AN INTERNATIONAL NETWORK OF GROUND-BASED MICROWAVE RADIOMETERS FOR THE ASSIMILATION OF TEMPERATURE AND HUMIDITY PROFILES INTO NWP MODELS

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ABSTRACT

Temperature and humidity retrievals from an international network of ground-based microwave radiometers (MWR) have been collected and synchronized to exploit the potential for data assimilation into Numerical Weather Prediction (NWP) modeling. This activity is carried on in preparation to the HyMeX Special Observing Period starting in September 2012. The domain under analysis is the HyMeX West Mediterranean (WMed) target area, using data assimilation tools developed for the Météo-France Arome-WMed NWP system. In this paper we introduce the data set and discuss preliminary results.

1. INTRODUCTION

Nowadays, ground-based microwave radiometers (MWR) are robust instruments providing continuous unattended operations and real time accurate atmospheric observations under nearly all-weather conditions [1, 2]. MWR products are used for a variety of applications including, but not limited to, operational meteorology, air quality monitoring, wave propagation studies, as well as site climatology characterization [1-4]. However, the use of MWR data for assimilation into Numerical Weather Prediction (NWP) models has been limited to a few sporadic cases. For example, 4-Dimensional Variational Assimilation (4DVAR) of data from a single ground-based MWR has been attempted for a winter fog event [5]. More recently, an Observing System Simulation Experiment (OSSE) considering a simulated network of some 200 MWR has been carried out for a winter storm case [6, 7]. To our knowledge, the assimilation of data from a real network of ground-based MWR has never been attempted before.

2. DATA SET

The recently established International Network of Ground-based Microwave Radiometers (MWRnet, http://cetemps.aquila.infn.it/mwrnet/) aims at defining the best practice for obtaining good quality MWR observations and retrievals, ultimately increasing the use of MWR data into NWP and other applications.

Table 1: Location, operating institution, height above mean sea level (MSL), and available products (Prod.) for the 13 MWR participating to this study. H and T stand for humidity abd temperature profiles, respectively.

Station	Institution	Lat	Lon	MSL	Prod.
Bern	IAP	46.88	7.46	905	H
Cagliari	INAF/OAC	39.5	9.24	623	T, H
Granada	CEAMA-UGR	37.16	-3.6	683	T, H
Kloten	MeteoSwiss	47.48	8.53	436	T
Lampedusa	ENEA	35.51	12.34	50	T, H
Madrid	UniLeon	40.49	-3.46	620	T, H
Padova	ARPAV	45.4	11.89	30	T
Payerne	MeteoSwiss	46.82	6.95	491	T, H
Potenza	IMAA/CNR	40.6	15.72	760	T, H
Rovigo	ARPAV	45.07	11.78	23	T
Schaffhausen	MeteoSwiss	47.68	6.62	437	T
Schneefernerhaus	UniCologne	47.42	10.98	2650	T, H
Toulouse	ONERA	43.38	1.29	144	T, H

At the same time, in the framework of the Hydrological cycle in the Mediterranean Experiment (HyMeX, http://www.hymex.org/) a Special Observing Period (SOP) is planned for September-October 2012, during which a large set of observations and NWP model simulations will be produced for three target areas in the Mediterranean basin. The target areas are the West Mediterranean (WMed), Adriatic, and South East

Mediterranean. Many activities in different countries have been carried out in preparation to the HyMeX SOP, including the development and test of data assimilation tools for the Météo-France Arome-WMed NWP system. A collaboration between Météo-France and MWRnet started in this context to investigate the potential for assimilating data from a real MWR network into NWP modeling. The observation data set exploited in this study includes temperature and humidity profiles from 13 MWR members of MWRnet from 15 October to 25 November 2011. The domain of Arome-WMed and the location of the MWR stations used here are displayed in Figure 1, while details on location, operating institution, height above mean sea level (MSL), as well as available retrieved products are reported in Table 1. Figure 2 and 3 show the time-height cross section of temperature and humidity profiles observed at two of the 13 sites, representing the extreme boundaries in altitude, these being Lampedusa (35.51 N, 12.34 E, 50 m MSL) in Italy and the Environmental Research Station at the Schneeferner glacier (47.42 N, 10.98 E, 2969 m MSL) in Germany. Information on the vertical resolution and the information content of the retrieved temperature and humidity profiles are given in [4,9].

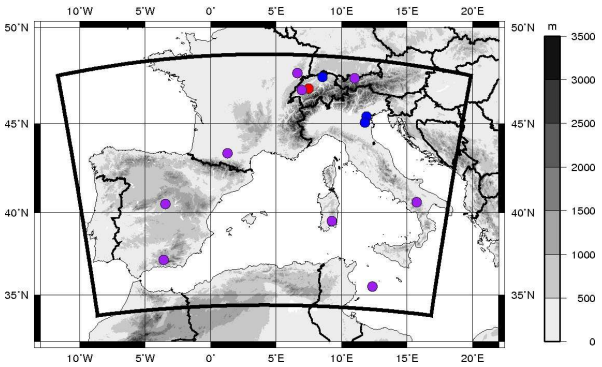

Figure 1. Domain of Arome WMed (black line) and locations of MWR sites (red: humidity only, blue: temperature only, purple: humidity and temperature).

3. NWP MODEL SET UP AND FIRST RESULTS

The NWP system used for this study is Arome-WMed, a particular version of the Arome system [9] covering the western part of the Mediterranean Sea (see Fig. 1). Arome-WMed has a horizontal resolution of 2.5 km, a non-hydrostatic dynamical core, detailed physics inherited from the research Meso-NH model, and is coupled with the global Arpege NWP system. It has a three-dimensional variational (3DVar) data assimilation (DA) system [10] with background covariances specially computed for the WMed domain. 3DVar analyses are performed every three hours and provide new initial states for subsequent forecasts.

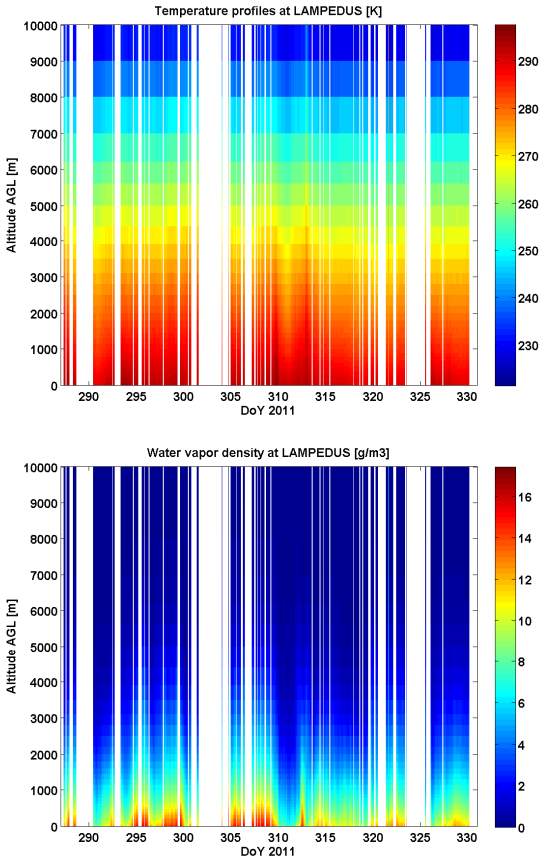

Figure 2. Time series of temperature (top) and water vapor density (bottom) profiles retrieved by the MWR in Lampedusa, Italy, for the period considered for this study. Missing data indicate periods with rain or other obstructions.

Data assimilated by the Arome DA system include observations from radiosondes, wind profilers, aircrafts, ships, buoys, automatic weather stations, satellites, GPS stations, and weather radars. This system has been set up to run in real-time during the first HyMeX SOP of autumn 2012 and guide the deployment of dedicated, mobile observing platforms. In this study, the period from 15 October to 25 November 2011, including several heavy precipitation events in Spain, France, and

Italy, has been simulated with Arome-WMed. As a first step towards the assimilation of MWR products, observation-minus-background (O-B) statistics have been computed for temperature and relative humidity to check the consistency between MWR products and 3-h Arome forecasts. Only profiles closest to analysis times (e.g., 0000 UTC, 0300 UTC, etc.) have been considered here. No attempt has been made to discard dubious data. Examples of bias (mean O-B) and O-B standard deviation are given in Fig. 4 and 5 for the MWR in Lampedusa and Potenza, respectively. For all MWRs, the standard deviations are generally consistent with those of radiosondes, but tend to increase with height. Biases are generally much larger than those found for radiosondes, except for Lampedusa where the temperature bias is particularly small (Fig. 4). Note, however, that these results are preliminary and should be confirmed by further analysis.

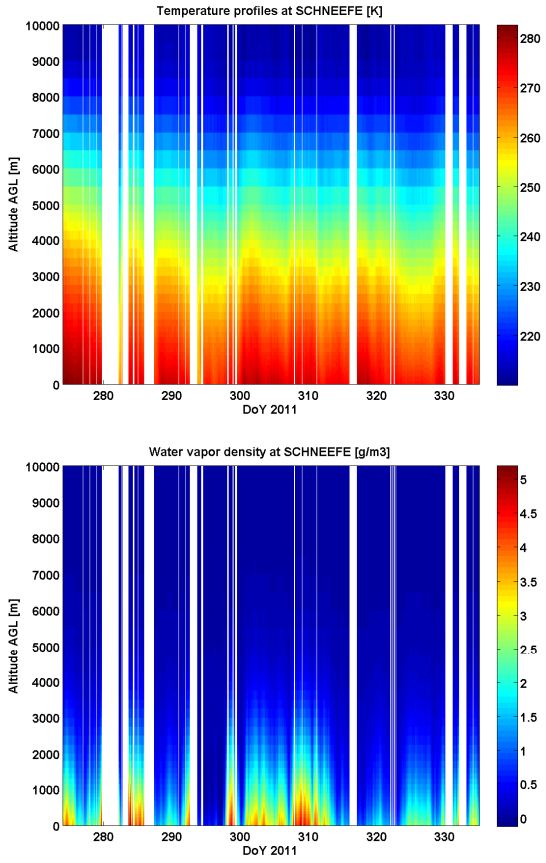

Figure 3. As for Figure 2 but for the MWR at the Environmental Research Station in Schneefernerhaus, Germany, for the period considered for this study.

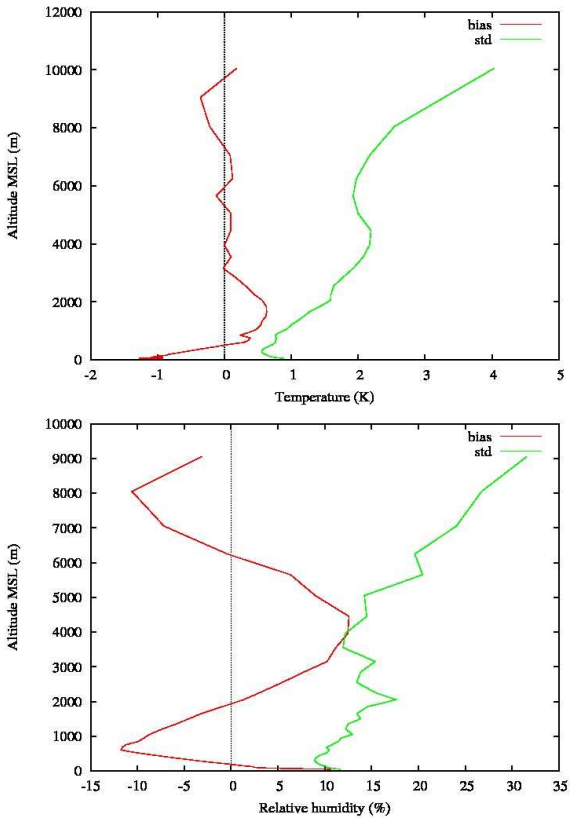

Figure 4. Bias (red) and observation-minus-background standard deviation (green) for temperature (top) and relative humidity (bottom) retrieved by the MWR in Lampedusa.

4. SUMMARY AND OUTLOOK

In this paper we present the recent efforts to demonstrate the potential for assimilating data from ground-based microwave radiometers into a NWP model. Future work includes the investigation of the large biases found in observation-minus-background statistics. After a careful screening of dubious data, MWR observations will be assimilated in Arome-WMed over the same domain and their impact on analyses and forecasts will be evaluated.

5. ACKNOWLEDGMENTS

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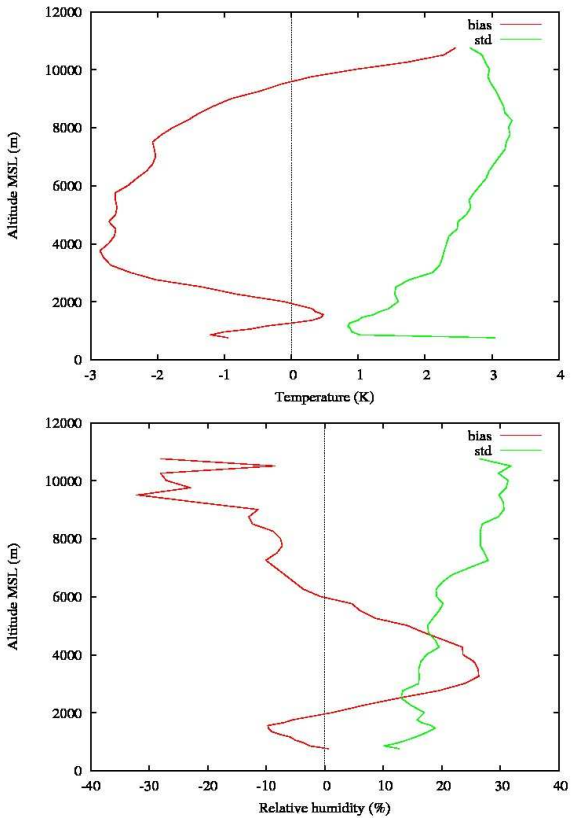

Figure 5. As for Figure 4, but for the MWR in Potenza,

6. REFERENCES

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