# Simulating an abrupt termination of the Holocene African Humid period using an optimised configuration of HadCM3


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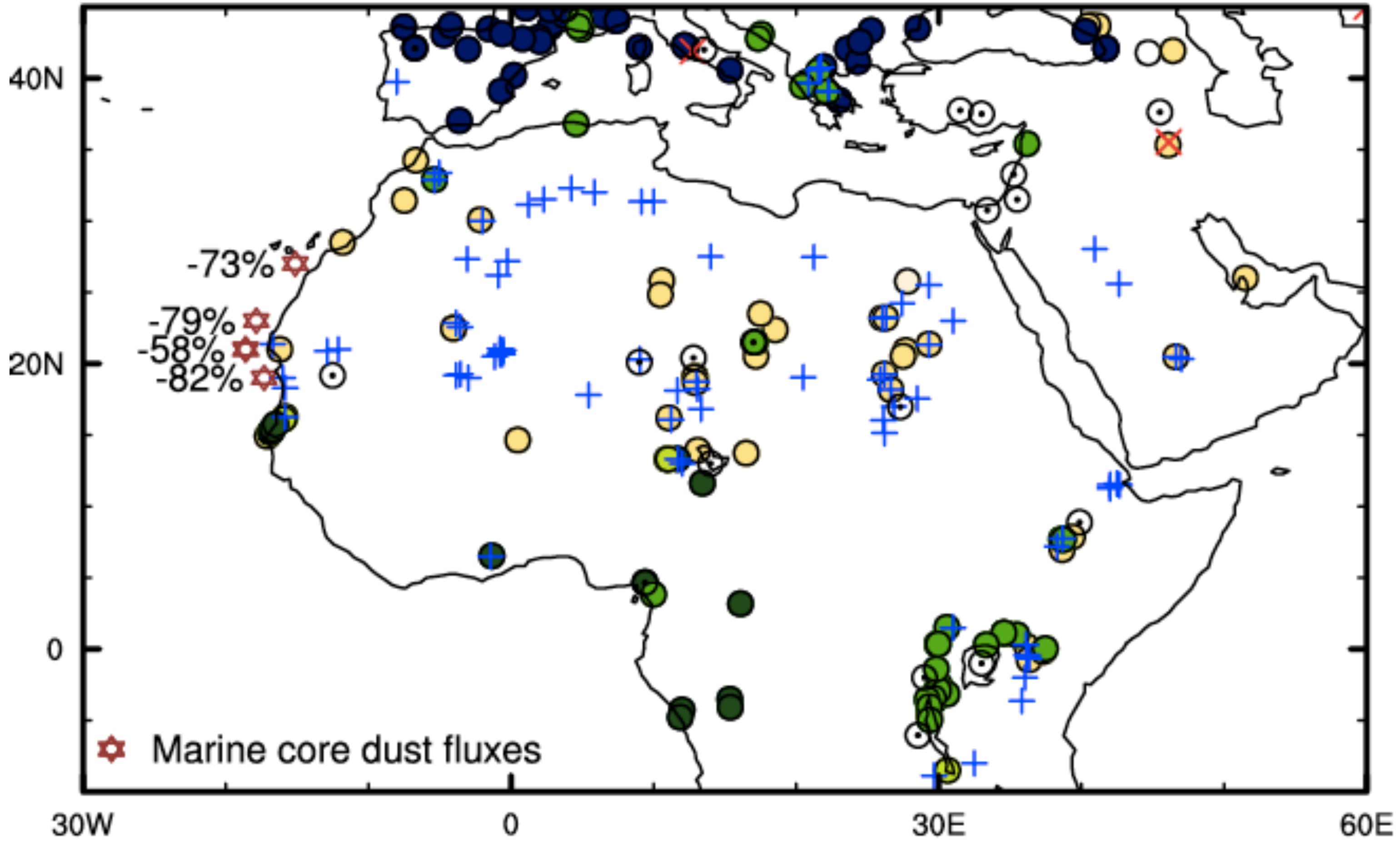
# Evidence for a 'Green' Sahara 11ka – 4ka

Pollen + Lake levels + Dust flux




**Biome type**

- Tundra
- Boreal forest
- Temperate forest
- Desert
- Grassland and dry shrubland
- Savanna and dry woodland
- Warm temperate forest
- Tropical forest

**Lake status**

- + Higher
- ⊙ No change
- × Lower

**Data from:**
Harrison, 2017
Kohfeld & Harrison, 2000
Egerer et al 2016, de Menocal et al 2000, McGee et al 2013

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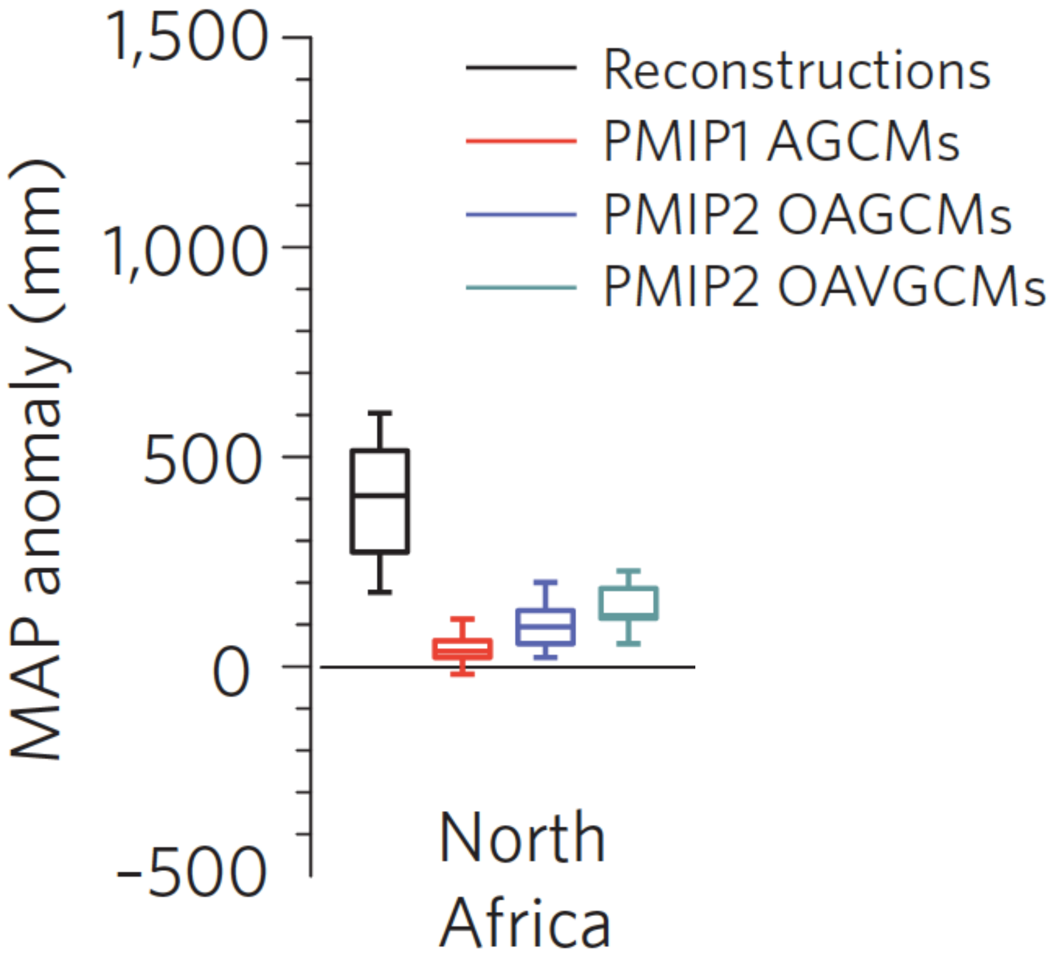
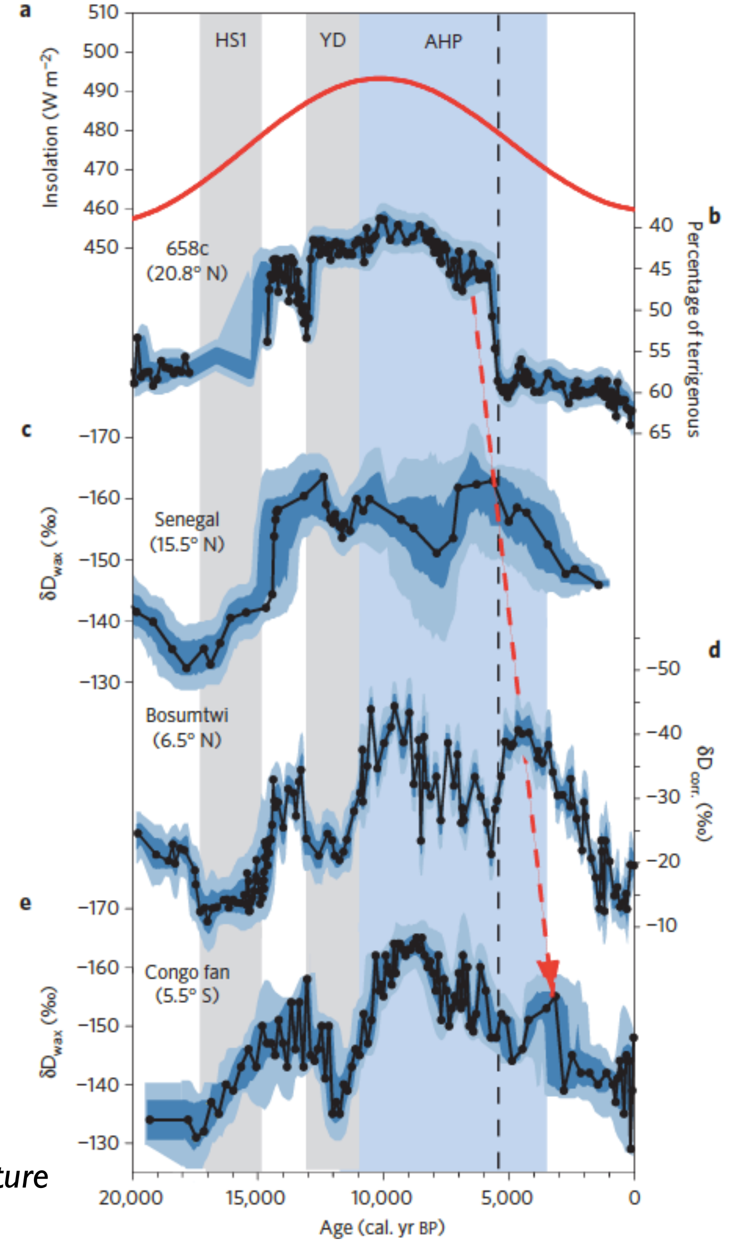
# Climate simulations: discrepancy for mid-Holocene




Braconnot et al 2012, *Nature Climate Change*

# Abrupt termination of the humid phase




Shanahan et al (2015), *Nature Geoscience*

# Four configurations of the coupled HadCM3 general circulation model

3.75°x2.75°x19L (atmosphere) 1.25°x1.25°x 20L (ocean)

1. HadCM3-M2.1 standard
   (Pope et al. 2000, Cox 2001, Valdes et al. 2017)

2. HadCM3-M2.1 + new vegetation moisture stress (Hopcroft et al. in prep.)

3. HadCM3-M2.1 + optimised atmospheric convection (Hopcroft et al. in revision)

4. HadCM3-M2.1 + new veg moisture stress + optimised convection

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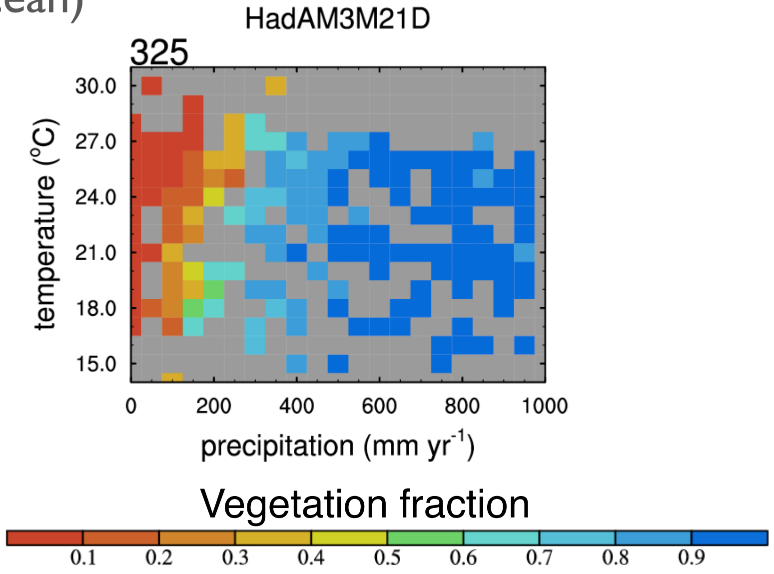
Better capturing the distribution of bare soil in the tropics in relation to precipitation (x-axis) and temperature (y-axis) for the present day.



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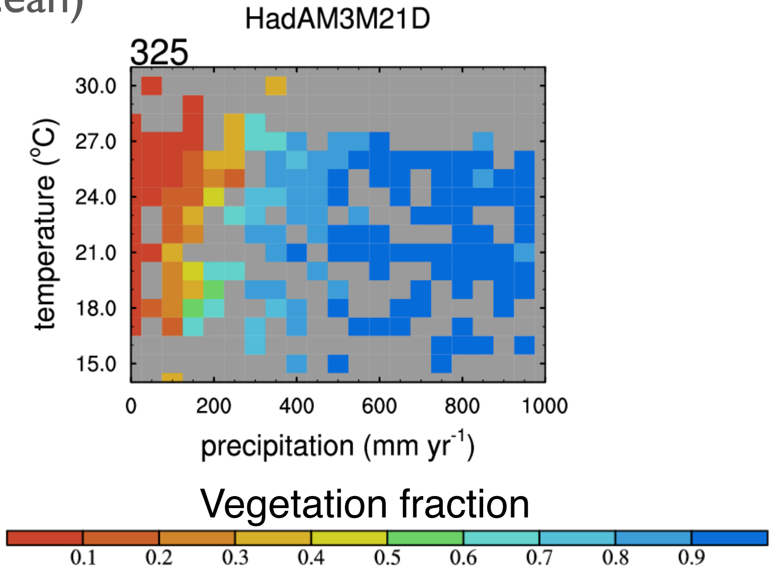
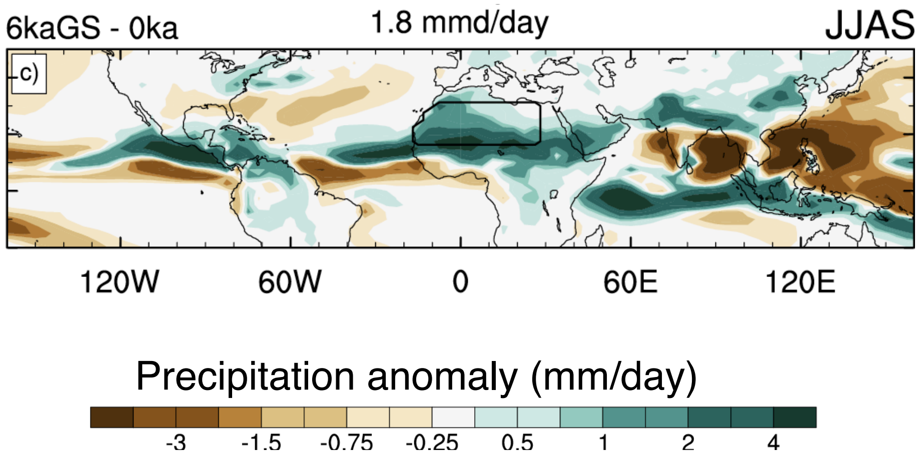


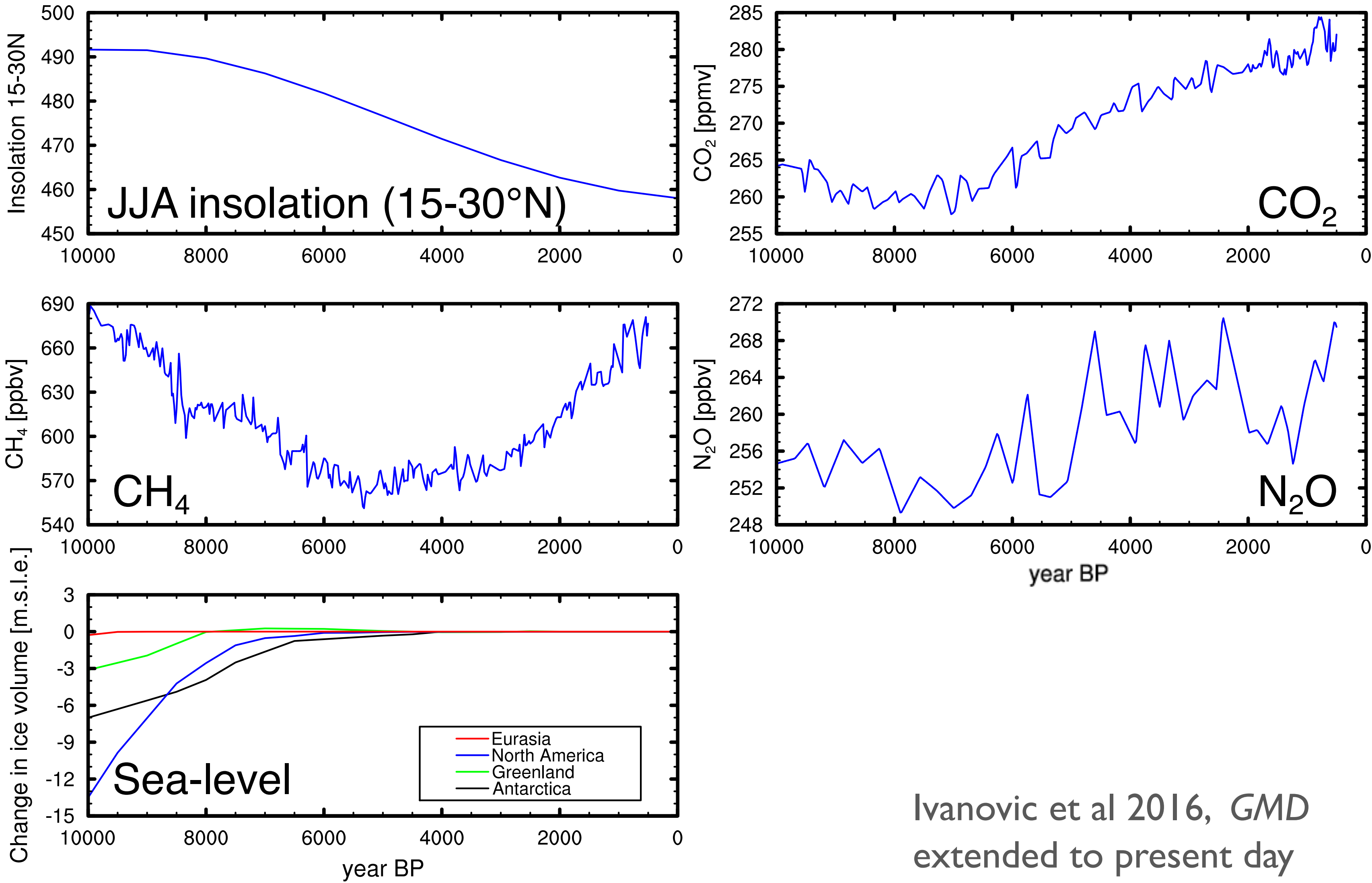

An altered vertical profile of convective entrainment (applied in both present day and mid-Holocene simulations) doubles the mid-Holocene rainfall anomaly over North Africa.



# External forcings applied in transient simulations from 10,000 years before present - present day (CE 1950)

**Orbit, $CO_2$, $N_2O$ & $CH_4$:**
updated every timestep

**Ice-sheets & sea-level:**
updated every 500 years




Ivanovic et al 2016, *GMD*
extended to present day

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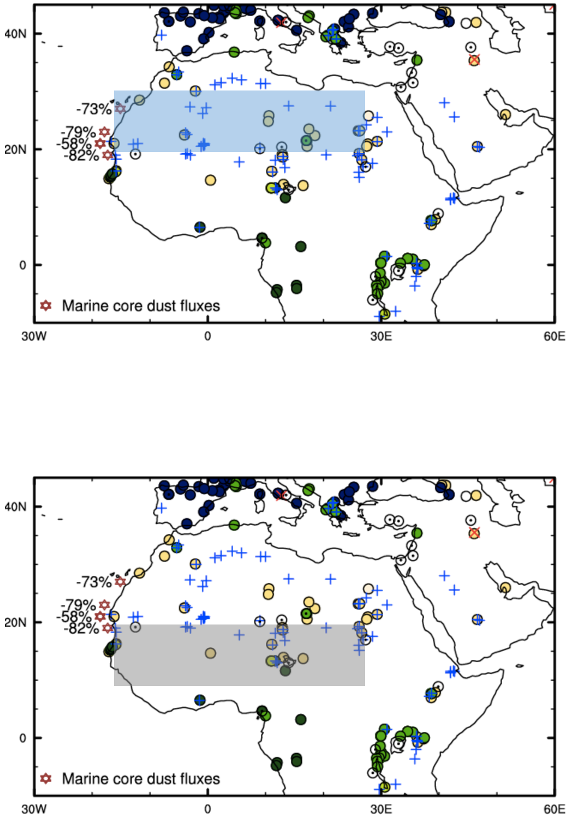
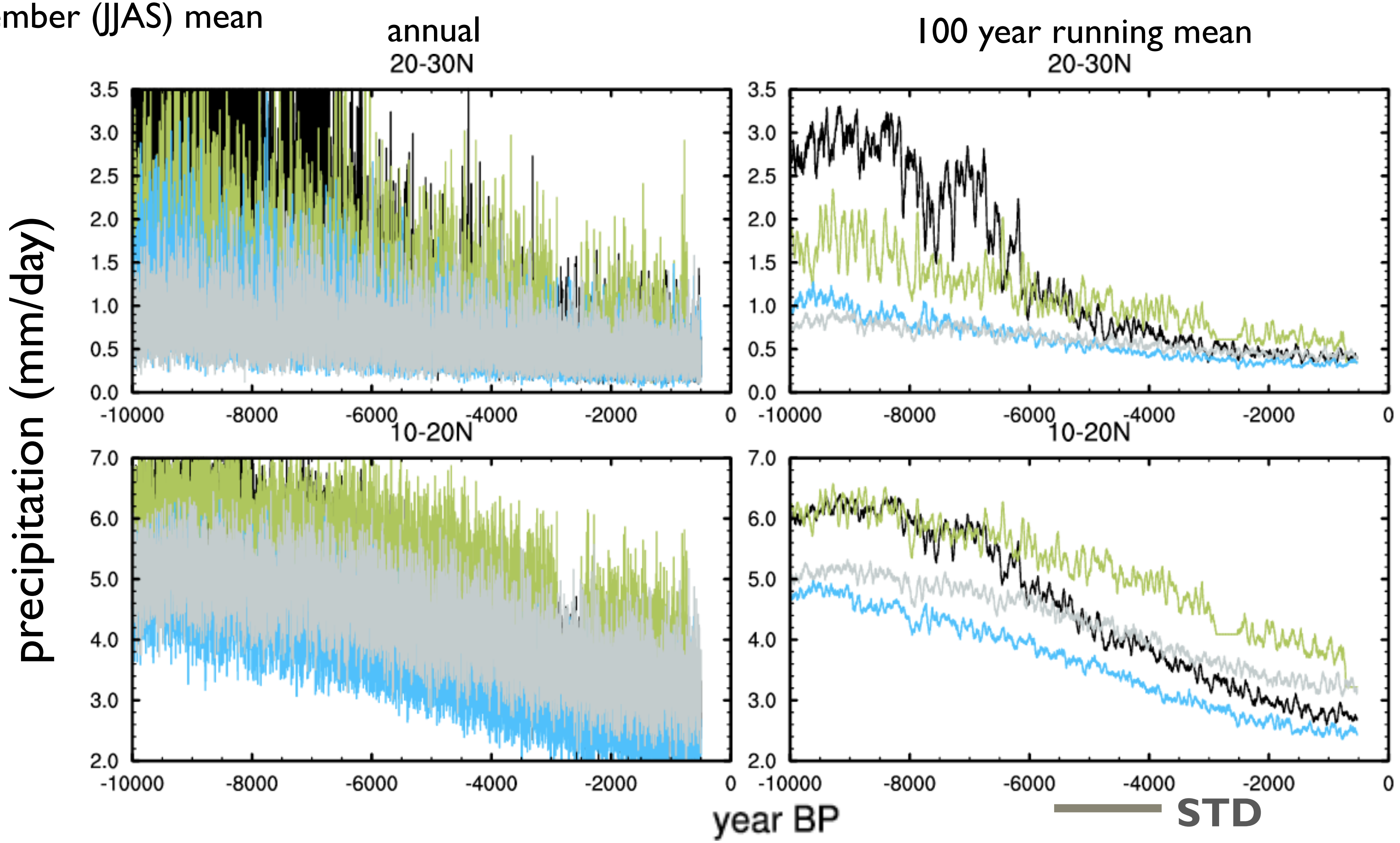
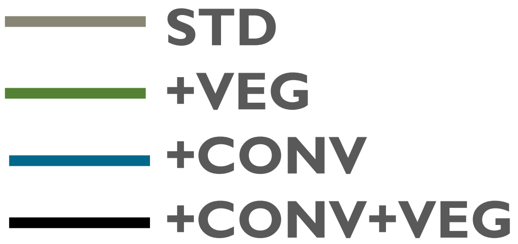
# Precipitation response in latitude bands over North Africa

June-July-August-September (JJAS) mean




+CONV+VEG is much wetter in early to mid-Holocene and shows abrupt behaviour around 6000 years BP

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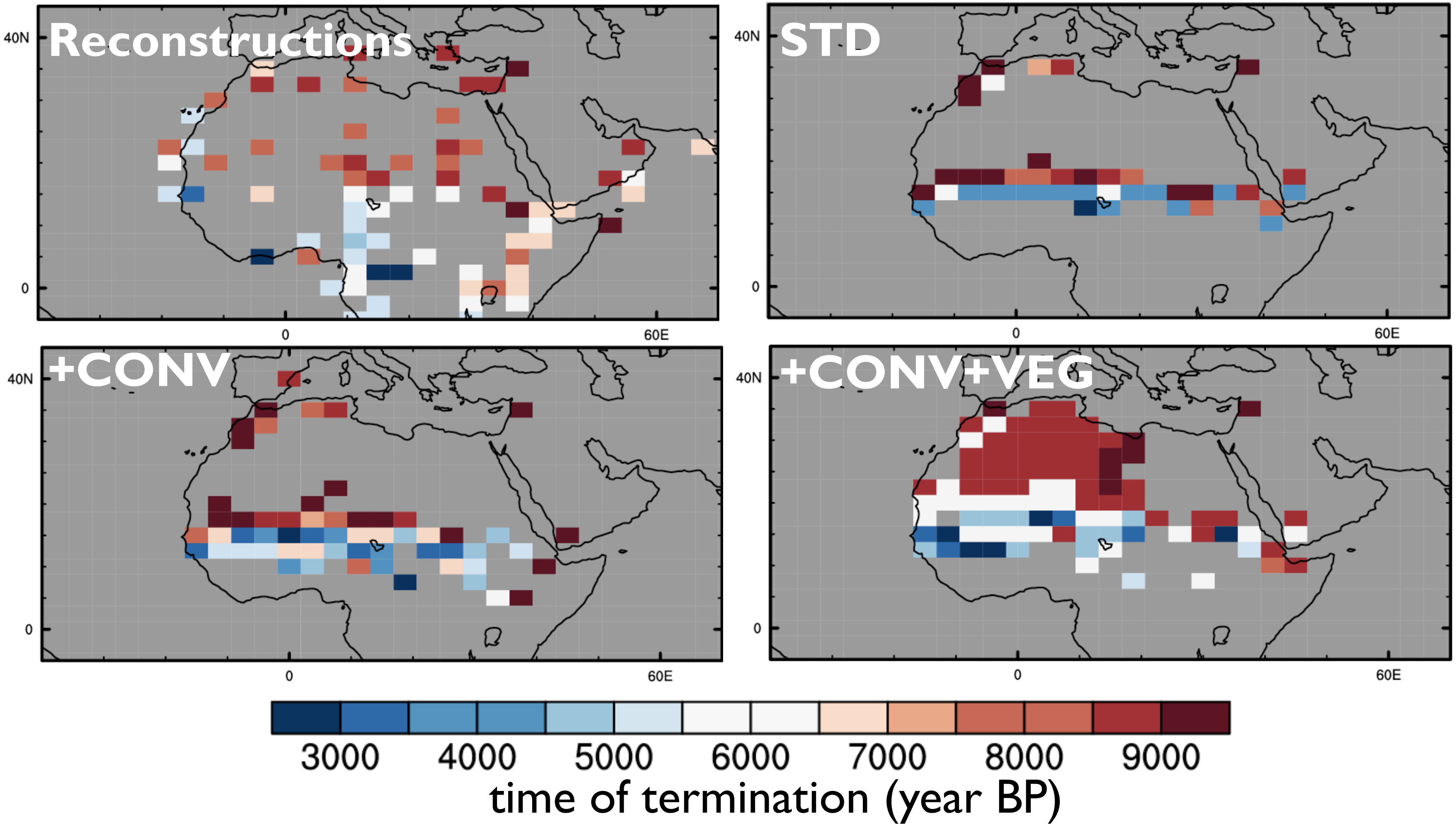
# Timing of aridification compared to reconstructions

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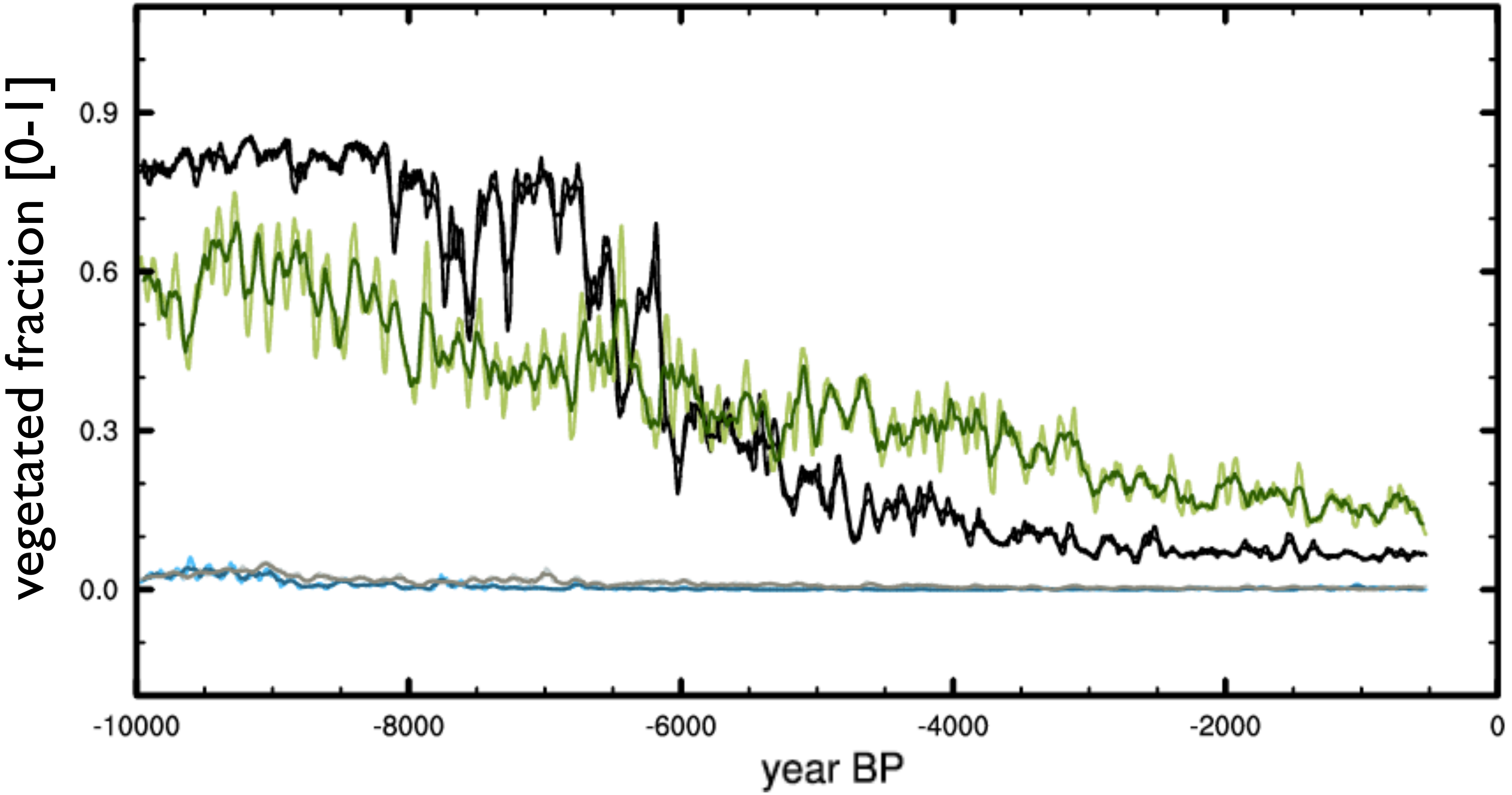
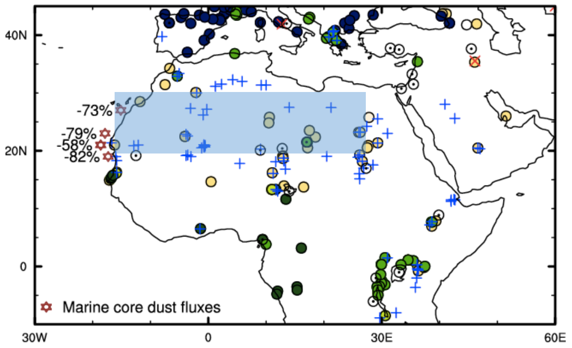
**Reconstructions:** Shanahan *et al.* 2015, *Nature Geoscience*
Dallmeyer *et al.* (2020), *Climate Past*

# Vegetation response

## Vegetation cover in North Africa: 20-30°N [0-1]




STD
+VEG
+CONV
+CONV+VEG

Hopcroft et al, in prep.

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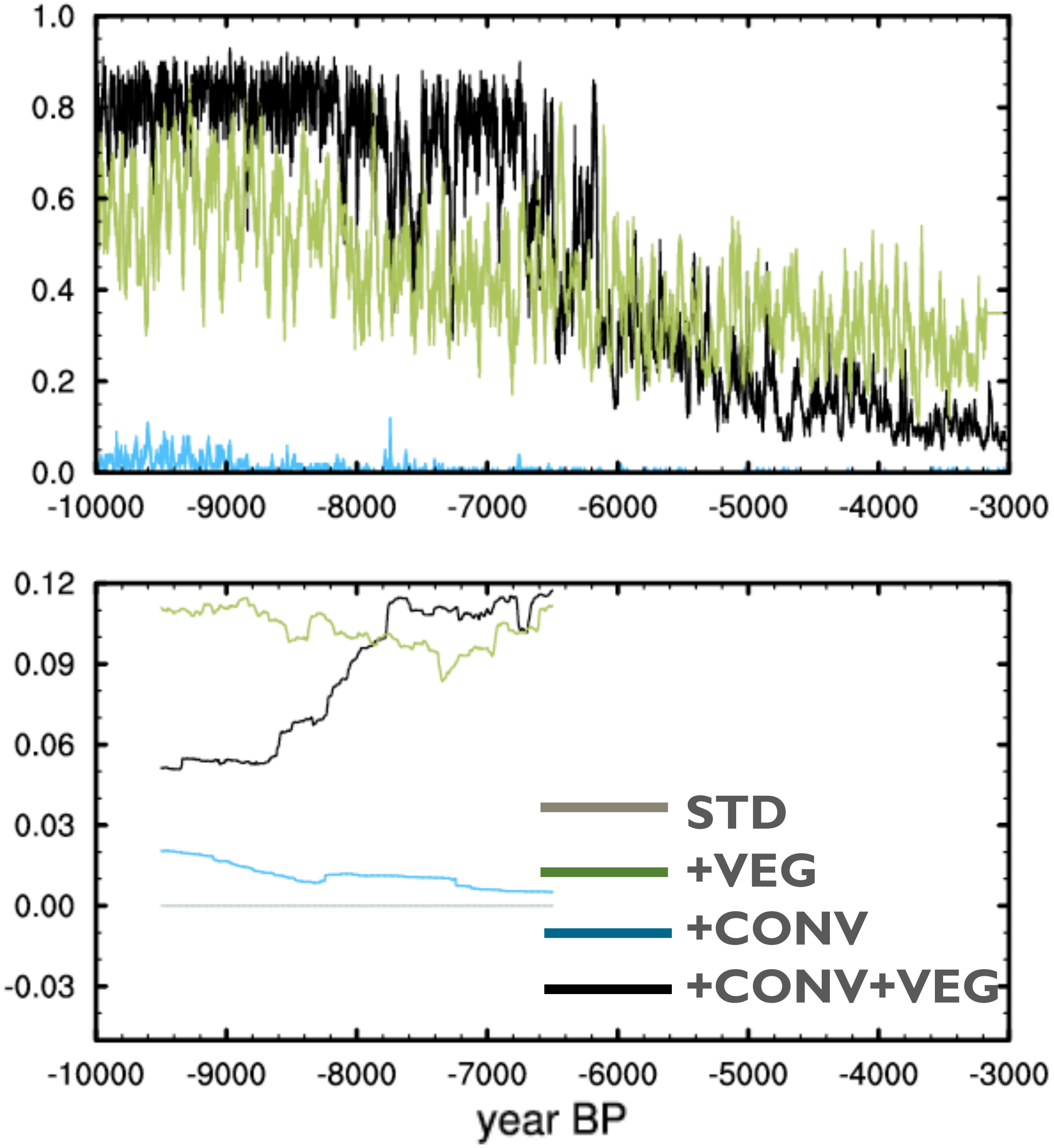
# Approaching the threshold

Vegetation fraction

Variance




The variance only increases in the +CONV+VEG run, even though +VEG samples some of the same state space in terms of vegetation cover.

→ interaction of the CONV and VEG leads to **new threshold behavior**.

STD
+VEG
+CONV
+CONV+VEG

e.g. Scheffer et al 2009, *Nature*

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