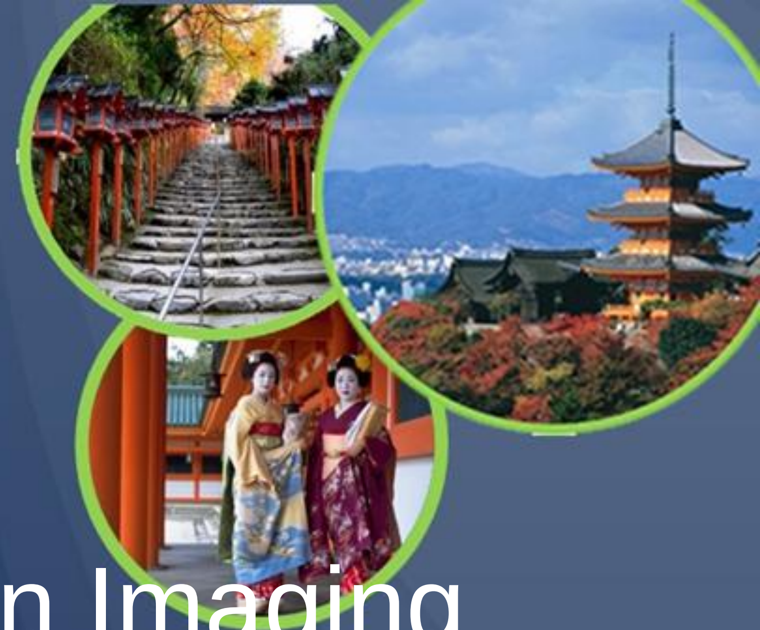
Committee on Earth Observation Satellites



Feasibility Study for an Imaging Spectrometer for Water Quality.

Ad-Hoc Working Group CEOS

Presented by A.G. Dekker

IGWCO/AquaWatch joint meeting

Koblenz, Germany, 8th June 2016

Scope of the Feasibility Study Imaging Spectrometer for Aquatic ecosystems

- The Committee on Earth Observation Satellites (CEOS) response to the Group on Earth Observations System of Systems (GEOSS) Water Strategy developed under the auspices of the Water Strategy Implementation Study Team (WSIST) was endorsed by CEOS at the 2015 Plenary.
- CSIRO has taken the lead on Water Strategy recommendation C.10 : A feasibility assessment to determine the benefits and technological difficulties of designing a hyperspectral satellite mission focused on water quality measurements……expanded to:

1) undertaking a high-level feasibility assessment of the benefits and technological difficulties of designing a hyperspectral satellite mission focused on inland, estuarine, deltaic and near coastal waters - as well as mapping macrophytes, macro-algae, seagrasses and coral reefs - at significantly higher spatial resolution than 250m and ….

Scope of the Feasibility Study Imaging Spectrometer for Aquatic ecosystems

- CEOS notes that new information has emerged from the GEO Water Quality community in recent months suggesting that alternative approaches, involving **augmenting designs of spaceborne sensors for terrestrial and ocean colour applications to allow improved inland, near coastal waters and benthic applications**, could offer an alternative pathway to addressing the same underlying science questions. Accordingly, CEOS will also analyse the benefits and technological difficulties of this option

Scope of the Feasibility Study
Imaging Spectrometer for Aquatic ecosystems

2) Also to examine threshold and baseline observation requirements for sensors suitable for water quality applications. This information will inform CEOS Agencies when considering the potential to adapt their sensors to add this application area to their mission designs.

3) That the GEO Water community define inland and near-coastal and benthic habitat essential variables for water quality, including an assessment of relative priority, linked to defined economic, social and environmental benefits. This information would be of great value in informing investment decisions.

CEOS Team
"Feasibility Study imaging Spectrometer":

Lead:	CSIRO	Arnold Dekker
Coordinator:	DLR	Nicole Pinnel

Members: (in brackets organisations that support)

CNES	Marie-Jose Lefevre & Xavier Briottet
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(EC)	Astrid-Christine Koch & Catharina Bamps
NASA	Kevin Turpie
(USGS)	Thomas Cecere
(NSO)	Mark Loos & Joost Carpaaij: experts pending…..

CEOS Report Contents "Feasibility Study imaging Spectrometer":

- **Table of Contents:** Feasibility Study for an Imaging Spectrometer for Water Quality vs 1.0 25th May 2016 by AD.
- Option 1(adapted from GEO CAPE by AD)
- 1. Background
- *1.1. Overview*
- *1.2. Strategic Direction for Studying inland Waters, Coastal Waters, Benthos and Shallow Water bathymetry*
- *1.3 Benefits to Society / Societal Impacts*
- *1.4. Current situation: sensors used (designed for either land or ocean observations)*
- *1.5. What we propose to do*

CEOS Report Contents
"Feasibility Study imaging Spectrometer":

2. Science Traceability Matrix

- *2.1. Science Questions*
- *2.2. Approach*
- *2.3. Measurement and Instrument Requirements (making use of bio-optical or RTF based forward models)*
- *2.3.1. Sensitivity requirements*
- *2.3.2. Temporal requirements*
- *2.3.3. Spatial resolution requirements*
- *2.3.4. Scanning Time and Coverage*
- *2.3.5. Spectral range and resolution requirements*
- *2.3.6 Atmospheric Corrections*
- *2.3.6.1. Aerosols*
- *2.3.7. Calibration and Validation*
- *2.4. Platform Requirements*
- *2.5. Ancillary Data Requirements*

CEOS Report Contents
"Feasibility Study imaging Spectrometer":

3. Application Science Traceability Matrix
- *3.1 Inland waters & wetlands(?)*
- *3.2 Estuarine, deltaic and lagoon waters*
- *3.3 Seagrasses and Coral reefs*
- *3.4 Shallow water bathymetry*

4. Instrument and Mission Design
- *4.1. LEO imaging spectrometer*
- *4.2. GEOstationary imaging spectrometer*
- *4.3. Adaptations to near future planned land focused imagers to make them more suitable for aquatic ecosystem assessments*
- *4.4. Adaptations to near future planned ocean focused imagers to make them more suitable for aquatic ecosystem assessments*
- *4.4. Augmentation*
- *4.3. Other Instrument Concepts*

CEOS Report Contents
"Feasibility Study imaging Spectrometer":

5. Aquatic Ecosystem Earth Observation Enabling Activities
- *5.2. Studies for Algorithm Development*
- *5.2.1. Atmospheric correction*
- *5.2.2. Air-water interface correction*
- *5.2.3. In water algorithms*
- *5.2.3.1. optically deep waters*
- *5.2.3.2. Optically shallow waters*
- *5.3. In situ Instruments*
- *5.3.1. SpectroRadiometers (AOP sensors) above and underwater*
- *5.3.2. Inherent Optical Properties sensors*
- *5.3.3. Biogeochemical sensors*
- *5.4. Sources of Uncertainties*
- *5.5. Field Campaigns and Priorities for Calibration/Validation Research*
- *5.6. Interdisciplinary Science Studies*

6. References

Current Status:

April 2016: Team created

May 2016: Contents established

June 2016: Self nomination process chapter leads and co-authors

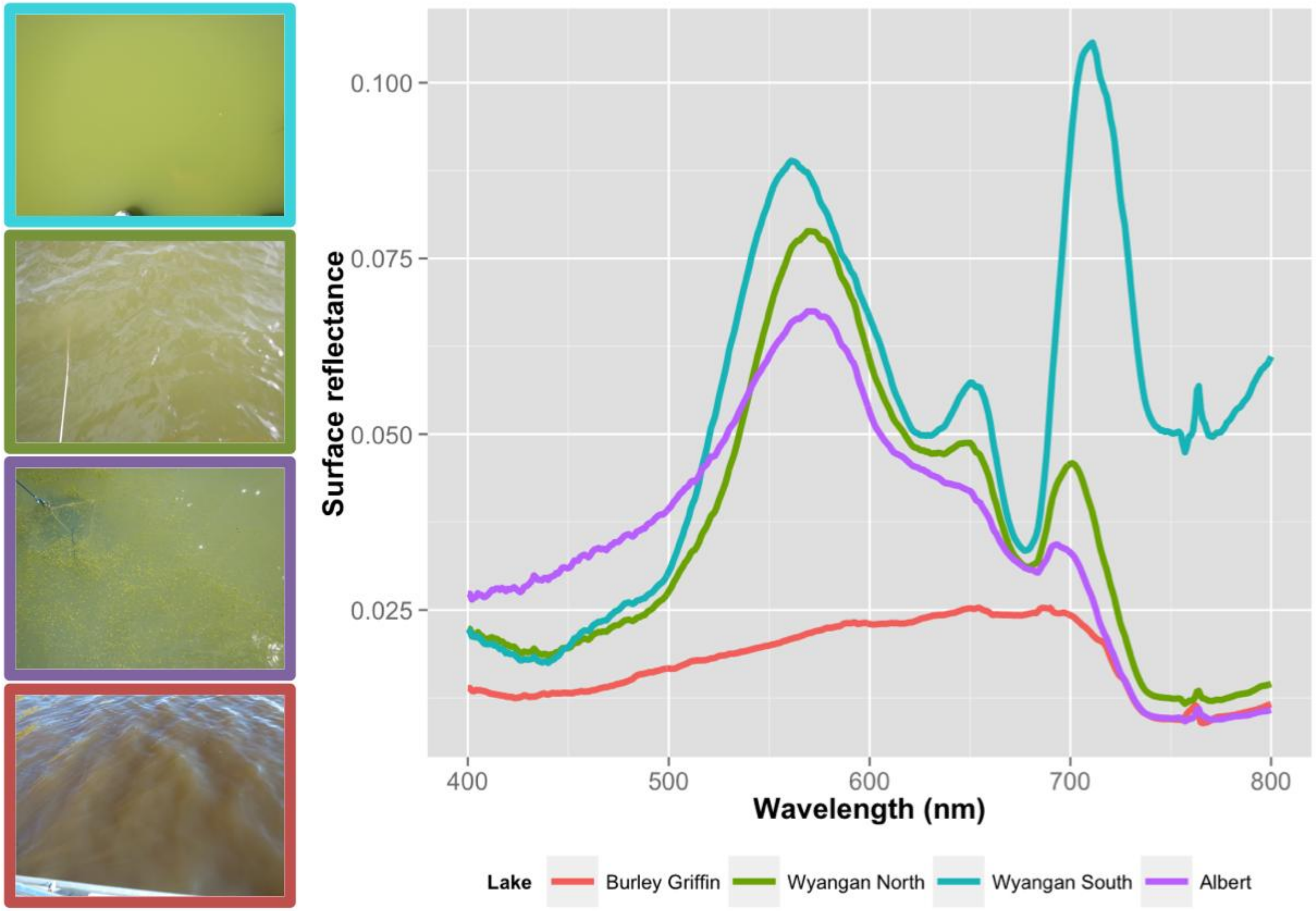
Timeline:

By September 2016 a first draft for presentation at CEOS Strategic Implementation Team (CEOS-SIT) Oxford UK

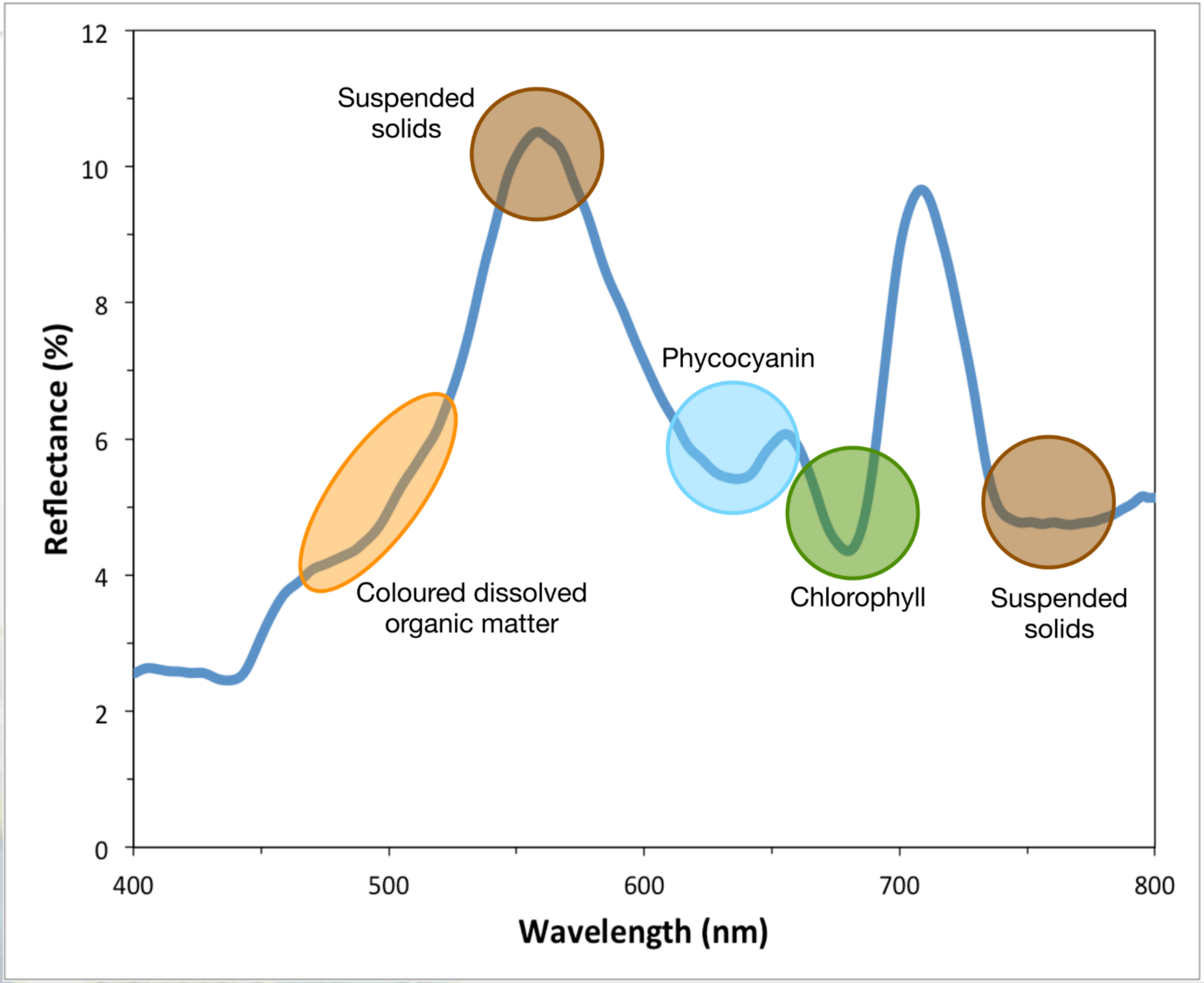
By November 2016 at CEOS Plenary a full draft Brisbane, Australia

By January 2017 final draft.

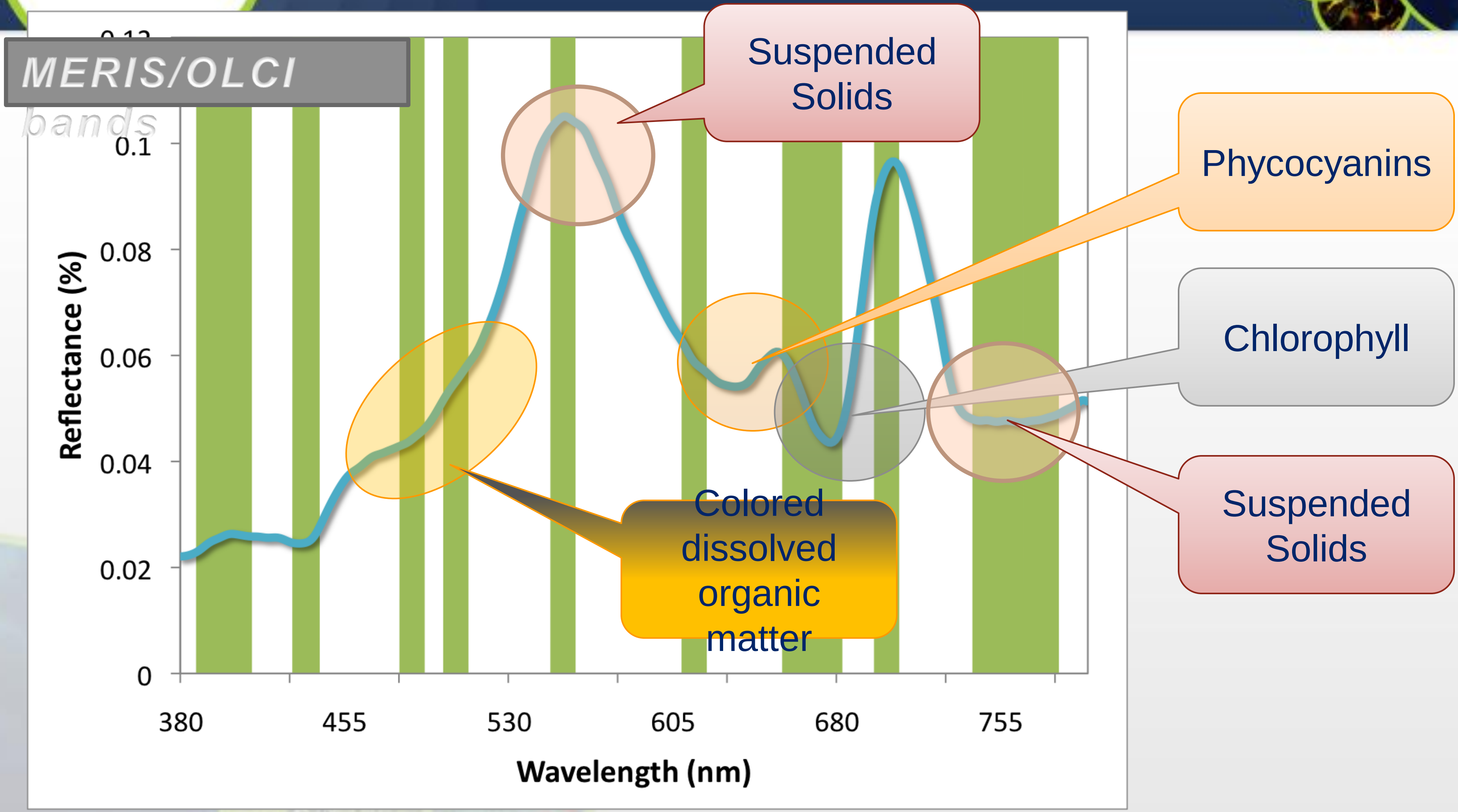
Driven by colour



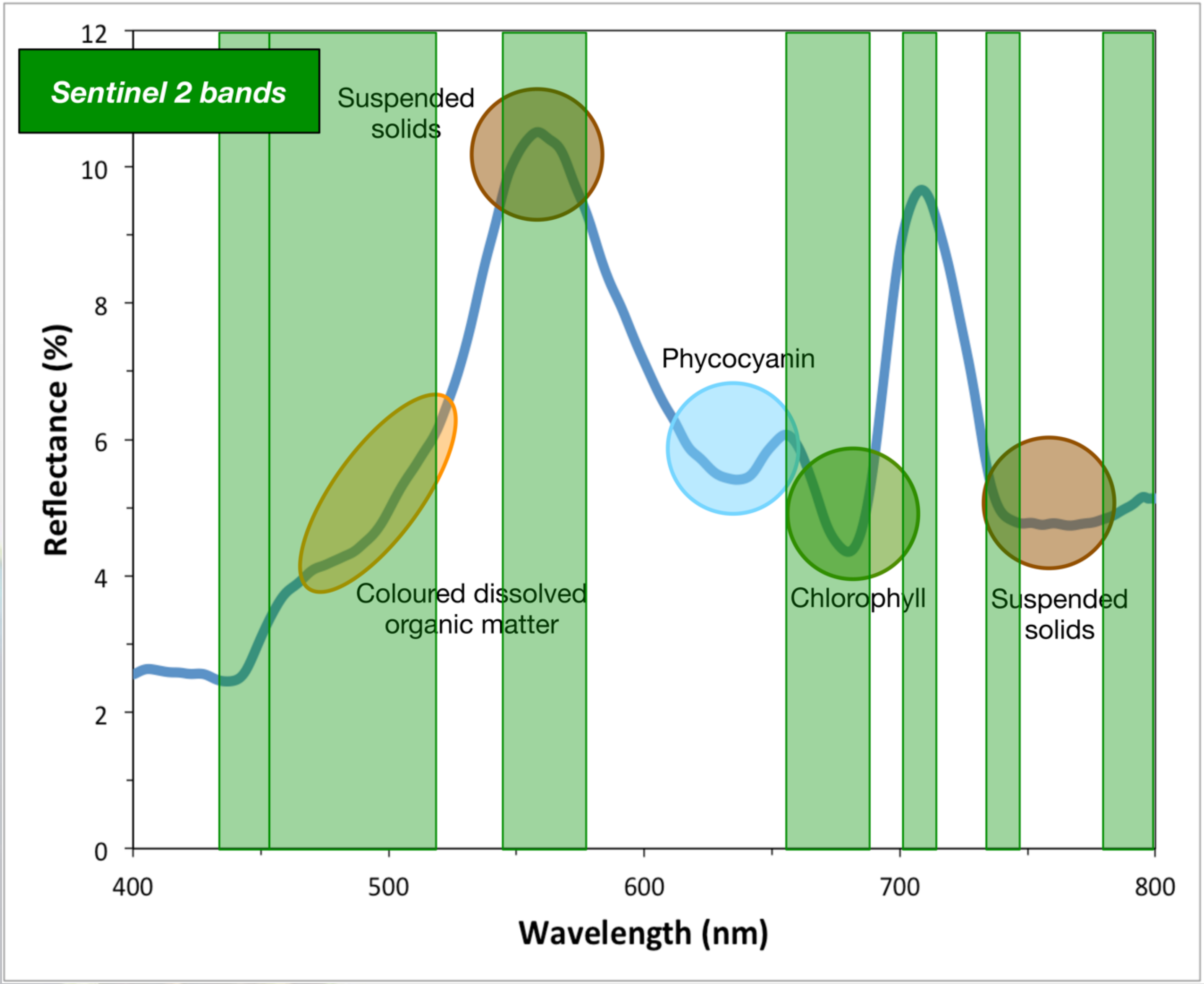
Information in spectral reflectance



Sentinel-3 @ 300 m resolution



Sentinel-2 @ 10 m spatial resolution could have been very suitable for inland waters with 2 or 3 additional spectral bands – opportunity missed!!



CEOS Report
"Feasibility Study imaging Spectrometer":

If also to be made suitable for:

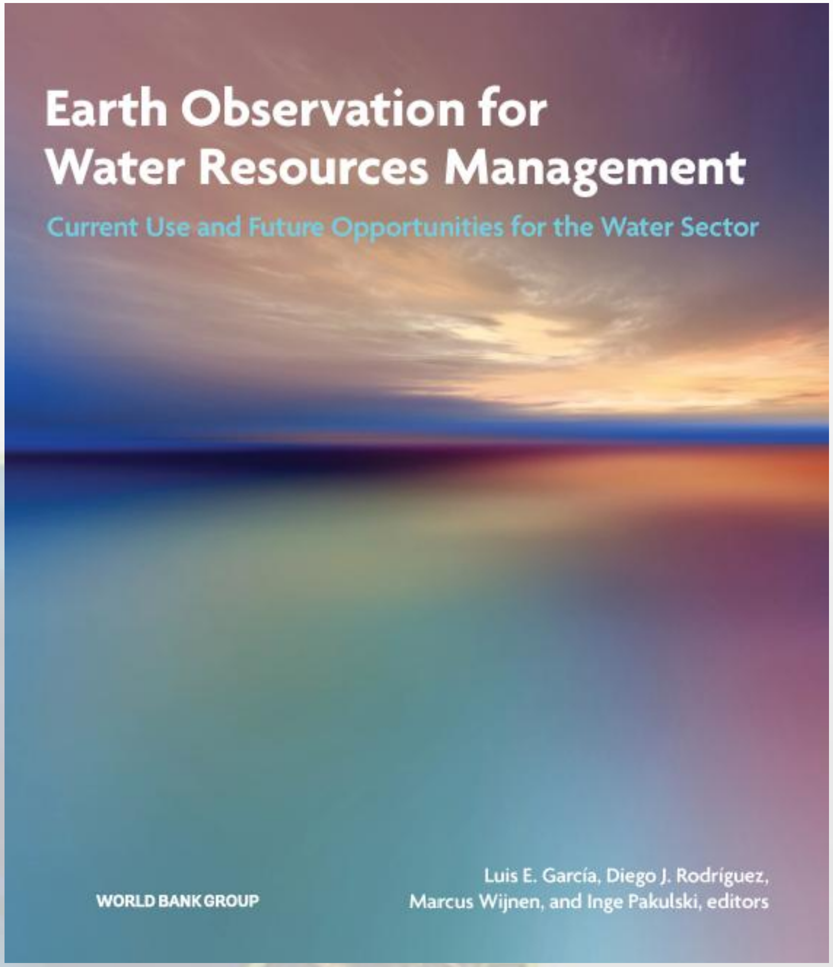
- Coral Reefs
- Seagrasses
- Macro-Algae
- Macrophytes (freshwater)
- Shallow Water Bathymetry

…..then imaging spectrometry makes most sense,

Earth Observation for Water Resources Management : Current Use and Future Opportunities for the Water Sector

- https://openknowledge.worldbank.org/handle/10986/22952

Page 120-132 Inland waters sensors

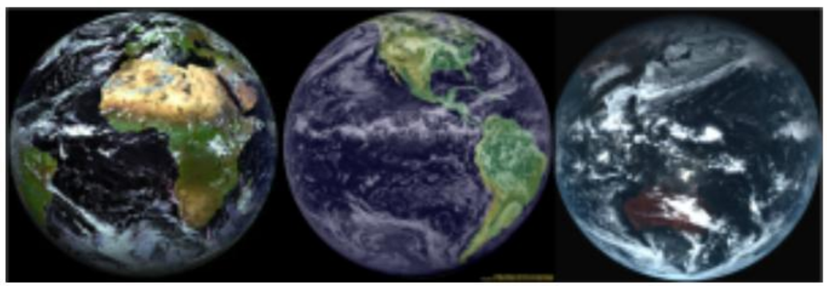


❶: highly suitable, ❷: suitable, ❸: potential, ❹: not suitable. Note 1: products in development are: coarse particle size distributions and phytoplankton functional types. Note 2: integrated products could be: eutrophication index; water quality index, algal bloom index; carbon contents and flux; contaminant estimation. CHL=Chlorophyll; CYP=cyanobacterial pigments such as cyanophycocyanin and cyanophycoerythrin; TSM=total suspended matter; CDOM =coloured dissolved organic matter; Kd= vertical attenuation of light coefficient; Turb= Turbidity; SD=Secchi Disk transparency.

❶: highly suitable, ❷: suitable, ❸: potential

Non-meteorological Applications

The Ad Hoc Team on Non-Meteorological Applications for Next Generation Geostationary Satellites



The 2016 CEOS Chair's Ad Hoc Team on Non-meteorological Applications for Next Generation Geostationary Satellites (NMA) investigates the combined potential of advanced meteorological geostationary (GEO) and Low Earth Orbit (LEO) satellites to deliver continuous monitoring of the high-temporal dynamics of the land, oceans, and atmosphere. This data will enhance and complement the LEO-based applications that have been the workhorse for monitoring of the broader environment.

The CEOS Ad Hoc Team on NMA was initiated at the 29th CEOS Plenary meeting in 2016 and tasked with developing a report that provides comprehensive and pragmatic guidance to CEOS on the new opportunities arising from next generation geostationary satellites and GEO-LEO synergies.

Links and Key Documents

- Presentation on 2016 CEOS Chair Initiatives (29th CEOS Plenary Item 38; November, 2015)
- The Ad Hoc Team on NMA Proposal (version 2.0)

Target Products/Applications

- Water-leaving Radiance
- Total Suspended Matter and IOPs
- Chlorophyll-a
- Diffuse Attenuation Coefficient for Downward Irradiance
- Particulate Backscattering Coefficient (510nm)
- Photosynthetically Available Radiation (PAR)
- Flood Plume Mapping
- Algal Bloom Detection
- True-colour Imagery
- Sea Surface Temperature

Water-leaving Radiance

– Remote sensing reflectance

Dependencies: Validation data, cloud masking algorithm, glint masking algorithm, glint correction algorithm, surface pressure map, ozone map

Potential end users: GBRMPA BoM CSIRO JCU JFA JCG

Algorithm Type	Developing Institution	Estimated Resources	Currently Funded
Artificial Neural Network	CSIRO (4), JCU (5)	0.3 FTE	Yes
Iterative coupled atmosphere-ocean inversion model	CU (1)	TBD	No
Gordon and Wang algorithm	JAXA/EORC (3)	0.1 FTE	Yes

Pr

(1)
(2)
(3)
(4)
(5)