The Impacts of Urbanization-associated Land Conversions on Ecohydrological and Meteorological Processes in the Lower Yangtze River Delta Region

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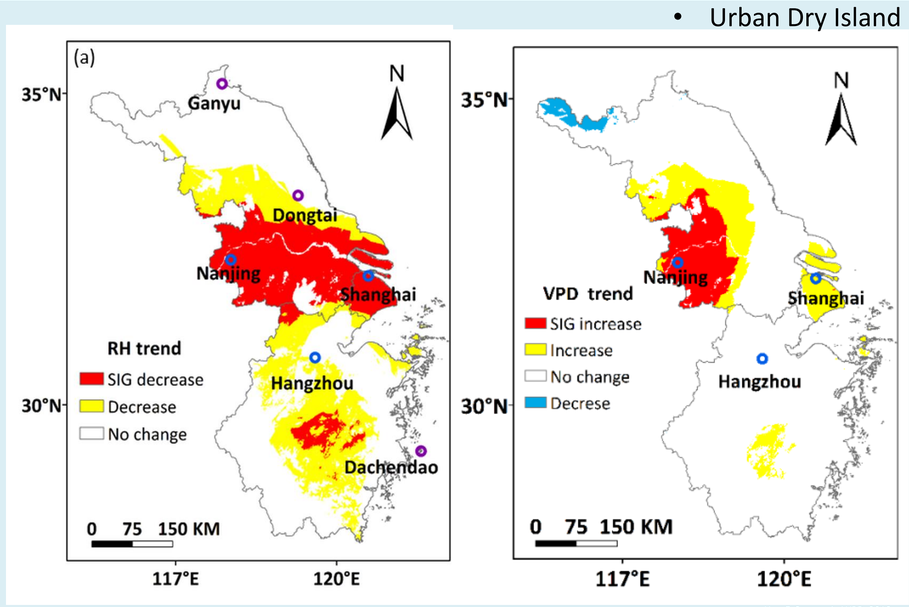
Motivations

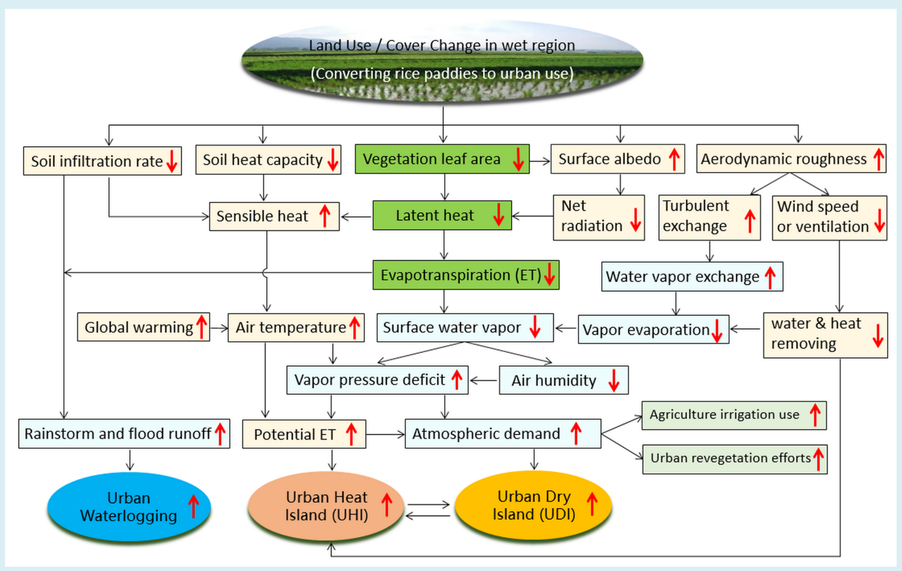
- Rapid urbanization alters terrestrial ecosystem structure and functioning permanently and inevitably leading to profound impacts on the water and energy balances.
- Results in or aggravates climatic and environmental consequences by influencing surface evapotranspiration (ET), i.e., five urban islands: Heat Island, Dry Island, Wet Island, Rain Island, and Turbid Island.
- ET plays an important role in driving local weather patterns, affecting turbulence, cloud formation, and convection.
- Converting wetlands with high ET to urban uses leads to a sharp decrease in ET in humid regions. The role of ET in affecting local hydrology and climate is especially pronounced in humid regions.
- Questions Asked
  - Could climate warming and climate variability explain the observed climatic and environmental consequences?
  - How urbanization-associated land conversions affects hydrometeorological processes?

- Urban Dry Island



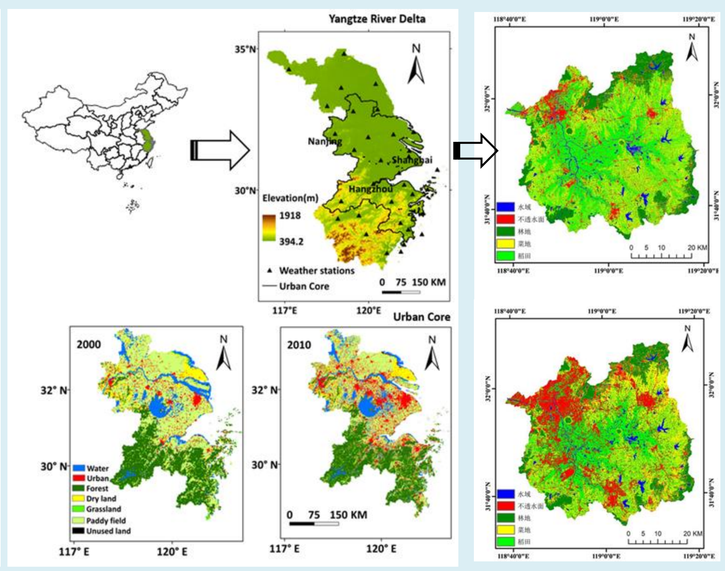
Hao & Sun et al., WRR, 2018

Conceptual Model and Study areas

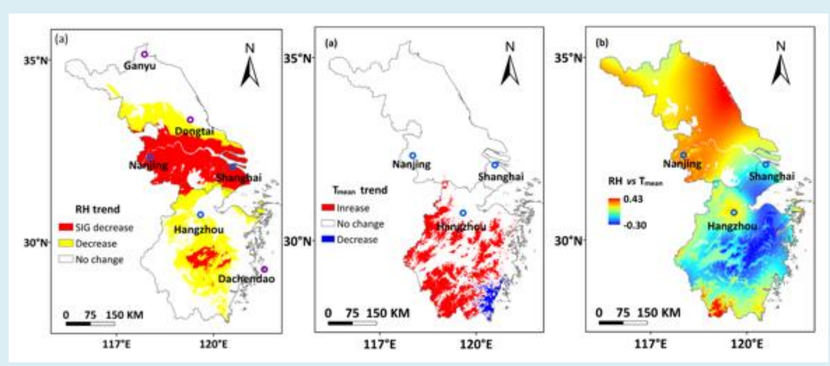


Regional Scale: Yangtze River Delta

Basin Scale: Qinhuai River Basin



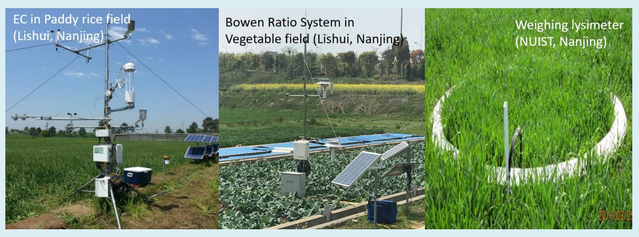
- Atmospheric Humidity Change Not Explained by Change in Air T in the Urban Core

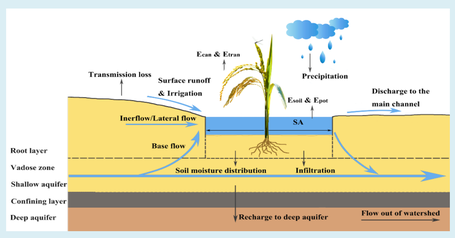


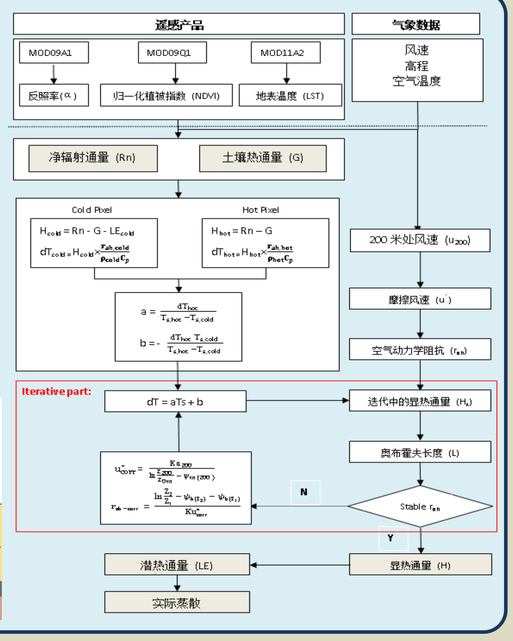
- Southern region dominated by forest covers
  - RH decreased significantly when T increased significantly: negative correlation
  - Air T was the potential dominant factor for the reduction of atmospheric humidity.
- Central urban core
  - RH decreased significantly while air T had no significant change: Positive relationships
  - Air T was not the dominant factor for the reduction of RH in this region.

Methods

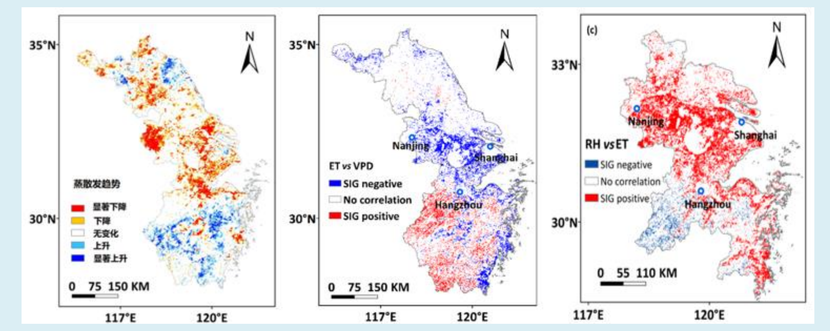
- Nonparametric Mann-Kendall test to detect the parameter trends
- ‘ Sensitivity Coefficient’ to compare the sensitivity of PET to changes in climatic variables.
- The Surface Energy Algorithm for Land (SEBAL) model was parameterized and validated using multiple field data sources including eddy covariance flux and lysimeter measurments and streamflow monitoring.
- Improved SWAT incorporating new algorithms for modelling hydrological processes of rice paddies.
- EC in Paddy rice field (Lishui, Nanjing) and Weighing lysimeter (NUIST, Nanjing)







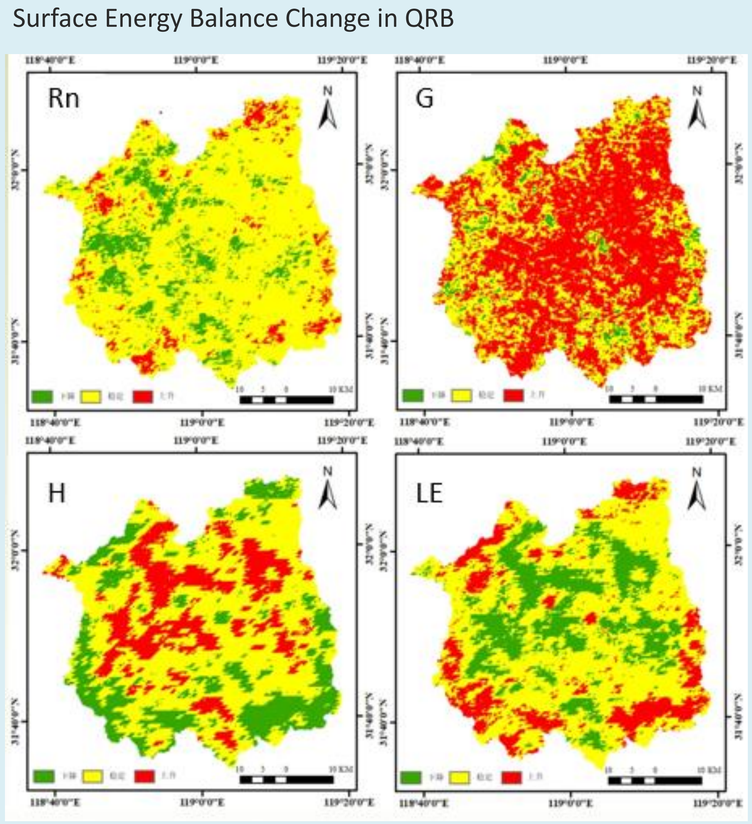
- Enhanced Urban Dry Island Explained by the Decreases in LAI and ET



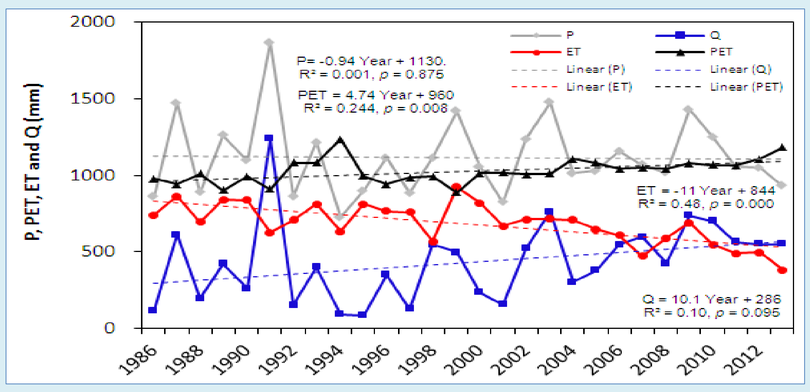
- The decrease of RH is not surprising when the climate is warming up in theory.
- However, it appears the sharper decrease in RH in the urban core when compared with rural areas was related to the decrease ET, thus the ecohydrological processes.
- We argued that the ET reduction reduced water vapor during urbanization.

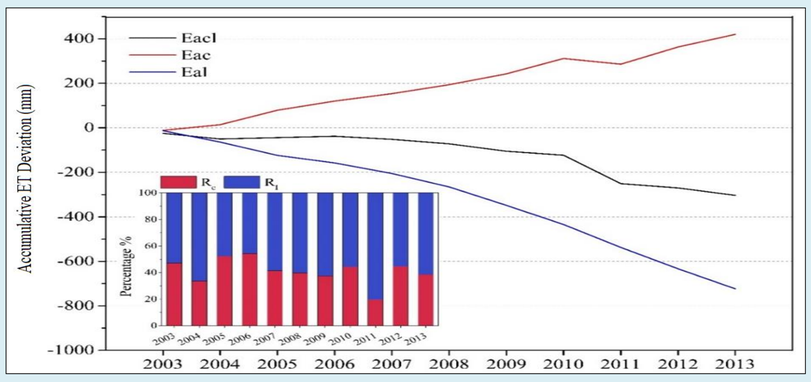
Results

Surface Energy Balance Change in QRB



Surface Water Balance Change in QRB





Conclusions

- Proposed Urban Dry Island (UDI) to characterize urbanization effects on reducing atmospheric humidity and elevating vapor pressure deficit (VPD).
- In addition to global warming and localized UHI, UDI is closely related to the loss of vegetation cover (i.e., natural wetlands and paddies).
- Reduction of ET or latent heat is another important factor contributing to UDI effects.
- Urban environmental change (UHI, UDI) and storm flow related to change in ET.
- Urban Heat Island and UDI effects are coupled and should be collectively addressed in urban planning and climate change assessment.

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