



The Global Climate Observing System

GCOS Secretariat, WMO



**GLOBAL CLIMATE
OBSERVING SYSTEM**

KEEPING WATCH OVER OUR CLIMATE



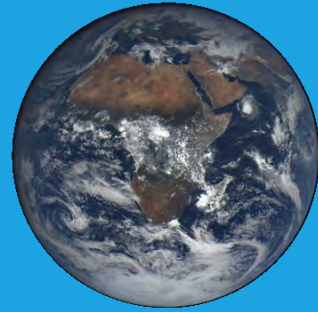
International
Science Council



GCOS supports observations and production of climate the data records that underpin climate service delivery, e.g. for weather, hydrology, ocean cryosphere and biosphere.

Sensing

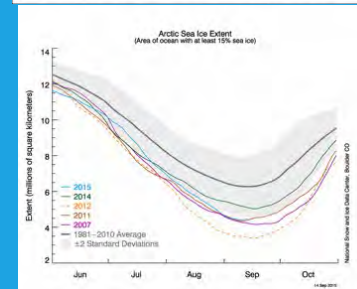
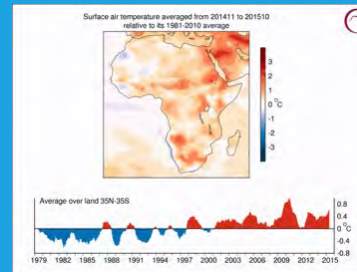
- Observation of the Earth System



Network and system operators: e.g. national meteorological services, satellite agencies

Data Records

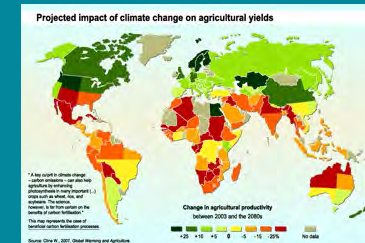
- Preparation of Climate Data records
- Archiving,
- Reanalysis,
- Production of long datasets
- Climate projections



Data Managers, Modeler, Re-Analyses (ECMFW, NCEP, DWD, JMA, Research, data Providers, etc.)

Delivery of Services

- Delivery of targeted information for specific applications or to inform decisions



Service companies & agencies, (Copernicus, ESRI, Google Maps, national meteorological services)

Decision Making and Implementation

- Implement actions based on the information



National authorities, insurance companies, private sector

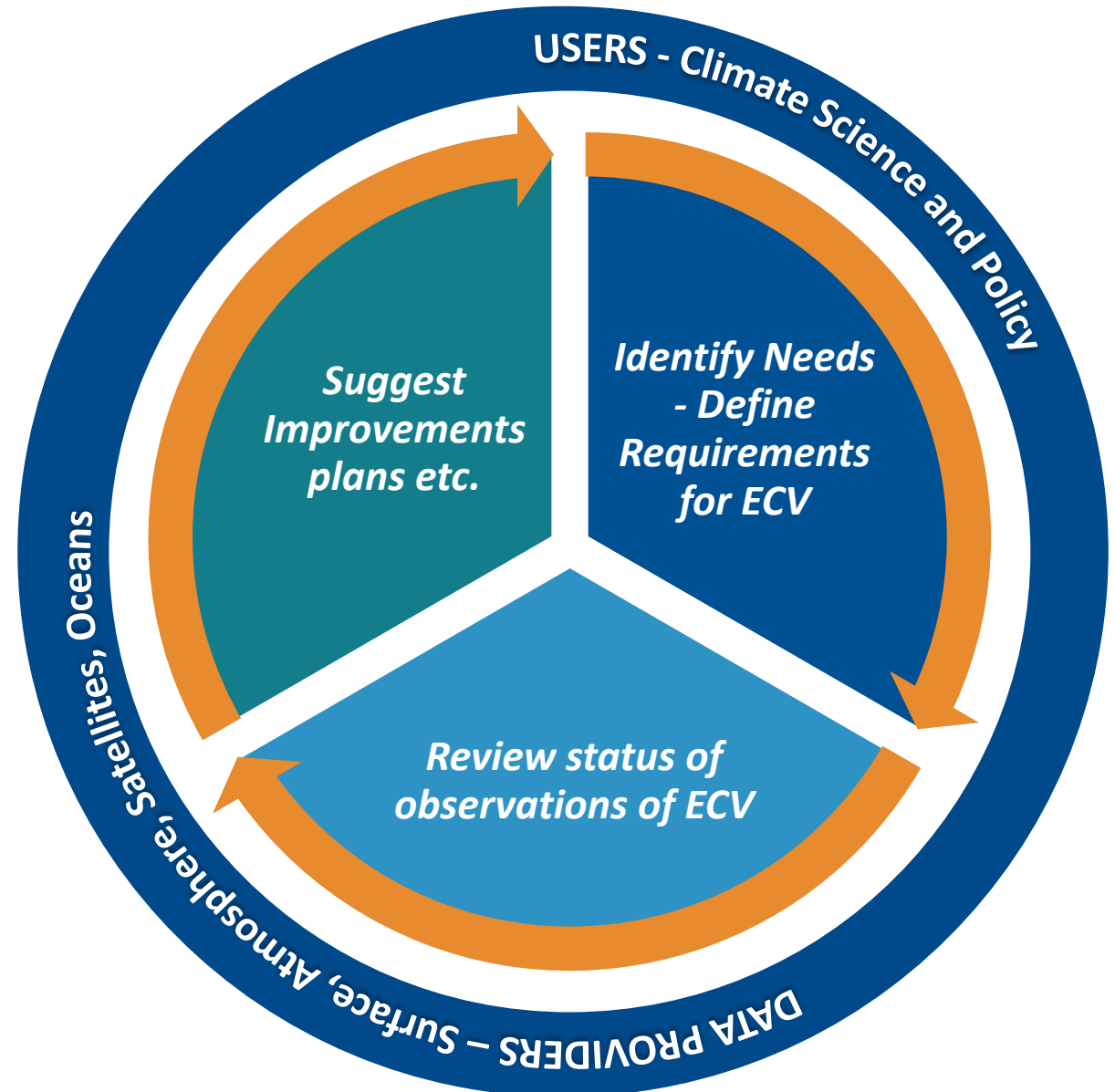
Feedback on user needs and gaps in observational and data systems

GCOS

- Identifies the needs for climate monitoring – Essential Climate Variables (ECV)
- Defines the monitoring requirements
- Promotes these requirements
- Monitors and reports on the status of the observing system
- Suggests plans and improvements

The Global Climate Monitoring System

- Is a system of systems
- Is based on existing observation networks
 - WMO for meteorology, water and cryosphere
 - IOC and GOOS for the oceans
 - CEOS/CGMS Joint WGClimate for satellite observations
 - A range of terrestrial networks for other ECV e.g. glaciers, permafrost, soil carbon.





Weather

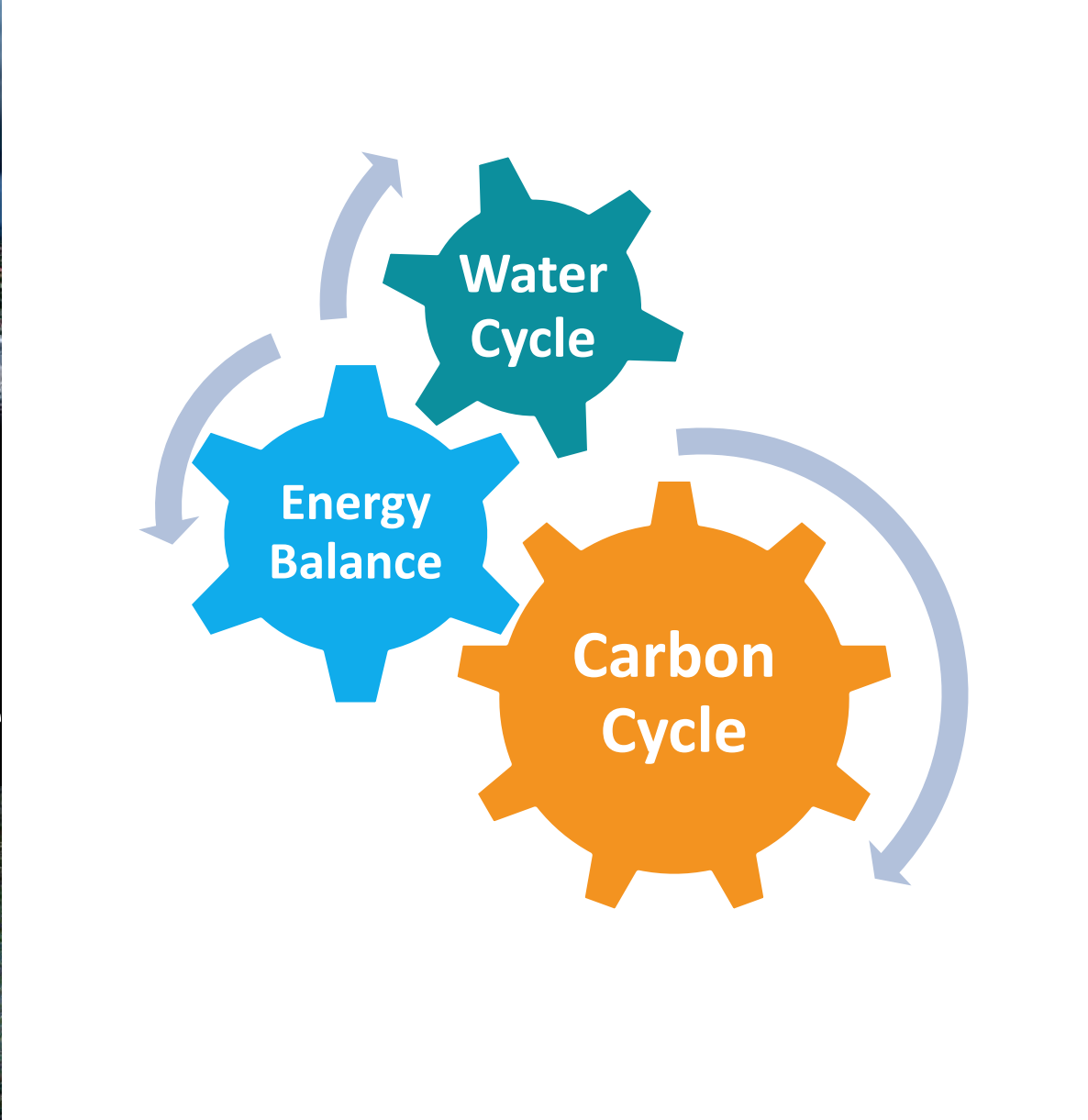
Climate Monitoring covers the whole climate system



Cryosphere



Biosphere



Oceans



Hydrology



Atmospheric
Composition

Not just weather!

SEA - SURFACE
TEMPERATURE,
OCEAN COLOUR



TEMPERATURE,
WATER VAPOUR,
TRACE SPECIES



CLOUD PROPERTIES,
PRECIPITATION



EARTH RADIATION
BUDGET



SEA LEVEL, SEA STATE,
SURFACE CURRENT



TEMPERATURE, WIND,
WATER VAPOUR, OZONE



CARBON



LAKES



ALBEDO, SURFACE
RADIATION BUDGET



PERMAFROST



ICE SHEETS,
GLACIERS &
ICE CAPS



SEA-ICE



WIND SPEED &
DIRECTION, LIGHTNING



FIRE DISTURBANCE,
LAND COVER
LAND SURFACE TEMPERATURE



SNOW COVER



TEMPERATURE,
SALINITY



AIR TEMPERATURE,
PRESSURE



OZONE & AEROSOL,
SUPPORTED BY THEIR
PRECURSORS



WATER VAPOUR



ABOVE-GROUND BIOMASS,
FAPAR, LEAF AREA INDEX



SURFACE

SUB-SURFACE

CARBON DIOXIDE PARTIAL
PRESSURE, OCEAN ACIDITY



SEA - SURFACE SALINITY,
PHYTOPLANKTON



NUTRIENTS, TRACERS,
OCEAN ACIDITY,
CARBON DIOXIDE
PARTIAL PRESSURE



OCEAN CURRENT,
OXYGEN



CARBON DIOXIDE,
METHANE & OTHER
LONG-LIVED
GREENHOUSE GASES



SOIL MOISTURE

GROUNDWATER



RIVER DISCHARGE,
WATER USE



Atmosphere

Surface

- Precipitation
- Pressure
- Radiation budget
- Temperature
- Water vapour
- Wind speed and direction

Upper-air

- Cloud properties
- Earth radiation budget
- Lightning
- Temperature
- Water vapour
- Wind speed and direction

Atmospheric Composition

- Aerosol and ozone precursors
- Aerosols properties
- Carbon dioxide, methane and other greenhouse gases
- Ozone

Ocean

Physical - Surface

- Ocean surface heat flux
- Sea ice
- Sea level
- Sea state
- Sea surface currents
- Sea surface salinity
- Sea surface stress
- Sea surface temperature

Physical - subsurface

- Subsurface currents
- Subsurface salinity
- Subsurface temperature

Biological/ecosystems

- Marine habitat properties
- Plankton

Biogeochemical

- Inorganic carbon
- Nitrous oxide
- Nutrients
- Ocean colour
- Oxygen
- Transient tracers

Essential Climate Variables

ECV

Land

Hydrosphere

- Groundwater
- Lakes
- River discharge

Cryosphere

- Glaciers
- Ice sheets and ice shelves
- Permafrost
- Snow

Anthroposphere

- Anthropogenic Greenhouse gas fluxes
- Anthropogenic water use

Biosphere

- Above-ground biomass
- Albedo
- Evaporation from land
- Fire
- Fraction of absorbed photosynthetically active radiation (FAPAR)
- Land cover
- Leaf area index
- Soil carbon
- Soil moisture
- Land surface temperature

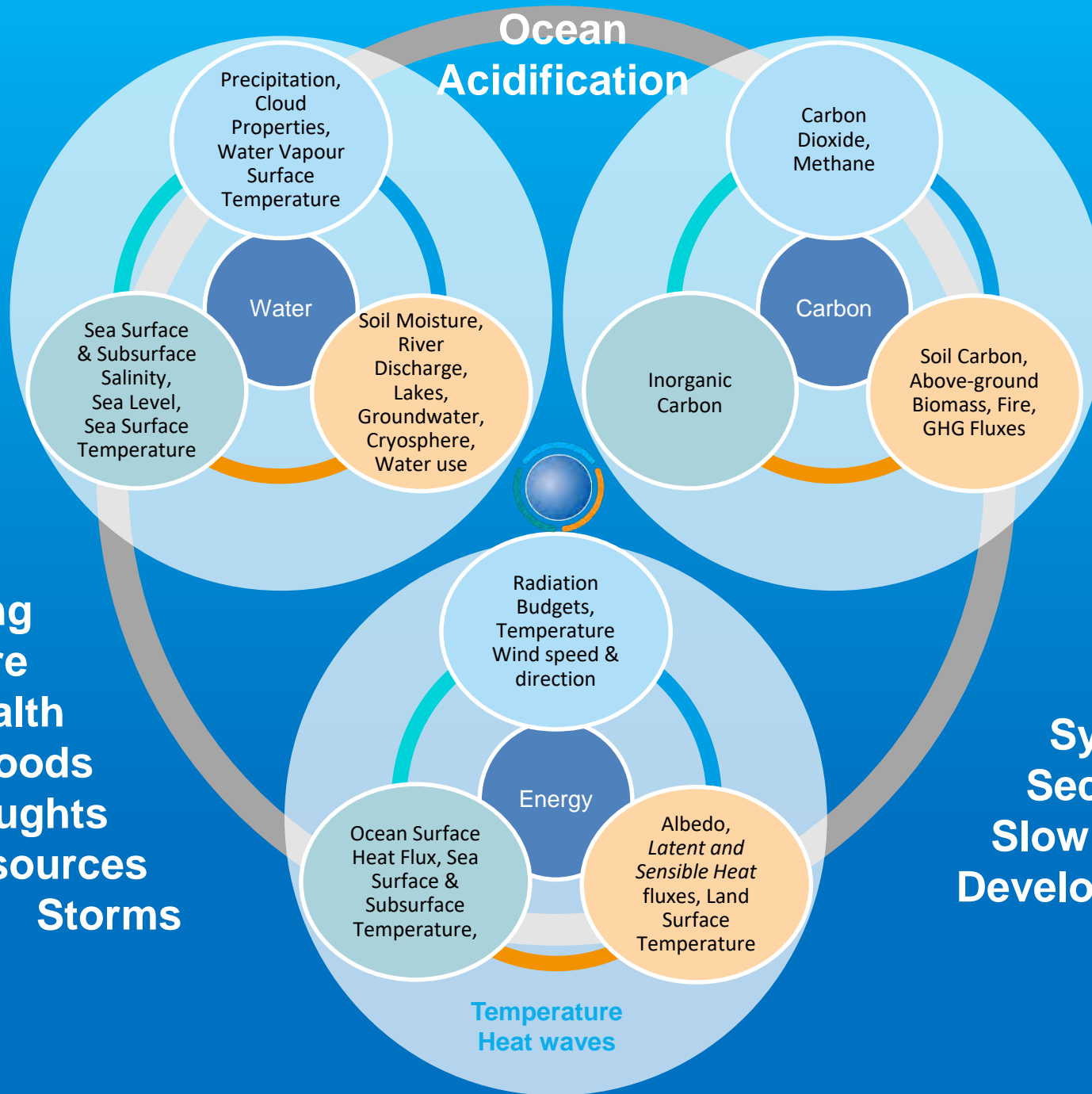
**Sea Level Rise
Fisheries**

**Coral Bleaching
Agriculture
Human Health
Floods
Droughts
Water Resources
Storms**

**Ocean
Acidification**

**Deforestation
Mitigation
Ecosystem Loss**

**Systemic Risks
Security
Slow Economic
Development**

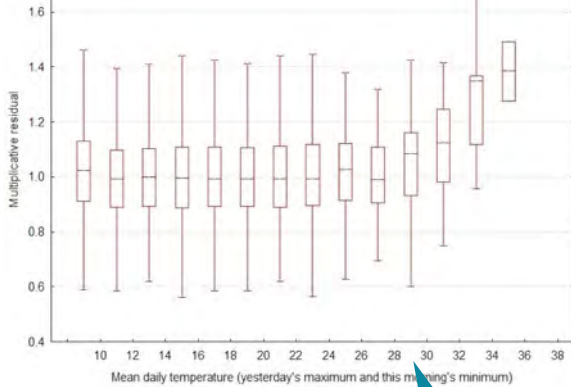


Public Information: Agreed Climate Indicators

	<u>Temperature and Energy</u>	<u>Atmospheric Composition</u>	<u>Ocean</u>	<u>Cryosphere</u>	<u>Biosphere</u>
Global Indicators	Surface Temperature Ocean Heat	Atmospheric CO ₂	Ocean Acidification Sea Level	Glacier Mass Balance Arctic and Antarctic Sea Ice	
Indicators under development	Heat Waves		Heavy Precipitation Droughts		Ecosystem change
Supplementary Indicators	Top of atmosphere energy balance	Methane N ₂ O Halocarbon GHG		Snow extent	
			<u>Water</u>		

Examples of remote sensing of responses to climate changes

Mortality increases with average temperature



Expected Mortality leads to Actions to cool Cities



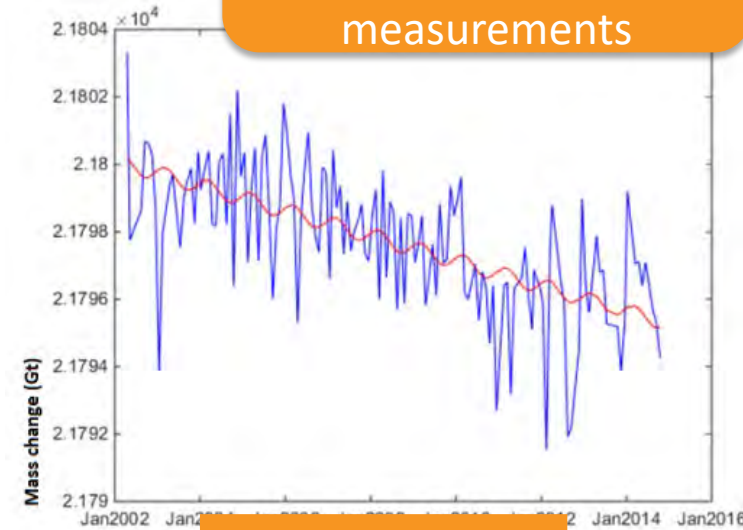
Overall impact of these actions can be monitored remotely



Adelaide. SOURCE: modified Copernicus Sentinel data (2017), processed by ESA, [CC BY-SA 3.0 IGO](#)

ECVs include:
Land Cover
Land Surface temperature
Ground water
Anthropogenic water use
Anthropogenic GHG

Ground water depletion in Saudi Arabia, GRACE measurements



Over extraction by agriculture



Above-ground biomass

ESSENTIAL CLIMATE VARIABLE (ECV)
FACTSHEET



ECV IN BRIEF

Domain: Terrestrial
Subdomain: Biology
Scientific Area: Carbon Cycle and other GHGs
Products: Maps of above-ground biomass



Above-ground biomass

Vegetation biomass is a crucial ecological variable for understanding the evolution and potential future changes of the climate system. Photosynthesis withdraws CO₂ from the atmosphere and stores carbon in vegetation in an amount comparable to that of atmospheric carbon. Vegetation systems have the potential either to sequester more carbon in the future or to contribute as an even larger source. Depending on the quantity of biomass, vegetation cover can have a direct influence on local, regional and even global climate, particularly on air temperature and water vapour.

ECV Products

PRODUCT	DEFINITION	REQUIREMENTS				
		FREQUENCY	RESOLUTION	REQUIRED MEASUREMENT UNCERTAINTY	STABILITY	STANDARDS/ REFERENCES
MAPS OF ABOVE-GROUND BIOMASS	XXX	Annual	500m-1km (based on satellite observations of 100-200m)	< 20% error for biomass values > 50 t/ha, and 10 t/ha for biomass values ≤ 50 t/ha	10%	No agreed standards but see: GOCF-GOLD (2015b); GFOI (2013)

Selected Data Sources

- ▶ Copernicus Global Land Service providing bio-geophysical products of global land surface
<http://land.copernicus.vgt.vito.be/PDF/portal/Application.html#Home>
- ▶ National Aeronautics and Space Administration (NASA) Moderate Resolution Imaging Spectroradiometer (MODIS) NDVI
<https://lpvs.gsfc.nasa.gov/producers2.php?topic=SurfRad>
- ▶ Copernicus Climate Change Service (C3S), European Centre for Medium-Range Weather Forecasts (ECMWF)
<http://apps.ecmwf.int/datasets/data/interim-full-daily/levtype=sfc/>



ECV IN BRIEF

Domain: Terrestrial
Subdomain: Human Use of Natural Resources
Scientific Area: Biosphere
ECV Stewards: Greet Maenhout
Products: Emissions from fossil fuel use, industry, agriculture and waste sectors;
 Emissions/ removals by IPCC land categories;
 Estimated fluxes by inversions of observed atmospheric composition – continental;
 Estimated fluxes by inversions of observed atmospheric composition – national;
 Hi-res CO₂ column concentrations to monitor point sources



Anthropogenic Greenhouse Gas Emissions

Global anthropogenic emissions of Greenhouse gases (CO₂, CH₄, N₂O and F-gases) continue to be emitted at an annual rate that is not yet significantly decreasing. The global warming potential of each of the greenhouse gases and their long residence time in the atmosphere are causing increased surface temperature and climate change. The scientific community illustrated with inverse models and data assimilation how consistent the reported inventories and the atmospheric observations are, which is taken up also in few national inventory reports (e.g. UK, Switzerland, Australia).

ECV Product¹

PRODUCT	DEFINITION	REQUIREMENTS			
		FREQ.	RES.	REQ. MEAS. UNCERT.	STAB. STANDARDS/ REFERENCES
Emissions from fossil fuel use, industry, agriculture and waste sectors	Anthropogenic emissions according to IPCC guidelines	Annual	By country and sector	Globally 5%; Nationally 10%	IPCC (2006); IPCC (2013)

¹ Current Products and Requirements as in the Implementation Plan 2016 (GCOS-200). GCOS is reviewing and will update the requirements until 2022. More information on: gcos.wmo.int and climatedata.wmo.int.



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in collaboration with



Emissions/ removals by IPCC land categories

Anthropogenic emissions and removals from the LULCF category according to IPCC guidelines	Annual	By country/ region	Globally 15%; Nationally 20%	IPCC (2006); IPCC (2013)
Estimated fluxes by inversions of observed atmospheric composition – continental	GHG emission/ removals (modelled using inversion of atmospheric composition), continental scale	Annual	1000 - 10,000 km	10%
Estimated fluxes by inversions of observed atmospheric composition – national	GHG emission/ removals (modelled using inversion of atmospheric composition), national scale	Annual	100-1000 km	30%
Hi-res CO₂ column concentrations to monitor point sources	Spatially resolved GHG emission plume around local source	4 hourly	1 km	1ppm

Data Sources²

- United Nations Framework Convention on Climate Change inventory data
<http://wgms.ch/> http://di.unfccc.int/time_series
- Emissions Database for Global Atmospheric Research (Edgar)
<http://edgar.jrc.ec.europa.eu/s/>
- Open-Data Inventory for Anthropogenic Carbon dioxide (ODIAC)
<http://db.cger.nies.go.jp/dataset/ODIAC/>
- Carbon Dioxide Information Analysis Center
<https://cdiac.ess-dive.lbl.gov/>
- The Global Carbon Project (GCP)
<https://www.globalcarbonproject.org/>
- Open-Data Inventory for Anthropogenic Carbon dioxide (ODIAC)
<http://db.cger.nies.go.jp/dataset/ODIAC/>
- Community Emissions Data System (CEDS)
<http://www.globalchange.umd.edu/ceds/>
- FLUXNET
<https://fluxnet.ornl.gov/fluxnetdb>

Global CO₂ Emissions

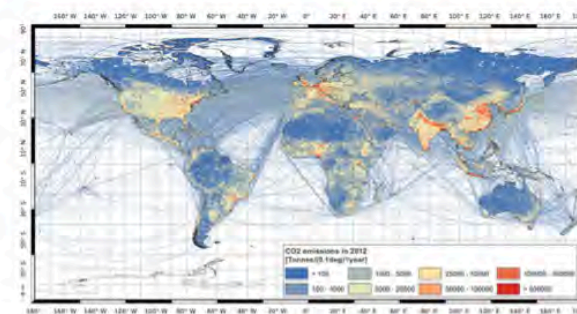


Figure: Gridded total CO₂ emissions of EDGARv4.3.2 from anthropogenic sources excluding the land use, land-use change and forestry sectors for 2012 of Janssens-Maenhout et al. (2019).

² This list provides sources for openly accessible data sets with worldwide coverage for which metadata is available. It is curated by the respective GCOS ECV Steward(s). The list does not claim to be complete. Anyone with a suitable dataset who would like it to be added to this list should contact GCOS.

<https://gcos.wmo.int/en/essential-climate-variables/ecv-factsheets>

Public Review of ECV requirements

January – March 2020

gcos.wmo.int



Monitoring the state of climate monitoring



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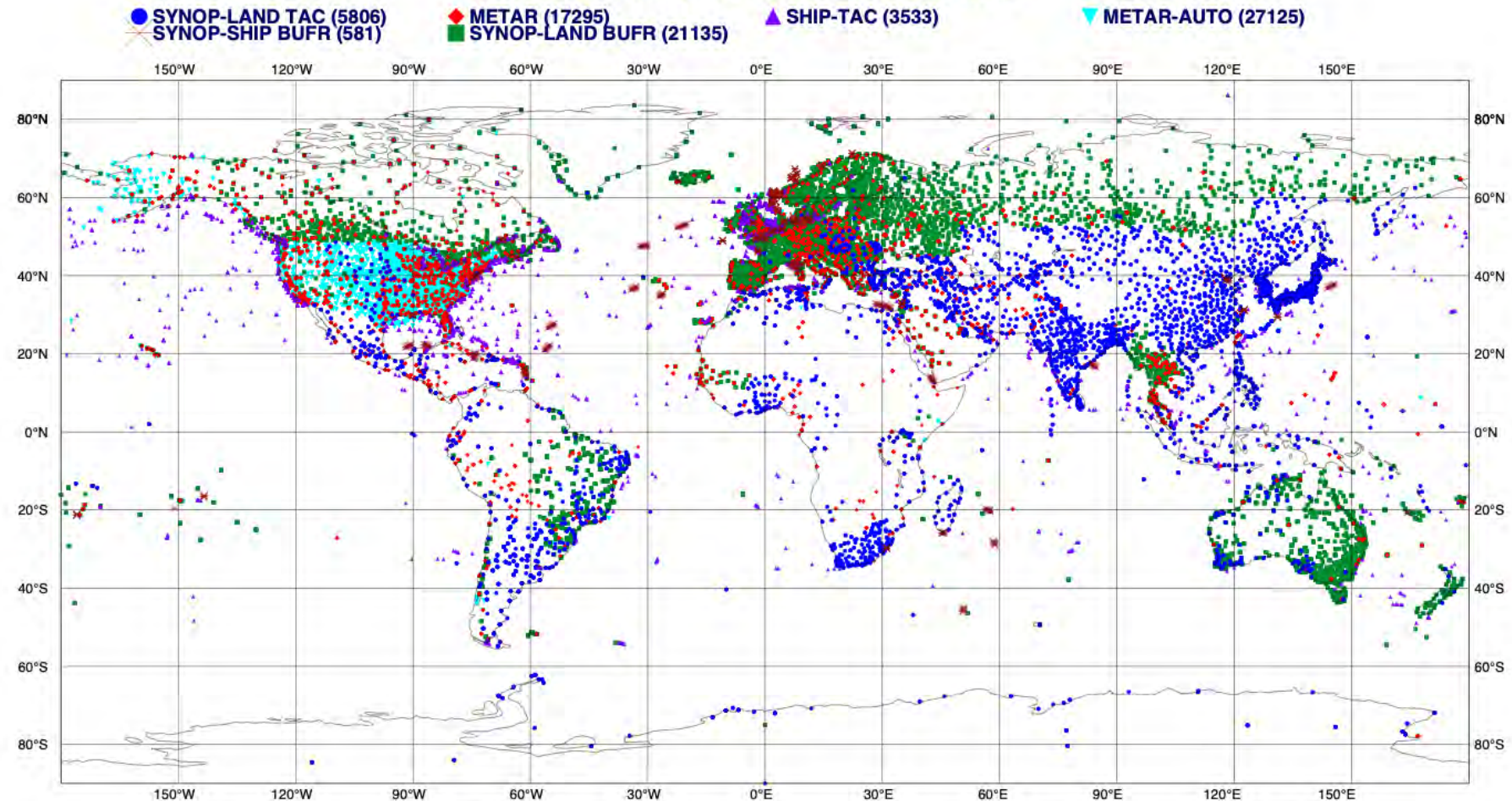
Surface Observations used by ECMWF in their models

- Sparse data coverage over some areas, especially Africa
- Other modelling centres show similar patterns
- This leads to poorer forecasts and projections in these areas
- This also contributes to lower skill of forecasts globally

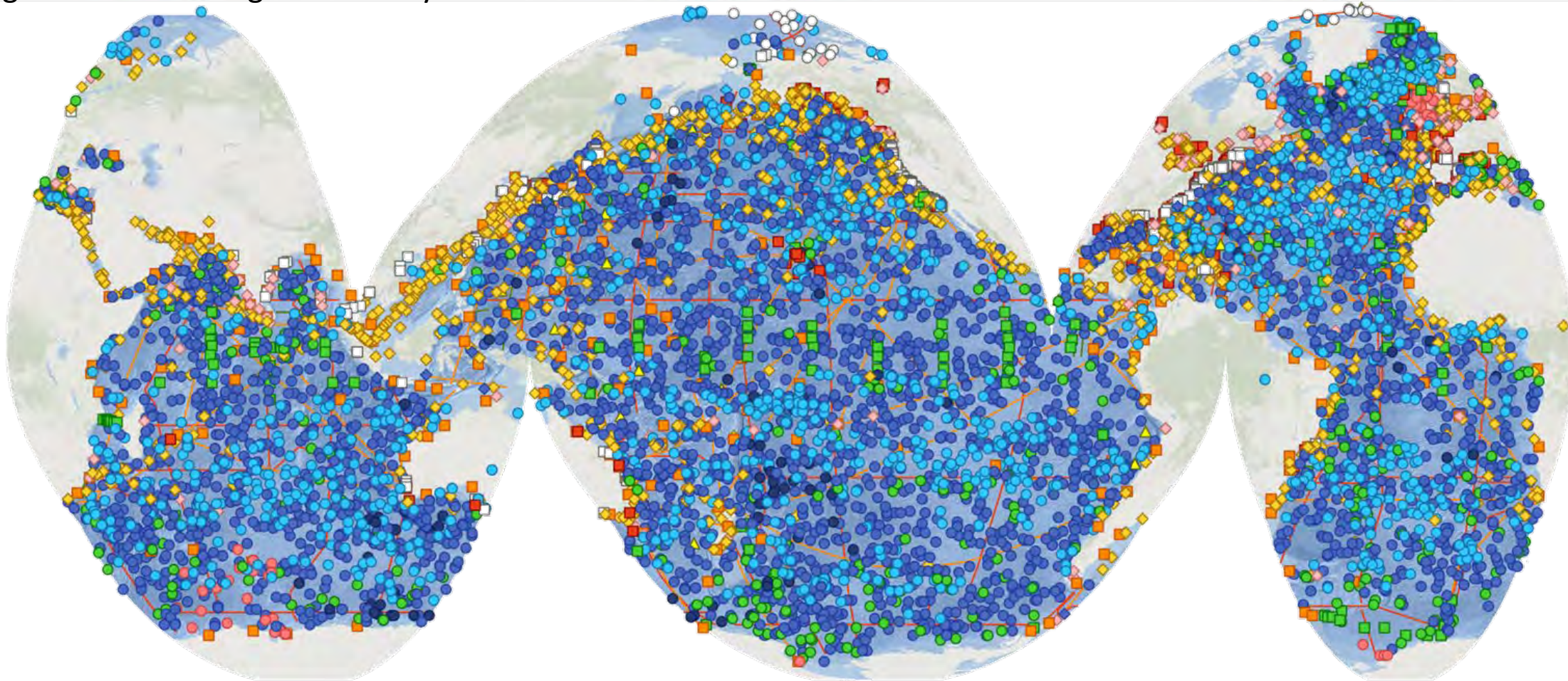
ECMWF data coverage (used observations) - SYNOP-SHIP-METAR

15/11/2019 00

Total number of obs = 75475



- Climate observations of the upper oceans are currently fairly well covered
- ARGO buoys reach 88% of target density and drifters 80% (with gaps in polar and coastal regions), while there are relatively few observations below 2000m.
- New technologies are becoming available especially for biological parameters and for below 2000m
- However, the funding is very fragile with sustainable funding for only 28% of ocean observations, and with 52% requiring renewed funding within 2-3 years.

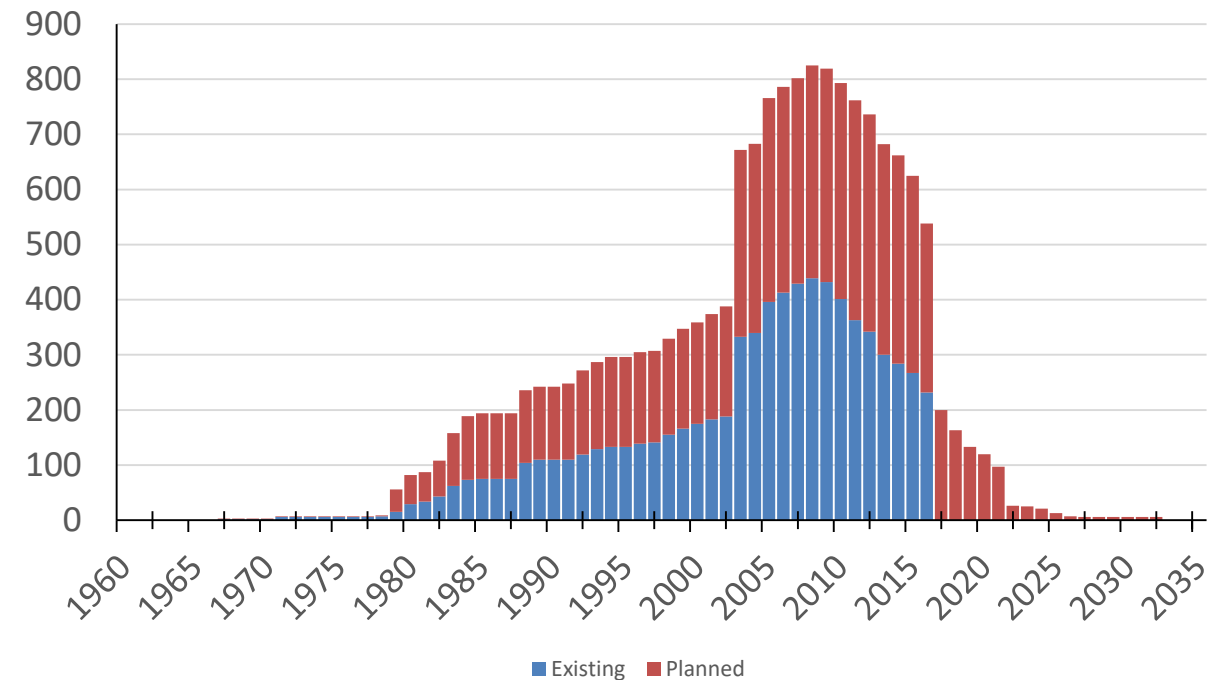
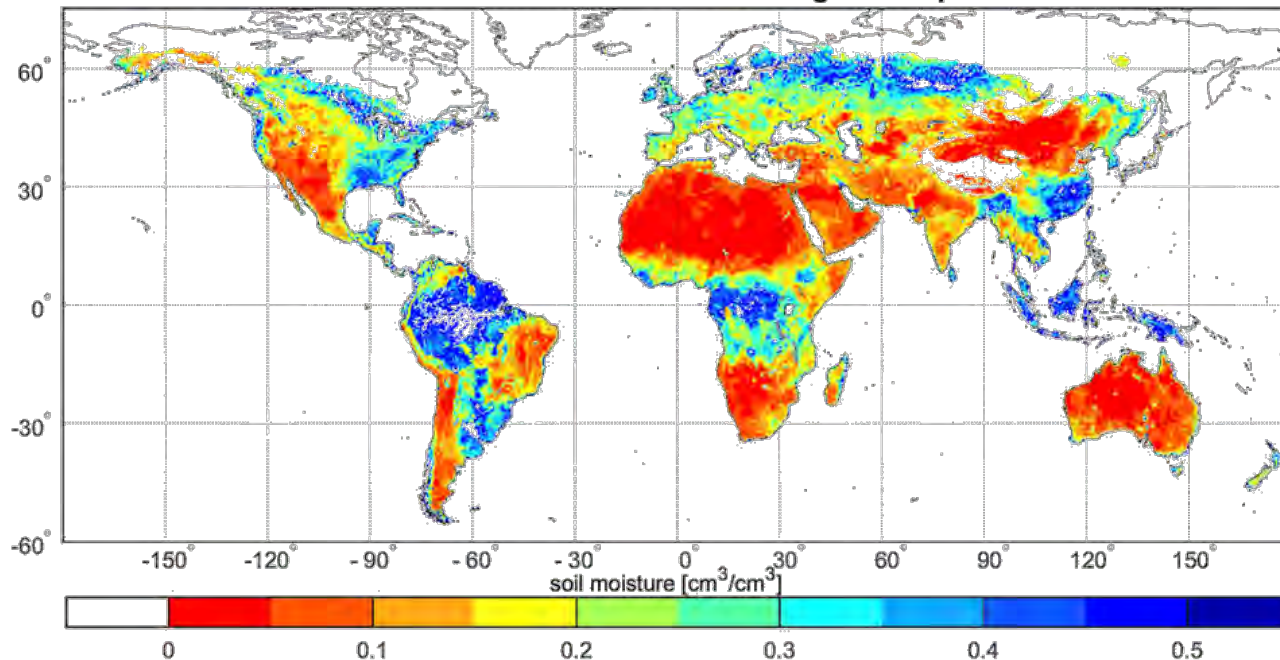


Satellite Based Climate Monitoring

- CEOS and CGMS coordinate the monitoring of the climate from space.
- Their ECV Inventory lists the climate data records available and planned and directs users to the datasets.
- Plot shows the number of existing (blue) and planned satellite-based climate data records



SMAP L3 Passive Soil Moisture Averaged for April 2016



GCOS works closely with the UNFCCC

For example:

1997

Decision 8/CP.3

Development of observational networks of the climate system

1998

Decision 14/CP.4

Research and systematic observation

2003

Decision 11/CP.9

Global observing systems for climate

2009

Decision 9/CP.15

Systematic climate observations

2016

Decision 19/CP.22

Implementation of the global observing system for climate

Climate observations also support



**SUSTAINABLE
DEVELOPMENT**

GOALS

Energy & Temperature

Other Physical Properties

Carbon Cycle and other GHGs

Hydrosphere

Snow & Ice

Biosphere

Human Resource Use

