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The response of the terrestrial biosphere to changing climate is one of the largest uncertainties in future climate projections.
Current US drought prediction capabilities failed to predict the intensity and magnitude of the 2012 US Midwest drought.
Plants regulate water loss (transpiration) by closing the pores on their leaves, but at the expense of shutting off CO₂ uptake for photosynthesis and risking carbon starvation. Transpiration performs the same cooling function as sweat; if plants cannot adequately cool themselves, they risk overheating and mortality due to heat stress.
Evapotranspiration is the key climate variable linking the water, energy, and carbon cycles. What is evapotranspiration (ET)?

ET describes the net exchange of water vapor between the land surface and the atmosphere, and is comprised of water evaporated directly from the soil or other surfaces and water transpired (i.e., used; consumptive use) by plants.
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HOW DO DIFFERENT PLANTS RESPOND TO CHANGES IN WATER AVAILABILITY?
WHICH PLANTS DIE FIRST?
How plants respond to changes in water availability can be expressed in terms of Water Use Efficiency (WUE), defined as the amount of carbon fixed per unit water used (gross primary production, GPP, divided by ET). Some plants have high WUE and can fix a large amount of carbon using a small amount of water; other plants are less efficient. Low WUE plants risk replacement with increasing droughts.
ECOSTRESS KEY SCIENCE QUESTIONS

1. HOW IS THE TERRESTRIAL BIOSPHERE RESPONDING TO CHANGES IN WATER AVAILABILITY?

2. HOW DO CHANGES IN DIURNAL VEGETATION WATER STRESS IMPACT THE GLOBAL CARBON CYCLE?

3. CAN AGRICULTURAL VULNERABILITY BE REDUCED THROUGH ADVANCED MONITORING OF AGRICULTURAL CONSUMPTIVE USE AND IMPROVED DROUGHT DETECTION?
ECOSTRESS SCIENCE OBJECTIVES

1. **Identify critical thresholds** of water use and water stress in key climate sensitive biomes (e.g., tropical/dry transition forests, boreal forests);

2. **Detect the timing, location, and predictive factors** leading to plant water uptake decline and/or cessation over the *diurnal cycle*;

3. **Measure agricultural water consumptive use** globally at spatiotemporal scales applicable to improving drought estimation accuracy.
ECOSTRESS CORE SCIENCE HYPOTHESES

$H_1$: The WUE of a climate sensitive hotspots is significantly lower than non-hotspots of the same biome type;

$H_2$: Daily ET is overestimated when extrapolating from morning-only observations;

$H_3$: Remotely sensed ET measured at the field scale will improve drought prediction over managed ecosystems.
APPROACH
What we need: accurate, high spatial, high temporal, diurnal cycle, global, ET.
Evapotranspiration (W m\textsuperscript{-2})

- Measured (FLUXNET)
- Landsat

Month:
- JUN
- JUL
- AUG
- SEP
- OCT
Water Stress Drives Plant Behavior

Evapotranspiration

Stomata close to conserve water

Diurnal Cycle
Gray shading represents mean diurnal variation in ET over 14-days. The afternoon decline in ET is related to water stress (clear day).

I  Xylem refilling after initial water release.
II  ET at maximum/potential rate in the morning.
III  Stomata shut down water flux in the afternoon.
IV  ET resumes at maximum/potential in early evening when demand is reduced.
AMERICA'S
NEXT GENERATION
WEATHER SATELLITE

GOES-R
The International Space Station (ISS)
NASA astronaut Drew Feustel seemingly hangs off the International Space Station while conducting a spacewalk with fellow NASA astronaut Ricky Arnold on March 29, 2018. Credits: NASA
The #COSTRESS team is doing critical work to better understand how plants react to heat and water stress by measuring the temperature of Earth's vegetation. Great job!

NASA Earth and NASA JPL
STARTUP
THE FALCON 9 FLIGHT COMPUTERS HAVE TAKEN CONTROL OF THE COUNTDOWN
2 JUL 2018
Earth Orbiting Mission Operations Control (EOMOC)