In-Flight Performances of PARASOL Inside the Aqua-train Atmospheric Observatory

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THE PARASOL MISSION (Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar)

1
- microsatellite launched the 18th Dec. 2004 carrying a POLDER-like instrument
- A-train orbit at 705km, 13h30 local time overpass, ±43°x51° field-of-view, swath = 1600km across track (2100km along track)
- analysis of Polarized / Bi-directional / Spectral signatures :
  ~14 viewing directions for 9 spectral bands from 443 to 1020nm among them 3 are polarized (I,Q,U Stokes parameters derived)
- objective : characterization of microphysical properties of clouds and aerosols using synergetic complementary data provided by the Aqua-train sensors (Calipso, MODIS-Aqua, Cloudsat)

Performance of PARASOL level-1 data (PER 2.0 and PEG 2.1 of July 2005) are here evaluated in term of radiometry and geometry

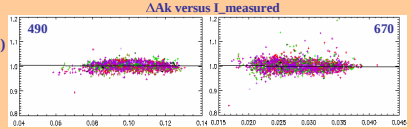
2 RADIOMETRIC CALIBRATION

Following results evaluate the level-1 data after in-flight recalibration (PER 2.0)
The illustrated parameter is ΔAk defined as :

ΔAk = I_measured / I_computed

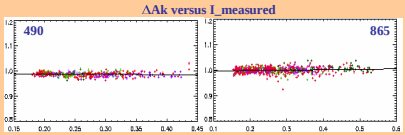
→ Absolute Calibration over Rayleigh Scattering

- spectral bands from 443 to 670nm
- accurate computation of Rayleigh scattering (90% of TOA signal) using Successive Order of Scattering code (SOS)
- selection of "Very-clear" pixels using threshold on 865
- correction of gaseous absorption and aerosol background
- marine reflectance (climatology over predefined oceanic sites)



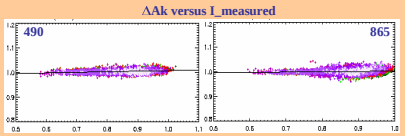
→ Interband Calibration over Sunglint

- bands from 443 to 1020nm
- accurate computation of Sunglint + Rayleigh scattering using Successive Order of Scattering code (SOS)
- sunglint intensity is estimated using a reference band (670)
- aerosol correction using a out-of-sunglint viewing at 865
- correction of gaseous absorption and marine reflectance (climato)



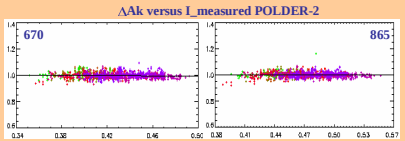
→ Interband Calibration over Bright Clouds

- bands from 443 to 865nm
- accurate computation of cloud reflectance using Discrete Ordinate code (OD)
- cloud optical thickness is estimated using a reference band (670)
- selection of bright convective clouds over predefined sites
- correction of gaseous absorption and rayleigh contribution



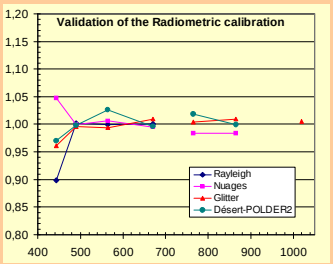
→ Cross-Calibration over Desert sites

- comparison with a reference sensor (POLDER-2, Aqua…) for all spectral bands and multi-temporal survey
- 20 desert sites selected (stability, homogeneity, cloud coverage)
- surface reflectance are computed using the reference sensor after atmospheric correction (gas, aerosol, molecules)
- TOA signal is computed after spectral interpolation and adding atmospheric contribution



→ Synthesis

- results are given by reference to the last level-1 reprocessing.
- very good results for 490, 670, and 865 between all methods
  confidence is close to ±1% for 490, 670, and 865
- good results for other spectral bands
  confidence is about ±2% for 565, 765
  confidence is estimated at about ±3-4% for 1020
- gaseous absorption bands, 763 and 910, are cross-calibrated with 765 and 865 respectively using pre-flight characterization
- bad results for 443 because of unresolved heavy stray-light contaminations (leading to bias + noise)



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Hagolle, Nicolas, Fougnie, Cabot, and Henry, "Absolute Calibration of Végétation derived from an Interband method based on sunglint over ocean sites, *IEEE TGARS*, vol.42, pp.1-10, 2004.
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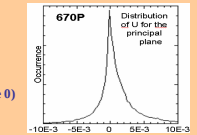
Schutgens, Tilstra, Stammes, Bréon, "On the relationship between Stokes parameters Q and U of atmospheric radiation", *J. Geophys. Res.*, v.109, D09205, 2004.

3 OTHER RADIOMETRIC CHARACTERIZATION AND PERFORMANCES

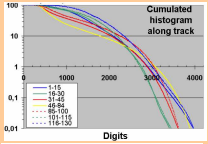
→ noise equivalent derived polarized reflectance :

- NeDRp was in-flight estimated through a specific algorithm
- dispersion of the U-Stokes parameter was analyzed for the principal plane (where U is expected to be 0)
- PARASOL performances are found to be comparable to POLDER-2



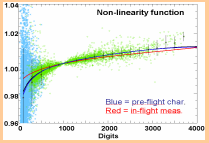
→ optimization of the dynamic range

- integration times were adjusted in order to respect mission requirements :
  PARASOL performs acquisitions for normalized radiance from 0.0 up to 1.0 without any saturation (except for some marginal specular reflections)
- PARASOL acquired the ability to adjust the integration time along the orbit track in order to compensate the decrease of sun irradiance when moving toward high latitude : radiometric performances are homogeneous along the orbit



→ in-flight non-linearity control

- experimental programming were made with various integration times to validate on-orbit behavior of the non-linearity of the radiometric sensitivity (2-3% from min to max)
- the principle was to compare over white targets, acquisitions of two close bands (ex. 765 and 865) programmed for very different integration time
- the preflight characterization was validated within 0.5% for the major part of the dynamic

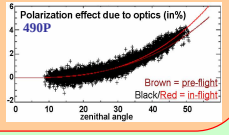


→ Inter-pixel calibration (high-frequency)

- statistical validation over bright targets of pre-flight coefficients within 0.2%

→ In-polarization calibration

- in-flight estimation of the polarization introduced by the optic
- use of ice-particle clouds near backscattering (x~170°, where observed polarization is expected to be 0)
- validation of the pre-flight characterization



3 GEOMETRIC CALIBRATION AND PERFORMANCES

→ Geometrical calibration :

general approach : spatio-triangulation and correlation
by research of the biases set minimizing residue of correlation
+ iterations (2 in the present case)

in microrad	Roll	Pitch	Yaw
Offset	-317.2	-955.1	-521.7
RMS	103.2	42.1	48.9

→ Registration performances : PARASOL = polarization + directionality + spectral

general approach : correlation between the different kinds of image
performances are given after geometric recalibration

	Comment	Meas.	Duration	Mission specification	Estimated In-flight Performance
Polarization	(I,Q,U) are derived using 3 measurements (0, 60, -60)	3	1 sec.	within a circle of 0.05 pix radius MAX	better than 0.05 (except for very large θv >45° for 670 and >50° for 490 and 865)
Spectral	9 spectral bands are available for each pixel	9	5 sec.	within a circle of 0.10 pix radius MAX	estimated at about 0.08 pixel
Directional	~14 viewing angles are available for each pixel	14	330 sec.	within a circle of 0.10 pix radius RMS	about 0.10 pixel (and < 0.12 pix) after calibration
Temporal	significant for monthly synthesis	30	30 days	within a circle of 0.125 pix radius RMS	not yet fully estimated expected at about 0.10 pix

→Absolute location accuracy (note : the level-1 grid resolution is 6,18 km)

general approach : GCP (ground control point) pointing using *Végétation* images as reference (or MODIS images)
mission requirements : 4 km with objective of 2 km
performance : 2 to 3 km, but still under refinement

CONCLUSION

- the commissioning phase held in July 2005 has approved and validated the proposed adjustment for calibrations
- the level-1 data archive reprocessing is now completed and data are available at http://parasol-polder.cnes.fr
- PARASOL is now fully operational and the product quality is optimum and consistent with mission requirements
- An important warning is addressed to users of the 443nm spectral bands because of degraded performances (stray-light)