Improving estimates of evaporation with the "Bowen ratio" method

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Background

- The application of the *Bowen ratio* method to estimate *evaporation* E is heavily affected by uncertainties on the measured quantities (*net radiation* R_n; *heat flux* G; *air temperature* T_i measured at height h_i; *vapor partial pressure* e_i measured at height h_i and derived from the corresponding *relative humidity* RH_i; *atmospheric pressure* P_a). This is evident by looking at:

$$E = \frac{R_n - G}{\rho_w(1+B)} \qquad \text{with} \qquad B = \frac{C_a P_a}{0.622\lambda_v} \cdot \frac{T_2 - T_1}{e_2 - e_1}$$

  with B *Bowen ratio*, ρ_w *water density*, C_a *specific heat of air at constant pressure per unit mass*, and λ_v *latent heat of evaporation per unit mass*.
- Standard techniques of error propagation can be used to compute δ_E, i.e. the uncertainty on the estimate of E, and to reject the estimated E for the time steps where an acceptance criterion ε is not met and a reliable value of E cannot be computed [1]. For example, the value can be rejected if $\delta_E / E > \varepsilon$. However, simply discarding some values might introduce a **bias** in the **cumulative evaporation** for long time intervals.
- One solution is to use a **Direct Sampling** technique (DS) [2], based on *multiple-point statistics simulation*, to **integrate the time series** of reliable evaporation estimates. In this work we test the application of this technique by exploring the impact that a different threshold of acceptance ε has on the final estimates of evaporation, and the influences of diverse simulation covariates.

Study area and data set

- The application of the DS for the reconstruction of evaporation is tested on a two years long time series (Jun.2009-Jul.2011) of data collected with a hydro-meteorological station located in the Po plain (Italy).
- The variables are collected with a time step of 20'.

Implications of using a different acceptance threshold ε

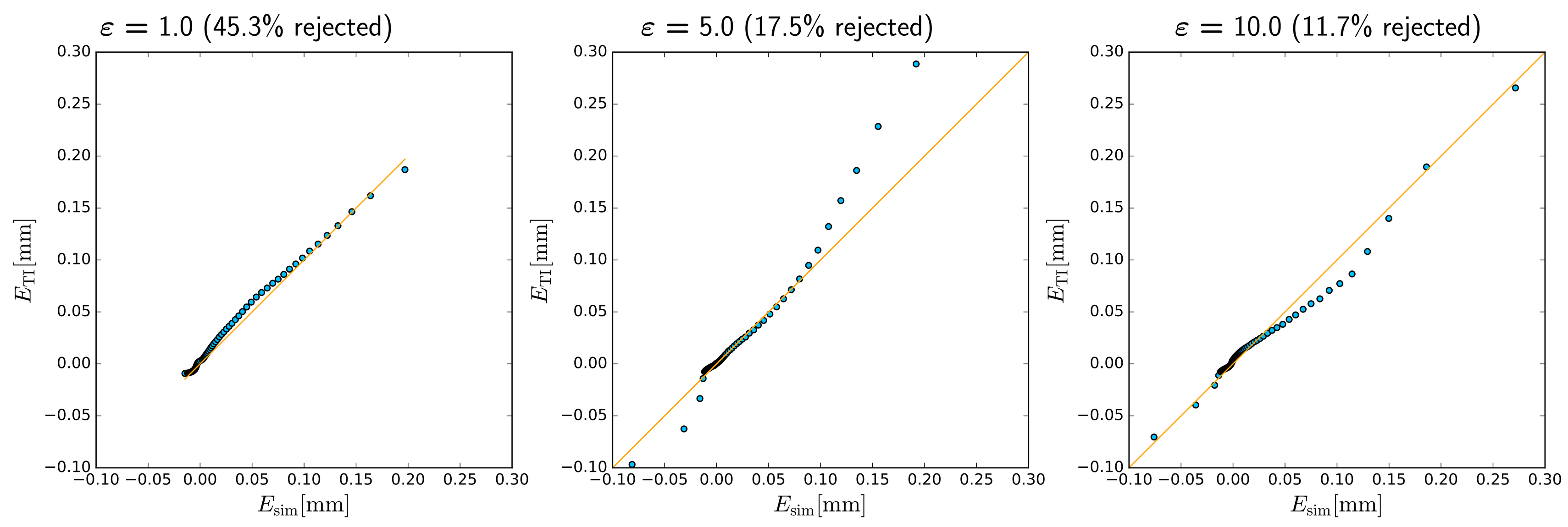

Figure 1: Q-Q plots of simulated E vs. training E for different values of ε.

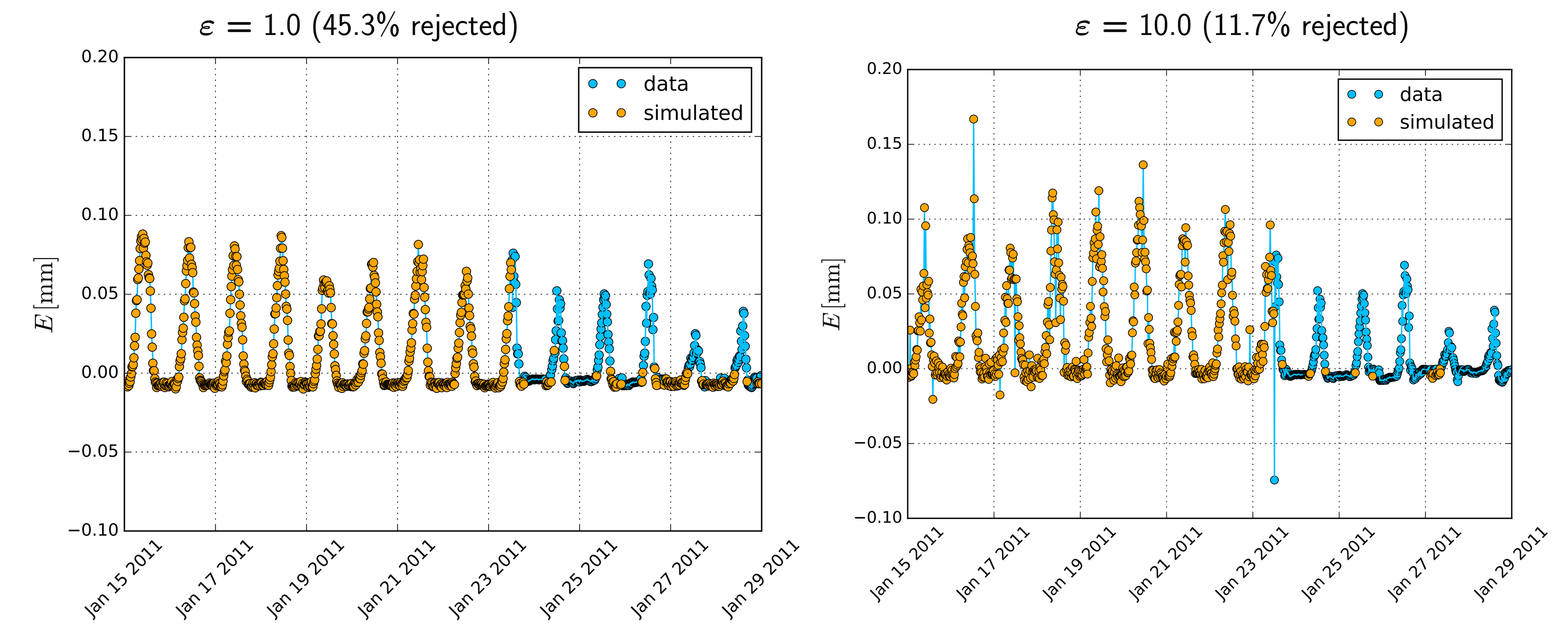

Figure 2: Q-Q plots of simulated E vs. training E for different values of ε.

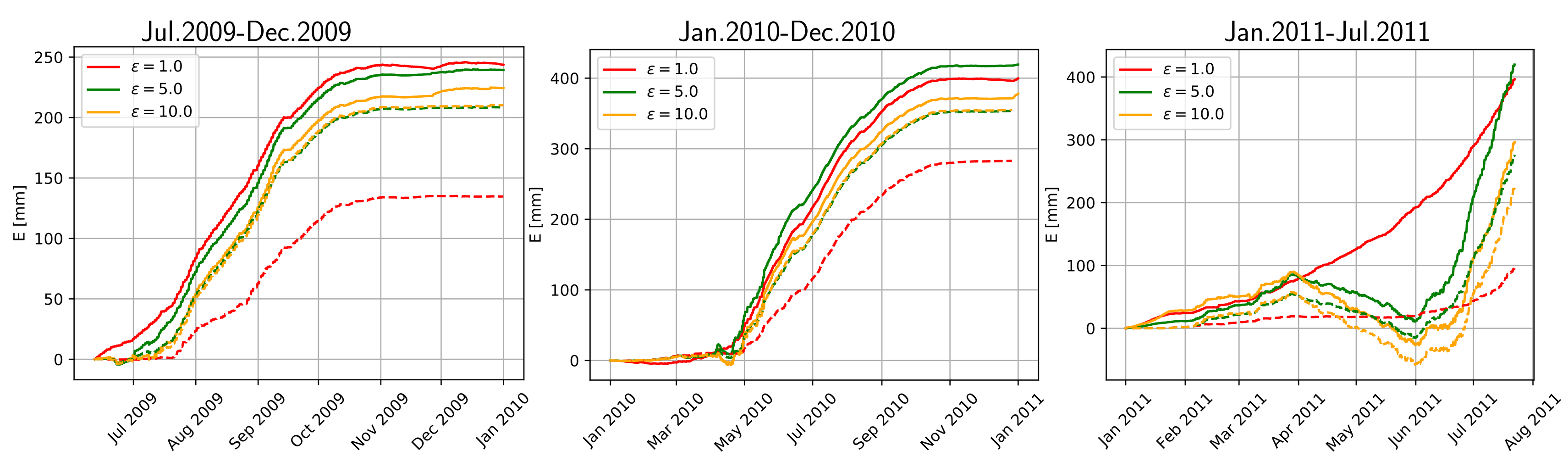

Figure 3: Cumulative E for diverse ε for simulation (continuous) and data only (dashed).

Simulation with covariates

- To better constrain the simulation, the DS method allows to simulate using one or more covariates. Here its performances are tested using as covariate T_1, RH_1, and T_1 together with its moving average (on a 4 weeks window).

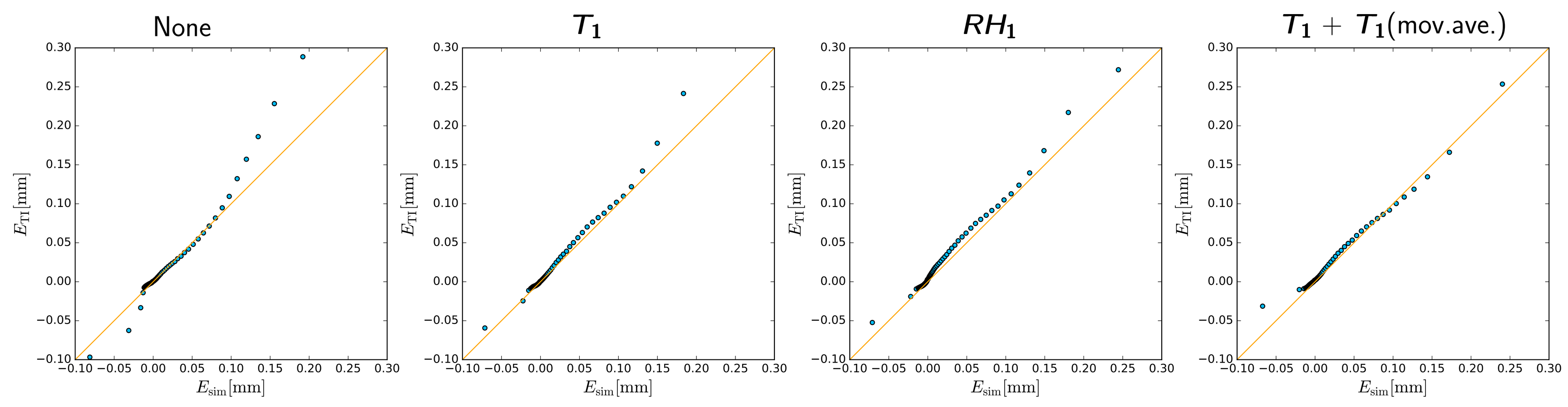

Figure 4: Q-Q plots of simulated E vs training E for diverse combination of covariates (for ε=5.0).

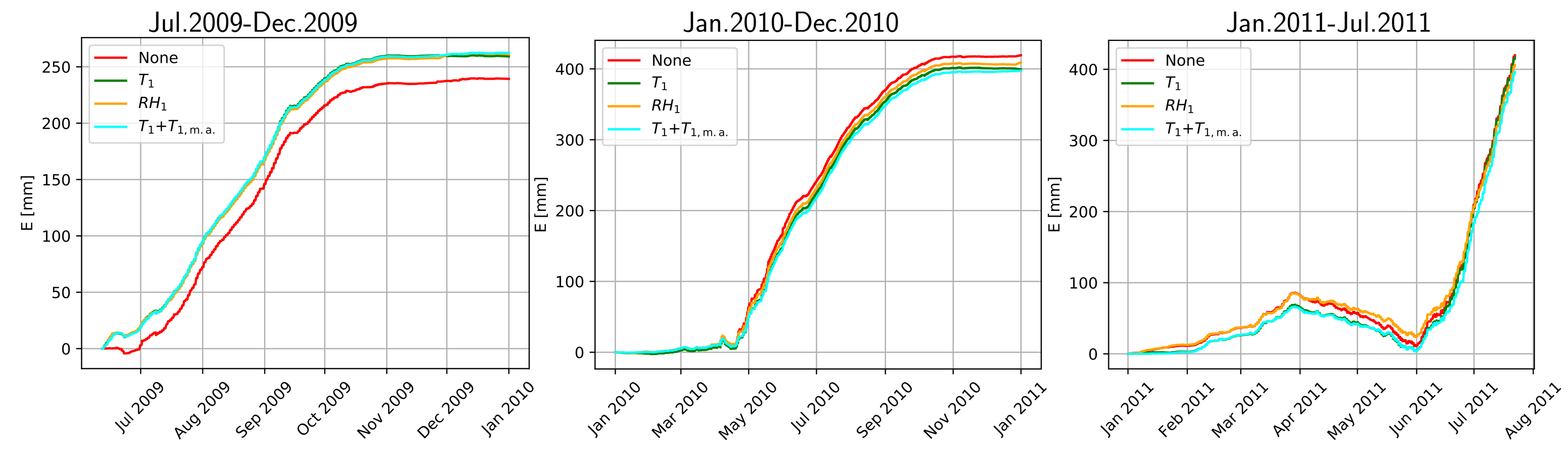

Figure 5: Cumulative E simulated using diverse covariates for the years 2009, 2010 and 2011.

Results so far - Future work

- By simulating the rejected values of E with the DS a reliable complete time series of E can be obtained [Fig. 1 and Fig. 2]. Using the complete time series puts in evidence the underestimation obtained using the rejected values of E only [Fig. 3].
  Unfortunately, a reliable independent estimate or field measurement of E is not available for comparison with the obtained complete time series.
- Including one or more covariate in the simulation procedure can have a noticeable effect, on the cumulative E curves too [Fig. 4 and Fig. 5]. However, so far the use of the covariate has different impacts along the time series [Fig. 5] and therefore its use and parameterization deserve further investigations.
- Here we illustrate only the results obtained by using as covariates RH_1, T_1 and T_1 together with its moving average. We are planning to explore the impact that diverse combinations of the variables measured at the hydro-meteo station can have when included as covariates in the simulation.

References

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Info

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