Harmful Algal Blooms and Climate Change: International Partnerships

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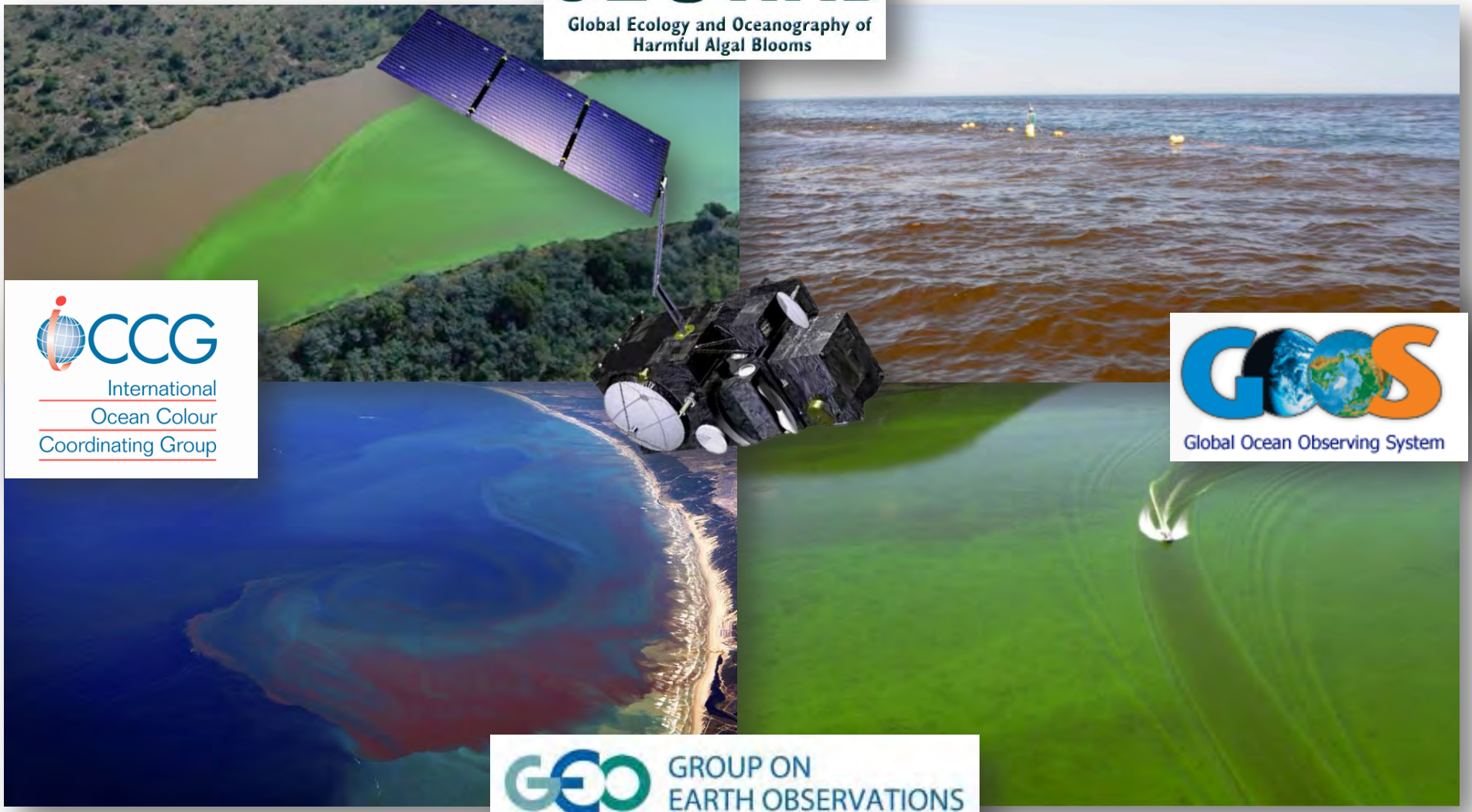
GEOHAB
Global Ecology and Oceanography of Harmful Algal Blooms



IOCCG
International Ocean Colour Coordinating Group

GOOS
Global Ocean Observing System

GEO GROUP ON EARTH OBSERVATIONS

International Partnerships: Outline & Conceptual Thinking

A brief review is presented of the partnerships between the HAB research community and international programmes of relevance to long term HAB and ecosystem observations. A key focus of such partnerships is to examine how they can be exploited to best advantage of the entire community….

These programmes or groups are primarily observational – which includes not only satellite and *in situ* based observations, but modelling and predictive capabilities. There is increasing interest from space agencies and international programmes in the high economic value, dynamic and productive near-coastal domain.

The HAB community are well placed to exploit this interest through an explicit and quantitative statement of the value of their research to aquaculture and marine resource economic interests – through a *value of information* type approach.

The community also has extensive, leading-edge skills in phytoplankton species/group-specific and sub-mesoscale observation and modelling, areas of increasing focus to operational marine service providers in the near coastal zone, and to the increasing interest in phytoplankton functional type observations and modelling from space agencies. Exploiting these skills beyond the HAB science domain would also be of significant wider community interest.

International Partnerships: Outline & Conceptual Thinking

Three partnerships are focused on:

- The **International Ocean Colour Coordinating Group (IOCCG)**, representing a path to highest value space-based HAB and phytoplankton dynamics observations both in terms of optimal exploitation of existing and upcoming sensors and multi-sensor constellations, and long term advocacy to space agencies to yield most appropriate HAB related specifications for emerging missions/products.

- The **Group on Earth Observations (GEO)**, representing a path to larger global, regional and national communities, resources and political support around maturing observational and forecasting capabilities in both the marine and freshwater domains

- The **Global Ocean Observing System (GOOS)**, representing a path to larger communities and political support in both the global and regionally focused ocean observing community.

International Ocean Colour Coordinating Group

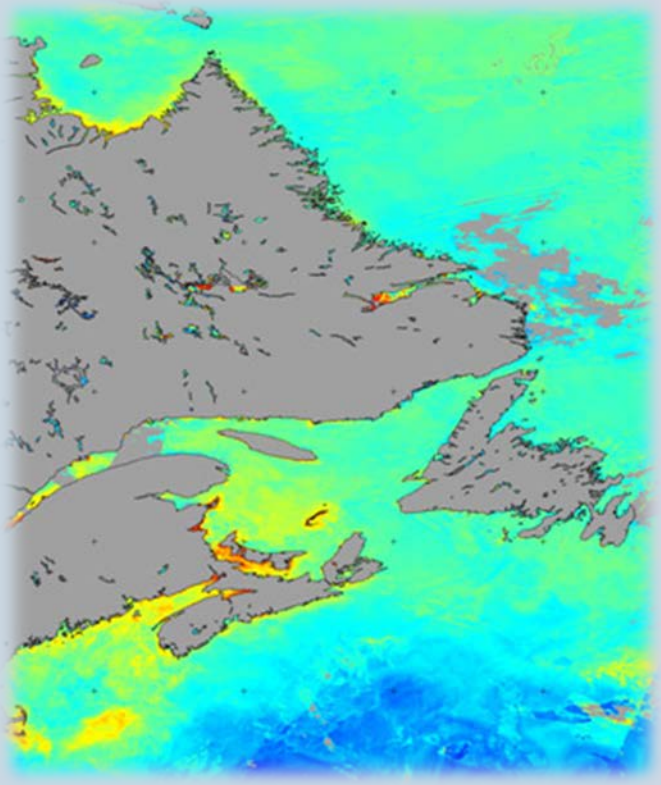
- Established in 1996 to promote the application of ocean-colour data at the world scale through coordination, liaison between providers and users, training, advocacy and provision of expert advice

- Project Office at the Bedford Institute of Oceanography, NS, Canada

- Committee consists of:

  space agency representatives who contribute financially and carry out the decisions endorsed by the group

  research scientists who address current research issues and make recommendations



ESA MERIS Chlorophyll, 3-9 Sept 2010 (image courtesy Cesar Fuentes-Yaco, DFO, Canada)

IOCCG Sponsors

- NASA (National Aeronautics and Space Administration)
- ESA (European Space Agency)
- JAXA (Japan Aerospace Exploration Agency)
- CNES (Centre National d'Etudes Spatiales, France)
- EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites
- CSA (Canadian Space Agency)
- CSIRO (Commonwealth Scientific & Industrial Research Organization, Australia)
- NOAA (National Oceanic and Atmospheric Administration)
- JRC (Joint Research Centre, EC)
- INPE (National Institute for Space Research, Brazil)
- ISRO (Indian Space Research Organisation)
- KIOST (Korea Institute of Ocean Science and Technology)
- DFO (Bedford Institute of Oceanography)
- Helmholtz-Zentrum Geesthacht (Germany)

Major HAB Mission objectives

IOCCG HAB Mandate

- To provide a common voice for the user community
- Liaise with space agencies
- Advanced training courses to foster expertise in using ocean-colour data
- Facilitate free and open access to ocean-colour data from all agencies
- Ensure continuity and quality of the ocean-colour data stream
- Advocate the importance of ocean-colour data to the global community (informative website, newsletters, brochures, IOCCG reports…)

International Ocean Colour Coordinating Group

International Ocean Colour Science Meetings

- Annual Committee Meetings
- Comprehensive Website
- Quarterly News Bulletins

Affiliated Program of SCOR

International Council for Science
Scientific Committee on Oceanic Research

Project Office

Capacity Building

- Advanced Summer Lecture Series (SLS)
- Introductory courses
- Over 500 students from 86 countries trained

Scientific Research Members

CCG

Space Agency Representatives

Scientific Working Groups

- IOCCG Report Series
- 15 IOCCG Reports plus Handbook

Liaison with CEOS

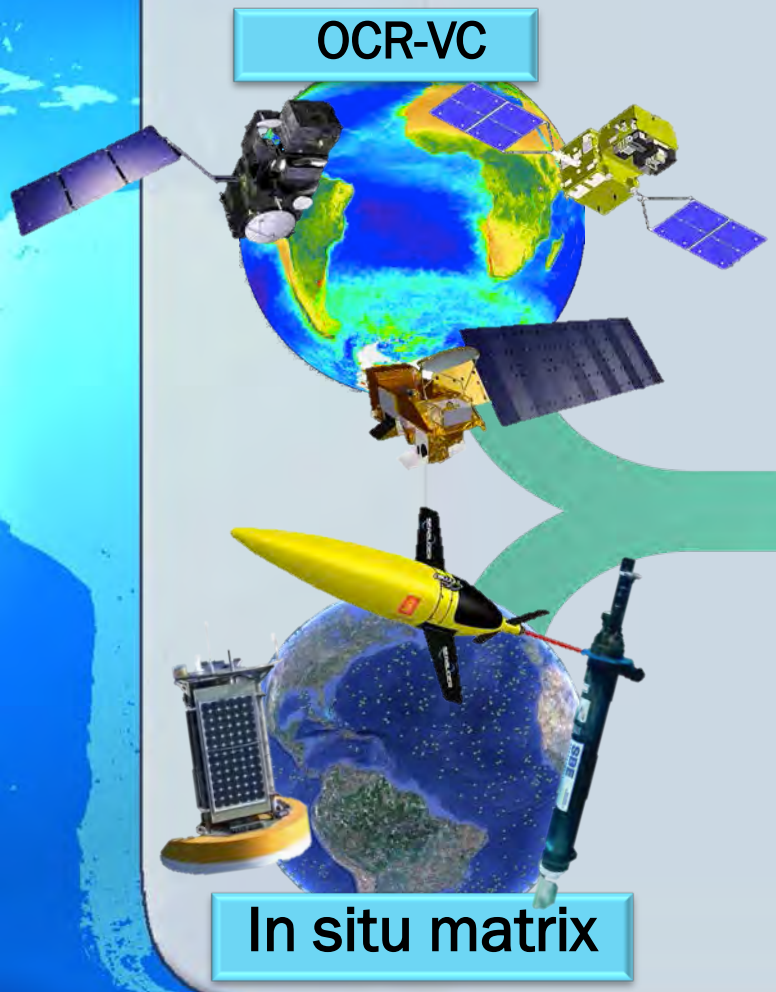
Associate member of CEOS

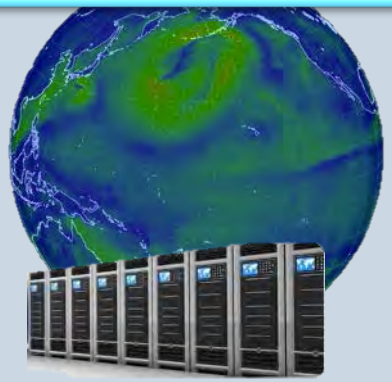
CEOS

- OCR-Virtual Constellation
- INSITU-OCR
- ECV Task Force
- Sensor Calibration Task Force

Developing Green Operational Oceanography

An Integrated Framework to Maximise the Value of the Virtual Constellation



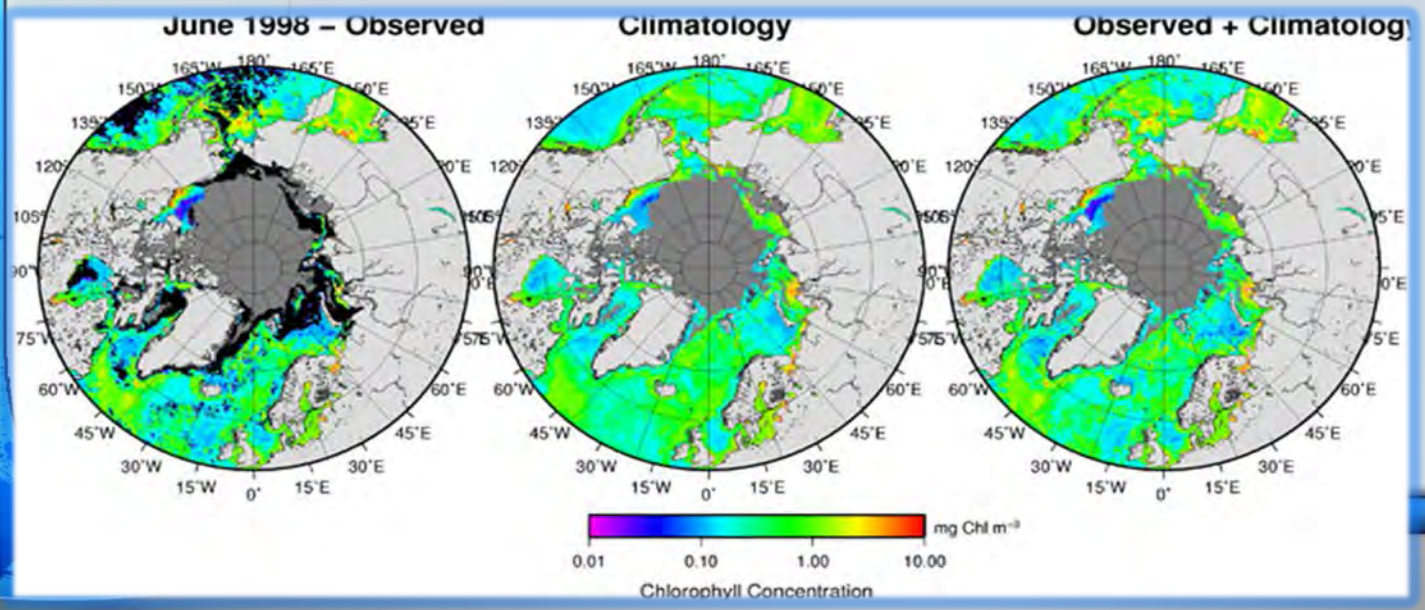


Applications

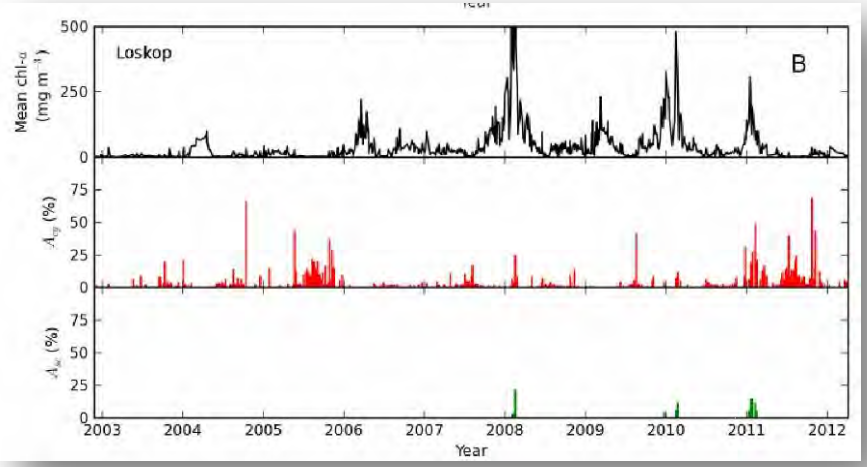
Water quality
Harmful Algal Blooms
Ecosystem Monitoring
Fisheries Management
Maritime Operations
Defence & Security
Sediment Dynamics
Marine Conservation
Carbon Management
.....

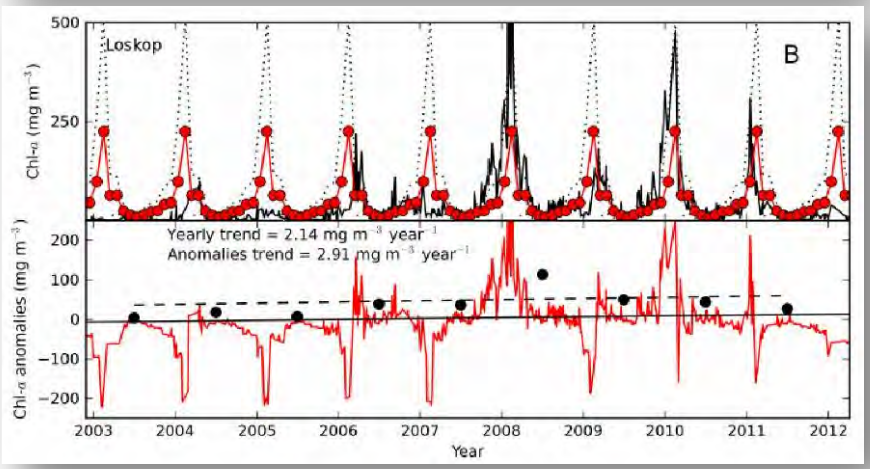
Current IOCCG Working Groups

1) Harmful Algal Blooms (IOCCG/GEOHAB – Stewart Bernard, South Africa)
2) Ocean Colour Remote Sensing in Polar Seas (Marcel Babin, Canada)
3) Uncertainties in Ocean Colour Radiometry (Roland Doerffer, Germany)
4) Retrieval algorithms for coastal waters (Cédric Jamet, France)
5) Earth Observations in Support of Global Water Quality Monitoring (Dekker, Australia; DiGiacomo, NOAA; Greb, U. Wisconsin)



IOCCG HAB WG: decadal characterisation of cyanobacterial blooms in South Africa





Loskop Dam. Time series for Chl and area coverage for cyanobacteria and surface scum for Loskop Dam (upper). Deconvolution of Chl into seasonal signal, showing anomalies and yearly averages (lower)

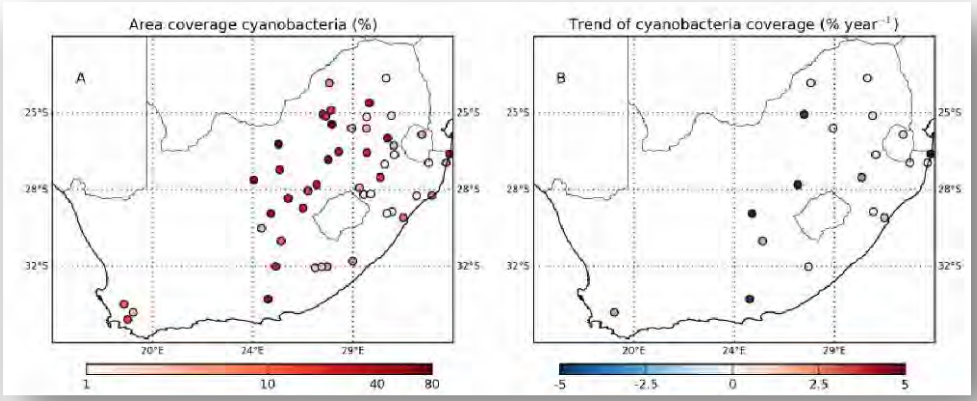
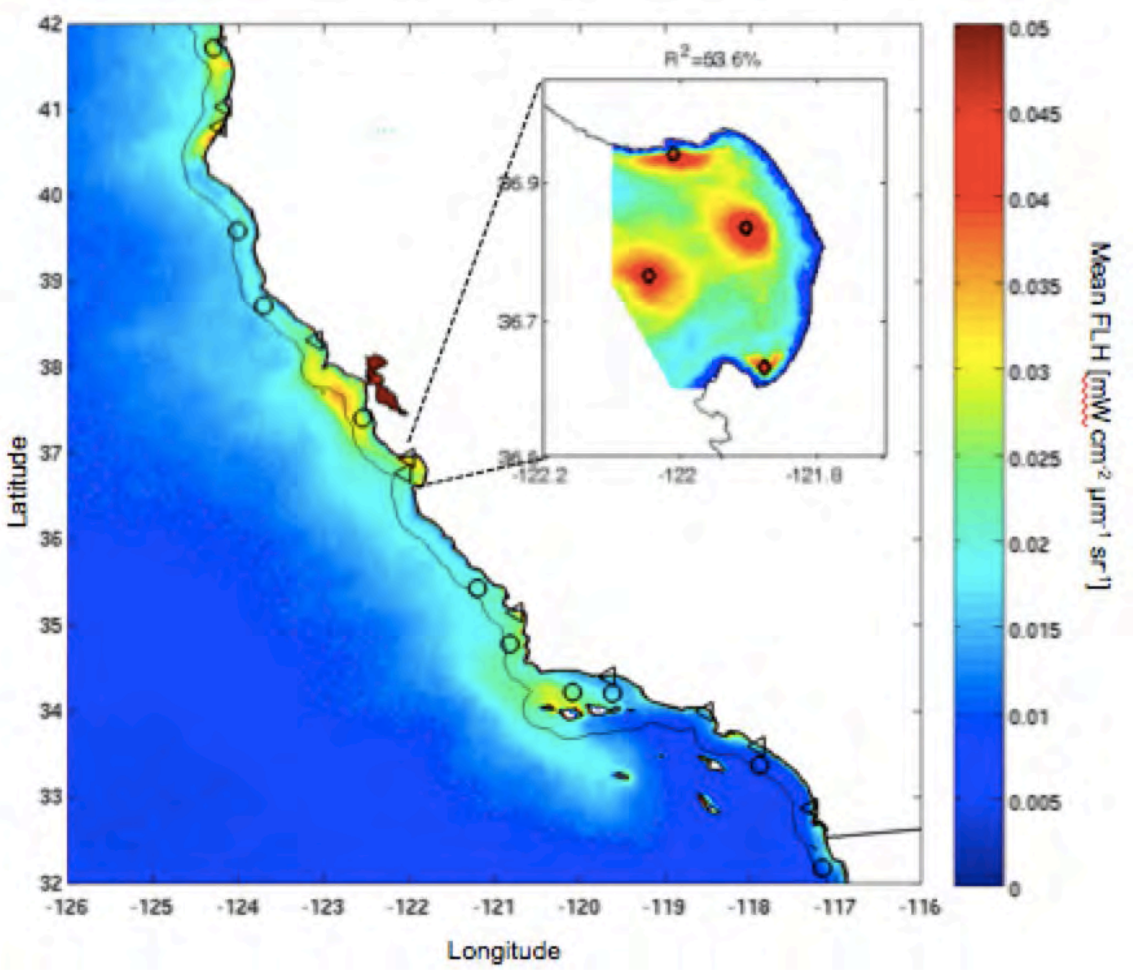


Figure 6.3.14: Status and trends of cyanobacterial blooms in 50 South African reservoirs. A) The mean cyanobacteria area coverage (%). B) trend coefficients of cyanobacterial area coverage (significant at the 95% confidence interval of student-t test).

10 years of MERIS FR data applied to 50 South African freshwater reservoirs, providing decadal analysis of cyanobacterial occurrence and eutrophication

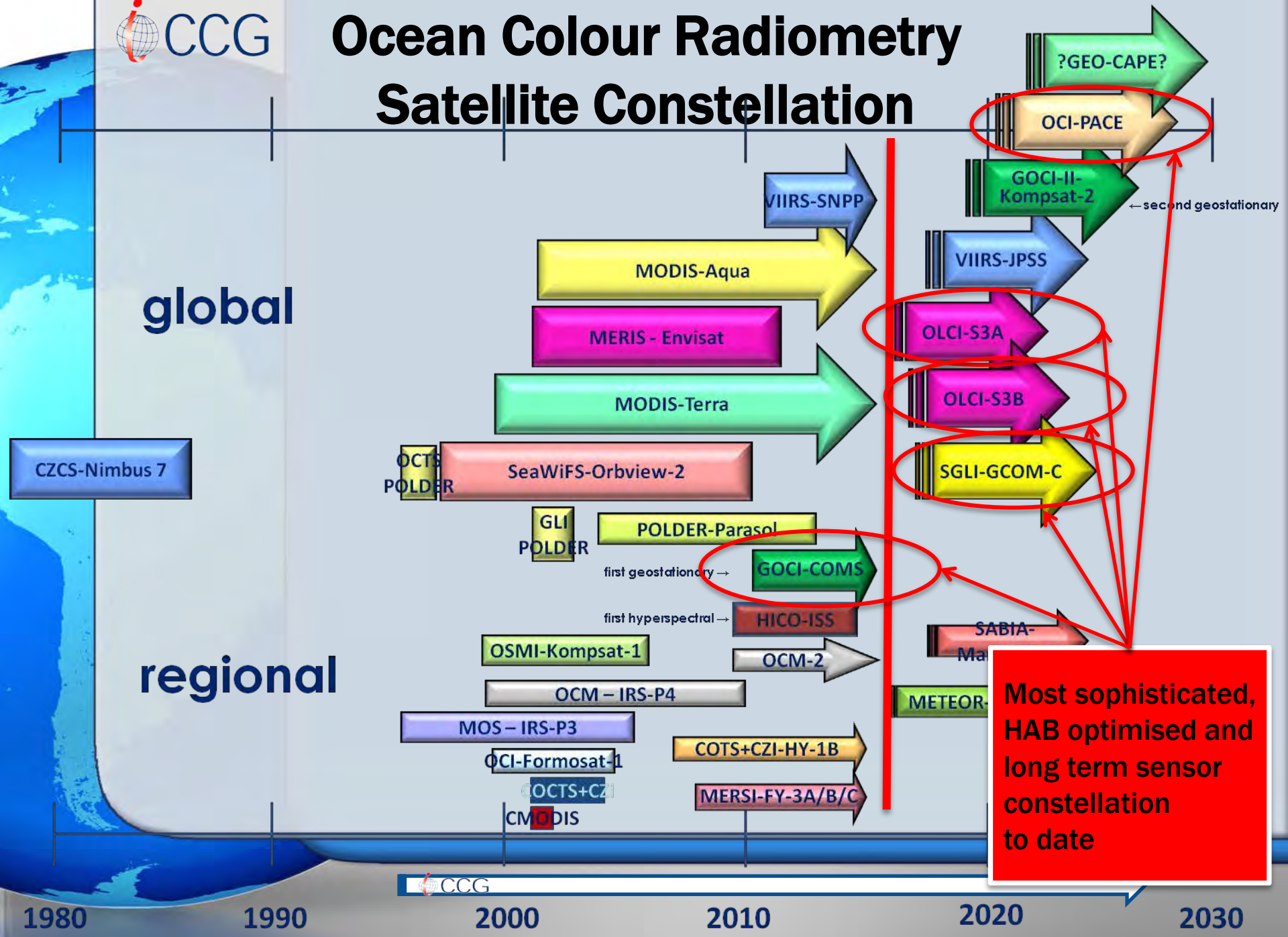
Matthews 2014, Matthews & Bernard 2015

IOCCG HAB WG: Climatology of Californian High Biomass HABs



Proposed (circles) and existing (triangles) HAB monitoring stations covering the California, USA, continental shelf, overlaid on climatological fluorescence line height (FLH). These optimal sites, in combination with satellite remote sensing, would capture 80+% of HAB events. Inset: variance of FLH (a proxy for high biomass HAB events) explained by existing moored and shore-based HAB stations for Monterey Bay, CA. While ~54% of the variance is captured by four stations, there is a distinct spatial bias, alleviated by combining observational sites with remote sensing and modelling. Figure adapted from Frolov et al. 2013.

Ocean Colour Radiometry Satellite Constellation



Envisioned INSITU-OCR Components

Mission Feedback

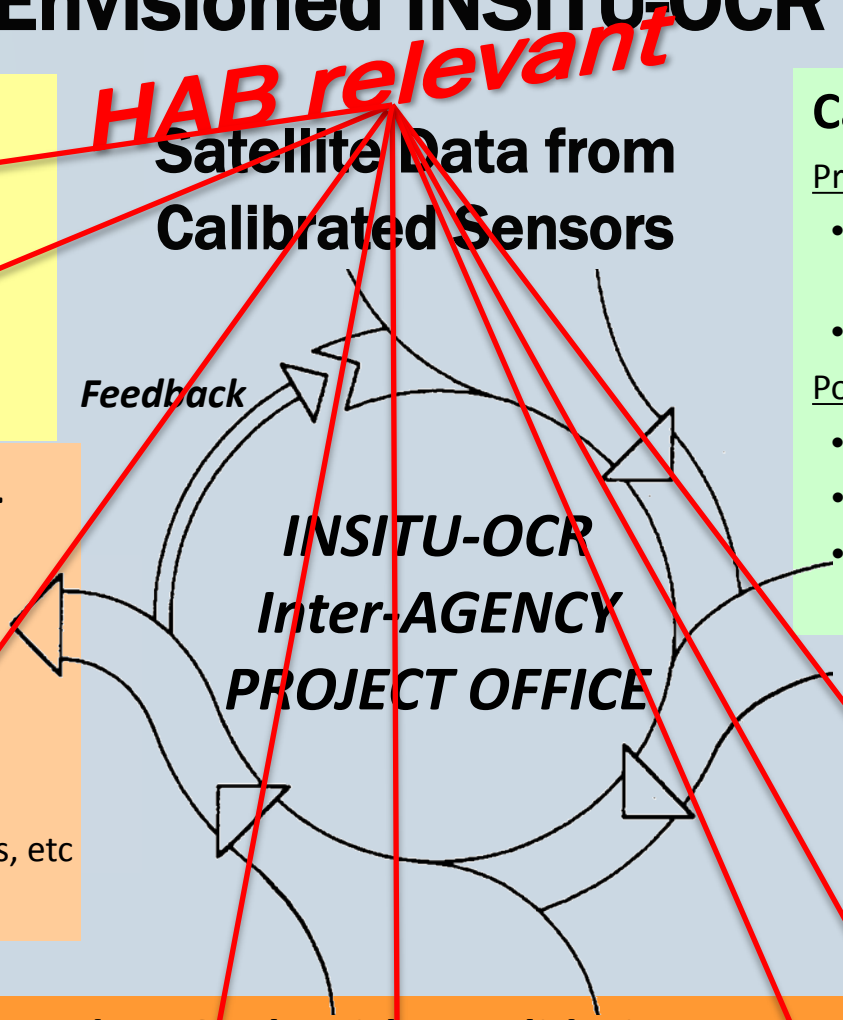
- Science community input
- Comparison with other appropriate products
- New Missions
- Protocol development

Improved Products & Algorithms

- Reprocessing due to improvements in calibration, masks, binning schemes, product compatibilities, etc.
- New products from bio-geochemical, atmospheric fields, etc
- Data distribution interface

Satellite data processing software

- SeaDAS & BEAM for ACE, OCM-2, MERIS, OLCI, SGLI, GOCI, PACE, etc.



Product & Algorithm Validation

- Atmospheric & bio-optical algorithm validation & development (INSITU-OCR PIs & project staff)
- Match-up analysis via Aeronet OC sites, satellite QC, time series eval., Bio-Argo, ChloroGIN etc.
- **Earth System/Climate Model data assimilation**

Calibration Strategy

Pre-launch

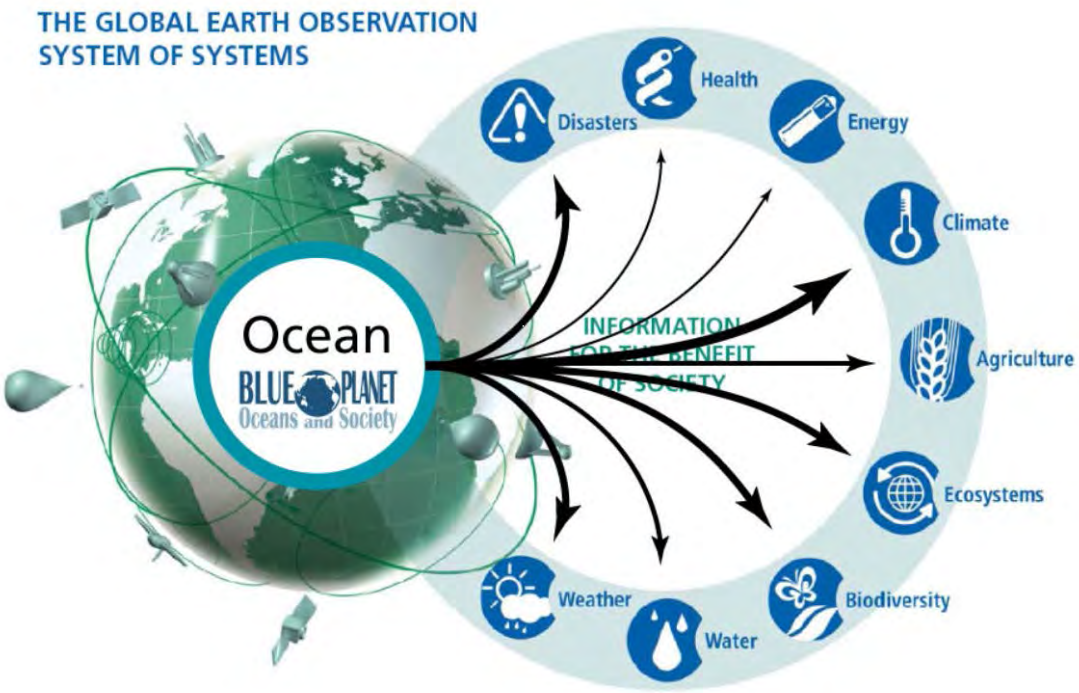
- Lab. characterization & calibration (SI-traceable)
- Solar calibration (transfer-to-orbit)

Post-launch (operational adjustments)

- Solar calibration (daily, every 2 weeks)
- Lunar calibration (monthly)
- Multiple sites L_{wn} time series for vicarious calib. (ISRO, MOBY-C)

In Situ Data

- Collection of required bio-optical and atmospheric measurements (INSITU-OCR PIs)
- *in situ* instrument calibration (Project round robin SI-traceable, IOPs, AOPs)
- Data collection following NASA Ocean Optics protocols
- Archive of calibrated QC *in situ* data (SeaBASS)
- Calibrated instrument pool
- Development of new instrumentation



European funding through the Horizon 2020 programme is guided by GEO structures, and there should be opportunity to exploit both the Blue Planet (marine) and Global Water Quality (freshwater) tasks, in co-ordination with the relevant European Framework Directives

GEO Tasks relevant to the HAB community

WA-01 C4 Global Water Quality

SB-01 C1: Global ocean information coordination and access

SB-01 C2 Operational Systems for Monitoring of Marine and Coastal Ecosystems

SB-01 C3 A Global Operational Ocean Forecasting Network

SB-1 C4 Applications of Earth Observations and Information to Sustainable Fishery and Aquaculture Management

GROUP ON EARTH OBSERVATIONS

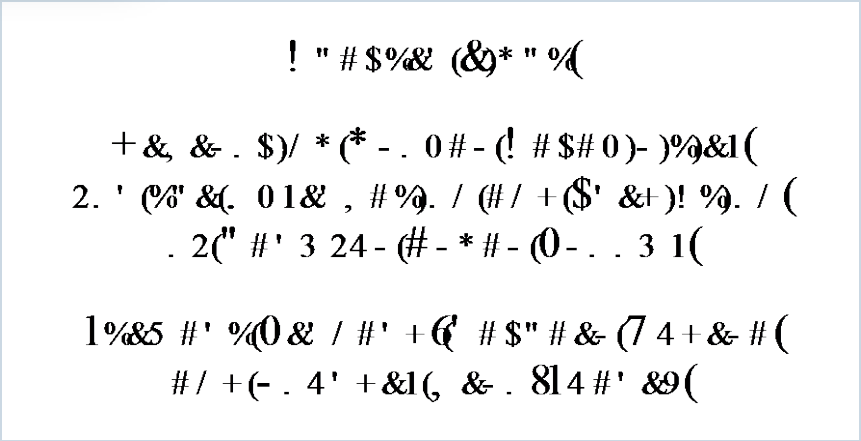
BLUE PLANET Oceans and Society

The added value to Blue Planet of GEO

- **Raises awareness** of sustained ocean observations at **national policy level**
- Provides flexible tool for **spiral development** of systems and infrastructure
- Science without borders, bringing together diverse disciplines
- Potential for **integration** of earth observations through common approaches, infrastructure, toolkits
- **Need all types of data and information to generate societal benefit**

GROUP ON EARTH OBSERVATIONS

Oceans and Society: Blue Planet, Edited by Samy Djavidnia, Victoria Cheung, Michael Ott and Sophie Seeyave. Cambridge Scholars Publishing.



"....Whilst no comprehensive global study has been conducted, global economic loss due to marine HABs can be estimated at several US$ billion annually. Marine HAB-related losses in the United States are conservatively estimated at ±US$95 million annually, adjusted for inflation (Hoagland and Scatasta, 2006); analogous losses in European coastal waters are estimated at more than€ 800 million (Scatasta *et al.*, 2003); HAB-related fisheries losses in Japan have been estimated at more than US$1 billion annually (Kim, 2006). In freshwater systems, potential eutrophication-related losses in the United States, primarily due to cyanobacterial blooms, are estimated at up to US$4.6 billion annually (Dodds *et al*, 2009); the 1998 season of cyanobacterial blooms in the Lake Tai catchment (China) resulted in estimated economic losses of US$6.5 billion (Le *et al.*, 2010); annual costs of freshwater algal blooms in Australia were estimated at ±A$200 million in 2000 (Atech, 2000), with similar annual eutrophication costs in the United Kingdom estimated at ±US$150 million (Pretty *et al.*, 2003) and in South Africa at ±US$250 million (Frost and Sullivan, 2010)...."

GOOS Framework for Ocean Observing

Managing structure

GOOS Steering Committee

(John Gunn and Eric Lindstrom, co-chairs;
Peak Bodies, Sponsors, Observing Panel Chairs,
Observing System leaders)

Relatively new panel of greater relevance to HAB observations

Observing System Panels

Physics and Climate (OOPC – M. Bourassa, T. Suga)

Biogeochemistry (led by IOCCP, T. Tanhua)

Biology/Ecosystems (N. Bax, S. Simmons)

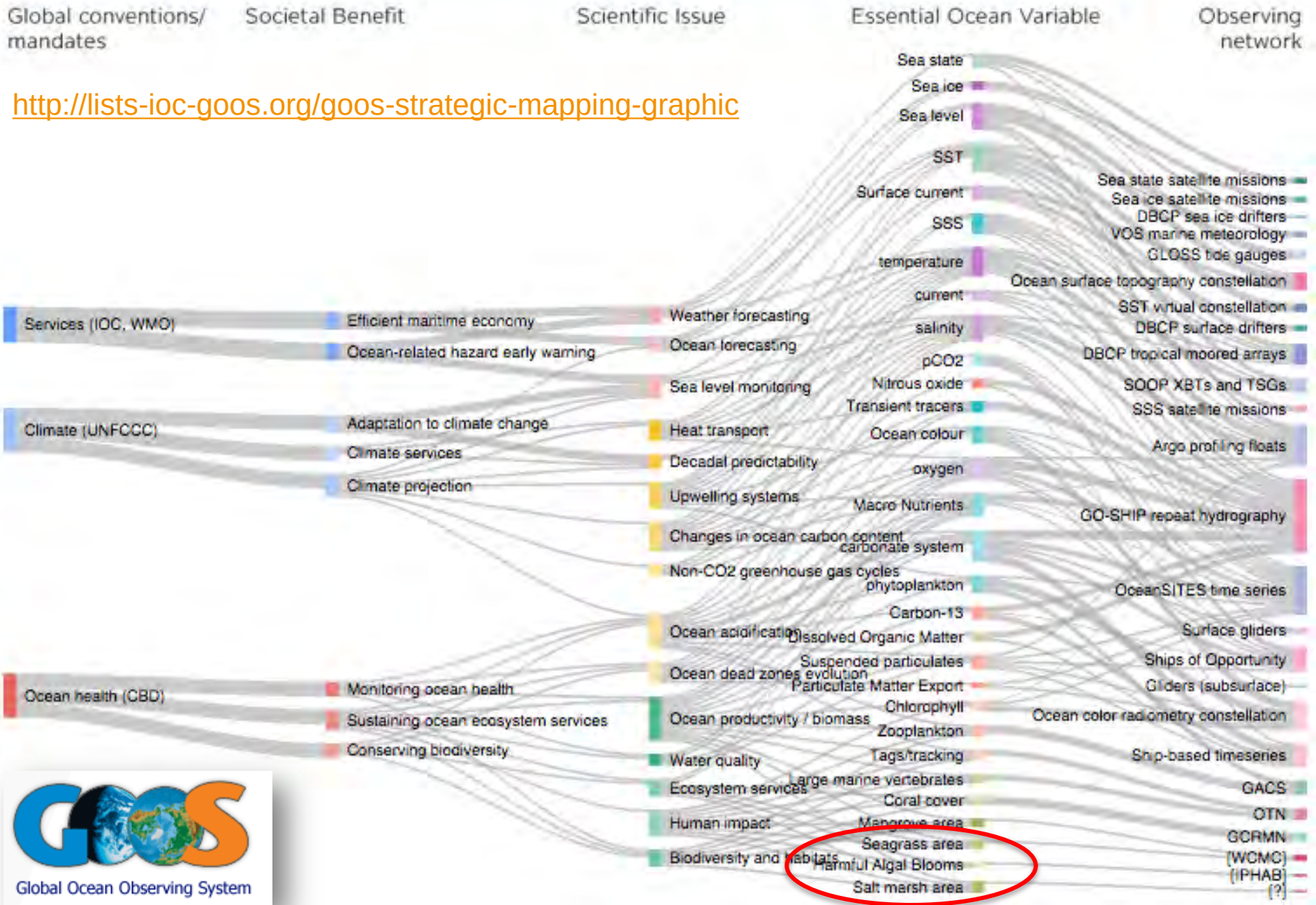
Technical Advisory Groups / Projects / GRAs

(Observing technologies and networks,
Variable focus: data and products, synthesis, link to models)

Framework for Ocean Observing

REQUIREMENTS

OBSERVATIONS



Global Ocean Observing System

What is GOA-ON?

GOA-ON
Global Ocean Acidification Observing Network

The **Global Ocean Acidification Observing Network** (GOA-ON) is a **international partnership** to:

1. **Document the status and progress of ocean acidification** in open-ocean, coastal, estuarine, and coral reef environments,

2. **Understand the impacts of ocean acidification on diverse marine ecosystems and societies**, and

3. **Support forecasts of ocean acidification conditions.**

www.goa-on.org

Why is a global approach needed ?

Processes are occurring at global scales; therefore we need to go beyond local measurements and **observe on global scales in order to understand OA and its drivers correctly.**

We need information and data products that can **inform policy and the public with respect to global status of OA and implications** for overall ecosystem health (status) of the planet.

We need sufficient data and understanding to **develop predictive skills and early warning systems**. This requires coverage at appropriate scales, nesting local observations within global context.

GOA-ON will provide:

Goal 1 An understanding of **global OA conditions**

Identify spatial/temporal patterns and assess generality of response; document and assess variation to infer driving mechanisms; quantify rates of change

Goal 2 An understanding of **ecosystem response to OA**

Track biological responses to physical/ chemical changes; quantify rates of change and identify areas and species of vulnerability or resilience

Goal 3 Data to **optimize modeling for OA & impacts**

Acquire and exchange spatially and temporally-resolved chemical and biological data to be used in developing models for societally-relevant analyses and projections

GOA-ON defined two data quality objectives:

- '**Climate data**': of sufficient and defined quality to assess long term trends with defined level of confidence

  Detection of changes in OA state over multi-decadal timescales

- '**Weather data**': of sufficient and defined quality to identify relative spatial patterns and short-term changes

  Mechanistic interpretation of the ecosystem response to local, immediate OA dynamics

International Partnerships: In Summary….

- The HAB community, through the International Ocean Colour Coordinating Group (IOCCG) and upwards to space agencies, can play a major role in optimal long term HAB use of single- and multi-sensor constellations – validation, synergy with *in situ* autonomous and discrete phytoplankton observations with high specificity, applications guidance, and integration with sub-mesoscale modelling represent potentially very high value contributions to agency strategy and mission implementation/value realisation….

- Similarly, the field of Phytoplankton Functional Type (PFT) observations from space, and associated integration/uptake by the modelling community, is attracting much agency attention, but requires quantitative constraint, guidance with regard to ecological application, and *assistance with regard to use of emerging sensors for routine/autonomous observations of the phytoplankton assemblage for validation.* The HAB research community are undoubted leaders in this domain, and should exploit this expertise to fullest advantage…. The HAB community may also be curating some currently under-exploited long term coastal data sets of phytoplankton community structure that could be of considerable value….

- The Group on Earth Observations (GEO) tasks (Blue Planet & Global Water Quality), represent significant and potentially highly resourced platforms to demonstrate applications of marine & freshwater HAB observation/modelling/predictive systems, and efforts to focus and place quantitative research outputs into these domains will certainly help the cause…

Thank you and apologies, regrets for not being able to attend…