Atmospheric Correction for Coastal and Inland Waters – Current Capabilities and Challenges

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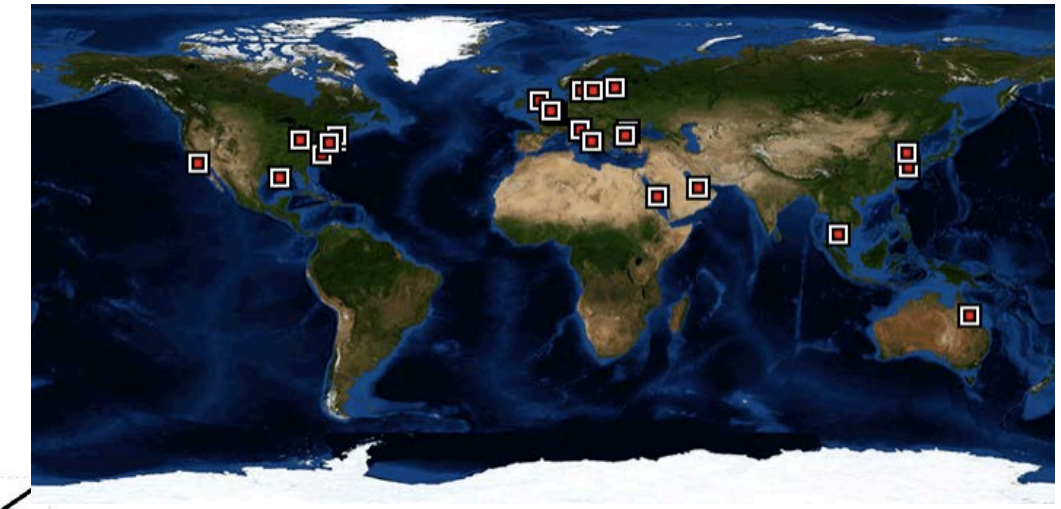
Science Systems and Applications Inc.

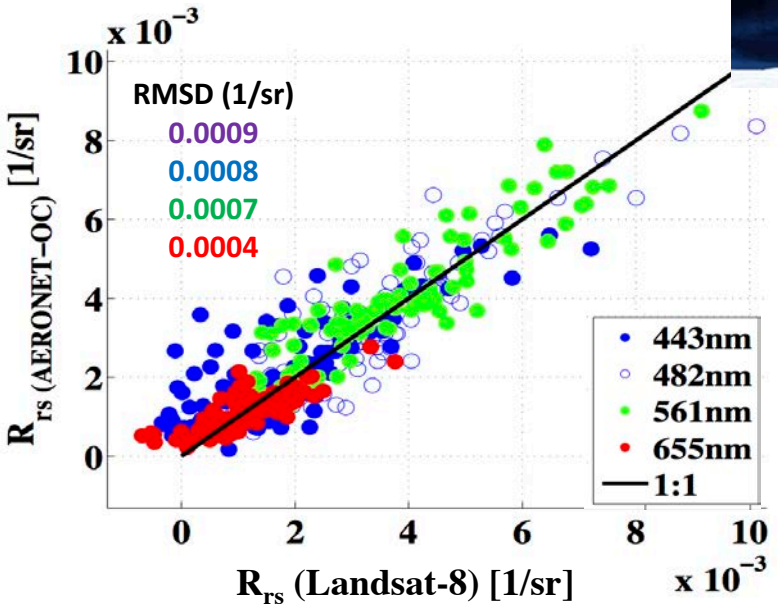
Outline

- In situ validations
- Challenges and issues
  - Aerosols
  - Absorbing waters
  - Extremely turbid waters
  - Calibration errors
  - Trace gases
  - Adjacency effects
  - Sunglint
  - Cloud shadows & wave facets

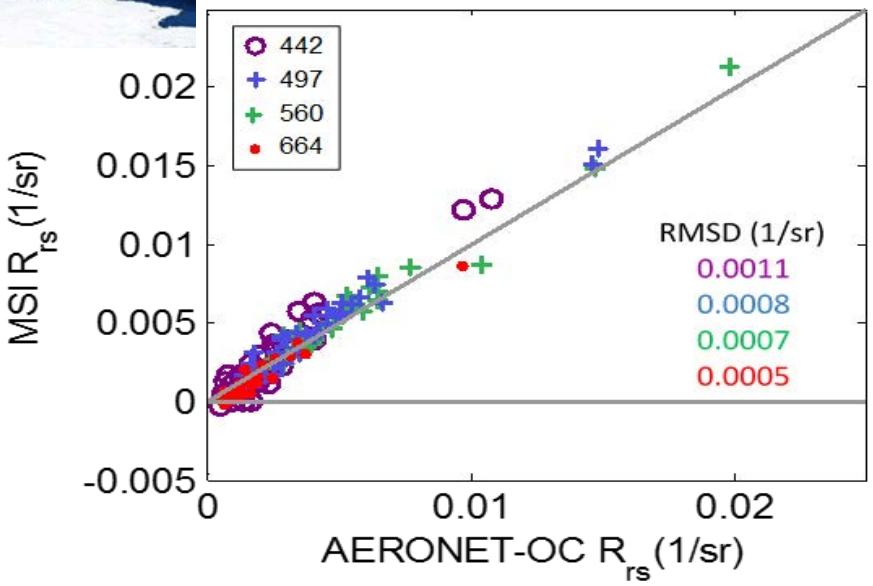
Validations using AERONET-OC data



Landsat-8 (OLI)



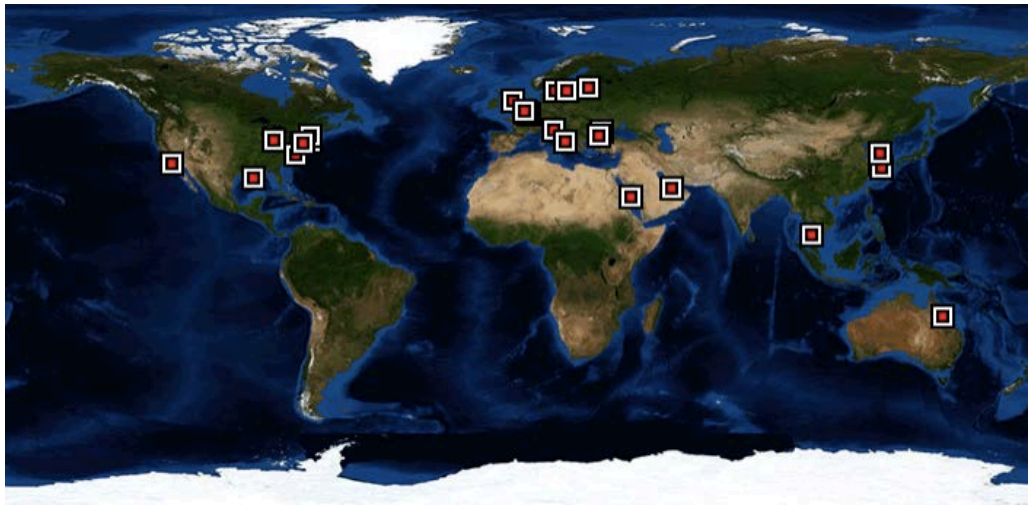
Sentinel-2A (MSI)



Pahlevan, N., Schott, J.R., Franz, B.A., Zibordi, G., Markham, B., Bailey, S., Schaaf, C.B., Ondrusek, M., Greb, S., & Strait, C.M. (2017). **Landsat 8 remote sensing reflectance (R rs) products: Evaluations, intercomparisons, and enhancements**. *Remote Sensing of Environment, 190*, 289-301

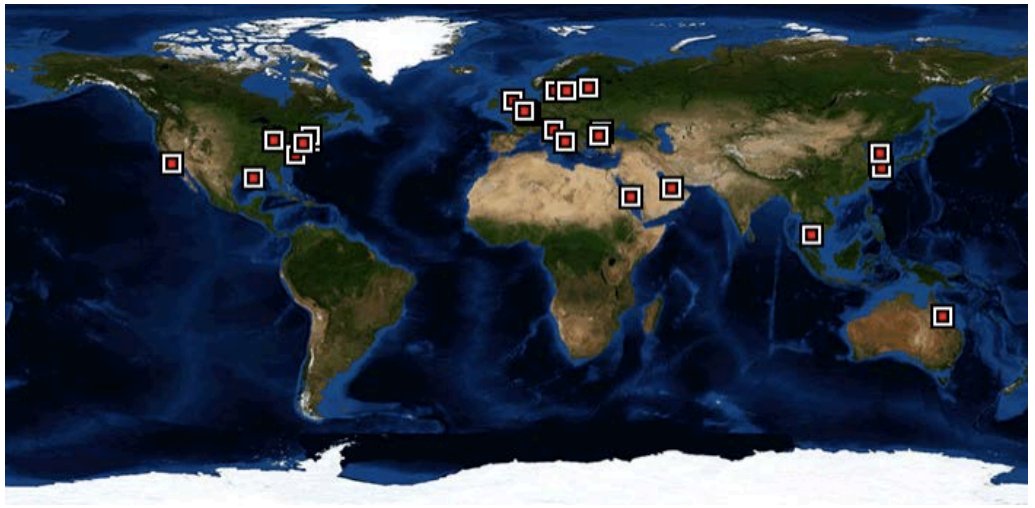
Pahlevan, N. , Sarkar, S., Franz, B. A., He, J. "**Sentinel-2 MultiSpectral Instrument (MSI) data processing for aquatic science applications: Demonstrations and preliminary validations".** Submitted to *Remote Sensing of Environment*

Validations using AERONET-OC data



By adopting heritage A/C method, **on average,** we are doing great!

Validations using AERONET-OC data

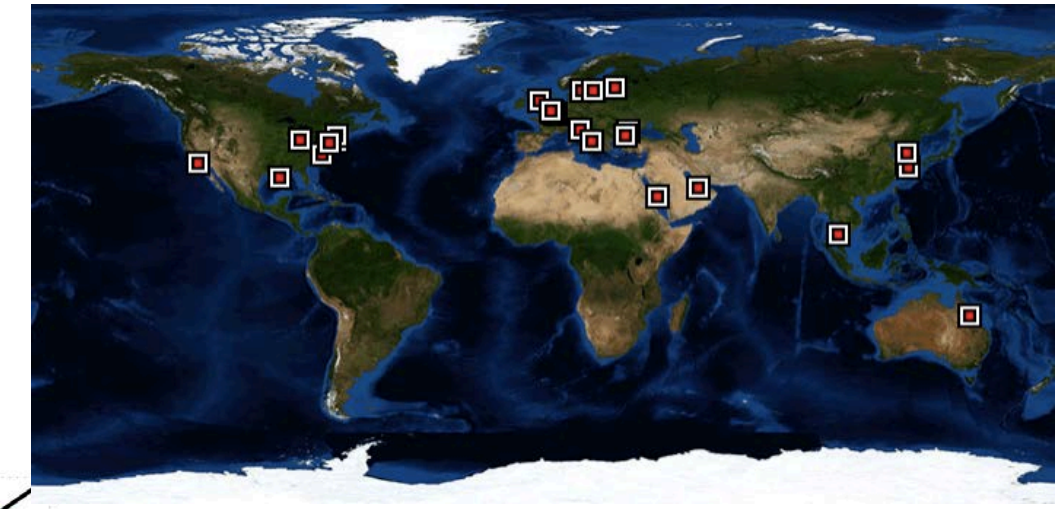


By adopting heritage A/C method, **on average,** we are doing great!

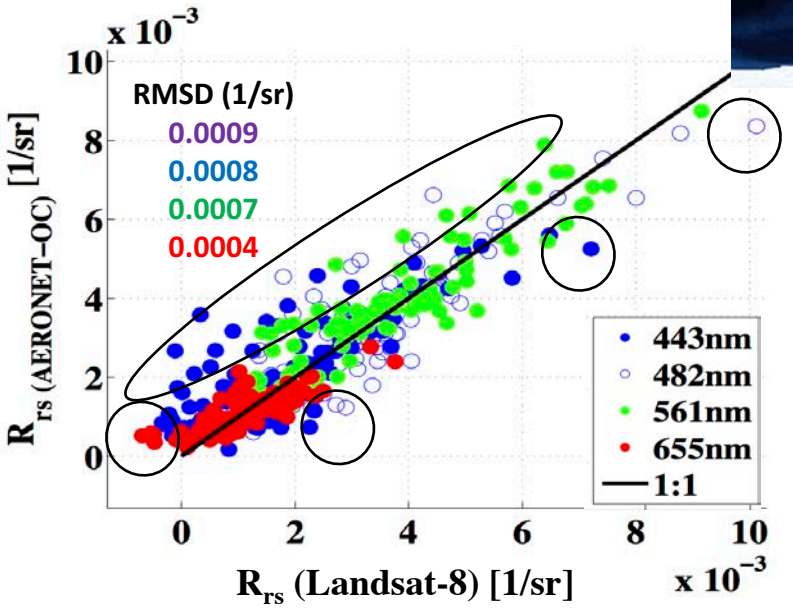
But

How well do we do retrievals **per-pixel**?
(maximize number of valid retrievals)

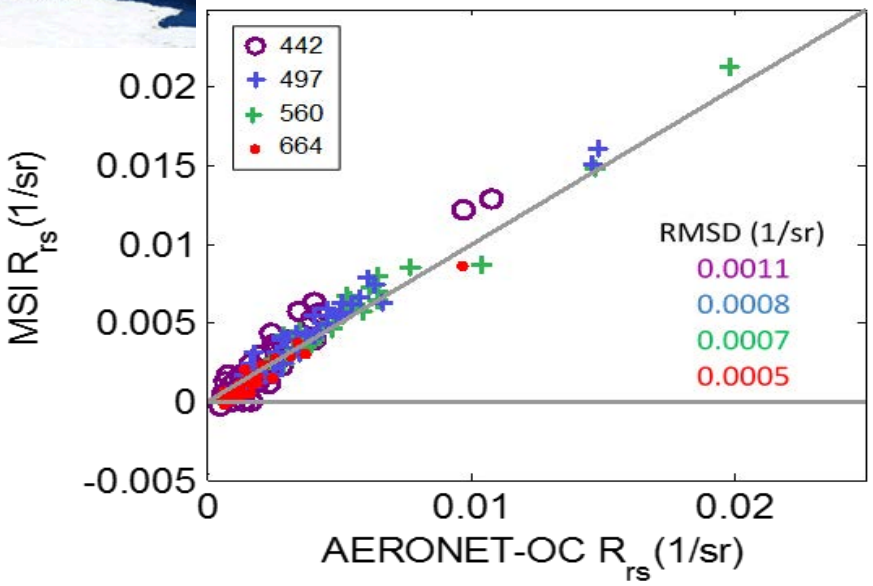
Validations using AERONET-OC data



Landsat-8 (OLI)



Sentinel-2A (MSI)



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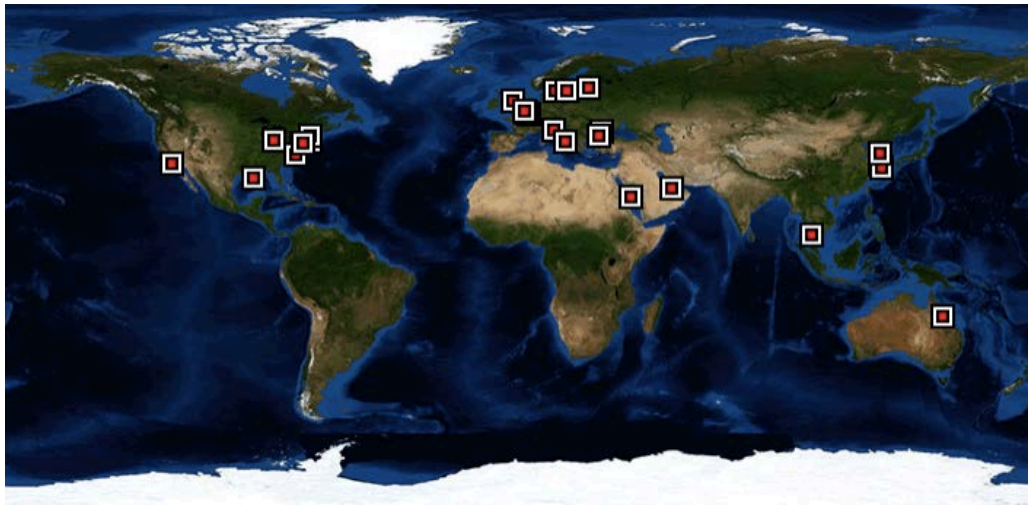
Validations using AERONET-OC: **Necessary but NOT sufficient**



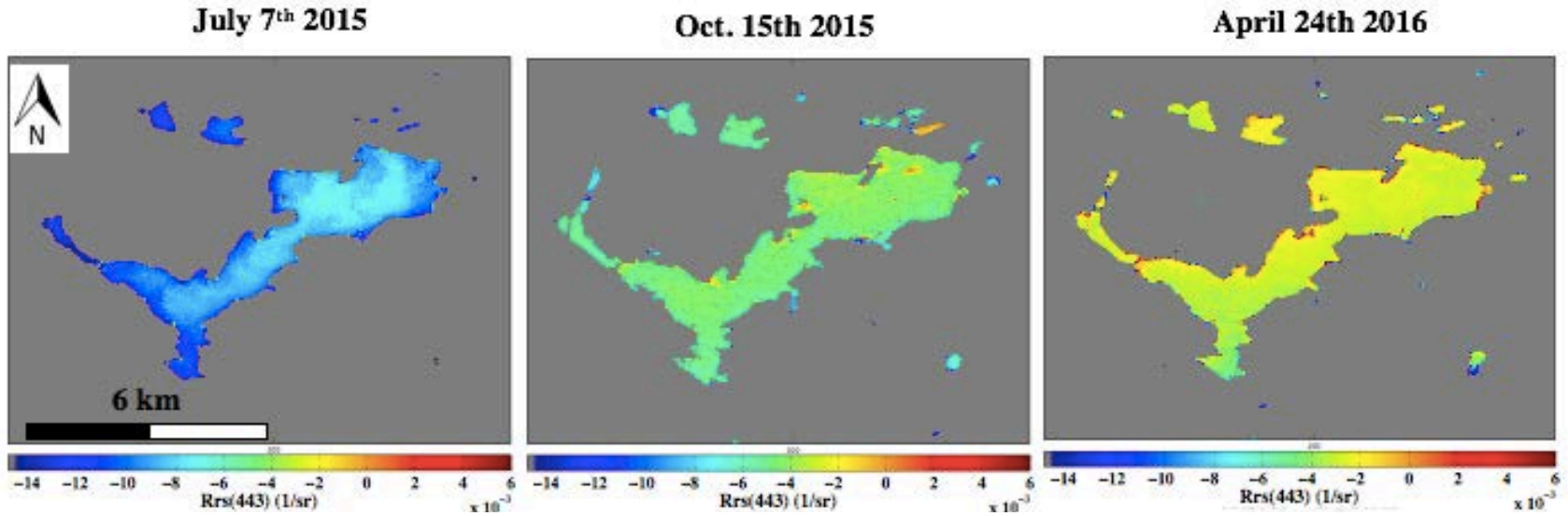
By adopting heritage A/C method, **on average,** we are doing great!

But

How well do we do over **areas NOT represented within AERONET-OC network**?

Issues with aerosol removal (absorbing waters): representativeness

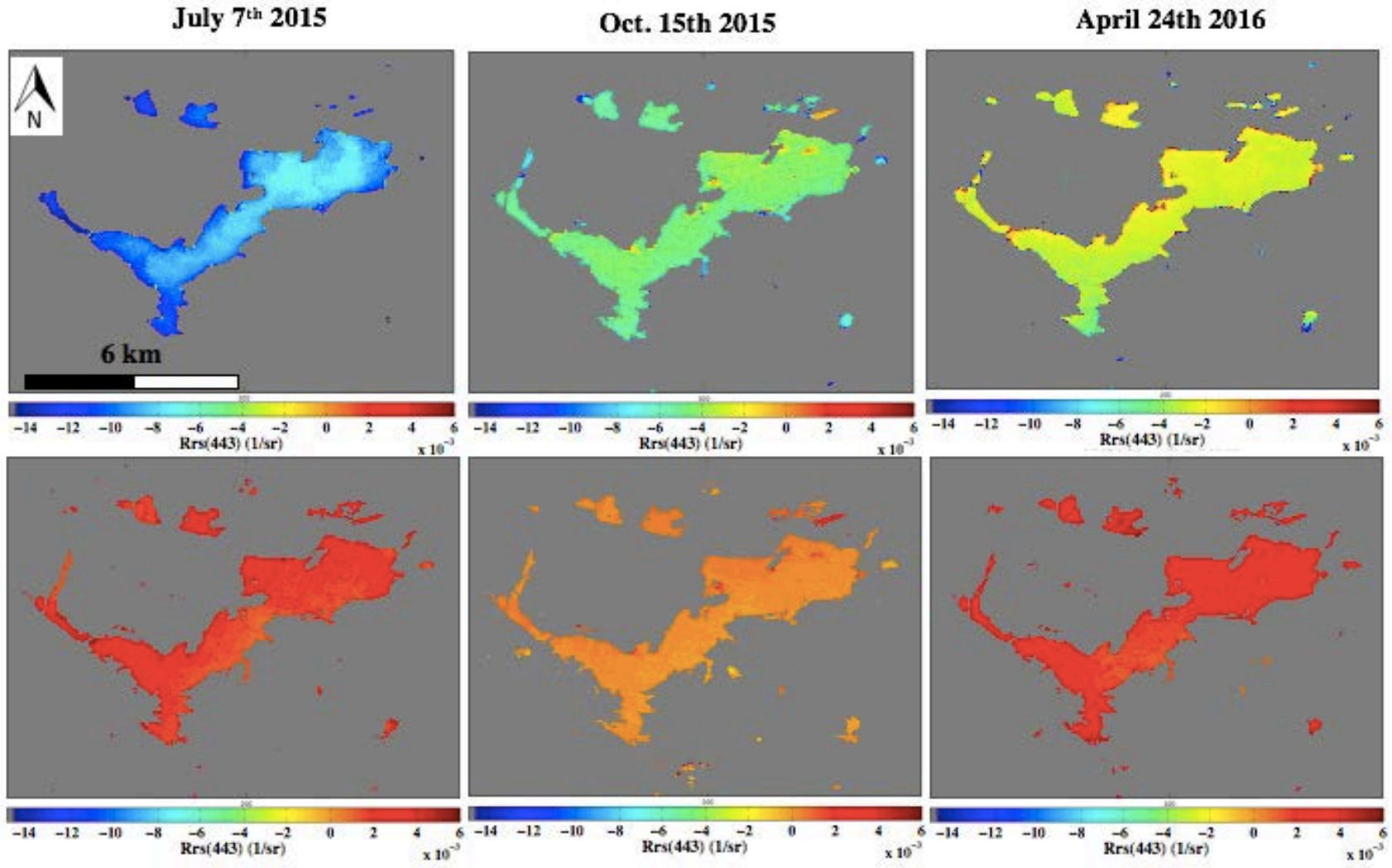
Landsat-8 derived **$R_{rs}(443)$** over Wachusett Reservoir in Massachusetts



Automated removal of aerosols using existing aerosol LUTs

Issues with aerosol removal (absorbing waters): representativeness

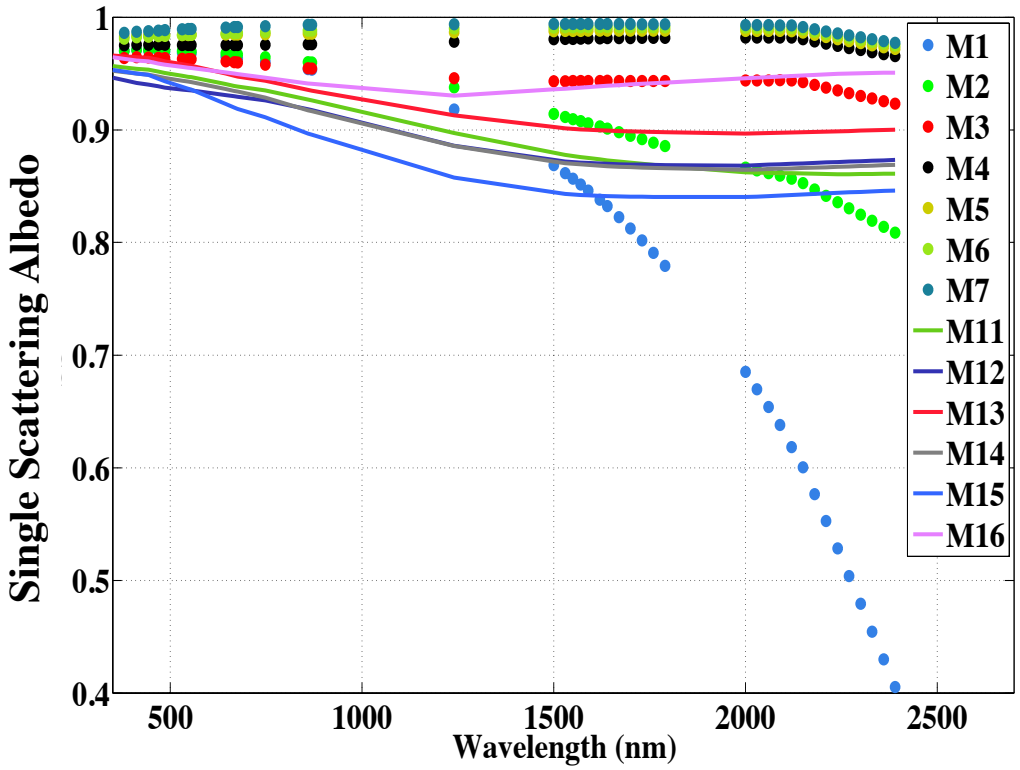
Landsat-8 derived **$R_{rs}(443)$** over Wachusett Reservoir in Massachusetts



Automated removal of aerosols using existing aerosol LUTs

Manual removal of aerosols using observed AOT spectra

Issues with aerosol removal: representativeness



Standard aerosol models
(Ahmad et al. 2010)

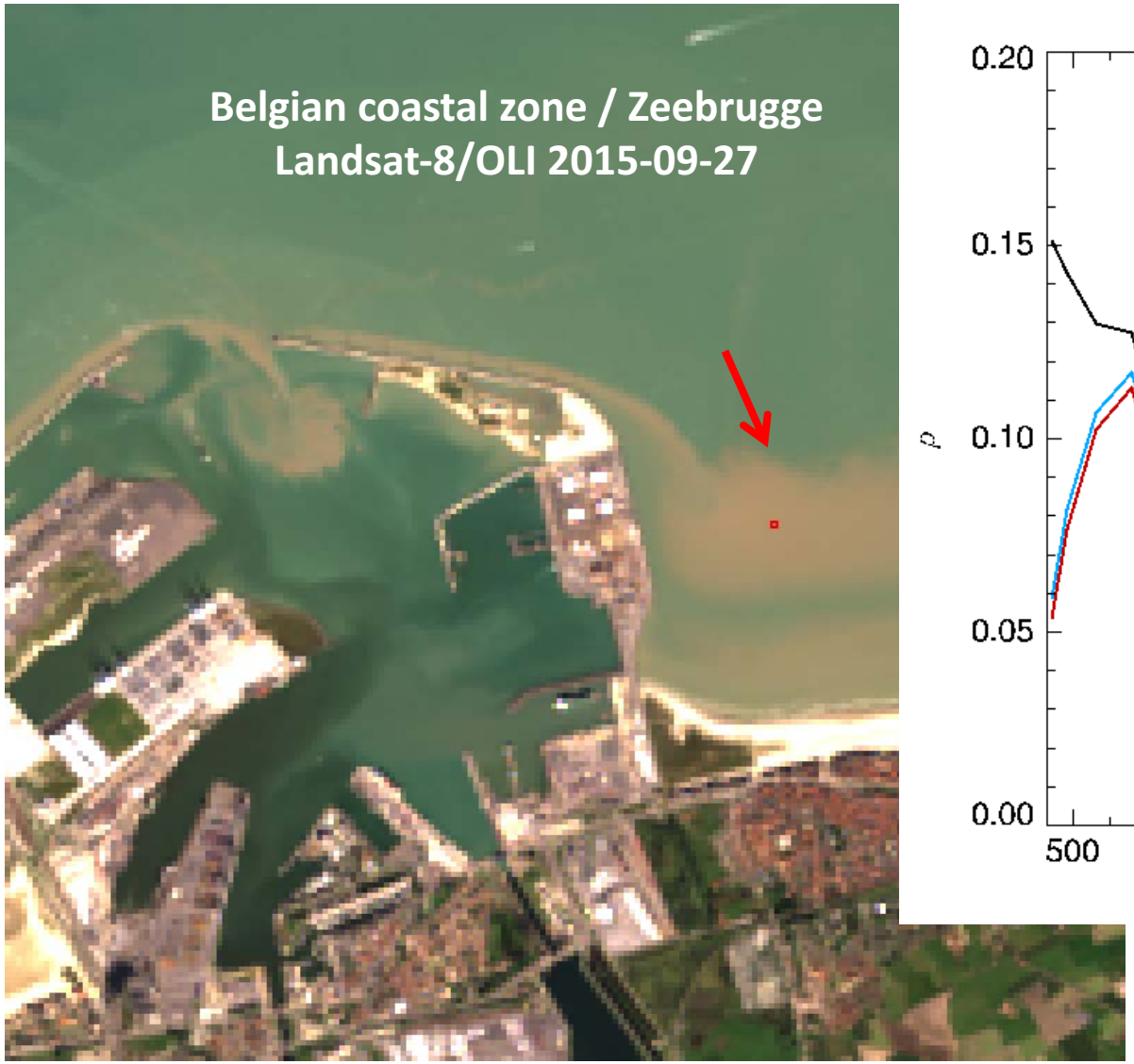
Observed/retrieved aerosol properties (coastal AERONET)

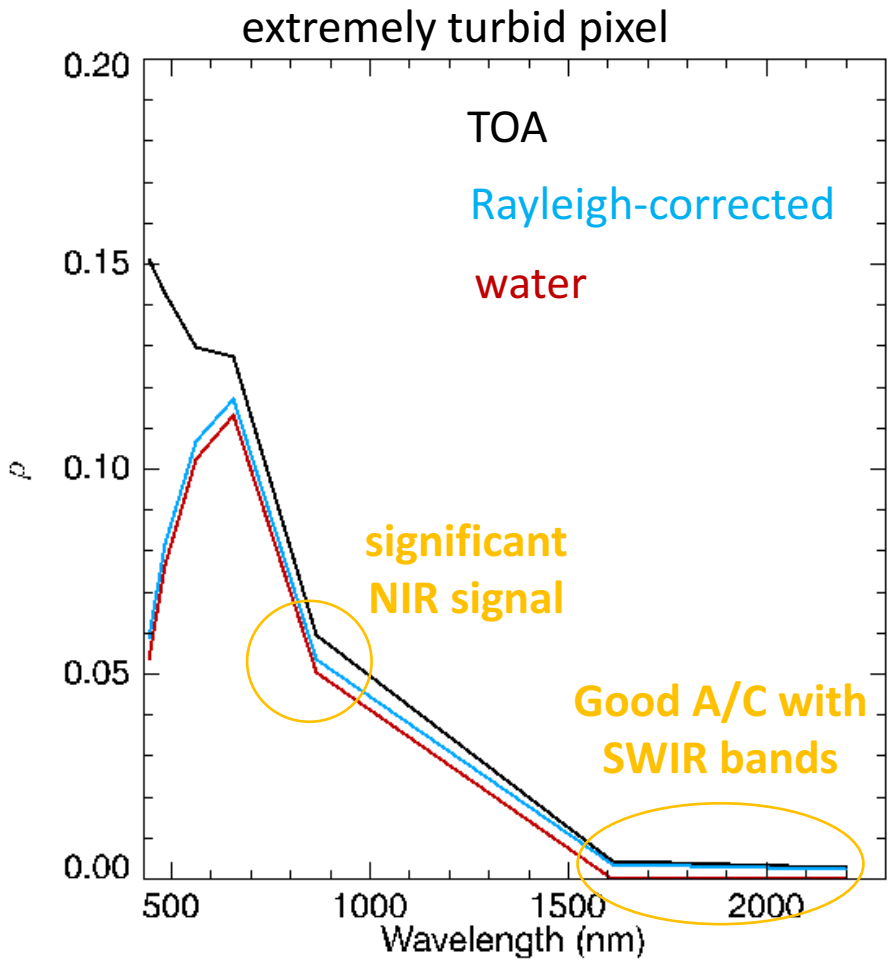
Pahlevan, N., Roger, J.-C., & Ahmad, Z. (2017). Revisiting short-wave-infrared (SWIR) bands for atmospheric correction in coastal waters. *Optics express, 25*, 6015-6035

The standard aerosol models

do **NOT** represent aerosols over inland and nearshore

coastal areas

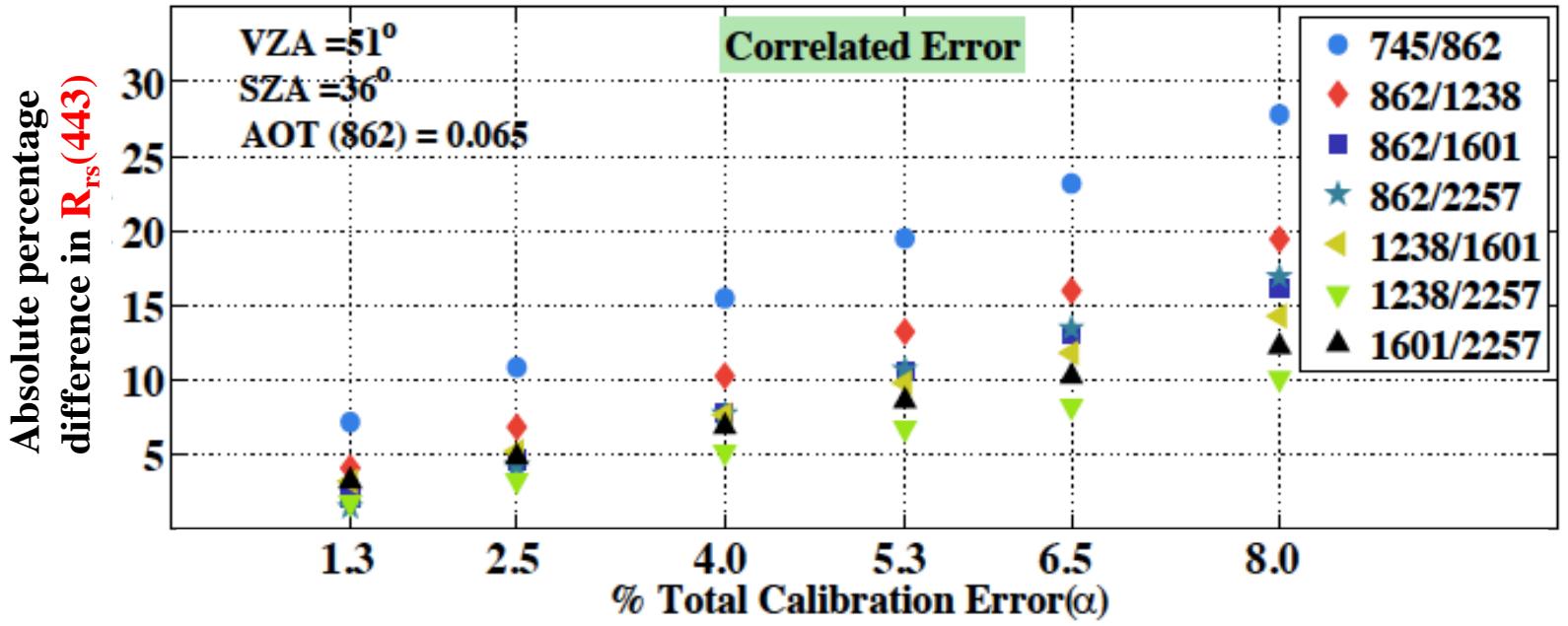




Credit: Quinten Vanhellemont

Calibration errors

- Use VIIRS NIR/SWIR band combinations to simulate the sensitivity of aerosol removal to calibration errors. The values shown are averaged for > 250 VIIRS observations.

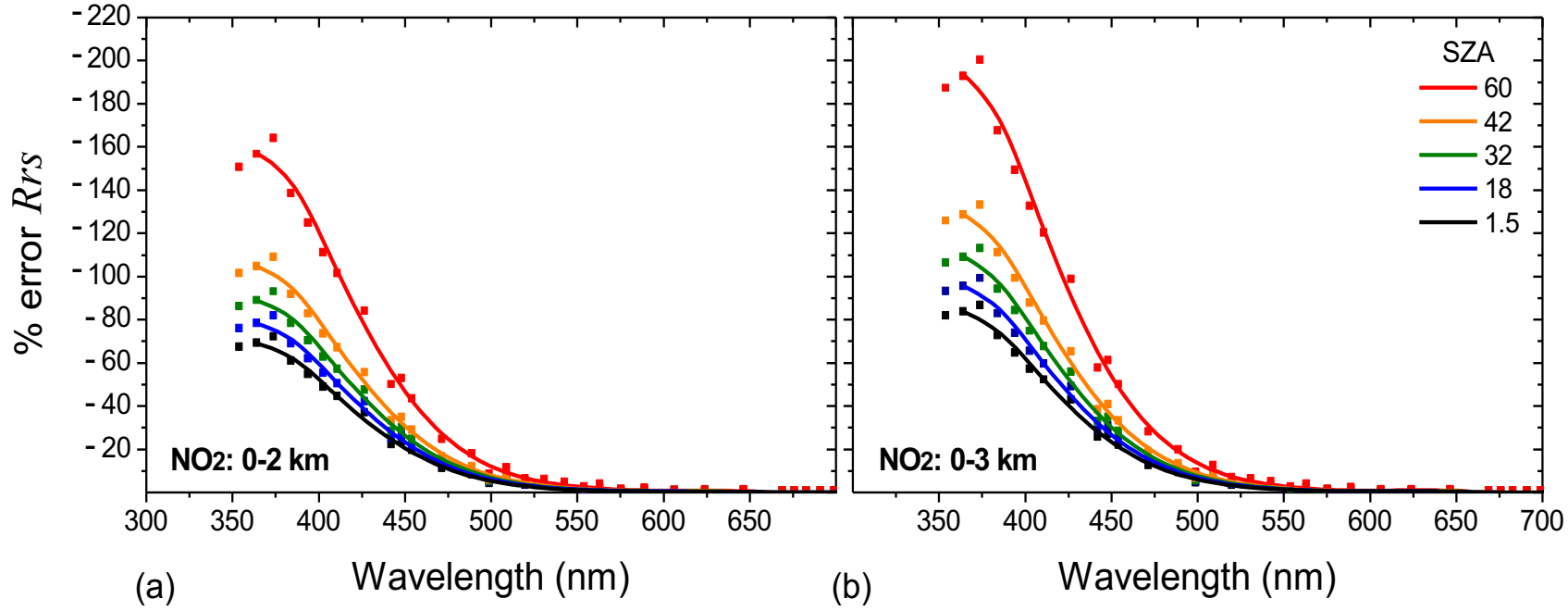


Pahlevan, N., Roger, J.-C., & Ahmad, Z. (2017). Revisiting short-wave-infrared (SWIR) bands for atmospheric correction in coastal waters. *Optics express, 25*, 6015-6035

Monitor calibration performances (@low radiances) more frequently to identify any short-term changes in responses within NIR/SWIR

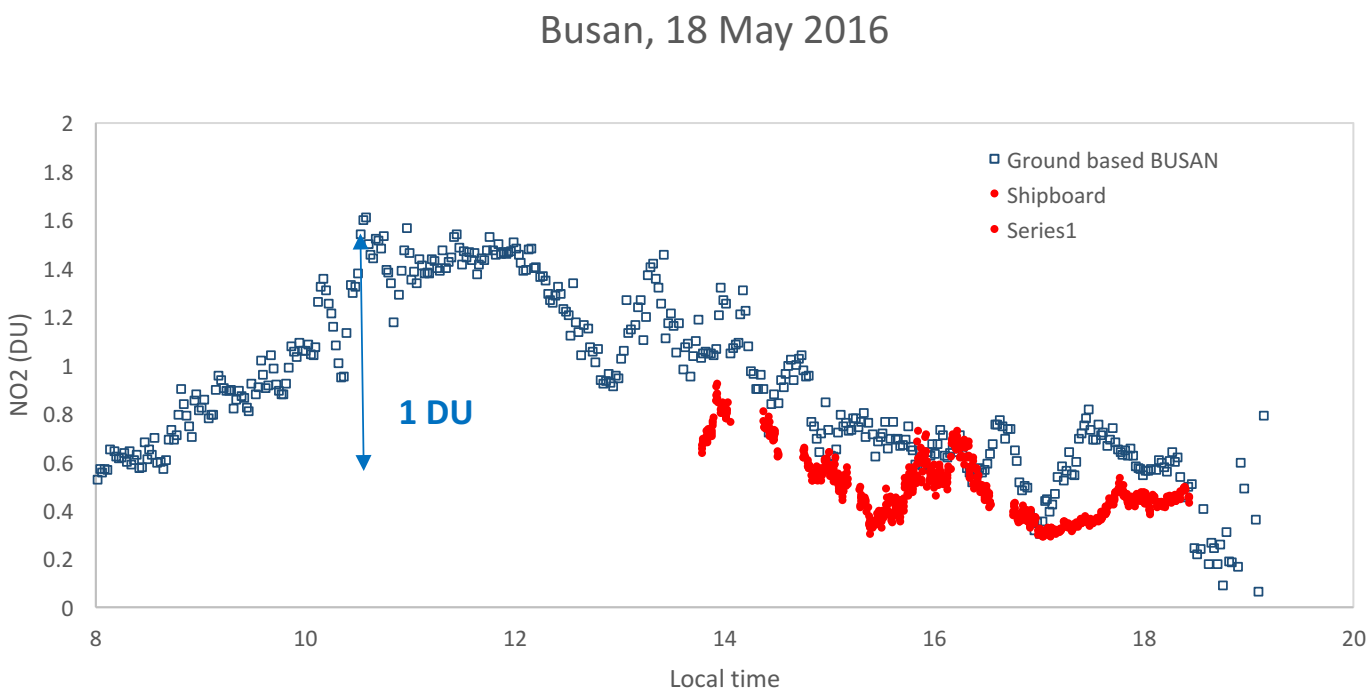
Issues with removal of **trace gases**: representativeness

1 DU error in NO_2 results in large errors in UV and blue



Tzortziou, M., Herman, J.R., Ahmad, Z., Loughner, C.P., Abuhassan, N., & Cede, A. (2014). Atmospheric NO2 dynamics and impact on ocean color retrievals in urban nearshore regions. *Journal of Geophysical Research: Oceans, 119*, 3834-3854

Issues with removal of **trace gases**: representativeness

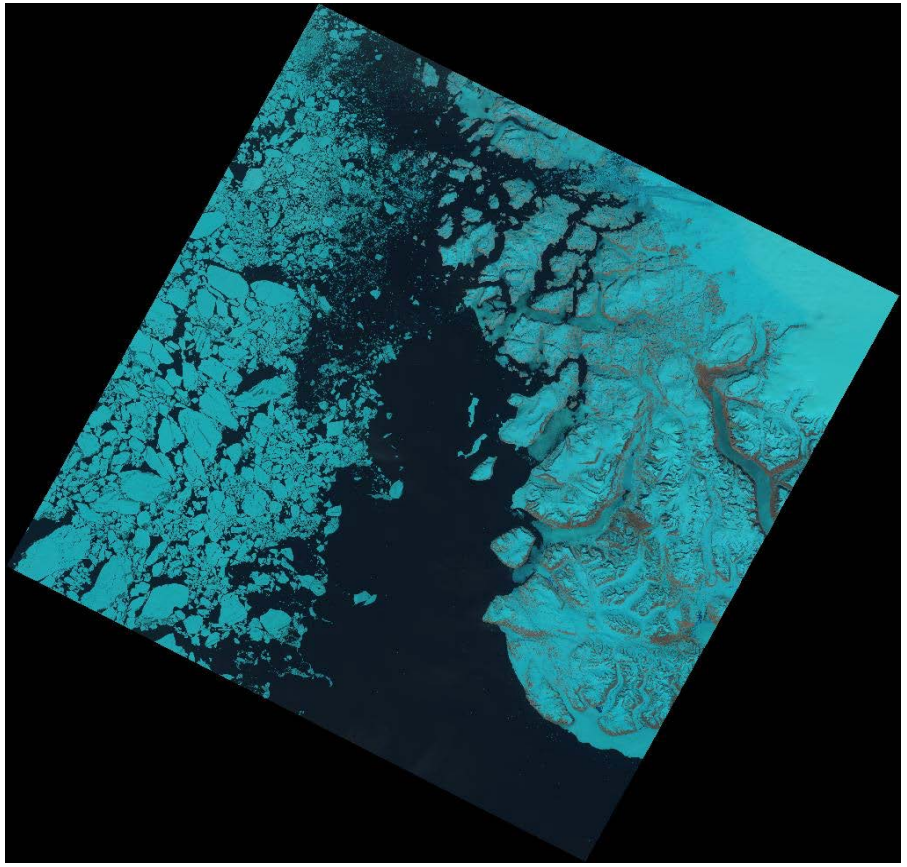


Currently, we use **climatology or coarse-resolution ancillary data** to correct for the effects of trace gases

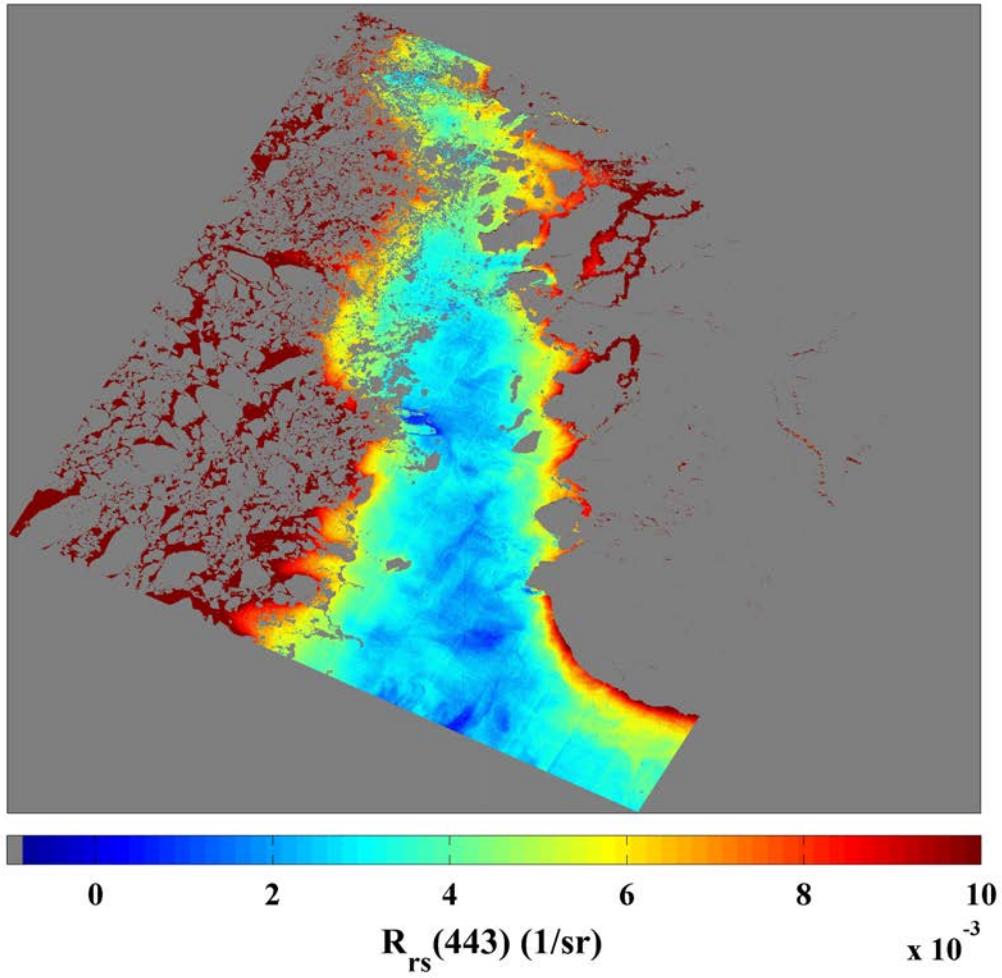
Credit: Maria Tzortziou (KORUS –OC field campaign)

Adjacency effects (ice)

Southwest Greenland (June 2nd 2014)



Landsat-8 (OLI) with ~ 30m spatial sampling



Adjacency effects (ice)

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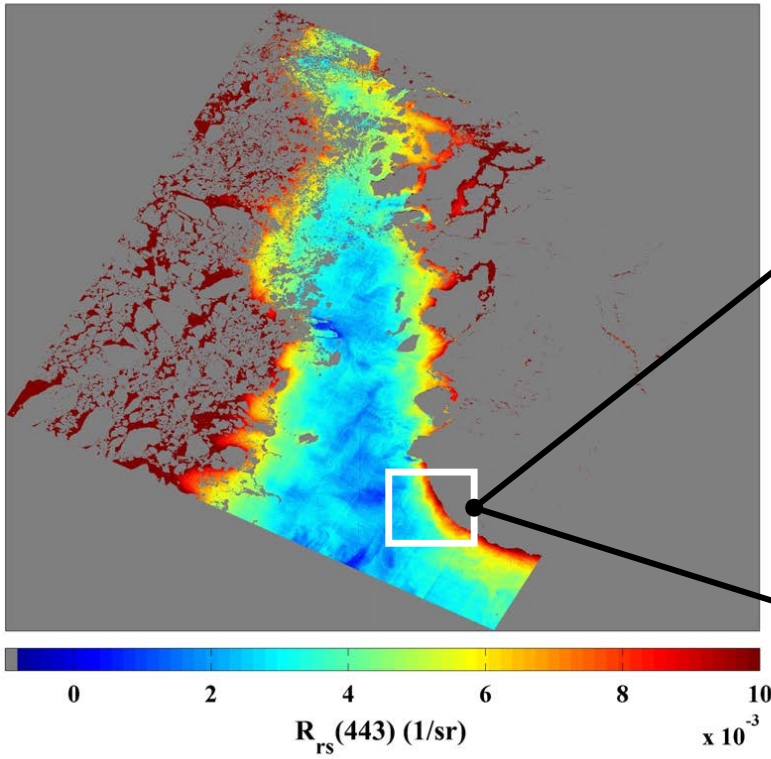
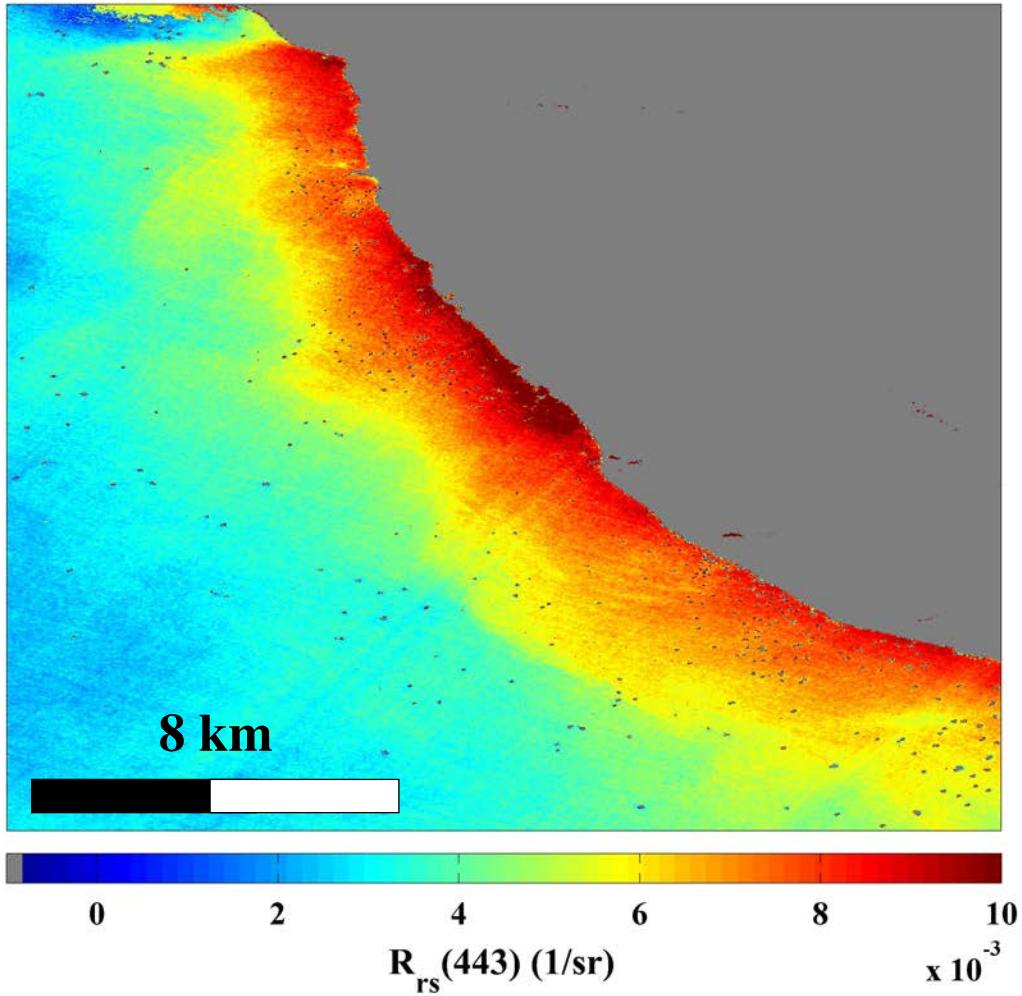
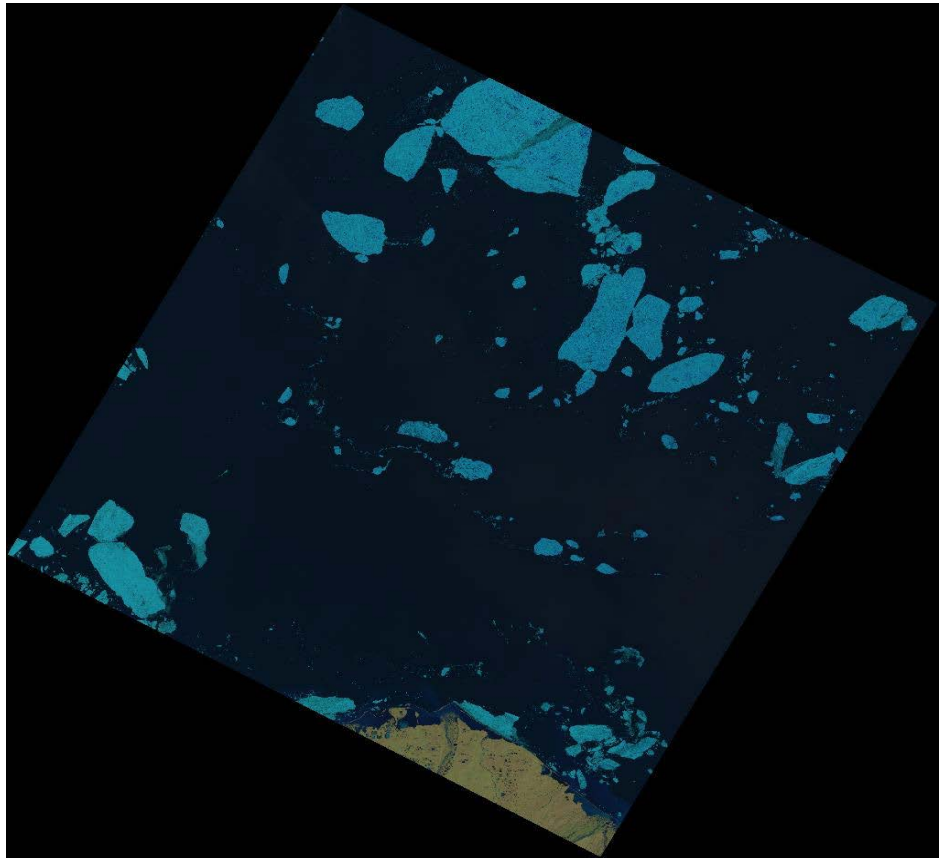




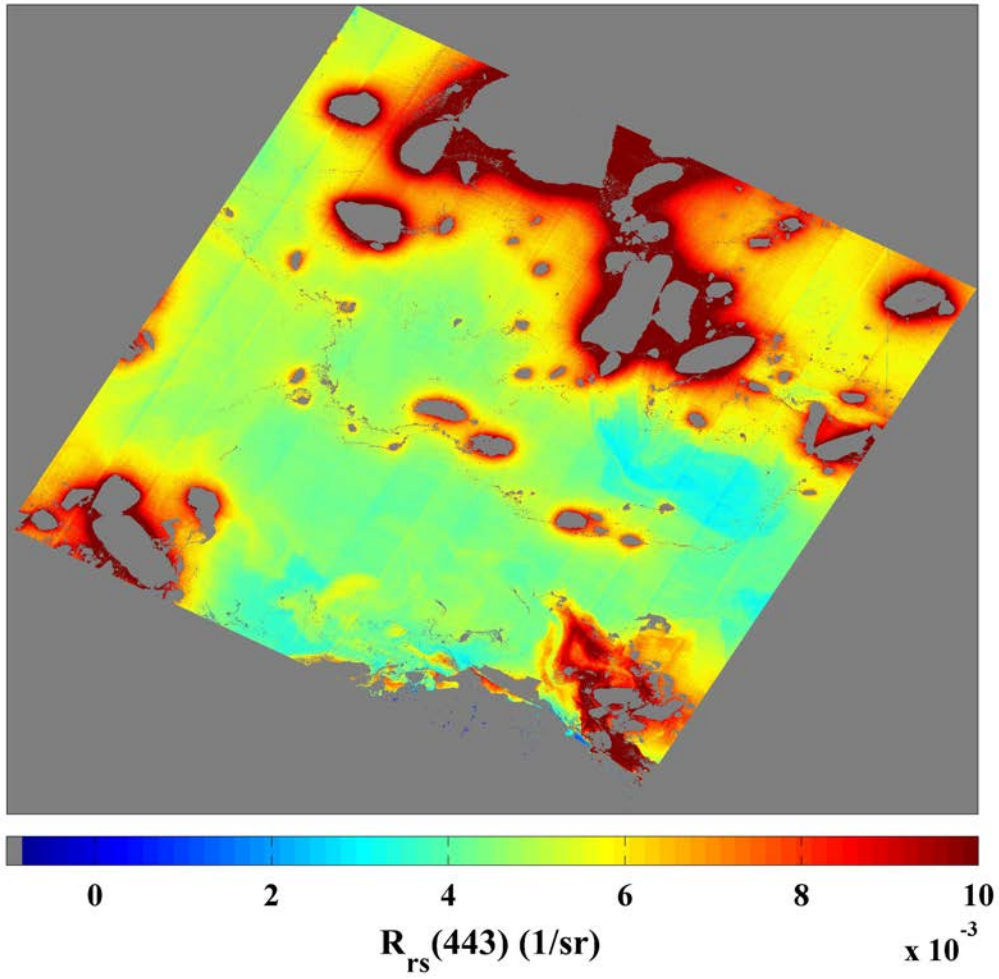
In collaboration with Clémence Goyens & Simon Bélanger

Adjacency effects (ice)

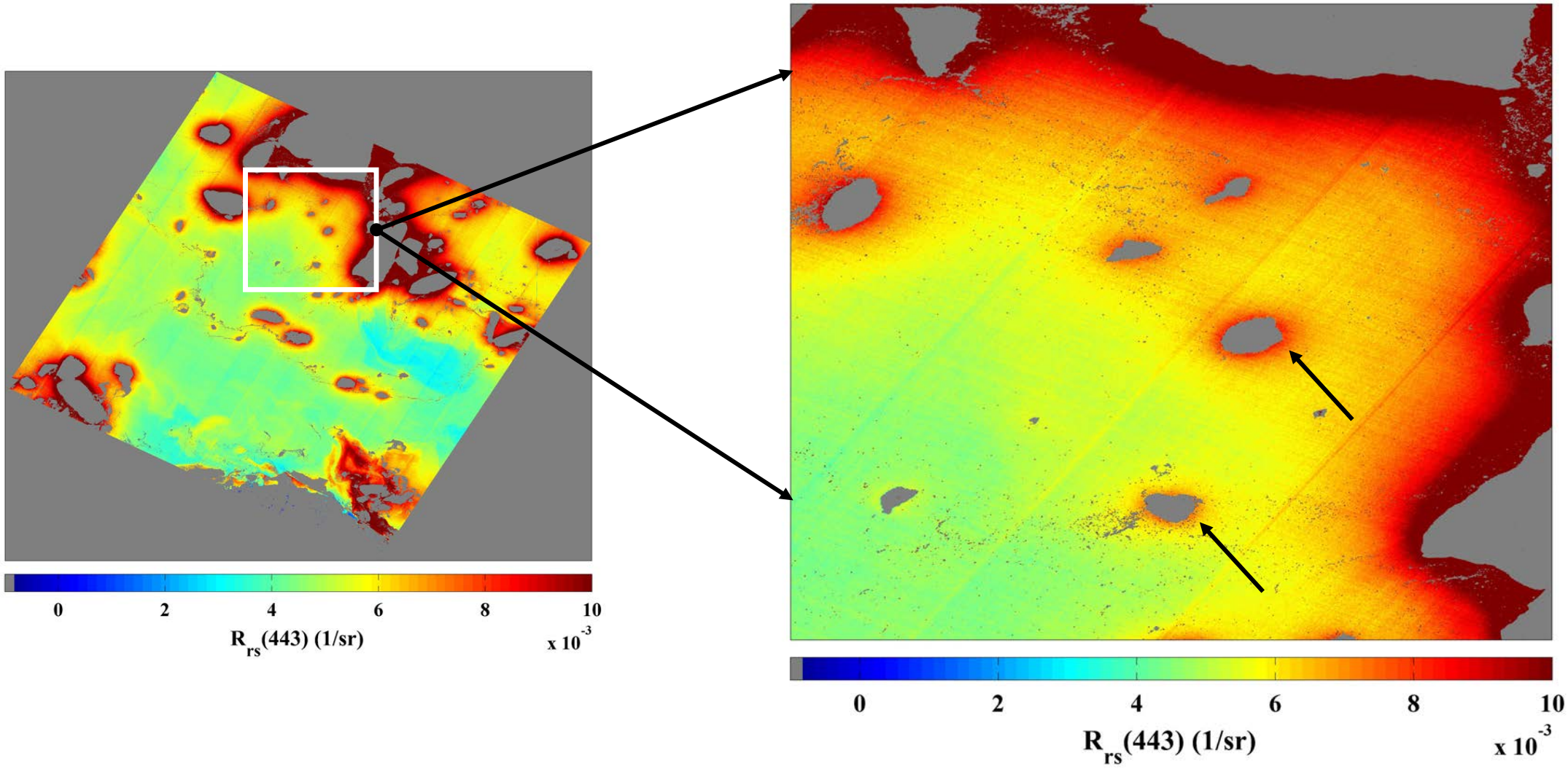
Mackenzie River Delta (June 24th 2016)



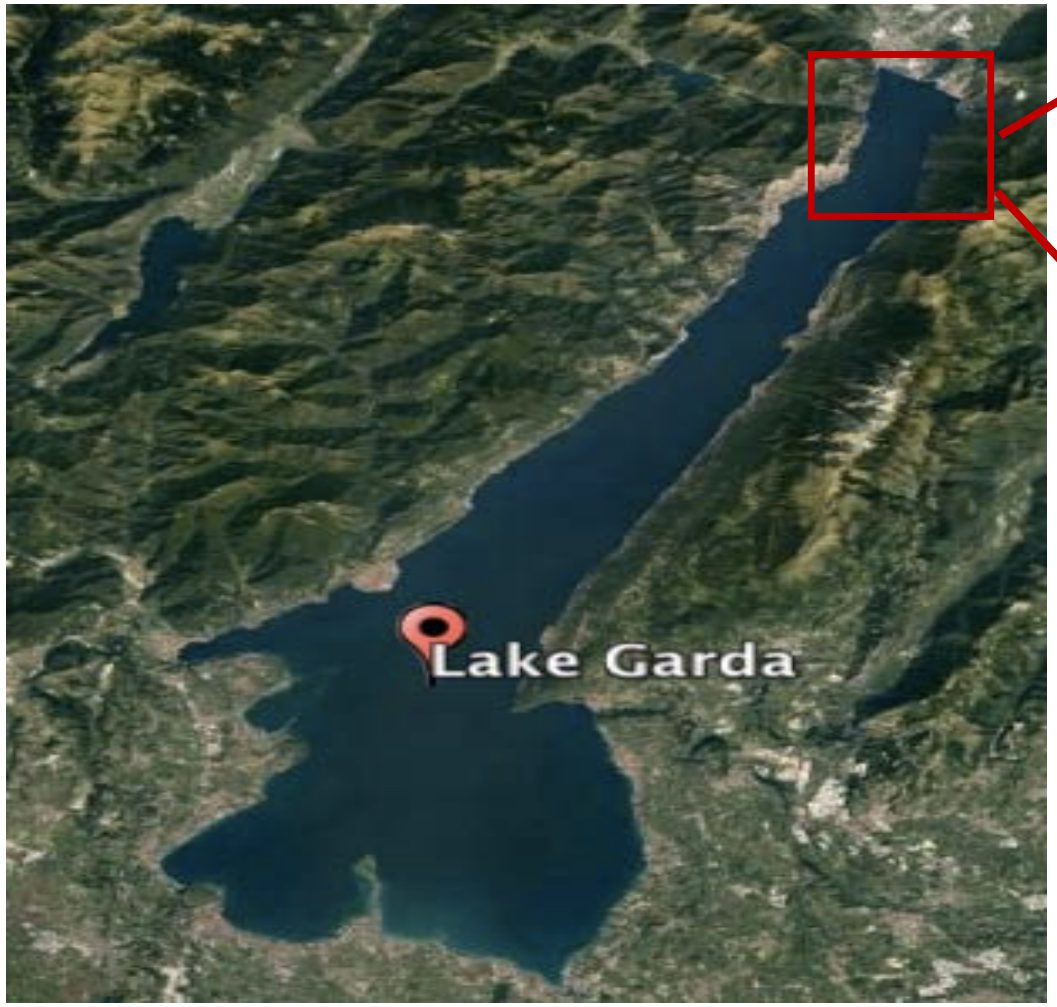
Landsat-8 (OLI)



Adjacency effects (ice)



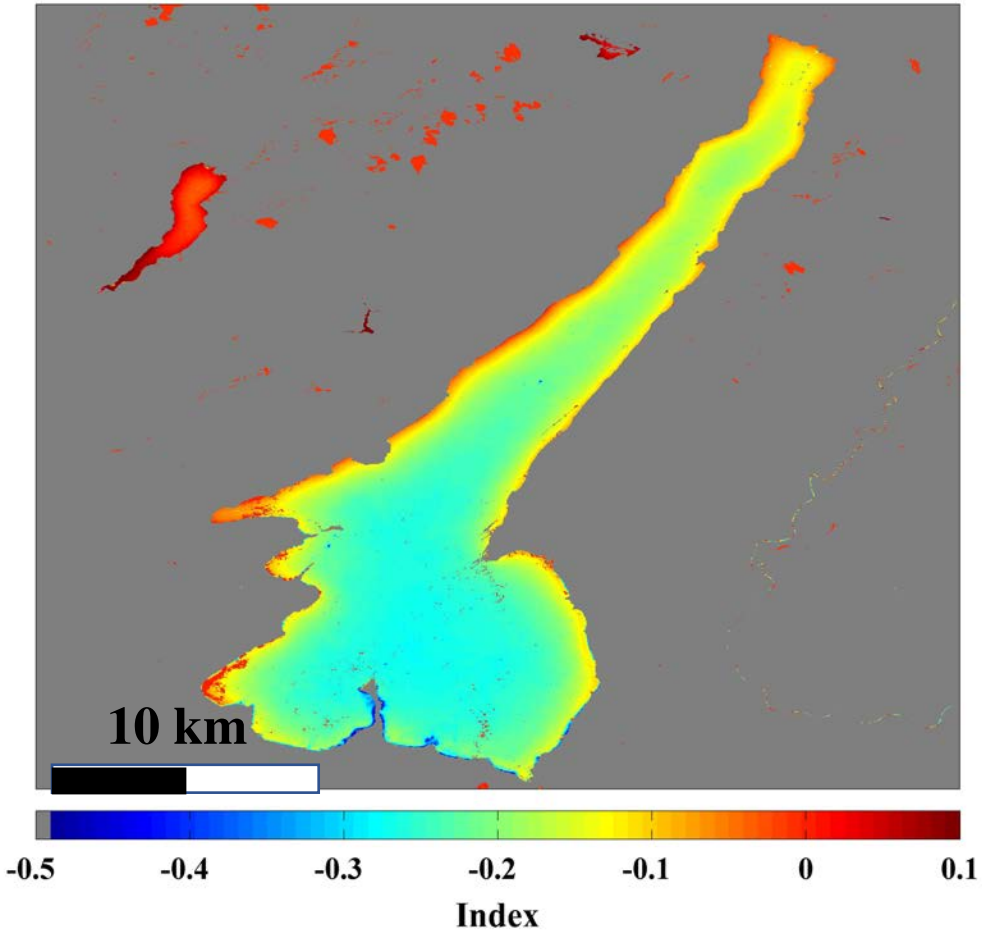
Adjacency effects (land)

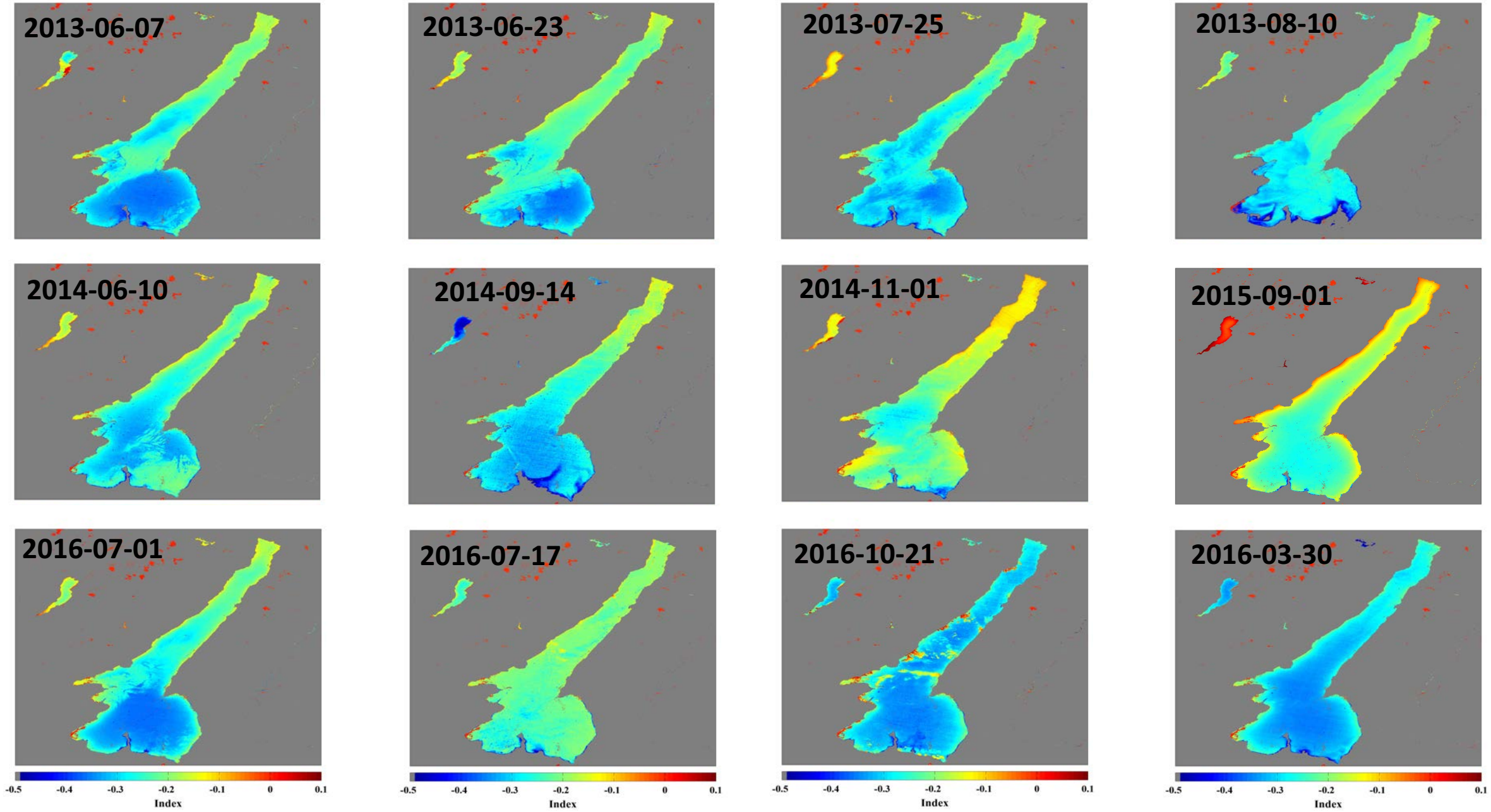


Adjacency effects (land)

- Landsat example(s)
  - NDVI calculated using Rayleigh-corrected radiance
  - **Warmer** colors indicate impacts of adjacency effects

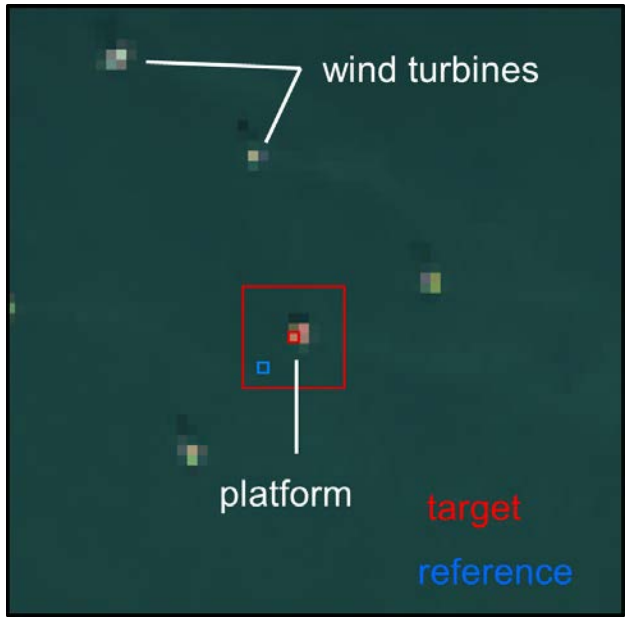
2015-09-01



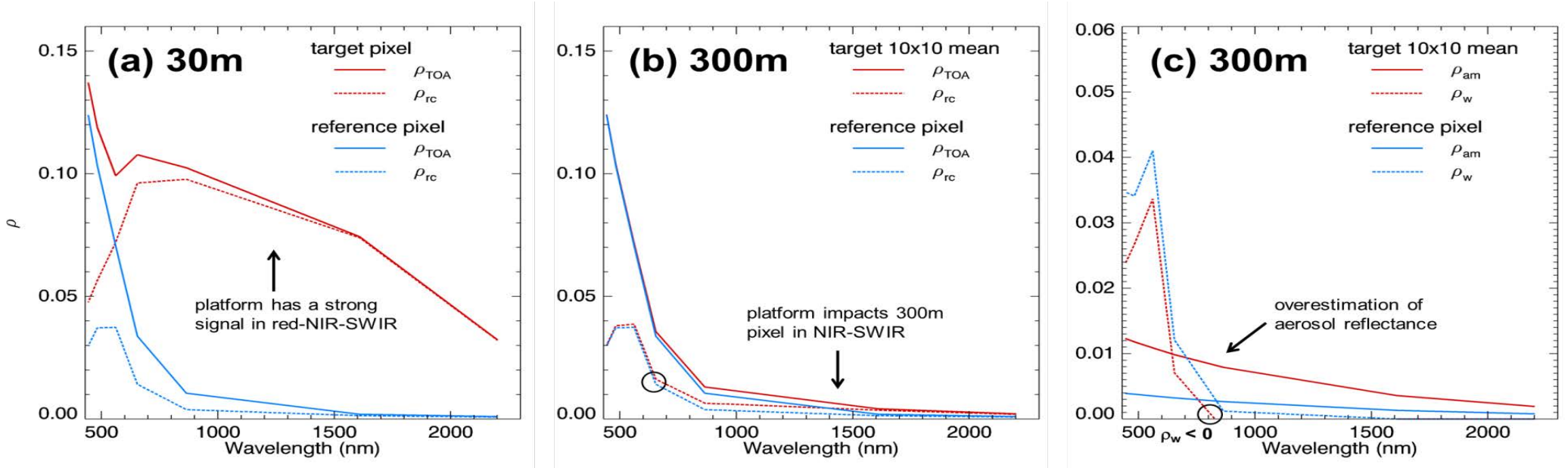


Note **how adjacency effects vary from time to time**. Dependency on environmental conditions & solar angles is clearly observed.

Adjacency effects (man-made structures)



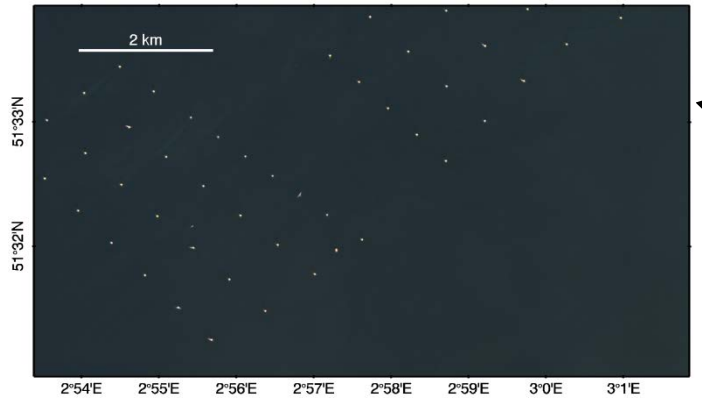
Landsat 8/OLI image of CPower wind farm &
OTS platform (AERONET-OC station)



Vanhellemont Q. & Ruddick K. (2015b) **Assessment of Sentinel-3/OLCI sub-pixel variability and platform impact using Landsat-8/OLI** Submitted for the proceedings of the Sentinel-3 for Science Workshop, ESA Special Publication SP-734

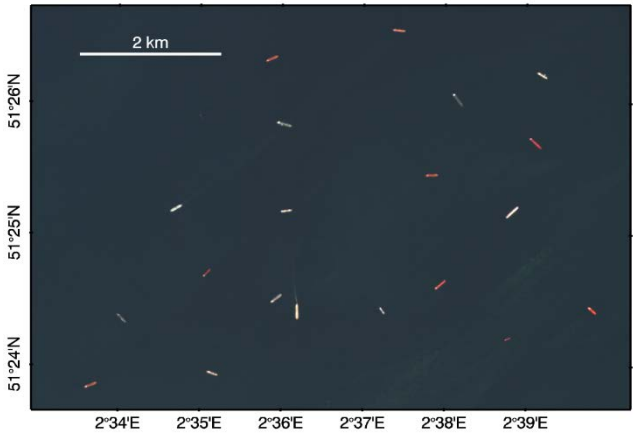
Adjacency effects (man-made structures)

CPower Windfarm



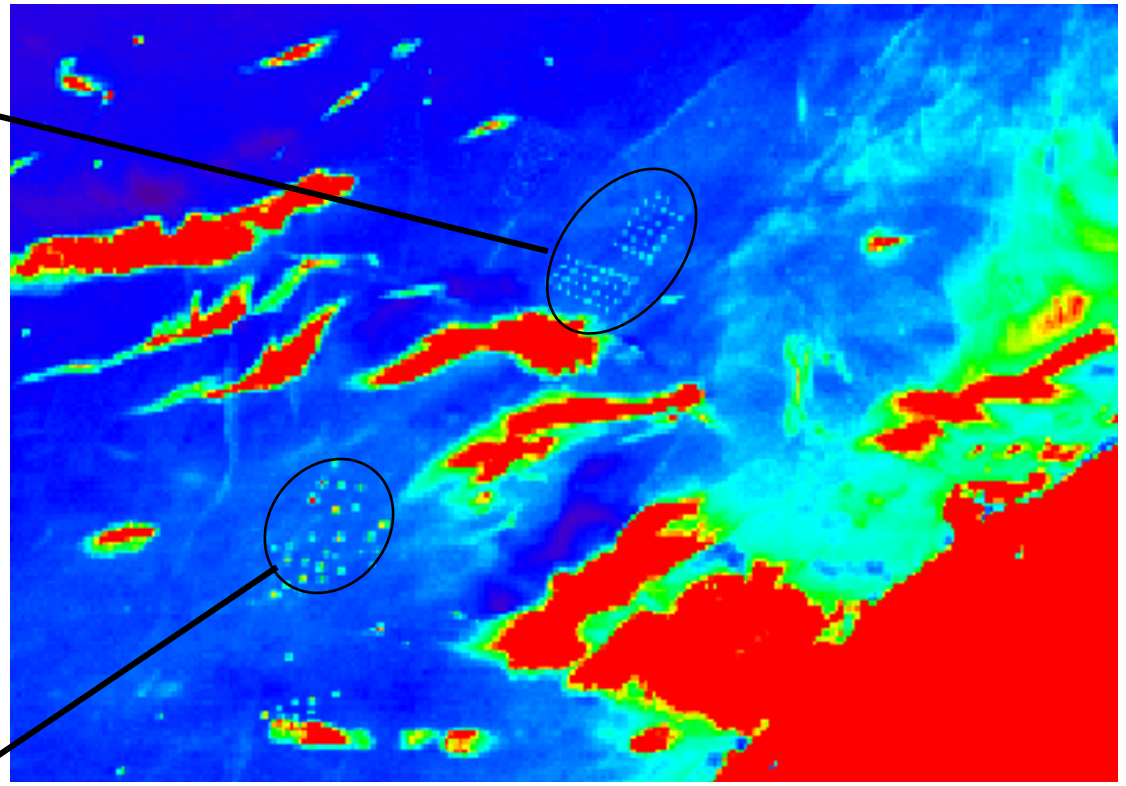
S2A/MSI 2016-09-08

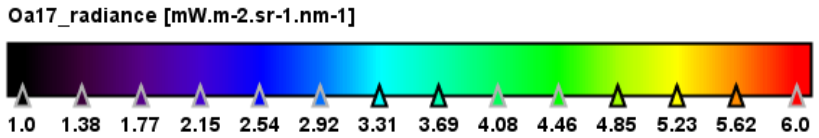
Ship Anchorage



S2A/MSI 2016-09-08

Belgian Coastal Zone 2016-07-18
OLCI TOA radiance 865nm

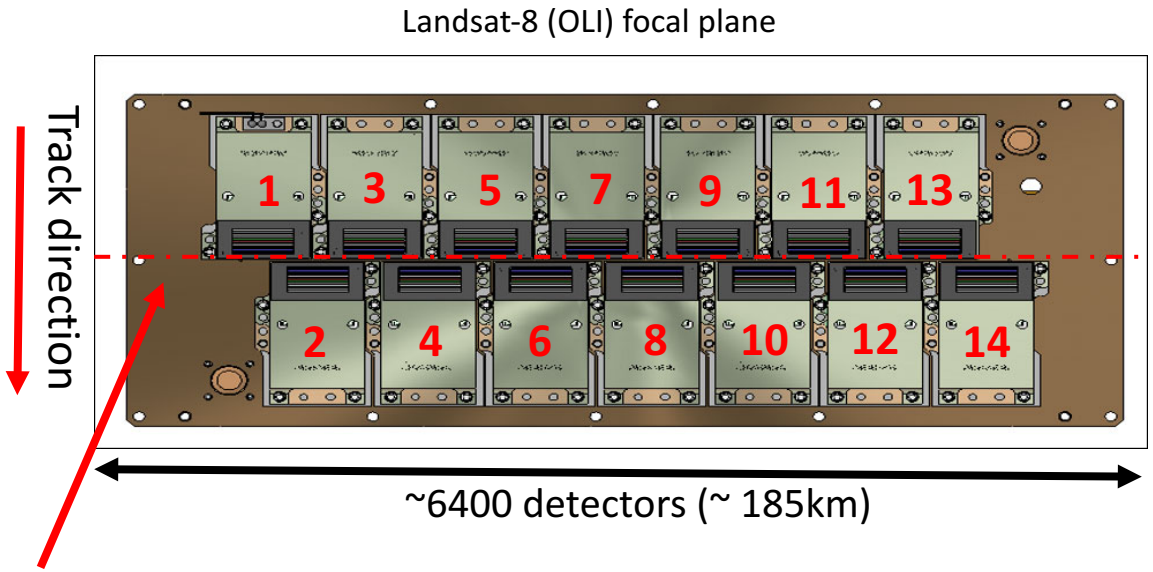


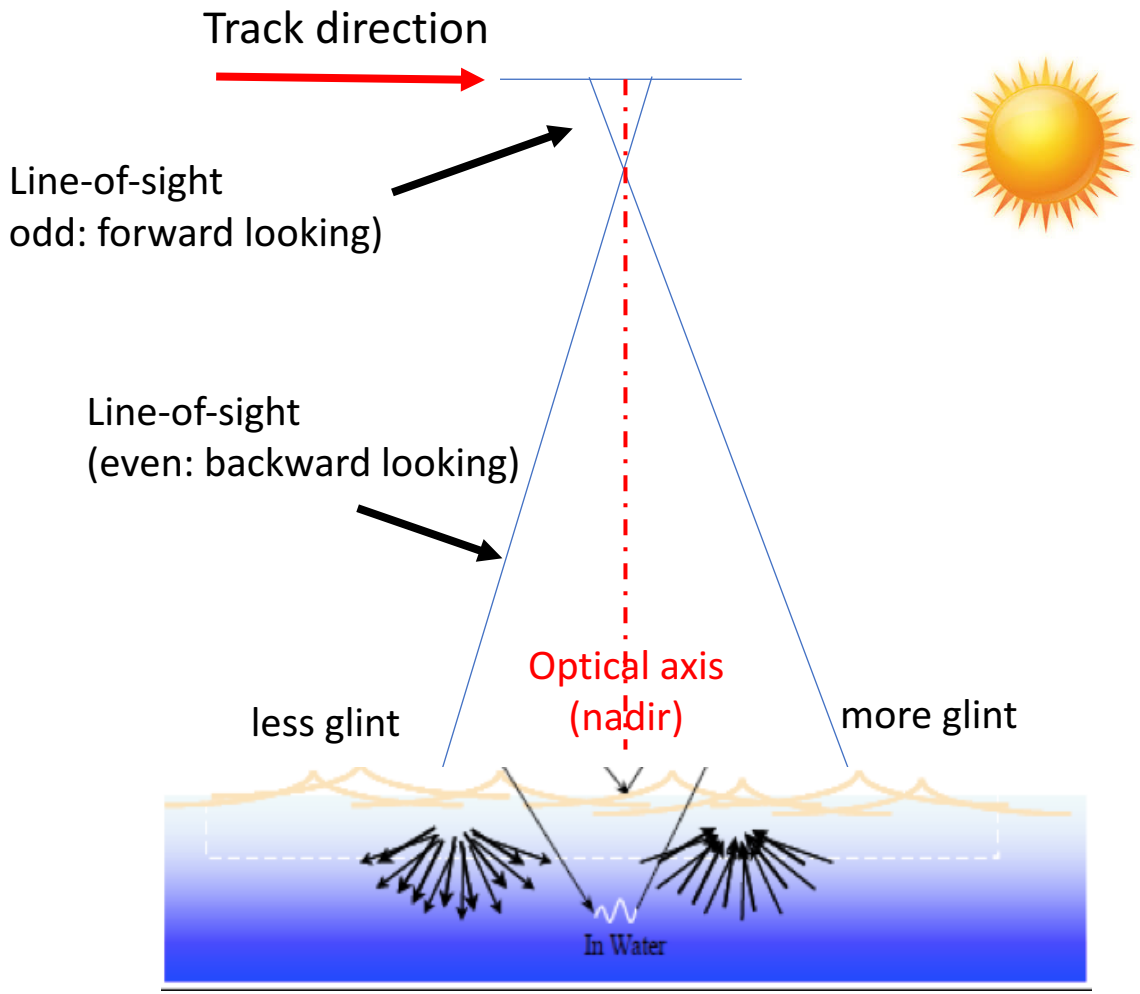


(presented by Héloïse Lavigne at S3VT)

Sunglint & impact of instrument design

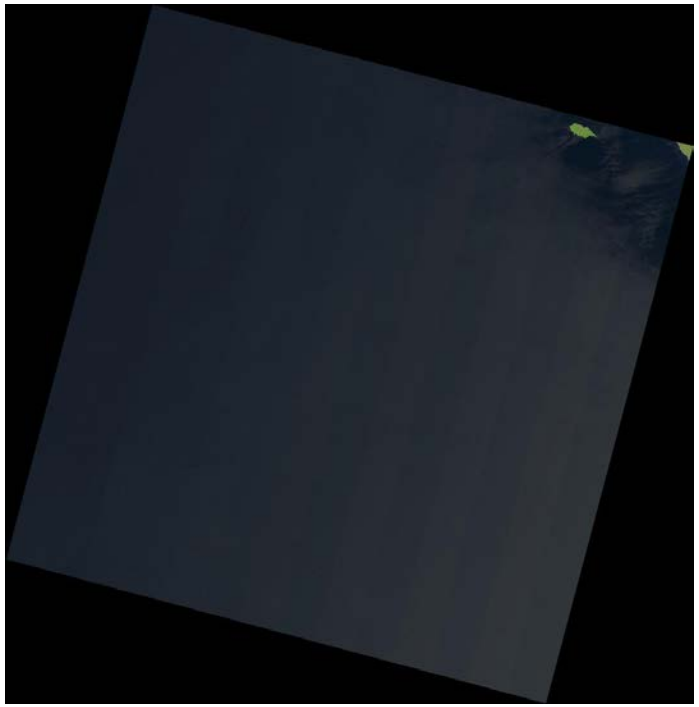
- Examples from Landsat-8/Sentinel-2



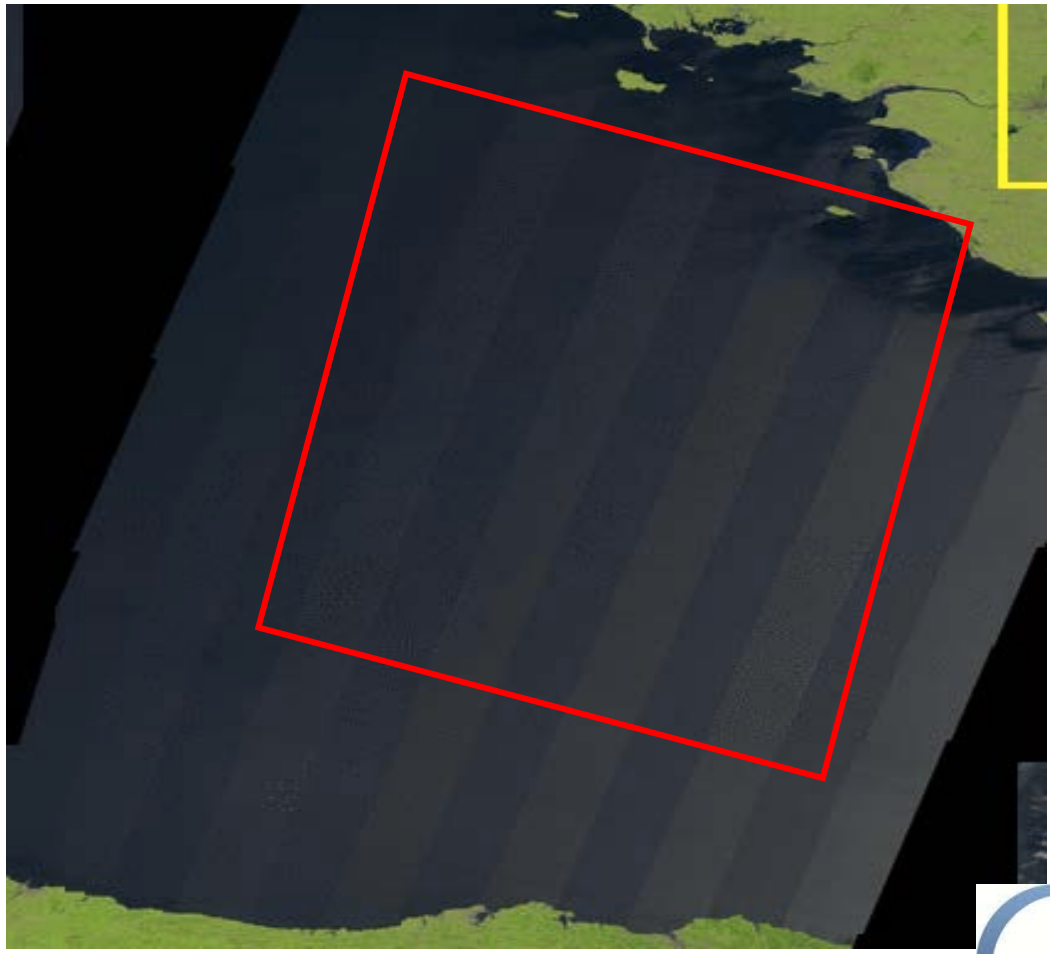


Sunglint: Near-simultaneous Landsat-8/Sentinel-2 Images

Landsat-8



Sentinel-2A



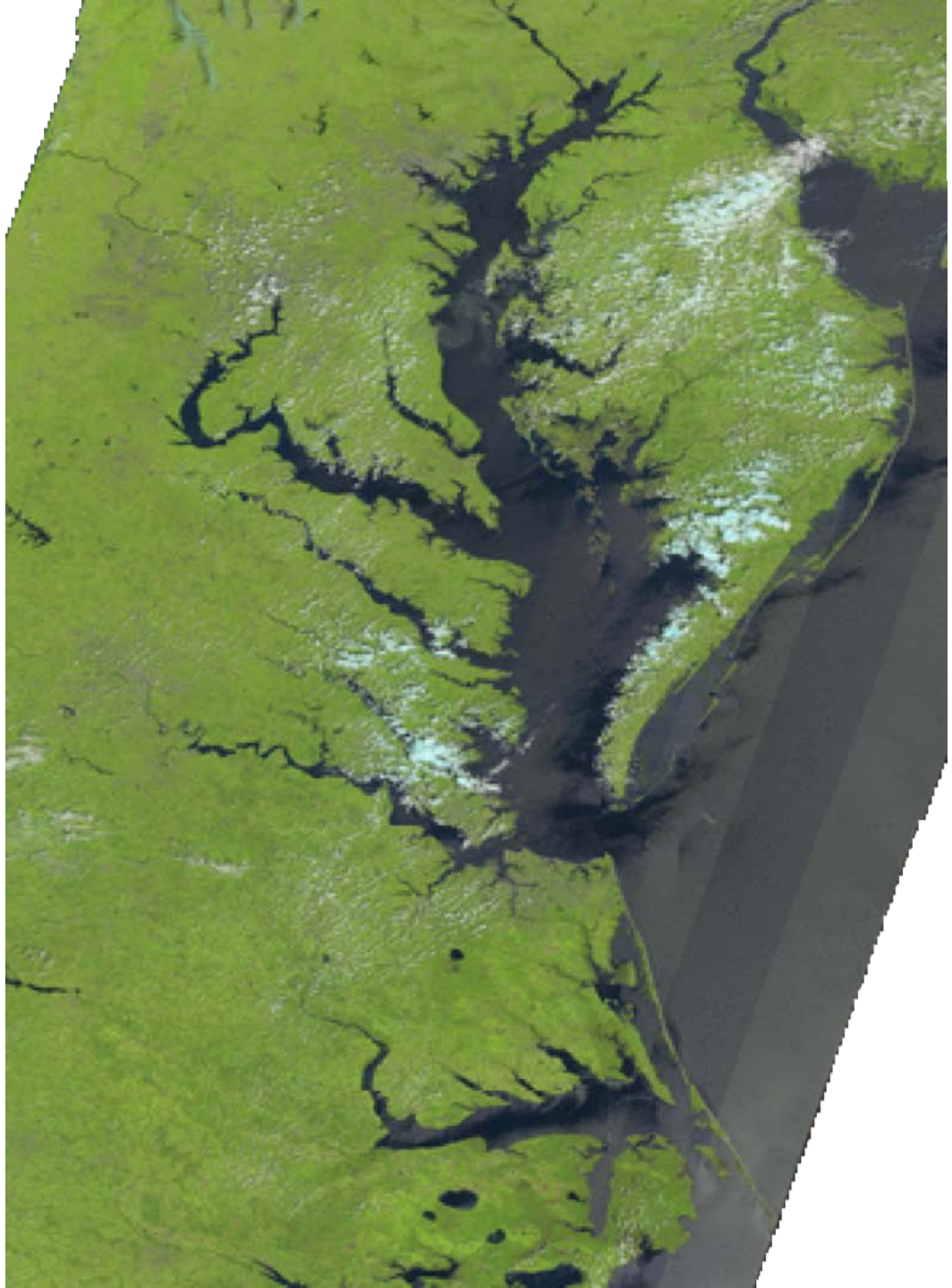
USGS science for a changing world

Copernicus The European Earth Observation Programme

Southern Italy & Malta
Sentinel-2A (MSI)
SZA ~ 22°
Time ~ 10:00

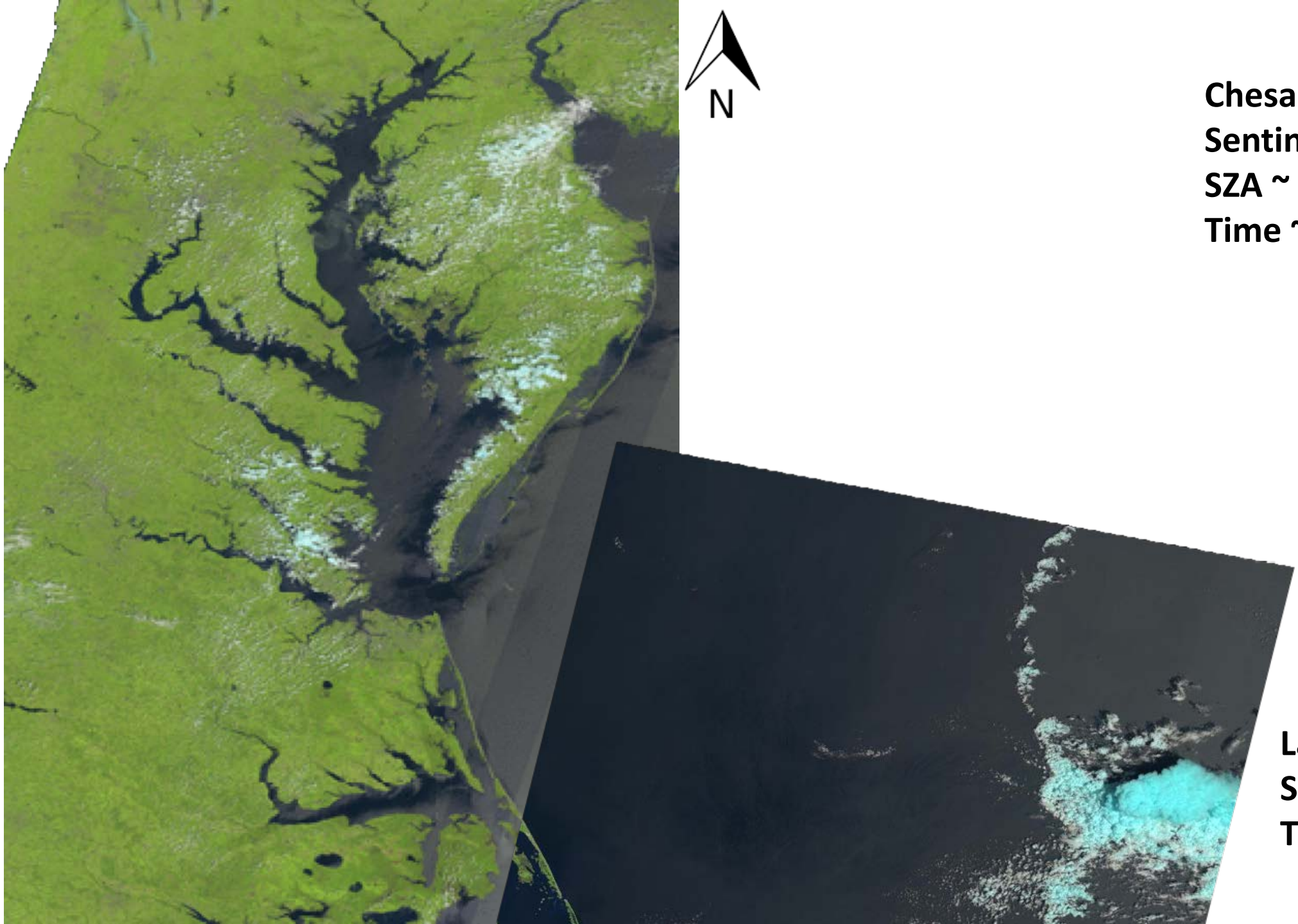
View zenith angle ~ 11°


Southern Italy & Malta
Sentinel-2A (MSI)
SZA ~ 22°
Time ~ 10:00
View zenith angle ~ 8°
Landsat-8 (OLI)
SZA ~ 26.2°
Time ~ 9:35 GMT
N



N

Chesapeake Bay
Sentinel-2A (MSI)
SZA ~ 22
Time ~ 16:00 GMT

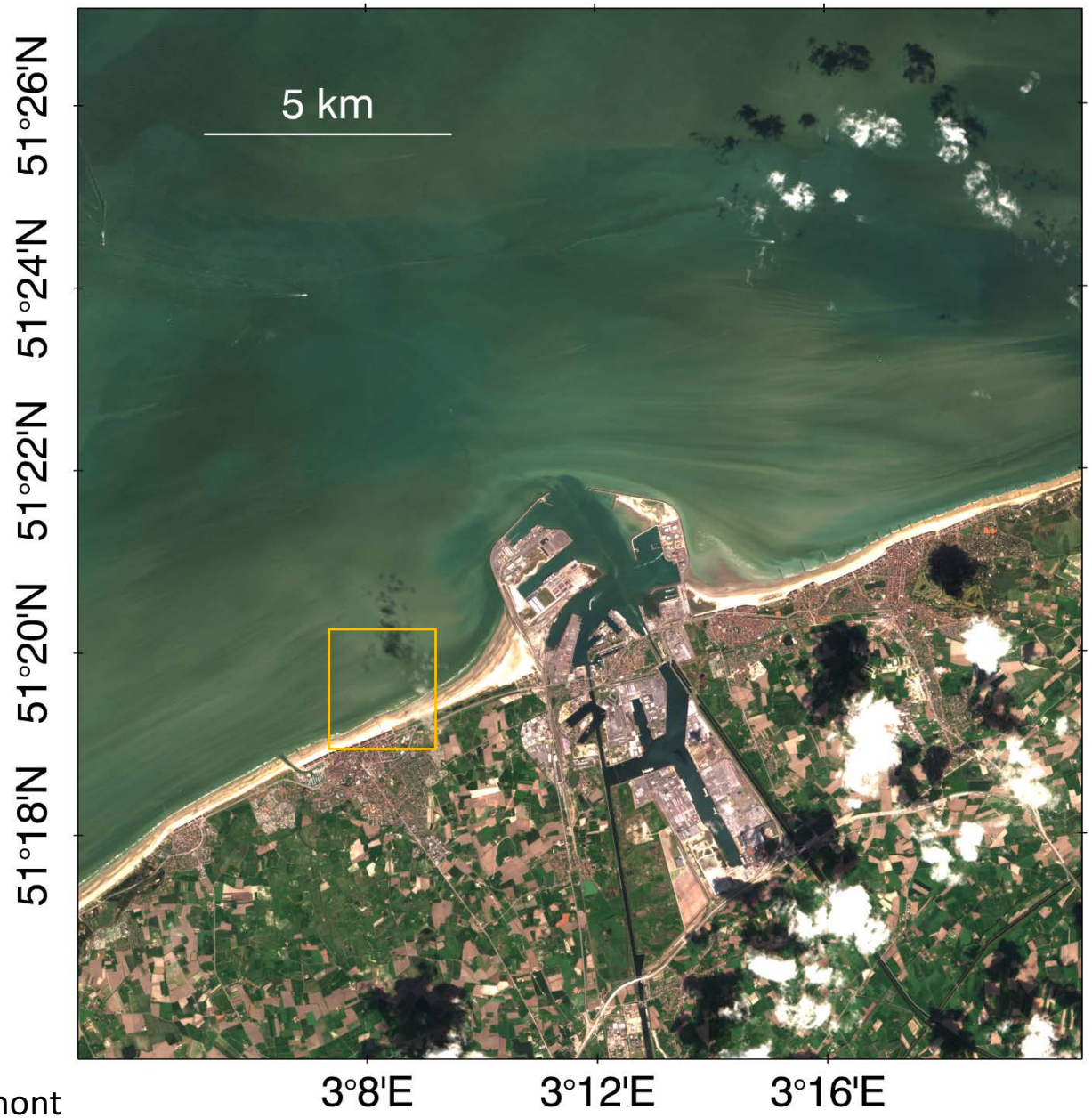


Chesapeake Bay
Sentinel-2A (MSI)
SZA ~ 22
Time ~ 16:00 GMT

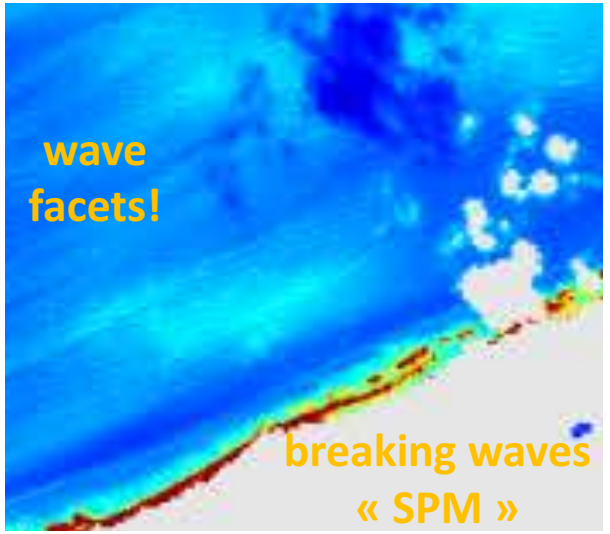
Landsat-8 (OLI)
SZA ~ 25°
Time ~ 15:35 GMT

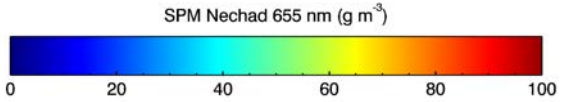
Cloud shadows & wave facets

Belgian coastal zone / Zeebrugge
Sentinel-2A/MSI 2017-04-19



Wave facets, breaking waves resolved -> SPM product

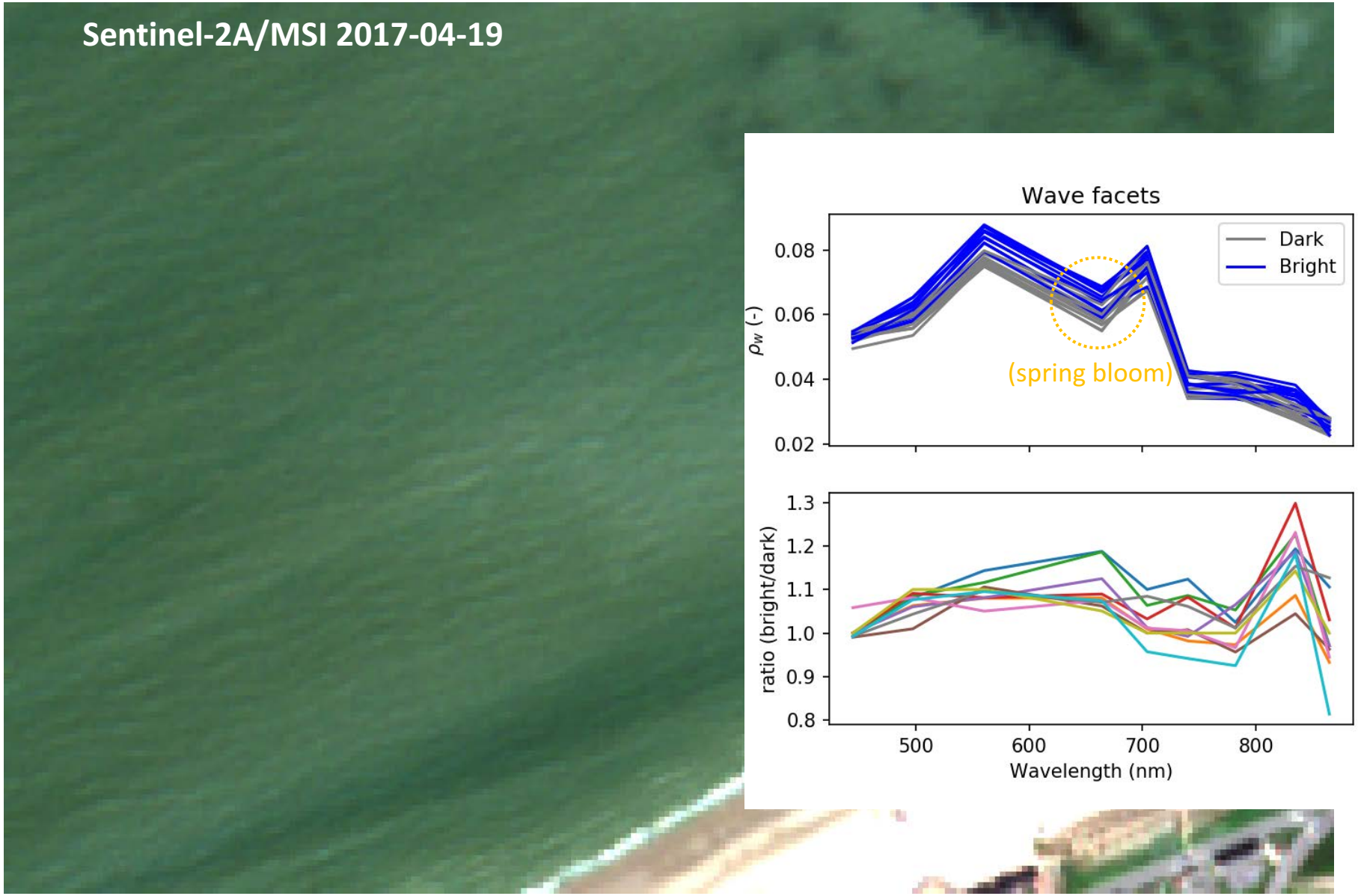




Credit: Q. Vanhellemont

Bright/dark wave facets: 10-30% difference in ρw

(+ timing/view differences across bands)



Credit: Q. Vanhellemont

Let’s discuss all these issues…