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Assimilation of FY-3B MWRI soil moisture over China using the EnKF method

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Introduction

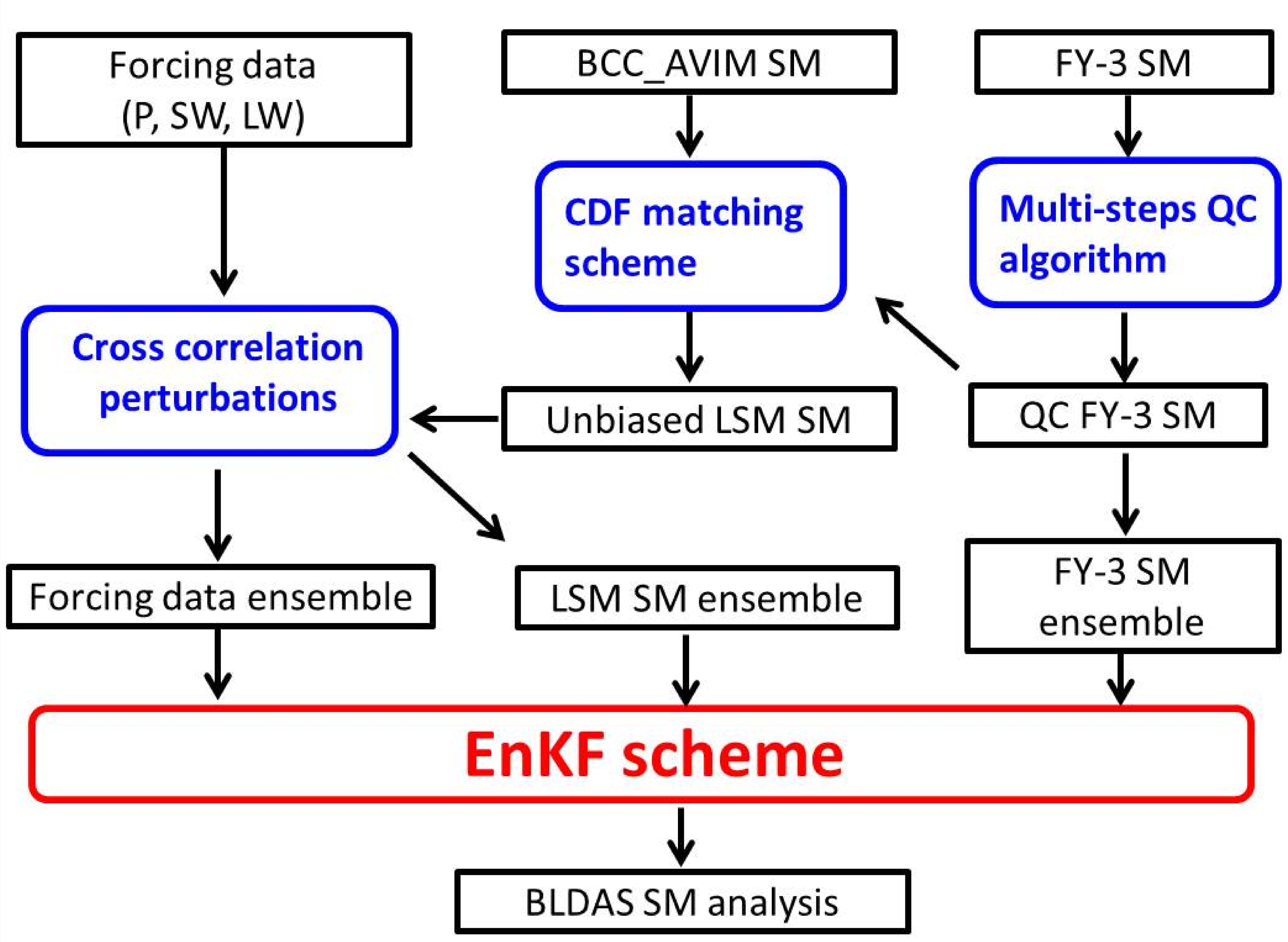
The Beijing Climate Center (BCC) Land Data Assimilation System (BLDAS) based on the Microwave Radiation Imager (MWRI) surface soil moisture (SM) products from the Chinese polar-orbiting Fengyun-3 series satellite (FY-3) is developed for the operational seasonal climate prediction in BCC. The current land surface analysis system is a global data assimilation system that based on the BCC Atmosphere Vegetation Interaction Model (BCC_AVIM) and the ensemble Kalman filter (EnKF) data assimilation method. A multiple steps strategy is designed to remove systemic biases and random errors of SM from model and FY-3 observation. This study verifies the performance of BLDAS against about 600 *in-situ* measurements in China.

Data and model

- **Forcing data**: Precipitation (P), downward SW radiation (SW), downward LW radiation (LW), 2m temperature (T), and wind were from NCEP-R1 dataset.
- **SM data**: Surface SM observation was from FY-3 satellite, the second generation polar-orbiting meteorological satellites of China Meteorological Administration (CMA).
- **Land surface model (LSM)**: The BCC_AVIM model used in this study is established by combining a modified biogeophysical framework of the NCAR Community Land Model version 3.0 (CLM3, Oleson et al., 2004) and the biogeochemical framework of AVIM (Ji, 1995). The change of soil moisture in the near surface layer and root zone is controlled by the change in water flux. Richards' equation for unsaturated flow is used for the simulation of this flux:

$$F(z) = -k(z)\left.\frac{\mathrm{d}\psi(z)}{\mathrm{d}z}\right|_z + k(z) \qquad z \neq 0$$

Flow chart of assimilation strategy



Results

Table1. Perturbation parameters for atmospheric forcing and SM state variables

	Forcing data cross correlation perturbations				
Type	SD	P	SW	LW	
Precipitation (P)	50 (%)	1.0	-0.8	0.6	
SW radiation (SW)	30 (%)	-0.8	1.0	-0.6	
LW radiation (LW)	30 W/m2	0.6	-0.6	1.0	
	SM cross correlation perturbations				
	SD	SM1	SM2	SM3	SM4
SM1 (0-10cm)	10(%)	1.0	0.6	0.4	0.3
SM2 (10-30cm)	8(%)	0.6	1.0	0.6	0.4
SM3 (30-80cm)	5(%)	0.4	0.6	1.0	0.6
SM4 (80-100cm)	4(%)	0.3	0.4	0.6	1.0

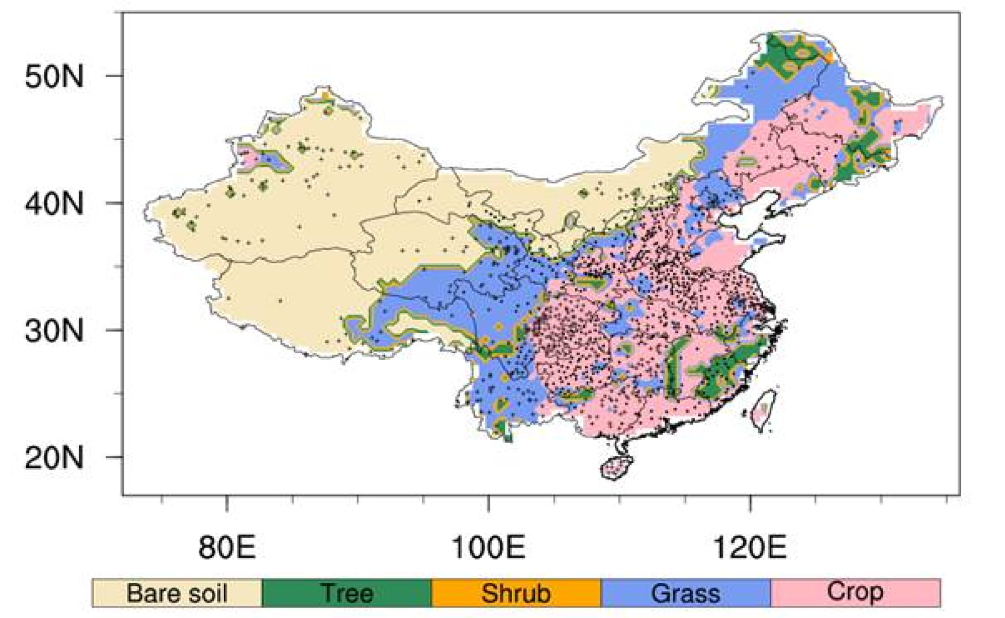


Fig. 1. The primary vegetation types (gridded at 0.5 degree resolution) over China and location of all 1166 SM in situ stations (pluses) and 633 selected verification stations (solid circles) stations with reporting rates greater than 80% in 2012.

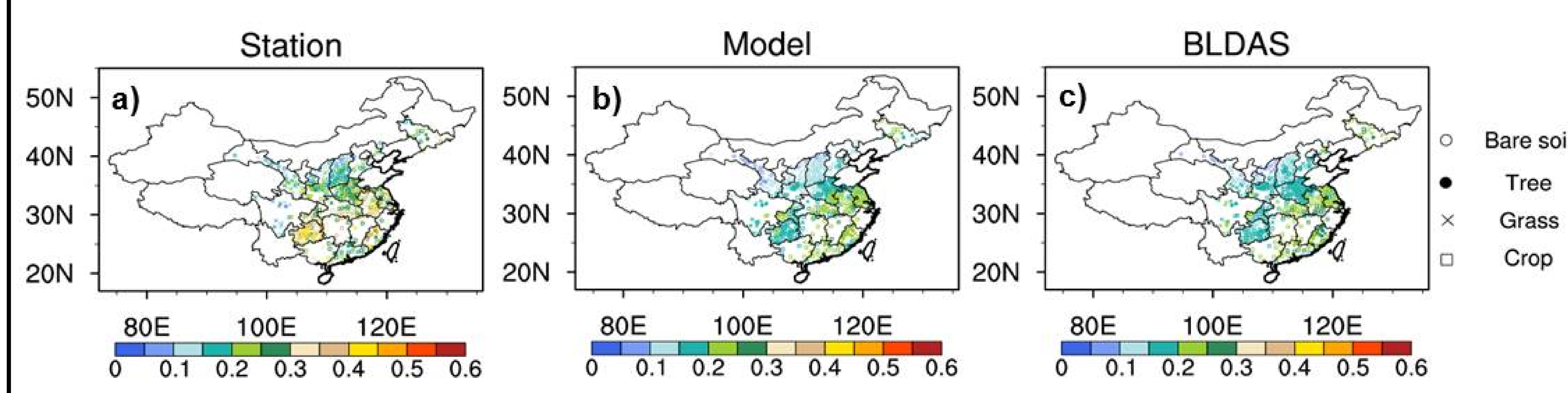


Fig. 2. The comparison between surface SM (mm^3/mm^3) of BCC_AVIM model, BLDAS and station measurement in terms of annual mean value for the study period of 2012.

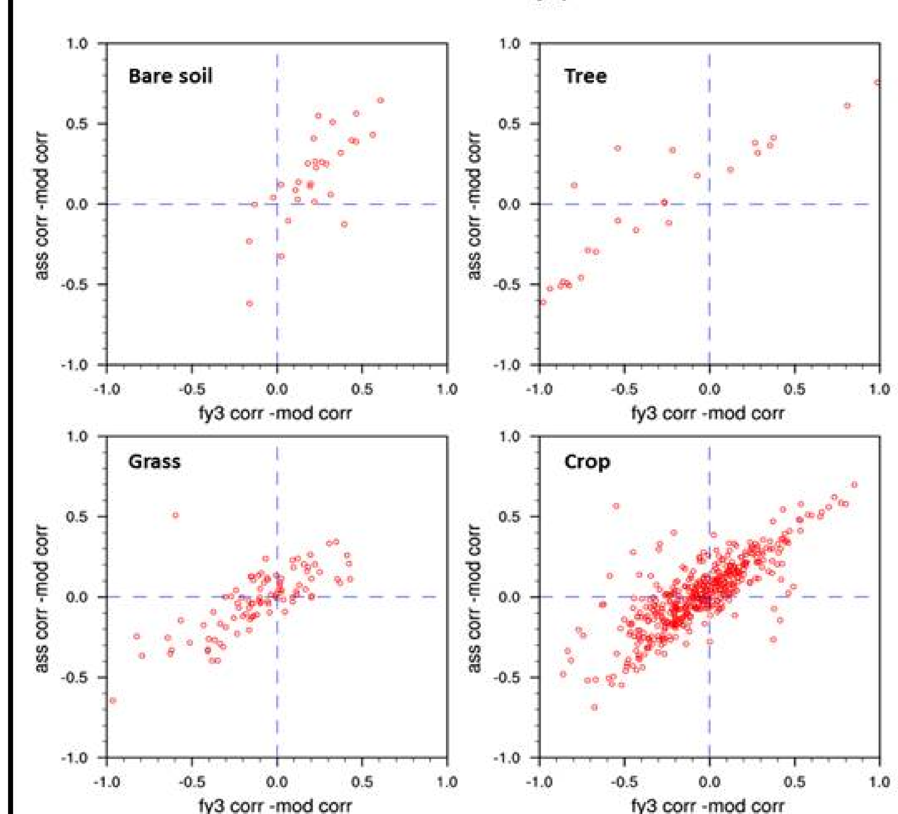


Fig. 3. Time correlation (TC) skill for the assimilation minus the model ($\Delta TC^{a\text{-}m}$, ordinate) against TC skill for the FY-3 observation minus the model ($\Delta TC^{o\text{-}m}$, abscissa) for different vegetation types.

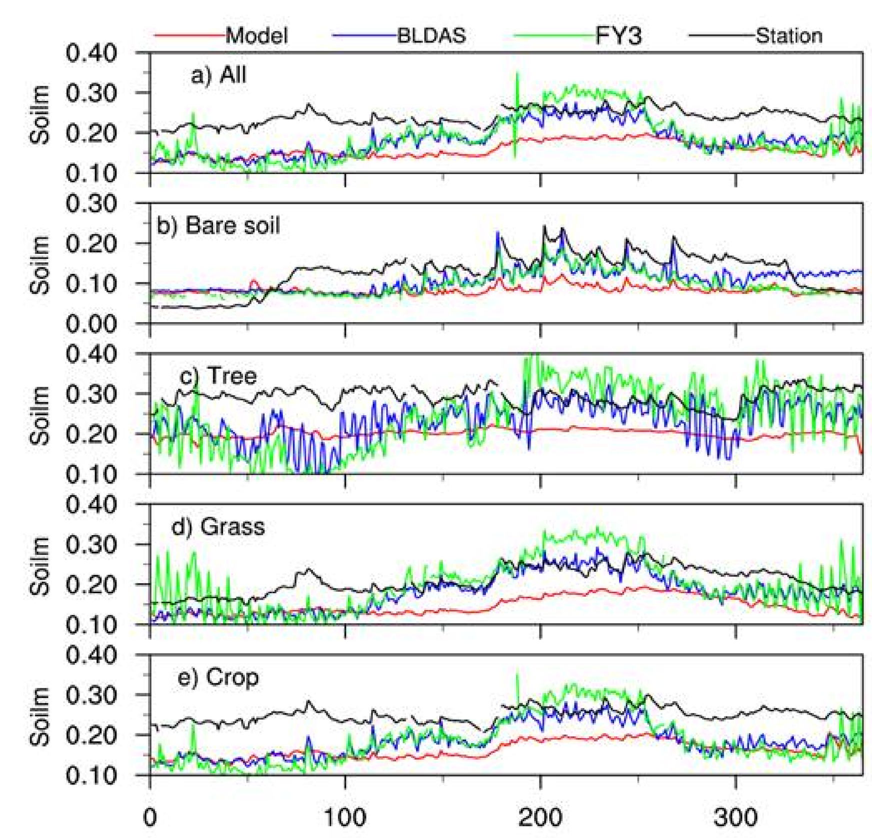


Fig. 4. Time series of type-mean surface SM (mm^3/mm^3) derived from model, BLDAS, FY-3 and station observations for the period of 2012.

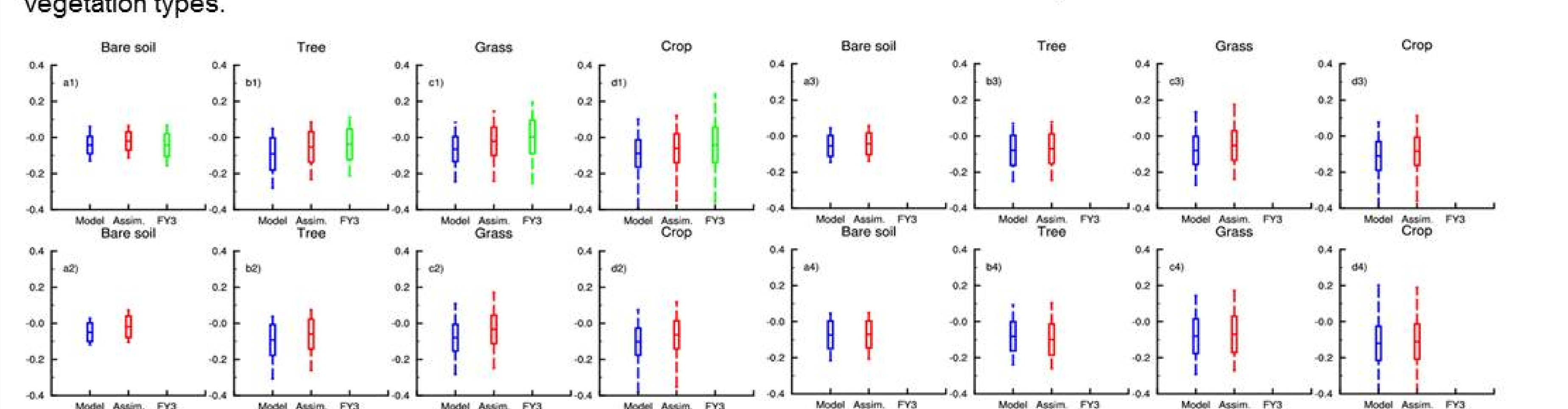


Fig. 5. The box maps of biases with respect to the station SM for different vegetation types in layer 1-4 (a-d).

Summary

- The annual mean SM1 of BLDAS is slightly closer to station measurements than LSM, which means the information from FY-3 exhibits positive contributions to the statement of surface SM.
- The TC skill improvement are strongly related to $\Delta TC^{o\text{-}m}$. The assimilation of FY-3 product in BCC_AVIM typically generated an improved TC skill for bare soil (grass, crop) as long as the FY-3 skill is no more than about 0.2 (0.6, 0.8) lower than the model skill.
- The FY-3 products can better capture the temporal variations of surface SM over bare soil than vegetated surface types (e.g. tree, grass, and crop). For all vegetation types, the FY-3 products have a higher accuracy during the summer period while have significant negative biases in other seasons.
- The assimilation of FY-3 SM product can improve the bias skill not only in surface layer but also deeper layers almost over all these different vegetation types.

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