Assessment of the Community Land Model version 04 snow model output estimates

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INTRODUCTION

The Community Land Model version 04 (CLM v04), the land model for the Community Earth System Model (CESM v1.0.4) (Vertenstein et al., 2011) is a spatially distributed one-dimensional vertical model that provides the lower boundary condition for the Community Atmosphere Model (CAM).

CLM snow outputs were assessed in preparation for multisensor data assimilation into the land model.

The primary goal of the assimilation is to develop an optimized approach for merging Terra MODIS snow cover, Aqua AMSR-E snow water equivalent (SWE), and GRACE terrestrial water storage change observations to generate spatially and temporally continuous global snow water equivalent fields, at high resolutions (~1/8 degree).

CLM simulation was conducted in offline mode for the period 2000-2010 and the Northern Hemisphere estimates of snow cover fraction (SCF), snow depth and snow water equivalent (SWE) were evaluated using observations listed below.

DATA & METHODS

Observations

1) **MODIS/Terra** daily snow cover fraction (Hall et al. 2002: MOD10C2; 0.05º resolution; northern hemisphere; 2002 to Present)

2) Interactive Multisensor Snow and Ice Mapping System (IMS) data (NOAA/NESDIS/OSDPD/SSD, 2004)

3) the Canadian Meteorological Centre (CMC) daily snow depth (Brown and Bransnett, 2010) and SWE estimates using the Sturm et al. (2010) snow densities.

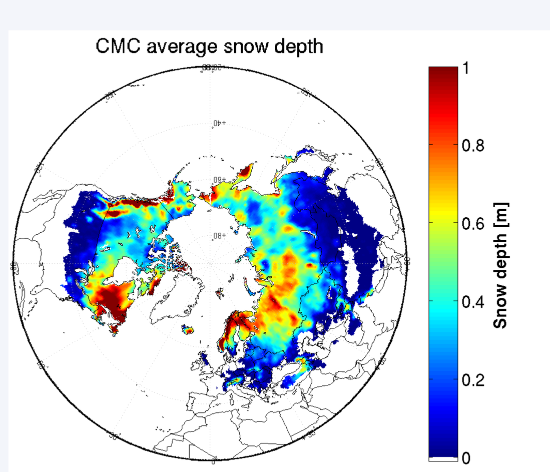


Fig 1 : Averaged Canadian Meteorological Centre daily snow depth snow depth for February (1998-2010).

4) the snowpack telemetry (SNOTEL), and the **Cooperative Station** snow depth and water equivalent Observations (COOP).

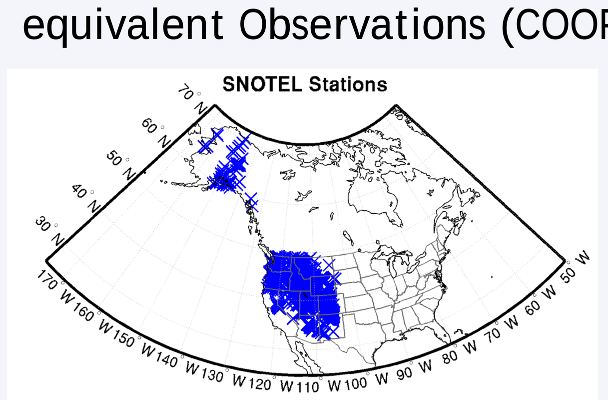


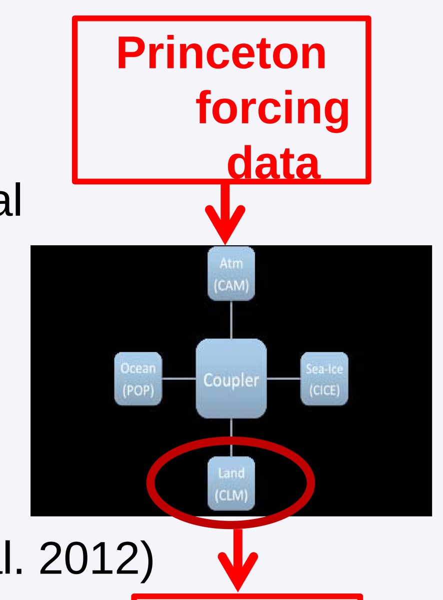
Fig 2: Snowpack telemetry(SNOTEL) station s locations

Simulation configuration

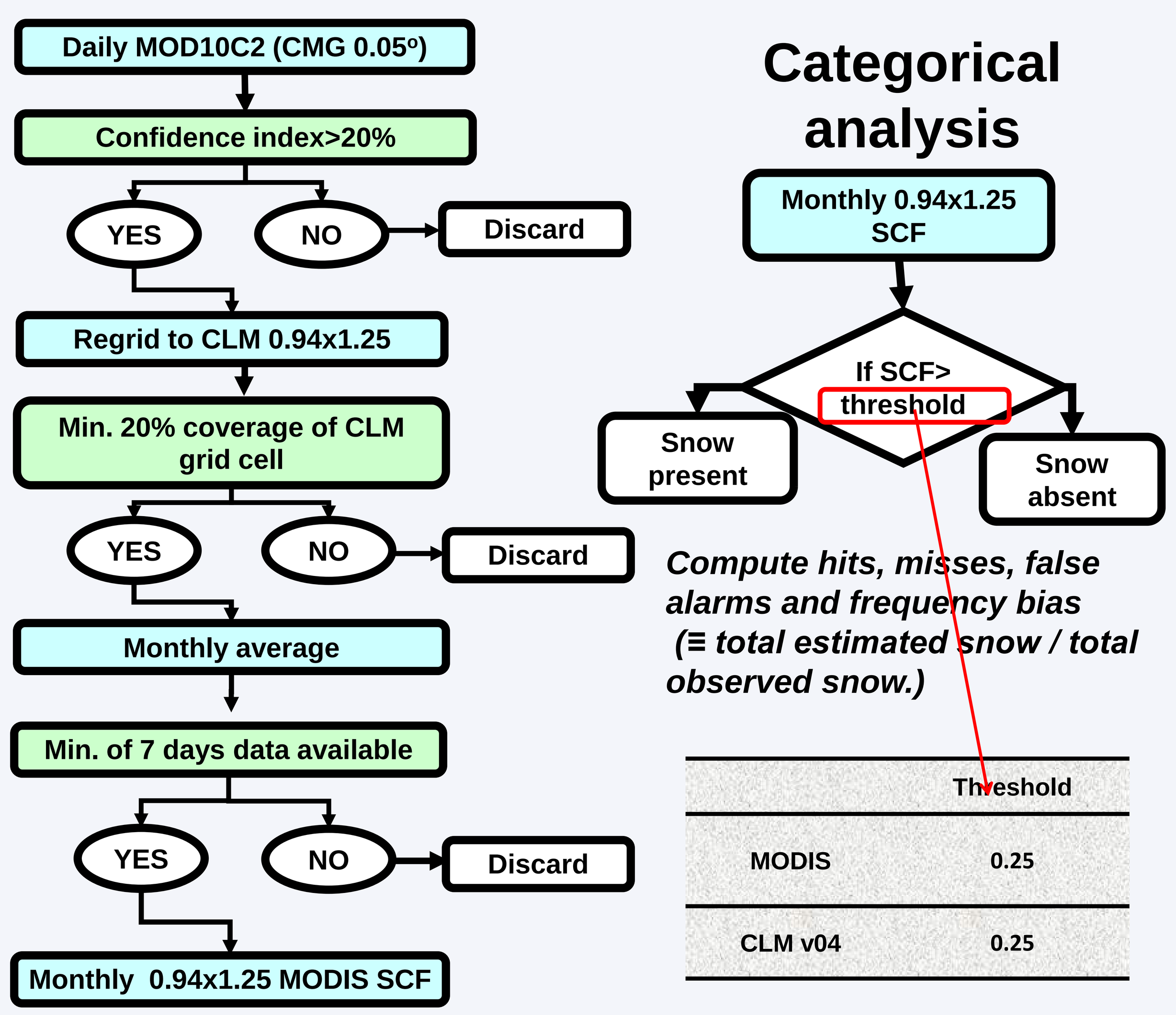
CESM is a coupled climate model used for simulating the Earth's climate system.

CLM was run in offline mode at 0.9 x 1.25 degree (latitude x longitude), forced with the Princeton meteorological fields (Sheffield et al.2006). The data are available at 3-hourly, at 1 degree. The precipitation has been bias-corrected to match the GPCC V5 monthly-mean dataset (Decharme et al. 2012)

The model was spun-up from 1948 to 1979.



CLM04 and MODIS Preprocessing



Compute hits, misses, false alarms and frequency bias (≡ total estimated snow / total observed snow.)

	Threshold
MODIS	0.25
CLM v04	0.25

RESULTS

a. Comparison of CLM Snow cover extent against MODIS

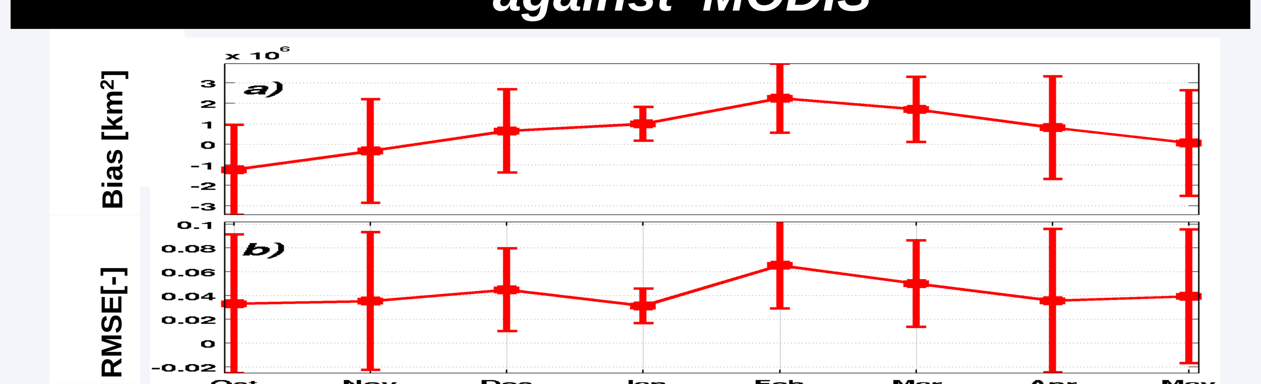


Fig 3: Mean bias(a) and normalized RMSE (b) vs. monthly MODIS snow cover extent (SCE) for Northern Hemisphere (NH) for 2001-2010. Bias and RMSE were computed for each grid and averaged over the NH. RMSE was normalized with the maximum annual SCE. Error bars show range of the 10 years.

b. Map difference

CLM04 vs MODIS

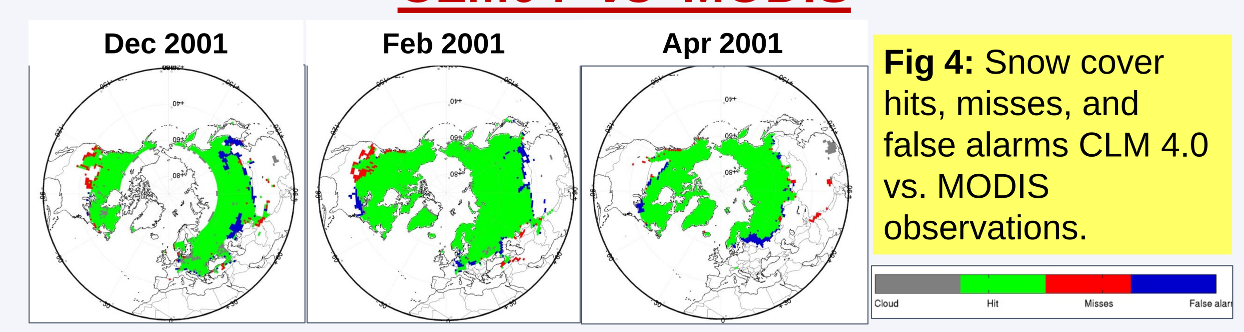


Fig 4: Snow cover hits, misses, and false alarms CLM 4.0 vs. MODIS observations.

CLM04 vs IMS

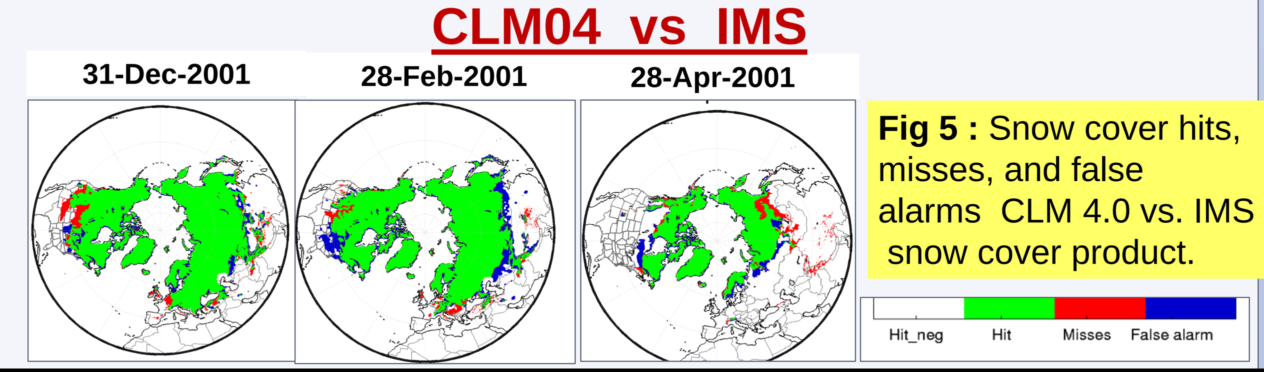


Fig 5 : Snow cover hits, misses, and false alarms CLM 4.0 vs. IMS snow cover product.

c. Categorical Analysis of SCF

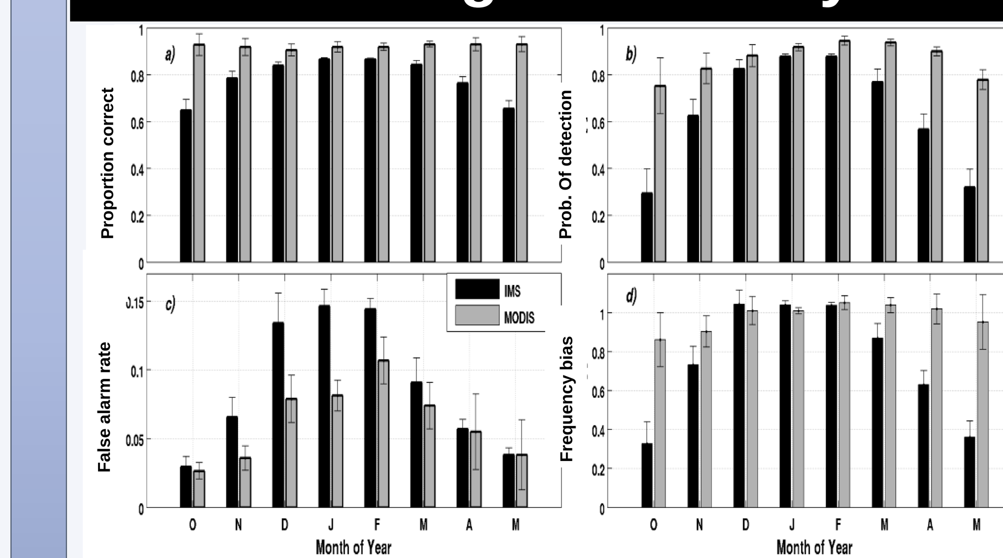


Fig 6 : Comparison of CLM 04 binary model estimates (snow/no snow) vs. MODIS and IMS for the Northern Hemisphere. Error bars show range of variations in 2001-2010.

CLM04 vs CMC

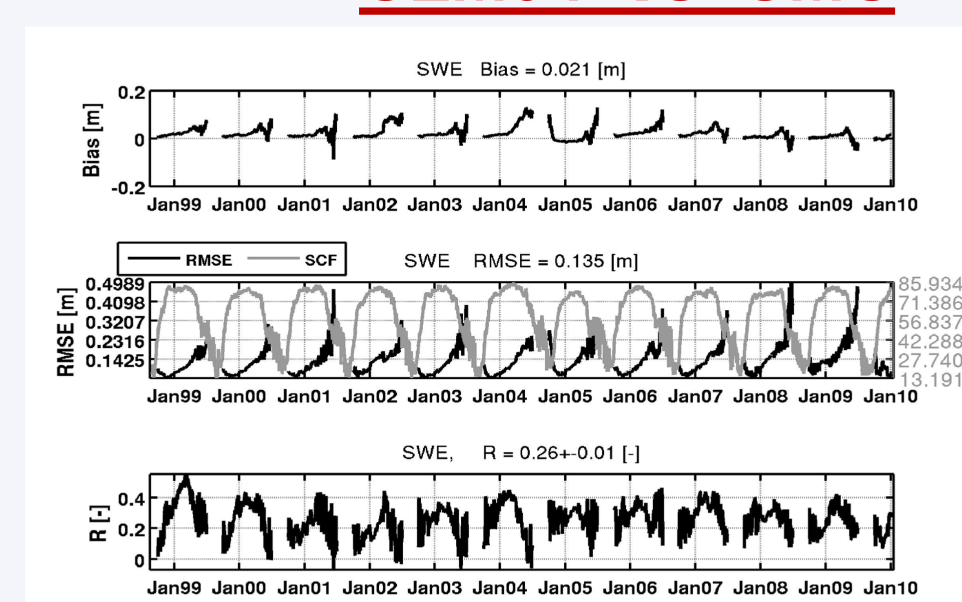


Fig 7 : Time series of bias, RMSE, and spatial correlation of CLM 04 model estimates with the CMC snow product for the Northern Hemisphere (2001-2010).

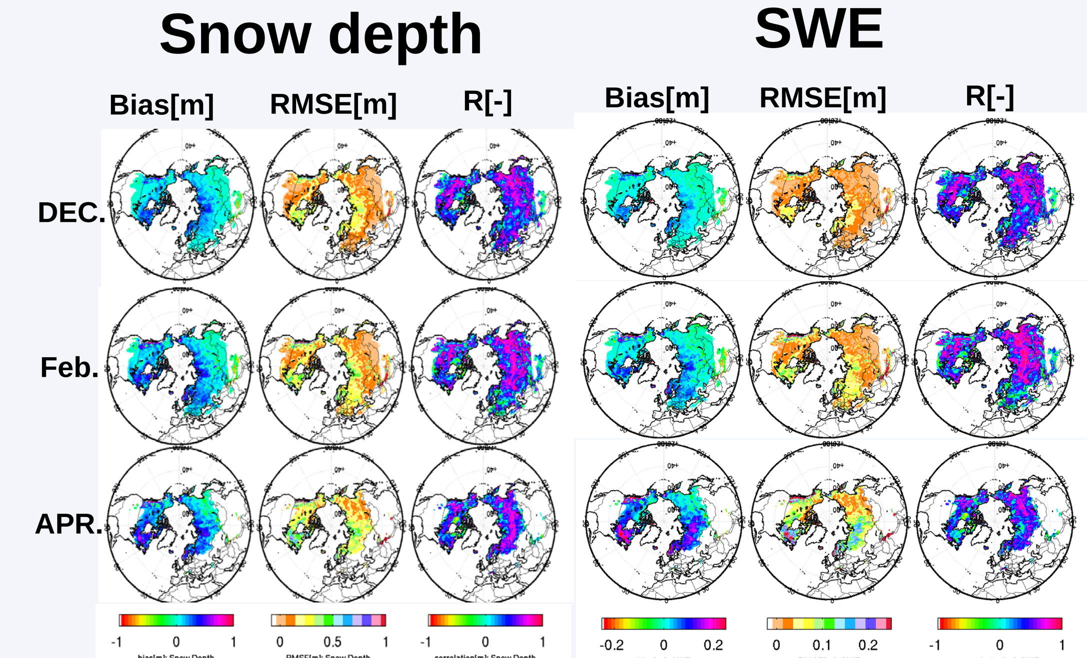


Fig 8 : Bias, RMSE, and daily correlation of simulated snow depth and SWE relative to CMC snow product for the Northern Hemisphere (2001-2010).

CONCLUSIONS

We used snow observations and products from various sources to assess the CLM version 4.0 snow model output.

Key Findings

CLM v04 SCF agrees well with MODIS SCF observations and IMS snow cover product especially in February when snow cover extent is at its maximum.

Generally, false alarms and misses occur mostly in the US Rocky mountains, in south-western Russia and on the Tibetan plateau.

CLM04 agrees reasonably well with the Canadian Meteorological Centre snow depth and SWE in the areas of shallow snow.

CLM04 shows large bias compared to SNOTEL data (results not shown here)

Future work

Assimilation of MODIS snow cover, Aqua AMSR-E snow water equivalent (SWE), and GRACE terrestrial water storage change observations.

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