Assimilation of polarimetric radar observations with the Arome model

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Motivation

Since a few years, some national weather services have begun (or planned) to upgrade their radar networks to dual-polarization capabilities. Dual-polarization observations provide valuable information about hydrometeors. It is thus of great interest to use these data to initialize high-resolution atmospheric models in order to improve their initial states and subsequent forecasts. This case study represents the first attempt to introduce information derived from polarimetric observations in the initial conditions of the Arome model. It is expected that data from polarimetric radars around the Mediterranean will be available during HyMeX SOPs (see green dots in Fig. 1), and that these data will be assimilated in the Arome-WMED model.

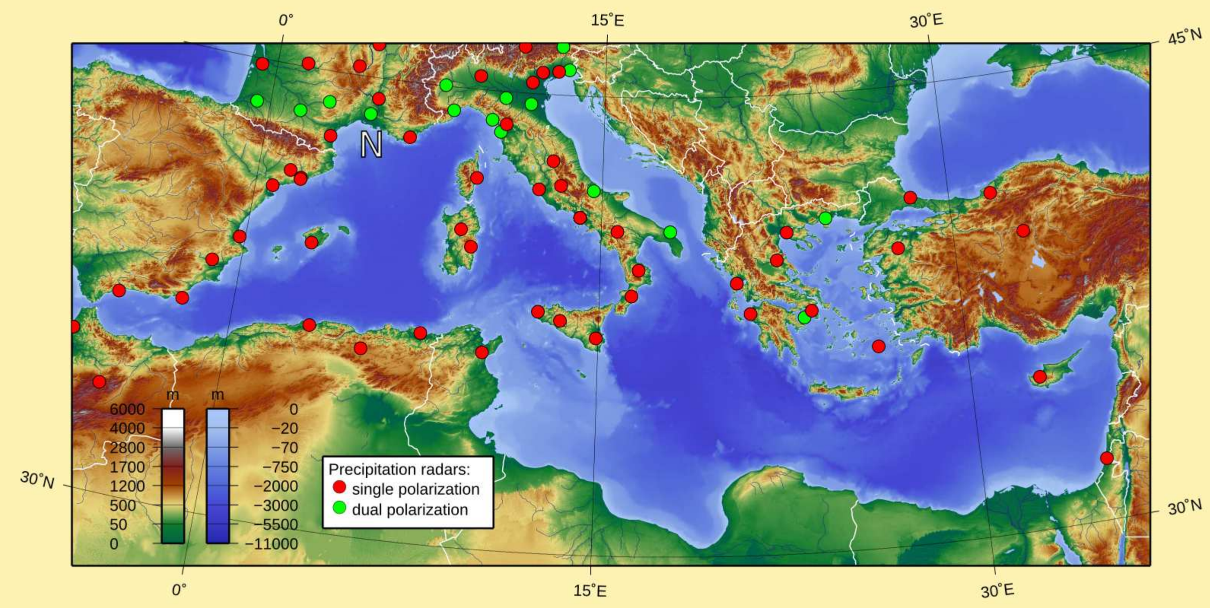


Fig. 1 - Operational radars potentially available during HyMeX SOPs. N denotes the Nîmes radar, the data from which are used in this study.

Chosen meteorological case

The chosen case is that of 21-22 Oct. 2009. On the 21st, deep convection on the Cévennes foothills followed by a cold front that swept through France brought more than 100 mm over the Cévennes foothills.

On the 22nd, deep convection occurred on the French Alps foothills, causing havoc with more than 170 mm at places (Fig. 2).

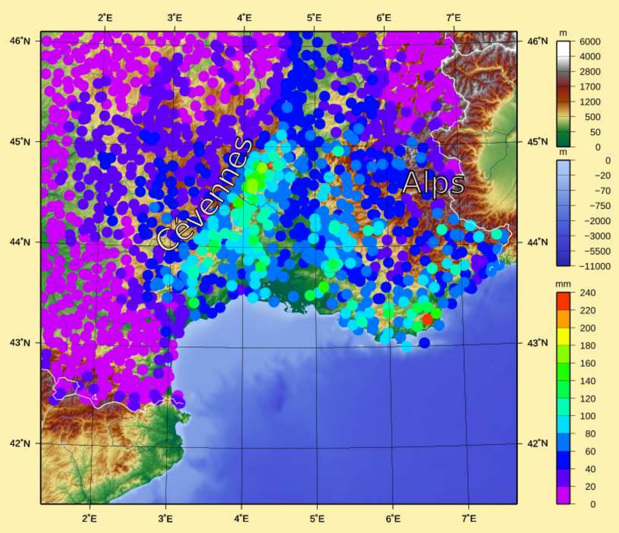


Fig. 2 - Accumulated precipitation from 21 to 22 Oct. 2009 (raingauges).

Observations

Data from the Nîmes S-band radar (N in Fig. 1) are used in this study. Each volume contains 8 different elevations ranging from 0.6 ° to 8 °. Raw dual-polarization polar observations (ZH, ZDR, KDP, and ρHV) are used in a fuzzy logic classification scheme based on the work by Park et al. (2009) to identify predominant hydrometeors in each radar gate. Then, Z-M relationships from the literature are used to derive hydrometeor contents (Fig. 3).

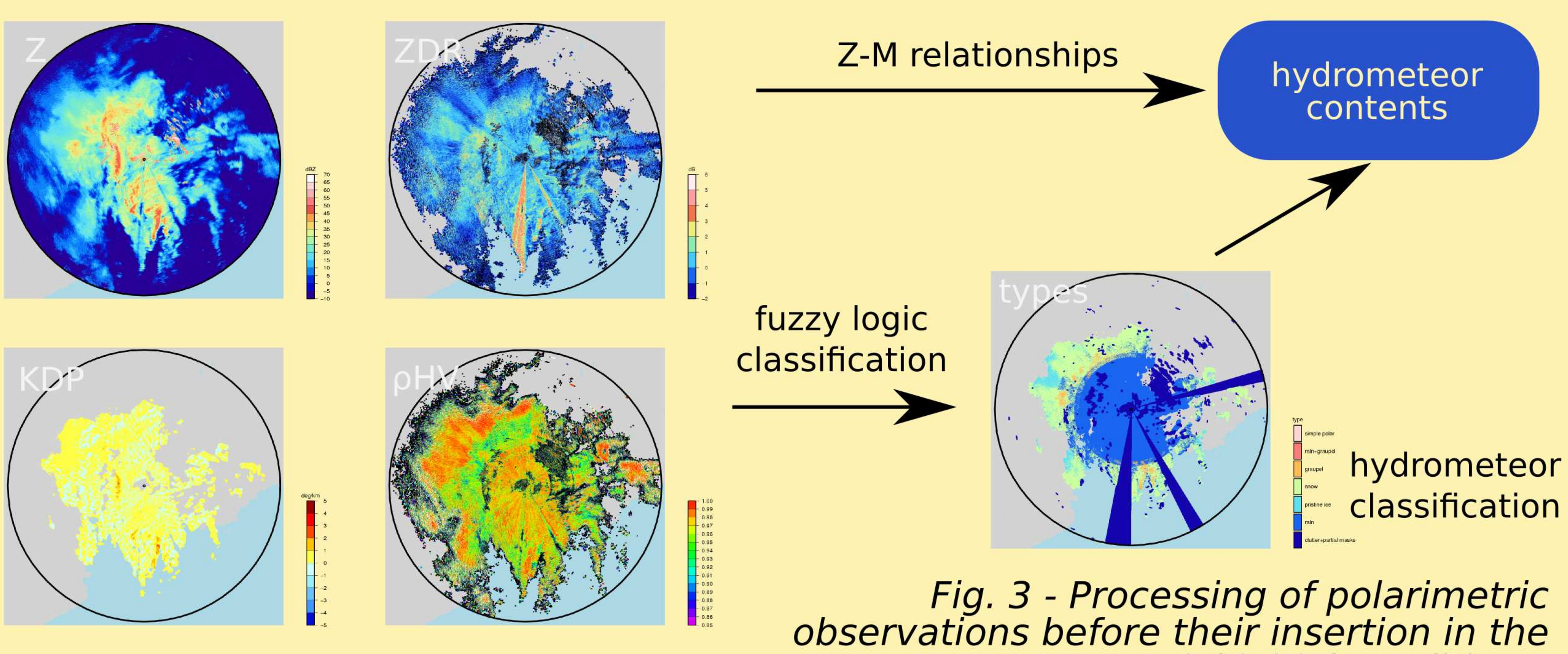


Fig. 3 - Processing of polarimetric observations before their insertion in the model initial conditions.

Model and experimental setup

In this study, the Arome model is used over the France domain (Fig. 4), in a configuration close to the operational version used at Météo-France: 2.5-km horizontal resolution, bulk microphysical scheme with 5 hydrometeor species (cloud water, Rain water, pristine Ice, Snow, and Graupel), direct coupling with the global Arpege model, own 3DVar 3-h assimilation cycle (incl. 1D+3DVar assimilation of reflectivity), etc.

In the CNTRL experiment, hydrometeor contents are not modified during the analysis step. In the POLAR experiment, retrieved hydrometeor contents are inserted in every analysis before the next run. This is simply done through a nearest-neighbour interpolation to the closest model grid point. Both experiments start at 00 UTC on 21 Oct. 2009 from the same analysis and end at 00 UTC on 23 Oct. 2009.

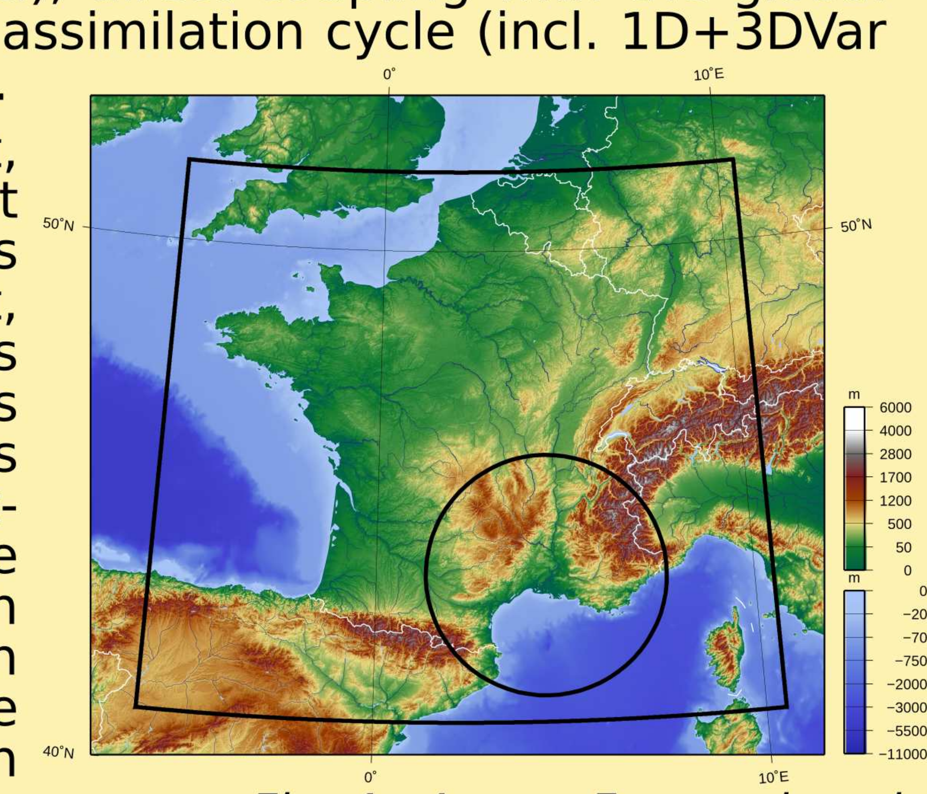


Fig. 4 - Arome-France domain (square) and Nîmes radar maximum range (256-km-radius circle).

Monitoring of observations vs. model

Retrieved hydrometeor contents are compared against their 3-h forecast model counterparts from POLAR (Fig. 5). Observed and forecast rain contents are very close to each other. Significant discrepancies occur for ice species, though. The maximum contents are at lower altitude in the observations than in the model. Also, the vertical profiles of pristine ice are quite different. The underestimation of observed ice species contents in the upper troposphere is caused by the difficulty to identify them at farther gates.

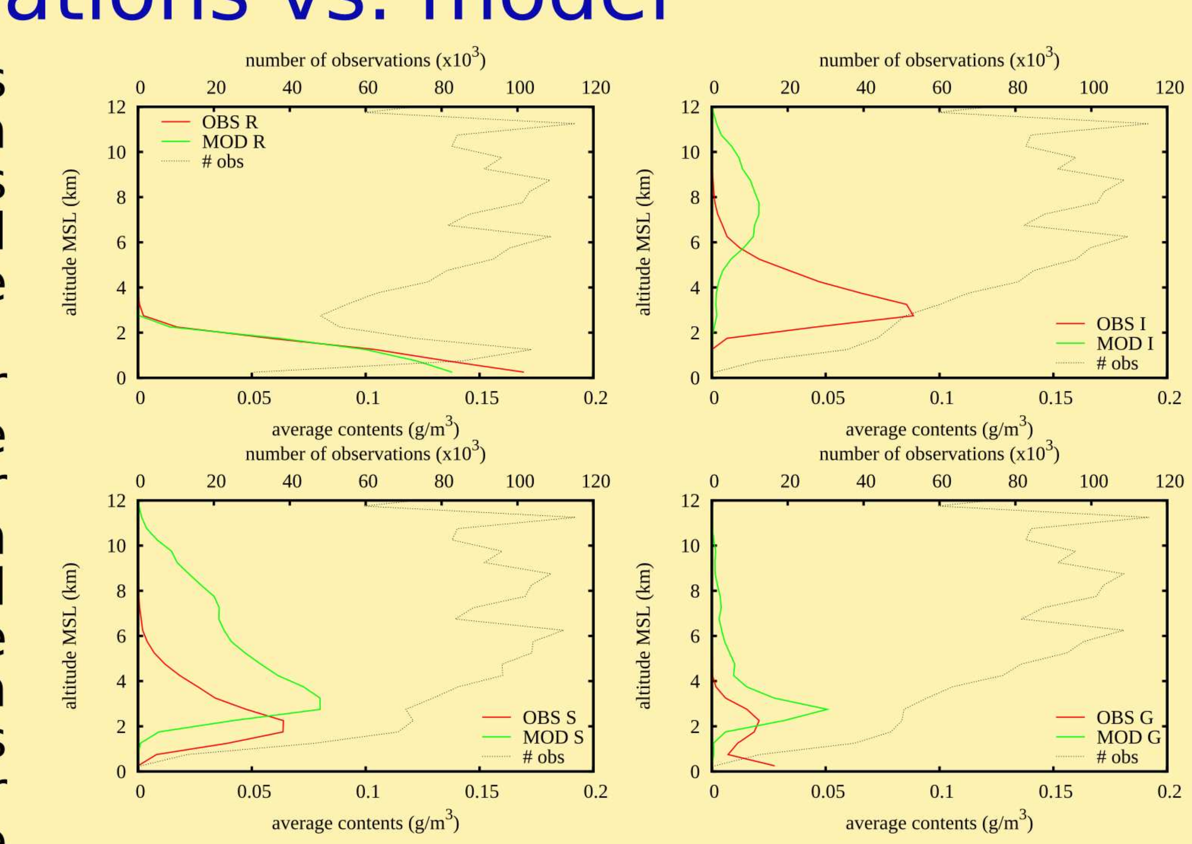
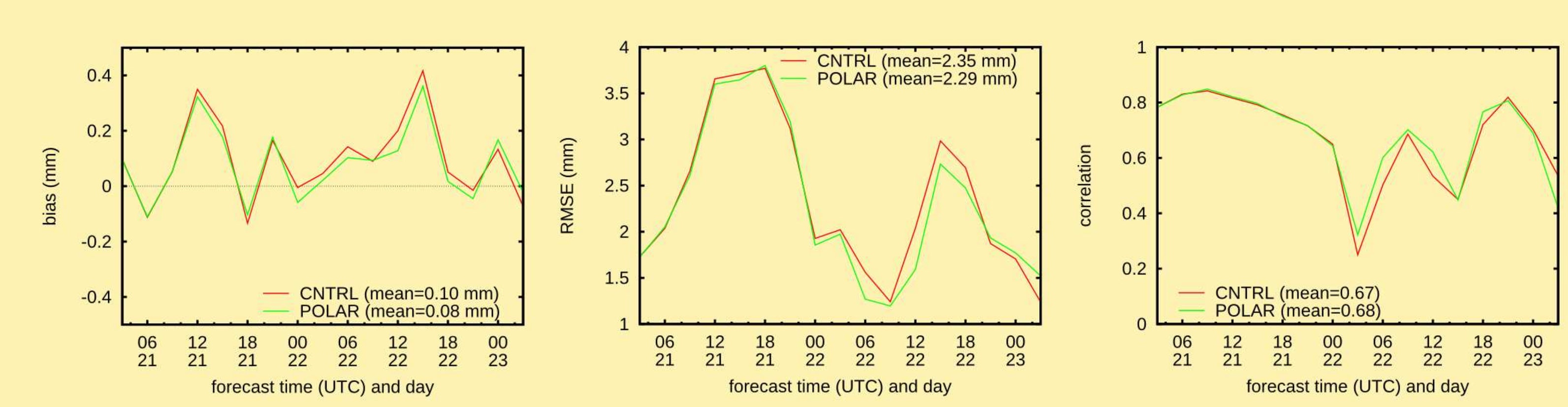


Fig. 5 - Vertical profiles of observed and Arome 3-h forecast hydrometeor contents averaged over the period of interest. The grey, dashed lines denote the numbers of observations used to compute average values.

Impact on precipitation forecasts

Skill scores have been computed for 3-h accumulated precipitation forecasts against raingauge observations (Fig. 6). Small improvements can be noticed in bias, root mean square error (RMSE), and correlation, when polarimetric observations are used. Probability of detection (POD) decreases a bit, especially for high thresholds, though, and hardly any change can be noticed in false alarm ratio (FAR). The lower performance in terms of POD is consistent with the underestimation of ice contents highlighted in the monitoring.



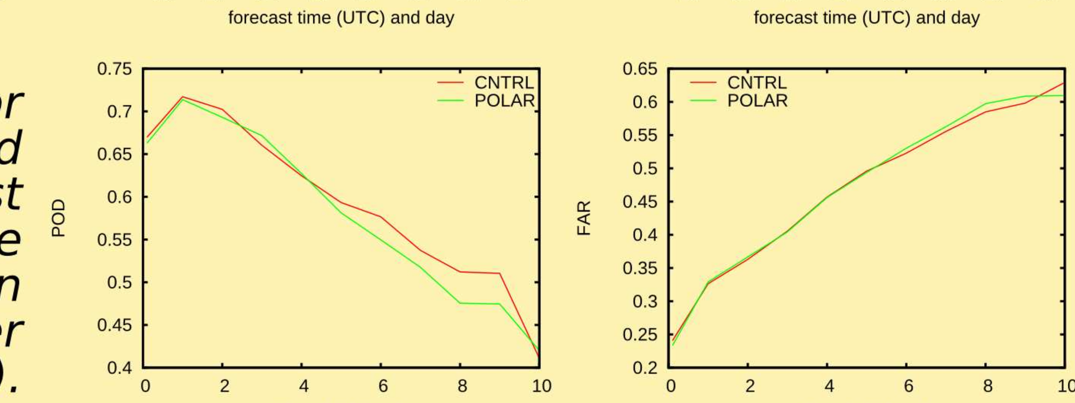


Fig. 6 - Skill scores for 3-h accumulated precipitation against raingauges on the Arome-France domain (data averaged over 0.2 ° x 0.2 °-boxes).

Bibliography

Park, H.-S., A. V. Ryzhkov, D. S. Zrnić, K.-E. Kim, 2009: The hydrometeor classification algorithm for the polarimetric WSR-88D: Description and application to an MCS, Wea. Forecasting, **24**(3), 730-748.

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