Field-scale mapping and forecasting of water budgets in intensively irrigated agricultural regions through an advanced ensemble modeling framework

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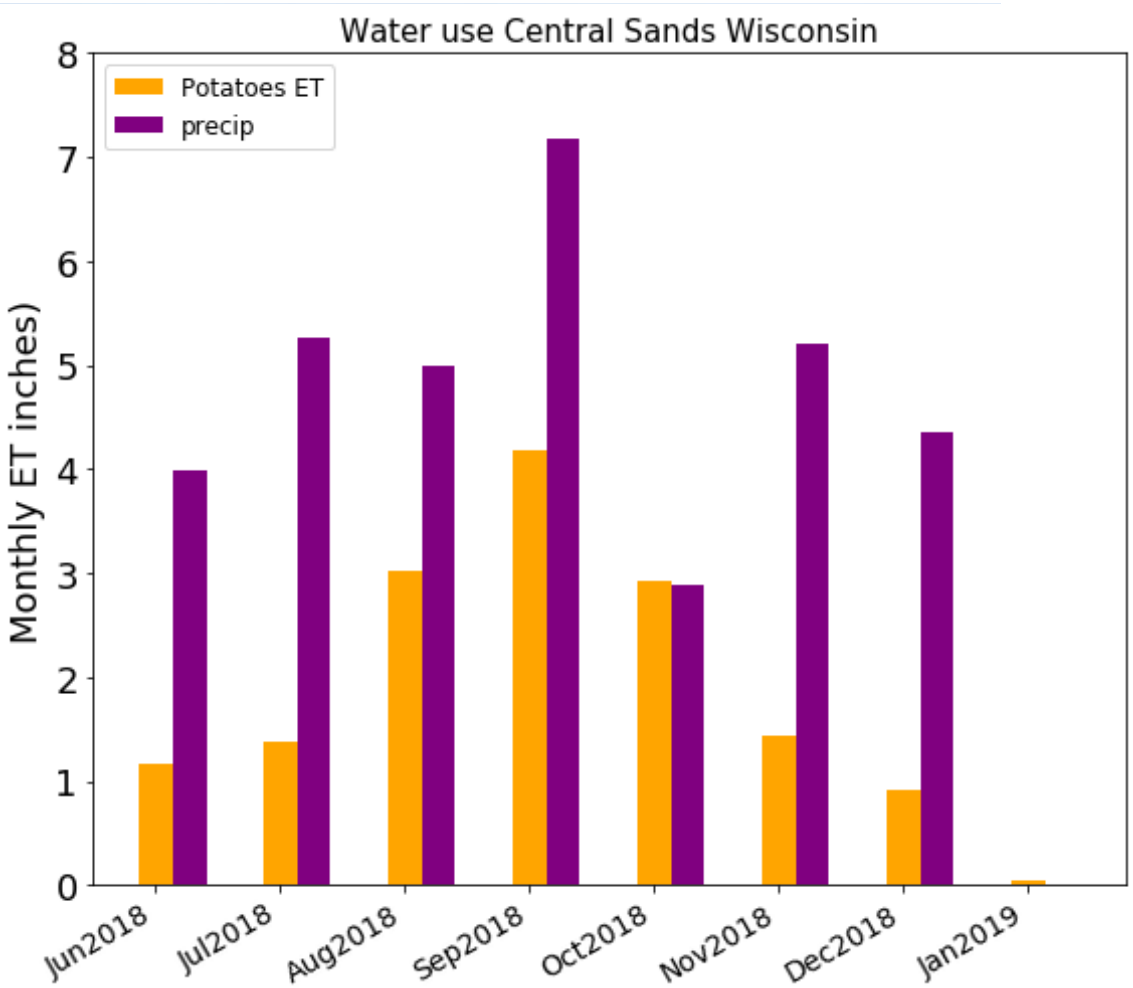
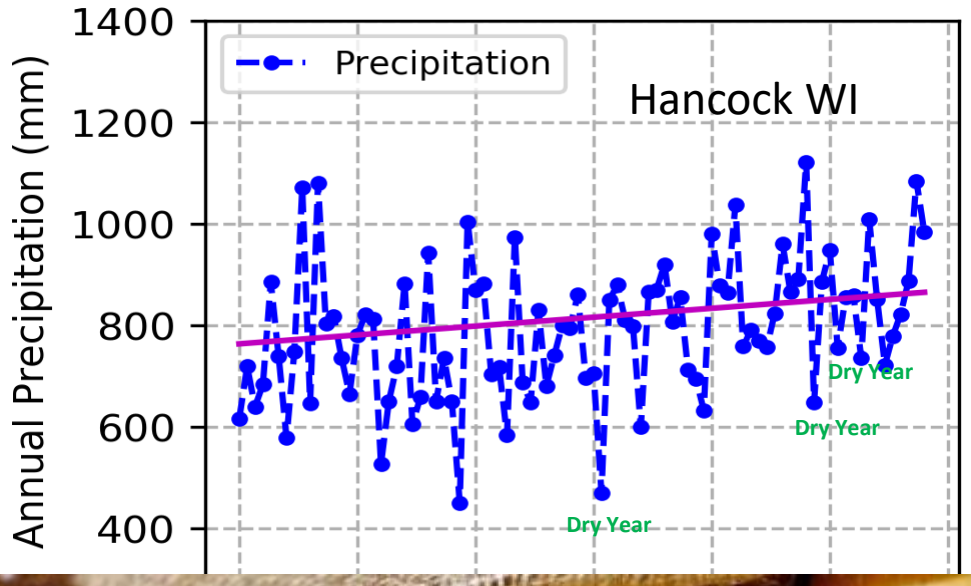
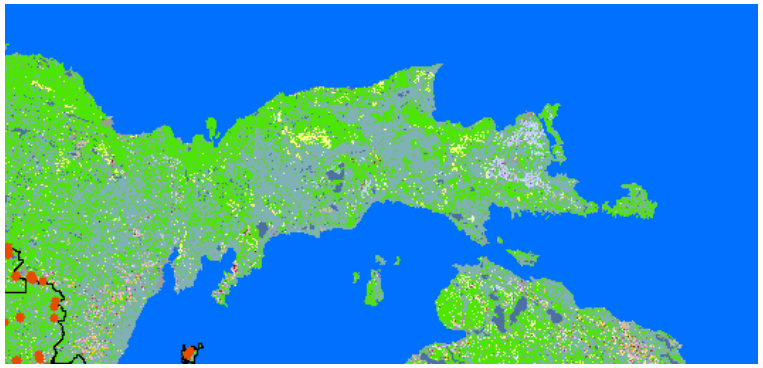
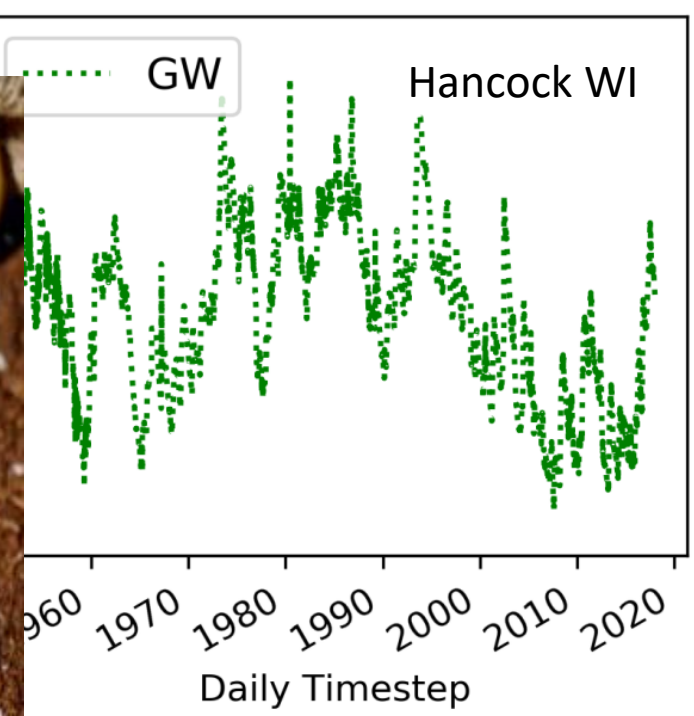
H23C-02 Tuesday 10th December 2019


Water use Central Sands Wisconsin
Potatoes ET
precip
Monthly ET inches)
0
1
2
3
4
5
6
7
8
Jun2018
Jul2018
Aug2018
Sep2018
Oct2018
Nov2018
Dec2018
Jan2019

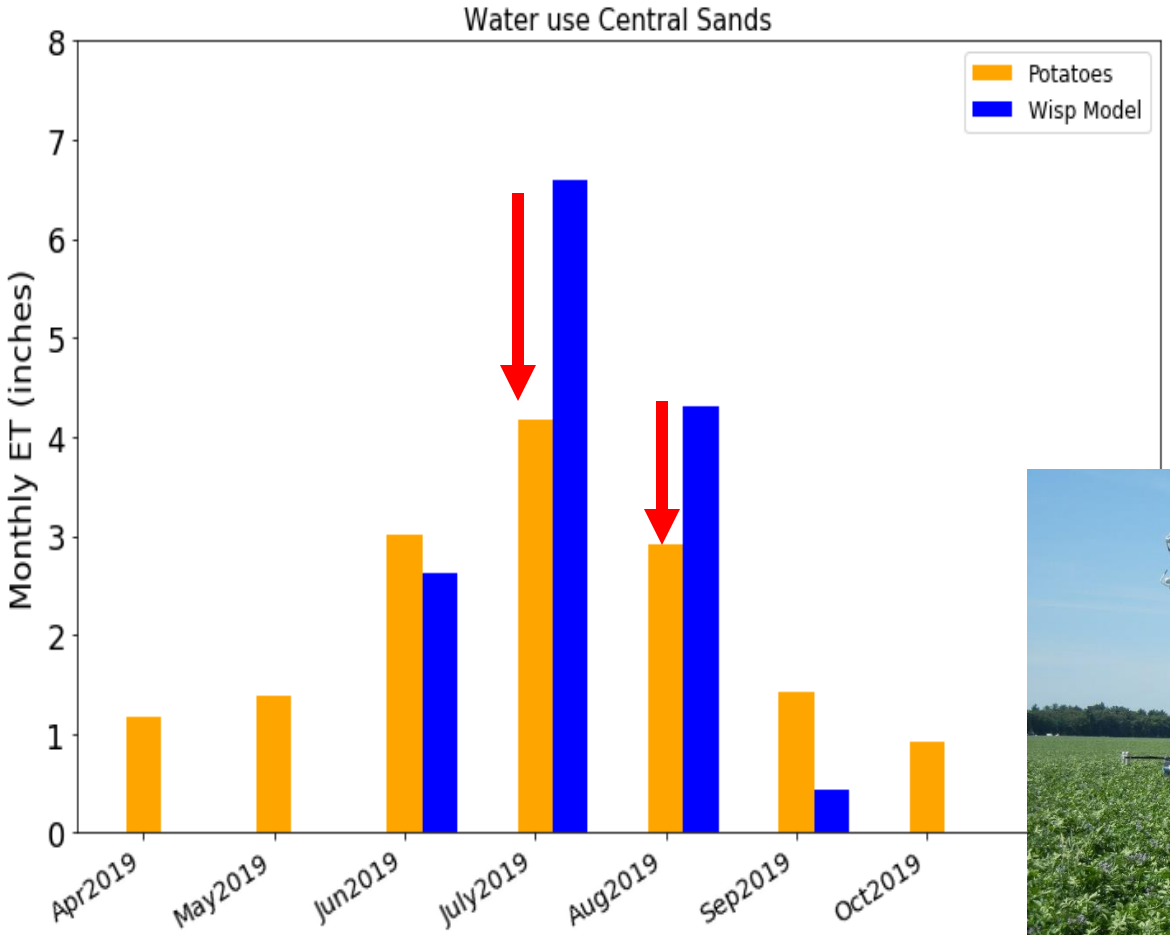


Irrigation wells in Wisconsin

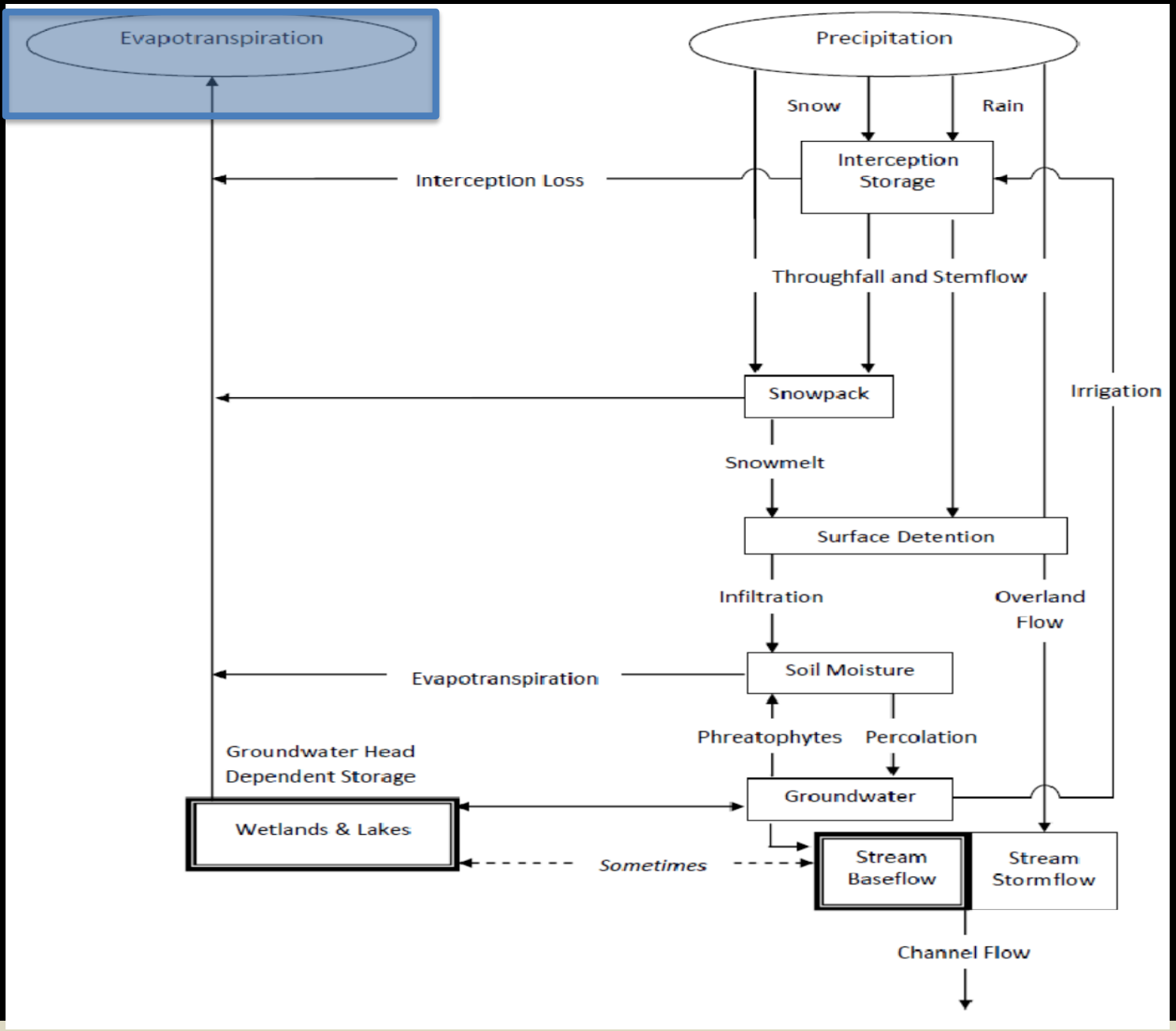




Comparison of Central Sands Flux tower with Model Observation



WISP Model : Wisconsin Irrigation and planning Scheduler based on remote sensing observation


Evapotranspiration
Precipitation
Snow
Rain
Interception Loss
Interception Storage
Throughfall and Stemflow
Snowpack
Irrigation
Snowmelt
Surface Detention
Infiltration
Overland Flow
Evapotranspiration
Soil Moisture
Phreatophytes
Percolation
Groundwater Head Dependent Storage
Groundwater
Wetlands & Lakes
Sometimes
Stream Baseflow
Stream Stormflow
Channel Flow

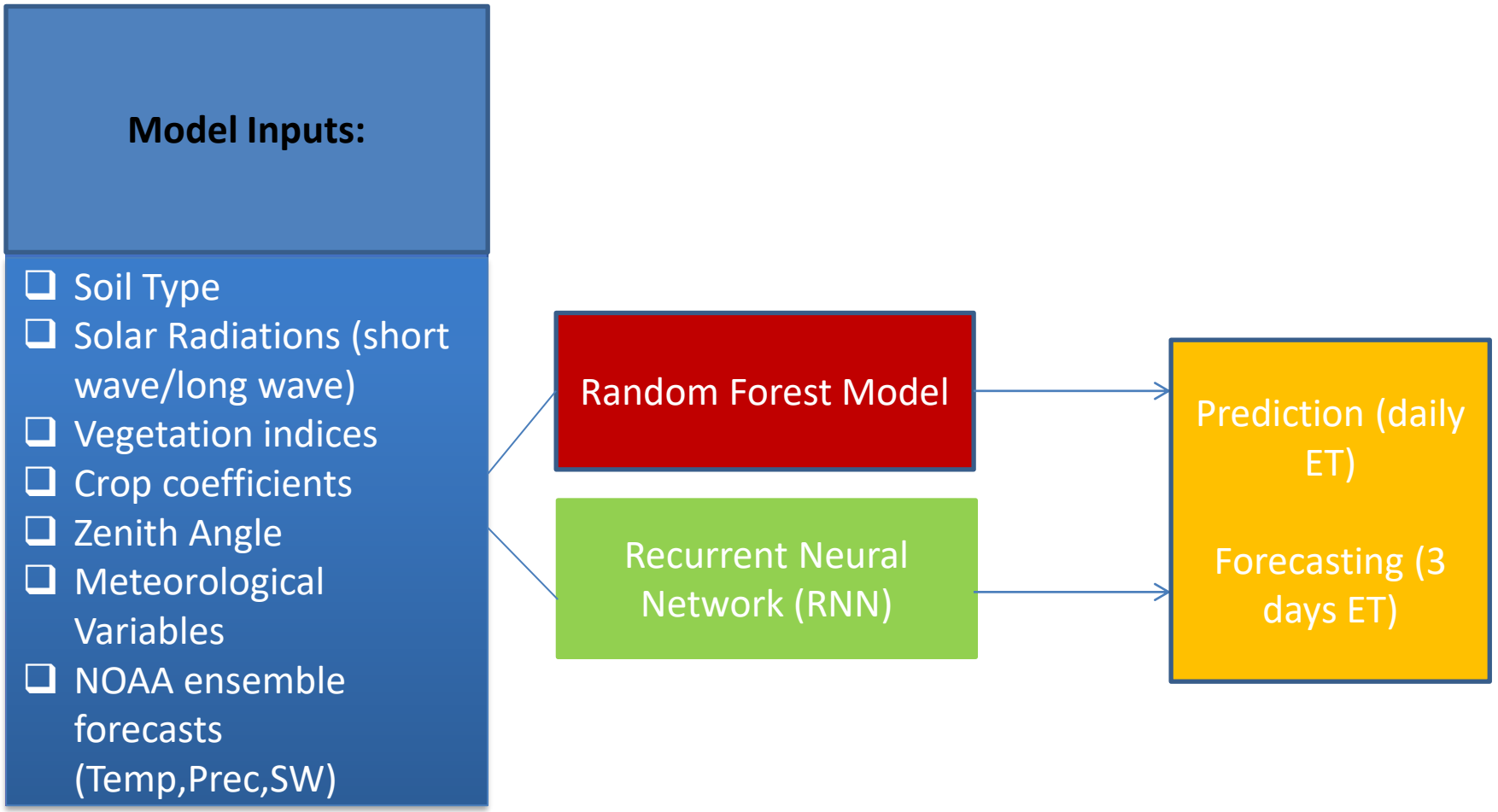
Goals/Objectives

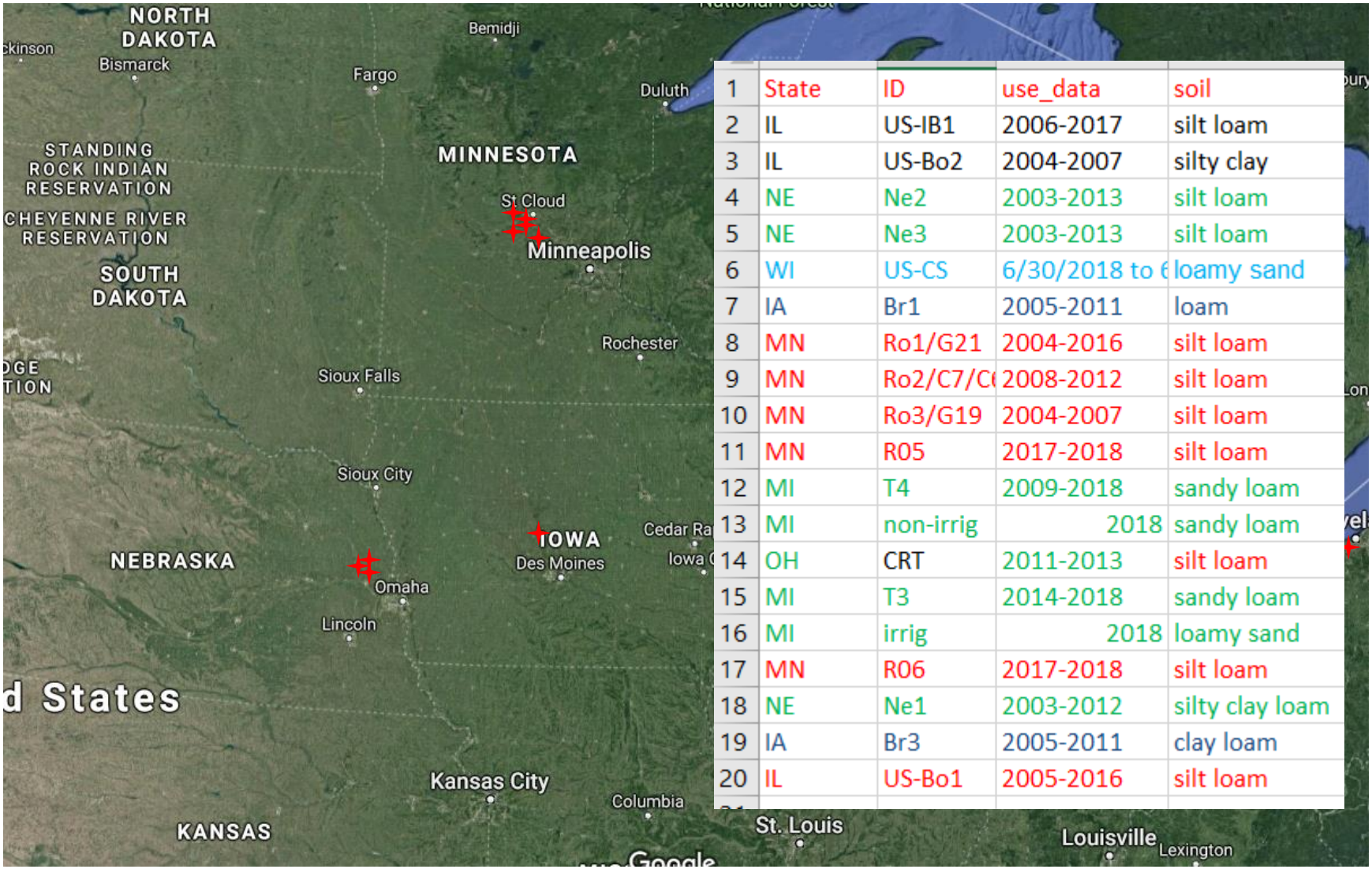
Can we better quantify evapotranspiration (ET) to improve understanding of crops water use and improve irrigation demand forecasting?

- ET prediction in intensively irrigated agricultural ecosystem
- Forecasting of ET 3 days in advance

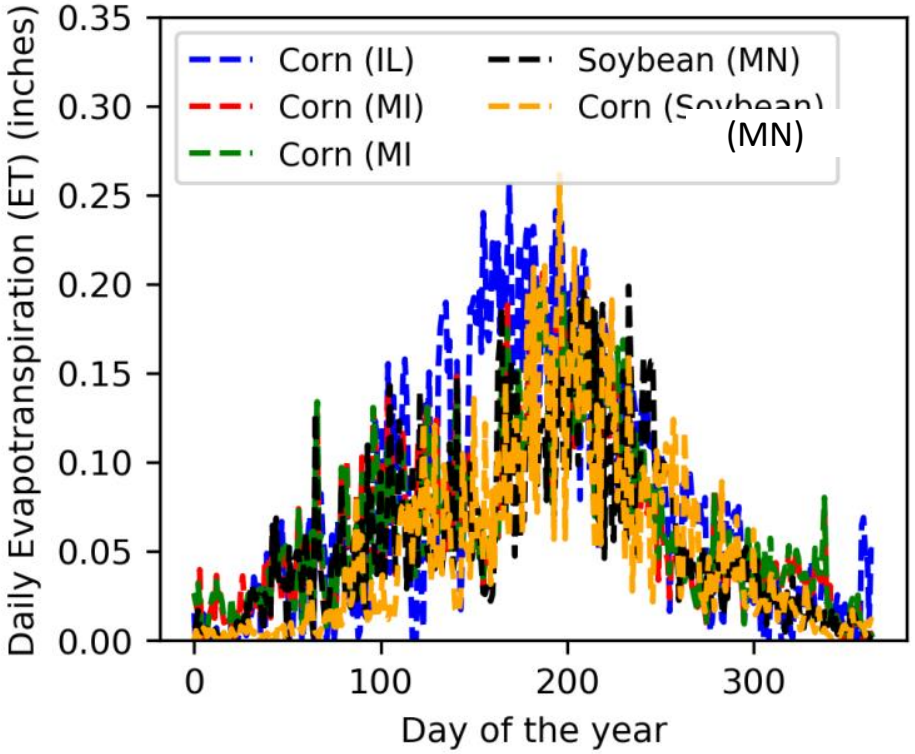
Approach: Prediction and Forecasting of ET with Ensembles Methods

Year 2003-2019
Soybean, Corn, Potatoes

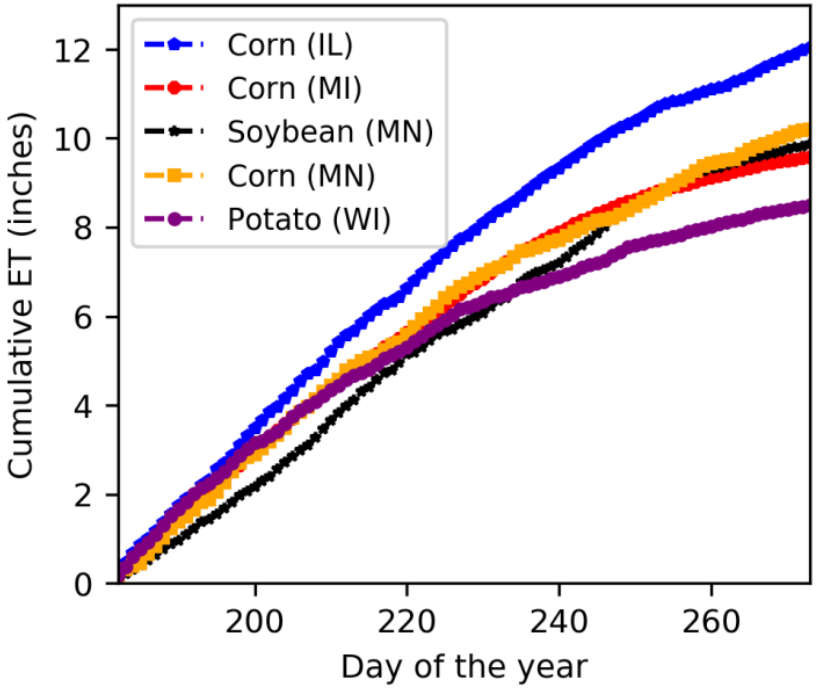




	State	ID	use_data	soil
2	IL	US-IB1	2006-2017	silt loam
3	IL	US-Bo2	2004-2007	silty clay
4	NE	Ne2	2003-2013	silt loam
5	NE	Ne3	2003-2013	silt loam
6	WI	US-CS	6/30/2018 to 6	loamy sand
7	IA	Br1	2005-2011	loam
8	MN	Ro1/G21	2004-2016	silt loam
9	MN	Ro2/C7/C(	2008-2012	silt loam
10	MN	Ro3/G19	2004-2007	silt loam
11	MN	R05	2017-2018	silt loam
12	MI	T4	2009-2018	sandy loam
13	MI	non-irrig	2018	sandy loam
14	OH	CRT	2011-2013	silt loam
15	MI	T3	2014-2018	sandy loam
16	MI	irrig	2018	loamy sand
17	MN	R06	2017-2018	silt loam
18	NE	Ne1	2003-2012	silty clay loam
19	IA	Br3	2005-2011	clay loam
20	IL	US-Bo1	2005-2016	silt loam

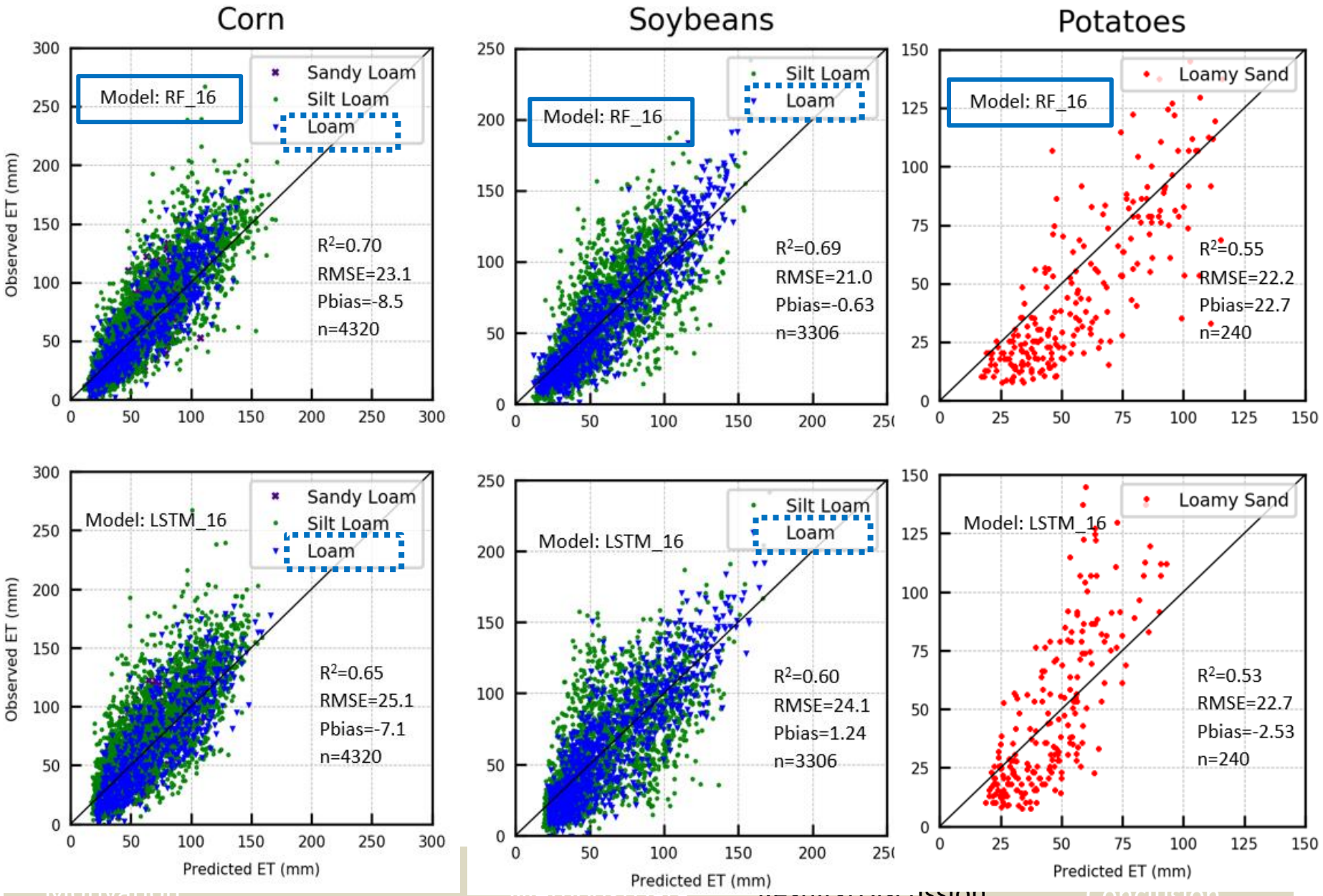


Year 2003-2019
Soybean, Corn, Potatoes
Model Training: 70%
Model Testing: 30%

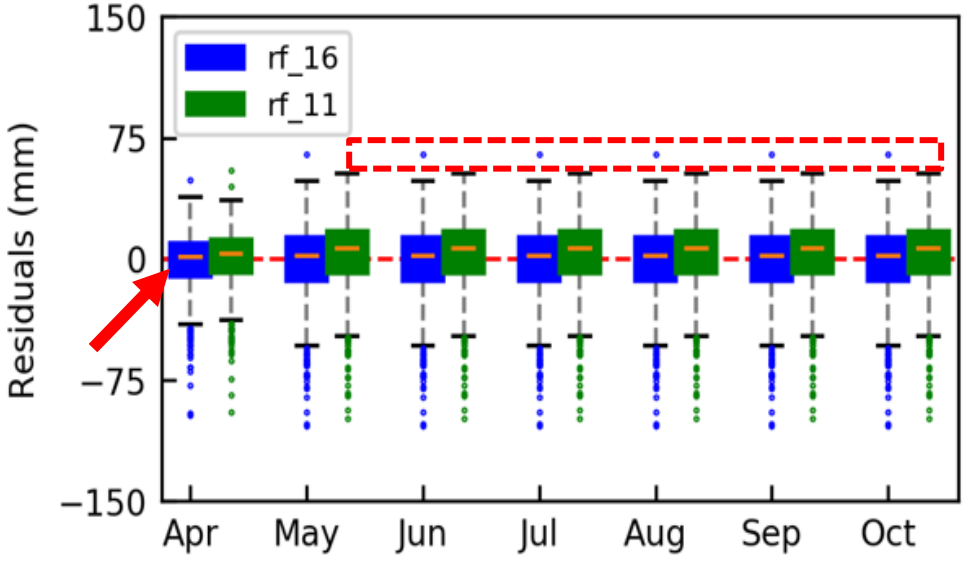


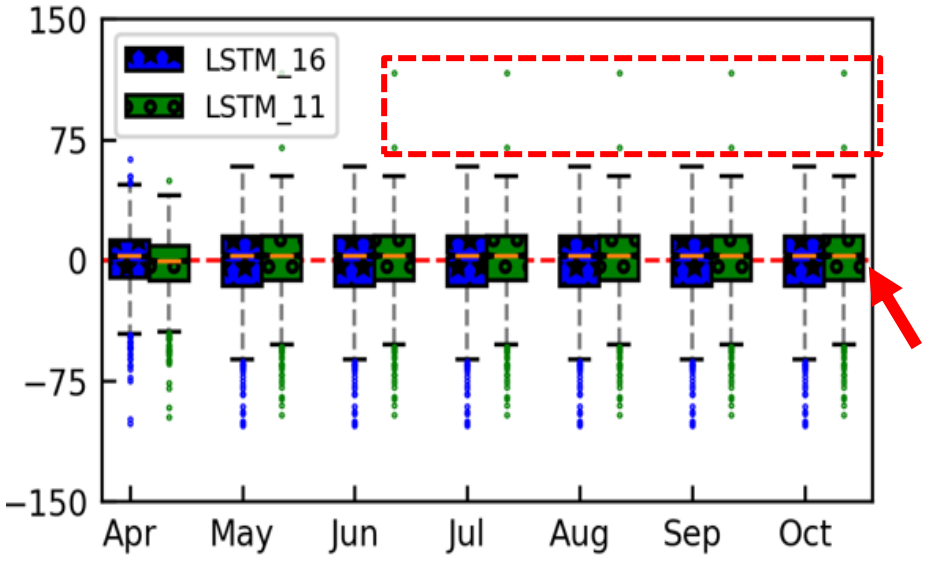
Water use by different crop types in Midwest (2017,2018) under different soil types. Even same crop type can lead to different water used based on soil condition

Prediction Model: Validation results

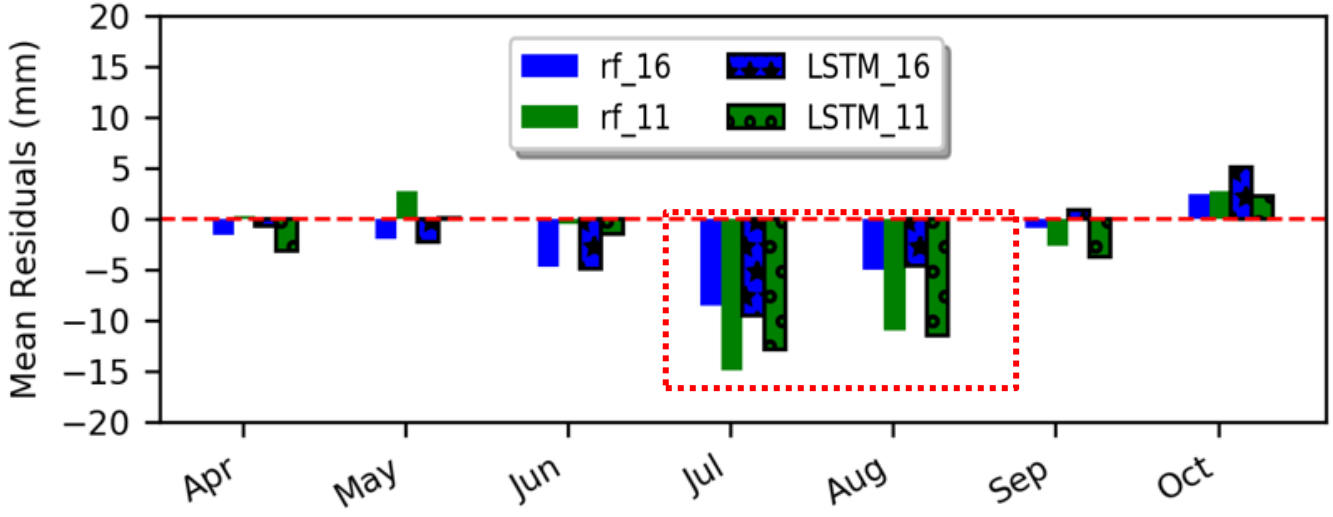


Prediction Model: Box plots of **daily residuals** (simulated minus observed) for validation results of rf and LSTM prediction models for sample size

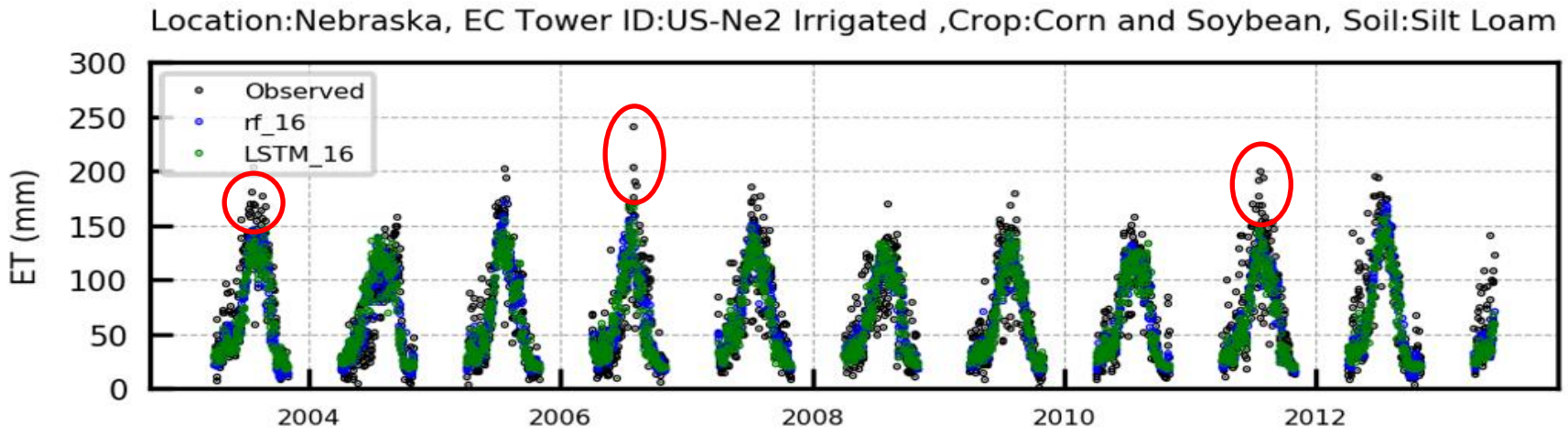


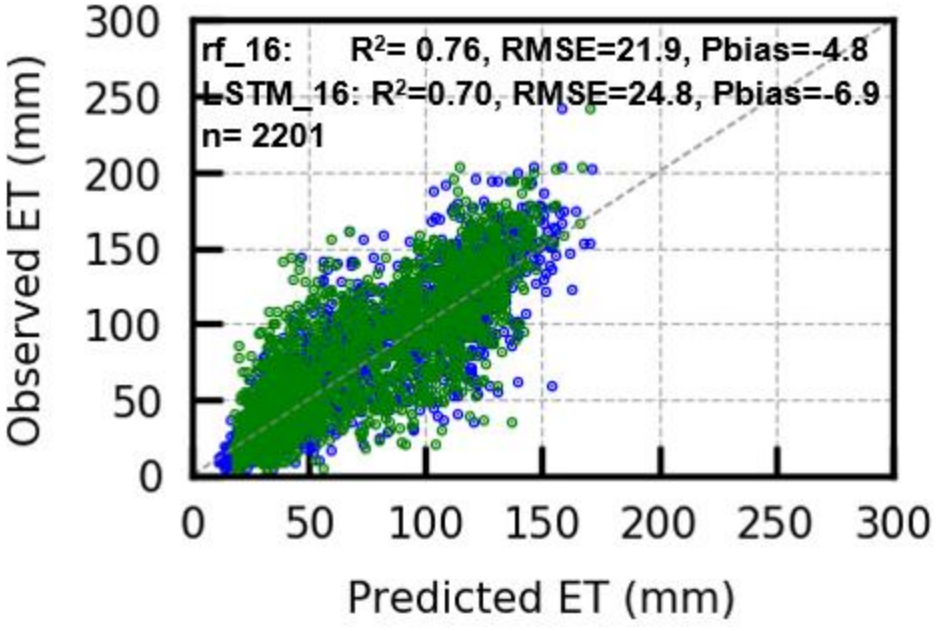


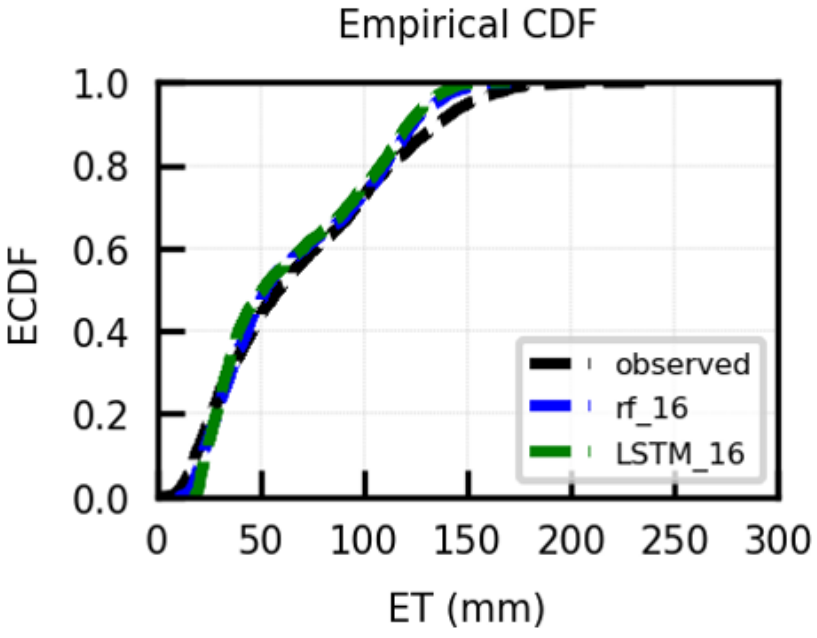
Higher Positive outliers for Complex(rf) model but overall lower mean errors



Prediction Model: Validation Site

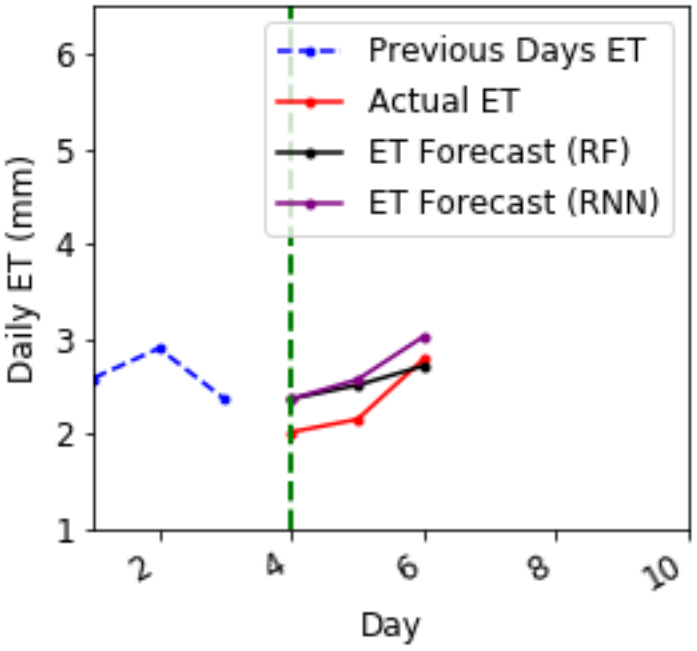




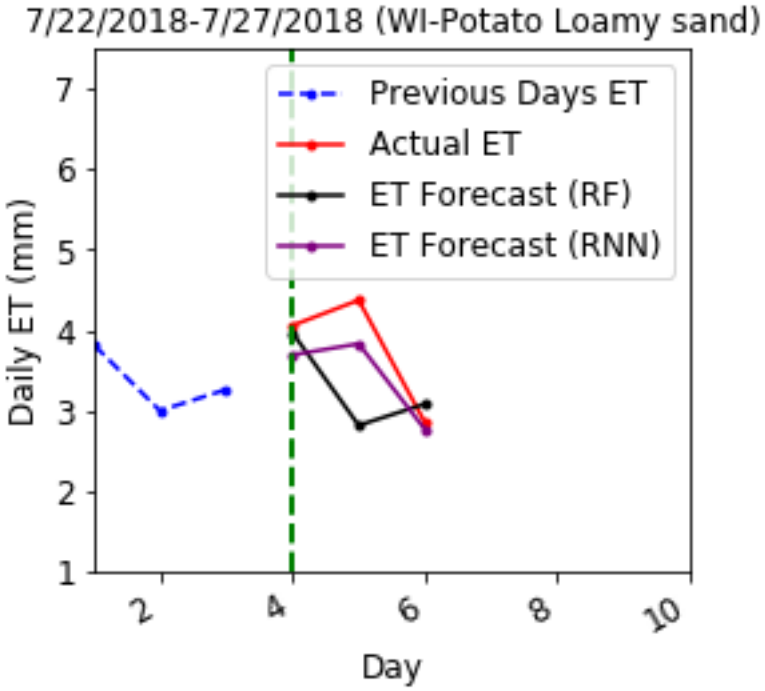


Forecast Model: ET three days in Advance

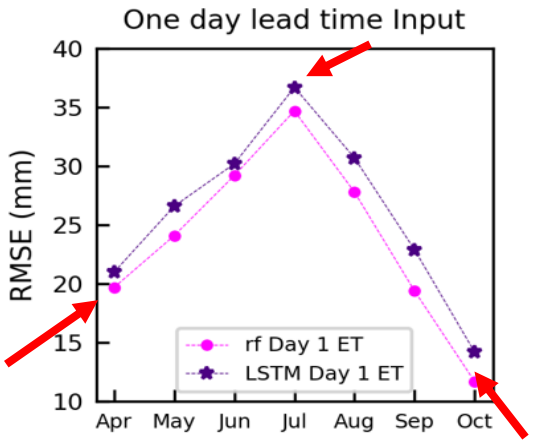
5/21/2017-5/26/2017 (MN-Soybean silt Loam)

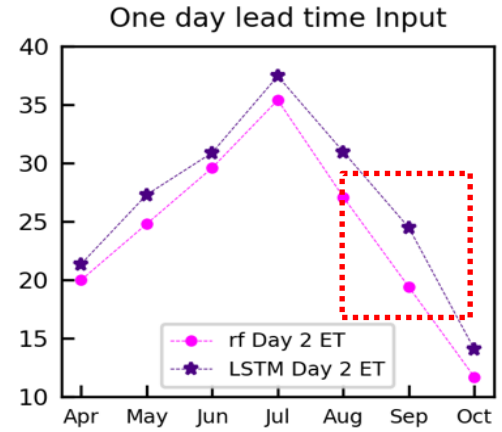


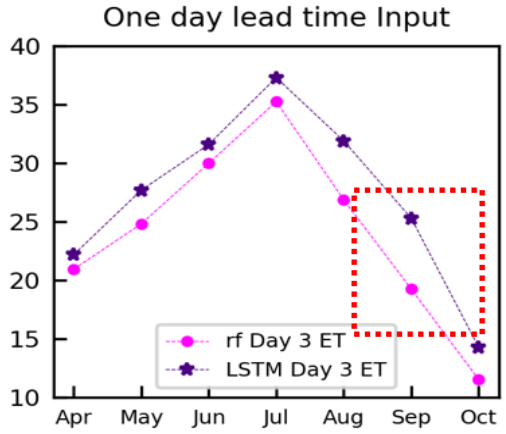
7/22/2018-7/27/2018 (WI-Potato Loamy sand)

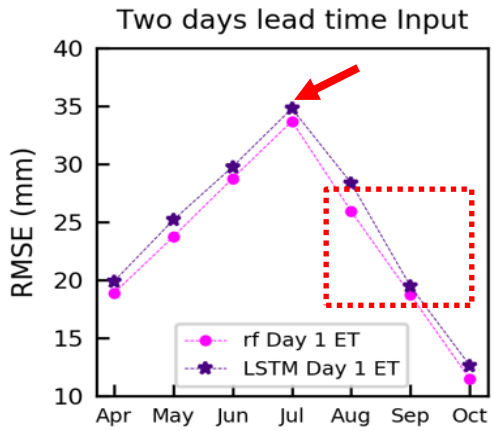


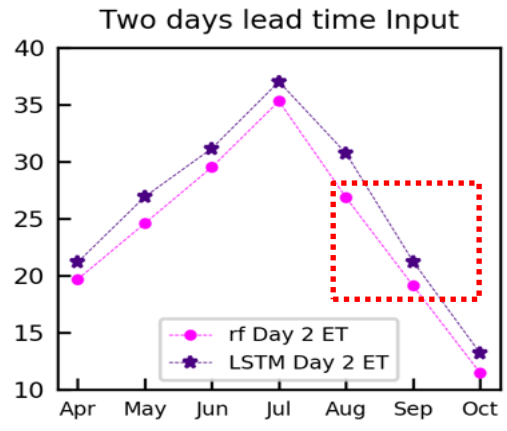
Forecast Model with Forecast Meteorology Input

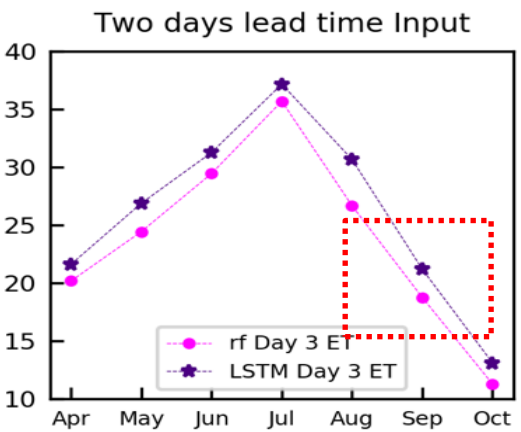


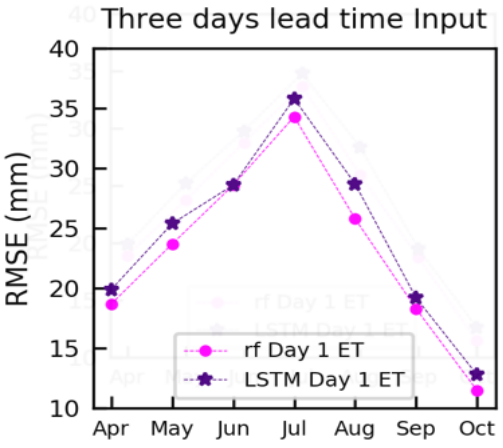


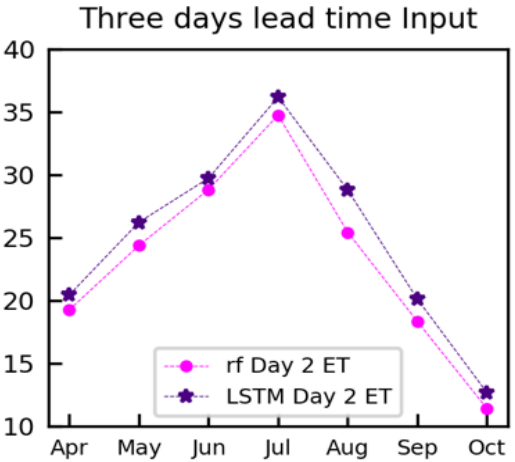


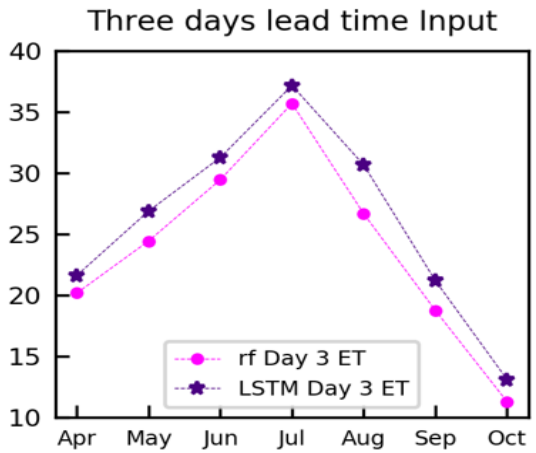




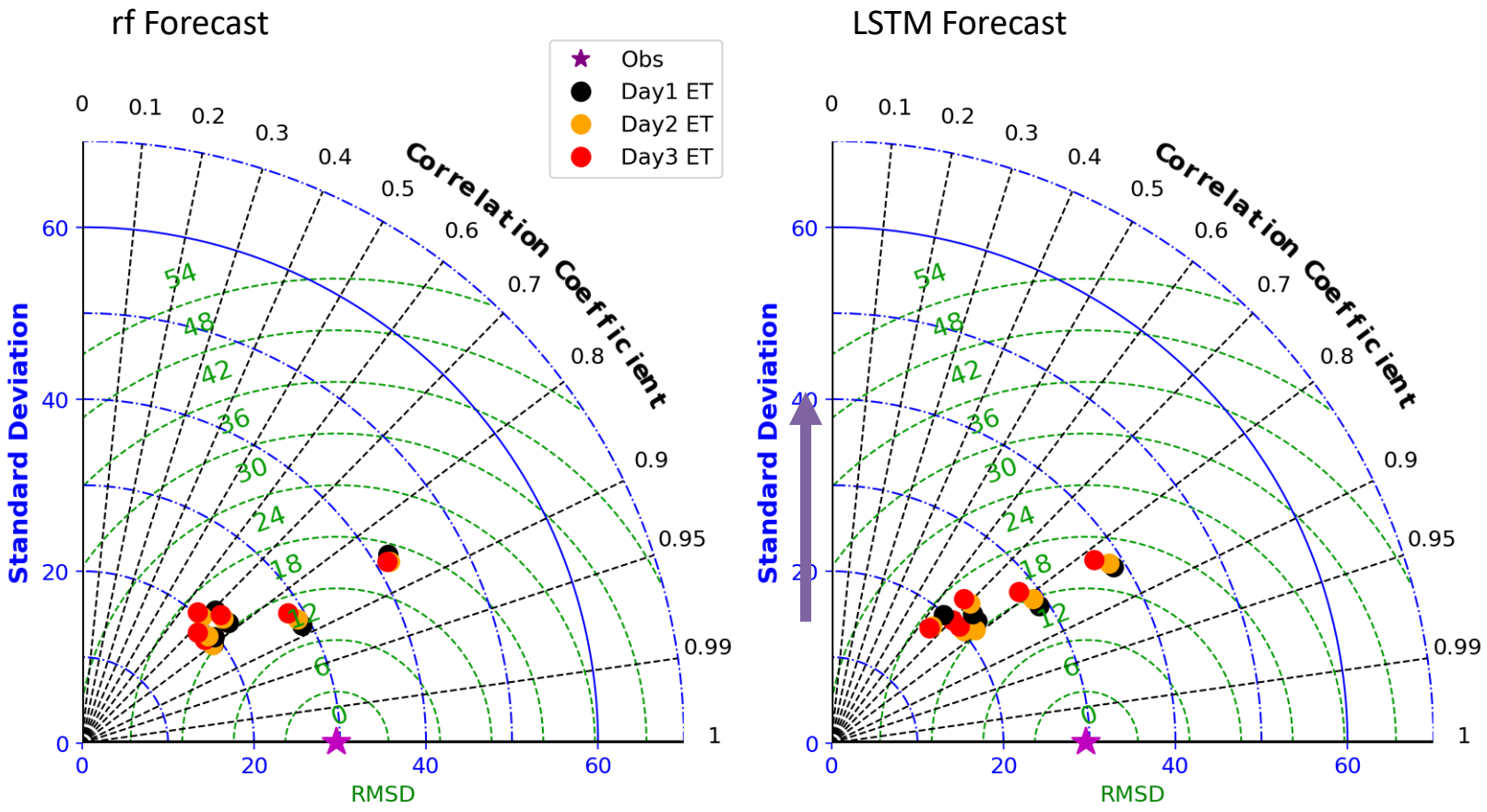








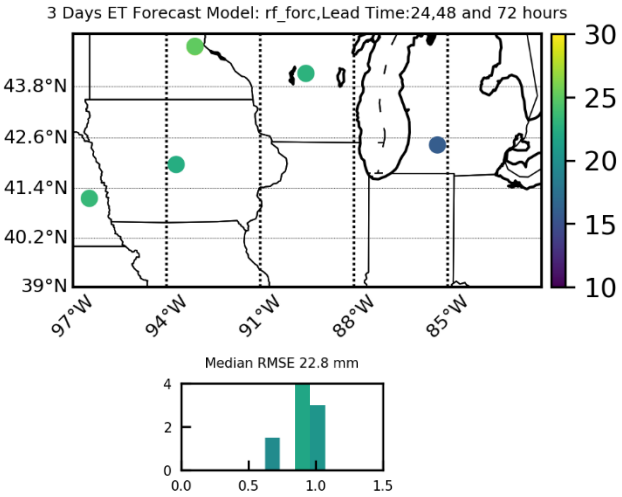
Forecast Model: Validation across Different Sites

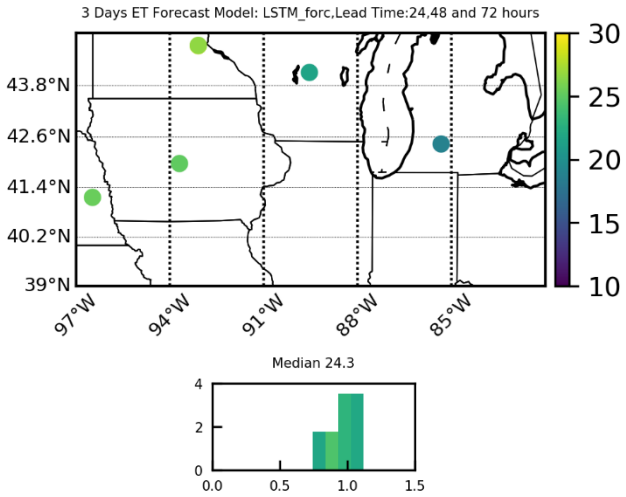


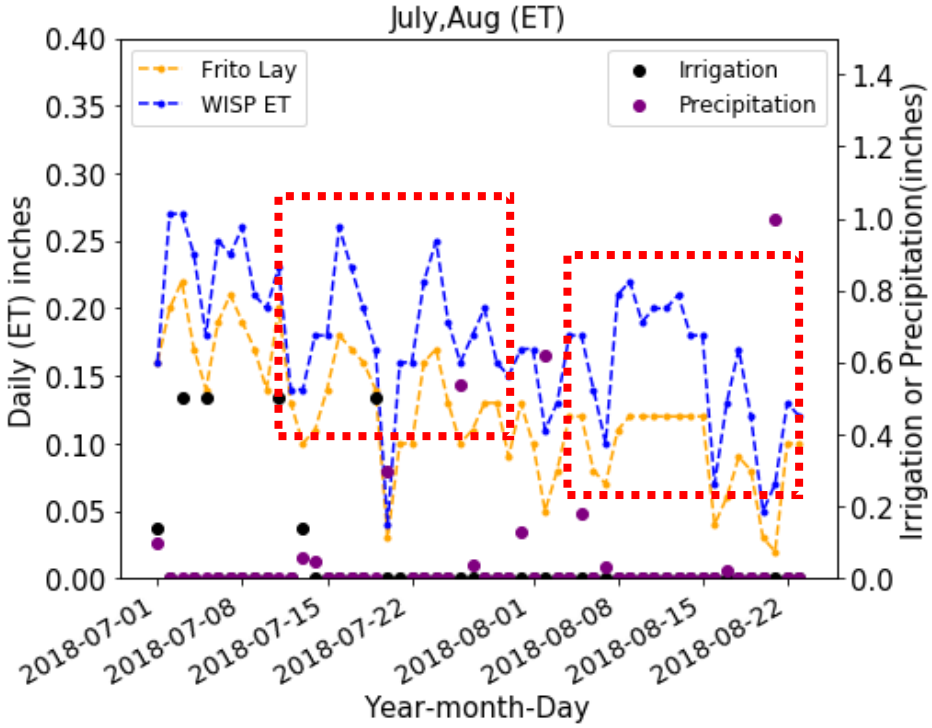
Conclusion

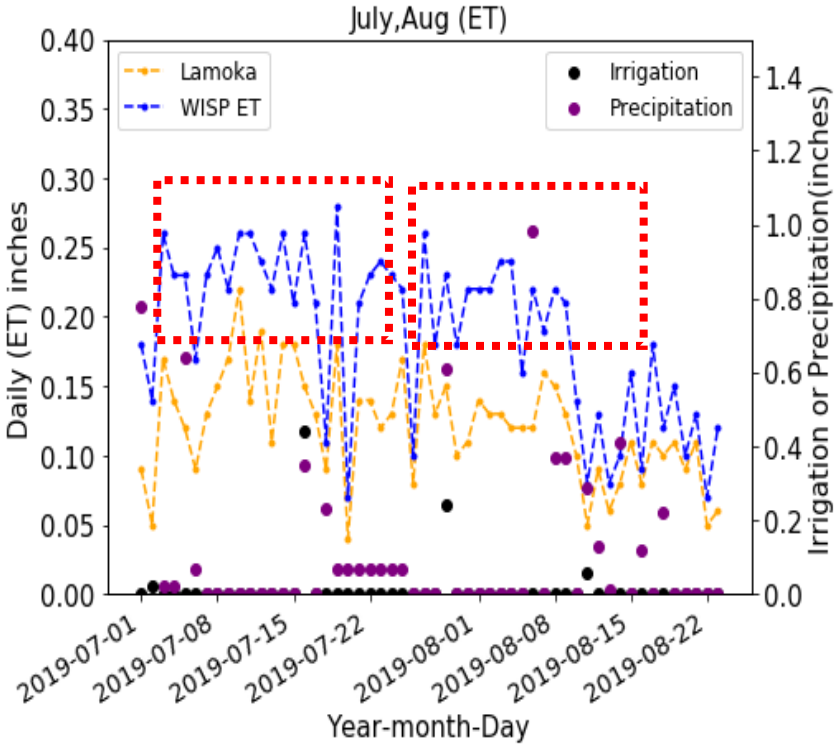
- ET forecast Ensembles models provide promising results for prediction and 3 days ET forecast.
- Ensemble models have the ability to learn and store long-term dependencies of the input–output relationship.
- Pre-trained knowledge can be transferred into different areas, which might be a possible approach for reducing the data demand and/or regionalization applications

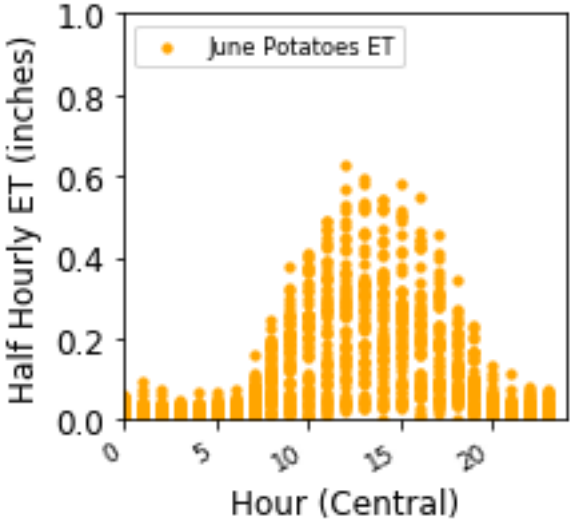
Looking to the future

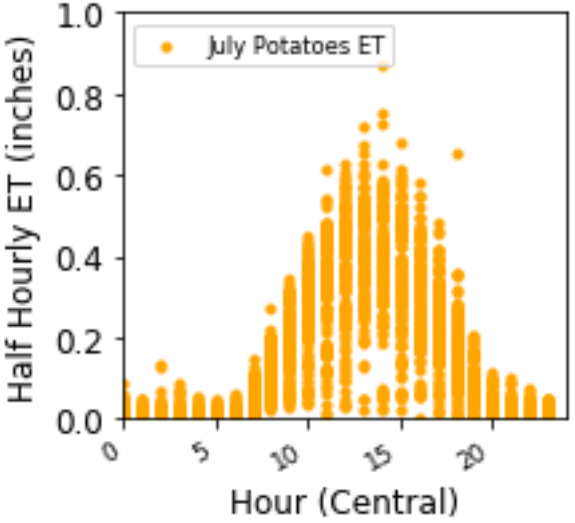

3 Days ET Forecast Model: rf_forc,Lead Time:24,48 and 72 hours
43.8°N
42.6°N
41.4°N
40.2°N
39°N
97°W
94°W
91°W
88°W
85°W
30
25
20
15
10
Median RMSE 22.8 mm
4
2
0
0.0
0.5
1.0
1.5


3 Days ET Forecast Model: LSTM_forc,Lead Time:24,48 and 72 hours
43.8°N
42.6°N
41.4°N
40.2°N
39°N
97°W
94°W
91°W
88°W
85°W
30
25
20
15
10
Median 24.3
4
2
0
0.0
0.5
1.0
1.5


July,Aug (ET)
Frito Lay
WISP ET
Irrigation
Precipitation
Daily (ET) inches
Irrigation or Precipitation(inches)
Year-month-Day
2018-07-01
2018-07-08
2018-07-15
2018-07-22
2018-08-01
2018-08-08
2018-08-15
2018-08-22


July,Aug (ET)
Lamoka
WISP ET
Irrigation
Precipitation
Daily (ET) inches
Irrigation or Precipitation(inches)
Year-month-Day
2019-07-01
2019-07-08
2019-07-15
2019-07-22
2019-08-01
2019-08-08
2019-08-15
2019-08-22


June Potatoes ET
Half Hourly ET (inches)
Hour (Central)


July Potatoes ET
Half Hourly ET (inches)
Hour (Central)

References

Wolf, S., Keenan, T.F., Fisher, J.B., Baldocchi, D.D., Desai, A.R., Richardson, A.D., Scott, R.L.,

Law, B.E., Litvak, M.E., Brunsell, N.A., Peters, W., & van der Laan-Luijkx, I.T. (2016). Warm spring reduced carbon cycle impact of the 2012 US summer drought. *Proc. Natl Acad Sci*, 113, 5880-5885, doi:10.1073/pnas.1519620113.

Wong, S., I. Cowan, and G. Farquhar (1979), Stomatal conductance correlates with photosynthetic capacity, Nature, 282, 424–426.

Acknowledgements

- Desai lab & CEE Faculty Graduate students,

- Jonathan Thom, UW-Madison Space Sciences and Engineering Center

- Tamas Houlihan, WPVGA Water Task Force
- Bob Smail, Wisconsin DNR

- Jeremie Pavelski, Heartland Farms
- Joe Raboin, Tri-County School Forest

- Mallika Nocco, University of Minnesota
- Jingyi Huang, UW-Madison Soil Science
- Ameriflux PIs

Thank you

- **CPEP (climate people and the environmental program) grant**
- **METER Grant A Harris Fellowship**
- **Wisconsin Potatoes and vegetable growers Associations (WPVGA) and Water Task Force State of Wisconsin DNR Funding**

QUESTIONS