Seasonally varying water use strategies in *Juniperus osteosperma* associated with GPP

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Introduction

Plant species exhibit a range of water use strategies to manage the tradeoff between carbon gain and water loss. One metric of hydraulic regulation (Martínez-Vilalta et al., 2014) utilizes the slope between predawn and midday water potential (Ψ), wherein isohydry (slope < 1) suggests a conservative approach to maintain water transport capacity and anisohydry (slope ≥ 1) suggests a profligate strategy to maximize carbon gain. However, recent evidence shows that some species can alter water use strategies seasonally (Guo et al., 2020), the detection of which has previously been limited by the frequency of Ψ measurements.

Questions

1. Does the relationship between predawn and midday Ψ vary over time in *J. osteosperma*?
2. Is the degree of iso/anisohydry affected by soil and atmospheric drivers?
3. Is the degree of iso/anisohydry associated with site-level GPP?

Methods

- Seven mature *J. osteosperma* instrumented with 2 automated stem psychrometers during the 2021 growing season (Fig. 1)
- Co-located with Ameriflux site (US-CdM) in southeastern UT
- *J. osteosperma* comprises ~92% of tree basal area, other woody species include *Pinus edulis* and *Artemisia tridentata*
- Psychrometers cleaned and rotated ~monthly
- Ψ measured ~monthly with a manual pressure chamber

Figure 1: Steve installs a stem psychrometer, May 2021. Courtesy Avery Driscoll

- Daily predawn and midday Ψ related to maximum daily VPD and VWC at 10 cm in a hierarchical Bayesian model:

$$\Psi_{MD_i} = \lambda_i + \sigma_i \cdot \Psi_{PD_i}$$
$$\lambda_i, \sigma_i = \beta_1 + \beta_1 \cdot D_i^{ant} + \beta_2 \cdot W_{10_i}^{ant} + \beta_4 \cdot D_i^{ant} \cdot W_{10_i}^{ant}$$

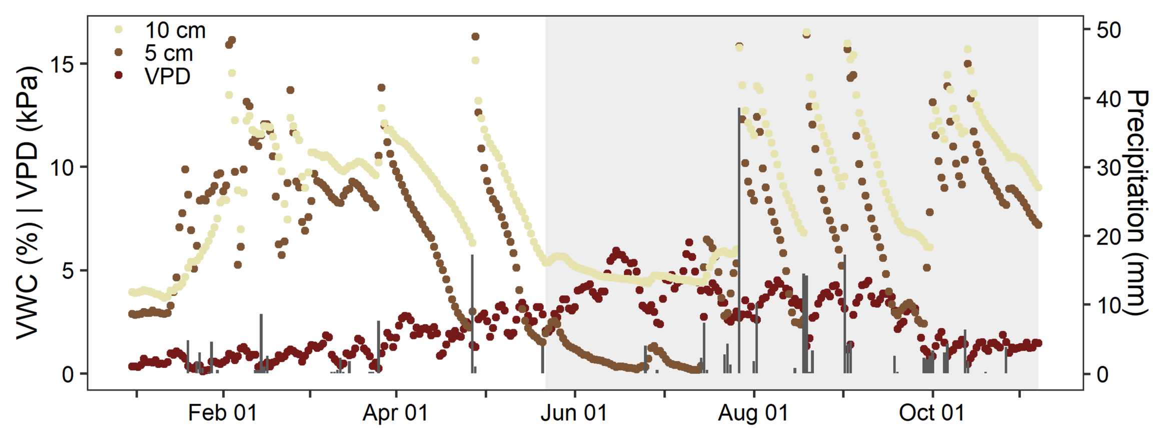

Figure 2: Site environmental characteristics in 2021. Gray box indicates period of psychrometer instrumentation

Results

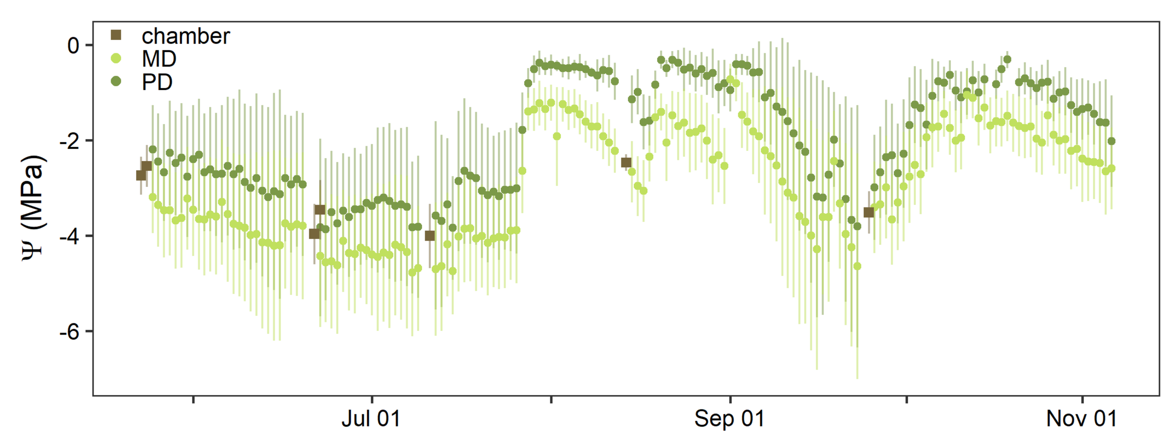

Figure 3: Automated and manual measurements of stem water potential during the 2021 growing season

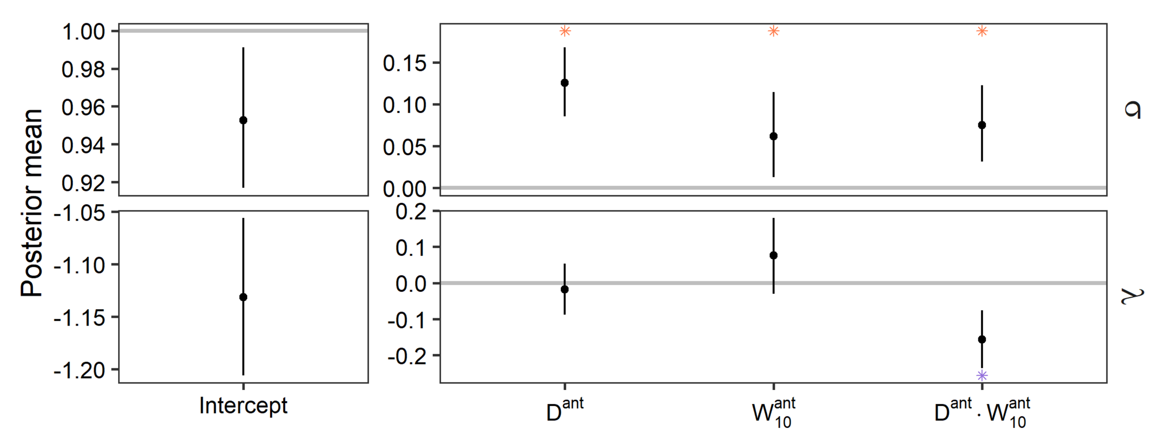

Figure 4: Posterior mean and 95% CI of covariate effect on σ and λ

- Due to strong monsoon in 2021 (Fig. 2), Ψ_{PD} remained above -2 MPa for most of August and the first half of September (Fig. 3)
- Model fit was high ($R^2 = 0.92$), with low bias
- Wet soil, dry air, and their combination are positively correlated with higher σ, or greater anisohydry (Fig. 4)
- *J. osteosperma* exhibited temporally variable hydraulic strategies, becoming extremely anisohydric following monsoon arrival (Fig. 5)
- Iso/anisohydry, as indexed by σ, was positively correlated with site-level GPP ($p < 0.001$, $R = 0.6$, Fig. 6)

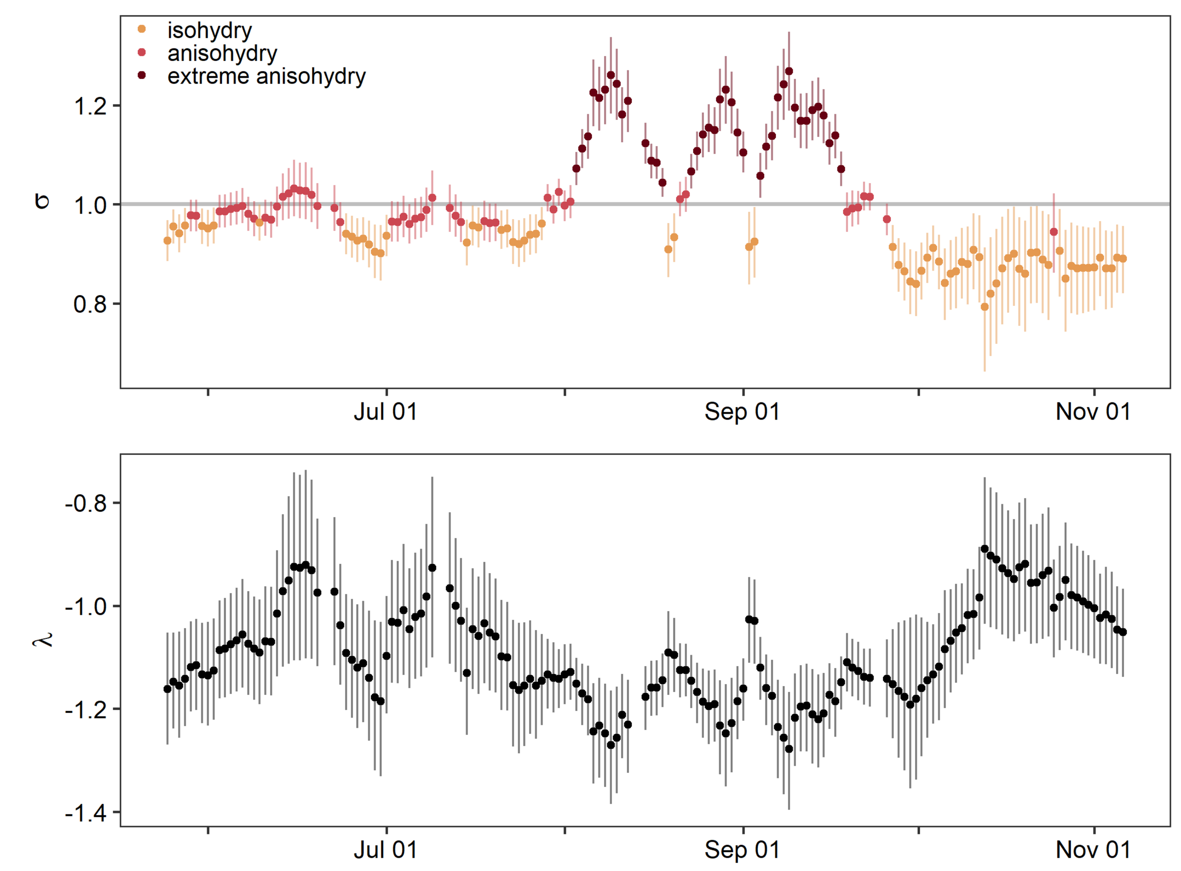

Figure 5: Predicted timeseries of σ and λ (posterior mean and 95% CI) based on fitted model

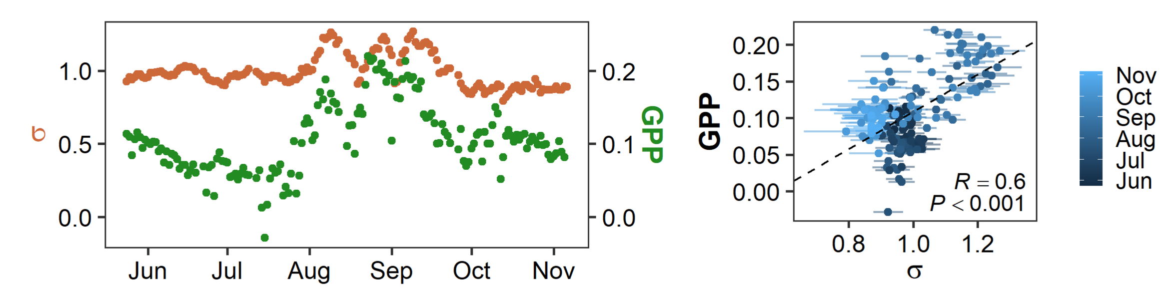

Figure 6: Overlapping timeseries of predicted σ and site-level GPP in 2021 (left) and their correlation (right)

Discussion

- Although *J. osteosperma* is considered to have an anisohydric response to drought, we found extreme anisohydry associated with monsoon onset
- Aligns with previous findings of conservative drought responses of *J. monosperma* under experimental conditions (Garcia-Forner et al., 2016)
- Classically anisohydric species (e.g., *Larrea tridentata*, *Juniperus spp.*) may be more flexible and responsive in their hydraulic strategies, not necessarily associated with high embolism
- Iso/anisohydry is well-correlated with GPP, confirming that extreme anisohydry is a strategy for maximizing carbon uptake
- Next steps include some kind of model comparison for evaluating the added value of iso/anisohydry for predicting GPP, suggestions welcome!

References

Garcia-Forner, N., Adams, H.D., Sevanto, S., Collins, A.D., Dickman, L.T., Hudson, P.J., Zeppel, M.J., Jenkins, M.W., Powers, H., Martínez-Vilalta, J., others, 2016. Plant, Cell & Environment 39, 38–49.
Guo, J.S., Hultine, K.R., Koch, G.W., Kropp, H., Ogle, K., 2020. New Phytologist 225, 713–726.
Martínez-Vilalta, J., Poyatos, R., Aguadé, D., Retana, J., Mencuccini, M., 2014. New Phytologist 204, 105–115.