Trends in the Amazon hydrology simulated between 1980 and 2050 in response to a severe scenario of deforestation

J. P. Boisier & AMAZALERT team

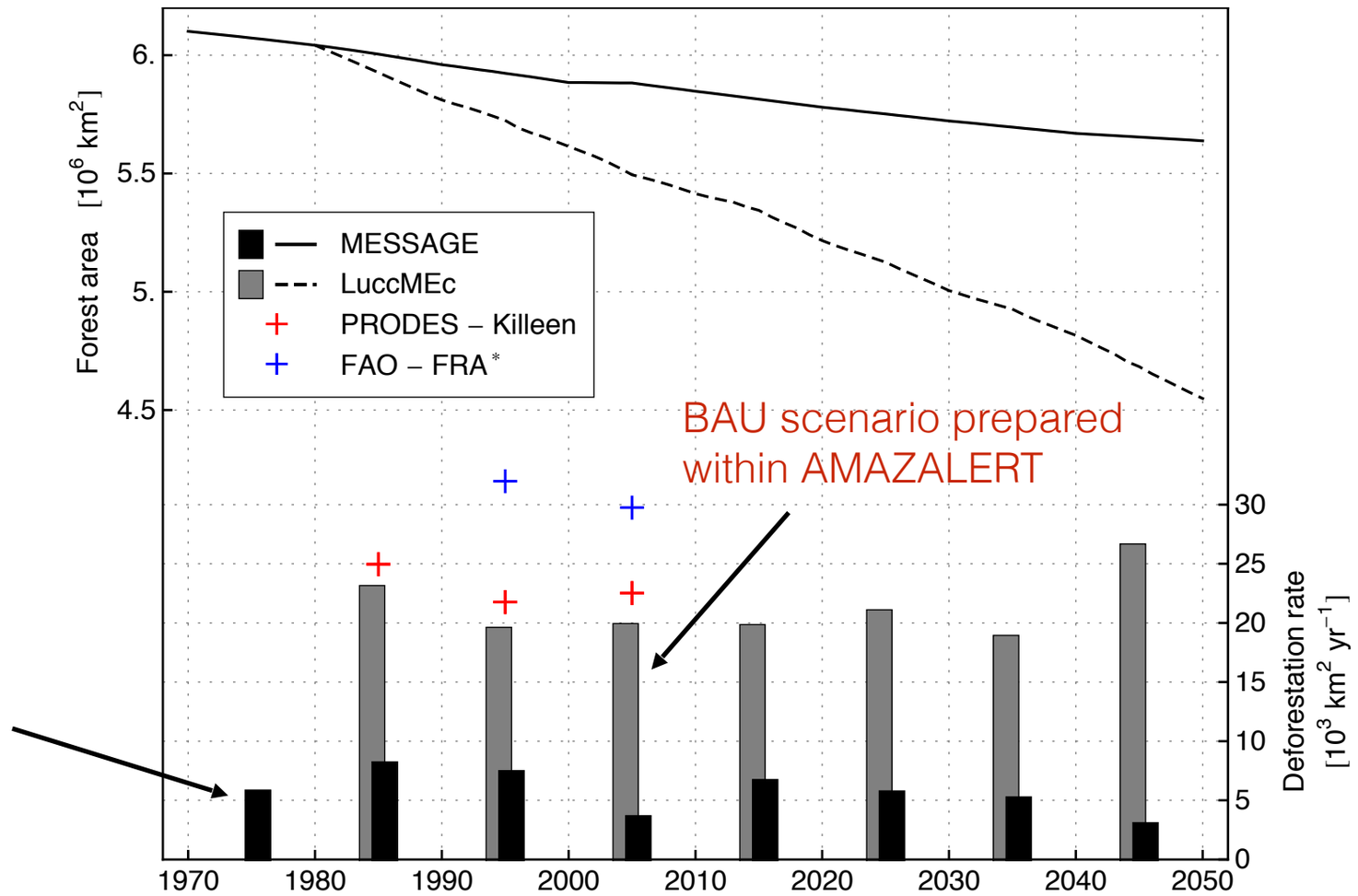
ORCHIDEE-DEV meeting
June 2014

Context/Motivation

LULCC is a major driving factor of the global carbon unbalance and of regional-scale climate shifts.
> Nowadays accounted for in most ESMs participating in CMIP initiative.

However, the historical and future (IAM-based) scenarios of LU used in CMIP5 —and the underlying climate/hydrological response of the models— seem to be particularly optimistic in the tropics (see Brovkin et al., JClimate 2013).

This is notably the case for the Amazon basin, where extensive deforestation occurred in the last decades.

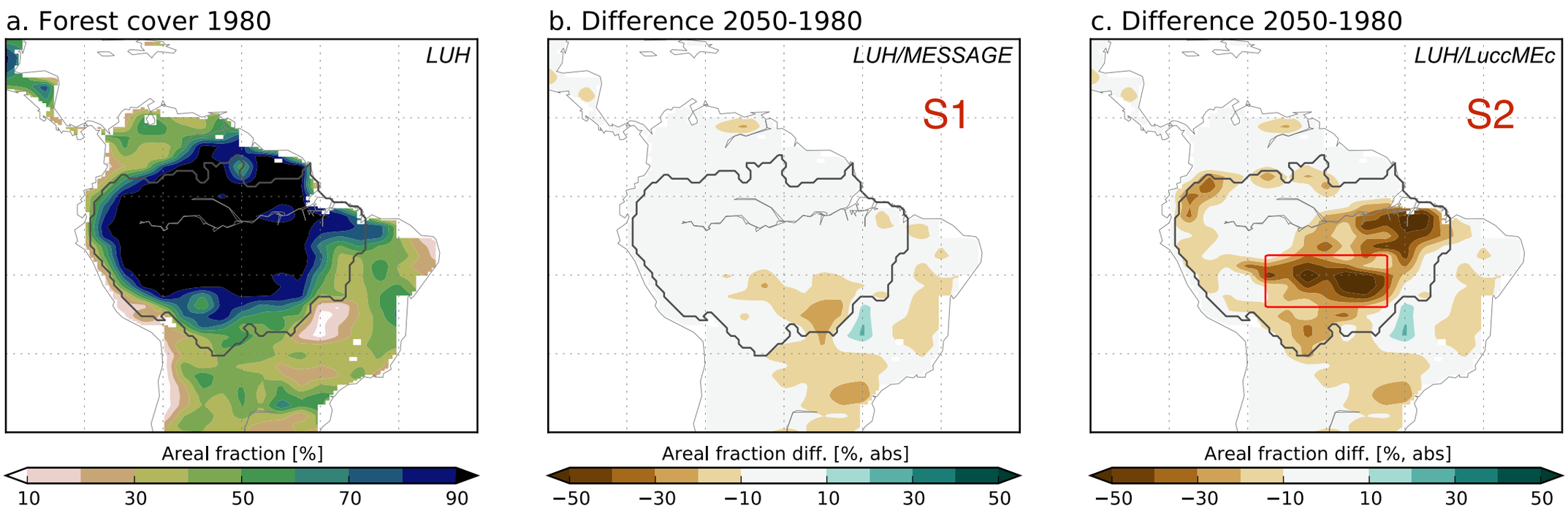


The historical and MESSAGE scenario (RCP 8.5) adapted in ORCHIDEE actually strongly underestimates the current rates of forest loss in Amazonia

Additional (CMIP5-like) RCP 8.5 runs were carried out with IPSL-CM5A (MR) in order to account for a severe but realistic pathway of Amazon LU, as projected by the LuccME scenario C.

Table 1. Set of IPSL-CM5A simulations used to evaluate biophysical and biochemical impacts of LU

Sim. reference	GHGs & aerosols	Land cover (Amazonia)	# runs
S1 (CMIP5)	1850-2005 (HIST) 2006-2100 (RCP 8.5)	1850-2005 (LUH-HYDE) 2006-2100 (LUH-MESSAGE)	3
S2 (AMAZALERT)	1980-2005 (HIST) 2006-2050 (RCP 8.5)	1980-2010 (PRODES-Killen) 2011-2050 (LuccMEc)	3

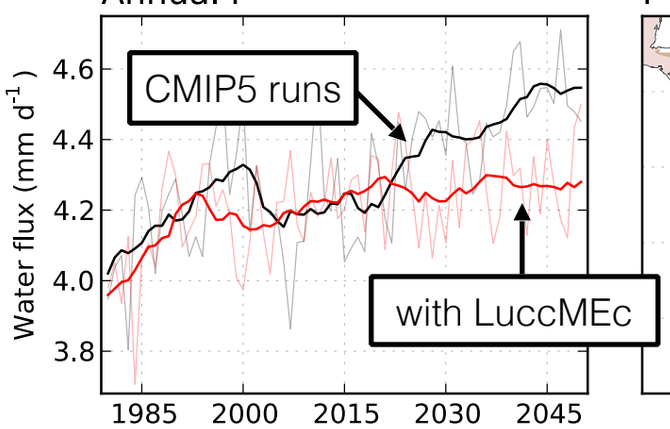


Climate vs. LU impacts

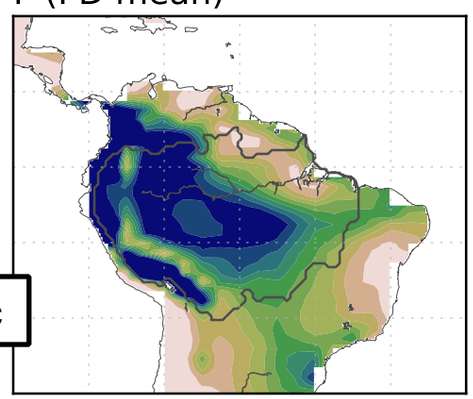
GHG-induced

LULCC-induced

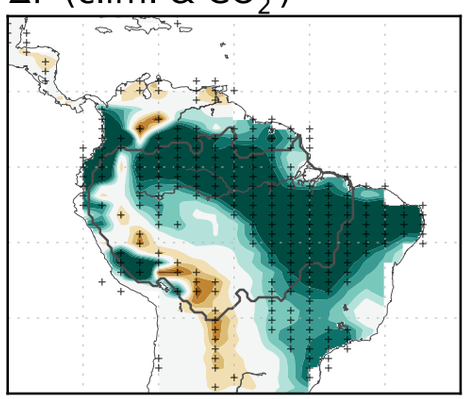
Annual P



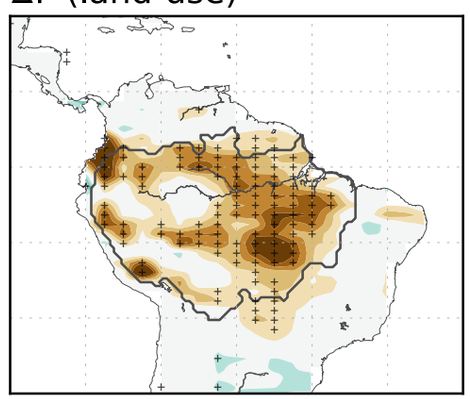
P (PD mean)



ΔP (clim. & CO_2)

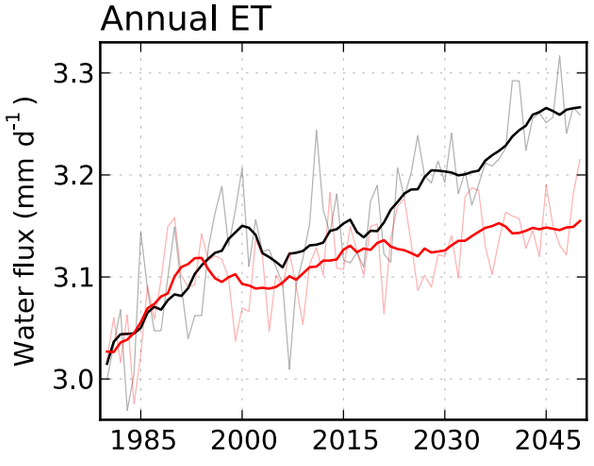


ΔP (land-use)

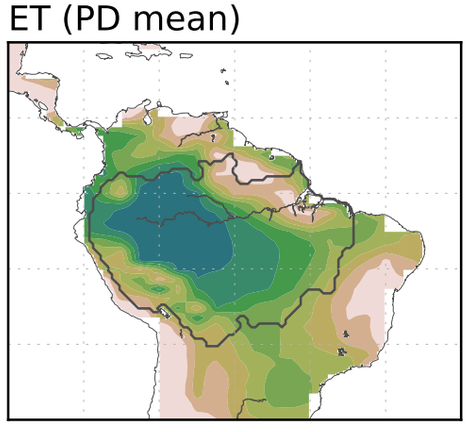


Precipitation

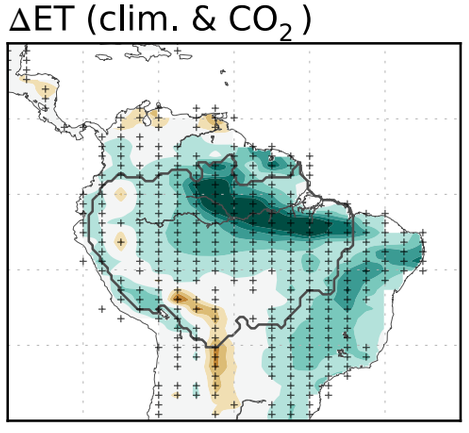
Annual ET



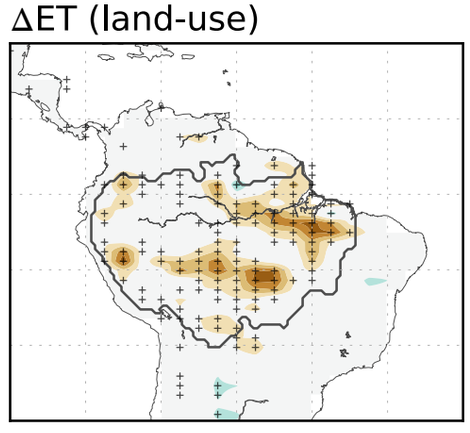
ET (PD mean)



ΔET (clim. & CO_2)

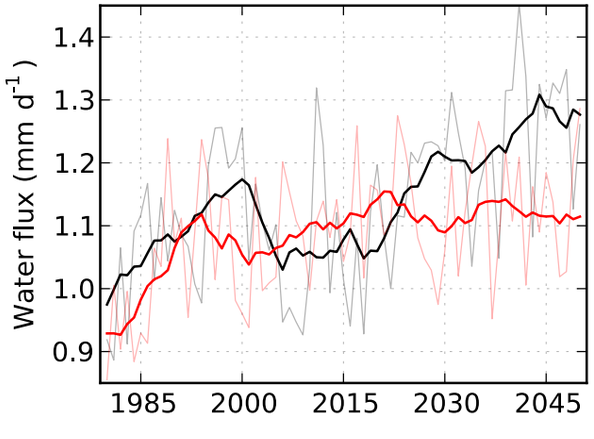


ΔET (land-use)

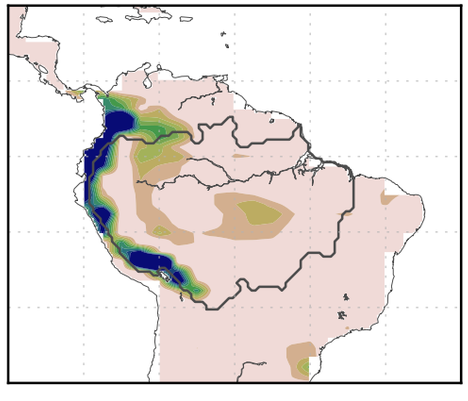


ET

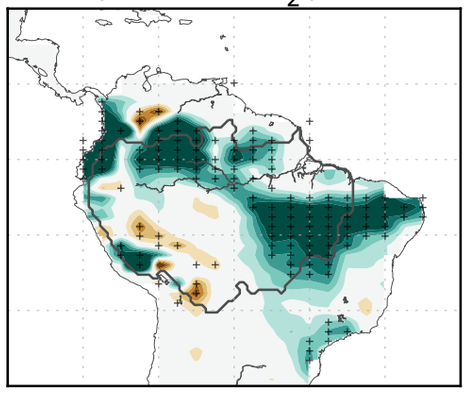
Annual RD



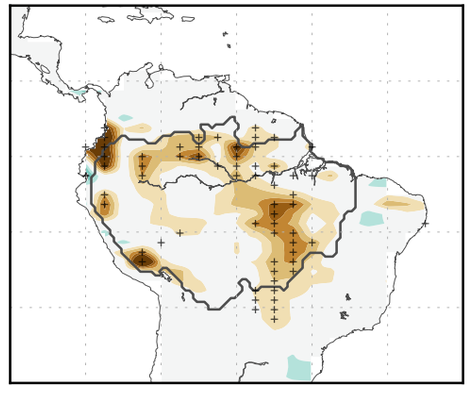
RD (PD mean)

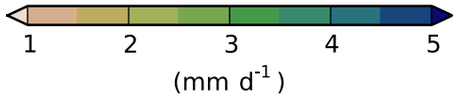


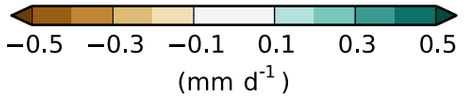
ΔRD (clim. & CO_2)

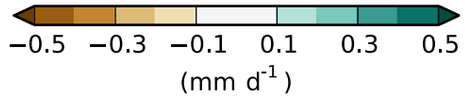


ΔRD (land-use)





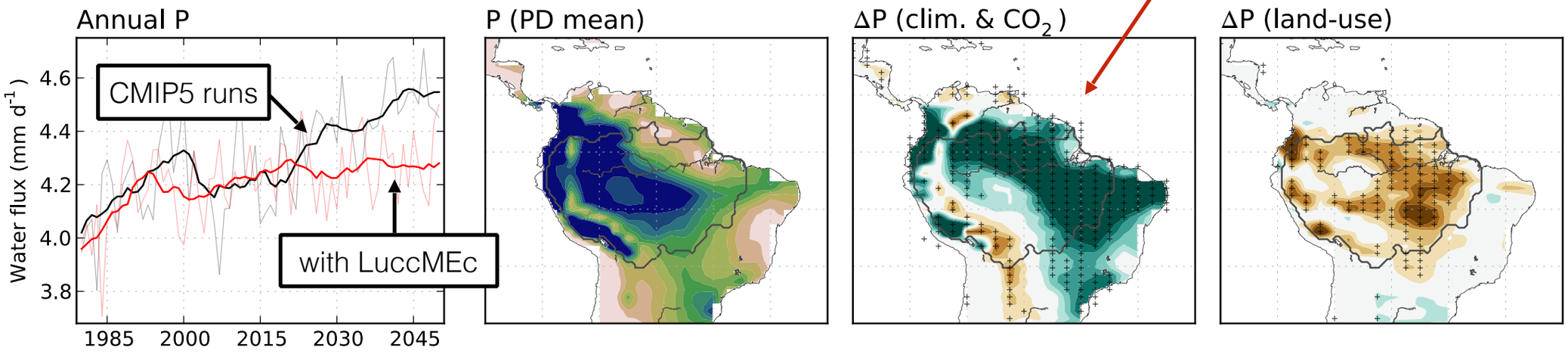




Runoff & drainage

Climate vs. LU impacts

Regional effect of CC: large (>+10% at the basin scale) but <u>very</u> uncertain

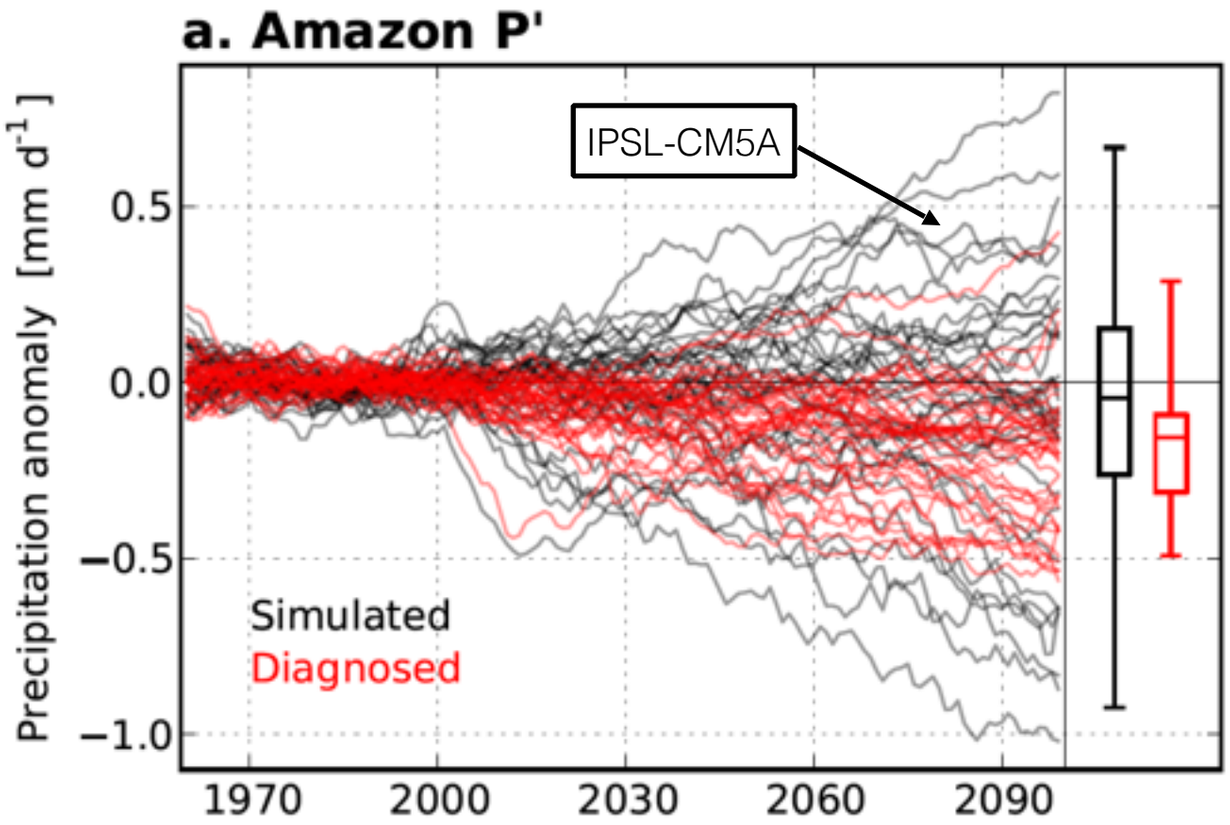


Precipitation

Annual rainfall is actually more likely to decrease within the Amazon basin.

This dominating pattern is associated with a lengthening of the dry season, a signal that also matches observed recent trends (Fu et al., 2013).

RCP8.5 projections within CMIP5

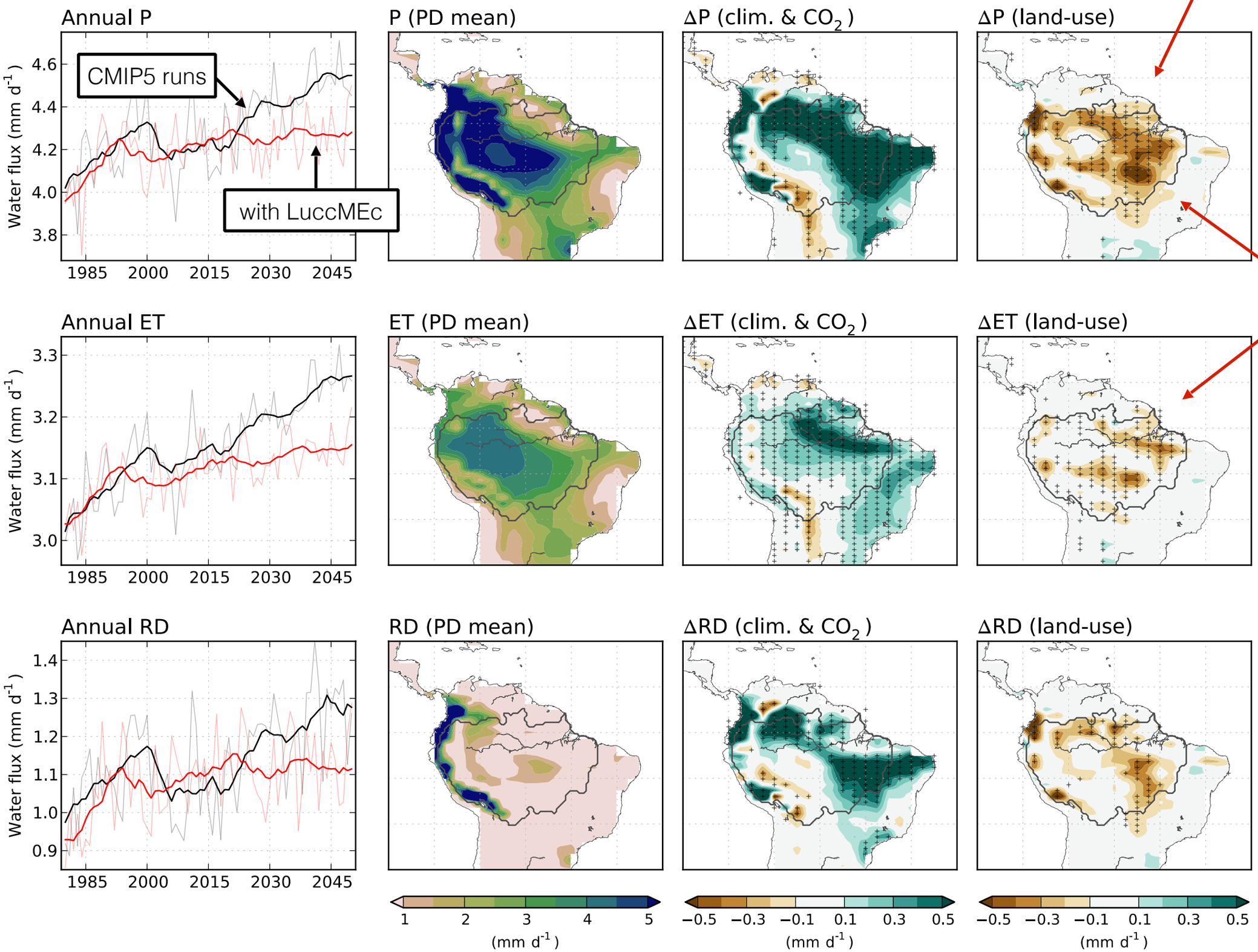


Climate vs. LU impacts

Significant and opposite (~–5%) impacts of LULCC

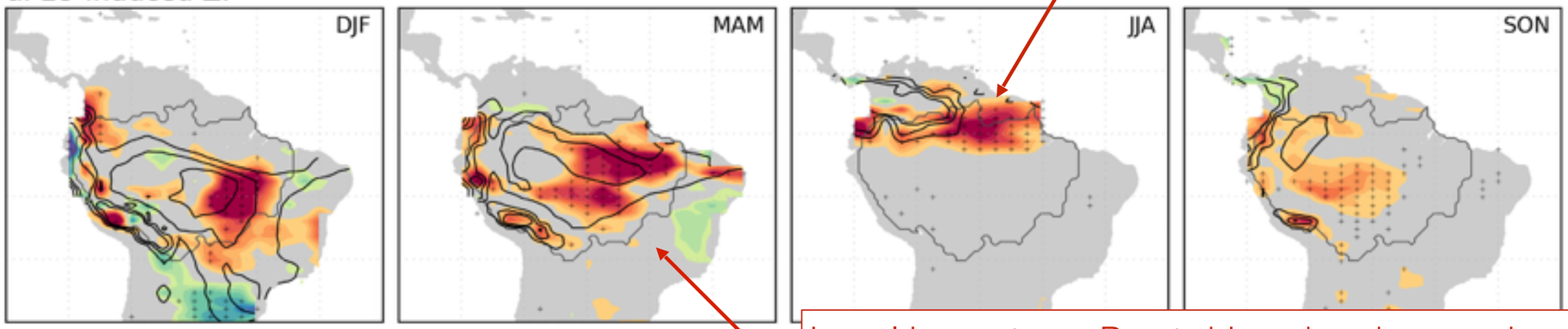
Strong feedbacks from LMDZ

The direction of changes in water discharge depends on the L-A coupling



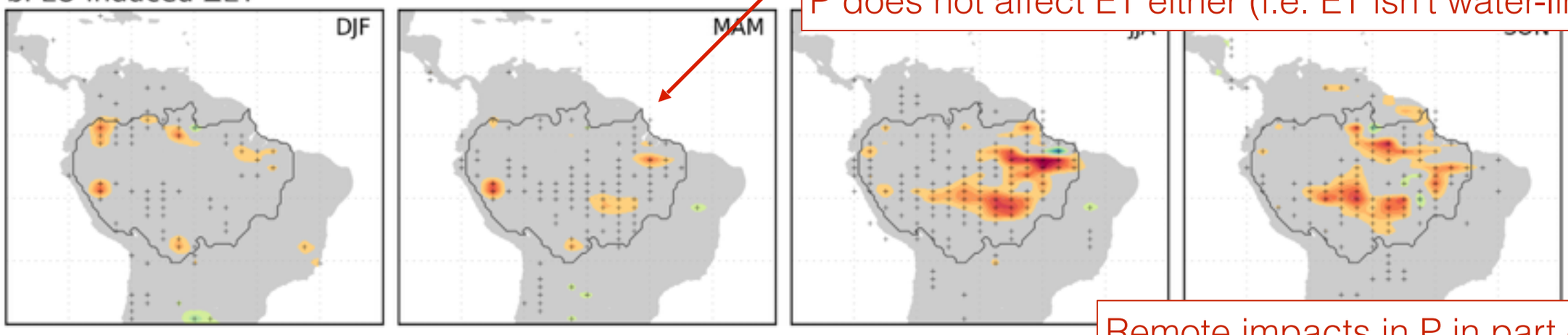
Large (~–20%) remote effects of LULCC in precip.

a. LU-induced ΔP



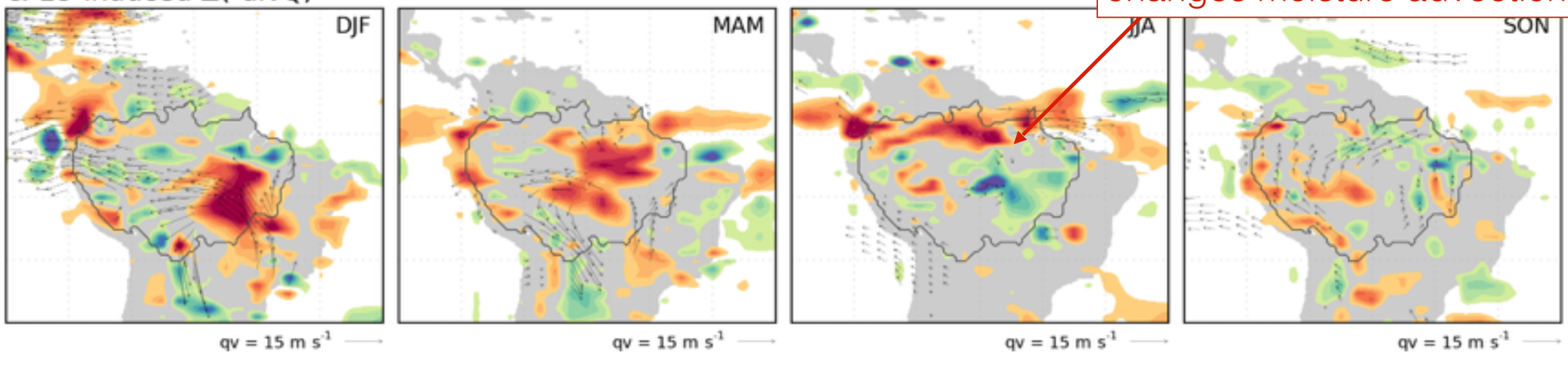
Local impacts on P not driven by changes in water recycling
P does not affect ET either (i.e. ET isn't water-limited)

b. LU-induced ΔET

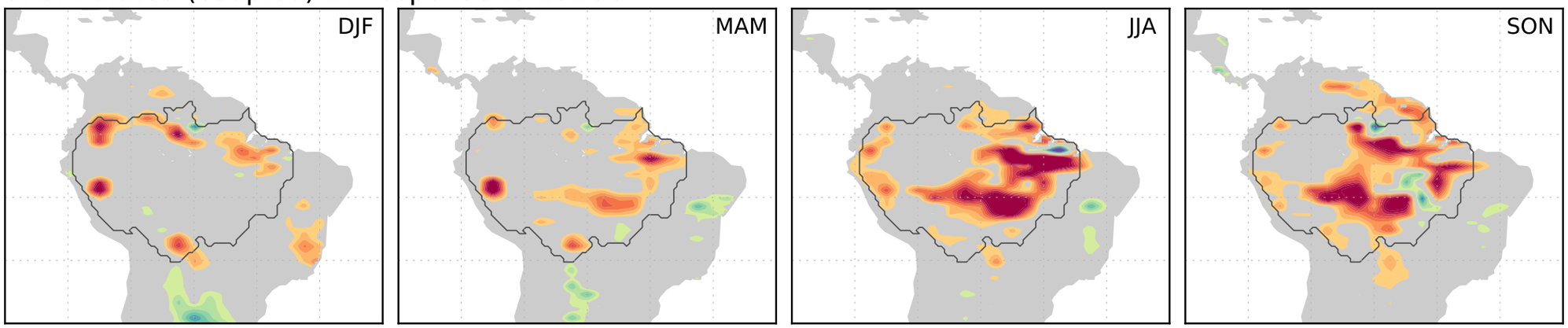


Remote impacts in P in part explained by changes moisture advection

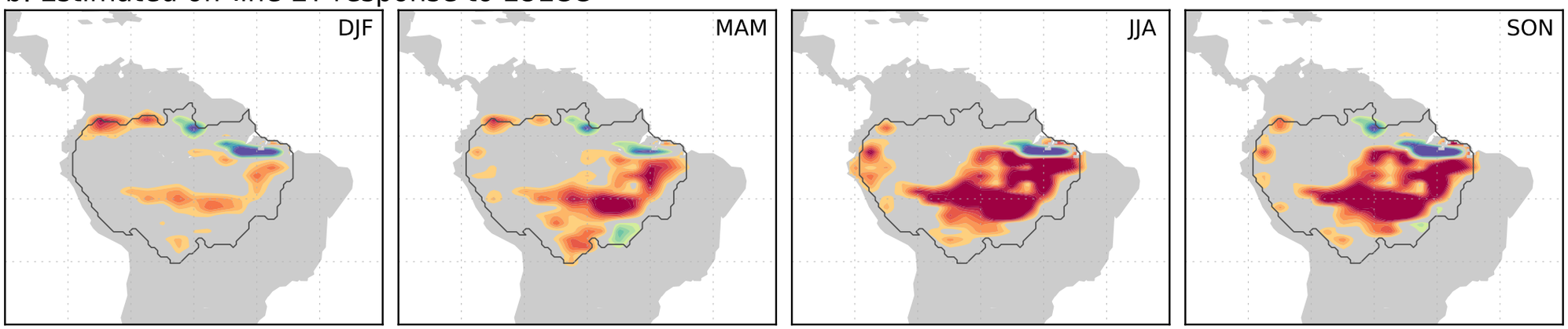
c. LU-induced Δ(-divQ)



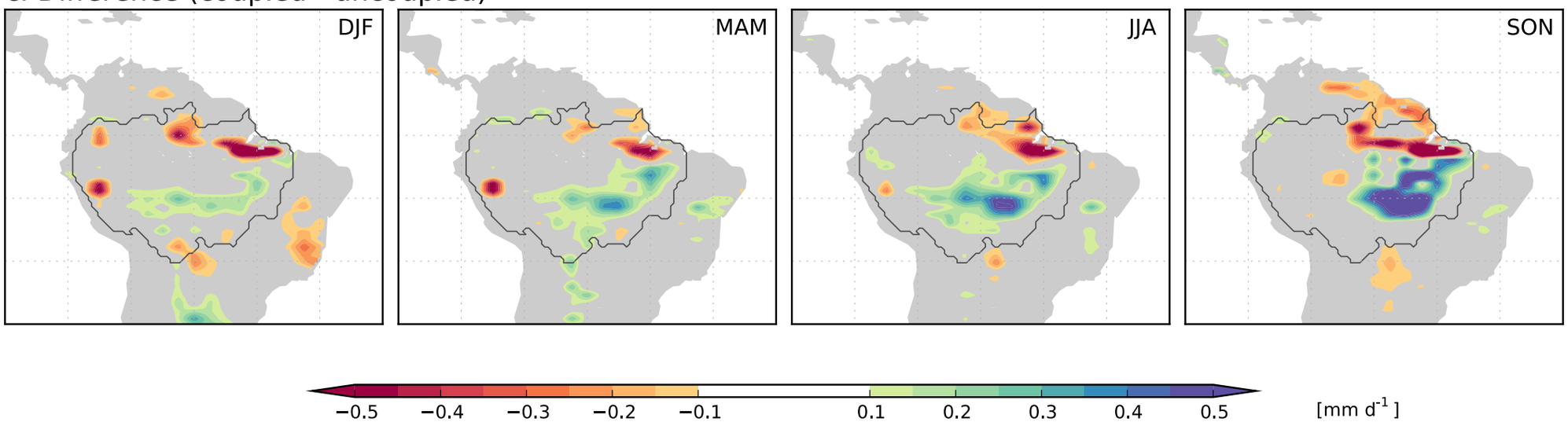
a. Simulated (coupled) ET response to LULCC



b. Estimated off-line ET response to LULCC



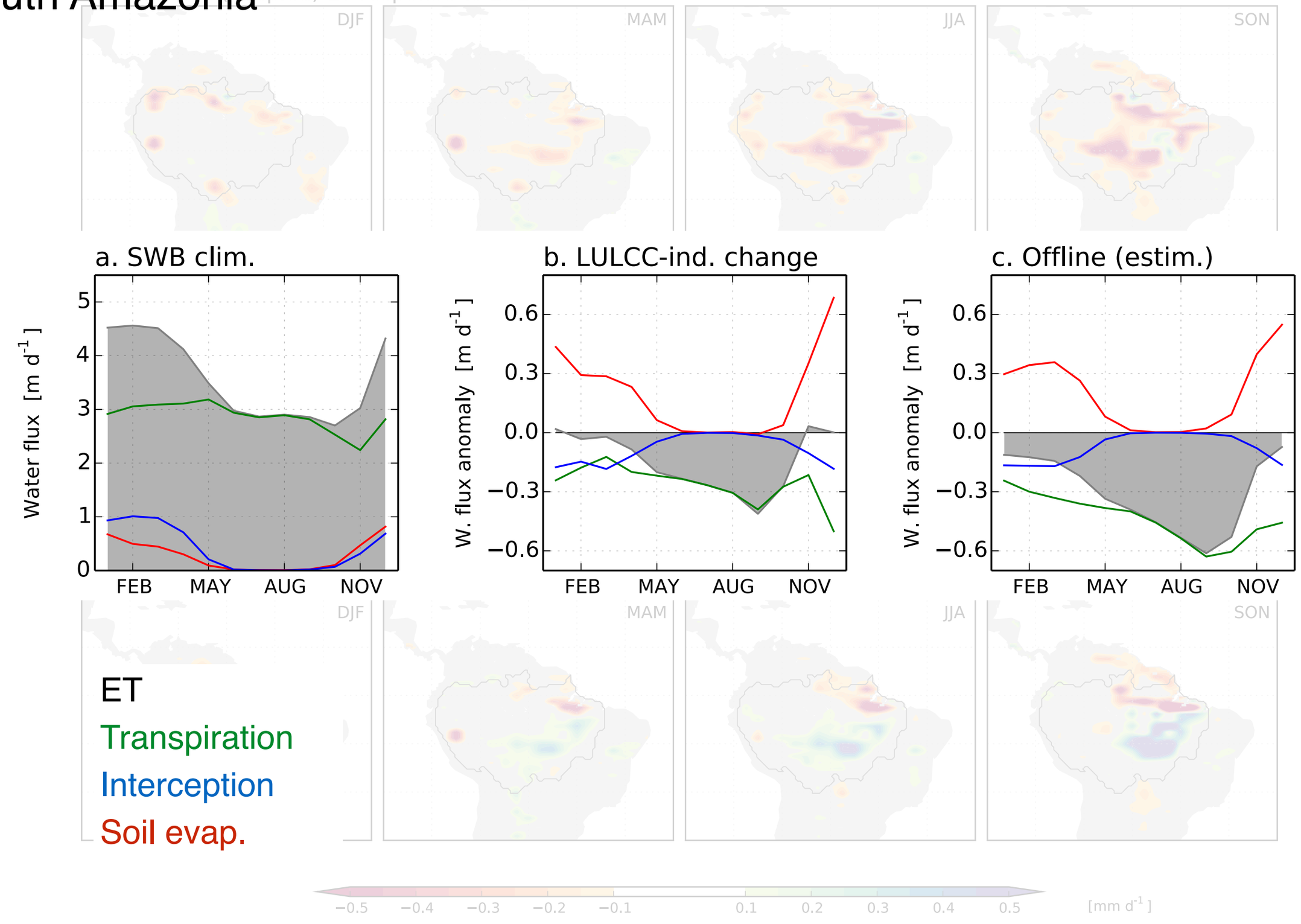
c. Difference (coupled - uncoupled)



The L-A coupling seems to produce a strong negative feedback on ET (VPD-driven ?)

> To account for when evaluating hydrological changes using forced simulations.

South Amazonia



The L-A coupling seems to produce a strong negative feedback on ET (VPD-driven ?)

> To account for when evaluating hydrological changes using forced simulations.

Summary

IPSL-CM5A simulates important changes in the Amazon water cycle in response to a severe but realistic scenario of deforestation (following present-day rates).

The land-atmosphere interaction seems to play a leading role controlling these changes both in areas of strong LU perturbations and away from them.

- Decreases in precipitation lead to decreases in runoff (the opposite impact of deforestation is expected from offline simulations)

- ET decrease in response to deforestation but the changes are of lower amplitude (~ 30%) than expected offline.

Based on these results, the key question within AMAZALERT remains particularly open:
Can the atmospheric feedbacks of LU perturbations trigger a natural response of vegetation ?