

Ecosystems water vapor fluxes along precipitation gradient  
in the dry Mediterranean region

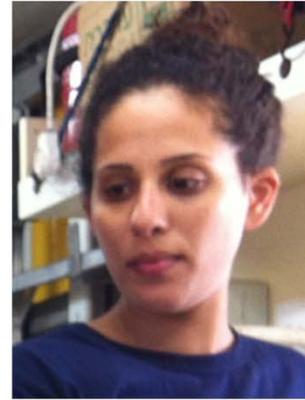
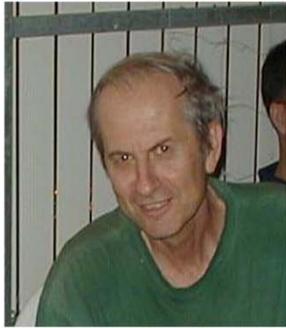


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Rohatyn S, Ramati E, Tatarinov F, Asaf D, Dicken U and Yakir D

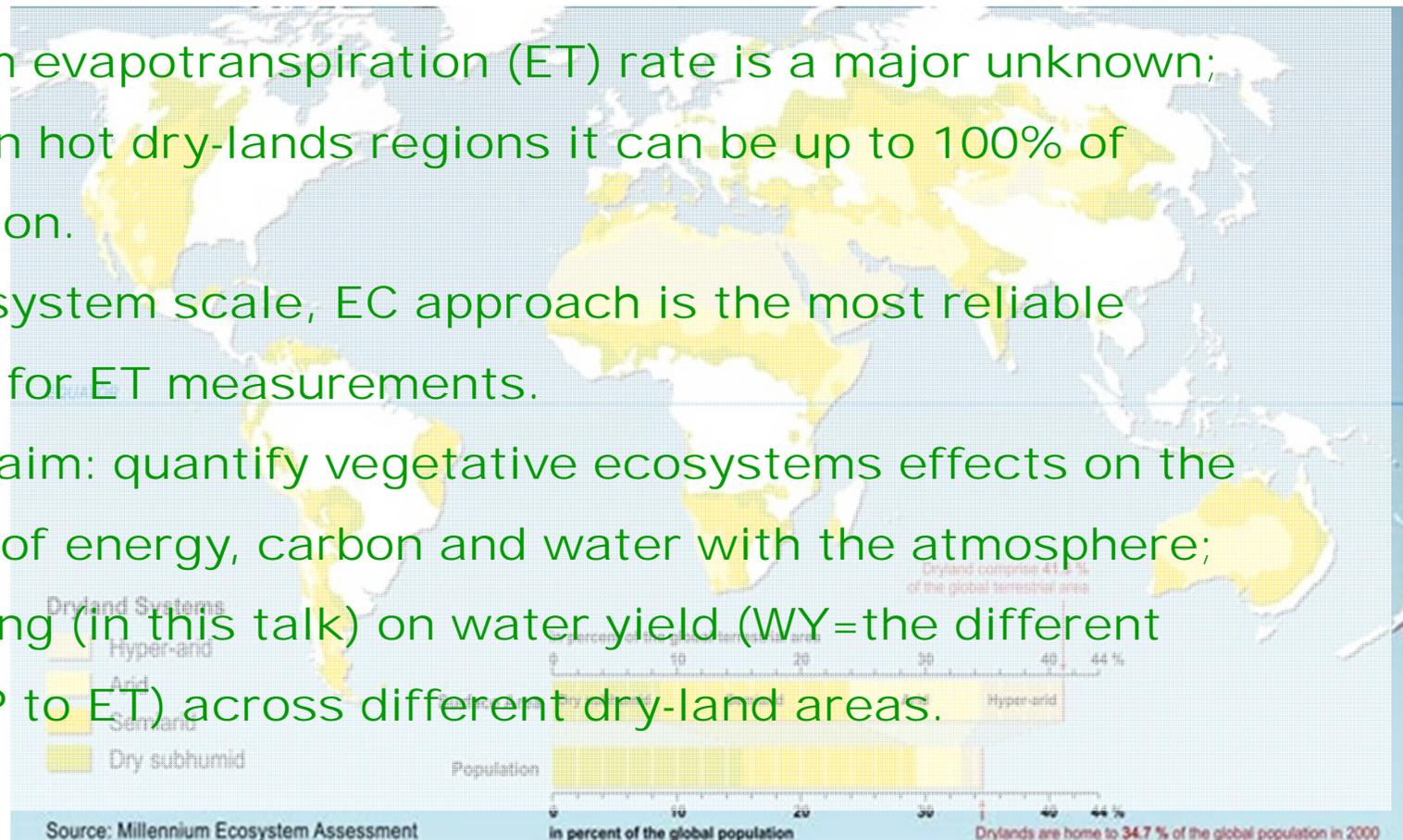
Earth & Planetary Sciences, Weizmann Institute of Science

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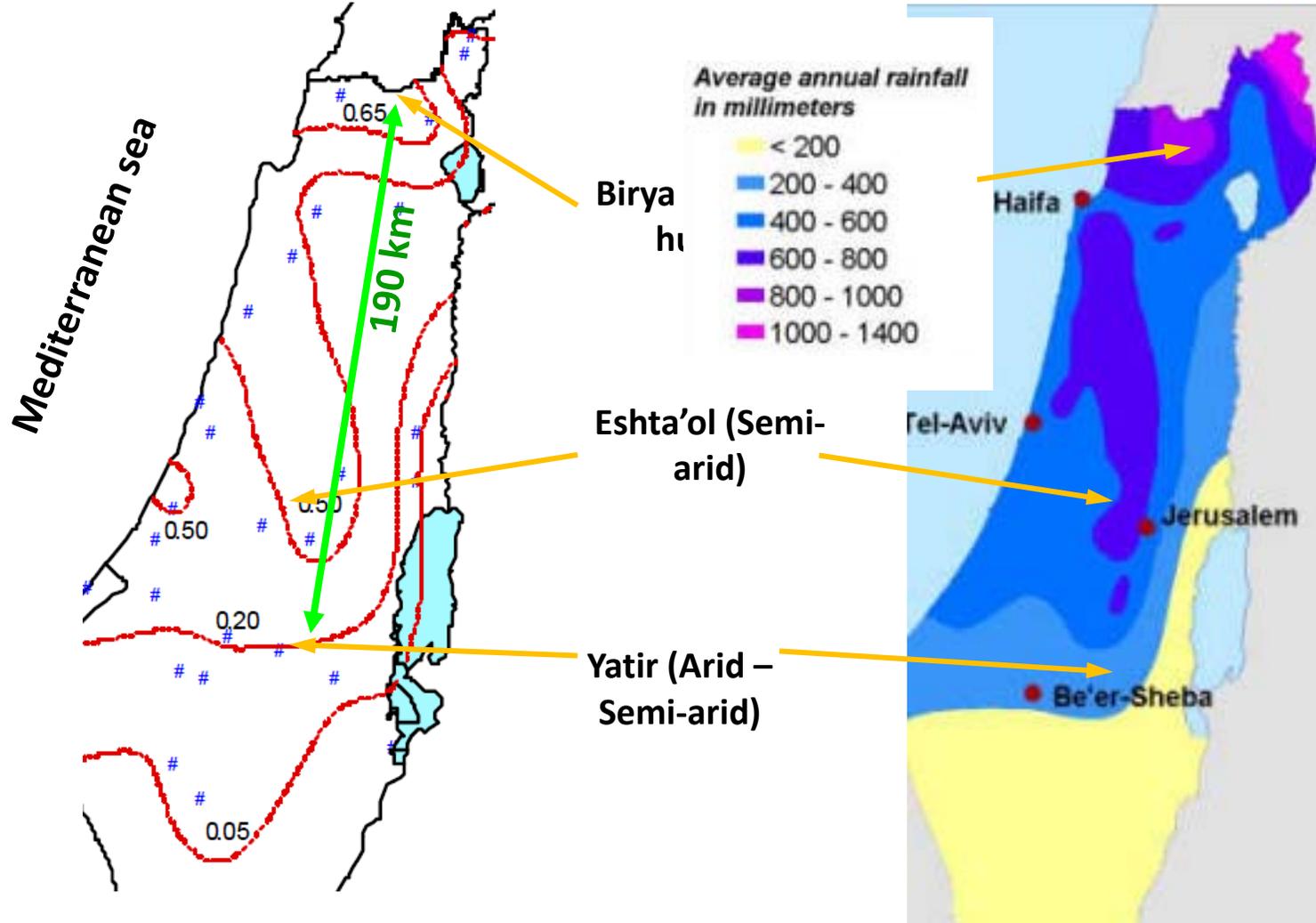
- ♣ Over 40% of the Earth land area is defined as dry land, about 1/3<sup>rd</sup> of the world population lives in these areas.
- ♣ 1/5<sup>th</sup> of the world population lives in countries with water scarcity (regions where annual water supply drops below 1,000 m<sup>3</sup> per person).
- ♣ Climate in these regions is mostly hot, and solar radiation load is high.

- ♣ Ecosystem evapotranspiration (ET) rate is a major unknown; although in hot dry-lands regions it can be up to 100% of precipitation.
- ♣ At an ecosystem scale, EC approach is the most reliable technique for ET measurements.
- ♣ Research aim: quantify vegetative ecosystems effects on the exchange of energy, carbon and water with the atmosphere; emphasizing (in this talk) on water yield (WY=the difference between P to ET) across different dry-land areas.



Israel is located in dry land region with steep rainfall gradient

Flux measurements locations

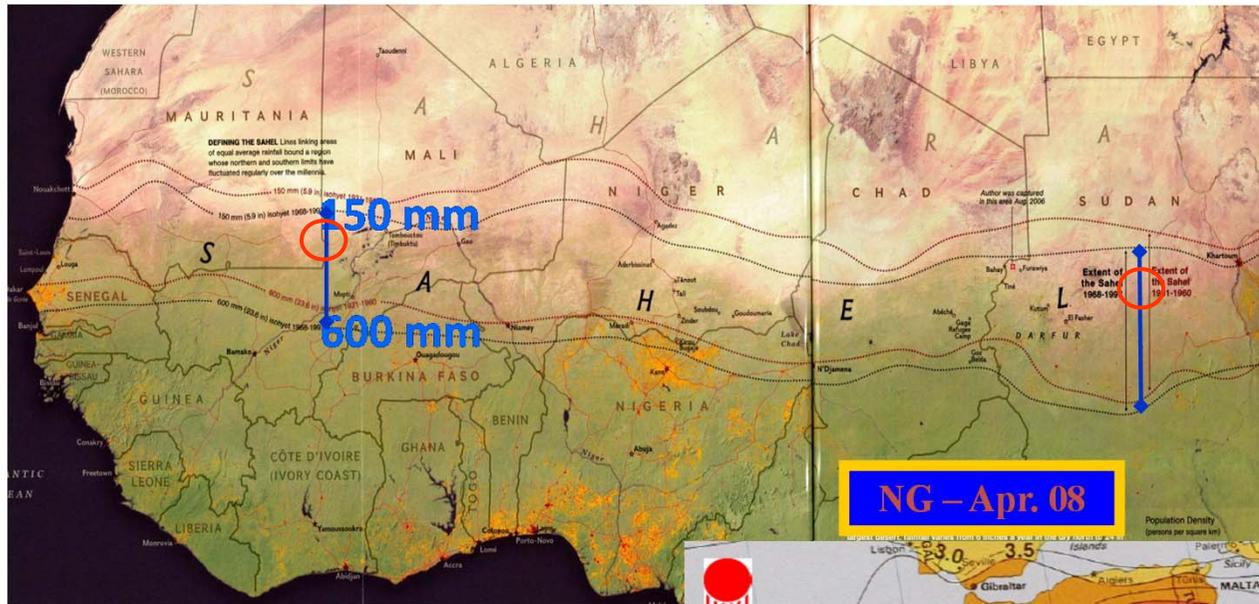


Israel Aridity Factor (AF) - P/PET, average for 1990 – 2000.  
Kafle H., M.Sc. Thesis, BGU

Annual rainfall map

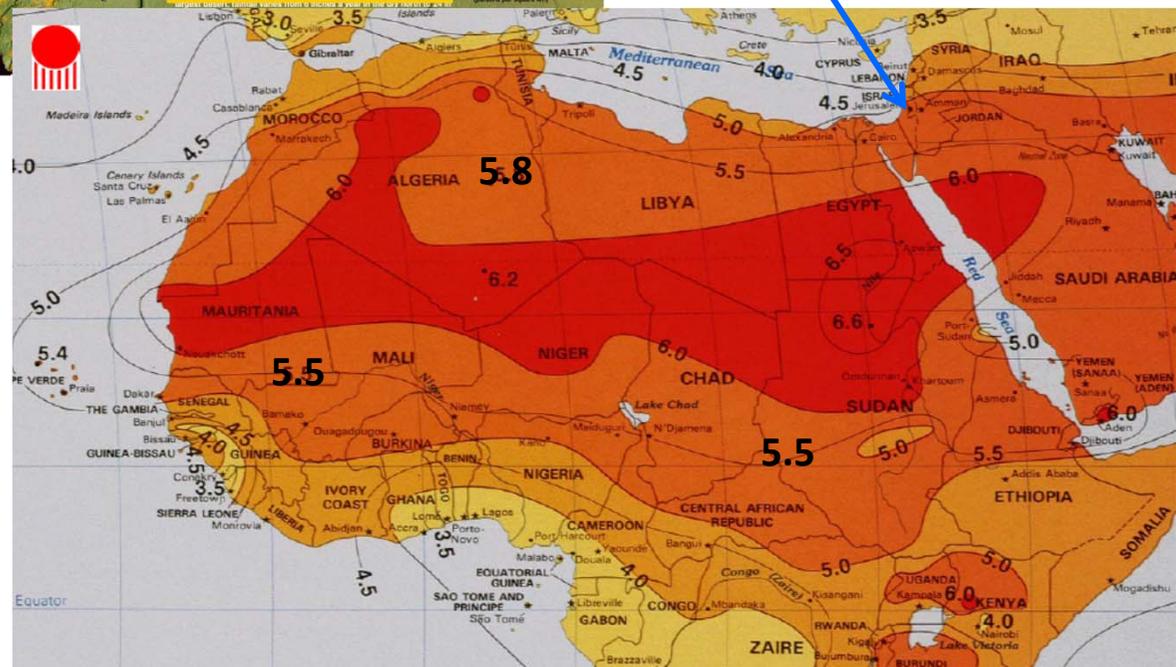
The Sahel, is ~450 km width is similar rain gradient of 150 – 600 mm and same insulation rate.

○ Yatir rainfall - 280 mma



Yatir's  $E_g = 5.7 \text{ KW hrs m}^{-2}\text{d}^{-1}$

The short, ~200 Km, distance AF gradient in Israel is representative of a large part of the Earth dry land conditions.

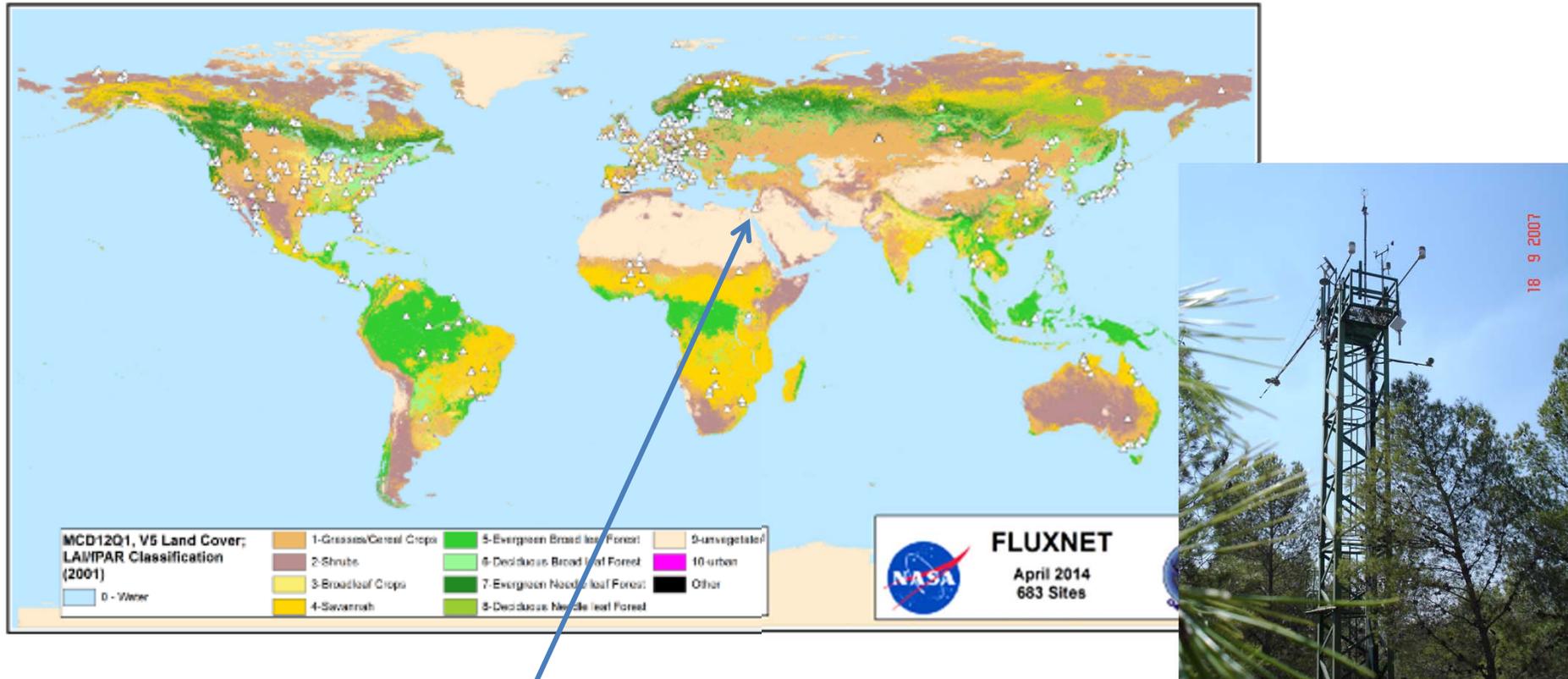


# Dry lands regions are highly fragmented

Long history (over 10,000 y) of human activities and large grazing pressure, major parts of the Mediterranean basin landscapes are fragmented into small size patches of different plant types and kinds.

Approach should be adopted to study the land atmosphere exchange fluxes and WY over fragmented and steep climatic gradient region...





### Yatir forest site

Since summer 2000, we continuously measure fluxes at the edge of the Israeli Negev desert, at the Yatir forest.



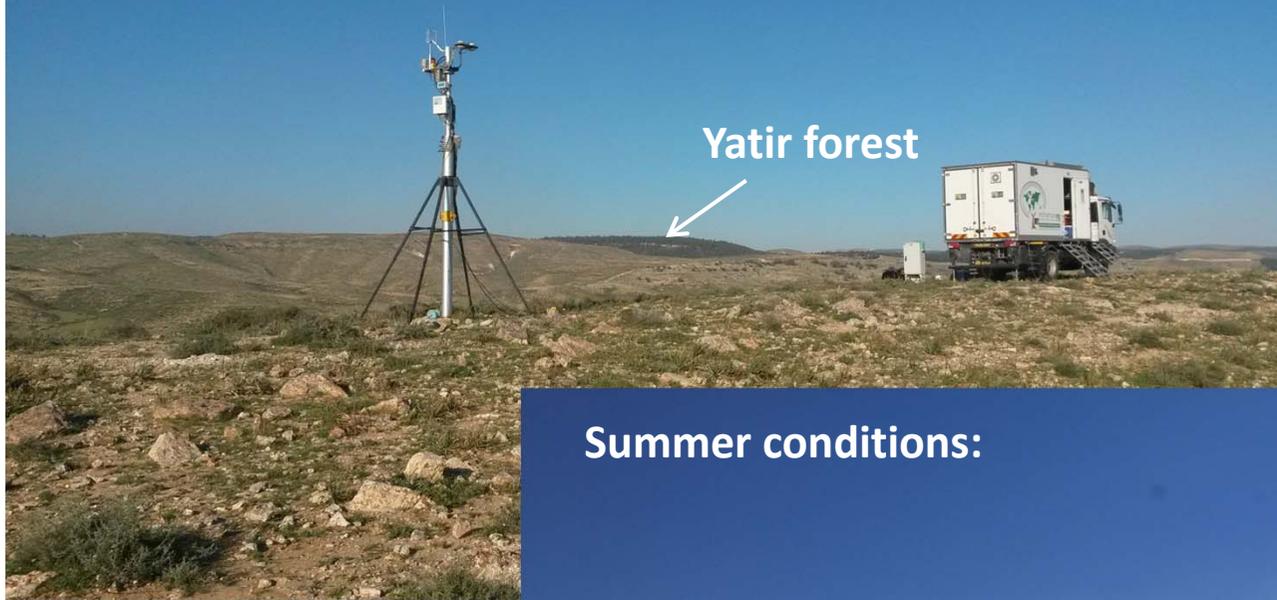
Measurements over range of ecosystems using newly developed mobile Lab:

- ♣ Fast deployment, power independent, all terrain (almost) mobile system.
- ♣ EC measurements (CO<sub>2</sub> & ET fluxes, radiations, others) on extendable mast (up to 28 m).

- ♣ Lab conditions for field operation of sensitive instrumentations (e.g., COS laser).
- ♣ Yatir continuous measurement site serves as reference to the others measured sites.

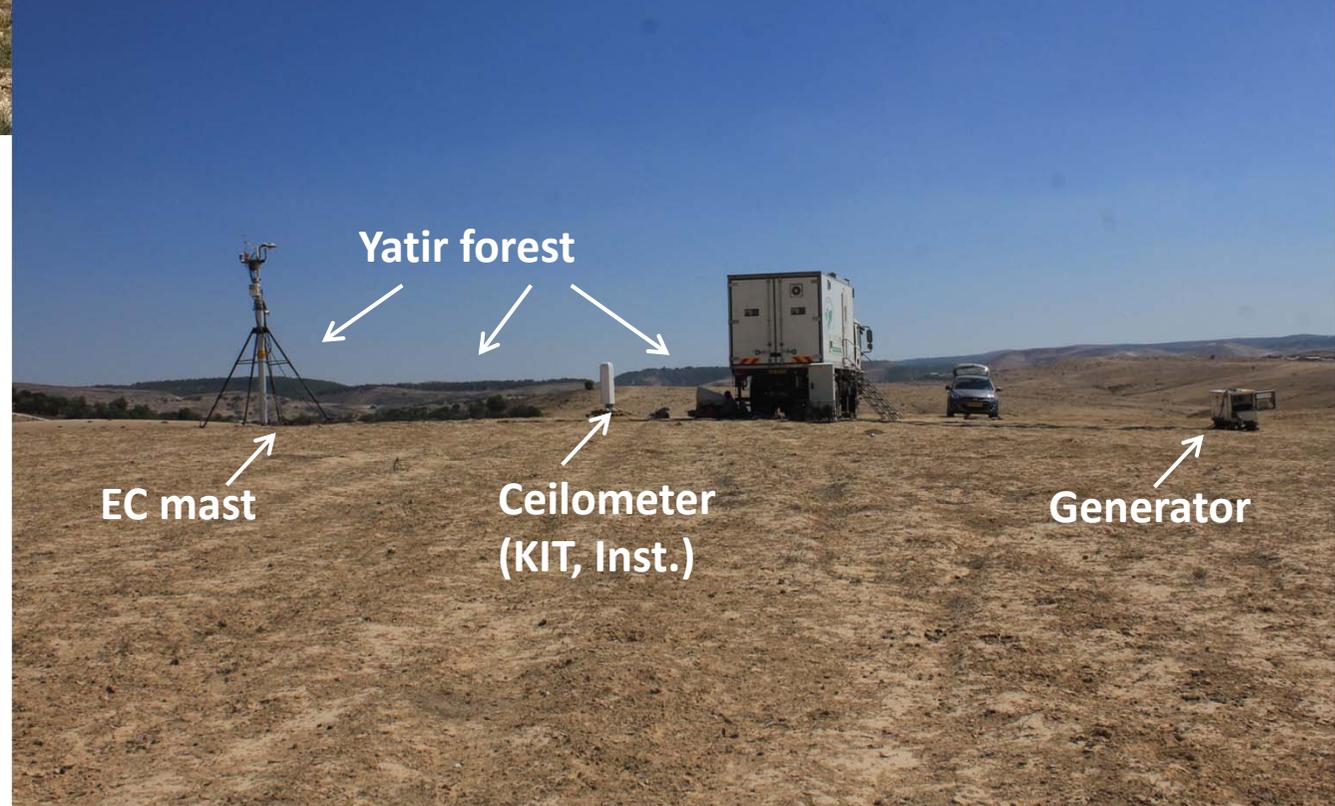


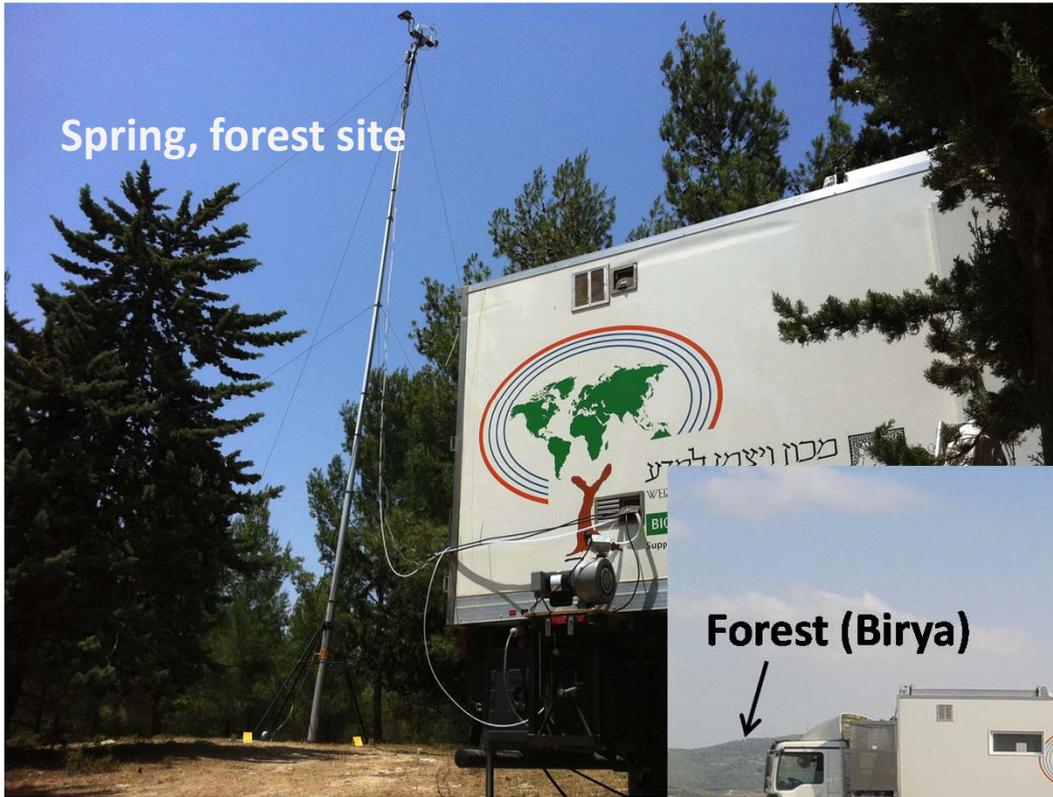
Winter conditions:



Southern most Yatir area, forest and non-forested sites, ~4 km apart.

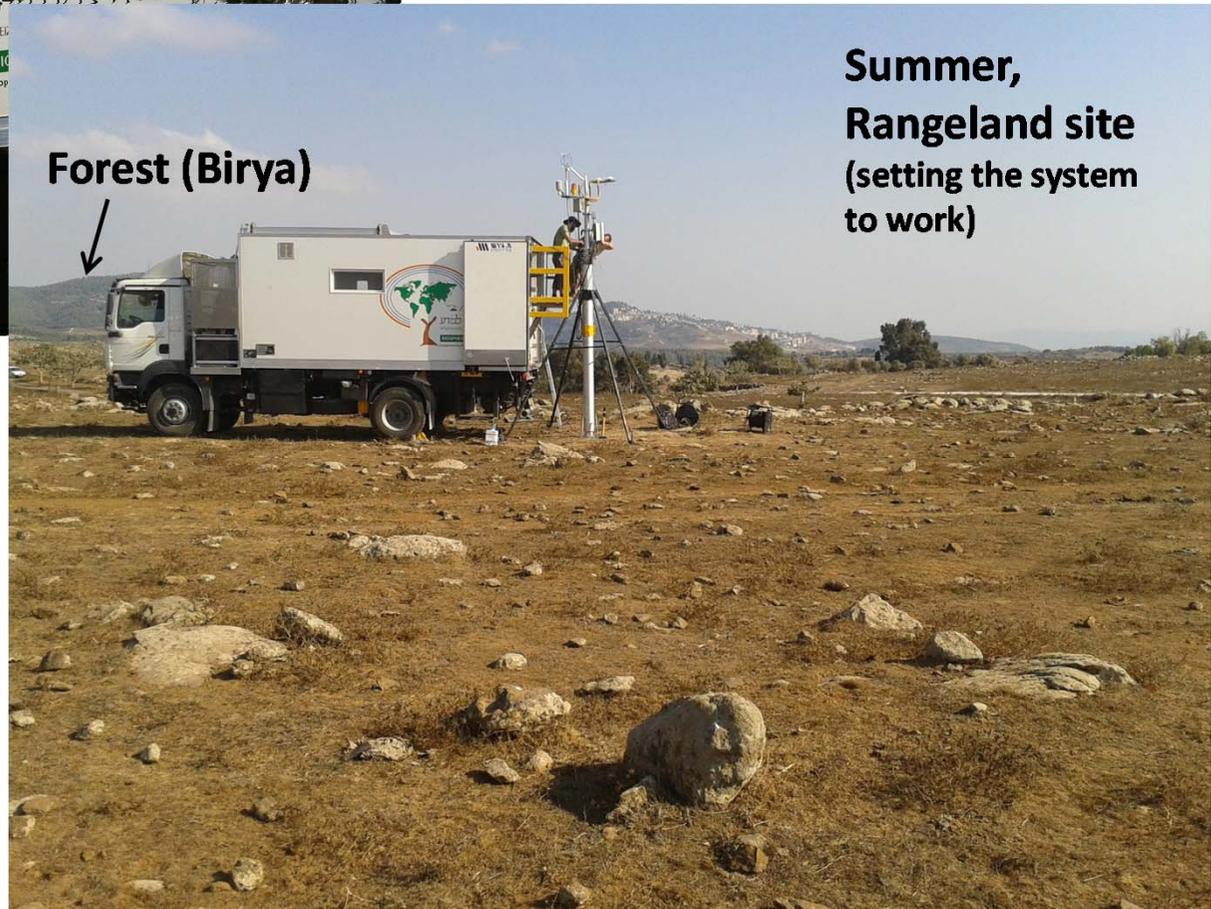
Summer conditions:





Spring, forest site

Northern (Birya) forest and the near by open space ecosystem.



Forest (Birya)

Summer, Rangeland site (setting the system to work)

**Campaign basic measurements plan in eight sites, about two weeks per campaign in different seasons since 2012.**

**In each climatic zone, measurements were conducted in forest and nearby rangeland ecosystems (~two weeks at each location).**

**About 150 measurements days in 2013 and over 100 days in 2012 and 2014.**

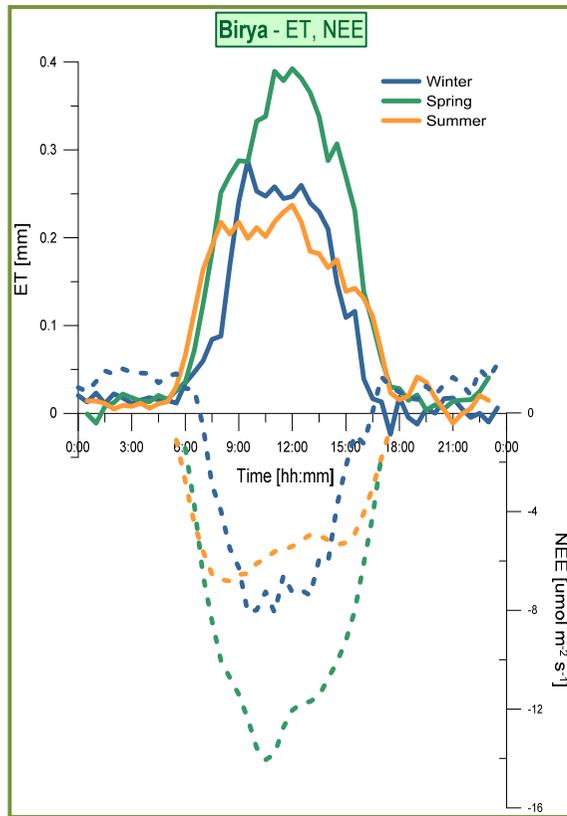
**In the followings, preliminary results will be presented.**

Mobile lab Campaigns 2012-2014													
	2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	Birya				△*					△*			
	Solelim												
	Eshtaol			△*				△*					
	Yatir				△*		△●						
	2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	Birya					△*	△●		△*				
	Solelim					△*			△*				
	Eshtaol		△*					△*					
	Yatir				△*				△●				
	2014	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	Birya		△*										
	Solelim			△*									
	Eshtaol				△●								
	Yatir				△●								

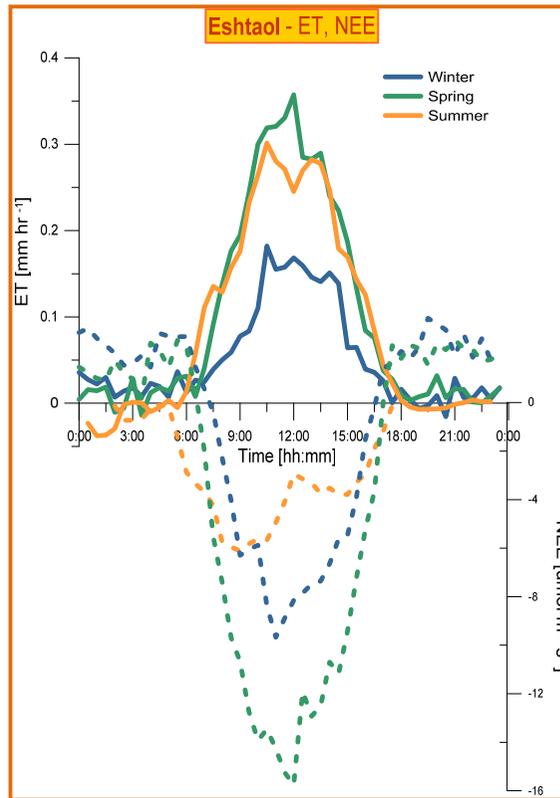
\* Mobile measurements in forest   ● Mobile measurements out of forest   △ Yatir tower measurements in forest

# Forest scale NEE & ET diurnal curves Along the climatic gradient

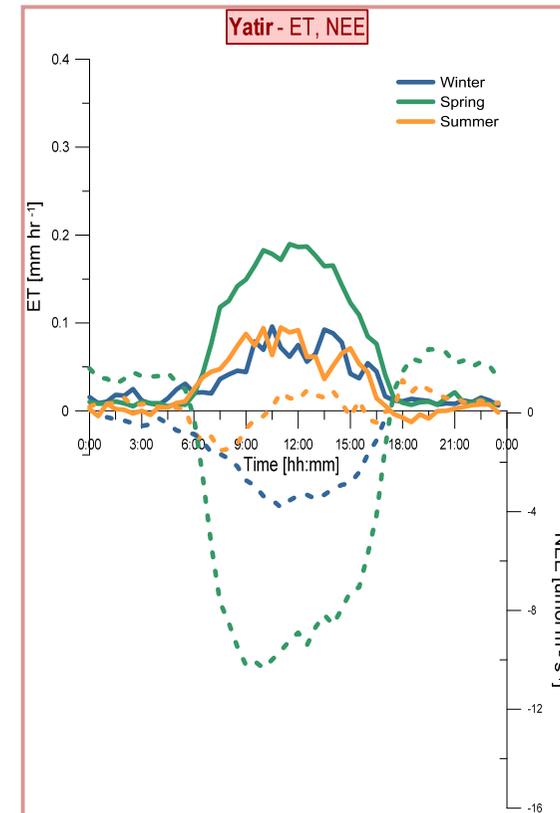
Each line represent, campaign daily average flux



**Sub-humid**



**Semi-arid**



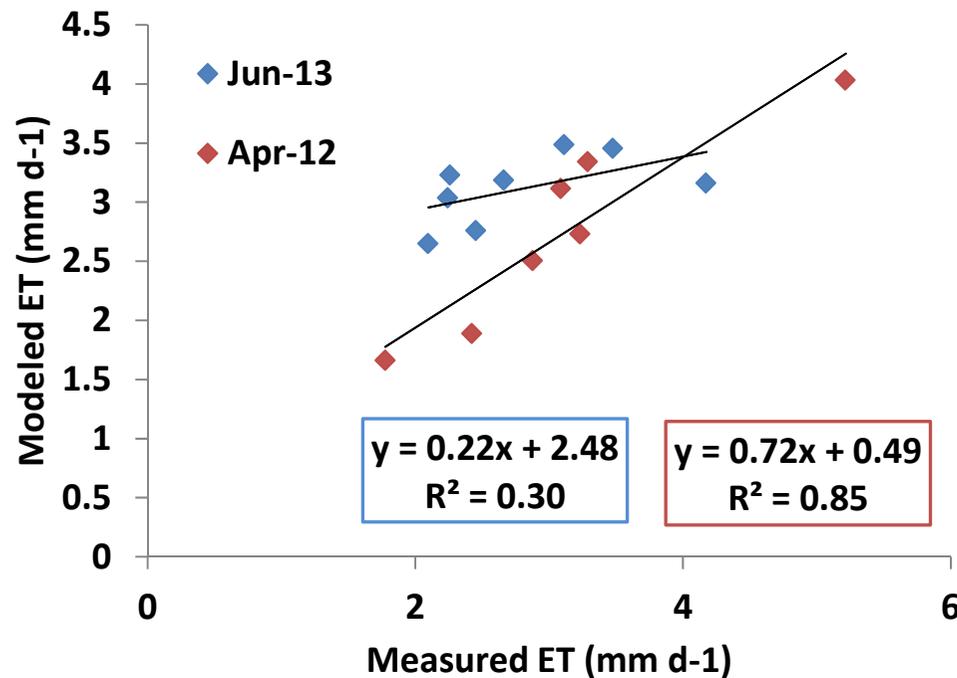
**Semi-arid/arid**

## From campaign-based measurements to annual budgets:

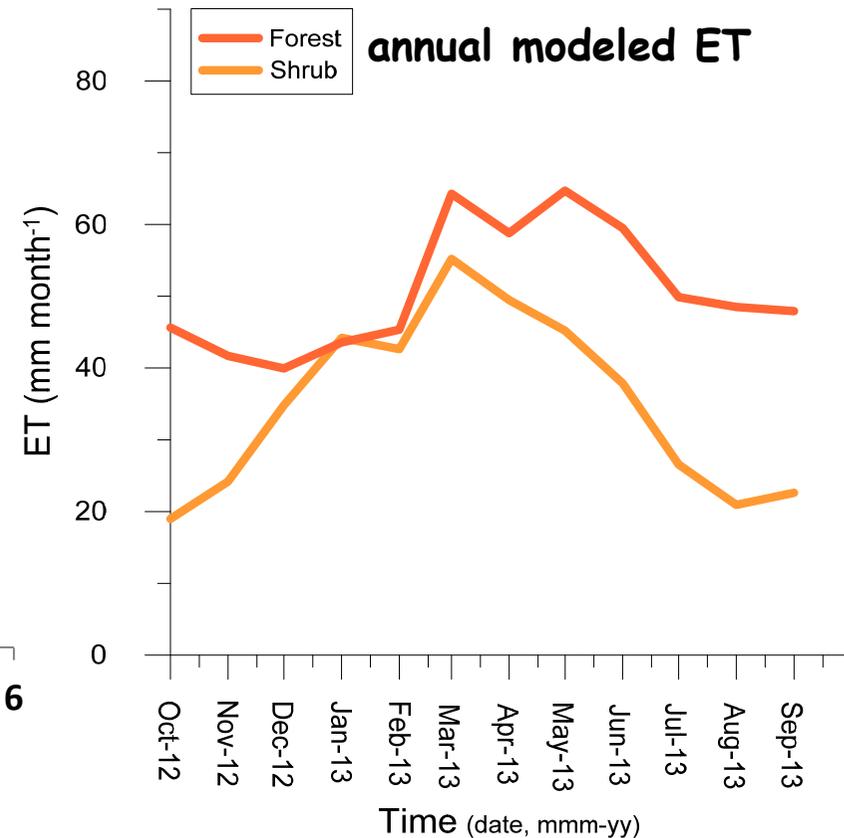
### Preliminary results

1. Correlating campaign measured fluxes with measured environmental conditions (Temp, Eg, RH and P).
2. Extended to annual scale fluxes based on nearby standard meteo' stations variables.

#### Measured ET vs. Modeled ET:



#### Eshta'ol- Forest & Shrubland

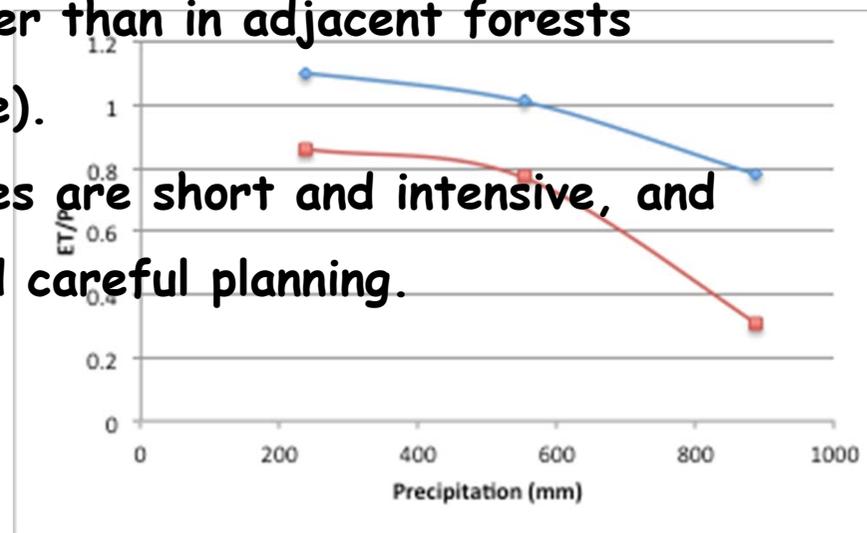


## Annual ET - 2012-13

### Forest vs. Shrub (preliminary)

Site	ET- Biryā	ET- Kadita	P	ET- Eshtaol	ET- Modiin	P	ET- Yatir forest	ET- Yatir desert	P
Sum [mm yr-1]	688	274	885.5	548	422	551.7	263	213	237.2
P-ET [mm yr-1]	197	611		4	129		-26	34	
ET/P	0.78	0.31		1.01	0.77		1.1	0.86	
(P-ET)/P	0.22	0.69		0.01	0.23		(-)0.1	0.14	

- Forests ET and relative ET (ET/P) are higher than adjacent range-lands sites.
- ET/P declines with increasing P (linearly in rangeland, non-linearly in forest)
- Rangelands WY in considerably larger than in adjacent forests (deference could be 100% and more).
- But note, annuals peak activity times are short and intensive, and campaign-based measurements need careful planning.



## Catchments runoff monitoring

- ≈ Catchment runoff measurements by water level sensors conducted at the sites (part of long term monitoring activity of the Israeli runoff research unit (Arbel & Argaman, *per. comm.*).
- ≈ *No runoff* from pine forest sites along the gradient, even at extreme rainfall episodes (over 100 mm daily).
- ≈ Rangelands runoff depend on rainfall conditions and biome cover:  
Runoff as high as 50% of P occurred at the over-grazed, low vegetation cover, semi-arid/arid site in heavy rainfall events.  
At northern sites and large rainfall events, runoff of over 10% P was recorded.

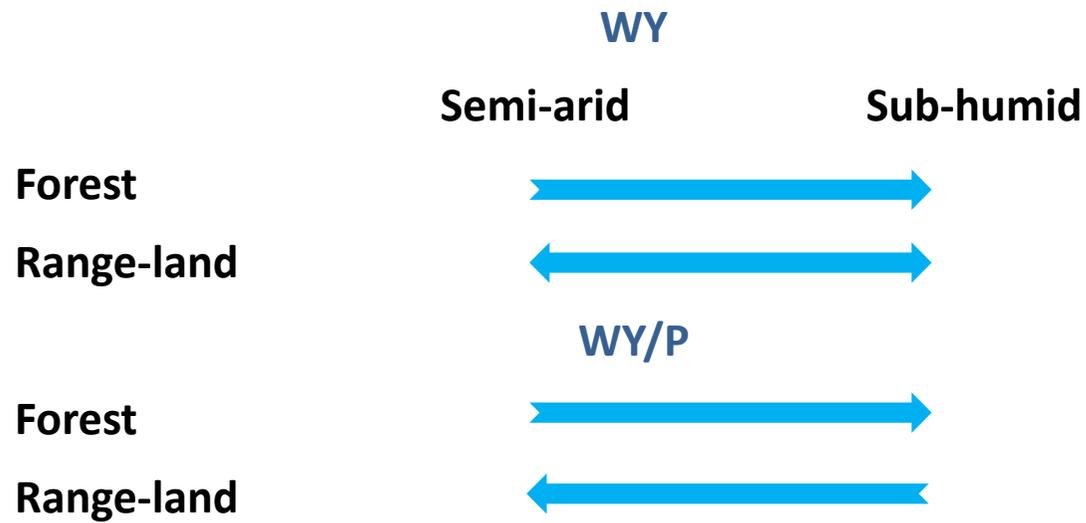
## Closing remarks

- ≈ **To understand water fluxes in dry land regions, quantifying ET is essential at hourly to multiyear time resolutions; Runoff data provides partial information for the total fluxes.**
- ≈ **Mobile EC system approach is able to provide the mean to study across climatic range, and assess the divers biomes variations in ET fluxes.**
- ≈ **Land covers and management practices have strong effects on ET, e.g., forests substantially reduce the available water for human consumptions (WY), grazing increases it.**
- ≈ **But, ecosystems effects on climate, floods, economics activities, bio-diversity and others aspects should also be considered.**

Thanks

Thank you

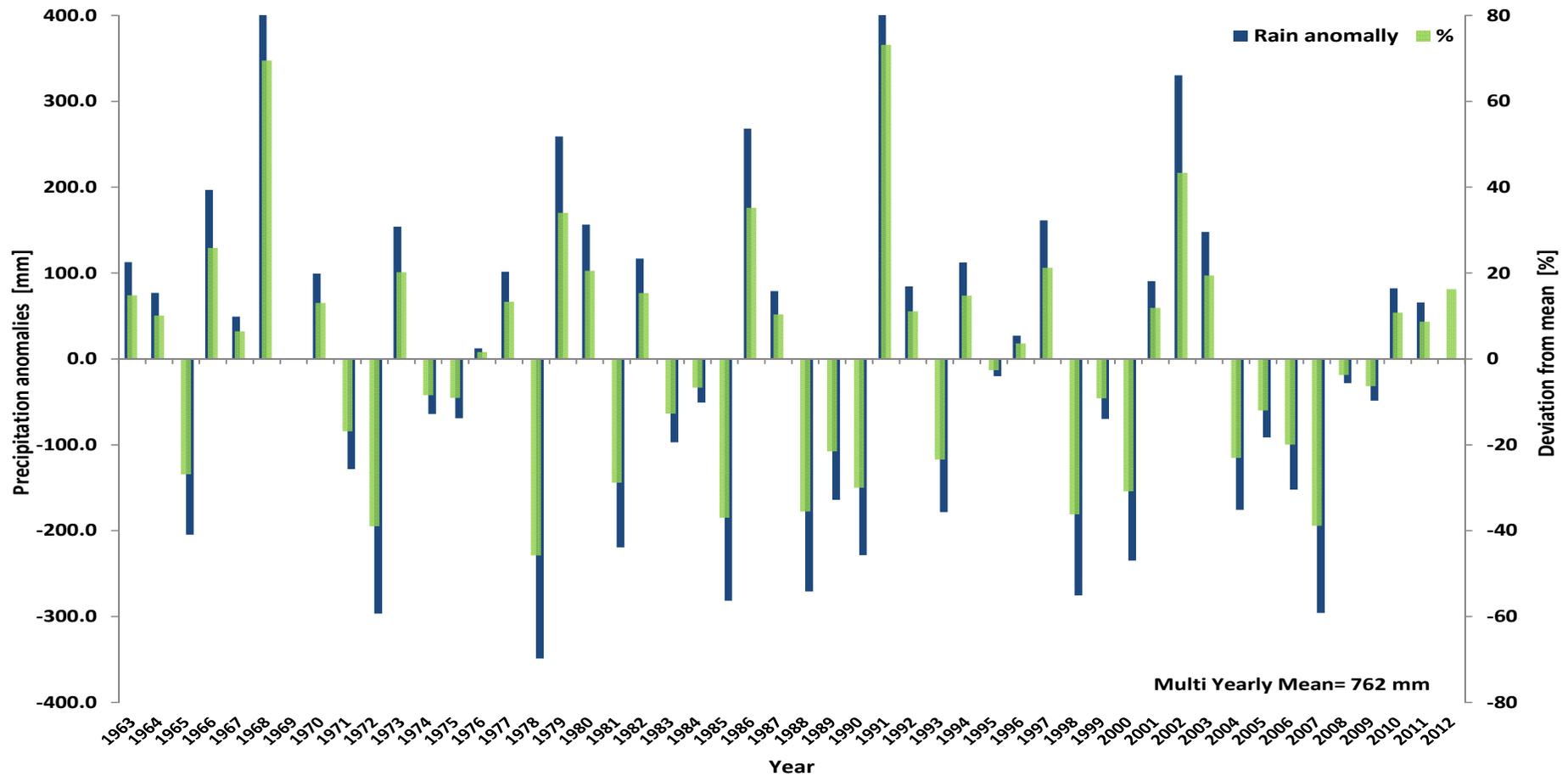
# Climate and ecosystems effect on water yield (suggested results)



## Dry-lands regions inter-annual rainfall variability are large,

- ♣ **Over 60% changes in annual rainfall, e.g., at the dry sub-humid site, P ranged between 450 to 1160 mm ann.,**
- ♣ **Up to 5 consecutive droughty years.**

Rainfall anomalies at the dry sub-humid (Birya) site with annual, 49 y, average 762 mm



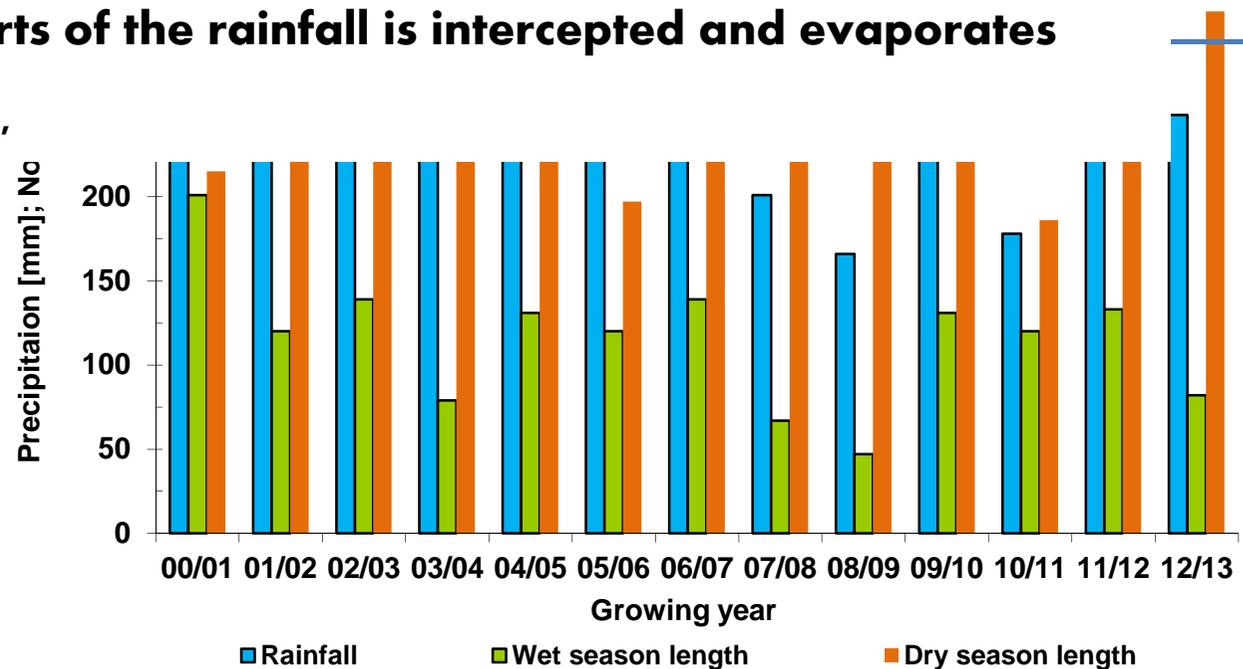
## 'Rain gaps' , rain intensities, and others obstacles ...

♣ **Water table at many dry-land sites is too deep for use by plants; plants thus have to live on short term (up to 2-3 years) water holding capacity of the top soil layers.**

♣ **Lengths of 'no-rain' season and rain-gaps within the rainy season could be very long, it was up to 340 'no-rain' days at Yatir,**

♣ **Water availability to the plants is a function of rain intensity, the amount of rainfall per rain event, which greatly varies between years; at 'low intensity' years large parts of the rainfall is intercepted and evaporates without charging the soil,**

♣ ....



# 10 years results from the continuous semi-arid Yatir forest station

- ♣ Long-term mean  $ET/P = 0.95$ .
- ♣ On wetter than avg. years  $ET < P$  by up to 15% (i.e., up to 40 mm 'storage'), on drought years  $ET > P$  by up to 15% (<25 mm 'storage used').

400

- ♣ 'Transferring rain water between years, another models' challenge.
- ♣ Yatir forest NEE is similar to moderate climate forests.

