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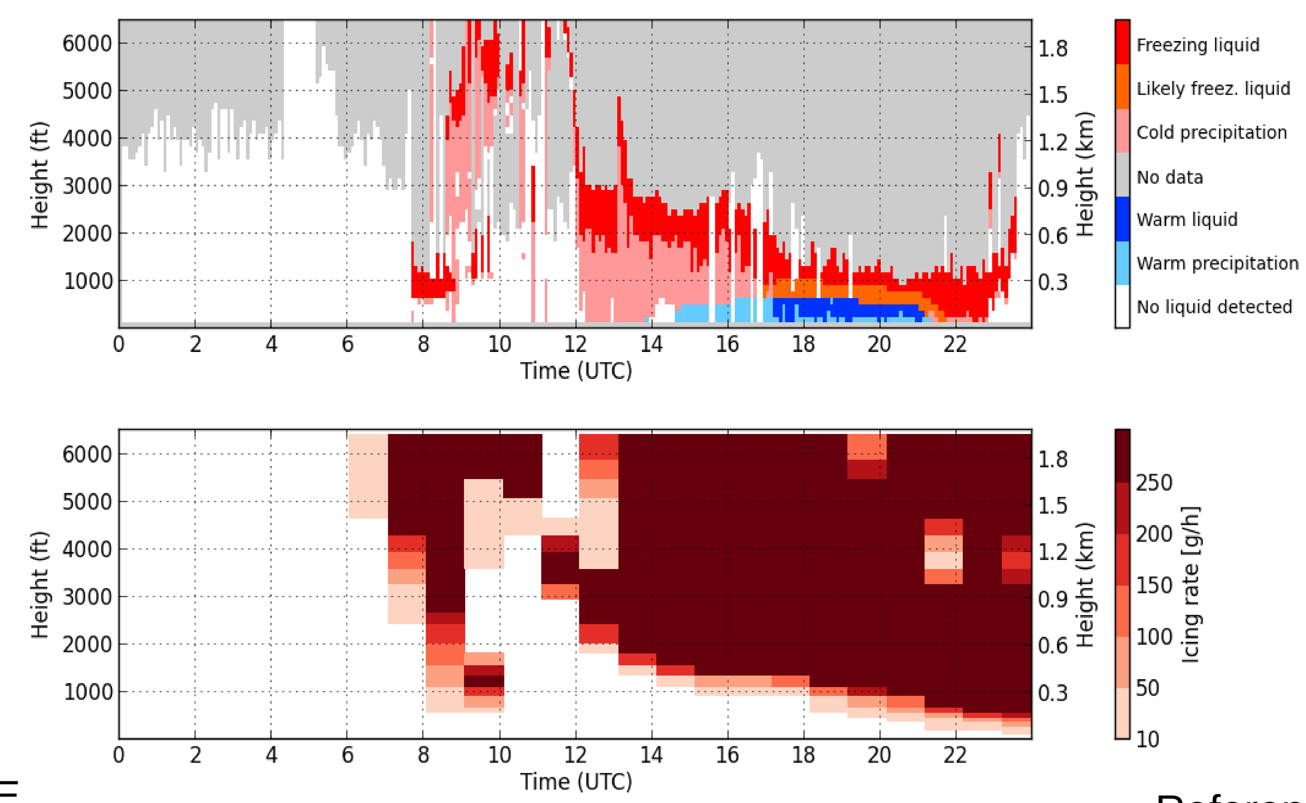
Evaluating atmospheric icing forecasts with ground-based ceilometer profiles

Background

- Atmospheric icing on wind turbine blades causes financial loss for the energy producers, when the accumulated ice reduces the aerodynamic properties of the wind turbine blades
- Important to know when and where atmospheric icing may occur
- New type of ground-based ceilometer observations enabling more detailed verification of icing forecasts
- The atmospheric icing model by FMI has been operational since 2017

Methods

- Post processing icing intensity from hourly HARMONIE AROME output : Temperature, wind, liquid water content (LWC)
- Ceilometer profiles from 6 Finnish stations combined with GDAS temperature profiles, to identify in-cloud icing conditions



Observed ceilometer icing classification profile (top panel) and the corresponding modelled icing profile forecast (lower panel) as a function of time

Main results

- Better vertical and geographical resolution of observations compared to mast measurements
- Model chain has good skill in predicting clear sky situations
- The icing model has a tendency to predict in-cloud icing at higher altitudes than observed; depends on NWP-model used for input
- The in-cloud icing is predicted more accurately for inland areas compared to coastal areas

Reference

Hämäläinen, K., Hirsikko, A., Komppula, M., Leskinen, A., O'Connor, E., Niemelä, S. (2020) : Evaluating Atmospheric Icing Forecasts with Ground-based Ceilometer Profiles, submitted to Meteorological Applications

Snow cover analysis over the Arctic

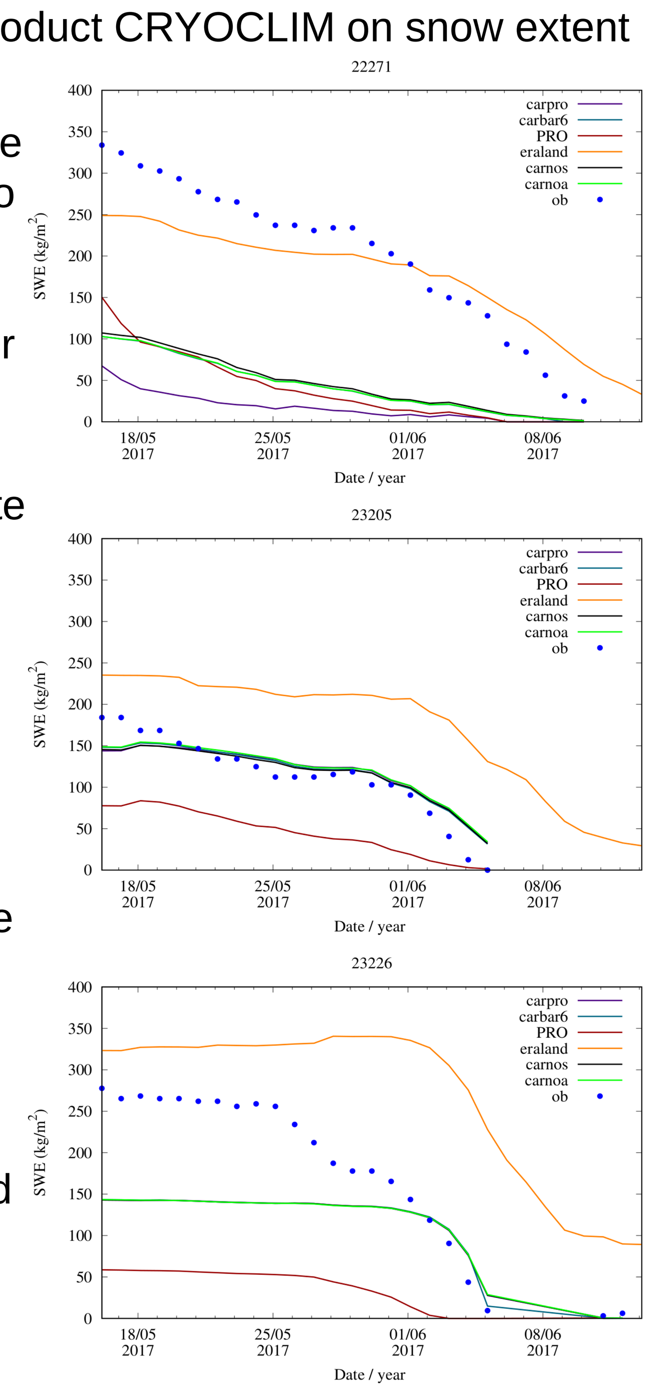
Evolution of snow cover in the Arctic is an important indicator of climate change. Copernicus Arctic Regional Reanalysis (CARRA) aims at improved description of snow cover and estimate of its uncertainties by using fine-resolution (2.5 km) HARMONIE-AROME simulations. Additional local snow observations and a retrospective satellite product CRYOCLIM on snow extent (SE) are included.

Snow data assimilation experiments over the CARRA Eastern domain were run in order to study the sensitivity of the snow analysis to satellite SE data. Four HARMONIE data-assimilation experiments were performed for March-June 2017:

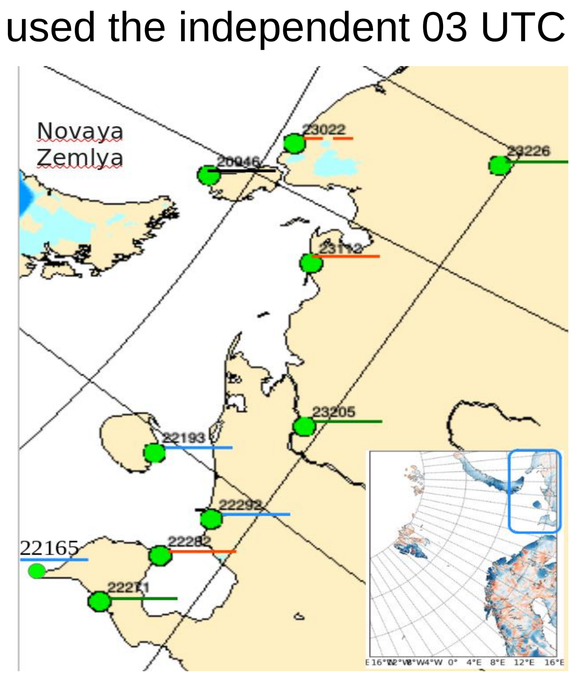
1. **carpro**, using CRYOCLIM satellite SE
2. **carbar6**, using EUMETSAT HSAF satellite SE
3. **carnos**, using the SYNOP snow depth only
4. **carnoa**, with no snow analysis

CARRA production data (**PRO**) and ERA5-Land reanalysis data (**eraland**) were included for comparison. **PRO** and **eraland** represent continuous data assimilation while the snow cover of the four experiments was initialized on 1 April based on ERA5 data.

The method to assimilate satellite SE data assumes correction of the snow depth (SD) background field only when SD < 10 cm and the presence/absence of snow in the background field and in the satellite observations are in contradiction.



Simulated snow water equivalent (SWE, kg/m^2) was compared with observations from the SYNOP stations in the Russian Arctic. Due to their eastern location, these stations perform SD observations at 03 UTC. Since in HARMONIE-AROME the snow observations are assimilated only at 06 UTC, these observations are not included. This means that over this part of the domain, the only observational input in CARRA is the satellite SE data. We used the independent 03 UTC SD observations for verification. **PRO** tends to underestimate while **eraland** overestimates the SWE. SWE by the four experiments was smaller and the differences between experiments were minor.



Comparison of the grid-average snow water equivalent (SWE) to local SD from SYNOP is not trivial due to the representativeness error. Most of these stations are coastal, and their location according to the model grid appears to be over water. Thereby, all simulation results could be compared to observations only at 3 of 10 stations.

Cloud ingestion in MetCoOp nowcasting

The MetCoOp HARMONIE-AROME-Nowcasting (MNWC) system produces hourly updated short-range forecast (+9h lead time), with an observation cutoff of 25 minutes and a rapid refresh approach (first-guess from the MEPS control member).

The MSG-NWCSAF cloud information is ingested into MNWC which improves the cloud-cover (see Fig.1) and convection initialization (compared to MEPS), but this also causes spin-up in the precipitation field.

For a 1-month experiment the MNWC with cloud ingestion improved the initial cloud-fraction SEDI-scores in 84% and 74% of the cases (compared to Reference) for cloud-free and cloudy weather conditions, respectively.

In MNWC, the Analysis by Degrees of Freedom for Signal (DFS; Chapnik et al., 2006) shows that satellite observations of brightness-temperature (IASI, AMSU-A/B) and radar reflectivity (RADAR-Z) have the biggest impact on the Absolute DFS (Fig.2). Other observations have relatively small impact in the Absolute DFS, but that is mainly due to fewer measurements.

Planned future work of MNWC includes:

- Further development of MSG-NWCSAF information for cloud initialization
- Assimilation of MODE-S data and radar winds
- Inclusion of public Netatmo observations in the surface assimilation
- Consideration to replace CANARI by GridPP (MET post-processor)
- Evaluation of a very high resolution domain (< 1 km)

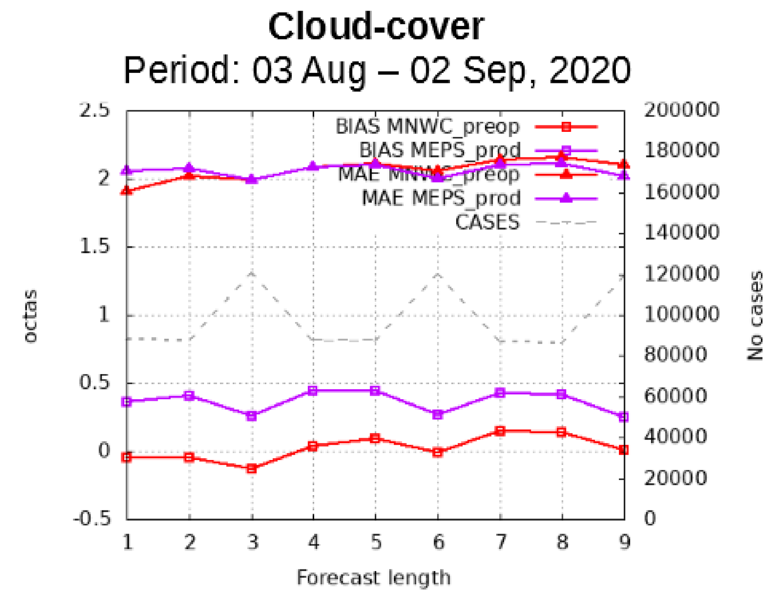


Figure 1

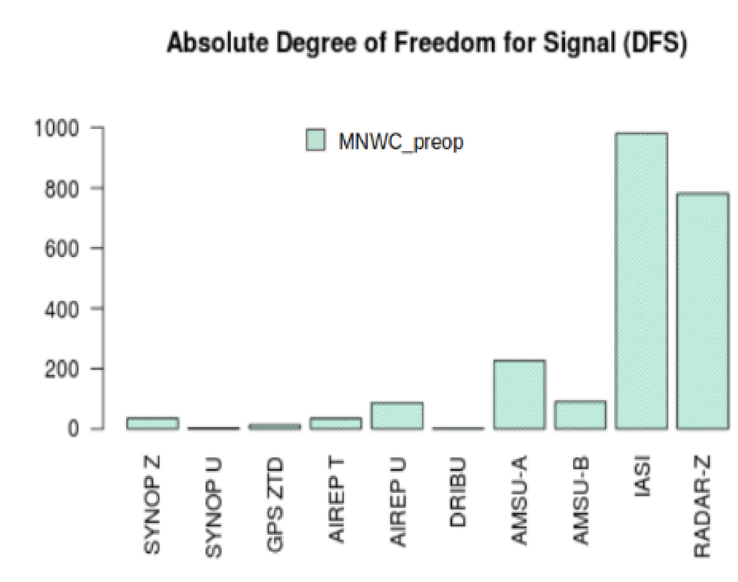


Figure 2

Reference

Chapnik, B., Desroziers, G., Rabier, F., Talagrand, O. (2006) : Diagnosis and tuning of observational error in aquasi-operational data assimilation setting. Q. J. R. Meteorol. Soc. 2006, 132, 543–565.