



u^b

^b
UNIVERSITÄT
BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Benefits of downscaled satellite-derived land surface temperature for permafrost modelling

Sonia Dupuis, Nando Metzger, Sebastian Westermann, Konrad Schindler, Frank Götsche, and Stefan Wunderle

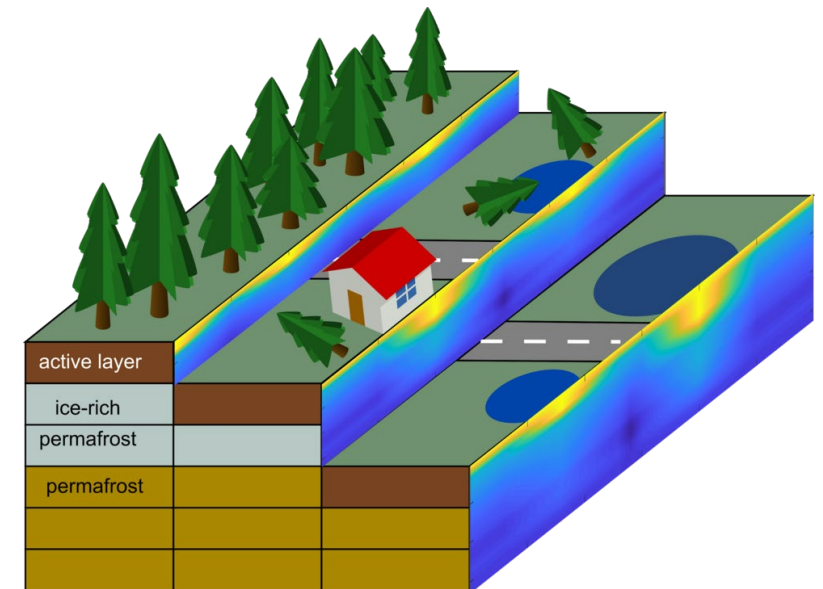
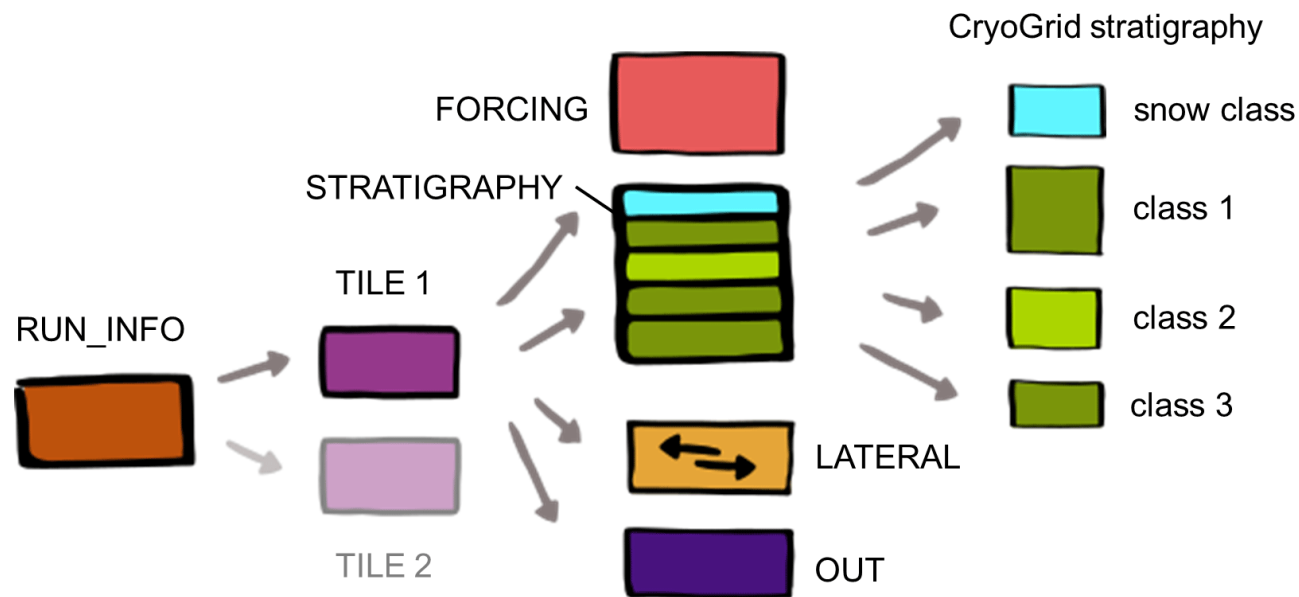
Contact: sonia.dupuis@unibe.ch

April 2025 - EGU 2025, Vienna

Exploiting land surface temperature (LST) for permafrost modelling

Modelling of the heat transfer between atmosphere and ground using land surface temperature, snow- and land cover observations from space.

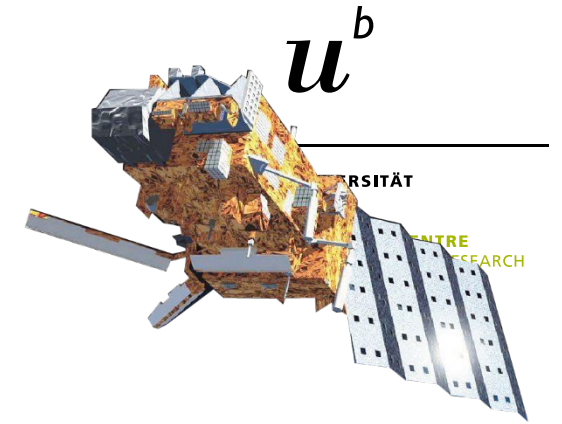
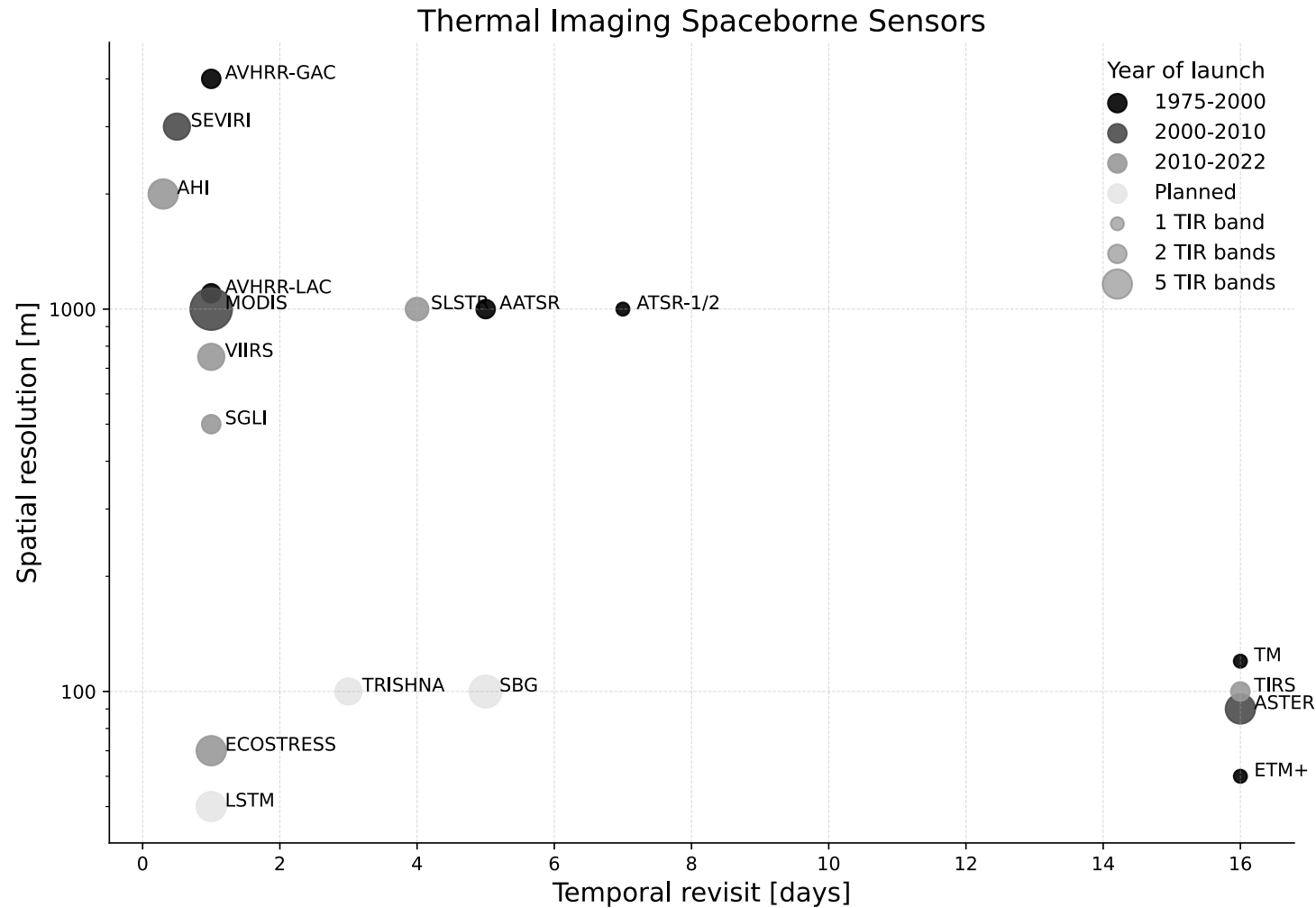
Input data (Forcing): Satellite LST (only clear-sky) and ERA5 reanalysis data



Permafrost modelling (credits: Moritz Langer, AWI)

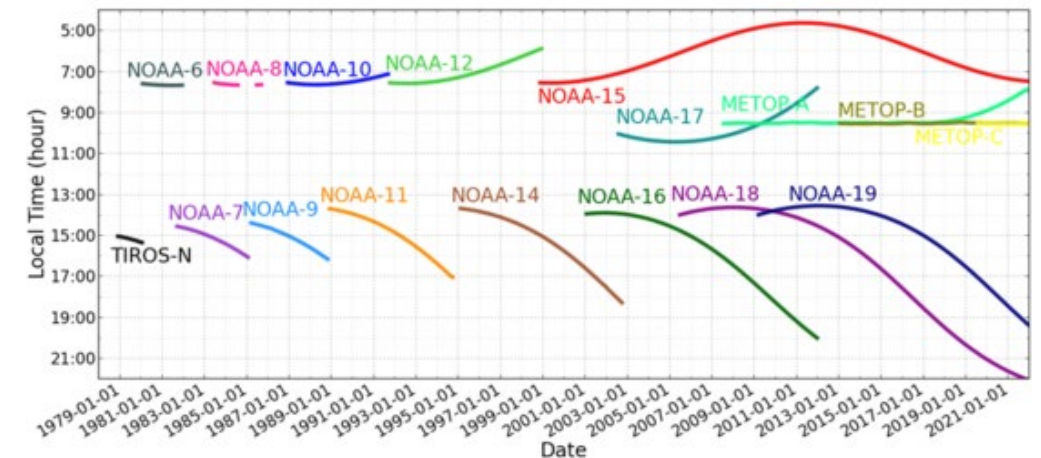
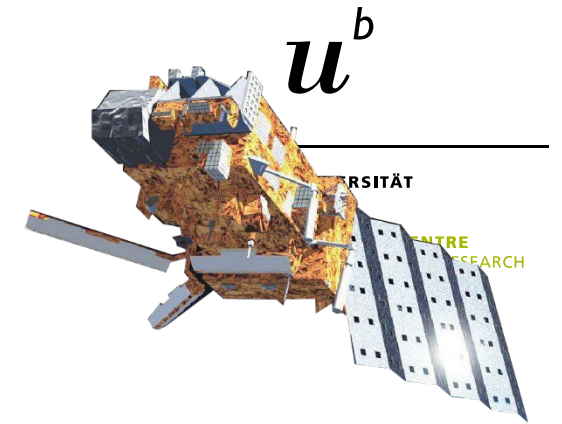
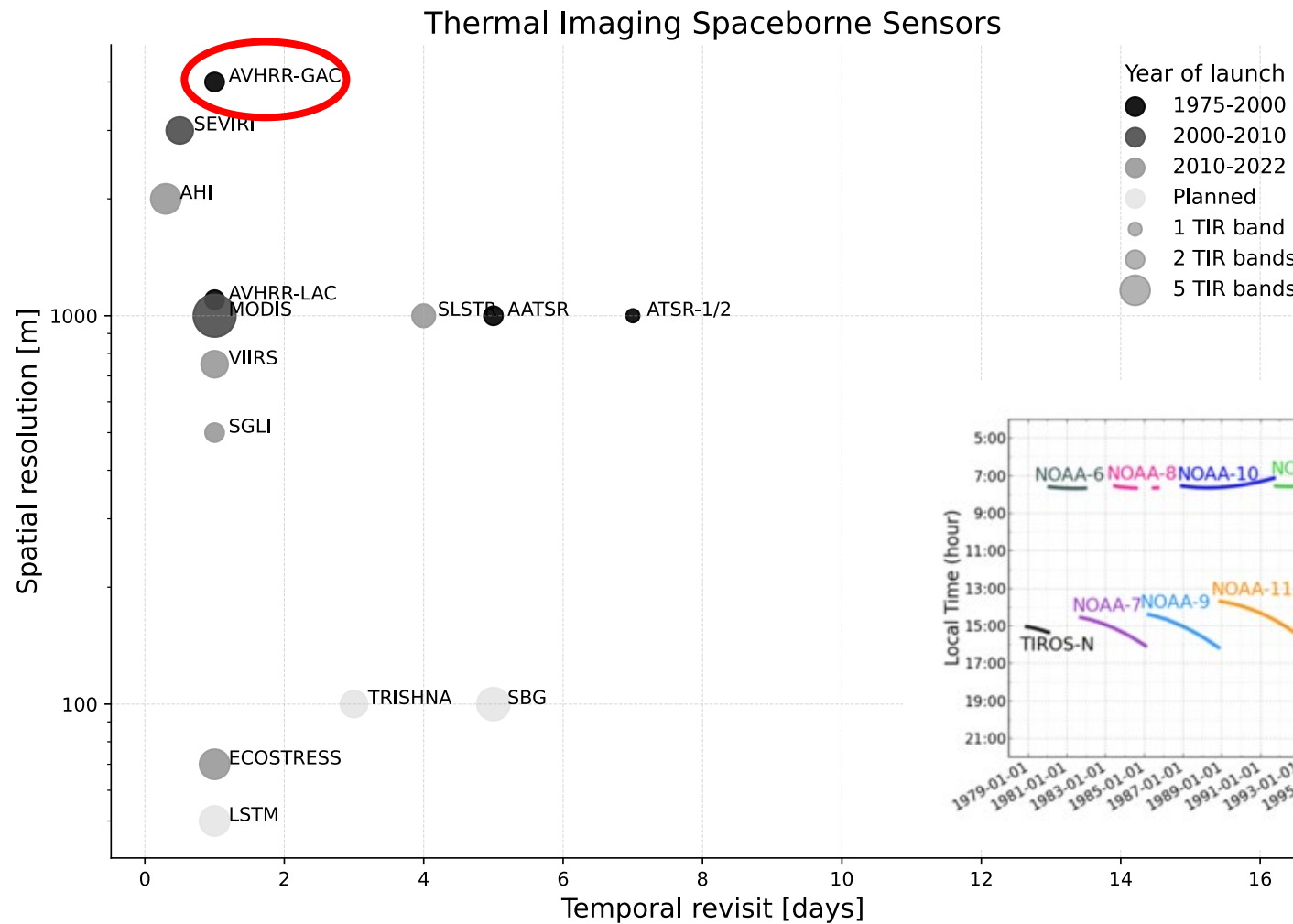
S. Westermann et al., *The CryoGrid community model (version 1.0) – a multi-physics toolbox for climate-driven simulations in the terrestrial cryosphere*, GMD, 2023

Satellite LST datasets



Adapted from **Adams, J. (2023)**. *Overview of thermal imaging spaceborne sensors*. University of Zurich. Retrieved from https://thermal-rs.earsel.org/wp-content/uploads/2023/07/Example_TIR_Mission-1536x1284.jpg

Satellite LST datasets



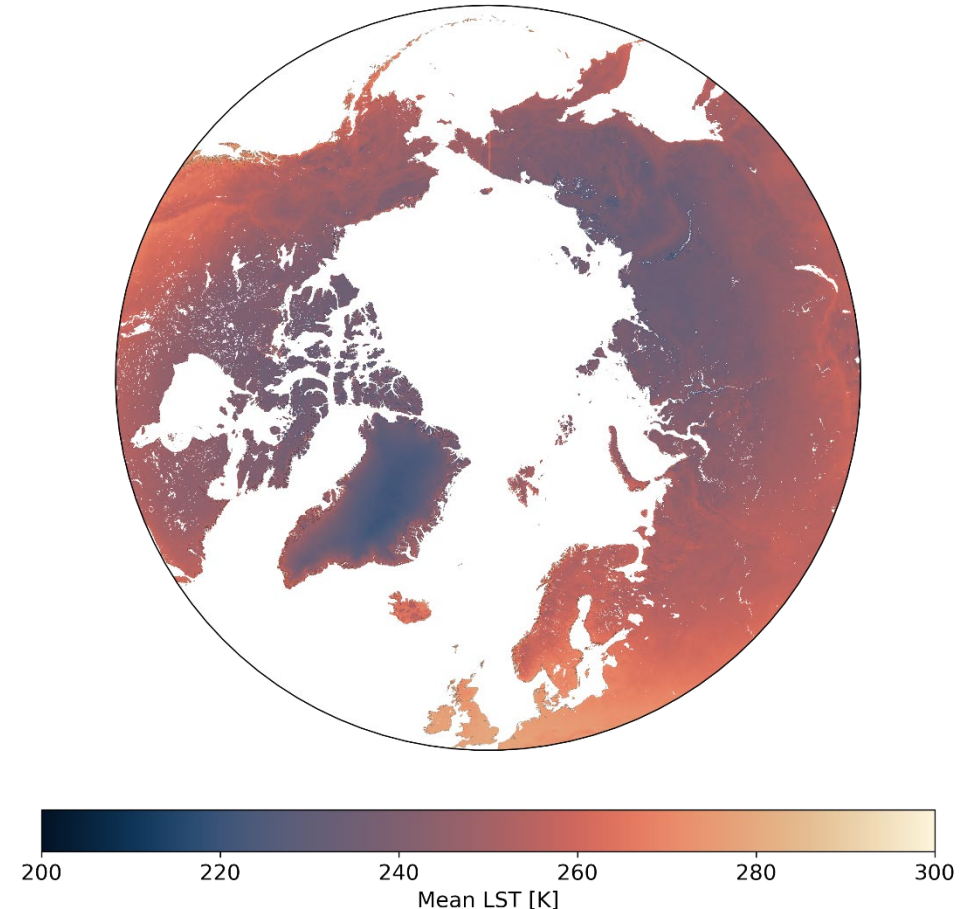
Adapted from **Adams, J. (2023)**. *Overview of thermal imaging spaceborne sensors*. University of Zurich. Retrieved from https://thermal-rs.earsel.org/wp-content/uploads/2023/07/Example_TIR_Mission-1536x1284.jpg

AVHRR LST pan-Arctic dataset

FACTSHEET: AVHRR LST pan-Arctic dataset

- 1981 – 2021 (**40 years**), EUMETSAT FDR, version 2023
- Twice daily data (day and night)
- 0.05° x 0.05° (~ 4km)
- LST retrieval based on the Generalized Split-Window Method (Wan & Dozier, 1996)
- Cloud mask from the EUMETSAT CLARA-A3 dataset
- Snow cover (SCFV and SWE) data from the ESA CCI+ snow project
- Pixel-wise tracking of conditions (SuZen, SatZen) and radiative transfer modelling performance
- Final product is validated against in situ measurements
- Available on Zenodo: <https://doi.org/10.5281/zenodo.13361744>

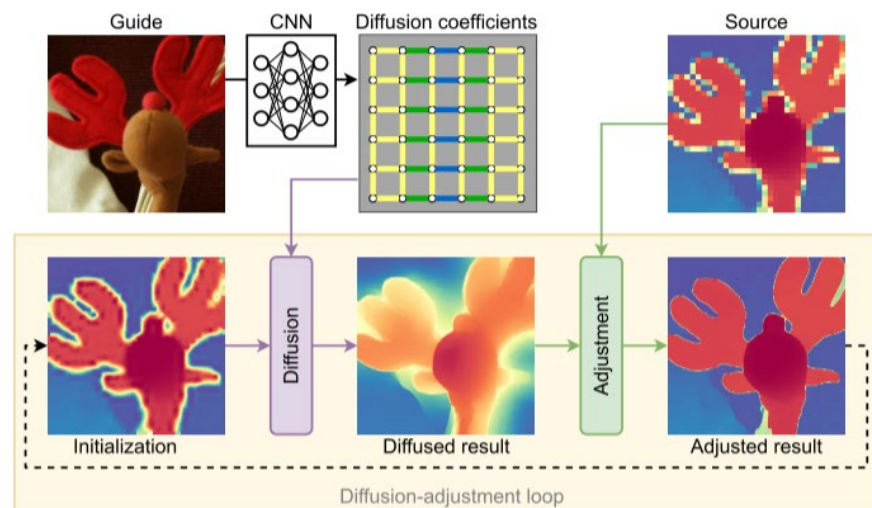
LST winter 1981-2020 mean



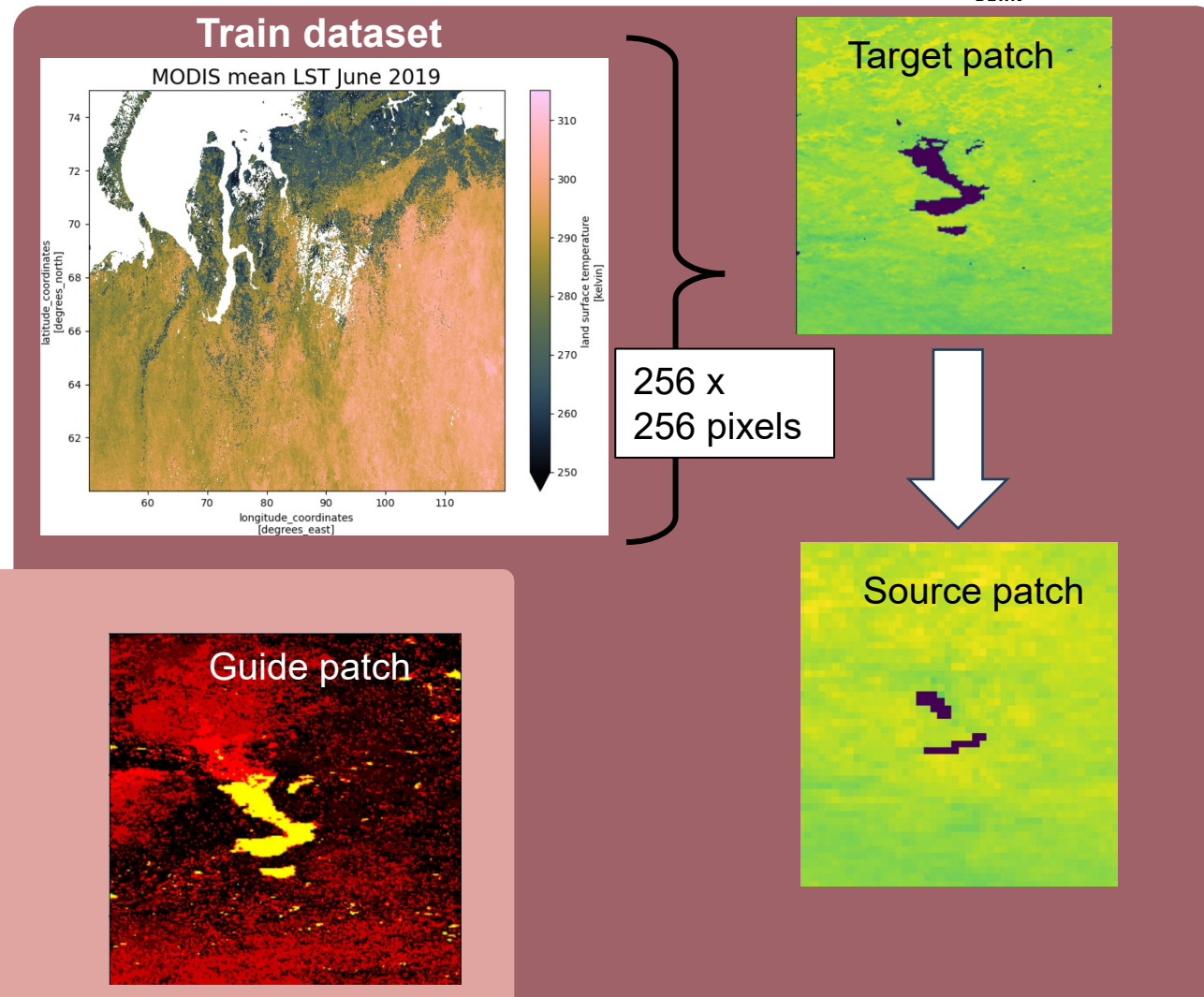
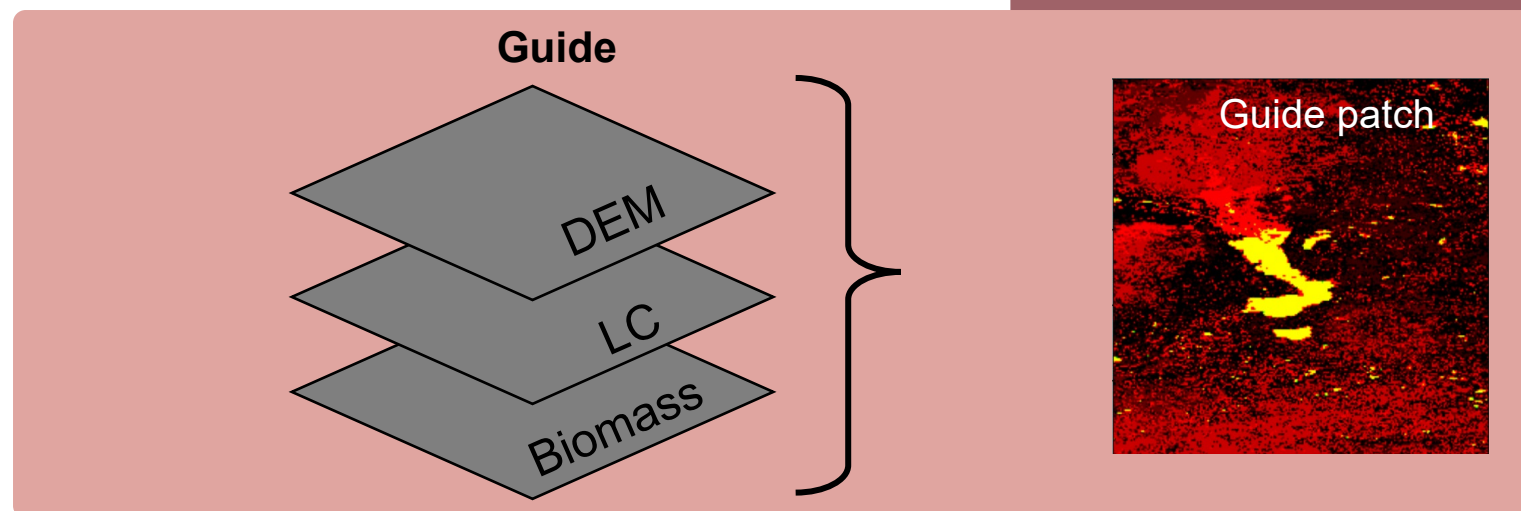
S. Dupuis, 2024, Temporal stability of a new 40-year daily AVHRR land surface temperature dataset for the pan-Arctic region

Downscaling of LST datasets

Guided Super-Resolution by Deep Anisotropic Diffusion



*Guided Depth Super-Resolution by Deep Anisotropic Diffusion,
Metzger et al., CVPR, 2023*

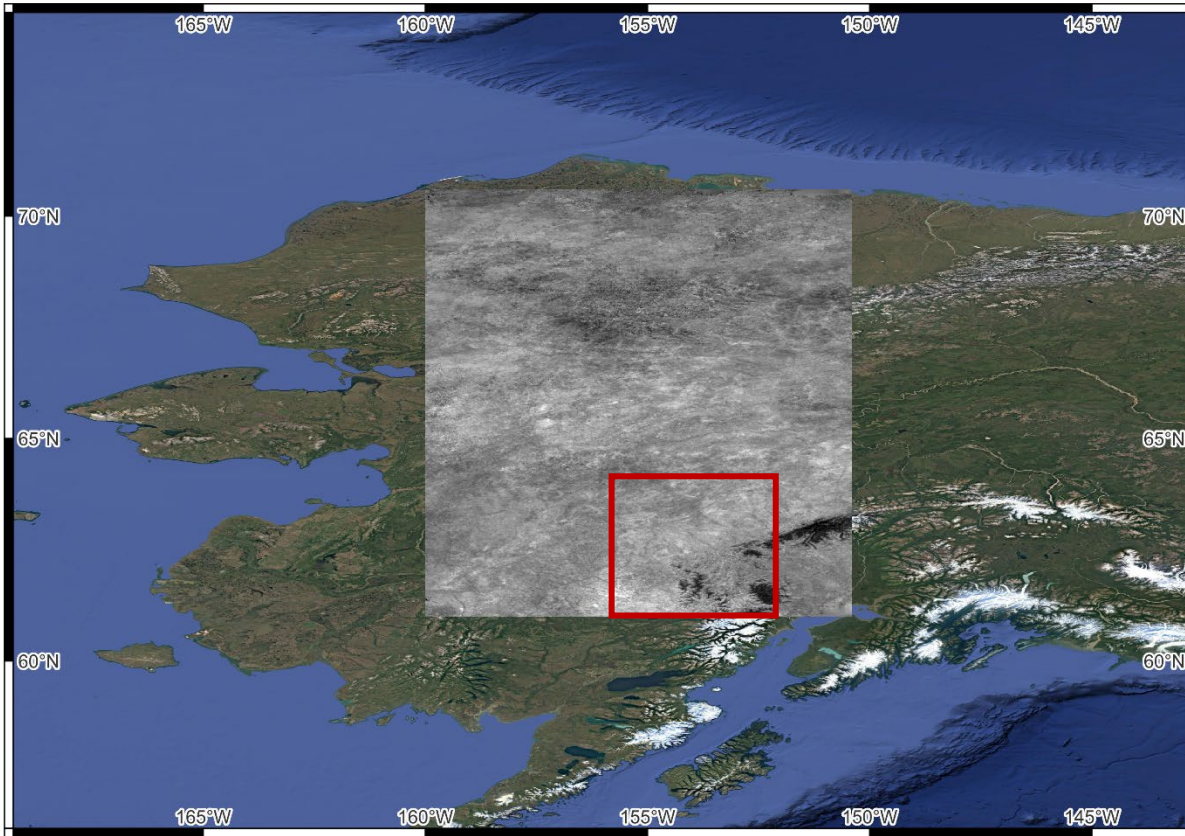


Downscaling with Anisotropic Diffusion: Evaluation example

u^b

^b
UNIVERSITÄT
BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

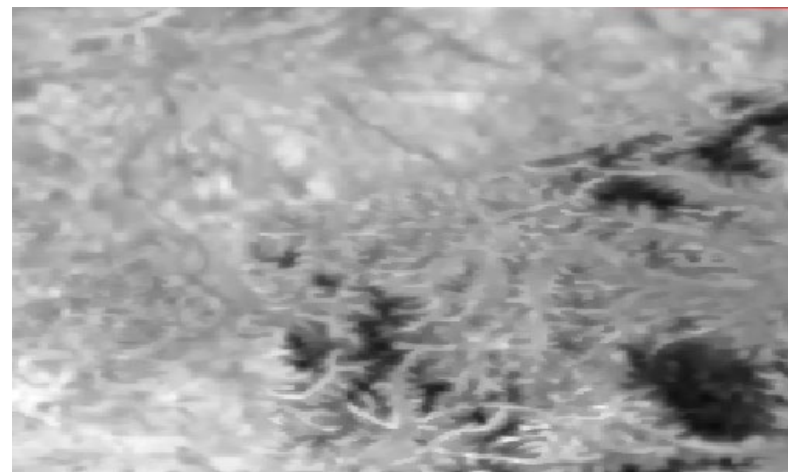


Downscaling with Anisotropic Diffusion: Evaluation example

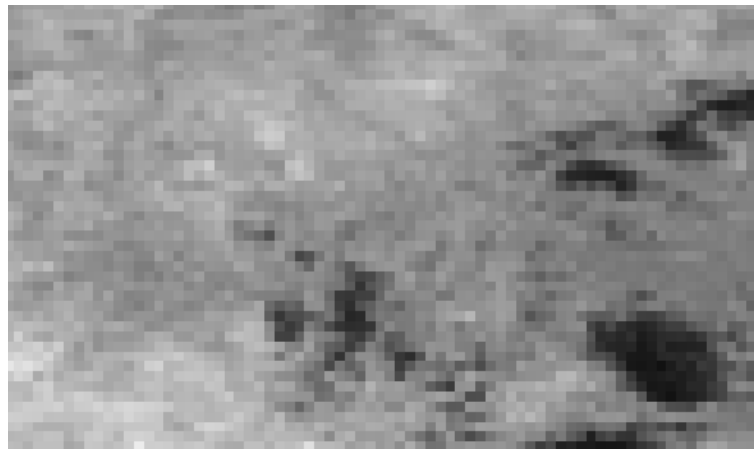
Original MODIS data



DADA downscaling



Source (Coarsened MODIS, factor 5)



Bicubic interpolation



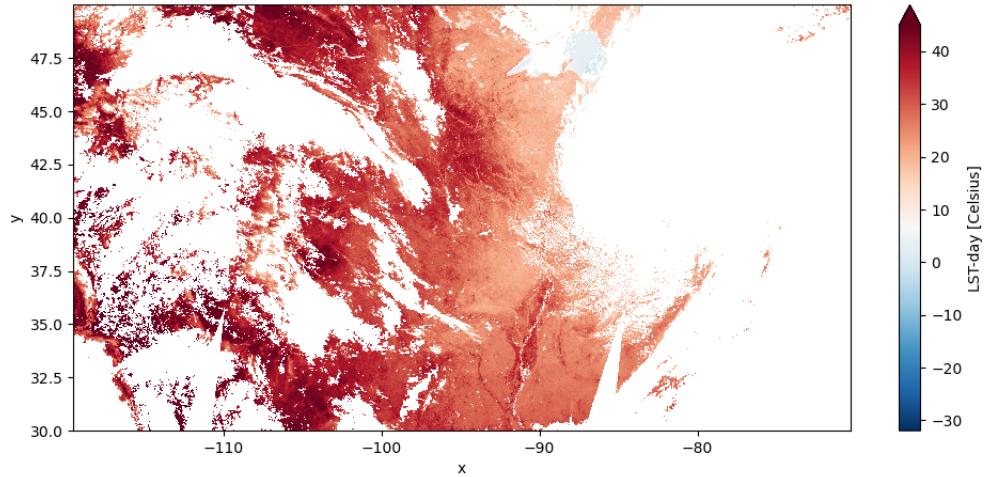
Comparison to LSA-SAF EDLST Product

u^b

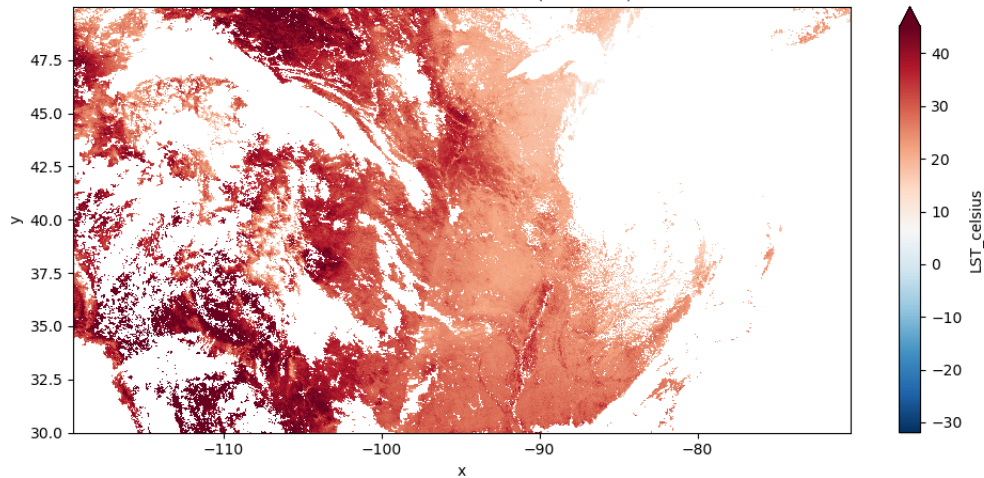
^b
UNIVERSITÄT
BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

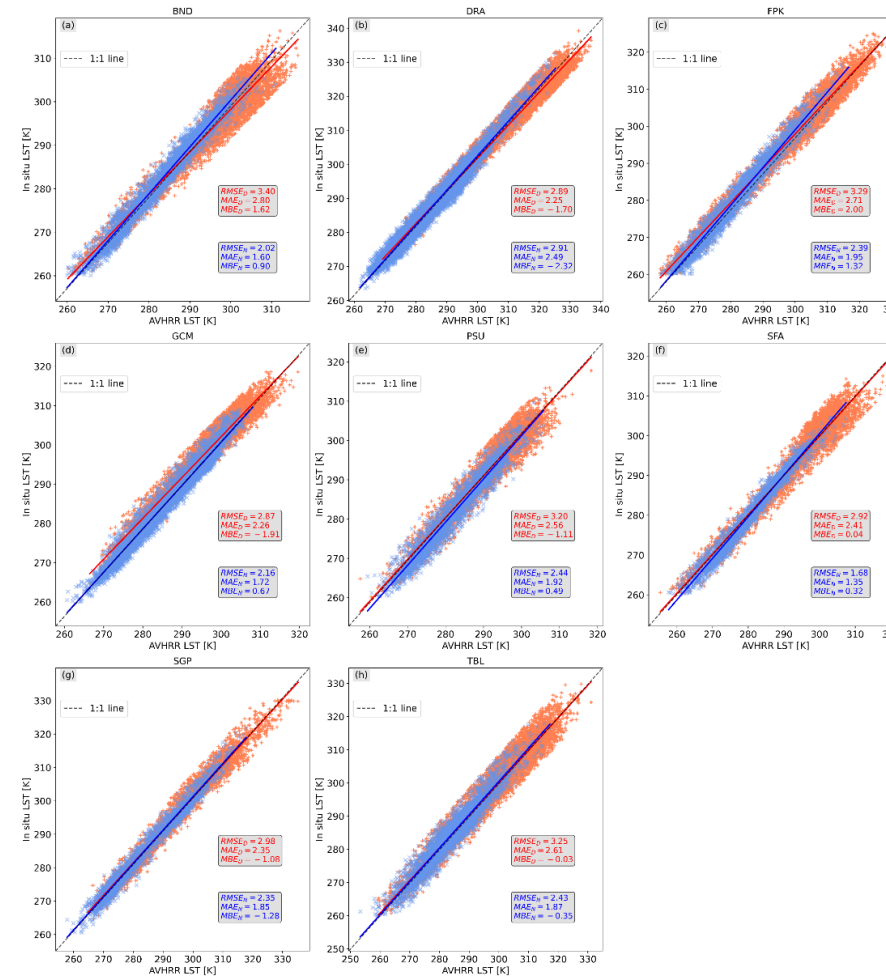
Comparison EDLST LSA SAF vs Downscaled AVHRR, 2019-06-13
EDLST (Cloud-masked)



Downscaled Pan-Arctic LST (No Water)

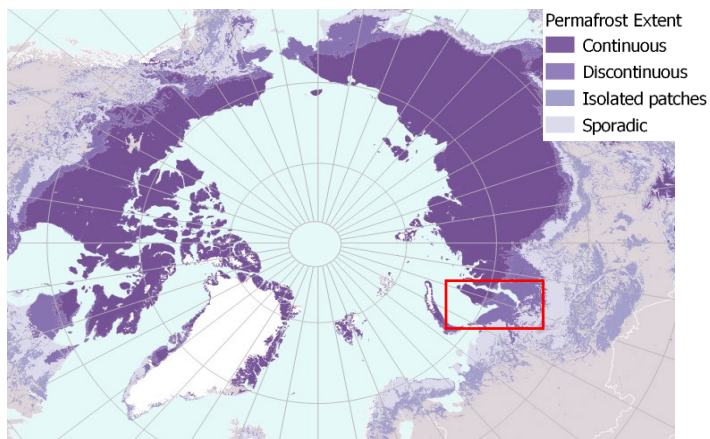


Validation with SURFRAD stations

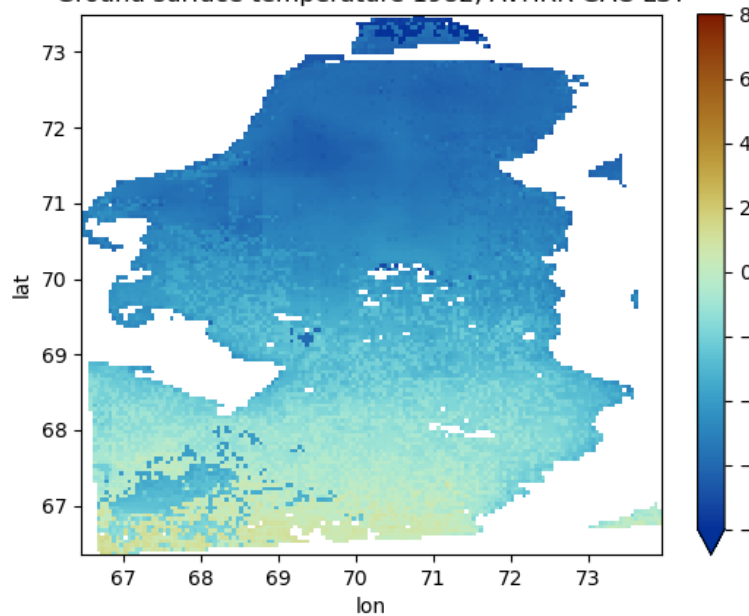


Contact: sonia.dupuis@unibe.ch

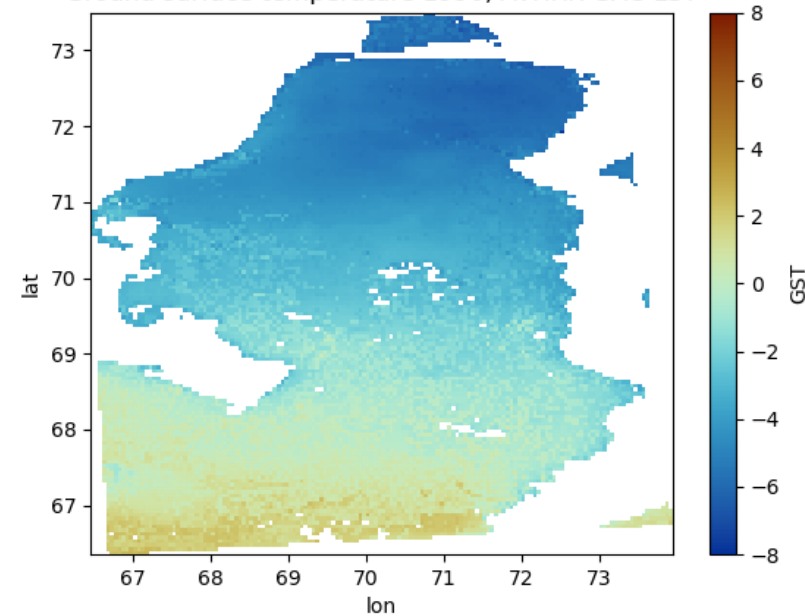
Permafrost modelling: Yamal Example



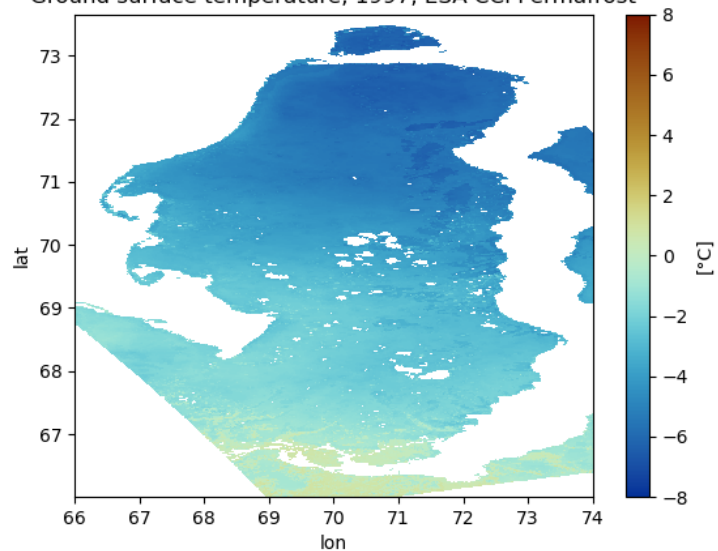
Ground surface temperature 1982, AVHRR GAC-LST



Ground surface temperature 1990, AVHRR GAC-LST



Ground surface temperature, 1997, ESA CCI Permafrost



Outlook and Conclusion

- LST derived from AVHRR can help to identify cooling or strong warming patterns under clear-sky conditions at a hemispheric scale
- The longevity of the AVHRR data (1981-present) can be exploited for permafrost modelling in the pre-MODIS Era
- Guided-super resolution allows to downscale AVHRR data only with static information