

Re-arranging the HIRLAM boundary relaxation treatment.

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1. Background.

FMI have been experiencing problems with ‘crashes’ which manifest themselves initially as ‘grid-point storms’ near the boundary. At IMS, on the operational 15km grid our forecasts runs do not ‘crash’, but we do see a strong hint of what is almost certainly the same phenomenon. See figure 1, which shows a 24h forecast of convective precipitation. Notice the unphysical values around the edges, both in regions of steep topography and over the ocean. The maximum rainfall amount is 800mm at (45.4N, 23.0E), right on the boundary. It is reasonable to speculate that on a finer grid such a phenomenon could lead to a crash.

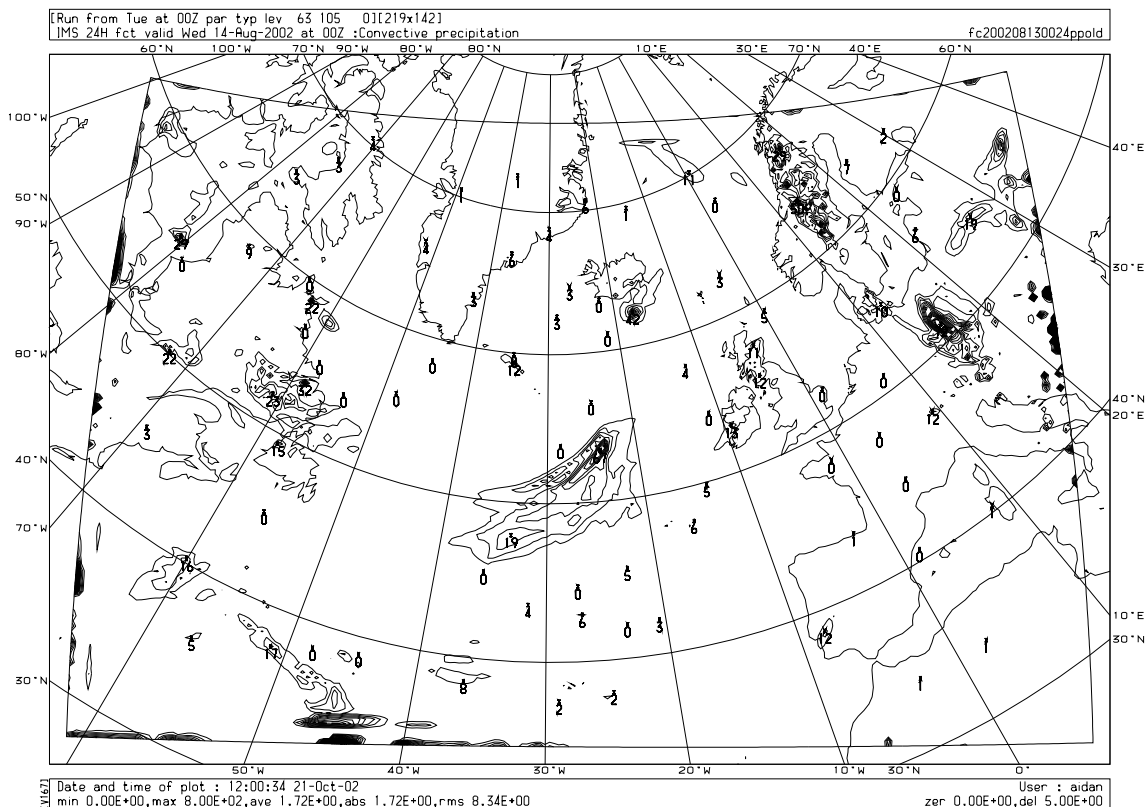


Figure 1: 24h forecast of the convective precipitation using and 31 levels on a 15km grid. (IMS operational HIRLAM).

2. Testing the MC2 boundary treatment.

As we learned at the Dublin Workshop the boundary relaxation is performed in a different order at MC2, (see Benoit et al., 1997), than in the HIRLAM, where the boundary relaxation is the final alteration to the fields, in which we relax the guest model fields toward the host model fields as follows:

$$f^{n+1} = (1 - \alpha)(f^g + \Delta t \Delta f_d^g + \Delta t \Delta f_p^g)^n + \alpha(f^h)^{n+1}. \quad (2.1)$$

Here $\alpha = 0$ in the interior and $\alpha = 1$ on the boundary line. The superscript ‘ h ’ represents the host model, and ‘ g ’ the guest model. The subscript ‘ d ’ represents the ‘dynamics’, and ‘ p ’ the ‘physics’.

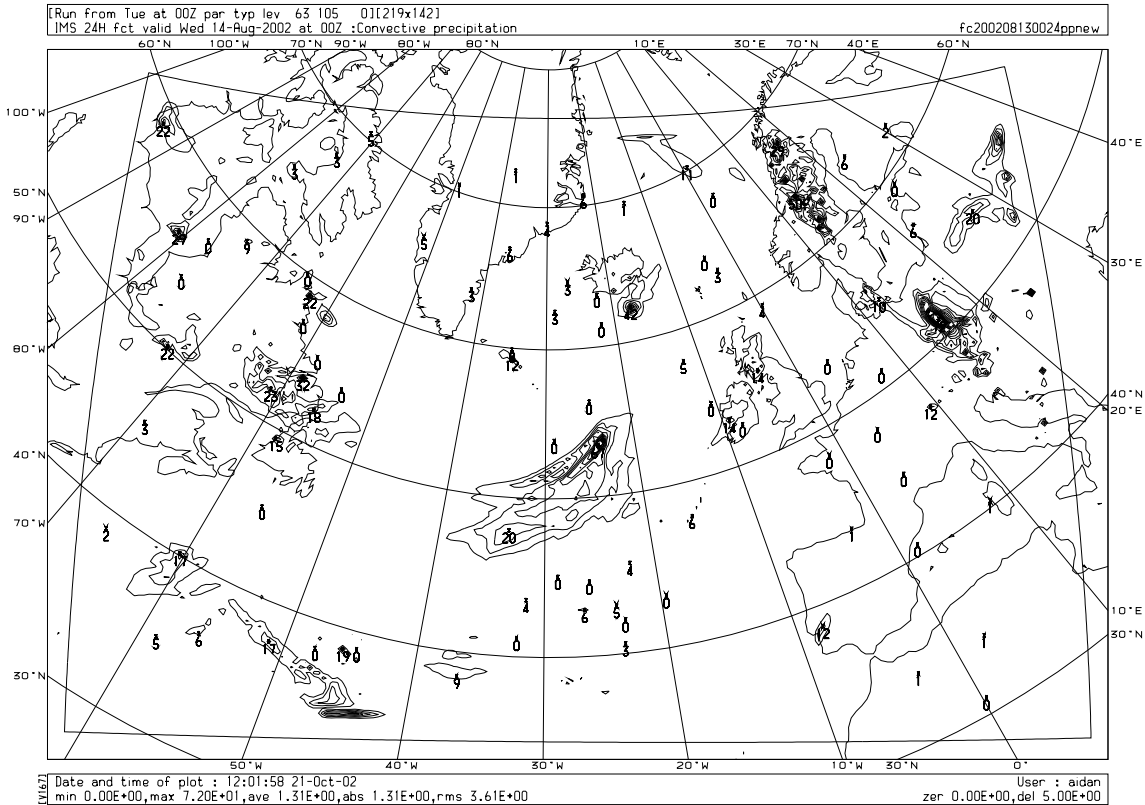


Figure 2: Same as Fig. 1, but now replacing the HIRLAM5.0 reference treatment of the boundary with that described in section 2.

The MC2 treatment, if I understand it correctly, is as follows. Once the dynamics is completed these updated fields are relaxed toward the host model fields:

$$f^* = (1 - \alpha)(f^g + \Delta t \Delta f_d^g)^n + \alpha(f^h)^{n+1}. \quad (2.2)$$

Next, the physics update is performed. Once that is finished, the change in the physics is relaxed toward zero:

$$f^{n+1} = f^* + (1 - \alpha)(\Delta t \Delta f_p^g)^n \quad (2.3)$$

At first glance Eq. (2.3) looks as if it gives the same result as Eq. (2.1). There is a difference, however. We are now driving the ‘physics’ with the field

$$\frac{\alpha}{\Delta t}[f^* - (f^g)^n] = (1 - \alpha)(\Delta f_d^g)^n + \frac{\alpha}{\Delta t}[(f^h)^{n+1} - (f^g)^n], \quad (2.4)$$

whereas with the reference HIRLAM we are driving the physics with

$$(\Delta f_d^g)^n, \quad (2.5)$$

which is very different as we approach the boundary and α tends to one.

If we replace the HIRLAM treatment with this new approach the impact is dramatic. See Figure 2, where the large rainfall amounts around the edges have been eliminated. The maximum rainfall amount is now a much more reasonable 72mm at (51.1N, 15.8E) .

3. Comment.

Although the changes in convective rainfall are dramatic near the boundary, the changes to all fields in the interior are minuscule. Thus, we can have some confidence that the new boundary strategy is not radically different, except close to the boundary line.

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References.

Benoit, R., M. Desgagné, P. Pellerin, S. Pellerin, Y. Chartier and S. Desjardins, 1997: The Candian MC2: a semi-Lagrangian, semi-implicit wideband atmospheric model suited for finescale process studies and simulation. *Mon. Wea. Rev.* **125**, 2382-2415.