Evaluation of drydown processes in global land surface and hydrological models using flux tower evapotranspiration data

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The earthH2Observe 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 (WRR1/WRR2/WRRENS), 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 online using the ILAMB system: http://earth2observe.github.io/water-resource-reanalysis-v1/

Here we'll show a drydown evaluation of WRR1

- **Model performance on drying rates at periods of no precipitation**
- **Pool of 4 LSMs and 6 GHMs**

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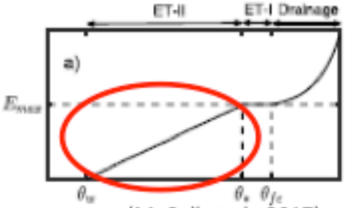
Drying down evaluation

Can we find a physical parameter that characterizes model drydown processes in water limited conditions?

assuming under vegetated areas, proportionality between evapotranspiration and S, $ET(t)=c*S(t)$, $ET(t)/PET=(S(t)-S_w)/S_{cap}$, and that there is no rainfall nor runoff/drainage under dry conditions, $dS(t)/dt=-ET(t)$ (Teuling et al., 2006)

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

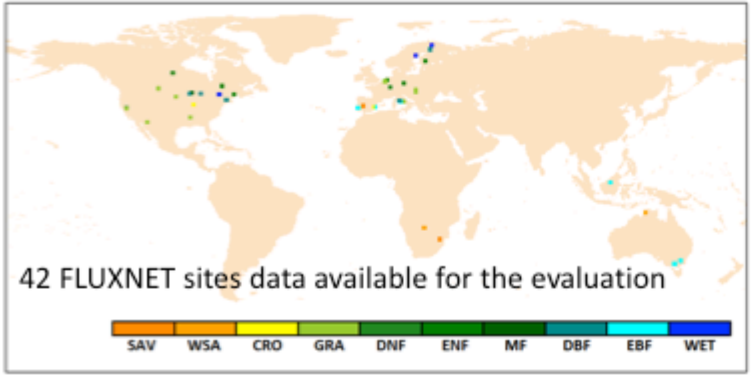
τ lifetime parameter



(McColl et al., 2017)

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

We just need time series for ET ratio



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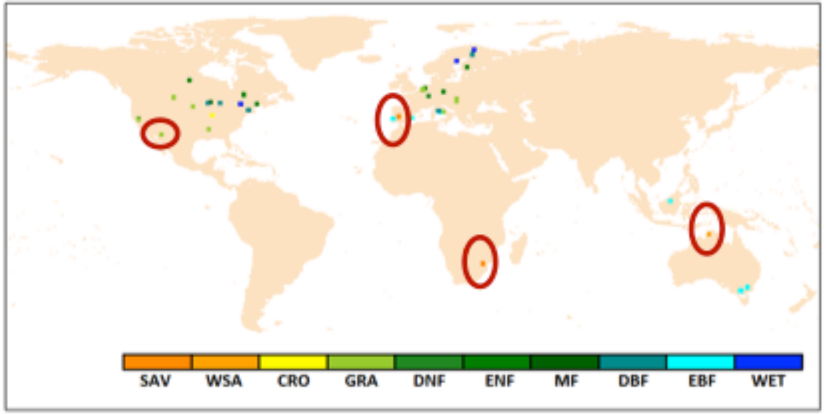
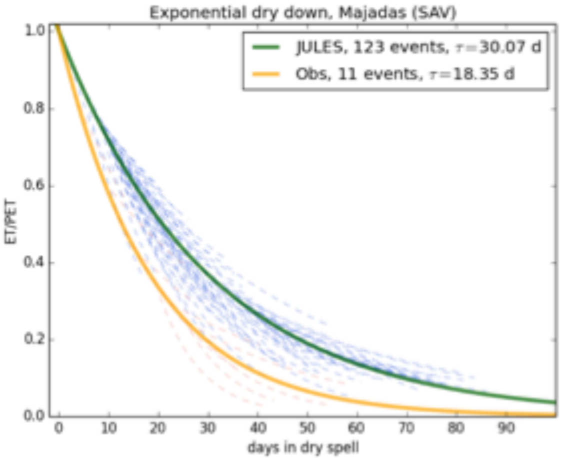
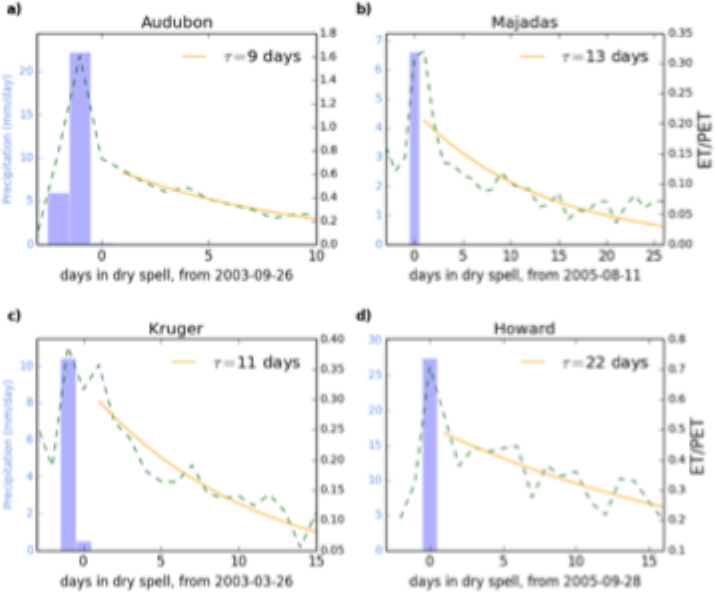
Drying down evaluation – site level





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

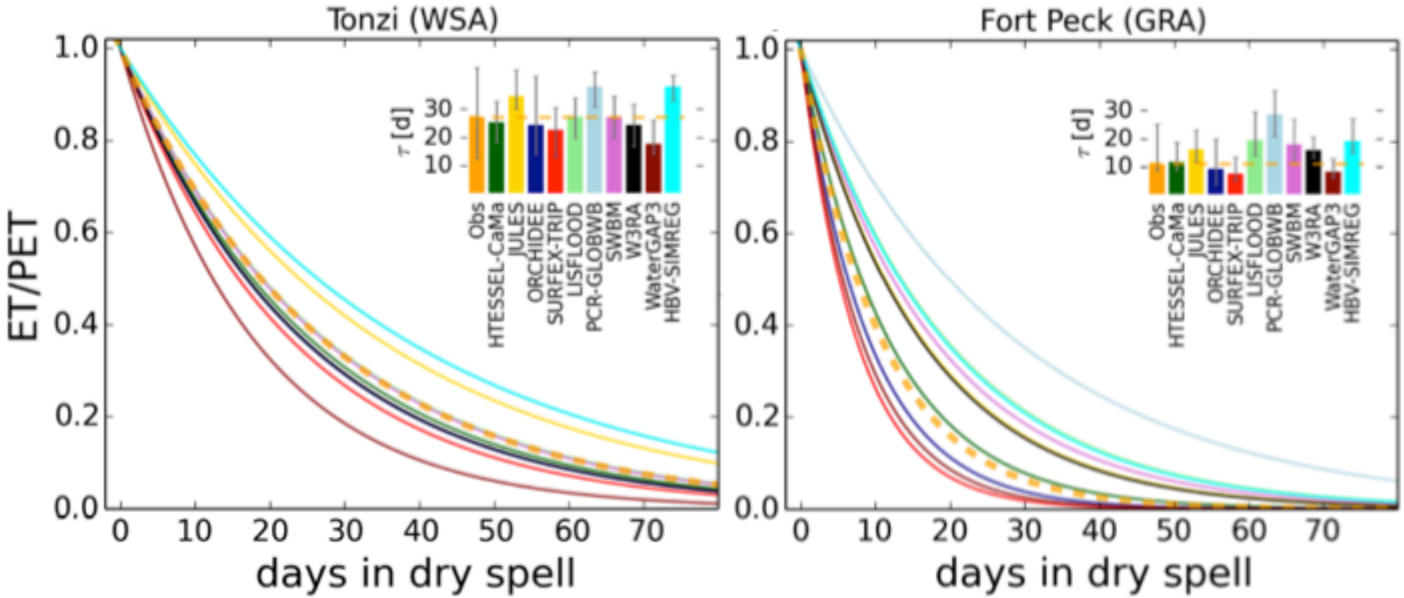


Applying exponential curve fitting to the site observations and models at the locations

Drying down evaluation – site level

160 total events in observations

SITE	Nevents	TAU med	SITE PFT
Rocca1	7	30.46	BLT
ElSaler	7	29.27	NLT
Tonzi	12	27.05	WSA
Mopane	12	24.67	WSA
Majadas	11	18.35	SAV
Kruger	9	18.41	SAV
Bondv	10	18.19	GRA
Vaira	13	16.84	GRA
FortPeck	8	10.89	GRA
Audubon	16	9.068	GRA



We need to evaluate per vegetation cover rather than per site, considering the data at the sites/grids by pft represented

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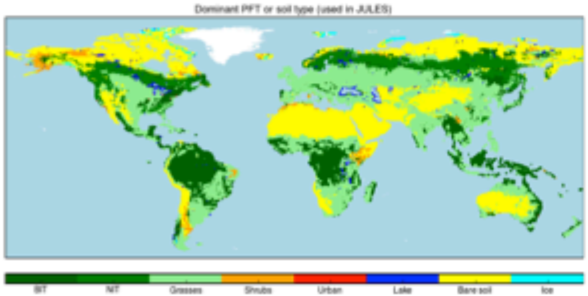
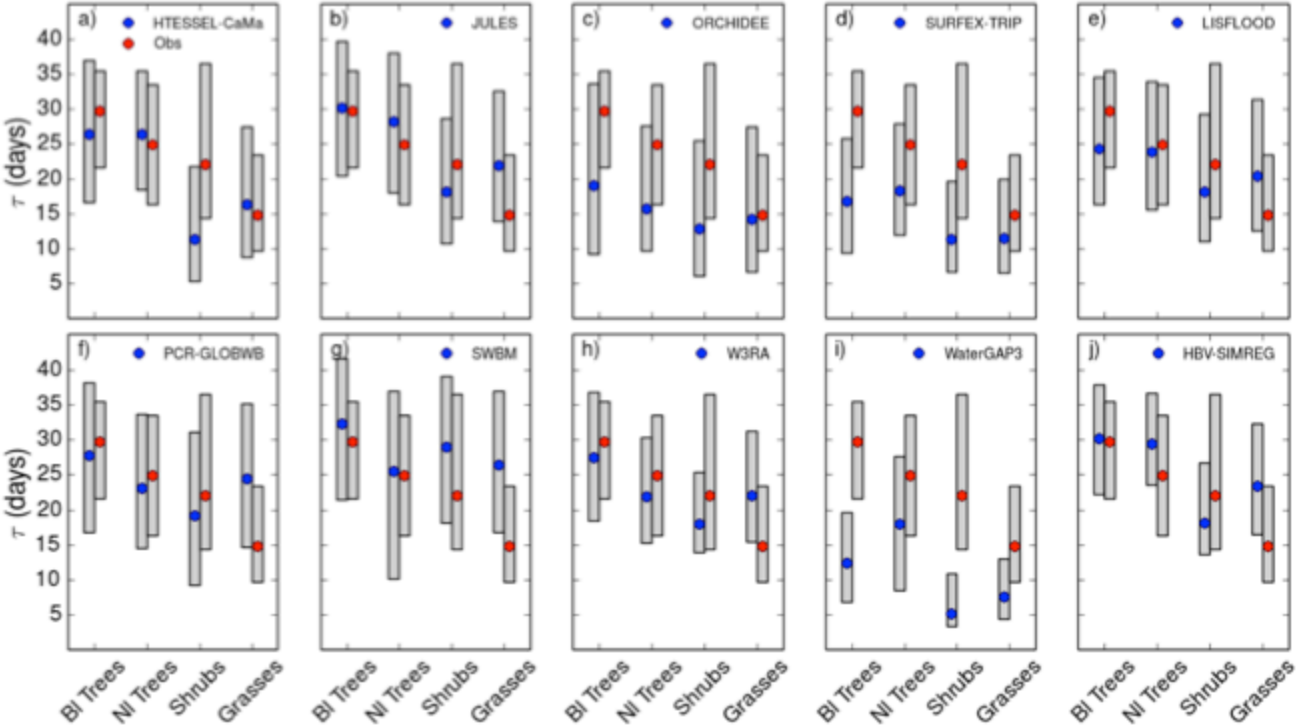
Drying down evaluation – site to global scale



Calculating the median τ (days) for BL Trees, NL Trees, Shrubs and Grasses



Linear relationship with PFT in observations and models
Shrubs drying quicker than grasses (sparse vegetation?)

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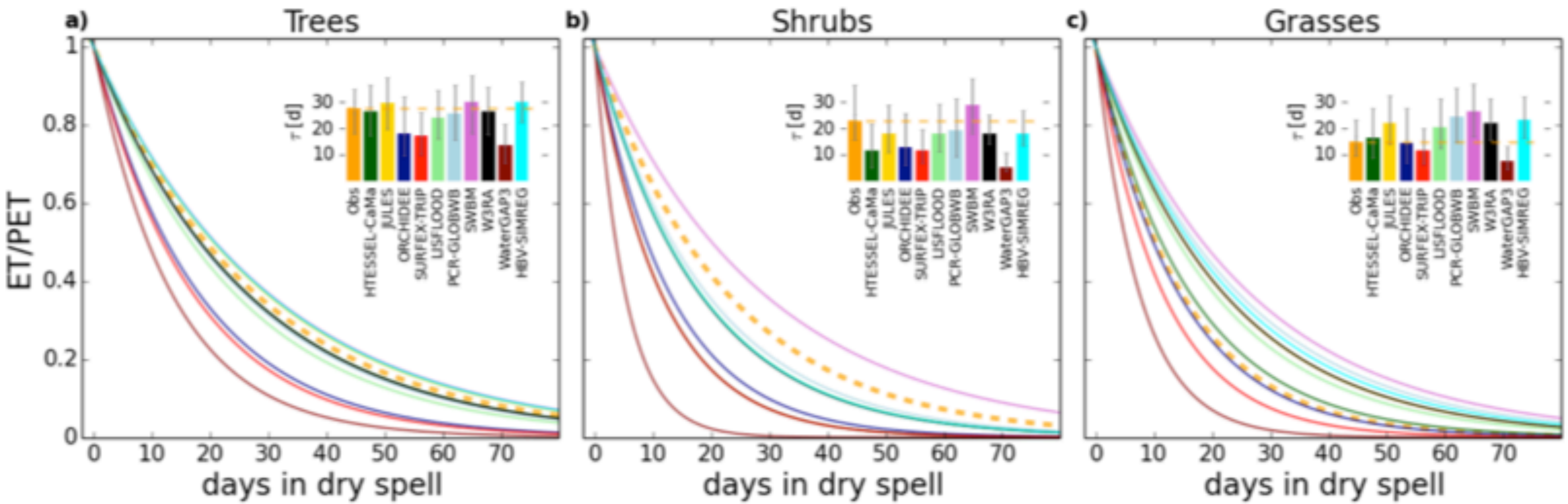
Drying down evaluation – site to global scale

Calculating the median τ (days) for Trees, Shrubs and Grasses as a first order vegetation type



- Again overestimation of shrubs drying rate
- SURFEX is systematically faster at drying down than the rest of LSMs, whereas JULES is slower
- GHMs slower in general (WaterGAP3 exception)
- GHMs less PFT variability (lower tree-grass reduction)

	Observations	HTESSEL-CaMa	JULES	ORCHIDEE	SURFEX-TRIP	LISFLOOD	PCR-GLOBWB	SWBM	W3RA	WaterGAP3	HBV-SIMREG
Trees	27.8	26.4	29.7	18.1	17.1	24.2	25.8	30.1	26.3	13.4	29.9
Grasses	14.8	16.2	21.9	14.2	11.6	20.3	24.5	26.5	22.0	7.5	23.3
% decrease	**47**	**38**	**26**	**21**	**32**	**16**	**5**	**12**	**16**	**44**	**22**

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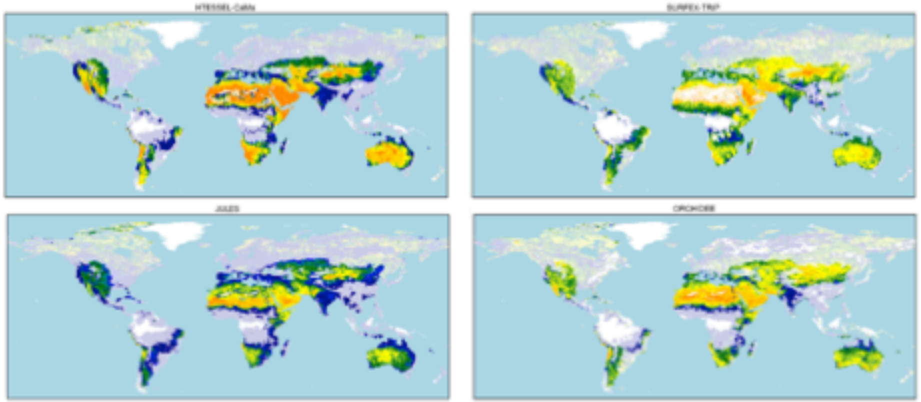
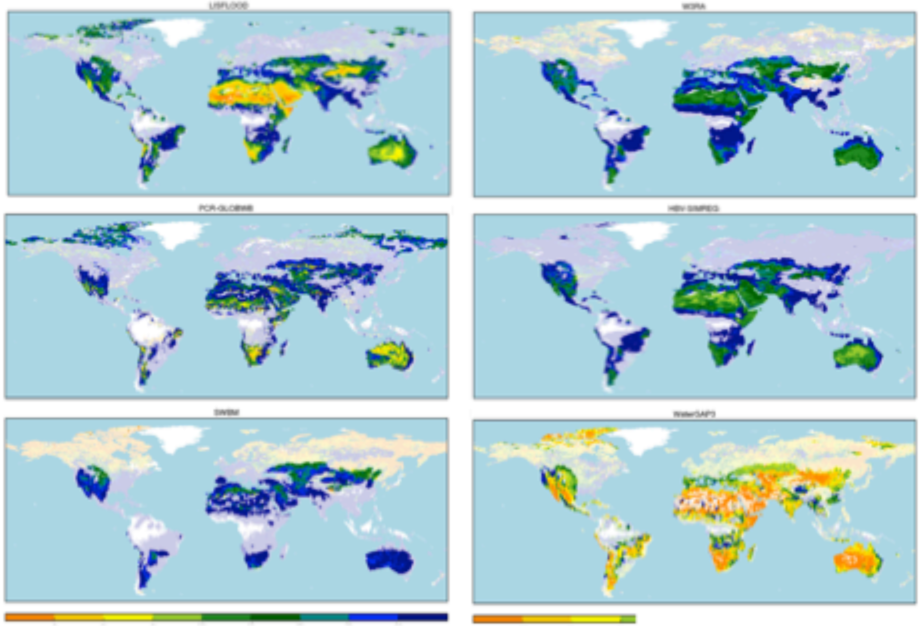
Drying down evaluation – global scale

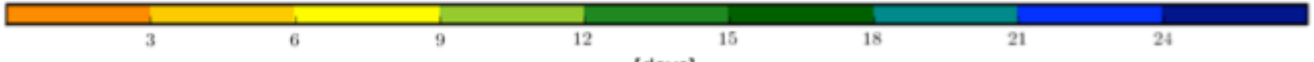
Dry down metric τ calculated at the global scale for the models (highlighted areas of number of dry down events, nevents > 1 per year)



General agreement in spatial patterns
SURFEX/ORCHIDEE faster drying than the rest of LSMs
JULES slowest drying out of LSMs

Global Hydrological models dry much slower than LSMs (too slow even over bare soil areas)
Strong outlier: WaterGAP3 quicker drying than LSMs





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THANK YOU

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.

- Vegetation cover PFT dependence for characterizing the drydown of the land (site obs, models)
- Model variability in responses:
    - LSMs differences robust across sites and PFTs
    - GHMs less PFT variability
    - GHMs slower than LMSs in general

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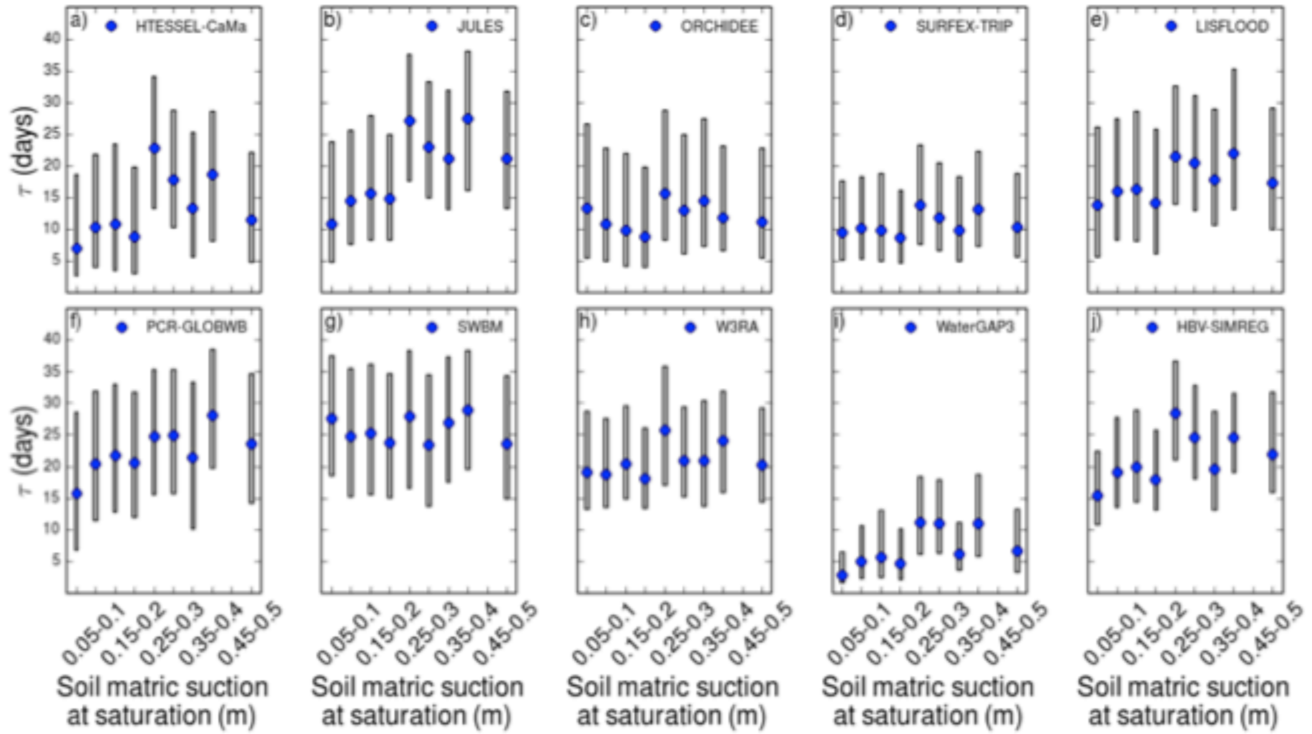
Extra on soil properties



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Extra

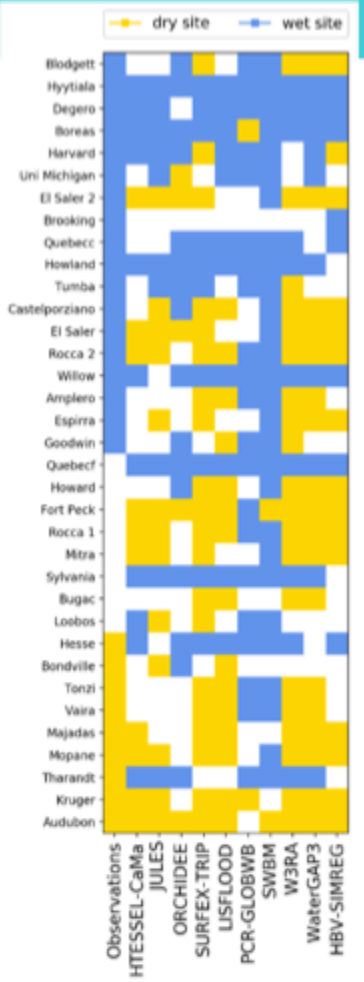
Identifying dry/wet events

The method can be applied only to water limited events

- No interception (start event after day 0)
- Exclude events with no drying ($\tau > 50$ d)

We label the sites as:

- wet ($N_{dry}/N_{total} < 0.25$)
- dry ($N_{dry}/N_{total} > 0.5$)



Valuable information before analyzing the drydown rates results

Observations and models do not always agree on identification of dry/wet sites (irrigated sites, other processes like lateral drainage not contemplated in models)

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Extra

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

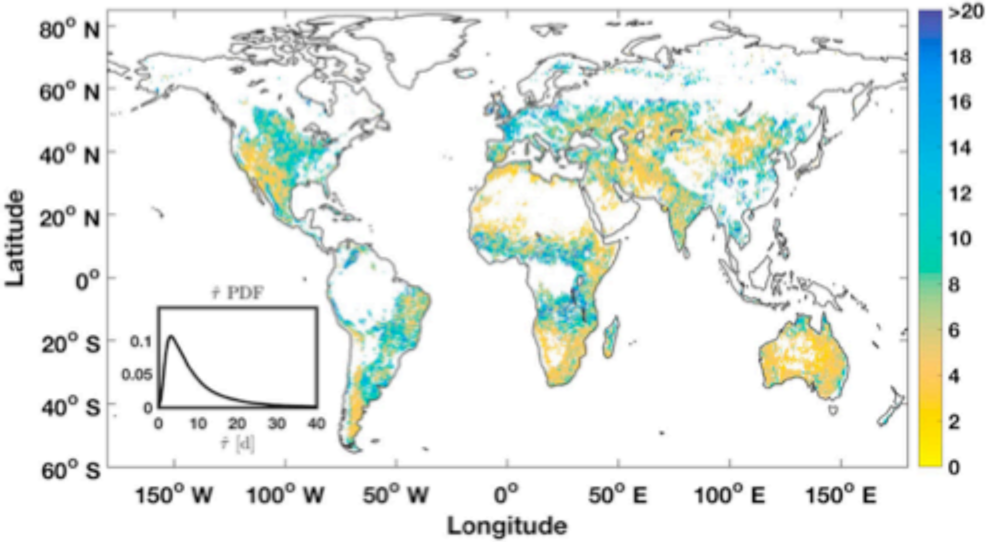
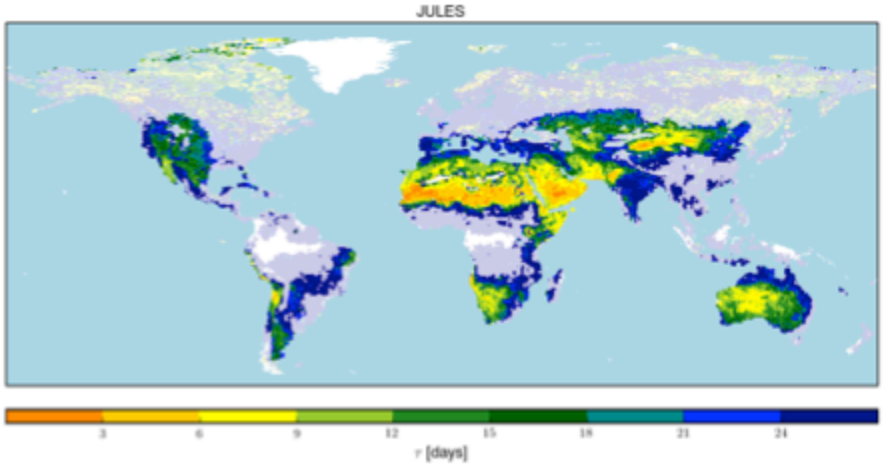


Figure 2. Median drydown time scale $\hat{\tau}$ (day). Inset: estimated probability density function (PDF) of $\hat{\tau}$. White regions were excluded from the analysis due to radio frequency interference, soil freezing, presence of small waterbodies, dense vegetation cover, or if less than three drydown 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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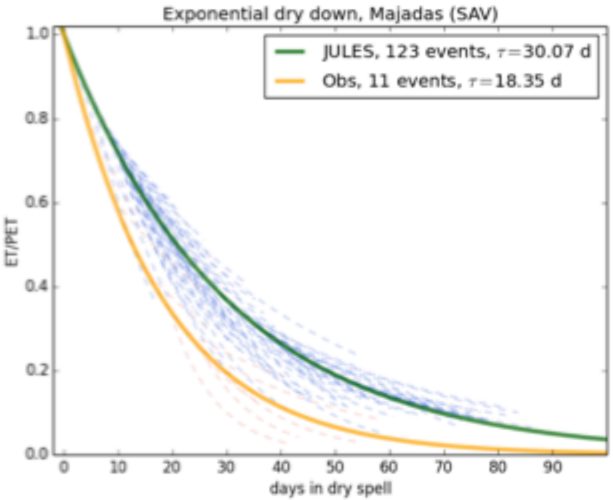
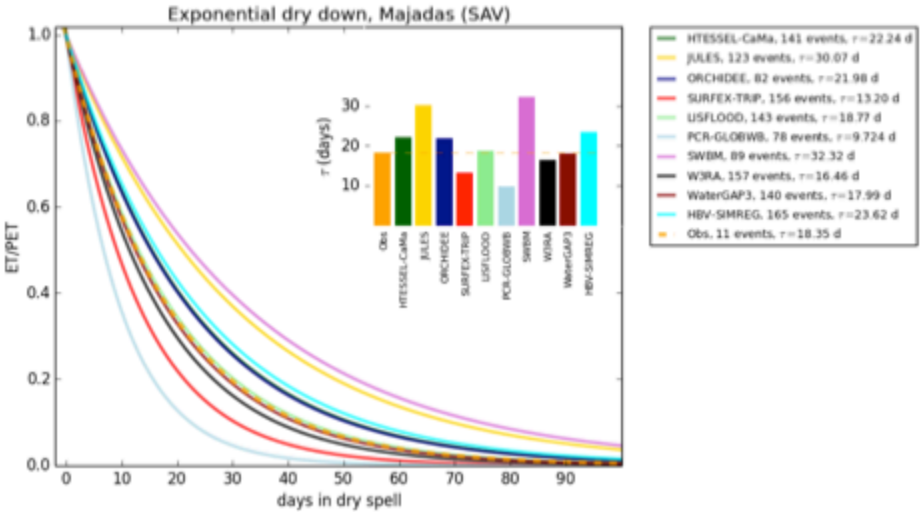
Drying down evaluation – site level



For all models



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

- LSMs differ, with JULES being slower and SURFEX quicker than observations
- GHMs present also different performances, W3RA and WaterGAP3 catch the process very well, with SWBM being a slow outlier and PCR-GLOBWB quicker than observations

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Extra on methods

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.
- Conditions to consider drydowns:
  - 1<tau<50 to use real drying curves
  - 0<ET/PET<1 during the whole period to avoid interception processes