Offline verification of the land surface model in the JMA operational global model

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1. Introduction

Both atmospheric and land surface models affect the accuracy of predictions near surface. Therefore, in order to reduce biases in the predictions near surface, it is necessary to separate causes of the biases into origins from atmospheric and land surface models. It has been noticed that the JMA operational global model (GSM) has biases near surface in the daytime.

GSM has a cold bias of screen level temperature (T_s) in the daytime (Fig.1) even though GSM overestimates surface downward SW (Short Wave) flux. This suggests existence of significant sources of the cold bias in other parts of GSM. Land surface processes in GSM can be candidates.

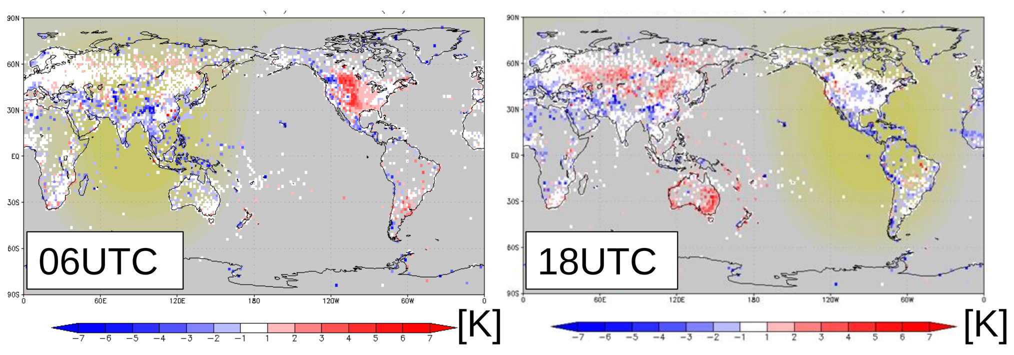

Fig.1: Mean error of T_s against SYNOP observation in Jul.-Sep. 2020. Yellow shade represents the area in the daytime.

Research Objective:
Investigate error characteristics of the land surface model in GSM, excluding the effect of coupling with the atmospheric part of GSM.

2. Land surface model in GSM

GSM uses iSiB (improved Simple Biosphere Model; JMA 2022).

- Two-source energy balance scheme based on SiB (Simple Biosphere; Sellers et al. 1986; Sato et al. 1989).
- Five components:
  - Canopy
  - Canopy air space
  - Ground (grass and bare soil)
  - Snow (up to four layers)
  - Soil (seven layers)
- Two tiles (snow-covered/snow-free)
- iSiB calculates heat and water exchanges between components, and provides latent heat, sensible heat and momentum fluxes to the atmosphere as boundary conditions for the atmospheric part of GSM.

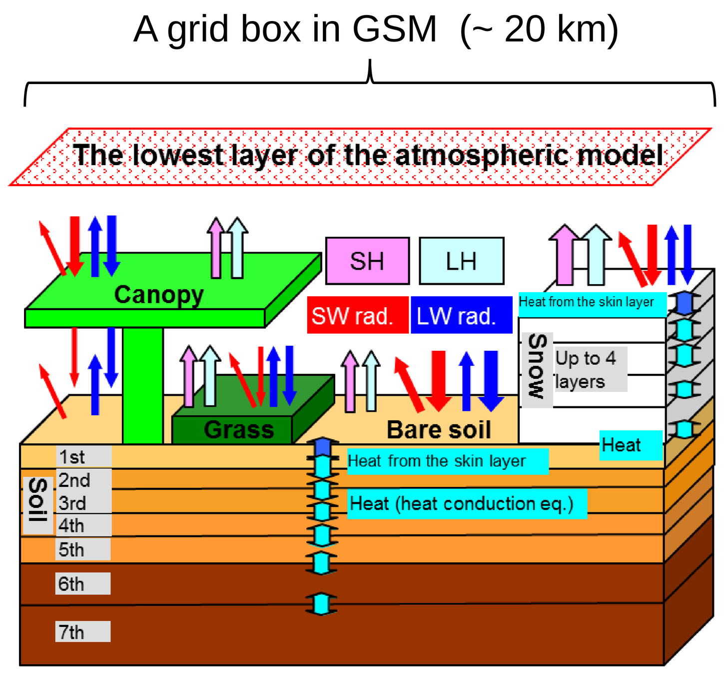

Fig.2: Schematic illustration about configuration of iSiB.

3. Offline version of iSiB and verification settings

Offline version of iSiB:
- Driven by the atmospheric forcing dataset of GSWP3 (Global Soil Wetness Project Phase 3; Kim 2017)
  - GSWP3 data has much lower errors in surface incident radiative fluxes than the atmospheric part of GSM.
- Every 6 hours, replace snow depth prediction value with analysis value.
  - Snow depth analysis data: JRA-55 (Kobayashi et al. 2015)

Verification settings:
- Compare offline iSiB prediction values with in-situ observation values.
- Verification period: Oct. 2002–Mar. 2005
- Observation sites used for verification: 48 (distribution shown in Fig.3)
- Variables: Surface radiative fluxes (SW & LW, Downward & Upward)
  Sensible & Latent heat fluxes
  Screen level temperature (T_s)

In-situ observation data:
- CEOP (Coordinated Energy and Water Cycle Observation Project; Roads et al. 2007)

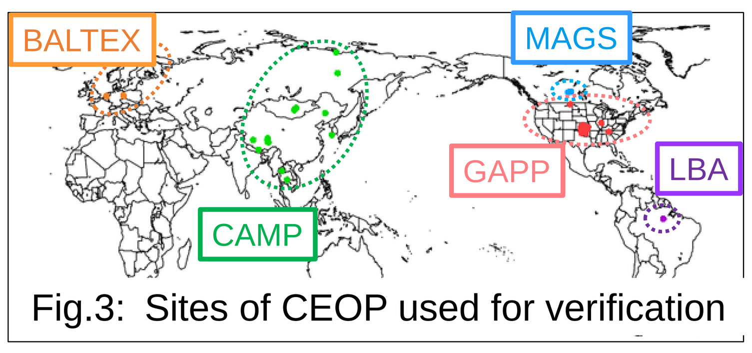

Fig.3: Sites of CEOP used for verification

4. Verification Results

Results show that iSiB driven by appropriate atmospheric forcing has no significant biases of T_s at most of the observation sites (Fig.4). On the other hand, various biases in variables related to surface heat budget exist.
- Underestimation of sensible heat flux, Overestimation of latent heat flux (Fig.5)
- Underestimation of upward SW (and underestimation of albedo), Overestimation of upward LW (Fig.6)

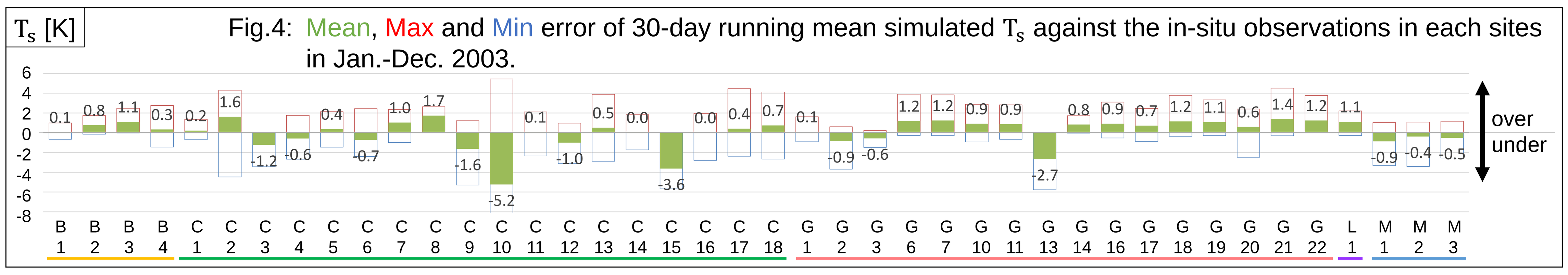

Fig.4: Mean, Max and Min error of 30-day running mean simulated T_s against the in-situ observations in each sites in Jan.-Dec. 2003.

The cold bias of T_s in GSM as the land-atmosphere coupled model was not seen in this offline verification. The source of the T_s error in the GSM could be due to land-atmosphere interactions or something other than iSiB. However, biases in radiative, sensible and latent heat fluxes exist robustly and compensate each other. In addition, the over- (under-) estimation of latent (sensible) heat fluxes can contribute to the daytime cold biases.

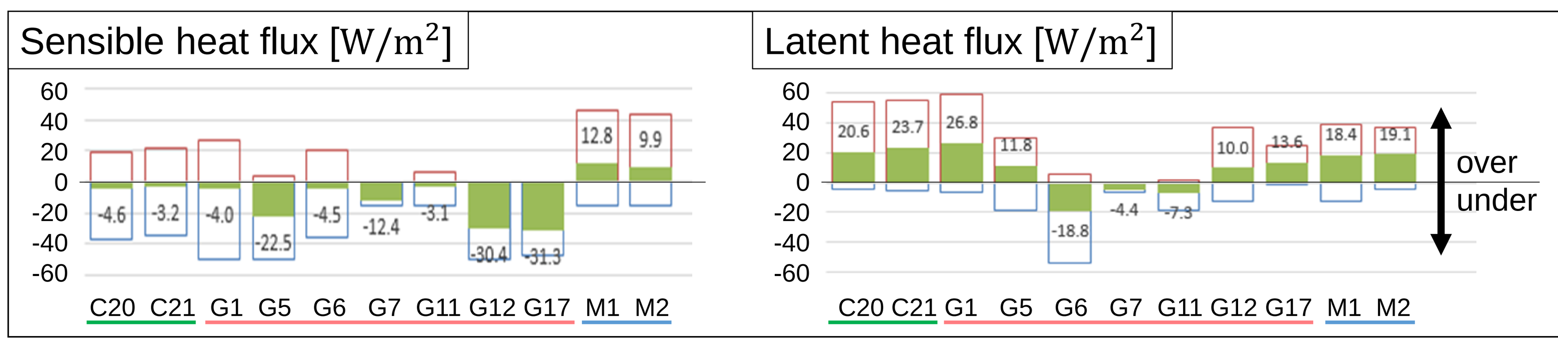

Fig.5: Same as Fig.4 but for heat fluxes in each sites in Jul.-Sep. 2004. Upward is positive.

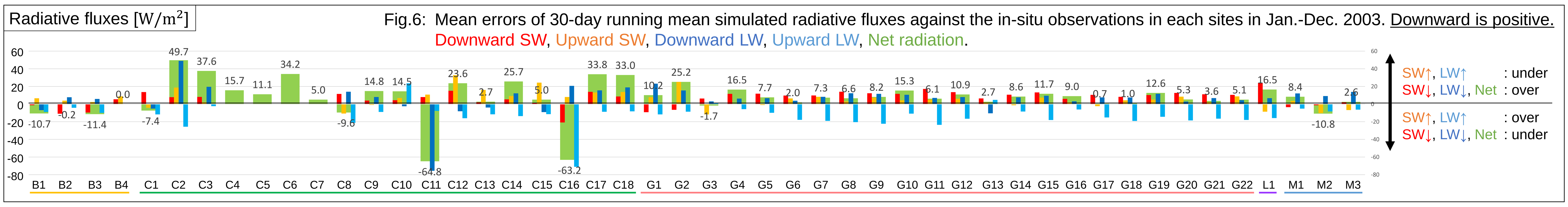

Fig.6: Mean errors of 30-day running mean simulated radiative fluxes against the in-situ observations in each sites in Jan.-Dec. 2003. Downward is positive.
Downward SW, Upward SW, Downward LW, Upward LW, Net radiation.

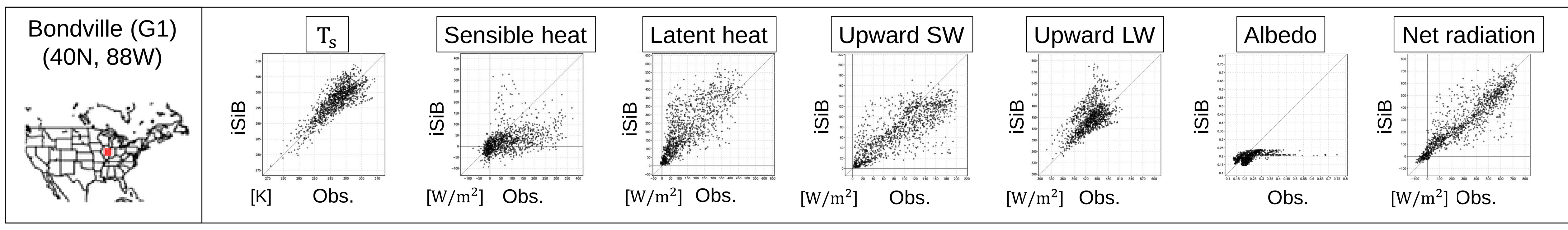

Fig.7: Scatter diagram of simulated values against the in-situ observations in Jul.-Sep. 2003 (only the daytime).

5. Summary and future works

Summary:
- In order to investigate error characteristics of iSiB alone, verification using the offline model and in-situ observation data is carried out.
- Verification results suggest there can be error compensation in surface heat budget of iSiB.

Future works:
- Further verification of biases in variables related to surface heat budget (e.g., ground surface temperature, ground heat flux) will be carried out as the next step.

Acknowledgements:
The author gratefully acknowledge the contributions and efforts of the National Center for Atmospheric Research (NCAR) in preparing the CEOP integrated database for in-situ observations. The atmospheric forcing dataset of GSWP3 provided by Dr. Hyungjun Kim was utilized. This dataset was also collected and provided under the Data Integration and Analysis System (DIAS), which was developed and operated by a project supported by the Ministry of Education, Culture, Sports, Science and Technology.

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