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Evaluating crop-specific responses to salinity and drought stress from remote sensing

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❖ Introduction

- ❖ Food security is threatened by co-occurring stresses (e.g. salinity and drought) under global climate change.
- ❖ Traditionally, the tolerance of crops is evaluated in highly controlled small-scale experiments involving only a limited number of crop types.
- ❖ To increase our understanding in actual agricultural tolerances, plant functioning, as observed by functional traits, need to be performed in real-life scenarios for as many crops as possible.
- ❖ Remote sensing is presently the only tool capable of monitoring such plant functional traits simultaneously over large areas.
- ❖ The aim of this research therefore is to evaluate the crop tolerances to jointly drought and salinity stress across various plant functions in real-life conditions.

❖ Methodology

- ❖ An approach that integrates multiple image-processing techniques, such as image classification, co-registration, land surface parameter retrieval, and time-series analysis was developed.

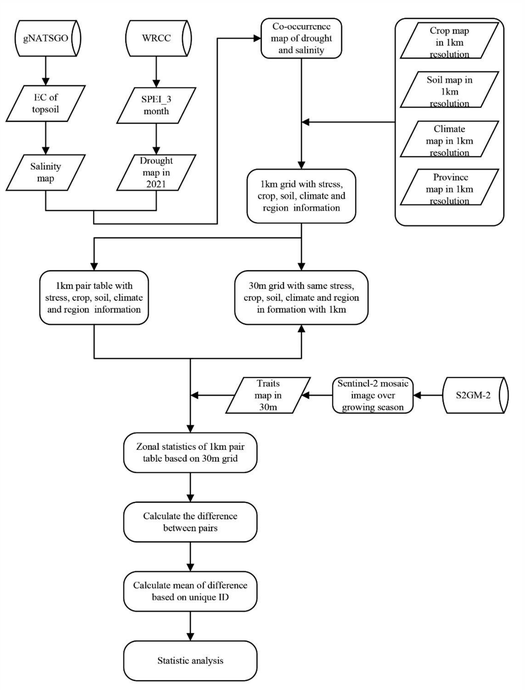

Figure 1: Technical workflow of pairwise dataset processing.

- ❖ A co-occurrence map of drought and salinity by superimposing a drought map in 2021 with a topsoil salinity map across the whole United States of America.
- ❖ A pair-wise method was adopted to estimate the difference between observations subjected to stress and un-subjected observations.

- ❖ The tolerance of eight crops to various drought and salinity stress conditions was characterized based on five retrieved traits including LAI, FAPAR, FVC, Cab, and Cw using Sentinel-2 remote sensing observations.
- ❖ The main effects of stress, month as well as three potentially confounding factors (soil, climate zone, and region) and their interaction were determined for five traits.
- ❖ The response of crops to drought and salinity stress for five traits from March to October were evaluated separately.
- ❖ The onset of stresses (drought, salinity, and their combination) on five traits was analyzed for each crop separately.

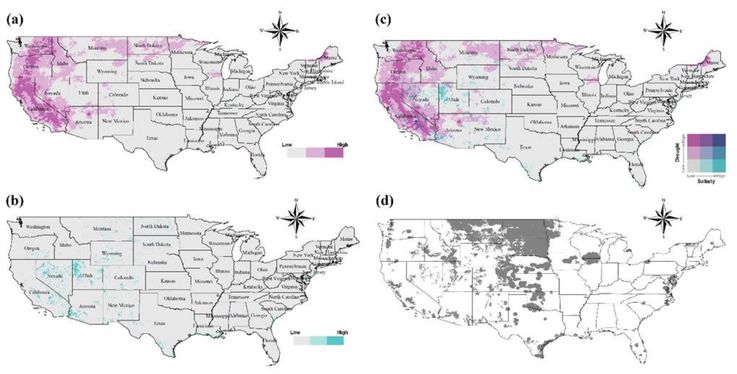

Figure 2: Drought map, salinity map, and co-occurrence map of drought and salinity in the USA in 2021.

Results and Discussion

- ❖ Stress impacts were highly dependent on the moment in the growing season.
- ❖ Crops were more sensitive to combined drought and salinity than to individual stresses, although stress impacts varied significantly between species and time

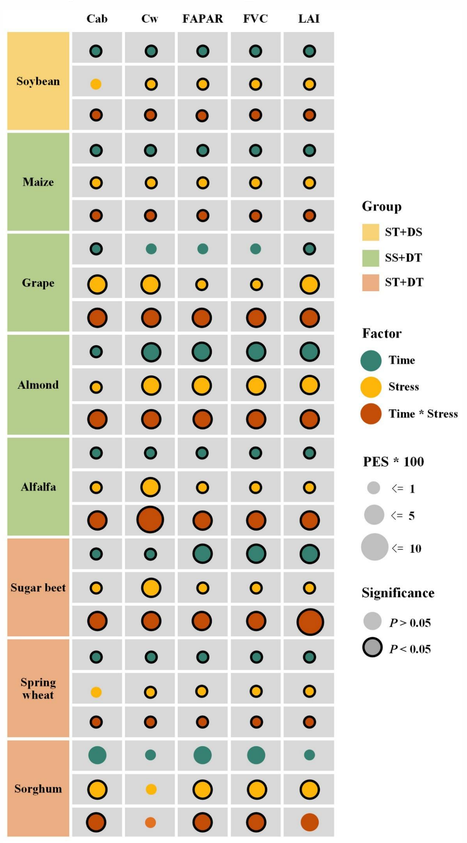

Figure 2: Results from two-way ANOVAs for different crop traits by stress, time, and their interactions

Figure 3: The pattern of LAI, expressing the severest stress conditions in different months.

- ❖ LAI was triggered first by stresses, followed by FAPAR and FVC, and Cab and Cw were the last to respond to stresses.

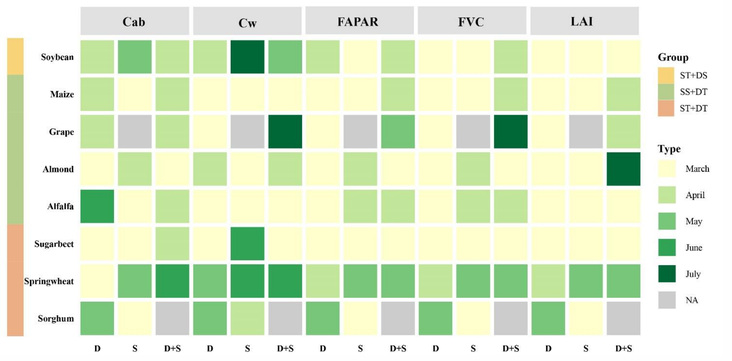

Figure 4: The onset of crop responses to stresses in the growing season.

Conclusions

In this study, we evaluated the responses of multiple crops to drought, salinity, and their combination based on five functional traits across the entire U.S. continent throughout crop growing season in 2021 from remote sensing. We found that stress impacts were highly dependent on the moment in the growing season. Moreover, different crops showed divergent responses to these stresses over time. In general, crops were more sensitive to the combined effects of drought and salinity stress compared to the individual effects of drought and salinity stress. Most crops first reduced their primary production capacity through reducing LAI before reducing water or chlorophyll contents. In combination, our study provides a way of evaluating the tolerance of diverse crops to co-occurrent stresses both individually and in combination. By allowing applications to other vegetation types and stresses, our approach creates a quantitative backbone to inform sustainable food production.

International Network of Salt-Affected Soils

Managing salt-affected soils for sustainable future