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Efforts and procedures to keep the data of old satellites sensors use- and accessible

The benefit of 40 years of AVHRR data

Stefan Wunderle, Christoph Neuhaus, Sergio Folco, Mirko Albani
Oeschger Centre for Climate Change Research
Institute of Geography
University of Bern
ESA – ESRIN Frascati

Advanced Very High Resolution Radiometer (AVHRR) 1978 – 2023 (2028)

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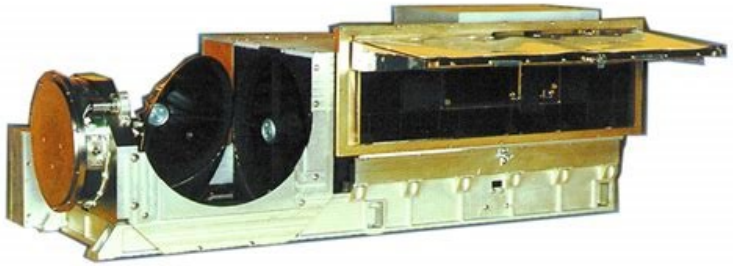

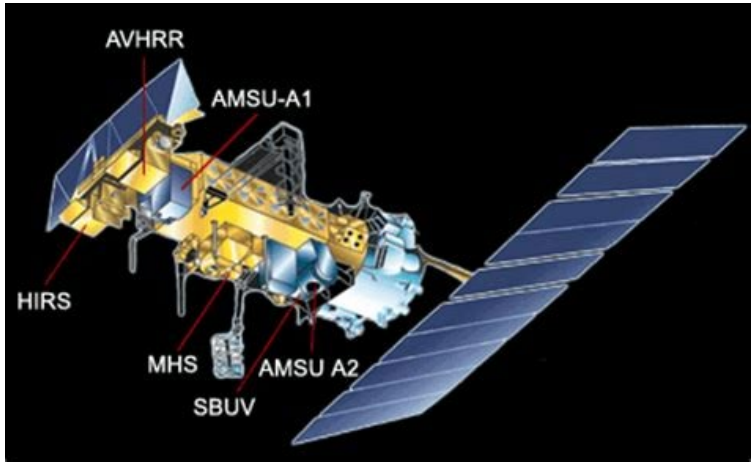

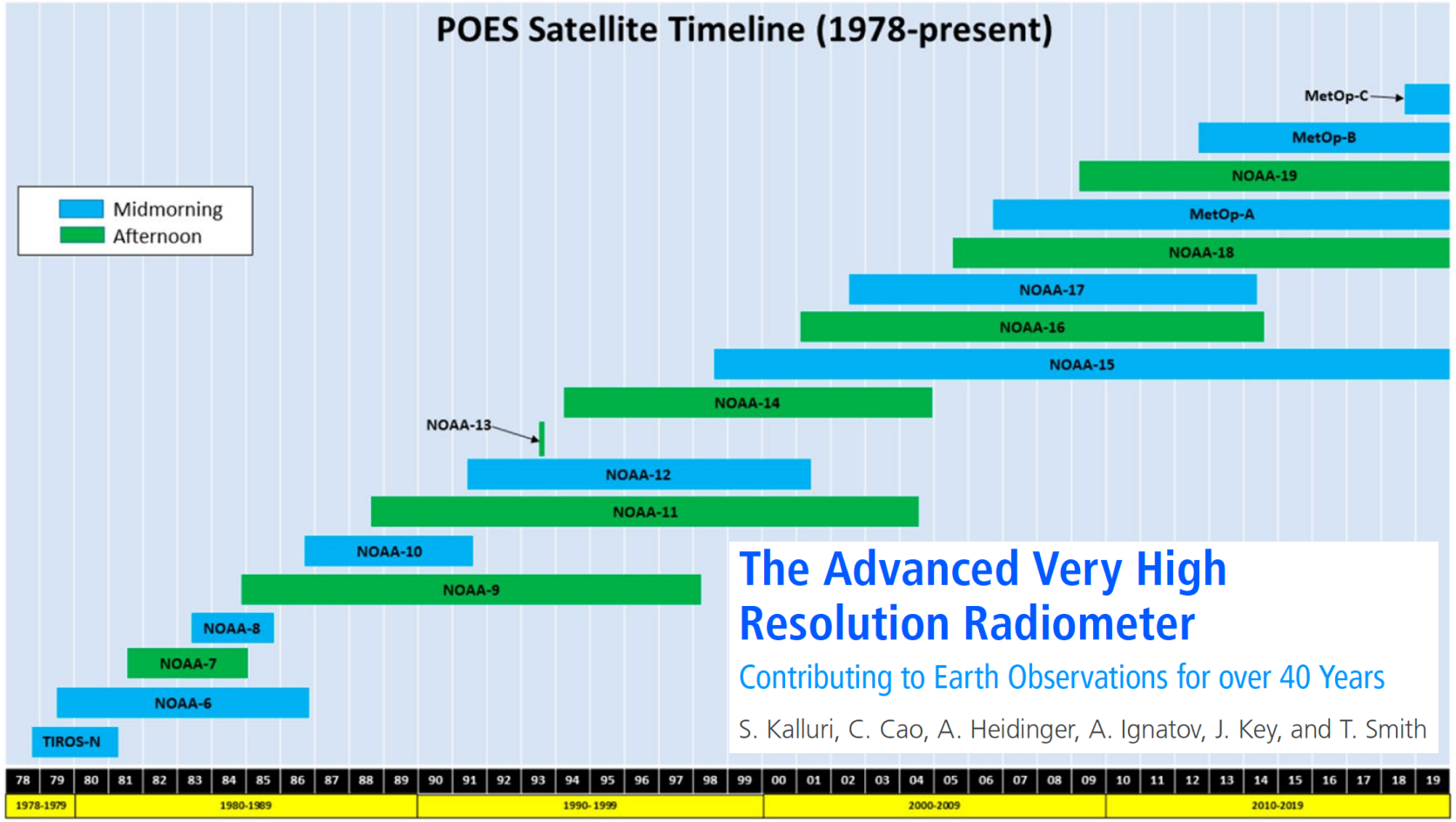

AVHRR – a success story. More than 40 years in orbit.

Channel configuration and satellite missions

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AVHRR/1

Central wavelength	Spectral interval
0.615 µm	0.55 - 0.68 µm
0.912 µm	0.725 - 1.10 µm
3.74 µm	3.55 - 3.93 µm
11.0 µm	10.5 - 11.5 µm

- NOAA 4th generation / Polar Operational Environmental Satellites (NOAA)
  - NOAA-8 (see instrument status) Mar 1983 - Dec 1985
  - NOAA-10 (see instrument status) Sep 1986 - Aug 2001
- National Oceanic and Atmospheric Administration - 4th generation (NOAA)
  - TIROS-N (see instrument status) Oct 1978 - Feb 1981
  - NOAA-6 (see instrument status) Jun 1979 - Mar 1987

AVHRR/2

Central wavelength	Spectral interval
0.615 µm	0.55 - 0.68 µm
0.912 µm	0.725 - 1.10 µm
3.74 µm	3.55 - 3.93 µm
10.80 µm	10.3 - 11.3 µm
12.00 µm	11.5 - 12.5 µm

- NOAA 4th generation / Polar Operational Environmental Satellites (NOAA)
  - NOAA-9 (see instrument status) Dec 1984 - Feb 1998
  - NOAA-11 (see instrument status) Sep 1988 - Jun 2004
  - NOAA-12 (see instrument status) May 1991 - Aug 2007
  - NOAA-13 (see instrument status) Aug 1993 - Aug 1993
  - NOAA-14 (see instrument status) Dec 1994 - May 2007
- National Oceanic and Atmospheric Administration - 4th generation (NOAA)
  - NOAA-7 (see instrument status) Jun 1981 - Jun 1986

AVHRR/3

Central wavelength	Spectral interval
0.630 µm	0.58 - 0.68 µm
0.862 µm	0.725 - 1.00 µm
1.61 µm	1.58 - 1.64 µm
3.74 µm	3.55 - 3.93 µm
10.80 µm	10.3 - 11.3 µm
12.00 µm	11.5 - 12.5 µm

- EUMETSAT Polar System (EUMETSAT)
  - Metop-A (see instrument status) Oct 2006 - Nov 2021
  - Metop-B (see instrument status) Sep 2012 - 2024
  - Metop-C (see instrument status) Nov 2018 - 2027
- NOAA 5th generation / Polar Operational Environmental Satellites (NOAA)
  - NOAA-15 (see instrument status) May 1998 - 2024
  - NOAA-16 (see instrument status) Sep 2000 - Jun 2014
  - NOAA-17 (see instrument status) Jun 2002 - Apr 2013
  - NOAA-18 (see instrument status) May 2005 - 2024
  - NOAA-19 (see instrument status) Feb 2009 - 2024

https://space.oscar.wmo.int/instruments/view/avhrr_3

ESA Heritage Programme and University of Bern experience in AVHRR processing

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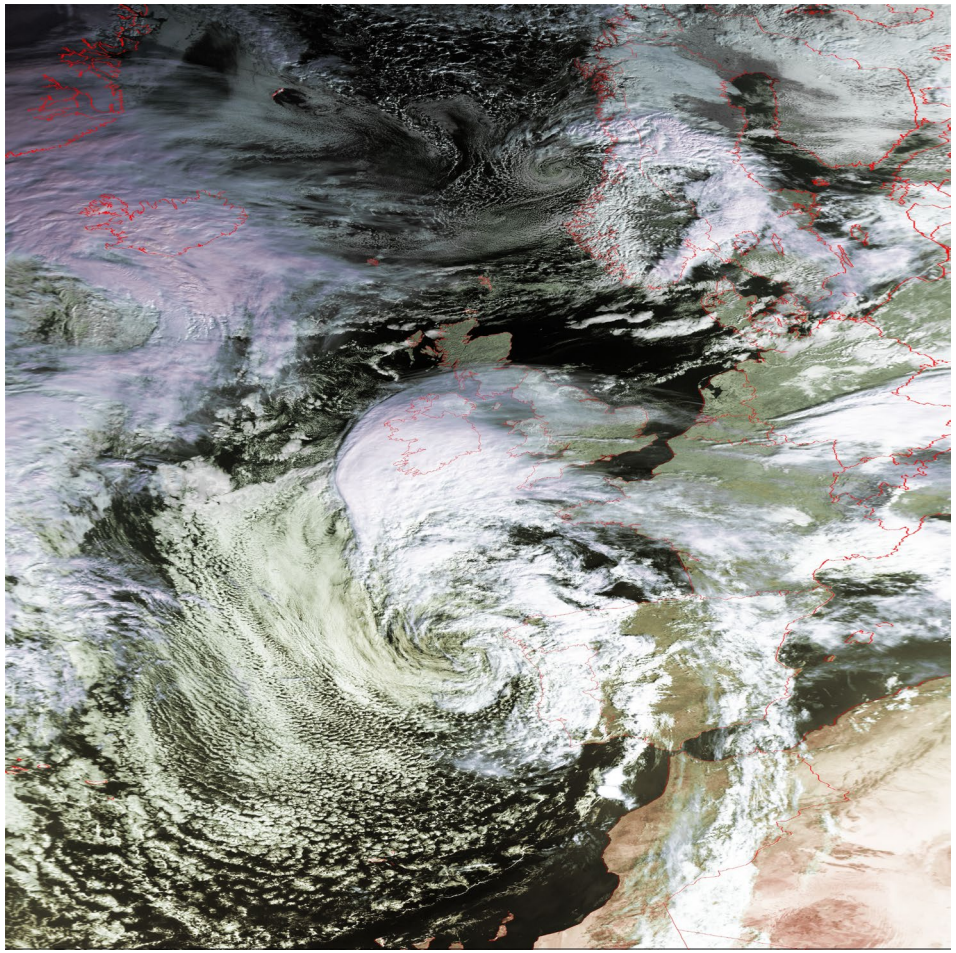
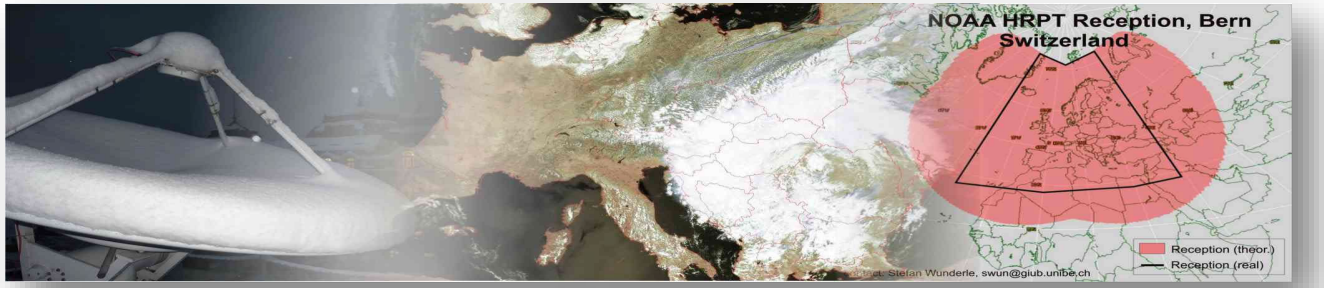
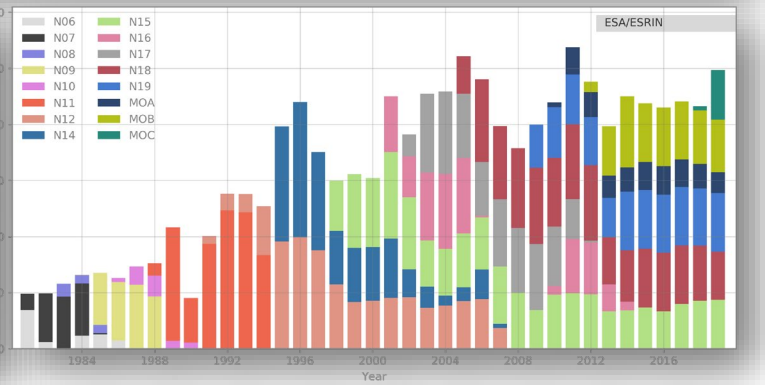


MetOp-B_20231017103930

- UniBern – long tradition of AVHRR reception, processing and retrieval of ECVs
- We see the need to make historical data accessible to the public and keep the data alive for an unlimited time.





ESA's Climate Change Initiative relies on long time series based on satellite data to retrieve ECV's

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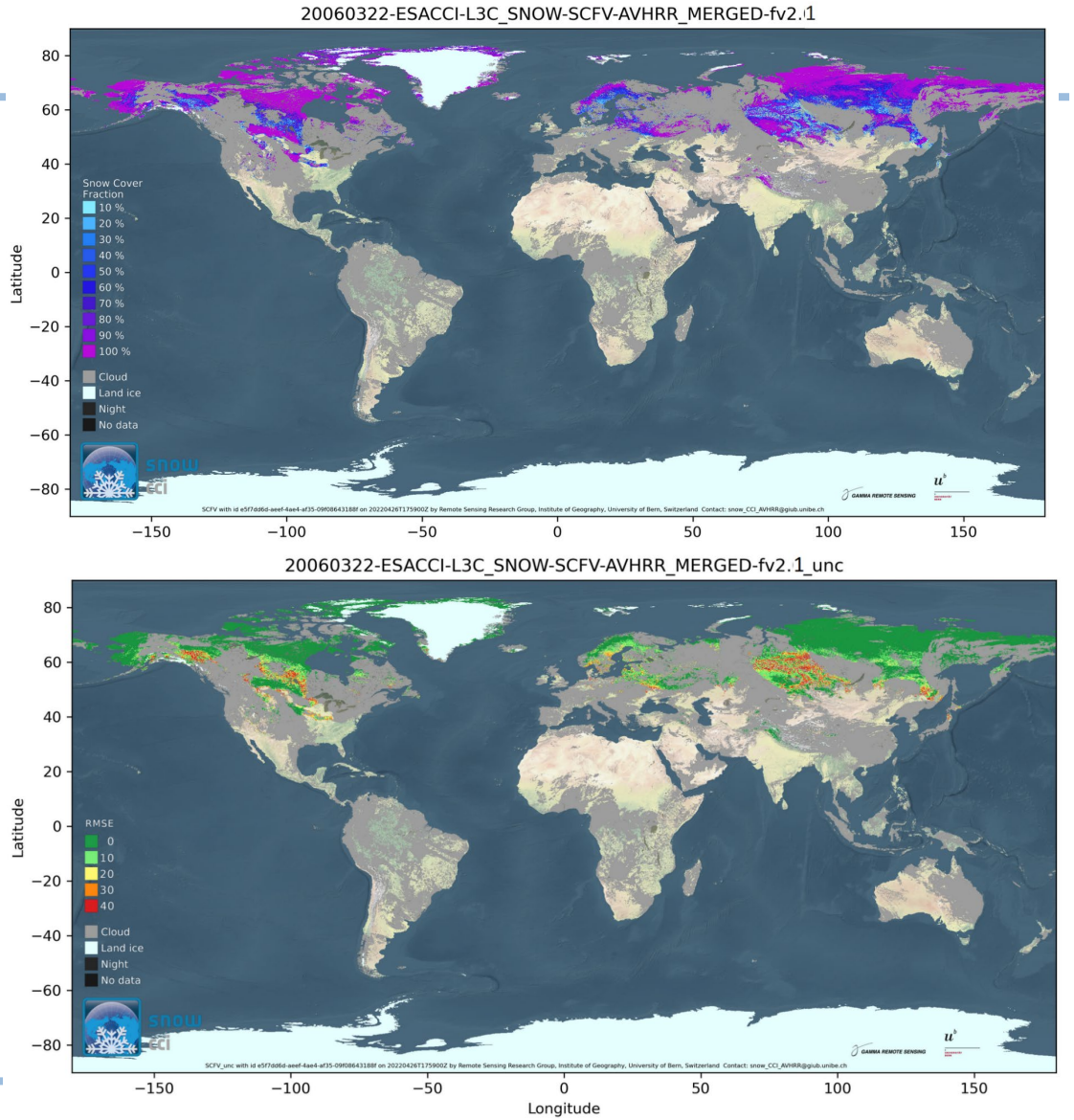
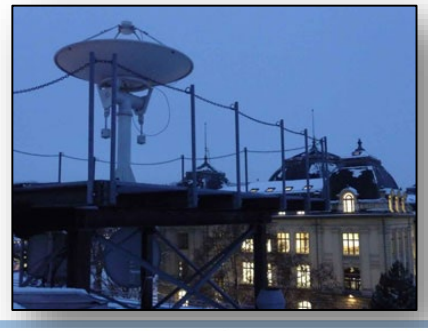
ESA's Climate Change Initiative performs R&D to generate pre-operational products and processing systems for over 25 Essential Climate Variables

AVHRR Snow Cover Fraction (global) by University of Bern

- Aim: consistent SCFV/SCFG (1978 – 2023)
- Data source:
  - AVHRR GAC, reprocessed by EUMETSAT
  - Morning and afternoon passes
  - CLARA-A3 daily composites from CM SAF
- Product availability:
  - Daily time series (V2.0) from 1982 - 2018
  - ESA CCI open data portal
  - V3.0 from 1980 – 2022 in process

Right: SCFV and uncertainty (20060322) based on AVHRR GAC





Lake Surface Water Temperature LSWT derived from AVHRR

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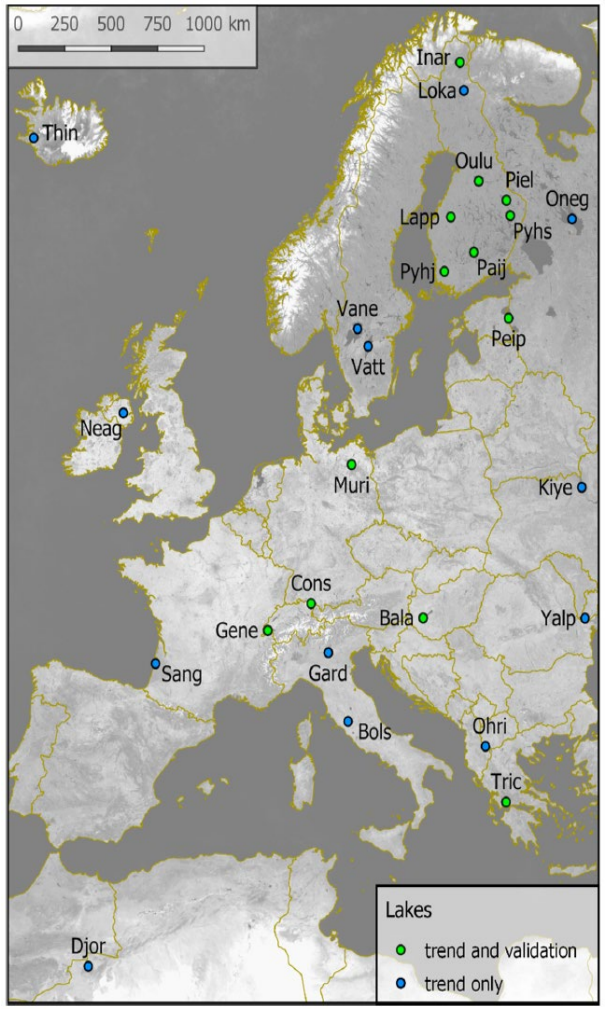
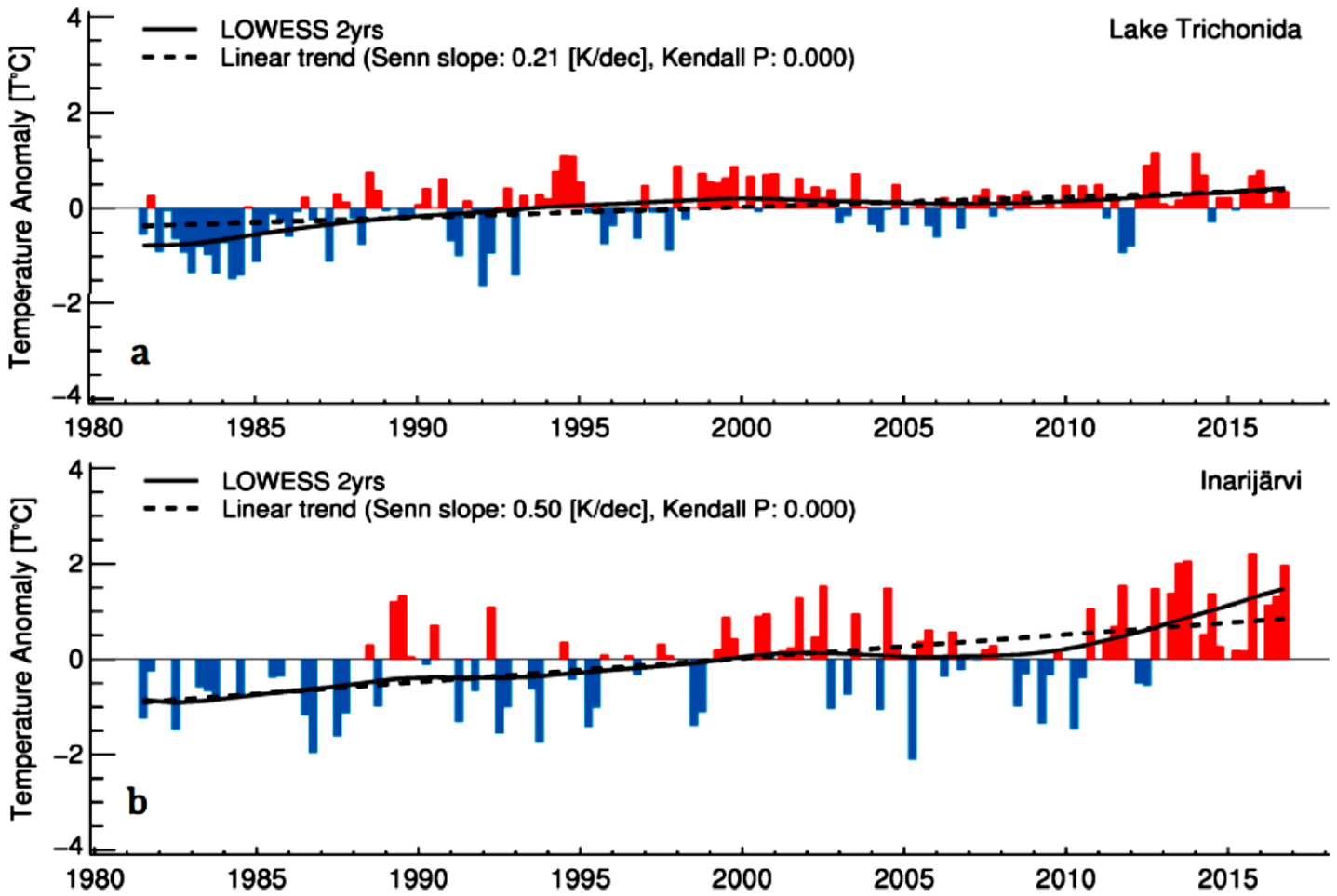
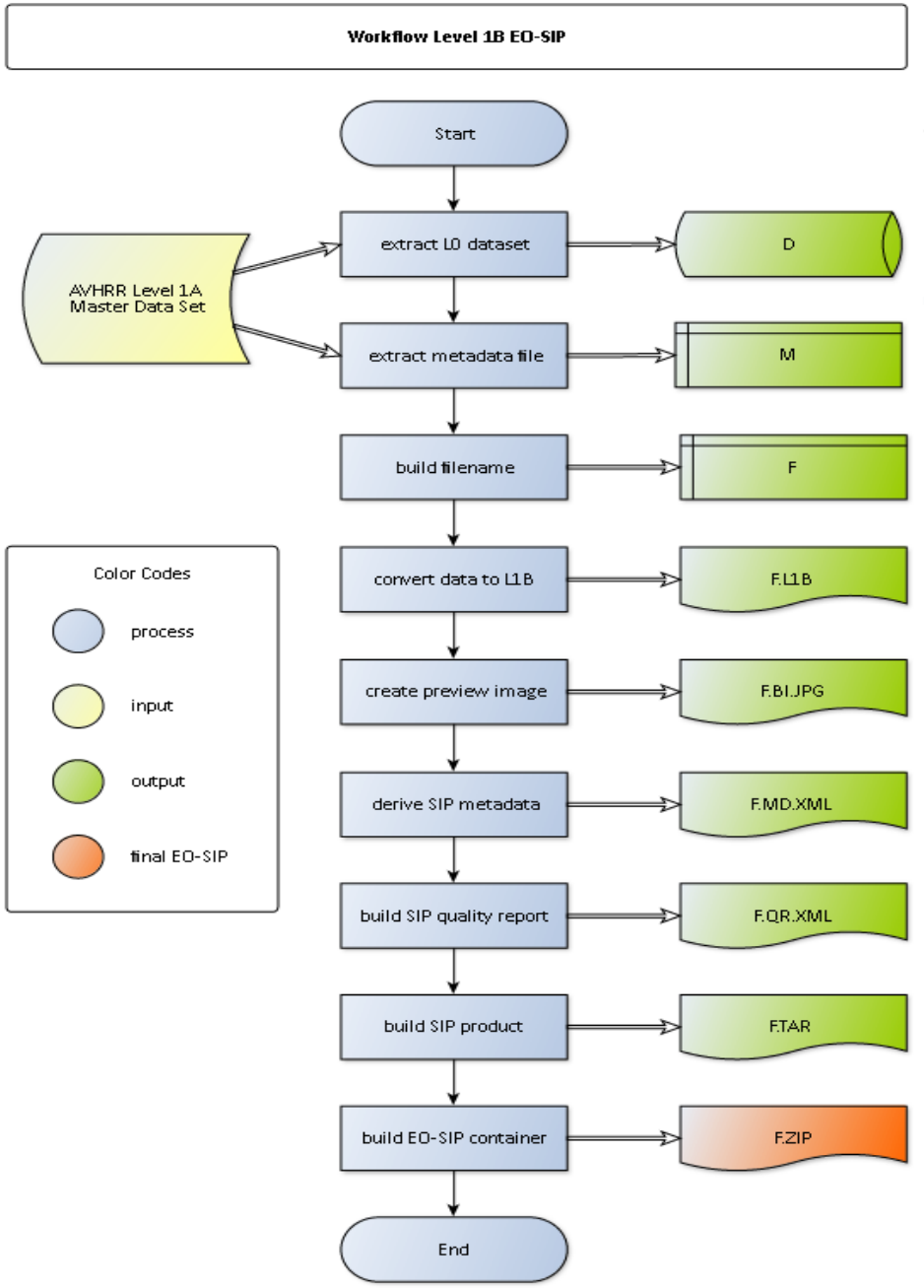




Lieberherr, Gian; Wunderle, Stefan (2018). *Lake Surface Water Temperature Derived from 35 Years of AVHRR Sensor Data for European Lakes.* Remote sensing, 10(7),

DEL-5: AVHRR master data set consolidation procedure, reprocessing

- Definition of EO-SIP content and structure
- Definition of NOAA AVHRR Level 0, Level 1A and Level 1B
  - Recommendation from expert group: provide the Level 1B data set
- Quality report
  - File integrity (checksum MD5), file content, processing
- Reprocessing procedure
  - Different archives; inventory files
  - Logical structure is to start with Level 0 → Level 1B
  - EO-SIP generation



EO-SIP package (Earth Observation – Submission Information Package)

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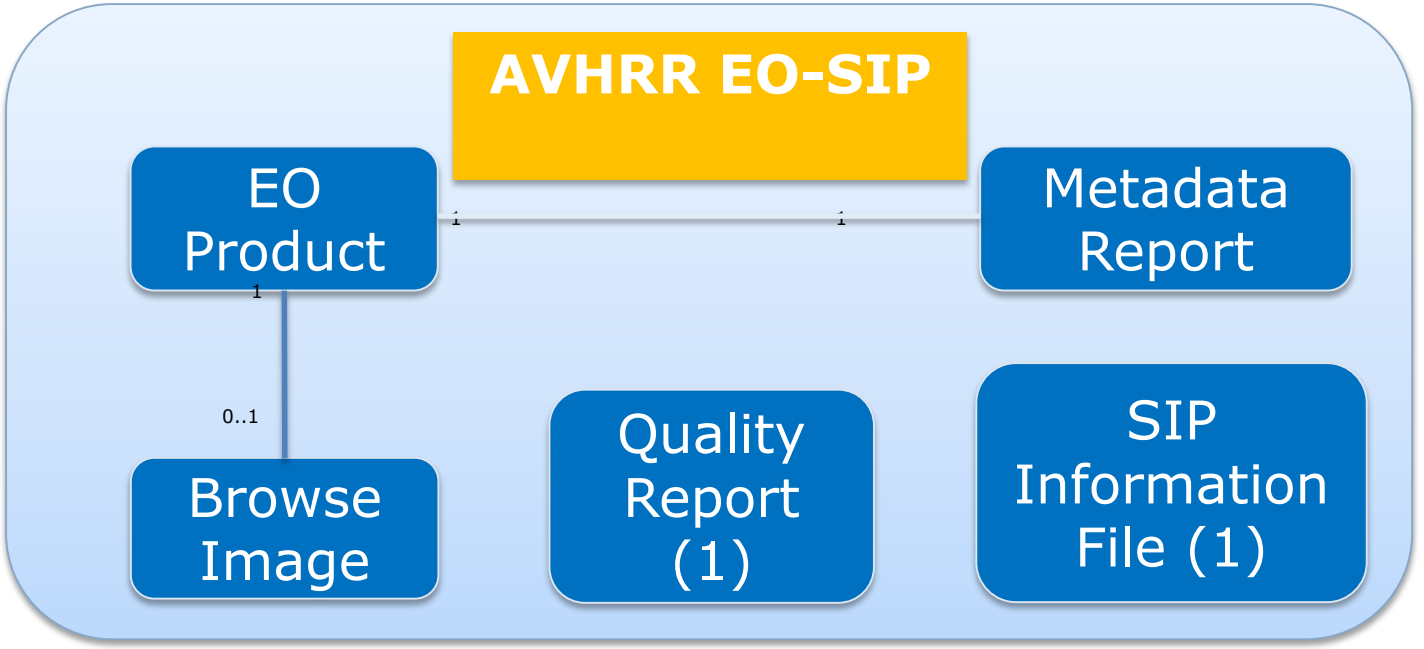
EO-SIP package structure, content and metadata attributes for the AVHRR products in scope, in line with the ESA infrastructure, to be used for archiving and dissemination.



European 1-km AVHRR archive hosted at ESA includes data from University of Bern, Dundee Satellite Receiving Station and ESA holdings. Period: 1981 - 2021

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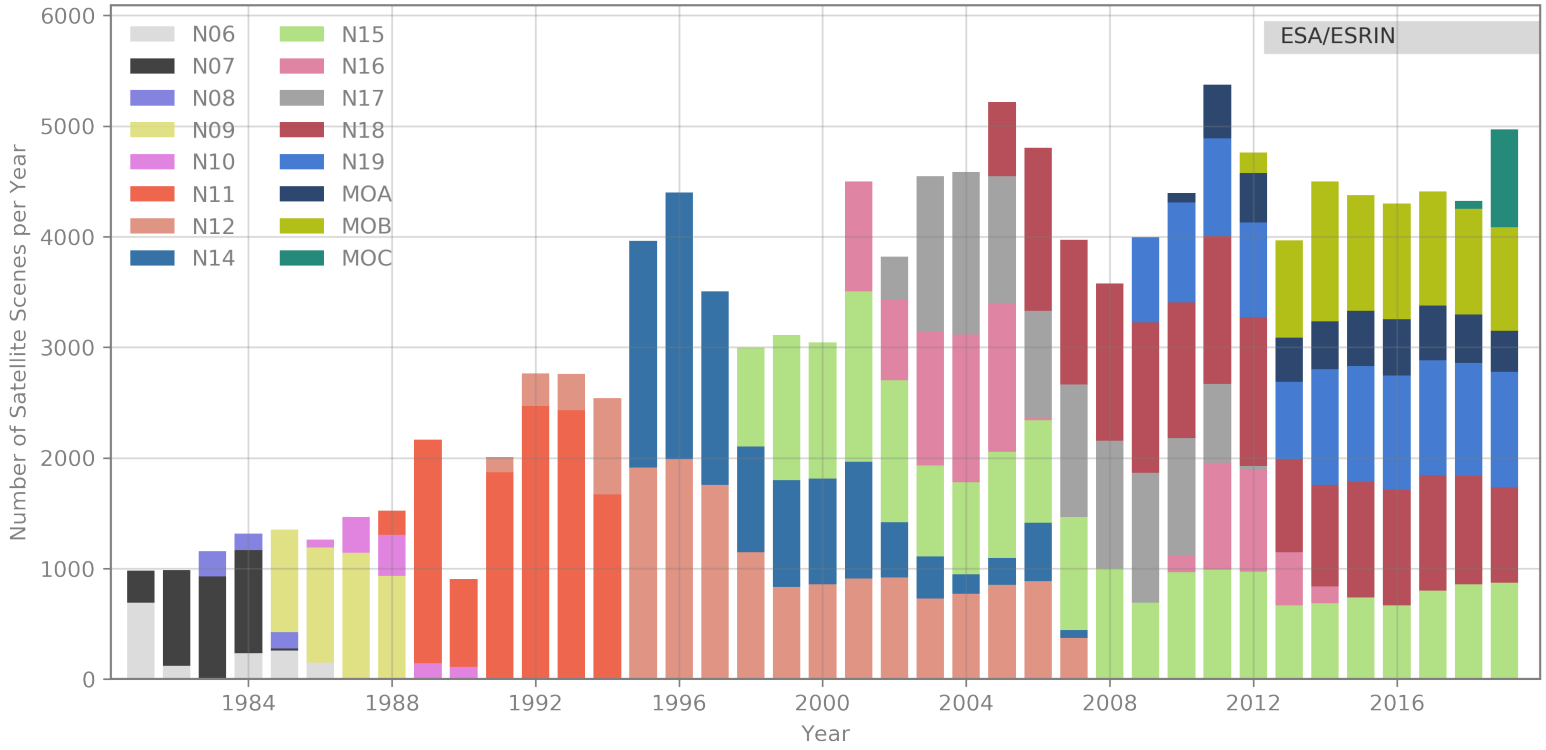
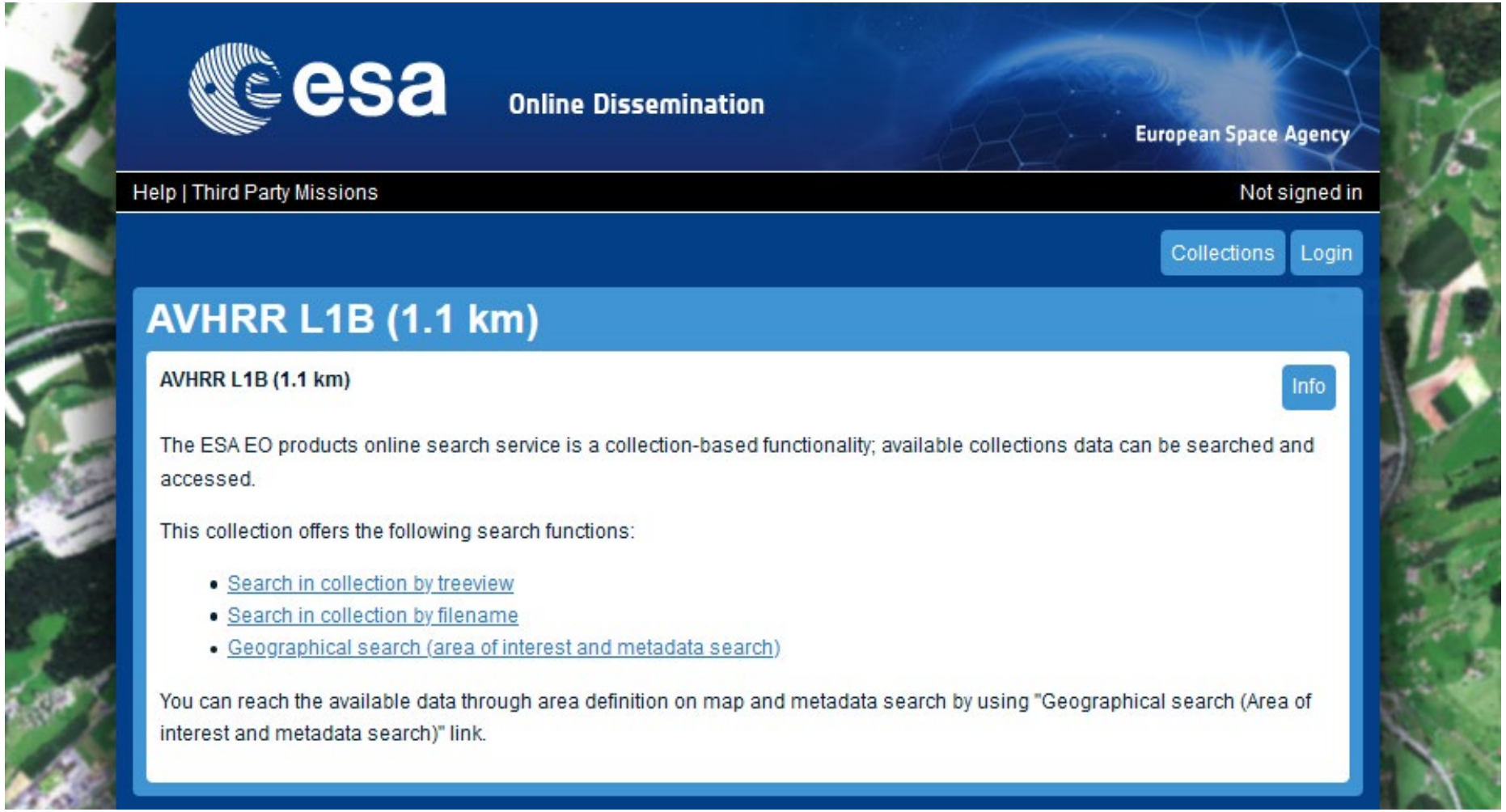


- Two-ten overpasses per day.
- Dataset consists of more than **260.000 data products** harmonized and consolidated through a dedicated ESA project (Heritage Space Programme).
- All accessible **free of charge via ESA dissemination services.**
- **Archived for unlimited time by ESA.**
- Processing to Level-1c ongoing.

https://earth.esa.int/eogateway/catalog/avhrr-level-1b-local-area-coverage-imagery

ESA Online Dissemination – AVHRR L1B data

https://tpm-ds.eo.esa.int/oads/access/collection/NOAA_AVHRR_L1B_LAC



esa Online Dissemination

European Space Agency

Third Party Missions on Earth Online | Not signed in

Collections | Login

Tree view: year, month and day

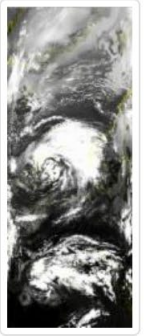
AVHRR L1B (1.1 km) Info

Collection	AVHRR L1B (1.1 km)
Year	1985
Month	05
Day	24

Available products (3)

N09_RPRO_AVH_L1B_1P_19850524T131432_19850524T132907_002301_v0100.ZIP

Download Product | Product Info | Browse | Download Metadata File | Download Quality Report



Start Date:	1985-05-24T13:14:32Z
Stop Date:	1985-05-24T13:29:07Z
Orbit:	2301
Orbit Direction:	ASCENDING
Product Type:	AVH_L1B_1P
Satellite:	NOAA 09

esa Online Dissemination

European Space Agency

Third Party Missions on Earth Online | Not signed in

Collections | Login

Tree view: year, month and day

AVHRR L1B (1.1 km) Info

Collection	AVHRR L1B (1.1 km)
Year	2020
Month	09
Day	19

Available products (10)

N19_RPRO_AVH_L1B_1P_20200919T174836_20200919T180150_059871_v0100.ZIP

Download Product | Product Info | Browse | Download Metadata File | Download Quality Report

Start Date:	2020-09-19T17:48:36Z
Stop Date:	2020-09-19T18:01:50Z
Orbit:	59871
Orbit Direction:	ASCENDING
Product Type:	AVH_L1B_1P
Satellite:	NOAA 19

Summary and Outlook

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> Summary

- A homogenous and consolidated AVHRR LAC time series (1981 – 2021) is now available via ESA dissemination service.
- More than 250.000 AVHRR data (level 1b) covering Europe are ready to be used
- Approx. 55.000 CEOS Sharp-1 segments were rescued, re-processed in a consistent way (EO-SIP) and are accessible via ESA dissemination service, too.
- Software and processing procedure developed at University of Bern is installed and tested at ESA facilities.
- Ongoing activity: generation of Level 1c data (calibrated and geocoded, in NetCDF format) for a better service to support communities without the needed expertise in AVHRR processing.

Outlook: 1 km AVHRR Land Project Data: 1992 to end 1999 – strong need to get access to the original swaths

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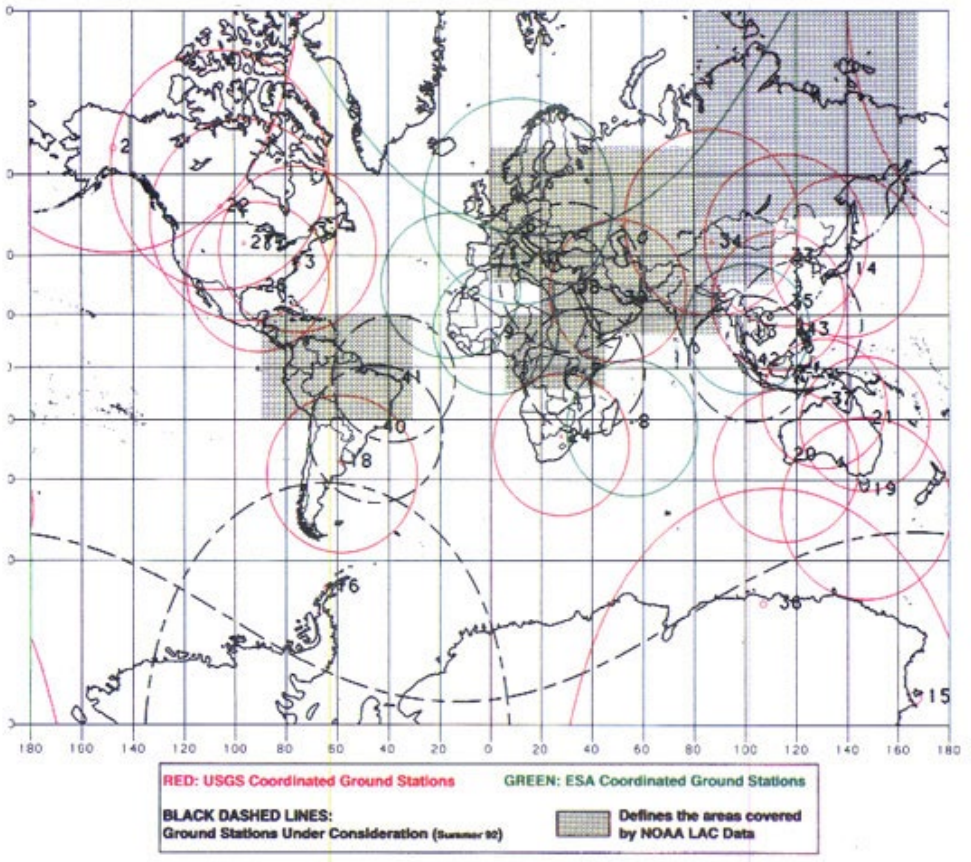
- USGS, NOAA, ESA and other non-US AVHRR receiving stations collected a global land 1-km multi-temporal AVHRR data set using NOAA's TIROS "afternoon" polar-orbiting satellite.
  - 23 stations worldwide divided in two groups plus the NOAA local area coverage (LAC) on-board recorders.
  - The global land 1-km AVHRR dataset is composed of 5 channels, raw AVHRR dataset at 1.1 km resolution from the NOAA-11 and NOAA-14 satellites covering land surfaces, inland water and coastal areas.
- **Stitched data from stations under USGS responsibility are available at ESA but not suitable for reprocessing and alignment to European Master Dataset.**
  Coordination ongoing with NOAA and USGS to retrieve the 31597 original (non-stitched) data.



Global Land 1 km AVHRR Data Set Project HRPT Ground Station Network (as of 1 April 1992) and Acquisition Areas for LAC Recorded Data

Next steps on the way to an AVHRR FDR following the definitions by GEOS / CGMS

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- Steps to bring the European AVHRR master data set (**1980 – 2023**) to a FDR:
  - **improved navigation, geocoding incl. orthorectification**
  - **inter-satellite calibration (all channels)**
  - **treatment of solar contamination in thermal channels**
  - reflective part of ch3 incl. better handling of noise
  - orbit drift (natural trend vs. trend caused by orbit drift)
  - **And adding uncertainty!**
- **Outlook**
  - New project to generate an AVHRR FCDR will start Dez.1, 2023; duration: 24 months
  - Consortium: Remote Sensing Group (lead), UoReading / NPL (uncertainty), SMHI (PyGAC development)
  - AVHRR FDR (ARD) will be available via ESA dissemination service.