Federal Ministry
of Research, Technology
and Space

ATMOSPHERIC CORRECTION FOR HYPERSPECTRAL MISSIONS:

Lessons learned from present narrow – like EnMAP – to future wide swath instruments.

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DLR

ADJACENCY CORRECTION

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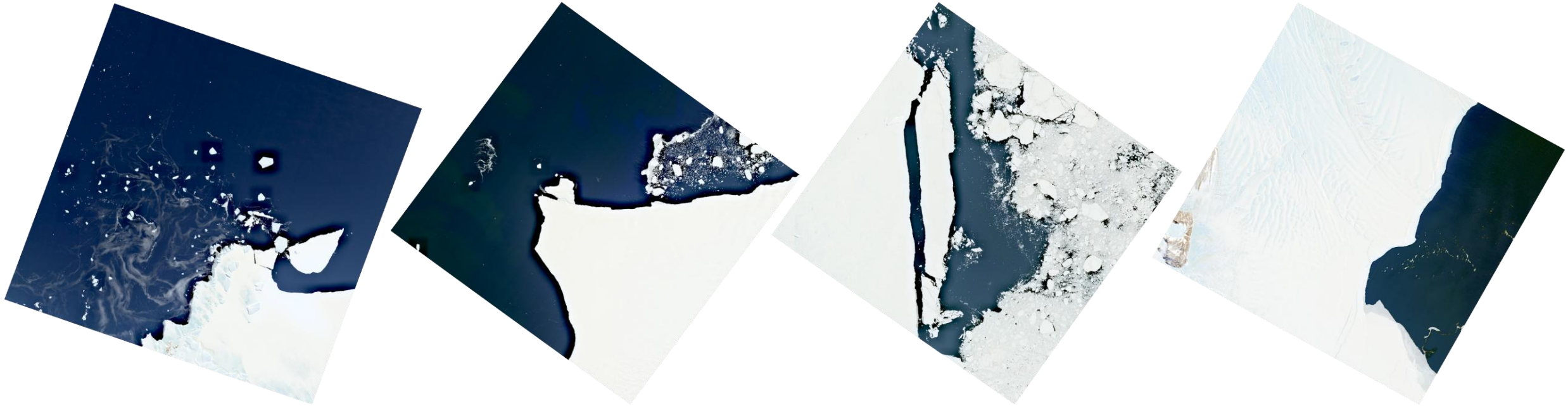
EnMAP acquisitions

- No detailed physical model needed
- Fast and drift ice over deep water
- **Assume**: deep water is spatially homogeneous
- Find adjacency **kernel** via optimization

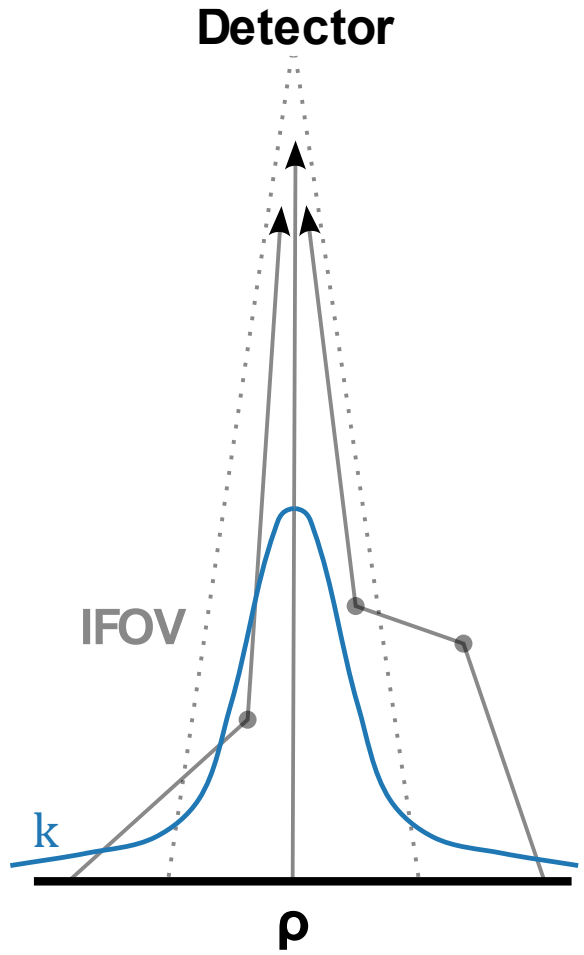


Approach

- **Model**: subtract difference of reflectance ρ to averaged reflectance $\bar{\rho}$ [1]

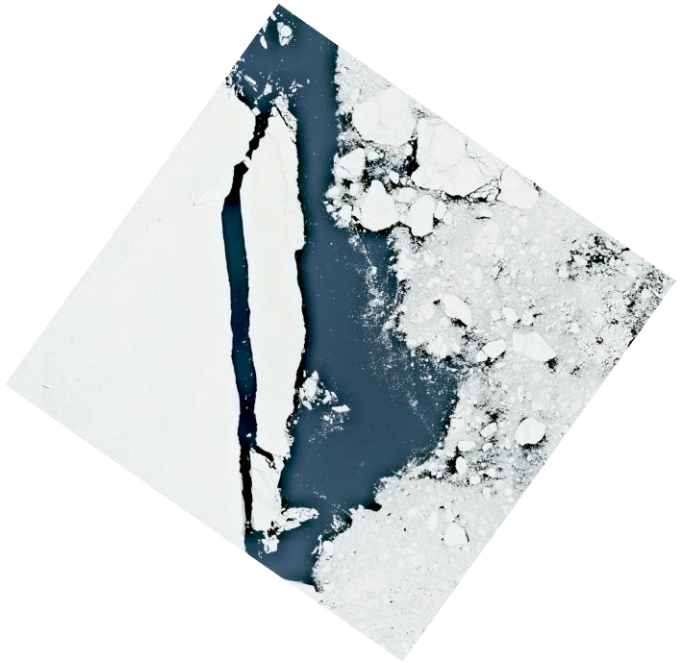
$$\rho' = \rho - \frac{\tau_{dif}}{\tau_{dir}}(\rho - \bar{\rho})$$

- $\bar{\rho} = k * \rho$ via convolution with kernel k
- **Aim**: find the averaging kernel k (independent of λ)
- λ dependence in diffuse-to-direct transmittance ratio $\frac{\tau_{dif}(\lambda)}{\tau_{dir}(\lambda)}$



[1] Rudolf Richter (1990): *A fast atmospheric correction algorithm applied to Landsat TM images*, REMOTE SENSING, 11:1, 159-166, DOI: 10.1080/01431169008955008

DT110541



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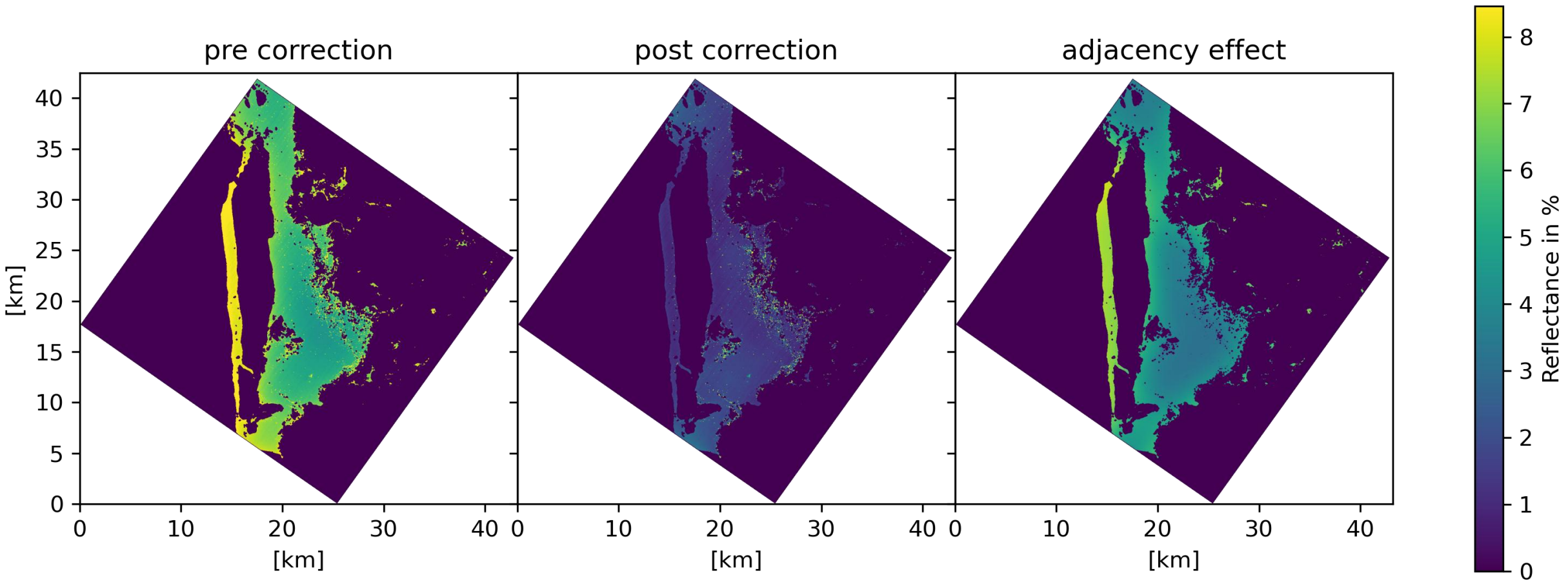
pre correction
post correction
adjacency effect
[km]
[km]
[km]
[km]
0
10
20
30
40
0
5
10
15
20
25
30
35
40
Reflectance in %
0
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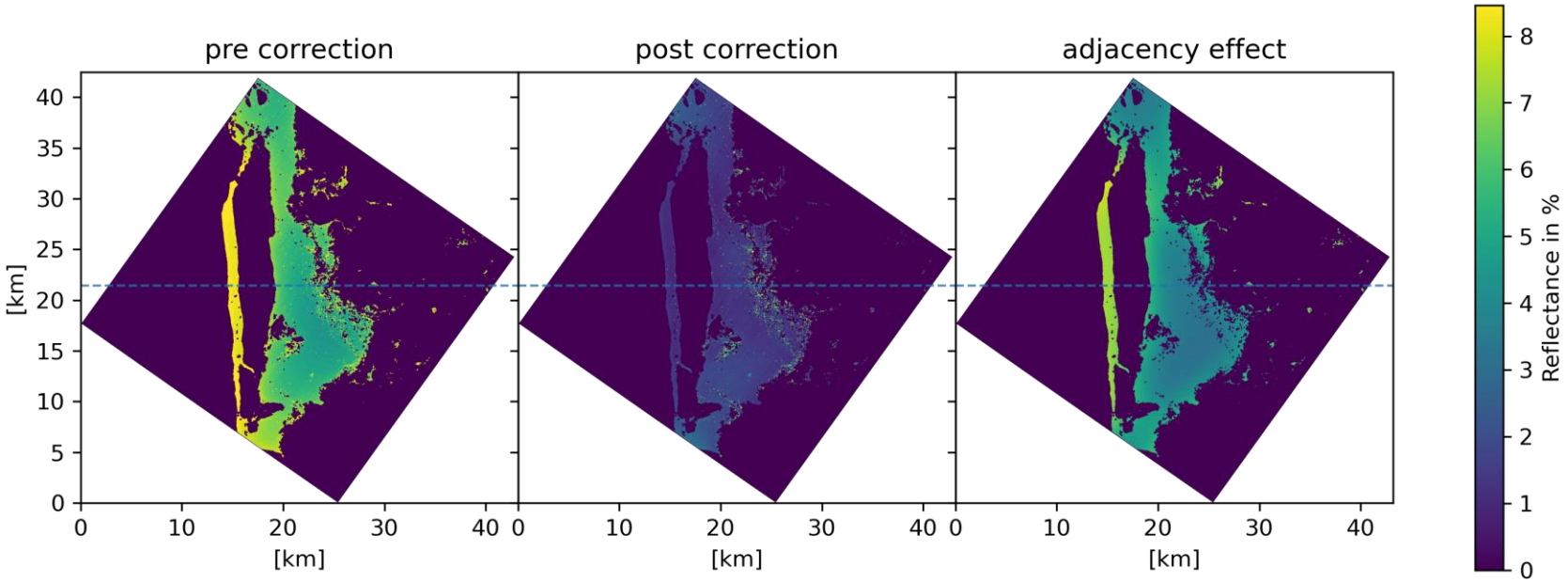
2
3
4
5
6
7
8

DT110541


pre correction
post correction
adjacency effect
[km]
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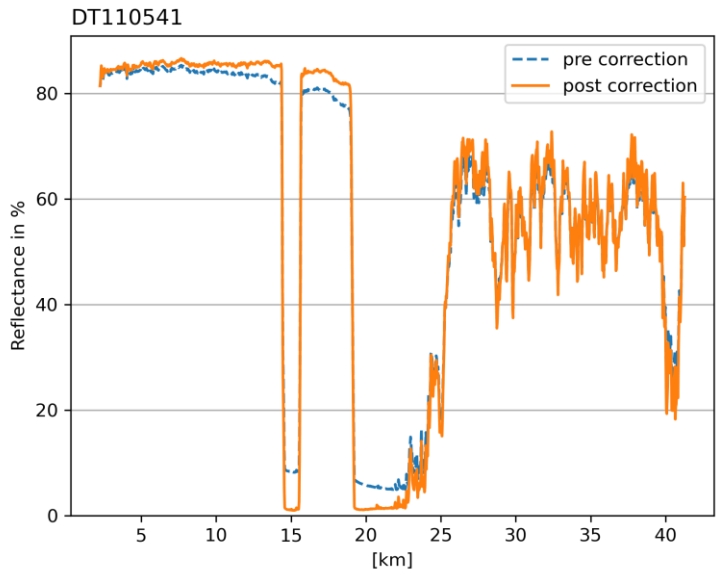
Reflectance in %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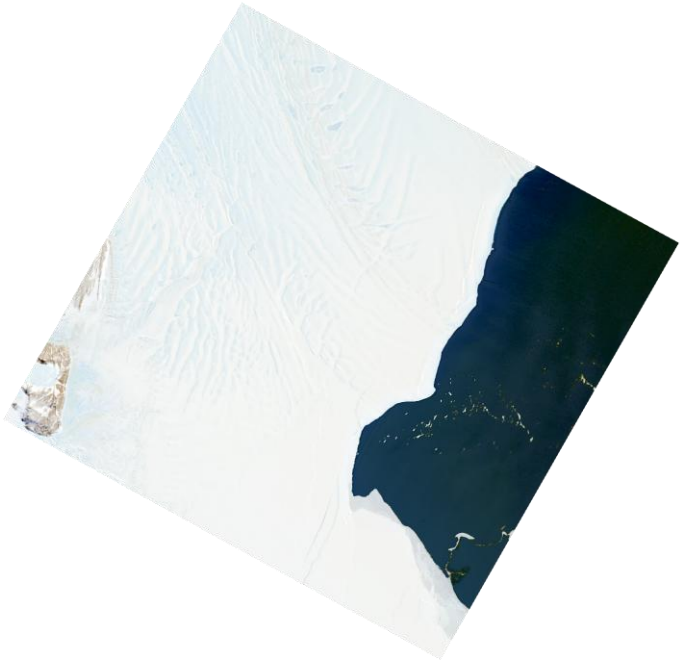
pre correction
post correction
Reflectance in %
[km]

DT168868



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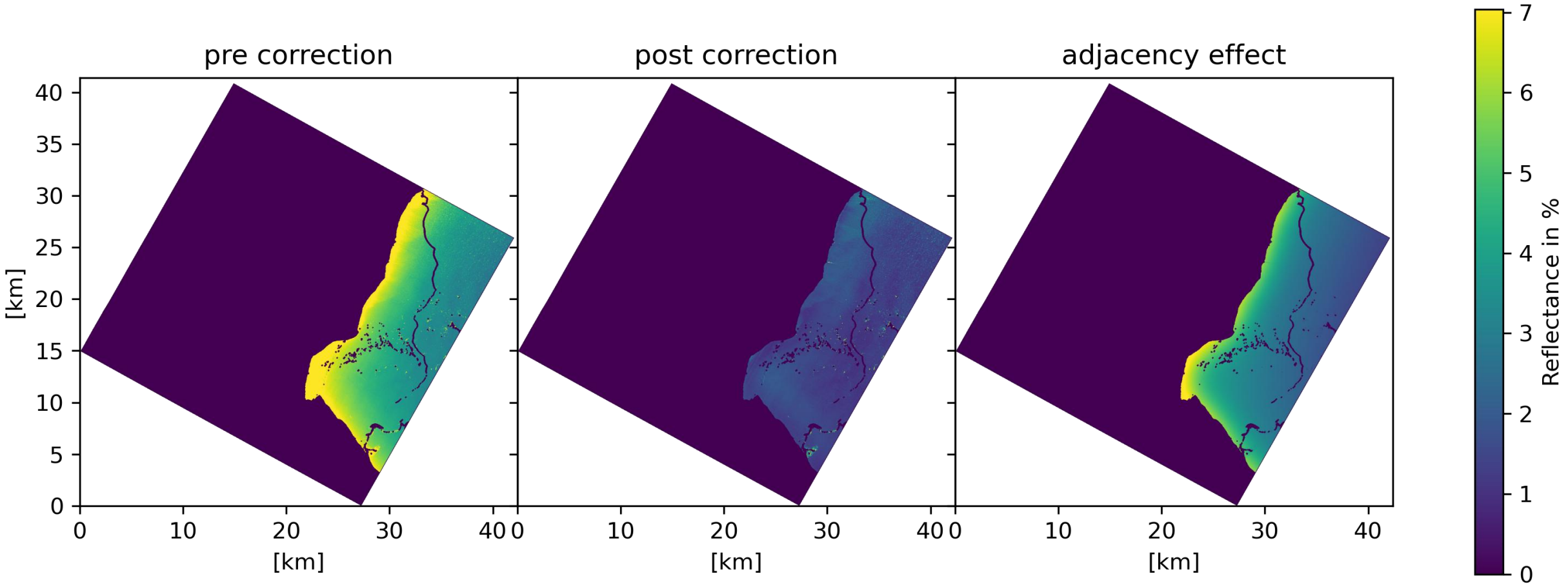
pre correction
post correction
adjacency effect
[km]
[km]
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Reflectance in %
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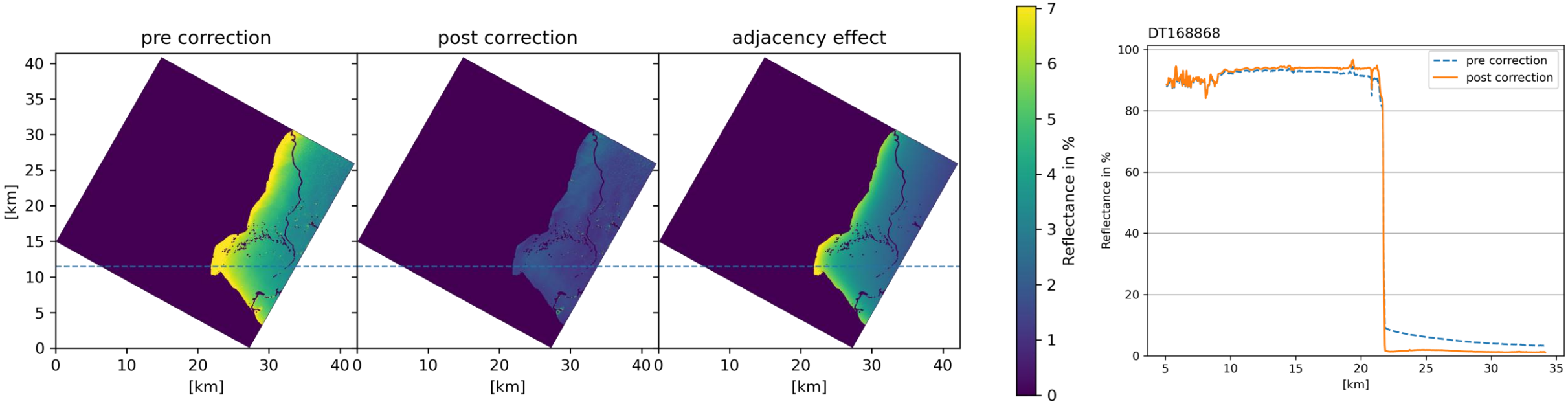
DT168868


pre correction
post correction
adjacency effect
[km]
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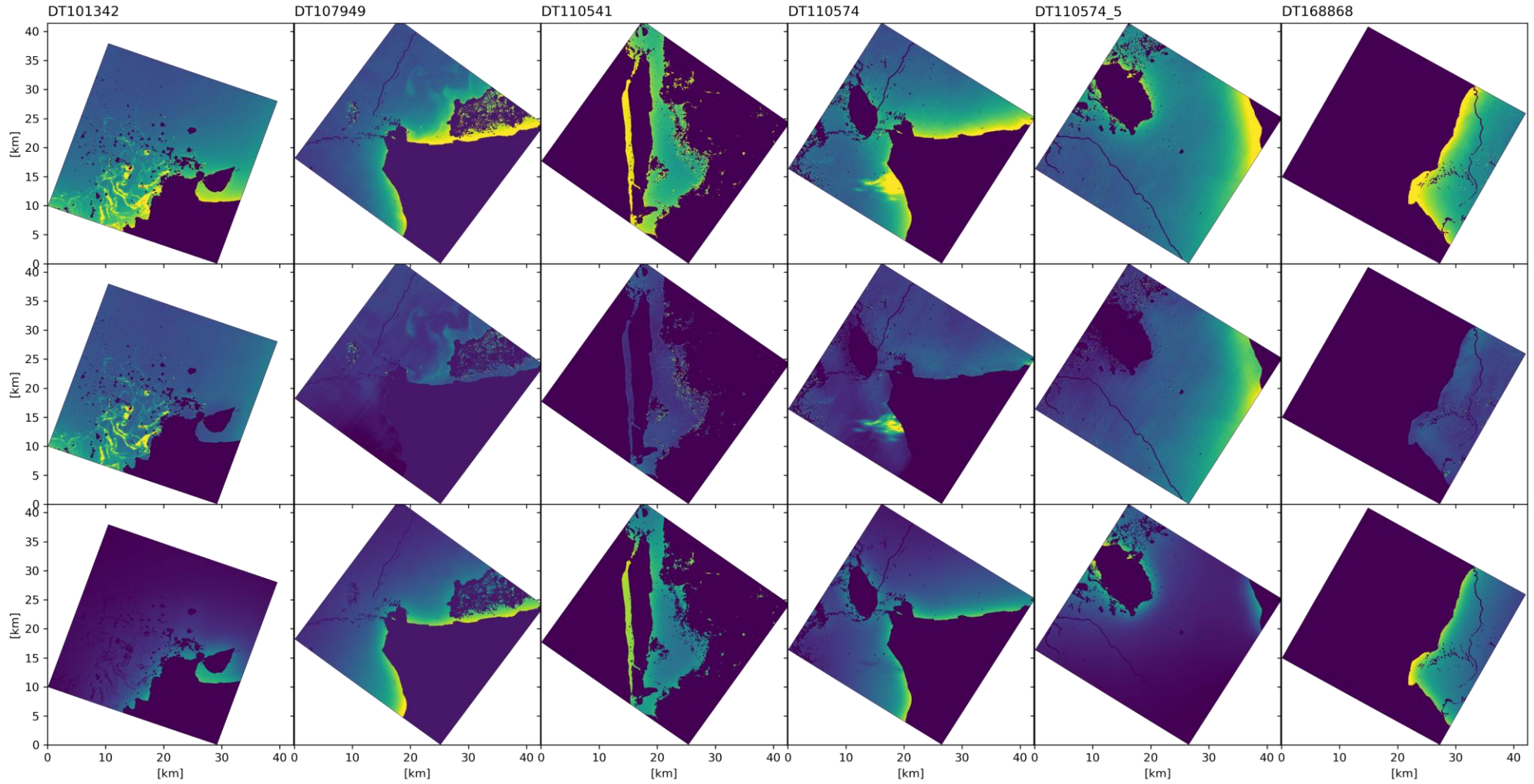
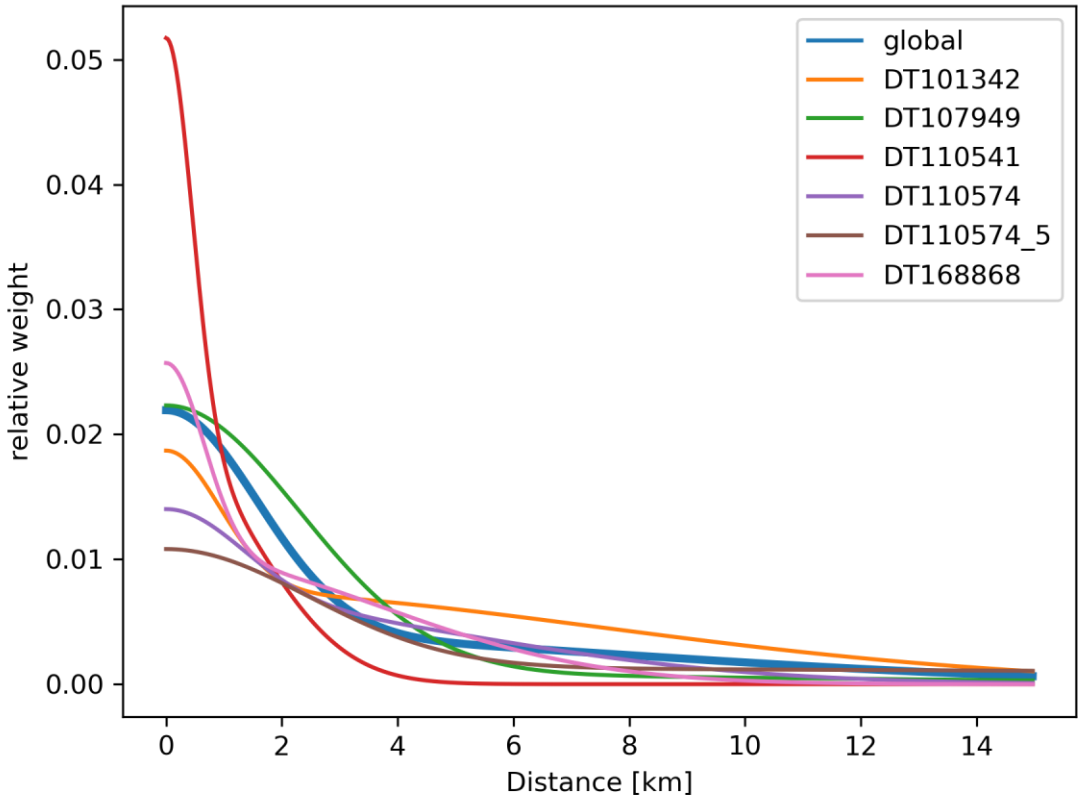
Reflectance in %
DT168868
pre correction
post correction
Reflectance in %
[km]

Overview


DT101342
DT107949
DT110541
DT110574
DT110574_5
DT168868
[km]
[km]

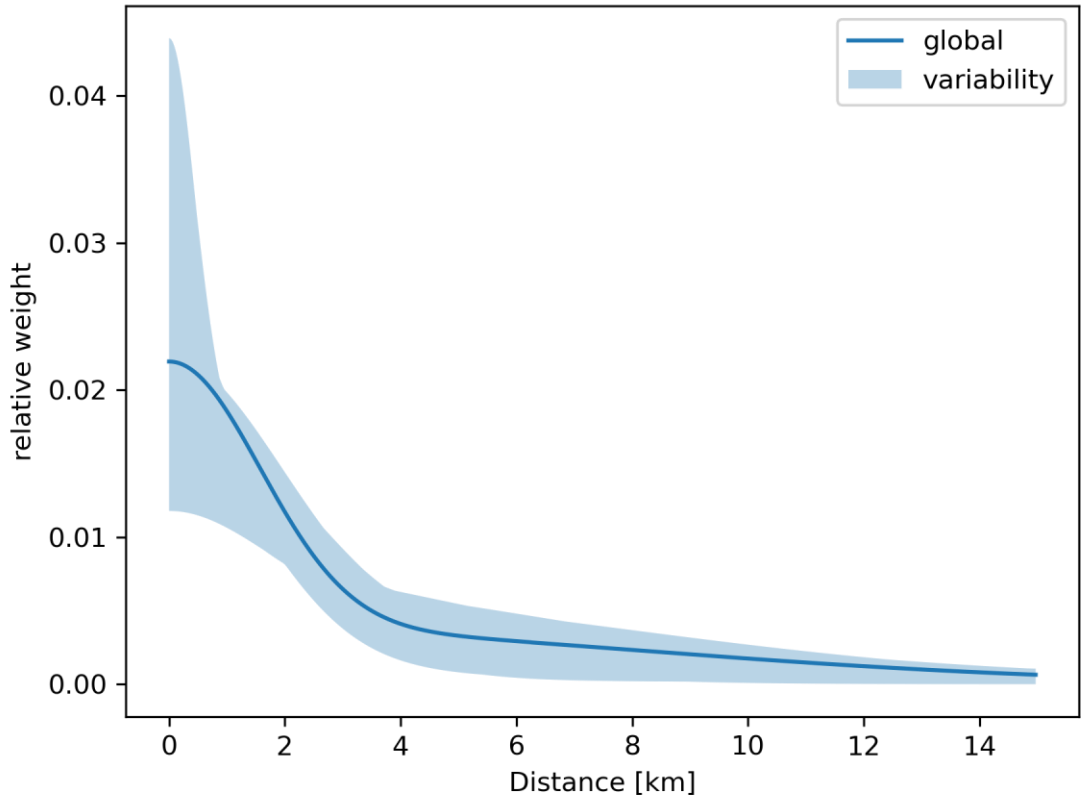
Kernel after per-scene optimization

Model:
Sum of two **Gaussians** with different scale and magnitude (i.e. four parameters to fit)



Kernel after multi-scene optimization

Model:
Sum of two **Gaussians** with different scale and magnitude (i.e. four parameters to fit)



Conclusions

- Need for:
  - more ice and deep water **scenes**
  - variety of **atmospheric conditions**
  - **in-situ** validation data
- Different homogenous surfaces to cover larger **dynamic range**
- Wider swath and longer strip (with consistent AC)

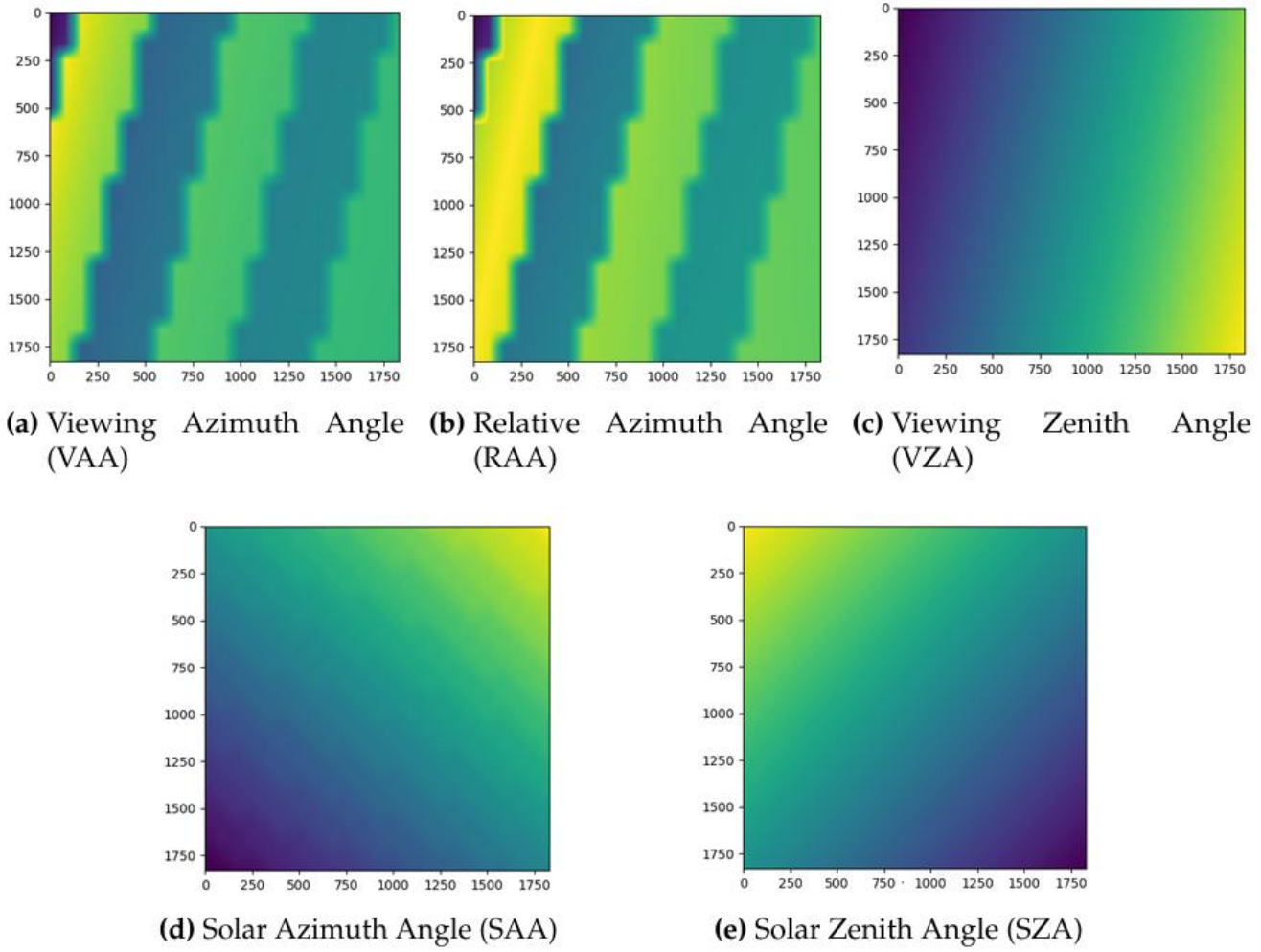
VIEWING ANGLE CORRECTION

Sentinel-2C

Previous Handling of Viewing Angles in PACO

S2 angular metadata has limitations:

- **Step-like artifacts** visible in the VAA and RAA geometry
- AC up to now was only using **mean scene angles** for LUT interpolation

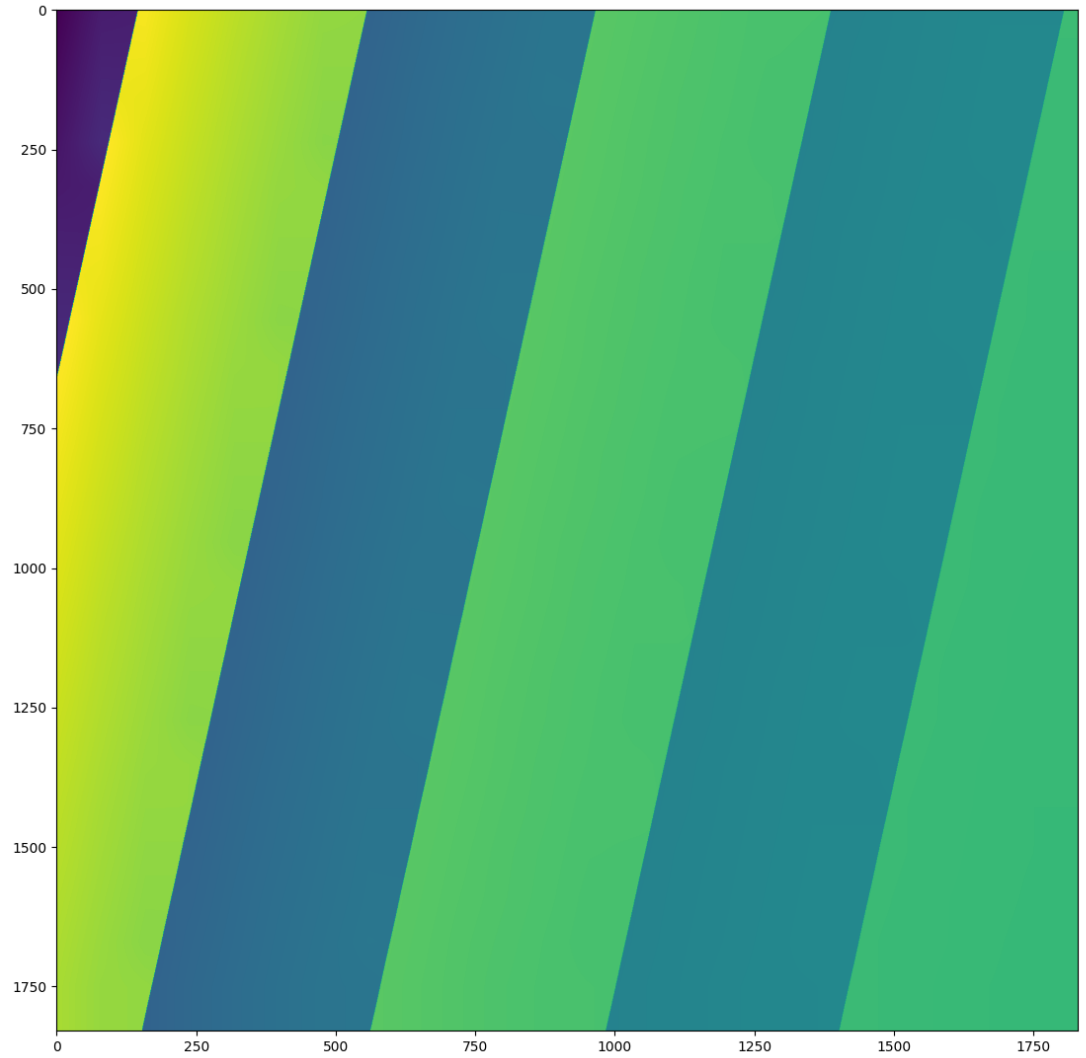


(a) Viewing Azimuth Angle (VAA) **(b)** Relative Azimuth Angle (RAA) **(c)** Viewing Zenith Angle (VZA)

(d) Solar Azimuth Angle (SAA) **(e)** Solar Zenith Angle (SZA)

Receiving the per-pixel angle values

1. Scale coarse angular metadata to band resolution
2. Map viewing angles to correct pixels based on detector map
3. Create high-resolution angle dataset



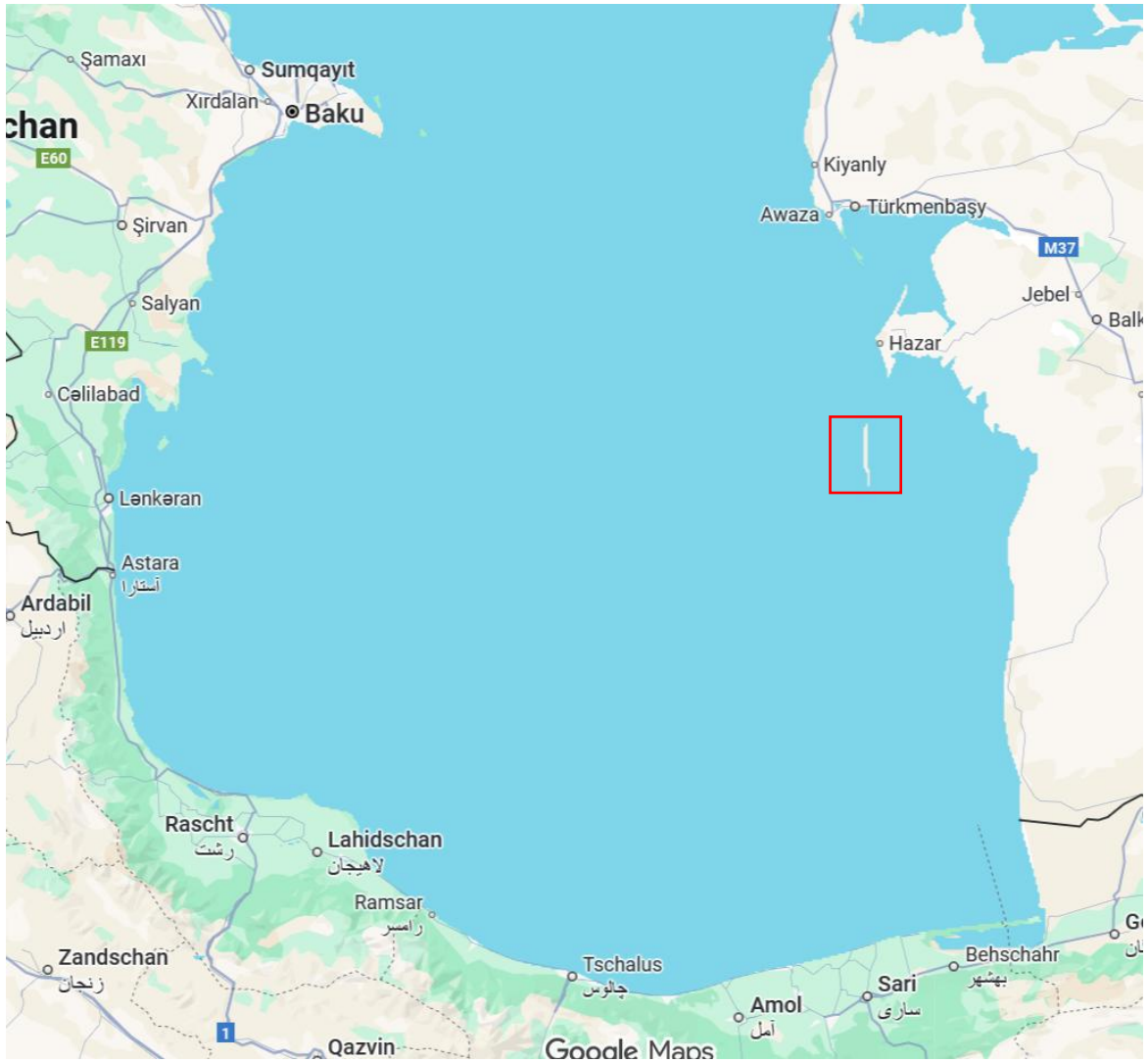
Method as provided in:

Alexis Deru et al. *“Sentinel-2 MSI Level-1 Radiometric Uncertainty Tool, status and application to tandem analysis. Presented at the session: Recent progress on uncertainty analysis for Earth Observation measurements – PART 1”,* Living Planet Symposium 2025. Hall N1/N2, Vienna, Austria, 27 June 2025.

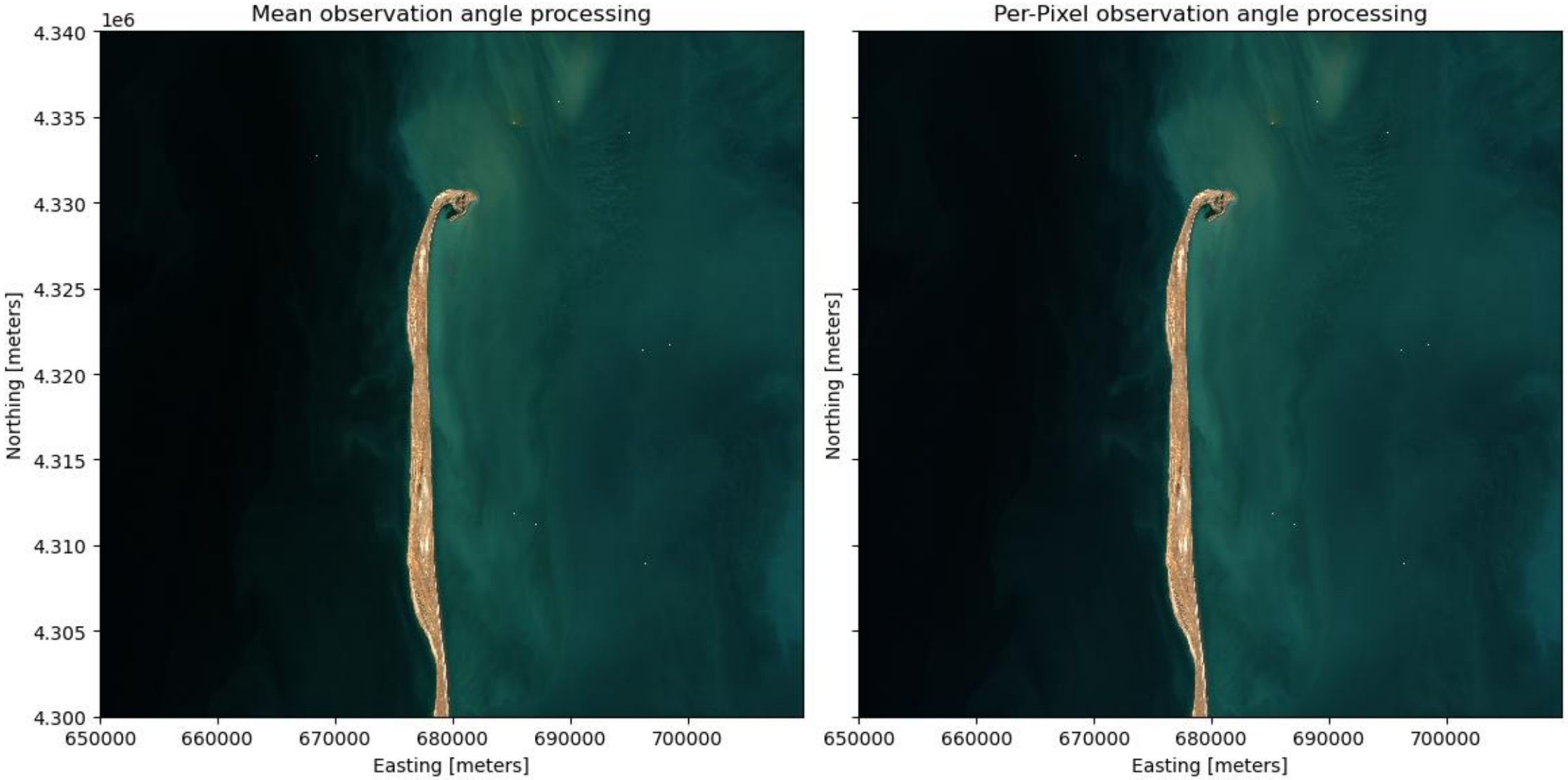
Validation of per-pixel angle processing

- Clear viewing conditions, no sun glint pollution
- Example:
  - Sentinel-2B scene
    East Caspian Sea 30 Oct 2018

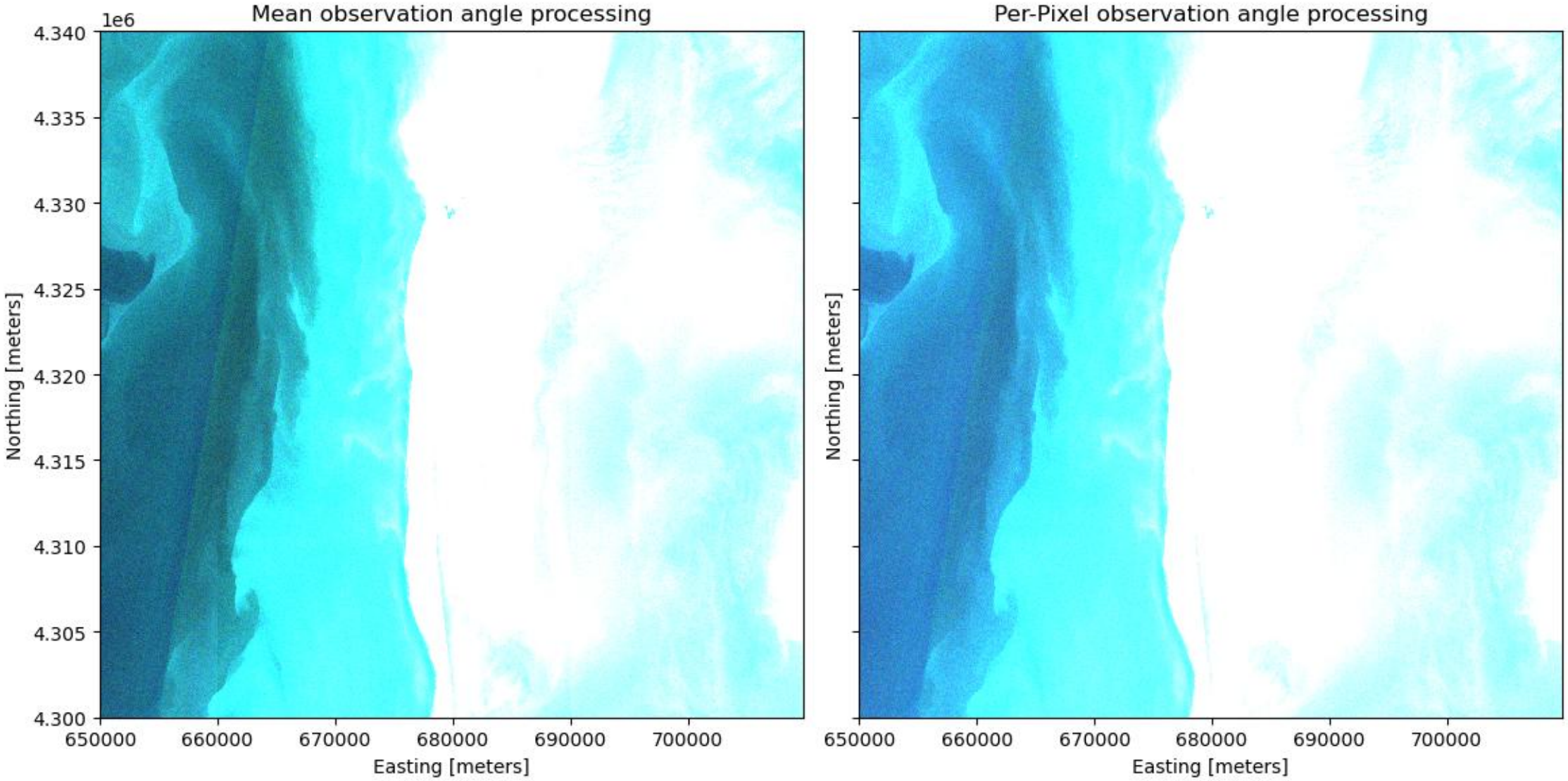
    (S2B_MSIL1C_20181030T072019_N0500_R006_T39SXD)



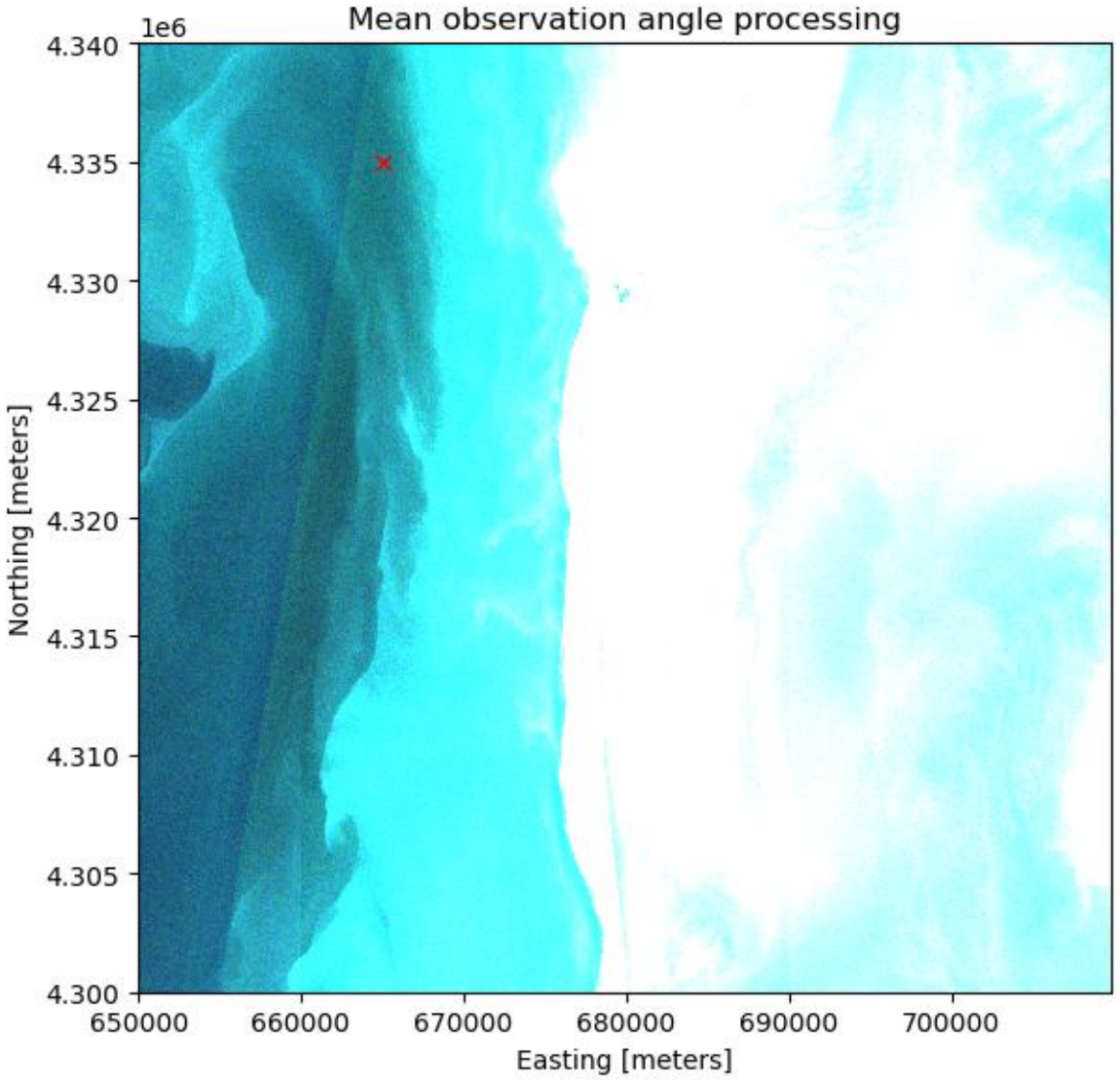
S2B L2A BOA reflectances (True colour)

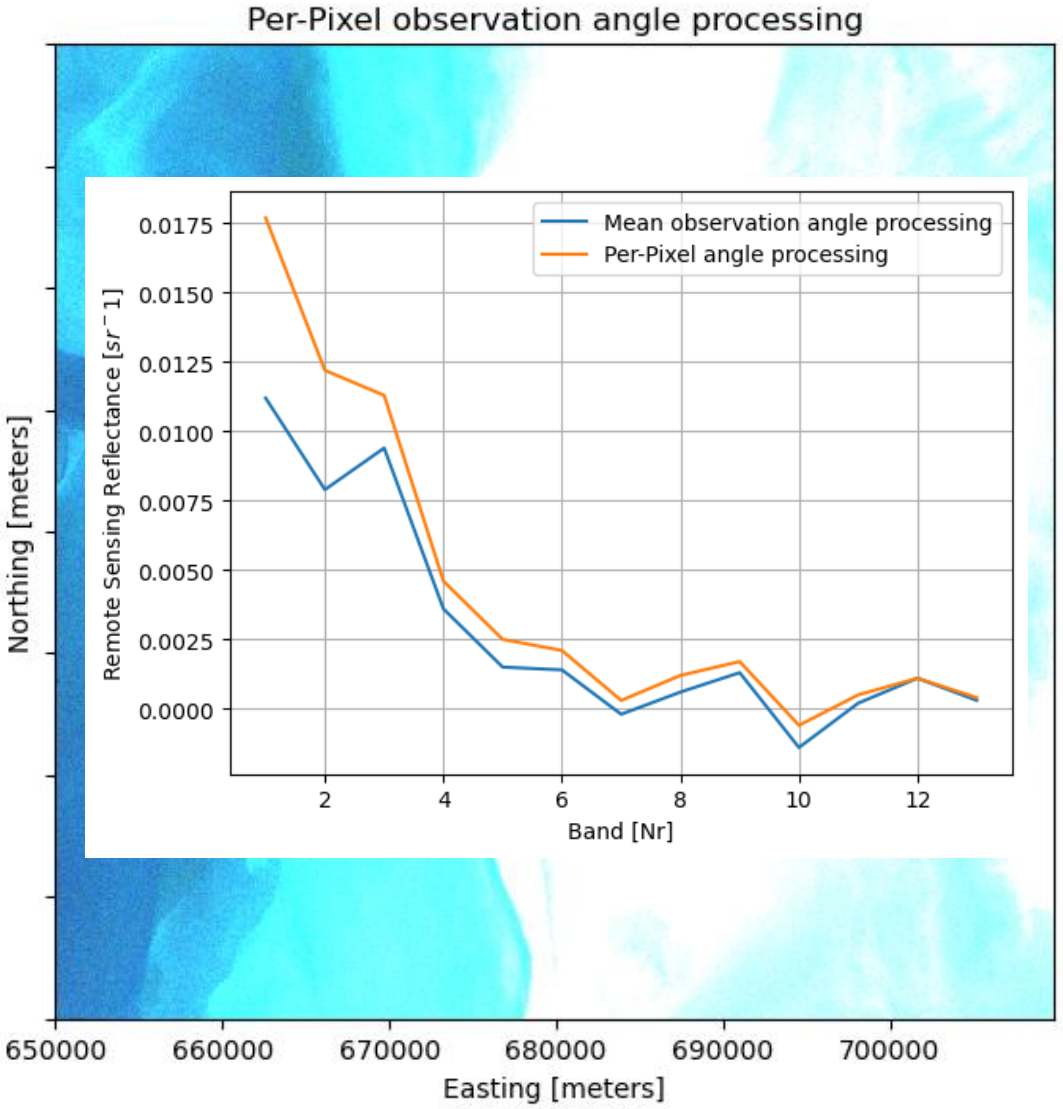


Comparison: S2B L2A BOA reflectances (True colour streched, stripes visible)

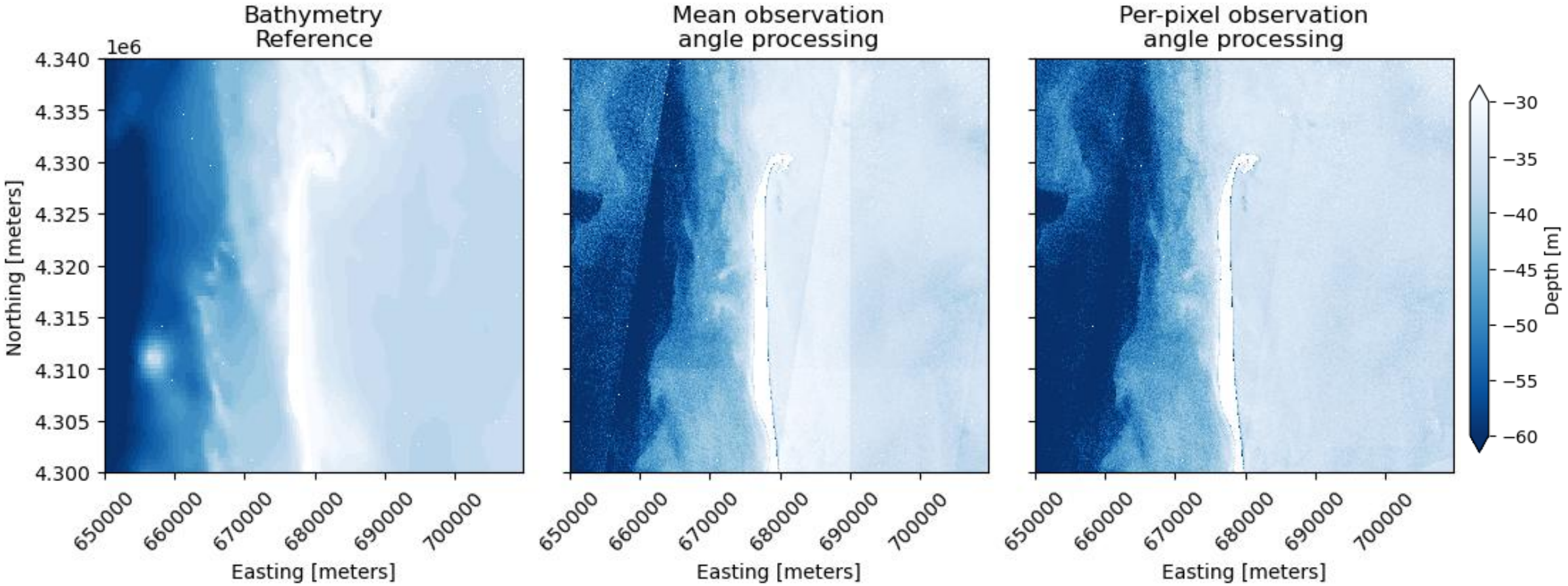


Comparison: S2B L2A BOA reflectances (True colour streched, stripes visible)





Application: Satellite-Derived Bathymetry Results



Imprint

Topic:	**Atmospheric correction for hyperspectral missions:** Lessons learned from present narrow – like EnMAP – to future wide swath instruments.
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Image sources:	All images “DLR (CC BY-NC-ND 3.0)” unless otherwise stated

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