Surface soil moisture dry-down in a land-atmosphere hotspot observed by SMOS and AMSRE/2, and modelled by ORCHIDEE

Ruscica R., Salvia M., Polcher J., Sörensson A., Piles M., Jobbagy E., and Karszenbaum H.

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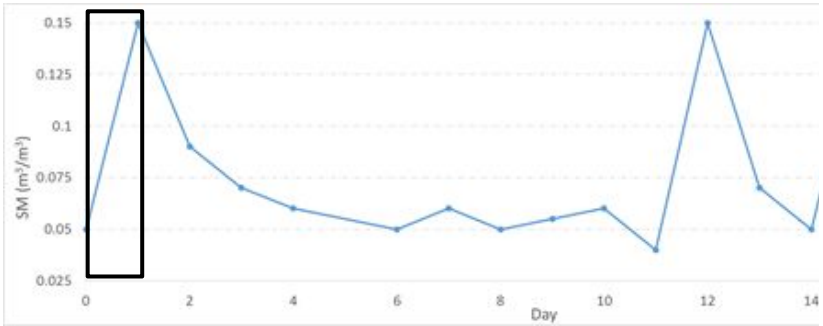
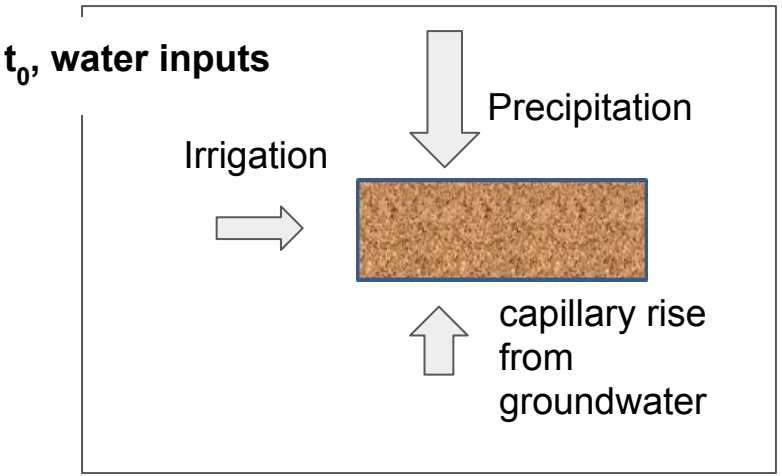
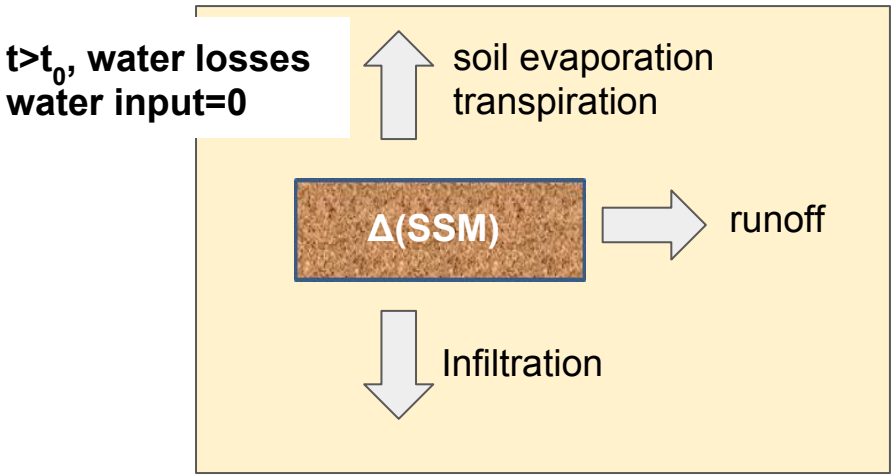
What do we mean by SSM dry-down?







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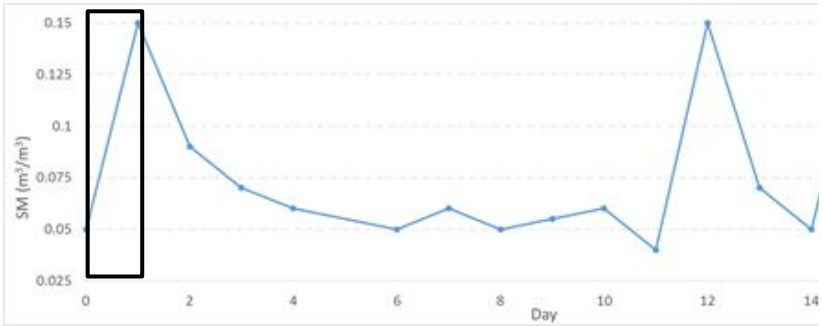


t_0, water inputs

Precipitation

Irrigation

capillary rise from groundwater

$t>t_0$, water losses
water input=0

soil evaporation
transpiration

Soil response to meteorological conditions, geophysical soil properties and vegetation cover during a dry period

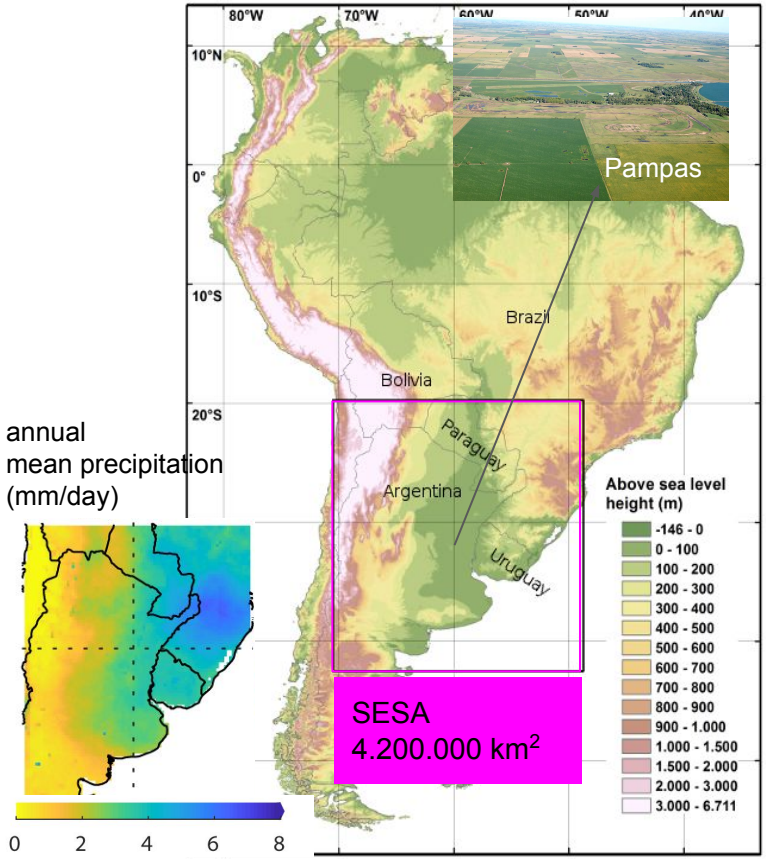
Motivation

Why do we look at regional SSM dynamics in Southeastern South America (SESA)? Because it ...

includes the low and flat Pampas plains where groundwater plays an important role and floods are recurrent;

is a transition zone between wet and dry climates, that has been recognized as a SM-atmosphere hotspot, where atmospheric predictability can be improved;

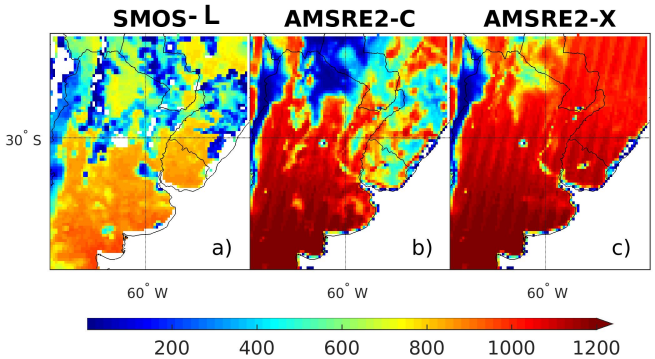
houses a large population density and productivity of agriculture and cattle raising



Surface soil moisture (SSM) data

is analyzed during the 2010-2014 with..

3 Microwave remote sensing products (MRSPs):
SMOS-L3, AMSRE-LPRM and AMSR2-LPRM



Number of available satellite estimates
(Sampling frequency ½, ⅔ days^{-1})

Sensed depth
L ~ 5 cm
C ~ 3 cm
X ~ 1 cm

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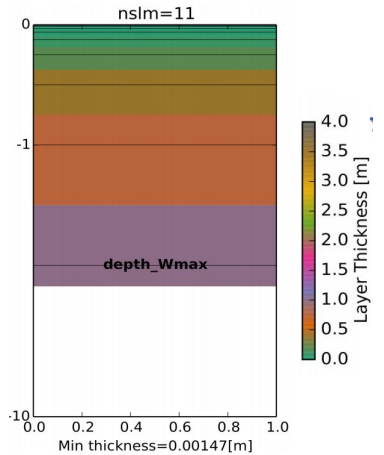
1 land surface model (LSM):
ORCHIDEE

large soil vertical resolution for the SSM representation which is highly valuable for comparison with SSM from MRSPs



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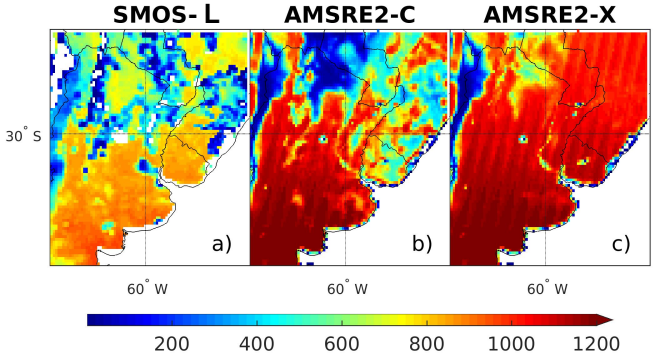

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25kmx25km

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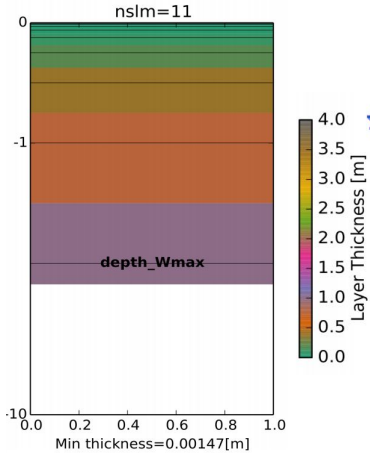


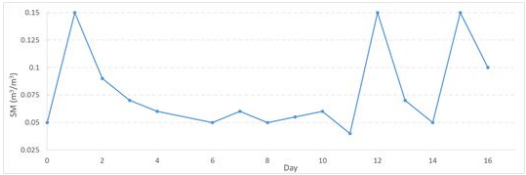
MRSPs spatio temporal data availability → ORCHIDEE full SSM time series

→ **ORCHIDEE resampled**

How do we quantify the dry-down?

$$SSM(t) = A * e^{(-t/\tau)} + SSM_f$$

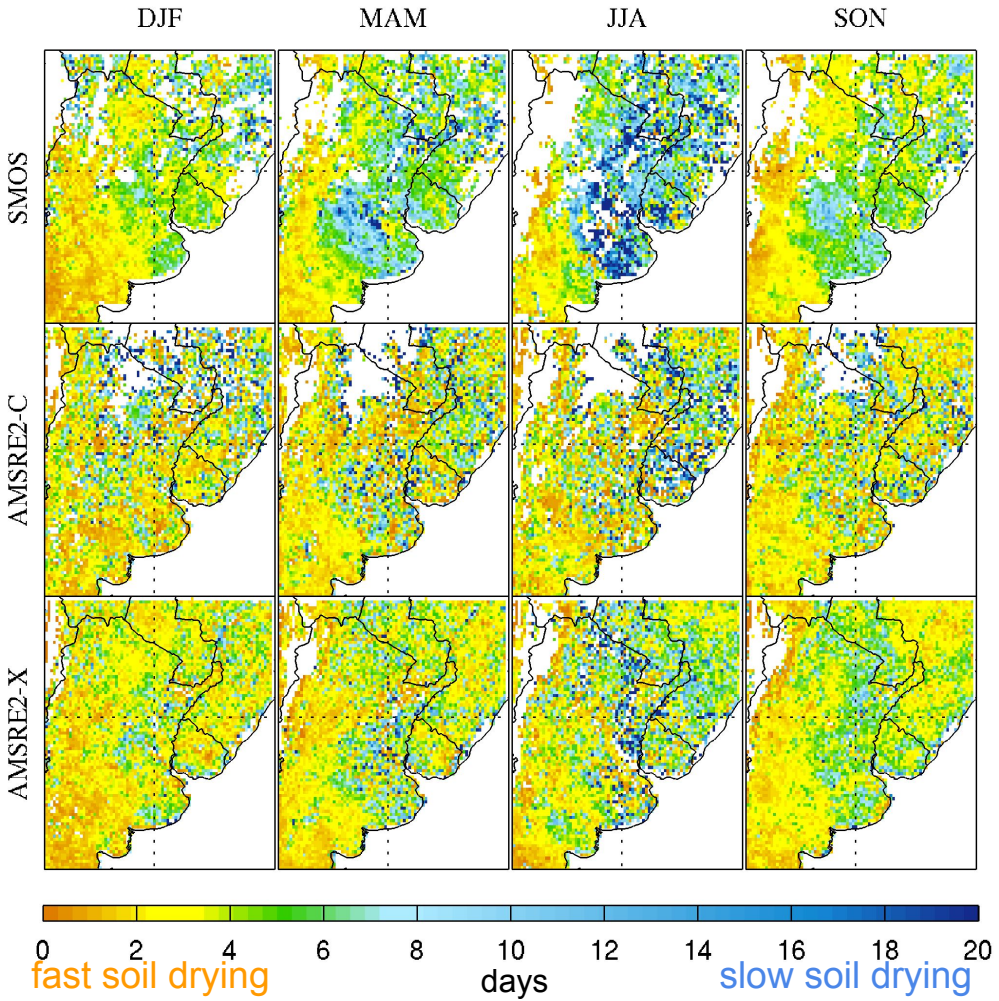
$\mathcal{T}$: dry-down time scale (days)
(e-folding parameter)



A low (high) dry-down time scale means
fast (slow) soil drying

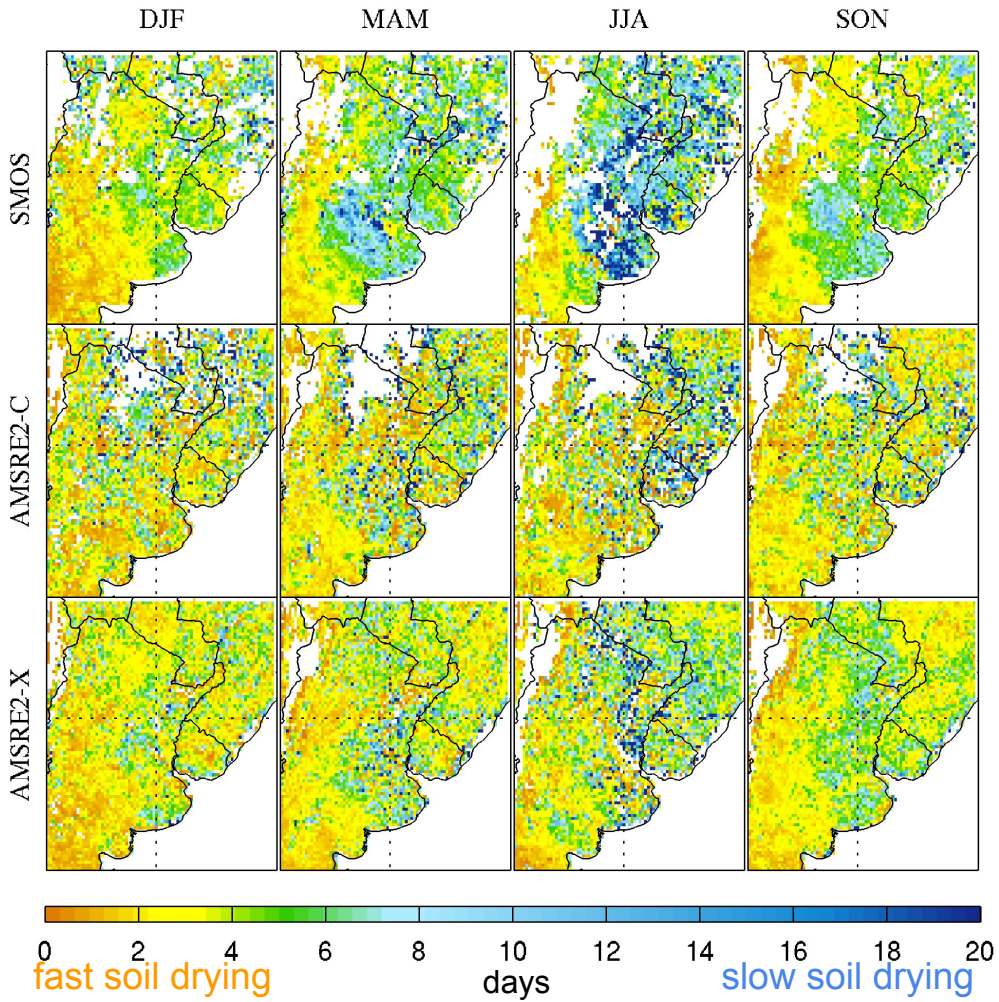
Daily SSM evolution
Seasonal analysis
Median $\mathcal{T}$values

Dry-down time scale in MRSPs



Dry-down time scale in MRSPs

SMOS detects smoother spatial patterns than AMSRE2 products due to less vegetation attenuation in L band than in C and X bands;



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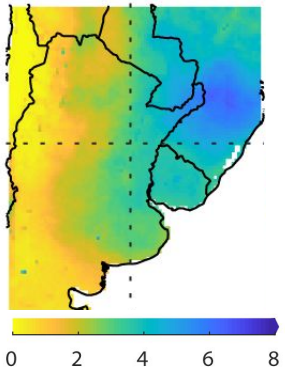

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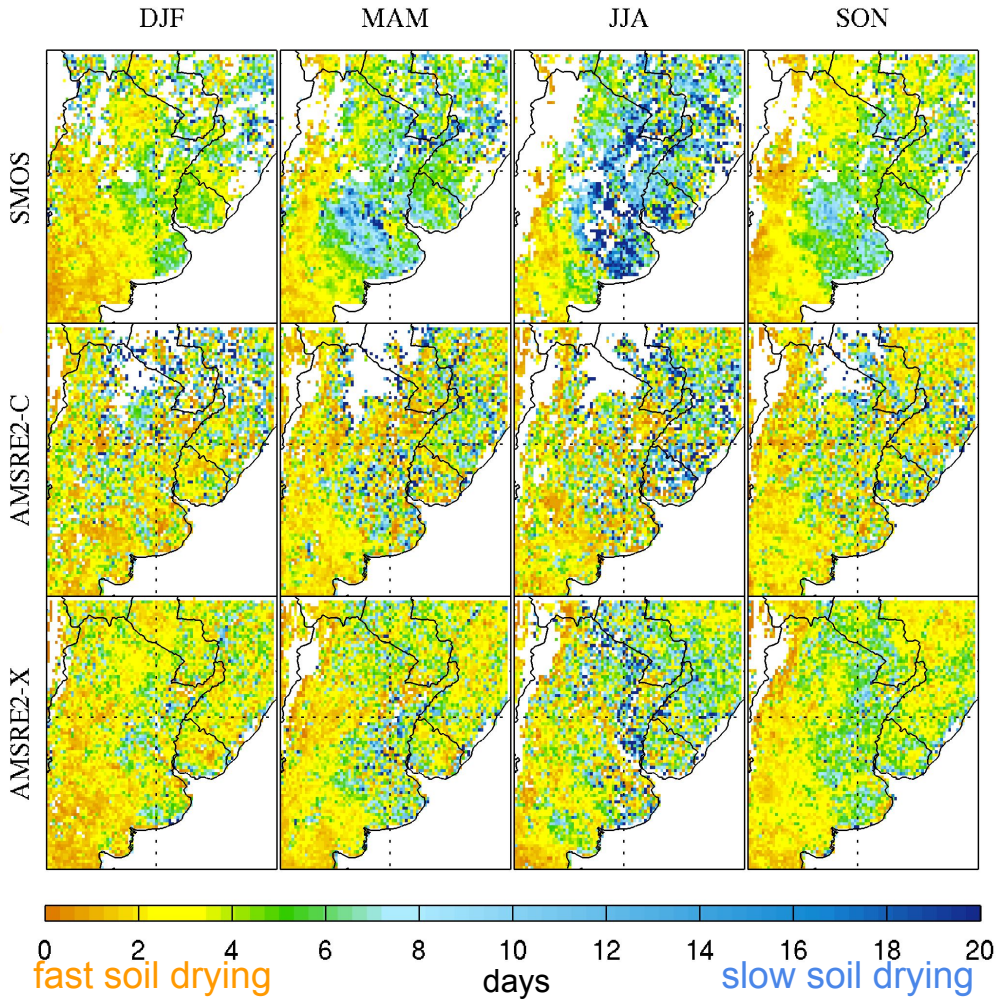

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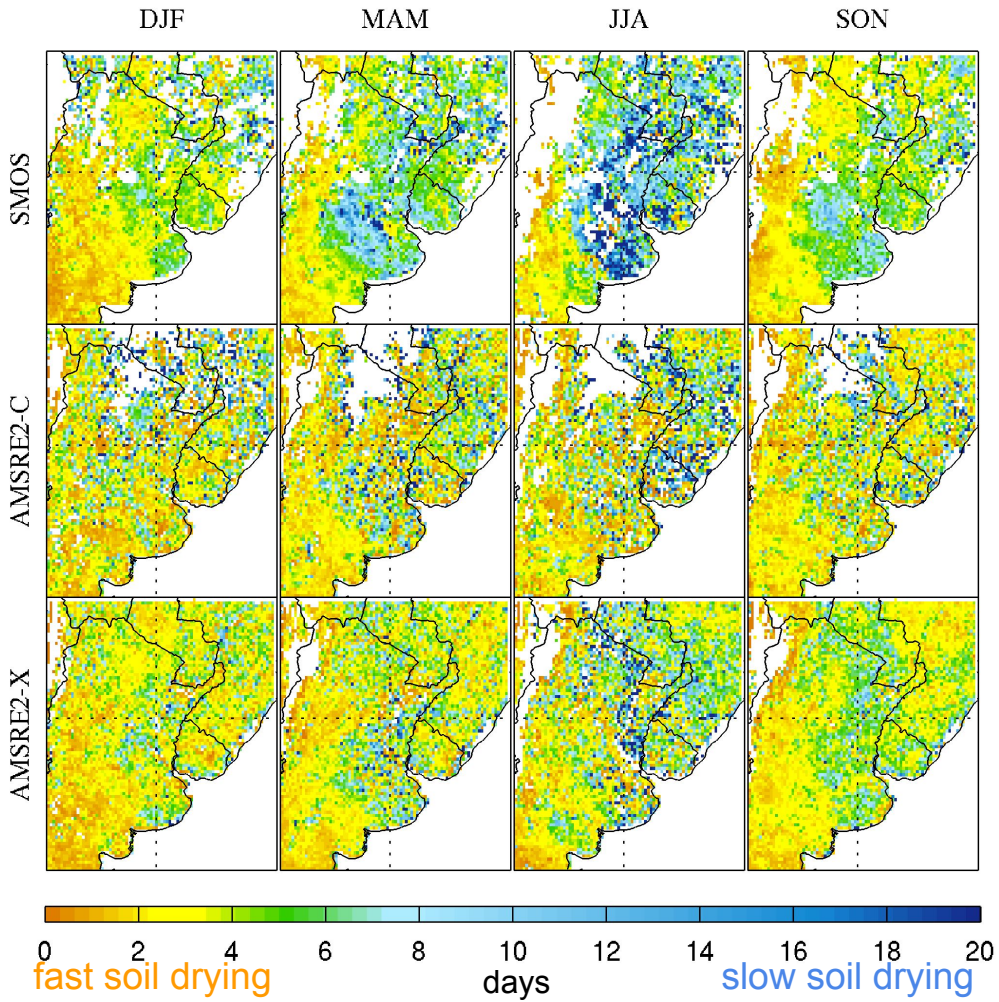
Noisier patterns in C band than in X band probably due to more RFI

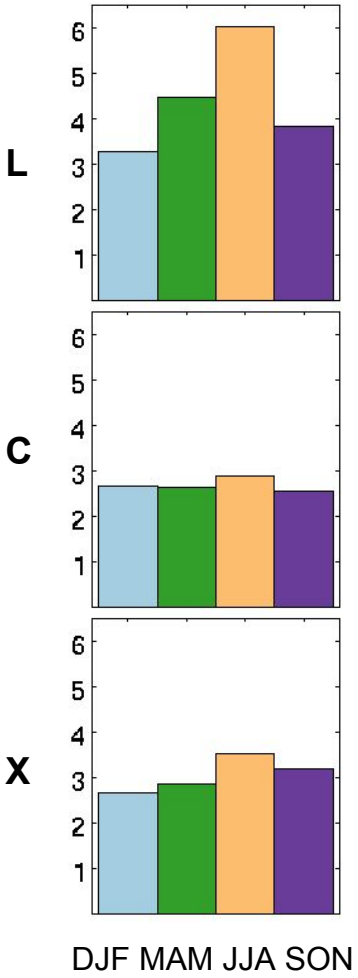


Dry-down seasonality

Slow soil drying during winter (JJA) coherent with less atmospheric demand than in other seasons

Clear seasonality in L band and in less degree in X band

Less reliable result in summer (DJF) due to more vegetation effects



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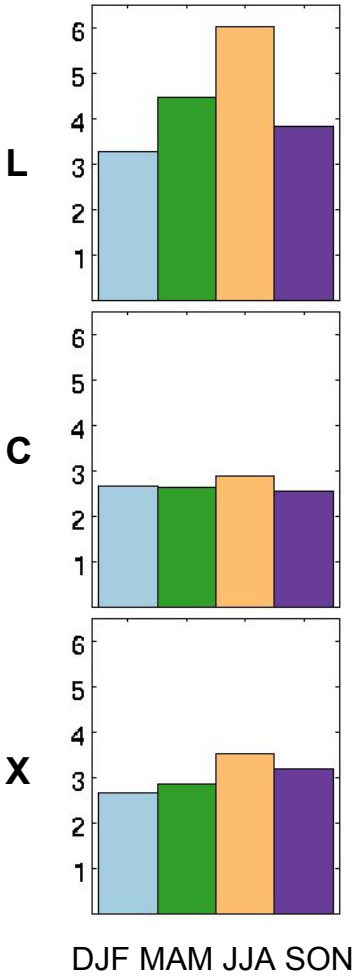
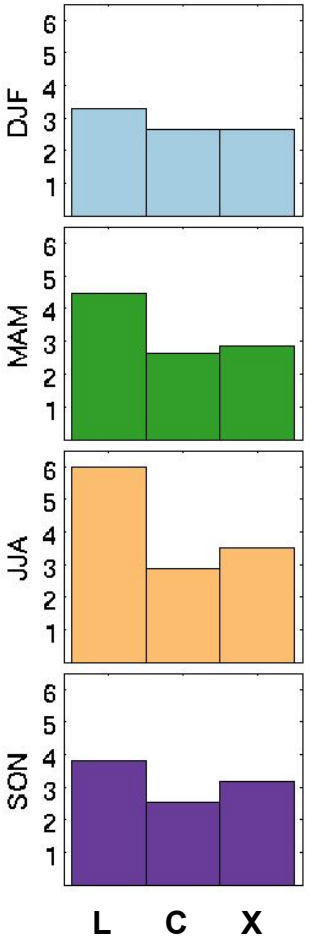


Dry-down band sensitivity

Slower soil drying for L band in all seasons, coherent with a sensing of a deeper layer

Why X > C if X detects a thinner layer depth?

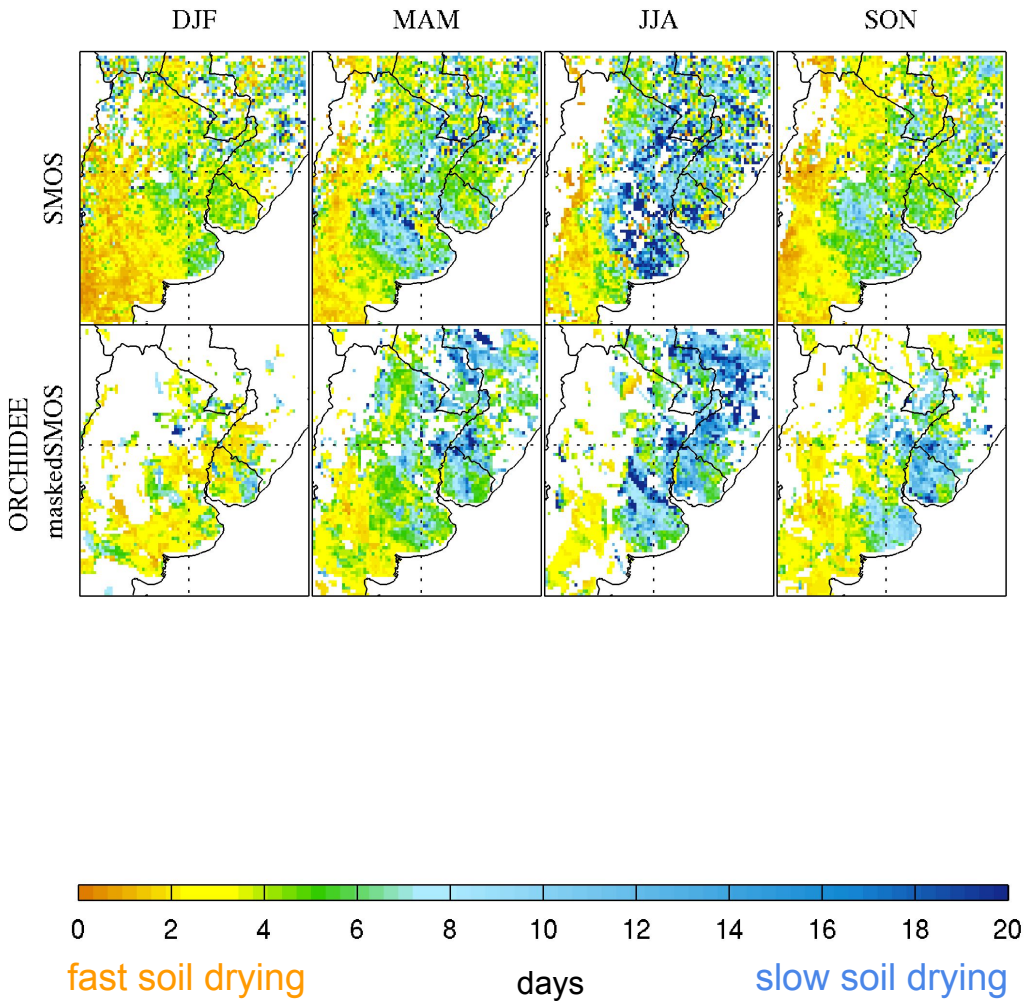
- Less number of dry-down events in C band
- Vegetation causes more attenuation in X than in C band



SMOS vs ORCHIDEE resampled

ORCHIDEE resampled by SMOS:

- detects the spatial humidity gradient and seasonality;
- has less spatial coverage because ORCHIDEE events do not necessarily match with SMOS ones



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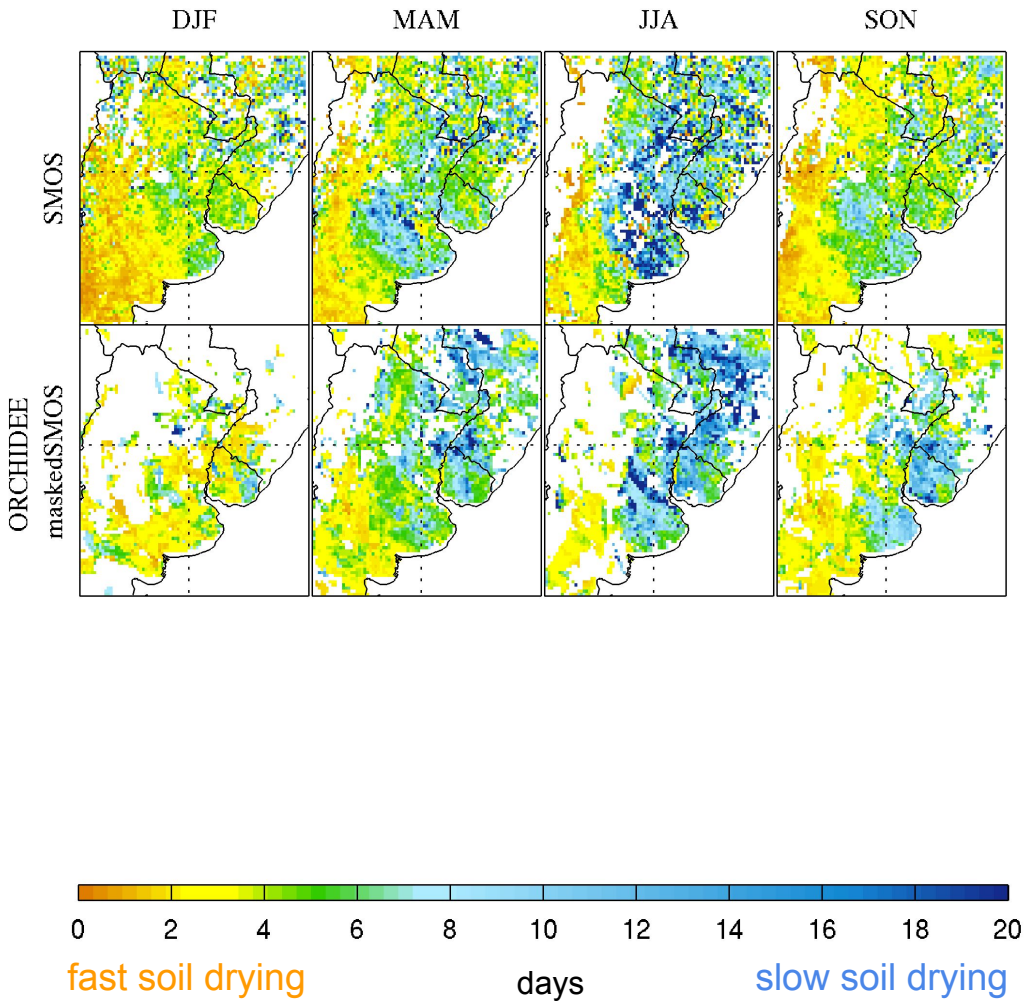
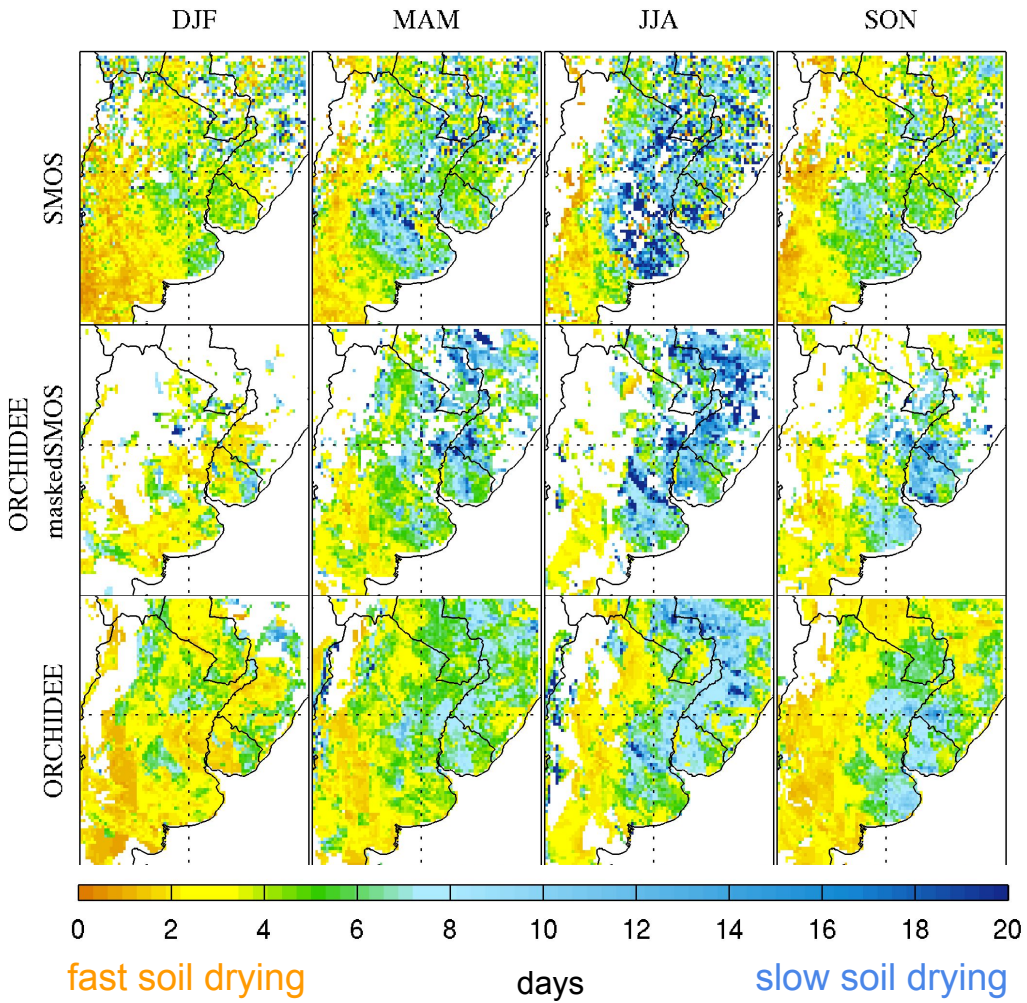
What does the full result look like when there is no sampling issue?



SMOS vs ORCHIDEE resampled vs ORCHIDEE

In general, spatial patterns are still there but median values are reduced, suggesting that SMOS sampling frequency tends to overestimate median dry-down time scales



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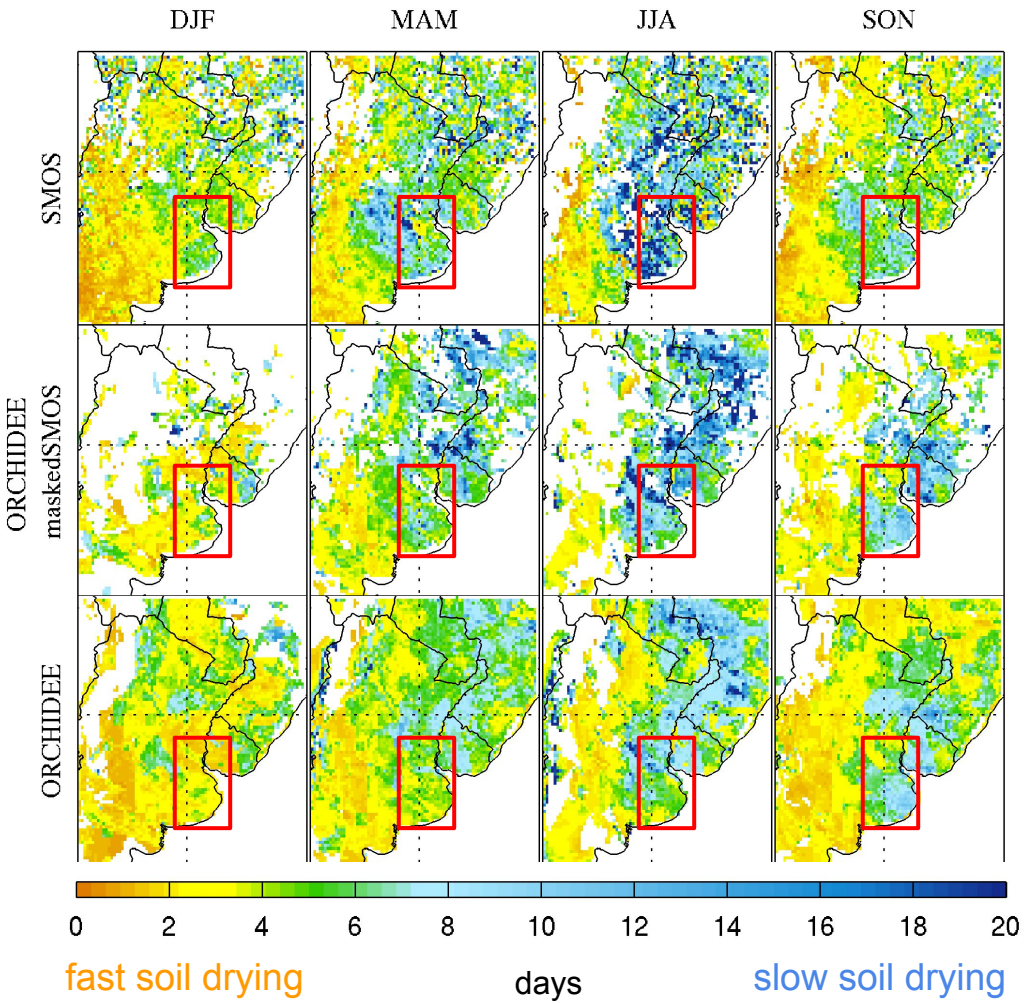
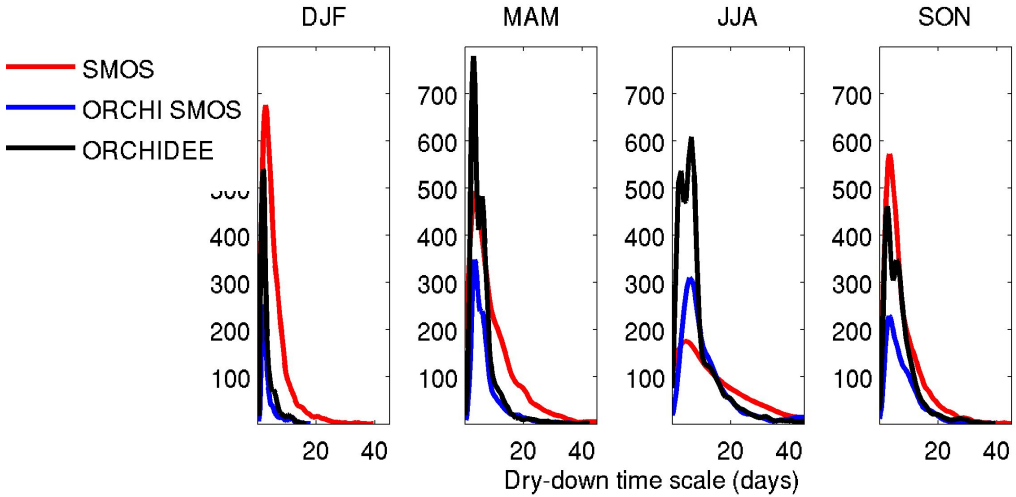
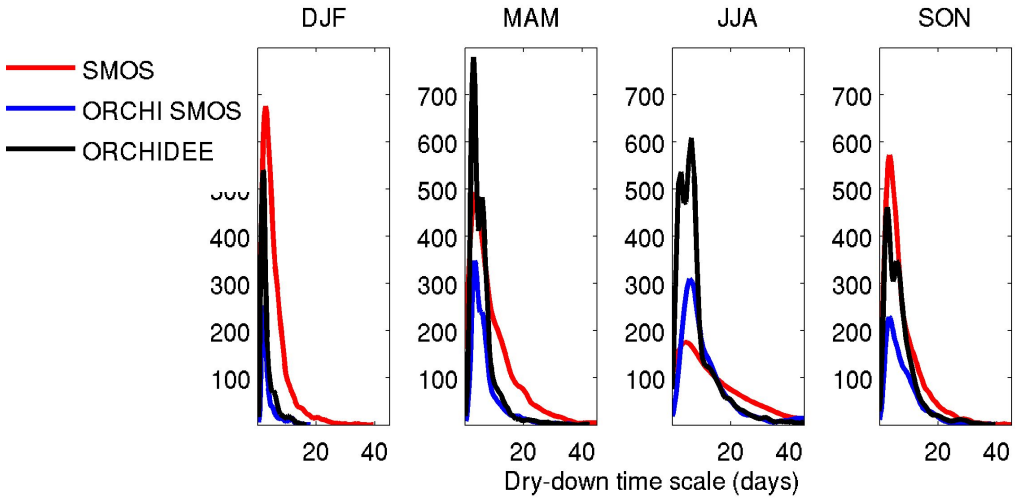
If we focus on a region with similar climate characteristics ...



Sampling effect



All positively skewed distributions, with SMOS more heavily tailed than ORCHIDEE;



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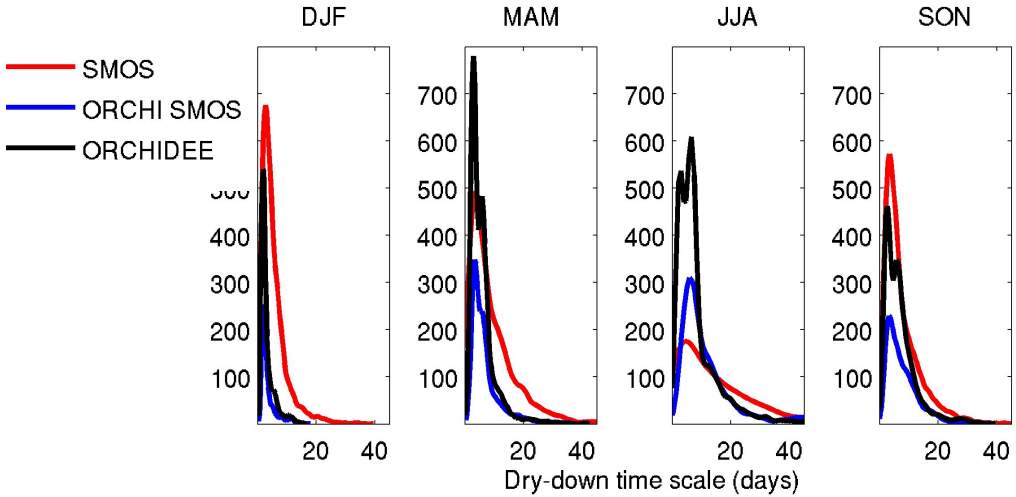
Re-Sampling ..

reduces the number of events and does not affect very long dry-downs;



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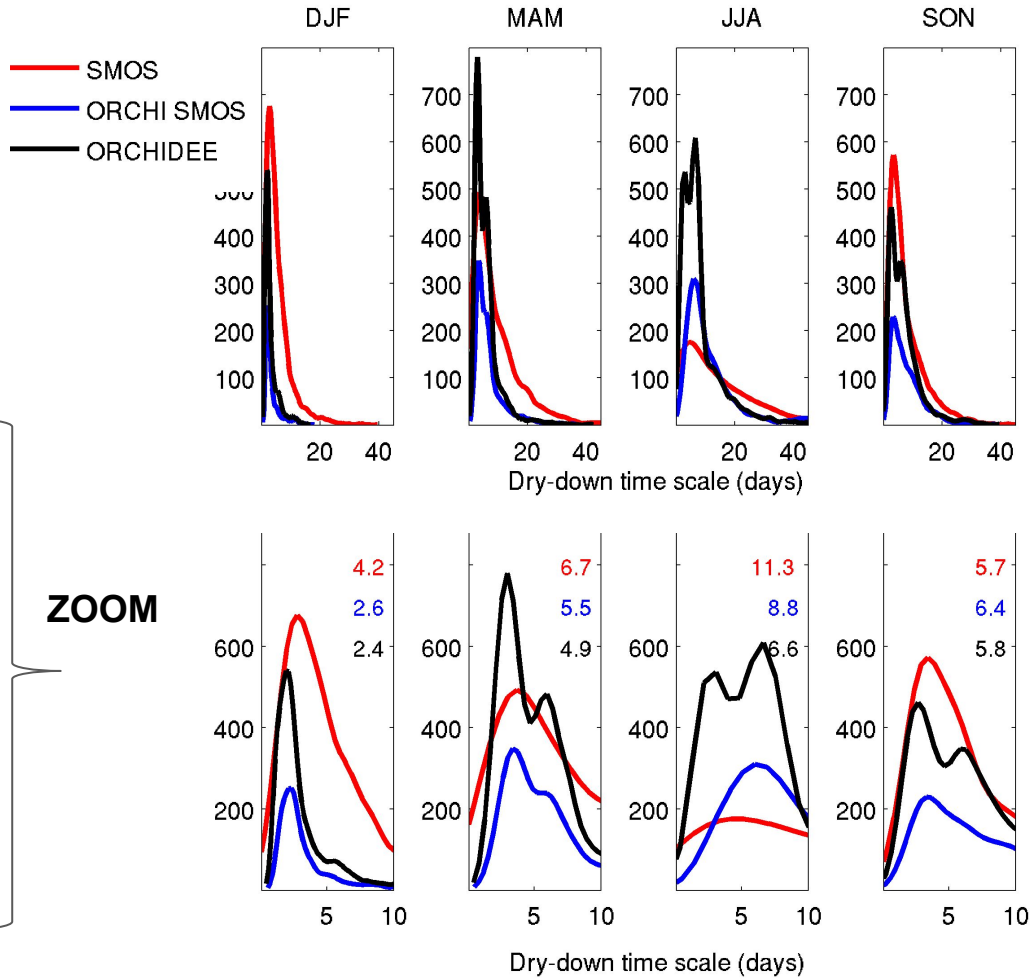
reduces the number of events and does not affect very long dry-downs;

does not change distribution characteristics in summer (DJF) because dry-downs are short;

eliminates the bimodality behaviour in JJA and SON and almost in MAM, approaching to SMOS unimodal distribution;

brings ORCHIDEE median (numbers) and mode (main peak) values closer to the ones from SMOS



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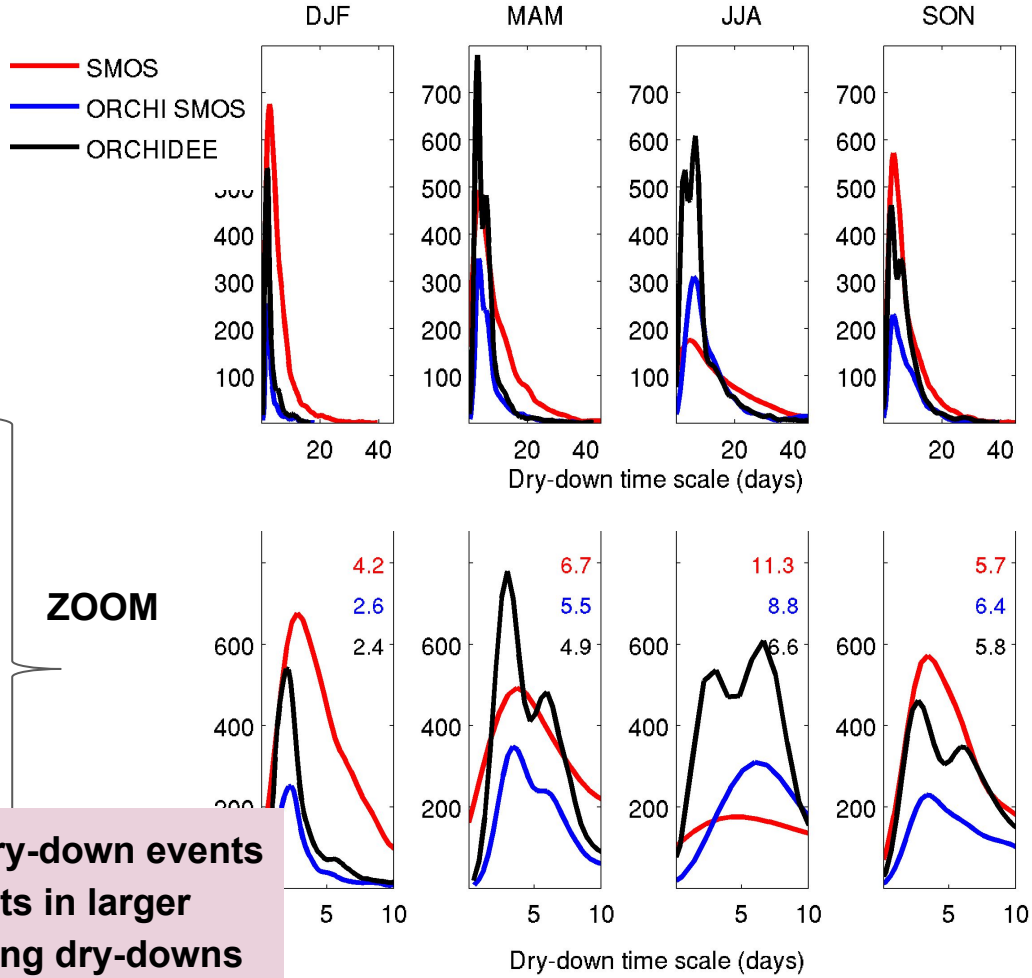

Basically, re-sampling reduces the number of dry-down events especially the short/fast ones and this results in larger statistical values (median, mode), mainly for long dry-downs

Final remarks

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- ➔ Less events and vegetation attenuation could cause faster soil drying in a thicker layer (C band) compared to a thinner one (X band);
- ➔ SMOS sampling frequency excludes the study of short dry-downs (e.g. Summer) and consequently overestimates statistical values mainly in winter when dry-downs are longer than in other seasons.

Thank you for your attention!

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This work was partially support by

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