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Olivier HAGOLLE, Agnes GUERRY, Laurent CUNIN, Bruno MILLET,

Jacqueline PERBOS, Jean-Marc LAHERRERE, Thierry BRET-DIBAT

(CNES Toulouse)

Laurent POUTIER

(CERT/ONERA Dero)

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Olivier HAGOLLE[1], Agnes GUERRY[1], Laurent CUNIN[1], Bruno MILLET[1], Jacqueline PERBOS[1], Jean-Marc LAHERRERE[1], Thierry BRET-DIBAT[1], Laurent POUTIER[2]

1. Centre National d'Etudes Spatiales (CNES)
18,avenue Edouard Belin - 31055 TOULOUSE CEDEX-FRANCE
Phone : (33) 61 28 21 35 - Fax : (33) 61 27 31 67 - e-mail : hagolle@qtis.cst.cnes.fr

2. ONERA/CERT
2,avenue Edouard Belin BP4025 - 31055 TOULOUSE CEDEX-FRANCE

ABSTRACT

POLDER (POLarization and Directionality of the Earth Reflectances) is a French Instrument that will be flown on-board ADEOS (ADvanced Earth Observing Satellite) polar orbiting satellite, scheduled to be launched in august 1996. POLDER is a multispectral imaging radiometer/polarimeter designed to collect global and repetitive observations of the solar radiation reflected by the Earth/Atmosphere System, with a wide field of view (2400 km) and a moderate geometric resolution (6km). The instrument concept is based on telecentric optics, on a rotating wheel carrying 15 spectral filters and polarisers, and on a bidimensionnal CCD detector array.

In addition to the classical measurement and mapping characteristics of a narrow-band imaging radiometer, POLDER has a unique ability to measure polarized reflectances at three different polarization angles (for three of its eight visible and near-infrared spectral bands), and to observe target reflectances from 14 different viewing directions during a single satellite pass.

All the data transmitted by POLDER are processed in the POLDER Processing Centre. Level 1 products include geometrically and radiometrically corrected data, level 2 products are elementary geophysical products created from a single satellite pass, and level 3 products are geophysical synthesis from several passes of the satellite.

This paper presents the radiometrical and geometrical algorithms of the level 1 processing : new algorithms developed for the removal of sensor artefacts (smearing, stray light), for the radiometrical model inversion (normalized radiance and polarization parameter extraction), and for the geometrical projection of the data on a unique grid are explained.

Key words : POLDER, ADEOS, Image, Polarization, Multispectral, Multi-directionnal, Stray light, Artefacts removal

1. INTRODUCTION

Basic products related to most remote sensing imagers (SPOT, AVHRR, VGT, OCTS...) are often simple products, constituted of nearly raw data and of ancillary data containing correction and calibration coefficients. POLDER products have been defined with a different logic : Level 1 product (POLDER basic product) is fully calibrated and georeferenced. All the data acquired during a whole orbit are projected on a unique geographical grid, and for each observed grid point, all the data coming from the different spectral channels (including polarized channels) and the multiple viewing angle observations are registered.

The reasons for this unusual approach are as follows : the amount of data is very important because of the multiple spectral bands and observations ; the processing algorithms are rather complicated and require a lot of technical parameters ; finally, since POLDER is dedicated to global monitoring of the environment, most users should be interested in data covering large areas for multitemporal studies. Therefore, it seems very difficult for a single user to make use of nearly raw data, and moreover this user would need important computer power to be able to process all these data.

POLDER scientific objectives have been described in Deschamps and al (2). The present paper first recalls the main features of POLDER instrument and ground segment (chapters 2 and 3). In the fourth chapter, the structure and content of the different products are detailed. Chapter 5 begins with a global presentation of the level 1 processing algorithm. It emphasizes on the three most important parts of the algorithm : radiometric model inversion, sensor artefacts removal, and geometrical projection.

2. POLDER INSTRUMENTAL CONCEPT

The POLDER instrument concept is based on a wide-field-of-view telecentric optics, a rotating wheel carrying spectral and polarizing filters and a charged coupled device (CCD) detector array (figure 1).

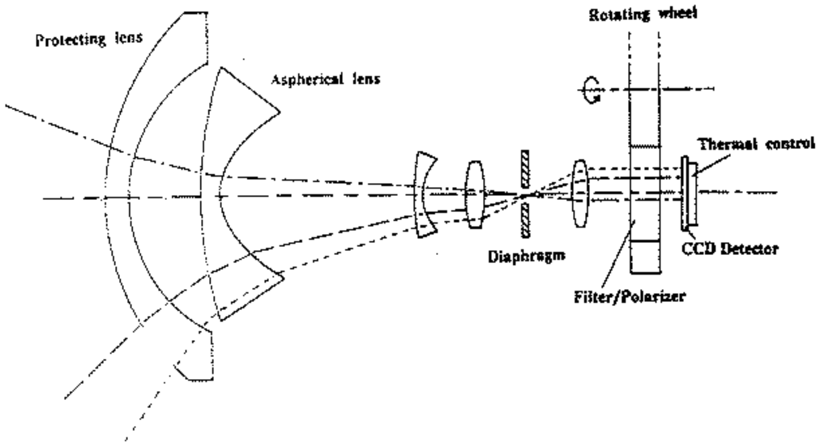

Fig 1 POLDER instrumental concept

The telecentric concept represents a major improvement over classical lenses, for it reduces the effect of the incidence angle on the entrance pupil area and provides near-perpendicular incidence of optical rays on the filters. The instrument has a focal length of 3.57mm opened to f : 4.6 and a field-of-view of ±43° along-track, ±51° across-track and ±57° in the diagonal. The two-dimensional footprint is partitioned into 242 x 274 pixels by the CCD matrix (see figure 2). From the ADEOS orbit, this geometry produces a swath width of about 2400 km while the arrangement of the photo-elements in the CCD matrix yields to a quasi-constant resolution throughout the swath, distorted only by the earth curvature and equal to 6 x 7 km^2 at nadir.

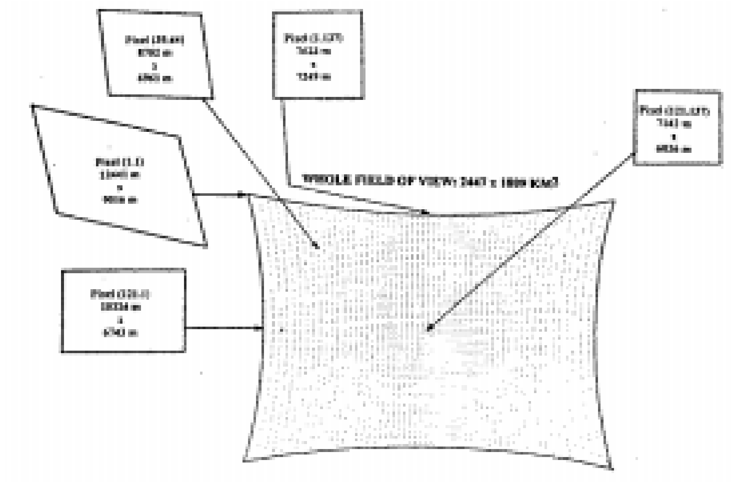

Fig 2. POLDER image on-ground footprint

Multi angle viewing is achieved by the over-riding of the successive images of the same spectral band. Thus, in single satellite pass, any target within the instrument swath can be observed quasi-simultaneously under up to 14 different viewing angles (see figure 3).

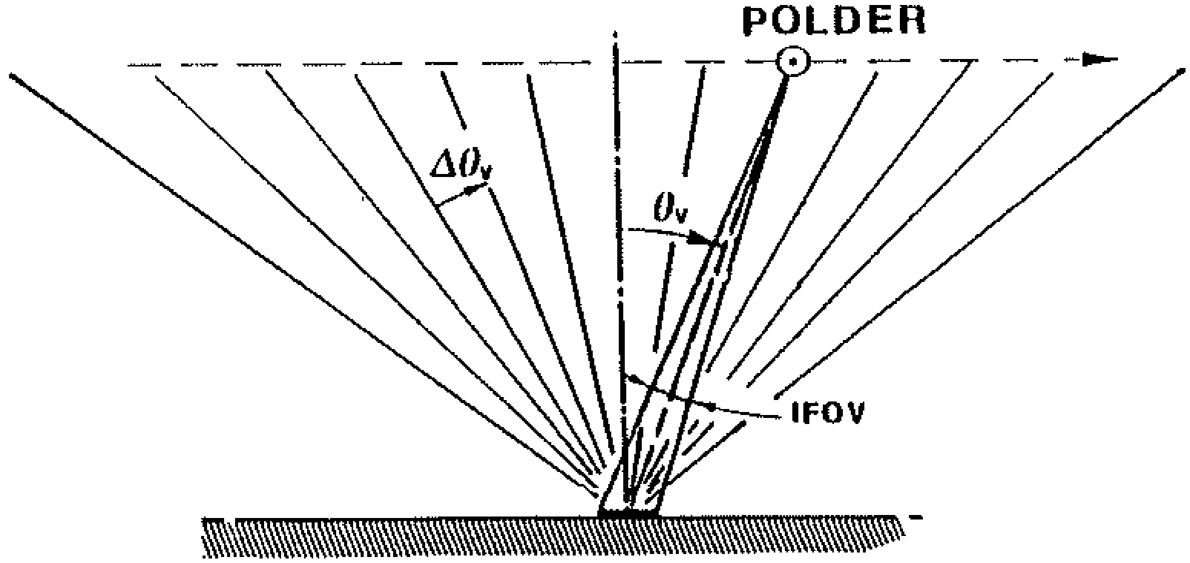

Fig 3. POLDER multiple viewing principle

The multi-polarization and multispectral capability is produced by the rotation of the wheel equipped with sixteen slots hosting interference filters and polarizers. The wheel rotates steadily with a period of 4.9s and the full 16 channel measurement sequence is activated every four rotations which corresponds to 19.6s. The filters mounted on the wheel allow to observe reflectances in nine narrow spectral bands of the visible and near infrared spectrum, namely 443P, 443 490, 565, 670, 763, 765, 865 and 910 nm. A sixteenth, opaque filter is mounted on the wheel for measurement of the CCD dark current at each wheel cycle and control of its stability.

For three of these bands centered on 443, 670 and 865 nm respectively, measurements are made at three different polarization angles 60 degrees apart, using three different channels per band. For each of the three bands, three polarized channels are obtained by superimposing identical spectral filters with one polarizer, the axis of which turns by 60° from one channel to the next. The three polarization measurements are successive. In order to compensate for the spacecraft motion during the time lag between the first and the last measurements and to co-register the three polarized images, a wedge prism is added to each polarizing assembly. 443 band is doubled because 443P polarized band does not meet the ocean color radiometrical resolution requirement

3. POLDER GROUND SEGMENT

The POLDER Ground Segment, located at the CNES Toulouse space centre is made up of three components :
- the POLDER Processing Centre;
- the Image Quality System computes calibration parameters, evaluates the sensor performances, and assesses the radiometric and geometric quality of Level 1 Products ;
- the Scientific Quality System assesses the Level 2 and 3 products quality and provides a scientific user service .

The POLDER Processing Centre itself is made of four subsystems:
- the Instrument Control System generates the instrument programming requests and monitors the housekeeping data,
- the Archiving and Management System archives level 0 data and POLDER Standard Products and delivers the distribution media for the user product requests,
- the User Service offers a catalogue service to external users, including POLDER mission and standard products information, inventory information to help in the choice of products, POLDER standard products ordering facilities and an electronic mail service.
- the Data Processing System systematically processes (and eventually reprocesses) every level 0 data into higher level products.

4. POLDER PRODUCTS

4.1. POLDER Earth reference grid

The final objective of POLDER data processing is to generate level 3 products which are global synthesis of various geophysical parameters (see section 4.3) from multitemporal data. But it is also necessary to register the multispectral and multidirectionnal data from the early processing stages to obtain level 1 and 2 products. Therefore, in order to avoid successive resamplings of the data, all POLDER products are generated on a unique, fixed, geocoded projection grid, called POLDER reference Earth grid. The criteria for the choice of this grid are : 1) a constant area grid, 2) a pixel shape close to a square and 3) a sampling step close to POLDER resolution. These criteria led to the equal area sinusoidal (or Samson Flamsteed) projection with a grid step of 6.17 km (18 pixel per degree of latitude). Samson Flamsteed projection has been slightly modified so that each half projection line (half parallel) is made of a whole number of pixels. This will allow to switch from a Greenwich centered projection to a 180° centered projection that shows the entire Pacific Ocean without a cut by a simple translation of the pixels inside a line.

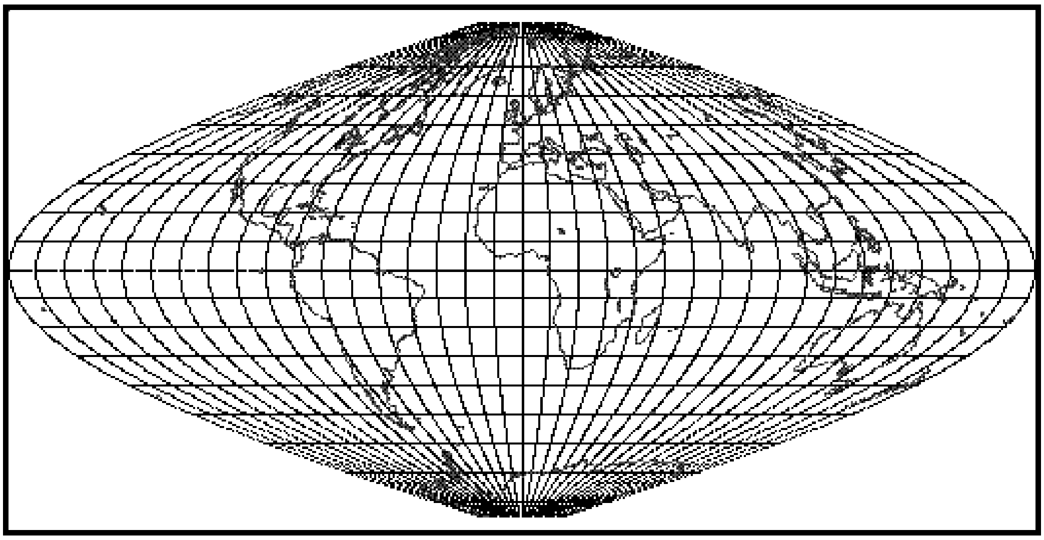

Fig 4 : The POLDER reference earth grid.

A POLDER data segment is the subset of points from the POLDER reference earth grid corresponding to a single satellite pass. The geographical extension of a given POLDER data segment depends on its relative position within the 41 day orbit cycle of ADEOS and the season which affects the extent and position of the sunlit portion of the orbit. The number of points of the grid observed during one data segment never exceeds 1.2 million points.

4.2 Level 1 product

POLDER main feature is to provide up to 14 observations with 14 different viewing directions for each observed grid point, each observation being made of 15 channels including 3 polarized bands. POLDER level 1 product has been conceived so that all the information belonging to a given grid point is gathered into the same file record. This disposition allows to use easily the bidirectional information acquired by POLDER. Each record contains the following information : for each viewing direction (up to 14), level 1 product gives the result of the nine spectral bands measurements, and the associated viewing angles. Each record contains also the solar angles, a land/sea mask, a coarse cloud mask, and some flags indicating the quality of the measurements. For each polarized band, the three measurements made for three different polarization angles are converted into Stockes parameters expressed in normalized radiance units. For the non-polarized channel, classical normalized radiances are derived.

4.3 Level 2 and 3 products

Level 2 and 3 products are generated using Level 1 data together with meteorological and ozone ancillary data. They are also georeferenced on POLDER reference earth grid. Level 2 products are created from a single satellite pass, and Level 3 products are global maps obtained by combining multiple orbit measurements. Three lines of products are generated: 1) Earth radiation budget and clouds, 2) Ocean and marine aerosols, 3) Land surfaces and continental aerosols. They include various geophysical parameters such as cloud coverage, cloud top altitude, atmospheric water vapor content and aerosol optical thickness, water leaving radiances and pigment concentration, surface reflectances corrected for atmospheric effects, as well as angular signatures for various scenes.

5. POLDER LEVEL 1 PROCESSING ALGORITHMS

5.1 Global presentation

POLDER data (called level 0 data) included in ADEOS telemetry are sent by NASDA data production center and received one week after acquisition in CNES POLDER processing centre. These data are self-consistent and include for each viewing segment :

- POLDER data: about 120 successive cycles of 16 channels are recorded continuously
- Ancillary data : these data include datation information, temperatures and restituted attitude angles of the satellite (sampled every seconds).
- Orbit data: one day satellite position and velocity vectors are sampled every minute.

The purpose of POLDER level 1 processing is to transform the 130 cycles of 15 channel images acquired during a viewing segment into radiometrically corrected, calibrated and geometrically rectified values covering one million grid points. A flowchart of the level 1 processing is given below (fig 5). The first step extracts and checks channel images, eliminating images with a lot of saturated pixels and interpolating missing or faulty pixels. During the second step, the necessary informations are extracted from ancillary data : satellite position vectors are interpolated for every channel acquisition instant. In the third one, each elementary measurement is converted into normalized radiance after some radiometric sensor artefacts are removed. The geometrical processing resamples each image onto the fixed reference grid during the fourth step. The last two steps consist in the estimation of viewing and solar angles and in the evaluation of the crude cloud mask.

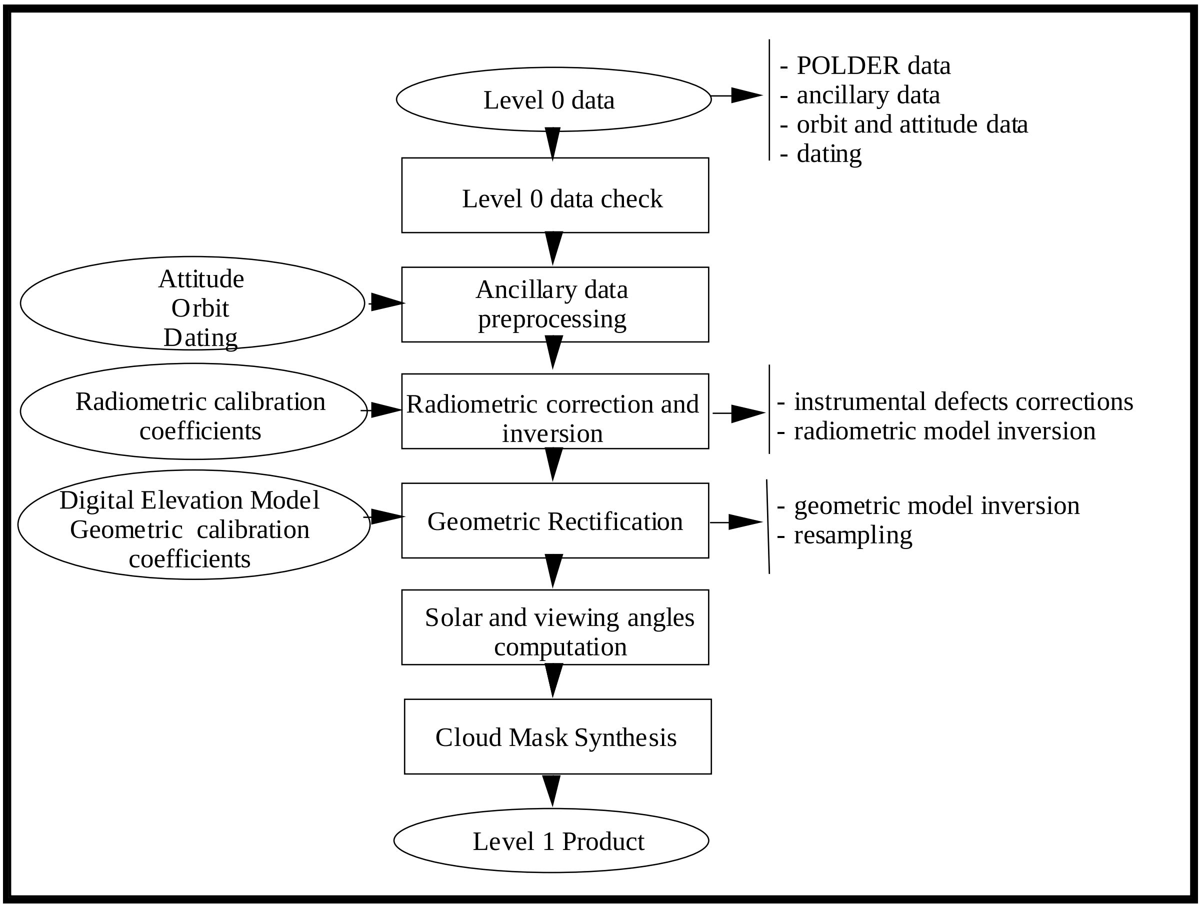

Fig 5.. Level 1 processing diagram

5.2 Removal of sensor artefacts

POLDER is affected by some low intensity artefacts which could be neglected with an 8 bit quantization, but have a higher impact because of the 12 bit quantization and the drastic radiometric mission requirements. These defects come either from electronic problems (dark currents, smearing effect, non uniformity of elementary detector sensitivity) or from optical defects (stray light). The magnitude of these defects is small enough so that the order of these corrections is not very important. However, since the incoming light first passes through the optics and then is measured by the electronics, the corrections are made in the reverse order : the level 1 processing first corrects the electronical defects and then the optical defects.

Most of the spectral bands will never be saturated (especially 443P), except the 3 ocean color bands (ie 443, 490, 565) which will be saturated over bright clouds and sunglint. Level 1 algorithm uses the normalized radiance measured in 443P channel to extrapolate the radiance of the saturated pixels in the ocean color bands. This extrapolation is rather good (a few %) because the only bright sources in ocean color bands are clouds and sunglint which are spectraly flat. However, the extrapolated information is only used for artefact removal, and all the saturated pixels will be flagged in the level 1 product.

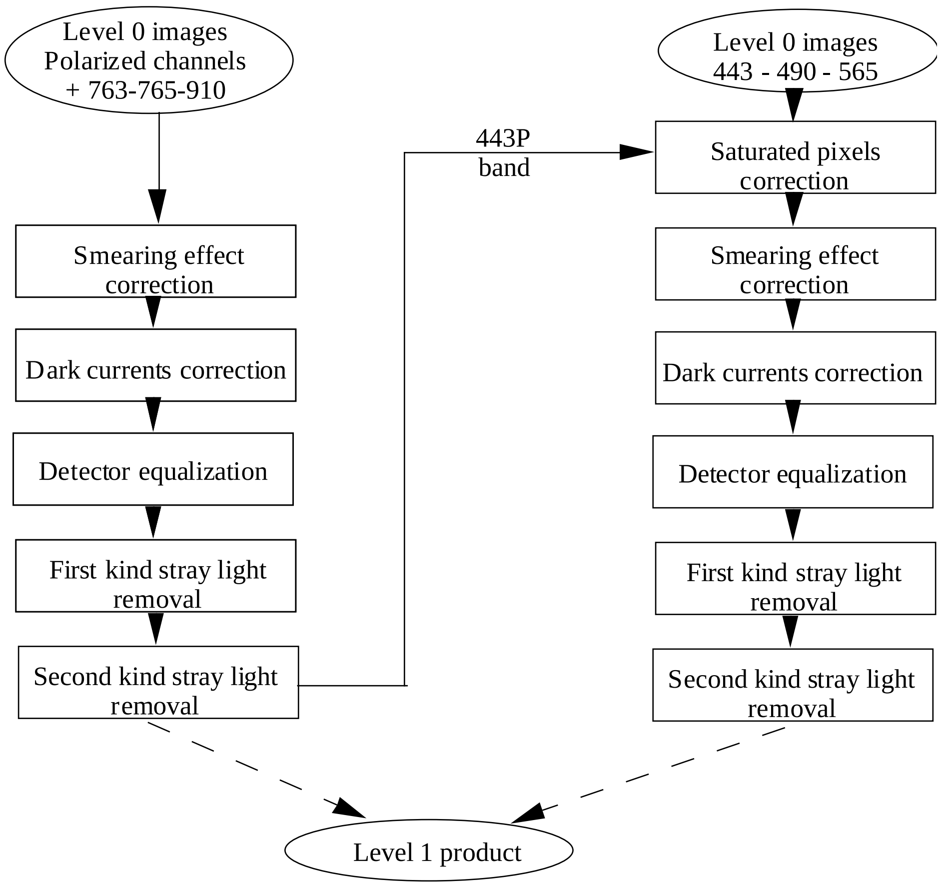

Fig 6. Diagram of sensor artefacts removal algorithm

5.2.1. Removal of smearing effect

The Smearing effect is an artefact related to the acquisition principle of POLDER matricial images. The CCD matrix is constituted of two zones of equal area : an acquisition zone, and a transfer zone which is always obturated and receives no light. At the end of the integrating period, the data acquired by the acquisition zone are shifted line by line towards transfer zone. During this brief transfer time, the elementary detectors of the acquisition zone keep on receiving light.

Let A (l_0,p_0) be an elementary detector of the acquisition zone. During its shift towards transfer zone, information X(l_0,p_0) coming from A receives extra charges from every detector of p_0 column closer than A to transfer zone. Let Y(l_0,p_0) be the new value of the information coming from A after it has been shifted towards transfer zone.

$$Y(l_0, p_0) = X(l_0, p_0) + \sum_{l=l_0+1}^{242} X(l, p_0) \frac{t_{shift}}{t_{integration}}$$

Where - t_{shift} is the time necessary to shift the data of one line towards the transfer zone
- $t_{integration}$ is the integration time ($t_{shift} << t_{integration}$)

In order to correct the smearing effect, it is necessary to know the value of $X(l,p_0)$ for all the detectors such that $l \geq l_0$. This value is obtained line by line using the fact that the pixels of line 242 are immediately shifted into transfer zone without receiving extra charges : $Y(242, p_0) = X(242, p_0)$. Provided that no information is missing or saturated, it is then possible to perfectly correct the smearing effect.

5.2.2. Removal of darkness signal

This is a problem which affects any type of CCD detector : even if no light reaches the CCD array, the measurements obtained by the elementary detectors are not equal to zero : these values are called "dark currents". One of POLDER rotating wheel filters is indeed an obturator and at the beginning of each cycle of the rotating wheel, a dark current image is recorded. For a better accuracy, each detector dark current value is averaged over nine acquisitions. This value is then substracted to the 15 channel measurements made by the elementary detector.

5.2.3. Detector sensitivity normalization

Sensitivity of the elementary dectectors is not uniform in the CCD array, because each detector slightly differs from the other ones. It is then necessary to normalize these differences during the processing of the data. This operation makes use of normalization coefficients determined for each channel on-ground and in-flight.

5.2.4. Stray light correction

First kind stray light

First kind stray light is an optical artefact caused by the fact that POLDER CCD array reflects an important part of the incoming light : the reflected light comes back towards POLDER optics and is reflected again onto the detectors by the diopters. POLDER has a large aperture telecentric telescope (i (fig 7) equals 4 degrees). Therefore the light beams reflected by the CCD array can come back to the matrix far from their starting point (up to 30 pixels). Reflection rates of the diopters are very low (less than 1%), but CCD reflection rate is high enough (60%) so that stray light intensity cannot be neglected. Because of first kind stray light, a low amplitude and long diameter spot appears around each enlightened pixel. When not only a pixel but a zone of the CCD array is enlightened, the spots corresponding to each pixel are added and the intensity of observed stray light increases (fig 8).

Physical explanation and measurements show that first kind stray light is a linear effect that can be modelised by a convolution. The point spread function can be neglected at a distance of 40 pixels, and is of very low intensity. It is the ideal case for the use of a simple deconvolution method. Deconvolution often increases noise level, but first kind stray light is so low that the amount of noise is nearly not modified. Level 1 processing algorithm uses Fast Fourier Transform to compute the deconvolution. The computation of the Fourier transforms of all POLDER images accounts for 10 % of the execution time of level 1 processing.

An important calibration campaign has been made on-ground to accurately measure the point spread functions for every spectral band. What remains after the correction of an image of a big bright cloud can be completely neglected at a distance of 5 pixels of the cloud (without correction, a distance of 30 pixels would be necessary).

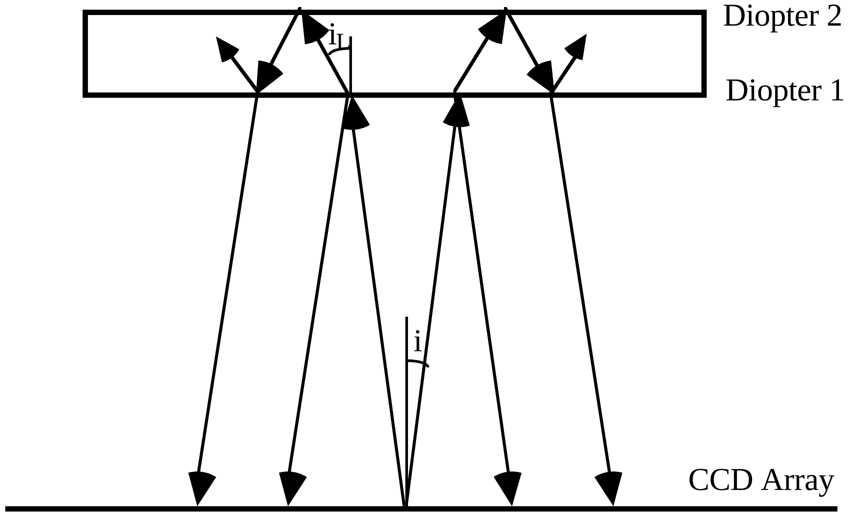

Fig 7. First kind stray light origin

Second kind stray light

Various stray light effects have been observed over POLDER images : all the effects that cannot be modelised as a deconvolution have been gathered under the denomination : second kind stray light. When the instrument is enlightened with a bright source covering a small circular zone of the CCD array, the rest of the matrix being not enlightened should be completely black. However, in this black part three different effects can be observed (fig 8):

- thin circles centered in the middle of the CCD array
- little spots called ghosts centered on the line that joins the source and the array centers
- a continuum which spreads all over the CCD array

Even if human eye first notices the circles and the ghosts, the most important effect is the continuum because its intensity increases as the area of the source increases. If only one pixel is enlightened and receives 1000 digital counts, the rest of the matrix will only receive 0.0005 digital counts, but if a 100*100 pixel bright zone is observed, the second kind stray light will increase up to 5 digitalcounts, which cannot be neglected anymore. What is more problematic is that second kind stray light varies with the location of the light source in the CCD array, beeing more intense when the source lightens the CCD center. It also differs depending on the spectral band and polarization.

The origins of these defects have been explained through an intensive numerical simulation of POLDER optics. The circles come from the edges of lenses, the ghosts are reflexions of the source over one of the elements of the filter assembly which are then focused onto the CCD array by one of the lenses, and the continuum is the sum of multiple unfocused ghosts.

A massive characterization of POLDER second kind stray light has been made in order to correct it : the CCD array has been divided into 13x17 rectangular zones of 16x19 pixels each. Each zone has been lightened by a bright spot, whereas the remaining of the matrix observes drastically black conditions. A digital filter corresponding to this zone is computed with the observed stray light on the black portion of the array.

The second kind stray light correction uses the 13x17 filters per channel to substract second kind stray light to every spectral image. The level 1 processing uses then 13x17x15 = 3315 filters to correct stray light, and this correction takes more than 20 % of processing time and uses 100 Megabytes of memory. Thus, second kind stray light correction has required a huge effort to model the different effects, to measure all the stray light filters, and to optimise the definition of the algorithm, but the result is that what remains after the correction has been reduced to the electronical noise level.

5.2.5. Example of sensor artefacts removal :

The four following images (fig 8) show different stages of sensor artefacts removal : the POLDER raw image is made of a small bright zone over a black background. This worst case image is some sort of a caricature and does not correspond to a realistic landscape observed by POLDER. The source is very bright in order to reveal all the artefacts : it is saturated three times, but the radiometric level of the saturated pixels is known. In order to emphasize on the artefacts, the raw image is in fact the average of ten successive acquisitions. The following sequence shows the different artefacts very well and presents how they successively disappear during the correction. POLDER digital counts range from 0 to 4091, but here, the histograms have been stretched in order to show the defects : black corresponds to a digital count of 0, and white corresponds to more than 10 digital counts.

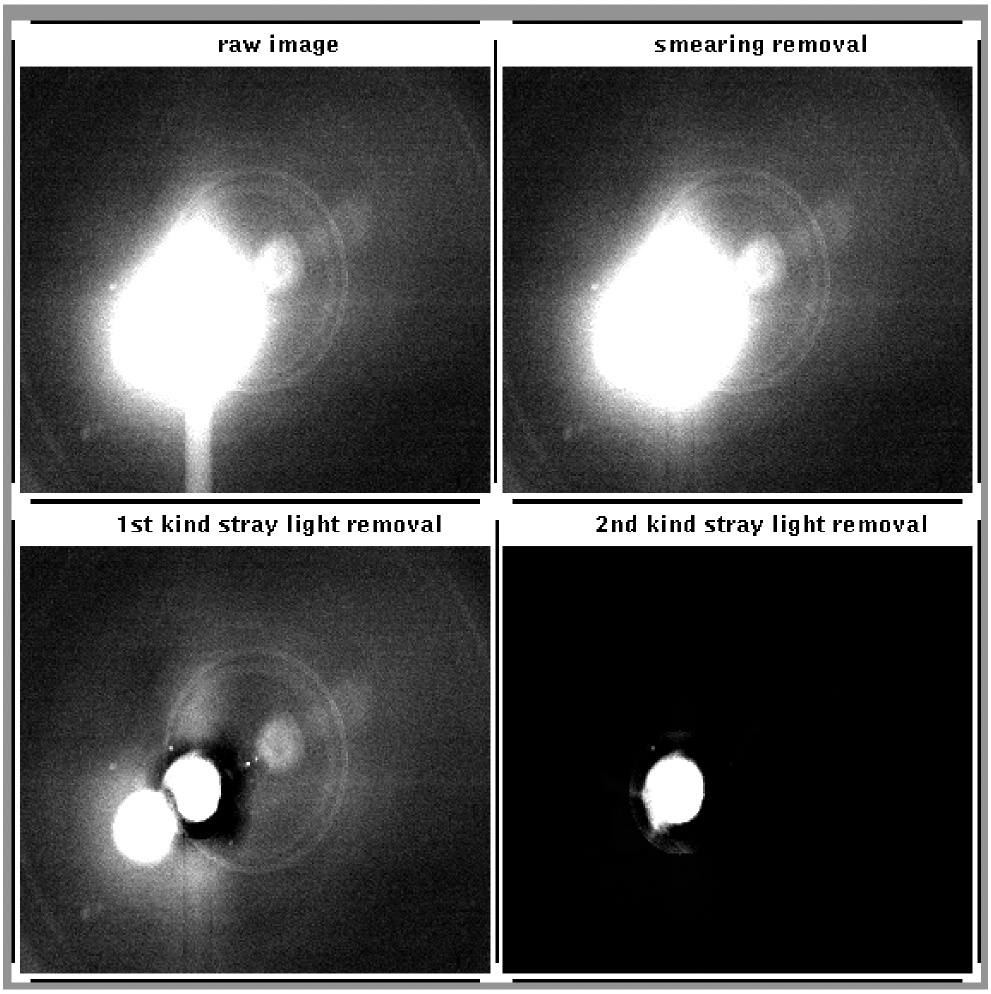

Fig 8 : Different steps of sensor artefacts removal

5.3 Radiometric model inversion

5.3.1 Stokes parameters :

The light observed at the top of the atmosphere is only linearly polarized. Thus, the light received by POLDER can be expressed with only three parameters : intensity of the light I, polarization rate P and polarization direction ϕ. In order to avoid trigonometric functions in the formulas and to allow the use of a matrix formalism, we use the Stokes parameters I, Q, U :

I : normalized total radiance = π. radiance / Solar flux

$$Q = I.P \cos \phi$$

$$U = I.P \sin \phi$$

In the following sections, Q and U are always expressed in a coordinate system such that U= 0 when the light is polarized in the radial direction (this coordinate system is different for every (l,p) detector. According to the Fresnel-Descartes laws, the unwanted polarization effect of the optics is only sensitive to the Q component of the Stokes vector.

5.3.2 Radiometric model

For the non-polarized channels, the radiometric model is written :

$$X_{lp}^{mk} = G^m . A^k . (P1^k_{lp} . I_{lp}^k + P2^k_{lp} . Q_{lp}^k) \qquad (1)$$

where :

- l : line number in the CCD matrix ($1 \le l \le 242$),
- p : column number in the CCD matrix ($1 \le p \le 274$),
- m : electronic amplification factor number ($1 \le m \le 7$),
- k : spectral band number ($0 \le k \le 9$),
- X_{lp}^{mk} : digital count measured by the pixel ($0 \le X_{lp}^{mka} \le 4095$),
- G^m : electronic amplification factor ($G^6 = 1$),
- A^k : absolute calibration coefficient
- I_{lp}^k : normalized radiance observed by (l,p)
- Q_{lp}^k : second component of stockes vector normalized radiance observed by (l,p)
- $P1^k_{lp}$ expresses the low frequency variations of the sensor sensitivity which dicreases a little when the viewing angle increases.
- $P2^k_{lp}$ expresses the variations of the unwanted sensor sensitivity to polarized light. $P2^k = 0$ for the matrix centre and increases up to 3% in the corners of the CCD array.

For the polarized channels, the radiometric model is written :

$$X_{lp}^{mka} = G^m . A^k . T^{ka} . (P1^{ka}_{lp} . I_{lp}^k + P2^{ka}_{lp} . Q_{lp}^k \cdot P3^{ka}_{lp} . U_{lp}^k) \qquad (2)$$

where :

- a : polarized channel ($1 \le a \le 3$),
- T^{ka} : relative calibration coefficient of polarisers,
- $P2^{ka}_{lp}$, $P3^{ka}_{lp}$: here express the effect of the polarizers and the polarization sensitivity on the stockes vector.

Combining the three equations of the radiometric models for the three polarized channels of the same spectral band, this model can be written under a matricial formalism that is used to compute the Stokes parameters :

$$\begin{pmatrix} X_{lp}^{k1} \\ X_{lp}^{k2} \\ X_{lp}^{k3} \end{pmatrix} = G^m A^k \begin{pmatrix} T^{k1}P1_{lp}^k & T^{k1}P2_{lp}^k & T^{k1}P3_{lp}^k \\ T^{k2}P1_{lp}^k & T^{k2}P2_{lp}^k & T^{k2}P3_{lp}^k \\ T^{k2}P1_{lp}^k & T^{k2}P2_{lp}^k & T^{k2}P3_{lp}^k \end{pmatrix} \begin{pmatrix} I_{lp}^k \\ Q_{lp}^k \\ U_{lp}^k \end{pmatrix} \qquad (3)$$

All calibration parameters are accurately determined before launch. They are then updated in flight in the Image Quality System. On-ground calibration methods are exposed in Bret-Dibat and al (4), required accuracies and in-flight calibration methods are detailed in Hagolle and al (5).

5.3.3 Radiometric model inversion

For a polarized band, the three Stokes parameters are computed by just inverting the above equation (3), which is rather simple.

For the non-polarized channels, it is not possible to obtain the three Stokes parameters since only one equation is available. However, it is possible to derive the normalized total radiance (first Stokes parameter) after correcting the polarization sensibility. For most optical remote sensors (AVHRR, OCTS, VGT), the unwanted polarization sensitivity of the optics is not corrected, other instruments have polarization scramblers (SEAWIFS, SPOT) to minimize this problem. This problem can be solved for POLDER images because the polarization rate is known in three of the nine spectral bands : since polarization rate varies less than total radiance, it is possible to extrapolate the ratio $Q_{lp}{}^{k} / I_{lp}{}^{k}$ using a second degree polynomial function. The normalized

$$I_{lp}{}^{k} = X_{lp}{}^{mk} \ / \ (G^{m} \ . \ A^{k} \ . \ (P_{1}{}^{k}{}_{lp} + P_{2}{}^{k}{}_{lp} \ . \ (Q_{lp}{}^{k} / I_{lp}{}^{k})_{extrapolated}))$$

Of course, the accuracy of this extrapolation varies with the kind of observed target, but the most important polarization effects are caused by either the atmosphere or the sunglint and these two effects have smooth spectral variations. The correction of polarization sensitivity seems to work very well and what remains after correction is allways below 0.3 % in the worst case (corners of the CCD array)

5.4 Geometrical rectification

The purpose of geometrical rectification is to map the images (acquired by the CCD array) onto POLDER reference earth grid, so that all the multi-spectral, multi-polarization and multi-directionnal images are registered. The expected registration performances are 0.1 pixel (max) for the 3 polarized channels, 0.2 pixel (max) for the 8 spectral bands, and 0.2 (RMS) for the registration of images corresponding to different viewing directions. These performances are achieved through an important on-ground and in-flight geometrical calibration process, and through very accurate computation in the level 1 process.

In order to register all the data on POLDER grid, a geometrical reverse model computation is needed : this reverse model is the function which gives the coordinates (l,p) in the CCD array corresponding to a given grid point (I,J). This model uses a Digital Elevation Model (NOAA's ETOPO 5), attitude and orbit data, and in order to be precise enough, is computed for every grid point observed by a POLDER image. A simple way to project the pixels of a given image would have been to scan the whole grid to find the (l,p) coordinates of all the observed pixels. But such a process would consume a lot of computation time. In order to save time, it is necessary to scan only the area of the grid observed by the image being processed. The observed area is the inner surface of the CCD array edges projection onto the cartographic grid. This projection is made using direct model which gives the grid point (I,J) corresponding to a (l,p) elementary detector.

Once the (l,p) coordinates corresponding to a given grid point are obtained, the pixel value is interpolated using bicubic function (the bicubic function is a polynomial function which fits the truncated Shannon function (on a 4*4 neighbourhood)).

6. CONCLUSION

To conclude, a comprehensive work has been performed on the POLDER Level 1 algorithm definition and validation. This effort was driven by mainly two objectives: 1) to correct the raw data for all the instrument and system defects in order to achieve the drastic radiometric accuracy required by the mission objectives, 2) to provide users with a self-consistent and fully calibrated product which is the unique basis for generating level 2 and 3 geophysical parameters in the various domains of interest covered by the POLDER mission.

POLDER level 1 processing software developped to meet the requirements of the algorithm represents approximately 20000 instruction lines. A whole viewing segment is processed in 30 minutes on one of the most powerful workstations and uses more than 250 Megabytes of RAM. POLDER processing centre has been equipped with four such computers in order to fulfil the objectives of systematic production of all level 1, 2 and 3 products.

An important validation campaign was led in order to validate this software, using simulated raw images, POLDER on-ground measurements and double coding of radiometric and geometric algorithms. The POLDER project team is now eager to apply this software to real in-flight data.

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