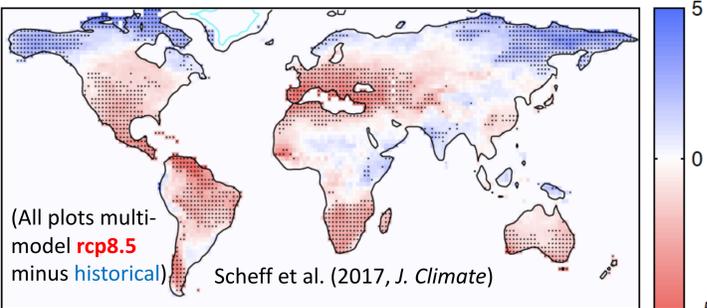


Drought indices overpredict the drought impacts of warming – in models and in reality

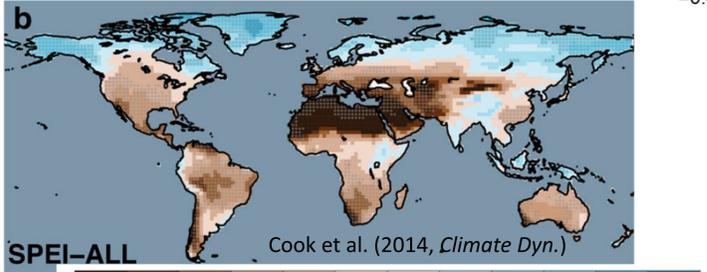
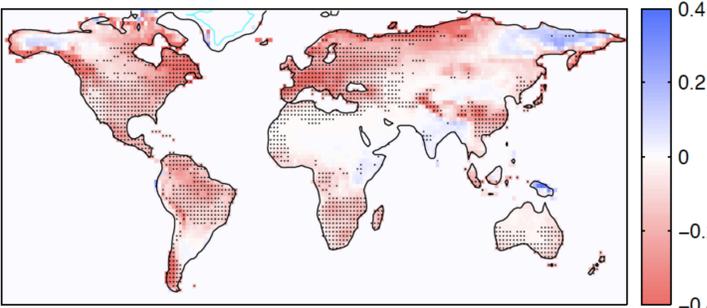
Jacob Scheff, Geography & Earth Sciences, University of North Carolina Charlotte (*Curr. Climate Change Rep.*, 2018)

Earth System Models project that PDSI, SPEI, and Aridity Index (P/PET) will all trend strongly toward global “dryness” with global warming.

d) PDSI change

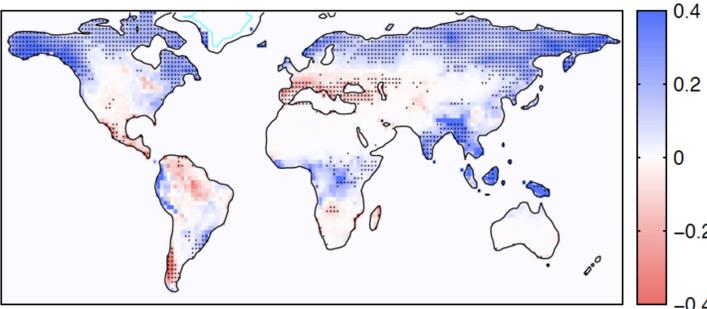


c) (P/PET) change

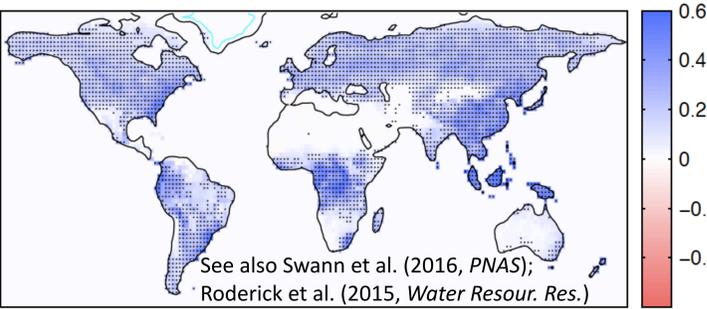


Yet the exact same models also project that runoff will variously increase and decrease – and that vegetation will increase globally.

g) P-E change (mm day⁻¹)

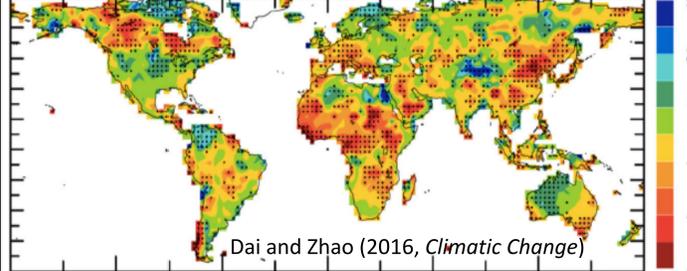


h) NPP change (kg C m⁻² yr⁻¹)

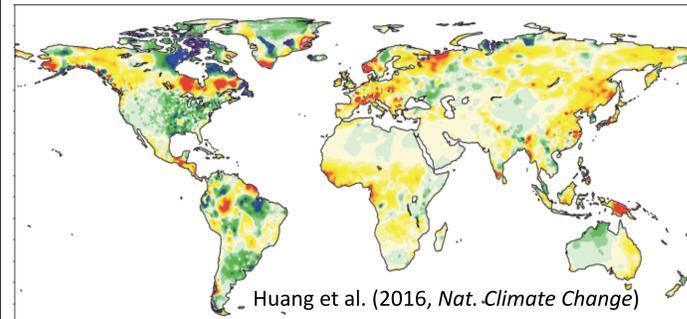


Is this believable? Yes – in fact it already seems to be happening: PDSI and P/PET are trending toward “dryness” globally...

(c) sc PDSI pm Trend (change/50yr), 1950-2012

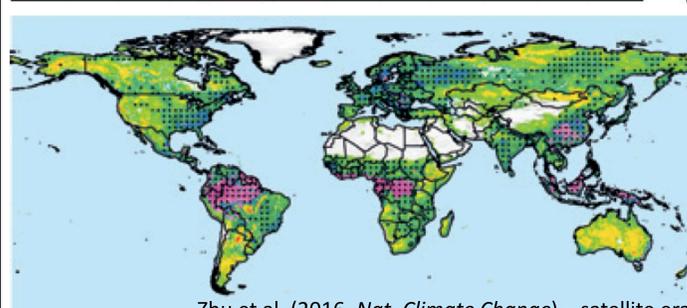
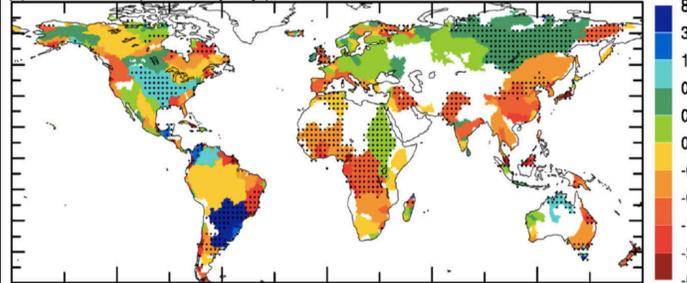


CPC annual P/PET (1948-2005) trend (change/58yr)



...while runoff is variously increasing and decreasing with no preferred polarity, and vegetation is increasing over many areas but decreasing almost nowhere.

(b) Runoff Trend (0.1mm/day/50yr), 1949-2012, ANN, Inferred from Streamflow Data

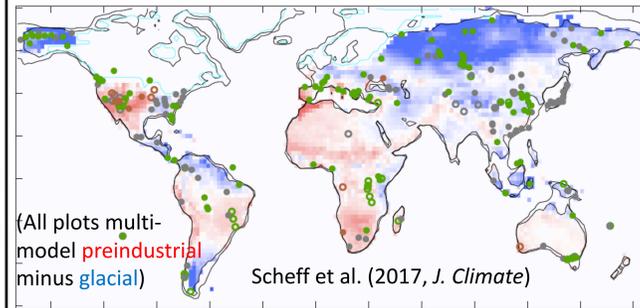


Trend in average observed LAI (10⁻² m² m⁻² yr⁻¹)

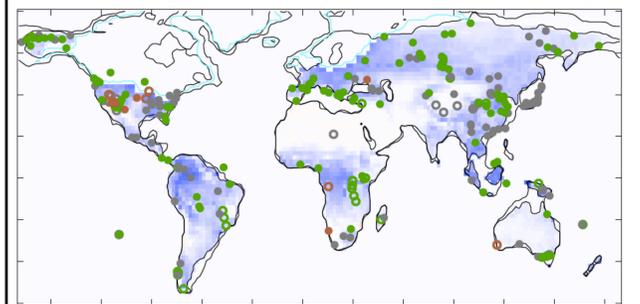
So, CO₂ warming does indeed seem to be characterized by index-based drying with greening vegetation and varied runoff response. Drought indices ≠ drought impacts.

And it happened going out of the last glacial: Earth warmed with CO₂; vegetation density (dots - from pollen) followed model NPP (increasing) rather than PDSI (declining)...

PDSI change, with observed vegetation change

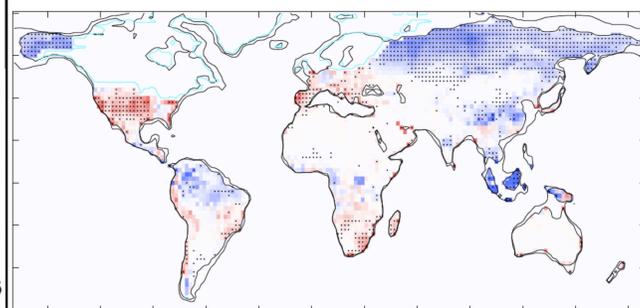


NPP change (kg C m⁻² yr⁻¹), with observed vegetation change

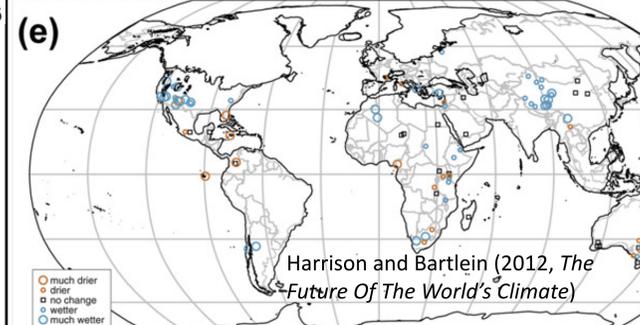


and runoff (from paleolake data) followed model P-E projections, validating them:

P-E change (mm day⁻¹)

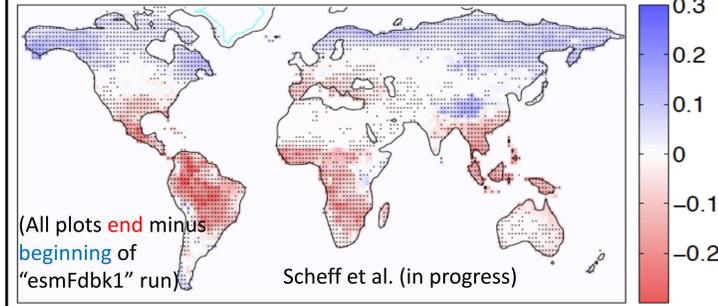


LGM Lake Status (n.b. sign convention reversed – glacial minus preind.)



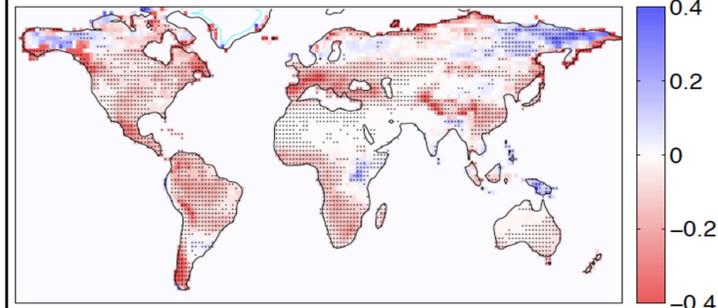
Why is this? Direct CO₂ effects on vegetation are often cited (e.g. Roderick et al. 2015 *WRR*, Swann et al. 2016 *PNAS*, Milly and Dunne 2016 *Nat. Climate Change*.) Indeed, CO₂ totally explains the NPP/veg increase:

NPP change (kg C m⁻² yr⁻¹) if plants are “blind” to CO₂ increase

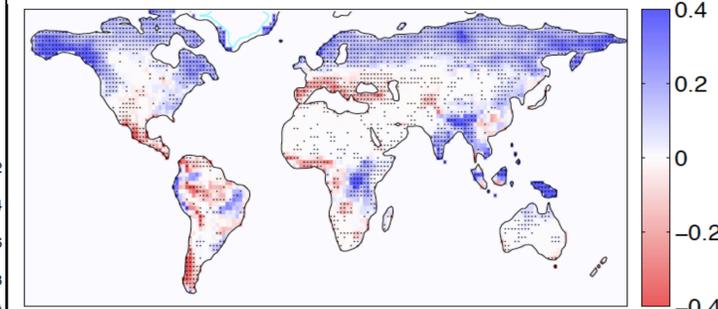


But, CO₂ fails to explain why the dryness indices don't predict the runoff response.

P/PET change if plants are “blind” to CO₂ increase



P-E change if plants are “blind” to CO₂ increase



So the mismatch between index-based drying and lack of actual runoff drying must be due to something other than CO₂-plant effects! Candidates include:

- increased VPD closing leaf stomata (Novick et al. 2016 *Nat. Climate Change*)
- increased precipitation intensity (e.g. Dai et al 2018 *Curr. Climate Change Rep.*) and/or seasonality (Chou et al. 2013 *Nat. Geosci.*)
- Penman PET formulation itself flawed (Milly and Dunne 2016 *Nat. Climate Change*)
- ... ???