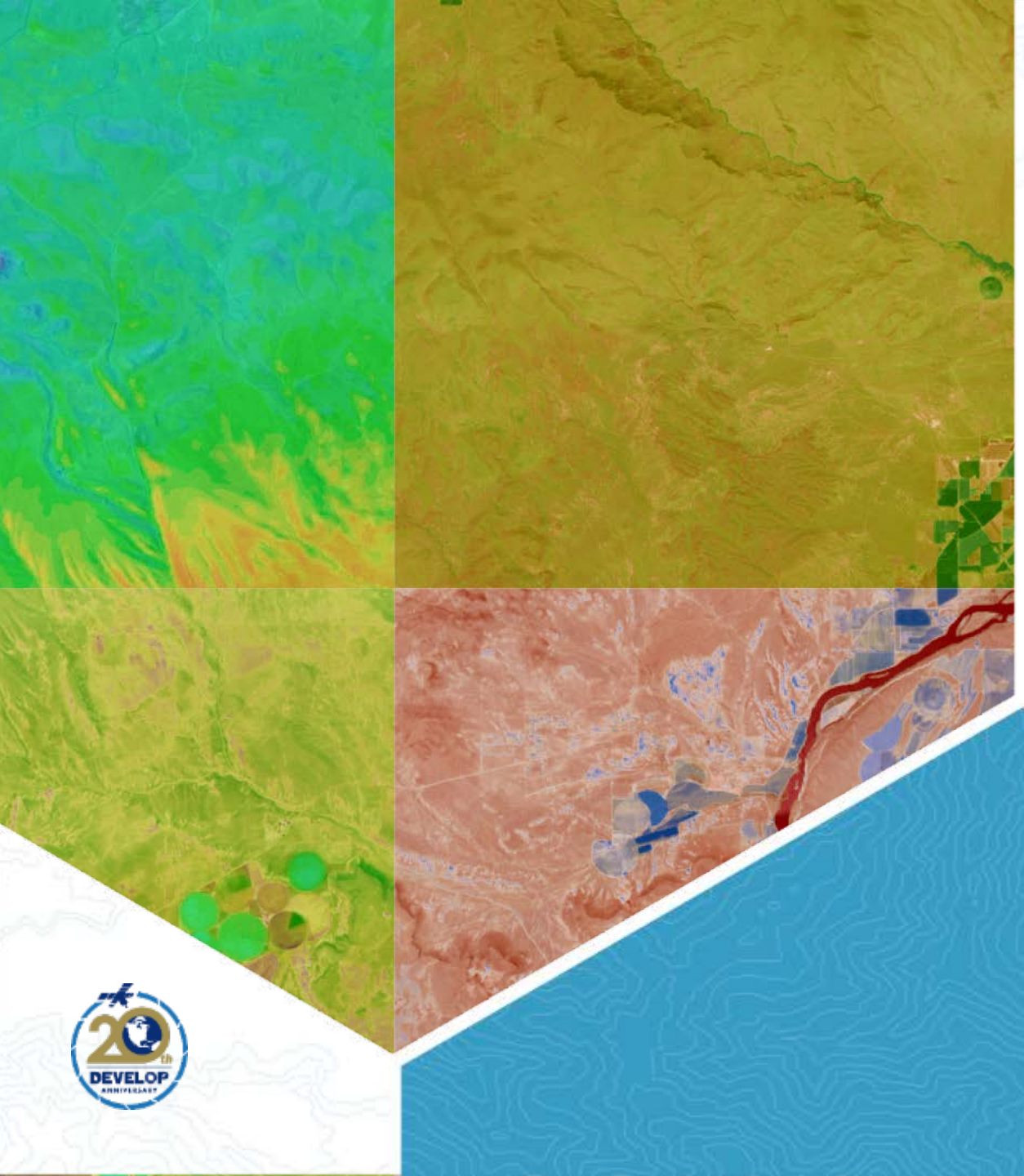

National Aeronautics and Space Administration

2018 Fall | Idaho – Pocatello

IDAHO WATER RESOURCES II

Evaluating Evapotranspiration and Water Budget Components in Semi-Arid Sagebrush Steppe

Ian Lauer

Carl Jurkowski

Carolyn Macek

Frank Zurek

Background

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- Receives an average of 12 inches of precipitation per year

Background

- 60% of Idaho is publicly managed land
- Receives an average of 12 inches of precipitation per year
- Landcover ranges from semi-arid sagebrush Steppe at low elevations transitions to mixed forest at higher elevations

Community Concerns

- The water balance is critical to managing semi-arid environments:
  - fire susceptibility
  - native plant management
  - wildlife range management
  - grazing allotments

Image Credit: Leah Kucera

U.S. FISH & WILDLIFE SERVICE

USDA Agricultural Research Service

NRCS

INL Idaho National Laboratory

Community Concerns

- The water balance is critical to managing semi-arid environments:
  - fire susceptibility
  - native plant management
  - wildlife range management
  - grazing allotments
- Our partners currently use field-based methods to collect ET data.
  - costly and time intensive
  - limited distribution for regional scales

Image Credit: Leah Kucera

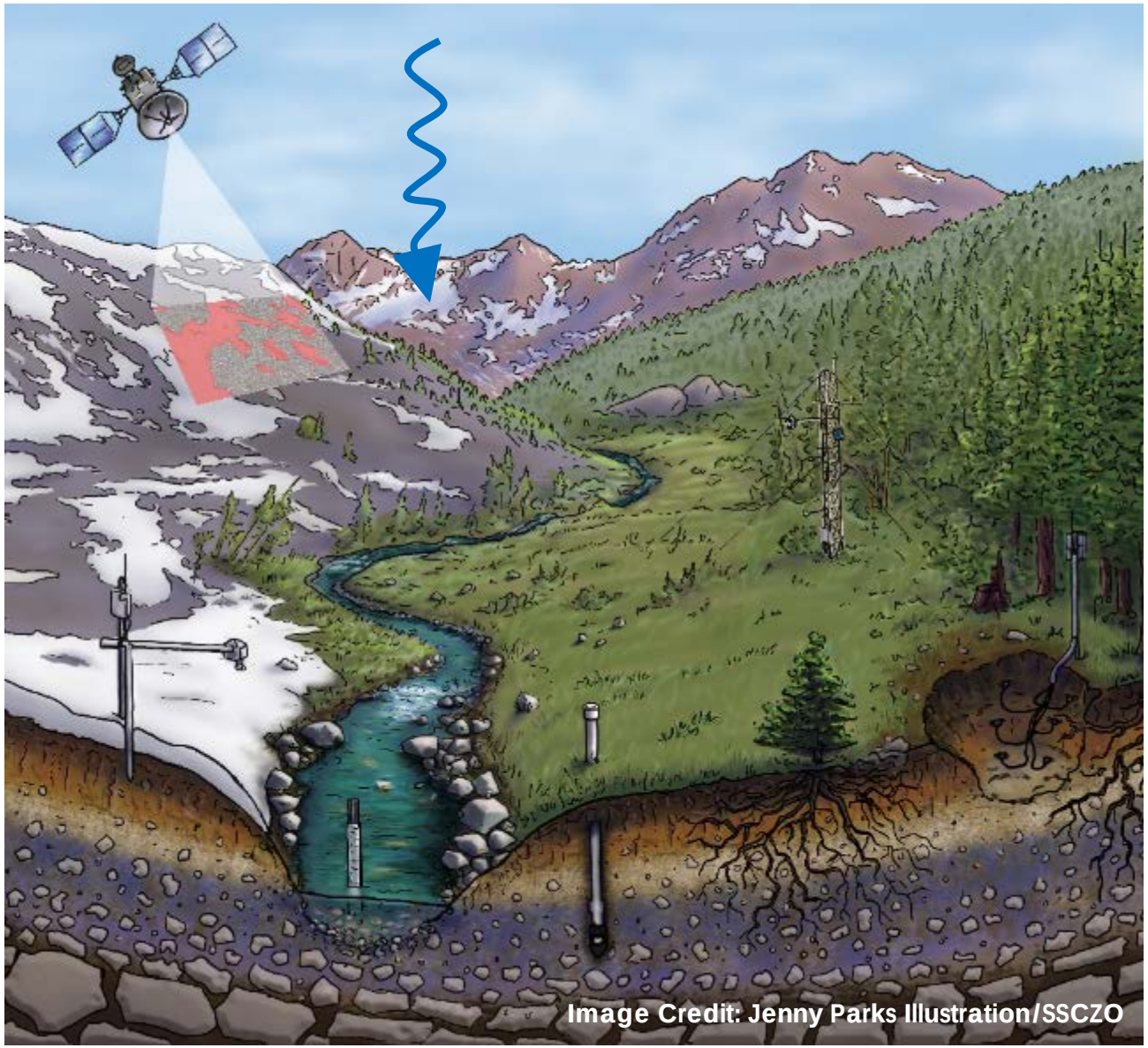
U.S. FISH & WILDLIFE SERVICE

USDA Agricultural Research Service

NRCS

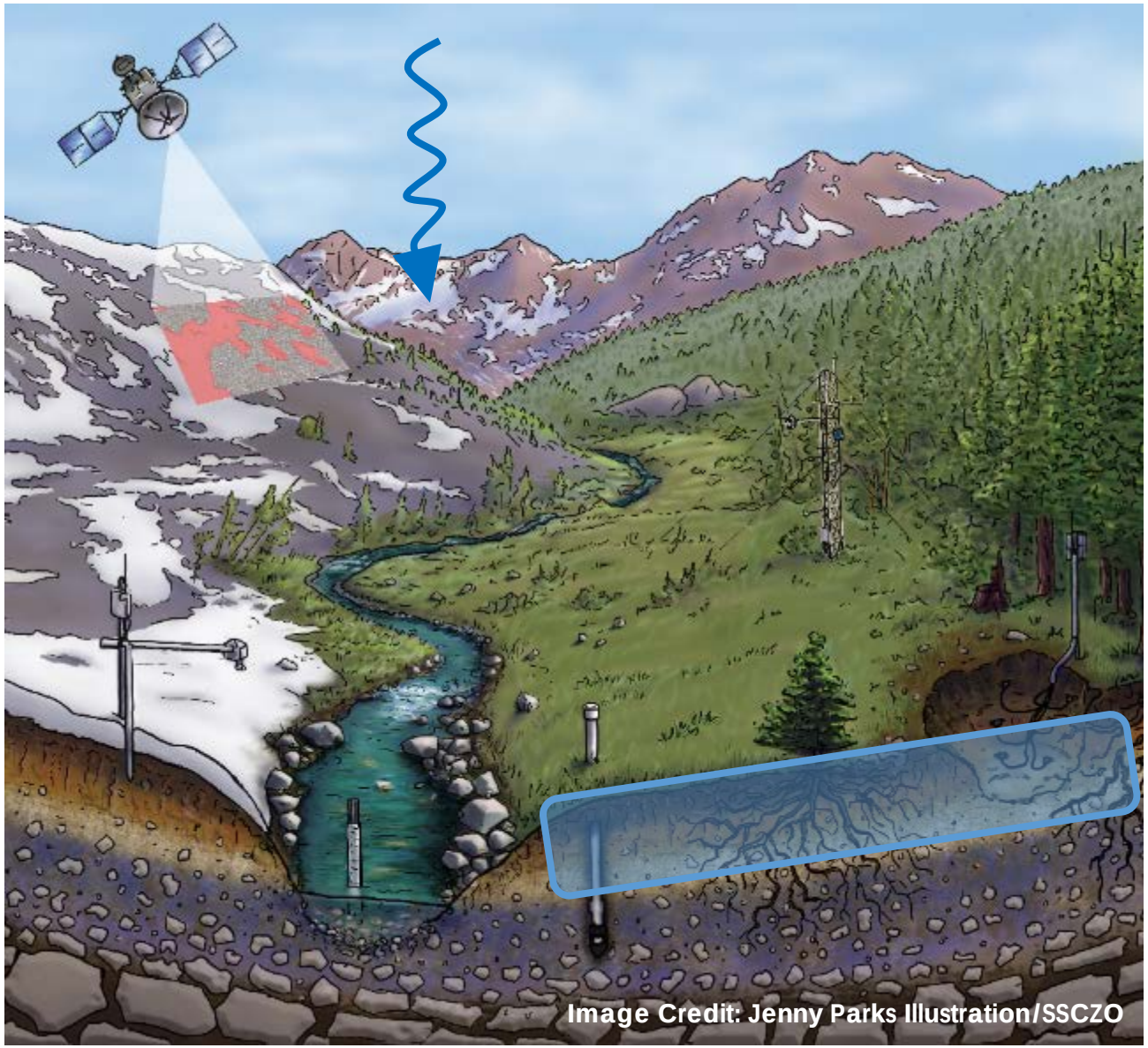
INL Idaho National Laboratory

The Water Cycle



- There are various inputs to the water cycle such as precipitation.

The Water Cycle



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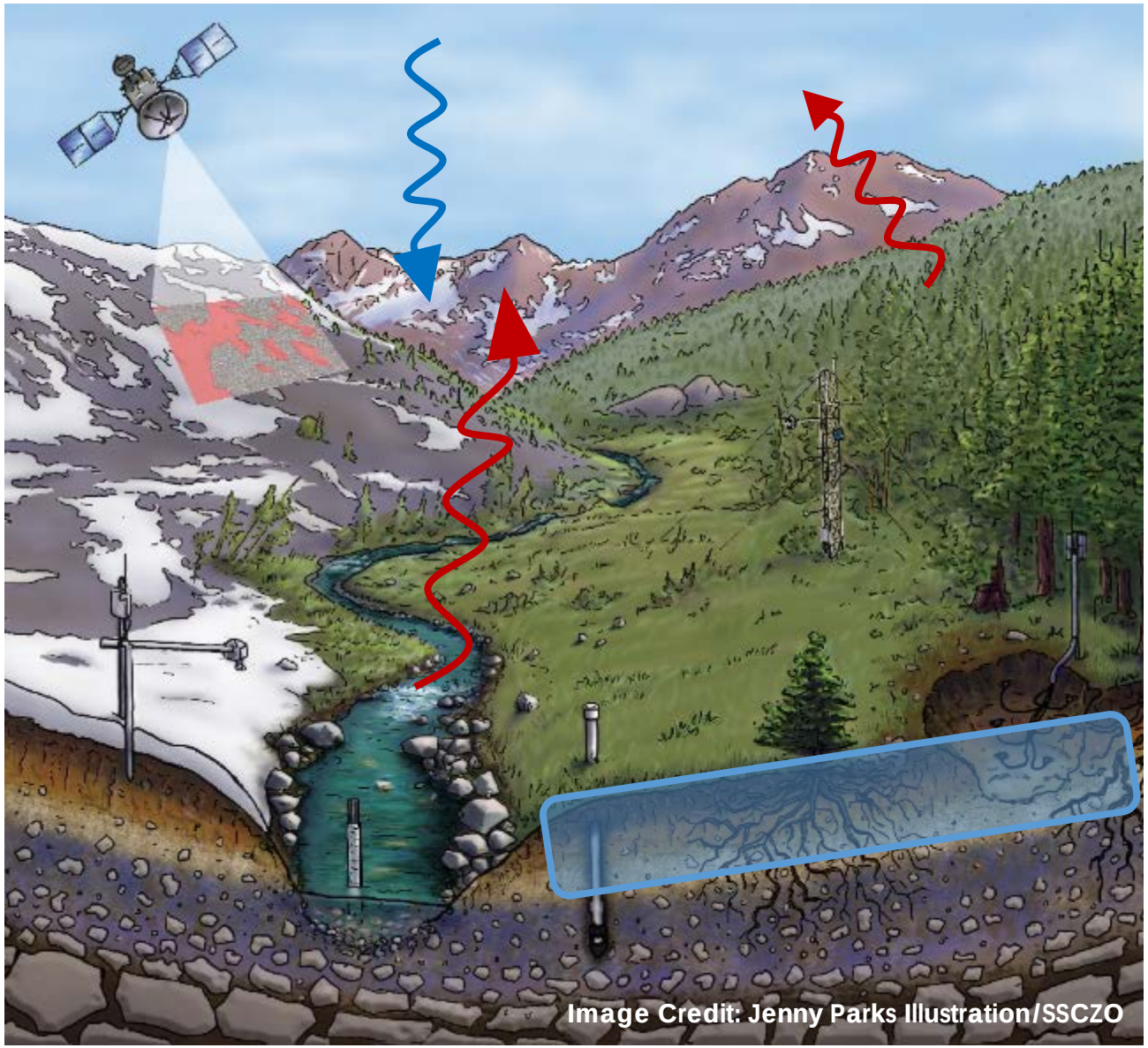
- The previous term focused on water storage as soil moisture.

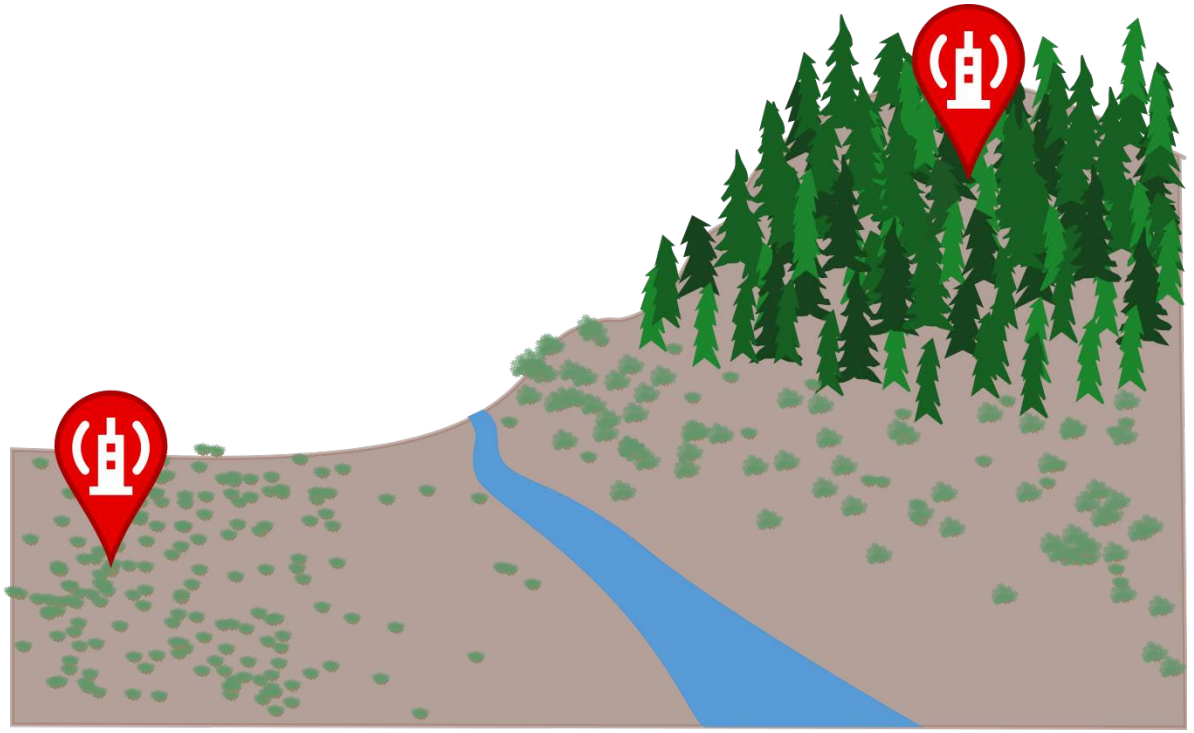
The Water Cycle



- There are various inputs to the water cycle such as precipitation.
- The previous term focused on water storage as soil moisture.
- This term focused on evapotranspiration (ET).
  - Transfer of water vapor from surfaces to the atmosphere
  - Evaporation + Transpiration

Objectives

- **ASSESS**
  - the potential of multiple models to map ET across semi-arid environments



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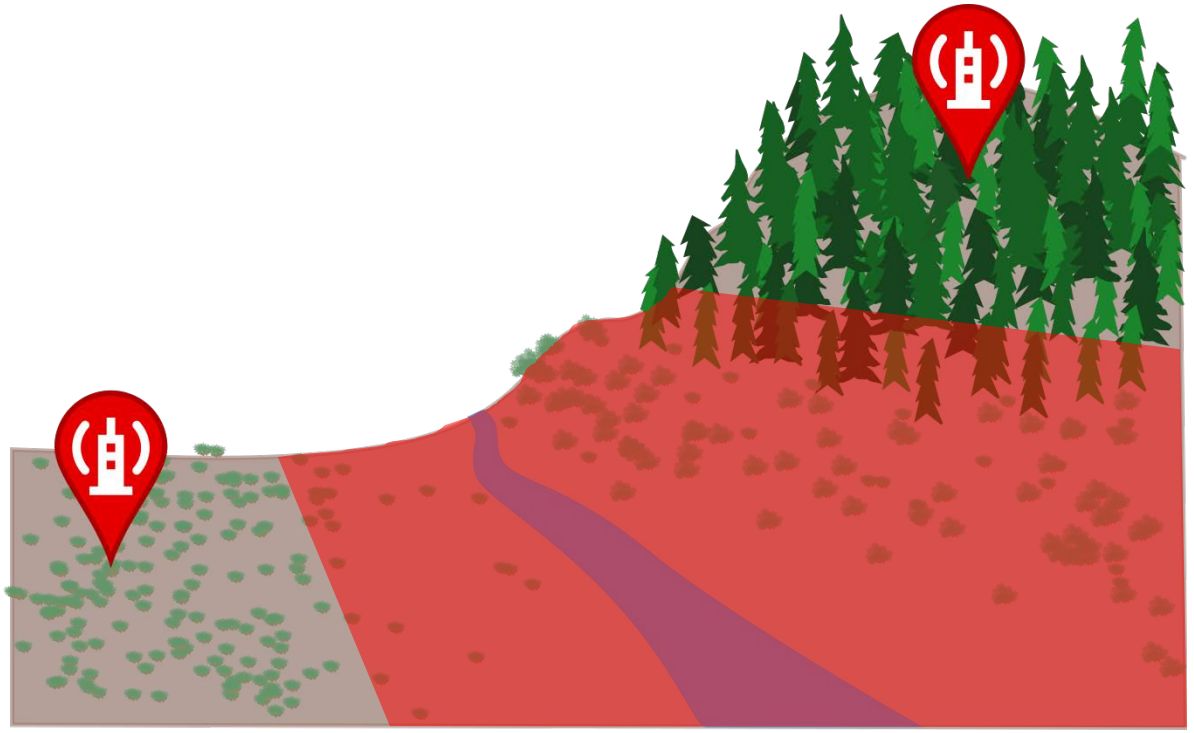

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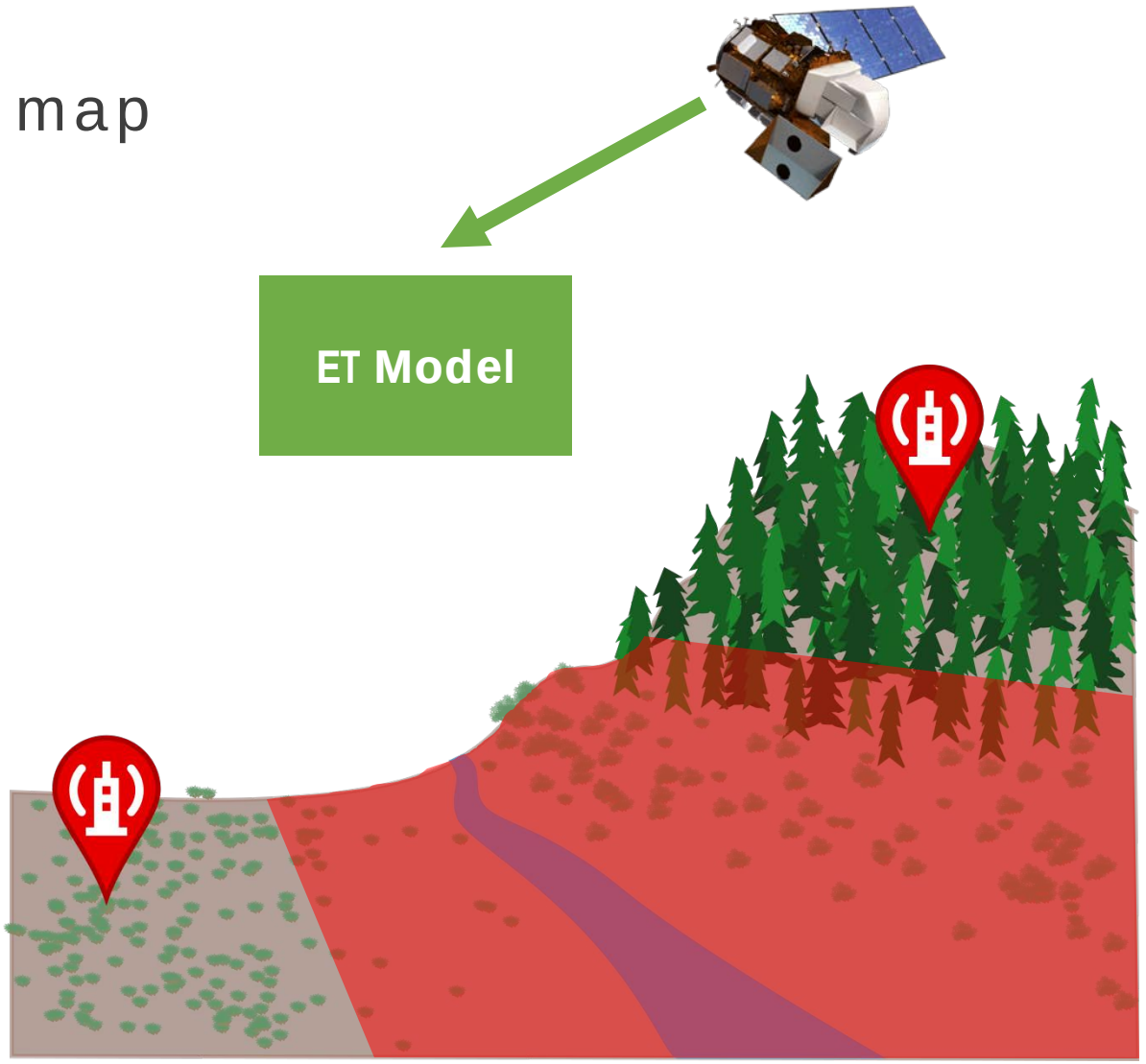

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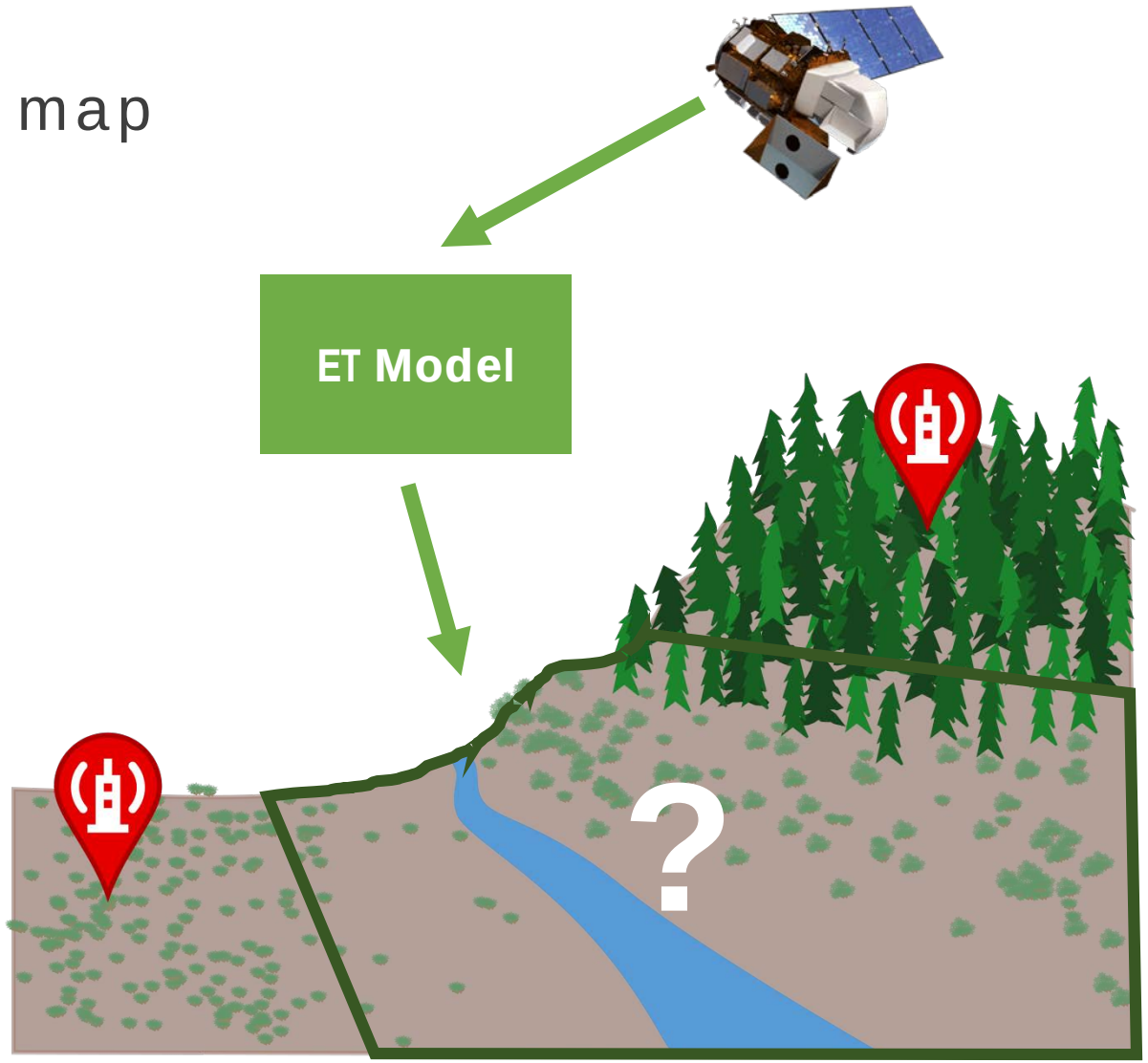

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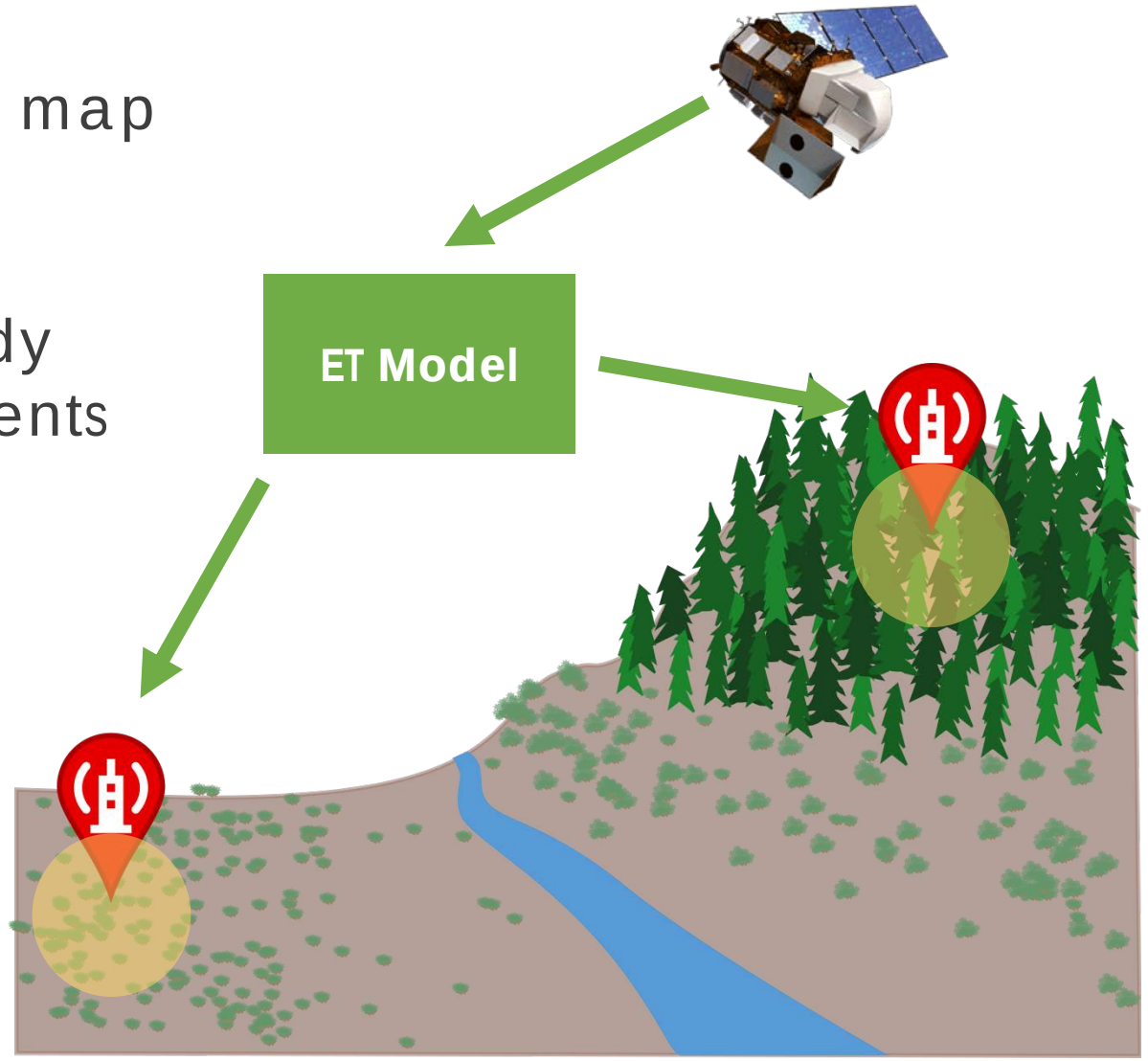
- **VALIDATE**
  - models by comparing them to Eddy Covariance Flux Tower Measurements



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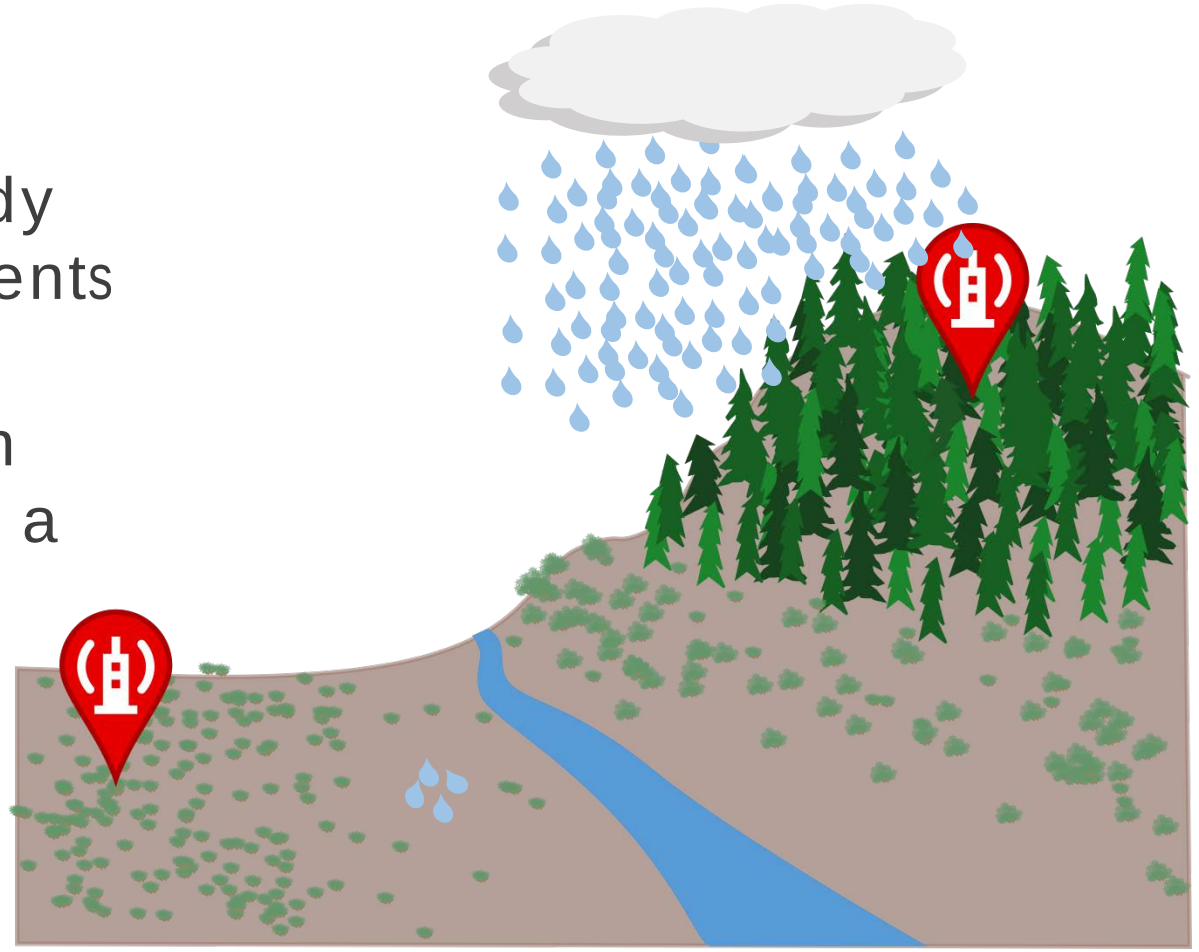
  - ET data to soil moisture, vegetation health, & precipitation to produce a holistic view of water availability



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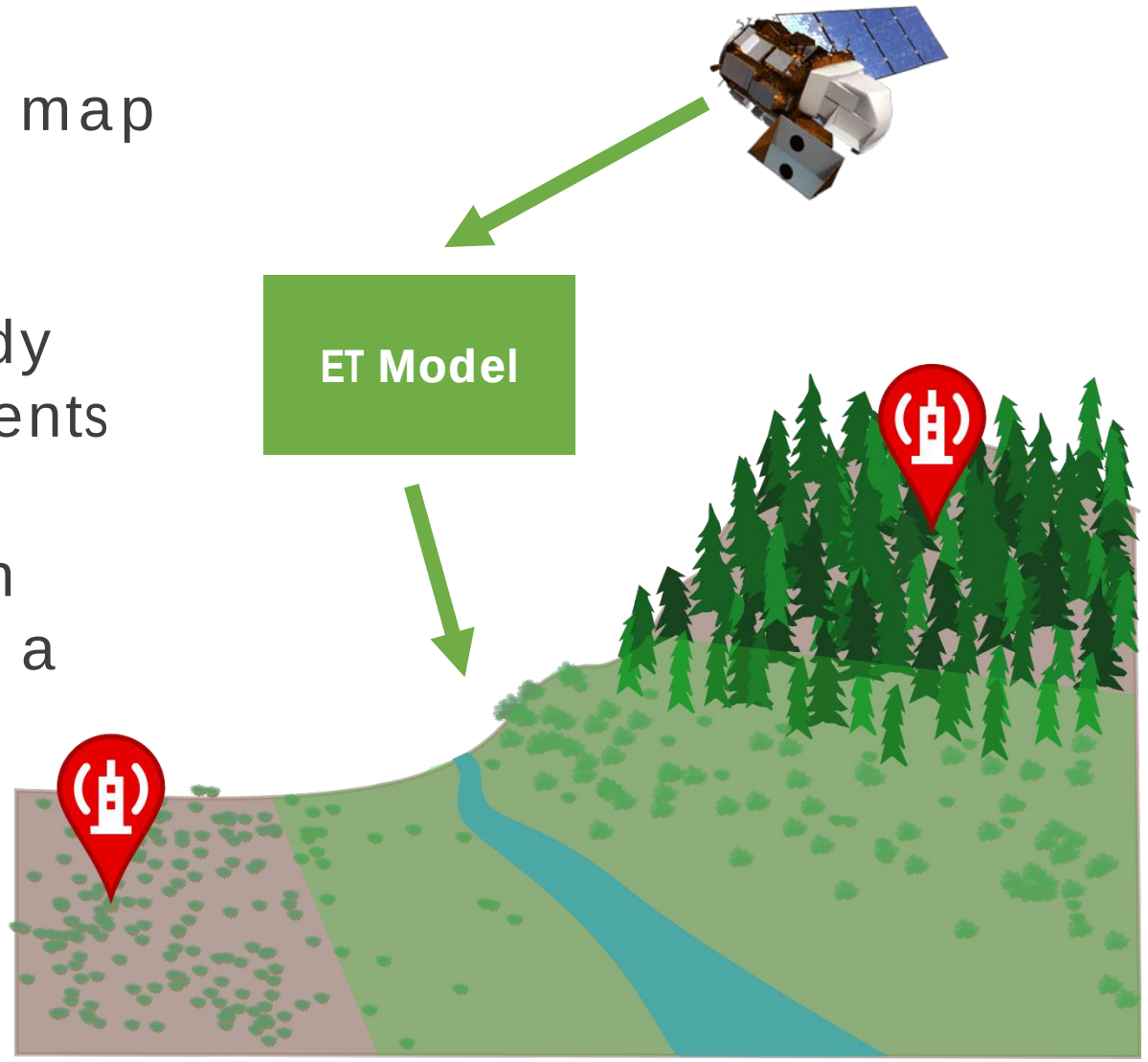
- **COMPARE**
  - ET data to soil moisture, vegetation health, & precipitation to produce a holistic view of water availability
- **SHARE**
  - A model or methodology that can be used by project partners in their respective disciplines



Methodology

DATA INPUTS | ANALYZE | COMPARE | OUTPUT

GEE ET Models:
EEFlux
MOD16
SSEBop

RCEW ET & soil moisture, MSAVI2

Other Models:
NLDAS-2-Noah

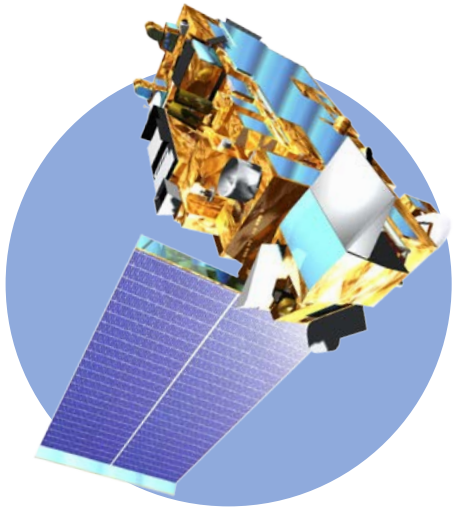
Google Earth Engine:
Combine GEE and *in situ* data; extract values at RCEW sites

ArcGIS Pro:
Clip to study area; extract values at RCEW Points

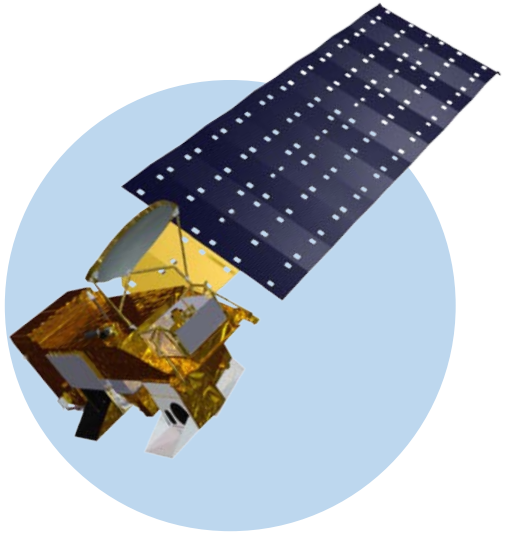
Compare ET maps to elevation, soil moisture, etc.

ET Maps & Correlation Plots

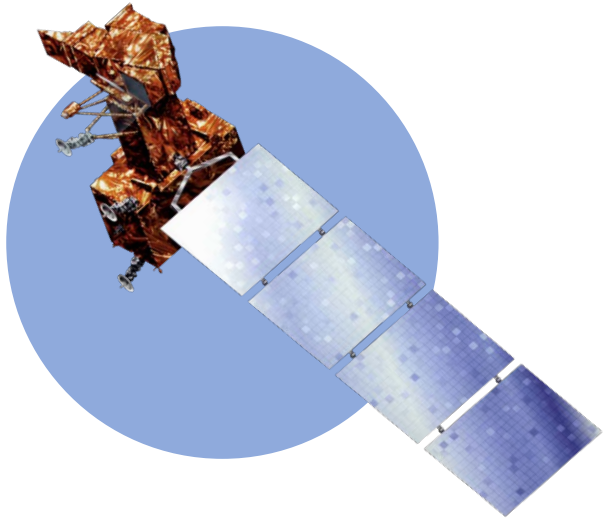
NASA Satellites Used



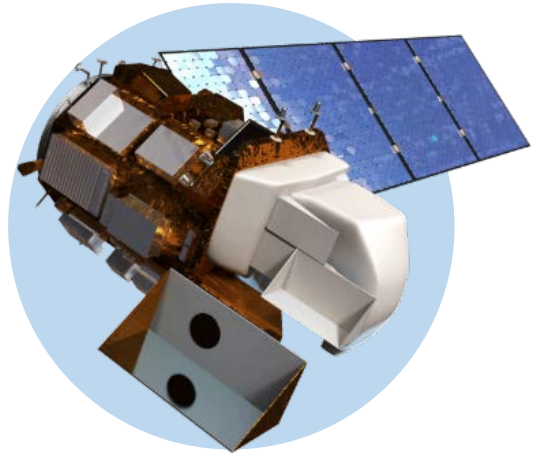
Terra
MODIS & ASTER



Aqua MODIS



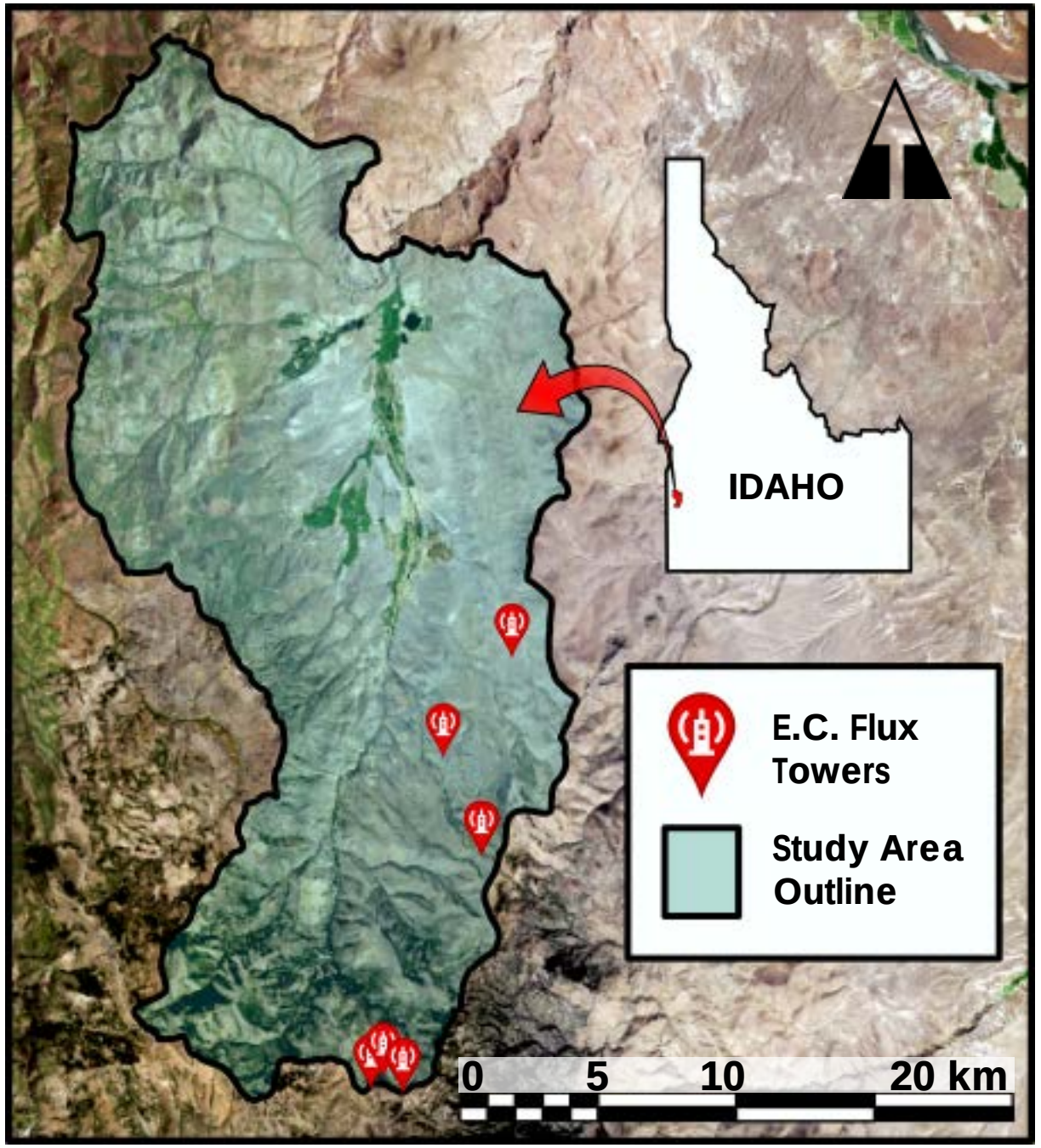
Landsat 8
OLI & TIRS



Landsat 8
OLI & TIRS

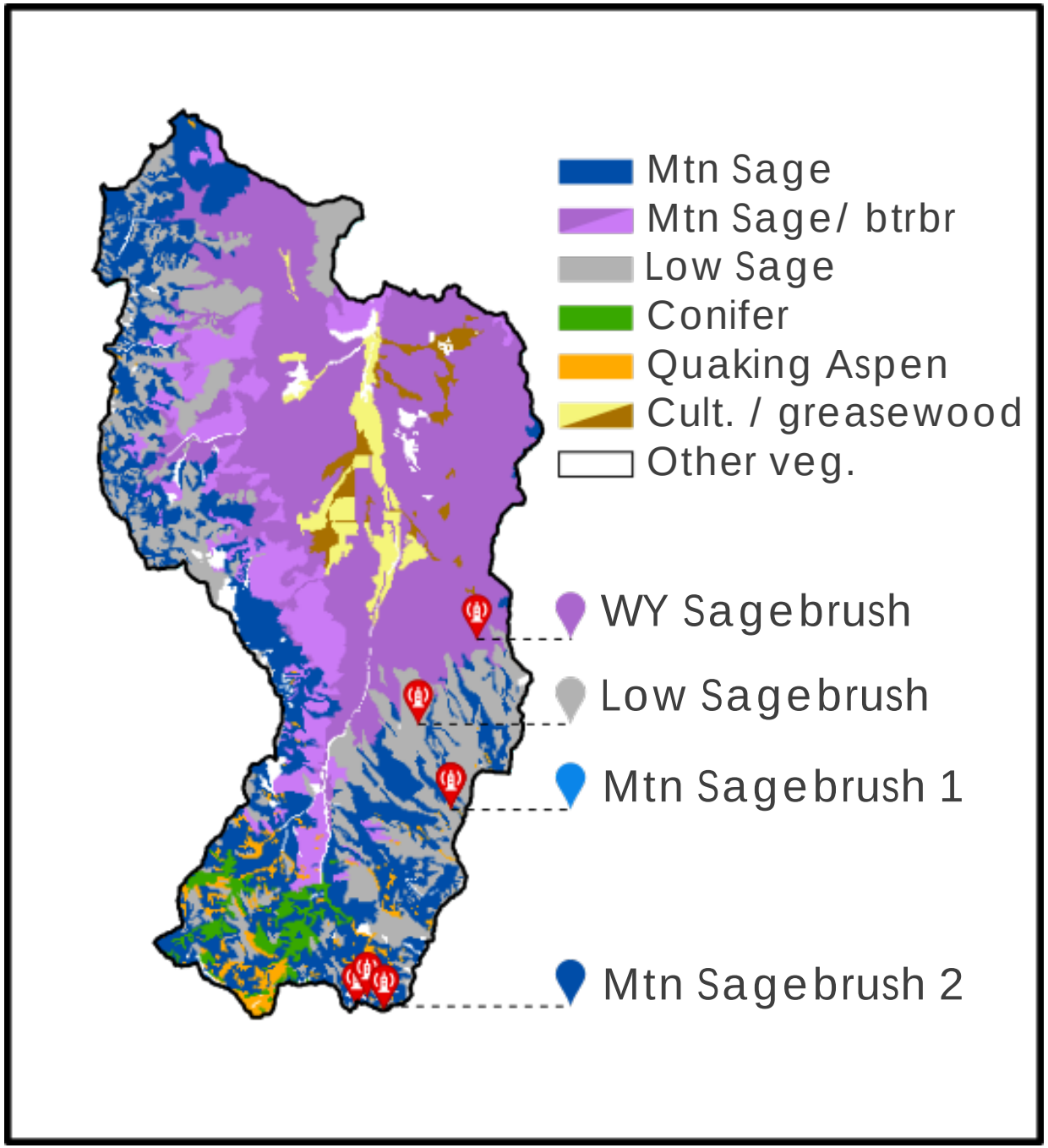
Study Area

- Validation Sites: **RCEW**
  - Reynolds Creek Experimental Watershed
  - founded in 1959 as an outdoor laboratory for study of critical zone processes

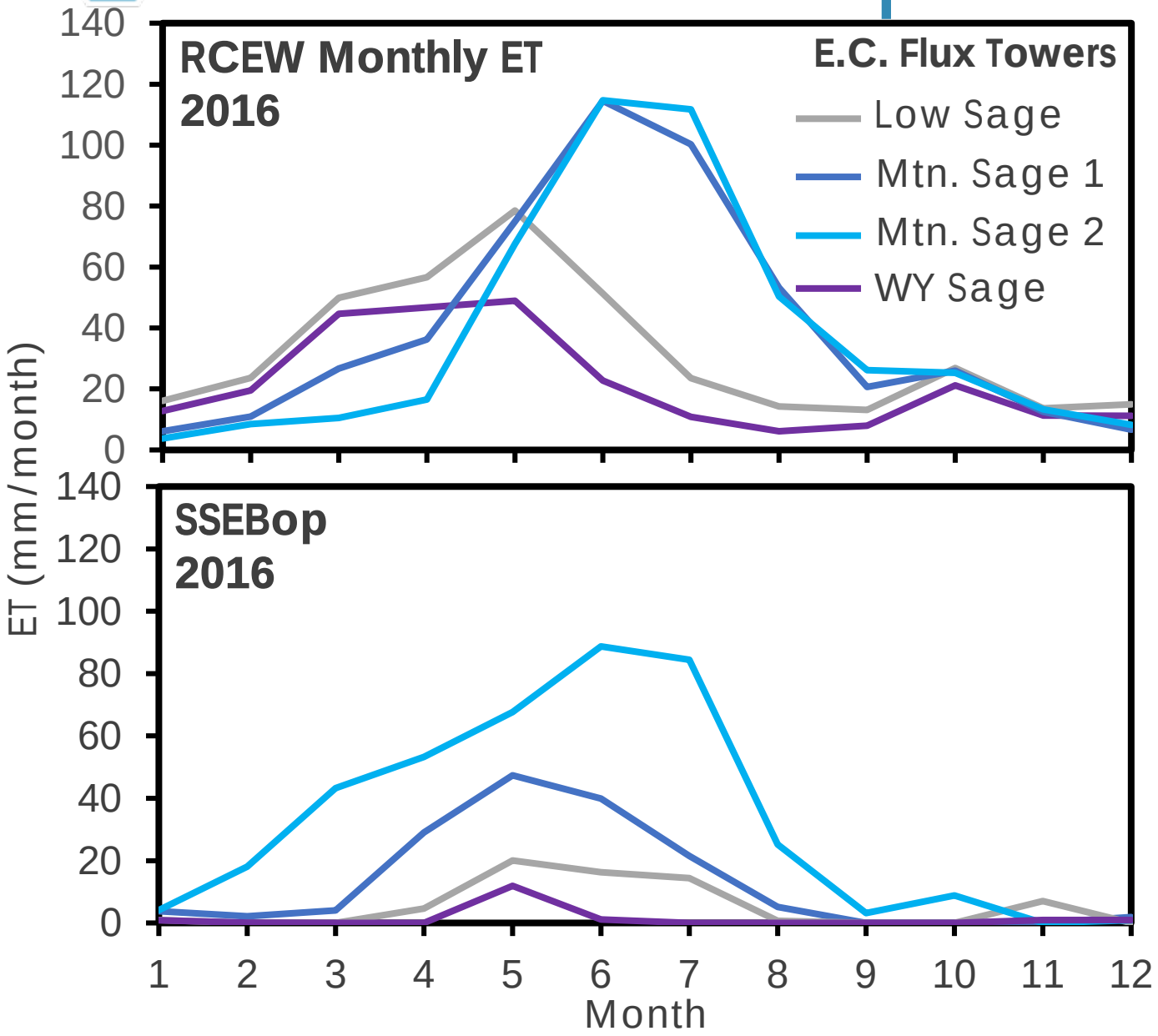


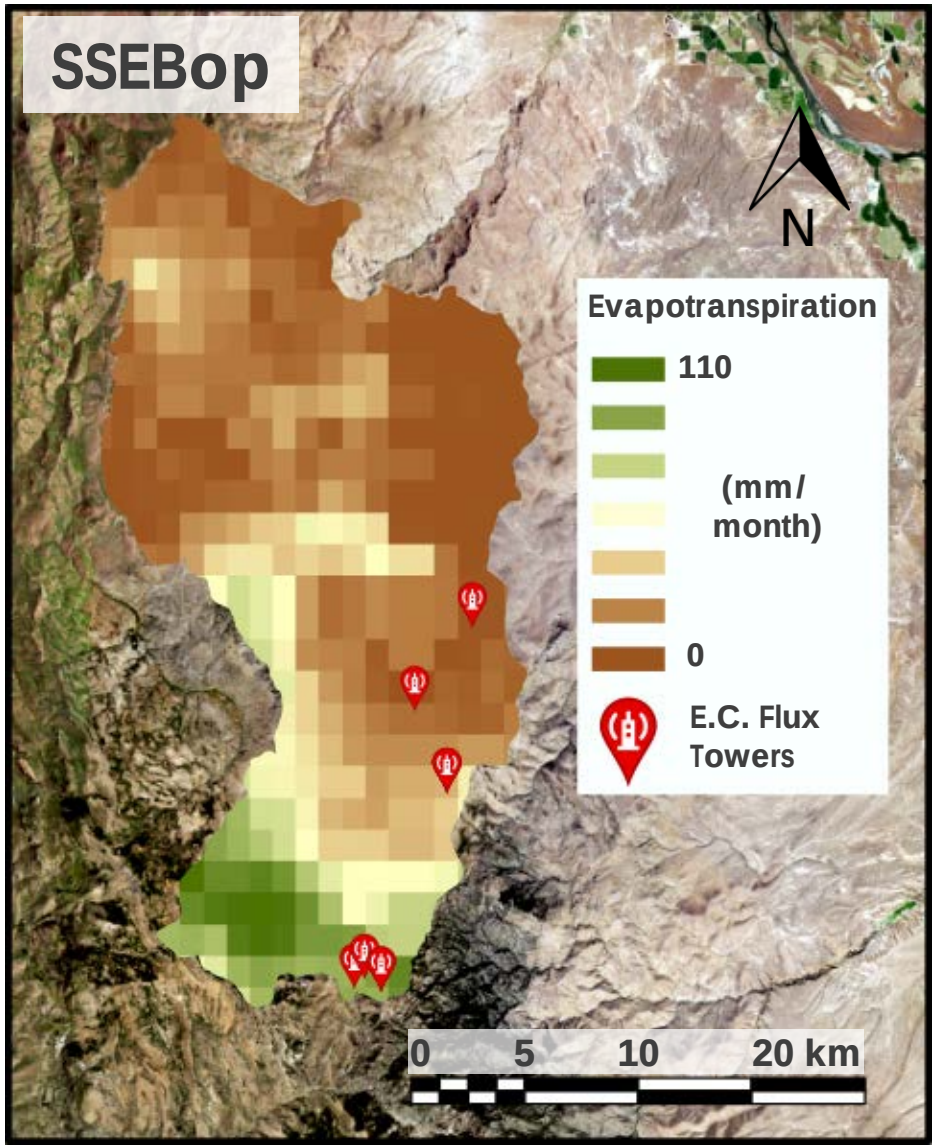
RCEW Sites & Vegetation

- Representative sagebrush steppe, high desert
- 4 Eddy Covariance Flux Towers
- 3 vegetation types
- Elevation gradient
  - WY Sage → Mtn. Sage 2



Results: SSEBop





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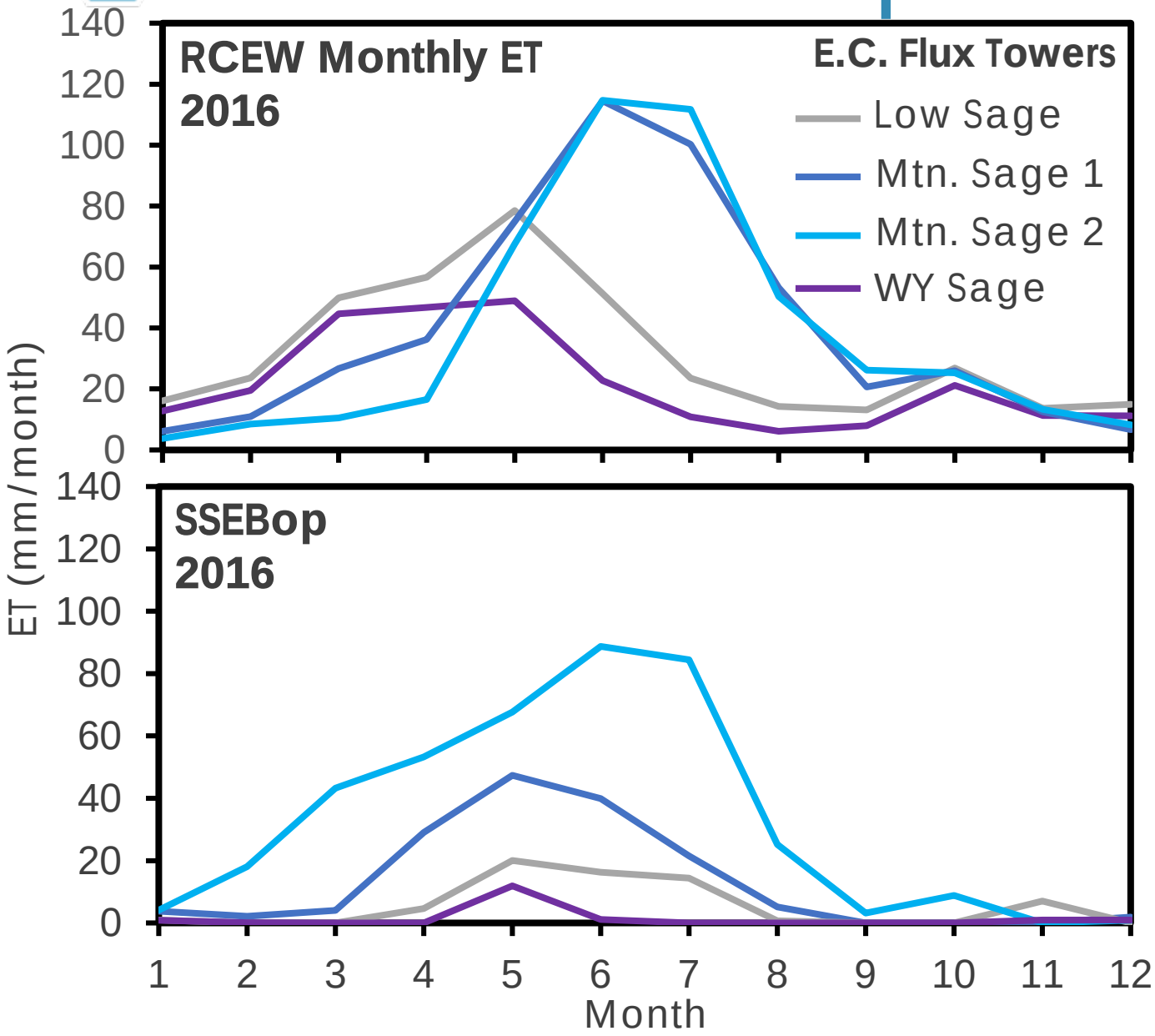
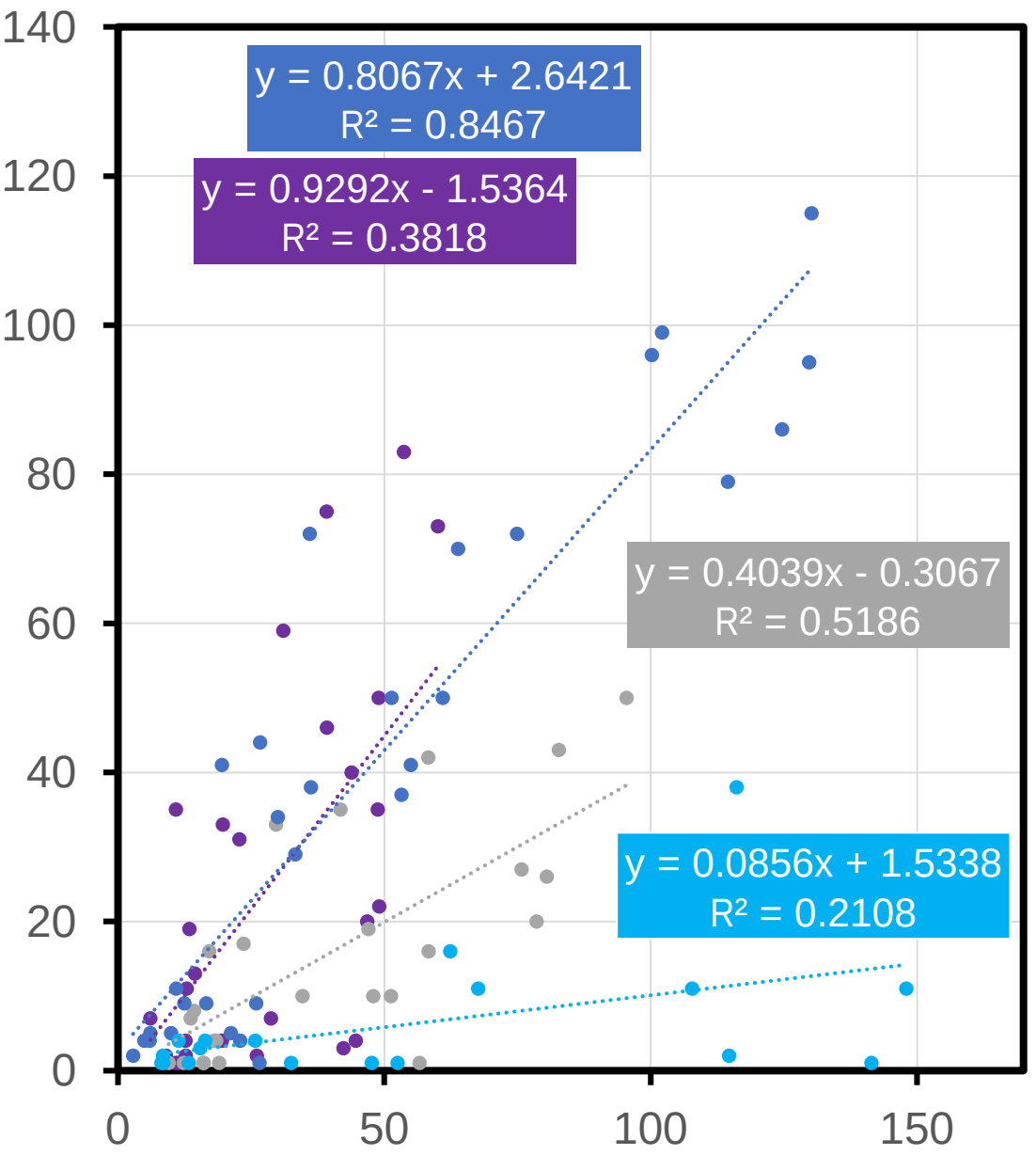
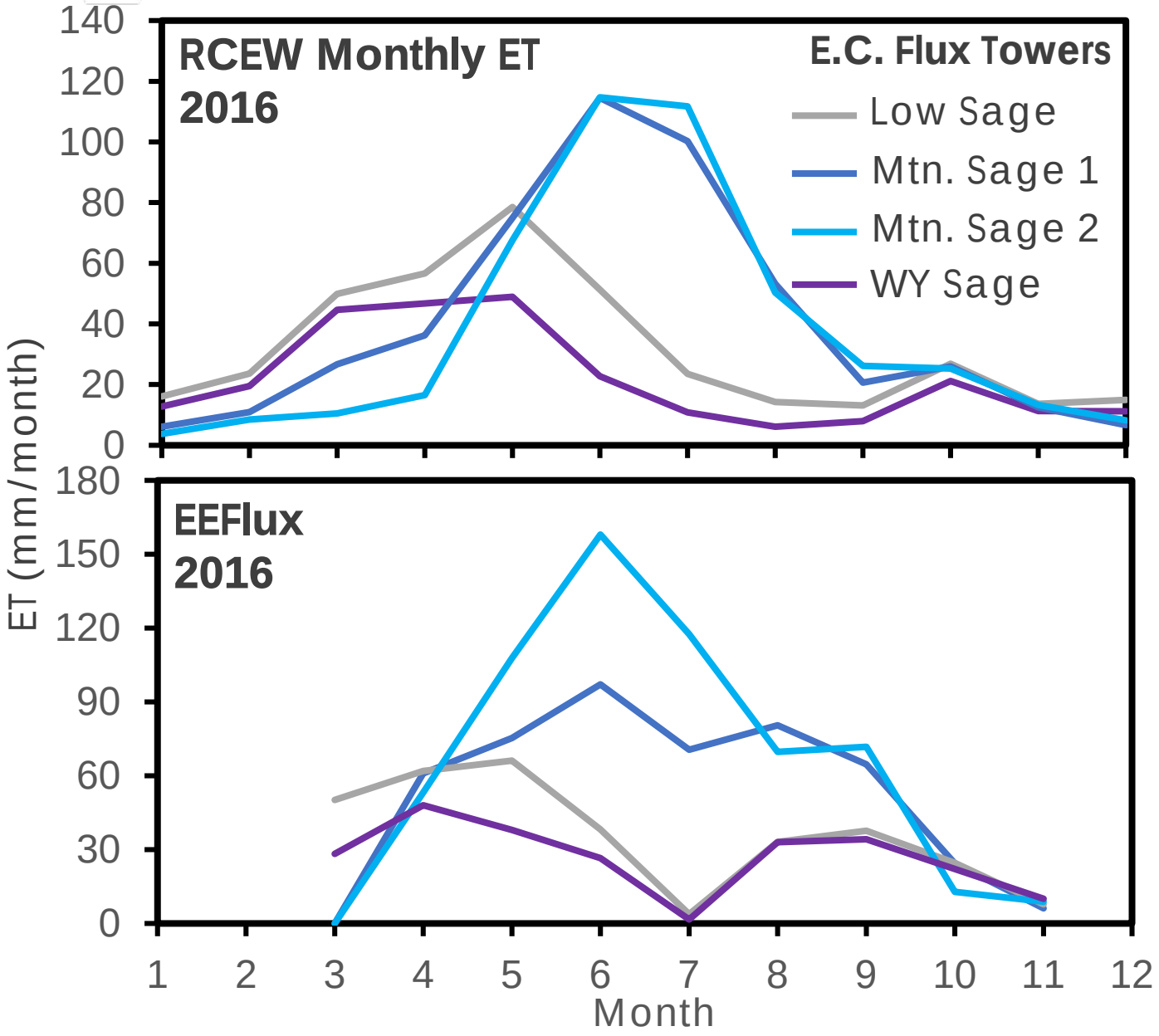
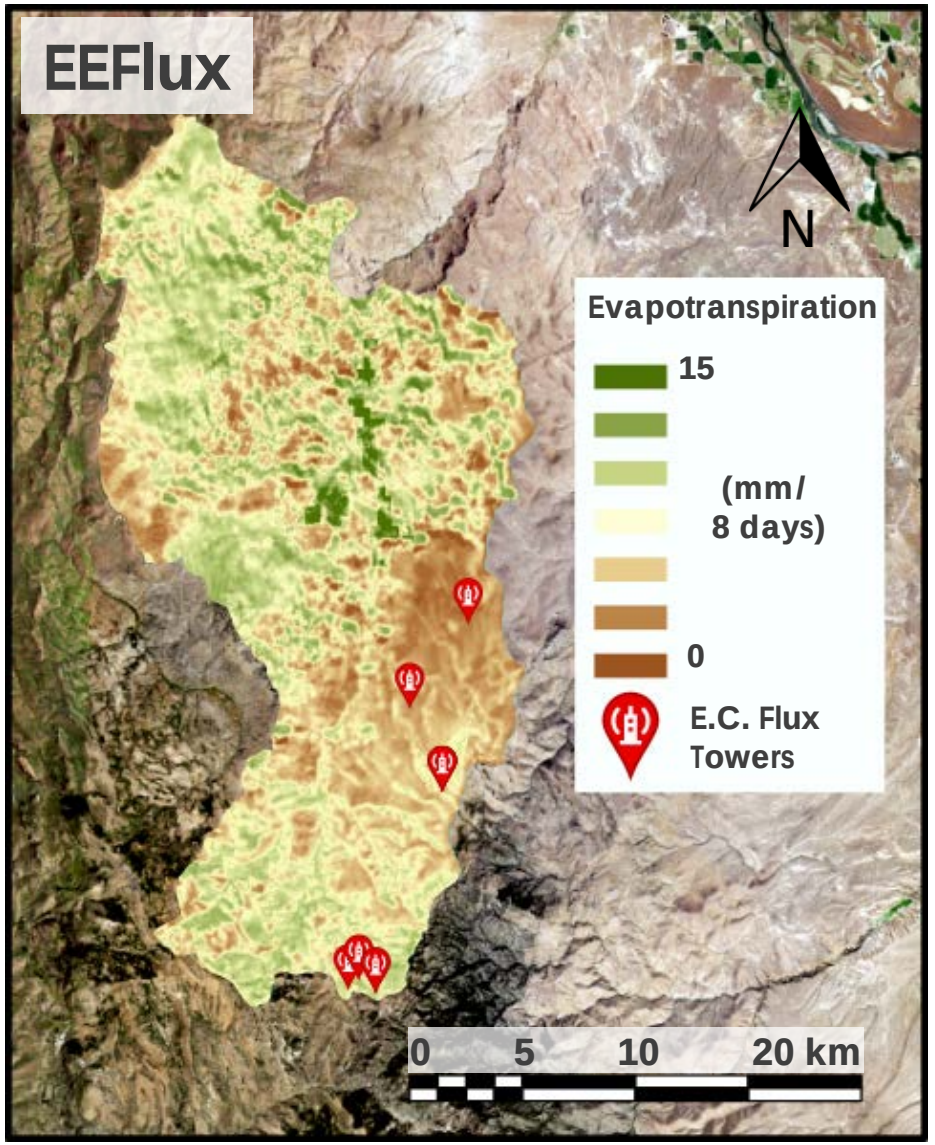




Results: EEFlux





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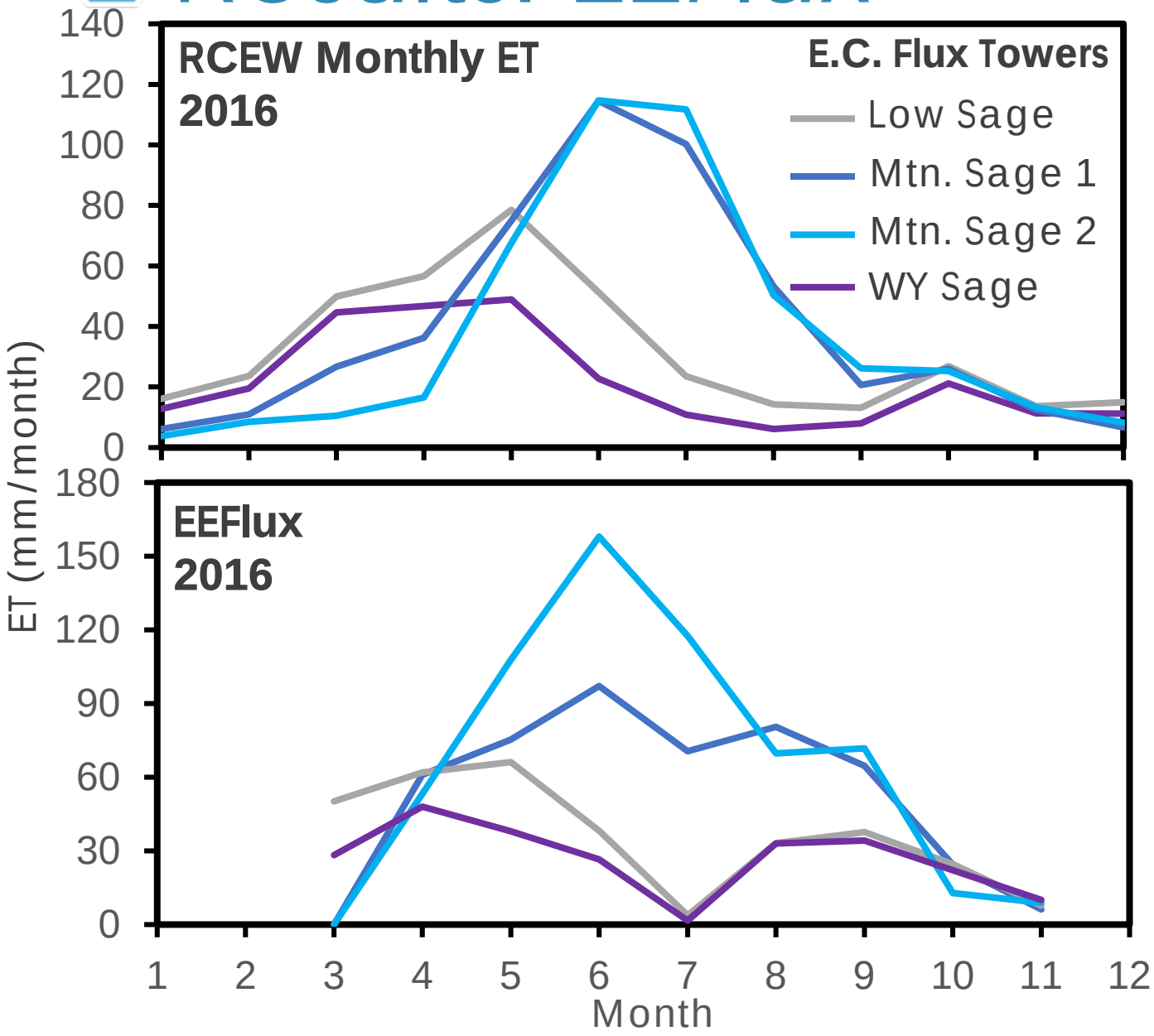
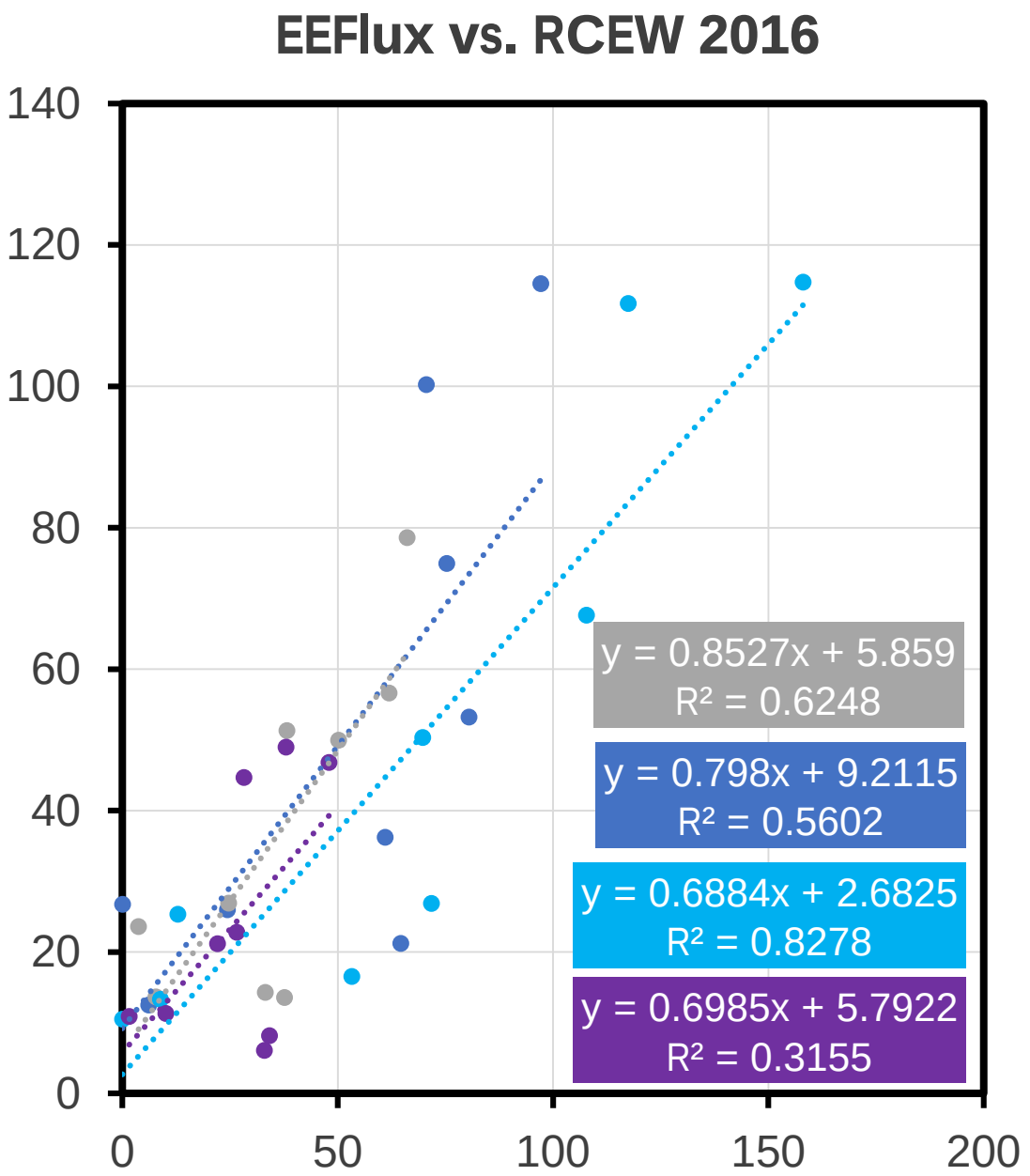
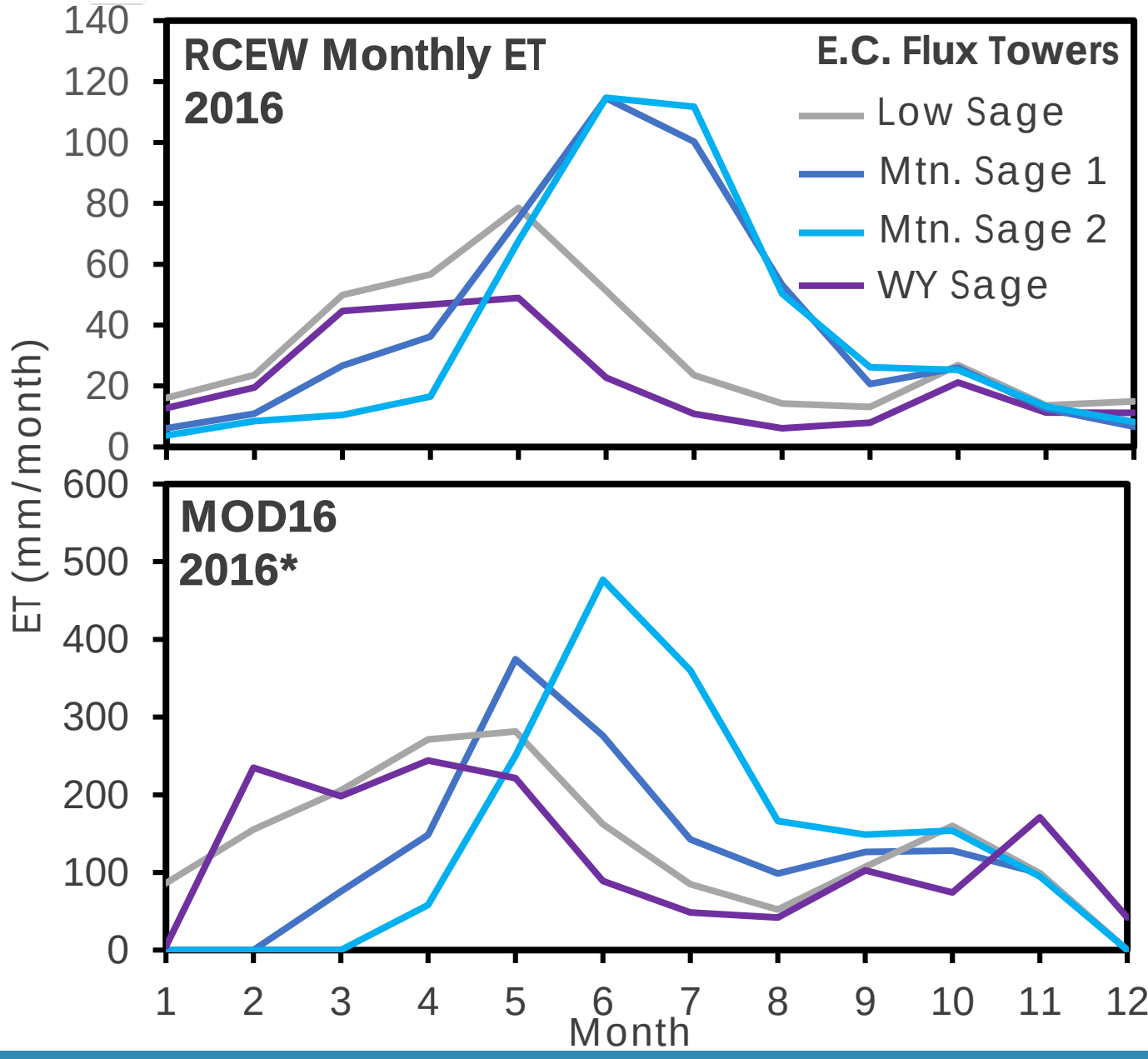
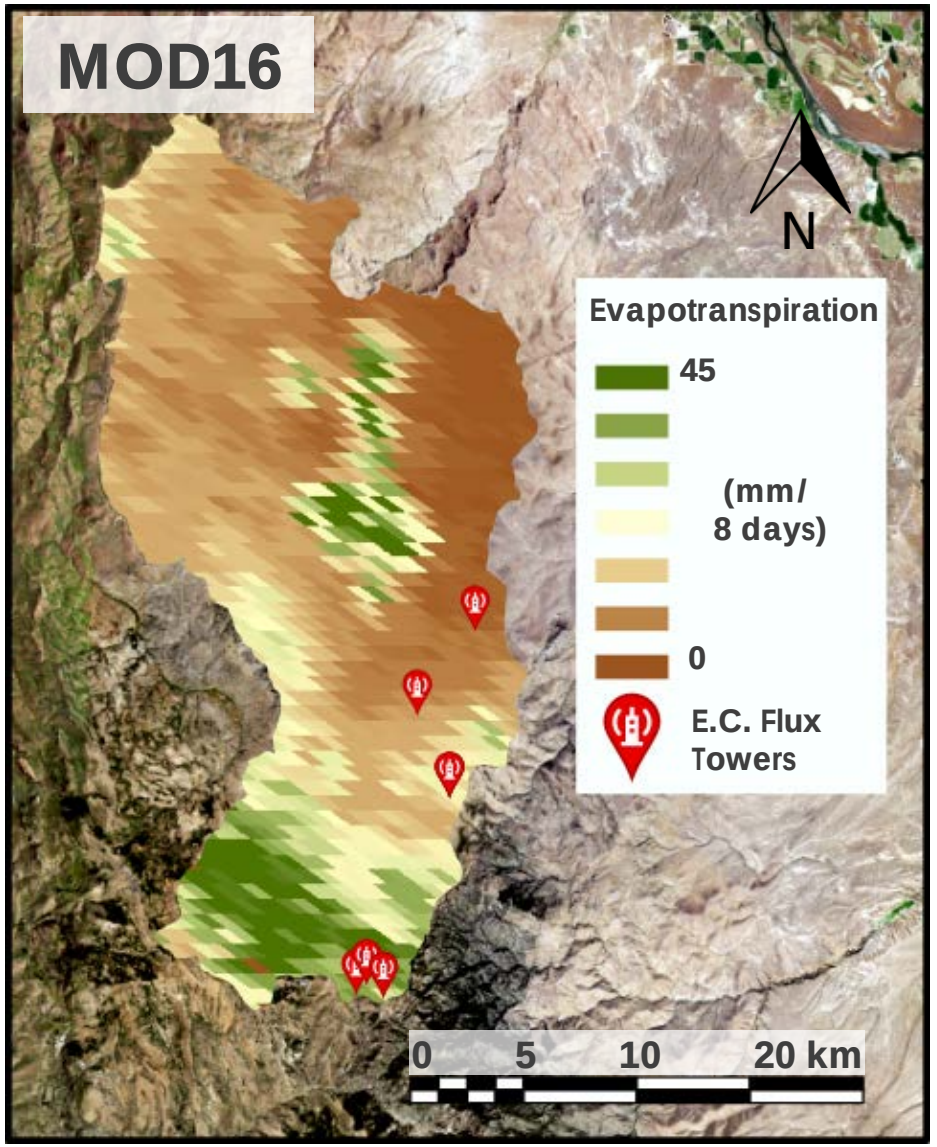




Results: MOD16





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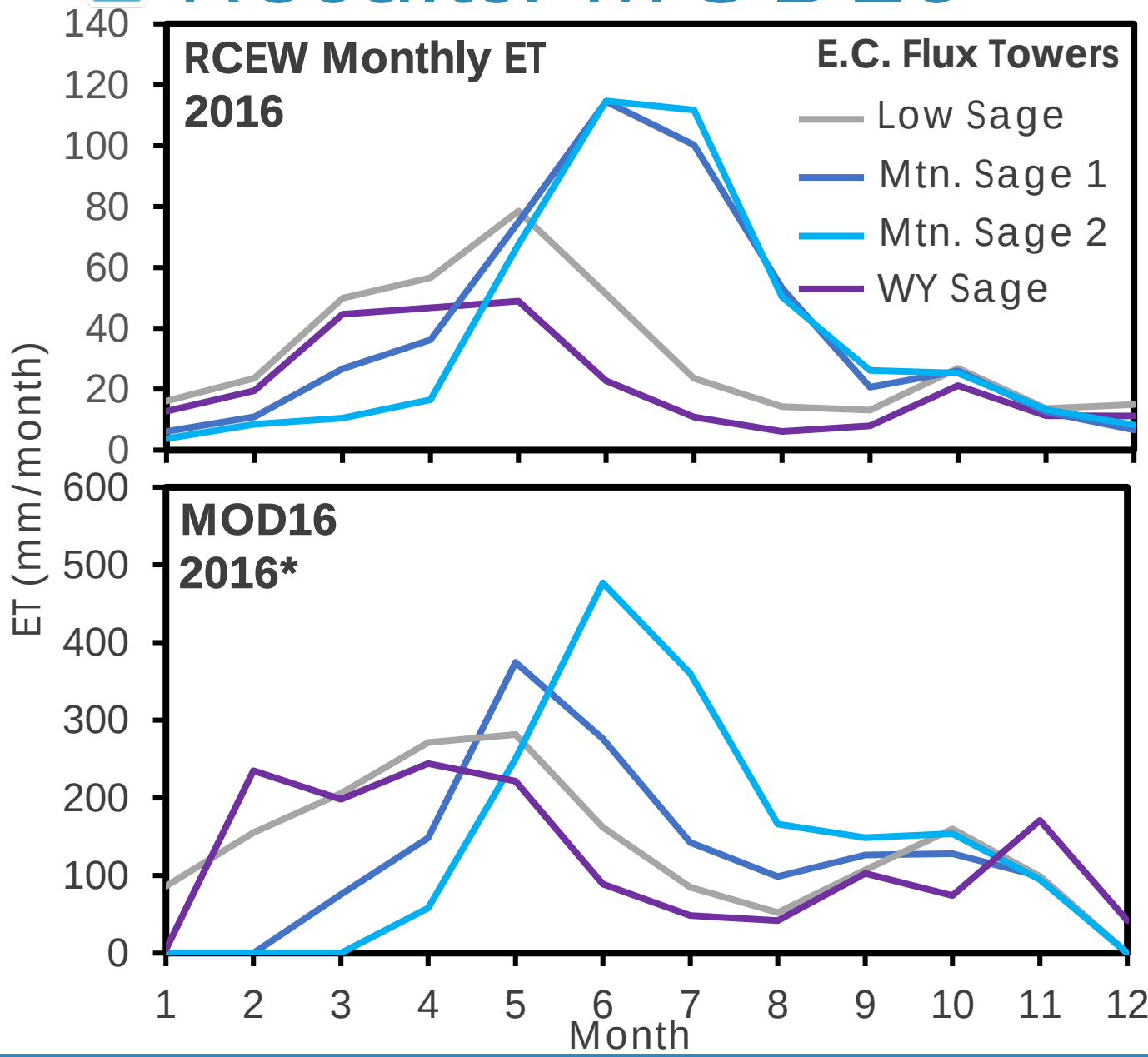
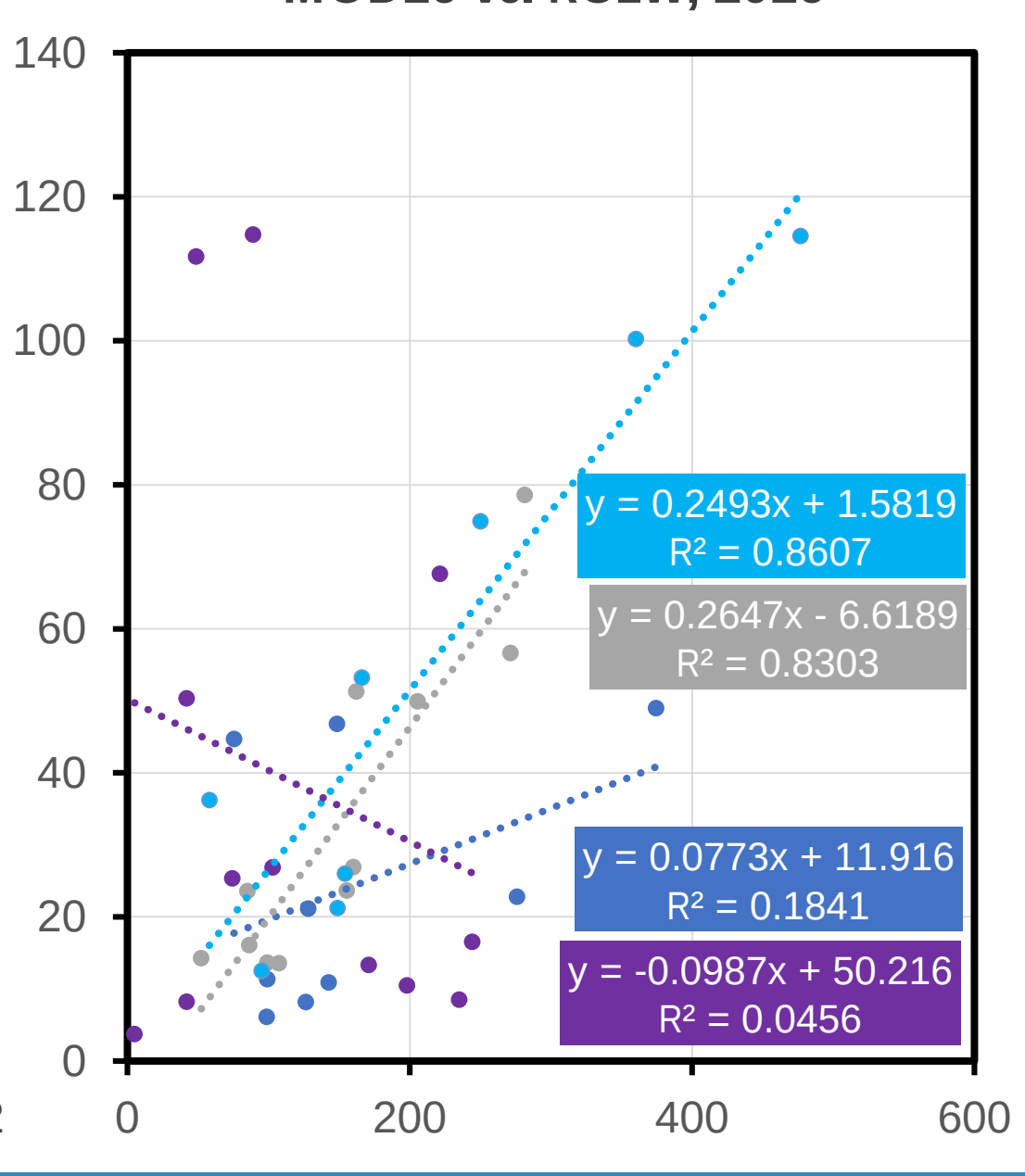
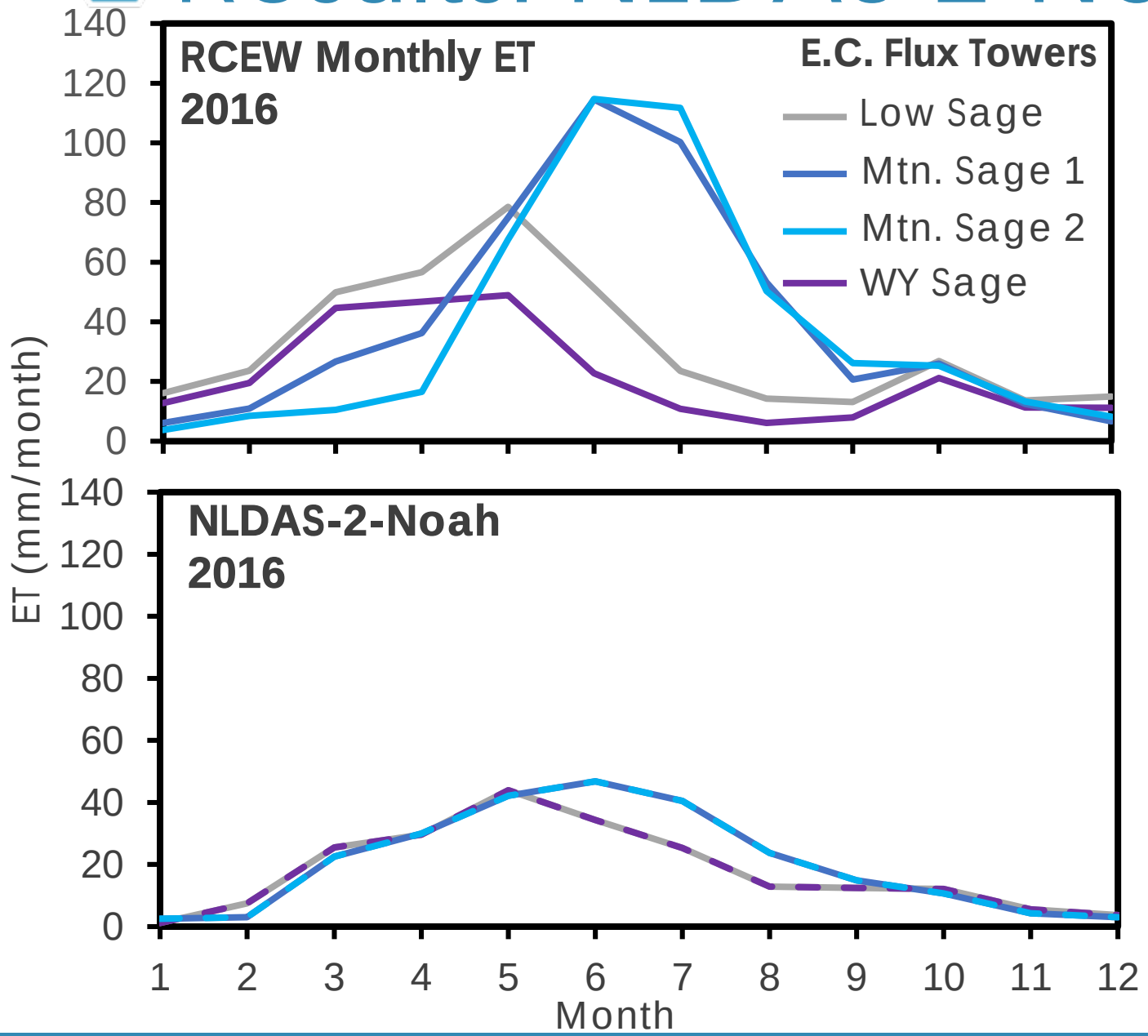
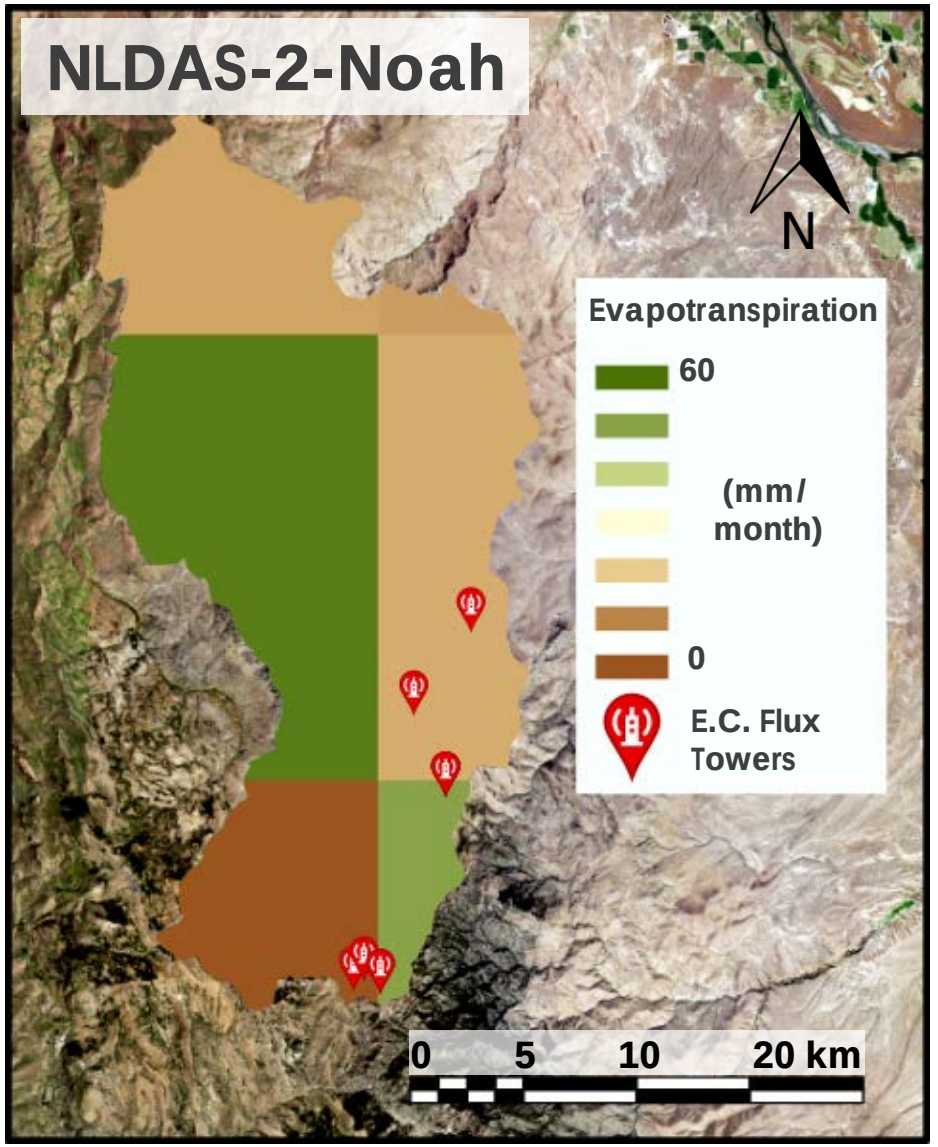




Results: NLDAS-2-Noah





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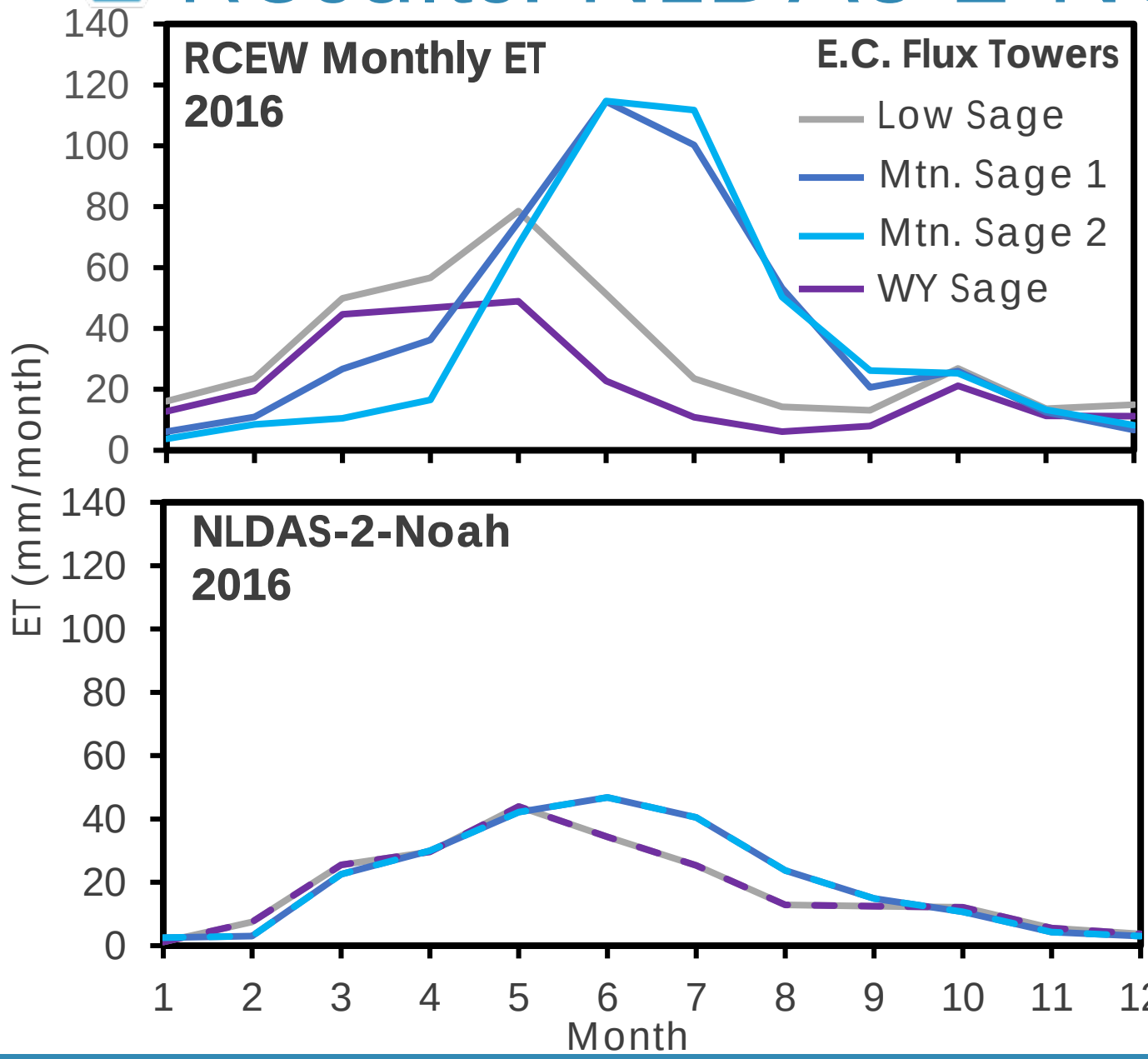

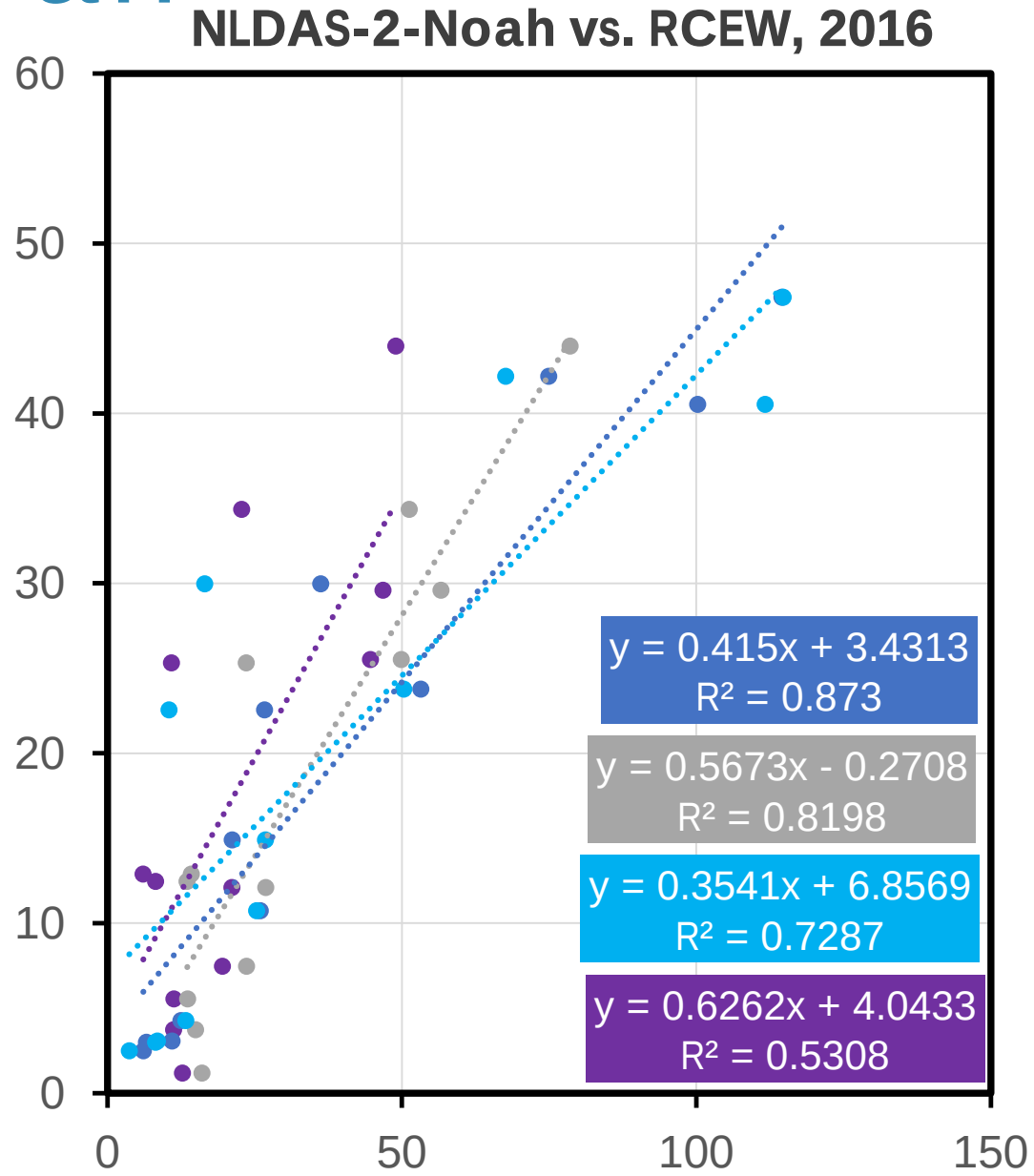

Results: Model Comparison

MODEL	PROS	CONS
SSEBop	▸ Easy to access/download data	▸ Underestimates ET ▸ Highly variable correlations depending on vegetation/elevation
EEFlux (METRIC)		
MOD16		
NLDAS		

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MOD16		
NLDAS		

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NLDAS		

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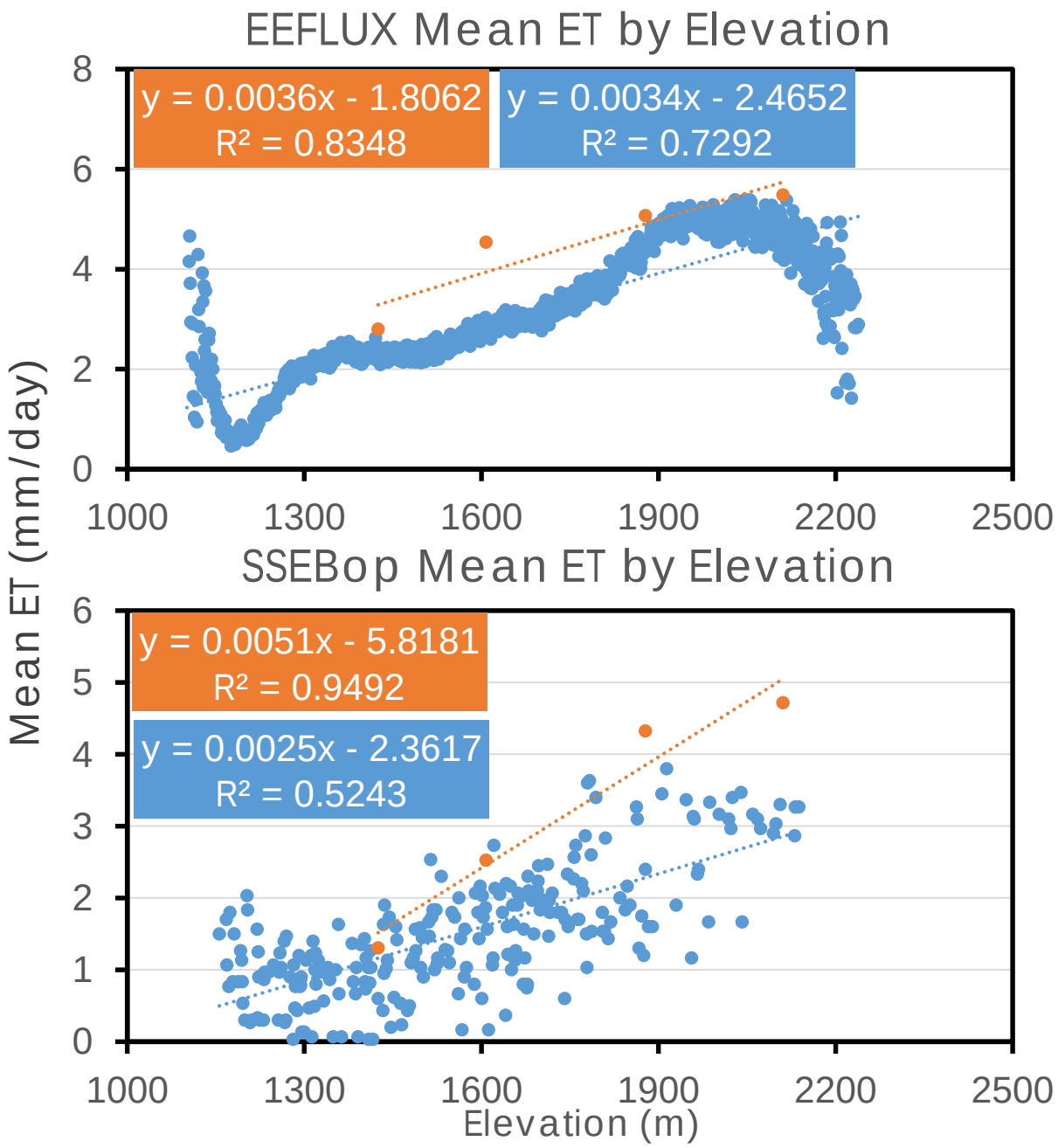
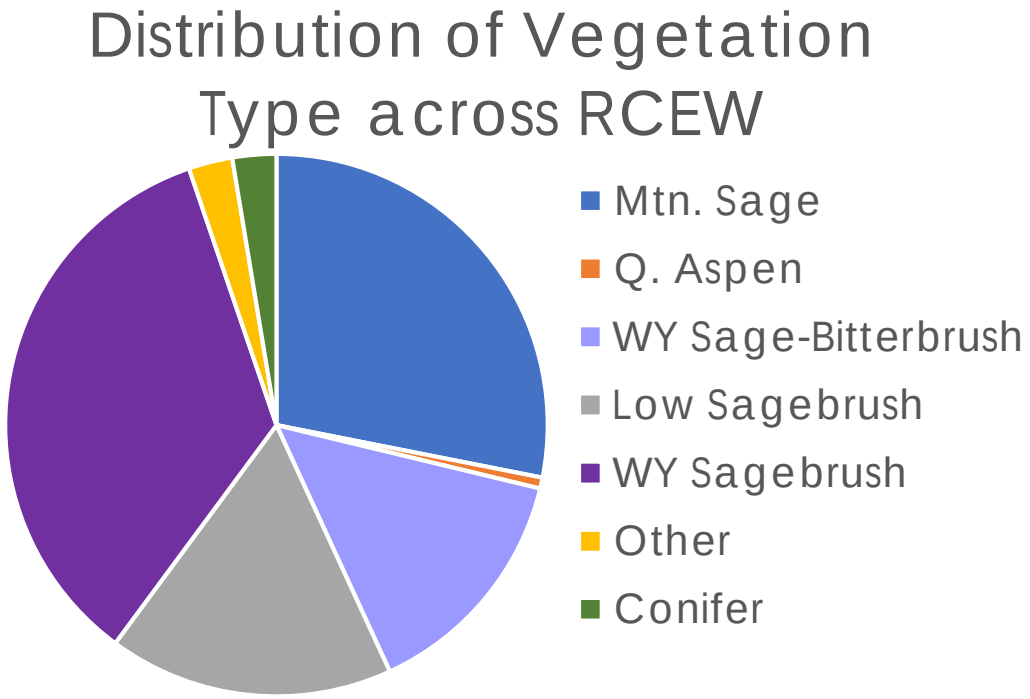
MOD16	▸ Fairly high spatial resolution	▸ Overestimates ET across the board
NLDAS	▸ Best correlations ▸ High temporal resolution	▸ Low spatial resolution ▸ Correlation may depend on availability of meteorological data

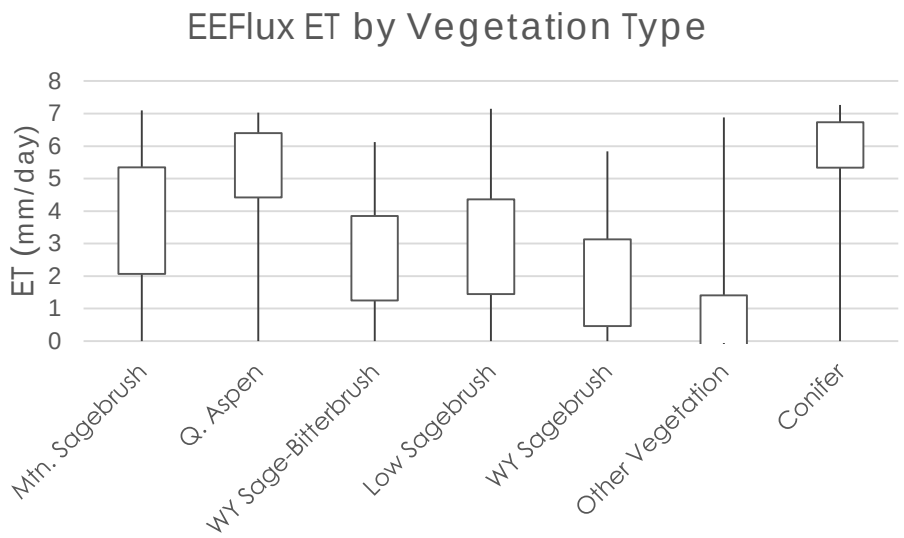
Results: Elevation

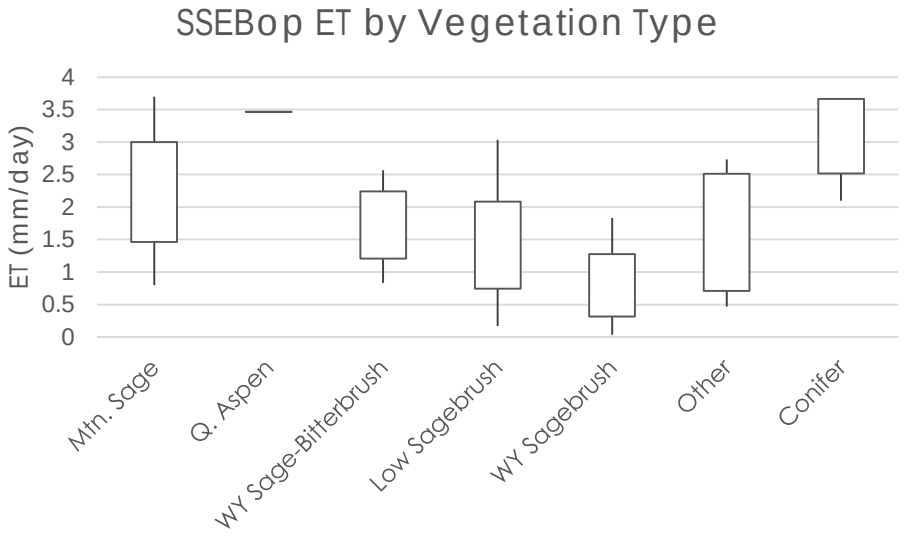
- EEFlux (METRIC)
  - EEFlux generally increases linearly with elevation from 1200-2000m
  - Low and high elevations show models sensitivity to plant type
  - Spatial resolution (30m) leads to greater sensitivity in elevation bins
- SSEBop
  - Linear increase in ET with elevation
  - Low sensitivity to different vegetation types at extremes of elevation, possibly due to spatial resolution (1000m)
- NLDAS-2 Noah
  - Not shown, spatial resolution is ~12km, containing a large range of elevations per pixel, too coarse for analysis



Results: Vegetation Type



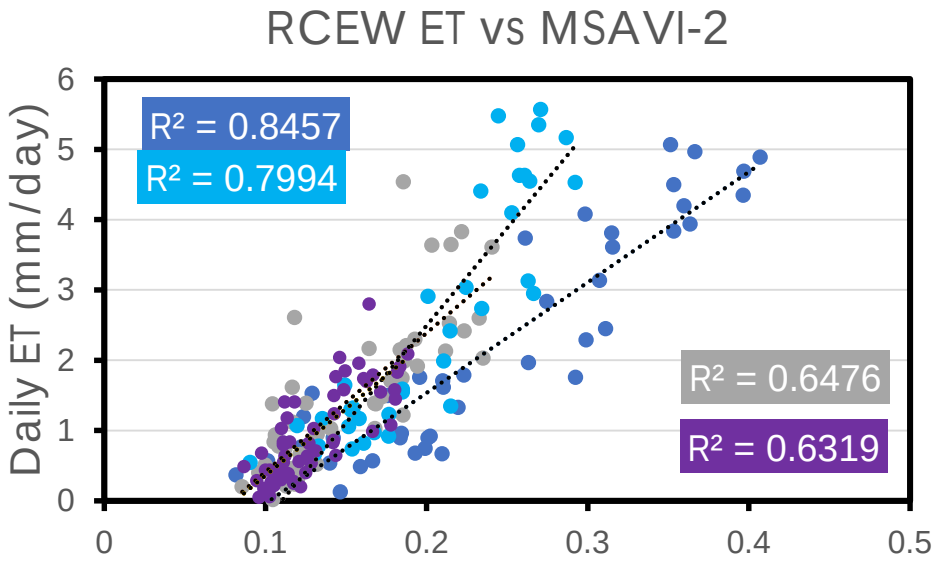


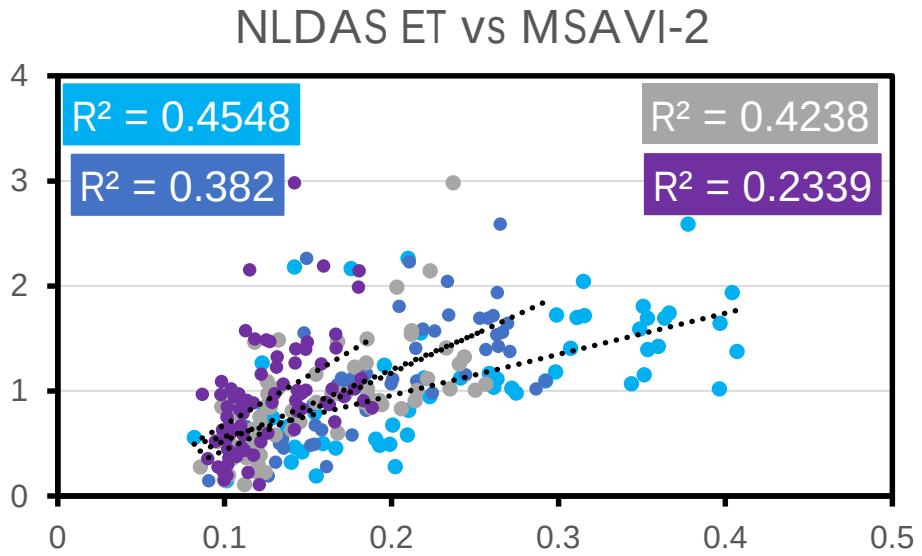


- Distribution of ET
  - Sagebrush types account for 94% of vegetation
  - Conifer and Aspen account for <4%
- ET by Vegetation Type
  - EEFlux, SSEBop, and MOD16 all showed similar trends in ET by vegetation type

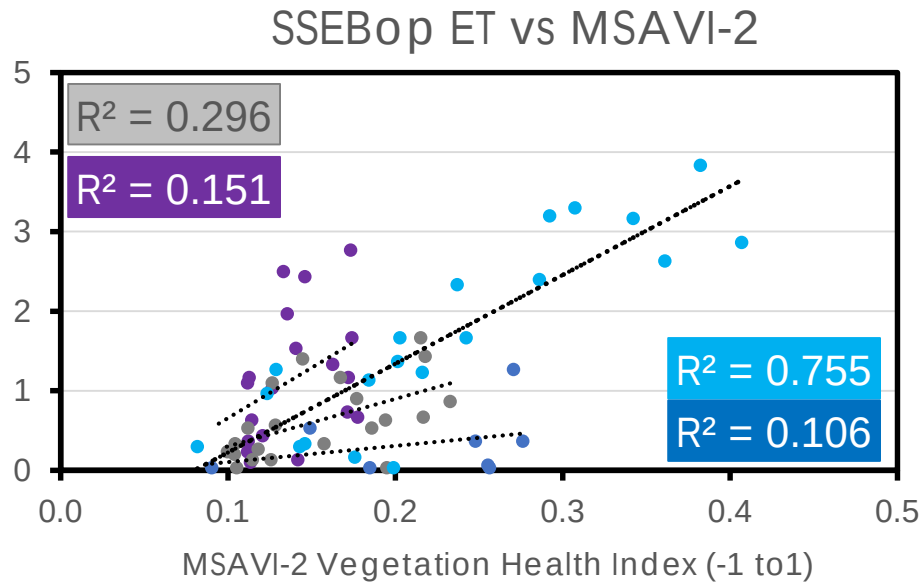
Results: Vegetation Health

- Mtn Sage 1
- Mtn Sage 2
- Low Sage
- WY Sage





- ET vs Vegetation Health
  - ET increased linearly with vegetation health in all 4 models and *in situ* data
  - Relationship is similar across sites, which vary in vegetation type, but are all dominated by varying species of sagebrush



Conclusions

- NLDAS-2 Noah was the best estimator of *in situ* ET measurements and had the best temporal resolution at 1 hr, but had the worst spatial resolution.
- Choose ET model based on the question you want to answer– Different spatial and temporal scales mean they would apply to different problems
- Sharpening high temporal resolution (NLDAS) data with high spatial resolution models (SSEBop, MOD16, or EEFlux) has the potential to be an ideal model


Image Credit: Reynolds Creek Experimental Watershed

Future Work

- Compare this term's ET model results to the Patagonia steppe in Argentina and apply a new model developed there to Idaho
- Evaluate the ability of Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) to measure ET in the semiarid sagebrush steppe

Acknowledgements

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- Brandon Crawford, Research Scientist

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Questions?