

Auroop R. Ganguly¹, Shih-Chieh Kao*, Karsten Steinhäuser and Esther S. Parish

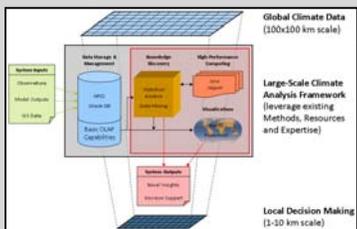
GIST Group, Computational Sciences and Engineering Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

Background

- Climate extremes (e.g., heat waves and storms or regional warming and rainfall) are projected to become more intense and frequent in the 21st century (IPCC, AR4).
- Potential impacts on food security, water resources, disease spread, hazards, humanitarian aid and migration need to be understood along with uncertainties.
- Challenges from multiple perspectives
 - Accuracy, resolution and credibility of projections
 - Massive multi-source data and nonlinear processes
 - Focus on tail behavior and complex dependence
 - Cascading uncertainty propagation
 - Complex interacting systems: Natural, built, human
- An urgent societal priority with complex trade-offs
- Regional preparedness and mitigation policies

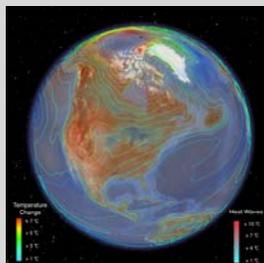
Objectives and Research Framework

- Quantifying the uncertainty of climate extreme by incorporating both the observation and simulation.
- Investigating the consistency (or inconsistency) among multiple climate projections in non-stationary environments
- Risk-based impact assessment



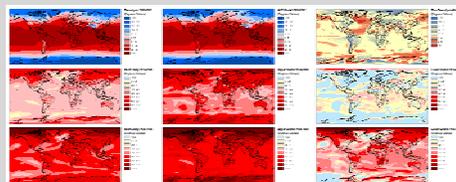
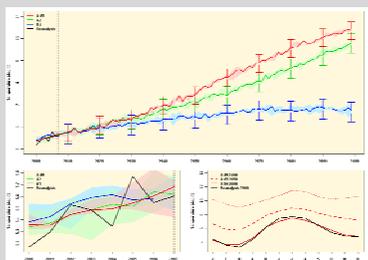
Temperature Extremes

- Higher trends but larger uncertainty of temperature extremes in the 21st century



Increased temperature and heat waves from CCSM A1FI projection comparing 2090-2099 with current decade..

- Trend corrections and confidence bounds developed by comparing model outputs with reanalysis data provide enhanced guidance to policy makers.

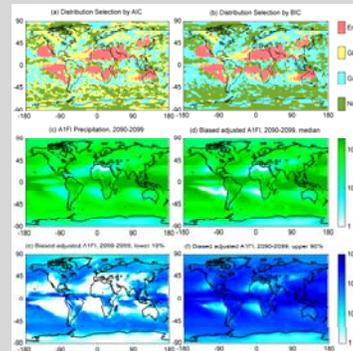


- Potential impacts on human mortality, food security, water availability, infrastructures, and energy consumption.

Reference
Ganguly *et al.* (2009), Higher trends but larger uncertainty and geographic variability in 21st century temperature and heat waves, *PNAS*, 106(37).

Uncertainty on Regional Hydrology

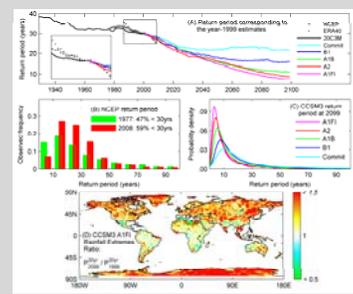
- Unlike temperature, precipitation errors cannot be modeled by a Gaussian distribution alone.
- Bias adjustment uses observations and simulations



Reference
Ganguly *et al.* (2009), Uncertainties in the Assessment of Climate Change Impacts on Regional Hydrology and Water Resources, *Invited submission, under double-blind review.*

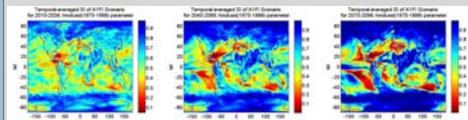
Intensified Rainfall Extreme

- More intense rainfall extremes are expected in the 21st century on the average: This can be inferred from both observations and climate models with extreme value theory.



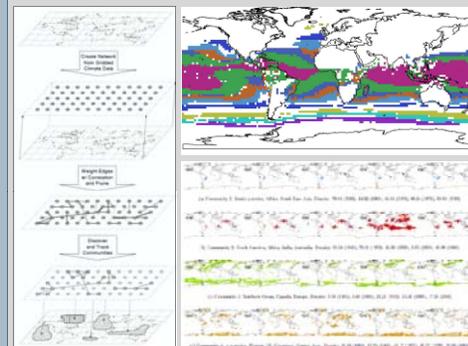
Droughts

- While the total global precipitation is expected to increase over time, the increment is not spatially uniform.
- Droughts projected over regions already experiencing or beginning to experience drought-like conditions.



Complex Network for Uncertainty Reduction

- Complex networks can unify data-guided descriptive analysis and predictive modeling for climate
- Descriptive oceanic clusters may predict land extremes



Reference
Steinhäuser, K., N.V. Chawla, A.R. Ganguly (2009): An Exploration of Climate Data Using Complex Networks. SensorKDD Workshop, ACM KDD Conference: Best Student Paper.

Policy Consideration and Decision Support

- An international climate change war game demonstrated the value of climate extremes and uncertainty to policy
Nature Blog: http://blogs.nature.com/news/blog/events/climate_war_game/
Nature News: <http://www.nature.com/news/2008/080807/full/454673a.html>
Env. Sc. & Tech: <http://pubs.acs.org/doi/full/10.1021/es802320z>



- Climate change support for the Department of Defense (DOD) Quadrennial Defense Review (QDR), <http://www.onr.gov/sci/knowledgediscovery/QDR/>



¹ Point of Contact

Auroop R. Ganguly, Ph.D.

Email: gangulyar@ornl.gov

<http://www.ornl.gov/knowledgediscovery/ClimateExtremes>

Geo. Information Sci. & Tech. Group
Computational Sci. & Eng. Division
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6017
Tel.: +1 (865) 241-1305
Fax: +1 (865) 241- 6261

This research was funded by the Laboratory Directed Research and Development (LDRD) Program of the Oak Ridge National Laboratory (ORNL), managed by UT-Battelle, LLC, for the U.S. Department of Energy under Contract DE-AC05-00OR22725.