CENTRE NATIONAL D'ÉTUDES SPATIALES

Comments

on Level-1 Requirements

IOCCG Working Group on Level-1 Requirements
Meeting 1 – 20th-21st April 2010

Introduction

History

French paradox =

- **No OC mission planned at CNES (last “one” : POLDER-2)**
- **But… several phase 0 studies these last years :**
  - **GMES-O3 (2005), Mission Couleur de l’eau (2006-2007), TradeOff LEO/GEO (2007-2008), OCAPI (2009-2010)**
- **…and several R&D studies about :**
  - **Atmospheric correction, OC product : sensitivity study, Geostationary aspects**

- **Feedback about :**
  - **SNR required, effective, and optimized… , definition ?**
  - **spatial resolution for NIR bands**
  - **Calibration accuracy**
  - **Polarization and straylight : avoid correction …**
  - **Spectral knowledge of the instrumental response : one crucial key**
    - Initial knowledge, variation inside the FOV, evolution with time…
  - **Sunglint contamination**

SNR definition

- **Atmospheric correction :**
  - **Historically : marine reflectance = 10% from TOA reflectance**
    - 5% required on Rw = 0.5% required on Rtoa
    - 200 SNR required on Rw = 2000 SNR required on Rtoa
  - **Statement :**
    - As if we are able to assess SNR=2000 on Rtoa (…?), it seems today unrealistic to claim SNR=200 on Rw
    - Atmospheric corrections propagate noise from NIR bands through OC bands
    - Caveat : are level-1 over-dimensioned in term of SNR ?
  - **Ideally, the transfer function SNR(Rw) to SNR(toa) depends on the AC algorithm**
  - **For classical AC algorithms (= use of NIR bands to estimate the aerosol load)**
    - 1000 seems sufficient in shorter wavelengths (NIR bands)
    - 1000 seems to be a goal for longer wavelengths (OC bands)
  - **For spectral AC algorithms (= use of spectral shape)**
    - less sensitivity to noise ratio
    - again 1000 seems sufficient
  - **Finally, the required SNR is strongly linked to :**
    - the atmospheric correction algorithm principle
    - the number of spectral bands that will be used

SNR definition

- **Caveat : are level-1 over-dimensioned in term of SNR ?**

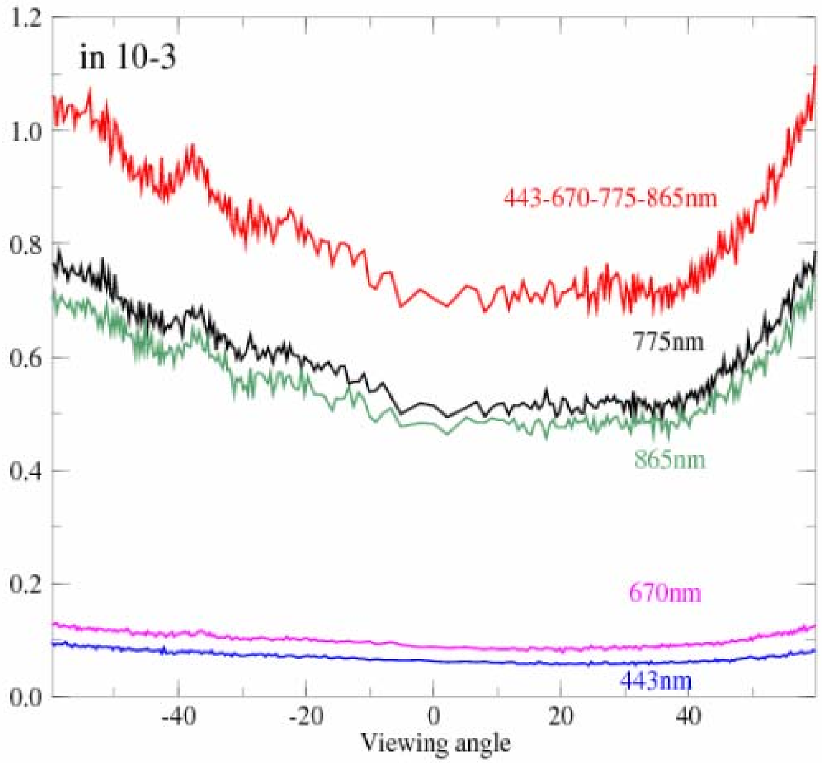


Figure 2.a. Standard deviation on marine reflectance in 10-3 retrieved at 443nm

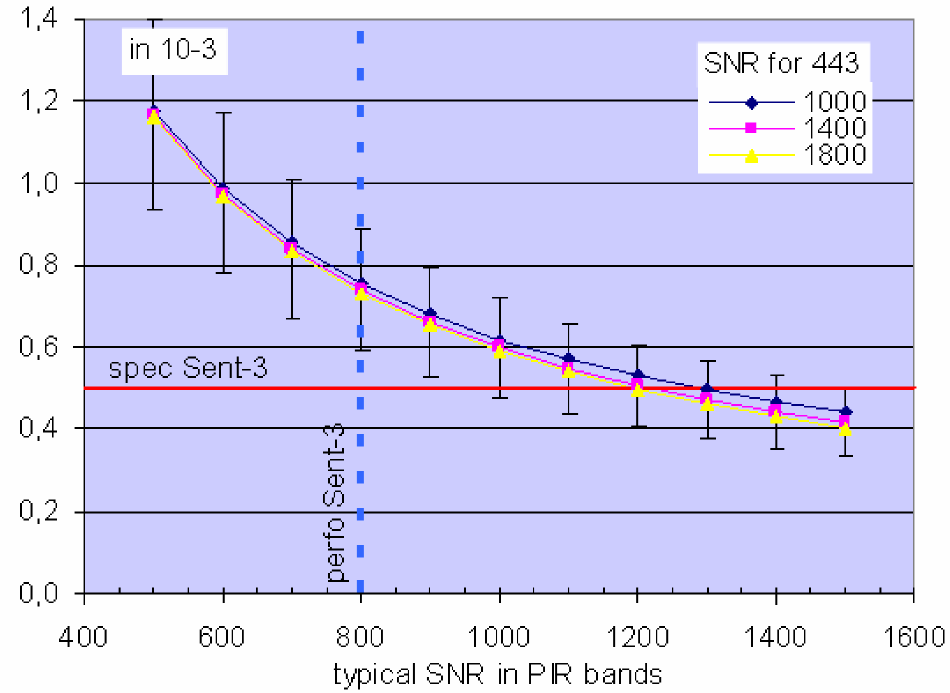


Figure 4. Noise retrieved on the marine reflectance at 443nm (in 10-3) for typical values of SNR in PIR bands and 3 different values of SNR at 443.

Ref : How the ocean color product quality is limited by atmospheric correction, Jolivet et al., Envisat Meeting, 2007

SNR definition

- **Caveat : are level-1 over-dimensioned in term of SNR ?**

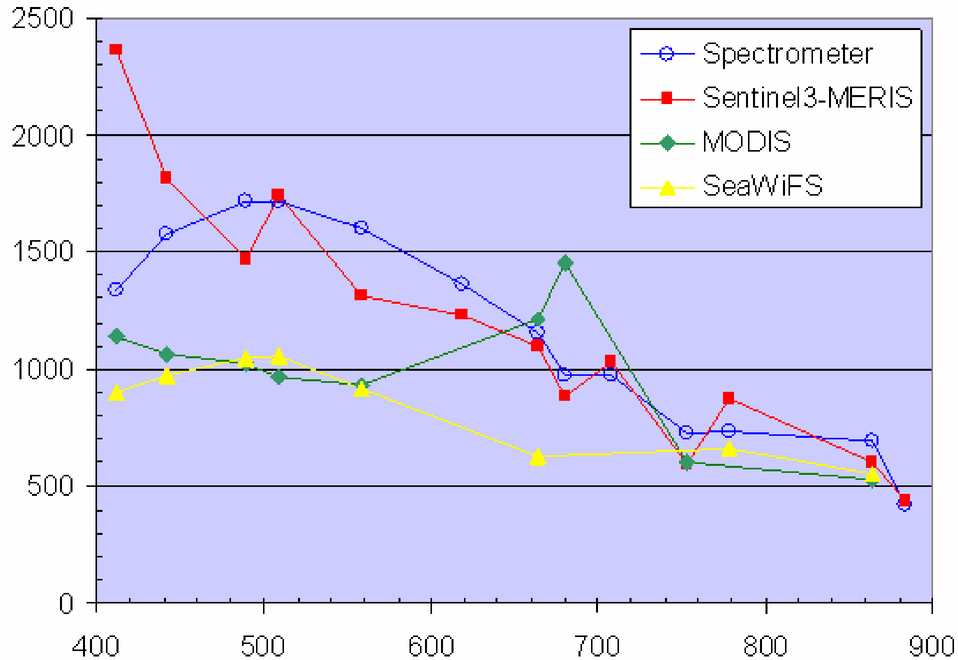


Figure 1. Signal-to-noise ratios for Sentinel-3/MERIS, a spectrometer in development, MODIS and SeaWiFS. SNR are given for the same resolution and converted for the same top-of-atmosphere radiance.

SNR definition

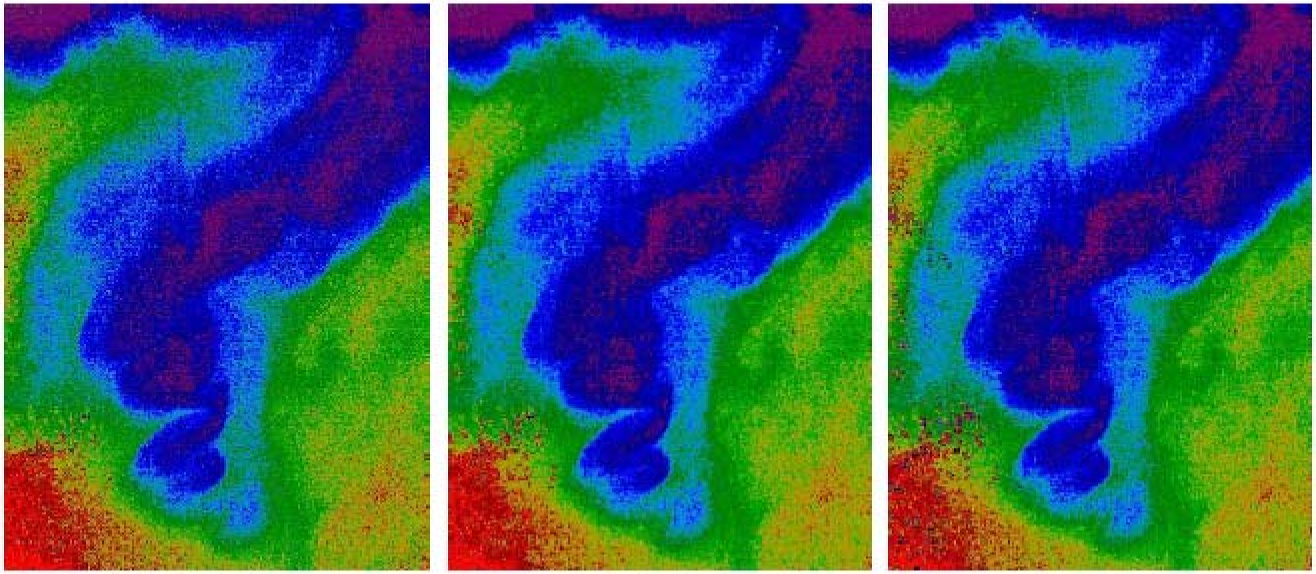
- What's the definition of the SNR ?
- For a bidimensional flat target, SNR must be defined by the ratio radiance / rms over this target
- A "system" SNR must be considered

  this is the noise that users really observe on their data
- For a given flat target, this "system" SNR includes
  - fluctuation of the signal : mainly considered on instrumental budgets
  - accuracy of the interpixel calibration : a 0.1% goal is already very accurate
  - more generally, the contribution of the radiometric model (i.e. non-linearity, dark current…)
  - possible contribution from : straylight, polarization, spectral rejection…
  - contribution from resampling of data on the final user geo-referenced grid
- Does it mean that, by construction, a SNR cannot be realistically

  greater than 1000 ???

NIR band spatial resolution

- **Goal : how to reach high SNR for NIR bands**
  - **Which spatial resolution is required for NIR bands ?**
  - **R&D analysis using Aeronet data, computed data, MERIS data**
- **Aerosol signal = fine mode + coarse mode**
  - **Dependence with atmospheric correction algorithms + number of spectral bands + associated SNR**
  - **As a first result, it seems that we :**
    - Need to keep a Full Resolution information for aerosol content (optical thickness)
    - Reduce spatial resolution for “angstrom coefficient” (spectral behavior)



1x1x1 pixel 1x1x2 pixels 1x2x2 pixels

Calibration accuracy

- **Historically : marine reflectance = 10% from TOA reflectance**
  - 5% required on Rw = 0.5% required on Rtoa
- **Various aspects of the calibration :**
  - Absolute calibration
  - Interband calibration
  - Multitemporal calibration
- **The on-board cals usually address multitemporal and interband aspects**
- **The absolute aspect is always "controlled" by vicarious cal using in-situ datasets**
- **Compensation of calibration errors through the atmospheric correction**
  - importance of the NIR band calibration
  - interband calibration is most important than absolute calibration for some algorithms

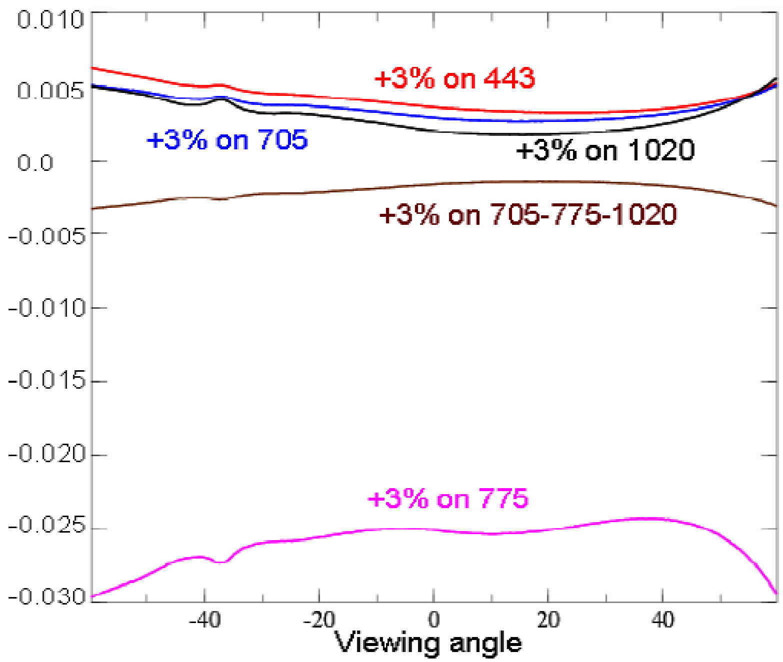


Figure 3. Bias observed on marine reflectance at 443nm when a 3% bias error is introduced separately on each spectral band or for all the NIR bands. Conditions are the same as for Fig.2.a

Miscellaneous

- **Polarization :**
  - **avoid a correction that requires a knowledge of the polarization state of the observed light**
  - **limit the instrumental sensitivity**

- **Spectral knowledge of the instrumental response**
  - **very crucial aspect**
  - **initial knowledge**
  - **variation inside the FoV**
  - **evolution with time**

Study for Alcatel Aliena Space

HYGEOS

Sentinel 3 Swath Extension:
Impact on specifications

Standard, 443nm, Equinox, 30°N	Ref	50°	55°	60°
Radiometric Absolute Calibration	0.23%	0.14%	0.12%	0.11%
Polarization Sensitivity	1.00%	1.00%	1.00%	1.00%
Wavelength Calibration	0.50	0.20	0.17	0.14
SNR visible (250m) (Spec. Improv. factor)	0.60	1.00	1.10	1.20
SNR IR (250m) (709-865)	2.40	3.00	3.30	3.60
Radiometric Interband Calibration (709-865) Radiometric Interband	0.50%	0.25%	0.20%	0.17%

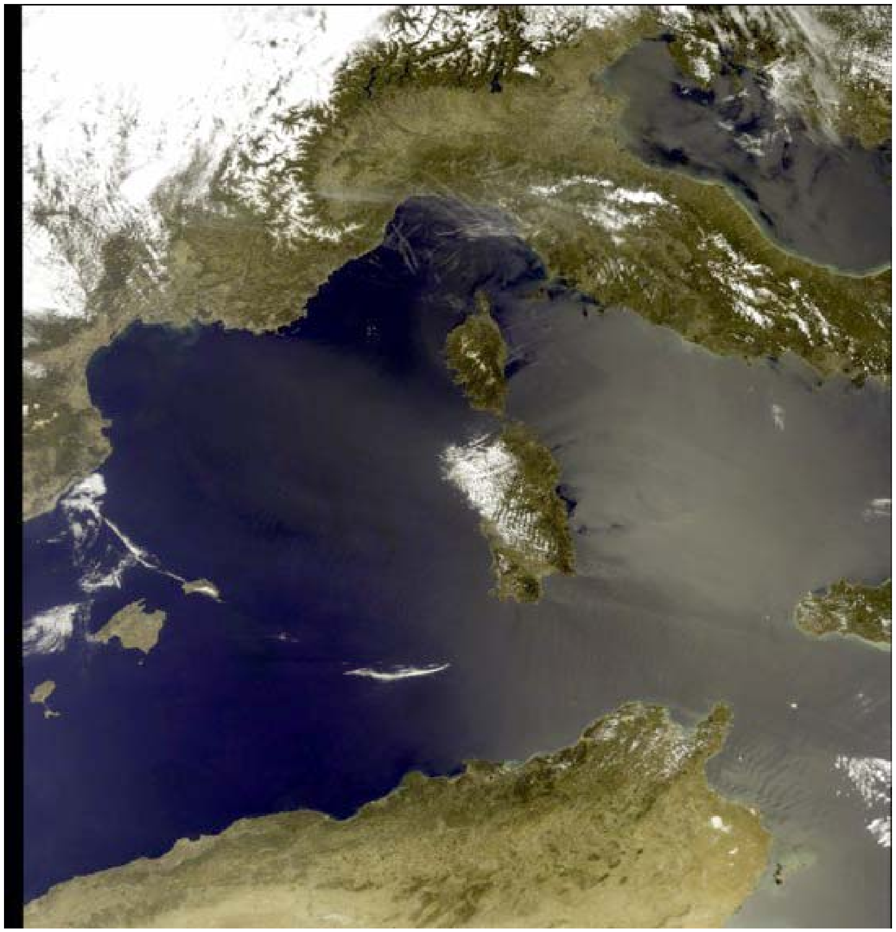
Standard, 443nm, Equinox, 60°N	Ref	50°	55°	60°
Radiometric Absolute calibration	0.18%	0.09%	0.08%	0.07%
Polarization Sensitivity	0.50%	0.38%	0.33%	0.31%
Wavelength Calibration (nm)	0.33	0.14	0.11	0.09
SNR visible (250m) (Spec. Improv. factor)	1.00	1.60	1.80	2.00
SNR IR (250m) (709-865)	4.00	5.40	6.00	7.20
Radiometric Interband Calibration (709-865) Radiometric Interband	0.28%	0.16%	0.13%	0.10%

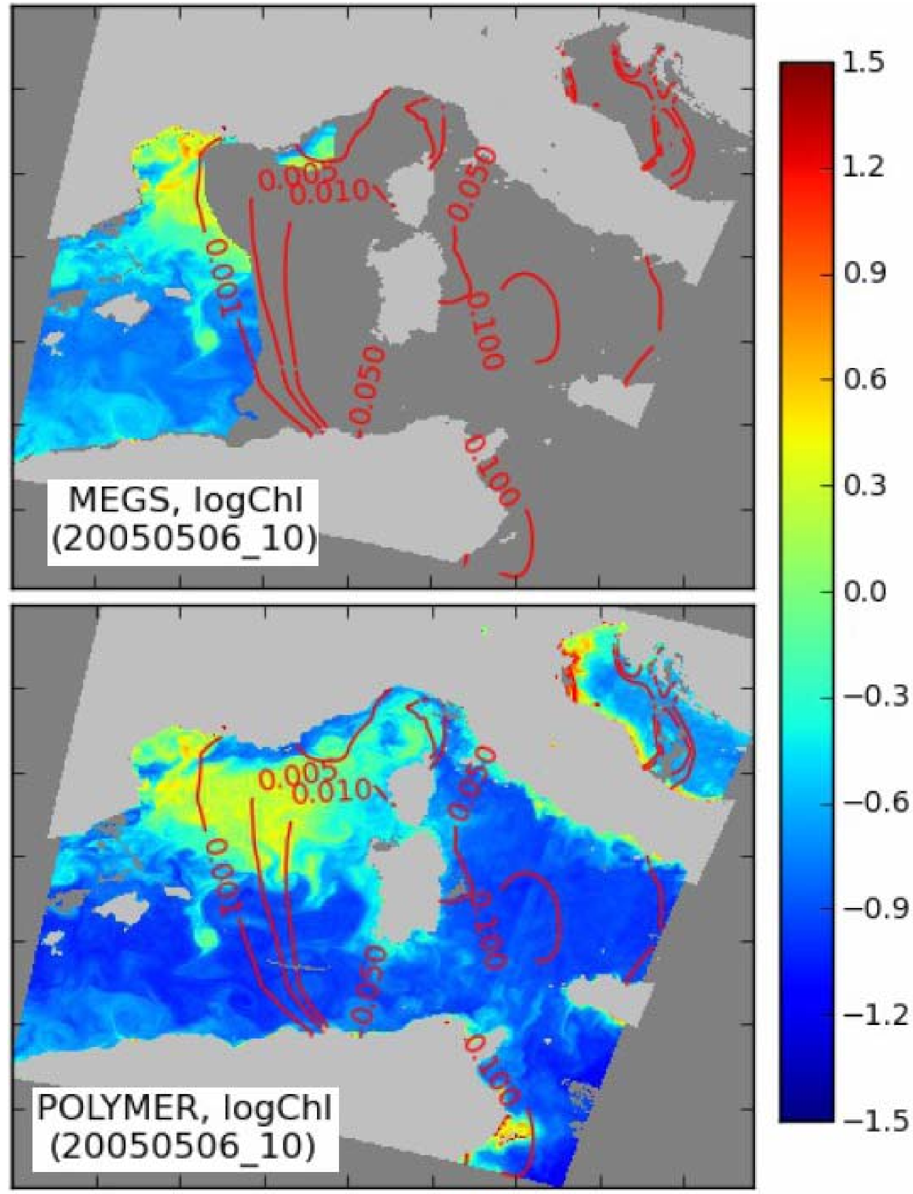
Tableau 7 : Specifications of instrument performances and algorithm accuracies to meet the objective of 5.10^{-4} accuracy on marine reflectance at 443 nm

Sunglint contamination

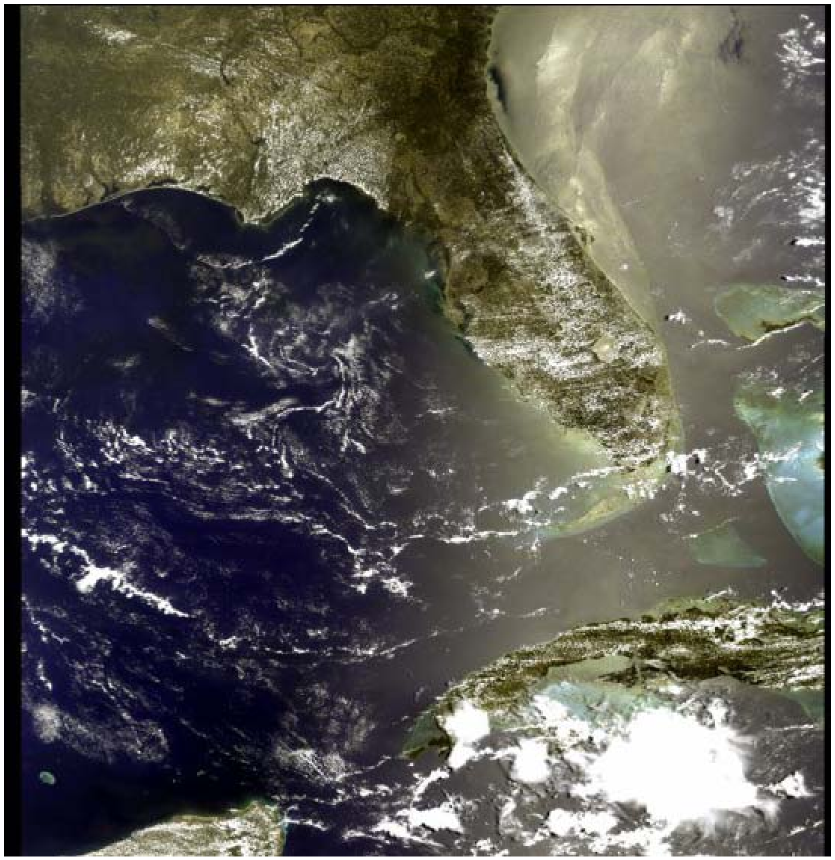
- **Sunglint may strongly affect observations (dep. on latitude and season)**
  - ex: ~50% of a MERIS-like swath may be unusable due to the sunglint perturbation
- **New generation of algorithms, still in development... Examples :**
  - OCEAN (Gross-Colzy et al.) based on ACP
  - POLYMER (Deschamps et al.) based on spectral decomposition
  - Others…
- **Results :**
  - Full correction for Chl-a
  - Nearly full correction for Rw
- **For the same level-1 quality, level-2 are strongly improved**
- **Other strong potentialities for :**
  - semi-transparent clouds
  - environmental effect around clouds
  - aerosol perturbed observations
- **Impact on the space system :**
  - Revisit requirements : % of “clean” data
  - N/S shift of the line of sight

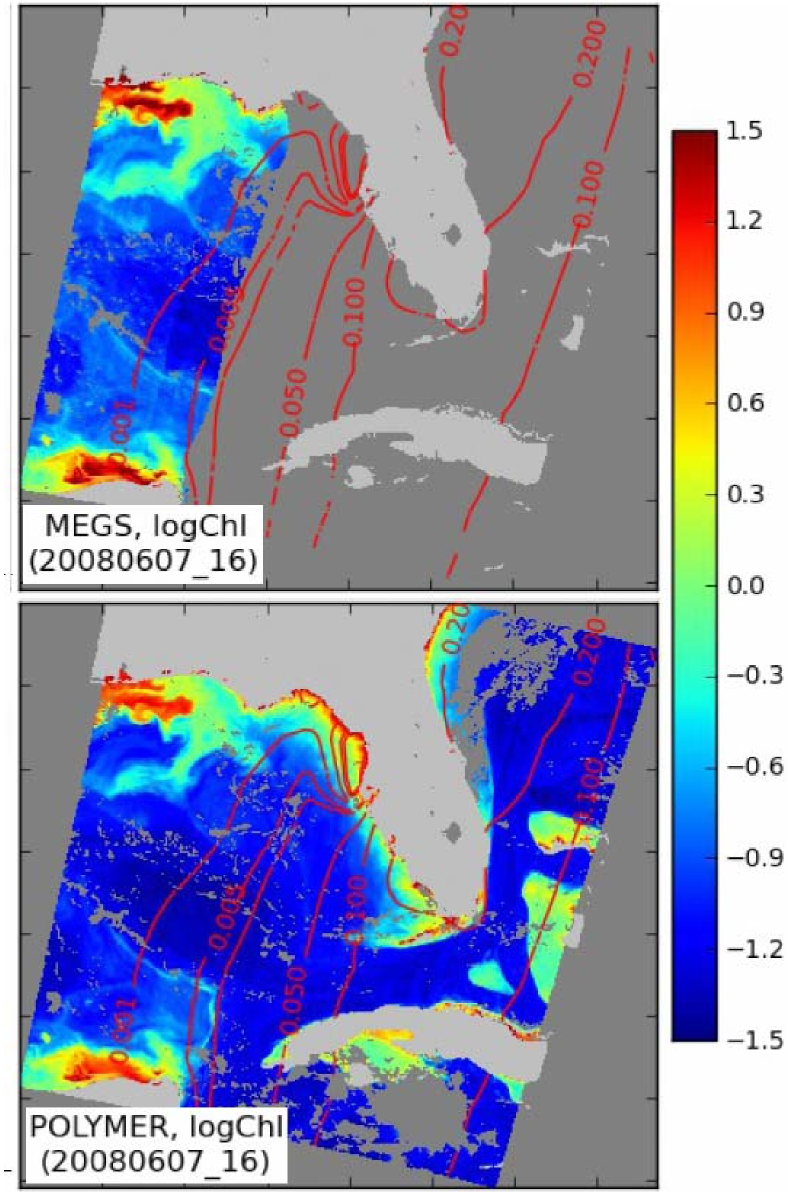
Sunglint contamination





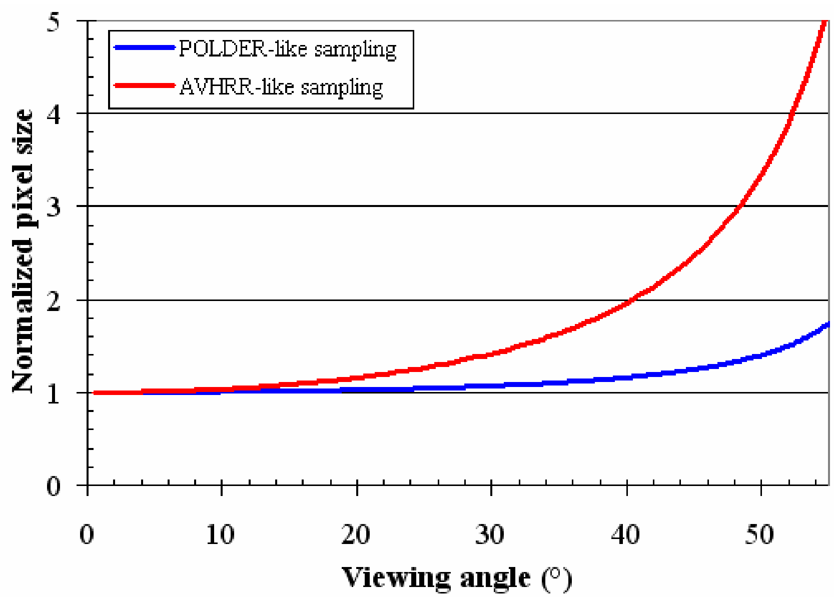
Sunglint contamination





About the spatial resolution

- **How to properly define the spatial resolution of a space system**
  - Usual definition : the nadir projection of a pixel
  - The projected pixel size may vary strongly depending on the concept
  - A more appropriate definition : to consider the resolution of the user's geo-referenced grid (= required resolution of the final product)
  - Recommendation : adopt this "user need value" as a mean pixel resolution (not nadir)



That's all folks !!!