GGOS and Essential Geodetic Variables

presented by
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21st International Workshop on Laser Ranging

November 5–9, 2018
Canberra, Australia

International Association of Geodesy

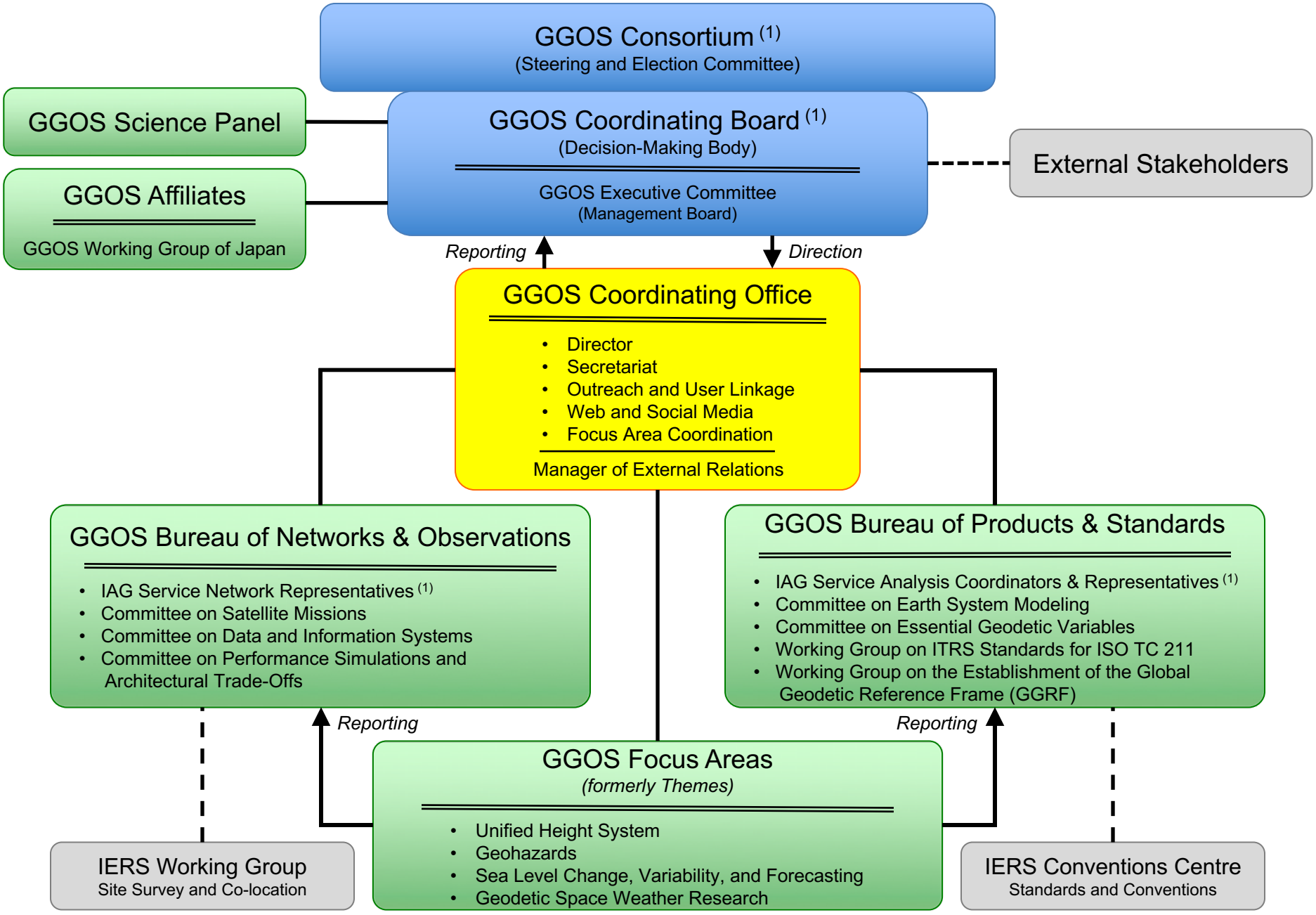
- The mission of the IAG is to advance geodesy
- This mission is performed by its components
  - Commissions and Inter-commission Committees
  - Services
  - Global Geodetic Observing System (GGOS)
- IAG Commissions & Inter-commission Committees
  - Represent the major fields of geodetic research within the IAG
  - Represent the IAG in all relevant scientific matters
    - Commission 1: Reference Frames
    - Commission 2: Gravity Field
    - Commission 3: Earth Rotation and Geodynamics
    - Commission 4: Positioning and Applications

IAG Services

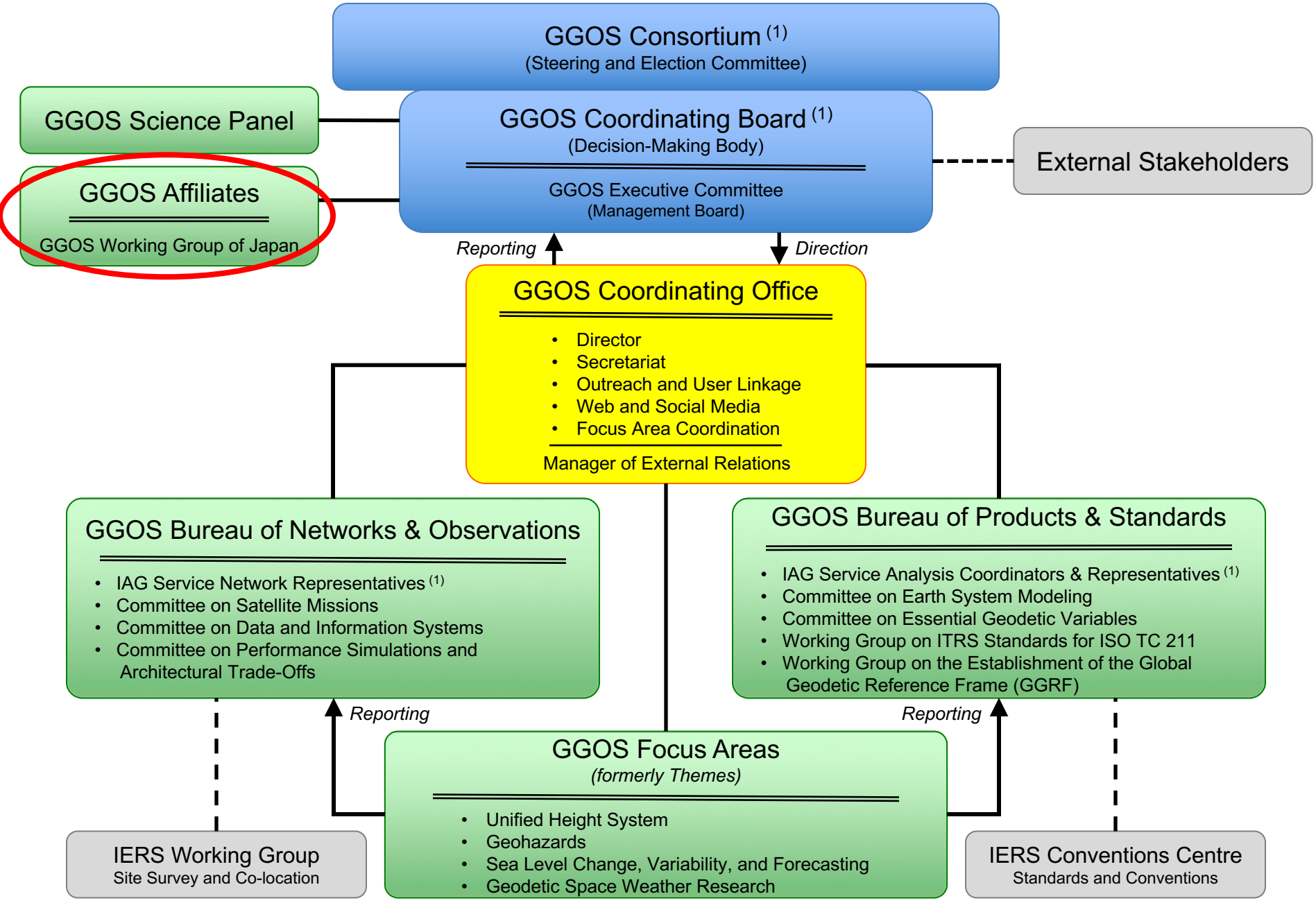
- Organize the collection and reduction of geodetic observations
  - Create the geodetic products needed for scientific research and societal applications
- Geometry
  - IERS, IGS, IVS, ILRS, IDS
- Gravimetry
  - IGFS, BGI, ISG, IGETS, ICGEM, IDEMS
- Oceanography
  - PSMSL
- Standards
  - BIPM

Global Geodetic Observing System

- Established by IAG
  - 2003 as IAG Project; 2007 as full component of IAG
- *The* observing system of the IAG
  - Organize the technique-specific Services under one unifying umbrella
  - Form a comprehensive geodetic observing insrument
  - Integrate the hitherto separate pillars of geodesy (shape, rotation, and gravity) into one consistent observing system
- Provide the geodetic expertise and infrastructure needed to monitor the Earth system and to conduct global change research
  - IAG Commissions and Services are the backbone of GGOS
- Represents IAG in GEO & contributes to GEOSS



(1) GGOS is built upon the foundation provided by the IAG Services, Commissions, and Inter-Commission Committees



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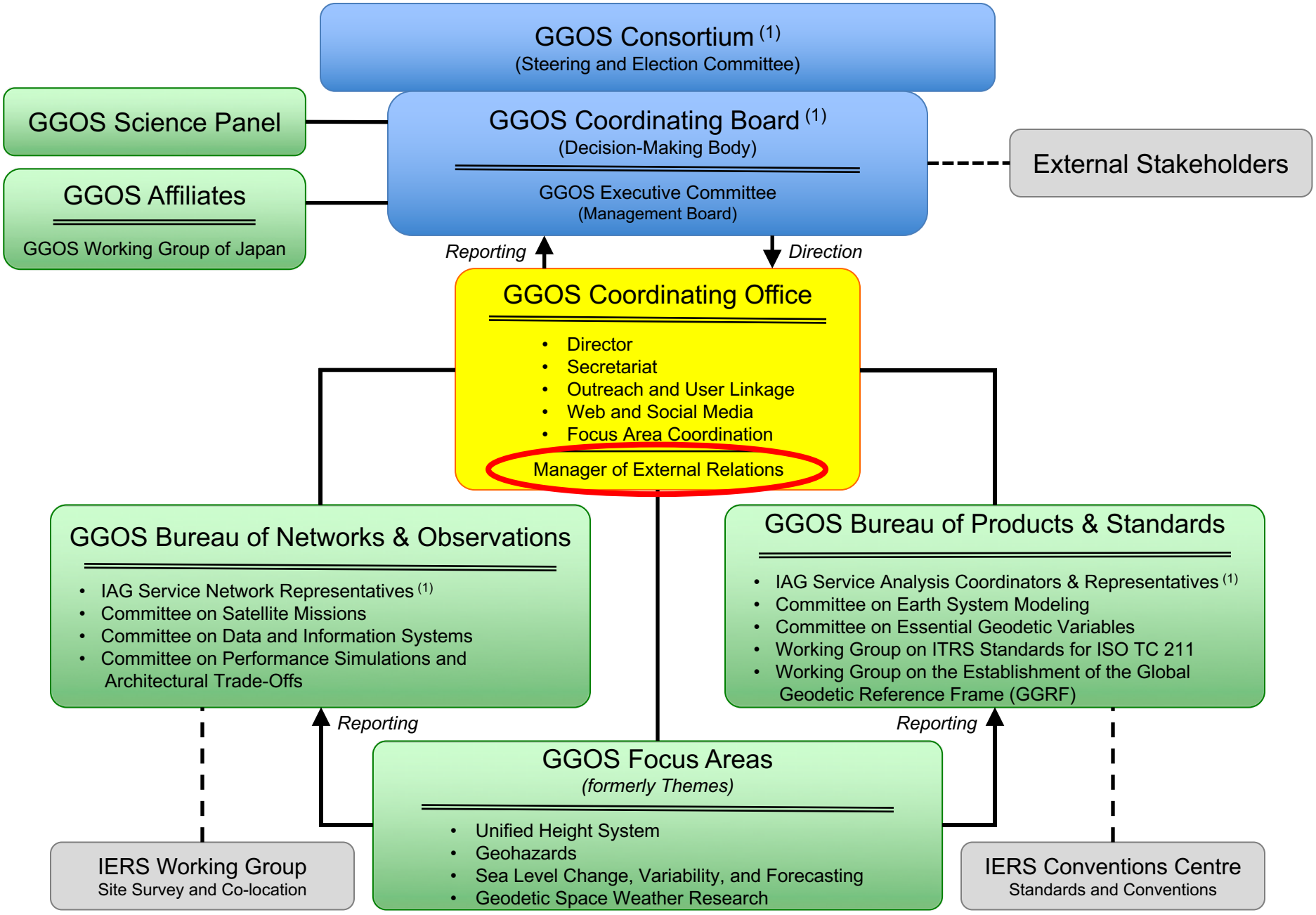
GGOS Affiliate

- National or regional organization
  - That coordinates space-geodetic activities there
- Established to increase participation in GGOS
  - Particularly from under-represented areas
    - Africa, Asia, South and Central America
- Is a component of GGOS
  - With representation on Consortium and Coordinating Board
    - Each GGOS Affiliate has 1 representative to Consortium
    - Collectively they have 2 representatives to Coordinating Board
- First GGOS Affiliate
  - GGOS Working Group of Japan
    - Established in 2013; Chair: Toshi Otsubo of Hitotsubashi University, Japan
    - Provides forum for multi-technique, space-geodetic discussions within Japan
    - Strives to improve quality of observations & encourage collaboration in Japan
- Encourage others to become GGOS Affiliates
  - Particularly important for nations/regions where multiple agencies own space-geodetic equipment



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Manager of External Relations

- Expanding involvement in external organizations
  - Group on Earth Observations (GEO)
    - GGOS Chair appointed to GEO Programme Board for 2018-2020
  - Committee on Earth Observation Satellites (CEOS)
    - Limited participation at present
    - Should be expanded to complement GGOS participation in GEO
  - UN-GGIM Subcommittee on Geodesy
    - Will establish an appropriate governance mechanism for sustaining GGRF
- Requires better approach to managing activities
  - Past approach rather *ad hoc* in nature
    - Volunteer-based
    - Little long-term stability in representation
- Position of Manager of External Relations created
  - To coordinate GGOS engagement with external organizations
    - Resides within GGOS Coordinating Office
    - Appointed by GGOS Chair subject to approval by GGOS Coordinating Board
    - Member of Coordinating Board and Executive Committee
- Allison Craddock selected as first Manager

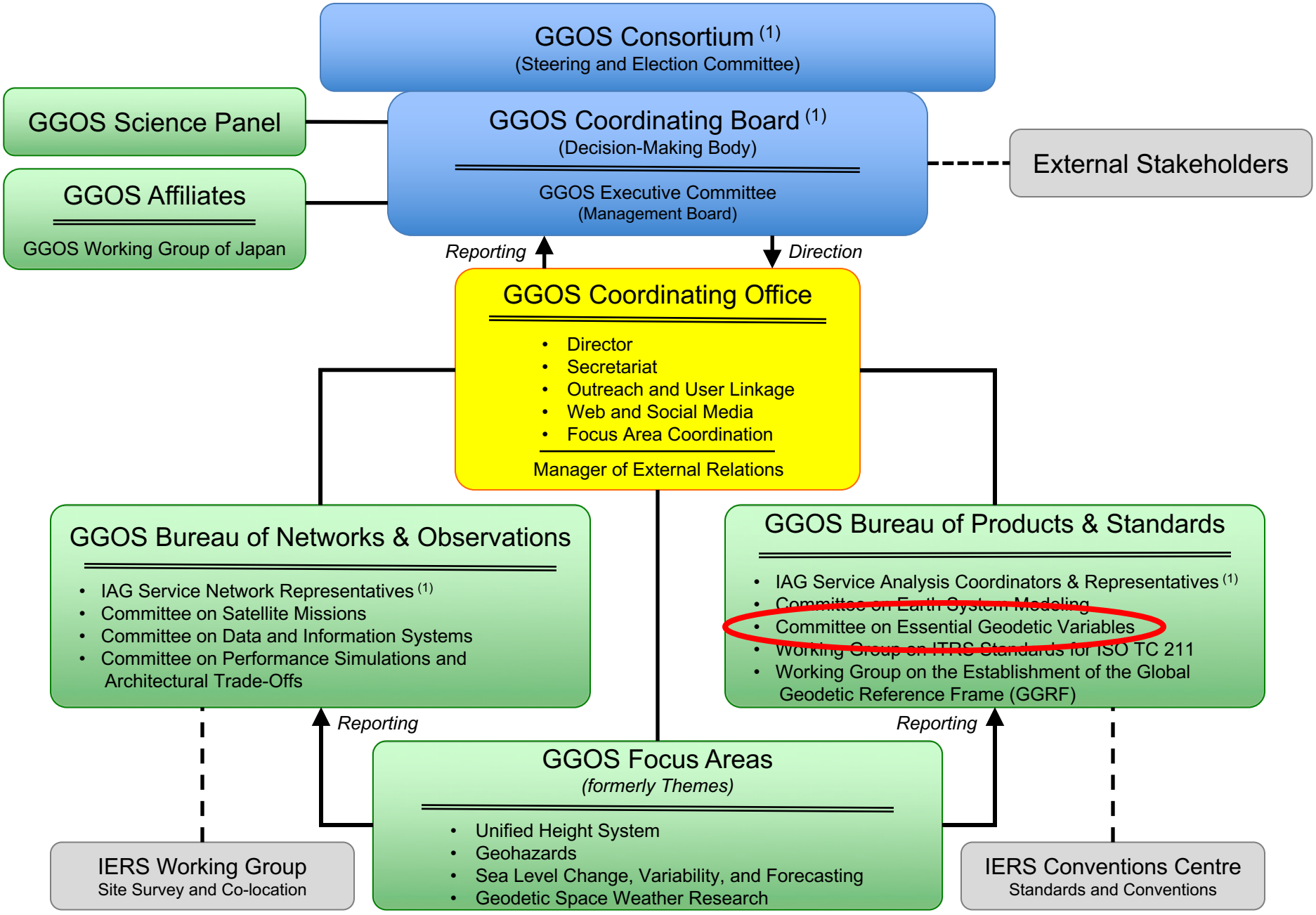
DOIs for Geodetic Data

DOIs for Geodetic Data

- Digital Object Identifiers (DOIs) for publications
  - Widely used by publishers
    - More than 5000 publishers participate in DOI system
  - Unique identifier of publication
    - DOI is resolved into URL where the publication can be found (landing page)
    - Landing page contains abstract of publication, PDF, etc.
  - DOI system managed by International DOI Foundation (IDF)
- DOIs for data sets
  - Benefits to users
    - Easy access to data cited in journal article – just click on DOI
    - Improves traceability of published results – eliminates confusion about data used
    - Improves discoverability of data sets – enables wider distribution of data sets
  - Benefits to data providers
    - Providers can include information about data set on landing page (metadata)
    - Easily allows number of data publications to be tracked
    - Allows number of times data is used to be counted
    - Allows data providers to receive proper credit for their published data

DOIs for Geodetic Data, cont.

- Registration agency
  - Manages DOI to URL mapping
    - Established by interested community (geodetic community)
    - Qualified by International DOI Foundation
  - Develops registration server to share among data providers
    - Registration agency assigns DOI prefix, data provider suffix: doi:prefix/suffix
- Granularity of DOI assignment
  - One data set = one DOI
    - Even if data set is updated
    - Example: IVS contribution to ITRF2014 (data set does not change)
    - Example: IGS Final combined EOPs (data set changes, but not file name)
- Establish Working Group
  - Representatives of Services, data centers
  - Establish procedures for assigning DOIs to geodetic data sets
    - Registration Agency
    - Standardized DOI naming convention
    - etc.



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Essential Variables

- Global Climate Observing System (GCOS)
  - Developed concept of Essential Climate Variables in 1990s
    - To provide guidance for observing critical climate variables in face of declining core observational networks
  - Essential Climate Variables (EGVs)
    - Variable (physical, chemical, biological) critical to characterizing Earth's climate
    - Provide empirical evidence needed to understand and predict evolution of climate, guide mitigation and adaptation measures, assess risks and enable attribution of climatic events to underlying causes, and underpin climate services
    - Identified based on relevance, feasibility, and cost effectiveness
    - Broadly adopted in science and policy circles as basis for prioritized requirements setting and focused, coordinated action
- Global Ocean Observing System (GOOS)
  - Identified Essential Ocean Variables

The Global Ocean Observing System

Essential Ocean Variables

[Click on each EOV for their repsective spec sheets]

PHYSICS	BIOGEOCHEMISTRY	BIOLOGY AND ECOSYSTEMS
Sea state	Oxygen	Phytoplankton biomass and diversity
Ocean surface stress	Nutrients	Zooplankton biomass and diversity
Sea ice	Inorganic carbon	Fish abundance and distribution
Sea surface height	Transient tracers	Marine turtles, birds, mammals abundance and distribution
Sea surface temperature	Particulate matter	Hard coral cover and composition
Subsurface temperature	Nitrous oxide	Seagrass cover
Surface currents	Stable carbon isotopes	Macroalgal canopy cover
Subsurface currents	Dissolved organic carbon	Mangrove cover
Sea surface salinity	Ocean colour *(Spec Sheet under development)*	Microbe biomass and diversity (*emerging)
Subsurface salinity		Benthic invertebrate abundance and distribution (*emerging)
Ocean surface heat flux		

http://www.goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114

The Global Ocean Observing System

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EOV: Sea Surface Height

Variable Information	
Name of Variable (ECV and/or EOV)	Sea Surface Height
Sub-Variables[1]	Sea level anomaly, sea surface height gradients, sea level extremes, tidal range
Derived Variables or Products [2]	Upper ocean heat content, tropical cyclone heat potential, ocean volume variability, sea level rise trends, surface geostrophic currents, data assimilative operational mesoscale ocean forecasts (e.g. Mercator-Ocean; HYCOM; ENSO)
Supporting Variables [3]	Geoid, mean sea surface, geodetic datum, gravity measurements, tidal harmonics, subsurface temperature and salinity, air pressure, sea state, land position, wind stress
Contact/Lead Expert(s) [4]	GLOSS Group of Experts for sea level stations; NASA/CNES Ocean Surface Topography Science Team and Sea Level Change Science Team chairs Coastal Altimetry Worksop chairs; EUMETSAT operational altimetry; Geoid and geodesy expert groups (DTU and NGDC)

EOV: Sea Surface Height

Requirements Settings					
Responsible GCOS/GOOS Panel	OOPC GCOS Implementation Plan/Status Reporting to UNFCCC				
Readiness Level [5]	Mature level 8. Tide gauge network is sparse in developing countries, and is also limited in parts of the Arctic Ocean.				
Phenomena [6] **to capture.**	**Sea Level**	**Coastal shelf exchange processed**	**Circulation**	**Fronts and Eddies**	**Extreme Events**
Temporal Scales of the Phenomena	Monthly	hourly	Weekly	Monthly	hourly
Spatial Scales of the Phenomena (order)	100km	10km	100km	10km	10km
Magnitudes/ range/ thresholds to capture for each process					

EOV: Sea Surface Height

Observation Deployment & Maintenance				
Observing Elements[8]	Satellite Altimetry (OSTST)	Tide gauges (GLOSS)	Moorings (OceanSITES, DBCP)	Tsunami Moorings (DART Network)
Relevant measured parameter(s)	SSH	Relative sea level and SSH	SSH variability	SSH Variability
Sensors /Technique	Pulse limited radar (T/P and Jason heritage); Delayed Doppler SAR-mode radar (CryoSat heritage)	Tide gauges	Bottom pressure/ inverted echo sounder	Bottom Pressure
Phenomena addressed	Circulation Sea Level Fronts and Eddies	Sea Level Extreme Events	Sea Level Circulation Extreme Events	Sea Level Extreme Events
Readiness Level [1]	Mature level 8 (sustained observations require better interagency collaboration)	Mature level 8	Mature level 7	Mature 8
Spatial sampling	1-D along-track ~30 km; 2-D ~100 km with multiple altimeters	Point samples	Point samples; networks at tens of km spacing	Specific locations
Temporal sampling	A few days with multiple altimeters	Better than 1 Hz to several samples per hour	Better than 1 Hz to several samples per hour	<hourly
Special Characteristics/ Contributions	Global coverage; greater precision with reprocessing; greater accuracy along repeat orbit ground-tracks; less accuracy with where geoid less certain near coast, shelf-edge, and in ice-covered regions	High precision and accuracy	High precision	Real time data delivery, continuous observations
Random Uncertainty estimate (units, one standard dev).	2 cm for 1 Hz (7-km) along-track sample; 5 mm for 10-day average analysis; 0.4 mm for yearly averages	1-5 cm for hourly average		
Uncertainty in the bias Units, one standard deviation)	Unknowable?	?		

OOPC_SSH_Specification_v5.2.pdf

EOV: Sea Surface Height

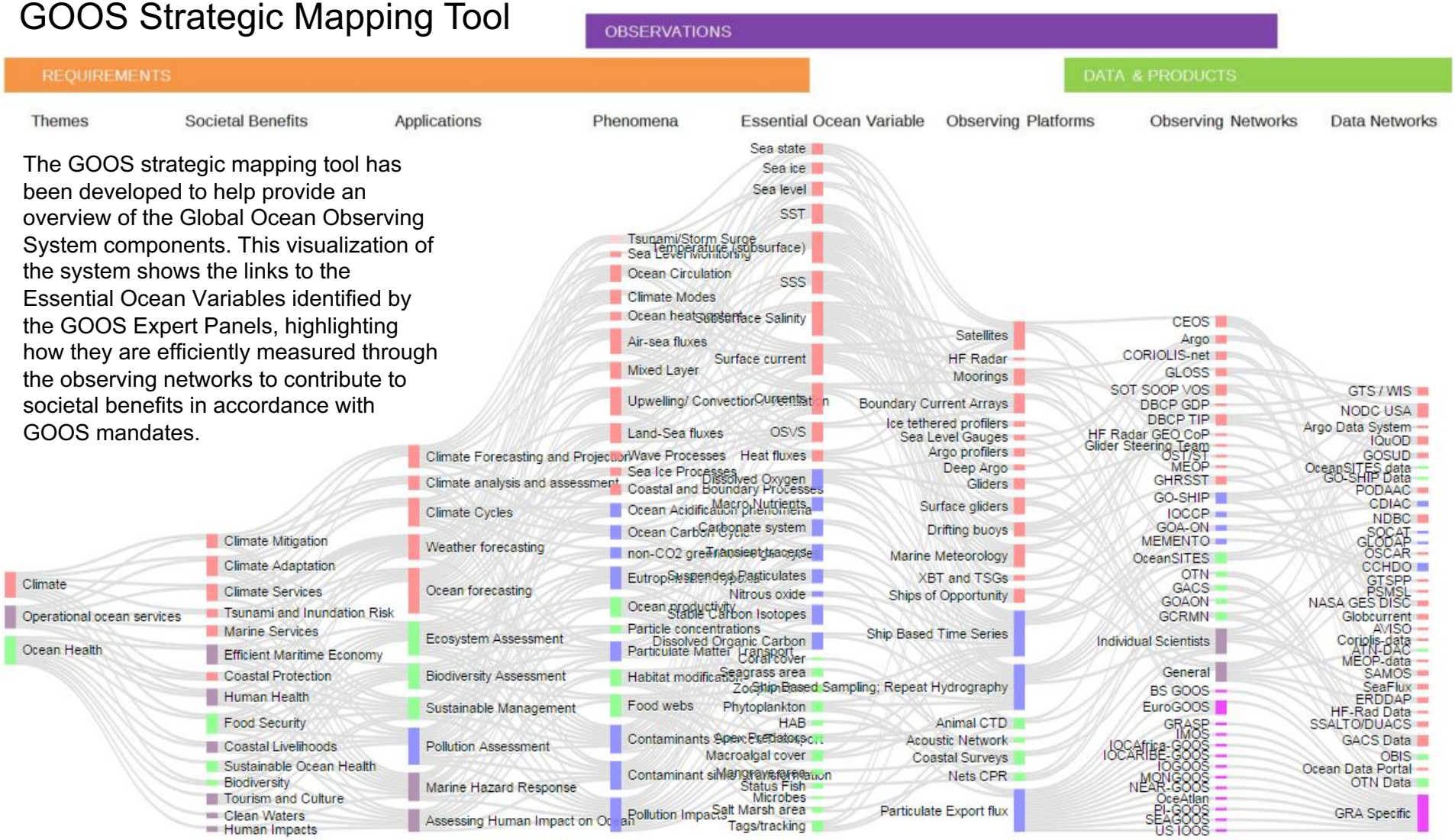
Future observing Elements		
Observing Elements	Satellite Swath altimetry	
Relevant measured parameter(s)	SSH; gradient(SSH)	
Sensors	cross-track interferometer based	
Phenomena addressed	Circulation Sea Level Fronts and Eddies Coastal Shelf Processes	
Readiness Level [1]	Pilot/Concept 3-4. Commitment to mission but won't fly until 2020. Active development of potential applications, and error budget; AirSWOT prototype	
Spatial sampling	1 km x 1 km; 120-km wide swath	
Temporal sampling	22 day repeat at nadir; 3-day repeat sub-cycle some tracks; 3 to 7 day revisit within swath view depending on latitude	
Special Characteristics or Contribution	Very high spatial resolution; 2-D swath gives vector SSH gradient	
Estimated time when part of the observing system	2020	
Random Uncertainty estimate (units, 1 standard deviation).	Order 1 cm	
Uncertainty in the bias Units, one standard deviation)		

OOPC_SSH_Specification_v5.2.pdf

The Global Ocean Observing System

GOOS Strategic Mapping Tool

The GOOS strategic mapping tool has been developed to help provide an overview of the Global Ocean Observing System components. This visualization of the system shows the links to the Essential Ocean Variables identified by the GOOS Expert Panels, highlighting how they are efficiently measured through the observing networks to contribute to societal benefits in accordance with GOOS mandates.



http://www.goosocean.org/index.php?option=com_content&view=article&id=120&Itemid=277

Essential Geodetic Variables

- Observed variables
  - Crucial to characterizing geodetic properties of Earth
  - Key to sustainable geodetic observations
    - Positions of reference objects (ground stations, radio sources), EOPs
    - Gravity measurements (ground-based, space-based)
- Assign requirements to each EGV
  - Accuracy, spatial and temporal resolution, latency, stability, …
- Derive requirements
  - On EGV-dependent products (TRF, CRF, …)
  - On infrastructure (observing systems)
- Can be used to update GGOS2020 book
  - Bottoms-up approach to deriving requirements
    - Complements top-down approach used in GGOS2020 book (user needs)
- Establish Committee within GGOS BPS
  - To create list of EGVs, assign requirements to them, etc.
  - Committee will include representatives of
    - IAG Services, Commissions, Intercommission Committees, GGOS Focus Areas

Committee on EGVs

GGOS
- Detlef Angermann (Germany)
- Richard Gross, Chair (USA)
- Harald Schuh (Germany)

GGOS Focus Area 1
(Unified Height System)
- Bernhard Heck (Germany)

GGOS Focus Area 2
(Geohazards Monitoring)
- Diego Melgar (USA)

GGOS Focus Area 3
(Sea Level Change)
- Don Chambers (USA)

GGOS Focus Area 4
(Space Weather)
- Ehsan Forootan (UK)

IAG Commission 1
- Markus Rothacher (Switzerland)
- Geoffrey Blewitt (USA)

IAG Commission 2
- Kosuke Heki (Japan)
- Thomas Gruber (Germany)

IAG Commission 3
- Jianli Chen (USA)
- Jose Ferrandiz (Spain)

IAG Commission 4
- Jens Wickert (Germany)
- Pawel Wielgosz (Poland)

IAG ICC Theory
- Yoshiyuki Tanaka (Japan)
- Mattia Crespi (Italy)

IERS
- Tom Herring (USA)

IGS
- Tom Herring (USA)
- Michael Moore (Australia)

ILRS
- Erricos Pavlis (USA)
- Jürgen Müller (Germany)

IVS
- John Gipson (USA)
- Johannes Böhm (Germany)

IDS
- Laurent Soudarin (France)
- Jean-Michel Lemoine (France)

IGFS
- Urs Marti (Switzerland)
- Georgios Vergos (Greece)

BGI
- Sylvain Bonvalot (France)

ICGEM
- E. Sinem Ince (Germany)

ISG
- Jianliang Huang (Canada)

IGETS
- Hartmut Wziontek (Germany)
- Jean-Paul Boy (France)

IDEMS
- Christian Hirt (Germany)
- Michael Kuhn (Australia)

PSMSL
- Lesley Rickards (UK)

BIPM
- TBD

Total: 35

Essential Polar Motion Variables

Variable Information

- Name of variable
  - Polar motion (PMX, PMY)
- Sub-variables
  - Polar motion rate (PMX-rate, PMY-rate)
- Derived variables or products
  - Excitation functions (chi-x, chi-y)
- Supporting variables
  - Longitude of observing stations (for LLR)
- Contact/lead expert(s)
  - IERS

Current Observing Elements

Responsible Service	IVS	ILRS	ILRS	IGS	IDS
Relevant Parameters	Polar motion	Polar motion	Variation of latitude	Polar motion	Polar motion
Sensors/Technique	VLBI	SLR	LLR	GNSS	DORIS
Readiness Level	Maturity level 8	Maturity level 8	Maturity level 8	Maturity level 8	Maturity level 7
Temporal resolution	1-day	1-day		1-day (UR, R, F)	1-day
Latency				3-9 hours (UR) 17-41 hours (R) 11-17 days (F)	
Uncertainty (Current Capability)				50 μas (UR) 40 μas (R) 30 μas (F)	
Uncertainty (Future Requirement)					

Future Observing Elements

Observing Element	GNSS	Ring Laser Gyroscope	Superfluid Helium Gyroscope
Relevant Parameters	Polar motion	Rotation vector	
Sensors/Technique			
Readiness Level	Maturity level 6	Maturity level 4	Maturity level 2
Temporal Resoluiton			
Latency	Near real time		
Uncertainty (Current Capability)			


شكراً جزيلاً
thank you
danke
рахмат
謝謝
ngiyabonga
teşekkür ederim
Баярлалаа
спасибо
mersi
kia ora
barka
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vinaka
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blagodaram
dank je
misaotra
matondo
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grazzi
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