Satellite based monitoring of aquatic systems

Bathymetry, benthic habitat surveys and water quality monitoring

A new paradigm for fast changing environments.

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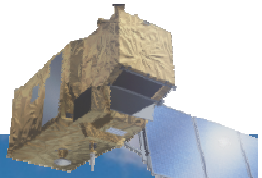


Challenges in monitoring of aquatic environments

How to retrieve a baseline of extended aquatic systems?

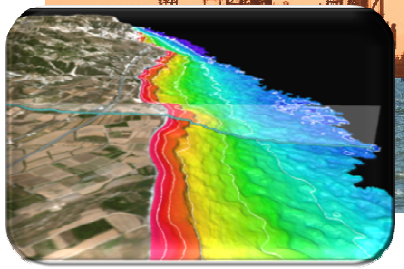
How to evaluate and monitor the socio-economic impact of:

- industries, mining, damns, agriculture on lakes, rivers, the coast?

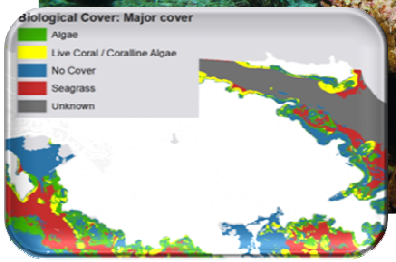
- ✓ *area wide*
  - ✓ *harmonized, independent, accurate*
    - ✓ *long-term*
      - ✓ *rapid*
        - ✓ *cost-effective*

EOMAP core business: aquatic mapping services

Bathymetry surveys for offshore industry



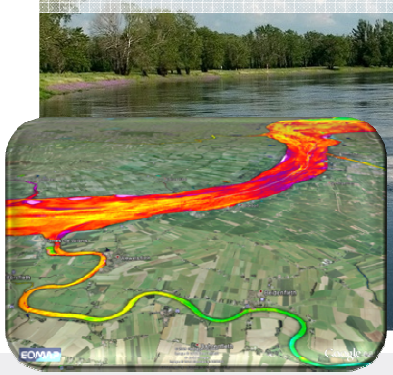
Environmental monitoring of coastal zones for offshore industry & agencies



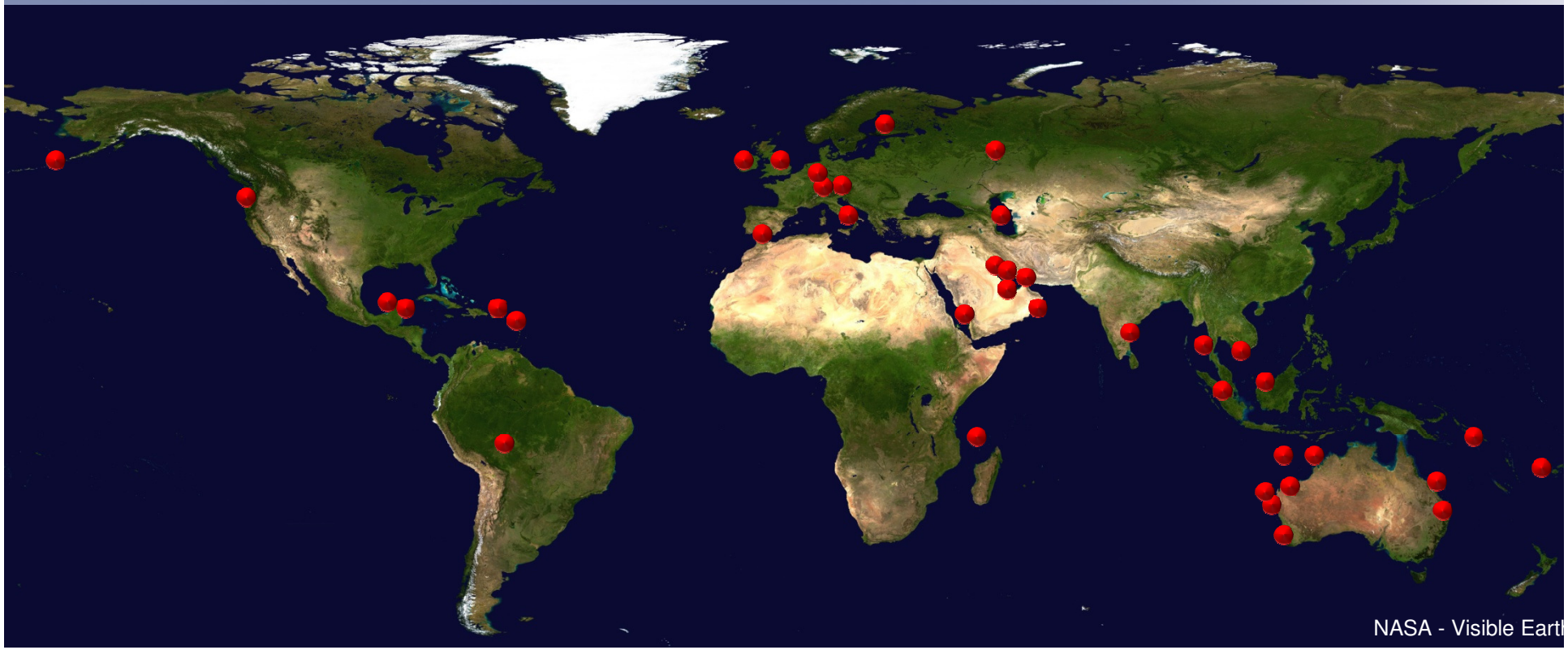
Services worldwide

Shell · woodside · bp · INPEX CORPORATION · Cardno · Van Oord · ATLAS ELEKTRONIK · THE WORLD BANK · CONABIO · bfg · CSIRO

Water quality monitoring for agencies and authorities

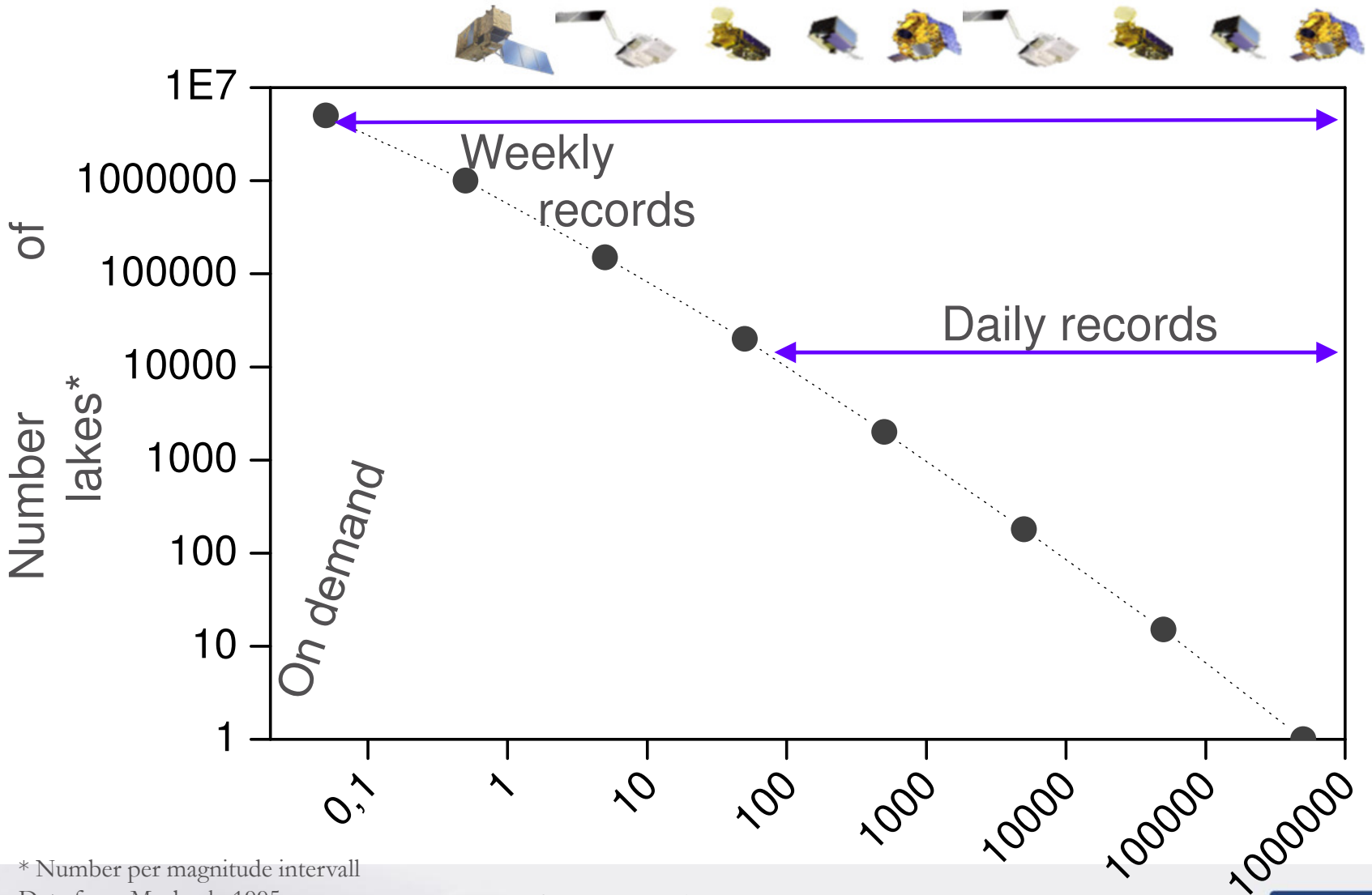


EOMAP services worldwide



Shell
woodside
bp
INPEX
INPEX CORPORATION
Cardno
Shaping the Future
Van Oord
Marine ingenuity
ATLAS ELEKTRONIK
A joint company of ThyssenKrupp and EADS
BAW
bfg
Bundesanstalt für Gewässerkunde
ILF
CONSULTING ENGINEERS
GSI
THE WORLD BANK
Australian Government
Geoscience Australia
Environment Agency ABU DHABI
THE UNITED KINGDOM HYDROGRAPHIC OFFICE
NOAA
BSH
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE
CONABIO
COMISIÓN NACIONAL PARA EL CONOCIMIENTO Y USO DE LA BIODIVERSIDAD
COMMISSION DE L'OCÉAN INDIEN
CSIRO
DLR
esa
European Commission
EOMAP

Number of lakes, and temporal resolution of satellite records



* Number per magnitude intervall
Data from Meybeck, 1995

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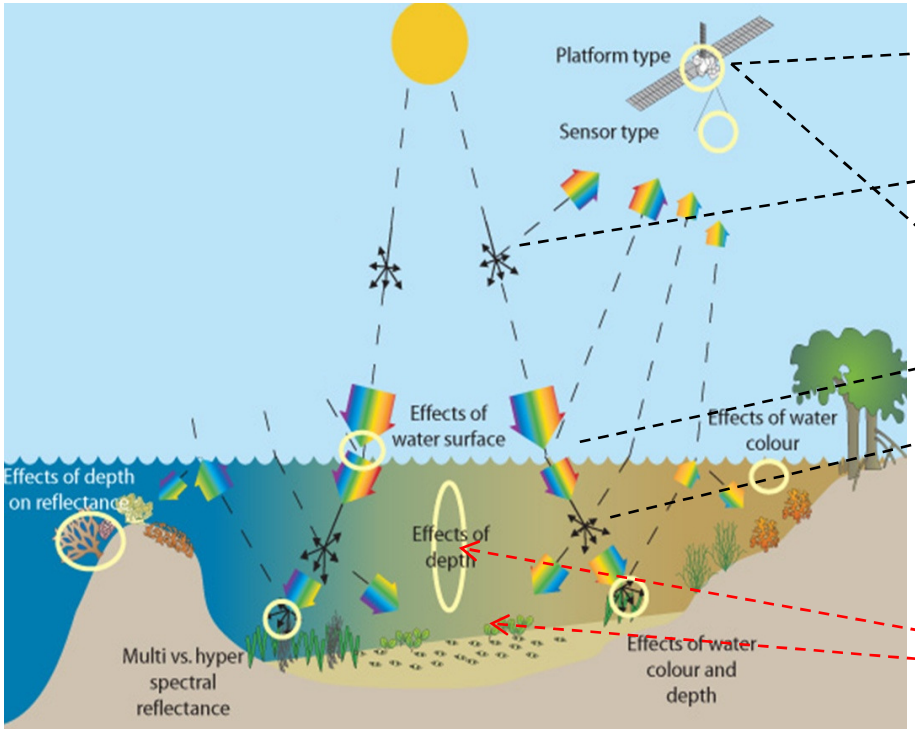
What is aquatic EO about

Schema of the light signal measured by optical satellites



Physical realization of the system

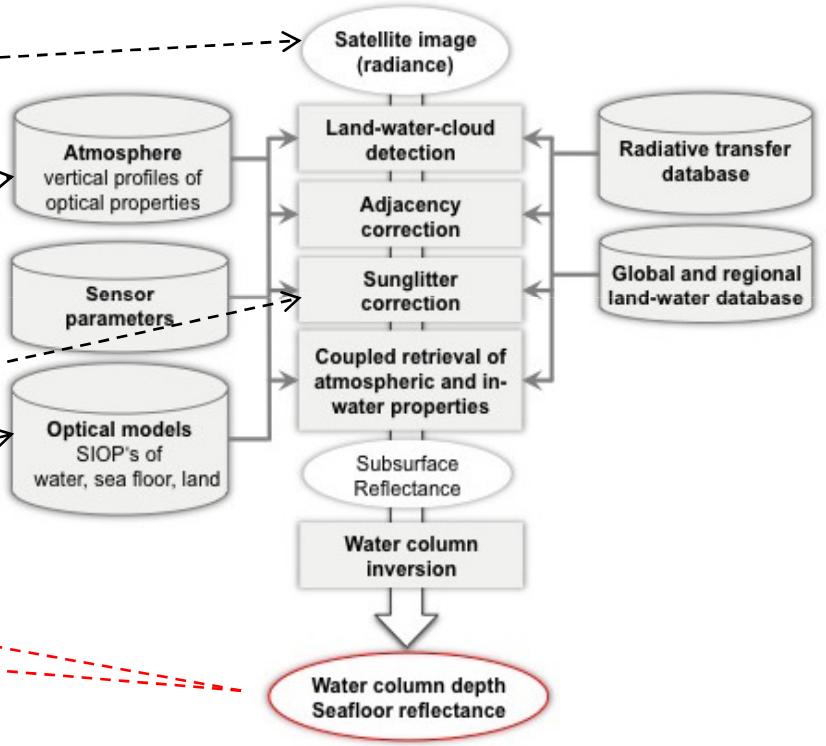
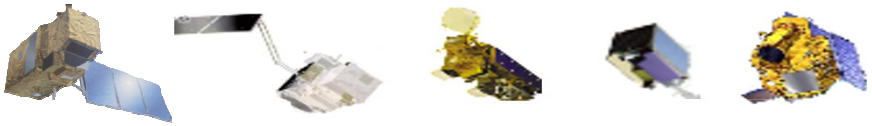
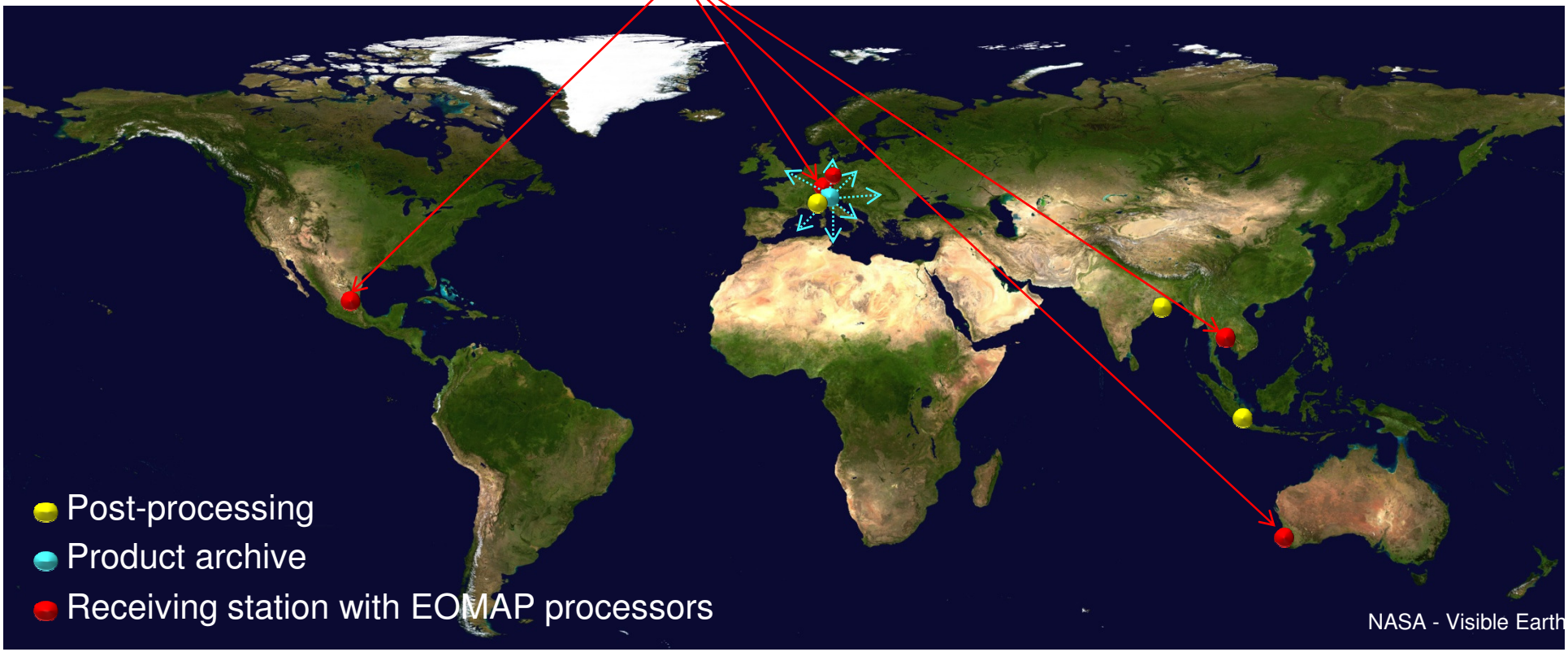


Image courtesy of the Centre for Spatial Environmental Research, University of Queensland)

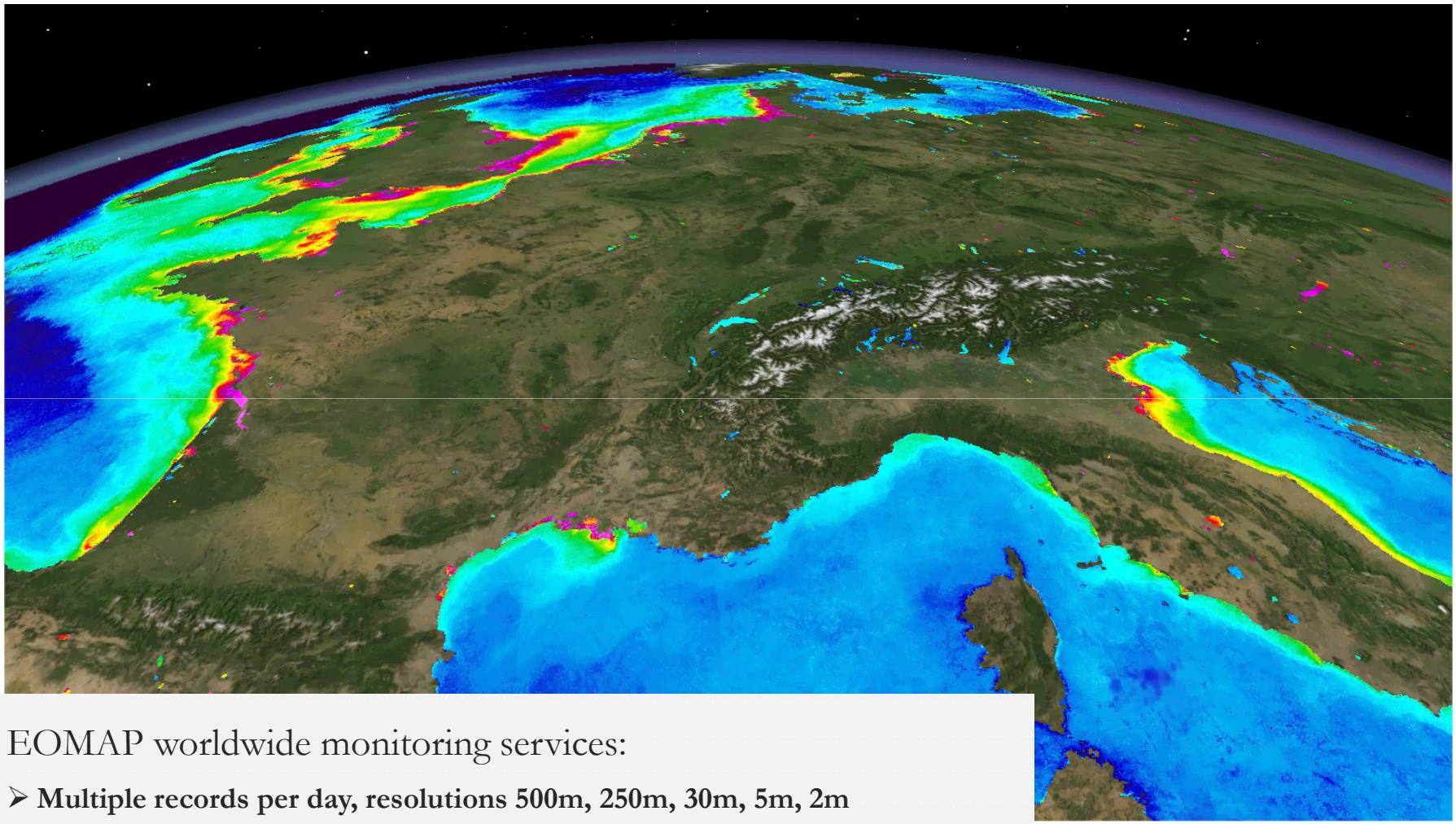
EOMAP production infrastructure





Satellite services for marine applications

Near-real-time & high resolution through EOMAP processors at ground segments



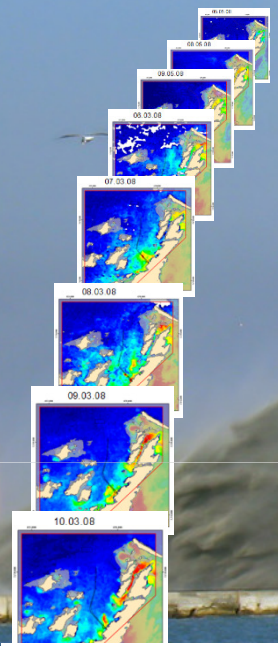
EOMAP worldwide monitoring services:

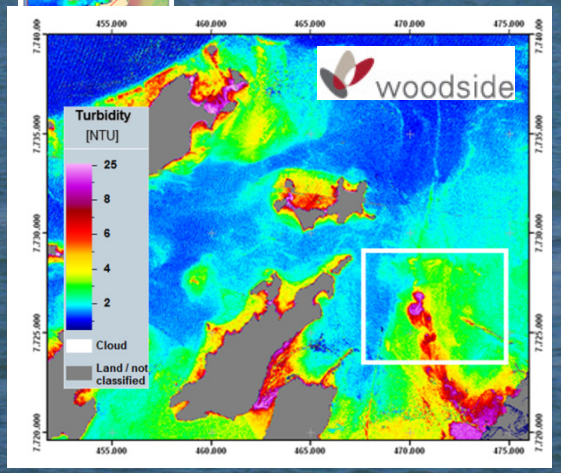
- **Multiple records per day, resolutions 500m, 250m, 30m, 5m, 2m**
- **Visibility, water quality, anomalies, obstructions**
- **Bathymetry, sea floor habitats**
- **For navigation in uncharted areas: minimum water depth at any locations**

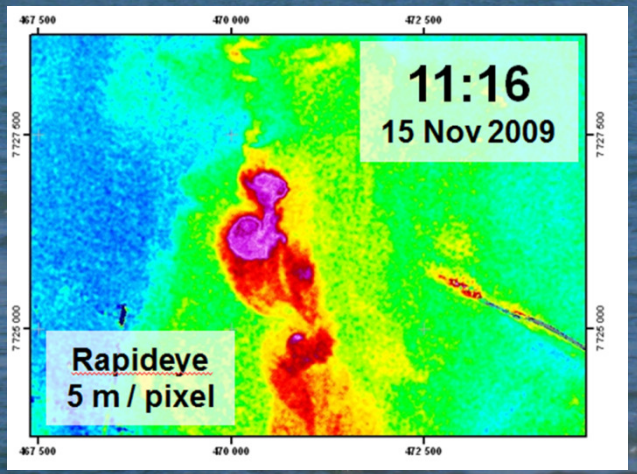
Dredge plume monitoring

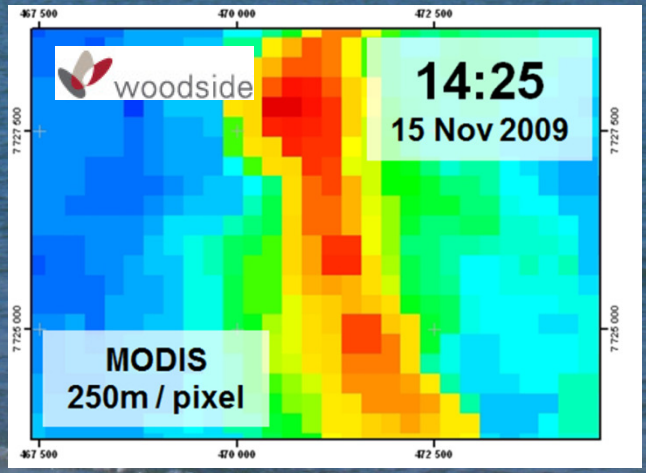
e.g. for Woodside Energy, Australia:

http://earth.eo.esa.int/workshops/gasoil2010/Hausknecht.pdf
www.eomap.com/OWIKI-MonitoringDredgingPlumesandWaterQuality-180811-0823-14-2.pdf
Cost savings for Woodside Energy: 1 000 000 AUD

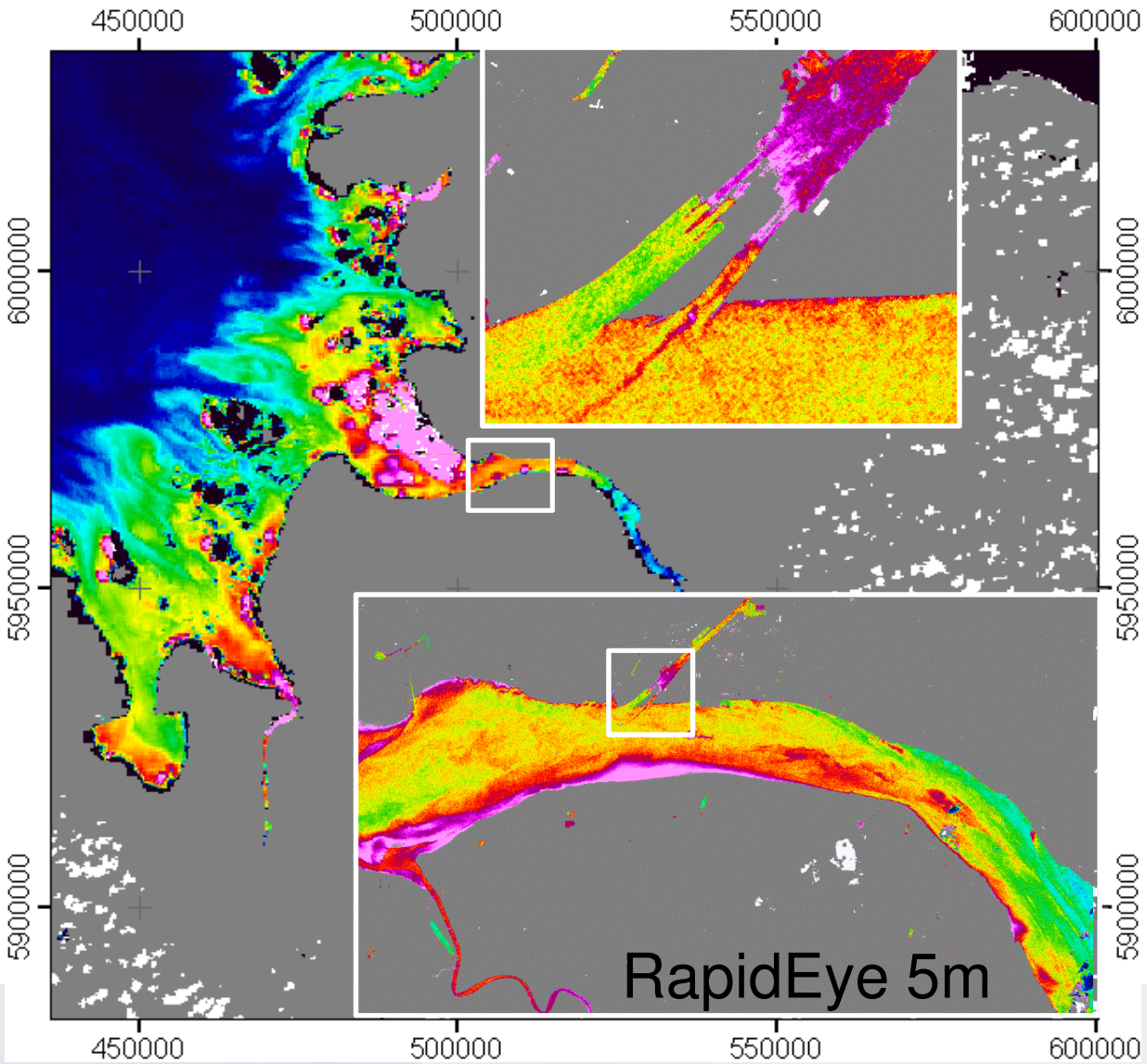








Multi-sensor water quality monitoring
Contracts by water authorities Germany



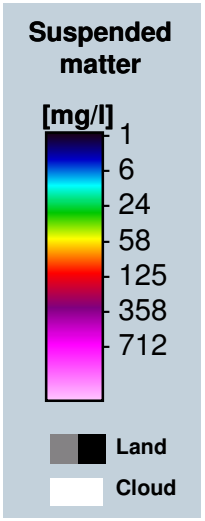
River Elbe / Germany

Suspended matter monitoring

Satellite sensors:

MODIS Terra, Aqua

MERIS, RapidEye

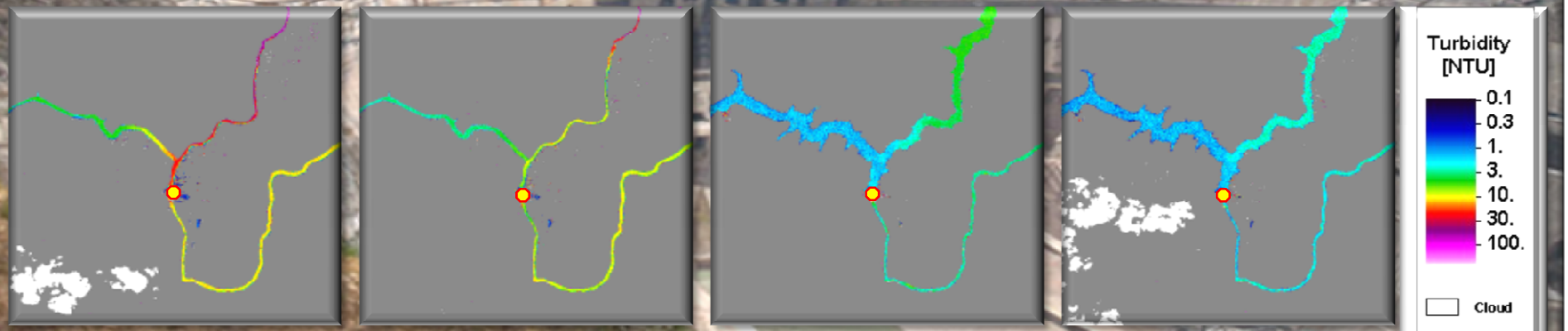


Reference coordinate system:
Projection: UTM Zone 32 N

Dams: Quantification of the impact

Example Mekong: transnational river system

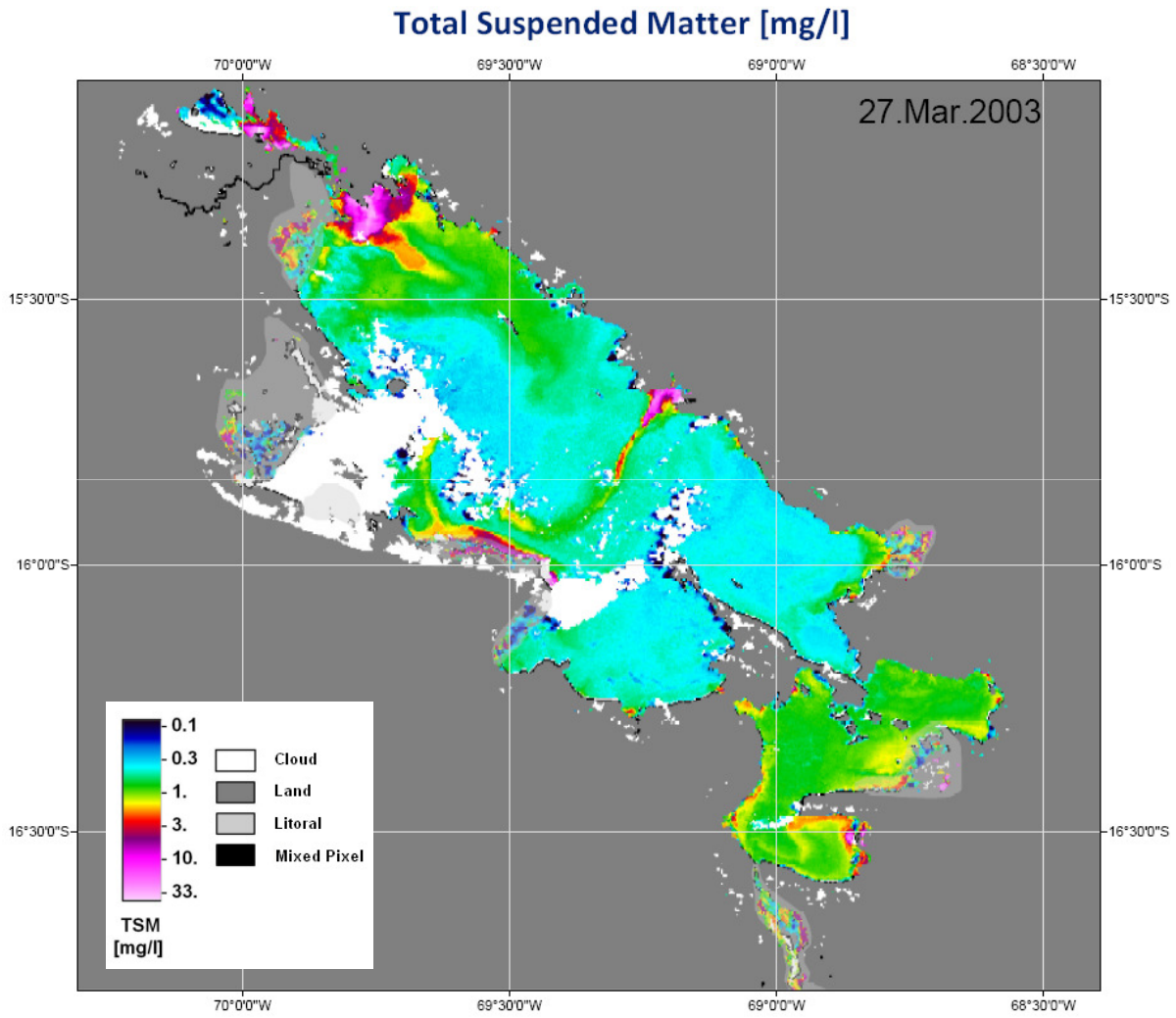
Requirement on harmonized long-term monitoring of
International river commissions
governmental authorities, insurers



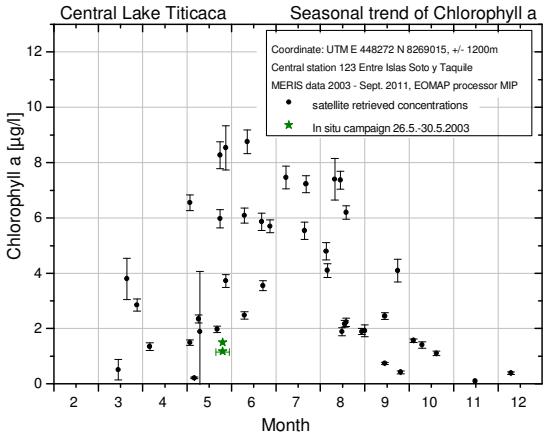
2009-01-09 2009-02-10 2009-11-09 2009-11-25

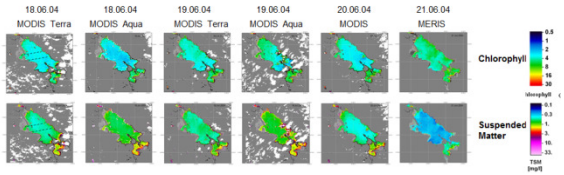
Location of Xiaowan Dam

Bolivia/Peru: 2003 - 2011
Lake Titicaca monitoring for Worldbank



Seasonal trends

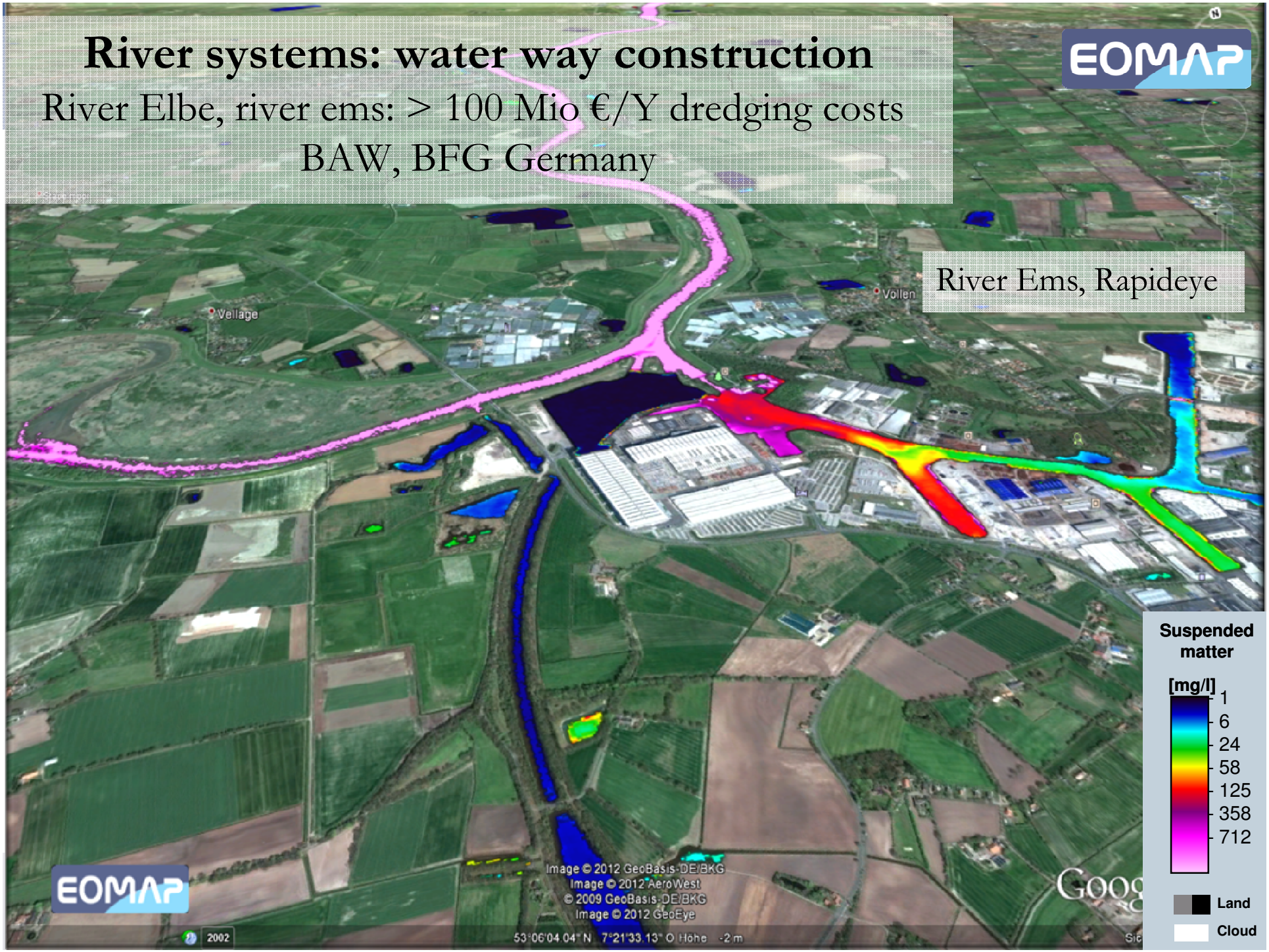




River systems: water way construction

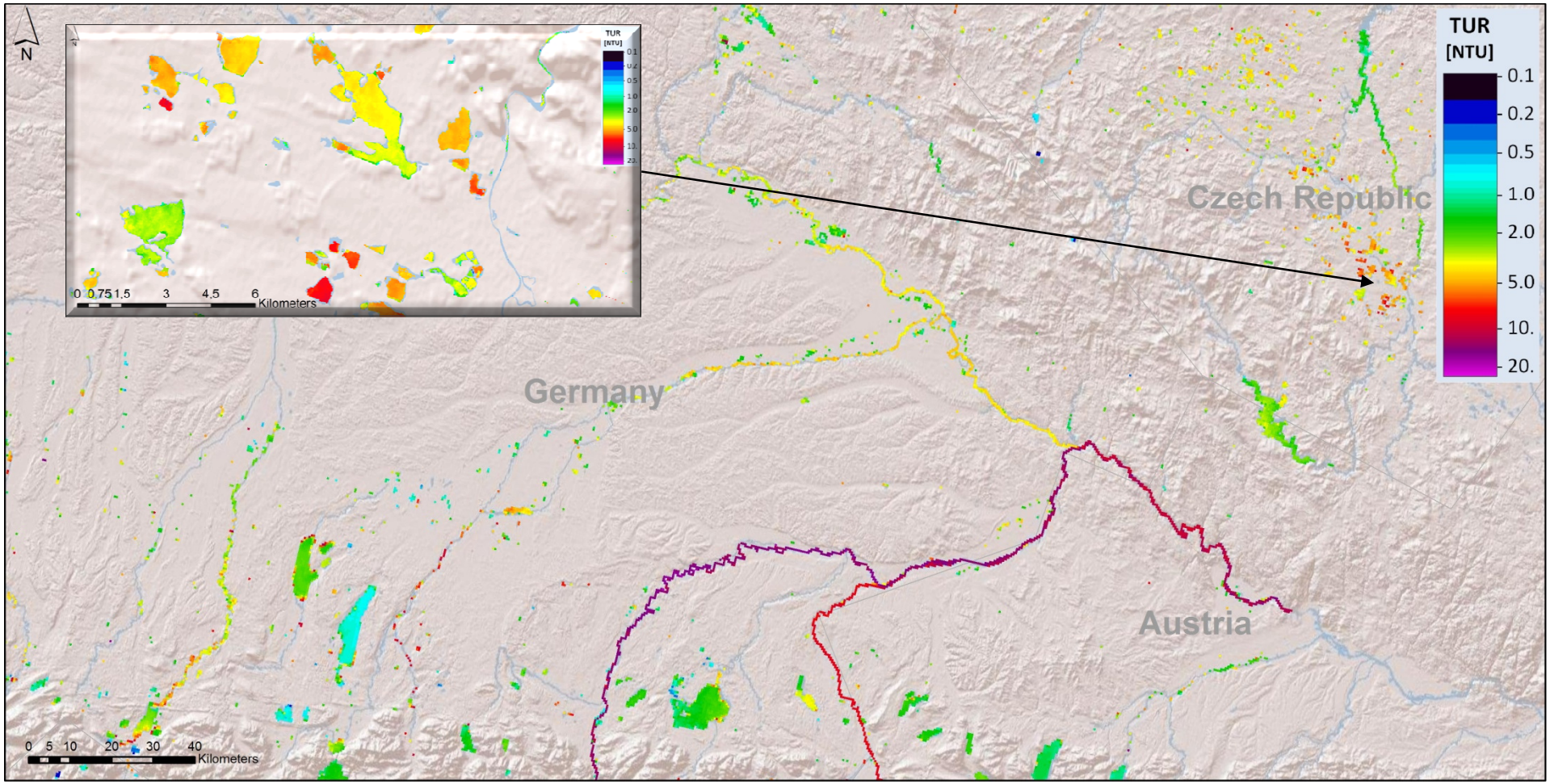
River Elbe, river ems: > 100 Mio €/Y dredging costs

BAW, BFG Germany



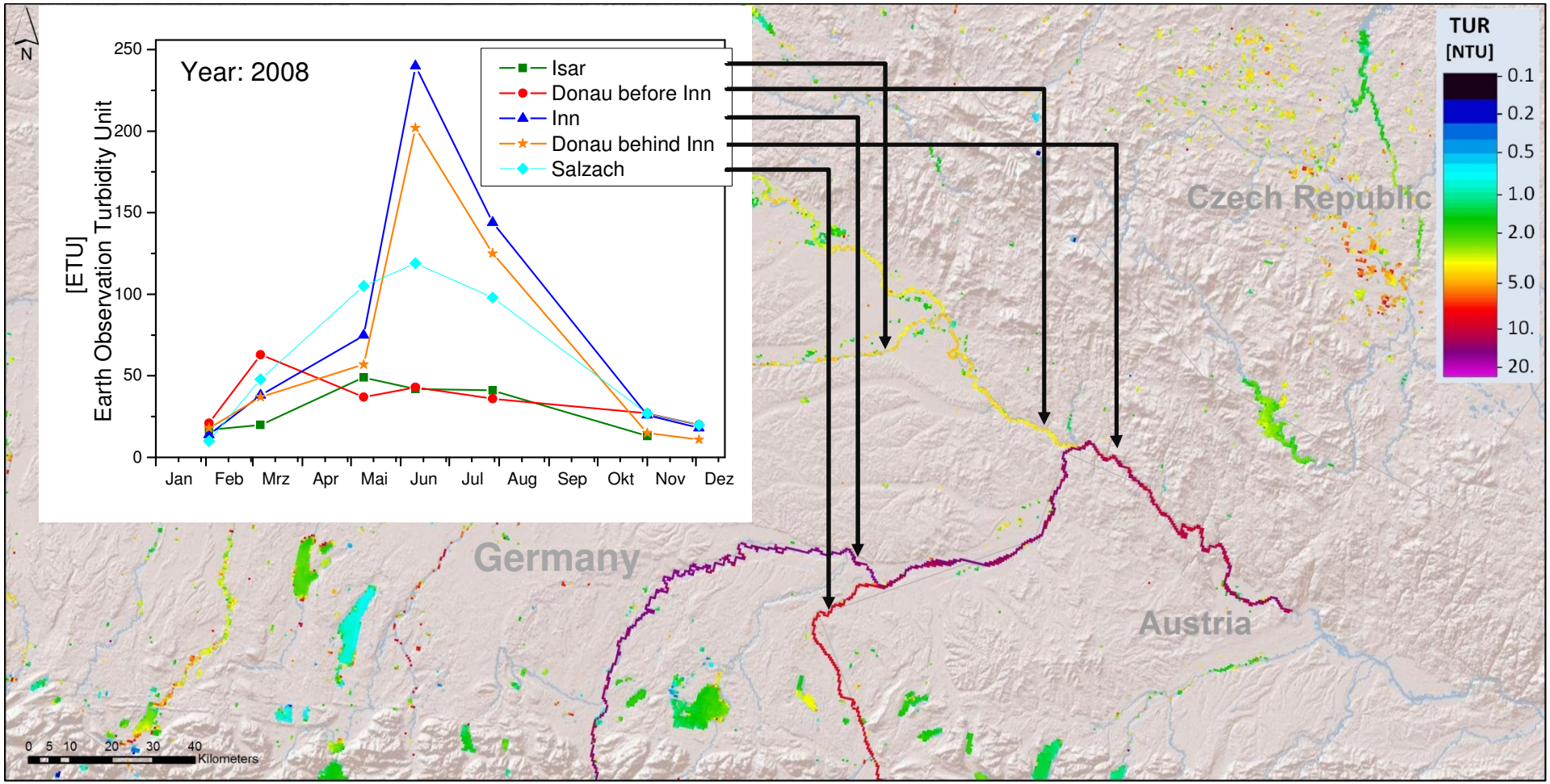
Danube Contributors (Germany, Czech Republic, Austria)

Turbidity, June – August, spatially aggregated (500m)

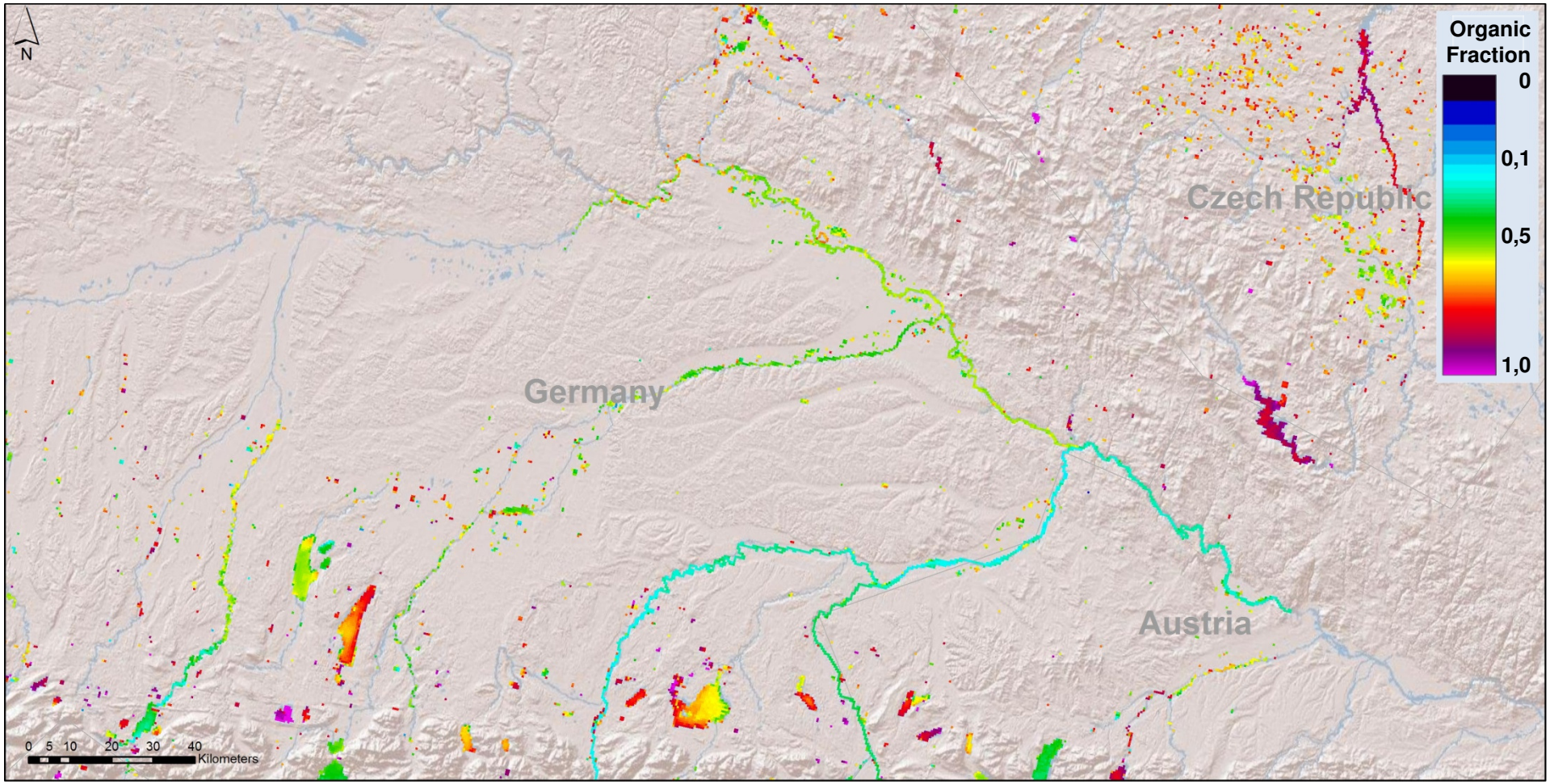


Danube catchment area

Seasonal turbidity in various rivers, 2008

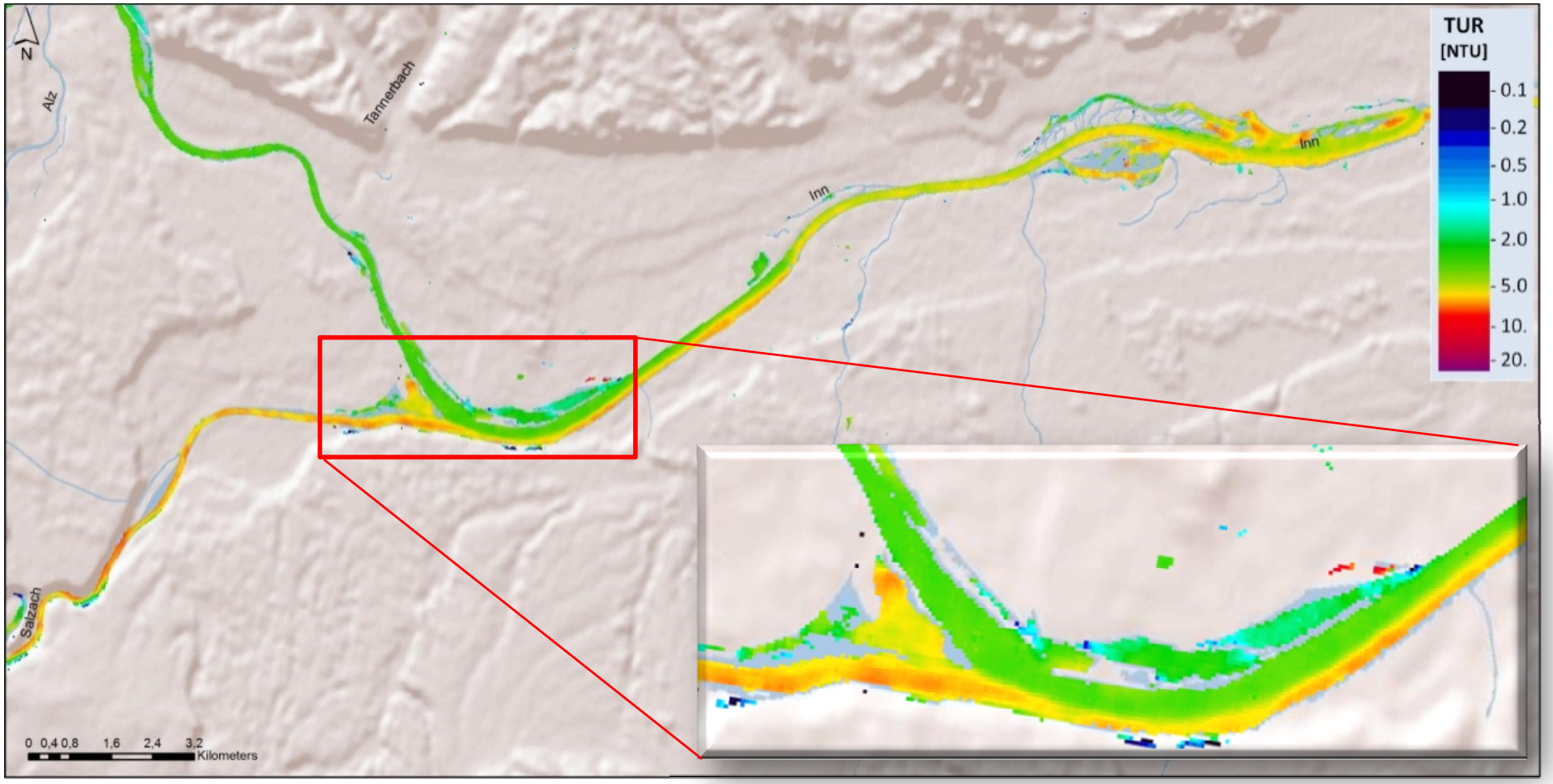


Danube catchment area
Organic Fraction, June – August



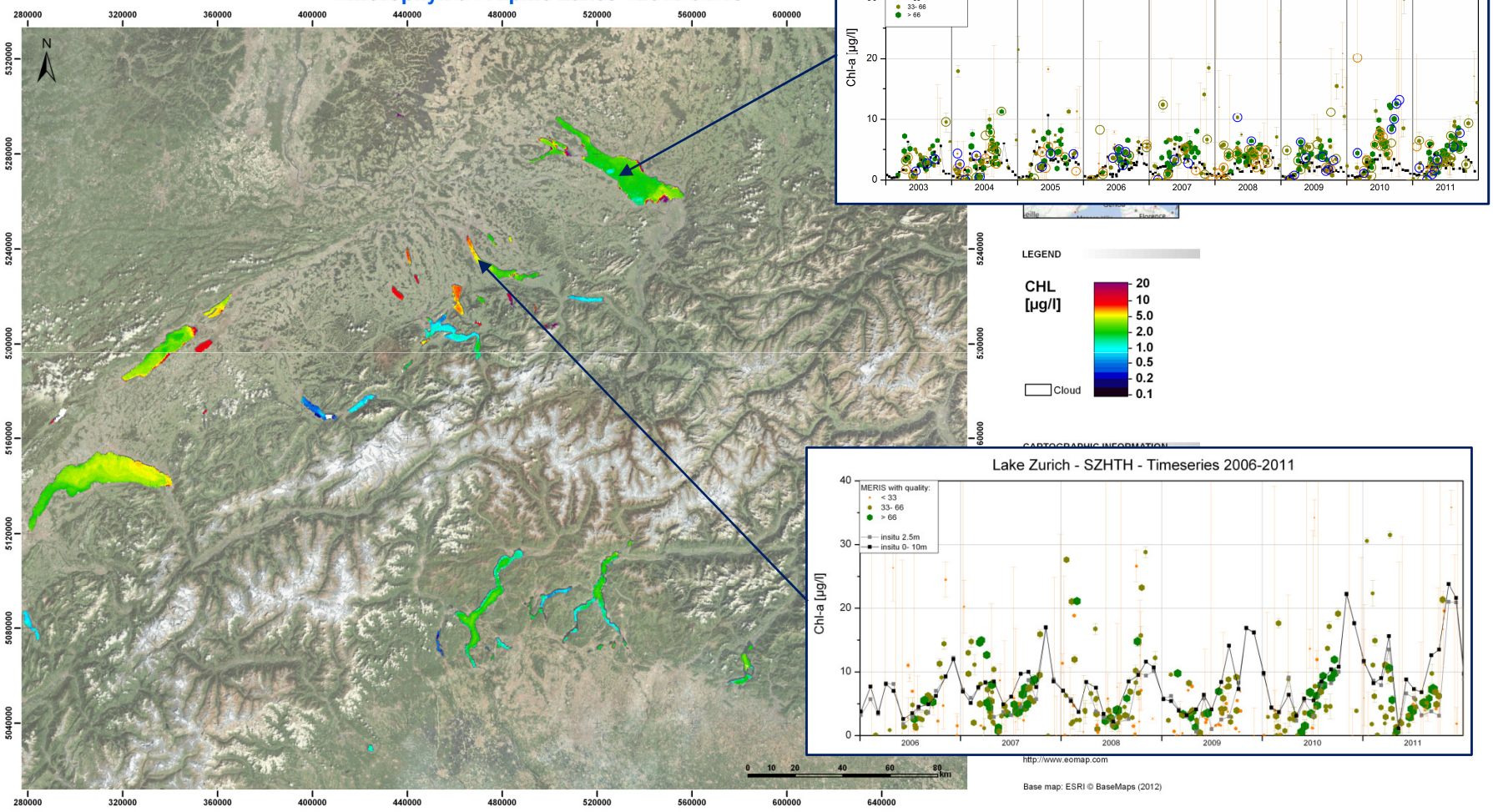
Turbidity in rivers: mixing processes

Bavarian rivers Inn and Salzach, Landsat 30m, 2012-03-17



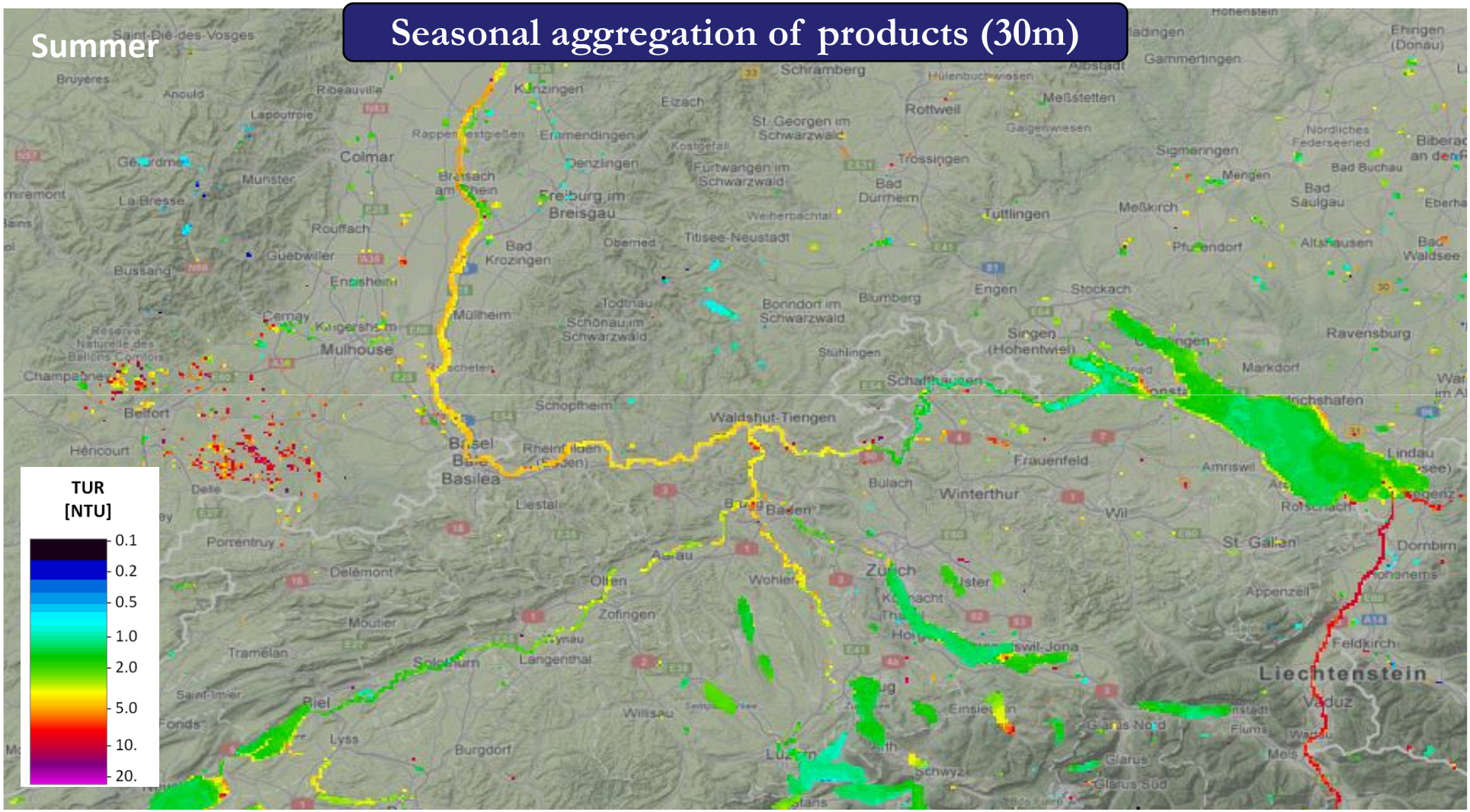
Long-term monitoring of chlorophyll in lakes

Alpine Lakes, 300m MERIS



Water Quality Atlas

Seasonal aggregation of products (30m)



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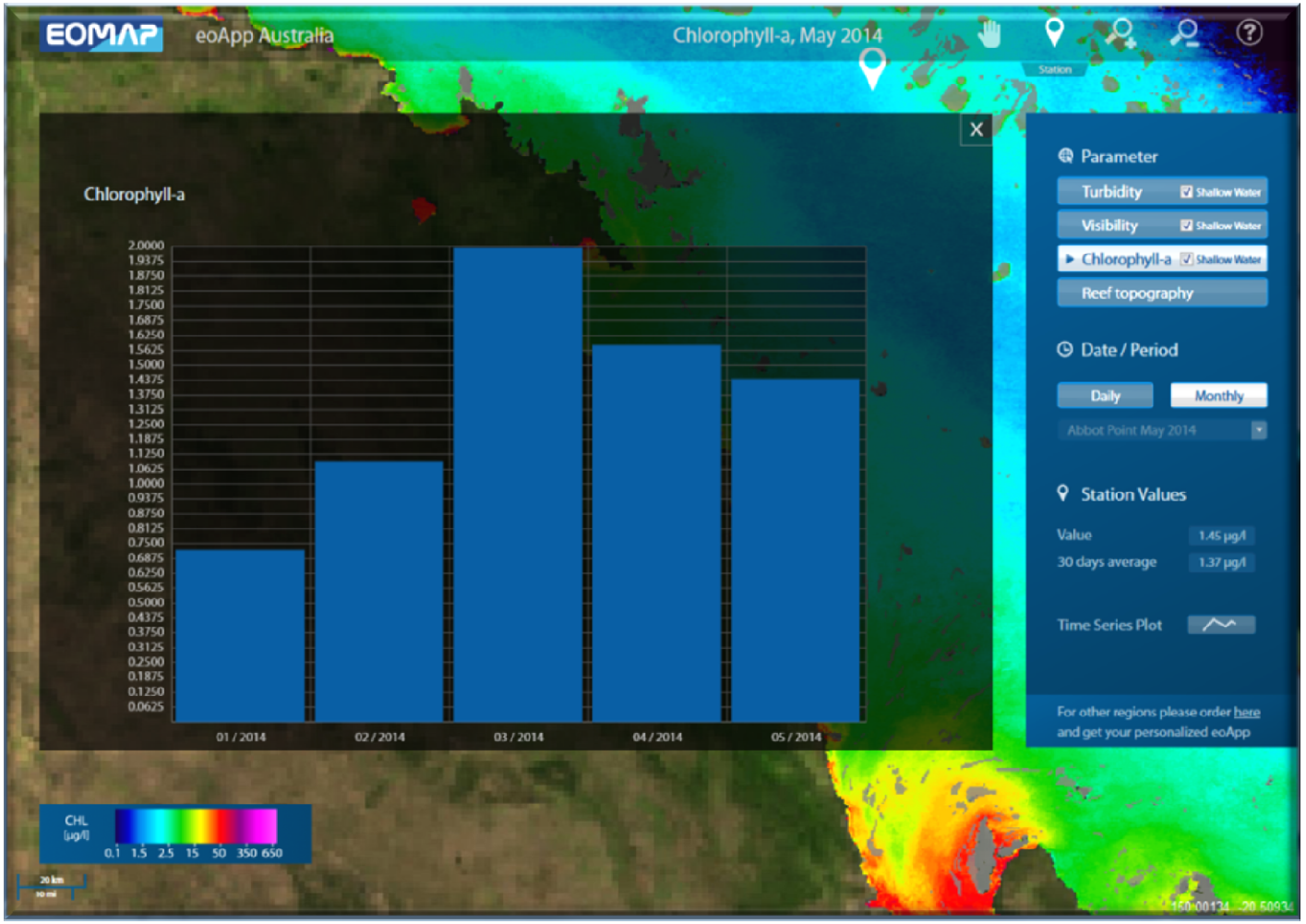
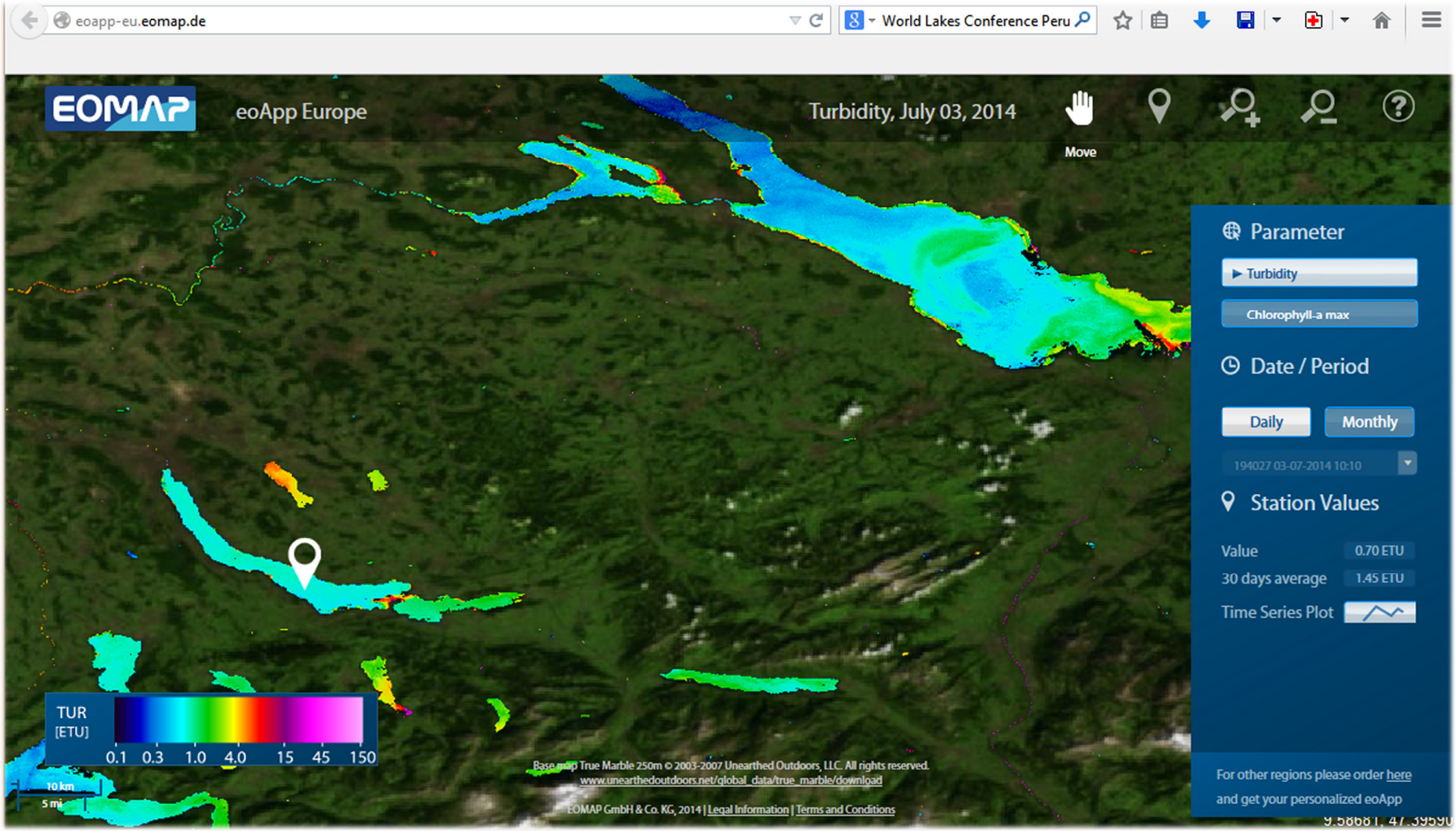
Web applications to services: eoApp

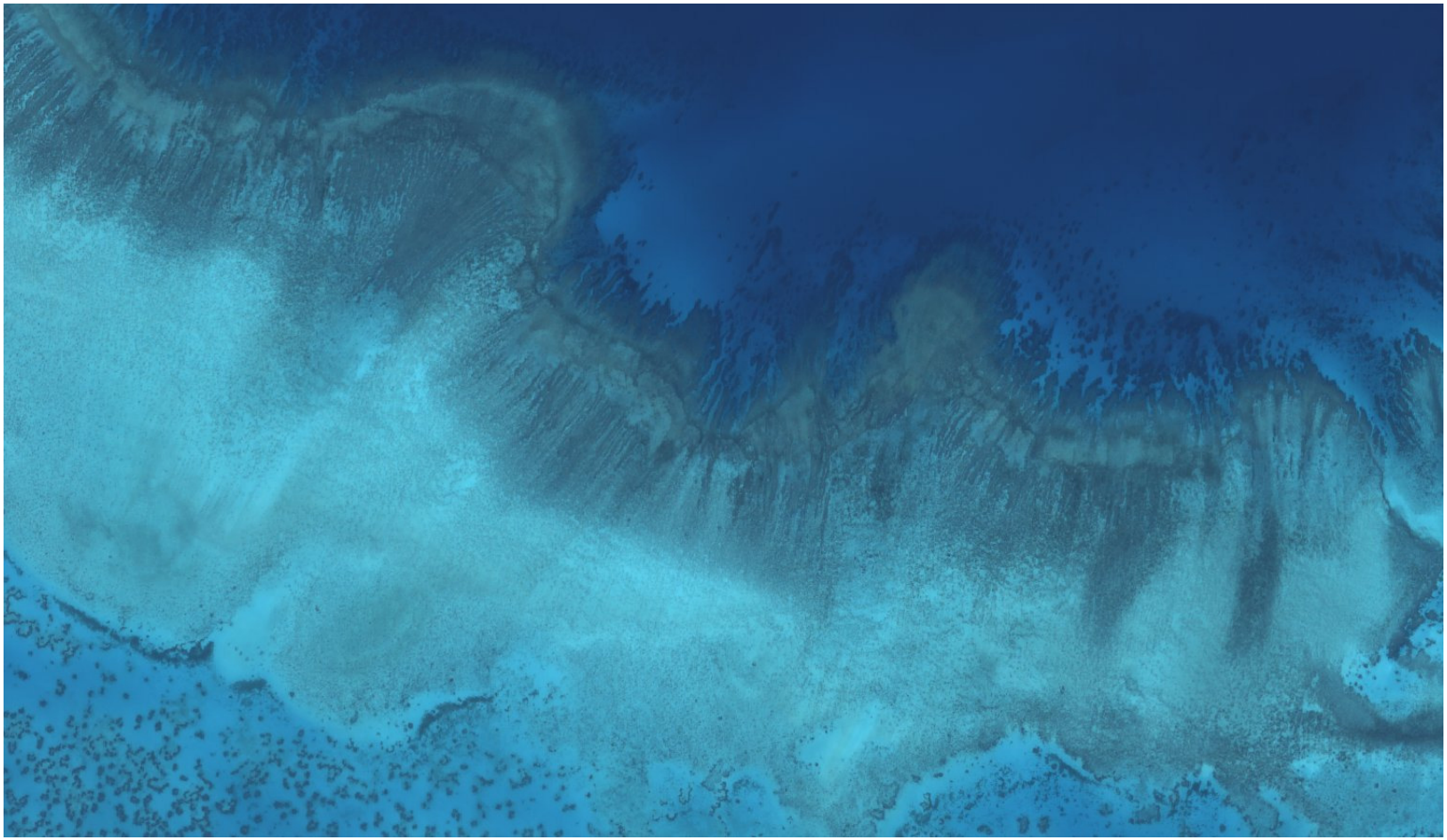


Web applications for an easy access and evaluation

eoApp Australia & eoApp Europe for water agencies



Un-corrected imagery: view at sensor
Heron Island, WorldView-2 Radiances (RGB: ch4, 3, 2)

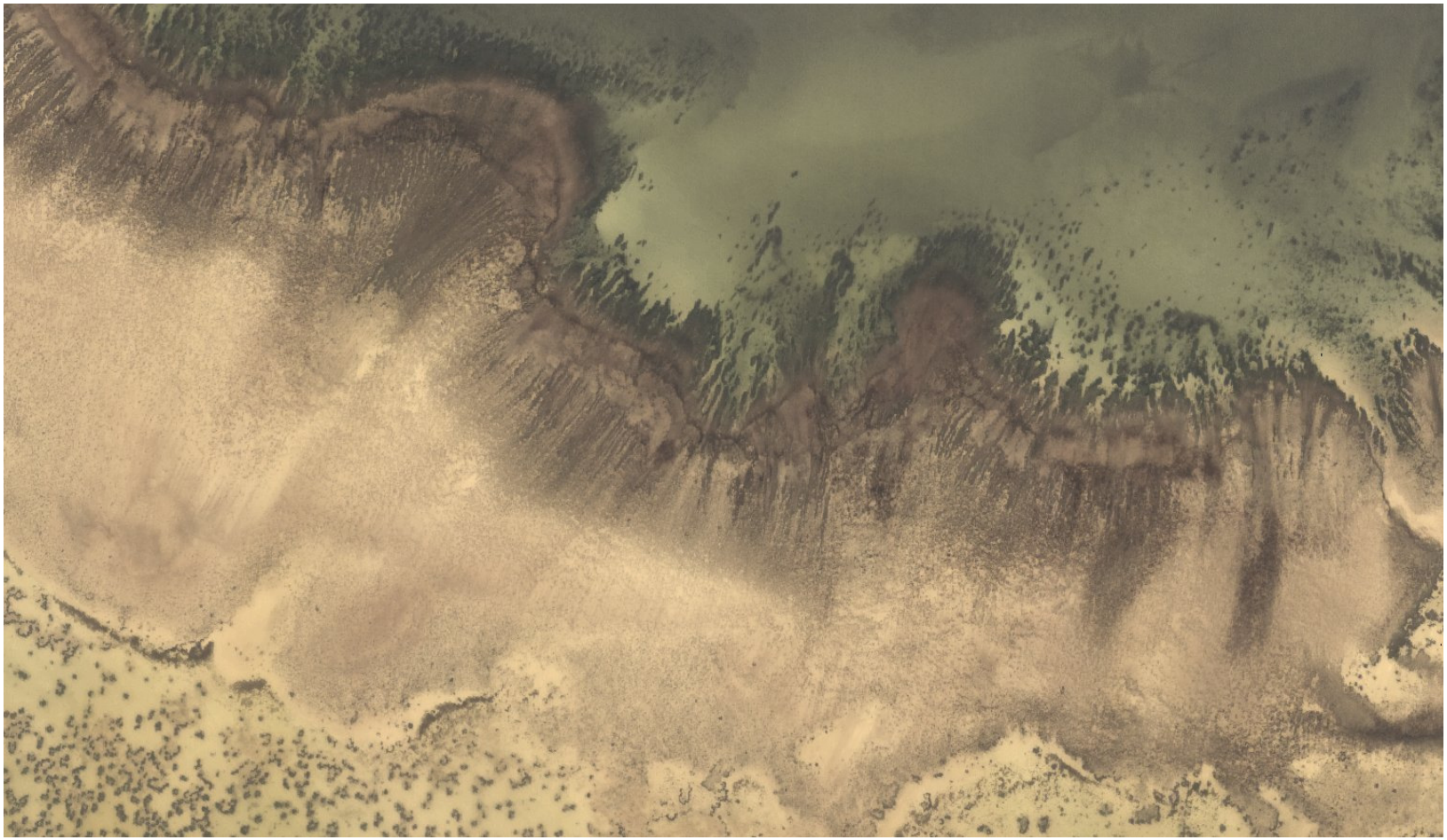


Source: DigitalGlobe WorldView-2, acquisition date: 2011-10-30

Atmospheric effects removed: view at sea surface
Heron Island, WorldView-2 Reflectance (RGB: ch4, 3, 2)

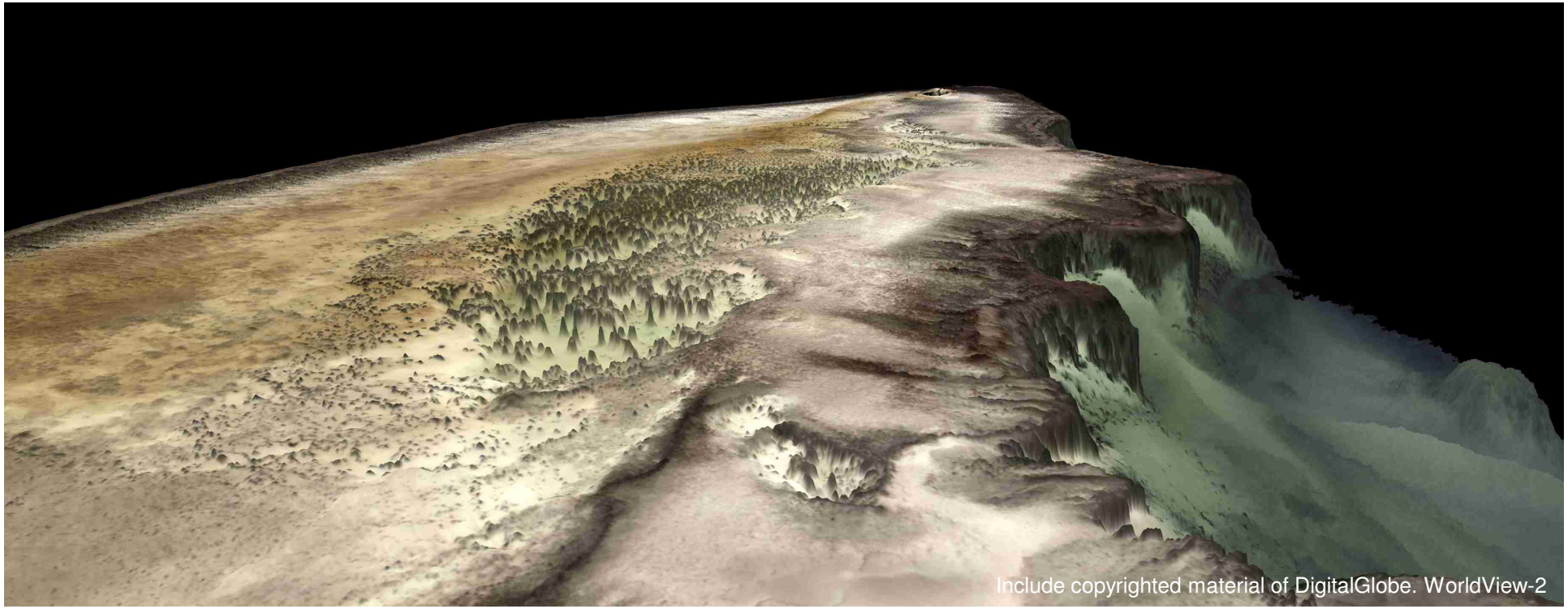
Source: DigitalGlobe WorldView-2, acquisition date: 2011-10-30

Water column removed: view at seafloor
Heron Island, WorldView-2 seafloor reflectances (RGB: ch3, 2, 1)



Source: DigitalGlobe WorldView-2, acquisition date: 2011-10-30

Satellite Derived Bathymetry SDB



Seafloor reflectance draped over bathymetry (Heron Island)

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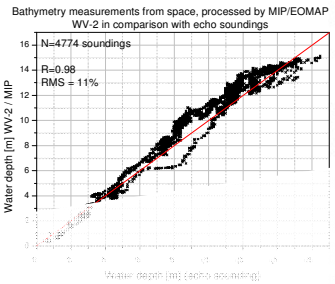
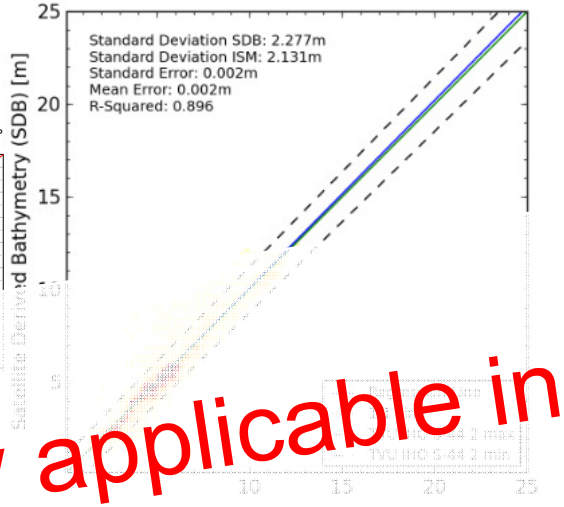
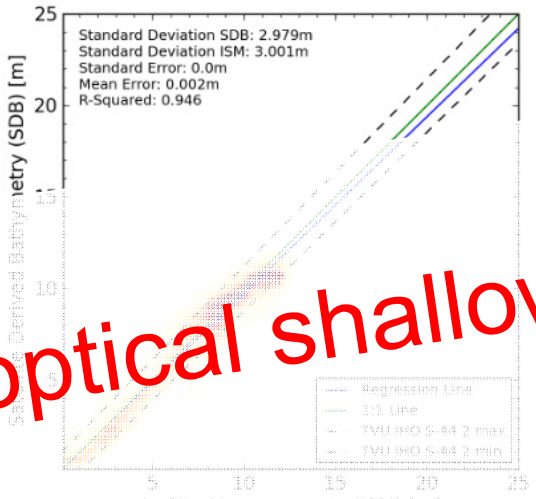
Uncertainty statistics: a realistic picture?

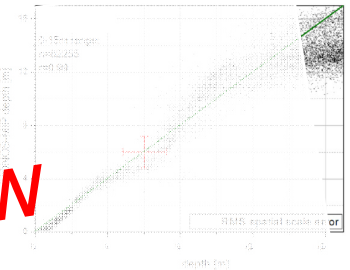
Red Sea





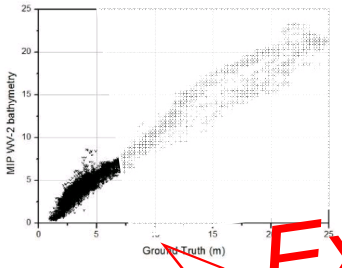


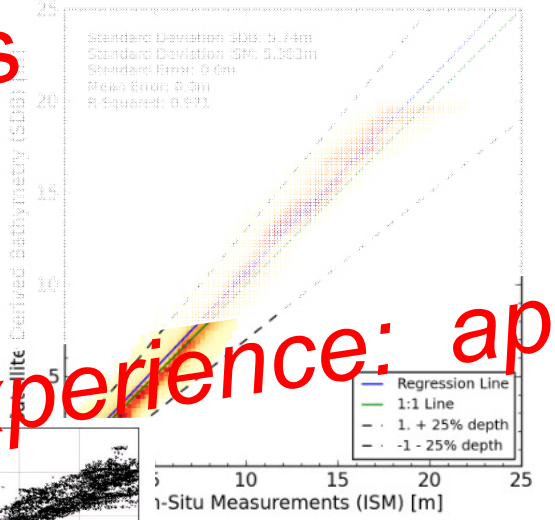
West-Australia



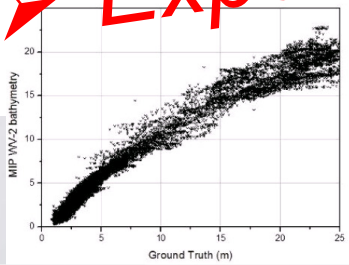
➢ Only applicable in optical shallow waters

Caribbean Sea

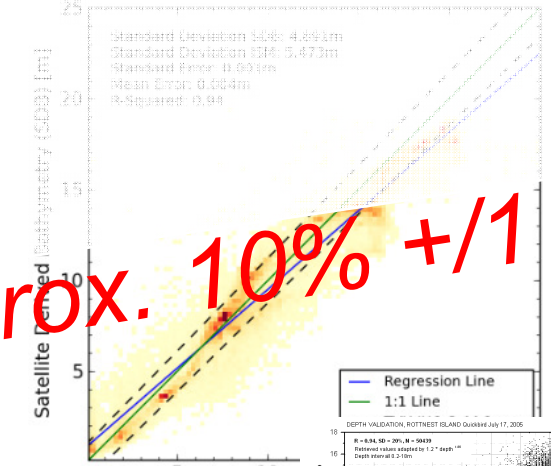


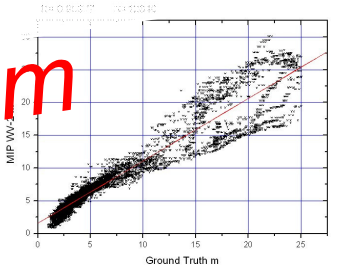


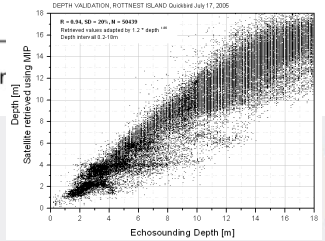
➢ Experience: approx. 10% +/1 m



Arabian Gulf







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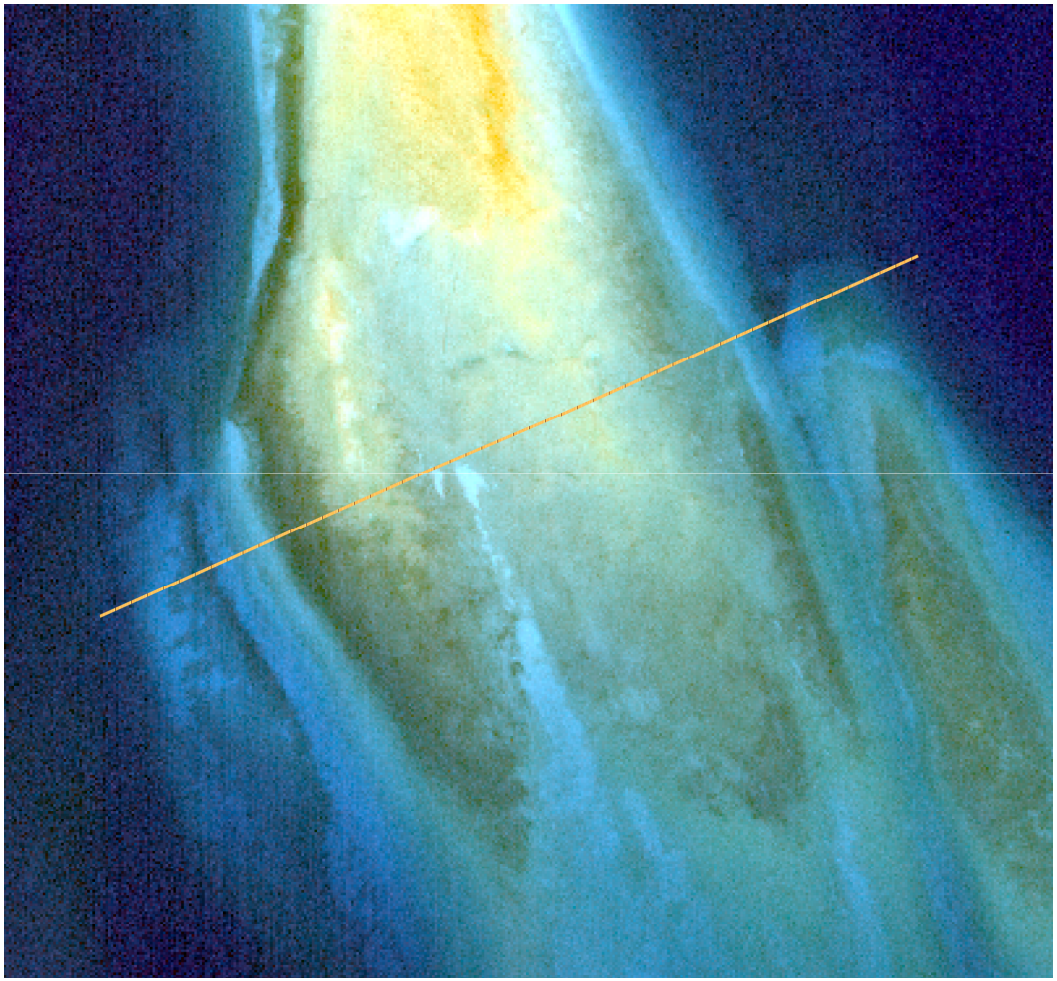
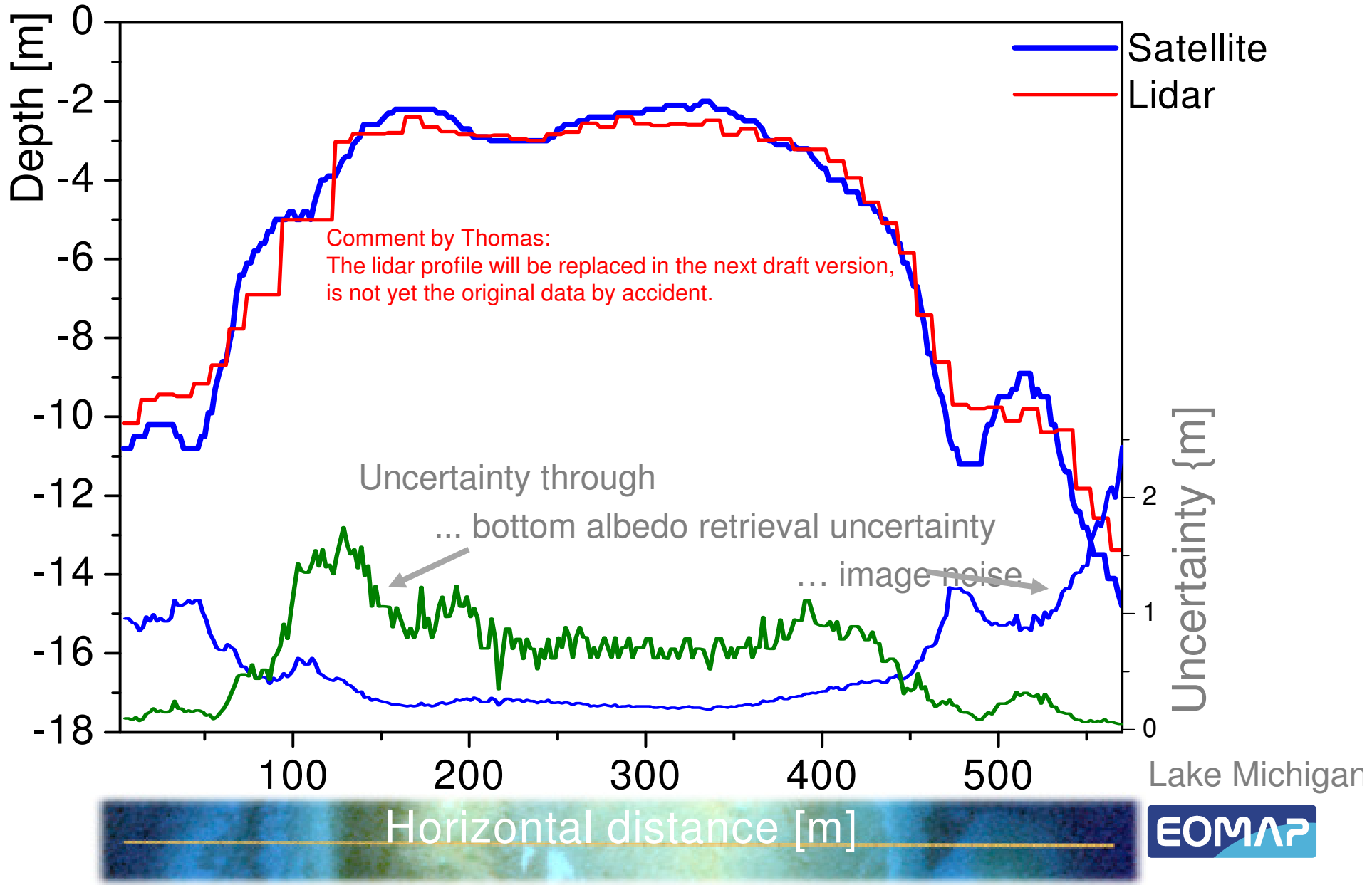
Uncertainties calculated for Lake Michigan

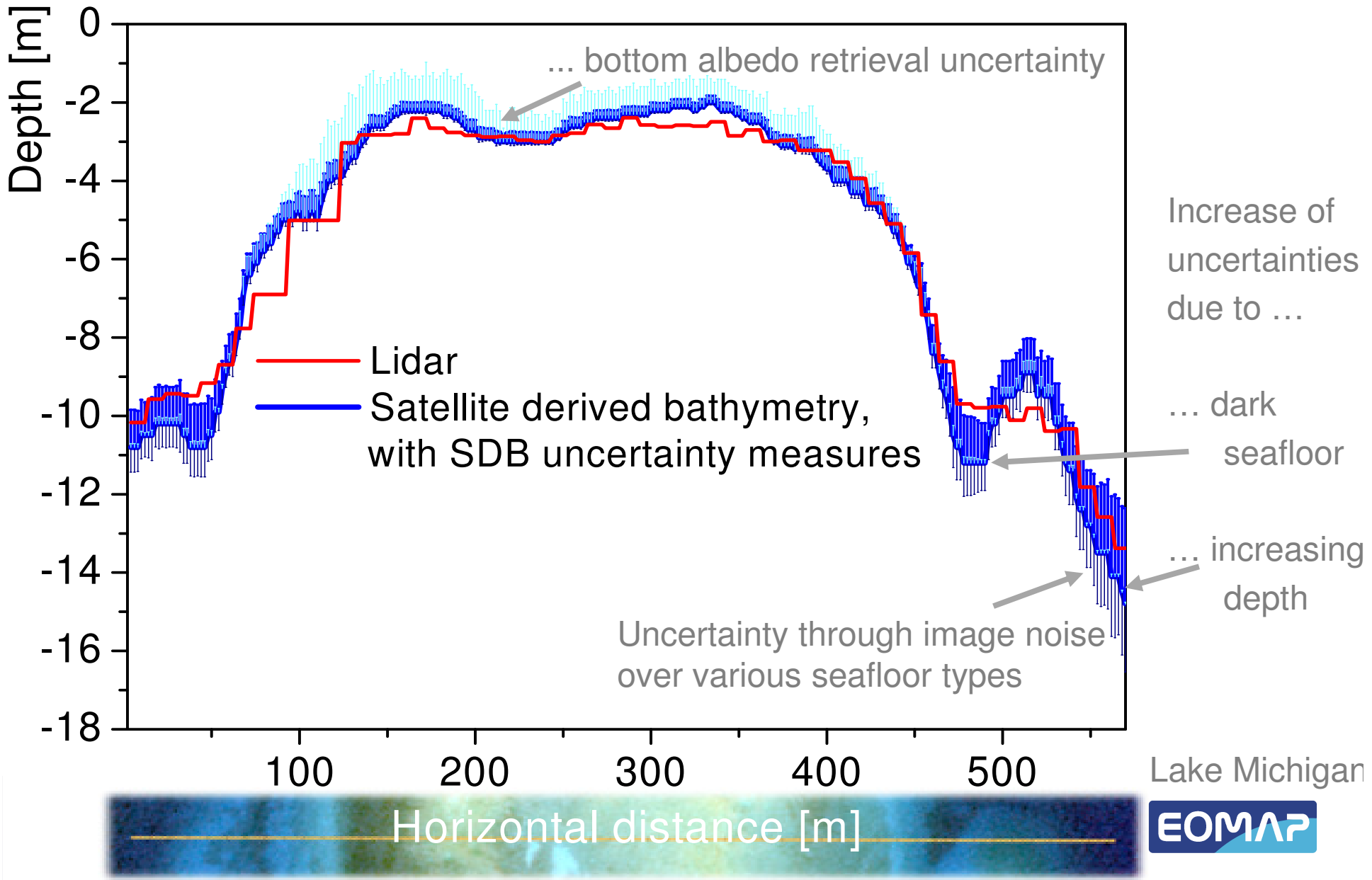


Location: Lake Michigan

SDB Uncertainty Estimation

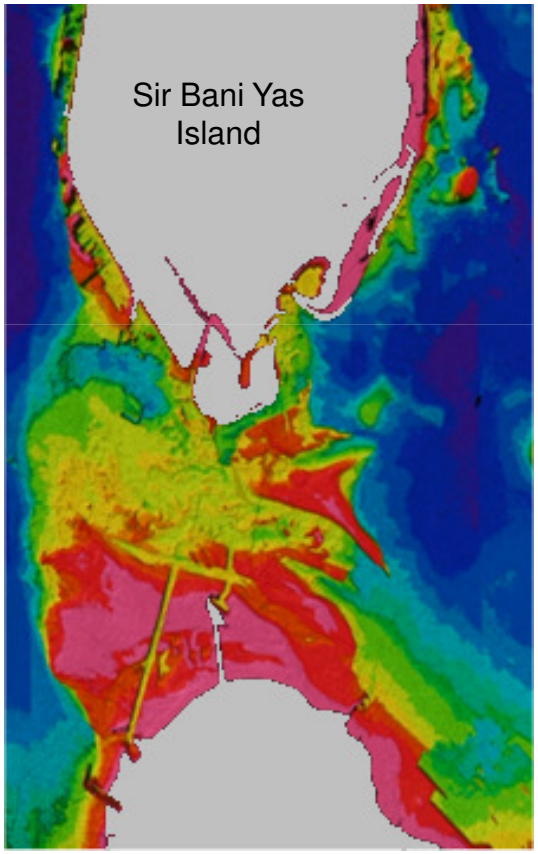


SDB Uncertainty Estimation

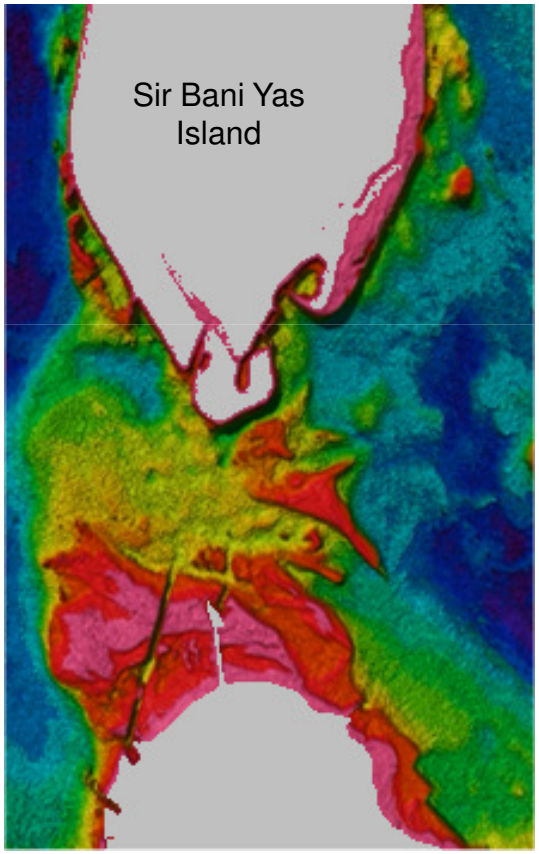


What's the value of Satellite derived Bathymetry?
Example: Sir Bani Yas island, Abu Dhabi

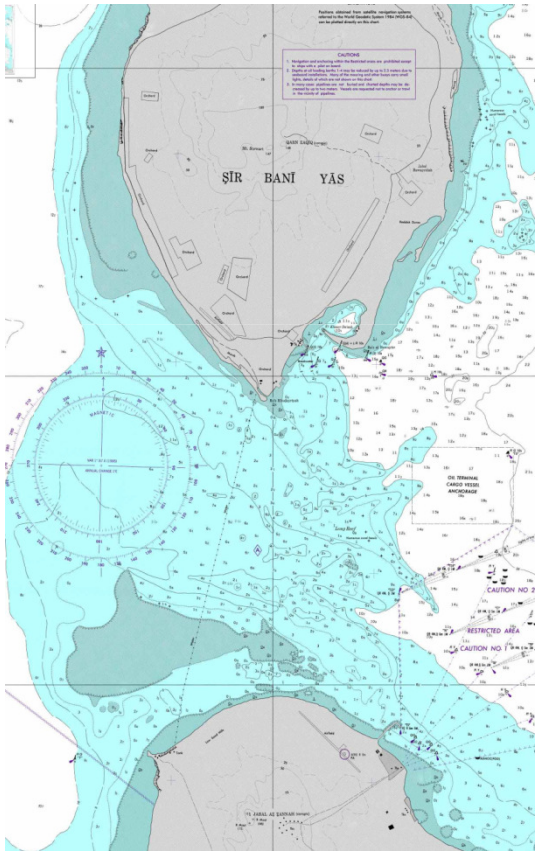
2m spatial resolution
Satellite Derived Bathymetry
Acquisition date: 3rd March 2013



15m spatial resolution
Satellite Derived Bathymetry
Acquisition date: 24th Jan 2014



Nautical chart
Scale: 1:35 000, Ed. 1980



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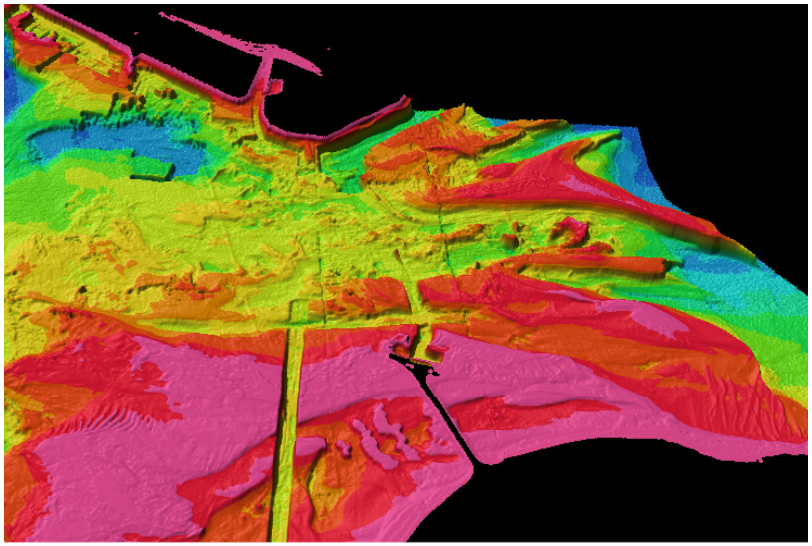
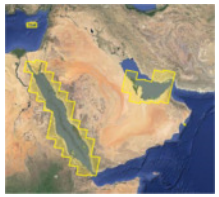
Satellite services for marine applications

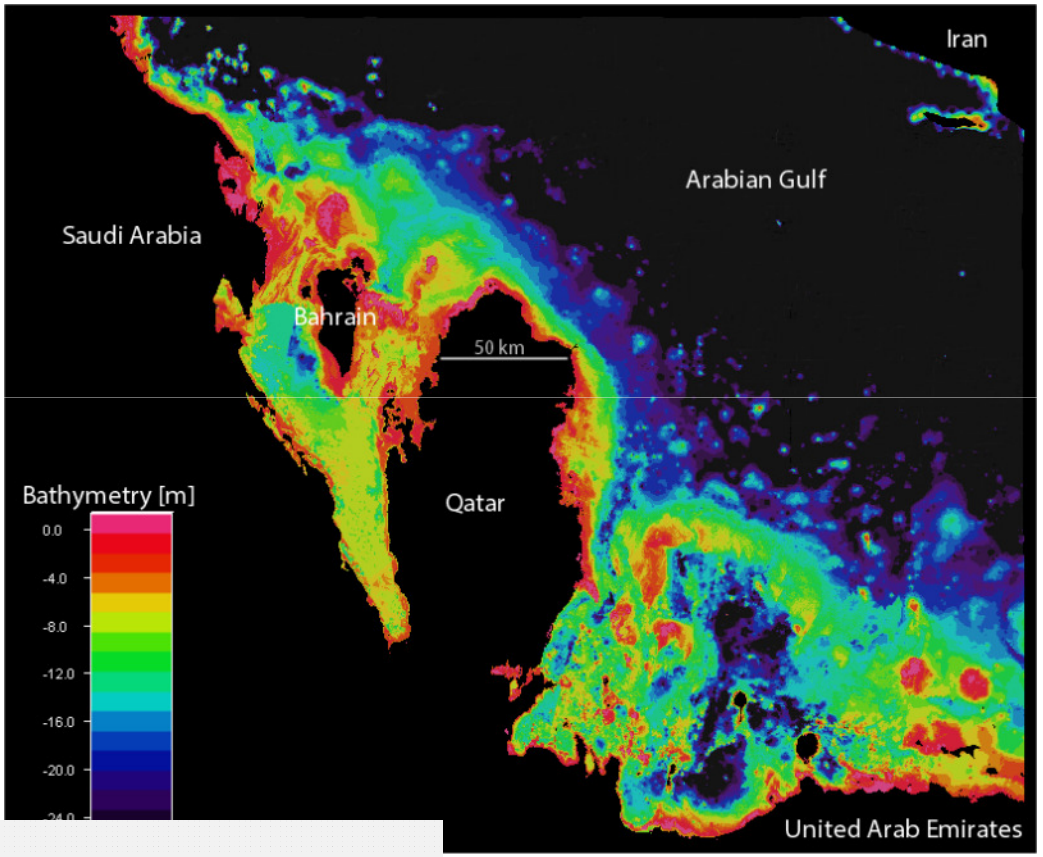
Bathymetry, Seafloor, Obstructions, Visibility, Water Quality

High resolution: 0.5 – 2m horizontal





International coverage: 15 – 30m res

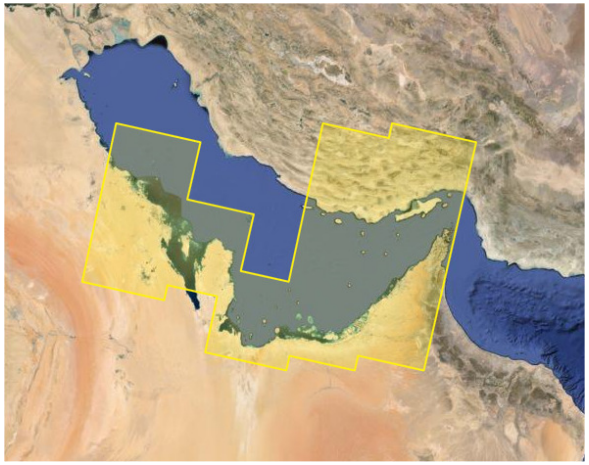


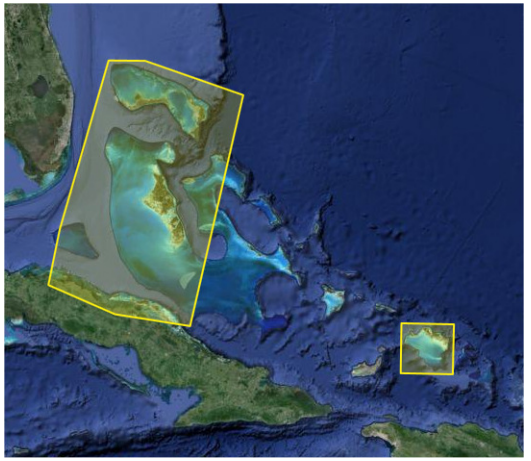
EOMAP worldwide monitoring services:

- **Multiple records per day for marine parameters such as in-water-visibility**
- **Various bathymetry products for marine operations support**

Fast map generation for worldwide locations

Off-the-shelf BATHYMETRY





Off-the shelf catalogue

Resolutions: 30m, 5m, 2m

http://www.eomap.com/off-the-shelf-data

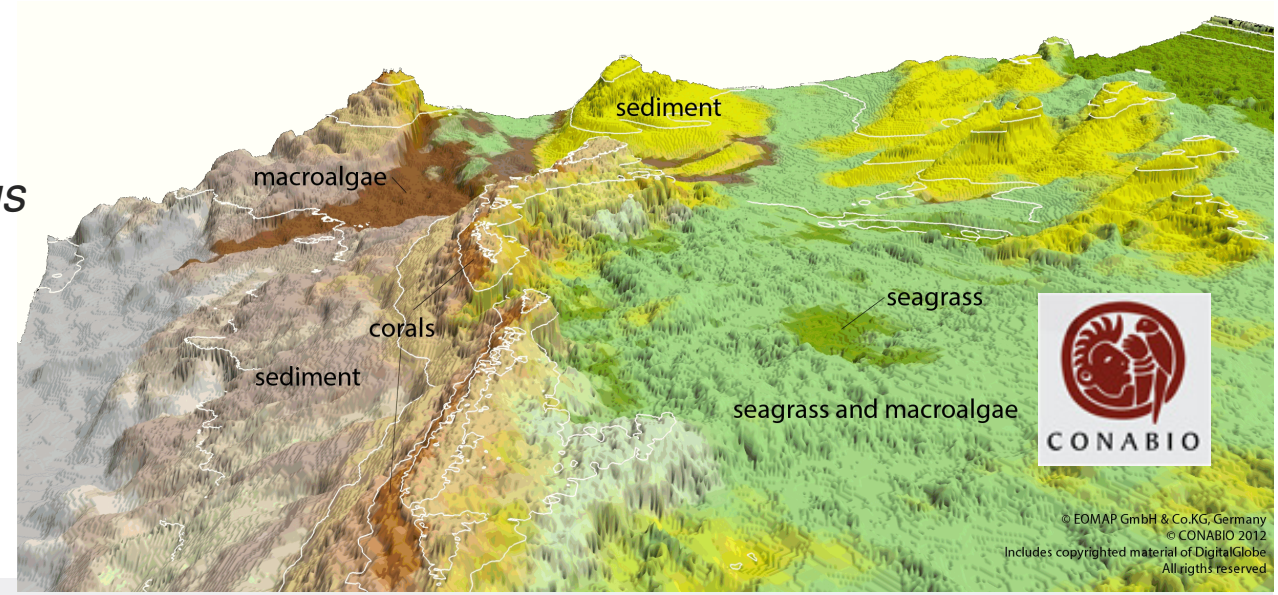
Coastal habitat mapping – submerged/land

Supporting ILF for pipeline routing in Italy/Adria

Environmental baseline monitoring of seafloor habitats for various OG clients and governmental bodies in Australia, Mexico, Abu Dhabi

- Satellite based survey of seagrass habitats
- eoBenthic 2m res (IKONOS, HYMAP, …)
- Quick delivery

- *Significant cost savings*
- *HSSE risks mitigated*
- *Project schedule efficiently supported*



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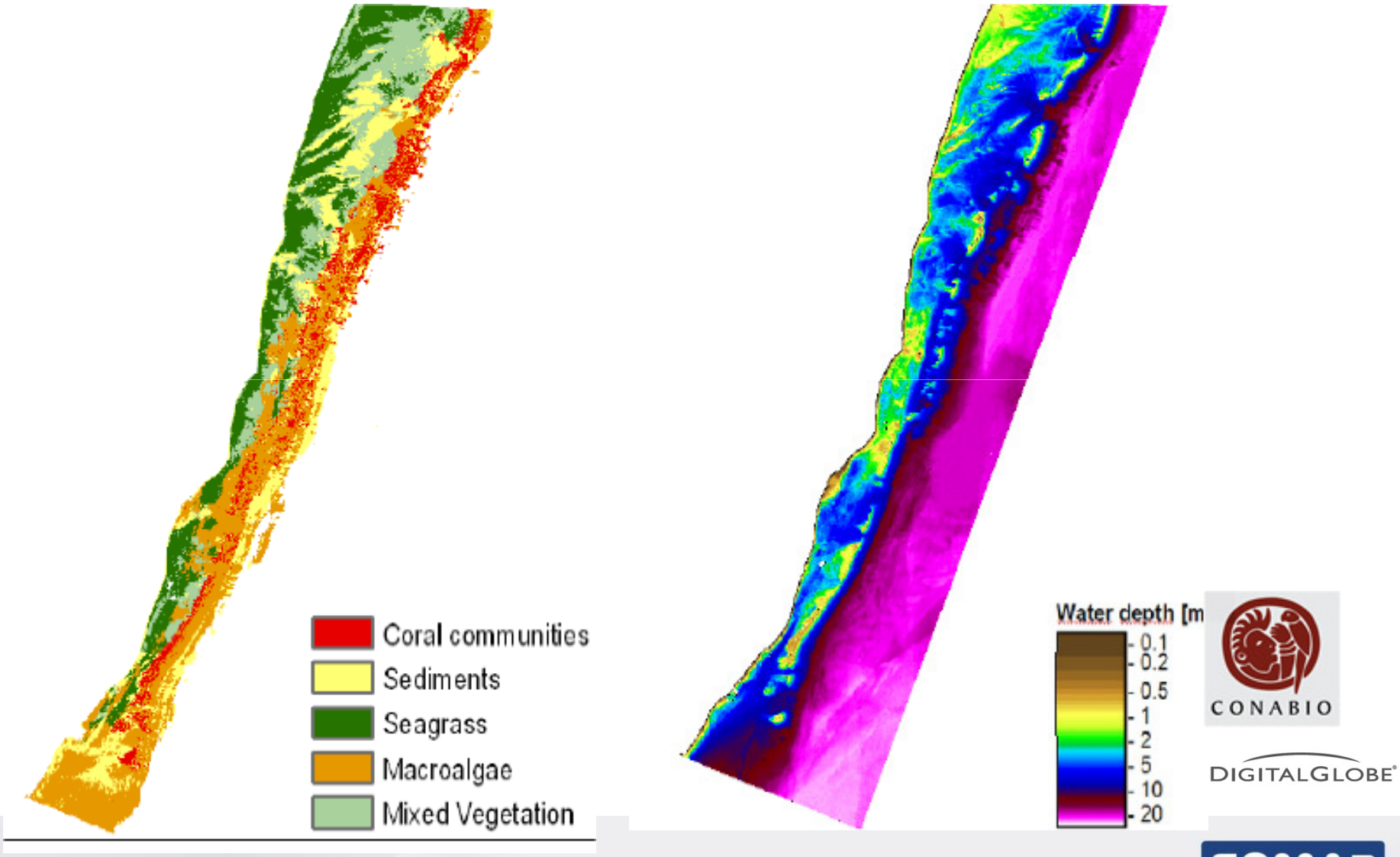
Sea floor classification Mexican Maya Coast

World View 2



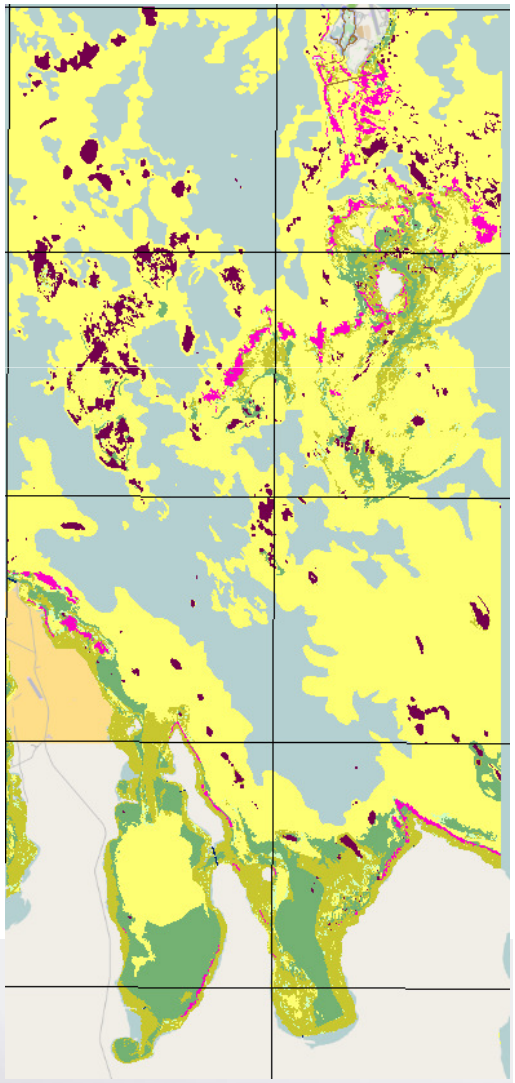
Cerdeira-Estrada et al. 2012

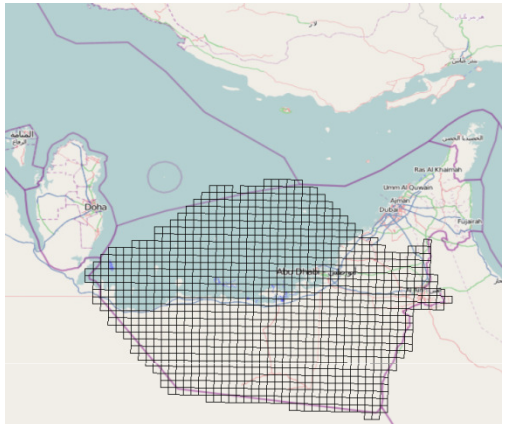
EOMAP

Abu Dhabi environmental baseline.

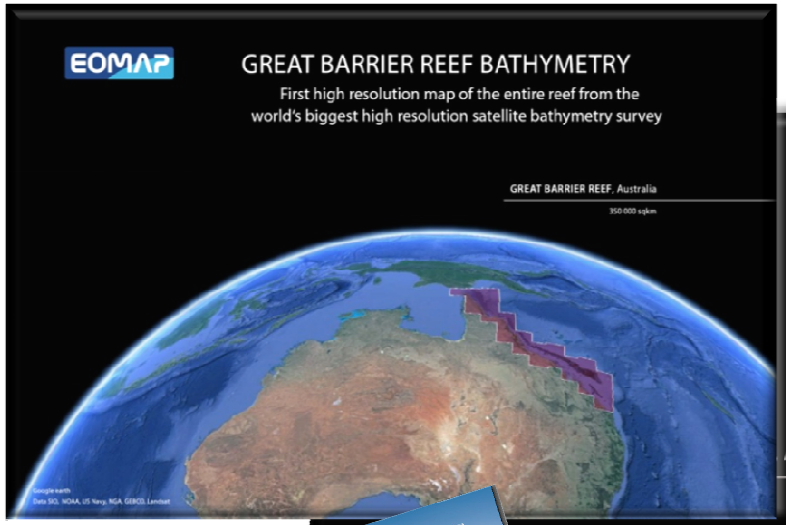
Bathymetry

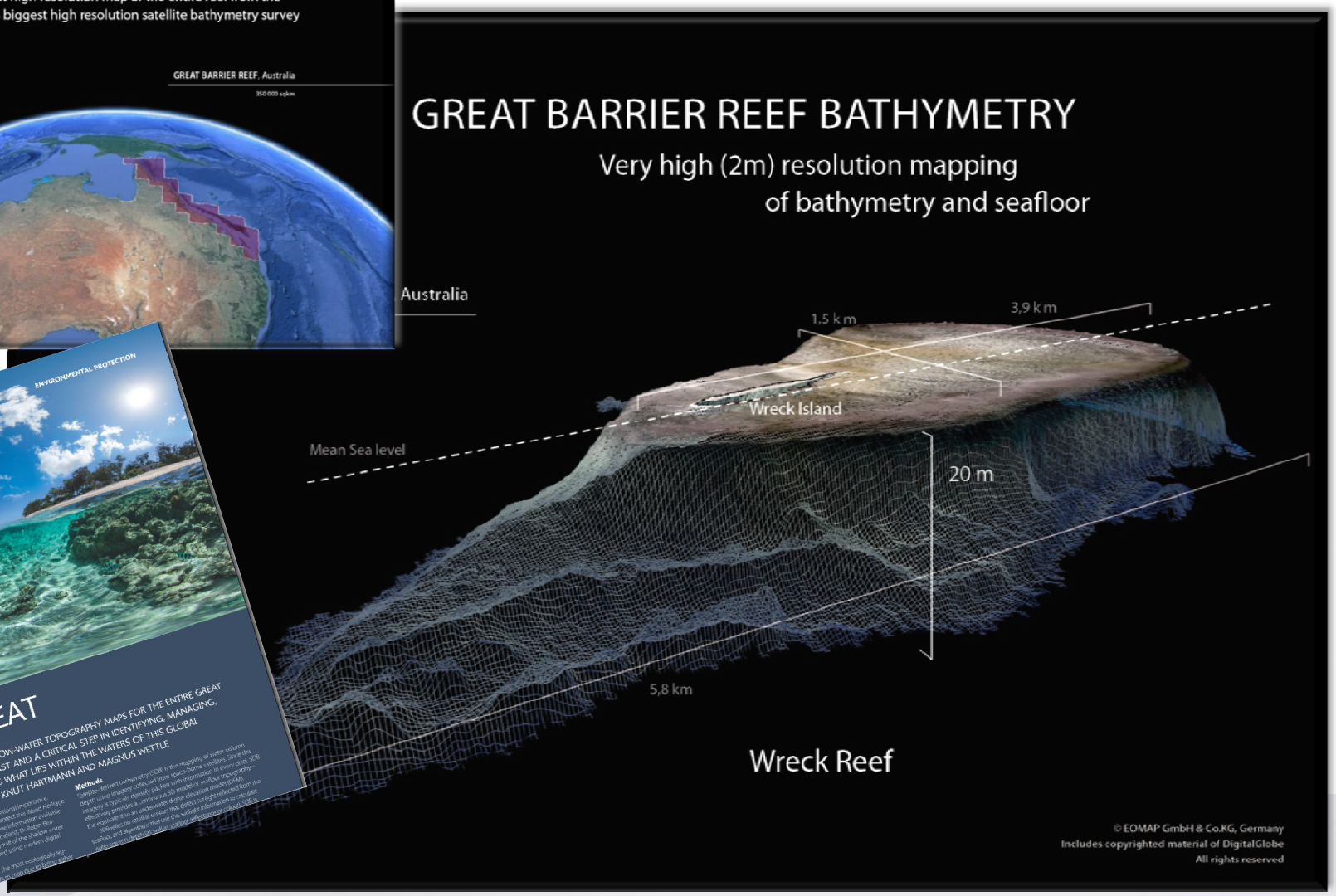
Seafloor habitat





Great Barrier Reef: First high resolution map of the entire reef





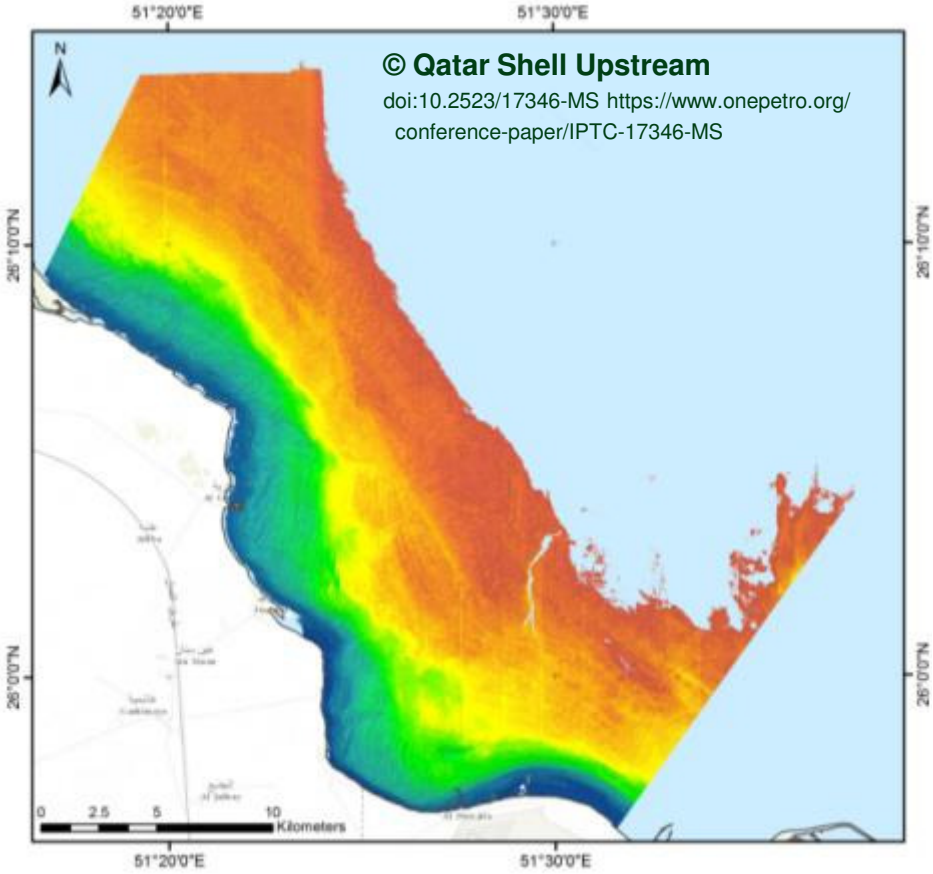
Use cases: Bathymetry for coastal planning / Shell

From: IPTC conference 2014 Shell/Siermann, OGEOzine article Q1 2014:

'Supporting Qatar Shell with the execution of onshore and offshore seismic programs'

- Satellite based bathymetry survey
- eoBathy 4m res (WV-2)
- 740 sqkm delivered rapidly
- 40cm accuracy

- *Significant cost savings > 1Mill $*
- *HSSE risks mitigated*
- *Project schedule efficiently supported*
- *Key technology to aid the planning and preparation of seismic surveys.*



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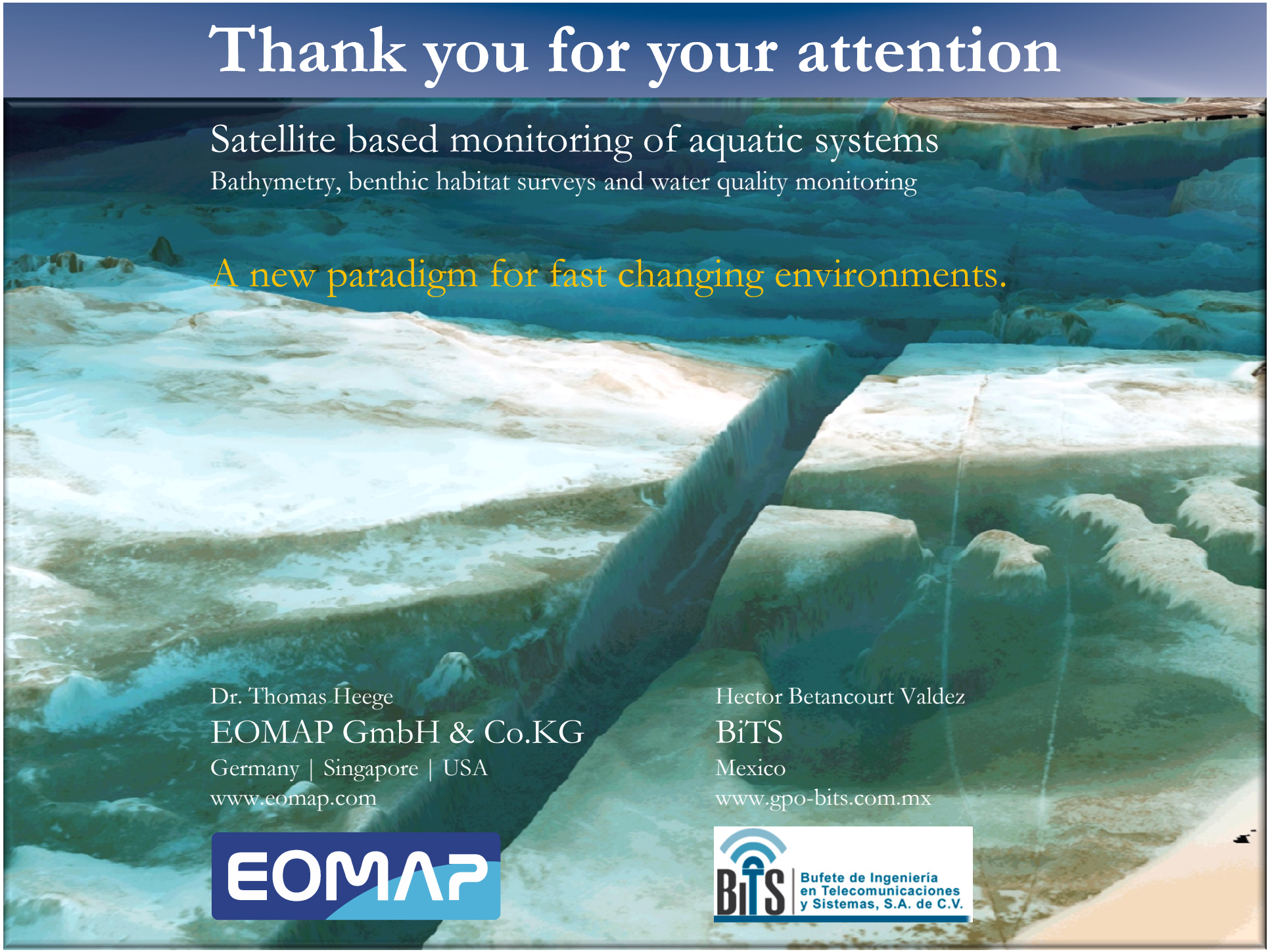
Thank you for your attention



Satellite based monitoring of aquatic systems

Bathymetry, benthic habitat surveys and water quality monitoring

A new paradigm for fast changing environments.

Dr. Thomas Heege

EOMAP GmbH & Co.KG

Germany | Singapore | USA

www.eomap.com

Hector Betancourt Valdez

BiTS

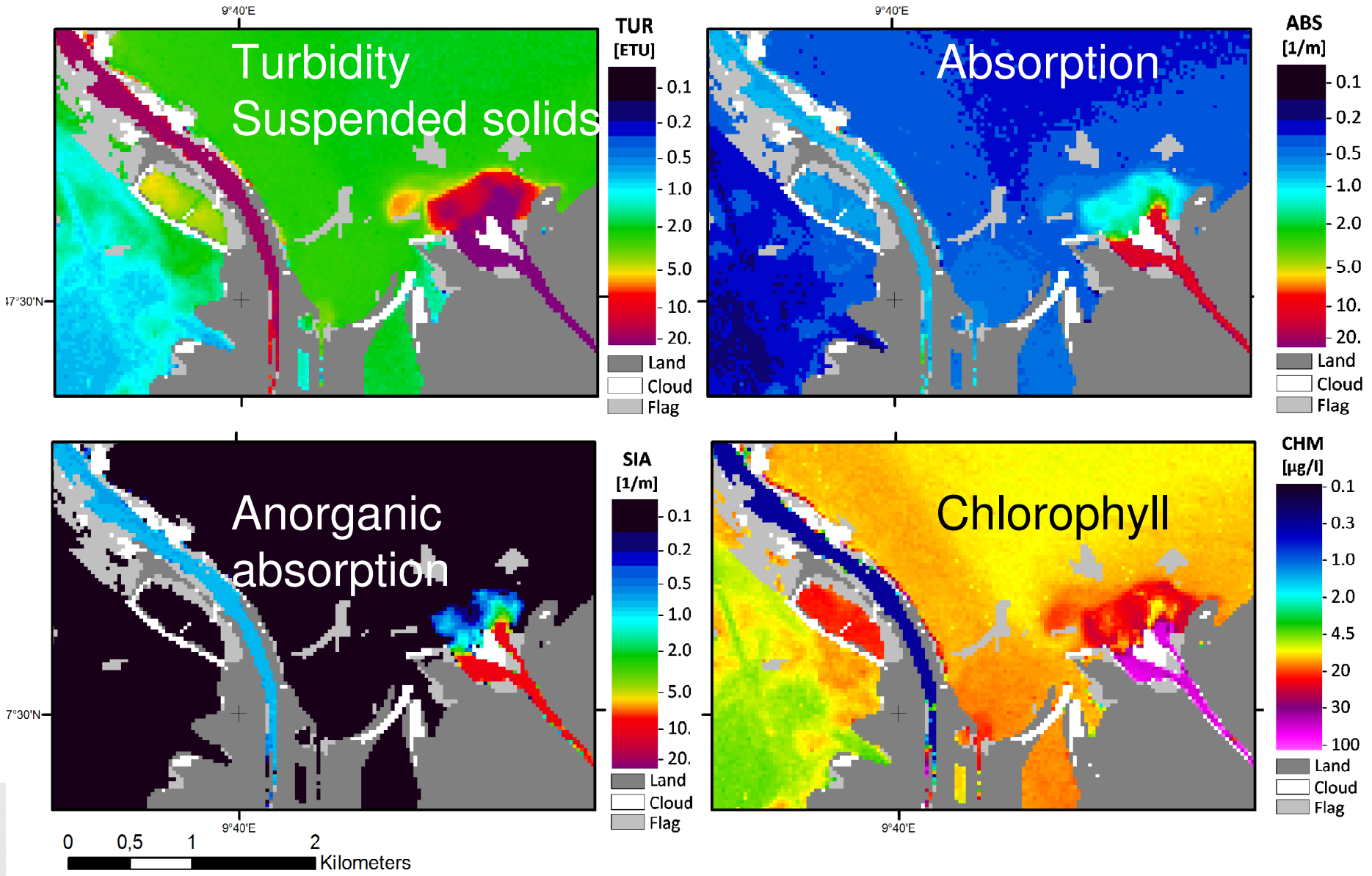
Mexico

www.gpo-bits.com.mx

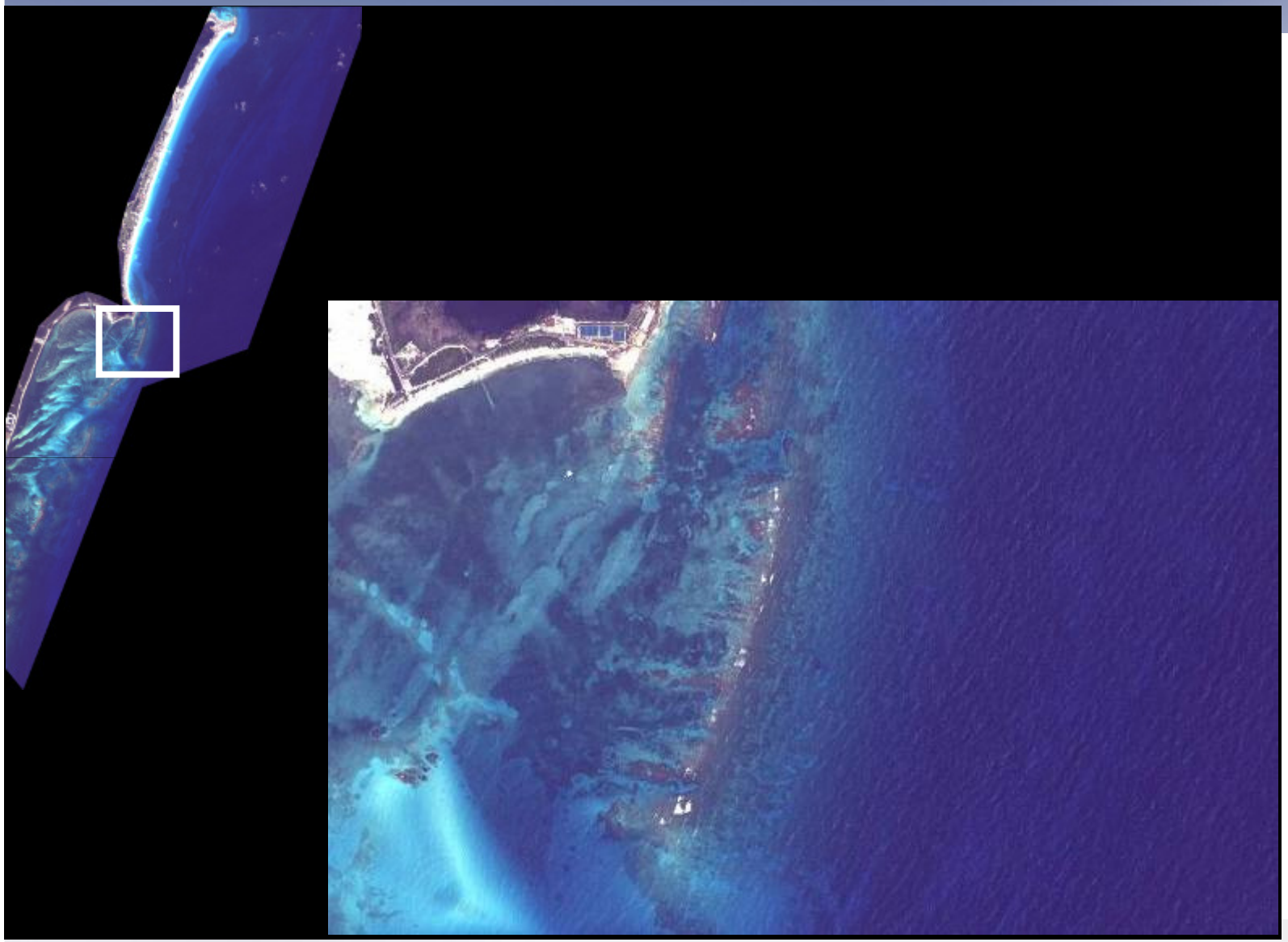
Bufete de Ingeniería en Telecomunicaciones y Sistemas, S.A. de C.V.

Water constituent components in different water types

Lake Constance and river inflows. Landsat 8, 4. August 2014



Satellite raw data - Quintana Roo coast, Mexico



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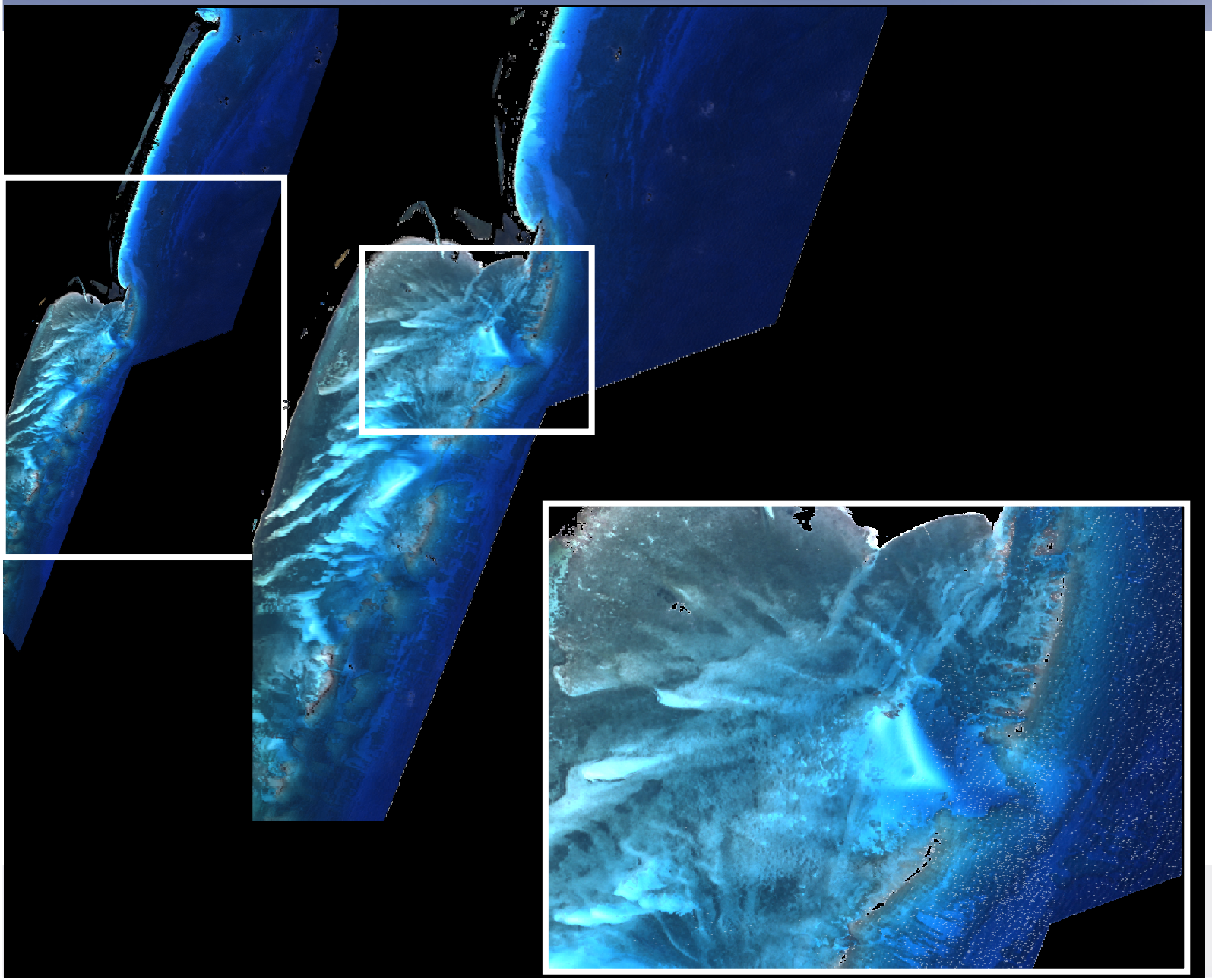
Subsurface reflectance. Channels 4, 3, 2 (RGB)

World View 2. MIP data processing. Product after atmospheric and sea surface correction



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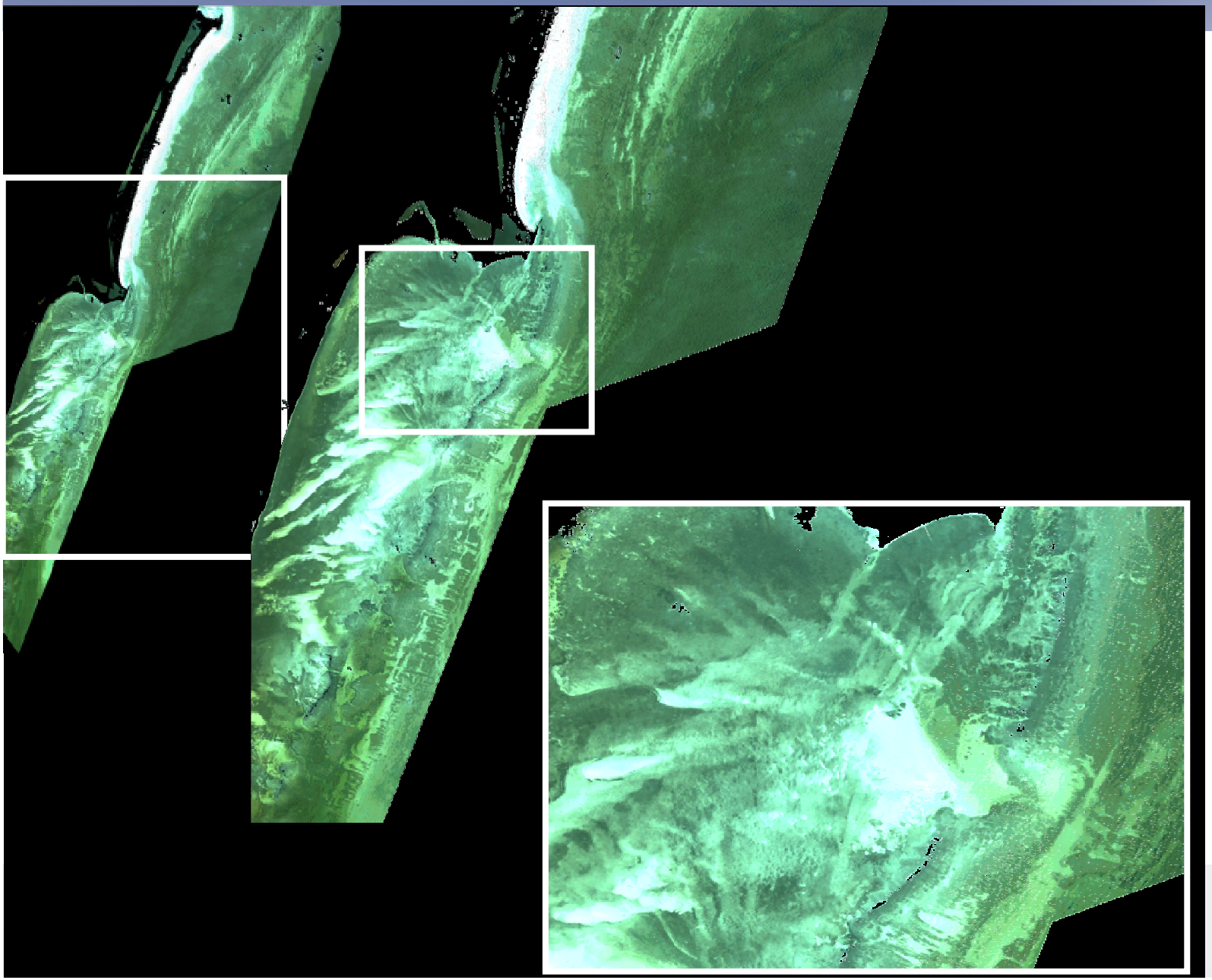
Sea floor albedo. Channels 3, 2, 1 (RGB)

World View 2. MIP data processing. Processing: water column correction & depth retrieval



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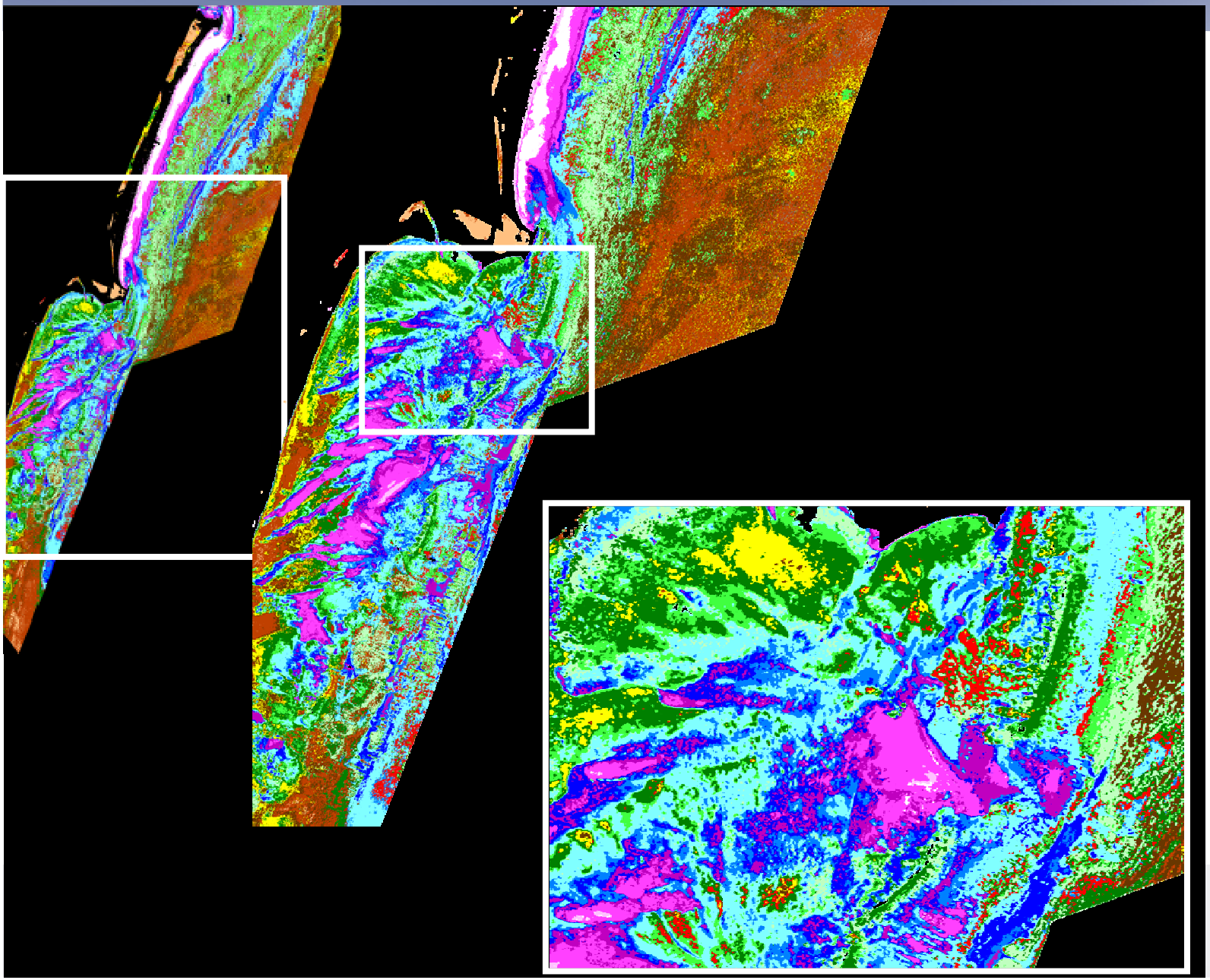
Seafloor Classification - Quintana Roo coast, Mexico

World View 2. MIP data processing. Spectral classes (Processing: clustering, classification)



Spectral Classes

- Class 1
- Class 2
- Class 3
- Class 4
- Class 5
- Class 6
- Class 7
- Class 8
- Class 9
- Class 10
- Class 11
- Class 12
- Class 13
- Class 14
- Class 15
- Class 16

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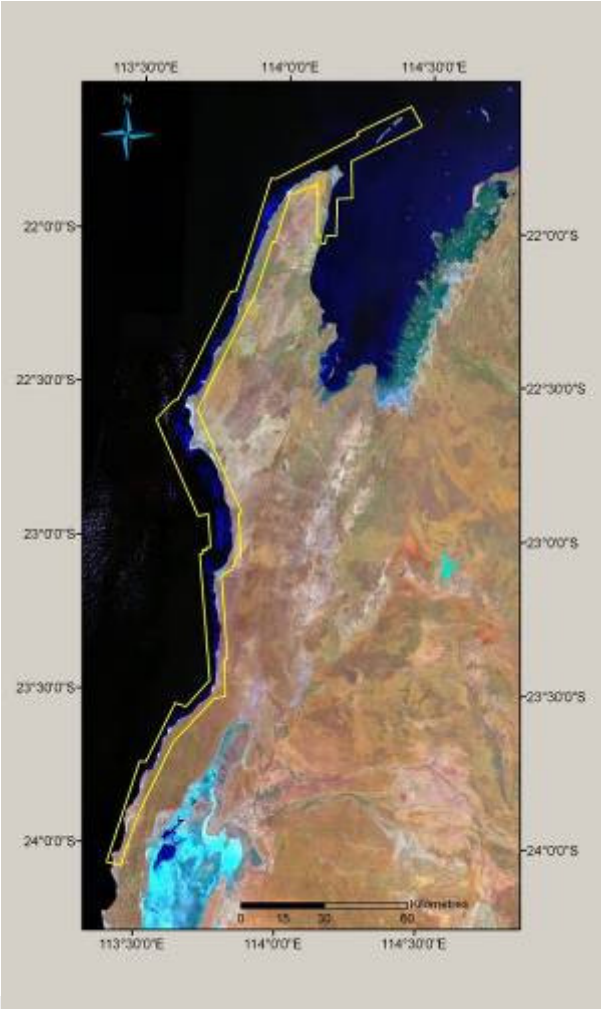
Ningaloo Marine Park:
Habitat and biodiversity mapping

Survey of ~3400km^2 of reef and shallow lagoon (to ~20m) using hyperspectral instrument (HyMap)



Focus is on:

- Operational method, suitable as a long term monitoring tool for large areas
- What is spectrally measurable and ecologically relevant
- Cover forming benthic components, e.g. corals, macroalgae, sand

CSIRO

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

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