Sentinel 2 Pre-processing Requirements for coastal and inland waters
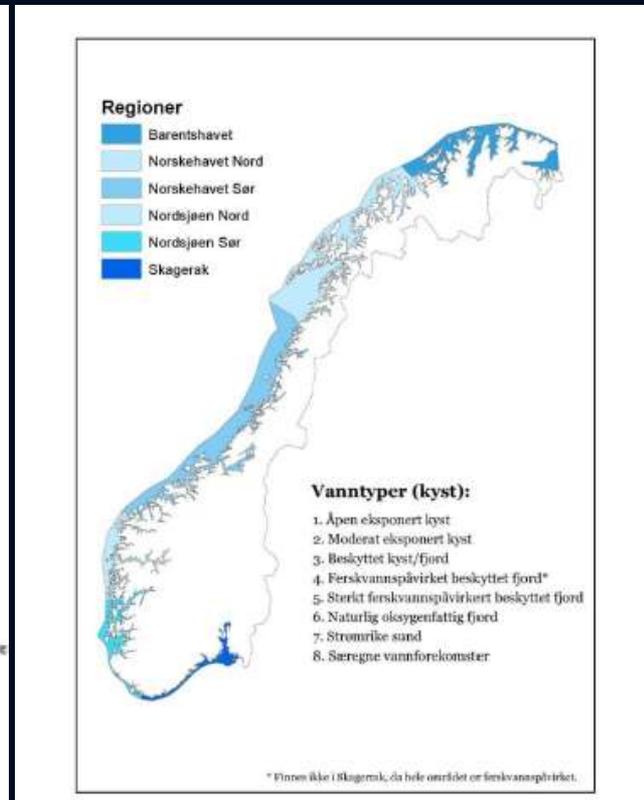
KAI SØRENSEN
NIVA
CARSTEN BROCKMANN

Brockmann Consult GmbH

# Ecological and chemical classification of water bodies in Norway

Water quality - products potentially possible from EO data

- Monitoring of surface phytoplankton

- Monitoring particle load, Turbidity/Total susp. material

- Monitoring turbidity/water transparency (Secchi Disc Depth)

- Coloured Dissolved Organic material

- Surface Water Temperature

- Ratio between green and blue-green algae

- Detection of Harmful Algal Blooms

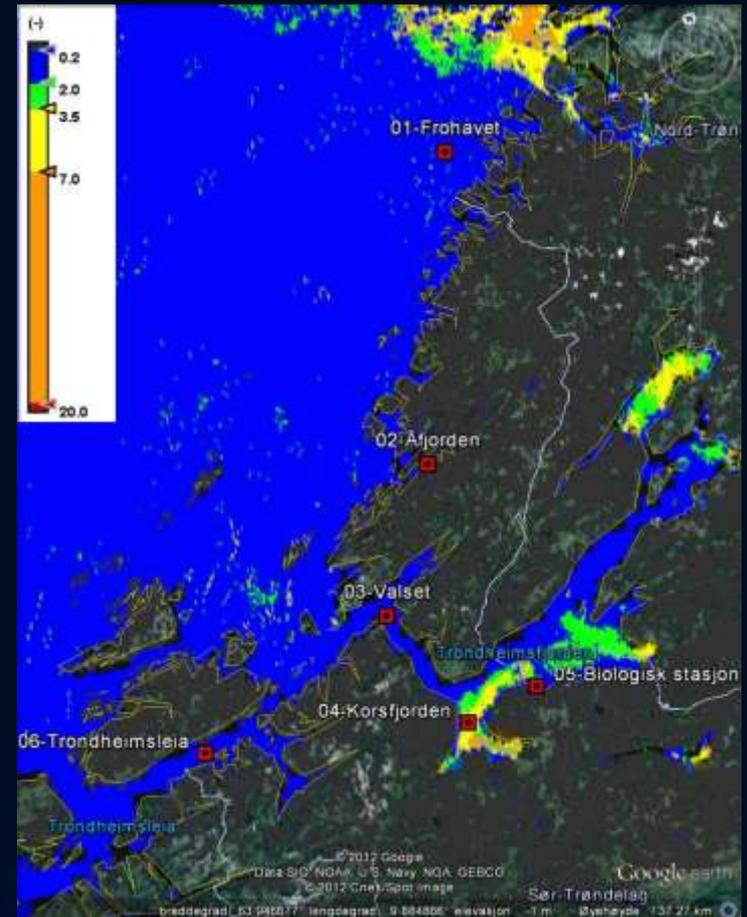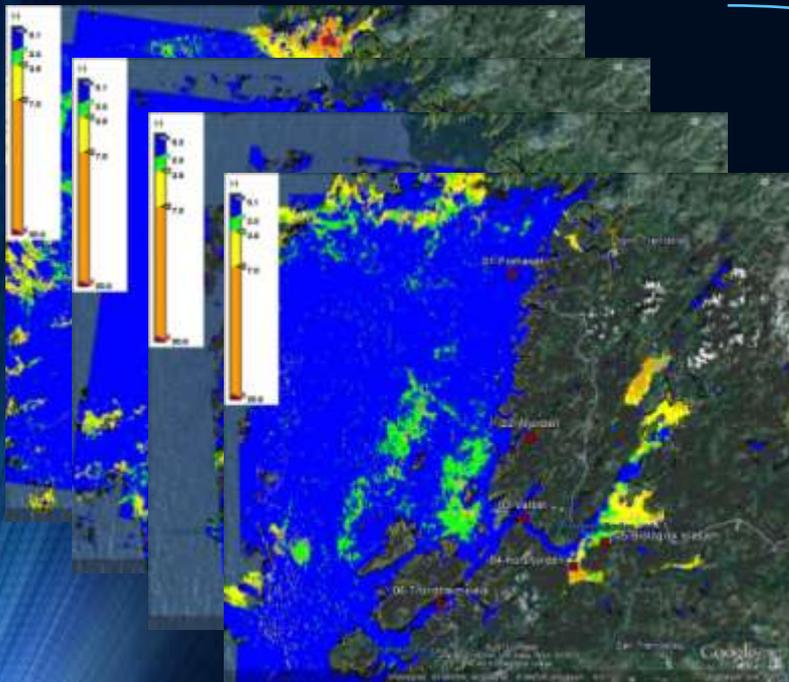- Mapping of shallow waters sea bed, coastline and shore

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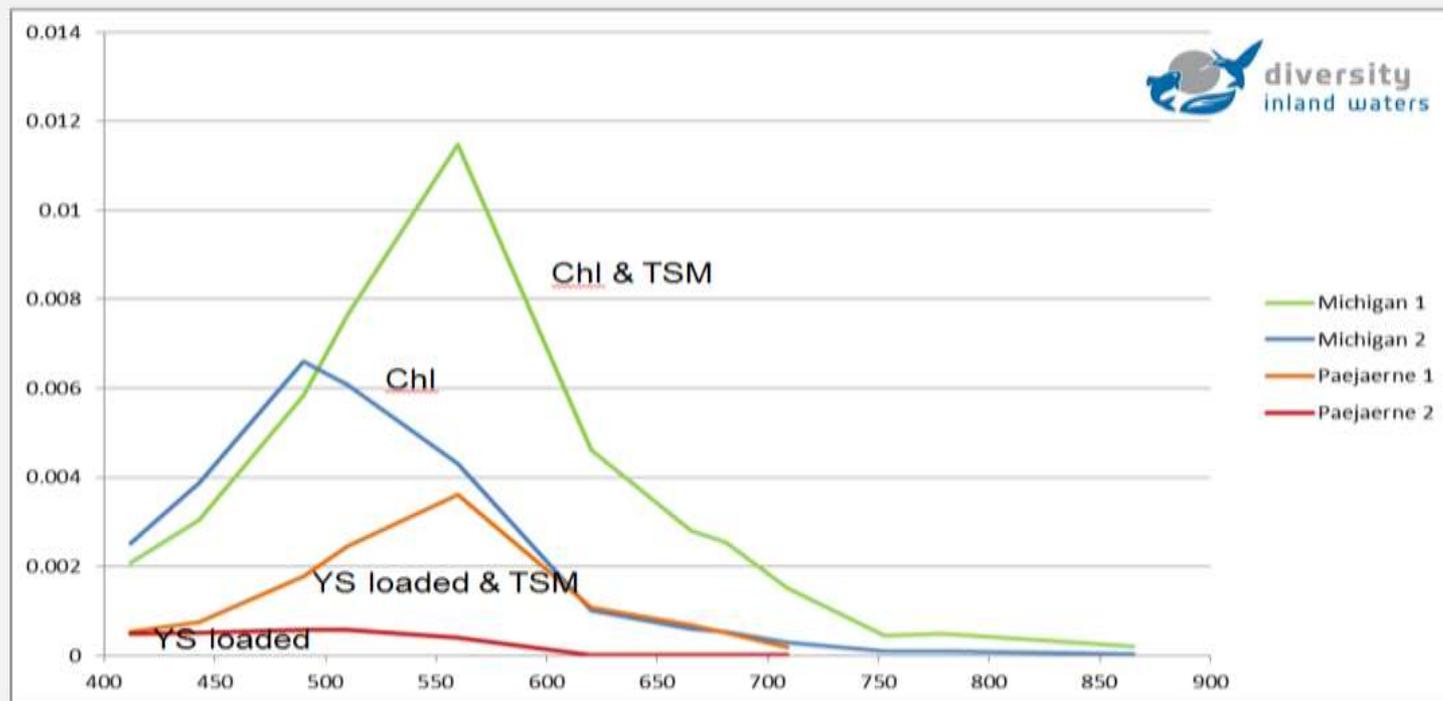# The in situ component are important for validation and verification
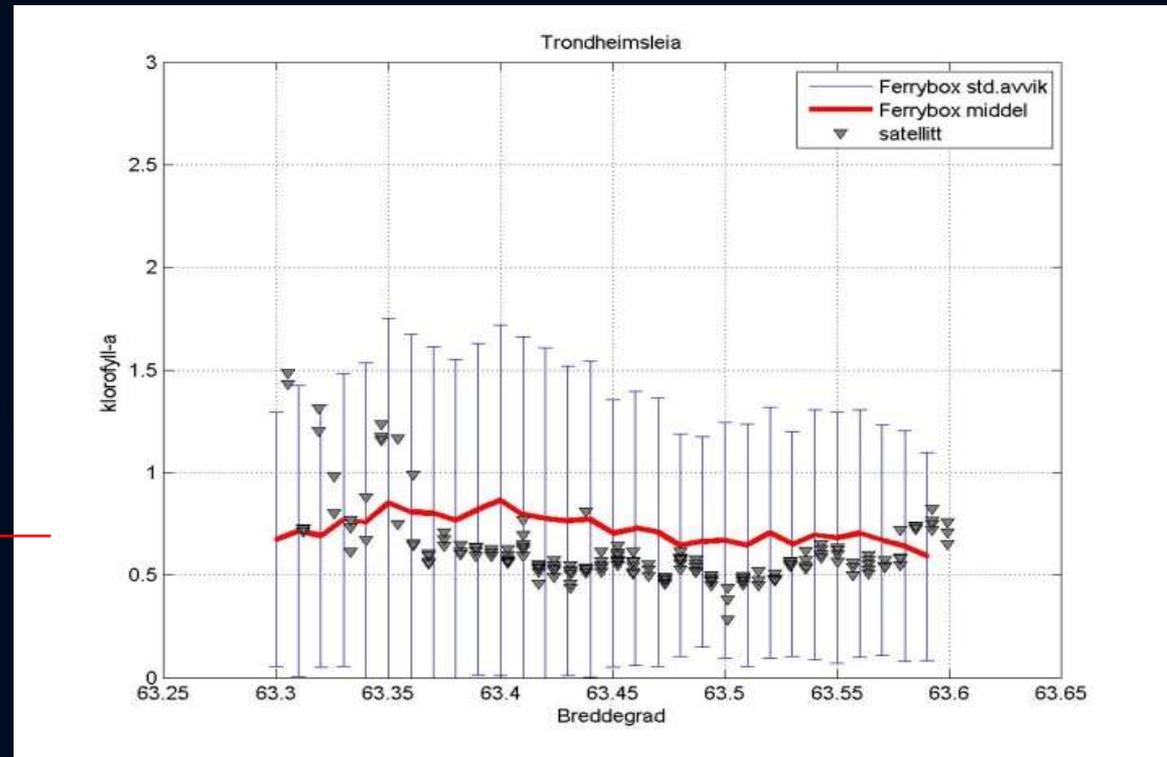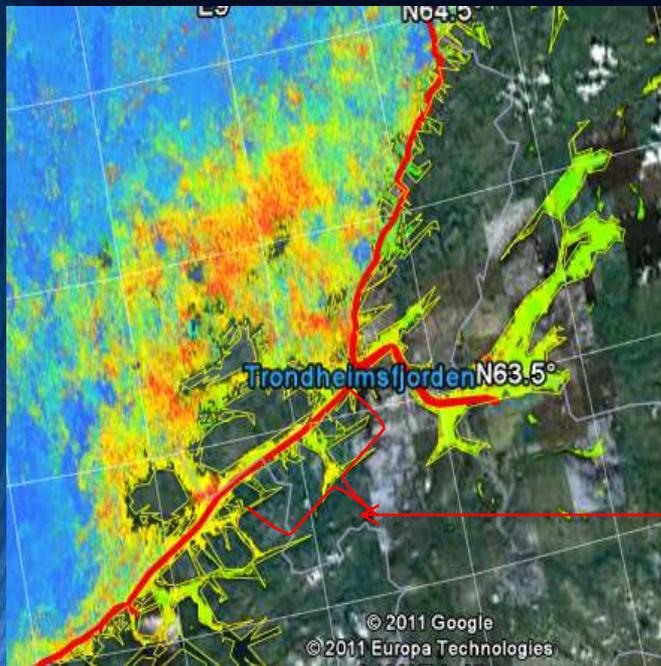
Example of input to marine classification!
Chlorophyll-a for June-Sept. 2011 in Trondheimsfjorden

From month mean to year or seasonal values.

Water reflectance spectra of main optical components in water

Water Leaving Spectra

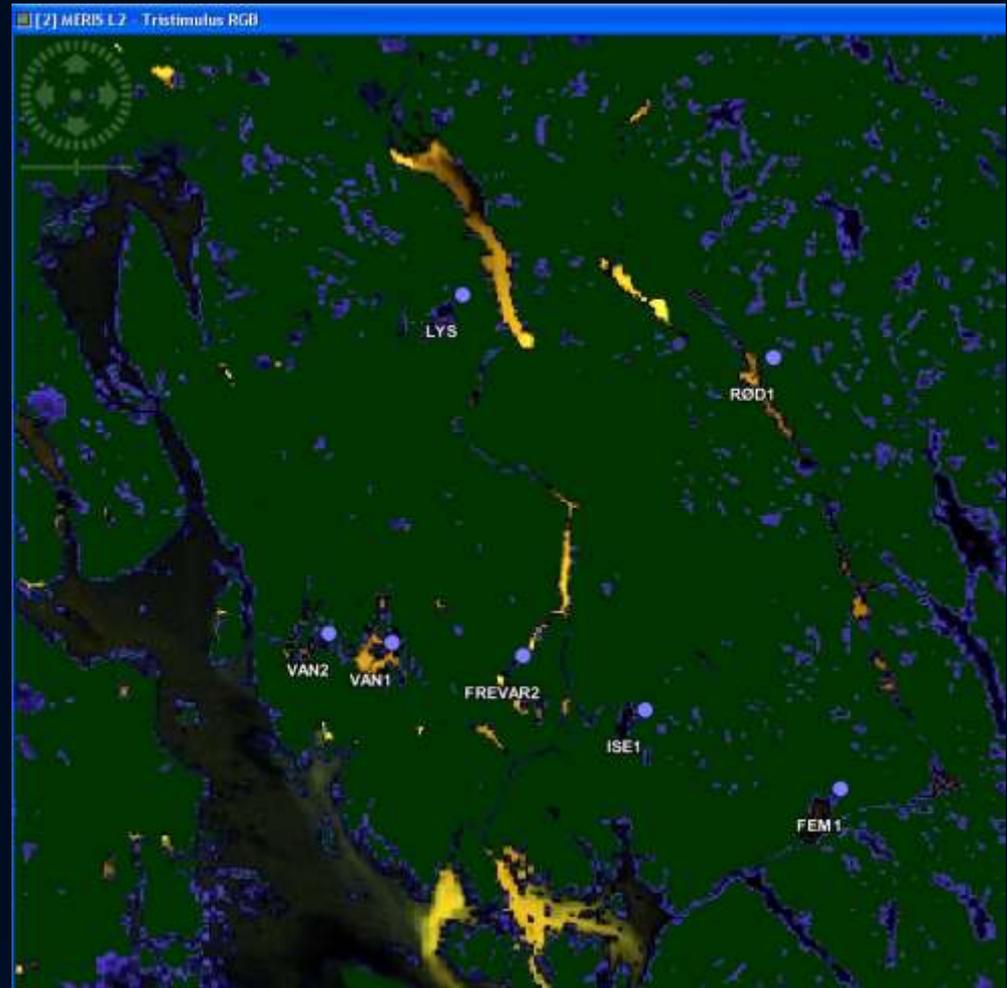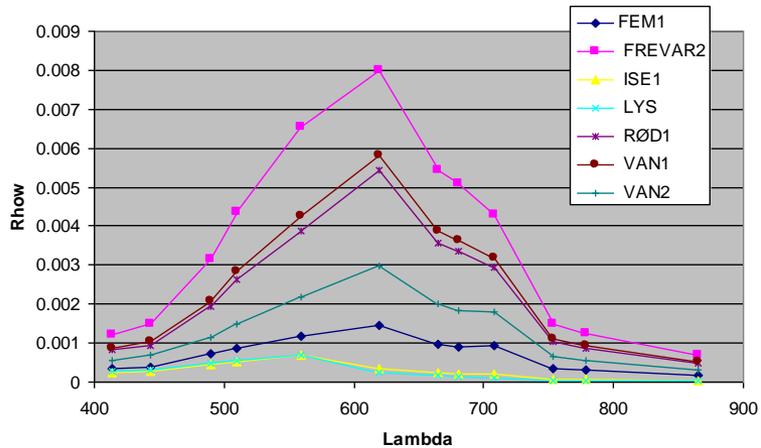Brockman, DIVERSITY II

Examples from some Norwegian Lakes

- Souther Norway

- MERIS 300m resolution

Example form a trend of phytoplanton in a Norwegian Lake
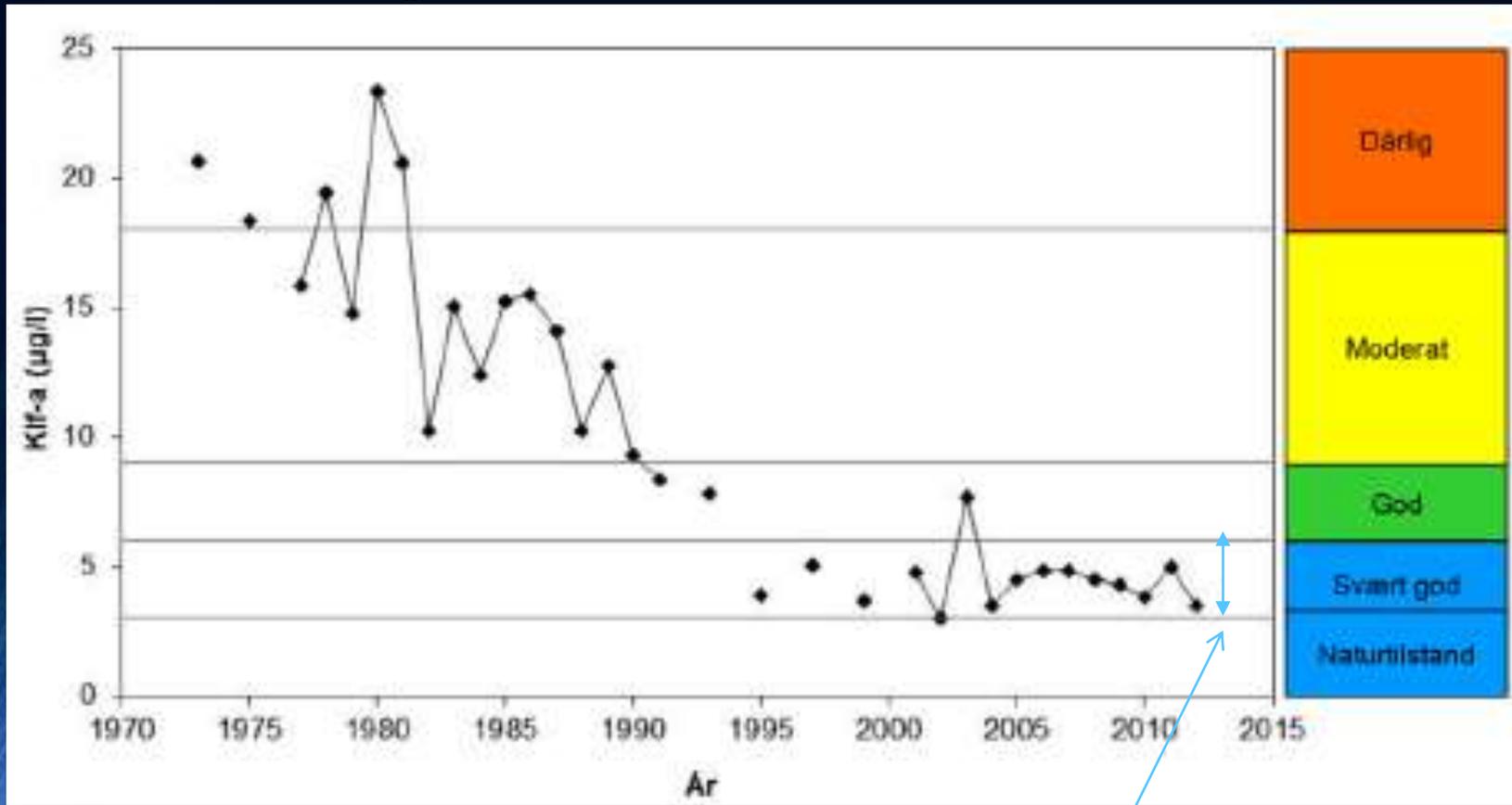
Need to have a robustnes in the algorithm. Around +/- 1-2 microgram/l Chl-a

Advantage of S2: spatial resolution

tsm [g m^-3]

| 0.75 |
| 1.00 |
| 1.15 |
| 1.40 |
| 1.62 |
| 1.85 |
| 2.05 |
| 2.25 |
| 2.50 |
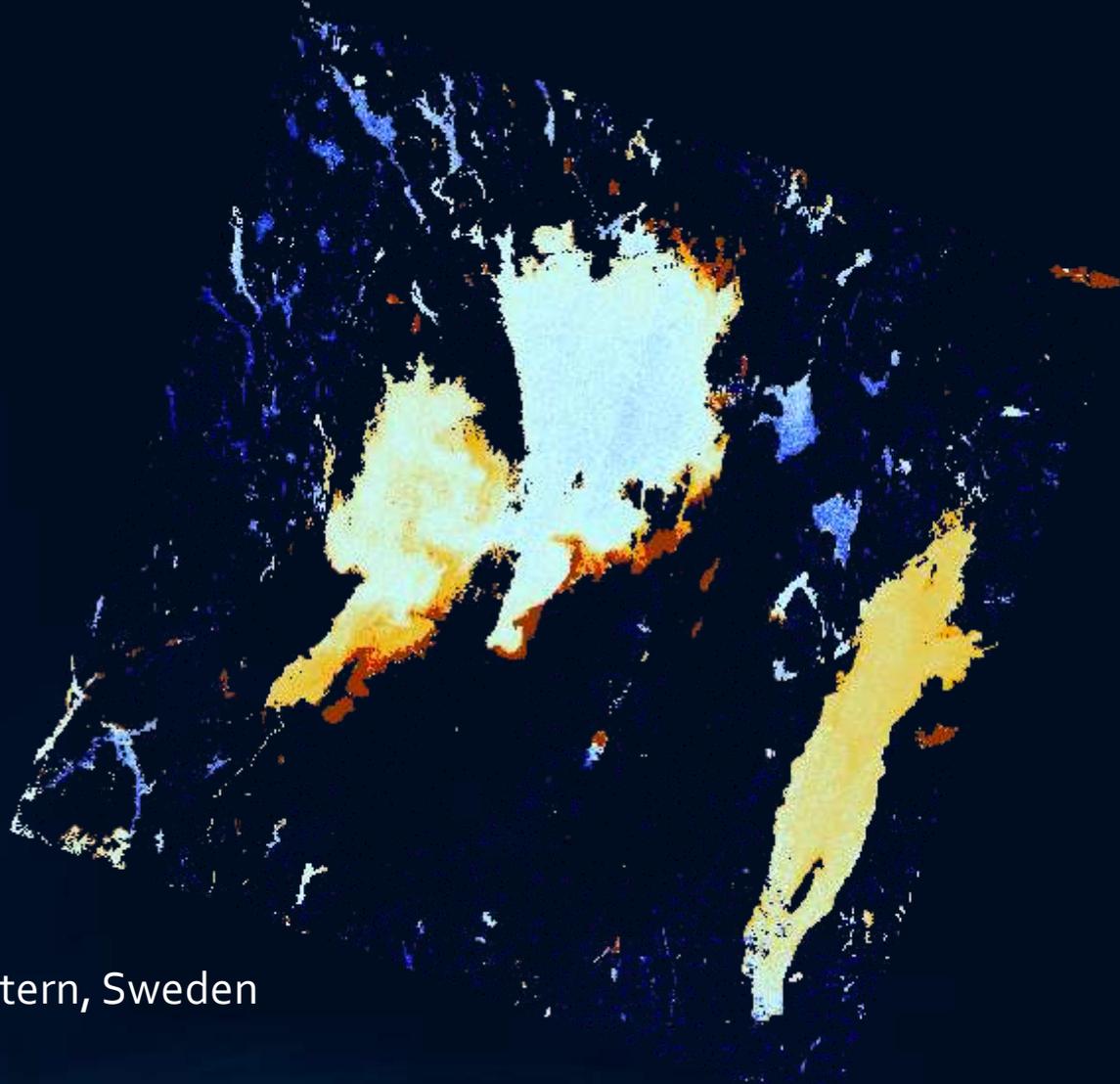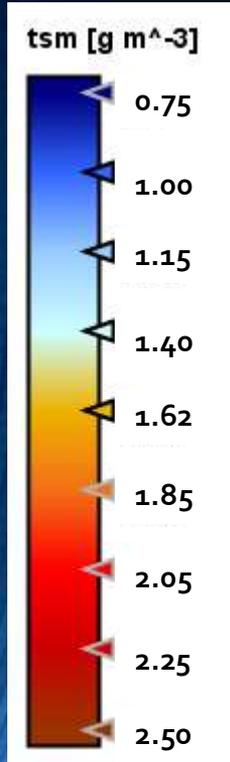
L8, Lake Vanern & Vattern, Sweden

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Water Quality in small bays and Fjords Full 30m resolution

tsm [g m^-3]

Brockmann Consult GmbH
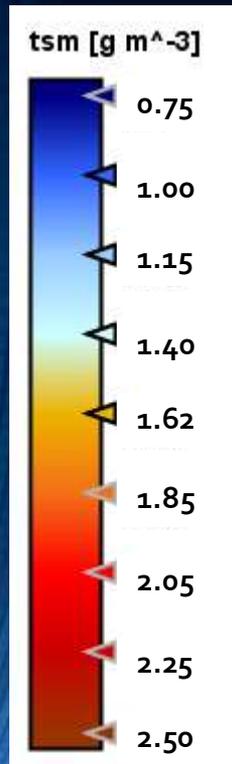
Example Lake Alakol

tsm [g m^-3]

0.5

40

80
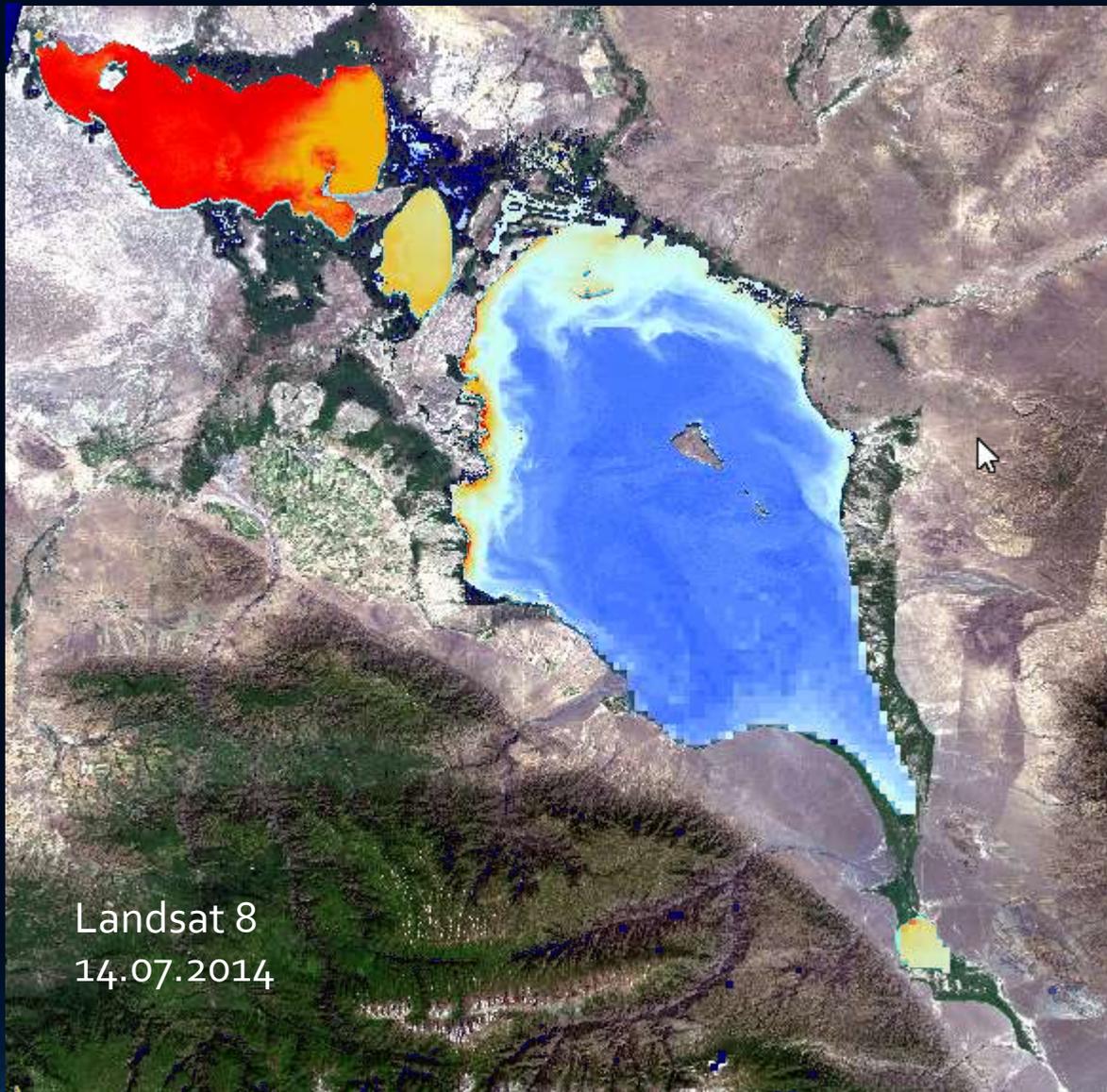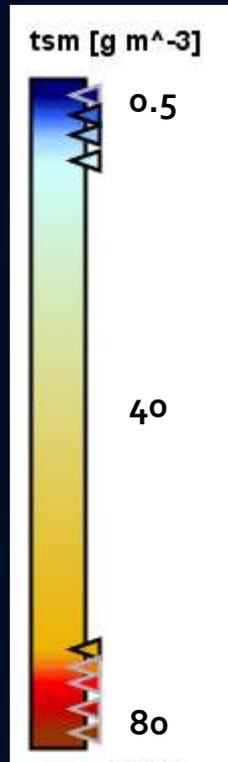
Saltwater lake in Kasachstan
2650km², 354m altitude

Landsat 8
14.07.2014

Brockmann Consult GmbH

tsm [g m^-3]

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divide by 2

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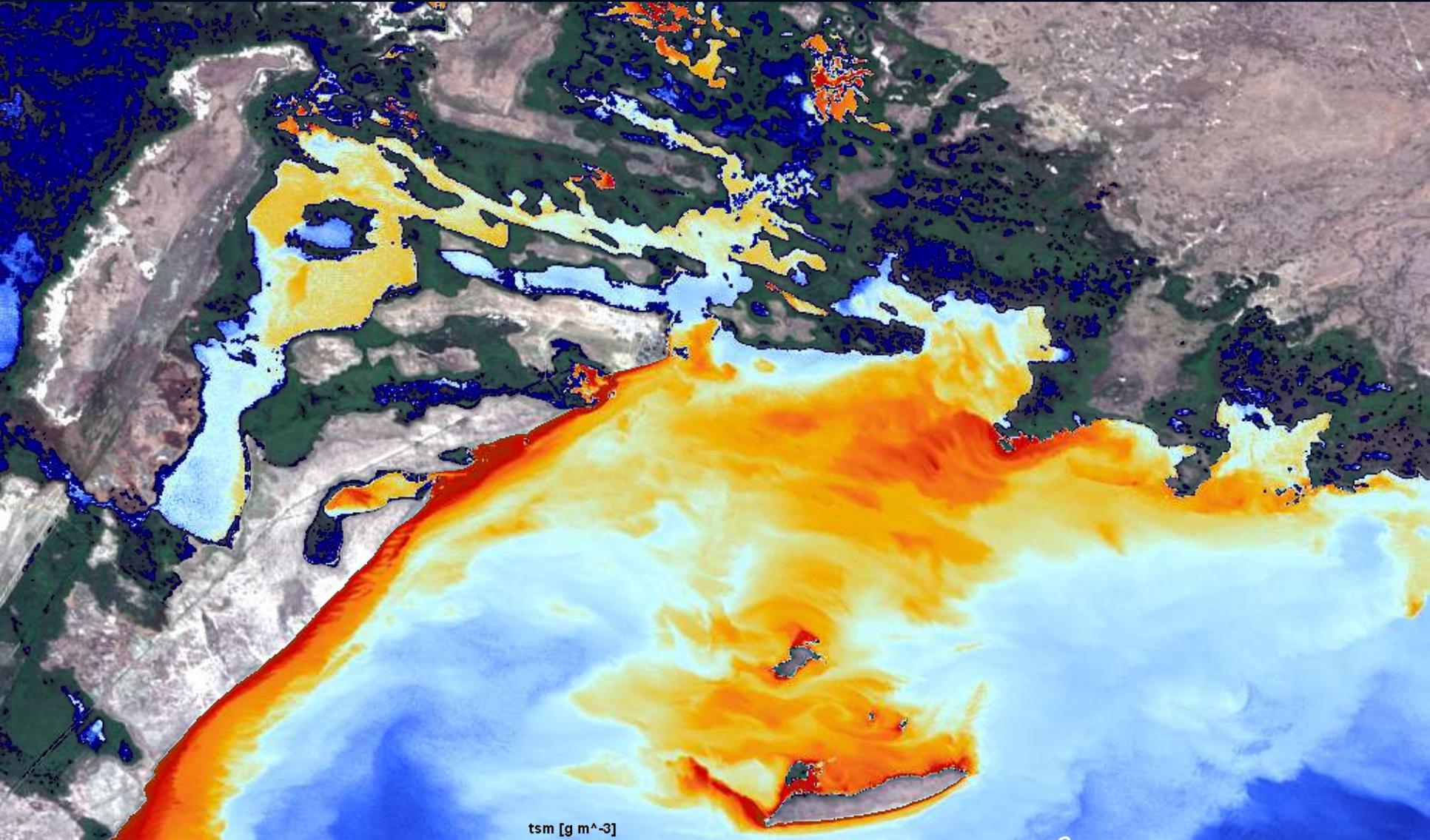
What do we need for good water quality retrieval (instrument point of view)?
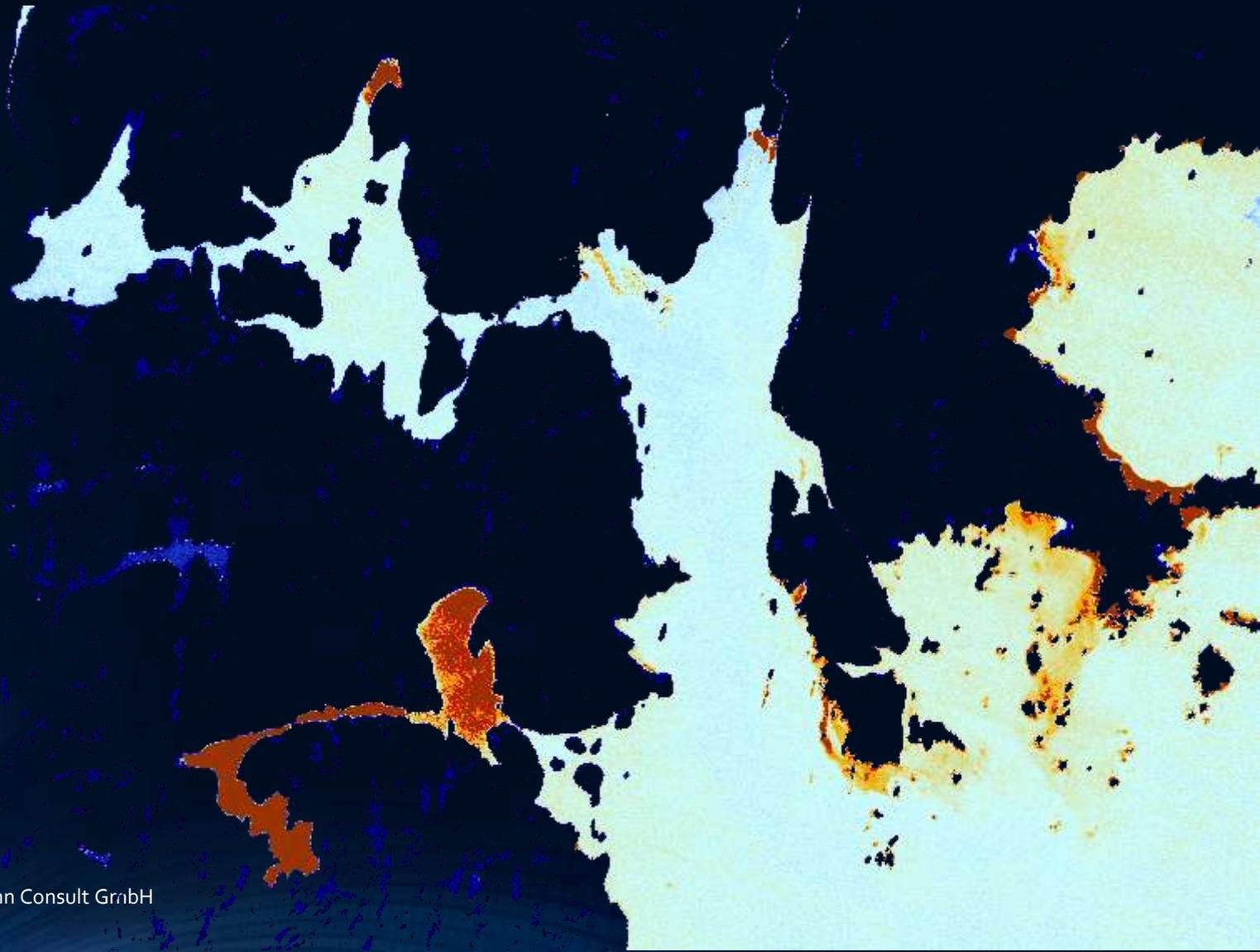
- The right radiometry
    - VIS-NIR bands resolving absorption and scattering of the water column
    - NIR-SWIR bands for atmospheric correction
    - Good SNR at typical water spectrum
    - Precisely calibrated

- Frequent observations
    - Water is a „moving target": advection & plankton dynamics
    - Cloud coverage
    - Ideally multiple images per day

- Spatial resolution
    - 100m or better for coastal area
    - 30m or better for inland waters

- Good geolocation
    - 1 pixel @ resultion < 100m

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Spectral Comparison
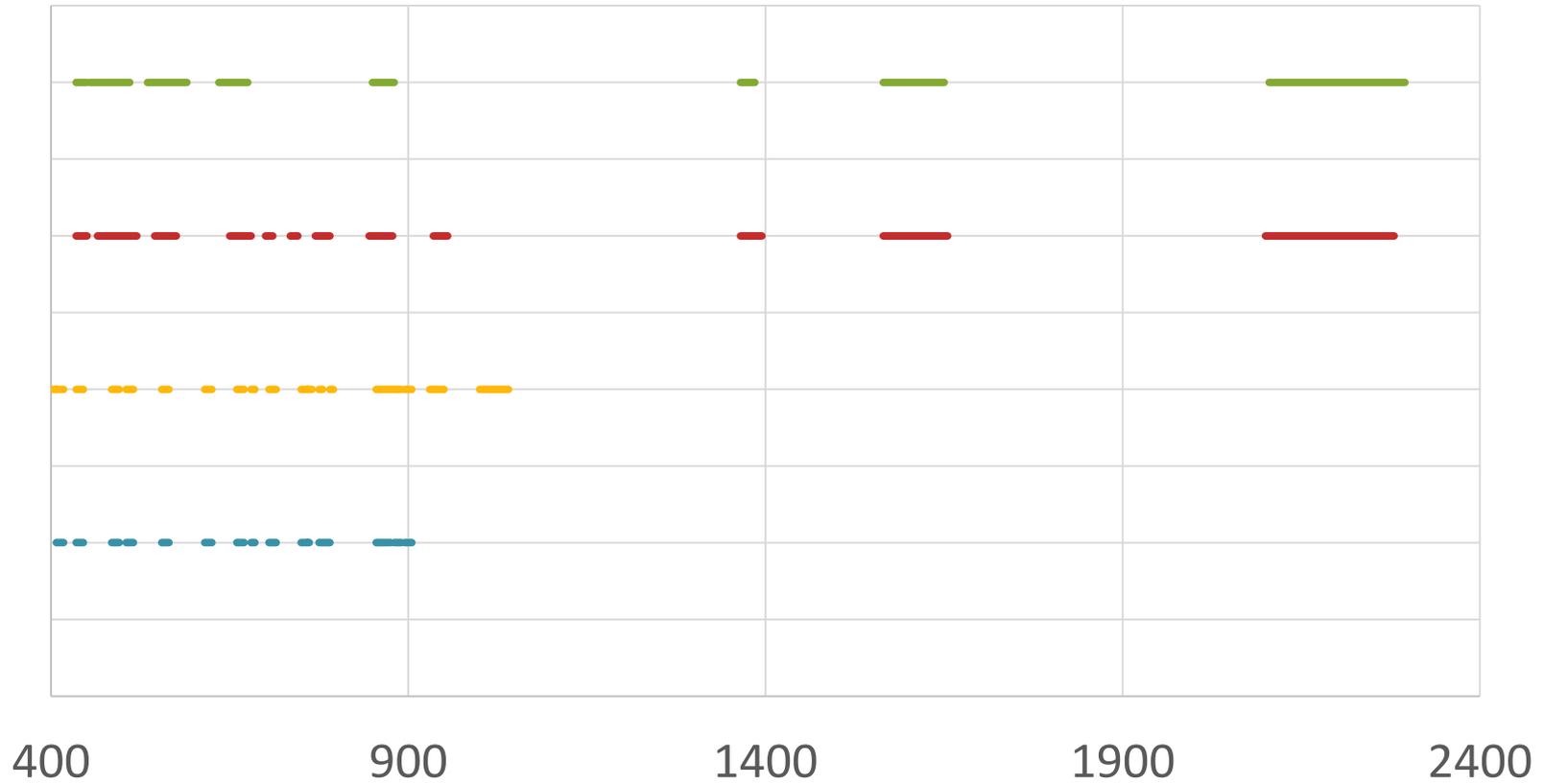
from ESA Data User Element Project „Diversity 2"

Spectral Comparison
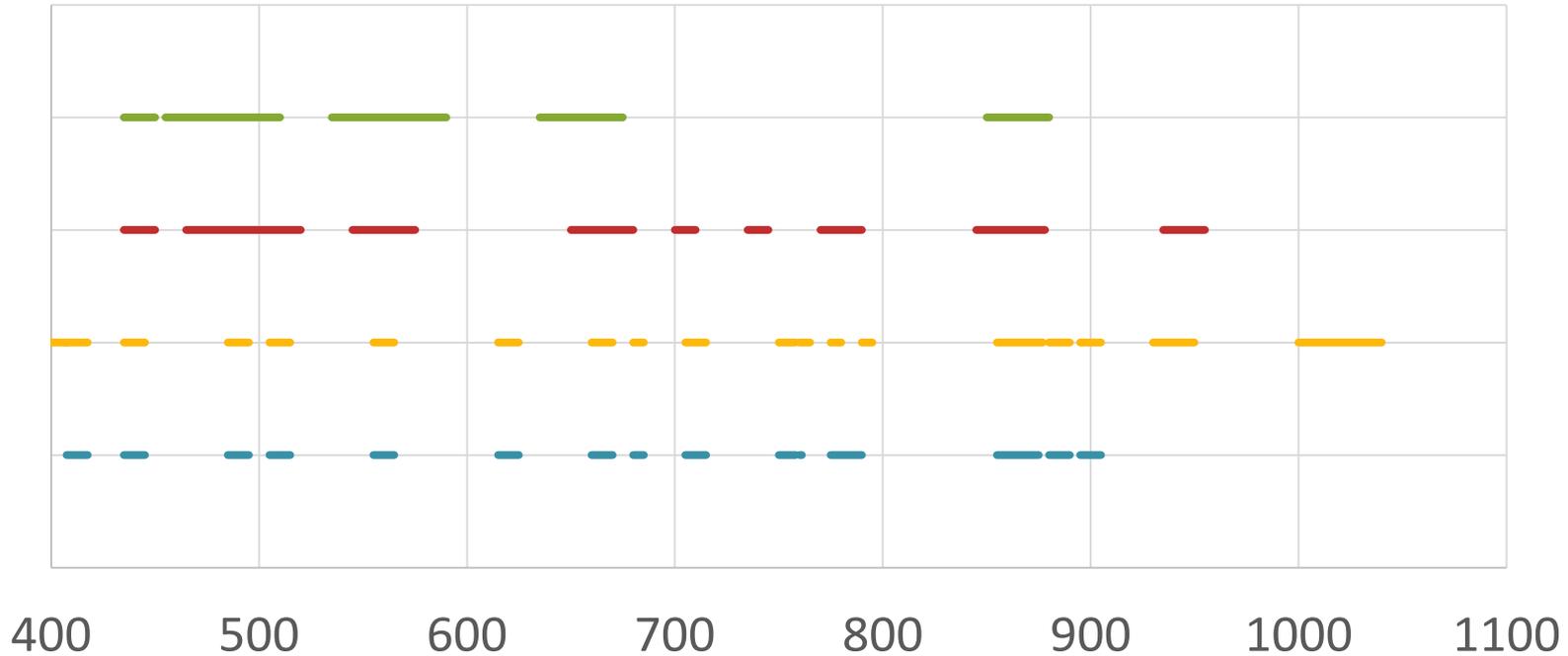
from ESA Data User Element Project „Diversity 2"

What do we need for a good water quality retrieval (algorithm requirements)?

Example:
ESA DUE DIVERSITY II
Processing Chain

pixel classification

geometric processing

atmospheric correction

in-water processing

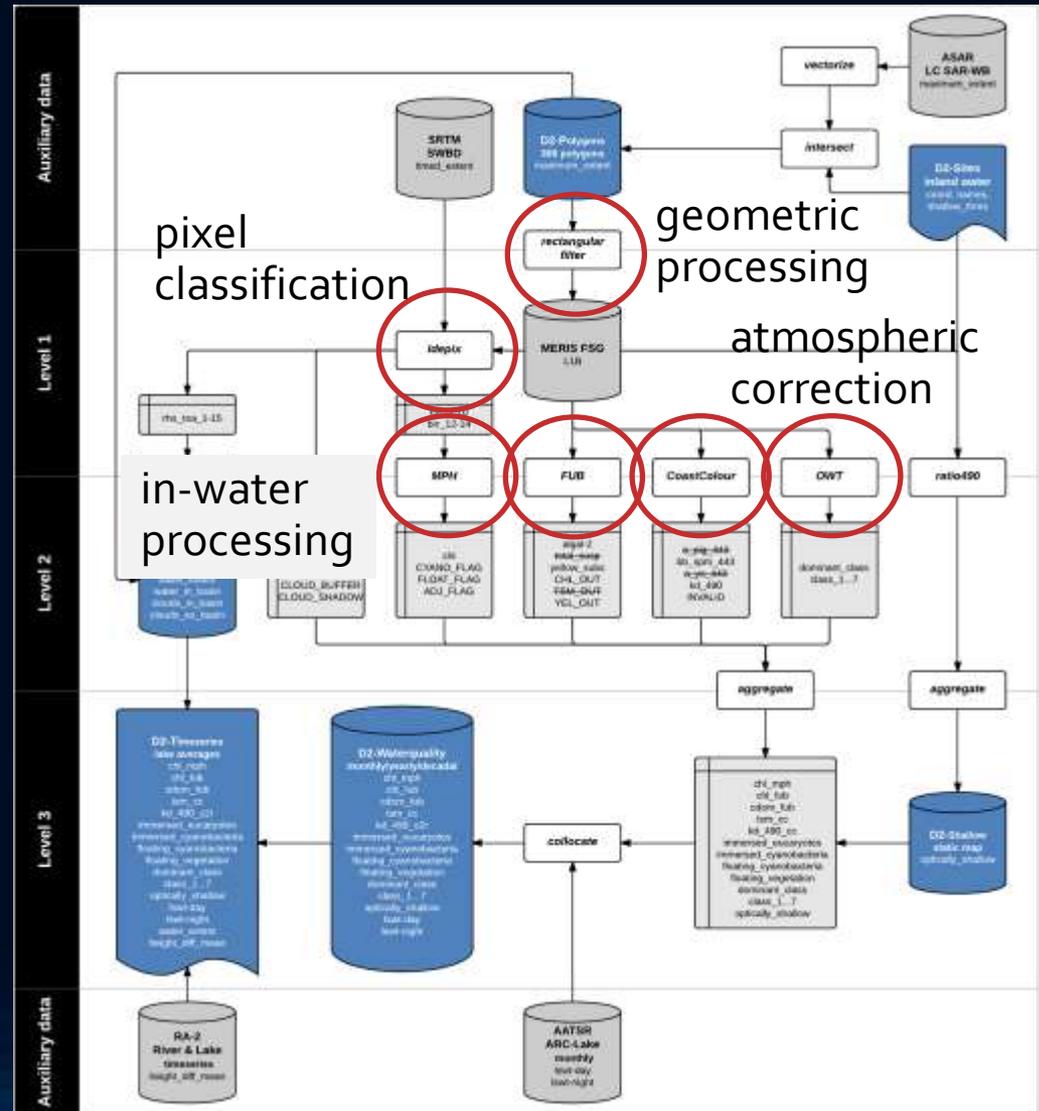Brockmann Consult GmbH

What do we need for a good water quality retrieval (algorithm requirements)?

- Geometric processing
    - accuracy 1 pixel is good enough
    - subsetting of large data volumes

- Pixel Classification
    - Clouds, cloud shadow, snow-ice, mixed water/non-water, floating vegetation, …

- Atmospheric correction
    - ancillary meteorological data: ozone, surface pressure, water vapour
    - aerosol retrieval
    - atmospheric path radiance retrieval including reflection at the water surface (sky radiance, Fresnel reflection, white caps, sun glint, …)

- In-water processing
    - concentrations of chlorophyll concentration, suspended sediments, CDOM etc

- Higher level processing
    - temporal and spatial aggregation, phenological parameters, …

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Cloud Screening – Pixel Classification
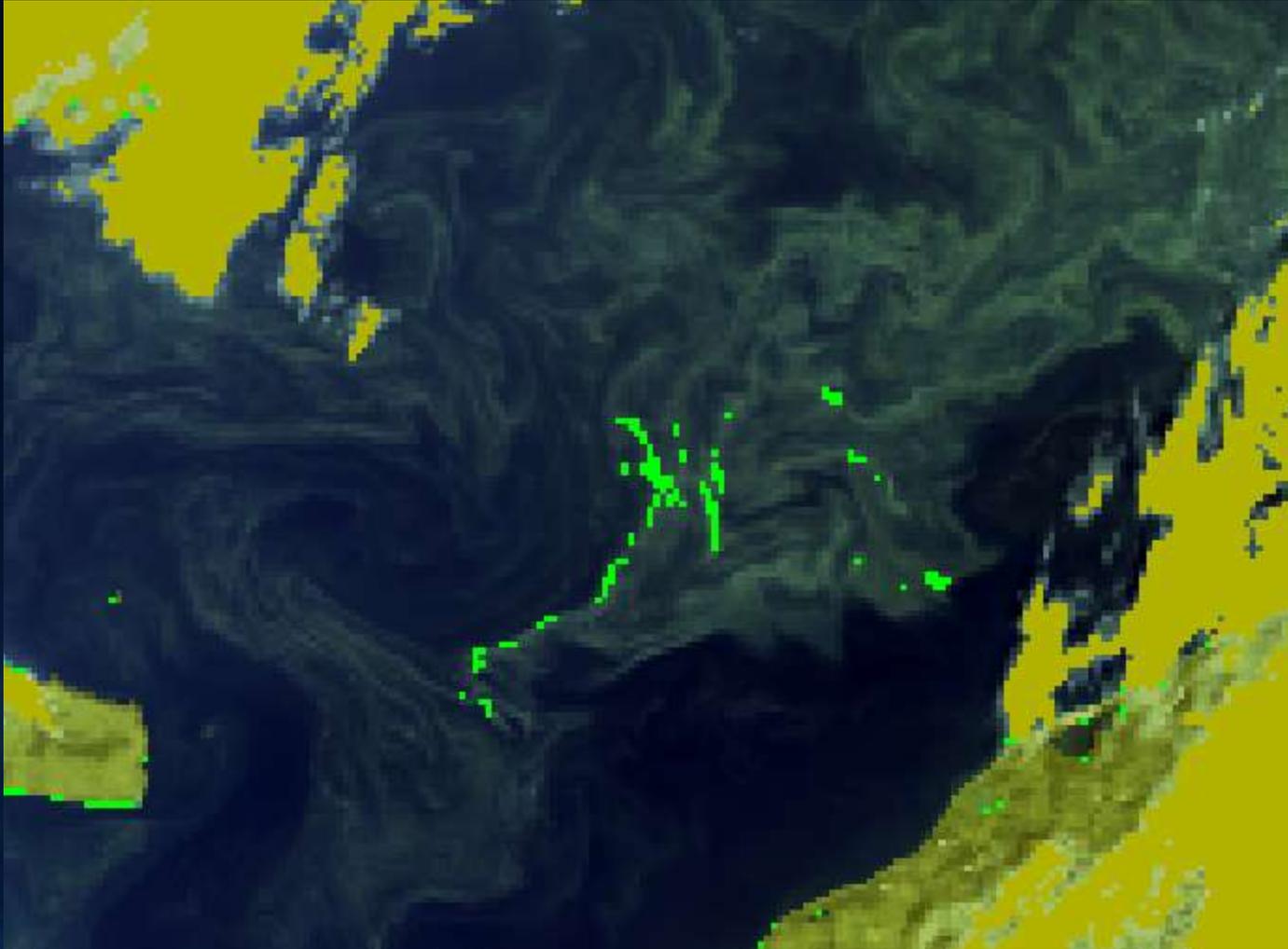
MERIS, 20.07.2010

Brockmann Consult GmbH
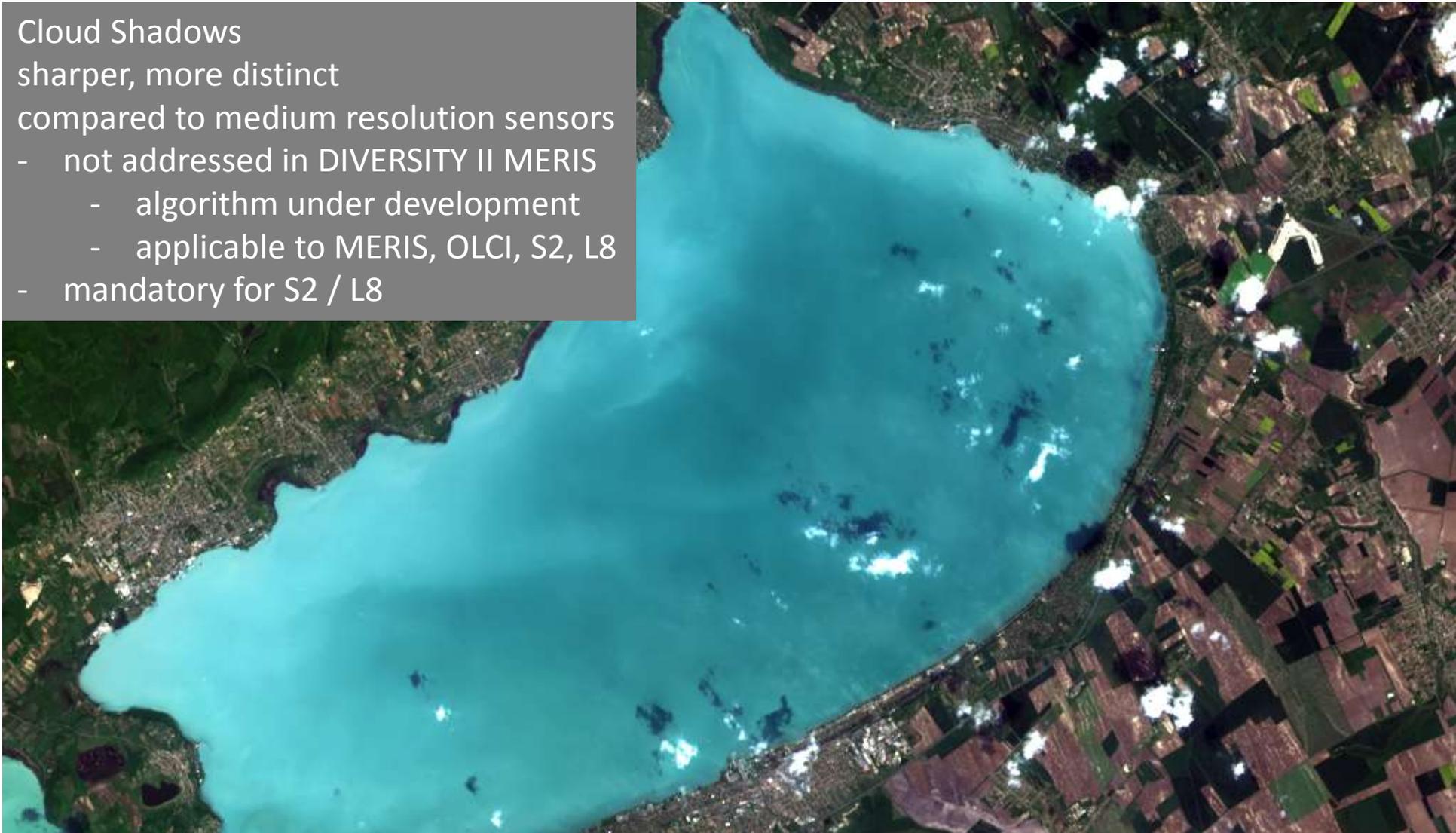
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Cloud Shadow

Cloud Shadows
sharper, more distinct
compared to medium resolution sensors
- not addressed in DIVERSITY II MERIS
  - algorithm under development
  - applicable to MERIS, OLCI, S2, L8
- mandatory for S2 / L8

Cloud Shadow MERIS/OLCI
Mountain Shadows on Fjords

- Prerequisite: Cloud screening

- Step 1: Potential cloud shadow area identification
  - Cloud top height (CTH) and cloud base (CBH) estimation
  - Intersection of line-of-sight with cloud
  - Gap filling and shadow buffering
  - Segmentation of potential cloud shadow areas (CloudShadowID)

- Step 2: Cloud shadow identification
  - For each segmented cloud shadow area perform k-means cluster analysis
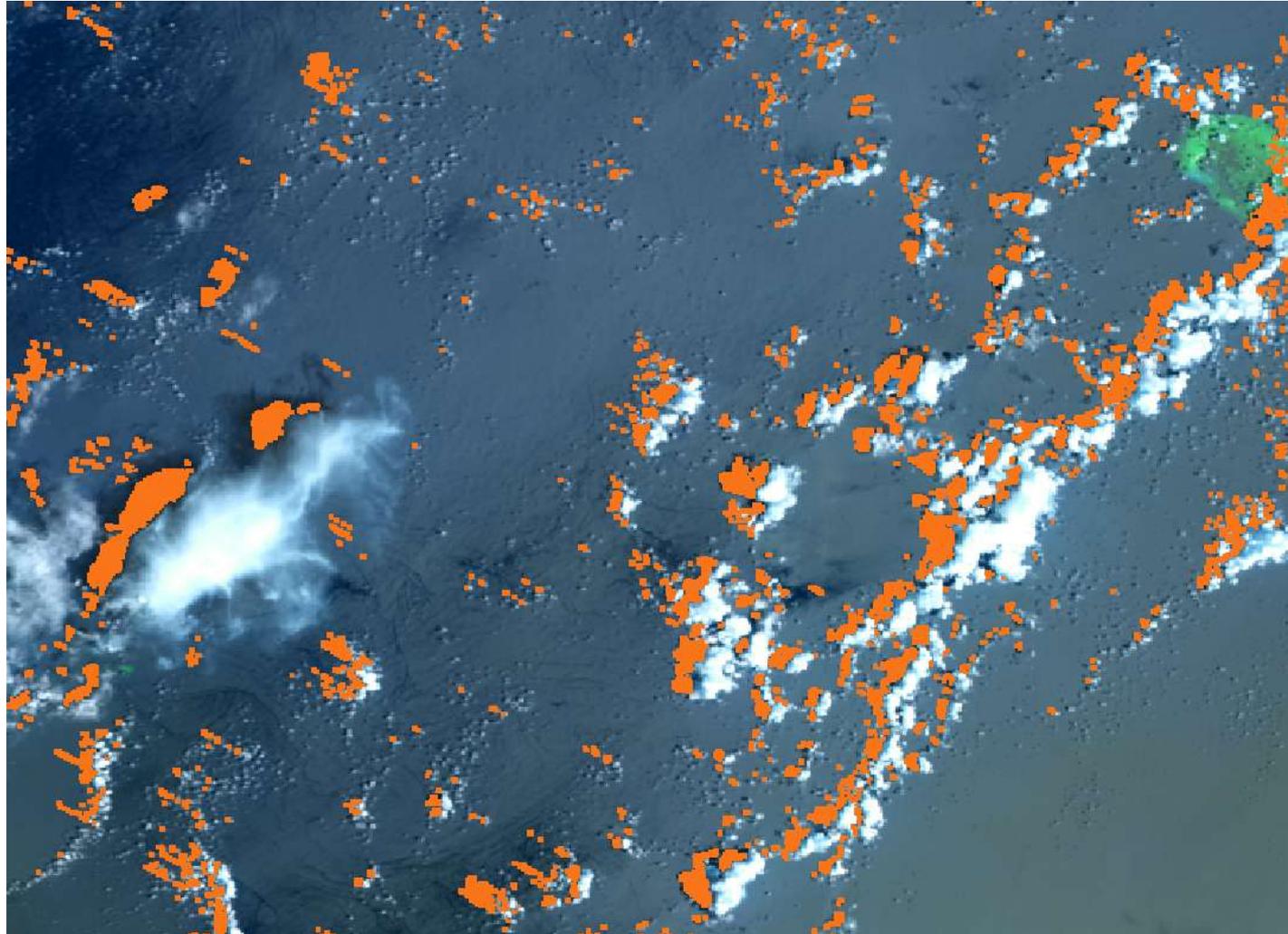 - Sort clusters into either clear and cloud shadow
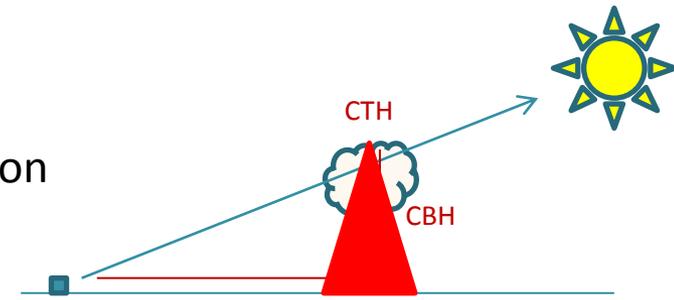
Cloud Shadow – Example - MERIS

MERIS-FSG
24. September 2011
16:31:44

- RGB

- Cloud detection
  IdePix

- Potential cloud
  shadow

- Cloud shadow &
  potential cloud
  shadow

- Cloud shadow

Atmospheric Correction (AC)

- „Ocean" type AC
  - Condition:
    - Surface signal contributes only few % to TOA signal
    - Low contrast of surface signal
  - Requirement: 3-5% accuracy of surface reflectance
  - Approaches:
    - analytical or numerical inversion of radiative transfer equation
    - assuming a water spectrum & retrieval of aerosol in the NIR
- "Land" type AC
  - Condition:
    - Surface signal dominates TOA signal
    - High contrast of surface signal
    - Large spatial and temporal variability of surface signal as well as atmospheric conditions
  - Requirement: less demanding than ocean
  - Approaches:
    - aerosol from VIS or as external input
    - explicit calculation of atmospheric path radiance
- For coastal & inland waters with S2 we will need both approaches!

„Ocean" Type AC Example Landsat 8
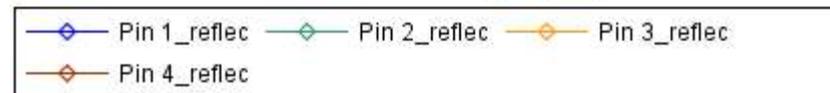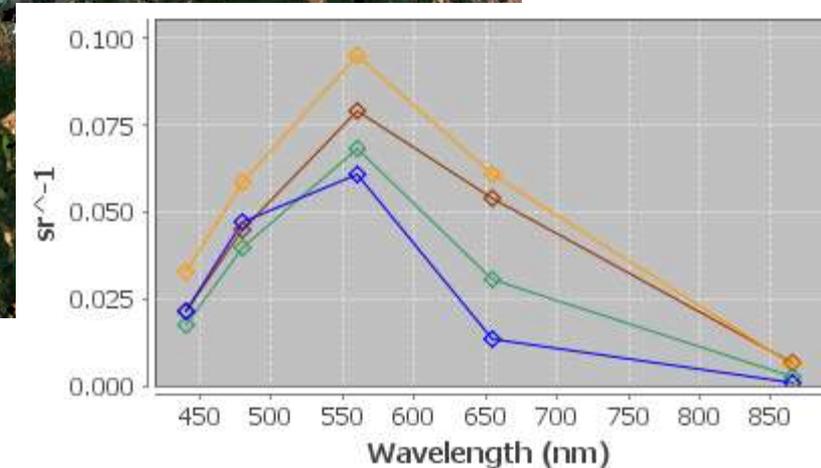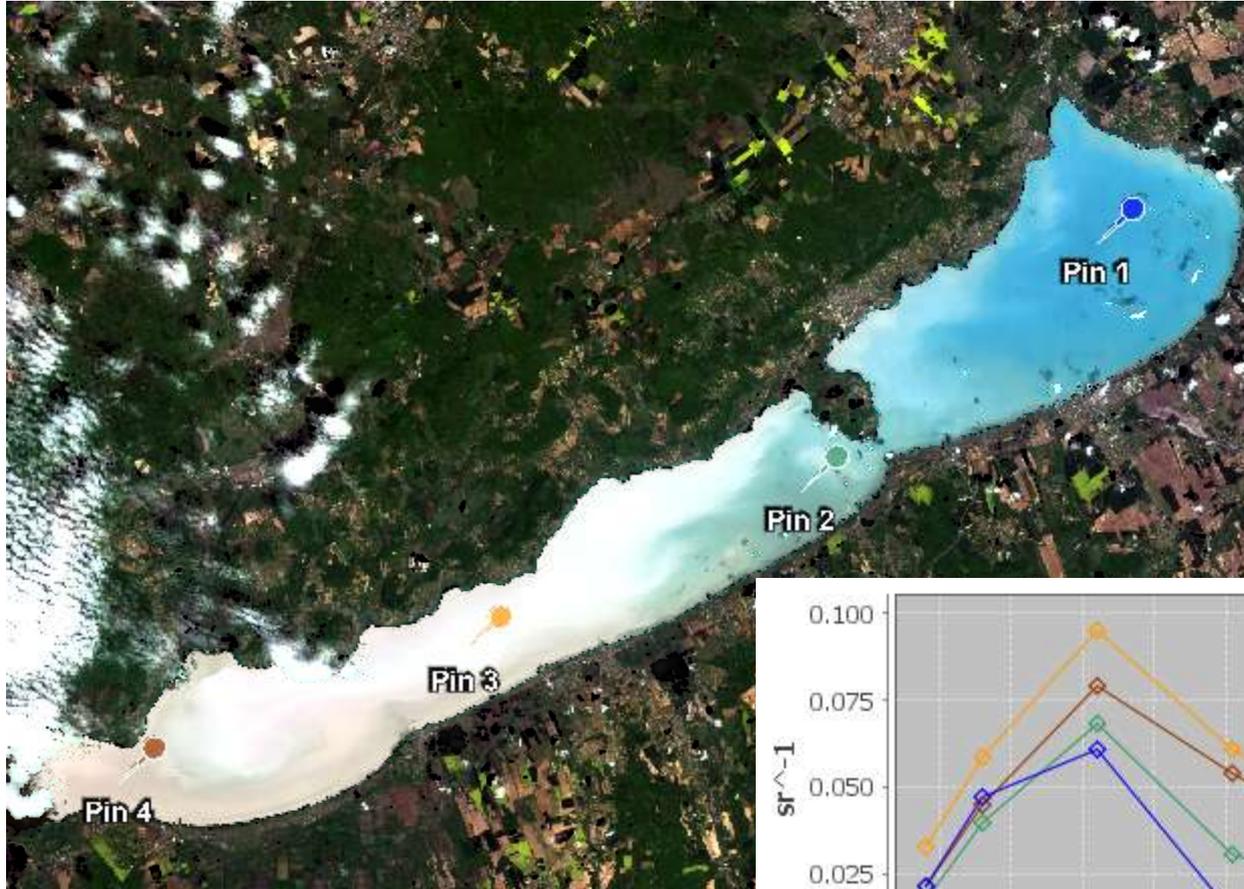
Landsat 8 – MODIS comparison

19.04.2014

TSM comparison

Structures captured, more definition with Landsat
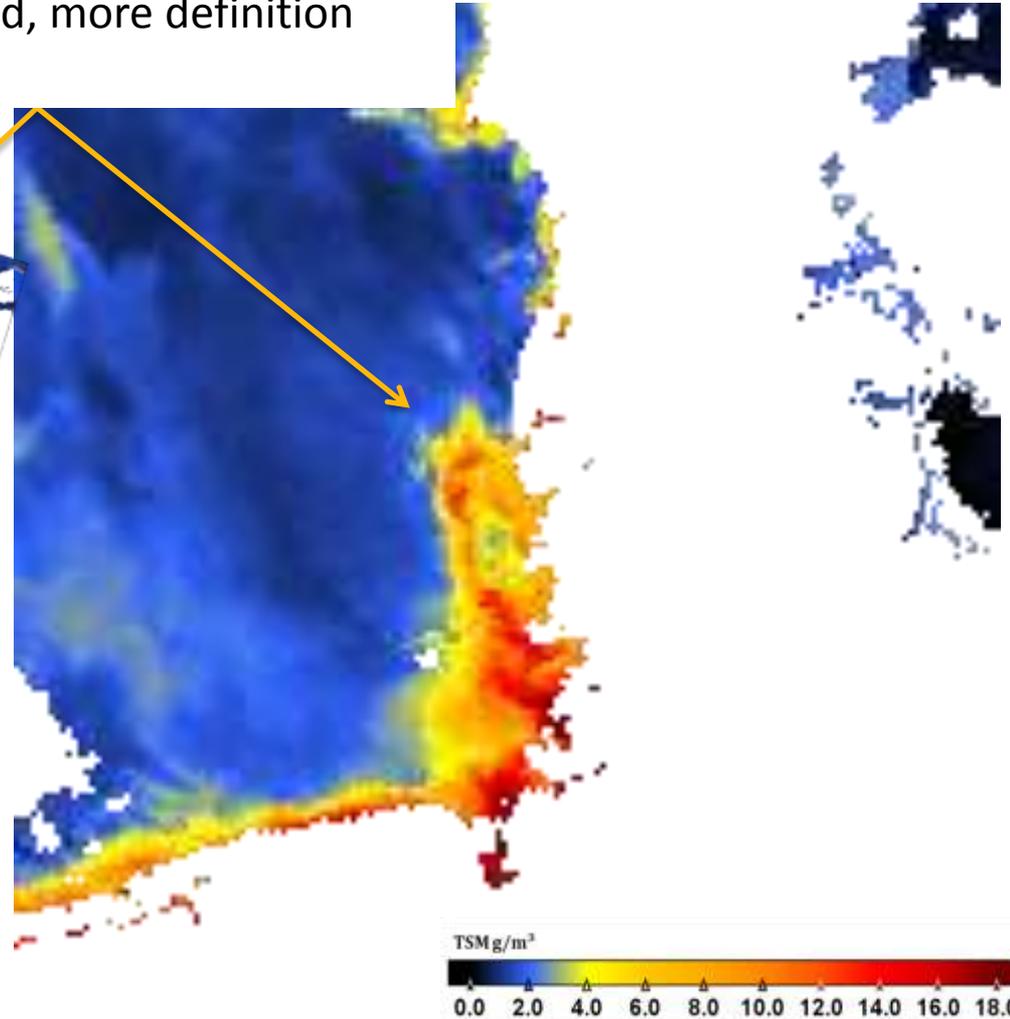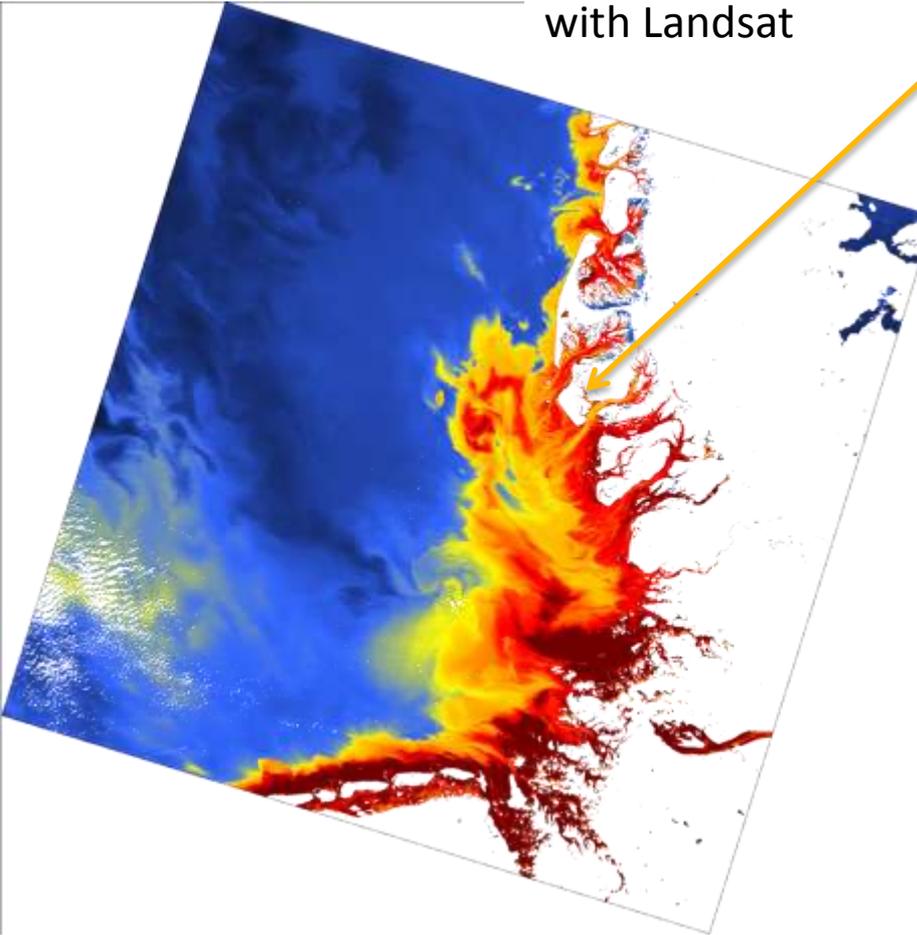
Landsat processed with NN

MODIS L2 processing –
TSM = 400.75 * PI * Rrs_678 /(1-PI*Rrs_678/0.1774)

Data Access and Availability

- Service Requirements
  - bi-weekly/monthly cloudfree product in order to catch events and resolve critical periods
  - blooming
  - ice melting
  - phenological cycle
- Data Access
  - NRT for operational purposes (fish farms)
  - 1 day latency for other

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Service Requirements
Stage 1: preprocessing, storage, access

- Spatial subsetting
  - probably supported by data hub

- System corrections
  - geometric and radiometric correction if neccessary

- Pixel classification
  - cloud screening and other pixel classification annotation

- Projection / mapping
  - if required projection to common grid
    (possibly better done at Level 2)

- Meta data, cataloguing and storage

- Hosted processing for time series processing and full mission reprocessing

- Long term stewartship

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GLaSS Core System

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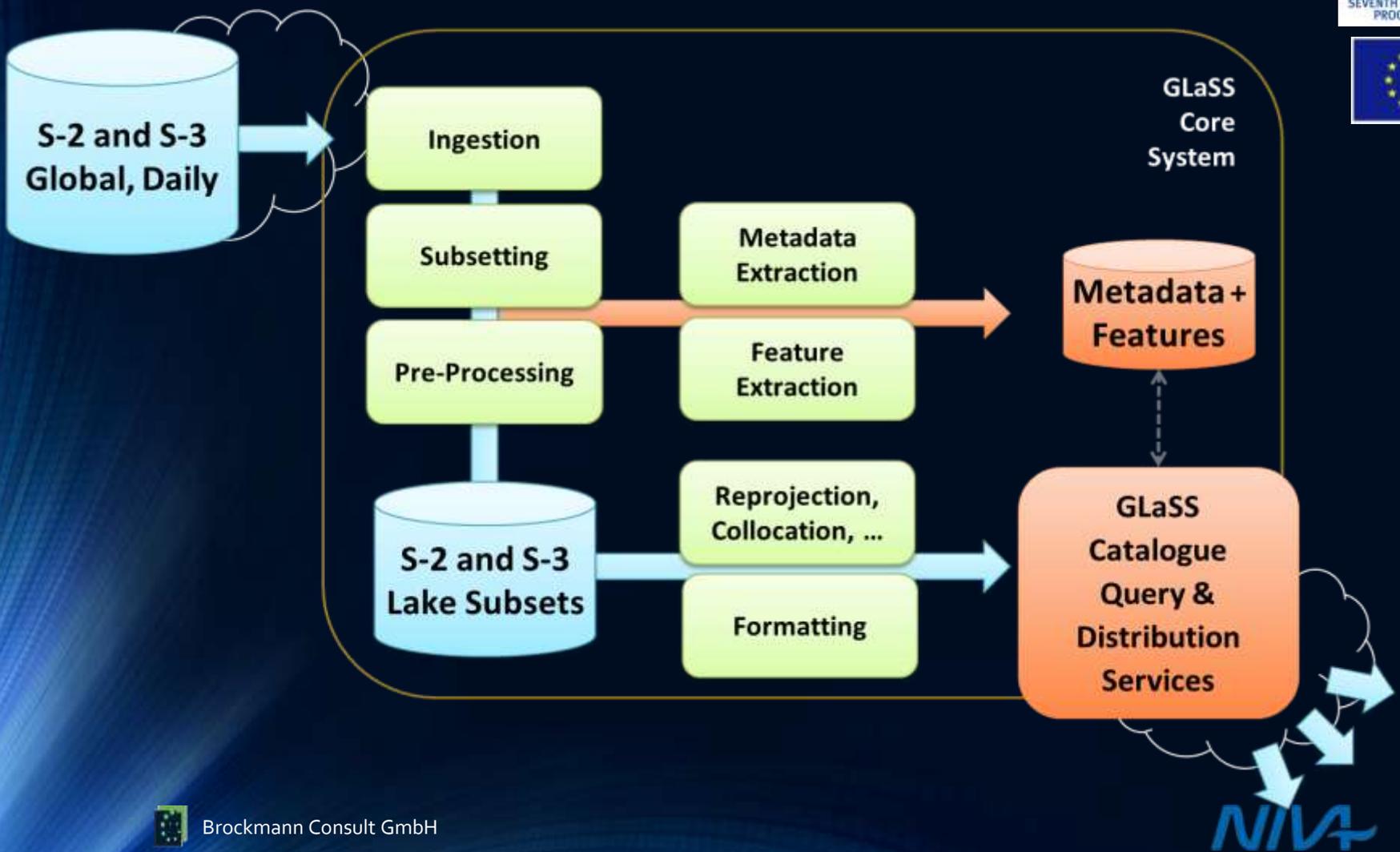
Service Requirements Stage 2: Value Adding

- Fast access to preprocessed data
  - data push / pull
  - search by features

- QC on input data

- Combination of all available source data (S1+2+3, L8, …)
  - intercalibration if required
  - vicarious calibration

- Sensor merging

- Atmoshperic correction

- Water type classification

- in-water processing: chl-a, TSM, YS

- filtering

- statistical analysis

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Requirements / unresolved issues

- S2 calibration accuracy
  - intercalication - CEOS WGCV?

- Atmospheric correction for inland waters
  - boreal area is specific
  - reflection from forests (adjacency effect)
  - mountain shadows and reflection

- In-water properties
  - characterisation of specific inherent optical properties
  - database of aparent optical properties (surface reflectances)

- Product & serviec development

- In-situ network
  - coastal waters .... excellent NIVA experience from ENVISAT, needs continued
  - dedicated ship cruises with dedicated equippment, internationally intercalibrated
  - needs to be complemented with inland water stations

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