e-shape solutions: Earth Observation for biodiversity and water management

14 - 15 February 2023
9.30 – 17.00 CET
The Hague - NSO Headquarter
Centre Court

e-shape

An event co-organised by

eurisy
ACTING COLLECTIVELY TO BRIDGE SPACE AND SOCIETY

Netherlands Space Office

How services based on Earth Observation can support monitoring for the EU Water Framework Directive

e-shape pilot 5.6

Annelies Hommersom

Presentation contents

- Short intro about the Water Framework Directive (WFD)
- Water quality monitoring based on Earth Observation (EO)

- e-shape pilot in Estonia
- e-shape pilot in the Netherlands

- Conclusions: what EO can contribute to the WFD

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EU water policies and regulations

- Water Framework Directive
- Floods directive
- Water Reuse Regulation
- Urban Waste Water Treatment Directive
- Nitrates Directive
- Drinking water Directive
- Bathing water Directive
- Marine Strategy Framework Directive
- Habitats and Birds Directives

Require monitoring of **surface water** quality

WISE
WATER INFORMATION SYSTEM FOR EUROPE

Information from WISE

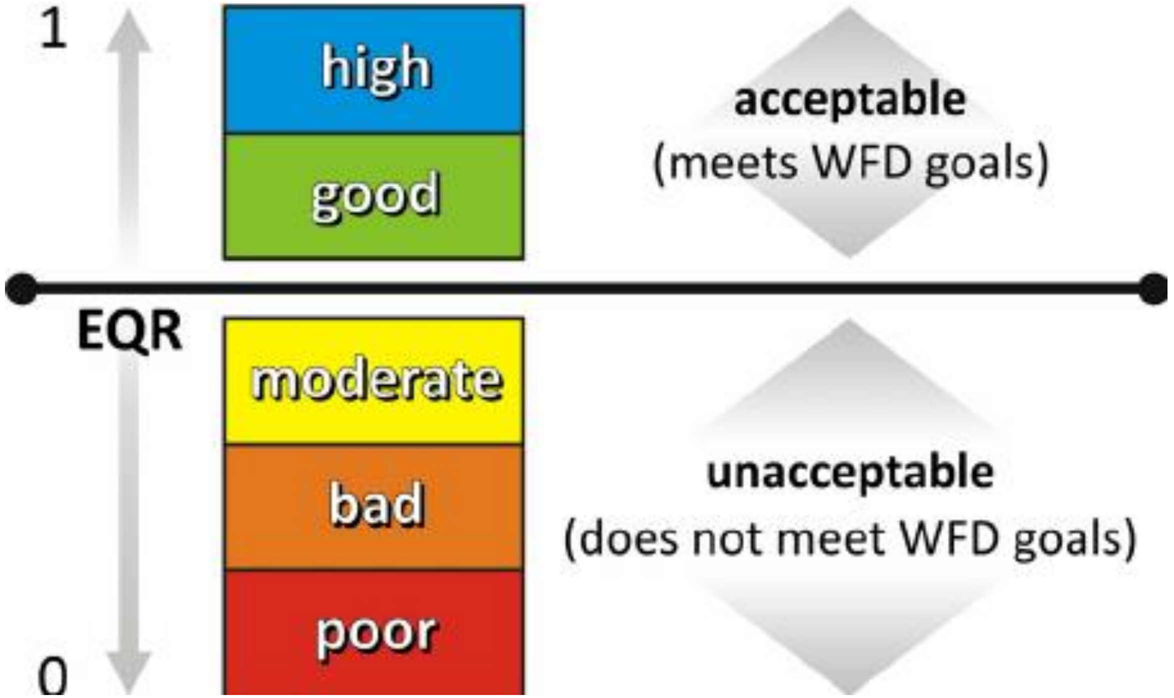
Water Framework Directive (WFD)

Purpose:

- Protection of inland surface waters, transitional waters, coastal waters and groundwater
- Achieving "good status" for all waters by a set deadline

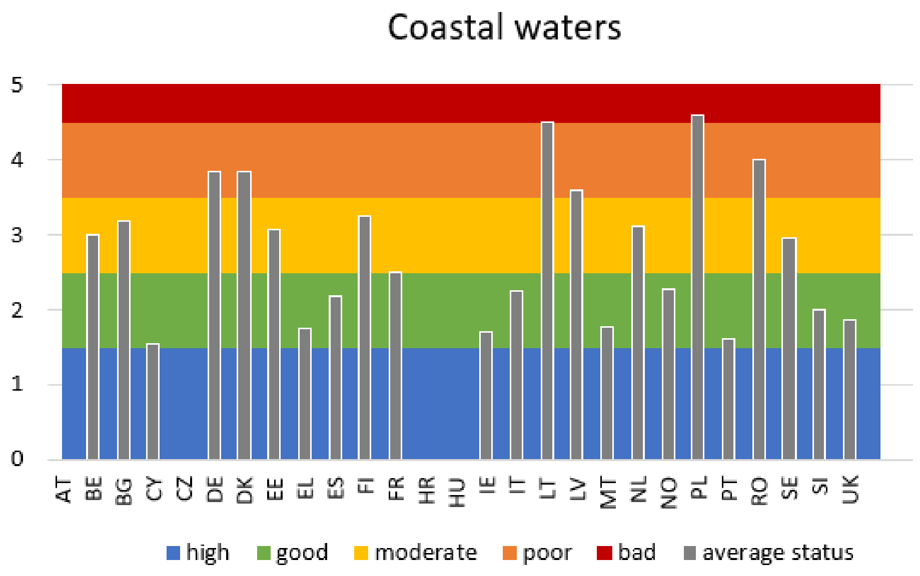
“Good status” means that water shows only a slight change from undisturbed conditions

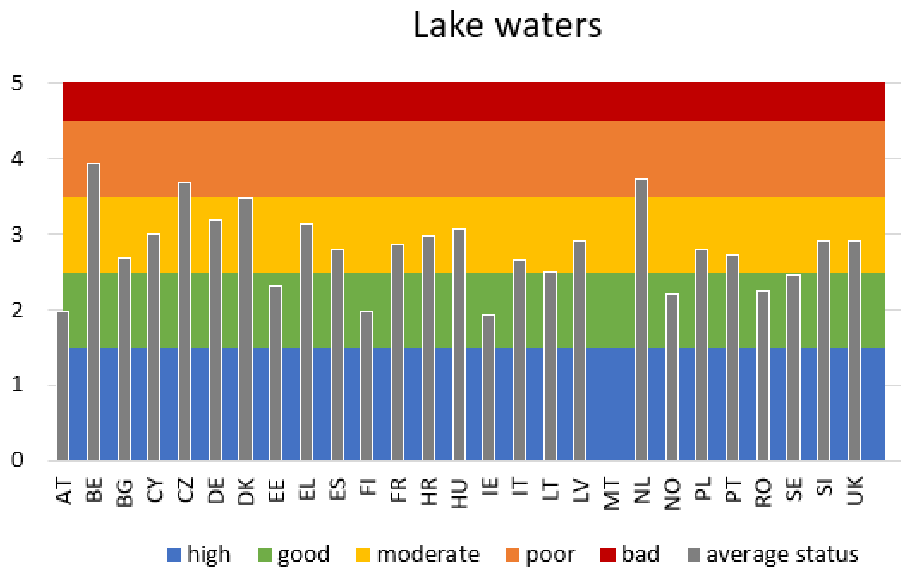
6-year cycles of reporting



Status classes

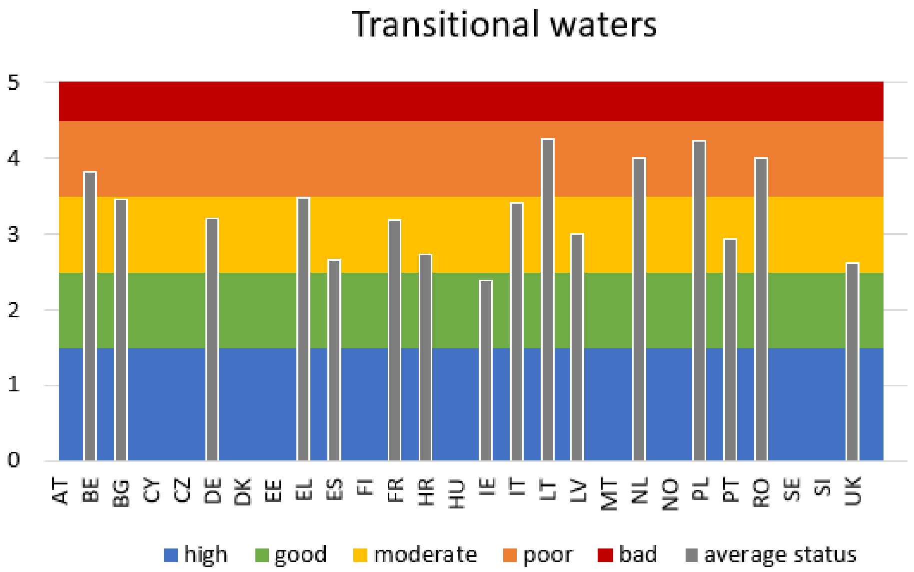
Average ecological status per country





Ecological status classes

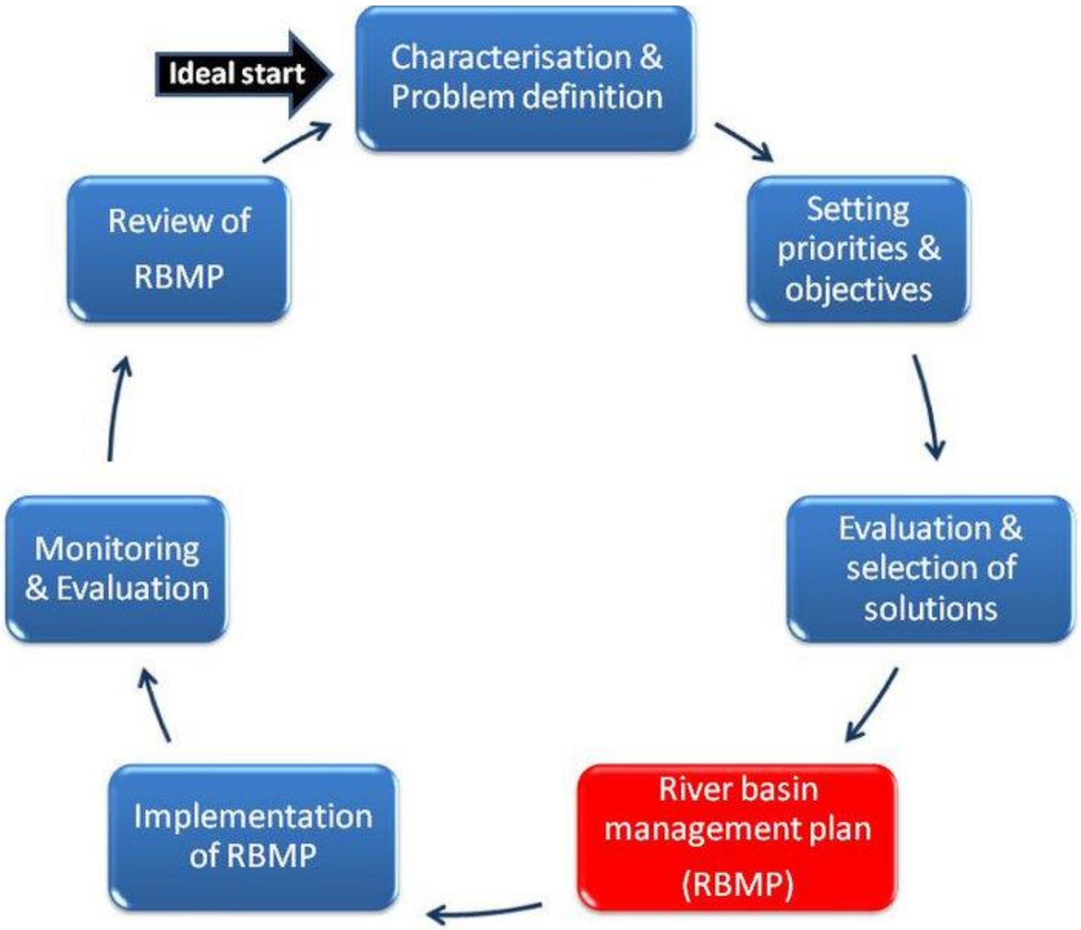
5	bad	
4	poor	
3	moderate	
2	good	
1	high	



Data from WISE-SoW database

6-Yearly cycles in the WFD

- Development of River Basin Management plans
- Define environmental objectives
- **Monitoring**
- Implementation of measures to achieve objectives
- Classification and status assessment
- Evaluation of measures (incl **monitoring**)



Cools, Jan. (2011). Tools for river basin management.

Earth Observation can contribute to monitoring for WFD

White paper

Table:

Column 1: WFD requirements

Column 2: implementation in national systems

Column 3: proxies from EO data to be considered

EOMORES CoastObs

EOMORES and CoastObs white paper

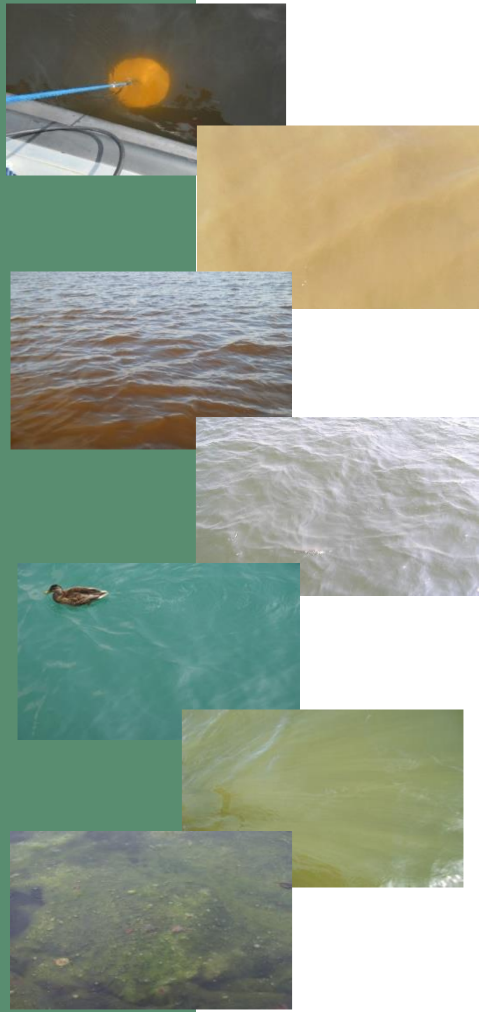
10.5281/zenodo.3463050

Table 1: Current in situ metrics and corresponding satellite-derived quality metrics to be considered

WFD requirements	National Systems	Satellite-derived proxies to be considered
QE1 Biological elements		
QE1-1. Phytoplankton		
Abundance and biomass	Extracted chlorophyll-a concentration[i] Biovolume of phytoplankton[i]	Chlorophyll-a concentration from in vivo pigment absorption[ii,iii] Trophic State Index derived from Chlorophyll-a
Composition	Biovolume of cyanobacteria[i] % of cyanobacteria of total biovolume[i] Various other metrics, trophic indices	Phycocyanin (cyanobacterial pigment) concentration[v] Functional size classes (only in oceanic waters)[iv]
Frequency and intensity of planktonic blooms	Not reported / not possible using conventional monitoring	Chlorophyll-a concentration[ii,iii] Phycocyanin (cyanobacterial pigment) concentration[v] Surface accumulations of cyanobacteria[vi]
QE1-2 Other aquatic flora		
Macrophyte abundance	Various trophic indices; Submerged vegetation cover[i] Total areal coverage[i]	Areal cover of floating vegetation
Macrophyte composition	Proportion of taxa	Not from current satellite sensors, but from airborne surveys[vii]
Macroalgal cover and angiosperm abundance	Combination of spatial extent and relative abundance (measured as density) of macrophytes Abundance of macrophytes[viii,ix]	Spatial extent In intertidal areas[x,xi,xii]: spatial distribution of seagrass density of sea grass, total surface area of seagrass beds
QE3. Chemical and physico-chemical elements		
QE3-1. General		
QE3-1-1. Transparency	Secchi disk depth (Dissolved organic carbon also used to characterise lake typology)	Satellite backscatter as turbidity, suspended particulate matter weight or vertical transparency (extinction or Secchi depth)[xiii,xiv]
QE3-1-2. Thermal conditions	Mean water temperature Water temperature range Air temperature	Surface water temperature[xv] (in open water >2 km from land)
QE3-1-4. Salinity	Electrical conductivity Refractometry	Only with regionally tuned models using Coloured Dissolved Organic Matter (CDOM) as freshwater proxy. In marine/ oceans: sea surface salinity
QE3-1-5. Acidification status	pH	Only in oceanic waters: from combining ocean colour, sea surface temperature, sea surface salinity[xvi]

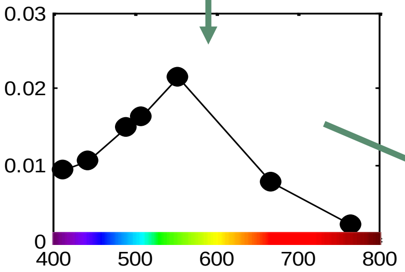
How does that work, water quality monitoring with Earth Observation?

Water colour



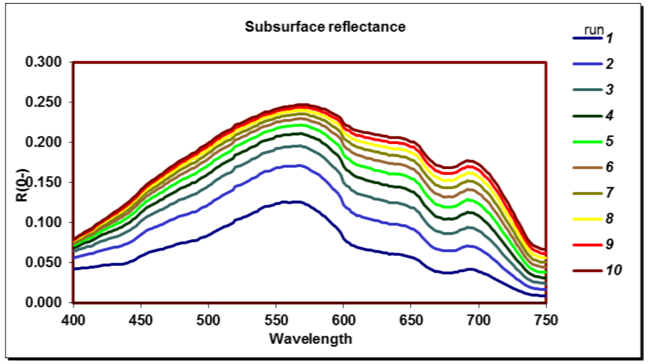
Satellite

Satellite photo

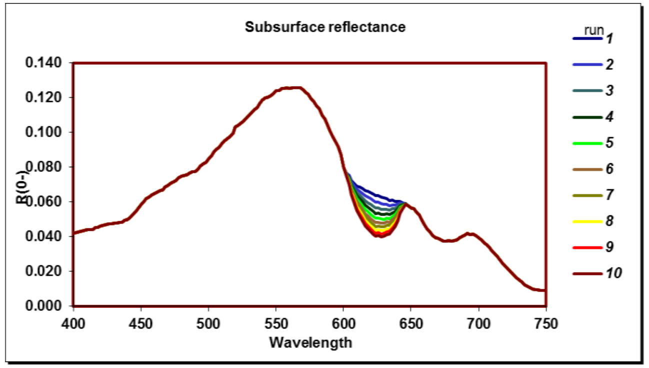


'reflectance' for each pixel: how much light is there of each colour

Modelled effect of suspended matter increase on reflectance



Modelled effect of chlorophyll increase on reflectance



Based on known effects of parameters on reflectance, algorithms can derive the parameters for each pixel

Water Insight

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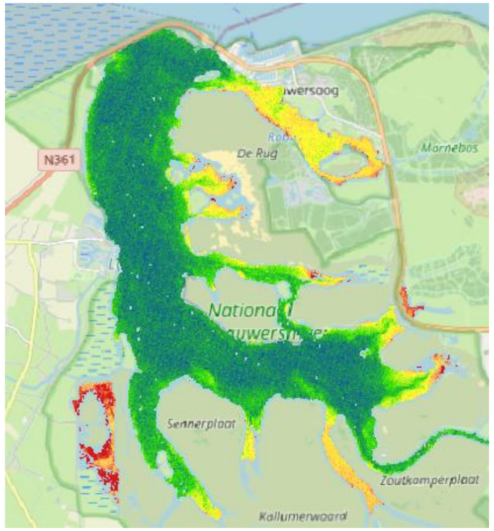
Example EO-based monitoring for the WFD

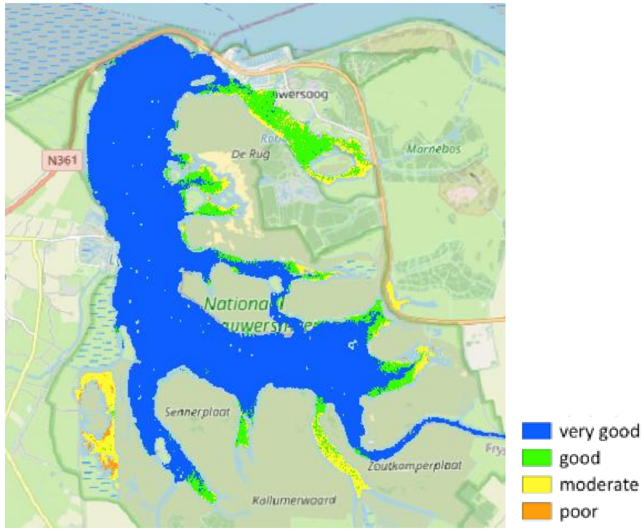
1. Map chlorophyll-a based on EO (Sentinel 2)
2. Chlorophyll-a is in the WFD used as proxy for the phytoplankton biomass
3. Apply WFD lake specific thresholds on Chl-a to derive WFD phytoplankton biomass status classes

RGB

Chl-a



WFD



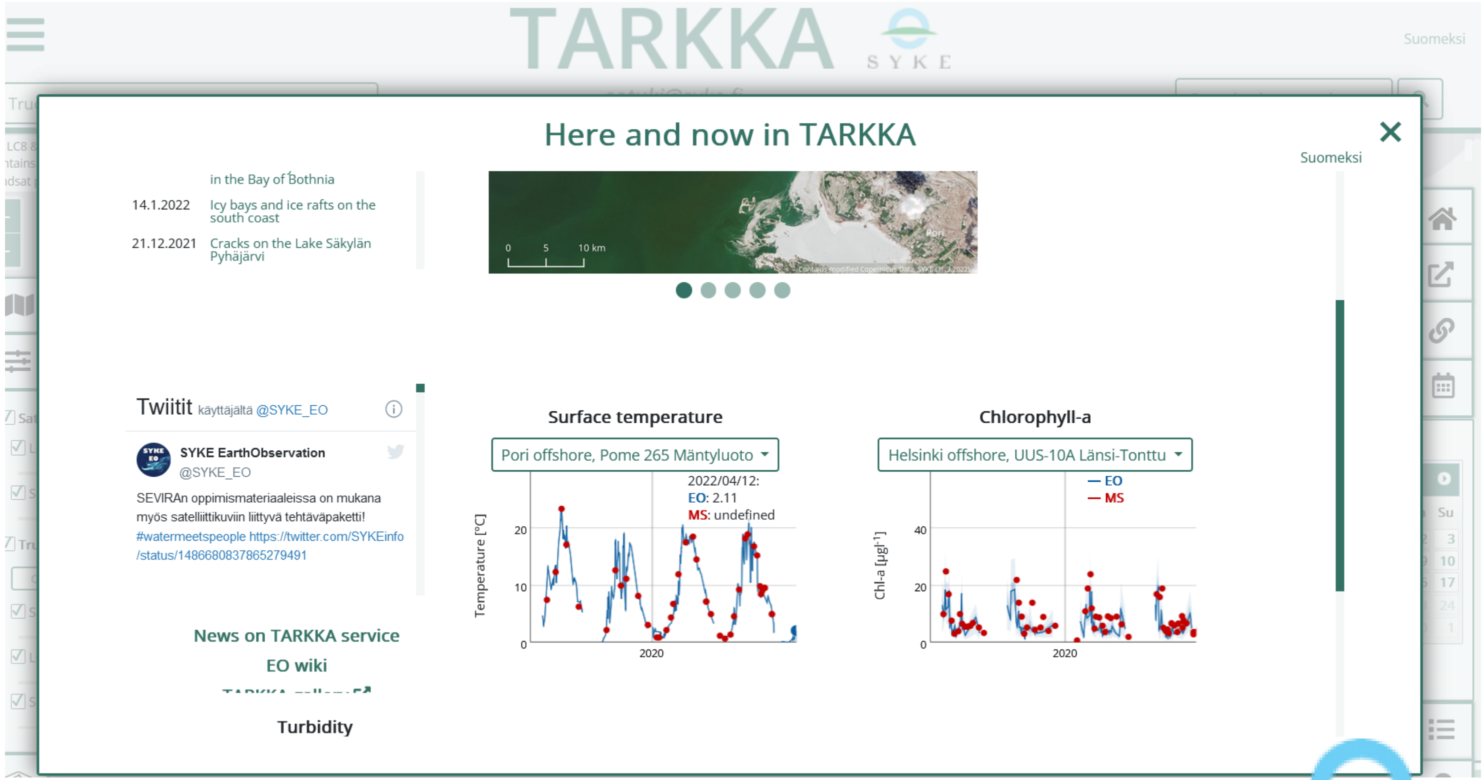
Is Earth-Observation based monitoring for WFD allowed?

For the EU Framework: yes

But national regulations differ

Often, national agencies prescribe certain methods

Use of a new data source requires re-thinking of monitoring plans and practices, additions to storage systems etc.



https://wwwi4.ymparisto.fi/i4/eng/tarkka

"Finland now uses operational satellite observation data in WFD reporting as complementary information for environmental status assessment. The work is carried out under direct guidance from the Ministry of Environment, and helps address the challenge of reporting on thousands of WFD waterbodies." EOMORES and CoastObs white paper 10.5281/zenodo.3463050

e-shape pilot 5.6 Case study in Estonia

The case study

- Most lakes are still in their natural state, either eutrophic or mesotrophic
- Limited in resources, so most monitoring effort goes to
  - largest lakes
  - some small lakes based on their importance and the chances of passing WFD thresholds
- Important is to monitor also the lakes with ‘good’ status

Pilot together with Eesti Maaülikool (EMÜ)

(Center for Limnological research, Estonia)

e-shape pilot 5.6 Case study in Estonia

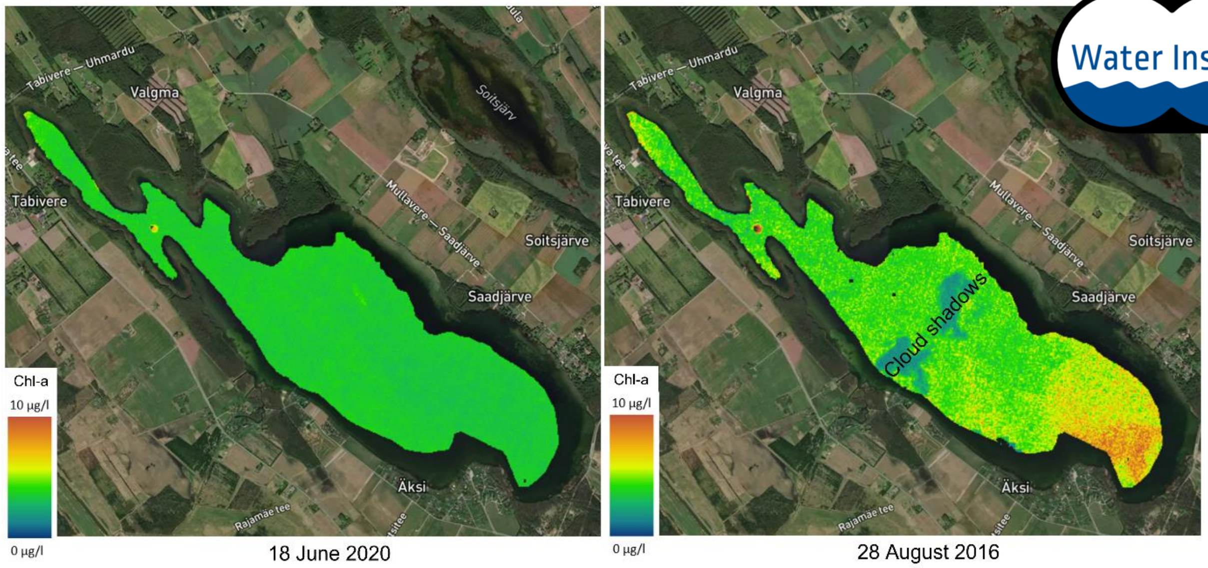
The case study

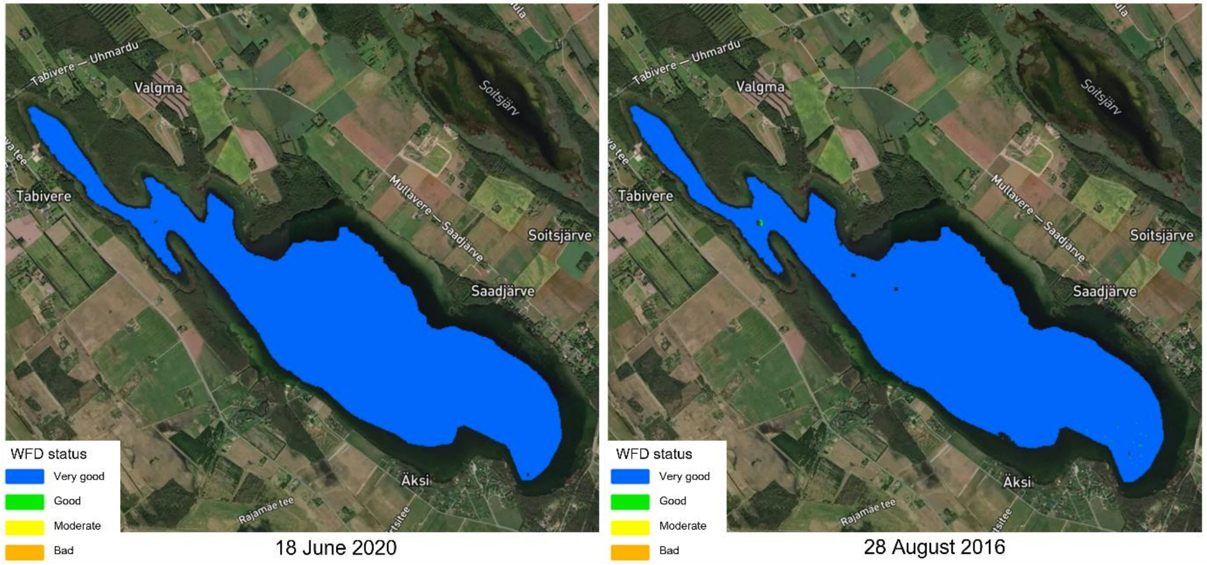
- Focus on two small clear water lakes (Saadjärv and Kuremaa järv)
- Phytoplankton biomass was mapped as Chl-a for monitoring, and WFD thresholds were applied to create status class maps
- Validation with in-situ buoy data of EMÜ

e-shape pilot 5.6 Case study in Estonia

Results

- EO confirms: Saadjärv is usually a lake with low Chl-a (example on the left)
- An example with slightly elevated concentrations of Chl-a in the south after runoff is shown (on the right)





Satellite-based WFD classification maps based on the maps of Chl-a concentrations. Although for most of the lake the WFD class is always 'very good', for a few pixels the class changed from 'very good' to 'good' on 28th August 2016

e-shape pilot 5.6 Case study in Estonia

Conclusions

- EO can be used to capture variations in phytoplankton biomass and WFD status levels even in clear-water lakes.
- EO data can therefore be used for cheap and automated monitoring for all under-sampled clear lakes, combined with targeted sampling in case of unexpected changes.

Waterschap Noorderzijlvest

e-shape pilot 5.6 Case study in the Netherlands

Water Insight

The case study

- Many stakeholders involved in WFD (planning, monitoring, reporting, monitoring requirements etc)

The pilot – apply e-shape co-design methods

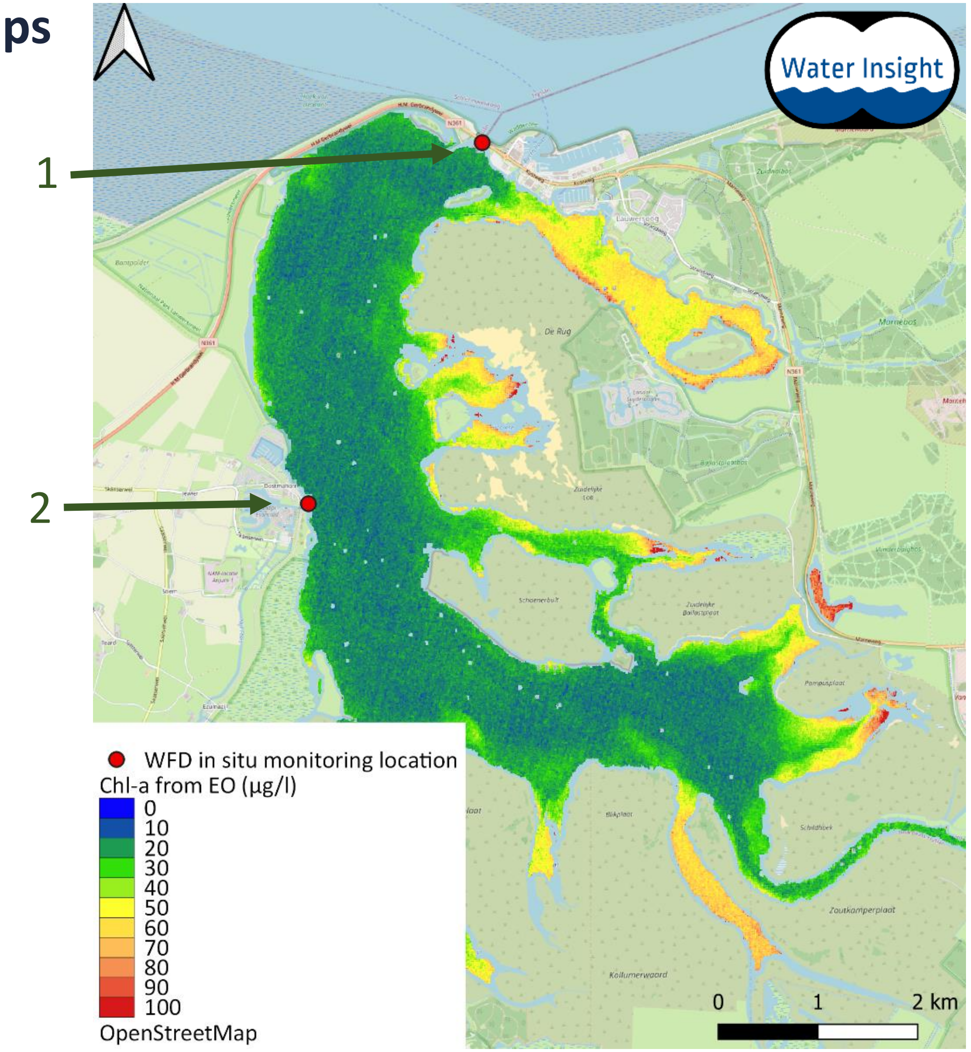
- Create examples
- Discuss with stakeholders
- Update examples
- Discuss the way forward

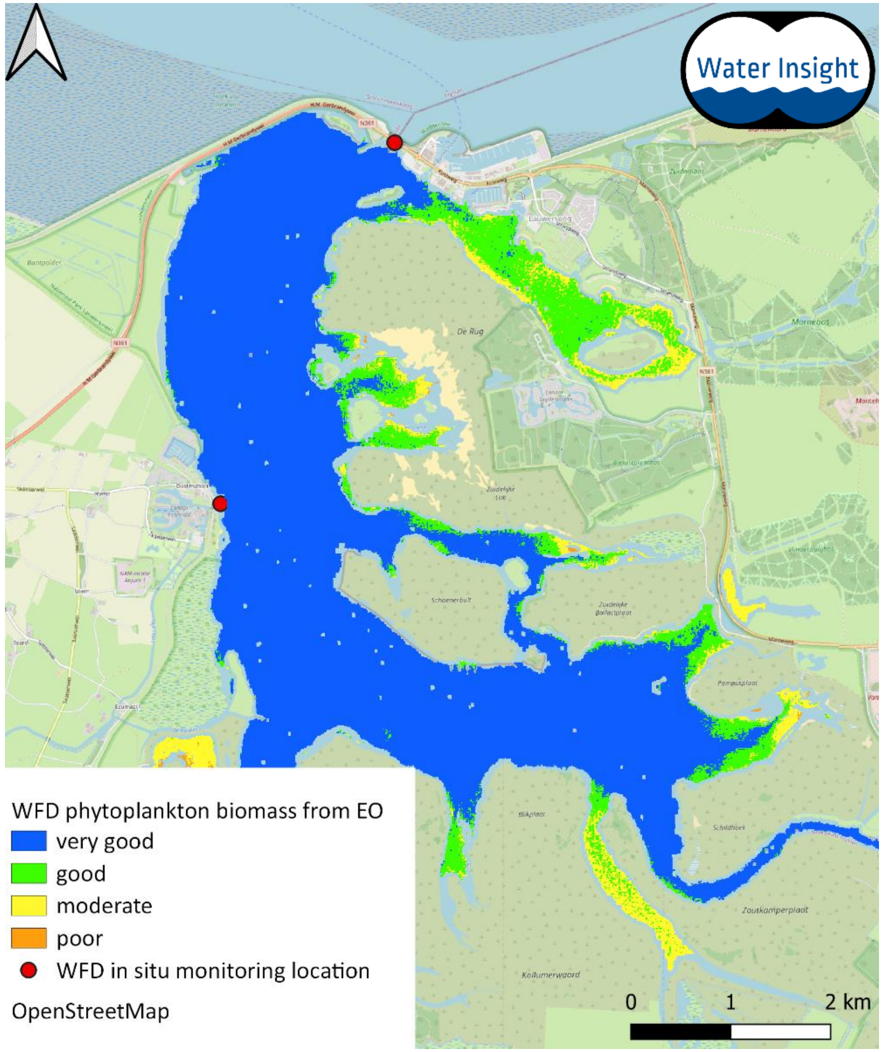
Pilot together with Waterschap Noorderzijlvest (local water authority, Netherlands)

e-shape pilot 5.6 Case study in the Netherlands

Stakeholders asked for maps to show representativeness of current stations

Results 1/3: maps





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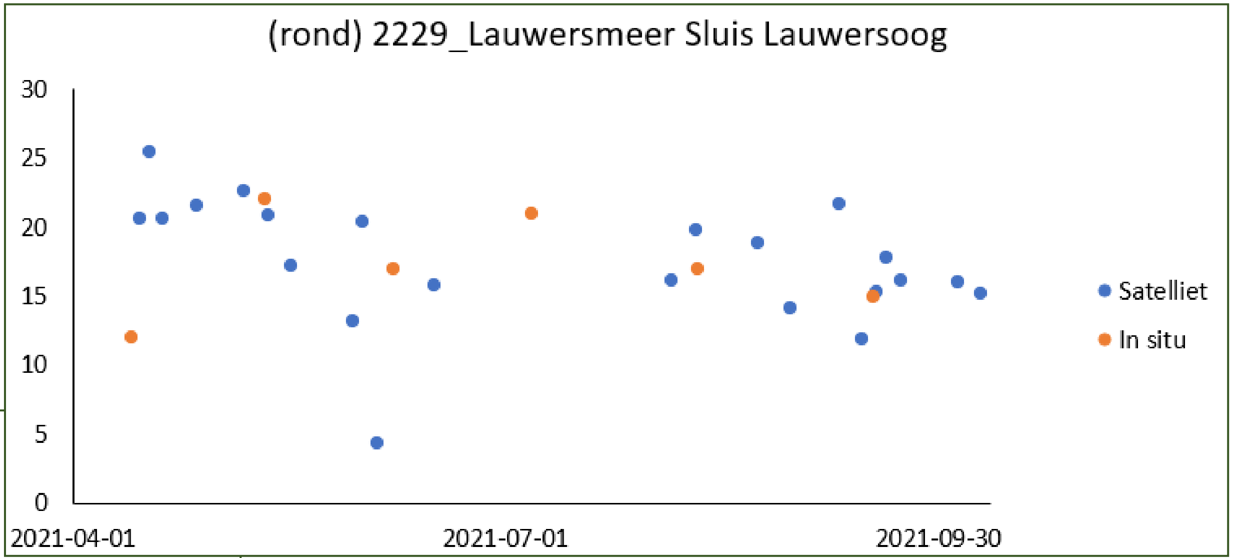
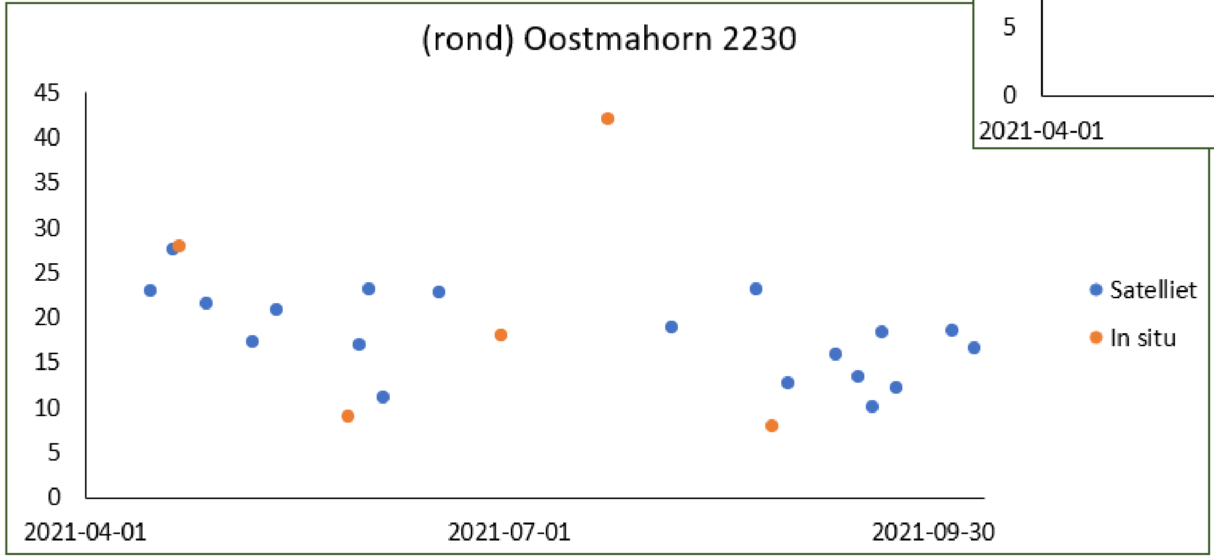
Stakeholders asked for validation in the Netherlands

Results 2/3: validation

1



2



e-shape pilot 5.6 Case study in the Netherlands

Results 3/3: Co-design

Results were discussed with stakeholders, after that the next steps. They agreed:

EO data/maps provide spatial information and can:

- help to pinpoint representative in situ locations
- be used to create additional monitoring locations
- allow to obtain this information in retrospect
- and with that fill knowledge gaps

Cost/benefit analysis seems positive

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Results 3/3: Co-design

It was agreed that the wealth of data from EO should be used.

The experts will:

- Start using EO-based data for e.g. systems analysis when suitable
- Involve their team, and introduce them to EO-data
- Built a community of practice to exchange experience with using EO-based data
- Communicate about the results to increase the awareness

Conclusion:
What EO-based monitoring can contribute to the WFD:

- Spatial coverage
- Pinpoint representative in situ locations
- Additional monitoring data
- Obtain information in retrospect
- Cheap monitoring for lakes without issues

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Read more

- **e-shape** success story ‘How satellite Earth Observation can help with monitoring for the Water Framework Directive’ https://e-shape.eu/index.php/success-stories
- **e-shape** success story ‘Earth Observation for operational monitoring and system analysis of aquatic systems’ https://e-shape.eu/index.php/success-stories
- **Carvalho**, L., *et al*., 2019. Protecting and restoring Europe’s waters: an analysis of the future development needs of the Water Framework Directive. Sci. Total Environ. 658, 1228–1238. https://doi.org/10.1016/j.scitotenv.2018.12.255
- **Water Insight water quality monitoring and reporting services** https://www.waterinsight.nl/solutions/glass-global-lakes-sentinel-services
- **EOMORES inland water monitoring services**: https://eomores.eu
- **CoastObs coastal monitoring services**: https://coastobs.eu
- dotSPACE 2022, **WaterForCE deliverable** D1.3 Links between missions-services-applications
- Papathanasopoulou, E., Simis, S. et al. 2019. Satellite-assisted monitoring of water quality to support the implementation of the Water Framework Directive. **EOMORES and CoastObs white paper**. 28pp. doi: 10.5281/zenodo.3463050

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