Deliverable D12.5: Delivery on in-situ and ground-based remote-sensing data to the database

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As reported in the previous ACTRIS-2 WP12 deliverables, surface-based direct eddy covariance (EC), and remote-sensing based (combined Doppler and aerosol LIDAR) measurements of particle fluxes have been performed at five different sites: Hyytiälä (Finland), Cabauw (the Netherlands), Košetice (Czech Republic), AGORA (Spain) and Pallas (Finland). Additionally in-situ EC measurements were made at Auchencorth Moss (UK). This data has been collected, processed, and delivered to the Cloudnet database for archiving, and for provision in an accessible form.

This deliverable provides information on the data that has been delivered. In deliverable 12.1, a list of variables to be recorded during the campaigns was proposed; Table 1 provides the list of the collected variables for the tower based EC measurements, and Table 2, for the remote sensing based measurements. Most of the proposed variables were eventually recorded, with the exception of chemically-resolved variables, since none of the sites had instrumentation available for chemically-speciated flux measurements during the campaigns, and the remotely-sensed particle-flux profile, since the technique for retrieving this is still under active development.
Webpages outlining the database and campaigns have been implemented here:

http://devcloudnet.fmi.fi/campaigns/jra2/

and data from the database is available by clicking on the link to data:

http://devcloudnet.fmi.fi/campaigns/jra2/data/

Note that the data has not yet been made public at this time, and access requires a username and password, available by request from the Cloudnet database maintainers at FMI.

The current form of the database allows for file-based download via point-and-click within a rudimentary directory structure. The preferred form of delivery is through files in netCDF format, which contain appropriate meta-data, hence there is processed EC flux data and remote-sensing data available in netCDF format, with processed and raw data also available in the original formatting.

For EC flux measurements, the data in netCDF format has common variable naming and attributes consistent across the various processing software packages used to create the data (e.g. Eddy UH from the University of Helsinki[1], or EddyPro from LI-COR[2]). This includes modification of variable names and units to match those supplied in Table 1, and the inclusion of an additional time coordinate variable 'time', which uses the Climate and Forecast Metadata Convention[3], with units of seconds, more specifically, 'seconds since 1970-1-1 00:00:00 00:00'.

Similarly for the remote-sensing data, variable names have been transformed to match the names supplied in Table 2, with common variable naming and attributes for data from every site. This was an easier task for the Doppler lidar data, since a common processing system was applied at all sites (Manninen et al., 2018). Note that the final remotely-sensed particle fluxes may not yet be available as characterisation and calibration of the lidar profiles is ongoing.

[1] https://www.atm.helsinki.fi/Eddy_Covariance/files/Short_introduction_to_EddyUH.pdf
[2] https://www.licor.com/env/support/EddyPro/home.html
[3] http://cfconventions.org/Data/cf-conventions/cf-conventions-1.7/cf-conventions.html

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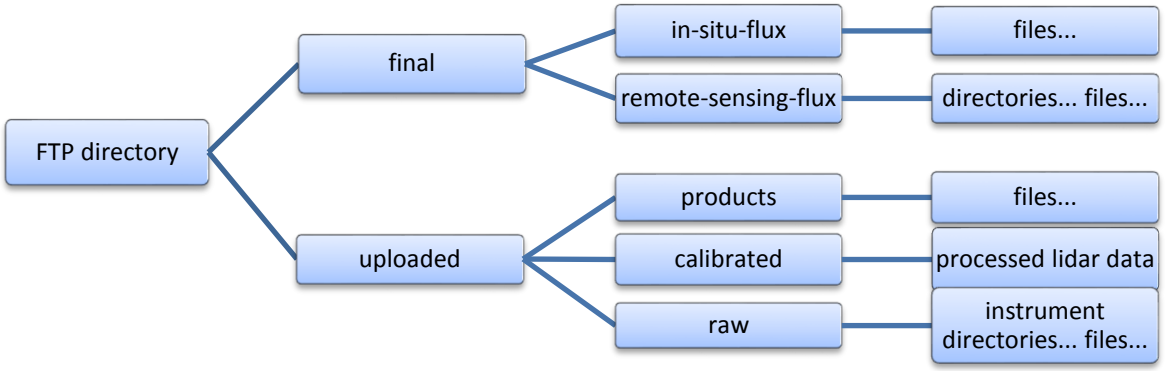
The directory structure comprises:



Also included is a short site description for each of measurement campaign. A more detailed description of the sites is provided in the previous deliverables 12.3 and 12.4.

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Table 1. Proposed and collected EC in-situ flux variables at the different sites. Original table of proposed variables is available in D12.1.

Variable	Units	AGORA, Spain	Auchencorth Moss (UK, NERC)	Cabauw (The Netherlands, KNMI)	Hyytiälä (Finland, UHEL)	Košetice (Czech Republic, CHMI)	Pallas (Finland, FMI)
Wind speed components	m s^{-1}	x	x		x	x	
Sonic temperature	K	x	x		x	x	
Diagnostics	-	x	x		-	-	
Particle concentration	particles cm^{-3}	x	x		x	x	
Chemically resolved concentrations	µg m^{-3}	-	-		-	-	
Operational variables (e.g. instrument temperature, pressure differences, water removal, line pressure)	-	-	x		x	-	
Externally measured volumetric flow rate	slpm	-	-		-	-	
Particle flux (level 1)	particles $m^{-2}s^{-1}$	x	x		x	x	
Particle flux (level 2)	particles $m^{-2}s^{-1}$	x	x		x	x	
Particle concentration	particles cm^{-3}	x	x		x	x	
Particle standard deviation	particles cm^{-3}	-	-		-	-	
Random error for particle flux	particles $m^{-2}s^{-1}$	-	x		x	x	
Time lag for particle flux	particles $m^{-2}s^{-1}$	-	-		-	-	
Friction velocity	m s^{-1}	x	x		x	x	
Sensible heat flux	W m^{-2}	x	x		x	x	
Mean wind components	m s^{-1}	x	x		x	x	
Mean wind speed	m s^{-1}	x	x		x	x	
Mean wind direction	°	x	x		x	x	
Mean sonic temperature	K	x	x		x	x	
Chemically resolved particle concentrations	µg m^{-3}	-	-		-	-	
Chemically resolved particle standard deviation	µg m^{-3}	-	-		-	-	
Chemically resolved particle fluxes	µg m^{-2} s^{-1}	-	-		-	-	

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Table 2. Proposed and collected remote sensing flux variables at the different sites. Original table of proposed variables is available in D12.1.

Variable	Units	AGORA, Spain	SLOPE	Hyytiälä (Finland, UHEL)	Košetice (Czech Republic, CHMI)	Pallas (Finland, FMI)
Particle backscatter profile	$km^{-1}\ sr^{-1}$	x		x	x	
Particle backscatter gradient	$km^{-2}\ sr^{-1}$	X		x	x	
Particle type classification profile	1	x		-	-	
Particle concentration profile (conversion from beta and type)	$\mu g\ m^{-3}$	x		x	x	
Particle concentration uncertainty	$\mu g\ m^{-3}$	-		-	-	
Particle backscatter fluctuation profile	$km^{-1}\ sr^{-1}$	-		x	-	
Vertical wind profile	$m\ s^{-1}$	x		x	x	x
Horizontal wind profile	$m\ s^{-1}$	x		x	x	x
beta-w-covariance	$km^{-1}\ sr^{-1}\ m\ s^{-1}$	x		x	x	
beta-w-covariance sampling error (noise)	$km^{-1}\ sr^{-1}\ m\ s^{-1}$	x		x	x	
beta-w-covariance flux error (systematic)	$km^{-1}\ sr^{-1}\ m\ s^{-1}$	-		-	-	
Dissipation rate profile	$m^{-2}s^{-3}$	-		x	x	
Particle flux profile (gradient method)	$\mu g\ m^{-2}s^{-1}$	-		-	-	
Particle flux profile (EC method)	$\mu g\ m^{-2}s^{-1}$					

Site descriptions

AGORA and Granada

In Spain, the tower-based particle flux measurements include a measurement campaign AMAPOLA conducted in an olive orchard between 18-29th April 2016, and continuous measurements made in the city of Granada. The AMAPOLA campaign was performed in an olive orchard, where greenhouse gas fluxes are continuously measured in the frame of ICOS (Integrated Carbon Observation System) infrastructure. During the period 18-29th April 2016, continuous particle flux measurements at the ICOS tower were carried out. At 50 m, there was also a remote system station including a Halo Streamline Doppler Lidar and an aerosol lidar operating at 355 nm.

After the AMAPOLA campaign, the same setup was moved to perform permanent measurements within the city of Granada with the aim of obtaining information on the flux of particles between an urban surface and atmosphere. In this case, the EC system was set up in the observation tower of the "Parque de las Ciencias", located 250 m away from the rooftop of the Atmospheric Physics Lab at the Andalusian Institute for Earth System Research IISTA-CEAMA, where the remote sensing instruments are operated.

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Auchencorth Moss (UK, NERC)
ACTRIS-2 particle flux measurements started at Auchencorth Moss in June 2016, using an older TSI CPC model (TSI3762) with a large (3 lpm) flow rate and sub-second response time, which was used at this site before (Nemitz et al. 2002). Unfortunately, this instrument failed about 2 weeks into the measurements and repair was no longer supported by the manufacturer. It took until December 2016 to find institute-internal funds, for the capital purchase procedures and delivery of a replacement instrument. These instruments have been operated at Auchencorth Moss continuously since 5th January 2017, with data being recorded initially at 1 Hz and since 25th March 2017, at 10 Hz. During the analysis, data from the MCPC are combined with high frequency measurements made by a Gill R3 sonic anemometer mounted on top of an open lattice tower at a height of 3 m above ground.

Cabauw (The Netherlands, KNMI)
The CESAR (Cabauw Experimental Site for Atmospheric Research, www.cesar-observatory.nl) Observatory is located in the western part of the Netherlands (51.971° N, 4.927° E) in a polder 0.7 m below average sea level. The nearby area is dominated by flat agricultural grassland with relatively little industry and households. In contrast, the wider surrounding area at distances 15 – 50 km away, more than 10 million people live and work in one of the most densely populated areas in Europe. The CESAR Observatory includes a 212 m tall tower specifically built for meteorological and air pollution studies. The EC system measuring the turbulent fluxes of aerosol is placed in the tower at 68 m above ground. The system consists of a Gill 3D ultrasonic anemometer (WindMaster Part 1590-PK-020) and a TSI Condensation Particle Counter (CPC 3775).

From the beginning of June until 7th July 2016, the experimental setup consisted of the two instruments located at different heights, with the ultrasonic anemometer at 60 m above the surface and the CPC down at the base of the mast.

Hyytiälä (Finland, UHEL)
The SMEAR II (Station for Measuring Ecosystem-Atmosphere Relations) is located in Hyytiälä in Southern Finland. The station is located in a boreal forest with majority of the tree species being pine trees. At SMEAR II, the tower-based aerosol particle flux measurements have been ongoing for several years at the height of 23 m above the ground (Rannik et al. 2009). The measurement altitude, however, now starts be too close to the forest canopy (mean height 15 m in 2007) and therefore within the framework of ACTRIS-2, a second EC setup was installed at the station in spring 2016 at a height of 35 m.

Košetice (Czech Republic, CHMI)
The National Atmospheric Observatory Košetice is situated in the agricultural countryside in the Czech Highlands (N 49°34'24", E 15°04'49", 534 m above sea level). In addition to meteorological parameters, many different air quality ground based parameters are measured at the station (PM10, PM2.5, NOx, NHx, O3, SOx, CO, POPs, VOCs) as well as aerosol characterization (PNSD, light absorption, light scattering, EC/OC). Further measurements are running at the 250 m high atmospheric tall tower. These measurements include vertical gradients of GHGs (CH4, CO2, CO, N2O), O3 and Hg. Flask sampling of 13C, 18O, H2, SF6 and O2/N2 are performed at the tower platform at 230 m above the surface.

Additionally, on 26th September 2016 continuous EC measurement in the atmospheric tower was started. The setup consists of a Gill ultrasonic anemometer and CPC (TSI3775). We stopped the measurement in January 2017 due to anemometer failure. The continuous measurements started again at the beginning of the Lidar campaign that took place from 15 August till 15 September 2017. A new EC measurement was started on the top of the mast at an altitude of 250 m above the surface on

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a 1.5 m long beam. After several days of campaign the CPC unfortunately failed and it was not possible to repair it. At the height of 250 m, currently only the 3d anemometer is running.

Pallas (Finland, FMI)

The Pallas research station comprises of versatile infrastructure for monitoring and studying the atmosphere, ecosystems and their interactions. Pallas (67.973°N, 24.116°E) is located 170 km north of the Arctic Circle, partly in the area of Pallas-Yllästunturi National Park. Pallas is a northern node of Pallas-Sodankylä research infrastructure of the Finnish Meteorological Institute, the other node being located in Sodankylä Arctic Research Centre. The main atmospheric measurements are conducted on top of a barren fell called Sammaltunturi (565 m above mean sea level). A supporting ecosystem site, Kenttärova, is situated on a hill (347 m above mean sea level) that is circa 60 m above surrounding planes near to the northern border of the boreal vegetation zone; close to the Sammaltunturi fell. EC measurements of CO2 has been conducted at the site since 2003. Continuous tower-based surface particle flux measurements with the EC technique were started at the site in September 2015 and are conducted using an ultrasonic anemometer (Metek USA-1) and a CPC (TSI3776).

References

Manninen, A. J., Marke, T., Tuononen, M. J., & O'Connor, E. J. (2018). Atmospheric boundary layerclassification with Doppler lidar. Journal of Geophysical Research: Atmospheres, 123, 8172–8189. https://doi.org/10.1029/2017JD028169

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