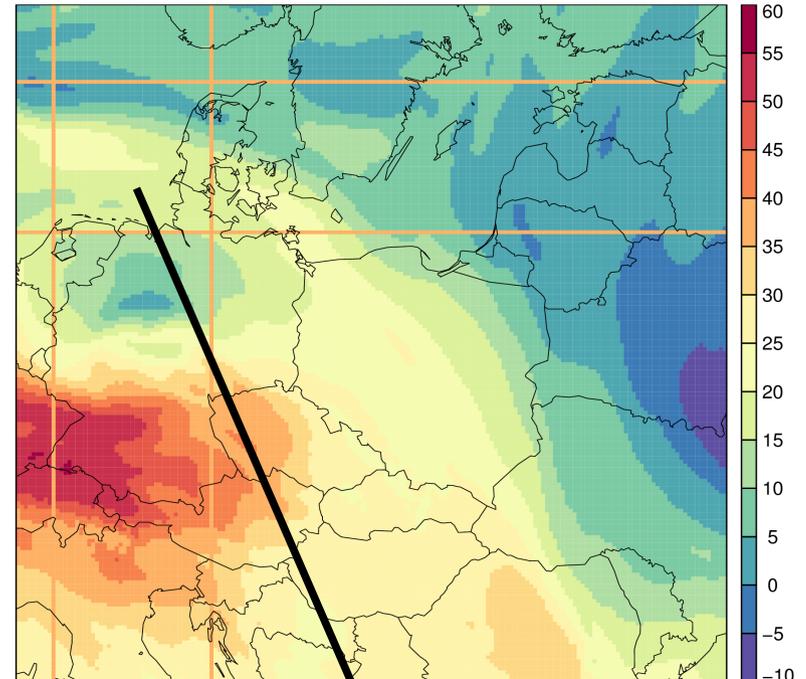
What is happening around the storm?

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



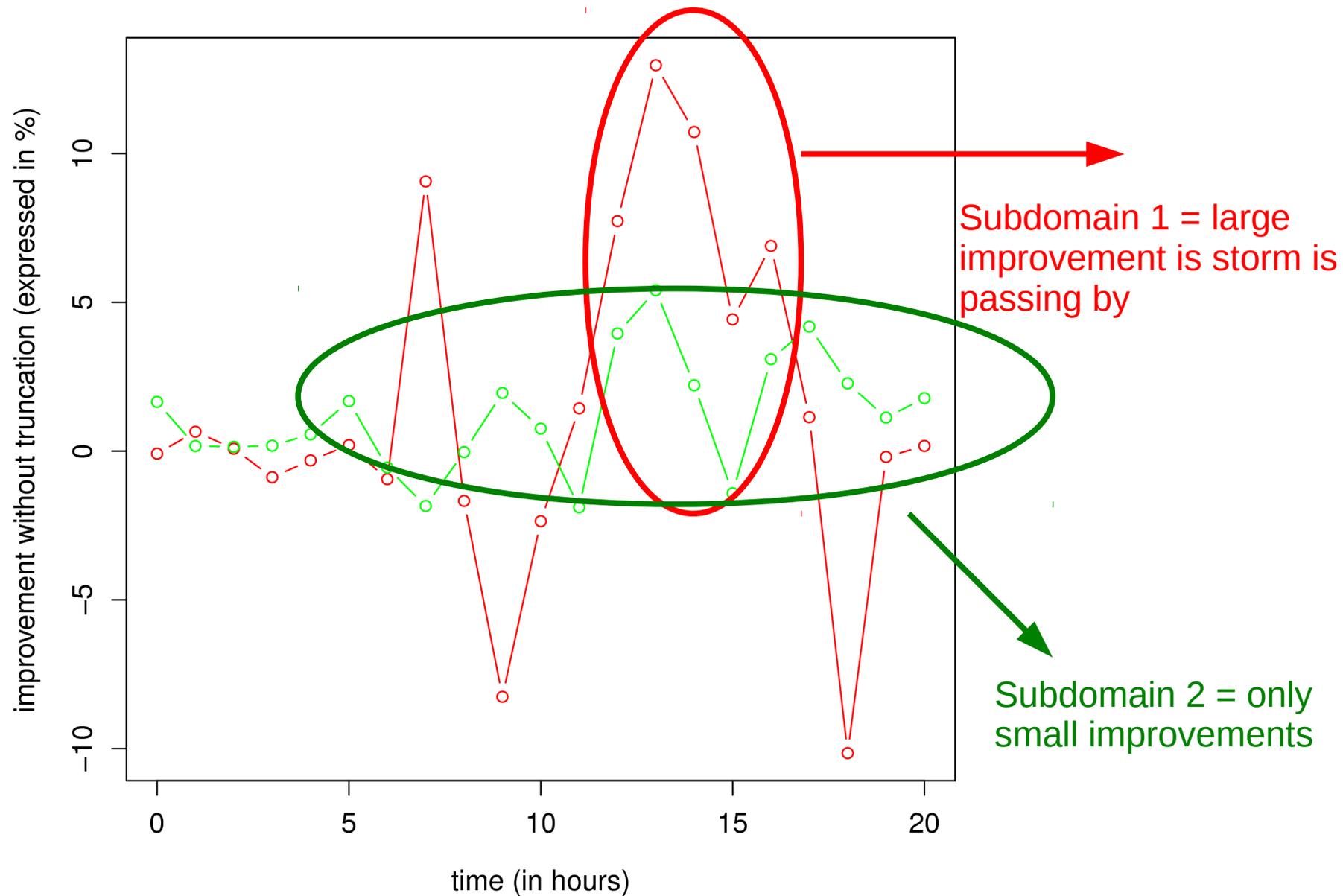
**Subdomain 1 on path
of the storm**

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

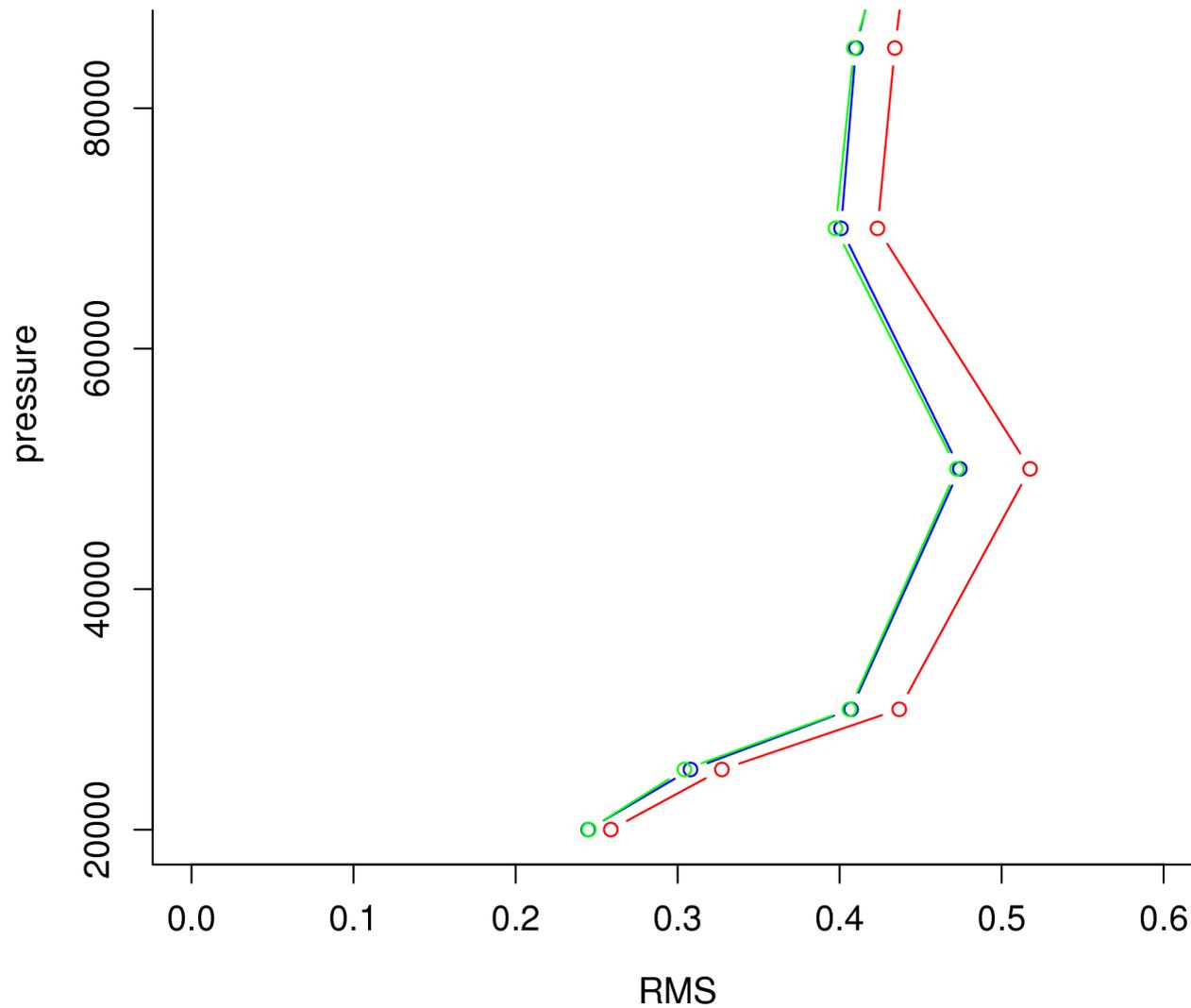


**Subdomain 2: quiet,
nothing special**

What is happening around the storm?



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

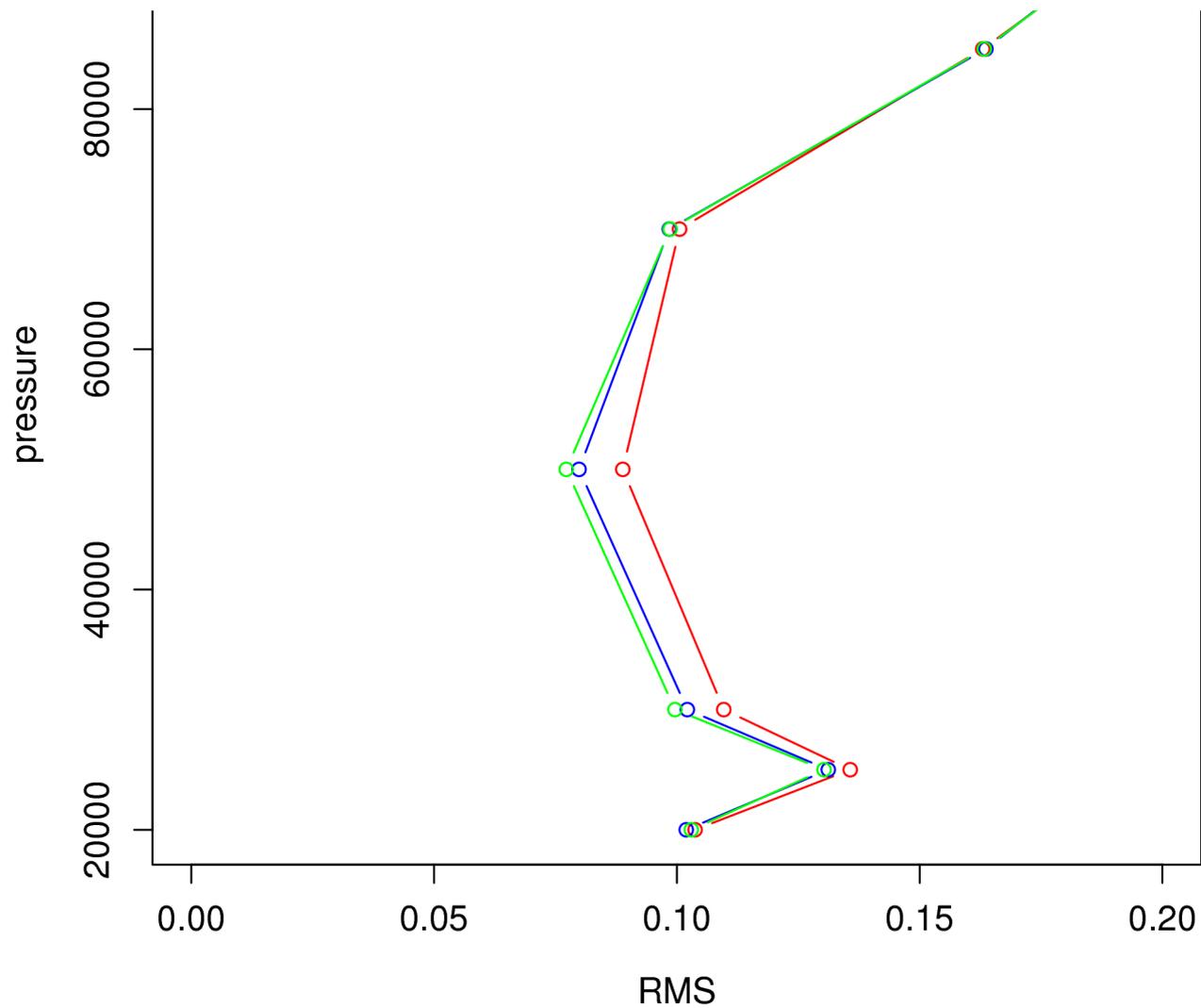


red = splines without SL trunc

blue = boyd with SL trunc

green = boyd without SL trunc

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



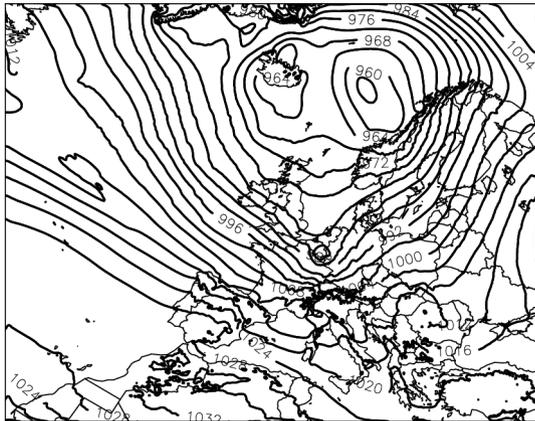
red = splines without SL trunc

blue = boyd with SL trunc

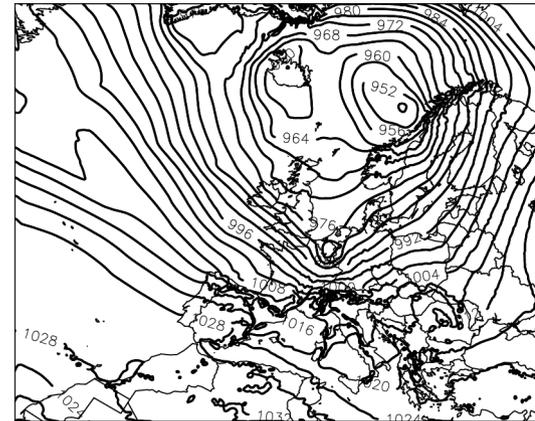
green = boyd without SL trunc

Can we see larger differences in adiabatic test cases?

WITH PHYSICS

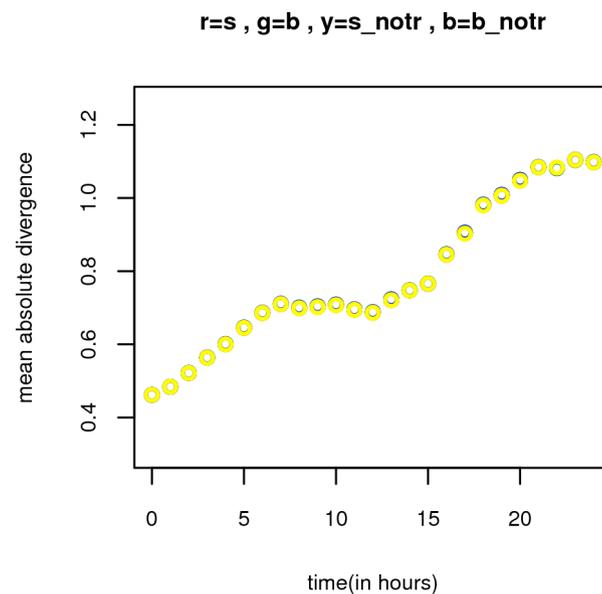
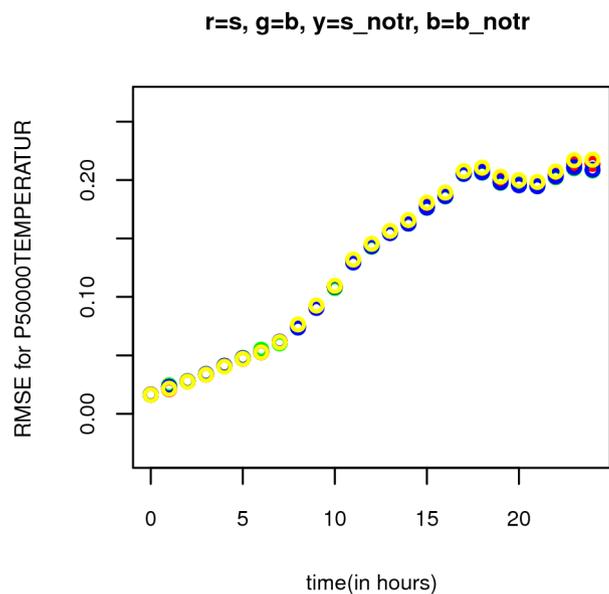
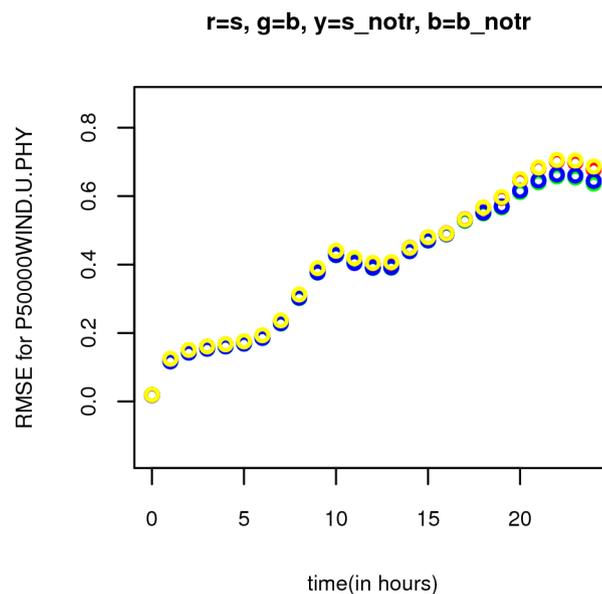
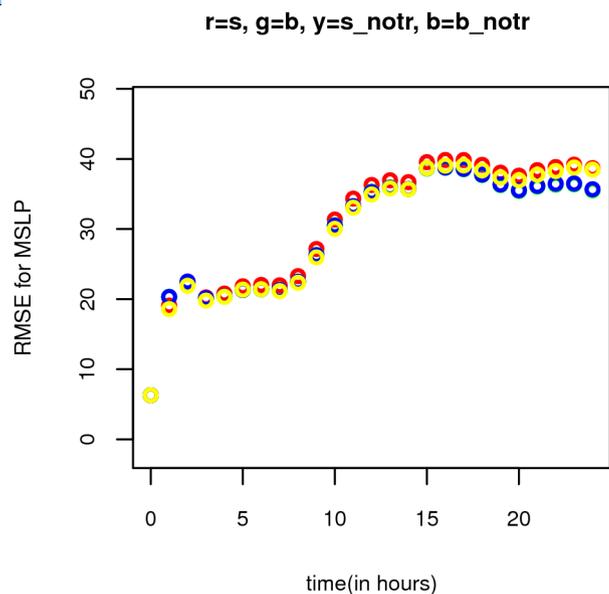


ADIABATIC



Storm is still in perfect model output.

Overview of some fields in adiabatic run.



red =spline

green=boyd

yellow=spline without SL-trunc

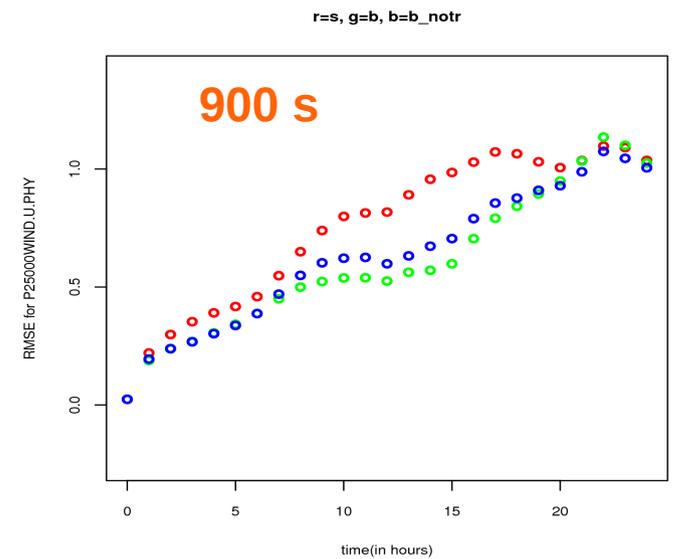
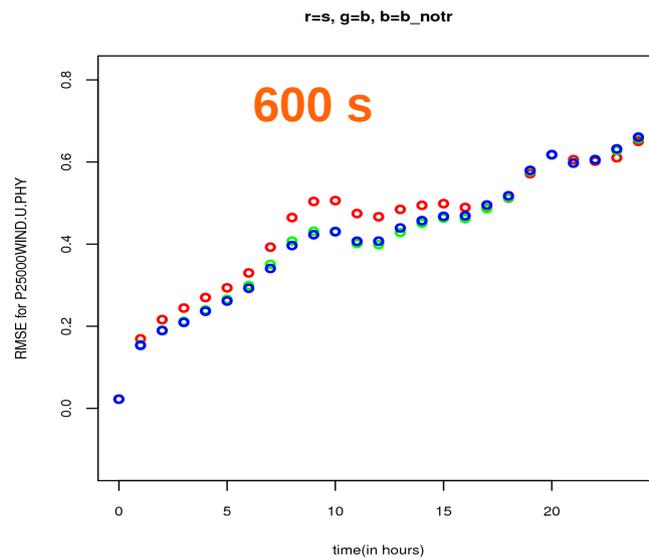
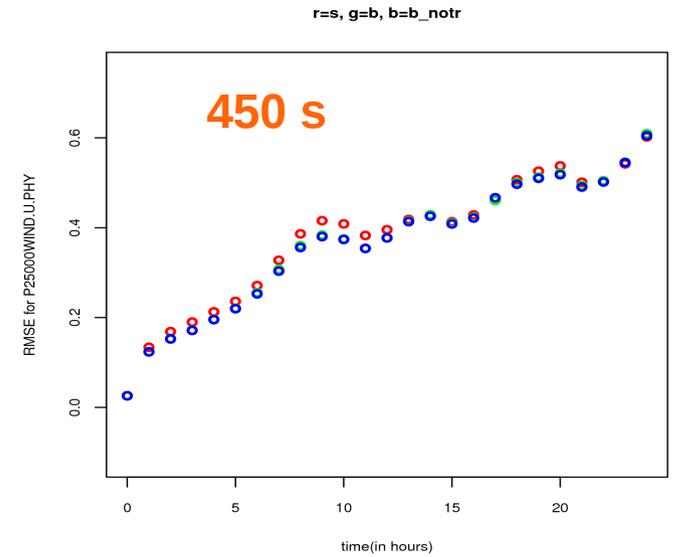
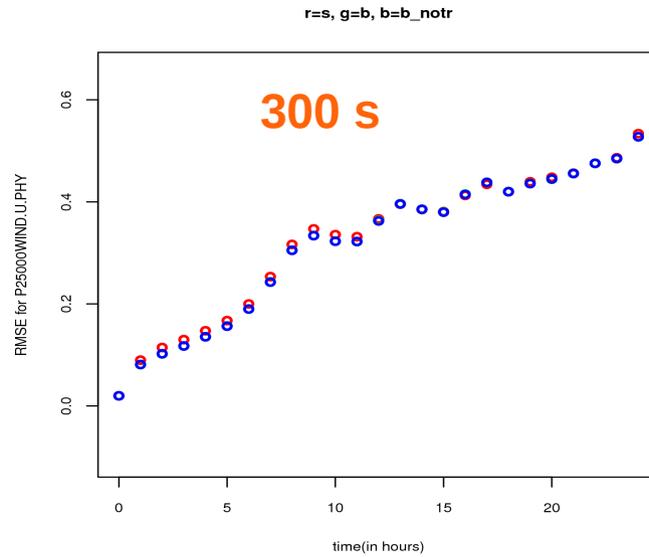
blue=boyd without SL-trunc

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.

