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# Regional climate impacts of irrigation and urbanization and their relevance for climate-resilient development

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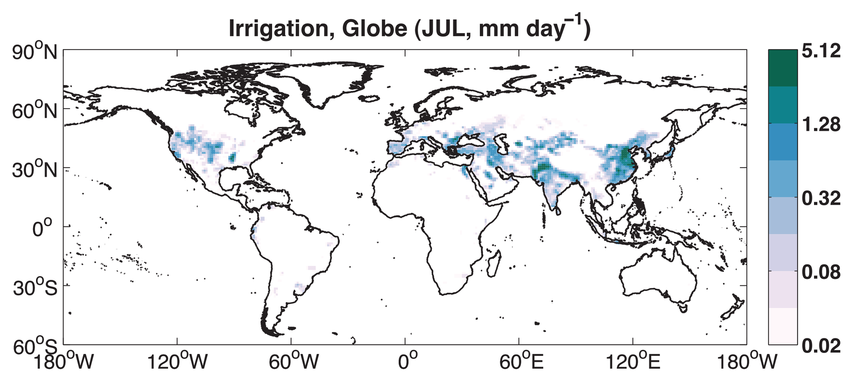
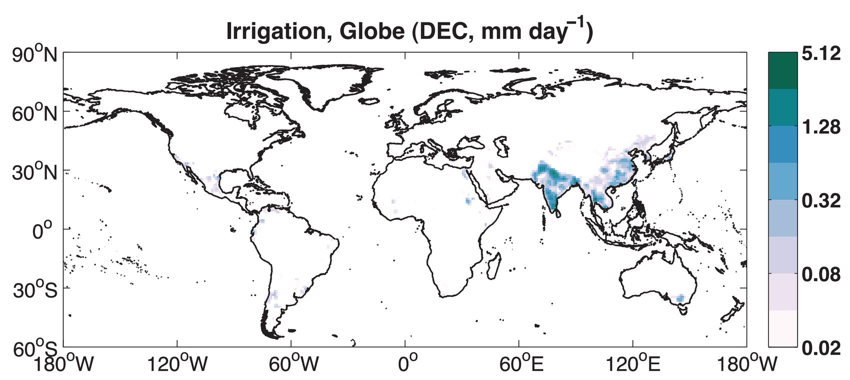
## ABSTRACT

Climate-resilient development is critical for society, especially in agricultural and urban regions, where issues such as rural-to-urban migration and food security are paramount. Decision-makers in these regions are challenged to produce robust, climate-resilient development strategies. To do so, a better understanding of the connections between land use and climate is needed at multiple spatial and temporal scales. While numerous studies have documented the influence of irrigation and urbanization on local climate, the relative impacts of each on regional climate are not well understood. The Goddard Institute for Space Studies global climate model is used to explore climatic impacts of irrigation and urbanization globally. We assess changes to extreme daily temperatures as well as precipitation for various scenarios. Ultimately, this type of knowledge should be used to inform adaptation and mitigation decisions that will be made to promote low-emission and climate-resilient development.

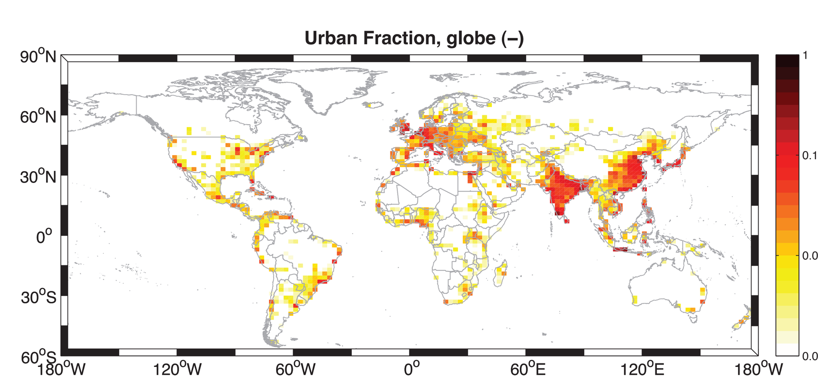
## GLOBAL DATASETS AND MODEL

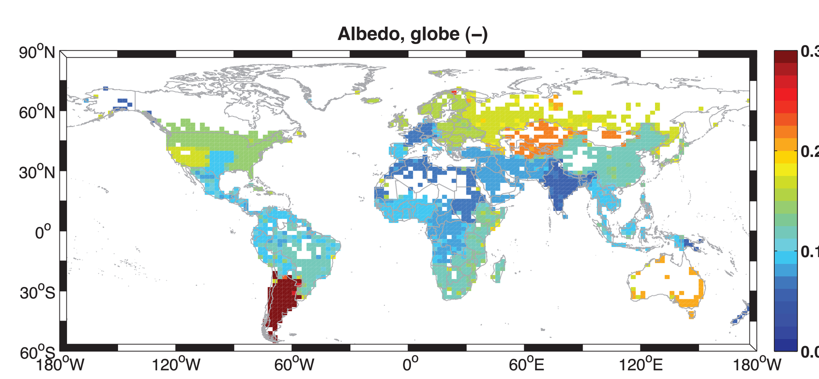
Global irrigation estimates are from a reconstruction of global hydrography by Wisser et al. [2010]. This dataset was derived using the areas equipped for irrigation estimates of Portmann et al. [2010]. The figures below show irrigation rates in July and December.




Jackson et al. (2010) recently developed a detailed dataset of present-day urban extent and urban properties. These authors derived urban extent from LandScan 2004 (http://www.ornl.gov/landscan/)], a population density dataset derived from census data, nighttime lights satellite observations, road proximity and slope. We aggregate their data from their 0.5° × 0.5° global grid and match the land mask of the NASA GISS ModelE, while attempting to preserve total global urban area. The figures below present the urban fraction of grid cells and the urban albedo of each grid cell, respectively.



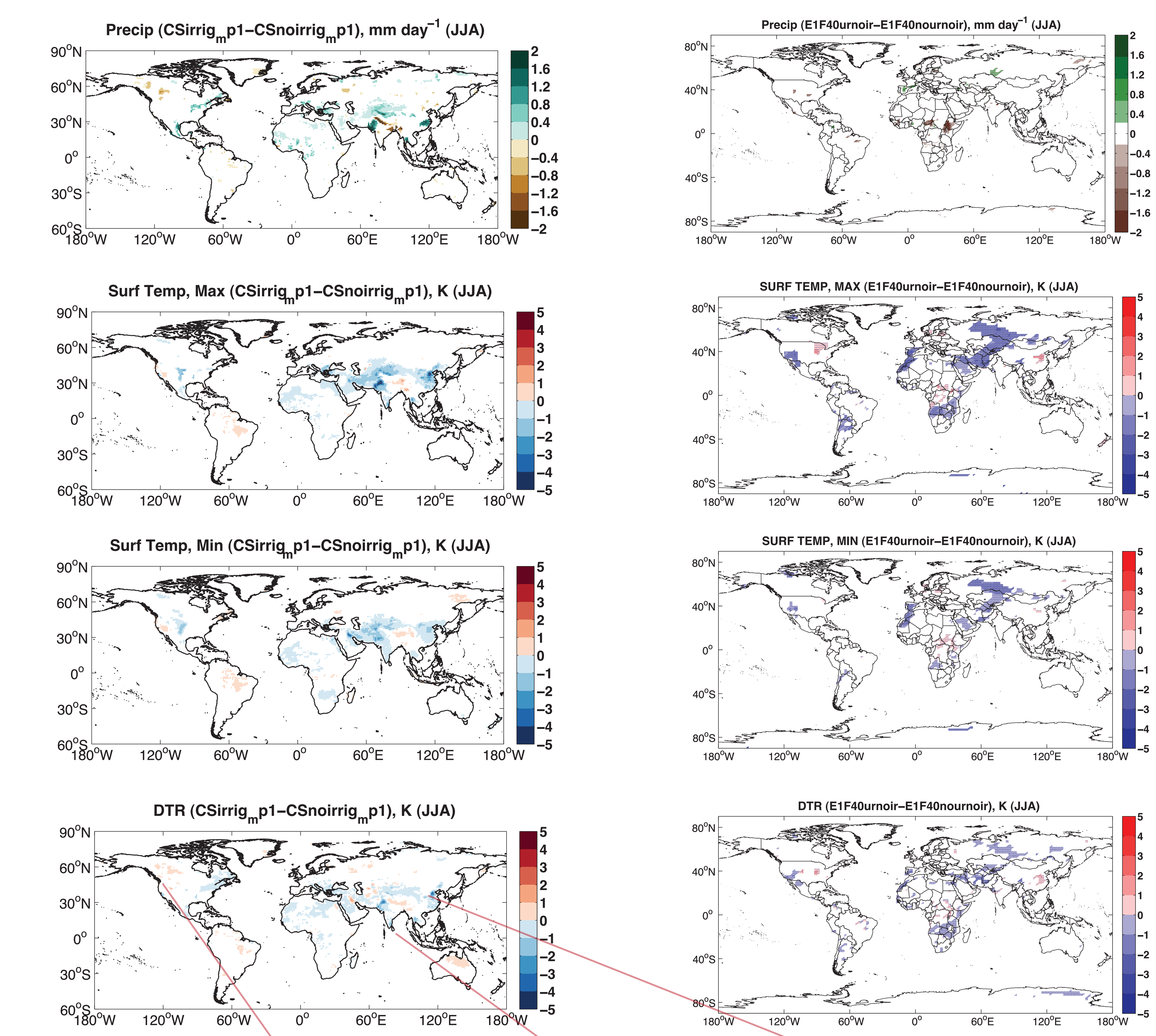




All experiments were conducted using the NASA Goddard Institute for Space Studies (GISS) atmosphere general circulation model ('ModelE') (Schmidt et al. 2006), run at two resolutions. For the irrigation experiments, the model is run at a horizontal resolution of 1°× 1° while the urban experiments were run at a 2°× 2.5° horizontal resolution. For these simulations, seas surface temperatures were prescribed. Irrigation is explicitly represented as described in Puma and Cook (2010) and Cook et al. (2011). Urban areas are treated as bare soil with the albedo adjusted to match the global urban albedo dataset.

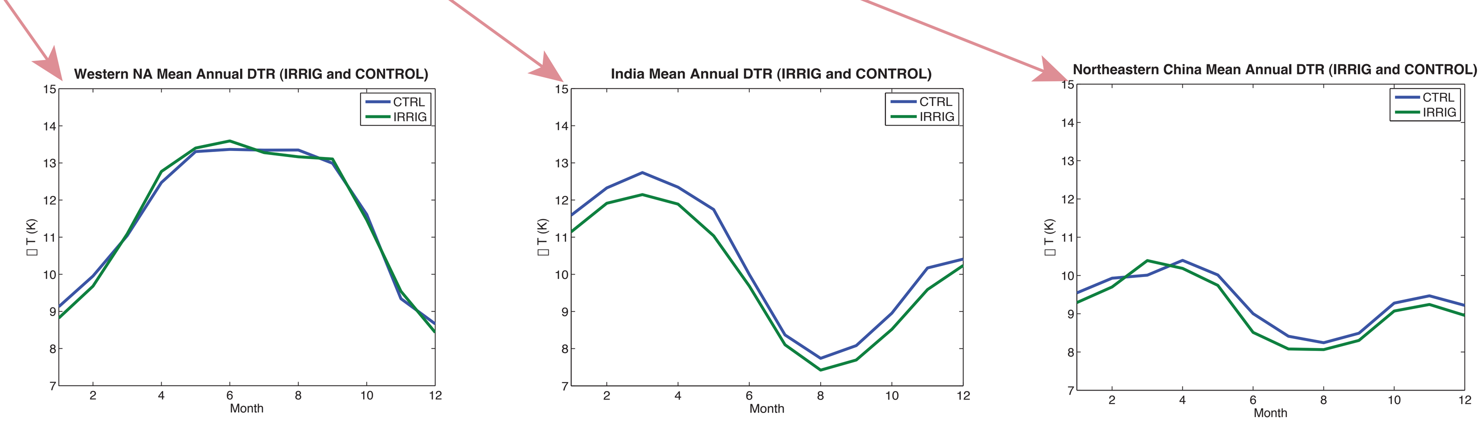
## REGIONAL CLIMATE EFFECTS

Regional impacts of irrigation and urbanization on precipitation and surface temperature (maximum, minimum, and diural temperature range) as predicted the GISS ModelE.

**IRRIGATION MINUS CONTROL** | **URBAN - CONTROL**




*Mean annual DTR differences for three regions (with and without irrigation).*




## ADAPTATION AND MITIGATION

Low-Emission and Climate-Resilient Development Strategies (LECRDS; http://www.undp.org/climatestrategies) are part of UNDP's efforts to promote long-term, climate-change management. This cutting-edge UNDP approach is a unique global effort, as it helps decision-makers and planners to recognize that climate-change responses are closely intertwined with development choices and actions, which involve multiple sectors, stakeholders, and ecosystems. Below, are the key steps that decision-makers may consider when developing Green LECRDS for their region.

**Step 1**
*Develop a Multi-stakeholder Planning Process*

**Step 2**
*Prepare Climate Change Profiles and Vulnerability Scenarios*

**Step 3**
*Identify Strategic Options Leading to Low-Emission, Climate Resilient Development Trajectories*

**Step 4**
*Identify Policies and Financing Options to Implement Priority Climate Change Actions*

**Step 5**
*Prepare Low-Emission, Climate Resilient Development Roadmap*

As decision makers consider various adaptation and mitigations options for agricultural and urban regions as part of their Green LECRDS, it is critical to understand how these decisions interact with the climate system at multiple spatial and temporal scales. Changes in irrigation rates have the potential to impact regional climate, with the response varying by region. For urban regions, one adaptation strategy that has been suggested is to use reflective roofing material or to paint existing roofs white (e.g. Oleson et al., 2010; Jacobson and Ten Hoeve, In press). At the same time, other propose using solar panels on roofs, which have a low albedo, to reduce greenhouse-gas emissions. The analyses here are intended to improve our understanding of these land-use impacts, so that we may better design Green LECRDS.

## ACKNOWLEDGEMENTS AND REFERENCES

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