i-Tree Tools for Mapping Extreme Heat Risk and Mitigation in New York State Disadvantaged Communities

Climate Justice Working Group New York State Department of Environmental Conservation Climate Leadership and Community Protection Act October 4, 2023 on WebEx

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Motivation: Reduce Extreme Heat Exposure & Vulnerability with Sustainable Urban Forests

Labor Day sizzle: Extreme heat spreads across two-thirds of US this weekend

By Mary Gilbert, CNN Meteorologist Published 12:11 PM EDT, Fri September 1, 2023

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https://www.cnn.com/2023/09/01/weather/labor-day-forecast-heat-rip-currents/index.html

September 6, 2023

As Heat Rises and Electric Bills Soar, Gov. Hochul Must Protect NYers By Passing NY HEAT Act

NY Governor Hochul must pass the NY HEAT Act in this year's budget to fight climate change and protect New York families

CONTACTS

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Marissa Solomon, marissa@pythiapublic.com

ALBANY, NY — After a hot, expensive, toxic, scorching summer, another dangerous, potentially record-breaking <u>heat wave</u> is blanketing New York this week. Liz Moran, New York Policy Advocate at Earthjustice, issued the following statement:

https://earthjustice.org/press/2023/as-heat-rises-and-electric-bills-soar-gov-hochul-must-protect-nyers-by-passing-ny-heat-act

2

i-Tree Tools for Nature-Based Solutions



i-Tree Tools as Numerical Models of Forest Structures, Functions, Services, Benefits & Values



Endreny, T. A. (2022). i-Tree Tools Assist with Strategically Designing Tree Cover and Improving Community Resilience. *Clear Waters - NYWEA, 52*(1), 46-50. Endreny, T. A. (2018). Strategically growing the urban forest will improve our world. *Nature Communications, 9*(1), 1160. doi:10.1038/s41467-018-03622-0

i-Tree Cool Air Model Theory Spatially Distributed, Vertical Energy & Water Balance



Yang, Y., Endreny, T. A., & Nowak, D. J. (2013). A physically based analytical spatial air temperature and humidity model. *Journal of Geophysical Research-Atmospheres*, 5 118(18), 10449-10463. doi:10.1002/jgrd.50803

i-Tree Hydro Supporting Cool Air with Dynamic Wetness Likelihood & Groundwater Depths

$$q_{i} = P_{w} \cdot a_{i}$$

$$q_{i} = T_{i} \cdot tan\beta_{i}$$

$$T_{i} = T_{o} \cdot exp\left(\frac{-S_{i}}{m}\right)$$

$$S_{i} = m\left[ln\left(\frac{R}{T_{o}}\right) + ln\left(\frac{a_{i}}{tan\beta_{i}}\right)\right]$$

$$TI_{i} = ln\left(\frac{a_{i}}{tan\beta_{i}}\right)$$

$$\overline{S} = -m \cdot ln\frac{R}{T_{o}} - m \cdot \overline{TI}$$

$$Q_{sub} = T_o \cdot exp(-\overline{TI}) \cdot exp(-\overline{S}/m)$$

- q_iis subsurface discharge (m²/hr)
- i is pixel element
- P_w is precipitation as recharge (m/hr)
- a_iis local basin area per unit width (m)
- T_i is local transmissivity (m²/hr)
- $tan\beta_i$ is local tangent of hillslope angle
- T_o is local saturated transmissivity (m²/hr)
- S_i is local soil moisture deficit (m)
- m is a scaling parameter
- TI is topographic index
- \overline{S} , \overline{TI} is basin average values
- Q_{sub} is subsurface flow (m³/hr)



Wang, J., Endreny, T. A., & Nowak, D. J. (2008). Mechanistic Simulation of Tree Effects in an Urban Water Balance Model. Journal of the American Water Resources Association, 44(1), 75-85. doi:10.1111/j.1752-1688.2007.00139.x

Inputs for i-Tree Cool Air: Elevation and Land Cover for Washington, DC





Land Cover: NLCD

Inputs for i-Tree Cool Air: Anthropogenic Heat, Tree & Impervious Cover for Washington, DC



Tree Cover: NLCD 10 Kilometers

Input Meteorological Data: Single Pixel Time Series of Observations using WeatherPrep.exe. Flow ...



<!-- Program generates output of: weather.<u>dat</u>, evaporation.<u>dat</u>, and <u>solarradiation.dat</u> --> <InputList>

<Input>

<Model>Hydro</Model><!-- Options: Hydro, Energy; Hydro generates 8 weather outputs, Energy generates 10
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<County>District of Columbia</State> <!-- Confirm name here: https://database.itreetools.org/#/locations
<County>District of Columbia</County> <!-- Confirm name here: https://database.itreetools.org/#/locations
<Place>Washington</Place> <!-- Confirm name here: https://database.itreetools.org/#/locationS
<Place>Washington</Place> <!-- Confirm name here: https://database.itreetools.org/#/locationS
</pre>

<EvergreenPercent>5</EvergreenPercent> <!-- Affects evaporation during leaf of period -->

<VegetationType>Tree</VegetationType> <!-- Options: Tree, Shrub, or Grass -->

<StartYear>2018</StartYear> <!-->Corresponds with input weather file -->

<EndYear>2018</EndYear> <!-- Corresponds with input weather file

<SurfaceWeatherDataFile>C:\iTree\a prep Weather\was_dc\2018\724050-13743-2018_out.txt</SurfaceWeatherDa <PrecipitationDataCsv></PrecipitationDataCsv> <!-- Optional Precip.csy to replace NOAA raw data values.

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i-Tree HydroPlus Configuration File w/ Parameter Settings, Visual Studio Editor, Batch Runs. Flow ...

Release + Win32

Local Windows Debugger

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-</HydroPlusConfig>

R Live Share

Validating i-Tree Cool Air: Washington, DC @ 6AM, 3 & 7 PM 8/28/18, Data from Prof. V. Shandas



Shandas, V., Voelkel, J., Williams, J., & Hoffman, J. (2019). Integrating Satellite and Ground Measurements for Predicting Locations of Extreme Urban Heat. *Climate, 7*(1), 5. 11 Yang, Y., Endreny, T. A., & Nowak, D. J. (2013). A physically based analytical spatial air temperature and humidity model. JGR-Atmospheres, 118(18), 10449-10463. doi:10.1002/jgrd.50803

Output of Scenario Differences: Map of Temperature for Base Case vs +/-20% TC & IC



Sinha, P., Coville, R. C., Hirabayashi, S., Lim, B., Endreny, T. A., & Nowak, D. J. (2022). Variation in Estimates of Heat-Related Mortality Reduction due to Tree Cover in U.S. 12 Cities. Journal of Environmental Management, 301, 113751. doi:https://doi.org/10.1016/j.jenvman.2021.113751.

Output of Scenario Differences: Map of Evaporation, Time Series of Temperature



iTCA Change in Evaporation: Base +/- 20% TC & IC

iTCA Time Series of Base Case vs Scenario +/- 20% TC & IC

Discussion: i-Tree Landscape Finds Vulnerability via Overlay of Demographic Data & Ecosystem Services



Exploring 3 Census Block Groups w/ Table of Income Overview & Map Overlay w/ HiRes Tree Cover, LST (Land Surface Temperature) Difference from Median of LandSAT scene. Map & Table show Vulnerability.

Discussion: Climate Change Exacerbates Threats to Urban Sustainability

- IPCC AR6 WG1 Physical Science Basis
 - Based on <u>CMIP6</u>, assessing multiple <u>RCPs and</u> <u>SSPs</u>
- Model, Observational, & Attribution Findings: <u>Regional Fact Sheets</u>
 - Forecast North American urban areas receive more extreme air pollution episodes in heavily polluted environments
 - Forecast Urban Areas receive more frequent extreme climate events, such as heatwaves, with more hot days and warm nights adding to heat stress in cities
 - Forecast Urban Areas receive sea level rise, storm surge, and extreme rainfall events will increase the probability of flooding



Discussion: Leverage Points to Improve the State of our Watershed; Resetting our Paradigms



Endreny, T. A. (2020). Leverage Points Used in a Systems Approach of River and River Basin Restoration. *Water, 12*(9). doi:10.3390/w12092606



https://danceforallpeople.com/haudenosaunee-thanksgivingaddress/haudenosaunee-thanksgiving-address-2/

Today we have gathered and we see that the cycles of life continue.

Now our minds are one.















Casey Trees

