

An aerial photograph of a vast sea ice field. The ice is covered in numerous snowdrifts of varying sizes, creating a textured, undulating surface. The lighting is soft, casting gentle shadows that emphasize the contours of the snow. The overall color palette is a range of blues and whites, from deep cerulean to bright, clean white.

Changing Snow on Sea Ice

Melinda Webster

NASA Goddard Space Flight Center

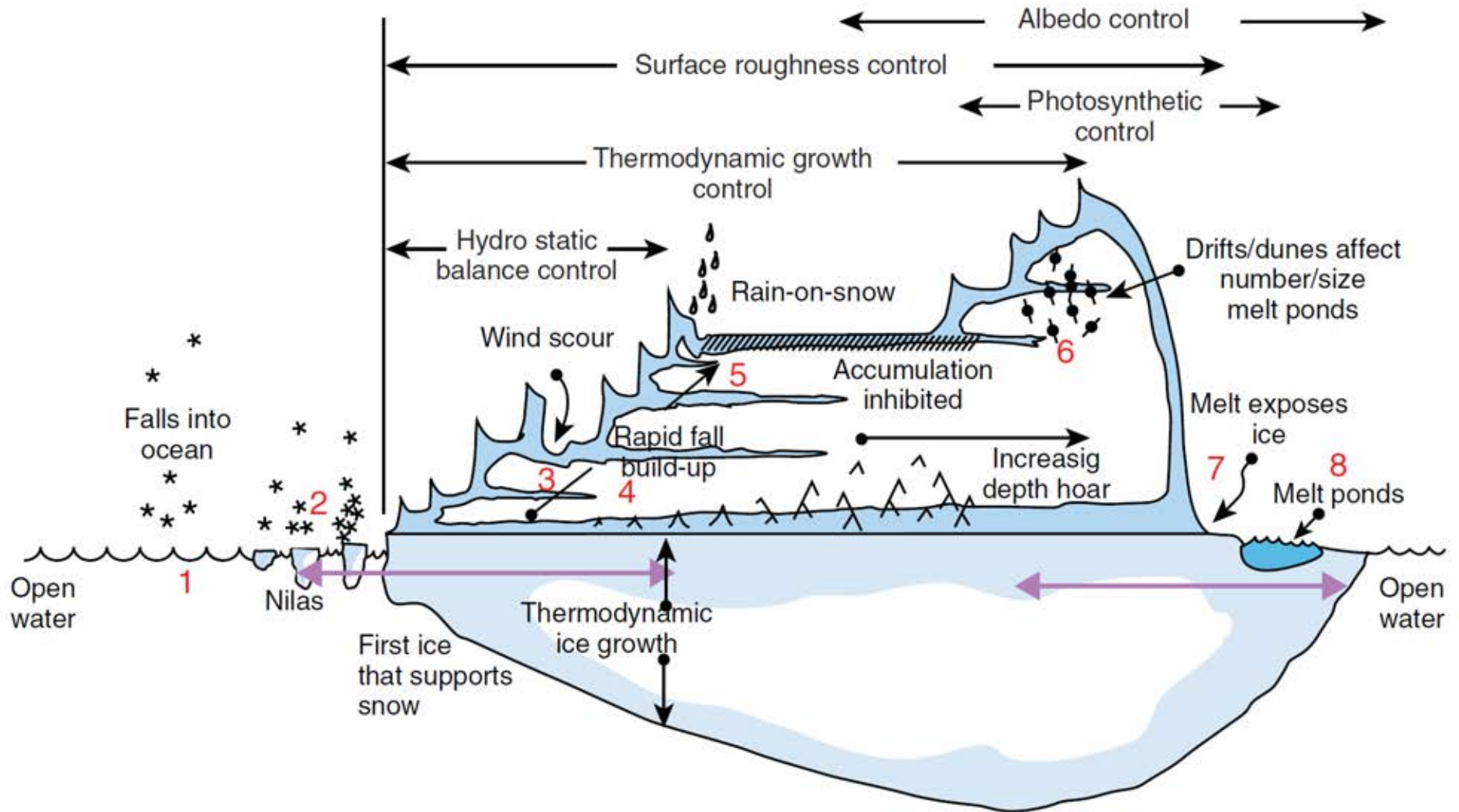
Snow on sea ice:

- Why is it important?
- Where is it distributed?
- What's changed?
- Which key processes are driving these changes?
- What can we anticipate in the future?



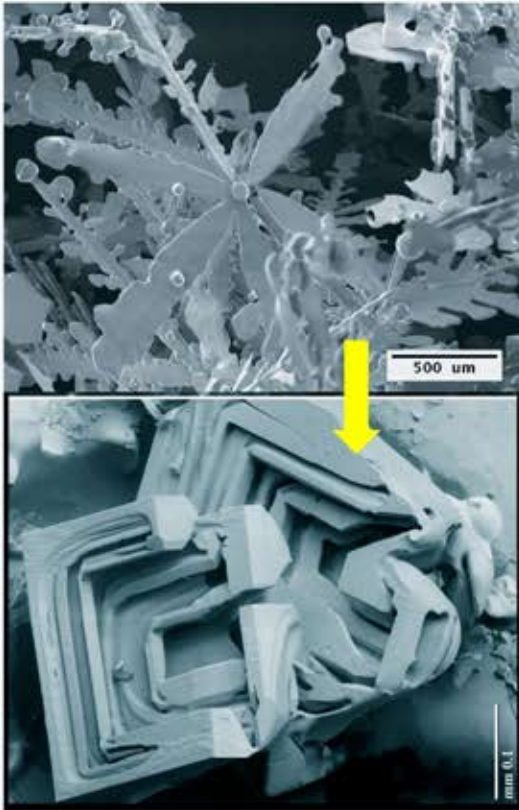
Bill Watterson

Why is snow on sea ice important?

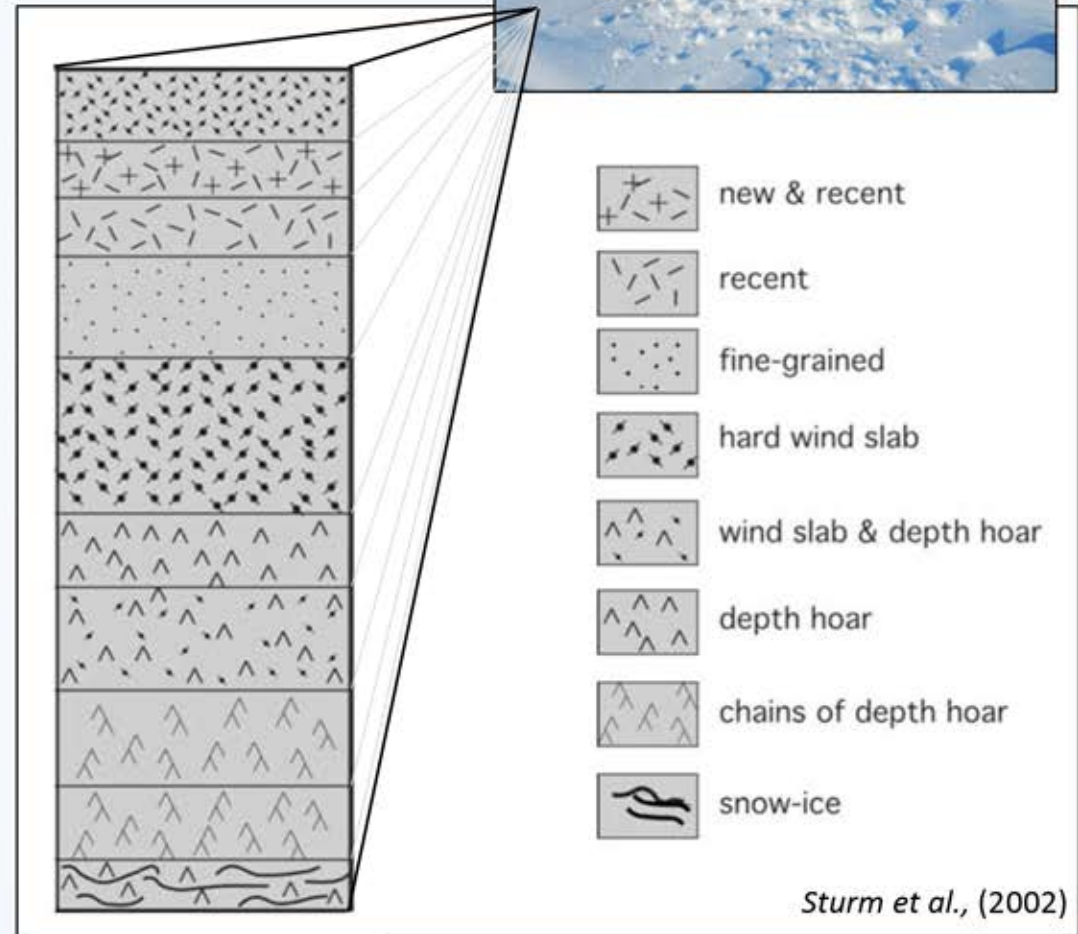


JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
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Snow's a complex medium:

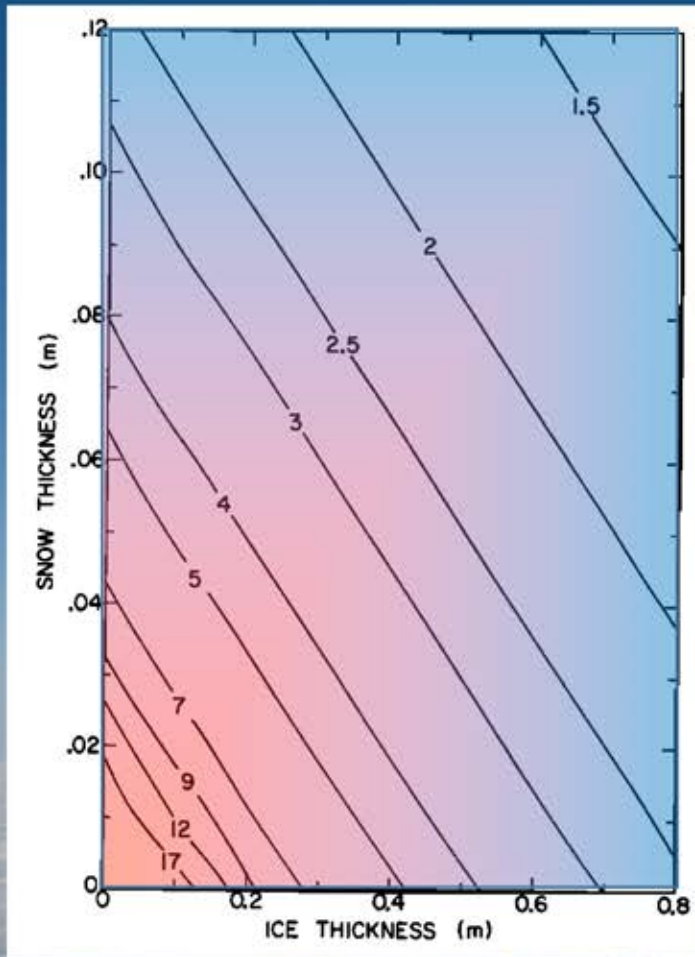


Left: ©Si Chen. Right: ©Beltsville Agricultural Research Center Electron and Confocal Microscopy Unit

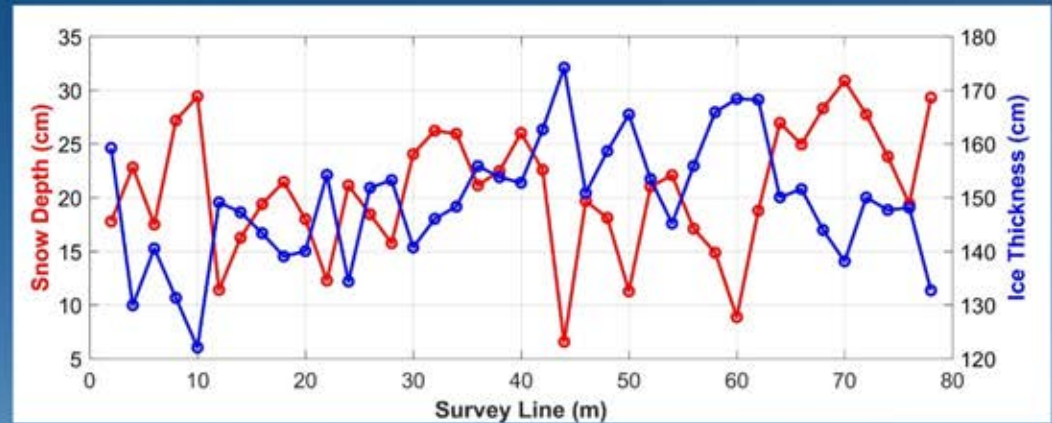


Sturm et al., (2002)

It's an excellent insulator:



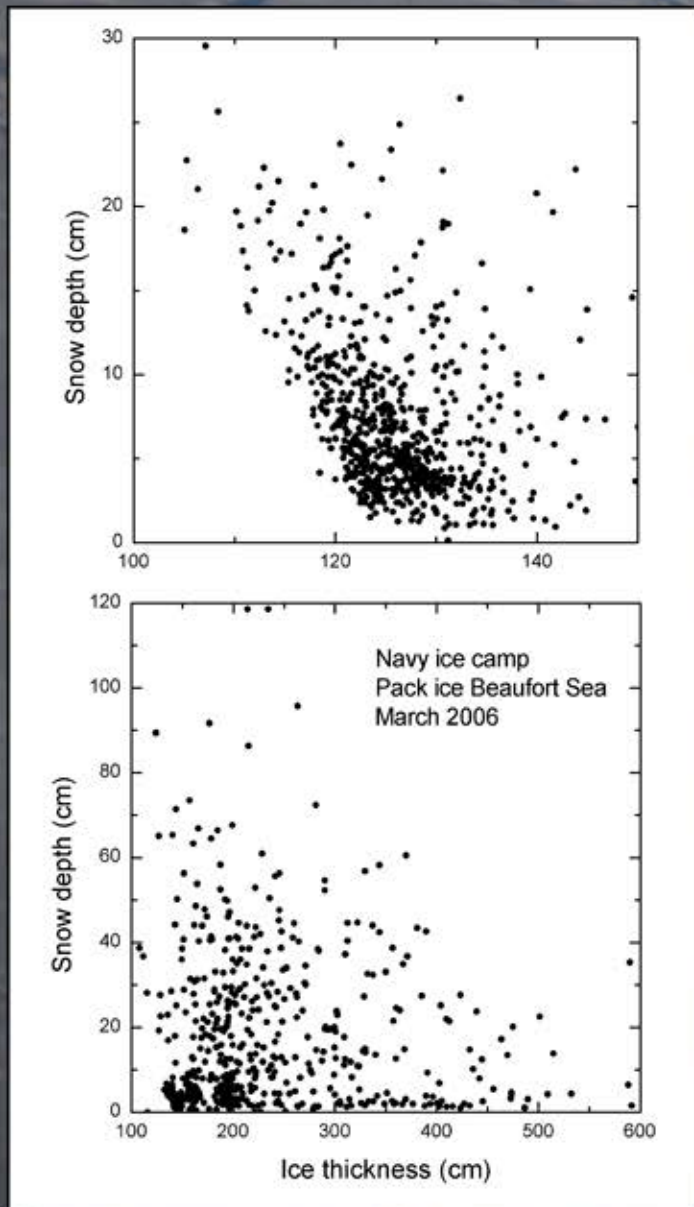
Maykut (1978)



Webster et al., (2012)



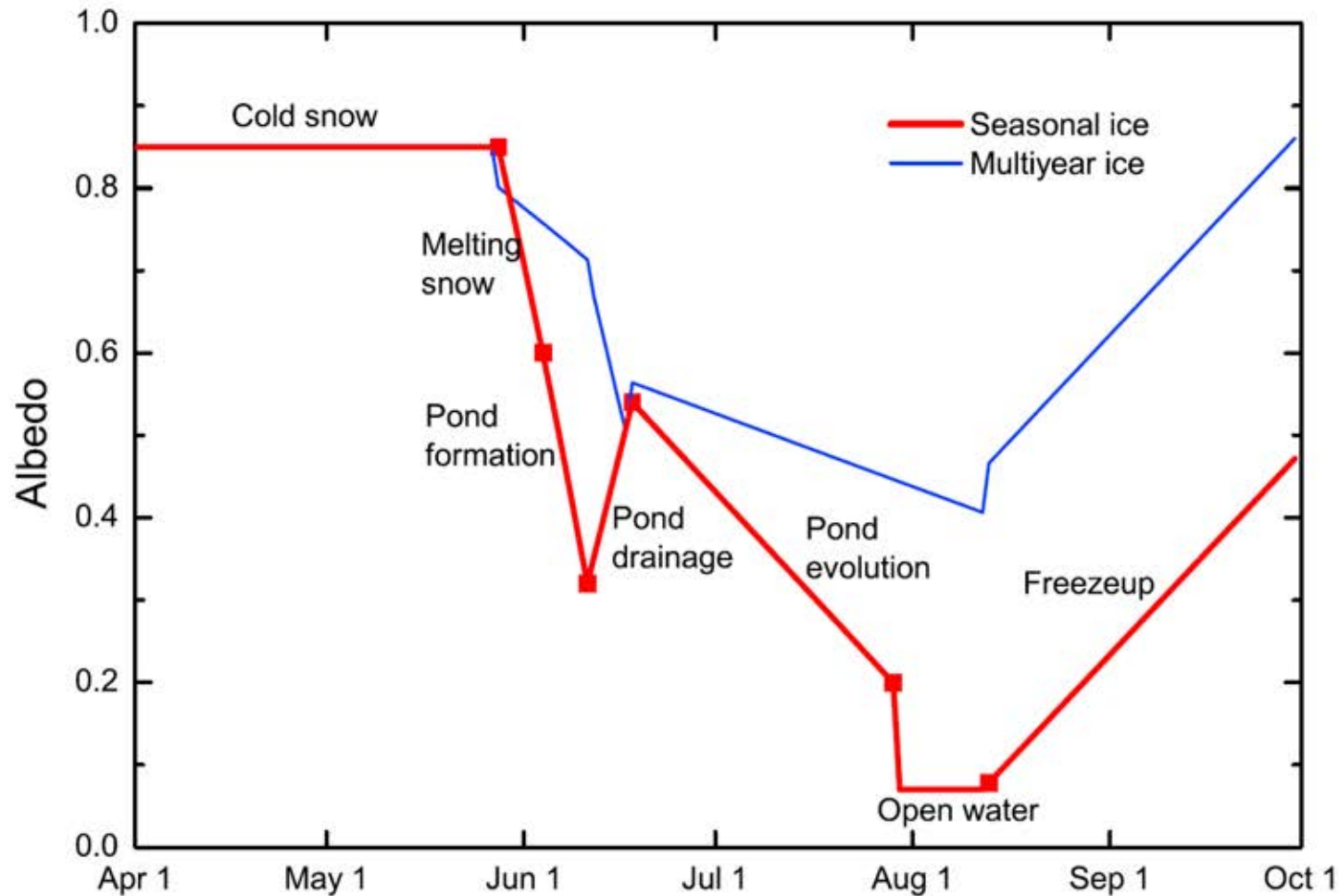
Snow & sea ice affect one another:



← Snow influencing sea ice thickness.

↗
← Sea ice influencing snow thickness.

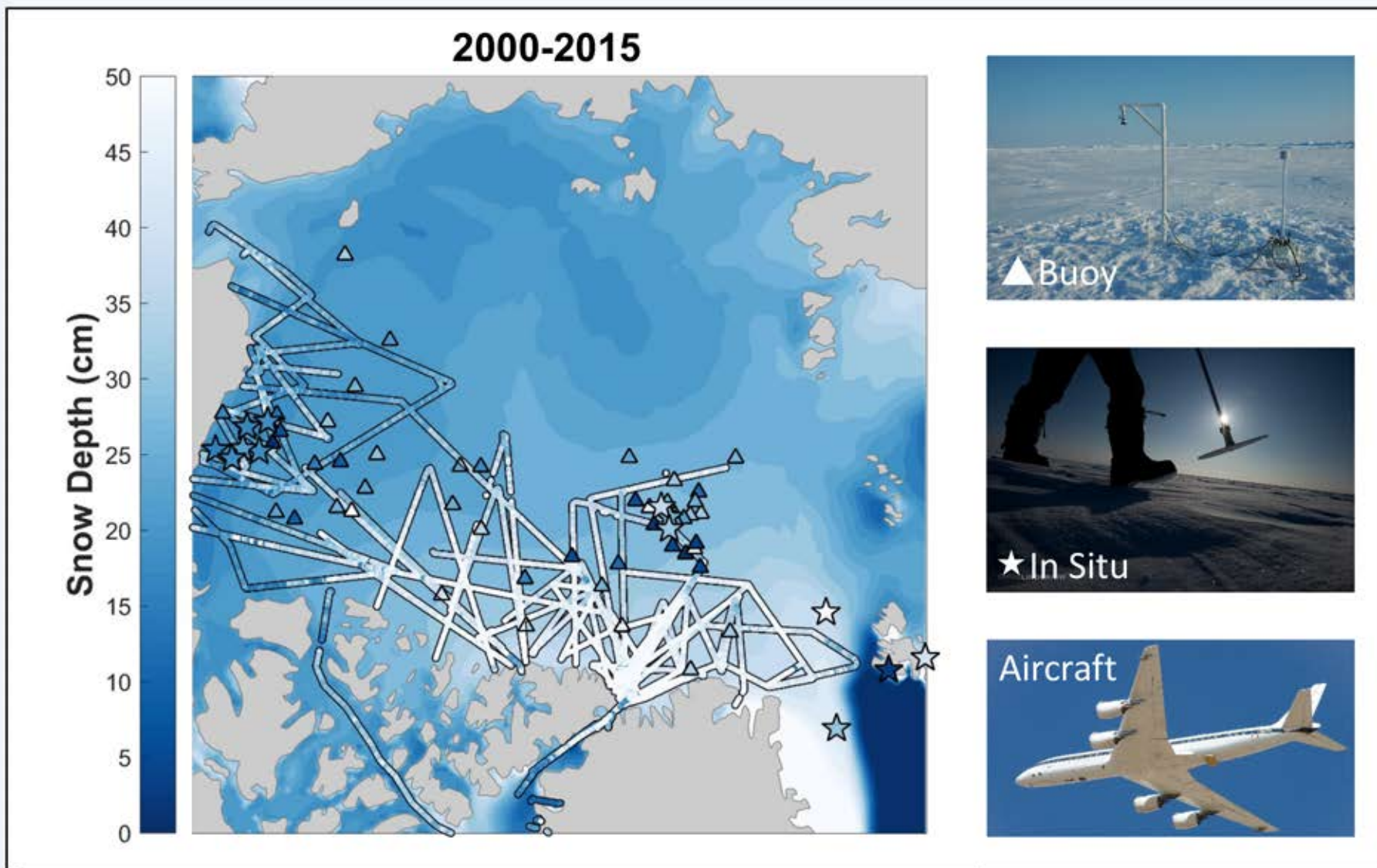
Incredibly reflective!



Perovich and Polashenski (2012)

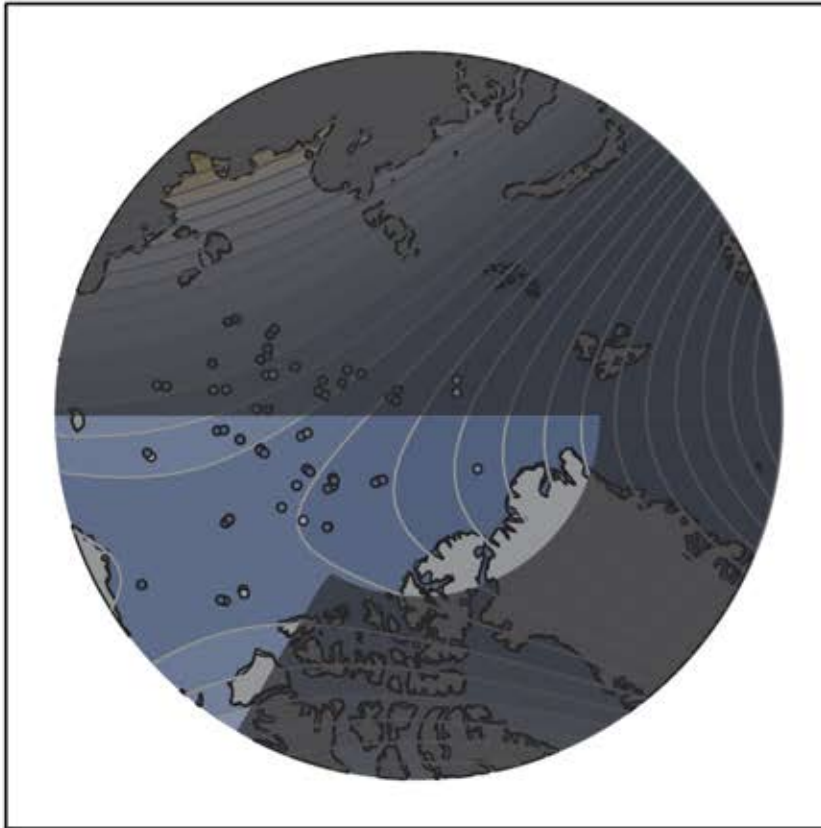


Where is all the snow?

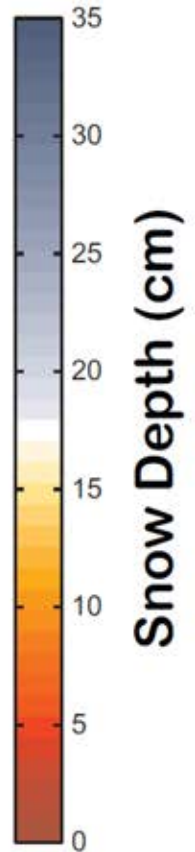
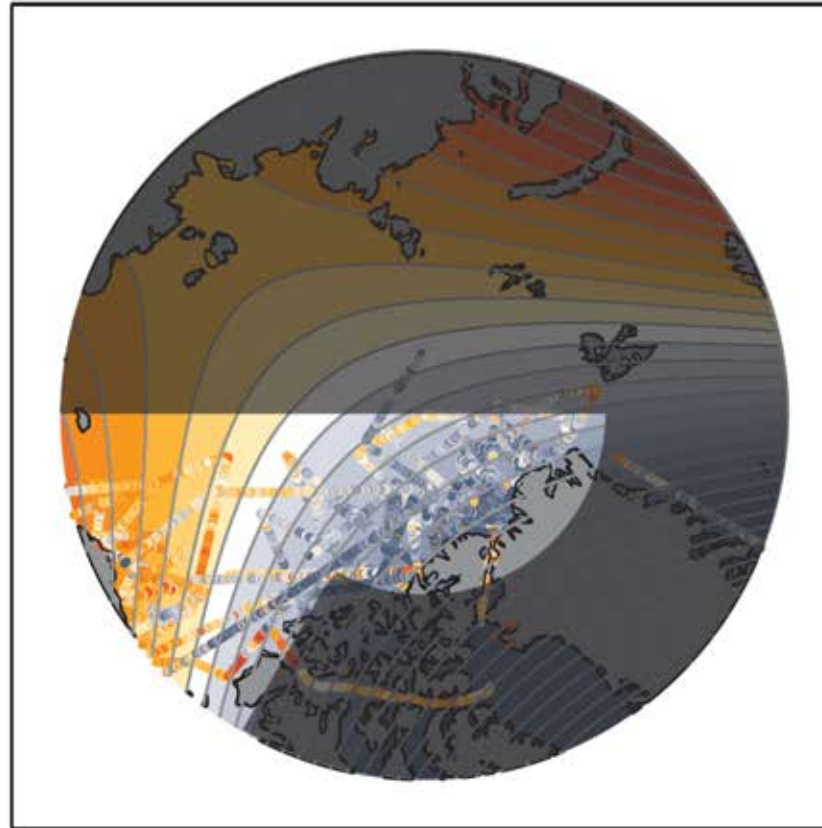


Snow depth distributions have changed:

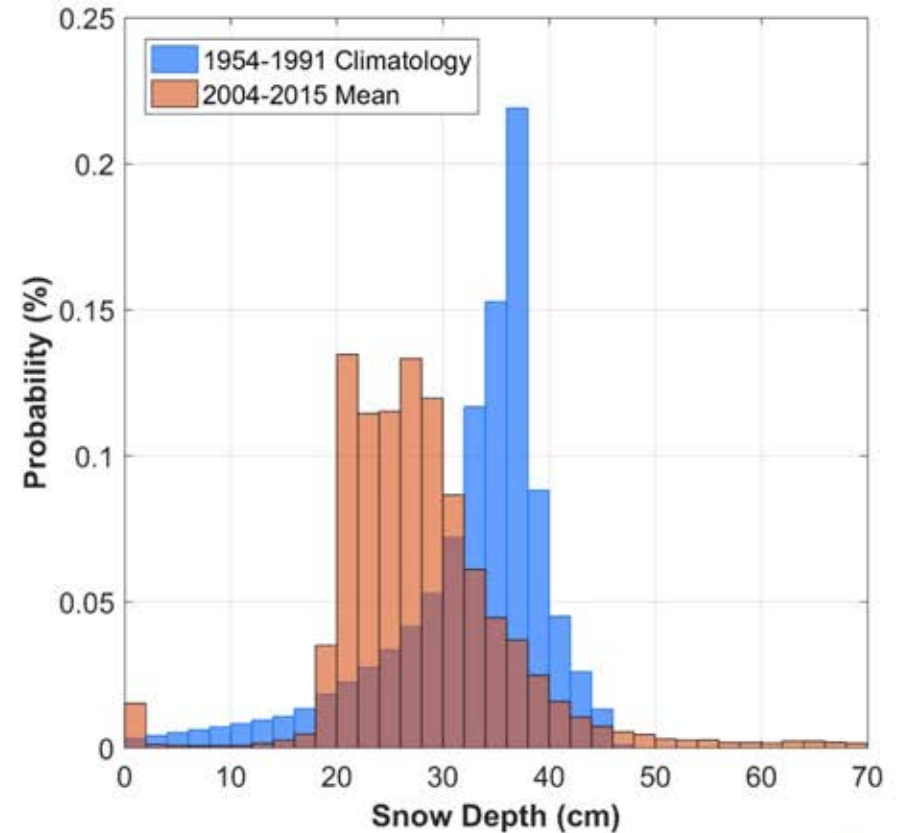
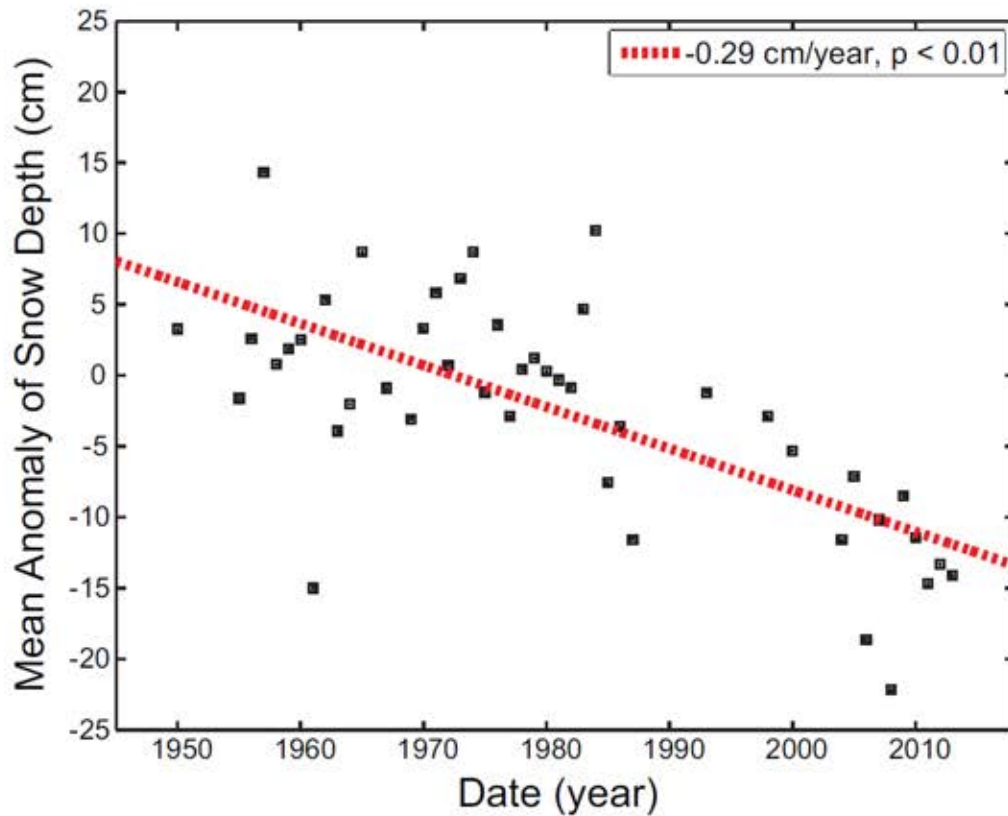
1954-1991



2009-2013



Observations & models agree:

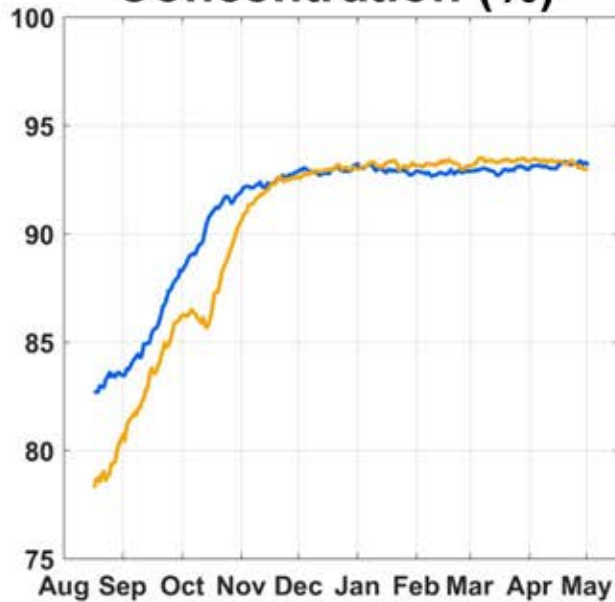


Which processes might be driving this trend?

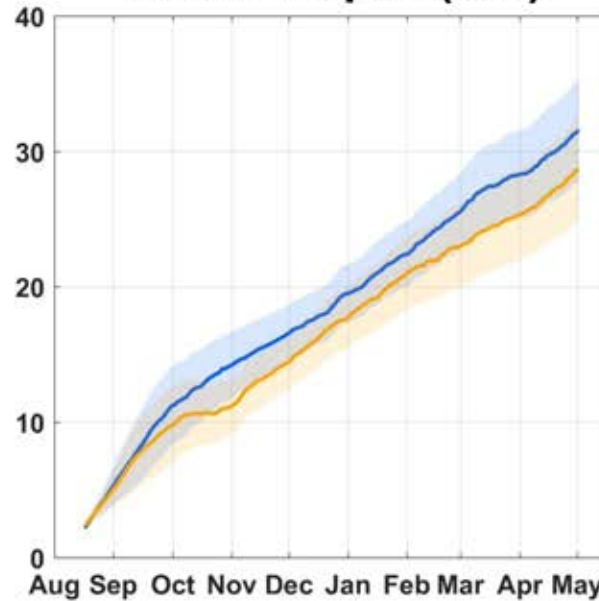
Models can reveal insight into processes:

Sea Ice

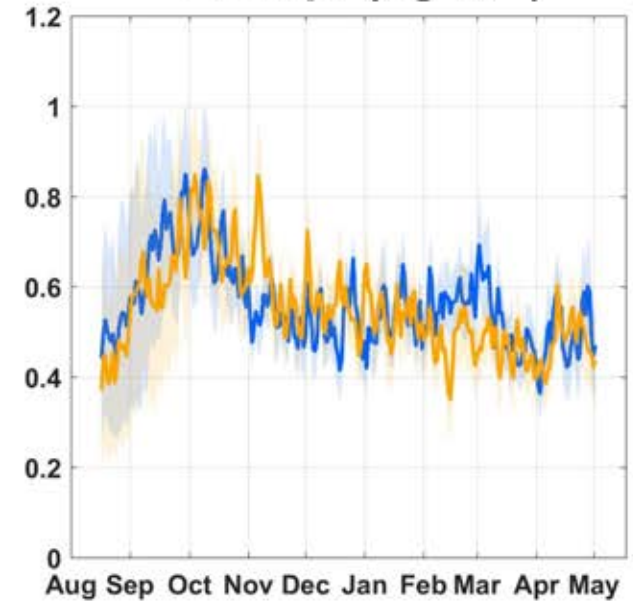
Concentration (%)



Snow Depth (cm)



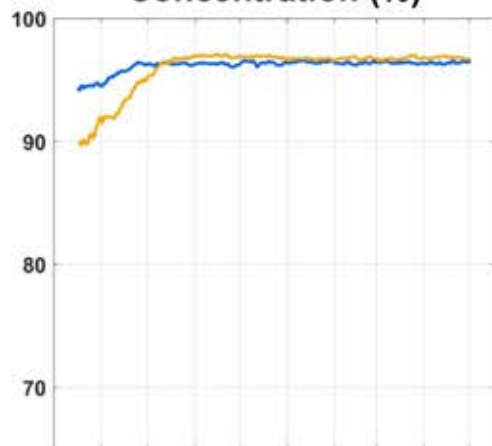
Precip. (kg m^{-3})



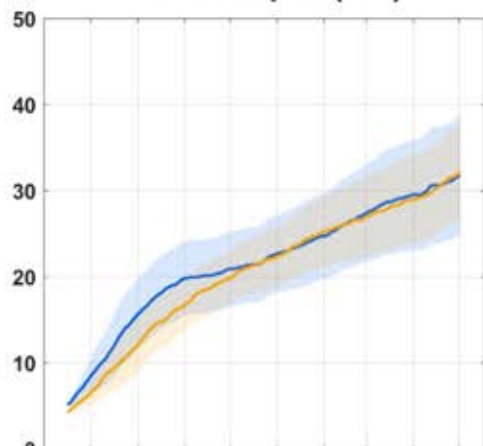
3+ week freeze-up difference N. of 70°N

1980-1991
2003-2014

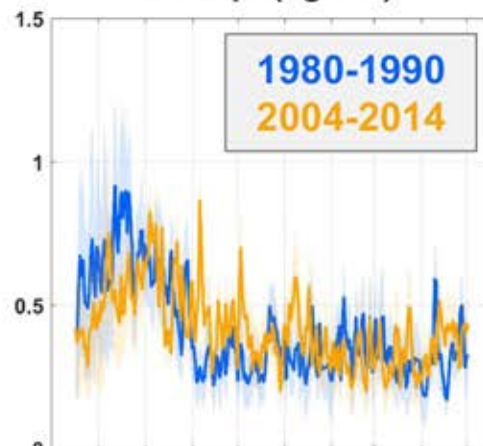
Sea Ice Concentration (%)



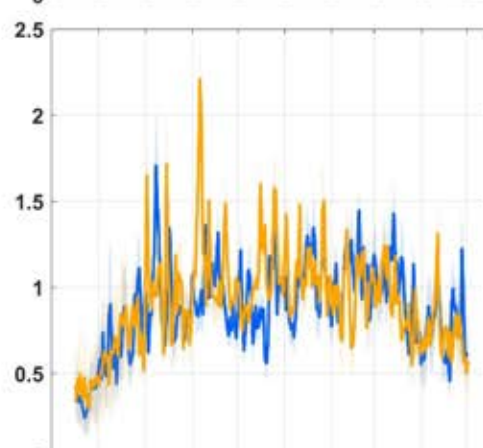
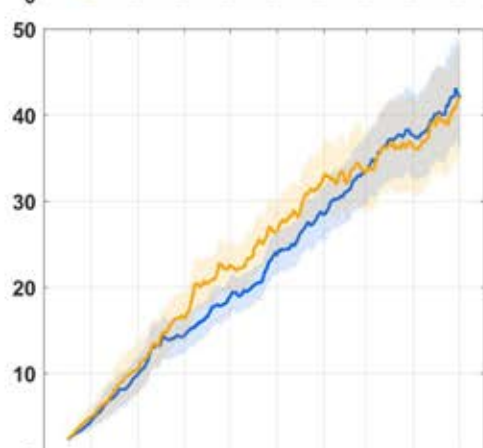
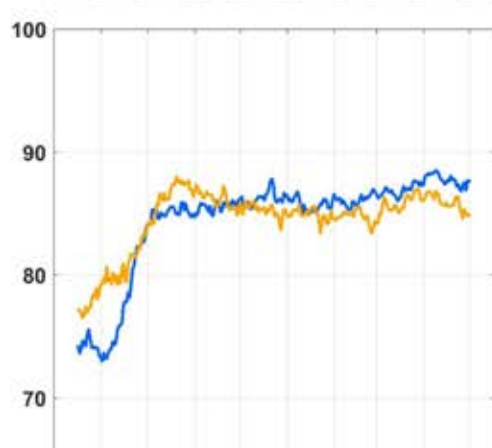
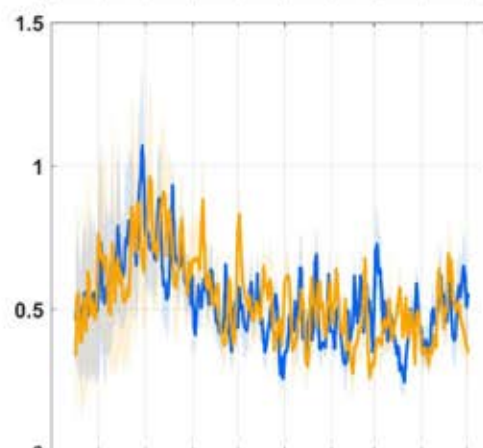
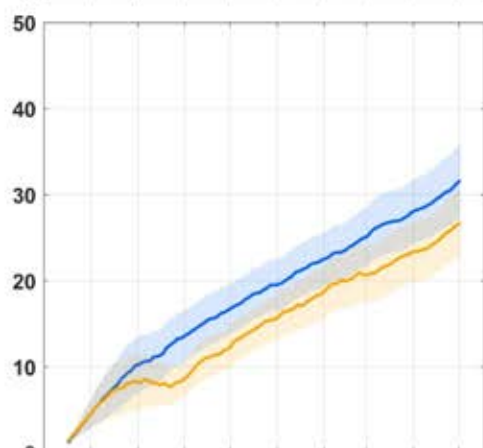
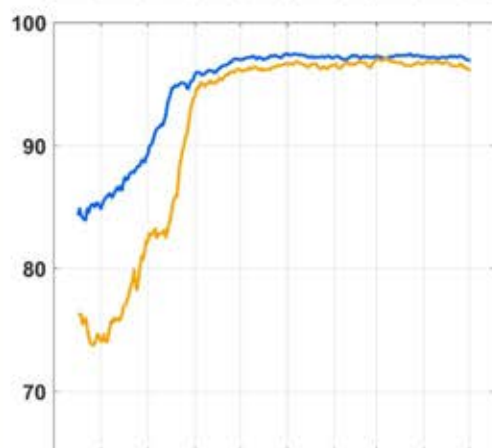
Snow Depth (cm)



Precip. (kg m⁻²)



Region



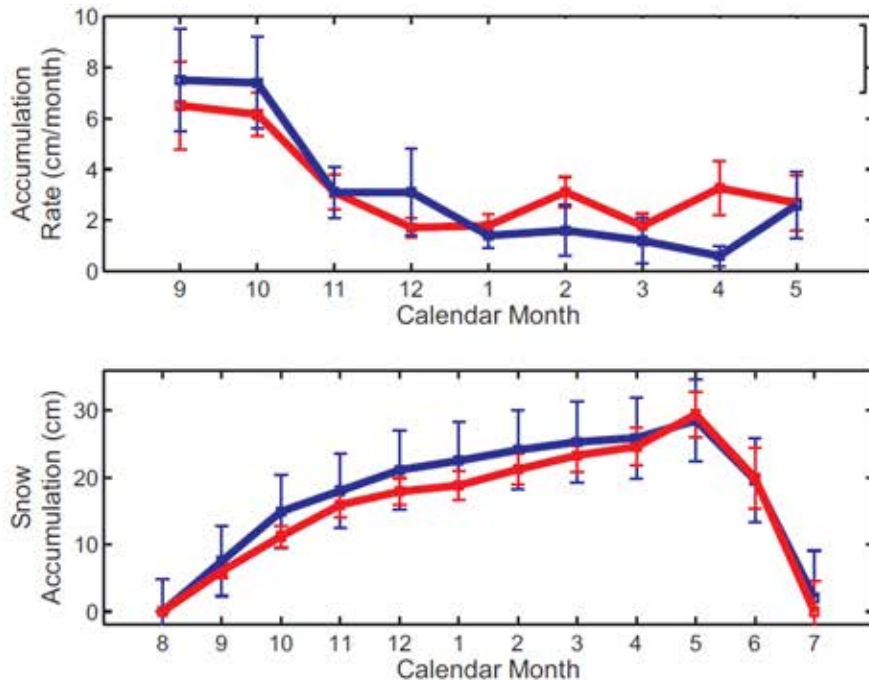
Aug Sep Oct Nov Dec Jan Feb Mar Apr May

Aug Sep Oct Nov Dec Jan Feb Mar Apr May

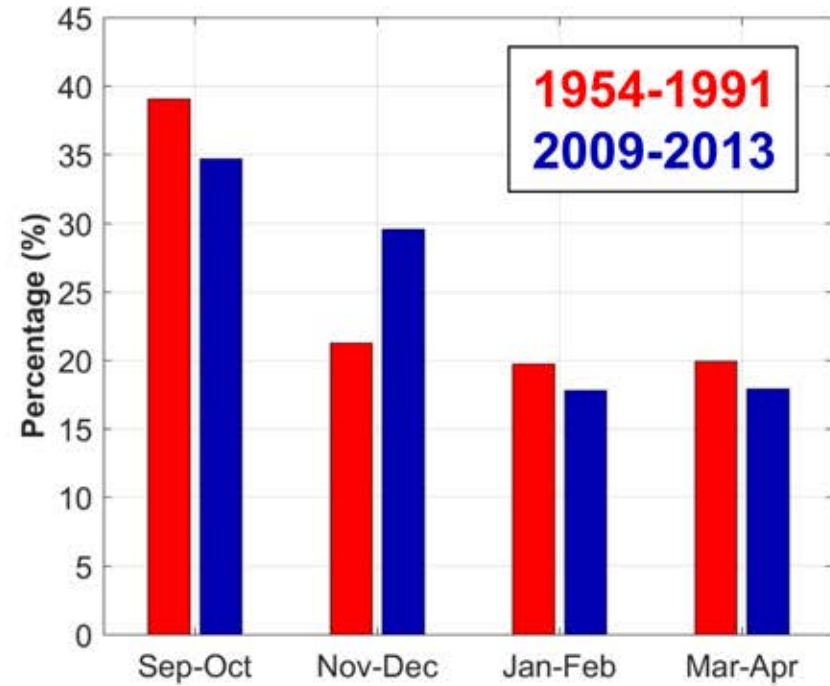
Aug Sep Oct Nov Dec Jan Feb Mar Apr May

The seasonal cycle is shifting:

Observations



Model

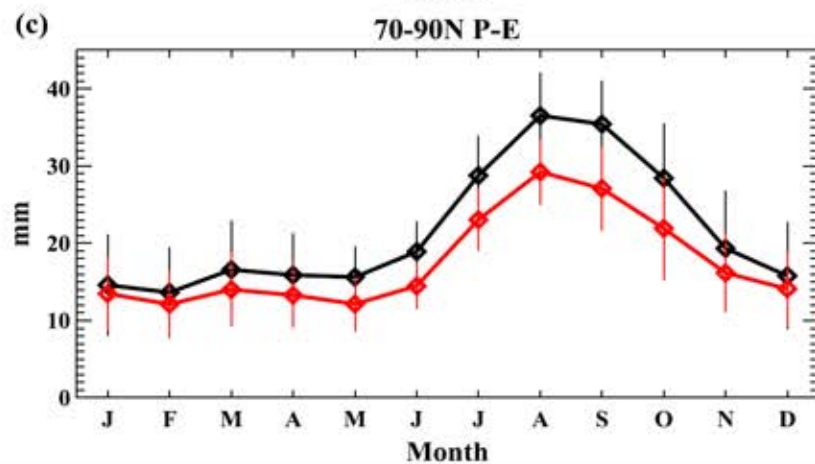
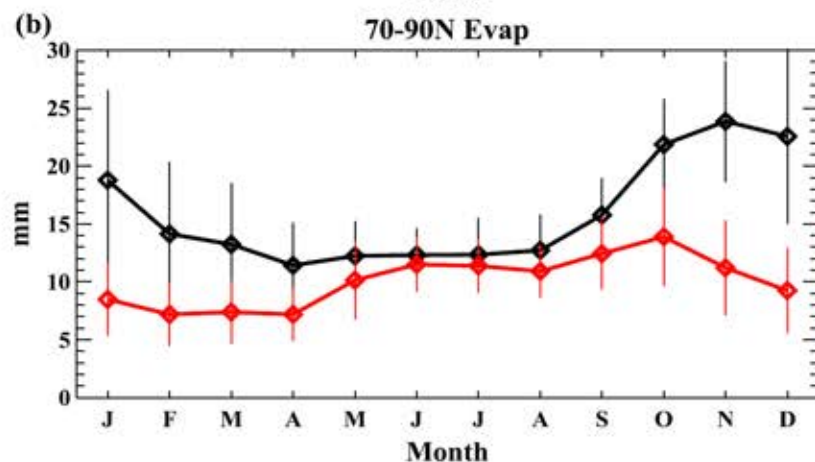
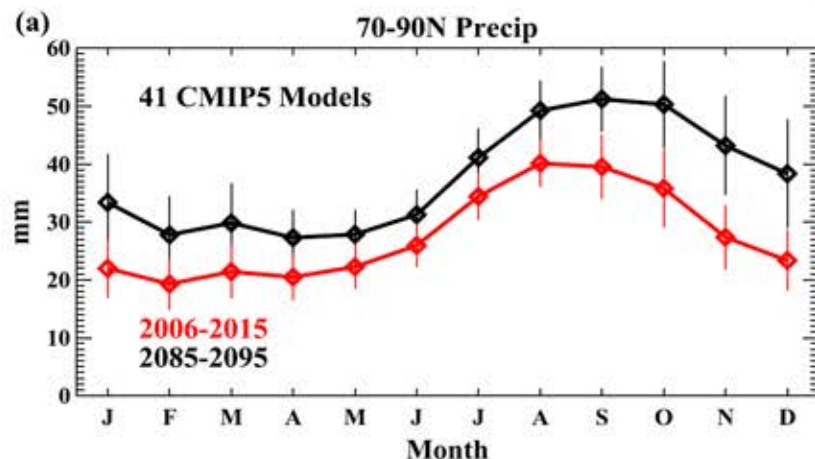
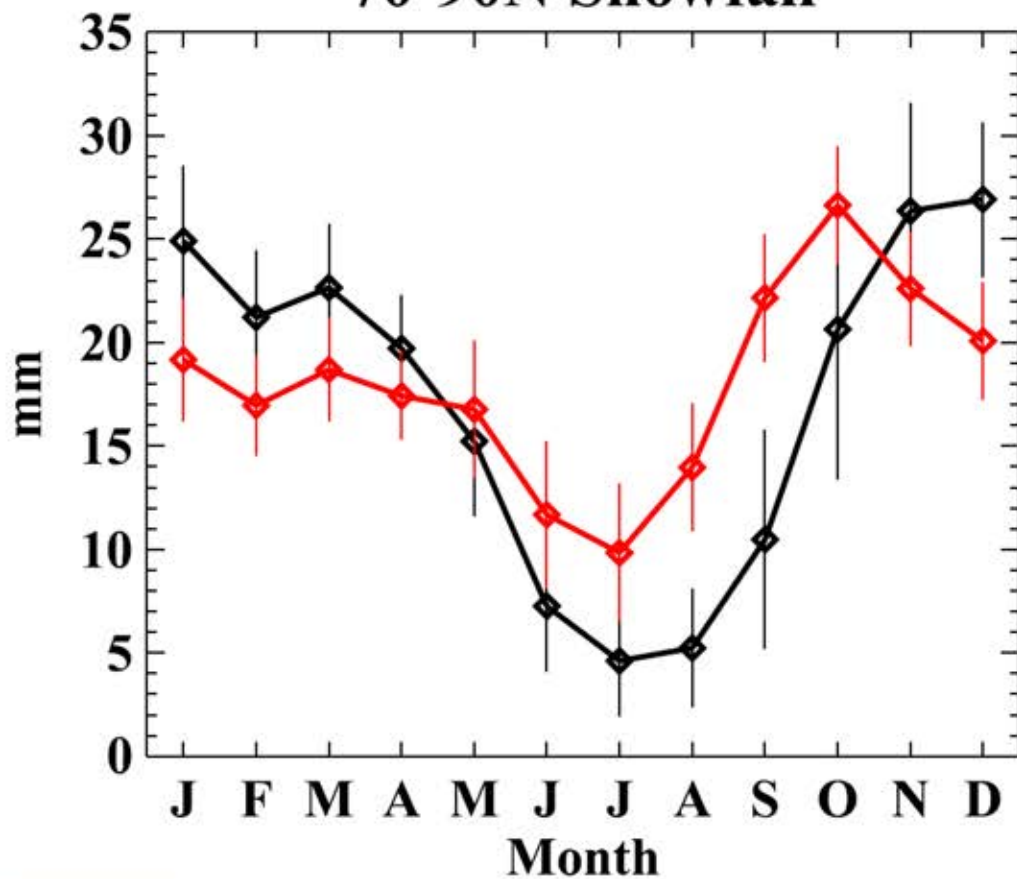


A photograph of a snowy, icy landscape. In the foreground, there are large, flat ice blocks and tracks in the snow. The background shows more ice blocks and a clear blue sky. The overall scene is cold and desolate.

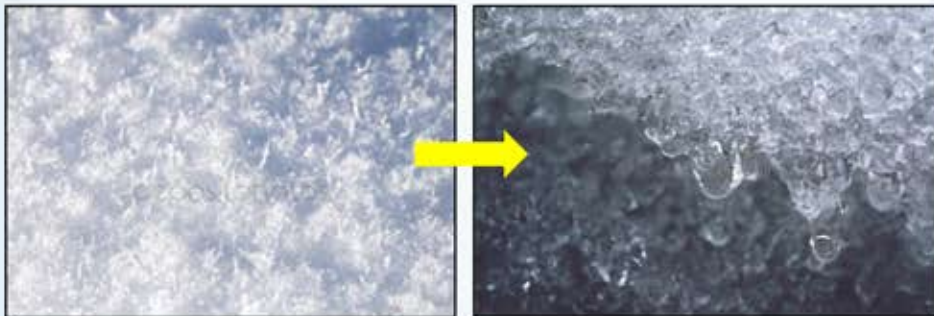
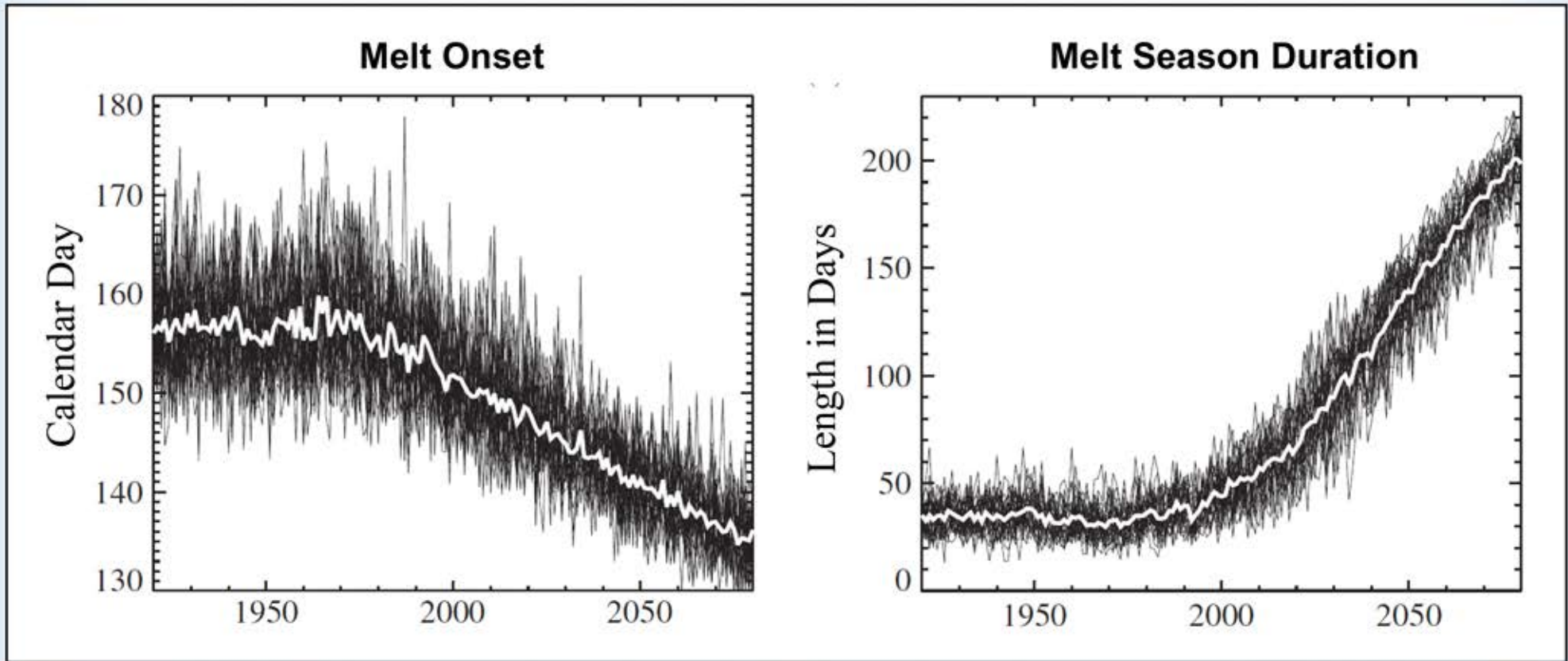
What can we anticipate as future scenarios?

More precipitation...

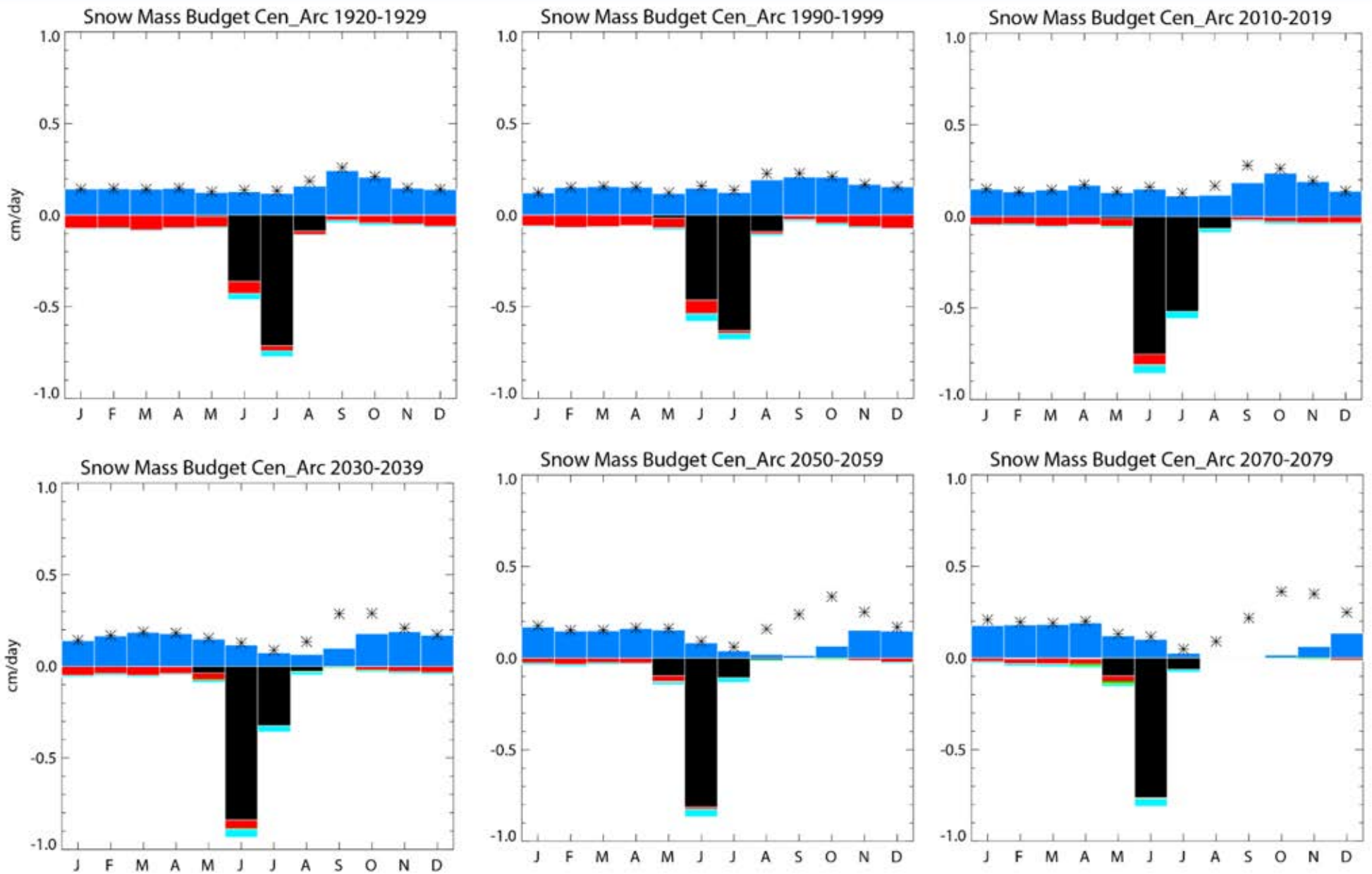
70-90N Snowfall



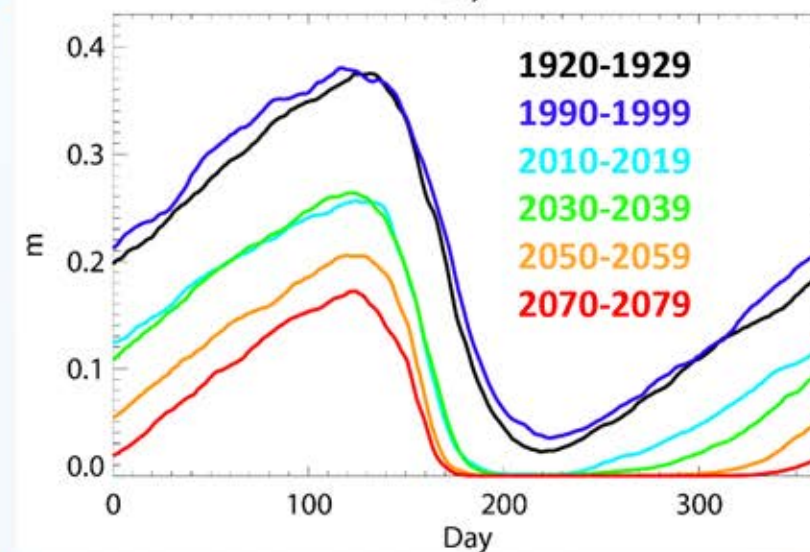
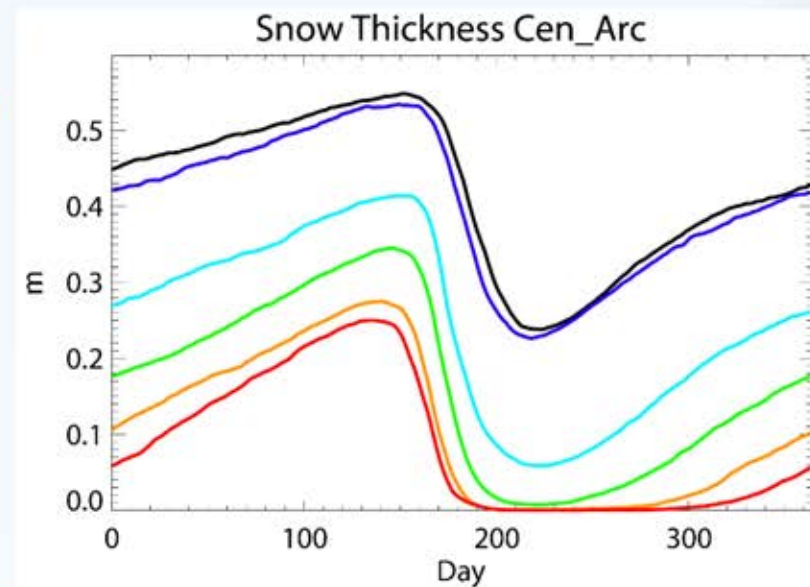
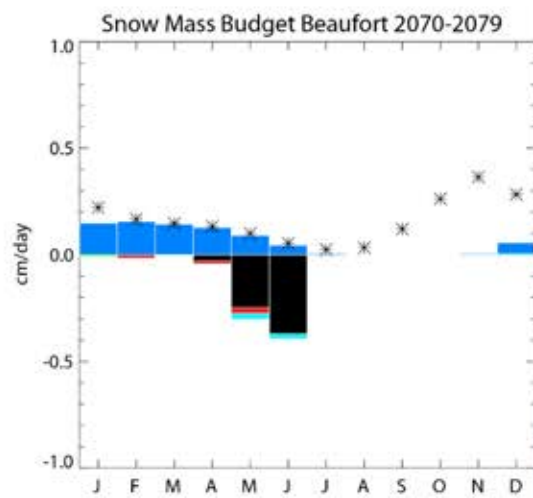
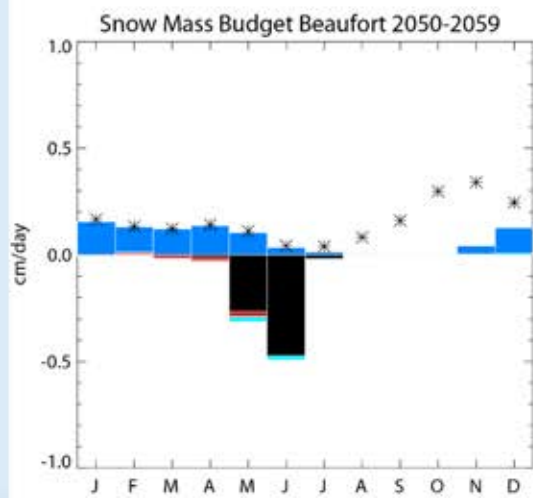
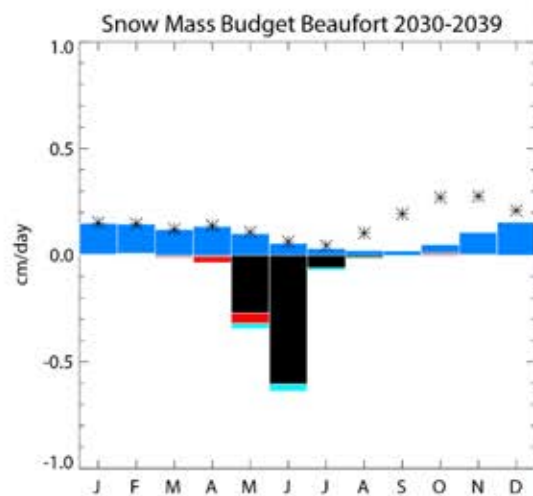
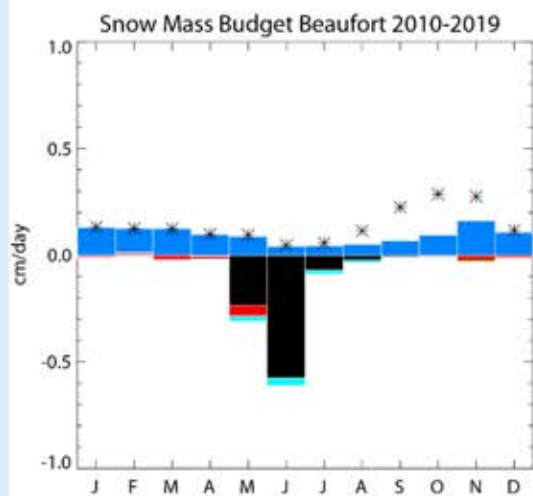
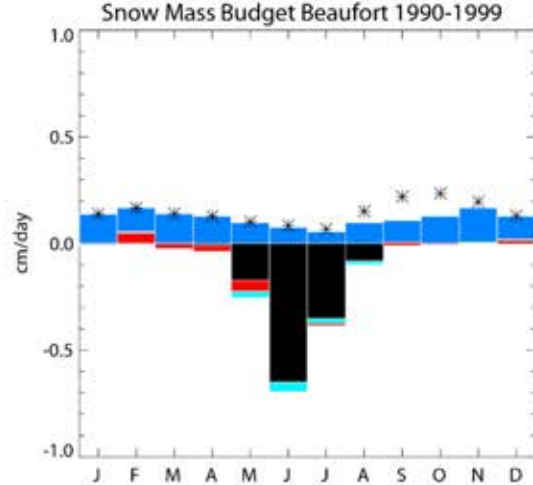
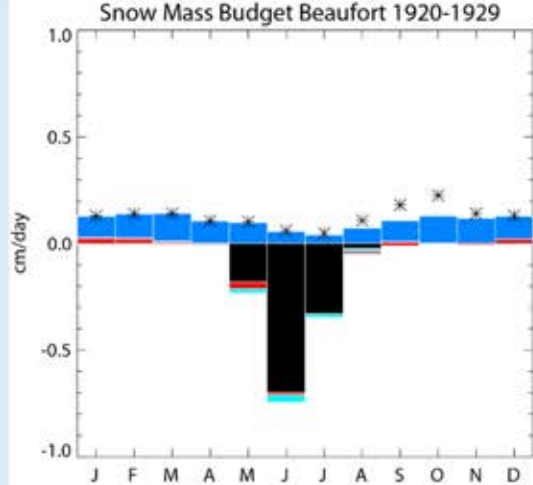
An earlier and longer melt season...



©Don Perovich



Snow accumulation, Melt, Ridging/Advection, Evaporation, Snow-ice formation, *Snowfall

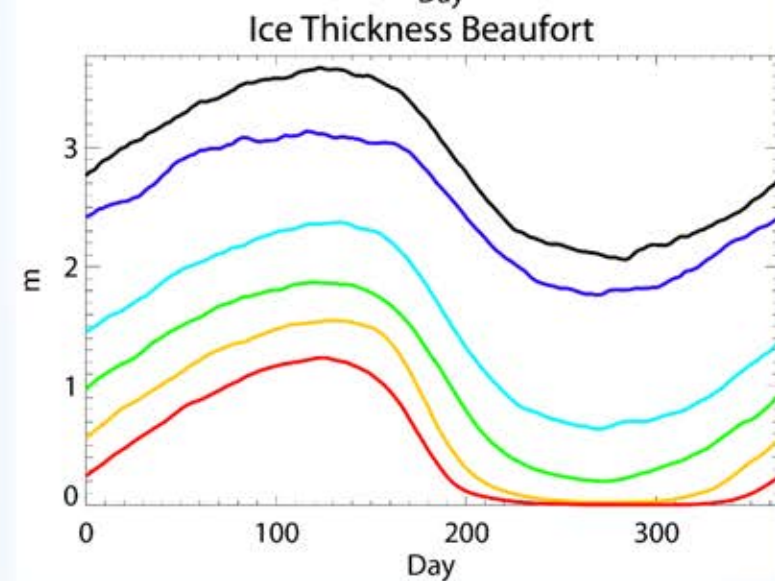
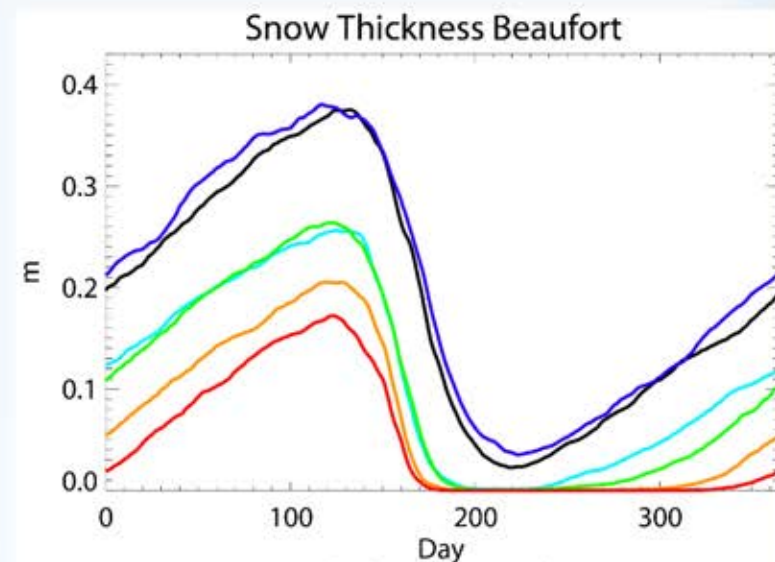
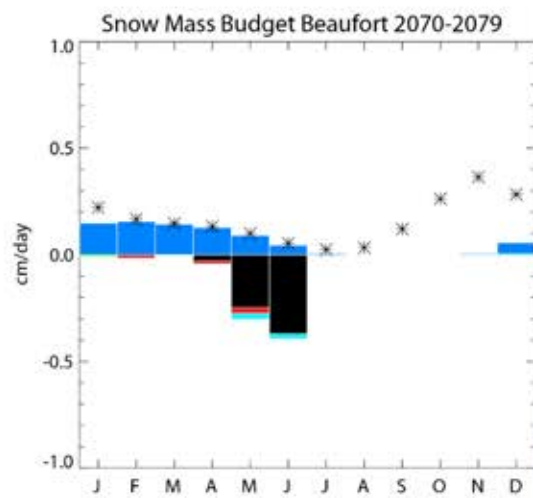
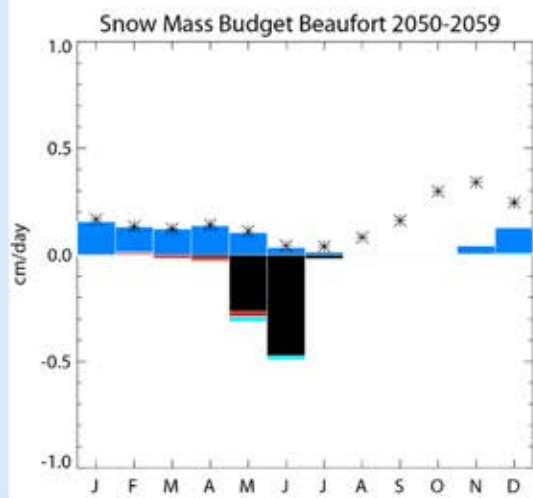
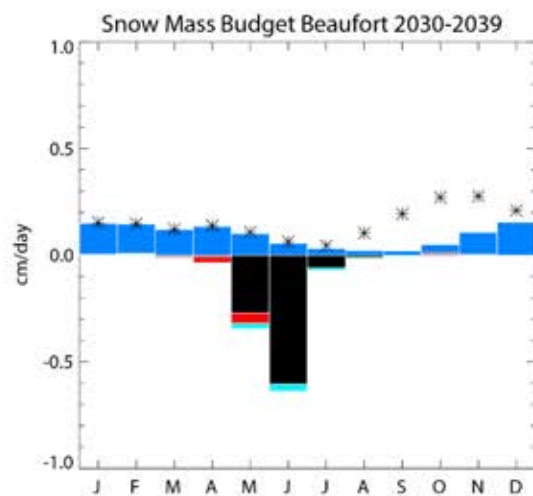
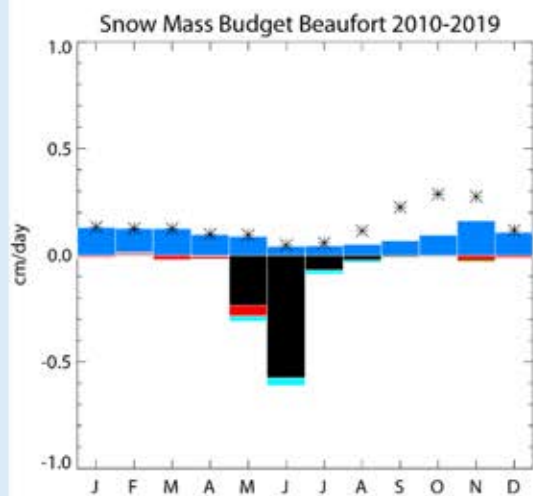
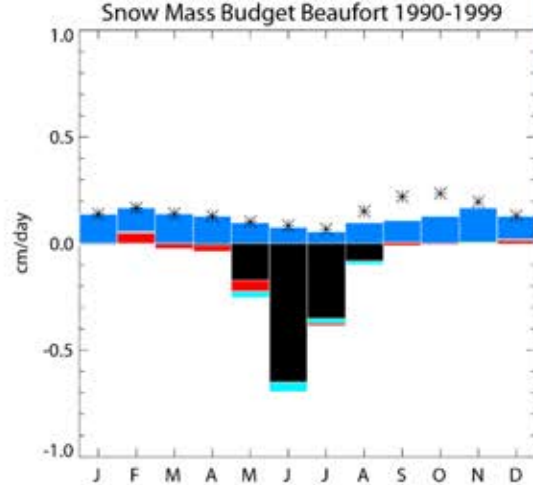
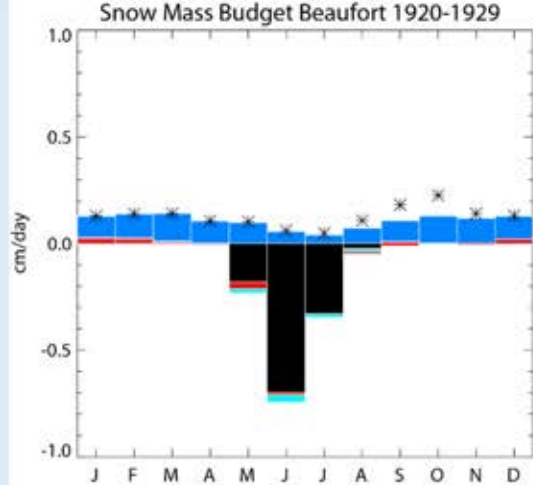


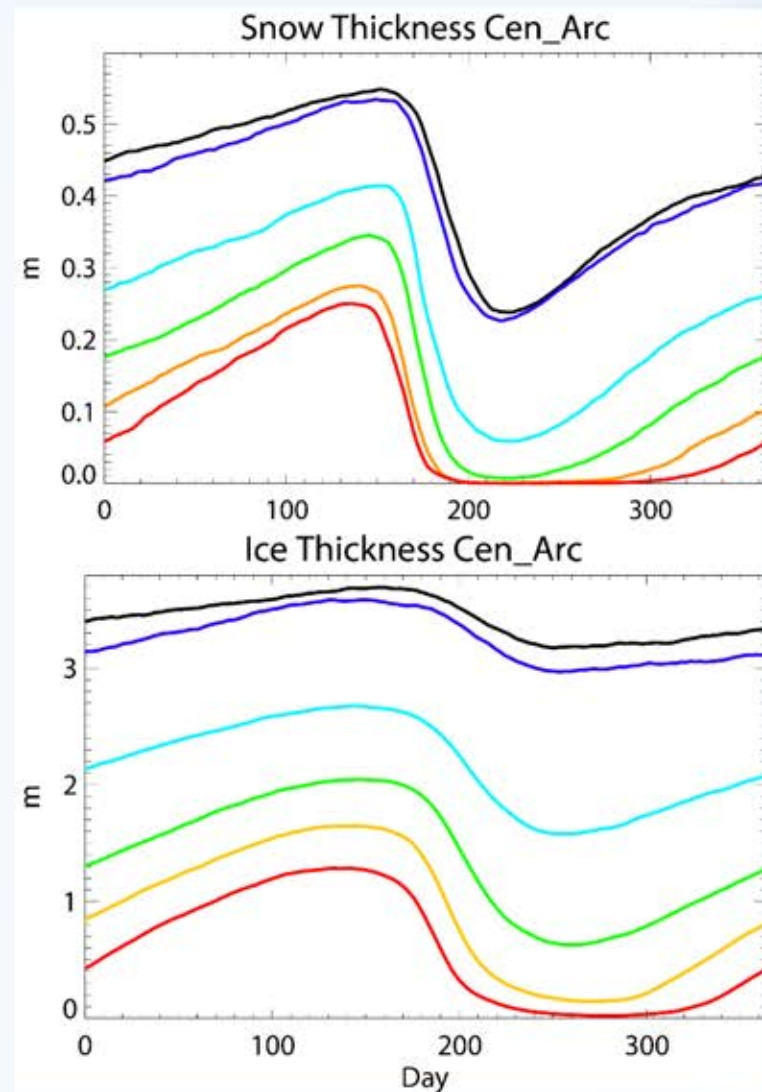
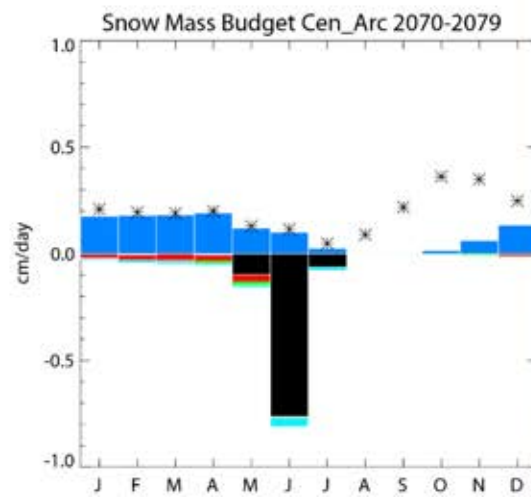
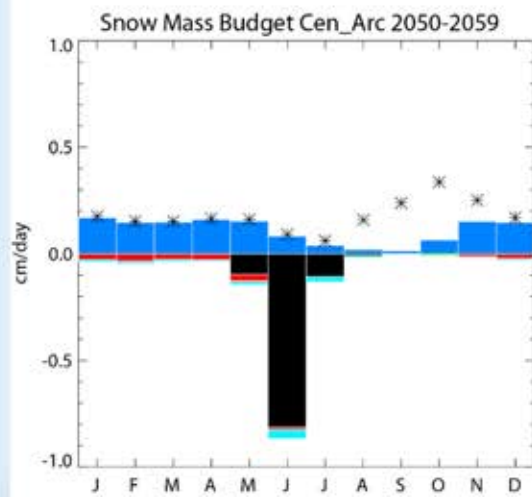
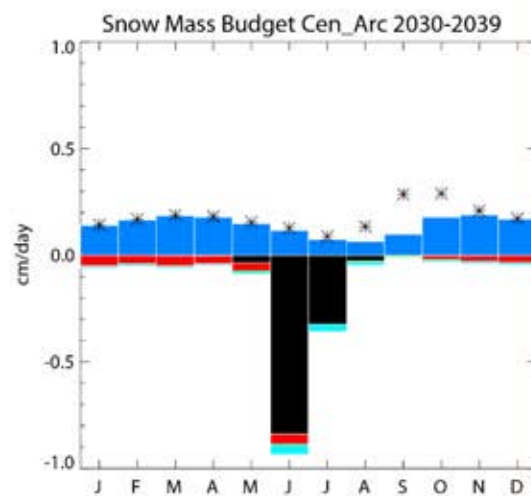
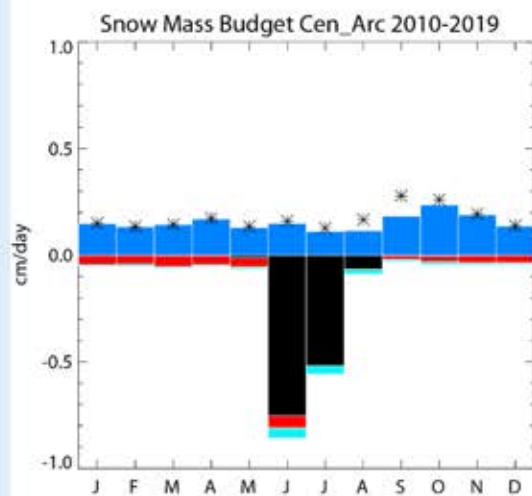
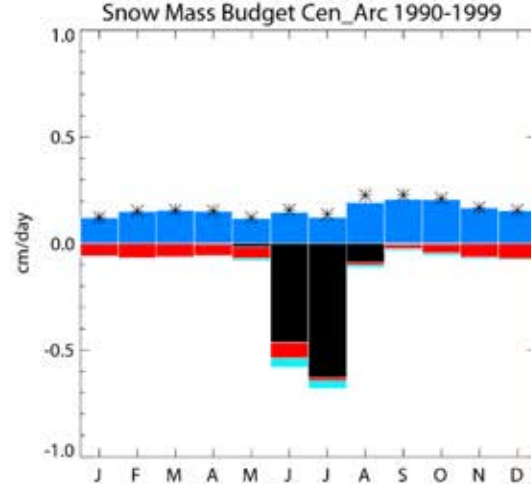
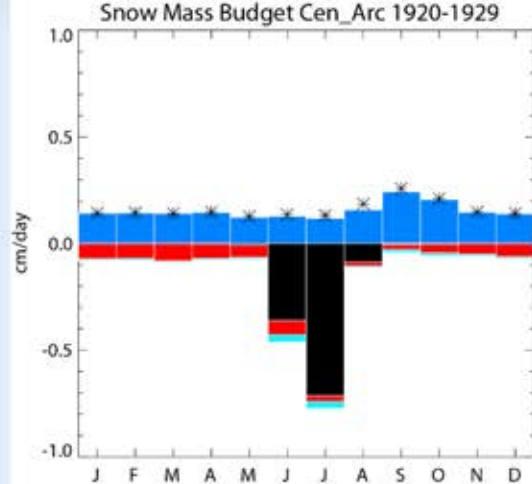
Summary:

- Snow is a complex medium, excellent insulator & reflector.
- The deepest snow is on multiyear ice; thinner snow is on younger ice.
- Less multiyear ice → less snow.
- We can anticipate shift in seasonal snow accumulation & less total snow.
 - Snow-albedo feedback?
 - Better ice growth conditions?

Extra:







Seasonal Contributions (%) to total depth

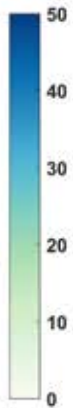
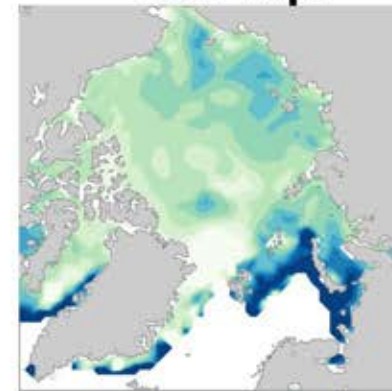
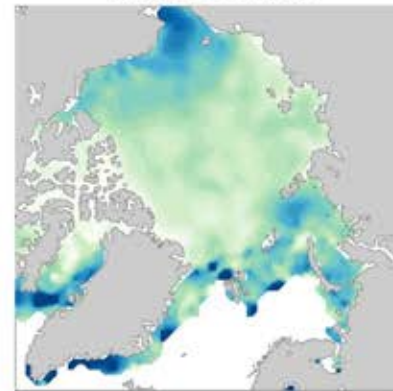
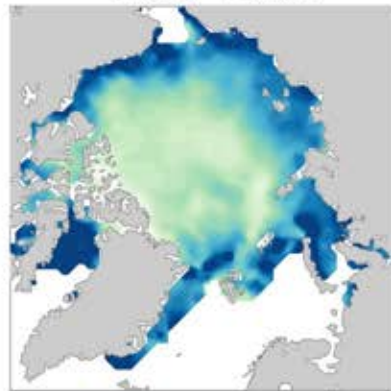
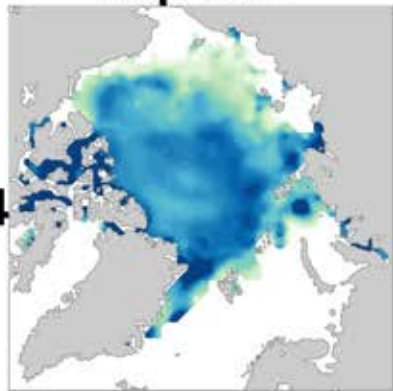
Sep-Oct

Nov-Dec

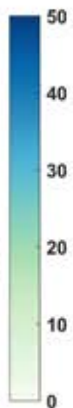
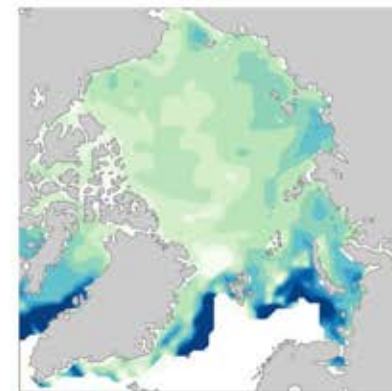
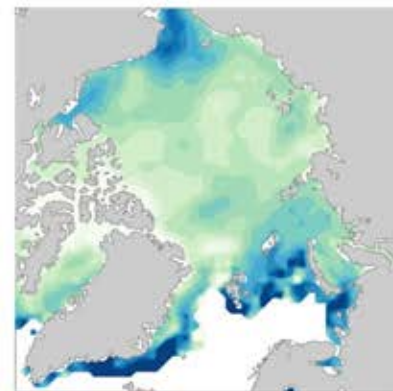
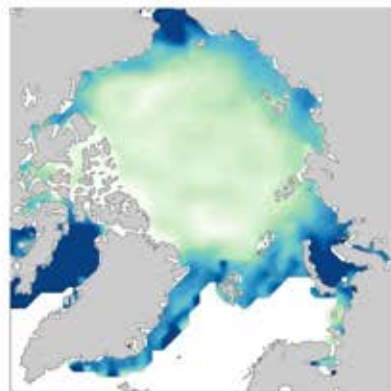
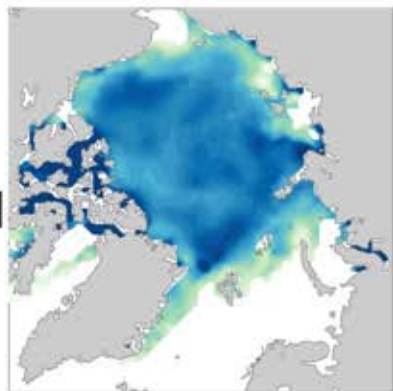
Jan-Feb

Mar-Apr

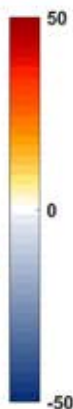
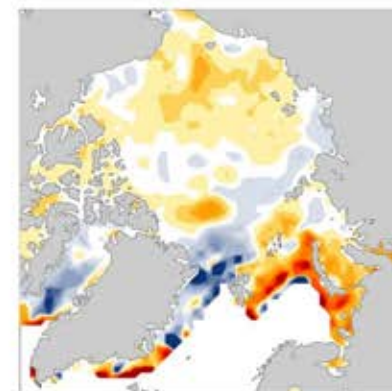
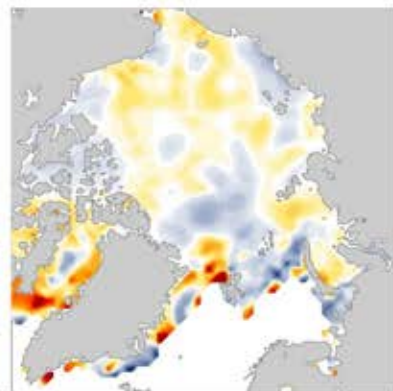
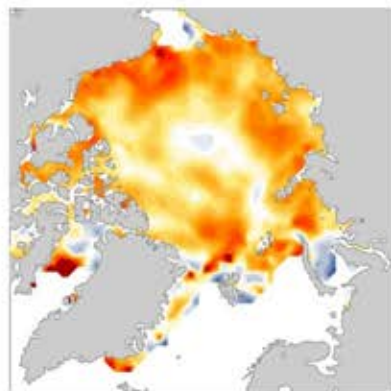
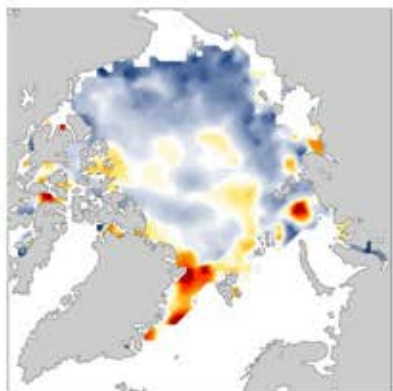
2014



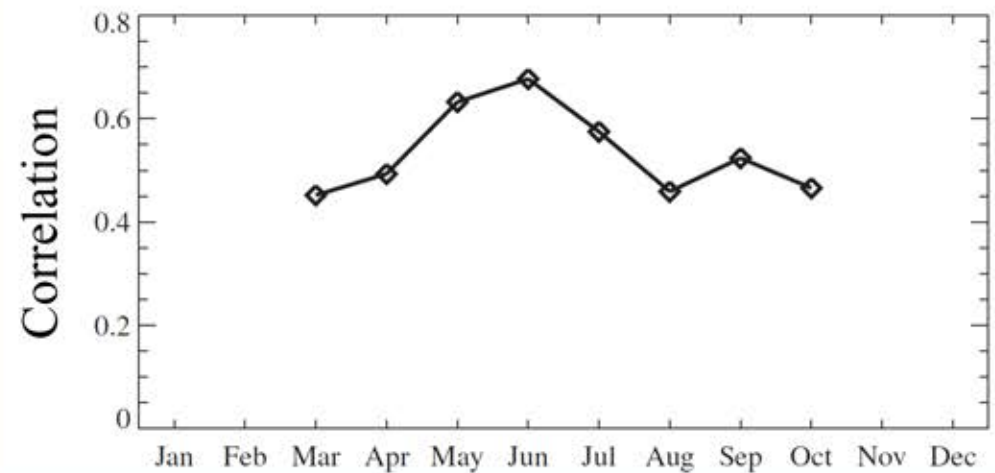
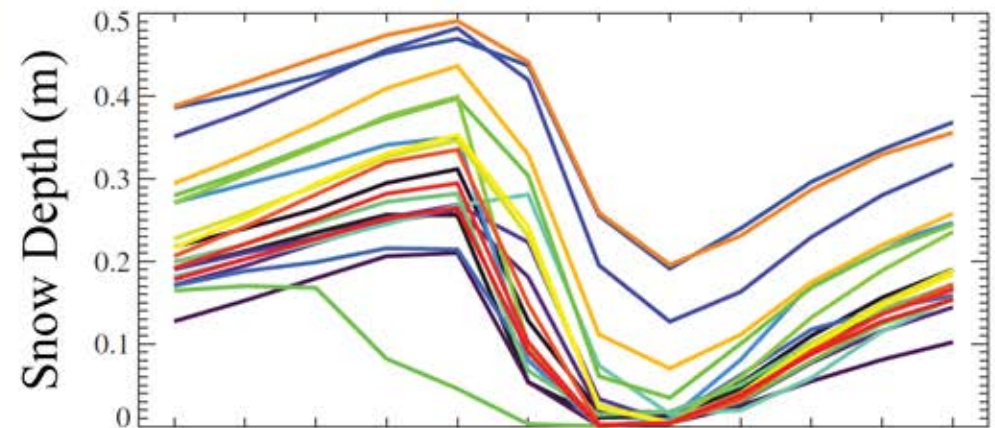
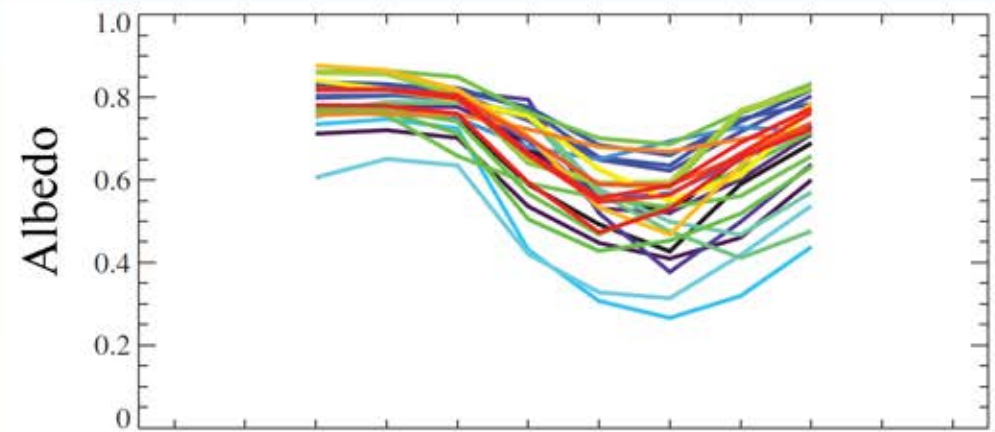
2011



2009



...more solar absorption...



Holland and Landrum (2015)