Satellite Observations for Sustainability and Climate Resilience

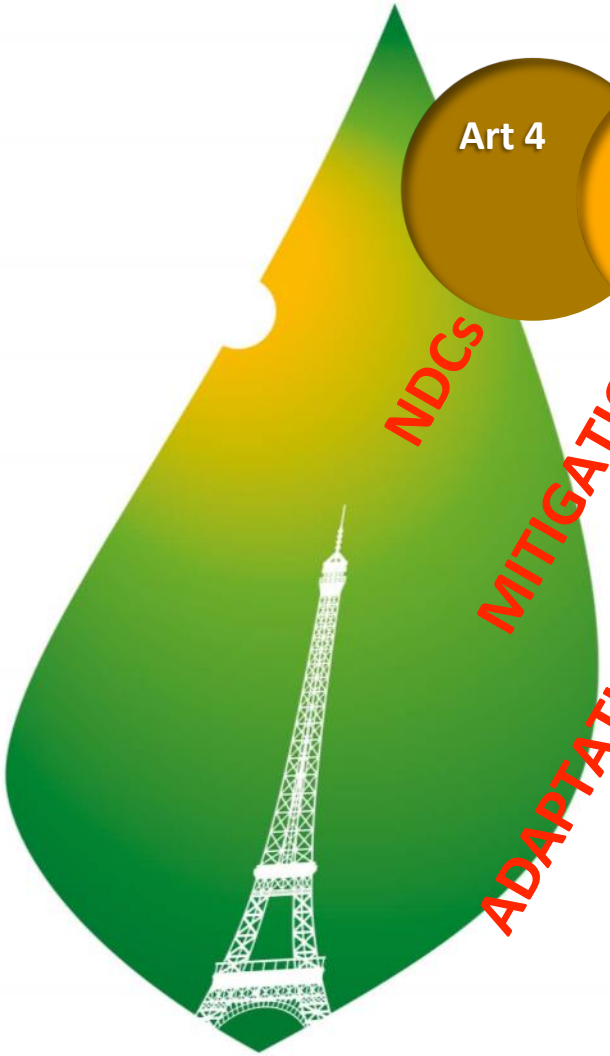
Prof. Stephen Briggs,
European Space Agency
& Chair, GCOS Steering Committee

13th RAL Space Day
7th December 2017

WMO UNESCO IOC INTERNATIONAL COUNCIL FOR SCIENCE UN environment

The importance of observations……..

Credit: Victor & Kennel, Nature Climate Change, 2014.



COP21 · CMP11

PARIS 2015

UN CLIMATE CHANGE CONFERENCE

Art 4

Art 5

Art 7

Art 8

Art 9

Art 10

Art 11

Art 12

Art 13

Art 14

NDCs

MITIGATION

ADAPTATION, EWS, RSO...

LOSS & DAMAGE, EWS...

FINANCE

TECH TRANSFER

CAPACITY BUILDING

COMMUNICATIONS

REPORTING/TRANSPARENCY

GLOBAL STOCKTAKE

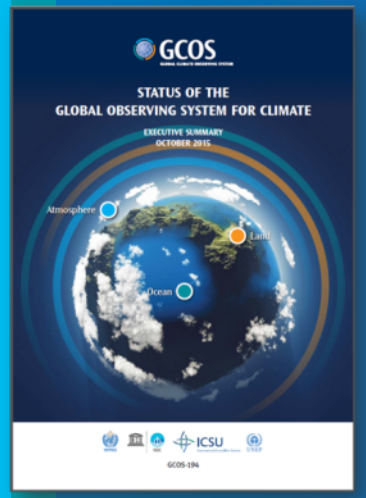
Art 7 (7c)

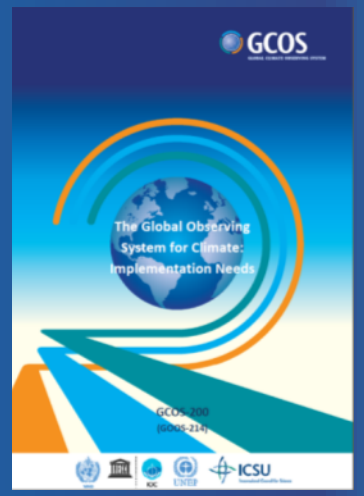
***Paris Agreement Article 7 (7c): Strengthening scientific knowledge on climate, including research, systemic observation of the climate system and early warning systems.**

GCOS Progress: Improving global climate observations

United nations conference on climate change
COP21/CMP11

COP-22, Marrakech
Decision 19/CP.22
SBSTA Conclusions





Support Adaptation & Mitigation

Water, Energy and Carbon cycles

Additional Essential Climate Variables

More help for networks in developing countries

Climate Indicators

- First Regional workshop held in Fiji for Pacific Island States
- Working group in Lightning starts work
- Working group on GCOS Reference Surface Network meets for first time

WGClimate | CEOS | CGMS

***ECV Inventory:** The Architecture for Climate Monitoring from Space in Action*

2015 **2016** **2017**

GCOS Essential Climate Variables – ECVs

- grouped by measurement domain and area covered.

The groups show how observations across all the measurement domains are needed to capture specific phenomena or issues.

	Atmosphere	Terrestrial	Ocean
Energy & Temperature	Surface Radiation Budget, Earth Radiation Budget, Surface Temperature, Upper Air Temperature, Surface and Upper Air Wind Speed	Albedo, *Latent and Sensible Heat* fluxes, Land Surface Temperature	Ocean Surface Heat Flux, Sea Surface Temperature, Subsurface Temperature
Other Physical Properties	Surface Wind, Upper Air Wind, Pressure, Lightning, Aerosol Properties		Surface Currents, Subsurface Currents, Ocean Surface Stress, Sea State, Transient Traces
Carbon Cycle and other GHGs	Carbon Dioxide, Methane, Other long-lived GHG, Ozone, Precursors for Aerosol and Ozone	Soil Carbon, Above-ground Biomass	Inorganic Carbon, Nitrous Oxide
Hydrosphere	Precipitation, Cloud Properties, Water Vapour (Surface), Water Vapour (Upper Air), Surface Temperature,	Soil Moisture, River Discharge, Lakes, Groundwater,	Sea Surface Salinity, Subsurface Salinity, Sea Level, Sea Surface Temperature
Snow & Ice		Glaciers, Ice Sheets and ice shelves, Permafrost, Snow	Sea Ice
Biosphere		Land Cover, Leaf Area Index (LAI), Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Fire	Plankton, Oxygen, Nutrients, Ocean Colour, Marine Habitat Properties
Human Use of Natural Resources		Water Use, Greenhouse Gases (GHG) Fluxes	Marine Habitat Properties

Climate observations also support

SUSTAINABLE DEVELOPMENT GOALS

- Energy & Temperature
- Other Physical Properties
- Carbon Cycle and other GHGs
- Hydrosphere
- Snow & Ice
- Biosphere
- Human Resource Use

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What is new in the GCOS Plan?

New Plan

2016

19 / CP.22
(Decision 19,
COP-22, Marrakech, Morocco)

Adaptation & Mitigation
I

Water, Energy and Carbon cycles
II

Additional Essential Climate Variables
III

Emphasis on more help for networks in developing countries
IV

Climate Indicators
V

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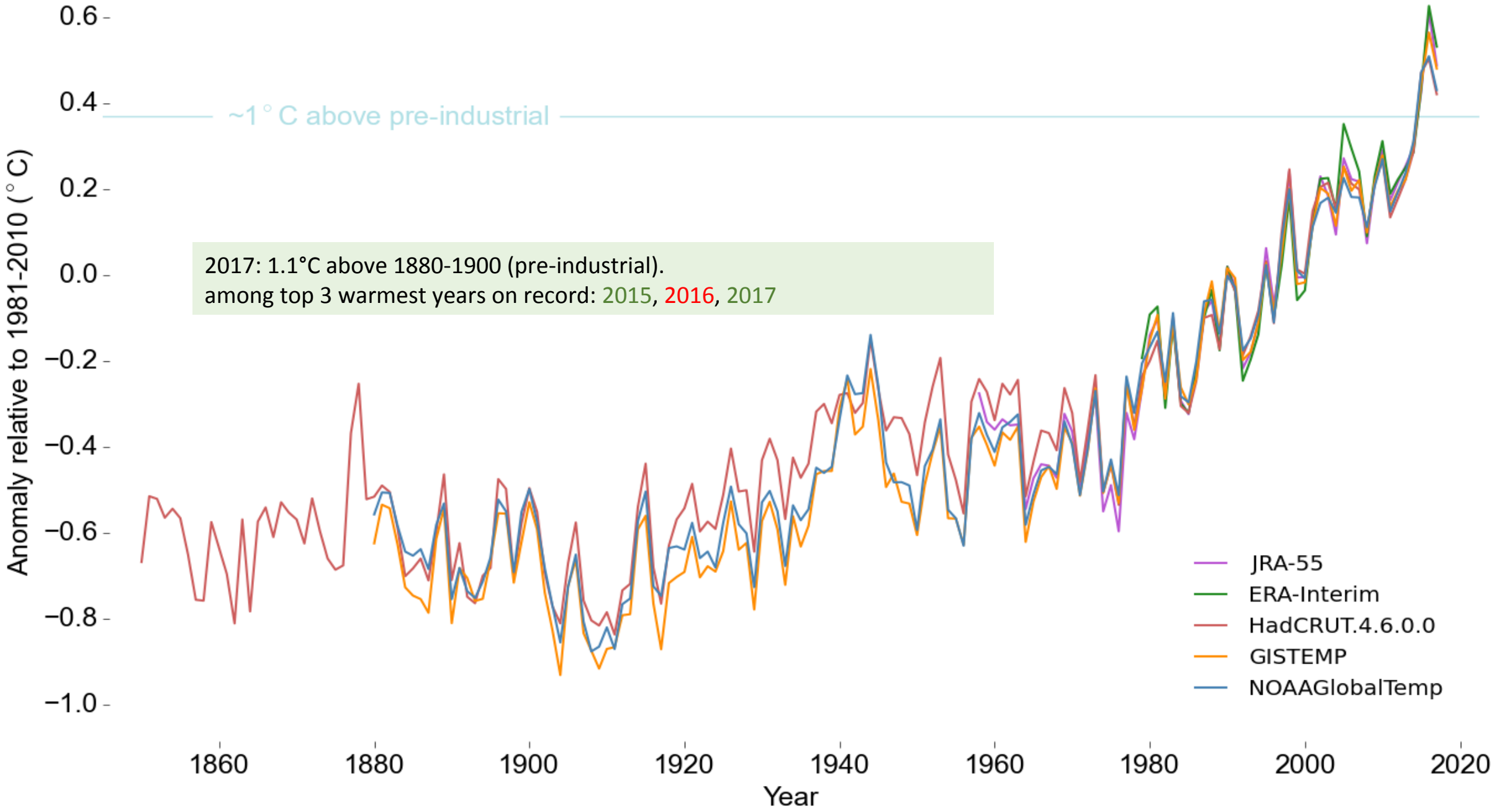
Global Climate Indicators

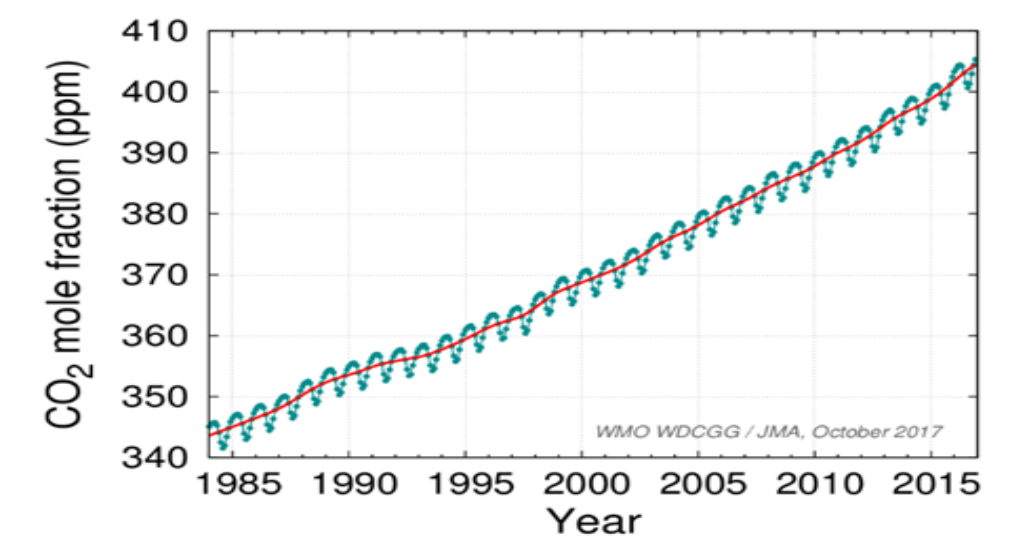
Headline Indicators

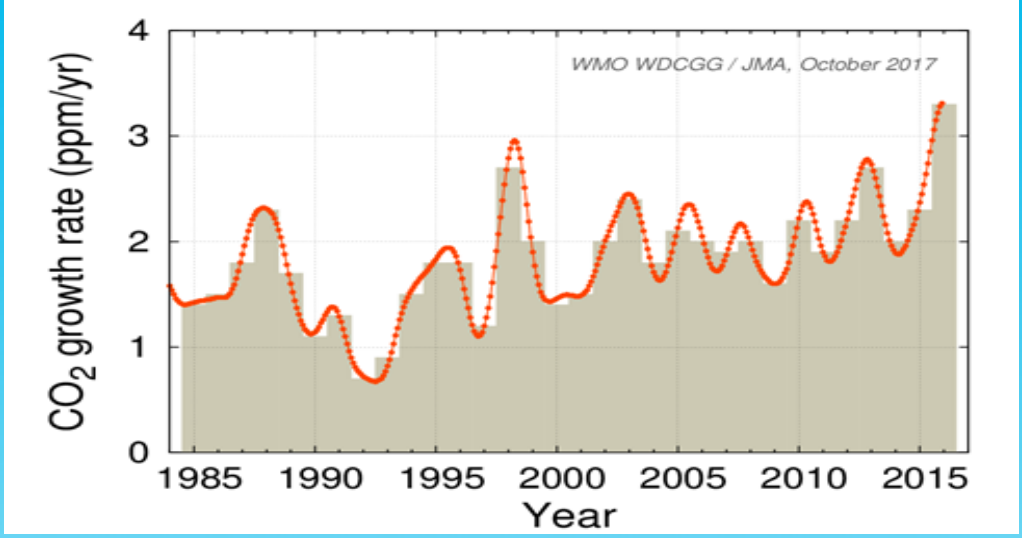
Temperature and Energy	Atmospheric Composition	Ocean and Water	Cryosphere
Surface Temperature	Atmospheric CO_2	Ocean Acidification	Glacier Mass Balance
Ocean Heat		Sea Level	Arctic and Antarctic Sea Ice Extent

Global temperature anomaly 1850-2017 relative to 1981-2010



Greenhouse gas concentrations continue to rise





GHG concentration reached new highs in 2016, with:

CO_2: 403.3 ppm 145 % of preindustrial level

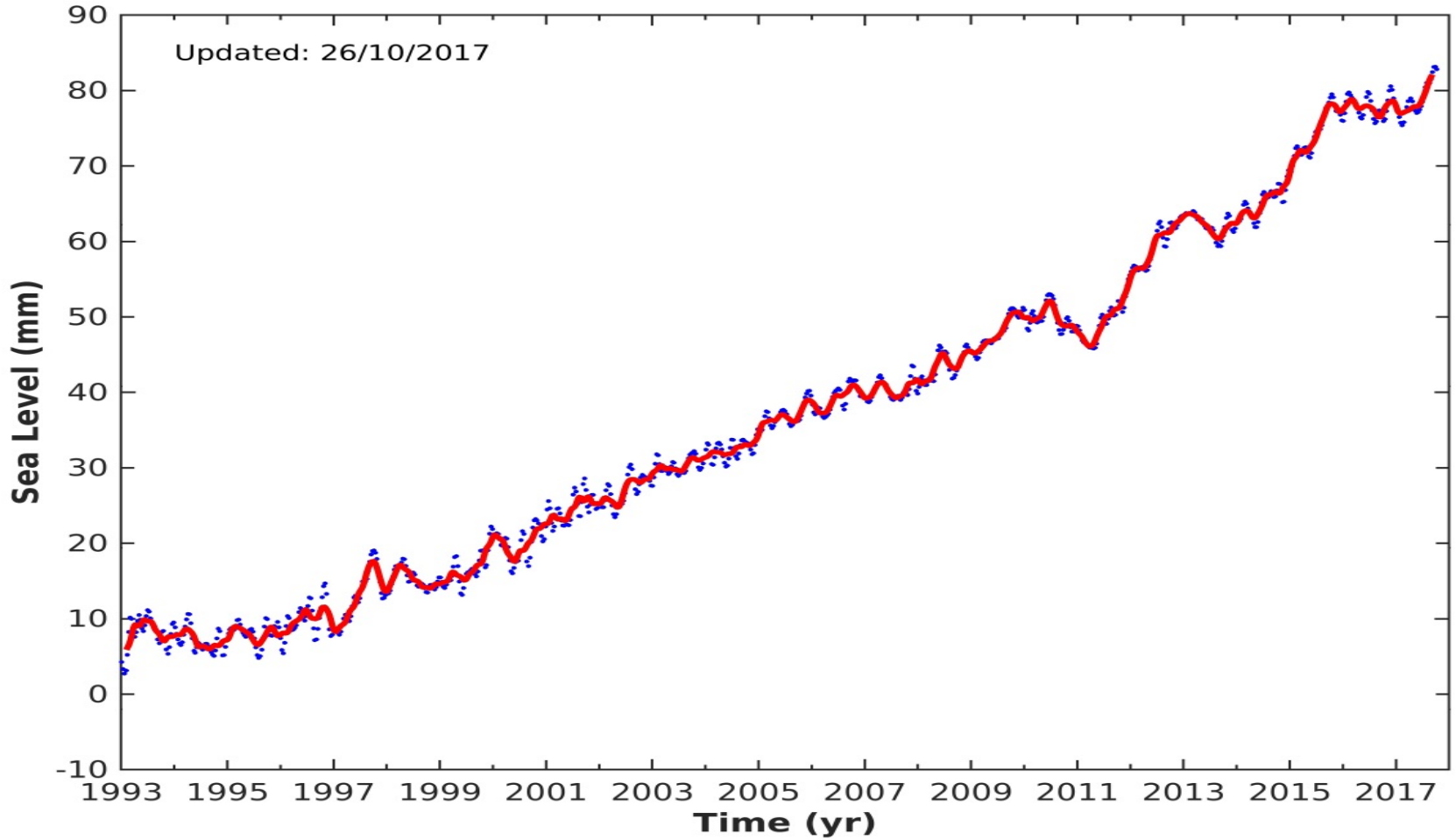
CH_4 : 1853 ppb 257 %.....

N_2O : 328.9 ppb 122 %.....

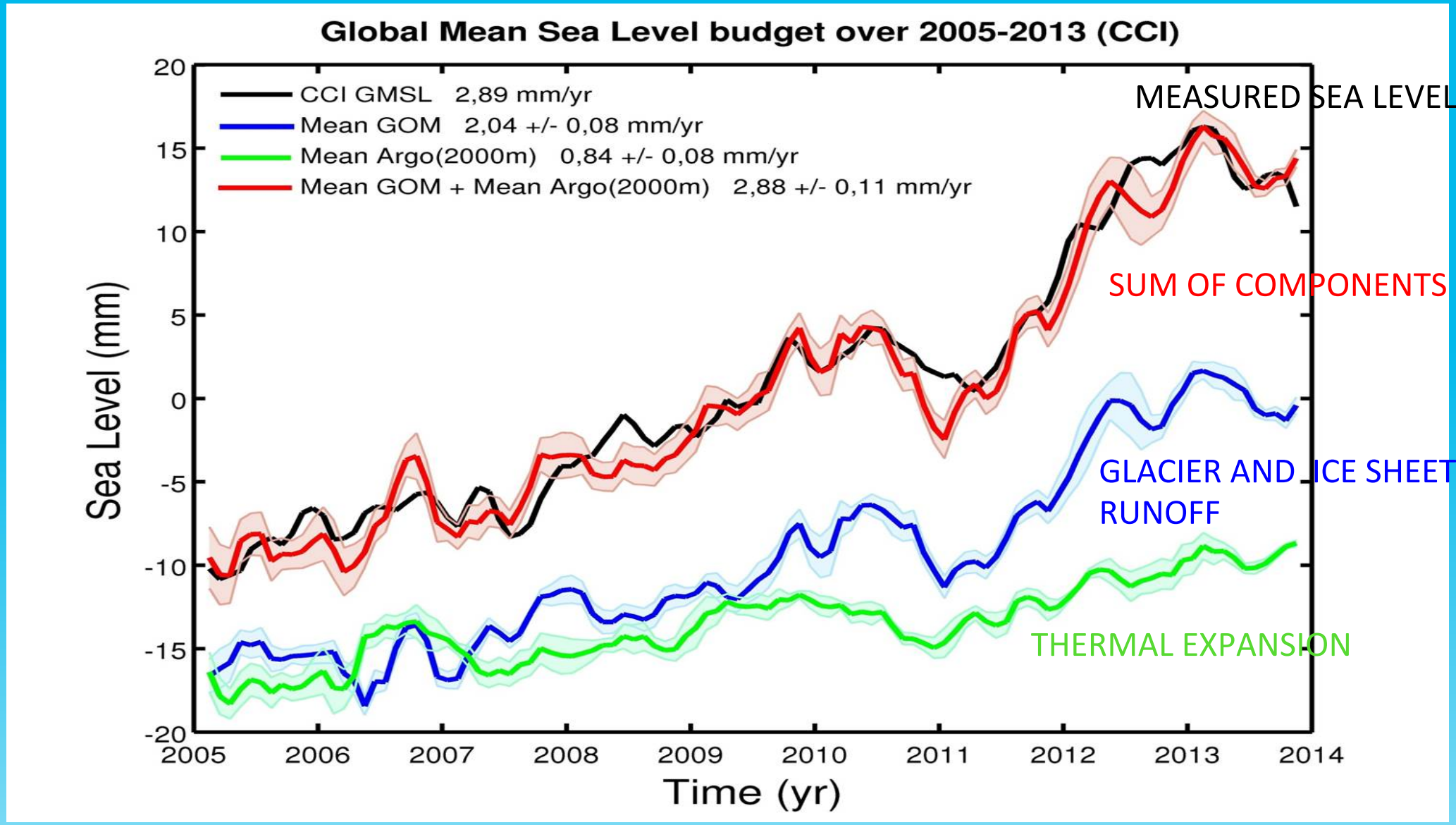
The increase in CO_2 from 2015 to 2016 was the largest annual increase observed in the post-1984 period.

The previous largest annual increase was in 1998, also at the end of a strong El Niño event

Global mean sea level continues its rising trend

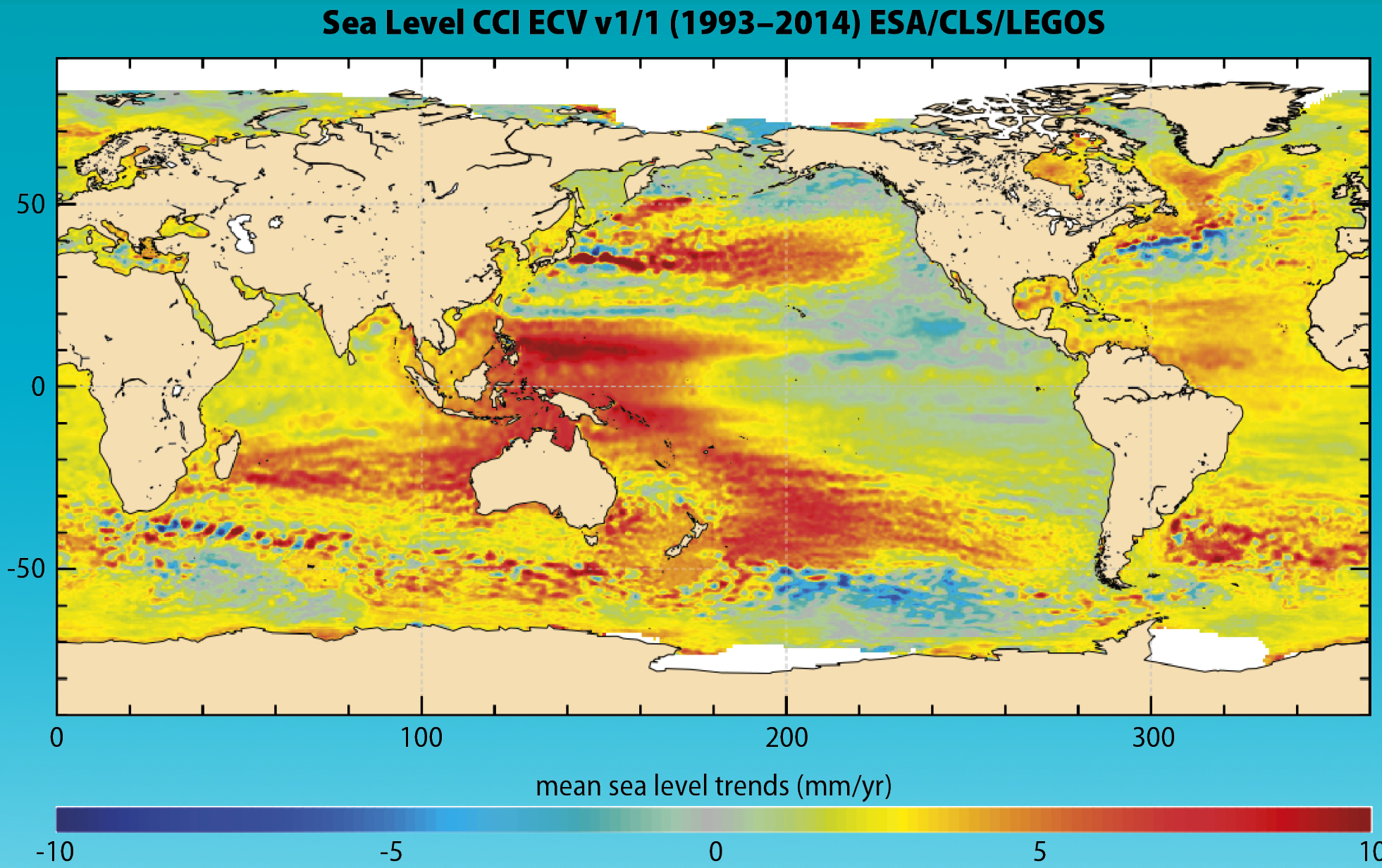


Global Sea-level Budget Workshop (ISSI Bern, Feb 2015) – COMPONENTS OF SEA LEVEL RISE



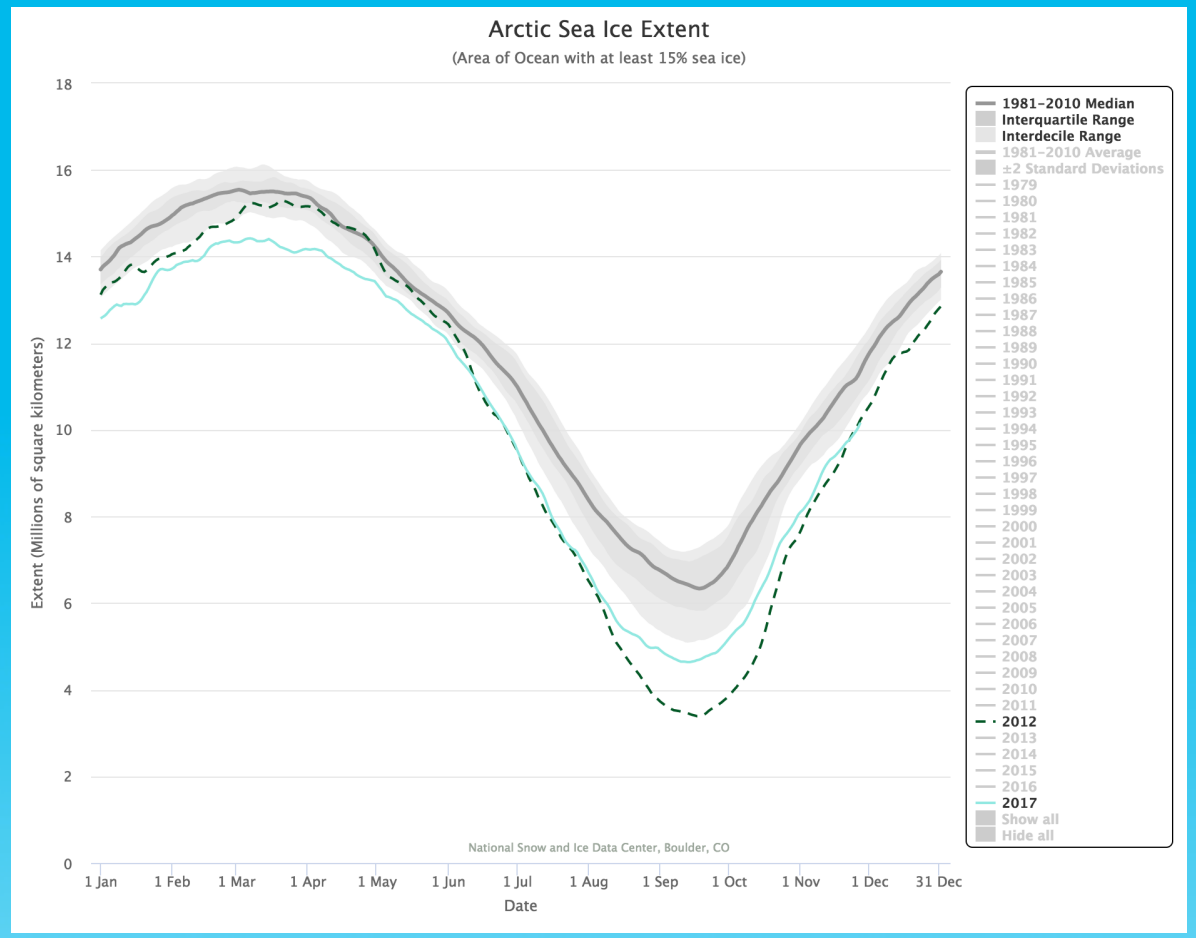
Regional distribution of many ECVs:

Satellites + ground stations = global picture

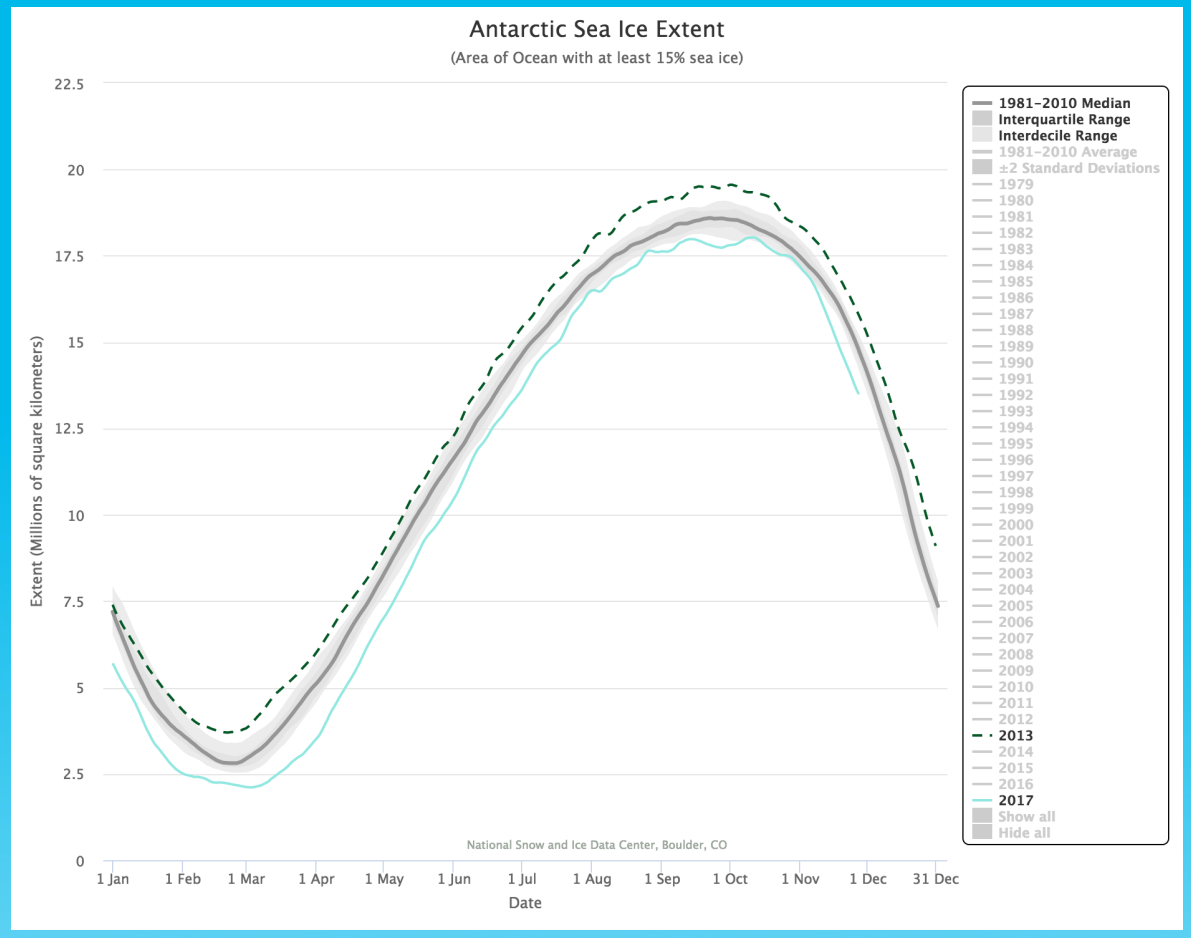


2017 Sea ice well below average at both poles

ARCTIC



ANTARCTIC



Data: US National Snow and Ice Data Centre (NSIDC) 2017

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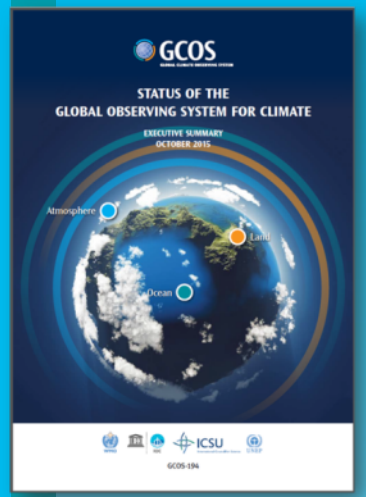

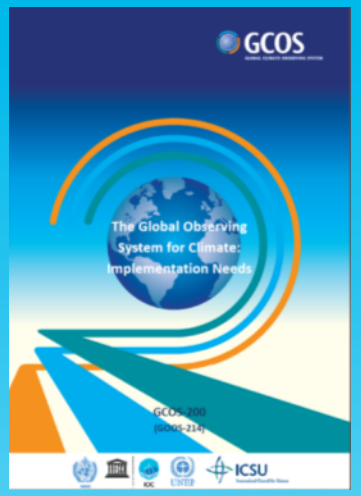

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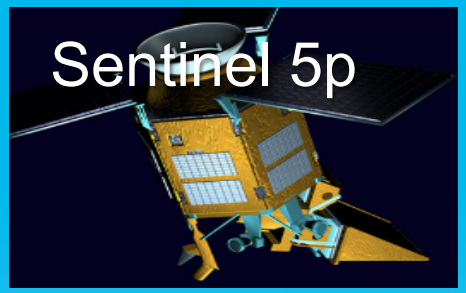
Evolving Satellite-based Carbon Measurement Capabilities

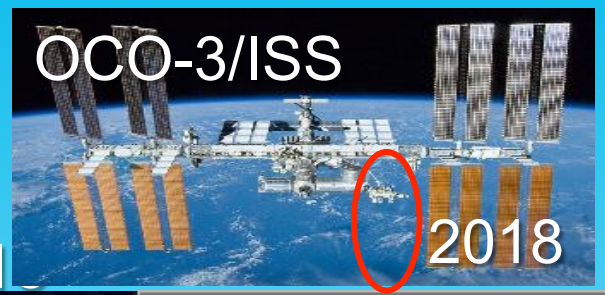
- TanSat Successfully Launched on 22 Dec 2016
- NASA Earth Ventures GeoCarb Selected
- CNES MicroCarb Approved for Implementation

PAST

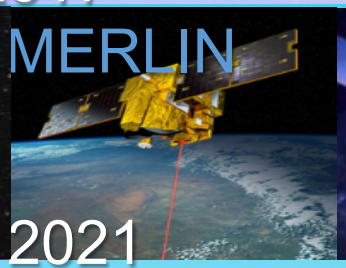
PRESENT

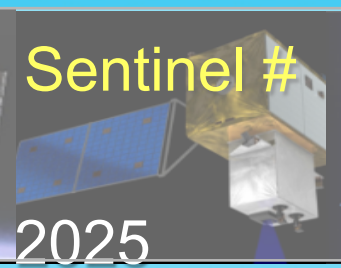


NEAR FUTURE



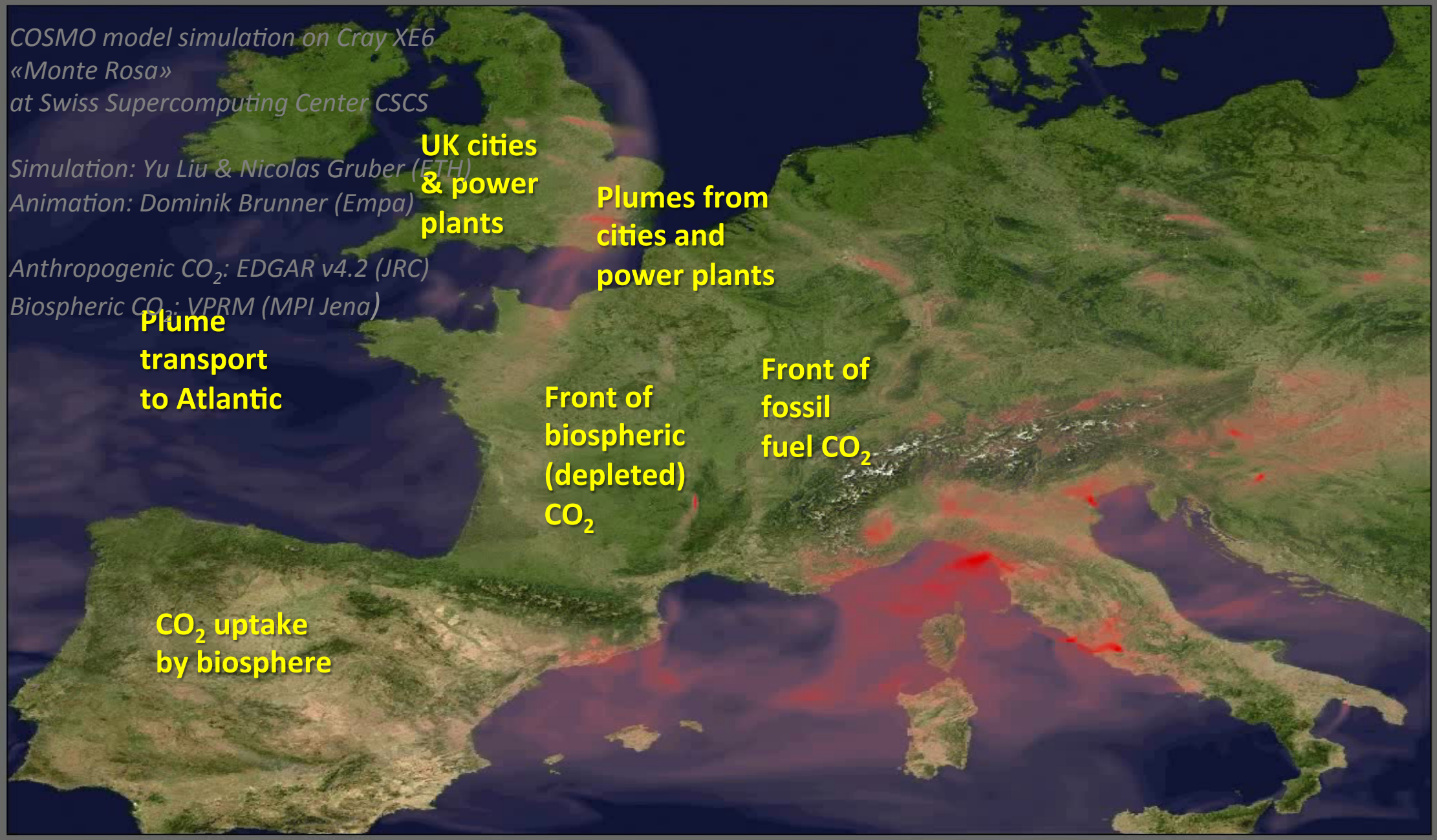
LATER

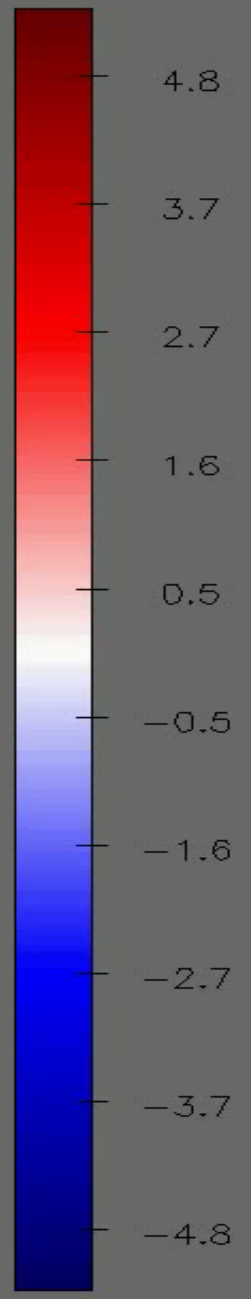




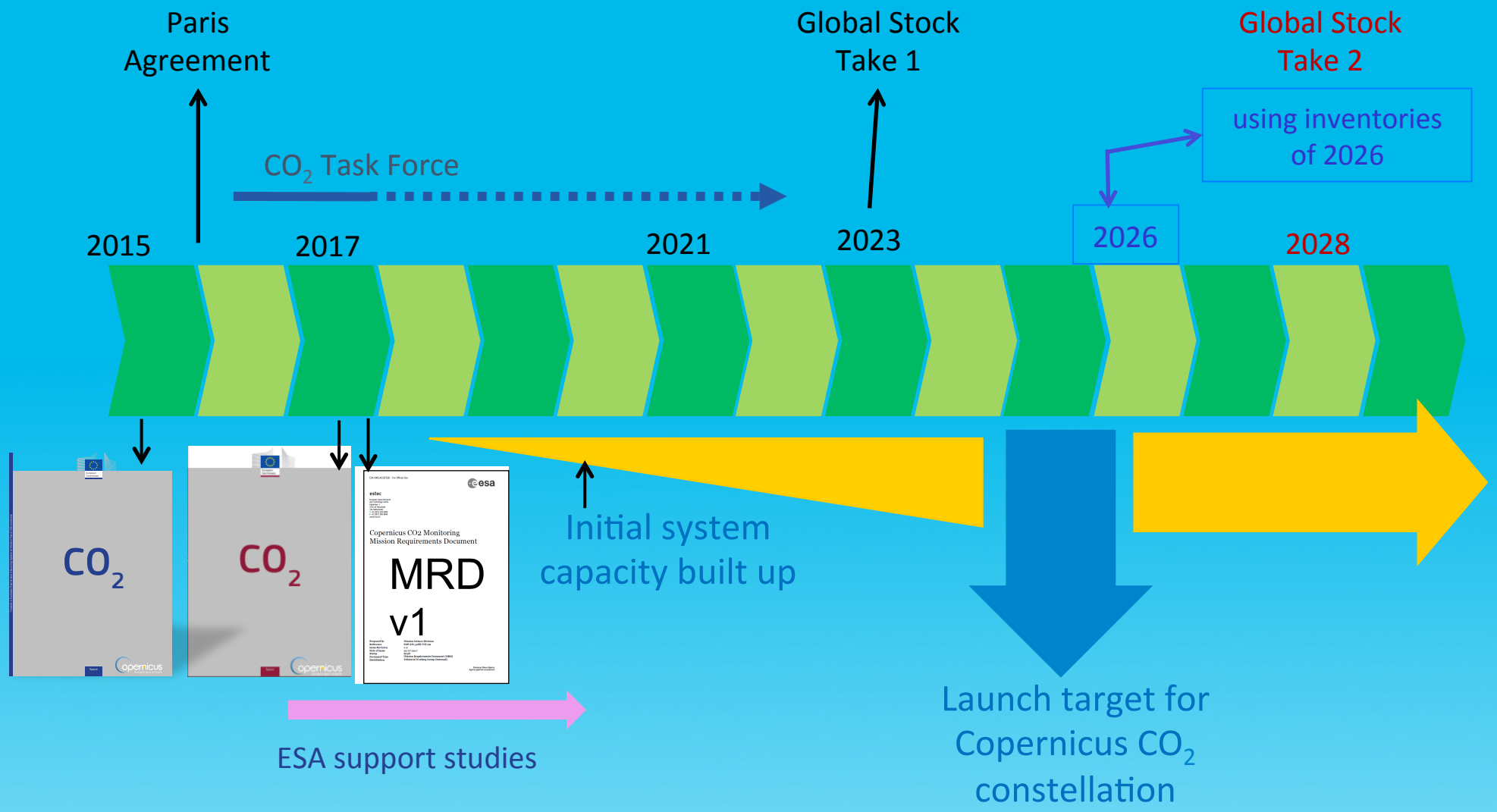
2008/03/20 00:00 UTC

Biogenic + anthropogenic XCO_2 [ppm]





Towards an anthropogenic CO_2 Monitoring & Verification Support Capacity



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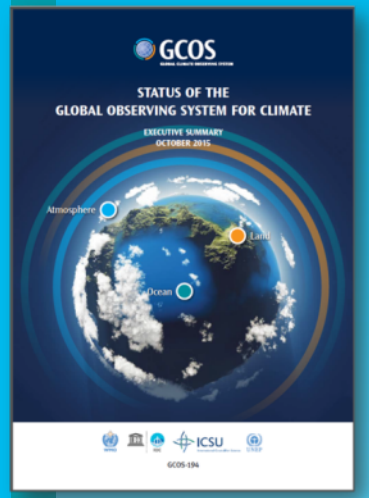

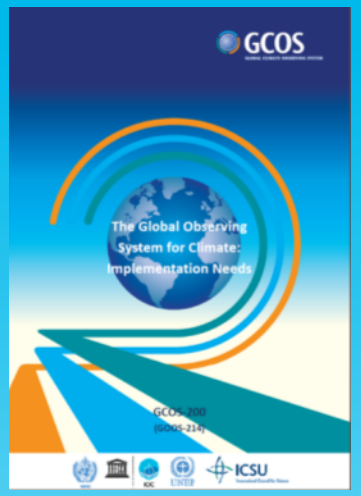

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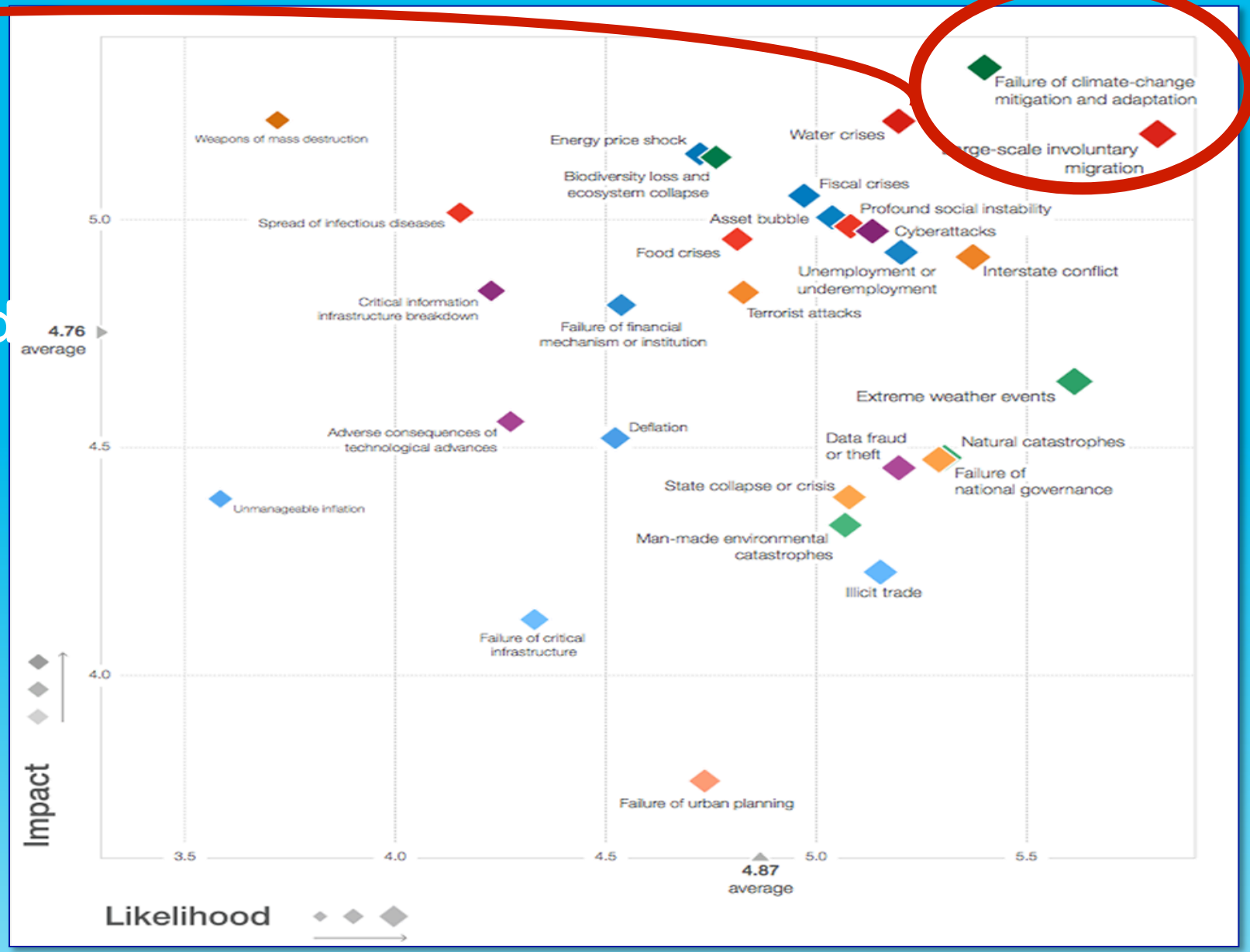
Global Risks Landscape 2016

Failure of climate-change mitigation and adaptation



Source World Economic Forum Global Risks Report 2016

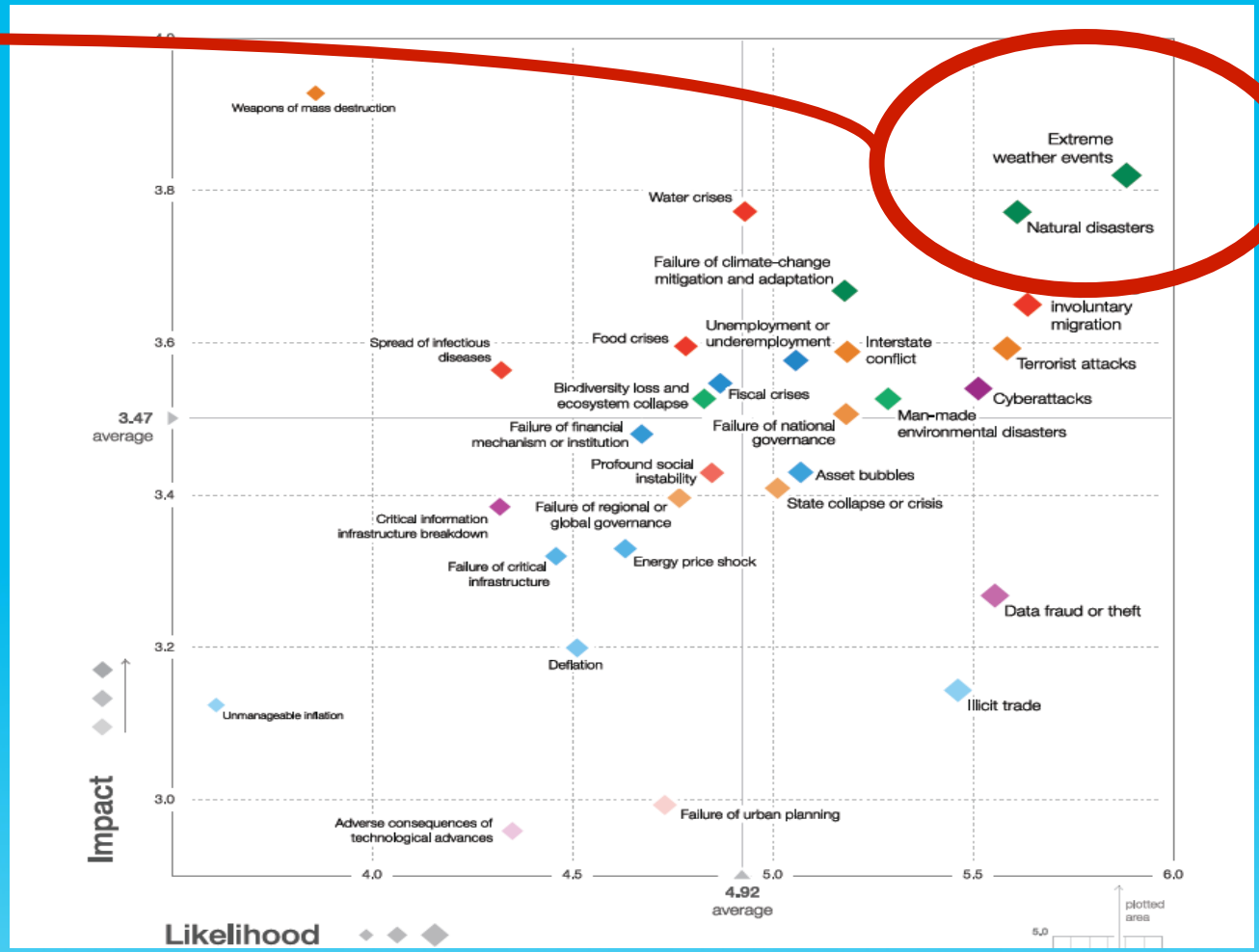
http://www.weforum.org/reports/the-global-risks-report-2016

Global Risks Landscape 2017

Extreme Weather

&

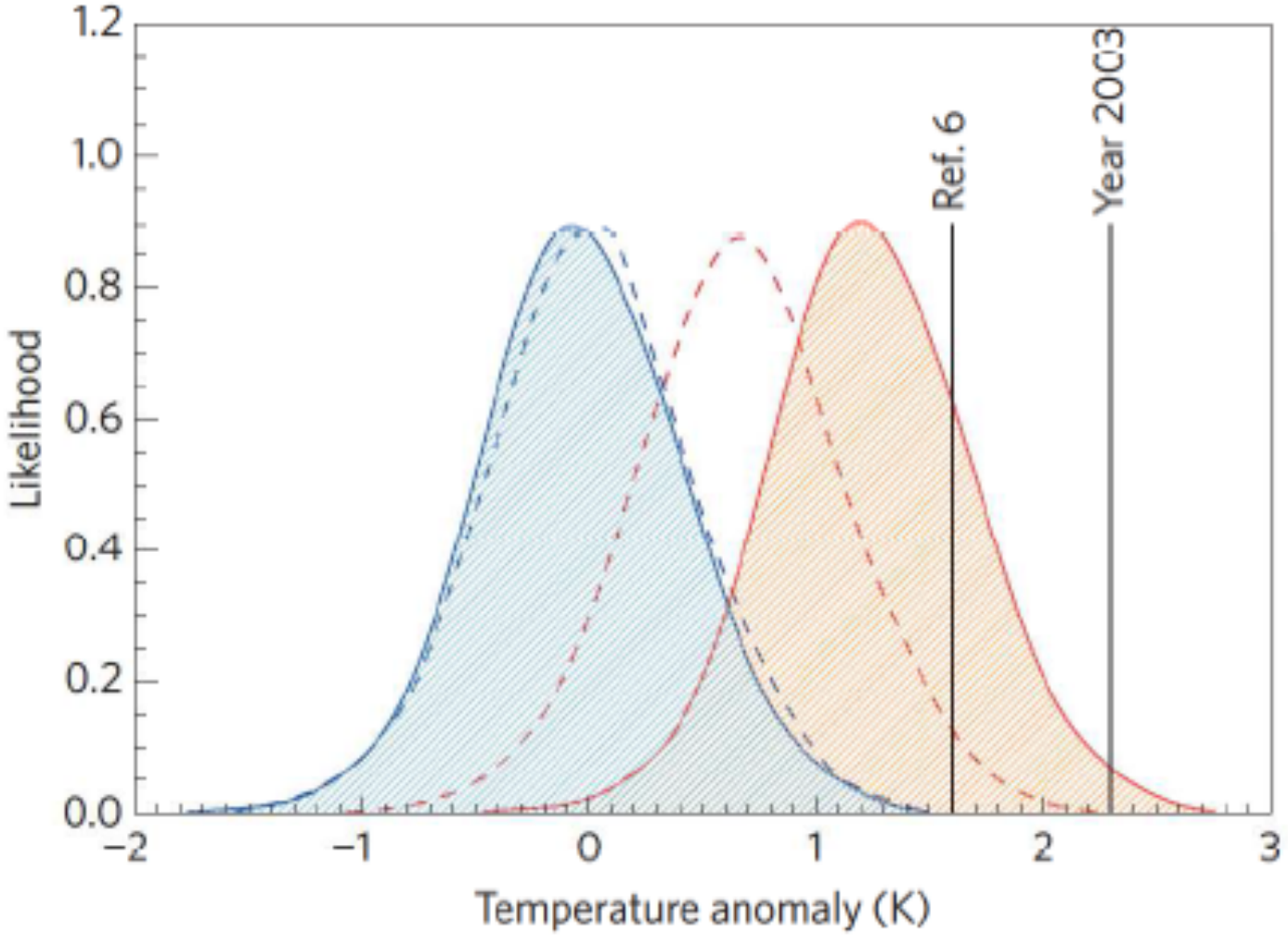
Natural Disasters



Source World Economic Forum Global Risks Report 2017

http://www.weforum.org/reports/the-global-risks-report-2017

Increased likelihood of 2003 heatwave event as function of anthropogenic change (Christidis et al. 2015)



Return times of summer heatwave with and without anthropogenic forcing

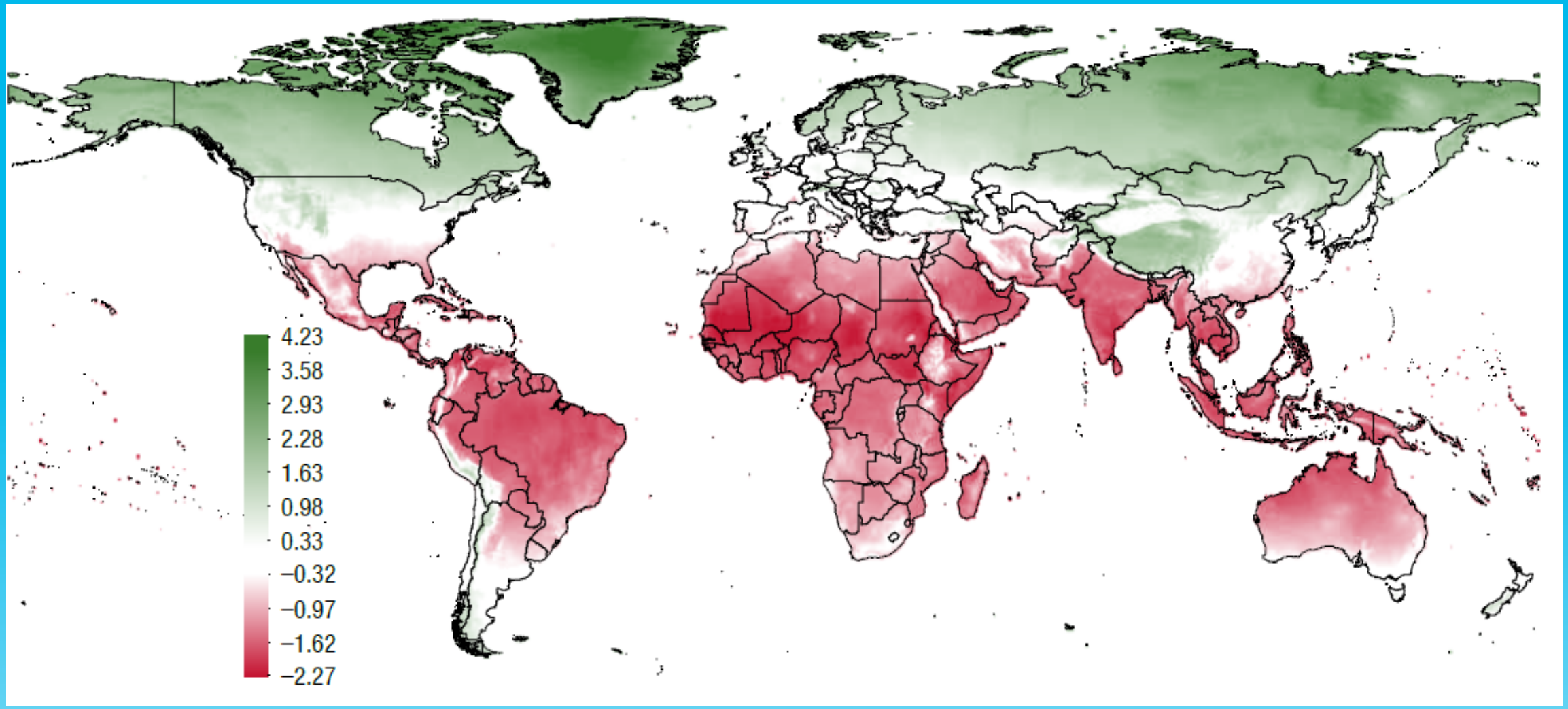
Table 1 | Return times (RT) of summer heatwave events in the reference region, characterized by temperature anomalies above a given threshold and estimated with and without the effect of human influence on the climate (ALL and NAT).

	Decade 1990–1999	Decade 2003–2012
	Threshold = 1.6 K	
*RT_{ALL} (years)	52 (14–444)	5 (2.7–11)
RT_{NAT} (years)	$>10^4$	$>10^3$
PRB_{ALL}/PRB_{NAT}	$>10^3$	$>10^3$
	Threshold = 2.3 K	
RT_{ALL} (years)	$>10^3$	127 (34–999)

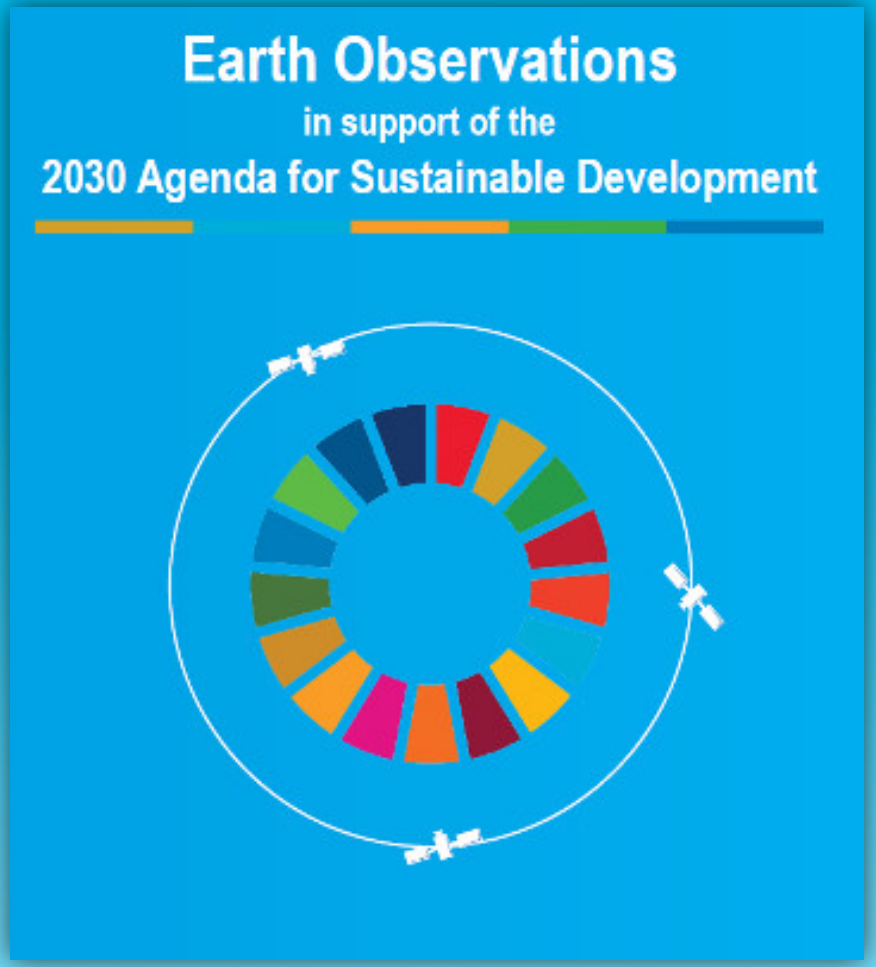
The change in the probability due to anthropogenic forcings (PRB_{ALL}/PRB_{NAT}) is also shown for the 1.6 K threshold. Estimates in brackets correspond to the 5–95% uncertainty range. For probabilities too small to be accurately estimated, a best approximation of the order of magnitude of the 5th percentile is reported.

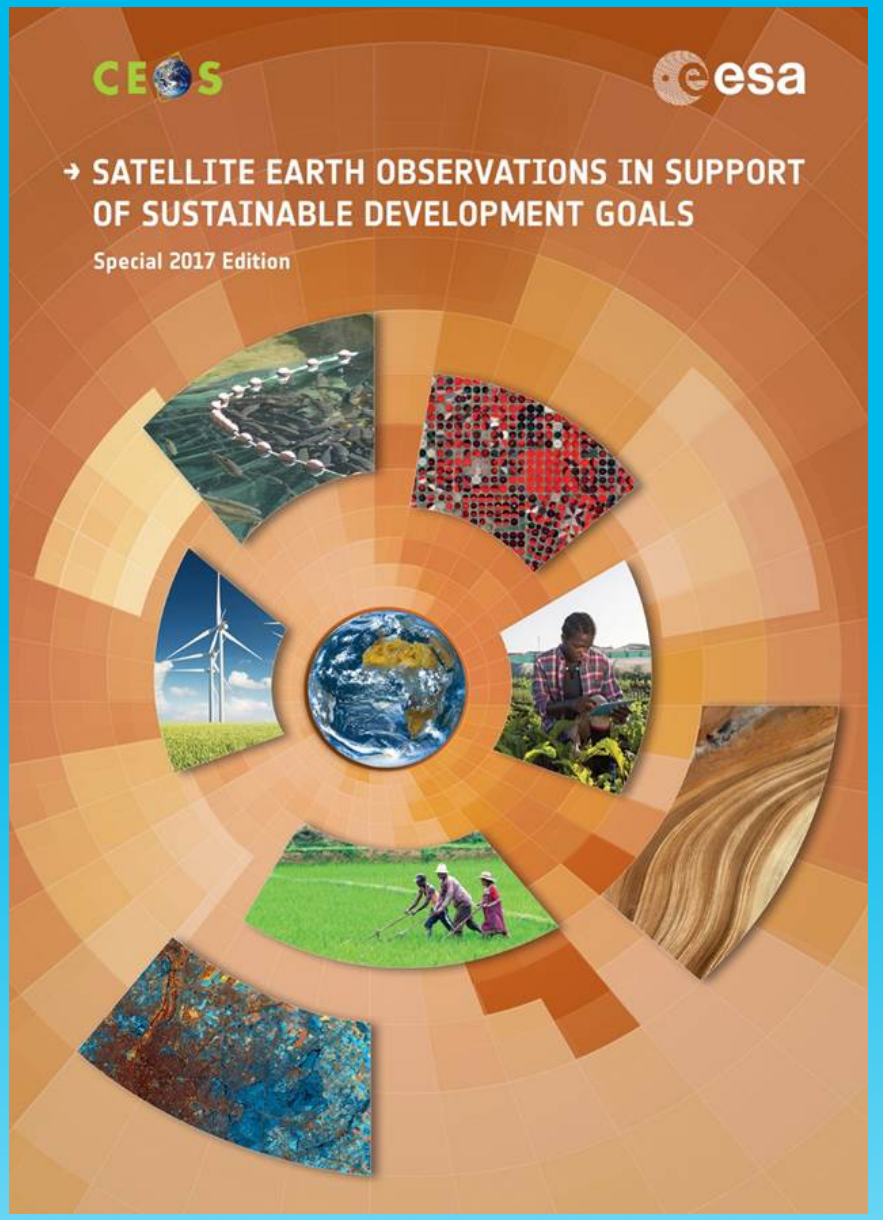
*NB for climate statistics of decade 1900-1910, RT_{ALL} >100

Effect of a 1°C increase in Temperature on Real per Capita Output



Space Agencies Supporting the SDGs





EO importance for the SDG's

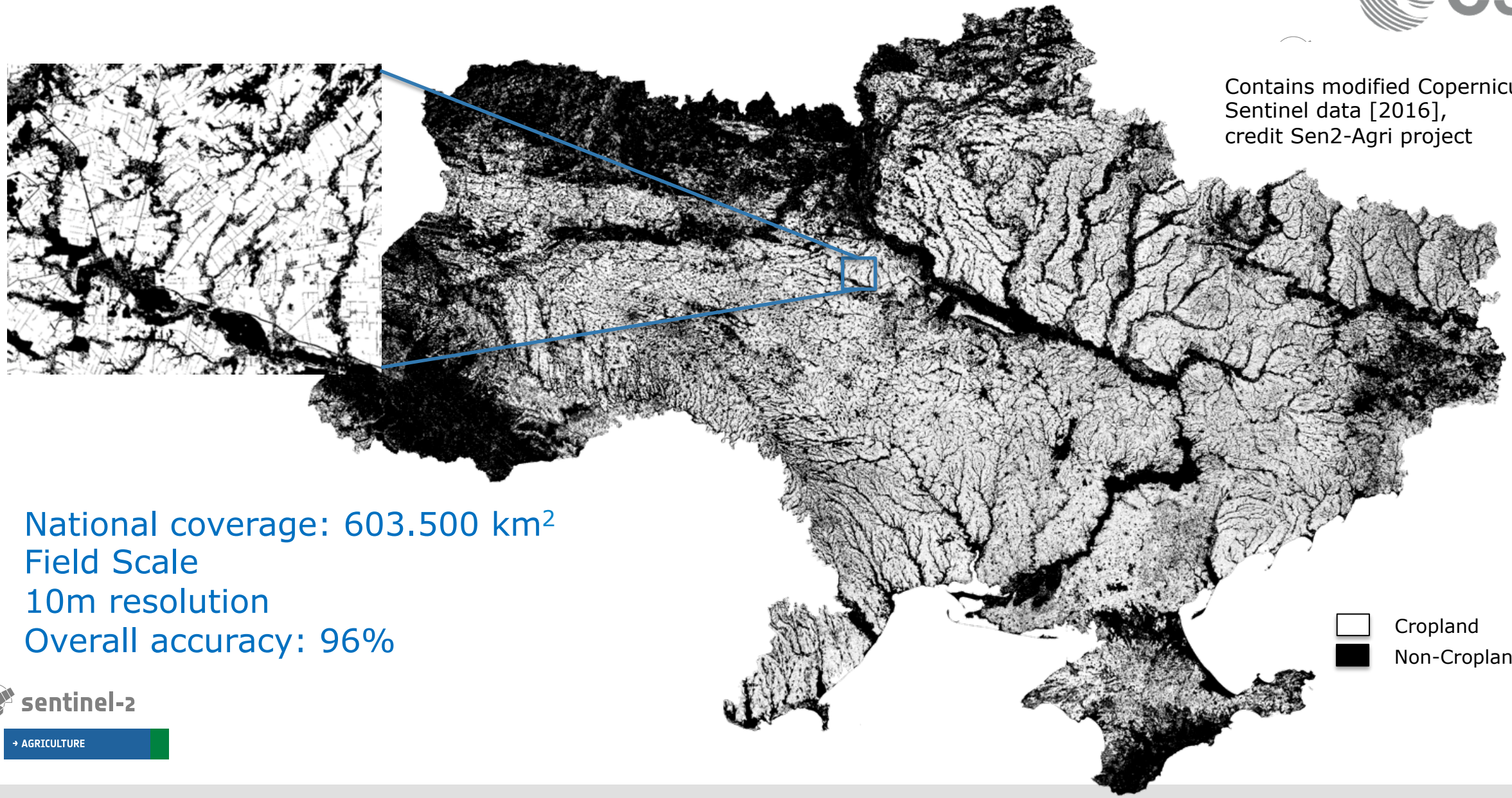
Earth Observations potential contribution to the SDG Targets and Indicators

SDGs with most opportunities for EO data

Analysis performed by the GEO EO4SDGs initiative

Target *Contribute to progress on the Target yet not the Indicator per se*								Goal	Indicator *Direct measure or indirect support*				
					1.4	1.5		1.4.2					
				2.3	2.4	2.c		2.4.1					
			3.3	3.4	3.9	3.d		3.9.1					
						5.a		5.a.1					
	6.1	6.3	6.4	6.5	6.6	6.a	6.b	6.3.1	6.3.2	6.4.2	6.5.1	6.6.1	
				7.2	7.3	7.a	7.b	7.1.1					
							8.4						
				9.1	9.4	9.5	9.a	9.1.1	9.4.1				
					10.6	10.7	10.a						
11.1	11.3	11.4	11.5	11.6	11.7	11.b	11.c	11.1.1	11.2.1	11.3.1	11.6.2	11.7.1	
			12.2	12.4	12.8	12.a	12.b	12.a.1					
				13.1	13.2	13.3	13.b	13.1.1					
	14.1	14.2	14.3	14.4	14.6	14.7	14.a	14.3.1	14.4.1	14.5.1			
15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	15.1.1	15.2.1	15.3.1	15.4.1	15.4.2	
							16.8						
17.2	17.3	17.6	17.7	17.8	17.9	17.16	17.17	17.18	17.6.1	17.18.1			

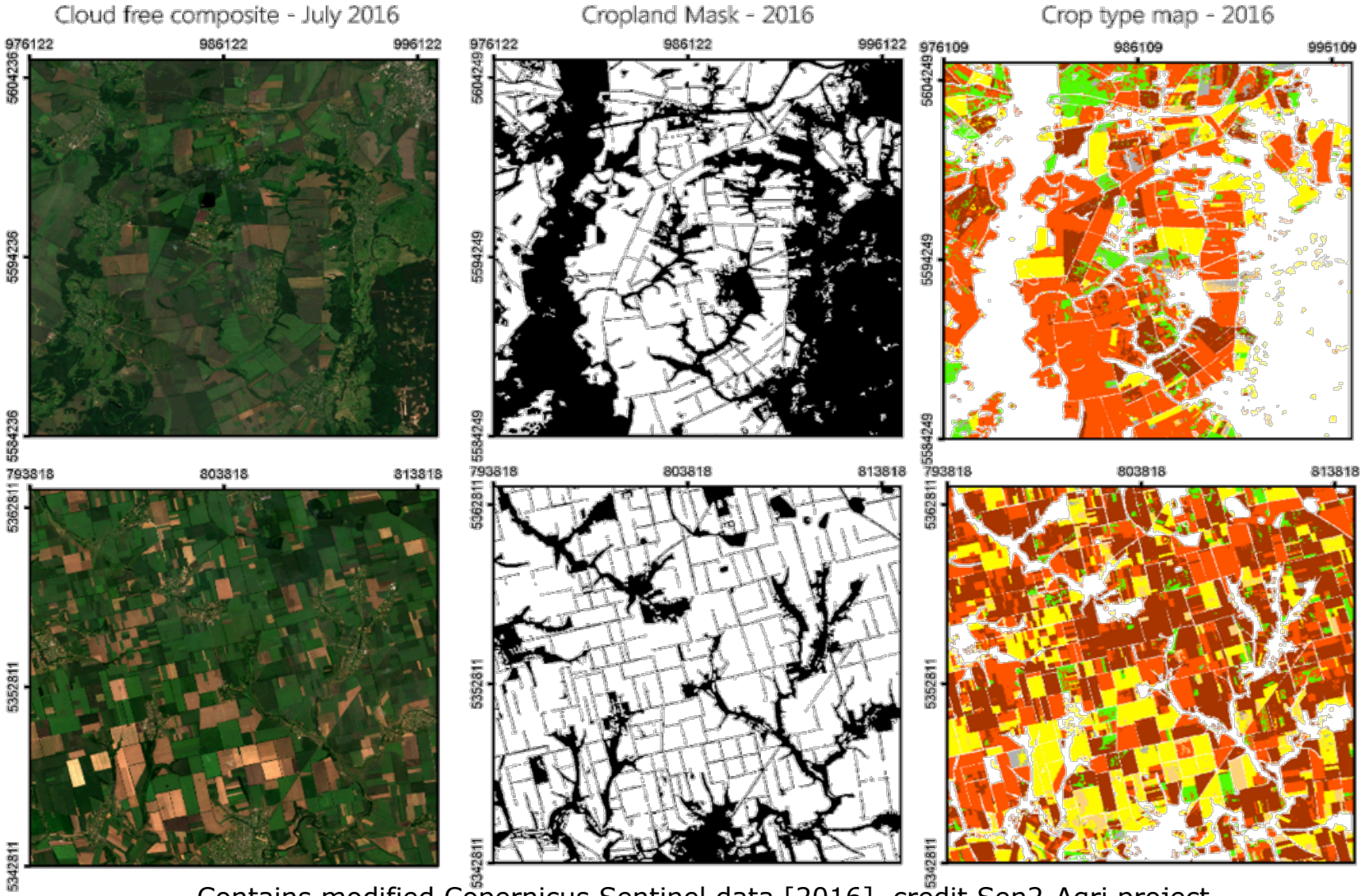
National crop mask (Ukraine 2016)



National coverage: 603.500 km²
Field Scale
10m resolution
Overall accuracy: 96%

sentinel-2
› AGRICULTURE

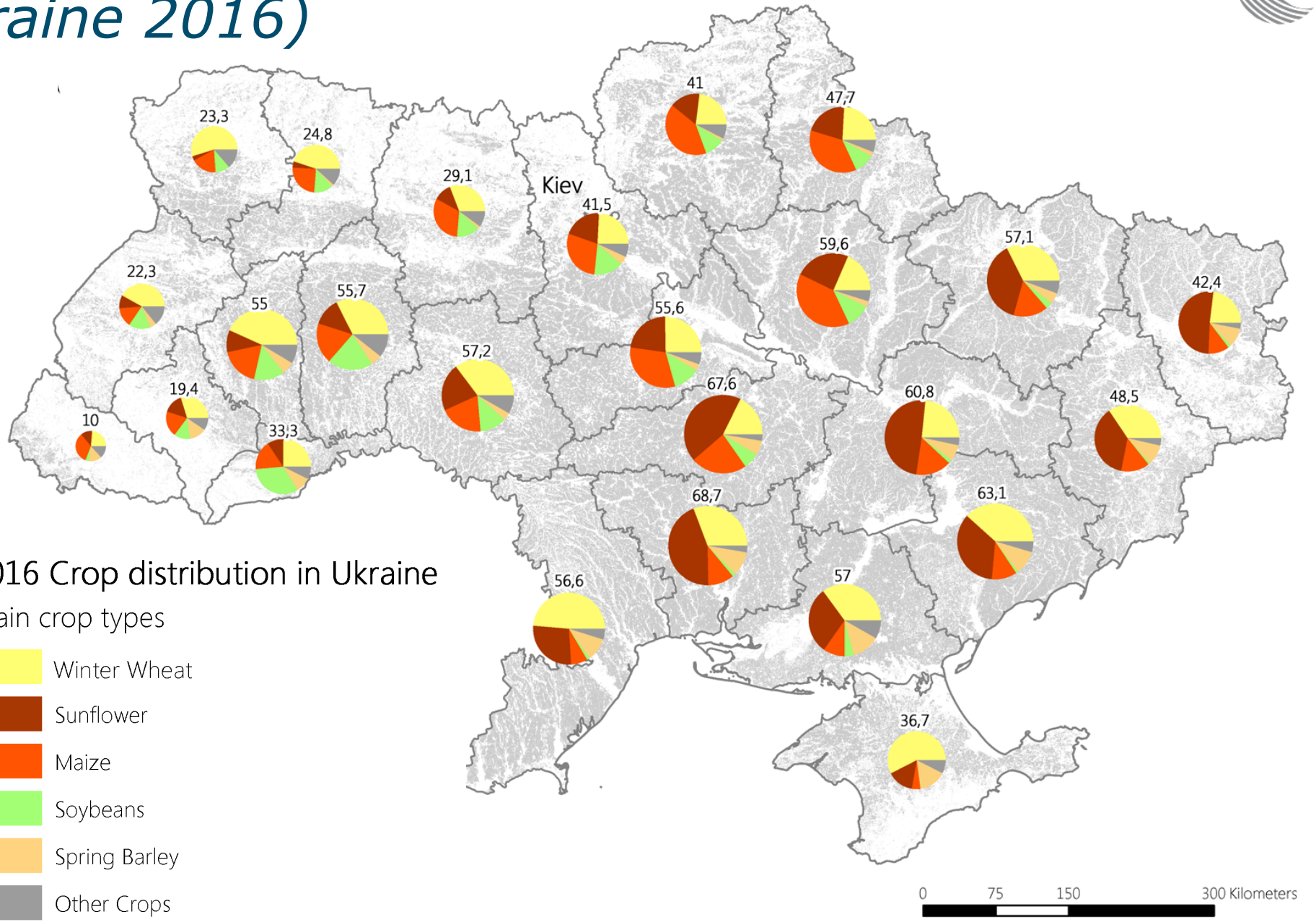
National crop type mapping at field scale
(Ukraine 2016)



sentinel-2
→ AGRICULTURE

Contains modified Copernicus Sentinel data [2016], credit Sen2-Agri project

National crop statistics by administrative units *(Ukraine 2016)*



sentinel-2

→ AGRICULTURE

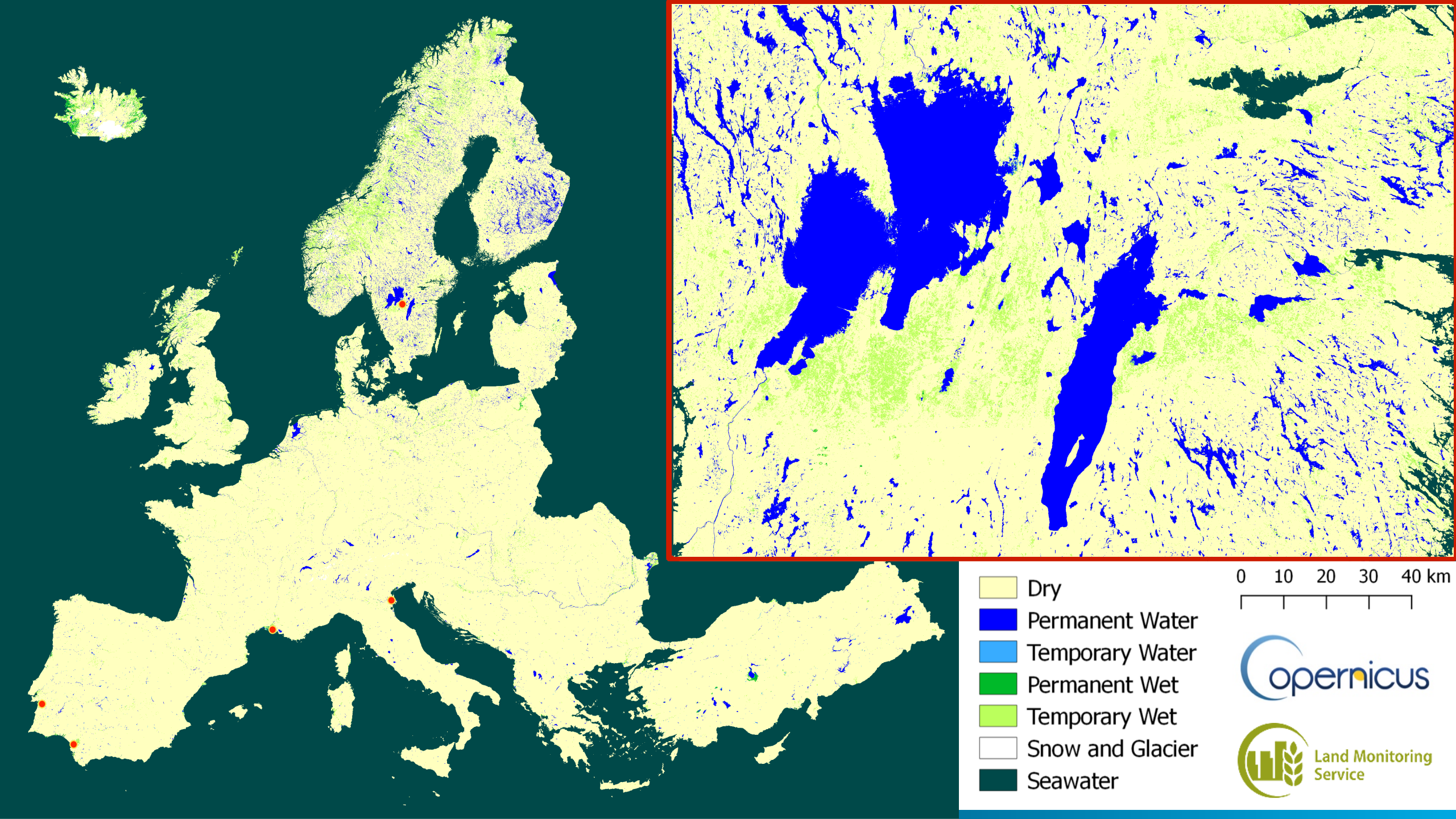
SDG 6

Ensure availability and sustainable management of water and sanitation for all

SDG Indicator 6.6.1: Change in the extent of water-related ecosystems over time

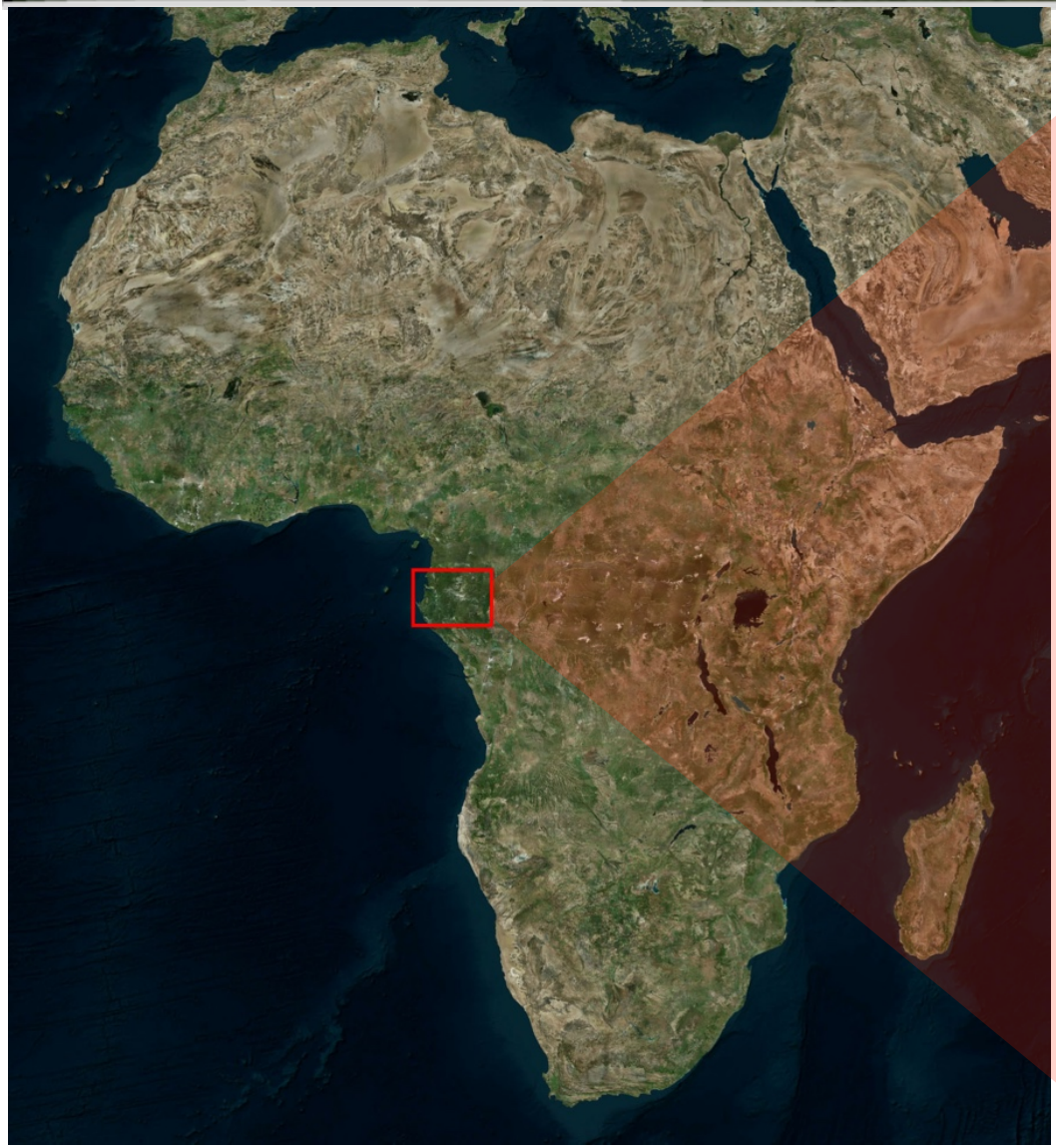
TIER III

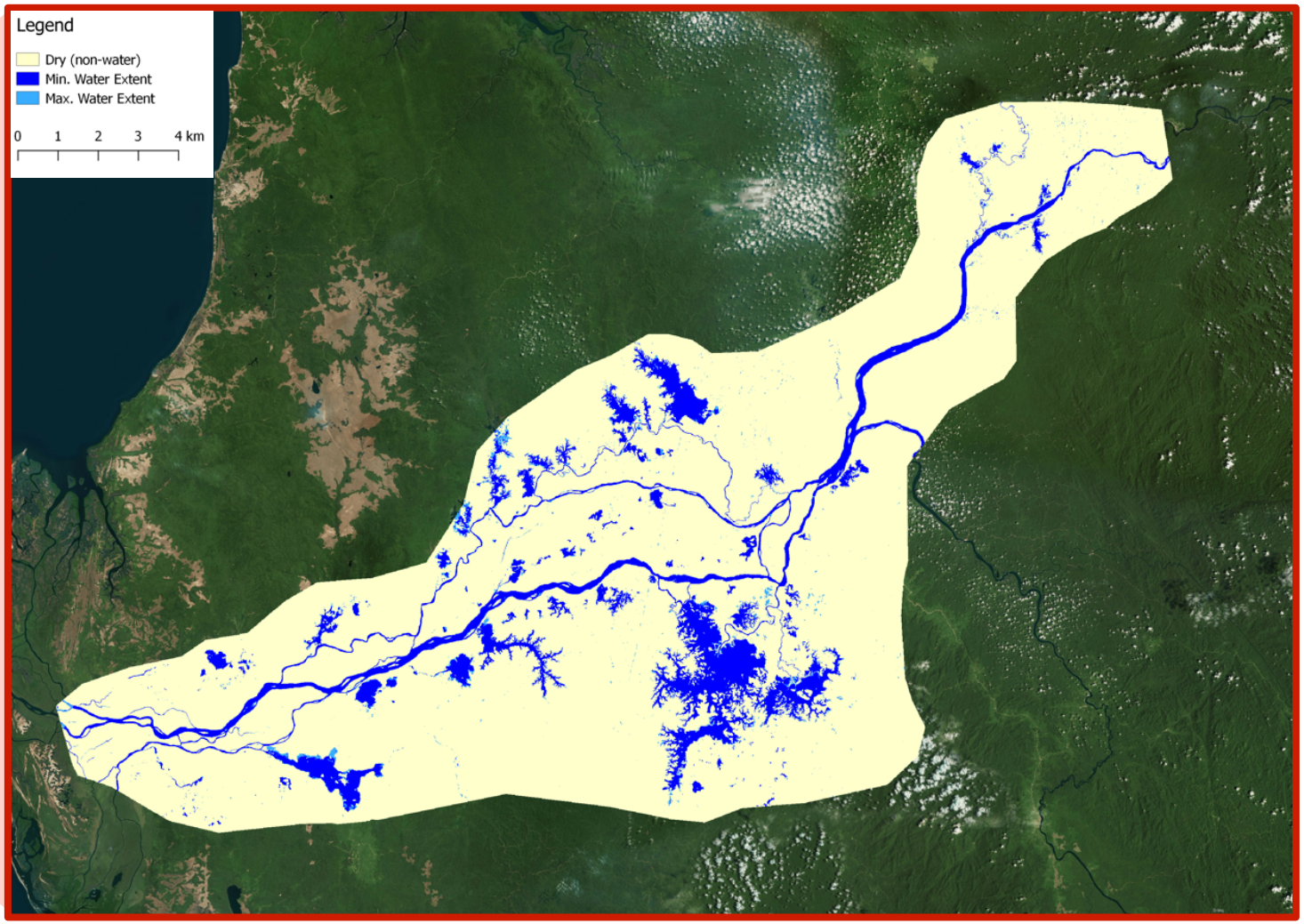
Ecosystem types	Extent/Volume/Flow sub-indicators	Ecosystem Health sub-indicators
Vegetated Wetlands (water dominated ecosystems such as swamps, marshes and peatlands)	**Spatial extent/area**	**Wetland health indices**
Inland open waters (lakes and reservoirs)	**Spatial extent/area** Quantity (volume)	Lake health indices **Water quality (6.3.2)**
Rivers and estuaries	Quantity (streamflow)	River health indices Water quality (6.3.2)
Groundwater aquifers	Quantity (depth to groundwater table)	Groundwater interaction with surface water


Dry
Permanent Water
Temporary Water
Permanent Wet
Temporary Wet
Snow and Glacier
Seawater
0 10 20 30 40 km
Copernicus
Land Monitoring Service

Mapping open surface waters with the Sentinels

Bas Ogooué River, Gabon





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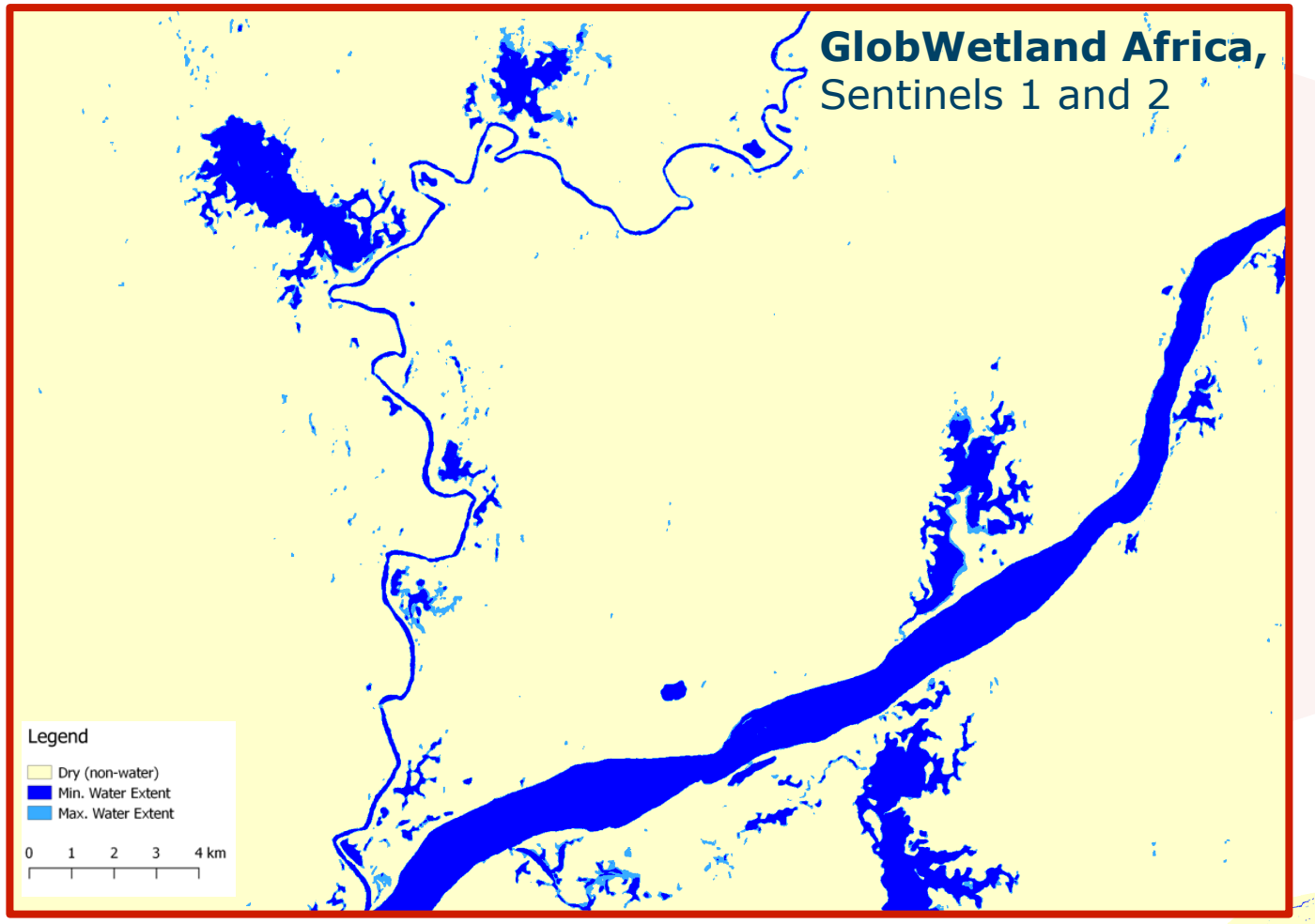
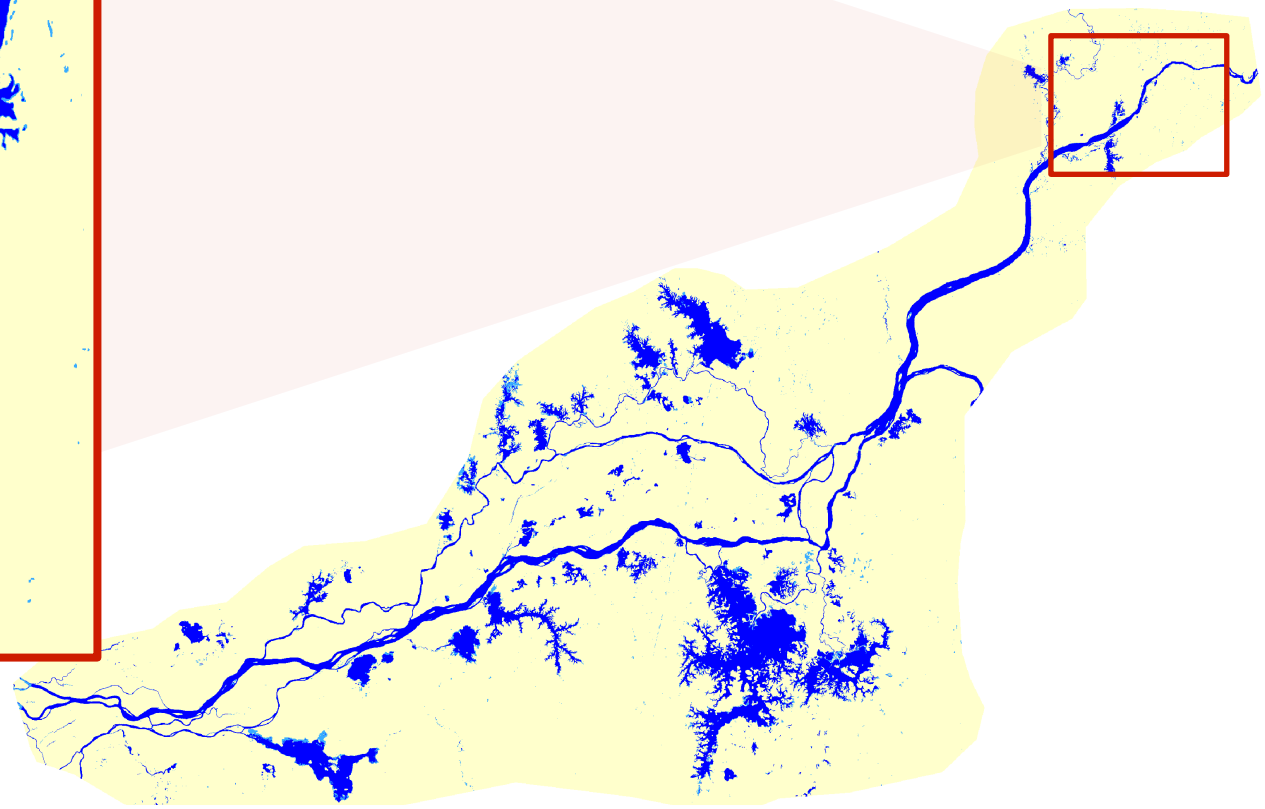




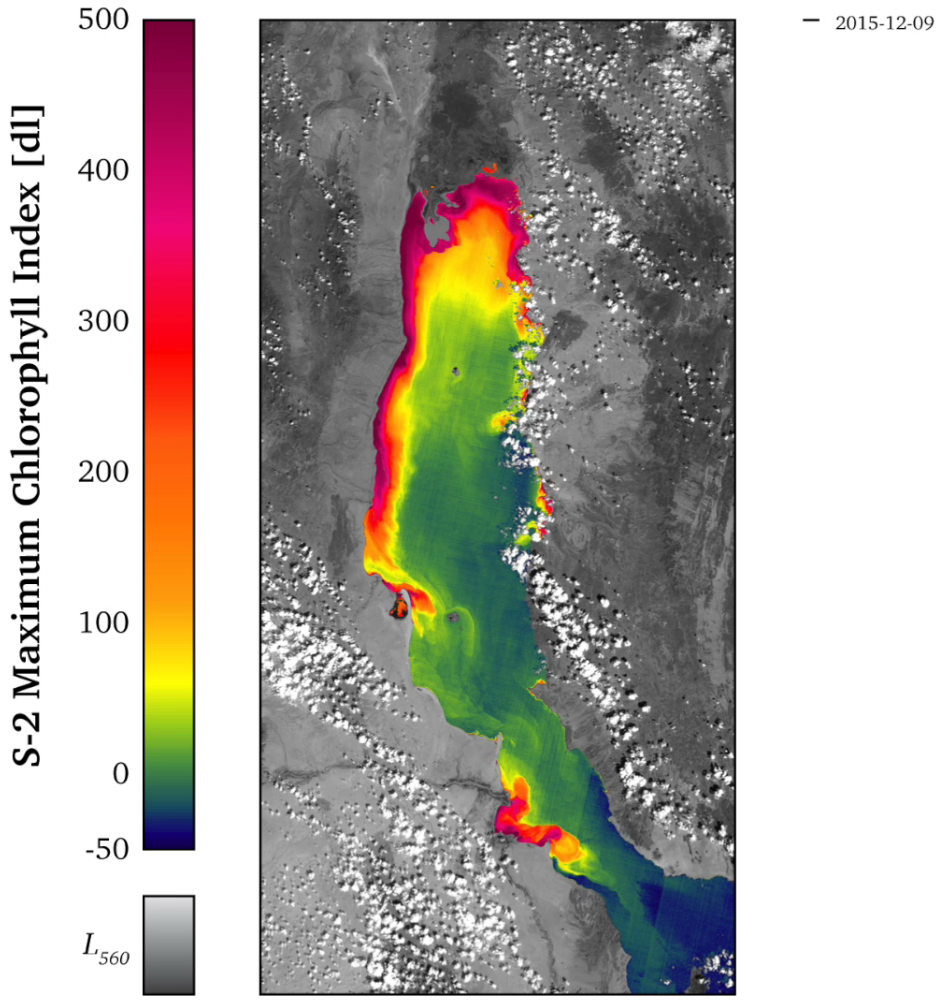
Monitoring Water Quality in open waters
Lake Turkana (Kenya)

SPOTLIGHT

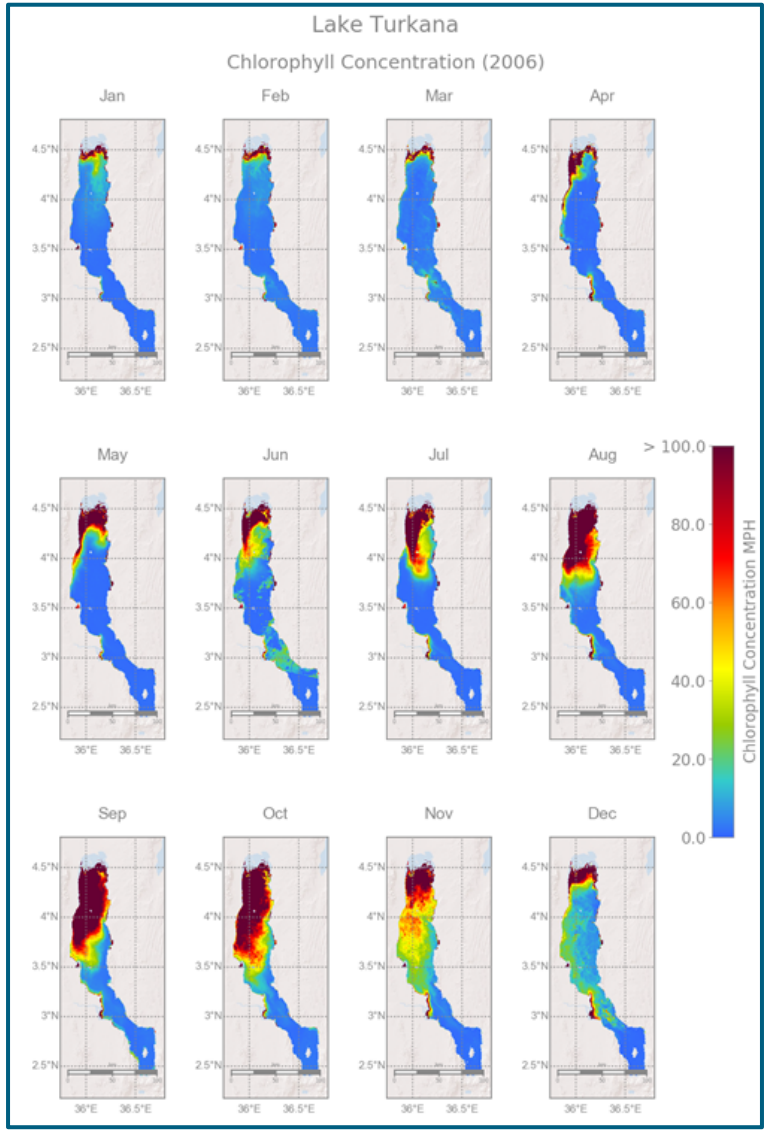
"I think Lake Turkana is going to be the second Aral Sea. It is one of the worst environmental disasters you can imagine."

|R. Leakey, Chair of Kenya Wildlife Service|

2015-16, Sentinel 2



2006, MERIS (S3 precursor)



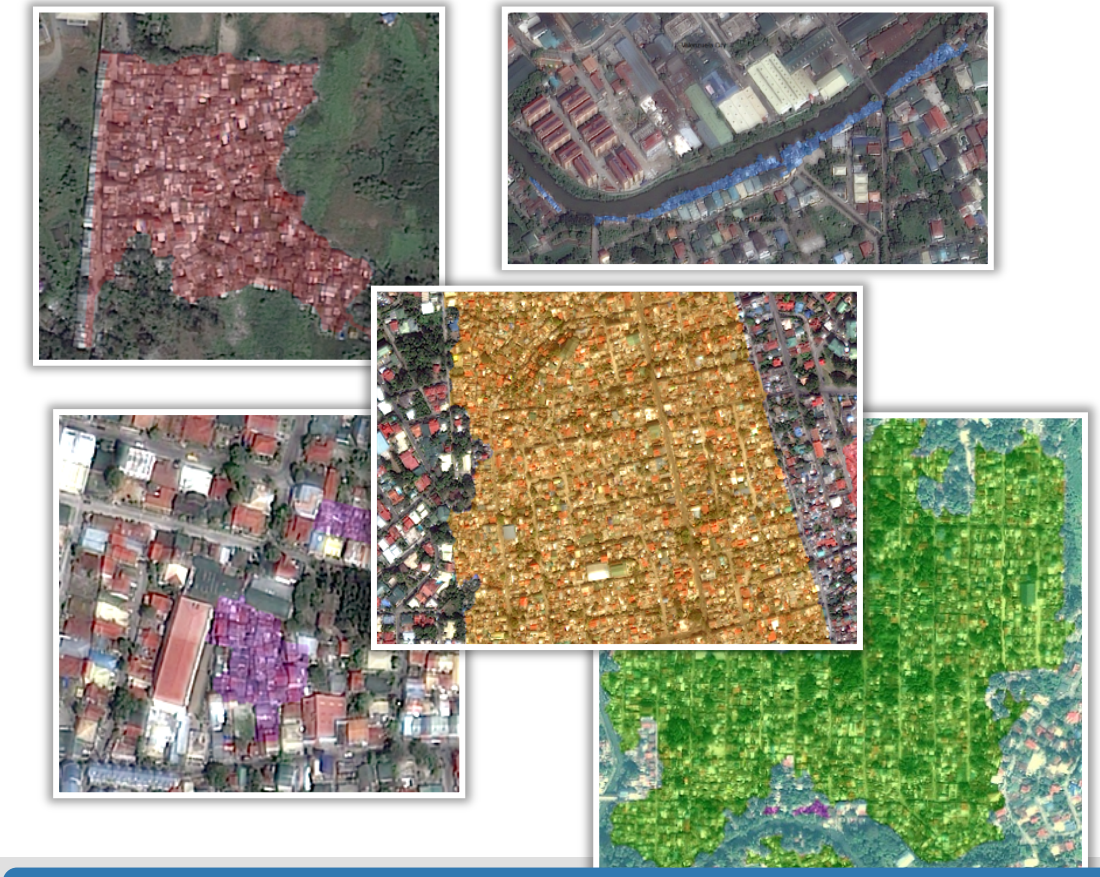
SDG 11

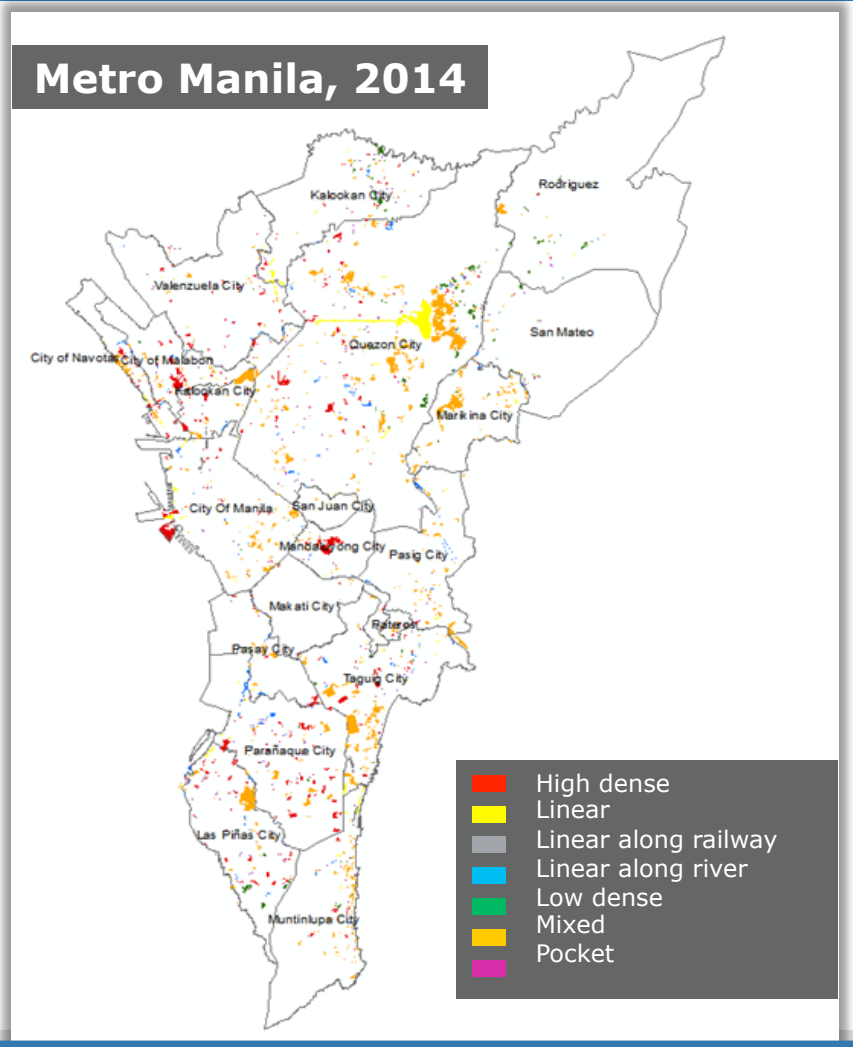
Make cities and human settlements inclusive, safe, resilient and sustainable

Target 11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums

Indicator 11.1.1 ***"Proportion of urban population living in slums, informal settlements or inadequate housing"***

- Population Distribution and Density
- **Extent and Type of Informal Settlement**





Extracted from very high resolution imagery. Often using advanced semi-automated Object-Based Image Analysis (OBIA) techniques.

Analysis and classification based on attributes reveals typology.

WORLD BANK GROUP

Data: Pléiades 1A.
Processing: GIM.

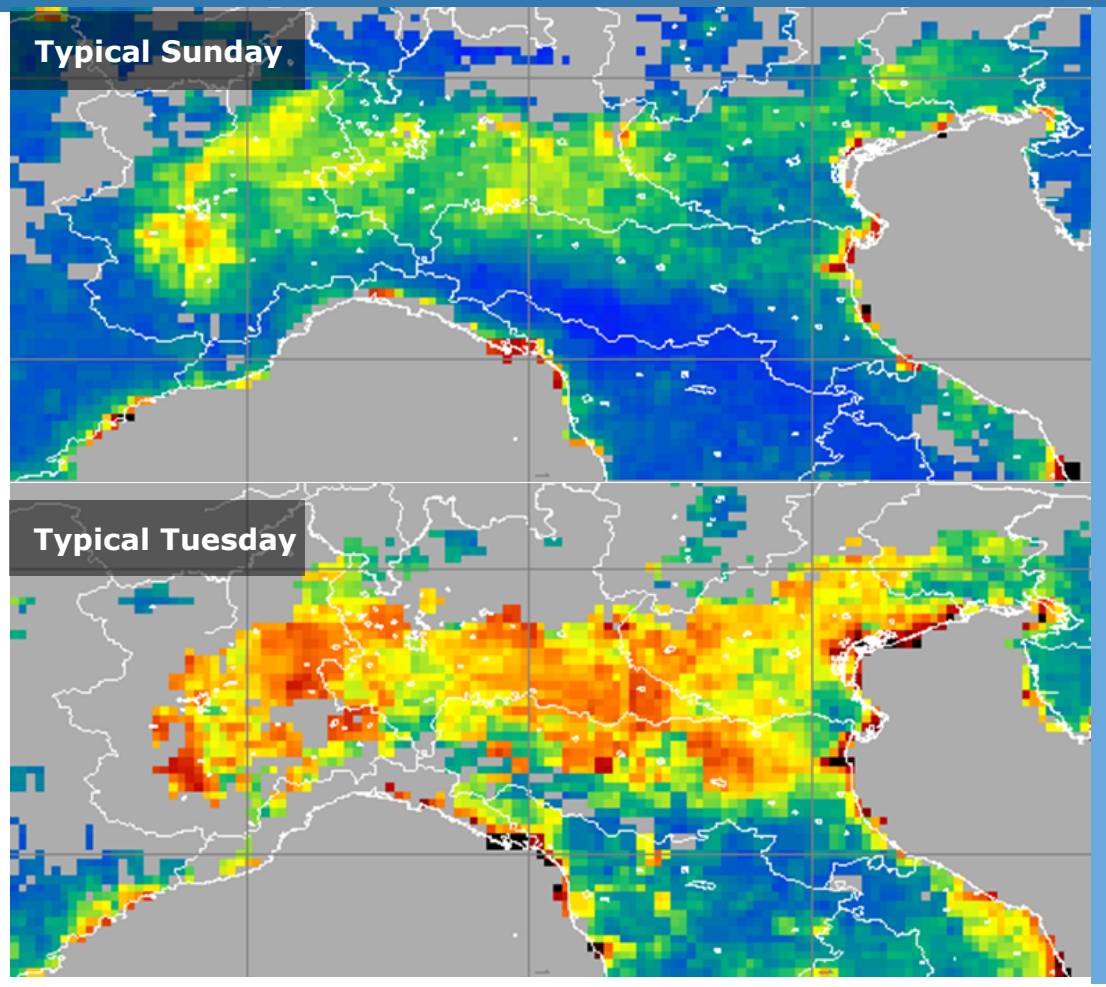
Detecting and characterising Informal Settlements using very high resolution imagery

Target 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

Indicator 11.6.2 ***"Annual mean levels of fine particulate matter (e.g. PM2.5 and PM 10) in cities (population weighted)"***

EO-derived parameters

- Annual mean levels of coarse particulate matter (PM10)
- Annual mean levels of fine particulate matter (PM2.5)



Aerosol thickness, e.g. optical depth of PM10 and PM2.5 (an indicator of the overall pollution).

Typical spatial resolutions: 1–10 km on a daily basis, with local improvements down to street level when adequate in-situ information and/or modelling is available

Data: MODIS/Aqua.
Processing: Carlo Gavazzi Space / ISAC-CNR.

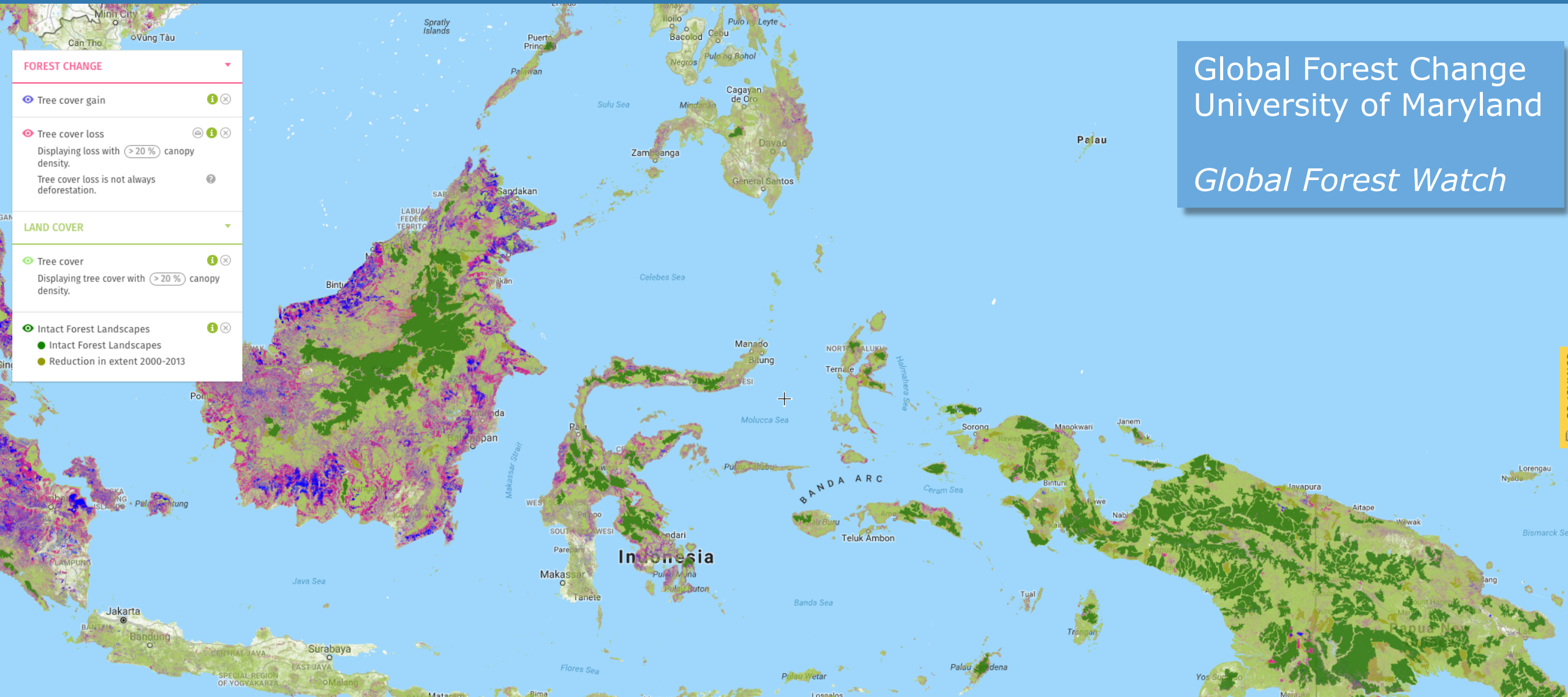
Fine particulate matter concentrations (2.5 and 10) over cities are estimated through numerical modelling, integrating satellite data (LEO/GEO through AOT assimilation) and in-situ data

SDG 15

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse

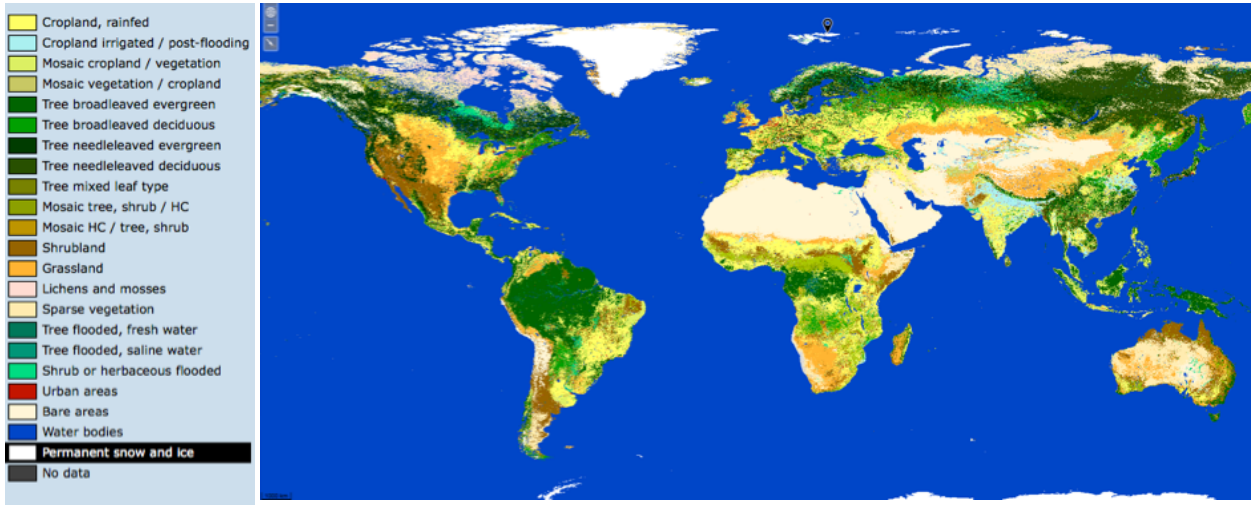
Target 15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements .

Indicator 15.1.1 ***"Forest area as a proportion of total land area"***



Target 15.3 By 2030, combat desertification, restore degraded land, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

Indicator 15.3.1 ***"Percentage of land that is degraded over total land area"***



Land Cover

GLOBAL LAND COVER MAP, 1992-2015 Annual maps

AVHRR SPOT VGT, MERIS, PROBA-V, S3 300m

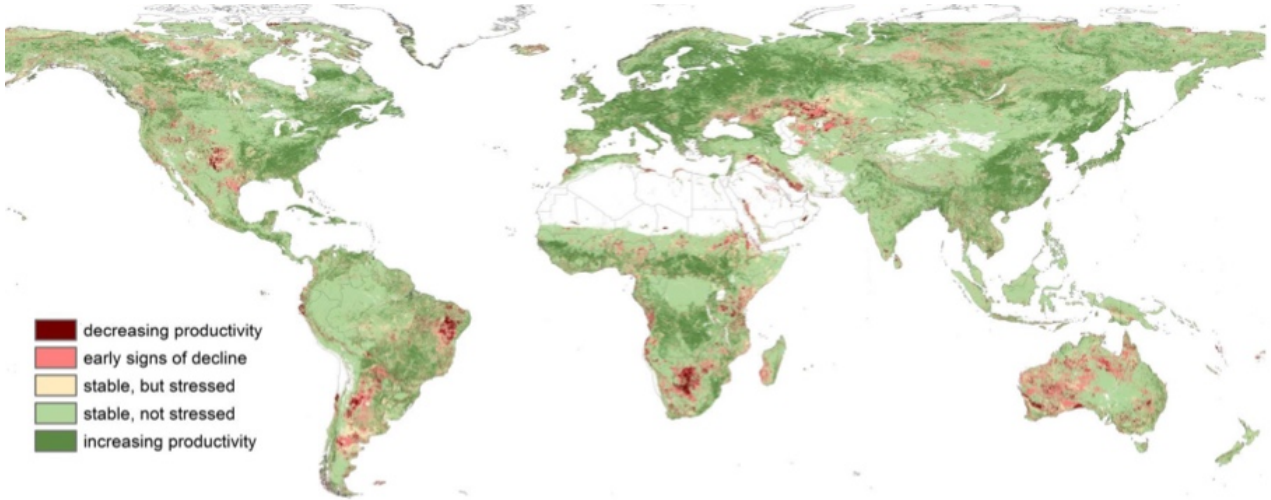
ESA Land Cover CCI

Custodian Agency:

- UNCCD (secretariat and Global Mechanism)

Other Involved Agencies

- FAO, UNEP/WCMC, CBD, UNFCCC



Land Productivity Dynamics

LPD derived from 1999-2013 NDVI phenological analyses

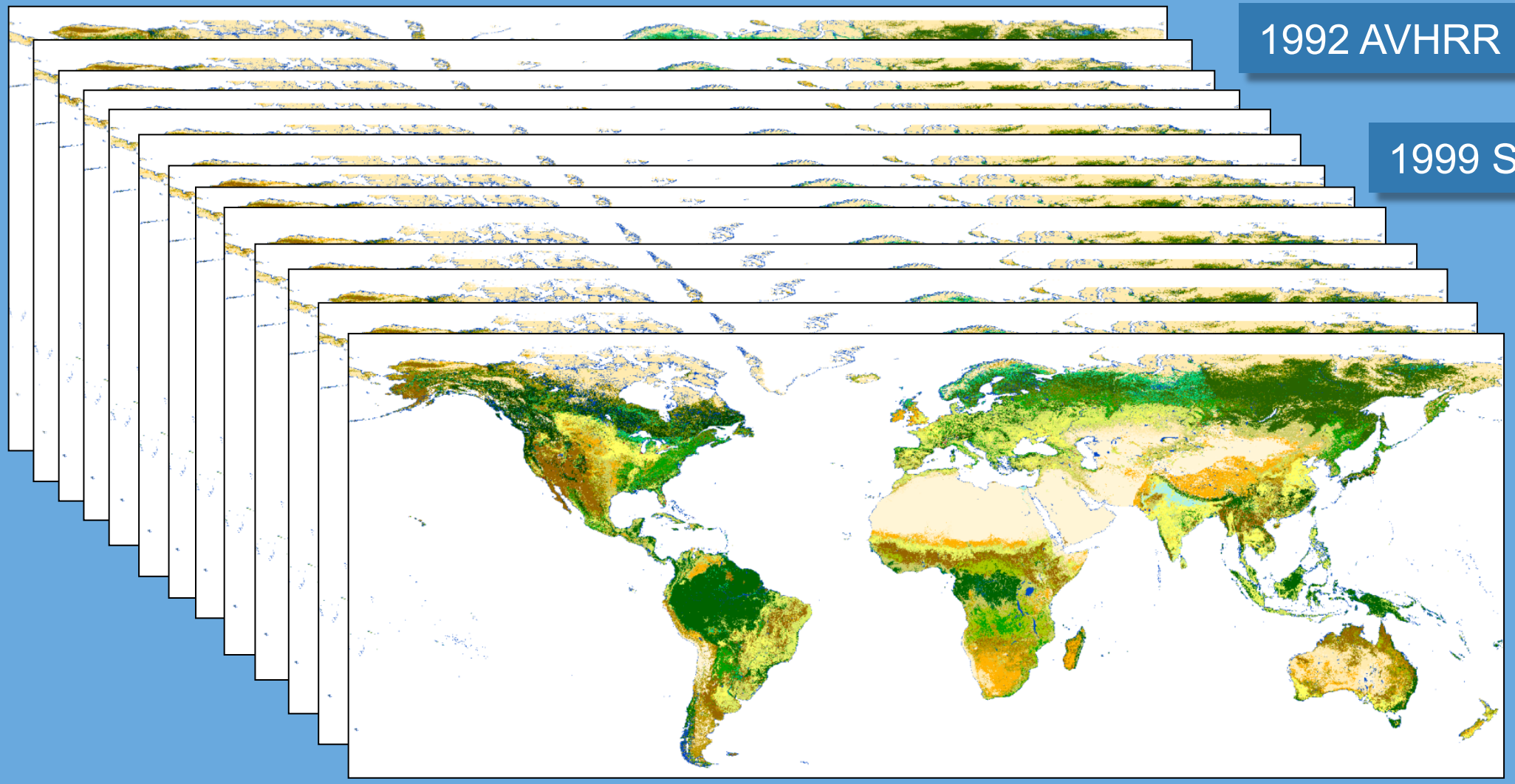
SPOT VEGETATION, 1km

EC Joint Research Center (JRC)

TIER III

Monitoring 15.3.1. on the status & trends in land degradation is based on sub-indicators:
(1) **Land Cover and Land Cover Changes** (2) **Land Productivity** (3) **Soil Organic Carbon**

Land Cover Land Cover Change



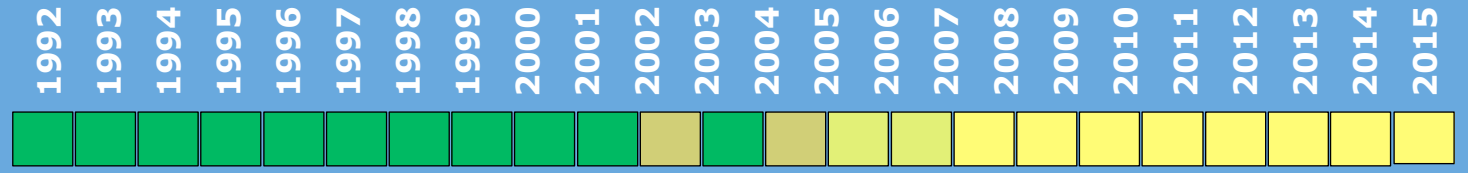
1992 AVHRR HRPT

1999 SPOT VGT

2013 PROBA-V

300m Automated annual Land Cover Maps

Pixel-based trajectory analysis and decision rules



Thank you

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