ALADIN Research activities at the RMIB

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Wavelet Representation of Background Error Covariance

In variational assimilation, the number of variables forces us to make some simplifications in the representation of the background error covariances. Often, it is assumed that horizontal correlations are homogeneous on the model domain. 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. We are therefore studying representations based on wavelets. These are functions that could be said to stand somewhere inbetween grid space and Fourier space. From the pletora of possible wavelets we have chosen to work with the Meyer wavelet. It is closely linked with spectral space and can be generalized to any domain size. Figure (1) shows a 1-dimensional Meyer wavelet. It is well localised in Fourier space, where it has compact support, but not very localised in grid space.

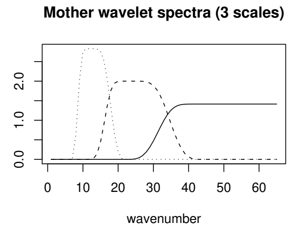

Figure 1: The spectrum of the Meyer wavelet at 3 consecutive scales

This single function is translated and dilated (usually by factors of 2, but this can be generalized) to form an orthogonal basis. Rather than describing a field by frequency or by location, wavelets describe it by *scale and location*.

When diagonalising the correlations in Fourier space, the matrix B is decomposed as

$$B_g = \Delta_g^* F^* B_f F \Delta_g, \qquad (1)$$

where F denotes the Fourier transform, D_f the correlation matrix in Fourier space and Δ_g the inverse standard deviations. In our wavelet approach, we generalise this to

$$B_g = \Delta_g^* F^* \Delta_f^* (F^{-1})^* W^* B_w W F^{-1} \Delta_f F \Delta_g, \qquad (2)$$

where W denotes the wavelet transform and B_w the correlation matrix in wavelet space. With this 3-basis approach, we effectively use the grid basis to model local variance, the Fourier basis to model mean correlation functions and the wavelet basis for local variations in e.g. anisotropy and correlation length.

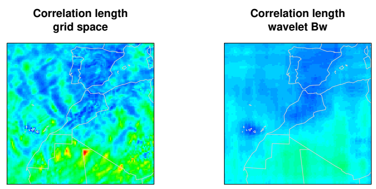

Figure 2: Temperature error correlation length at model level 13

Reference:

Alex Deckmyn and Loïk Berre, *Wavelet Methods for Representation of BAckground Error Covariance*, in preparation.

Impact of the ALADIN-Belgium domain size on a deep convection case (16 of july 2003)

Overall situation at 6 hour UT: a core of low pressure is on the English Channel, along the Bretonne coast. The cold associated front extend from the area of Saint-Malo and skirts the french atlantic coast. On this front, from this moment and during the day, there is appearance of different and sometimes very violent storms. In the hot sector, there is a contribution of tropical hot air coming from the south-east.

Fig. 3 shows the result of a Aladin run at + 15 hours for the 10m wind, 2m temperature, pressure and precipitations, obtained for a 700*700 km domain.

Fig. 4 shows the result for the same range, but this time for a 1600*1600 km domain, identically centered on Belgium.

Fig. 5 shows precipitations obtained using the radar of Wideumont.

One notes very big differences of cumulated precipitations between the runs with the current operational domain and the extend domain and in particular the intense core of deep convection precipitation, located on the west and the center of Belgium disappears. The differences obtained for the other fields (temperature, wind and pressure) are much weaker.

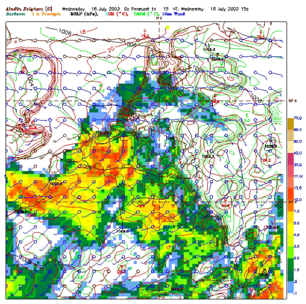

Figure 3: Surface fields for a 700*700 km domain.

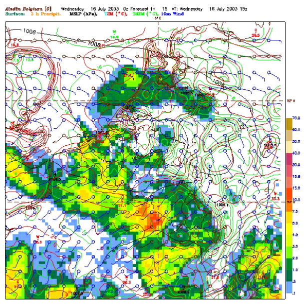

Figure 4: Surface fields for a 1600*1600 km domain.

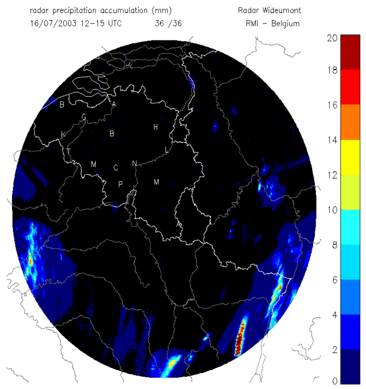

Figure 5: Precipitation obtained with the Wideumont radar.

Predicting extreme peaks of pollution with ALADIN

It is well known that the meteorological state of the atmosphere has an important influence on the observed concentrations of air pollutents. In the case of low-wind-speed and stable stratifications, air pollution stays where it is emitted and gets accumulated in the stagnant air, causing a clear peak in the measured concentrations. Since the meteorological conditions are predominant in these cases we use the NWP ALADIN model to predict them.

A characteristic length scale l can be calculated from the wind speed $\bar{u}$ and the Brunt-Väisälä frequency ν,

$$l = \frac{\bar{u}}{\nu}, \qquad (3)$$

where $\bar{u}$ is the wind speed and

$$\nu = \sqrt{\frac{g \partial\theta}{\theta \partial z}}, \qquad (4)$$

reflects the stability of the atmosphere, where z is height, g is gravity and θ the potential temperature. The smaller l will be found for a smaller $\bar{u}$ (weak horizontal transport) and a more stable atmosphere (weak vertical transport). In fact, this implies that when l reaches the lowest observed values, one can be sure that both the wind is weak and the atmosphere is very stable.

It was found that concentrations of non-reactive pollutants extreme peaks can be well forecasted from the model output of this index. Although NO_2 reacts chemically with ozone, during winter this element can be practically treated as a non-reactive pollutant due to the low ozone background concentrations.

The meteorological model output is considered as *unfavorable* for the dispersion for non-reactive pollutants if *there exists a layer at the surface for a time span of the order of 24 hours, where $l < 100m$. During these 24 hours there should be an uninterrupted span of 12 hours or more in which the layer is deeper than $100m$. In such layers, there may appear instabilities near the surface due to heating during the day. These instabilities can be ignored if they are covered with an $l < 100m$ layer from above, preventing the escape of the pollutants upwardly.*

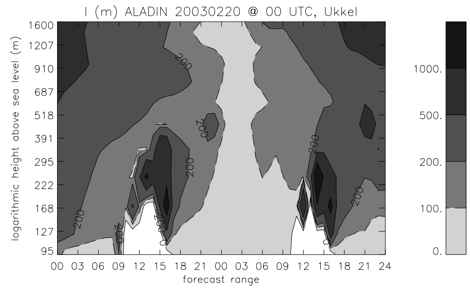

Figure 6: model output that is unfavorable for the dispersion of non-reactive air pollution.

Fig. 6 shows an example of such conditions.

This index was validated during the three winters 2000-2001, 2001-2002, and 2002-2003, to forecast pollution peaks in the Brussels-Capital Area. Extreme peaks of NO_2 were well forecasted on 4 days (We 17 January 2001, Th 18 January 2001, Th 15 February 2001, Th-Fr 20-21 February 2003).