Climate Information for Urban Resilience

Lawrence Buja - NCAR

Climate 1.0 Is anthropogenic climate change occurring?

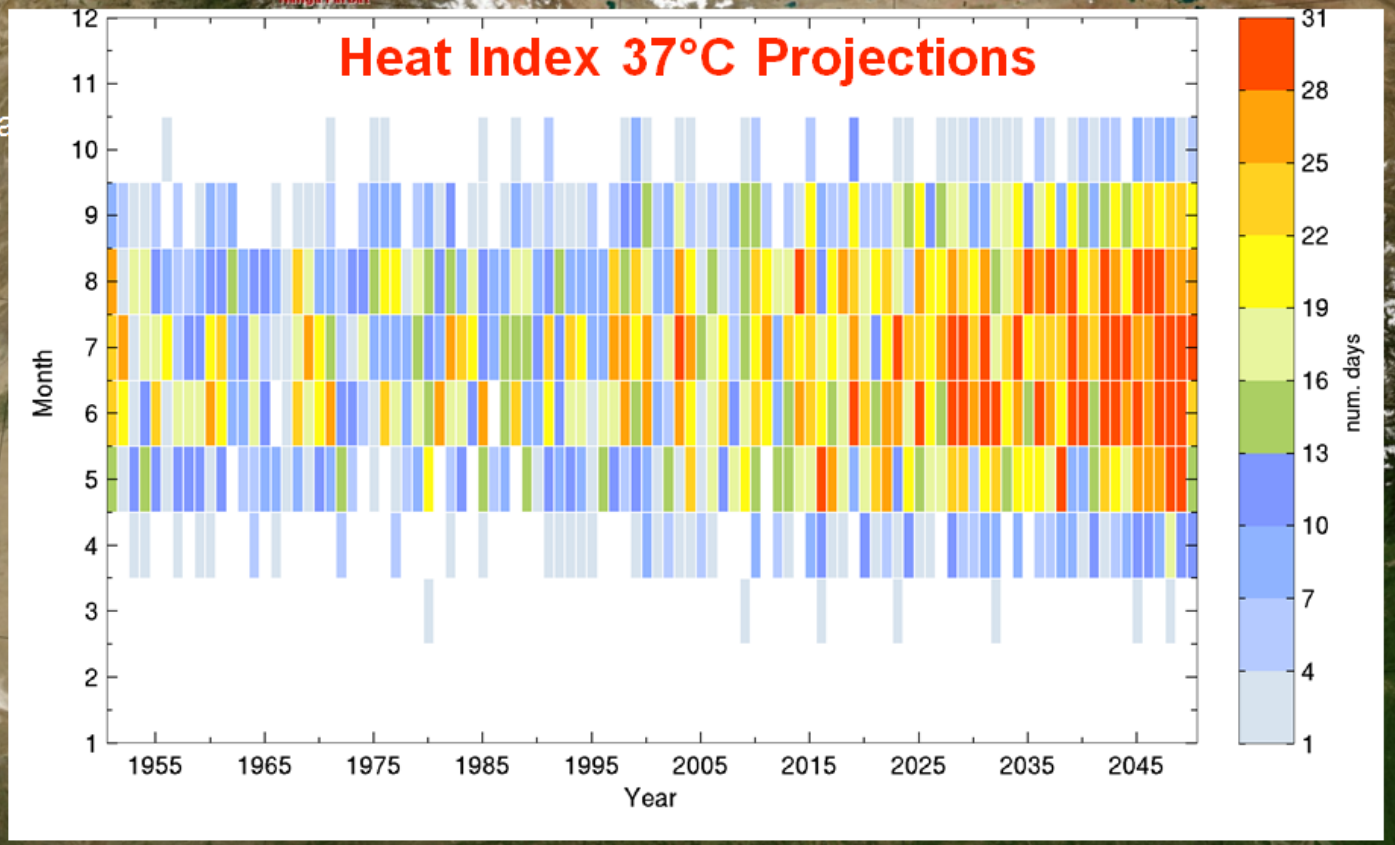
Climate 2.0 What is the impact on human & natural systems?

Climate 3.0 How are you partnering with regional/local groups to create usable science for decision making?

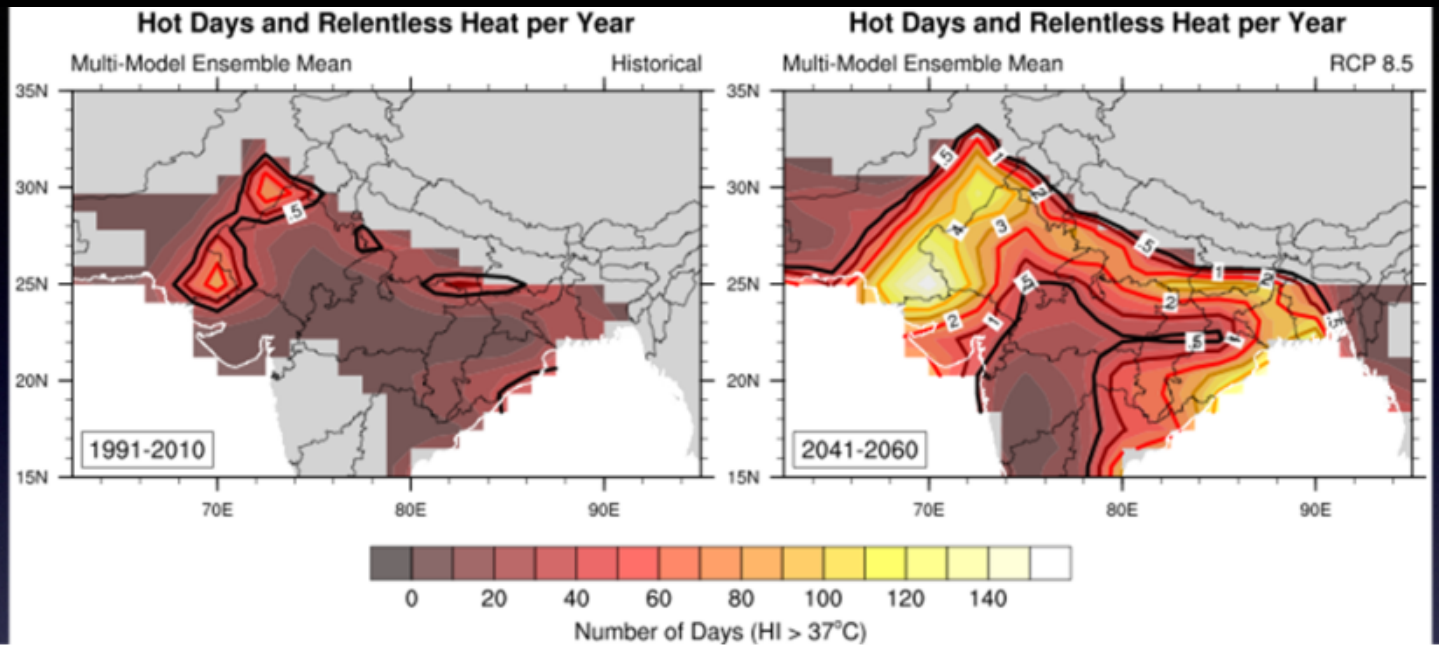
- "Actionable" Science for Sustainable Systems:
  Energy, Food, Water, Security, Health, Cities, Ecosystems
- Societal Impacts: GIS, extremes, climate services -> RISK
- 2-way Dialog and ownership required at multiple scales

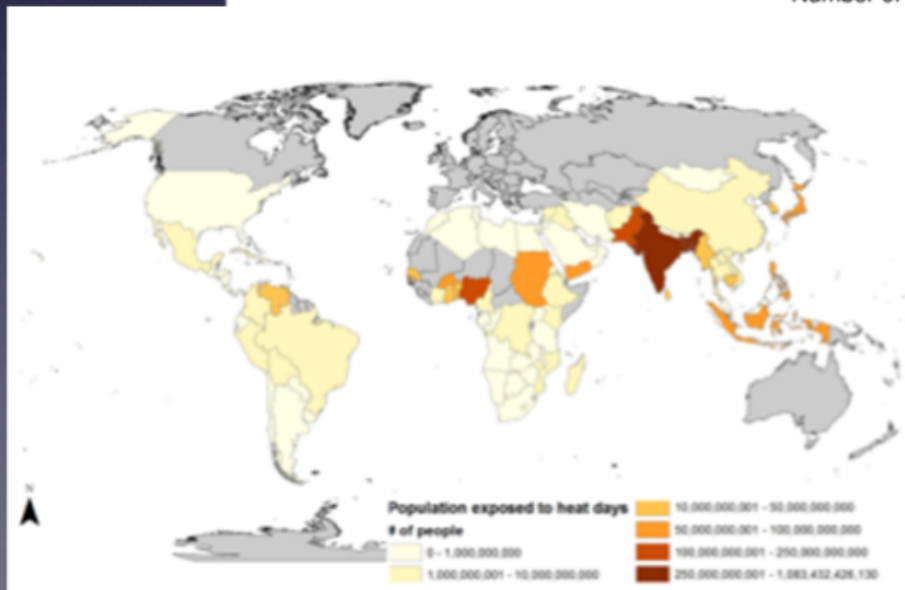
(Sasha's question: What is Climate 4.0?)

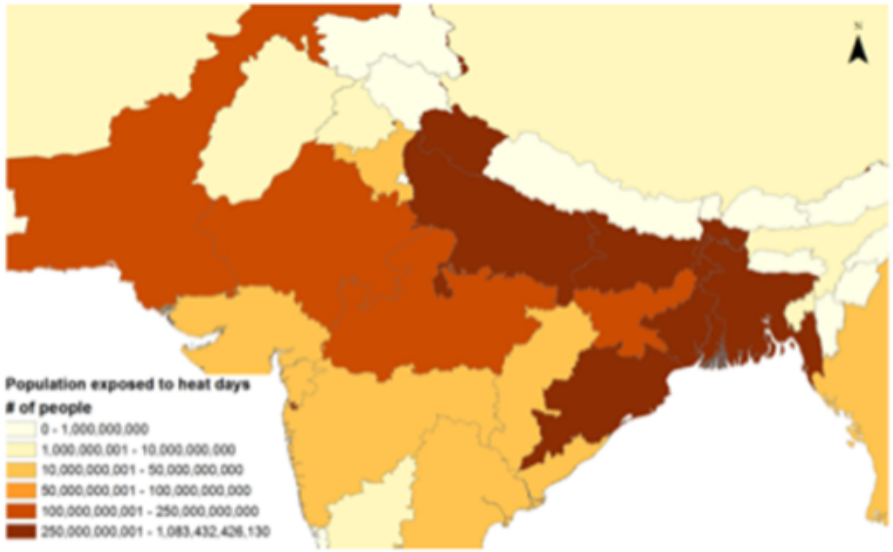
Climate 2.0 – Climate Hazards



Climate 2.0 – Climate Impacts

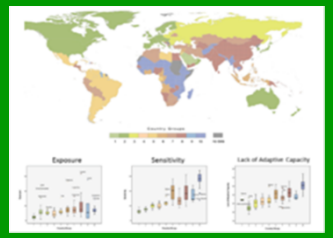






Ammann et al. (in review)

Climate 3.0: The Socio-Urban Context

URBAN FUTURES		
Regional to Global Scale		Urbanization dynamics shaping emissions, vulnerability/ capacity & risk
Neighborhood to City Scale		Socio-demographic, Economic, Technological, *E*nvironmental, and Governance (SET*E*G)
Individual and Household Scale		Differences in capacity to respond

Paty Romero-Lankao

NCAR

Climate 3.0: The Socio-Urban Context

1. Urbanization often shapes its own risks,
   - Affects human security by creating the conditions for vulnerabilities,
   - Offers capacities and options to help build sustainable futures.
2. Risks & opportunities most acute in rapidly urbanizing regions.
3. Interactions between urbanization and climate change occur at multiple spatial and temporal scales.
   - these scales may not fit with the scales at which human institutions manage risk.
   - Actions to enhance resilience in one location may increase risk elsewhere.
4. **Institutional Fit:** institutional arrangements that "map" the features of their problems to produce desirable, sustainable outcomes at diverse scales.

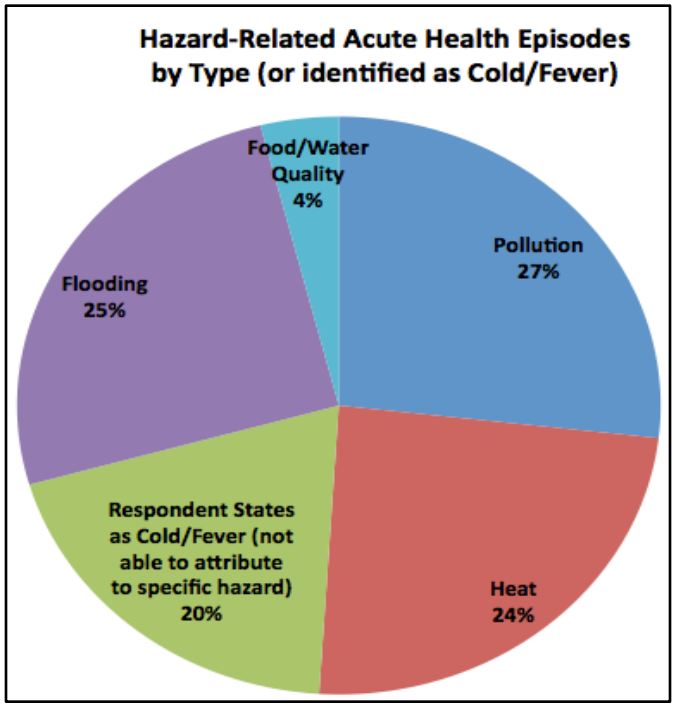
Urban Futures in the US, India & China

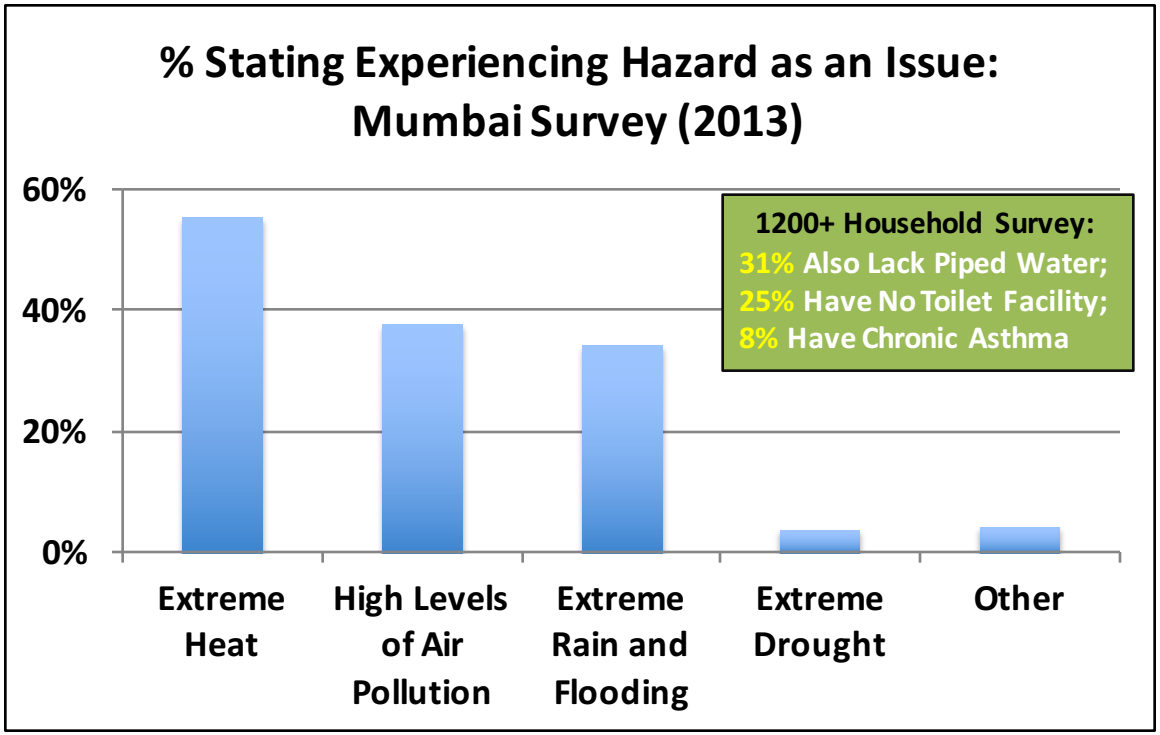
Paty Romero Lankao | Josh Sperling NCAR/RAL/CSAP

Funded by the NSF Partnerships for Int'l Research & Education Program

- **MUMBAI:** Hazard Mitigation & Vulnerability Assessment
- **BEIJING:** Urbanization- & Flood-Related Risk Mgmt.
- **US-INDIA-CHINA:** Drivers of Low-Carbon & Resilient Cities

Researchers and students from six U.S. , five Indian and three Chinese institutions are designing infrastructural and governance options to develop low-carbon, sustainable, healthy, and resilient cities in the U.S., India, and China, resulting in improved quality of life and increased global stability.





Typhoon Vincente Causes Record Flooding in Beijing on July, 2012

100 dead: 38 in Beijing core
$1.6 billion in urban damage
57,000 forced from homes

Urban vulnerability to temperature-related hazards

Romero-Lankao, P., Qin, H., and Dickinson, K., 2012: Urban vulnerability to temperature-related hazards: A meta-analysis and meta-knowledge approach, *Global Environmental Change*, 12: 670-683

Urban populations' vulnerability to temperature-related hazards has mostly been examined using thirteen factors that account for 60% of vulnerability determinates:

- hazard magnitude (i.e., temperature level),
- population density,
- age,
- gender,
- pre-existing medical conditions,
- education,
- income,
- poverty,
- minority status acclimatization, and
- access to home amenities such as air conditioning and swimming pools.

They also found that research on urban vulnerability has predominantly focused on populations in the United States and Europe, with lower- and middle-income countries remaining understudied.

Urban vulnerability to temperature-related hazards

Romero-Lankao, P., Qin, H., and Dickinson, K., 2012: Urban vulnerability to temperature-related hazards: A meta-analysis and meta-knowledge approach, *Global Environmental Change*, 12: 670-683

- What we know depends fundamentally on what questions we ask and how we go about answering those questions (i.e., the kind of methods and data we use or have available to us).
  - The vast majority of studies have quantified the relationship between hazards and health outcomes, while controlling for age and other confounding factors.

- However, they have **omitted underlying societal processes explaining populations' differentiated access to air conditioning, health services and other assets and options, and thus, differences in vulnerability.**

- A **more integrated approach** to the multiple dimensions and determinants of urban vulnerability is needed. The central understanding of this integrated approach will be that each paradigm can shed light on only a small piece of a complex puzzle.

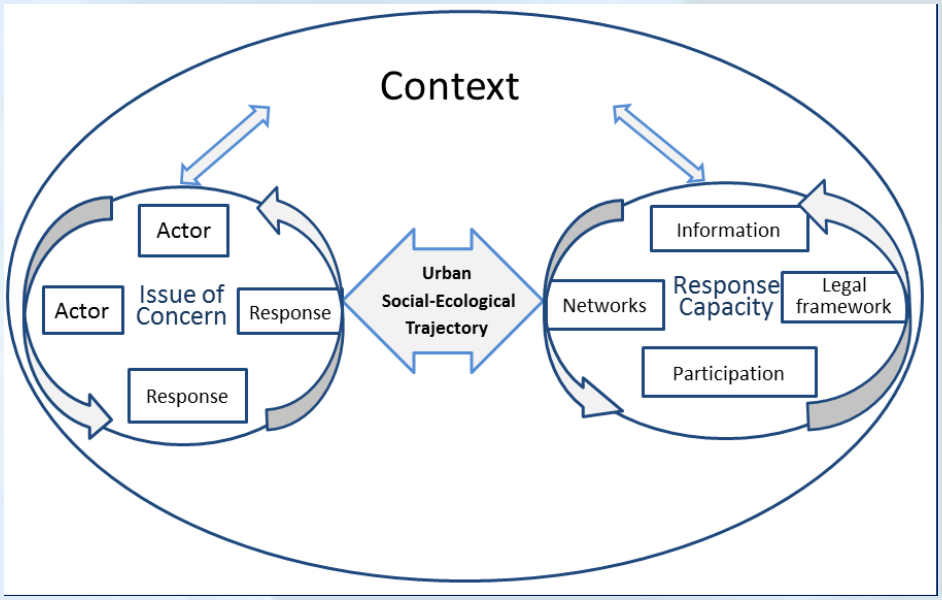
Multilevel Governance and Institutional Capacity for Climate Change Responses in Latin American Cities.

Romero-Lankao, P., Hardoy, J., Hughes, S., Rosas-Huerta, A., Borquez, R., & Gnatz, D.M. 2015: Multilevel Governance and Institutional Capacity for Climate Change Responses in Latin American Cities. In *"The Urban Climate Challenge Rethinking the Role of Cities in the Global Climate Regime", Cities and Global Governance*. Routledge, pp. 179–204.

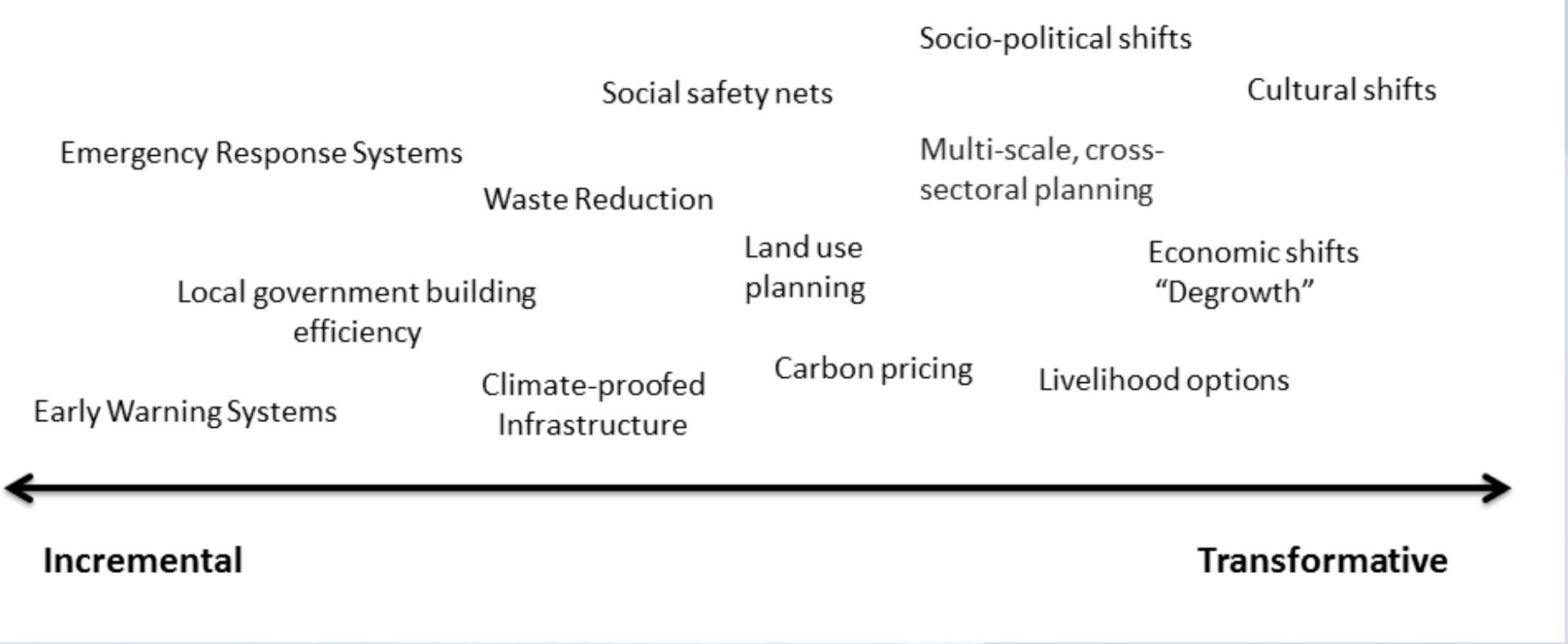
- Cities are responsible for 71 to 75% of global anthropogenic GHG emissions. However, often only a small fraction of emissions produced within a city are under the direct control of local governments.
- What are the key factors shaping the design and implementation of mitigation and adaptation policies in the cities **of Buenos Aires, Argentina, Mexico City, Mexico and Santiago, Chile.** These cities have been molded by similar processes that have been instrumental in putting climate change on their policy agendas.
- **Result:** The level of authority provided to Mexico City within Mexico's legal framework to take steps to address climate change, and the city's extended experience with monitoring and tracking air pollution, have enhanced institutional response capacity and likely help to explain why Mexico City is a regional frontrunner in responding to climate change.

Institutional capacity to govern carbon and climate in cities

- Most actions: incremental and fragmented
- Tension: stability of institutions and flexibility of autonomous actions
- Science that urban actors look for not produced at required scale
- Metrics to evaluate adaptation and mitigation responses and their drivers are critical



Urban Climate Change governance strategies



address adaptation and mitigation in isolation

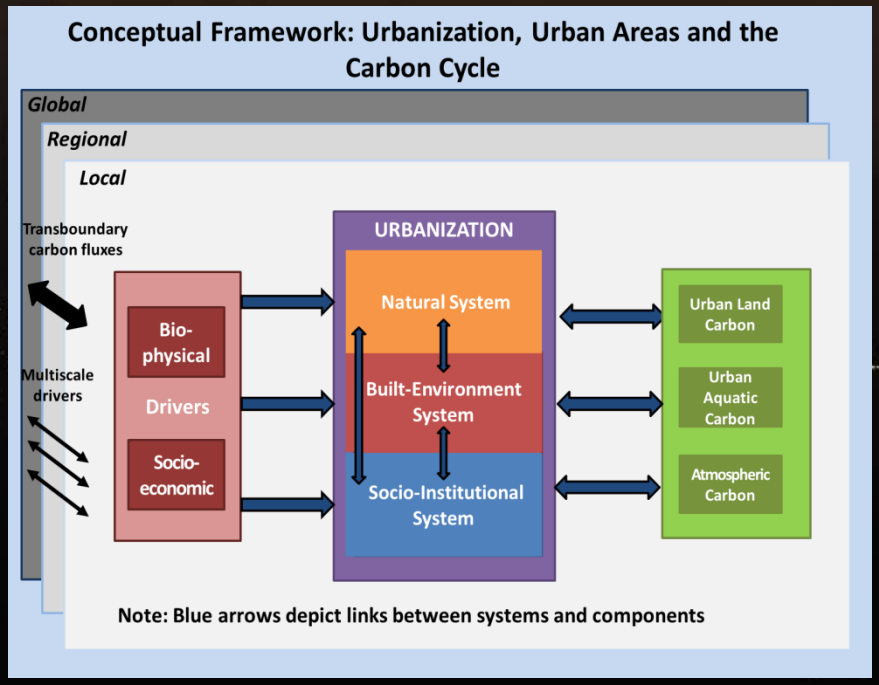
integrate adaptation and mitigation.

Relative location along the y-axis is not significant.

Critical knowledge pathway to low-carbon, sustainable futures: Integrated understanding of urbanization, urban areas and carbon

Romero-Lankao, P., Gurney, Seto, et al. (2014), A critical knowledge pathway to low-carbon, sustainable futures: Integrated understanding of urbanization, urban areas, and carbon, Earth's Future, 2(10), 515–532, doi:10.1002/2014EF000258.

Calls for interdisciplinary explorations of how different urbanization processes, and socio-ecological and technological components of urban areas affect the spatial and temporal patterns of carbon emissions, differentially over time and within and across cities



Key Points:

- Urbanization uncertainties are of similar magnitude to carbon uncertainties
- Lock-ins in urbanization, cities, and carbon constrain low-carbon transitions
- integrated, coproduced approaches to urbanization, urban areas, and carbon are needed

Next Steps:

- USGCRP cross-agency urban-carbon program

Background public domain via pixabay.com/en/pollution-industrial-plant-588810

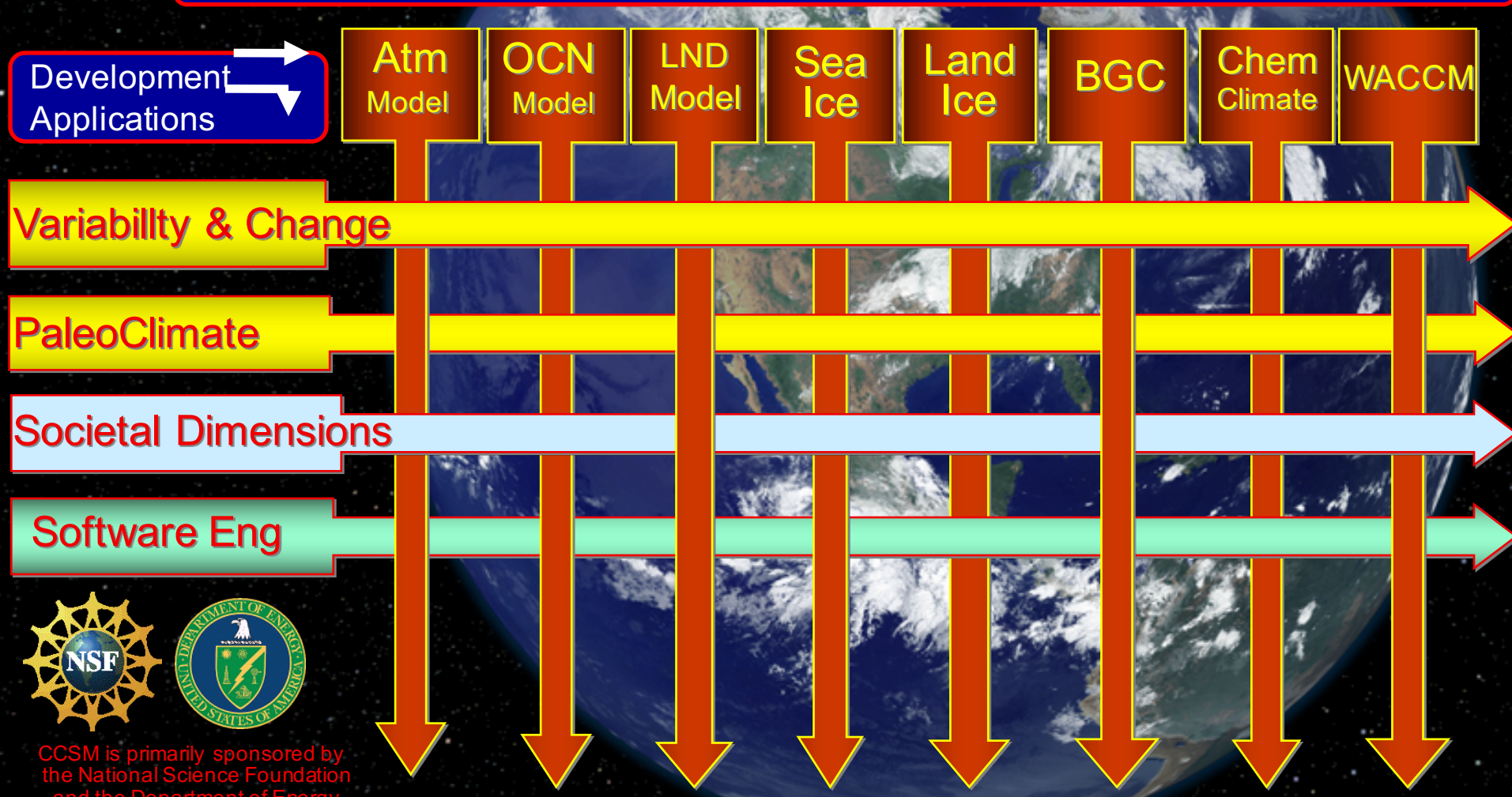
Data Needs

- Economic growth, population size, structure and rates of growth
- Technologies and technological change
- Urban planning and regulations
- Infrastructure planning and code specifications
- Market instruments, legal mandates, growth caps
- Political discourses surrounding fossil fuels and land use
- Lifestyle choices, cultural beliefs (preference for big vehicles, detached houses) and marketing
- Urban form: e.g., density, land use mix and connectivity, and
- Carbon e.g.,
  - Carbon embedded in urban infrastructures and built environments,
  - Carbon in soils,
  - Carbon sequestered in urban green spaces, and
  - Carbon emitted to the atmosphere

CESM Working Group Structure

CESM Scientific Steering Committee (J.F Lamarque, Chief Scientist)

CESM Advisory Board



CCSM is primarily sponsored by the National Science Foundation and the Department of Energy

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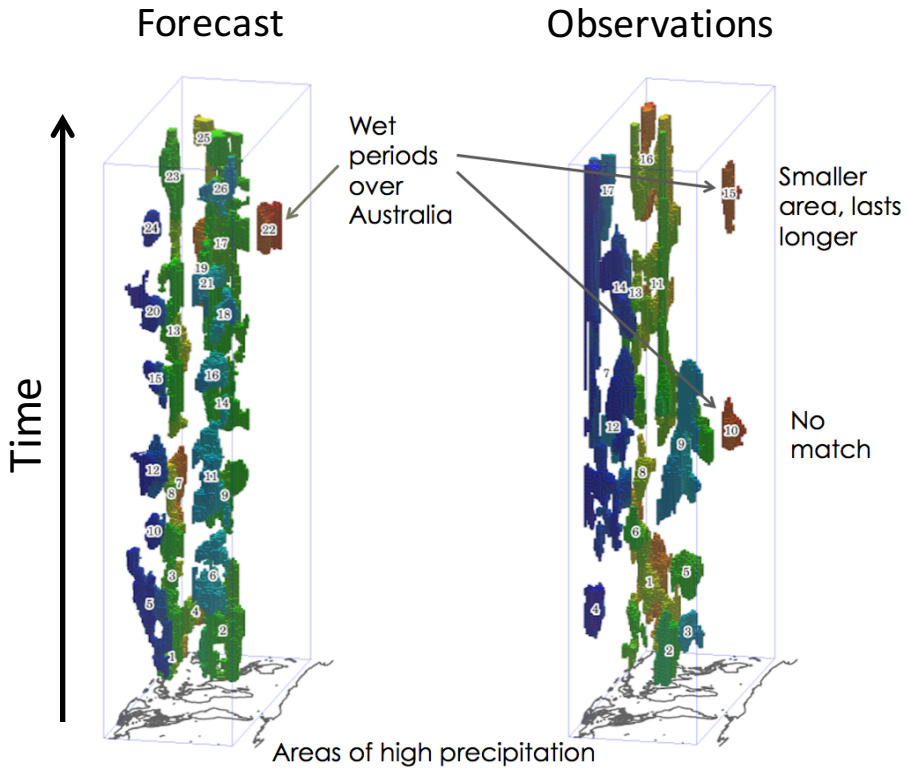
CESM Societal Dimensions Working Group

Working group scope expanded beyond initial IAM/water focus to full range of climate/society impacts sectors

- IAM & Impacts: Water, Infrastructure, Health, Agriculture, Transportation

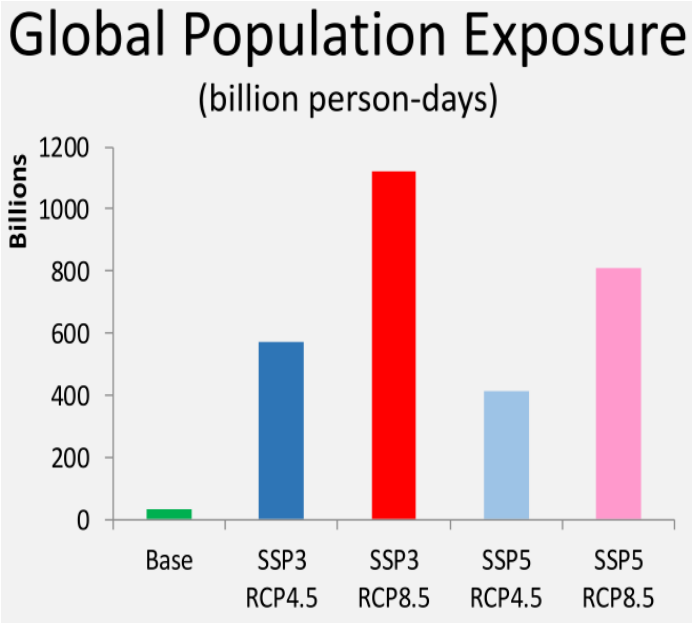
- EaSM Usable science for water planning
  - **Climate Data Evaluation**: Implementing a capability to compute transparent, standardized metrics that offer application-oriented information about quality of data and their uncertainties.
  - New **Space-Time Object Verification** Methods, originally developed for weather forecast verification, are being tested in a climate context



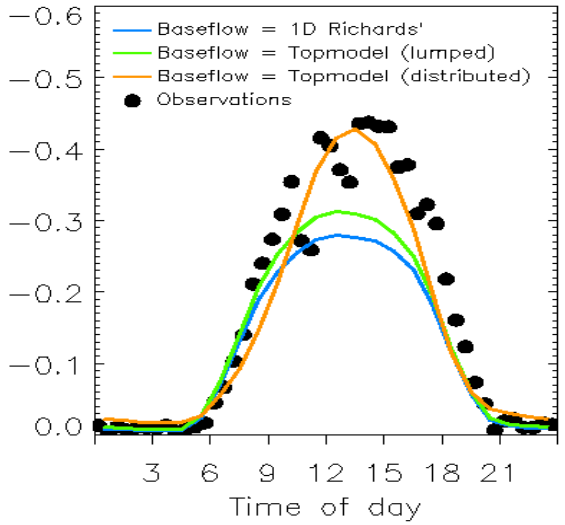
Searching for three-year precipitation extremes in models and observation

SDWG 2015 Highlights

- New project on the Benefits of Reduced Anthropogenic Climate changE (BRACE)
  - Employing CESM ensembles for RCP8.5 and RCP4.5 to investigate differences in impacts
  - Special issue of *Climatic Change* established and under way, 20+ papers involving NCAR and 8 other institutions



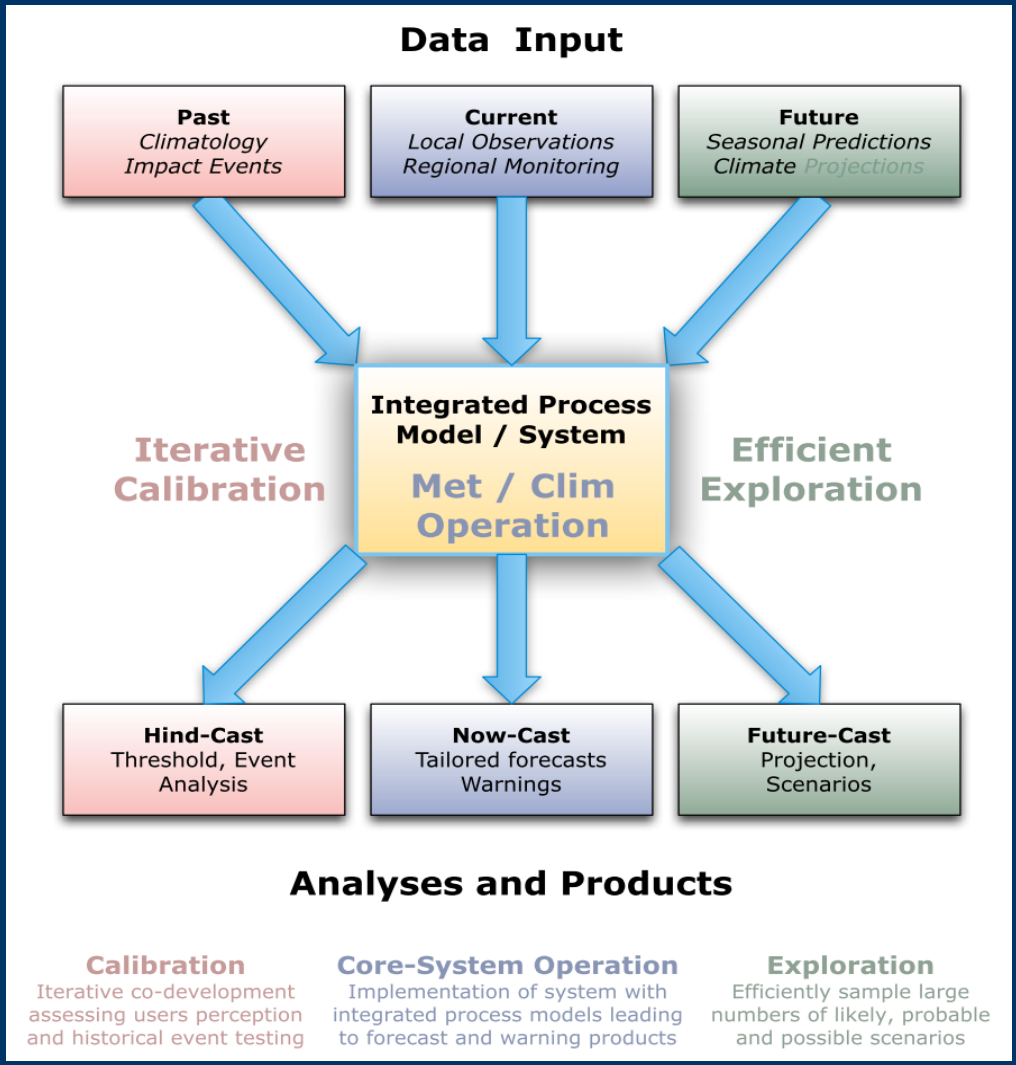
- Project on improving the representation of hydrologic processes in Earth System Models with LMWG (Martyn Clark & David Lawrence) with ACE & BOR
  - Land surface model hydrology schemes with horizontal transport (orange) perform better than those without (blue) when compared to observations



Clark et al. WRR 2015

Tools: Climate Risk Management Engine

- **Contextualized Climate Information**
- **Standardized evaluation & distribution protocols for high-resolution regional climate data**
- **Translation of the climatic data, information and knowledge for diverse applications**
- **Four initial sectors:**
  - water management,
  - agriculture,
  - human health and,
  - ecosystems.
- **World Bank Climate Change Knowledge Portal**
- **www.ral.ucar.edu/csap**



Thanks! Any Questions?

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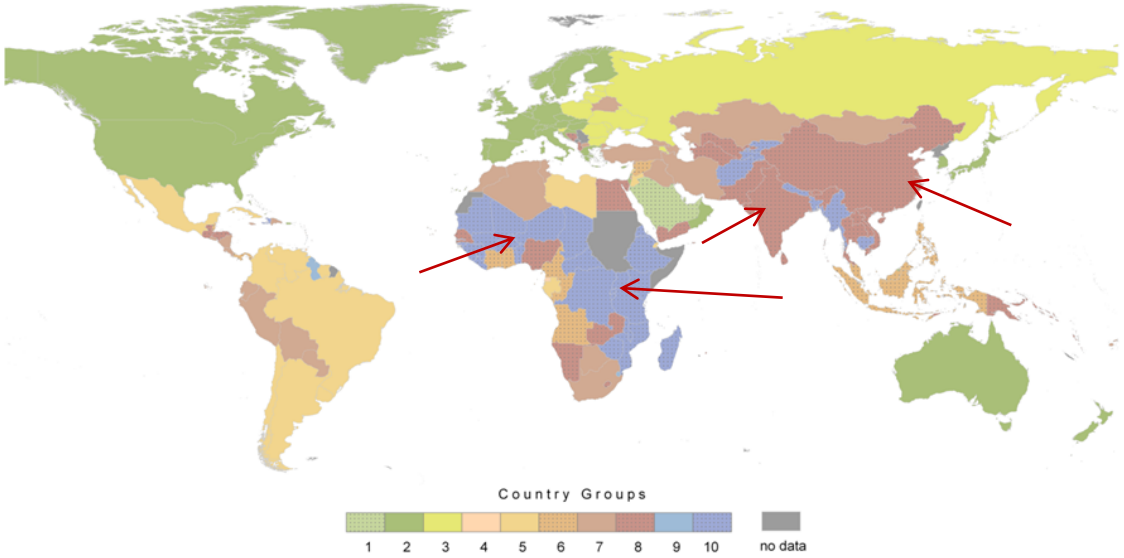
Highlight goal 1: Dynamics of urbanization shaping risk

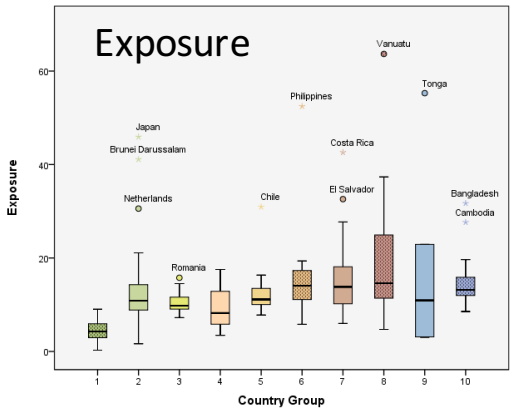
1. Methods

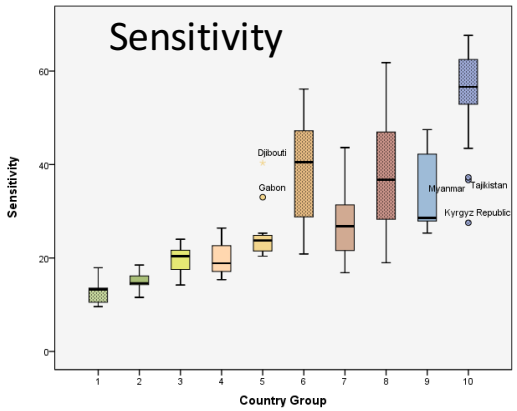
- Urbanization and economic indicators used to cluster countries
- Cross-correlation of clusters with national-level normalized sub-indices of hazard exposure, sensitivity, and adaptive capacity (World Risk Index 2012)

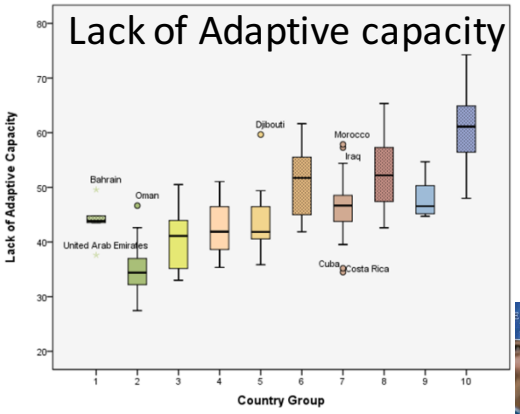


2. Rather than exposure differences , differentials in sensitivity and capacity are key

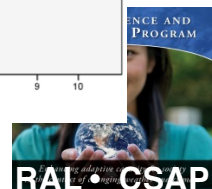
3. Levels and particularly rates of urbanization influence vulnerability







Source: Garschagen and Romero-Lankao 2013 *Climatic Change*



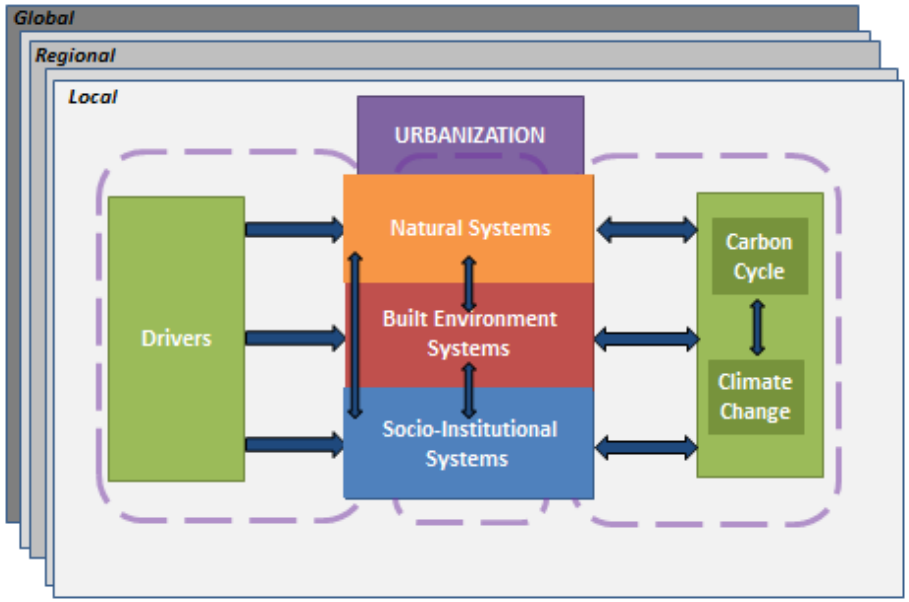
Highlight goal 2: Conceptual framework on key relationships for an improved understanding of urbanization and carbon flow

Core questions

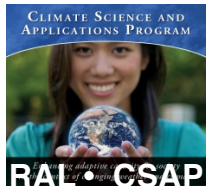
1. **Drivers of carbon emissions brought on by urbanization space, time, and scale**
2. **Relationship between urbanization and carbon flow and how does it vary across the world**
3. **The major uncertainties associated with questions 1 and 2?**
4. **When and how do carbon emissions brought on by urbanization "lock in" such that future emission trajectories are difficult to alter?**
5. **What are the Opportunities for altering urbanization trajectories towards lower carbon pathways?**

Three outcomes:

- 2014 paper accepted with revisions by Nature
- Lead of Special Issue in Earth's Future
- White paper for funding agencies



K.R. Gurney (ASU), P. Romero-Lankao (NCAR), K. Seto, (Yales) C. Kennedy (Toronto), N. Grimm (ASU), J. Ehleringer (Utah), P. Marcotullio (CUNY), S. Pincetl (UCLA), J.J. Feddema (Kansas), S. Hughes (EPA), M.V. Chester (ASU), L. Hutyra (Boston), J. Sperling (NCAR), D. Runfola (NCAR)



Differences in Underlying Multi-Dimensional Vulnerabilities Within and Across Cities