

Groundwater withdrawals under drought: reconciling GRACE and models in the United States High Plains Aquifer

Wanshu Nie¹, Benjamin Zaitchik¹, Sujay Kumar², Matthew Rodell²

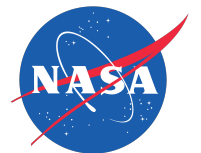
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Acknowledgements: David Mocko, Joseph Santanello, Hamada Badr, Patricia Lawston, Guoyong Leng, Jonathan Case, Kristi Arsenault, Martha Anderson, Christopher Hain, Virginia McGuire



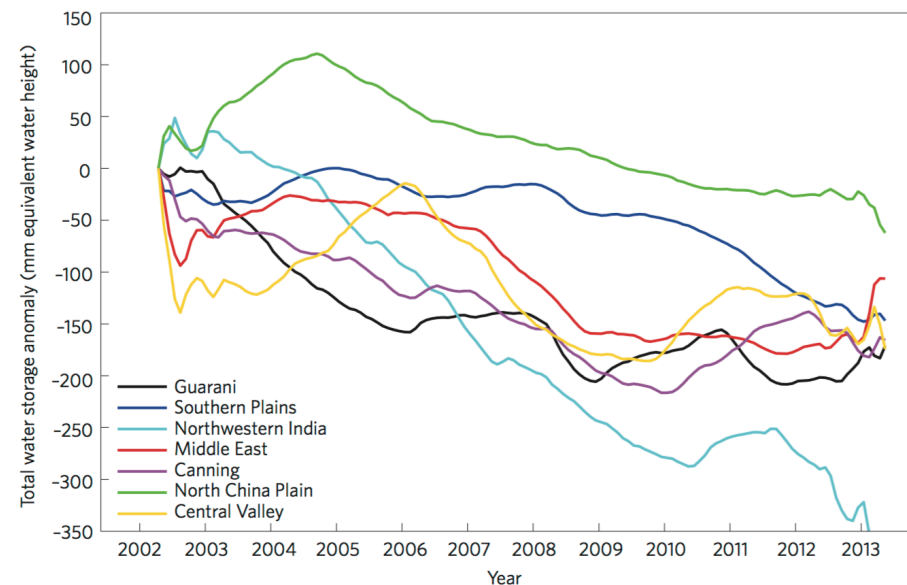
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Motivation

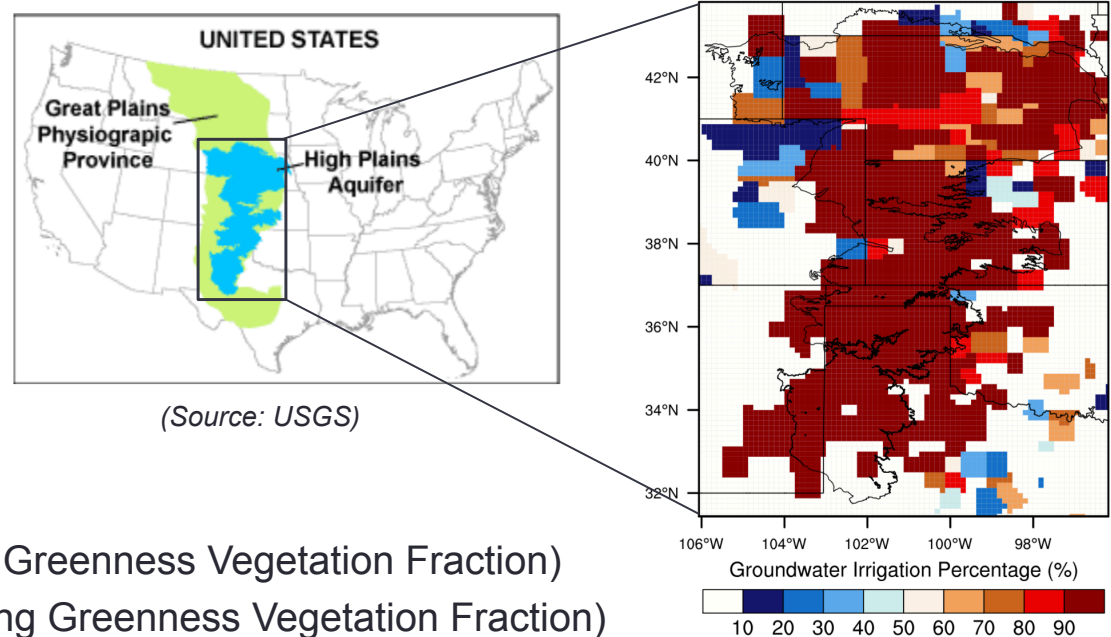
- ❑ Improve the model representation of water cycle in heavily utilized region.
 - ❑ Better representation of water balance by introducing a groundwater pumping irrigation scheme.
 - ❑ Pave the way to improve the drought monitoring and forecasting.



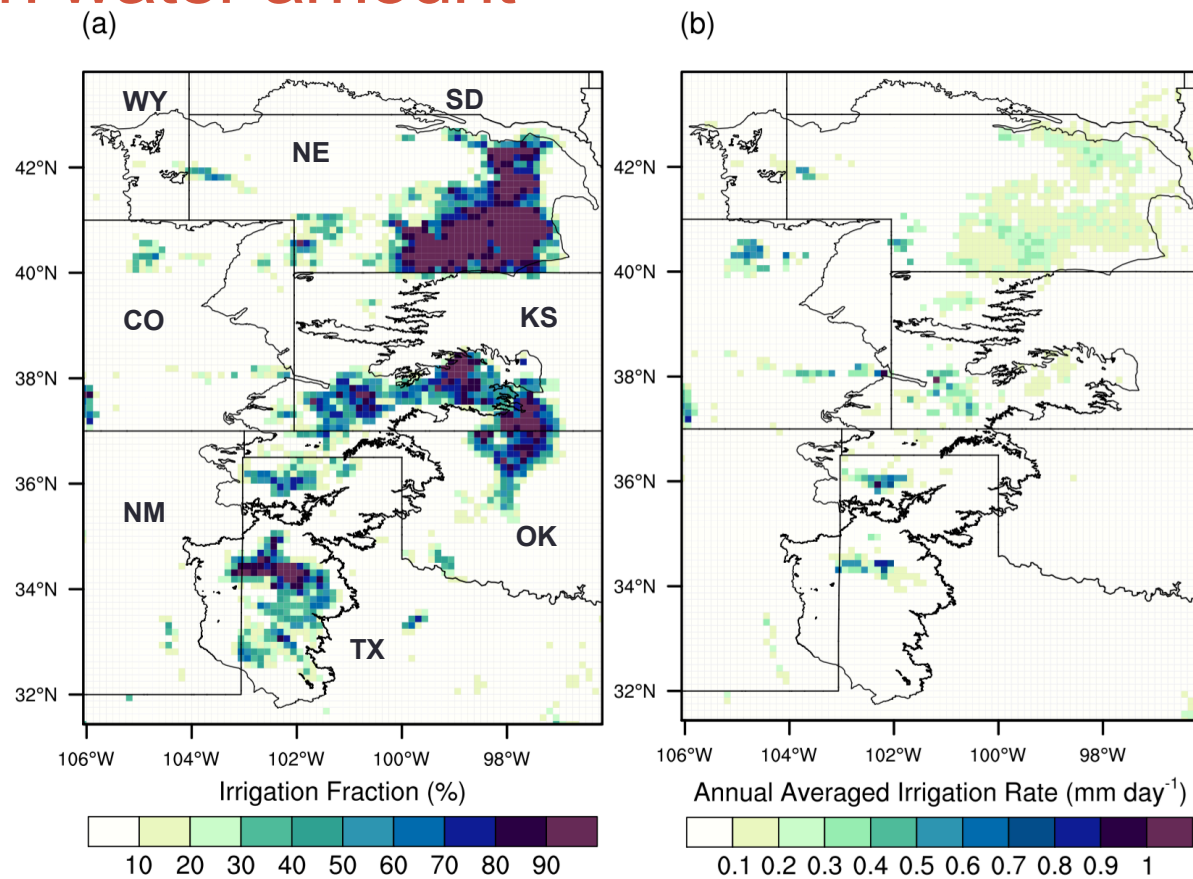
(Source: Famiglietti 2014)

LIS-based NLDAS Testbed

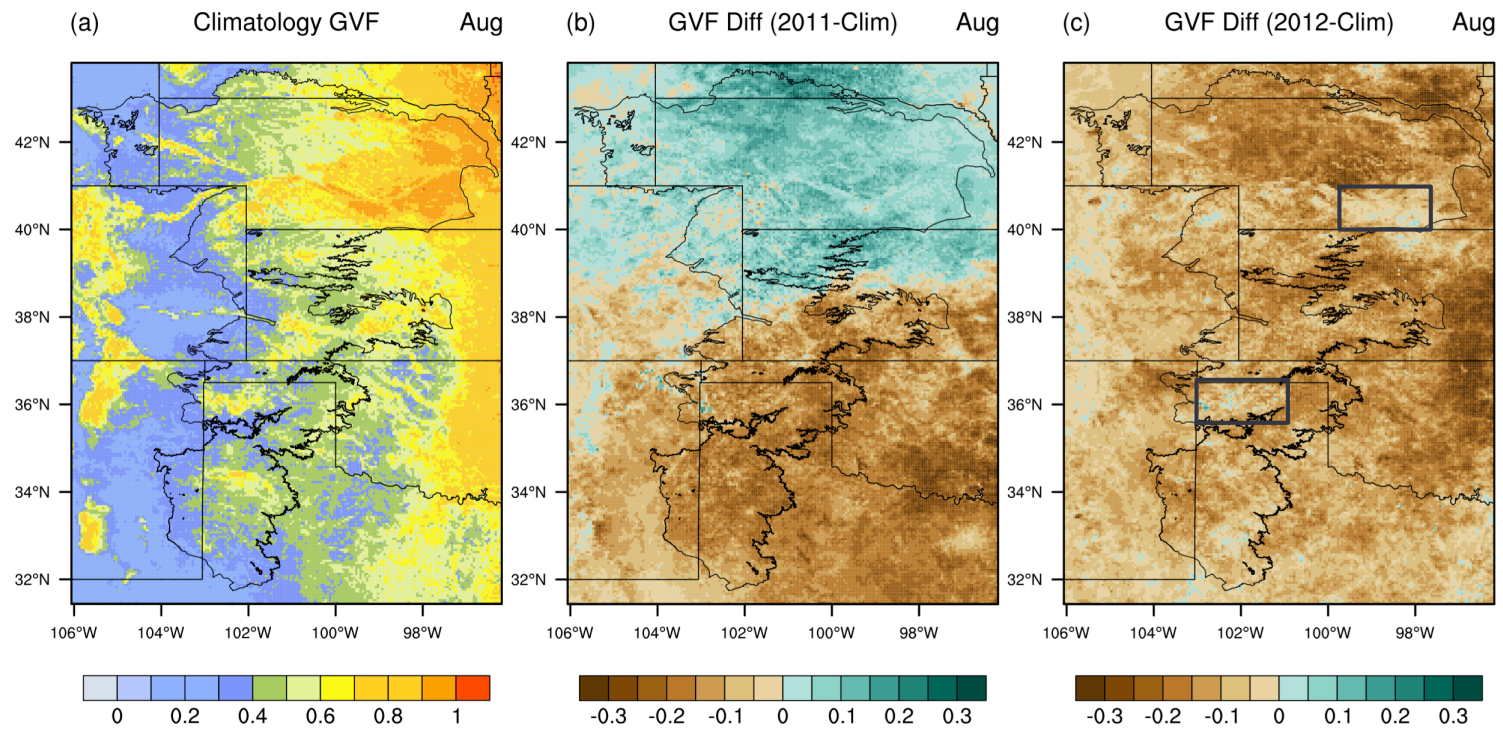
- **Study area:** High Plains Aquifer
- **Spatial resolution:** 12.5 km
- **Forcings:** NLDAS Phase 2
- **Simulations:**
 - **noIRR:** no irrigation
 - **IRR_C:** irrigation (Climatology Greenness Vegetation Fraction)
 - **IRR_TR:** irrigation (Time-varying Greenness Vegetation Fraction)
- **Time period:** A 21-year spin-up (1995-2015) was performed retrospectively for three times and the restart file of 2015.12 is used to simulate **2002-2015**.



Irrigation water amount

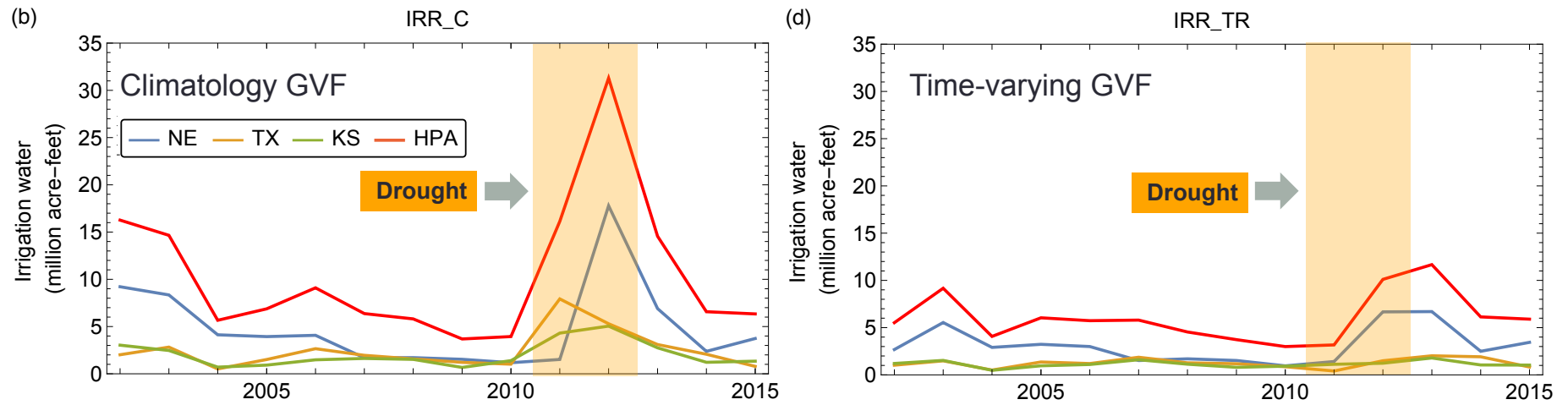


HPA drought 2011-2012

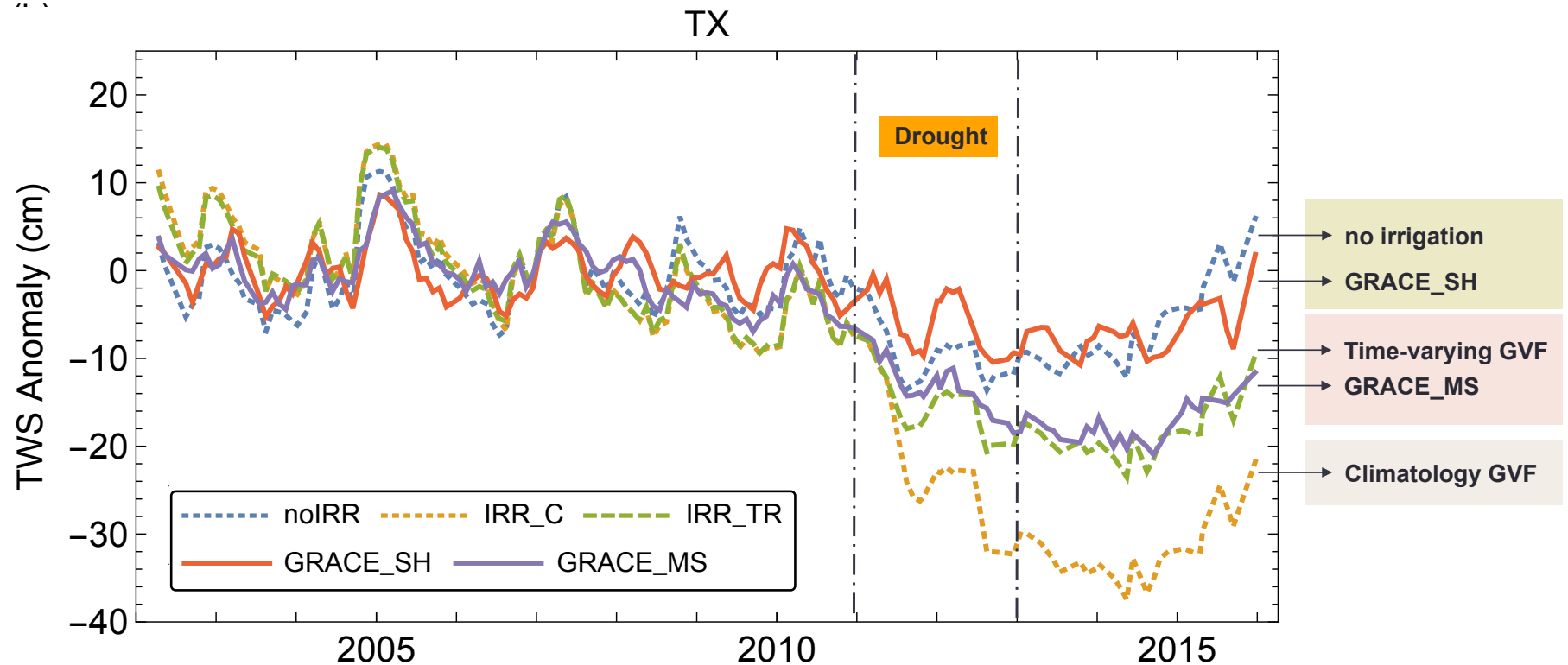


GVF = Greenness Vegetation Fraction

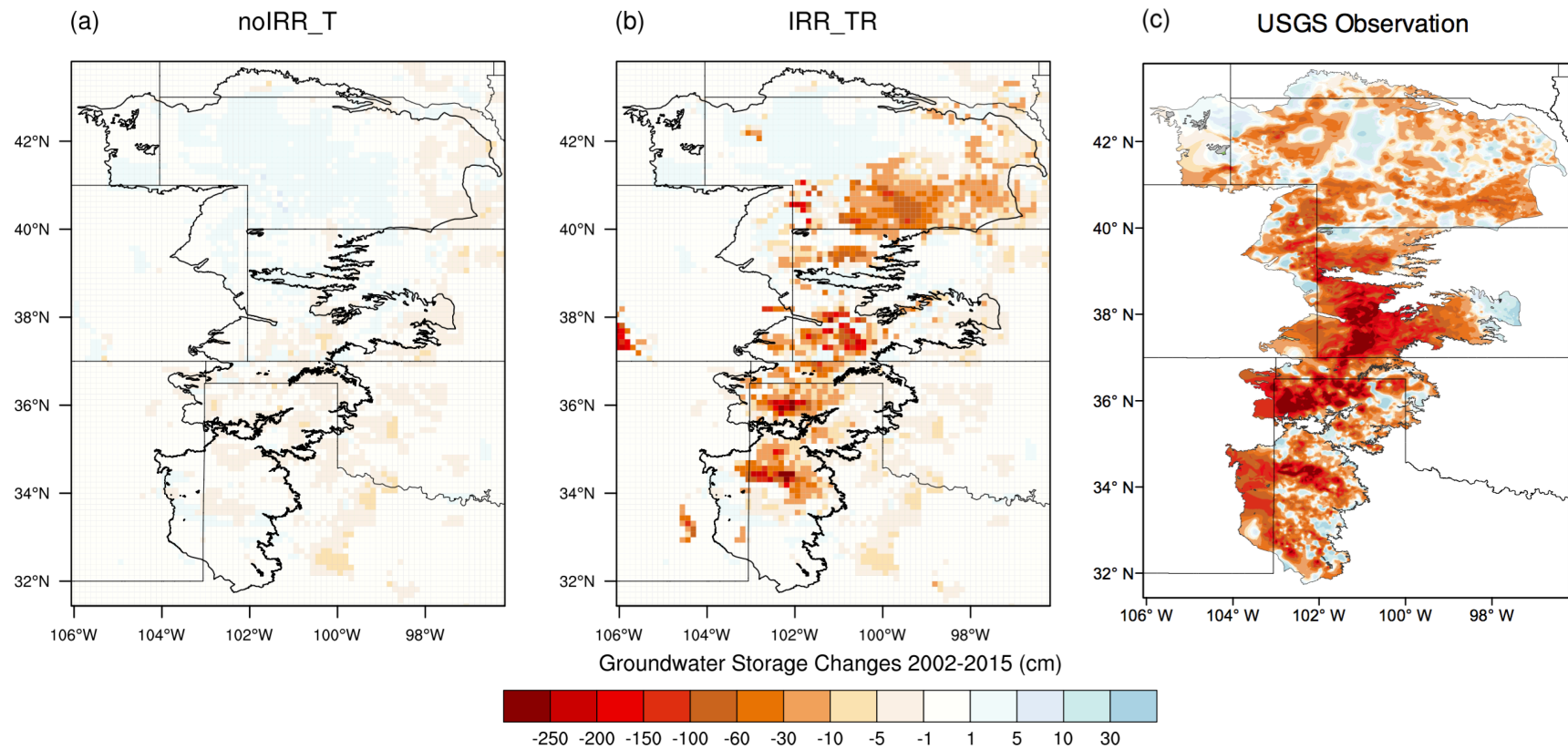
Simulated irrigation water amount



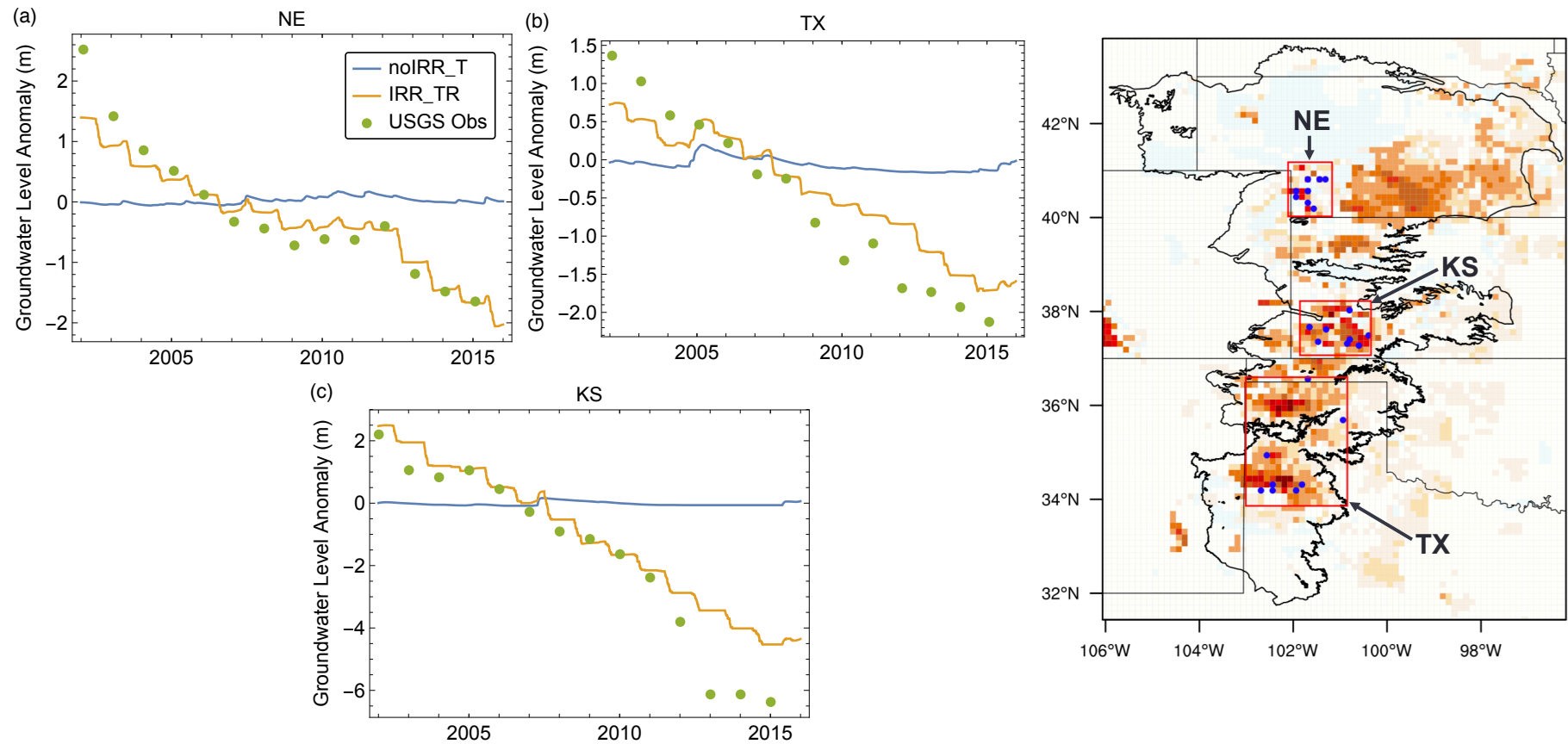
Comparison between simulated and GRACE TWS anomaly



Comparison between simulated and USGS observed groundwater storage change



Groundwater level decline

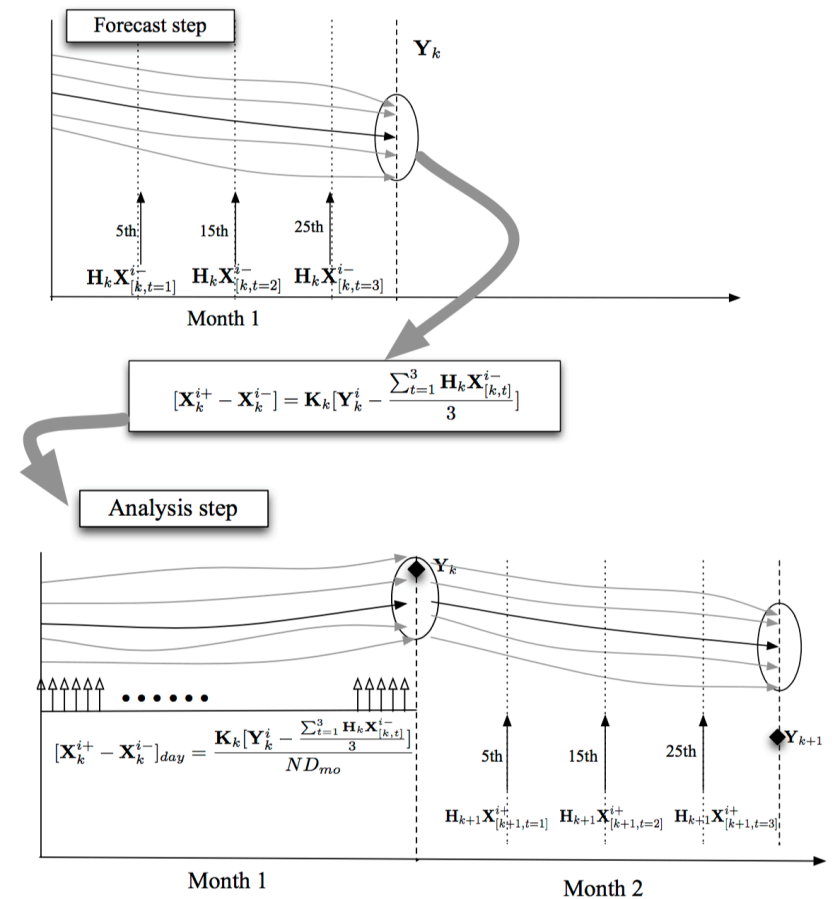


Summary

- ❑ Adding irrigation and GW extraction schemes to Noah-MP improves model simulation of multiple states and fluxes (not all results shown here).
- ❑ Information on time-varying GVF is required to capture changing irrigation strategies under drought.
- ❑ Comparisons with GRACE are informative but product-dependent. Careful interpretation of GRACE products is necessary.

LIS-GRACE TWS Data Assimilation Framework

- ❑ 3-D Ensemble Kalman Smoother (EnKS) temporally disaggregates the observations into a finer, daily scale and then update simulations with the analysis calculated by Kalman gain matrix.
- ❑ We hope that the irrigation enhanced Noah-MP in combination with the GRACE observations could improve the TWS data assimilation system and improve the drought monitoring and forecasting skills.



(Source: Kumar et al. 2016)

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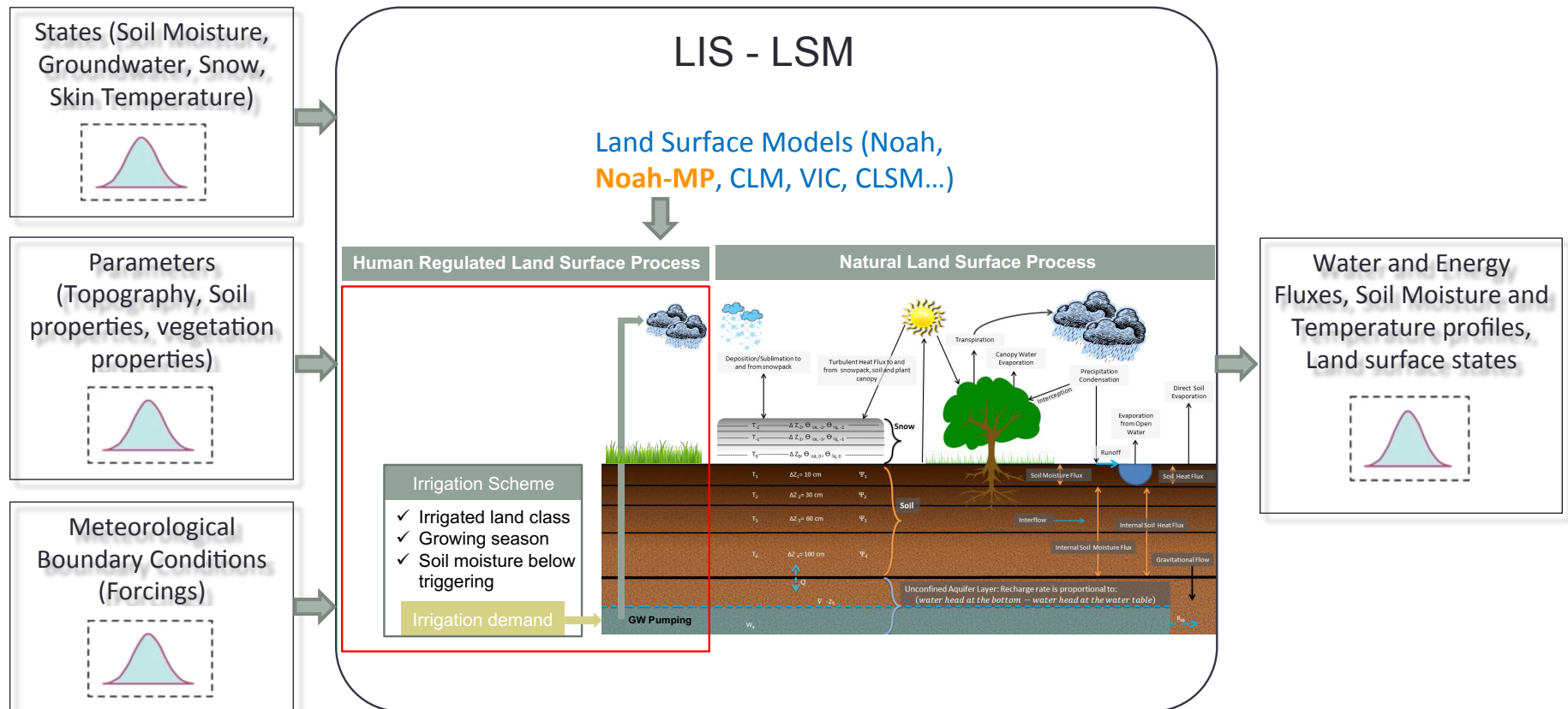
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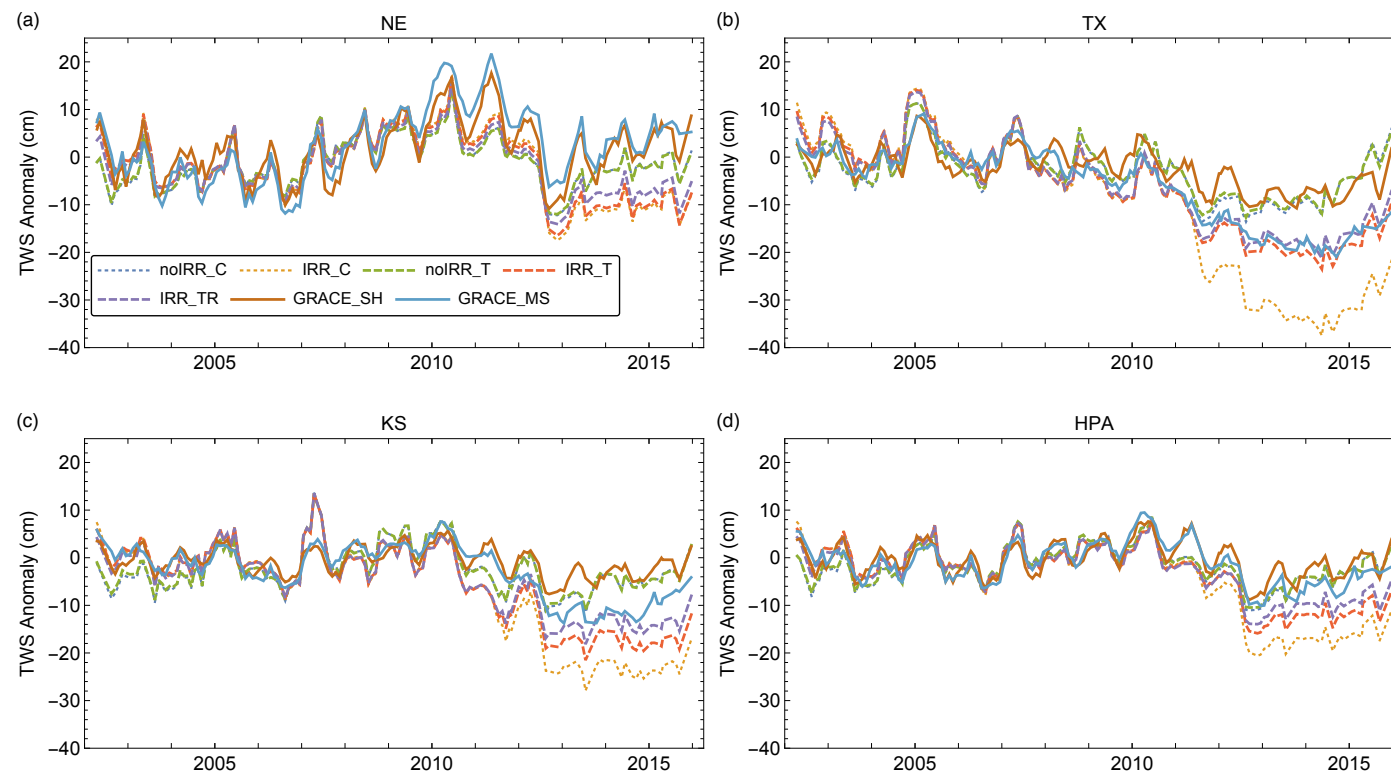
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NASA Land Information System (LIS)



Comparison between simulated and GRACE TWS anomaly



Simulated irrigation water amount

