The 'Urban Oasis': High Resolution Landsat 5TM and ASTER Thermal Imagery Shows the Influence of Water Usage on City-Wide Temperatures in Dubbo, Australia



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Motivation for this Study





Melbourne - Heat Threshold for Excess Deaths in >64 year olds



Suggests that even a slight temperature reduction (1-2°C) in EHEs (i.e. **heat mitigation**) would be sufficient to save many lives.



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Nicholls, Skinner, Loughnan and Tapper, 2008



A Simple Question Driving this Research

What is the potential for city-scale irrigation to deliver city-wide cooling under hot dry environmental conditions characteristic of Australian cities?



Famous diagram from Spronken-Smith et al., 2000





Study Area, Methodology and Data





City of Dubbo, NSW, Australia







32°15′25″S 148°36′4″E Population 42,108 Hot, dry summers (often >38°C) On Macquarie River

The Australian 'Millenium Drought'

- An extraordinary period of low rainfall, affecting much of south and east Australia,
- Began in 1997 and lasted until 2009/10 saw many urban areas come perilously close to running out of water
- While many cities abandoned or severely restricted watering of public and residential open space, through much of the drought the <u>City of Dubbo</u> <u>maintained high levels of watering for much of the</u> <u>drought</u> using water from the Macquarie River
- Potential for an interesting controlled experiment!





Rainfall and Total Water Consumption for Dubbo – Toward the End of the 'Millenium Drought'



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Satellite Imagery

- TM imagery on board Landsat 5 and ASTER imagery on board EOS-Terra satellites (16 day return) were available during the 'Millenium Drought'
- 20 images (14 TM and 6 ASTER) were obtained for ~10.45 local time on hot summer cloud-free days (>30°C) between 2003 and 2011.
- Data were re-sampled to 30 m, radiometric and atmospheric corrections made.
- LST, NDVI calculated and seven key land uses extracted. NDVI >0.35 considered moist/irrigated
- Meteorological data from Dubbo Airport





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Results





Example from Early Drought, High Urban Irrigation Period – 26 December, 2003 (1045 Local Std Time)



Peak LST 62°C (un-irrigated rural) Lowest LST 35°C (irrigated rural) Surface Urban Cool Island (SUCI) ~3.6°C Suggestive of urban air temperatures ~1.5°C cooler overall than un-irrigated rural land uses

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Example from Post-Drought, Uniformly Moist Vegetation – 11 January, 2010 (1045 Local Std Time)





Wetlands along Macquarie River are notably cooler





0 0.5 1 2 3 4 Kilometers



'Oasis' Effects – Overall Patterns in SUCI and SUHI Across the 20 Days/11 Years



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Concluding Comments

Evidence is clear that city-wide irrigation supports a SUCI via a strong daytime 'oasis' effect during drought

- The following <u>might</u> be generalized from these results
 - Urban irrigation within a dry rural landscape supports a SUCI and associated reduced air temperatures as a result of enhanced evapotranspiration.
 - Reduced urban irrigation suppresses the SUCI since drier vegetated areas within the city begin to exhibit similar evaporative characteristics to urban surfaces
 - Wet vegetation everywhere (urban and rural) <u>may</u> support a modest SUHI and warmer urban air temperatures since it is only urban impervious surfaces that are dry, thereby enhancing sensible heat flux to the urban atmosphere (more observations are needed to confirm this)







Other Papers at ICUC9 Associated with the CRC-WSC and Monash Climate Group

- -PLENARY4: Plenary session IV: 24/Jul/2015: 8:30am-9:**30am** *Green Infrastructures for Cities*, Andrew Coutts
- -UCP11: 22/Jul/2015: 2:15pm-4:00pm *The climatic and bio-climatic impact of a small central city park on the surrounding urban environment during extreme heat events*, Asieh Motazedian, Andrew Coutts, Nigel Tapper
- -CCMA7: 23/Jul/2015: 11:00am-12:30pm · *The implementation of biofiltration systems, rainwater tanks and urban irrigation in a single-layer urban canopy model*, Matthias Demuzere, Andrew M. Coutts, Ashley M. Broadbent et al.
- -BPH3: 22/Jul/2015: 11:00am-12:30pm · *Visitor perception of thermal comfort in two contrasting public landscape gardens during extreme heat events*, Cho Kwong Charlie Lam, Margaret Loughnan, Nigel Tapper
- -GD5: 22/Jul/2015: 2:15pm-4:00pm · *Comparison of modelled thermal comfort during a heatwave in Melbourne*, Australia, Stephanie Jeanne Jacobs, Ailie Gallant, Nigel Tapper, Danijel Belusic
- -CCMA7: 23/Jul/2015: 11:00am-12:30pm · *The effect of irrigation on air temperature during heatwave conditions,* Ashley Mark Broadbent, Nigel Tapper, Andrew Coutts, Jason Beringer, Matthias Demuzere
- -TUKUP7: 24/Jul/2015: 2:15pm-4:00pm *The Urban Heat Island effect during heatwaves in Melbourne*, Cassandra Denise Wilks Rogers, Nigel Tapper, Ailie Gallant
- -NOMTM1: 21/Jul/2015: 4:30pm-6:15pm · VTUF: An urban micro-climate model to assess temperature moderation from increased vegetation and water in urban canyons, Kerry Nice, Nigel Tapper, Jason Beringer, Andew Coutts, Scott Krayenhoff
- -CCMA7: 23/Jul/2015: 11:00am-12:30pm · *Passive irrigation of street trees to improve tree health and support urban cooling,* Andrew Coutts, Stephen Livesley, Christopher Szota, Jasmine Thom



