

Parsing Apart the Relative Impacts of Temperature and VPD on Tropical Forest GPP

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- Tropical forest photosynthesis can decline at high temperatures due to:
 - (1) biochemical responses to increasing temperature
 - (2) stomatal limitation due to increasing vapor pressure deficit (VPD)
- Temperature and VPD are tightly correlated
 - it is challenging to parse apart the influence of temperature vs VPD on photosynthesis



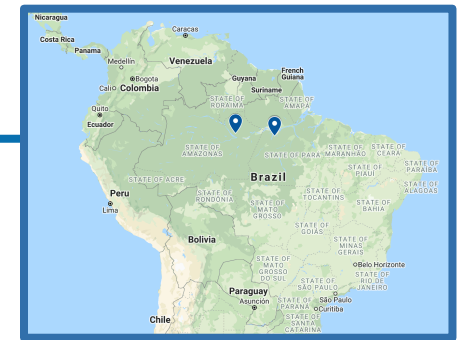
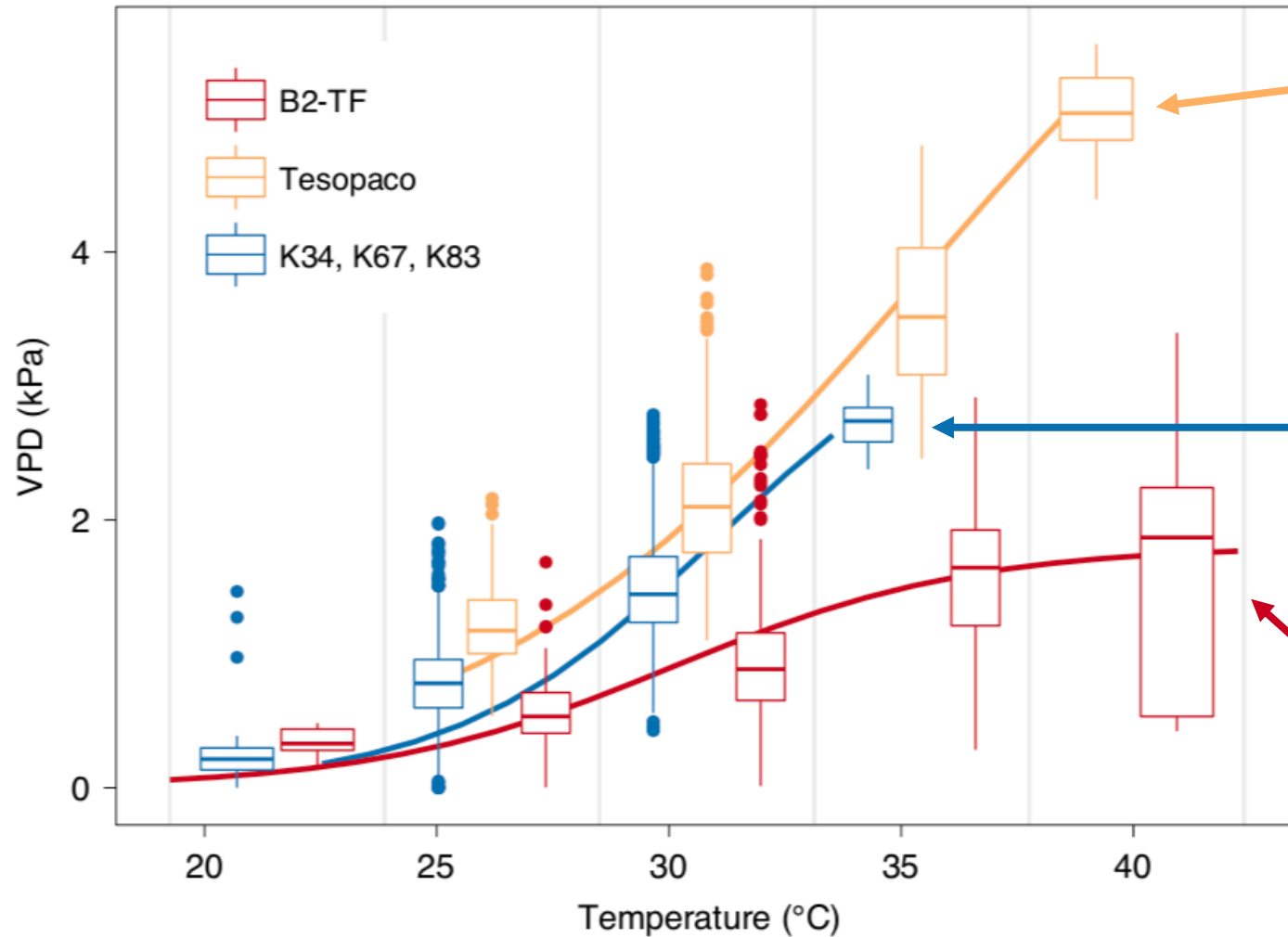
- Smith et al. (2020) used data from Biosphere 2 to disentangle direct temperature effects from indirect VPD effects on GPP



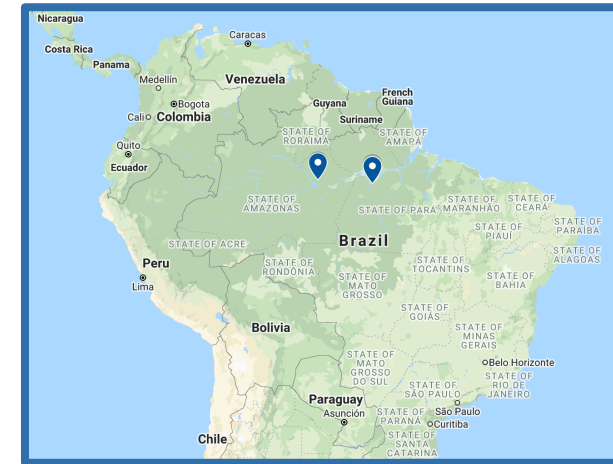
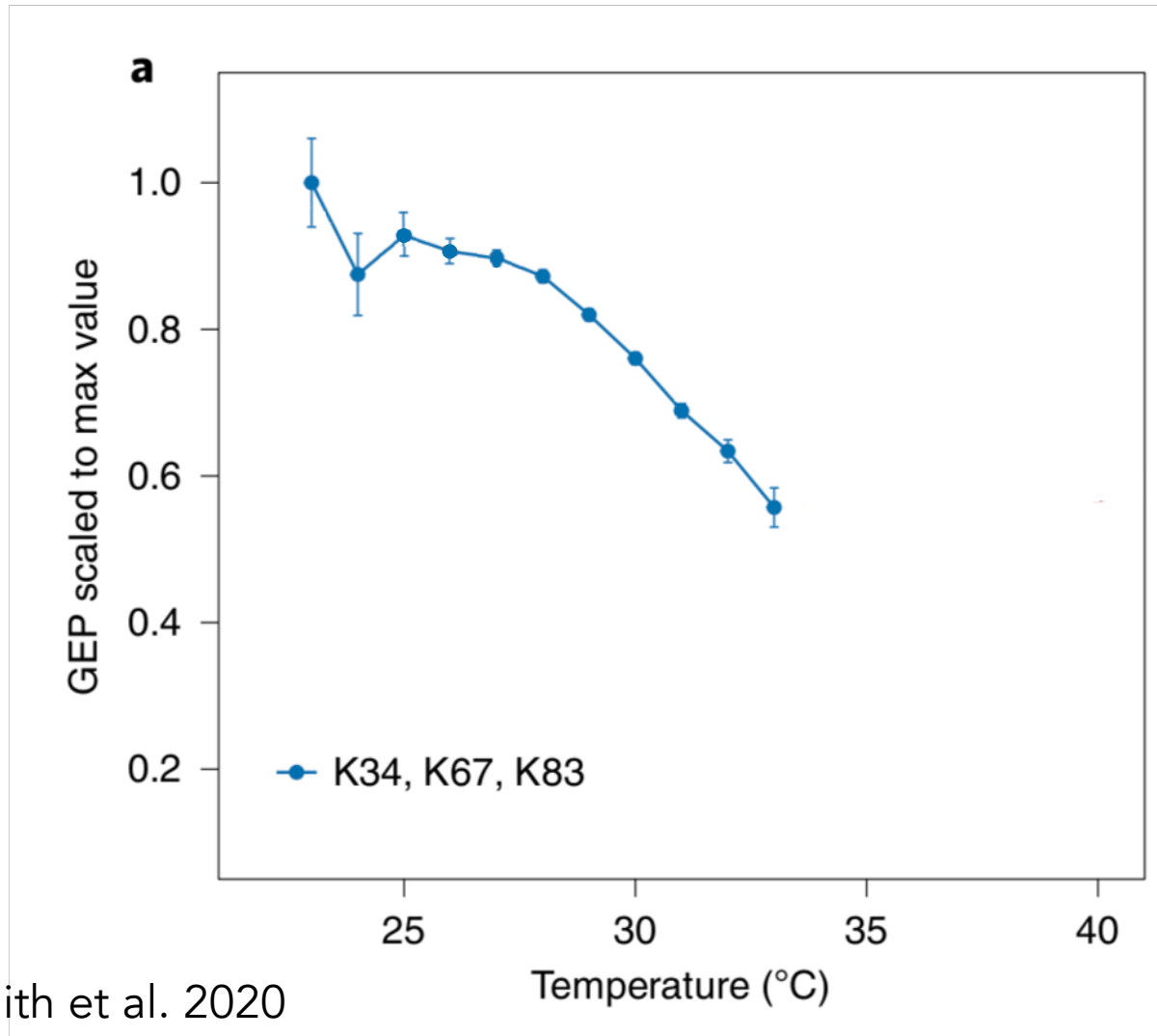
- Biosphere 2 contains an experimental tropical forest which remains humid even at high temperatures

[Photos of Biosphere 2, from University of Arizona](#)

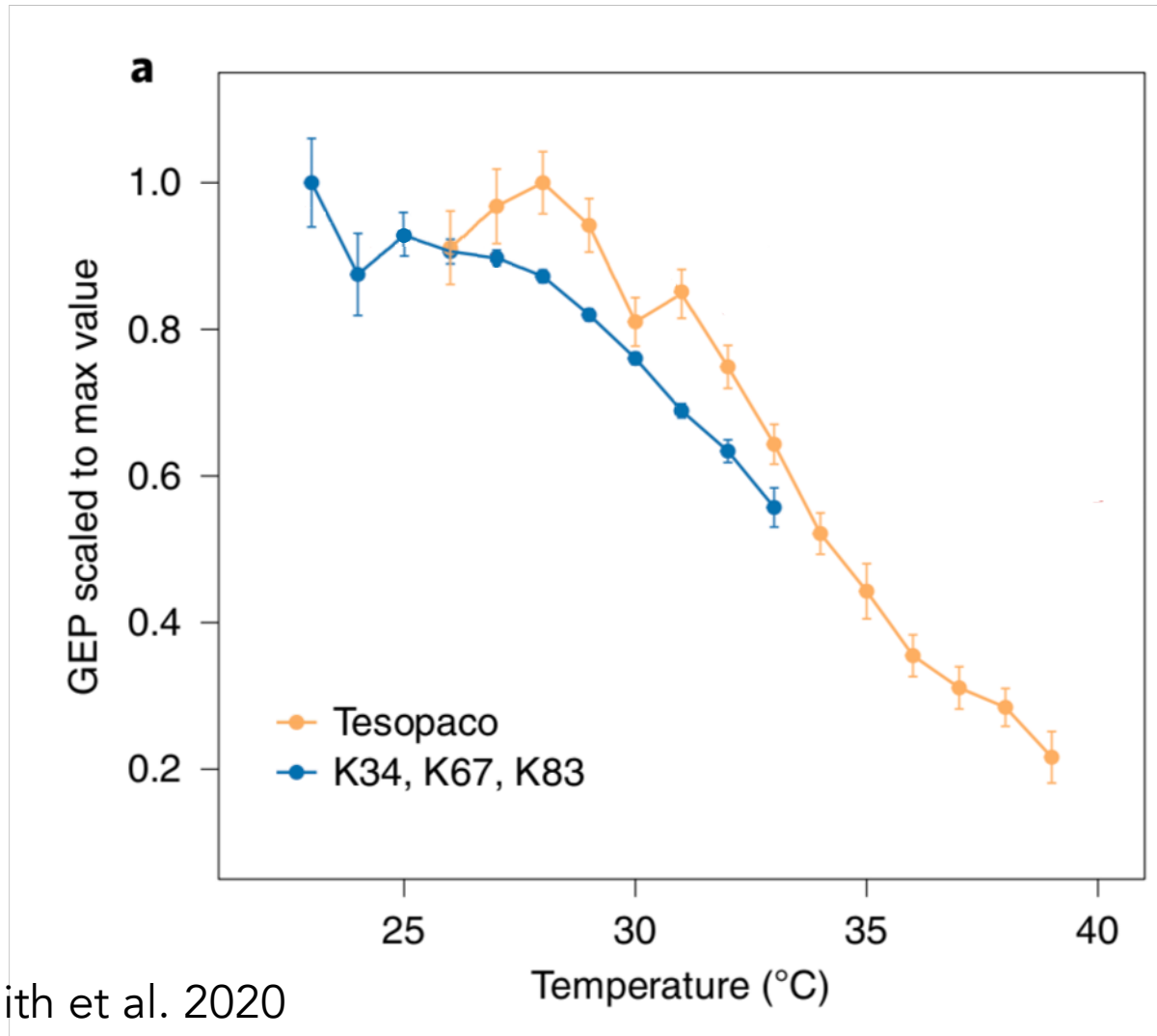
At high temperatures, Biosphere 2 has lower VPD than natural tropical forests



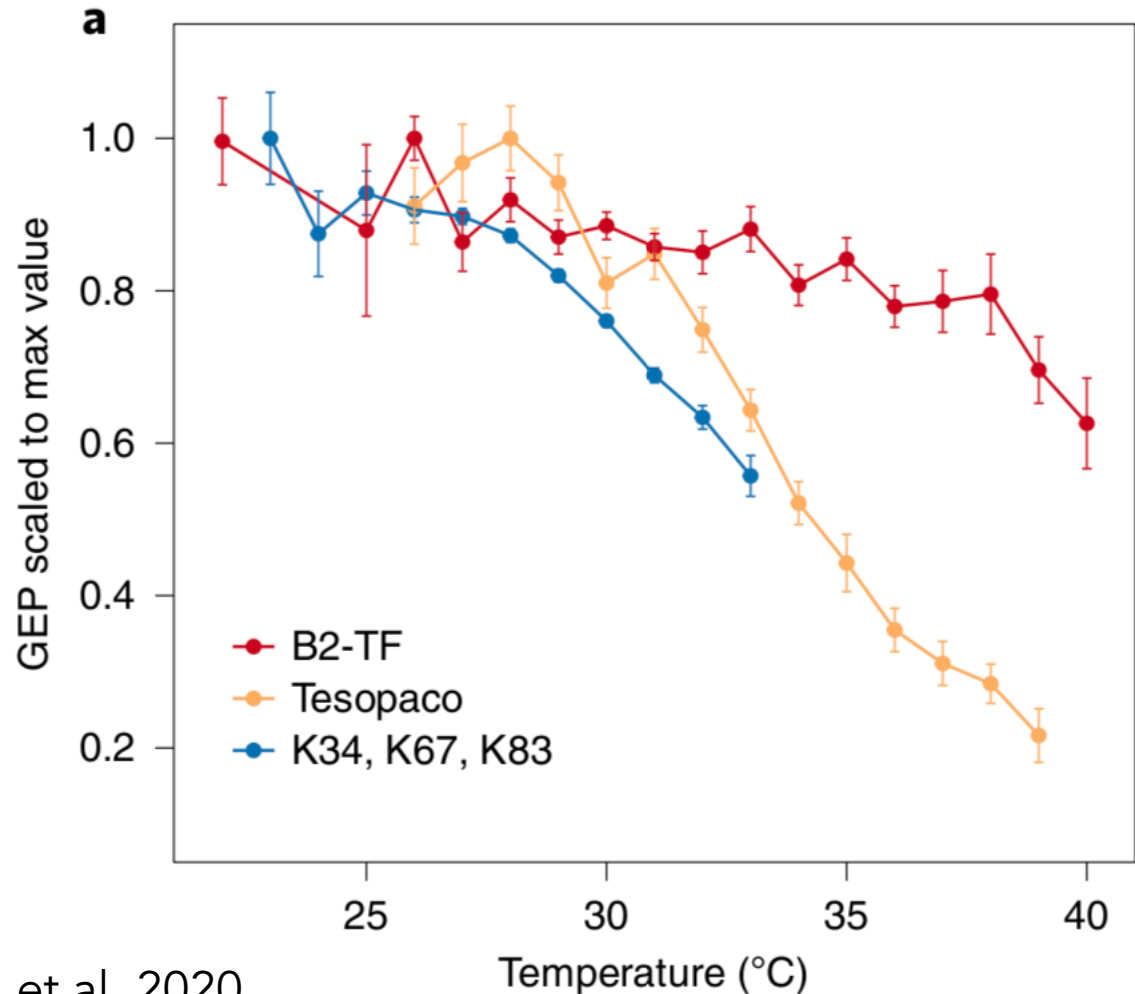
High temperatures decrease light-saturated photosynthesis less in B2 than in natural ecosystems, because B2 is more humid



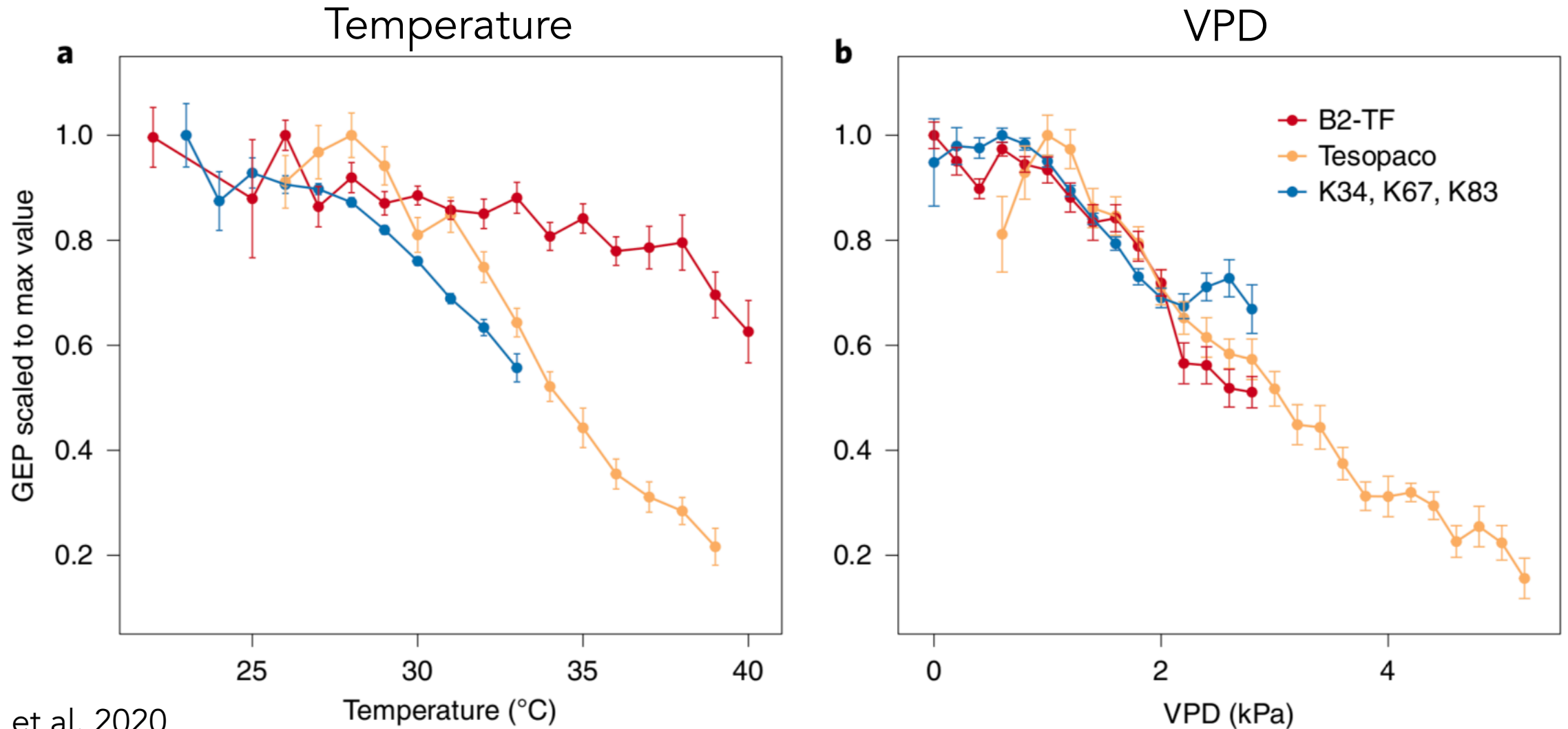
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 - Stronger biochemical responses: less resilient to future climate
 - Stronger stomatal response to VPD: potentially more resilient

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 - Stronger biochemical responses: less resilient to future climate
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- What about Biosphere 2 enables it to maintain high photosynthetic rates at high temperatures?
- What are the implications of Smith et al.'s findings for tropical forest resilience to future warming?

How will temperature vs. VPD influence tropical forest productivity in a warmer climate?

- Test whether FATES captures the tropical forest GPP responses to VPD vs. temperature identified by Smith et al. (2020)

How will temperature vs. VPD influence tropical forest productivity in a warmer climate?

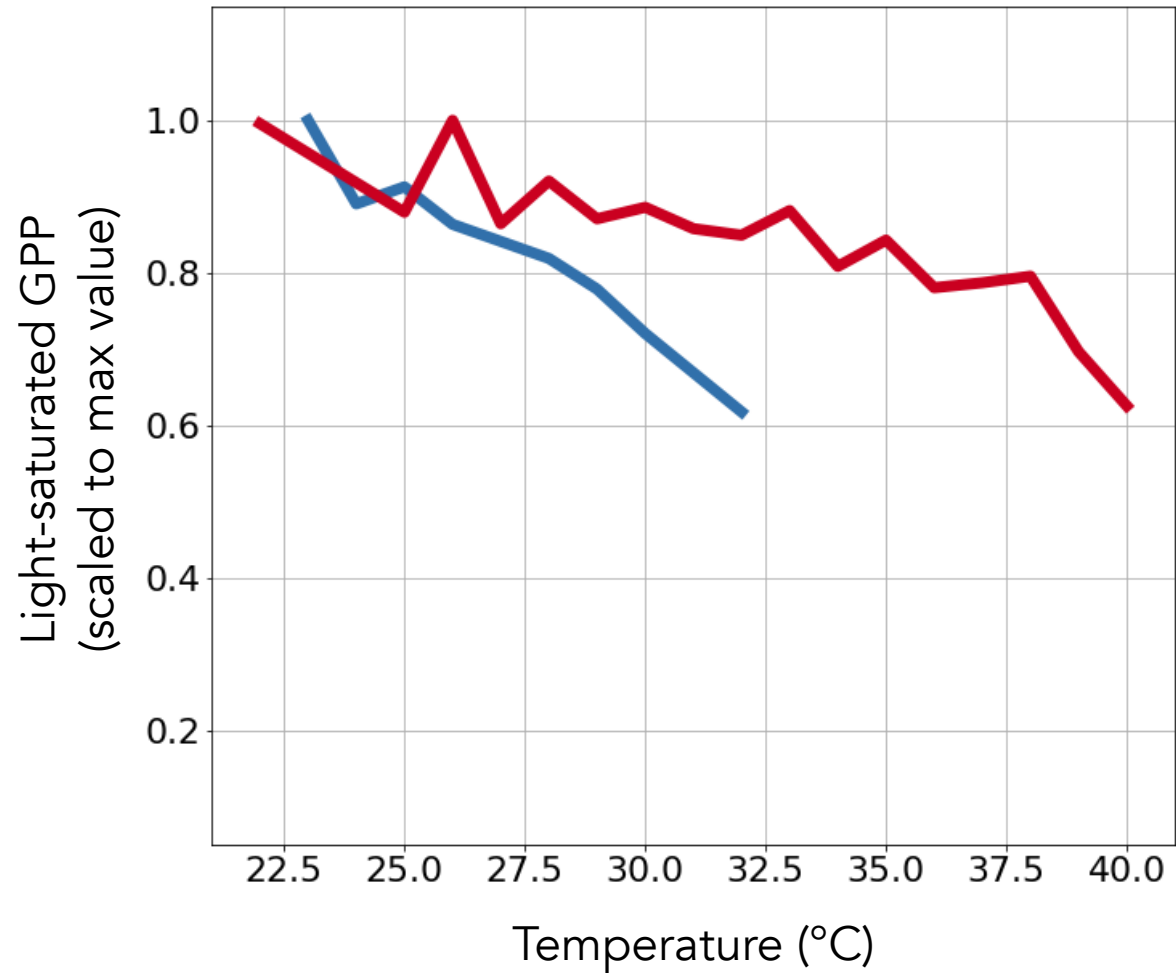
- Test whether FATES captures the tropical forest GPP responses to VPD vs. temperature identified by Smith et al. (2020)
- What differences between Biosphere 2 and natural tropical forest sites result in the different GPP response curves? Planning to test:
 - Meteorology (temperature, humidity, solar radiation)
 - CO₂ concentration
 - Functional traits
 - Forest structure

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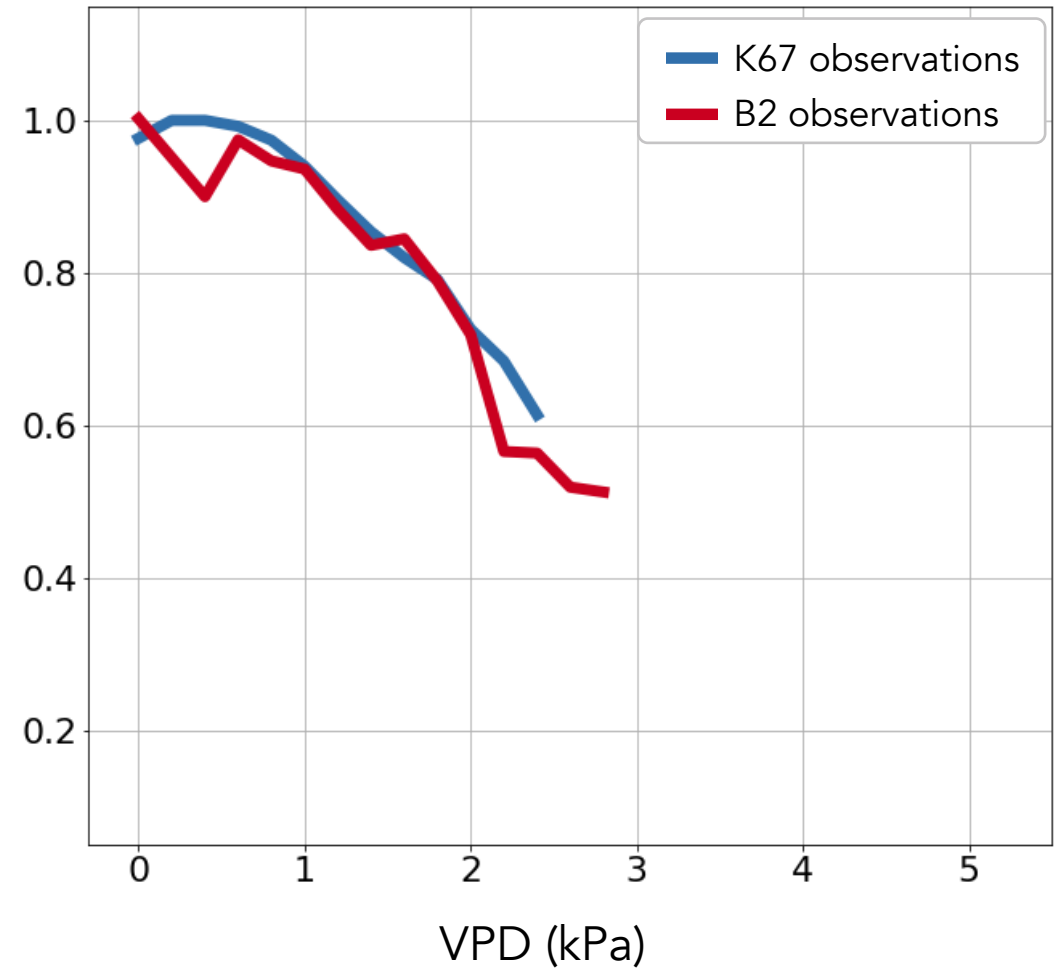
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 - Meteorology (temperature, humidity, solar radiation)
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- Quantify temperature vs. VPD impact on tropical forest productivity under climate change

Observed response of light-saturated GPP to temperature and VPD

Temperature

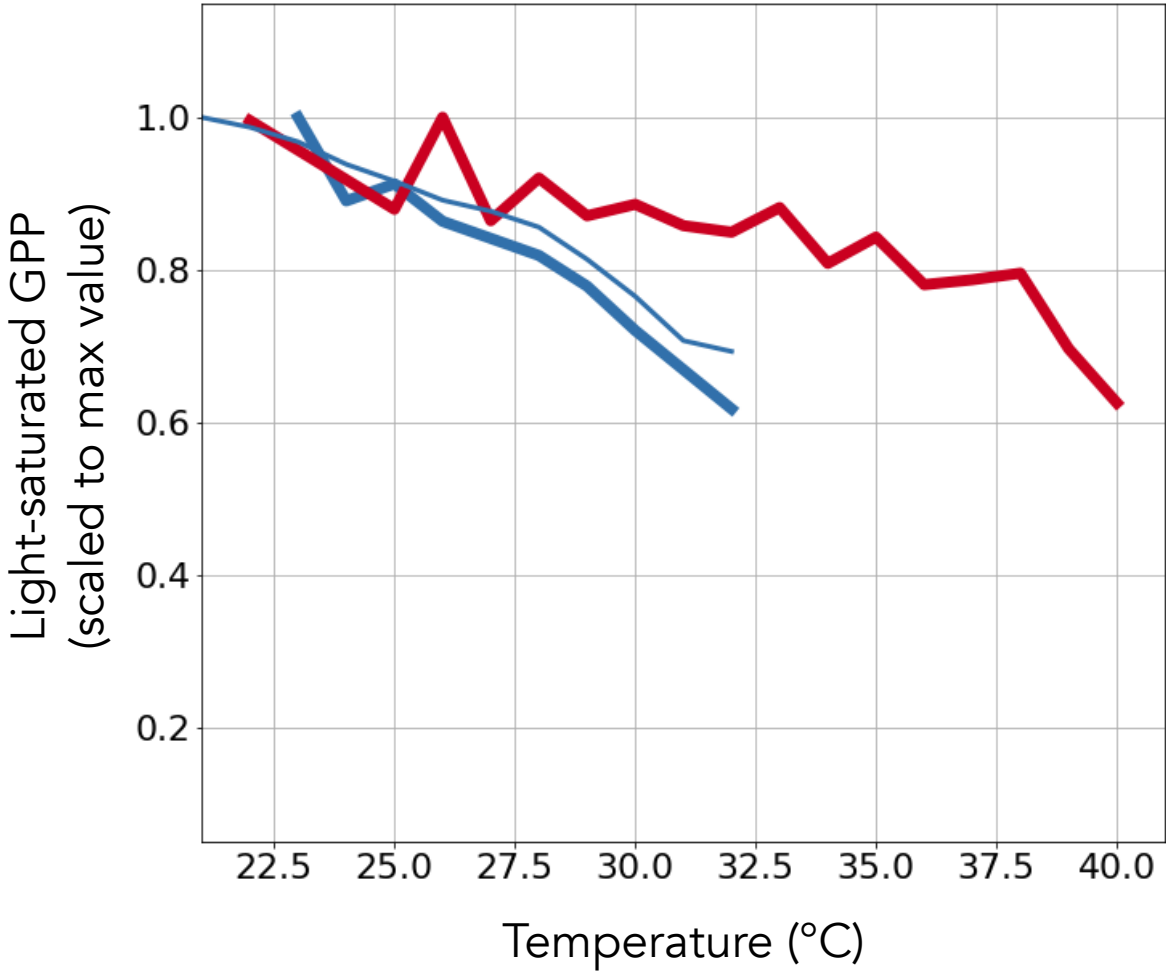


VPD

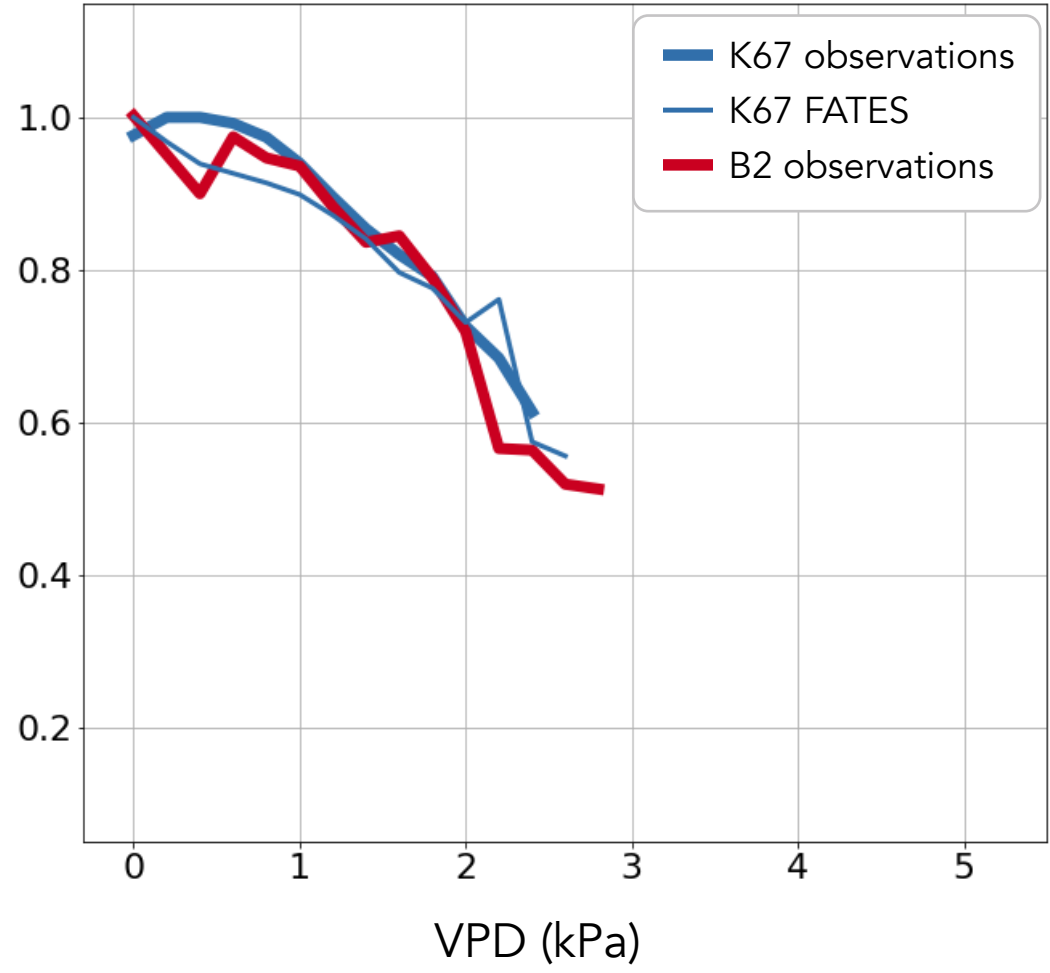


FATES matches the K67 light-saturated GPP responses to temperature and VPD relatively well

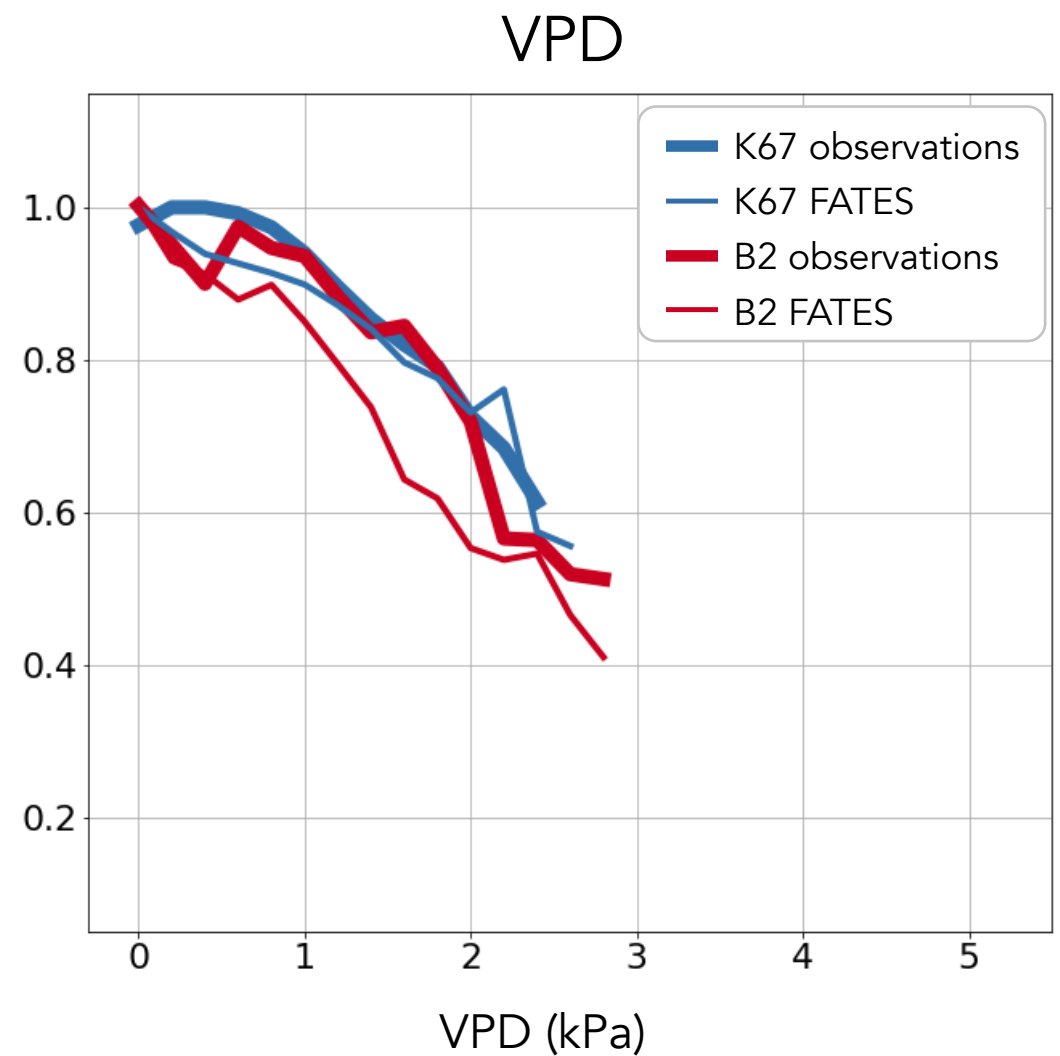
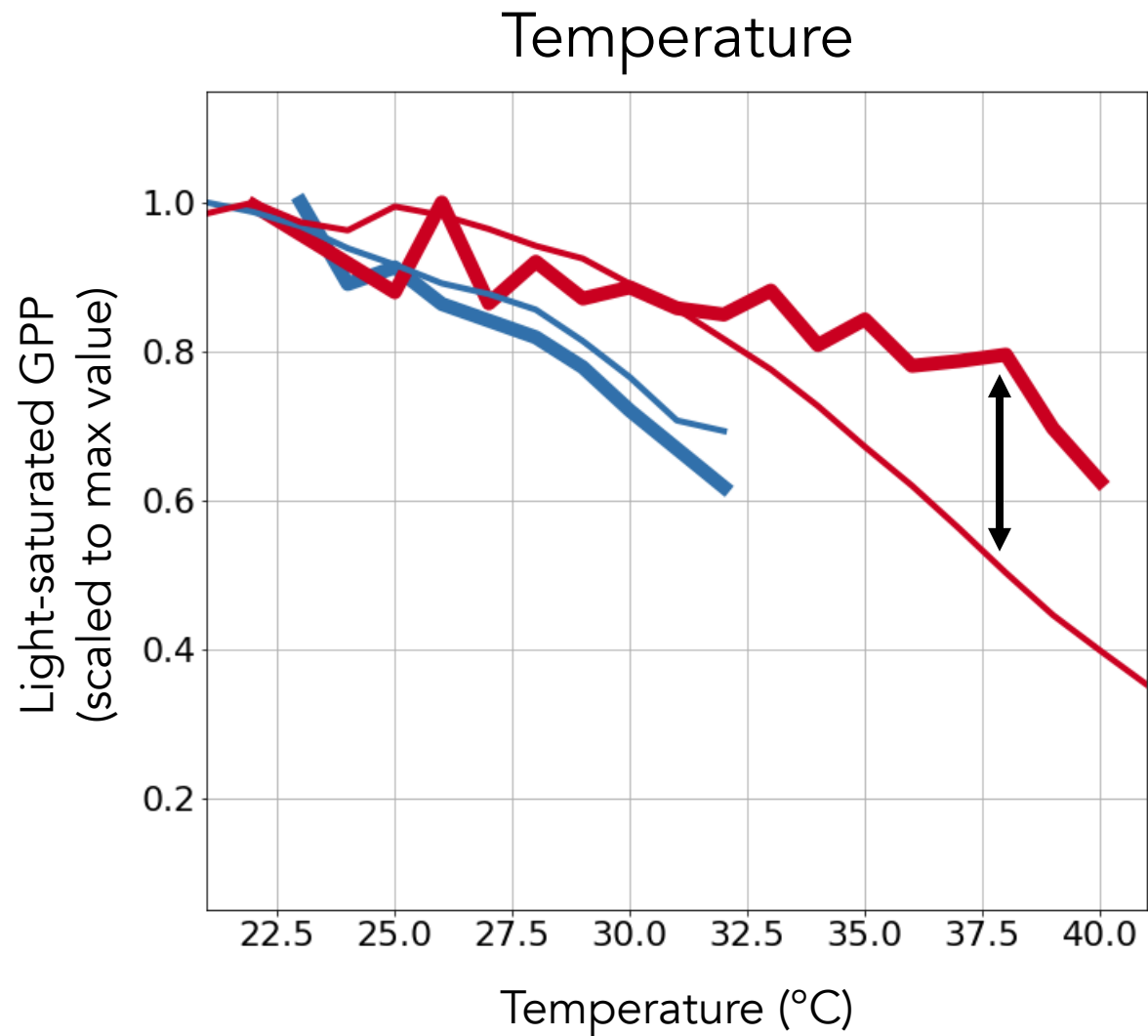
Temperature



VPD

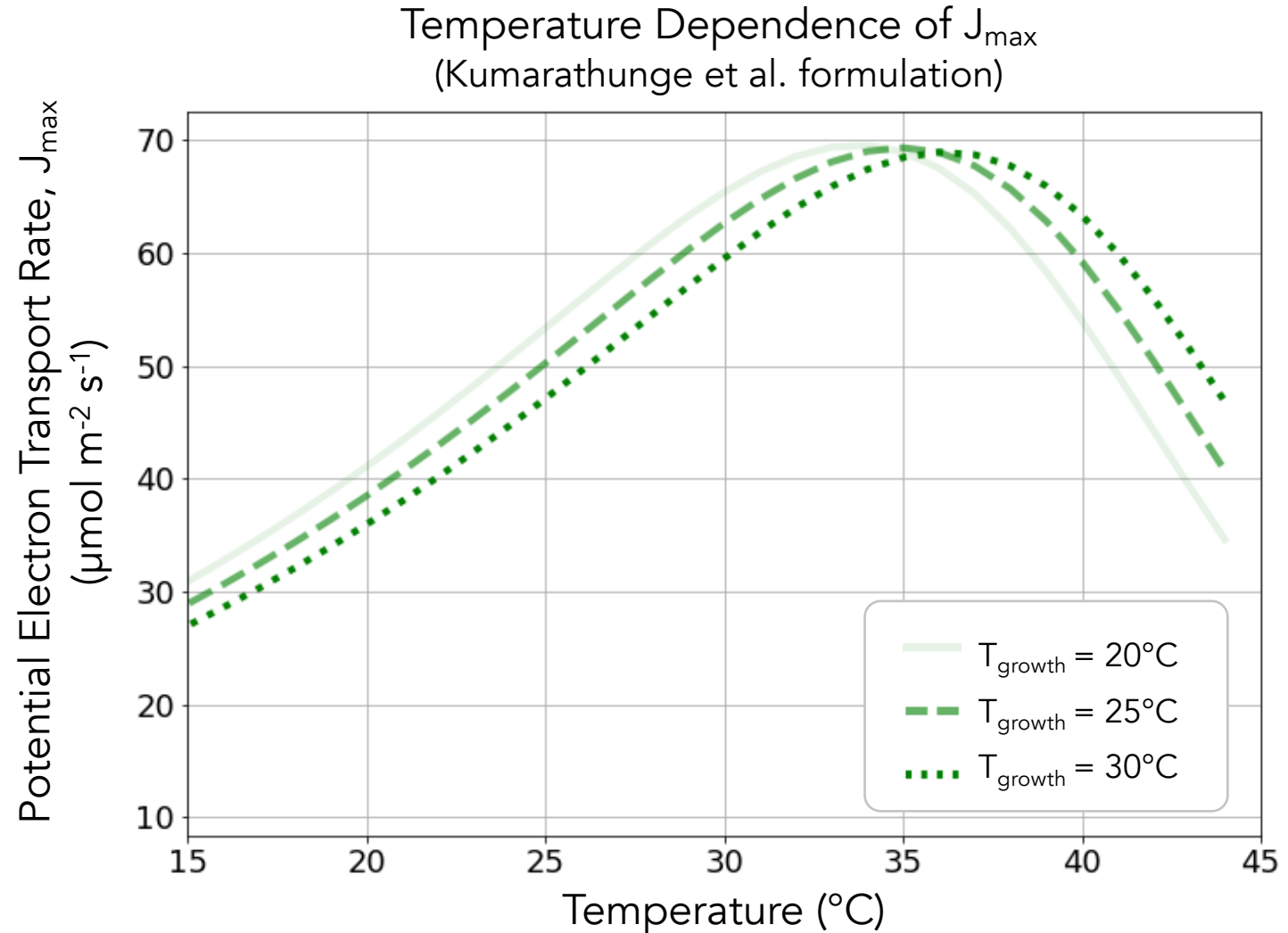


FATES GPP declines too much at high temperatures in Biosphere 2



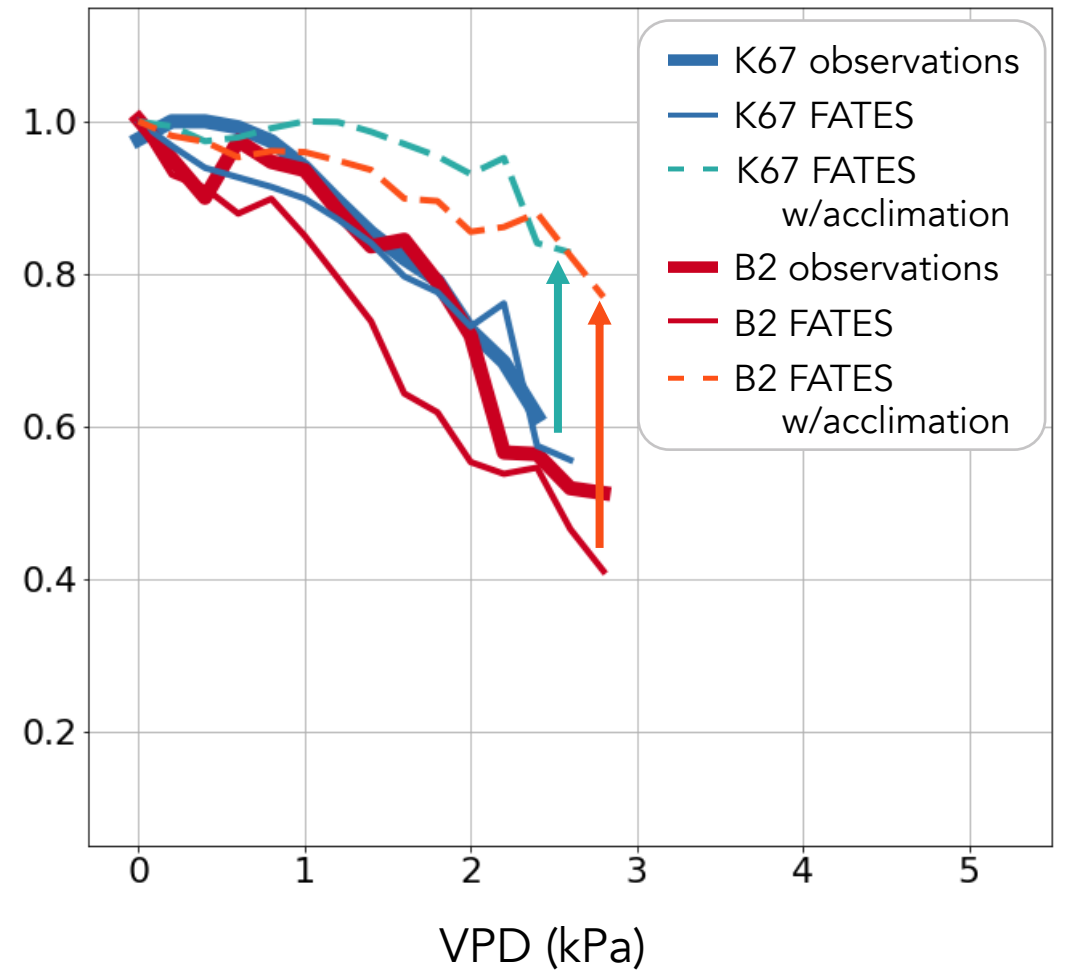
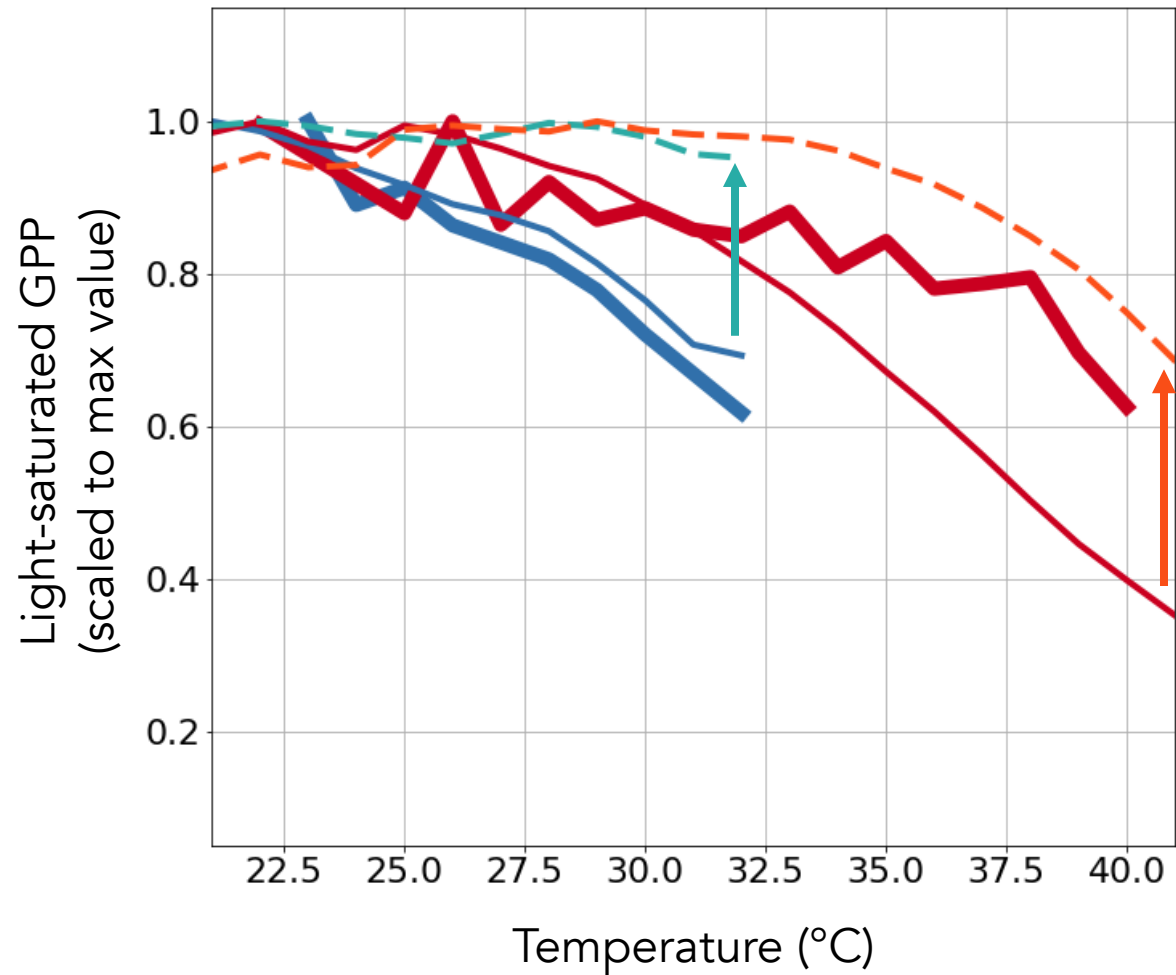
Plants can acclimate to different growth temperatures

- The temperature dependence of V_{cmax} and J_{max} (i.e. the shape of these curves) changes with growth temperature
- Added preliminary photosynthetic temperature acclimation to FATES, based on Kumarathunge et al. (2019)

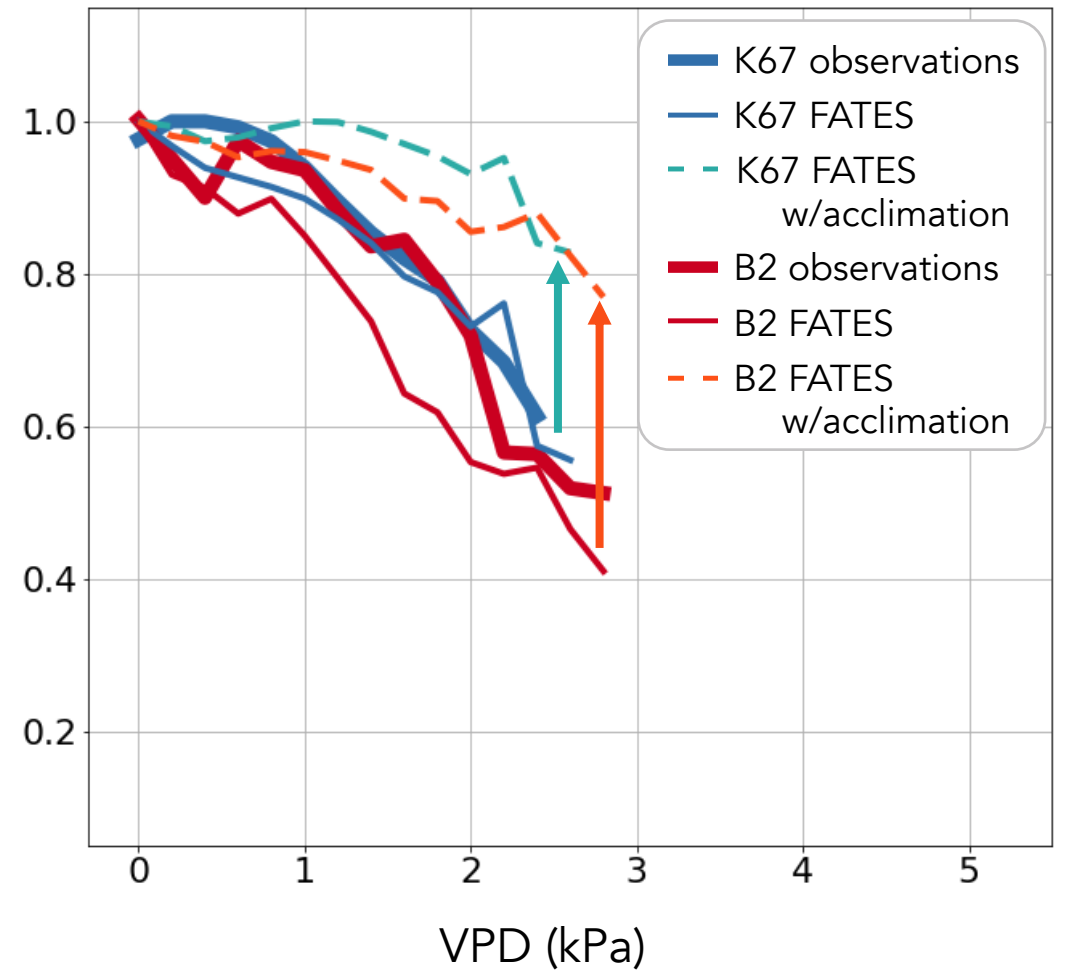
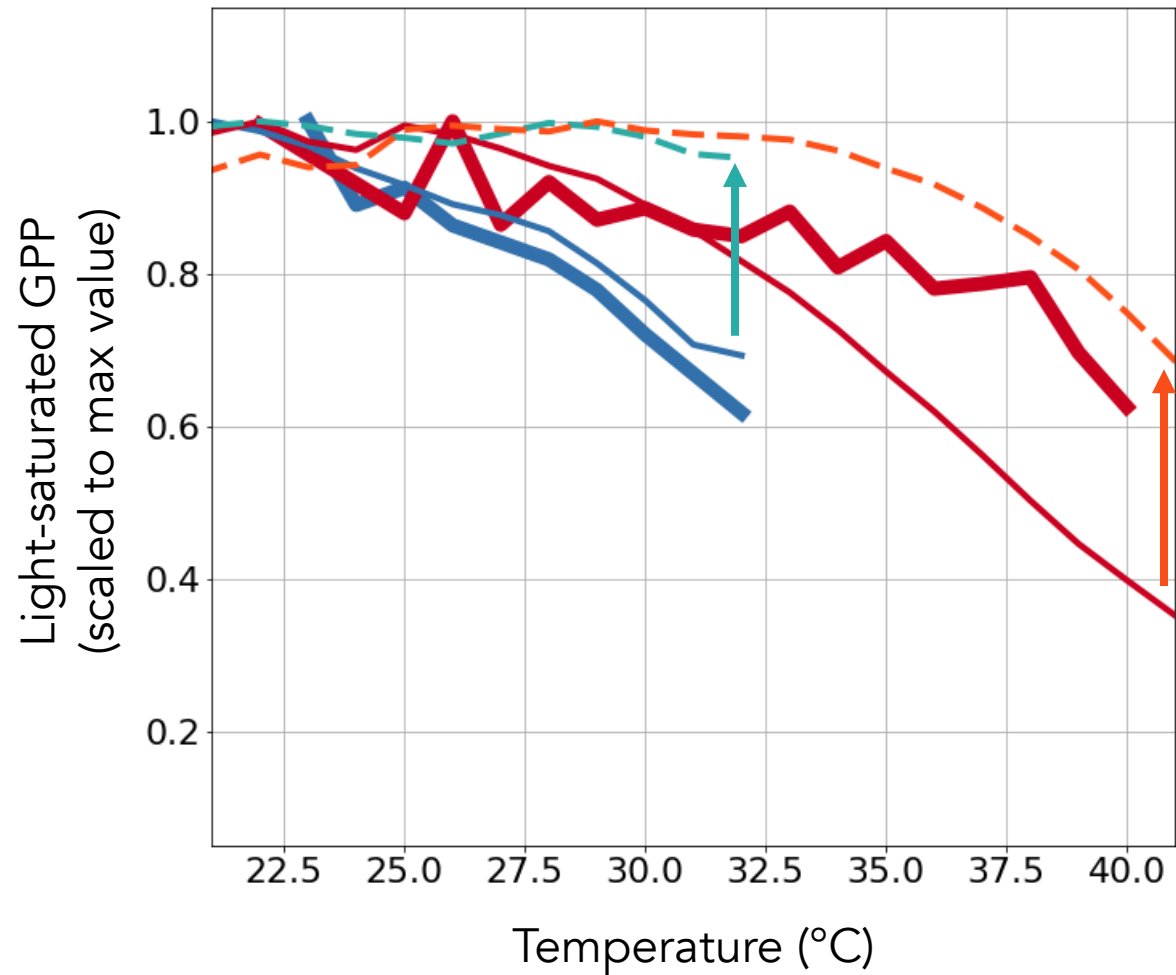


Curves based on $T_{\text{home}} = 25^{\circ}\text{C}$

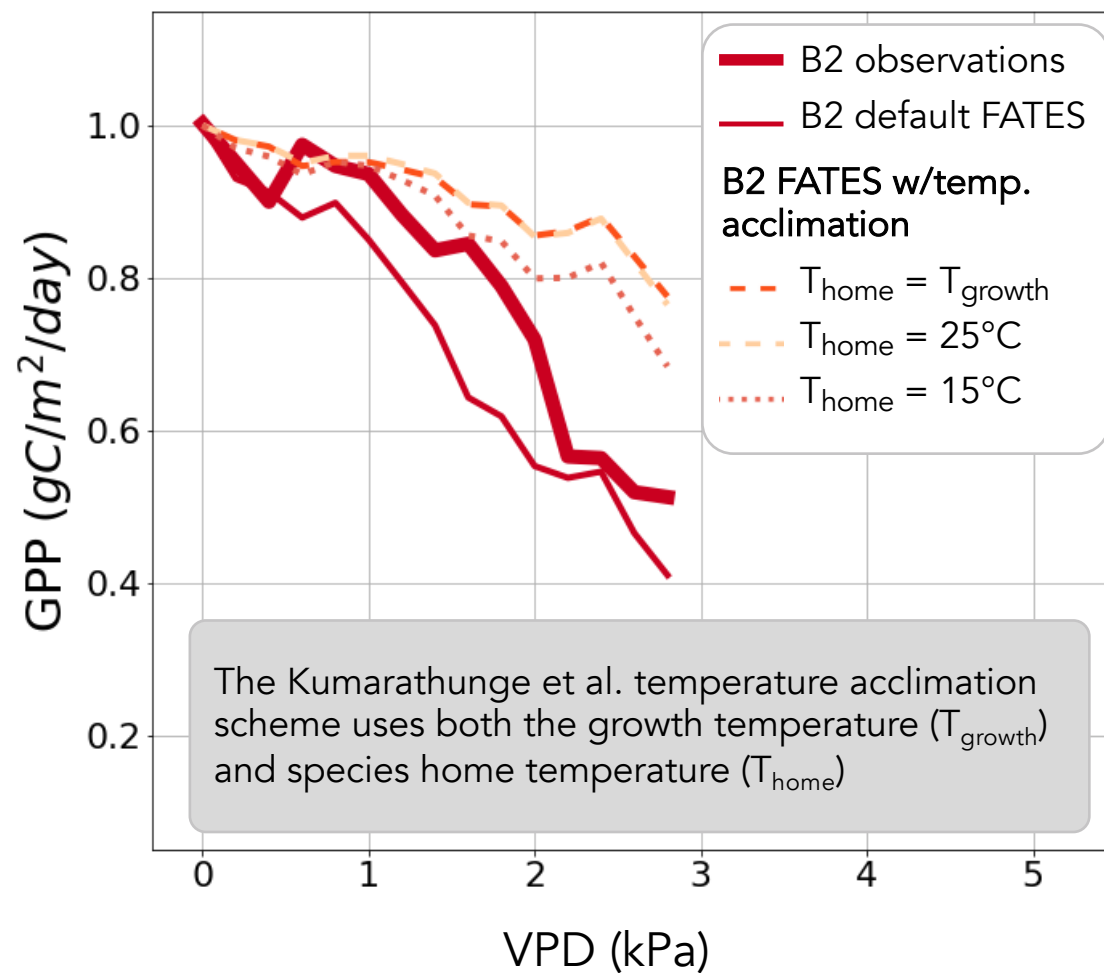
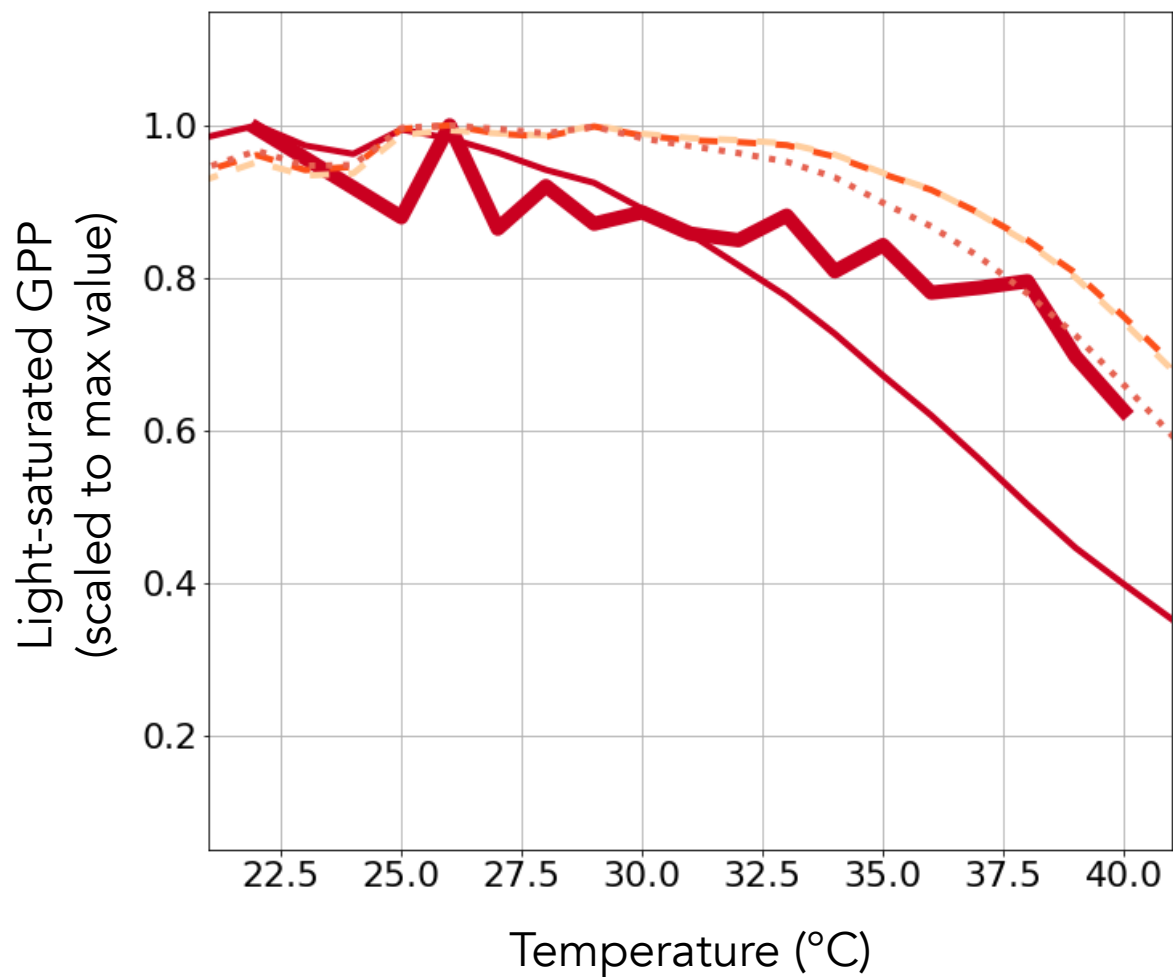
Adding temperature acclimation flattens the GPP temperature response curves



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Details of Kumarathunge et al. temperature acclimation implementation don't change temperature and VPD response curves much



Next steps

- Continue configuring B2 and K67 simulations to better represent those sites (e.g. alter plant traits)
- Turn on / off different plant processes (e.g. different stomatal models, plant hydraulics)
- Continue swapping features of B2 and K67 (e.g. meteorology, plant traits) to quantify their impact on GPP response to temperature
- Incorporate other tropical forest sites
- Run simulations under future climate change scenarios, and quantify impact of temperature vs. VPD on GPP