Seasonality and inter-annual variability of above and below canopy fluxes in a semi-arid oak-savanna forest: What can modeled results tell us on how well we understand ecosystem behavior?

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1. Motivation:

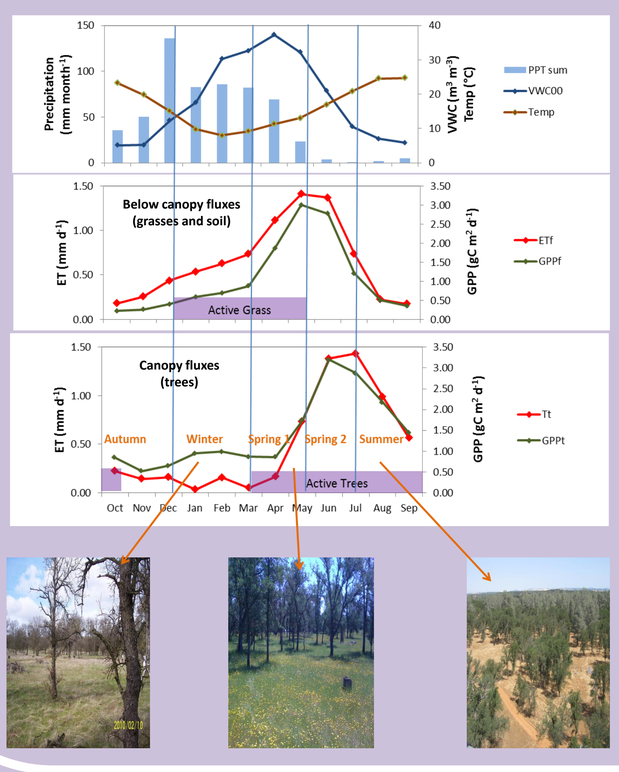
10 years of eddy-flux measurements above and below the canopy enabled to separate fluxes, and produced a platform to investigate:

- Sensitivity of the water and carbon fluxes to climatic variables
- Partitioning of tree and grass fluxes
- Model compatibility to the observed changes

Biometeorological models used for comparison:

BEPS - Chen, J.M and Sonnentag, O. (Department of Geography and Program in Planning, University of Toronto).
3D-CANOAK – Baldocchi, D. and Kobayashi, H. (Department of Environmental Science, Policy an Management, UC Berkeley).

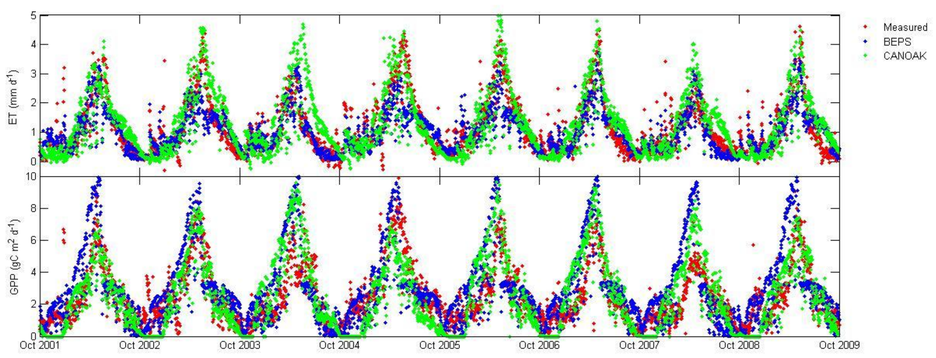
2. Seasonality at Tonzi :



Grasses are active during the wet-soil seasons (winter and early spring). Trees are active during the warm seasons (spring and summer).

This creates a time-based separation of fluxes and large seasonality.

3. Model comparison:

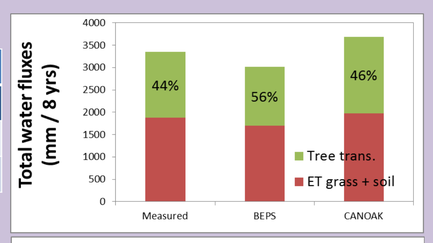


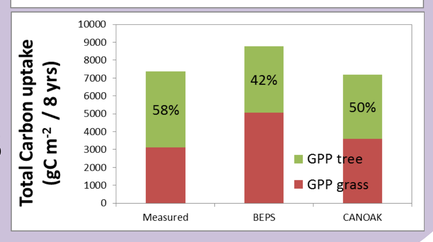
Models successfully reconstructed fluxes and trends.

Water fluxes (ET) were better fitted than carbon fluxes (GPP), by means of correlation (linear regression, R-square) and precision (root mean square error, RMSE):

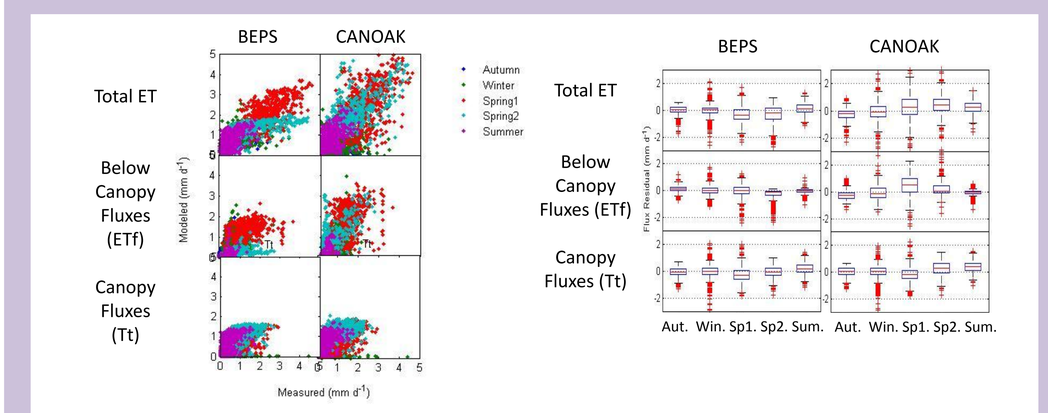
	ET		GPP	
	R-square	RMSE	R-square	RMSE
BEPS	0.656	0.412	0.446	1.727
CANOAK	0.556	0.717	0.554	1.541

Flux partitioning:
For the whole 8-yr period, fluxes from the canopy (trees) accounted for 44% of ET and 58% of GPP.





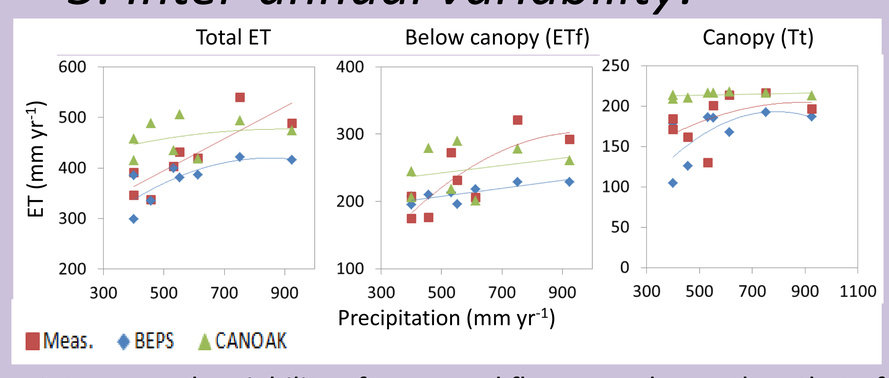
4. How well do models partition fluxes? Reproduce seasonality?



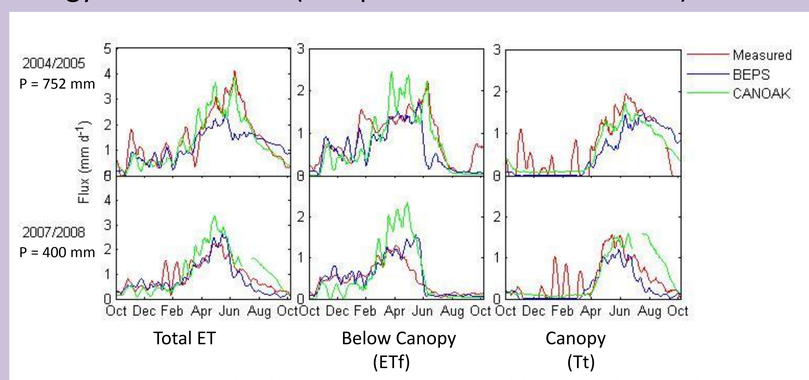
Areas of weakness:

- Partitioning between below and above canopy fluxes decreased models' fit.
- Most problematic was the spring season, having high fluxes and combining fluxes from trees and grasses.
- The 3-D radiative transfer algorithm in CANOAK improved calculations of below canopy fluxes, but also resulted in overestimation of this component during the spring.
- BEPS sensitivity to prescribed phenological changes decreased residuals and noise, but also resulted in underestimation of spring fluxes (see below).

5. Inter-annual variability:



- Inter-annual variability of measured fluxes was larger than that of modeled fluxes.
- The below-canopy component was more sensitive to precipitation changes; the tree component was more conservative. These trends were not captured by the models.
- Below canopy fluxes were underestimated during wet years. This was due to an extended high-flux spring period measured after the change in phenology was observed (and prescribed in the models):



Data smoothed with Savitzky-Golay filter, 21 d period

6. Summary:

- The Mediterranean oak-grass savanna creates a complex ecosystem, highly variably on seasonal and inter-annual scales.
- The below-canopy component (grass and soil) was more sensitive to annual precipitation changes, while the tree component was buffered by groundwater uptake during dry years and a threshold of constant annual fluxes when annual precipitation exceeded ~ 600 mm.
- Models were better in recreating water fluxes than carbon fluxes. Partitioning fluxes decreased fit. Models were less sensitive to inter-annual variability. Prescribing grass die-off, especially during extreme years, produced an error in modeled below-canopy (grasses and soil) fluxes during the spring.