

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

- ↳ 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

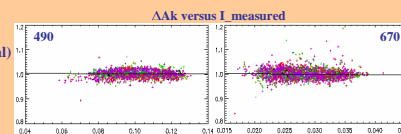
### 2 RADIOMETRIC CALIBRATION

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

$$\Delta A_k = I_{\text{measured}} / I_{\text{computed}}$$

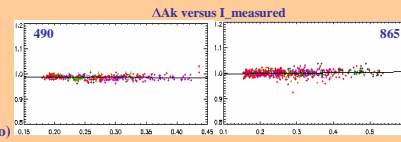
#### → Absolute Calibration over Rayleigh Scattering

- ↳ 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)



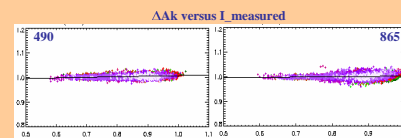
#### → Interband Calibration over Sunglint

- ↳ 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 an out-of-sunglint viewing at 865
- ↳ correction of gaseous absorption and marine reflectance (climatology)



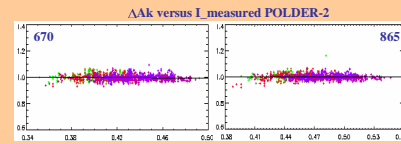
#### → Interband Calibration over Bright Clouds

- ↳ bands from 443 to 865nm
- ↳ accurate computation of cloud reflectance using Discrete Ordinate (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



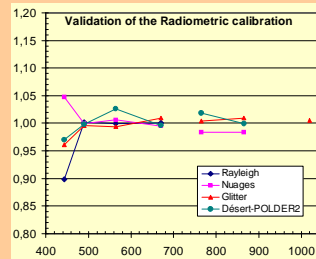
#### → Cross-Calibration over Desert sites

- ↳ 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

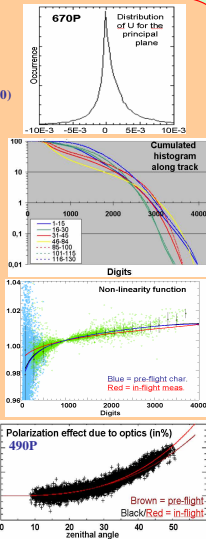
- ↳ results are given by reference to the last level-1 reprocessing.
- ↳ very good results for 490, 670, and 865 between all methods confidence is close to ±1% for 490, 670, and 865
- ↳ good results for other spectral bands confidence is about ±2% for 565, 765
- ↳ confidence is estimated at about ±3-4% 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)



References : Hagolle, Goloub, Deschamps, Cossefroy, Briottet, Bailleul, Nicolas, Parol, Lafrance, and Herman, "Results of POLDER In-Flight Calibration," *IEEE TGARS*, v.37, pp.1550-1566, 1999.  
 Hagolle, Nicolas, Fagnie, Cabot, and Henry, "Absolute Calibration of Vegetation derived from an Interband method based on sunglint over ocean sites," *IEEE TGARS*, vol.42, pp.1-10, 2004.  
 Lafrance, Hagolle, Bonnel, Fouquat, and Brogniez, "Interband Calibration Over Clouds for POLDER Space Sensor," *IEEE TGARS*, v.40, no. 1, pp.133-142, 2002.  
 Cabot, Hagolle, Ruffel, and Henry, "Use of remote sensing data repository for in-flight calibration of optical sensors over terrestrial targets", *Proc of SPIE 99*, Denver, CO, USA, July 1999.  
 Fagnie, Hagolle, and Cabot, "In-flight measurement and correction of non-linearity of the POLDER-1S sensitivity", *8th Symposium of the ISPRS*, Aisois, France, 8-12 January 2001.  
 Schutgens, Tibstra, Stammes, Britton, "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)