Surface recovery after a rain event during the west african monsoon

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(2) Centre National de Recherches Météorologiques/GAME
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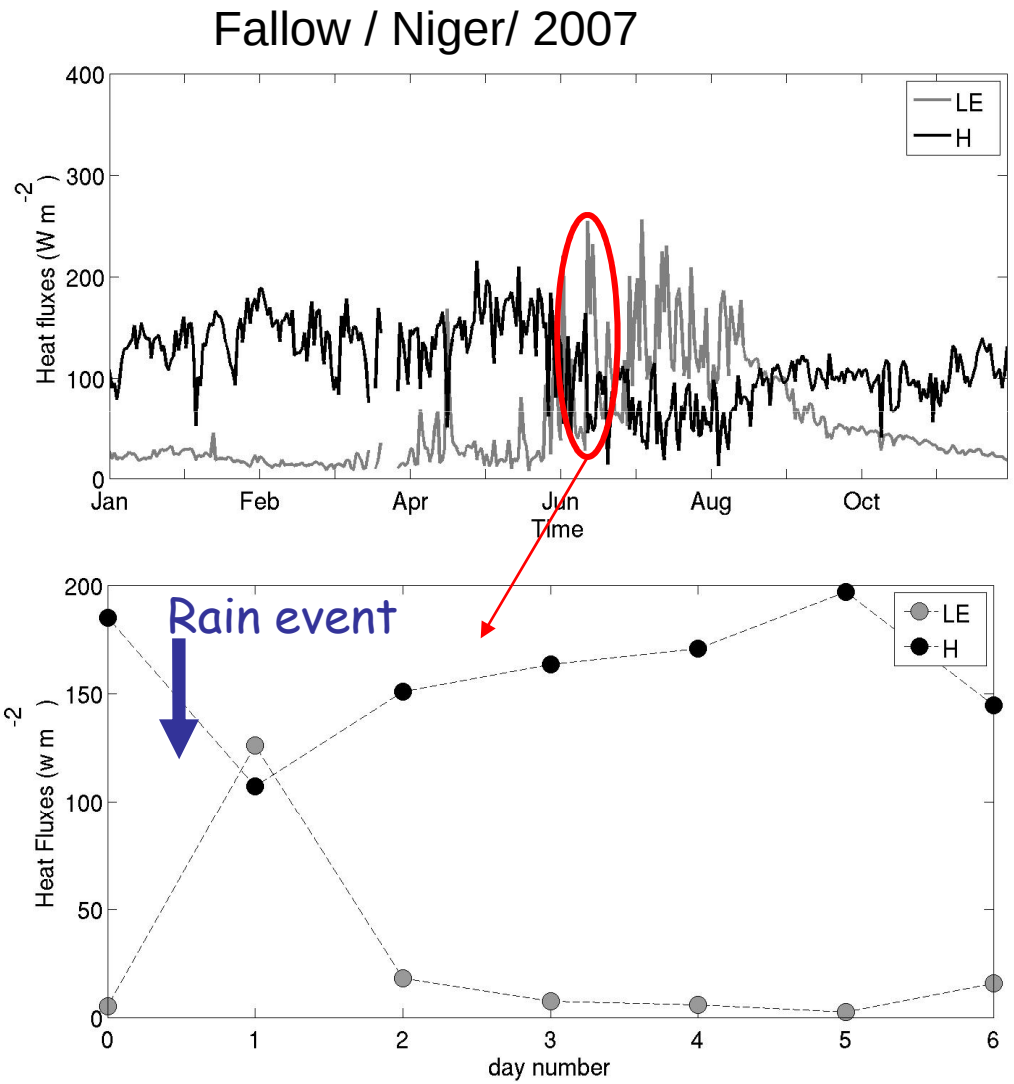
(4) Laboratoire HydroSciences Montpellier
(5) Laboratoire d'étude des Transferts en Hydrologie et Environnement
(6) DREIF/Laboratoire Régional de l'Ouest Parisien
(7) Centre for Ecology and Hydrology

Surface recovery after a rain event



Objectives:

Using surface measurements:

- To determinate the parameters which lead the surface response amplitude.
- To determine the recovy law.

Using ALMIP data set

- To evaluate the Land Surface Model at the rain event time scale over the monsoon season.

Several sites and vegetation covers

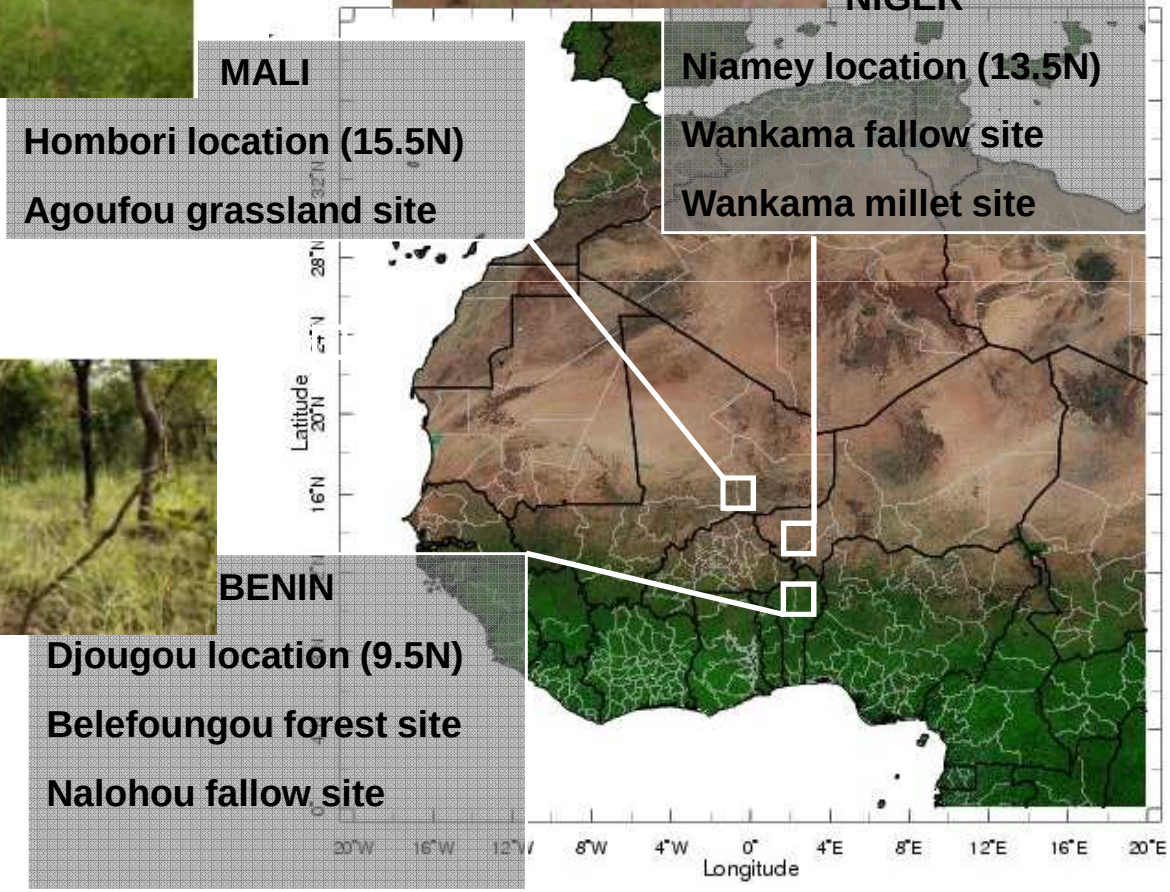
Grass / MALI : Sandy soil / Annual grass + 2% tree cover

Fallow / NIGER : Sandy soil / annual grass + tree + shrub

Millet / NIGER: Sandy soil / Millet (pocket 1-m to 4-m spacing) + annual grass + guiera shrub

Forest/ BENIN: Isoberlinia Doka

Fallow/ BENIN: Annual grass



Timouk et al., J. Hydrol., 2009 / Ramier et al., J. Hydrol, 2009 / Frappart et al., J. Hydrol, 2009/ Mougin et al., J. Hydrol, 2009 / Boulain et al., J. Hydrol, 2009

ALMIP (AMMA Land Surface Model Intercomparison Project)

LSM Forcings

Vegetation and soil texture: ECOCLIMAP

Surface meteorology: ECMWF

Rain: TRMM

Incoming LW and SW: LSA SAF and ECMWF

Boone et al., BAMS, 2009

Boone et al, CD, 2010

Dadson et al., JGR, 2010

Grippa et al., WR, 2011

…..

Model Acronym	Institute	Recent references	ALMIP model configuration
HTESSEL	ECMWF, Reading, UK *G. Balsamo*	Balsamo et al. (2009)	4L, 6 tiles, 1E, SV: ECMWF
ORCHIDEE-CWRR	IPSL, Paris, France T. *Orgeval and P. deRosnay*	d'Orgeval et al. (2008), de Rosnay et al. (2002)	11L, 13 tiles, 1E, SV: ECOCLIMAP
ISBA[a] ISBA-DIF[b]	CNRM, Météo-France, Toulouse *A. Boone*	(a) Noilhan and Mahfouf (1996), (b) Boone et al. (2000)	3L[a], 5L[b], 1 tile, 1E, SV: ECOCLIMAP
JULES	CEH, Wallingford, UK *P. Harris*	Essery et al. (2003)	4L, 9 tiles, 1E, SV:ECOCLIMAP
SETHYS	CETP/LSCE, France *S. Saux-Piccard and C. Ottlé*	Coudert et al. (2006)	2L, 12 tiles, 2E, SV: ECOCLIMAP
NOAH	CETP/LSCE (NCEP) *B. Decharme and C. Ottlé*	Chen and Dudhia (2001), Decharme (2007)	7L, 12 tiles, 1E, SV: ECOCLIMAP
CLSM	UPMC, Paris, France *S. Gascoin and A. Ducharne*	Koster et al. (2000)	5L, 5 tiles, 3E, SV: ECOCLIMAP
SSiB	LETG, Nantes, France; UCLA, Los Angeles, USA *I. Poccard-Leclercq*	Xue et al. (1991)	3L, 1 tile, 2E, SV: SSiB
SWAP	IWP, Moscow, Russia *Y. Gusev and O. Nasonova*	Gusev et al. (2006)	3L, 1 tile, 1E, SV: ECOCLIMAP

Boone et al., BAMS, 2009

Atmosphere and soil characteristics

SURFACE STATIONS

1. Sensible (H) and Latent (E) heat fluxes *(Eddy-covariance)*

$$EF = \frac{E}{H+E}$$

(~30min / 2 km)

2. Rain amount

3. Vertically Integrated Soil Moisture 1m deep. *(CS616 reflectometer)*

4. Leaf Area Index *(1-km transect / hemispheric pictures + albedo correction)*

   LAI > 0.1 vegetated surface

   LAI <= 0.1 bare soil

ALMIP LSM

1. Sensible (H), evapotranspiration (E) fluxes

$$EF = \frac{E}{H+E}$$

(~3 h / 0.5°)

2. Rain amount

3. Time change in vertically integrated Soil Moisture ΔS.

$$\frac{\partial S}{\partial t} = P - E - R$$

$$SWCA(t) = \int_{t0}^{t} \Delta S \; dt$$

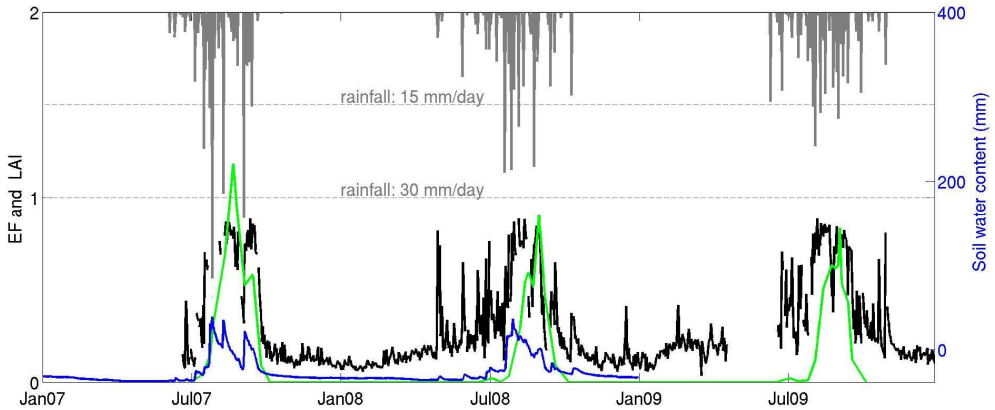
4. Vegetation activity TR / E

   TR / E > 0.1 vegetated surface

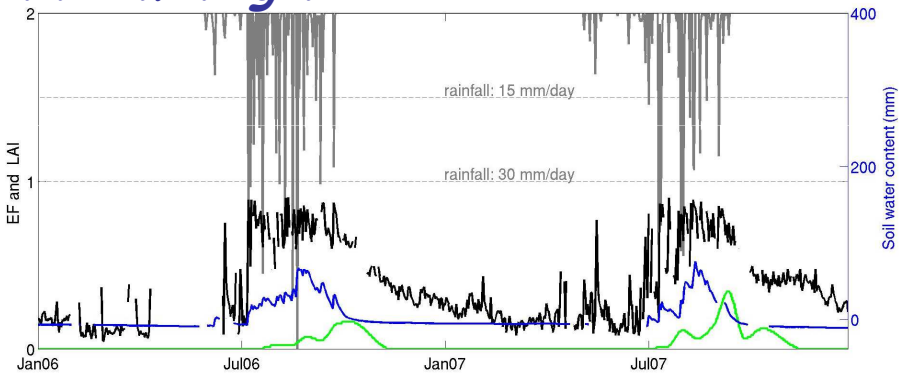
   TR / E <= 0.1 bare soil

Seasonal overview: surface measurements

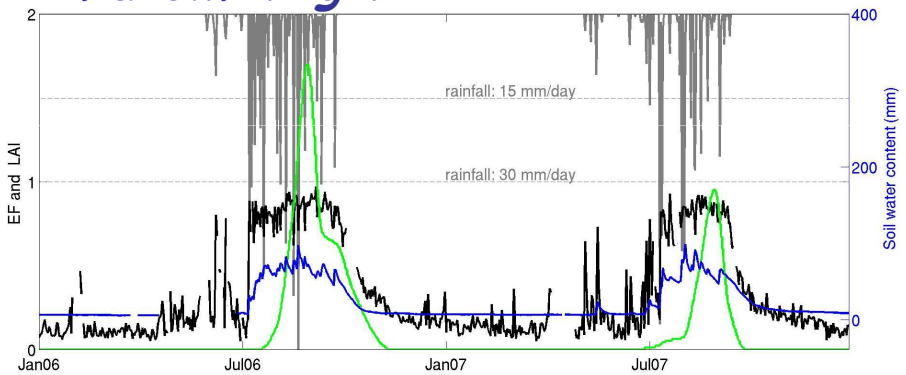
Grassland/ Mali



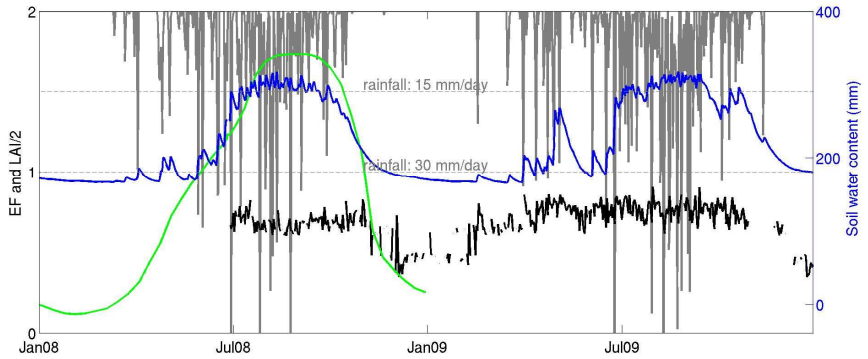
Millet/ Niger



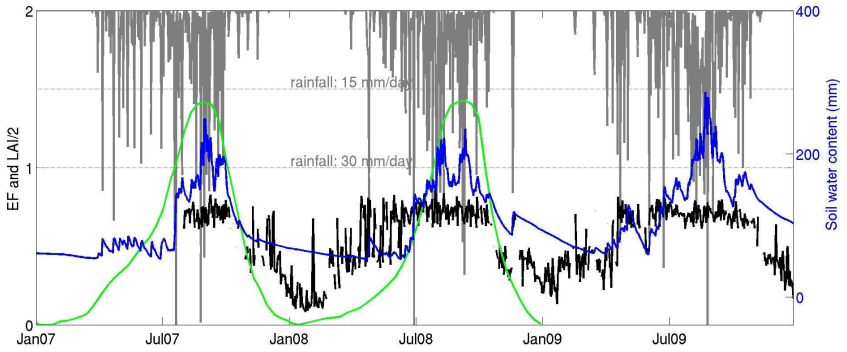
Fallow/ Niger



Forest/ Benin

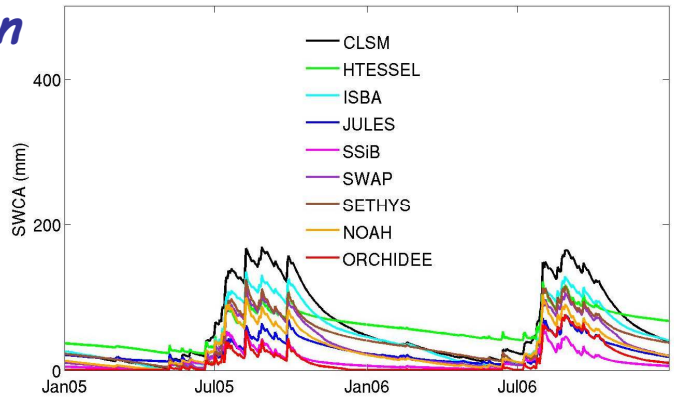


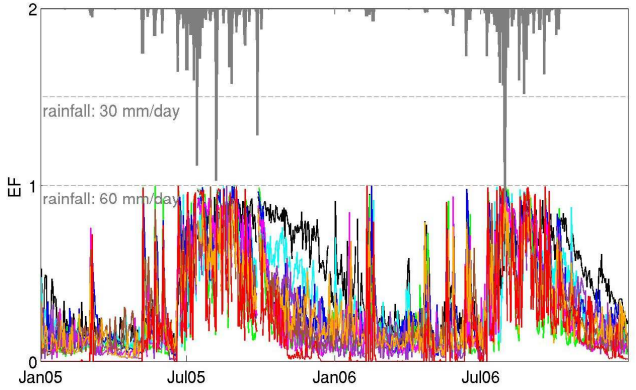
Fallow/ Benin



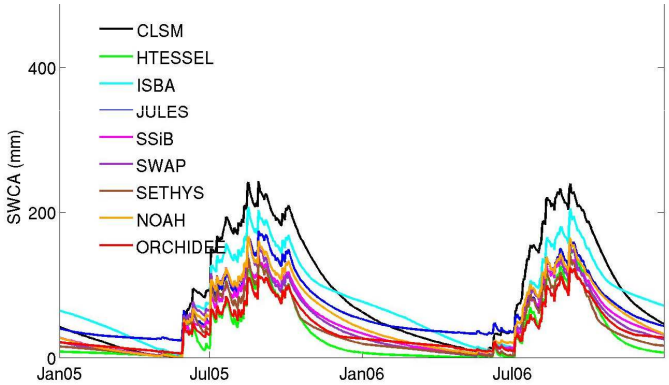
Seasonal overview: ALMIP LSM

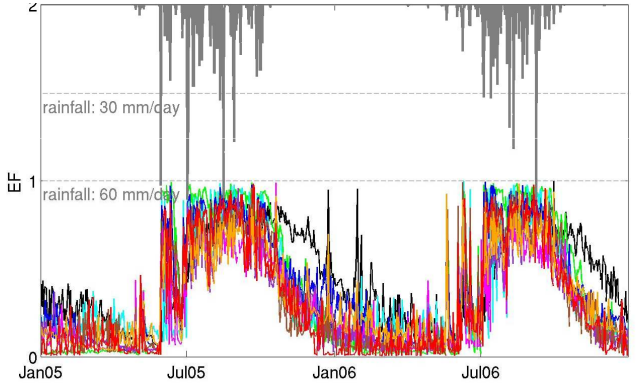
Agoufou location (Mali)



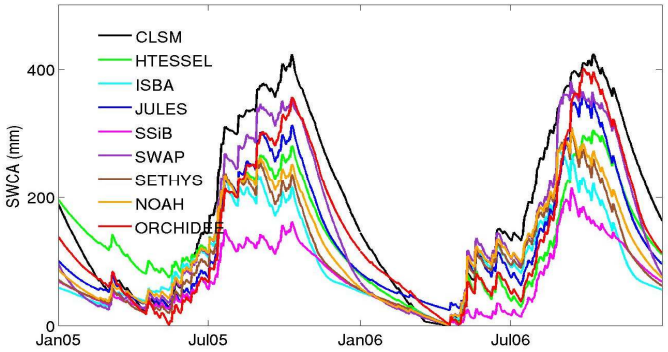


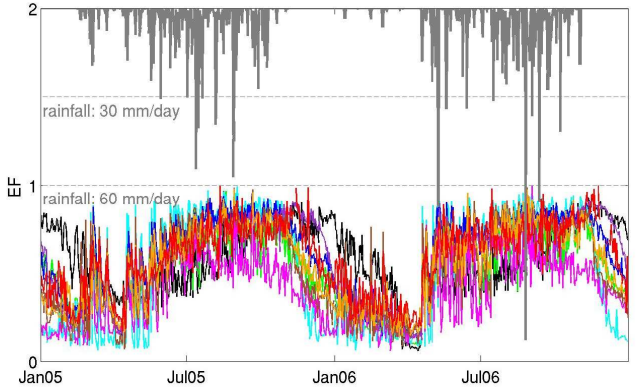
Niamey location (Niger)





Djougou location (Benin)





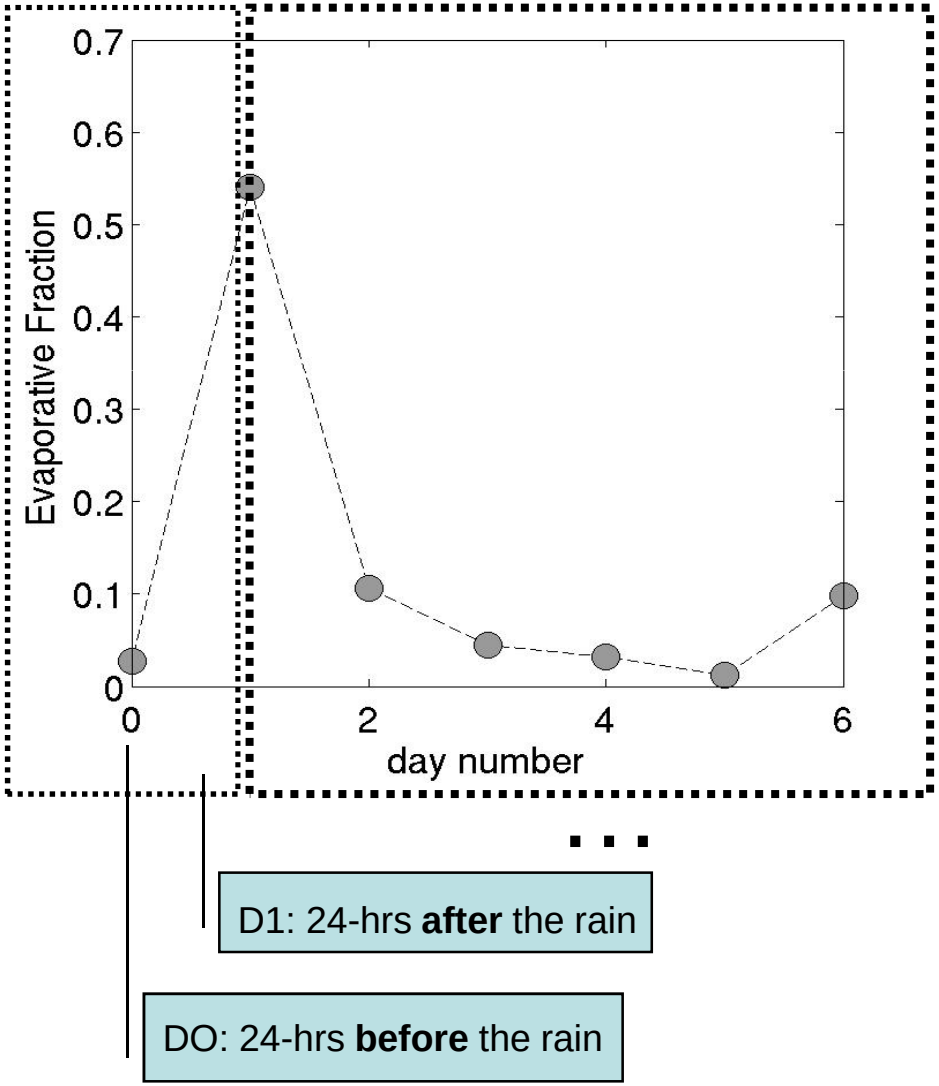
Rain selection method

***Rain selection**: cumulated rain > 3 mm* ⟶ 11 to 17 rain events / year

Surface immediate response

↓

EF(D1) / EF(D0)



Recovery period

↓

EF(D1 to D6) / EF(D1)

Hunt et al., 2002

Kurc and Small, 2004

Scott et al., 1997

Wood, 2003

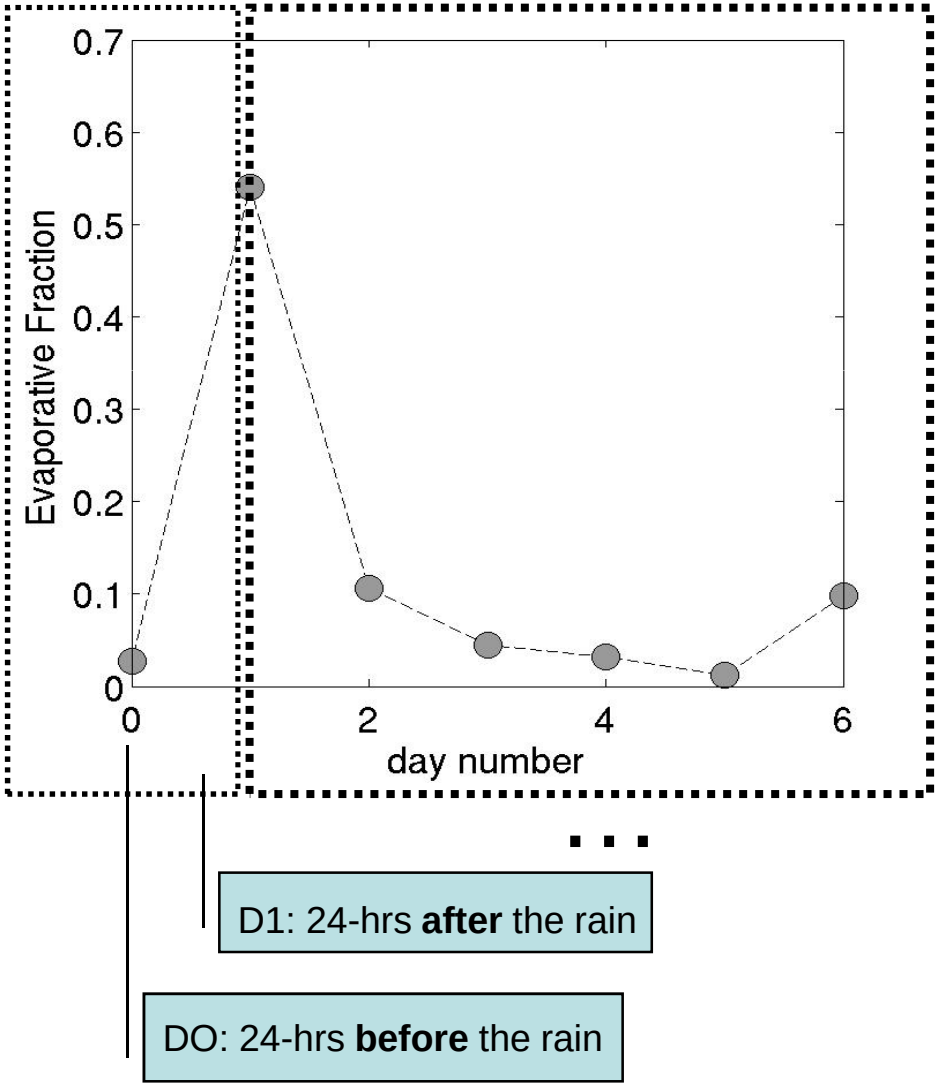
Rain selection method

***Rain selection**: cumulated rain > 3 mm* ⟶ 11 to 17 rain events / year

Surface immediate response

↓

EF(D1) / EF(D0)



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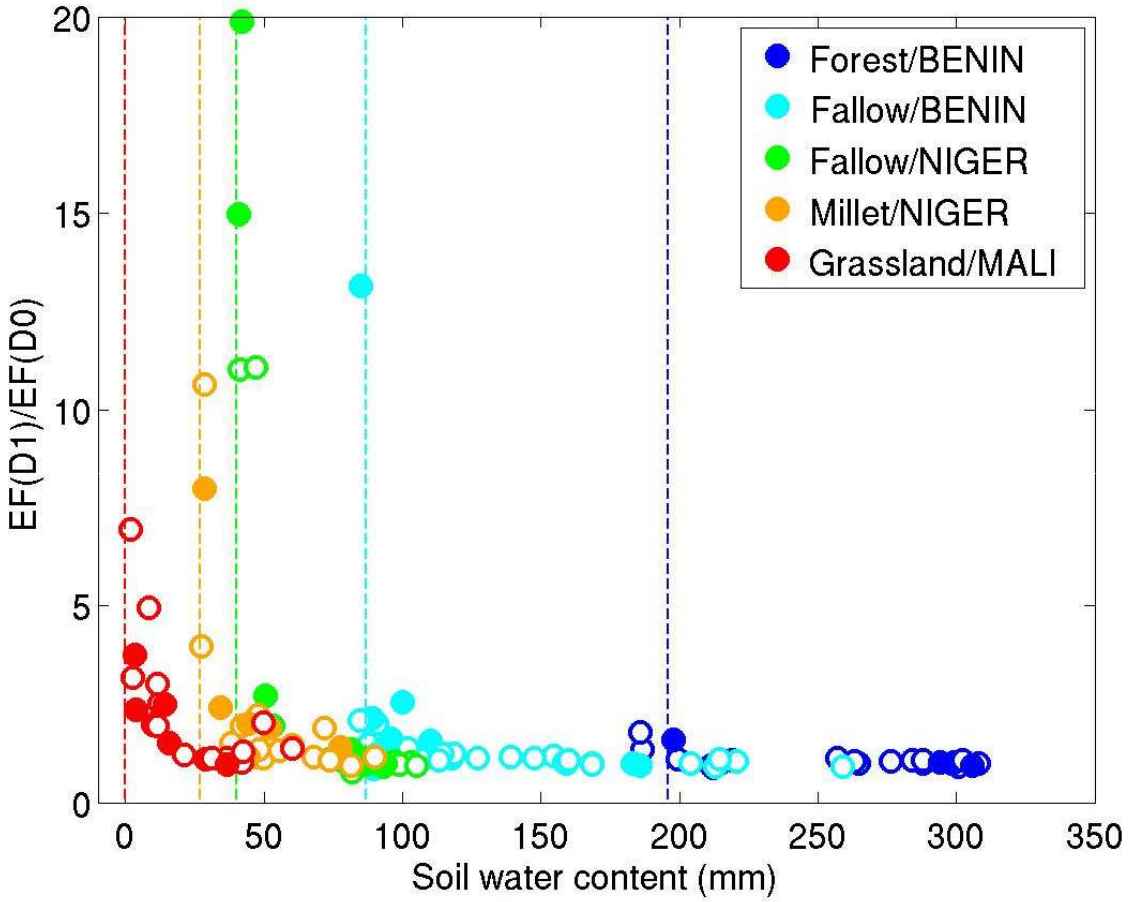
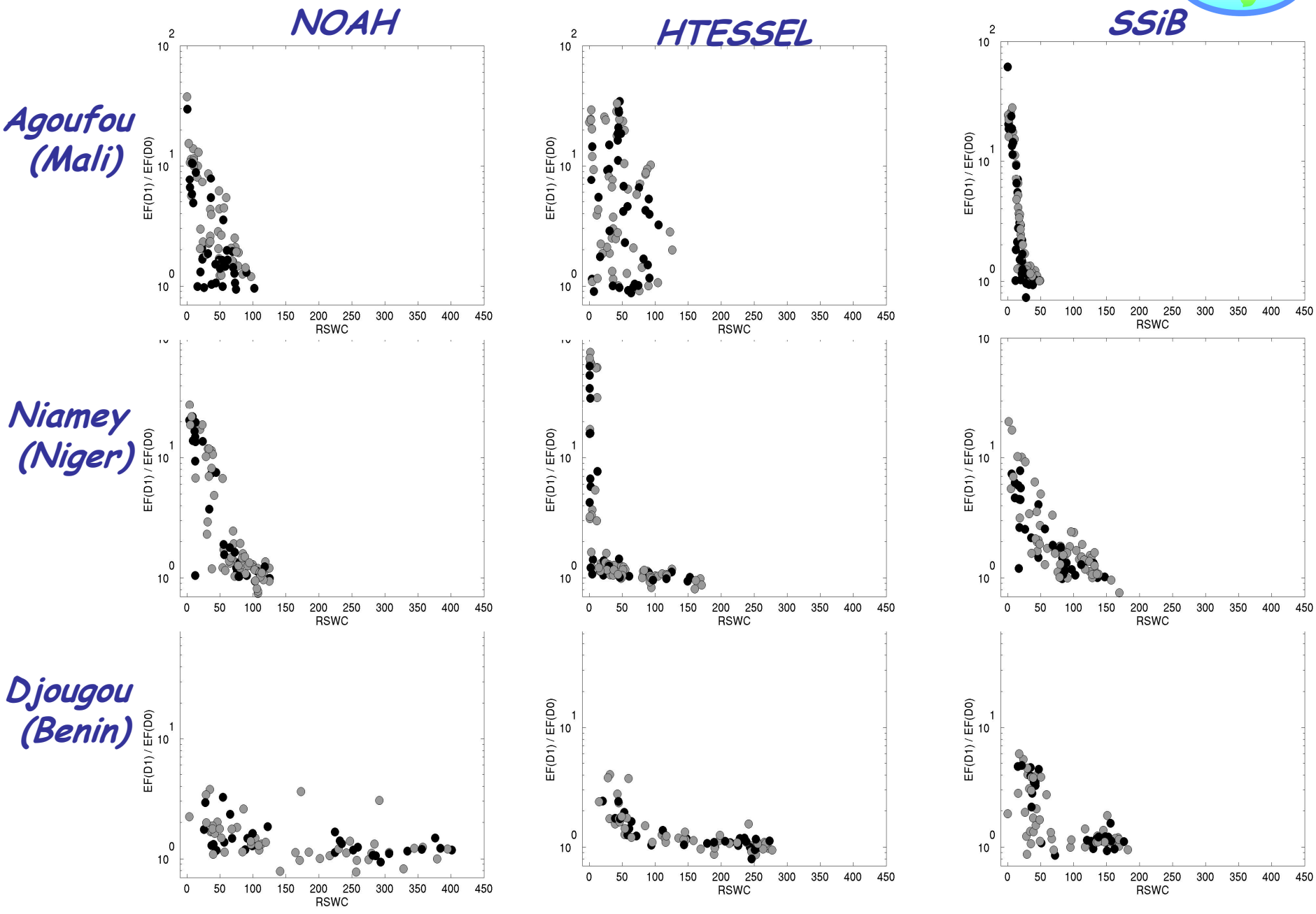


Surface immediate response

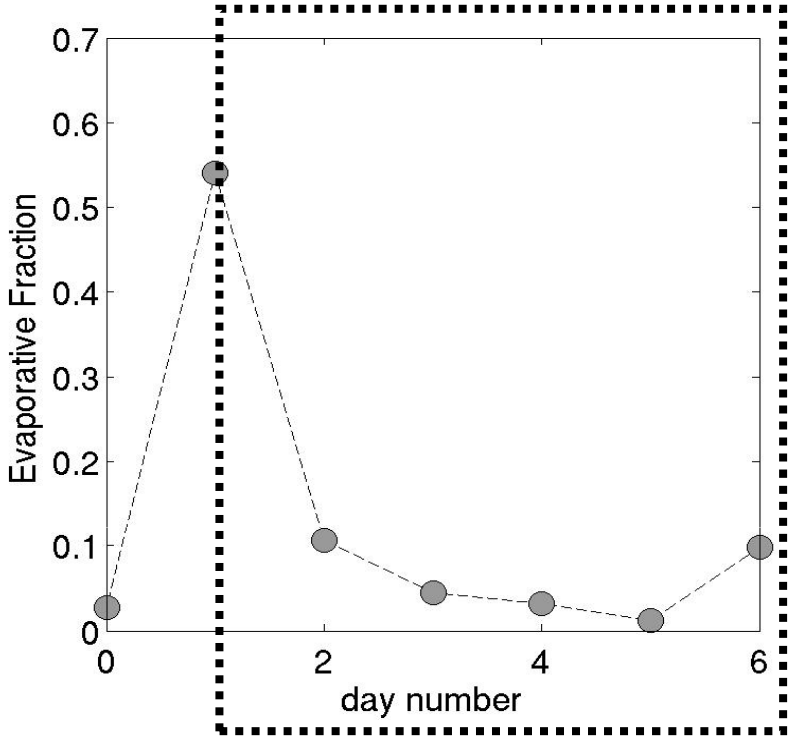


Recovery period

Recovery period

Kurc and Small, 2004 / New Mexico

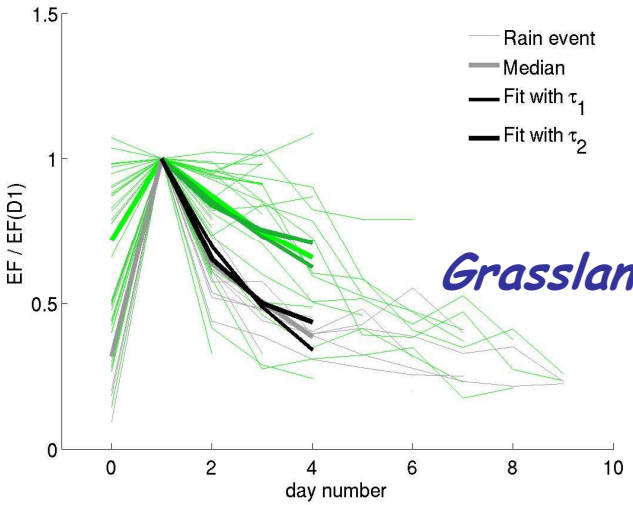
Hunt et al., 2002 / New Zealand



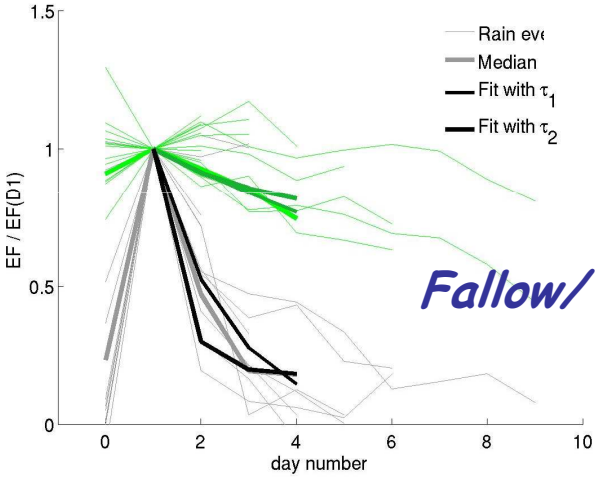
Recovery period

Vegetated surface (LAI < 0.1)

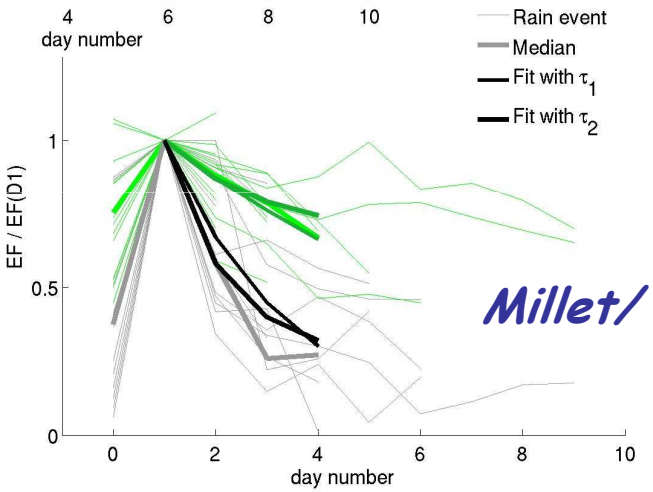
Bare soil (LAI >= 0.1)



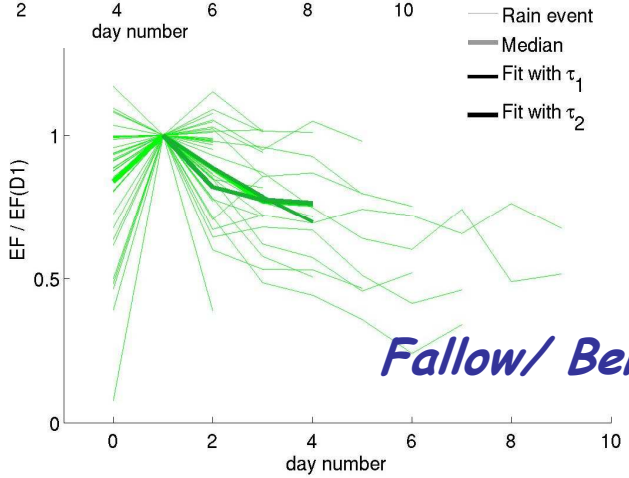
Grassland/ Mali



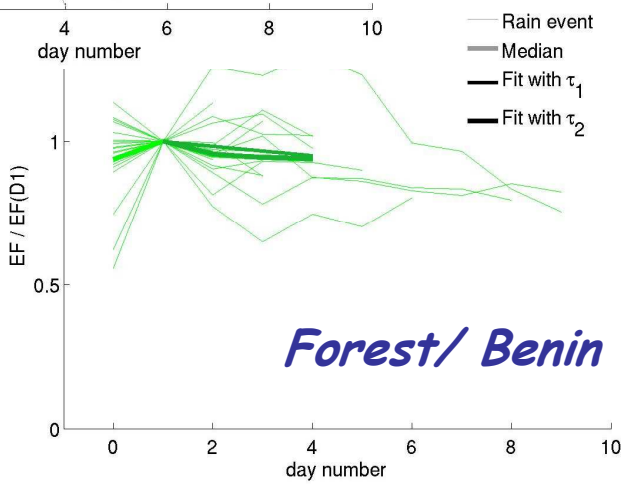
Fallow/ Niger



Millet/ Niger



Fallow/ Benin



Forest/ Benin

Recovery period

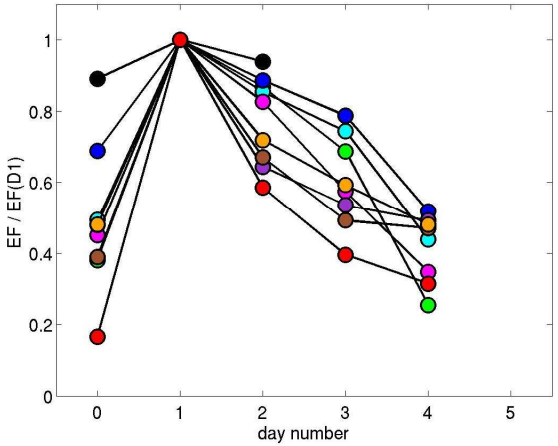
Vegetation	AMMA			Hunt et al. (2002)	Kurc and Small (2004)
	Benin	Niger	Mali	New Zealand	New Mexico
	τ_1, τ_2	τ_1, τ_2	τ_1, τ_2	τ_1	τ_2
Bare		**1.5-2.5**, 0.5-1.2	**2.8**, 1.2		
Fallow	**8.3**, 0.71	**11.5**, 2.5			
Grass			**6.5**, 1.5		2
Tussock grassland				**6**	
Rye grass				**10**	
Millet		**7.3**, 2			
Forest	**58**, 0.8				
Shrub					1.8

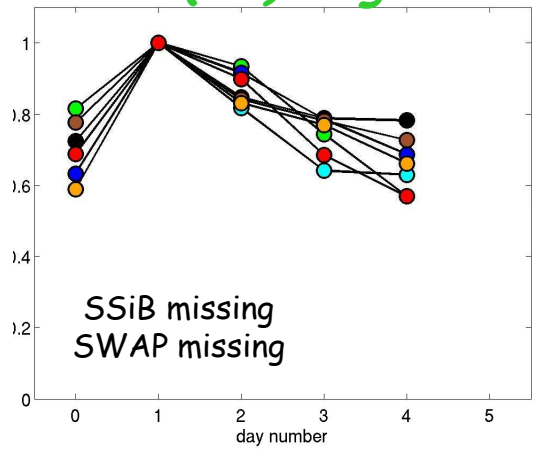
Recovery period

EF / EF(D1) Bare soil

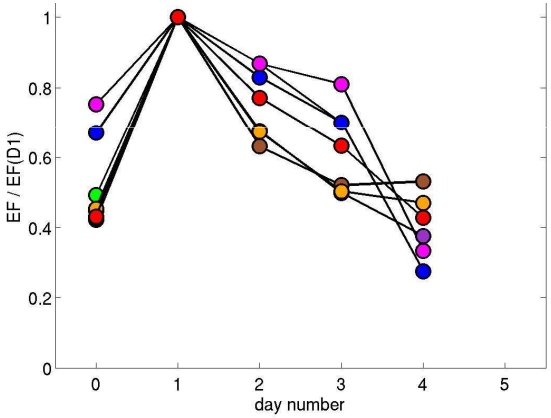
EF / EF(D1) Vegetated

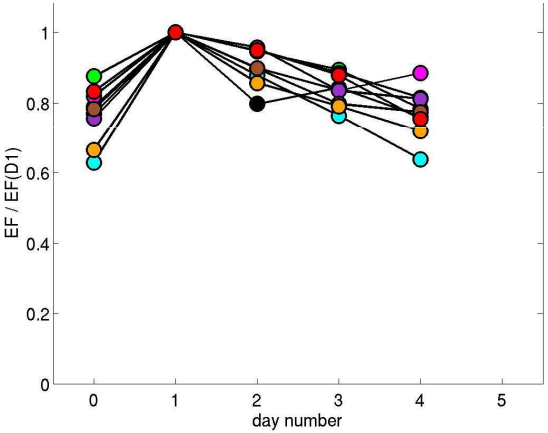
Agoufou location (Mali)



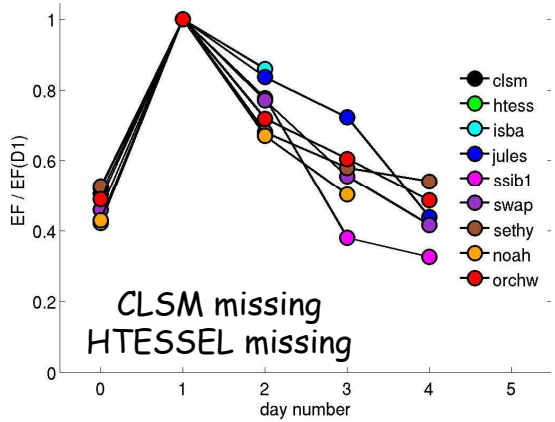


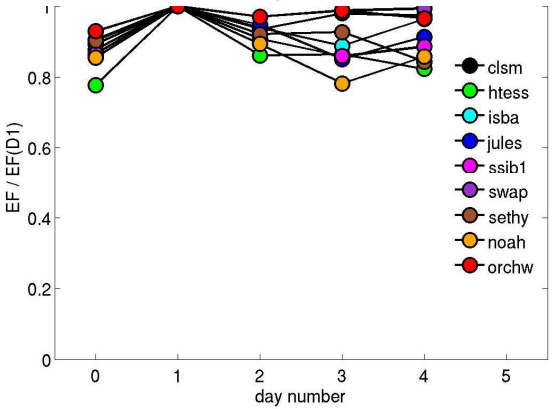
Niamey location (Niger)



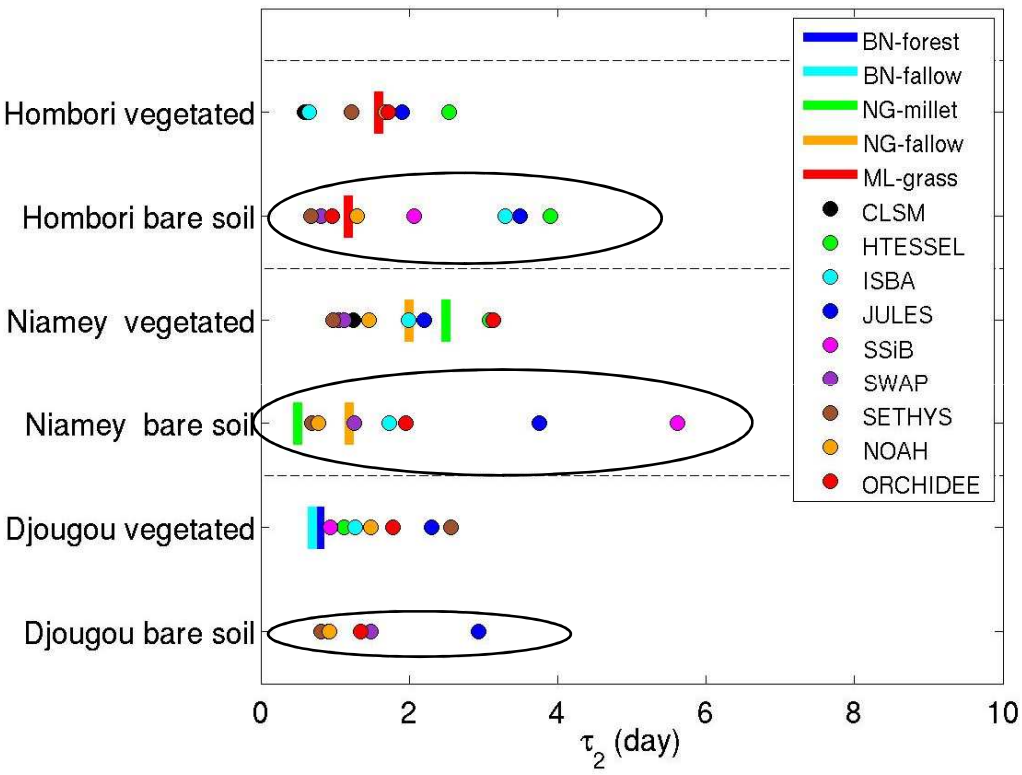


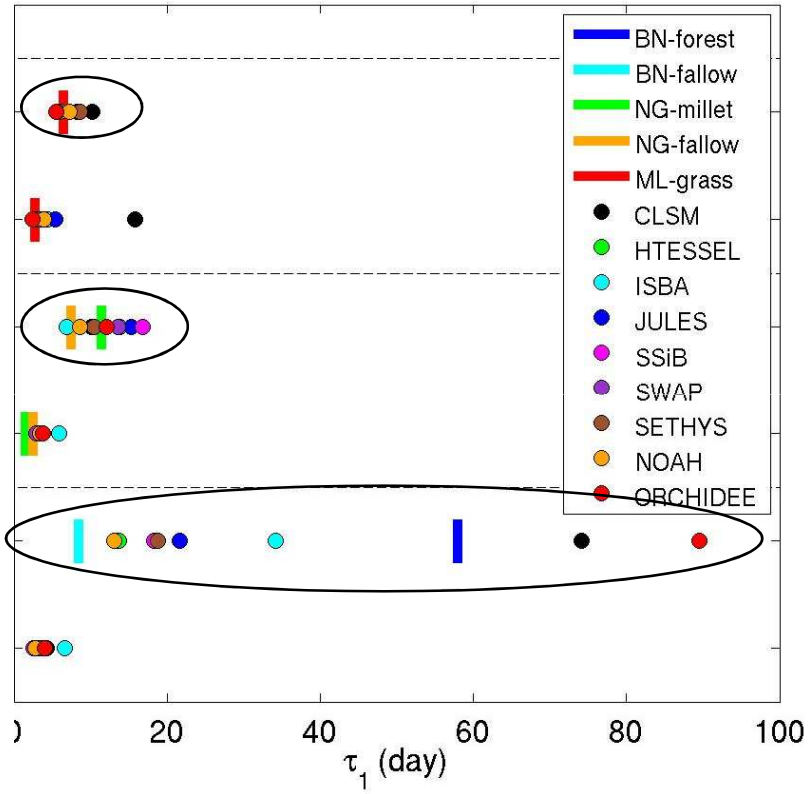
Djougou location (Benin)





Recovery period





Conclusion

Coté expérience

❖ Fort couplage entre l'humidité du sol et l'amplitude de la réponse de la surface à un évènement pluvieux.

❖ Lois exponentielles proches de celles déjà trouvées dans la littérature.

- Sol nu: échelle temporelle de 1 à 2 jours
- Végétation: dépendant de la profondeur des racines

(herbe : 6 jours / forêt: 58 jours)

Coté LSM

❖ Pas de loi liant l'amplitude de la réponse de la surface et l'humidité du sol.

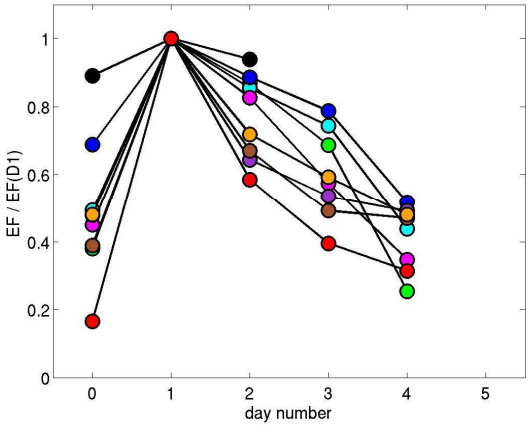
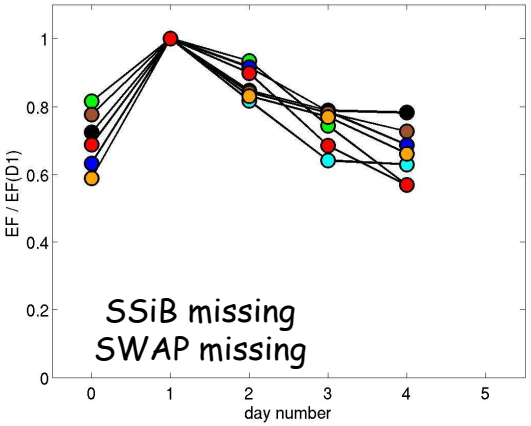
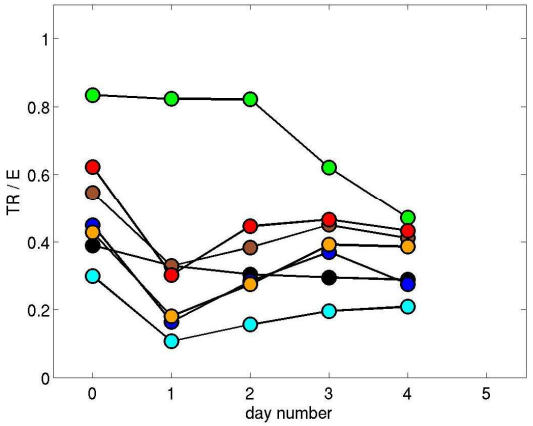
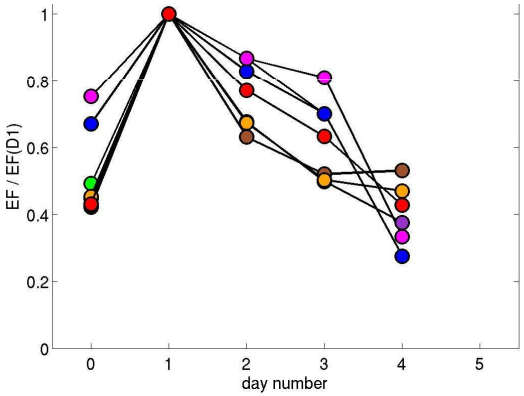
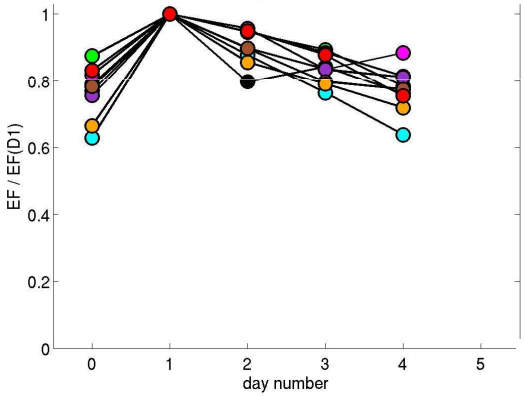
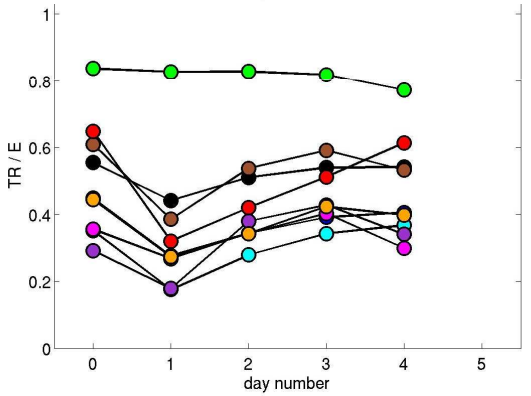
❖ Dispersions des runs LSM plus importantes:

- ❖ Sur les sols nus que sur les sols avec de la végétation.
- ❖ Sur les paysages comportant une végétation variée.

Merci aux expérimentateurs et aux modélisateurs d'avoir alimenté ces bases de données !!

THANK YOU

Recovery period

	EF / EF(D1) Bare soil	EF / EF(D1) Vegetated	TR / E vegetated
Agoufou location (Mali)			
Niamey location (Niger)			
Djougou location (Benin)