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Form for
Regular Reporting of CIMO Testbeds and Lead Centres

(expand the cells as required to properly reflect your activities)

Terms of Reference for CIMO Testbeds and Lead Centres are available under:
ttp://www.wmo.int/pages/prog/www/IMOP/Testbeds-and-LC.html

Name of Testbed / Lead Centre	**MeteoSwiss Payerne CIMO Testbed**
Location of Testbed / Lead Centre	**Payerne, Switzerland**

Contact Person for the Testbed/Lead Centre	
Courtesy Title	Dr.
Family name	**Ruffieux**
First name	**Dominique**
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Has contact person changed in last 2 years?	Yes / No NO
If yes, who was the previous contact person?	

Report on Activities

1. Radiosounding (Dominique Ruffieux)

The year 2017 was characterized by the operation of the new SRS-C50 since February 1st, 2017 (as the new MeteoSwiss Payerne operational sonde). New software called UMSS (Universal Measurement Sounding System) from the Swiss company Meteolabor is used for data acquisition and data processing. To document the changes between the former operational SRS-C34 and the

SRS-C50, comparison are done by adding these radiosondes to the GRUAN research flights. This comparison will be undertaken during at least one more year (Figure 1).

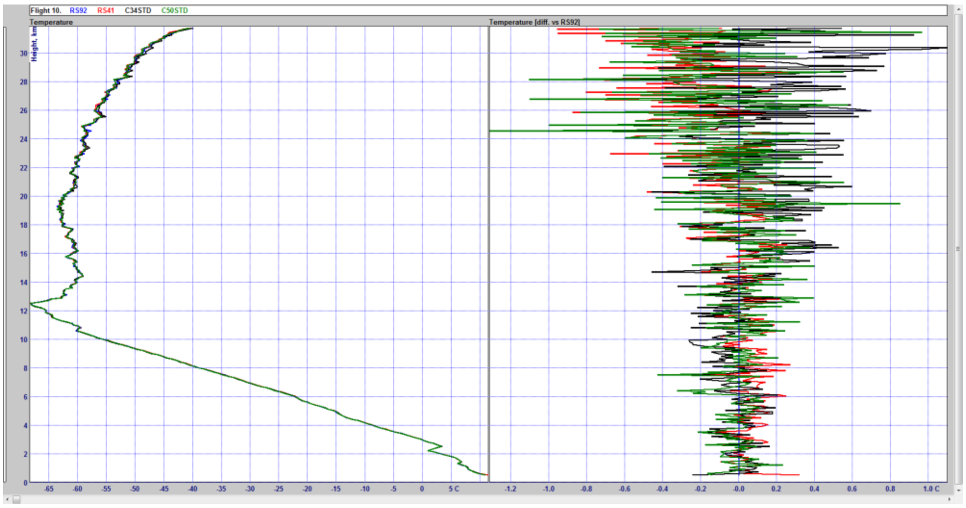

Figure 1. Comparison flight between various types of sondes including the new SRS-C50. Simultaneous temperature profiles (left panel) and temperature differences related to RS92 sonde (right panel).

In parallel research flights are launched every week (Vaisala RS92-SGP as well as the Vaisala RS41 is with SRS-C34 radiosondes) alternating one flight during the night and one flight during the day. Since February 1st, 2017, a SRS-C50 is also added to this payload. During one night flight per month a Meteolabor SnowWhite / Cobald sensor is added to the GRUAN launch for research purposes in collaboration with ETHZ. These research flights are of first importance for various validation purposes.

Since end of May, 2017, Dr. Rolf Philipona, the responsible person for scientific activities related to radiosounding is not working at MeteoSwiss anymore. Replacement of his position will be decided in 2018.

2. Ground-based remote sensing (Alexander Haefele)

2.1 Raman lidar

The Raman lidar RALMO deployed at the Payerne site since 2008 is designed to measure humidity, temperature and aerosol profiles for operational meteorology and for long term observations of high quality. RALMO is fully automatic and shows a data availability of >50% on average.

During the reporting period, the main activities focused on several topics.

- **Calibration**

Instabilities in the internal calibration system (see previous report) forced us to look for new ways to track changes in the calibration factor for water vapor. Using the sky itself as a reference light source has been proposed some decades ago but is not used operationally by any group to our best knowledge. The method has two main advantages: 1) the reference light (i.e. sky background) enters the system using the same optical path as the backscattered light from the laser; 2) the method can be used backward in time since the sky background is determined from the uppermost portion of the regular measurements. In our implementation calibrations are performed at constant solar zenith angles and for clear sky to ensure as homogeneous conditions as possible during calibration. The ratio between the sky background in the nitrogen channel and the water vapor channel at time t divided by the same ratio at time t_0 is the relative change of the calibration factor since t_0. Our implementation showed to be consistent with external calibrations using different radiosondes (see Figure 2) and is used operationally since spring 2017. Future work includes the correction for aerosol effects.

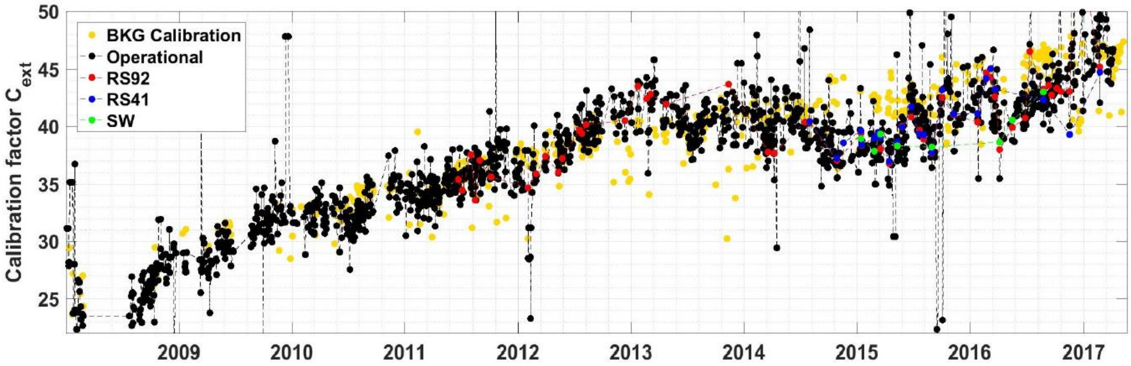

Figure 2: The time series of the water vapor calibration factor derived from the solar background and a reference calibration factor (yellow), derived from external calibrations using the operational radiosonde (black) and reference radiosondes (red, blue and green) respectively.

In parallel, we implemented a trajectory method for the external calibration of the water vapor data. The trajectory method accounts for the displacement of the air parcel during the radiosonde ascent and chooses the time integration period for the lidar accordingly to make sure that both instruments are observing the same air. In particular in presence of a quickly varying water vapor field, we find better agreement in the vertical structure of the radiosonde and lidar profiles when accounting for the trajectories which is an indication of the added value.

– **Continued development of optimal estimation methods for Raman lidar retrievals**

After successful implementation of an optimal estimation method (OEM) scheme to retrieve water vapor and temperature from Raman and Rayleigh scattering data, respectively, we started to work on an implementation of an OEM for temperature retrieval from rotational Raman channels. One of the main advantages of OEM is the fact that an extensive uncertainty budget can be calculated on a profile by profile basis.

- **Renewal of laser source**

After 9 years of 24/7 operation with an average up time of 50% the laser source reached the end of its lifetime. The new laser source has been selected after a careful evaluation procedure with a strong focus on high reliability, low maintenance and excellent beam stability. The installation of the new laser took place between 5 and 23 February 2018. First measurements reveal equal or better performance compared to the old laser source. Figure 3 shows measurements with the elastic and Nitrogen channels compared to a modelled Rayleigh-scatter profile. The good match between the modelled and measured profiles indicate a good alignment and beam quality.

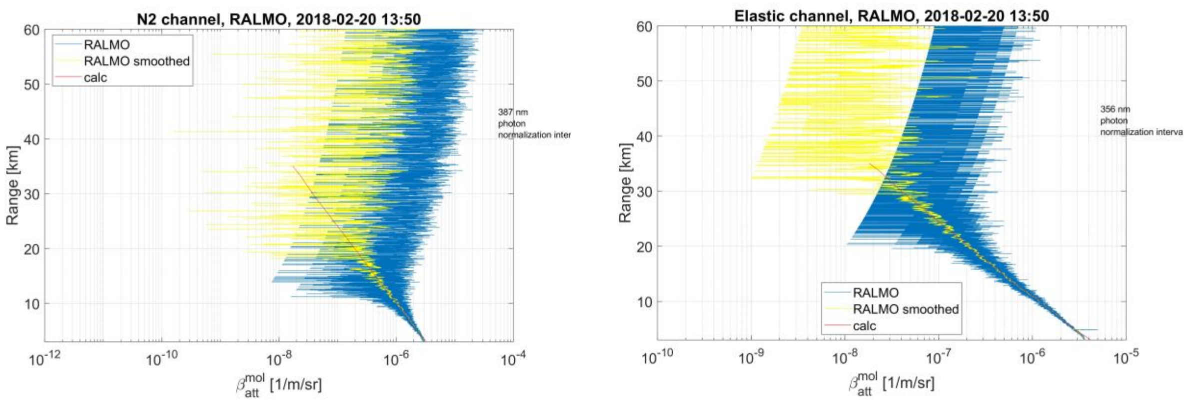

Figure 3: First measurements of the Raman lidar with the new laser source integrated over 30 min during daytime. Left panel: Nitrogen Raman channel, right panel: elastic channel.

Related publications:

Martucci et al., Characterization of high temporal resolution PRR acquisition by Fast Com Tec card: Dead time, PRR desaturation, temperature calibration and retrieval, *Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.

Mahagammulla et al., First Application of the Optimal Estimation Method to Retrieve

Temperature from Pure Rotational Raman Scatter Lidar Measurements, *Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.

Sica et al., How to apply the optimal estimation method to your lidar measurements for improved retrievals of temperature and composition, *Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.

Hicks et al., A calibration of the MeteoSwiss Raman lidar for meteorological observations (RALMO) water vapor mixing ratio measurements using a radiosonde trajectory method, *Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.

– **Contribution to NDACC, GRUAN, NWP**

The data from various systems operated at Payerne and including the Raman lidar are operationally transmitted to NDACC and WMO-GRUAN as well as for NWP models for assimilation (radiosoundings, radar wind profilers) and validation (Raman lidar, microwave radiometer). First tests to assimilate the Raman lidar water vapor information in the high resolution model of MeteoSwiss are ongoing.

2.2 Automatic elastic lidar and ceilometer

- **European network of automatic lidars and ceilometers**

As coordinating member of the EUMETNET E-PROFILE program and as co-chair of the COST action TOPROF significant efforts have been made to integrate European ceilometers and automatic lidars into a network. Data are now received from 90 sites and calibrated centrally at the data hub. The main product is attenuated backscatter coefficient which is distributed in real time in BUFR over the GTS. Quick looks are accessible here.

Related publication:

Haefele et al.: The E-PROFILE/TOPROF network of automatic lidars and ceilometers for profiling of aerosols and volcanic ash, *in Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.

- **Operational estimation of the planetary boundary layer**

The planetary boundary layer height (PBL height) is an important parameter for air quality and the dispersion of pollutants in the atmosphere. We have developed a new algorithm based on the pathfinder principle for the detection of the PBL height. The algorithm has been validated extensively at the observatory of Payerne and at the high alpine site Jungfraujoch. A publication is available in Atmospheric Chemistry and Physics (ACP) Journal.

- **Estimation of total cloud cover with the Swiss ceilometer network**

The automation of human observations, in particular of clouds, is a strategic activity within MeteoSwiss. In the framework of a 12 month internship the cloud cover product of the CL31 ceilometer has been validated against human observations (SYNOP) and other surface and space based methods. The ceilometer cloud cover product compares well with other automatic methods and is negatively biased compared to SYNOP (see Figure 4), which is partially due to the fact that the ceilometer does not see clouds above 7 km above ground level. A combination of ceilometer and satellite imagery reveals very promising results with nearly zero bias and a standard deviation of 1.2 okta for the Payerne site (not shown).

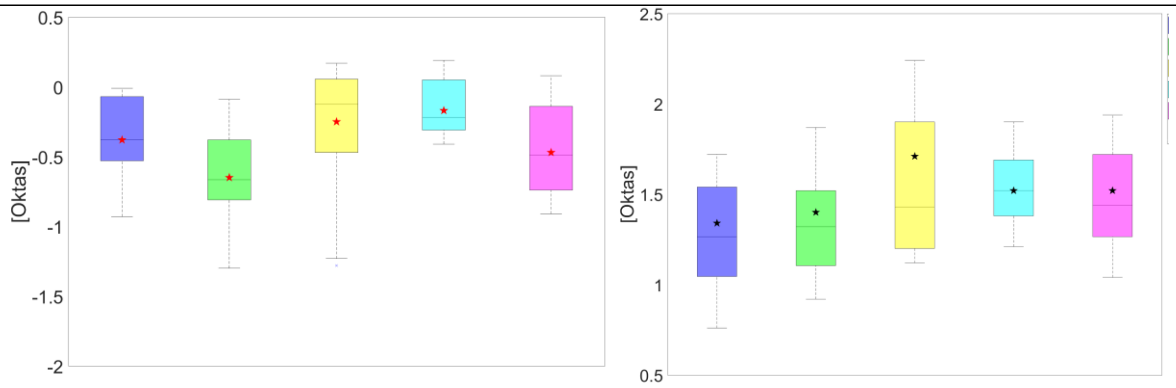

Figure 4: Box plots of monthly bias (left) and standard deviation (right) of BACADA (blue), APCADA (green), CMSAF (yellow), NWCSAF (cyan) and ceilometer (purple) versus SYNOP.

Related publication:

Poltera, Y., Martucci, G., Collaud Coen, M., Hervo, M., Emmenegger, L., Henne, S., Brunner, D., and Haefele, A.: PathfinderTURB: an automatic boundary layer algorithm. Development, validation and application to study the impact on in situ measurements at the Jungfraujoch, Atmos. Chem. Phys., 17, 10051-10070, https://doi.org/10.5194/acp-17-10051-2017, 2017.

2.3 Microwave radiometer profilers

Two microwave radiometers are operationally used in Payerne. The SOMORA ozone profiler is running at 142GHz while the commercially available HATPRO (20-50GHz) provides temperature and water vapor profiles in real-time. SOMORA ozone profiles are available every two hours and allow a detailed study of the diurnal cycle of stratospheric and mesospheric ozone. We analyzed, for the first time to our knowledge, ozone trends as a function of daytime (see Figure 5) and preliminary results reveal a significant trend of +10%/decade during nighttime in the mesosphere while the daytime trend is not significant. A publication is in preparation.

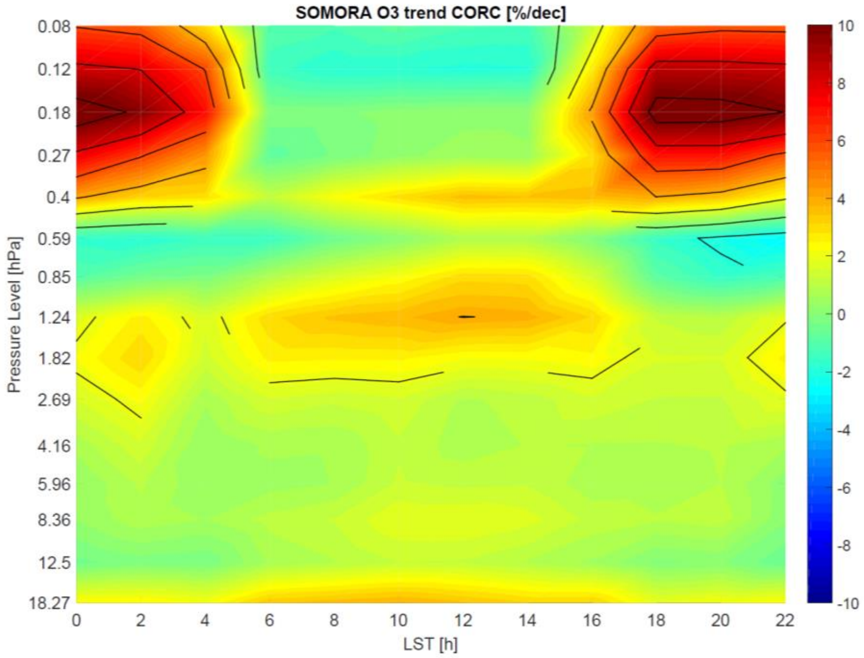

Figure 5: Trend in stratospheric and mesospheric ozone as a function of daytime and height. The black lines mark altitudes where the trend is significant (2-σ).

2.4 Radar wind profilers

The radar wind profiler of Payerne is one segment of the nuclear power plant meteorological surveillance system of Switzerland. A major effort has been made to improve the suppression of parasitic radar echoes from objects at the surface (trees, antennas, buildings, etc) called ground clutter.

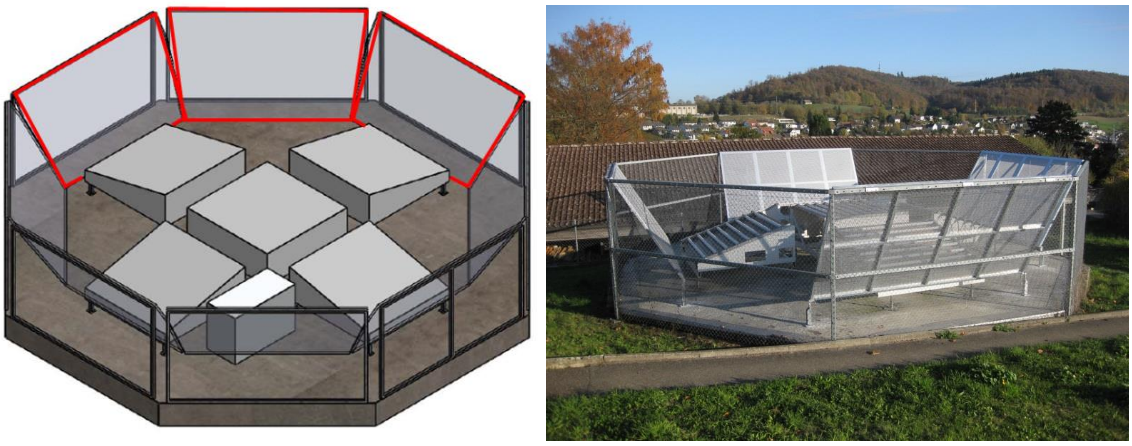

Figure 6: Design (left) and realization (right) of the new additional clutter fence panels. Based on cost-benefit considerations, only 4 out of 8 panels have been installed..

Experiments have been carried out with additional clutter fence panels which were placed diagonally between the antennas and the original clutter fence as illustrated in Figure 6. A detailed analysis of the intensity of the ground echoes showed that these additional panels suppress ground clutter by more than 10 dB (see Figure 7). First results of monthly statistics indicate an improvement in wind speed and direction in terms of bias and standard deviation compared to the radiosonde (see Figure 8).

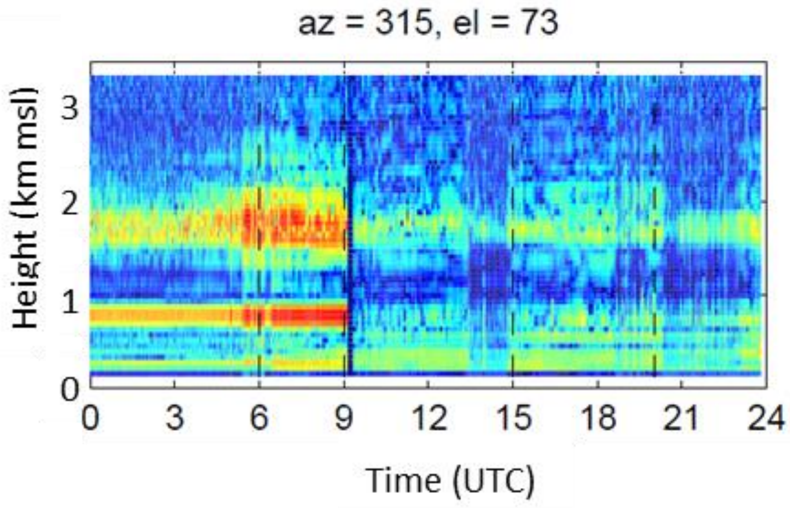

Figure 7: Ground clutter intensity as function of height. Strong echoes are observed at 1 and 2 km between 0 and 9h. At 9h an additional clutter fence panel has been installed which causes significant suppression of the clutter (see text).

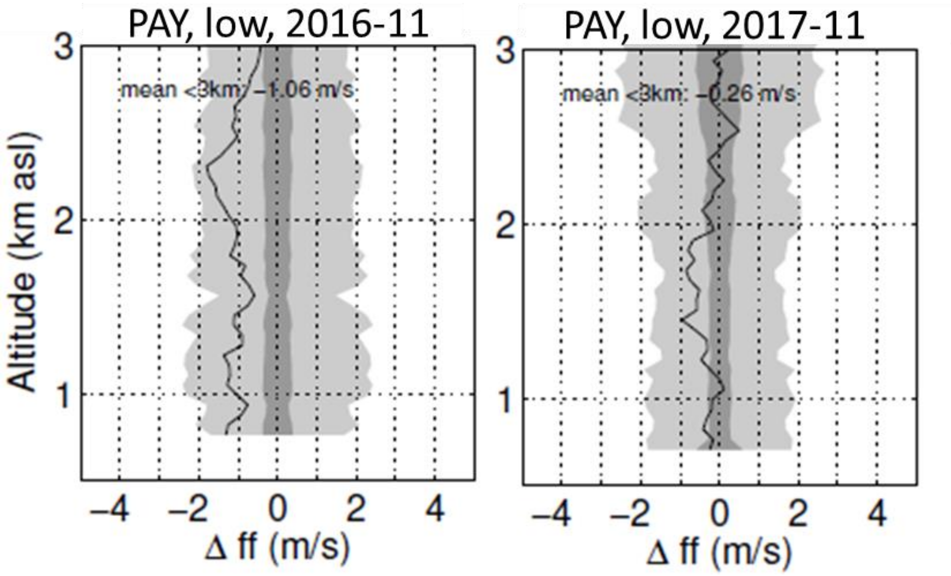

Figure 8: Bias (black solid line) and standard deviation (grey shaded area) of the differences between the radar windprofiler low mode and the operational radiosonde for November 2016 (left) and 2017 (right).

3. Performance evaluations related to radiation (Laurent Vuilleumier)

3.1 Introduction

In the previous reports, a contribution for evaluating the performance of radiometers designed for the solar energy sector was described. This was an effort to better understand the performance of these instrument within an emerging "regulatory" framework (e.g., standard operating procedures, certification, traceability, etc.) for such monitoring**.**

This activity included the organization by MeteoSwiss of an inter-comparison of radiometers measuring Direct Normal solar Irradiance (DNI) from 15/06/2012 to 15/09/2013. The goal was comparing target instruments to high accuracy radiation monitoring instruments (references) from the Baseline Surface Radiation Network (BSRN) Payerne site. Final results were described in the previous report, a refereed journal paper described the accuracy of the reference instruments (Vuilleumier et al., 2014), two other referred papers described various aspects of the inter-comparison (Badosa et al., 2014; Vignola et al., 2016) and the final results are to be published in Meteorologische Zeitschrift (Vuilleumier et al., 2017).

During the period 2014-2017, radiation measurements from two high accuracy radiation monitoring stations were used to validate Direct Normal Irradiance estimates obtained using satellite information from Meteosat Second Generation (MSG). These stations were the Payerne BSRN station (Switzerland) and the Plataforma Solar de Almeria (PSA), a solar power research facility in Southern Spain operated by the German Aerospace Centre (DLR) and the Centre for Energy, Environment and Technological Research (CIEMAT).

3.2 Validation of Direct Normal Irradiance from Meteosat Second Generation

Direct normal irradiance (DNI) estimates from the HelioMont algorithm using MSG/SEVIRI data were validated with ground-based data collected at two sites during year 2015. One site is the Plataforma Solar de Almeria (PSA), a 1km x 1km solar power research facility in Southern Spain hosting a half-dozen pyrheliometers. These provide high-quality DNI measurements at a site of the scale of the MSG/SEVIRI pixel resolution. The PSA DNI measurements are thus particularly well suited for satellite validation purposes. The other site is the Swiss Payerne BSRN station. At PSA, the availability of circumsolar ratio measurements allows correcting the measured DNI for circumsolar irradiance included in the pyrheliometer opening angle. The availability of several pyrheliometers at PSA allows checking the influence of spatial averaging, and the 1 minute resolution allows similar verification with temporal averaging.

The HelioMont algorithm (Stöckli, 2013) belongs to the Heliosat algorithm family. It first estimates the clear-sky irradiance using look-up tables derived from a radiative transfer model (RTM), then it applies a cloud modification factor (CMF) accounting for the effect of cloudiness using an empirical algorithm and the satellite imagery data. Clear-sky data allow verifying the RTM. Its most important uncertainty source is the aerosol optical depth (AOD) used as input.With locally-measured AOD, an expanded uncertainty of about ±5-6% with a negative bias of 1-2% is found. Using AOD estimates by the Copernicus Atmosphere Monitoring Service (CAMS), the uncertainty is increased to about ±15% with a negative bias of ~1-3%. An aerosol climatology by Kinne (2008) was also tested, resulting in a significant negative bias of ~15% and a dispersion of ±18% around it. The CMF estimated by HelioMont was compared with one deduced by dividing the ground-based DNI measurements by the HelioMont clear-sky estimates. The satellite derived CMF is found to be in good agreement with the one deduced from DNI measurements for clear-sky situations. On the other hand, the satellite-derived CMF is found to be generally overestimated for cloudy situations, i.e. there are too few very low CMF. An important scatter is found when comparing the satellite and ground-based CMF, but 1-hour temporal averaging or spatial averaging using the multiple pyrheliometer measurements at PSA allows a significant reduction of the scatter.

Related publications:

Badosa, J., J. Wood, P. Blanc, C. N. Long, L. Vuilleumier, D. Demengel, and M. Haeffelin (2014). Solar irradiances measured using SPN1 radiometers: uncertainties and clues for development, , Atmospheric Measurement Techniques, 7, 4267-4283, doi:10.5194/amt-7-4267-2014.

Kinne, S. (2008), Clouds in the perturbed climate system, Chap. Climatologies of cloud related aerosols: Particle number and size, ISBN: 978-0-262-01287-4.

Stöckli, R. (2013), The HelioMont Surface Solar Radiation Processing, Scientific Report MeteoSwiss, 93.

Vignola, F.; Derocher, Z.; Peterson, J.; Vuilleumier, L.; Félix, C.; Gröbner, J., and Kouremeti, N. (2016). Effects of changing spectral radiation distribution on the performance of photodiode pyranometers. Solar Energy, 129, 224-235, doi: 10.1016/j.solener.2016.01.047.

Vuilleumier, L., M. Hauser, C. Félix, F. Vignola, P. Blanc, A. Kazantzidis, and B. Calpini (2014). Accuracy of ground surface broadband shortwave radiation monitoring, J. Geophys. Res. Atmos., 119:D24, 13'838-13'860, doi:10.1002/2014JD022335.

Vuilleumier, L., C. Félix, F. Vignola, P. Blanc, J. Badosa, A. Kazantzidis, and B. Calpini (2017). Performance Evaluation of Radiation Sensors for the Solar Energy Sector, accepted for publication in Meteorologische Zeitschrift. doi:10.1127/metz/2017/0836.

Main activities that TB/LC carried out in the last 2 years for which results will soon be available:

- Raman lidar measurements of tropospheric temperature: operational, validation in progress.
- Automatic calibration of ALC, suited for network implementation.
- Performance evaluation of the radiometers designed for the solar energy sector: report in preparation.
- SPICE experiment (final report in progress, final version will be presented during CIMO session in October 2018 at Amsterdam).

Which guidance documents/standard procedures were developed during the last 2 years (please include full reference and web-link if available)?

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Which IOM reports / peer-reviewed publications were published in the last 2 years (please include full

reference and web-link if available)?

- Kräuchi A and R. Philipona: Return glider radiosonde for in situ upper-air research measurements. Atmos. Meas. Tech., 9, 2535–2544, 2016, doi:10.5194/amt-9-2535-2016.
- Haefele et al.: The E-PROFILE/TOPROF network of automatic lidars and ceilometers for profiling of aerosols and volcanic ash, *in Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.
- Poltera et al., Pathfinder TURB: an automatic boundary layer algorithm. Development, validation and application to study the impact on in-situ measurements at the Jungfraujoch, *Atmos. Chem. Phys. Discuss*., https://doi.org/10.5194/acp-2016-962, Revised manuscript accepted for ACP, 2017.
- Martucci et al., Characterization of high temporal resolution PRR acquisition by Fast Com Tec card: Dead time, PRR desaturation, temperature calibration and retrieval, *Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.
- Mahagammulla et al., First Application of the Optimal Estimation Method to Retrieve Temperature from Pure Rotational Raman Scatter Lidar Measurements, *Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.
- Sica et al., How to apply the optimal estimation method to your lidar measurements for improved retrievals of temperature and composition, *Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.
- Hicks et al., A calibration of the MeteoSwiss Raman lidar for meteorological observations (RALMO) water vapor mixing ratio measurements using a radiosonde trajectory method, *Proceedings of ILRC28*, 25-30 June 2017, Bucharest, Romania.Badosa, J., J. Wood, P. Blanc, C. N. Long, L. Vuilleumier, D. Demengel, and M. Haeffelin (2014). Solar irradiances measured using SPN1 radiometers: uncertainties and clues for development, , Atmospheric Measurement Techniques, 7, 4267-4283, doi:10.5194/amt-7-4267-2014.
- Kinne, S. (2008), Clouds in the perturbed climate system, Chap. Climatologies of cloud related aerosols: Particle number and size, ISBN: 978-0-262-01287-4.
- Stöckli, R. (2013), The HelioMont Surface Solar Radiation Processing, Scientific Report MeteoSwiss, 93.
- Vignola, F.; Derocher, Z.; Peterson, J.; Vuilleumier, L.; Félix, C.; Gröbner, J., and Kouremeti, N. (2016). Effects of changing spectral radiation distribution on the performance of photodiode pyranometers. Solar Energy, 129, 224-235, doi: 10.1016/j.solener.2016.01.047.
- Vuilleumier, L., M. Hauser, C. Félix, F. Vignola, P. Blanc, A. Kazantzidis, and B. Calpini (2014). Accuracy of ground surface broadband shortwave radiation monitoring, J. Geophys. Res. Atmos., 119:D24, 13'838-13'860, doi:10.1002/2014JD022335.
- Vuilleumier, L., C. Félix, F. Vignola, P. Blanc, J. Badosa, A. Kazantzidis, and B. Calpini (2017). Performance Evaluation of Radiation Sensors for the Solar Energy Sector, accepted for publication in Meteorologische Zeitschrift. doi:10.1127/metz/2017/0836.

Title(s) of IOM report(s) presently being developed by your Testbed/Lead Centre:
(please specify level of development: draft, ready for review, …)

-
-

Has your Testbed/Lead Centre collaborated with one or more CIMO Expert Teams in developing guidance material? Yes/No YES

If yes, with which CIMO Expert Team(s)?

- Strong relations were maintained with the Lindenberg DWD site for various GRUAN activities as well as with Table Mountain (USA) for Raman lidar activities.
- Strong relations with the Expert Team on Instrument Inter-comparisons and with Expert Team on Operational In Situ Technologies.

Capacity Building and Training Activities

Which capacity building/training activities have been carried out by the Testbed in the last 2 years?

- A regular teaching activity (about once a year) is performed with staff from the Kenyan Meteorological Service (KMD) at Nairobi (radiosounding and Dobson)

Has your testbed developed a twinning activity / special relationship with a companion station/site from a developing country? Yes/No YES

If yes, with which station/site?

A continuous collaboration is maintained between Meteoswiss and the Kenya Meteorological Department (KMD) at Nairobi. The main focus of this partnership is the ozone measurements with both in-situ (radiosounding) and remote sensing (Dobson) ozone measurements.

Is your Testbed/Lead Centre making an oral/poster presentation at this year's TECO? Yes / No YES
(If yes, please specify Title(s) and Author(s) of the presentation(s))

- Presentation of the final report SPICE by Yves-Alain Roulet

Recent Changes in Circumstance

Have there been any recent changes in your Test Bed/Lead Centre's capabilities? If so, please specify:

-
-
-

Have there been any recent changes in your Test Bed/Lead Centre's infrastructure? If so, please specify:

-
-

Have there been any recent changes in your staffing? If so, please specify, and advise whether replacement staff have the required competencies:

-
-

Future Plans	
What are your plans for the next two years? • Continuation of the efforts to develop Payerne as a GRUAN site. • Starting in Spring 2018, part of Payerne operational radio soundings will be carried out using an automatic launcher. • Reinforcement of the lidar–related activities (both Raman lidar and ceilometers). • Operational assimilation of Raman lidar.	
Is your Testbed/Lead Centre able to continue in the role of a Test Bed/Lead Centre during the coming two years?	Yes / No YES

Other relevant information (other activities of special interest to CIMO, etc.)
•

22 February, 2018	Dominique Ruffieux
Date	**Name of Person Filling the Form**