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Information on ALOS AVNIR-2 / PRISM Products for ADEN users

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TABLE OF CONTENTS

1 INTRODUCTION

1.1 Purpose of this document

The Advanced Land Observing Satellite (ALOS) was launch on 24 January 2006. ALOS has three remote-sensing instruments: the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) for digital elevation mapping, the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) for precise land coverage observation, and the Phased Array type L-band Synthetic Aperture Radar (PALSAR) for day-and-night and all-weather land observation.

Purpose of this document is to provide a basic description on ALOS mission, to list main characteristics of the optical instruments on board ALOS and to clarify issue regarding the product levels.

1.2 Reference documents

This section describes the related documents and applied conventions to be considered within the present document.

R-1	*CALIBRATION AND VALIDATION OF PRISM ON BOARD ALOS* Tadono T and al. ISPRS 2004 http://www.isprs.org/istanbul2004/comm1/papers/3.pdf
R-2	Products specifications, http://www.eorc.jaxa.jp/ALOS/doc/format.htm
R-3	ALOS home page, http://www.eorc.jaxa.jp/ALOS/index.htm

1.3 Abbreviations and Acronyms

This section controls the definition of all abbreviations and acronyms used within this document. Special attention has been paid to adopt abbreviations, acronyms and their definitions from international standards as ISO, ANSI or ECSS.

ADEN	ALOS Data European Node
ANSI	American National Standards Institute
ALOS	Advanced Land Observing Satellite
AVNIR-2	Advanced Visible and Near Infrared Radiometer type 2

DEM	Digital Elevation Model
JAXA	Japan Aerospace Exploration Agency
PRISM	Panchromatic Remote-sensing Instrument Stereo Mapping

2 ALOS MISSION

The Advanced Land Observing Satellite (ALOS) will perform high-resolution observation of the earth's surface to assist in the process of compiling very detailed. ALOS will also be used to monitor disasters for environmental protection and for maintaining and developing earth observation technology.

2.1 Objectives

- Cartography,
- To perform regional observation for "sustainable development", harmonization between Earth environment and development (Regional Observation),
- To conduct disaster monitoring around the world (Disaster Monitoring),
- To survey natural resources (Resources Surveying),
- To develop technology necessary for future Earth observing satellite (Technology Development)

2.2 Instruments onboard ALOS

The ALOS has three remote-sensing instruments: the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) for digital elevation mapping, the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) for precise land coverage observation, and the Phased Array type L-band Synthetic Aperture Radar (PALSAR) for day-and-night and all-weather land observation. In order to utilize fully the data obtained by these sensors, the ALOS was designed with two advanced technologies: the former is the high speed and large capacity mission data handling technology, and the latter is the precision spacecraft position and attitude determination capability. They will be essential to high-resolution remote sensing satellites in the next decade. The ALOS will be launched by an H-IIA launch vehicle from the Tanegashima Space Center, Japan in 2005.

2.3 Repeatability - revisit

ALOS instruments are capable to observe the surface of the entire world within the following limits:

- Any place within two (2) days.
- Around the equator: about 60% of the area within one day.
- At latitudes of 35º: about 70% of the area within one day.

- At latitudes larger than 55º: any place every day (provided there is no cloud cover for the optical instruments).

Daytime observation modes: PRISM (fore, nadir & aft) and AVNIR-2 simultaneously
Nighttime observation modes: PALSAR (Note: AVNIR-2 and PALSAR are able to operate simultaneously).

2.4 Orbit

Category: Sun-synchronous, sub-recurrent orbit
Local sun time at descending node: 10:30 am +/- 15 min
Orbit altitude equator: 691.56 km
Orbit inclination: 98.16 degrees
Period 98.7 minutes
Revolution: 14+27/46 rev/day
Recurrent period: 46 days
Longitude repeatability: +/- 2.5 km
Minimum distance between orbit (above equator): 59.7 km (latitude direction)

3 ALOS OPTICAL INSTRUMENTS

3.1 AVNIR-2

3.1.1 PRESENTATION

The Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) is a visible and near infrared radiometer for observing land and coastal zones and provides better spatial land coverage maps and land-use classification maps for monitoring regional environment. The AVNIR-2 is a successor to the AVNIR onboard the Advanced Earth Observing Satellite (ADEOS) launched in August 1996.
Applications: monitoring of regional environment (land coverage and land-use maps, etc.).

3.1.2 TECHNICAL ASPECTS; OVERVIEW

Resolution: Its main improvement over AVNIR's is its instantaneous field-of-view (IFOV). The AVNIR 2 provides **10-meter** spatial resolution images compared with the 16 m resolution of the AVNIR in the multi spectral region. The higher resolution was realized by improving the CCD detectors (AVNIR: 5,000 pixels per CCD, AVNIR-2: 7,000 pixels per CCD) and their electronics.
Pointing capability: AVNIR-2 features a pointing capability of ±44º in the across-track direction, thereby providing a wide field of regard (FOR) for disaster monitoring. The silicon CCD detector arrays have 7000 pixels per line (push broom type instrument).

Data compression: A quasi-lossless data compression technique of DPCM (Differential Pulse Code Modulation) with Huffman coding is employed for a source data reduction from 160 Mbit/s to 120 Mbit/s.
Calibration: AVNIR-2 uses two onboard calibration lamps, which are used for absolute and relative calibration sequences. In addition, internal electrical calibration is provided.

3.1.3 CHARACTERISTICS AND SPECIFICATIONS

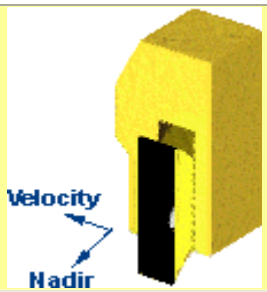
AVNIR-2 - characteristics and specifications	
Instrument illustration	
Number of Bands	4
Wavelength	Band1 : 0.42 - 0.50 micrometers Band2 : 0.52 - 0.60 micrometers Band3 : 0.61 - 0.69 micrometers Band4 : 0.76 - 0.89 micrometers
Spatial Resolution	10 m (at Nadir)
Swath Width	70 km (at Nadir)
S/N	>200
MTF	Band 1~3 : >0.25 Band 4 : >0.20
Number of Detectors	7000 / band
Pointing Angle	- 44 to + 44 deg.
Bit Length	8 bits
Data rate	About 160 Mbit/s of raw data, a quasi-lossless (DPCM) data compression technique reduces the actual downlink data rate of AVNIR-2 to 120 Mbit/s (3/4 reduction)

table 1 - Some characteristics of the AVNIR-2 instrument.

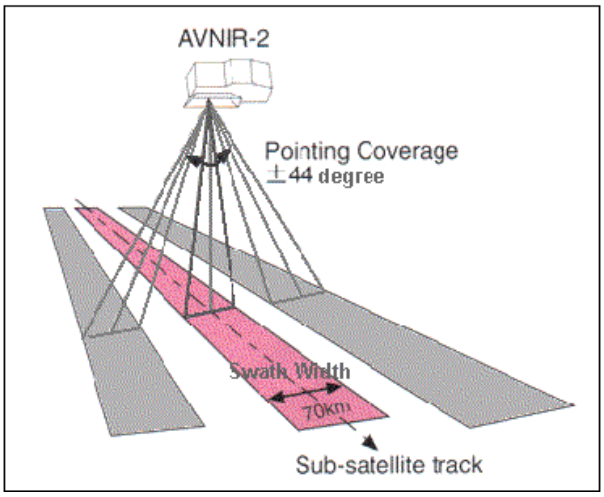


fig. 1 - Illustration of AVNIR-2 observation capabilities

Note: AVNIR-2 cannot observe the areas beyond 85 degrees south and north latitude.

3.2 PRISM

3.2.1 PRESENTATION

The Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) is a panchromatic radiometer with 2.5-meter spatial resolution. Its data will be used for extracting highly accurate digital elevation model (DEM).

3.2.2 TECHNICAL ASPECTS; OVERVIEW

Three optical systems: The PRISM has three independent optical systems for nadir, forward and backward looking to achieve along-track stereoscopy. Each telescope consists of three mirrors and six or eight Charge Couple Device (CCD) detectors for push-broom scanning.

Width coverage: The nadir-looking radiometer provides 70 km width coverage; forward and backward radiometers provide 35 km width coverage each.

Base-to-height ratio: The radiometers are installed on both side of its optical bench with precise temperature control. Forward and backward radiometers are inclined + and – 23.8 degrees (distance between observed area is about 310 km between two consecutives cameras) from nadir to realize a base-to-height ratio of one.

Electrical pointing: Each radiometer will use electrical pointing function (within +/- 1.5 degree), to compensate Earth rotation and thus to provide fully overlapped three-stereo (triplet) images (35 km width) without mechanical scanning or yaw steering of the satellite.

3.2.3 CHARACTERISTICS AND SPECIFICATIONS

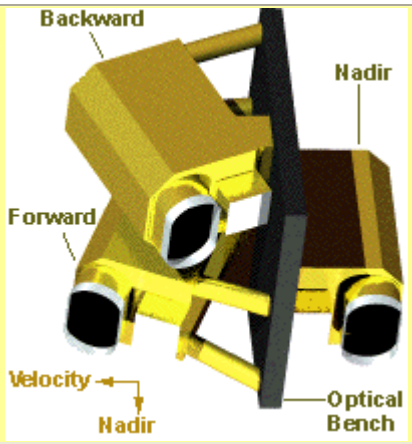
PRISM Characteristics	
Instrument illustration	
Number of Bands	1 (Panchromatic)
Wavelength	0.52 ~ 0.77micrometers
Number of Optics	3 (Nadir; Forward; Backward)
Base-to-Height ratio	1.0 (between Forward and Backward looking)
Spatial Resolution	2.5m
Swath Width	70km (Nadir only or Nadir + Backward) 35km (Triplet mode)
S/N	>70
MTF	>0.2
Number of Detectors	28000 / band (Swath Width 70km) 14000 / band (Swath Width 35km)
Pointing Angle	-1.5 to +1.5 deg. (Triplet Mode, Cross Track)
Bit Length	8 bits
Data rate	960 Mbit/s of raw data, a lossy JPEG compression is used based on DCT quantization and Huffman coding technique. The actual downlink data rate of PRISM is reduced to either 240 Mbit/s (1/4.5 reduction) or to 120 Mbit/s (1/9 reduction)

table 2 Some characteristics of the PRISM instrument.

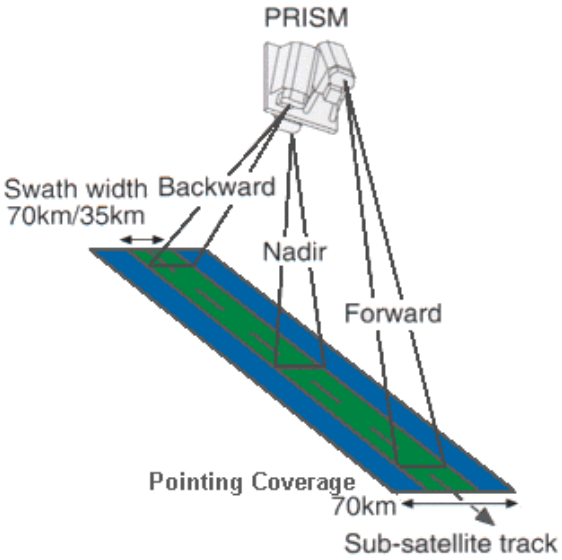


fig. 2 Illustration of the PRISM instrument and three-line imaging configuration

Note:
PRISM cannot observe the areas beyond 82 degrees south and north latitude.
PRISM optics are mounted on a rigid optical bench which is thermally controlled within ±3º C to minimize distortions in the optics system.
JAXA does not plan to make Nadir and Backward mode operational during commissioning phase.

4 PRODUCT FORMAT SPECIFICATIONS

ALOS products follow the standard CEOS format convention. The detailed product format specifications have been defined and are maintained by JAXA. Detailed information is available at:
http://www.eorc.jaxa.jp/ALOS/doc/format.htm

5 AVAILABLE PRODUCTS

Products provided by ADEN are generated using the Jaxa processor, integrated in the ADEN ground segment. Therefore, product format and auxiliary information provided in the product (product coordinates, calibration parameters, etc) are those defined by Jaxa.

5.1 AVNIR-2

5.1.1 AVNIR-2 STANDARD PRODUCTS AVAILABLE TO USERS

Level	Definition	Option	Note
1A	Uncompressed, reconstructed digital counts appended with radiometric calibration coefficients and geometric correction coefficients (appended but not applied)		Separate image files for each band
1B1	Radiometrically calibrated data at sensor input		Separate image files for each band
1B2	Geometrically corrected data Option G: Systematically Geo-coded R: Systematically Geo-referenced	**Map-Projection:** UTM, Polar Stereographic **Resampling:** Nearest Neighbour Cubic Convolution Bi-Linear	Separate image files for each band

table 3 ADEN AVNIR-2 products availability

NB : Level 0 is not available for use

5.1.2 AVNIR-2 PRODUCTS CHARACTERISTICS

- Level 1A is not calibrated.

- A summary file (ASCII file) is joined to data processed into summary file. This ASCII file embeds basic information on product metadata.

- Pixel spacing:

Pixel spacing to be applied for transformation from level 1B1 to level 1B2 is strongly depend on pointing angle of AVNIR-2 instrument when observing the area of interest.

This parameter is fixed by the processor following the pointing angle:

Pointing angle	0 to 31.6 degrees	angle 31.6 to 40.3 degrees	More than 40.3 degrees
Pixel spacing (m)	10	15	20

table 4 Pixel spacing vs pointing angle

- Gain and offset:

Radiometric rescaling gain and offset values per each band are expressed in W/m²str m and can be retrieved from product processed into CEOS format. These values are stored in the scene header record. Processing chain is applying a pre flight calibration. Coefficients have determined before launch. No in flight calibration is applied yet, results from internal calibration lamps are used for monitoring only.

- Spectral Solar irradiance:

Solar spectral irradiance values are not provided with the product processed into CEOS format. It can be computed using article from Thuillier 2003 and are following ones:

Band	Band 1	Band 2	Band 3	Band 4
Central Wavelength (nm)	463	560	652.1	820.6
Solar spectral irradiance (W/m2/ m)	1943.3	1813.7	1562.3	1076.5

table 5 Solar irradiance

- Projection parameter:

Users can choose between UTM or Polar Stereographic.
The projection parameters are fixed by the processor.
The Polar stereographic parameter corresponds to the latitude/longitude of the scene centre.
The UTM zone parameter is fixed. It follows the numbers reported in the figure below.

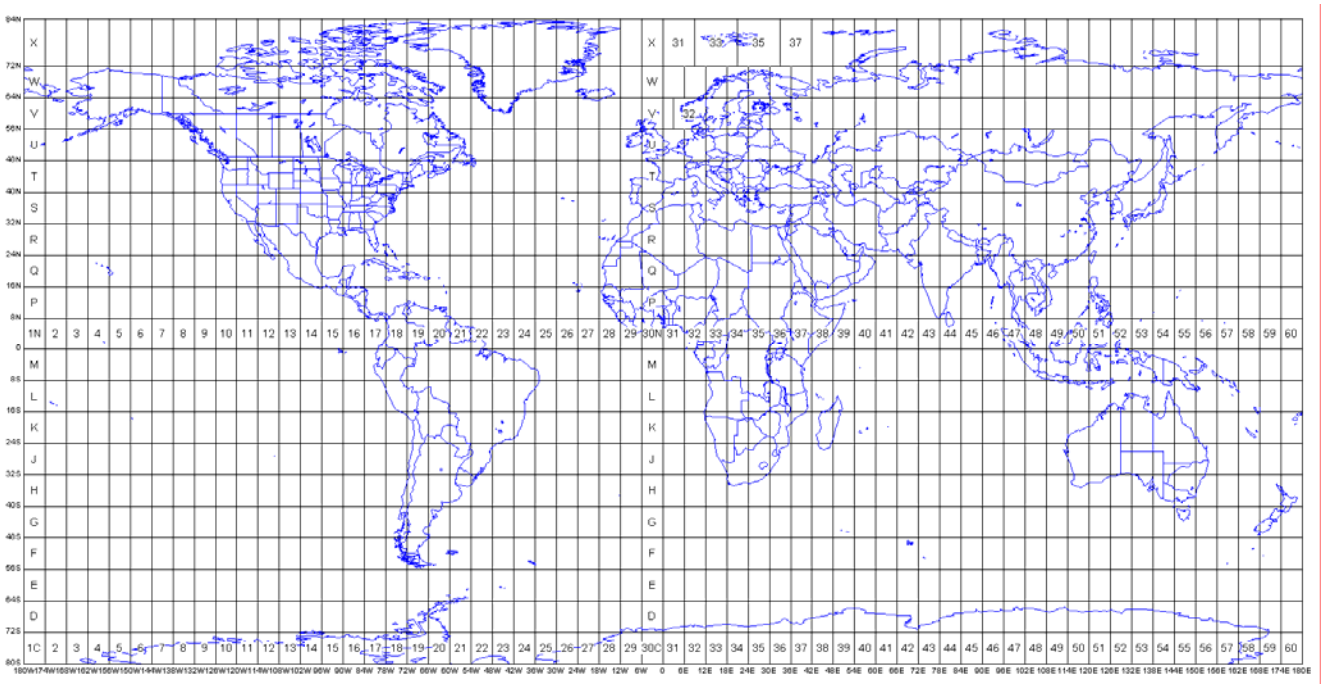


fig. 3 UTM zone

No Rational Polynomial Coefficients (RPC) are provided with product format. If user wants to apply himself map projection; to transform geo referenced product to geo coded product, he shall use polynomial coefficient provide with CEOS format. Because only planimetric computation (X,Y) are done; polynomial coefficient does not offer a good geo location accuracy.

- A quality status can be summarized as follow as output of verification phase (December 2006).

Image quality of AVNIR-2 is good; and MTF results are within specifications.
The products geolocation remains between 500 and 1500 metres; the target accuracy (100 m) is not yet reached, but should be in near future.
The radiometric calibration accuracy remains within 10%. The accuracy needs to be confirmed and refined with time.

5.2 PRISM

5.2.1 PRISM STANDARD PRODUCTS AVAILABLE TO USERS

Level	Definition	Option	Note
1A	Uncompressed, reconstructed digital counts appended with radiometric calibration coefficients and geometric correction coefficients (appended but not applied) Individual files for forward, nadir and backward looking data.		Separate image files for each CCD
1B1	Radiometrically calibrated data at sensor input		Separate image files for each CCD
1B2	Geometrically corrected data Option G: Systematically Geo-coded R: Systematically Geo-referenced	**Map-Projection:** UTM, Polar Stereographic **Resampling:** Nearest Neighbour Cubic Convolution Bi-Linear	Single image file

table 6 ADEN PRISM products availability

- Level 0 is not available for user.

5.2.2 PRISM PRODUCTS CHARACTERISTICS

- Level 1A is not calibrated.

- A summary file (ASCII file) is joined to data processed into

summary file. This ASCII file embeds basic information on product metadata.

- Geolocation information

No Rational Polynomial Coefficients (RPC) are provided with product format. If user wants to apply himself map projection; to transform geo referenced product to geo coded product, he shall use polynomial coefficient provide with CEOS format. Because only planimetric computation (X,Y) are done; polynomial coefficient does not offer a good geo location accuracy.

- Projection parameter:

Users can choose between UTM or Polar Stereographic.
The projection parameters are fixed by the processor.
The Polar stereographic parameter corresponds to the latitude/longitude of the scene centre.
The UTM zone parameter is fixed. It follows the numbers reported in figure 1.

- A quality status can be summarized as follow as output of verification phase (December 2006).

Image quality of PRISM image strongly depends on compression rate used when transferring data from spacecraft to ground station, when high compression rate is applied, blocking artefact are visible and alter image quality.

The products geo location remains above the target accuracy (3 m with no ground control point). It should be improved in near future.

Detector equalization is not performed yet. We can observe vertical striping. It will be corrected in the future.

NB: ***it should be noted that there is no time information given with L1B2, all the geometrical correction being already applied. The time can be obtained from the L1B1 product. This might be a constraint, when the zenith and azimuth angle is requested (for calibration verification for example). Indeed the computation of angles requests the satellite position at scene center.***