Estimating tomato LAI from daily minimum soil temperature data.

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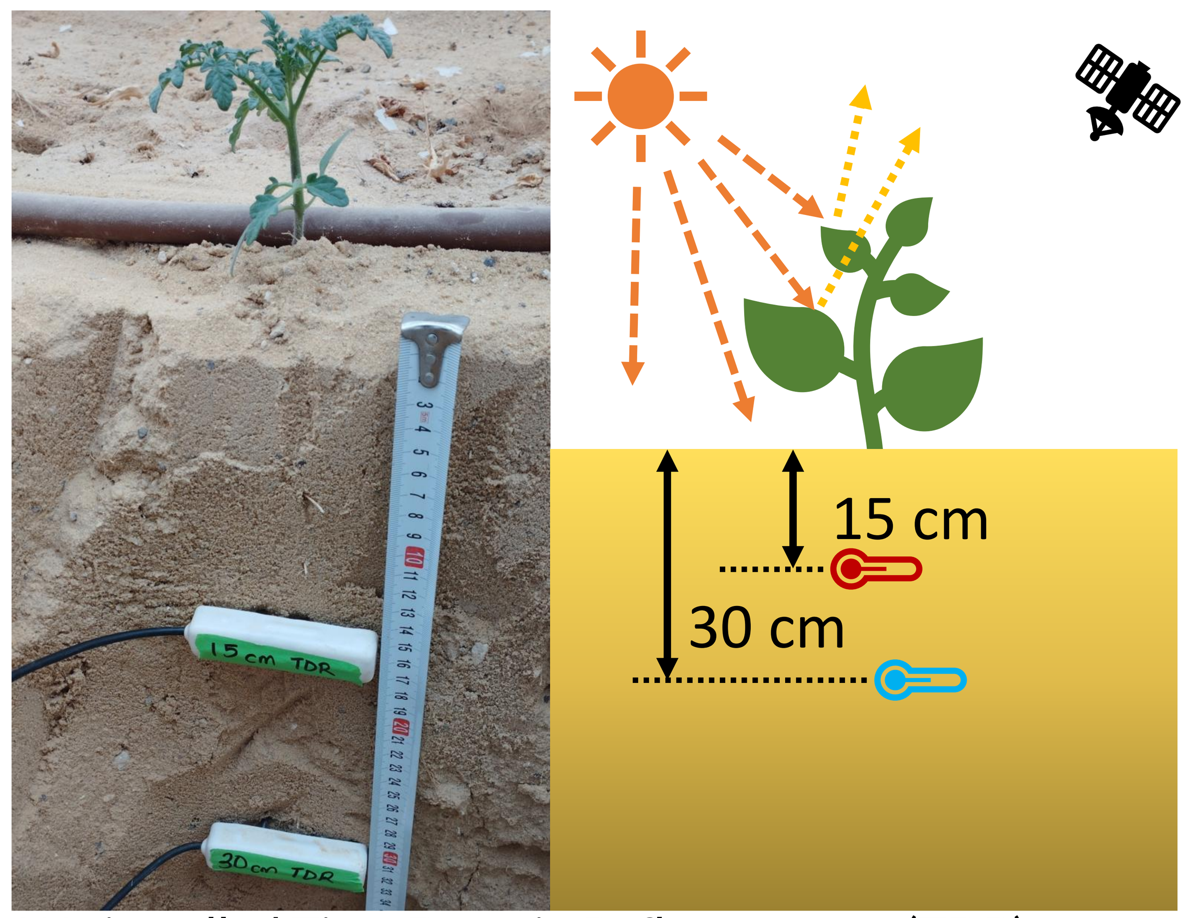
BACKGROUND:

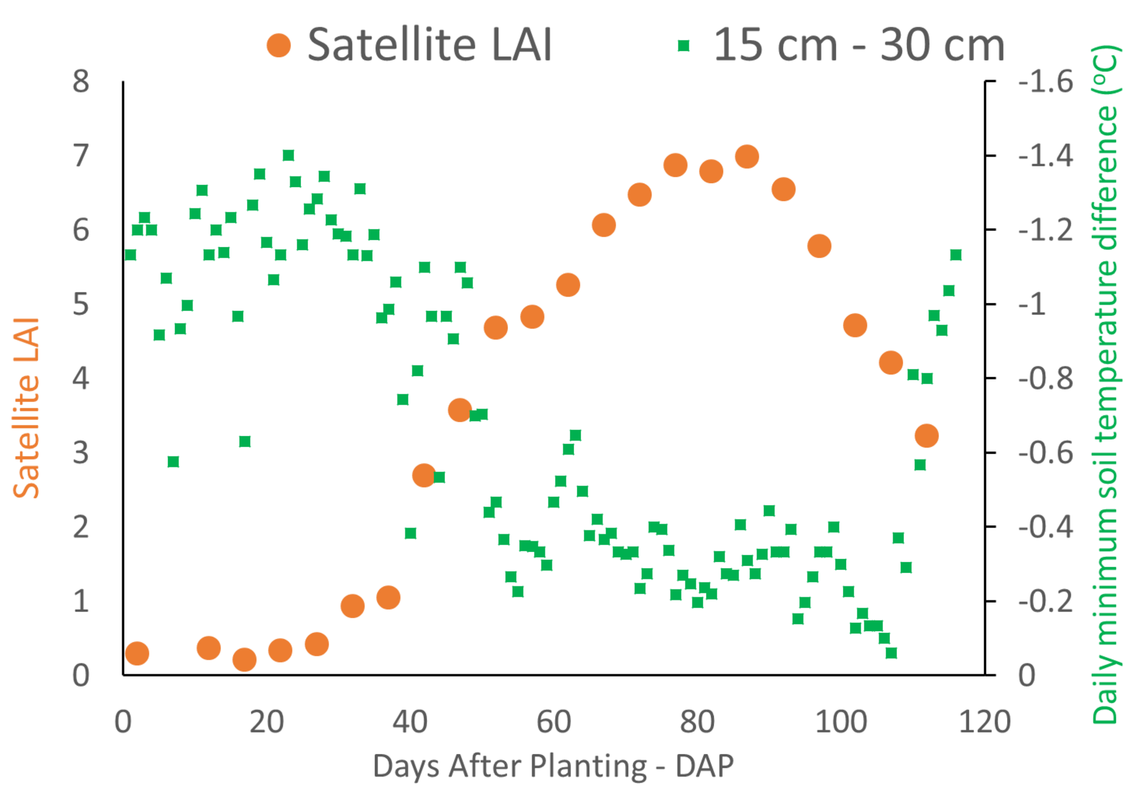
Existing LAI determination methods are often time-consuming, expensive, destructive or have low temporal resolution hence the need for new approaches.

METHODS



We installed Time Domain Reflectometry (TDR) sensors at depths of 15 and 30 cm directly beneath plants in a tomato field. The tomato plant's LAI evolution throughout the season was determined every 5 days by Kaplan et al., (2021)'s satellite-based model.

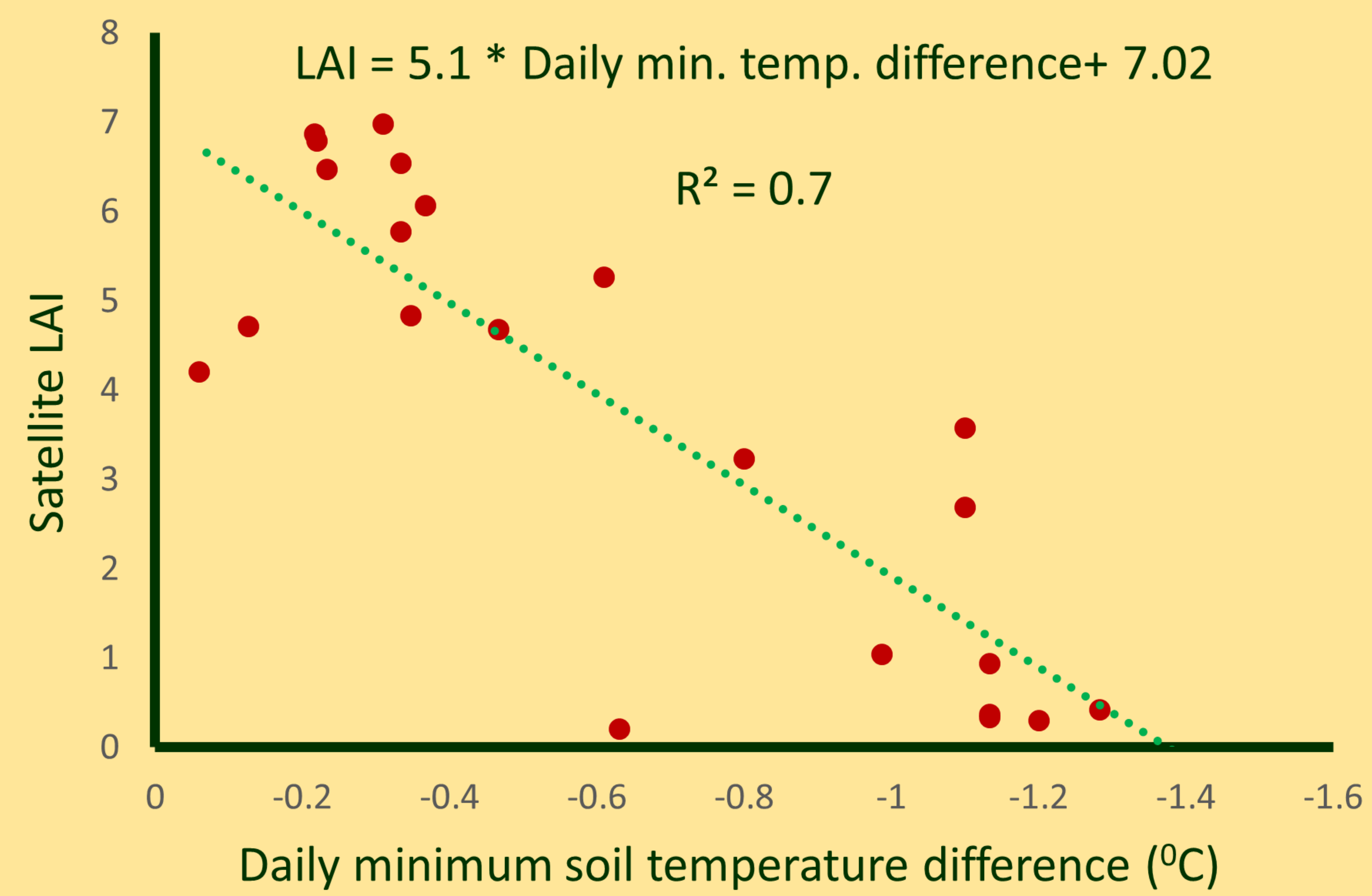
RESULTS



Daily minimum soil temperature difference (°c) = Daily minimum soil temperature at 15 cm (°c) - Daily minimum soil temperature at 30 cm (°c)

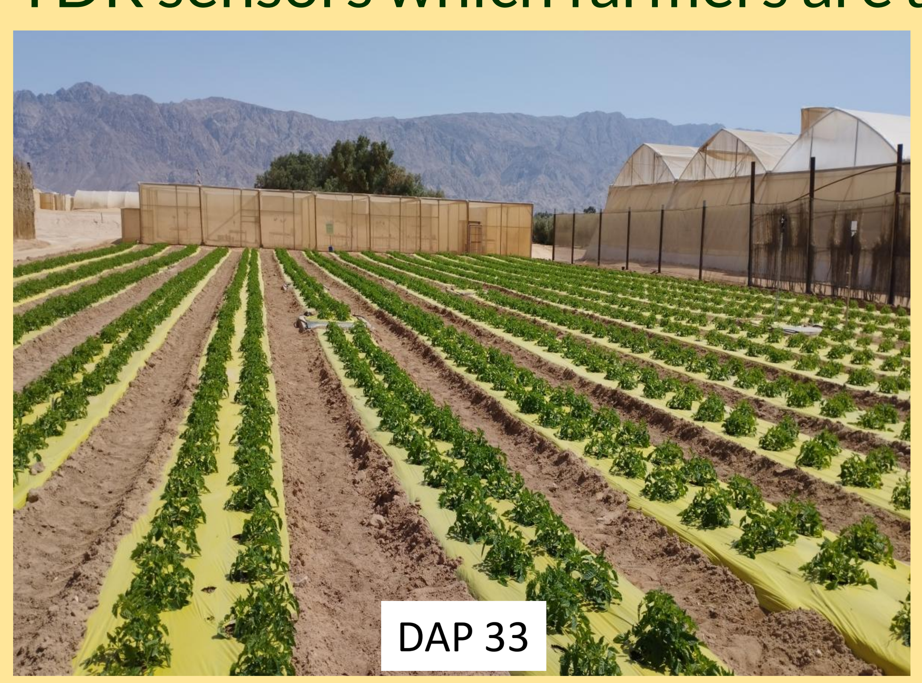
As LAI increases, the daily minimum soil temperature difference is reduced.

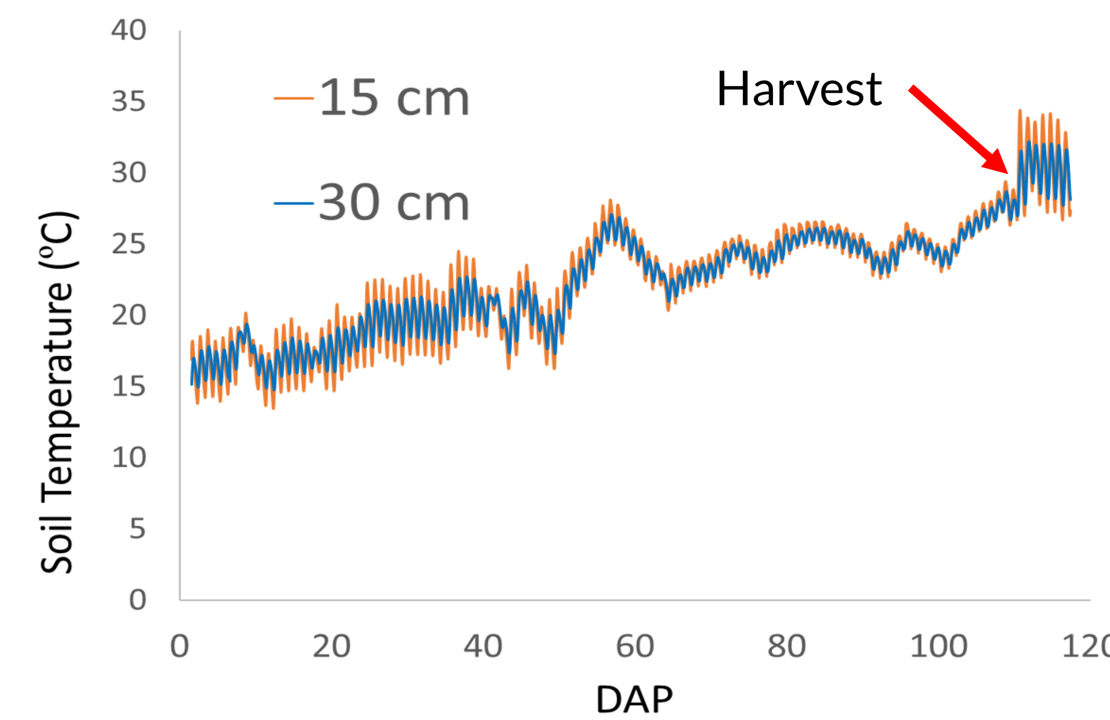
A faster, low cost, non - destructive way to determine LAI from readily available soil sensor data.

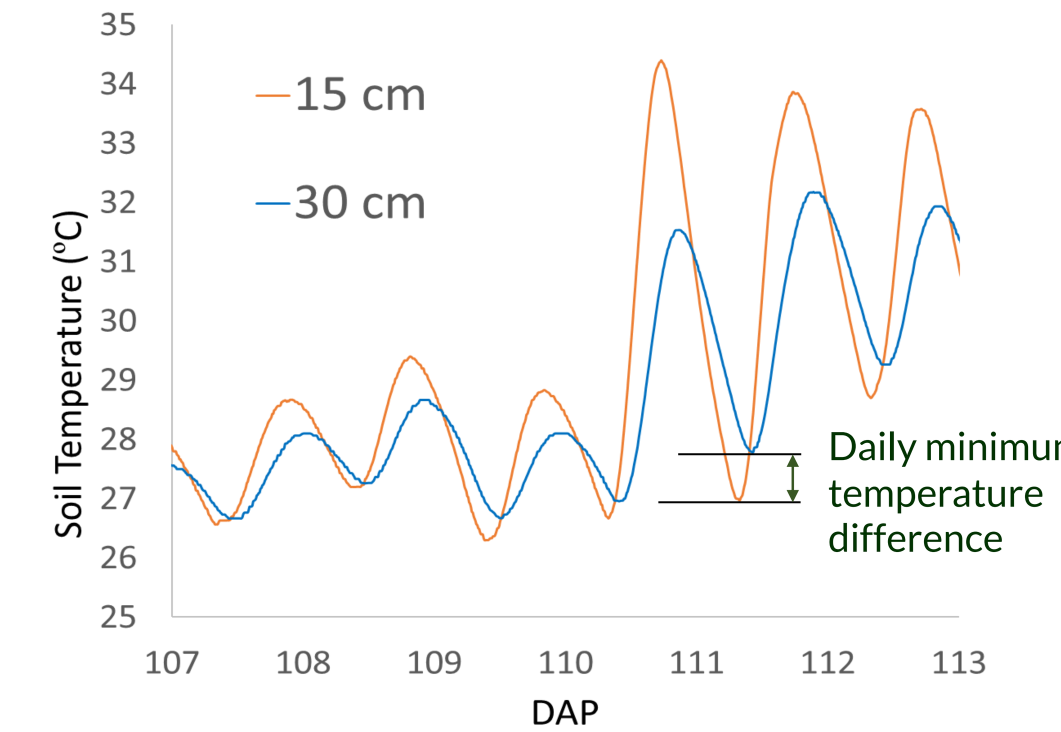


The inverse relationship between LAI and the daily minimum temperature difference between two depths can be characterized by a linear equation with a moderately strong R^2 value of 0.7.

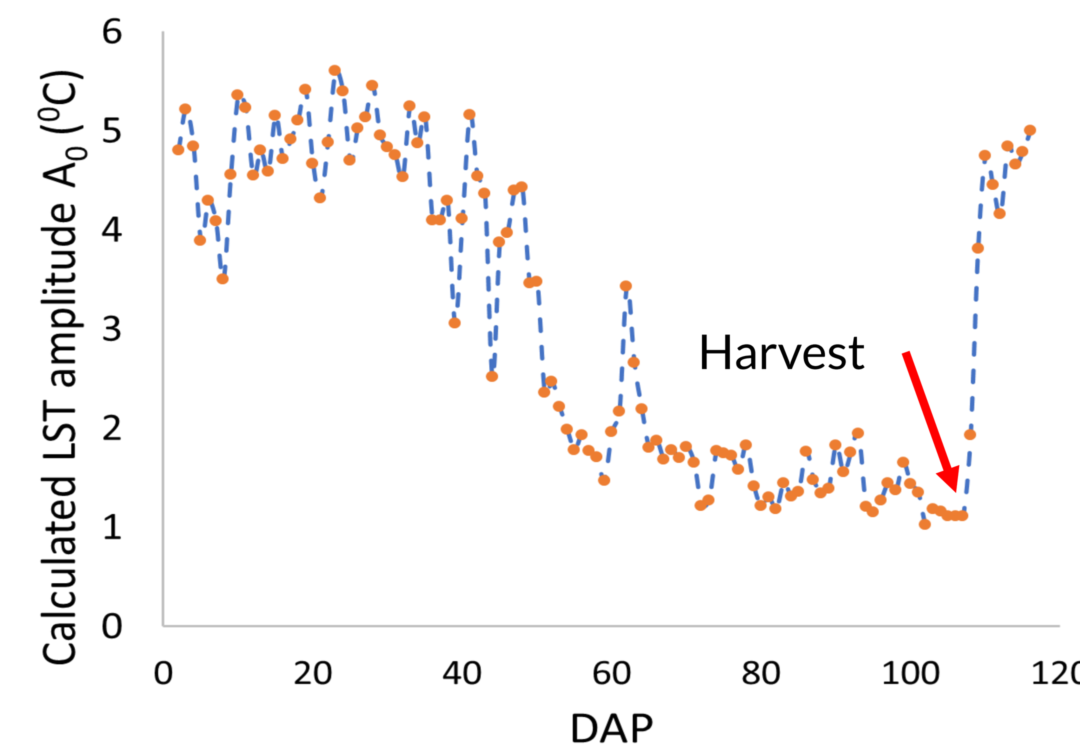
It can reasonably be concluded that LAI progression within a season can be estimated daily using soil temperature data from TDR sensors which farmers are already using.







The red arrow points to a drastic change in the soil temperature pattern immediately following harvest of above ground biomass done on the 110th day after planting (DAP). The diagram on the right above zooms into this period.



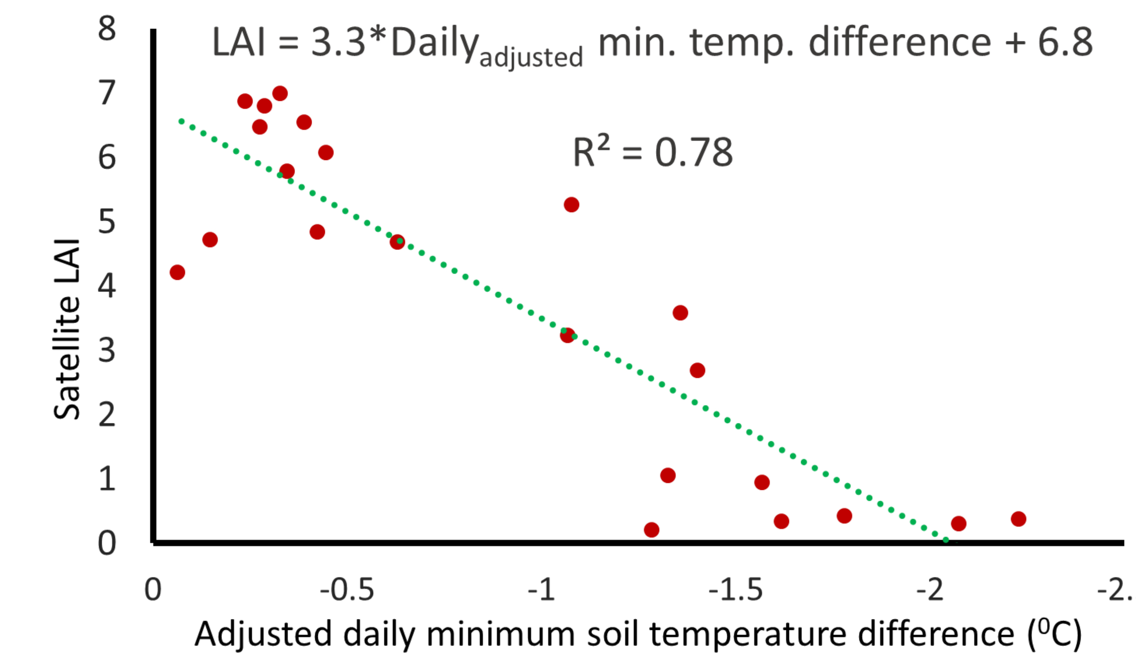
$$A_0 = A_{z_1} \cdot e^{\frac{z_1 \cdot \ln(A_{z_1}/A_{z_2})}{z_2 - z_1}}$$

The graph on the left was calculated using soil temperature data from the two depths using the above equation. It shows the calculated land surface temperature (LST) amplitude throughout the season. The LST amplitude will be used to account for the influence of water content on the soil's damping factor at the different depths.

Future work

The correlation between LAI and temperature response can be improved by taking into account net energy and soil properties as shown on the graph on the right with a higher R^2 of 0.78.

Future efforts will be to develop a bio-physical model for estimating LAI that takes into account relevant energy terms and soil properties.



Adjusted daily minimum soil temperature difference = Daily minimum soil temperature difference X (Seasonal maximum cumulative daily global radiation / Cumulative daily global radiation)

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