Estimating irrigated areas from satellite and model soil moisture data over the contiguous US

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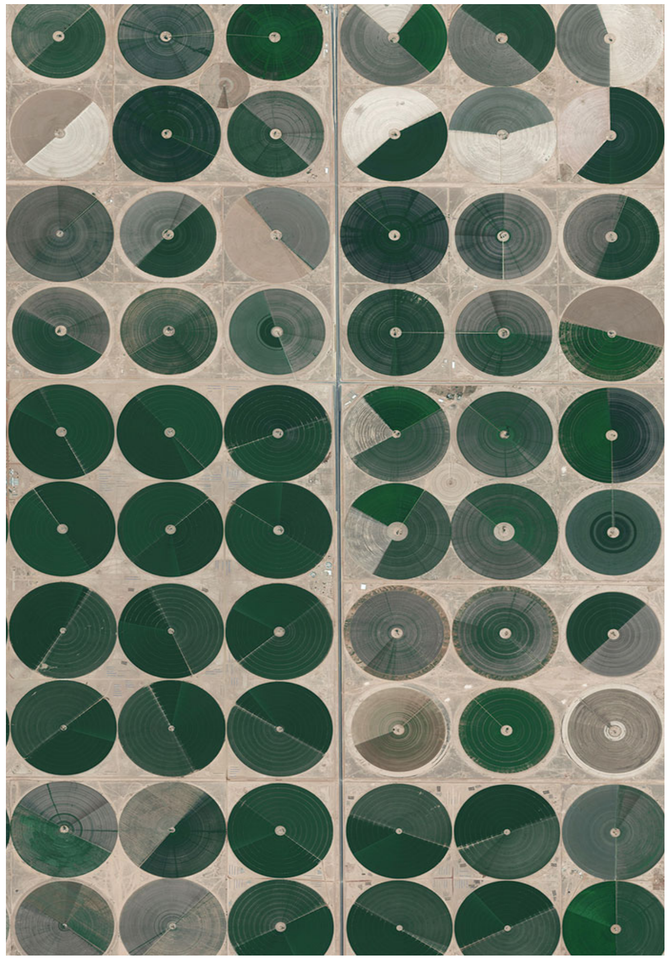
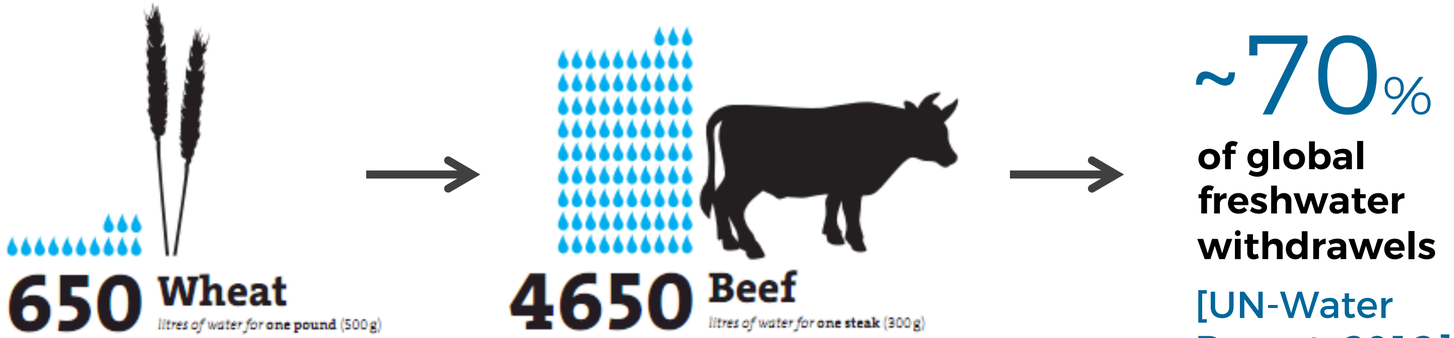
Why study Irrigation?



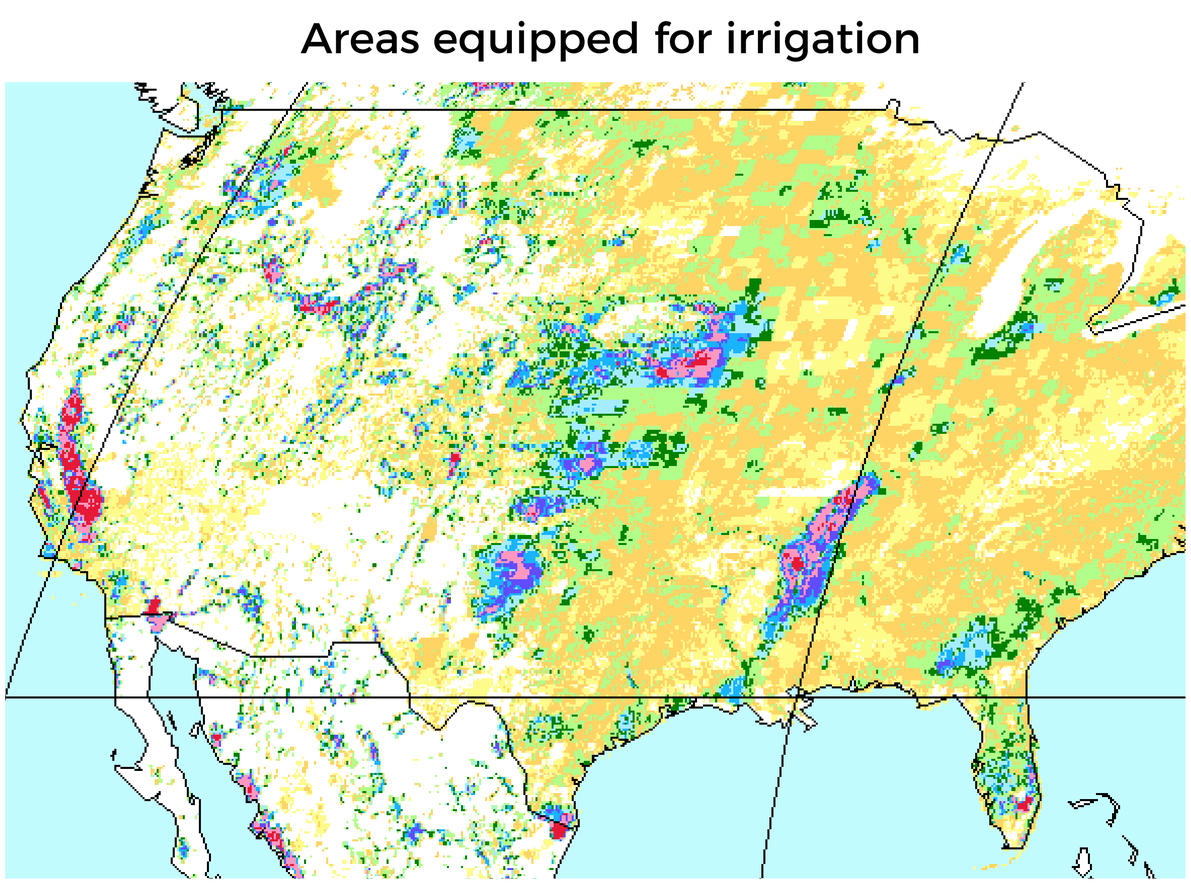


~70%
of global freshwater withdrawels
[UN-Water Report, 2012]

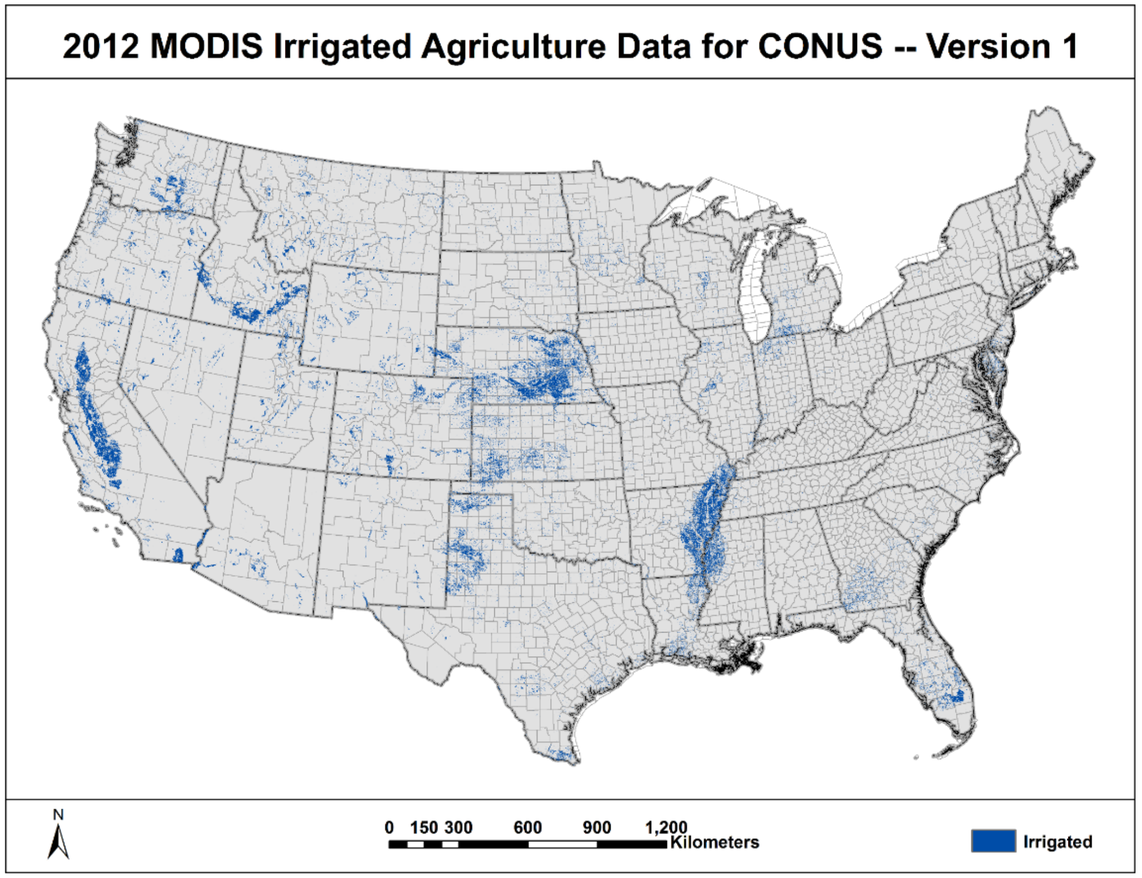
Data valuable for:

- Water-Footprinting, Drought management
- Yield management, Crop monitoring
- Land-Atmosphere interaction → Land Surface Models
- Future Climate Projections

Past Research (I)



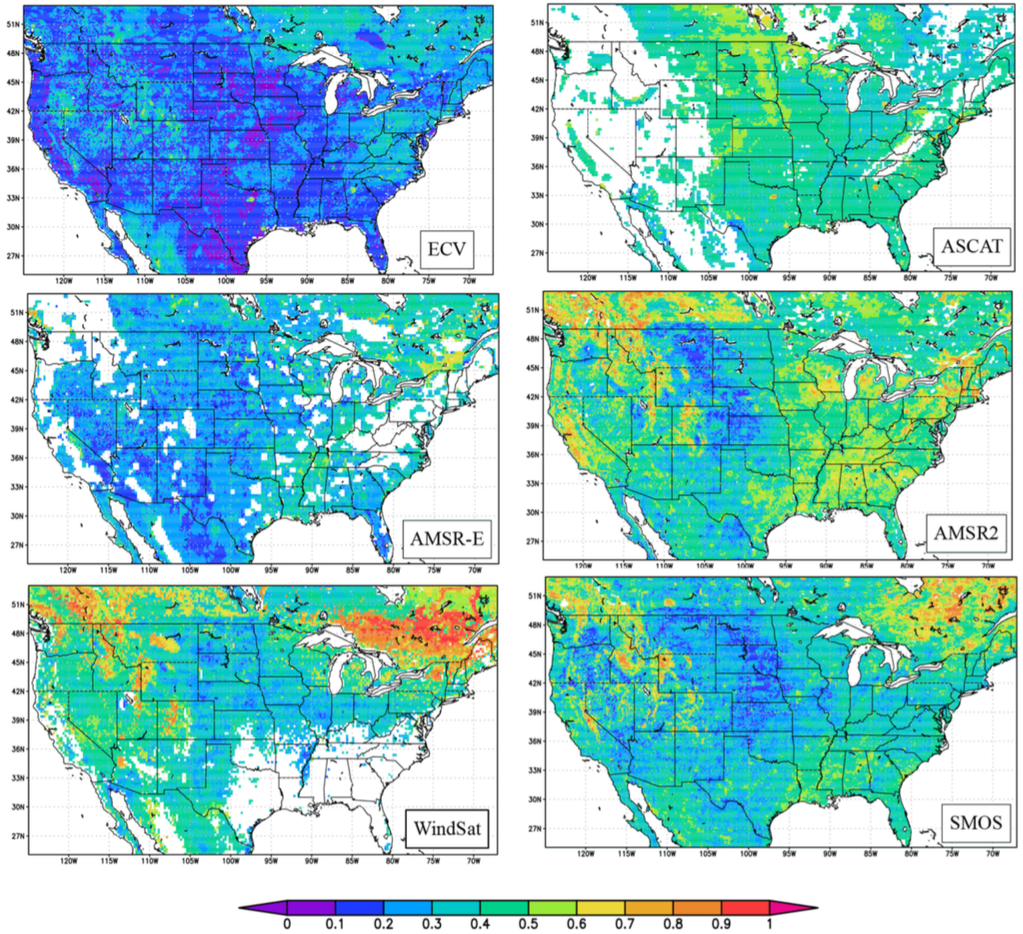
[Siebert et al., Aquastat, 2013]



[Pervez, M.S. and Brown, J.F., 2010. Remote Sensing]

Past Research (II)

- K-S distance from the comparison of soil moisture distributions
- idea of confronting satellite and model soil-moisture data
- spared out agricultural statistics, moving towards a more physical relationship



[Kumar et al., 2015. *Hydrol. Earth Syst. Sci*]

From Research Question to Hypothesis

Is it possible to derive irrigated areas directly from soil moisture?

↓

Spatial patterns of irrigation can be derived from

temporal soil moisture variations

of modelled and remotely sensed time series data.

Assuming that:

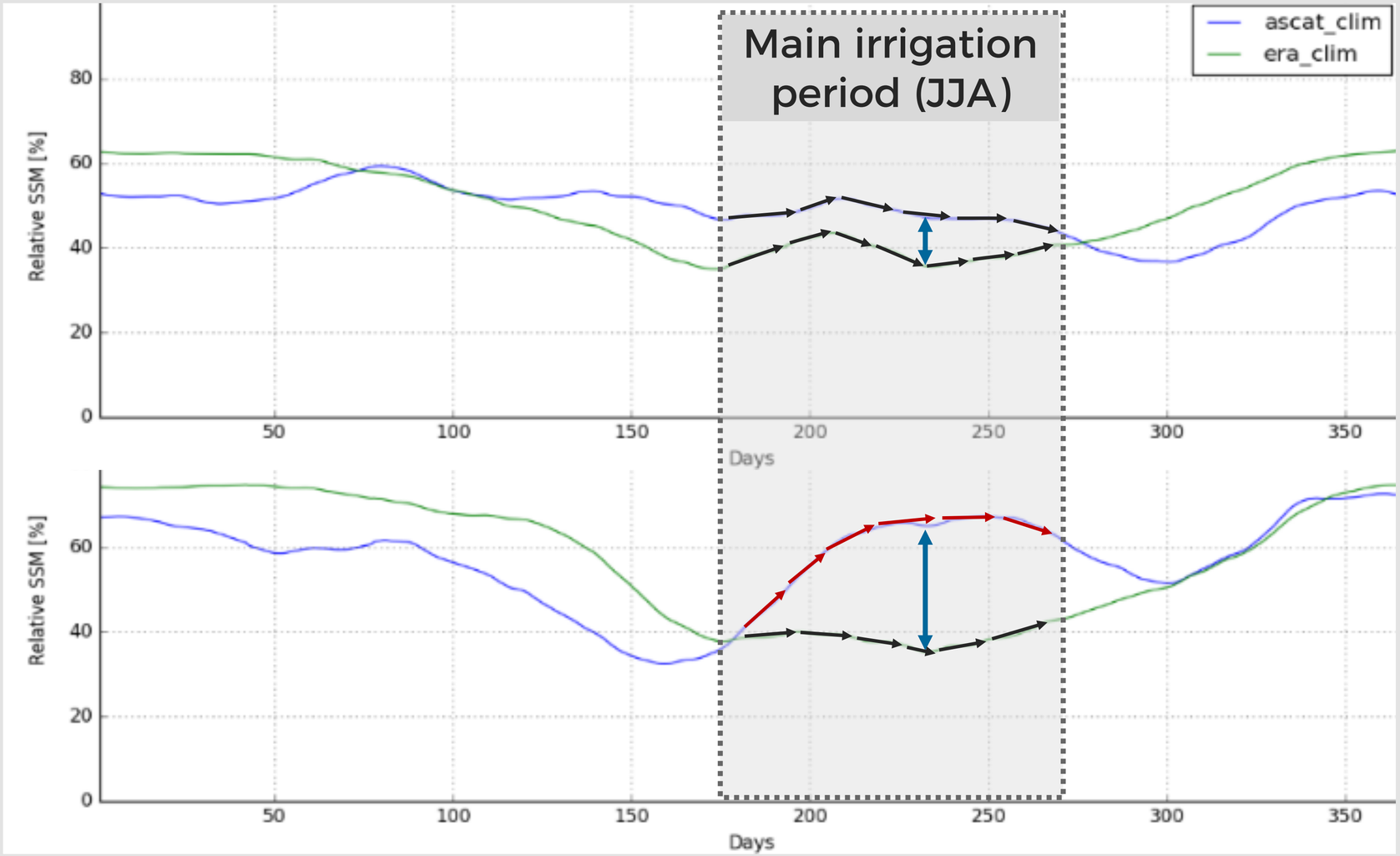
1. Irrigation is NOT modelled in the LSM, nor contributing to forcing data
2. yet IS affecting the remotely sensed observations

Motivation: Pixel-level Observations

Cropland

Non-irrigated

Irrigated

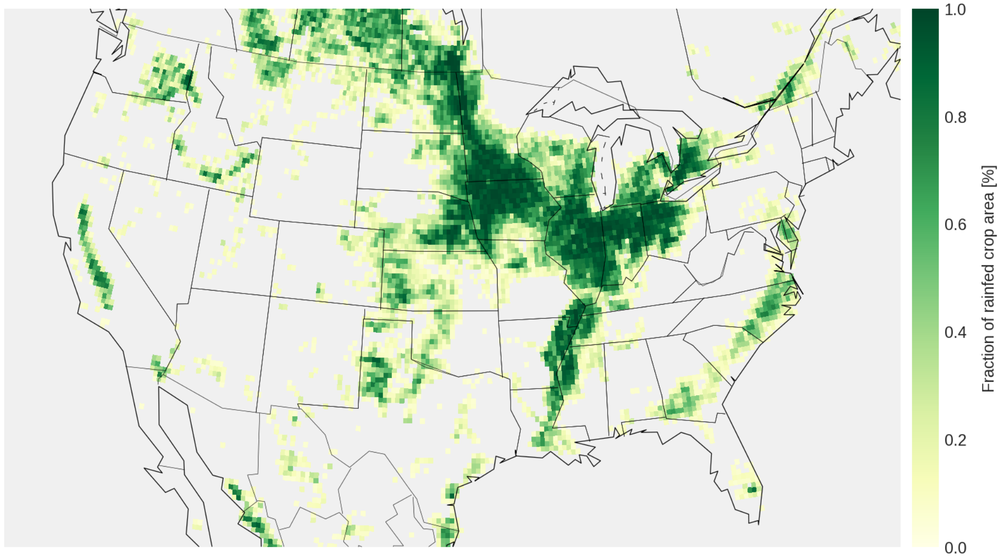


Data sources

Soil Moisture

Source	Specification	Resolution		Resampling		Coverage	
Satellite	HSAF H109 Metop ASCAT	25 km	1-3 d	0.25°	daily	Cont. US	2007 – 2013
LSM	ERA–Interim/ Land reanalysis	0.7°	6h				

Land Cover



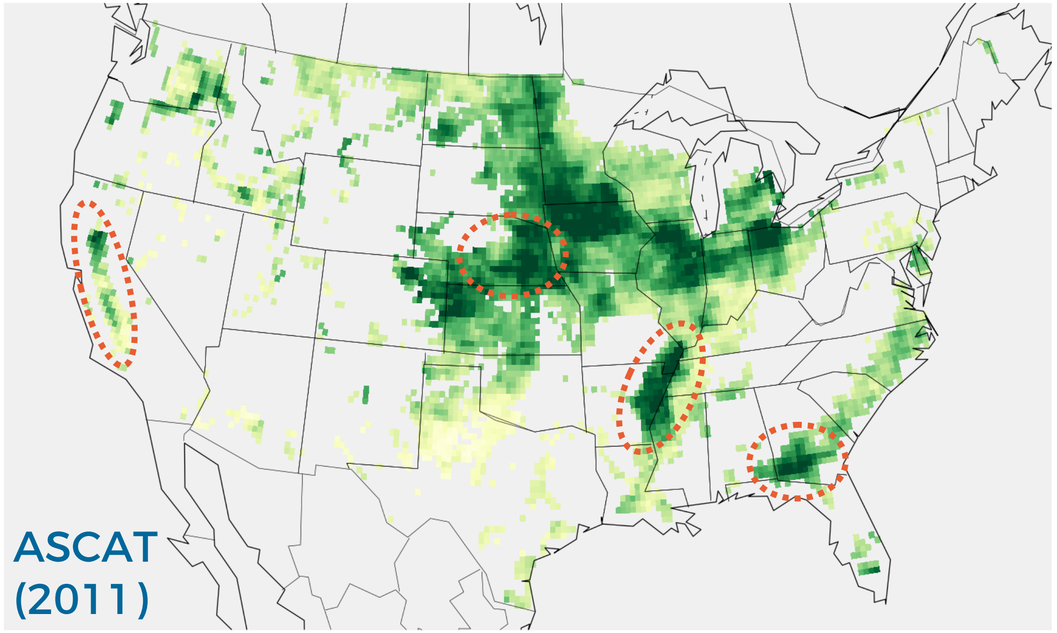
- CCI – Land Cover dataset
- % of pixel area classified as cropland
- resampled to 0.25° grid

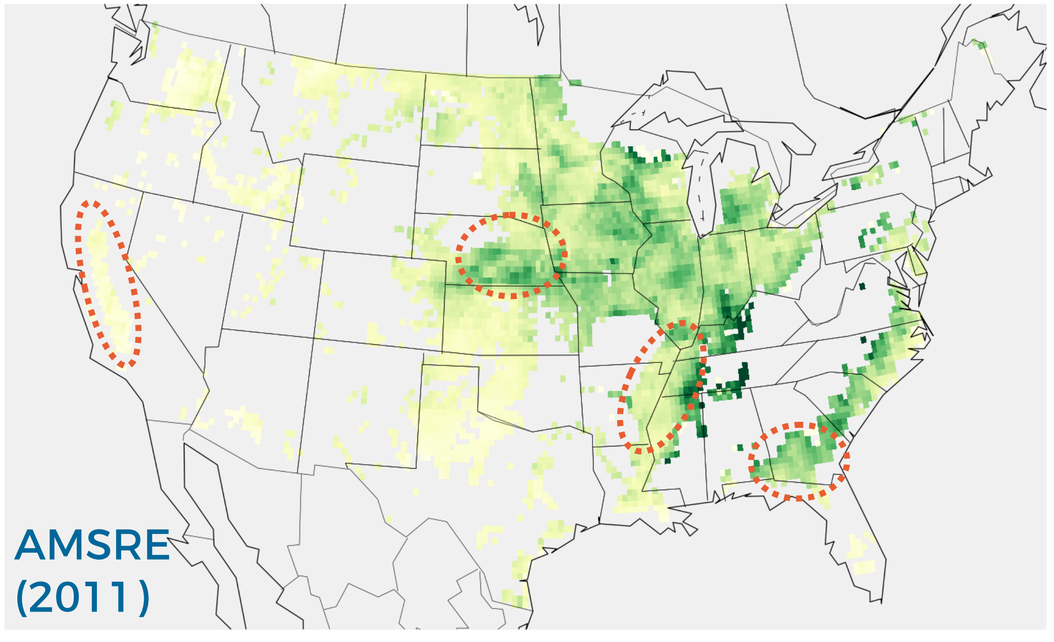
Our Process

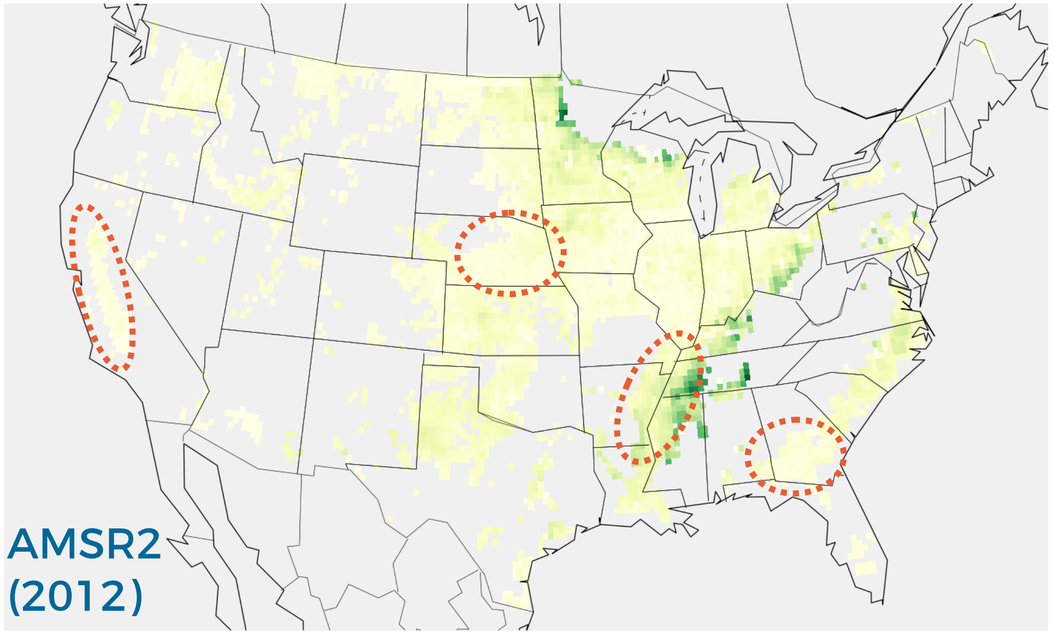
1. select pixel if fractional crop area $\geq 5\%$
2. apply gap-filling to time series if gap < 10 days
3. apply moving-average filter (5 week window)
4. scale model to satellite data
5. calculate temporal slopes and sum up positive differences

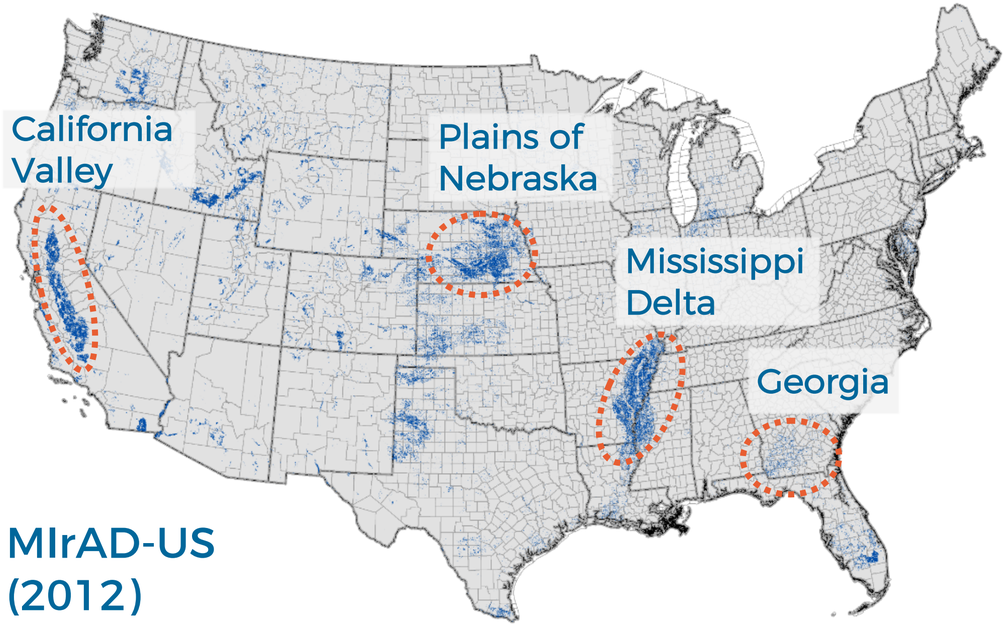
$$\mathbf{S(i)} = \sum_{\mathbf{i}}^{\mathbf{n}} \left(\frac{\mathbf{d}\, sm_{\mathbf{i,\,sat}}}{\mathbf{dt}} - \frac{\mathbf{d}\, sm_{\mathbf{i,\,model}}}{\mathbf{dt}} \right) \mathbf{if} \; > \mathbf{0}$$

Results (JJA)

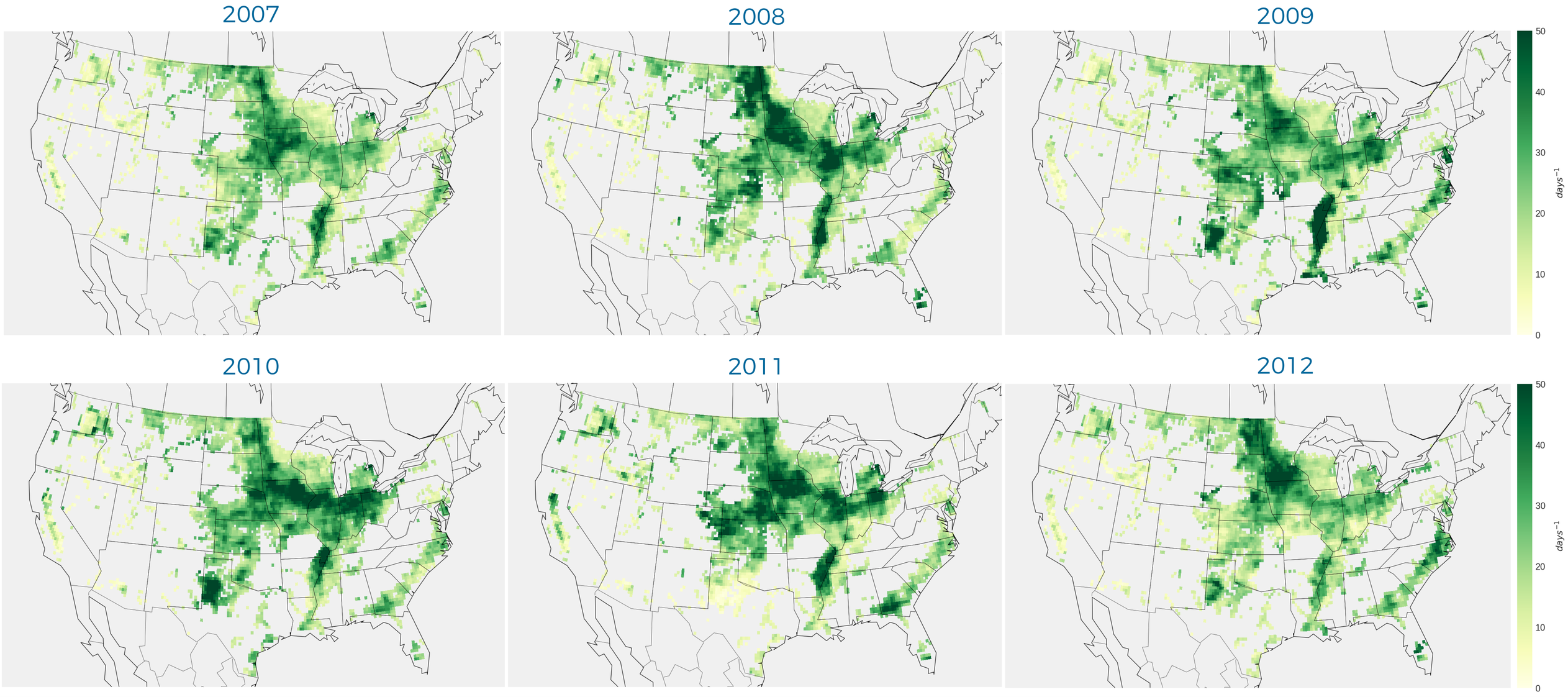

ASCAT
(2011)


AMSRE
(2011)
50
40
30
20
10
0
days⁻¹


AMSR2
(2012)

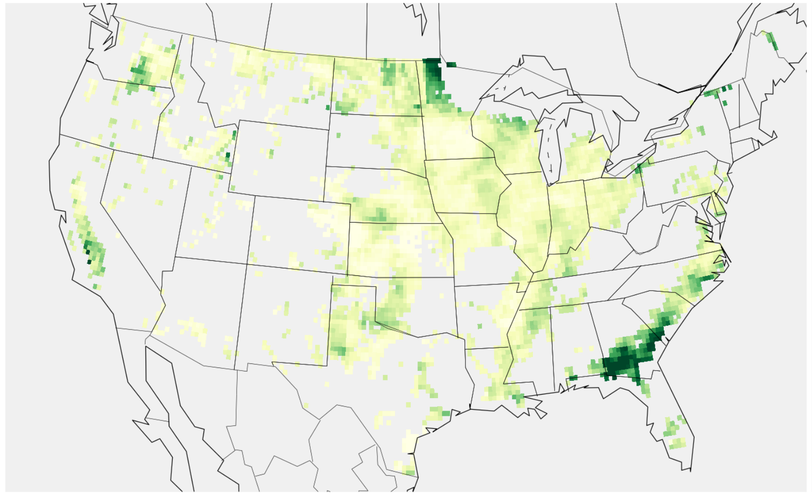

California
Valley
Plains of
Nebraska
Mississippi
Delta
Georgia
MIrAD-US
(2012)

Interannual Variability (JJA)

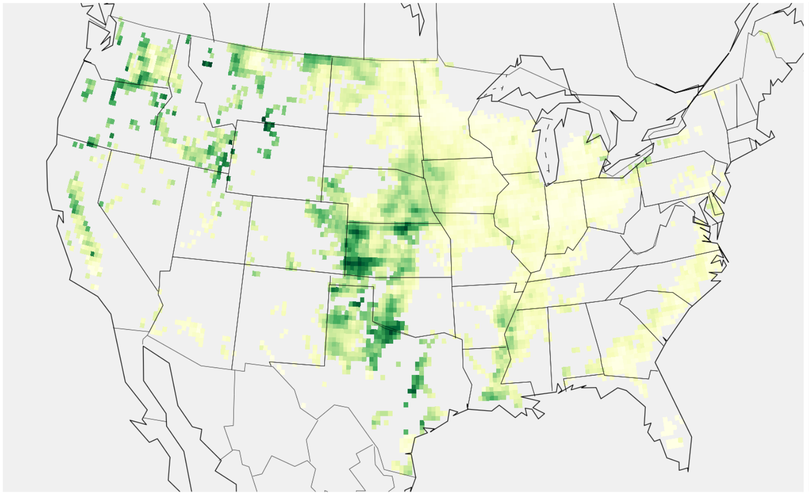


Monthly Variability (Apr – Sept 2009)

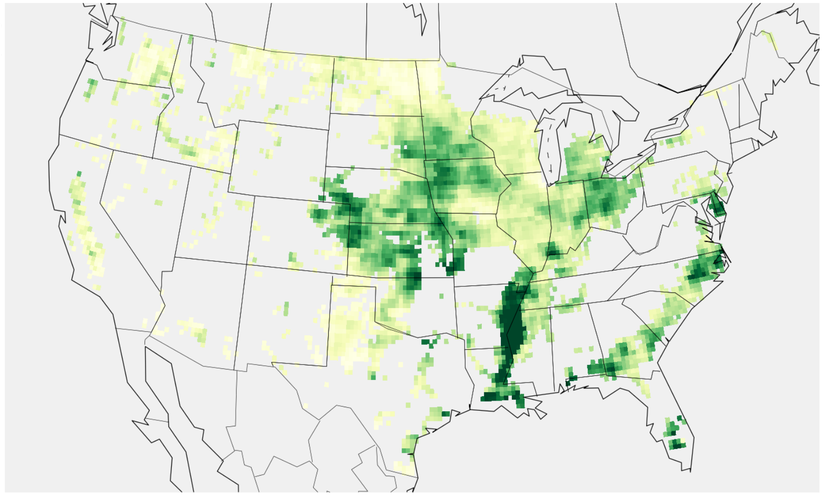
April



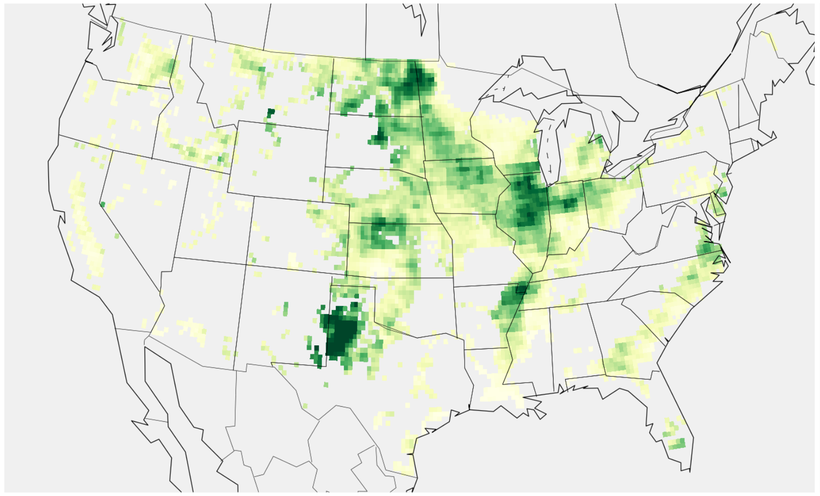
May



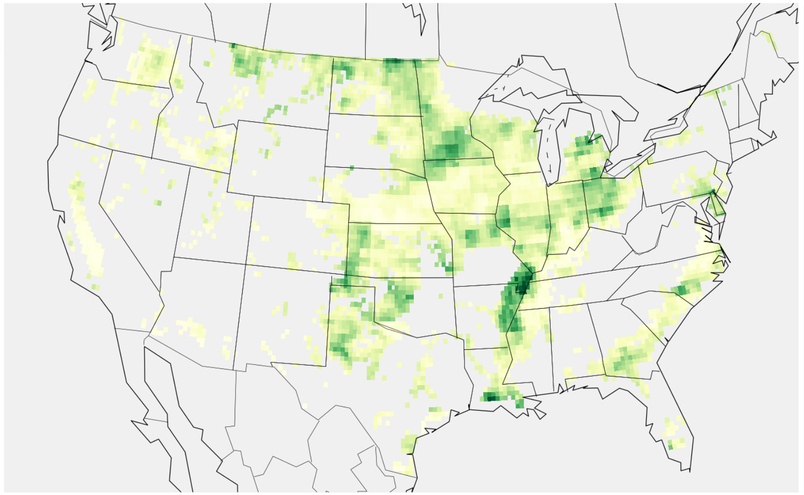
June



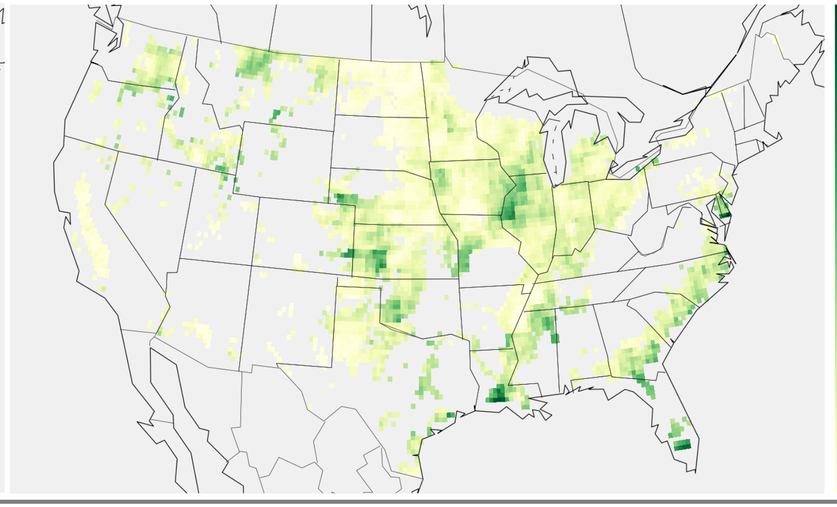
July



August



September



Conclusion(s)

? Validation → how reliable are the reference data?

? Strong signal around the Great Corn Belt

? Multiple irrigation practices → Re-reflection effects

? Different crop types and cultivation periods

? Spatial resolution vs. field size

\+ **Good agreements with reference data**

\+ **Spatial and temporal variability observable**

\+ **Potential use for future LSM-Versions**