Surface perturbations by Cycling Surface Breeding

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Introduction

- Underdispersiveness of (LAM)EPS, especially for surface weather variables
- Importance of the surface $\Rightarrow$ perturb surface to quantify the uncertainty

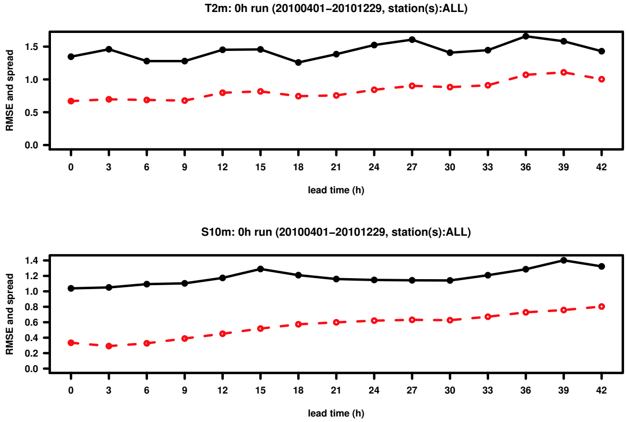


Figure: RMSE of ensemble mean and (average) spread of LAEF over Belgium. Top panel: 2-meter temperature (T2m), bottom panel: 10-meter wind speed (S10m). Verification period: 1 April 2010 - 29 December 2010 (run = 00h).

LAEF experiments

- ALADIN LAM(s) coupled to ECMWF-EPS, 16 perturbed members.
- Multiphysics.
- Surface perturbations with Non-Cycling Surface Breeding (NCSB).
- Focus on the surface $\Rightarrow$ no upper-air breeding-blending cycle, but downscaling instead.

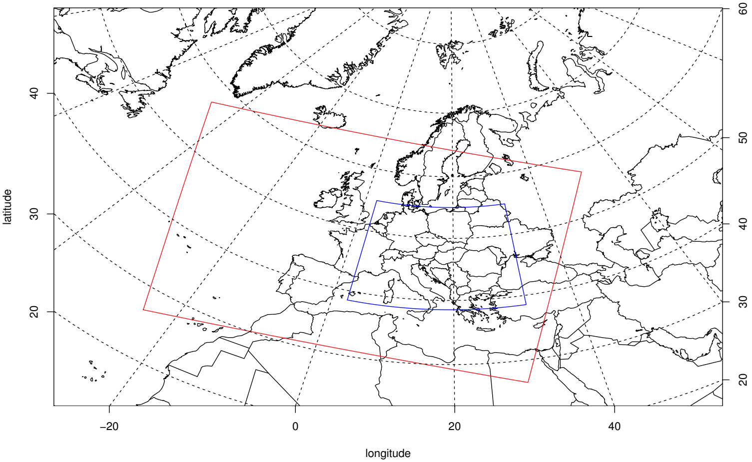


Figure: LAEF domain (18km horizontal resolution) is depicted in red . The verification domain, which covers Central Europe, is given in blue.

Surface perturbations (NCSB)

Non-cycling Surface Breeding

- ARPEGE surface analysis C (control), replaces ECMWF surface.
- 12h surface forecasts P_n ($n = 1 \ldots 16$).
- Perturbed surface A_n:

$$\begin{aligned} A_n &= C + s_n \Delta_n \\ \Delta_n &= P_n - C \end{aligned}$$

Operationally, $s_n \equiv 1$ for all n, i.e. $A_n = P_n$.

Surface perturbations (NCSB2 and CSB)

Centering and rescaling

- Centered difference Δ_n^c (instead of Δ_n):

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

  odd ('positive') members P_n^+ $(= P_{\lfloor (n+1)/2 \rfloor})$,
  and even ('negative') members P_n^- $(= P_{\lceil n/2+1 \rceil})$.
- Again, perturbed surface A_n:

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

- NCSB2: fixed scale $s_n \equiv 2$ (and centering).

Surface perturbations (CSB)

- Cycling Surface Breeding (CSB): surface forecasts P_n from previous run, instead of 12h surface forecasts integrated from previous analysis.
- We control size of perturbations by rescaling (s_n not fixed anymore):

$$
\begin{aligned}
s_n &= \sqrt{\frac{S}{|min(\Delta_n^c) * max(\Delta_n^c)|}} \\
S &= avg\left(|min(\Delta_n) * max(\Delta_n)|\right)
\end{aligned}
$$

- We do this for the field 'SURFTEMPERATURE'. Same scale s_n for other perturbed surface fields.

Surface perturbations (NCSB2 and CSB)

Perturbed surface fields

We perturb the following surface fields (ISBA):

- ‘SURFTEMPERATURE’ and ‘PROPFTEMPERATURE’ (surface and deep soil temperature)
- ‘SURFRESERV.EAU’ and ‘PROFRESERV.EAU’ (surface and deep soil liquid water content)

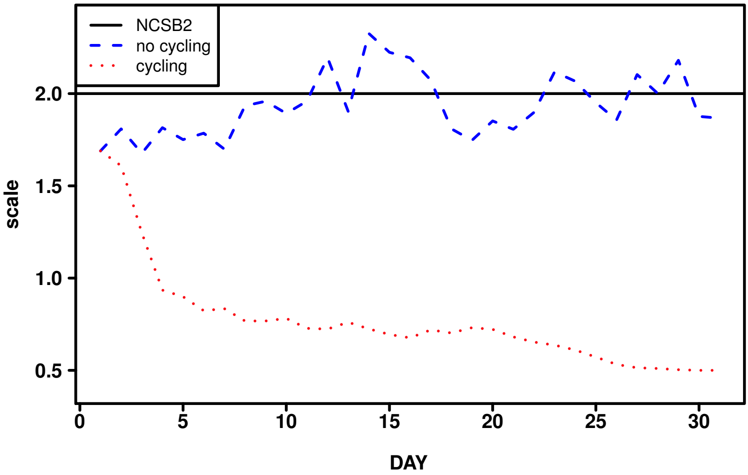


Figure: Evolution of scale s (averaged over all members).

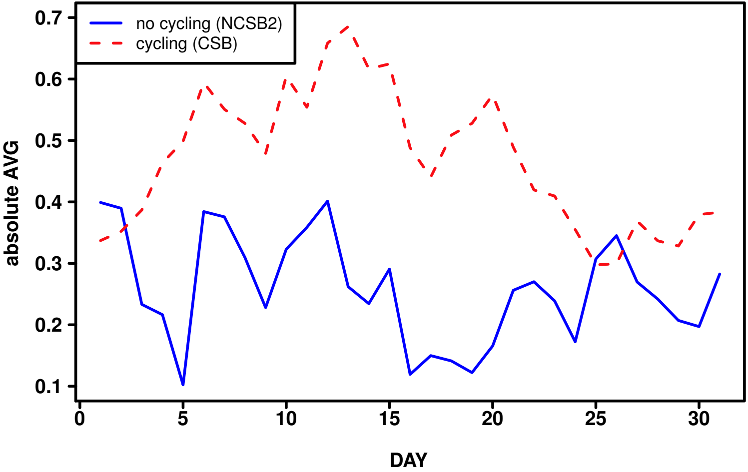


Figure: Average of the surface temperature perturbation (average over the verification domain, and absolute average over all members).

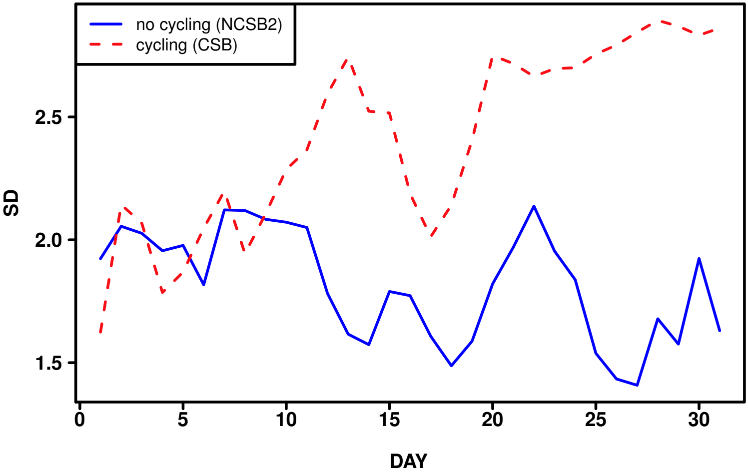


Figure: Standard deviation of the surface temperature perturbation (average over the verification domain and over all members).

Verification scores

- Station based verification (verification domain). No bias/height correction.
- Focus on T2m and S10m (in this presentation).
- Verification period: 20/06/2007-20/07/2007 (run = 00h).
- Scores are averages over the verification period and over the verification domain.

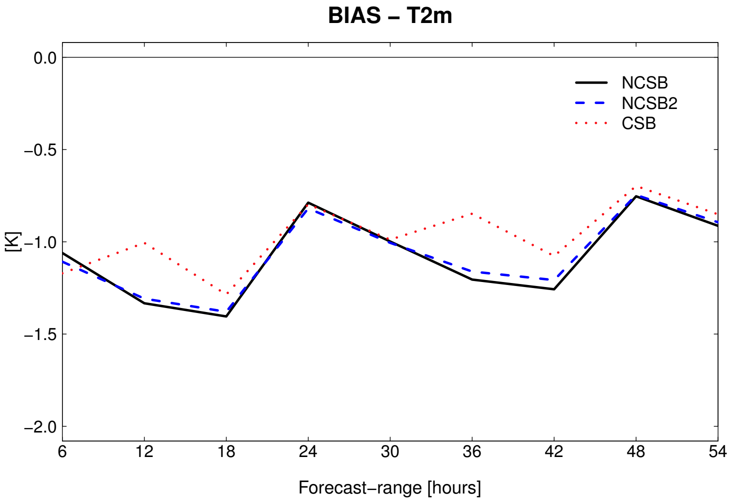


Figure: Bias for 2-meter temperature.

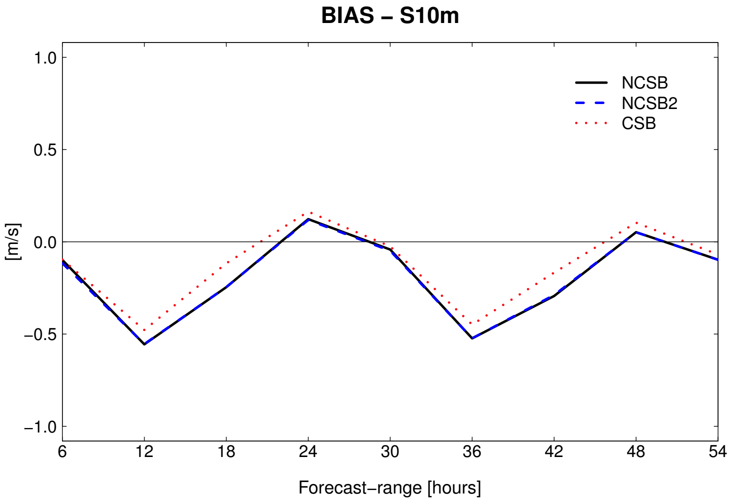


Figure: Bias for 10-meter wind speed.

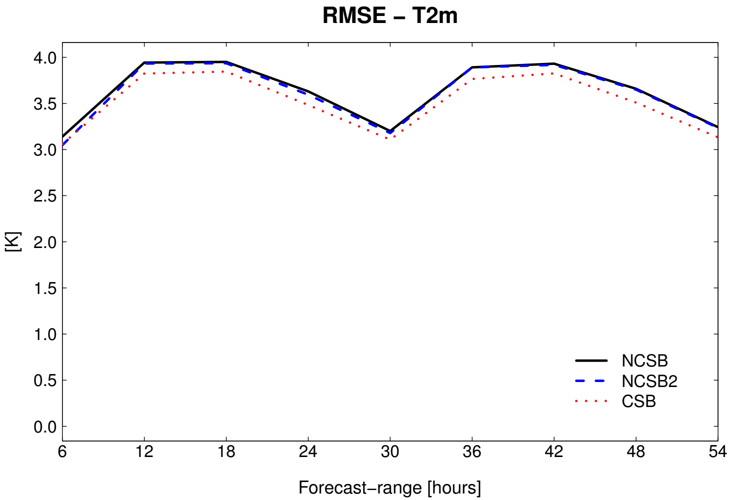
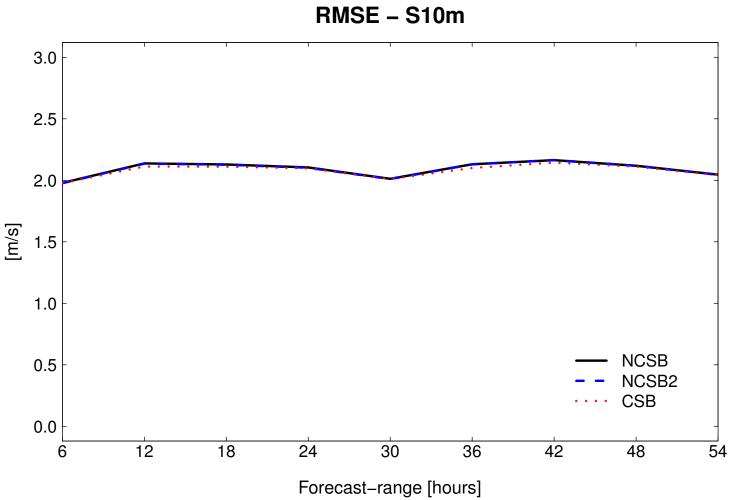


Figure: RMSE for 2-meter temperature.



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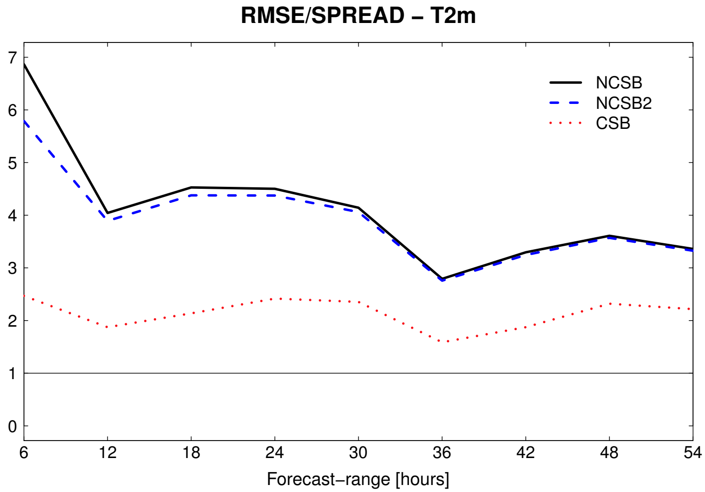

Figure: RMSE to spread ratio for 2-meter temperature.

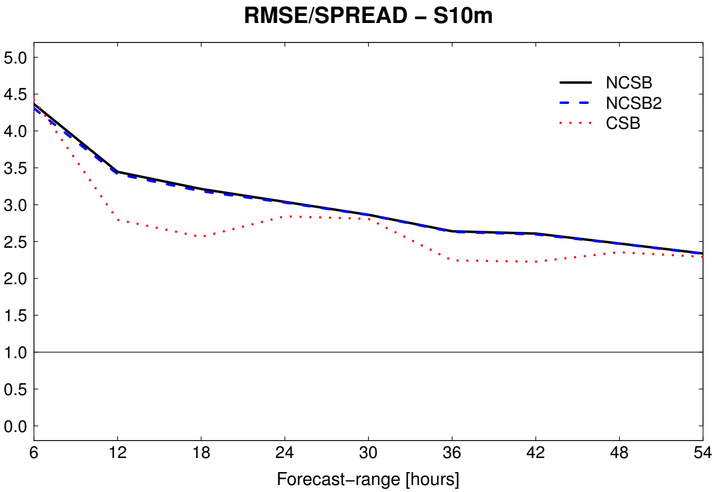

Figure: RMSE to spread ratio for 10-meter wind speed.

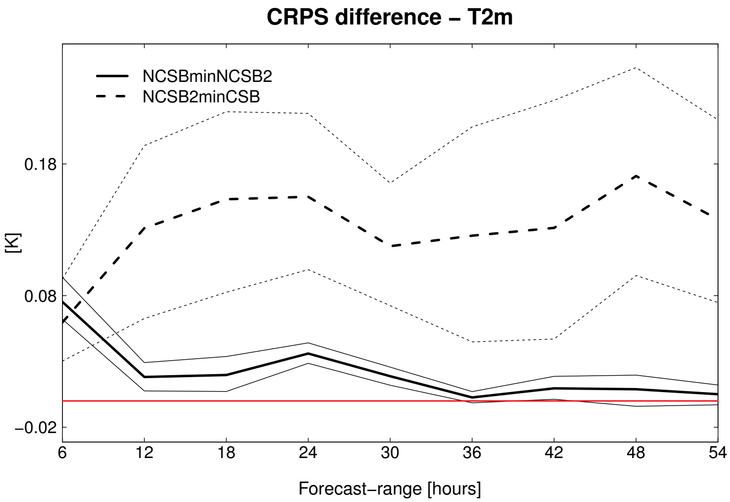

Figure: Difference in CRPS with bootstrap confidence intervals for 2-meter temperature.

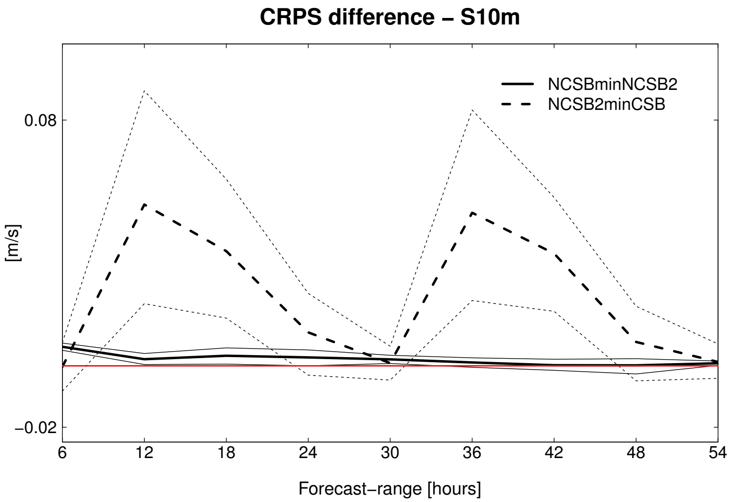

Figure: Difference in CRPS with bootstrap confidence intervals for 10-meter wind speed.

Summary/Conclusions

NCSB2:

- Small positive effect on surface weather variables, most clearly visible in T2m. Mainly better spread.
- Especially in first 24h, difference decreases with lead time.

CSB:

- Large positive effect for T2m, smaller for S10m, mixed results for precipitation.
- For T2m, (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.

Possible future work

- Different rescaling for each perturbed field, instead of using one scale for all fields.
- Comparison with other surface perturbation methods, e.g. CANARI surface data assimilation.

THANK YOU

Appendix:CRPS

Continuous Ranked Probability Score

$$CRPS(forecast) = \frac{1}{ncases} \sum_{i=1}^{ncases} \int_{x=-\infty}^{x=+\infty} \left(F_i^f(x) - F_i^o \right)^2 dx$$

- F_i are cdf's, with F_i^o usually a (Heaviside) step function.
- Lower CRPS is better.