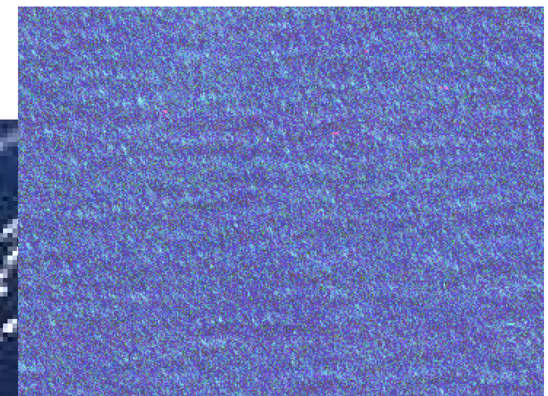
In-flight Calibration using Natural Targets

Calibration over Rayleigh Scattering

In-situ view

PARASOL view



SPOT view

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In-flight Calibration using Natural Targets

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- Historically, methods using natural targets were developed in order to validate/adjust the pre-flight calibration of instruments
  - including sensors equipped with on-board calibration device

- Main aspects of in-flight calibration are :
  - absolute calibration : bias in interpretation
  - multi-temporal calibration : error in temporal trends
  - multi-angular calibration : noise on synthesis
  - cross-calibration : biased analysis and comparison

- Methods using acquisitions over selected natural targets were developed to assess these aspects

Calibration over Rayleigh Scattering : method

- Statistical approach over molecular scattering (Rayleigh) :
  - observe the atmosphere above ocean surface (= dark surface)
  - calibration from blue to red 443nm to 670nm
  - contributions to the TOA signal
    - Rayleigh molecular scattering : accurately computed (SOS code)
      - main contributor : ~85/90% of the TOA signal
    - ocean surface : prediction through a climatology
      - no foam because of threshold on wind speed
    - aerosols : rejected using threshold + corrected
      - background residue using 865nm band + Maritime-98 model
      - for POLDER criteria : <τa> = 0.025 and max(τa) = 0.05
    - gaseous absorption : O3 (TOMS), NO2 (climato), H20 (meteo)

Rayleigh

ocean

aerosols

	molecular	aerosol	marine	gaseous	I_mean
443	**84.25**	**1.25**	**14.48**	**-0.56**	**0.1177**
490	**85.25**	**1.98**	**12.75**	**-1.84**	**0.0842**
565	**90.56**	**3.76**	**5.67**	**-8**	**0.04456**
670	**90.23**	**7.5**	**2.25**	**-3.67**	**0.02308**

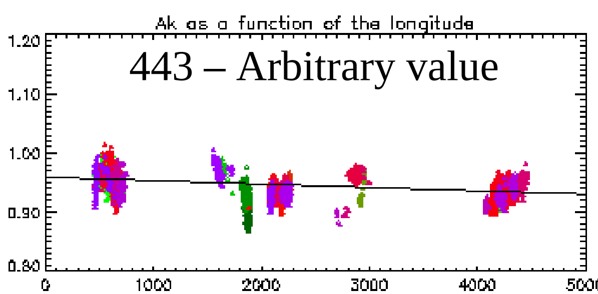
Main contributors to TOA reflectance (in %)

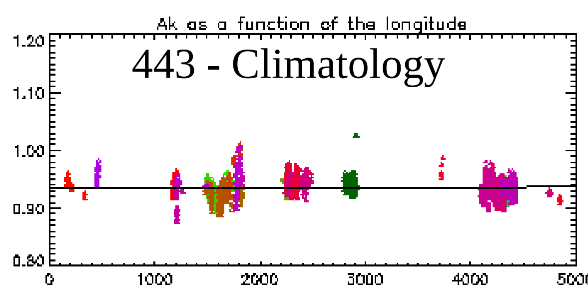
  - accuracy : typically 2% (3% in blue)

Calibration over Rayleigh Scattering : method

- **analysis over 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

  - Benefit to calibrate over various oceanic sites
    - 1 site = still a small possible bias due to exact knowledge of ρw
    - statistical approach : distinguish sensor from sites behaviors
    - analysis of correlations with various geometrical or geophysical parameters
      - different for each sites (Latitude / monthly variations)
      - strong credibility when a phenomenon is observed for each site (ex: time evolution)
      - more accurate analysis

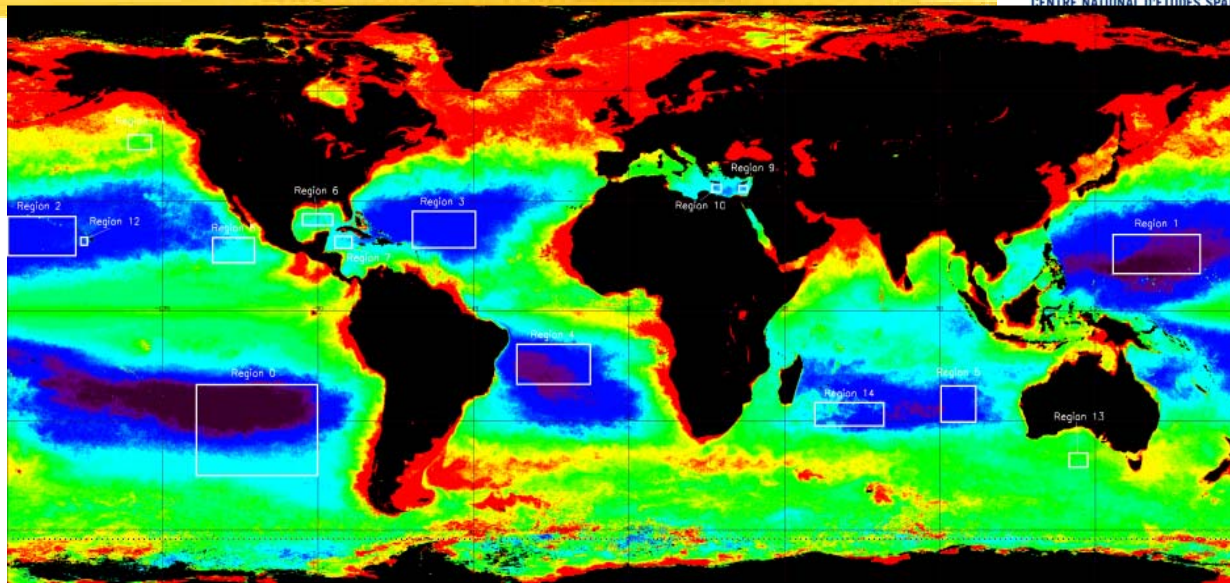




Calibration over Rayleigh Scattering : method

- ClimZOO :

  Climatology of Oligotrophic Oceanic Zones

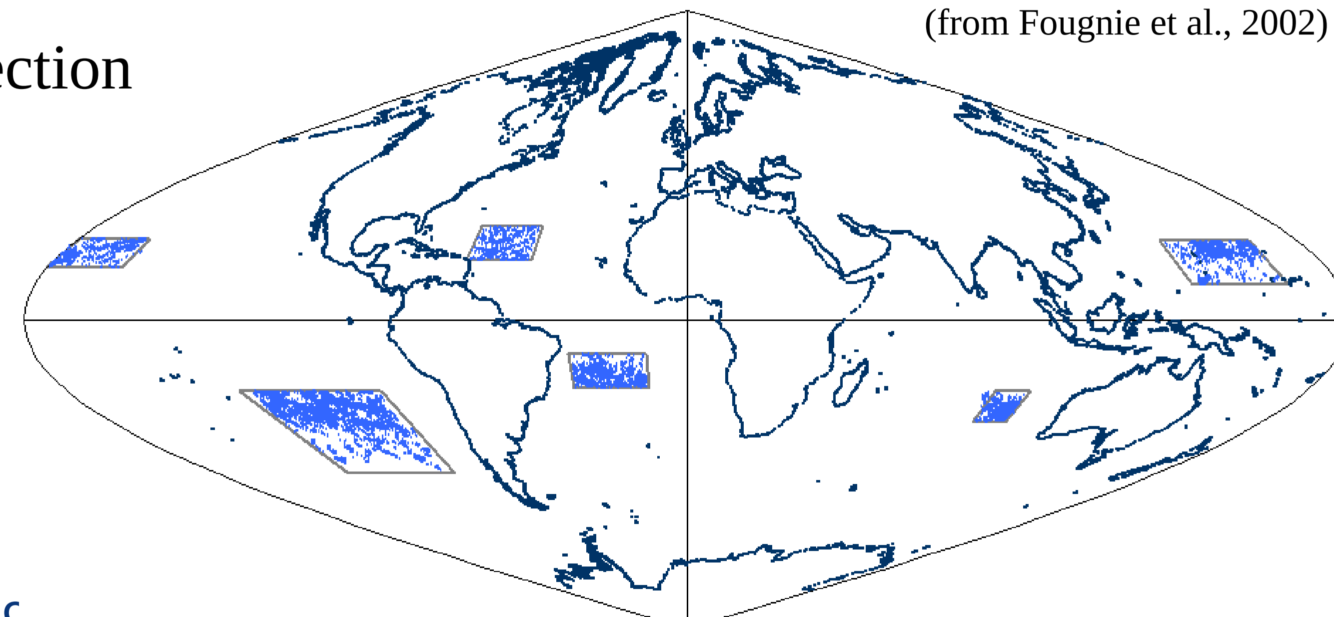


(from Fougnie et al., 2002)

- Measurement Selection

(POLDER3 - 14,000 points

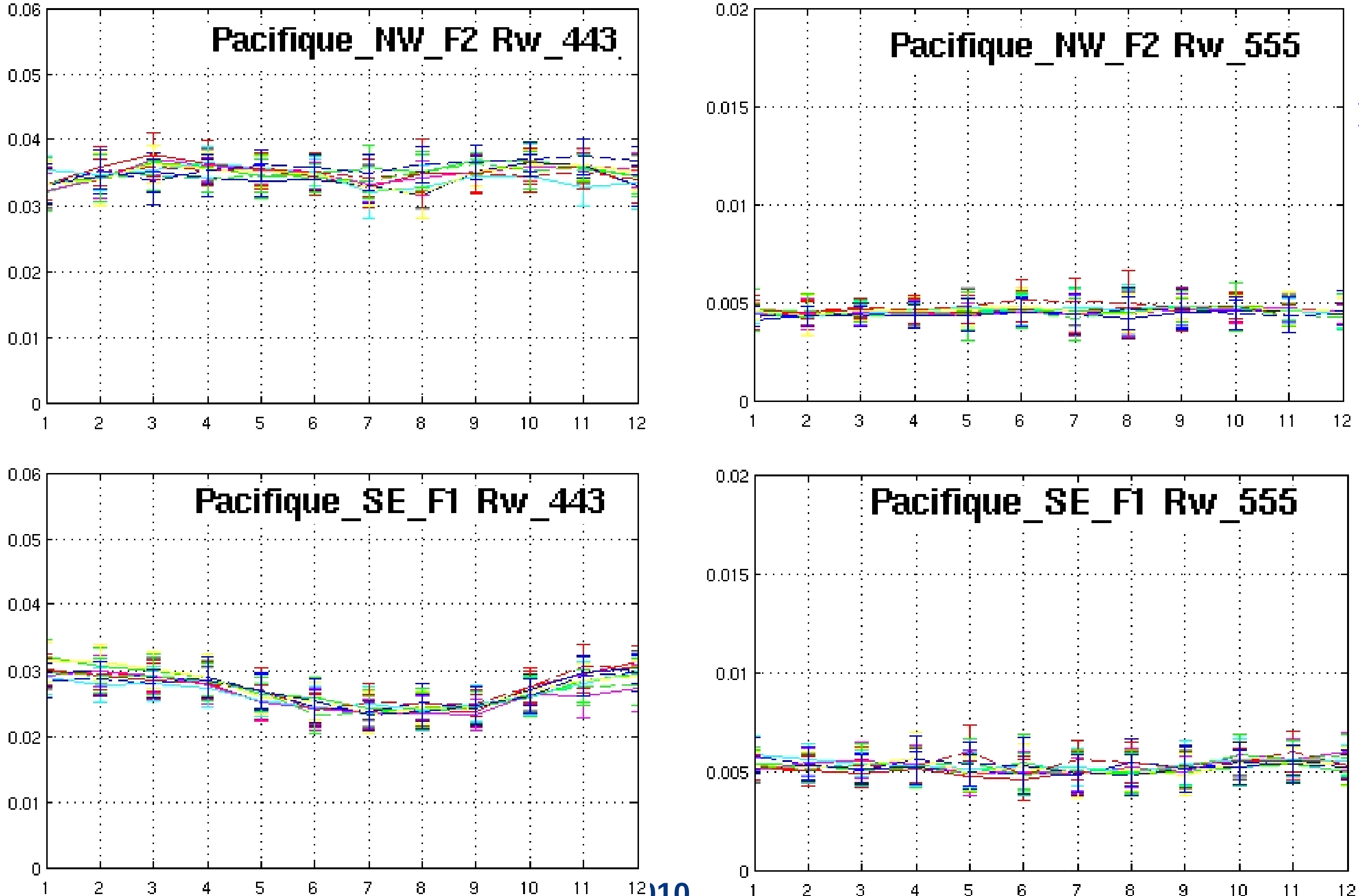
from Jan 05 to Sep 06)



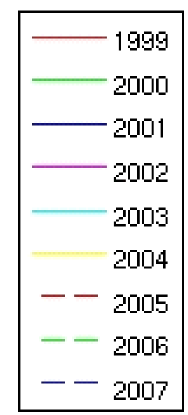
Calibration over Rayleigh Scattering : method

- ClimZOO : Climatology of Oligotrophic Oceanic Zones – 9 years of SeaWiFS data

  2 examples : very good sites in Northern and Southern hemispheres



marine reflectance versus month



(from Fougnie et al., 2010)

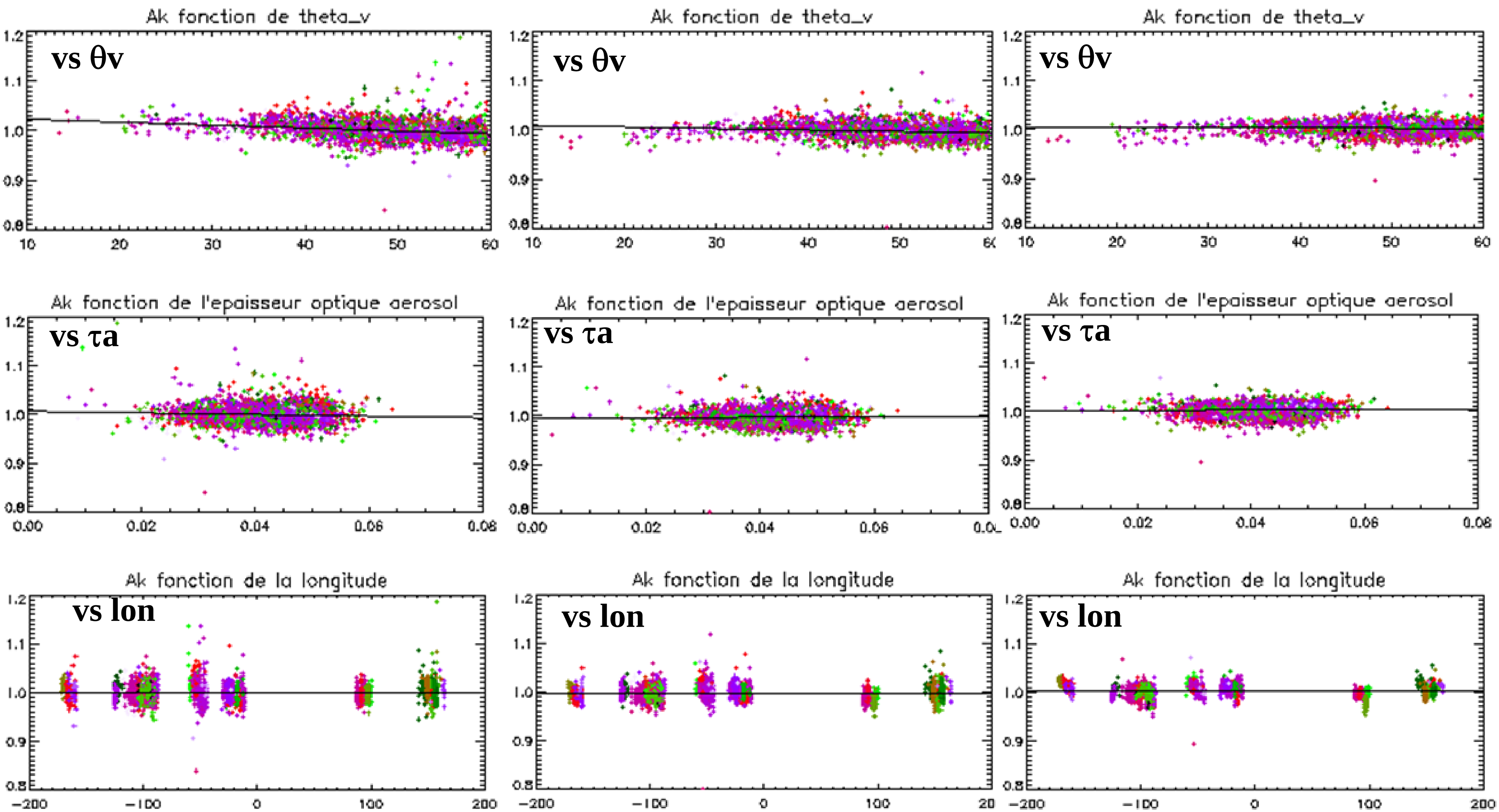
Calibration over Rayleigh Scattering : results

PARASOL

670 Ak=0.999 σ=0.022

565 Ak=0.997 σ=0.014

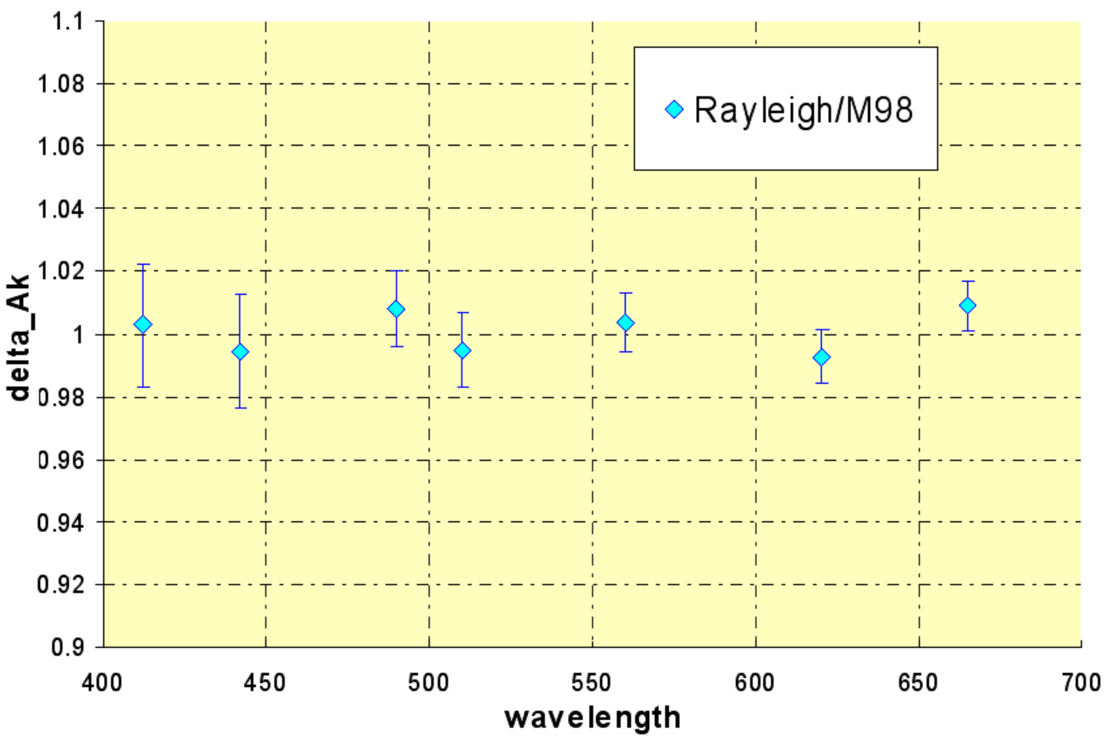
490 Ak=1.003 σ=0.011



(from Fougnie et al. 2007)

Calibration over Rayleigh Scattering: results

- Absolute calibration for all the visible range
  - MERIS example from 412 to 670 nm (using 15,000 measurements in 2003)
    very good accordance with the official calibration



  - Results being updated

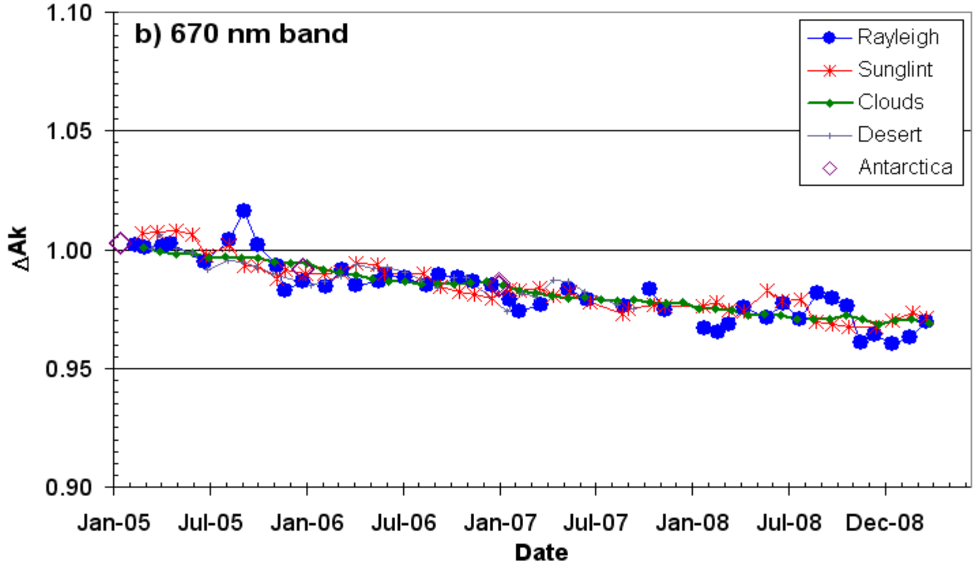
(from Hagolle et al. 2006)

Calibration over Rayleigh Scattering: results

- Valuable for multi-temporal monitoring validation :
  - PARASOL example

    validation of the operational method using DCC

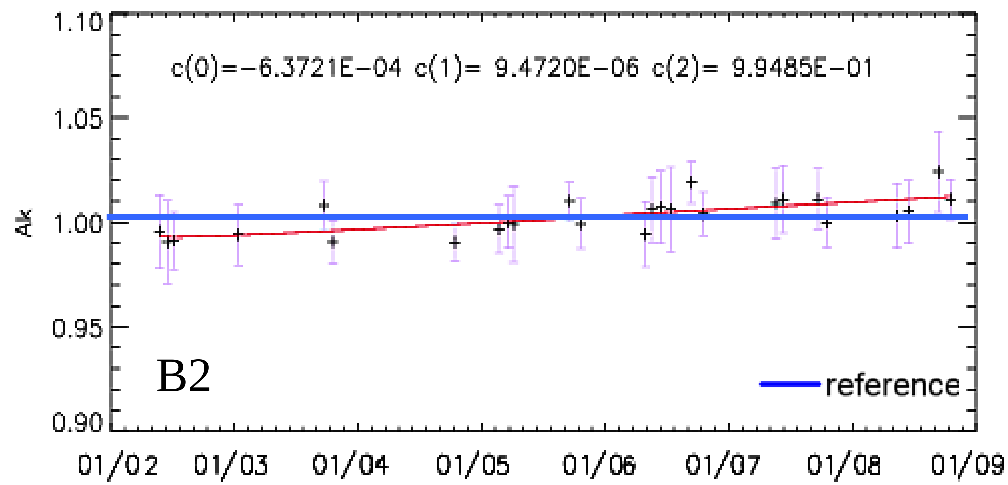
    The red band



  - Végétation-2 example

    comparison to official calibration

    The red band



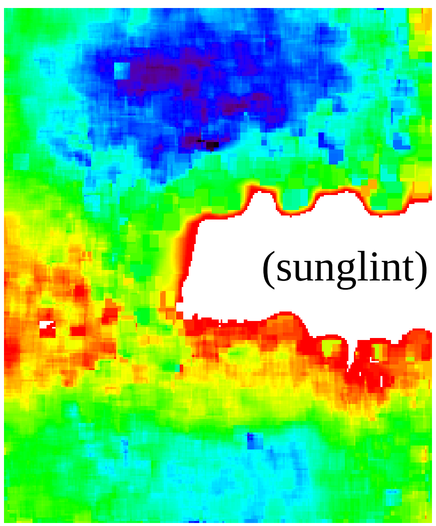
(from Fougnie et al. 2009)

Calibration over Rayleigh Scattering: results

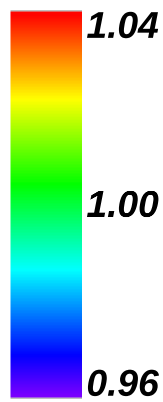
- Potentiality for multi-angular calibration :
  - Example with PARASOL

    Evolution of the calibration in the field of view after 2 years in orbit for band 490

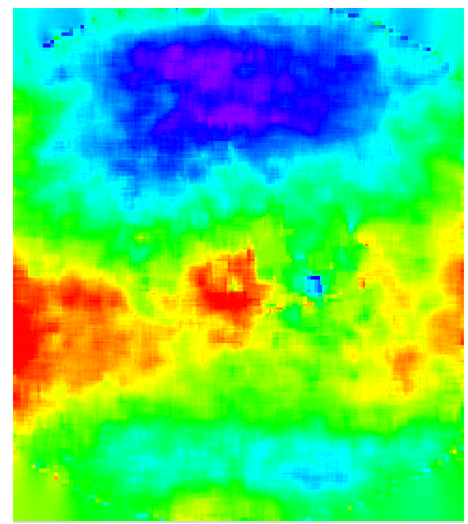
Calibration over Rayleigh Scattering



derived using acquisitions over ocean



Calibration over Clouds



derived using acquisitions over Deep Convective Clouds

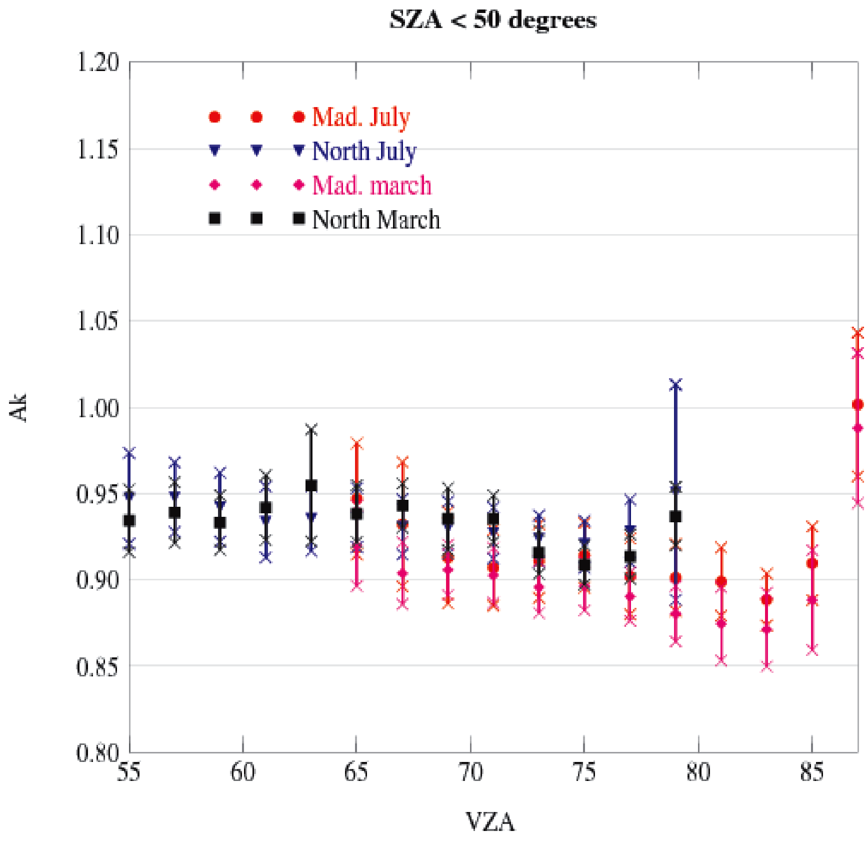
(from Fougnie et al. 2010)

Calibration over Rayleigh Scattering: results

- Applicable for geostationary missions :
  - Example with SEVIRI

    For band 670nm

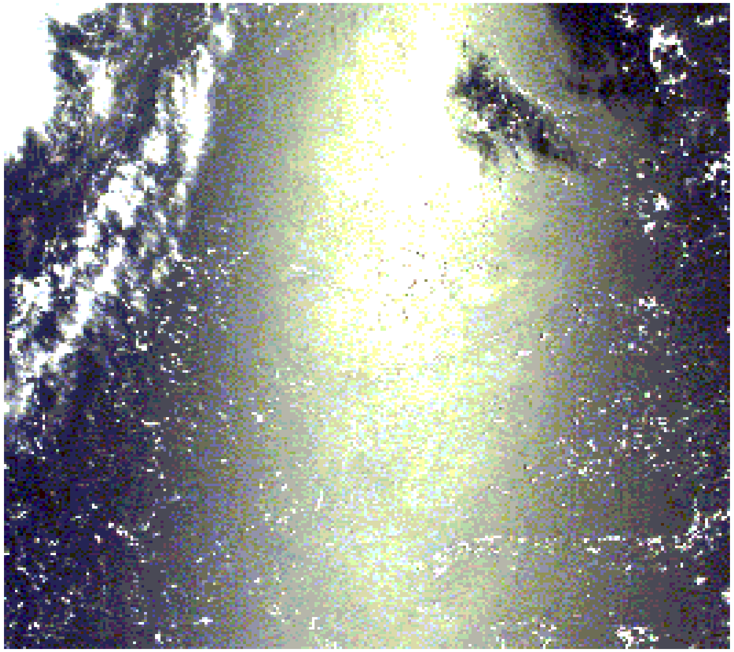
    method extended for very large airmass (improved radiative transfer computation)



(from Jolivet et al., 2009 [Hygeos])

Propagation of the Rayleigh Scattering Calibration to NIR bands

Calibration over Sunglint (+Rayleigh)



Pushbroom view

2D sensor view

Interband calibration over sunglint : method

- Interband method
  - observe the “white” reflection of the sun over the ocean surface
  - inter-calibration of blue to SWIR bands (440 to 1600nm) with a reference band : red band (670) usually adopted as reference & calibrated over Rayleigh
  - accurate computation of the 2 main contributors :
    - Rayleigh scattering
    - sunglint strongly depend on the wind speed estimated using a reference band
      - both computed using Successive Order of Scattering code
      - use of a spectral refraction index of water (not constant) + Cox and Munk model
  - other minor contributions :
    - ocean surface : predicted using climatology
    - aerosol : threshold + correction
      - threshold using another viewing direction or exogenous data (SeaWiFS)
      - background correction considering Maritime-98 with aot of 0.05
    - gaseous absorption : O3 (TOMS), NO2 (climato), H20 (meteo)
  - dedicated selection

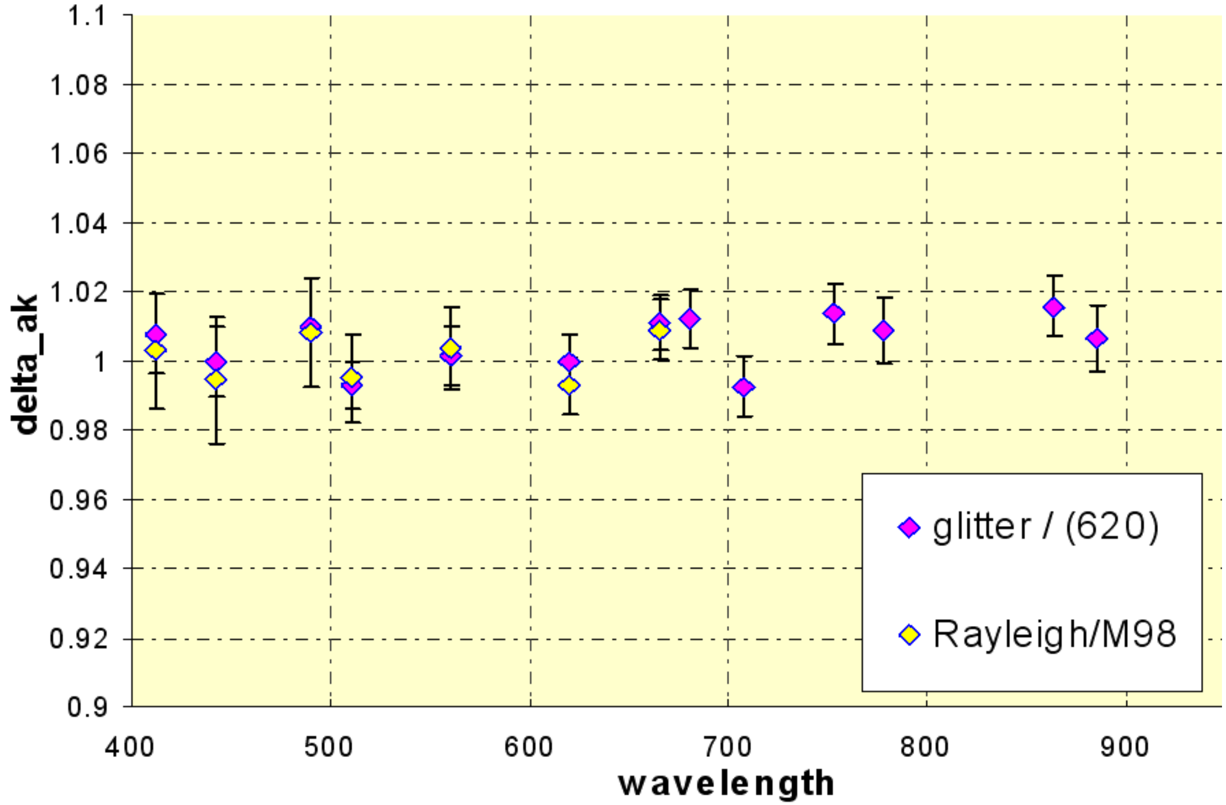
Interband calibration over sunglint : results

- Interband calibration efficiency :

  ex : MERIS calibration for NIR bands

  – Dispersion very low for bands close to 620 (reference)

In-flight calibration versus reflectance at reference 620



(from Hagolle et al. 2006)

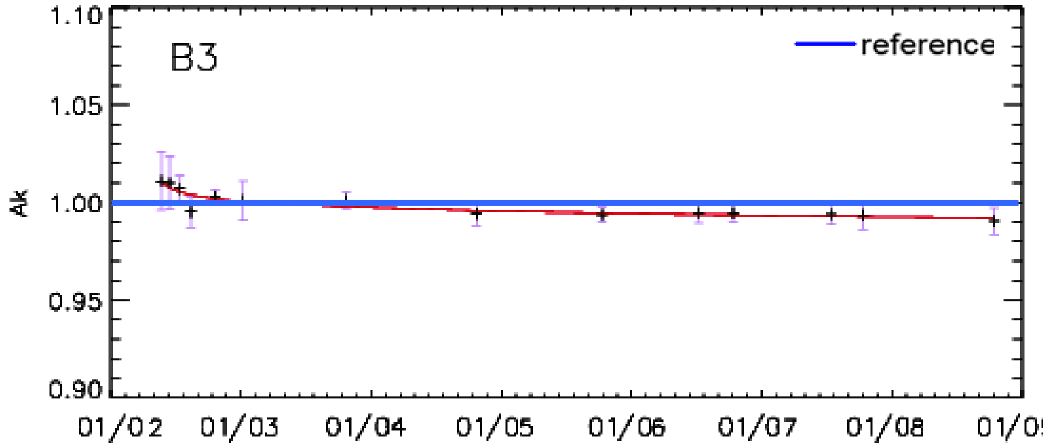
Interband calibration over sunglint : results

- Multi-temporal survey :
  - efficiency depending on sampling (geographic and temporal)

***Végétation*-2**
B3 NIR band

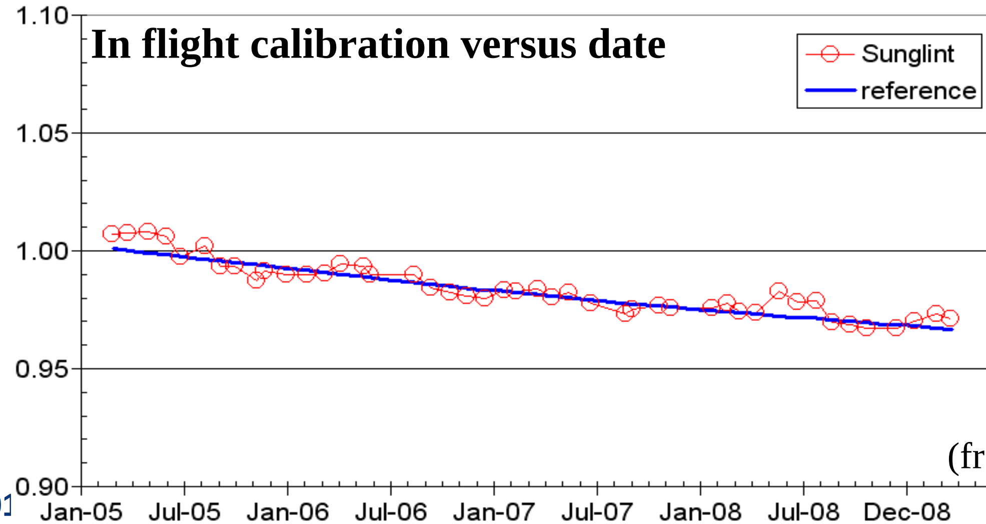
Temporal decrease in fact due to a drift of the reference band B2

Absolute calibration versus date



PARASOL
670nm band

Reference band = 765
Temporal decrease confirmed by all other methods

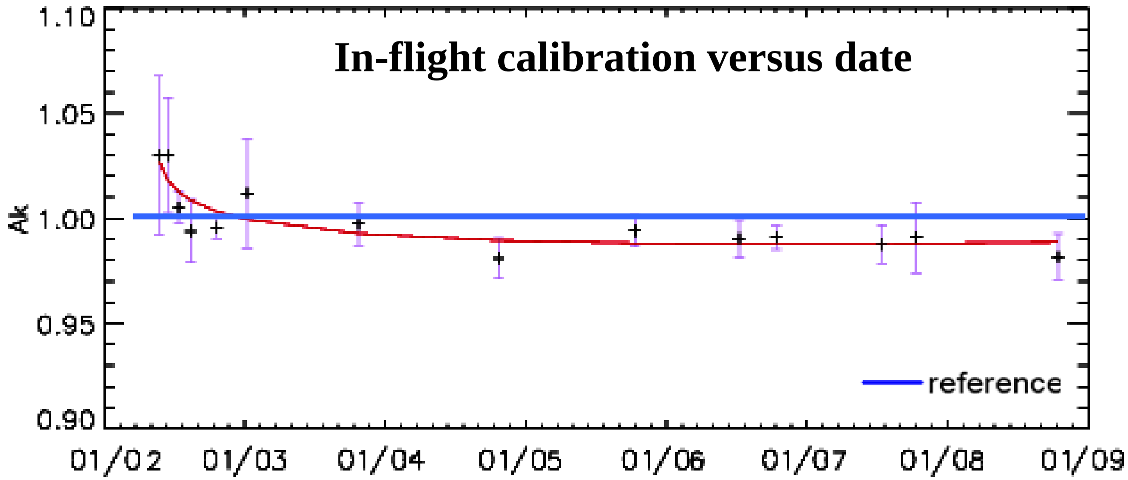


(from Fougnie et al. 2009)

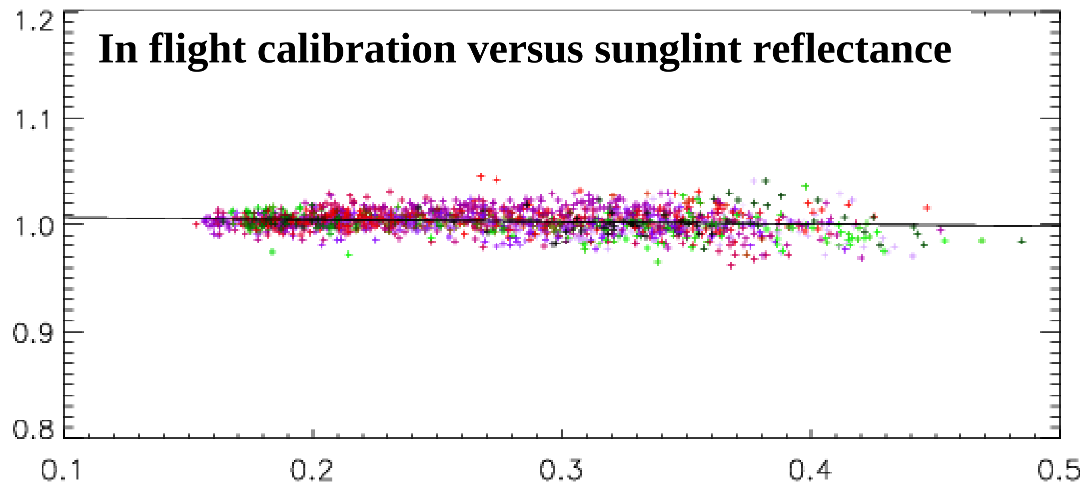
Interband calibration over sunglint : results

- Valuable for SWIR band calibration :

Végétation
SWIR-1600nm band



PARASOL
1020nm band



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