Copernicus Arctic Regional Reanalysis

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on behalf of the DMI, IMO and C3S D322 Lot 2 teams:

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Why perform an Arctic regional reanalysis?
Why high resolution? It is crucial to represent critical processes.

Surface wind verification for Greenland, Dec 2016 - Feb 2017
C3S - Copernicus Arctic Regional Reanalysis

Official 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
Climate Change CARRA – goals of this meeting
System Configuration

- System: based on the operational Harmonie-AROME 40h1.1.1 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 April 2019
  - 3x 9-yr time slicings
  - Data will be available via Copernicus CDS by 2021
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
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)
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 other sources.

(Bolli Palmason, Teresa Valkonen Matti Horttonainen, Ekaterina Khoreva)
Assimilation of Cryoclim satellite snow (5 km)

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
Climate Change

**Satellite data**

**Daily albedo grids**

- MODIS-Terra
- 2000-present
- denoised
- gap-filled
- validated 0.05 RMSE

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

(Figures by Bolli Palmason (IMO))

(P. Samuelsson, B. Palmason & K. P. Nielsen)
Assimilation of the daily gap-filled GEUS MOD10A1 C6 snow and glacier albedo dataset as provided by Box & Mankoff.
The effect of multiple reflections underneath clouds

Simulations for a cloud with 100 g/m² cloud water load and 10 µm effective radius.

From (Nielsen, Gleeson & Rontu 2014; GMD)
Atmospheric effects of albedo changes

When the surface physical parameters are changed, this changes the atmospheric state as well.

This shows the importance of coupled modelling!
Impact of satellite-derived albedos
Impact of satellite-derived albedos
Impact of satellite-derived albedos
Comparison with ERA-5

Statistics for 16 PROMICE stations
MOD init experiment $D_{10m}$ [deg.] 2012-07-01 12+3 UTC

MOD init experiment $T_{surf.}$ [K] 2012-07-12 00+01 UTC
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