

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



Jessica S. Guo¹, Steven A. Kannenberg², Mallory Barnes³, William R.L. Anderegg²



¹ Arizona Experiment Station, University of Arizona

² Department of Biological Sciences, University of Utah

³ O'Neill School of Public and Environmental Affairs, Indiana University

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 (σ) between predawn and midday water potential (Ψ), wherein isohydry ($\sigma < 1$) suggests a conservative approach to maintain water transport capacity and anisohydry ($\sigma \geq 1$) 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. Here, we monitor and evaluate the hydraulic strategy of *Juniperus osteosperma*, a drought-tolerant conifer classically described as anisohydric.

Questions

1. Does the relationship between predawn and midday Ψ vary over time in *J. osteosperma*?
2. Is the degree of iso/anisohydry driven 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 each 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 stochastic antecedent model (Ogle et al., 2015):

$$\begin{aligned}\Psi_{MD_i} &= \lambda_i + \sigma_i \cdot \Psi_{PD_i} \\ \lambda_i, \sigma_i &= \beta_1 + \beta_1 \cdot D_i^{ant} + \beta_2 \cdot W_{10i}^{ant} + \beta_4 \cdot D_i^{ant} \cdot W_{10i}^{ant}\end{aligned}$$

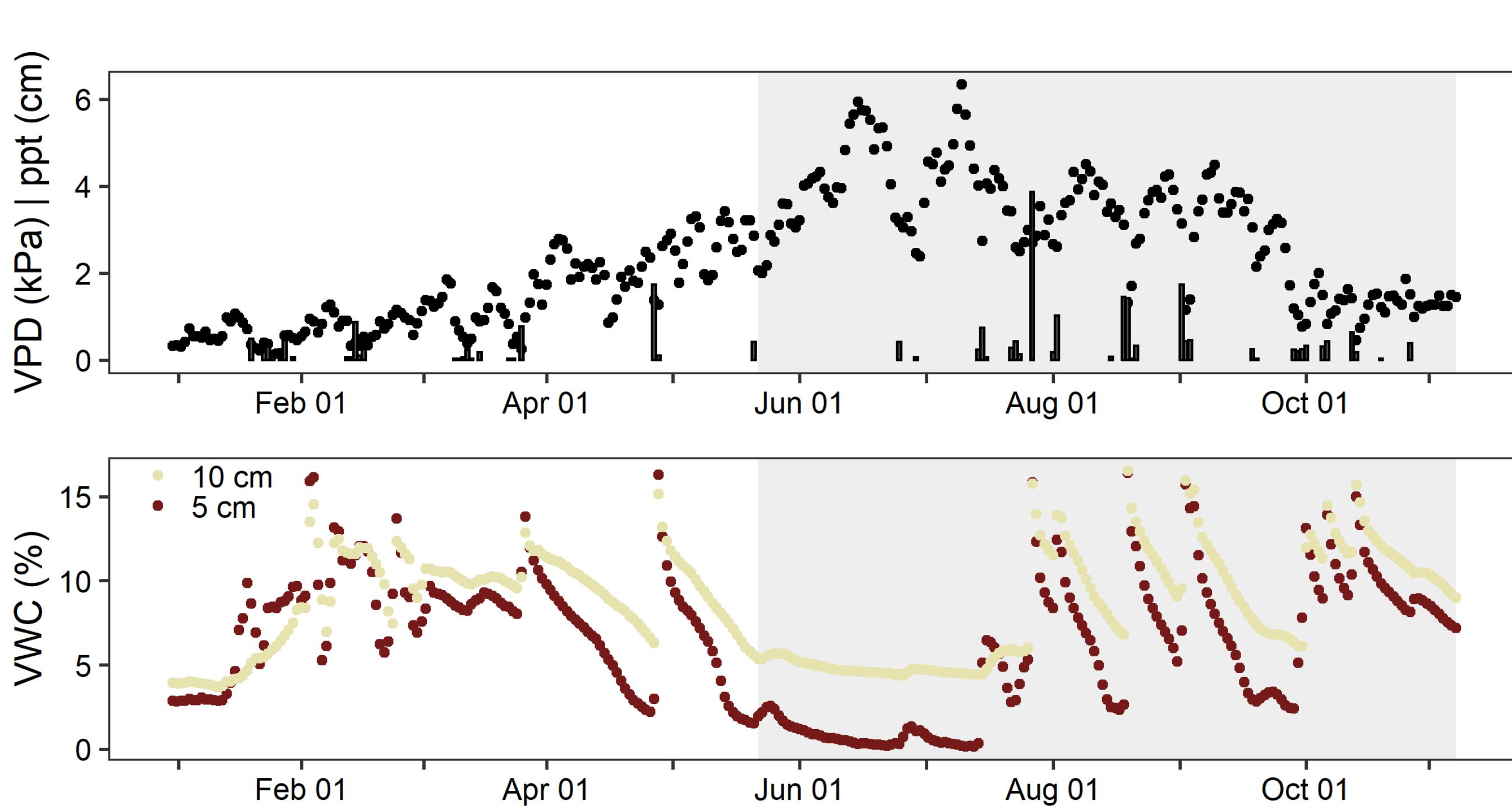


Figure 2: Site environmental characteristics in 2021. Gray box indicates period of psychrometer instrumentation

Results

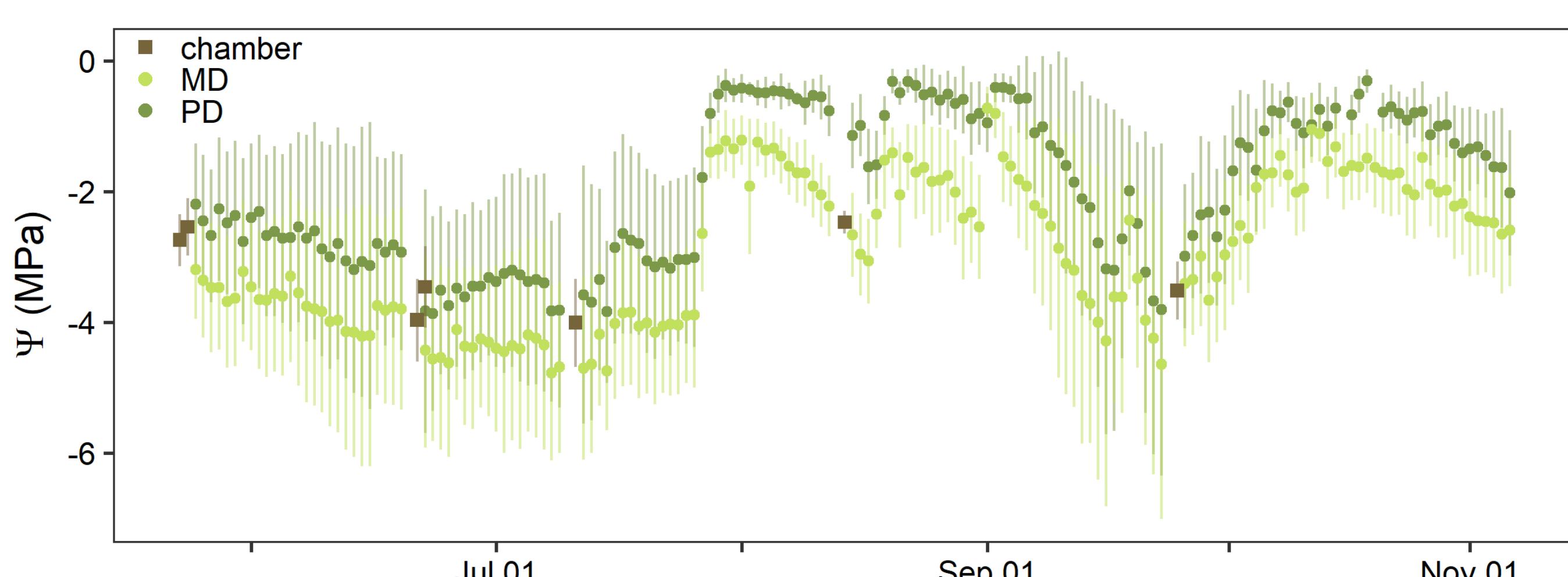


Figure 3: Automated and chamber measurements of stem water potential during the 2021 growing season

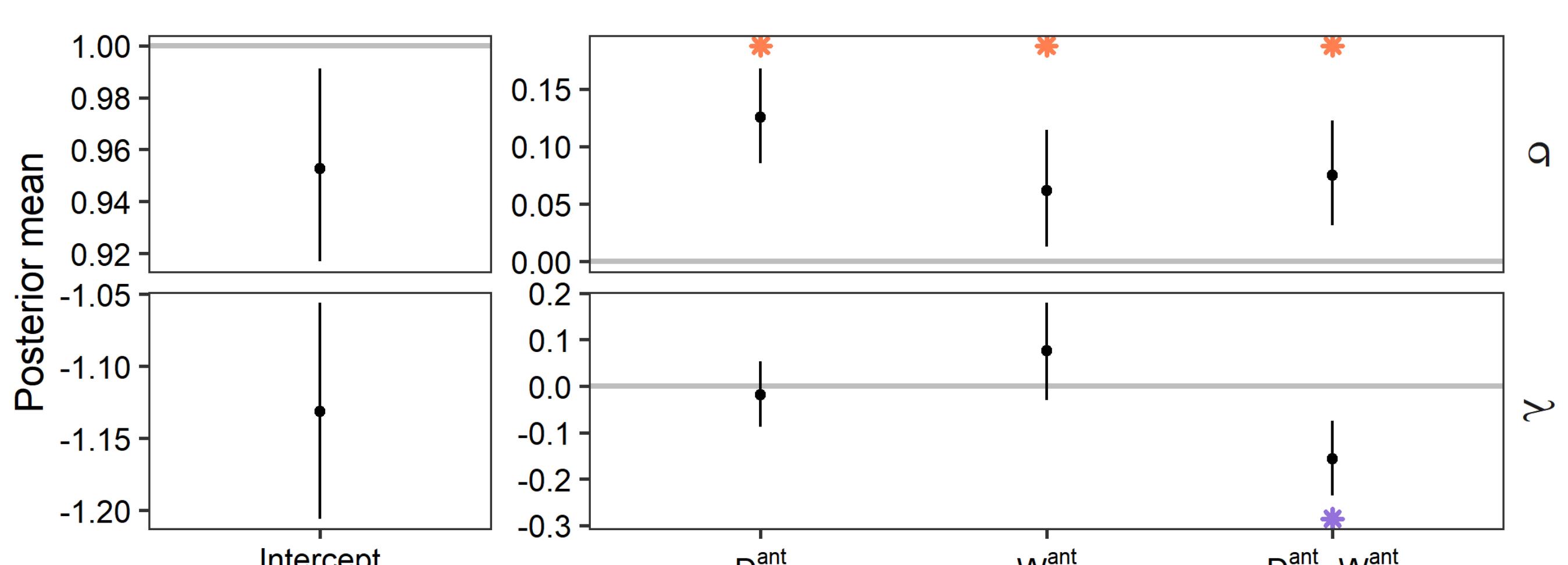


Figure 4: Posterior mean and 95% CI of the antecedent covariate effects on σ and λ

- 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 were positively correlated with higher σ , or greater anisohydry (Fig. 4)
- The combination of wet soil and dry air caused the pressure drop at $\Psi_{soil} = 0$ (λ) to decrease significantly (Fig. 4)

- *J. osteosperma* exhibited temporally variable hydraulic strategies, becoming extremely anisohydric ($\sigma > 1$) after monsoon onset (Fig. 5)
- Iso/anisohydry, as indexed by σ , was positively correlated with site-level GPP ($p < 0.001$, $r = 0.6$, Fig. 6)

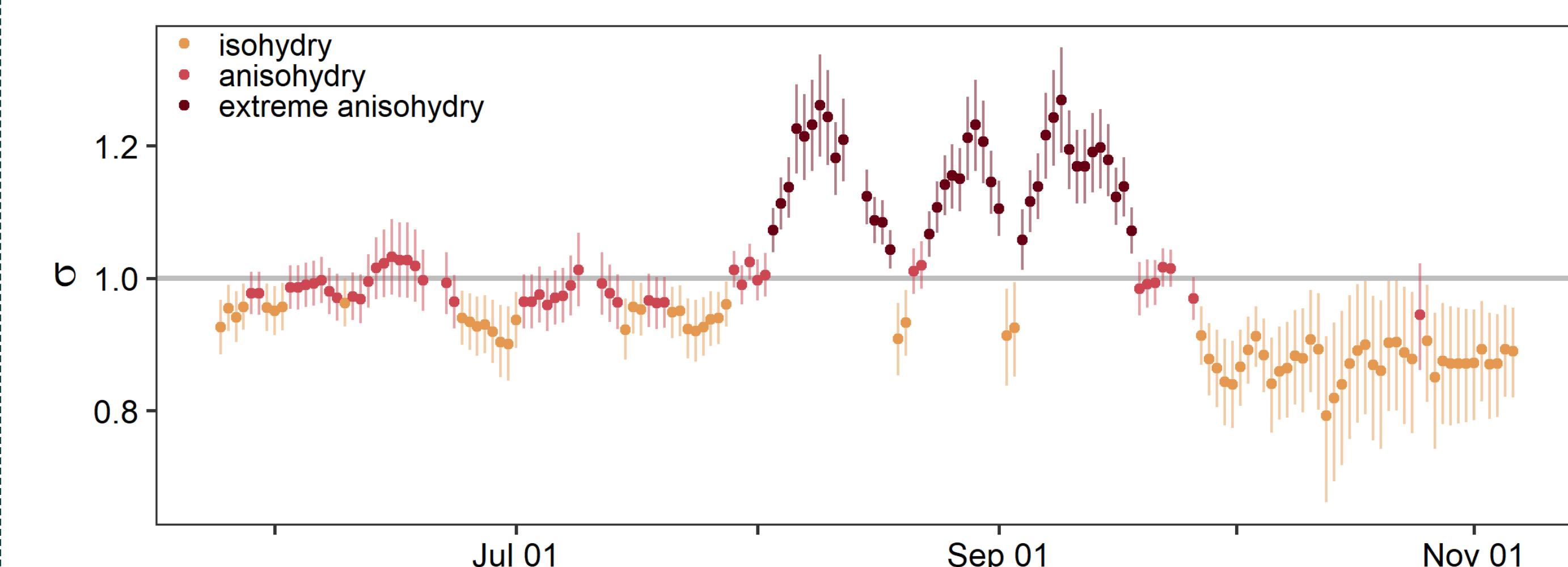


Figure 5: Predicted timeseries of σ (posterior mean and 95% CI)

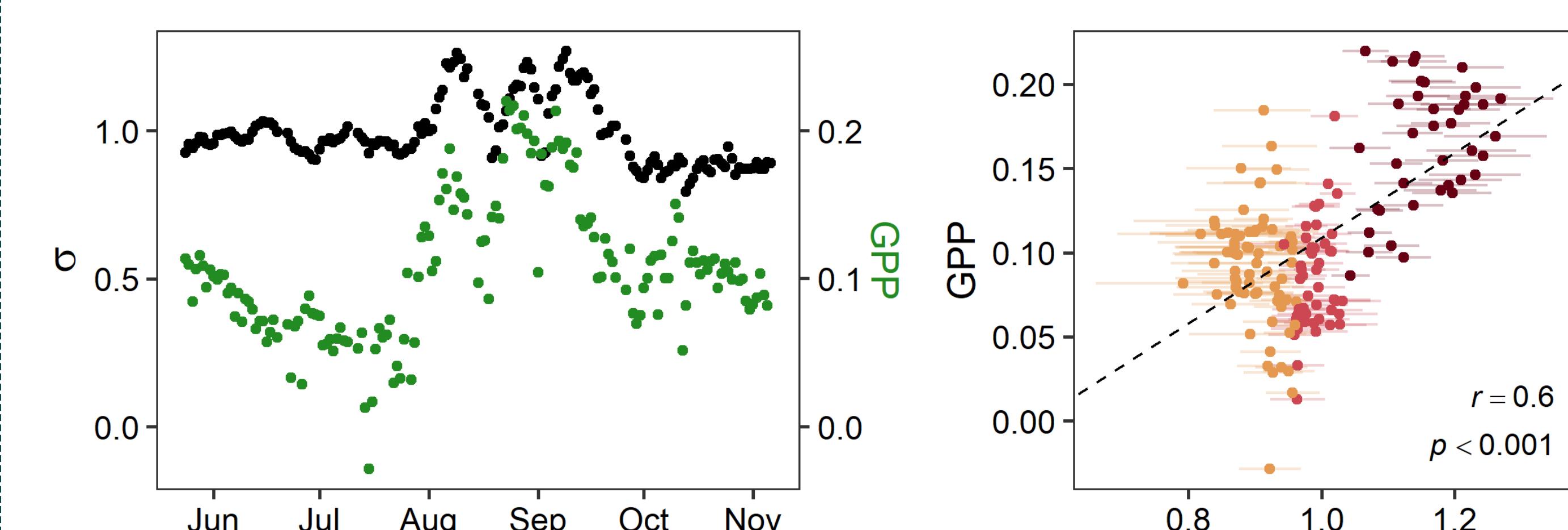


Figure 6: Overlapping timeseries of predicted σ and site-level GPP in 2021 (left) and their correlation (right)

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.
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 Ogle, K., Barber, J.J., Barron-Gafford, G.A., Bentley, L.P., Young, J.M., Huxman, T.E., Loik, M.E., Tissue, D.T., 2015. Ecology Letters 18, 221–235.