Understanding Land - Atmosphere Interactions on Mesoscales Using Observations over the Sahel

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Land surface properties such as soil moisture is known to impact atmospheric moisture conditions through induced energy and moisture fluxes. Semi-arid regions such as the Sahel in Africa demonstrate higher sensitivity of surface fluxes to soil moisture (SM), which in turn affects precipitation (Pr) variability and initiation of convective rain storms.

Motivation :

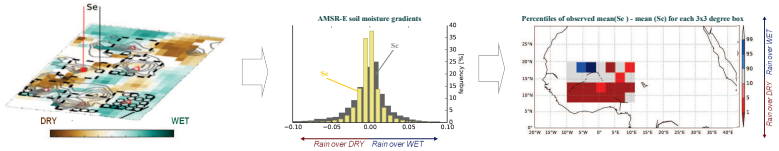
- Understand complex interactions and system of feedbacks between SM and Pr at mesoscales;
- Provide significance to the feedback estimates by utilizing 5 years of state-of-the-art satellite products;
- Evaluation of the numerical simulation schemes.

Objectives :

- Analyze effect of event definition (convective precipitation or initiation itself) on the soil moisture - precipitation feedback;
- Identify sensitivity of precipitable water to soil moisture anomalies;
- Characterize strength and features of the SM imprint onto boundary layer.

Metric of Taylor et al., 2012

Correlations between soil moisture (SM) and precipitation (Pr) are "contaminated" by the *precipitation* ⟹ *SM* signal, and are difficult to interpret. Relating spatial structure of SM to the probability of convective event occurrence is a useful statistical tool to study *SM* ⟹ *Pr* feedback.

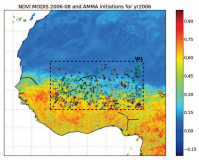


- *Event = max of ∑(12-21UTC) TMPA precipitation*
- *AMSR-E* ascending: SM anomalies at 13:30LT*
- *Se = SM (at Pr max) - SM (at Pr min)*
- *Observed SM gradients (Se) are shifted towards DRIER soils*
- *SM grads in non-event locations (Sc) are distributed symmetrically*
- *Hypothesis testing reveals more frequent negative feedback*

* TMPA = TRMM Multi-satellite Precipitation Analysis * AMSR-E = Advanced Microwave Scanning Radiometer - EOS

DATA & Domain

Data Set	Parameter	Resolution	Frequency	Time span
TRMM	TMPA - precip	0.25	3 - hrs	1998-present (v7)
AMSR-E	SM	0.25	1:30 am/pm	2002-2011 (v5)
CCI SM	ESA - SM	0.25	daily	1979-2010
Meteosat	LandSAF - ET	0.03	30 mins	2009-present (v4.0.3)
Meteosat	LandSAF - LST	0.03	15 mins	2005-present (v7.7)
Meteosat	Chris Taylor	0.03	15 mins	2006-2010 (JJAS)
MODIS (polar)	TPW	0.01(NIR)/ 0.05 (IR)	10:30, 1:30 am/pm	Mar2000 - pres (v5)
MODIS (polar)	LST	0.01	10:30, 1:30 am/pm	Mar2000 - pres (v5)
C_Taylor, AMMA	initiations	locations	event scale	2006-2010
ERA Interim	t,h	0.75	6hrs	



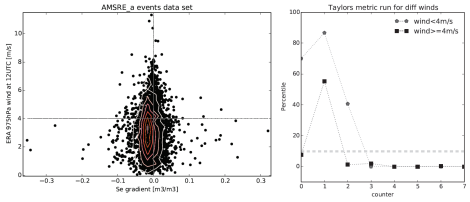
- Tested for T12 metric
- Next steps

- Time period: JJAS 2006-2010
- Domain of AMMA* convective initiations: 10:20°N / -10:10°E

* AMMA = African Monsoon Multidisciplinary Analysis

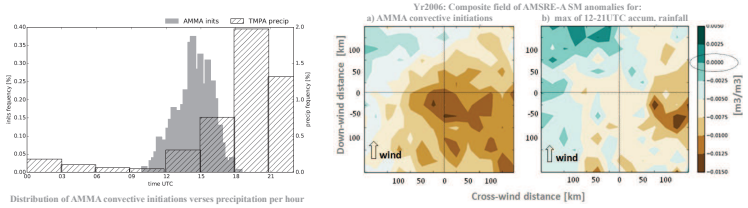
Results

1. Metric sensitivity to wind around convective events:



- Maximum frequency occurs over negative gradients and light winds
- Feedback is robust over the observed wind range of identified events
- Non-events must be included to observe a change to a positive feedback

2. Feedback sensitivity to event definition:



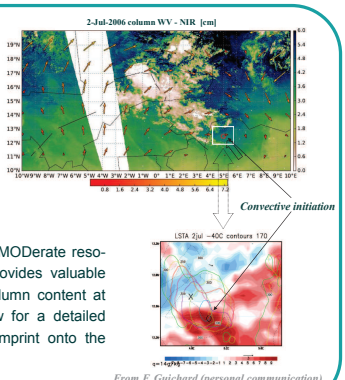
- 3-4 hours delay between precipitation (first rain) and initiation maxima
- The negative feedback exists in rather coarse (25 km) AMSR-E SM
- Though metric reveals negative feedback, it can not be explained by induced local circulations
- Local convergence is only observed around initiations (not accumulated precipitation events)

Next Steps ...

1. Event definition related:
Why does composite SM field around rainfall events show different behavior?

2. Total precipitable water (TPW):
What does TPW see?

The total precipitable water product from MODerate resolution Imaging Spectrometer (MODIS) provides valuable information on the atmospheric water column content at the 1 km resolution, and thus can allow for a detailed analysis of soil moisture heterogeneity imprint onto the atmospheric boundary layer.



From F. Guichard (personal communication)

Conclusions

1. Relating spatial structure of SM to probability of event occurrence is a useful statistical tool to study the feedback, but should be treated with care due to multiple limitations, product resolution, as well as definition of convective event.

2. About 80% of all events (regardless event definition) occur under relatively light (<5 m/s) wind conditions with maximum at 3 m/s.

3. The precipitation parameter carries different information with respect to initiation; shows dissimilar spatial structure of SM, that may affect feedback statistics.

References:

***Taylor, C.M.**, de Jeu, Richard A. M., Guichard, Francoise, Harris, Phil P. and Dorigo, Wouter A., **(2012)**: Afternoon rain more likely over drier soils. Nature 489. 423-426.10.1038/nature11377*

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