Modeling Urban Irrigation Impact on Land Surface Temperature in Central Arizona

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I. Introduction

Rapid urbanization in the Phoenix Metropolitan Area has transformed this region from a small agricultural center to a major metropolis through the fastest growth rates in the U.S. To mitigate the thermal stress resulting from urbanization in an arid area, green spaces are used extensively to provide cooling capacity through shading and enhanced evapotranspiration (ET). As a result, urban irrigation is extensively applied to maintain vegetated landscaping. Reliable and comprehensive assessment of the efficacy of urban irrigation requires accurate prediction of ET and land surface temperature (LST). However, prior numerical modeling studies share limitations by using static and tabulated land surface parameters over a complex urban surface that can result in considerable errors in simulating the urban hydroclimate. In this work, we aim to improve the modeling of urban irrigation by integrating multiple remote sensing observations into an existing modeling framework.

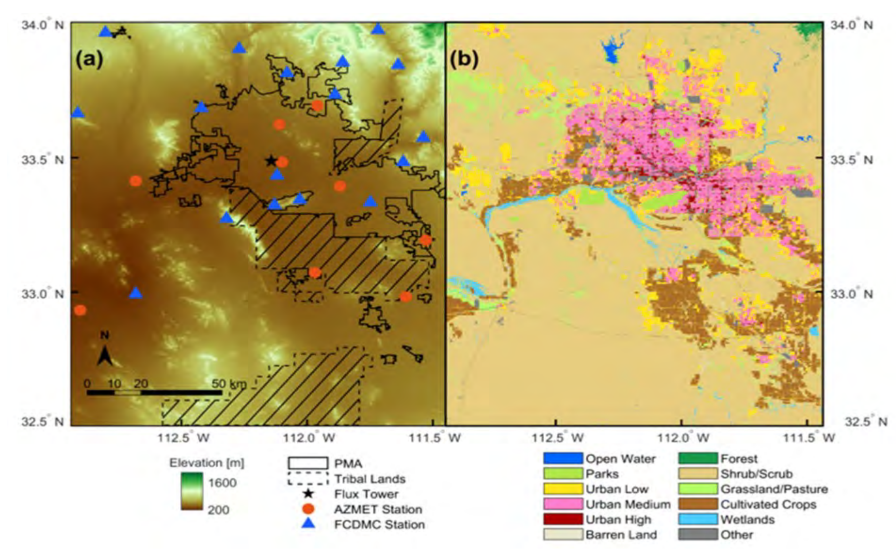


Fig. 1. (a) 30 m resolution DEM for the study domain, with the locations of FCDMC, AZMET stations and Urban flux tower for VIC model evaluation. (b) Land cover map of the study area based on NLCD 2011.

II. Methodology

Model Setup:

Variable Infiltration Capacity (VIC) model Release 5.1.

Remote Sensing Products:

Irrigation Extent

Urban Irrigation:

National Agricultural Imaging Program (1-m), USDA Aerial imagery, Object-based Classification

Agriculture Irrigation:

Cropland Data Layer (30-m), USDA, Landsat TM

Vegetation Phenology

Normalized difference vegetation index (NDVI) MODIS, NASA

Climate Forcing Datasets:

Historical simulations

- Gridded meteorological forcings
- Precipitation, temperature and wind speed.

Simulation Period:

Year 2004-2013

1-km spatial resolution, hourly time step

Forcings:

Near-surface daily gridded meteorological data, disaggregated to 1-hr using MetSim model

Surface weather stations (bias-correction)

Observations used to test model performances:

Urban flux observation from eddy covariance tower

LST from MODIS (1 km, daily)

LST from GOES (5 km, hourly)

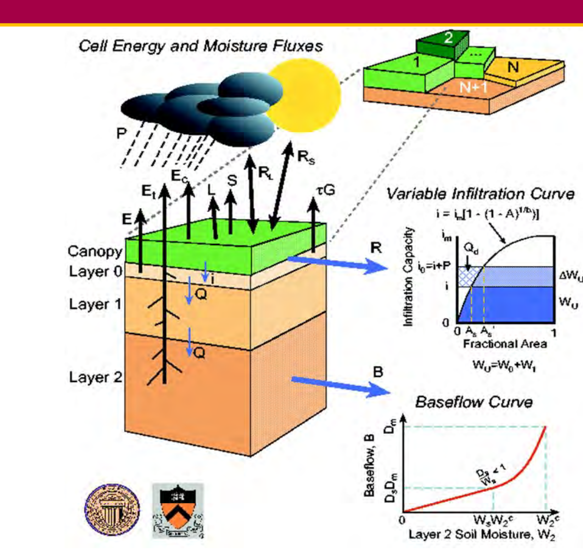


Fig. 2. VIC hydrology model.

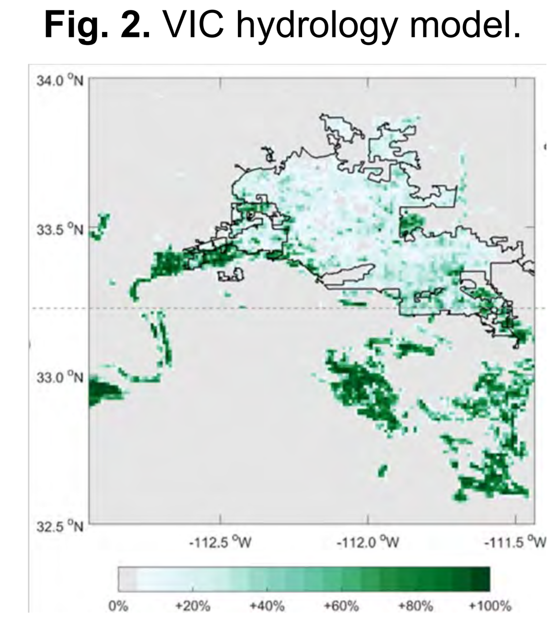


Fig. 3. Area fraction of planted area.

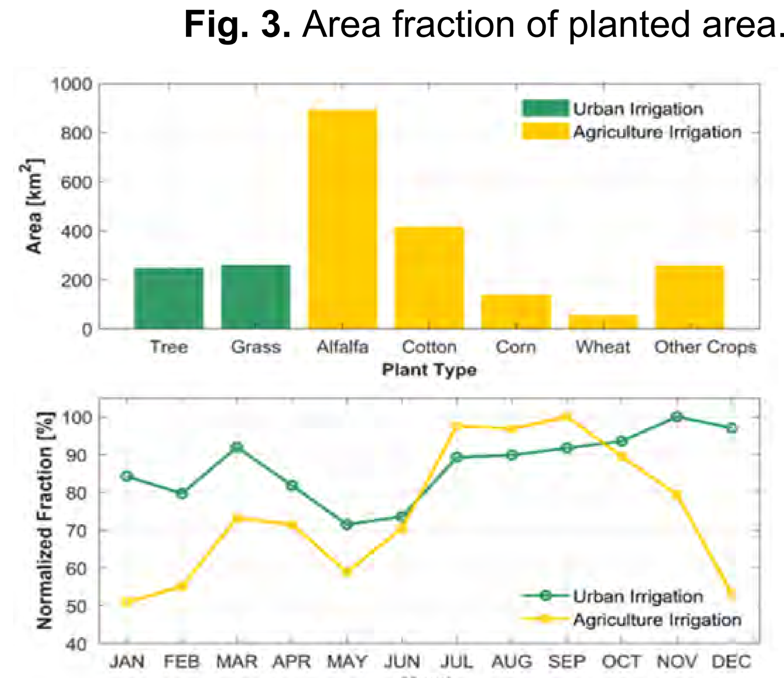
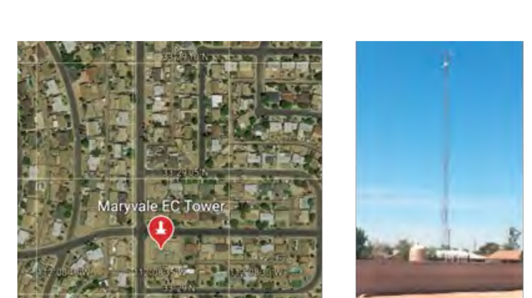


Fig. 4. (a) Area of Planted Area by Category. (b) Temporal Variation of Irrigation Fraction in the Region.



22.1-m EC flux tower in the Maryvale, west Phoenix

III. Results

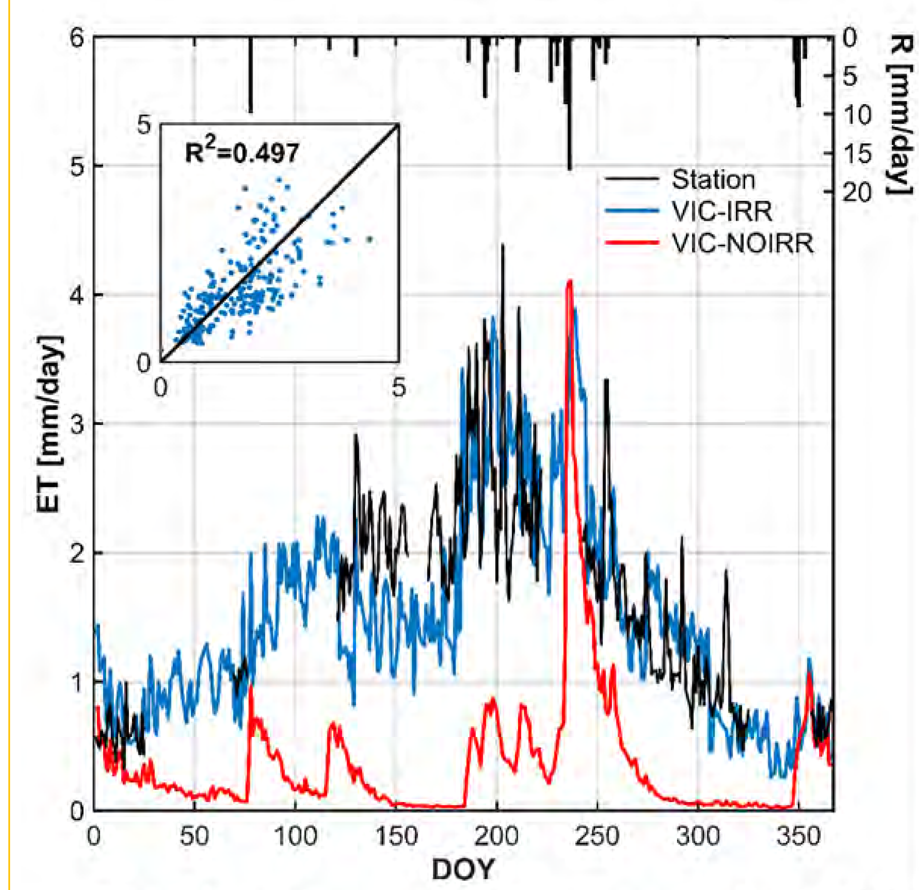


Fig.4 Model Performance at Tower Site in 2012.

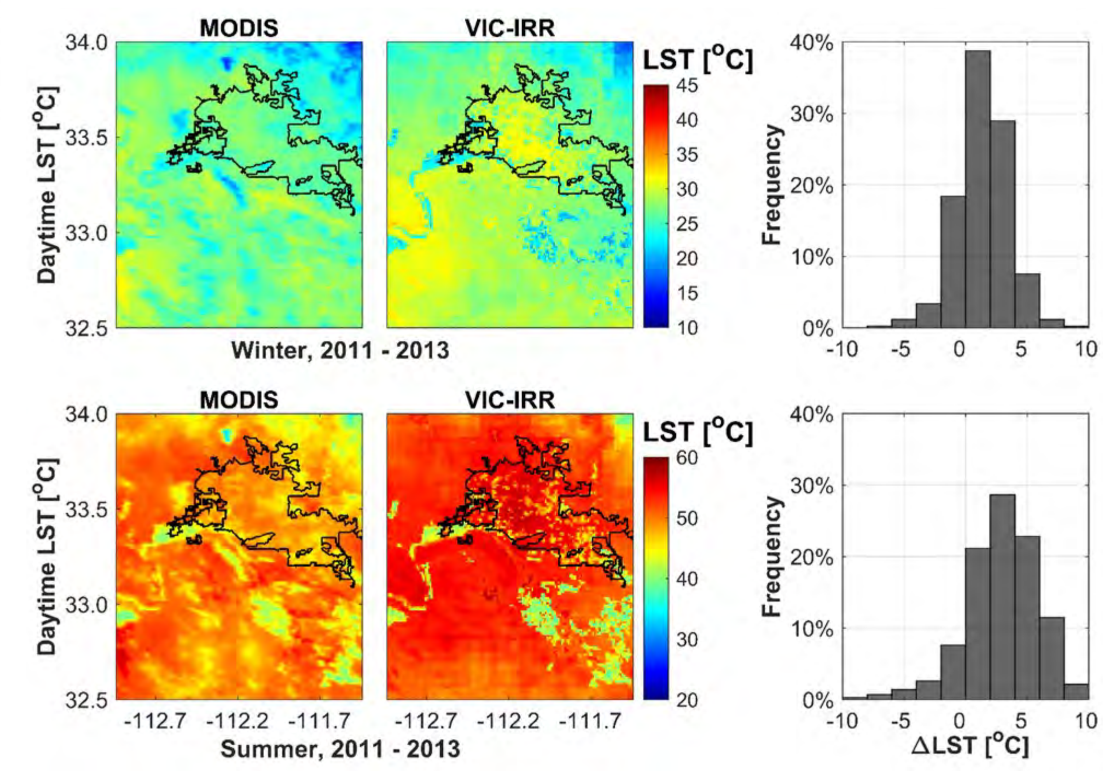


Fig.5 Model Performance of LST Spatial Pattern Diurnal Cycle in Difference Ecosystems as Compared to MODIS Products.

VIC-IRR model captures the enhanced ET due to anthropogenic water use.

Good agreement of both ET and LST between VIC-IRR and observation.

VIC-IRR captures the spatial pattern of LST as compared to MODIS.

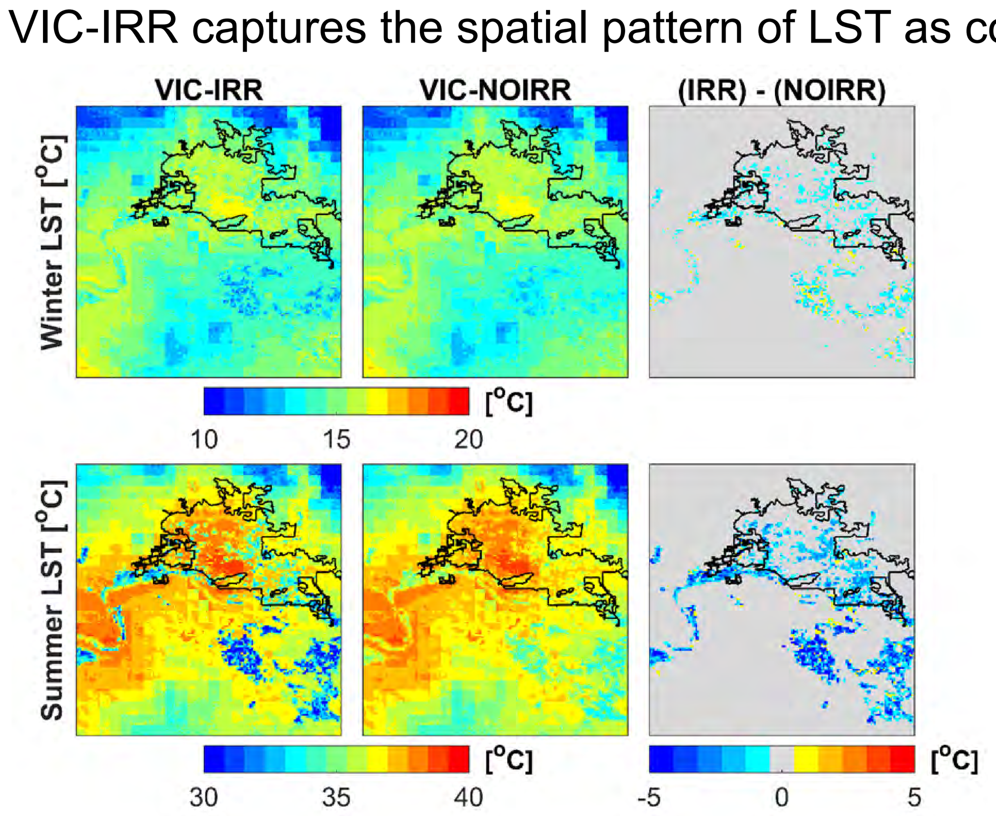


Fig.6 Simulated LST between VIC-IRR and VIC-NOIRR.

Croplands show lower LST than surrounding natural shrublands.

Cooling effect of irrigation has seasonal changes as amount varies.

VIC-IRR captures the cooling effect in both cropland and urban areas.

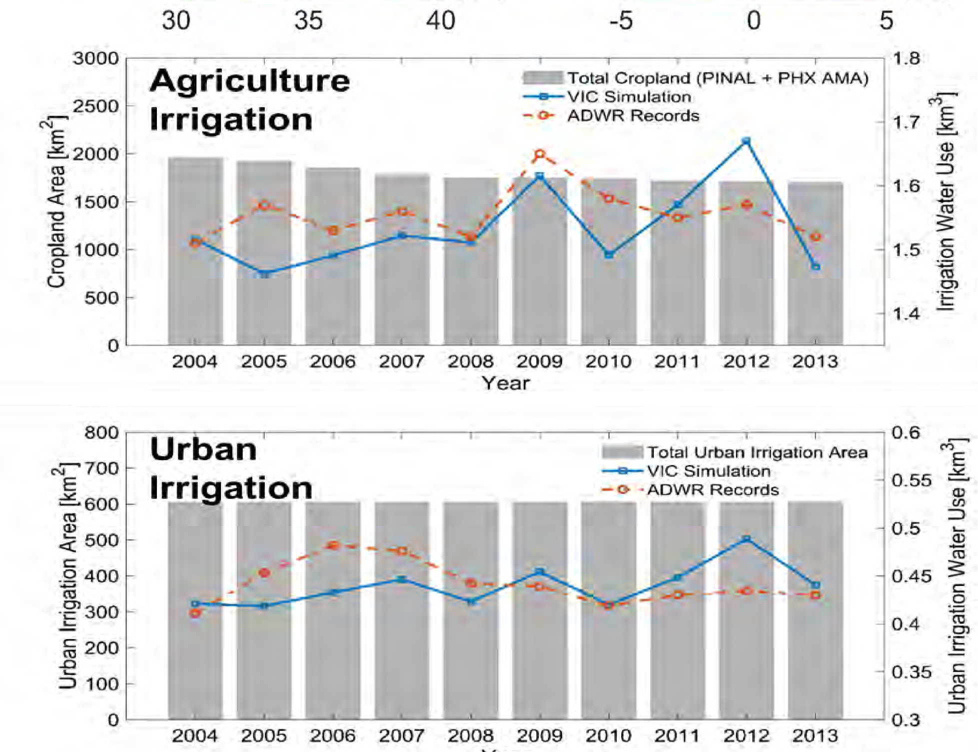


Fig.7 Simulated Irrigation Water Use.

We found a good agreement of the irrigation water use in VIC-IRR with the annual government records of crop and urban irrigation.

IV. Conclusions

High-resolution remote-sensing observations are useful for capturing the spatial and temporal dynamics of irrigated vegetation.

With time-varying vegetation and irrigation parameters, VIC shows good agreement with LST observations from point to regional scales.

VIC-IRR can be used to investigate future climate and land use change impact on the urban thermal comfort and other applications.

V. Acknowledgements

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