Intraseasonal Influences on Terrestrial Snow Cover in the Northern Hemisphere

MIDN Emily L. Kreyenhagen, Gina R. Henderson, Bradford S. Barrett
Oceanography Department, United States Naval Academy, Annapolis, MD

INTRODUCTION

Recent studies have shown a long–term decline in Arctic sea ice extent in all seasons (Stroeve et al. 2012). However, variability of Northern Hemisphere (NH) snow cover extent (SCE) displays more complexity (Brown and Mote 2009). SCE has been found connected to the well-known modes of NH low frequency atmospheric variability including the North Atlantic Oscillation (NAO) and the Arctic Oscillation (AO) (Bamzai 2003; Brown et al. 2010; Saunders et al. 2003).

Despite work on the seasonal and decadal time scales, less is known about the influence of shorter-term, lower-latitude oscillations on NH SCE. One such tropical oscillation that has recently been shown to affect atmospheric circulation, temperature, and even sea ice extent in the Arctic is the Madden-Julian Oscillation (MJO) (Henderson et al. 2014; Zhou et al. 2011). The MJO's effect on NH terrestrial snow cover, however, remains largely unknown.

PURPOSE

- This project explores teleconnections between the MJO and the high latitudes by observing how Arctic and sub-Arctic SCE vary in accordance with phases of MJO.
- The hypothesis of this study is that Pacific convection (MJO) excites a poleward wave train that affects atmospheric variables (temperature, SLP, precipitation, etc.) in the Arctic and impact NH SCE **(Fig 1)**.

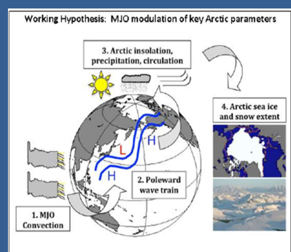


Fig 1: *Working hypothesis for MJO modulation of Arctic snow.*

DATA AND METHODS

DATA

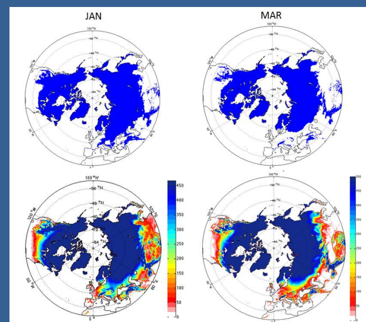
- Snow data was obtained from the National Snow and Ice Data Center's (NSIDC) Interactive Multisensor Snow (IMS) daily NH snow analysis at 24 km resolution from (NSIDC 2008) spanning from February 1997 to December 2012.
- Index values (1997-2012) from the Real-time Multivariate MJO Index (RMM, Wheeler and Hendon 2004) were used to define phase and amplitude of the MJO.

METHODS

- Atmospheric data from NCEP Reanalysis II (NOAA PSD 2012) was binned by phase of MJO and expressed as anomalies from the 1979-2012 mean for each month.
- 2-m temperature (TEMP), mean sea level pressure (MSLP), and 500hPa geo-potential height (GPH) were analyzed.

METHODS

- Data was expressed as monthly means and counts of daily SCE **(Fig 2)**.
- SCE data from active MJO days (RMM amplitude > 1) were binned by phases of MJO (Wheeler and Hendon 2004).



- Fractional net daily snow change was calculated for each phase of each month through the process outlined in **Fig 3.**
- By using fractional net daily snow change, the effects of snow memory between different phases were minimized.

Fig 2: *Top panel: Blue areas represent regions with SCE frequency of 50% or greater and white areas represent SCE frequency of less than 50%. Bottom panel: Total number of days where SCE was present.*

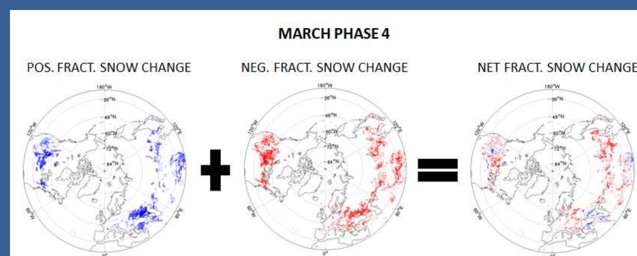


Fig 3: *Daily SCE change was first calculated and expressed as occurrences of 'positive fractional snow change' (snow arriving, left), 'negative fractional snow change' (snow leaving, middle), and 'net fractional snow change' (right). Values were expressed as fractional changes, as each phase was standardized by the number of days occurring in each phase.*

RESULTS

- Fractional net daily snow change is compared with TEMP, MSLP, and GPH anomalies for January **(Fig 4)** and March **(Fig 5).**

SCE area calculations in million sq. km

Month	Phase	Mean	Net Neg. (Red)	Net Pos. (Blue)
JAN	3	48.28	0.2123	0.3679
	8		0.3278	0.2727
MAR	4	40.99	0.4609	0.2057
	8		0.0938	0.9267

Table 1: *Summary of fractional net daily change in snow areas (Fig 4 and 5).*

- In Jan, neg. net snow change was more prevalent in phase 8 (-0.33 million sq. km), while pos. net snow change was more prevalent in phase 3 (+0.37 million sq. km) **(Table 1).**

RESULTS

- Over E. USA in phase 3, areas of neg. net snow change were nearly collocated with areas of statistically significant pos. TEMP, and MSLP anomalies. In phase 8 over E. USA, areas of pos. net snow change were nearly aligned with statistically significant MSLP and GPH anomalies (**Fig 4**).

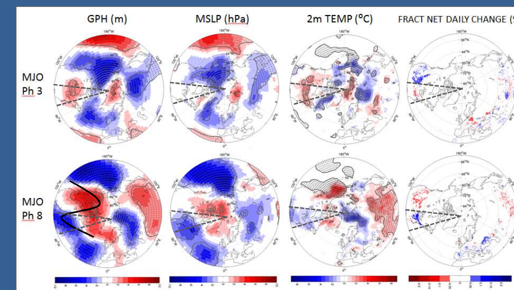


Fig 4: *January fractional snow change (right) where blue (red) areas represent net snow arriving (leaving) and anomaly plots of 2-m temp (middle right), MSLP (middle left), GPH (left) for January. Red (blue) shading indicates positive (negative) anomalies.*

- In March, neg. net snow change was more prevalent in phase (-0.46 million sq. km), while pos. net snow change was more prevalent in phase 8 (+0.93 million sq. km) **(Table 1).**
- In phase 8, areas of pos. net snow change were nearly collocated with areas of statistically significant neg. TEMP, MSLP, and GPH anomalies particularly over W. Europe and E. USA. Over W. USA in phase 4, neg. net snow change was nearly aligned with pos. TEMP MSLP and GPH anomalies.

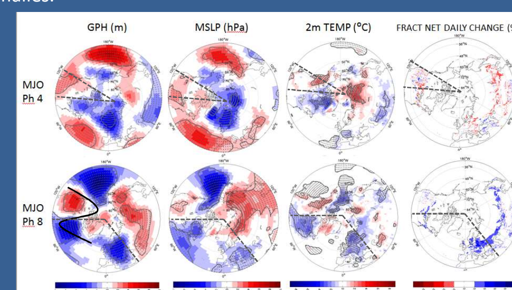


Fig 5: As in Fig 6 but for March.

CONCLUSION

- The marginal areas of SCE throughout each season are the zones in the NH most clearly impacted on an intraseasonal time scale.
- Alternating positive and negative fractional net daily snow change patterns suggest a wave-like atmosphere governed by MJO phase.
- Terrestrial snow cover responds to atmospheric variability. In this case, anomalous temperatures, MSLP and 500 hPa GPH modulate NH SCE.

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