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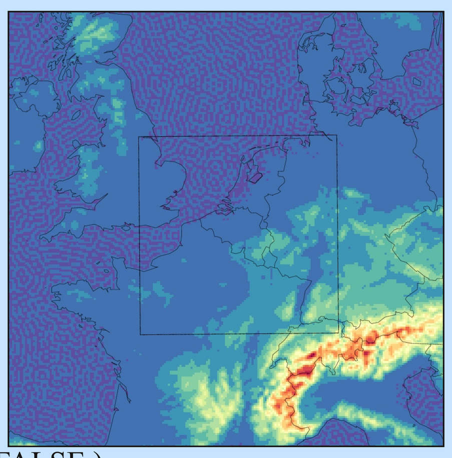
The operational ALADIN-Belgium model

1. Main features

- Model version: AL35t1 + ALARO-0 + 3MT
- 60 hour production forecasts four times a day (0, 6, 12 and 18 UTC).
- Lateral boundary conditions from Arpège global model.

2. The computer system



- SGI Altix 4700.
- 196 Itanium2 CPUs.

3. Model geometry

- 7 km horizontal resolution (240*240 points), 4 km resolution (192*192).
- 46 vertical levels.
- Linear spectral truncation.
- Lambert projection.

4. Forecast settings

- Digital filter initialization (DFI with LSPRT=.FALSE.).
- two time level semi-implicit semi-Lagrangian - SISL - advection scheme.
- Time step: 300s (7 km), 180s (4 km).
- Lateral boundary condition coupling at every 3 hours.
- Hourly post-processing (latitude-longitude and Lambert).

5. Operational suite/technical aspects

- Transfer of coupling file from Météo-France via Internet (primary channel) and the Regional Meteorological Data Communication Network (RMDCN, backup).
- Model integration on 40 processors (7 km), 20 processors (4 km).
- Post-processing on 8*1 processors.
- Continuous monitoring supported by a home-made Kornshell/Web interface.
- Monitoring with SMS (Supervisor Monitor Scheduler).

Initial surface perturbations in LAMEPS by Cycling Surface Breeding

(Geert Smet)

Introduction

Most EPS and LAMEPS are underdispersive, i.e. have too little spread, especially for the surface weather variables. While there are many possible reasons for this, one important reason is that the surface uncertainty is often not (sufficiently) taken into account. A new method to introduce initial surface perturbations in LAMEPS called Cycling Surface Breeding (CSB) was investigated with the ALADIN-LAEF system, and compared with the operational Non-Cycling Surface Breeding (NCSB) and a variant of this method called NCSB2.

ALADIN-LAEF experiments

The ALADIN-LAEF system consists of 16 perturbed members, which are produced by coupling 16 different versions of the ALADIN limited area model (i.e. multi-physics) to the first 16 perturbed members of the ECMWF ensemble prediction system. Operationally, an upper-air breeding-blending cycle is implemented, but in the experiments pure downscaling was used for the upper-air, in order to focus on the effects of the surface (perturbations).

Initial surface perturbations

Non-Cycling Surface Breeding (NCSB)
In the operational NCSB method, 12h surface forecasts P_n (n = 1,...,16) for time t are created by integrating the ALADIN-LAEF members up to 12h, starting at time t-12h, with the ARPEGE surface analysis of time t-12h. The perturbed surfaces A_n for time t are then calculated as

$$A_n = C + s_n \Delta_n$$
$$\Delta_n = P_n - C$$

with (control) C the ARPEGE surface analysis of time t. Operationally, $s_n \equiv 1$ for all n, i.e. $A_n = P_n$.

Centering and Rescaling (NCSB2)
We tested a version of NCSB that used a centered difference Δ_n^c (instead of Δ_n):

$$\Delta_n^c = (-1)^{n+1} (P_n^+ - P_n^-)$$

with odd (`positive') members $P_n^+$ (= $P_{\lfloor (n+1)/2 \rfloor}$), and even (`negative') members P_n^- (= $P_{\lceil n/2+1 \rceil}$). The perturbed surface A_n was again calculated as above:

$$A_n = C + s_n \Delta_n^c$$

but with a fixed scale $s_n \equiv 2$ (and centering).

Cycling Surface Breeding (CSB)
In Cycling Surface Breeding (CSB), surface forecasts P_n from the previous run are used, instead of 12h surface forecasts integrated from the previous analysis. The size of the perturbations now has to be controlled by rescaling (i.e. s_n is not fixed anymore):

$$s_n = \sqrt{S / | \min(\Delta_n^c) * \max(\Delta_n^c) |}$$
$$S = \mathrm{avg} (|\min(\Delta_n) * \max(\Delta_n)|)$$

with `min'/`max' denoting the minimum/maximum over the LAEF domain, and S a fixed size factor, determined by looking at the average difference between a 12h surface forecast and a surface analysis, averaged over all members and the whole experiment period. The scales s_n are calculated using the surface temperature field, and then the same scales are used for the other perturbed surface fields (surface liquid water, deep soil temperature and deep soil liquid water) as is also done in NCSB and NCSB2.

Verification

The verification was done against observation stations, for the 00h run, and scores shown (figures 2-5) are averages over all stations in the verification domain (see figure 1) and over the whole verification period (20/06/2007-20/07/2007). We show some scores for T_{2m} (2-meter temperature), where the difference between the three experiments is most visible. No bias/height correction was applied, hence the rather large bias and RMSE in T_{2m}.

Conclusions

NCSB2:
- Small positive effect on surface weather variables, most clearly visible in T_{2m}. Mainly better spread.
- Especially in first 24h, difference decreases with lead time.

CSB:
- Large positive effect for T_{2m}, smaller for S_{10m} (10-meter wind speed), mixed results for precipitation.
- For T_{2m}, (large) positive effect at all lead times. Not only better spread, but also RMSE and bias.
- Differences between the experiments are larger during the day than at night.

References

- Wang Y., Kann A., Bellus M., Pailleux J., Wittmann C. (2010), *A strategy for perturbing surface initial conditions in LAMEPS*, Atmos. Sci. Let. 11: 108-113.
- Wang Y., Bellus M., Smet G., Weidle F. (2011), *Use of the ECMWF EPS for ALADIN-LAEF*, ECMWF Newsletter No.126 - Winter 2010/11, p.18-22.

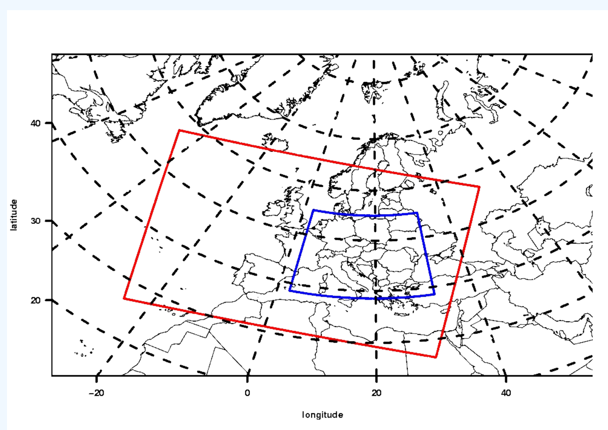


Figure 1: ALADIN-LAEF domain (18 km horizontal resolution) is depicted in red (large box). The verification domain, which covers Central Europe, is given in blue (smaller box).

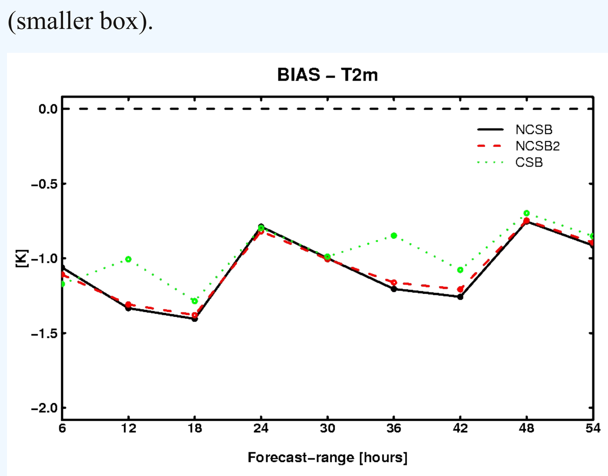


Figure 2: Bias of 2-meter temperature for NCSB (black full line), NCSB2 (red dashed line) and CSB (green dotted line).

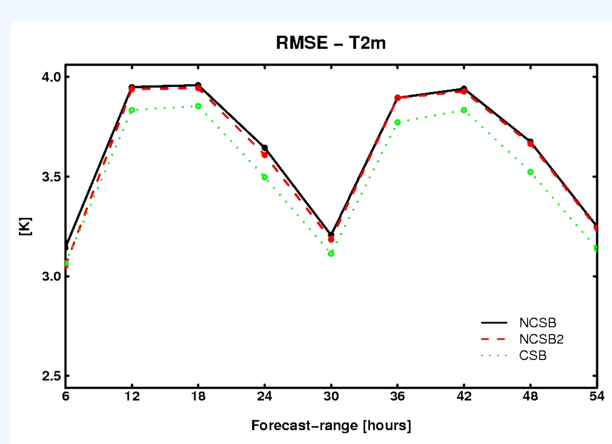


Figure 3: RMSE to spread ratio of 2-meter temperature for NCSB (black full line), NCSB2 (red dashed line) and CSB (green dotted line).

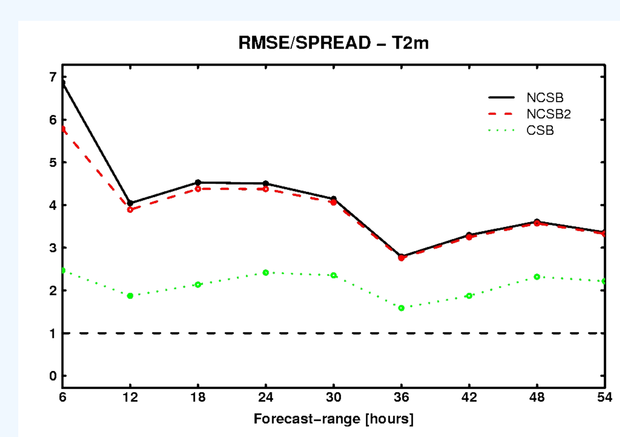


Figure 4: RMSE to spread ratio of 2-meter temperature for NCSB (black full line), NCSB2 (red dashed line) and CSB (green dotted line).

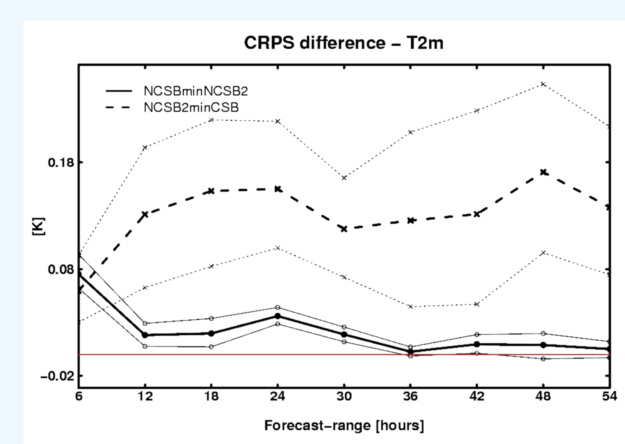


Figure 5: Difference in CRPS (thick lines) with bootstrap confidence intervals (thin lines) of 2-meter temperature for NCSB versus NCSB2 (full lines) and NCSB2 versus CSB (dashed lines).

The Integrated RMI Alert system (INDRA)

Introduction

INDRA is a system is under development at the Royal Meteorological Institute of Belgium (RMI), to improve our capability to issue alerts and warnings to the public for extreme events, in particular heavy precipitation, flooding and thunderstorms. The relevance of this was confirmed in 2011 by the famous Pukkelpop thunderstorm, where the RMI carried out its task according the current meteorological state of the art, but which also pointed out potential for developing new applications to further improve the warnings for such cases.
The main aim of INDRA is to integrate and provide a common platform for RMI products that involve warnings for extreme precipitation (rain and snow), high waters and thunderstorms.

INDRA components

- ECMWF Ensemble Prediction System (EPS).
- Grand Limited Area Model Ensemble Prediction System (GLAMEPS).
- INCA-BE nowcasting system.
- BElgium Lightning Location System (BELLS).
- RMI hydrological ensemble prediction system (SCHEME).

Pukkelpop 2011

On the 18th of August 2011, around 16h15 UTC (18h15 local time) a summer thunderstorm hit the festival site of Pukkelpop, a popular annual music festival near the city of Hasselt, Belgium. Around 60.000 people were present. The thunderstorm had an unusually big impact: 5 deaths and approximately 140 wounded.

INCA-BE (Reyniers and Delobbe, 2012) became (pre-) operational during Spring 2012. A post-analysis of the Pukkelpop storm was performed, showing the 1h forecast was quite accurate, except for a time shift of approximately 10 minutes.

Outlook

- After the Pukkelpop thunderstorm, the RMI decided to offer a custom product for organisers of outdoor events: the Outdoor Event Forecast. The biggest outdoor mass events in Belgium were integrated in the INCA-BE system.
- The thunderstorm was forecast rather well, according to the current state of the art, but had an unusually big (and arguably unforeseeable) impact. However, to predict downbursts probably much higher resolutions are necessary.
- INDRA will be further developed: EPS based probability of thunderstorm maps, implementation of an automated alert system

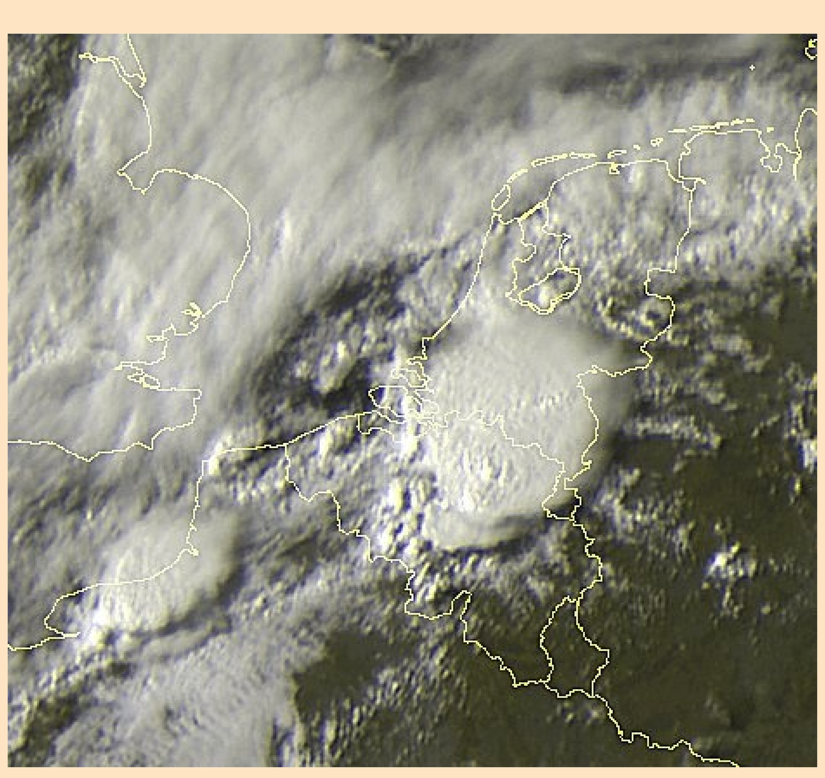


Figure 1: Visual satellite image of 18 August 2011, 15h45 UTC. Overshooting top visible over the province Limburg, Belgium.

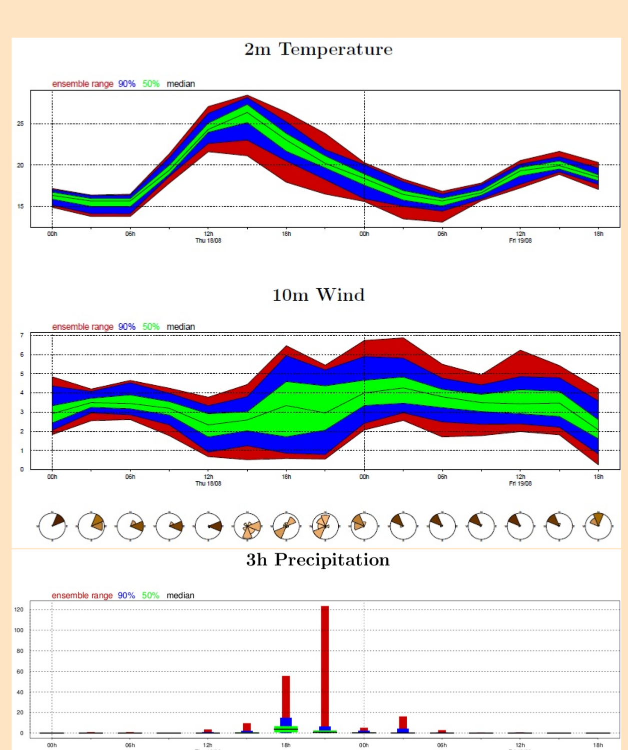


Figure 2: GLAMEPS-o-grams for T2m, S10m and AccPcp3h (at the Pukkelpop festival site).

Study of the Jacobian of an Extended Kalman Filter for soil analysis in SURFEX

(Annelies Duerinckx & Rafiq Hamdi)

Introduction

The equation for the Extended Kalman Filter (EKF):

$$x^a_t = x^b_t + BH^T (HBH^T + R)^{-1} [y^o_t - \mathcal{H} (x_b^o)]$$

H is the jacobian matrix of the observation operator $\mathcal{H}$ and is calculated with a finite difference approach:

$$H_{ij} = (y_i (x + \delta x_j) - y_i (x)) / (\delta x_j)$$

A small perturbation δx_j is added to one of the soil prognostic variables x_j at time t_0. Then the perturbed model stated is evolved from time t_0 to time t, the analysis time. At time t the model state is projected into observation space to obtain the corresponding observation value $y_i(x_j+\delta x_j)$. The value of the Jacobian thus depends on how the observation value changes after a 6 hour run, when the soil prognostic variable is perturbed at the initial time.

Problem

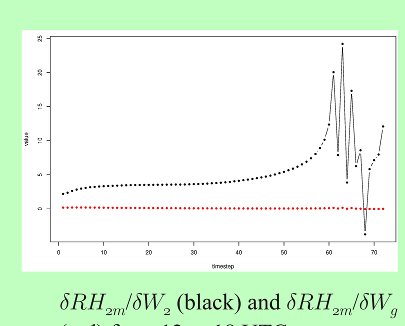
Figure 1 shows the evolution of the Jacobian values during the 6 hour forecast run with SURFEX offline from 12UTC to 18UTC. The figure shows how an oscillation sets in near the end of the 6 hour window. This oscillation in the Jacobians stems from an oscillation in the screenlevel simulated observations (figure 2). The oscillation is caused by a decoupling of the surface and the atmosphere during sunset. This creates small oscillations in the fluxes and screenlevel parameters but big oscillations in the Jacobian values that are derived from them.

Solutions

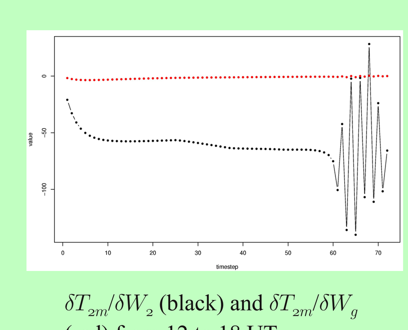
- Filter the oscillation in T_{2m} and RH_{2m} before calculating the Jacobians
- Use forcing files from an earlier run to allow the atmosphere more time to adjust to the surface. In this case the oscillation does not occur.
- Use the Canopy scheme, which introduces additional layers between the lowest atmospheric model level and the surface, to prevent the decoupling of the surface and the atmosphere.

Experimental setup

- ALARO (4km resolution, 46 vertical levels, v36t1) + SURFEX (two-layer version)
- surface assimilation (6h cycle) with an Extended Kalman Filter
- screenlevel observations (T_{2m} and RH_{2m})
- soil prognostic variables used in EKF: superficial and deep soil temperature (T_s, T_2), superficial and root zone soil moisture (W_g,W_2)

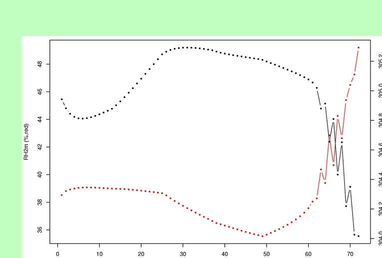


$\delta RH_{2m}/\delta W_2$ (black) and $\delta RH_{2m}/\delta W_g$ (red) from 12 to 18 UTC

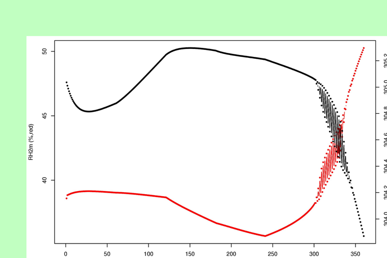


$\delta T_{2m}/\delta W_2$ (black) and $\delta T_{2m}/\delta W_g$ (red) from 12 to 18 UT

Figure 1: Evolution of T_{2m} (black) and RH_{2m} (red) during a 6h SURFEX reference run for 2 July 2010 from 1200 UTC to 1800 UTC in a point in the middle of the 4km Belgian domain (output plotted every timestep).



T2m_RH2m_evolution_JACtest_12-18



T2m_RH2m_evolution_JACtest1_12-18

Figure 2: Evolution of the Jacobian value during a 6h offline SURFEX run for 2 July 2010 in a point in the middle of the 4km Belgian domain (output plotted every timestep). Perturbation size for the initial perturbed states is 10^{-5}.