Multi-sensors vicarious calibration activities at CNES

Patrice Henry, Bertrand Fougnie

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CNES background in image quality monitoring of operational Earth observation systems

- **Since the launch of SPOT1 in 1986, CNES has cumulated more than 110 years of in-orbit image quality monitoring**
  - **SPOT1, SPOT2, SPOT3, SPOT4, SPOT5 (HR)**
  - **VGT 1 & 2**
  - **POLDER 1&2, PARASOL**
  - **Scarab 1&2, Scarab MT**
  - **Calipso/IIR**
  - **Helios series**
  - **Pleiades 1A&1B**

- **Different resolution, different types of mission, different thematic…**
  - **Different skills to develop (geometry, radiometry, MTF, polarized geometry…)**
  - **Different tools (as generic as possible)**
  - **Different types of users to satisfied…**

CNES background in radiometric 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 area)**
  - **Lunar calibration**
  - **Autonomous calibration station (for high resolution)**

- **Most of them are used on an operational basis**
  - **Monitoring the CNES sensors calibration (SPOT(s), VGT(s), POLDER(s), Pleiades(s)…)**
  - **Monitoring of other agencies sensors (MERIS, MODIS, SeaWiFS, AVHRR, Formosat2, Kompsat2, Theos…)**

Summary

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- *Example of VGT calibration*
- *Example of PARASOL calibration*
- *Example of MERIS*
- *The CNES Calibration Toolbox*

Conclusion

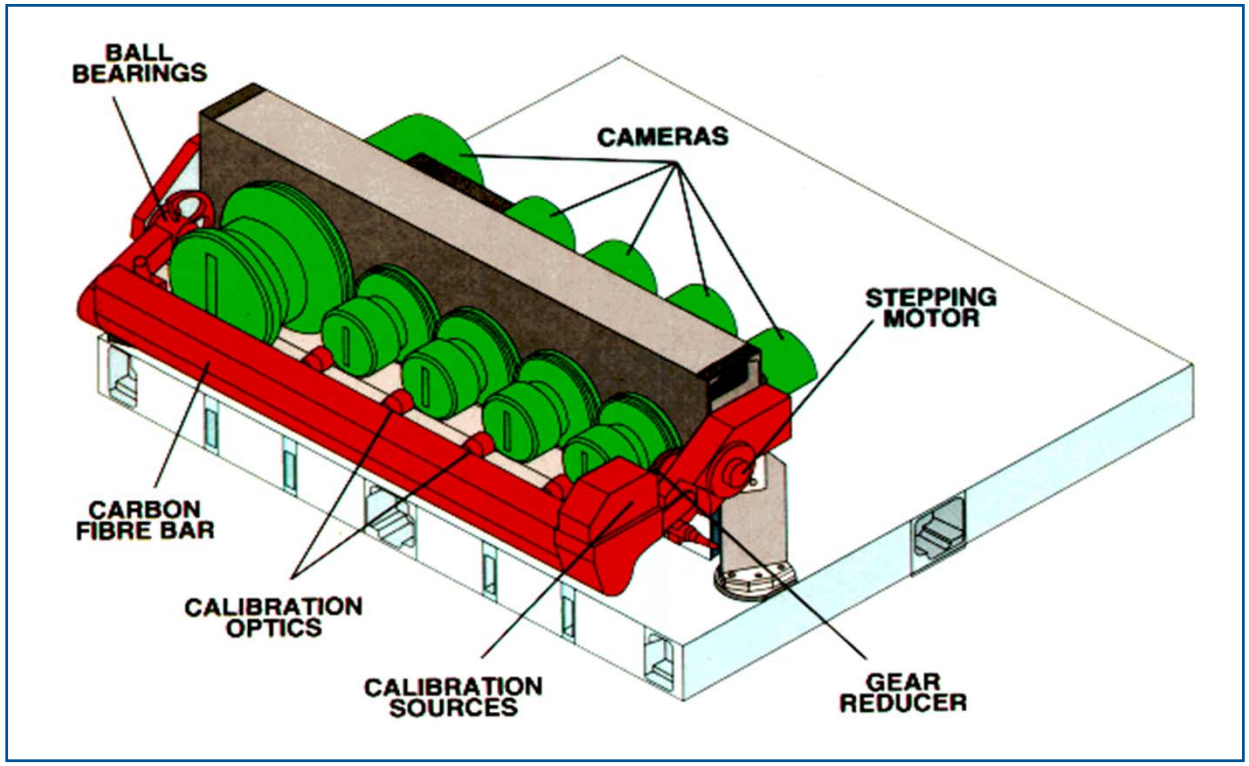
Example of

SPOT/VEGETATION calibration

VGT On-Board Calibration Device

Simultaneous lighting of the 4 cameras by means of a lamp device mounted on a rotating fiber bar :

- **only 100 detectors are simultaneously lighted**
- **calibration duration: about 3 min.**



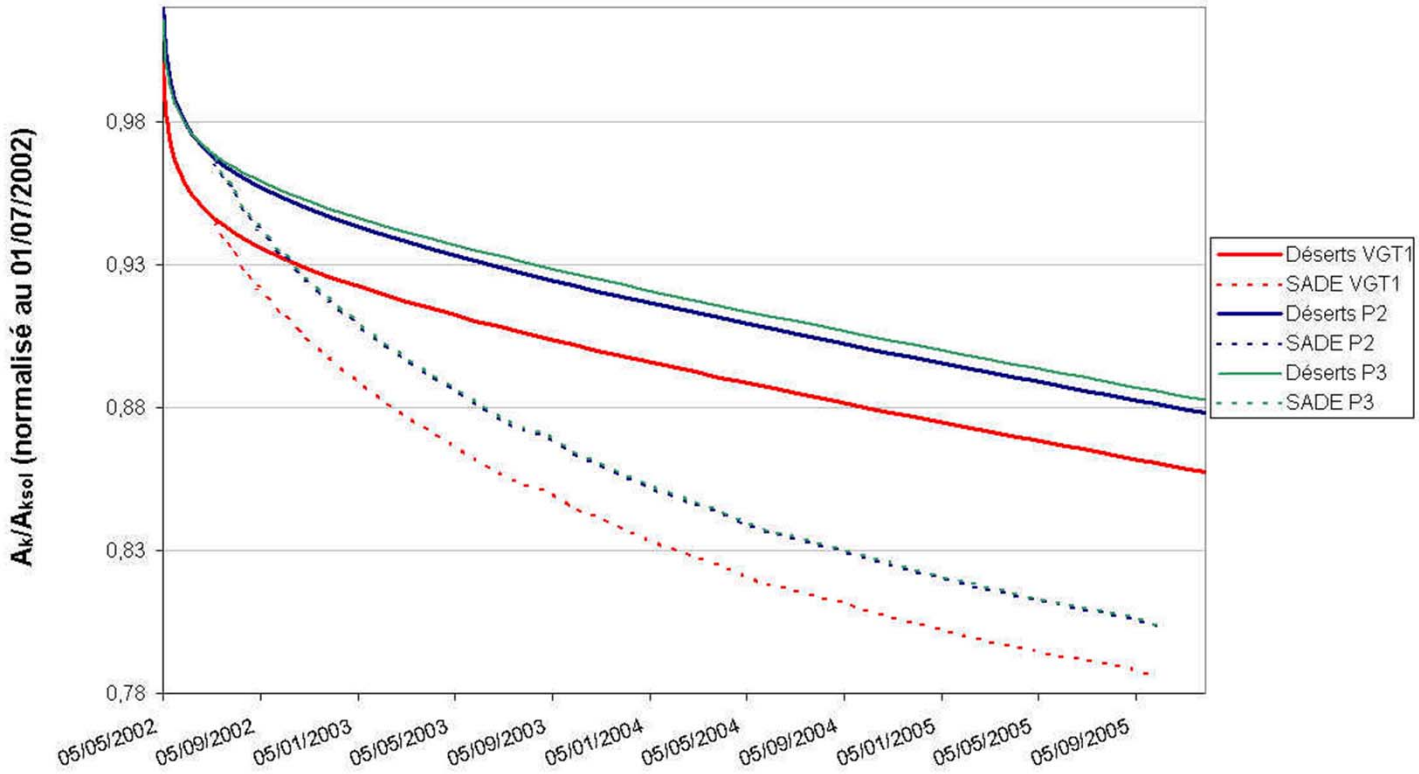
VGT Routine Calibration Monitoring using On-Board Lamp

- **On-board calibration device proved to be efficient for the VGT1 calibration monitoring (6 years) thanks to regular comparison to vicarious calibrations**
- **No anomaly detected during VGT2 commissioning period (6 months): some discrepancies with vicarious calibration but in the order of magnitude of the methods accuracy**

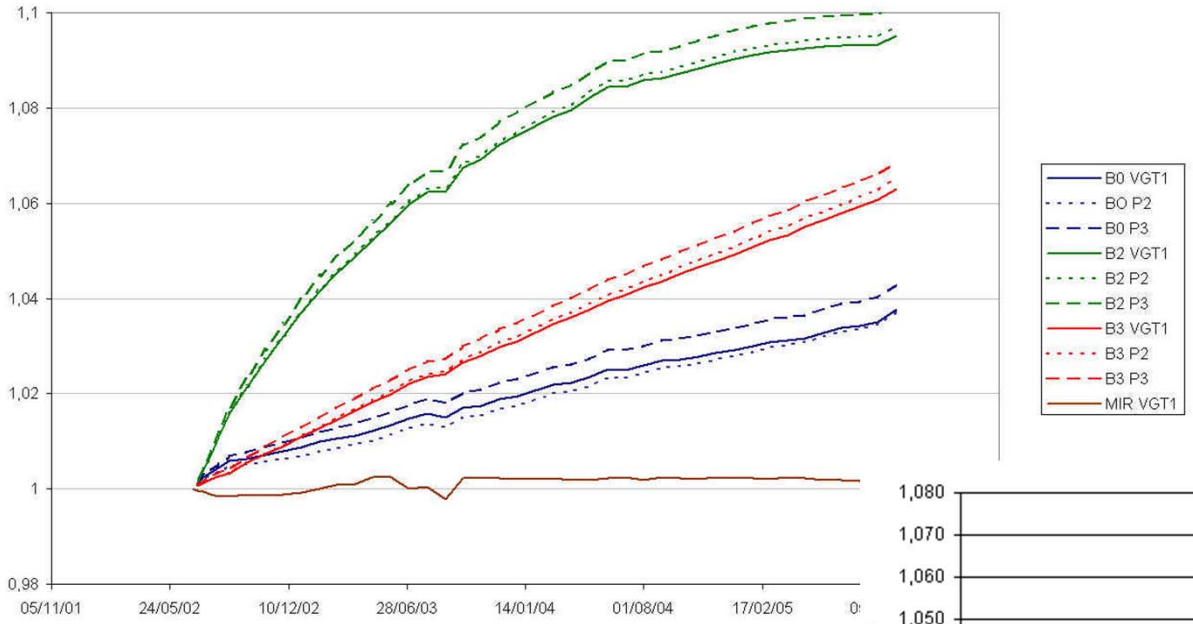
⇒ **Decision was made to base VGT2 operational calibration monitoring on the on-board lamp measurement for the operational phase**

VGT 2 calibration check over deserts (B2 band)

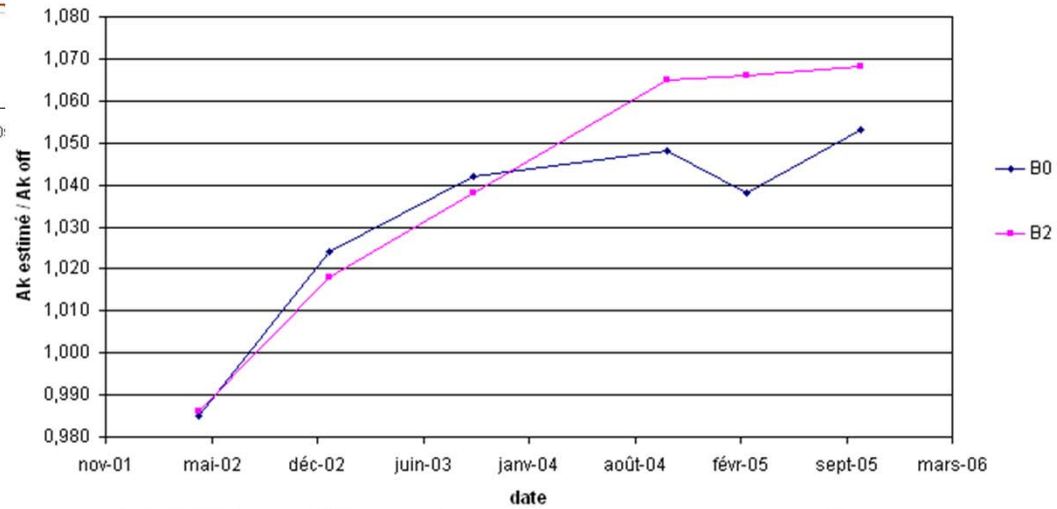
VGT2 calibration monitoring over deserts versus different references (POLDER2, POLDER3, VGT1) compared to calibration monitored with the on-board lamp after 3 years in orbit



VGT 2 calibration error confirmed by different methods



VGT2 calibration error as seen by deserts inter-calibrations
(normalization 1st July 2002)



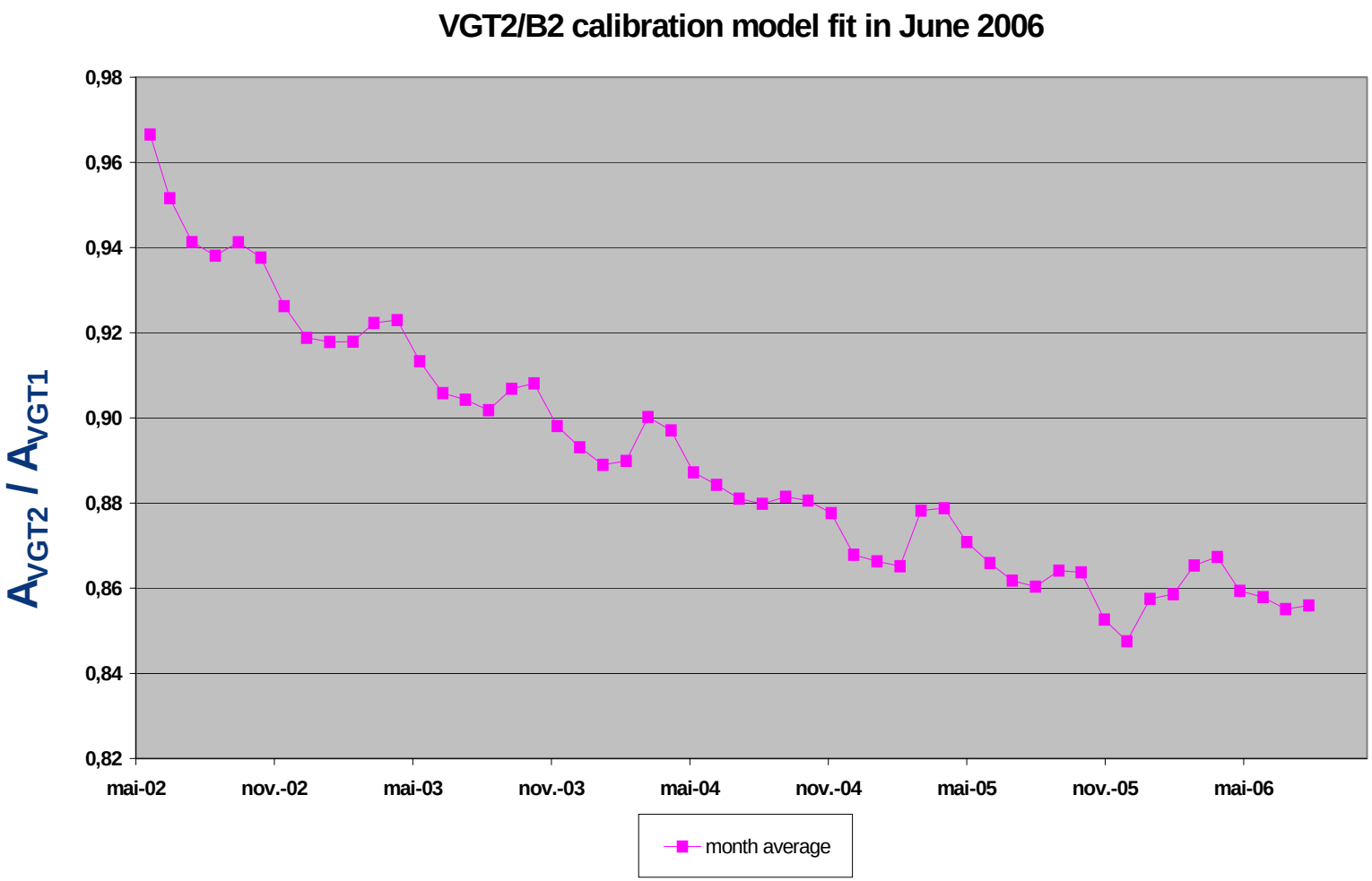
VGT2 calibration error as seen by Rayleigh scattering calibration
(normalization 1st July 2002)

Urgent to change the operational calibration monitoring procedure !!!

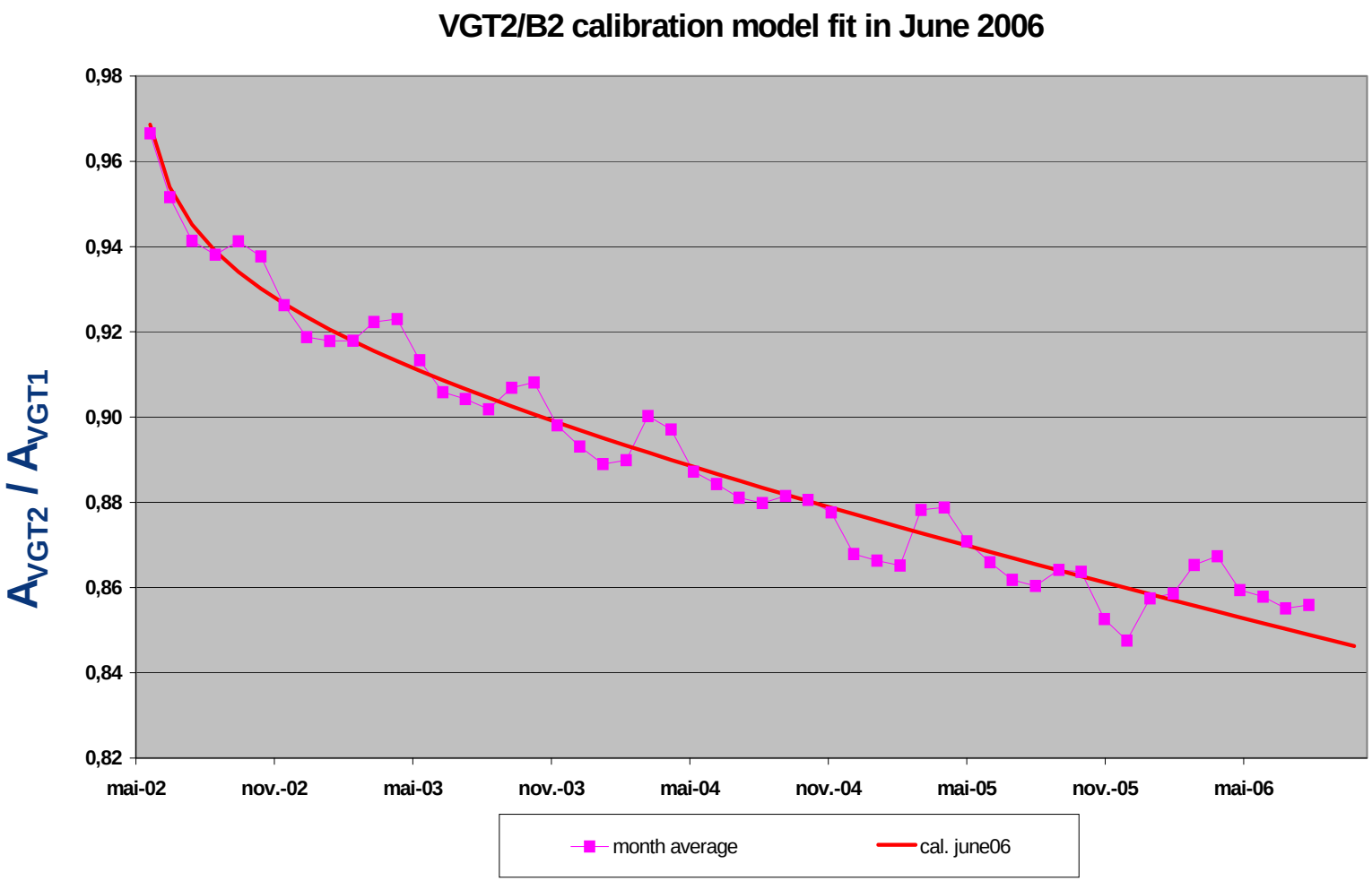
Switch to an operational calibration monitoring over desert sites

(VGT = land monitoring mission)

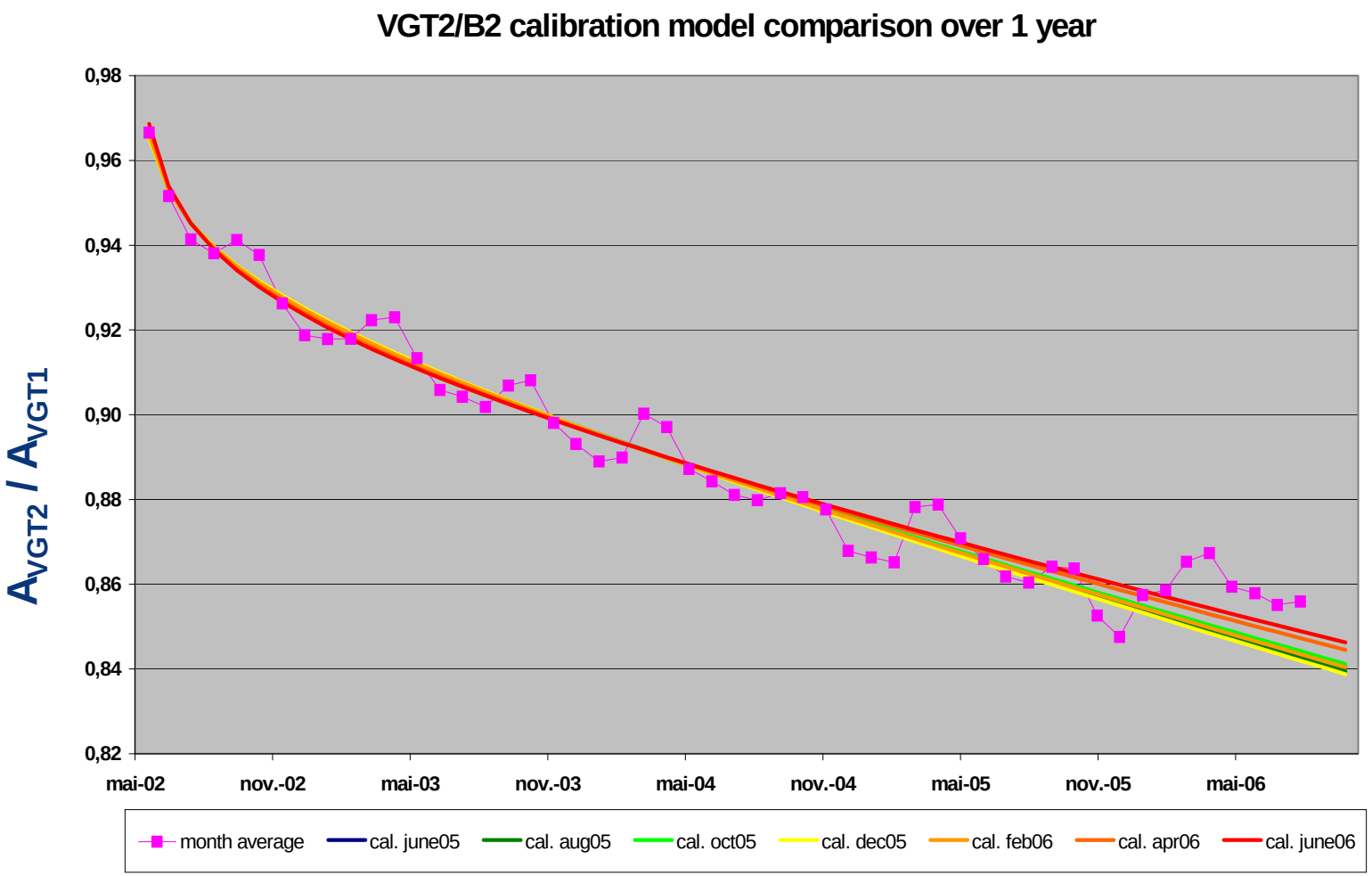
VGT 2 calibration monitoring over deserts : month averaging



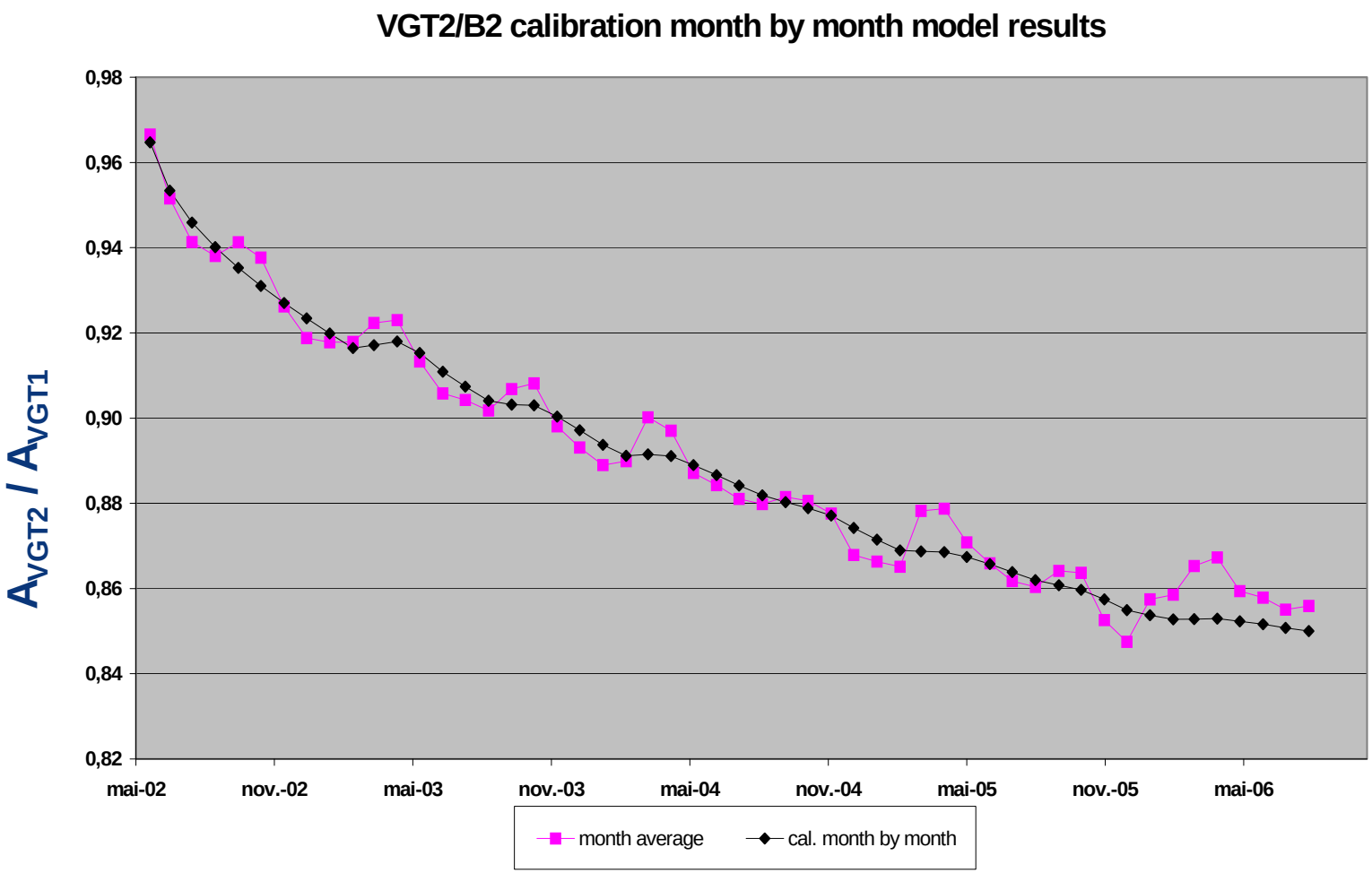
VGT 2 calibration monitoring over deserts : model fitting



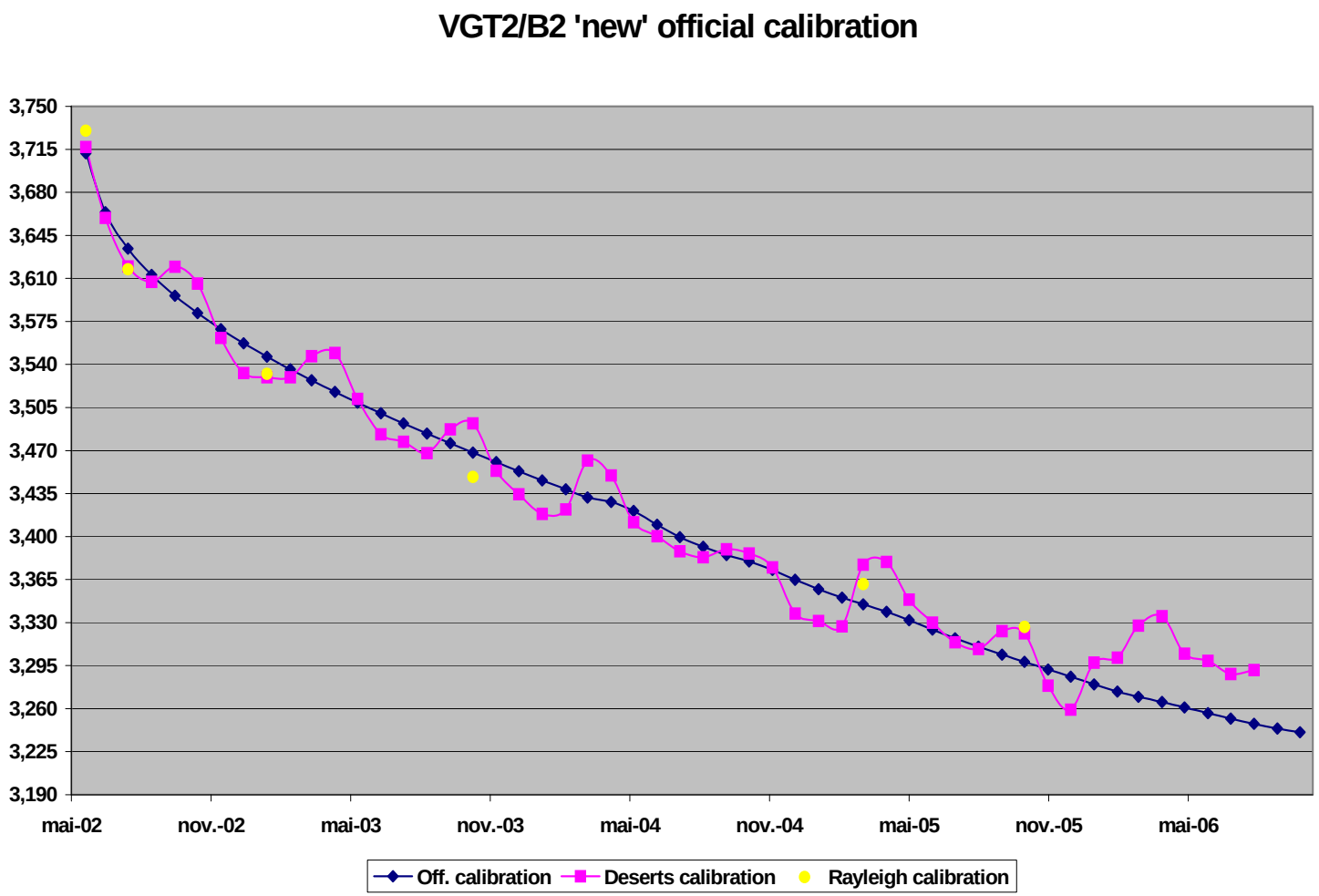
VGT 2 calibration monitoring over deserts : monthly fit



VGT 2 calibration monitoring over deserts : seasonal effects

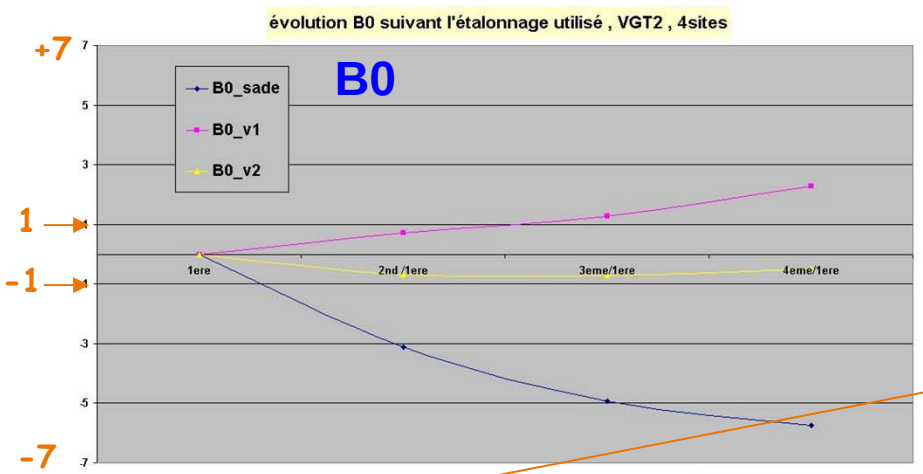


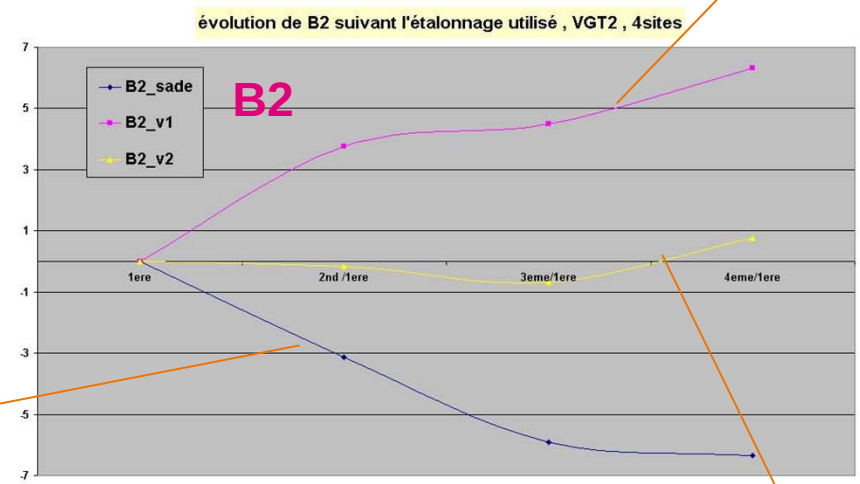
VGT 2 calibration monitoring over deserts : final result



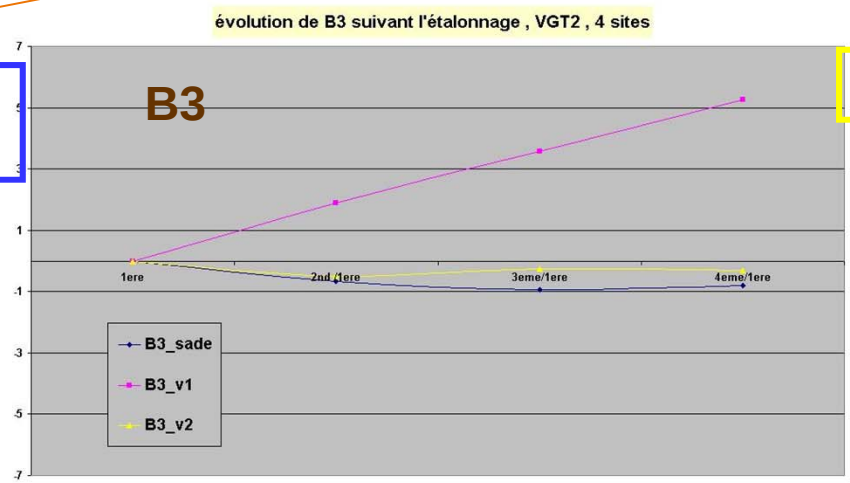
Validation of VGT2 new calibration over Dôme C

Purple: 'lamp' calibration





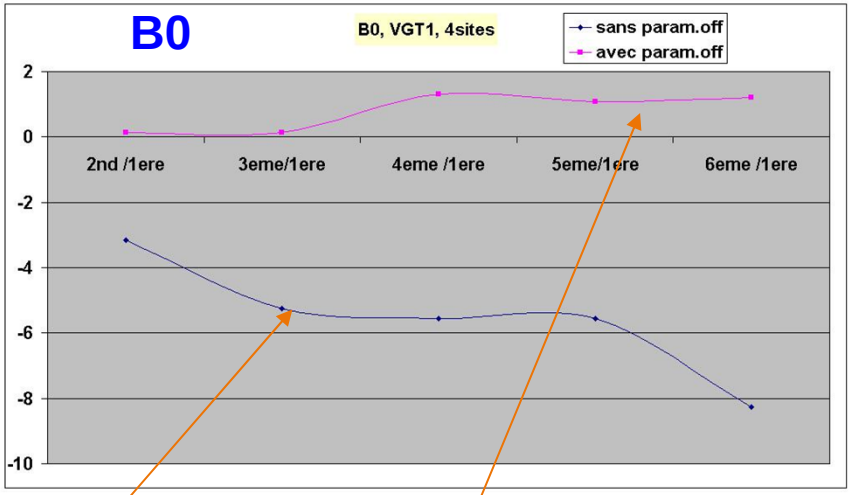
Blue : ground calibration (constant)

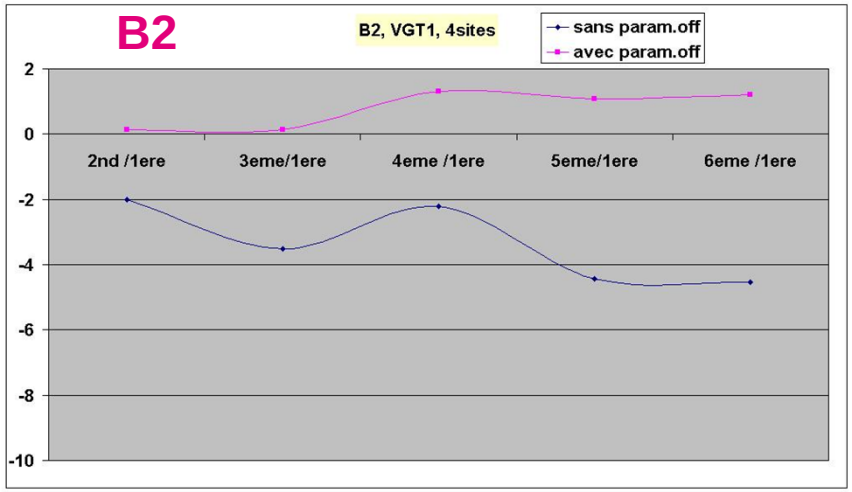


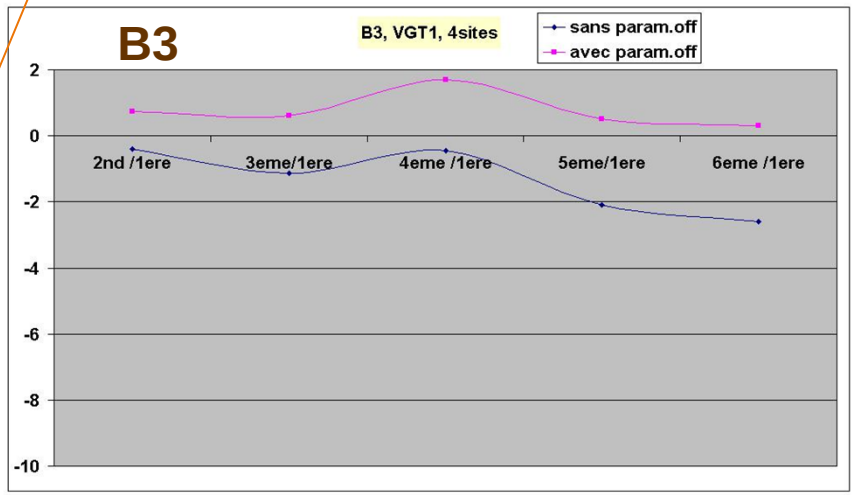
Yellow: 'deserts' calibration

New calibration error : < 1% over 3 years

VGT1 lamp calibration validation over Dôme C





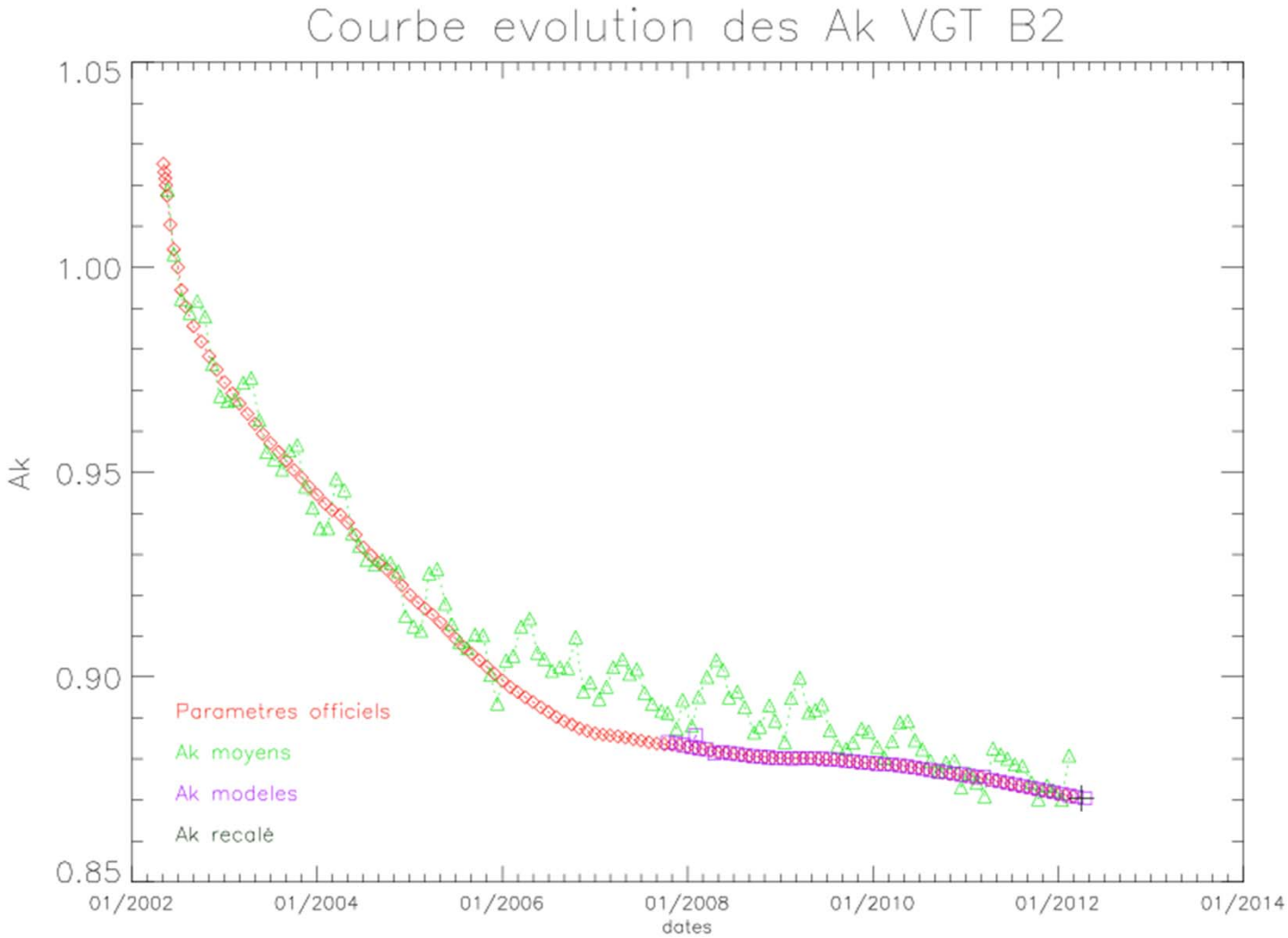


Blue : ground calibration (constant)

Purple: 'lamp' calibration

Calibration error : < 2% over 6 years

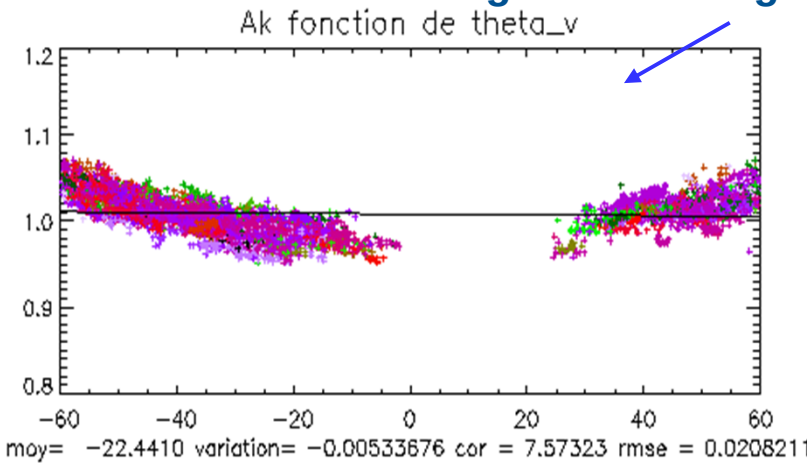
Operational calibration monitoring procedure
(performed on a monthly basis)



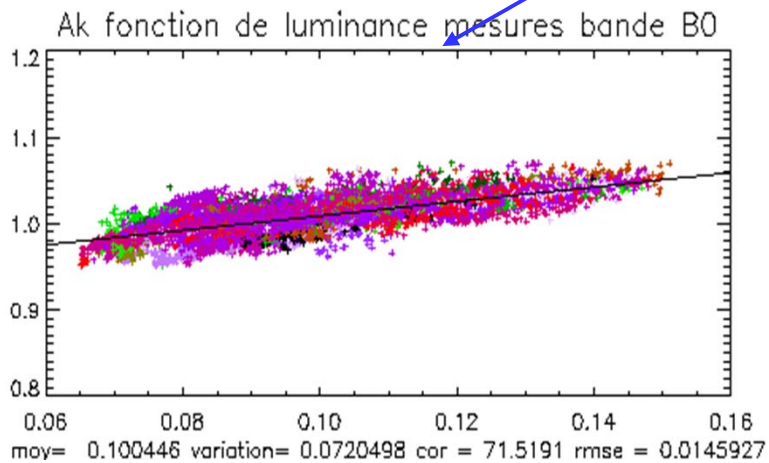
But calibration shall not be resumed to a single value !

B0 VGT2 Rayleigh Scattering (spring 2007)

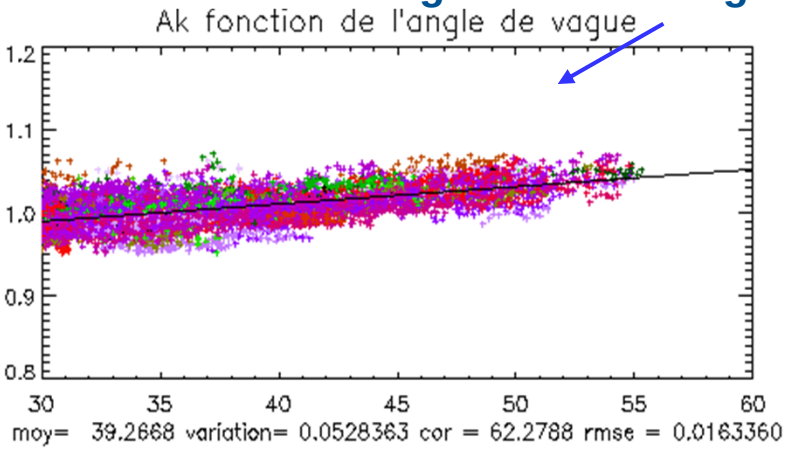
against viewing zenith angle



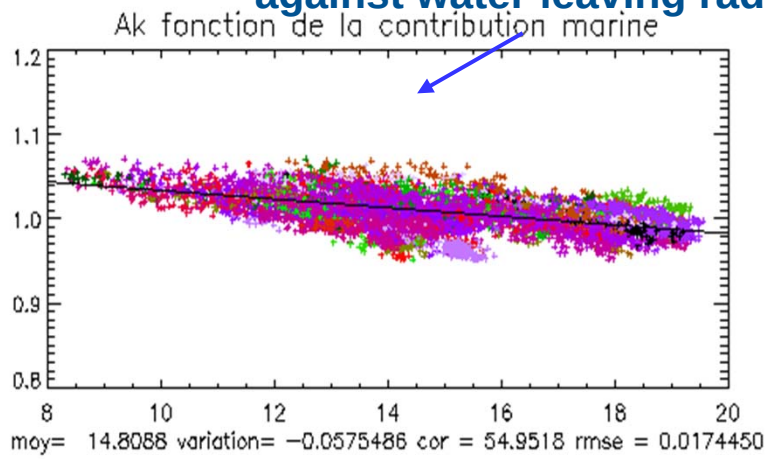
against measured radiance



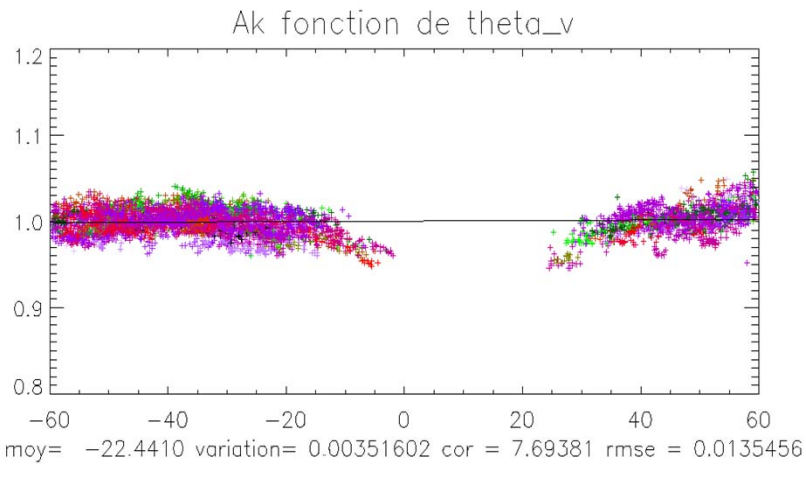
against wave angle

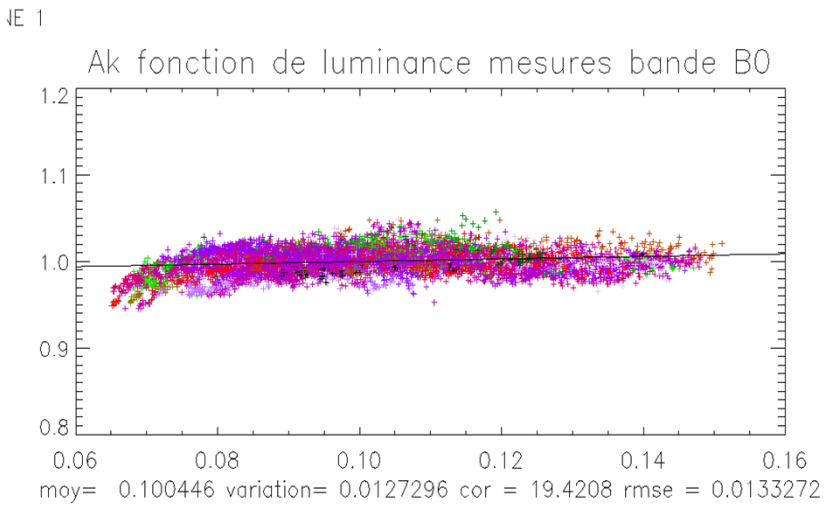


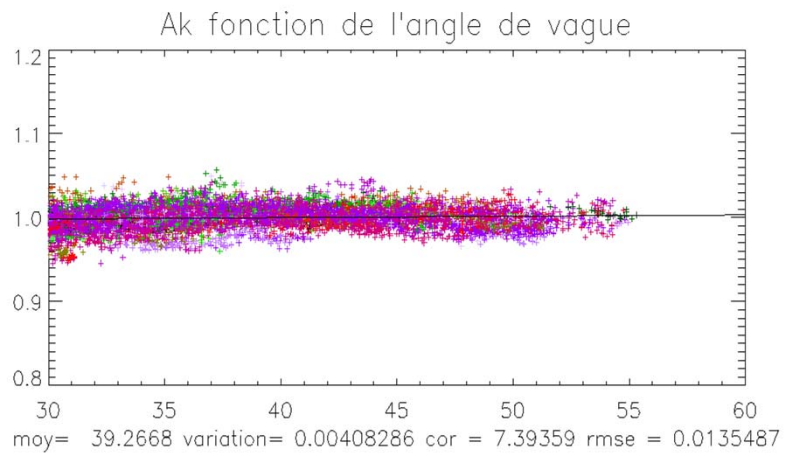
against water leaving radiance

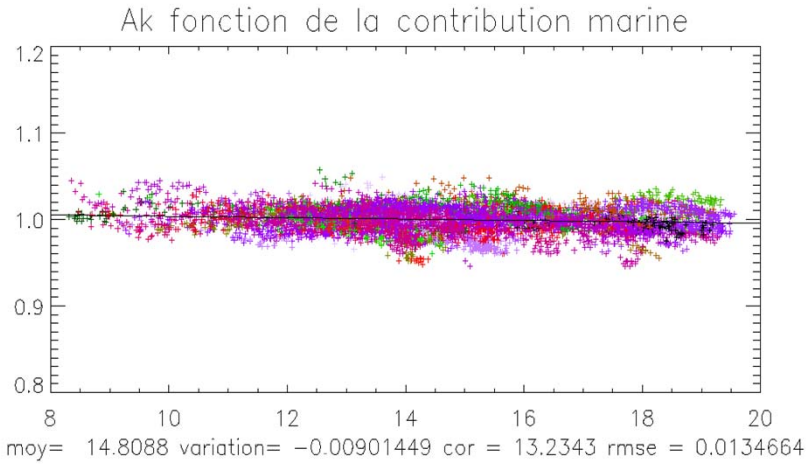


B0 VGT2 Rayleigh Scattering after correction





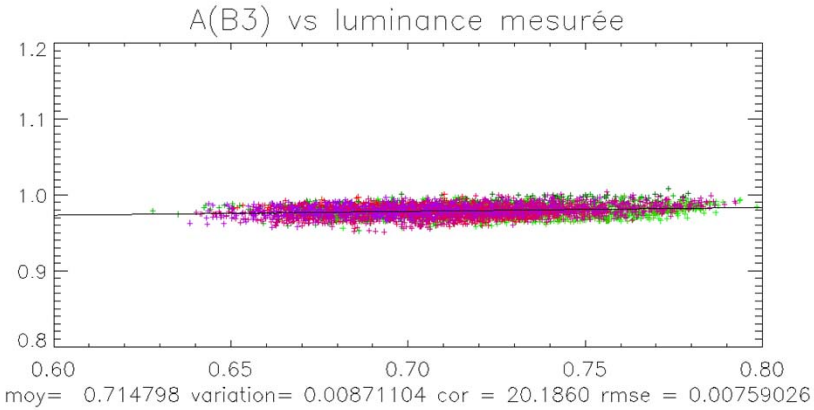


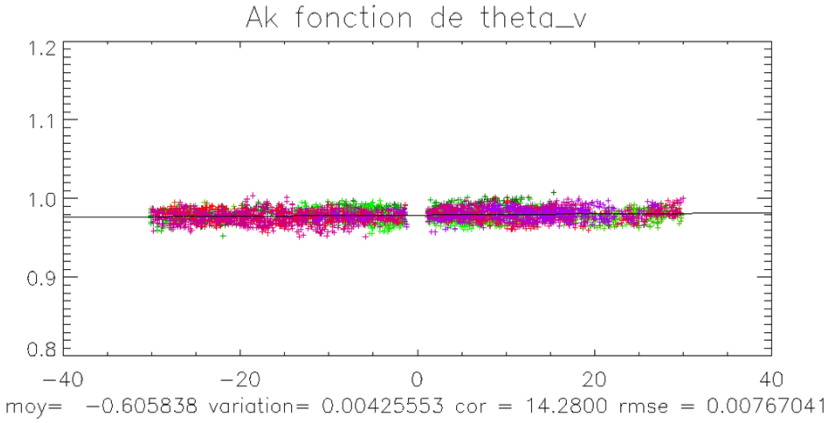


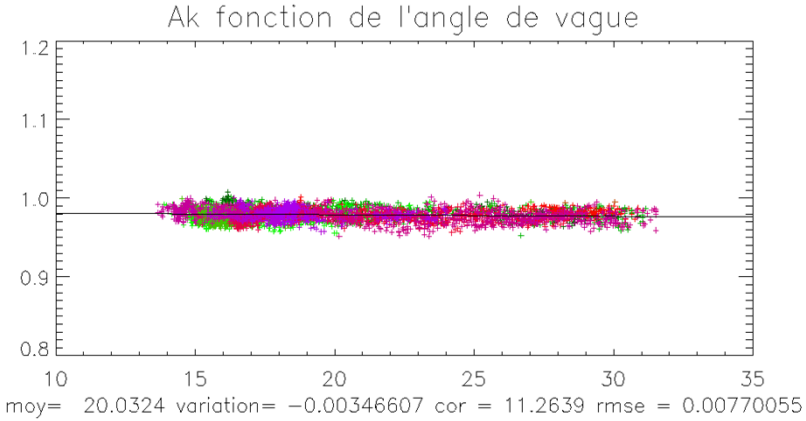
Other vicarious calibration methods used for VGT calibration validation

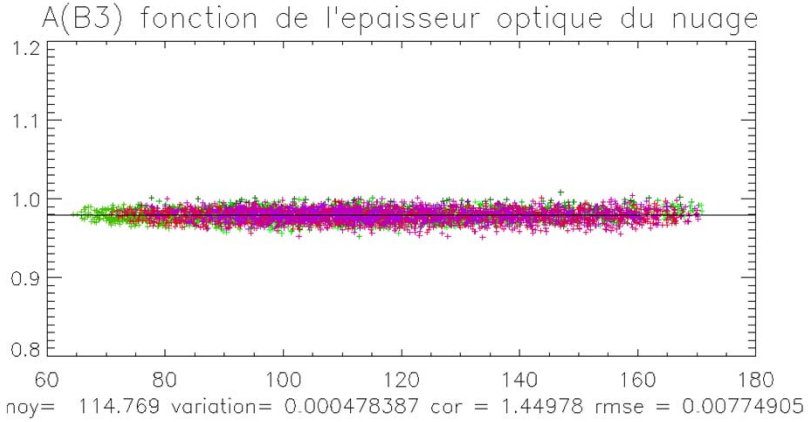
VGT2 calibration validation over clouds (spring 2007)

Interband calibration B3 vs B2



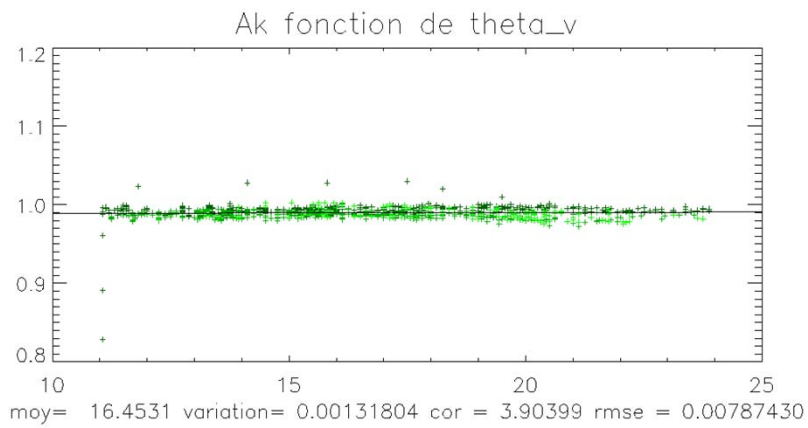


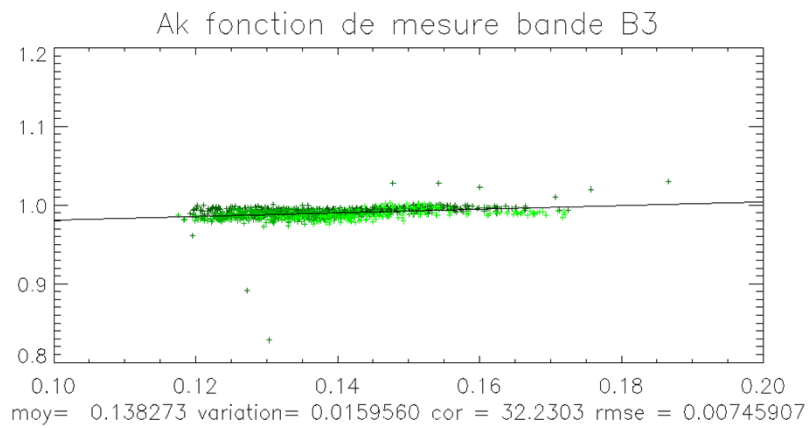


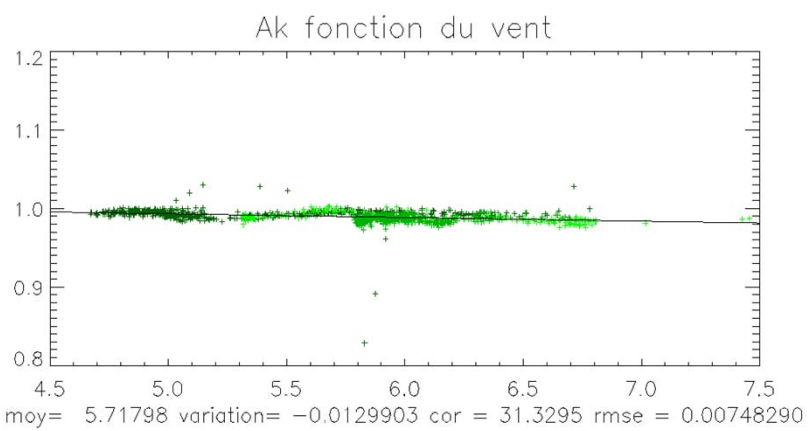


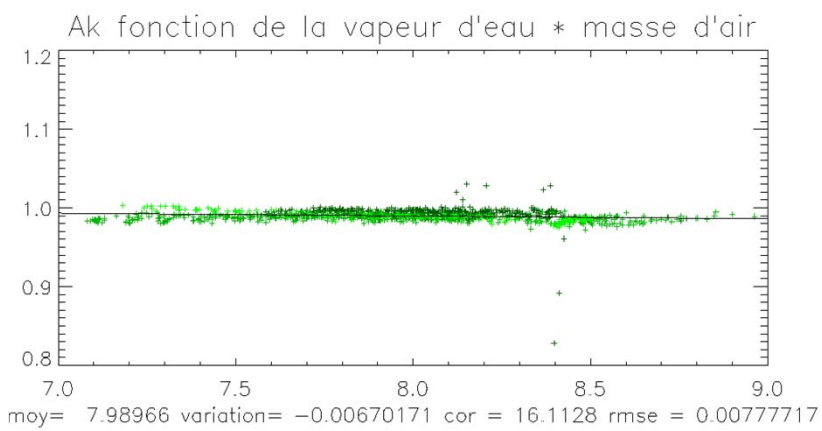
VGT2 calibration validation over sun glint (summer 2007)

Interband calibration B3 vs B2







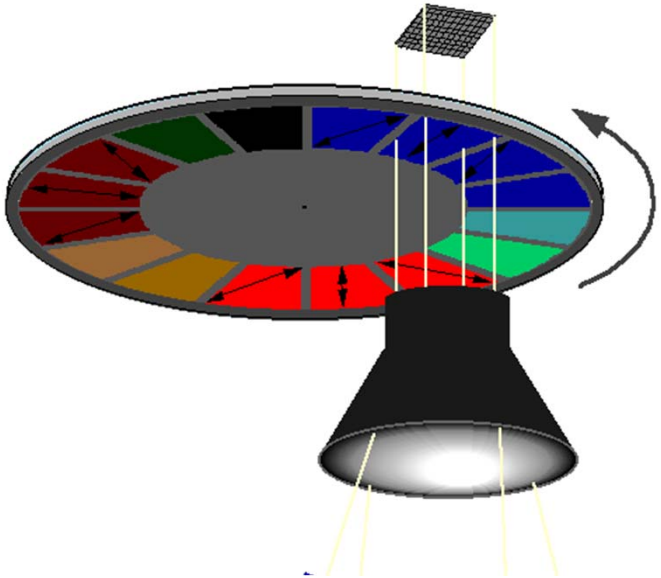


Example of

PARASOL/POLDER-3 calibration

PARASOL/POLDER-3 presentation

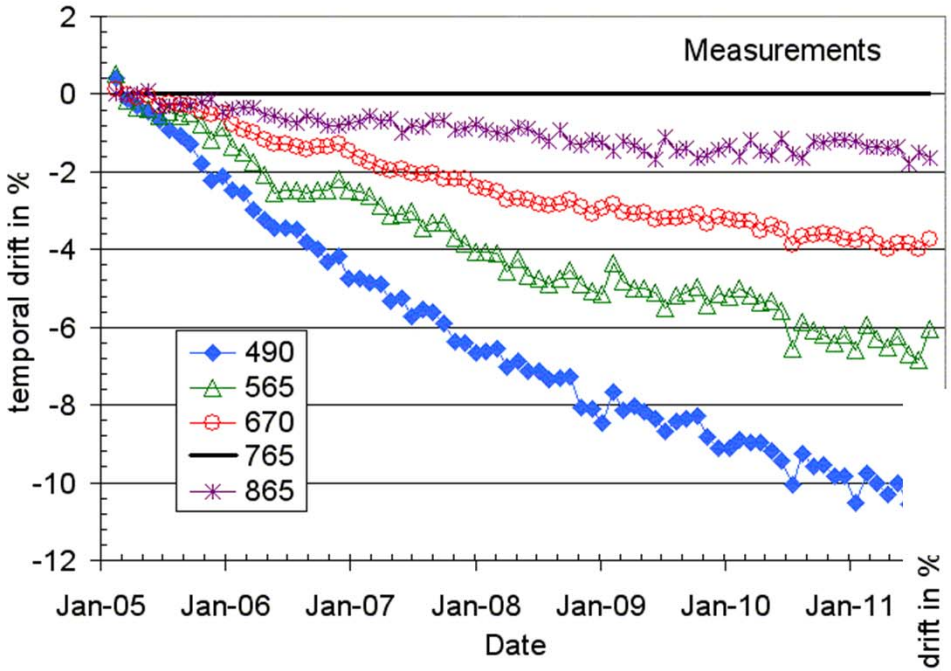
POLDER instrument is a camera composed of:
- **a two-dimensional CCD detector array,**
- **a wide field of view telecentric optics,**
- **a rotating wheel carrying spectral and polarized filters.**



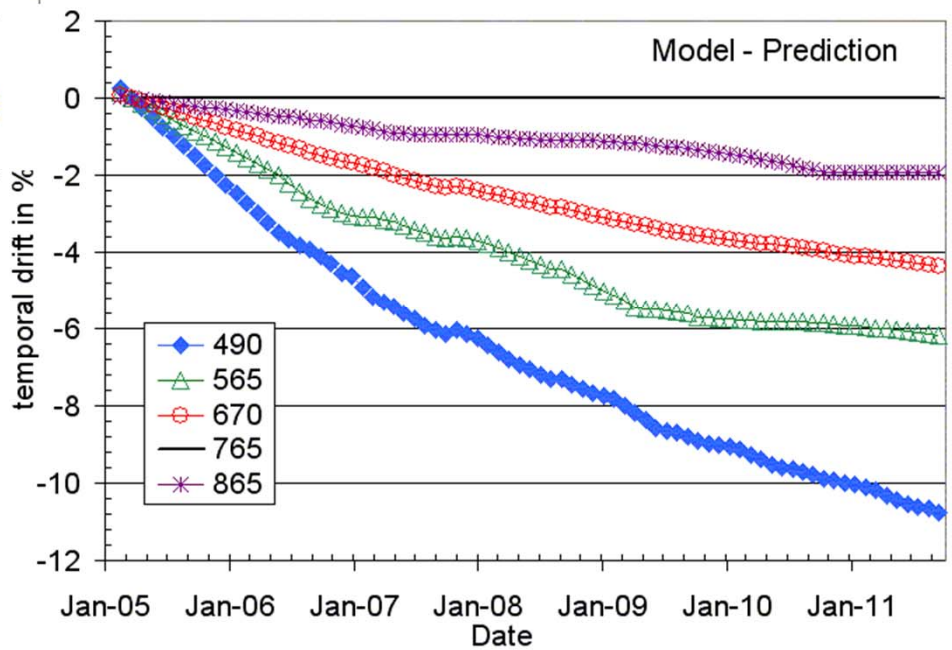
No on-board calibration device

- **End of life of PARASOL scheduled in Sept. 2013**
  - **Complete reprocessing of the full archive (2005 → 2013)**
  - **Level 1 and level 2**
  - **Great interest for an 'a posteriori' recalibration**

PARASOL operational calibration monitoring over DCC



Monthly average of DCC calibration results



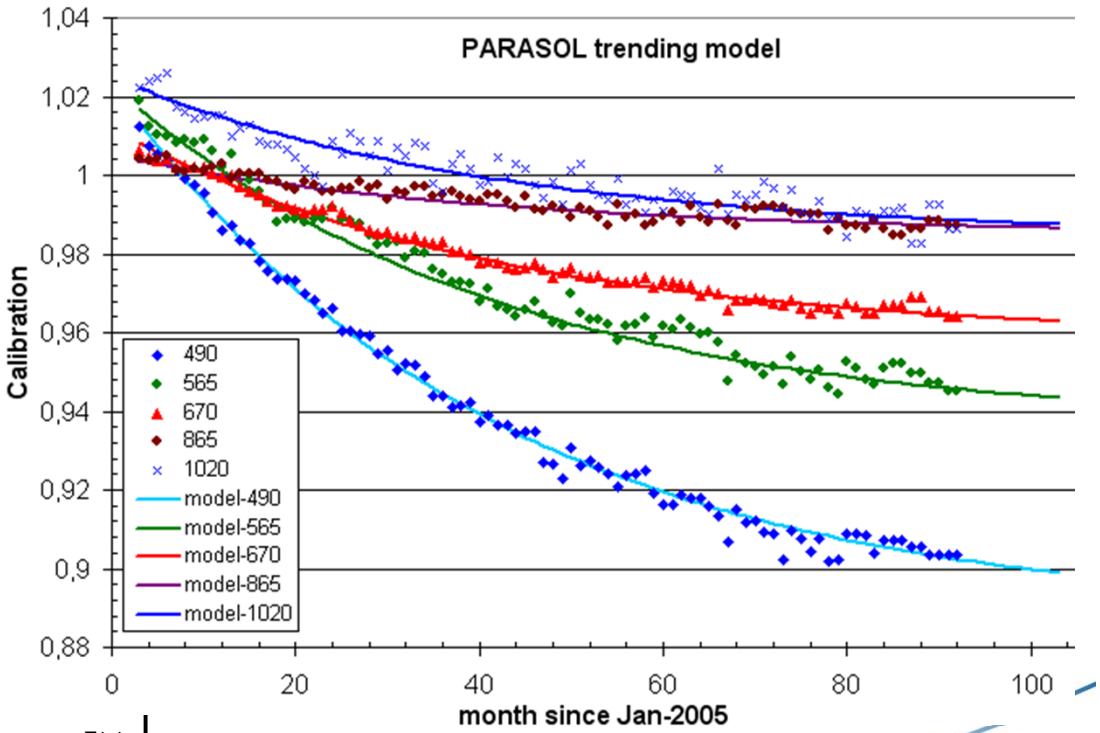
Calibration coefficients delivered every month (extrapolated linear fit)

A ‘post mortem’ physical calibration model

- **A simple physical model (simplified Barnes model…)**
  - **Time constant: D_k (ageing contributor)**
  - **Amplitude: B_k**

$$A_k(t) = A_k(t_o).\left[1 - B_k.(1 - \exp(-D_k.[t - t_o])\right]$$

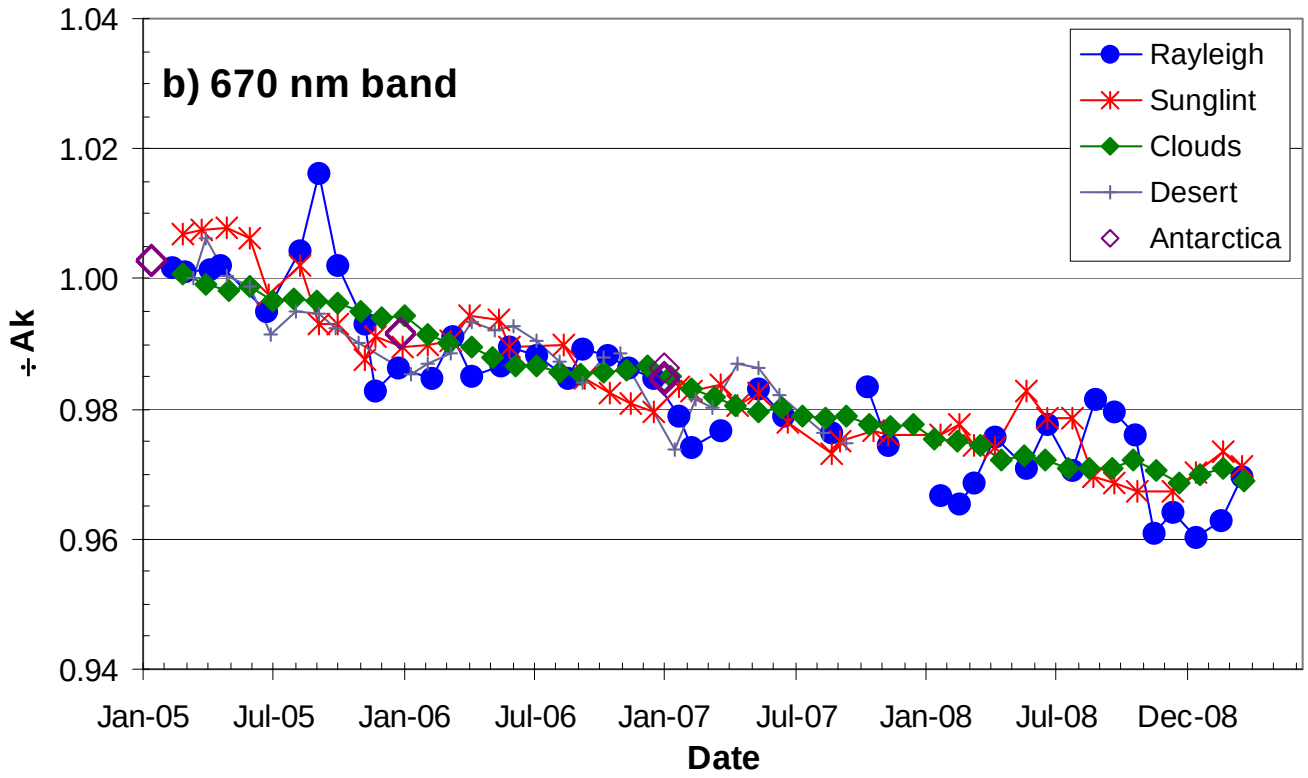
- **D_k identical for all bands**
  - **Single camera**
  - **D = 0.000787 day^{-1}**
  - **B_k ajusted for each band**



- **Model extended to relative calibration coefficients**

$$g_{lpk}(t) = g_{lpk}(t_0)\left[1 - \beta_{lpk}.(1 - \exp(-D.[t - t_0]))\right]$$

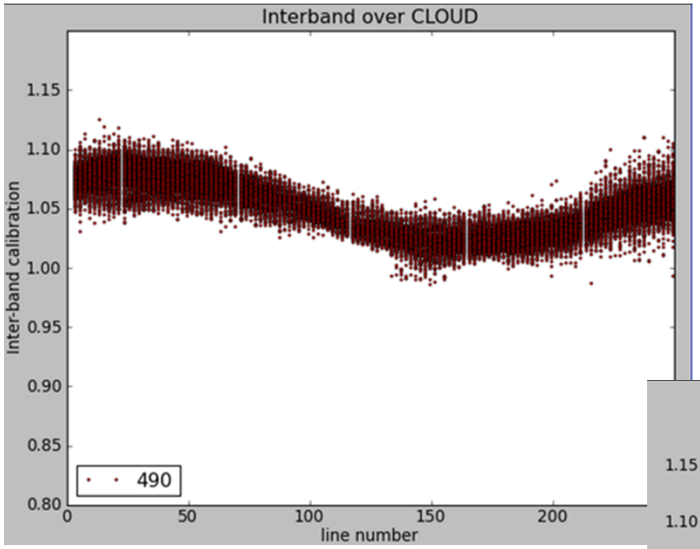
PARASOL - Validation of trending using various methods



Relative calibration correction

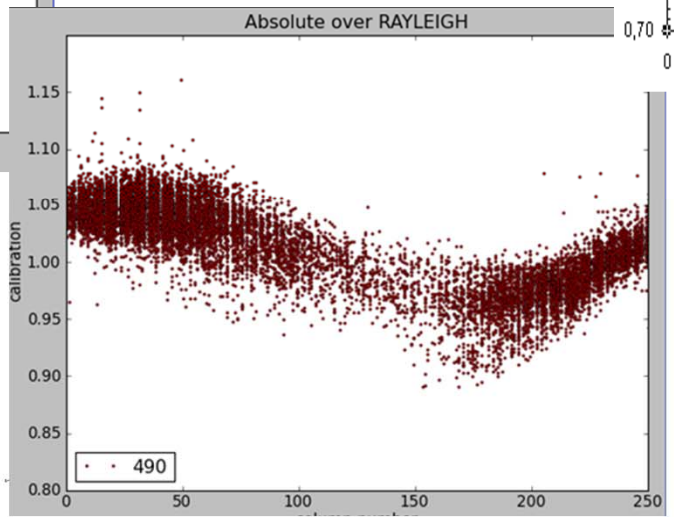
- **Relative calibration in the field of view**
  - » **Combination of different calibration methods**

Clouds
Interband calibration

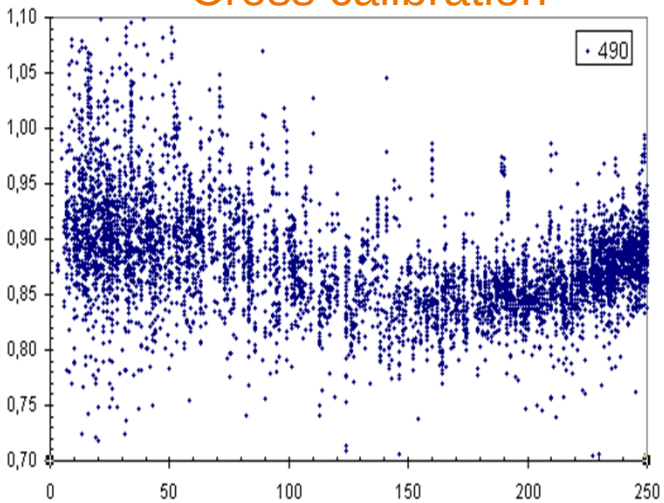


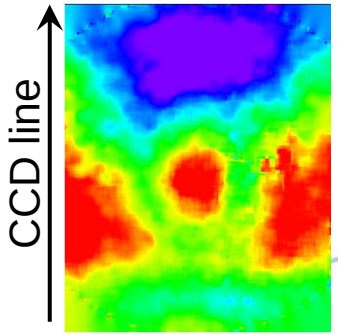
490nm calibration as a function of the CCD matrix line

Rayleigh
Absolute calibration



Desert
Cross calibration

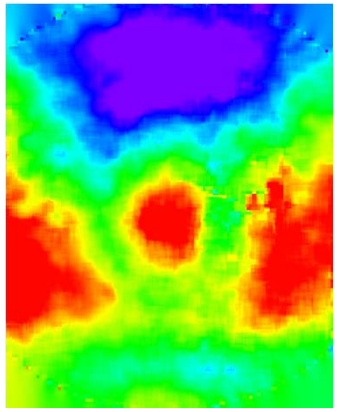




2D visualization of relative calibration discrepancies

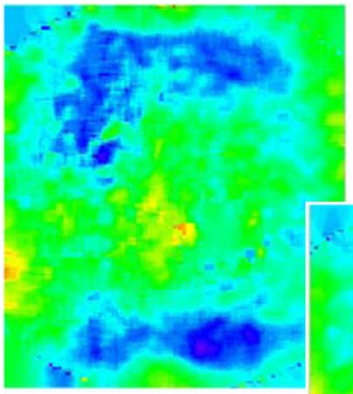
Variable ageing in the field of view

- Continuous drift
- Detected with different methods (DCC, deserts, Rayleigh)
- Not yet corrected in level 1 product
- Easy to identify, but more difficult to correct
  → fine estimation and modeling

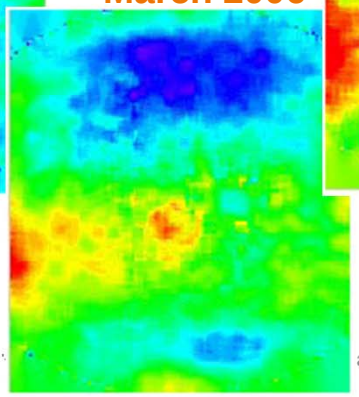


March 2011

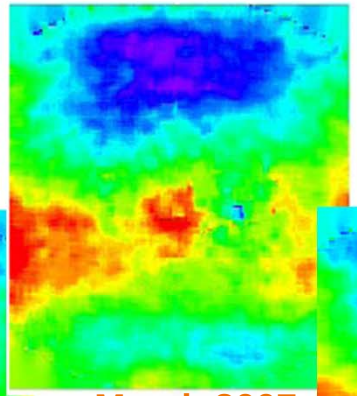
490nm band



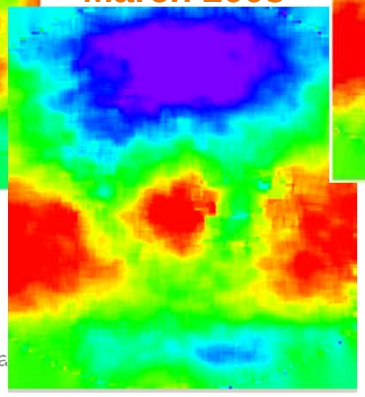
March 2005



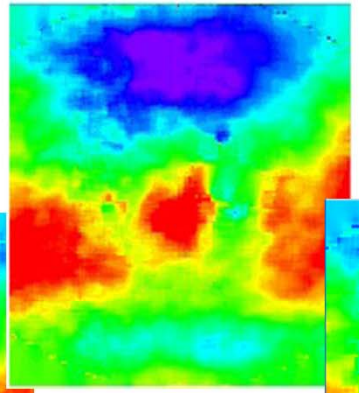
March 2006



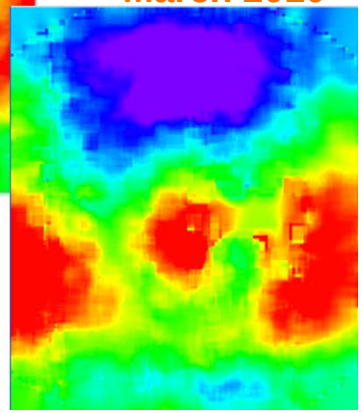
March 2007



March 2008



March 2009

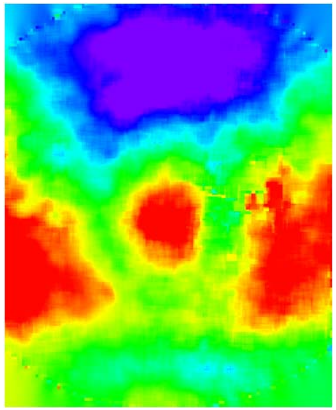


March 2010

Relative calibration for the different bands

Spectral behaviour of the variable 2D ageing

- DCC calibration: averaging 3 month in 2009



490 nm March 2011