Royal Meteorological Institute,
Brussels, Belgium

IRM

16 November 2013

Ref: gmd-2013-86

Dear Reviewer 1,

First, we would like to thank you for your careful and constructive review of our paper. We have tried to follow all your requests as best as we could and believe that it helped to substantially improve the manuscript. A point by point explanation follows below for your comments:

Comments:

- *Abstract: P4055L11: Which scores? Upper-air or surface? Which variables? If details are not appropriate in the abstract then it is better to refer more generally to "forecast performance".*

Reply: We agree, we now write in the revised manuscript "...**which degrades the 2m temperature scores**."

- *P4055L13: Similar comment for the sentence reporting "Promising improvements from TEB": on which variables?*

Reply: Since the improvement is related to different variables, we prefer to refer more generally to the forecast performance in the abstract (as suggested earlier). We now write in the revised manuscript "**The results also show that promising improvements with a demonstrated positive impact on the forecast performance are achieved by introducing the Town Energy Balance (TEB) scheme**".

- *Main text: P4056L9: remove "roughly"*

Reply: Corrected.

- *P4056L17: bigger → larger*

Reply: Corrected.

- *P4057L3: physic-dynamics → physics-dynamics 2 Model: description and configurations*

Reply: Corrected.

- *P4060L25: "For operational application running with long time steps, the TEB scheme is not activated and the town is replaced by rocks." Why this is done? Is TEB an explicit scheme?*

Reply: Yes it is. We now write in the revised manuscript " **The ISBA scheme is therefore used for all grid points of the domain because of numerical instabilities in the coupling with <u>explicitly computed TEB variables</u> at the time of testing**".

- *P4062L13: "the" is repeated twice*

Reply: Corrected.

- *P4064L4: Which FAO dataset is used for soil texture? Please specify.*

Reply: We now refer in the revised manuscript to FAO (2006). The new reference is added to the list:

FAO: World reference base for soil resources 2006, A framework for international classification, correlation and communication, World soil resources report No. 103, Food and Agriculture Organization of the United Nations, 2006.

- *P4066L20: "During daytime the three simulations compare relatively well to the observations with a rmse below ±2∘ C". Not sure whether this makes sense, as RMSE is positive definite, so the use of +/- is not justified. Please explain or correct.*

Reply: We completely agree with the reviewer, ± is now removed in the revised manuscript.

- *P4069L4: This paragraph seems too short and would benefit from further comments. What is the main reason of the marked improvement in daytime fluxes? Please add comments that can help the user to understand why and how SURFEX changes results. In Table 5 results cannot be really appreciated due to the choice of "+ 0 –" symbols, but without quantitative values of the fluxes. I tend to disagree with this choice as other scientists may benefit from having quantitative fluxes errors to compare with SURFEX-Cabauw. Please provide motivations of your choice or consider adding more quantitative information.*

Reply: We completely agree with the reviewer and more quantitative information is now added in the revised manuscript. Some explanations about how the use of SURFEX changes the results are also included. We now write in the revised manuscript "**In fact, the average mean bias and rmse of the upward short wave radiation flux is significantly reduced (up to 10 W/m², not shown) during the summer when using SURFEX. There is also a significant improvement of the surface heat flux especially during the summer with a reduction (not shown) up to 20 W/m² in the rmse of sensible and latent heat flux. These improvements in the upward radiative flux and surface heat flux when using SURFEX are probably due to (i) the use of an improved physiographic data within the ECOCLIMAP database compared to the one used by ALARO and (ii) to the tiling approach used in SURFEX since for the 4km domain also TEB was activated. Finally a**

three-layer force-restore version of ISBA is used within SURFEX instead of the former two-layer version used by ALARO."

- *P4071L23: ". . .ie. the EKF is in fact a SEKF" is not easy to read for a non-specialist. I suggest rewording the sentence as "the EKF is simplified by assuming a constant B matrix and it is therefore labeled simplified EKF or SEKF." or similar wording.*

Reply: The definition of the SEKF is already mentioned in section 2.4 "Two common soil analysis techniques are Optimum Interpolation (OI) and the Extended Kalman Filter (EKF) or a simplified version of the Extended Kalman Filter (SEKF) in which the background error covariance matrix is kept constant." We now write in the revised manuscript "**The EKF is simplified by assuming a constant B matrix and is therefore a SEKF**."

- *P4073L16: Some considerations on the high values of WG2 accumulated increments on Figure 14. Typical precipitation errors (one the prominent source of error of soil moisture) do not add up to such large values of WG2 (+/- contours are exceeding 100mm). What are the possible reasons for such a large accumulated increments? Or is just the contour being misleading here?*

Reply: We checked the innovations in T2M and RH2M and the innovations are mostly negative for T2M, so in general the model is too warm, while the RH2M innovations are positive so the model is also too dry. The WG2 increments are, therefore, correcting the too dry and warm model by continuous positive increments in soil moisture. And this seems to add up to more than 100mm accumulated over the month of July which was an exceptional warm month with some heat wave period over Belgium. Also, when comparing our results to the literature (e.g. Mahfouf et al. 2009) our values seem to be similar. The values of the accumulated increments for July 2010 for WG2 for the EKF are between -120 and 240mm and for OI between -80 and 110mm. So, new figures with lower boundaries of the legend are now put in the revised manuscript.

- *P4074L5: What is a possible reason for the slight low-level deterioration? Which SURFEX configuration is used here (with CANOPY)? Could it be the lack of a newly analyzed land surface state (e.g. soil temperature) partially responsible for the deterioration? Are there planned tests or future investigations (e.g. with the offline land data assimilation providing new initial conditions)?*

Reply: For this test CANOPY scheme was not activated but some recent test using CANOPY gives better results for the lowest models levels. We now write in the revised manuscript "**However, during the winter SURFEX slightly deteriorates the temperature rmse for the lowest model levels. A <u>recent test (Kullmann, 2011, personal communication) using SURFEX together with the CANOPY scheme gives better results for the lowest model levels</u>.**".

- *P4075L3: "The comparison for Belgium shows that the forecast scores are similar between the Extended Kalman Filter and the classical Optimal Interpolation scheme." This sentence should maybe be reworded to account the benefits of the SEKF that open up to future extension of the land data assimilation system (e.g. using satellite remote sensing and ground-based observed precipitation).*

Reply: We now write in the revised manuscript "**The comparison for Belgium shows that the forecast scores are <u>at least similar</u> between the Extended Kalman Filter and the classical Optimal Interpolation scheme. <u>However, the use of EKF will address some fundamental limitations when using the Optimal Interpolation coefficients (e.g. in usage of satellite remote sensing and ground-based observed precipitation)</u>**"