Evaluation of dry-down processes of global models (hydrological and LSMs) using flux tower evapotranspiration data

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The eartH2Observe project

- EartH2Observe brings together the modelling (LSMs and global hydrological models) and EO communities
- It integrates available global earth observations, in-situ datasets and models and builds a global water resources re-analysis dataset of significant length (1979-2015)
- The reanalysis data (Tier 1), as well as the EO datasets participating in the project, are available at the Water Cycle Integrator portal: https://wci.earth2observe.eu/
- World Water Resources Reanalysis 1 (WRR1) benchmarking results using a series of EO datasets (Schellekens et al., 2017) also on line using the ILAMB system: http://earth2observe.github.io/water-resource-reanalysis-v1/
- We at CEH are partners providing the JULES model runs and evaluation of all models (ILAMB and new drydown metric)

earth2Observe

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Drying down evaluation

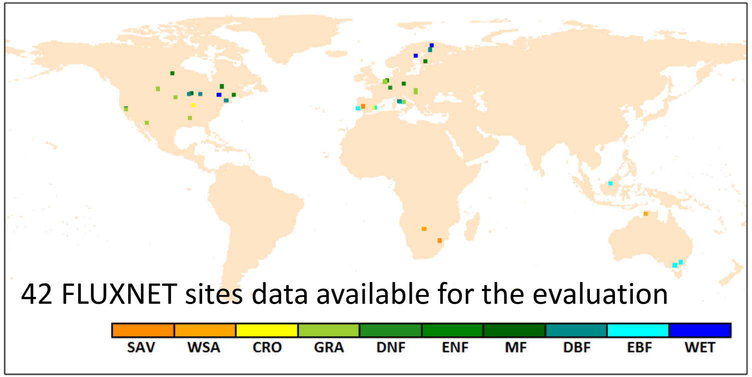
- **Can we find a physical parameter that characterizes model dry-down processes in water limited conditions?**

  assuming under vegetated areas, proportionality between evapotranspiration and S, ET(t)=c*S(t), and that there is no rainfall nor runoff under dry conditions, dS(t)/dt=ET(t) (Teuling et al., 2006)

$$E/PE = (E/PE)_0 e^{-t/\tau}$$

τ lifetime parameter

- **Can we evaluate such parameter against in-situ ET observed data?**



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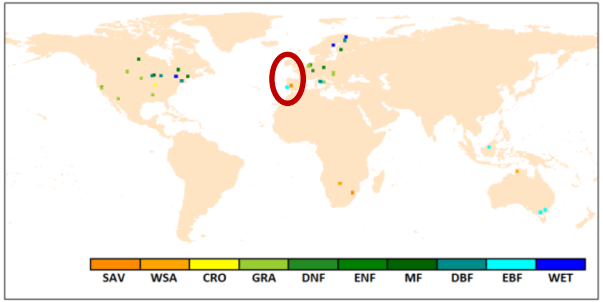
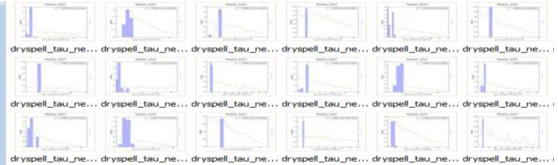
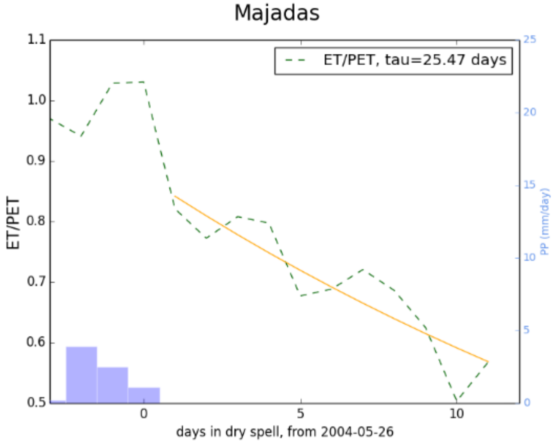
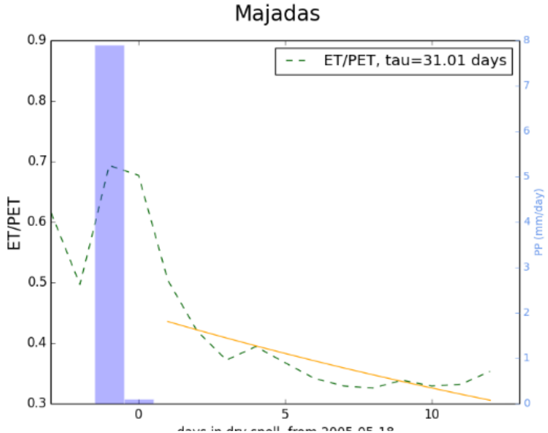
Drying down evaluation – site level

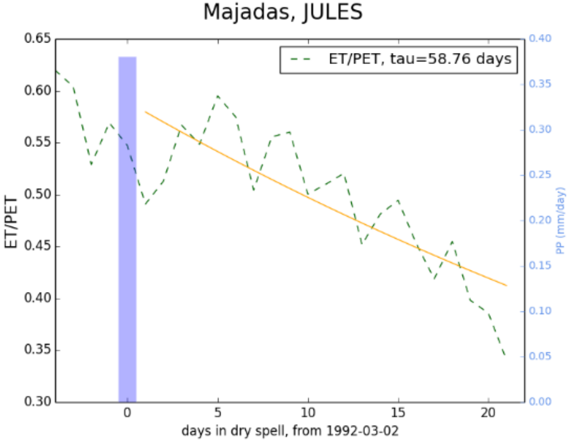


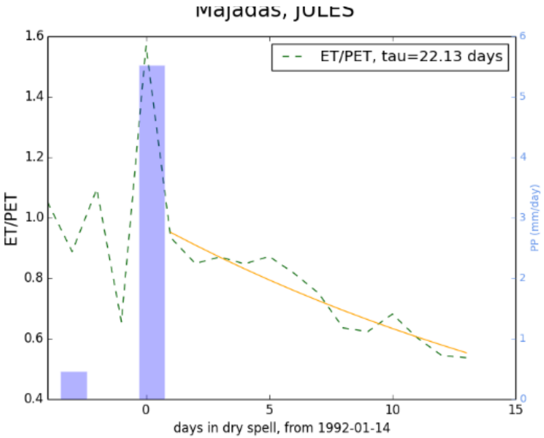


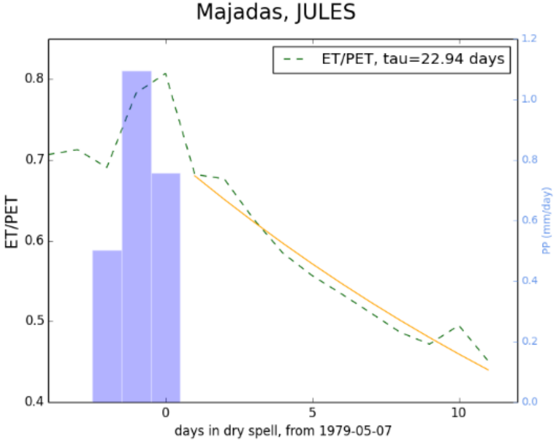
Majadas del Tietar (Spain), 13 dry events (+10 days of no precipitation) in 3 years of data



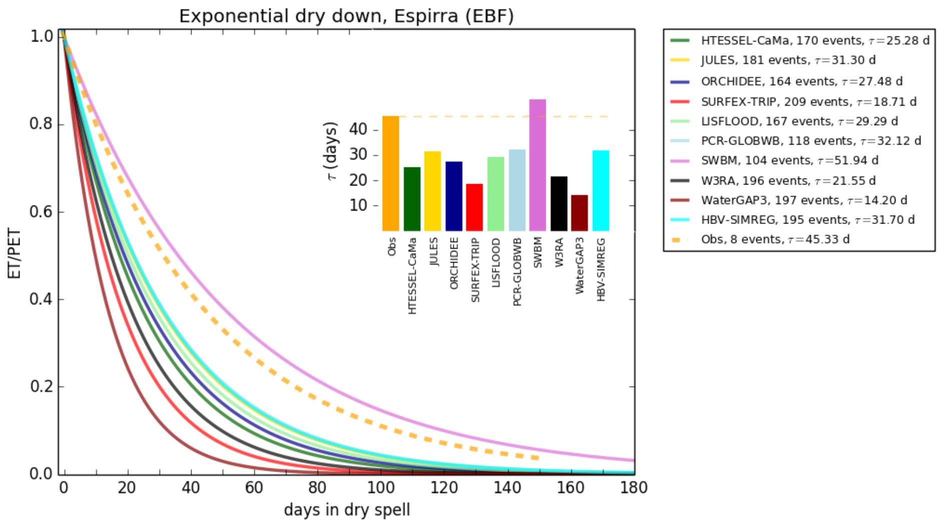


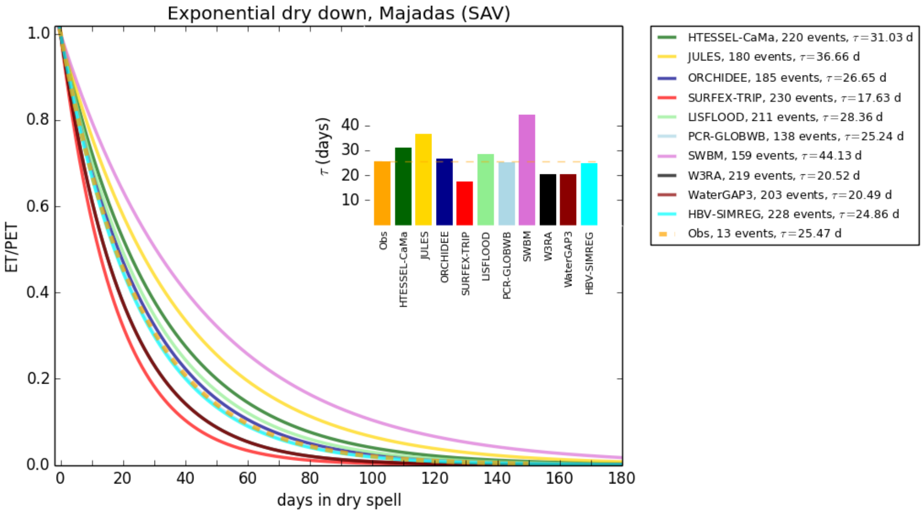






Drying down evaluation – site level





Calculating the median τ (days) for all drying down events (1979-2012 for the model and 2004-2006 for the observations)

- LSMs differ but seem to catch the dry down process generally well, with JULES being slower and SURFEX quicker than observations
- GHMs present also three different performances, PCR-GLOBWB and HBV catch the process very well, with SWBM being a slow outlier and W3RA and WaterGAP3 quicker than observations

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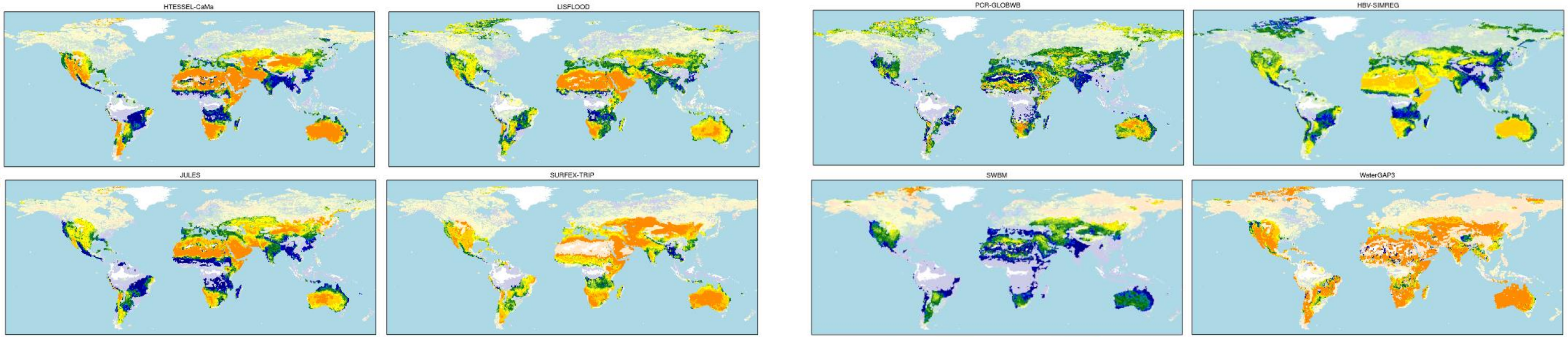
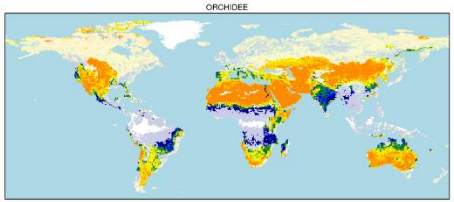
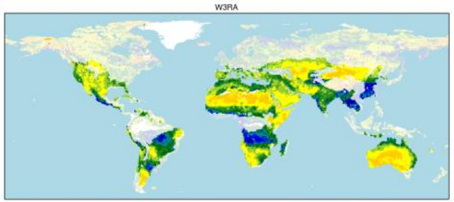
Drying down evaluation – global scale

Dry down metric τ calculated at the global scale for the models (highlighted areas of number of dry down events, nevents > 1.5/year)





LSMs in agreement in general patterns
SURFEX faster drying than the rest
JULES seems again slower than HTESSEL, ORCHIDEE



Less agreement among Global Hydrological models
Strong outliers: WaterGAP very quick, SWBM very slow

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Drying down evaluation – global scale

From McColl et al., 2017. Drydown τ from SMAP Soil Moisture data

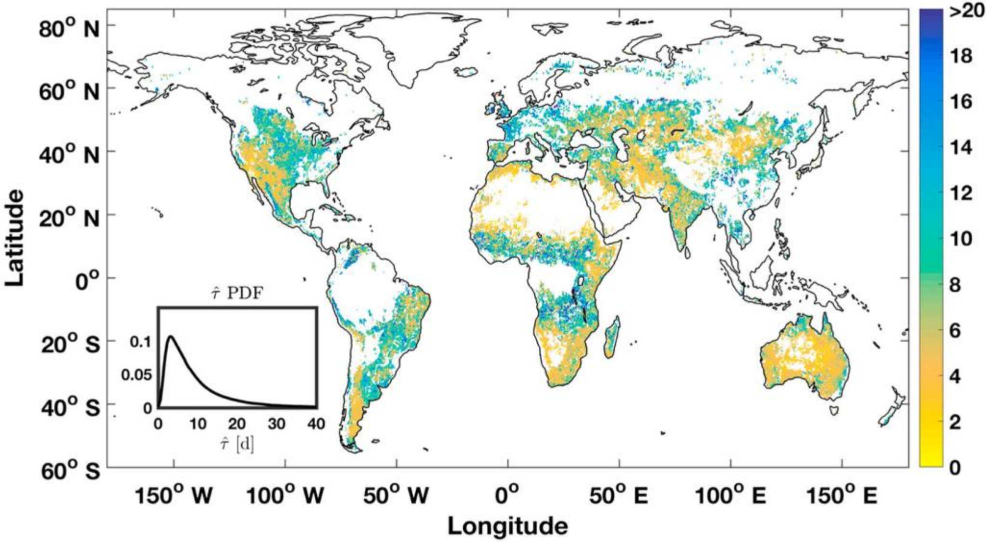
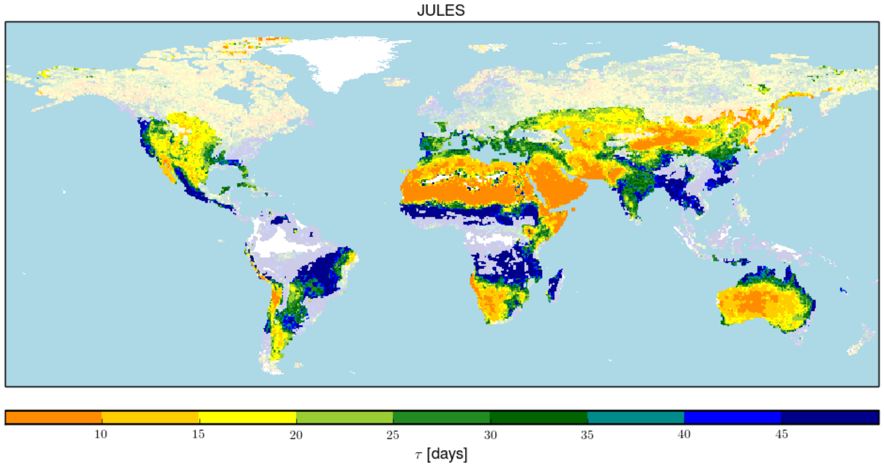


Figure 2. Median drydown time scale τ̂ (day). Inset: estimated probability density function (PDF) of τ̂. White regions were excluded from the analysis due to radio frequency interference, soil freezing, presence of small waterbodies, dense vegetation cover, or if less than three drydown events were identified.

drydown τ from ET/PET JULES e2o wrr1 simulation



Important bias in the scale of the τ metric
(access to deeper soil by using ET from models/flux tower data)

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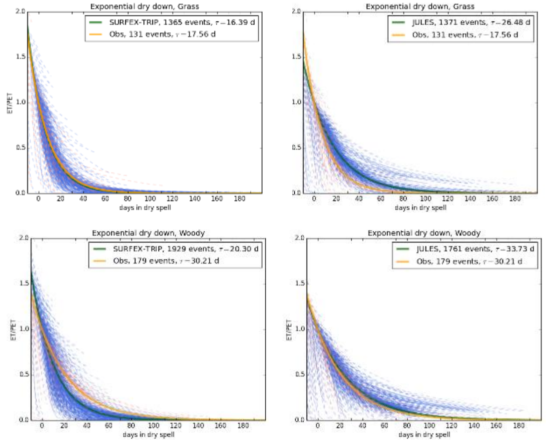
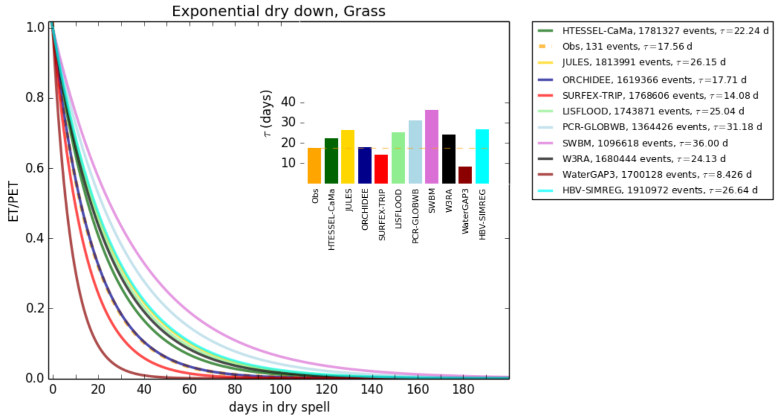
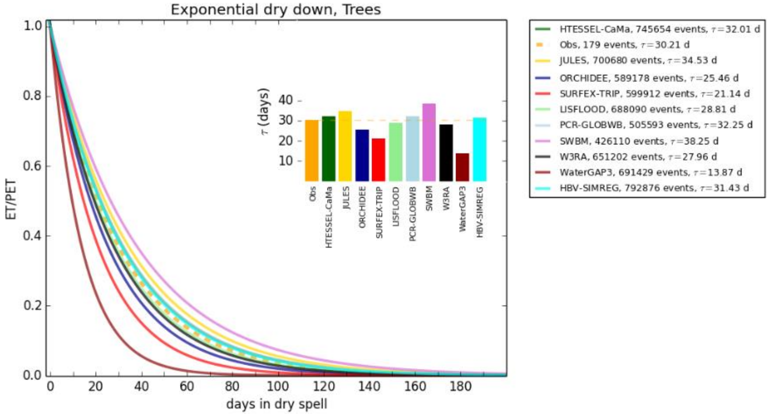
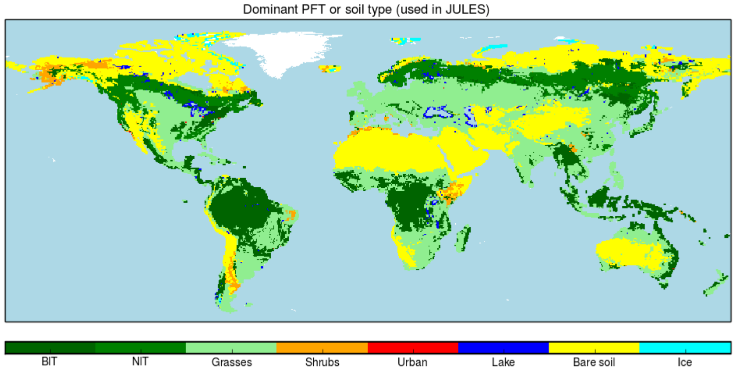
Drying down evaluation – site to global scale





Calculating the median τ (days) for Trees (BlT+NlT+Shrubs) and Grass dry down events at the global scale





Final remarks

- We have calculated the drydown lifetime parameter for 10+ days of no precipitation using flux tower ET data from 42 FLUXNET sites and evaluated 10 e2o models with this metric
- LSMs agree with Obs in showing a strong difference in dry down speed from trees to grasslands, as trees can reach deeper soil and therefore keep transpiring soil water for a longer time during dry events. GHMs, however, do not show as significant a jump from tress to grasslands.
- Some conclusions obtained at the site scale (Majadas example) in regard to the different model behaviour translate robustly at the global scale: SURFEX is systematically faster at drying down than the rest of LSMs, and GHMs disagreements are stronger than those of LSMs.
- We conclude that flux tower data can be used to evaluate evapotranspiration processes in global models and the behaviour of different global models during drying down periods varies significantly.

THANK YOU

But before I go: http://jules.jchmr.org/content/evaluation

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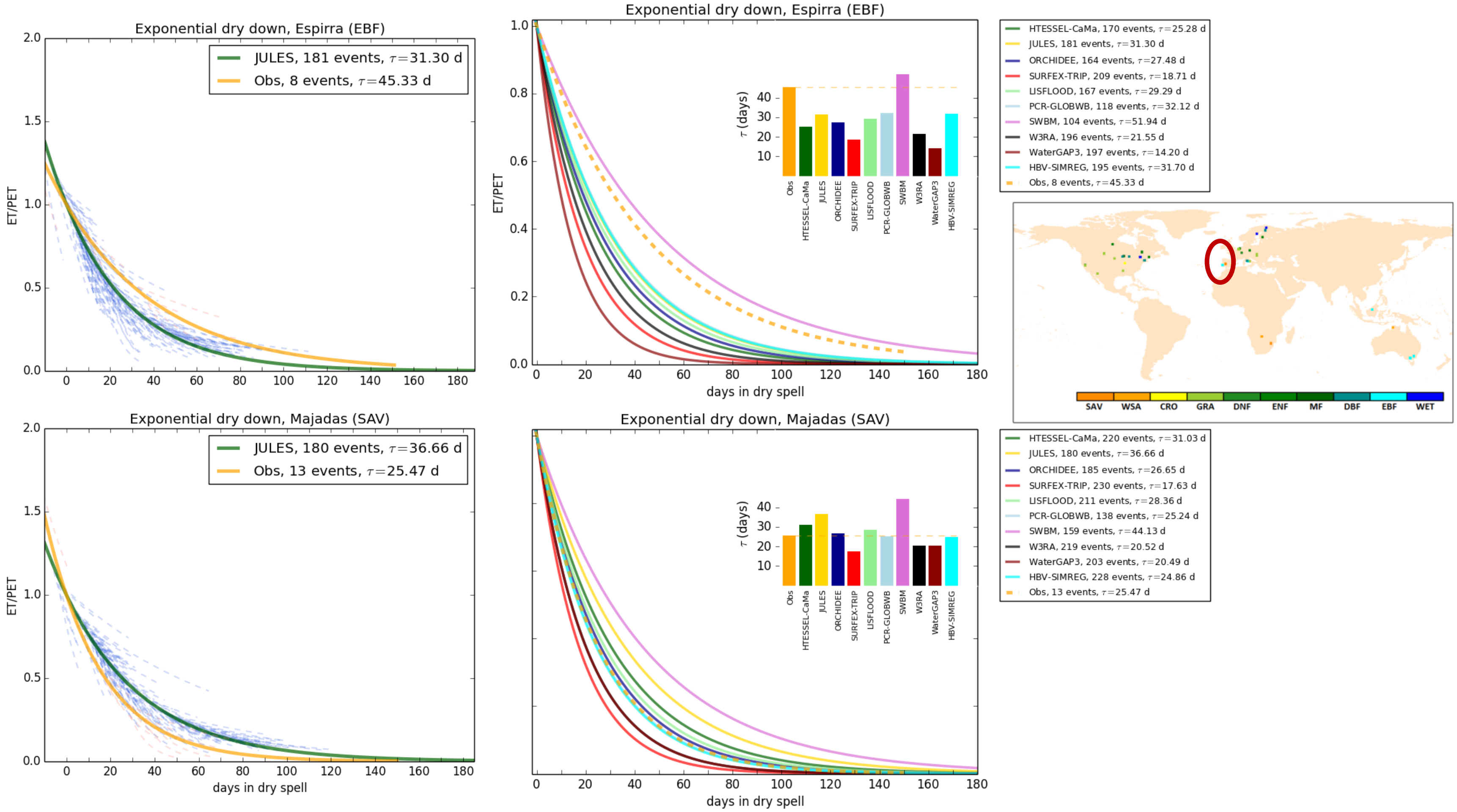
Drying down evaluation – site level



Notes on methodology:

- We evaluate the data from one day after the rainfall stops to avoid interception processes.
- We use evaporative fraction as ET/PET (evapotranspiration over potential evapotranspiration) in order to focus on water limited conditions.
- PET is calculated using the Penman-Monteith equation (as Robinson et al., 2017)
- We use flux tower data for total evaporation.
- PET for the flux tower data is calculated from meteorological observations at the site.
- For the models, PET is calculated from the WFDEI driving data (Weedon et al., 2014) that was used for all modelling partners to drive their runs.