Copernicus Arctic Regional Reanalysis

Climate Change

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Danish Meteorological Institute

on behalf of **C3S D322 Lot 2** team:

Harald Schyberg (PL), Heiner Körnich, Roger Randriamampianina, Xiaohua Yang *and many others*

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Outlines

- Background
- System configuration
- Added values and enhancements
  - efforts on input data, assimilation algorithm and modelling aspects
- Status and schedule

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C3S - Copernicus Arctic Regional Reanalysis

Motivation

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

(Animated gif: NASA)

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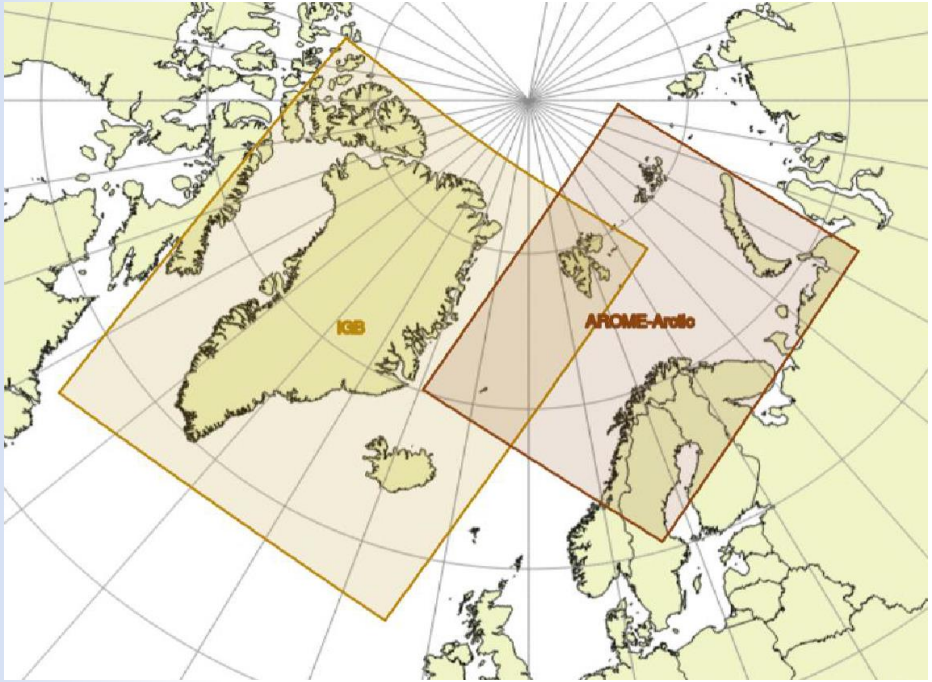
C3S - Copernicus Arctic Regional Reanalysis



- **Regional reanalysis datasets for July 1997-June 2021**
- Very high resolution regional model Harmonie-AROME (2.5 km, 65 layers)
- **Two domains, main areas of interest in the European sector of the Arctic; One year proof-of-concept reanalysis for a pan-arctic domain**
- **3D-VAR with extensive use of satellite data and use of local surface observation available in the partner countries**
- Special emphasis on NWP schemes and observations for the handling of "*cold surfaces*": Snow, sea ice, glaciers

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Why high resolution? It is crucial for surface quantities

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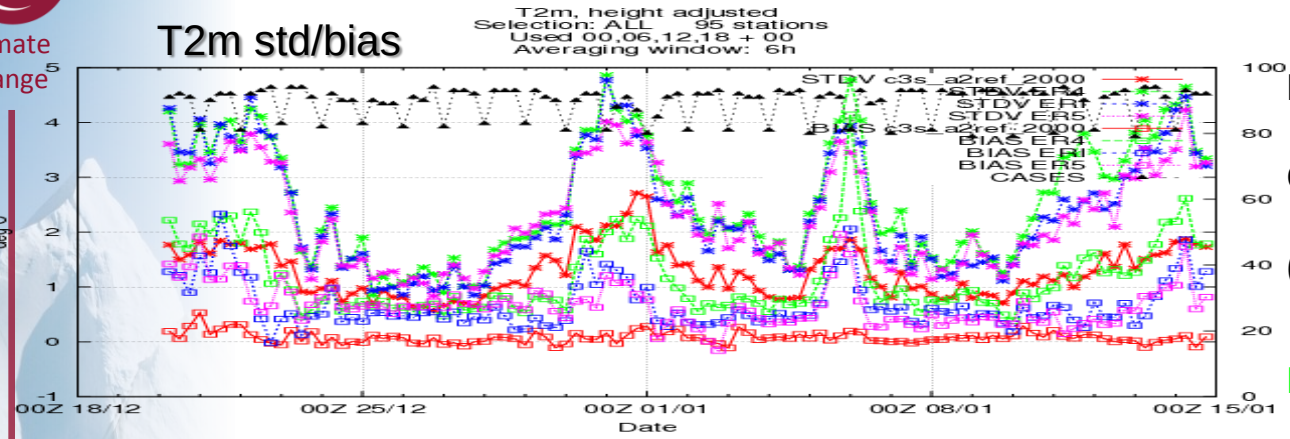
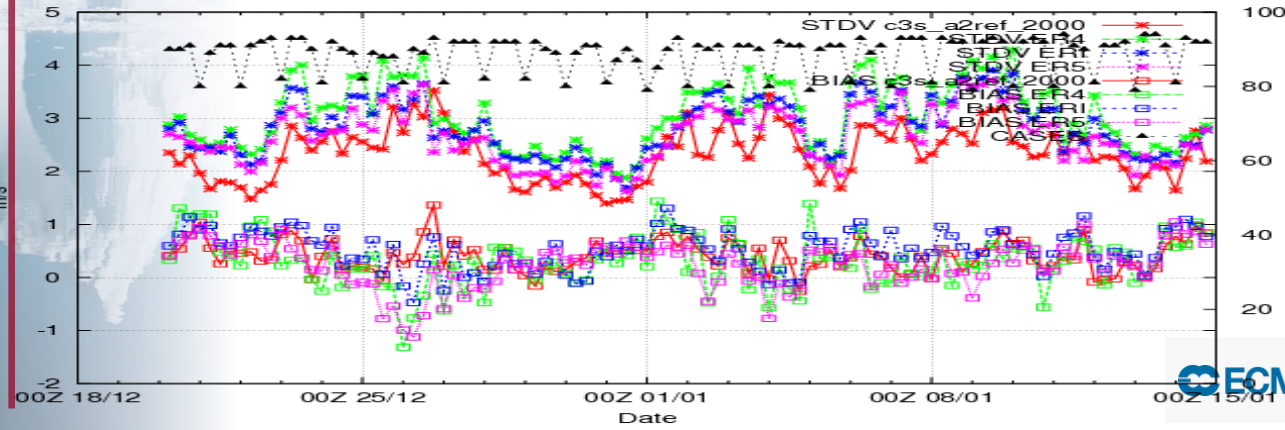
T2m std/bias



W10m std/bias



Dec 20 1999 - Jan 15 2000

C3S East Arctic domain

(North Scandinavia, Svalbard)

ERA 40 125 km

ERA Interim 80 km

ERA5 31 km

C3S Arctic (Provisional) 2.5 km

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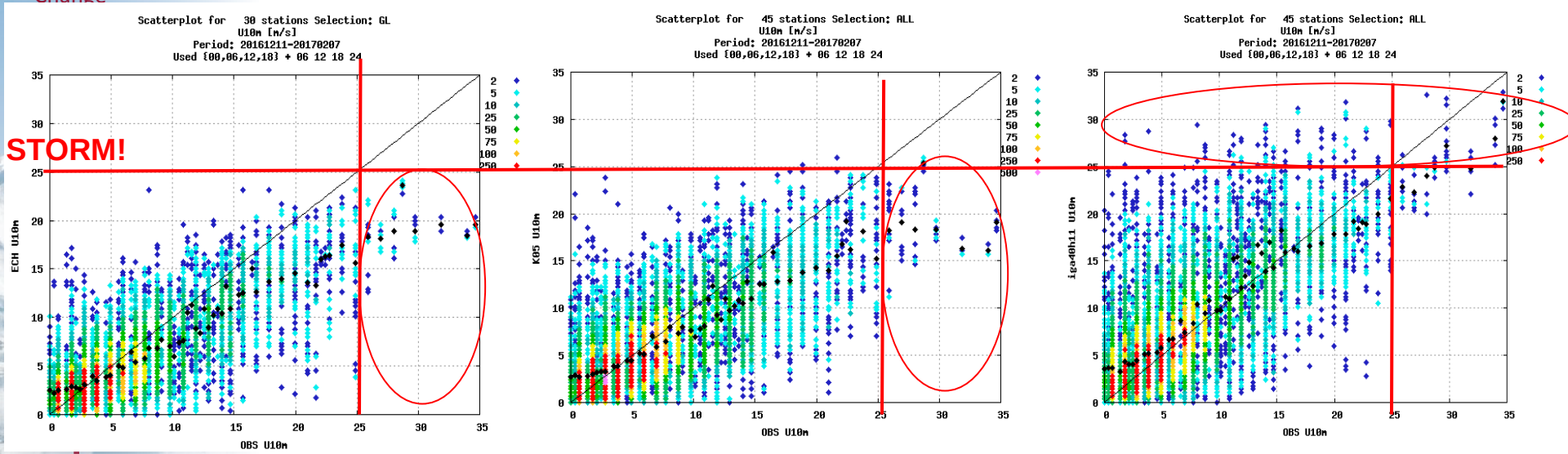
Why high resolution? It is crucial to represent critical processes



ECMWF HiRes
9 km

HIRLAM-K05
5 km

Harmonie-IGA
2.5 km

Surface wind verification for Greenland, Dec 2016 - Feb 2017

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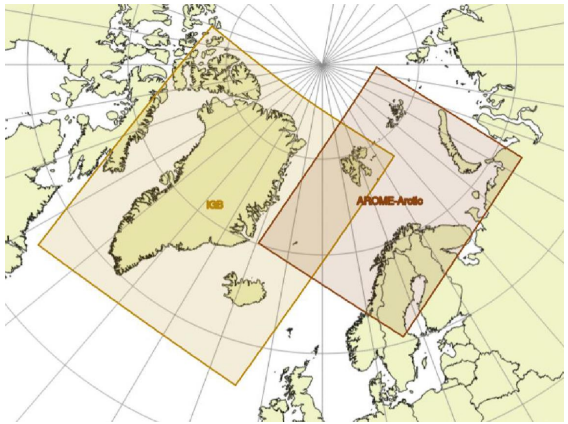
System Configuration

- System: based on the operational Harmonie-AROME 40h1 at DMI/IMO and met.no
  - **Two domains with Greenland/Iceland, Svalbard/Northern Scandinavia**
  - 2.5 km grid, 65 levels below 10 hPa
  - 3D-VAR with enhanced observation input
    - 8 cycles/day, 30h forecast at 00/12
    - Reprocessed AMV/Scatterometer/RO
    - High resolution sea state data



- Main adaptations: ERA5, extra input data
  - hourly LBC from ERA5 4DVAR

- Computations on ECMWF HPC
  - Production starts in May 2019
  - 3x 9-yr time slicings
  - Data will be available via Copernicus CDS by 2021

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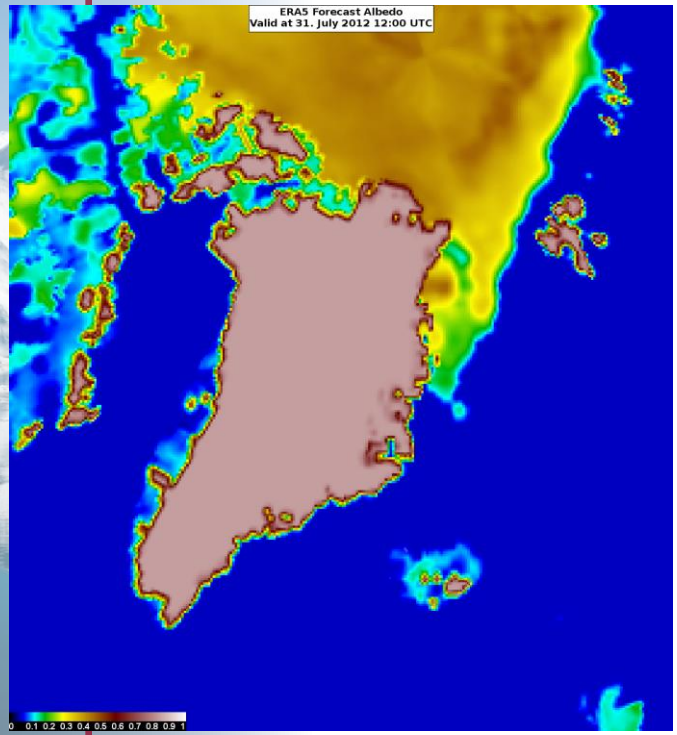
Albedo over arctic glaciers

ERA5



GEUS (Box et al)

MOD10A1 C6 product
2000-2017, daily, 500m

+ age data
+ covering Greenland, Iceland Svalbard & adjacent areas
+ climatologies using 2000-2006 data
+ In C3S Arctic, external albedo values will be assimilated

(P. Samuelsson, B. Palmason & K. P. Nielsen)

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Figures by Bolli Palmason (IMO)

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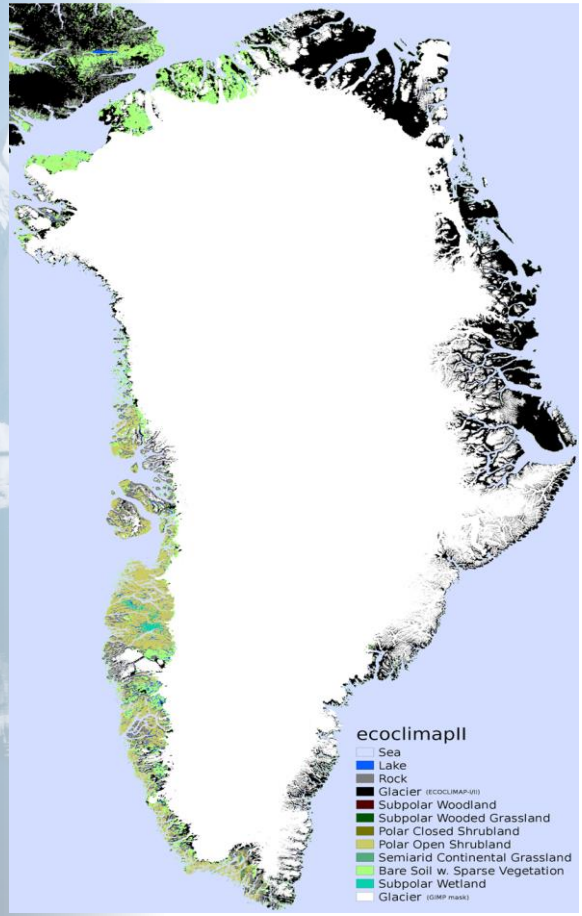
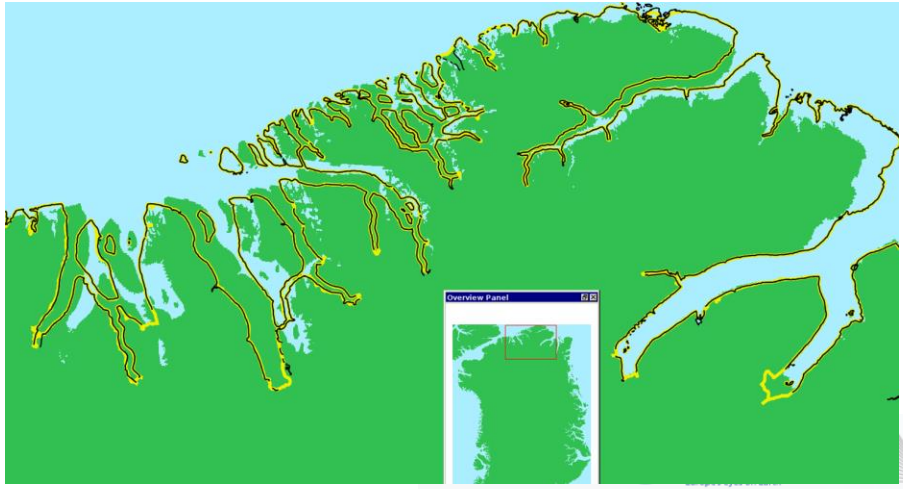
Corrections of physiographic data (PGD)



- **Svalbard icesheet/glacier extents corrected**
- Clay and sand extents from Soilgrid used
- **Topography improved with better DEM datasets**
- Coastline errors corrected with coastlines from the Danish mapping authorities and the GIMP ice mask

(Bolli Palmason, Teresa Valkonen Matti Horttonainen, Ekaterina Khoreva)



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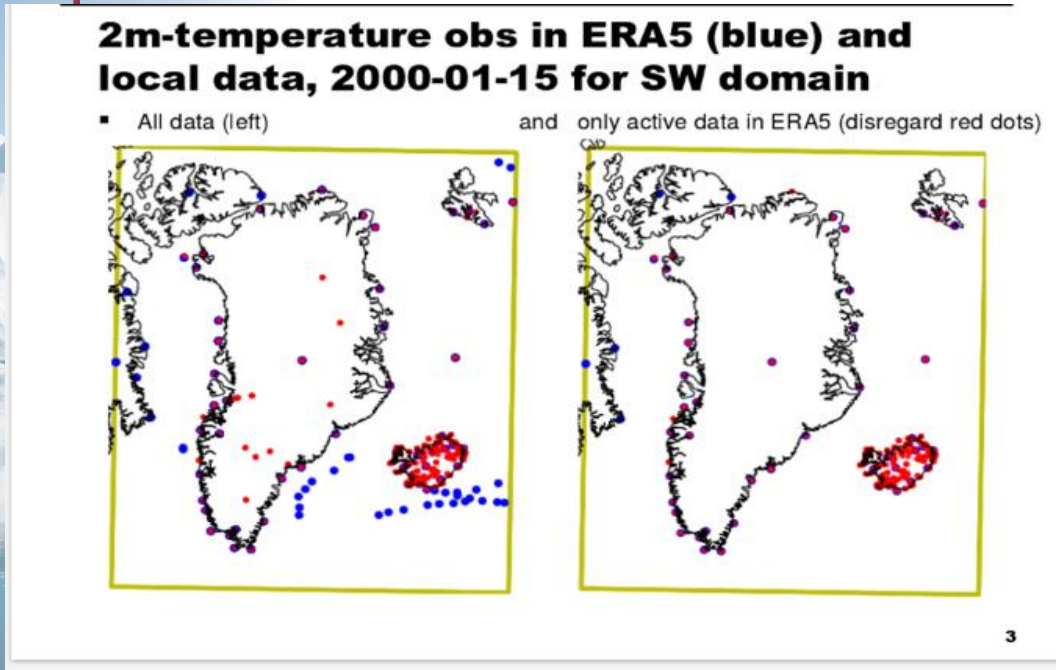
Arctic area is extremely data sparse!



- **Very limited number of stations, especially few about moist parameters.**
- No snow depth obs over Greenland
- **Mostly coastal stations**
- **Significant portion of obs not on GTS**
- Collect and use more surface data
  - Iceland, Greenland SYNOP
  - snow depth data form non-GTS
  - use better quality-checked data
  - PROMICE/GCNET/ASIAQ data
- **Use more satellite data**
  - **Radiance, RO, AMV, Scatterometer**

(Magnus Lindskog et al)

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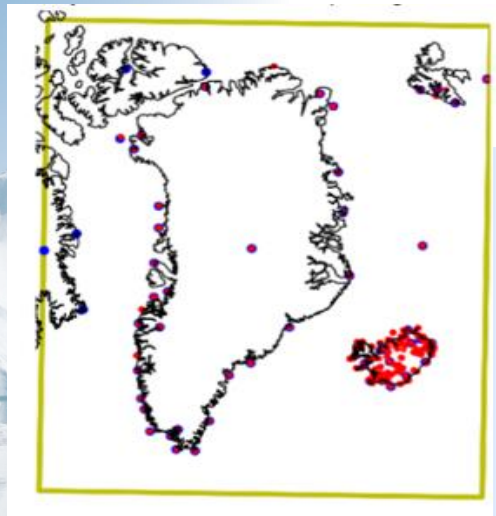
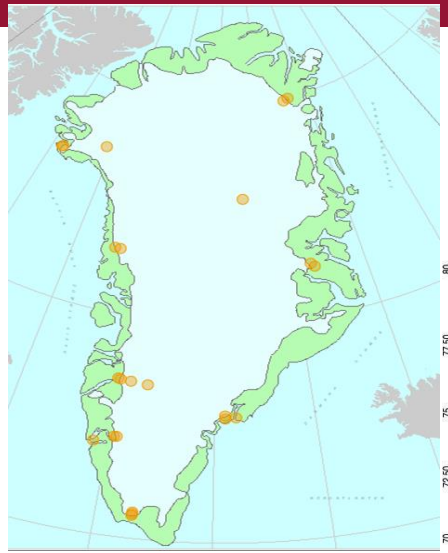
Enhanced surface observation data



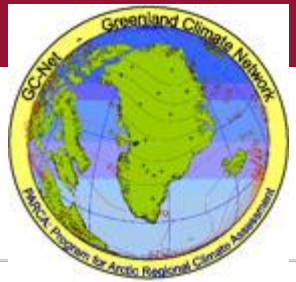
ERA-5 (GTS)

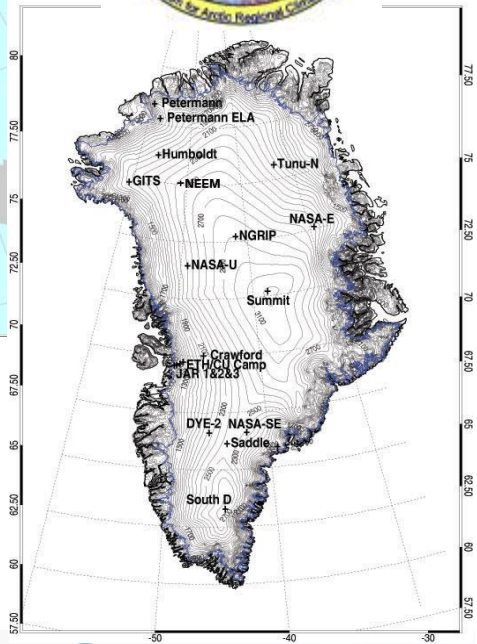
(Bjarne Amstrup et al)



PROMICE

(2008-)





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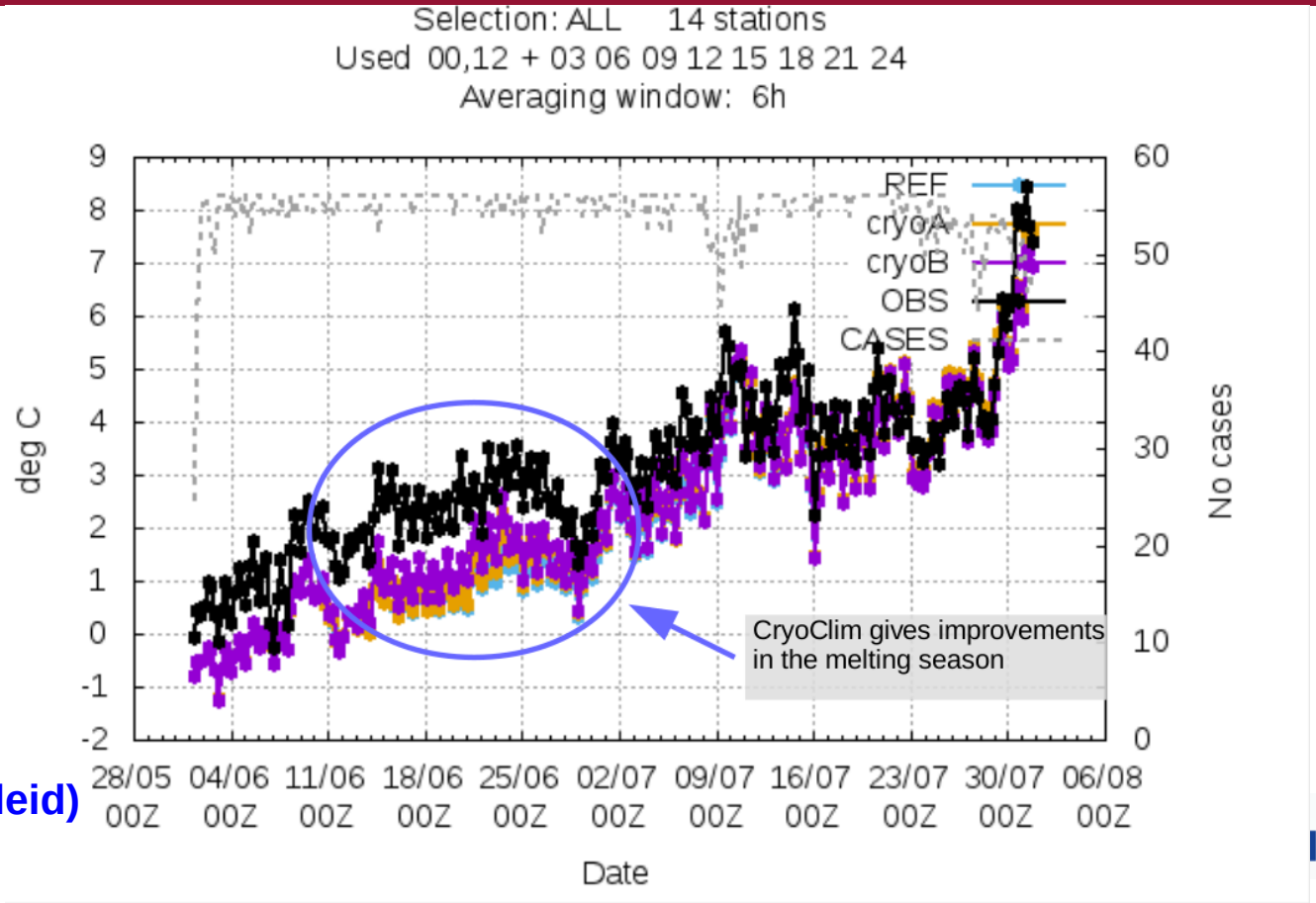
Assimilation of Cryoclim satellite snow (5 km)

Summer 2015
Svalbard



(Mariken Homleid)

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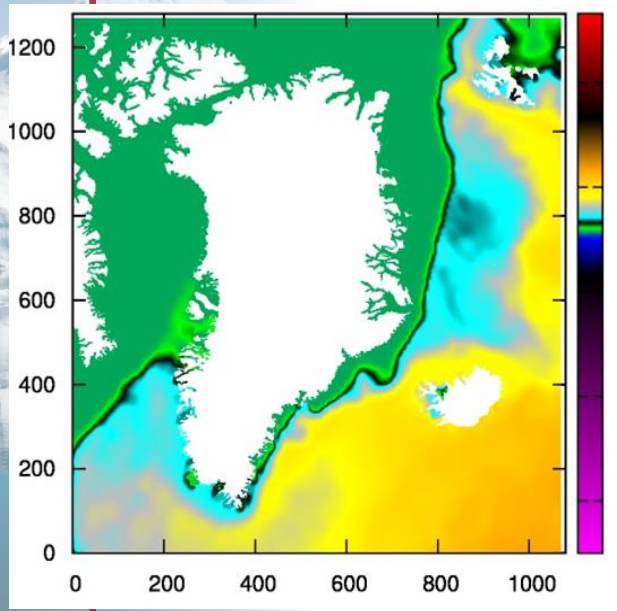
High resolution SST (~5km) & Ice cover (~10 km)

A seamless product tailor made for C3S Arctic (Pia Nielsen-Englyst et al.)

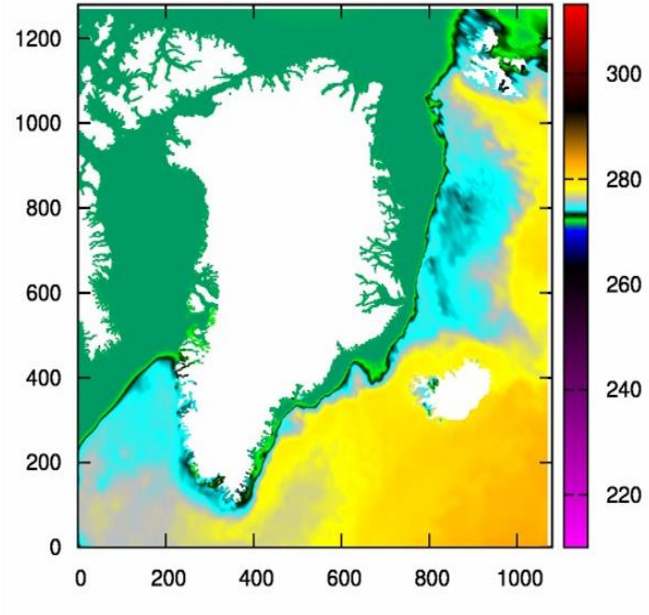
Sea Ice : ESA CCI SICCI and Eumetsat OSI-SAF Sea ice CDR

SST: Eumetsat OSISAF Level 4 + ESA CCI CMC L4

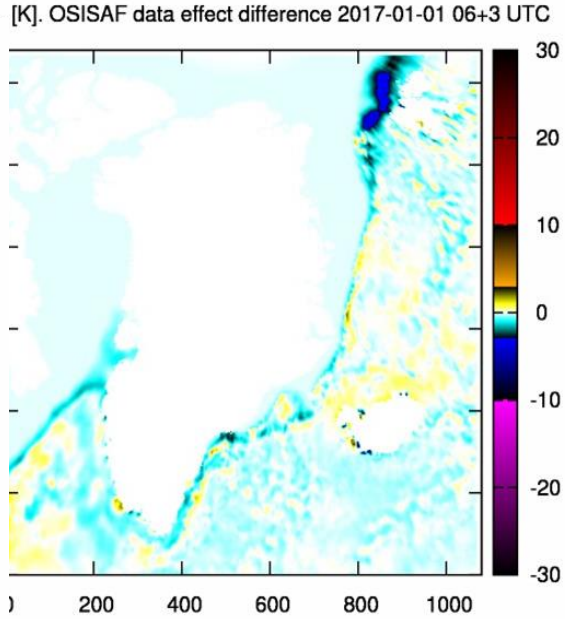
2017-01-01-09 UTC



ERA 5 SST



OSI SAF-CCI SST



SST difference

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Schedule for production of the C3S Arctic reanalysis

September 2017: Project start

→

September 2018: System beta

→

April 2019: Final system, and production start

→

June 2021: Production end; complete dataset released

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Provisional C3S vs ERA-5, East domain

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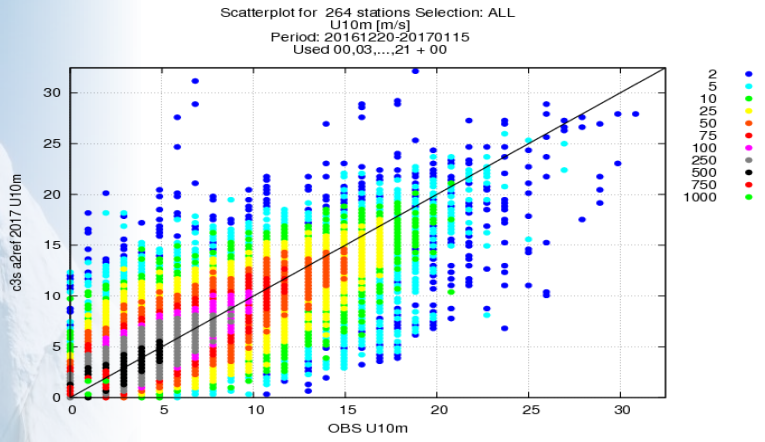
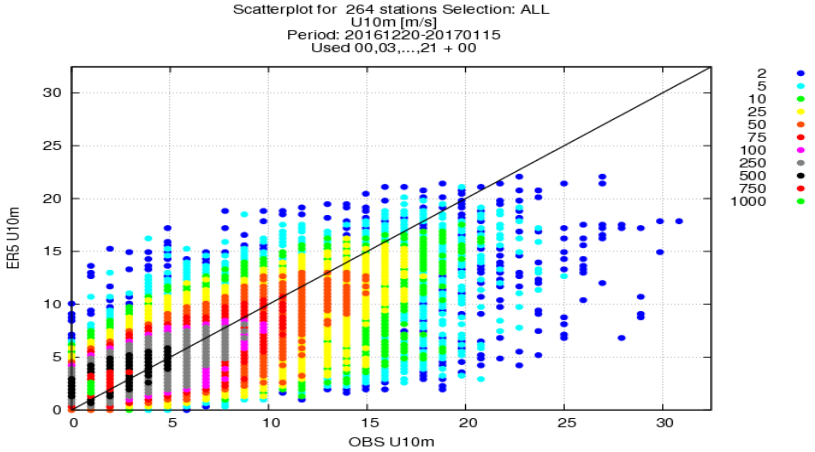
Wind

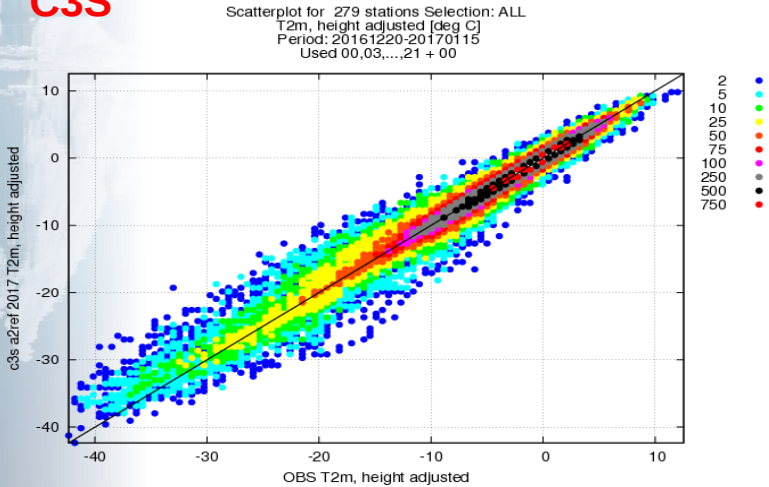
T2m

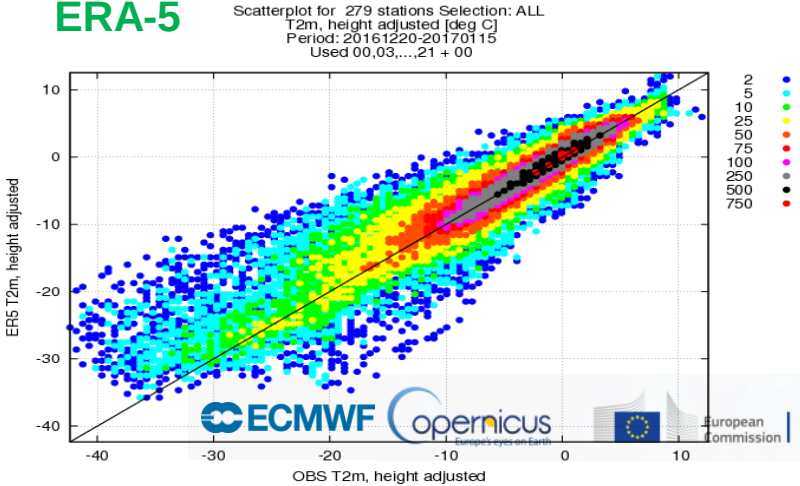
C3S





ERA-5





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THANK YOU FOR YOUR ATTENTION!

Summary:

C3S Arctic is a ***very high resolution*** 24-year regional re-analysis for arctic regions. Preparation phase features major efforts to address 1) cold surface processes and 2) sparse observation:

- enhanced handling of ***snow and arctic glaciers***
- enhanced model description about ***surface features***
- ***enhanced observation data input*** with local synoptic, reprocessed satellite, and sea states data
- also, some measures of uncertainty e.g. through EDA on time slicing
- Technical and meteorological baseline in good shape; provisional C3S datasets confirm added value over ERA5
- C3S production starts in ***May 2019***

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Preparation: system enhancements

- Adaptation necessary for use of Harmonie-arome in re-analysis; monitoring
- In particular, data assimilation for a very data sparse area
  - Enhanced use of observation data
    - collection of additional local data
    - assimilation of remote sensing data (radiance, reprocessed AMV/RO/ scatterometer)
    - high resolution sea state input (OSISAF-CCI,SST ~5 km, ICE ~10 km)
  - Algorithm enhancement
    - Large scale constraint, Evolving B, uncertainty information
- Focus on arctic surface processes
  - enhanced handling of glacier
    - snow modelling with use of external albedo data
  - enhanced snow assimilation including use of satellite data
- enhanced PGD data (orography, glacier mask, LAI, soil)

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Provisional C3S vs ERA-5, T2m error time series

Climate Change

Winter 2017

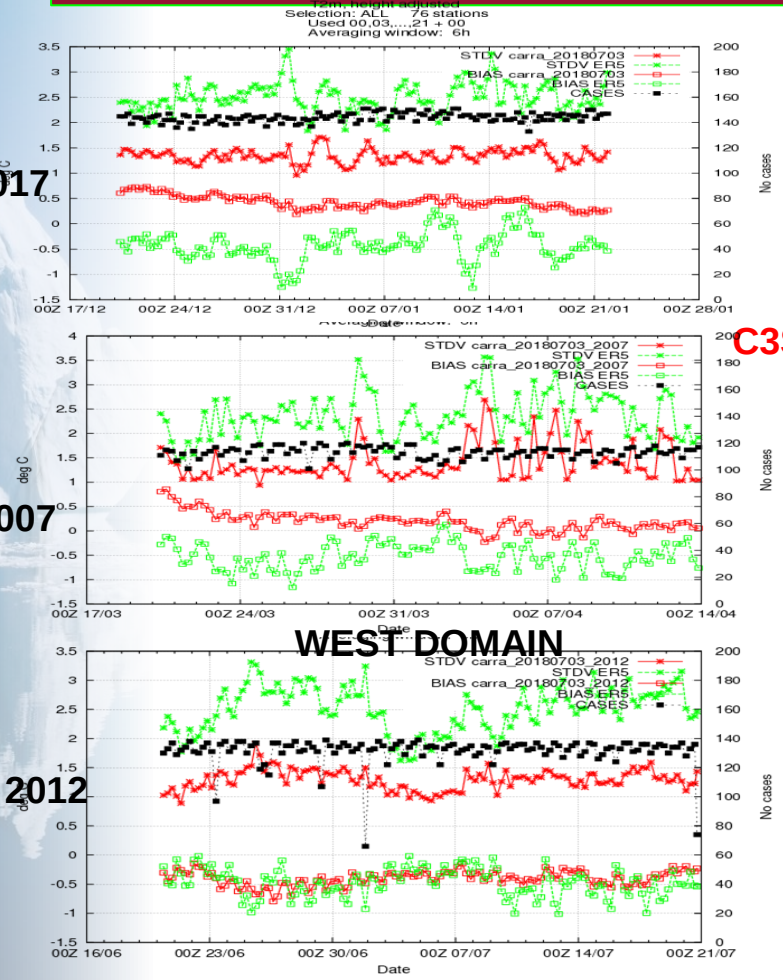
Spring 2007

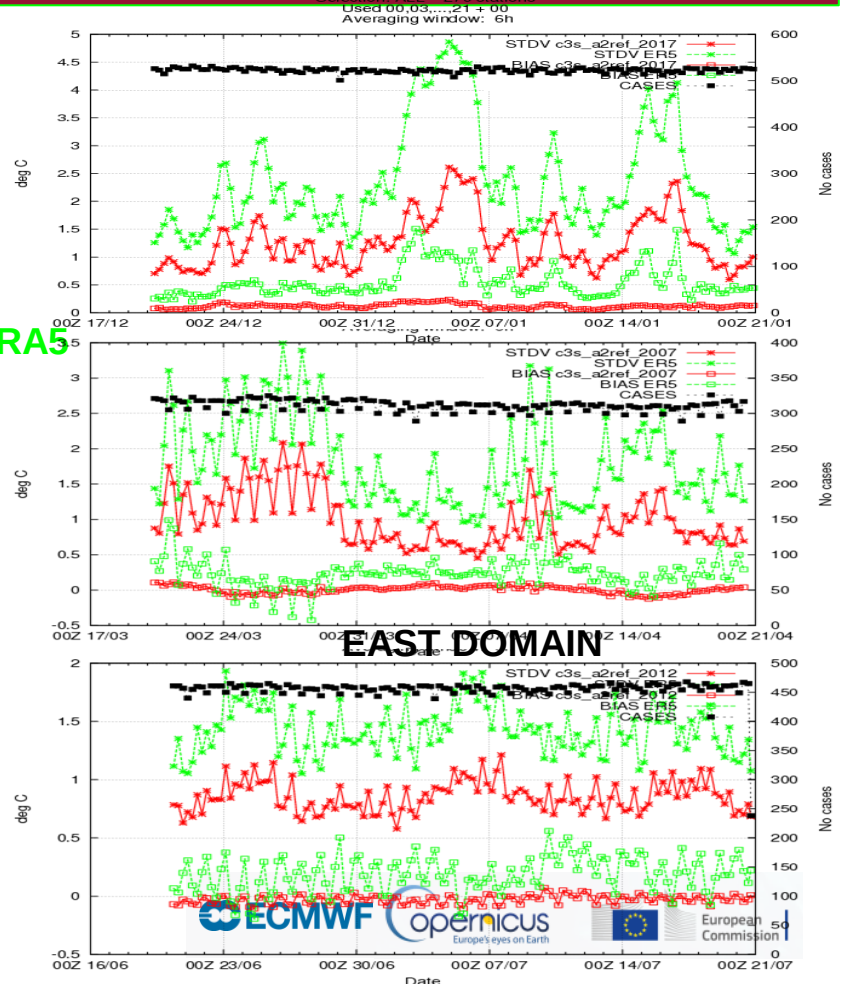
Summer 2012

C3S vs ERA5

WEST DOMAIN

EAST DOMAIN





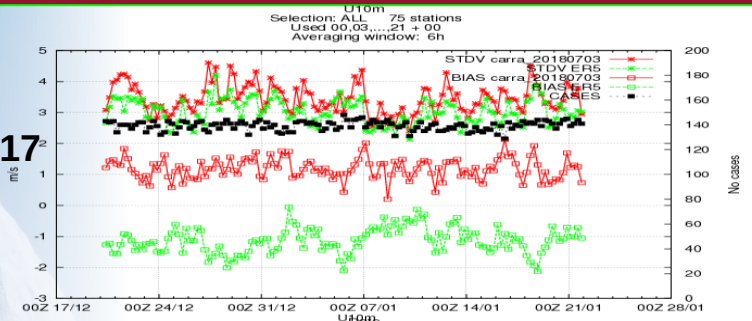
Provisional C3S vs ERA-5, W10m error time series

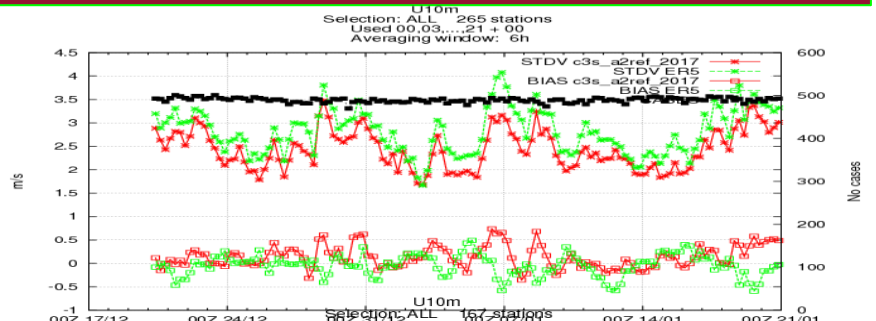
Climate Change

Winter 2017

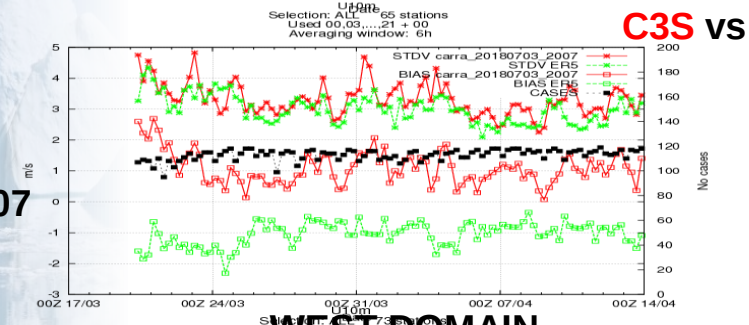
Spring 2007

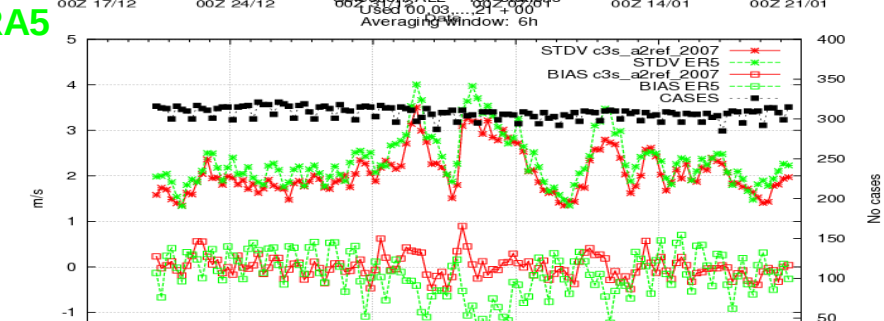
Summer 2012





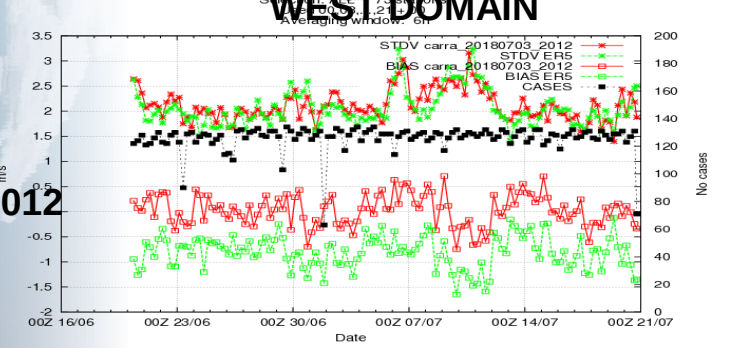
C3S vs ERA5

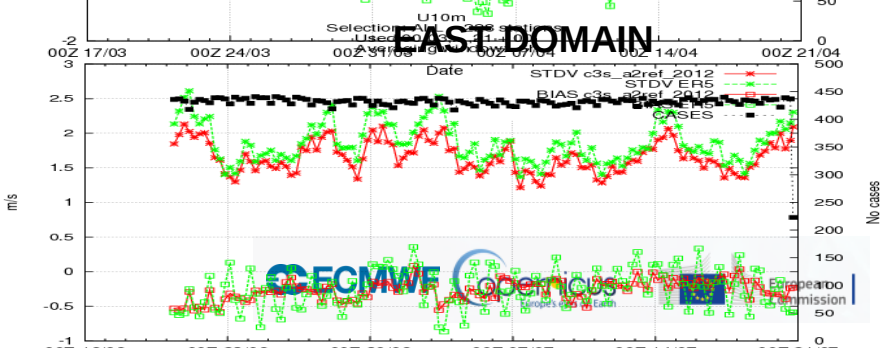




WEST DOMAIN

EAST DOMAIN





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Provisional C3S vs ERA-5, Td2m error time series

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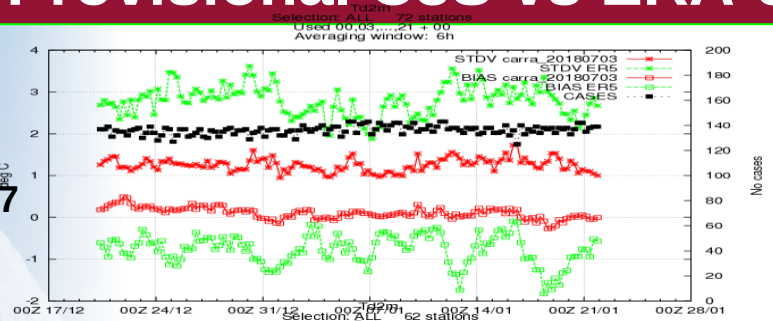
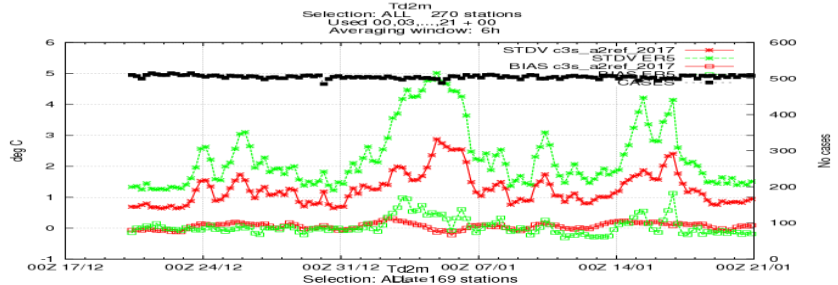
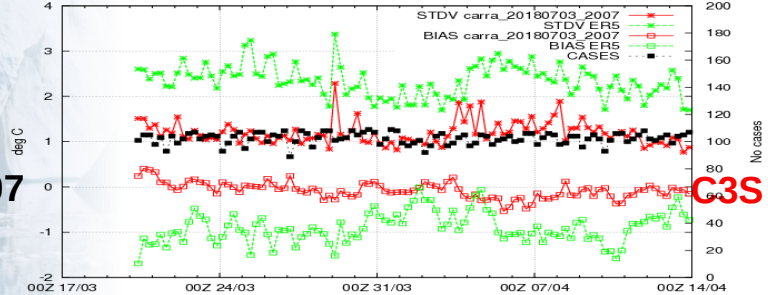
Winter 2017

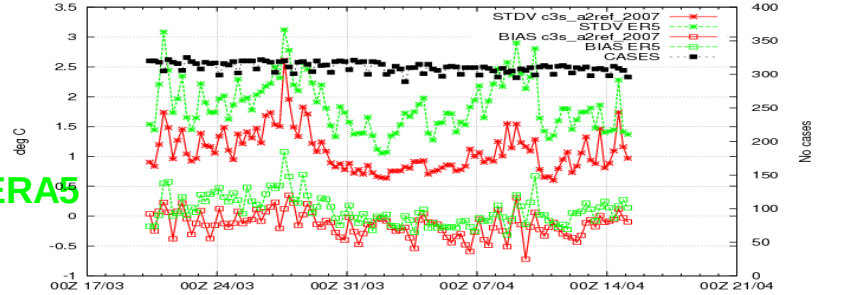
Spring 2007

Summer 2012





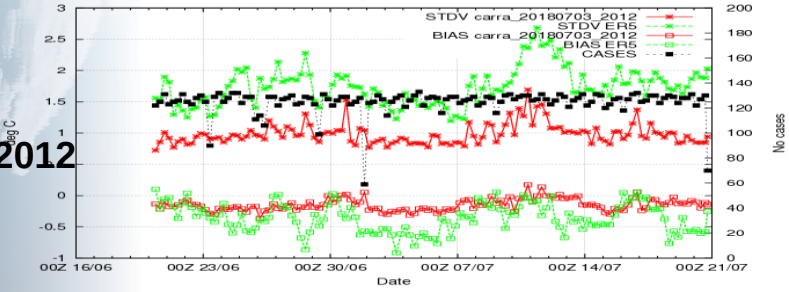


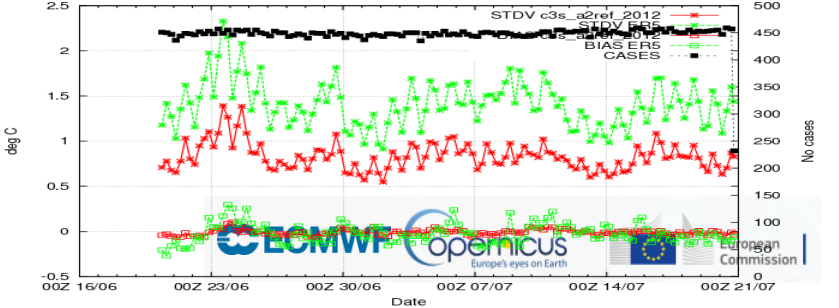


C3S vs ERA5

WEST DOMAIN

EAST DOMAIN





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