TOPROF – Towards Operational Ground-based PROFiling with ceilometers, Doppler lidars and microwave radiometers for improving weather forecasts:

Anthony Illingworth, U of Reading, UK

MC7 – Dublin - 4 September 2017

21 OCT 2013 to 20 Oct 2017: < 2 months left

22 countries in total signed up **15 National Weather Services.**

Vice Chair – Dominique Ruffieux: Grant Holder – Nico Cimini

WG1 – Ceilometers – **Martial Haeffelin + Ina Mattis**
WG2 - Doppler Lidar - **Ewan O'Connor**. + Anne Hirsikko.
WG3- Microwave Radiometers – **Uli Loehnert/Nico Cimini**
WG4 – Data Assimilation - **Roland Potthast + Cristina Charlton-Perez**

ACTIONS FROM MC6 1-3 June 2016, Varna

MC6A1 WG leaders provide relevant text for June 2016 report complete

MC6A2 Coordinate with E-Profile at 26-30 Sept 2016 Madrid meeting. complete

MC6A3 Harmonize TOPROF and ACTRIS definitions and recommendations for MH retrievals
questionnaire being circulated – review paper planned

MC6A4 Put a document together showing how different measurements techniques can be used to assess mixing layer parameters - completed (swg)

MC6A5 MWR manufacturers to characterize uncertainties + drift between calibrations + applied offset to be included in the data stream in progress by RPG

MC6A6 Each WG to produce a sketch of the data flow complete

MC6A7 Examples of researcher(s) from a non-ITC researcher that has benefited an ITC researcher. closed

MC6A8 WG3 to RPG to discuss data structure and compatibility with e-profile complete

ACTIONS FROM MC6 1-3 June 2016, Varna (cont)

MC6A9 Provide level 1 MWR data for 2014 for: Payerne, Lindenberg, Cabauw, Juelich, Leipzig, & Paris WG leaders provide relevant text for June 2016 report complete

MC6A10 WG leaders to provide a list of participants (ITC and non ITC) + locations of future SWGs + STSMs complete

MC6A11 Final 2017 MC meeting/workshop timing and location to be approved by MC via email when the financial Harmonize situation following this meeting is known complete

ACTIVITIES SINCE VARNA MEETING (June 2016)

5 SWGs SPECIAL WORKING GROUP MEETINGS **Since Varna**

6 STSMs SHORT TERM SCIENTIFIC MISSIONS **since Varna**

Reports on these SWGs and STSMs this morning.

FUNDING REMAINS FOR several SWGs and STSMs – but must hurry.

28 attended successful TOPROF User Workshop yesterday

1. Data from 89 ceilometers (15 institutions/12 countries) now being delivered in real time by E-PROFILE. Should be 250 by the end of the year. (Maxime Hervo). 2018 – Doppler Wind Lidar data should start to flow. 2019 proposal to add MWRs
   (Toprof decision: Ceilometers to point 3deg north off-zenith?)
2. Many, many new parameters derived from Doppler Wind Lidars.
3. MWR, O-B stats unbiased & Gaussian, 1D-Var increments derived.

4. **COST will fund 'TOPROF' paper in BAMS - abstract accepted.**
5. **Follow – on mission 'PROBE' to be submitted by Friday 8 Sep.**

TOPROF OBJECTIVES

The main objective of the Action is to co-ordinate the operation of the many ceilometers, Doppler lidars and microwave radiometers installed across Europe, so they can be networked and provide quality controlled observations to National Meteorological and Hydrological Services (NMHSs) in near real time.

SECONDARY OBJECTIVES **WG1 Automatic Lidars and Ceilometers.**

1. To implement a harmonized ceilometer network reporting quality-controlled calibrated attenuated backscatter profiles of aerosols and clouds in near real time across Europe.

2.To evaluate the backscatter profiles predicted by the prognostic aerosol schemes within the next generation of European forecast models for forecasting air quality as exemplified by the EU-FP7 MACC model at European Centre for Medium-Range Weather Forecasts (ECMWF).

3. To set up a system to monitor the spatial distribution, height and density of aerosol plumes (e.g. volcanic ash, mineral dust, biomass burning, or industrial accidents) over Europe, which are key information for air traffic safety, and to monitor the depth through which surface emitted species are mixed or trapped over Europe, a key factor for pollutant concentration predictions.

WG2 DOPPLER LIDARS

4.To establish the operational procedures for the new Doppler lidars by defining suitable scan strategies which combine zenith viewing operation to sense vertical wind structure and turbulence with azimuth scanning operation to provide accurate and representative high resolution profiles of horizontal winds.

5. To investigate the ability of the Doppler lidars to identify the various boundary layer states, such as, stable, unstable, coupled and decoupled, so that boundary layer classification and parameterization schemes implicit in NWP models can be evaluated.

WG3 MWR – Microwave Radiometers

6. To establish the operational procedures for the microwave radiometers by defining protocols for calibration procedures, scanning strategies, and maintenance.

7. To foster the utilization of disparate microwave radiometer observations by implementing a harmonized microwave radiometer data processing chain to provide quality-controlled calibrated multiple frequency radiances (for direct data assimilation into forecast models) and accurate profiles of temperature and humidity as well as cloud liquid water path in a near real time monitoring network.

8.To investigate optimized means of using downwelling radiance observed with the microwave radiometer network to derive profiles of temperature with highest accuracy in the boundary layer, lower resolution humidity profiles and the integrated water vapour and cloud liquid water path in the observed column.

WG4 Data Assimilation

9. To collaborate with researchers running NWP models in NMHSs to ensure that the quality controlled data from the remote sensing networks of ceilometers, Doppler lidars and microwave radiometers meets their requirements.

10. To discuss with climate modellers their precise requirements for long term data sets acquired by these ground based networks and their use in evaluating the parameterisation schemes in climate models run in forecast mode. If the climate models are based on sound physical principles rather than empirically tuned parameterization schemes, then there will be greater confidence in their ability to predict climate change.

FOUR DELIVERABLES

The specific deliverables of the Action will be:

i) Standardised techniques for calibrating, maintaining and operating ceilometers, Doppler lidars, microwave radiometers so that the products derived from them are quality controlled and accompanied by quantified errors.

ii) Standardised formats and data protocols, so that observations can be exchanged in near real time between the various NMHSs across Europe.

iii) Standardised retrieval algorithms for ceilometers, Doppler lidars and MWRs so that key atmospheric properties (clouds, humidity, temperature, aerosol, and winds) can be derived together with their errors.

iv) Forward models and metrics for model evaluation.

FINAL REPORT – due end of November.

This is an evolution of the PROGRESS REPORT produced each year. FINAL REPORT an evolution of Nov '16 report.

FROM EACH WG NEED:

a) 60 words for the executive summary (total 500 words).
b) Are we meeting each objective –at least one hyperlink per objective
c) Meeting deliverables (four)
d) Achievements
e) Any FP7/H2020 spin off proposals or actions started
f) Publications – with hyperlink – four last year.
g) Networking (so far E-profile, national weather services)
h) Impacts
i) Exploitation
j) Dissemination

a) 60 words for the executive summary for each WG

WG3: Microwave radiometers provide temperature and humidity profiles together with column integrated water vapour and liquid cloud water. Two calibration campaigns have been completed; recommendations for common calibration and uncertainty characterization among different instruments of the network have been drafted and distributed. A common data been established, so that the observations ('O') can be compare with NWP model background ('B') in order to create pseudo-operational 'O-B' statistics.

b) For each objectives - with links to paper, report etc

MoU objective	Achieved Yes/ Partially/ No	Evidence of (partial) achievement including hyperlink to enable assessment of the achievement[1]. Justification if full achievement is not foreseen
1 To implement a harmonized ceilometer network reporting quality-controlled calibrated attenuated backscatter profiles of aerosols and clouds in near real time across Europe	Partially	Four Tasks are carried out within Work Group 1 to reach these objectives: 1. A new version of the RAW2L1 (python language) converting tool to put all ALC data in a common data format has been developed (available since autumn 2015) and delivered to E-PROFILE. The RAW2L1 can be accessed from the French Renater research forge https://sourcesup.renater.fr/projects/sirta-raw2l1/ 2. WG1 developed ALC calibration software and recommend specific calibration techniques dependent on ALC detection technology (Rayleigh calibration technique for photon-counting detection and cloud calibration technique for analog detection). Software delivered to E-PROFILE. Implementation at E-PROFILE Hub on-going (at UK MetOffice). http://www.toprof.imaa.cnr.it/index.php/short-term-scientific-mission/8-1-short-term-scientific-mission

c) Deliverables (there are four)

MoU deliverable	Level of progress[1]	Evidence of (partial) delivery achievement including hyperlink to enable assessment of the delivery[1]. Justification if full achievement is not foreseen
1Standardised techniques for calibrating, maintaining and operating ceilometers, Doppler lidars, microwave radiometers so that the products derived from them are quality controlled and accompanied by quantified errors.	Partial	A document providing recommendation for ALC configuration, operation, and calibration is under development. An operational procedures document describing instrument siting, calibrating and scan selection, together with uncertainty quantification is in progress. A document summarizing the best practises to calibrate and operate microwave radiometers is the output of SWG3.1. The document will soon be available through the action website,

d) Additional outputs and achievements

Additional outputs and achievements

Please describe any other outputs and achievements that have resulted or are in progress, focusing in particular on those that contribute to the COST mission of "COST enables break-through scientific developments leading to new concepts and products and thereby contributes to strengthen Europe's research and innovation capacities."

1. The four European manufacturers of ALCs are member of the action, as are the two manufacturers of Doppler Wind Lidars, and the only European Manufacturer of Microwave Radiometers. This is a field where European manufacturers are currently dominating the market.

2. TOPROF activities have led to a modification of ALC firmware by European manufacturer to enable qualitative exploitation of attenuated backscatter profiles provided by the instruments.

3. TOPROF activities have led to a significant adaptation of the common microwave radiometer liquid nitrogen calibration methods as well as modification of microwave radiometer firmware and software of the leading European manufacturer.

4. TOPROF activities have shown that Doppler wind lidars can provide wind gust estimates.

e) Publications

11	Haeffelin, M., Laffineur, Q., Bravo-Aranda, J.-A., Drouin, M.-A., Casquero-Vera, J.-A., Dupont, J.-C., and De Backer, H.: Radiation fog formation alerts using attenuated backscatter power from automatic Lidars and ceilometers, Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-182, in review, 2016.	~~Haeffelin~~	6		1			http://www.atmos-meas-tech-discuss.net/amt-2016-182/
12	Hervo, M., Poltera, Y., and Haefele, A.: An empirical method to correct for temperature dependent variations in the overlap function of CHM15k ceilometers, Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-30, in review, 2016.	~~Hervo~~	3		1			http://www.atmos-meas-tech-discuss.net/amt-2016-30/
13	Lotteraner, C., and M. Piringer, 2016: Mixing-height time series from operational ceilometer aerosol-layer heights. Boundary-Layer Meteorology, accepted.	~~Lotteraner~~	2		1			

f) H2020/FP7 spin offs

FP7/ H2020 Proposals and projects

This table contains FP7/ H2020 proposals/ projects spinning off from Action activities and including in the proposing consortium at least three Action particip

NO.	Title	Name and country of main proposer	Number of proposers	Action participants listed among the proposers (Name, country, role[3] in the Action)	Funding a submitted
Projects					
1	GAIA-CLIM (http://www.gaia-clim.eu/). The leader of WG3 on Microwave Radiometers (MWR) is responsible for the MWR component of this recently started action.	Peter Thorne, Ireland	20 parties in total: 17 parties from 9 EU countries, 3 international parties and 2 from USA	Cimini, IT, WG3 co-chair Haeffelin, FR, WG1 chair Gueldner, DE, WG3 member	EU
2	ACTRIS-2: starting in May 2015: http://www.actris.net. TOPROF via the leader of WG2 on Doppler Lidars has contributed to the Doppler Lidar component of this action.	Gelsomina, Pappalardo, Italy	31 parties, from 21 EU countries and 7 outside the EU	Alabados, Spain, ALCs, Baars, Germany, ALCs Bortoli, Pt, ALCs Cimini, I, MWRs Haeffelin, F, ALCs Illingworth,UK, cloudradar Msaddon, I, ALCs Nicolae, Ro, O'Connor, FI, DLRs	EU

g) Networking

Added value of the Networking

1.E-PROFILE: Strong interaction with this Eumetnet activity (organised by National Weather Services, NWSs) and the establishment of the European ceilometer network. E-PROFILE is responsible for the instrument installation and the near-real time exchange of data. TOPROF is responsible for calibration and algorithm development. E-PROFILE is currently testing the calibration routines developed and written by TOPROF at the EXETER (UK) data hub.

2.National Meteorological Hydrological Services. The MC has representatives from 16 NWSs NMHSs

3. Representatives from TOPROF made presentations at the ICAP (International Co-operative for Aerosol Prediction, http://icap.atmos.und.edu) 12-14 July 2016, College Park Md, USA, describing the operational ceilometer network being implemented across Europe and how it will provide real-time information on the height and intensity of aerosols in the atmosphere.

Please describe here the added value of the networking, highlighting in particular anything that would not have happened without the Action networking.

Extent of the networking

1.E-PROFILE. Chair of E-Profile attended MC/WG meetings 2 and 3; MS/WG meeting in Oct 2015 wasi hosted by MeteoFrance and will have a joint E-PROFILE-TOPROF session. TOPROF scientists visit the European data hub in Exeter (UK) and have installed their calibration routines.

2.NHMSs – 16 National Weather Services are taking part of the action and attending the six monthly MC meetings. Every one of the STSMs and Special Working Group Meetings so far has involved National Weather Services as either visitors or hosts.

3.ITCs: Representatives from Bulgaria, Hungary, Poland, Portugal, Romania, and Turkey were present at recent MC meetings. Six of the 22 (27%) participating countries are ITCs.

4. At the combined MC/WG meeting in Granada, of the 70 participants, 17 were ECIs and 18 were women. The vice chairs of the four WGs are all women.

h) Impacts

The impacts that have resulted, or might result from the Action are described in the following table:

Description of the impact	Type of impact[5]	Timing of impact[6]
TOPROF has been involved with defining the ISO standard for Doppler wind lidars.	Economic	Acceptance of ISO is Imminent.
TOPROF scientists from NMHSs are leading the installation of the European ceilometer network	Economic	End of Action
Fog forecasting at airports – large economic implications. Experimental implementation at Paris CDG airport	Economic	End of Action
Volcanic ash monitoring/forecasting – large economic implications	Economic	End of Action
ICOS – Integrated Carbon Observation System- part of ERIC https://www.icos-ri.eu - for calculating fluxes requires boundary layer mixing height observations provided by TOPROF instruments	Scientific	End of Action
WG3 is responsible for the microwave radiometer guidelines of the Global Climate Observing System Reference Upper Air Network (GRUAN)	Scientific/ technological	First draft delivered in April 2016

i) Dissemination

I.E Dissemination and exploitation of Action results

Describe the Action's dissemination and exploitation approach as well as all activities undertaken to ensure dissemination and exploitation of Action results and the effectiveness of these activities.			
Add description here			
Item/ activity	Target audience	Result	Hyperlink
Participation in the World Weather Conference. 16-20 Aug 2014 Montreal, Canada	Members of Nat Met Services & Universities. Media	Presentations by chairs/v-chairs of WG2, WG4 & WG3 representative	http://wwosc2014.org/pdf/20140825-WWOSC-FinalBookofAbstracts.pdf
Doppler lidar network: Presentation at EMS Sept 2015, Bulgaria	Members of National Met Services & Universities.	Will take place September 2015.	http://www.emetsoc.org/meetings-events/ems-annual-meetings
Representation at ITARS summer school 2014 (EU-Marie-Curie ITN)	ITARS PhD students and their universities	Three PhD students from NL, D and I made presentation to MC3 meeting Roskilde, DK, Nov. 2014.	http://tinyurl.com/ITARS-talk-TOPROF-Roskilde-pdf
Participation in 6th WMO Workshop on the Impact of Various Observing Systems on NWP. 13-16 May 2016 Shanghai, China	Members of Nat Met Services & all major NWP centres	Presentations by WG2/3/4 representative	https://www.wmo.int/pages/prog/www/WIGOS-WIS/meetings/NWP-6_May2016_Shanghai/WMO-NWP-6_Programme_2016-05-12.pdf
Special session at ISARS Bulgaria. 6-9 June 2016	Members of National Met Services & Universities	Chair of conference is on TOPROF MC	http://isars2016.org/isars/sites/storm.cfd.meteo.bg.isars/files/Programme30May2016Monday.pdf
Participation in ICAP meeting 12-14 July 2016	International science community predicting aerosol loading.	Presentation on the potential near real time data source from ceilometers.	http://icap.atmos.und.edu

The specific scientific impacts of TOPROF will be:

i) Better observations of the levels of pollution over Europe and how such pollution evolves.

ii) A coordinated system for the observation of any future volcanic ash episodes.

iii) The evaluation of pollution transport models, which can also be used for predicting the transport of other hazardous materials.

iv) Evaluation of the performance of present models for predicting the levels of pollution, clouds, humidity, temperature and winds over Europe.

v) Identification of the shortcomings of such models and suggestions as to how such models could be improved.

vi) The direct real-time assimilation of the high resolution observations into forecasting models so they are more accurately initialised.