Impacts of 21st-Century Urbanization and Climate Change on Coastal Winds in Delaware

Brian P. Frei, Dana E. Veron, and Jing Gao

University of Delaware

Abstract

Climate change and urbanization have the potential to alter coastal wind patterns through changes in large-scale flows, local thermodynamics and surface roughness, among other atmospheric and oceanic phenomena. These changes are important to understand as coastal winds have important impacts on temperature moderation and offshore wind resource. We propose to simulate high climate change and high urbanization scenarios using Representative Concentration Pathway (RCP) 8.5 and Shared Socioeconomic Pathway (SSP) 5 scenarios along with changes to the land surface model. Future climate data will be dynamically downscaled by using the Weather Research and Forecasting (WRF) model as a regional climate model. Downscaling coarse climate model output to higher resolution WRF domains will allow us to capture smaller-scale phenomena such as the sea breeze, which is a major driver of coastal wind variability in Delaware. These simulations will improve our ability to predict the impact of changes in coastal winds on energy demand, offshore wind power, pollutant transport, and coastal weather.

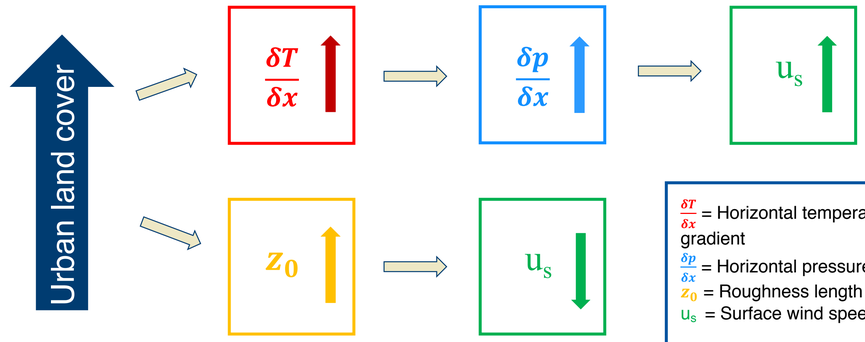
Background

- The sea-breeze circulation, which has the largest influence on wind variability in coastal Delaware[4], has been studied under present conditions, but there is a lack of research on the impacts of climate change on coastal wind environments.
- One study indicates only minimal changes in the Mid-Atlantic wind field[7], but uses a resolution in WRF that is too coarse to simulate the complex coastal environment in Delaware.
- Land-use changes are known to alter climate conditions[6] and have been shown to impact sea-breeze[1]. Additionally, urban land use is projected to expand drastically in the coastal Mid-Atlantic by the end of the century under the SSP5 scenario[3]. However, there is a gap in the literature addressing the individual and combined effects of future urbanization and climate change on coastal winds.

Research Questions

- Will high climate change scenario RCP 8.5 have a significant impact on average coastal wind patterns in the Mid-Atlantic?
- How will increased urbanization in coastal Delaware affect horizontal temperature gradients and surface roughness, and will those changes impact the sea breeze circulation and offshore wind resource?
- Will the combined impacts of climate change and urbanization interact to cause larger changes in coastal winds?

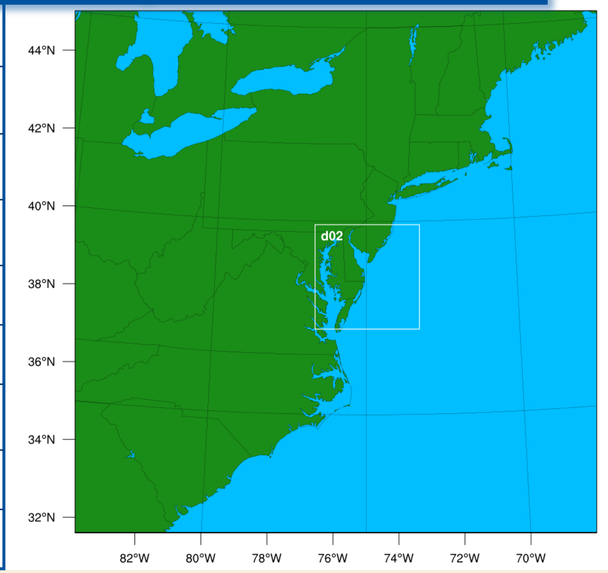
Expected Physical Effects of Increased Urban Land Cover



WRF Configuration

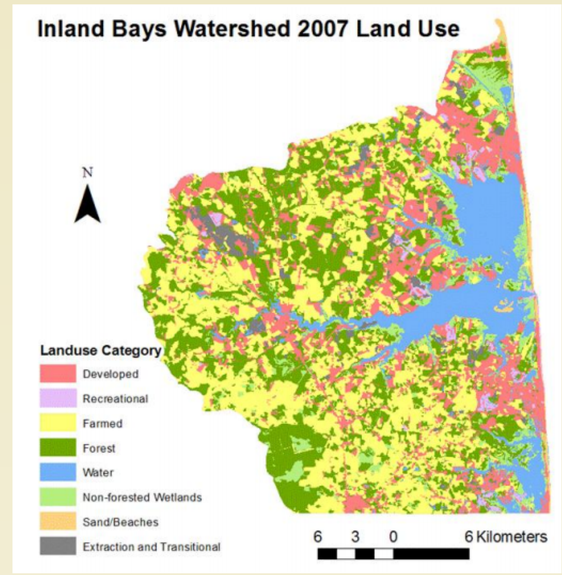
Physics Options

Microphysics	Morrison 2-moment Scheme
Planetary Boundary Layer Physics	MYNN2.5
Cumulus Parametrization	Kain-Fritsch Scheme (Parent Domain)
Shortwave Radiation	RRTMG
Longwave Radiation	RRTMG
Land Surface Physics	Noah–MP Land Surface Model
Surface Layer Physics	Eta Similarity Scheme
Urban Surface Physics	Urban Canopy Model



WRF Simulations

- Forcing data: Community Earth System Model Version 2 (CESM2)[2]
  - Used in the Coupled Model Intercomparison Project Phase 6 (CMIP6)
  - Demonstrated limited wind speed bias over the Atlantic Ocean[8]
- Scenarios
  1. Present conditions (2010 – 2020)
  2. High climate change (RCP8.5 SSP5, 2090-2100)
  3. High urbanization (2010 – 2020)
  4. High climate change and urbanization (2090 – 2100)



Hughes, C. P. (2016)

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