CCI Land variables

Emilio Chuvieco (Universidad de Alcalá, Spain: FireCCI)
On behalf of Land Science leaders

CLIMATE CHANGE INITIATIVE MID-TERM REVIEW

→ THE EUROPEAN SPACE AGENCY

ESA CCI Programme (2010-2024): Land variables

Land 2010

- fire cci
- land cover cci
- soil moisture cci

Land 2016

- biomass cci
- high resolution land cover cci
- lakes cci
- land surface temperature cci

Land 2022

- vegetation parameters cci

Land 2023

- river discharge cci
- anthropogenic water use cci

- cmug cci
- open data portal cci
- toolbox cci

Transversal

Cross-ECV projects (2023)

- XFires cci
- reccap-2 cci

CDR generated from Land variables

	Main products	Source	Validated	Best resolution	Temporal extent	Area
Land Cover	Land cover + changes Plant Functional Type maps	AVHRR (1992–1999), SPOT-VGT (1999–2013), PROBA-V (2014–2019), OLCI, SLSTR (2020–2022)	Yes	300 m	30 years	Global
Fire	Burned area	MERIS, MODIS, LTDR, SYN Sentinel-2 MSI	Yes	300 m / 20 m	42 years 2 years	Global / regional
Soil Moisture	Soil moisture + changes	19 microwave sensors	Yes	0.25 d	45 years	Global
HRLand Cover	Land cover + changes	Landsat + Sentinel 2	Yes	10 m	30 years	Regional
LST	Land Surface temperature	MODIS, SLSTR, VIIRS, AVHRR, Landsat, SSM/I, AMSR, GOES, Himawari	Yes	100 m	29 years	Global
Lakes	Water Level, extent, surface temperature, reflectance, ice cover and thickness	Topex/P; Envisat; Jason1/2/3; Saral; JSentinel-1/2/3/6; MODIS, AVHRR; Landsat 4/5/7/8/9; ATSR2; AATSR; SLSTR	Yes	1/120° (~1km)	30 years	Global
Biomass	Aboveground Woody Biomass (AGB) + changes	ALOS-1 & -2, Sentinel 1, Envisat ASAR + other sensors	Yes	100m	11 years	Global
River discharge	Water surface elevation + river discharge	ERS-2, Envisat, Saral, Topex-Poseidon, Jason-1/2/3, Sentinel-3 (SRAL+OLCI), Sentinel-6, MODIS, MERIS; Sentinel-1/2, Landsat-/5/7/8/9	Yes	Point-based	20 years	53 sites
Vegetation parameters	Leaf Area Index, fPAR (albedo, fPARgreen, SIF)	1km: VIIRS. AVHRR, SPOT-VGT, PROBA-V 300m (2026): MERIS, MODIS, OLCI	Yes	300 m	22 years	932 sites Regional

Land variables' links with other variables

	Outputs to other ECV	Inputs from other ECV
Land Cover	Biomass, Fire, LST,	Permafrost, Glaciers
Fire	Land Cover, Aerosols, Ozone, GHG	Land Cover,
Soil Moisture	Precipitation, Agricultural Water use, ET, Ground water	
HRLand Cover		
LST	Permafrost	Land Cover, Snow
Lakes	none	none
Anthropogenic water use		
River discharge	None	None
Biomass	Fire	Land Cover
Vegetation parameters	none	none

Impacts from Land variables

	Coverage by IPCC reports	Use by Scientific Publications	Number of users	Impact on SDG	Transfer to Copernicus services
Land Cover	Yes	>350	>20,000	#15	Yes
Fire	Yes	>470	>6,800	#13, #15	Yes
Soil Moisture	Yes	>1000	1000s (no longer tracked)	#13, #14, #15	Yes
HRLand Cover	Yes			#6, #11, #13	No
LST	Yes	619	>2,000	#2, #3, #11, #13, #15	Not yet, under review
Lakes	Yes	37	100	#6, #13	Partially
River discharge	Yes	Not yet, all products available since October 2024	17	#6	Not yet, under consideration
Vegetation parameters	No	<10	15	#2, #6, #13, #15	Not yet

Climate linkages of Land variables

	Meeting GCOS requirements	Input to CMIP	Other climate initiatives	Other space agencies	Other initiatives
Land Cover	Yes	Yes	HURTT, HYDE, HILDA+	Eumetsat	GEOBON, Wildlife Conservation Society (WCS), IPBES, FAOSTAT, OECD, JRC EDGAR, LifeWatch ERIC, UNFCCC
Fire	Only regional products	Yes	CEOS Climate	Eumetsat, NASA	GOFC-GOLD Fire IT, GCOS TOPC, EARSeL Fire SIG, CEOS Climate
Soil Moisture	Partly, depending on region. GCOS requirements for SM are disputed	Yes	CEAO Climate	Eumetsat, NASA, JAXA, CMA	BAMS State-of-the-Climate, EStoC, Global Water Monitor
LST	Yes	In progress	CEOS Climate	Eumetsat, NASA, UKSA	CEOS LSI-VC
Lakes	Partly (not all lakes for all variables, and some gap filling)	No	No	CNES	BAMS State-of-the-climate, GLEON (Global Lake Ecological Observatory Network
River discharge	Yes for threshold requirements, no for others	No	No	No	No
Vegetation parameters	Partially (uncertainty and temporal resolution not yet)	Yes	No	NASA	FLEX

Highlights of Land Cover
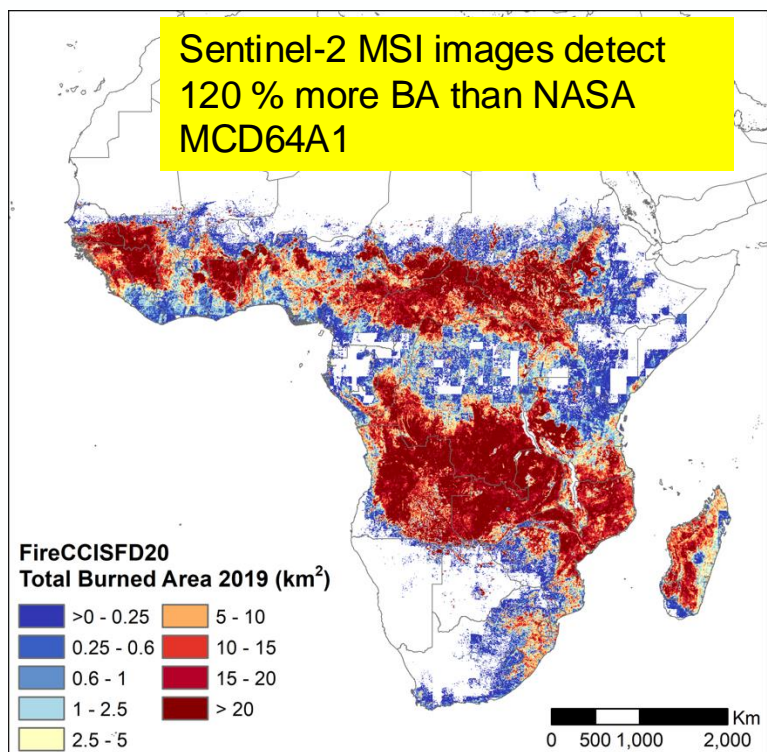## Pierre Defourny (Univ. Leuven, Belgium)

The Land_Cover_cci dataset adheres to GCOS requirements, achieving a 300 m spatial resolution with over 30 years of annual observations. With a stable accuracy of ~71% (70.7% ± 0.3% from 2016–2022), validated annually using independent robust reference data in line with CEOS-LPV guidelines.

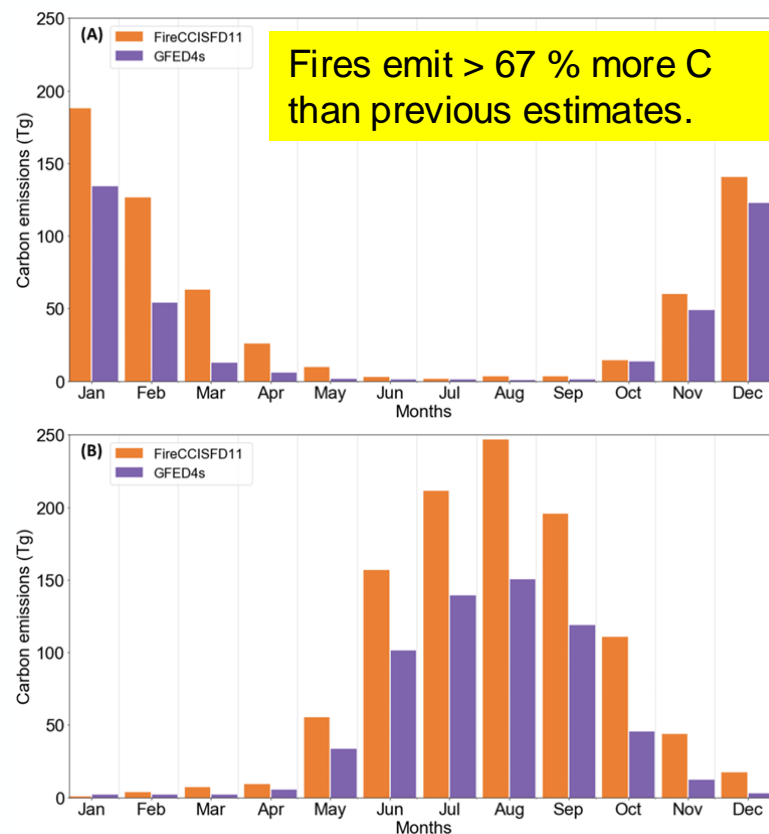**Land_Cover_cci**

30 years of global Land Use Land Cover Change | 300 m |

1992–2022
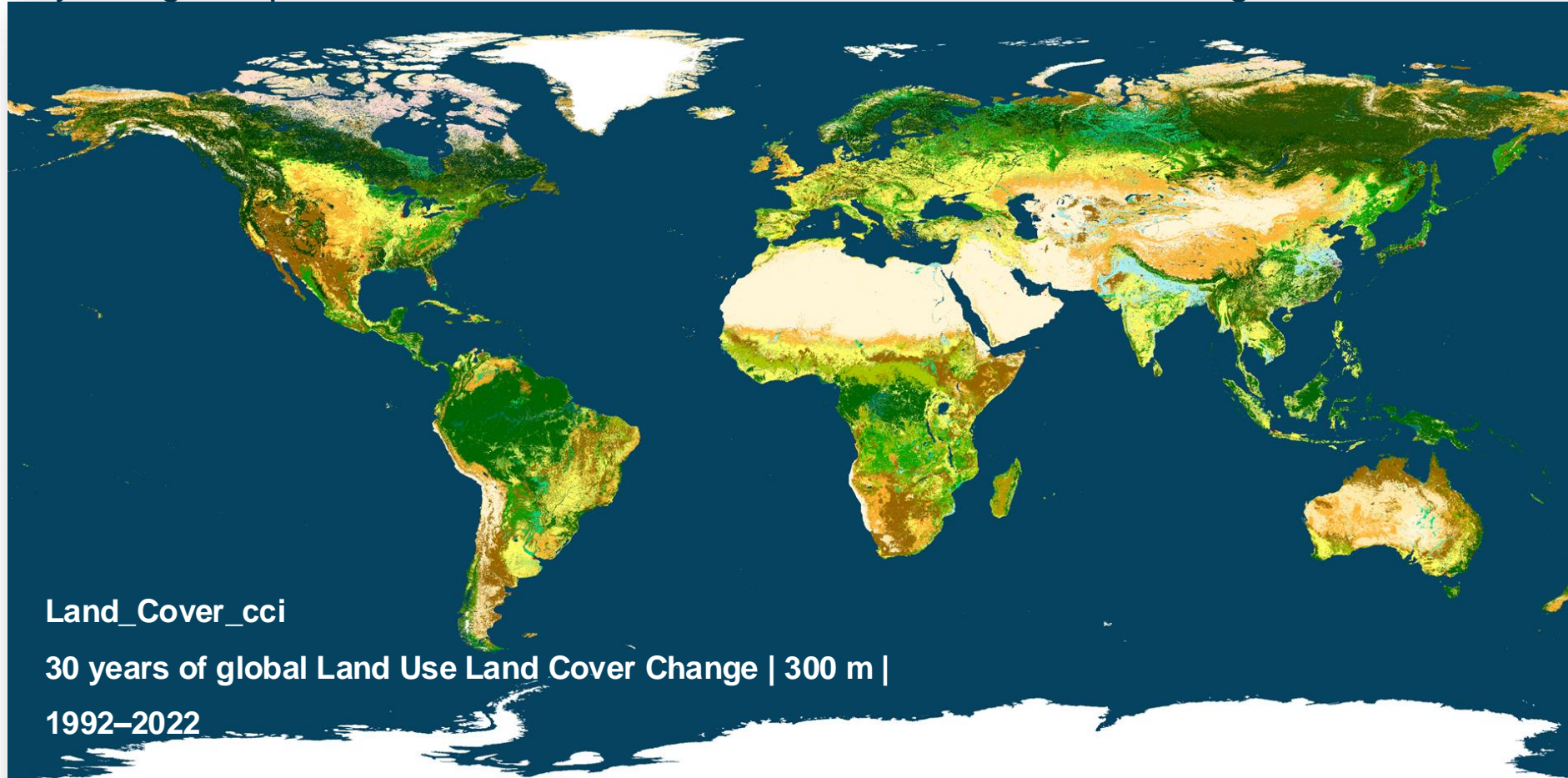
Highlights of Fire
Emilio Chuvieco (Univ. Alcalá, Spain)

FireCCI is providing consistent, long-term time series of burned area information from MODIS 250m (2001-2022) and Sentinel-3 SYN 300 m (2019-2024) data, and delivers for the first time regional burned area products from Sentinel-2 MSI data, characterizing for the first time the impact of small fires (< 100 ha).

Sentinel-2 MSI images detect 120 % more BA than NASA MCD64A1

(Chuvieco et al., 2022, STOTEN)

Fires emit > 67 % more C than previous estimates.

Ramo et al., 2021, PNAS)

Fires contribute to >46 % of total forest losses over SSA (double than previous estimates).
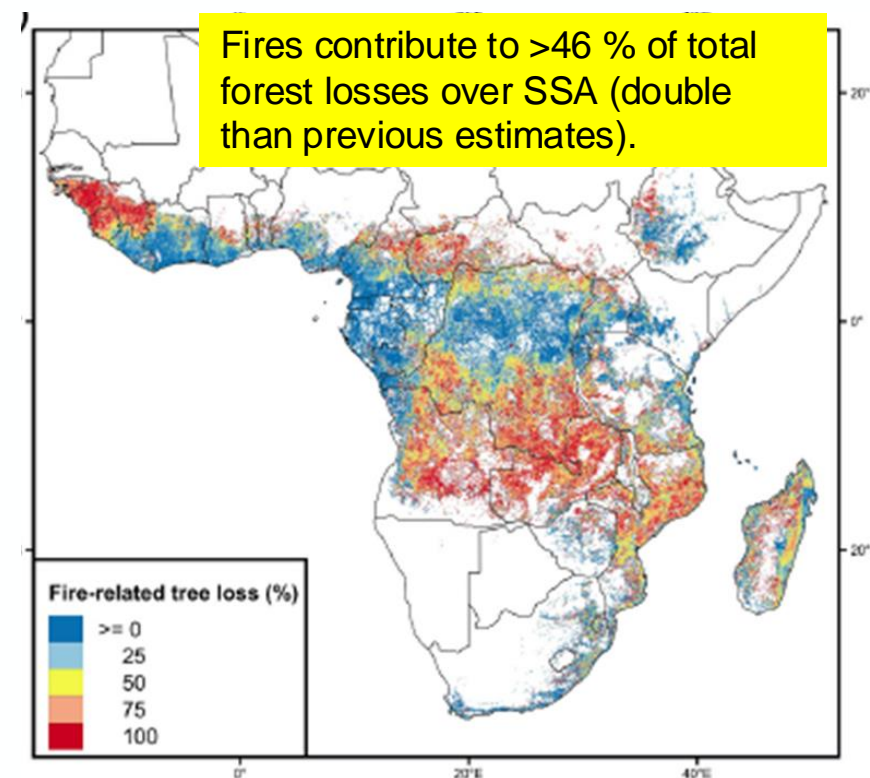
(Khairoun et al., 2024, STOTEN)

Highlights of Soil Moisture
Wouter Dorigo (TU Wien, Austria)

ESA CCI soil moisture complements land surface, hydrological, and climate models with crucial evidence regarding pressing environmental and socio-economic issues, e.g.:
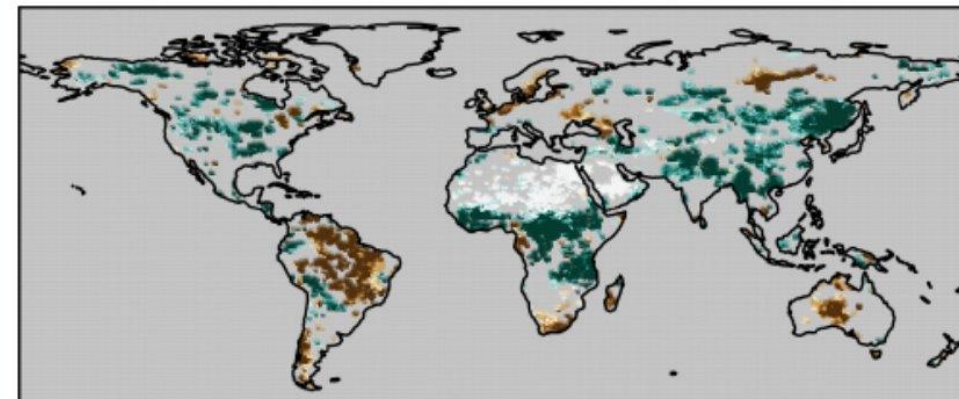
- Is the water cycle accelerating?
- Do droughts intensify?
- Which parts of the world progressively face food insecurity?

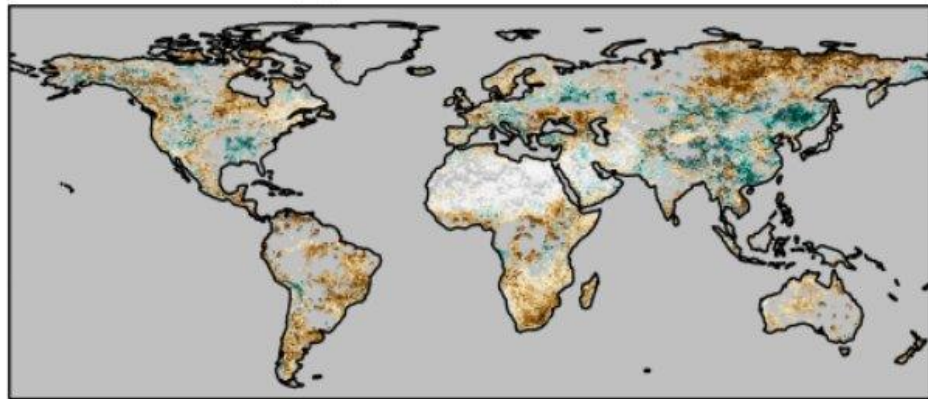And is input to many other ECV products, e.g. ground water, agricultural water use, land evaporation

(b) ERA5-Land surface

$$-0.0020 \quad -0.0015 \quad -0.0010 \quad -0.0005 \quad 0.0005 \quad 0.0010 \quad 0.0015 \quad 0.0020$$
m3 m-3 year-1
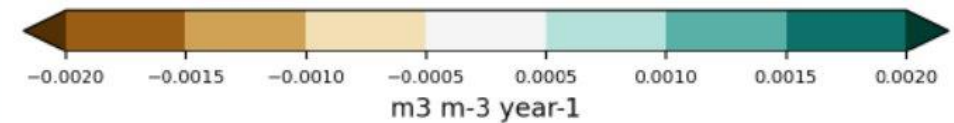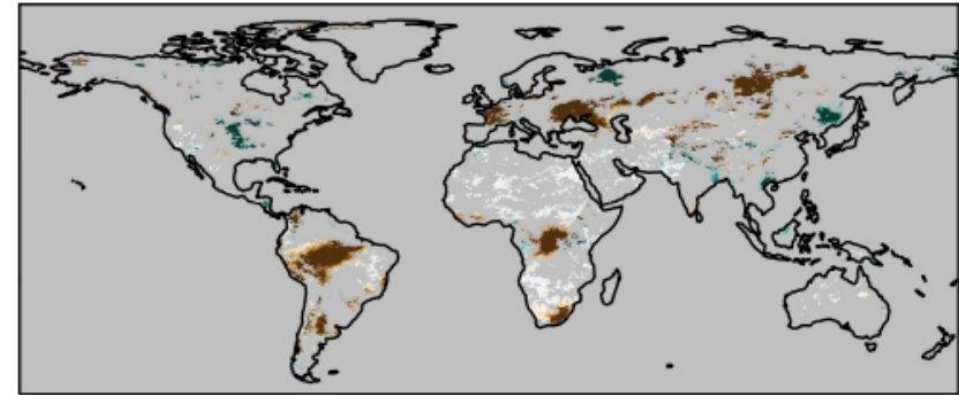
(d) ESA-CCI-COM

Trends in dry-season surface soil moisture (25% climatologically driest days of the year) 2000-2022 [Hirschi et al., 2024, HESS]

(c) MERRA-2 surface

Highlights of Land Surface Temperature
Darren Ghent (University of Leicester, UK)

- High resolution LST products being developed for cities

- Information on trends, means, and extremes could contribute to IPCC Special Report on Cities.
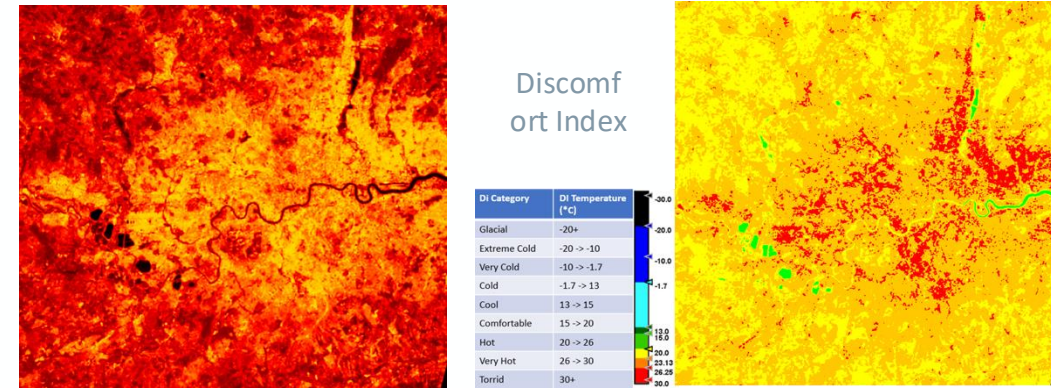
- Creating adaptation indicators for identifying, assessing, and supporting the reduction of climate-related health risks

- Applying innovative AI techniques to merge infrared with microwave data to deliver gap-filled data needed by climate modellers

- Downscaling LST data to high resolution is meeting the demands for globally-local products providing the underpinning actionable information for proposed adaption to be evidenced

LST

Discomfort Index

Merged MODIS & AMSR V3.1 - 2019-06-02
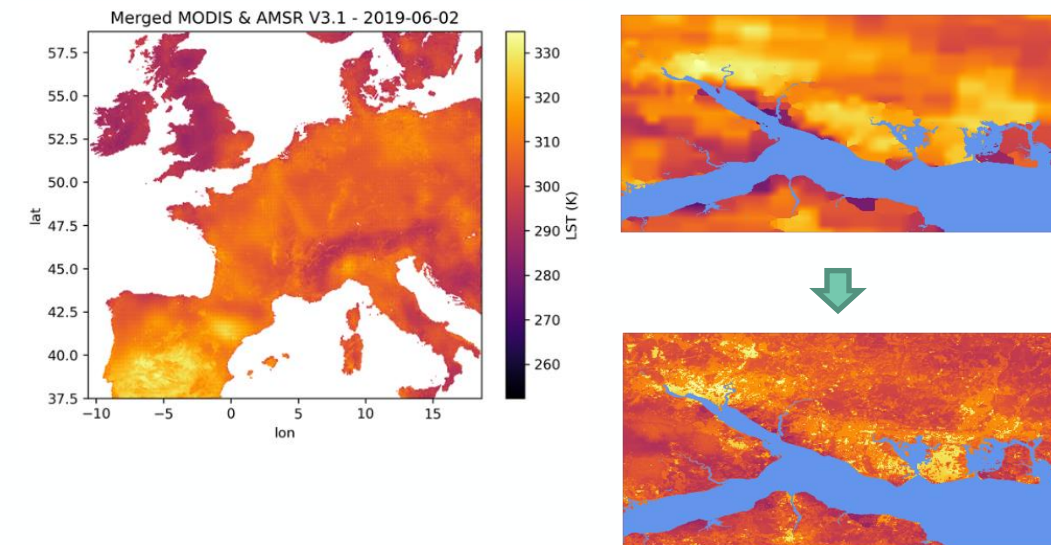
# Highlights Lakes: satellite altimetry for lake monitoring in Africa
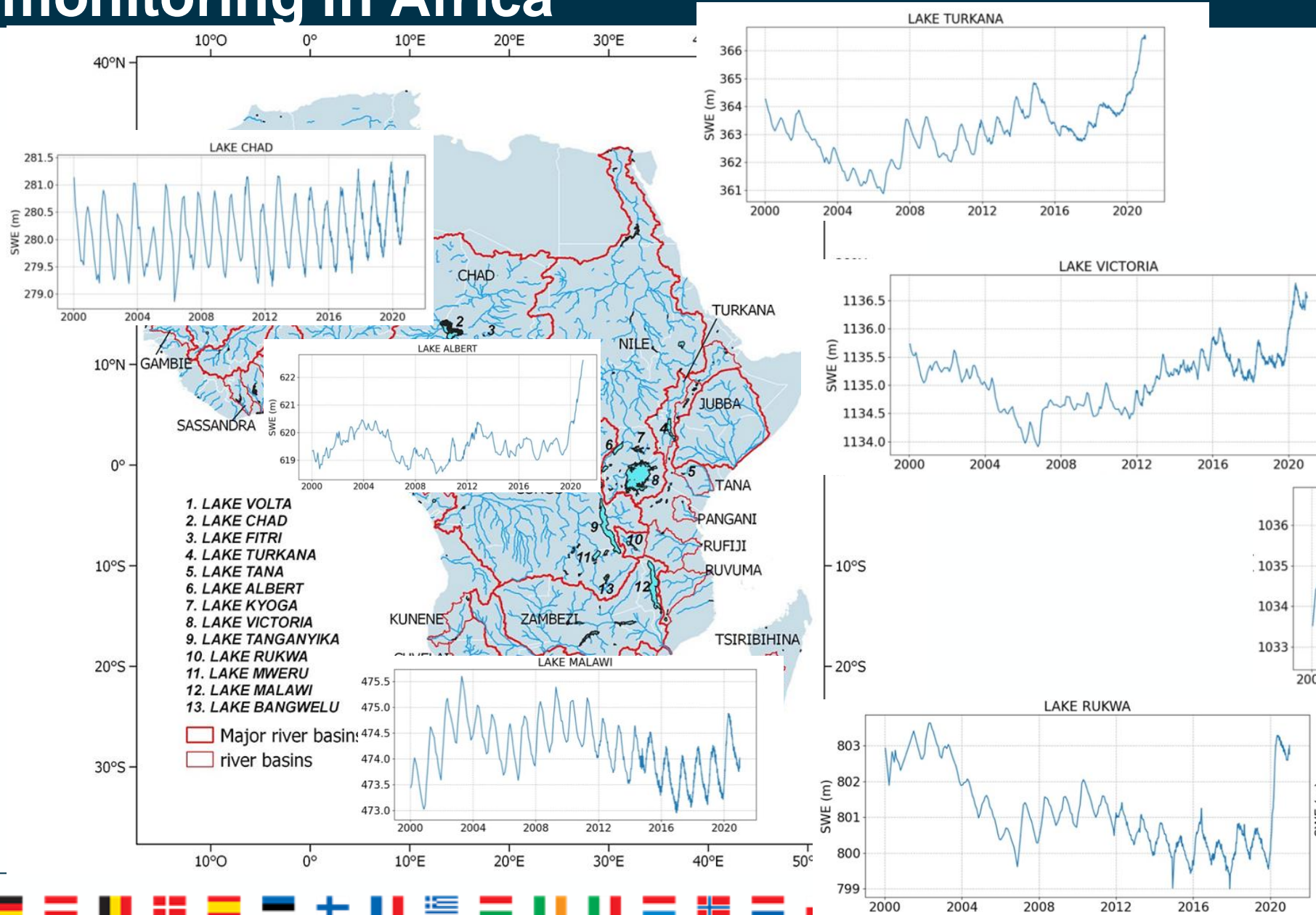
For most of the east African great lakes, the surface water level has strongly increased Near Real time water level are released from radar altimetry in hydroweb.theia-land.fr

Papa et al., 2023, survey in Geophysics
Cretaux et al., 2023, survey in Geophysics

Highlights Water discharge: first results at Borgoforte (drainage area = 62,450km²)

From nadir altimetry – Po river at Borgoforte (uncertainties computed but not plotted)
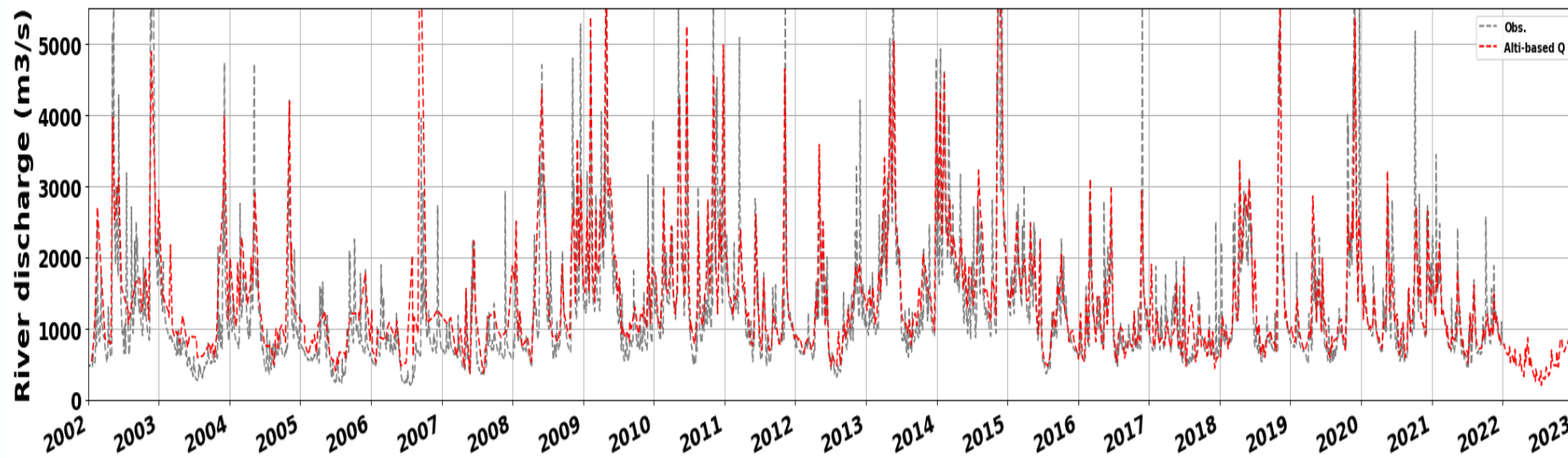
From multispectral imagery – Po river at Borgoforte

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