ALADIN Research activities at the RMIB

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Integrated scheme for clouds microphysics and convection

The scheme addresses the problem of combining subgrid and resolved contributions to the cloud condensation and the precipitation, especially at resolutions where the convective systems are partly resolved by the model grid.

A single microphysics (derived from Lopez, 2002) is used, with prognostic variables for cloud ice and liquid water. The precipitation contents are obtained from diagnostic solid and liquid precipitation fluxes. The exchanges between all phases (vapour, ice, liquid, snow, rain) are described by fluxes of water and heat.

The convective updraught (prognostic mass flux scheme, representing the effects of the different updraughts within a grid box by a mean equivalent) detrains cloud condensates, which add to the condensate produced by resolved condensation (Smith scheme) in the rest of the grid box. There is no precipitation in the updraught itself.

The auto-conversion processes include a parametrisation of the Wegener-Bergeron-Findeisen effect, through an auto-conversion gain (van der Hage, 1995) for conversion of droplets to solid precipitation.

Collection distinguishes the aggregation of snow, the riming of droplets by snow, and the accretion of droplets. The phase partition of the mixed phase (taken as a function of temperature, between the triple point and -40^{o}C) has to be re-adjusted all along, implying some transfers (of water and heat) between cloud ice and liquid.

The cooling flux associated to precipitation evaporation may spawn a downdraught, which is computed afterwards.

The introduction of cloud condensates has strong consequences for the dynamics of the precipitation. Compared to the earlier scheme, where all condensed water was immediately converted to precipitation reaching the surface in one time step, we observe a reduction of the precipitation amounts. There is often some confusion over the interpretation of the precipitation amounts produced by a model: these should normally represent averages over the area of each grid box, covering tens of km^2. But the final user is most often interested in the maximum quantity collected at a punctual location, and the measures are also local. A direct check of the validity of the precipitation amounts forecast seems very difficult; one possibility would be to input them to a hydrological model.

On 14 August 1999, a squall line brought damage to houses and buildings in Western Belgium.

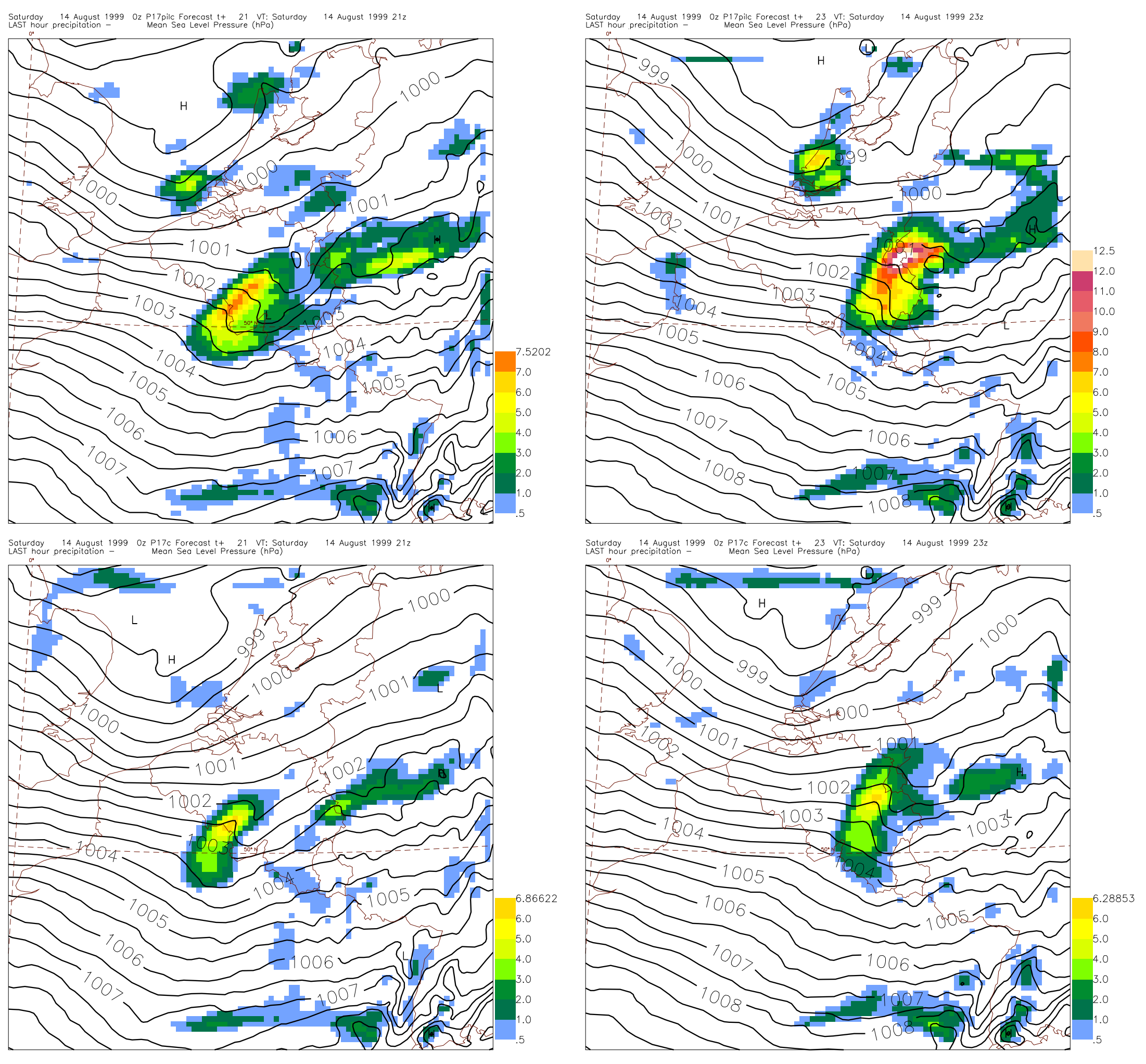
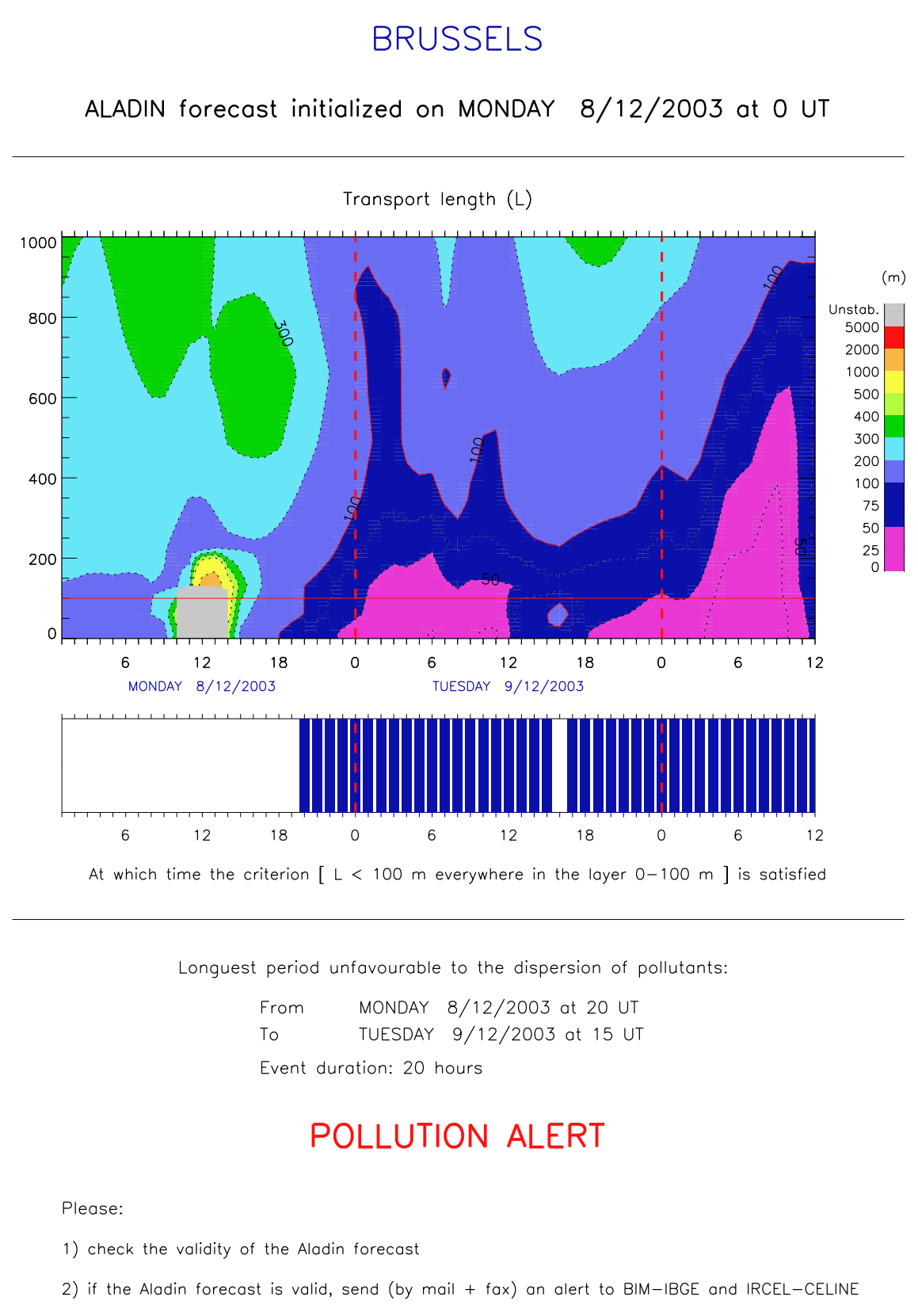


Figure 1: Evolution of MSL pressure and precipitation

The charts of the first line show the evolution when the microphysics is applied only to the resolved clouds and precipitation, while the convective scheme precipitates immediately. The scheme wrongly develops very high precipitation after passing the damaged region. Below, the corresponding forecasts with the new integrated scheme (where the convective scheme contributes to the microphysics), present a maximum of intensity over the damaged area (left), while the squall line gradually fades while progressing to the East.

Pollution Warnings

In Termonia and Quinet (2004), a new transport index was introduced to predict meteorological conditions that are unfavorable for the dispersion of air pollution. For situations of low wind speed and stable atmosphere, when atmospheric transport is weak, it is sufficient to make reliable predictions of peaks of extreme concentrations of non-reactive pollutants.



BRUSSELS

ALADIN forecast initialized on MONDAY 8/12/2003 at 0 UT

Transport length (L)

At which time the criterion [L < 100 m everywhere in the layer 0–100 m] is satisfied

Longuest period unfavourable to the dispersion of pollutants:

From MONDAY 8/12/2003 at 20 UT
To TUESDAY 9/12/2003 at 15 UT
Event duration: 20 hours

POLLUTION ALERT

Please:

1) check the validity of the Aladin forecast

2) if the Aladin forecast is valid, send (by mail + fax) an alert to BIM–IBGE and IRCEL–CELINE

Figure 2: Pollution warning, December 8, 2003

Based on the new index, a procedure has been developed by the Royal Meteorological Institute of Belgium in collaboration with the Brussels Institute for the Management of the Environment and with the Belgian Interregional Cell for the Environment, to forecast pollution peaks and to send warnings to the public and to the policy makers in such cases. Fig. 2 shows one of the typical warnings that are distributed in case of pollution alert. The procedure is currently operational and was successful in predicting the extreme peaks in 2003 and 2004.

Wavelet Representation of Background Error Covariances

Due to the very large size of the background state vector (around 10^7), it is not possible to represent the full background error covariance matrix (which contains around 10^{14} elements). This matrix is thus rather modeled using various simple and efficient approaches, such as a diagonal representation in some well-chosen space. In spectral coordinates this simplifies the covariance matrix to a diagonal one.

Even on a local area model, though, orographic and other variations can cause local changes in error correlation that are lost by the assumption of homogeneity.

In Deckmyn and Berre (2004) a new approach is introduced based on orthogonal wavelets. Rather than representing the covariance matrix $\mathbf{B}$ as a diagonal matrix in one basis, a hybrid representation is introduced that combines diagonal matrices in 3 different orthogonal bases:

$$\mathbf{B} = \mathbf{D}_g\mathbf{F}^{-1}\mathbf{D}_f\mathbf{F}\mathbf{W}^{-1}\hat{\mathbf{B}}_w(\mathbf{W}^{-1})^*\mathbf{F}^*\mathbf{D}_f^*(\mathbf{F}^{-1})^*\mathbf{D}_g^*, \qquad (1)$$

where $\mathbf{W}$ denotes the wavelet transform and $\hat{\mathbf{B}}_w$ the diagonal matrix in wavelet space. With this 3-basis approach, the different spaces are combined, to model that aspect of the covariance matrix they are best suited for: Fourier space models the average correlation function and the average tilt, wavelet space the local and scale-dependent heterogeneities that remain, and grid space the local variance (which could also be seen as the heterogeneity at the smallest grid resolution).

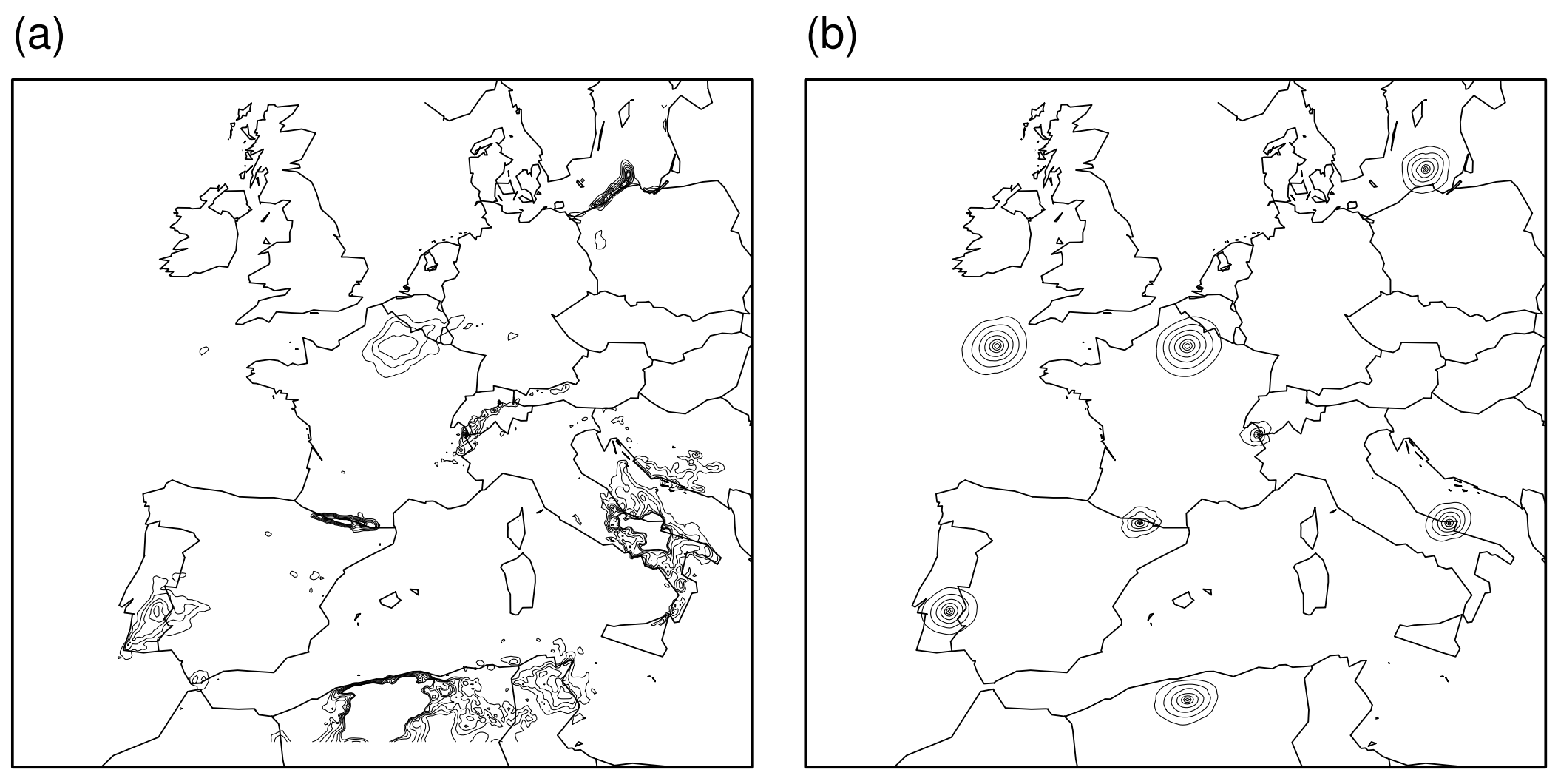


Figure 3: Correlation functions for surface temperature, from grid data and hybrid wavelet approach.

Monitoring the Coupling-Update Frequency

An underestimation of the famous Lothar storm on 26 December 1999 was caused by the limitations in the data transfer of the lateral-boundary conditions for the ALADIN models, being restricted to updates with intervals of 3 or 6 hours, see Termonia (2003). A solution was found by Termonia (2004).

This was approached as a problem of undersampling. The coupling-update frequency can be monitored by using a digital recursive filter in the coupling model. An example of such a filtering of the prognostic variable $\ln P_s$ is given in Fig. 4, detecting information loss in the data transfer with 3-h coupling updates.

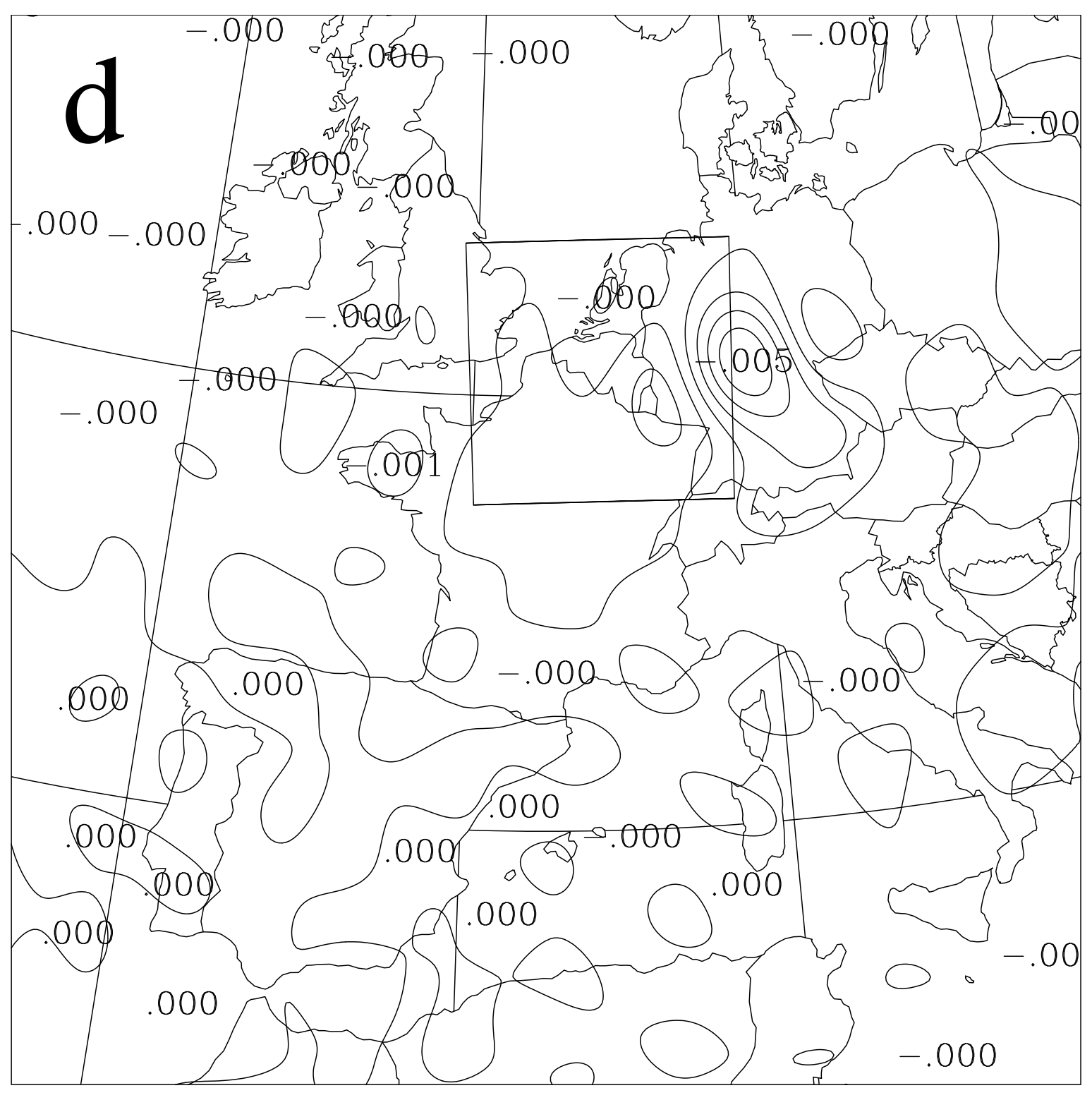


Figure 4: The Christmass storm: estimated information loss (filtered $\ln P$) at 1330 UTC, 26 December 1999.

This monitoring algorithm has been implemented in cy28t2 and opens the way to adopting one of the following coupling strategies:

- Couple with increased update interval when information loss is detected in the coupling zone, using guidelines as presented in Termonia and De Meyer (2004).
- Restart the forecast after the information loss of the storm is detected inside the domain. This is technically possible with ALADIN.
- Restart as in the previous point, but make a smooth transition by *blending*. This should still be investigated.
- Spectral coupling, i.e. inject the storm in the large scales. Extra research is needed for this.

References

[1] Deckmyn, A. and L. Berre, 2004: Wavelet Approach to Representing Background Error Covariances in a Limited Ar ea Model, *submitted to Mon. Weath. Rev.*.

[2] Termonia P., 2003: Monitoring and Improving the Temporal Interpolation of Lateral-Boundary Coupling Data for Limited-Area Models, *Mon. Wea. Rev.* **131**, No. 10, pp 2450-2463.

[3] Termonia P., 2004: Monitoring the Coupling-Update Frequency of a Limited-Area Model by means of a Digital Recursive Filter, *Mon. Wea. Rev.*, **132**, 2130-2141.

[4] Termonia, P., and F. De Meyer: On the Choice of the Coupling-Update Frequency of a Limited-Area Model, *submitted to Mon. Weath. Rev.*.

[5] Termonia, P. and A. Quinet, 2004: A New Transport Index for Predicting Episodes of Extreme Air Pollution, *J. Appl. Meteor.*, **43**, 631-640.

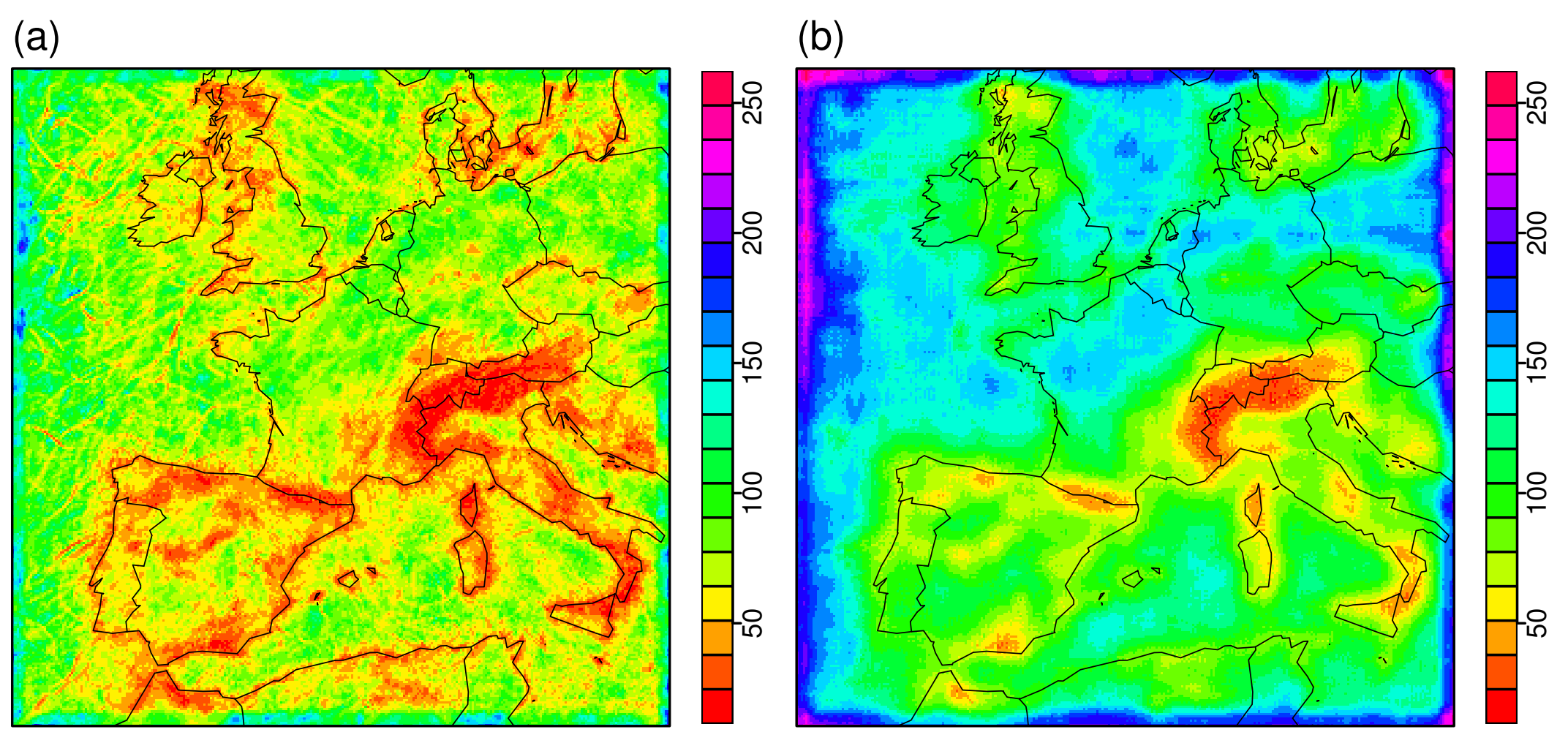


Figure 5: Lengthscale at surface, from grid data and modelled by wavelets.