CENTRE NATIONAL D'ÉTUDES SPATIALES

CNES in-orbit calibration activities for visible and NIR sensors

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CNES background in calibration activity

- CNES has developed different calibration methods over natural targets for visible and NIR optical sensors
  - Rayleigh scattering over ocean
  - Sun glint over ocean
  - Deep convective clouds (DCC)
  - Stable African deserts
  - Antarctica (Dome C site)
  - Autonomous calibration station (for high resolution)
  - Lunar calibration
- Most of them are used on an operational basis
  - Monitoring the CNES sensors calibration (SPOT, VGT, POLDER…)
  - Inter calibration with other sensors (MERIS, SeaWiFS, AVHRR, MODIS, Formosat2, Kompsat2…)

Calibration monitoring activities for CNES missions (1)

- **POLDER 3 on-board PARASOL (A-train)**
  - Routine calibration monitoring using DCC calibration (every month)
  - Regular calibration check with other methods : Rayleigh scattering, sun glint, desert sites (every 6 months)
- **VGT2 on-board SPOT5**
  - Misfunctioning of the on-board calibration device
  - Routine calibration monitoring using desert sites (every month)
  - Regular calibration check with other methods : Rayleigh scattering, sun glint, Antarctica sites (once a year)
- **High resolution instruments on-board SPOT4 & SPOT5**
  - Routine calibration monitoring over desert sites
  - Calibration campaigns over La Crau and Negev desert (twice a year)

Calibration monitoring activities for CNES missions (2)

- IIR on-board CALIPSO (A-Train)
  - Calibration monitoring using on-board device
- IASI on-board METOP
  - Radiometric and spectral calibration
  - Regular performance checks
  - IASI / AIRS inter-calibration

<u>Soon to come</u> :

- Recalibration of VGT1 data
  - To insure with VGT2 a consistent set of data over 10 years

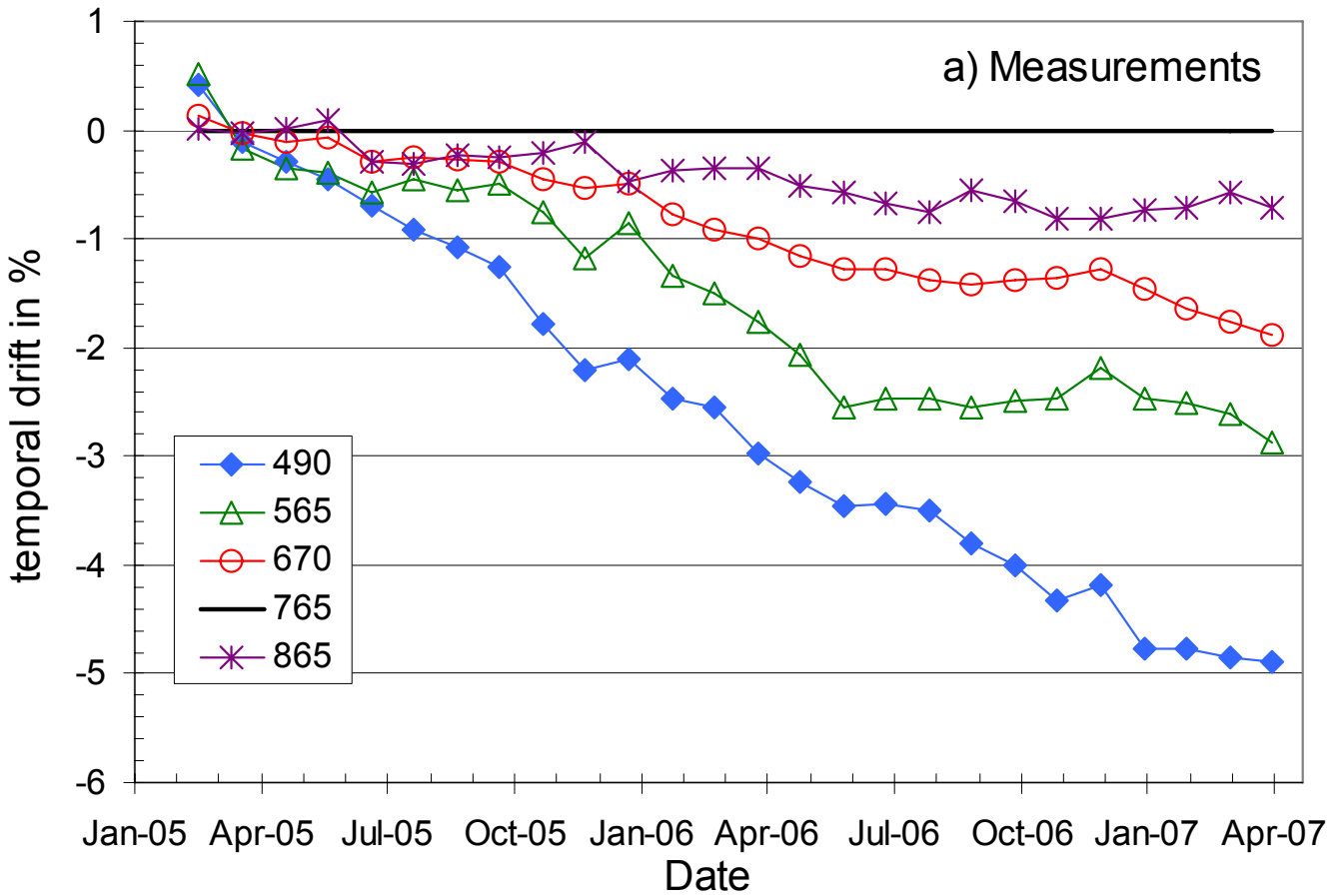
Cal/Val activities in cooperation with other agencies

- **FORMOSAT2 calibration for NSPO**
  - Activity started in 2005
  - Calibration monitoring over deserts, absolute calibration over La Crau, programming gains optimization using the worldwide CNES data base
- **Kompsat2 Cal/Val activities for KARI**
  - Activity in progress
  - Geometric calibration, FTM assessment, radiometric calibration…
- **MERIS for ESA**
  - Desert, Rayleigh and glitter calibration on an operational basis
- **Other inter-calibration activities**
  - MODIS, AVHRR (in the framework of GSICS activities)

Recent results

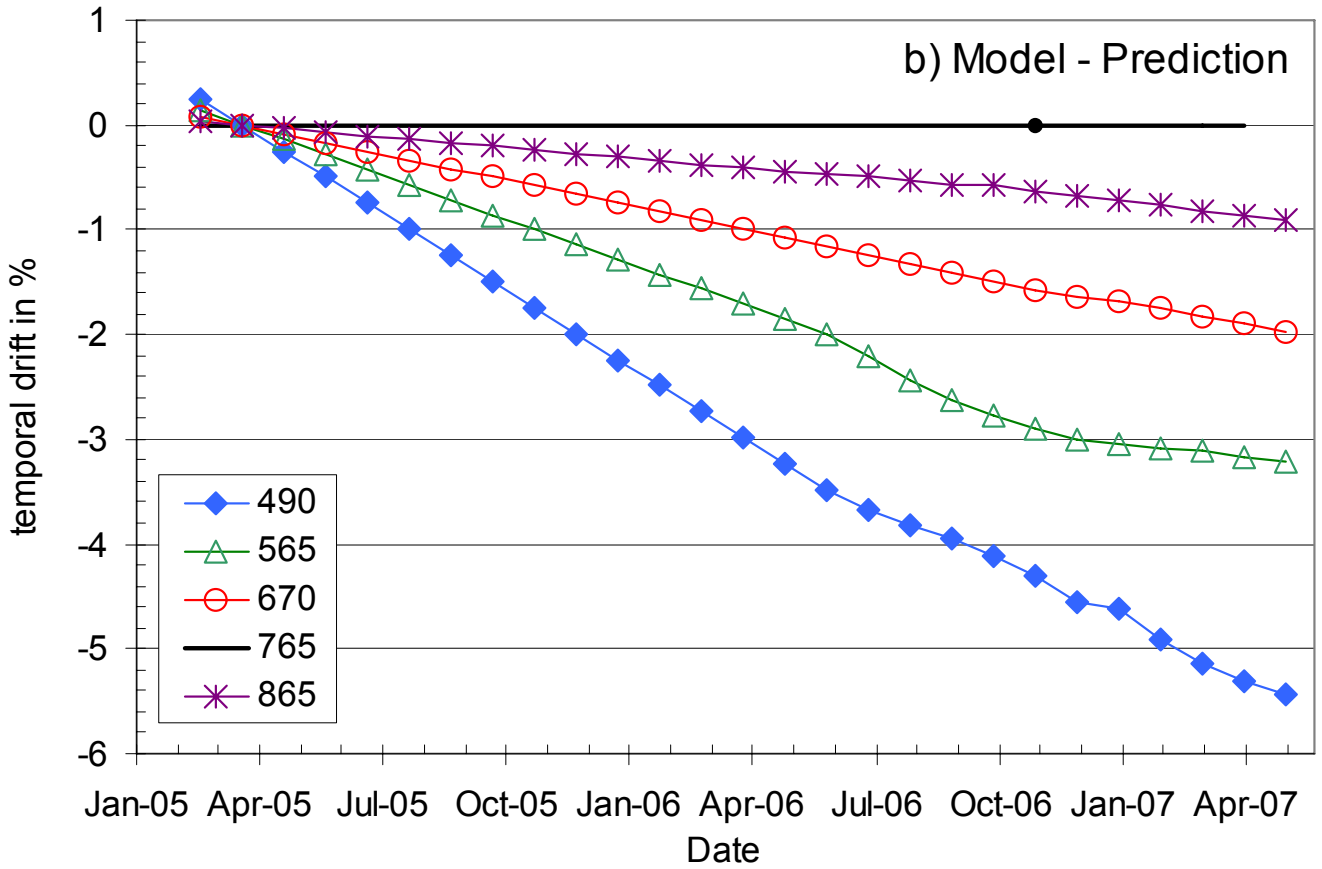
2 years of PARASOL calibration over DCC (1)

- **Calibration measurements performed every month (using 1 week of data)**

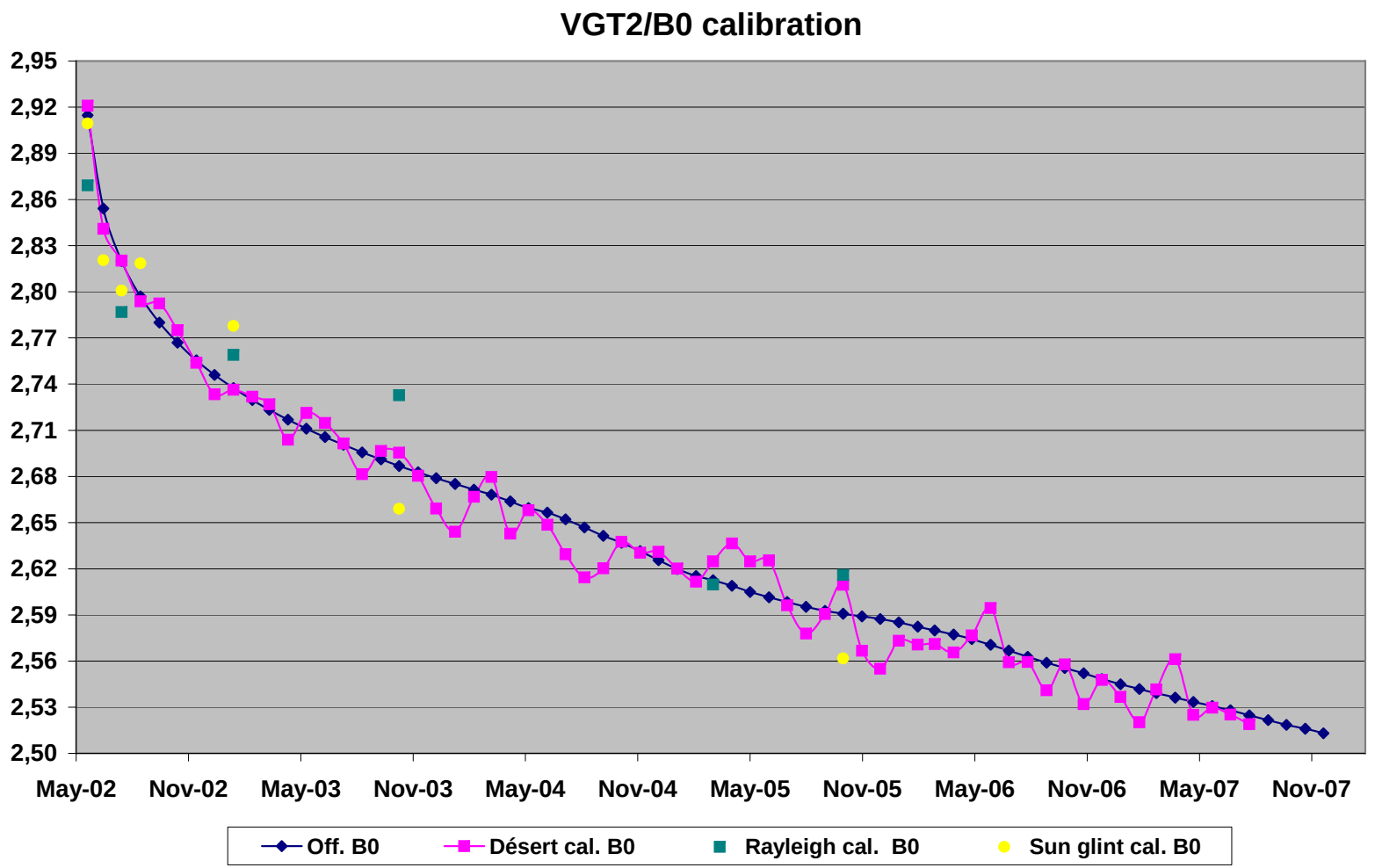


2 years of PARASOL calibration over DCC (2)

- **Calibration model (fitted with 18 months of measurements) + extrapolation performed every month using new measurements**



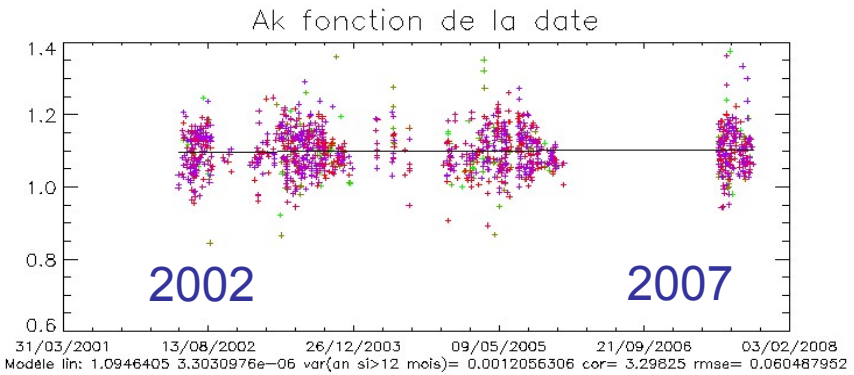
VGT2 calibration monitoring over desert sites



MERIS calibration monitoring

based on cross-calibration with PARASOL over 20 desert sites

490



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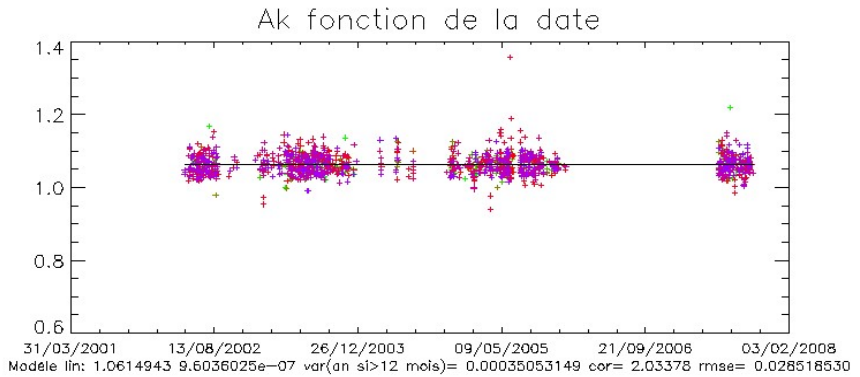

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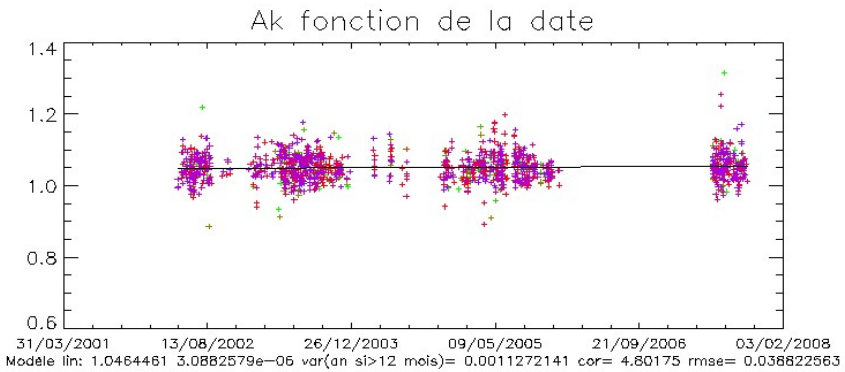

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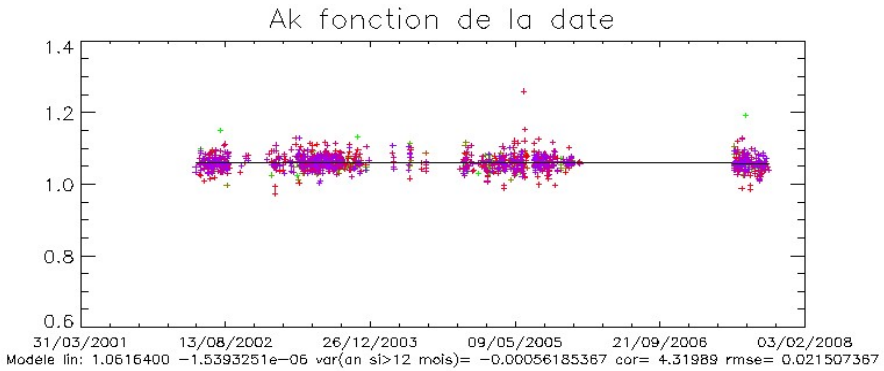
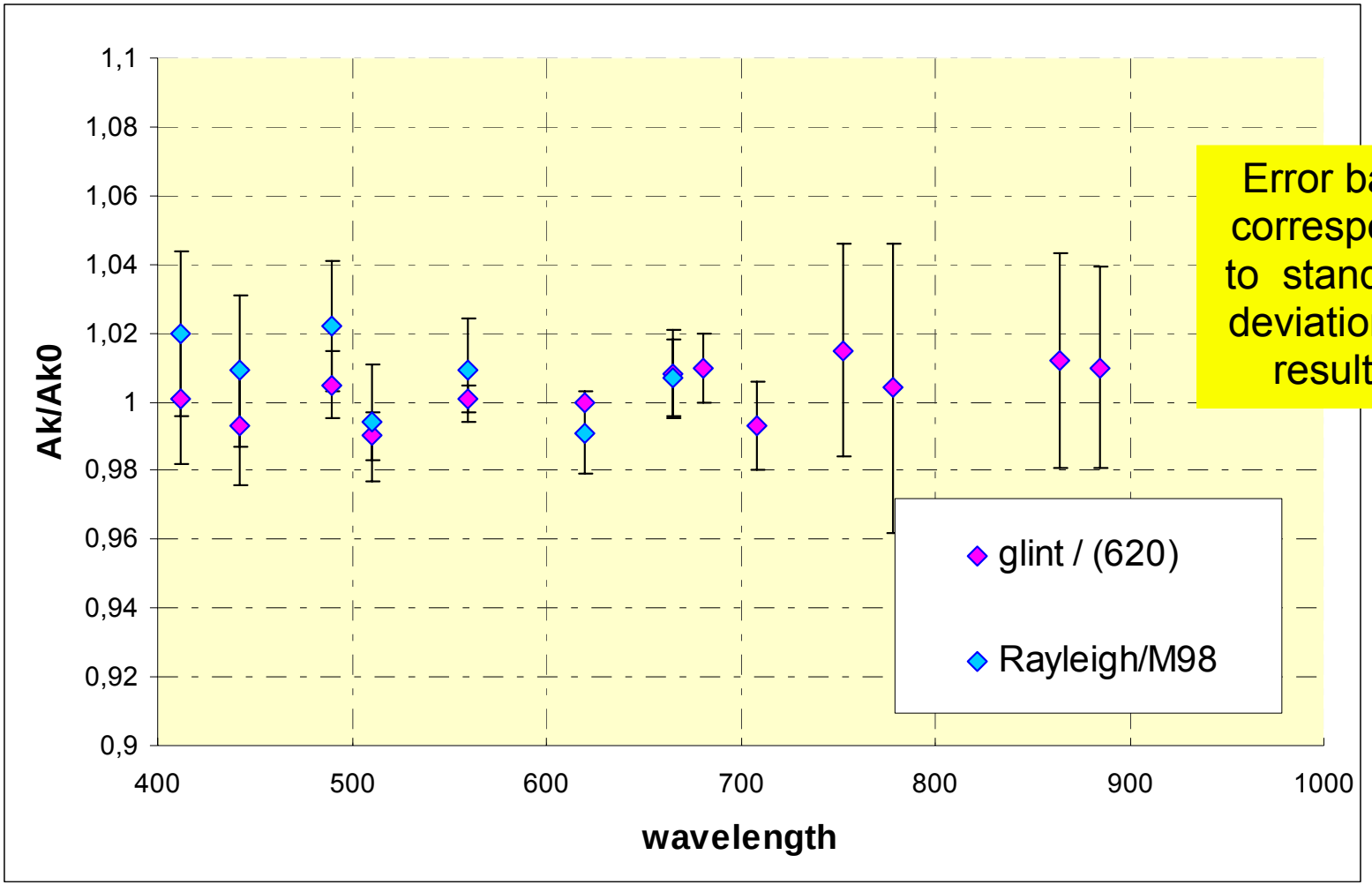


No significant variation with time

Validation of MERIS calibration

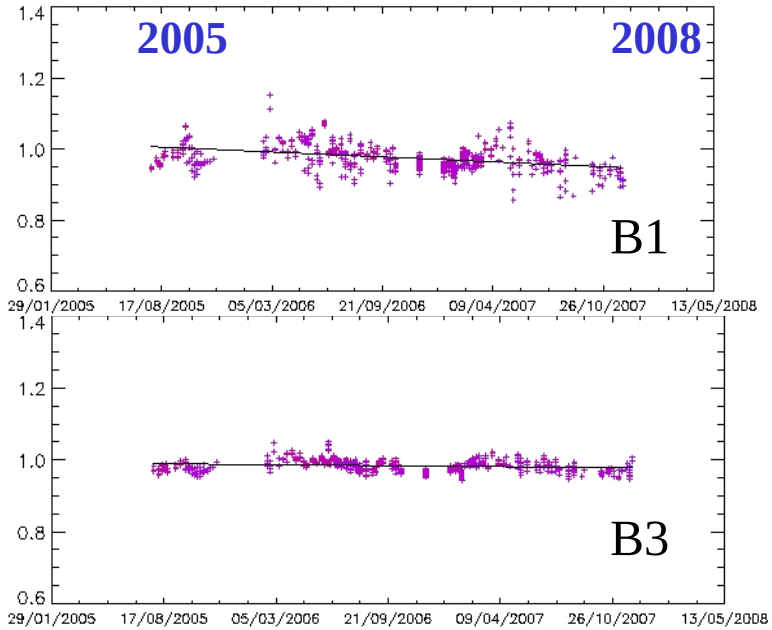
using Rayleigh scattering and sun glint methods

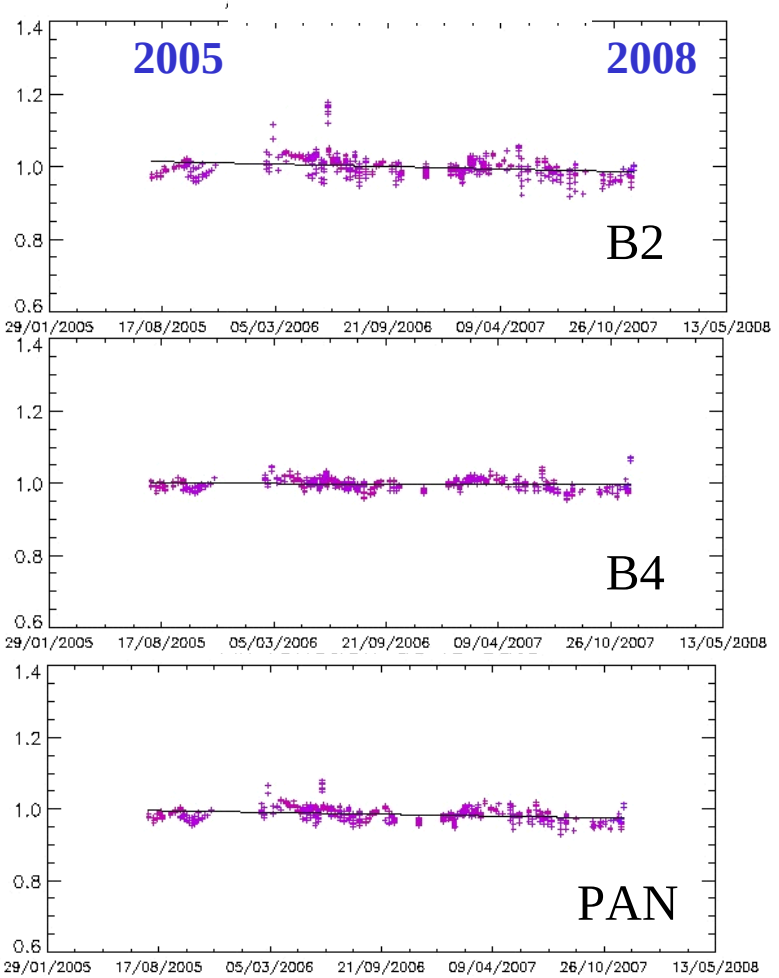


No discrepancy greater than 2%

Formosat 2 calibration monitoring

based on cross-calibration with POLDER1 over 20 desert sites





Spectral band	Loss (in 2.5 years)
B1	~ 4 %
B2	~ 1.5 %
B3	< 1 %
B4	negligeable
PAN	< 1 %

700 calibration points from July 2005 until Nov 2007

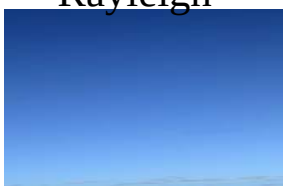
Back-up slides

Calibration over Rayleigh scattering

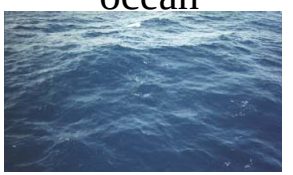
Calibration over Rayleigh scattering : method

- **General description of the method**
  - **Use of the atmosphere Rayleigh scattering signal (= blue sky) above ocean surface (= dark surface)**
  - **Absolute calibration for blue, green and red bands (443 to 670nm)**
- **Operating procedure**
  - **Accurate estimation of Rayleigh contribution (SOS code)**
    - **For chosen conditions, main contributor : ~85/90% of TOA signal**
  - **Others contributions**
    - **Ocean surface : prediction through a climatology**
      - no foam because of wind speed threshold
    - **Aerosols : rejected using threshold and correction of residue using NIR band measurement and extrapolation with Maritime-98 model**
    - **Gaseous absorption correction : O_3 (TOMS), NO_2 (climato), H_20 (meteo)**
- **Accuracy : typically 2% (3% for blue bands)**

Rayleigh



ocean



aerosols

Calibration over Rayleigh scattering : formalization

$$L_k \approx \left(L_{ray} + L_{aer} + \left(L_w + L_f\right) \cdot T^A + L_{oa}\right) \cdot T_g$$

L_{ray}: radiance due to molecular scattering, function of atmospheric pressure (around 80% of the signal)

L_{aer}: radiance due to aerosols, estimated from NIR measurements

L_w : ocean radiance, function of chlorophyl content

L_f : foam radiance, depending on wind speed

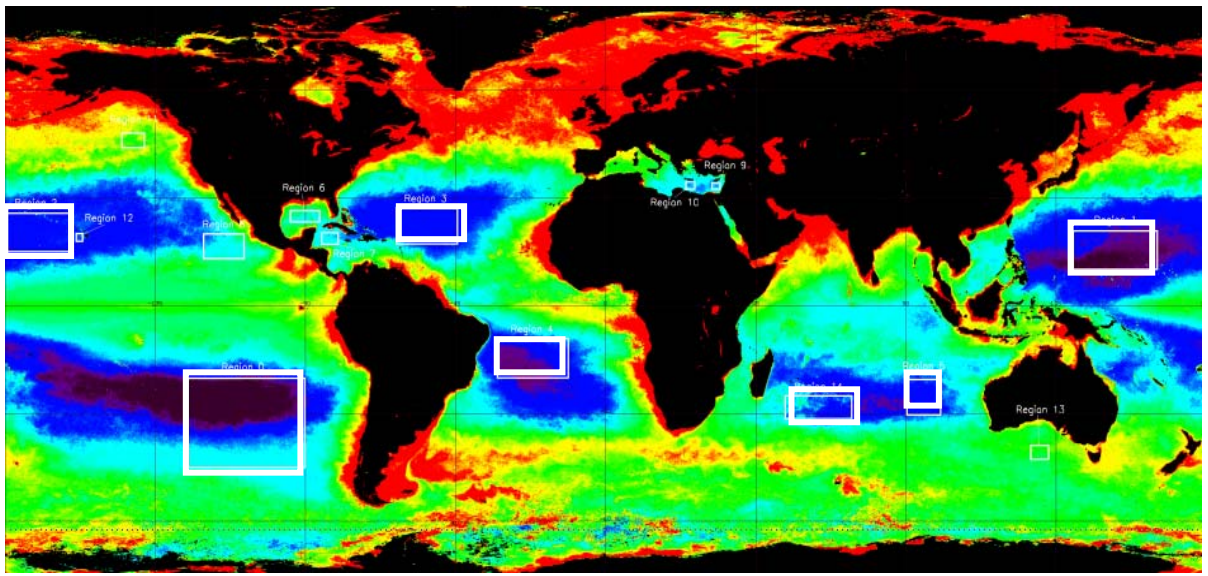
L_{oa}: radiance due to ocean-atmosphere interaction

T^A : atmospheric diffuse transmission (aerosols + molecular scattering)

T_g : gazeous transmissions (H_2O, O_2, O_3, NO_2) → meteo data

Calibration over Rayleigh Scattering : sites

- **Predefined and characterized oceanic sites**
  - **Selection of candidate sites**
    - **through a climatology based on SeaWiFS data**
    - **spatial homogeneity for each site + limited “controlled” seasonal variation**
    - **Homogeneity is important because :**
      - few variations due to marine reflectance
      - analysis of correlations with various geometrical or geophysical parameters



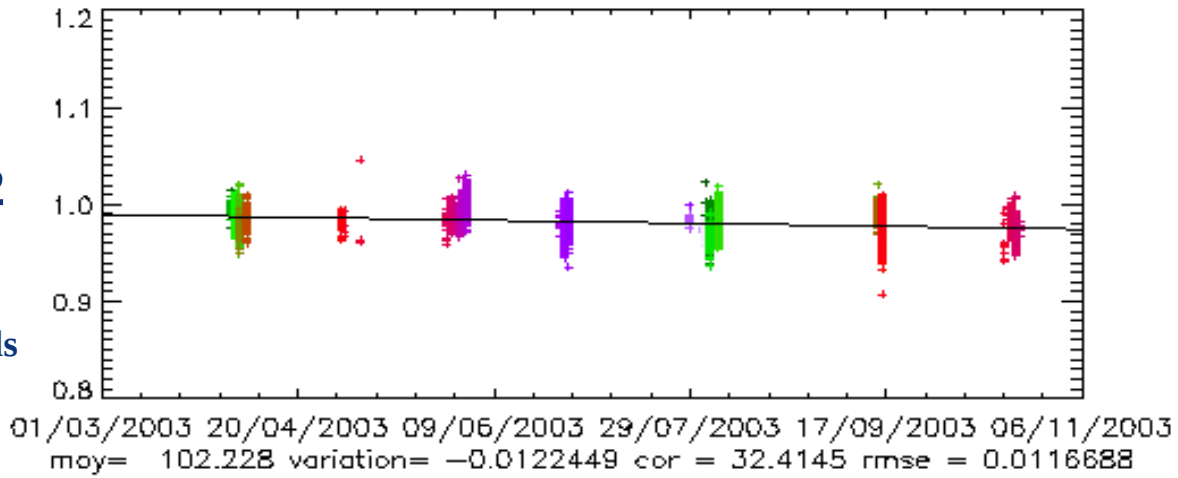
Calibration over Rayleigh scattering : results

Multi-temporal monitoring

POLDER-2 on-board ADEOS2 490nm band

1.5% decrease confirmed by all other methods

In flight calibration versus date



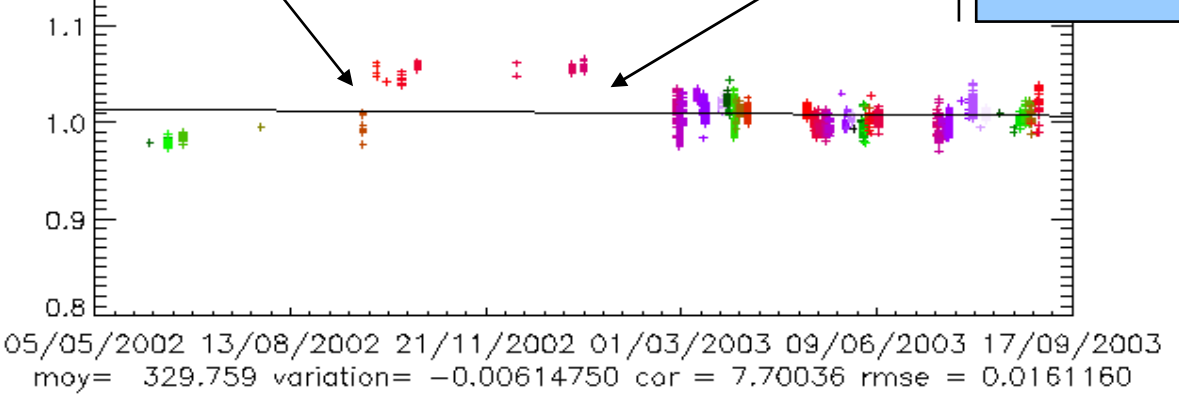
MERIS on-board ENVISAT 490nm band

detection of gaps (few %) explained by processing and calibration changes in level-1 data

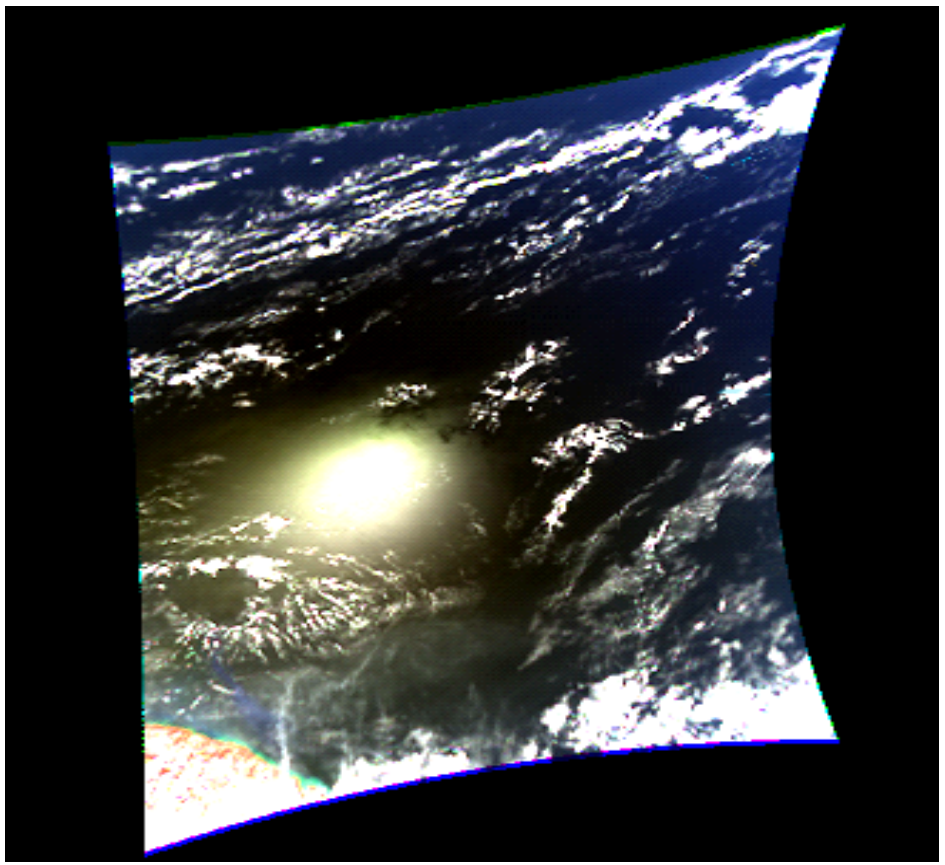
Processing change 25/09/02

In flight calibration versus date

Calibration change 04/03/03



Interband calibration over Sunglint



Interband calibration over sunglint : method

- General description of the method
  - Observation of the “white” reflection of the sun over the ocean surface
  - Interband calibration for blue up to SWIR bands (440 to 1700nm)
  - One band shall be chosen as reference band (usually red band)
- Operating procedure
  - Accurate computation of the 2 main contributors :
    - Sunglint contribution characterized using the ref. band (depend on wind speed) + Cox and Munk model for wave distribution
    - Rayleigh scattering (SOS code)
  - Other minor contributions :
    - Ocean surface : predicted using climatology
    - Aerosol threshold : inappropriate observations rejection using exogenous data (SeaWiFS daily aerosol products) and background correction with aot of 0.05
    - Gaseous absorption correction : O_3 (TOMS), NO_2 (climato), H_20 (meteo)

Calibration over sunglint : formalization

$$L_k \approx \left(L_{ray} + L_{aer} + \left(L_{gli} + L_w + L_f\right) T^A\right) T_g$$

L_{ray}: radiance due to molecular scattering, function of atmospheric pressure

L_{aer}: radiance due to aerosols

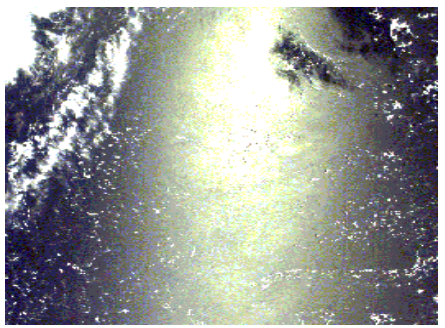
L_{gli}: sunglint radiance, depending on wind speed, but spectral band invariant, estimated from a reference band (red)

L_w : ocean radiance, function of chlorophyl content

L_{oa}: radiance due to ocean-atmosphere interaction

T^A : atmospheric diffuse transmission (aerosols + molecular scattering)

T_g : gazeous transmissions (H_2O, O_2, O_3, NO_2) → meteo data



Interband calibration over sunglint : method

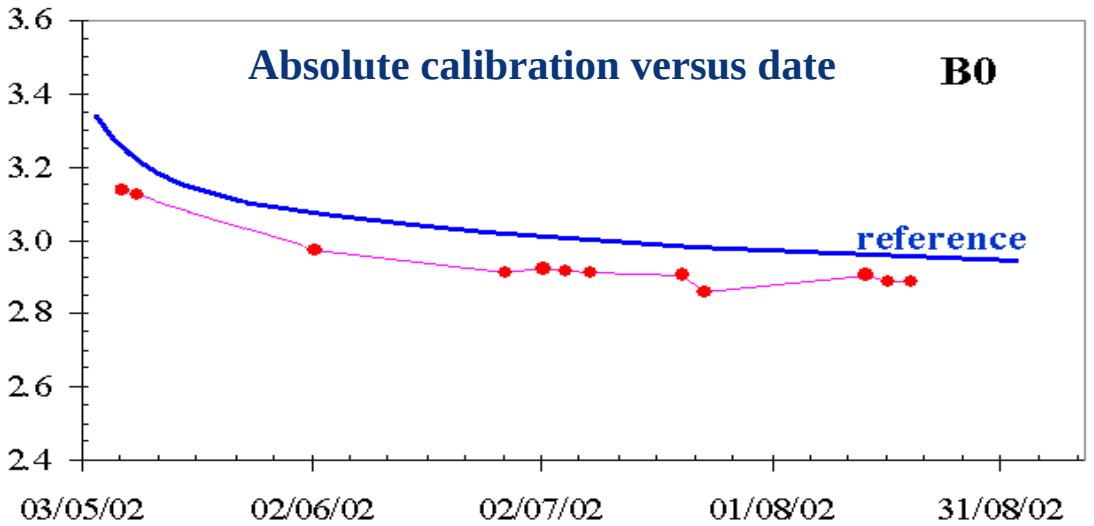
- **Selection of measurements**
  - Geographic selection over oceanic sites (same as for Rayleigh calibration)
  - Geometrical selection (wave angle) : limited area
  - Wind speed limited to 5 m/s
- **Accuracy**
  - Interband calibration : typically 2% (about 1% for bands close to the ref. band)
  - Possible bias on the reference band is reported on other bands
  - Efficiency depending on the density of points (geographic and temporal)

Interband calibration over sunglint : results

Multi-temporal monitoring

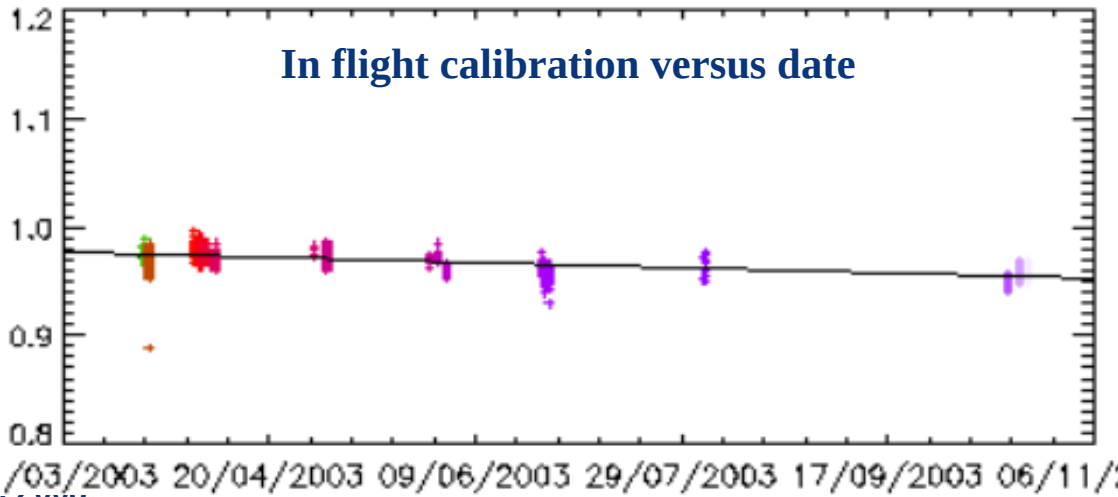
***Végétation*-2 on-board SPOT5**
B0 blue band

temporal decrease
observed by on-board lamp (reference)
and due to outgassing of dichroics



POLDER-2 on-board ADEOS2
490nm band

confirmation of a decrease
found by all other methods



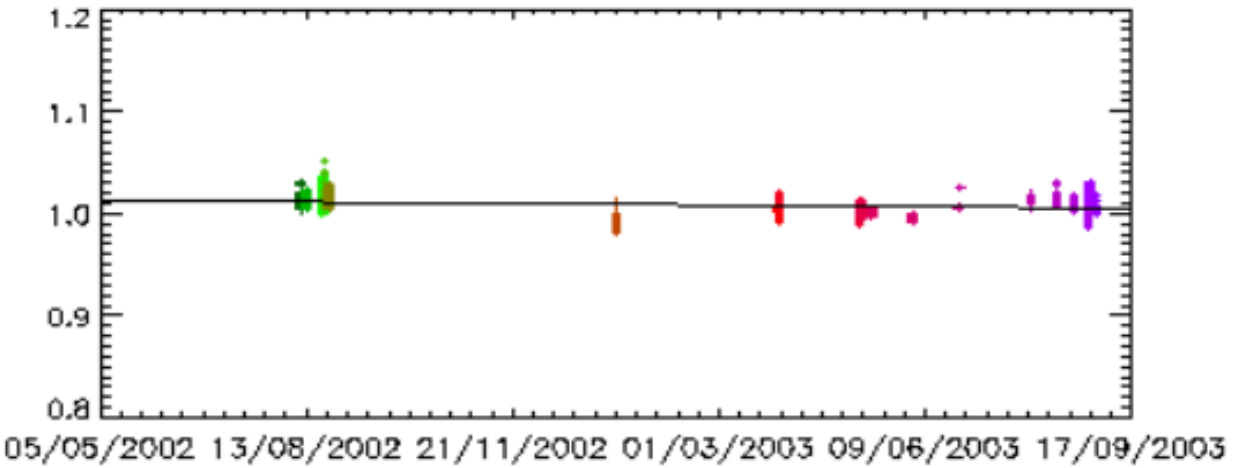
Interband calibration over sunglint : results

Multi-temporal monitoring

MERIS on-board ENVISAT 490nm band

no particular variation found

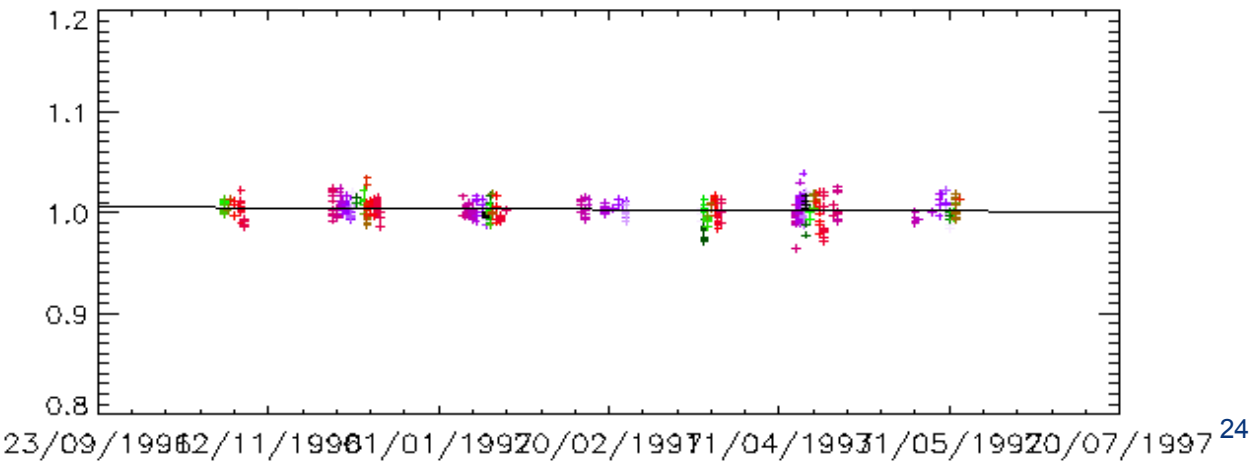
In flight calibration versus date



POLDER-1 on-board ADEOS1 490nm band

no particular variation found

In flight calibration versus date

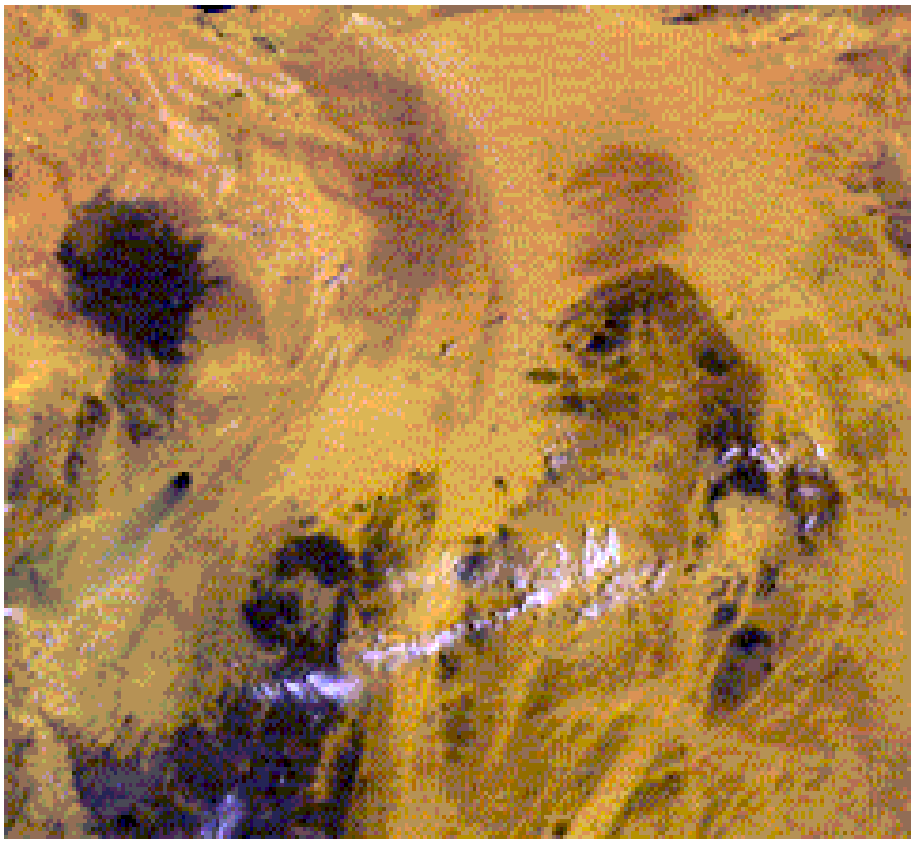


Interband calibration over bright clouds

Calibration over bright clouds

- General description of the method
  - Observation of large and thick clouds considered as spectraly “white ” sources
  - Interband calibration from blue to NIR bands
  - One band shall be chosen as reference band (usually red band)
- Operating procedure
  - Selection of convective clouds (12/13 km altitude) at sub-tropical latitude and over ocean : no surface reflectance nor cirrus contamination, atmospheric effects minimization
  - Cloud signal modelized for different ice cristal types
  - Gaseous absorption correction : O_3 (TOMS), NO_2 (climato), H_20 (meteo)
- Accuracy
  - Interband calibration : typically 2% (about 1% for bands close to the ref. band)
  - Possible bias on the reference band is reported on other bands

Interband calibration over desert sites



Calibration over desert sites