Impact of Eurasian snow cover on inter-annual variability of the NH winter circulation: simulations forced by satellite observations

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Snow cover influences regional and global climate
Strong interest in impact of surface conditions on climate variability (SST, sea ice, snow)
Retreating snow cover acts as a positive feedback to global warming through albedo feedback
But besides albedo feedback, hydrological and dynamical feedbacks could be important too

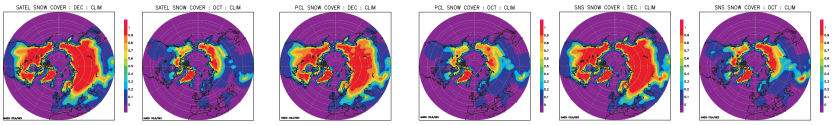
Previous work on Eurasian snow cover impact upon global climate and teleconnection patterns
- Eurasian Spring snow cover influences the Asian monsoon (Douville et al., 1995), and wave-trains over the North Pacific (Clark and Serreze, 2000)
- Eurasian Autumn snow cover (Saito et al., 2001) correlates to NAO in following winter

Snow cover in climate models
- General circulation models tend to simulate a snow cover that is not variable enough from year to year.
- Nudging is an approach to provide more realistic, imposed snow conditions potentially leading to better modelled climate variability
- Previous "nudged" GCM simulations relied on modelling few, extreme years with exceptional snow conditions
- We have performed decadal-scale simulations with imposed, observed snow cover extent, derived from satellite observations

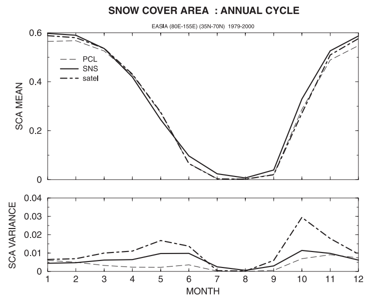
Climate model simulations with ARPEGE climat
- 21-year run (1979-2000)
- Ensemble approach (5 members) [only ensemble-mean used here]
- Resolution : T63, 31 levels
- Observed SSTs, sea-ice (Reynolds dataset)

FORCED SNOW COVER simulation (SNS)
- Global, observed snow cover nudged into model
- Snow cover data : NISDC EASE (Boulder, Colorado) weekly gridded dataset based on visible satellite imagery

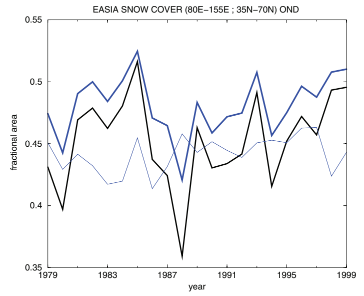
PROGNOSTIC SNOW COVER control simulation (PCL)
- Freely-evolving snow variables



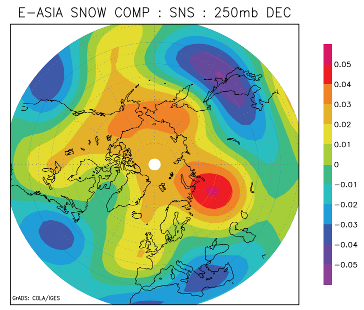
Snow cover extent in October and December
- Snow cover fraction in the satellite observations, the control and the forced-snow simulations



Climatological annual cycle of snow cover, and its variance
- The forced simulation has higher snow cover extent in winter than the control simulation, and higher variance in the transition seasons (autumn, spring)
- Variance is not as high as in the satellite observations

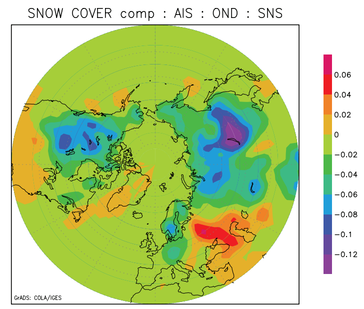


Autumn (OND) East Asian snow cover
- Model prognostic snow (PCL, thin blue) does not have enough year-to-year variability, while the model forced snow (SNS, thick blue) follows observations.
- Forced simulation not reproducing the years with smallest snow cover, and slightly higher than observations



Composite of the Eastern Eurasia snow index
- Composite difference of geop at 250mb in DEC for high minus low snow index shows lowered heights on southern/western flank of Aleutian Low

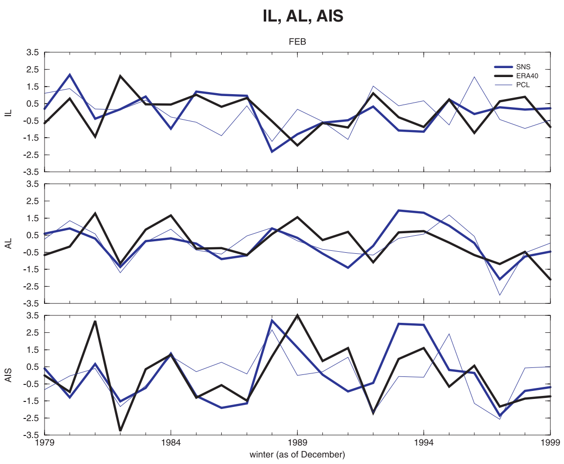
(units: km)



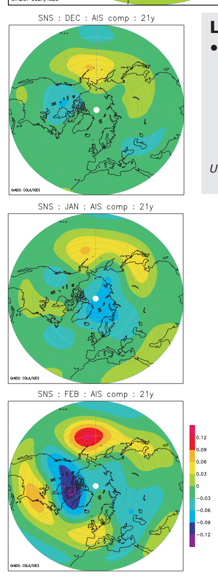
Precursory autumn snow cover to the AIS
- Composite difference of the autumn (OND) snow cover upon the AIS index (in FEB)
- Negative phase of AIS (deeper Aleutian Low) means more extensive snow cover over Eastern Eurasia in autumn

Impact on the Aleutian-Icelandic Low seesaw (AIS) teleconnection
- There is recent evidence that climate variations over the North Pacific and Atlantic sectors are coupled in late winter, through an Aleutian (AL)-Icelandic (IL) Low Seesaw (Honda et al., 2001; Orsolini et al., 2008)
- Our underlying hypothesis is that snow cover anomalies over Eastern Eurasia (esp. in autumn-early winter) influence the North Pacific, the Aleutian Low, and hence the Euro-Atlantic sector through the AIS in late winter. This is in addition to the ENSO forcing of the AIS.

Conclusions
- We achieve a much improved hindcast of Aleutian and Icelandic Low in late-winter (FEB) in simulations with satellite-derived snow cover, compared to earlier studies.
- The snow-forced model runs show a realistic AIS pattern and lifecycle, and an anti-correlation with both ENSO, and Eastern Eurasian snow cover
- The study leads credence to earlier model and observational studies linking anomalous Eurasian snow cover to wave trains over the North Pacific
- Through late-winter influence on the Icelandic Low, our results are also largely consistent with those of Cohen et al. linking Eurasian autumn snow cover and negative NAO in following winter (but we emphasize horizontal propagation through AIS)



Late-winter (FEB) hindcast of the AIS
- AIS correlates better with observations in SNS than PCL. Such as high hindcast skill score is a new result (Corr: 0.66)
- Ensemble-mean Icelandic (IL), Aleutian (AL) and Aleutian-Icelandic (AIS) indices in ERA40 (black), and the various simulations (SNS: thick blue, CLI: dash blue, PCL: thin blue)
- Indices are based on SLP normalised anomalies in February. The AIS index is AL minus IL



Life-cycle of the Aleoutian-Icelandic Seesaw
- Ensemble-mean, lagged composite differences in geopotential height (250mb) showing the externally forced life-cycle of the seesaw from December through February, based on February values of the AIS index (SNS simulation)

Units are km

References:
Douville, H,. and J., F. Royer, 1996, Clim. Dyn., 12, 449-466.
Honda, M., et al., 2001, *J. Climate*, 14, 1029-1042.
Orsolini, Y., et al., *J. Met. Soc. Japan*, in press, July 2008.
Saito K., et al., *Mon.Wea.Rev.*, 129, 2746-2760, 2001.
Clark, M.P. and M.C. Serreze, *J. Clim.*, 13, 3700-3710, 2000.

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