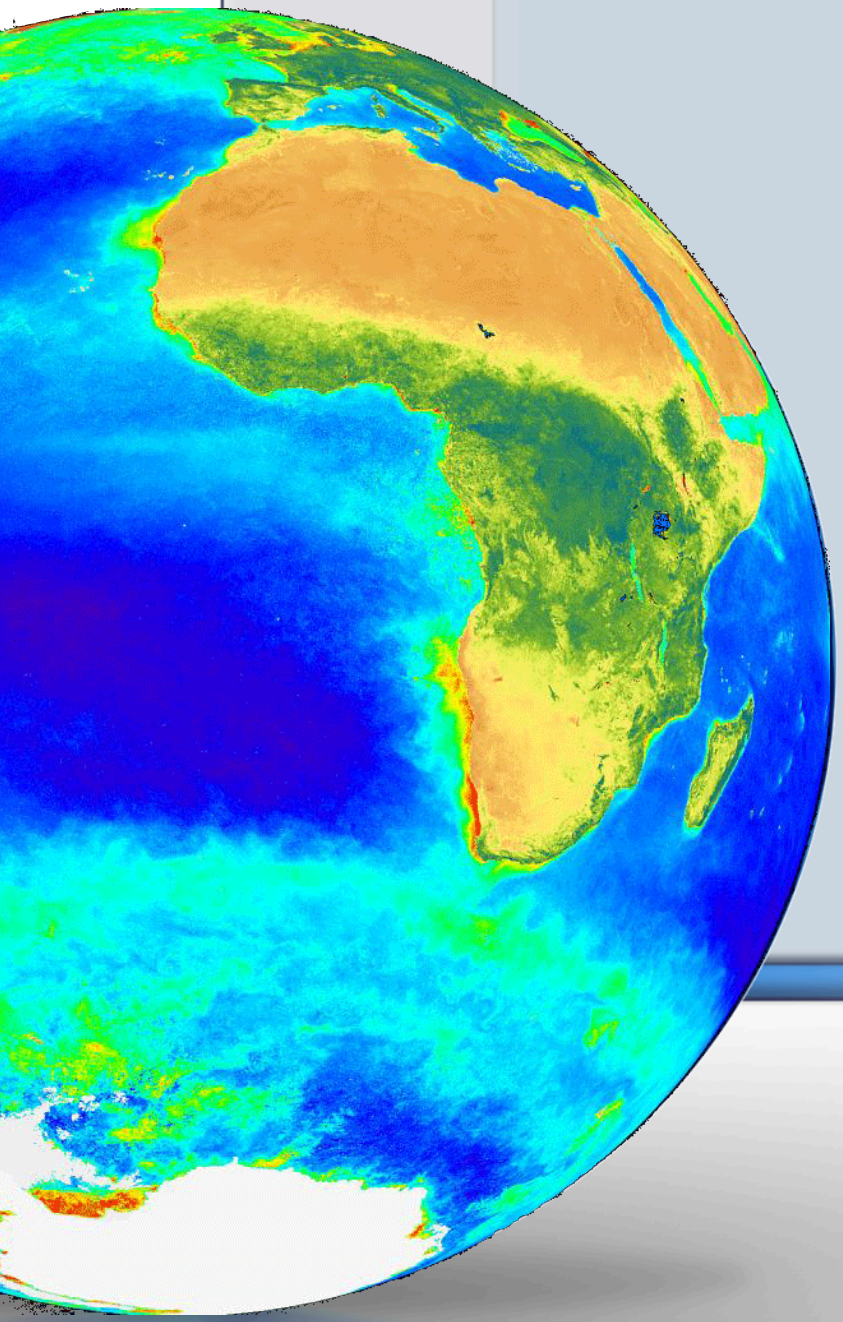


The Ocean Colour Virtual Constellation

GHRSST XV, June 2014

The International Ocean Colour Coordinating Group

International Ocean Colour Coordinating Group

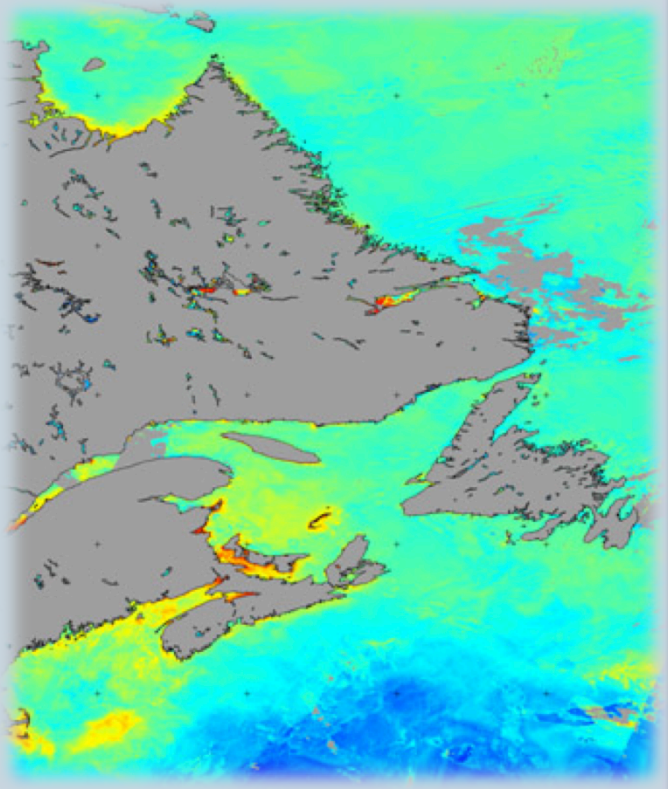
- Established in 1996 to promote the application of ocean-colour data at the world scale through coordination, liaison between providers and users, training, advocacy and provision of expert advice

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

- Committee consists of ~25 members including:

  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

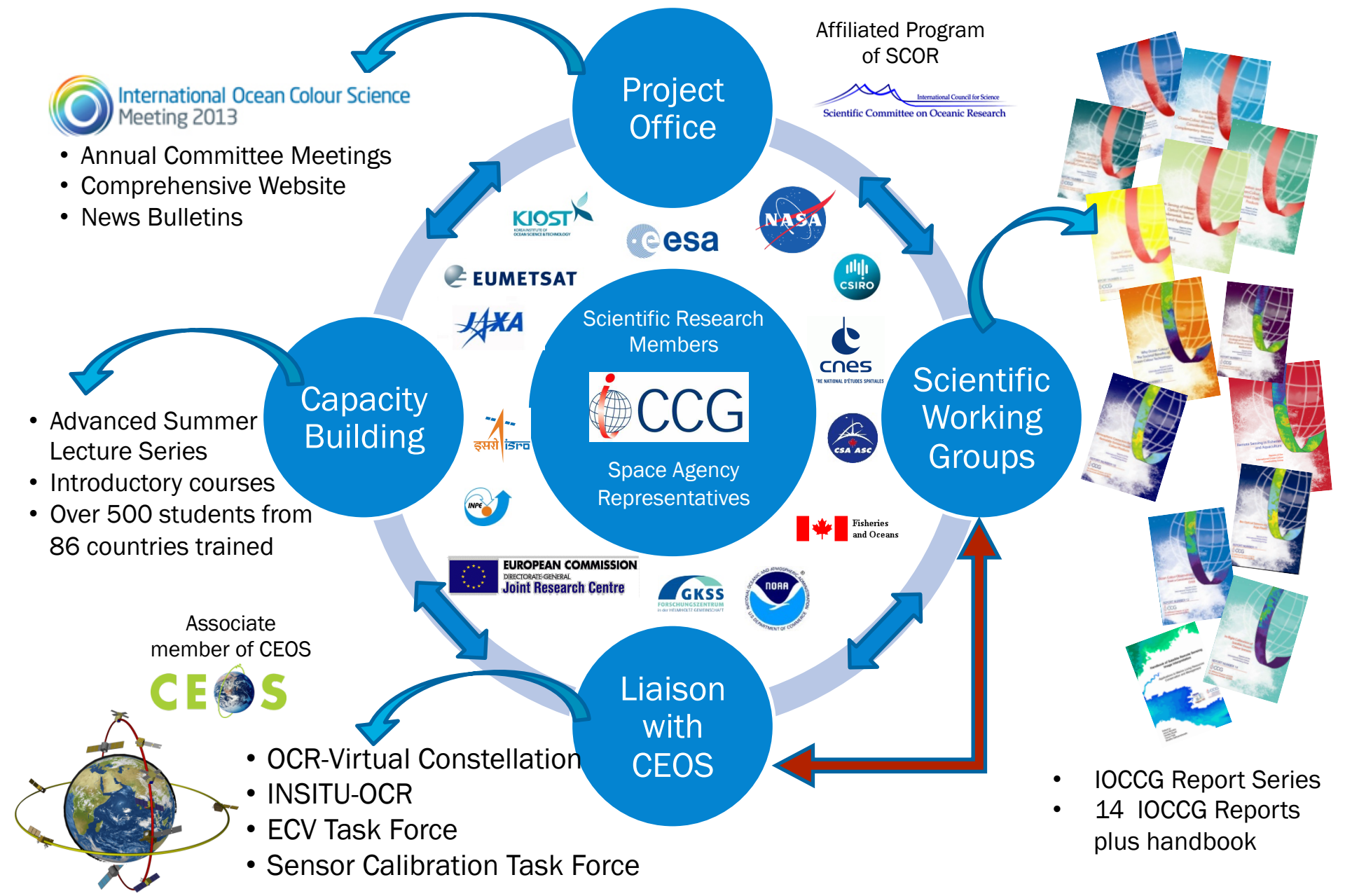


ESA MERIS Chlorophyll, 3-9 Sept 2010 (image courtesy Cesar Fuentes-Yaco, DFO, Canada)

IOCCG Mandate

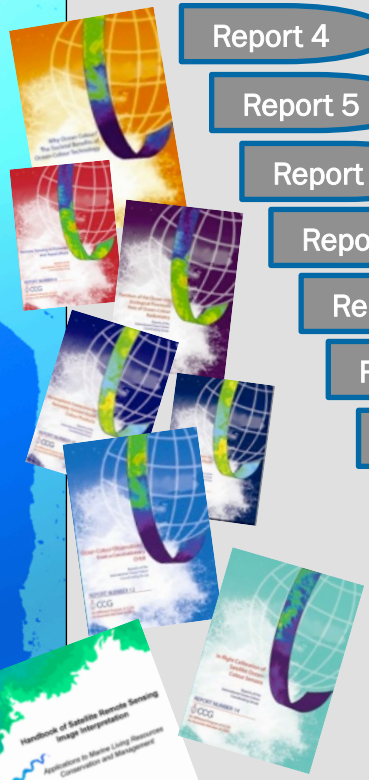
- To provide a common voice for the user community
- Liaise with space agencies
- Advanced training courses to foster expertise in using ocean-colour data
- Facilitate free and open access to ocean-colour data from all agencies
- Ensure continuity and quality of the ocean-colour data stream
- Advocate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

International Ocean Colour Coordinating Group



IOCCG Report Series

Widely cited, definitive works (14 published to date, plus handbook). Available on IOCCG website at www.ioccg.org/reports_ioccg.html



- Report 1 — *Minimum Requirements for an Operational Ocean-Colour Sensor (1998)*
- Report 2 — *Status and Plans for Satellite Ocean-Colour Missions (1999)*
- Report 3 — *Remote Sensing of OC in Coastal and Other Waters (2000)*
- Report 4 — *Ocean-colour, Level-3, binned data products (2004)*
- Report 5 — *Remote Sensing of IOPs: Fundamentals and Algorithms (2006)*
- Report 6 — *Ocean-Colour Data Merging (2007)*
- Report 7 — *Why Ocean Colour? The Societal Benefits of Ocean-Colour Technology (2008)*
- Report 8 — *Remote Sensing in Fisheries and Aquaculture (2009)*
- Report 9 — *Partition of the Ocean into Ecological Provinces (2009)*
- Report 10 — *Atmospheric Correction (2010)*
- Report 11 — *Bio-Optical Sensors on Argo Floats (2011)*
- Report 12 — *Ocean-Colour Observations from a Geostationary Orbit (2012)*
- Report 13 — *Mission Requirements for Future Ocean-Colour Sensors (2012)*
- Report 14 — *In-flight Calibration of Satellite Ocean-Colour Sensors (2013)*
- Report 15 — *Phytoplankton Functional Types from Space (expected 2014)*

- Handbook — *Handbook of Satellite Remote Sensing Image Interpretation: Applications for Marine Living Resources Conservation and Management (2011)*

International Ocean Colour Science Meeting 2013

Darmstadt, Germany, 6-8 May 2013

Advancing Global Ocean Colour Observations

- To maintain consultation and interaction with the broader ocean colour user community
- Series of meetings in different parts of the world - provisionally every two years
- Sponsored by NASA, EUMETSAT, ESA and CNES

Format of first IOCS meeting

- Invited keynote speakers: Charles McClain, Steve Ackleson, Shailesh Nayak, Stewart Bernard, Frederic Melin
- 12 Splinter sessions on various topical issues:
  - NASA Ocean Colour Research Team meeting
  - Phytoplankton community structure from ocean colour
  - Climate variables and long term trends
  - *In situ* measurement protocol revision for cal/val
  - System vicarious calibration etc.....
- Information talks by space agency representatives
- Poster sessions to highlight the latest research in OCR
- Open floor discussions
- **Second IOCS meeting May 2015, USA**

EUMETSAT esa cnes NASA

Ocean Colour in Support of Climate, Applications and Services

Ocean colour data users, applications and products are very diverse

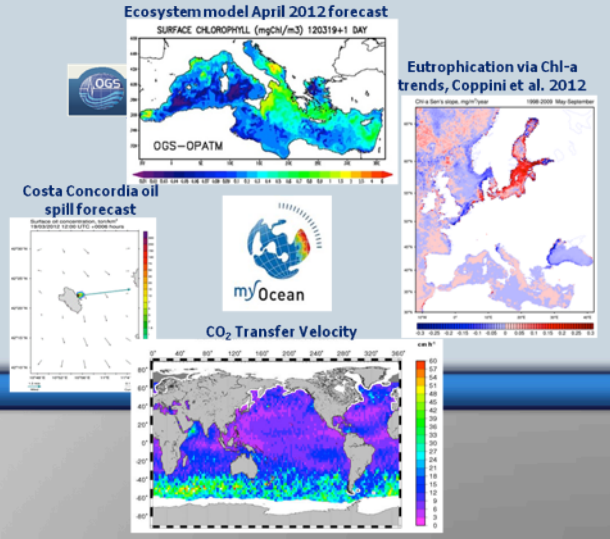
- Timescales for most applications are much longer than the standard NRT operational paradigm → distribute NRT data and consistent long-term measurement time series
- The quality of operational ocean colour data is of critical importance → ensure state of the art calibration and algorithms
- Data continuity and sustainability of product delivery need to be assured → secure long-term programmes, such as EC Copernicus and US JPSS

Climate
- CO_2 sequestration – carbon cycle, CO_2 sources, sinks and transport

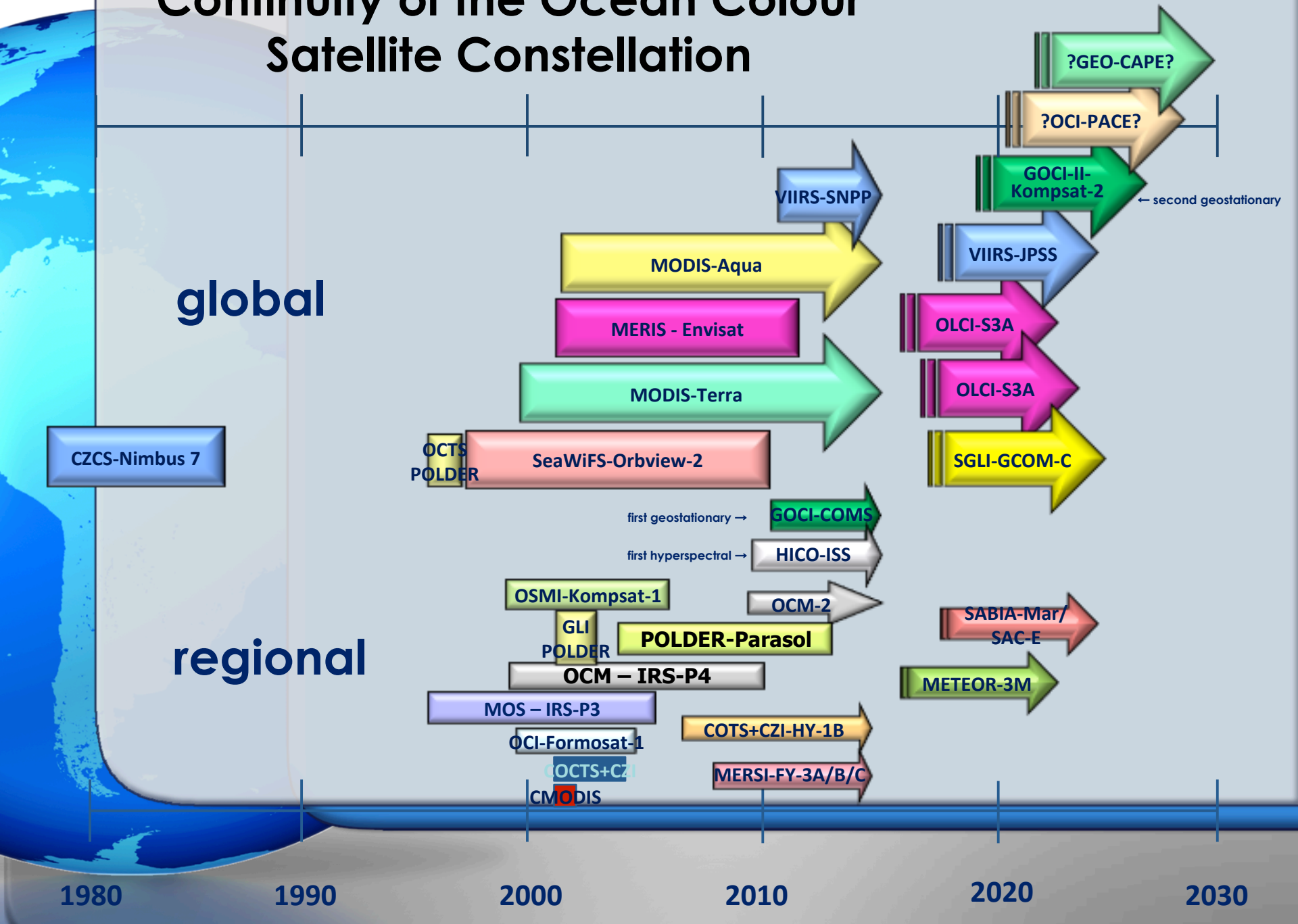
Marine/Coastal/Lake environment monitoring and forecasting
- good environmental status of marine environment (e.g. EC's Marine Strategy Framework Directive)
- water quality
- harmful algal blooms, natural disasters, human activities
- sediment load and transport, water transparency
- eutrophication

Coupled physical-biogeochemical models, NWP
- air-sea heat flux – phytoplankton absorption, optical turbidity
- ecosystem models

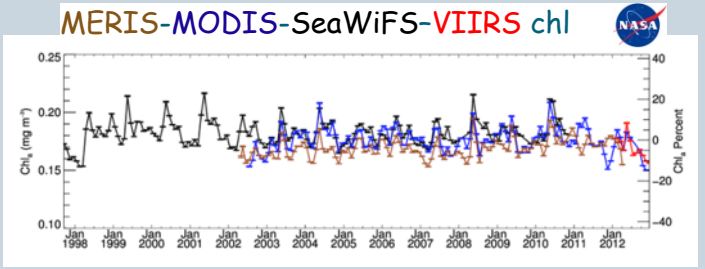
Marine resource management
- fisheries, aquaculture
- good ecological and chemical status (e.g. EC's Water Framework Directive)
- water resources



Continuity of the Ocean Colour Satellite Constellation



Ocean Colour LEO Mission Continuity Requirements

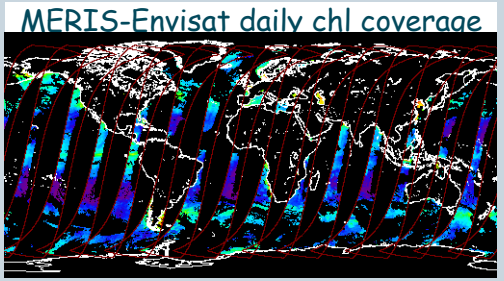


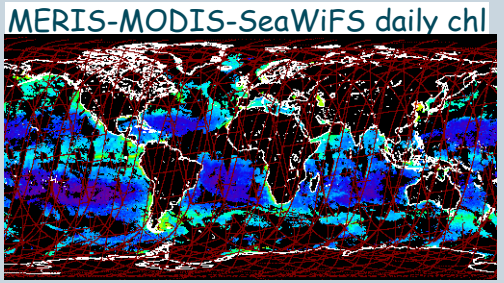
Multi-mission data requirements

- climate and operational applications require multi-decadal time-series to observe trends and anomalies
- operational services require daily coverage from three operational satellite streams to provide robust services
- regional applications require regionally adapted multi-mission time-series

Continuity and consistency requirements

- continuous and consistent multi-mission time-series is required
- instrument calibration is the primary driver of ocean colour time-series consistency, accuracy and long-term stability (IOCCG Reports #13 & #15 being followed up on by agencies)
- provision of open-source processors and tools is crucial for regional algorithm adaptation, cal/val and product development
- universal access to uncalibrated L0 or L1A products is required for users to assemble time-series repositories because calibration-driven reprocessings are routine and repeated transfers of large data volumes are expensive





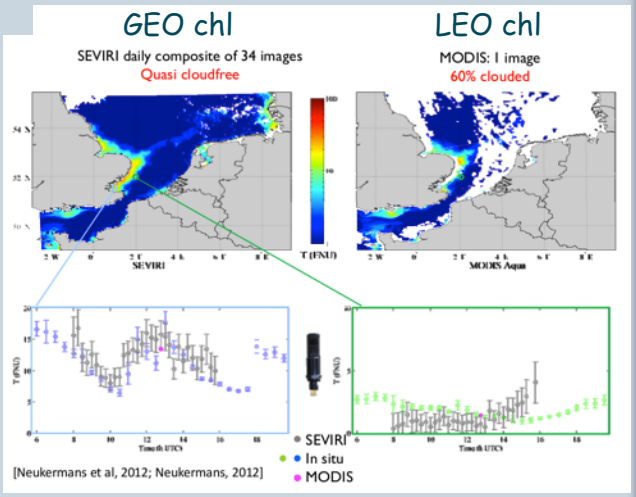
Ocean Colour Geostationary Mission Requirements

Geostationary ocean colour applications

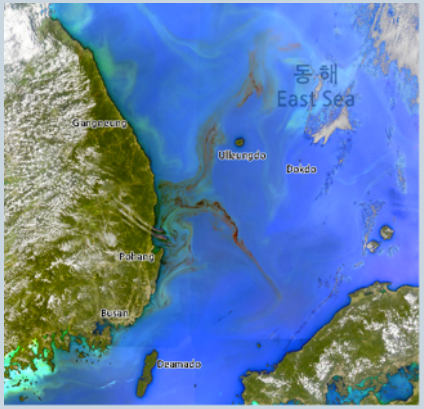
- GOCI on COMS from Korea Institute of Ocean Science and Technology – the first and only geostationary ocean colour mission
- dramatic improvements in coverage in between cloudy spells
- dramatic improvements in sampling frequency: monitoring of quickly-varying processes such as tidal cycles, sediment transport, diurnal bloom evolution, fishing grounds, surface currents, ocean fronts, natural disasters, human activities
- potential for new products and applications

Continuity and consistency requirements

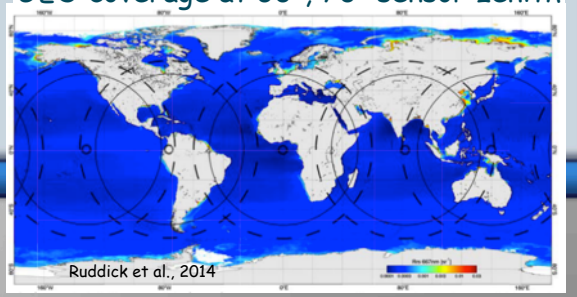
- no geostationary ocean sensors are currently approved except for KIOST GOCI-II on Kompsat-2
- community recommendations for geostationary ocean colour mission exist, IOCCG Report 12, 2012
- inter-agency coordination on geostationary missions and harmonization on mission requirements is proposed



GOCI monitoring of harmful algal blooms



GEO coverage at 60^0, 70^0 sensor zenith



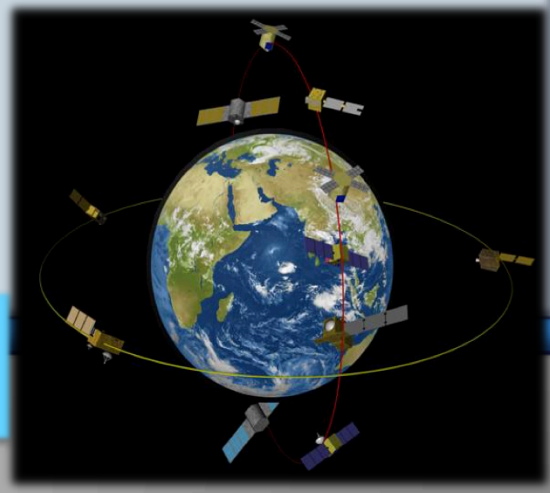
Ocean Colour Radiometry – Virtual Constellation (OCR-VC)

Established by IOCCG through CEOS to provide a long time series of calibrated ocean colour radiances from measurements obtained from multiple satellites.

Goals of the OCR-VC

1) To ensure the continuity of the ocean colour time series – Climate Data Record
2) To provide high quality data sets through a concerted inter-agency effort on activities relating to sensor inter-comparison (**INSITU-OCR**)
3) Data harmonization, support implementation of ECVs (IOCCG Task Force on **ECV Assessment**)
4) Facilitate timely and easy access to data (user interface)
5) Capacity building and outreach

All space agencies on the IOCCG Committee contribute to the OCR-VC



Within the OCR-VC Framework

INSITU-OCR

International Network for Sensor Inter-comparison and Uncertainty Assessment for Ocean Colour Radiometry. SIMBIOS follow-on: plan to establish an Inter-Agency Project Office. Produced a White Paper with recommendations on:

- space sensor radiometric calibration, characterization and temporal stability;
- development and assessment of satellite products;
- in situ data generation and handling;
- information management and support.

Task Force on ECV Assessment

Provides guidance on the generation of better, long-term OCR climate data records.

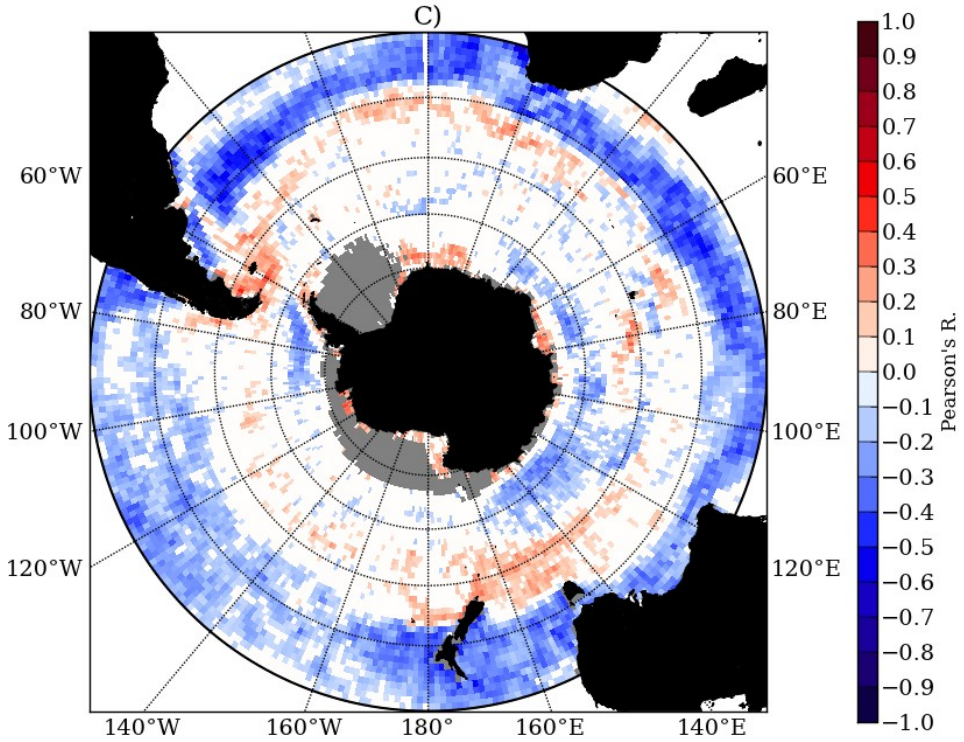
Task Force on Satellite Sensor Calibration

Proposed Inter-Agency task force to facilitate collaboration to maximize the accuracy and stability of ocean-colour radiometry records from individual missions.

Coordination of In Situ Measurement Protocols

Proposed group to coordinate and revise in situ measurement protocols.

OC and SST Oceanic Interdependence



Supplementary figure C: Sub-seasonal correlation between Chl-a and Sea-Surface-Temperatures (SST) during October March. SSTs are taken from the OISST (AVHRR only V2) dataset as downloaded from the National Climate Data Center (at ftp://eclipse.ncdc.noaa.gov/pub/OI-daily-v2/). Detailed of the merging procedure between different AVHRR sensors is available in May et al, (1998). The period 1998-2009 has been extracted, averaged over the same 8 days composite calendar and interpolated on a regular 1 degree x 1 degree grid. This figure provides an observation-based only estimate of the relationships between ocean physics and Chl-a concentrations. See **Figure 2a** in the manuscript for comparison.

Fauchereau et al 2011, GRL

OC and SST Coastal Interdependence

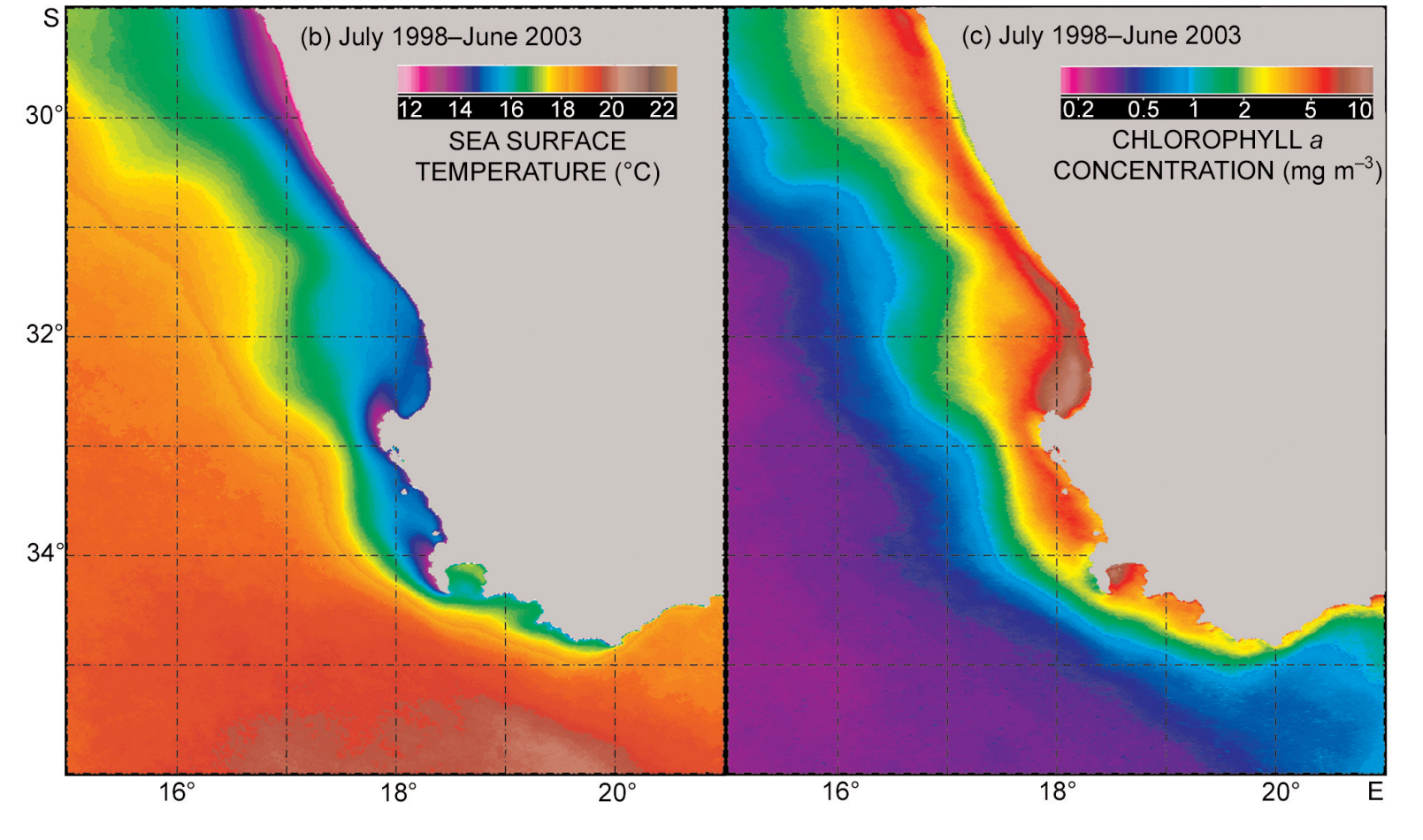
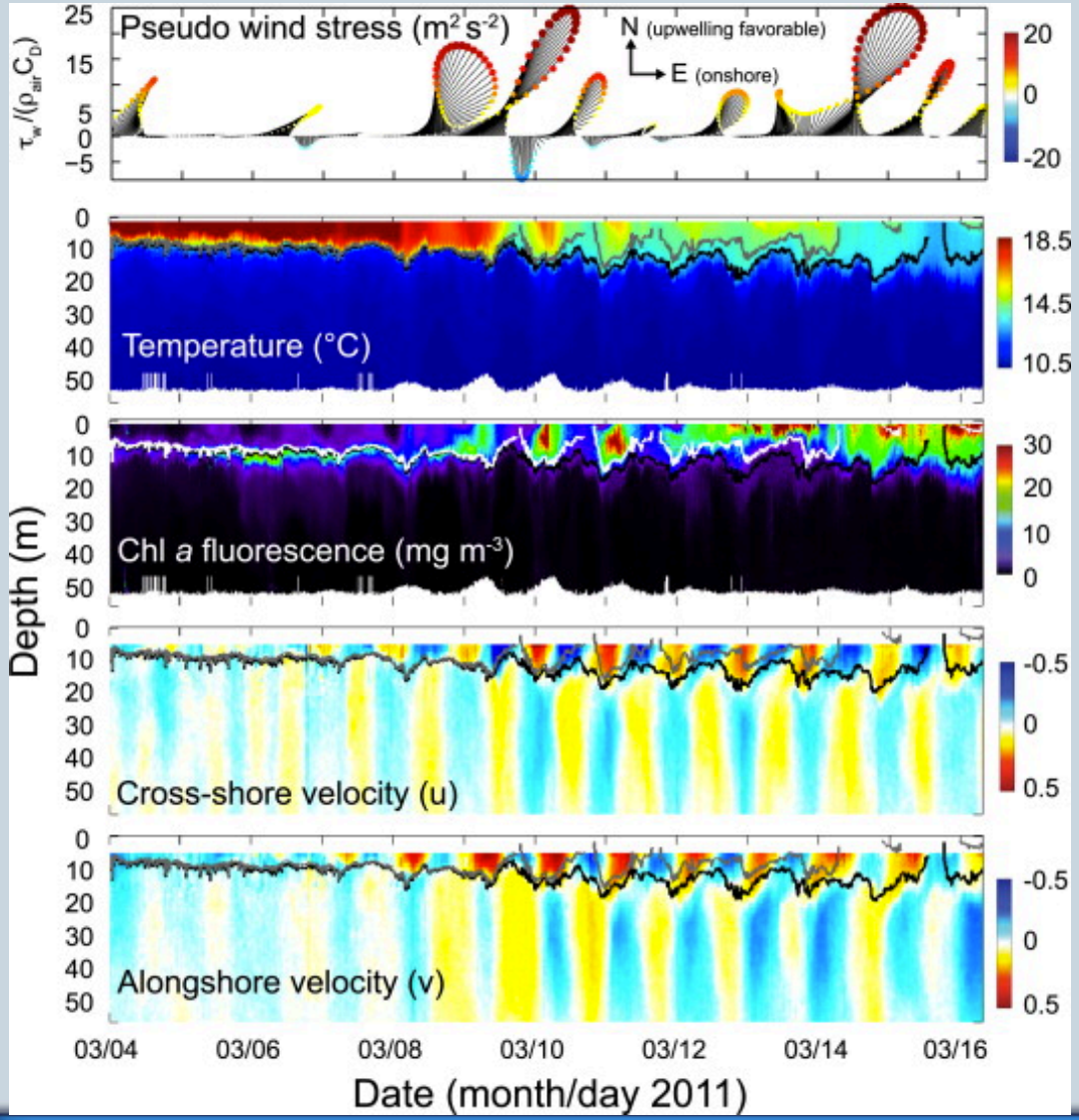


Figure 2: (a) Southern Benguela bathymetry: inner shelf: 0–100m (blue), mid-shelf: 0–200m (green), and outer shelf: 200–500m (red), (b) mean SST for July 1998–June 2003 and (c) mean chlorophyll for July 1998–June 2003. The three key latitudinal lines, for which the Hovmöller latitudinal plots were generated, are overlaid on the bathymetry map

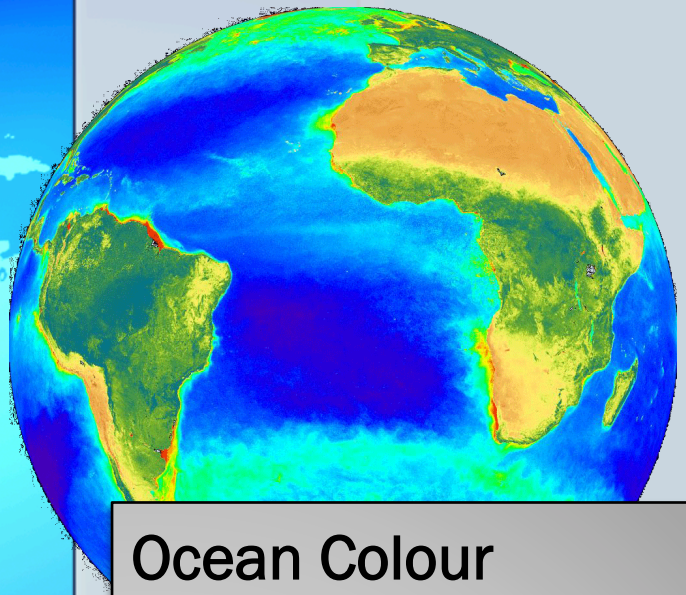
Weeks et al 2006

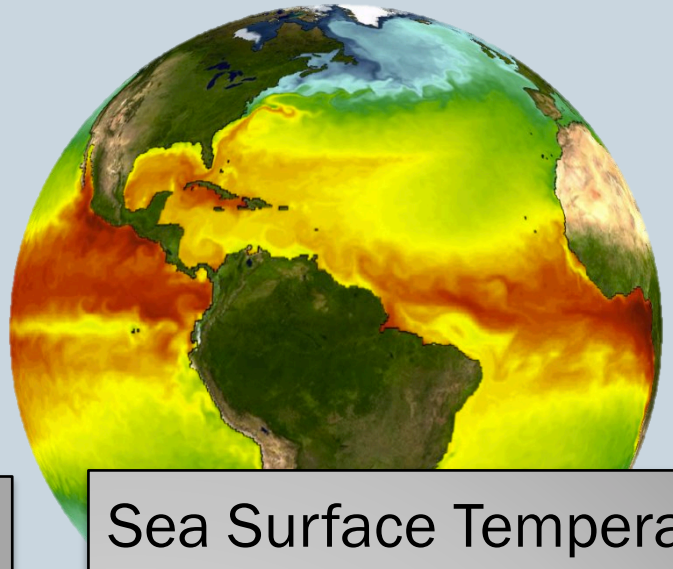
OC and SST Coastal Interdependence



Lucas et al 2013

OC and SST Virtual Constellation Comparison





Ocean Colour

Signal: log scale
Signal Ambiguity: very high
Error: still poorly known > 30%
Regional Variability: large
Validation need: essential regional
Model Pull: Not yet
RT VC Product: Not yet

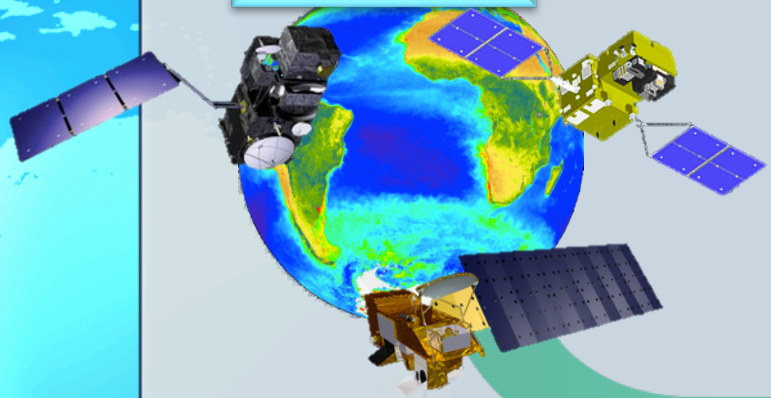
Sea Surface Temperature

Signal: linear scale
Signal Ambiguity: small
Error: well characterised
Regional Variability: in extreme systems
Validation need: global
Model Pull: major motivation
RT VC Product: GHRSST various

Developing Green Operational Oceanography

An Integrated Framework to Maximise the Value of the Virtual Constellation

OCR-VC



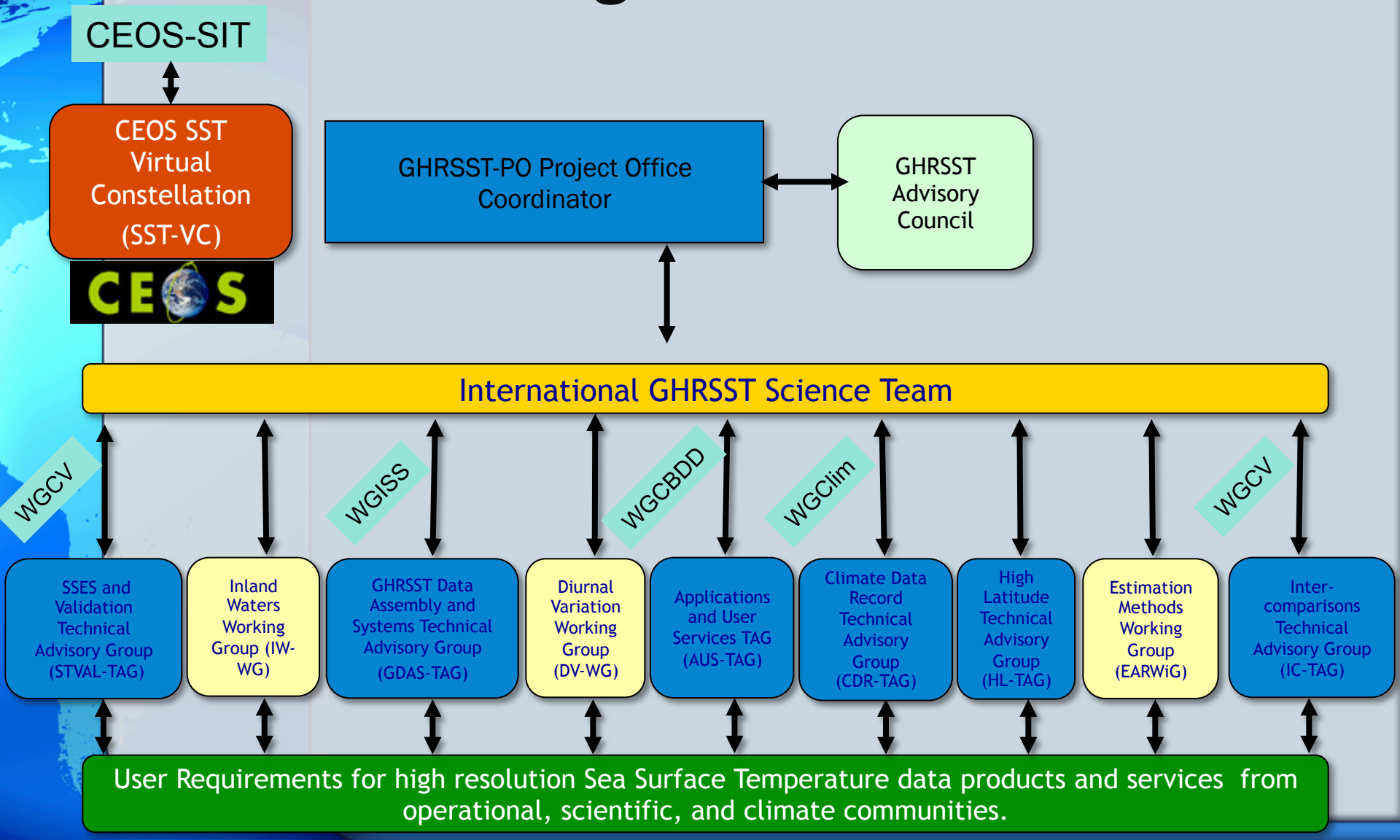
In situ matrix

Biogeochemical Models

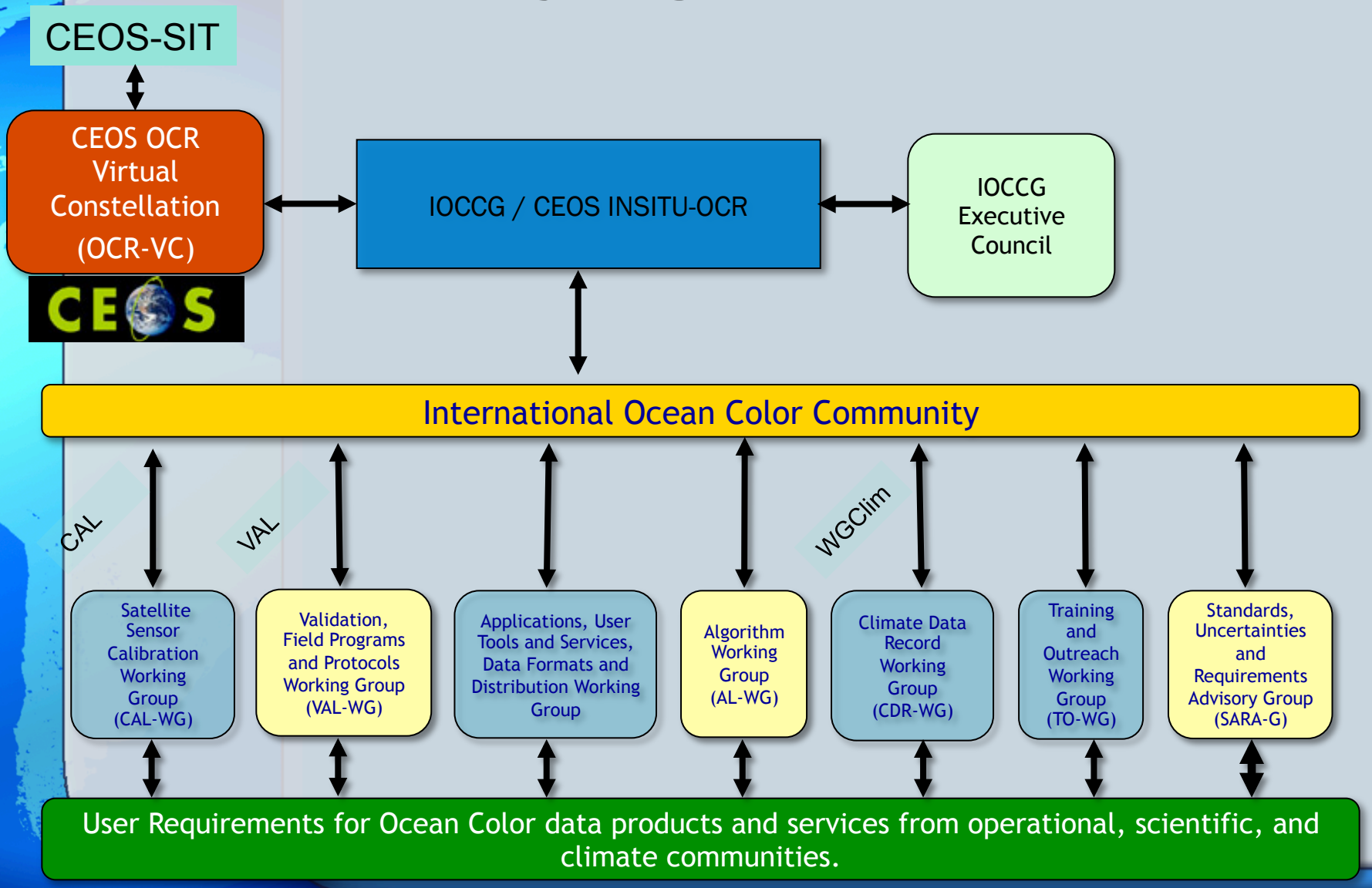
Applications

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

GHRSST ST Organisation



OC Community Organization draft



Conclusions/Way Forward

- Need for GODAE-style Biogeochemical model at both global and sub-mesoscale resolution, e.g. coastal pilot site, to act as model pull for observation matrices of OCR-VC and Bio-Argo+
- Need for OCR-VC to find ways to produce “single product meets all needs” offering using branching classification & algorithm framework schemes e.g. dealing seamlessly with Case-2, shallow waters, regional ambiguity, adjacency, inland, etc
- DDS/Felyx offers strong point of convergence, using similar techniques for critical regional validation/confidence estimates
- Stronger expression of multiple-use user needs required, both for OCR-VC and synergistic OCR/SST usage - and not just for climate change focused usage….