Impact of a prescribed groundwater table on the near surface climate in the IPSL land-atmosphere coupled model

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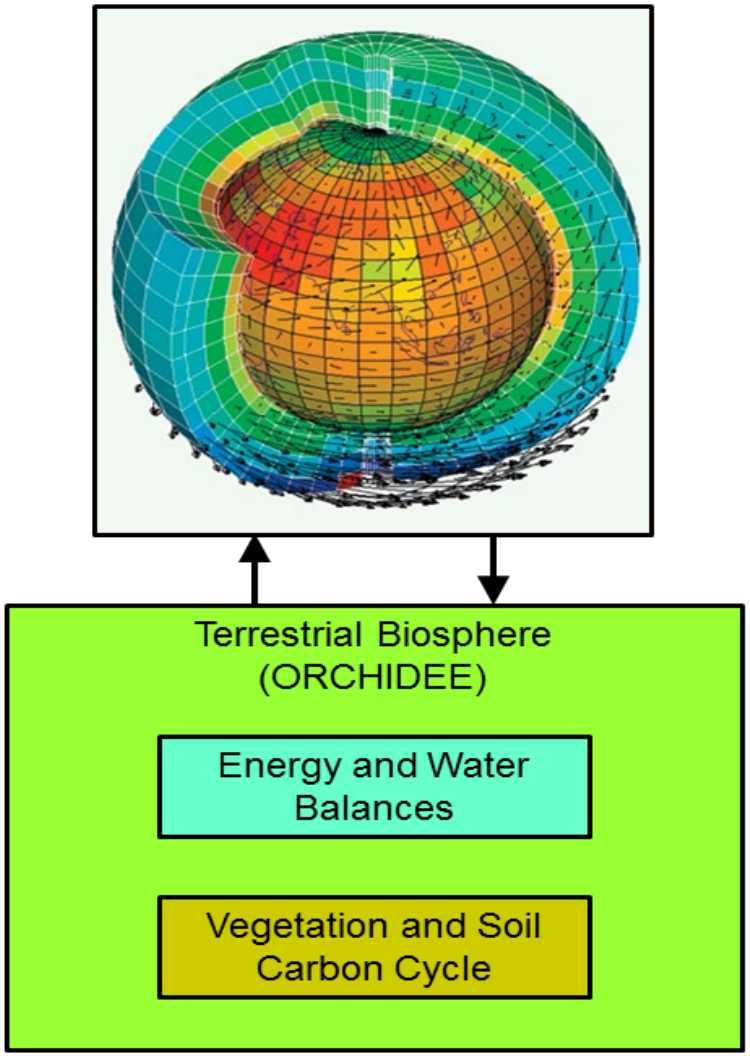
Research objectives

- Water table varies diurnal, seasonal, inter-annual scales
- Recent changes of groundwater storage over globe.
- Fluctuation of groundwater level impacts climate.
- Most studies/analysis regional scales (e.g., Asia, US).

- **Objective:** to investigate the physical mechnisms of evaporation and precipiation changes when groundwater table is accounted over globe.

LMDZ-ORCHIDEE Coupled Model



Atmosphere – Land component of IPSL integrated model

LMDZ: General circulation model, CMIP5 version (standard physics)

ORCHIDEE: land component,

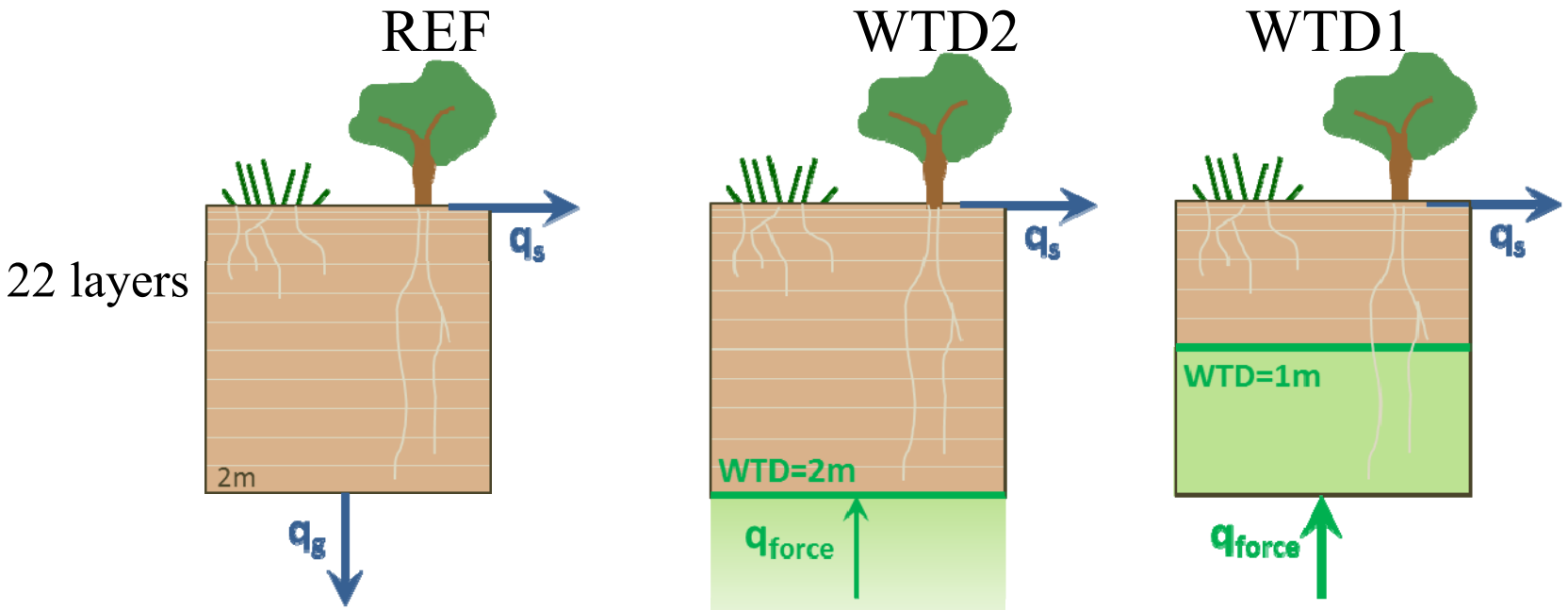
2-meter depth, free drainage at bottom

Resolution:

144 (lon) × 142 (lat) × 39 (vertical)

http://labex.ipsl.fr/orchidee/index.php/about-orchidee

Numerical experiments



gravitational drainage

Saturated below WTD; Impermeable bottom

- ✓ Simulation period: 1979-2005 after spinup.
- ✓ Boundary condiditons:

  Land use: same as IPSL-CM5 [*Dufresne et al.*, 2013].

  Twelve soil texture map: USDA [*Reynolds et al.* [2000].

  Solar forcing, GHG, aerosols, SST, sea-ice: inter-annual variability.

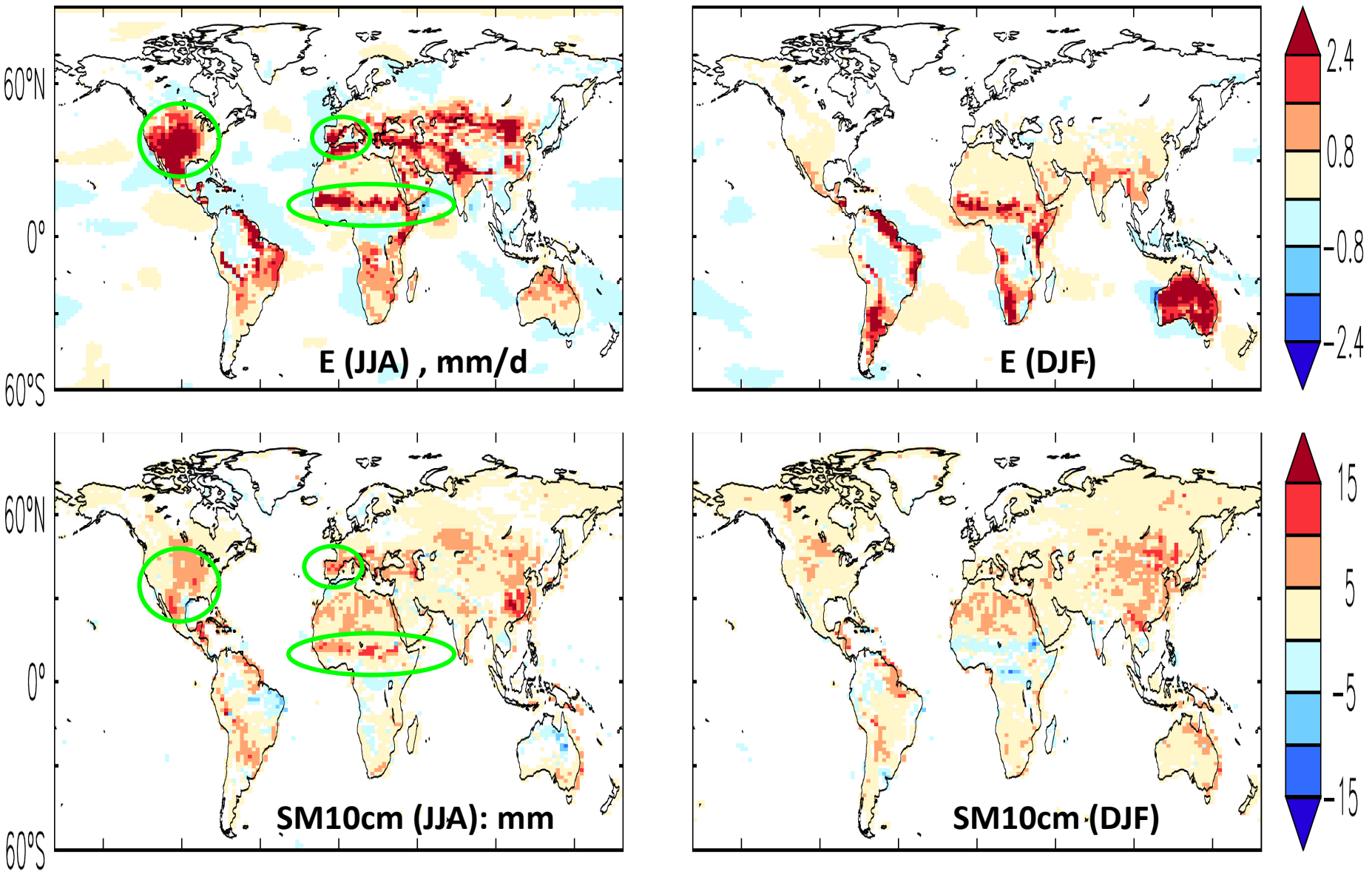
Experiments inter-comparison (global average)

	Land				Ocean				Global			
	Obs.	REF	WTD2	**WTD1**	Obs.	REF	WTD2	**WTD1**	Obs.	REF	WTD2	**WTD1**
P (mm/d)	2.18	2.397	*2.523 5.26%*	***2.933 +22.36%***	3.03	3.18	*3.189 0.28%*	***3.222 +1.32%***	2.79	2.892	*2.929 1.28%*	***3.058 +5.74%***
E (mm/d)	1.32	1.619	*1.776 9.70%*	***2.310 +42.68%***	3.37	3.585	*3.581 -0.11%*	***3.573 -0.33%***	2.79	2.893	*2.931 1.31%*	***3.059 +5.74%***
T2m (K)	286.46	286.6	*286.4 -0.2*	***285.5 -1.1***	290.87	290.4	290.4 0	***290.5 +0.1***	287.22	287.1	287.1 0	***286.8 -0.3***
Q2m (g/kg)	9.50	7.265	*7.437 2.37%*	***8.165 +12.39%***	11.51	11.74	11.74 0	***11.73 -0.085%***	10.41	10.14	*10.18 0.39%*	***10.36 +2.17%***

- Impacts of WT on near-surface meteorology: land > ocean.
- WTD1 & WTD2 far from obervations/reanalysis. (water not conserved)
- Difference: WTD1 - REF > WTD2 - REF ➔ WTD1 further analyzed.

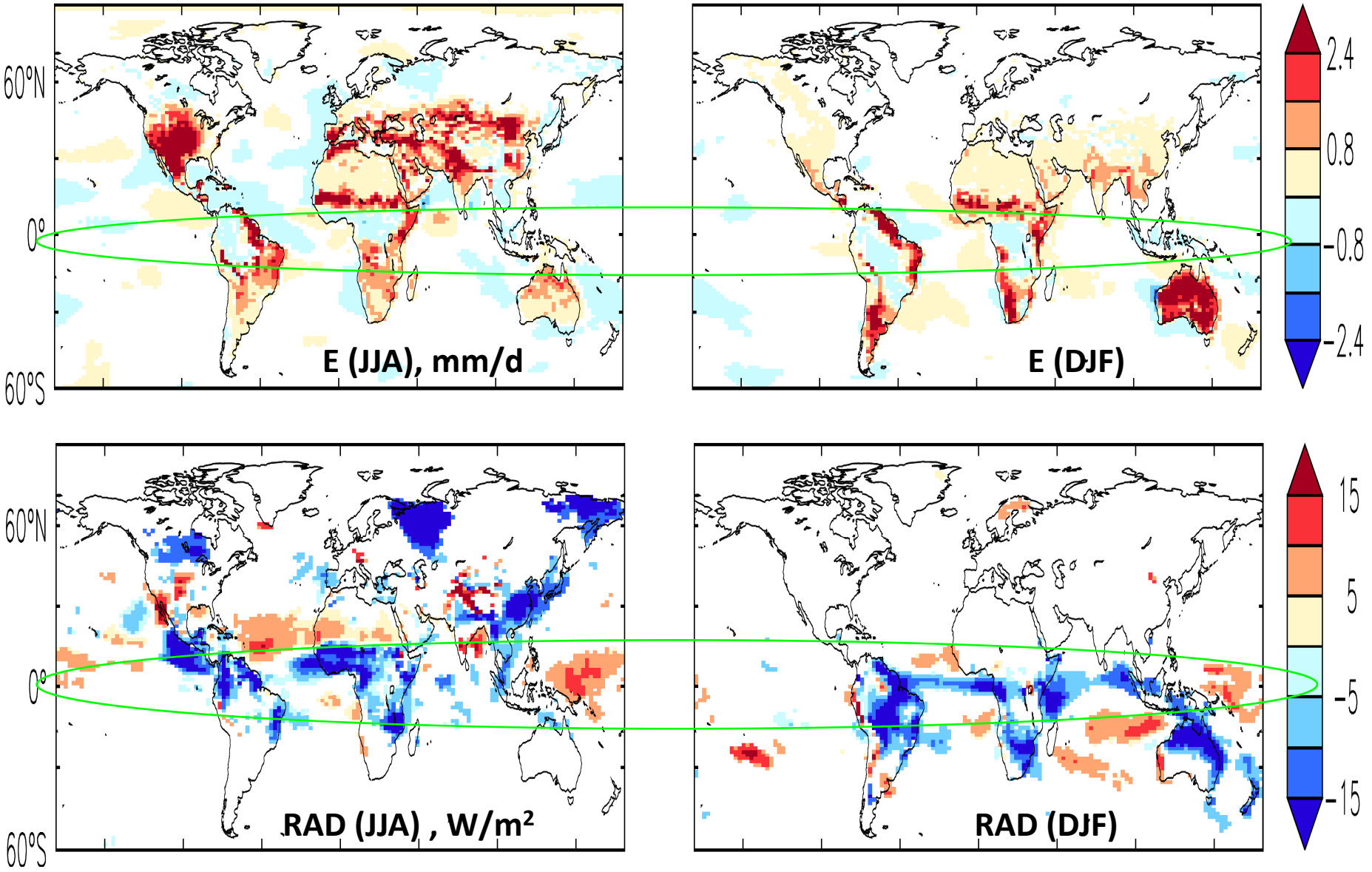
Obs. from Rodell et al. [2015] (P, E) and NCEP reanalysis(T2M, Q2M).

Impact of WT on Evaporation (WTD1-REF)



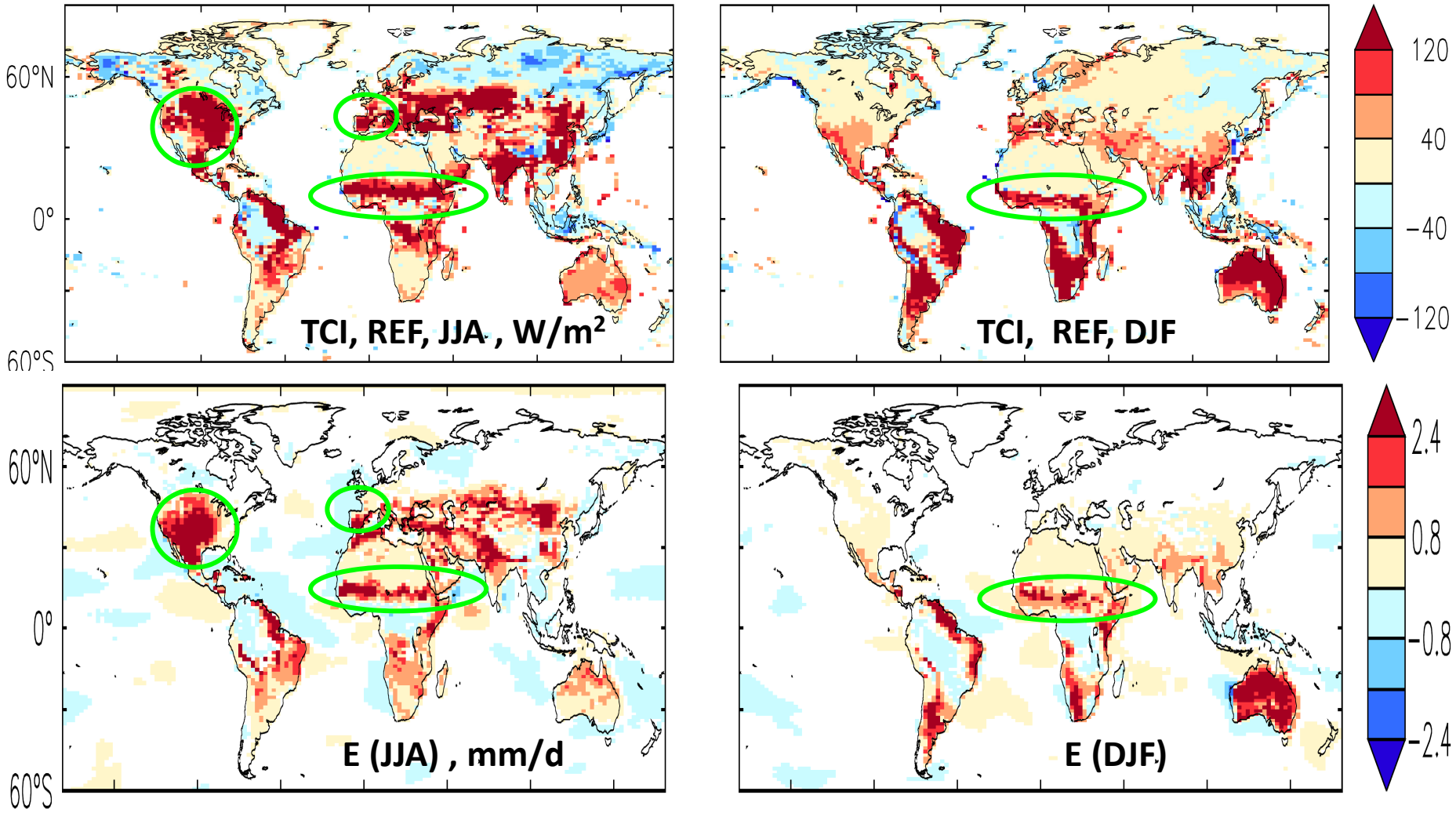
- Water-limited regions: SM ↑ → *E* ↑.

Impact of WT on Evaporation (WTD1-REF)



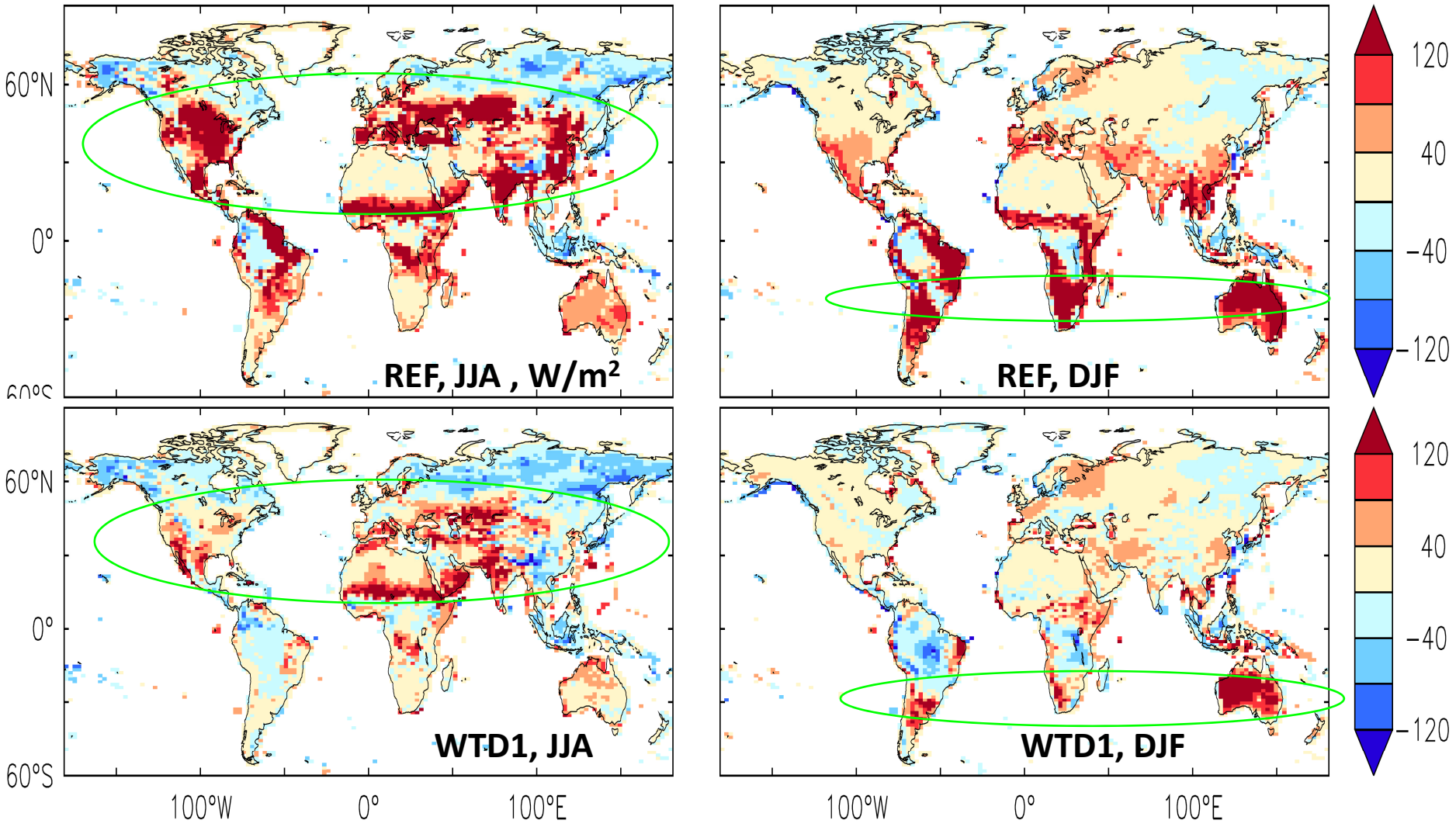
- Energy-limited regions: downwelling radiation at surface ↓ → E ↓ .

ΔE (WTD1-REF) vs. SM-E coupling strength



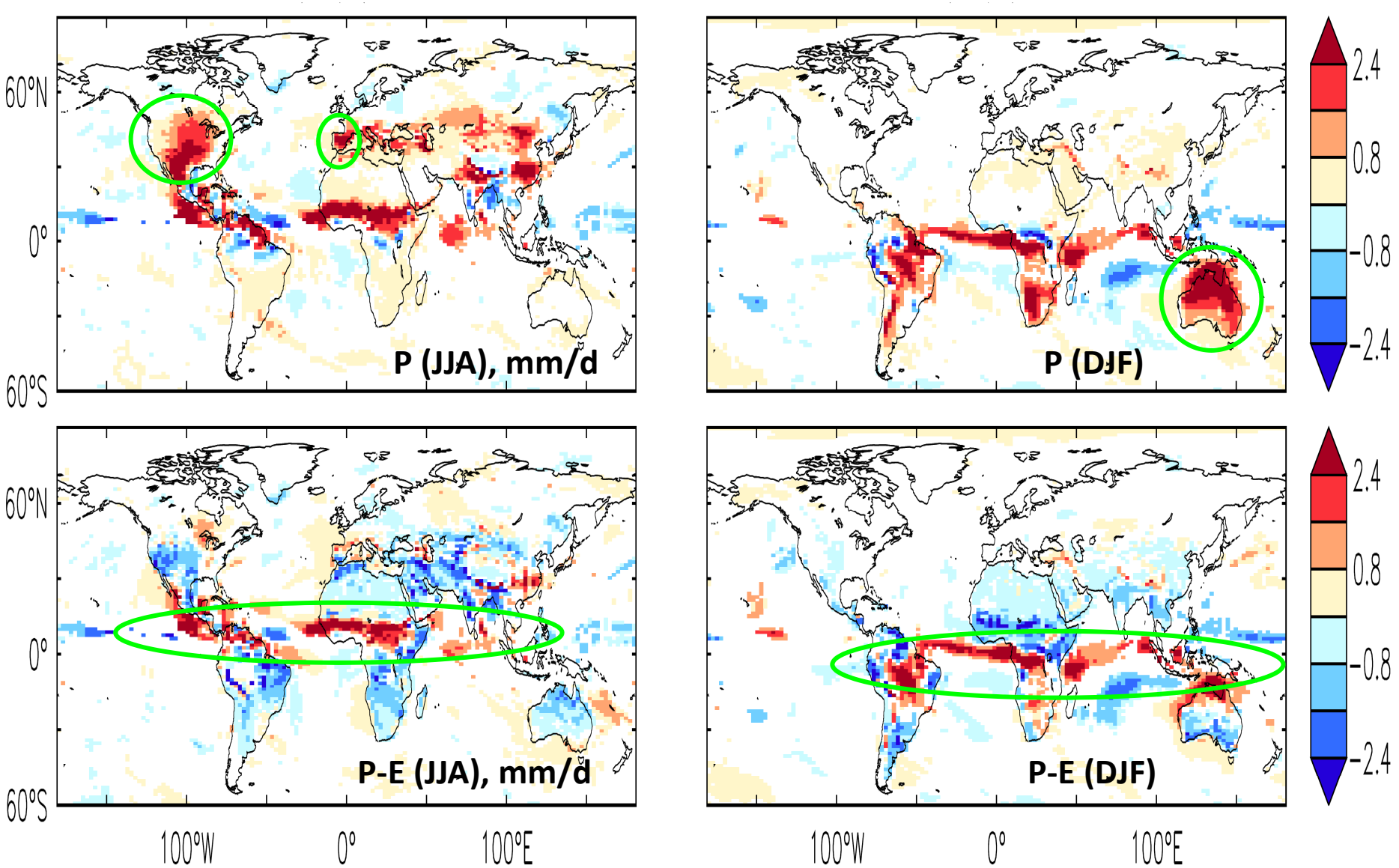
- Terrestrial Coupling Index (*TCI*) [*Dirmeyer*, 2011]: $TCI = -\frac{\sigma'_{E_{m,y}} Cov(SM'_{m,y} \cdot E'_{m,y})}{\sigma'_{SM_{m,y}} \sigma'_{E_{m,y}}}$
- positive → SM controls *E*; negative → energy controls *E*.
- The patterns of positive TCI are similar to ***ΔE***.

Impact of WT on SM-E coupling strength



- positive (arid) → SM controls *E*; negative (humid) → energy controls *E*.
- SM increases → SM-E coupling strength weakness.

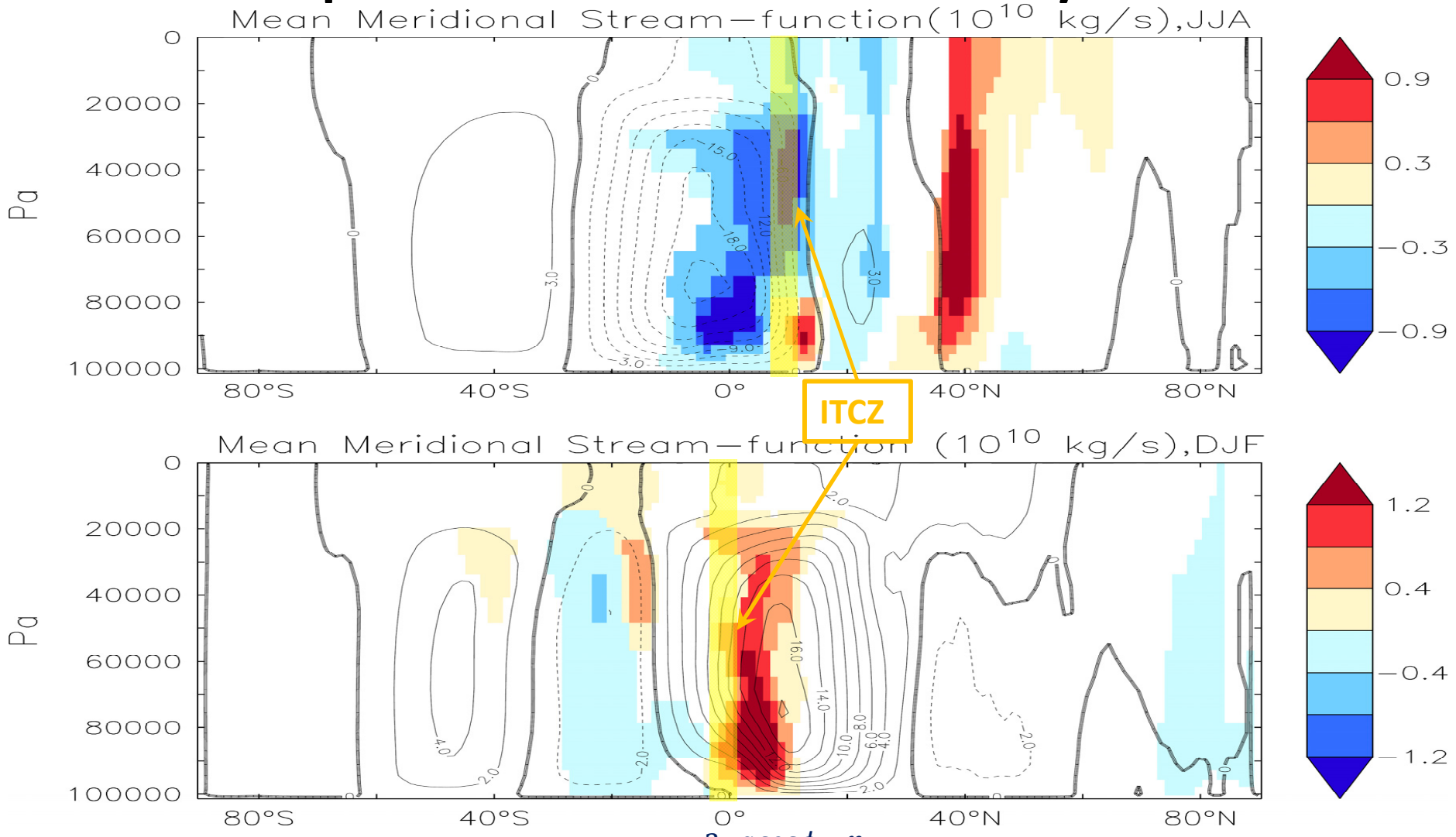
Impact of WT on *P* and *P-E* (WTD1-REF)



✓ Variation of *P* occurs mostly over land (largest +2.4 mm/d).

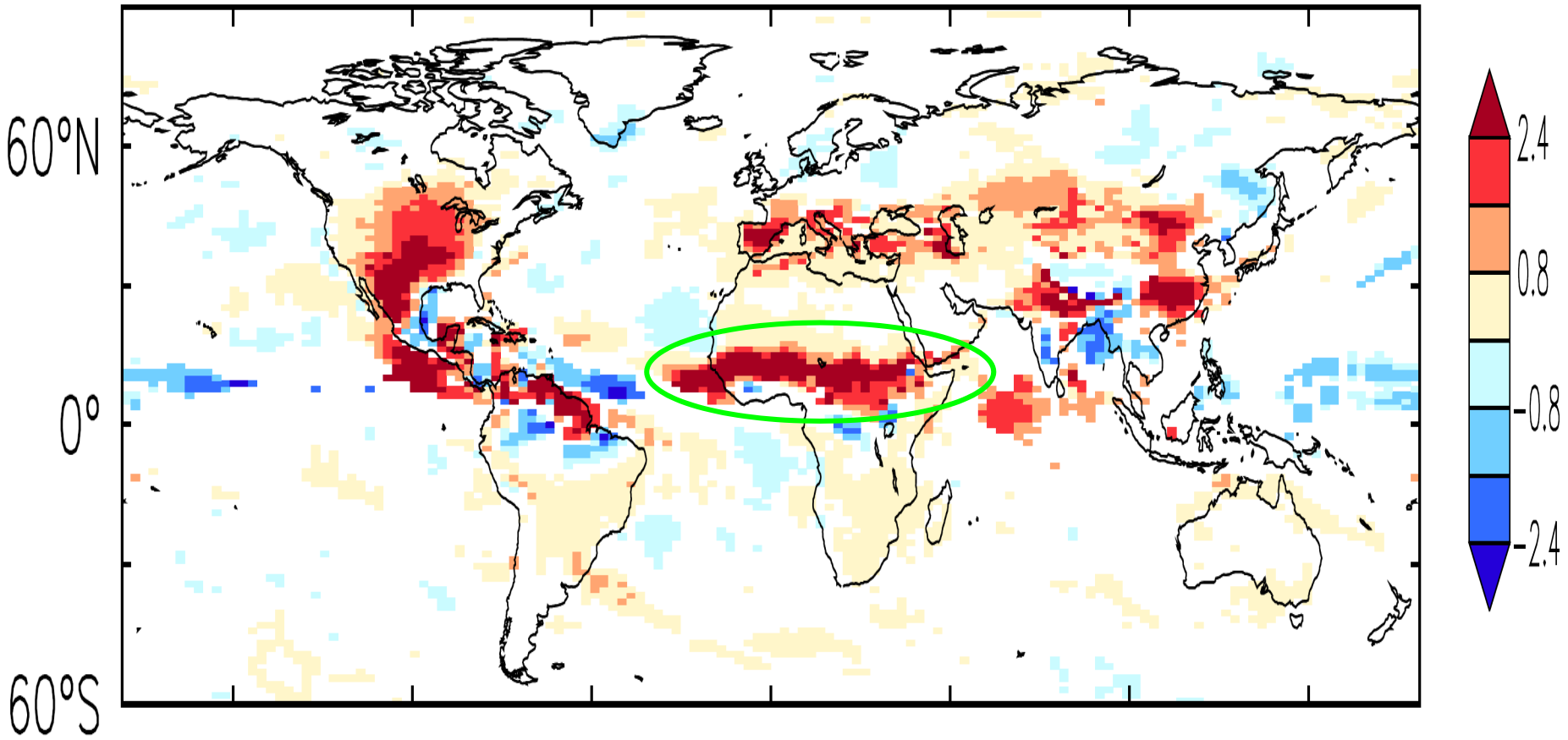
✓ *P-E* ↑ ITCZ; *P-E*↓ over extra-tropics (*E* increases > *P*).

Impact of WT on Hadley cell



- Mean meridional Stream-function: $\Psi_M = \frac{2\pi a cos\phi}{g}\int_0^p vdp.$
- Clockwise, positive (NH, DJF); counter-clockwise, negative (SH, JJA).
- $\Psi_M\uparrow$ DJF (5S-10N), $\Psi_M\downarrow$ JJA (0-10N)→strengthened Hadley C.→$P\uparrow$ (ascending branch)

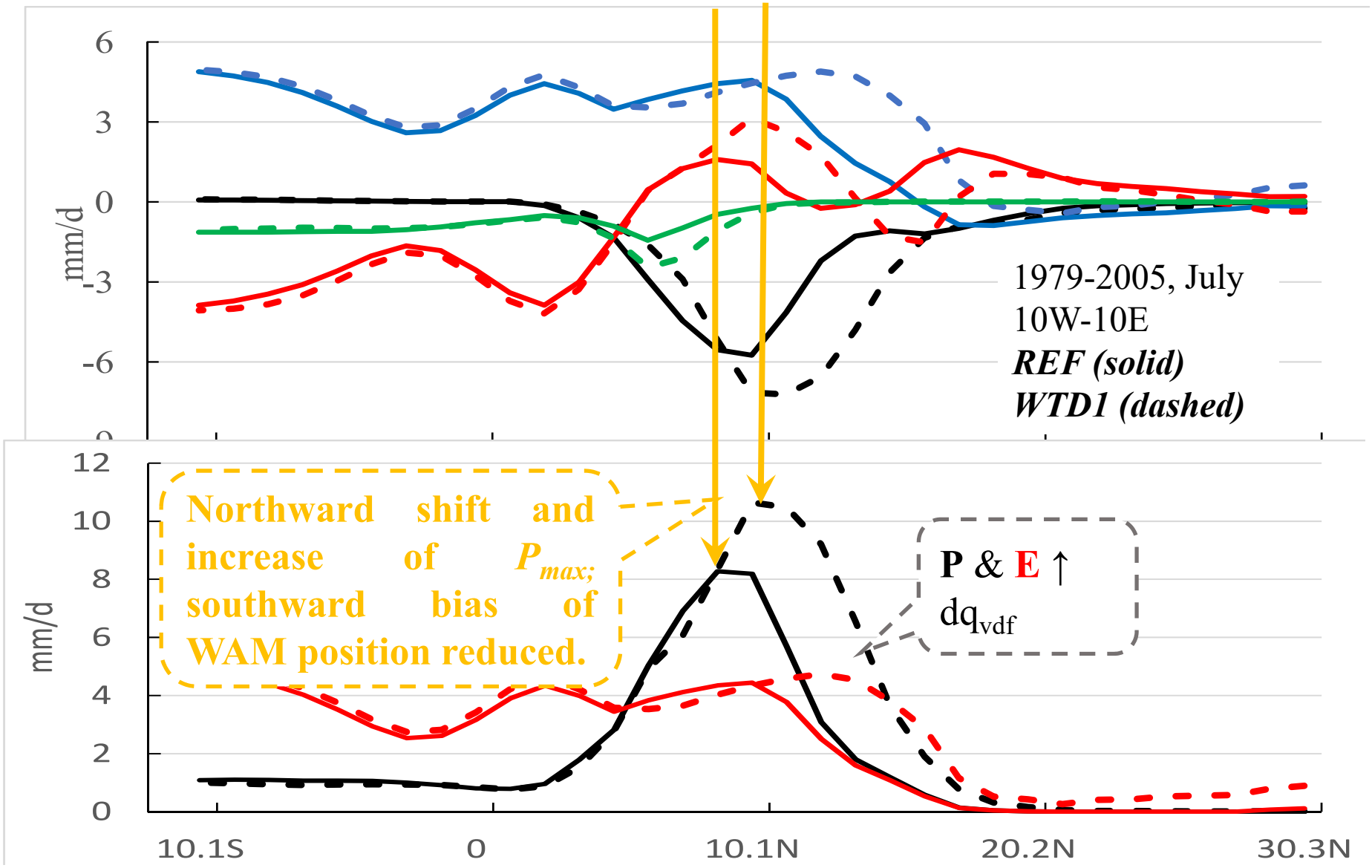
Impact of WT on *P* (WTD1-REF): JJA



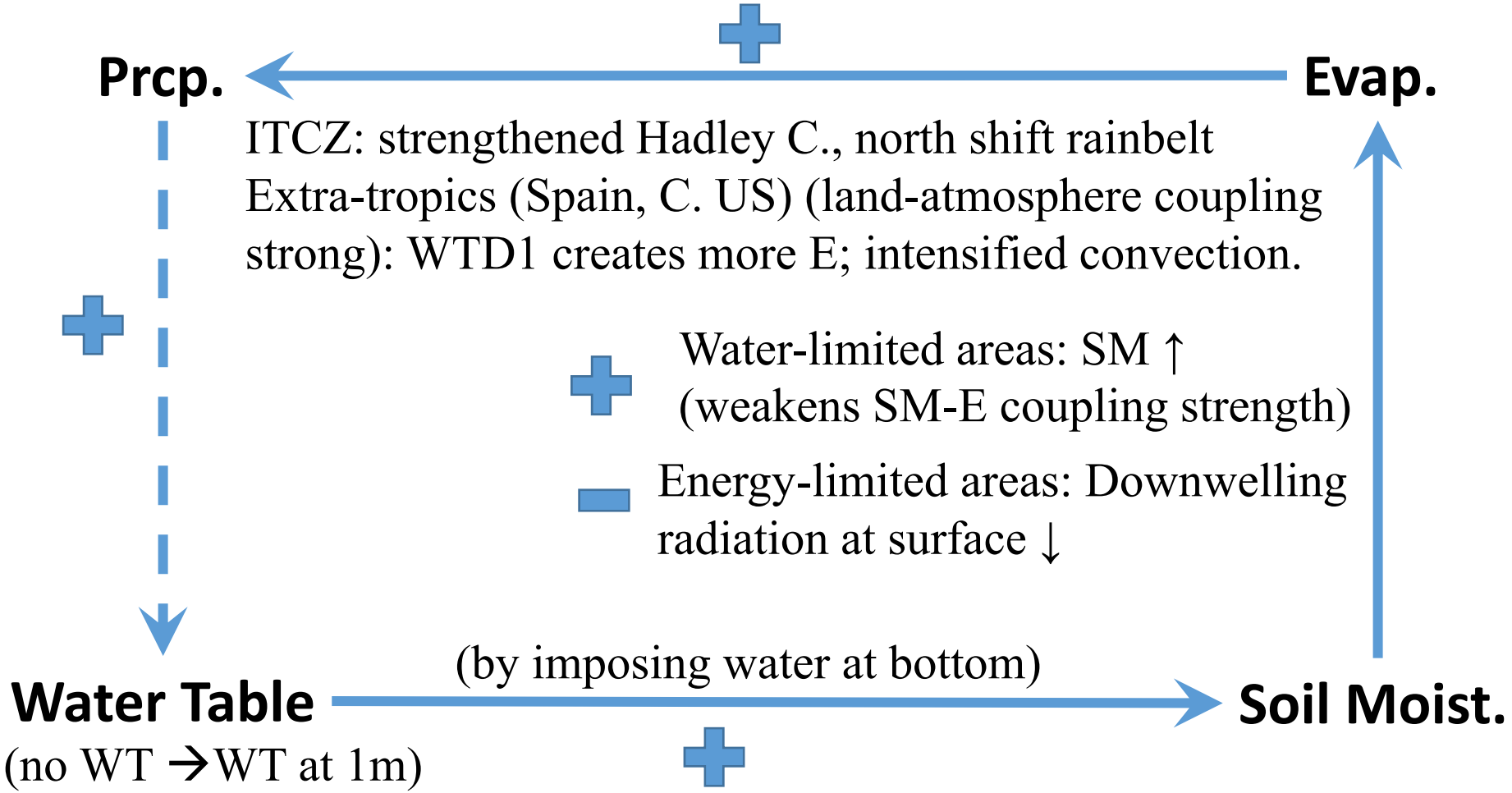
✓ Strong impacts over the West African Monsoon (WAM) region.

Impact of WTD on West African Monsoon

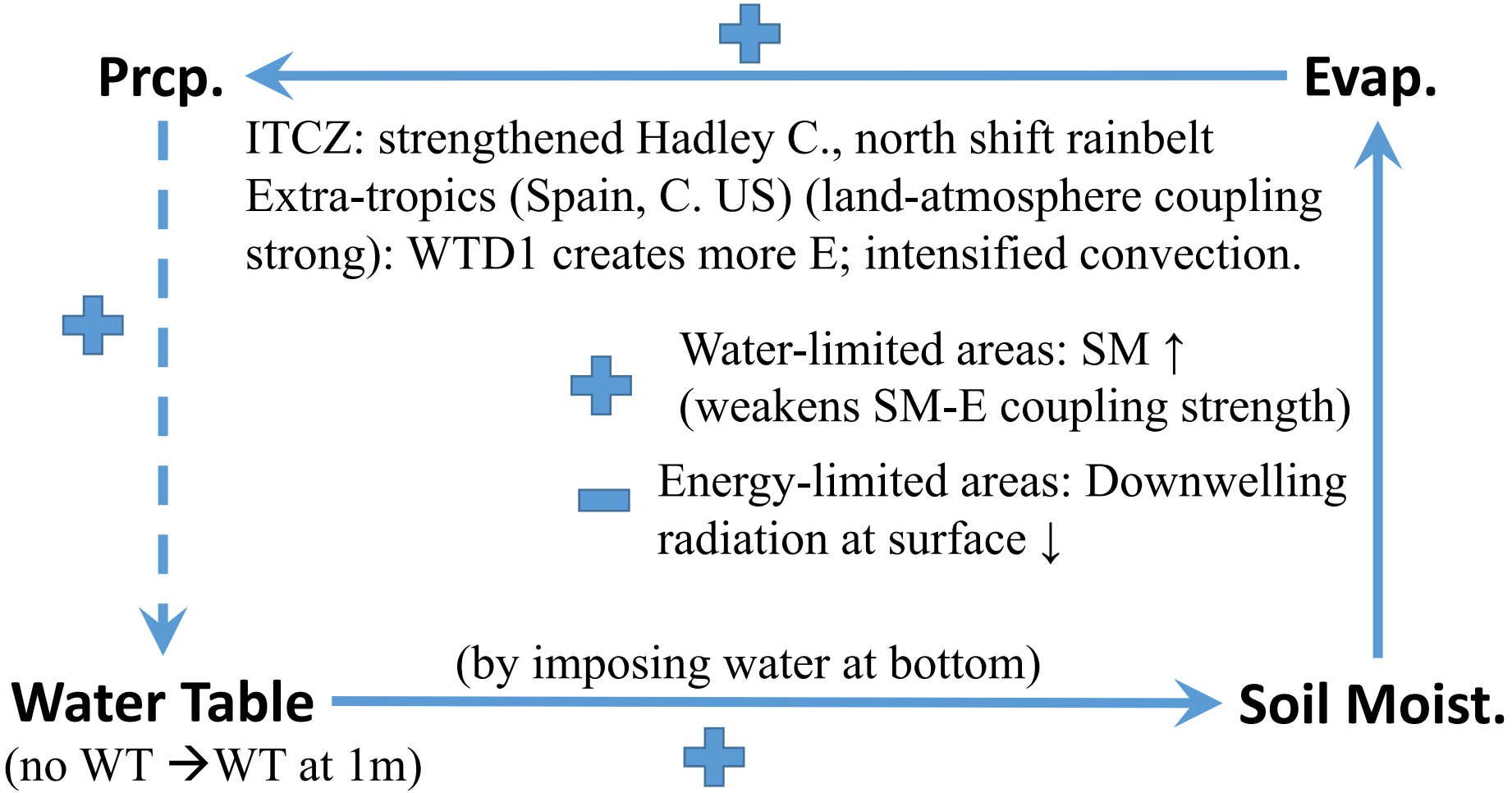
Monsoon flux well established, quasi-steady: $\left.\frac{\partial\langle q\rangle}{\partial t}\right|_{CON} + \left.\frac{\partial\langle q\rangle}{\partial t}\right|_{DYN} + \left.\frac{\partial\langle q\rangle}{\partial t}\right|_{VDF} + \left.\frac{\partial\langle q\rangle}{\partial t}\right|_{LSC} \approx 0$



WT - P Interaction Mechanism



WT - P Interaction Mechanism



WTD1: non-relistic WT; impacts maximized; water balance not conserved; idialized simulation (no ocean coupled).

Future work: to develop a real water table in IPSL-CM.

Thanks for your attention

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