# ESA/ESRIN Software Demonstration: AVHRR Data Production and Access From Acquisition to Delivery

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**ABSTRACT**: This paper describes the software presentation of the ongoing developments to improve the operational processing and access procedures of AVHRR data at ESA. Operational acquisition and processing stations installed in Europe, Africa and South-East Asia are participating to the **ESRIN Coordinated Tiros Network (ECTN)**. Different products derived from the ESA in house processing system are processed and packaged in a common data format. A central archive of these products located in Frascati is accessible through Eurimage and the ESRIN user service. The archive visibility is achieved through on line and off line access to a catalogue and to the Quick Looks archive. The development of higher level products including atmospherically corrected products as well as more refined tools to visualize the available products are described here. Moreover ESA/ESRIN is managing a complete copy of the **"Global Land 1 km AVHRR Data Set"** which is an international project in collaboration with **NOAA, NASA, USGS and CSIRO**. This project and the ECTN operations give ESA the opportunity to learn about handling such an amount of data in an operational context. These lessons will serve to the development of the ground segment of the future ESA missions and in particular of the **Medium Resolution Imaging Spectrometer (MERIS)** and the **Advanced Along Track Radiometer (AATSR)** instruments inboard **ENVISAT** (Pittella, 1994).

## 1 Introduction

It is recognized that efforts shall be put on the processing and distribution of satellite data to the user community. This note describes the activities in course at ESRIN in order to up-date the data products, to ease the data access and to improve the data visibility to the user through different off-line and on-line mechanisms. In particular the AVHRR mission is taken as example here through a similar work has been done for Nimbus-7/CZCS and will be developed for the SeaWiFS mission. This software presentation is concentrated on:

- The generation of high level products based on improved cloud detection, atmospheric correction and Land Surface Temperature generation.
- The data visibility with the Ionia "1 km" Net Browser dedicated to browse the "Global Land 1 km AVHRR Data Set" through network access.

## 2 The Acquisition of data

Several acquisition stations exist in Europe and outside Europe operated by national entities carrying out local observation programmes, (HRPT, 1991). With the purpose of coordinating the European activities for NOAA/AVHRR and in order to provide the European users with uniform access to wide-coverage data through a common archive and a central catalogue, ESRIN has set-up a network of ground facilities called ECTN composed by a number of existing acquisition stations and a central facility at Frascati, (Fusco and Muirhead, 1987, Fusco et al., 1989, Fusco and Pittella, 1991).

The ECTN tasks are:

- The collection of data at a number of worldwide receiving stations.
- The generation of standard products.
- The creation and the maintenance of a central archive and a catalogue at ESRIN.
- The distribution of products to users.
- The development of the needed algorithms and processing software.

The ECTN is receiving and archiving the AVHRR data from 10 stations covering Europe and Africa as well South East Asia. The stations participating or having an agreement to contribute to the ECTN central archive in Frascati are the following: Tromsoe, Oberpfaffenhoffen, Scanzano, Cairo, Mas Palomas, Niamey, Nairobi, La Reunion, Manila, Terranova and Dundee. A world map representing the station coverage is given in Figure 1.

For most number of stations, the processing and archiving is performed locally using the ESA developed Standard-family HRPT Reprocessing Kernel (SHARK) software, (Pittella and Bamford, 1989). Other stations send directly to ESRIN the HRPT raw data, which is then converted to SHARP format and archived at ESRIN.

Since April 1992, HRPT and LAC data are exchanged with NASA/USGS to ensure that the full archive of the "Global Land 1 km AVHRR Data Set Project" is available at ESRIN (20 000 pass per project year, Buongiorno et al., 1993). To complete this data set some of the ECTN station were asked to send to ESRIN HRPT data as well as the normal SHARP products.

## 3 Overview of the Processing System

SHARK is a hardware and software system that extracts AVHRR imagery from the raw HRPT data stream, processes it and writes the processed data in SHARP format, (SHARK's Users' Manual, 1993, SHARK Technical Reference Guide, 1993). SHARP (Standard Family HRPT Archive Request Product) is an archive and distribution format for AVHRR and TOVS data. It conforms to the Landsat Technical Working Group's "Standard Family Tape Format". The SHARK system fulfil the ECTN requirements providing the following functions:

- HRPT data acquisition.
- Display of acquired data and selection of scenes to process.
- Generation of SHARP products and digital Quick Looks.
- Generation of entries in the catalogue of all archived data.
- On line quality control.
- Archiving of products on optical disk.
- Archive management and CCT/exabyte user product generation.

The SHARK system is in demonstration during the symposium at the ESA stand. It includes the different steps in processing from HRPT up to SHARP Level 2A and 2B described hereafter.

## 4 The Products

All SHARP products consist of segments of AVHRR imagery that contain no fewer than 720 scan-lines and no more than 1440 scan-lines. These size limits correspond to 2 and 4 minutes transmission time. The data is ordered with the northern-most scans first, irrespective of the direction in which the satellite was flying when the image was scanned. Figure 2 shows the products available now and in the near future.

## 4.1 SHARP Level 1 products

The ESRIN AVHRR products are archived under the SHARP 1B format (SHARP level 1, 1989). These products are made of 4 minutes of raw data from all 5 or 4 geometrically located channels. Each SHARP scene contains the unmodified 10-bit AVHRR pixel values, and calibration information to convert pixel values for the infrared bands into equivalent brightness temperatures. The SHARK software calculates the calibration information for each scan-line as it reformats the raw data. At the same time it calculates the histograms of the raw pixel values in each band and writes these into the SHARP product as well.

To aid the interpretation of the imagery, SHARP products include the geographical position of the centre of each pixel on a subsampled lattice within the image. The lattice is included every 32nd pixel on every 16th scan-line. SHARP products also include the azimuth and elevation of the sun and satellite from the centre of each pixel of the lattice. The process of calculating the geographical position of an image is known as image navigation. Graphical overlays of the coastline, state boundaries and a latitude-longitude grid are included in each SHARP product. Each overlay can be plotted over the image data independently as required.

## 4.2 SHARP Level 2 products

A level 2 product can be derived under request, (SHARP level 2, 1992-a and -b). This product consist of data that have been further processed from level 1. Two level 2 products have been defined, known as 2A and 2B. Each consists of 5 bands with the same restrictions on size and the same ancillary data as level 1 products. all daytime passages acquired by the ECTN stations can be processed to generate SHARP level 2 products. A passage is considered to be day-time if the AVHRR band 1 histogram read from the SHARP level 1 trailer file has a mean value greater than a given unit. Because of the possibility of making changes in the data calibrations procedures or in the geophysical data retrieval algorithms, the SHARP level 2 is not archived.

The SHARP level 2 format (SHARP, 1992-a) has the same structure as the SHARP level 1. SHARP level 2 is a 5 bands image in LINN format. Together with the image data, other information can be found in the prefix and suffix data of the imagery records. SH ARP level 2 pixel is organized in 2 bytes (SHARP 2, 1992-a). Starting from the Less Significant Bit there are:

- 10 bits used for image data.
- 3 bits used for state boundary, coastlines and Lat/Long grids flags.
- 3 bits used for classification flags. Presently the classification of Muirhead and Malkawi, (1989) is used.

However, instead of the raw pixel values, which are written to level 1 products, each band in a level 2A product contains calibrated data from the corresponding AVHRR channel. Thus, bands 1 and 2 of a level 2A refers to calibrated reflectance of channel 1 and 2 using the coefficients given by Kaufman and Holben, (1993), while band 3 contains radiance of channel 3 and bands 4 and 5 the brightness temperatures from channel 4 and 5, (Lauritson et al., 1979).

Level 2B product is more complicated. Bands 2, 3 and 4 are identical to those in the level 2, but the type of data in bands 1 and 5 varies depending on the nature of the target. Each pixel in a level 2 is classified as either land, sea, cloud, snow/ice or sun-glint. There is also an extra, unclassified class. The class to which pixel is assigned determines which type of data it holds.

Pixels in band 1 which are classified as land contain the Normalized Difference Vegetation Index (NDVI). All other pixels contain the AVHRR band 1 reflectance as in level 2A product. Similarly, pixels in band 5 which are classified as either sea or sun-glint contain the Sea Surface Temperature (SST). This SST has been calculated using the non linear split window algorithm from Mc Clain et al., (1990). This algorithm accounts for the satellite zenith angle variations within the image. The brightness temperature are corrected from the non linearity effects of the detectors, (Weinreb et al., 1990). All other pixels contain the AVHRR channel 5 brightness temperature.

The data are coded on 10 bits. The reflectance values are coded on 1000 levels with 0.001 resolution. The spectral radiance in band 3 is multiplied by 100. The brightness temperature are coded from 0 to 1023 representing respectively 223 K and 323.3 K with 0.1 K resolution. The SST is coded from 0 to 500 representing 0 C to 50 C. The NDVI is multiplied by 1000.

# 5 The Data Visibility

Based on past experience the data visibility is assured through an inventory (also called Catalogue) which is a high level description of the archived data products and a Browse products data set (generally a set of Quick Looks). The way of physically viewing the data products is done through printed Quick Look inspection, CD-ROM collection or network access. The useful tool to manipulate the Quick Look data set is "called" Browser. The Figure 3 summarize the different mode to evaluate the data before ordering products.

## 5.1 Central Catalogue

AVHRR data information are collected into a catalogue system maintained by ESRIN and called "LEDA" fully described in the LEDA Users Guide (Earthnet, 1990, Tobiss and Muirhead, 1989). LEDA makes use of the Inventory Exchange Format (IEF) information collected through the stations and centralised at ESRIN. For the description of the IEF please refer to CEOS, (1992). LEDA allows user to interrogate remotely about the availability of a scene entering the time and location of the request. The query can refer to other types of information like the cloud cover per image.

## 5.2 Visibility of the ESA Archive

The concept developed for CZCS was improved for AVHRR: Quick Looks, corresponding inventory and a browse software were interfaced to provide to the user an easy to use service distributed on CD or accessible through network.

### 5.2.1 The Ionia Quick Look products

A new AVHRR Quick Look generation algorithm has been developed in order to:

- give a better visual impression of the image quality.
- be valid for any NOAA satellite and independent of latitude and acquisition time (calibrated data).
- highlight land ocean atmosphere geophysical features (e.g. cloud height, water temperature, sun glint, vegetation strength, active fire, ice and snow).

This Quick-Look image is a 3 colour composite of channel 1 reflectance, channel 2 reflectance, channel 4 brightness temperature. A classification into water, vegetation, bare soil, cloud has been performed on each channel before multiple histogram equalization. The Quick Look is a 512x480 pixels (3x3 pixels average) image coded on 8 bits representative of the SHARP image product. Furthermore the red pixels mark the active fire detected by the Quick-Look algorithm, (Arino et al., 1993).

This Quick Look extends the standard geographical and cloud cover information to additional qualitative but also to quantitative information on the features that appears in the higher level application products (e.g. land monitoring, oceanography, biomass burning, clouds statistic and physique,...)

### 5.2.2 The Ionia CD-Browser

ESRIN has developed a tool called "CD-Browser' for digital Quick Look consultation and product selection from CD-ROMs, (Melinotte and Arino, 1993, Arino et al., 1993). The AVHRR CD-Browser Ionia is a demonstration CD-ROM. ESA wishes to encourage and receive the maximum user community feedback on this demonstration before initiation of a routine CD-ROM Quick Look production service. The AVHRR Quick-Look images provided on this CD-ROM give a partial view of the ESA AVHRR SHARP data archive. This CD-ROM is available at the ESA Stand.

CD-Browser is a generic image base consultation system specifically designed for CD-ROM. CD-Browser provides a complete service, from the Query definition to the generation of product Orders. CD-Browser uses "standards" formats, the Inventory Exchange Format (IEF) for the catalogue information and the Graphics Interchange Format (GIF) for the Quick look images. The AVHRR CD-Browser is the second member of the ESA CD-Browser family, OCEAN CD-Browser, dedicated to CZCS data, being the first realised (also available at the ESA stand).

### 5.2.3 The Ionia Net Browser

INTECS has developed for ESRIN an experimental Ionia Net-Browser software using public domain system: the networked browser NCSA's Mosaic (Andreessen, 1993). The core of the NCSA Mosaic system is based on the World Wide Web, a distributed hypertext-based information system developed at CERN. As such NCSA Mosaic speaks a lot of common TCP/IP network porticoes, including HTTP, Gopher, FTP, and NNTP. The Quick Looks, Previews and Inventory information are integrated within NCSA's Mosaic allowing their retrieval by simple click on the underlined word or phrase which is a hyperlink to another document anywhere in the network. NCSA's Mosaic supports the GIF image formats as well as other standard formats. The ESRIN Internet World Wide Web address is: http://tracy.esrin.esa.it:5555/browse.html.

## 5.3 Visibility of the "Global Land 1 km AVHRR Data Set"

ESA/ESRIN is archiving since 1 April 1992 the data of the "Global 1 km AVHRR Data Set" project. The project has been reconducted for another year leading to a 30 months duration, (Buongiorno et al., 1993). This project is recognised by the scientific community to be the most important for ongoing global change studies, (Townsend et al., 1992). It is also recognised that access as soon as possible to this data set is needed.

ESA/ESRIN will be in a position to give access to this data set in April 1994. **The visibility of the data set to users** is assured through the generation of the corresponding Quick Look's. Their collection on CD-ROMs with the appropriate software is to be completed by that date as well as their access through network.

The design of the "1km" CD-Browser and of the "1km" Net-Browser software take into account the very **positive comments** received about the Ionia CD-ROM product. The requirements emitted by the initiators of this "1 km" data set and namely the **global change researchers** were driving the implementation of this service.

### 5.3.1 The "1km" Quick Look Products

In consultation with users, the Quick Look product for this project has been identified as follow: colour composite in GIF format subsampled 6 km using the Ionia algorithm, (Arino and Melinotte, 1993 and Arino et al., 1993). The Quick Look size is based on the archived HRPT pass length, which is variable depending on its origin. The width is fixed to 462 pixels and takes into account the satellite viewing angle so that each pixel is representative of an area of 6x6 km. The maximum size of this Quick Look is around 300 kilobytes.

For processing time reasons active fires are not detected, while coastlines, state boundaries and Latitude Longitude grid is not reported on the Quick Look products. Nevertheless, it is easy to locate the region of interest due to the length of the pass.

### 5.3.2 The Ionia "1km" Multi Platform CD-Browser software

The browse software is based on the Ionia CD-browser philosophy, overall it will work on Multi Platform including, Unix machine, Mac and PC and will be included in the Multi Mission Browsing System actually under development at ESRIN and will allow: to address the overall data set, to emit a query, to display the Quick Look products, to select/deselect and finally to generate a product order.

### 5.3.3 The Ionia "1km" Net-Browser software

The Ionia "1km" Net-Browser is based on the same software environment as its predecessor described above. When linked, a normal session begins with the query parameters to be entered by the user (geographic coordinates and time). The geographic selection can also be done using the mouse by clicking on a world map. The retrieved items are presented as time dependent lists of products coming from the overall accessible Quick Look archive. When clicking in this list the IEF information and the previews can be viewed after transmission through the network. Further detailed inspection can be done by retrieving the full size Quick Look. The Ionia '1km" Net-Browser is in demonstration during the symposium at the ESA stand, (Mungo et al., 1994).

## 6 Improving and extending SHARP Level 2 production

Recognised and consolidated scientific software have been interfaced with the SHARK processing system in order to extend the AVHRR geophysical products available to the users. The project is actually in a prototyping phase and addresses the following points: cloud detection and classification, atmospheric corrections and Land Surface Temperature (LST) generation. A set of specifications for the operational phase has been generated from the tests of the prototypes. Some of these software prototypes are in demonstration during the symposium and includes:

- APOLLO (Saunders and Kriebel, 1988, Gesell et al., 1993) modified to cope with tropical conditions.
- 5S, (Tanre et al., 1990) for the atmospheric corrections of the visible channels and LOWTRAN 7 (Kneizys et al., 1988) for the atmospheric correction of the infrared channels.
- Land Surface Temperature (LST), (Ottle and Vidal Madjar, 1992) generation given the knowledge of surface emissivity.

Data output described in Figure 2 will be distributed under the SHARP level 2 format. Maintaining the coherence between formats allow the users to re-use the same software to address the new data products. In any SHARP level 2 generation, the classification derived from the APOLLO software will replace the old classification, (Muirhead and Malkavi, 1989), in the spare bits of the imagery file. The atmospherically corrected radiometry of the five channel will form a product and will be called the SHARP level 2S. LST will be put in band 5 of the actual SHARP level 2B for the cloud-free pixels over land where you can actually find the SST over sea.

### 6.1 Cloud detection and classification

Cloud detection, together with classification into more than 21 meaningful classes including land, water, ice, not ice, snow, not snow, totally cloudy, cloud free and partially cloudy is performed using an extended version of APOLLO (Saunders and Kriebel, 1988, Gesell et al., 1993) modified to cope with tropical conditions.

The APOLLO software makes use of a battery of 5 threshold algorithms to detect cloud free pixels and 2 threshold algorithms for fully cloudy pixels. APOLLO was developed for AVHRR over temperate regions. It has been adapted to cope with tropical regions (i.e. warm surfaces) over land by adding a test on the brightness temperature in channel 4 to recover the pixels considered as cloudy by the visible test whereas this is due to high reflective and warm surfaces. The thresholds are automatically set as a function of location (latitude) and time (in the year). The implementation of APOLLO within SHARK is fully described by Gesell et al., (1993). The classification into more than 21 meaningful groups of pixels (land/sea, cloud, snow, ice) will be reported in the

spare bits of the imagery file for any SHARP level 2 generation. In this demonstration the SHARK system is used to display the results obtained. These results have been integrated in the 3rd spare bit of the imagery file. This bit is set to 1 in Channel 1 if fully cloudy, in Channel 2 if land, in Channel 3 if snow, in Channel 4 if cloud-free and in Channel 5 if ice.

## 6.2 Atmospheric corrections

Only the surface brightness temperature retrieval is presented in the software demonstration. The retrieved values are surface brightness temperatures for channel 4 and channel 5 where the emissivity has been fixed to 1. The emissivity of channel 3 has been set to 0.90 but can be changed by the user. The correction of the infrared channels of the AVHRR is performed by creating Look Up Tables (LUT's) from LOWTRAN 7 with a 8 degrees increment for the viewing angles (15 strips for the overall image). Standard atmospheric profiles of the LOWTRAN library can be used as input as well as radiosonde data entered by the user. The climatic model used has been set following these rules: from -20 to 20 degrees in latitude tropical, from 20 to 60 and -20 to -60 Mid-latitude and from Latitudes greater than 60 Polar. The seasons obey to the following rules: summer from April to September included and winter for the other months in the northern hemisphere, the inverse for the south hemisphere. No season change is considered for tropical regions. More than the standard available model within LOWTRAN, the users has presently the possibility to input his own radiosondes formatted with the LOWTRAN rules. In operation this option will certainly be frozen.

The visible and near infrared channels of the AVHRR are corrected by inverting an improved version of 5S, (Tanre et al., 1990) where the Rayleigh scattering and the gaseous absorption calculation have been improved. Two aerosol models will be available: maritime and continental. Three levels of corrections are planned: Rayleigh only, Rayleigh + gaseous absorption by O2, O3, H2O, CO2, Rayleigh + gaseous absorption + aerosol scattering. In operation the software will run using either climatological atmospheric contents for ozone, water vapour, and visibility or user defined values. The validation of the implementation of the software using in situ measurements over the HAPEX SAHEL site in Niger is in course in CRPE.

The output format is identical to the input formats and will be called SHARP level 2S with the corrected radiometry replacing the TOA measurements and comments of the applied processing in the Radiometric Ancillary Record of the Leader File. 255 characters (bytes 893 to 1147) are reserved to comments the correction applied: the climatic model used and the emissivity used for channel 3.

## 6.3 LST generation

Over land, the LST can be obtained using either of the two competitive methods:

- One uses the 11 micrometer channel by inverting LOWTRAN 7 with the knowledge of the emissivity at this wavelength.
- The other uses the Ottle and Vidal-Madjar, (1992) split window method where the coefficients are dependent on angle, emissivity and type of atmosphere (polar, temperate, tropical) as previously described in the atmospheric corrections section. The user has actually the possibility to chose its own split window coefficients. This possibility will be frozen for operational use.

The emissivity to be entered is the channel 4 channel 5 average emissivity. To effectively obtain the LST in an operational scheme, the average emissivity shall be retrieved from the data set itself. It means that further investigation are needed to derive this emissivity, one being to find potential relations between the emissivity in these channels and the reflectance in the visible channels.

The output format will be put in the SHARP level 2B where, over land, the LST will be put in channel 5 with comments on the applied processing in the Radiometric Ancillary Record of the Leader File.

## 7 Conclusion

This work is part of the effort presently being done in ESRIN in order to achieve the necessary experience for the exploitation of the future ESA/ENVISAT mission. In particular the use of NOAA/AVHRR, Nimbus/CZCS and Seastar/SeaWiFS allow to: generate long time series of data, develop new algorithms, experiment the usefulness of data products in term of content, amount of data as well as format and media for distribution, to test the data distribution modalities vis-a-vis the user application and finally to promote the user exploitation of new data. This experience can fruitfully used for the MERIS and AATSR as the spatial and spectral resolution of the five instruments is close as well as their potential applications.

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## 8 References

Andreessen M., 1993: NCSA Mosaic Technical Summary. Revision 2.1, May 4 1993, National Center for Supercomputing Applications, 605 E. Springfield, Champaign IL 61820.

Arino O, J.-M. Melinotte and G. Calabresi, 1993: Fire, cloud, land, water: the "Ionia" AVHRR CD-Browser of ESRIN. Earth Observation Quarterly, 41, July 1993, ESA/ESTEC, Noordwijk.

Arino O. et al: Standardization and synthesis of AVHRR and ATSR data. Software prototypes to derive high level products within ESA operational context. Proceeding of the 6th European AVHRR Data Users' Meeting, Belgirate 29 June-2 July 1993.

Buongiorno A., G. Pittella and J. Eidenshink, 1993: Environmental project "Global Land 1km AVHRR data set": The status of data collection archiving and processing after the first year of experience. Proceeding of the 6th European AVHRR Data Users' Meeting, Belgirate, 29 June-2 July 1993.

CEOS Inventory Exchange Format, Version 2.1.1, 7 February 1992, CEOS WGD Catalogue Subgroup.

Earthnet TIROS AVHRR Catalogue user guide, 1990, ESA/ESRIN, Frascati.

Fusco L. and K. Muirhead, 1987: AVHRR Data Services in Europe. ESA bulletin, 49, February 1987, ESA/ESTEC, Noordwijk.

Fusco L., Muirhead K. and G. Tobiss, 1989: Earthnet's Coordinated Scheme for AVHRR Data. International Journal of Remote Sensing, 10, 625-636.

Fusco L. and G. Pittella, 1991: CEOS (Committee on Earth Observation Satellites) AVHRR Work Plan: An International Effort for the Coordination of AVHRR Related Activities. Proceeding of the 5th European AVHRR Data Users' Meeting, Tromso, 25 June-28 June 1991.

Gesell G., T. Koenig, K.T. Kriebel and H. Mannstein, 1993: SHARK-APOLLO: Quantitative satellite data analysis based on ESRIN/SHARP-2A and DLR/APOLLO. Proceeding of the 6th European AVHRR Data Users' Meeting, Belgirate, 29 June-2 July 1993.

HRPT Groud Station Database, 1991: Worldwide review of High Resolution Picture Transmission Ground Stations. Release June 1991, ESA/ESRIN, 1991.

Kaufman Y.J. and B.J. Holben, 1993: Calibration of the AVHRR visible and near-IR bands by atmospheric scattering, ocean glint and desert reflection. International Journal of Remote Sensing, 14, 21-52.

Kneizys et al., 1988: users guide to LOWTRAN 7. Report AFGL-TR-88-0177, AFGL, Hanscom AFB, MA 01731, USA, 137 p.

Lauritson L., G.J. Nelson and F.W. Porto, 1979: Data extraction and calibration of TIROS-N/NOAA radiometers. NOAA technical Memorandum NESS 107, NOAA, Washington D.C.

Mc Clain E.P., Walton C.C. and L.L. Stowe, 1990: CLAVR cloud/clear algorithms and non linear atmospheric corrections for multichannel sea surface temperatures. Fifth conference on satellite meteorology and oceanography, 3-7 September 1990, London, 133-138.

Melinotte J.-M. and O. Arino, 1993: AVHRR CD-Browser "Ionia". Proceeding of the 6th European AVHRR Data Users' Meeting, Belgirate, 29 June-2 July 1993.

Muirhead K. and O. Malkawi, 1989: Automatic Classification of AVHRR Images. Proceeding of the 5th European AVHRR data users' meeting, Rothemburg, 5-8 September 1989.

Ottle C. and D. Vidal-Madjar, 1992: Estimation of land surface temperature with NOAA 9 data. Remote Sensing of the Environment, 40, 27-41.

Pittella G. and C. Bamford, 1989: The EARTHNET "SHARK" system for TIROS data acquisition processing and archive. Proceeding of the 5th European AVHRR Data Users' Meeting, Rothemburg, 5-8 September 1989.

Pittella, G., 1994: Using Non-ESA Missions to prepare for ENVISAT. ESA bulletin, 7&, In print, ESA/ESTEC, Noordwijk.

Saunders R.W. and K.T. Kriebel, 1988: An improved method for detecting clear sky and cloudy radiances from AVHRR data. International Journal of Remote Sensing, 12, 123-150.

SeaShark: Development of the SeaShark software system for the SeaWiFS European Data Information System (SEDIS). Invitation To Tender AO/1-2489/93/I-HGE, 10 June 1993, ESA/ESRIN, Frascati.

SHARK Users' Manual, 1993. ESA/ESRIN, Frascati.

SHARK Technical Reference Manual, 1993. ESA/ESRIN, Frascati.

SHARP level 1 Technical Specification of CCT Format, Release 1.1, 1989. ESA/ESRIN, Frascati.

SHARP level 2 Technical Specification of CCT Format, Release 1.0, 1992. ESA/ESRIN, Frascati.

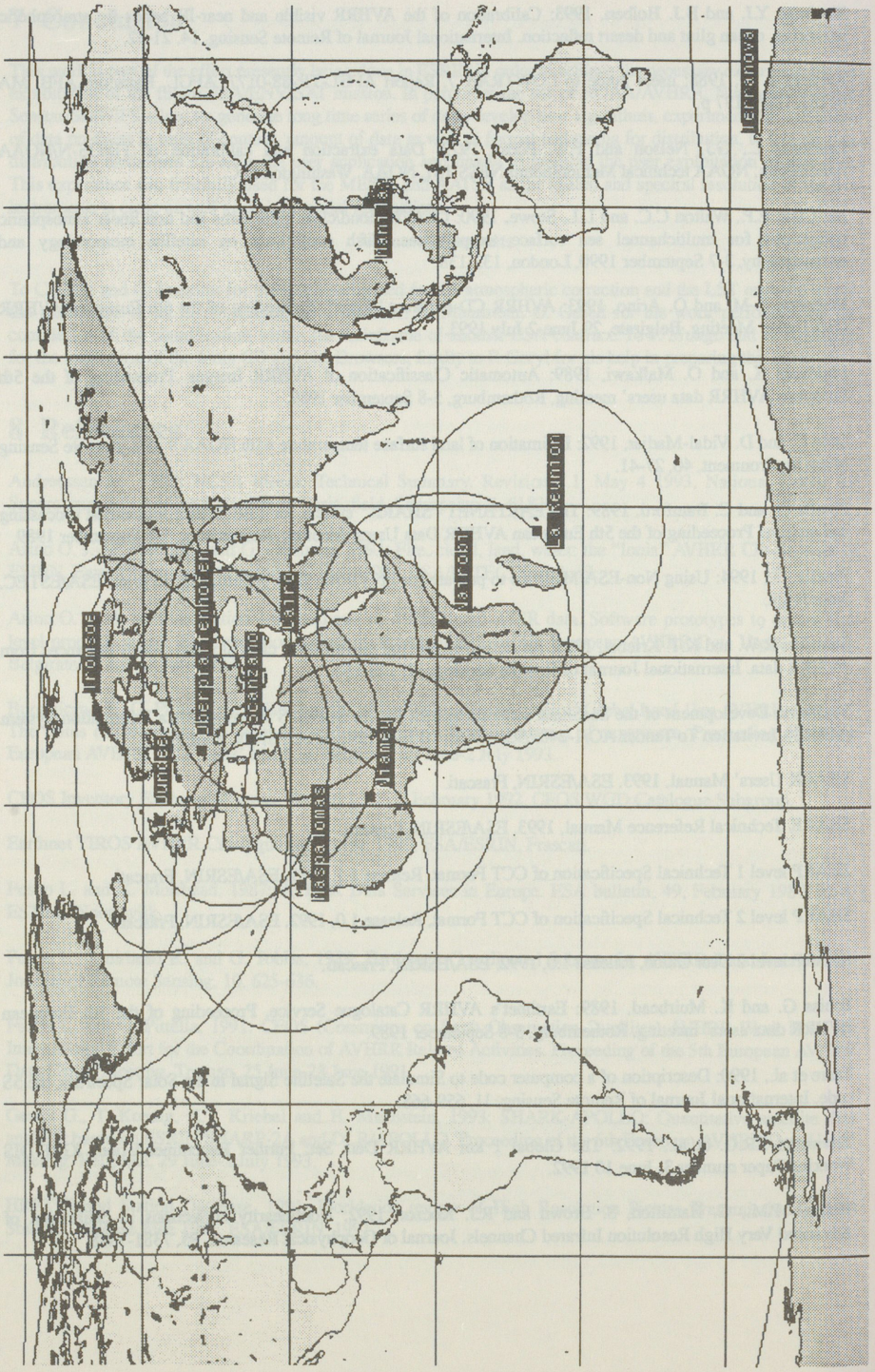
SHARP level 2 User Guide, Release 1.0, 1992. ESA/ESRIN, Frascati.

Tobiss G. and K. Muirhead, 1989: Earthnet's AVHRR Catalogue Service. Proceeding of the 5th European AVHRR data users' meeting, Rothemburg, 5-8 September 1989.

Tanre et al., 1990: Description of a computer code to Simulate the Satellite Signal in the Solar Spectrum, the 5S code. International Journal of Remote Sensing, 11, 659-668.

Townsend J.R.G. et al., 1992: The Global 1 km AVHRR Data Set: Further Recommendation. IGBP-DIS Working Paper number 3, June 10 1992.

Weinreb P.M., G. Hamilton, S. Brown and R.J. Koczor, 1992: Nonlinearity corrections in calibration of Advanced Very High Resolution Infrared Channels. Journal of Geophysical Research, 95, 7381-7388.


Ilam
Terranova
La Reunion
Jairobi
Cairo
Tromsoe
Uberpfaffenhofen
Canzano
Dundee
Dramey
Maspalomas

# AVHRR DATA PRODUCTS

| | SPARE BITS | BAND 1 | BAND 2 | BAND 3 | BAND 4 | BAND 5 |
|---|---|---|---|---|---|---|
| **LEVEL 1 B** | 3 | RAW | RAW | RAW | RAW | RAW |
| **LEVEL 2 A** | CLASSIF | REF 1 | REF 2 | RAD 3 | BT 4 | BT 5 |
| **LEVEL 2 B** | LAND | NDVI | REF 2 | RAD 3 | BT 4 | LST |
| | SEA | REF 1 | REF2 | RAD 3 | BT 4 | SST |
| | OTHER | REF 1 | REF 2 | RAD 3 | BT 4 | BT 5 |
| **LEVEL 2 S** | CLASSIF | S REF 1 | S REF 2 | S RAD 3 | S BT 4 | S BT 5 |
| | ATMOSPHERIC CORRECTED | | | | | |

soon available demo here

soon available demo here

soon available

**FDP** (Fast Delivery Product) → RAW

QUICK LOOK

ACTIVE FIRE

SURFACE NDVI

SST

soon available

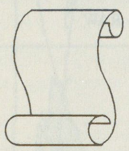
image size: 512 x 480

on 1 byte / 2 bytes

geocoded or not

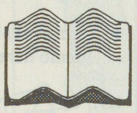
Figure 2.

# AVHRR DATA VISIBILITY



**Inventory: LEDA** ⟶ **Synthetic informations on ESA archived products**

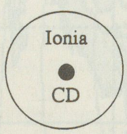
Network access: X25 link, Internet, span



**QUICK LOOK Files** ⟶ **QL paper**

Via fax, or at ESRIN

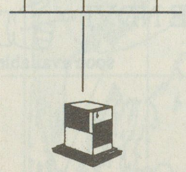
**Ionia CONCEPT: Catalogue + Quick Look + Browse Software**




**CD 1) Demonstration Ionia CD**

**ESA Archived products** demonstration here

**2) "1 Km" Multi Platform available April 94**



**Net Browser 1) Experimental Iona Net Browser**

**2) Experimental "1 Km"**

Network access: Internet World Wide Web NCSA's Mosaic

WWW address: http://tracy.esrin.esa.it:5555/browse.html

Figure 3.