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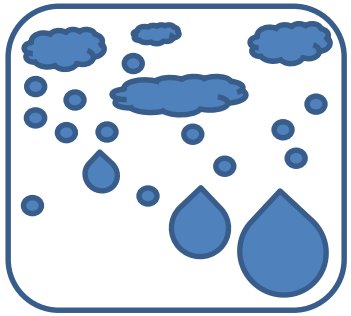
Statistical Downscaling of Precipitation in Florida : Experiments and Observations



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Statistical Downscaling

From a drop of water a logician could predict an Atlantic or a Niagara
- Sir Arthur C. Doyle.

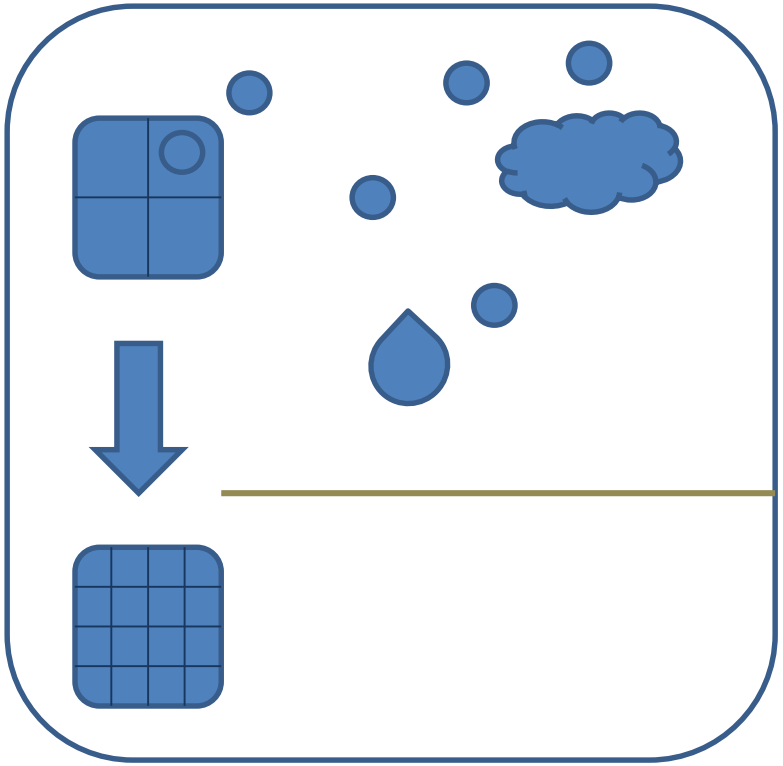


Illustration source: Teegavarapu (2012)

Precipitation Extremes

- Climate change models suggest an increase in global average annual precipitation during the 21st century, although changes in precipitation may vary from one region to another.

- Natural climate variability and future changes in climate that may alter precipitation intensities or storm durations would have consequences for stormwater infrastructure designed under the stationarity assumption.

- Urban drainage design practices are continuously revisited by:
  - Incorporating climate change factors
  - Analyzing trends in precipitation extremes and their frequencies
  - Evaluating impacts of changing extremes using downscaled precipitation data from GCMs
  - Designing frameworks for risk and uncertainty management

Arnbjerg-Nielsen, 2011. *Arnbjerg-Nielsen*, 2012, *Benestad* et al., 2008 , *De Toffol et al.*, 2009, *Fowler et al.* 2007

Focus of Recent Works

Precipitation Extremes & Characteristics

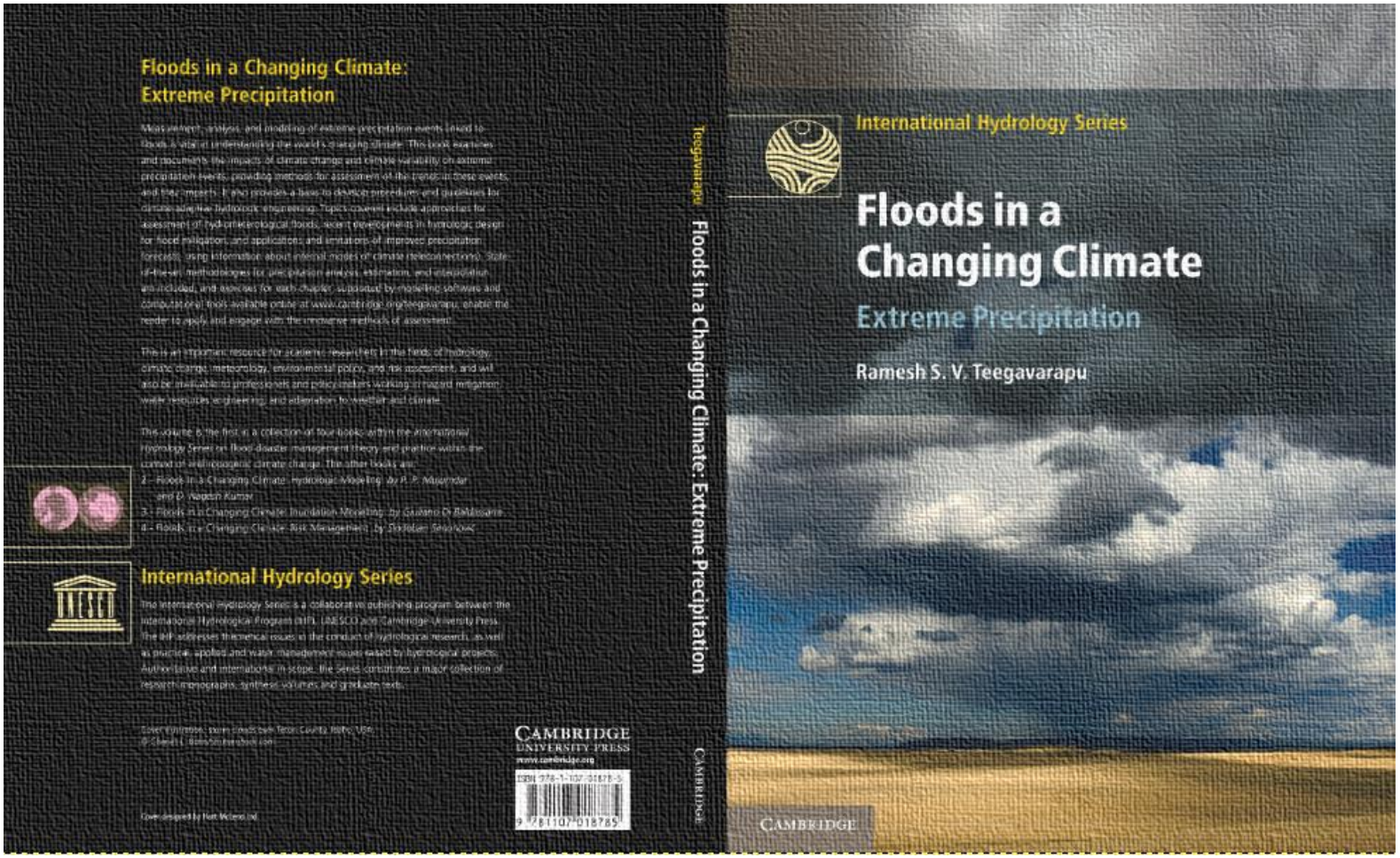
Ramesh S. V. Teegavarapu, Climate Change-Sensitive Hydrologic Design under Uncertain Future Precipitation Extremes, Water Resources Research, 49(11), 7804-7814, 2013.

Ramesh S. V. Teegavarapu, Aneesh Goly and Jayantha Obeysekera, Influences of Atlantic Multi-Decadal Oscillation on Regional Precipitation Extremes, Journal of Hydrology, 495, 2013, 74–93.

Ramesh S. V. Teegavarapu and Anurag Nayak. Evaluation of Long-term Trends in Extreme Precipitation: Implications of Infilled Historical Data and Temporal-Window based Analysis, Journal of Hydrology, 2015.

Aneesh Goly, Ramesh S. V. Teegavarapu, Arpitha Mondal, Evaluation of Statistical Downscaling Models for Monthly Precipitation in Florida, Earth Interactions, 2014.

Aneesh Goly, Ramesh S. V. Teegavarapu, Optimization and Variants of Quantile Mapping -based Methods for Bias Corrections of Downscaled Precipitation Data, Water Resources Research (under final review). 2015


Floods in a Changing Climate:
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Downscaling methods

- Main Focus
  - Statistical downscaling of Precipitation
  - Florida and South Florida.

- Spatial Resolution
  - Point and Different Grid Scales
- Temporal Resolution
  - Monthly and Daily (work in progress)

- Analyses
  - Evaluation of different Methodologies
  - Comparative evaluation of other methodologies (e.g., BCSD-based data)
  - Optimal Predictor sets
  - Use of available traditional and machine learning techniques to develop transfer functions
  - Downscaling skill – use of performance measures
  - Extreme Events
  - Methodologies to handle stationarity issues

Main Issues

- Spatial scale (resolution) of downscaling
- Temporal scale (month, day or sub-daily) of downscaling
- Function Approximation techniques for developing predictor-predictand relationships
- Stationarity of relationships
- Optimal selection of predictor variables – variations in region- and site-specific selections
- Skill of the models
  - Replication of historical behavior
  - Characterizing extremes and other region specific anomalies
- Assessment Metrics (Performance measures, error measures and others)
- Model Selection
- Bias corrections – Multi-objective Framework
- Evaluation and handling of GCM-based multiple scenario and multi model uncertainties
- Propagation of uncertainties in hydrologic simulation and determination of climate change-sensitive hydrological design.

Precipitation Extremes

- The inabilities of climate change models in reproducing precipitation extremes accurately and limitations of downscaling models in replicating the spatial and temporal variability of the same are discussed in different studies
- Temperature can be downscaled with more skill than precipitation.
- Emission scenarios and limited skills of multi-model GCM-based projections of future are considered to be the first and second sources of uncertainty respectively.

[*Jacob and Hurk*, 2011]. *Stainforth et al.* [2007]

Sustainable Hydrologic Design

- An adaptive approach for stormwater management is to upgrade existing infrastructure with changing IDF relationships over time and evolving temporal precipitation distributions.
- Sustainable hydrologic design that identifies a compromise between current and future climate-based conditions can be devised.
- Preferences of hydrologists, water managers or design personnel towards future climate change can be included in such a design process.
- Studies have explored different hypotheses about how different characterizations of climate change uncertainty may affect water managers' beliefs, opinions, choices and actions.

Groves et al. [2008]

Potential Solutions

- Acknowledging the limitations of the climate change models hydrologists may develop perceptions towards the accuracy of results from these models.

- Perceptions can be translated to preferences towards predicted future changes in the main hydrological inputs*

- Methodologies already exist to develop IDF curves based on downscaled GCM simulations and also upper and lower limits of precipitation extremes considering multi-model scenario uncertainties.

- Bounds on the precipitation intensities are used and a mathematical programming formulation with an objective of modeling preferences of decision makers towards future precipitation intensities is solved.

Conclusions

- Different methods are experimented for dowscaling precipitation data in Florida.
- NCEP-GCM and GCM-based downscaling methods are evaluated at point and different grid scale resolutions.
- The grid-scale resolutions include : 1/8, ½ and 1 Degree resolutions.

- Transfer functions linking GCM scale and grid-scale predictors in NCEP-GCM approach is critical in obtaining improved downscaling values at different resolutions.

- The downscaling models provided improved precipitation estimates (based on Canadian Centre for Climate Modeling and Analysis model – CGCM-CGCM3.1/T63 Model) compared to BCSD values at different stations in Florida. It is important to note that no bias corrections have been applied to the outputs of downscaling methods.

- A search for optimal selection of variables (as predictors) is on and methodologies are planned for selection of optimal number and type.

Thank you