Noah-MP Workshop May 23-24

Agriculture Water Managements in Noah-MP

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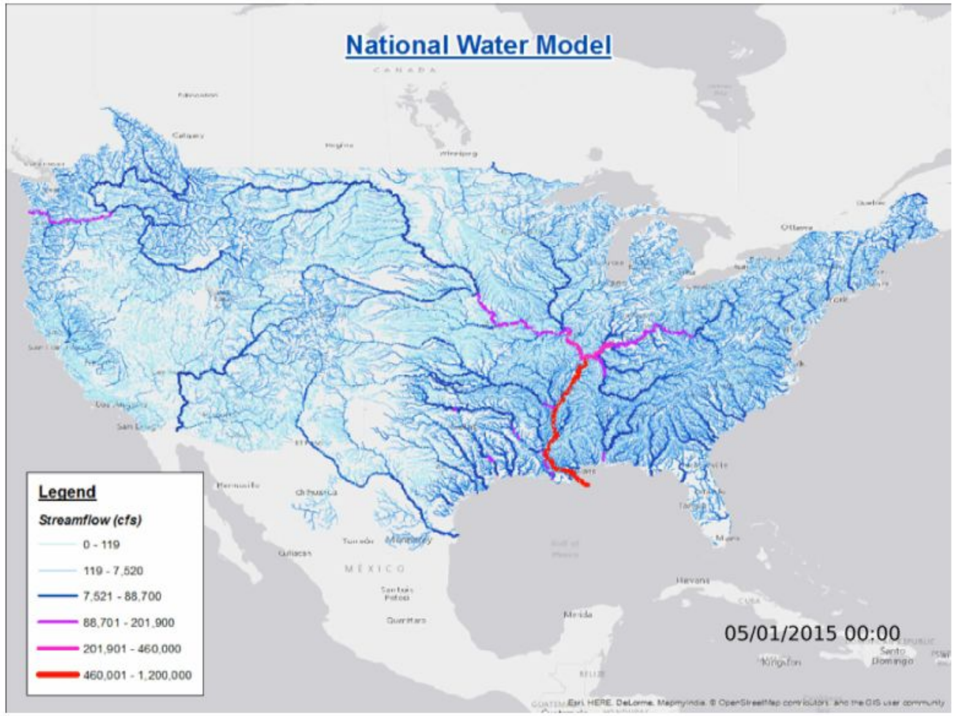
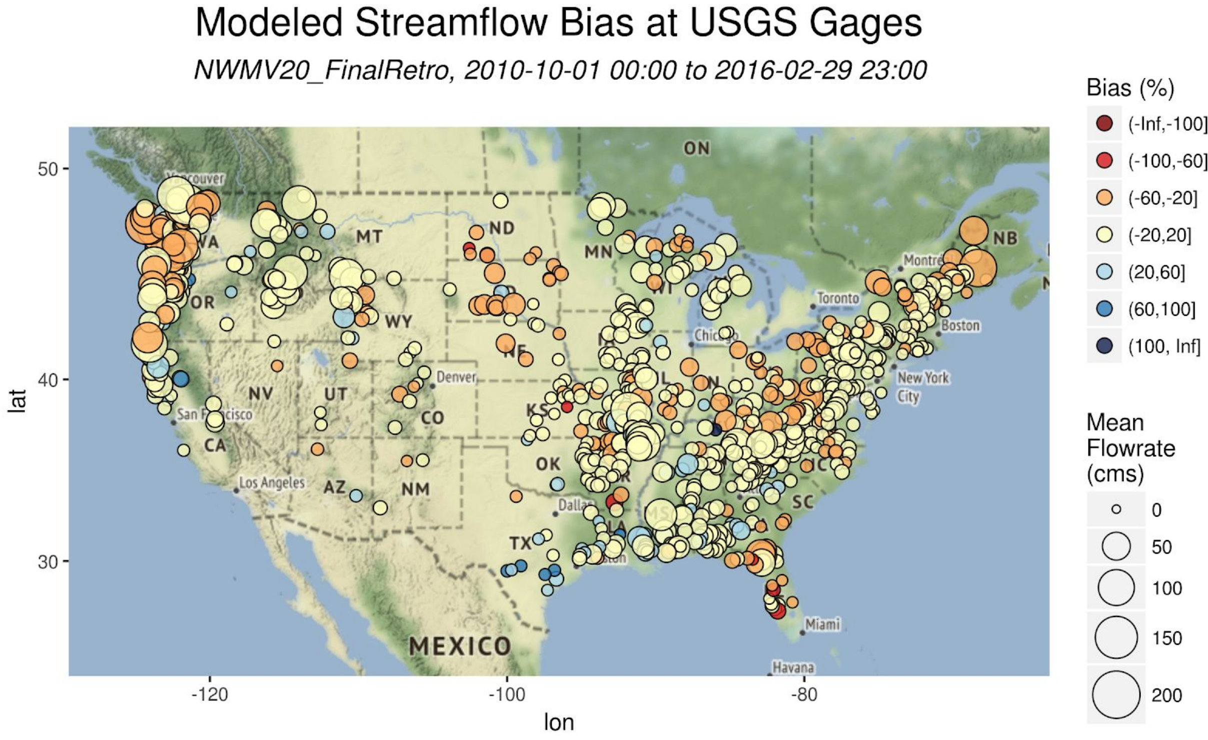
National Water Model (NWM)



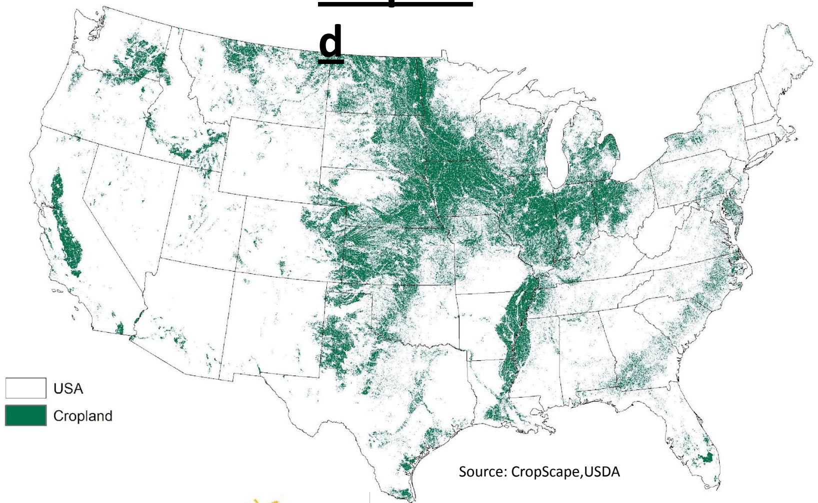


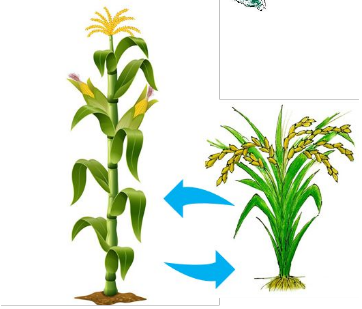
(Source: Dugger et al., 2017)

- NWM has considerable uncertainties in the streamflow prediction over the Midwestern US.
- One of the reasons for the underperformance of the NWM can be the lack of representation of agriculture managements in the NWM.

Agriculture Water Managements in the US

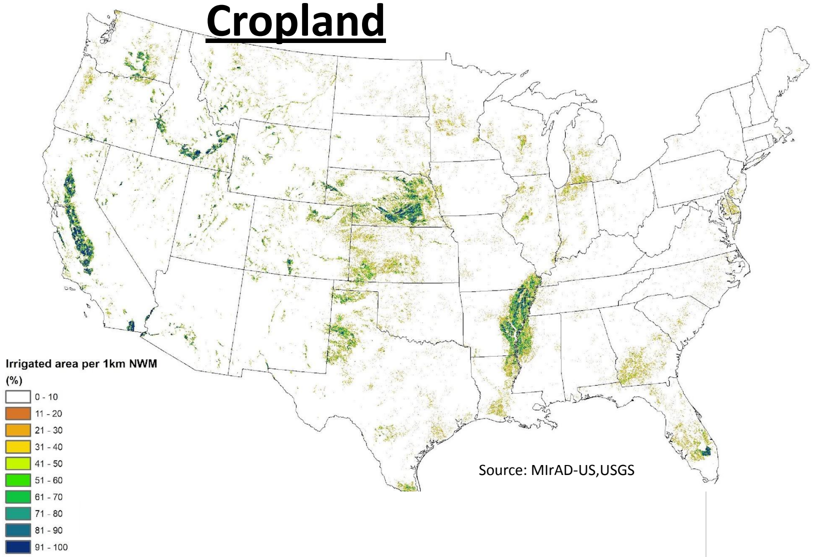
Cropland

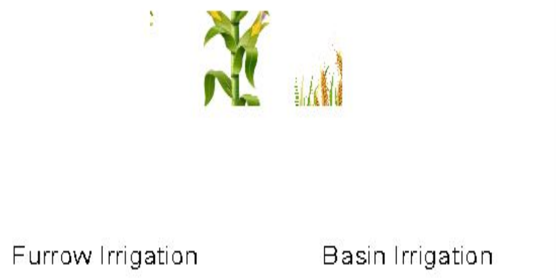




- About 20% of the contiguous United States (CONUS) is croplands
- 166 Mha area
- Cultivate different crops
- Impact land surface energy-water balances

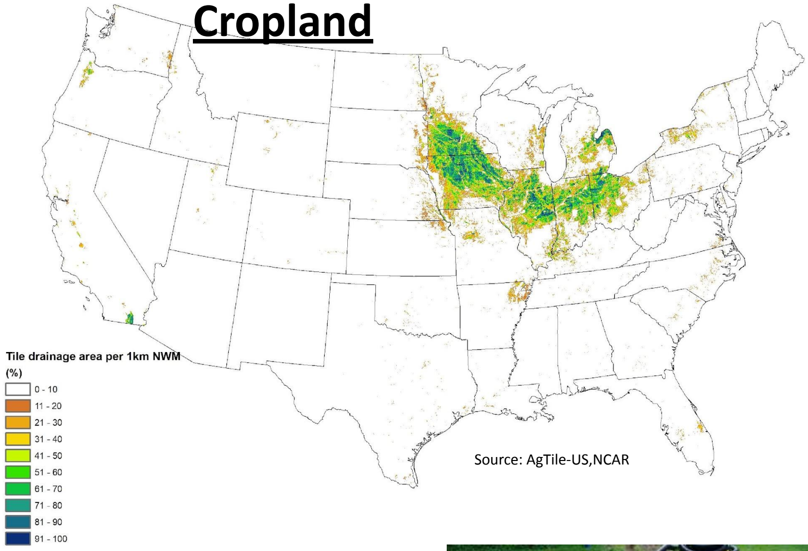
Irrigated Cropland

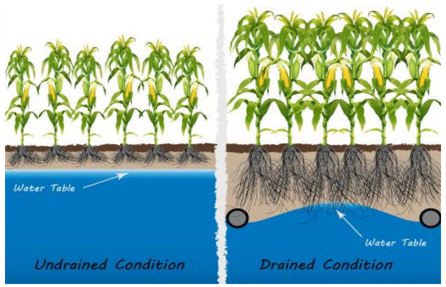




- Irrigation on precipitation limited croplands
- Enhance crop productivity
- About 14% of the CONUS croplands are irrigated
- 22.7 Mha area
- Follow sprinkler, micro or surface flooding

Tile-drained Cropland



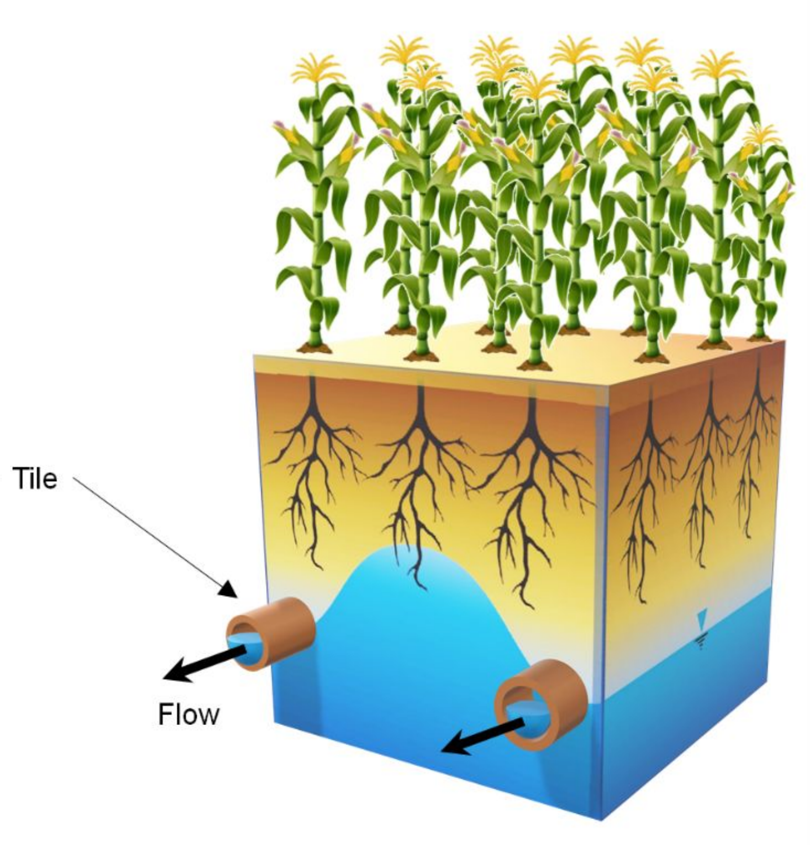


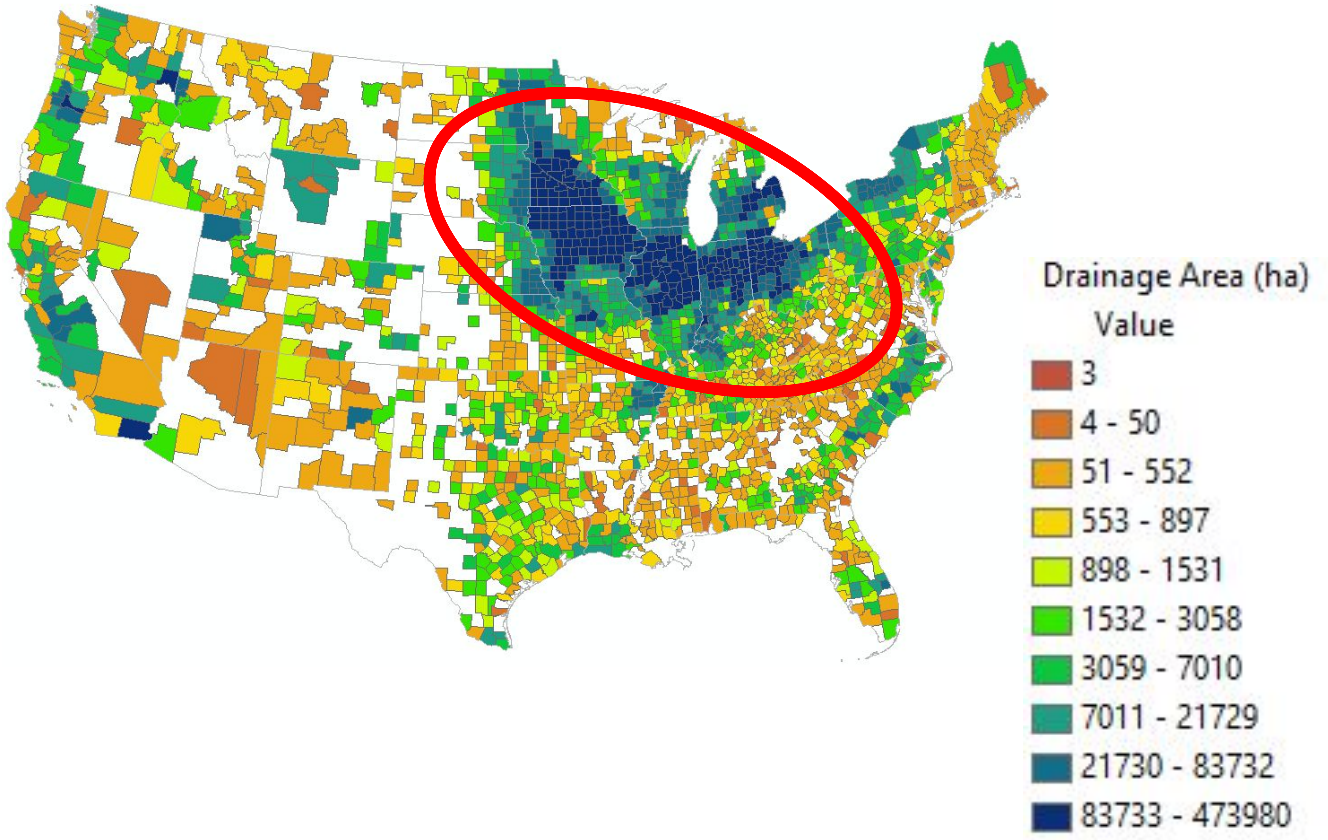
- Practices where high precipitation and shallow water table occurs - persisting saturated soils
- Artificial drainage of excess root zone water to enhance crop growth
- About 14% of the CONUS croplands are tile-drained
- 22.48 Mha area

1. Implementing Tile Drainage in NWM / Noah-MP

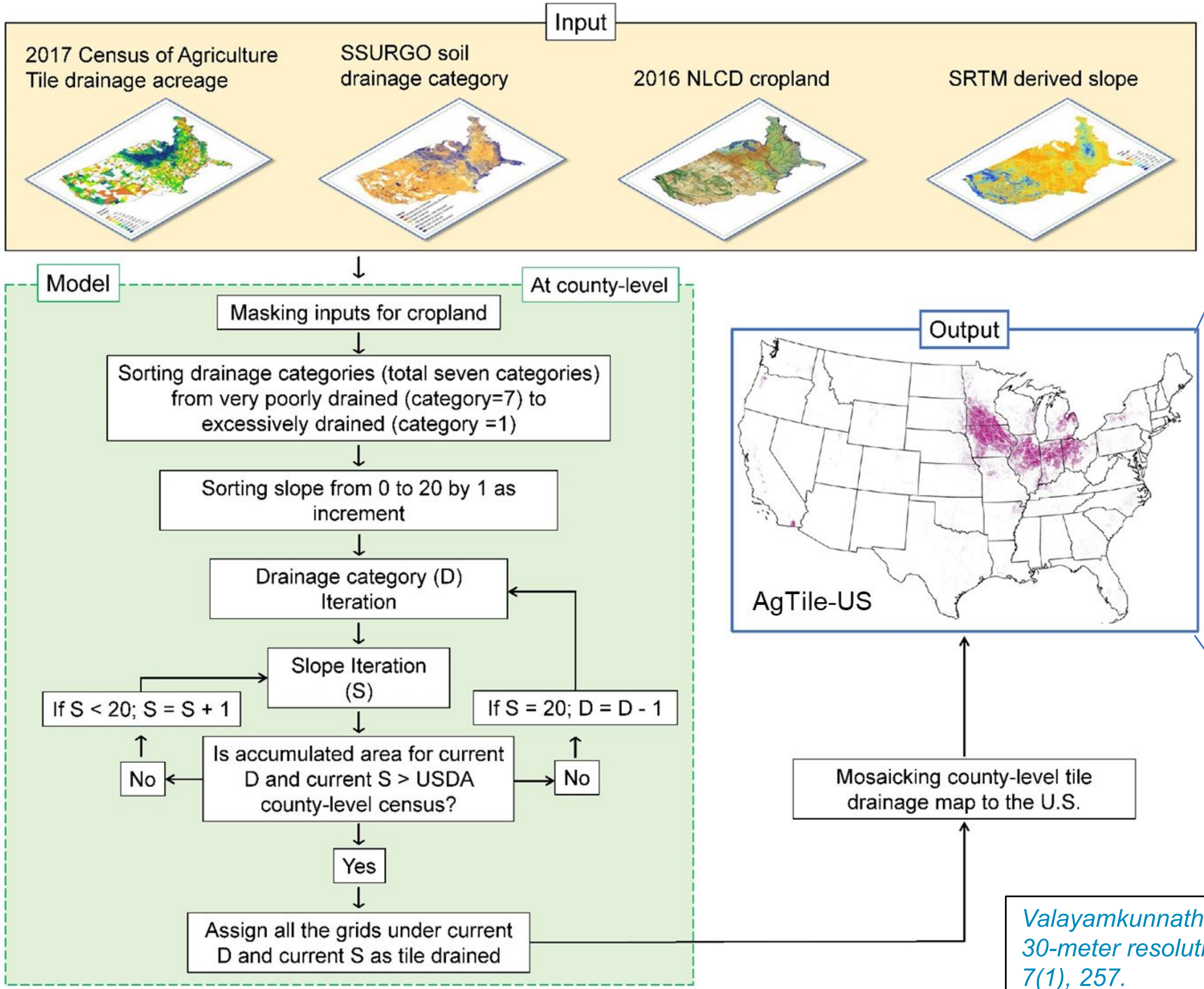
Challenge?

- **No CONUS-scale tile drainage model**
- **No field-scale data or high resolution tile drainage data for the CONUS-scale modeling**

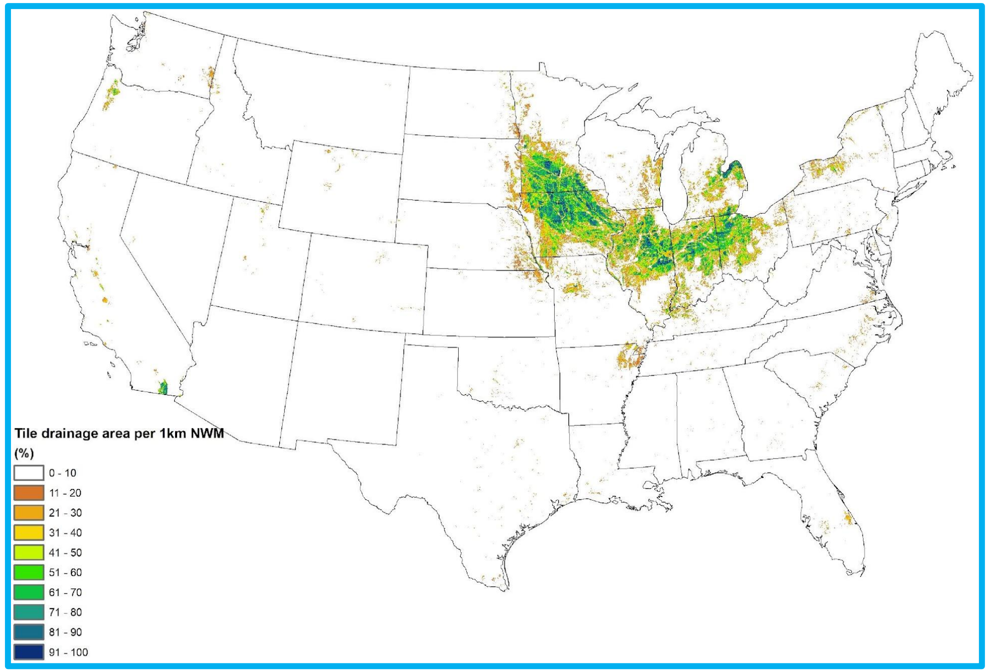




1. Implementing Tile Drainage : Generate Tile Drainage Data

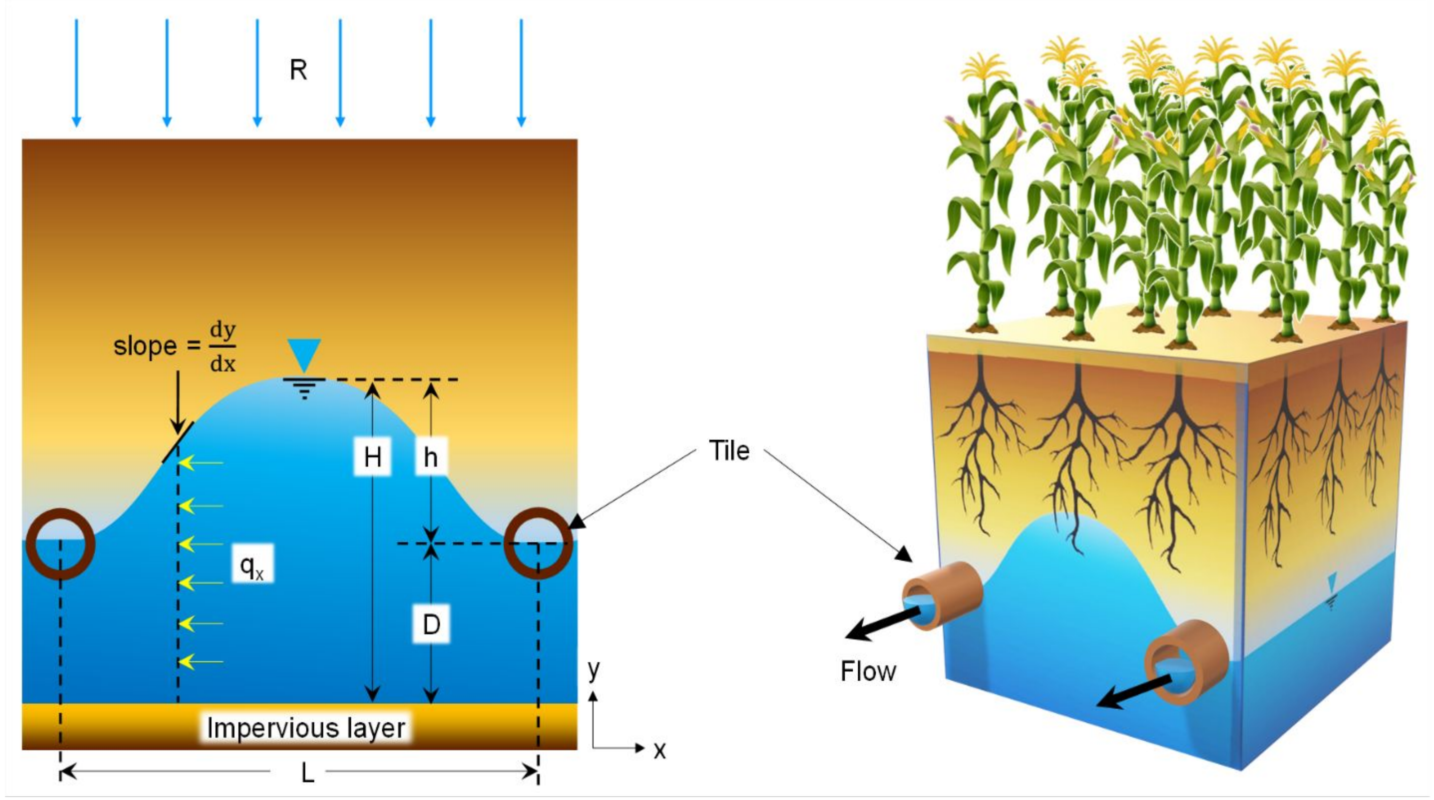


Overall accuracy when compared with 16000 ground truths is **86.03%**



Valayamkunnath, P., Barlage, M., Chen, F., Gochis, D. J., & Franz, K. J. (2020). Mapping of 30-meter resolution tile-drained croplands using a geospatial modeling approach. Scientific data, 7(1), 257.

1. Implementing Tile Drainage : The Hooghoudt's Scheme



Hooghoudt's Tile Drainage

- Extract water from the NoahMP soil layers using Hooghoudt's equation

- Amount of water drained,

$$q = \frac{8\,K\,D\,h + 4\,K\,h^2}{L^2}$$

Where, K is saturated hydraulic conductivity

Valayamkunnath, P., Gochis, D. J., Chen, F., Barlage, M., & Franz, K. J. (2022). Modeling the hydrologic influence of subsurface tile drainage using the National Water Model. Water Resources Research, 58(4), e2021WR031242.

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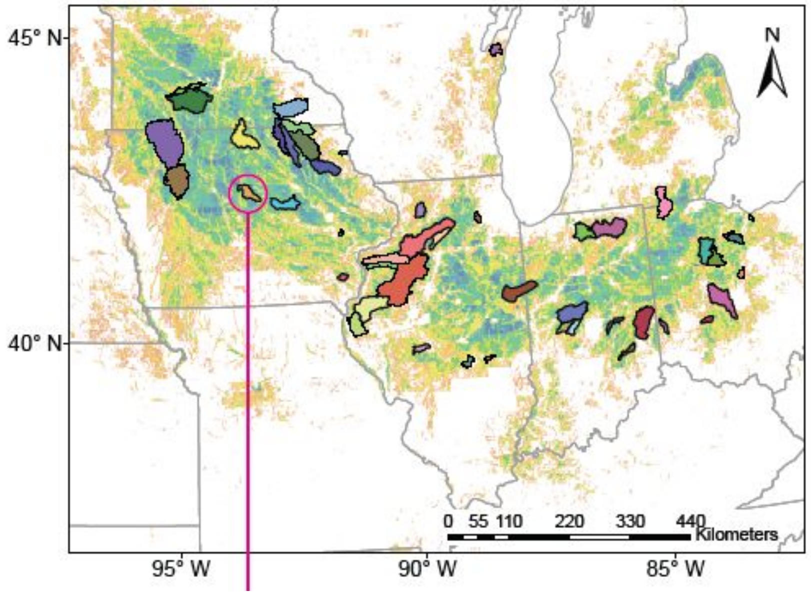
1. Implementing Tile Drainage : NWM Streamflow calibration

Calibration Basins

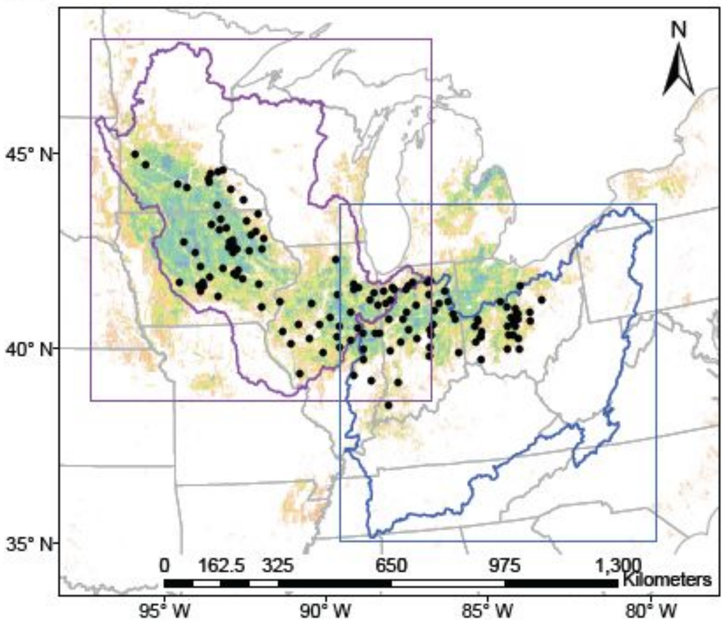


- **49** calibration basins (USGS) are identified based on (area tile drained/basin area) > **10%**

Calibration

Calibration Period :
10/1/2007 – 10/31/2013
Validation Period :
10/1/2013 – 10/31/2019
Forcings and time periods are similar to NWM V2.1

Regional Simulation



USGS streamflow gage
Upper Mississippi River Basin (UMRB)
Ohio River Basin (ORB)
UMRB NWM domain
ORB NWM domain

NWM Experiments

Default: Uncalibrated NWM

DefaultTD: Uncalibrated NWM with TDS

Calib: Calibrated NWM

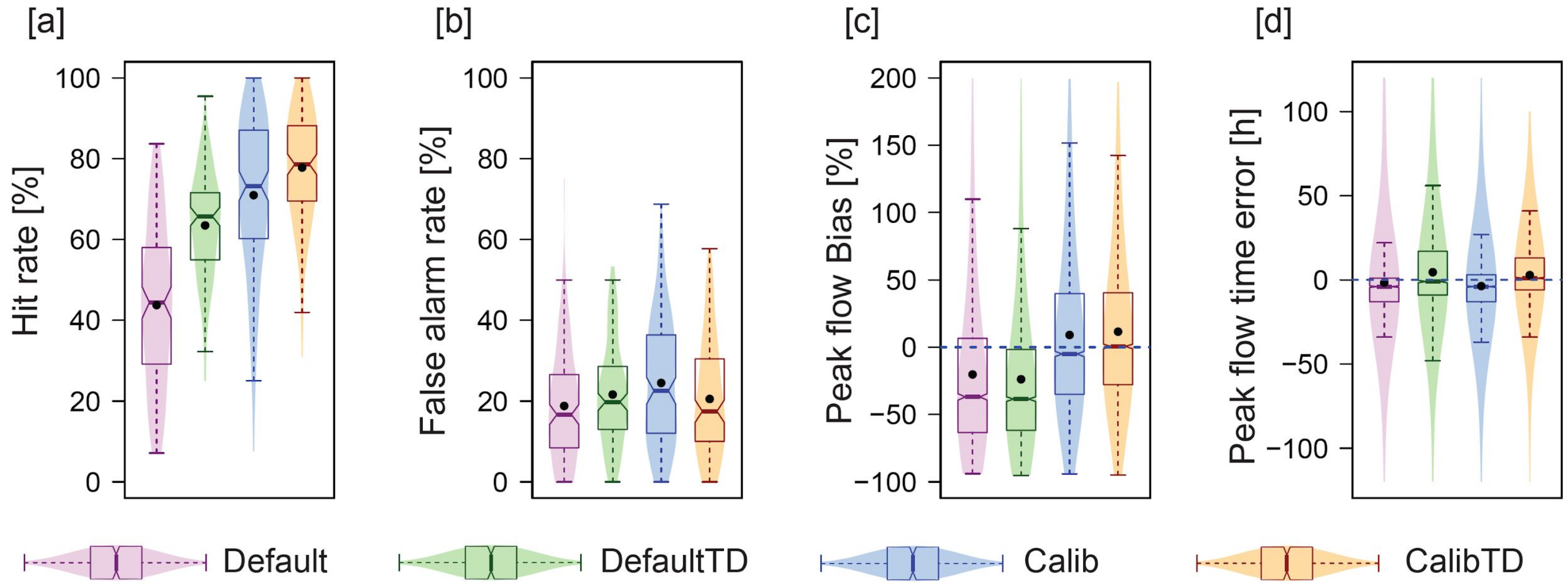
CalibTD: Calibrated NWM with TDS

Tile drainage parameters calibrated

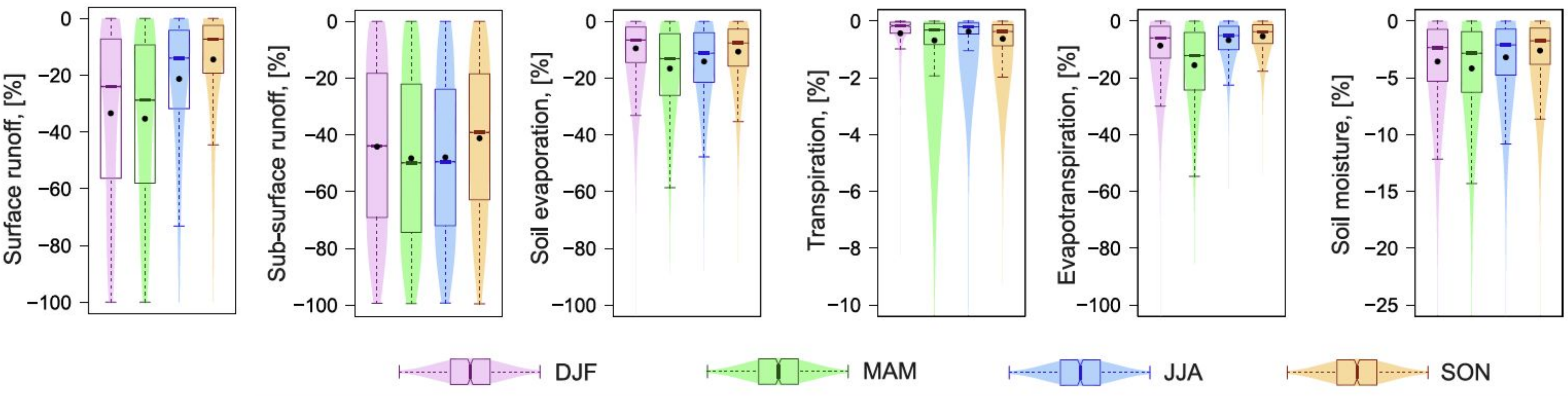
- TD_SPAC - tile spacing

NWM better capture flood events when tile drainage is active

Event-based evaluation of NWM simulated streamflow against USGS observations over the regional domain

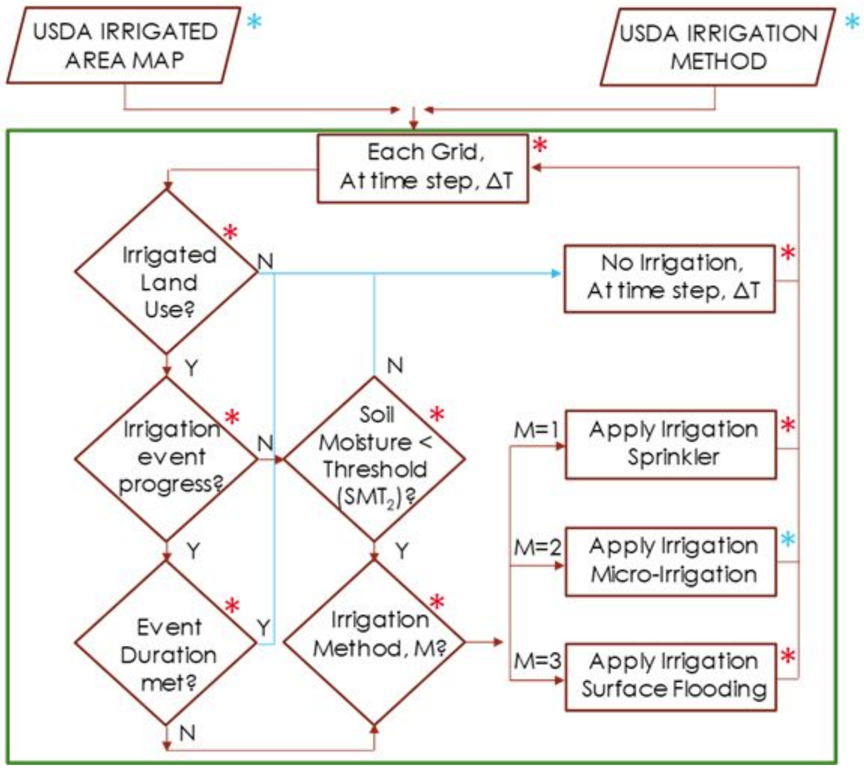


Impacts of tile drainage on Noah-MP water balance components

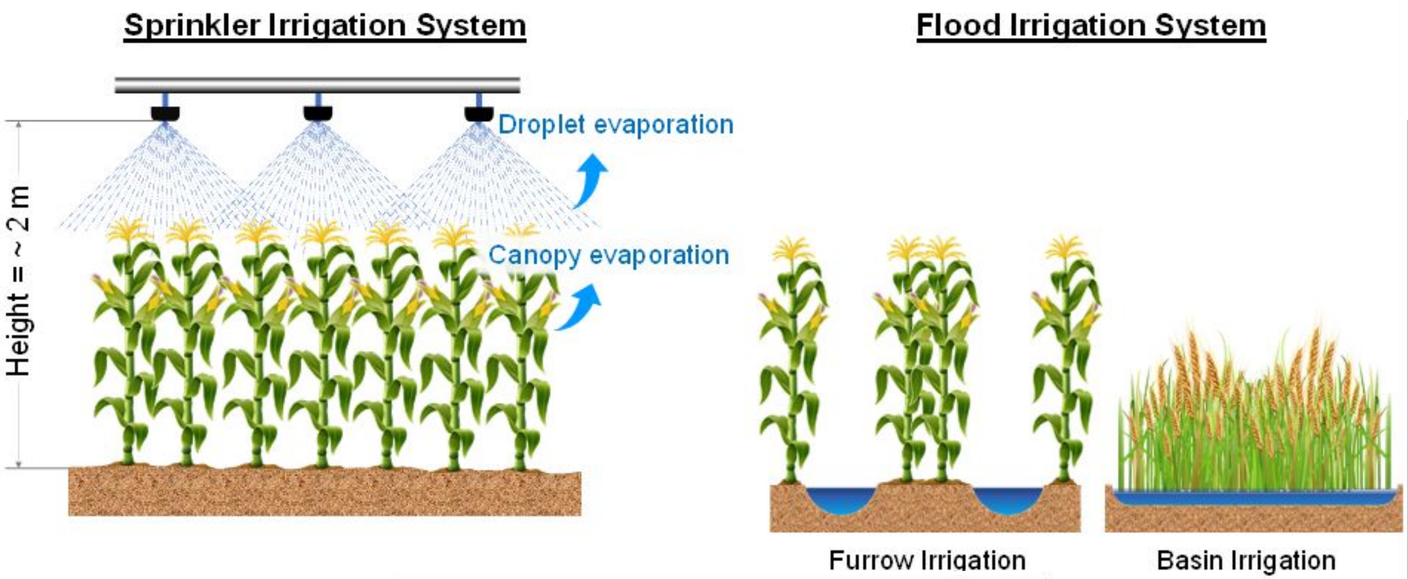


2. Implementing Irrigation process in NWM / Noah-MP

Noah-MP Dynamic Irrigation Scheme

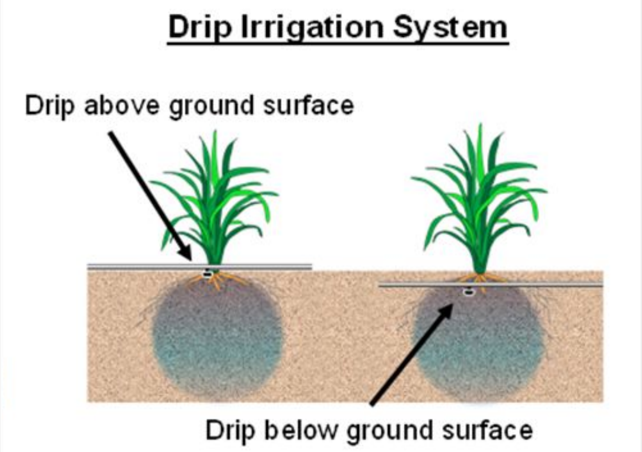


1) where to irrigate?
2) when to irrigate?
3) what amount of water to irrigate? and
4) how to irrigate?



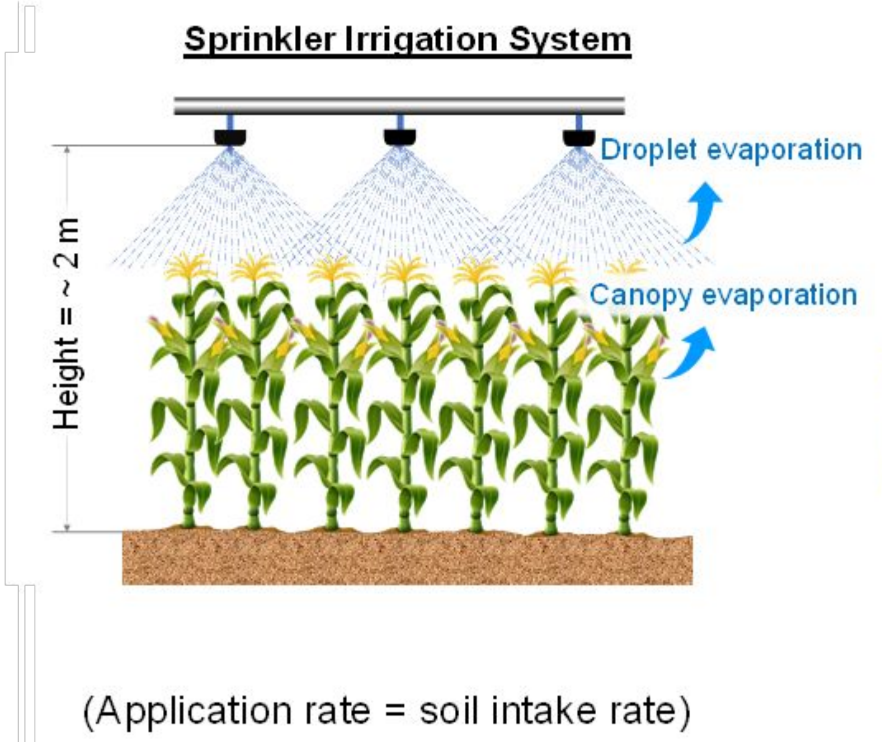
(Application rate = soil intake rate)

(Application rate > soil intake rate)

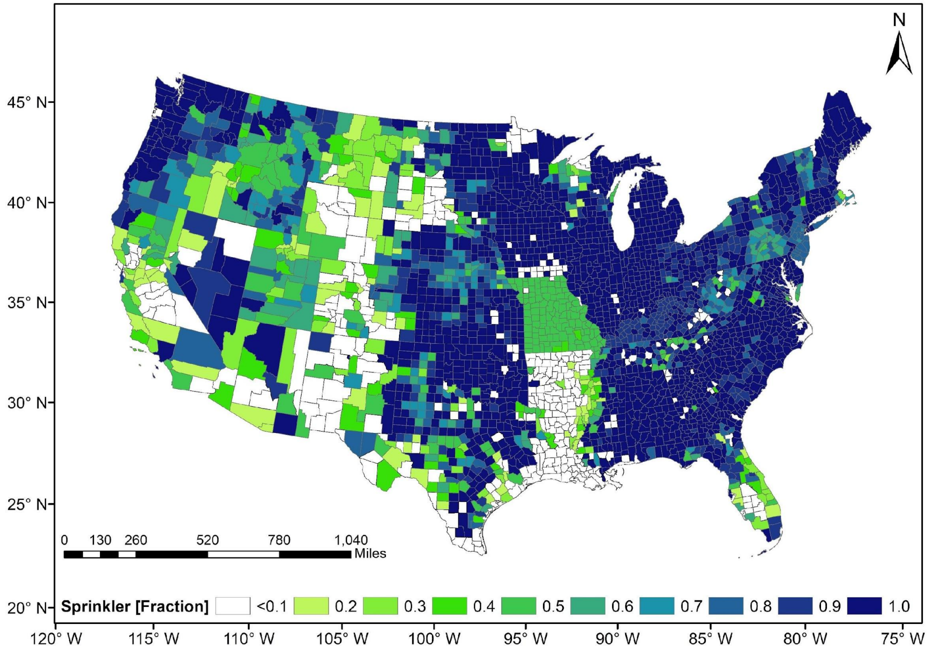


(Application rate <= soil intake rate)

2. Implementing Irrigation process in NWM / Noah-MP



Sprinkler Irrigation Fraction



- Applying water from certain height (~2m) above ground.

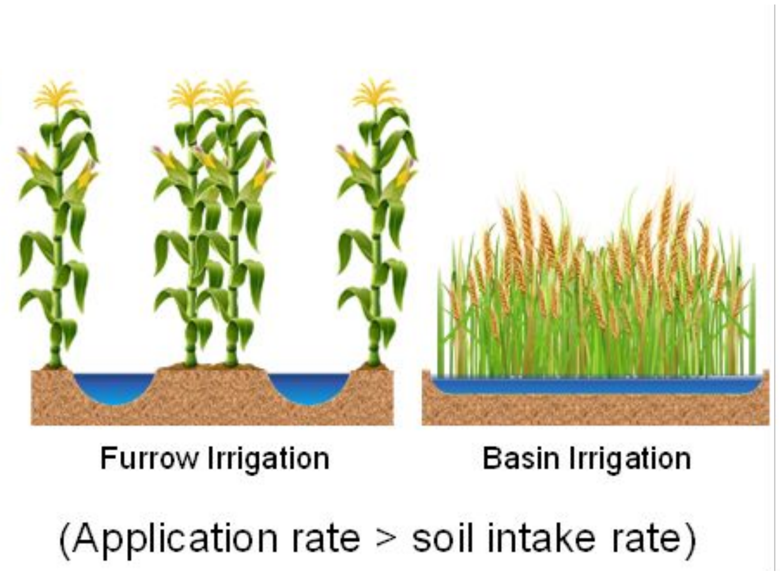
- Needs to consider
  - Canopy water storage
  - Evaporation of irrigation water before reaching the ground

$$E = 4.375 \exp(0.106u)(e_s - e_0)^{-0.092} T_a^{-0.102} \quad (3)$$

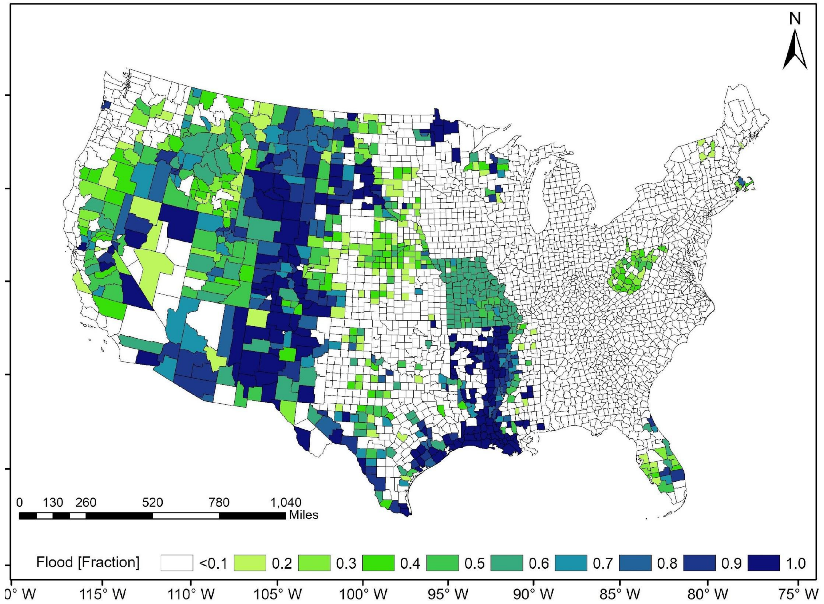
Bavi, A., Kashkuli, H. A., Boroomand, S., Naseri, A., & Albaji, M. (2009). Evaporation losses from sprinkler irrigation systems under various operating conditions. Journal of Applied Sciences, 9(3), 597-600.

2. Implementing Irrigation process in NWM / Noah-MP

Flood Irrigation System



Flood Irrigation Fraction



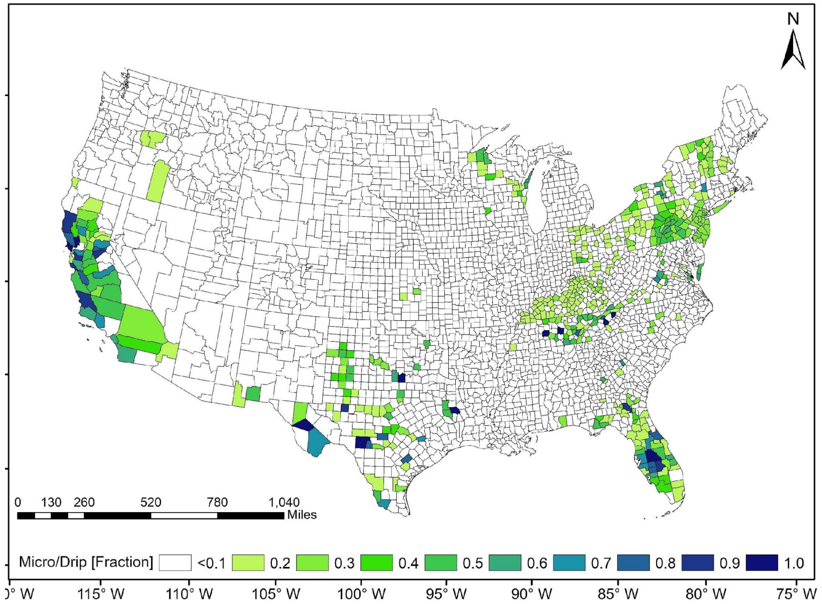
- Applying water on the surface and Saturate it.
- Unlike other methods, water applied from one edge and advances the flow to other edge.
- Application rate will be higher than maximum infiltration rate

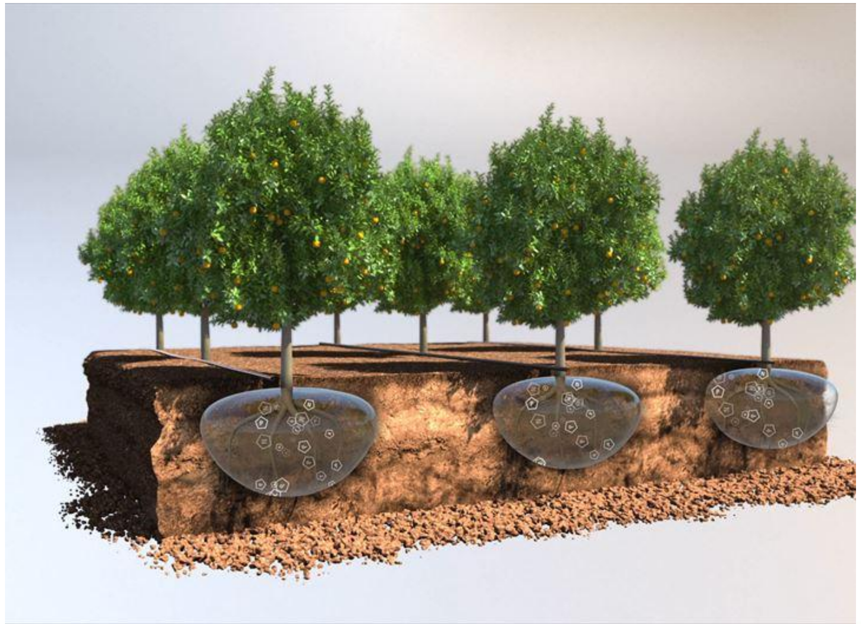
2. Implementing Irrigation process in NWM / Noah-MP

Micro Irrigation System

- Applying water on the surface or subsurface
- Low application rate (drips)
- In Noah-MP micro irrigation scheme will apply water at the 0-10 cm layer at a prescribed rate

Micro Irrigation Fraction





Micro Sprinkler (15-30 cm height)

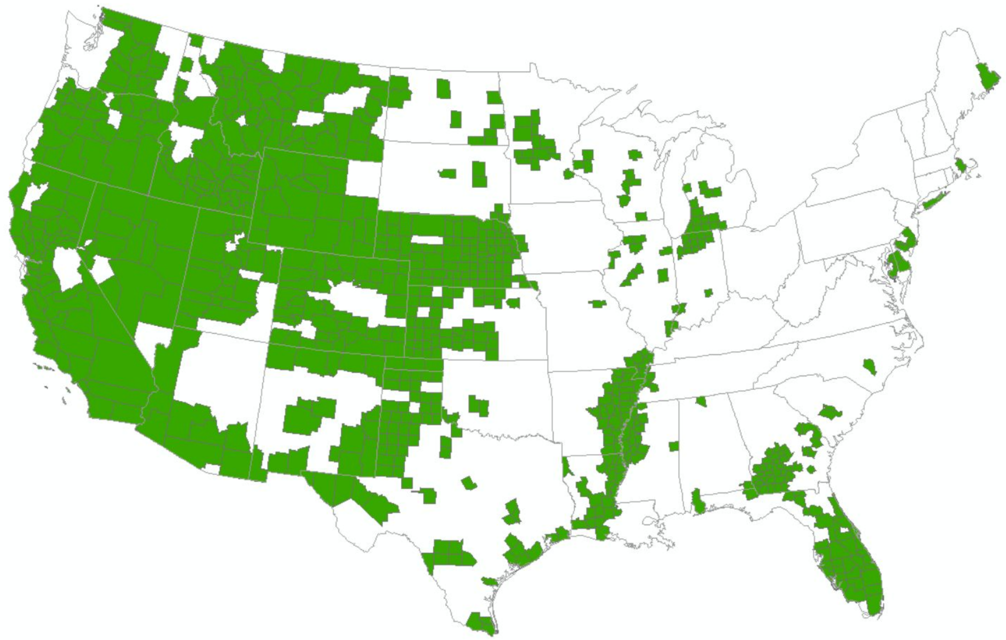
2. Implementing Irrigation process in NWM / Noah-MP

Noah-MP Dynamic Irrigation Scheme Parameters

```
&noahmp_irrigation_parameters
 IRR_FRAC          = 0.10        ! irrigation Fraction
 IRR_HAR           = 20          ! number of days before harvest date to stop irrigation
 IRR_LAI           = 0.10        ! Minimum lai to trigger irrigation
 IRR_MAD           = 0.60        ! management allowable deficit (0.0-1.0)
 FILOSS            = 0.50        ! flood irrigation loss fraction (0.0-0.99)
 SPRIR_RATE        = 6.40        ! mm/h, sprinkler irrigation rate
 MICIR_RATE        = 1.38        ! mm/h, micro irrigation rate
 FIRTFAC           = 1.20        ! flood application rate factor
 IR_RAIN           = 1.00        ! maximum precipitation [mm/hr] to stop irrigation trigger
/
```

2. Noah-MP Irrigation Scheme: CONUS Calibration

Noah-MP irrigation- County-level Calibration

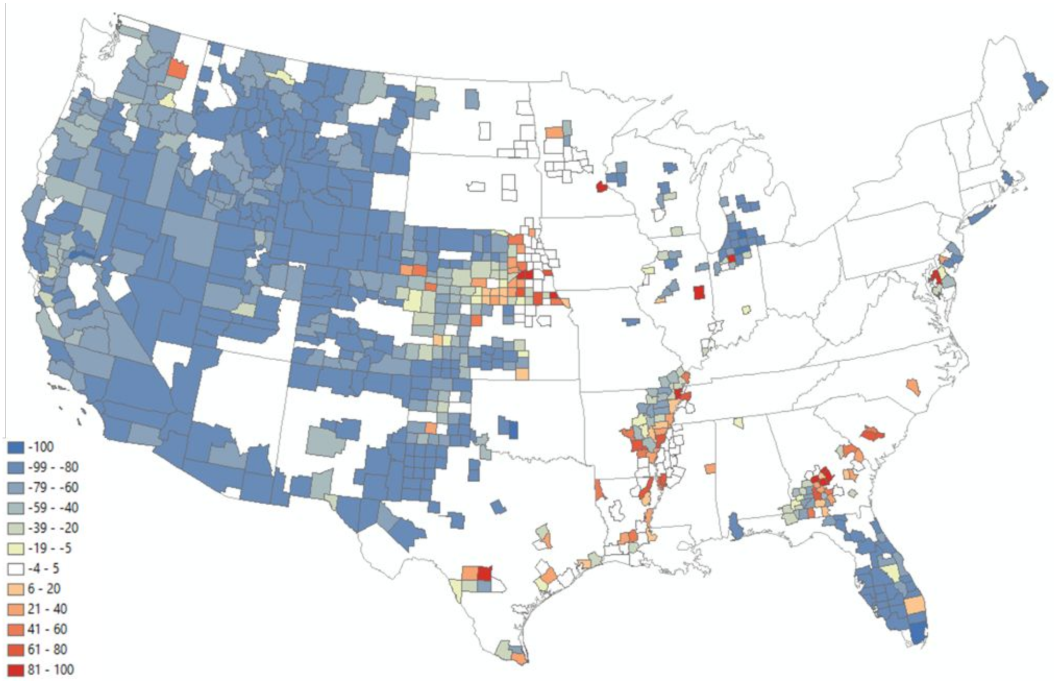


Parameter	Minimum value	Maximum value
IRR_LAI (minimum LAI to start the crop season)	0.01	1.0
IRR_MAD (management allowable deficit)	0.20	1.0
FILOSS (flood irrigation loss factor)	0.0	1.0
SPRIR_RATE (sprinkler irrigation rate)	1.0	12.0
MICIR_RATE (micro irrigation rate)	0.5	6.0
FIRTFAC (flood irrigation rate factor)	1.0	10.0

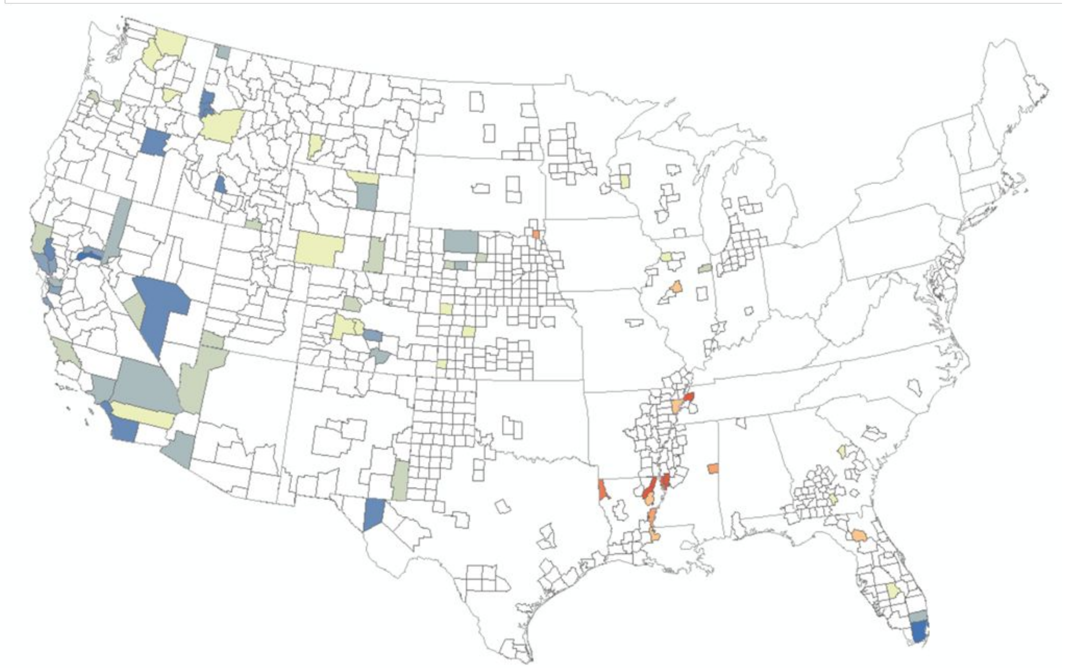
- Selected heavily irrigated 747 counties (green counties in above figure) and optimized all the irrigation scheme parameters that are listed in Table 1 against USGS County-level irrigation water use.

Calibration result: Bias in Noah-MP estimated irrigation water

With default parameters



With calibrated parameters



- Percentage bias in annual irrigation water simulated by the dynamic irrigation scheme, compared to USGS county-level water use.

- White color indicates the bias is between ± 5%.

NWM-Irrigation Calibration

- The 114 basins are selected for the basin with irrigation fraction higher than 10%

Calibration

Calibration Period :
10/1/2007 – 10/31/2013
Validation Period :
10/1/2013 – 10/31/2019
Forcings and time periods are similar to NWM V2.1

NWM Experiments

Default: Uncalibrated NWM

Calib: Calibrated NWM

CalibIRR: Calibrated NWM with DIS

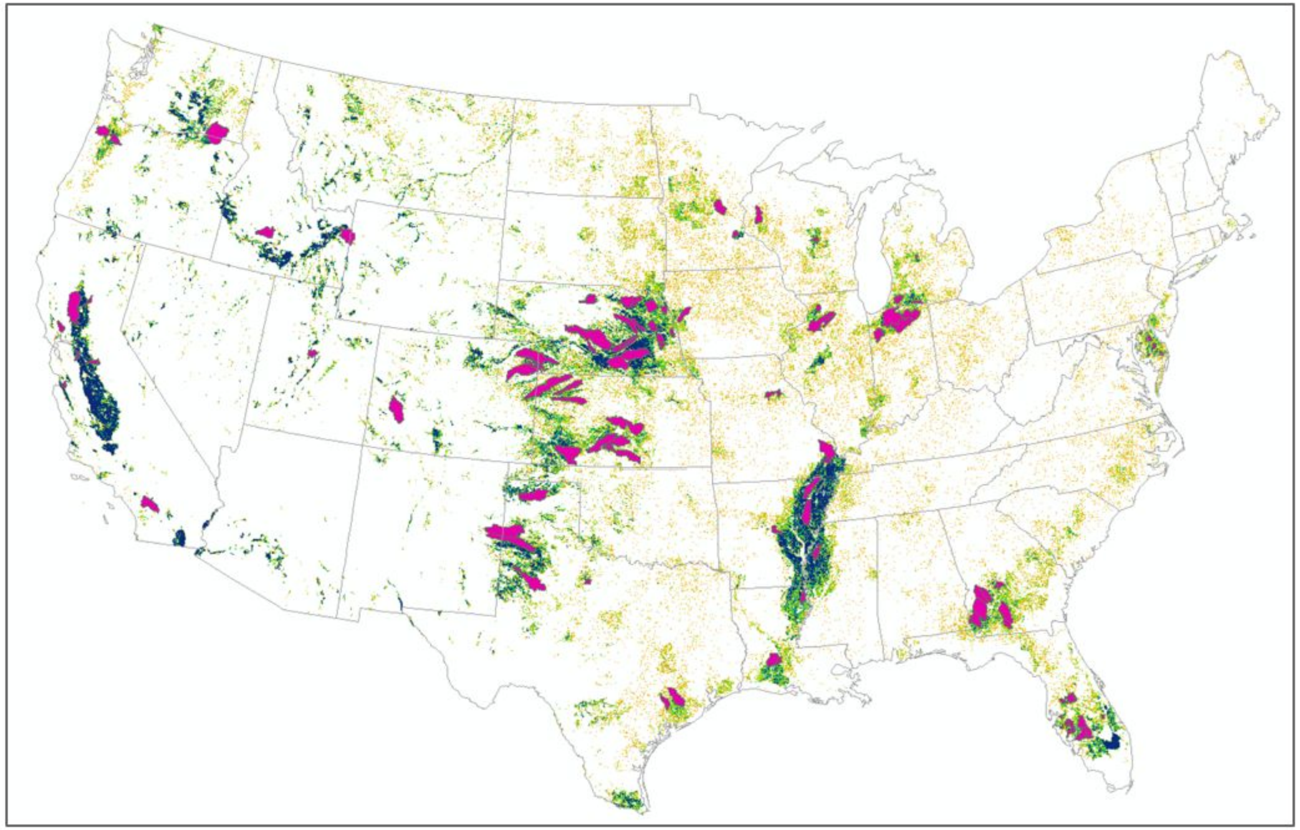
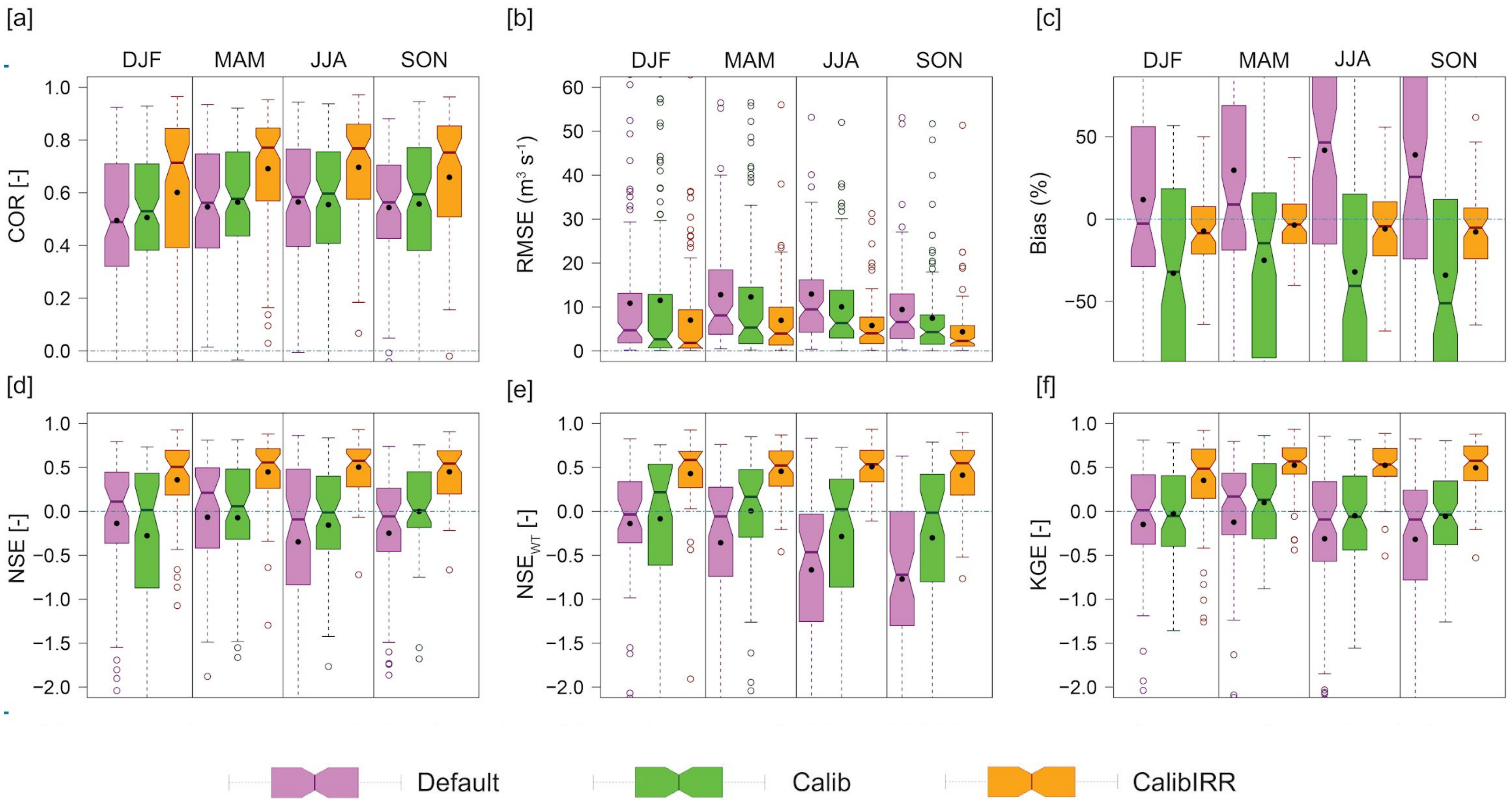


Fig. 114 basins selected for NWM-Irrigation model calibration. The shaded color indicates the irrigation fraction at 1-km NWM grid. Blue indicate higher fraction of irrigated area and orange indicate lowest irrigation fraction.

NWM performs better with irrigation scheme



Conclusion

- Overall, incorporating agriculture management practices into the National Water Model enhanced the NWM performance in simulating streamflow over the CONUS.

- Especially, implementing tile drainage improved the NWM streamflow hit rates and reduced false alarm rates.

- Irrigation scheme reduced the bias and error in the NWM simulated streamflow

- Our findings highlight the importance of incorporating the tile drainage irrigation processes into the operational configuration of the NWM

Ongoing Noah-MP Work

- Groundwater Pumping: Coupling irrigation scheme with MMF groundwater scheme
- Represent Rice/Paddy Irrigation in Noah-MP Dynamic Irrigation Scheme
- Developing Noah-MP calibration suite "RNoahMPCalib"

```
RNoahMPCalib
├── calib
│   ├── adjust_noahmpParam.R
│   ├── calib_param.tbl
│   ├── calibration.R
│   └── util.R
├── core
│   ├── module_checkstatus.R
│   ├── module_copy_domainFiles.R
│   ├── module_copy_TBLs.R
│   ├── module_copy_wrfexe.R
│   ├── module_excecute_model.R
│   ├── module_ij_processors.R
│   ├── module_namelist_hrldas_back.R
│   ├── module_namelist_hrldas.R
│   ├── module_parallel_script.R
│   ├── module_setup_calibDomains.R
│   ├── module_write_calibration.R
│   ├── module_write_jobs.R
│   ├── module_write_spinup.R
│   └── module_write_validation.R
├── driver_setup_experiment.R
├── namelist.irr
├── run_calibration.R
└── run_spinup.R
```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Thank you!