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Global Patterns in Plant Phenolics Revealed with Spaceborne Imaging Spectroscopy

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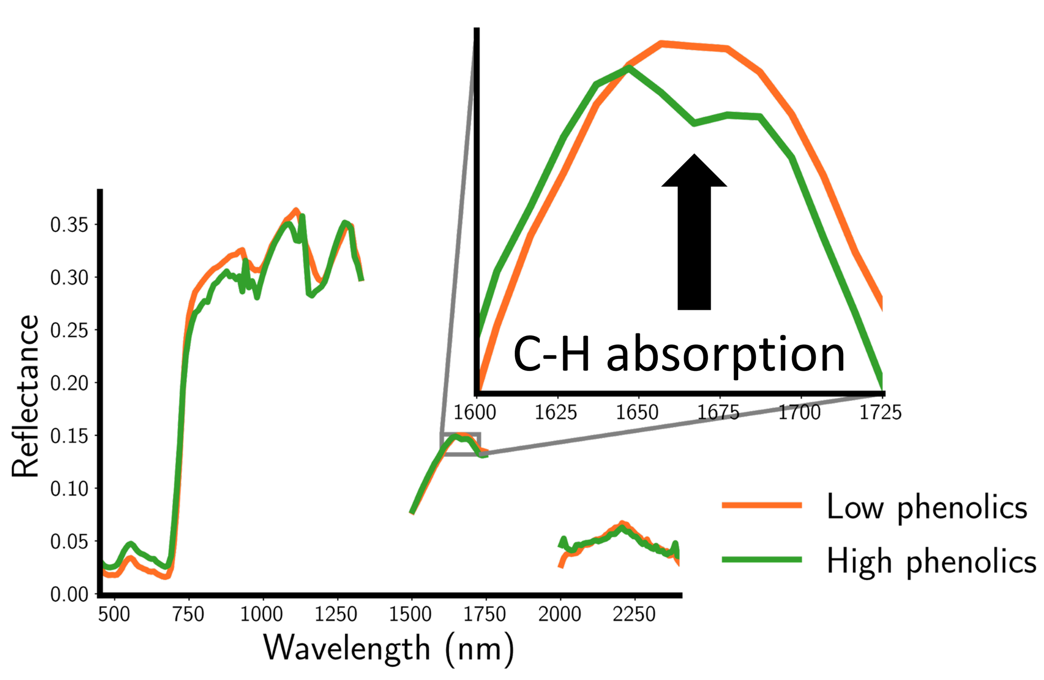
Introduction

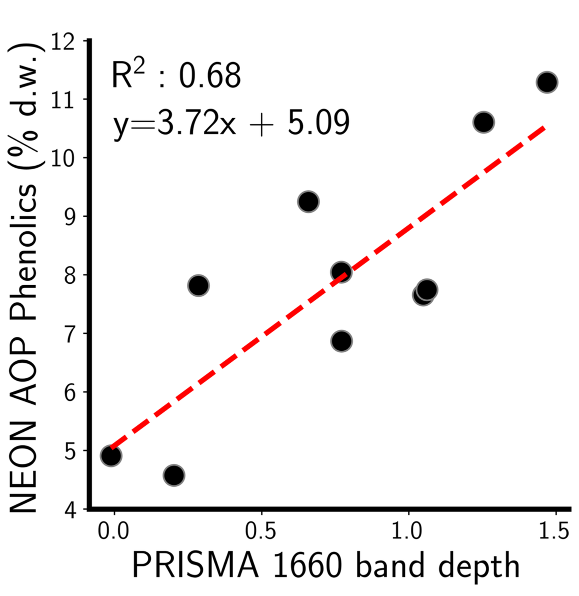
- Phenolics are ecologically important plant metabolites that defend against herbivory, protect against UV radiation and regulate decomposition of litter and sequestration of carbon.
- Despite their importance, much is still unknown about how phenolics vary globally. Comprehensive measurements through space and time will be critical for understanding the drivers of plant phenolics as well as the responses to and consequences of changing environmental conditions.
- Phenolic compounds exhibit an absorption feature near 1660 nm resulting from carbon-hydrogen bonds (C-H). We used PRISMA imaging spectroscopy data to measure the depth of this absorption feature and map concentrations of vegetation phenolics across a globally distributed set of scenes.

Methods

First, we used a per-pixel band depth calculation centered at 1660 nm to quantify the magnitude of the phenolic C-H absorption feature.



PRISMA vegetation reflectance spectra



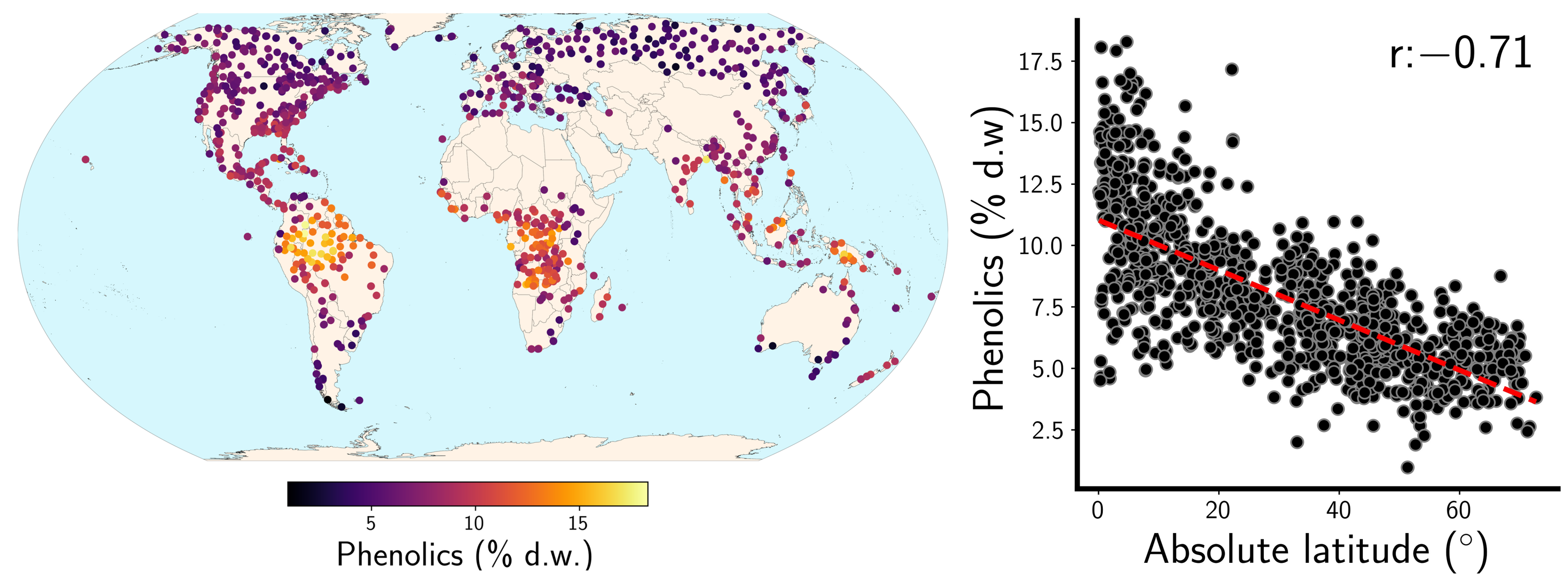
Next, band depths were converted to physical units, % dry weight, by regressing band depth maps against coincident maps of phenolics derived from the NEON Airborne Observatory Platform (AOP).

Finally, we investigated how scene average phenolics varied across biomes and with climate, soil and topographic variables.

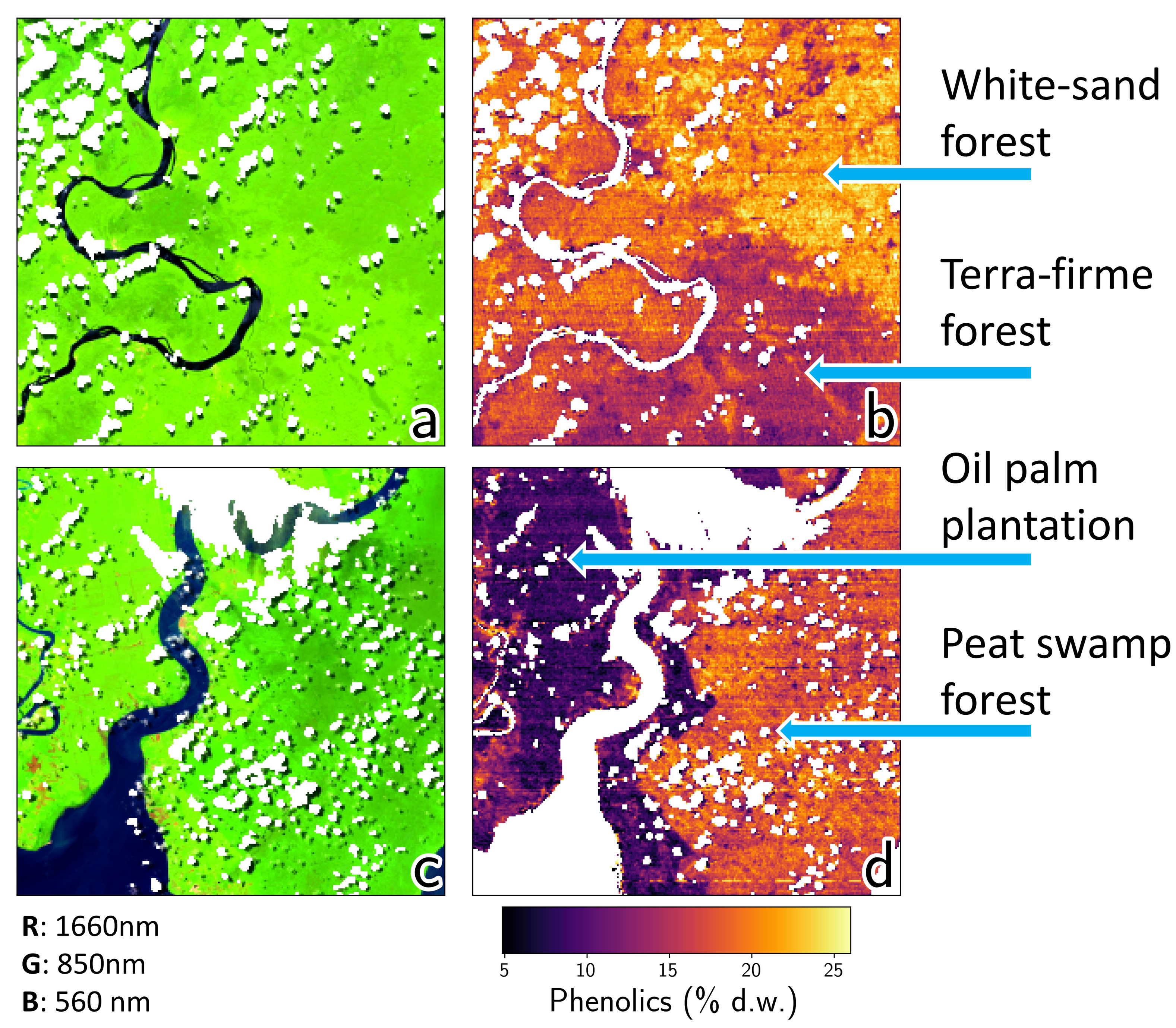
Conclusion

- Using spaceborne imaging spectroscopy we demonstrate the ability to leverage a narrowband molecular absorption feature for mapping plant phenolics across the globe.
- We found strong latitudinal and climatic gradients in plant phenolics.
- Sites with low fertility, like white-sand and peat swamp forests, had high levels of phenolics, potentially reflecting greater investment in defense due to high costs of growth.
- Current and future spaceborne missions, like EMIT and SBG, will provide the opportunity for continued measurements and provide a better understanding of the spatiotemporal dynamics of plant phenolics and their impacts on ecological processes.

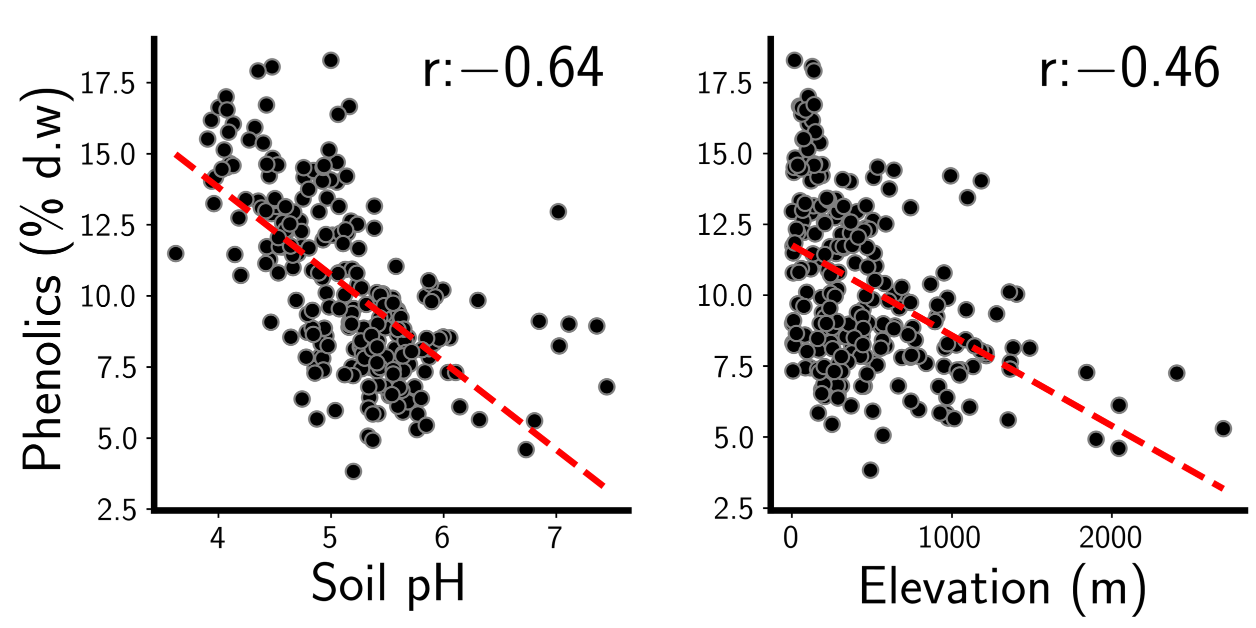
Results



Phenolics decreased with increasing distance from the equator and were significantly correlated (p < .01) with absolute latitude (r: -.71), mean annual temperature (r: .68) and mean annual precipitation (r: .61).



Concentrations of phenolics were highest in the white-sand forests of the Amazon (a, b) and peat swamp forests of Borneo (c, d).
a, c) False color RGB; b, d) Phenolics map.



In tropical forests, phenolics were negatively correlated with soil pH (r: -.64) and elevation (r: -.46). Phenolics were generally weakly correlated or uncorrelated with environmental variables in other biomes.

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