Comparison between the operational observation operator and the new canopy observation operator within the EKF off-line soil analysis scheme

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1. Jacobien of canopy observation operator

As a first experiment, the control vector x contains three prognostic variables of the ISBA-2L model: the root soil water content WG_2, the surface temperature TG_1, and the deep soil temperature TG_2. The observation vector contains the screen level temperature T_{2m} and relative humidity HU_{2m}. In this study, two observation operator are examined: (i) the vertical interpolation from the surface as computed from the ISBA-2L scheme to the observations level following the formulation of Geleyn (1988), (ii) the prognostic 2m values calculated with the new surface boundary layer scheme developed by Masson and Seity (2009) (Canopy scheme).

First, as suggested by Mahfouf et al. (2009), the elements of the Jacobian matrix are calculated using positive and negative perturbations which are set to 10^{-4} for w_2 and 10^{-5} for T_S and T_2. The Jacobian of T_{2m} with respect to T_S is presented in Figure 1, corresponding to the four 6-h assimilation window examined on the 2 May 2009.

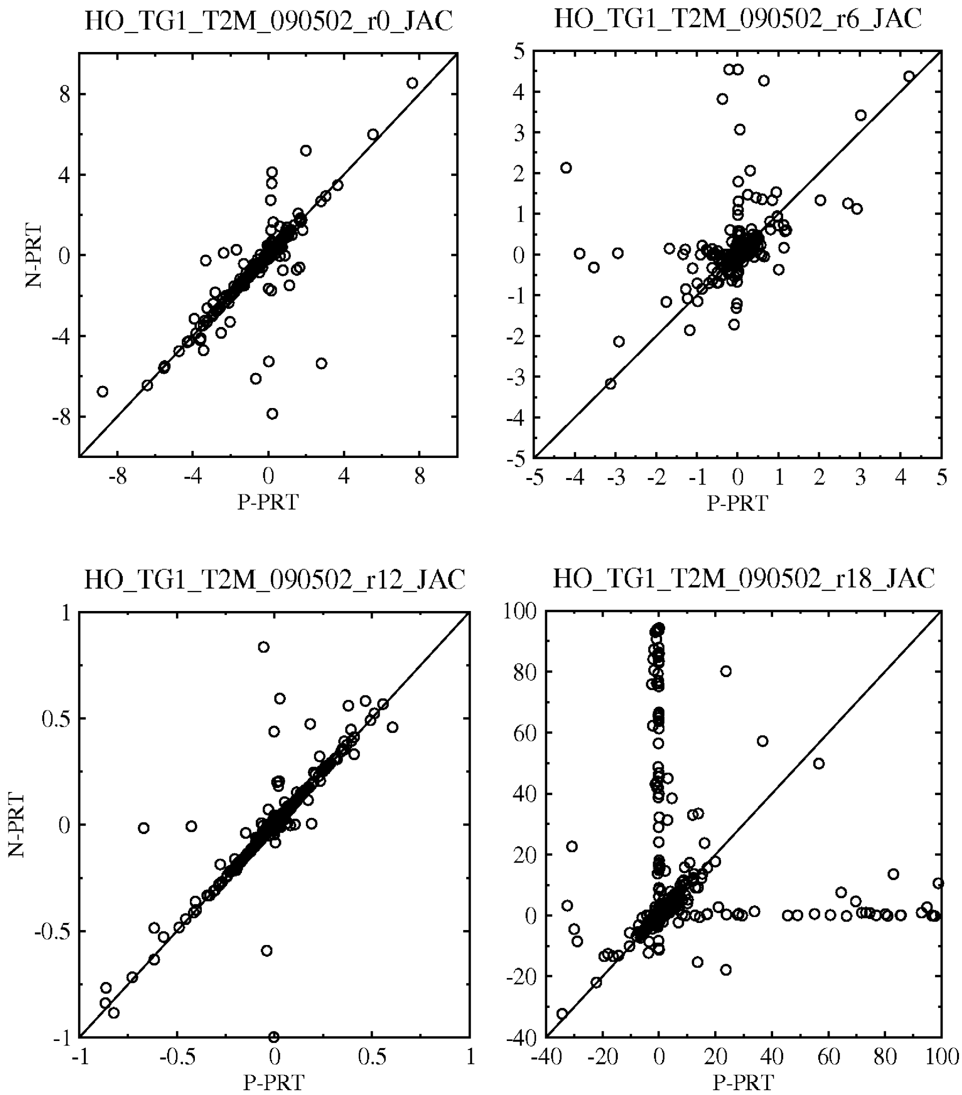


Figure 1.

Examination of the diurnal cycle reveals that the largest Jacobian are obtained for the night time (1800—0000) assimilation window. However, for this period, there are a number of points along the zero x (y) axis, indicating that in these instances there was no sensitivity to the negative (positive) perturbations, while the positive (negative) perturbations produced Jacobians with significant values. The locations of these points are mapped in Figure 2. At these points the perturbations are not small enough to reproduce the tangent-linear behavior of the observation operator. In fact, during the night the positive (or negative) perturbation of the surface temperature changes the stability regime of these locations and the validity of the linear regime breaks down. The same result is found for the the Jacobian of HU_{2m} with respect to T_S (see Figure 3).

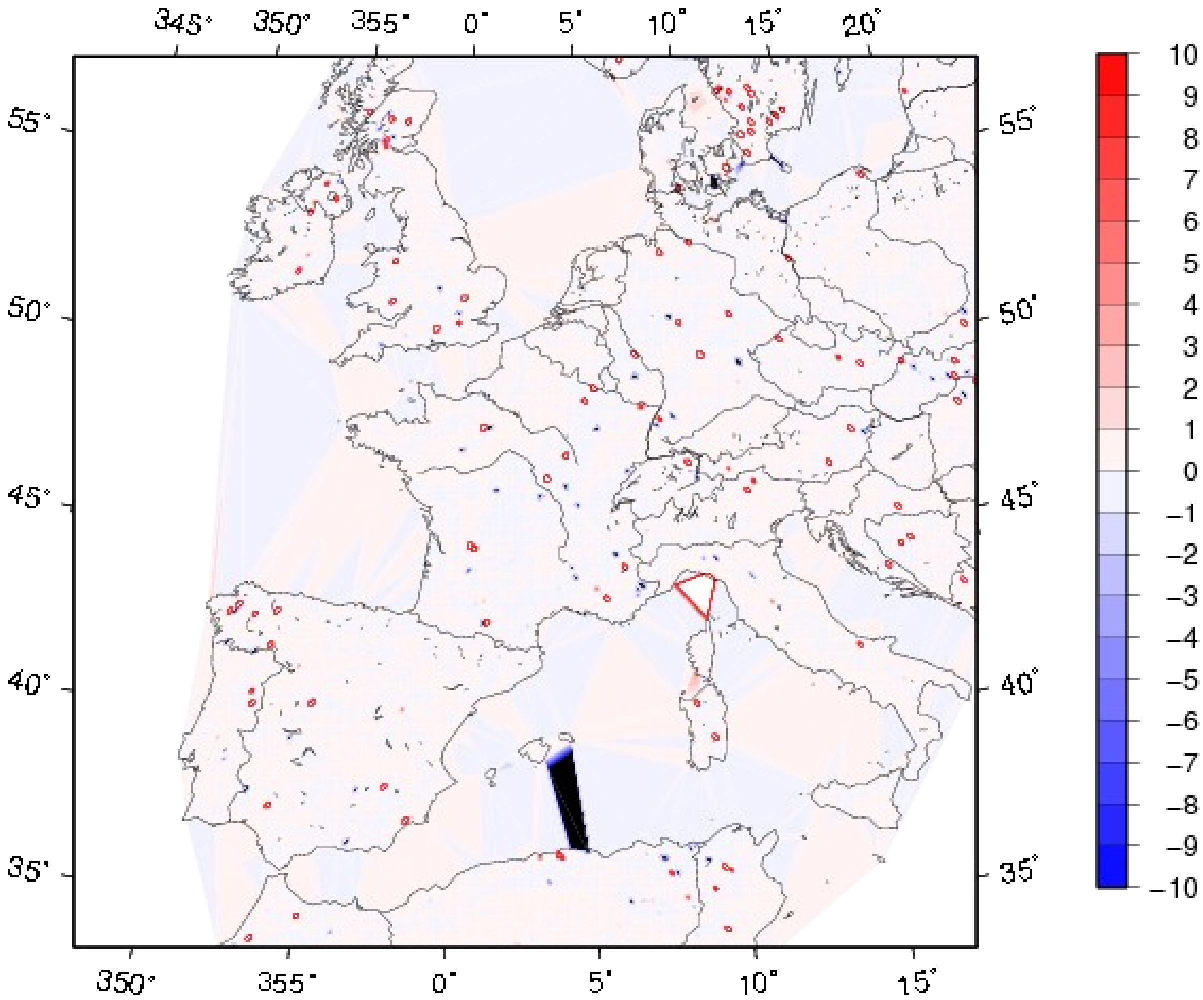


Figure 2.

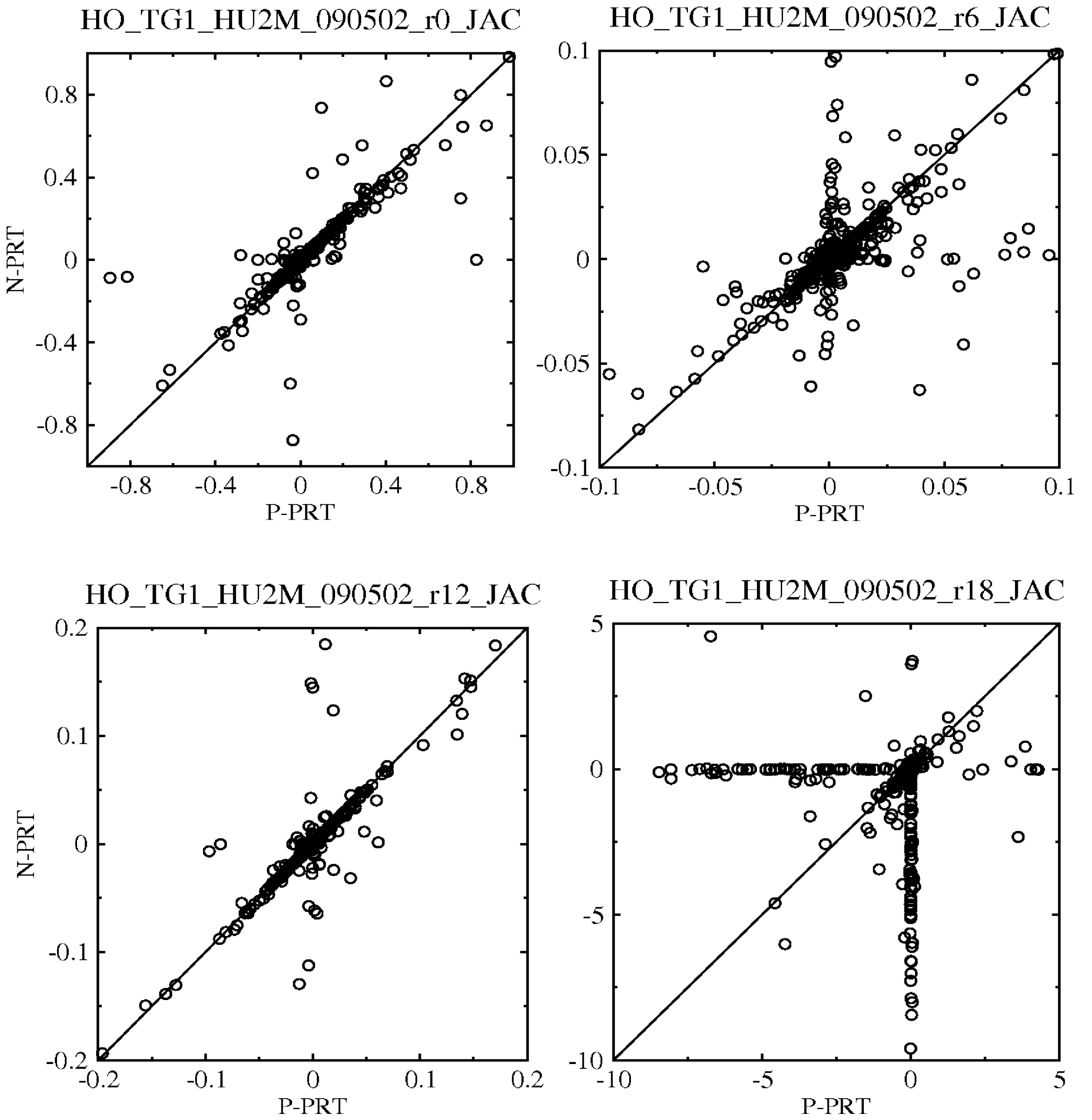


Figure 3.

A new experiment is performed using smaller perturbation for temperature (10^{-6} instead of 10^{-5}) and the same perturbation for the volumetric water content (10^{-4}), the control vector x contains now the four prognostic variables of the ISBA-2L model: WG_2, WG_1, TG_1 , and TG_2. The new Jacobian of T_{2m} and HU_{2m} with respect to TG_1 is plotted in Figure 4. Almost all of the points are aligned along the one-to-one diagonal indicating that the finite difference estimates are now within the linear regime of the observation operator.

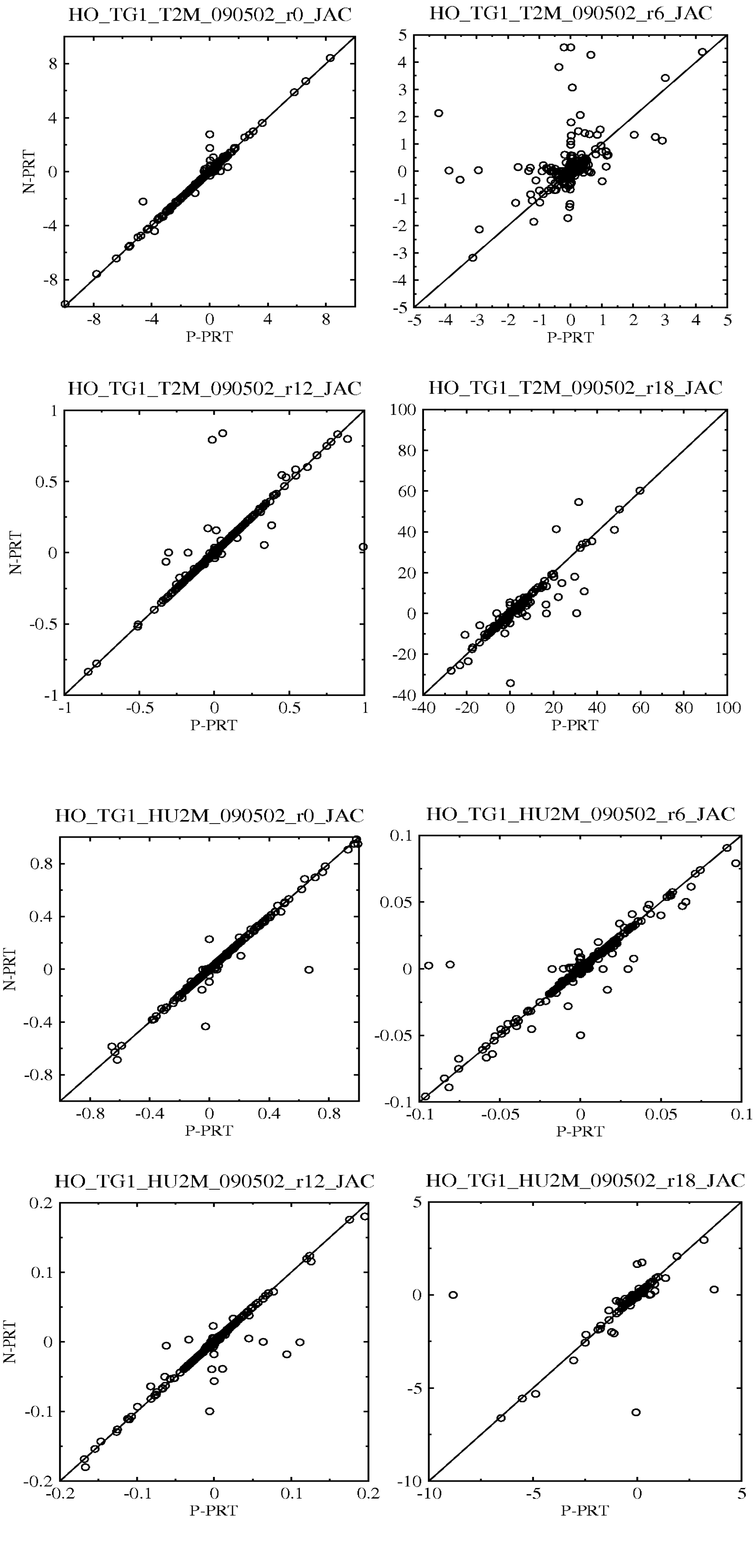

HO_TG1_T2M_090502_r0_JAC
HO_TG1_T2M_090502_r6_JAC
HO_TG1_T2M_090502_r12_JAC
HO_TG1_T2M_090502_r18_JAC
HO_TG1_HU2M_090502_r0_JAC
HO_TG1_HU2M_090502_r6_JAC
HO_TG1_HU2M_090502_r12_JAC
HO_TG1_HU2M_090502_r18_JAC
N-PRT
P-PRT

Figure 4.

2. Canopy observation operator & Geleyn observation operator

Since the Jacobians for the screen level variables with respect to WG_1 and TG_1 are an order of magnitude lower than those for WG_2 and TG_2 the comparison between the operational observation operator (based on the Geleyn's method) and the canopy observation operator will be done only for those two control variables. Figure 5 compares the Jacobians of T_{2m} with respect to TG_2 corresponding to the four 6-h assimilation window.

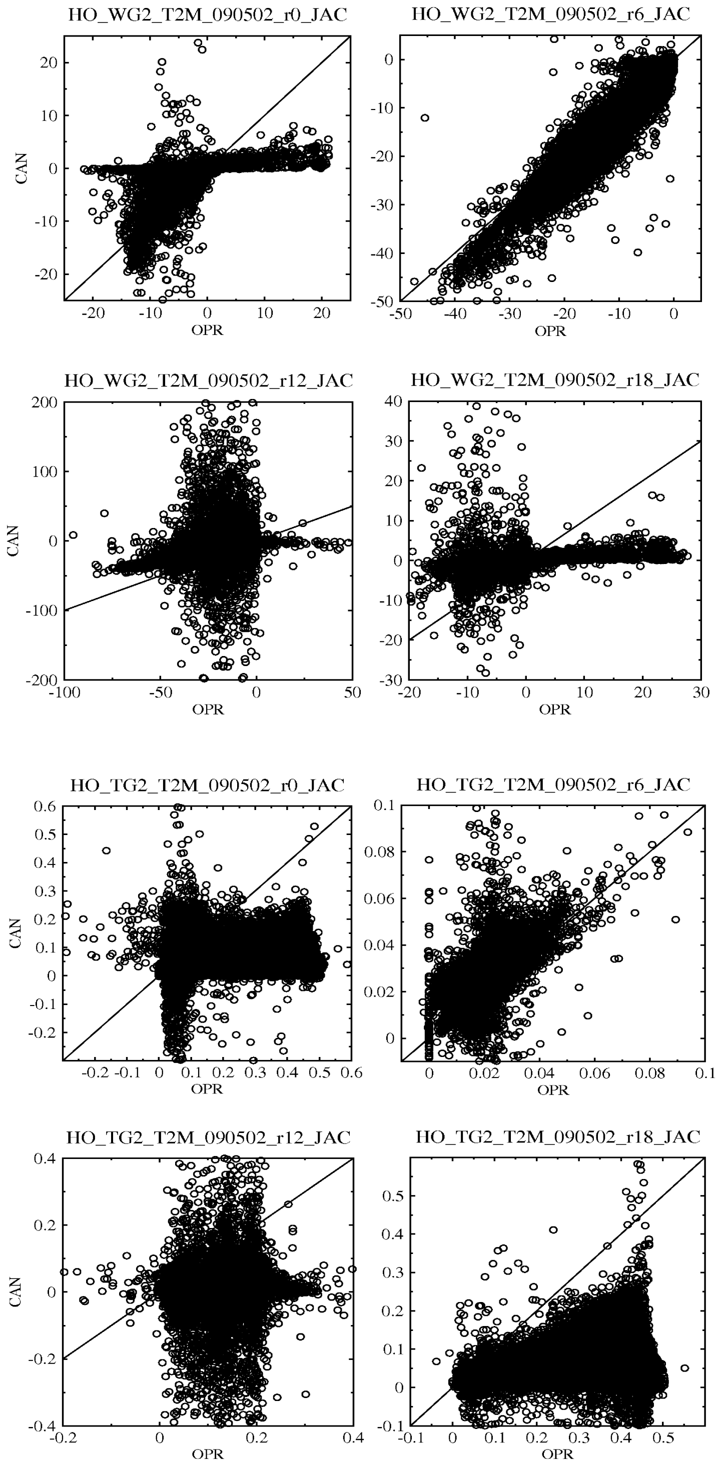


Figure 5.

It seems that the sensitivity of T_{2m} with respect to deep soil temperature (deep soil moisture) is lower (larger) with the canopy scheme especially during nighttime (daytime) where the Jacobians have their largest values. The difference between the Jacobians of T_{2m} with respect to WG_2 calculated with the operational and the new canopy observation operator for the period 1200 1800 is plotted in Figure 6.

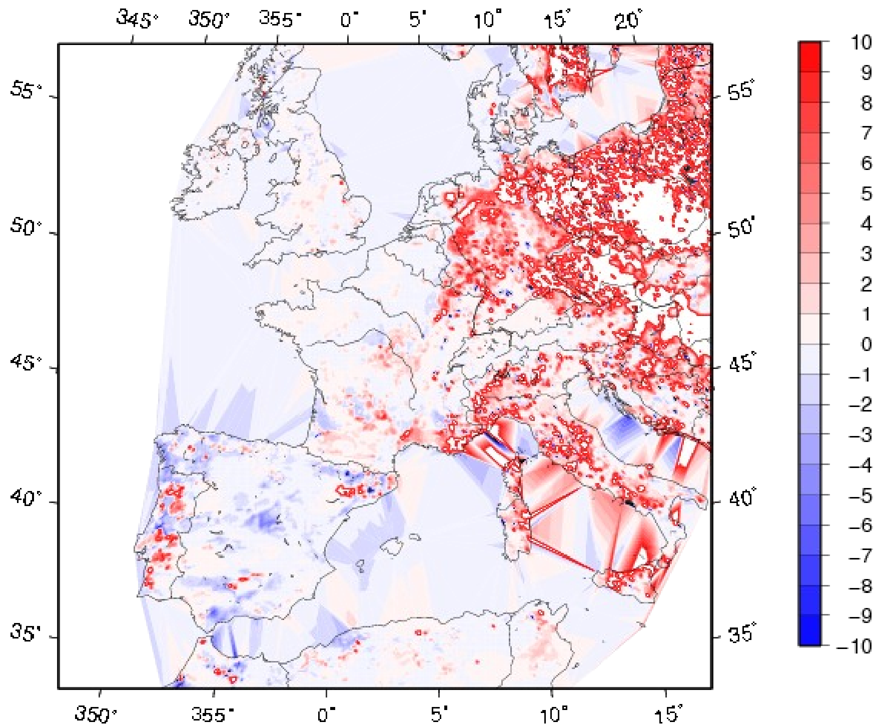


Figure 6.

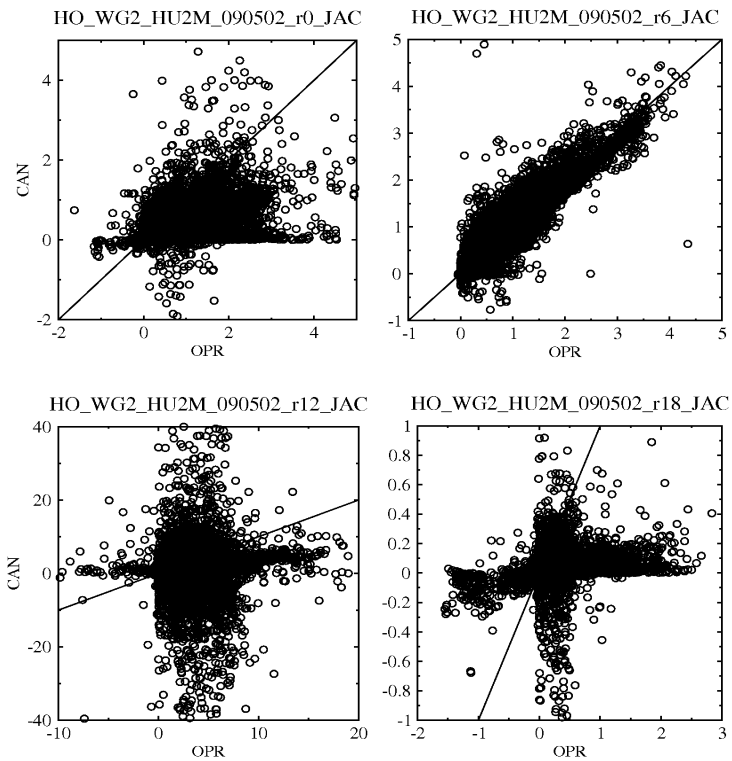
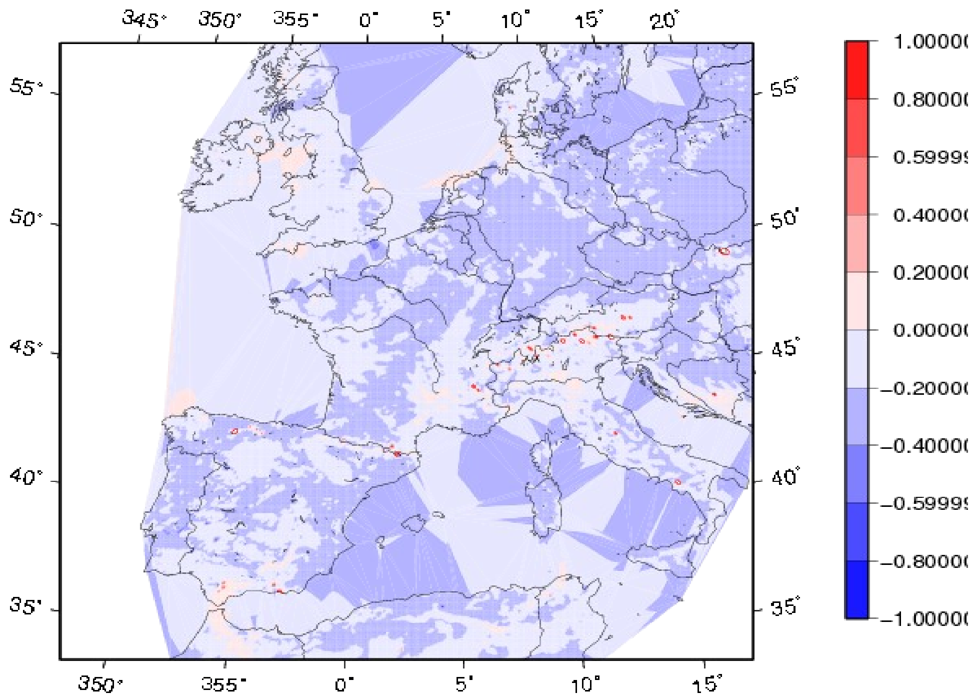


Figure 7.

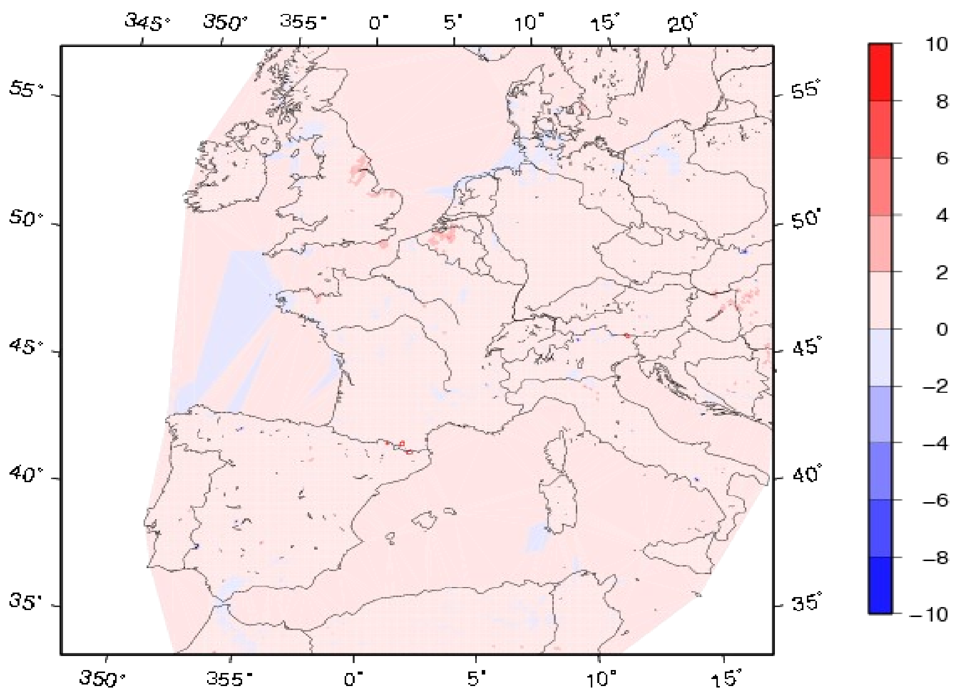
3. Kalman Gain Matrix

Figure 8 compares the Kalman gain matrix elements differece between CAN and OPR: (i) TG_2 increments with respect to T_{2m} innovations, (ii) TG_2 increments with respect to HU_{2m} on the 2 May at 1800.

(I) TG_2 with respect to T_{2m}

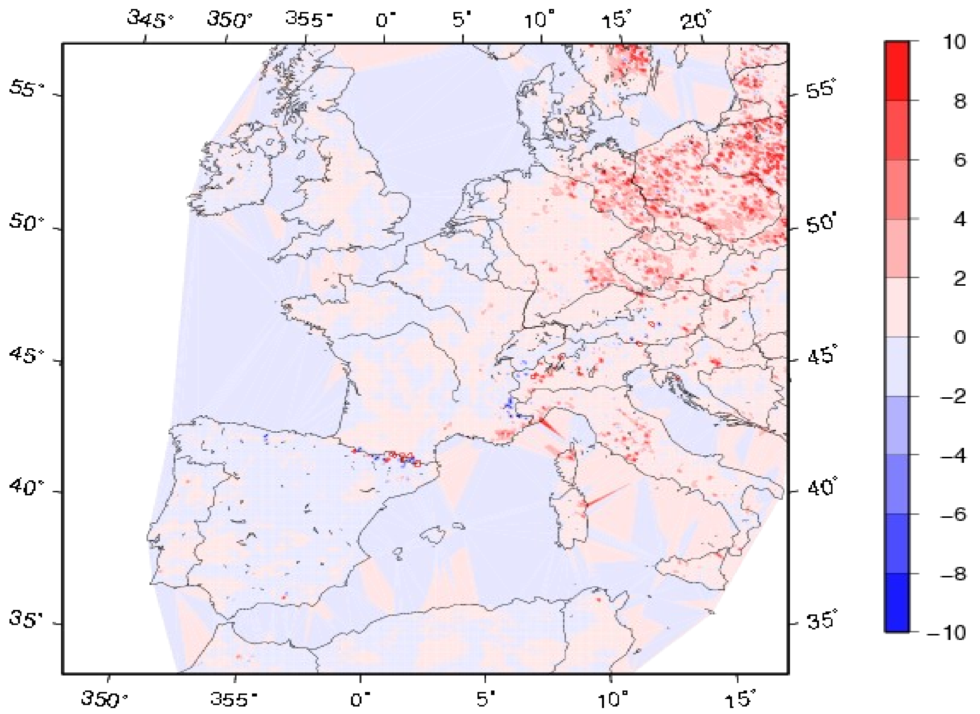


(ii) TG_2 with respect to HU_{2m}

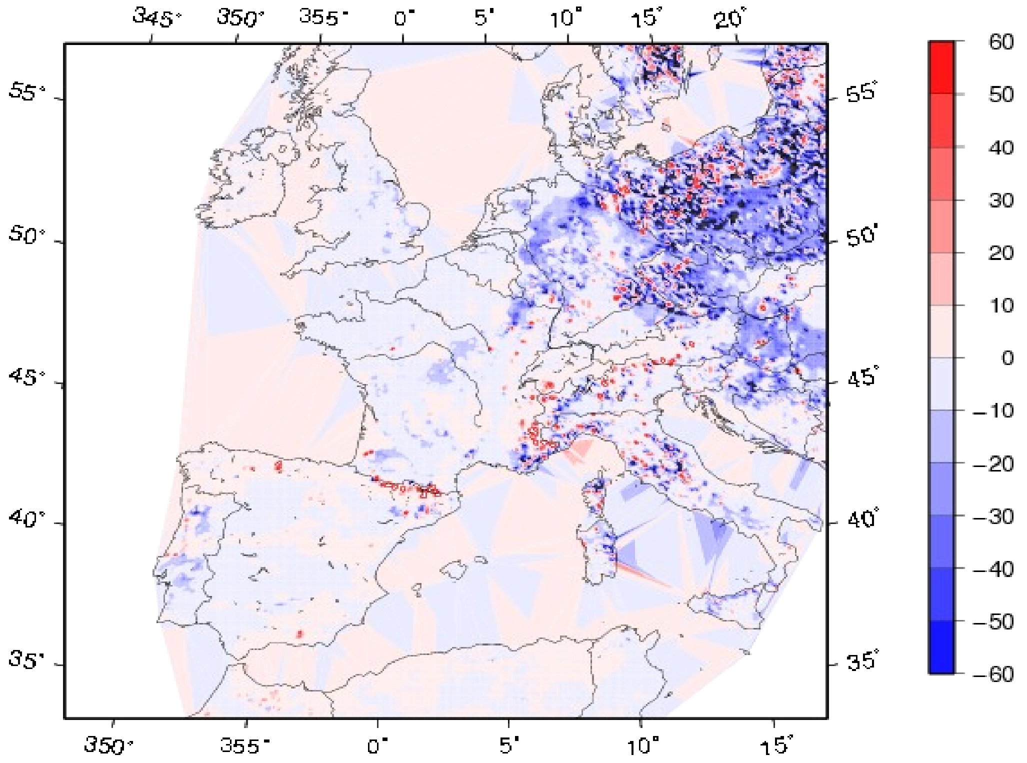


The link between screen level innovation and soil moisture correction in the root zone is plotted in Figure 8. The coefficients are multiplied by the soil depth on the 2 May at 1200.

(I) WG_2 with respect to T_{2m}



(ii) WG_2 with respect to HU_{2m}



4. Screen level analysis

The difference between OPR and CAN of the soil moisture increments in the root zone WG_2 on 2 May at 1200.