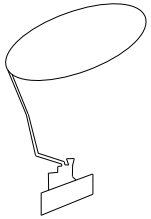

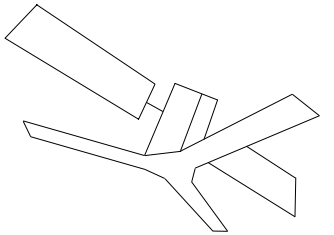

Using Cosmic-ray Neutron Sensors to Improve Satellite Soil Moisture

Is the Thermal to Fast Neutron Ratio Correction for the Effect of Vegetation on Cosmic-ray Neutron Sensors Independent of Crop Type?

Brian Hornbuckle, Kati Togliatti, Victoria Walker, Richard Cirone
Andy VanLoocke, Theo Hartman
Mike Cosh, Trenton Franz, Andy Suyker, Carl Bernacchi

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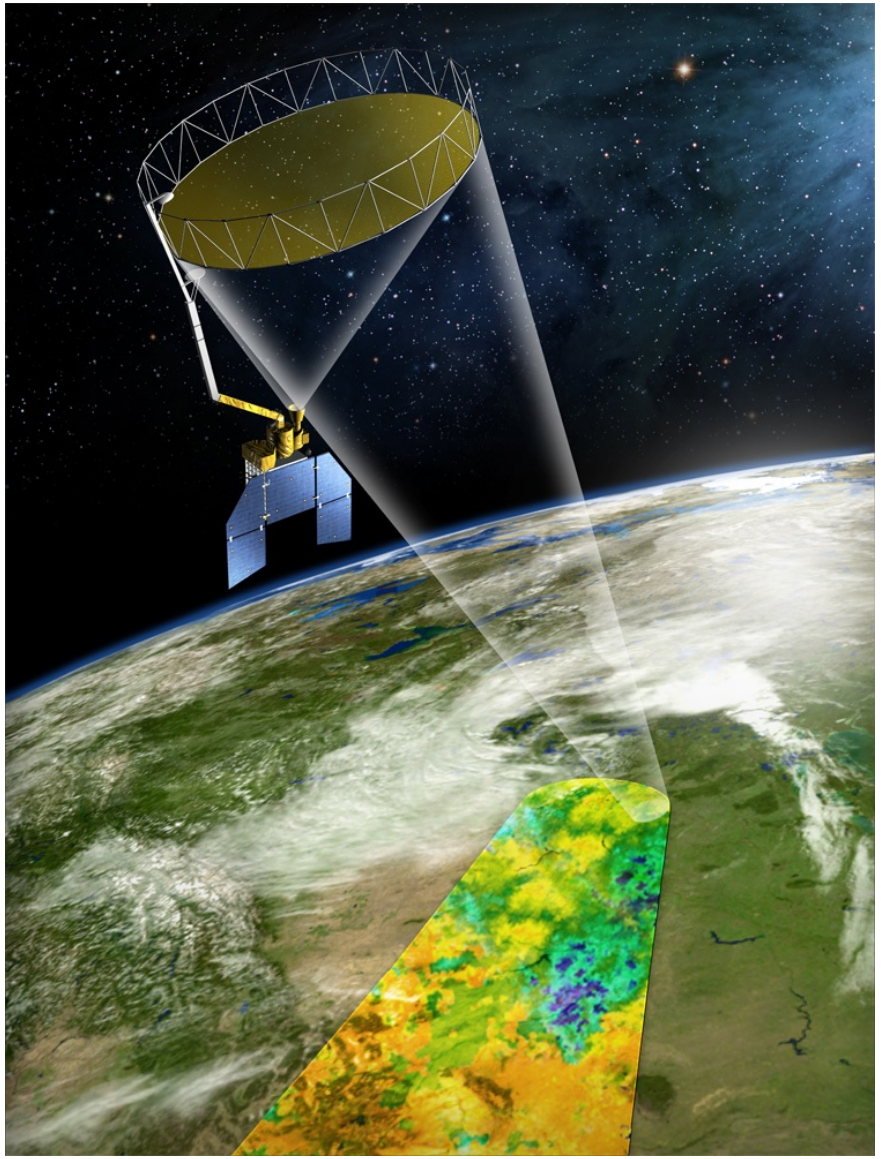
Use CRNS to Improve Satellite Soil Moisture



Soil Moisture Active Passive
(SMAP)
satellite mission

Launched January 31, 2015.

Observations of soil moisture:
volumetric water content
of soil at Earth's surface.

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Use CRNS to Improve Satellite Soil Moisture

European Space Agency

Soil Moisture and Ocean Salinity (SMOS) satellite mission

Launched in late 2009.

Observations of soil moisture: volumetric water content of soil at Earth's surface.

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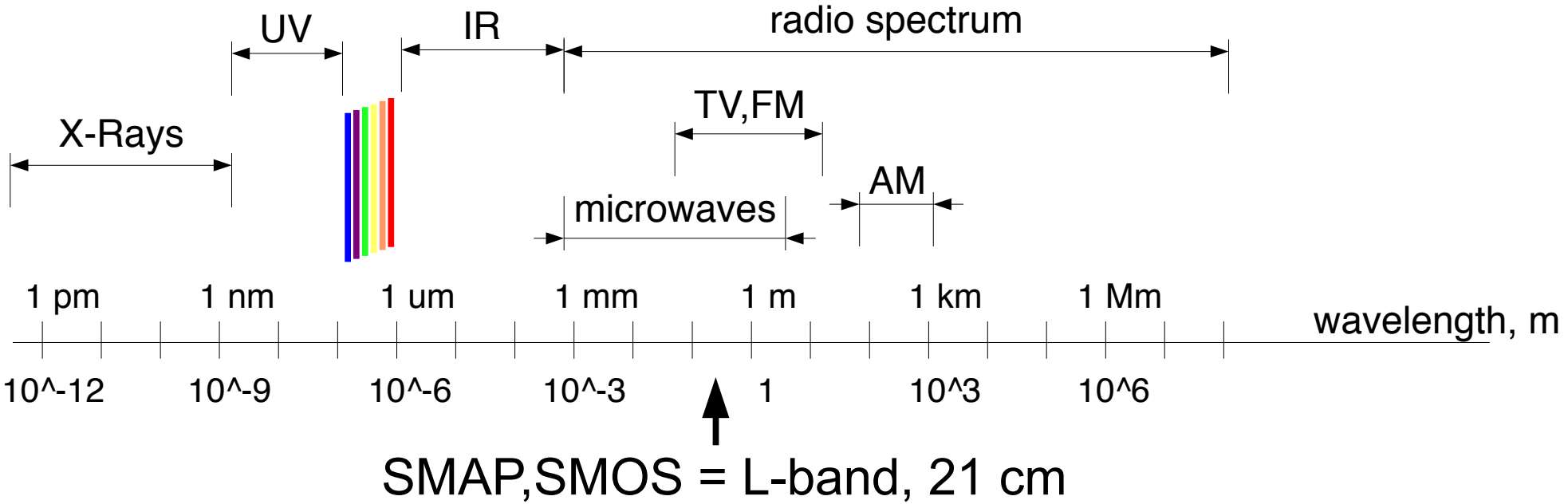

Microwaves: *longer wavelengths* than visible, infrared!

Consequence: vegetation canopy *semi-transparent.*

Main point: microwave remote sensing can "see through" vegetation, into the soil.

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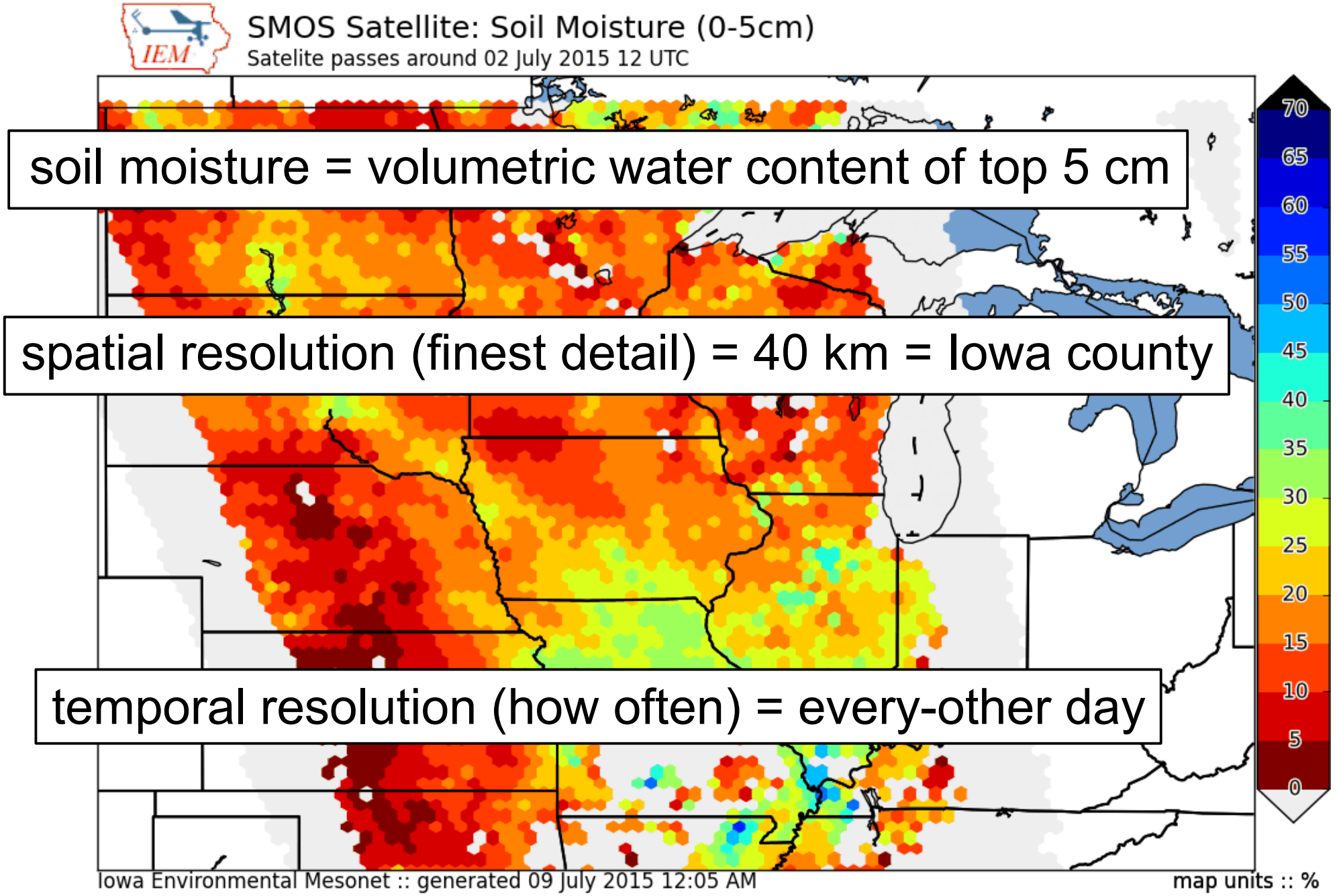

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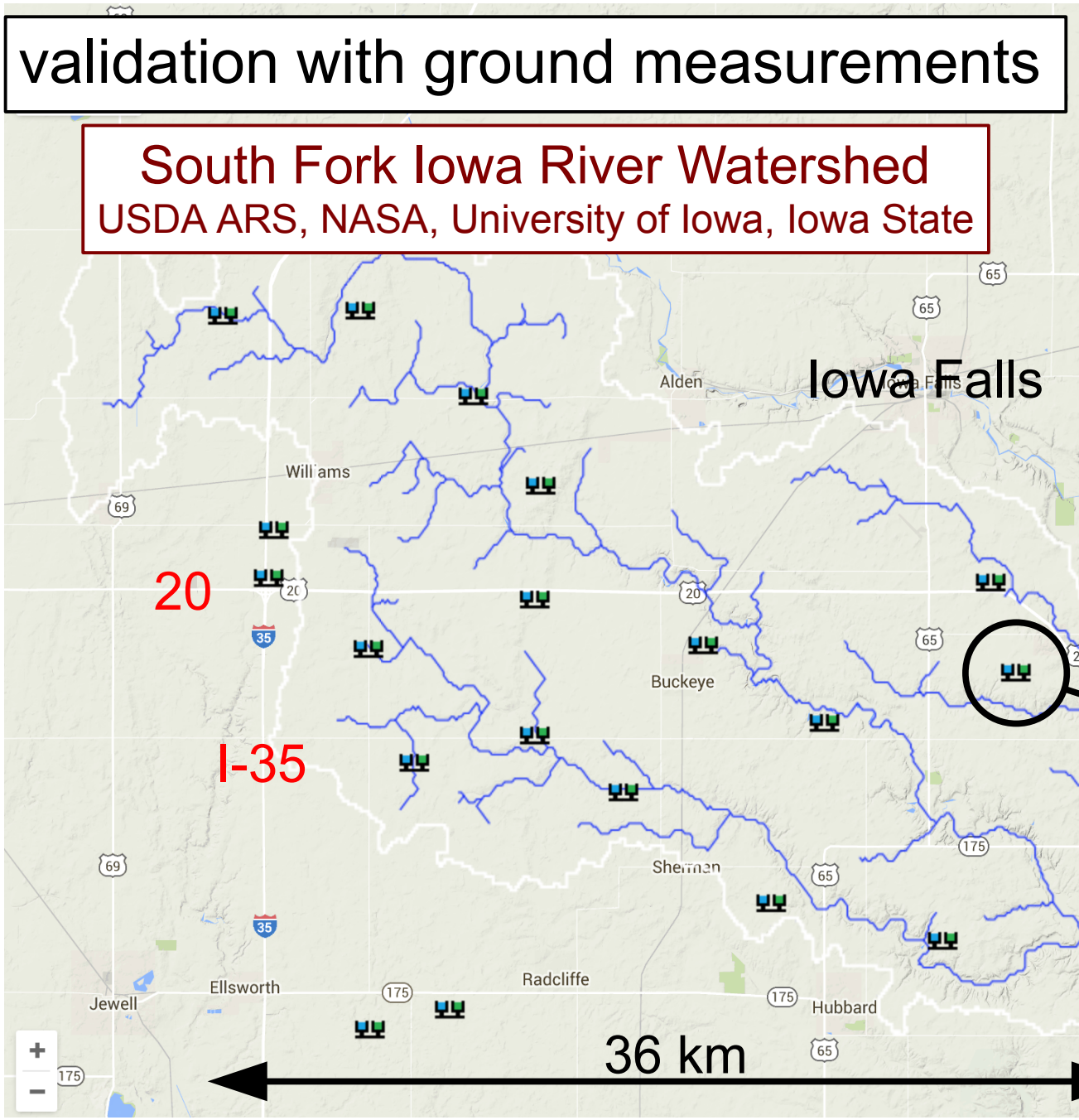
Use CRNS to Improve Satellite Soil Moisture

validation with ground measurements

South Fork Iowa River Watershed

USDA ARS, NASA, University of Iowa, Iowa State



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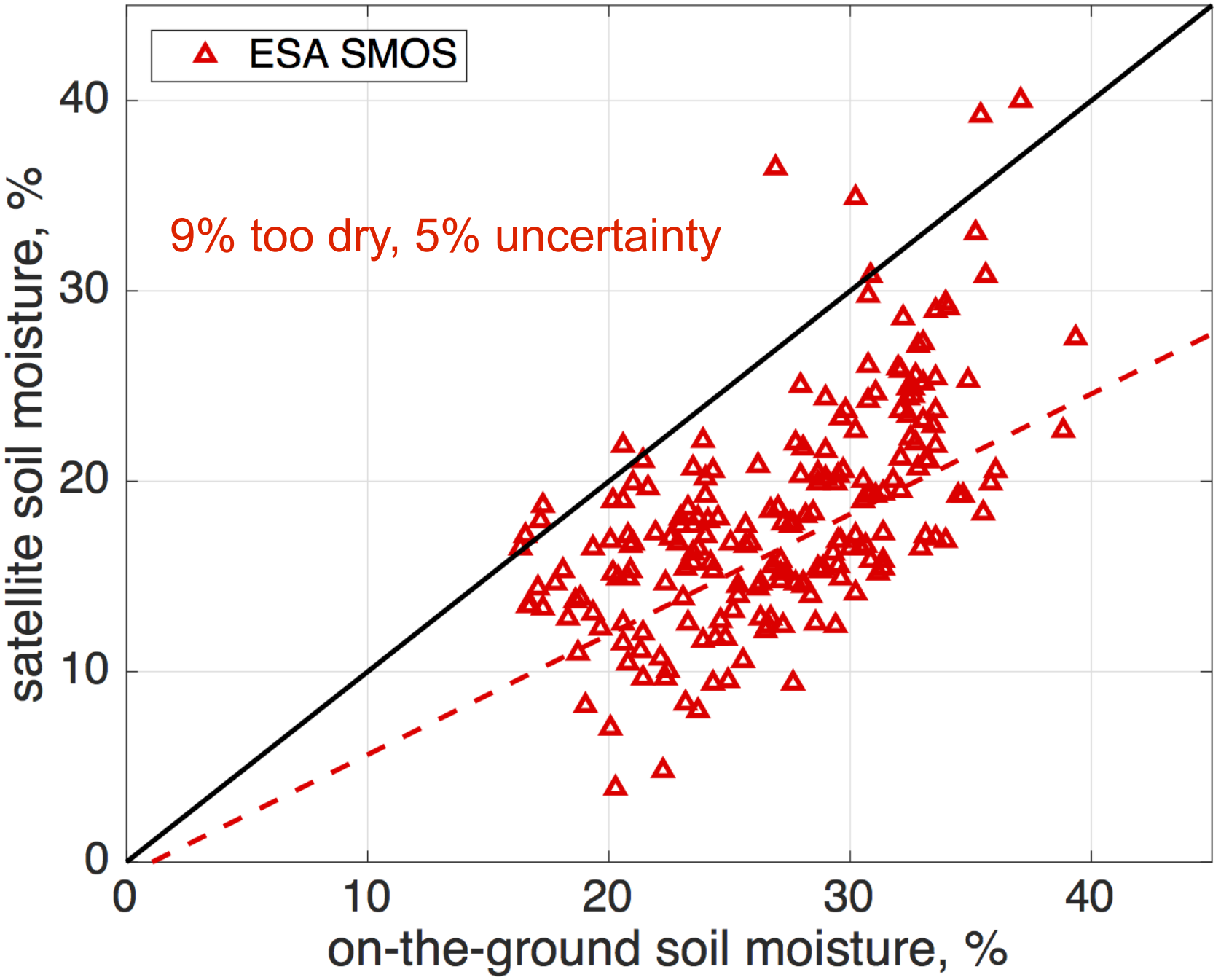

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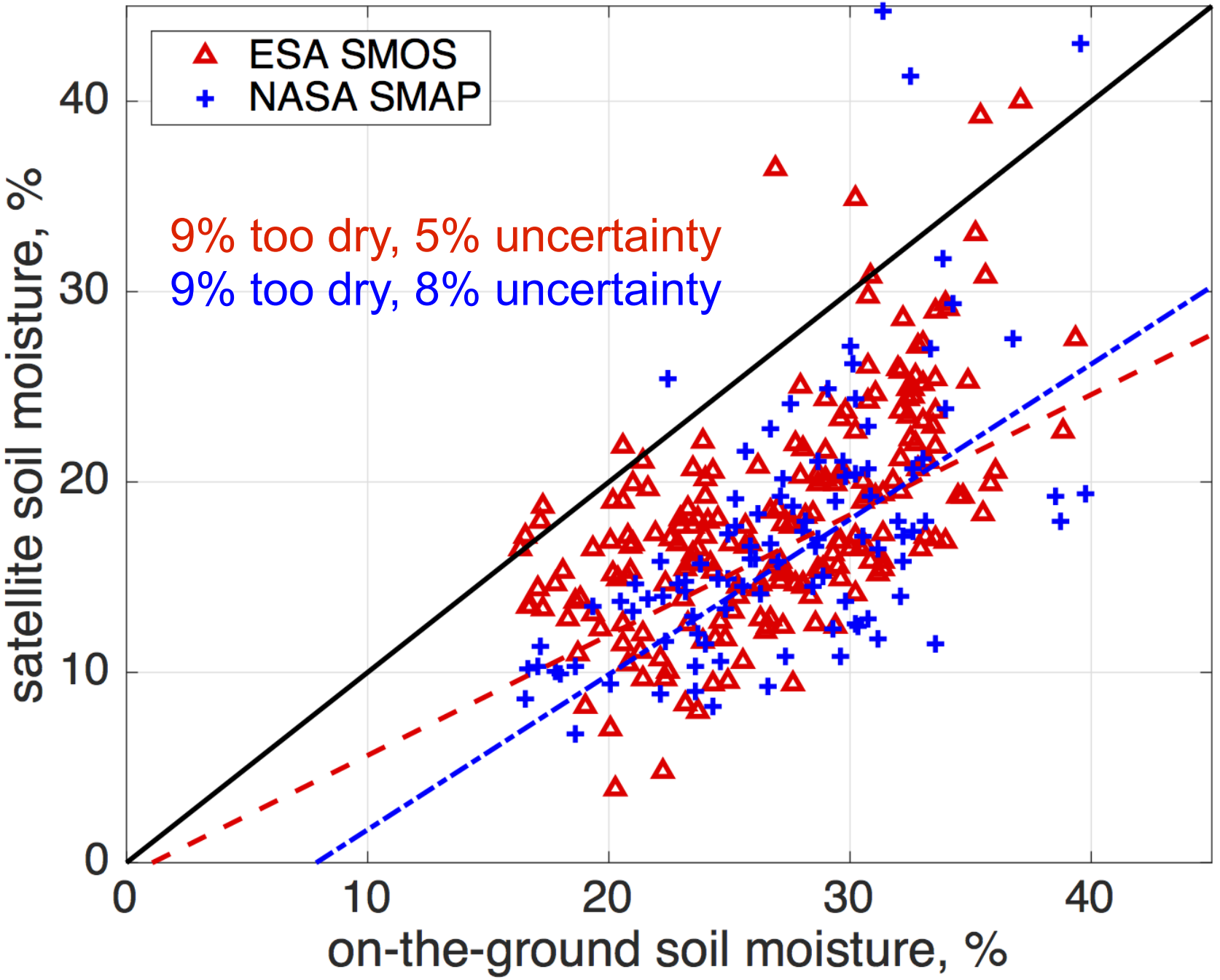

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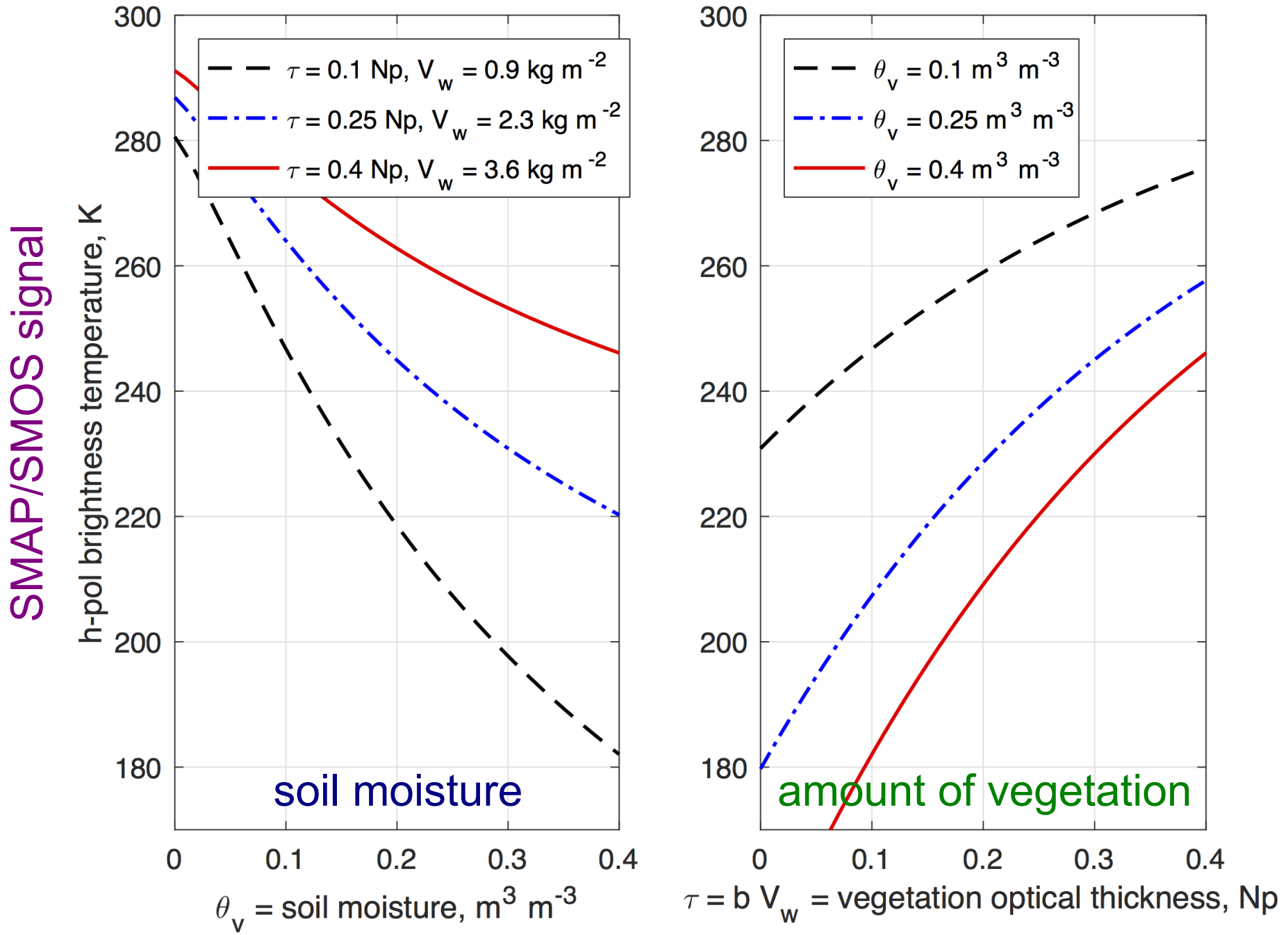

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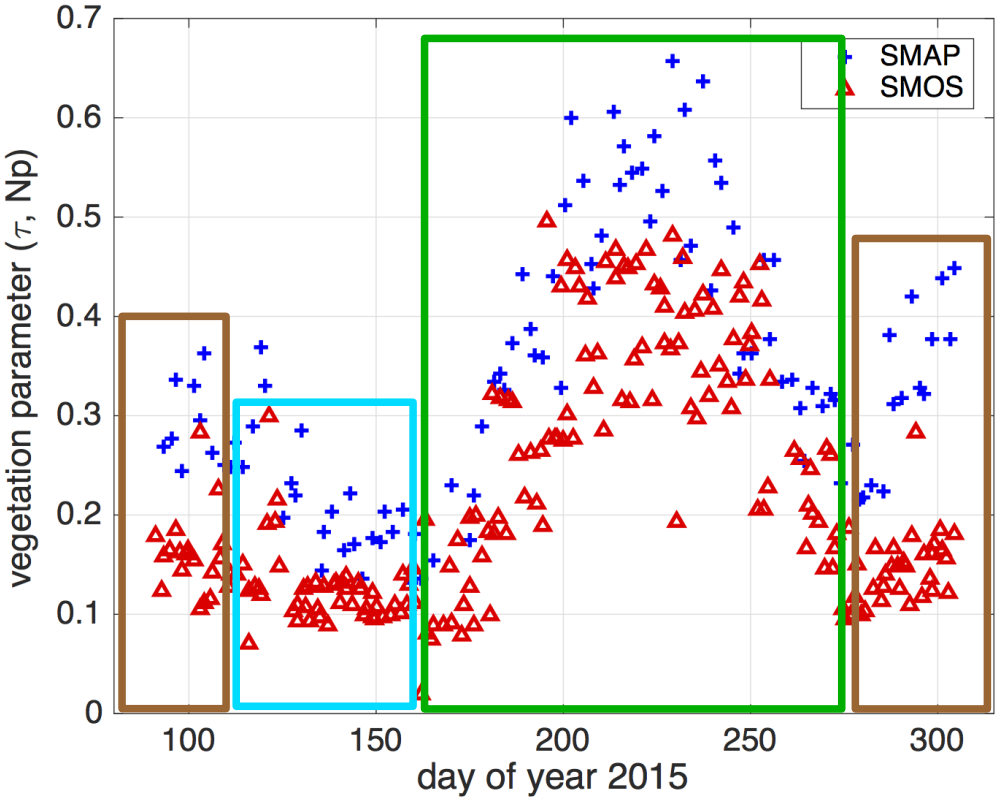
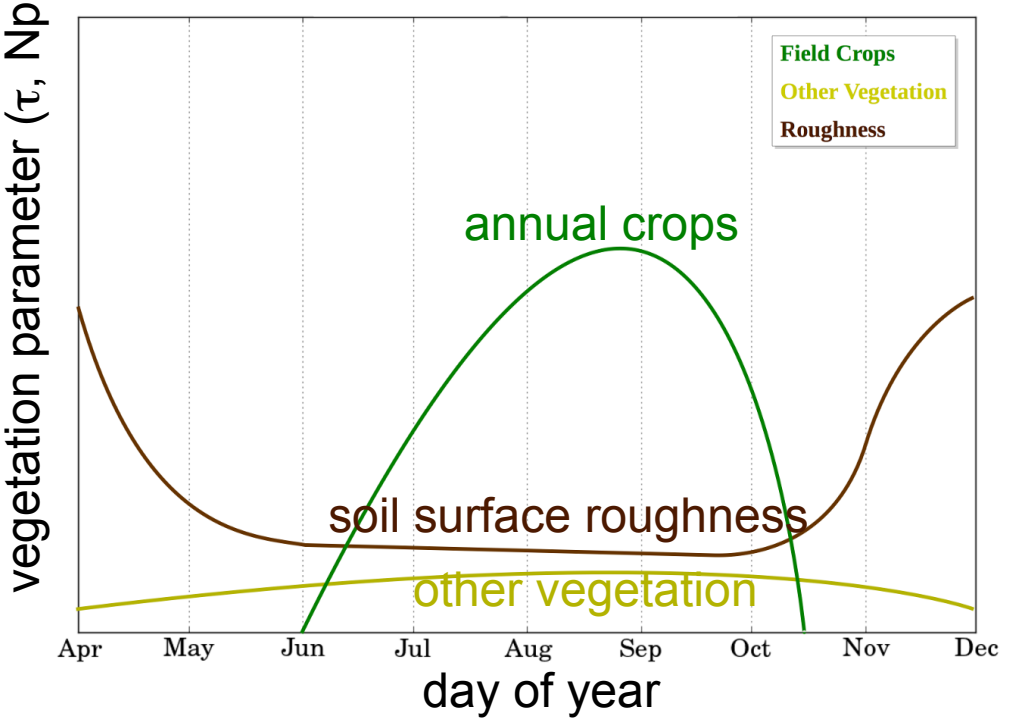
Use CRNS to Improve Satellite Soil Moisture

vegetation parameter (τ, Np)



conceptual understanding of vegetation parameter (τ, Np)



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Use CRNS to Improve Satellite Soil Moisture

Problem: SMAP/SMOS are too dry in agricultural areas.

Hypothesis: Algorithms are not correctly accounting for the effects of vegetation and soil surface roughness.

Need: quantification of pixel-scale vegetation, roughness.

Issues: SMAP/SMOS τ parameter is a combination of vegetation and soil surface roughness.

SMAP/SMOS pixels are large in size and there is significant heterogeniety.

Satellite vegetation indices don't directly measure τ!

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Use CRNS to Improve Satellite Soil Moisture

cosmic ray neutron sensor = hydrogen detector

Element	A	σ_{sc}	NC	ξ	SP	C
H	1.0079	22.02	18	1.000	22.016	—
O	15.9994	4.232	149	0.120	0.508	487 875
C	12.011	5.551	113	0.158	0.875	87 638
Si	28.0855	2.167	257	0.070	0.151	281 367
Na	22.9898	3.28	211	0.085	0.277	23 206
Ca	40.078	2.83	364	0.049	0.139	70 963
Al	26.9815	1.503	247	0.072	0.109	58 015
Fe	55.847	11.62	505	0.035	0.411	28 980
Mg	24.305	3.71	223	0.080	0.297	13 436
K	39.0983	1.96	355	0.050	0.099	19 137

Zreda et al., 2012, HESS Discussions

hydrogen: water in soil, also water (and dry matter) in vegetation

CRNS are NOT sensitive to soil surface roughness!

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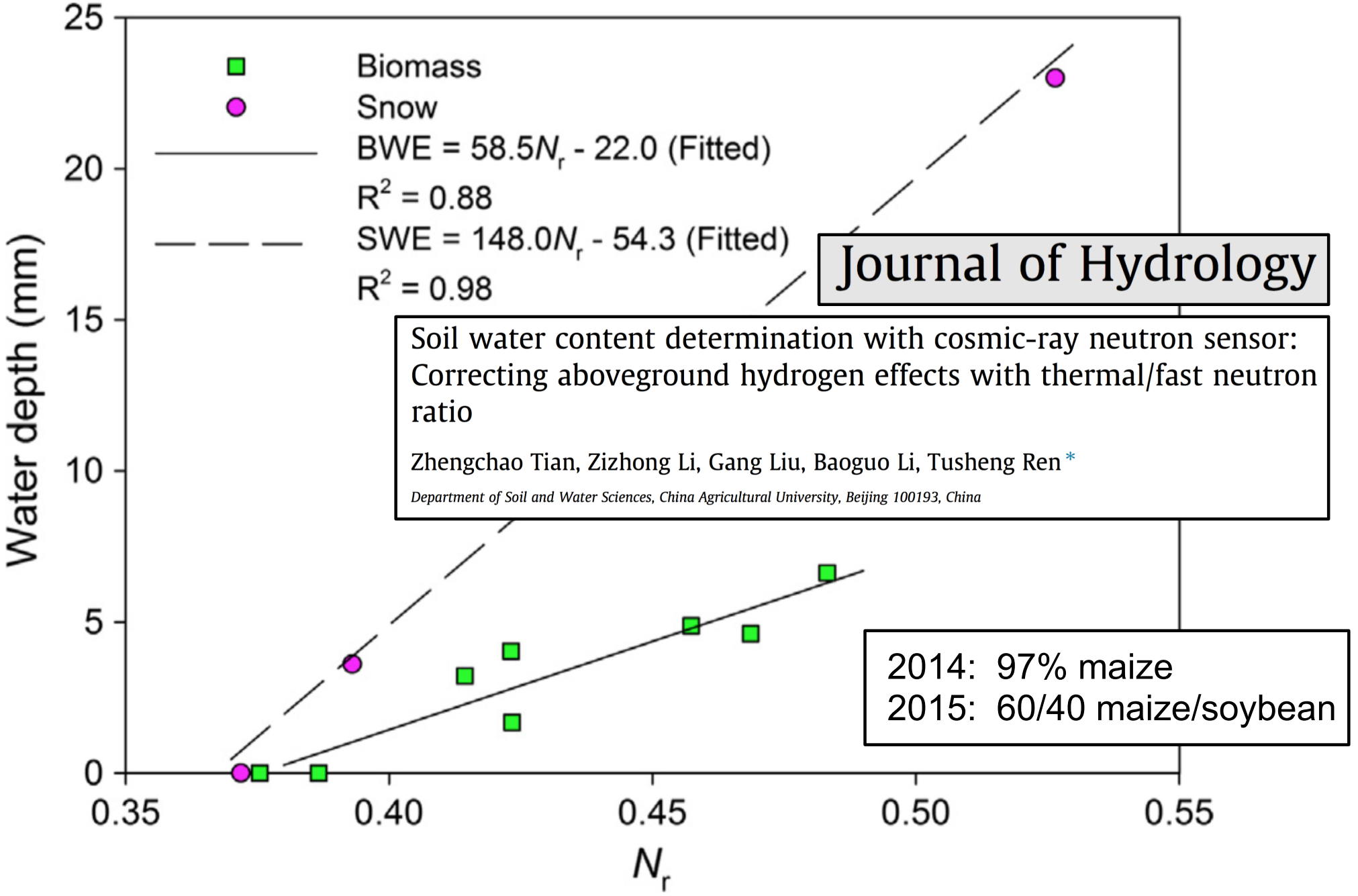

Journal of Hydrology

Soil water content determination with cosmic-ray neutron sensor: Correcting aboveground hydrogen effects with thermal/fast neutron ratio

Zhengchao Tian, Zizhong Li, Gang Liu, Baoguo Li, Tusheng Ren *

Department of Soil and Water Sciences, China Agricultural University, Beijing 100193, China

2014: 97% maize
2015: 60/40 maize/soybean

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Use CRNS to Improve Satellite Soil Moisture

Strategy:

SMAP/SMOS τ at 1-km^2, fixed location

- calibrate CRNS vegetation water with in-situ sampling
- convert to SMAP/SMOS τ
- sub-daily observations

SMAP/SMOS τ at 1-km^2, across SMAP/SMOS pixels

- calibrate satellite vegetation indices to CRNS footprint
- weekly/bi-monthly observations

Agricultural sites identified in Iowa, Nebraska, Illinois.
Multiple years of data already collected via COSMOS.

Will work best early in growing season (remember wavelength issue).

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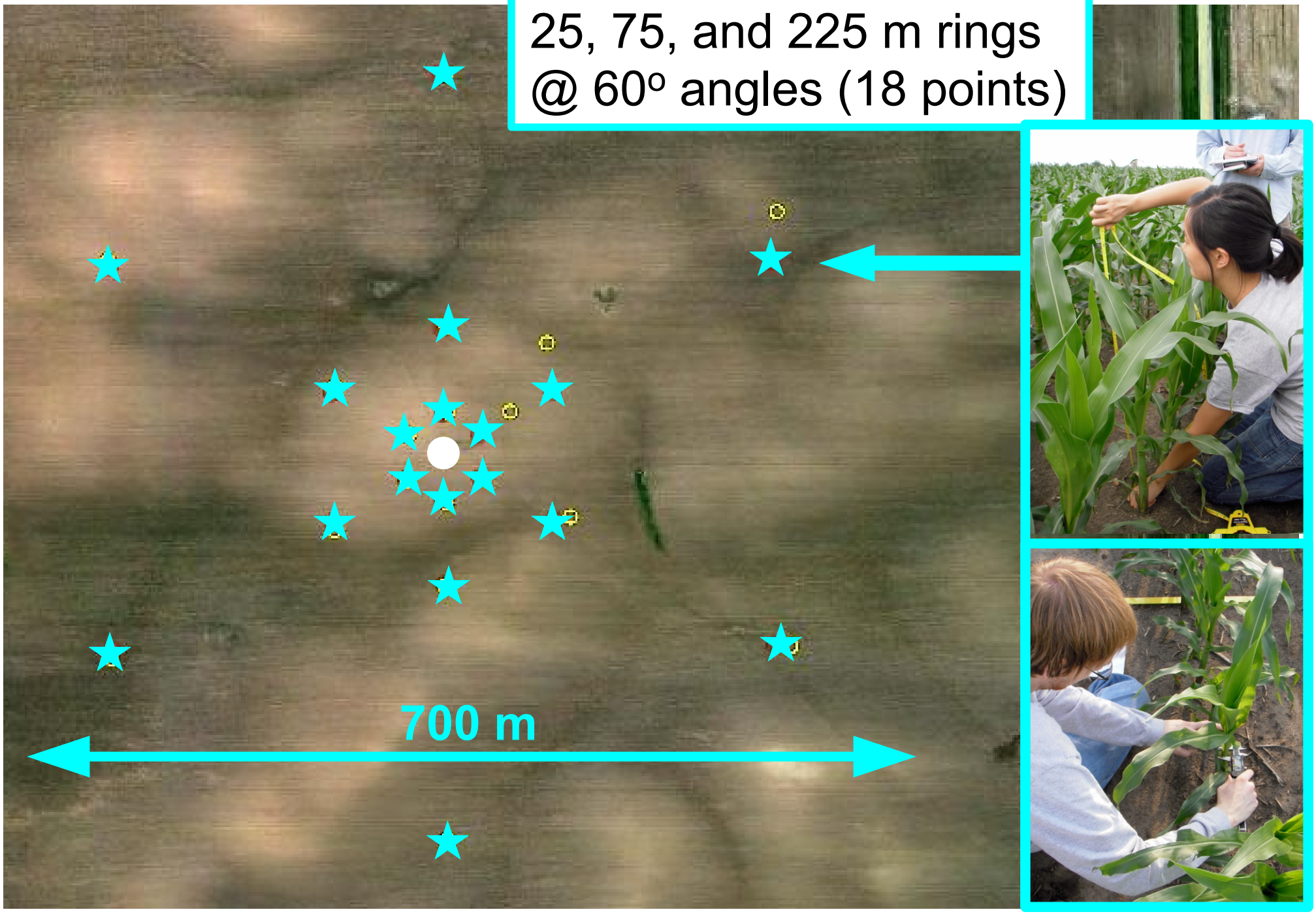
Use CRNS to Improve Satellite Soil Moisture

25, 75, and 225 m rings
@ 60º angles (18 points)



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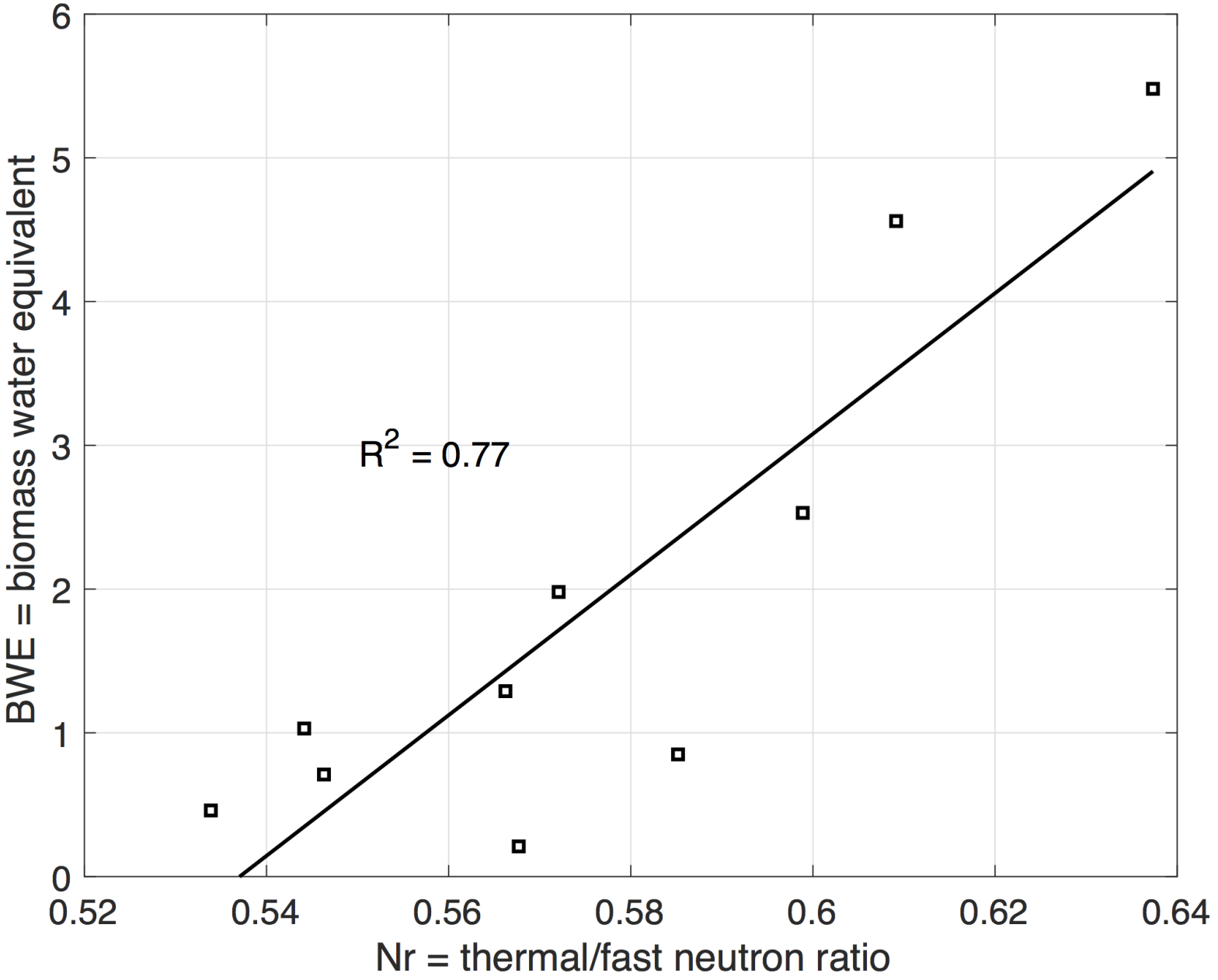

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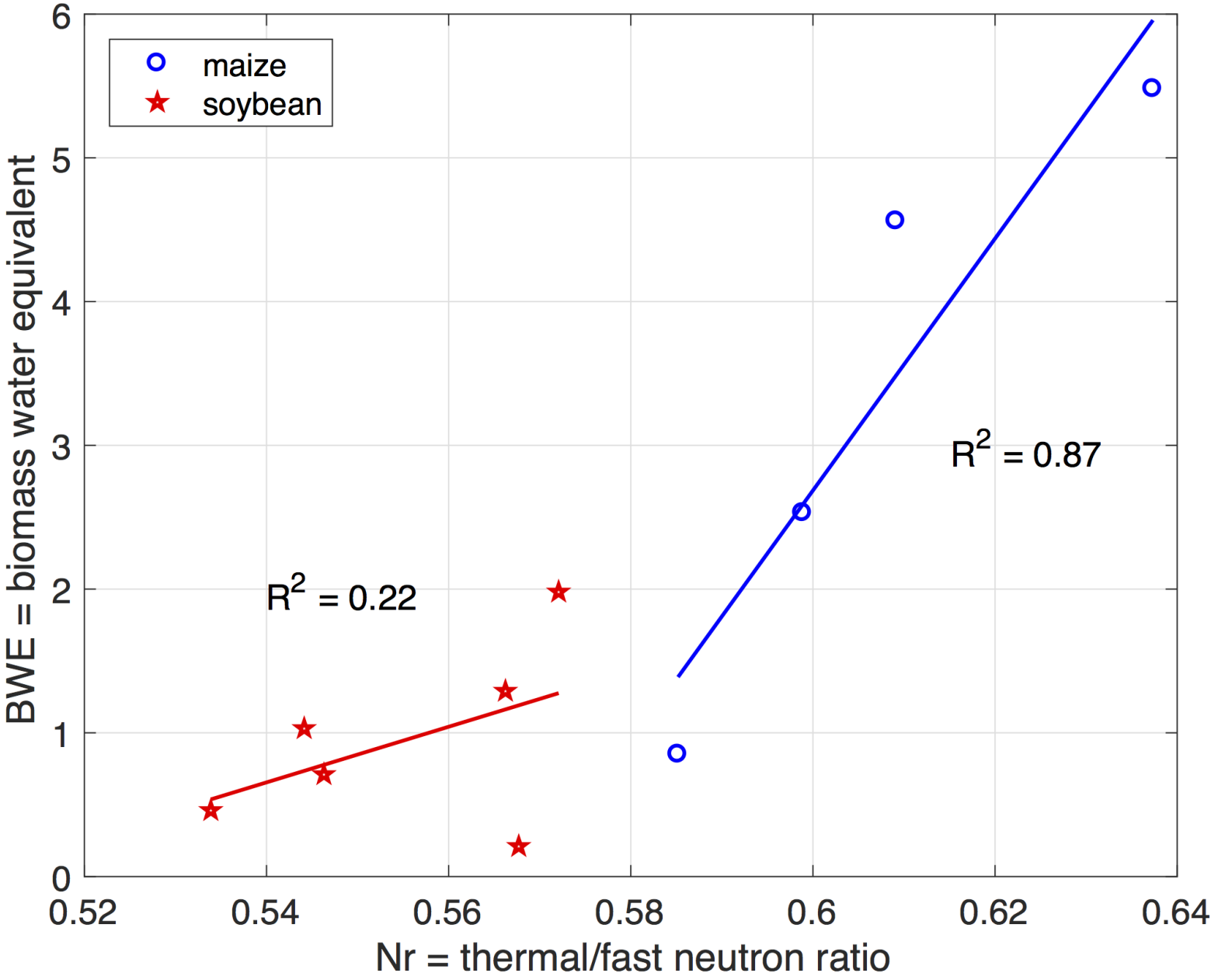

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Use CRNS to Improve Satellite Soil Moisture

Is the thermal to fast neutron ratio correction for the effect of vegetation on cosmic-ray neutron sensors independent of crop type?

Possibly... but more, careful validation that accounts for all pools of hydrogen (including residue and roots) is needed.

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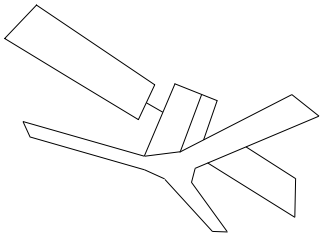

Summary:

Satellite soil moisture is too dry in agricultural areas.

Hypothesis: vegetation and soil surface roughness not accounted for correctly in retrieval algorithms.

Challenges: large, heterogeneous satellite pixels.

Strategy: use CRNS measurements, which are sensitive to vegetation but not roughness, to calibrate satellite vegetation indices that can capture heterogeniety.

Issues: must account for all pools of hydrogen (soil water, vegetation water, and dry matter) within CRNS footprints.