Copernicus Arctic Regional Reanalysis

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on behalf of C3S D322 Lot 2 team:

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Outlines

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

EMS 2018, Budapest
Why high resolution? It is crucial for surface quantities

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
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
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
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)

Figures by Bolli Palmason (IMO)
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)
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)
Enhanced surface observation data

ERA-5 (GTS) (2008-)

(Bjarne Amstrup et al)
Assimilation of Cryoclim satellite snow (5 km)

Selection: ALL 14 stations
Used 00,12 + 03 06 09 12 15 18 21 24
Averaging window: 6h

CryoClim gives improvements in the melting season

Summer 2015
Svalbard

(Mariken Homleid)
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
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
Provisional C3S vs ERA-5, East domain

Scatterplot for 264 stations Selection: ALL
Period: 2016/2019
U10m (m/s)
Used 00,03,...,21 + 00

C3S

ERA-5

Scatterplot for 279 stations Selection: ALL
T2m, height adjusted [deg C]
Period: 2016/2019
Used 00,03,...,21 + 00

Wind

T2m
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
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)
Provisional C3S vs ERA-5, T2m error time series
Provisional C3S vs ERA-5, W10m error time series

Winter 2017

Spring 2007

Summer 2012

West Domain

East Domain

C3S vs ERA5
Provisional C3S vs ERA-5, Td2m error time series

Winter 2017

Spring 2007

Summer 2012

WEST DOMAIN

EAST DOMAIN