LATE REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: Norway

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Project Title: Development in HARMONIE model framework - adoption of new observational network (NetAtmo) in data-assimilation

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** _____	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2020	
Would you accept support for 1 year only, if necessary?	YES X	NO ☐

Computer resources required for the years: (To make changes to an existing project please submit an amended version of the original form.)		**2020**	**2021**	**2022**
High Performance Computing Facility	(SBU)	2M	18M	
Accumulated data storage (total archive volume)[2]	(GB)	20’000	50’000	

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project’s activities, etc.

[2] If e.g. you archive x GB in year one and y GB in year two and don’t delete anything you need to request x + y GB for the second project year.

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Extended abstract

This application is about assimilation of private weather station observations into the HARMONIE (HIRLAM ALADIN Research on Mesoscale Operational NWPIn Europe) forecasting system.

Introduction

MET Norway, SMHI (Sweden), FMI (Finland) and CSC (Finland) are presently cooperating on improving our use of observations data in NWP through the project iOBS (Improved Observation Usage in NWP). iOBS is funded 50% by Nordforsk (an organisation under the Nordic Council of Ministers), with the remaining 50% comprising in-kind contributions from the project partners. The results of the project will be utilised by MetCoOp, the operational NWP cooperation between Finland, Norway, Sweden and Estonia.

Project objectives are centered around improved quality control and NWP use of observation data from private weather stations. A major objective is to test private weather station observations in the HARMONIE data assimilation, part of the HARMONIE (HIRLAM ALADIN Research on Mesoscale Operational NWPIn Europe) forecasting system (Bengtsson et al 2017). In order to run these data assimilation experiments, we would like to apply for a special project in addition to spending a portion of the national computing resources of Sweden, Finland and Norway.

Methods and developments

Developments for improvements of convective scale DA that includes utilization of observations is important (Gustafsson et al., 2018). Private weather station networks offer a new source of high spatial resolution of traditional meteorological surface variables (Clark et al., 2018), such as pressure data from Netatmo weather stations (Netatmo SAS, 2018). These observational datasets are of high interest to be used within NWP, see work done by Hintz et. al. (2019a, 2019b), as a complement to the conventional SYNOP observations and especially in data sparse areas. In the iOBS project the research and code development have been progressed to include the Netatmo observations actively in the NWP model runs, in order to validate their potential to improve the analyses and forecasts.

In this study, surface pressure observations from the network of public Netatmo stations are being tested within the HARMONIE data-assimilation (DA). These observations do suffer from several quality issues, where several aspects are to be considered; i) the installation by private persons, i.e. placement in wrong environment, for example indoor or at tall buildings, ii) the adjusted surface pressure to mean sea-level pressure using a standard atmosphere; see Eq. 1) done by the Netatmo

data collectors before dissemination, and iii) the quality of the Netatmo instrument itself. According to Netatmo the conversion to mean sea level pressure is done according to:

$$p_s = p_0 \cdot \left(1 - \frac{\Gamma h}{T_0}\right)^{g\frac{M}{RL}}, \quad (1)$$

where p_s is the surface pressure and p_0 is the mean sea level pressure. Γ is the lapse rate for dry air (≈ 0.0065 K/m). T_0 is a constant standard temperature of 288.15 K and g is the gravitational constant. M is the molar mass of dry air (≈ 0.02897 kg/mol), and R_0 is the universal gas constant and h is the height above sea level of the station.

The first problem i) can be handled by applying different quality controls (QC), for example comparison between neighboring observations and statistical/climatological realistic values. If not suitable, the observation will be removed from the dataset. The second issue ii) is handled by simply converting the pressure back to the station altitude, using the same standard atmosphere together with Eq. 1, and with available topographical information. The effect from this calculation and recalculation as well as from iii) is that systematic errors will be introduced, e.g by the use of a standard atmosphere. Regarding the instrument quality in iii), a temperature dependence or similar can also lead to systematic errors. To be able to correct these systematic observation errors and make the pressure observations useful as input for the HARMONIE model a variational bias correction (VarBC) can be applied (Lindskog et al., 2017). Since this type of citizen observations is a new observation type it needs to be investigated how this VarBC and other error handling should best be made.

Along with the QC handling another important aspect should be considered, i.e. how to thin this very large dataset. Data thinning is applied to ensure that the assumption of no observation error correlations is true in the 3D-Var system. There are several ways that this data reduction can be made, such as super observations, nearest to model grid point or similar. Investigations will be made to find the most suitable method for Netatmo stations and to find the optimal thinning distance to get the most positive impact of data from this high-resolution observational network.

Plan of implementation and configuration of experiments

The application of VarBC for surface pressure from Netatmo stations will be primarily studied based on passive DA experiments and standard VarBC methods. The length of the spinup period needed for the VarBC coefficients, i.e. reach stable, non-variable state of the values, will be investigated by running the Netatmo observations in passive mode. In order to save SBUs, these runs will be made only with short forecasts, enough to provide a new first guess, but still, several runs need to be performed for different periods and to test different methods (described below).

From initial experiments the spin-up seems to need at least one month. Figure 1 shows examples of the VarBC coefficients from two stations; “UIFL2760” and “MyfgE8L5”, both located in the west of Norway in rather complex terrain. The former shows increasing VarBC coefficients with time but after 17 days it starts to reach a more stable level however a few more days would be needed to make sure that it has really reached a stable state. The latter on the other hand (station “MyfgE8L5”) show that the VarBC coefficients have not reached a stable state during this spinup time and would thus need more time to spin up properly.

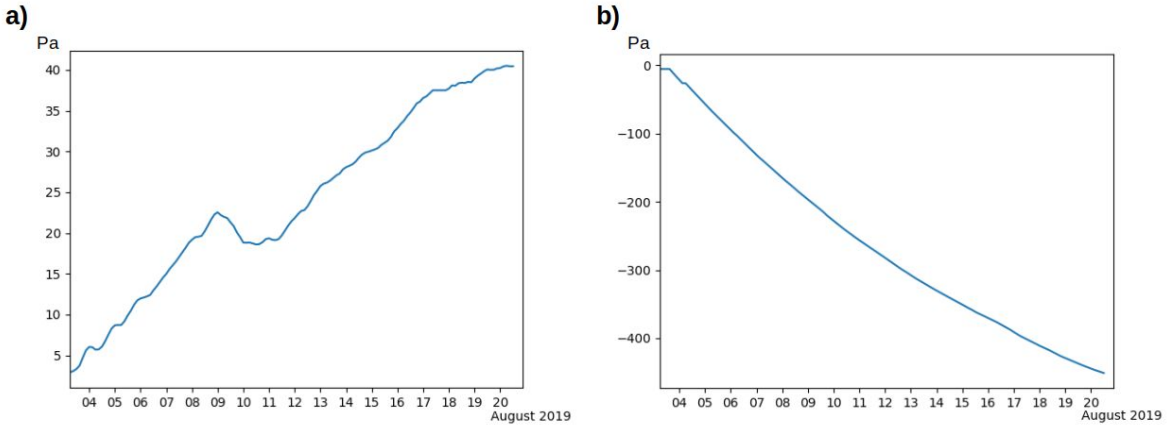

Figure 1. Spin-up of VarBC coefficients for two Netatmo stations; a) "UIFL2760" and b) "MyfgE8L5". The y-axis has unit pressure (Pa) and x-axis is the date of month.

Spinup of the VarBC coefficient with another start value than zero, which is normally used in HARMONIE, will also be tested and compared to the method described above. This "new" method starts from a mean value of the first guess departures and will thereby reduce the spinup time. First results of such experiments, presented in Figure 2, show a remarkable reduction in the spin-up time. Though, the method has not been tested carefully in the HARMONIE system, or for these observations, and needs deeper analyzes and understanding.

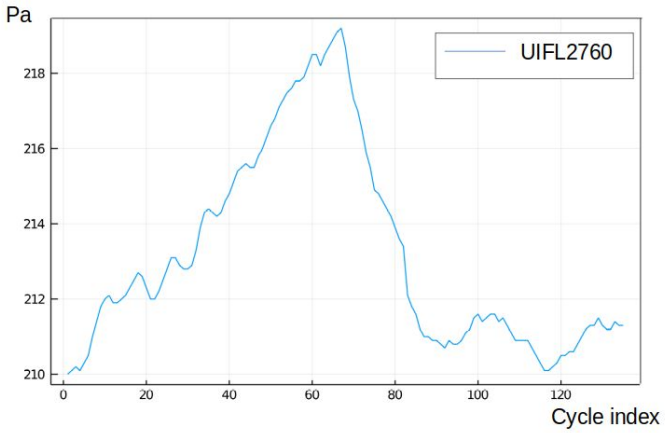

Figure 2. Spin-up of VarBC coefficients (left) for Netatmo station "UIFL2760", using an experimental spin-up method. The y-axis has unit pressure (Pa) and x-axis is the cycle index.

When a suitable VarBC method is found and the VarBC coefficients are stable, the Netatmo surface pressure observations will be run as active in the DA to investigate if they have the potential to improve the analysis and forecasts. This will require several experiments in order to have a robust material to validate. Additionally, we will test different approaches to prepare the observation dataset, including thinning and clustering of data, how to do proper QC on the Netatmo observations and what resolution, i.e. distance between observations, that will be most beneficial for the DA of this new dataset in the HARMONIE model. This will require several monthly validation runs for different experimental setups.

Justification of the computer resources needed

This application covers the period November 2020 to July 2021. Within this project we are using HARMONIE cy43 for the MetCoOp-25D operational domain; 949x1069 grid-points, 65 model levels and 2.5 km resolution. The experiments will be run with as short forecasts as possible, in order to save SBUs.

We estimate that 1 month requires ~1MSBUs and all together we expect the sum to be 20 MSBUs, including following experiments:

- 6 shorter VarBC technical setup experiments (~2 weeks/run), testing of methods = ~3 MSBUs

- 6 experiments with different thinning methods, both shorter and longer runs = ~5 MSBUs

- 4 spinup runs of 1-2 months, cheaper but longer than the experiments = ~4 MSBUs

- 8 longer VarBC development and validation of experiments (~1 month/run) = ~8 MSBUs
The national resources (from Sweden, Finland and Norway) have been used and will be used in addition to this special project. Though, in order to not use all the national resources for this project, we would find it very beneficial to receive specific resources in order to fulfill the required and foreseen experiments needed in the iOBS project.

The accumulated data storage (total archive volume) for the period is estimated to be 50’000 GB.

References

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