Evaluation The Performance Of WRF Using An Improved Albedo Parameterization Scheme During A Heavy Snowfall Event Over The Tibetan Plateau

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Abstract

Albedo, a vital parameter in land surface processes and main determinant of net radiation flux, changes remarkably during snow events, which is determined by snow-related variables, i.e. snow age, density and depth. There are some shortcomings in albedo calculation in the widely used land surface models. In this study, the impact of an improved albedo scheme in WRF coupling with Noah was investigated. The scheme was developed using satellite retrievals of albedo and involves snow depth and age. Numerical experiments were carried out to model a severe snow event in March 2017. The performance of the model applying the improved albedo scheme was compared with the model applying the default scheme and with WRF applying CLM's complex scheme. The improved albedo scheme shows significantly applicable potential in land-atmosphere interaction estimates during heavy snow events.

Albedo parameterization schemes

- **Noah albedo scheme**

$$\alpha_{s1} = \alpha_s + L_v(0.85 - \alpha_s)$$

$$\alpha_{s2} = \alpha_{s1}(A^{(\frac{t_s}{86400.0})^B})$$

$$\alpha = \alpha_{bg} + S_c(\alpha_{s2} - \alpha_{bg})$$

- **Improved albedo scheme** (Oerlemans & Knap, 1998)

$$\alpha_{snow}^{(i)} = \alpha_{firn} + (\alpha_{freshsnow} - \alpha_{firn})e^{(\frac{s-i}{t^*})}$$

$$\alpha^{(i)} = \alpha_{snow}^{(i)} + (\alpha_{ice} - \alpha_{snow}^{(i)})e^{(\frac{-d}{d^*})}$$

$d(i) - d(i-1) \geq 0.02$ m snowfall on day i

Experimental designs

Exp.	LSM	Albedo scheme	estimate parameters in albedo scheme
EXP1	Noah	Noah default	None
EXP2	Noah	**The improved**	Observed SD and MODIS reflectance
EXP3	Noah	**The improved**	Model SD and MOD09CMG
EXP4	CLM	CLM default	None

Results

Near-surface air temperature

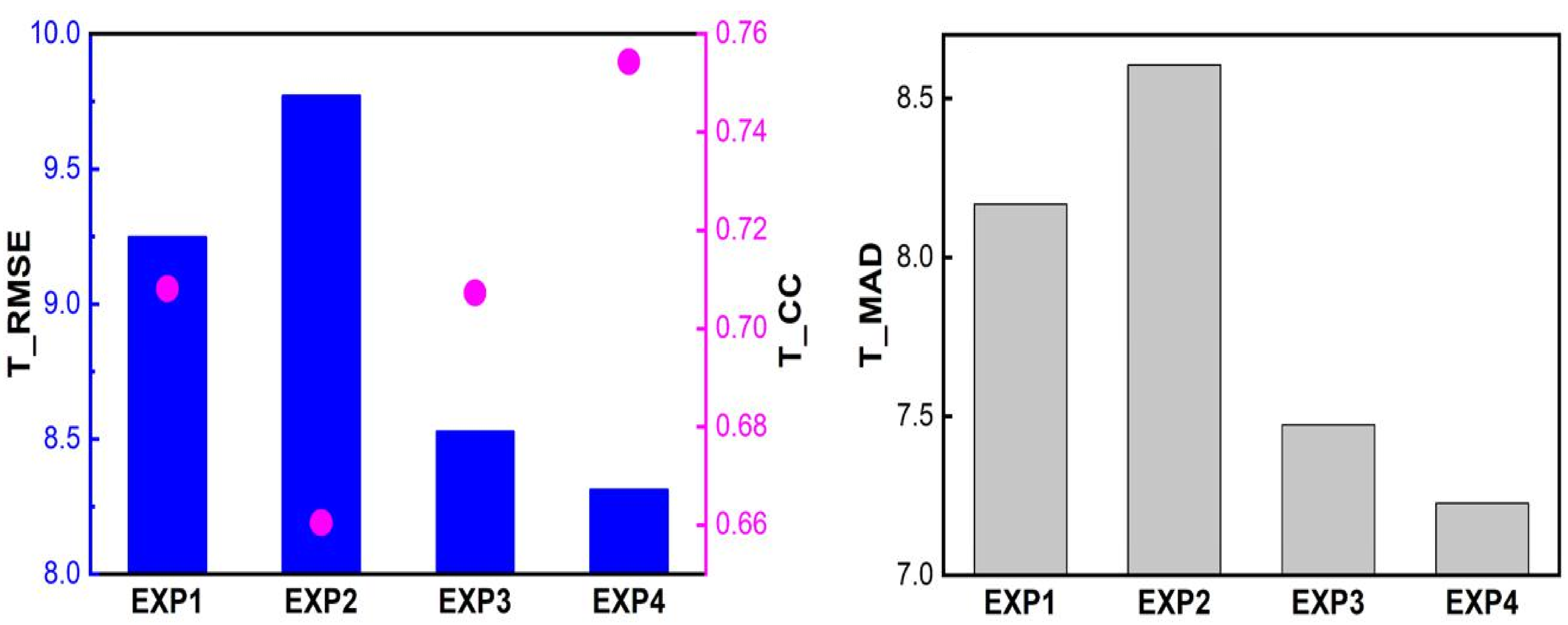

Fig. 1 RMSE, correlation coefficient (CC) and mean absolute deviation (MAD) of near-surface air temperature estimates

Snow water equivalent

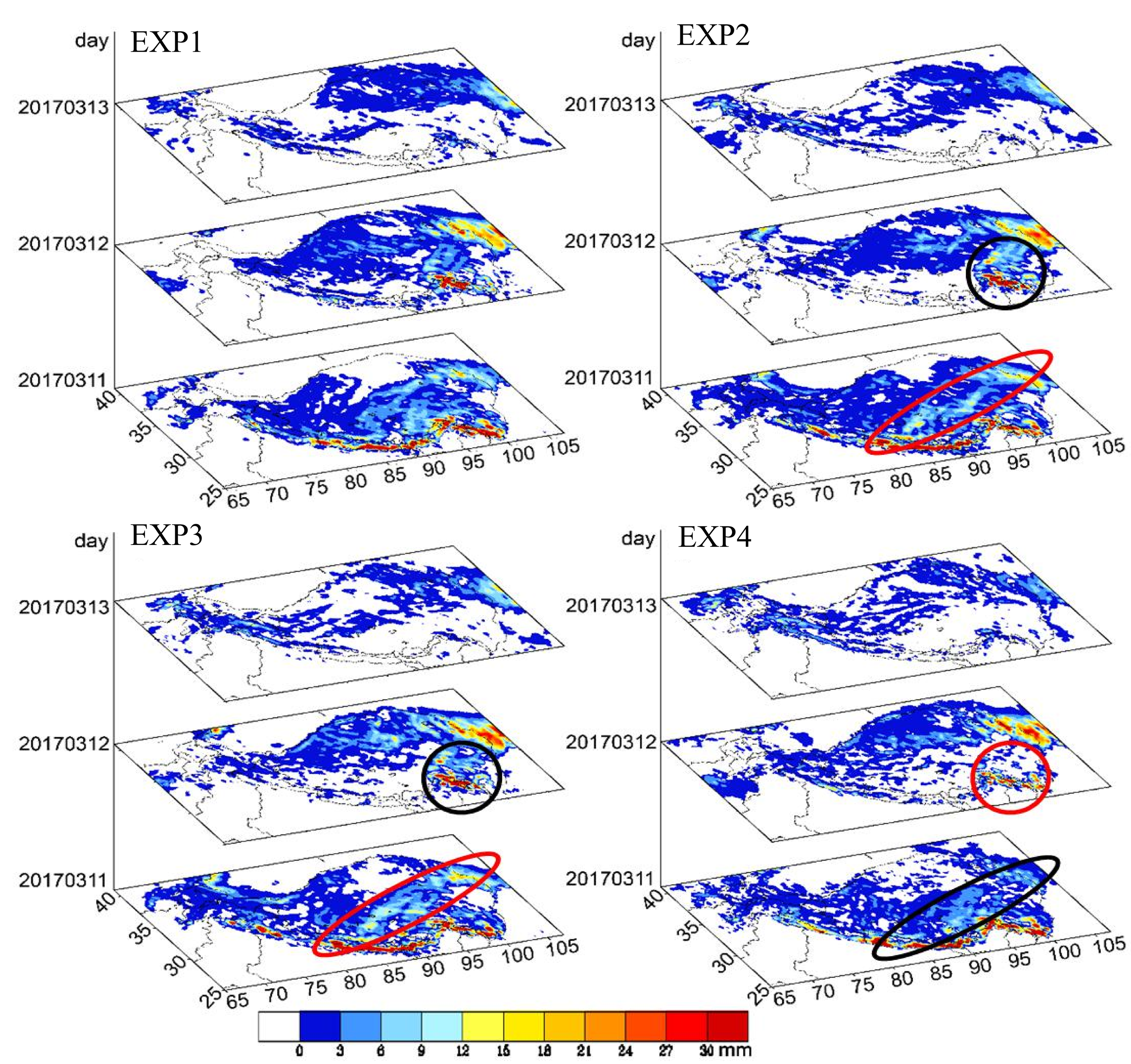

Fig. 4 Daily SWE estimates from numerical experiments

Albedo

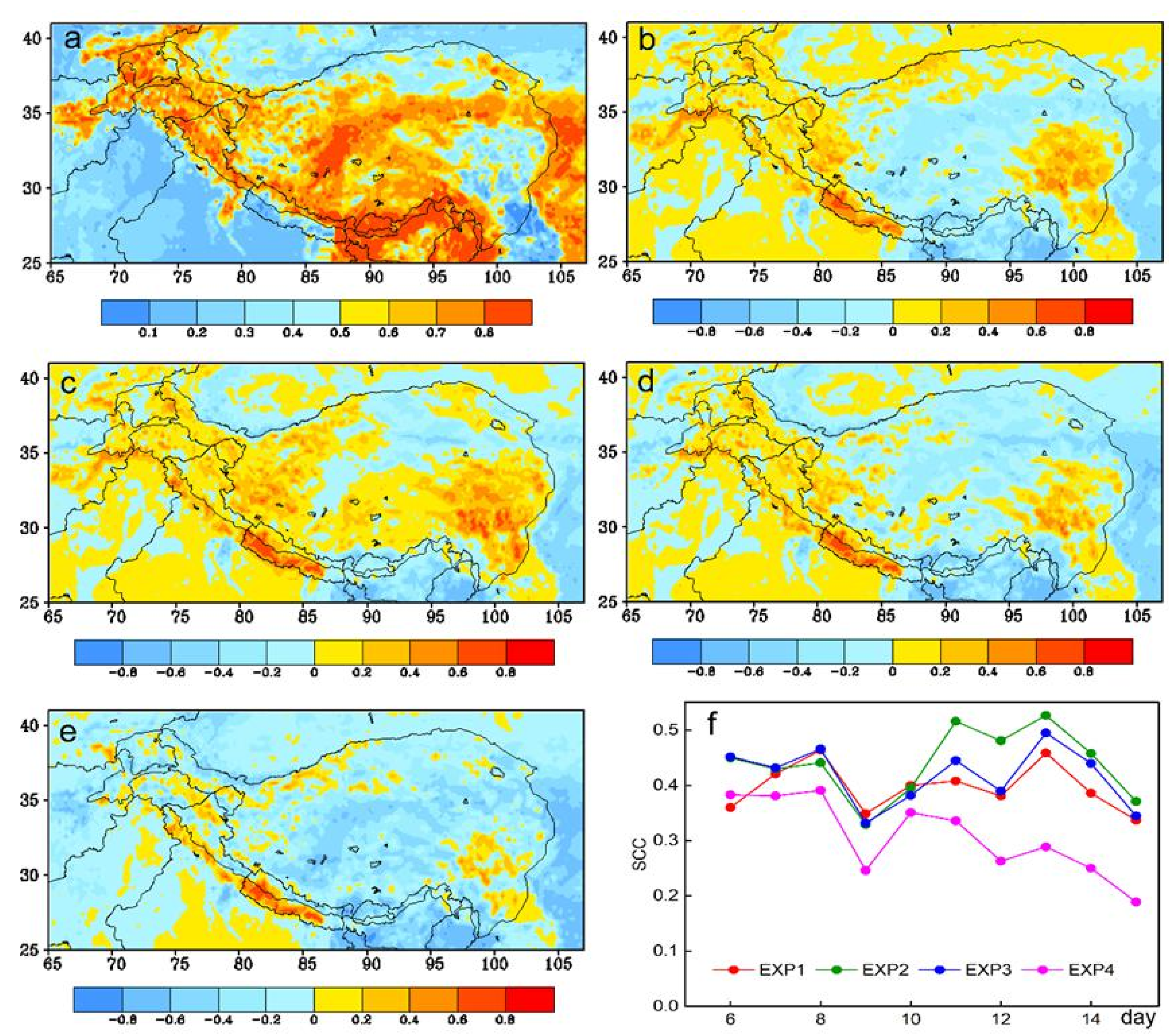

Fig. 2 MODIS albedo product (a), albedo difference between model estimates and MODIS product (b-e) on March 11th; spatial correlation coefficient (SCC) of albedo estimates (f)

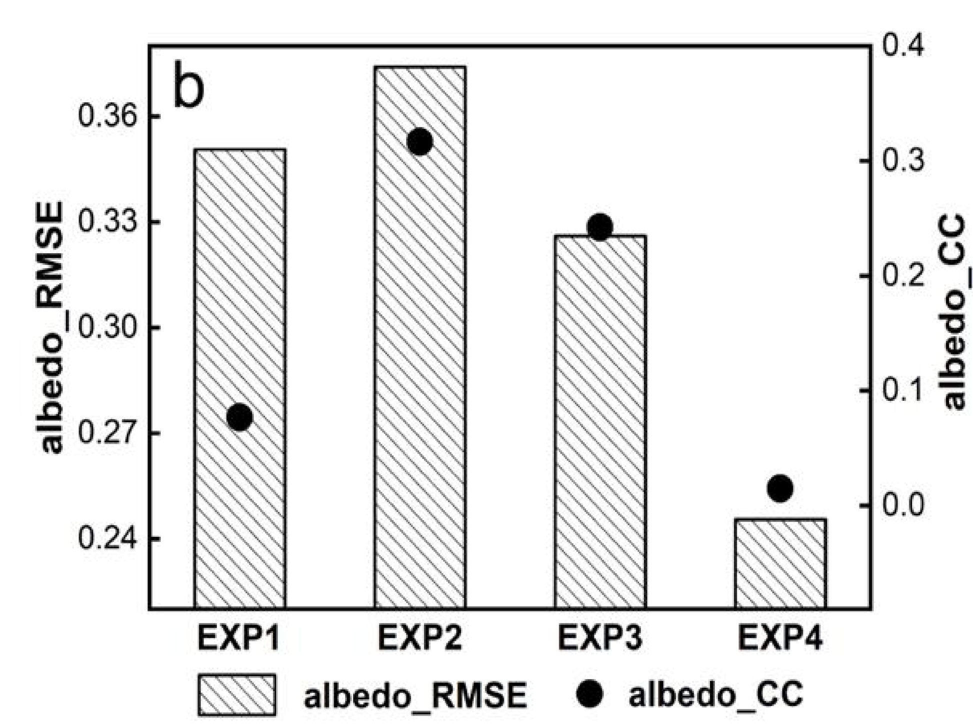

Fig. 3 RMSE and correlation coefficient (CC) of albedo estimates at six CAS stations

Conclusions

- The improved albedo scheme largely reduces the WRF + Noah albedo overestimation in the southeastern Plateau, greatly reducing cold bias estimates by 0.7 ℃ air temperature RMSE;
- The improved albedo scheme gives the highest correlation between satellite-derived and model estimated albedo, contributing to successfully capturing the SWE spatial pattern and heavy snow belt (SWE > 6 mm). The performance of the improved scheme is comparable with the advanced CLM's albedo scheme in the heavy snow event simulations.

Reference

Oerlemans, J., Knap, W. H. (1998). A 1 year record of global radiation and albedo in the ablation zone of Morteratschgletscher, Switzerland. J. Glaciol., 44(147), 231-238.