Gap-filling plant trait data for Earth System Models

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Introduction

- Land ecosystems play a vital role in carbon cycling
- Rising temperatures have contributed to an increase of CO_2 in the atmosphere which has caused an imbalance in carbon cycling
- The primary goal of Earth System Modeling (ESM) is to predict if land ecosystems will still be able to function as carbon sinks in the future
- Next generation ESMs must integrate physiological parameters with plant water-economy traits

The Problem

- Knowing what combinations of plant trait values to use in ESMs is critical
- Current trait correlations are limited and cover only a fraction of plant species

Focal Traits

- **V_{cmax25}**: determined from paired measurements of net CO2 assimilation rate and internal CO2 concentration
  - capacity of a plant for doing photosynthesis and may correlate with plant growth rate
- **K_s**: water flux rate for a giving driving force and normalized by segment length
  - How fast a plant can transport water
- **P_{50}**: Xylem water potential at 50% loss of hydraulic conductivity
  - Measure of embolism resistance and drought tolerance

Hypotheses

1. K_s should increase with V_{cmax25} because species with a higher rate of photosynthesis need a higher ability to transport water[1]
2. P_{50} should increase (less negative) with V_{cmax25} because species with higher rates of photosynthesis tend to live in more favorable, wetter environments, making them less resistant to drought[2]
3. K_s should increase with P_{50} (less negative), in other words species with a lower tolerance to embolism we expect to trade off with a higher water transport rate[3]

Methods

- Species averages were determined and joined in R from an existing trait database
- Data collected by searching for missing traits in a species list where one or two traits were present
- Web of Science and Google Scholar used
- Traits were searched for by typing species name in quotes, the trait name and key words
- Ex. "*Abies alba*" AND (vmax OR vcmax OR jmax OR carboxylation)

Results

Searches for 370 out of 1061 species completed

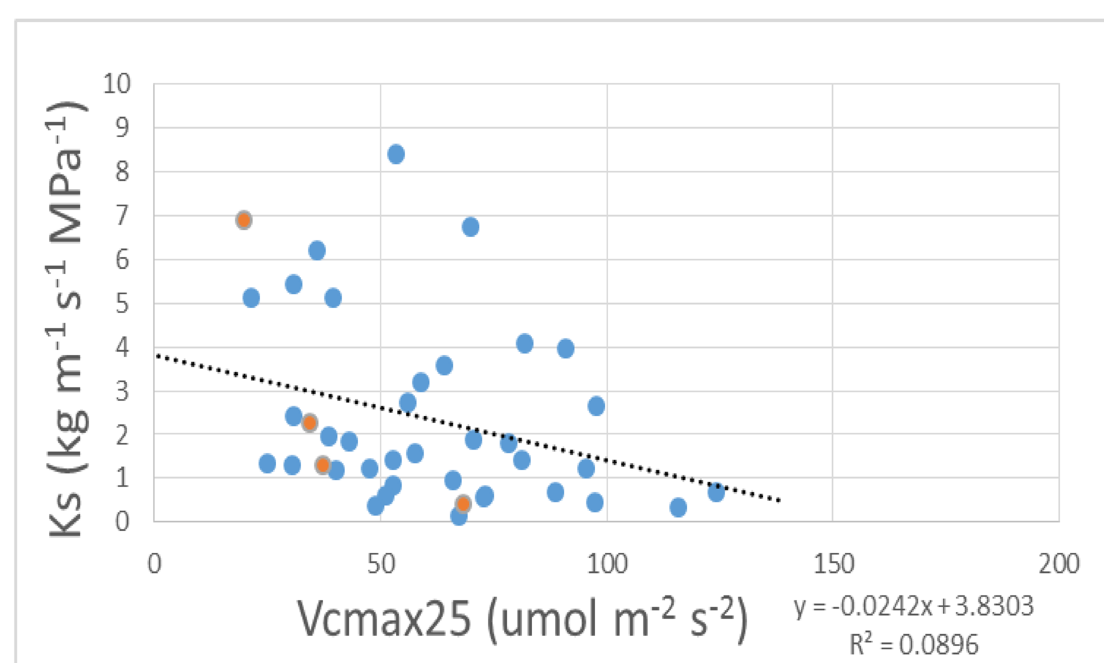

Figure 1.

Relation between species-average K_s and V_{cmax25}
$p = 0.076$

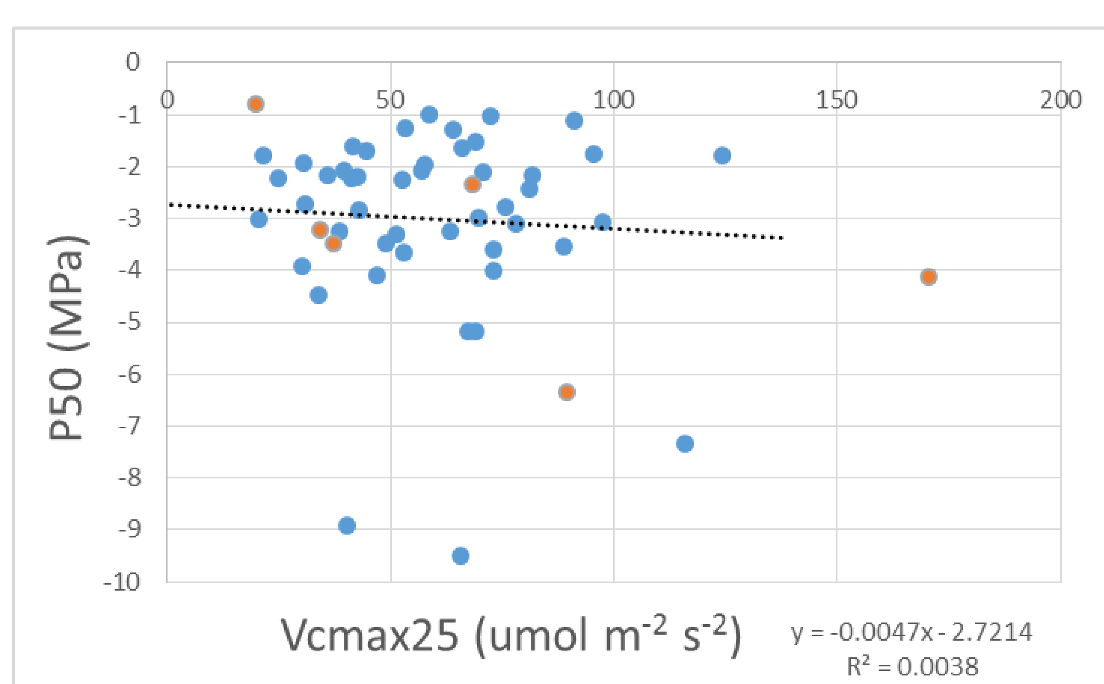

Figure 2.

Relation between species- average P_{50} and V_{cmax25}
$p = 0.681$

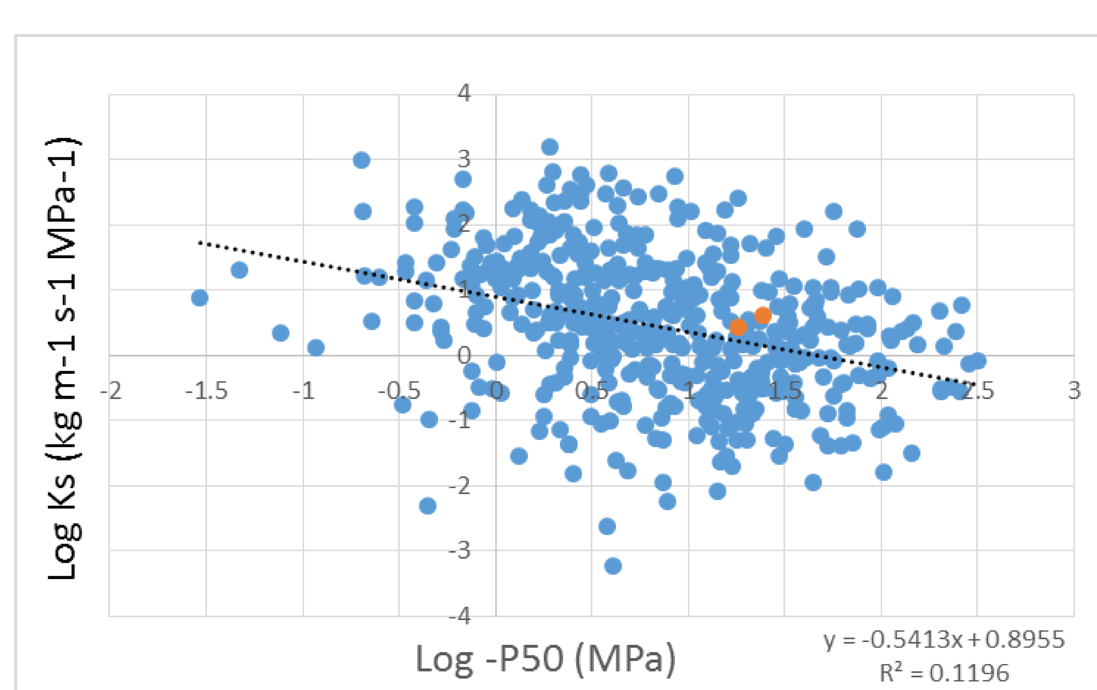

Figure 3.

Relation between species- average K_s and P_{50}
$p < 0.0001$

Main Findings

- **There may be a correlation** (opposite of our H1) **between K_s and V_{cmax25}** which may strengthen with more data (Fig. 1)
- There is **no significant correlation between P_{50} and V_{cmax25}** indicating no support for H2 (Fig. 2)
- There is a **significant correlation between K_s and P_{50},** which supports H3 (Fig. 3); however, the r^2 value indicates a lot of unexplained variability

Discussion

K_s and V_{cmax25}

Possible artefacts:

- Individual variability, leaf age variability, sun and shade variability

Possible explanation:

- In arid environments, there may be a high K_s and a low V_{cmax25} because areas with low frequency rainfall events may need to maintain K_s

P_{50} and V_{cmax25}

- More data are needed to clarify relationship

K_s and P_{50}

- This relation is expected because both traits are related to the water-economy of the plant

Future Directions

- More data are needed to further detect relations between plant traits
  - More data are available in graphs and need extracting
- Sampling should target sub-species scale to resolve intraspecific and individual variation
- Future research should prioritize measuring species that are lacking one or more traits

References

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2. Grime JP. (1979). Plant Strategies and Vegetation Processes. John Wiley & Sons
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