TEN YEARS SURFACE-ATMOSPHERE WATER BUDGET FROM THE ISAC MICROMETEOROLOGICAL BASE IN SALENTO PENINSULA AND COMMENTS ON THE AQUIFER BALANCE.

P. Martano, M. Delle Rose, C. Elefante *, F. Grasso

CNR-Istituto di Scienze dell’Atmosfera e del Clima - UOS Lecce, Via Monteroni, 73100 Lecce, Italy
*Ripartizione Informatica, Università del Salento, Viale Gallipoli 49, 73100 Lecce, Italy.
Salento is a plane area at the southern end of Apulia region, south-east of Italy. Mediterranean climate, 650 mm precipitation annual average.

The base (dot) is located at about 5 km west from Lecce (N40°20’11”; E18°07’21”) within the Salento University campus in a suburban green area characterized by a mixture of Mediterranean vegetation (shrubs, short olive trees, pine trees) alternated by connection roads and two-story buildings.

*Salento peninsula with averaged precipitations (1921-1996). The dot indicates the measurement site.*
THE MEASUREMENT SITE: underground

-Geological scheme of the Salento peninsula. 1, Main Faults; 2, Tertiary and Quaternary carbonates and marly deposits; 3, Miocene carbonates; 4, Cretaceous carbonates. Dot indicates the location of the micrometeorological station.

-Hydro-geological scheme. The lowered block (graben) made up by different stratigraphic units has a complex groundwater circulation compared to the uplifted block (horst) that contains only the diffusely karstified deep aquifer.
Telescopic mast with fast response instrumentation

It is a 6-elements telescopic mast of 16 m height in full extension equipped with a 20 Hz ultrasonic anemometer, a fast Krypton hygrometer, a surface radiative temperature sensor, a net radiometer a slow response thermohygrometer. Data are collected and processed by a dedicated notebook with a dedicated software that allows automated statistical averaging (half-hour) in the ‘streamline’ coordinate system.

Automated Meteorological Station.

It is equipped with standard meteorological sensors and soil data sensors. Standard sensors: cup anemometer, thermohygrometer, global and net radiometers, rain gauge, barometer. Soil sensors are devoted to collect temperature, moisture and heat flux data at 2 levels depth: 2 thermistor temperature sensors, 2 moisture content capacitive sensors 2 thermopile soil heat flux sensor. Data are stored and half-hour averaged on a dedicated datalogger expanded with a multiplexer.
CALIBRATIONS.

Termometers: controlled by comparison with mercury cell

Standard hygrometer: laboratory calibration in airtight mini chamber

Fast Krypton Hygrometer: continuous field calibration monitoring by comparison with standard hygrometer

Soil moisture sensors: calibration in water content controlled (by precision weigh) local soil samples

Radiometers: Field calibration controlled by comparison with reference instrument

The micrometeorological station is totally solar powered.
DATA PROCESSING

Data are averaged stored in datalogger (meteorological station) and a dedicated netbook for a fast response processing (eddy correlation system) with a labwindows developed software.

Up to second order statistics are computed in real time for all fast response data $<v>$, $<vv>$, $<T>$, $<TT>$, $<vT>$, $<q>$, $<Vq>$, $<qq>$, $<qT>$, etc.

At the end of the chosen average time (30 minutes) the calculated statistics are used to:

1) Build the streamline rotation matrix
2) Output the average moments in the streamline system (McMillen, 1988)

$$Us = |V|, Vs=0, Ws=0$$

$$<vw>_s = 0$$
THE DATABASE
Data are sent to the database once per day by UMTS connection and stored after a quality check (www.basesperimentale.le.isac.cnr.it). They are available also in the HyMeX database, updated every 6 months (http://mistrals.sedoo.fr/HyMeX/).
**Timeseries processing: SPECTRAL CORRECTIONS**
(simplified formula, after Massman, AFM 2000)

- Applied to turbulent heat fluxes as they can generate relevant errors in annual cumulants.
- \( z/L > 0 \)
  - \( f_x = \frac{(u_u/zz)^*(-1.92/(1+0.5*z/l))}{z/L < 0} \)
    - \( f_x = 0.855u/z \)
- \( b = 2\pi*taublock*fx = 1800*6.28*fx; \)
- \( p = 2\pi*taulatsep*fx = 6.28*fx*0.15/u; \) (taulatsep>>tausonicpath)

\[ spcor = \frac{b}{(b+1)} \frac{b}{(b+p)} (p+1) \]  
(no trend removal term)  
(\textit{Cava et al.}, AFM, 2008)

Webb correction also applied to the real evapotranspiration flux \( Evr \) (Webb et al., 1980)

\[
Evr = \left(1 + \frac{1.6\rho_w}{\rho_a}\right) \left[<w'\rho'> + (\rho_w/T) <w'T'>\right]
\]
Timeseries processing: UNCERTAINTY ESTIMATIONS

Uncertainties in the annual/seasonal averages are estimated as the maximum between the measurement uncertainty and the uncertainty due to gaps of lacking data. Statistically significant trends in the averaged time series are verified by two independent tests.

- Uncertainty = \text{max}(\text{meas.err.}, \text{gaps.err.})
- For slow response sensors:
  Measurement errors = sensor uncertainty
- For eddy correlation data
  Measurement errors = stat. uncertainty in the eddy corr. averaging period (n data)
  Fluxes: \text{meas.err.} = \sqrt{\langle (q'w' - \langle q'w' \rangle)^2 \rangle}/n = \sigma_q \sigma_w \sqrt{n} + |\langle q'w' \rangle|/\sqrt{n}
- Data gaps uncertainty (dN data missing for N total data, dN<<N):
  Gapserr = \sigma_N \sqrt{dN/N} \quad \text{for N-average values}
  Gapserr. = |\text{MEAN}|*dN \quad \text{for N data sums.}
SOME DERIVED INDICES

- EVAPORATIVE FRACTION \( EVF = \frac{LE}{(LE+H)} \)

- ARIDITY INDEX \( AI = \frac{\text{Precipitation}}{\text{PotentialEvapotransp}} \)

- WATER STORAGE FRACTION \( WSF = \frac{\text{Prec.} - \text{Evapotr.}}{\text{Prec.}} \).

- PRECIPITATION INTENSITY \( Pl = \text{wet days average prec.} \)
  \( \text{wet day: prec.} > 1 \text{mm} \)

- NORTH ATLANTIC OSCILLATION INDEX (from WEB)

\( NAO = \text{normalized sea level pressure difference between Lisbon, Portugal and Stykkisholmur/Reykjavik, Iceland} \)
Over the ground: EVAPORATIVE FRACTION AND REAL EVAPOTRANSPIRATION TRENDS

A tendency to a global decreasing of the evapotranspiration has been pointed out by:

**Jung et al.**: Recent decline in the global land evapotranspiration trend due to limited moisture supply. Nature, 2010
doi: 10.10138nature0936

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**Graph Description**
- **Evaporative Fraction** (circles) and **Real Evapotranspiration** (squares).
- Not significant trend (possible no tendency).
Over the ground: PRECIPITATION, WATER STORAGE (infiltration) FRACTION AND ARIDITY INDEX TRENDS

precipitation (circles), water storage fraction (squares) and aridity index (triangles). fairly significant trend (improbable inverse tendency)

aridity index versus soil moisture (year ave). corr=0.85
Over the ground: PRECIPITATION INTENSITY AND NAO TRENDS

Local climatic projections still uncertain: statistical downscaling suggests an increasing precipitation over Puglia region, especially in summer (L Palatella, M Miglietta, P Paradisi P.Lionello: Climate change assessment for Mediterranean agricultural areas by statistical downscaling. Nat. Hazards and Earth System Sciences, 2010)
Under the ground:......what’s happening in Salento’s groundwater deep aquifer?

Salento is a karstic area...more then 80% fresh water coming from deep underground aquifer ....evidence of increasing salt content (from marine water intrusion due to decreasing aquifer pressure) in almost all deep water wells in the past decades.... (Margiotta and Negri, 2004)

...and also in the last decade (chemical analyses from one sixty meters deep well water sample...:

<table>
<thead>
<tr>
<th>year</th>
<th>hardness (F)</th>
<th>Cl(mg/l)</th>
<th>resid180°(mg/l)</th>
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<tr>
<td>2004</td>
<td>39</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>2014</td>
<td>43</td>
<td>125</td>
<td>730</td>
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</tbody>
</table>
Over and under the ground: PUTTING EVERYTHING TOGETHER

• Evapotranspiration and evaporative fractions do not show increasing trends although precipitations are likely increasing, because of ➔

• Precipitation INTENSITY increasing (decreasing NAO) in a semiarid karstic mediterranean region, implies ➔

• Water Storage Fraction (infiltration) likely increasing together with Aridity Index likely decreasing, that is ➔

• Increasing deep aquifer water storage availability but decreasing soil surface moisture content. It suggests ➔

• Water drainages for agricultural/general use are increasing the salinity of the aquifer even in conditions of increasing water storage availability. A WARNING FOR THE FUTURE!
THANK YOU!