OBSERVING ACTUAL EVAPOTRANSPIRATION WITHIN A HILLY WATERSHED: CASE STUDY OF THE KAMECH SITE, CAP BON PENINSULA, TUNISIA

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Plan

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   - Gap filling methods

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1.1 Actual evapotranspiration ETa

Water scarcity increases → Need to observe water cycle components in order to diagnostic processes and pronostic future trends

Hydrological observatories increases but ETa is rarely observed

Flux tower observatories increases but few are in agricultural system and under hilly topography

Agricultural hilly watersheds are widespread on Earth and allow intensification of agriculture
1.2 Long term series ETa under hilly topography

**Eddy covariance (EC) techniques**
permit continuous monitoring of land surface fluxes, including ETa

**EC Missing data**
sensor or power failures, maintenance and calibration procedures, improper weather conditions, and rejection of data induced by quality checks.

For hilly conditions

Necessary to adapt correction methods for EC measurements, or to account for footprint changes according to wind direction.

For long term series

Several gap filling techniques are proposed in littérature but existing gap-filling methods have not been examined over hilly cropping systems.
2. Objective

Obtaining continuous ETa time series from Eddy Covariance measurements collected within a small hilly watershed, which implied adapting gap-filling techniques to these particular conditions.
3. Experiments and methodology

3.1 Study site: Kamech agricultural watershed
3.2 Instruments: Flux tower
3.3 Flux calculations
3.4 Gap filling methods
3.1 Kamech agricultural watershed

http://www.obs-omere.org

area of 2.45 km²
Hilly topography
Rainfed

Crops

Cereals: Wheat/Oat/Barley
Legumes: Favabeans/ Chickpeas
Rangeland: natural vegetation

Climat

Annually averaged over the 2004-2014 period
Precipitation 680 mm
Penman-Monteith reference evapotranspiration 1366 mm

two dominant wind directions, that might interact with the hilly topography.
3.2 Eddy covariance flux tower

Data collected from: 04/2010 to 08/2013

Open path gas CO₂ / H₂O analyzer (LI-7500, LiCor Biosciences, USA)
3D anemometer (CSAT3, Campbell Scientific, USA)
3.3 Flux calculations

Raw EC data: vertical wind speed, air temperature and humidity

Flux calculation and corrections

ECpack
ECpack library version 2.5.22

Contrôl quality
Steady State test
Integral Turbulence characteristics test

Hourly convective fluxes
sensible heat (H) and latent (\(\lambda E\))

With missing data 53% for H and 78% for \(\lambda E\)
3.4 Gap filling

Model of Gap-filling

1
Original version (with all data)

2
Separation of wind direction

H_{REP} and \lambda E_{REP}

H_{RNS} and \lambda E_{RNS}

Hourly data (\lambda E and H) reconstructed

\lambda E = ETa and H

24 h and monthly

Reichstein et al. (2005)
REddyProc package
4. Results

4.1 Climatic conditions
4.2 Gap filling
4.3 Seasonal variations of daily surface fluxes
4.4 Monthly evapotranspiration
4.1 Climatic conditions

As a typical Mediterranean site, two contrasting periods were clearly distinguished:
- a little evaporative demand (ET0) and available water (humid period) (from October to April)
- a high evaporative demand and dry period (from May to September).

ET0 is almost similar between the four years of the experiment

Rainfall shows differences during humid period but it is almost null during summer
4.2 Impact of taking into account the wind direction in REddyProc

**Sensible heat (H)**

- **Hourly**: Differences observed when discriminating wind direction for H and $\lambda E$

- **Daily**: No differences observed

- **Monthly**: No differences observed when discriminating wind direction for H and $\lambda E$

**Latent heat ($\lambda E$)**

- **Hourly**: Differences observed when discriminating wind direction for H and $\lambda E$

- **Daily**: No differences observed

- **Monthly**: No differences observed when discriminating wind direction for H and $\lambda E$
4.3 Seasonal variations of daily surface fluxes

The time series of $H$ and $\lambda E$ emphasized the high consistency of the land surface fluxes obtained over this hilly watershed.

REddyProc was able to gap-fill missing flux data most of the time, except when the duration of the periods with missing data were too long.
4.4 Monthly evapotranspiration

ETa deduced from EC measurements exhibited a very good consistency for the four years. Clear and coherent seasonal variations of the ratio $\text{ETa}/\text{ET}_0$

Maximum of Eta is reached on April, it is the maximum of vegetation growth for the rainfed crops of the watershed.

In August, for bare conditions, Eta is 1 mm for the four years.
5. Conclusion

5.1 Methodological conclusion
5.2 General conclusion
5.1 Methological conclusion

The REddyProc method was chosen to gap-fill the missing flux data, but was adapted to our particular conditions by separating the flux dataset between the two dominant wind directions. It was demonstrated that at hourly timescale, it was necessary to discriminate between wind directions. Conversely, the fluxes obtained with or without discriminating wind directions were very similar at daily and monthly timescales.
5.2 General conclusion

Our results gave great confidence in the observation of land surface fluxes by EC measurements over a small hilly watershed.

These flux time series could be further used for validating hydrological models, or for testing water management scenarios to mitigate the effect of global change.
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