CCI –C3S – collaboration on R&D

Introduction

- CCI-C3S workshop on common R&D interests took place in April-May 2020, including
  - Gap analysis on current activities, i.e. ECV having been transferred from CCI to C3S and are common to both agencies
  - Update on ECVs only run by CCI, that might be of interest to C3S in future
  - Potential future activities, to be included in the portfolio
- Discussion was split into atmosphere, land and ocean ECVs
- All ESA and C3S technical officers provided input and participated in the discussion
- This presentation will cover
  - Main recommendations/ atmosphere & ocean & land
  - Potential future activities

Programmatic background

Climate Change Service
climate.copernicus.eu

esa

ESA

- CCI+ mid-term review in Dec 2020
- Definition of activities for CCI+ phase 2 in Feb 2021
- New climate programme for ESA Ministerial Council in 2022

Need for collaboration & coordination

C3S

- Copernicus new MFF
- New C3S programme proposal due Q3 2020
- Expected start of Copernicus 2.0 Q3 2021
- Continuity rather than enhancement but possible expansion in the list of ECVs

ESA Technical Officer	ESA Support	Science Lead	Project	Next Annual Review	CCI I -	+ T			U -	C3S_312 a	b	Project(s)	Contract Offcer
								Atmospheric					
Simon Pinnock	-	M.Hegglin (U.Reading) & M. Sch	Water Vapour CCI	19 / 20 May 2020		1	§4.5.3	Water Vapour	->		L1	C3S_312b Lot1 - Water Vapour	Hans Hersbach
Simon Pinnock	-	M. Stengel (DWD)	Cloud CCI	8 Apr 2020 (KO)	.	2	§4.5.4	Cloud Properties	->				
Christian Retscher	-	M.Buchwitz (U.Bremen)	Greenhouse Gases CCI		.	2	§4.7.1	Carbon Dioxide	->	L6	L2	C3S_312a Lot6 & C3S_312b Lot2 - CO2	Dinand Schepers
					.	2	§4.7.2	Methane	->	L6	L2	C3S_312a Lot6 & C3S_312b Lot2 - Methane	Dinand Schepers
Christian Retscher	-	M.van Roozendael (BIRA)	Ozone CCI		.	2	§4.7.4	Ozone	->	L4	L2	C3S_312a Lot4 & C3S_312b Lot2 - Ozone	Dinand Schepers
Simon Pinnock	-	T.Popp (DLR)	Aerosol CCI	tbd ; Apr 2020	.	2	§4.7.5	Aerosol	->	L5	L2	C3S_312a Lot5 & C3S_312b Lot2 - Aerosol	Dinand Schepers
							§4.3.5	Precipitation			L1	C3S_312b Lot1 - Precipitation	Hans Hersbach
							§4.3.6	Surface Radiation Budget			L1	C3S_312b Lot1 - Surface Radiation Budget	Hans Hersbach
							§4.5.5	Earth Radiation Budget			L1	C3S_312b Lot1 - Earth Radiation Budget	Hans Hersbach
								Oceanic					
Craig Donlon	Paolo Cipollini	C.Merchant (U.Reading)	Sea Surface Temperature CCI	19 Jun 2020	.	2	§5.3.1	Sea-Surface Temperature	->	L3	L3	C3S_312a Lot3 & C3S_312b Lot3 - SST	Julian Nicolas
Craig Donlon	Paolo Cipollini	J.Boutin (LOCEAN-IPSL) / N. Reul	Sea Surface Salinity CCI	tbd ; Jun/Jul 20		1	§5.3.2	Sea-Surface Salinity					
Jerome Benveniste	-	A.Cazenave (CNES)	Sea Level CCI		.	2	§5.3.3	Sea Level	->	L2	L3	C3S_312a Lot2 & C3S_312b Lot3 - Sea Level	Julian Nicolas
Craig Donlon	Paolo Cipollini	F.Ardhuin (CNRS)	Sea State CCI	tbd ; Jun/Jul 20		1	§5.3.4	Sea State					
Anna Maria Trofaier	-	T.Lavergne (Met.no)	Sea Ice CCI	5 / 6 Mar 2020	.	2	§5.3.5	Sea Ice	->	L1	L3	C3S_312a Lot1 & C3S_312b Lot3 - Sea Ice	Julian Nicolas
Craig Donlon	Paolo Cipollini	S.Sathyendranath (PML)	Ocean Colour CCI	tbd ; Jun/Jul 20	.	2	§5.3.7	Ocean Colour			L3	C3S_312b Lot3 - Ocean Colour	Julian Nicolas
								Terrestrial					
Clement Albergel *	Paolo Cipollini	J.F.Crétaux (CNES) / S. Simis (PM	Lakes CCI	1 / 2 Apr 2020		1	§6.3.4	Lakes	->		L4	C3S_312b Lot4 - Lakes	Joaquín Muñoz Sabater
Anna Maria Trofaier	-	T.Nagler (ENVEO)	Snow CCI	tbd ; Sep 2020		1	§6.3.5	Snow Cover					
Anna Maria Trofaier	-	F.Paul (U.Zürich)	Glaciers CCI		.	2	§6.3.6	Glaciers & Ice Caps	->	L8	L4	C3S_312a Lot8 & C3S_312b Lot4 - Glaciers	Joaquín Muñoz Sabater
Marcus Engdahl	-	A.Shepherd (U.Leeds)	Antarctic Ice Sheet CCI		.	2	§6.3.7	Ice Sheets	->		L4	C3S_312b Lot4 - Ice Sheets	Joaquín Muñoz Sabater
Marcus Engdahl	-	R.Forsberg (DTU)	Greenland Ice Sheet CCI		.	2							
Frank Martin Seifert	-	A.Bartsch (bGEOS)	Permafrost CCI			1	§6.3.8	Permafrost					
Olivier Arino	-	P.Defourny (U.C.Louvain)	Landcover CCI		.	2	§6.3.10	Landcover	->		L5	C3S_312b Lot5 - Land Cover	Joaquín Muñoz Sabater
Olivier Arino	-	L.Bruzzone (U.Trento)	High Resolution Landcover CCI			1							
Frank Martin Seifert	-	S.Quegan (U.Sheffield)	Biomass CCI			1	§6.3.13	Above-Ground Biomass					
Clement Albergel *	-	E.Chuvieco (U.Alcalà)	Fire CCI	3 / 4 Mar 2020	.	2	§6.3.15	Fire Disturbance	->		L5	C3S_312b Lot5 - Fire Disturbance	Joaquín Muñoz Sabater
Clement Albergel *	-	W.Dorigo (TU Wien)	Soil Moisture CCI	23 / 24 Apr 2020	.	2	§6.3.16	Soil Moisture	->	L7	L4	C3S_312a Lot7 & C3S_312b Lot4 - Soil Moisture	Joaquín Muñoz Sabater
Simon Pinnock	-	D.Ghent (U.Leicester)	Land Surface Temperature CC	24 / 26 Jun 2020 (User		1	§6.3.17	Land-Surface Temperature					
							§6.3.9	Albedo		L9	L5	C3S_312a Lot9 & C3S_312b Lot5 - Albedo	Joaquín Muñoz Sabater
							§6.3.11	FAPAR		L9	L5	C3S_312a Lot9 & C3S_312b Lot5 - FAPAR	Joaquín Muñoz Sabater
							§6.3.12	Leaf Area Index		L9	L5	C3S_312a Lot9 & C3S_312b Lot5 - LAI	Joaquín Muñoz Sabater
Simon Pinnock	-	R. Jones(UKMO)	CMUG	tbd ; Nov 2020	.	3		Cross-ECV & Knowledge Exchange					
Anna Maria Trofaier	-	-	Living Planet Fellowships		.	3							
Jerome Benveniste	-	-	Sea-Level Budget Closure		.								
Marcus Engdahl	-	A.Shepherd (U.Leeds)	IMBIE		.	3							
Clement Albergel *	-	P.Ciais (LSCE)	RECCAP		.	3							
Susanne Mecklenburg	Paul Fisher Sophie Hebden Ed Pechorro	Carsten Brockmann (BC)	CCI Knowledge Exchange			4							

ESA U

e Agency

Climate Change

Current portfolio of satellite ECVs: →closing the budget

Atmospheric physics
- Precipitation
- Surface radiation budget
- Water vapour
- Cloud properties
- Earth radiation budget

Coordination with CM-SAF / ROM SAF / ESA CCI / Uni. Maryland / NASA / NOAA

Atmospheric composition
- Carbon dioxide
- Methane
- Ozone
- Aerosol

Coordination with ESA-CCI and other national projects

Ocean
- Sea surface temperature
- Sea level
- Sea ice
- Ocean colour

Coordination with ESA-CCI / OSI-SAF

Land hydrology & cryosphere
- Lakes
- Glaciers
- Ice sheets & ice shelves
- Soil moisture

Coordination with ESA-CCI, GloboLakes, Arc-Lake, HydroWeb

Land biosphere
- Albedo
- Land cover
- Fraction of absorbed photosynthetic
- Leaf area index
- Fire

Coordination with ESA-CCI, CGL, QA4ECV, LSA-SAF

ECVs requirements

- 1: top-down requirements based on climate science /climate monitoring principles
- 2: requirements driven by our own internal use of ECVs (both C3S and ECMWF as a whole)
- 3: requirements formulated by some of our ~60K users
- 4: new and emerging requirements

Climate Change

Type 1 requirement → Permafrost

#thawing_permafrost_matters

- Releases large amounts of GHG
- Reinforces global warming feedback loop
- Active layer deepens & threatens wetlands

- Increasing concern of the speed of permafrost thawing and the role in global warming

Courtesy of Joaquin Muñoz

#thawing_permafrost_matters

- Permafrost degradation makes the ground unstable
- Makes difficult to build and maintain infrastructure
- Already costs billions of dollars in losses and repairs

Several variables describing the state of permafrost can be derived from satellite observations

- e.g. depth of active layer (m) and permafrost temperature (K) can be obtained by combining LST, SWE and land cover EO (cross-ECV activity)

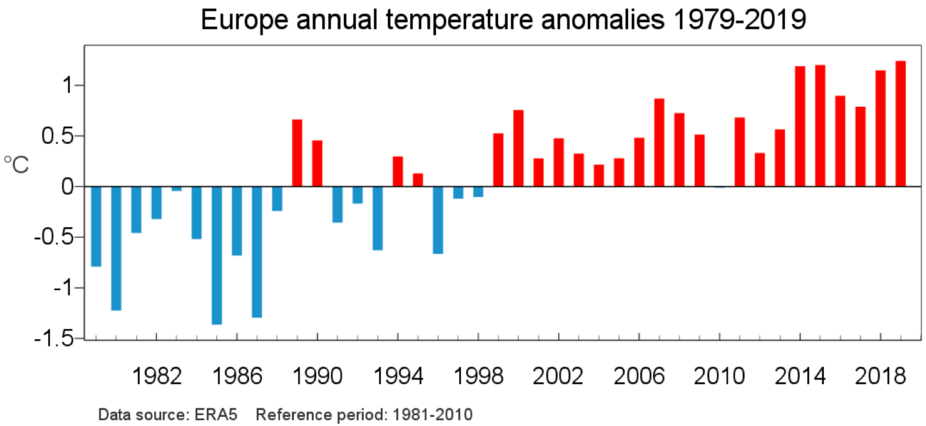
Climate monitoring of the Eurasian arctic

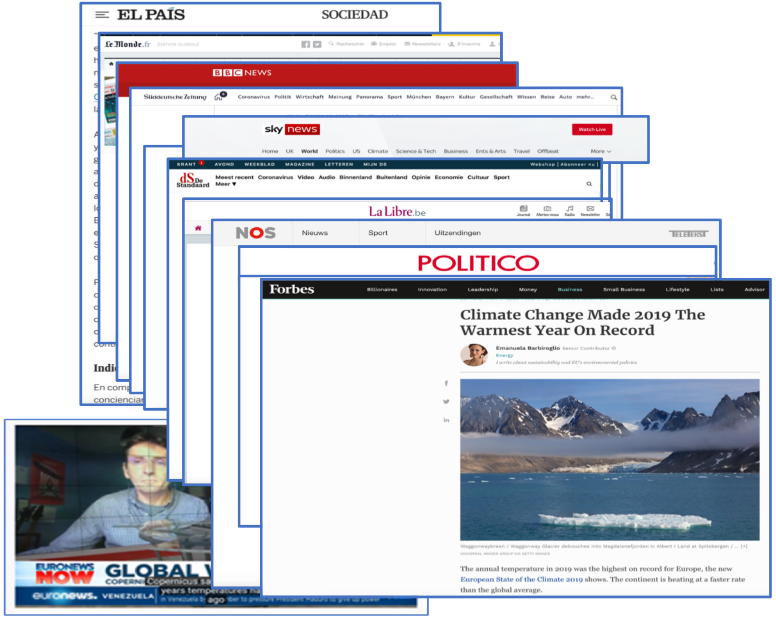
Climate Change

Annual publication since 2018

- Update of climate in Europe compared to long-term trends
- Builds on 20+ datasets in the CDS + others
- Written by experts across the C3S community & other Copernicus services

➢ **climate.copernicus.eu/ESOTC**





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European Commission

IMPLEMENTED BY ECMWF

Climate Change

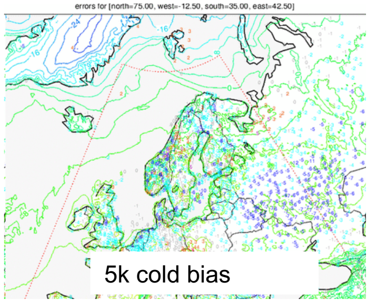
Type 1: e.g. cryosphere

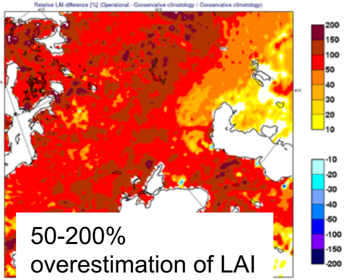
		ECV	Products	ESA CCI	EUMETSAT	C3S	CGLS
CRYOSPHERE	12	Glaciers	Glacier Thickness	NO	NO	NO	NO
			Glacier Mass Change	YES	NO	YES	NO
			Glacier Elevation Change	YES	NO	YES	NO
			Glacier Area	YES	NO	YES	NO
	13	Ice sheets and ice shelves	Grounding Line and Thickness	YES	NO	NO	NO
			Ice Volume Change	YES(+)	NO	NO	NO
			Ice Velocity	YES	NO	YES	NO
			Surface Elevation Change	YES	NO	YES	NO
	14	Permafrost	Permafrost extent	YES (+)	NO		NO
			Rock Glacier Kinematics	YES(+)	NO		NO
			Active Layer Thickness	YES (+)	NO		NO
			Thermal State of Permafrost	YES (+)	NO		NO
	15	Snow	Snow water equivalent	YES(+)	YES		YES
			Snow Depth	NO	NO	NO	NO
			Area Covered by Snow	YES (+)	YES		YES

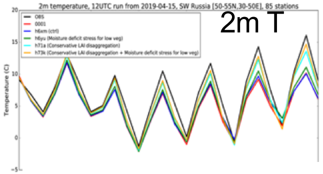
Courtesy of Joaquin Muñoz

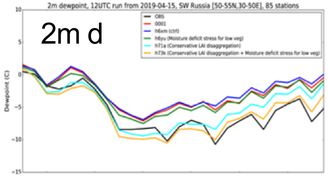
LAI high/low vegetation disaggregation operator

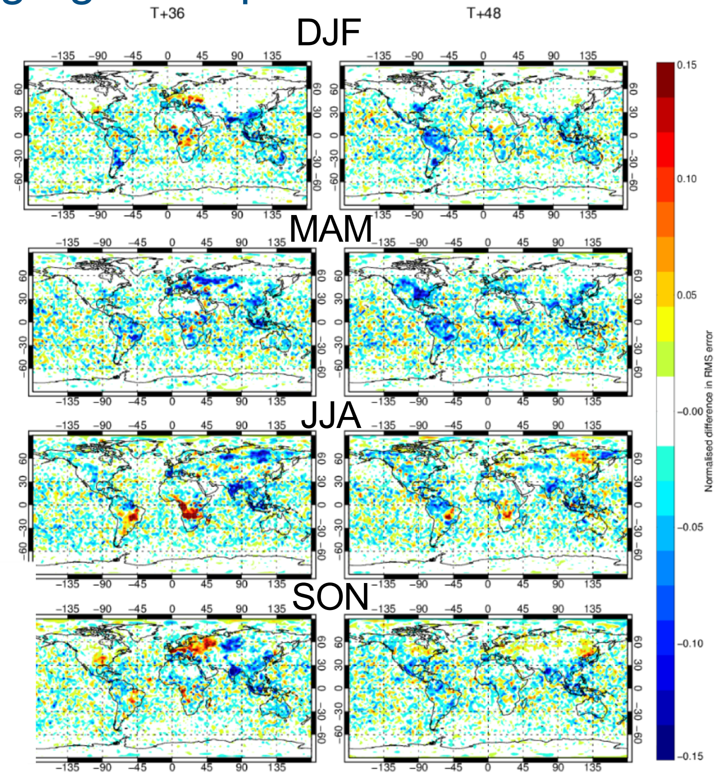
April 2019 SW Russia case











Change in RMSE error of the 2m temperature

Courtesy of Gianpaolo Balsamo

- SW Russia case shows that using new LAI disaggregation correct for an overestimation of the LAI that lead to a cold/wet bias.
- Overall beneficial for the scores of near surface atmosphere (although some adjustment of the vegetation parameters might be necessary to overcome the autumn bad scores over Eur

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Type 2 requirement: e.g. biosphere

		ECV	Products	ESA CCI	EUMETSAT	C3S	CGLS
Biosphere	1	Above-ground biomass	Above-ground biomass	YES (+)	NO		?
	2	Albedo	Albedo	NO	YES	YES	YES
	3	Evaporation from land	Transpiration	NO	YES	NO	NO
			Interception Loss	NO	YES	NO	NO
			Bare Soil Evaporation	NO	YES	NO	NO
			Sensible Heat Flux	NO	YES	NO	NO
			Latent Heat Flux	NO	YES	NO	NO
	4	Fire	Burnt Area	YES	NO	YES	YES
			Active Fires	?	YES	NO	NO
			Combustion Completeness	?	NO	NO	NO
			Fire Radiative Power	Partly	YES	YES	NO
	5	Fraction of absorbed photosynthetically active radiation (FAPAR)	Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)	NO	YES	YES	YES
	6	Land cover	Maps of key IPCC land use, related changes and land management types	?	NO	NO	NO
			Maps of High Resolution Land Cover	YES (+)	NO	NO	YES
			Maps of Land Cover	Partly	NO	YES	NO
	7	Land Surface Temperature	Land Surface Temperature	YES (+)	YES		YES
			Soil temperature	?	NO	NO	YES (skin)
	8	Leaf are index	Leaf Area Index	NO	NO	YES	YES
	9	Soil carbon	Peatlands total depth of profile, area and location	NO	NO		NO
			Mineral soil bulk density to 30 cms and 1m	NO	NO		NO
			Carbon in Soil	NO	NO		NO

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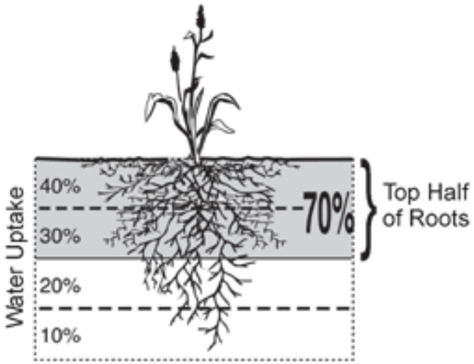
Type 1 +3 requirements

Soil moisture derived from direct satellite observations

- Satellite observations are only sensitive to the water content of the top few cms of soil. Dense forests mask the soil signal.
- High variability in time and space may limit representativeness



However, for many applications the variable of interest is the root-zone soil moisture

- The root-zone determines the depth at which plants extract water from the soil.
- Key variable for hydrological and ecosystem processes (flood and agricultural forecasting).
- Prediction of the severity of forest fires can be improved
- Important role in weather predictability – particularly in the sub-seasonal to seasonal,
- Provides a more realistic representation of ET feedbacks for climate change projections

Courtesy of Joaquin Muñoz

Root-zone soil moisture from satellite observations

- Not directly observable from current satellite platforms
- But it can be derived from surface soil moisture observations (ERS, ASCAT, SSM/I, AMSRE, SMOS, SMAP) or by constraining LSM by several EO data sets (LST, SSM, …)

→ cross ECV activity

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User driven programme

URDB operational since last year

The Copernicus Climate Change Service User Requirements Database   Home   Requirements

Home / Requirements

List of Requirements

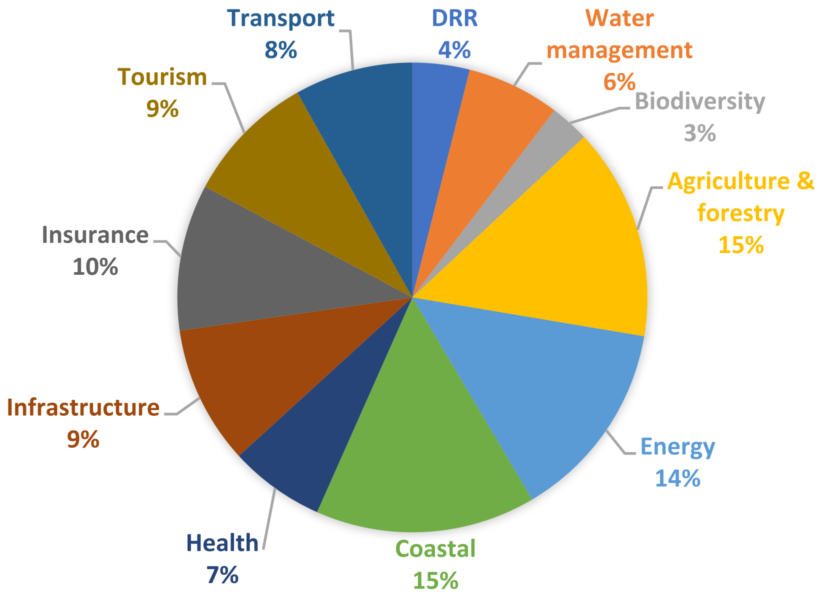
Showing 3480 requirements

Filter results   Export results

Visible columns

ID	SUMMARY	TOPIC	SUBJ					
C3S-000001	Provide a comprehensive database for climate data where we can choose the variables according to our needs	SIS General	Web					
C3S-000002	Provide indicators tailored to the tourism sector: TCI/CIT/HCI	SIS Data	New					
C3S-000003	Provide indicators tailored to the tourism sector: sea level rise data	SIS Data	New data request	Tourism	Horizontal: It depends of the sectors and studies but the finest resolution available	Interview		Edit
C3S-000004	Provide indicators tailored to the tourism sector: Fire Weather Index	SIS Data	New data request	Tourism	Horizontal: It depends of the sectors and studies but the finest resolution available	Interview		Edit

Requirements per sector



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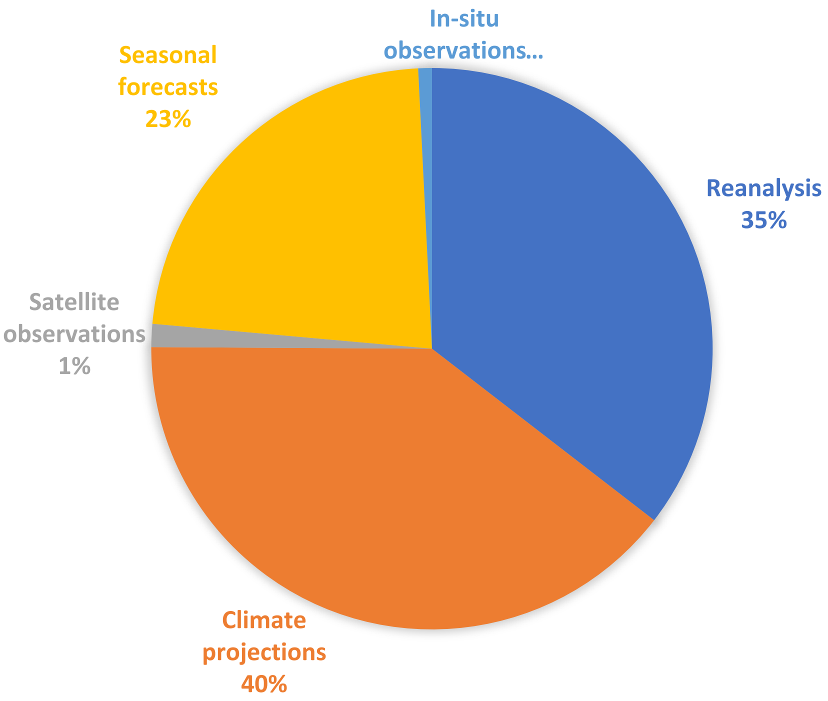
User driven programme

Requirements per Dataset Category



Most common GCOS ECVs

Precipitation (260)
Surface air temperature (194)
Sea level (54)
Sea state (48)
Snow (43)
Land cover (29)
Earth radiation budget (29)
Soil moisture (24)
LAI (23)
FPAR (23)
Pressure (23)
SST (21)
Evaporation from land (16)
Surface water vapour (16)
Sea ice (12)
Lakes (12)

Courtesy Andre Obregon

**actual numbers higher as respective field not always filled; revision in progress*

Analysis of URDB

Land ECVs: River Discharge & Groundwater

Courtesy of Chiara Cagnazzo

SECTOR	APPLICATIONS	USER REQUIREMENTS FOR RESOLUTION AND COVERAGE
Coastal, Fishery	Coastal Eutrophication Marine Spatial Planning	High resolution for resolving coastal areas
Water Management	Flooding	River basin area Municipality level
Infrastructure	Road conditions and management	2km resolution, daily
Energy	Hydropower generation Power blackouts	Sub-daily, country level and cluster scale
Insurance	Specific risk analysis	-
Health	Pathogens impact Decision support tools for waterborne and foodborne infection	European domain

Other : Inland navigation, Extremes in wet and dry conditions, Specific hydrological studies, Environmental analyses

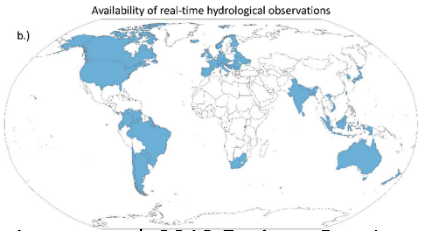
Emergency Manageme nt

B r i d g i n g t h e o b s e r v a t i o n g a p

Hydrological observations

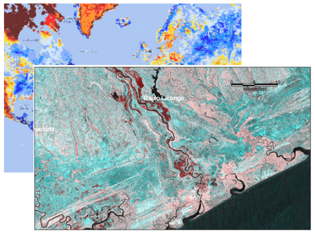
- Limited availability/numbers/quality

In situ



Lavers et al. 2019 Environ. Res. Lett.

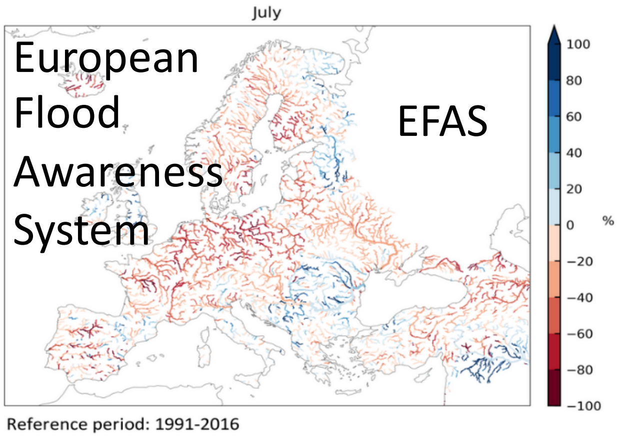
Satellite



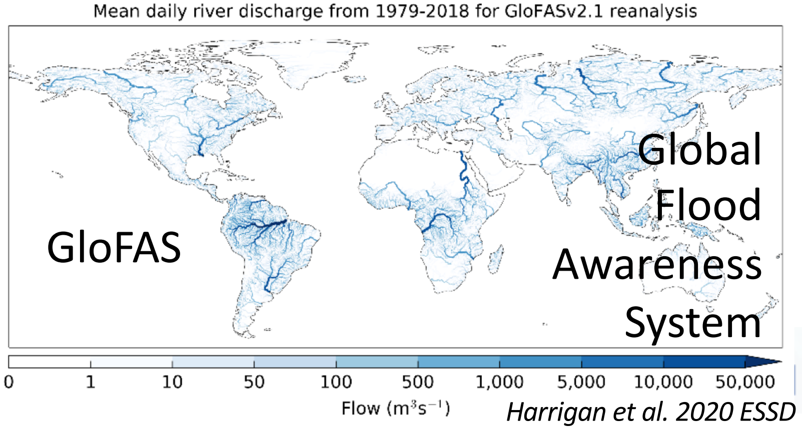
Hydrological simulations

- Copernicus Emergency Management Service (CEMS) offers hydrological estimates through the Climate Data Store with homogeneous coverage

+



Courtesy of EFAS team



Harrigan et al. 2020 ESSD

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Type 1+3 requirements: e.g. hydrology

		ECV	Products	ESA CCI	EUMETSAT	C3S	CGLS
HYDROLOGY	16	Groundwater	Groundwater Quality	NO	NO	NO	NO
			Wellhead Level	NO	NO	NO	NO
			Groundwater Discharge	NO	NO	NO	NO
			Groundwater Recharge	NO	NO	NO	NO
			Groundwater Storage Change	NO	NO		NO
			Groundwater Level	NO	NO	NO	NO
	17	Lakes	Lake Ice Cover	YES (+)	NO	NO	YES
			Lake Ice Thickness	YES(+)	NO	NO	NO
			Lake Water Leaving Reflectance	YES (+)	NO	NO	NO
			Lake surface water temperature	YES (+)	NO	YES	YES
			Lake Water Extent	YES (+)	NO	NO	YES
			Lake Water Level	YES (+)	NO	YES	YES
	18	River discharge	Water Level	NO	NO		YES
			River discharge	NO	NO		NO
			Freeze/thaw	surface soil moisture ancillary product			
			Surface Inundation (dynamic surface water)	surface soil moisture ancillary product			
			Root zone soil moisture	YES	YES		NO
	19	Soil moisture	Surface soil moisture	YES	YES	YES	YES

GAPs

Courtesy of Joaquin Muñoz

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Type 4 requirements → Biodiversity

Ocean habitats

- Investigate EO + in situ observations for determining ocean/coastal habitats (coral reefs, seagrass, mangroves, macroalgae)

Policy drivers

- Nature based solutions contributing to NDCs (**Paris Agreement**)
- **SDG 14** – Life Below Water
- European Green Deal
- Quantifying contributions to the **Convention on Biological Diversity** (Aichi target 11)
- Maritime spatial planning (**MSFD**)
- Assessing marine protected areas (**Natura 2000**)
- Marine renewable Energy

Image - ESA

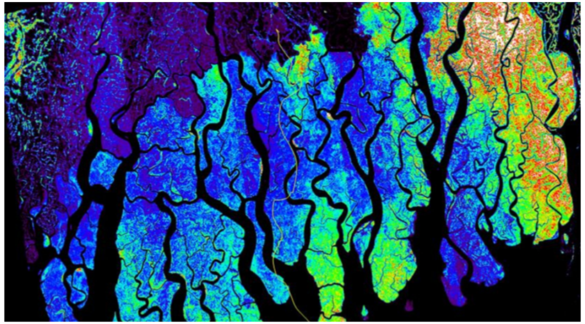

Image - ESA

Courtesy of Samantha Burgess

- Partnerships required with:
- Global Ocean Observing System (GOOS)
- Group on Earth Observations Biodivdersity Observations Network (GEO BON)
- Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES)

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C3S ESA-CCI

A COMMON WAY FORWARD

Main points / Atmosphere

Ozone/GHG/Aerosol/WV/Cloud

General points

- Extend CDRs with new/oncoming sensors (e.g. Sentinel-3/4/5P, IASI-NG, IRS, JPSS, Aeolus, Earthcare etc)
- Coordination between CCI, C3S, CAMS and EUMETSAT, in particular for Ozone and GHG, but also WV and Aerosol, for requirements definitions and responsibilities
- Higher level products needed L2/L3, in particular for Ozone and GHG

Detailed points

Aerosol

- Improve existing algorithms and test new ones (e.g. CISAR/Rayference)
- Address gaps: uncertainty estimates, extension back in time with AVHRR over ocean, multi-sensor CDR
- Possible new products: Mineral dust, joint aerosol-cloud product, PSC, merged multi-sensor AOD

WV

- C3S interest in work on case studies: e.g. atmospheric rivers and WV total column for evaluation of CMIP6, ERA5 and MERRA
- Coordinate with CAMS on enhanced WV product for stratosphere (e.g. merged limb/nadir UTLS water vapour)

Cloud

- Include geostationary ring to satisfy GCOS requirements on frequent updates
- Surface radiation budget can be derived from retrieved aerosol, cloud and surface temp fields. Need to confirm interest by C3S and required accuracy.

Main points / Ocean
SST/OC/SL/Sea Ice/SSS/Sea State (currents)

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- C3S: increasing the synergies among Copernicus Services and streamlining the production of ECVs in coordination with other relevant service (e.g. Mercator for Ocean ECV, Land for terrestrial...)
- On existing ECVs, available from both CCI and C3S
  - Link **SST** R&D to CAMS' requirements for the CO2 service
  - Recognise that **Ocean Colour** (including Primary Production) is crucial input for carbon budget
  - **Sea Level**: clarify R&D activities between CCI and C3S
  - **Sea Ice**: special situation with CCI providing R&D input to OSISAF SIC. New R&D activities could consider round robin exercise on algorithm selection for melt-pond fraction, which is important auxiliary data for both SIC and SIT, building on previous inter-comparison exercise of sea ice drift algorithms to create a CCI Sea Ice drift CDR.
- On ESA only ECVs
  - **Sea Surface Salinity**: R&D useful for C3S to understand whether SSS will be included in their portfolio
  - **Sea State**: CDR useful for quantification of ocean/atmosphere exchange
  - Possible future activity: **surface geostrophic current** is a possible addition to ECV portfolio - scope for discussion with CMEMS

Main points / Land

SM/Fire/Lakes/Glaciers/Permafrost/Biomass/Snow/LST/ Ice sheets

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Need for coordination amongst the different soil moisture related activities in Europe (C3S, CGLS, EUM, CCI)

Soil moisture new R&D topics to include

- Retrieval of higher spatial (0.1-1 km) and temporal (<1-day) resolutions
- Inclusion of state-of-the-art sensors, candidate missions
- Development of a global satellite-based Root-zone soil moisture product by constraining Land Surface Models with several EOs (soil moisture, vegetation…)

Vegetation

- **Leaf Area Index** (LAI), one of the most important terrestrial ECV
  - Prototype at C3S / EUMETSAT
  - Latest ECV requirement review 2020: develop higher spatial and temporal resolutions LAI
  - ➔ Combining information from Sentinels data
  - ➔ VOD can be used as an analogue to vegetation product (~daily availability)
  - Strong user requirement that LAI is provided with provision of the related Land Use / Land Cover
- **Biomass** new R&D topics to include
  - Inclusion of new sensors in a "Golden Age" of biomass estimation
  - Consistency of data sets in both time and space: combination of high spatial resolution estimates with more frequent estimates from coarser resolution data

Main points / Land

SM/Fire/Lakes/Glaciers/Permafrost/Biomass/Snow/LST/ Ice sheets

Fire

- Adapting CCI MODIS algorithm to S-3 OLCI & Homogenization of time series (MODIS and OLCI BA products)
- Generation of fire severity from OLCI and SLSTR data

LST

- Great potential for many use cases (assimilation into atmosphere/ice sheet model, UHI and urban climate studies, upscaling of biosphere-atmos CO2 and CH4 fluxes, monitoring evapotranspiration and water stress
- Ongoing work to capture global diurnal cycle
- Foster link with model community (evaluation & development, data assimilation)

Lakes (LWE, LWL, LSWT, LWLR, LIC, *LIT*)

- Ensure consistency of Lake variables (5 variables, 6^{th} to come)
- New algorithms for LWE (Combined with LWL, consistent with Land Cover)
- Extending the CDR & further address product uncertainty

Main points / Land

SM/Fire/Lakes/Glaciers/Permafrost/Biomass/Snow/LST/ Ice sheets

Climate Change Service
climate.copernicus.eu

esa

Snow

- Great potential for user application
- R&D on L-band SAR to compute higher resolution SWE data in mountain areas is needed

Glacier

- Improve products in mountainous regions (new Copernicus DEN)
- Glacier thickness (Retrieval from high-res DEM)
- Possible use of CryoSat-2 data (accumulation and ablation rates from altimeters)
- Improvements required: clouds, snow or debris on glacier, automation

Ice sheet

- IMBIE cross-ECV project
- Surface melting from active/passive MW
- Grounding Line Location (GLL) Antarctica-wide.
- Ice shelf volume changes

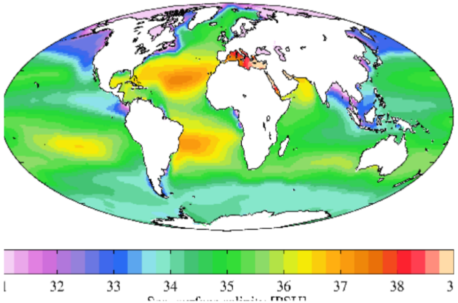
Main points / Land (continued)

Terrestrial Hydrology

River discharge:. One of GCOS ECVs, contributes to the evaluation of global freshwater flux → critical for understanding the mechanism of global climate change.

Reviewed by J. Benveniste at CCI/C3S WS April 2020

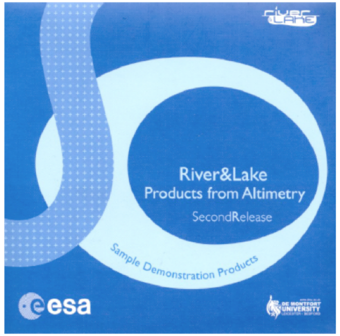
- Key variable in the water cycle
- Essential for water resources management (floods and drought)
- Necessary for the flood prediction (hydraulic risk)
- Important for the reduction of the ocean salinity and the thermohaline circulation.



Main points / Land (continued)
Terrestrial Hydrology

Maturity of River Level and Discharge

- First, the **level** of the river is computed from altimetry at virtual stations (intersections river / satellite track)



- River/Lake Level is quite mature (techniques similar to those in Lakes CCI)
- ESA has considerable experience since early 2000s ('River & Lake' project - products were promoted at tens of international events for more than a decade
- Other relevant European expertise: Hydroweb (CTOH Toulouse) → Theia → Copernicus LMS , DAHITI (TU Munich)

- Challenge: The real benefit for users is to **derive RIVER DISCHARGE** from Altimetric River Stage and auxiliary data -- from space (optical, SAR imagers), in situ and/or model.
- The international community is working on it (see for istance dedicated WG in NASA/SWOT, and recent review paper from Gleason et al., 2020
- Based on the State-of-the-art and the level of maturity, **we propose to add River Discharge to the ESA CCI ECV Portfolio.**

Thanks for your attention!

Carlo Buontempo and Susanne Mecklenburg