Climate Change Service

Climate Change

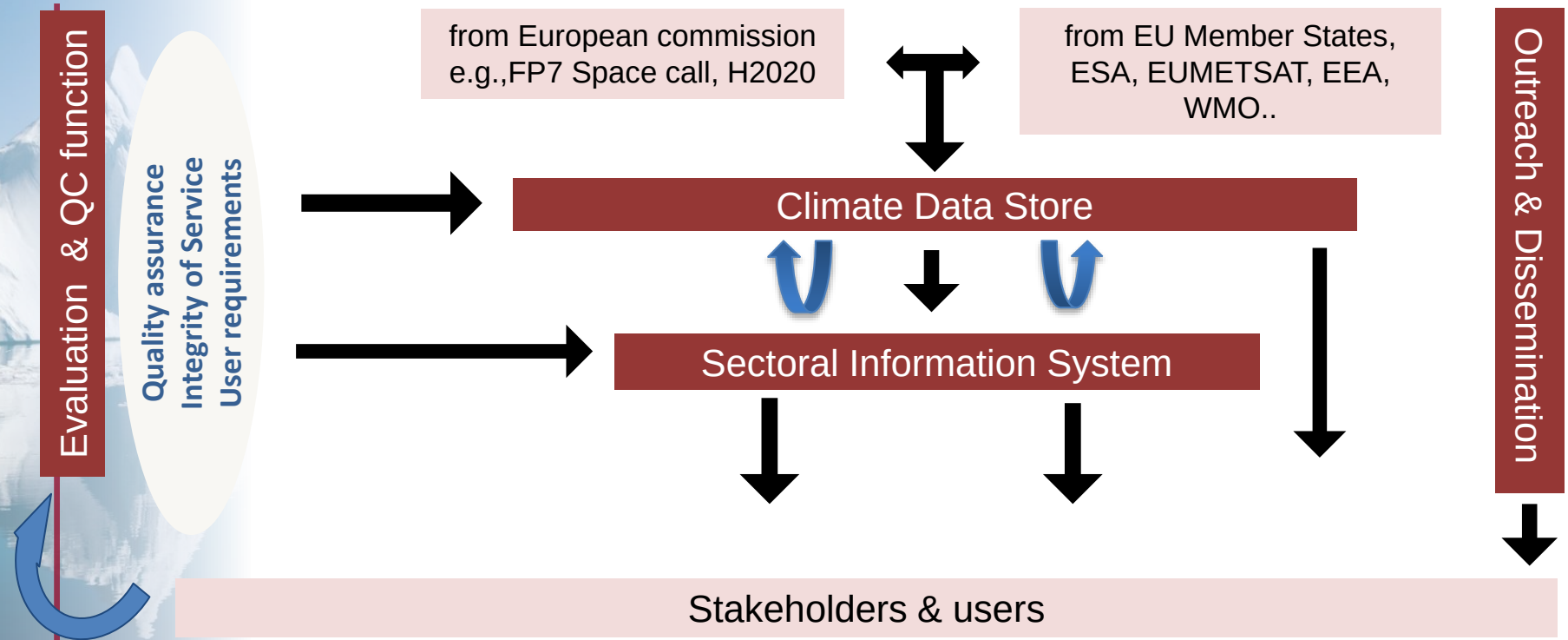
Status and Plans on snow and ice monitoring

Joaquín Muñoz Sabater - ECMWF

Copernicus Europe's eyes on Earth | European Commission | ECMWF

C3S in a nutshell

Climate Change



Copernicus Europe's eyes on Earth | European Commission | ECMWF

Climate Data Store content (January 2018)

Climate Change

Scientific basis:

- Essential Climate Variables as defined by GCOS
- GCOS Status Report and Implementation Plan
- IPCC, CMIP

Action engaged

In progress

Not started

Observations	Global estimates of ECVs from satellite and in-situ observations	Reprocessed CDRs, reference observations	Support for data rescue, climate data collections	Climate Indicators
Climate reanalysis	Global atmosphere, ocean, land	Regional reanalysis for Europe	Coupled climate reanalysis for 100 years (*)	
Model output	Multi-model seasonal forecast products	Access to CMIP data and products (global and regional)	Reference set of climate projections for Europe	

(*): CERA_20C accessible via the CDS

Copernicus Europe's eyes on Earth

European Commission

ECMWF

Climate Change

ECV products based on Earth Observations

			C3S_312a				
				C3S_312b			
		GCOS	2017	2018	2019	2020	2021
Atmospheric physics							
	Precipitation	4.3.5		Lot 1			
	Surface Radiation Budget	4.3.6					
	Water Vapour	4.5.3					
	Cloud Properties	4.5.4					
	Earth Radiation Budget	4.5.5					
Atmospheric composition							
	Carbon Dioxide	4.7.1	Lot 6		Lot 2		
	Methane	4.7.2	Lot 6				
	Ozone	4.7.4	Lot 4				
	Aerosol	4.7.5	Lot 5				
Ocean							
	Sea Surface Temperature	5.3.1	Lot 3		Lot 3		
	Sea Level	5.3.3	Lot 2				
	Sea ice	5.3.5	Lot 1				
	Ocean Colour	5.3.7		Lot 1			
Land hydrology & cryosphere							
	Lakes	6.3.4					
	Glaciers	6.3.6	Lot 8		Lot 4		
	Ice sheets and ice shelves	6.3.7					
	Soil moisture	6.3.16	Lot 7				
Land biosphere							
	Albedo	6.3.9	Lot 9		Lot 5		
	Land Cover	6.3.10		Lot 1			
	Fraction of Absorbed Photosyntheti	6.3.11	Lot 9				
	Leaf Area Index	6.3.12	Lot 9				
	Fire	6.3.15		Lot 1			
			2017	2018	2019	2020	2021

- Snow as ECV is currently not part of this list, but covered in reanalysis

C3S_312a:

- 12 ECVs in 9 Lots

C3S_312b:

- 22 ECVs in 5 Lots
- Continuity of service

Heritage/coordination:

- ESA CCI
- EUMETSAT SAFs
- Other Copernicus Services
- etc..

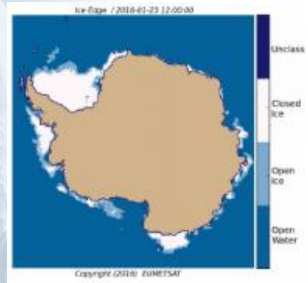
Copernicus Europe's eyes on Earth | European Commission | ECMWF

Climate Change

Sea Ice Production Service (DMI)

Complementary with EUMETSAT OSI SAF & ESA CCI

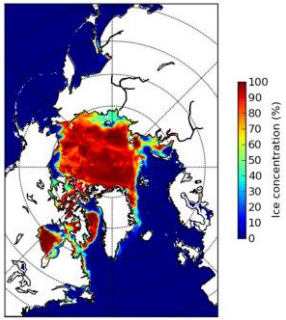
Sea Ice Edge:



Distinguish between Open water, Open Ice and Closed Ice
Global coverage
10 km resolution

CDR: 1979 – 2016
ICDR: 2016 – onwards

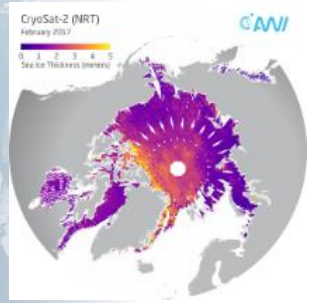
Sea Ice concentration:



OSI SAF CDR (OSI-409) and ICDR (OSI-430)
Global coverage
10 km resolution
Includes uncertainty estimates

CDR: 10.1978 – 04.2015
ICDR: 05.2015 - onwards

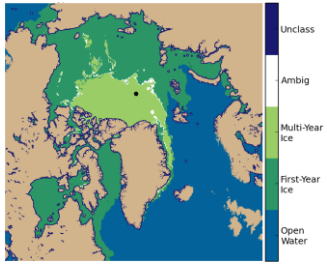
Sea Ice Thickness:



Nothern Hemisphere
25 km resolution
Includes uncertainty estimates

ICDR: 2010 – onwards

Sea Ice Type:



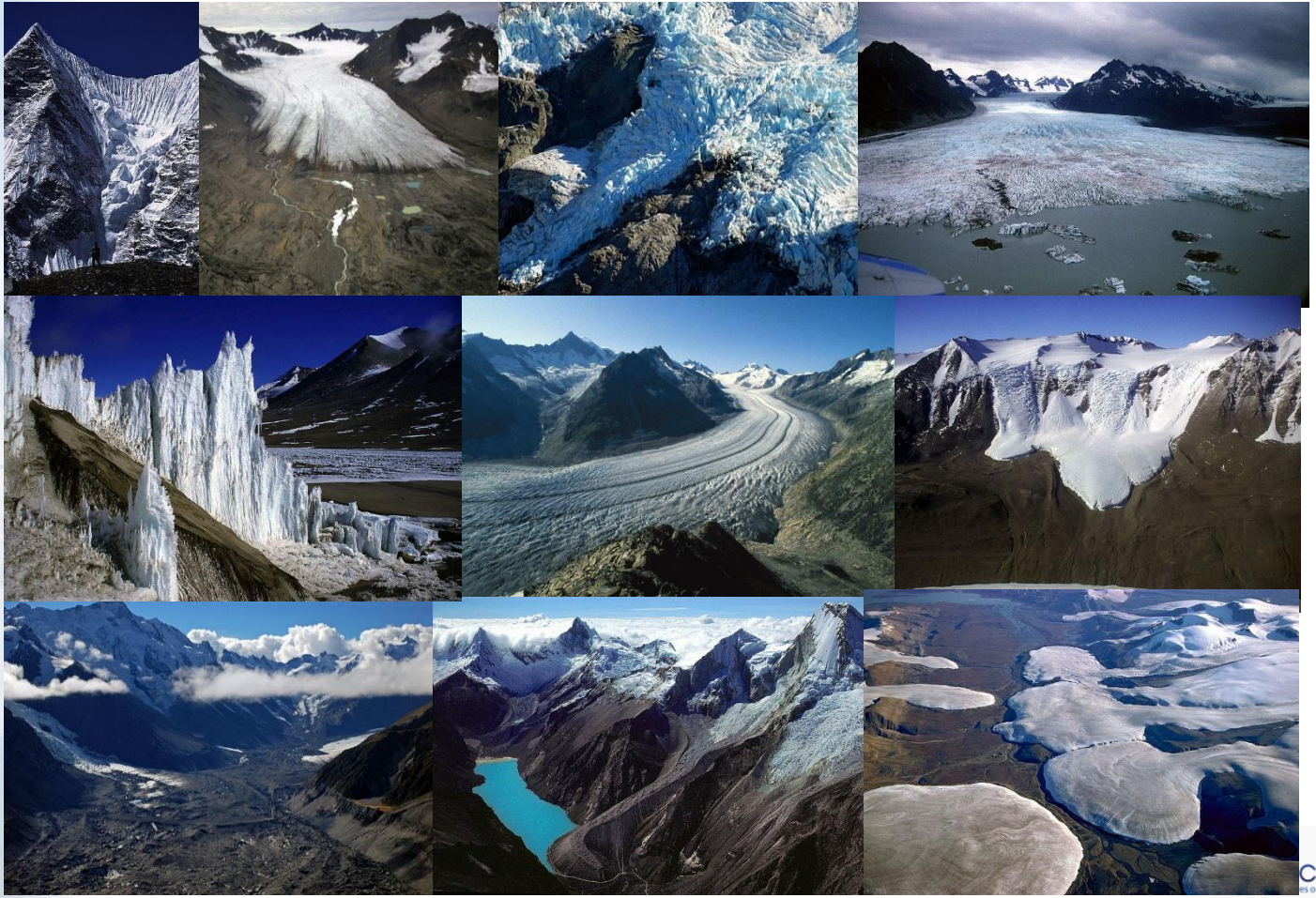
Distinguish between First-Year Ice and Multi-year Ice
Nothern Hemisphere
10 km resolution

CDR: 1979 – 2016
ICDR: 2016 – onwards

Copernicus Europe's eyes on Earth | European Commission | ECMWF

Climate Change

Glaciers & Ice Caps Services (Univ. Zurich)



Climate Change

Glaciers & Ice Caps Services (Univ. Zurich)

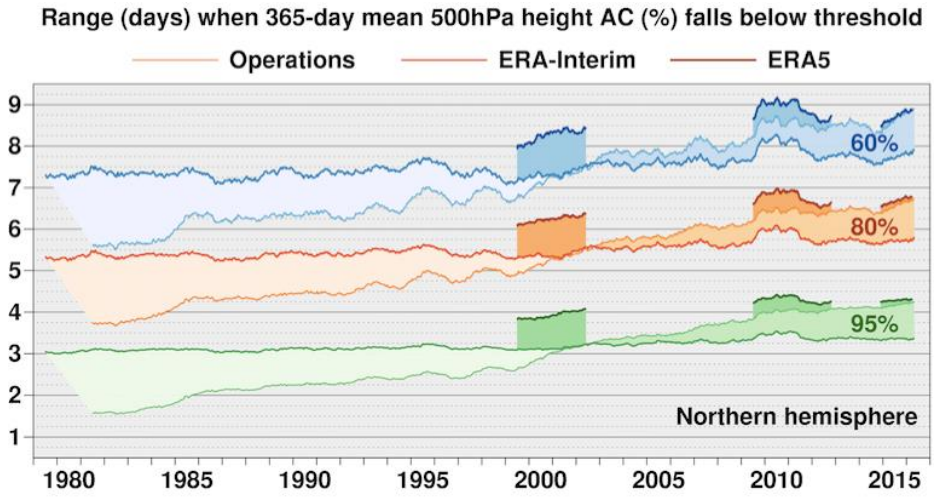
- **A globally distributed ECV and monitoring concept**
  - Glaciers occur globally and have a wide range of surface/dynamic characteristics
  - Their monitoring is based on a global network of observers and has a >100 yr tradition
  - RS data processing is also globally distributed (GLIMS) & based on scene-by-scene analysis
  - GCOS accuracy reqs. can only be met when manual editing is applied (debris, clouds)
- **The Glacier Distribution and Change Service in C3S is based on**
  - Glacier mapping & change assessm. with optical satellite data (L8/S2) in key regions
  - Utilizing latest DEMs (TanDEM-X, Arctic DEM) to obtain glacier-specific elevation changes
  - Enriching and improving pre-existing datasets (GLIMS/RGI & WGMS database)
  - Collecting and integrating already published data from the community (reach out)
- **Developing of adaptors for integration of glacier data in the CDS**
  - Step 1: Adaptor 1 & 2 brings existing RGI (inventory) & FoG (WGMS) databases into the CDS
  - Step 2: Updating the CDS with new datasets (new, enriched, and collected products)
  - Step 3: Adaptor 3 merges extents & elevation changes for improved calculation of sea level

Climate Change

Climate Data Store: Reanalyses

ERA5 global reanalysis:

- Atmosphere/land/wave parameters
- 31 km global resolution, 137 levels
- Hourly output from 1979 onward
- Using improved input observations
- Ensemble data assimilation
- Providing uncertainty estimates



However, need to

- provide better regional estimates of surface parameters by using improved model representations of surface fluxes;
- assimilate observations that are not used well (or not at all) in global reanalyses;
- improve the representation of extreme values and extreme events.

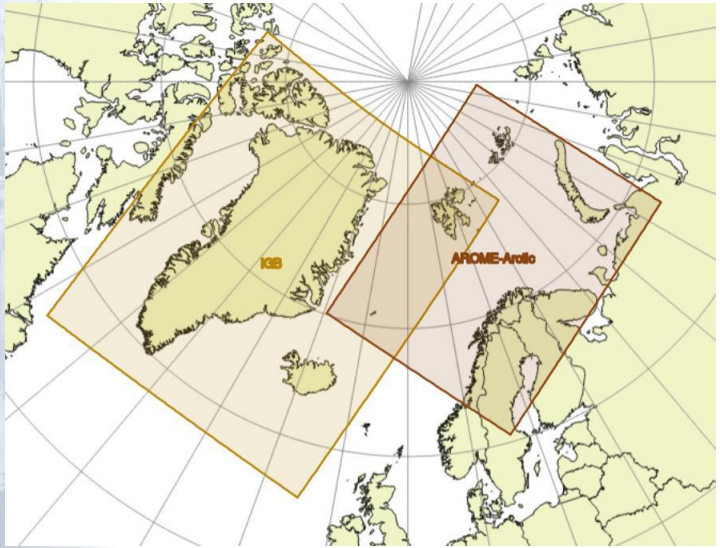
→ **Regional reanalysis (European + Arctic domains)**

C3S_322 Lot 2: Regional reanalysis for the Arctic

Climate Change

- Warming in the Arctic (observational records and future scenarios) roughly twice as high as global average
- Need for understanding and management of change processes
- Increased economic activity in the region

(Animated gif: NASA)



Coverage in two domains, main areas of interest in the European sector of the Arctic

High resolution (2,5 km) adds value to global products

Extensive use of satellite data

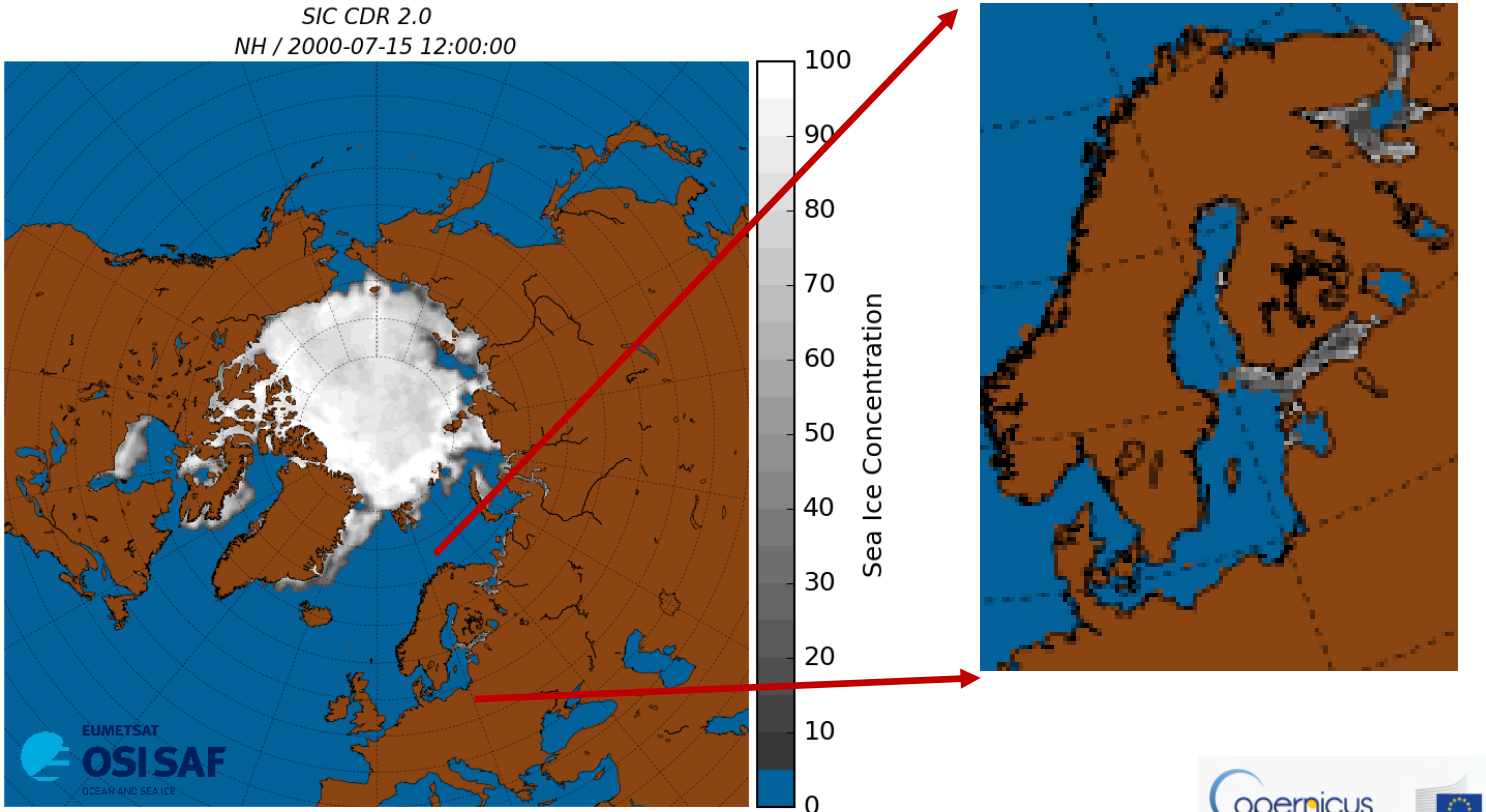
Use of local surface observation datasets available in the partner countries

Special emphasis on NWP schemes and observations for the handling of "*cold surfaces*": Snow, sea ice, glaciers

Copernicus Europe's eyes on Earth | European Commission | ECMWF

Sea-ice monitoring

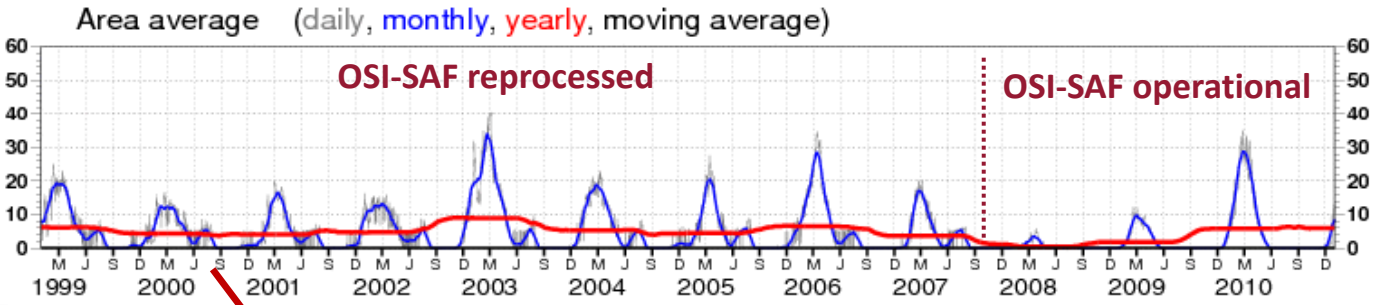
- Spurious sea ice in the Baltic Sea.

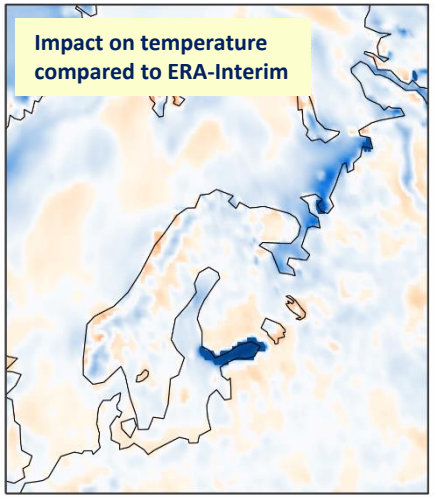


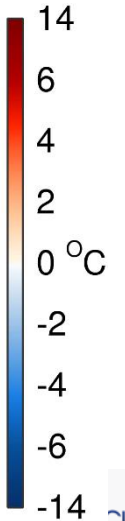
Climate Change

Frequency and impact

Occurs each year (from 1979 - 2007)
Has detrimental effect on atmosphere and waves







Courstesy of H. Hersbach

Copernicus Europe's eyes on Earth

European Commission

Climate Change

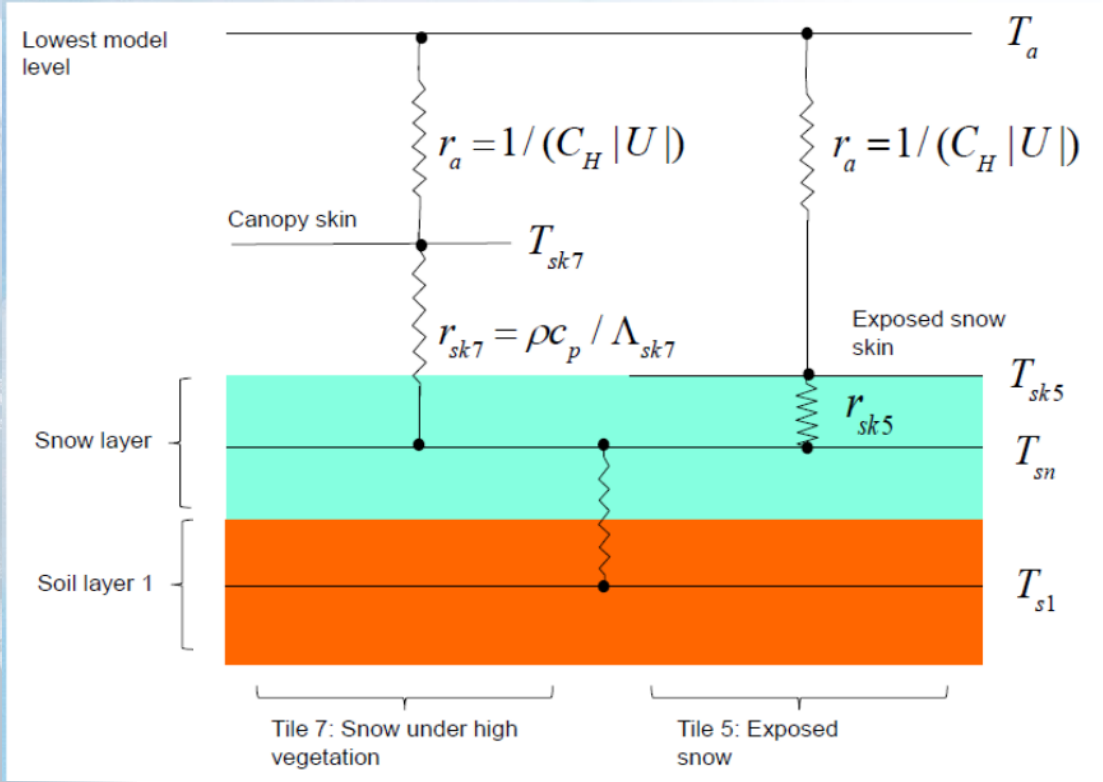
Snow products in ERA5 & relevance for NWP

- These products benefit from **modelling & data assimilation activities at ECMWF**
- In the past few years major development in the ECMWF modelling and data assimilation (DA) system affecting forecasts and analyses at Polar regions
- Snow DA assimilation crucial for NWP
  - Significant improvement of near-surface meteorology
  - In the absence of satellite dedicated missions, in-situ snow depth observations is by far the most relevant information for snow DA.
  - GAPS, in snow reports availability in the GTS
    - Some areas with poor reporting (Iceland)
    - Areas with seasonal reporting because they only report on snow covered areas
    - For some countries the data exist and is available in NRT → need to include it in the GTS network (decisions, resources)
    - For other countries (Finland) data policy issues
    - For all areas with gaps awareness is necessary

Snow representation at ECMWF

E. Dutra

- **Global and regional reanalysis benefit from advances in modelling and data assimilation activities. Observations (truth) are needed.**



Two tiles:
1) **Exposed snow;**
2) **Snow under high vegetation**

Single snow-pack evolution

Prognostic evolution:
1)Snow mass
2)Snow density
3) Snow temperature
4) Snow Albedo

Diagnostics:
1) **Snow depth**
2) **Snow cover fraction**
3) **Liquid water content**

Climate Change

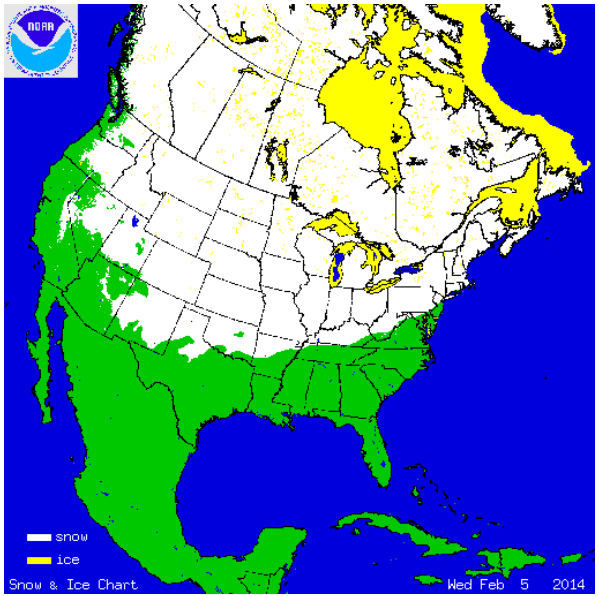
Snow data assimilation at ECMWF

Snow depth

Methods: Cressman for ERA-Interim, 2D Optimal Interpolation (OI) for NWP & ERA5

Conventional observations: *in situ* snow depth (SYNOP & additional National data)

Satellite data: NOAA/NESDIS IMS Snow Cover Extent (daily product).



Soil Temperature and Snow Temperature

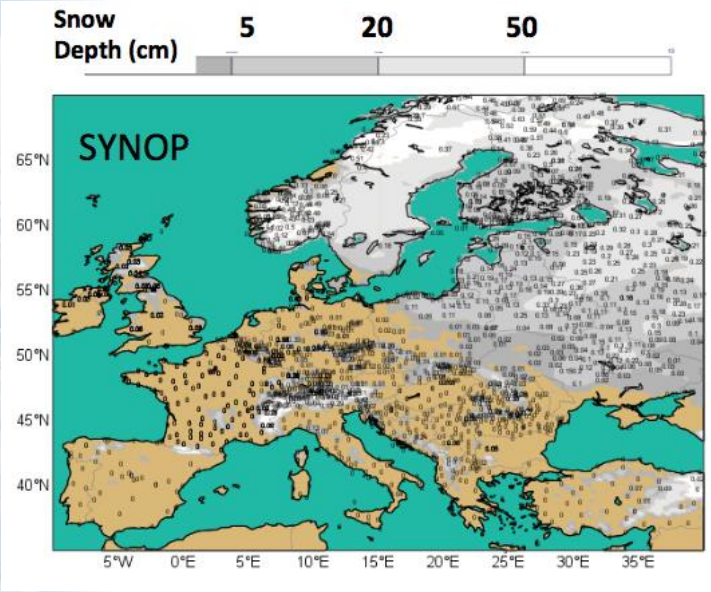
1D-OI using analysed T2m as observation (NWP, ERA-Interim, ERA5)

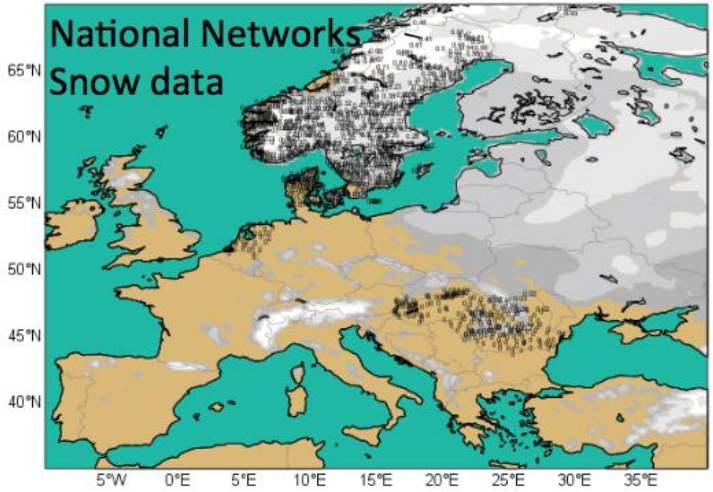
Snow data assimilation at ECMWF

P. de Rosnay

Available in the global GTS

January 2017



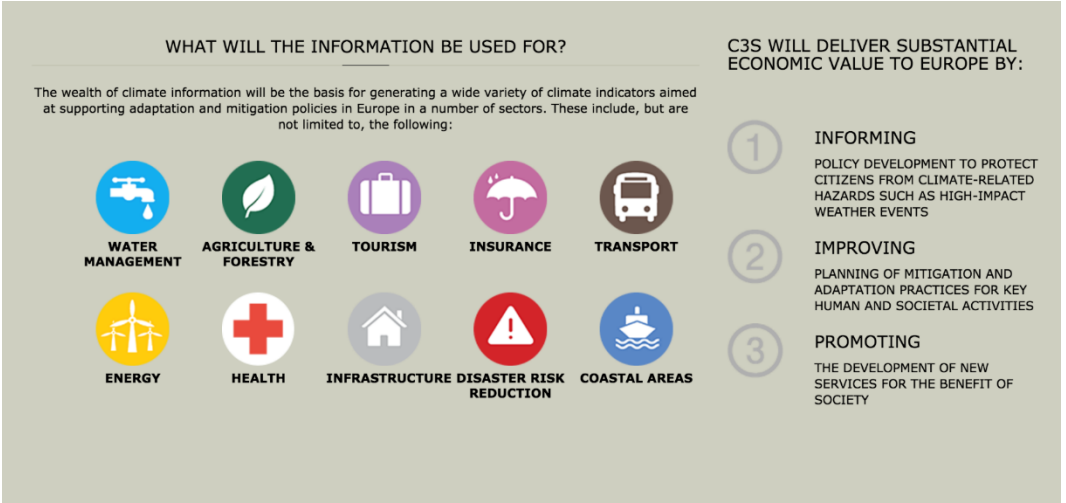


Climate Change

Sectoral Information System

Proof-of-concepts of climate services: Demonstration of the value chain with several end-to-end demonstrators

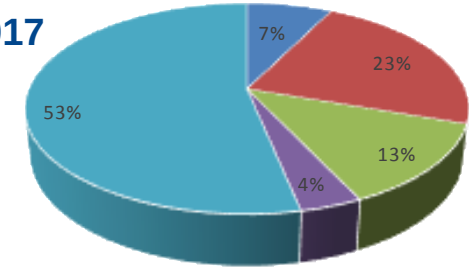
As an operational Service, C3S ambitions to become an enabler of downstream climate services, by providing or brokering high quality and sector relevant climate data and indicators, good practices, tools and by supporting compelling use cases.

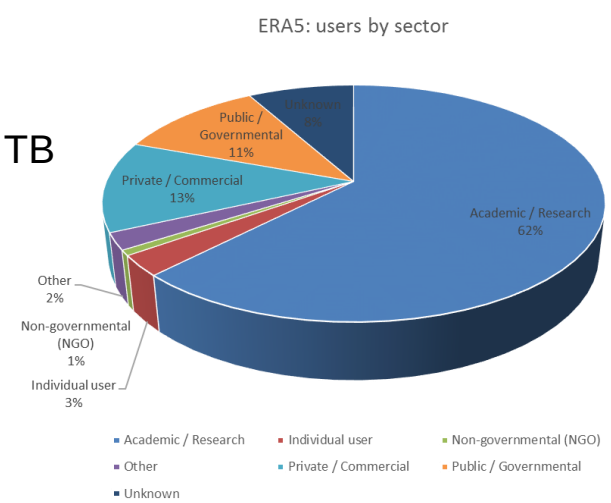


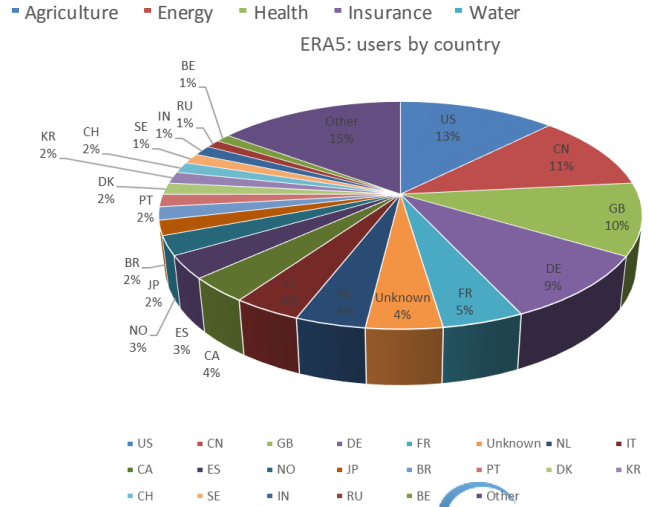
	Title	Start	End	Key deliverables
C3S_51 Lot 2	Quality Assurance for ECV Products Derived from Observations	01/10/16	31/12/18	• **User requirements for climate data** • Inventories of existing climate datasets • Scientific assessments and gap analysis for a selection of datasets • Recommendations for further development of the CDS • Recommendations for further development of the EQC function
C3S_51 Lot 3	Quality Assurance for Multi-Model Seasonal Forecast Products	01/07/16	30/09/18	
C3S_51 Lot 4	Quality Assurance for Multi-Model Climate Projections	01/08/16	31/10/18	
C3S_511	Quality Assessment of ECV Products	01/11/17	30/06/21	• Quality assessments for individual ECV products (appr. 100 datasets) • Multi-product assessments for each ECV (appr. 39 ECVs) • Thematic assessments for sets of related ECVs (appr. 6 themes)

- Active users:
  - Global reanalysis: 7,362
    - ERA-Interim: 7,089
    - ERA5: 579
  - Seasonal forecast: 879 (web users)
  - SIS: 4,565 (web users)
- Data delivery
  - Global reanalysis
    - ERA-Interim: 333 TB
    - ERA5: 491 TB

Overall C3S usage in Q3 2017







Climate Change

Summary

- C3S provides an increasing volume of climate information relevant for ice and snow covered areas, based on a combination of satellite and in-situ observations using the latest methods and tools.

- The Climate Data Store will offer a “one-stop-shop” access to this information
  - Data (including sectoral information)
  - Tools (data accessible and discoverable)
  - Best practices

- The Copernicus data policy is “full-free-open” → This will foster uptake by downstream services (national, local, private and public) and therefore support market development for EO and climate services in Europe.

Climate Change

Future

ECVs

Snow and permafrost part of ESA CCI+ → once maturity possibly part of the C3S ECV portfolio

Reanalysis

Regional reanalysis in the Arctic will continue developing. Antartic?

Snow & ice modelling and DA still integral part of ECMWF activities

Agreements with other countries to access national network of snow observations

User driven service

The C3S service driven by user requirements and user needs → EQC

Snow & Ice monitoring essential for SIS and impact on socio-economical sectors

Climate
Change

Copernicus
Europe's eyes on Earth

European
Commission

Climate Change

Back up slides

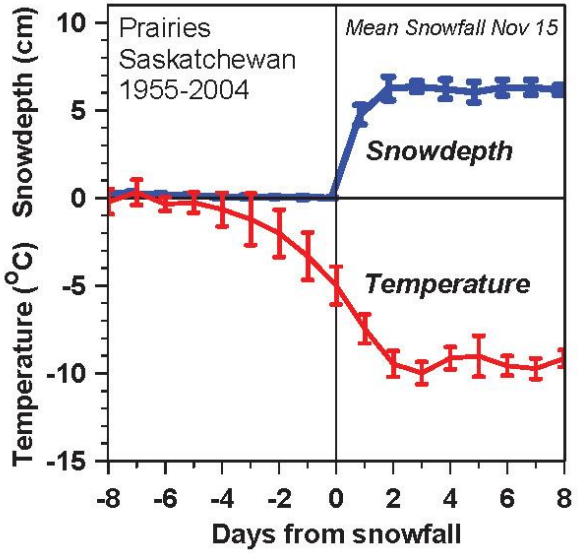
Copernicus Europe's eyes on Earth

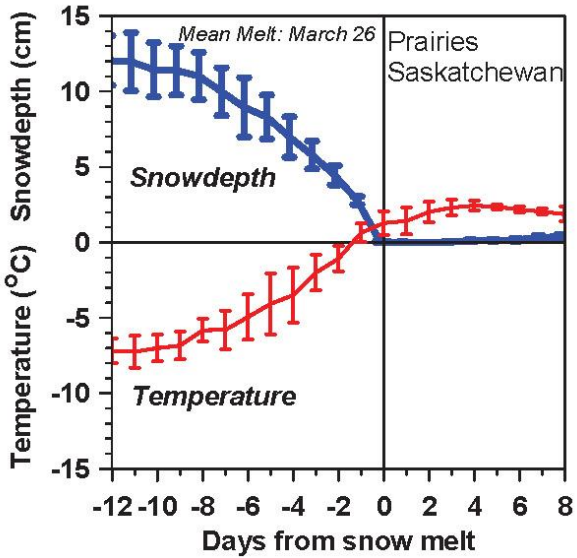
European Commission

Climate Change

Earth surface role, observational evidence (snow)

- **Global and regional reanalysis benefit from advances in modelling and data assimilation activities. Observations (truth) are needed.**





- **Temperature falls/rises about 10K with first snowfall/snowmelt**

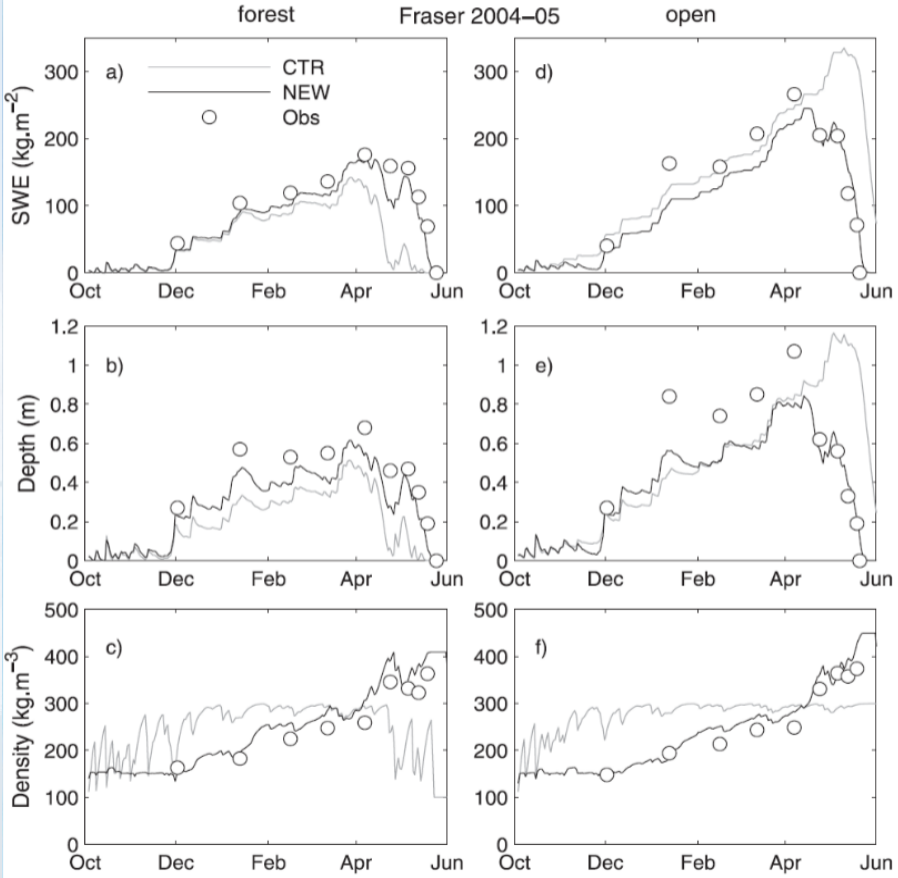
Betts et al. 2014

- ***Snow reflects sunlight; shift to cold stable BL***
  - ***Local climate switch between warm and cold seasons***
  - ***Winter comes fast with snow***

Snow representation at ECMWF – Point evaluation

E. Dutra

Climate Change



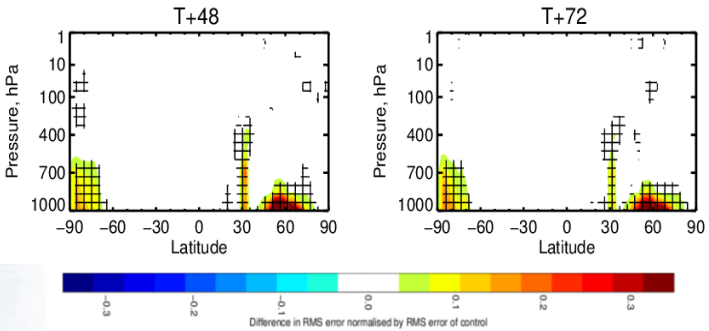
Point simulations (offline) in a forest and open areas nearby
CTR (gray) : model before 2009
NEW (black) : current model

- **Better simulations of snow mass**
  - **Albedo changes**
  - **Liquid water representation**
- **Improved snow density**
  - **Before – exponential increase**
  - **Snow follows closely observations. Still some problems during melting**

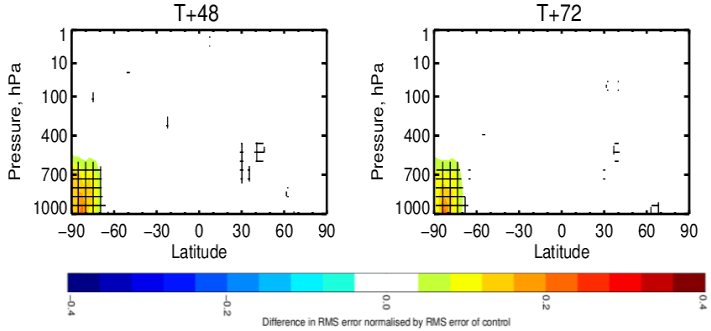
Climate Change

Relative Soil & Snow forecast impact

Snow processes (winter 2015-16)



Snow processes (summer 2015)



- Snow has both NH/SH impact (20-30% winter, 10-20% summer) lower troposphere

Copernicus Europe's eyes on Earth

European Commission