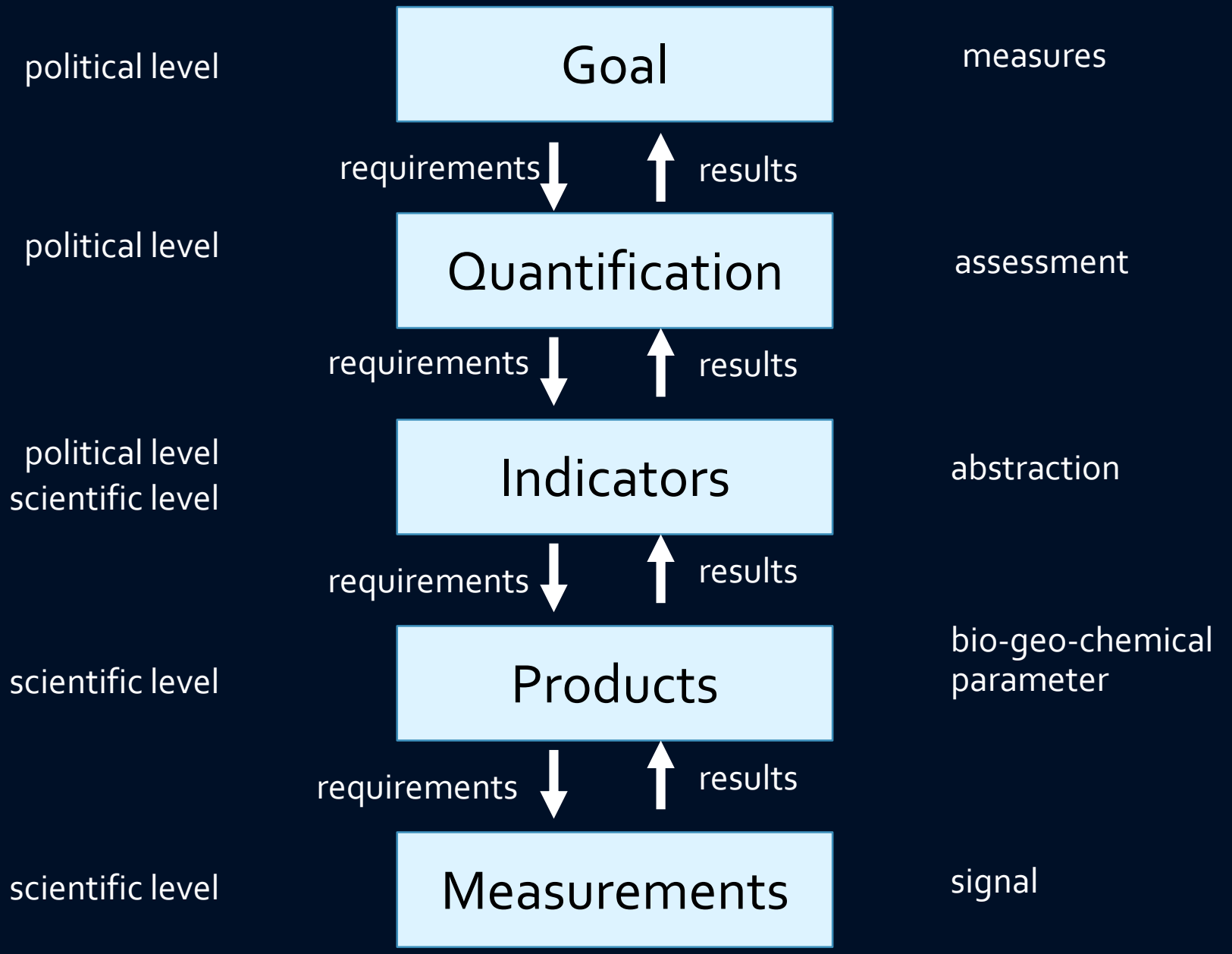
Earth Observation in support of reporting to European Legislation on surface water quality; technical offers and uptake by users

CARSTEN BROCKMANN

WITH CONTRIBUTIONS FROM
KERSTIN STELZER, KAI SORENSEN
AND PETRA PHILIPSON

Brockmann Consult GmbH


political level
Goal
measures
requirements
results
political level
Quantification
assessment
requirements
results
political level
scientific level
Indicators
abstraction
requirements
results
scientific level
Products
bio-geo-chemical parameter
requirements
results
scientific level
Measurements
signal

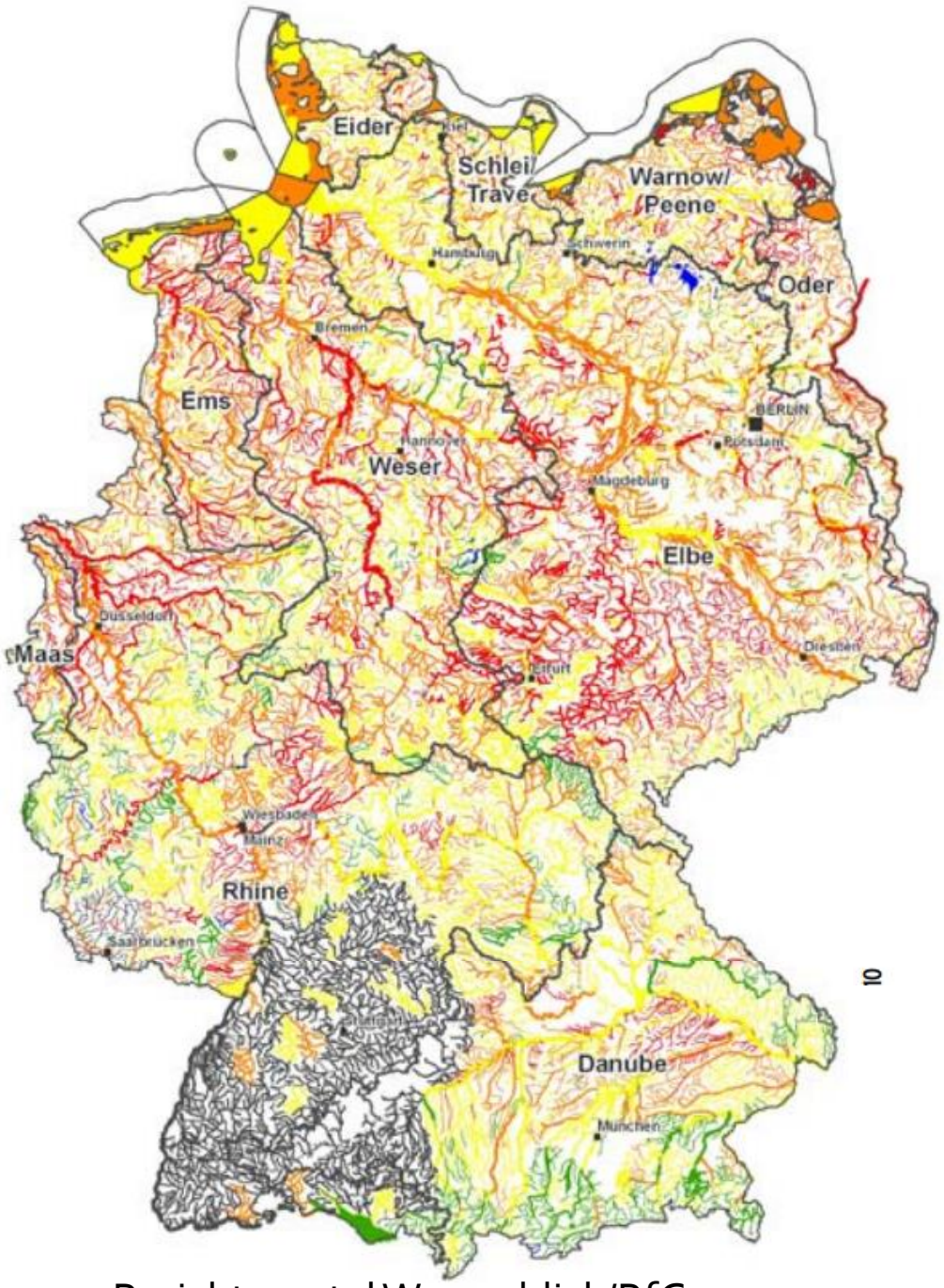
Goals – Legislation in Europe

- Good ecological status
  - EU Water Framework Directive (WFD)
  - EU Marine Strategy Framework Directive (MSFD)
  - OSPAR & HELCOM
- Nature Conservation
  - EU Natura 2000 Directives
  - Trilateral Monitoring and Assessment Programme (North Sea Wadden Sea)
- Health
  - EU Bathing Waters Directive
- Biological Diversity
  - UN-CBD Convention on Biological Diversity

WFD Reporting Germany Status 2010

lakes, coastal waters, and transitional waters

- high
- good
- moderate
- poor
- bad
- uncertain
- N/A



source: Berichtsportal Wasserblick/BfG, 22.03.2010

Indicators for good ecological status (Water Framework Directive)

Table 1. Quality elements to be used for the assessment of ecological status/potential based on the list in Annex V, 1.1, of the Directive (for further details see text in 2.2).

Annex V 1.1.1. RIVERS	Annex V 1.1.2. LAKES	Annex V 1.1.3. TRANSITIONAL WATERS	Annex V 1.1.4. COASTAL WATERS
BIOLOGICAL ELEMENTS			
HYDROMORPHOLOGICAL ELEMENTS SUPPORTING THE BIOLOGICAL ELEMENTS			
• *Hydrological regime* ➔ *quantity and dynamics of water f* ➔ *connectio water bo* • *River co* • *Morpho* ➔ *river dep variation* ➔ *structure of the riv* ➔ *structure riparian*	• *Hydrological regime* ➔ *quantity and dynamics*	• *Tidal regime* ➔ *freshwater flow*	• *Tidal regime* ➔ *direction and dominant*
CHEMICAL AND PHYSICOCHEMICAL ELEMENTS SUPPORTING THE BIOLOGICAL ELEMENTS			
• *General* ➔ *Thermal conditions* ➔ *Oxygenation conditions* ➔ *Salinity* ➔ *Acidification status* ➔ *Nutrient conditions* • *Specific pollutants* ➔ *Pollution by priority substances identified as being discharged into the body of water* ➔ *Pollution by other substances identified as being discharged in significant quantities into the body of water*	• *General* ➔ *Transparency* ➔ *Thermal conditions* ➔ *Oxygenation conditions* ➔ *Salinity* ➔ *Acidification status* ➔ *Nutrient conditions* • *Specific pollutants* ➔ *Pollution by priority substances identified as being discharged into the body of water* ➔ *Pollution by other substances identified as being discharged in significant quantities into the body of water*	• *General* ➔ *Transparency* ➔ *Thermal conditions* ➔ *Oxygenation conditions* ➔ *Salinity* ➔ *Nutrient conditions* • *Specific pollutants* ➔ *Pollution by priority substances identified as being discharged into the body of water* ➔ *Pollution by other substances identified as being discharged in significant quantities into the body of water*	• *General* ➔ *Transparency* ➔ *Thermal conditions* ➔ *Oxygenation conditions* ➔ *Salinity* ➔ *Nutrient conditions* • *Specific pollutants* ➔ *Pollution by priority substances identified as being discharged into the body of water* ➔ *Pollution by other substances identified as being discharged in significant quantities into the body of water*

WFD Indicators

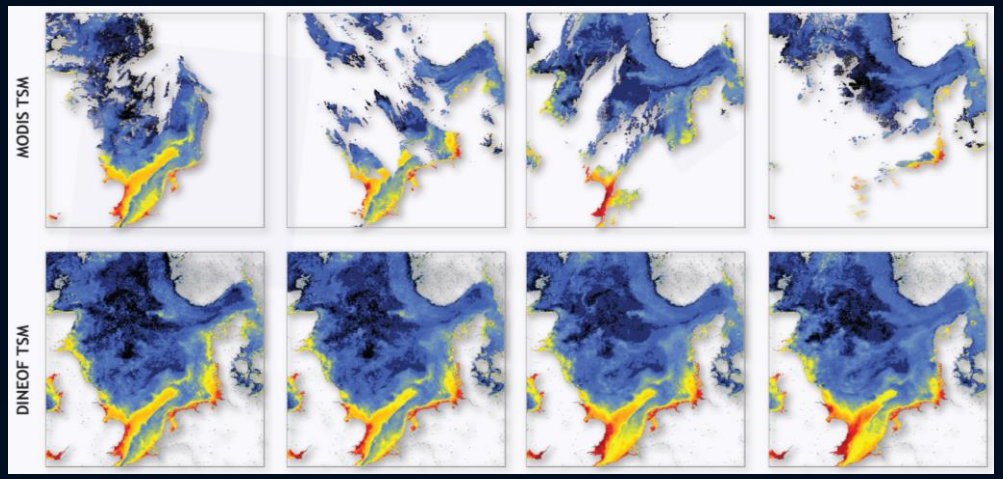
EO derived WQ parameters cover the following quality elements for classification of ecological status

Summary of parameters covered by EO data for WFD

Surface water body type	Biological element	Chemical and physico-chemical elements	Hydromorphological elements
Rivers	✓ Frequency/intensity of planktonic blooms	✓ Thermal conditions	✓ River continuity
Lakes	✓ Abundance of phytoplankton in terms of Chl concentration ✓ Frequency/intensity of planktonic blooms	✓ Transparency ✓ Thermal conditions	
Transitional waters	✓ Abundance of phytoplankton in terms of Chl concentration ✓ Frequency/intensity of planktonic blooms	✓ Transparency ✓ Thermal conditions	

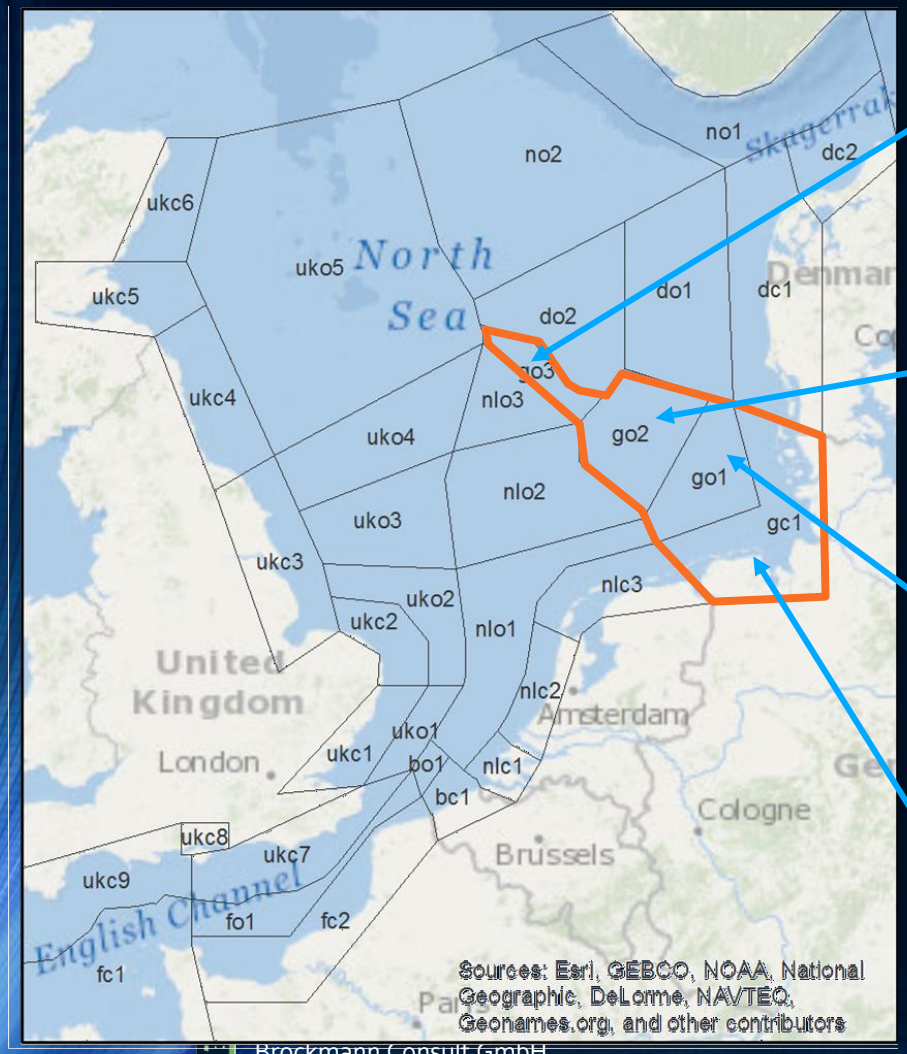
From Product to Indicator

- Often the same basic quantity – e.g. Chl-a concentration
- Temporal and spatial aggregation
  - proper data filtering!
  - Geostatistics
  - Level 3 binning
  - Big Data
- Statistical quantities
  - P90
  - median
- Combination of basic quantities
  - Water Type classification
  - Fish poulation density



The advantage of EO data is the dense spatial and temporal sampling!

Monitoring timing of the spring bloom (OSPAR)



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Month

Year

GO3	1	2	3	4	5	6	7	8	9	10	11	12
2006					0.5	0.5	0.3	0.4	0.7	0.6	1.8	
2007	1.7	1.4	1.3	0.9	0.7	0.5	0.4	0.5	0.9	0.8	1.4	
2008		1.0	1.7	1.0	0.7	0.4	0.4	0.5	0.7	1.3	0.9	
2009	1.6	1.2	1.0	1.1	0.7	0.4	0.4	0.4	0.7	1.1		1.4
2010		1.1	1.4	0.8	0.6	0.4	0.4	0.5	0.9	0.8	0.9	1.3
2011	1.0	1.1	1.1	1.1	0.5	0.4	0.4	0.5	0.7	0.6		

GO2	1	2	3	4	5	6	7	8	9	10	11	12
2006					1.6	1.3	0.9	1.0	1.1	1.4	2.1	3.4
2007	2.4	1.0	0.7	1.8	2.1	1.0	0.9	1.4	1.6	1.4	1.7	
2008	1.9	0.8	0.7	2.3	1.5	0.7	0.8	1.2	1.5	2.1	2.1	1.8
2009	1.6	1.0	1.0	2.7	1.5	1.1	0.7	1.0	1.2	1.9		2.0
2010	2.1	0.8	1.0	1.2	1.1	0.8	0.5	1.3	0.9	1.0	1.8	1.8
2011	1.2	0.6	0.8	1.6	2.2	0.9	0.9	1.0	1.2	1.6		

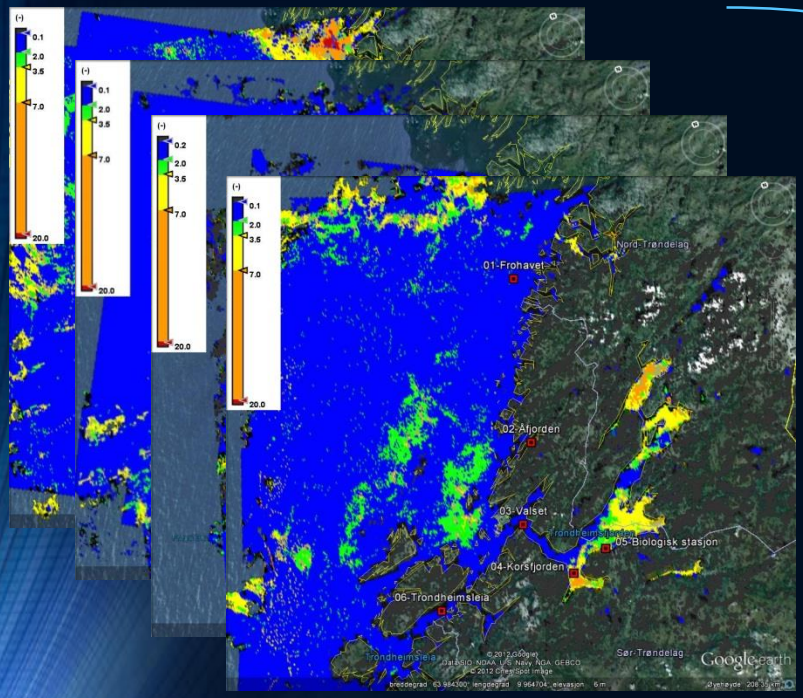
GO1	1	2	3	4	5	6	7	8	9	10	11	12
2006					4.0	2.8	2.8	2.2	2.5	2.6	3.2	3.2
2007	2.4	1.9	1.2	3.5	3.7	1.6	2.7	2.8	3.7	3.1	3.2	
2008	2.3	1.0	1.3	4.9	4.1	1.8	2.0	2.4	2.2	2.6	2.2	1.7
2009	1.3	1.4	2.3	4.6	1.8	2.3	2.4	2.9	2.5	3.8		2.0
2010	1.9	0.4	1.4	2.8	1.9	2.4	2.4	2.7	2.3	2.3	2.9	2.4
2011	2.4	0.9	1.2	2.8	3.9	1.8	2.6	1.9	1.6	2.9		

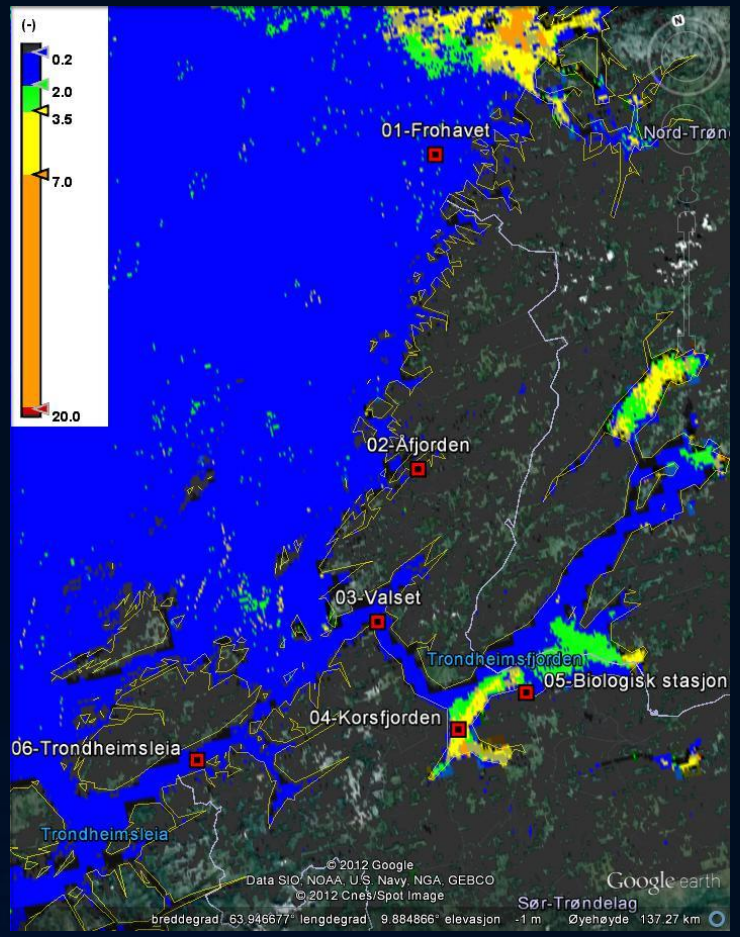
GC1	1	2	3	4	5	6	7	8	9	10	11	12
2006					9.5	9.2	10.5	8.8	7.7	7.6	7.5	8.6
2007	7.5	5.4	6.7	11.3	14.6	10.5	9.4	8.9	8.1	8.2	8.8	
2008	4.6	5.8	7.3	14.3	15.8	9.6	9.3	8.0	8.0	7.9	6.7	9.3
2009	4.3	6.2	6.9	15.9	12.2	9.5	9.1	6.9	7.1	8.5		6.7
2010	3.5	3.1	7.0	17.6	11.5	9.9	11.0	9.6	8.2	9.0	8.7	1.9
2011	8.1	7.5	6.9	11.1	13.2	10.1	8.7	6.8	5.2	7.7		

Example of input to marine classification

Chlorophyll-a for June-Sept. 2011 in Trondheimsfjorden

From month mean to year or seasonal values.





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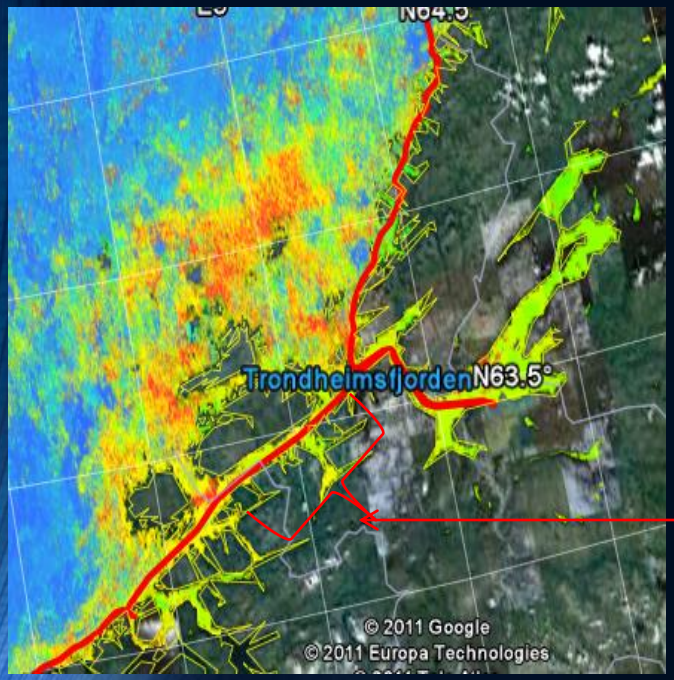
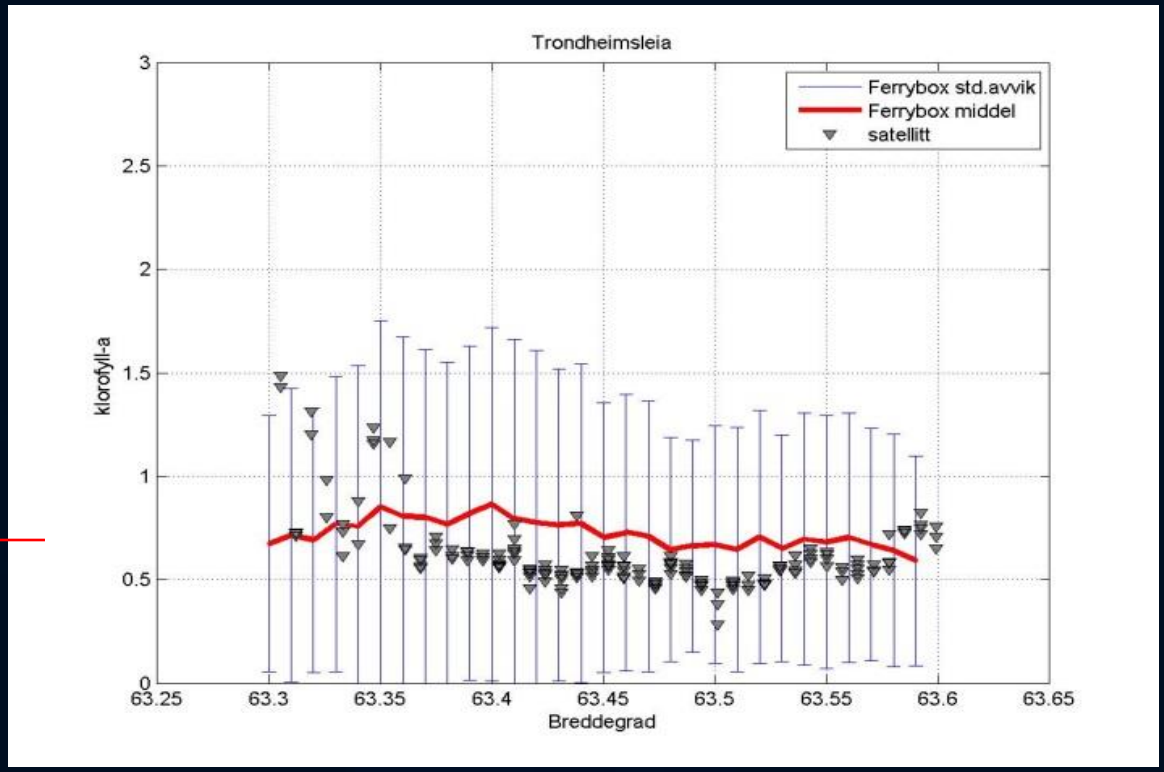
NIVA

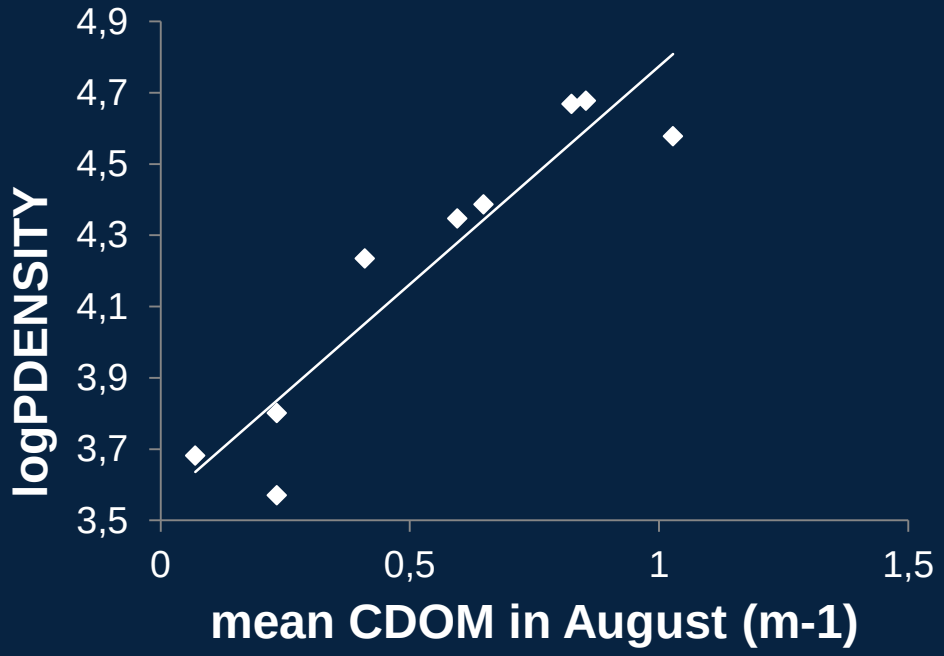
The in situ component is important for validation and verification

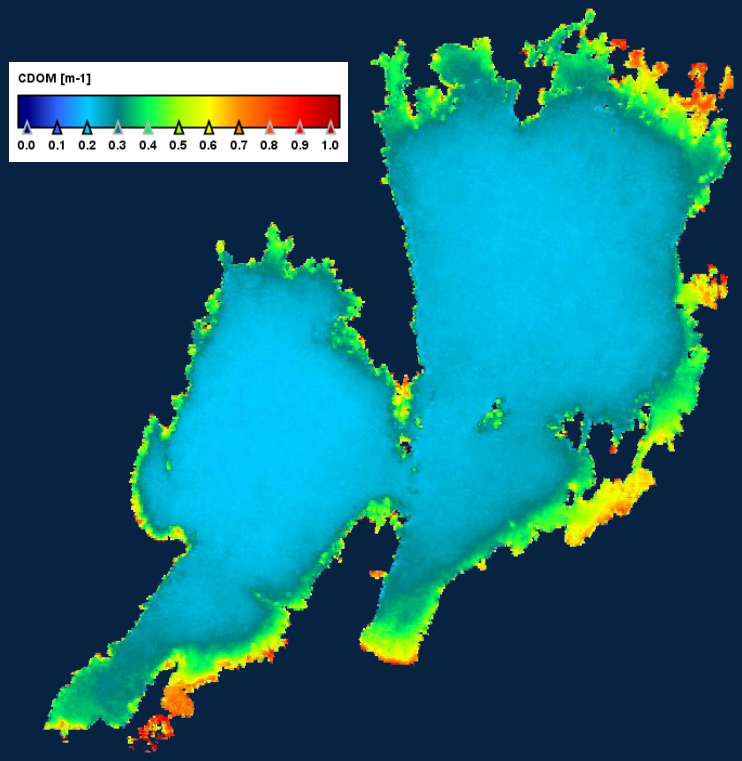




EO supported assessment of fish ecology in Lake Vänern: Fish - Indicator I

Pelagic fish density

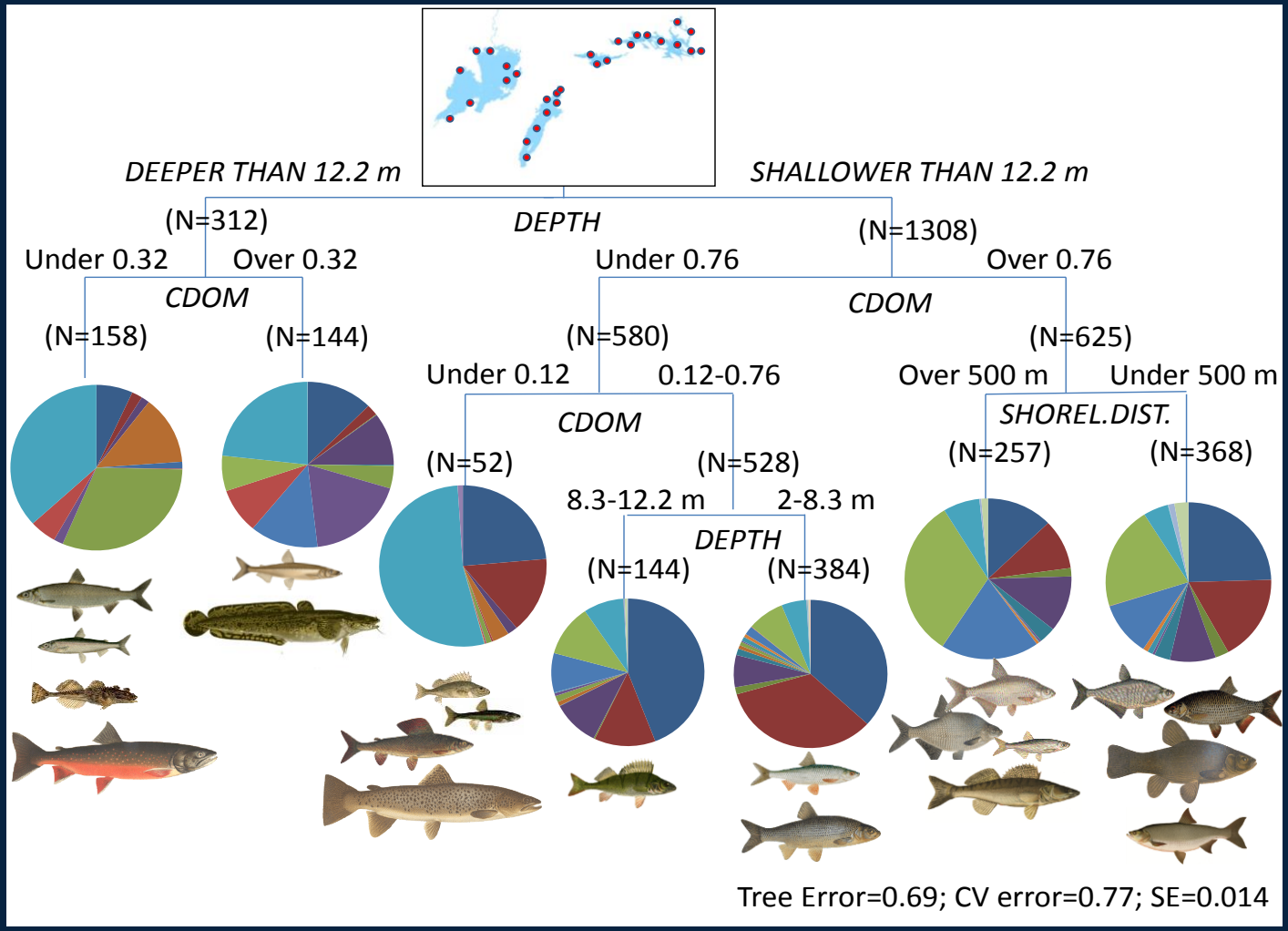




SLU

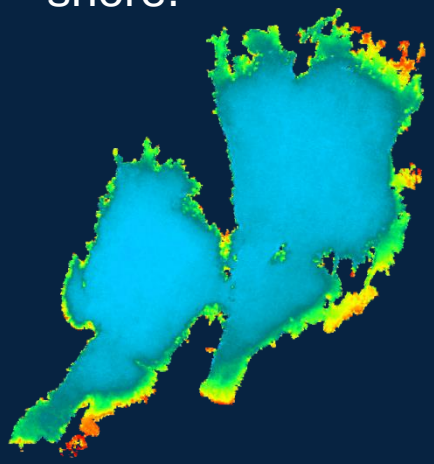
Brockmann Geomatics Sweden AB

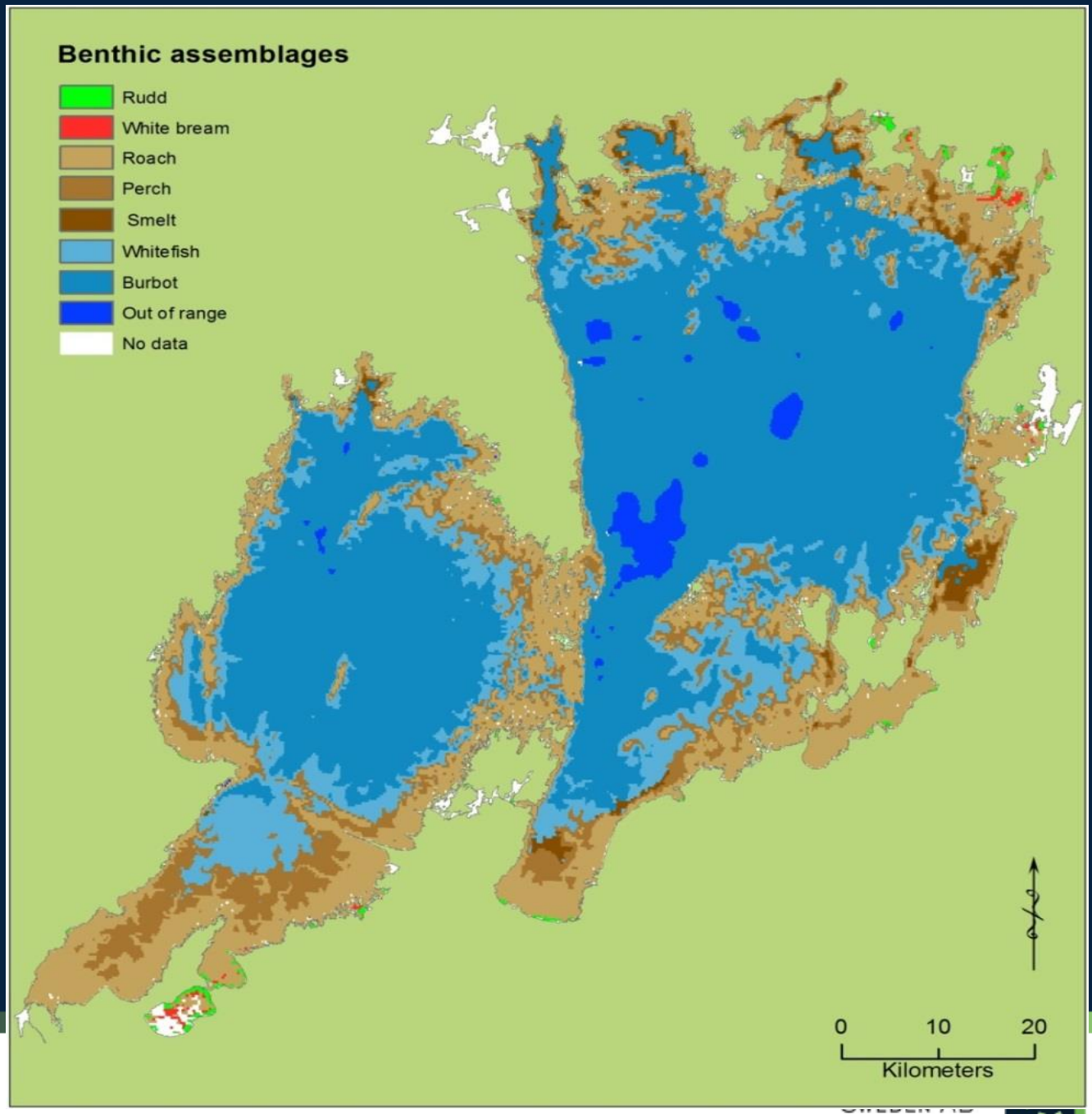
Species distribution



Prediction of species distribution

Using depth, CDOM and distance from shore.

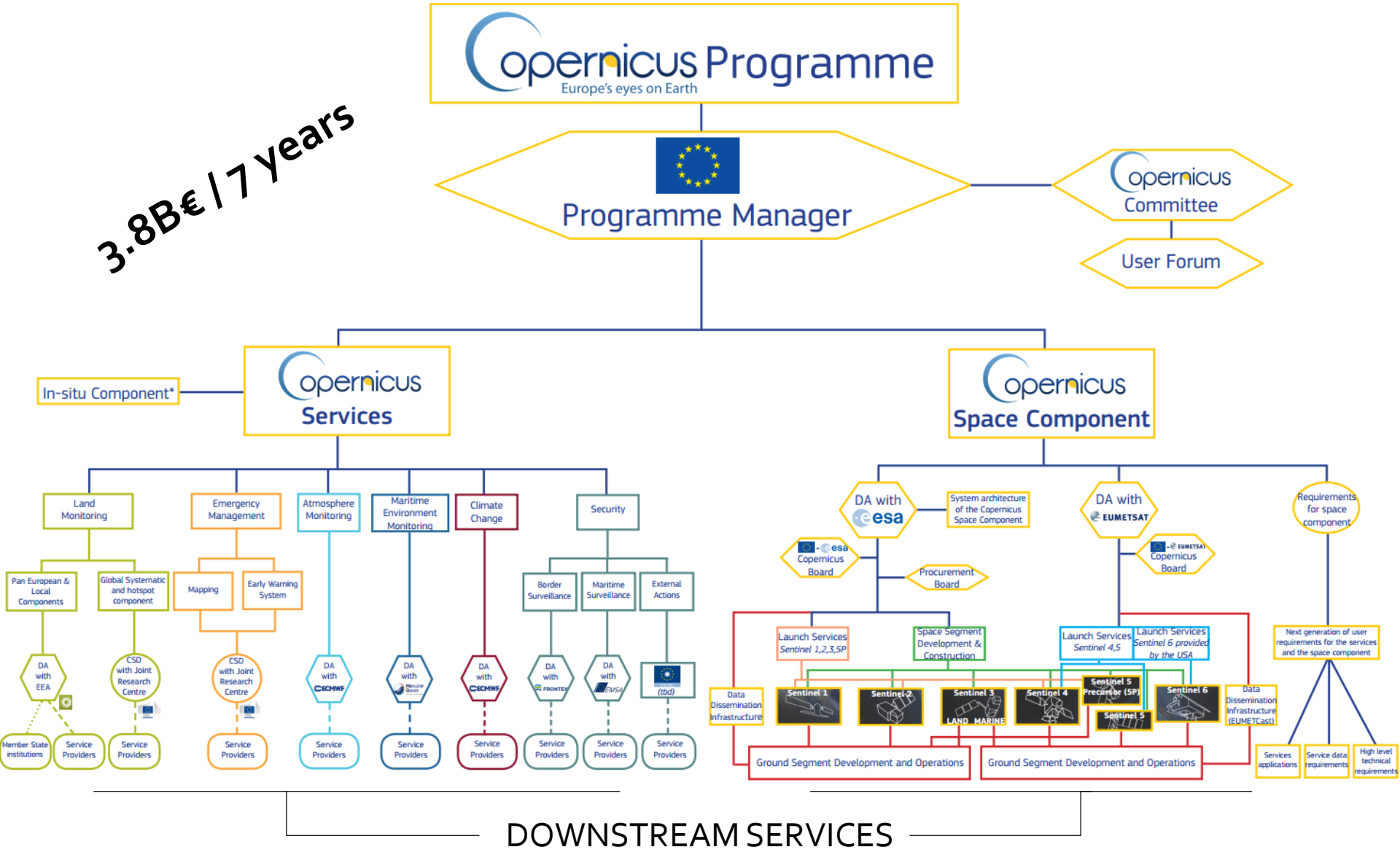




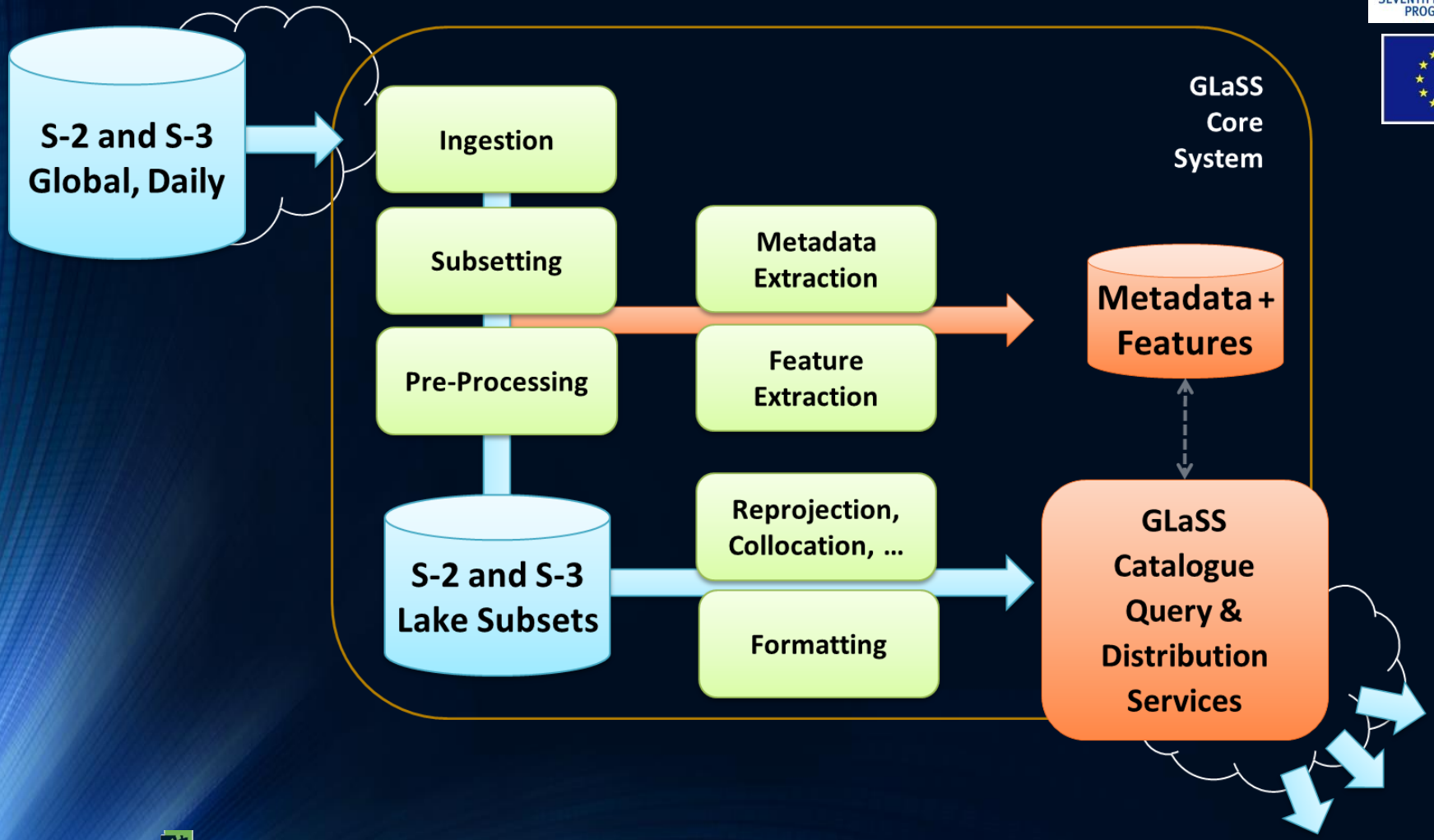
EO to support WQ legislation - Technical Readiness

- Satellite data
  - (Hopefully) good situation thanks to Landsat 8, Sentinel 3 & 2
  - Data access problematic but preparation in reasonable good shape
- Algorithms
  - European coastal waters well studied and properly addressed
    - Validation with users during past 10 years helped to make algorithms, service providers and users fit for purpose
  - Inland waters improved a lot during past 3 years but (much) more needs to be done; fiducial reference data are lacking!
- Operational services
  - Basically in place thanks to Copernicus programme
    - Mainly downstream services provided by service providers acting at national level
    - Marine core service aiming at large scale picture; reference condition for WFD reporting
  - Inland Water core service as an extension to the Copernicus Land Service under discussion

Copernicus Europe's Eye on Earth



Preparing S2+3 ingestion: GLaSS Core System



Summary and Conclusion

- Driver is the goal – a consensus of the community to improve the ecological status of our coastal and inland waters, or at least to preserve the status. This is expressed in national and internal legislation.
- This goal needs quantification → **indicators.** EO can provide **observations** feeding into serveral indicators.
- Earth Observation provides a unique basis due to its **spatial coverage**, **repetitiveness** and **global coverage** (=comparability)
  - in-situ data remain indispensable for algorithm development, calibration and validation
- In some European countries EO is considered a valid contributing technology to the reporting obligation. The process to bring it into more national implementations needs to be continued.
- The **dialogue with users** creates mutual understanding of requirements for monitoring, and advantages of EO method. This needs to be continued (coastal) and intensified (inland water)
- The technological backbone is reasonable good shape
  - Space segment with a minumum set of sensors will be in place soon
  - Technical development should prepare next generation (hyperspectral, geostationary)
  - Data access and algorithms are in progress; more works needs to be done to achieve full operationality
  - Most important R&D requirements are on inland water algorithms, fiducial reference data and validation, and higher level indicator development