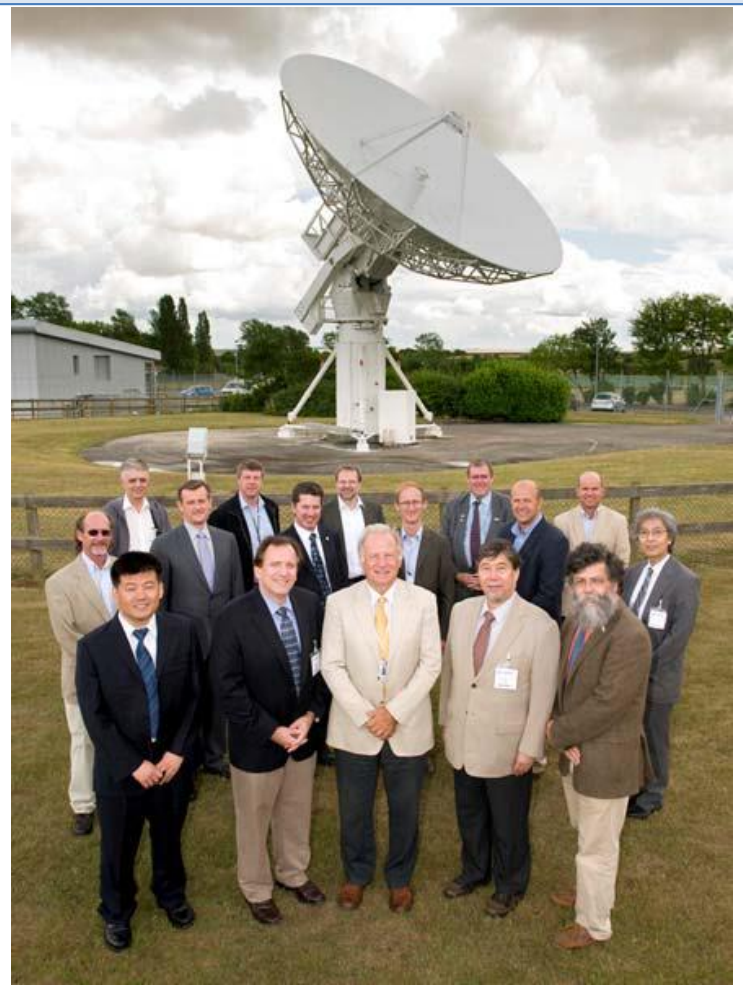
Space Agency Contributions in Support of the Paris Agreement

Jörg Schulz, EUMETSAT, Chair Joint CEOS/CGMS Working Group on Climate

M. Dowell (EC) and D. Crisp (NASA)

and contributions from many experts

WGClimate: Short History



- CEOS Working Group on Climate endorsed at CEOS Plenary in 2010;
- The joint development of the high-level architecture for climate monitoring from space led to the formation of the Joint CEOS/CGMS WGClimate endorsed by CEOS and CGMS Plenaries in 2013;
- Major Task is: Coordinate and encourage collaborative activities between the world's major space agencies in the area of climate monitoring.

JWGClimate
Chair: Jörg Schulz (EUMETSAT)
Vice Chair: Albrecht von Bargen (DLR)

WMO Global Framework for Climate Services (GFCS)

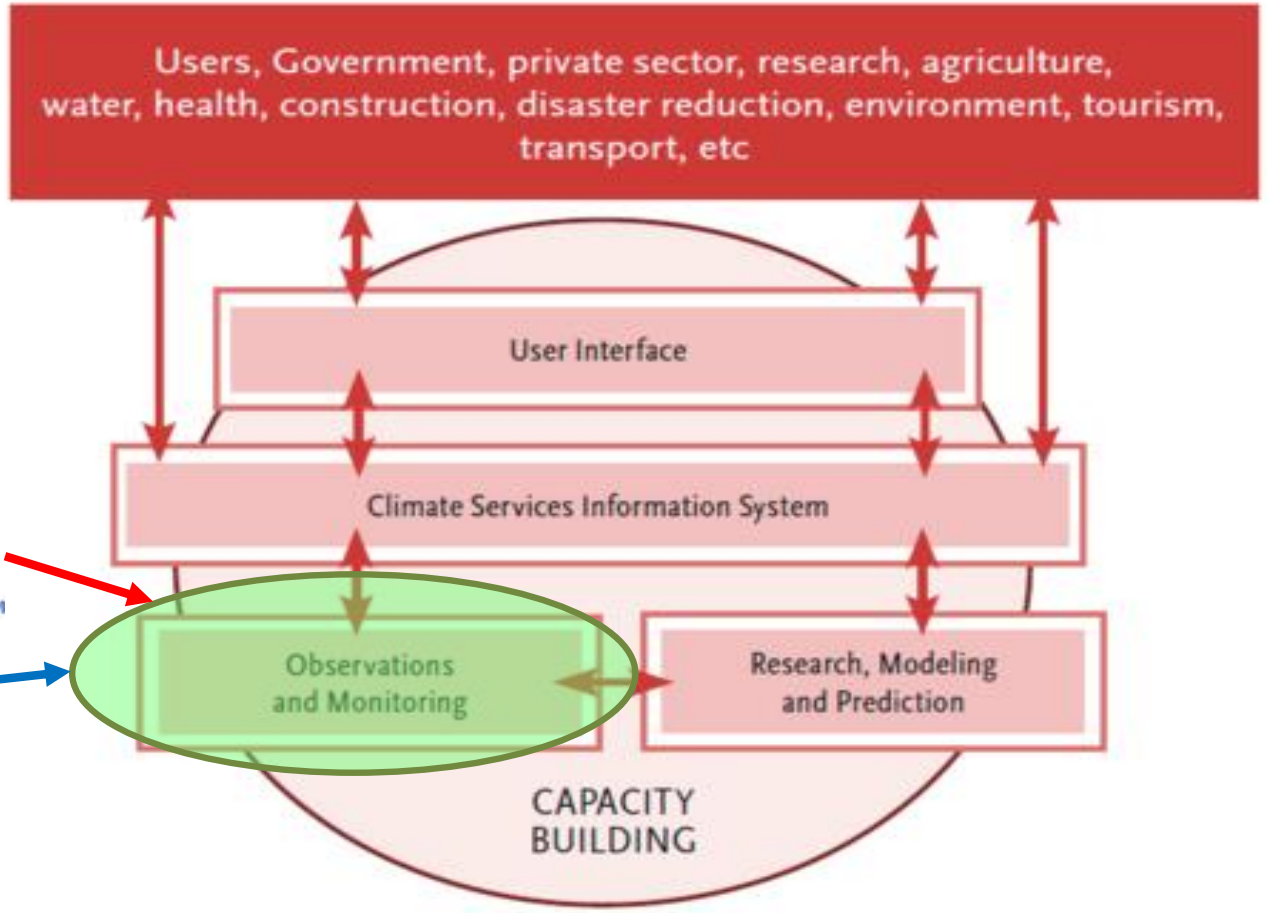
The Vision of GFSC:

"Enable better management of adaptation to climate change through the development and incorporation of science-based climate information and prediction into planning, policy and practice"

GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

WGClimate
The Joint CEOS/CGMS Working Group on Climate

Space Agency contribution



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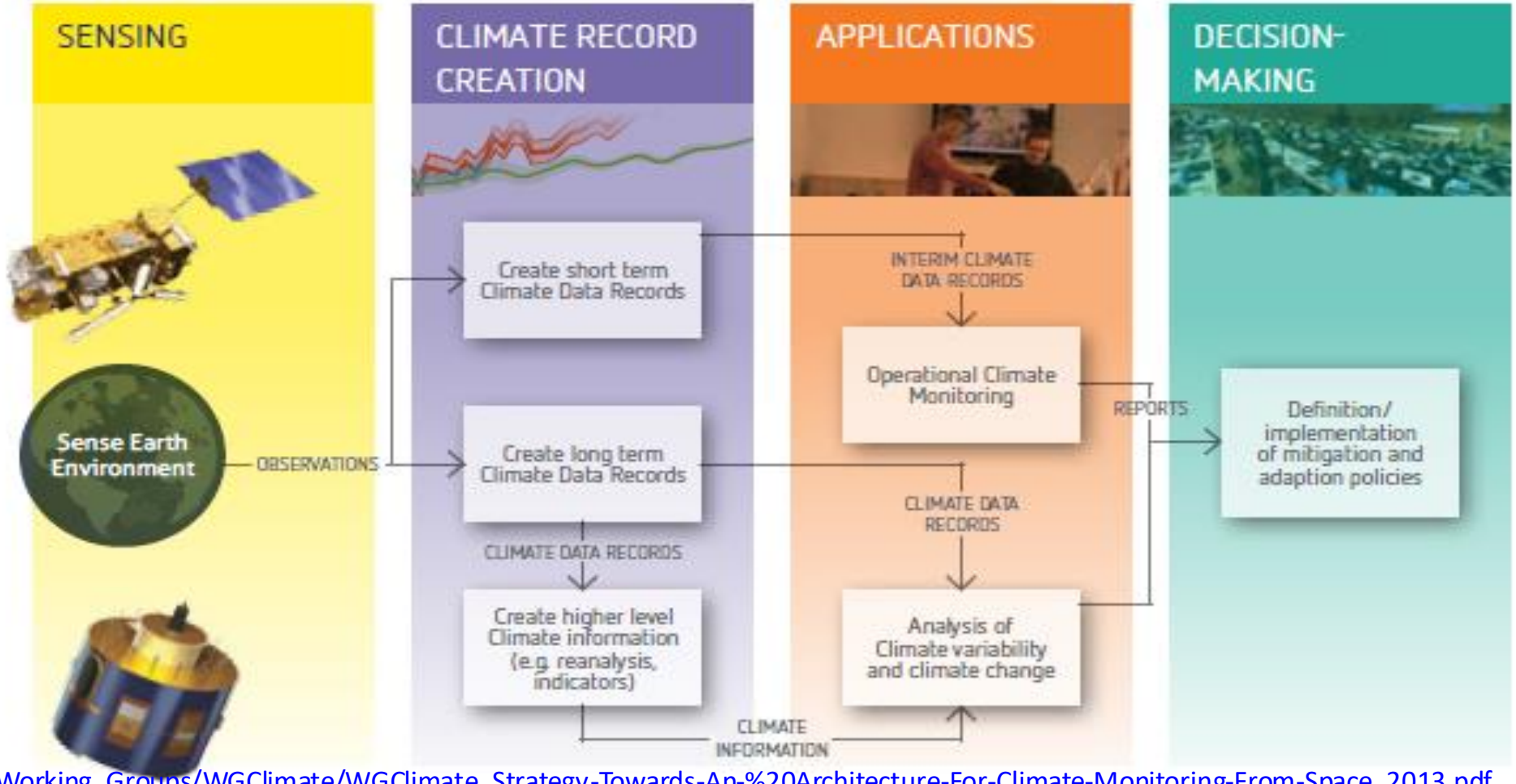
The Architecture for Climate Monitoring from Space



http://ceos.org/document_management/Working_Groups/WGClimate/WGClimate_Strategy-Towards-An-%20Architecture-For-Climate-Monitoring-From-Space_2013.pdf

The Paris Agreement

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

- The 2015 United Nations Framework Convention on Climate Change (UNFCCC) Agreement entered into force on 4 November 2016;
- To this date, 185 Parties have ratified of 197 Parties to the Convention;
- The Paris Agreement will drive climate policy during the next two decades and beyond.

Major Aims

AIMS

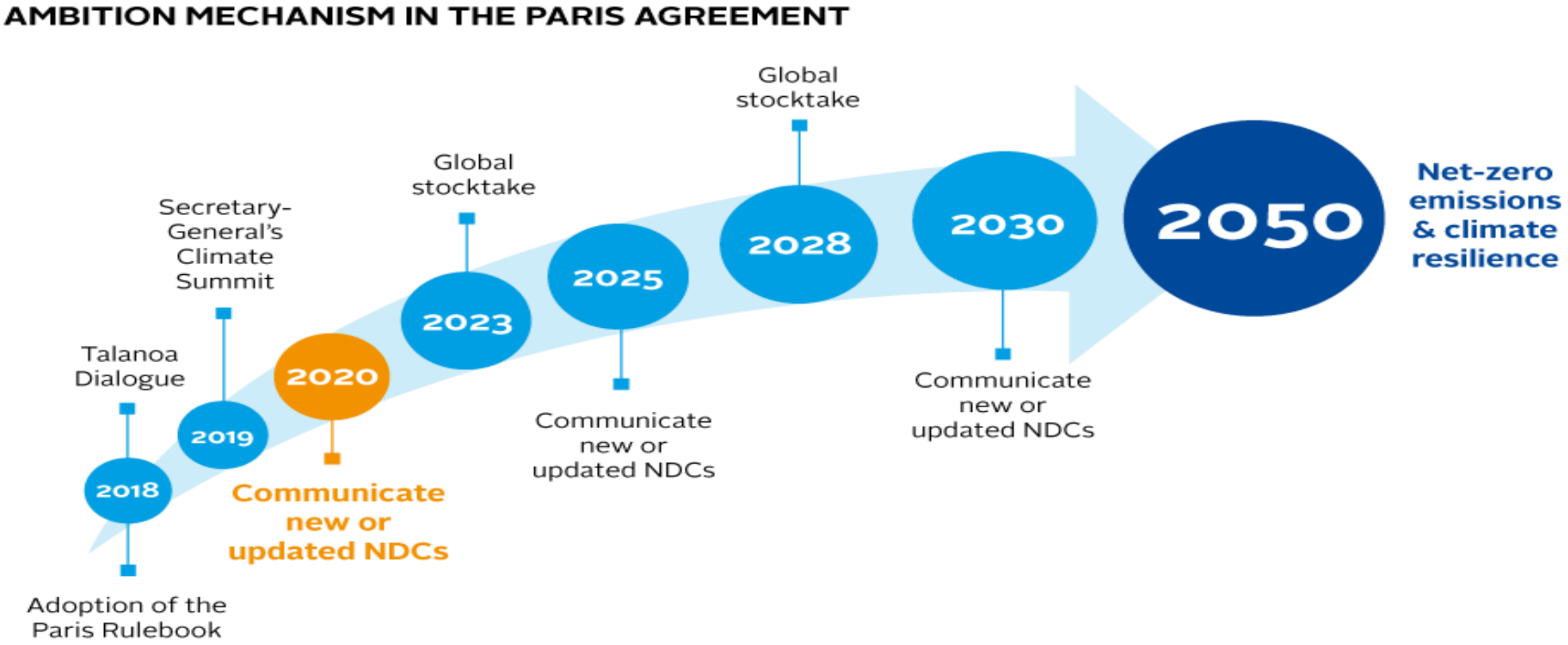
Limit the temperature increase to well below 2°C and targeting 1.5°C above pre-industrial levels.

Improve the ability to adapt to adverse impacts of climate change.

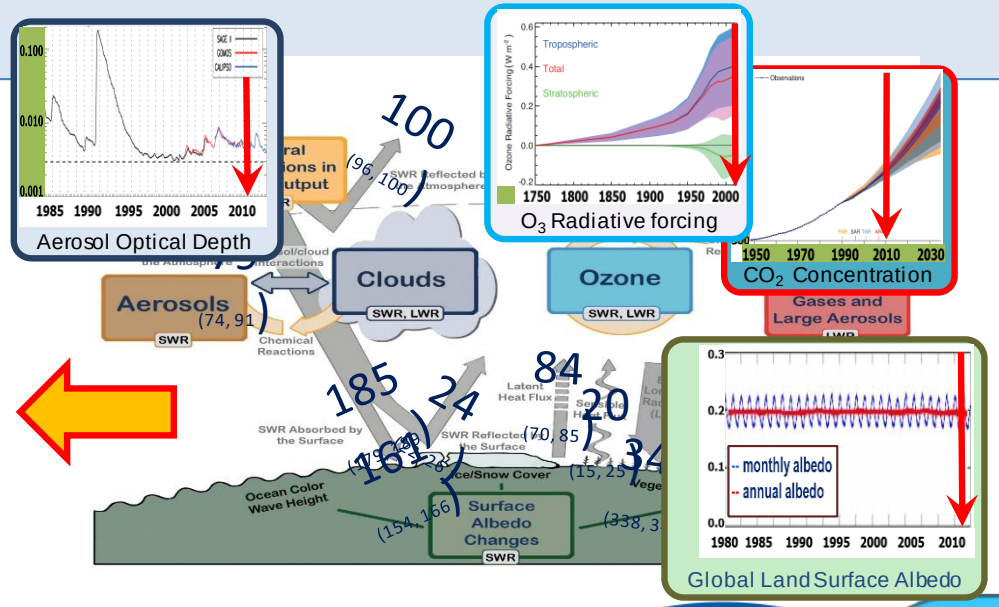
Make finance flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development.

- The first two aims can be supported by observations including satellite data.

The Ambition at COP-24 (2018)



Contributions



IPCC reports
SBSTA reports

Potential for satellite data

- NDC: Global and regional constraints on GHG sources and sinks;
- Adaptation, loss & damage: (de)forestation, changes in disaster impacts (storms, floods, drought), sea level rise, evolution of urban areas, etc.

ASSESS PROGRESS

- Transparency Framework (Art. 13)
  - Reporting
- Global Stocktake (Art. 14)
  - Facilitate
- Committee to facilitate compliance (Art.15)

Increasing ambition

5-year reviews

ACTIONS

- Nationally Determined Contributions (Art. 4)
- Conservation of Sinks and REDD+ (Art. 5)
- Voluntary Cooperation & non-market mechanisms (Art. 6)
- Improvement of adaptive capacity (Art. 7)
- Loss and Damage (Art. 8)
- Provision of financial support (Art. 9)
- Technology transfer (Art. 10)
- Capacity Building (Art. 11)
- Education and public awareness (Art 12)

UNFCCC/GCOS – CEOS/CGMS Relations

United Nations Climate Change

COP-21 Paris Agreement: Adaptation (Article 7(c)):
Strengthening scientific knowledge on climate, including research, **systematic observation of the climate system** and early warning systems, in a manner that informs climate services and supports decision-making.

Reports on Progress @ SBSTA/COP

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Needs and Requirements

Coordinated Response

GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

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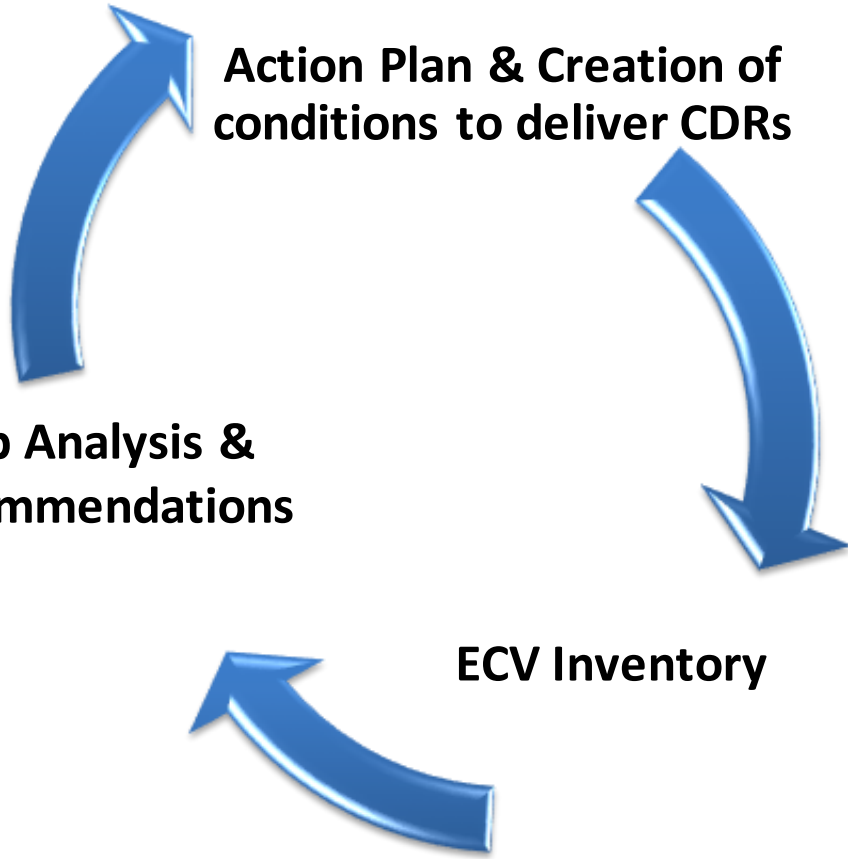
ECV Inventory - Resource for Coordinated Response to GCOS

http://climatemonitoring.info/ecvinventory



Existing data records | Planned data records | *Details (existing)*

Refresh

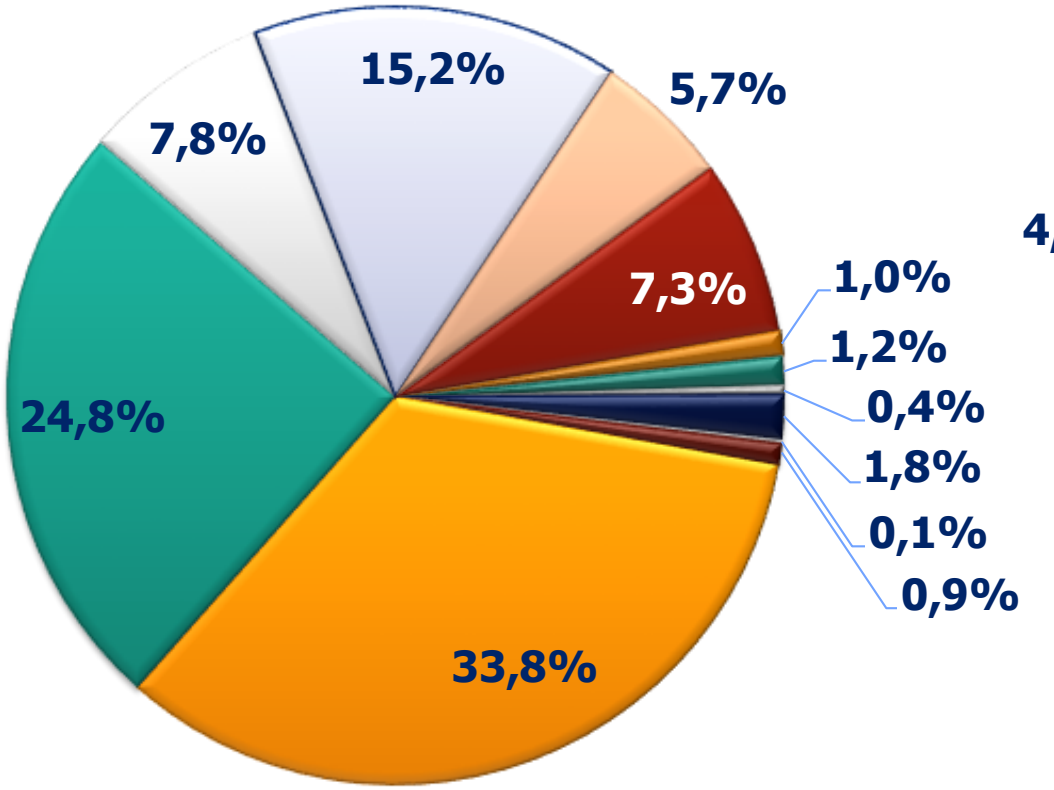
Detailed information for existing data record

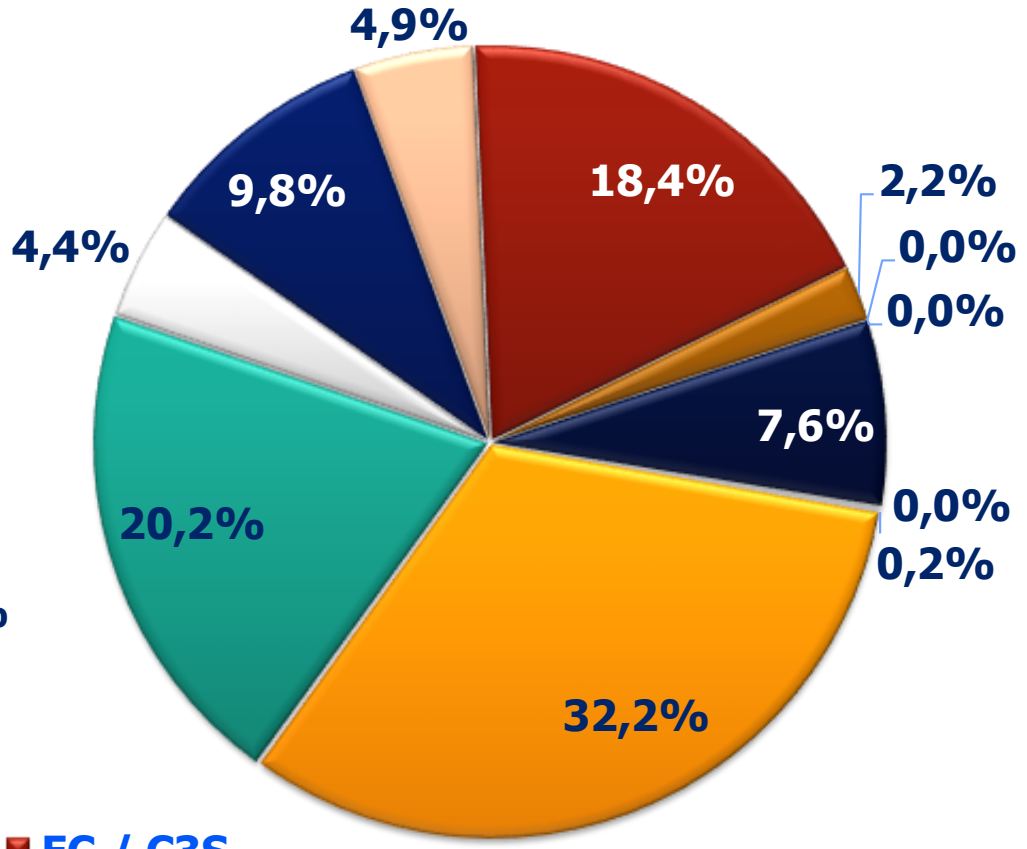
Record Information | Stewardship | Generation Process | Record Characteristics | Documentation | Accessibility | Applications

Responder name		Rainer Hollmann
Responder E-mail		rainer.hollmann@dwd.de
Co-editor E-mail (optional)		
Observer E-mail (optional)		
Data Record identification	Data record identifier	http://dx.doi.org/10.5676 ... M_SAF_CM/CLARA_AVHRR/V001
	Data record name and version (optional)	CLARA-A1
	TCDR family	CLARA
	Official citation reference (optional)	Karlsson et al. 2012: CM SAF cLouds, Albedo and Radiation dataset from AVHRR data - Edition 1 - Monthly Means / Daily Means / Pentad Means / Monthly Histograms. Satellite Application Facility on Climate Monitoring. DOI:10.5676/EUM_SAF_CM/CLARA_AVHRR/V001. http://dx.doi.org/10.5676 ... M_SAF_CM/CLARA_AVHRR/V001 publication reference: Karlsson et al. 2013: http://doi.org/10.5194/acpd-13-935-2013
Responsible Organisation		EUMETSAT (CM SAF)
Collection Organisation		NOAA (USA)
Calibration Organisation		NOAA (USA) EUMETSAT (CM SAF)
FCDR Organisation		EUMETSAT (CM SAF)
Inter-calibration Organisation		EUMETSAT (CM SAF)
TCDR Organisation		EUMETSAT (CM SAF)
GCOS Requirements Organisation		EUMETSAT

CDR Inventory Contributions
Inventory #3 (Provisional)

Existing: 817
Planned: 481
Total: 1298



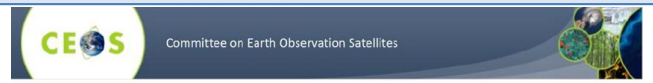


NASA EUMETSAT CNES ESA NOAA EC / C3S
UKSA USGS JMA JAXA KMA Others

Greenhouse Gas Monitoring

CEOS/CGMS provided a white paper describing a constellation architecture for monitoring atmospheric CO2 and CH4 concentrations and their natural and anthropogenic fluxes from space[1] to support climate policy

- 166-page document, 88 authors representing 47 organizations
- Executive Summary (2 pages)
  - Overview of objectives and approach for policy makers, CEOS/CGMS Agency leads
- Body of report (75 pages)
  - Science background and requirements, current and near-term mission heritage and system implementation approach, intended for program scientists and project managers
- Technical Appendices (42 pages)
  - "Textbook" summarizing state-of-the-art in measurements and models for scientists, engineers, and inventory community



A CONSTELLATION ARCHITECTURE FOR MONITORING CARBON DIOXIDE AND METHANE FROM SPACE

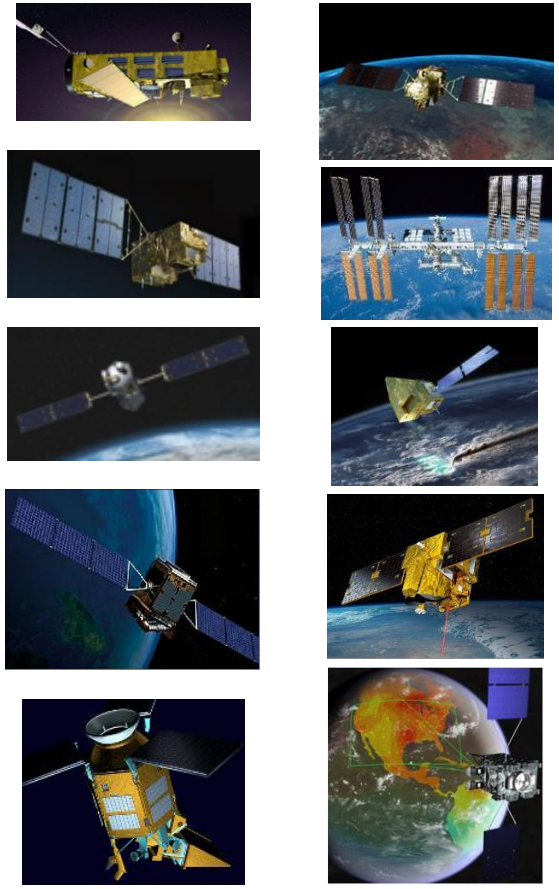
Prepared by the CEOS Atmospheric Composition Virtual Constellation Greenhouse Gas Team

Version 1.2 – 11 November 2018

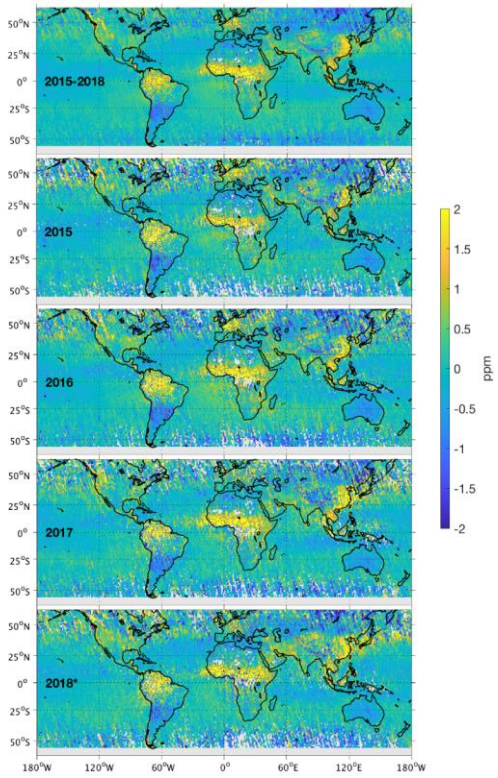
[1] http://ceos.org/document_management/Virtual_Constellations/ACC/Documents/CEOS_AC-VC_GHG_White_Paper_Publication_Draft2_20181111.pdf

Collecting GHG Observations from Space
The Evolving Fleet

- **Space agencies have supported a series of pioneering space-based GHG sensors including:**
  - ESA's ENVISAT SCIAMACHY,
  - Japan's GOSAT TANSO-FTS, NASA's OCO-2, China's TanSat AGCS, Feng Yun-3D GAS and Gaofen-5 GMI, Copernicus Sentinel 5 Precursor TROPOMI.
- **Other space-based sensors have just been added to the fleet:**
  - Japan's GOSAT-2 TANSO-FTS-2 and NASA's ISS OCO-3
- **Others are under development:**
  - CNES MicroCarb, CNES/DLR MERLIN, NASA's GeoCarb
- **The next step - purpose-built GHG constellations**
  - The Copernicus CO_2 Sentinel



Space-based Measurements are Only One Component of an Atmospheric GHG Inventory System



Observations

- **Satellite Measurements of CO_2 and CH_4**
- **Ground and Airborne Measurements of CO_2 and CH_4**
- **Meteorology** Satellite & in-situ
- **Auxiliary Data** Satellite observations of CO, NO_2, clouds, aerosols ...

Prior Information

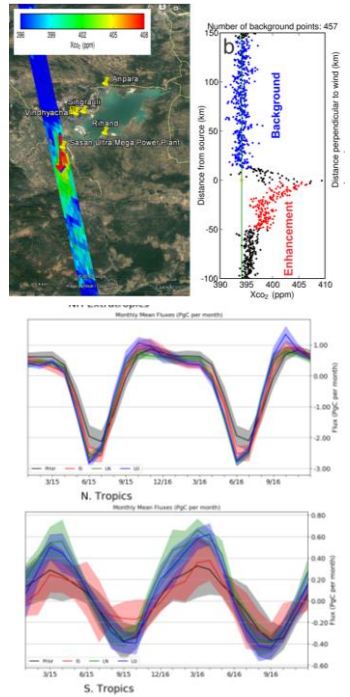
Fluxes, model parameters, emission reports, economic statistics.

Integration & Attribution

- **Estimation system** Data assimilation and uncertainty estimation
- **Models** Transport, land & ocean carbon cycle, fossil fuel emissions.

Outputs

- **CO_2 and CH_4 emissions & removal Hot-spots** with uncertainties
- **Country/region CO_2 and CH_4 emissions & removals** with uncertainties
- Other Carbon Cycle Products

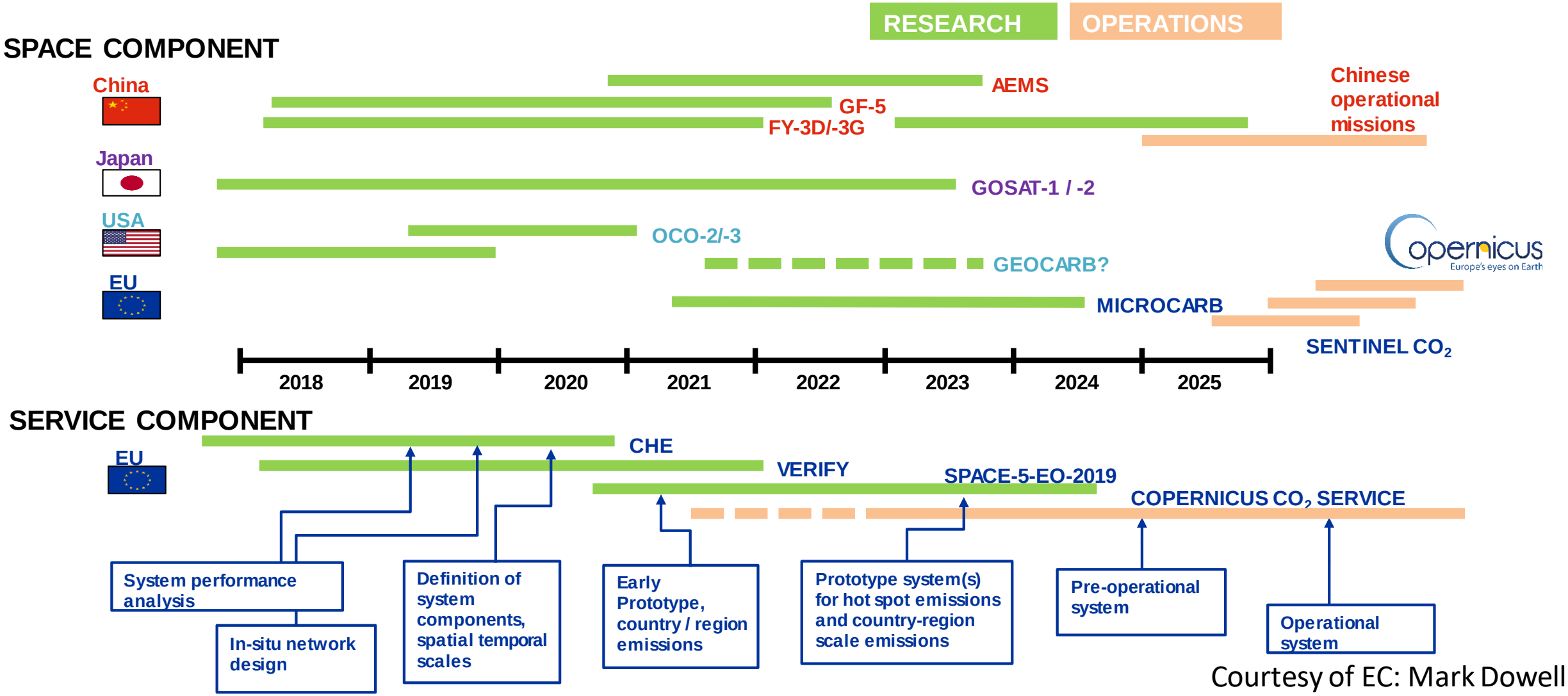


Developing Atmospheric GHG Inventories

The GHG White Paper recommends the following process:

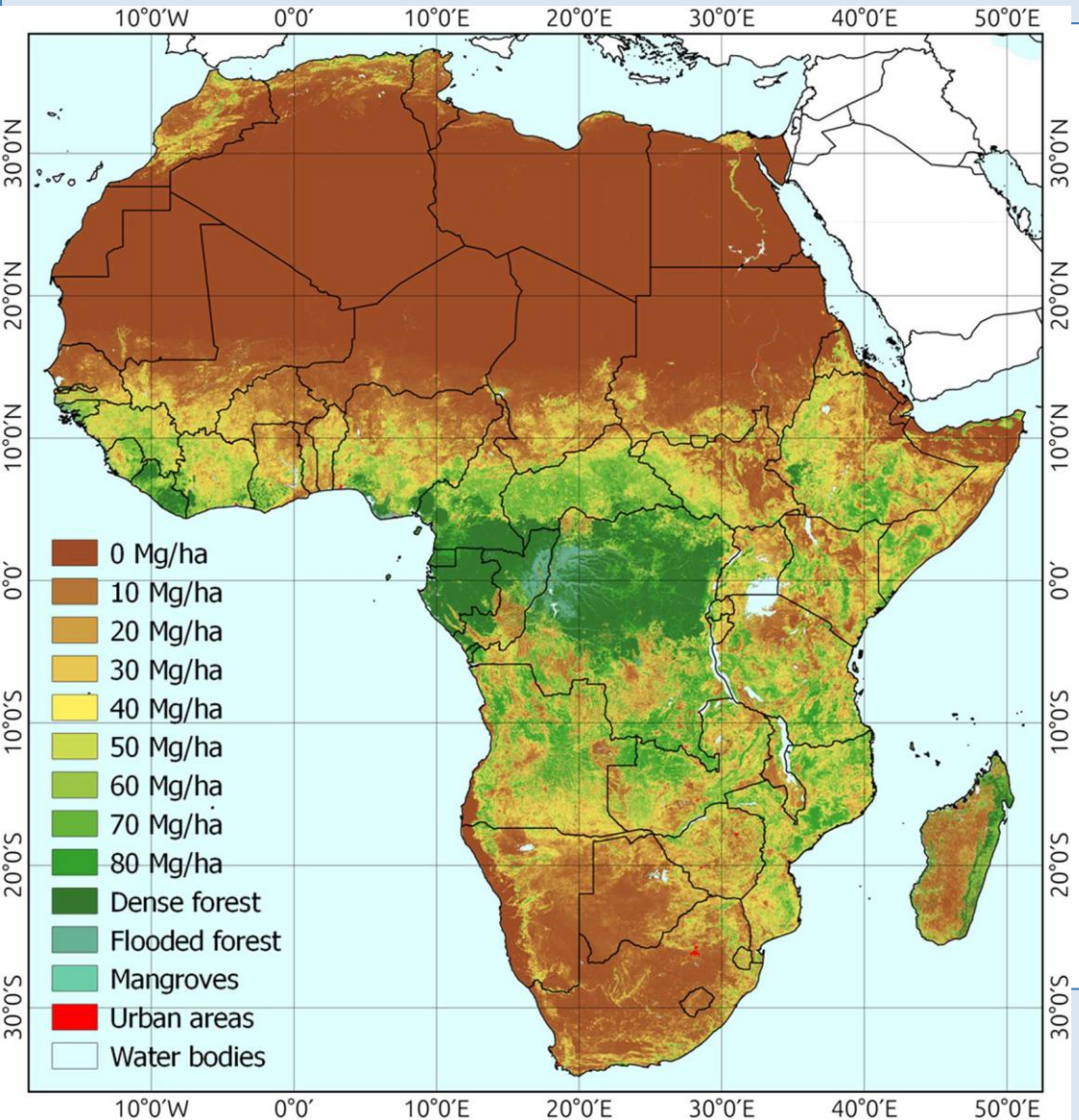
1. Foster collaboration between the space-based and ground-based GHG measurement and modeling communities and stakeholders in the inventory and policy communities to **refine the requirements and implementation plans for top-down atmospheric flux inventories;**
2. Exploit the capabilities of the Committee on Earth Observation Satellites (CEOS), Coordination Group on Meteorological Satellites (CGMS) and the WMO Integrated Global Greenhouse Gas Information System (IG3IS) to **produce a prototype atmospheric CO2 and CH4 flux product that is available in time to inform the bottom-up inventories for the 2023 global stocktake**; and
3. Use the lessons learned from this prototype flux product to **refine the requirements for a future, purpose-built, operational, atmospheric inventory system that more completely addresses the inventory process** in time to support the 2028 global stocktake.

Roadmap for an Operational CO_2 Emissions Monitoring Service



Courtesy of EC: Mark Dowell

Above Ground Biomass



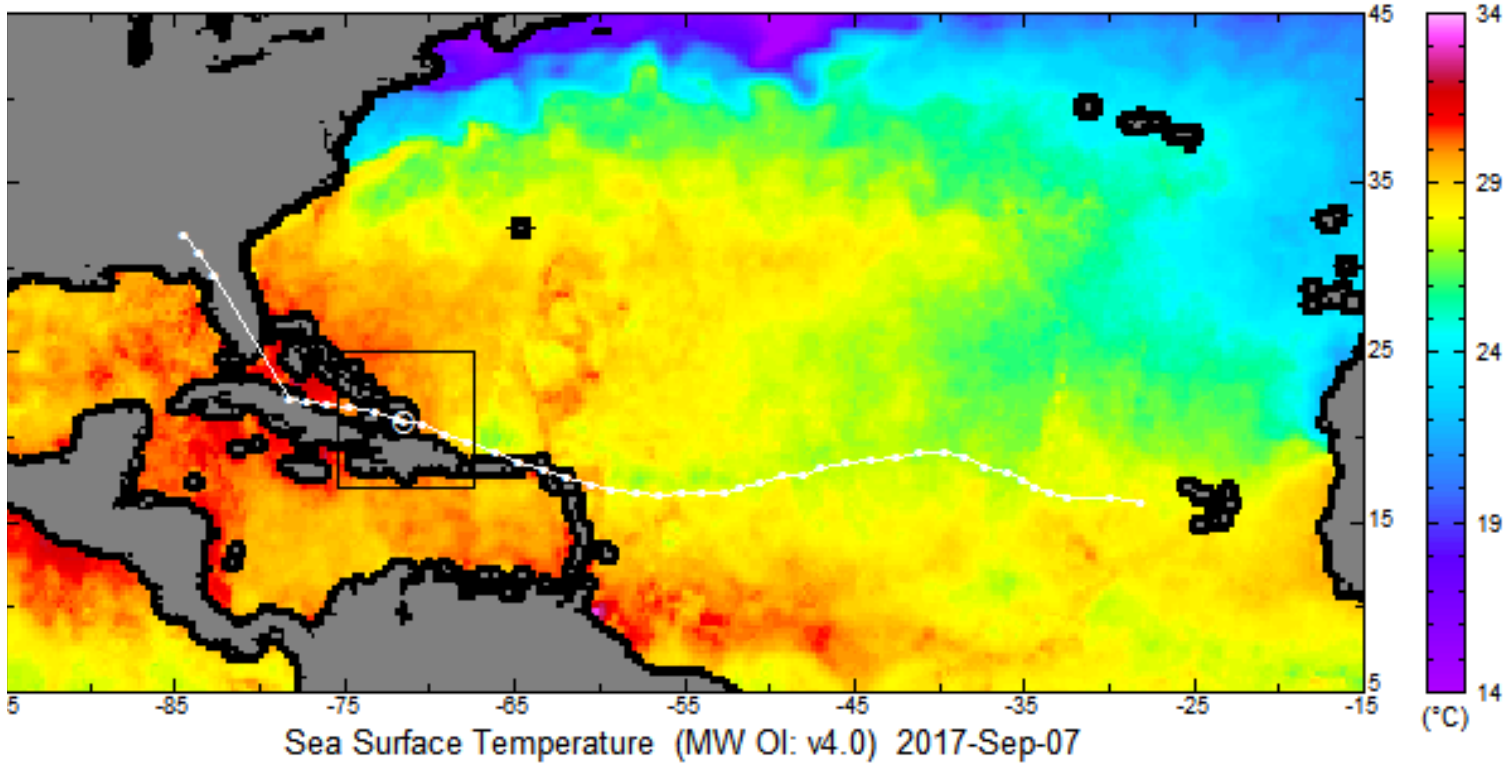
- Above-ground biomass map of African savannahs and woodlands at 25 m resolution derived from the 2010 ALOS L-band PALSAR mosaic (JAXA).
- Dense forest and non-vegetated areas are mapped out using land cover data sets;
- RMSD of 8 to 17 $Mg \cdot ha^{-1}$;
- The data are used to derive carbon stocks.

Bouvet A. , S. Mermoz, T. Le Toan, L. Villard, R. Mathieu, L. Naidoo, G. P. Asner, An above-ground biomass map of African savannahs and woodlands at 25m resolution derived from ALOS PALSAR, Remote Sensing of Environment, 206, 2018, 156-173.

Intensity of Cyclones and Upper Ocean

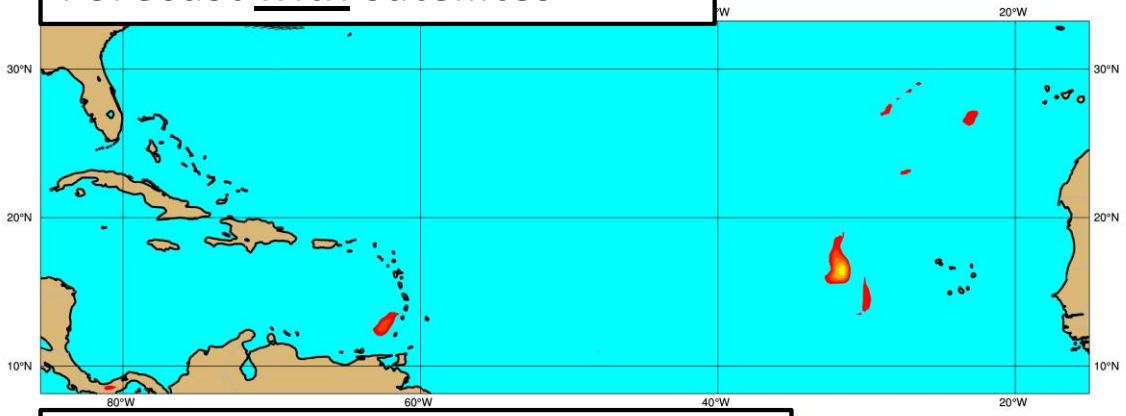
Category 5 hurricane (SSHWS)

Duration	August 30 – September 12
Peak intensity	180 mph (285 km/h) (1-min) 914 mbar (hPa)

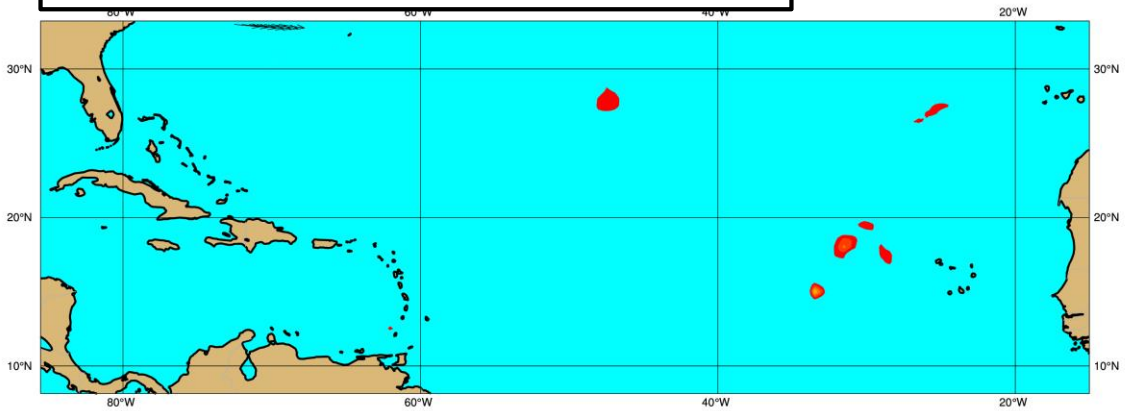


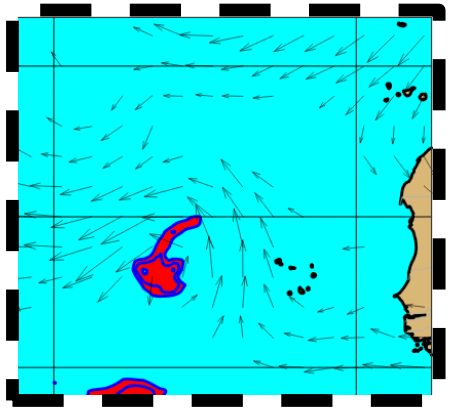
Weather Impacts and Preparedness

Forecast with satellites



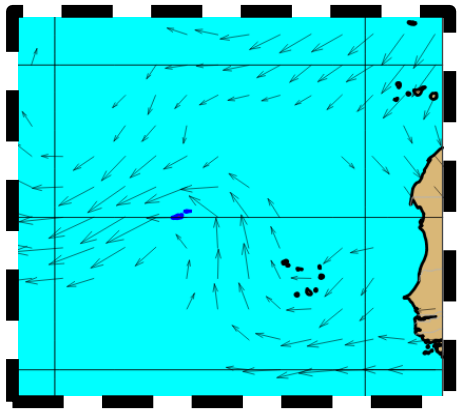
Forecast without satellites





700hPa initial conditions with satellites

Red shading humidity > 95%



700hPa initial conditions without satellites

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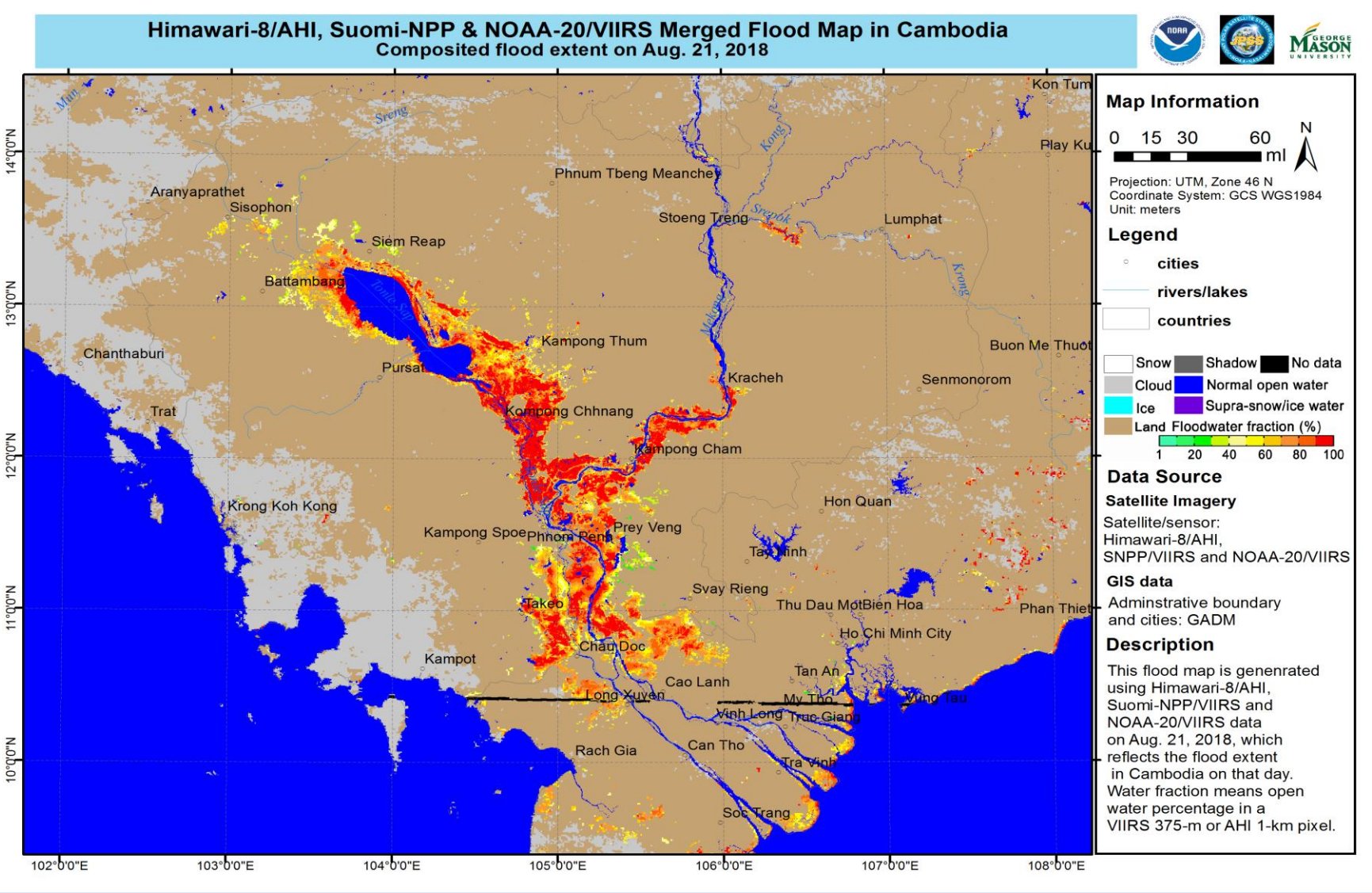
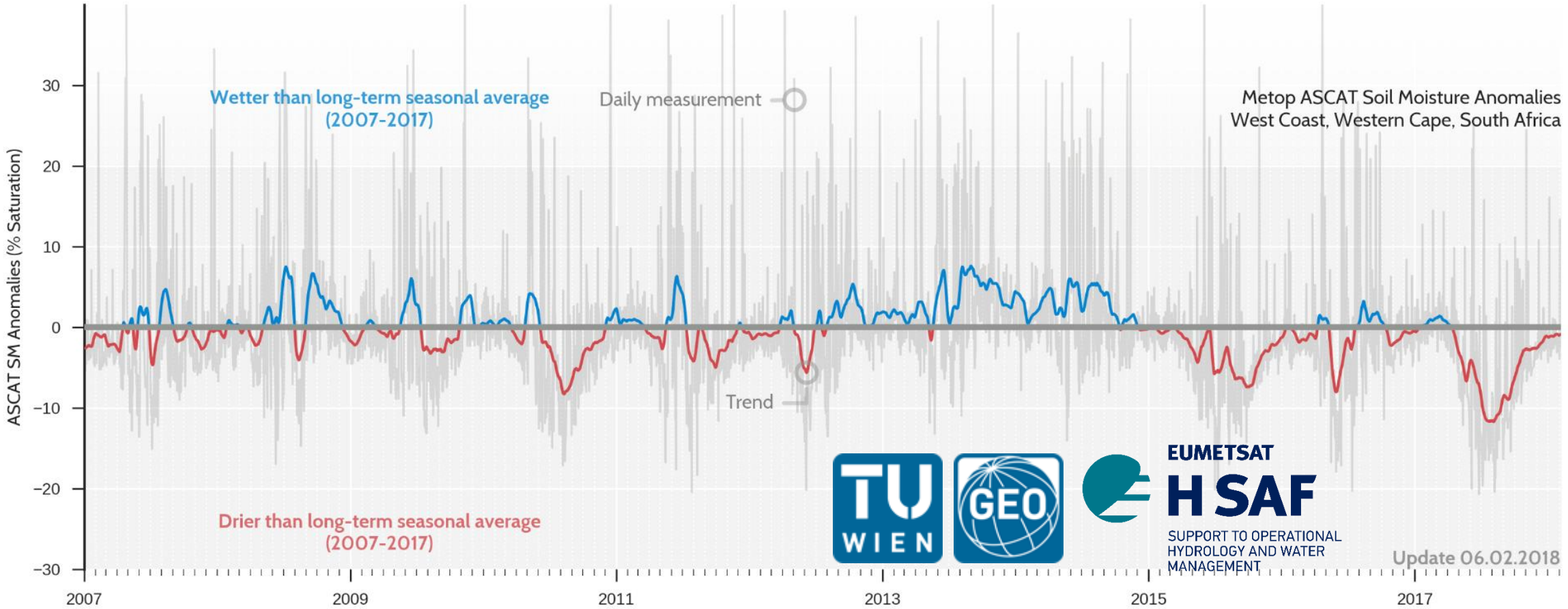
Floods



- Combined use of satellite data from geostationary and polar orbit;
- Enables disaster responders to act;
- Analysis of past events enables risk assessment as function of time as climate changes.

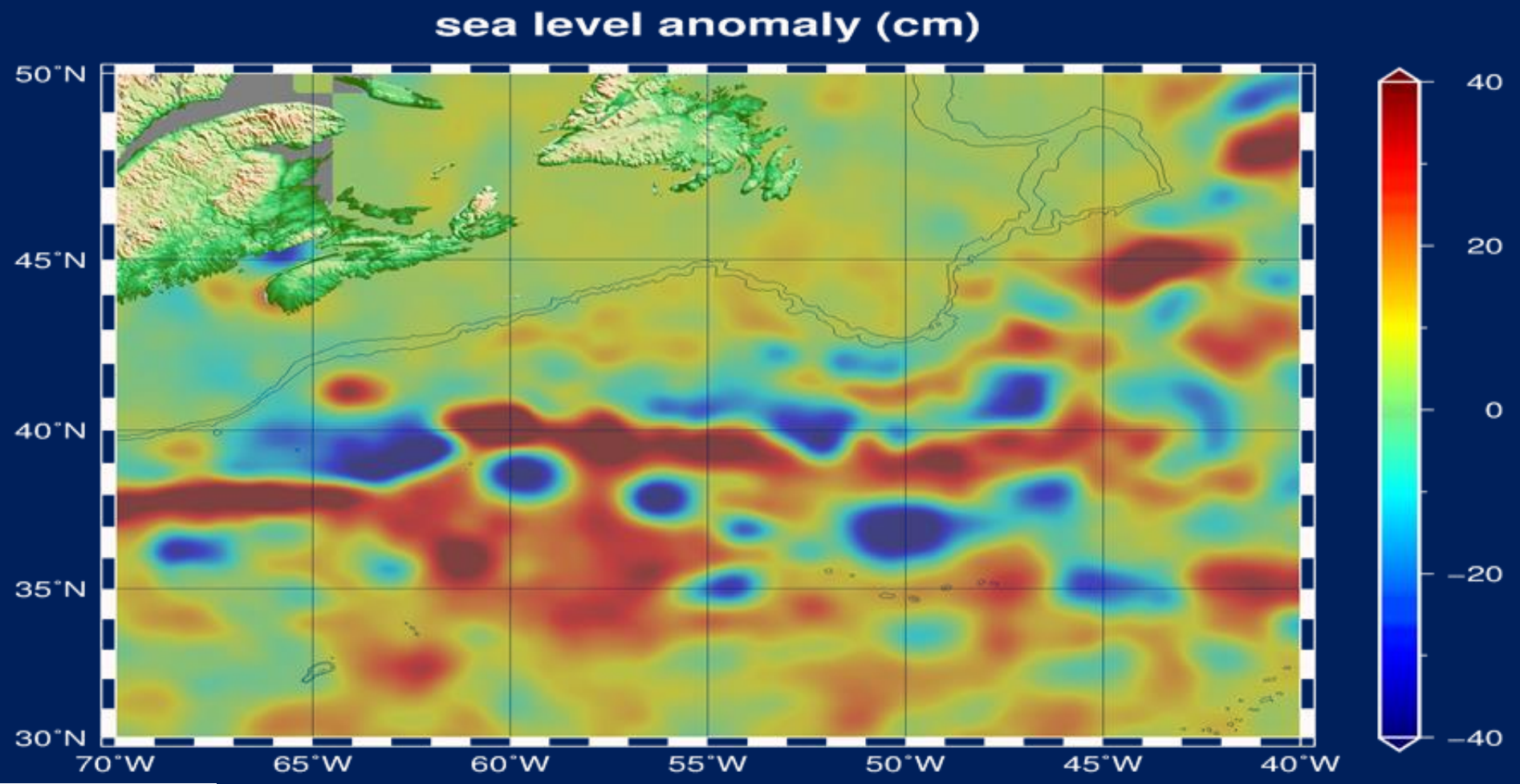
Courtesy, Mitch Goldberg, NOAA, USA

Drought: 2018 Capetown, South Africa



Courtesy Mariette Vreugdenhil/TU Wien, EUMETSAT H SAF

Sea Surface Topography: Six missions are operational and interoperable – Ready to continue the time Series



R. Scharroo, EUMETSAT

EUMETSAT

Conclusion

- Space agencies have significantly evolved the systematic observation of the climate system from space;
- CEOS and CGMS have an established structure that is capable of efficiently responding to the needs that arise from the implementation of the Paris Agreement;
- Analysis of satellite-based climate data records contributes to IPCC reports that are relevant for global stocktakes;
- GHG observations have the potential to support NDC reports by providing global and regional constraints on GHG sinks and sources;
- Better climate resilience can be achieved by better understanding and prediction of events causing loss and damage;
- Use of space based observations with undoubted quality in global stocktakes can play a supporting role of providing evidence for the success of the implementation of the Paris Agreement.