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Dataset Paper

A Database for Long-Term Atmosphere-Surface Transfer Monitoring in Salento Peninsula (Southern Italy)

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The micrometeorological base of ISAC-CNR in Lecce, southeast of Italy, has been active since 2002, in collecting experimental data about surface-atmosphere transfer of momentum heat and water vapour. It operates in a suburban site inside the Salento University campus and has been improved along the past years in terms of active sensors to give a quite complete description of the soil-atmosphere vertical transfer. It is composed by a 16 m mast with fast response (eddy correlation) instrumentation and an ancillary automatic meteorological station collecting also soil data at 2 levels of depth. Fast response data are preprocessed in half-hour averaged satistics and stored in a web database. At present, the Lecce database is also a pilot reference structure for the Climate Change Section of the CNR-DTA GIIDA project (Integrated and Interoperative Management of Environmental Data project, Earth and Environment Department, National Research Council), aimed to build a spatial data infrastructure between different CNR-DTA structures collecting environmental data. It is also a data provider for the Hymex project database (Hydrological Mediterranean Experiment).

1. Introduction

Surface-atmosphere transfer fluxes are the main input/output of atmospheric energy and water vapour, and they are at the same time effects and causes of the larger-scale atmospheric motions. Indeed the radiative energy from the solar source transforms into conductive/turbulent vertical fluxes of heat and vapour after impinging on the earth surface, and momentum fluxes are constantly exchanged due to the friction between wind and earth surface [1].

Although mainly responsible for the climatic conditions in the lower atmosphere, surface fluxes are subject to change due to local changes in land use and water moisture availability at ground level causing in turn changes in larger-scale climatic conditions driving atmospheric winds and precipitations [2].

The eddy covariance technique for direct field measurement of the surface turbulent fluxes spread out in the early 1980s, and in the following years, many studies improved its reliability, concerning density, spectral, and vertical velocities corrections for the measured fluxes [3–5].

In the decade of 1990s, this improved knowhow led to a general increased technique reliability and applicability [6, 7]. This fact, together with the increasing concerns about the climate effects of the global warming with interest in quantifying large-scale CO_2 and water vapour surface exchanges, led to the creation of several international networks for continuous long-term flux monitoring (FLUXNET, EUROFLUX, and AmeriFlux) as well as long lasting regional soil-vegetation-atmosphere transfer experiments (LBA) (http://fluxnet.ornl.gov, http://www.unitus.it/dipartimenti/disafri/progetti/eflux/euro.html, http://public.ornl.gov/ameriflux/, http://www.lbaeco.org/lbaeco/). Nevertheless, together with these great international successfully efforts, some regions are still out of the long-term network monitoring, even where routine surface meteorological monitoring has been present for a long time.

Focusing on Europe, a glance to the site maps for the existing networks shows that all sites concerning the Italian peninsula are located between the north and the centre of the country, with almost no site being in the southern regions that have quite different climatic conditions and also different projections for the future climate, compared to the rest of the country. In particular, Salento peninsula has quite characteristic climatic features, due to its position in the Otranto channel, with moderate northern dry winds typically blowing in high-pressure conditions, with consequent very clear skies and strong insolation, and scarcity of precipitations due to the lack of relevant orography and the blocking effect of the Apennines for the incoming Atlantic moisture. This is accompanied however by a relevant low-level nocturnal surface moisture deposition due to the anywhere close surrounding seas and the relevant diurnal thermal cycle above the ground [8] that may result in a significant fraction of the surface moisture supply in dry summer periods.

The CNR ISAC micrometeorological base is placed in a suburban area 5 km southwest from Lecce, within the Salento University campus (Latitude: $40^{\circ}20'12''$; Longitude: $18^{\circ}7'17''$) characterized by mixed typical local vegetation (Mediterranean shrubs, pines, and olive trees) with an increasing content of buildings and nonnatural surfaces that makes it interesting also from a land-use change study point of view. Buildings and trees have an average height of about 10 m and with estimated roughness length z_0 and displacement height d of about 0.5 m and 7 m, respectively [9], which can change with changing land use around. The database is at present a data provider for the Hymex project long-term campaign (Hydrological Mediterranean Experiment, http://www.hymex.org/) and also a pilot reference for the CNR DTA GIIDA project (Integrated and Interoperative Management of Environmental Data project, Earth and Environment Department, National Research Council).

2. Methodology

At present the station is mainly devoted to water and energy surface-atmosphere transfer.

It is composed by two complementary systems. A 16 m height mast is equipped with a fast response eddy covariance system and standard meteorological instruments routinely collecting half-hour averaged data. The mast height allows a flux footprint fetch of the order of several hundreds of meters [10, 11], thus taking contributions from the campus and some immediately surrounding vegetated areas. Data are collected and processed in a local netbook by homemade software developed in the LabWindows platform that allows an easy user-friendly real-time control of measurements as well as of the basic user parameters such as calibration constants and averaging periods. After processing and averaging, they are stored in a daily data file. An ancillary Campbell meteorological station collects also standard meteorological and soil surface data in a dedicated datalogger. The connection to the web database is made by an additional local low-power computer interacting with the datalogger through homemade software to collect the ancillary station data and downloading also the eddy covariance daily data file. Both data files are stored in local memory and then transferred to the web database once per day through UMTS connection system. The whole local system is totally solar energy powered.

The web database has been developed in by the Open-Source MySQL with a logic structure able to catalogue tables of data and information (metadata) for each kind of sensor. Before final storage, data pass through a light quality control to eliminate out-of-range data generated by possible problems in the sensors.

Details of the instrumentation are the following.

First is the telescopic mast with fast response instrumentation. It is a 6-element telescopic mast of 16 m height in full extension, with 3 possible measurement levels. In the upper level, one has the following: (1) one Solent-Gill 20 Hz ultrasonic anemometer and one Campbell Kh20 Krypton hygrometer for open path optical measurements of water vapour turbulent fluctuations; both instruments constitute the core of the eddy covariance system, (2) one surface temperature sensor Everest 4000 GL, measuring the radiative surface temperature by a blackbody-like internal cavity, (3) one net radiometer (Siap-Micros Radnt), measuring the difference between the total radiation (short and long wavelengths) emitted from the sky and from the earth surface; on-site calibration is periodically performed by comparison with a reference radiometer, and (4) one slow response thermohygrometer for the air temperature and moisture (Rotronic MP100); calibration is periodically performed for the humidity sensor; temperatures are controlled periodically by cross-comparison and comparison with sonic temperature.

Eddy covariance data statistics are output in half-hour averages as a compromise between nocturnal and diurnal turbulence time scales, although there are some evidences that longer averaging periods could be required to ensure a better surface energy budget closure especially in diurnal conditions. For this same reason, no detrending or filtering is applied to raw time series [12]. The obtained half-hour statistics are then rotated in the streamline coordinate system [13] before storage in the daily data file.

Second is the automated meteorological station. It is equipped with standard meteorological sensors and soil data sensors. Standard sensors (2-meter height) are as follows: cup anemometer (Campbell A100R), windvane (Campbell W200P) thermohygrometer (Rotronic MP100), global (Campbell LI200X) and net radiometer (Rebs Q∗7.1, periodically calibrated on site by comparison with a reference sensor), precipitation gauge (EM ARG100, periodically calibrated on site), and barometer (Campbell PTB101B).

Soil sensors are devoted to collect temperature, moisture, and heat flux data at 2 levels underground: (1) two thermistor temperature sensors (Campbell107L, 2 and 5 cm depth), (2) two thermopile soil heat flux sensors (Hukseflux HFP01, 2 and 5 cm depth), and (3) two moisture content capacitive sensors (Decagon EC-5, 2 and 30 cm depth). On-site calibration has been performed by comparison with soil samples with weighted moisture content.

Data are acquired and half-hour averaged on a dedicated Campbel CR10-X datalogger expanded with a multiplexer.

3. Dataset Description

The dataset associated with this Dataset Paper consists of one item which is described as follows.

Dataset Item 1 (Table). The enclosed dataset is a one-year (2011) sample from the complete dataset of the web database. The data are rounded up according to the accuracy of each measurement sensor that can be considered about five times the last significant digit in the dataset, with the exception of the precipitation data in which uncertainty is twice the last digit. However, for eddy covariance measurements, the statistical uncertainty can be much greater than the sensor accuracy [4–7, 12]. After Date and Local Solar Time (end of the measurement period), the dataset contains the columns of half-hour averaged variables in the following order. Wind Direction was measured at 14 m height above ground, in degrees clockwise from north (manufacturer calibration); Soil Heat Flux, 2 cm depth underground (manufacturer calibration); Potential Temperature Flux, 14 m height above the ground (manufacturer calibration); and Water Vapour Flux, 14 m height above ground (manufacturer calibration). Precipitation Amount was measured in millimeter, half-hour total (manufacturer calibration), and Atmospheric Pressure was measured in hectopascal (manufacturer calibration). Net Radiation was measured at 2 m height above ground from Rebs net radiometer (on-site calibration); Reynolds Stress, 14 m height (manufacturer calibration); Air Temperature, 14 m height (manufacturer calibration); Soil Temperature, 2 cm depth underground (manufacturer calibration); Relative Humidity, 14 m height above ground in percentage of the saturation value (on-site calibration); Soil Moisture, 2 cm underground (on-site calibration); and Wind Speed, 14 m height above ground (manufacturer calibration). The number −9999 in the dataset identifies missing or invalid data.

Column 1: Date

Column 2: Local Solar Time

Column 3: Wind Direction (°)

Column 4: Soil Heat Flux (Wm^{-2})

Column 5: Potential Temperature Flux ($m\,K\,s^{-1}$)

Column 6: Water Vapour Flux ($g\,s^{-1}\,m^{-2}$)

Column 7: Precipitation Amount (mm)

Column 8: Atmospheric Pressure (hPa)

Column 9: Net Radiation (Wm^{-2})

Column 10: Reynolds Stress ($m^2\,s^{-2}$)

Column 11: Air Temperature (°K)

Column 12: Soil Temperature (°K)

Column 13: Relative Humidity (%)

Column 14: Soil Moisture ($m^3\,m^{-3}$)

Column 15: Wind Speed ($m\,s^{-1}$)

4. Concluding Remarks

The collected dataset has been already used in past years for studies regarding different characteristics of the local atmospheric boundary layer [9, 12, 14, 15]. Since the last year, measured data are routinely provided to Hymex project database. At present, ongoing studies are undertaken on characterizing and modelling evapotranspiration and surface heat flux partition in the warm-arid region of the base area and on how the surface transfer is affected by increasing surrounding urbanization.

Dataset Availability

The dataset associated with this Dataset Paper is dedicated to the public domain using the CC0 waiver and is available at http://dx.doi.org/10.7167/2013/946431/dataset. Additional data are available in the Base Sperimentale database at http://www.basesperimentale.le.isac.cnr.it/ and are also available on the Hymex site for subscribed users (http://mistrals.sedoo.fr/HyMeX).

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