



Centre National de Recherches Météorologiques (CNRM)

CNRM/UMR 3589 Météo-France/CNRS

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Assimilation of winds from the space radar mission WIVERN in the global Numerical Weather Prediction model ARPEGE

Subject: 15-month scientist fellowship starting in the 3^d quarter of 2022, at Météo-France, in the Numerical Weather Prediction Research Group of the Centre National de Recherches Météorologiques (CNRM) in Toulouse (<http://www.umr-cnrm.fr/>)

Starting date: September 1st 2022

Context: Numerical Weather Prediction (NWP) models are assimilating many observations of various types on the atmosphere in order to improve their initial state and thereby providing better weather forecasts. Most of the observations used in global models come from satellites providing information on the vertical structure of the atmosphere in terms of temperature and water vapour. Even though wind observations from spaceborne instruments still represent only a tiny fraction of the data actually assimilated in NWP models, recent studies demonstrated the benefits brought by the assimilation of Aeolus winds at Météo-France (Pourret et al. 2021) and at ECMWF (Rennie et al 2020). However, Aeolus wind observations are only available at nadir, and cannot penetrate deeply within the clouds. To fill the gap within the existing observing system, the WIVERN mission (Illingworth et al. 2018) has been proposed in December 2020 in response to the Earth-Explorer 11 call. With its dual polarization Doppler conically scanning W-band radar, WIVERN will provide slant profiles of line-of-sight winds and cloud reflectivities at 41 degree off zenith with an 800 km swath-width.

Main duties and key responsibilities: The successful applicant will study the impact of WIVERN Horizontal Line-Of-Sight (HLOS) wind observations in the global Numerical Weather Prediction (NWP) model ARPEGE of Météo-France. Ensemble of parallel 4D-Var data assimilation will be run to assess the impact of the future spaceborne Doppler W-band radar WIVERN. The current Ensemble Data Assimilation (EDA) system of Météo-France consists of 50 members each one running a simplified four-dimensional variational (4D-Var) data assimilation system at low resolution, from which background and analysis error statistics are derived (Bouyssel et al., 2021). Unlike observing system simulation experiments (OSSEs), that can also assess the impact of new data in an NWP context but need all observing systems to be simulated from a so-called “nature run” (outputs from a model simulation representing the “truth”), the EDA approach only needs new observations to be simulated. The impact of observations is measured by their capacity to reduce the EDA spread at analysis time and also at other forecast lead times.

The work will primarily entail:

- **The generation of simulated WIVERN HLOS winds.** Analyses of the operational NWP ARPEGE model at high resolution (5 to 25 km) will be considered to represent the true state of the atmosphere and to simulate WIVERN HLOS winds. They will be interpolated at the location and time of the derived observations for use in the low resolution EDA system. Then a simple observation operator, to be derived from the one already developed for the assimilation of Aeolus HLOS winds will be considered (Pourret et al., 2021). Different orbital options will be studied.
- **Errors and quality controls for the simulated observations will have to be defined.** Indeed, the spread of an EDA system strongly relies on the use of perturbed observations for each member based on observation error statistics. A number of EDA experiments will be defined with various settings. It is planned to

examine the importance of vertical resolution, low level observations (i.e. sensitivity to ground clutter), different orbital scenarios, and also reflectivity threshold above which measurements will become useless.

- Conduct EDA experiments with the ARPEGE 4D-Var 6-hour cycle NWP system over a few months period with simulated WIVERN HLOS winds on top of a reference observing system (similar to the current operational configuration). Various experiments corresponding to the specifications defined in the previous steps will be undertaken. The reduction of analyses and background errors will be quantified by comparing the ARPEGE analyses and forecasts to EDA results from the reference observing system. The expected results will be a good indicator of the improvements that could be expected from the HLOS winds from the WIVERN mission in an NWP context.

Workplace: The candidate will be assigned to the “OBS” team with the NWP research group (GMAP) of the Centre National de Recherche Météorologique (CNRM-UMR 3589 Météo-France / CNRS, <http://www.umr-cnrm.fr/>). The work will be done at Météo-France, 42, avenue Gaspard Coriolis, 31057 Toulouse Cedex 1 France

Duration : 15 months from September 1st 2022.

Salary: The gross salary will be provided according to Météo-France salary rates and is between 2552 € and 3280 € depending on experience.

Area of expertise: Atmospheric sciences, satellite observations, radar technology, numerical modeling, data assimilation

Qualifications and experience required: Experience in remote sensing and in numerical modeling is required. Theoretical and/or practical knowledge on data assimilation is desirable. Strong skills in a programming language such as Fortran/Python and in the manipulation of large data volumes are necessary. A PhD in one of the areas of expertise would be an advantage.

Personal attributes: The candidate will have to demonstrate scientific curiosity, autonomy, team spirit, responsiveness, analytical skills and rigor in the interpretation of results and their formatting. He/She will have to be able to report his/her activity to the project team. The candidate should also be fluent in English (oral expression and writing). In the context of the project, a number of trips within Europe are planned.

How to apply: Interested candidates should send before 15 May 2022 the following documents by e-mail to Jean-François Mahfouf (jean-francois.mahfouf@meteo.fr), Mary Borderies (mary.borderies@meteo.fr) and Philippe Chambon (philippe.chambon@meteo.fr):

- Curriculum Vitae detailing experience in research and other skills. A list of publications and communications in conferences is mandatory;
- A sample of research publication or communication;
- Application letter explaining research interests and motivation for the job;
- The names and contact details of two referees (recommendation letters shall be appreciated but are not compulsory);

References:

Pourret, V., Savli, M., Mahfouf, J.-F., Raspaud, D., Doerenbecher, A., Bénichou H., and Payan, C., 2021: Operational assimilation of Aeolus winds in the Météo-France global NWP model ARPEGE. *Quart. J. Roy. Meteor. Soc.* (submitted)

Bouyssel, F., Berre, L., Bénichou, H., Chambon, P., Girardot, N., Guidard, V., Loo, C., Mahfouf, J.-F., Moll, P., Payan, C., and Raspaud, D., 2021: The 2020 global operational NWP data assimilation system at Météo-France. *Data assimilation for atmospheric, oceanic and hydrologic applications (Vol. IV)*. Editors: Seon Ki Park and Liang Xu (in press)

Rennie, M., & Isaksen, L. (2020). The NWP impact of Aeolus Level-2B winds at ECMWF. *ECMWF Technical Memoranda*