

Hydroclimatological evaluation of CLM5 simulations using multiple data sources for land-atmosphere interaction studies over Scandinavia



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Land-ATmosphere Interactions in Cold Environments

The role of Atmosphere - Biosphere - Cryosphere - Hydrosphere interactions in a changing climate

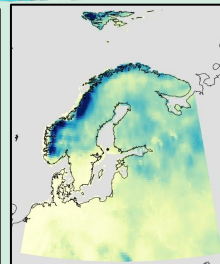
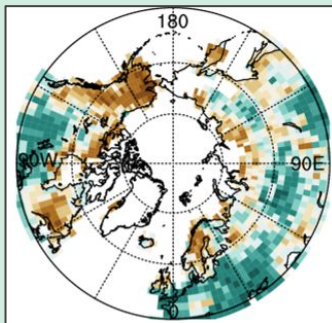
Field studies



(Finse ECHO)
Finse Eco-Hydrological Observatory

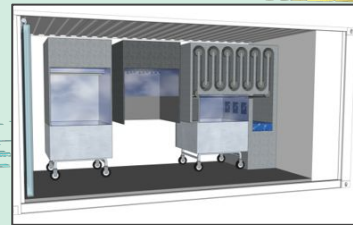


Modeling



Global, regional,
site-level modeling

Laboratory experiments

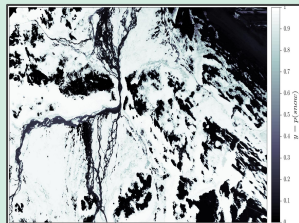


Cryo-chamber

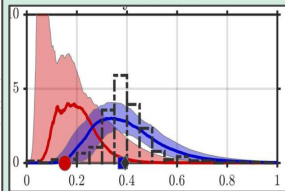


Phytotron

Data analysis

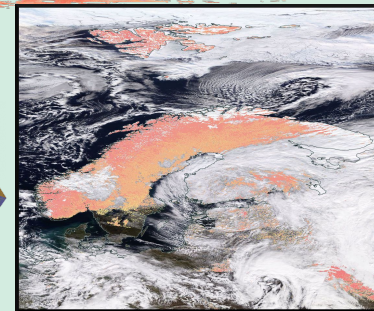
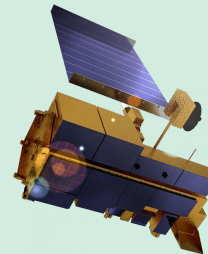


Machine learning



Data assimilation

Remote sensing

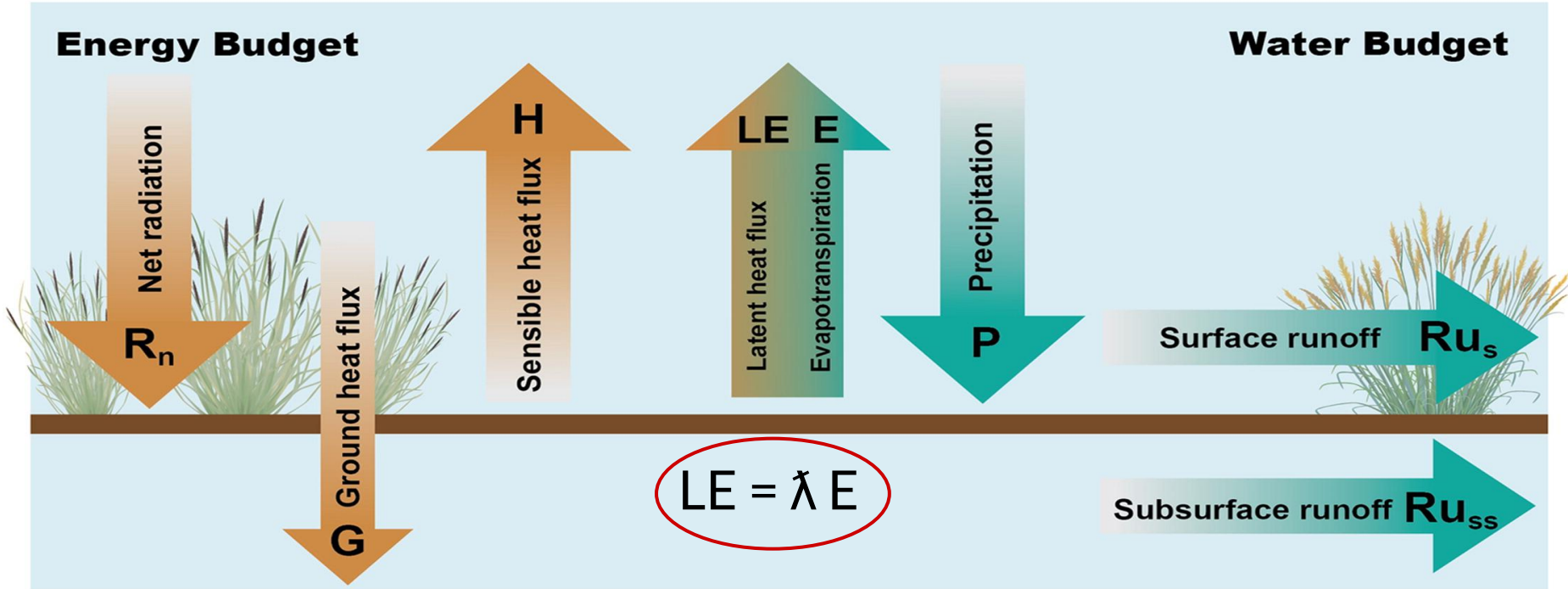


Satellite imagery

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Surface Energy and Water Balance



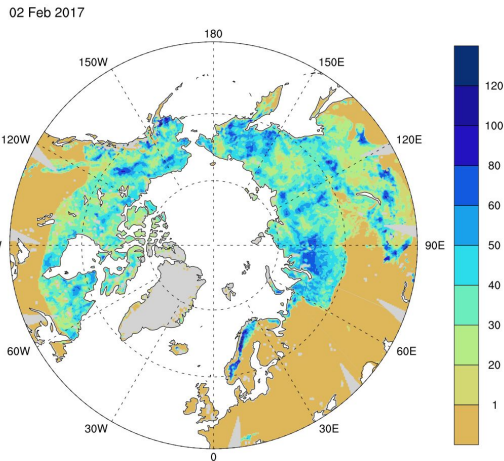
$$\frac{dH}{dt} = R_n - \lambda E - SH - G$$

$$\frac{dS}{dt} = P - E - R_s - R_g$$

The Satellite Era



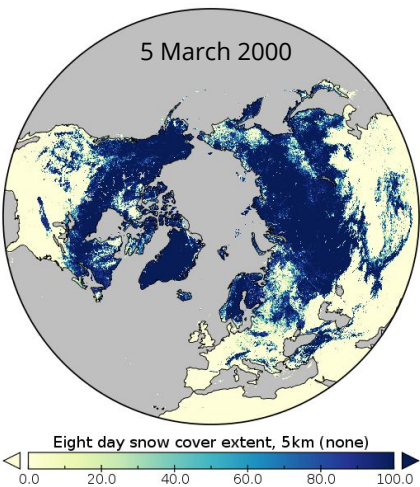
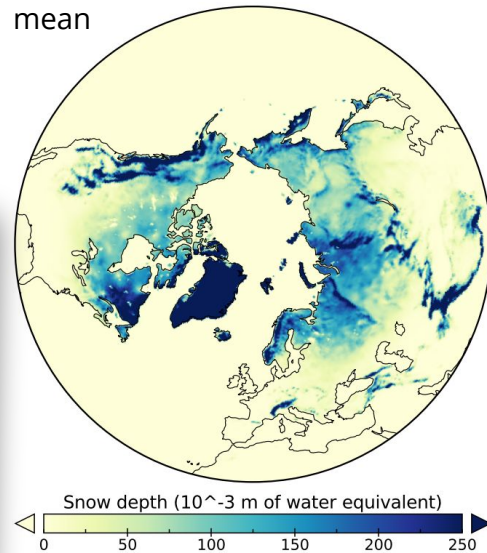
AMSR Unified Daily SWE



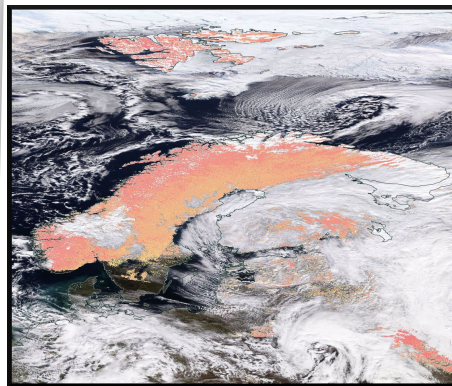
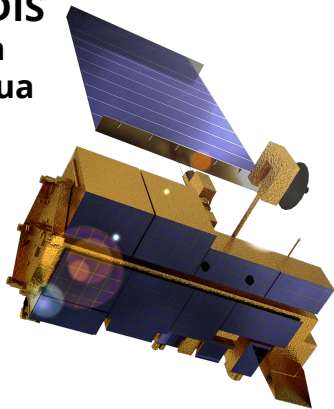
& Reanalyses

ERA5

Annual
mean



MODIS
Terra
& Aqua

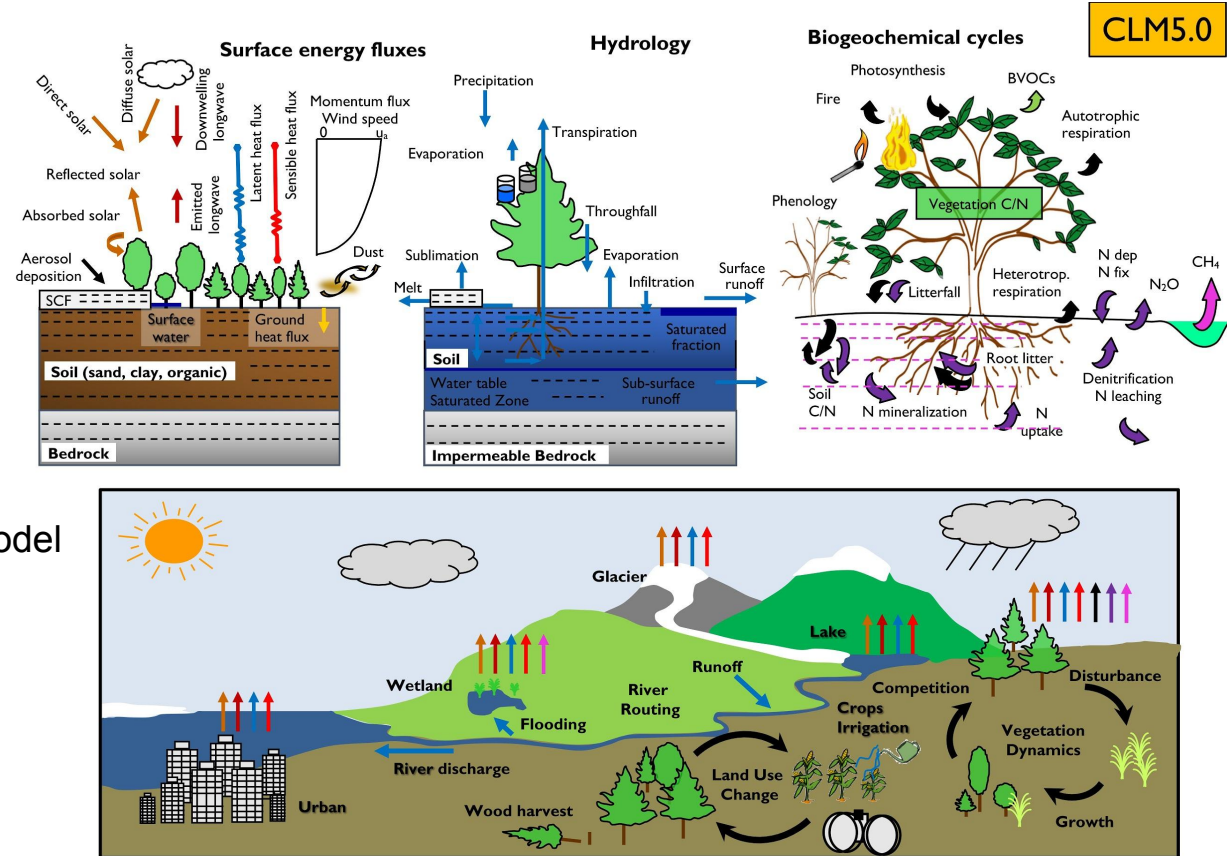


MODIS satellite image showing the snow
cover over Scandinavia on 11 March 2019.
(NASA Worldview)

	Data set	Variables	Spatial Res.	Temporal Coverage
Reanalysis	ERA5 (ERA5 Land)	skin temperature, latent and sensible heat fluxes, net radiation, snow water equivalent	0.25° (0.1°)	01/1979 (01/2001) - present
	MERRA-2		0.5° x 0.625°	01/1980 - present
	GLDAS		0.25°	01/2000 - present
Satellites	GRACE	terrestrial water storage	1°	04/2002 - 01/2017
	MODIS Terra (Aqua)	snow-covered area	0.05°	03/2000 (07/2002) - present
	AMSR-E & AMSR2	snow water equivalent	25 km	06/2002-09/2011 & 08/2012-present
Sites	Finse Echo	surface temperature, latent and sensible heat fluxes, net radiation	point	2016 - present
	Bayelva (Svalbard) Boike et al. (2018)	air temperature, net radiation, snow depth	point	1998 - 2017

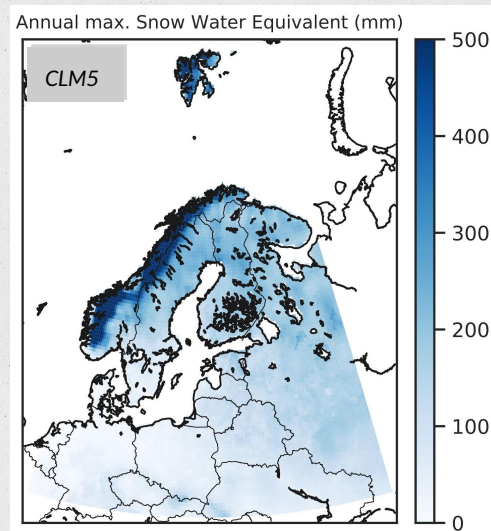
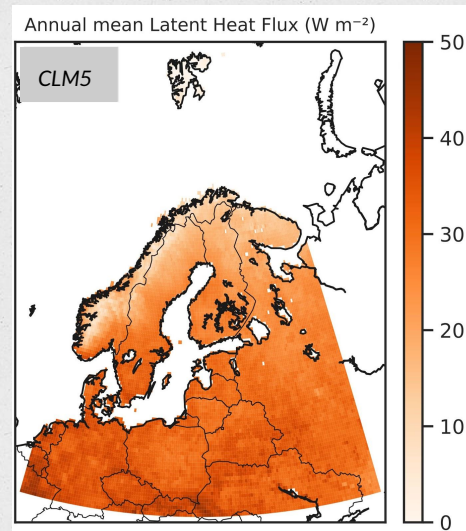
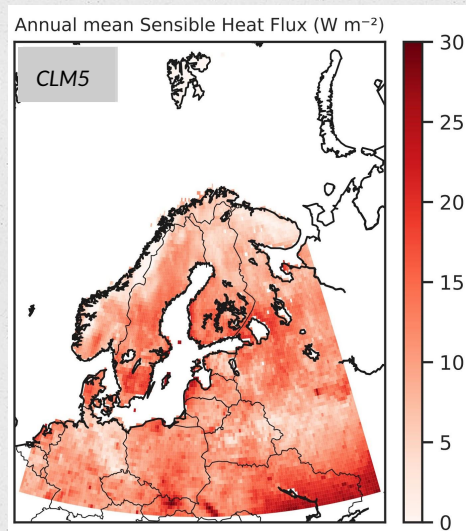
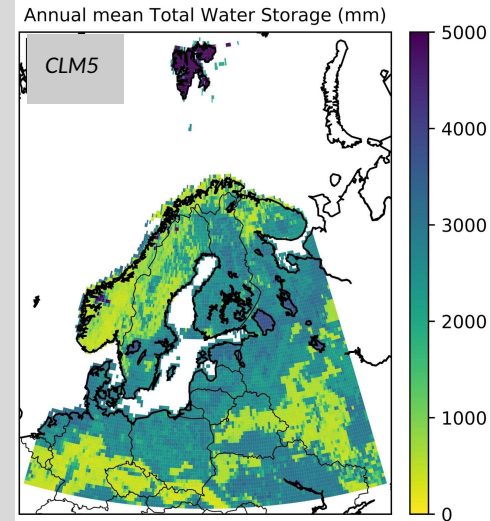
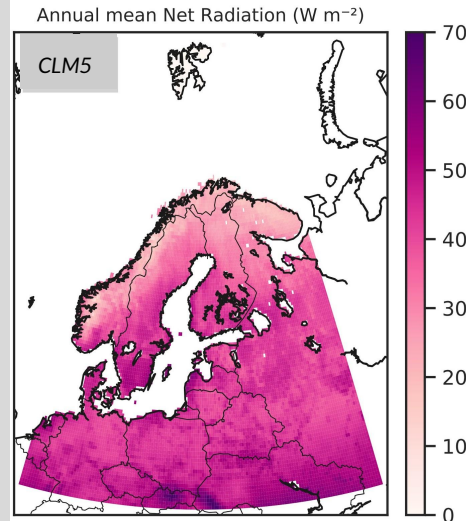
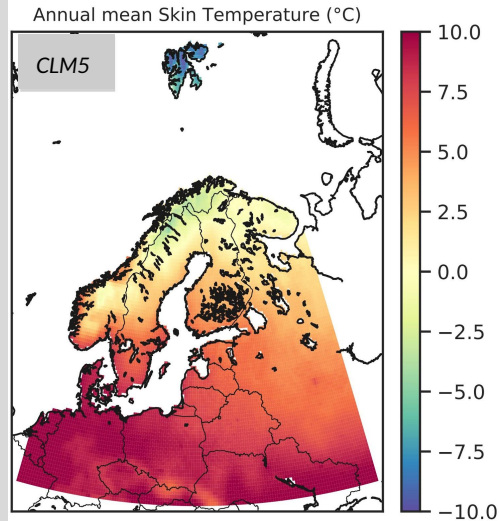
The Community Land Model (CLM)

- Terrestrial components of an Earth System framework
- Land component of the
Community Earth System Model (**CESM2**)
Norwegian Earth System Model (**NorESM**)
- CLM5  CTSM
Community Terrestrial Systems Model
- CTSM is NCAR's new unifying land model for **climate**, **weather**, **water**, and **ecosystems** studies.



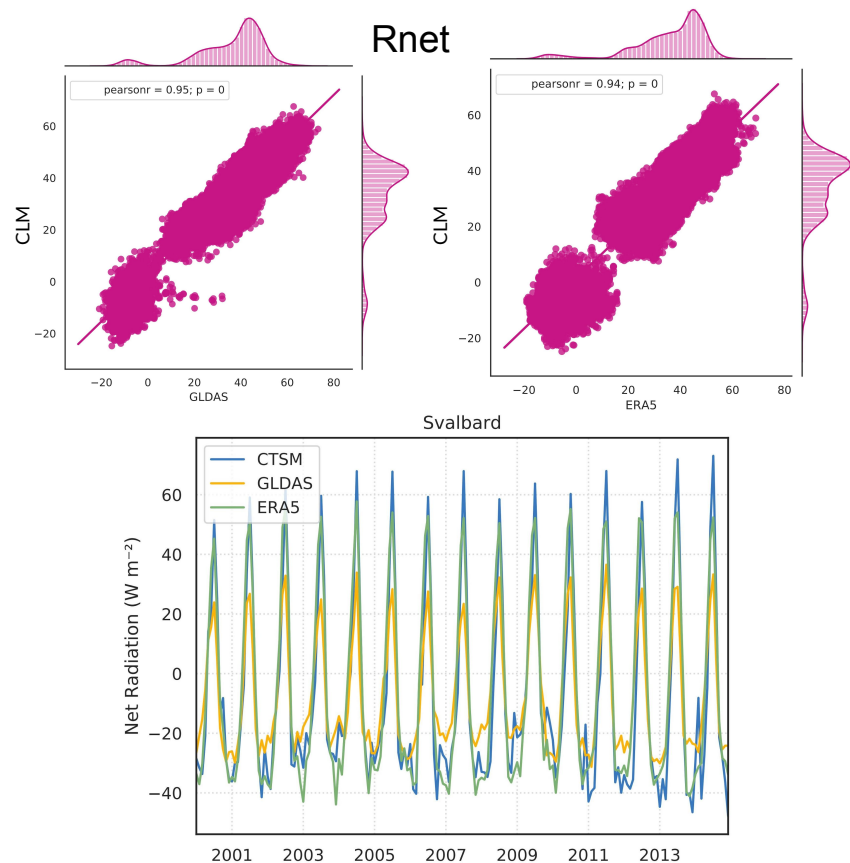
CLM5 outputs over Scandinavia

- * Satellite Phenology
- * GSWP3 forcing
- * 50-years spinup
- * 2000-2016 sim. period
- * 0.25° spatial resolution

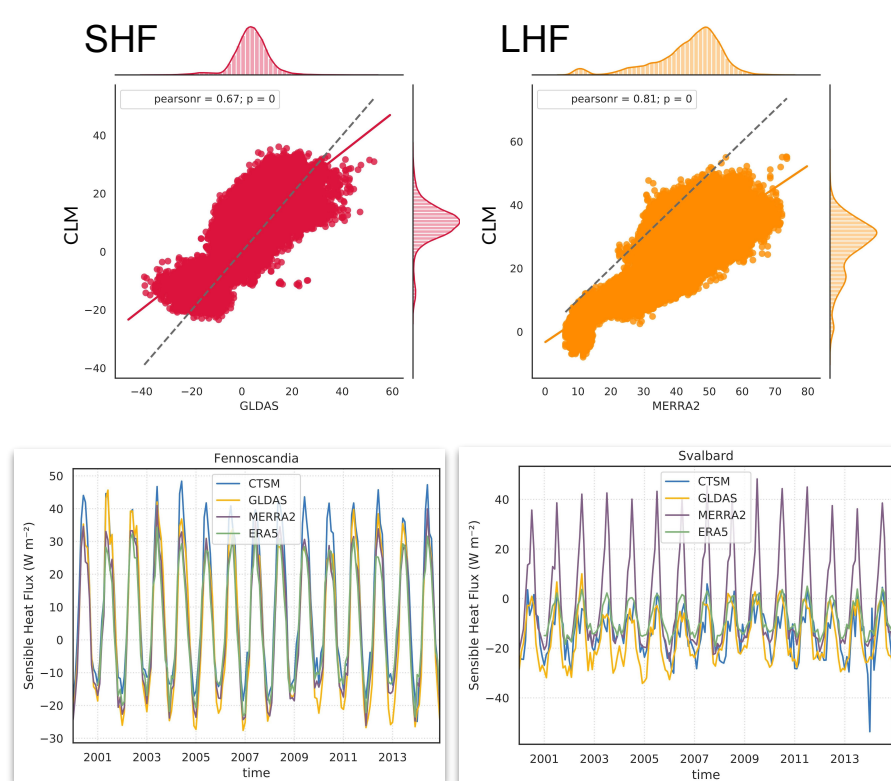


Energy Balance

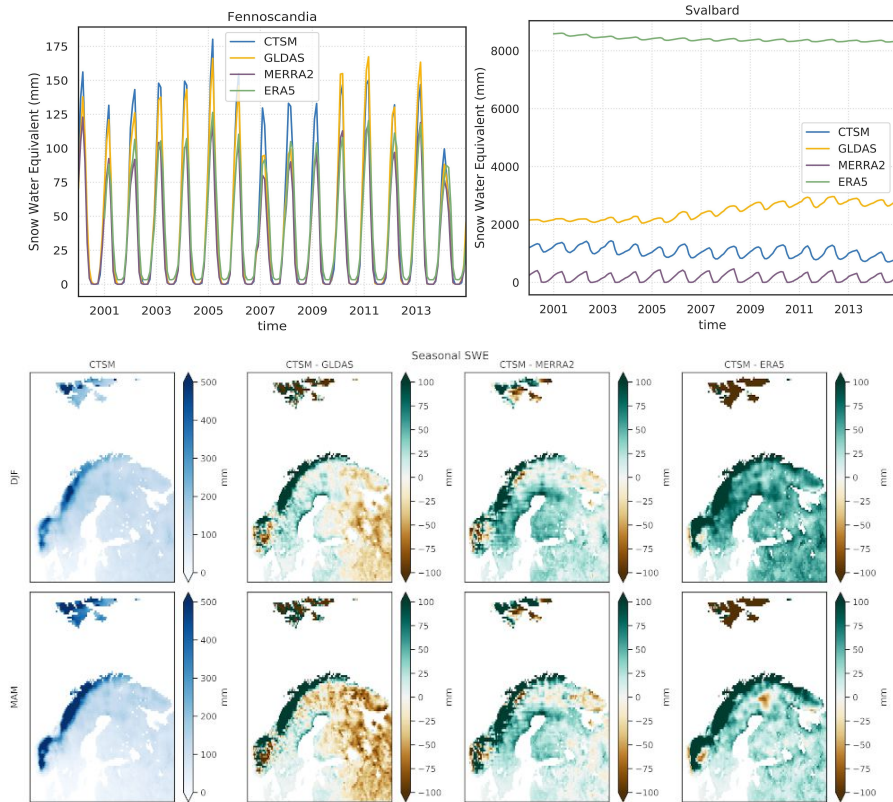
Radiative Components



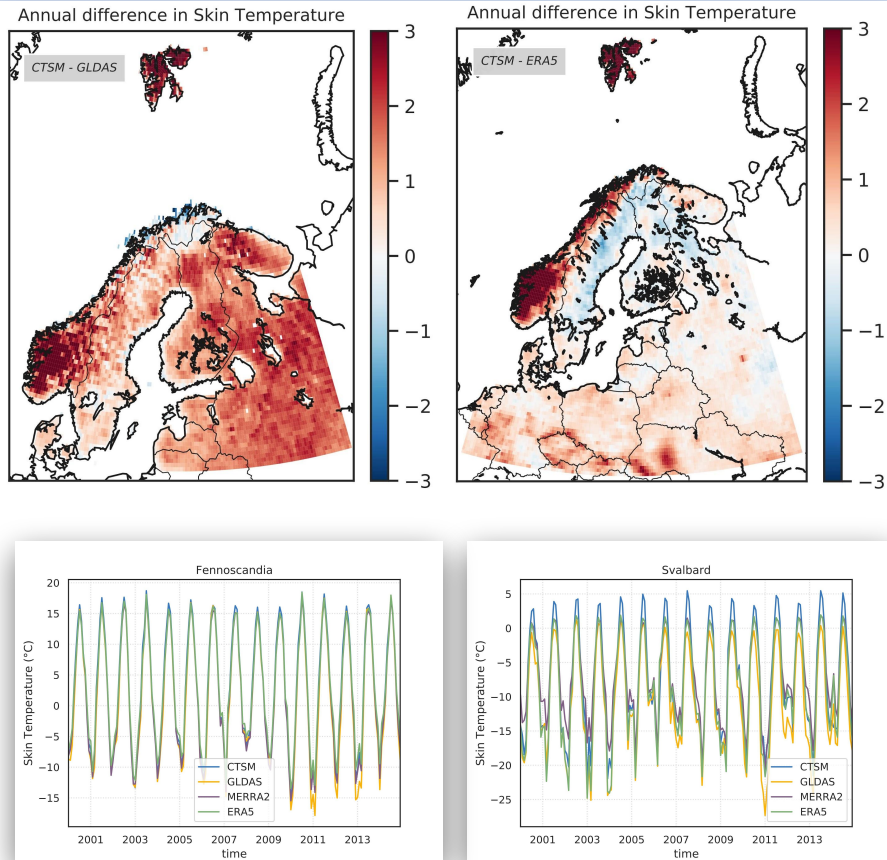
Non-Radiative Components



Snow Water Equivalent

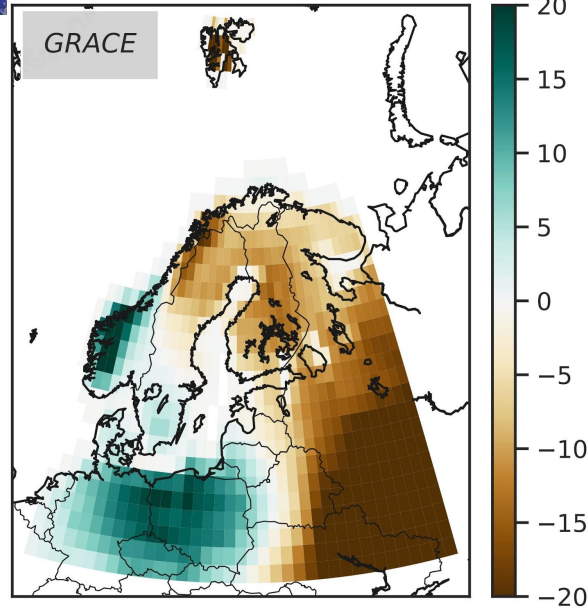


Skin Temperature

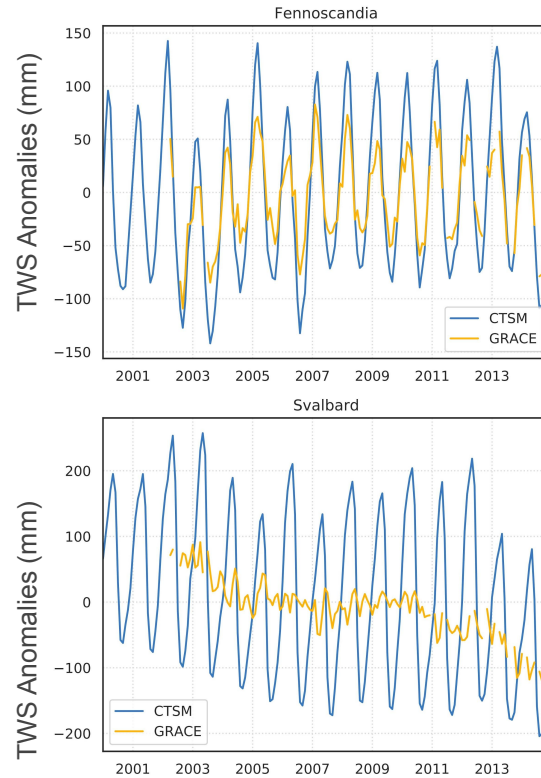




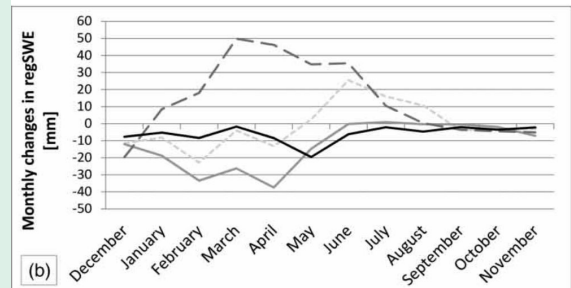
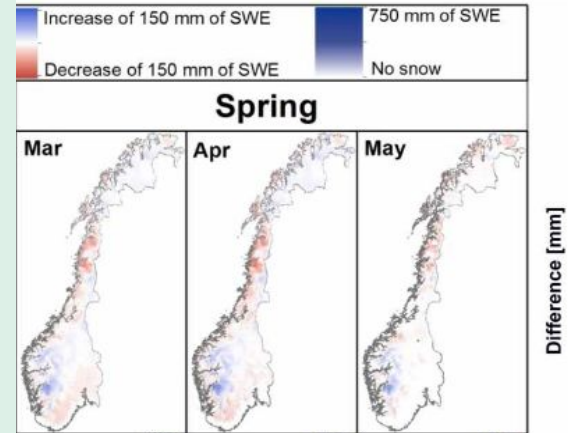
Terrestrial Water Storage Anomalies



TWS anomalies (mm) retrieved from GRACE satellites (2002-2014).

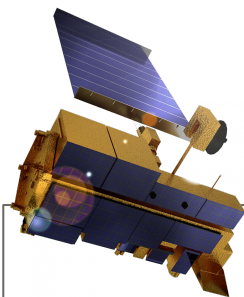
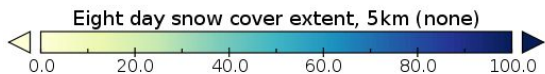
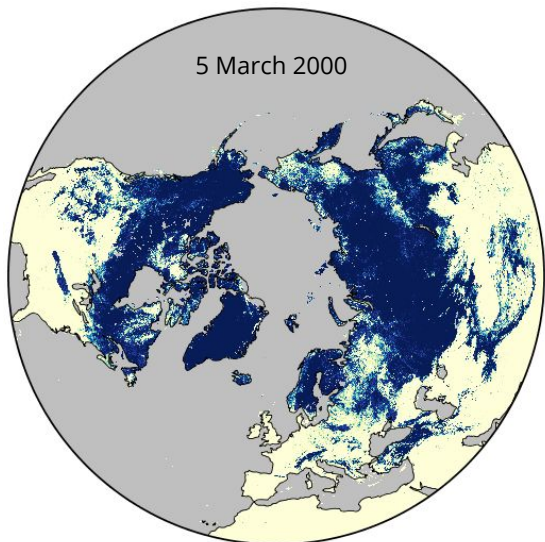


How are TWS anomalies related with changes in the snowpack?



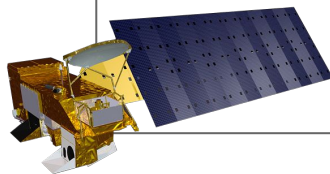
Rizzi et al. (2017)

MODIS Snow Cover



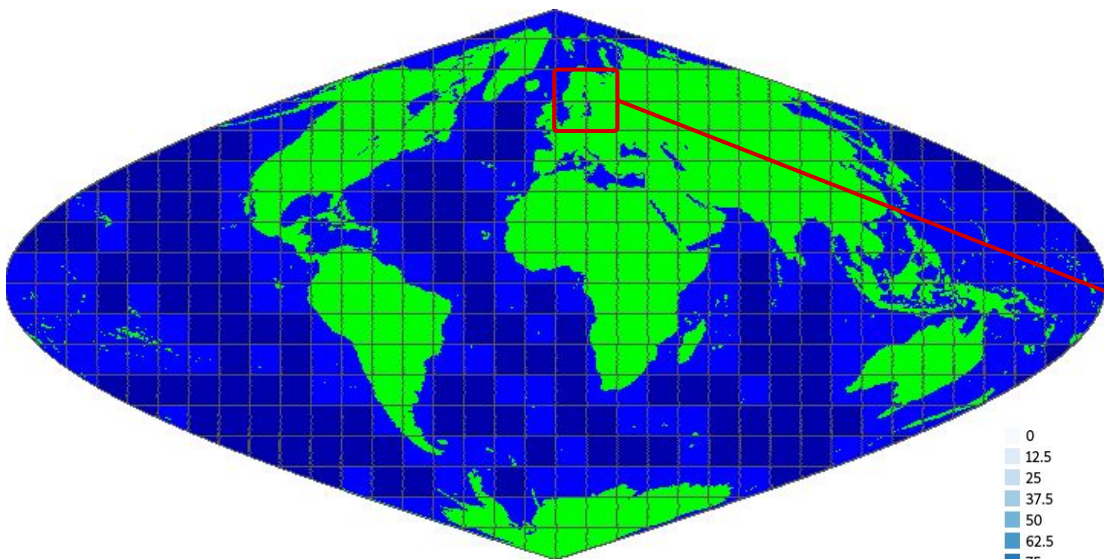
Terra

MODIS ID	Temporal resolution	Spatial resolution	Temporal coverage
MOD10A1	Daily	500m	24-02-2000
MOD10C1	Daily	0.05 deg	24-02-2000
MOD10A2	8-day	500m	24-02-2000
MOD10C2	8-day	0.05 deg	24-02-2000
MOD10CM	Monthly	0.05 deg	01-03-2000
MYD10A1	Daily	500m	04-07-2002
MYD10C1	Daily	0.05 deg	04-07-2002
MYD10A2	8-day	500m	04-07-2002
MYD10C2	8-day	0.05 deg	04-07-2002
MYD10CM	Monthly	0.05 deg	04-07-2002

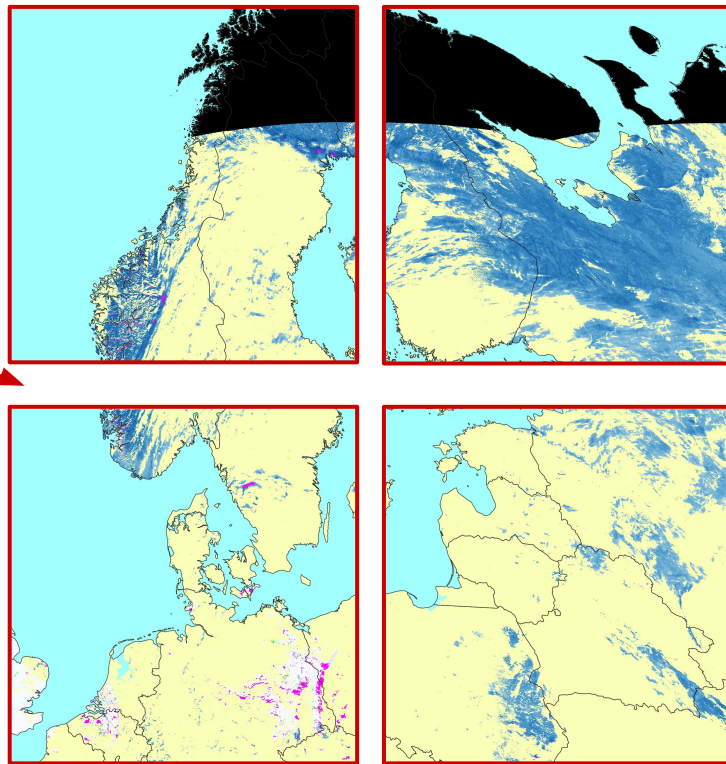


Aqua

Obtaining MODIS Snow Cover data (4 tiles over Scandinavia)



MODIS Sinusoidal Tile Grid. Tiles cover $10^\circ \times 10^\circ$ at the equator or approximately 1200 km x 1200 km (Source : NSIDC)



MODIS/Terra tiles over Scandinavia on 28.01.2019

Processing steps

MODIS - NDSI (Normalized Difference Snow Index)



fSCA : fractional snow-covered area

$fSCA = a * NDSI + b$ (a,b are universal constants - Salamonson and Appel (2004))

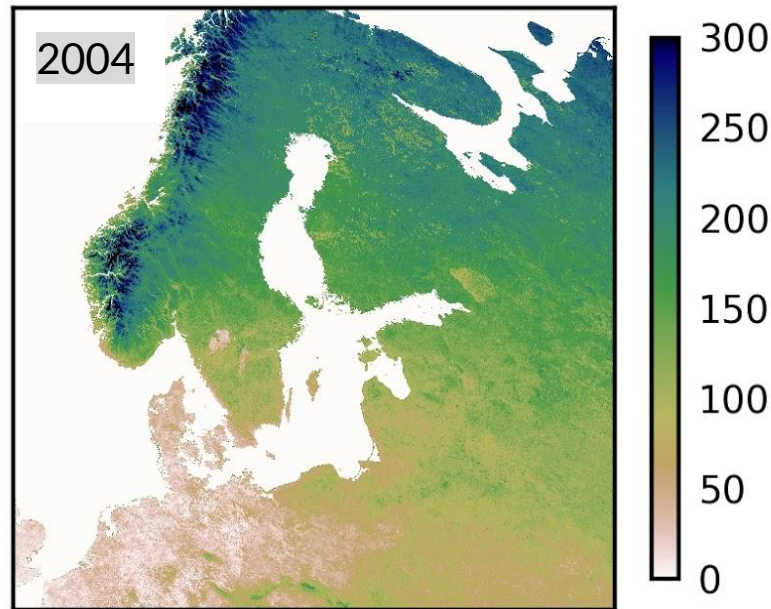


Cloud gap filling (Hall et al., 2019)

Snow metrics (through water year - from 1 Sep to 31 Aug)

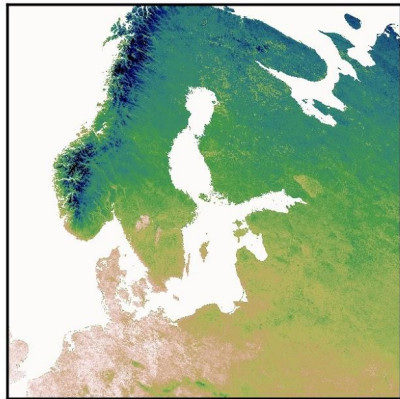
- Snow cover duration (SCD)
- Snow cover extent (SCE)
- Cloud persistence count (CPC)
- First snow day (FSD)
- Last snow day (LSD)
- Consecutive snow cover days (CSC)

Snow Cover Duration (days)

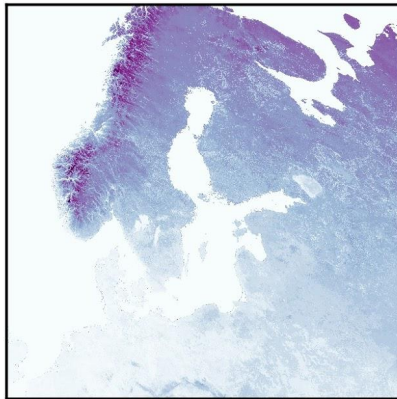


2004 (water year)

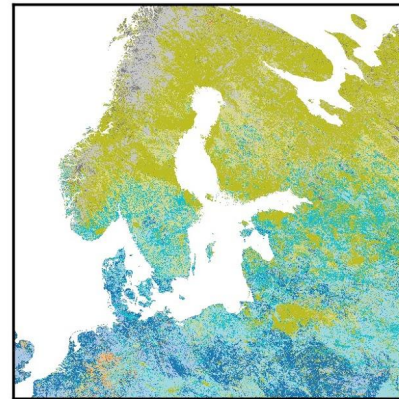
Snow Cover Duration (days)



Consecutive Snow Cover (days)



First Snow Day (DOY)



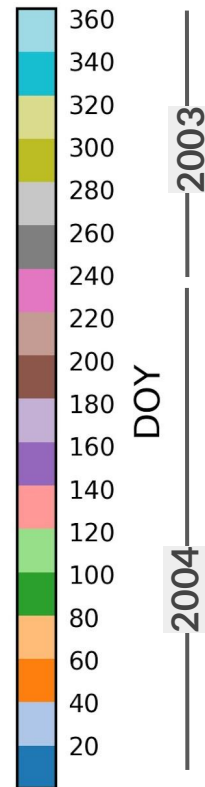
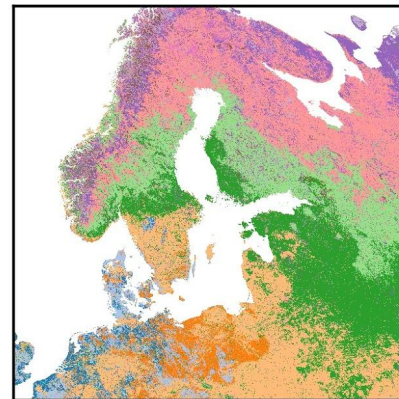
Snow Cover Extent (ha)



Cloud Persistence Count (days)



Last Snow Day (DOY)



Summary

- **Ongoing analysis** of changes in the terrestrial energy and water balance over Scandinavia.
- Merging information from multiple satellites and reanalyses into the Community Land Model (CLM5).
- Focusing on the changes in the snowpack and water storage.
- Preliminary results were presented for the establishment of a testbed.
- Currently processed MODIS-based snow metrics are being analyzed at multiple scales.

References

- Boike, J., Juszak, I., Lange, S., Chadburn, S., Burke, E., Overduin, P. P., Roth, K., Ippisch, O., Bornemann, N., Stern, L., Gouttevin, I., Hauber, E., and Westermann, S.:** A 20-year record (1998–2017) of permafrost, active layer and meteorological conditions at a high Arctic permafrost research site (Bayelva, Spitsbergen), 2018, *Earth Syst. Sci. Data*, 10, 355–390, <https://doi.org/10.5194/essd-10-355-2018>
- Hall, D. K., Riggs, G. A., DiGirolamo, N. E., and Román, M. O.,** 2019: Evaluation of MODIS and VIIRS cloud-gap-filled snow-cover products for production of an Earth science data record,, *Hydrol. Earth Syst. Sci.*, 23, 5227–5241, <https://doi.org/10.5194/hess-23-5227-2019>
- Lawrence, D. M., Fisher, R. A., Koven, C. D., Oleson, K. W., Swenson, S. C., Bonan, G., et al (** 2019). The Community Land Model version 5: Description of new features, benchmarking, and impact of forcing uncertainty. *Journal of Advances in Modeling Earth Systems*, 11. <https://doi.org/10.1029/2018MS001583>
- Lofgren, B.M., A.D. Gronewold, A. Acciaioli, J. Cherry, A. Steiner, and D. Watkins,** 2013: Methodological Approaches to Projecting the Hydrologic Impacts of Climate Change. *Earth Interact.*, 17, 1–19, <https://doi.org/10.1175/2013EI000532.1>
- Rizzi, J., Nilsen, I.B., Stagge, J.H., Gislås, K., Tallaksen, L.M.,** 2018: Five decades of warming: impacts on snow cover in Norway. *Hydrology Research*; 49 (3): 670–688, <https://doi.org/10.2166/nh.2017.051>
- Salomonson, V.V. and Appel, I.,** 2004: Estimating fractional snow cover from MODIS using the normalized difference snow index, *Remote Sensing of Environment*, 89, 351–360, <https://doi.org/10.1016/j.rse.2003.10.016>



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Thank you for your interest!

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