WGISS-58
AVHRR Data Recovery Project Updates

CEOS
Committee on
Earth Observation Satellites

M.Albani, ESA

Agenda Item 3.1

WGISS-58

16-17 October 2024

Sioux Falls, South Dakota, USA

AVHRR a unique long time data series

AVHRR data available as GAC (4 km) or LAC (1km). 1-km AVHRR LAC data gives new insights on structural changes on land in comparison of coarse resolution AVHRR GAC data.

GAC DATASETS

- NOAA POES AVHRR GAC global archive: 1978 onwards

LAC DATASETS

- EUMETSAT MetOp AVHRR 1km FRAC global archive: March 2008 onwards
- Global Land 1-km AVHRR data set covering the period 1992-99 *“1Km project”*
- Many national / regional data archives of LAC data around the world covering a longer period with high value for the retrieval of ECVs. Some of them accessible to users, others not due to unknown accessibility, responsibility, data format and structure.

AVHRR 1 Km digital data archives (excerpt)

- **Europe**: ESA & University of Bern (Switzerland), STFC CEDA (UK, including Dundee Satellite Receiving Station), MeteoFrance (France), DLR (Germany), METoffice (UK), IGiK (Poland);
- **Americas**: NOAA and USGS (USA), NRCan/CCMEO (Canada), GiDyC-Servicio Meteorológico Nacional (Argentina), INPE (Brazil);
- **Africa**: SANSA (South Africa), ASI / University of Rome (Kenya);
- **Asia**: CMA (China), IRIM (Mongolia), GITSDA (Thailand), Jaxa (Japan), ISRO (India);
- **Australia**: CSIRO.

- Datasets from Meteorological Institutes, Universities and other organizations all over the globe

Fundamental to ensure accessibility of 1-km LAC data from all available sources (in particular in the period before 2008)

Cooperation Activities on AVHRR

Objective: Build a worldwide coverage AVHRR LAC data series from 1978 onwards

1. Unfolding and making accessible 1km AVHRR data from regional archives (possibly open and free);

2. Transcribing unique data from heritage media;

3. Identifying a common format for AVHRR Level-1b and Level-1c data and pursuing (re)processing from AVHRR data owners/holders and data accessibility;

4. Facilitating data discovery through the WGISS Connected Data Assets Infrastructure.

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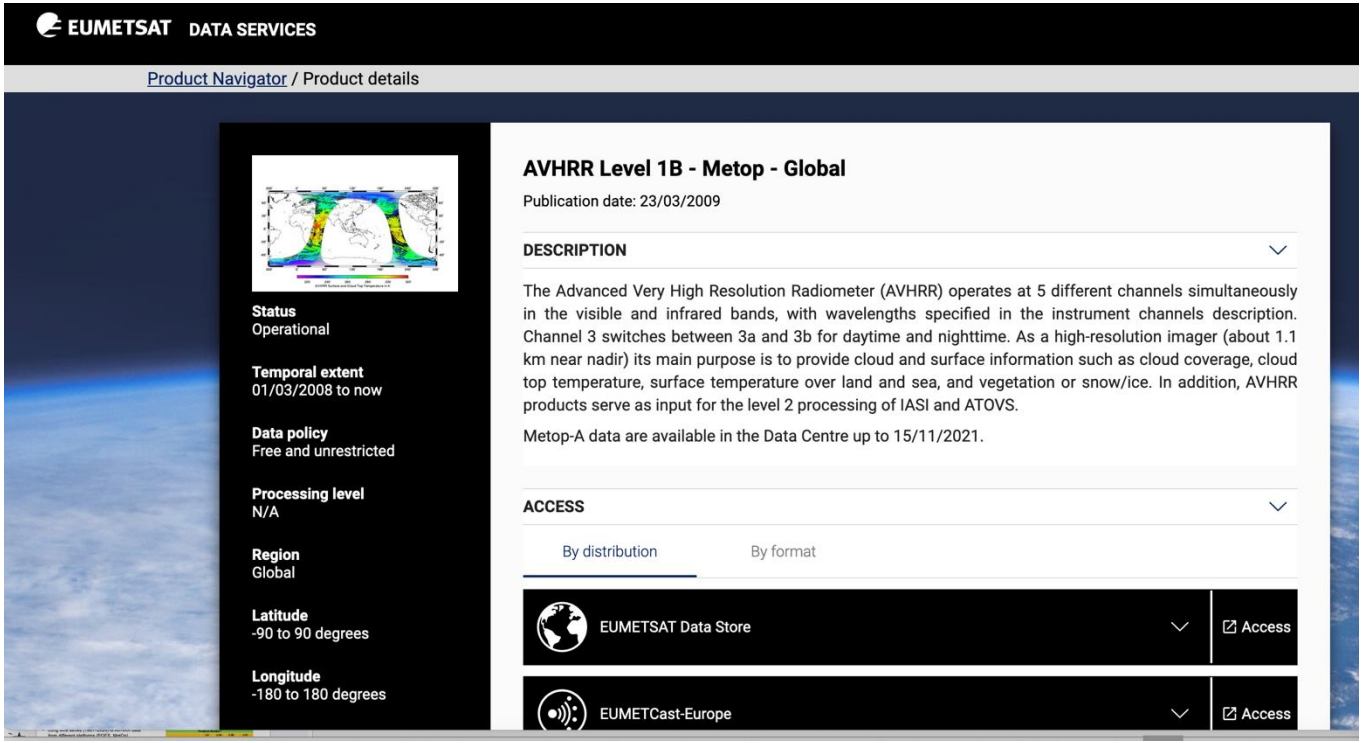
AVHRR Global Land 1km Dataset

Global 1km AVHRR dataset 2008 - today



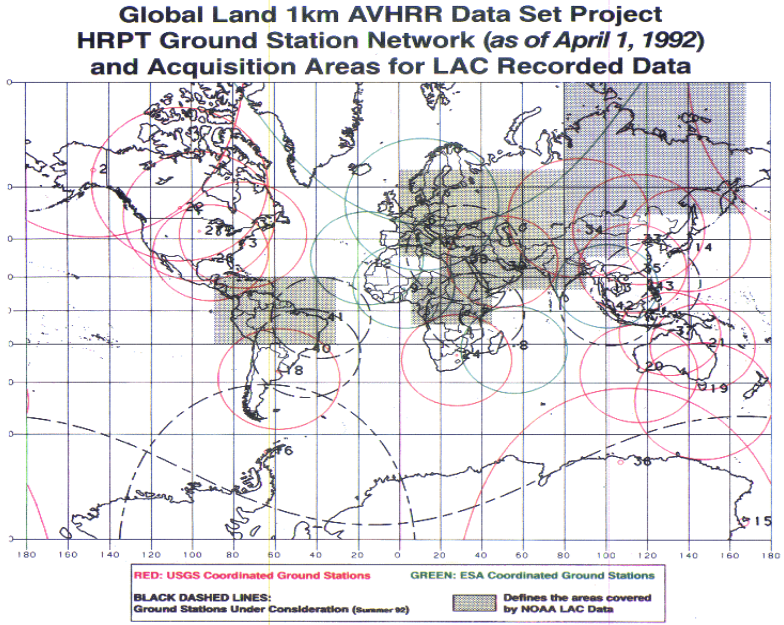
Metop satellites operated by EUMETSAT

Temporal extent: 01/03/2008 to today

Level-1b data

Open and Free

Global 1km AVHRR dataset 1992-1999



AVHRR receiving stations contributing to global land 1km AVHRR data set. (https://lta.cr.usgs.gov/1km/hrpt_image)

Products Number*				
	L0	L1A	L1B	L1C
1Km-Project (out of Europe)		3901	3901	2991

* No L0 available.

Two different global Land 1-km AVHRR datasets covering the period 1992-1999 are available at ESA :

1. **Data acquired at ESA network stations** (Terranova, Nairobi, Manila, etc..) were processed up to L1C and published in the ESA web page as dataset *Out-of-Europe*.

2. **Data in stitched format (.arch files) from USGS network stations** not accessible at USGS/NOAA and not processable at ESA due to unknown data format.

1. Support received from CSIRO (email exchange) on data format and names of reading tools/processors:
   - Recently digitised old documentation retrieved at ESA with description of stitched product format (.arch files).
   - Stitched product reader tool also retrieved at ESA.
2. Software converter from stitched format to HRPT files is under development.
3. Next Steps: conversion, full processing into level-1B and Level-1C, open access to users.

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AVHRR Regional LAC Archives

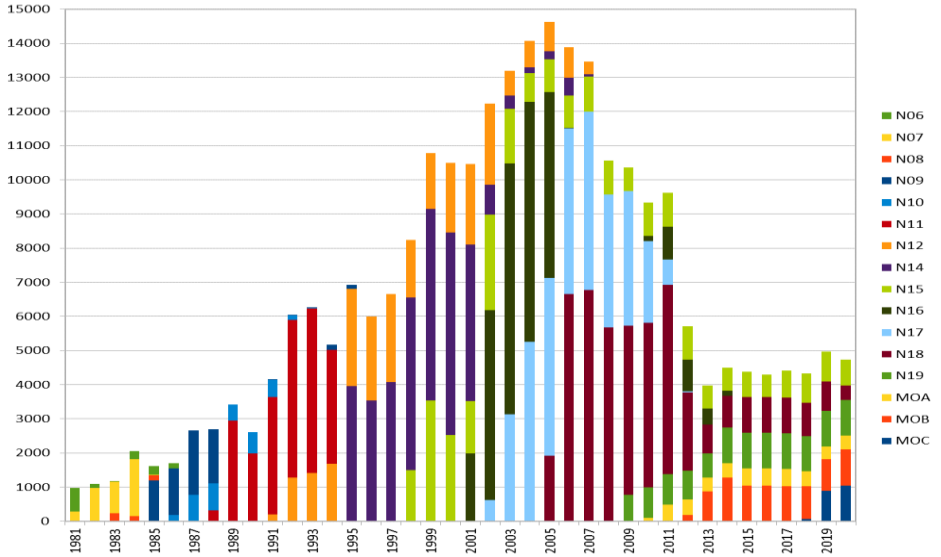
Europe – ESA & University of Bern

- Long time series (1981–2020) of AVHRR data from different platforms (POES, MetOp)
- Unique source to retrieve Essential Climate Variables (ECV) to investigate climate change over last 40 years.

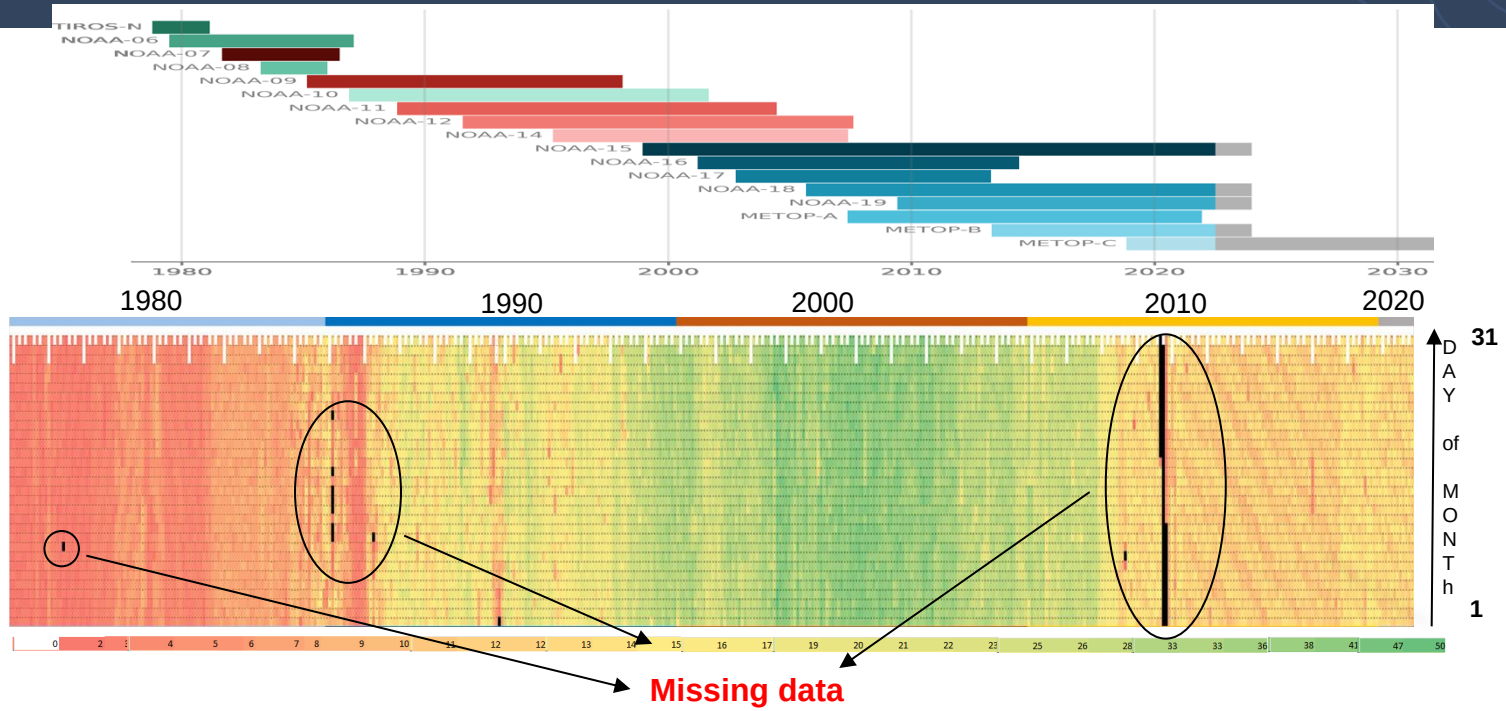
- European dataset includes data from University of Bern, Dundee Station and ESA holdings: **260.000 products. harmonized** and **consolidated** through a dedicated ESA project (Heritage Space Programme).
- All **data accessible free** of charge via ESA dissemination services and safely archived at ESA**.**
- **Processing to Level-1c completed,** data will be **opened to users in Oct'24**.

Products Number*				
	L0	**L1A**	**L1B**	**L1C**
Europe	145231	259747	260060	259164

*The L0, L1A and L1B input data are scattered.

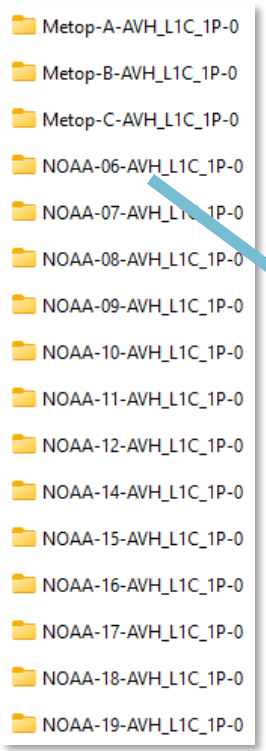


Europe - ESA Data temporal coverage

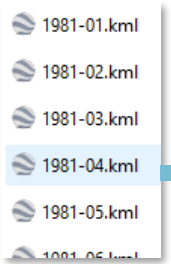


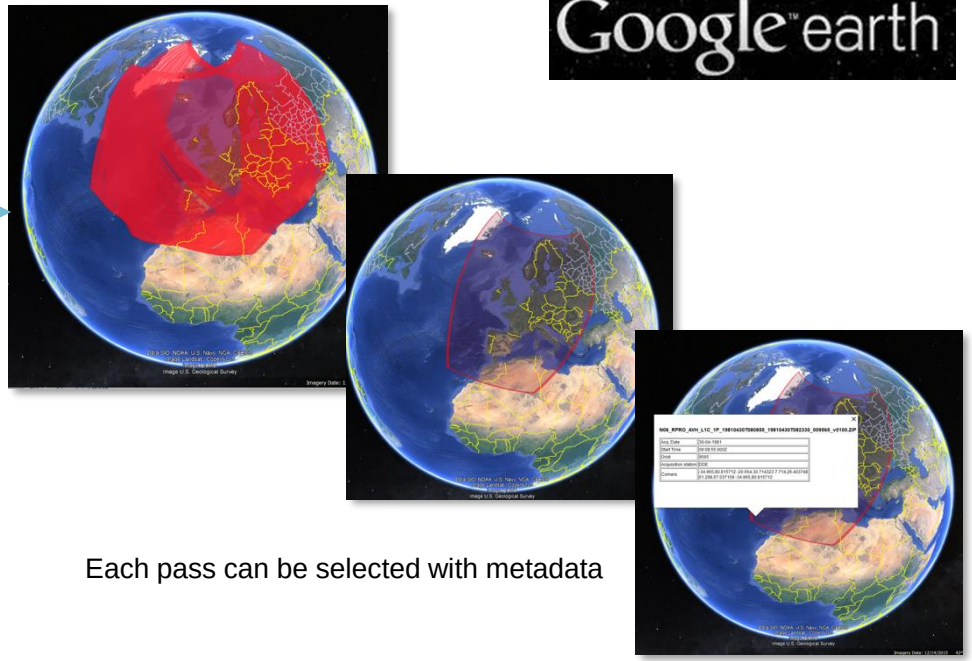
- **Metadata** extracted from ESA **L1C** products to build a **heat chart** on data acquisition frequency per day:
  - min value: 1
  - max value: 50
  - Missing data: **black**
- Data gap will be closed getting missing products from other sources

Europe - ESA Data geographical coverage



- **Metadata** extracted from ESA **L1C** products
- Built a **KML** file for each mission, year and month;



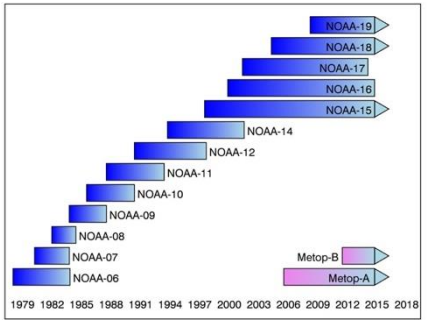


Each pass can be selected with metadata

FDR for Advanced Very-High-Resolution Radiometer instrument (FDR4AVHRR)

New project started in **Q1/2024:**

- Reprocessing AVHRR series LAC products (NOAA & MetOp missions) **40+ years of length** → climate record;
- Generating innovative Earth system data records;
- **FDRs for TIR and VNIR channels** mainly over Europe +
- **Cross-mission calibrated** AVHRR FDR dataset at 1km spatial resolution for all channels;
- Generating dataset including **new modules** for improved **geocoding / orthorectification, error propagation** and **accurate uncertainty estimates** in the calibration module **with related documentation**;
- Extending ESA 2020 AVHRR European Data Set Version 1.0: 1) with **data beyond 2020** over Europe; 2) adding data covering Greenland and northers areas; 3) adding selected regions across the world (**Argentina, Kenya, South Africa, etc…)**



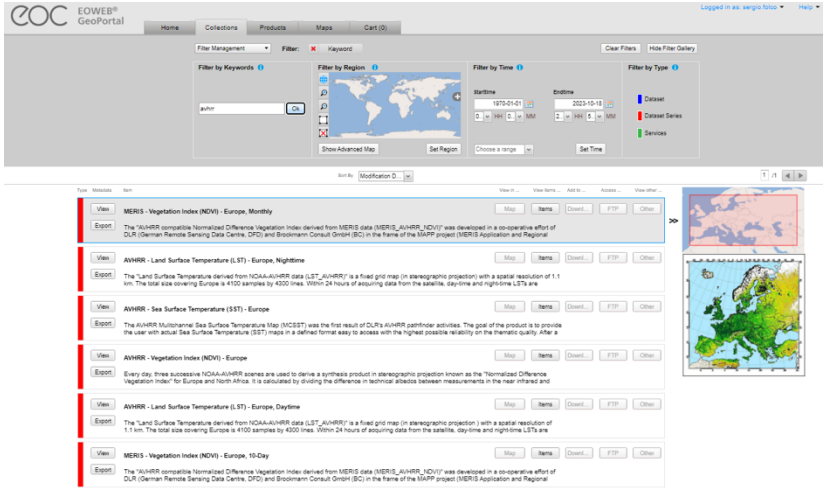
Presentation at WGISS#57 and #58

Europe – DLR

Four AVHRR datasets over Europe (N14,N16,N17,N18,N19) available in the DLR catalogue:

- AVHRR - Land Surface Temperature (LST) - Europe, Nighttime;
- AVHRR - Sea Surface Temperature (SST) - Europe;
- AVHRR - Vegetation Index (NDVI) - Europe;
- AVHRR - Land Surface Temperature (LST) - Europe, Daytime.

High redundancy with ESA dataset; not clear if L0 data available at DLR.



Presentation at WGISS#57

Europe – IGIK (Poland)

- Polish Institute of Geodesy and Cartography.
- Department of Remote Sensing maintains a database of satellite images and products derived from NOAA satellites since 1996 and used for agriculture studies
- The receiving station recorded data in HRPT, SeaWiFS (and other formats) from NOAA, Seastar, Metop and NPOESS polar-orbiting satellites.
- AVHRR products are not accessible from the web site.

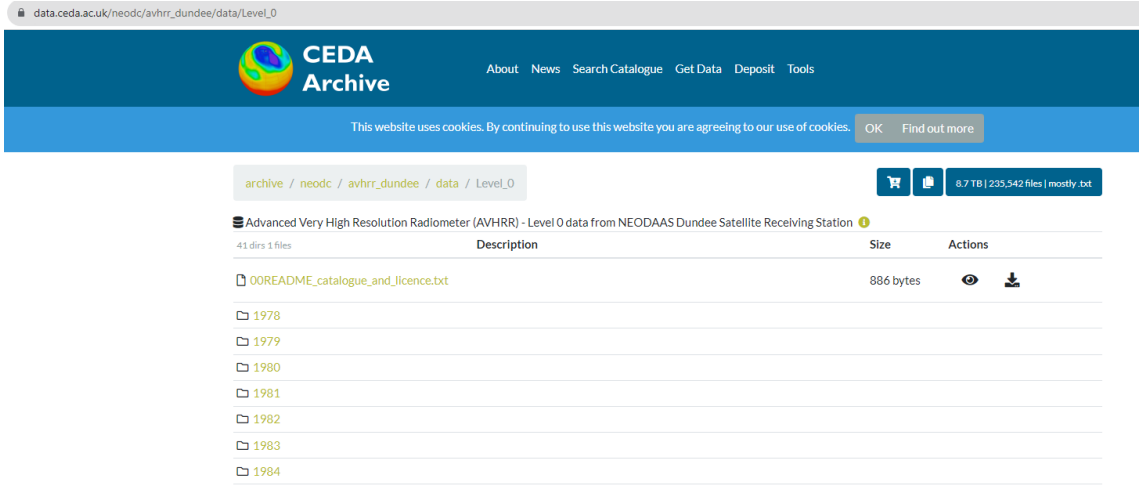
Map of NDVI distribution
as compared to previous year

Point of contact:
Dr. Dariusz Dukaczewski (dariusz.dukaczewski@igik.edu.pl)
Dr. Jan Musial (jan.musial@igik.edu.pl)

ESA contacted the IGIK point of contact in 2023 and 2024, still waiting for feedback.

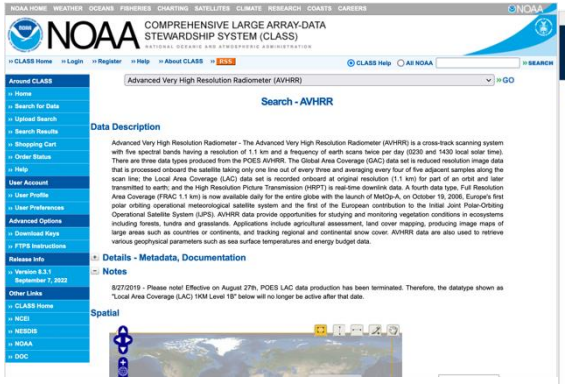
Europe – Dundee Station data at CEDA

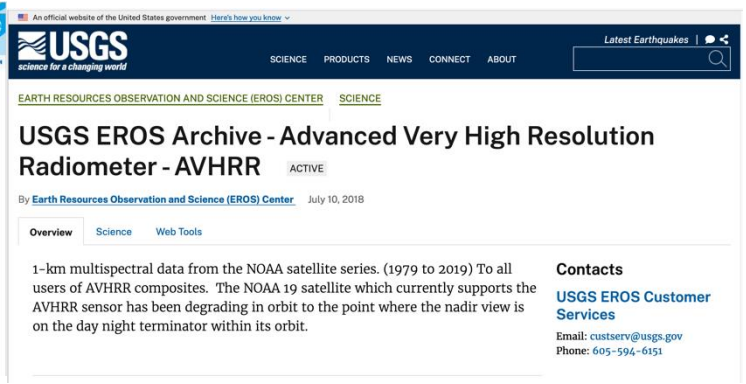
- 1978 – 2018 AVHRR L0 data available with free and open access.
- **ESA has downloaded the full Dundee NOAA L0 products** (8.9TB and 235541 L0 products). ESA partially reprocessed this level 0 dataset (AVHRR Data Curation Project) to extend the European Master Dataset to the early 80's. → Credits already provided to Dundee
- Other data will be integrated to further extend geographical coverage towards Greenland and extend in time back to 1978



Presentation at WGISS#56

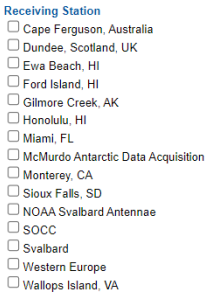
North America – NOAA & USGS





NOAA presentation at WGISS#55

- GAC (global) and LAC (North America and other areas) data from 1978: few products in 1980/1981/1984, no data 1983
- LAC L1B products over Russia (**WGISS action to further check**):
- CLASS acquisition stations not fully aligned with the “USGS 1-KM project” acquisition stations list; 1-KM specific region of world (Africa, Asia, etc..) are always acquired at “Wallops Island” and “Gilmore Creek” station (likely those data acquisitions were recorded on board and downloaded to these two stations).

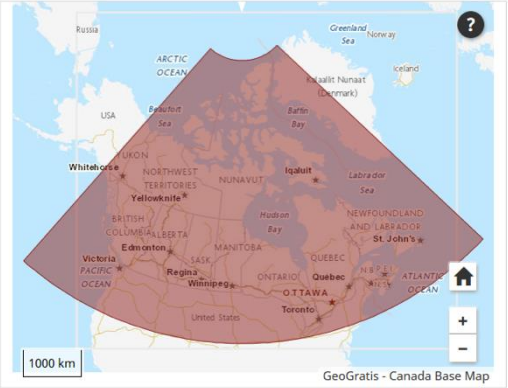


Next Steps: USGS will be invited to make a presentation at WGISS#59

Canada – NRCan/CCMEO (1/2)

1981 – 2013 (+ AVHRR L1B LAC/HRPT received after that date); L1C at CCMEO
These are open source data covered by WMO CGMS data distribution policy, they can be shared freely and without charge

- The Canadian sector is of high value to analyze changes of the environment.
- The former developed pre-processing and retrieval of ECVs by A. Trishchenko and K.Klopenkov was of high quality and the standard for many other AVHRR processing chains.
- Further development and processing was stopped some years ago but raw AVHRR data are available by NRCan.



https://open.canada.ca/data/en/dataset/9045136a-d6e7-a825-491d-ee5dc77a2620

Canada – CCMEO (2/2)

Multi-Spectral Clear-Sky Composites of AVHRR Channels (1 - 5) Over Canada at 1 km Spatial Resolution and 10-Day Intervals Since January, 1985

Data was produced by the Canada Center for Remote Sensing (CCRS) and from Canada government portal, specific data products are available:

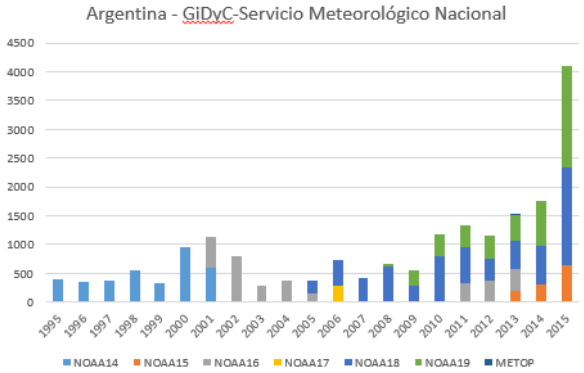
- Processing includes geolocation, calibration, and compositing using Earth Observation Data Manager (Latifovic et al. 2005), cloud screening (Khlopenkov and Trishchenko, 2006), BRDF correction (Latifovic et. al., 2003), atmosphere and other corrections as described in Cihlar et. al. (2004);
- (NOAA) 9,11,14,16,17,18 and 19 satellites were used to generate Canada-wide 1-km 10-day AVHRR composites;
- Rescuing the data owner, other data could be over the North pole.

Next Steps: NRCan/CCMEO will be invited to make a presentation at WGISS#59

Argentina - GiDyC-Servicio Meteorológico Nacional

Initial products Metadata

- Source: Jefa Departamento Teledetección Y Aplicaciones Ambientales, GiDyC-Servicio Meteorológico Nacional, Buenos Aires, Argentina
- Number of products: 19360
- Volume size: 740GB
- Satellites: N14, N15, N16, N17, N18, MetopA/B
- Time Period: 1995 – 2015
- Extent: roughly Lat=[-30,15] Lon=[-60,-15]
- Format: QUO (HRPT)



Downloaded products metadata*:

- Number of products: **25504**
- Volume size: **1.02 TB**
- Time Period: **1995-2017**
- Format: **.rar, .quo, .WI**

- Data transfer to ESA is on-going. *Downloading was stopped in April 2024 to upload new data in the GiDyC servers, restarted in October.*
- Next steps: complete transfer, full processing into level-1B and Level-1C, open access to users.

Brazil - INPE

- Satellites: METOP-A, METOP-B, N12, N14, N15, N16, N17, N18, N19,
- Number of L0/L1A : 287325
- Volume size < 18TB
- Time Period: 1998 - 2024
- Extent: Brazil
- Format: HRPT and others

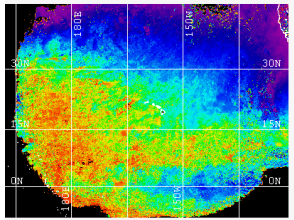
METOP-B	May 2013-Ma-2024	HRPT	29237
METOP-C	Dec 2019-Mar 2024	HRPT	7924
NOAA_12	Aug 1998-Aug 2007	HRPT	16333
NOAA_14	Aug 1998-Jun 2007	HRPT	10976
NOAA_15	Jul 2001-Aug 2019	HRPT	36816
NOAA_16	Aug 2001-Dec 2014	HRPT	20692
NOAA_17	Jan 2003 - Mar 2013	HRPT	24575
NOAA_18	May 2005 – Mar 2024	HRPT	52626
NOAA_19	Jan 2012 - Mar 2024	HRPT	39791
S1*	---	Unknown	48355

- Data transfer to ESA completed.
- Next Steps: full processing into level-1B and Level-1C, open access to users.

** The S1* files are under investigation because they could be single data/calibration for channel.*

Hawaii – University of Hawaii

An AVHRR dataset was acquired at the Hawaii University between 1990 and 2000. Data are still on Exabyte tapes, some were extracted covering the islands but accessibility not clear.



NOAA-AVHRR images data & processing

Time series:

9300 images from NOAA-AVHRR 11,12 & 14
July 10, 1991 to Dec. 31, 1999

Data received at the SeaSpace HRTP station of the University of Hawaii

Processing:

- internal calibration
- manual navigation to 1-km accuracy
- cloud detection (daytime ch 2; night-time ch 3 – ch 4)
- remapping to a common grid (1.25 km pixel)
- domain of 1250 x 1250 km²
- estimation of multi-channel SST using NOAA coefficients
- estimation of vegetation index (ch 2 - ch 1 / ch 2 + ch1)

- All exabyte tapes and hardware were shipped to ESA/ESRIN.
- Transcription chain is being assembled.
- The ESRIN laboratory is manufacturing a special device to roll/unroll the tapes at very slow speed and clean the tape surface from moisture.
- Next steps: transcription, full processing into level-1B and Level-1C, open access to users.

HI HRPT wiki

Topics
Action items?
Blog
Technical issues
HI Catalog
HI Data
HI Analysis
Exabyte info
Pictures
Contractors
HI proposal?

wiki help

edit

Main /
University of Hawaii HRPT data rescue wiki

Metadata from the website

Objectives

From 1990 to 2000, the University of Hawaii operated a receiving station for the NOAA polar orbiter satellites, under joint NASA/ONR/NSF funding, to receive the High Resolution Picture Transmission (HRPT) telemetry, providing Local Area Coverage (LAC) resolution of 1 km for the Advanced Very High Resolution Radiometer (AVHRR).

This station was shutdown in 2000 due to lack of funding to upgrade the SeaSpace software to fix the year-2000 bug in the satellite orbit computation libraries.

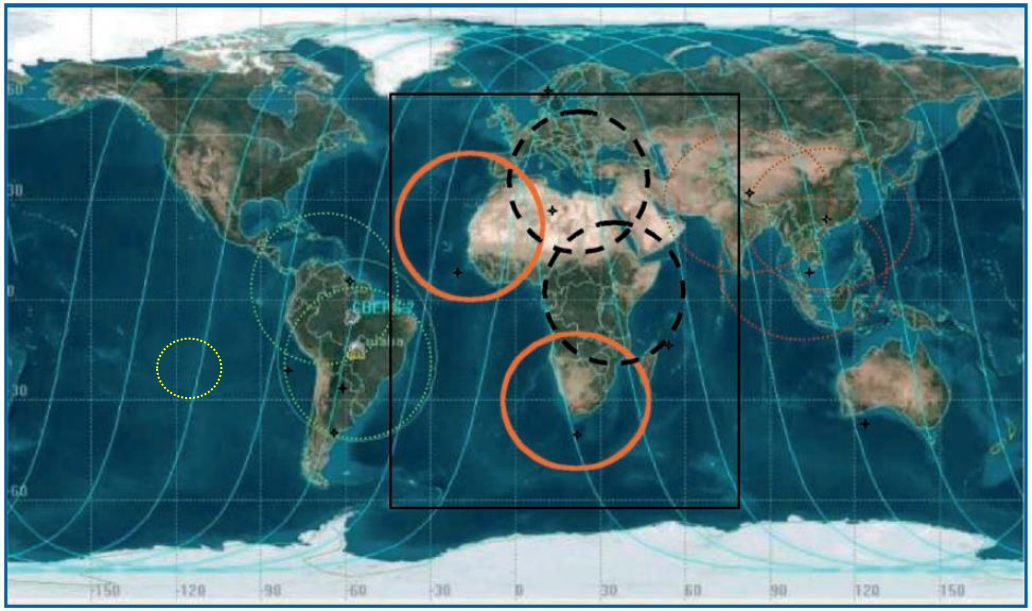
About 500 Exabyte tapes holding close to 10,000 satellite passes have been archived and last read in 2002 to extract a subset covering the Hawaii islands.

It is proposed to rescue these data and transfer them to HDD for distribution and copy to National Centers. This involves delicate handling of potentially decaying media and tape drives, requiring specific expertise.

Scientific justification

African Coverage

The combination of AVHRR data acquired in Maspalomas (Spain), Matera (Italy), Cairo (Egypt), Niamey (Niger), Hartebeesthoek (South Africa) and Malindi/Nairobi (Kenya) can provide full coverage of Africa;



Running (Green for Brazil, red for China) and planed Ground Stations for Africa. The locations of the ground stations are Canary Islands (Spain), Hartebeesthoek (South Africa), Malindi (Kenya) and Matera (Italy).

South Africa - SANSA

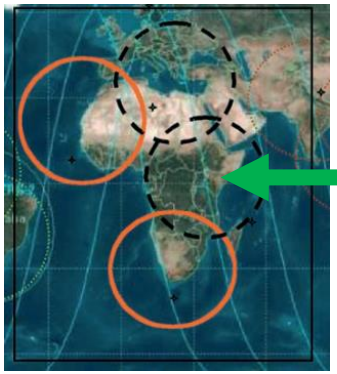
1km NOAA AVHRR data received at Hartebeesthoek, South Africa (25° 53' S 027° 42' E) and maintained by SAC/SANSA – South African National Space Agency

NOAA 9	1985-1987
NOAA 11	1989-1993
NOAA 14	1995-2001
NOAA 16	2001-2005
NOAA 17	2005-2010
NOAA 18	2005-2009

- Number of products: 7684
- Volume size: 464GB

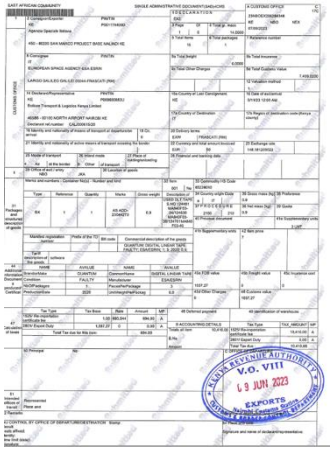
- Data transfer to ESA completed.
- Next steps: full processing into level-1B and Level-1C, open access to users.

Central Africa (Kenya) - ASI/UniRoma



Data acquired at the Malindi station in Kenya from **2001** to **2009** and stored on **44 DLT** tapes.

- **8452 products** in L1B sharp format.
- Volume: **614 GB**

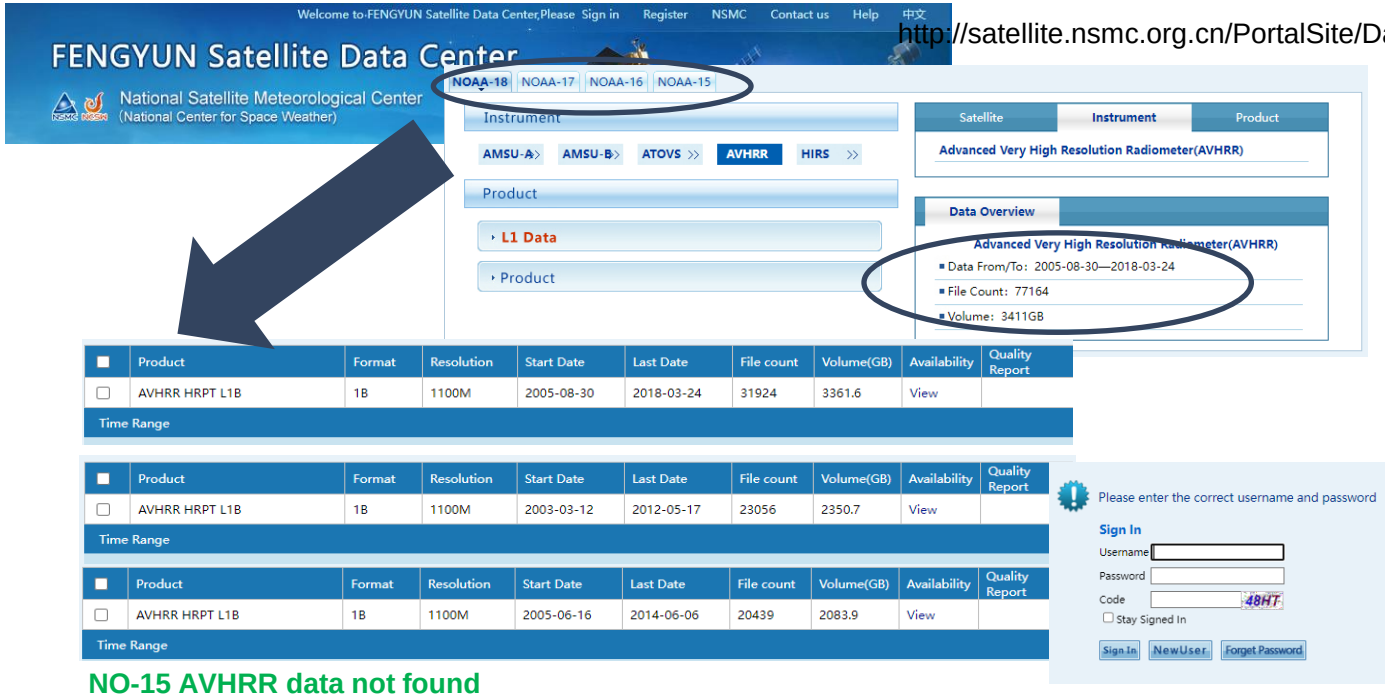


- ESA transcribed the DLTs content successfully.
- Next steps: complete transfer, full processing into level-1B and Level-1C, open access to users.

China – CMA/NSMC

- AVHRR-receiving stations for global 1km land product (coordinated by USGS): Beijing, Urumqi, Guanzhou
- AVHRR 1-km data covering Himalaya-Hindukush of the period 1981 – 1992 would be of exceptional value

http://satellite.nsmc.org.cn/PortalSite/Data/Satellite.aspx



NO-15 AVHRR data not found

- Sent request for accessing the data download data area.
- Next Steps: CMA will be contacted and invited to make a presentation at WGISS-59.

India - ISRO

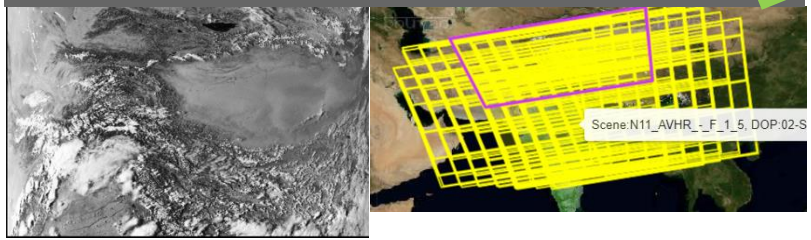
https://bhoonidhi.nrsc.gov.in/bhoonidhi/index.html

Filters (Optional)

- Open/Priced
- Resolution
- Imaging Spectrum
- Satellite
  - LandSat-9
  - NOAA-11
  - NOAA-12
  - NOAA-14
  - NOAA-16
  - NOAA-17
  - NOAA-18
  - NOAA-19
  - Novasar-1
- Sensor Type
- Products
- Themes

NOAA-11	25-Aug-1994 - 13-Sep-1994	1000 m
NOAA-12	14-Sep-1994 - 4-Nov-1995	1000 m
NOAA-14	3-Apr-1995 - 22-Sep-2010	1000 m
NOAA-16	20-Jun-2001 - 11-Aug-2005	1000 m
NOAA-17	20-Sep-2005 - 13-Apr-2010	1000 m
NOAA-18	1-Oct-2005 - 9-Oct-2009	1000 m
NOAA-19	29-Apr-2010 - 29-Oct-2014	1000 m

Example over Hymalaya region



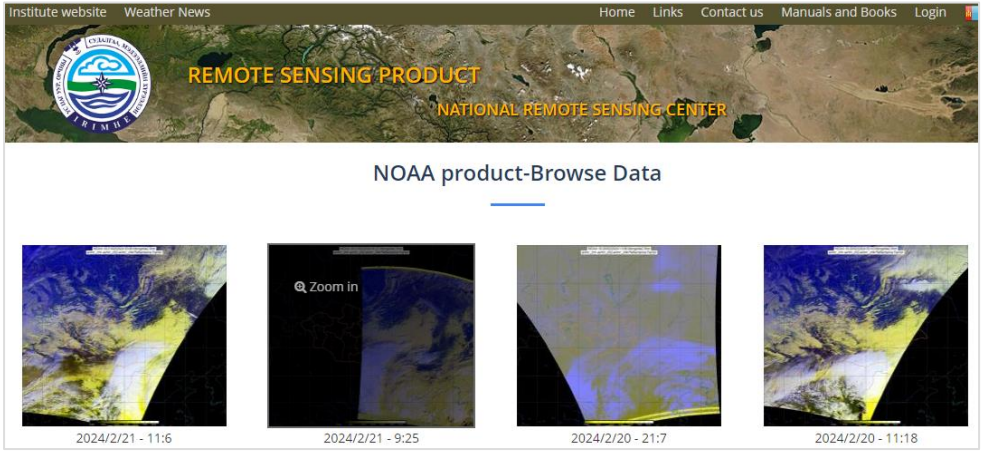
Presentation at WGISS#57

NOAA products are *open-data* and, after user registration, the products are downloadable.
No products number or volume can be extracted from the web site.

Mongolia - Remote Sensing Department, Information and Research Institute of Meteorology, Hydrology and Environment

From UniBern

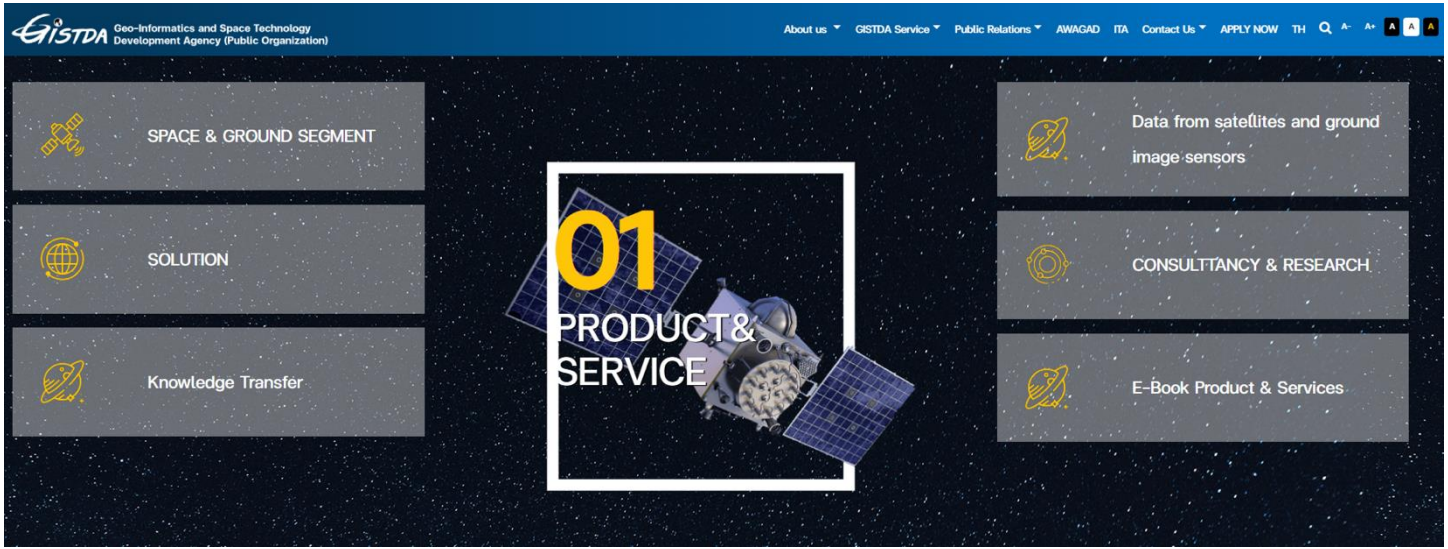
- AVHRR UBM data
- Source: Remote Sensing Department, Information and Research Institute of Meteorology, Hydrology and Environment, Ulaanbatar, Mongolia
- Number of Scenes: 5.016
- Satellites: N09, N11, N12, N14, N15
- Time Period: 1993 – 1999
- Extent: roughly Lat=[20,70] Lon=[80,120]
- Format: hmf (origin: dat, grid, lut)
- Further info:- UBMx station data were included in the Global Land 1km AVHRR Data Project



Browsing the NOAA data, the acquisitions are from 01/01/2017 up to now. Available data (raw,L1b,L1c) to download from 10/12/2023 (http://119.40.97.75:8080/thredds/catalog.html)

Next steps: The institute will be contacted to get information on data volume and status of accessibility

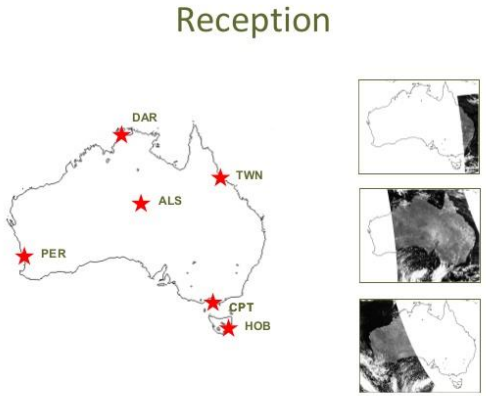
Thailand - GITSDA



GITSDA has been contacted and confirms they keep data from last six months. No further action.

Australia – CSIRO (1/2)

AVHRR reception based on 6 stations for continuous 1-km data set.
Multiple state and federal agencies have been acquiring the data in this manner with reception stations in Hobart, Melbourne, Perth, Alice Springs, Darwin and Townsville.
Since the early 1990s CSIRO has been merging these separate local data sets to produce a stitched archive which makes use of the redundancy arising from overlap between reception stations to produce a higher quality and consistently formatted data set with national coverage.
The assembly of this data set continues within CSIRO today, though it is likely to come to an end sometime this decade as the last of the AVHRR sensors has now been launched.
Data availability: 1981 (NOAA-7) onwards.



Ian Grant, Bureau of Meteorology, Australia

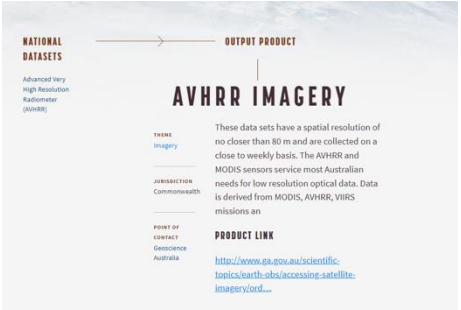
https://link.fsdf.org.au/dataset/advanced-very-high-resolution-radiometer-avhrr

Presentation at WGISS#56/57/58

Australia – CSIRO (2/2)

ESA and CSIRO exchanged emails (from Sep'23 up to Feb'24):

- CSIRO has a raw (HRPT) record – **stitched** together from multiple reception stations including essentially all POES overpasses from **1992/04 to the present**, covering essentially the greater Australasian region and NZ and held the individual reception station data (pre-stitching);
- **HRPT passes from 1981-1992**, with lower frequency than 1992+;
- CSIRO has collections of raw HRPT from several **Antarctic** reception stations late-1990 onwards. These are likely a subset of the Bureau's holdings (that is, the Bureau will have a more complete collection);
- CSIRO has just **completed** the first attempt at **processing** the daytime Australian dataset from 1992-2023 to top of atmosphere parameters, with encouraging results;
- **ESA provided** CSIRO with few sample of **L1B and L1C products** reprocessed during the European Data Curation Project.



https://link.fsdf.org.au/dataset/avhrr-imagery

- ESA and CSIRO will continue to exchange information

Other organizations

- Inventory of existing national/regional HRPT and LAC data archives Version 3 has been produced in Q1 2024
- List of Met offices and other organizations around the world who might have AVHRR LAC data being compiled at ESA
- ESA will perform a worldwide AVHRR LAC data gap analysis extending the one done for Europe
- ESA will contact additional organizations who might have AVHRR LAC data to investigate possibility to fill identified gaps

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AVHRR Media Transcription

AVHRR 1 Km data on media

Several hundred heritage media (optical disks, DLTs, Exabytes) with potentially unique AVHRR LAC data identified:

- ESA (Optical Disks)
- University of Reading (Optical Disks)
- University of Rome / ASI (DLTs)
- University of Hawaii (Exabytes)

LM 1200 optical Disk 2.4GB

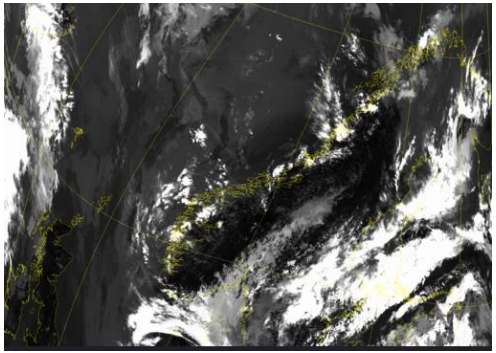
300 CLV DISKS

100 ATG GM-9001/5 DISKS

Exabyte tapes

Optical Disks

- ESA pilot activity completed in 2023 with successful transcription of 2 different brands of optical disks originally held at ESA and University of Reading.
- Transcription of the full batch of available optical disks (around 522) contracted to a commercial company.
- In Oct23, ESA received the content of the first 15 transcribed optical disks. L1B products successfully processed using the ESA processor.
- In Feb ’24, 50 media were successfully transcribed and data inventory/screening under finalization (media containing both AVHRR and Nimbus CZCS data).
- Transcription of additional media ongoing with some delays due to hardware failures.

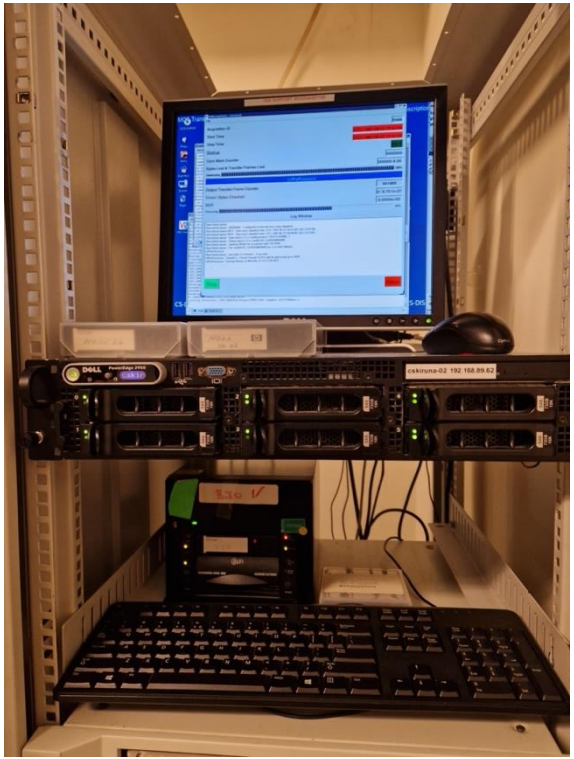


This scene over Norway is not in ESA archive.

300 CLV DISKS

100 ATG GM-9001/5 DISKS

DLT Tapes



- DLT transcription chain set-up at ESA/ESRIN to transcribe tapes containing unique AVHRR / SPOT and ERS data.
- Tapes received from ASI / University of Rome successfully transcribed and **8452** AVHRR products acquired in Malindi (Kenya) from **2001-2009** now safely archived on disks at ESA.

Exabyte Tapes

- Exabyte transcription chain being set-up at ESA/ESRIN to transcribe tapes containing unique Hawaii AVHRR data.
- The ESRIN laboratory is manufacturing a special device to roll/unroll the tapes at very slow speed and clean the tape surface from moisture.

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AVHRR Data Processing and Access

Next Steps

1. Continue ongoing transcription activities, coordination and projects and contact additional organizations with potentially unique AVHRR LAC data

2. Provide AVHRR points of contact and stakeholders with the AVHRR Dataset Consolidation Procedure and Processing Format used in the European consolidation project run at ESA. Collect feedback and discuss possibility to have a common/harmonised format (Q1/Q2 2025)

3. Check status of Discoverability of AVHRR datasets worldwide and pursue common entry point through WGISS CDA infrastructure (Q1 2025)

AVHRR Session follow-on will be held at WGISS#59