



Snow Cover Monitoring at CCRS – Methods & Applications

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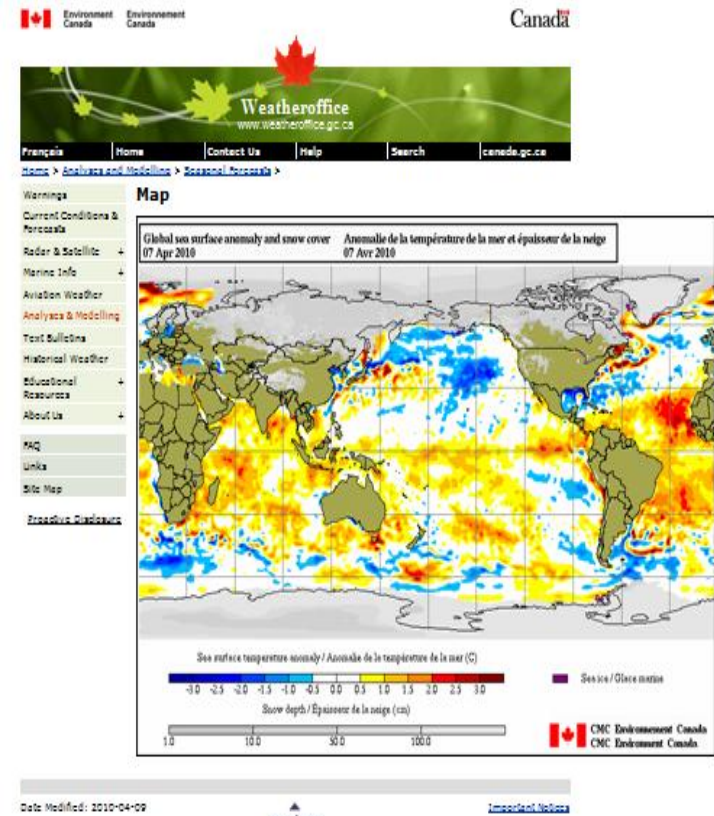
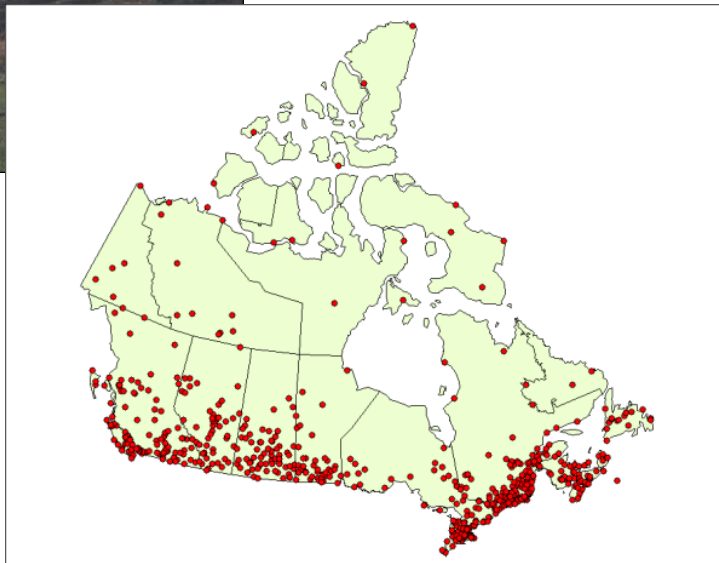


Rationale

- **Snow cover is an Essential Climate Variable.**
- **Snow cover information is required for:**
 - Climate trend analysis
 - Assessing climate models
 - Improving weather models
 - Habitat assessment
 - Water resource management
- **GCOS Requires daily, 1km, 90% accuracy.**



In-situ based snow-cover information

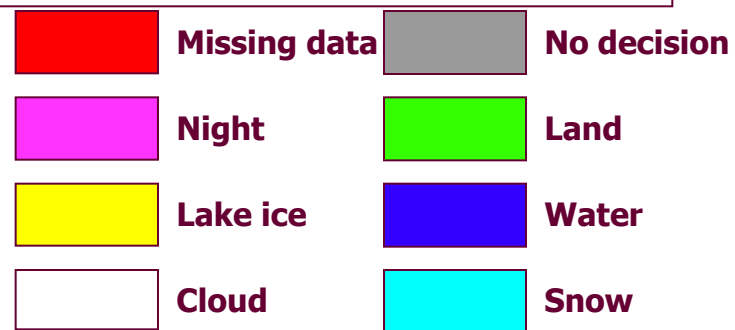
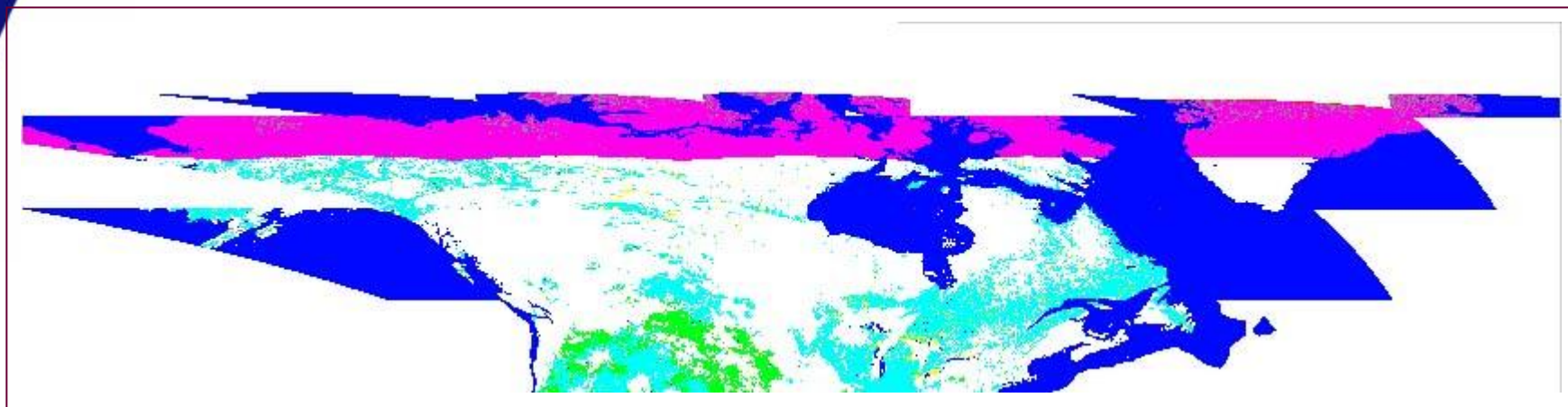


Brown, Ross D. and Bruce Brasnett. 2010. *Canadian Meteorological Centre (CMC) Daily Snow Depth Analysis Data*. © Environment Canada, 2010





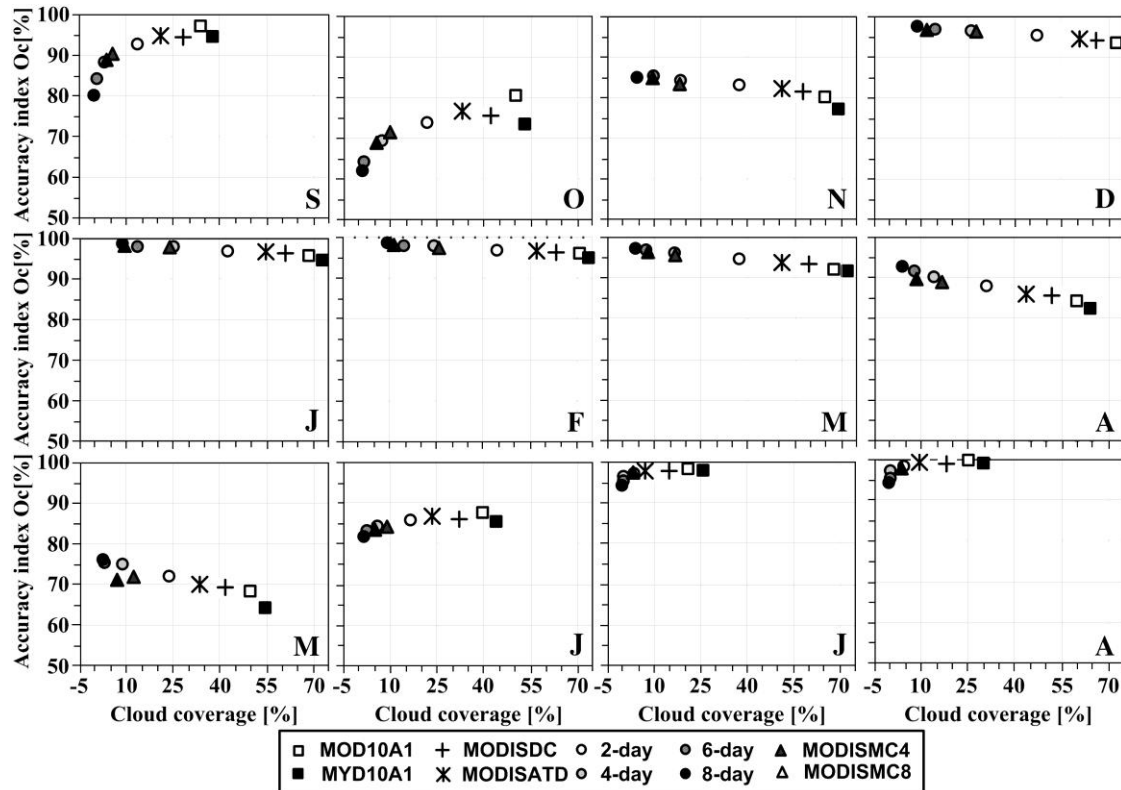
NASA MODIS Snow Cover



Simic and Fernandes, Hydrological Processes, 2003.



Cloud Effects on MODIS Snow Cover



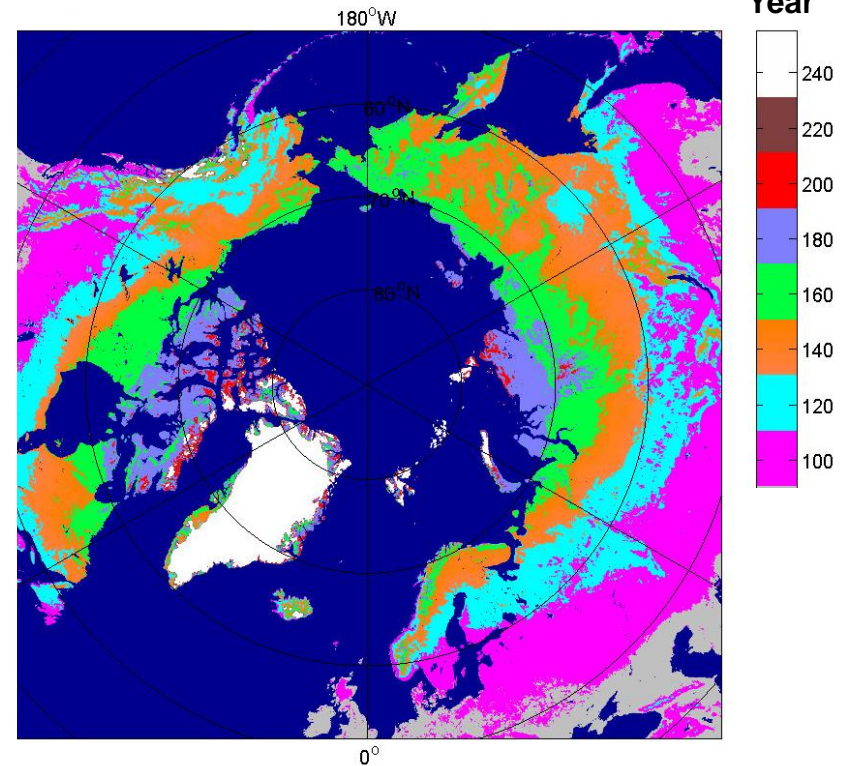
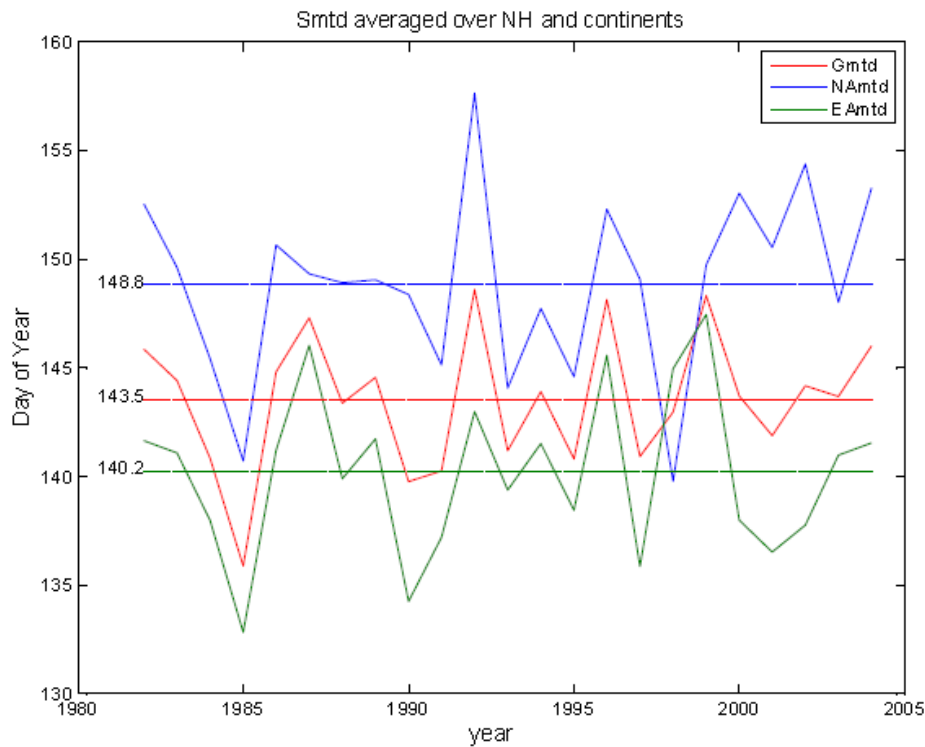
Gao, Y., H. Xie, T. Yao, and C. Xue, 2010. *Remote Sensing of Environment*, Vol 114(8): 1662-1675. doi:10.1016/j.rse.2010.02.017





CCRS Daily Snow Cover from AVHRR

Extracted melt date 1981-2004



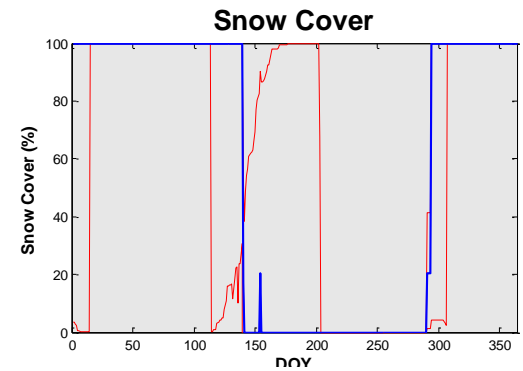
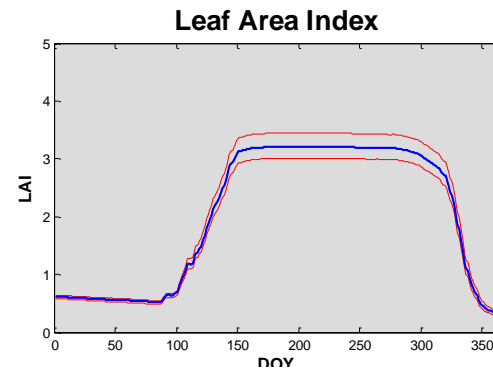
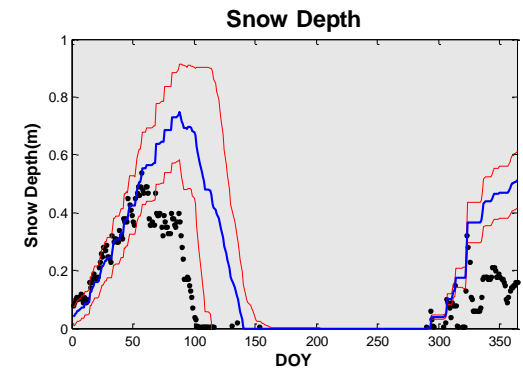
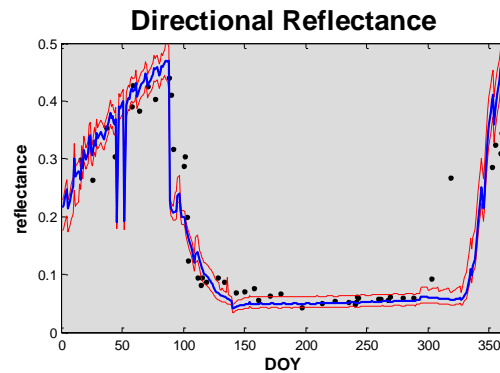
Zhao and Fernandes, JGR-Atmospheres, 2009.





Data Assimilation Approach

● Data
— Modelled Value

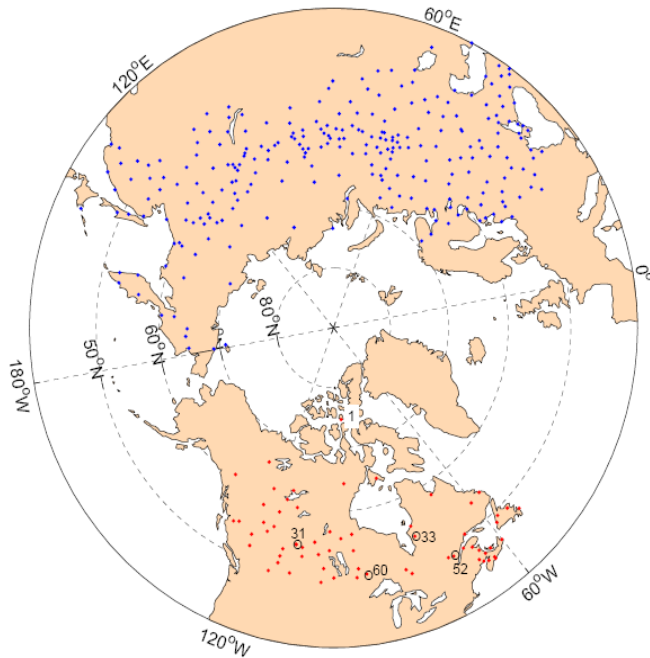


Fernandes, R. and Zhao, H., ESA-Special Publication 1211, 2009.





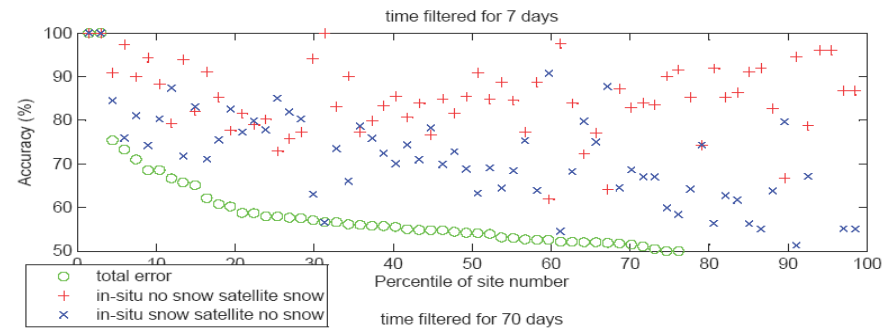
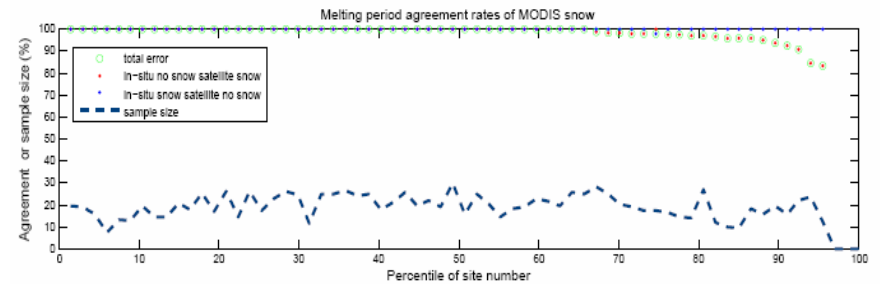
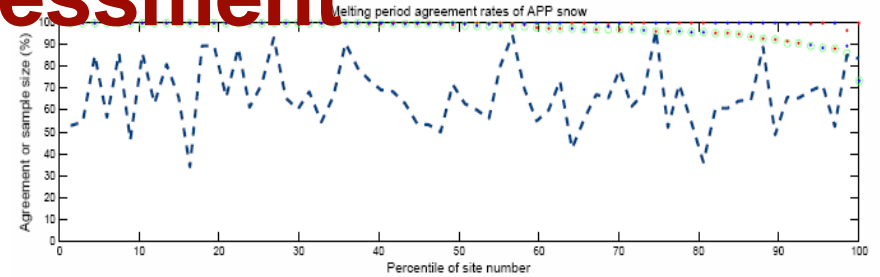
Performance Assessment



CCRS AVHRR

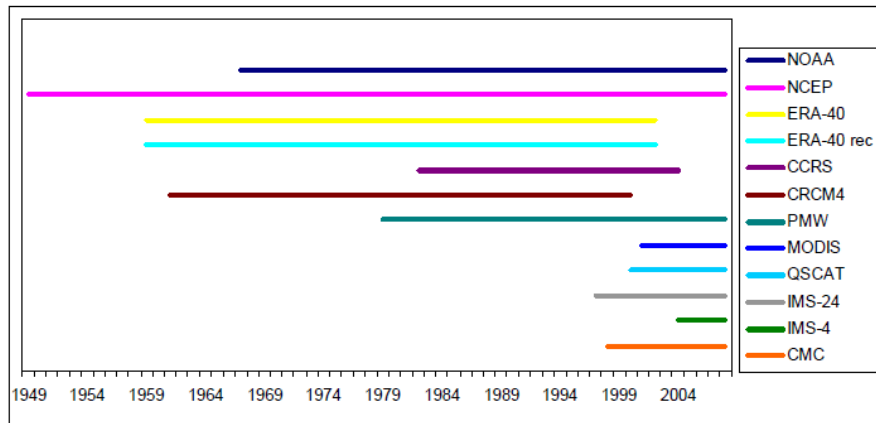
MODIS

MODIS gap filled



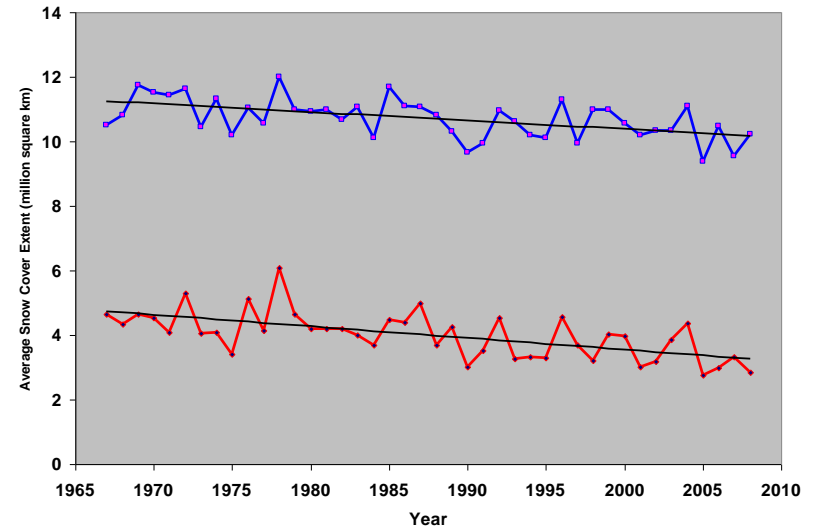


Application – Climate Trends



Temporal distribution of NH snow cover data sets (CRCM4 only available for North America)

Trends in Arctic Snow Cover Extent



Brown et al., JGR-Atmospheres, 2010.





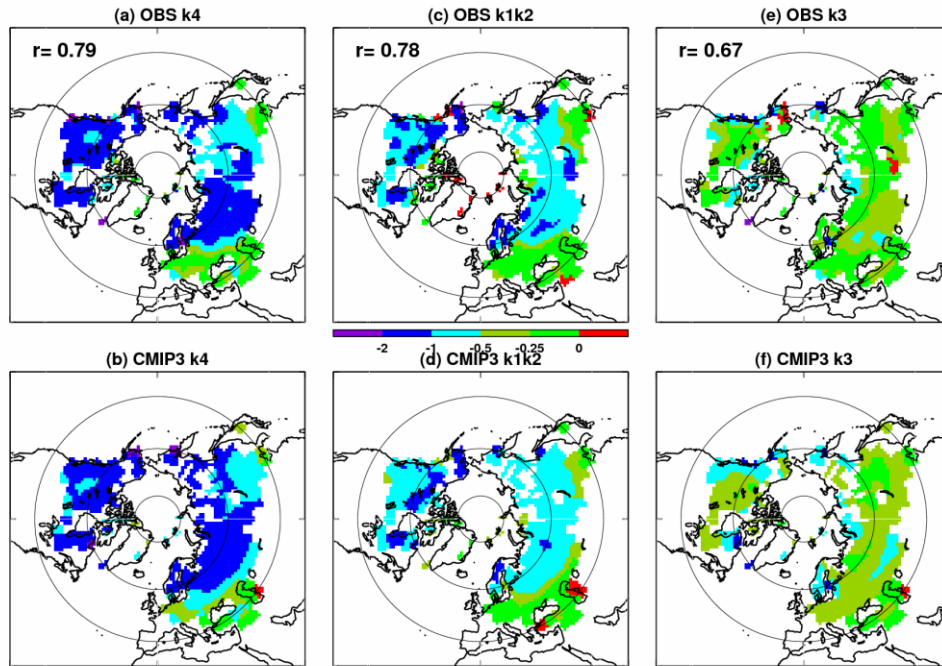
Application – Climate Model Assessment

Observations

Snow Albedo

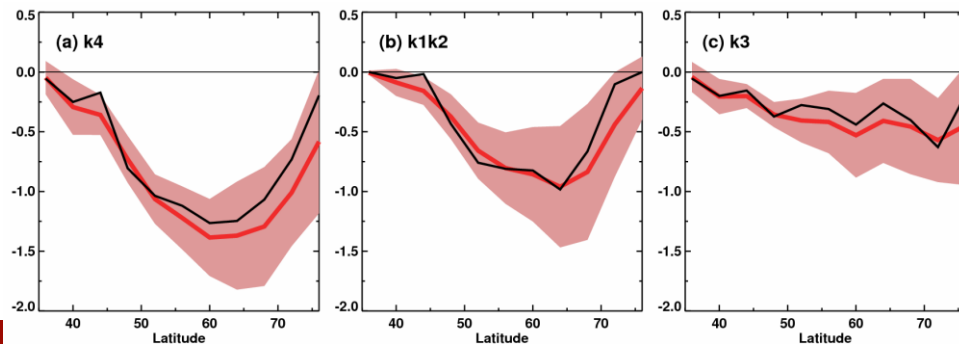
Snow Cover

Snow Metamorphosis



Climate Models

Observations vs.
Climate Models



Fernandes et al. Geophysical Research Letters, 2010.
Fletcher et al. JGR-Atmospheres, submitted.





Application – Snow Cover Indicator

Month: Date: Year:

CCRS MODIS-NGAA 500M W A SNOW 2005 Nov 13

Legend:

- Missing data
- No decision
- Night
- Land
- Inland water
- Lake ice
- Snow
- Boundary

Search SOCC



Application – Caribou Habitat





SAR & SNOW

- **SAR image magnitude for onset of snow melt**
 - Wet snow absorber while dry snow transparent
- **INSAR for snow depth – research underway**
 - RCM has potential due to rapid revisit
- **SMAP for SWE – future**
 - Active/passive combination for SWE



Conclusions

- Continuous daily snow cover estimation is feasible from optical imagery.
- Data assimilation allows for continuous daily snow cover estimate from optical imagery.
- SAR useful for high arctic cold snow monitoring.
- Need to extend spatial and temporal coverage and increase resolution.
- Widespread global to regional applications.