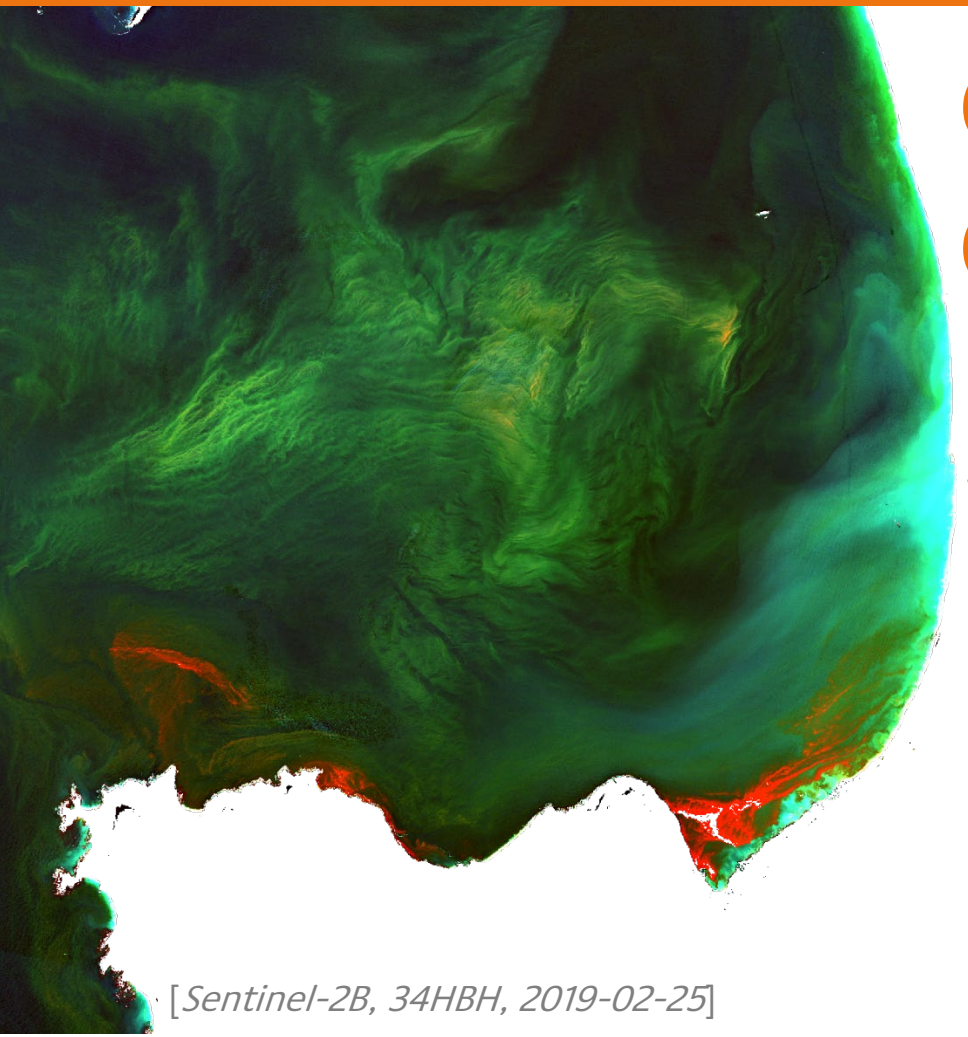


[*Sentinel-2B, 34HBH, 2019-02-25*]

GRS processor: Glint Removal for Sentinel-2

Scheme and implementation

Tristan Harmel, GET, tristan.harmel@get.omp.eu
Jean-Michel Martinez, GET, IRD
Guillaume Morin, Nathalie Reynaud, INRAE, ECLA
Thierry Tormos, OFB, ECLA

Atmospheric correction: a necessary step for aquatic remote sensing

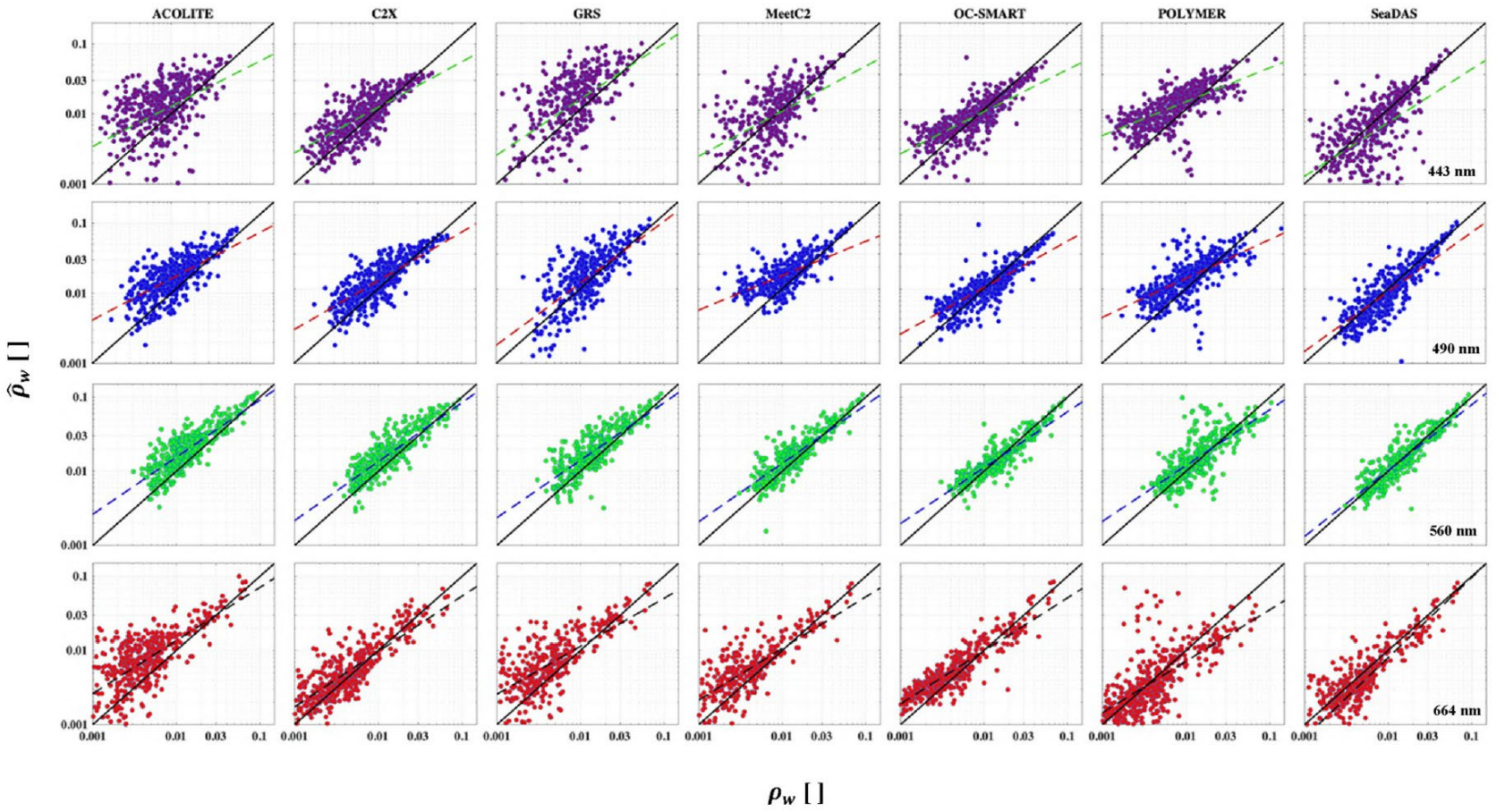
Several algorithms dedicated to water targets:

ACOLITE, C2X, GRS, iCOR, MeetC2, OC-SMART, POLYMER, SeaDAS...

were recently evaluated (ACIX-II, ESA/NASA, Pahlevan et al., RSE, 2021)

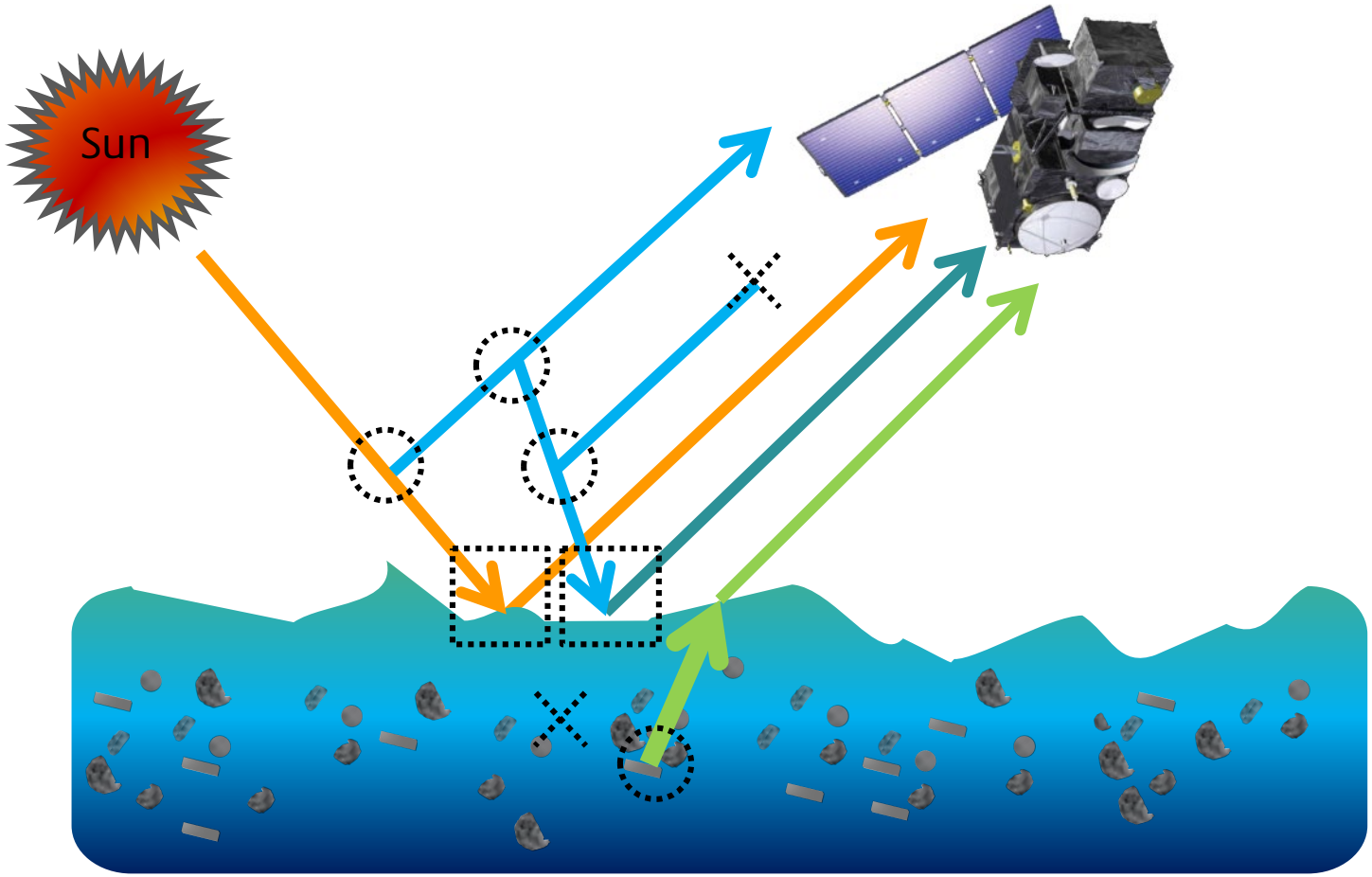
...

But “sunglinted” pixels were removed from evaluation



Background

Simplified picture of the TOA signal over aquatic scene



: Absorption

: Scattering

: Fresnel reflection

Diffuse light:
skylight,
reflected skylight
water-leaving radiance

Direct light:
sunglint

Background

Simplified picture of the TOA signal over aquatic scene

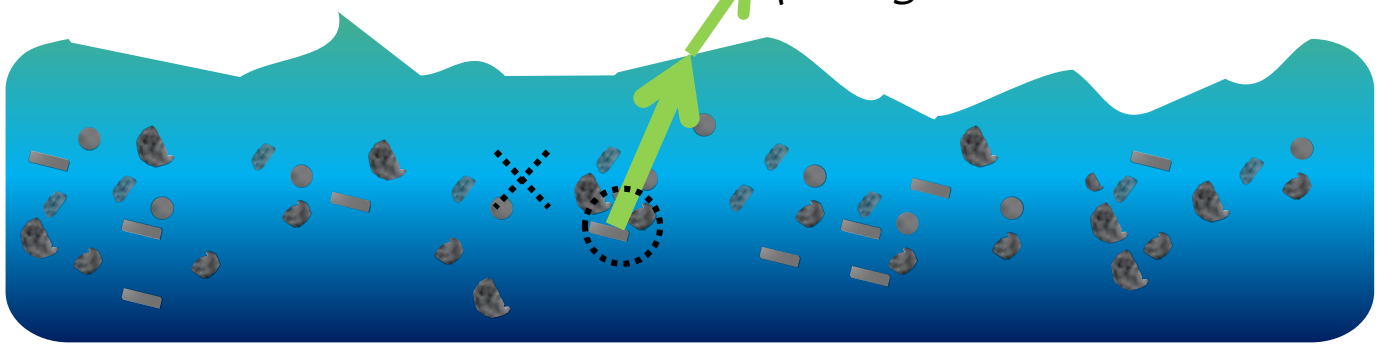
Sun

: Absorption

: Scattering

: Fresnel reflection

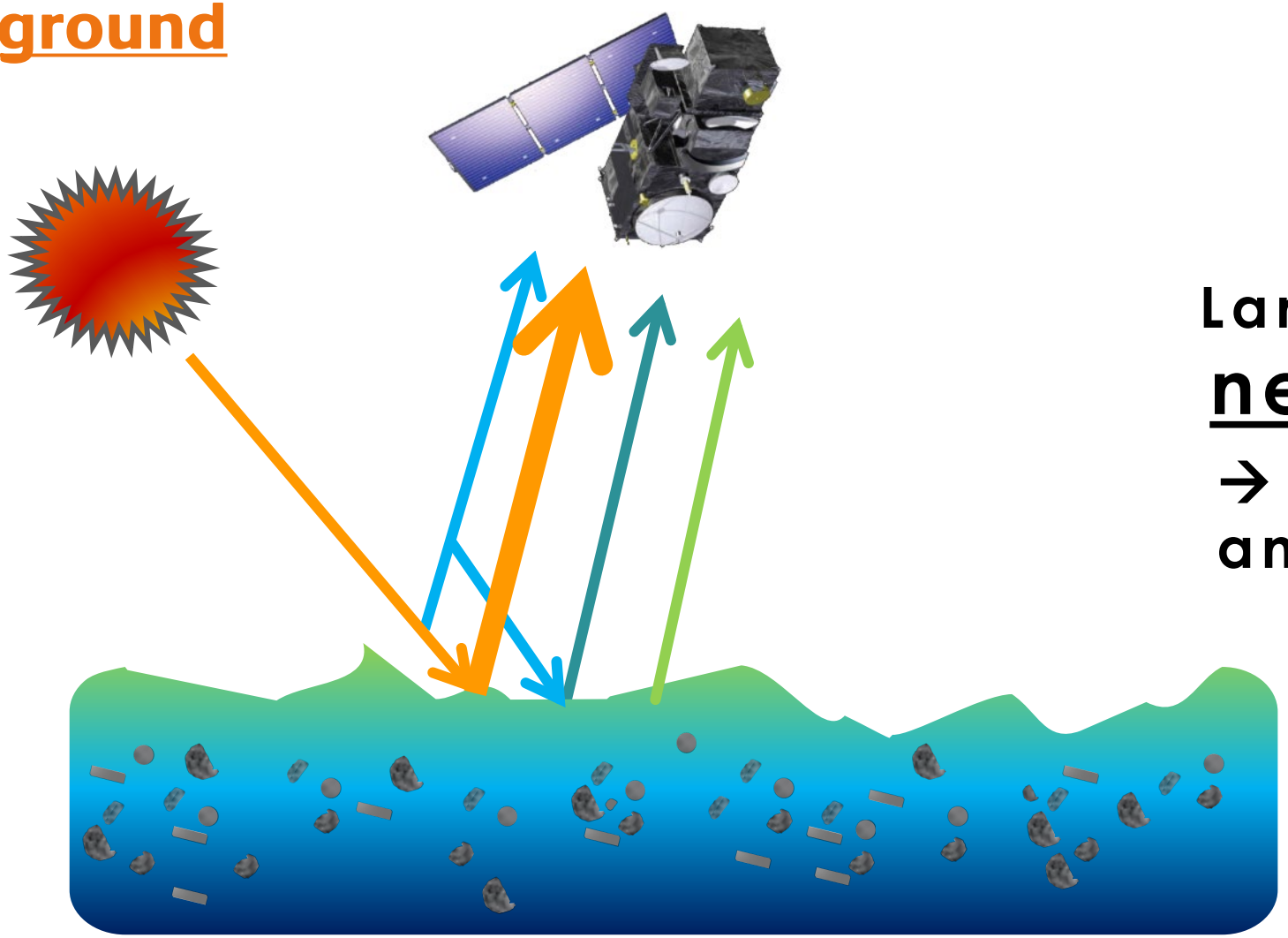
L_w *(sought-after information)*



Diffuse light:
skylight,
reflected skylight
water-leaving radiance

Direct light:
sunglint

Background



Landsat / Sentinel-2:

near-nadir view

→ Increased probability and intensity of sunglint

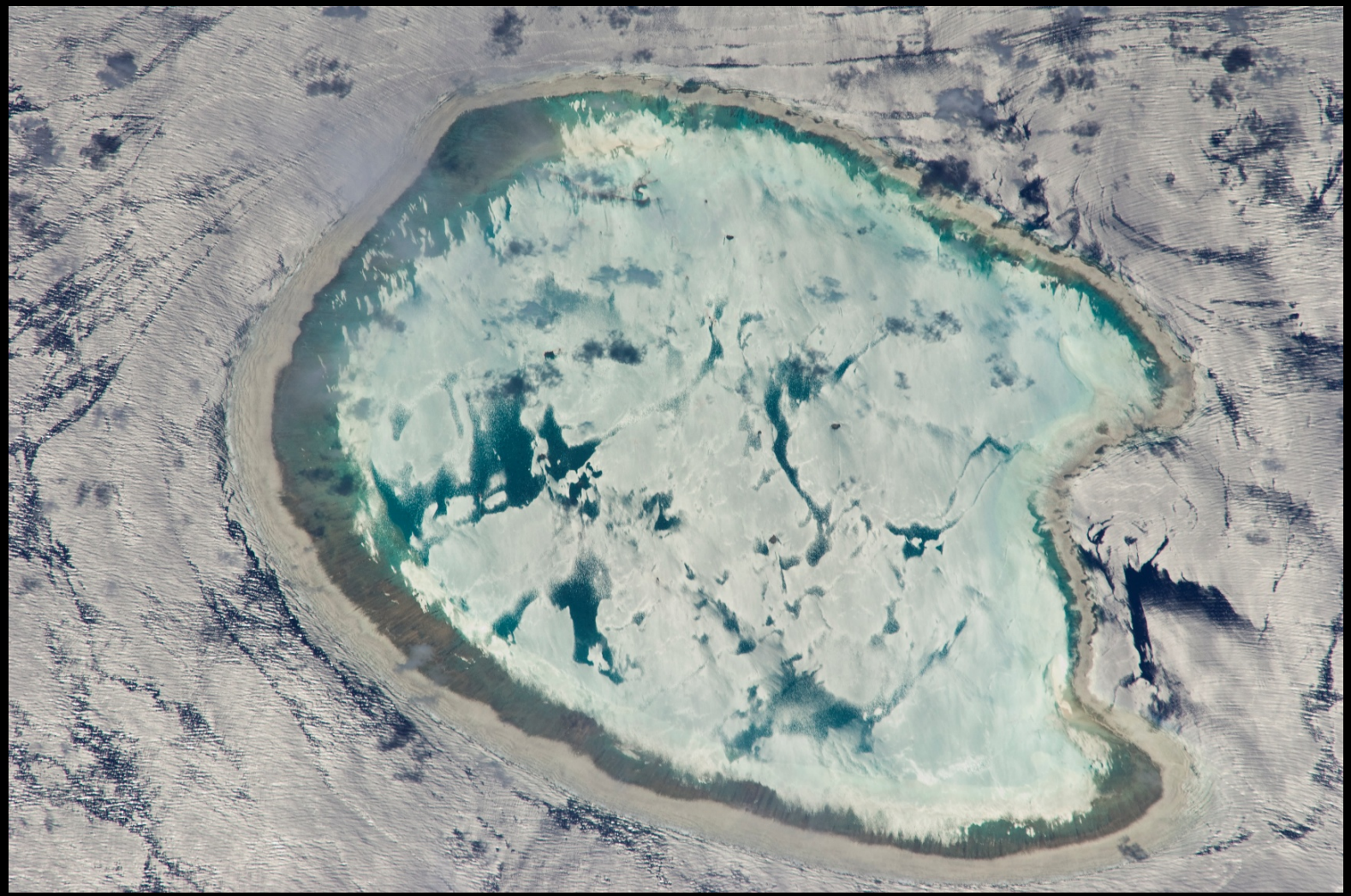
near-nadir view

→ Increased probability and intensity of *sunglint*

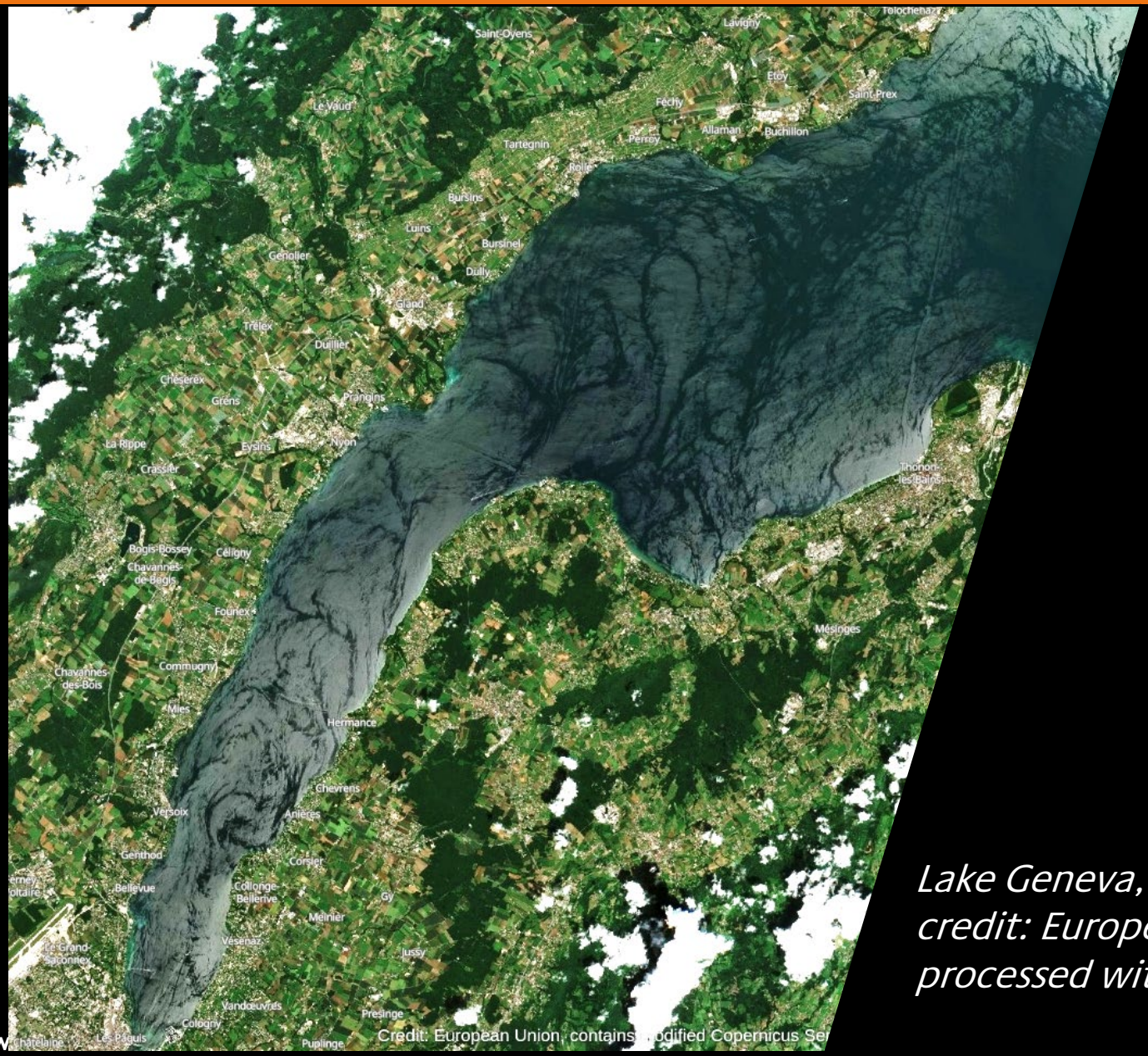
VendéeGlobe from airborne regular camera

near-nadir view

→ Increased probability and intensity of *sunglint*



Atoll from nadir-viewing sensor on ISS



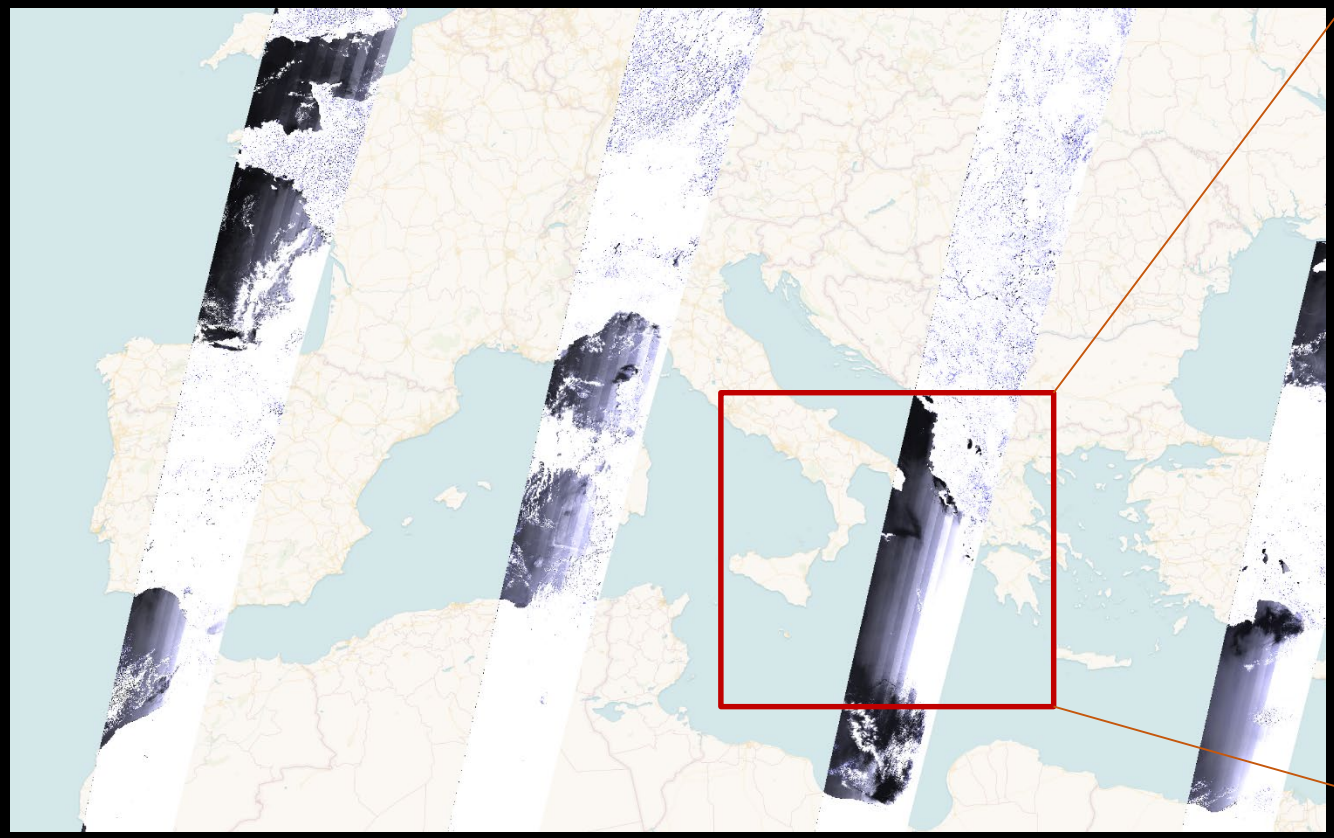
near-nadir view

→ Increased probability and intensity of *sunglint*

Lake Geneva, 2021-06-21, Sentinel-2, credit: European Union, Copernicus, processed with EO-Browser

Sentinel-2 imagery (pixel ~10 m, operating since 2015)

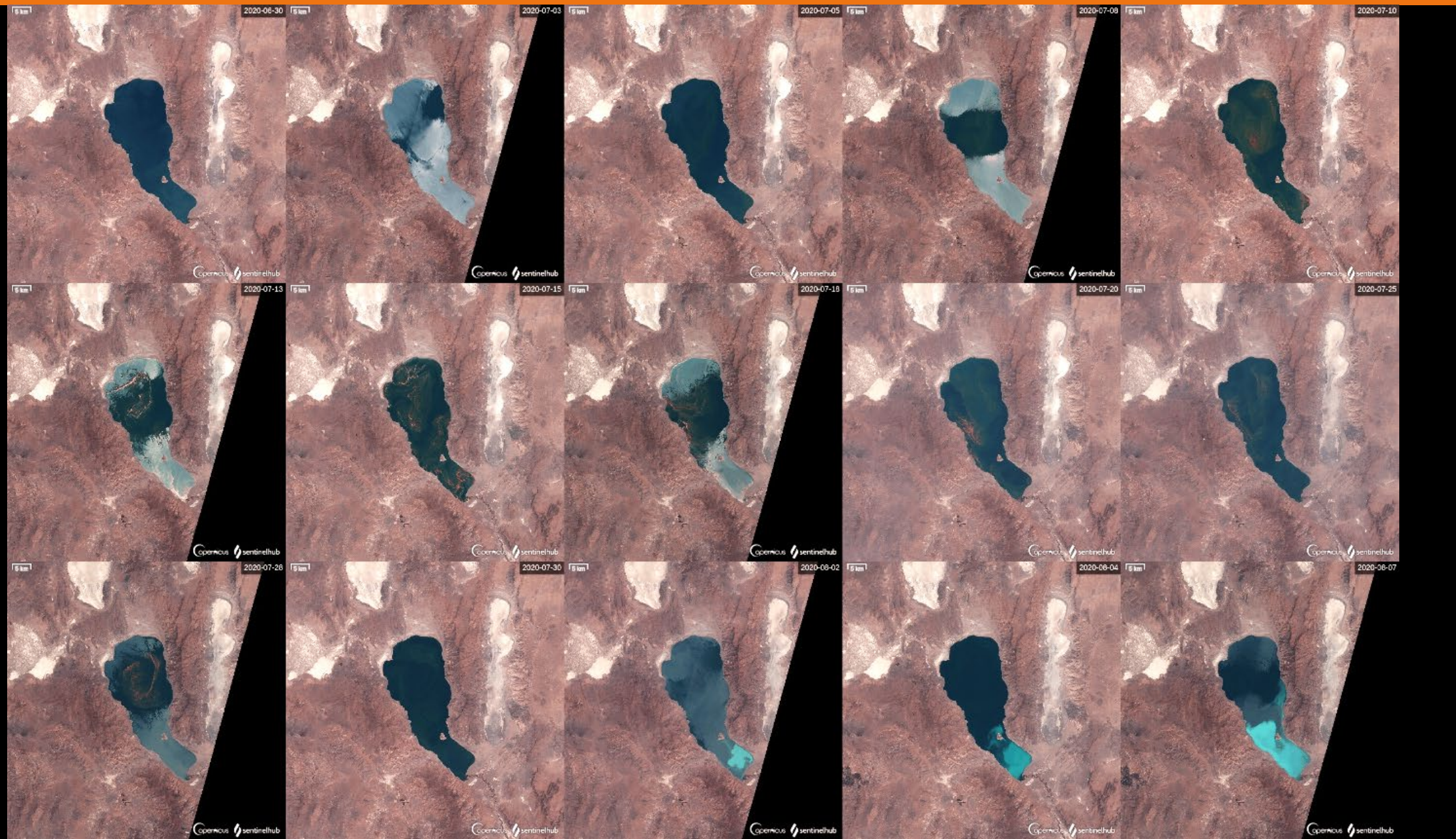
The whiter, the more sunglint



Sentinel-2, 2019-06-21
credit: European Union, Copernicus

LES UTILISATIONS DE LA TÉLÉDÉTECTION POUR LA QUALITÉ DES EAUX CONTINENTALES ET AUX INTERFACES

Pyramid Lake
(Nevada, USA)
Summer, 2020



Sunglint: not only a noise… but provides insights on water surface

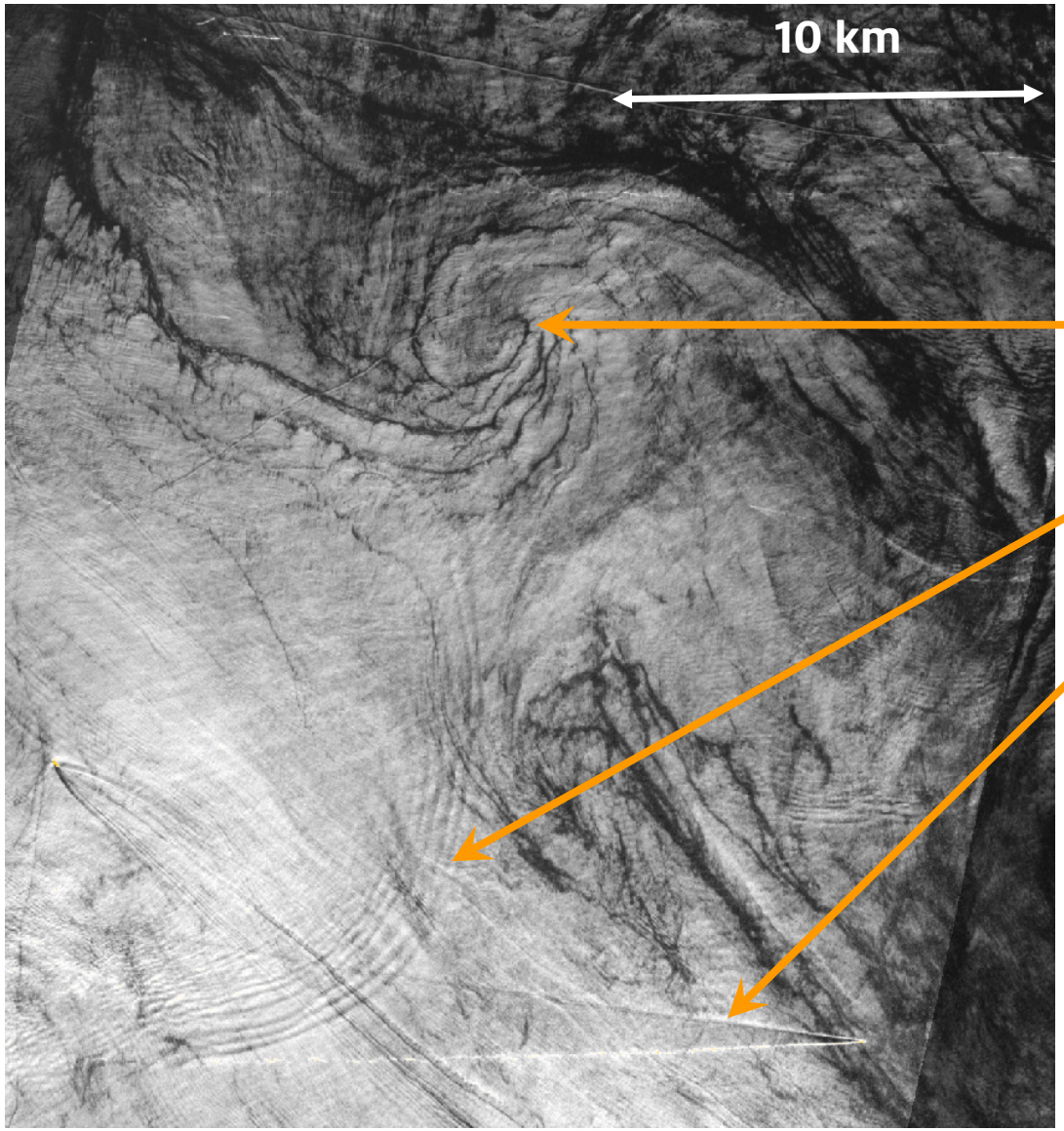


Image Sentinel-2, SWIR-band (~2200nm)

Patterns:

Eddy with surfactant (biological or oil spill…)

Wave packet (internal waves)

Ship wake

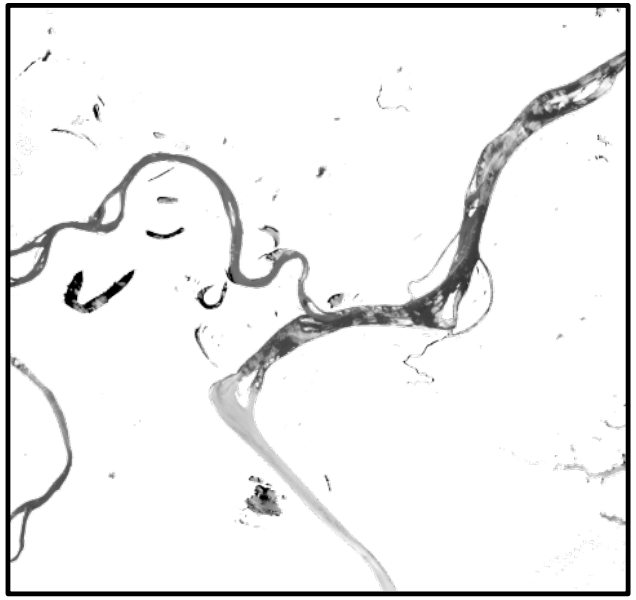
…

Atmospheric correction: Glint Removal for Sentinel-2-like imagery

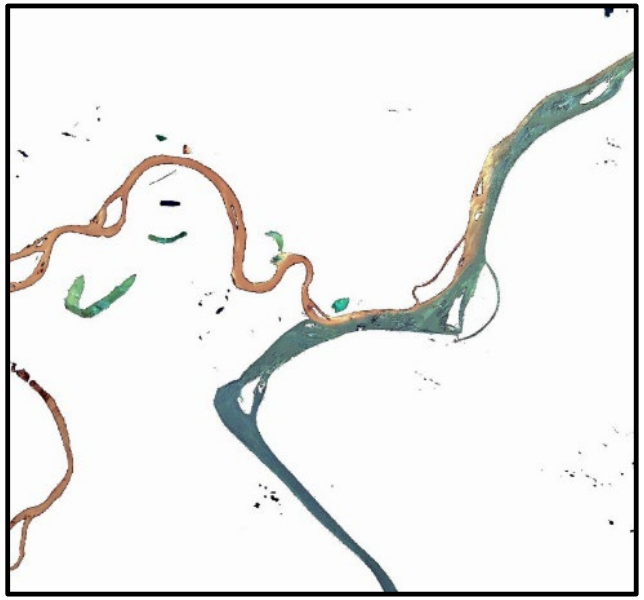
Image L1

GRS

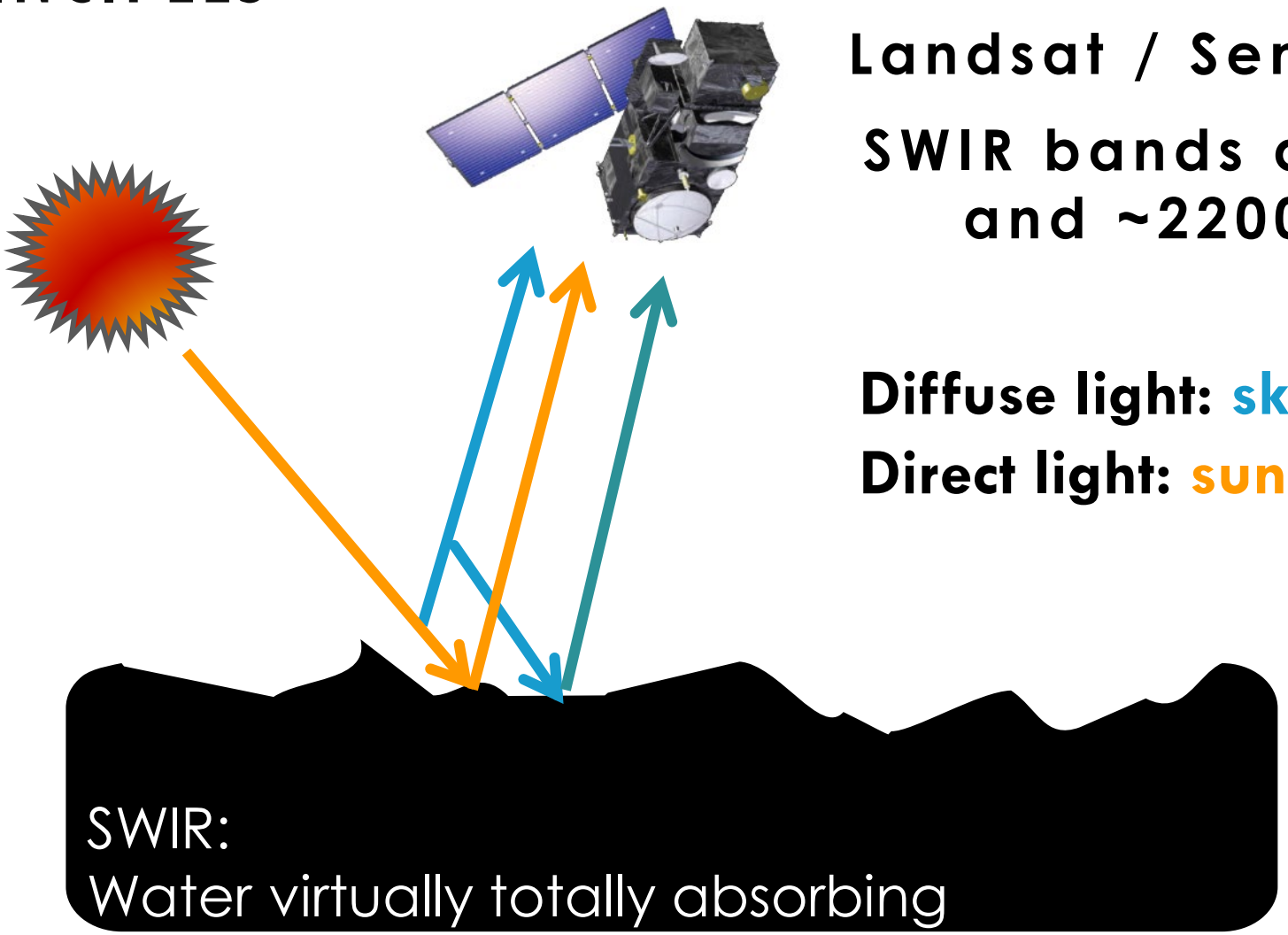
Water surface radiance



Water-leaving radiance



PRINCIPLES



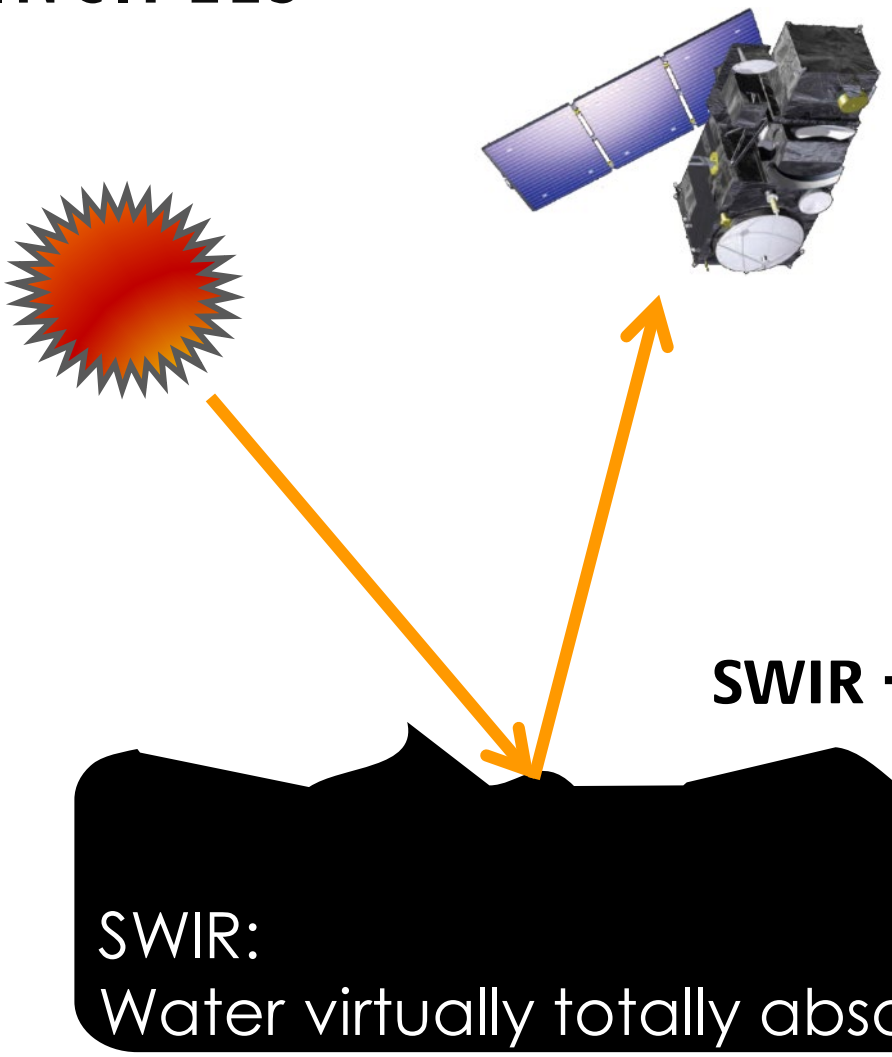
Landsat / Sentinel-2:

SWIR bands at ~1600 and ~2200 nm

Diffuse light: skylight, reflected skylight

Direct light: sunglint

PRINCIPLES



If aerosol known

+

dedicated radiative transfer code

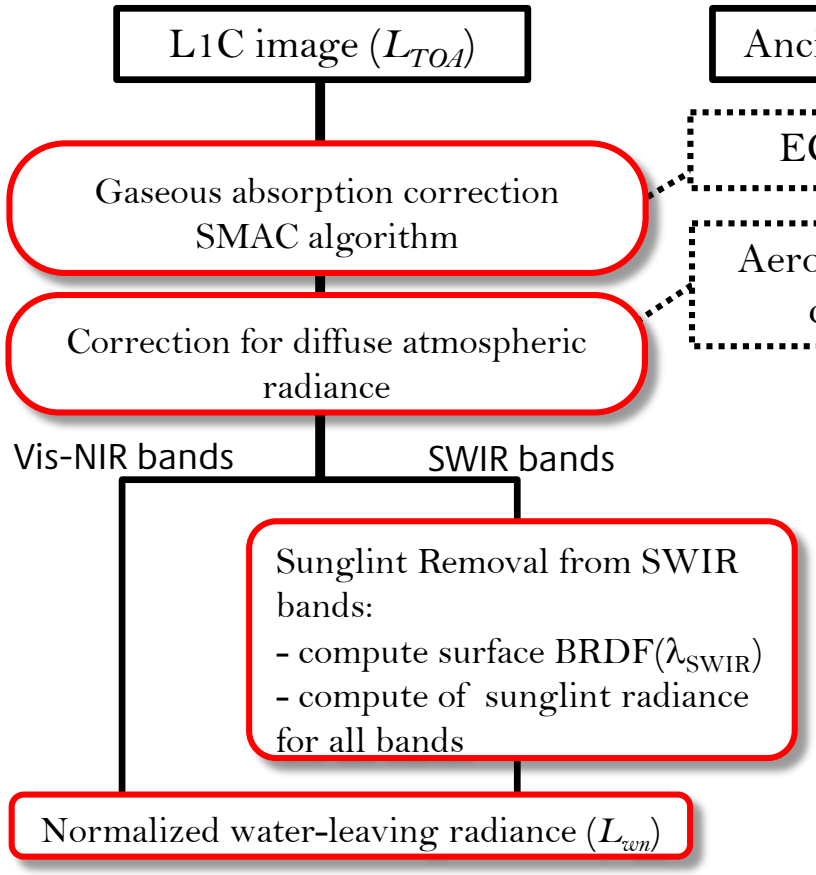
=

Radiance for skylight and skylight reflection

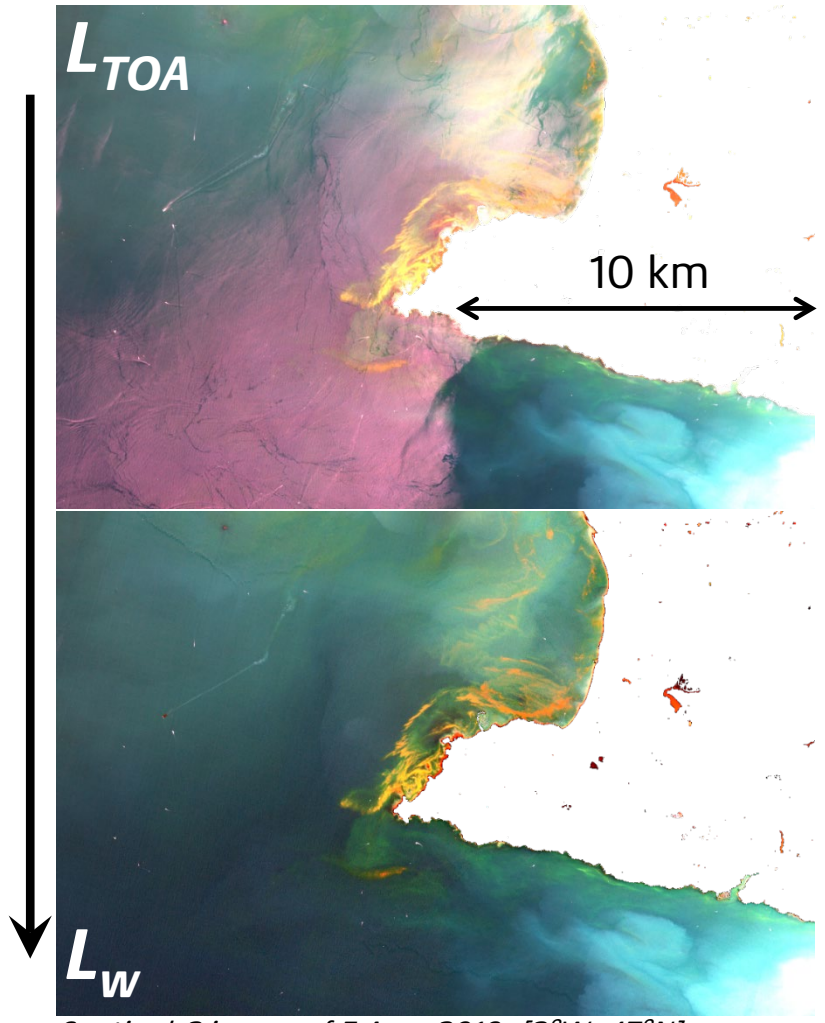
SWIR → sunglint (direct light) → BRDF of water surface

GRS Algorithm (Glint Removal for Sentinel-2-like data) *[Harmel et al., RSE, 2018]*

GRS: coded in python and FORTRAN, main lib: snappy (ESA)
Can process: Sentinel-2 A & B, Landsat 5, 7 & 8…(9)



Implemented on CNES HPC

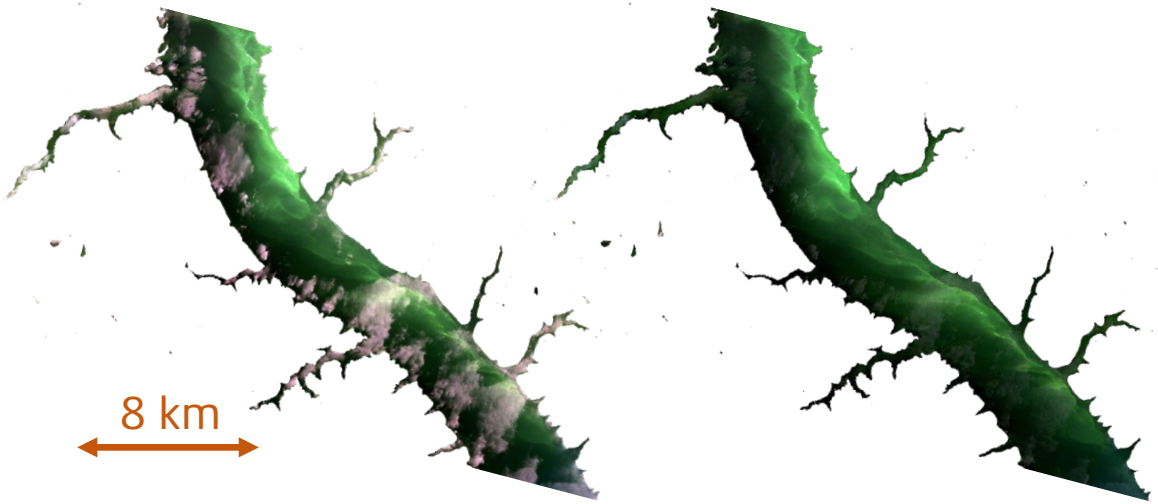


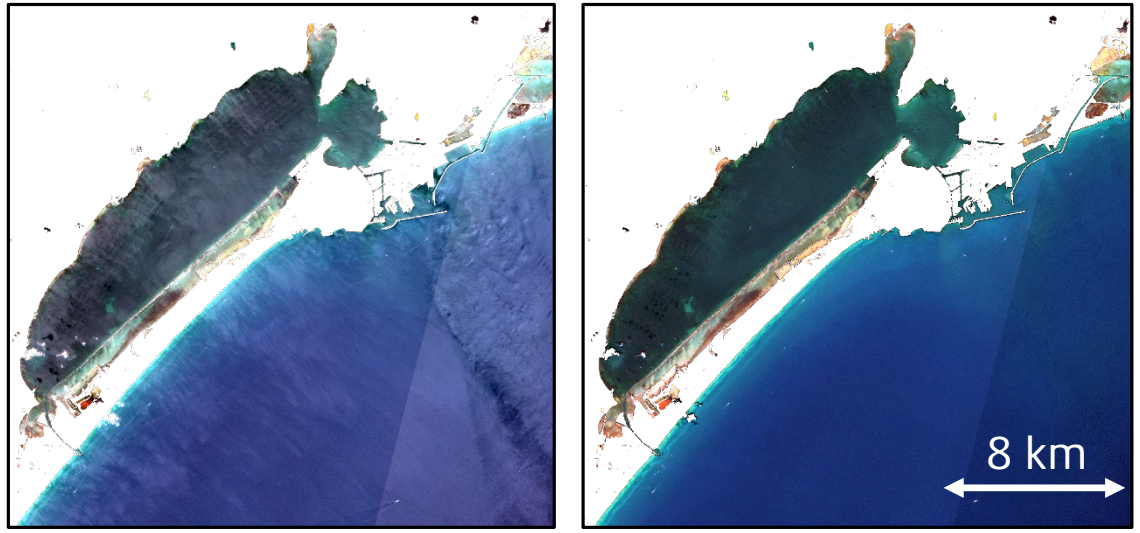
Sentinel-2 image of 5 Aug. 2018, [2°W, 47°N]

LES UTILISATIONS DE LA TÉLÉDÉTECTION POUR LA QUALITÉ DES EAUX CONTINENTALES ET AUX INTERFACES

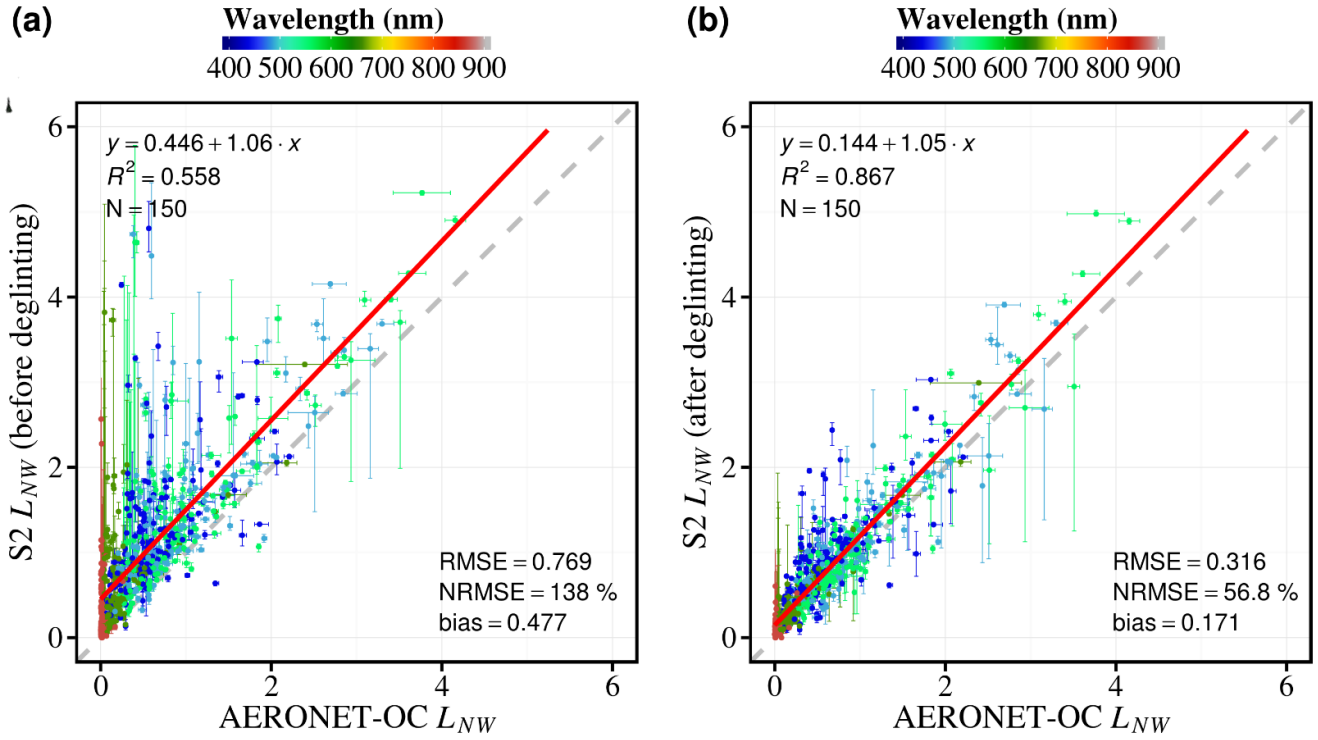
AC: *Atmospheric Correction*

AC only ***AC + glint removal***





AC only ***AC + glint removal***

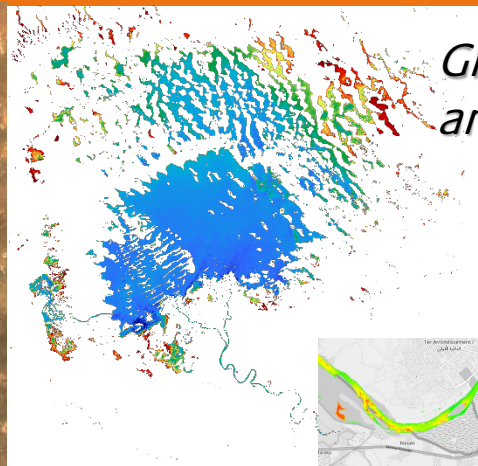


[Harmel et al., 2018]

150 satellite images (S2)
16 AERONET-OC (14 coastal, 2 lake sites)

GRS achievements

UNESCO web portal for water monitoring in Chad basin

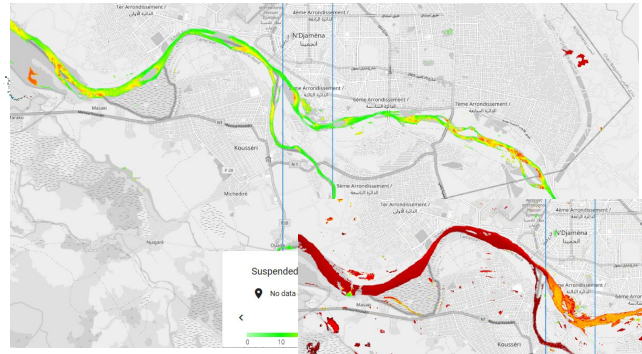


Global analysis

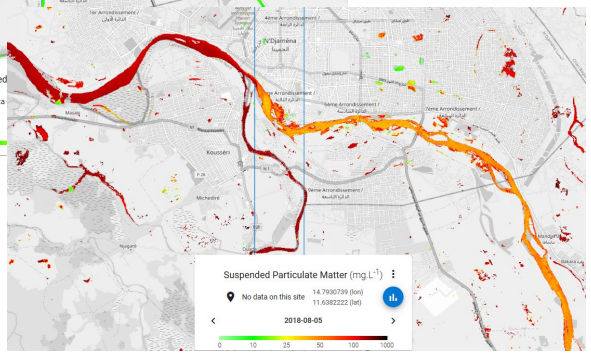
United Nations Educational, Scientific and Cultural Organization

International Hydrological Programme

International Initiative on Water Quality



Local analysis



Time series

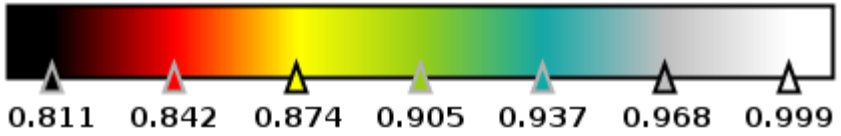
magellium

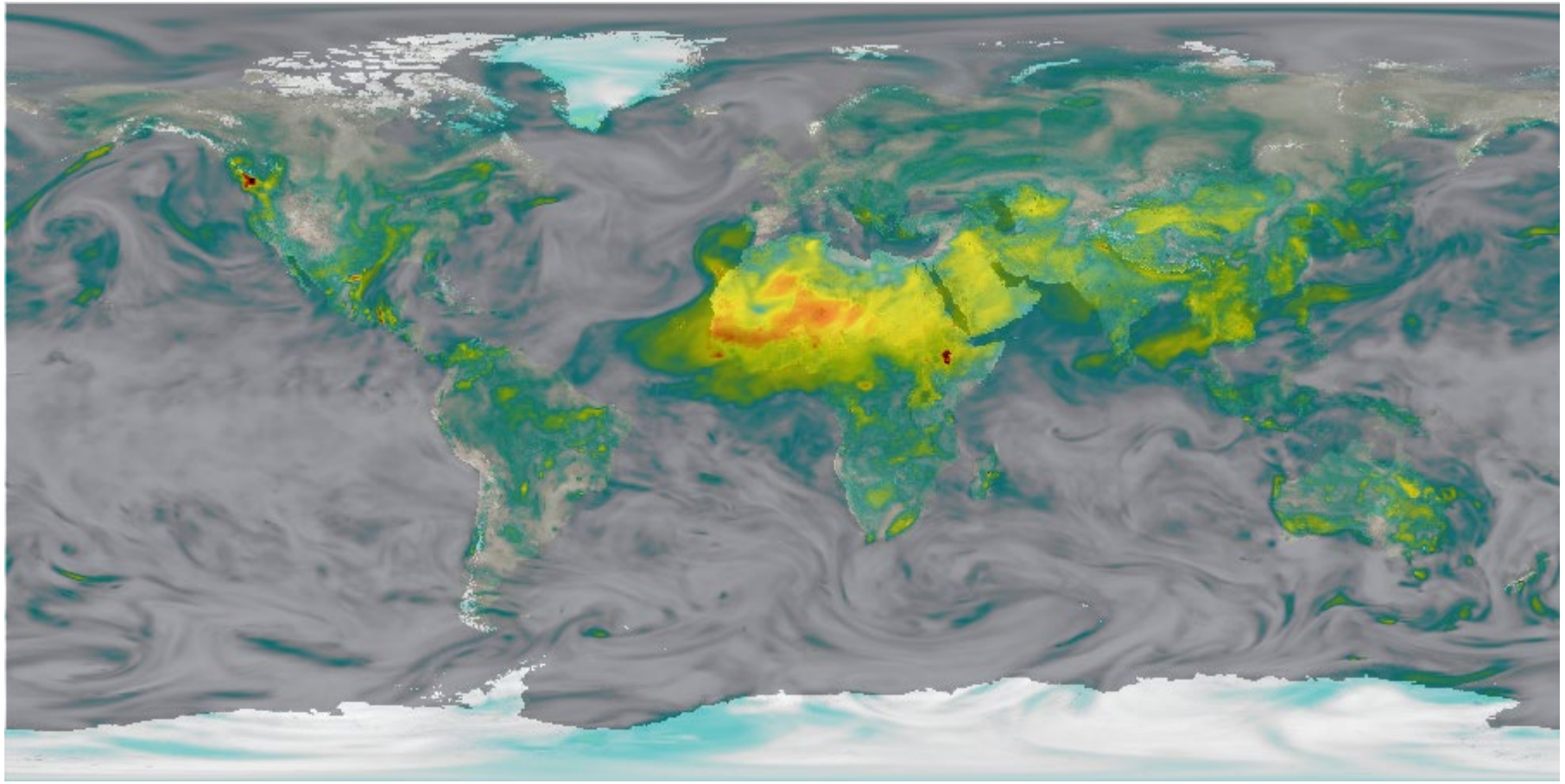
GRS v1.3: handling absorbing aerosols

Atmosphere Monitoring Service

SSA: *single scattering albedo*

SSA at 550 nm





CAMS - *global atmospheric composition forecasts*
2021-03-25

GRS v1.3: handling absorbing aerosols

Total aerosol optical thickness:

scattering + absorption

$$\tau_a^{tot}(\lambda) = \tau_a^{sca}(\lambda) + \tau_a^{abs}(\lambda)$$

Provided by CAMS - *global atmospheric composition forecasts for several wavelengths* 400, 500, 550, 645, 670, 800, 865, 1020, 1240, 1640, 2130 nm

Bulk single scattering albedo:

$$ssa_{tot}(\lambda) = \frac{\tau_a^{sca}(\lambda) + \tau_{...}(\lambda)}{\tau_a^{tot}(\lambda) + \tau_{...}(\lambda)}$$

LUT simulations with OSOAA code [Chami et al., 2015]
Atmosphere through interface/water coupled system.
Aerosols models (size lognormal, Mie calculations):

	r_m (µm)	σ	r_{eff} (µm)	n_r
fine	0.10	0.60	0.25	1.40
coarse	0.80	0.60	1.98	1.35

See flash presentation at Theia website

From CAMS

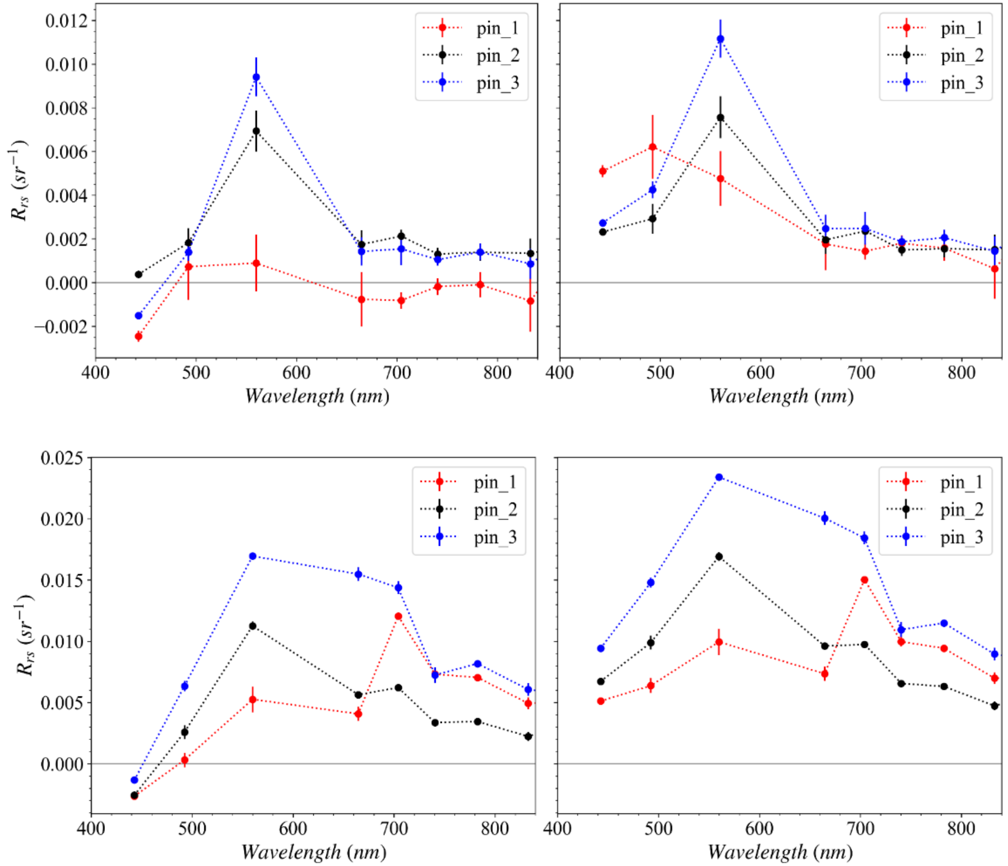
$$L_{sky}(\lambda, \tau_a) = ssa_{tot}(\lambda)\left[\gamma L_{sky}^{fine}\left(\lambda, \tau_a^{sca}\right) + (1-\gamma) L_{sky}^{coarse}\left(\lambda, \tau_a^{sca}\right)\right]$$

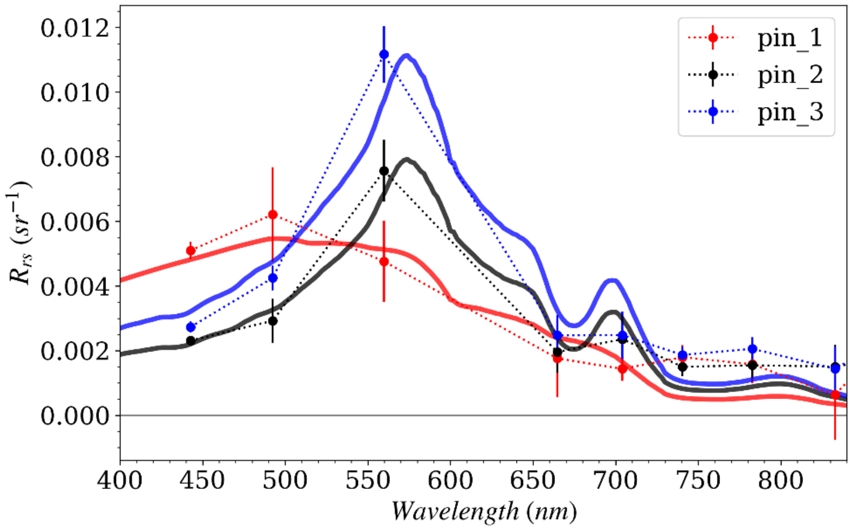
Interpolated within LUT

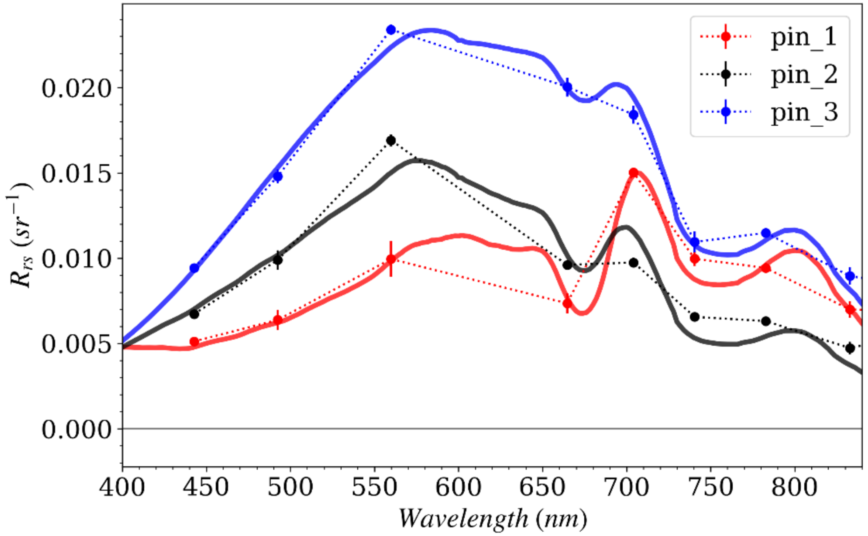
Inverse radiative model: InvRrs package

[Harmel et al., in prep]

GRS v1.2 GRS v1.3

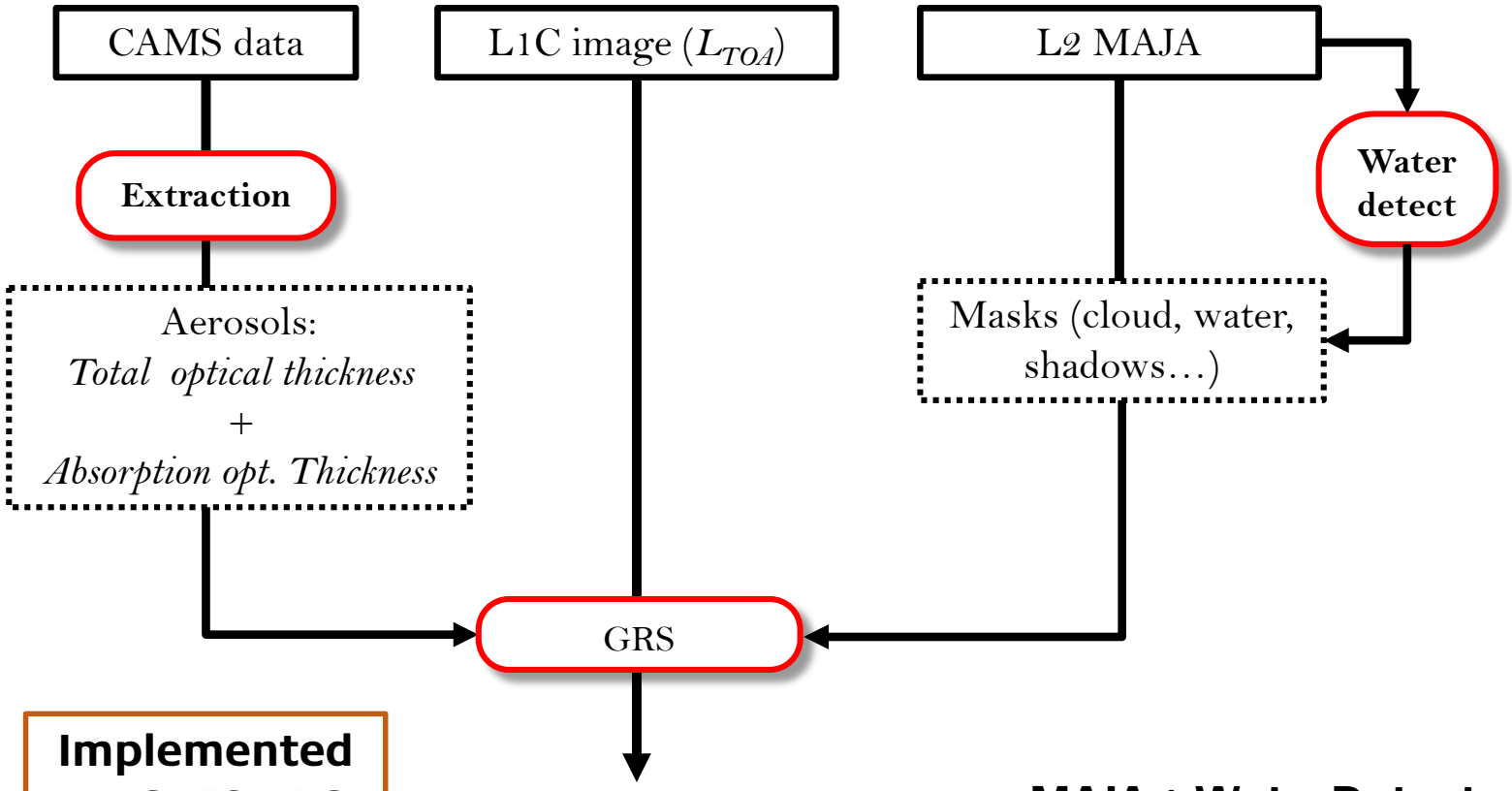






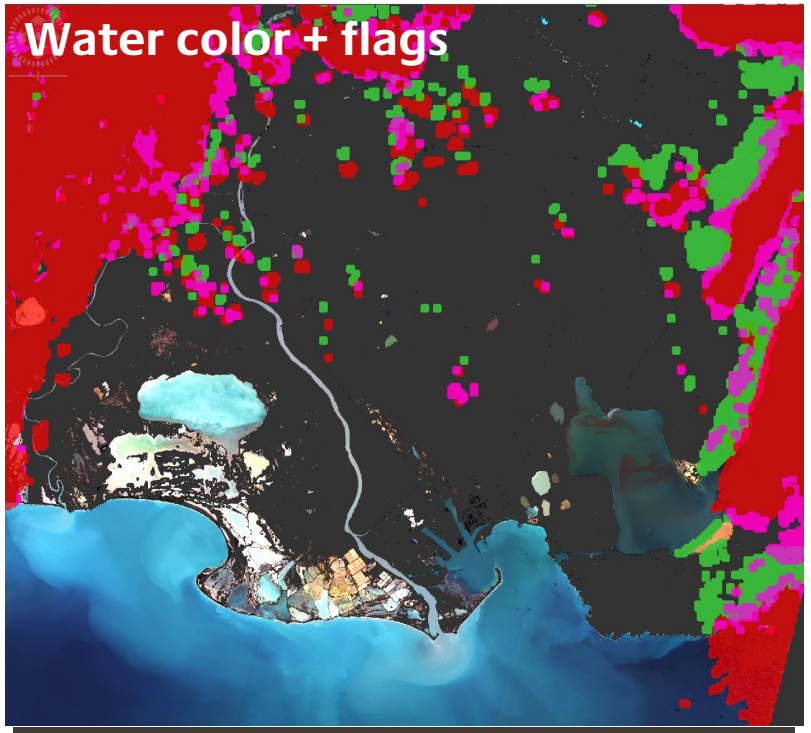
See flash presentation at Theia website

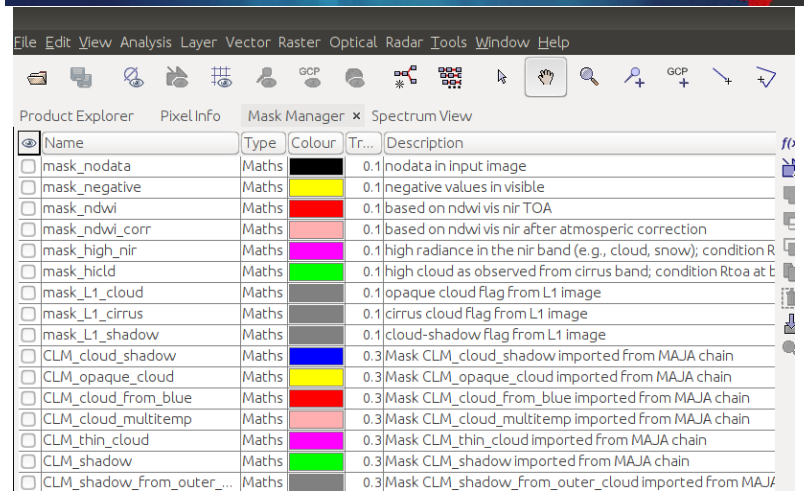
LES UTILISATIONS DE LA TÉLÉDÉTECTION POUR LA QUALITÉ DES EAUX CONTINENTALES ET AUX INTERFACES



Implemented on CNES HPC

MAJA + WaterDetect flags

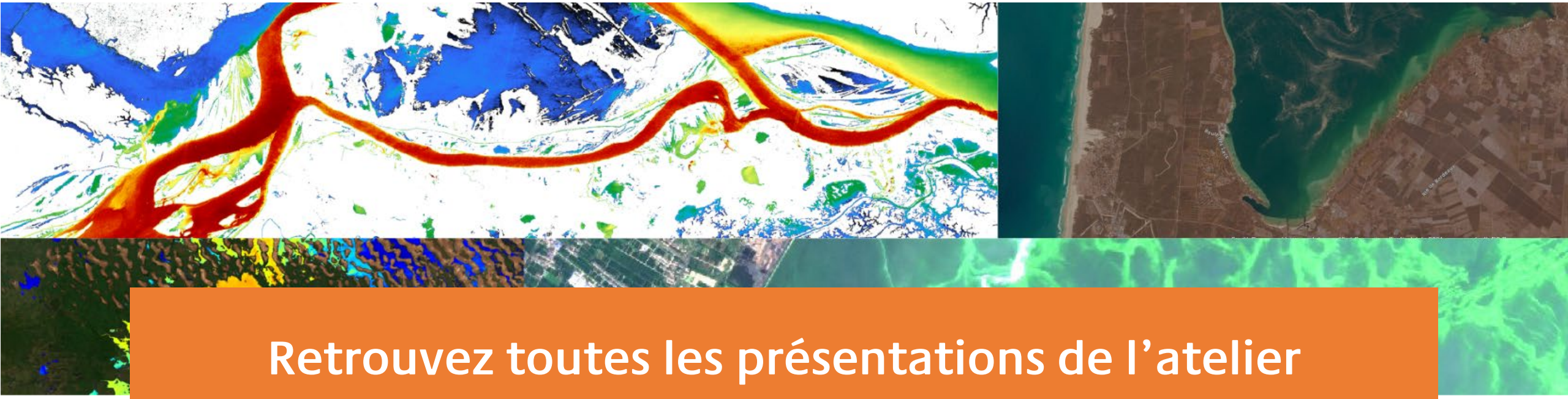




- Mask → Water pixel / quality control
- Aerosol + Absorption prop. from CAMS improves atmospheric correction of water pixels under polluted areas

Thank you!

Financial support:
CNES / TOSCA
TELQUEL, OBS2CO, OBS2MOD

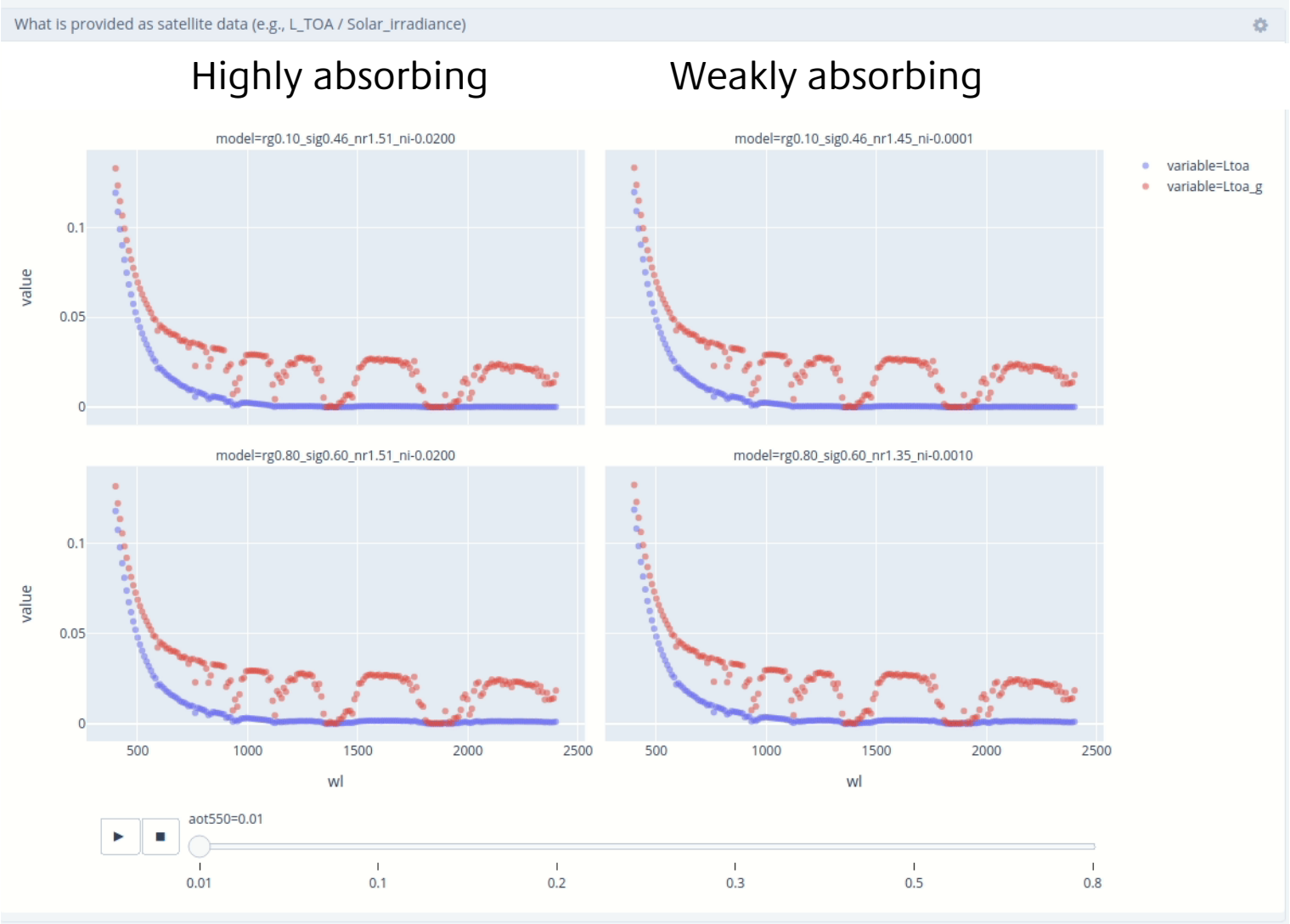


Retrouvez toutes les présentations de l'atelier

LES UTILISATIONS DE LA TÉLÉDÉTECTION POUR LA QUALITÉ DES EAUX CONTINENTALES ET AUX INTERFACES

sur www.theia-land.fr/eaux21

Top-of-atmosphere signal simulations

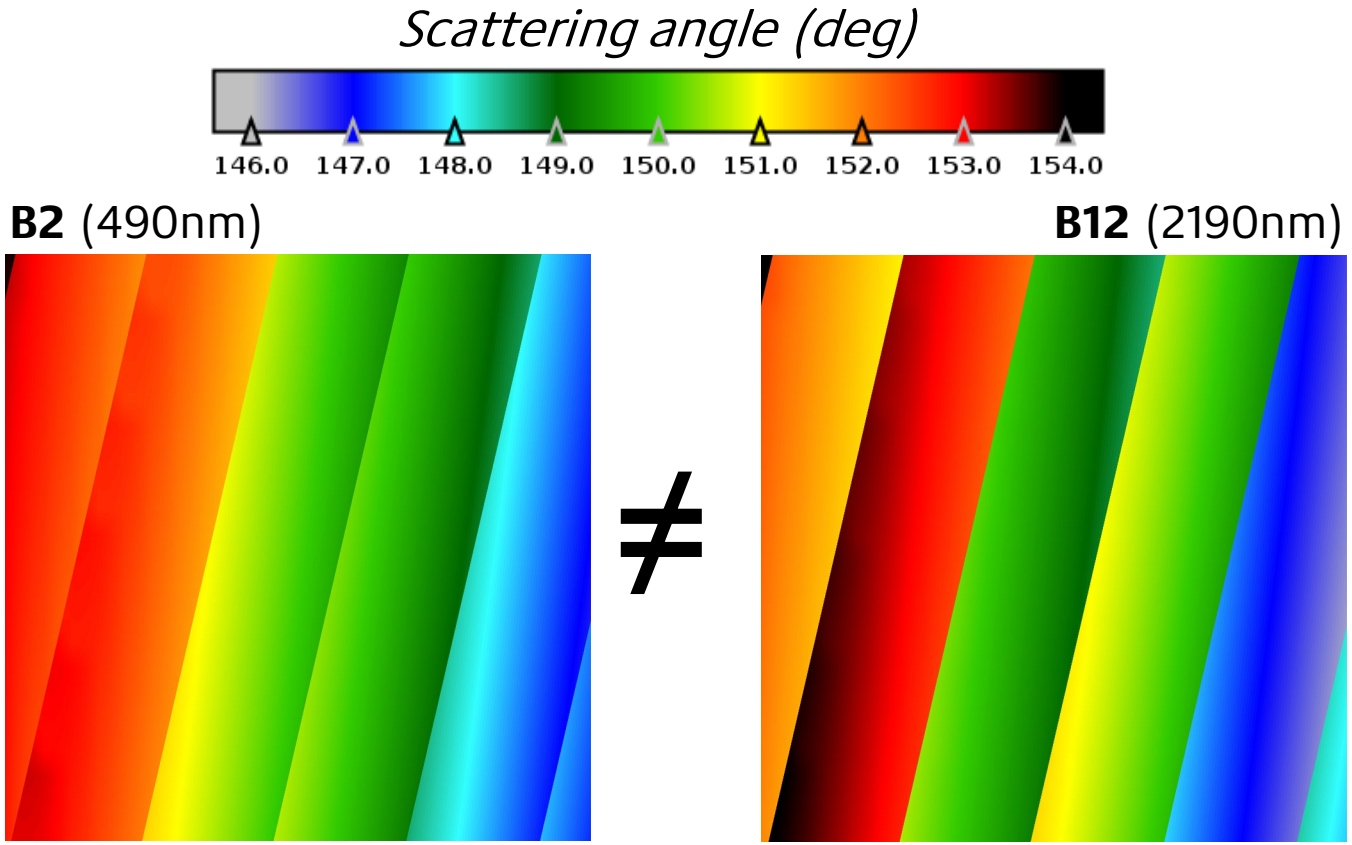


With sunglint

Without sunglint

CURRENT LIMITATIONS

Differences in viewing angles between spectral bands are not accounted for at the pixel level



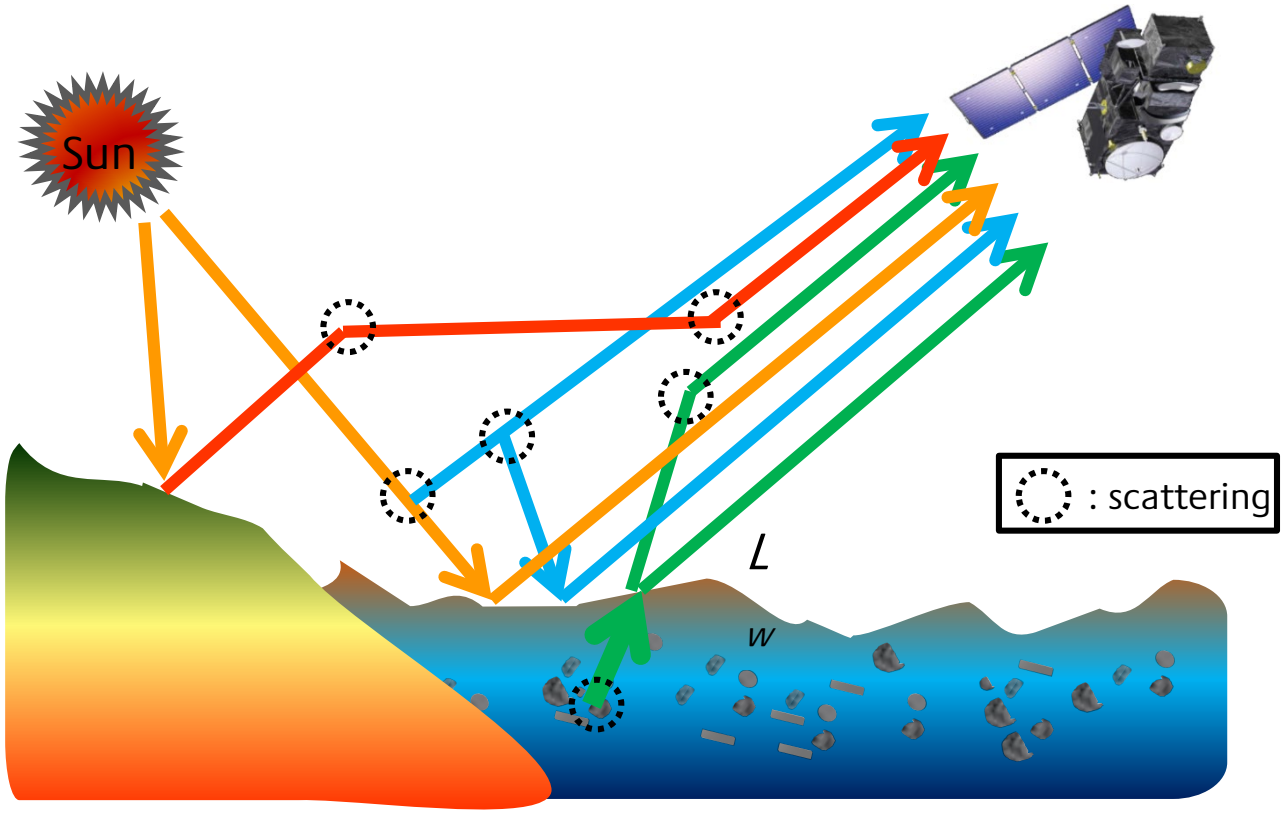
[Image S2A, tile 32TQR, 2016-07-18]

Adjacency effects

CURRENT LIMITATIONS

Collaboration – ADJEFF (TOSCA – O. Hagolle)

- Correction effets d'environement (Adjacency effects)



Codes:

- Transfert radiatif 3D + polarisation (SMART-3G, HYGEOS)
- Correction atmospherique: GRS, MAJA

Clusters de calculs:

HPC-CNES

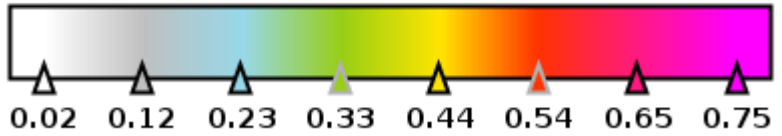
Images satellite:

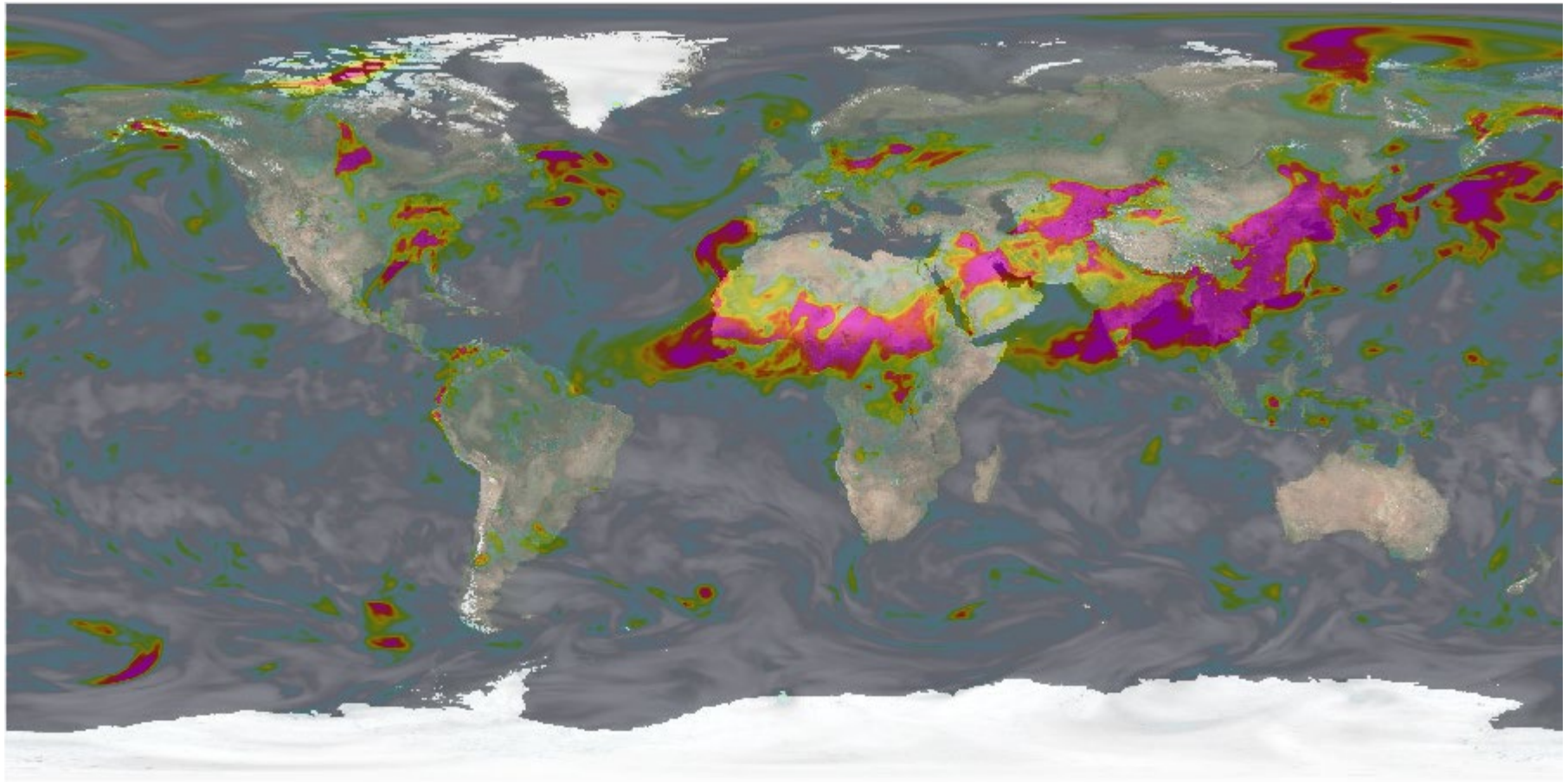
Landsat-4..8
Sentinel-2
Sentinel-3

Atmosphere Monitoring Service

AOT: *aerosol optical thickness*

Total AOT at 550 nm





CAMS - *global atmospheric composition forecasts*
2021-03-25