A revised snow scheme and its performance in the next seasonal prediction system at JMA (CPS4)

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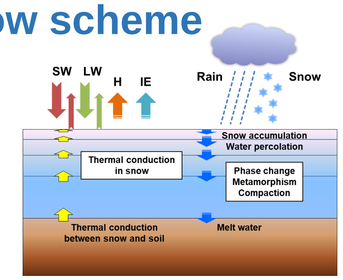
1. Introduction

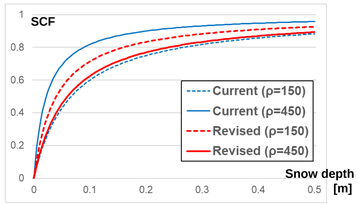
- The current seasonal prediction system (CPS3; Hirahara et al. 2023) has negative and positive biases in surface albedo on shallow snow for winter and spring, respectively. They result in systematic biases in surface temperature.
- One of the reasons is that the current snow cover fraction (SCF) parametrization represents less SCF for shallow snow and larger SCF for melting snow than the observed relationship.
- In order to address the systematic biases, snow-related parametrization in the land surface model has been revised and evaluated for CPS4.

2. The land surface model and revised snow scheme

- CPS3 uses the iSiB (improved Simple Biosphere Model; JMA 2024).
  - It has 7 layers for soil and up to 4 layers for snow.
- The following snow-related processes have been revised:
  - Modify diagnostic formulation for SCF (described in the bottom right)
  - Modify maximum and minimum snow albedo

    $\alpha_{vis,max}$=0.95, $\alpha_{nir,max}$=~~0.65~~0.75, $\alpha_{vis,min}$=~~0.76~~0.58, $\alpha_{nir,min}$=~~0.33~~0.38
  - Introduce snow unloading from canopy by wind (Roesch et al. 2001)
  - Revise rain-snow partitioning scheme (Lawrence et al. 2019)
  - Enhance snow compaction by thermal metamorphism and melt water
  - Reduce thermal conductivity of snow (Calonne et al. 2011)

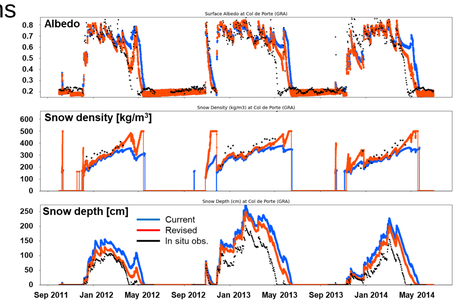




Relationship between snow depth and SCF in the snow schemes.

3. Offline simulations at the ESM-SnowMIP sites

- The revised snow scheme was evaluated using in situ observations of the ESM-SnowMIP (Krinner et al. 2018; Ménard et al. 2019).
- Offline simulations forced by the atmospheric forcing show better performance of the revised scheme.
  - Larger reduction of snow albedo during melting phase
  - Increased snow density, especially during melting phase
  - Reduced systematic biases in snow depth



Time series of albedo, snow density and snow depth for Col De Porte (France).

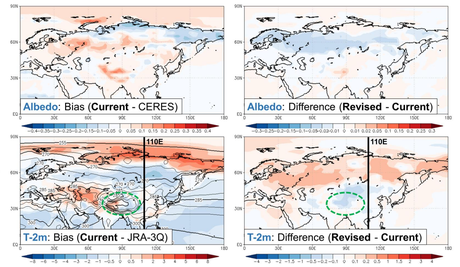
4. Reforecast experiment settings

- 2 reforecast experiments were conducted using the current and the revised snow scheme in CPS4.
- JRA-3Q (Kosaka et al. 2024) and CERES EBAF product (NASA 2019) were used to validate the reforecasts.

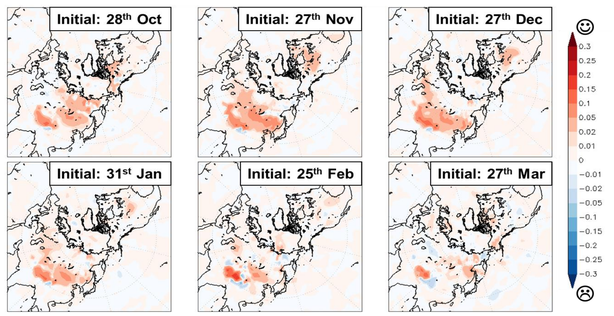
	Atmospheric and Land Model	**Ocean Model**
Horizontal Resolution	TL319 (~55km)	0.25° (Lon) × 0.25° (Lat)
Period	1991 - 2020	
Initial Date	31st Jan / 25th Feb / 27th Mar / 28th Oct / 27th Nov / 27th Dec	
Ensemble Member	5-member	

5. Results of reforecast experiments

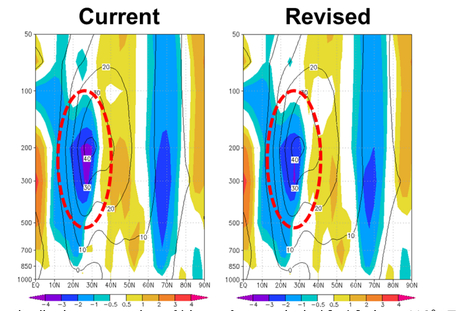
- Systematic positive biases in surface albedo and negative biases in 2m temperature are reduced in the Northern Hemisphere.
- Forecast skill in 2m temperature is improved for all the initial dates.
- The revised snow scheme increases SCF on the Tibetan Plateau, leading to colder surface temperature and stronger jet stream in East Asia. It reduces weak biases of zonal wind in the troposphere.



Biases and differences of effective albedo [-] and 2m temperature [K] for April (initial date: 27th March).



Differences of Anomaly Correlation Coefficient (ACC) for 2m temperature at a lead time of 3-9 days.



Latitudinal cross section of biases for zonal wind [m/s] along 110° E at a lead time of 6-12 days (initial date: 27th March).

6. Summary

- The revised snow scheme improves systematic biases in snow albedo, snow density and snow depth.
- The reforecast experiments show better skills for not only near-surface variables but also the middle-upper troposphere, especially in East Asia around the Tibetan Plateau.

Reference:

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