# TOPROF WG 3: Microwave radiometers (MWR)



Activities since last MC meeting in Varna (including 2 SWG and 1 STSM)

Nico Cimini, Ulrich Löhnert, Bernhard Pospichal, Harald Czekala, Pauline Martinet, Franciso De Angelis, Umar Saaed, Nils Küchler, Leif-Leonard Kliesch, Olivier Caumont, Alexander Haefele, Henk Klein-Baltink, Francisco Navas and many others



## **Objectives WG3**

**O1) Establish operational procedures** for MWR: protocols for calibration procedures, measurement configuration and maintenance

O2) Implement a network-wide MWR harmonized data processing chain to provide quality-controlled data for first O-B statistics and data assimilation trials

**O3)** Optimize retrievals suitable for network use

- temperature profiles
- humidity profiles
- integrated water vapor and cloud liquid water path
- boundary layer height



#### WG3 Cloud Radar & Radiometer (O1)

A W-band radar-radiometer system for accurate and continuous monitoring of clouds and precipitation Nils Küchler, Stefan Kneifel, and Ulrich Löhnert, Pavlos Kollias, Harald Czekala and Thomas Rose

Early on-line release: *Journal of Atmospheric and Oceanic Technology* https://doi.org/10.1175/JTECH-D-17-0019.1



TOPROF MC/WG, Dublin, Sept. 4, 2017

# SWG WG3 (O2)

#### Status and next steps towards the assimilation of ground-based MWR observations (DWD, 12-14 December, 2016)

#### **Decisions taken**

- 1. MWRnet stations to commit to a daily submission of MWR data
- 2. Operator forum
- 3. New developments on real-time data streaming & monitoring
- 4. Long-term monitoring of MWR data on a daily basis (O-B)
- 5. EUMETNET/E-PROFILE proposal for next phase starting 2019 & maintenance of RTTOV-gb
- Assimilation, definition of business case → activities in cooperation with DWD



# Publication on O-B Statistics (O2)

**MC6A9** Provide level 1 microwave data for 2014 for the following stations: Payerne, Lindenberg, Cabauw, Juelich, Leipzig, & Paris

- Submitted publication on one year of level1 O-B analysis (based on RTTOV-gb)
- DeAngelis et al. Long term Observations minus Background monitoring of ground-based microwave radiometer network. Part 1: Brightness Temperatures
- First reviews positive, second submission under review



## De Angelis et al. 2017 (O2)



Figure 6: Statistics of the differences between TB observations and model background (solid lines), and TB observations and model analysis (dashed lines). Simulated TB are computed with RTTOV-gb respectively from AROME-France 3-hour forecast (solid lines) and AROME-France analyses (dashed lines) profiles in clear-sky conditions for Joyce at zenith. Panels A, and B, refer respectively to 90 and 19.2° elevation angle. Biases are shown with black lines, standard deviations with red lines and RMS with blue lines.



## STSM1 WG3 – Advanced Retrievals (O3)

One-year of 1DVAR retrievals from ground-based microwave radiometers (10-14 April 2017)

> Pauline Martinet 1 (Météo France) visiting Domenico Cimini (IMAA-CNR)

→ Prepare a processing chain flexible to perform 1DVAR retrievals on different sites with different instrumental configurations.



# **Advanced Retrievals (O3)**

#### Software tools developed (DeAngelis / Martinet / Cimini)

- » RTTOV-gb
  - fast FM for ground-based MWR
  - Ingests atmospheric profiles
  - Computes Tb and Jacobiann
- > 1DVAR
  - fast inversion scheme
  - Ingests ground-based MWR obs
  - Computes retrievals of T and H profiles and LWP
- > Net1D
  - network 1DVAR retrievals
  - Ingests ground-based MWR obs from a network (curr. 6 nodes)
  - Computes 1DVAR retrievals consistent throughout the network



## STSM2 WG3 – RTTOV-gb Application (O2)

Coupling the RTTOV-gb with COSMO-DE (reanalysis) (26-30 September, 2016)

Maria Toporov (University of Cologne, Germany) visiting Francesco De Angelis (Cetemps – University of L'Aquila, Italy)

 → Couple RTTOV-gb to COSMO environment for 1.) synergetic retrieval studies
2.) DA assimilation trials in the COSMO KENDA environment (both currently on-going)



### **STSM2 WG3 – RTTOV-gb Performance**



89 COSMO clear-sky cases

Bias (black), standard deviation (red), and RMS (blue) of differences between Tb simulated with RTTOV-gb and LBL model for clear sky conditions and at 90° elevation angle. Left: K-band channels. Right: V-band channels.



### STSM2 WG3 – RTTOV-gb Jacobians



Absolute humidity (left) and temperature (right) Jacobians, calculated with K-module of RTTOV-gb for 14 HATPRO frequencies



# STSM2 WG3 – RTTOV-gb retrieval applications for atmospheric stability





# Als from Varna Meeting (O1)

MC6A5 Software adaptation by manufacturers to characterize uncertainties + drift between calibrations + applied offset; to be included in the data stream End of 2016 Manufacturers of microwave radiometers

Status: on-going software development at RPG (no implementation yet), but adjustments as recommend by WG3 will be included (Czekala)

- regular channel covariance determination (ambient / cold calibration load)
- improved absolute uncertainty characterization
- automatic monitoring of instrument stability for users
- advanced spectral consistency checks for data quality monitoring



# Als from Varna Meeting (O1)

**MC6A6** Each WG to produce a sketch of the data flow (which software and format and software, at various levels (0,1,2, ..)

#### mwr\_pro (MicroWave Radiometer PROcessing)

- version 4 downloadable at<u>ftp://gop.meteo.uni-koeln.de/pub/loehnert/mwr\_data\_flow/</u>
- with basic instructions (including example data)
- Also available: example output files generated by mwr\_pro



#### mwr\_pro data flow



#### mwr\_pro data structure

level2 columns

- vertically integrated products
- mwr\_l2\_prw: pathintegrated water vapor (IWV)
- mwr\_l2\_clwvi: pathintegrated liquid water (LWP)

• brightness temperatures (tb)

level1

- mwr\_l1\_tb: in specified azimuth and elevation directions
- mwrBL\_l1\_tb: boundary layer scans (RPG specific)

#### level2 - profiles

- mwr\_l2\_ta: temperature profiles along specified azimuth and elevation direction
- mwr\_l2\_hum: humidity profiles along specified azimuth and elevation direction
- mwrBL\_l2\_ta: temperature profiles in zenith from boundary layer scans



## Als from Varna Meeting (01, 02)

**MC6A8** WG3 to MC: Request to RPG to discuss the **data structure** from the MWR to ensure it is **compatible with E-profile requirements** 

- discussed at SWG Status and next steps towards the assimilation of ground-based MWR observations (DWD, 12-14 December, 2016); current mwr\_pro data structure as first attempt for first E-profile applications
- RAGNAR-Server (RPG) software implementation planned: make data from a certain site directly accessible to NWS



## **Planned Contents of final report WG3**

- Suggestions to manufacturers for improving hardware and software
  - HATPRO G5
  - Calibration campaign; new calibration load
  - ODIN/RAGNAR software developments at RPG
  - Spectral consistency checks
- MWR Operation procedure suggestion
- RTTOV-gb development
- O-B operational setup
- 1DVAR development NET1D
- ABL classification (U. Saaed / M. Collaud Coen)
- Link to associated projects initiated in TOPROF time
  - ACTRIS CC connection; microwave calibration center
  - EUMETNET/E-PROFILE business case possible
- Check publications & conferences participations (TOPROF)

