



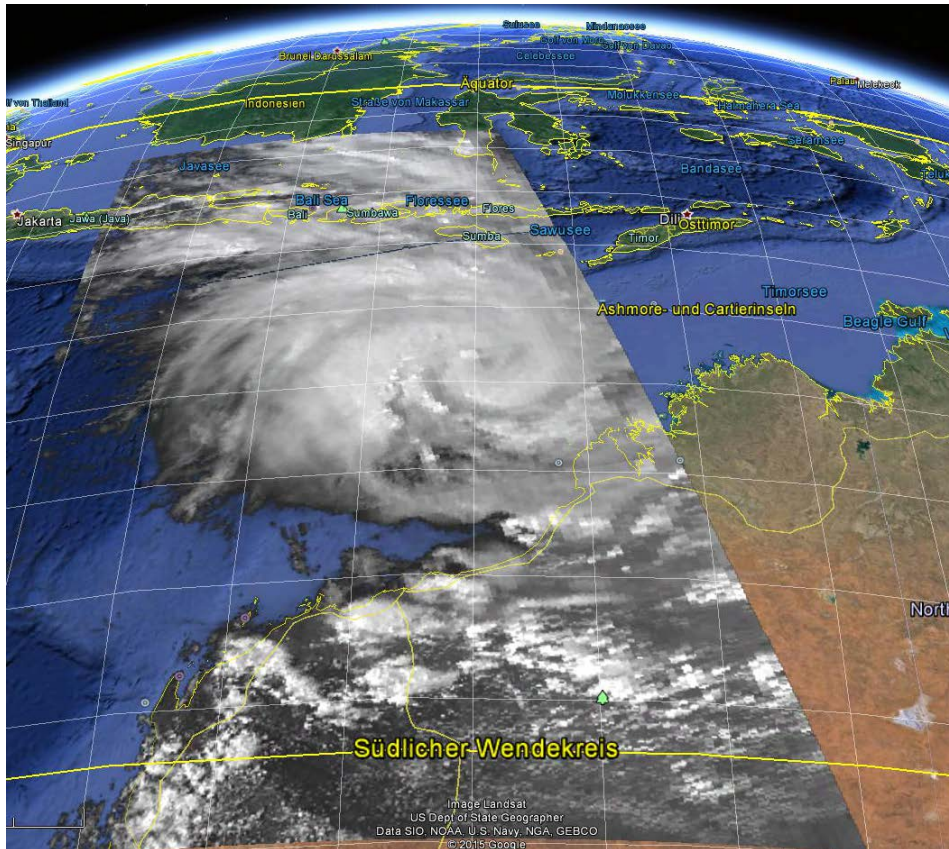
AVHRR GAC and LAC data for the retrieval of ECV time series: complementary or synergistic?

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Advanced Very High Resolution Radiometer (AVHRR/2; AVHRR/3)

GAC (global area coverage): approx. 4km x 4km nadir

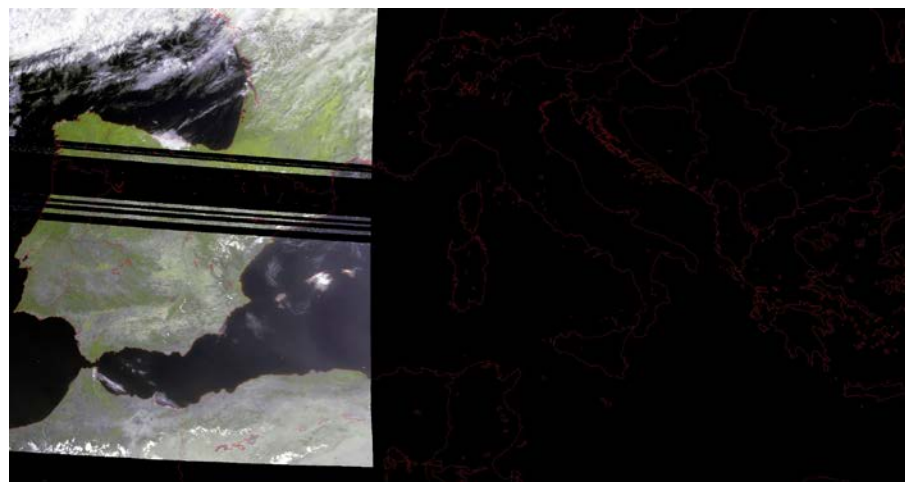
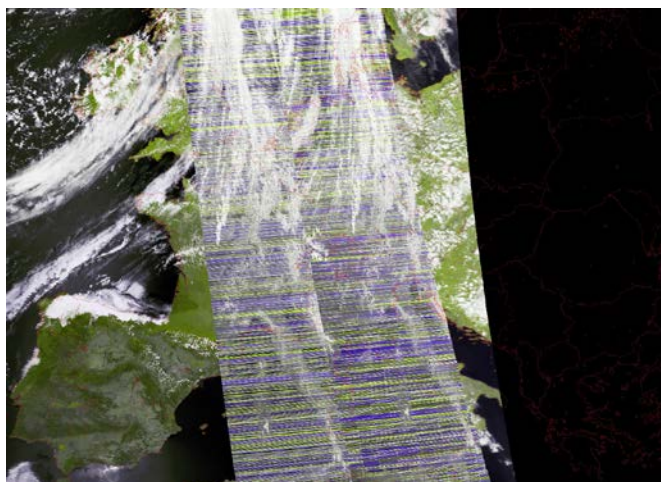
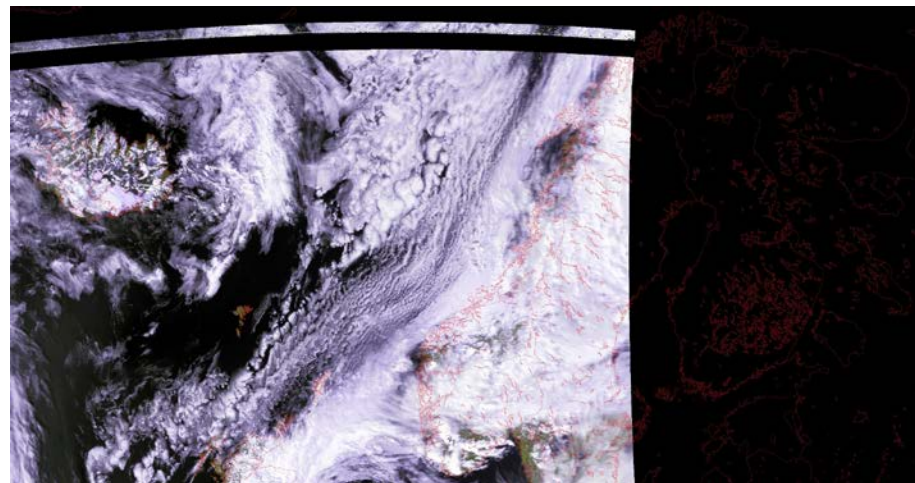
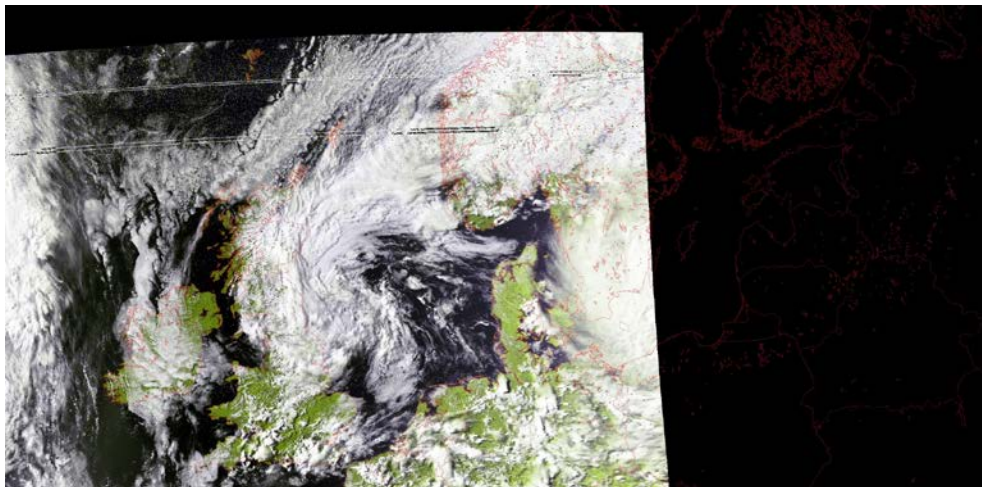
LAC (local area coverage): 1.1km nadir



NOAA-6 VIS, 20. January 1980

- > **1981 – approx. 2026**
- > Platform: NOAA and MetOp
- > 5 channel radiometer
 - 1: 0.58 – 0.68 μm
 - 2: 0.725 – 1.0 μm
 - 3A: 1.58 – 1.64 μm
 - 3B: 3.55 – 3.93 μm
 - 4: 10.30 – 11.30 μm
 - 5: 11.50 – 12.50 μm
- > Spatial resolution (LAC): 1.1km in nadir
- > Swath: 2.700 km

AVHRR: sleepless nights ...



Towards a Fundamental Climate Data Record (FCDR) - Availability of AVHRR data

AVHRR GAC	AVHRR LAC	
global	Continental / regional	global
1981 - 2019	1981 - 2019	1992 - 1997

More than 30 years are required for a time series to fulfill WMO / GCOS requirements and guarantee a sound statistical analysis.

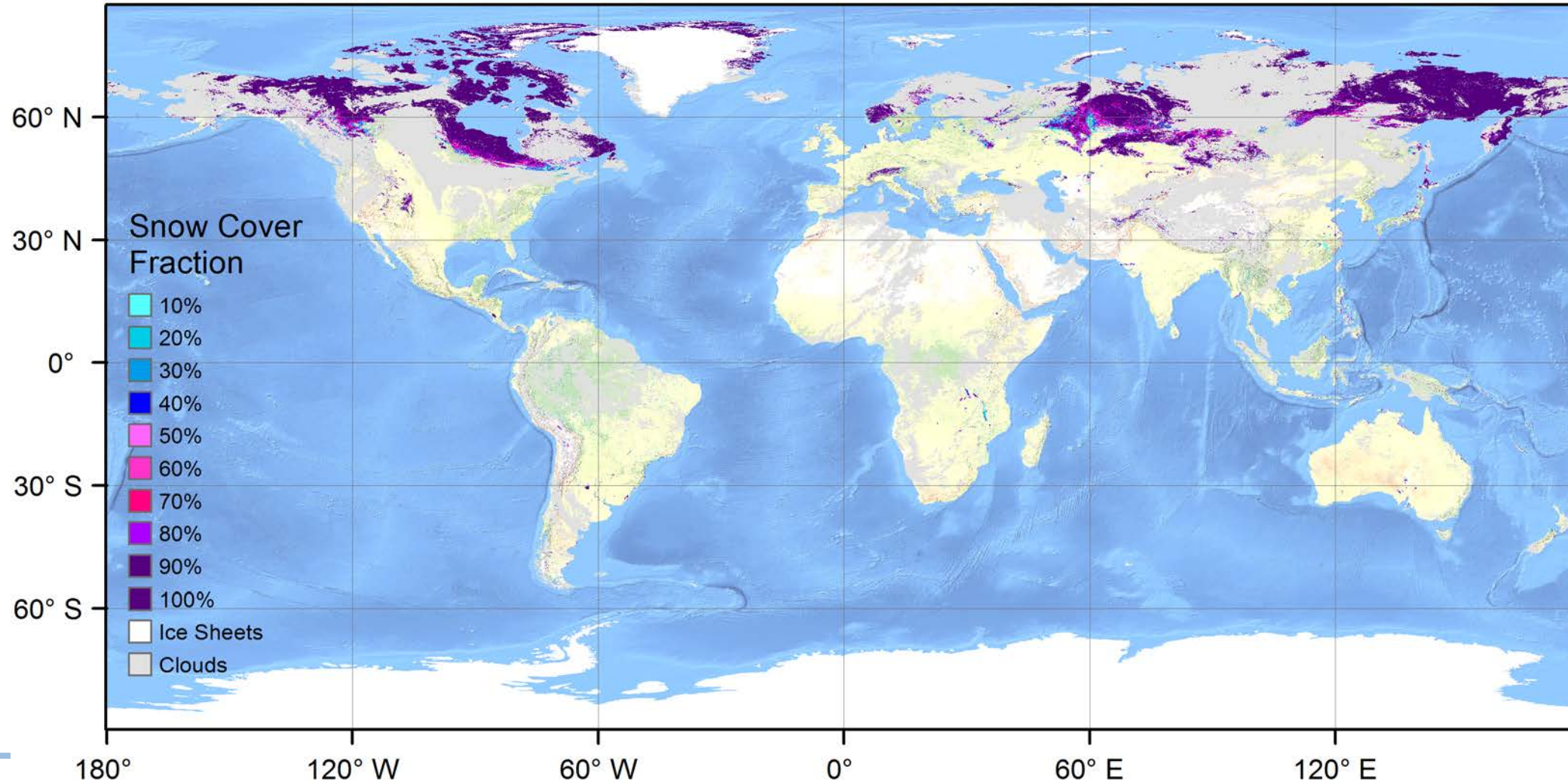
Background image: David Taylor

Essential Climate Variables (ECVs)

Domain	GCOS Essential Climate Variables
Atmospheric (over land, sea and ice)	Surface: Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget
	Upper-Air: Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance)
	Composition: Carbon dioxide, Methane, and other long-lived greenhouse gases, Ozone and Aerosol , supported by their precursors
Oceanic	Surface: Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton
	Sub-Surface: Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers
Terrestrial	River discharge, Water use, Groundwater, Lakes , Snow cover , Glaciers and ice caps, Ice sheets, Permafrost, Albedo , Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance , Soil moisture.

ESA Climate Change Initiative – snow project

Snow Cover Fraction derived from CM-SAF AVHRR GAC cloud data set, vers.3



AVHRR scan geometry: spatial resolution

Nadir: 1.1km → swath edge: 4 x 6 km

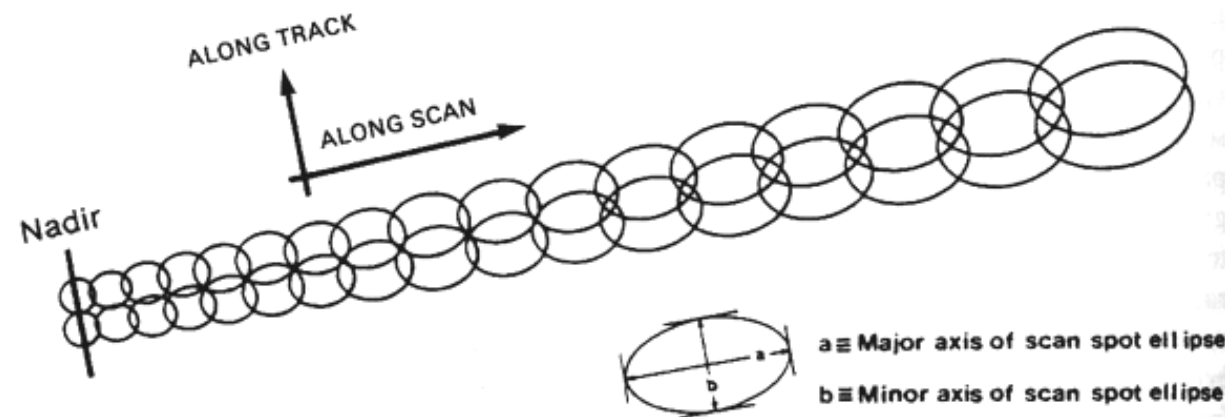
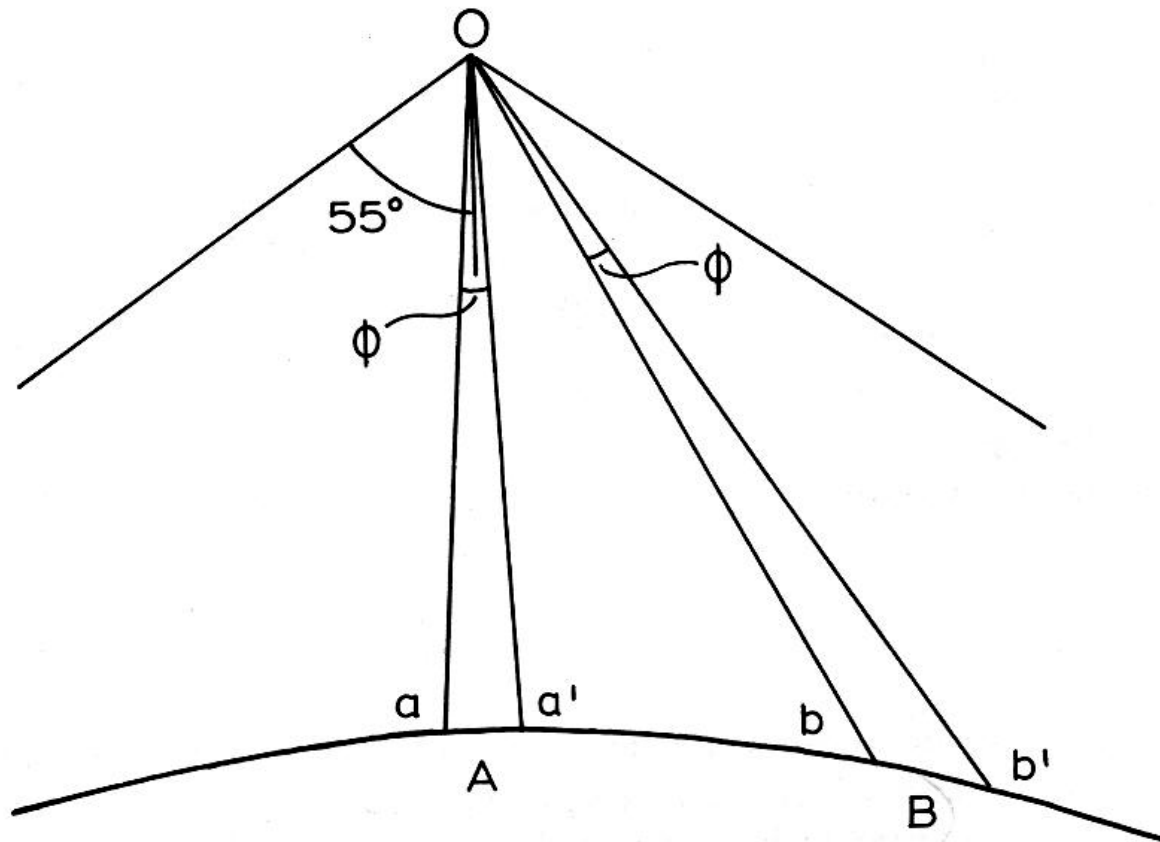


Figure 3.8 Sketch of pixel geometry for the AVHRR for adjacent scan lines showing the scan spot (IFOV) overlap in the along-track and cross-track directions (Breaker 1990).

Cracknell, 1997

blurring of information due to enlarged footprint

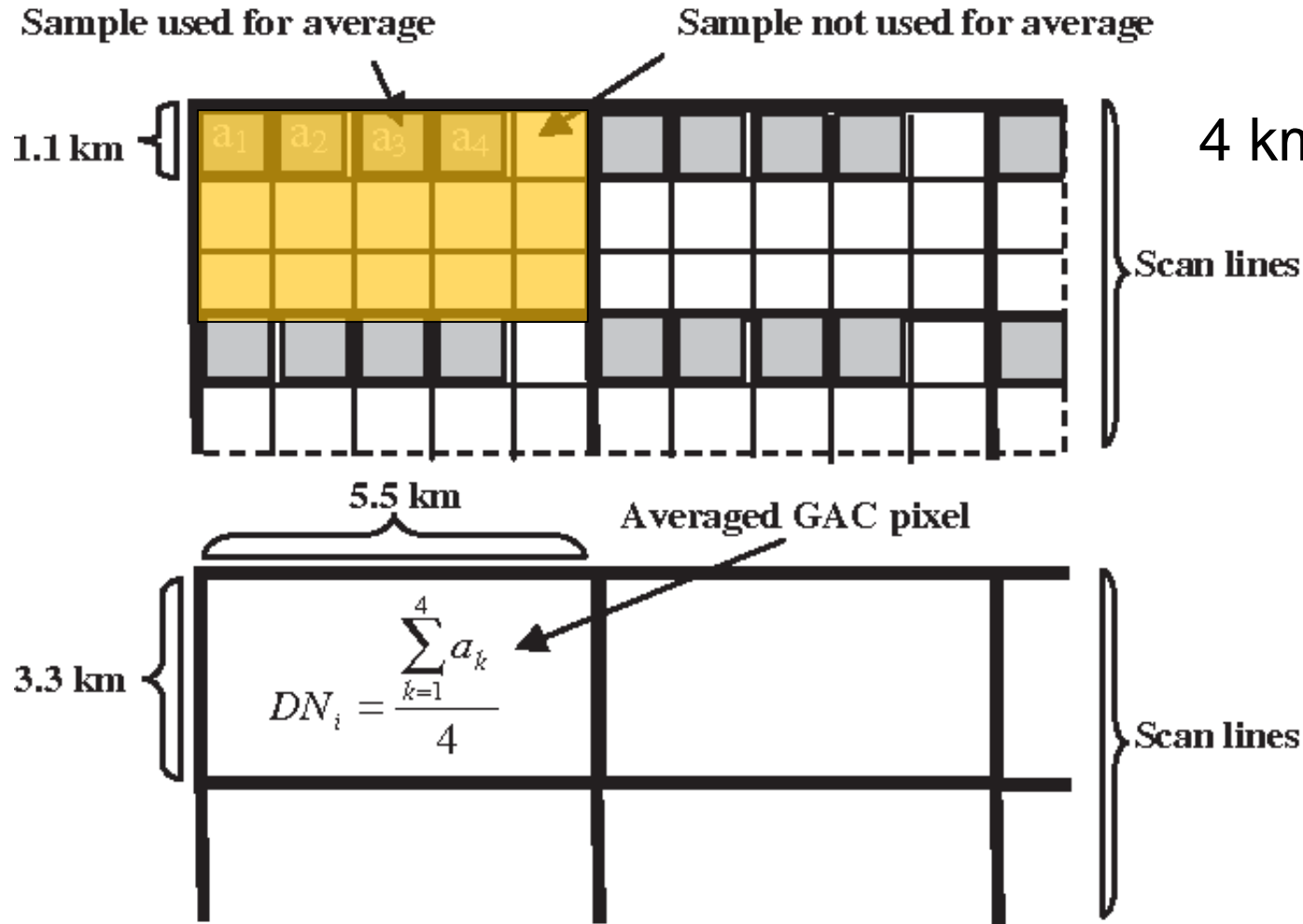
AVHRR Global Area Coverage (GAC) sampling scheme

LAC nadir: 1.1km

GAC: 3.3 km x 5.5km

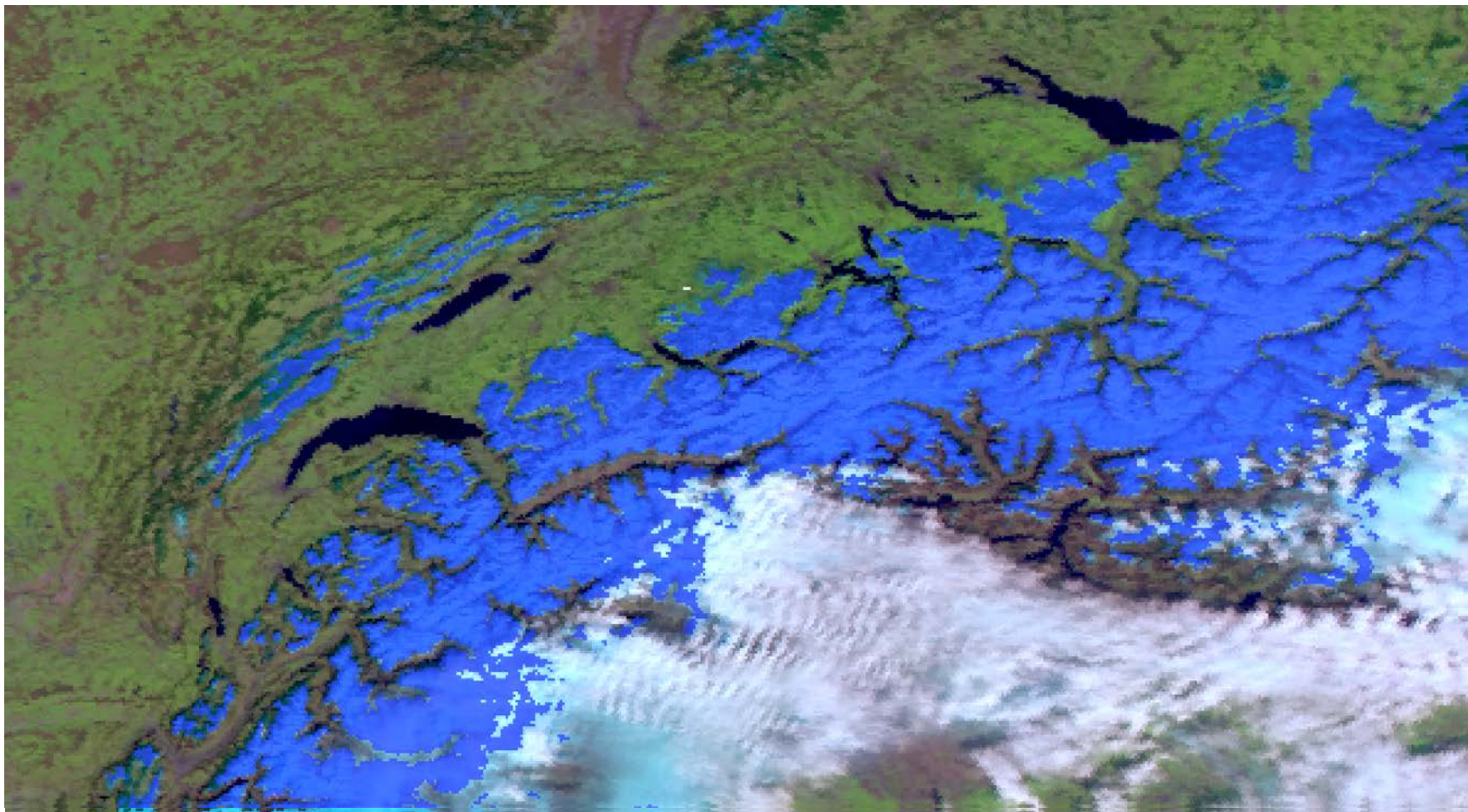
swath edge: 4 km x 6 km

12km x 30km



Often: GAC is gridded to 4km x 4km

Influence of GAC resampling on retrieval accuracy of ECVs (example snow cover extent (SCE))



LAC

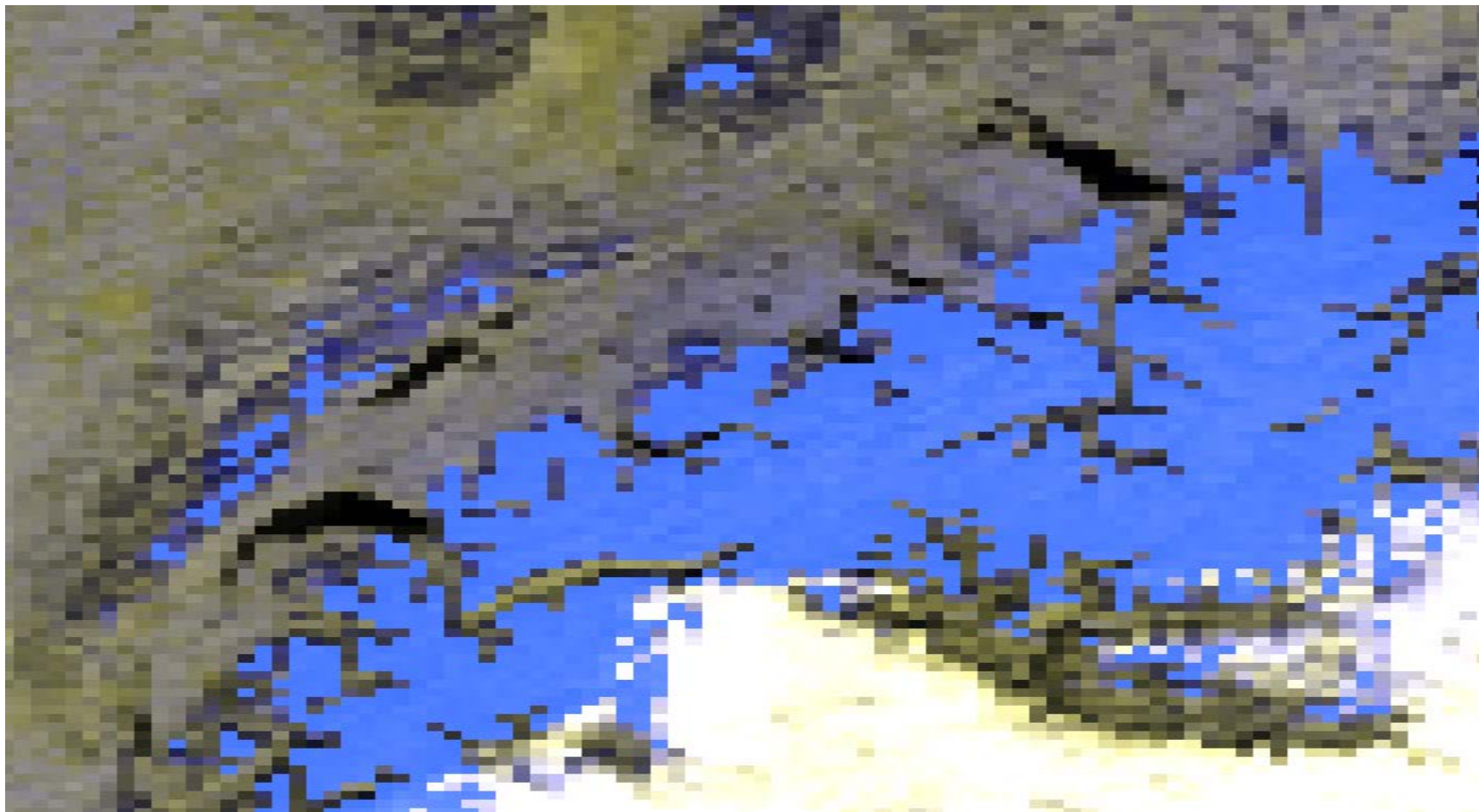
NOAA-17 AVHRR/3

11. March 2007

10:42 UTC

Received and
processed at UniBe

Influence of GAC resampling on retrieval accuracy of ECVs (example snow cover extent (SCE))



GAC

NOAA-17 AVHRR/3

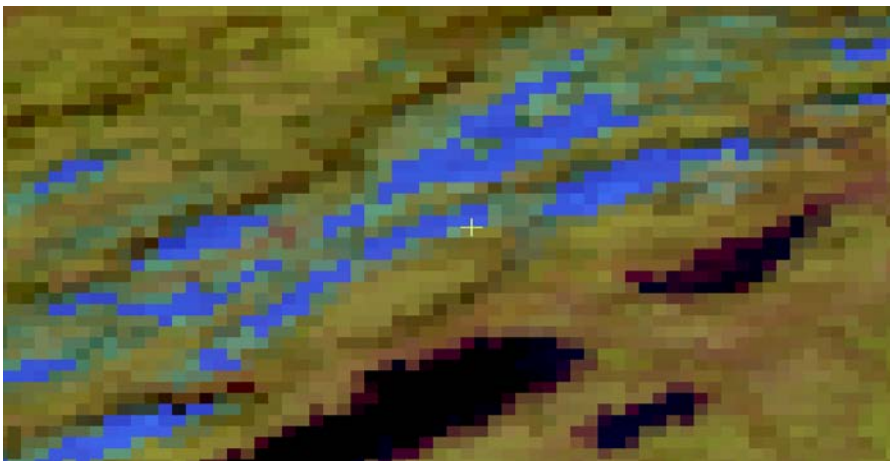
11. March 2007

10:42 UTC

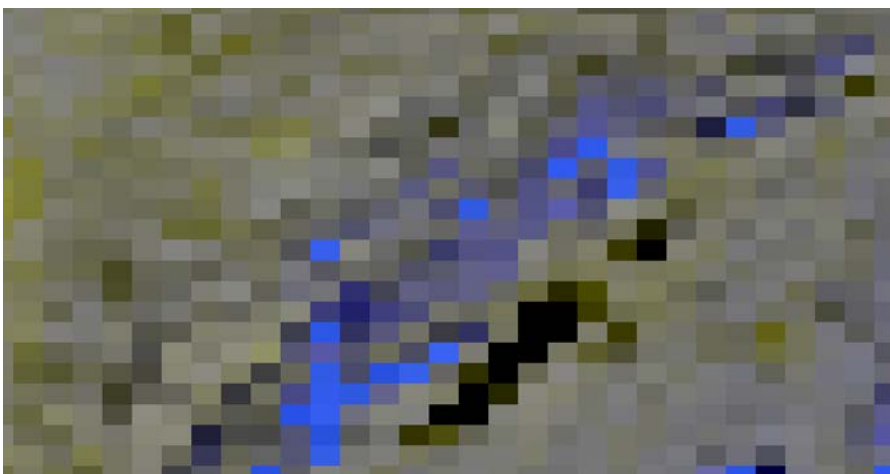
Resampled LAC →
GAC

Normalized Difference Snow Index (NDSI) of nadir pixels (THR > 0.4 → snow)

LAC



GAC

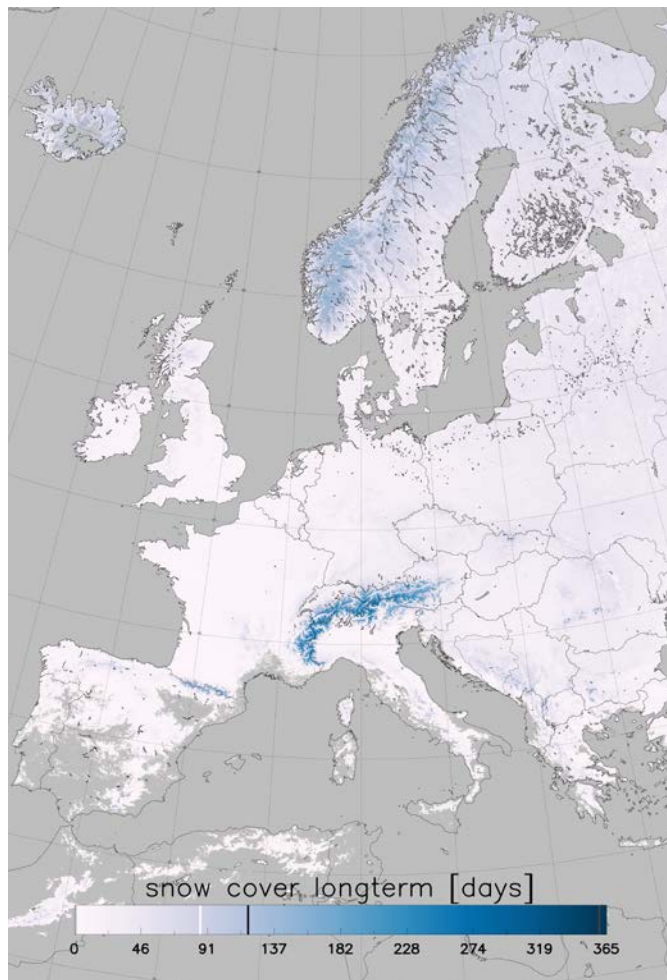


0.37	0.71	0.18	-0.05	0.43
0.41	0.86	0.78	0.04	0.21
0.38	0.61	0.29	0.89	0.12

GAC (NDSI): avg 0.30 → no snow
for 18.15 km² (3.3km x 5.5 km)

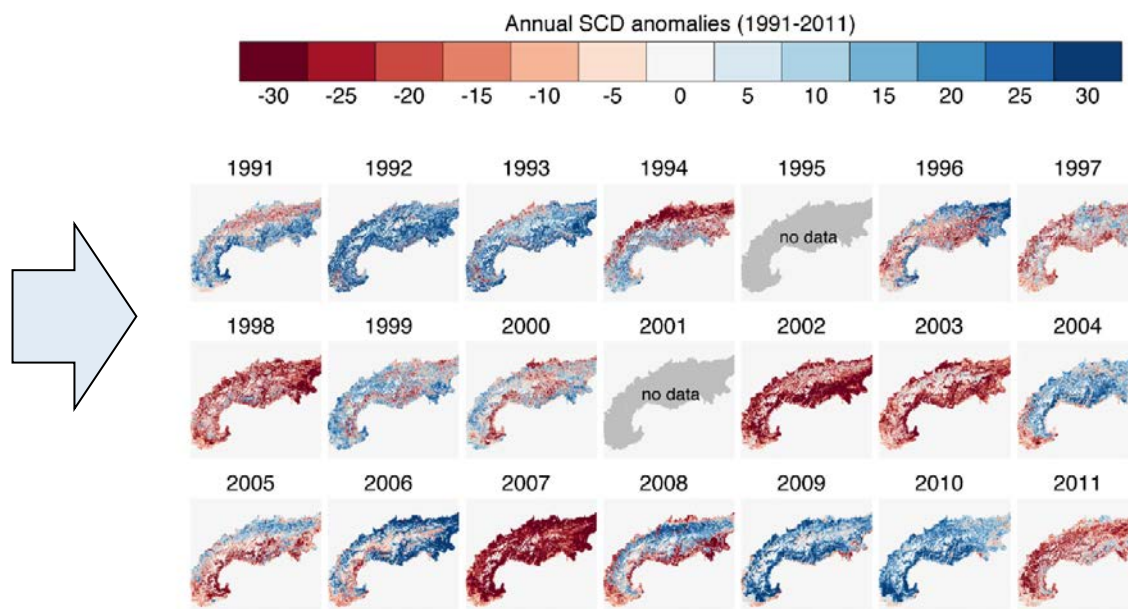
LAC (NDSI): THR 0.4 → snow for
8.47 km²

Snow cover duration in Europe retrieved from AVHRR data (1982 – 2017)

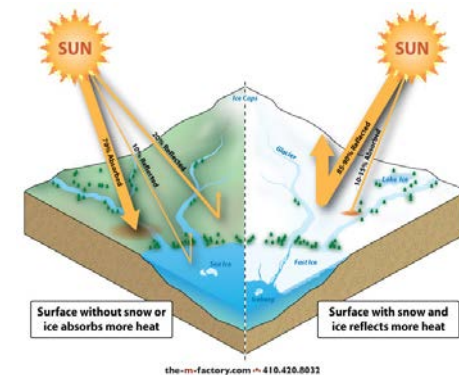
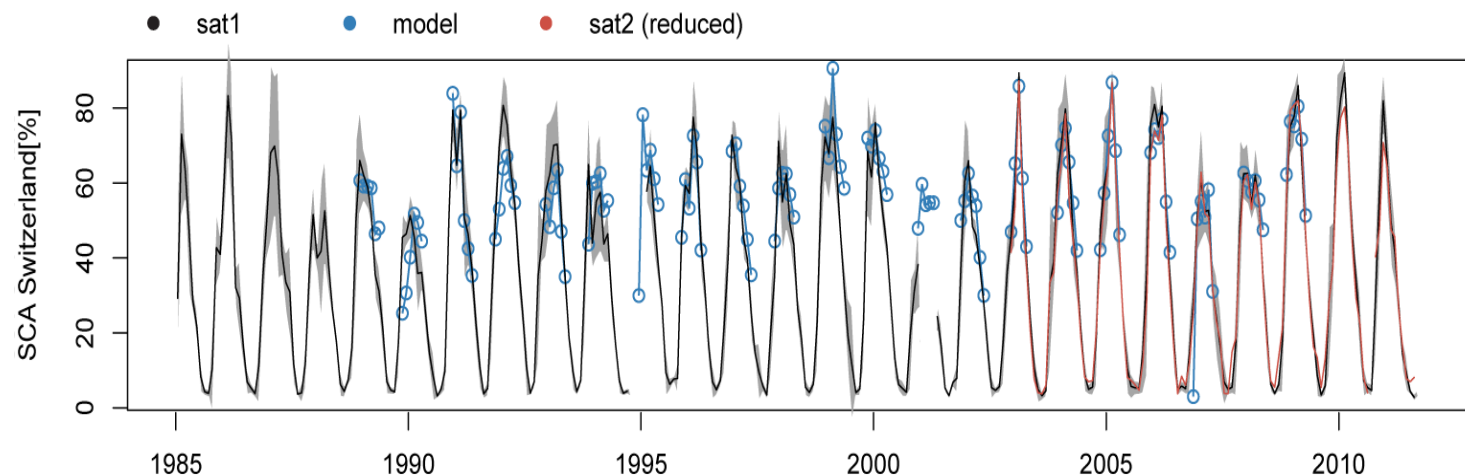


Snow cover distribution in Europe

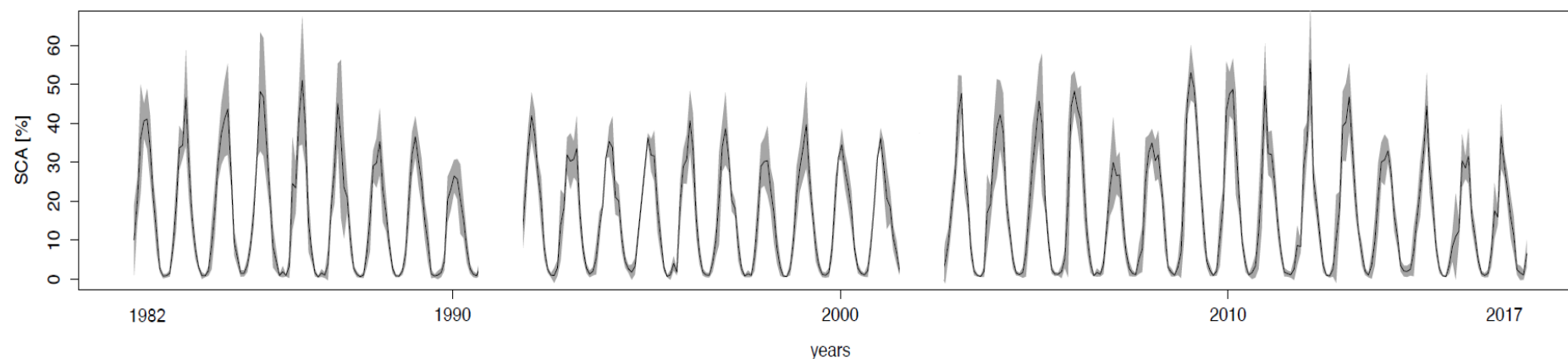
- retrieval using AVHRR data archived at University of Bern; spatial resolution: 1.1km; temporal resolution: daily; temporal and spatial gap filling



Snow cover time series based on AVHRR for Switzerland (up) and European Alps (low)



Snow Covered Area (SCA) of the European Alps (1982 - 2017)



How does this curve look using GAC data?

AVHRR GAC vs LAC

> AVHRR GAC:

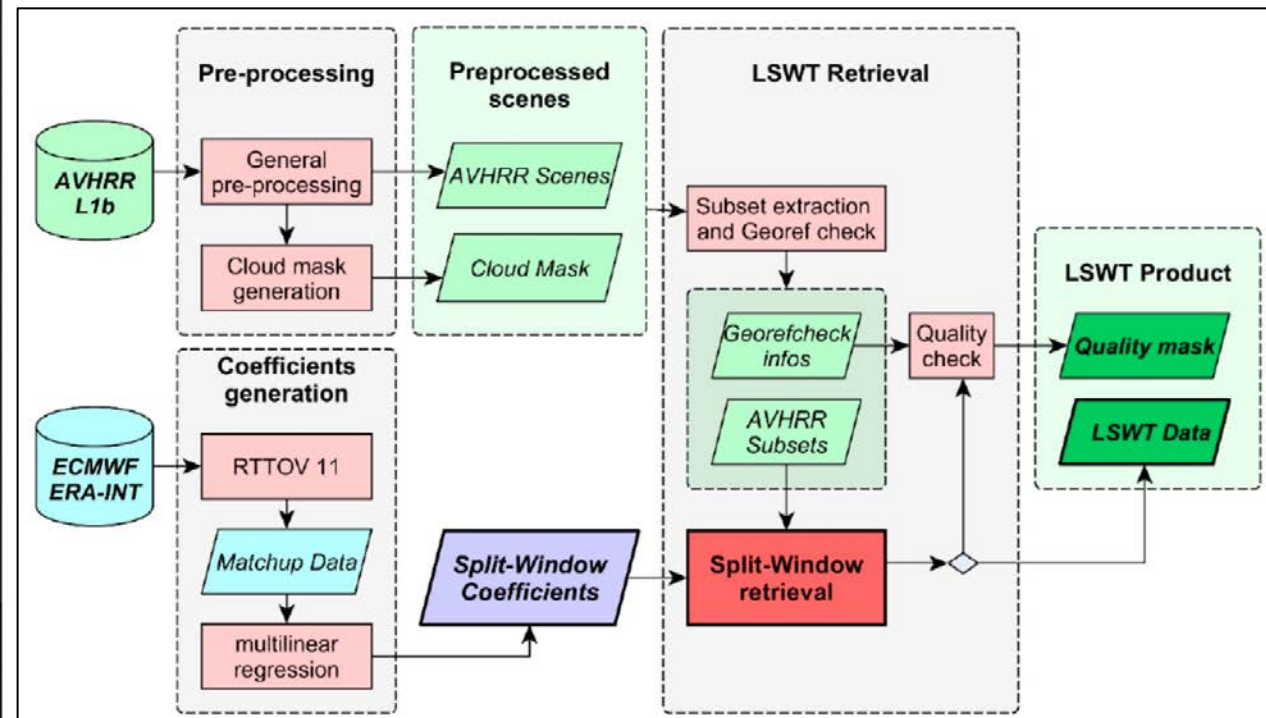
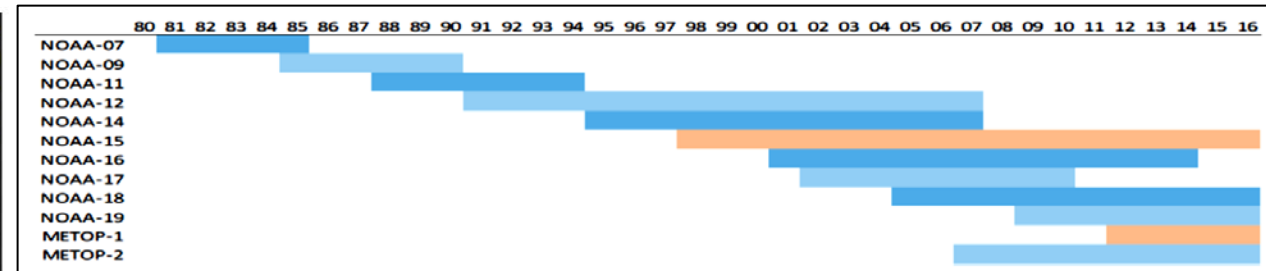
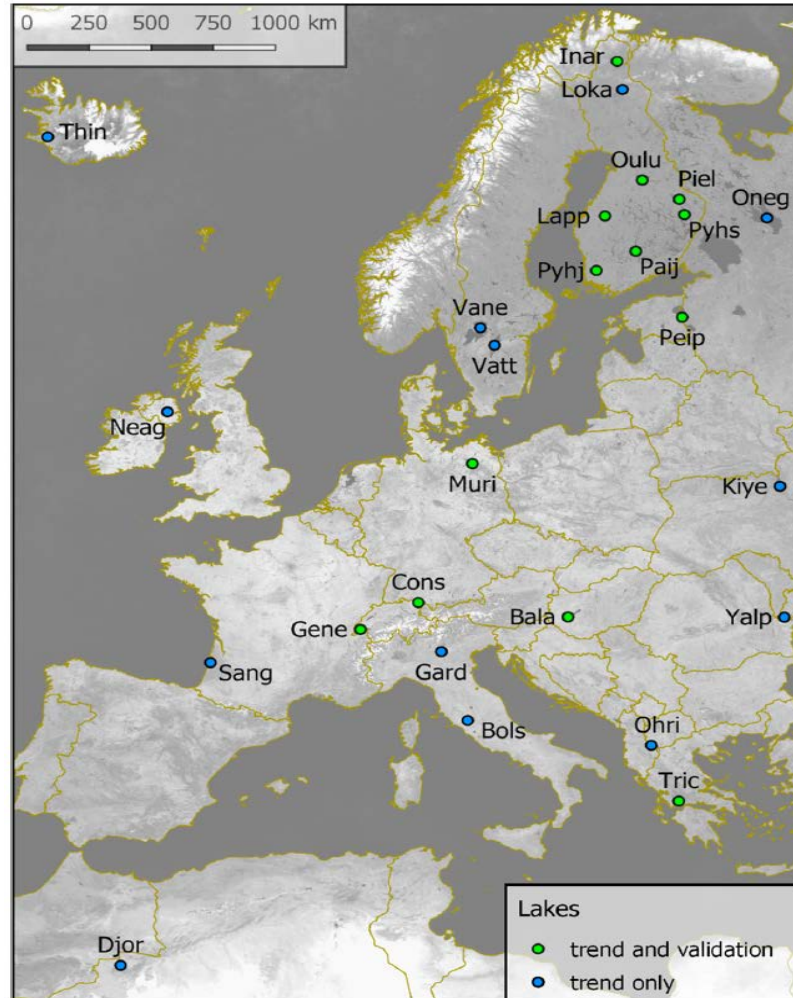
- Global available from 1981 – 2019
- Limited depth of pre-processing (geocoding based on time information)

> AVHRR LAC:

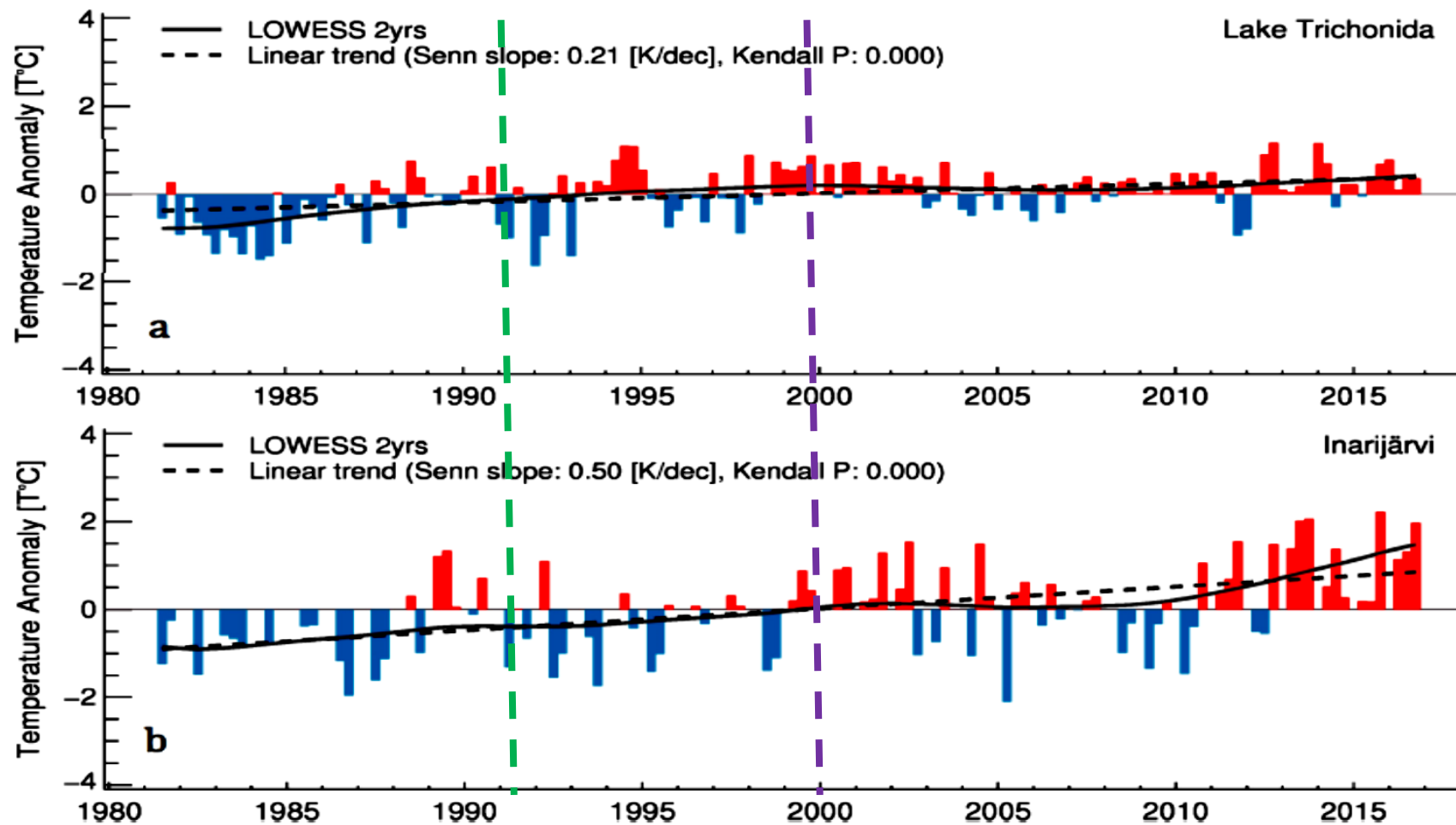
- spatial resolution of 1.1km (nadir) offers the possibility to map smaller features on ground (e.g. snow on mountains – NDVI in valleys; **small lakes** (3 km x 3km; albedo,))
- Correct the ortho-shift (orthorectification)
- Availability from 1981 – 2019 for some regions / continents
- Global availability: 1992 – 1997 (1999)

> **Difference between GAC and LAC depends on heterogeneity and scale of surface features.**

Lake Surface Water Temperature Derived from 35 Years of AVHRR Sensor Data for European Lakes

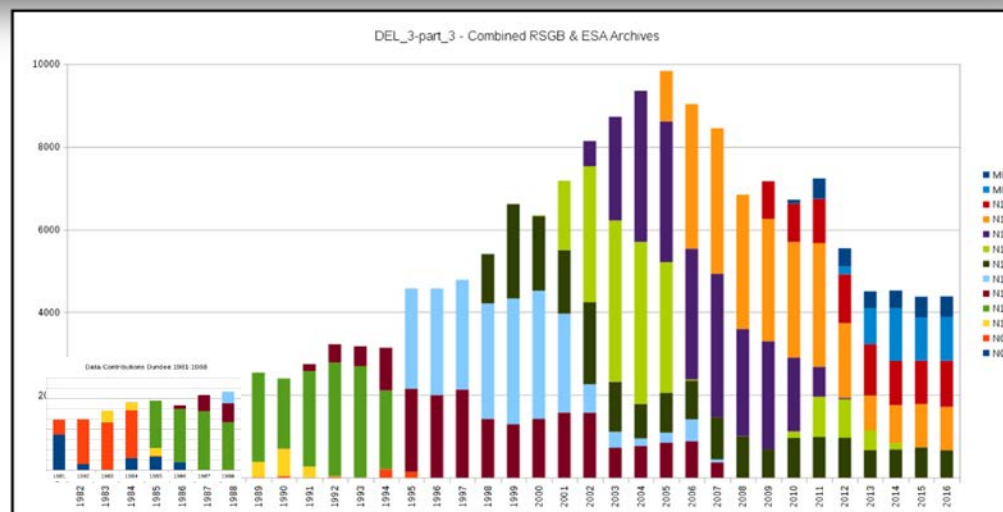
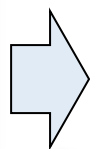


Anomaly of LSWT (1981 – 2016) for North-South transect



Keep the data alive!

AVHRR reception, coverage and data at University of Bern (1981 – 2019)

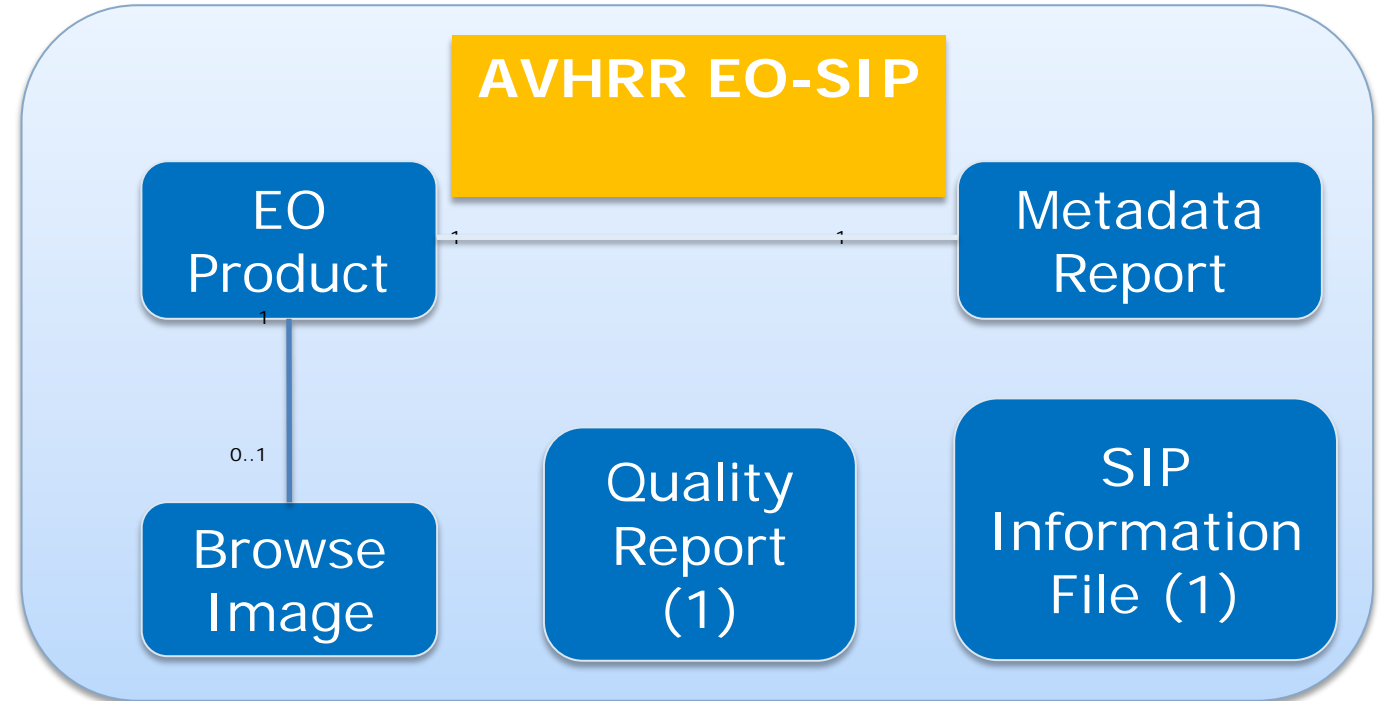


AVHRR data archived at UniBe from 1981 – ongoing

University of Bern AVHRR level 1b (120.000) data are transferred to ESA ESRIN in the frame of ESA's LTDP

Processing of ESA AVHRR will start soon (100.000)

- > EO-SIP (Earth Observation – Submission Information Package) structure, content and metadata attributes for the AVHRR products in scope, in line with the ESA Next Generation Multi-Mission PDGS Infrastructure, to be used for archiving and dissemination.



Synergy or complementary?

- > Only AVHRR GAC data fulfill the requirement of global time series of more than 30 years
- > The on-board resampling scheme generates an unknown uncertainty of retrieved ground information depending on topography and scale of land use; strong degradation of signal near edge of swath
- > Geocoding of GAC data can be improved to consider the ortho-shift
- > Retrieval schemes developed for LAC data can be applied for GAC but we should be aware of the differences, which may vary depending on ECV and scale of surface structure
- > **Study is needed to investigate the differences between LAC and GAC products and proof consistency over time**

Thank you!

Acknowledgements:

- Konstantin Khlopenkov
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- Dundee Satellite Receiving Station team
- CM-SAF team (Martin Stengel, Rainer Hollmann)

UniBern AVHRR receiving station; winter 2013