Aquatic Remote Sensing Research

Motivation and facilities at Hereon

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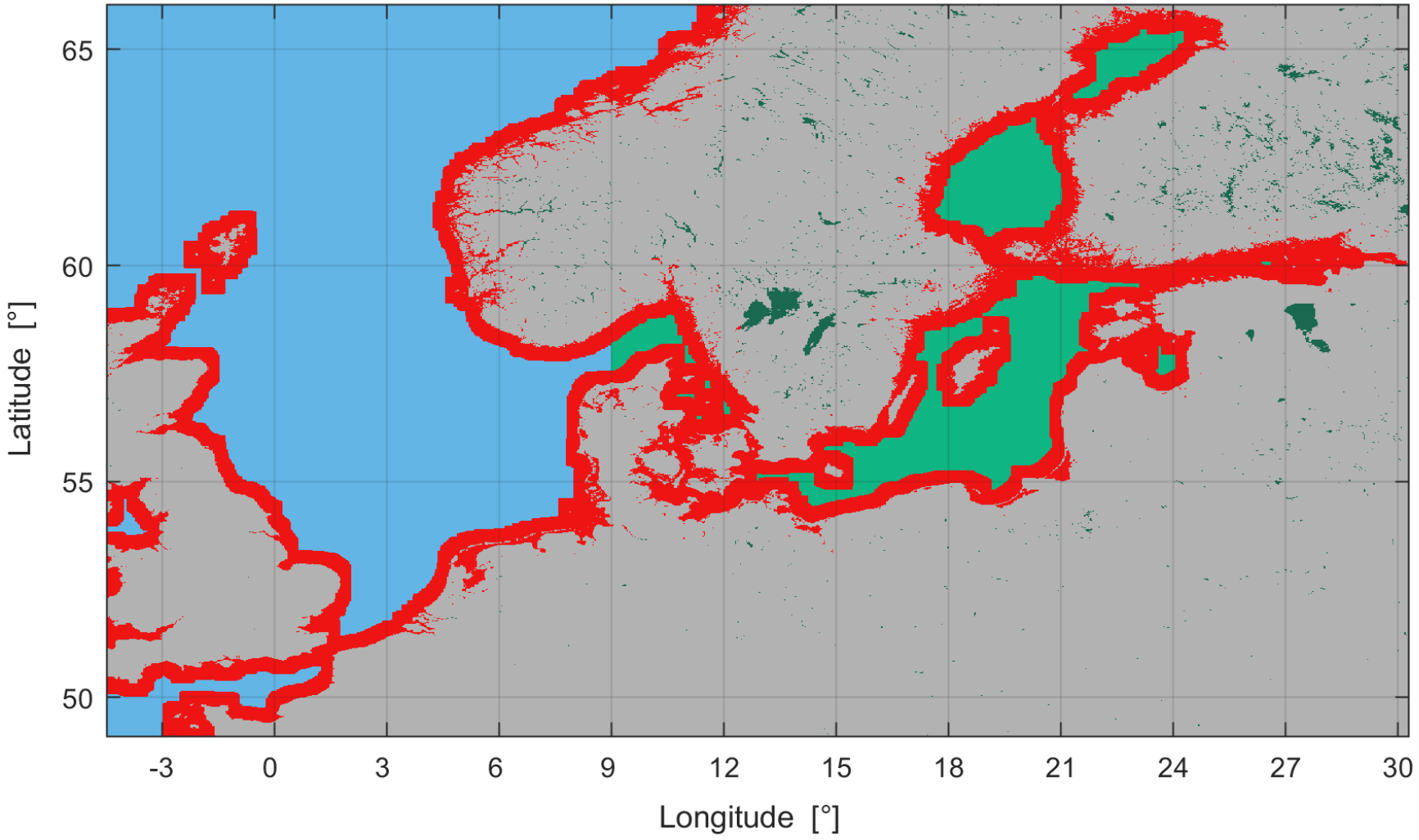
Tartu Observatory, University of Tartu, Estonia | 20 – 22 May 2025

Helmholtz-Zentrum hereon

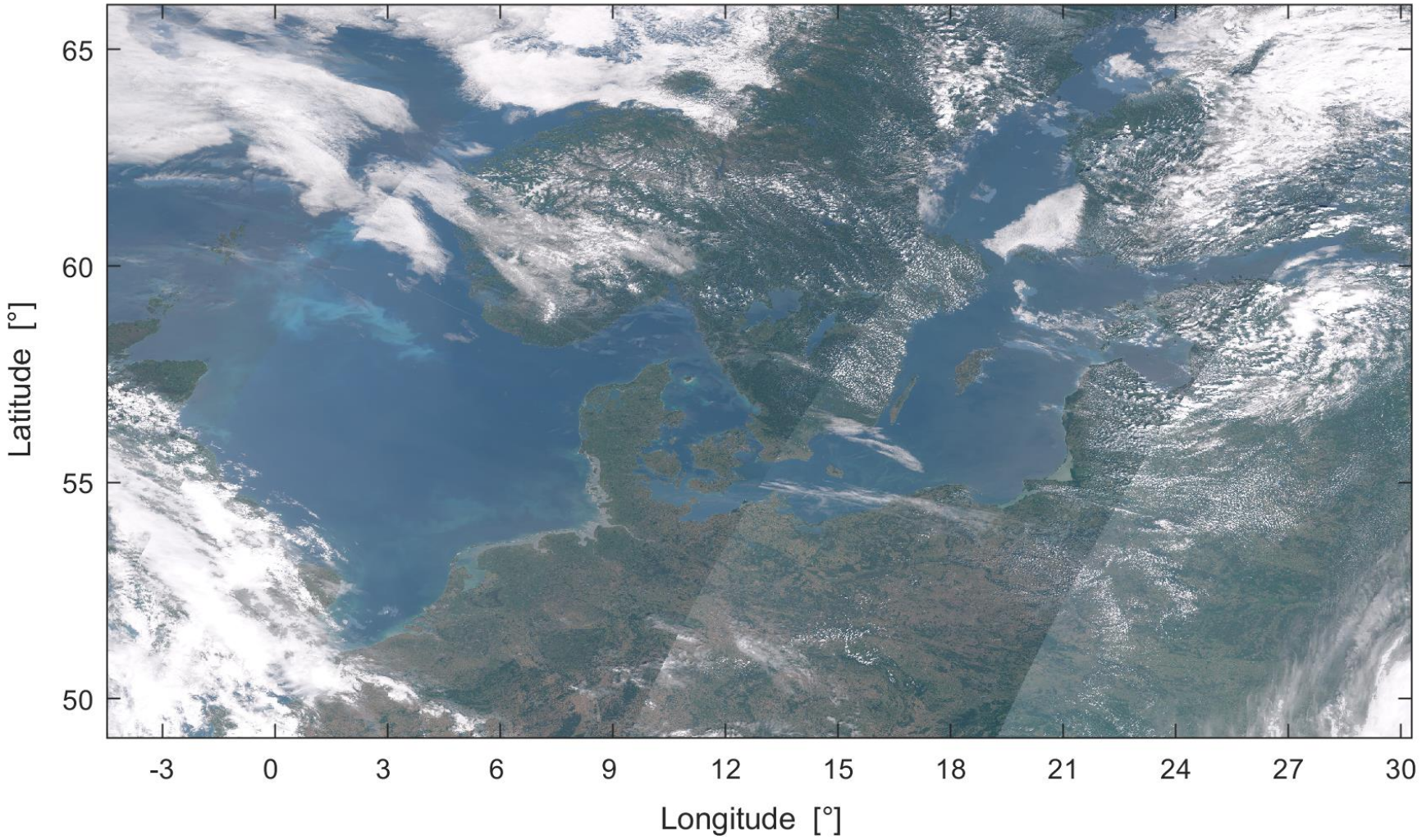
Research in Optical Oceanography

- Determination of water constituents at global scale
  - Pools of Carbon, Land-Sea & Air-Sea fluxes, Seasonal and long-term changes
- Radiative transfer modelling
  - IOP measurements and modelling of phytoplankton diversity
  - Optical closure with measurements of IOPs, concentrations, light field & Rrs
- Research technology developments
  - Hyperspectral IOPs: PSICAM, QFT-ICAM, VSF-meter, LWCC-system & HyFi-bb
  - Commercial spectrometer: RAMSES, Cubert-Camera, Qmini (~1 nm), Avantes (0.25 nm)
- Ocean Colour algorithm development
  - MERIS Case-2, C2RCC, A4O-ONNS
  - Optical Water Type classification → requires large dynamic range of sensors (350 – 1000 nm)

Research focus on land-sea transition



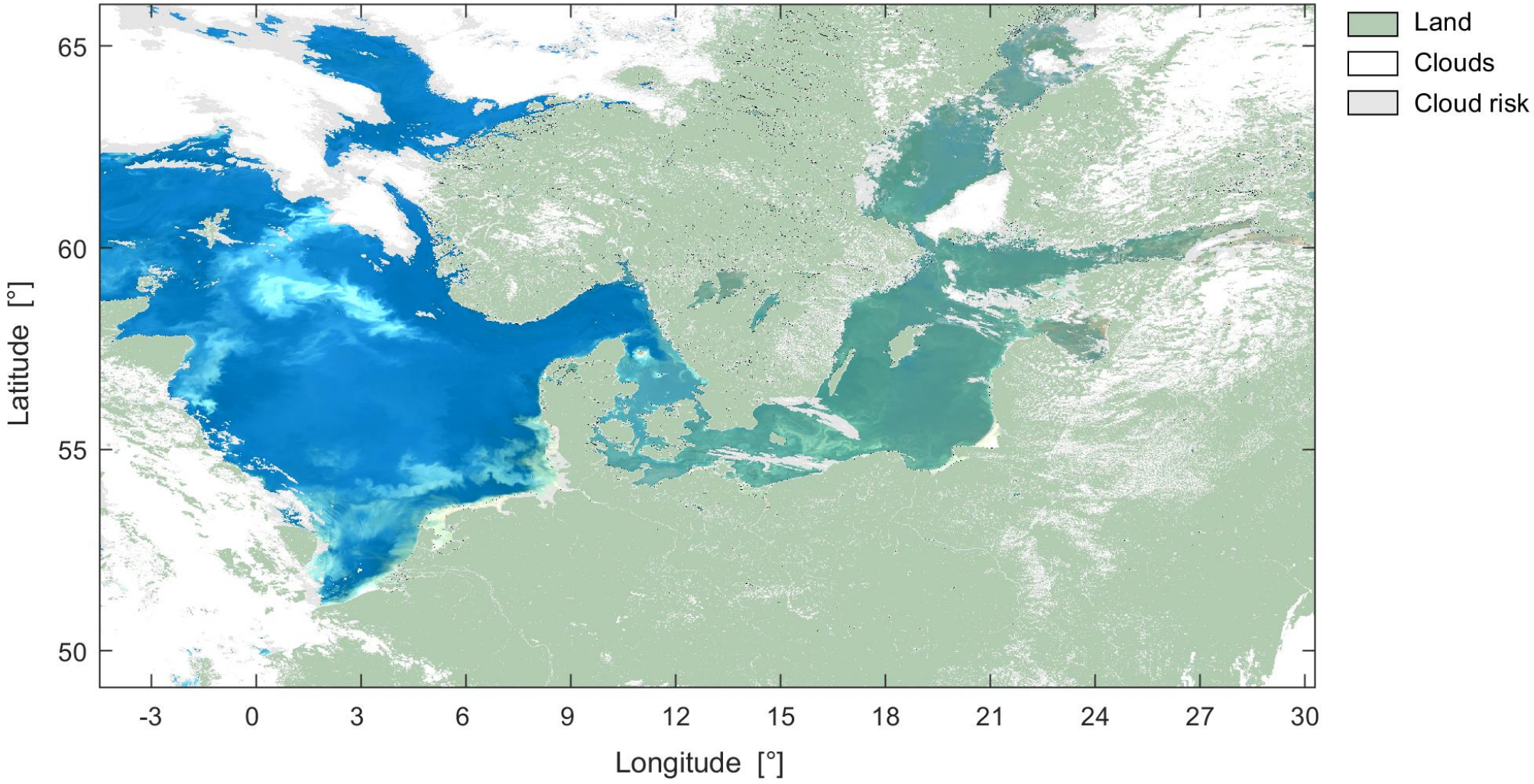
Development of A4O-ONNS water algorithm



- Composite of all Sentinel-3 OLCI images at TOA 2023-07-08

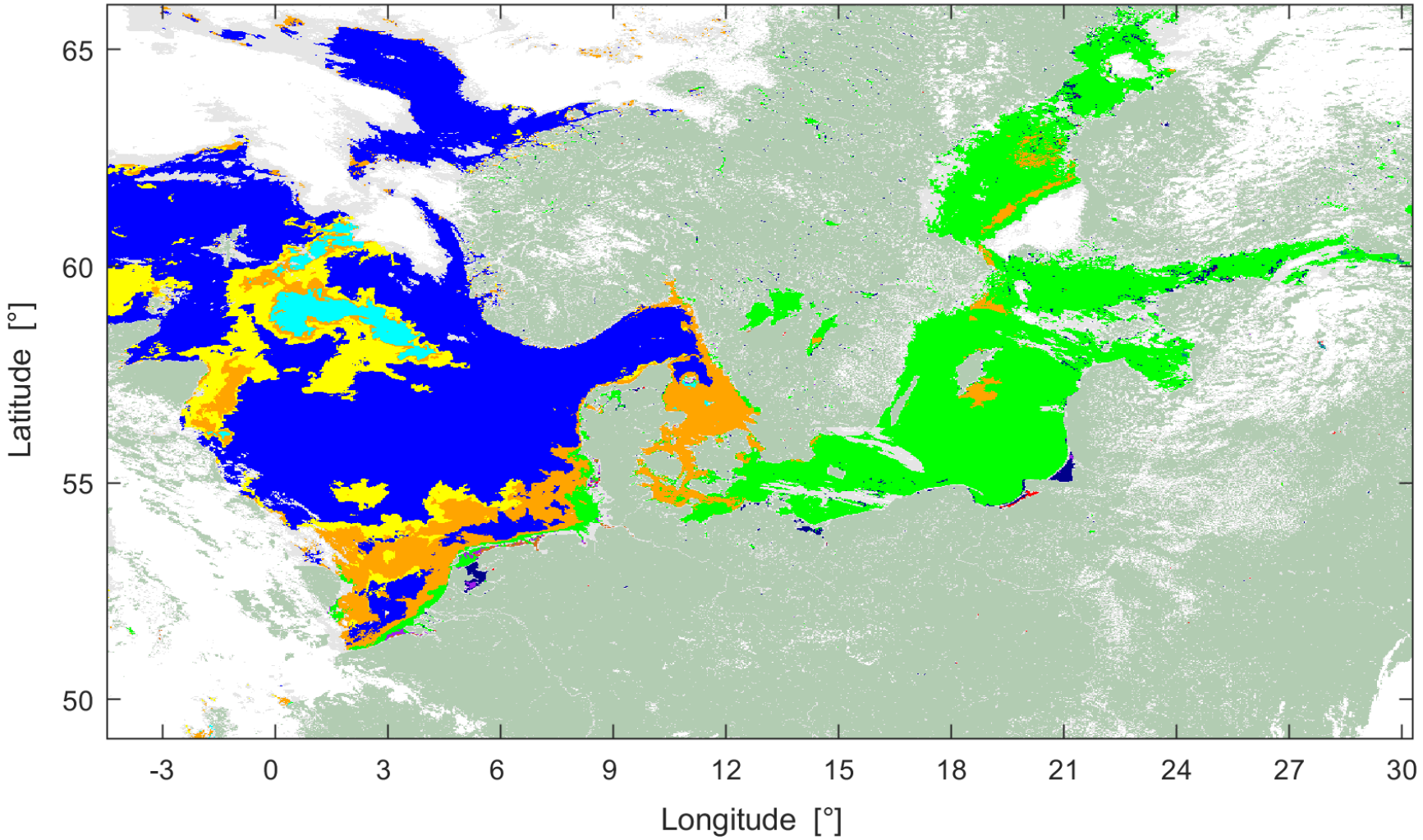
Hieronymi, M., Bi, S., Behr, D. (2024): Sentinel-3 OLCI daily averaged earth observation data of water constituents, World Data Center for Climate (WDCC) at DKRZ.

After Atmospheric Correction (A4O)



- In situ data needed for validation / further development, flagging, determination of uncertainties

Optical Water Type classification

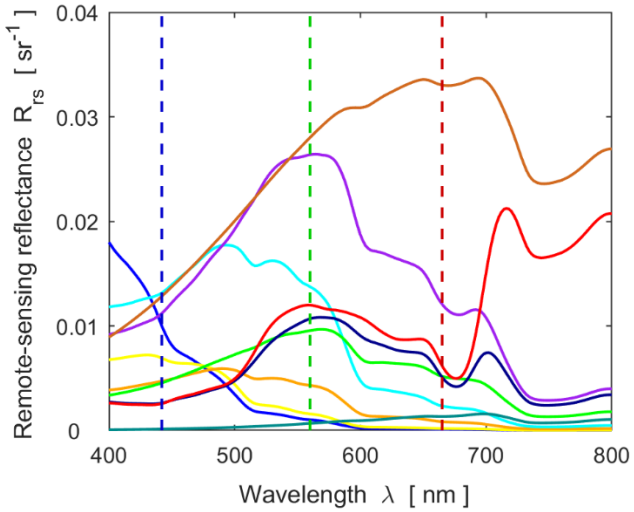


Land
Clouds
Cloud risk

Optical Water Types

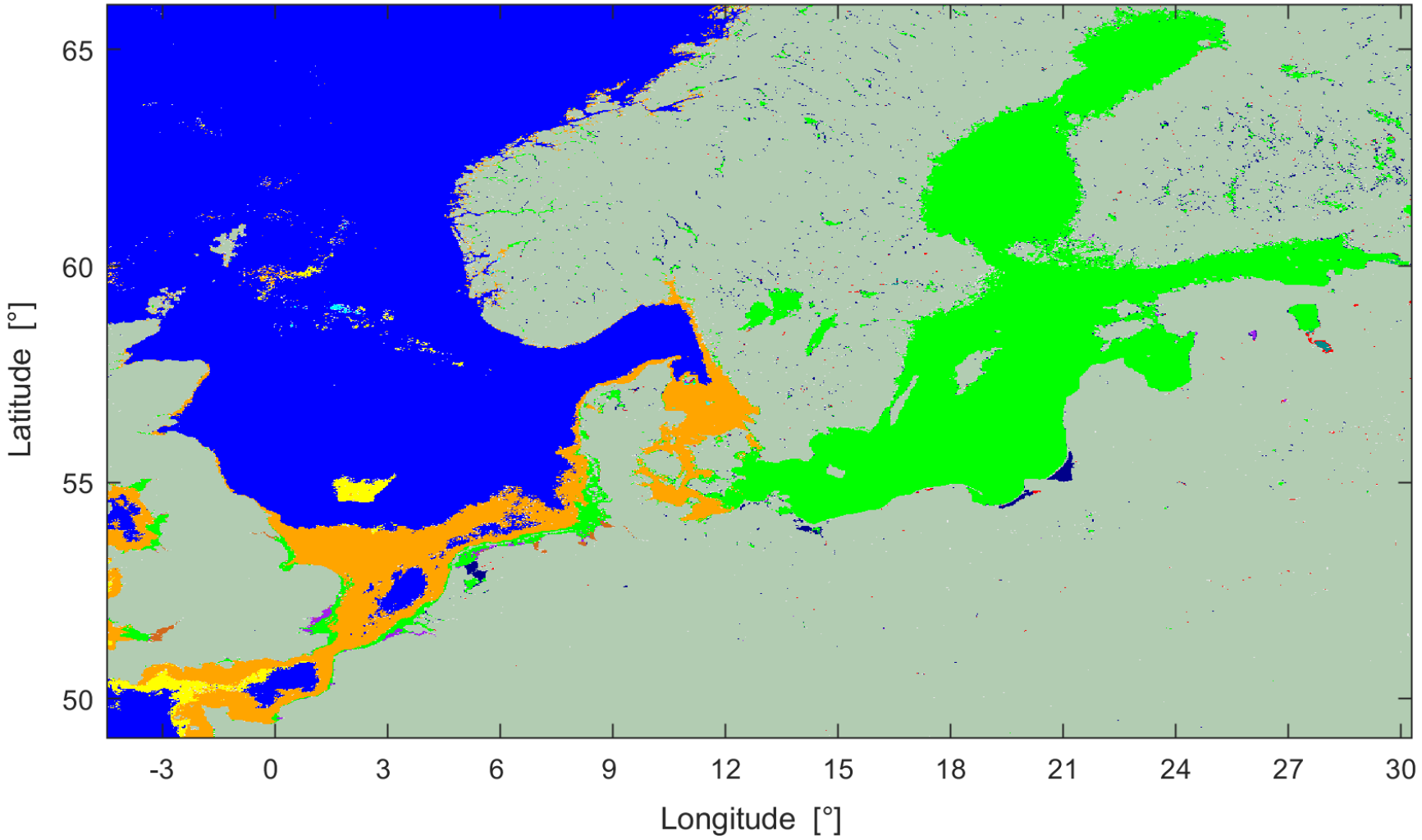
OWT [-]

7
6
5b
5a
4b
4a
3b
3a
2
1



Bi, S., & Hieronymi, M. (2024): Holistic optical water type classification for ocean, coastal, and inland waters, Limnology and Oceanography

Optical Water Type classification

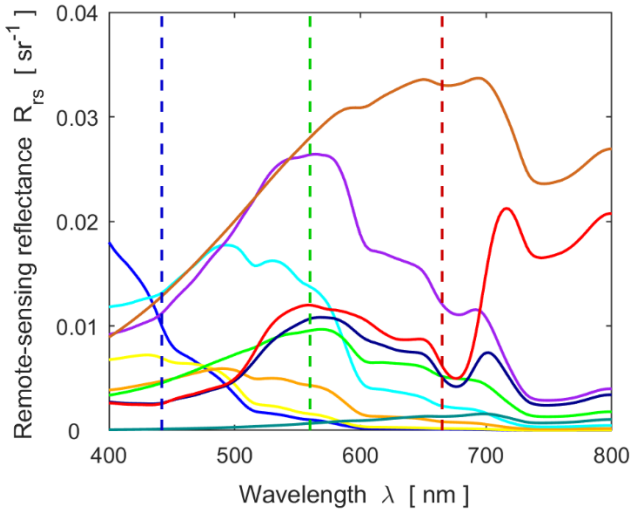


Land
Ambiguous

Most common OWT

[-]

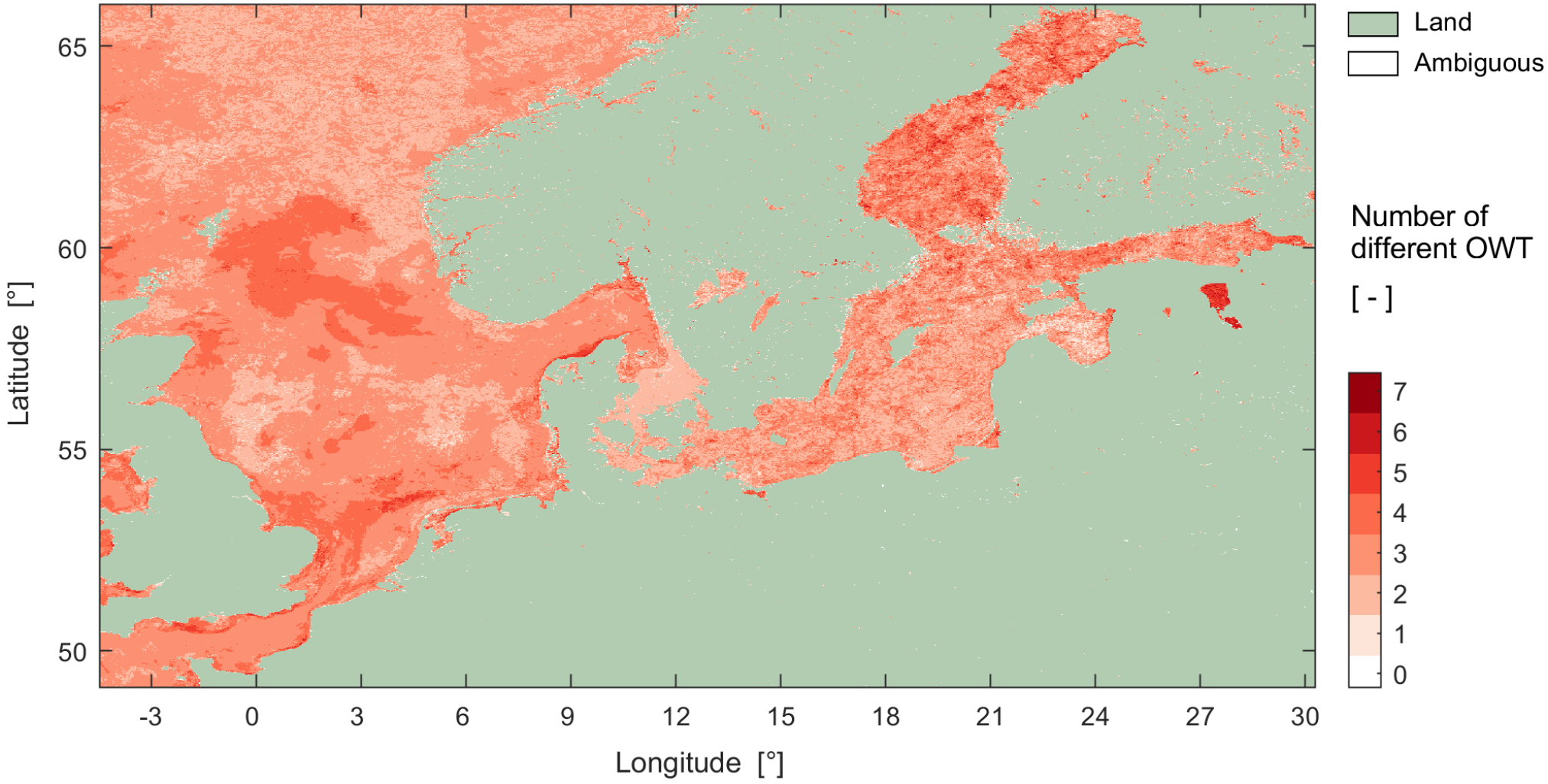
7
6
5b
5a
4b
4a
3b
3a
2
1



- Region covers all defined optical water types

Bi, S., & Hieronymi, M. (2024): Holistic optical water type classification for ocean, coastal, and inland waters, Limnology and Oceanography

Optical Water Type classification



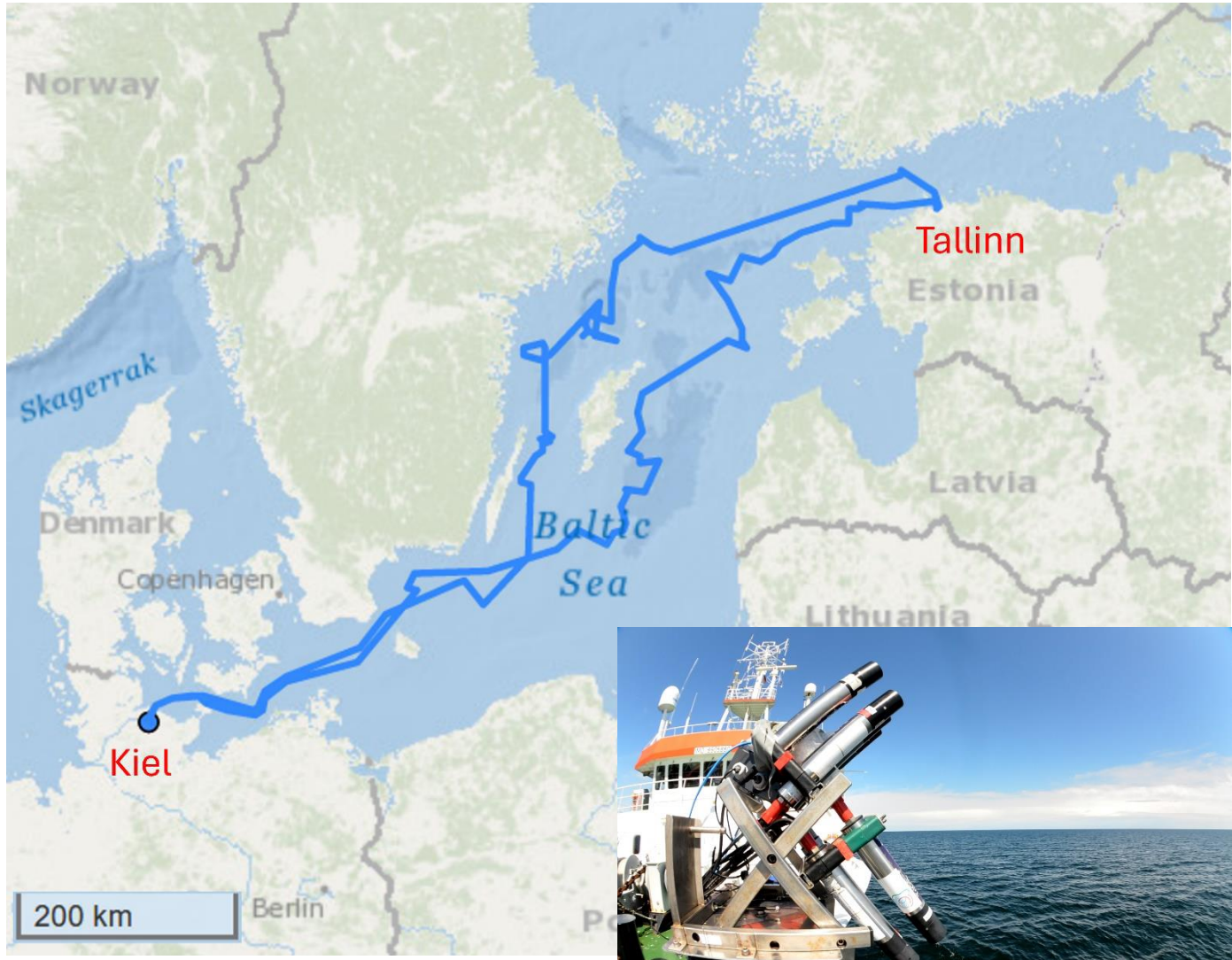
- For CalVal many different types needed; for SVC as homogenous as possible

Validation activities at Hereon

- Long time contributing to MVT & S3VT
  - 25 years of Trios RAMSES calibration at Hereon
- Contributions to FRM4SOC
  - Laboratory inter-comparison experiment LCE-2, 2017, Tartu, Estonia
  - Fiducial inter-comparison experiment for Sentinel-3, 2018 & 2022, AAOT, Italy
- Globally campaigns with focus on optical diversity
  - 2025: RV Meteor (Nice to Azores Islands)

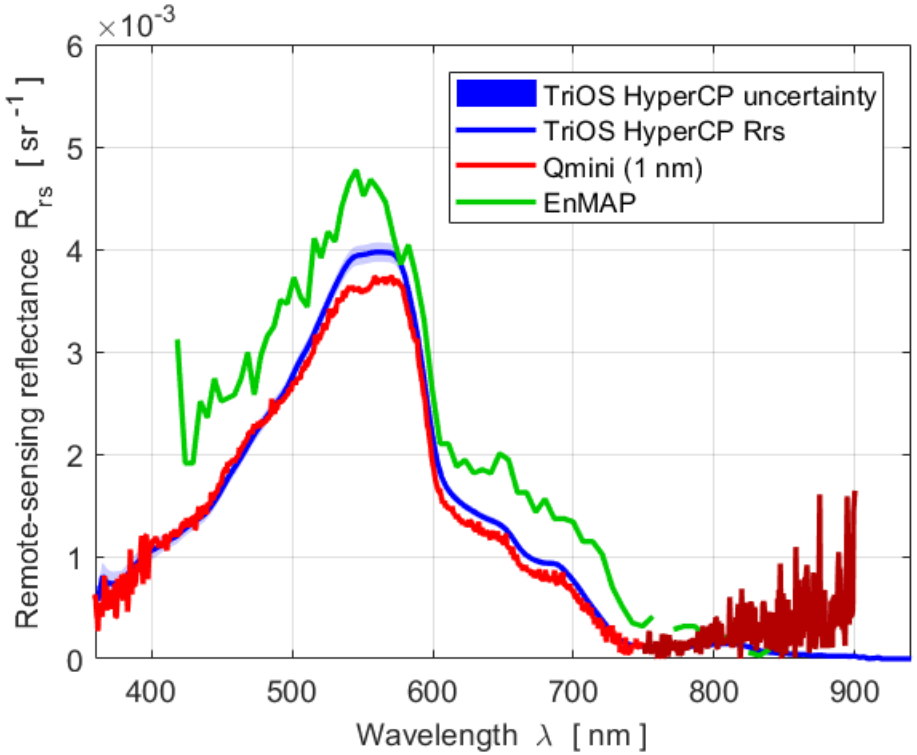
Match-up-optimised ship tracs

- RV Alkor cruise in July 2023 with partners from Tartu, Stockholm, Nantes
- Main objective was match-ups with Sentinel-3 OLCI, Sentinel-2 MSI, EnMAP etc.
- Comparison of
  - RAMSES, Qmini, TACCS
  - Rrs from above-water, under-water at surface & from profiles
  - At stations and underway
  - Different processing incl. HyperCP



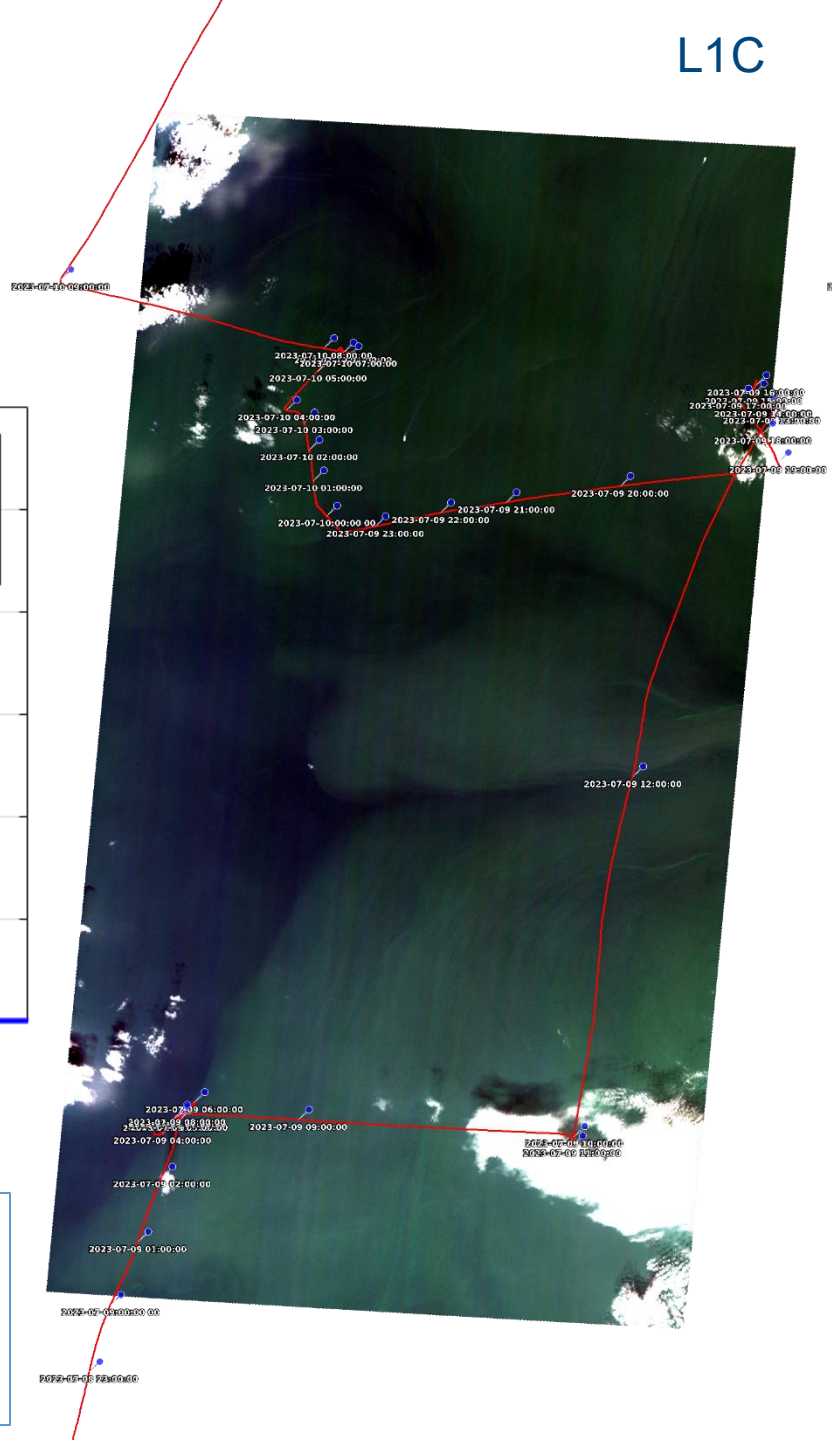
EnMAP match-ups

- 30 km swath, 30 m pixel



Tilstone, G.H., Jordan, T.M., Aurin, D., Bialek, A., Deru, A., Ramsay, A., Hieronymi, M., Dall'Olmo, G., Ligi, M., Kovach, C., Ansko, I., Ondrusek, M., Vabson, V., Zibordi, G., Gossn, J.I., Kwiatkowska, E., Vendt, R. (2025): Radiometric field inter-comparison of fiducial reference measurements using an open source community processor. Optics Express.

L1C

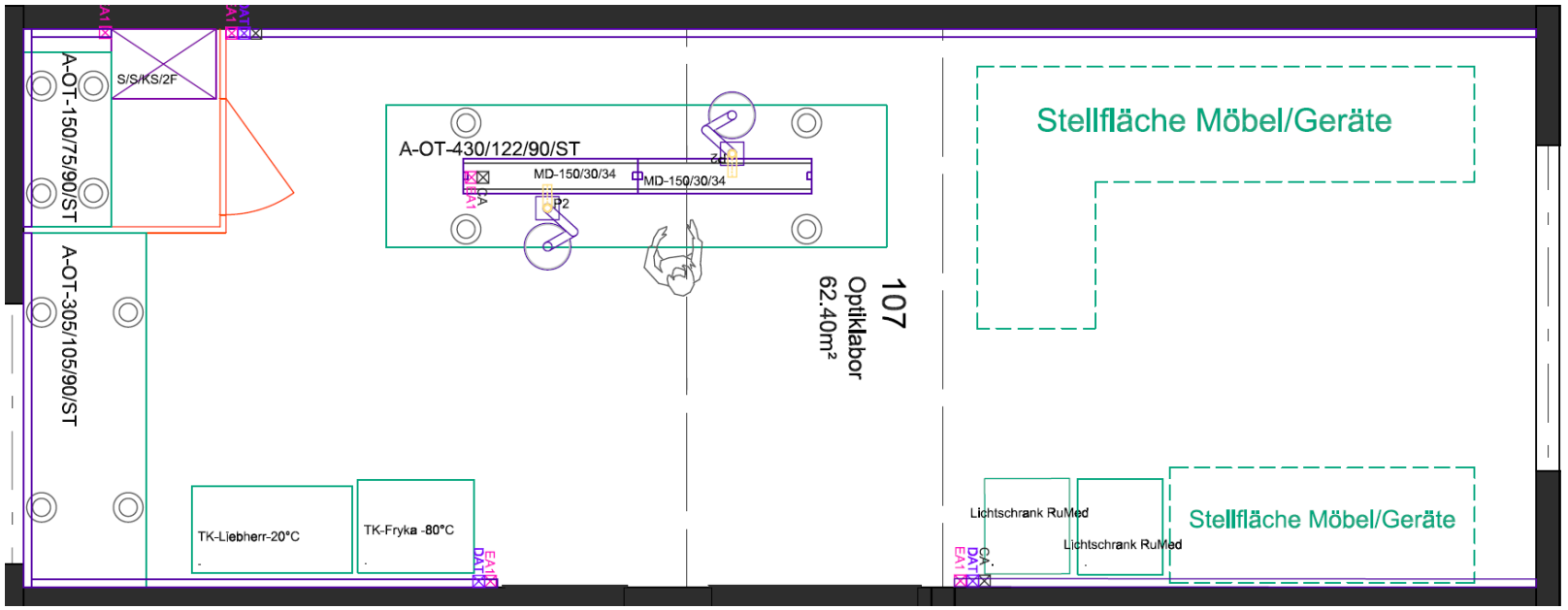


L2A

2023-07-09

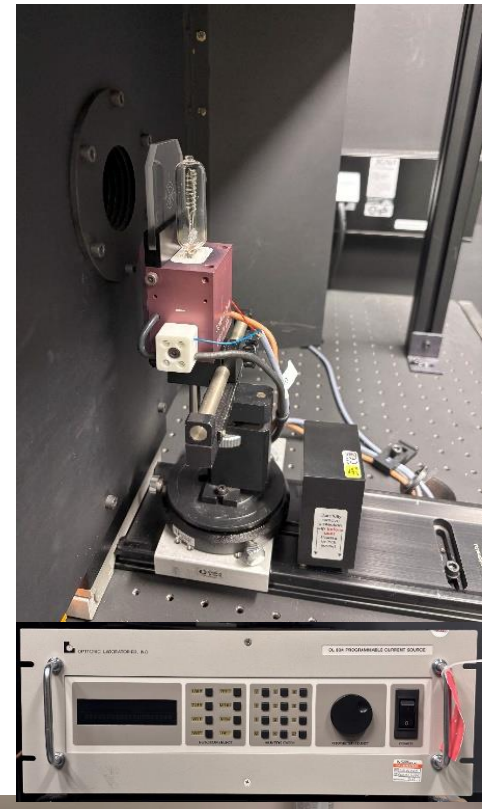
Optical laboratory at Hereon

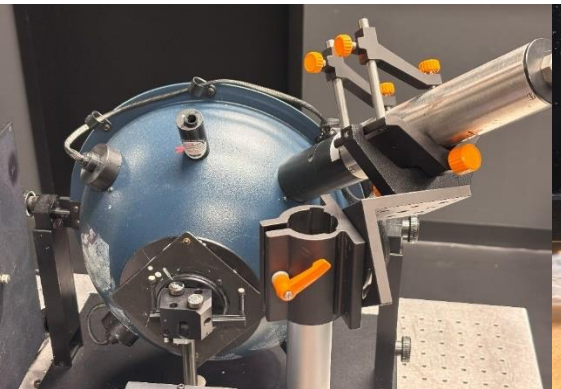
- Dark Lab of approx. 13 m x 4.5 m with Nextel Velvet-Coating 811-21 in most exposed areas and matt black paint for walls and interior
- Temperature stabilized & Temperature tracking (ambient & instruments housing, shunt resistor)
- Dust minimization by excess pressure



Laboratory equipment & Traceability

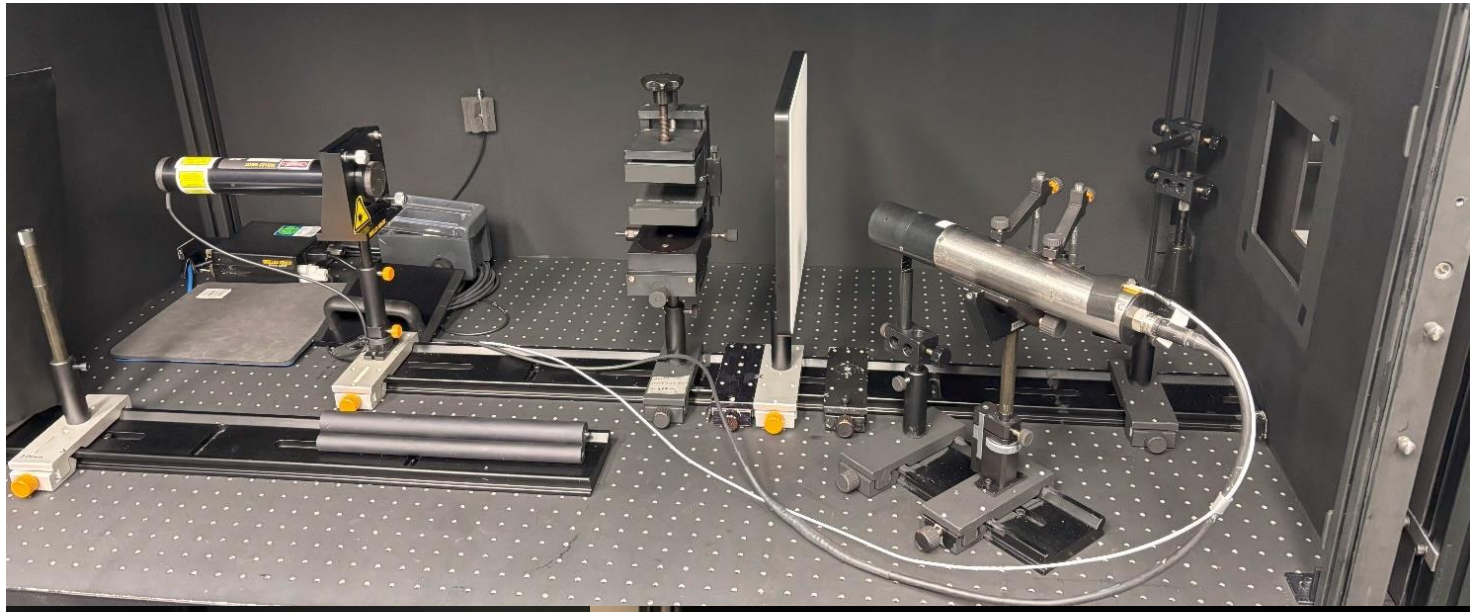
- Tungsten lamp (Gigahertz Optic calibrated, needs recalibration by PTB)
- PTFE-Spectralon target SRT-99 (Labsphere calibrated at 8°, 2018, needs calibration at 45° by PTB)
- Stabilized current source (Optronic Laboratories)
- High precision shunt resistor for lamp current supervision
- High precision DAQ/ Multimeter for tracking temperatures, current and voltage @ each radiometric measurement
- Integrating spheres, photometer (PE Lambda 950), double-monochromator
- Inter-comparison of sensors Trios, Avantes, Qmini, OceanOptics, …

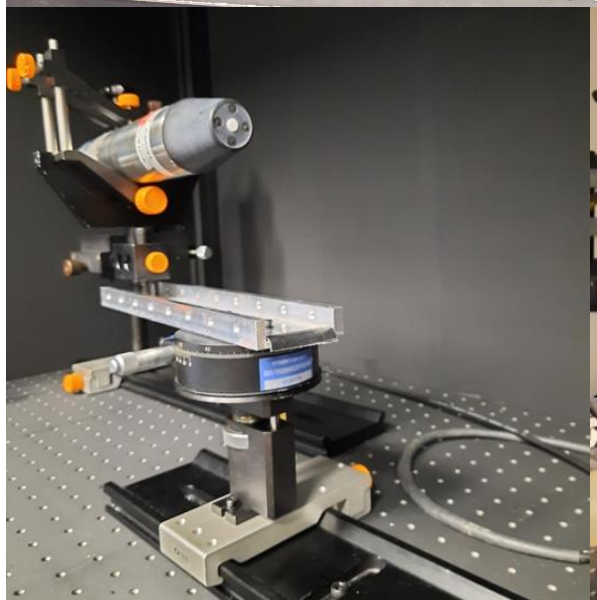


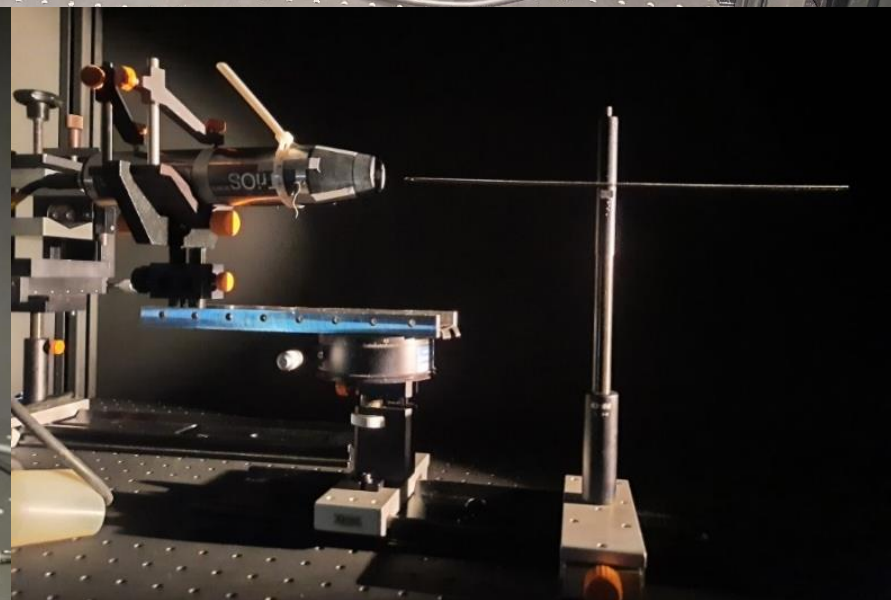


Calibrations with long-term tracking

- Radiometer intercalibration since late 90’s with FEL lamp and PTFE target
- Regularly (~ twice a year)
  - Irradiance and radiance of TriOS Ramses and Qmini
- Occasionally / Tested:
  - Nonlinearity (by intensity, not only by integration-time)
  - Stray light matrice
  - Irradiance cosine-response setup

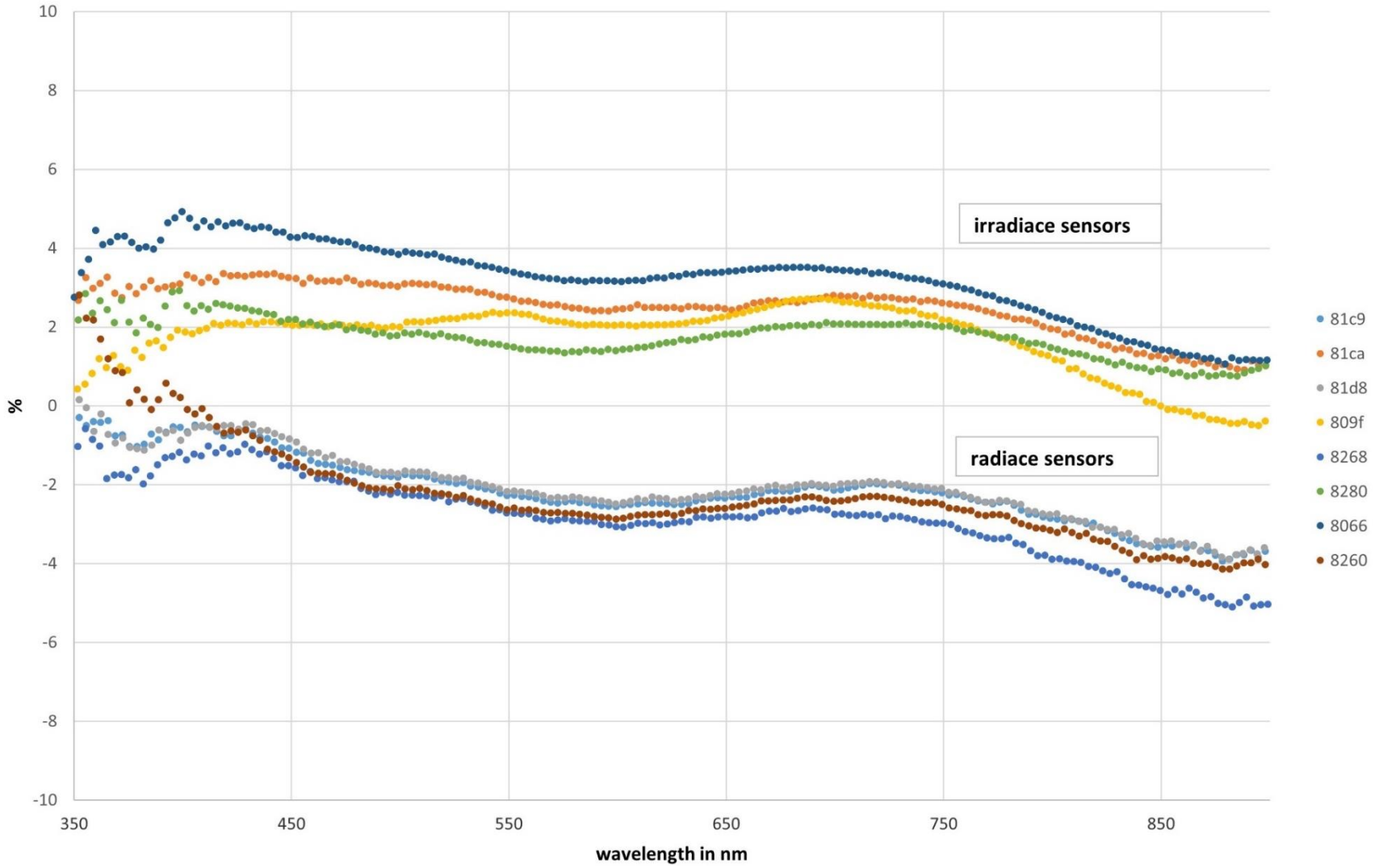






Comparisons of calibration with TO

- New standards (lamp and target in 2018
- Deviation of cal-factors (responsitivities) Hereon-lab (06/23) vs TO-lab (07/22) derived by two different integration times (not all corrections included)



Conclusions

- Motivation for OCR cal/char capabilities is developments of own sensor and measuring devices
- Already participated in many inter-comparisons and willing to participate in future initiatives
- Sensor focus on high spectral resolution → Qmini, Avantes
- Major traceability challenges: Relocation of the laboratory (2017) and changes to the setup
- Sustainability of resources with some uncertainties but secured in the medium term