Monitoring the water quality by using Sentinel and Landsat satellite series – VESISEN

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SYKE

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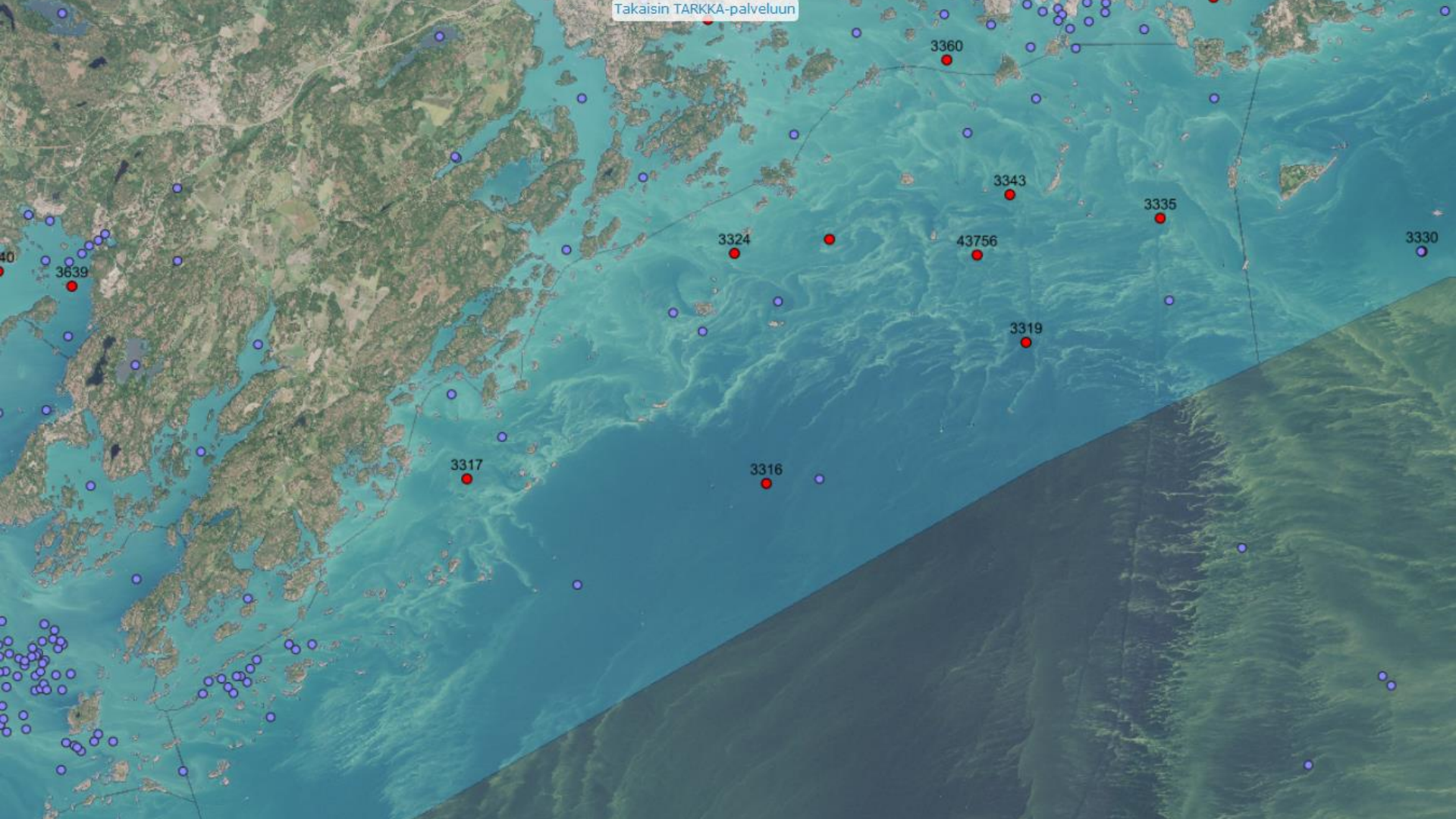
EOMORES

Satellite observations for WFD reporting?

- EO = Earth Observations, remote sensing, satellite observations
- EU Copernicus programme (https://www.copernicus.eu/)
  - Offers information services based on EO
  - Sentinel satellite series guarantee continuation of long term assessment data (until 2030 and beyond)
- WFD ecological classification elements available from EO data are:
  - Chlorophyll *a*, Secchi depth, information on cyanobacteria & macrophytes
  - Supporting elements: Turbidity/total suspended matter, CDOM (coloured dissolved organic matter)

SYKE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EO for WFD in Finland

- Finnish Ministry of Environment has supported and funded method development for using EO data as complementary data for directive reporting.
- SYKE (Finnish Environment Institute) has developed approaches and web applications for using satellite instrument observations (Sentinels & Landsat) for the directive use.
- EO data portals were directly linked by available water body to the national water body information system used in WFD.

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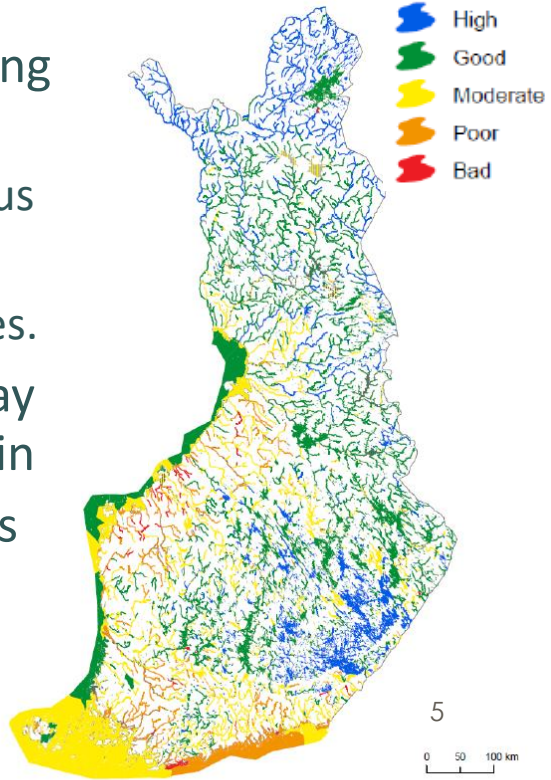
EOMORES

EO for WFD in Finland

- In Finland, the obligations set by EU for WFD reporting are particularly extensive
  - Fragmented coastline and thousands of islands of various sizes.
  - about 4500 lake and more than 250 coastal water bodies.
- EO methods enable automated and cost-efficient way to derive more water quality information especially in areas out of reach for station sampling or sampling is sparse.

Ecological status of surface waters 2015



Classification is based on data from years 2006-2012.
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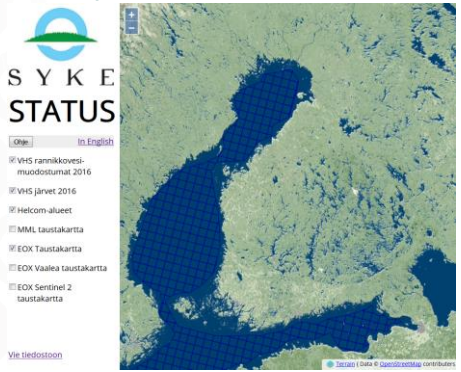
User interfaces to access water quality EO

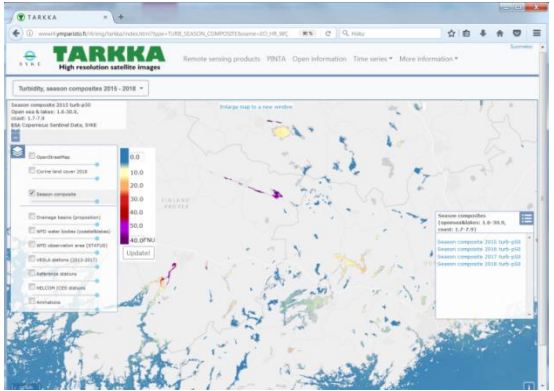
STATUS

- Water body based database and interface for combining and analyzing water quality monitoring data.
- For authorities (regional and SYKE)



TARKKA

- Web application for distributing EO water quality products over Finnish lakes and the Baltic Sea.
- Open for public.
- http://syke.fi/TARKKA/en



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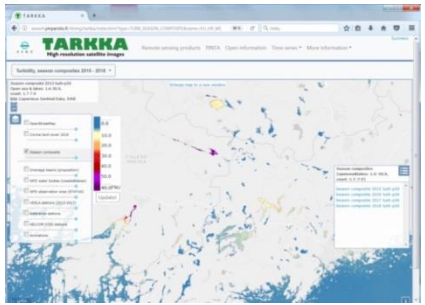
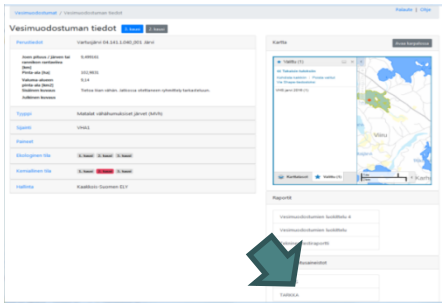
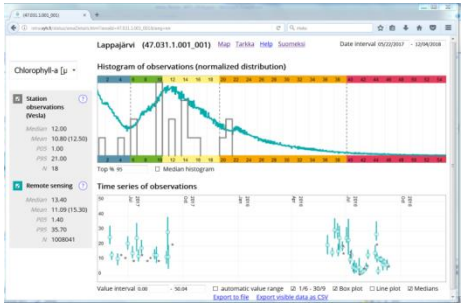
EO for WFD in Finland

- The dataset covers:
  - Chl-a: 2011 (coastal waters), 2015 – 2018
  - Secchi depth, turbidity (CDOM) 2013 – 2018
  - 87% of the lake and almost all coastal water area
  - 44% of Finnish lake water bodies
  - Excluded: shallow and small (narrow) lake water bodies.

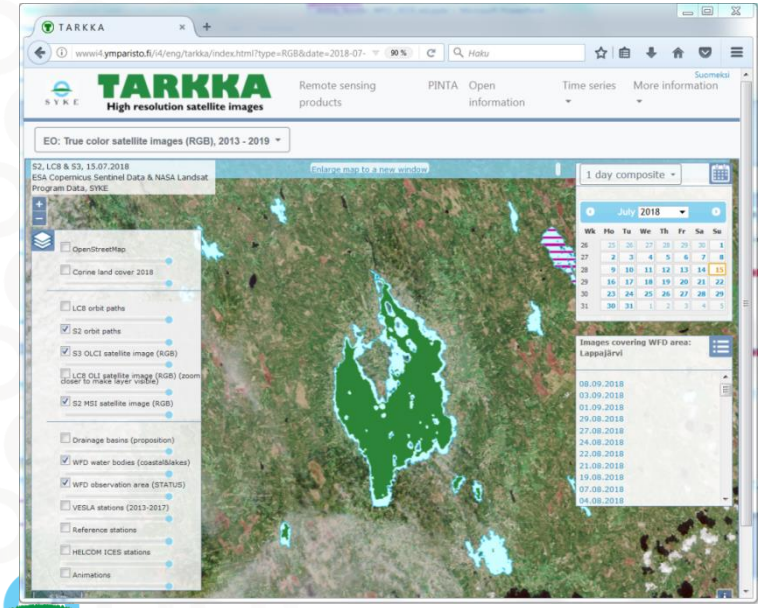


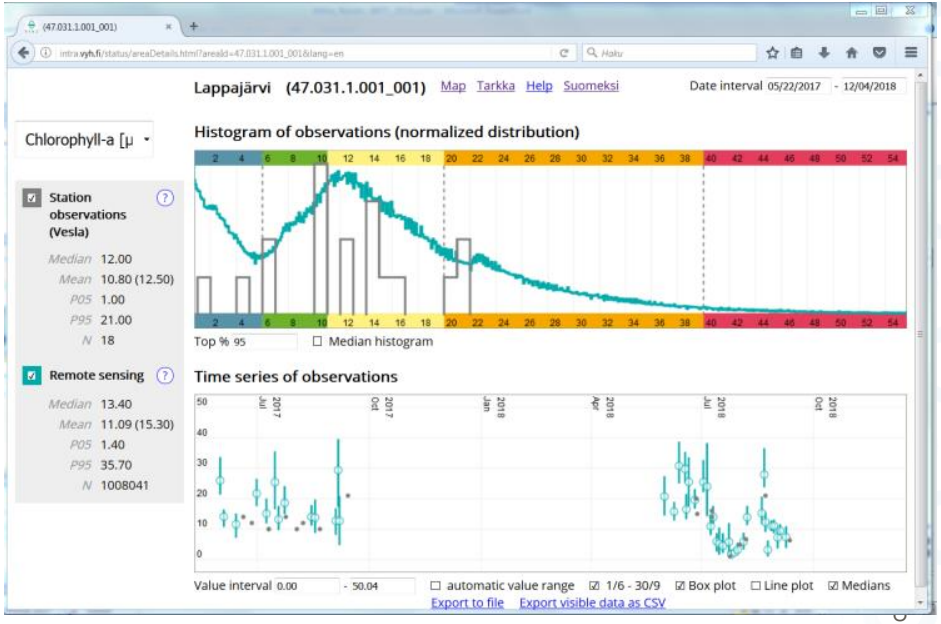




SYKE

EO directly linked to water body information system for each water body





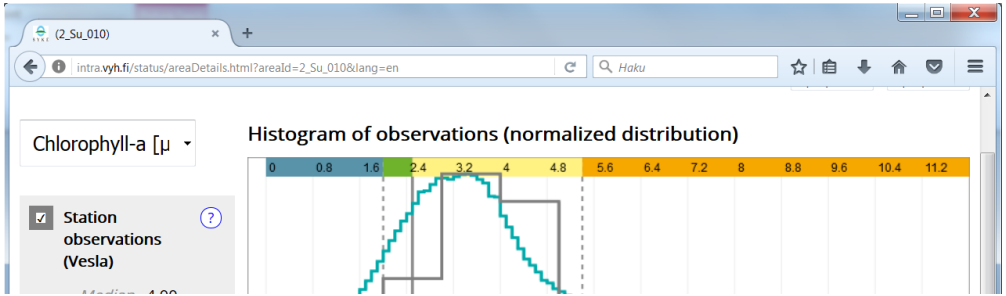
SYKE

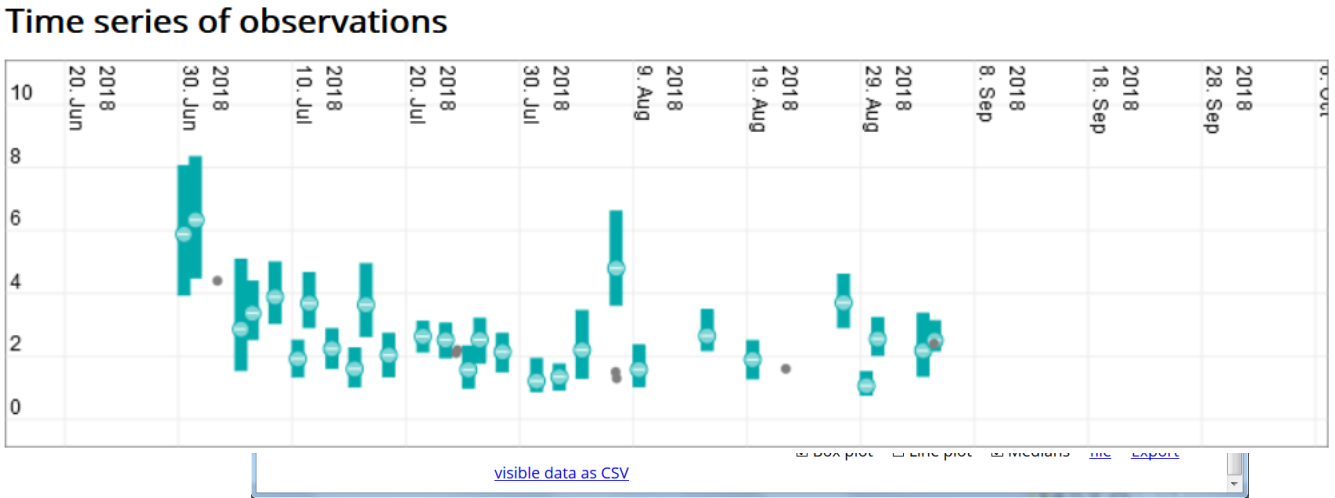
STATUS interface shows

- Distribution of all observations for monitoring station sampling and EO
- Statistics
- Time series

In the histogram plots, WFD status classes are visualised by colours:

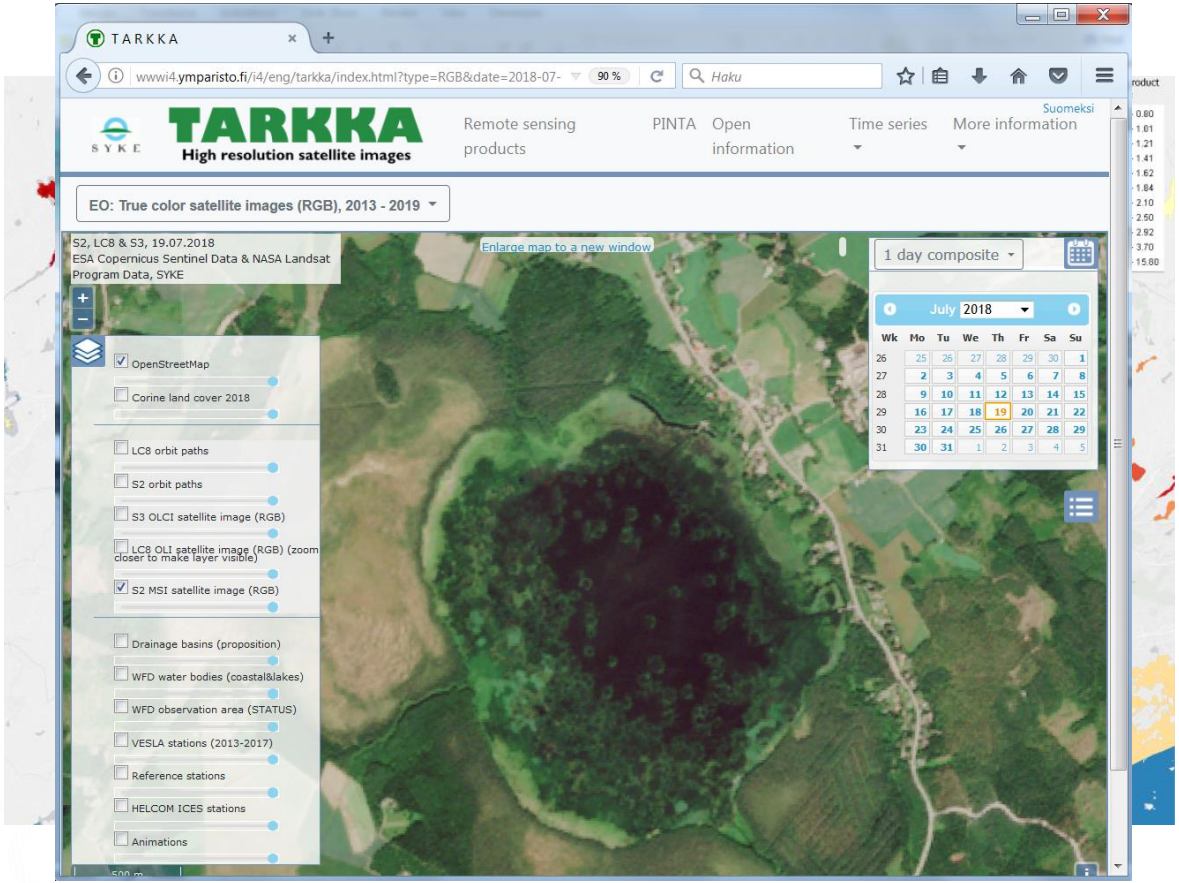
- blue: excellent,
- green: good,
- yellow: moderate,
- orange: poor,
- red: bad





TARKKA:

water body aggregated maps over WFD assessment period and areas:



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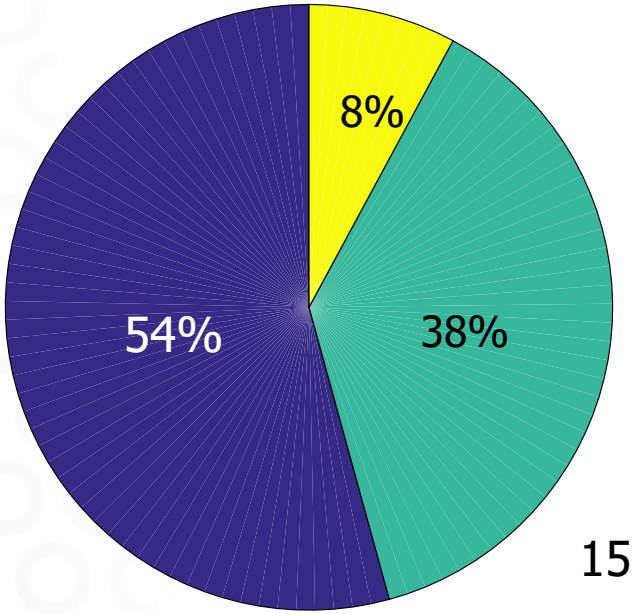
EO & station sampling based status class in Finnish lakes



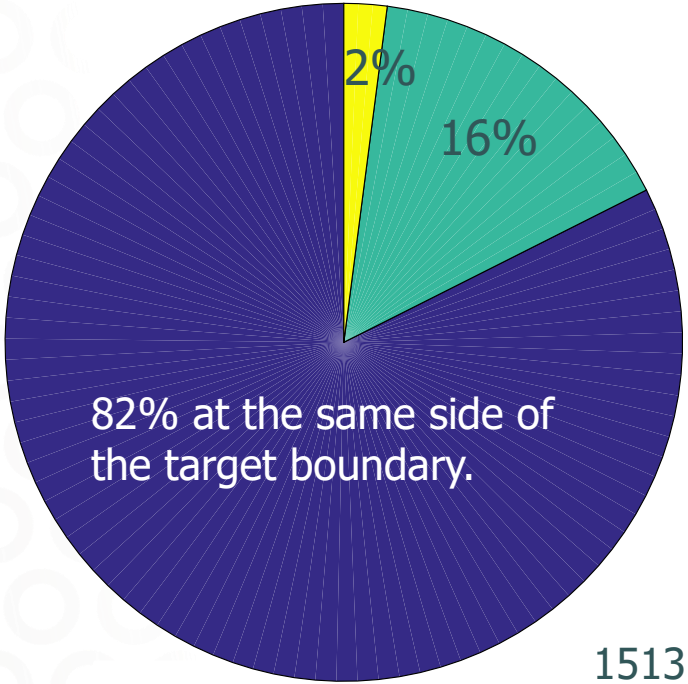
WFD chl-a status class by EO and station sampling is the same: 54%

WFD status class defined by EO ends up in better status than by station sampling: 38%

1513 cases

SYKE

EO and station sampling at the threshold between chl-a status classes ‘good’ and ‘moderate’.



82% at the same side of the boundary between ‘good’ and ‘moderate’ status. Minority ended up to better (16%) and worse (2%) side of this status class boundary

1513 cases

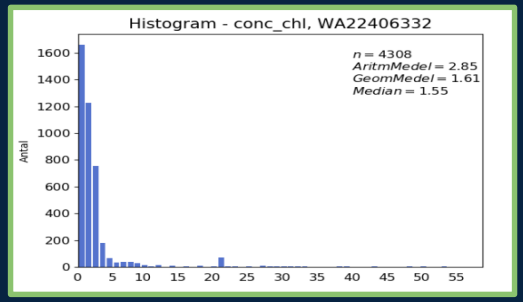
SYKE

EO supported WFD status assessment in Sweden 2019

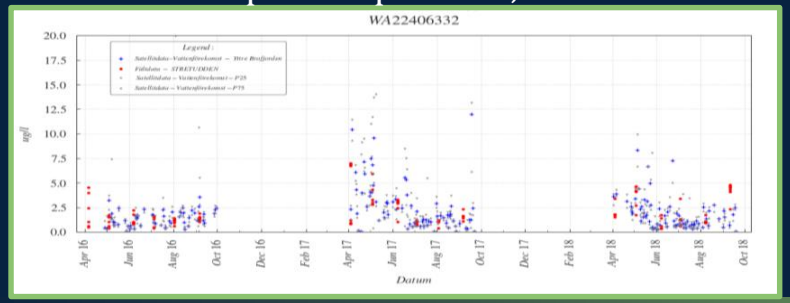
Sentinel-3 OLCI data, collected between 2016-2018, was used to produce water quality (WQ) estimates per water body and date. The information was delivered to SwAM and coastal County Boards:

- Tabulated WQ estimates per water body and date
  - ✓ Chl a, Secchi Depth, Turbidity and a_{dg}(443 nm)
- Tabulated Status class (SMHI Ecostat Calculator)
  - ✓ High, Good, Moderate, Poor and Bad

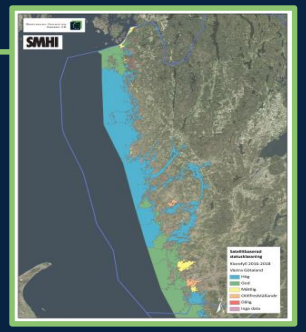
Histograms for Chl a and Secchi Depth



Time series: April – September, 2016-18



- Maps (shape-files)



And interpretation support to the County Boards during the actual assessment work.

Petra Philipsson
Brockmann Geomatics Sweden AB

Swedish Agency for Marine and Water Management

In collaboration with:

Brockmann Consult GmbH

SMHI

EO can best complement station sampling in

- Substantially higher spatial and temporal coverage.
- Areas, where
  - Status is uncertain or near the class boundary of two status classes
  - Station sampling is sparse or not available
    - 500 small water bodies with no sampling but more than 10-20 EO chl-a observations (2015 – 2018)
  - A study by (Kotamäki et al., 2019) estimated that on 70% of the Finnish lakes and coastal water bodies (the 2nd round of WFD) confidence of chlorophyll a could be increased.

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WFD EO in the future?

- Many EU countries have expertise and are utilizing or making preparations for using EO methods for WFD.
- Copernicus services do not yet provide consistent EU wide material for this purpose, but national and project-based efforts exist.
- White paper for directive renewal in preparation in EOMORES/H2020 project (NL, UK, IT, EST, LT, FIN):
  - Recommends: actions should be taken to accept, promote and support the uptake of EO derived metrics in the WFD.
  - Level of readiness should be defined for each country; EO-derived metrics should be used where possible in WFD.

Thank you!

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EO vs Station sampling in WFD reporting?

- The difference in statistical metrics calculated by EO and station sampling was 23% (Attila et al., 2018) – well within the uncertainty limits of chl-a laboratory analyses.
- In 2006- 2011, EO(MERIS) chl-a fell on the same status class (or better) as station sampling in over 80% of the coastal water bodies (80 in total).
- For the ongoing WFD classification in 2018-2019, a similar dataset using Sentinel-series instruments was produced and covered 87% of the area of Finnish lakes water bodies and almost all of the coastal water bodies.

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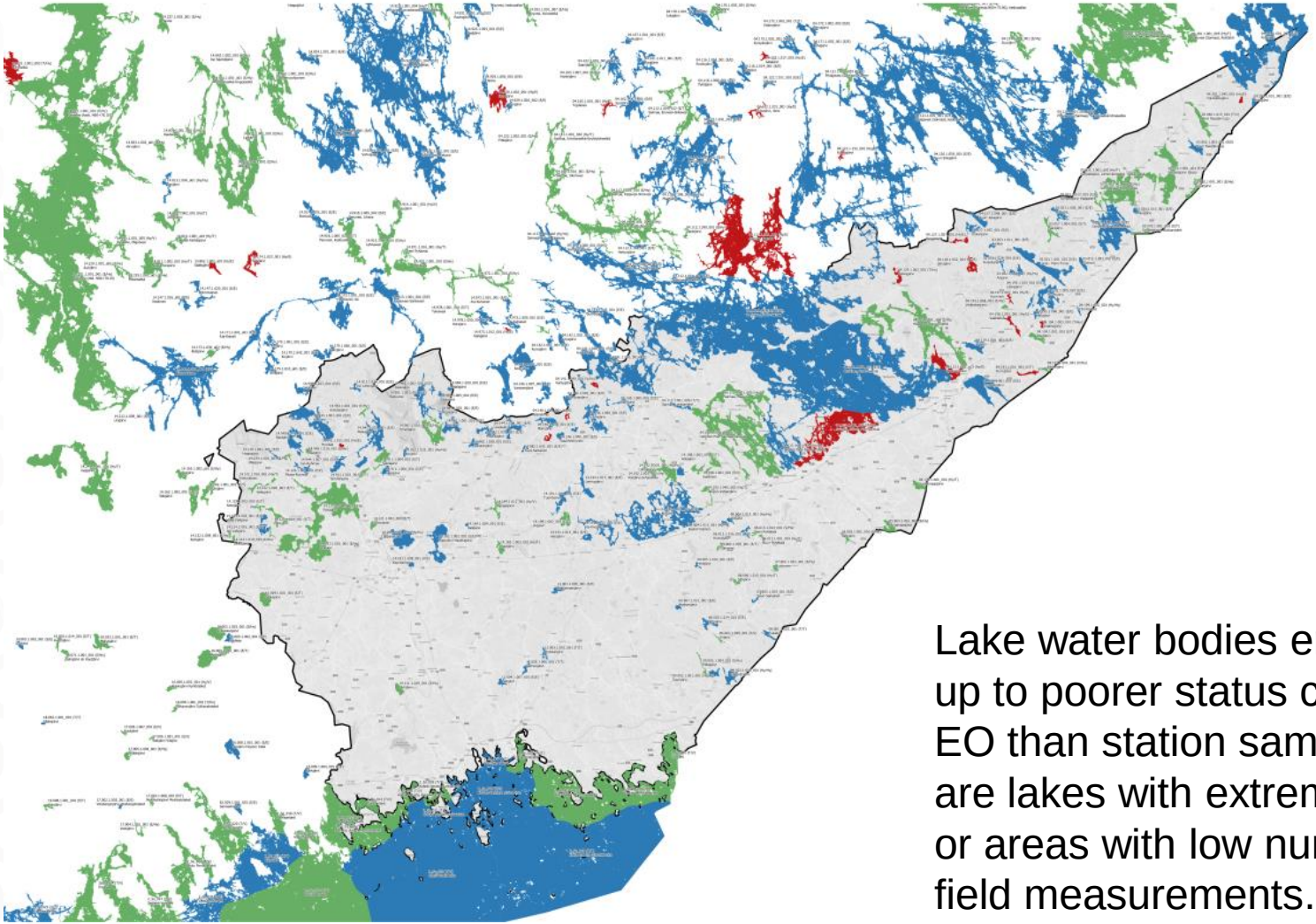

Lake water bodies ending up to poorer status class via EO than station sampling are lakes with extreme WQ or areas with low number of field measurements.

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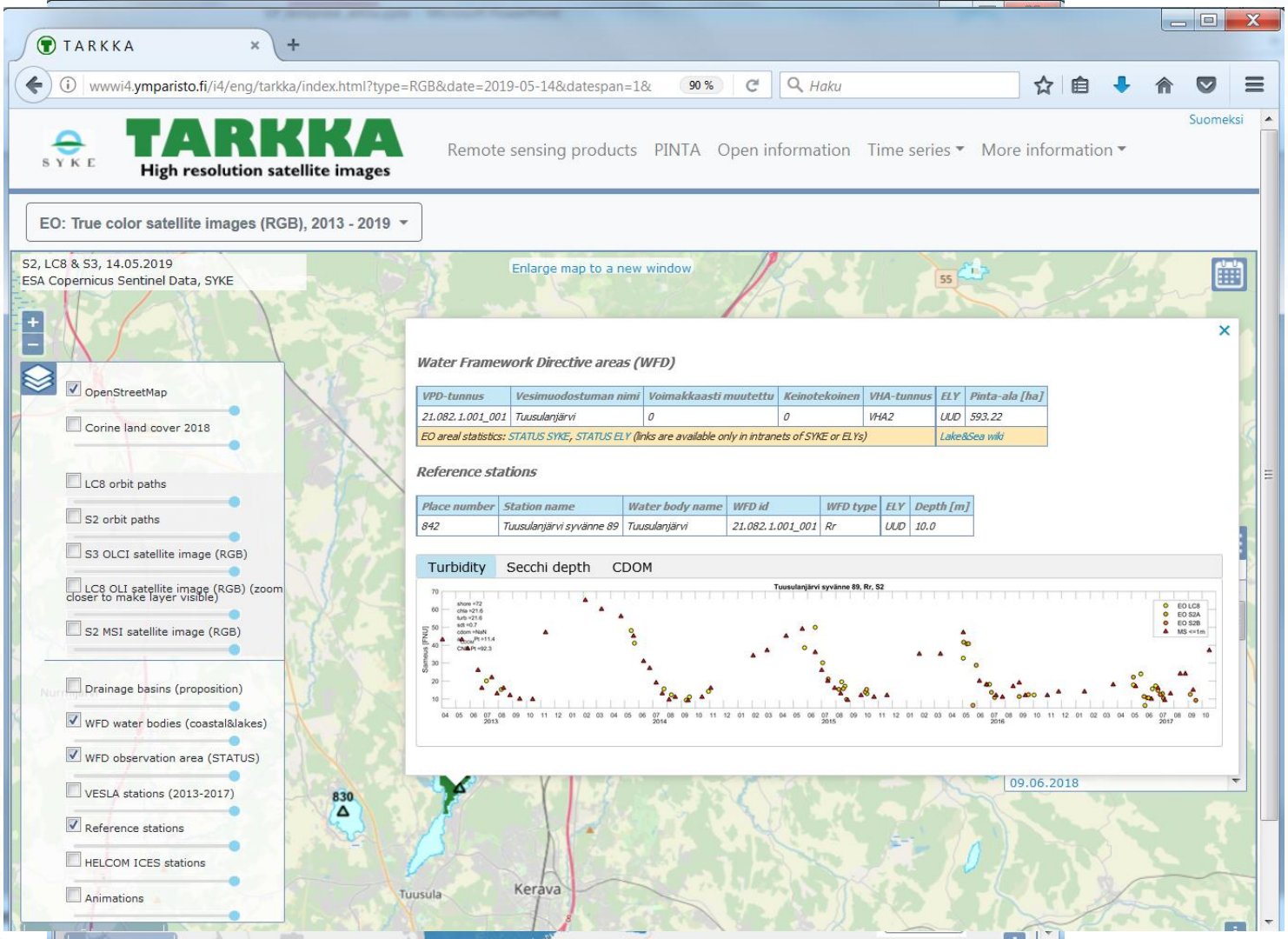
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Haku
Suomeksi
TARKKA
High resolution satellite images
Remote sensing products
PINTA
Open information
Time series
More information
EO: True color satellite images (RGB), 2013 - 2019
S2, LC8 & S3, 14.05.2019
ESA Copernicus Sentinel Data, SYKE
Enlarge map to a new window
OpenStreetMap
Corine land cover 2018
LC8 orbit paths
S2 orbit paths
S3 OLCI satellite image (RGB)
LC8 OLI satellite image (RGB) (zoom closer to make layer visible)
S2 MSI satellite image (RGB)
Drainage basins (proposition)
WFD water bodies (coastal&lakes)
WFD observation area (STATUS)
VESLA stations (2013-2017)
Reference stations
HELCOM ICES stations
Animations
Water Framework Directive areas (WFD)
VPD-tunnus
Vesimuodostuman nimi
Voimakkaasti muutettu
Keinotekoinen
VHA-tunnus
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Lake&Sea wiki
Reference stations
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