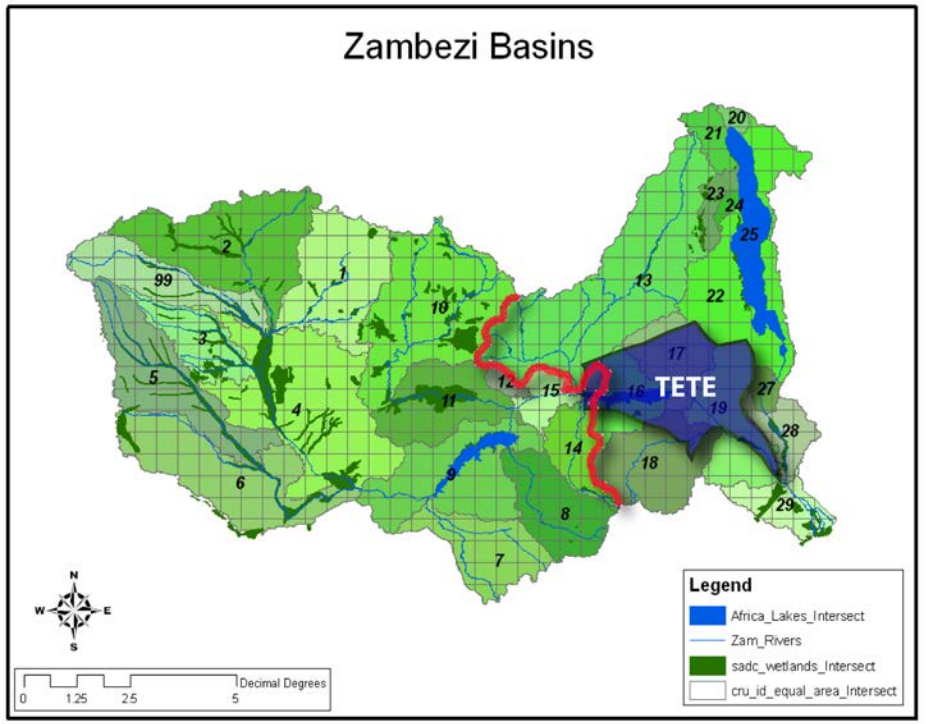
Quantifying the Likelihood of Climate Change over the Zambezi River Basin: A Hybrid Approach

Quantify the climate-change risk of the greater Zambezi River Basin, by covering the range of uncertainty in the global and regional climate response as well as emissions under climate policies.



C. Adam Schlosser (MIT), Ken Strzepek (MIT), Channing Arndt (WIDER), Xiang Gao (MIT), Andrei Sokolov (MIT), James Thurlow (WIDER), Sergey Paltsev (MIT), Arthur Gueneau (MIT), Charles Fant (WIDER), and Sherman Robinson (IFPRI)

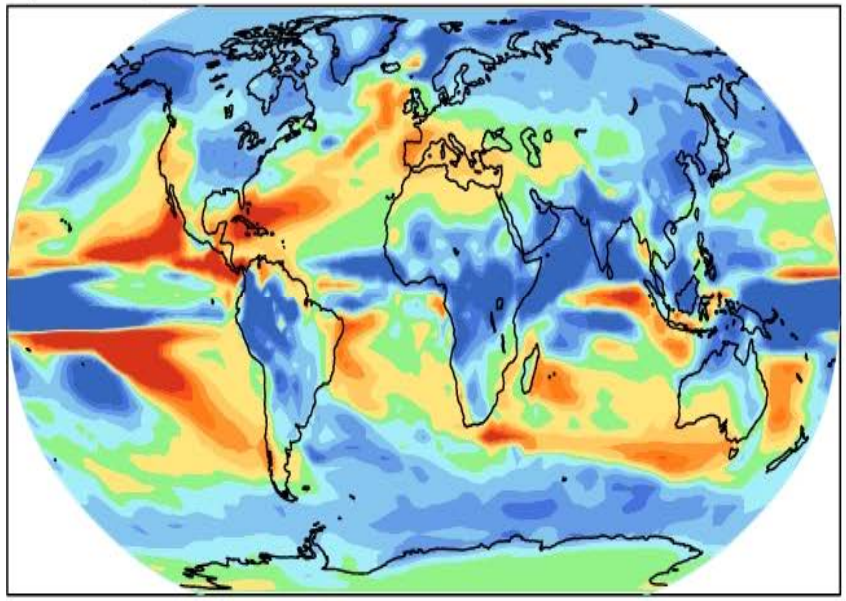
MIT JOINT PROGRAM ON THE SCIENCE AND POLICY of GLOBAL CHANGE

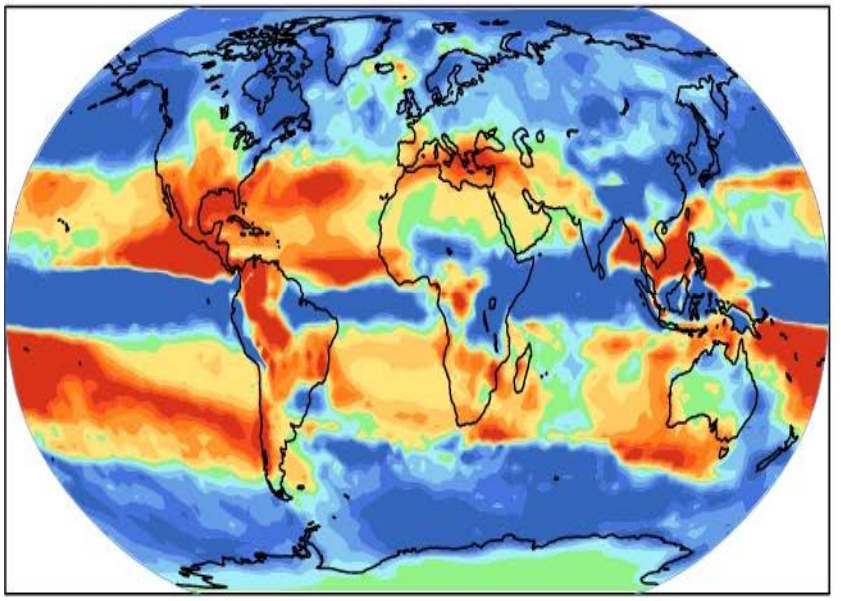
U.S. DEPARTMENT OF ENERGY

UNITED NATIONS UNIVERSITY
UNU-WIDER
World Institute for Development Economic Research

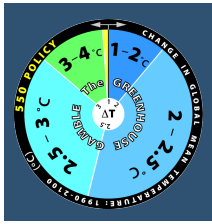
Uncertainty in Regional Change

Simulated Precipitation Change in 21st Century: A1B Scenario
Opposing Climate Model Results at the Regional Scale

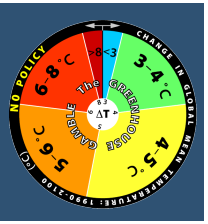




How to prepare when regional changes differ in sign?



Underpinning Remarks



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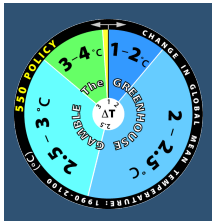
  ⇒A positive spin: "No model is perfect, but many are suitable."



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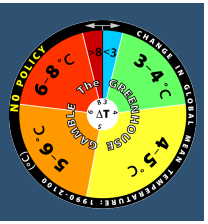

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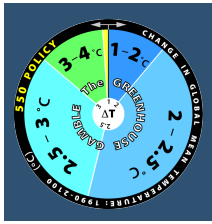

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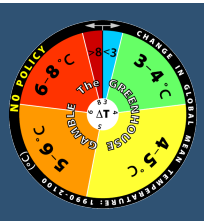

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- Growing evidence that 'superior' model skill does not always apply.
  ⇒So we consider all "plausible outcomes".

- "Model mean" performance superior (even including "bad" models).
  ⇒Caveat: By averaging models you smooth extreme events, which have large impact. ***Frequency distributions of impacts from each model outcome considered separately, more appropriate.***

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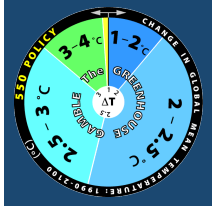
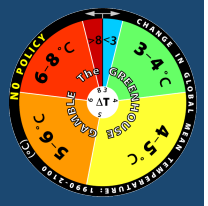
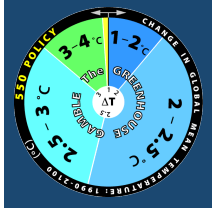


How "Dependable" Are Climate-Change Forecasts?



We cannot calculate the response of the atmosphere, oceans, and land systems precisely…



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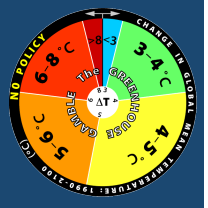

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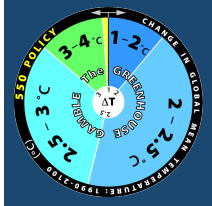

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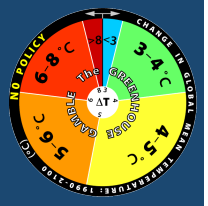

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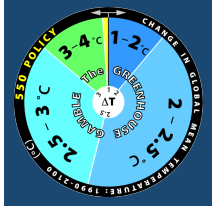

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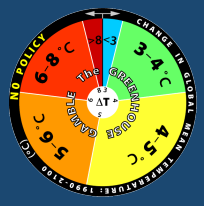

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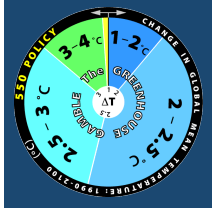

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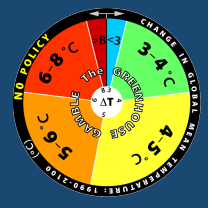

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Add to this our limited confidence in how much greenhouse gases we will emit…

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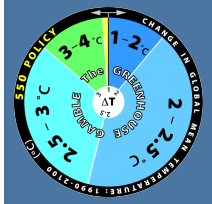
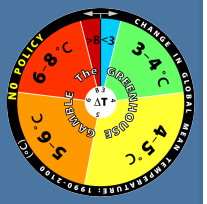
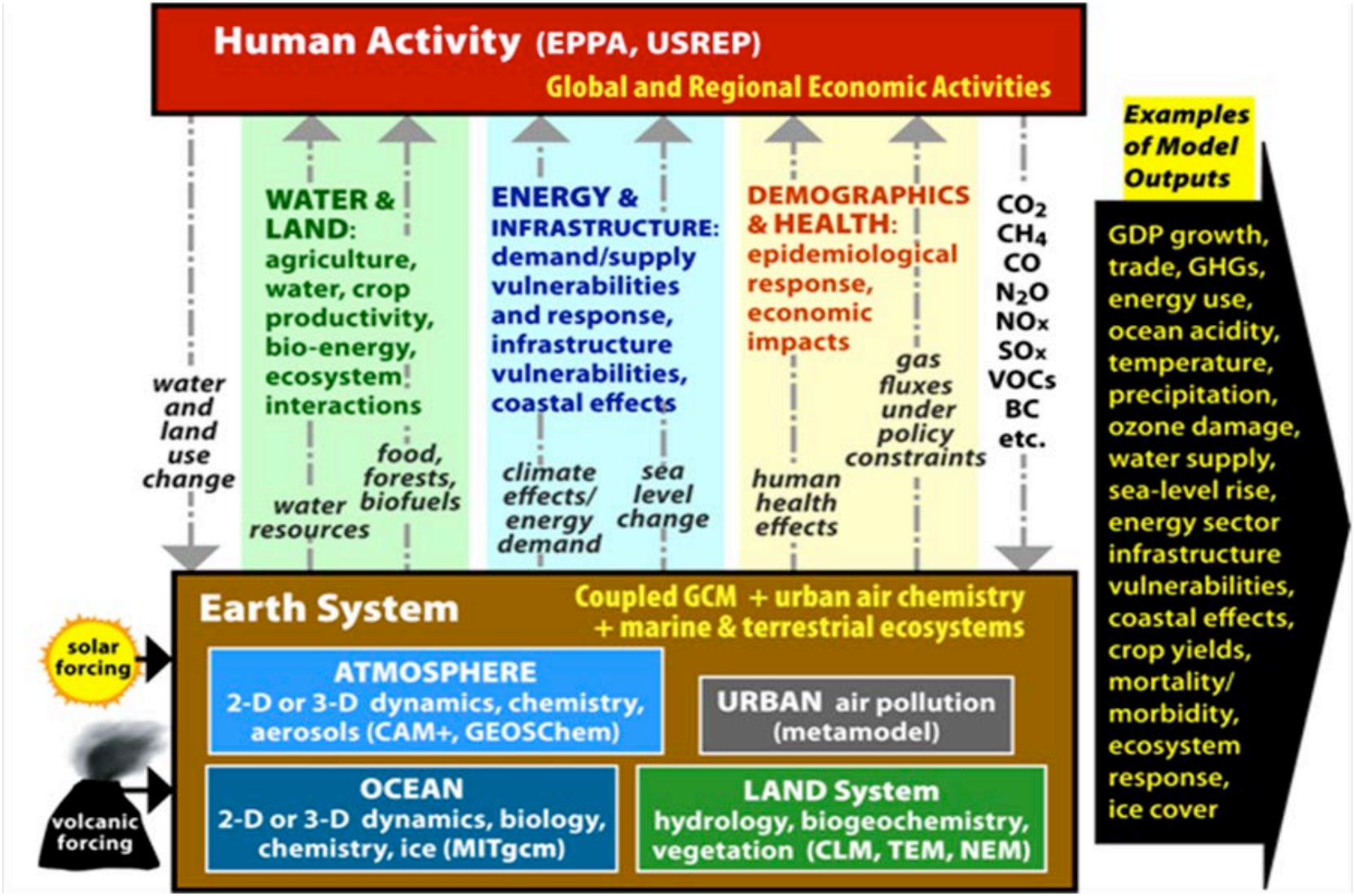
So – we perform *many simulations* (at least on the order of a few hundred) to estimate the chances climate change given our range of confidence in emissions and the climate response.



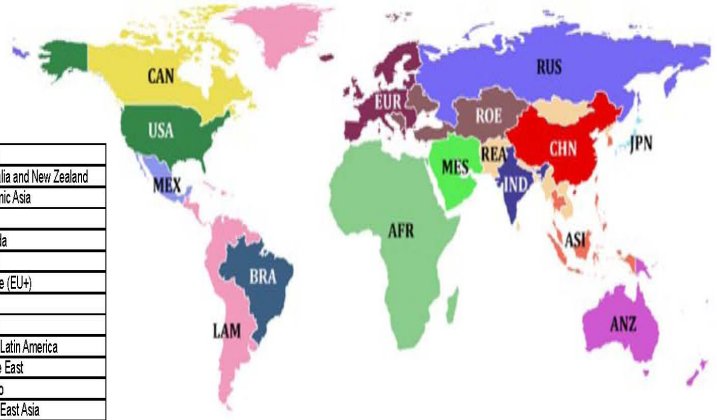
The MIT Integrated Global System Model (IGSM)
An Integrated Assessment Model (IAM)

(IGSM2: Sokolov et al., 2005, JP Tech. Report #124 EPPA: Paltsev et al. 2005, JP Tech. Report #125
Land: Schlosser et al., 2007 JP Tech Report #147 Ocean: Dutkiewicz et al., 2005, JP Tech. Report #122)





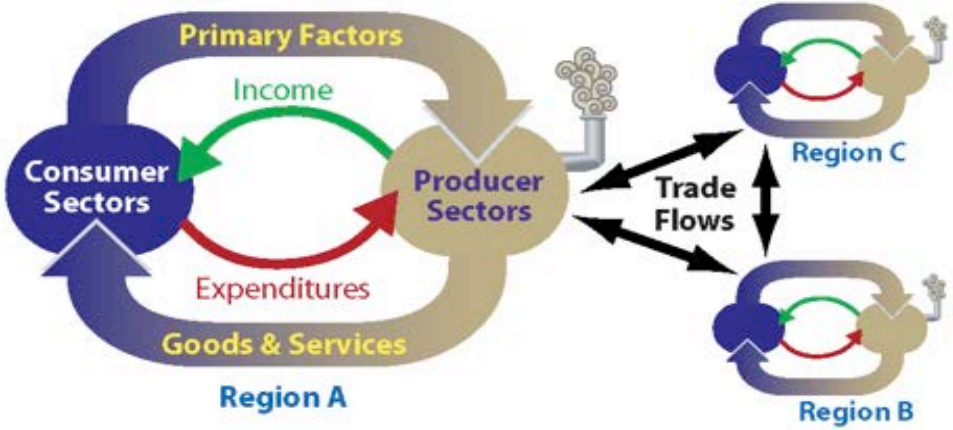
Emissions Policy and Prediction Analysis (EPPA)



16 regions:

AFR	Africa
ANZ	Australia and New Zealand
ASI	Dynamic Asia
BRA	Brazil
CAN	Canada
CHN	China
EUR	Europe (EU+)
IND	India
JPN	Japan
LAM	Other Latin America
MES	Middle East
MEX	Mexico
REA	Other East Asia
ROE	Other Eurasia
RUS	Russia
USA	USA

Regional data tables are available at: http://globalchange.mit.edu/Outlook2012



Model Features
- All greenhouse-relevant gases
- Flexible regions
- Flexible producer sectors
- Energy sector detail
- Welfare costs of policies

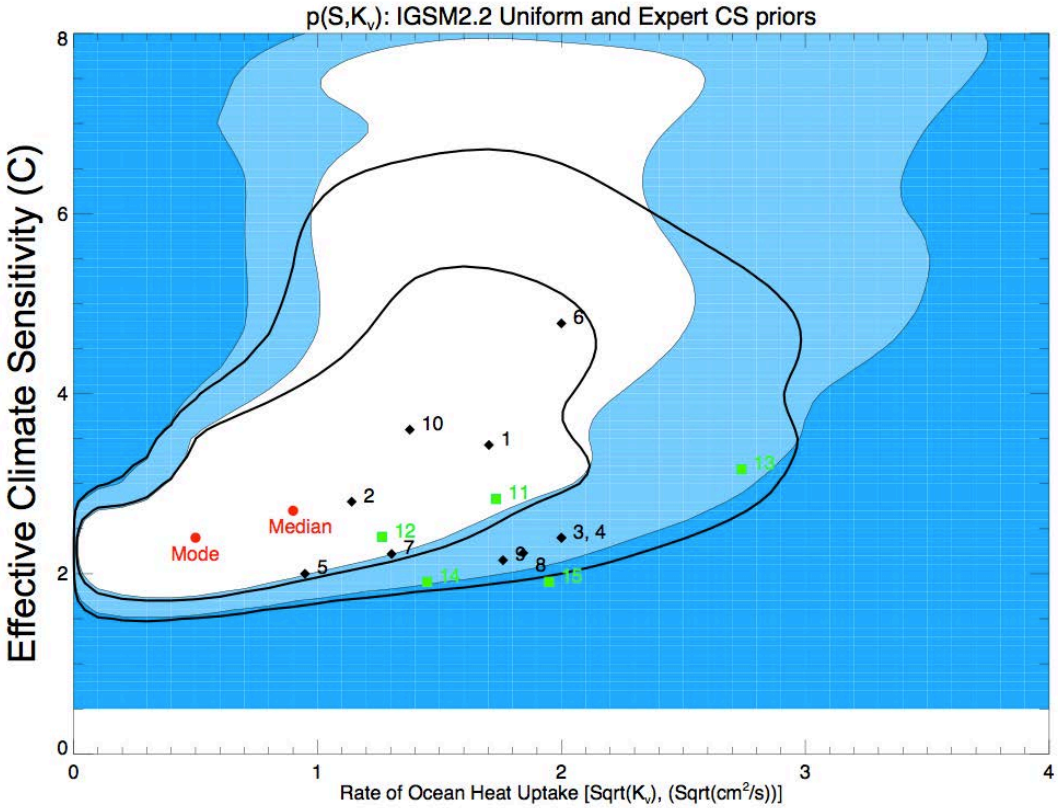
Mitigation Policies
- Emissions limits
- Carbon taxes
- Energy taxes
- Tradeable permits
- Technology regulation

- Approximately 100 (uncertain) parameters that include:
  - Productivity growth
  - Energy efficiency
  - Ease of substitution
  - Costs of new technology

- Main Outputs: Emissions, Prices, GDP, and Welfare

Key Uncertain Elements in Climate Change

- Emissions Uncertainty
- Climate Sensitivity (change in Temperature due to change in radiative forcing).
- Heat uptake by Deep Ocean (& Carbon Uptake)
- Radiative Forcing of Aerosols
- CO_2 Fertilization Effect on Ecosystem (wide range)
- Trends in Precipitation Frequency

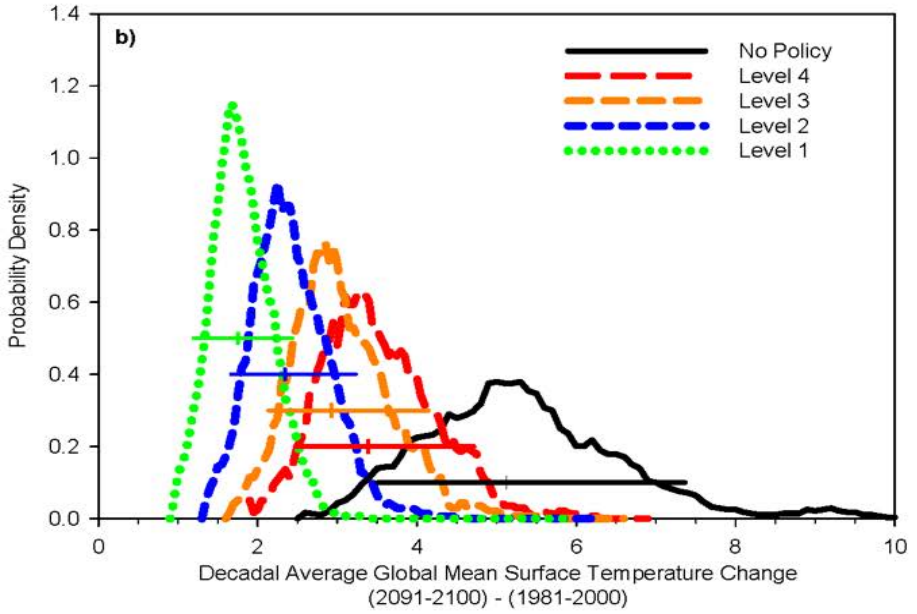


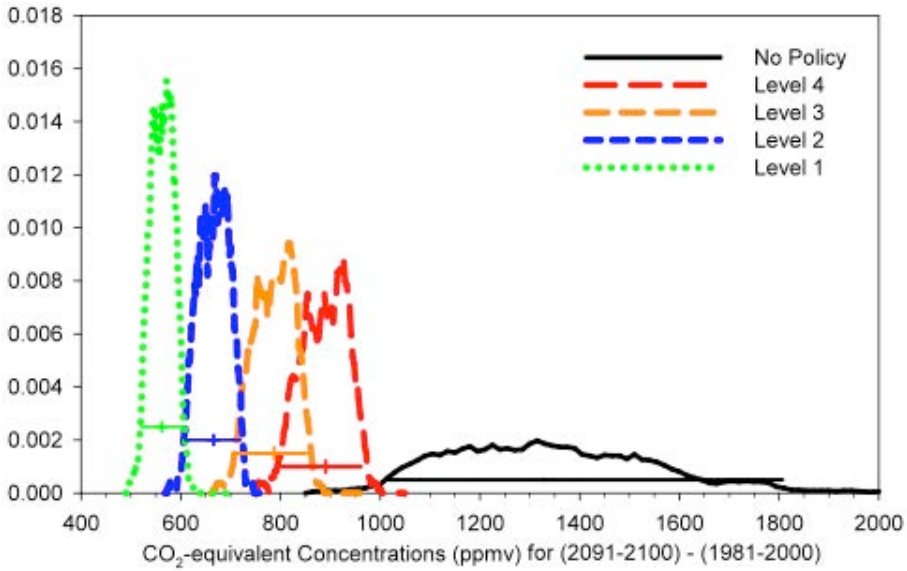
Forest et al., 2008

IGSM Scenarios
(Sokolov et al., 2009, and Webster et al., 2009)

No Policy (Reference):
- "Unconstrained Emissions"

Policy Scenarios:
- U.S. CCSP Level 4
- U.S. CCSP Level 3
- U.S. CCSP Level 2
- U.S. CCSP Level 1





HOW CAN WE EXPRESS THE VALUE OF A CLIMATE POLICY UNDER UNCERTAINTY THAT TRANSLATE INTO "ODDS" OF CLIMATE CHANGE?

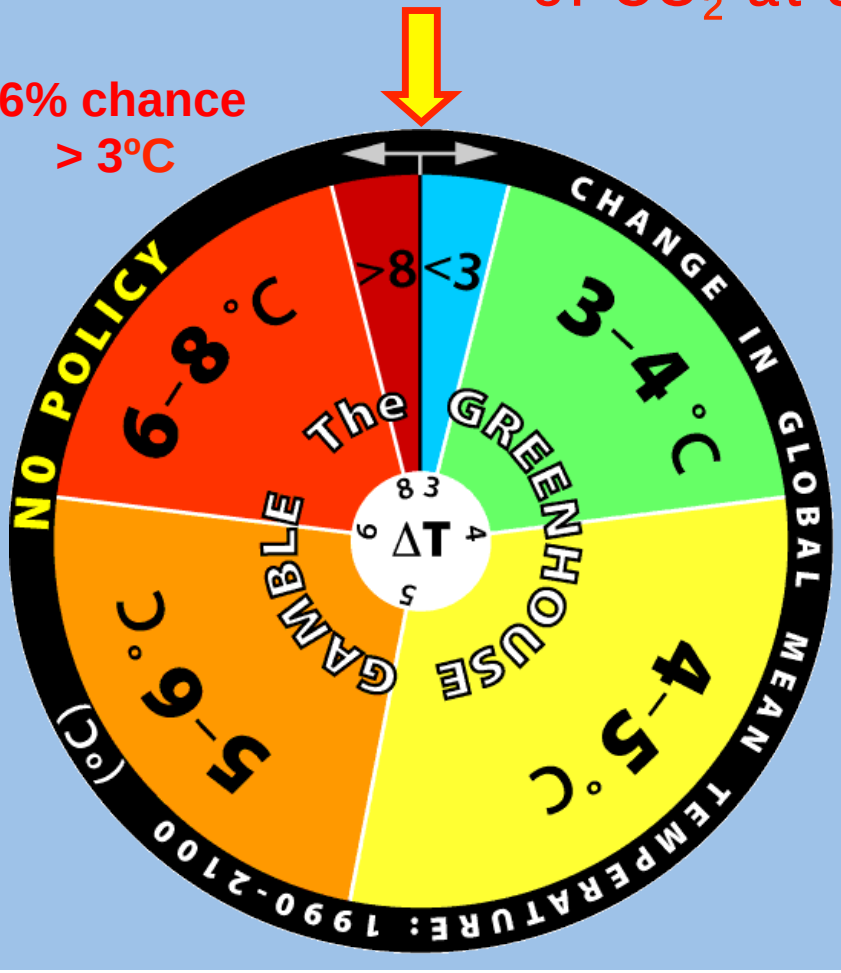
Compared with NO POLICY

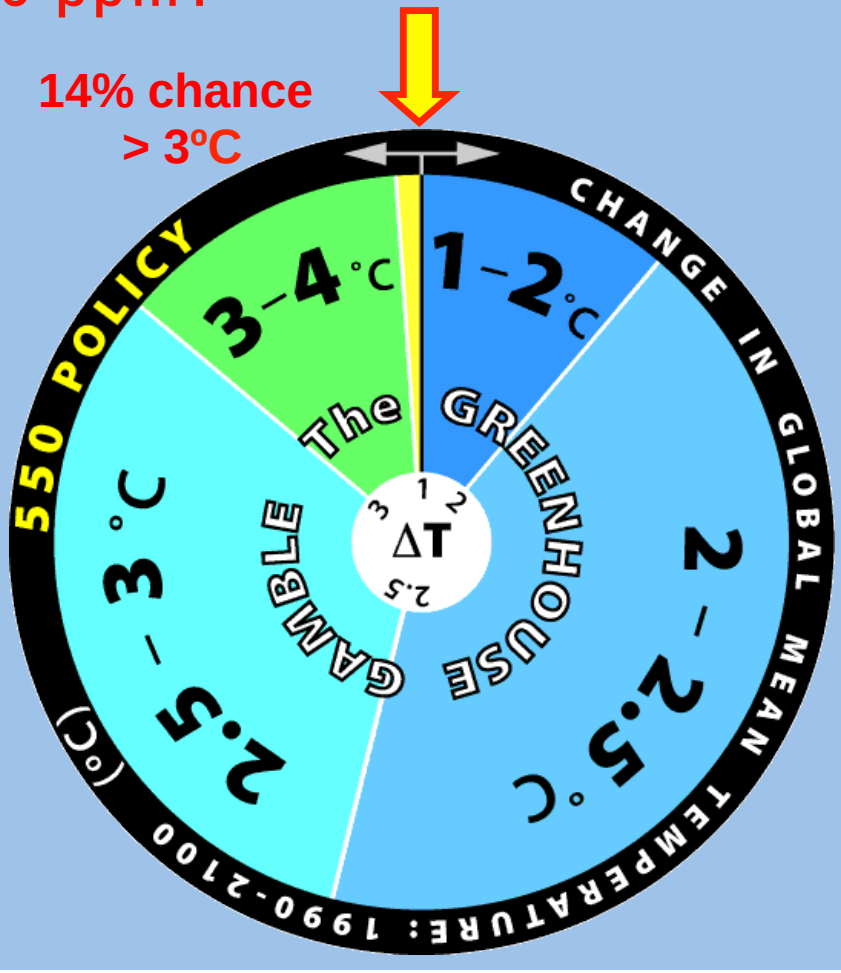
What would we achieve with STABILIZATION of CO_2 at 550 ppm?

A NEW WHEEL with lower odds of EXTREMES

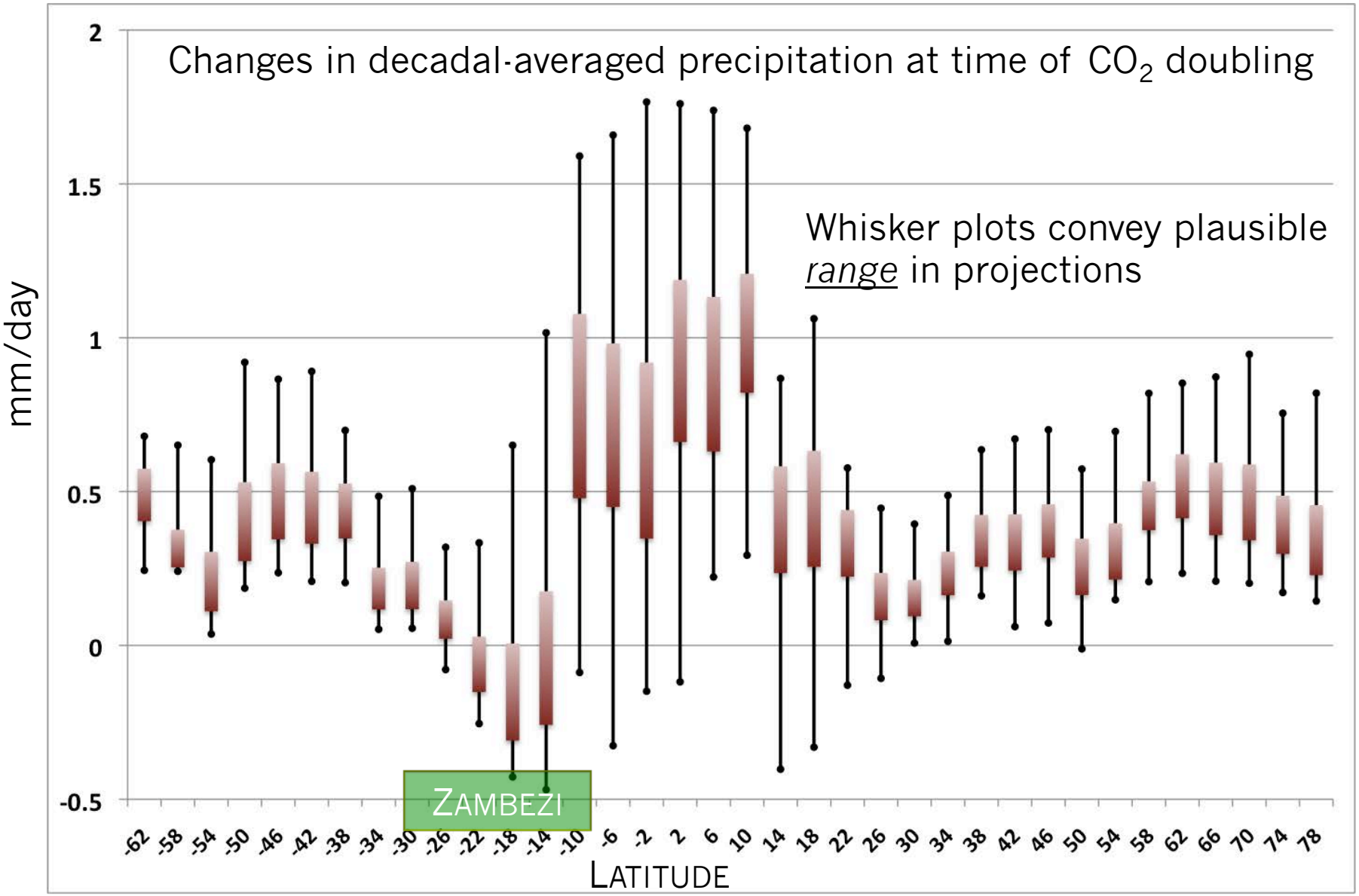
96% chance > 3°C

14% chance > 3°C





IGSM Precipitation Changes: Unconstrained Emissions



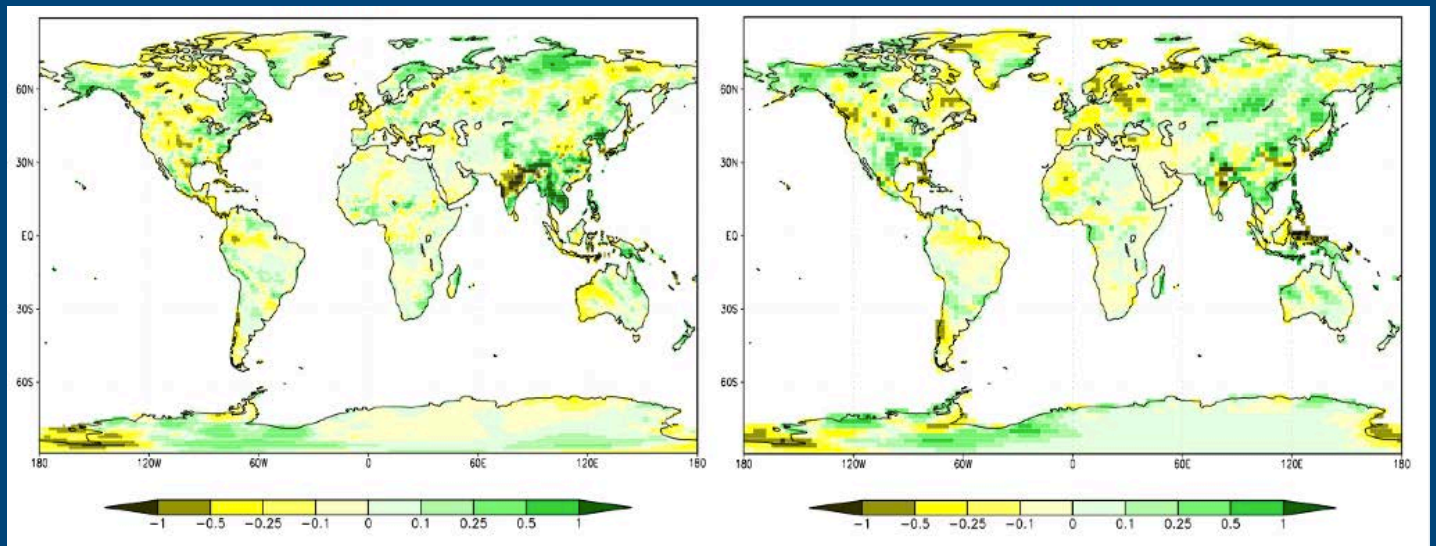
CHARACTERIZING REGIONAL CLIMATE-CHANGE UNCERTAINTY IN THE IGSM: A HYBRID APPROACH

Schlosser et al., Journal of Climate, 2012 (in press)

$$V_{x,y}^{IGSM} = (C_{x,y} + \frac{dC_{x,y}}{dT_{Global}} * \Delta T_{Global}^{IGSM}) * \overline{V}_{y}^{IGSM}$$

$$\frac{dC_{x,y}}{dT_{Global}}:$$

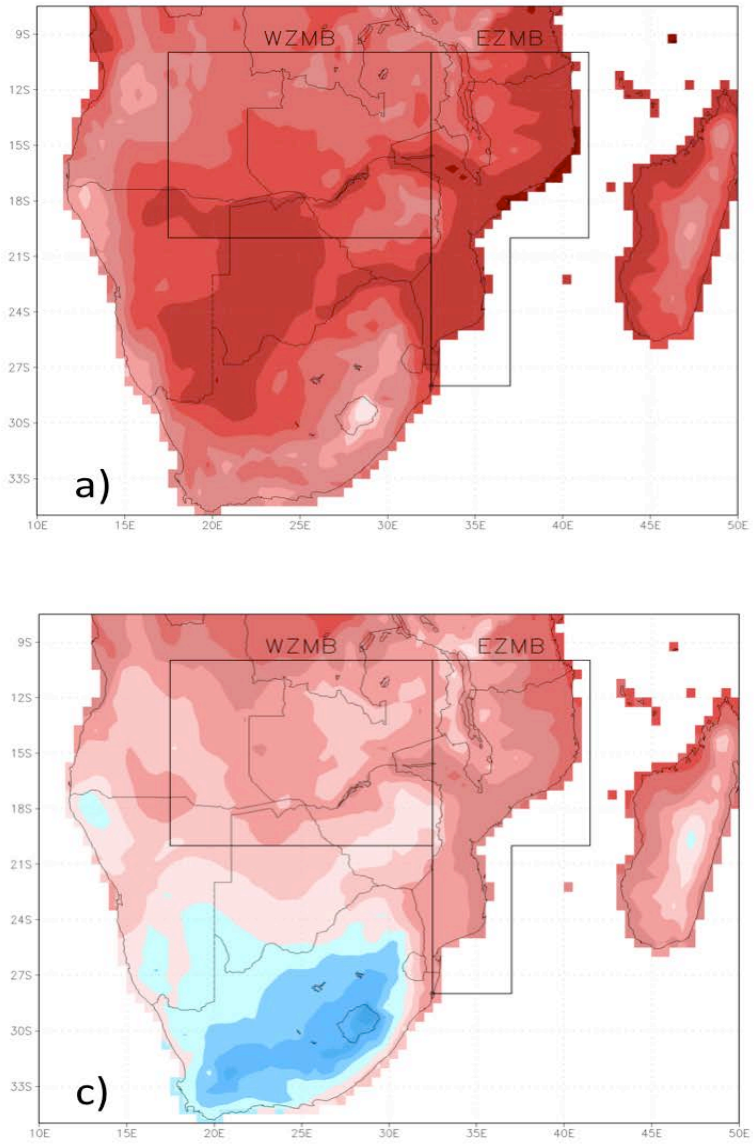
"Regional climate change kernel" – *shift in patterns* in tandem with global temperature, based on the CMIP3/IPCC archive (~17 GCMs).



Surface-air temperature: Seasonal Averages

December-February
"Summer"

June-August
"Winter"



Precipitation: Seasonal Averages

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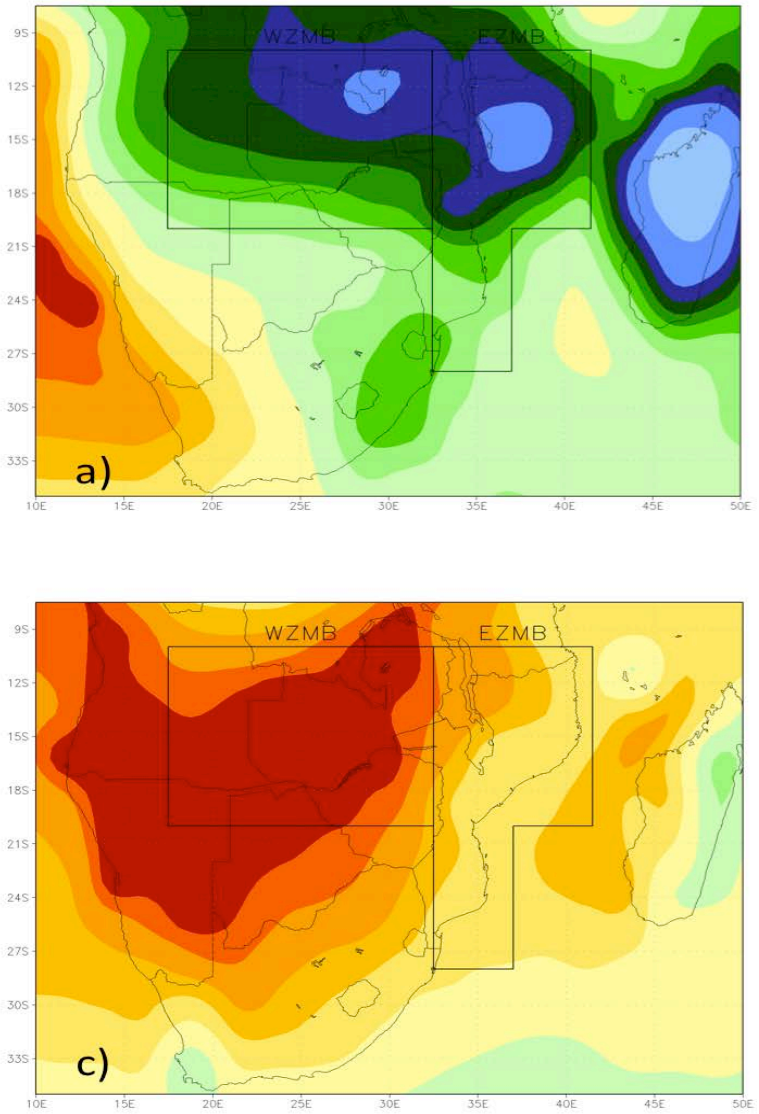
SH Summer

June-August
SH Winter



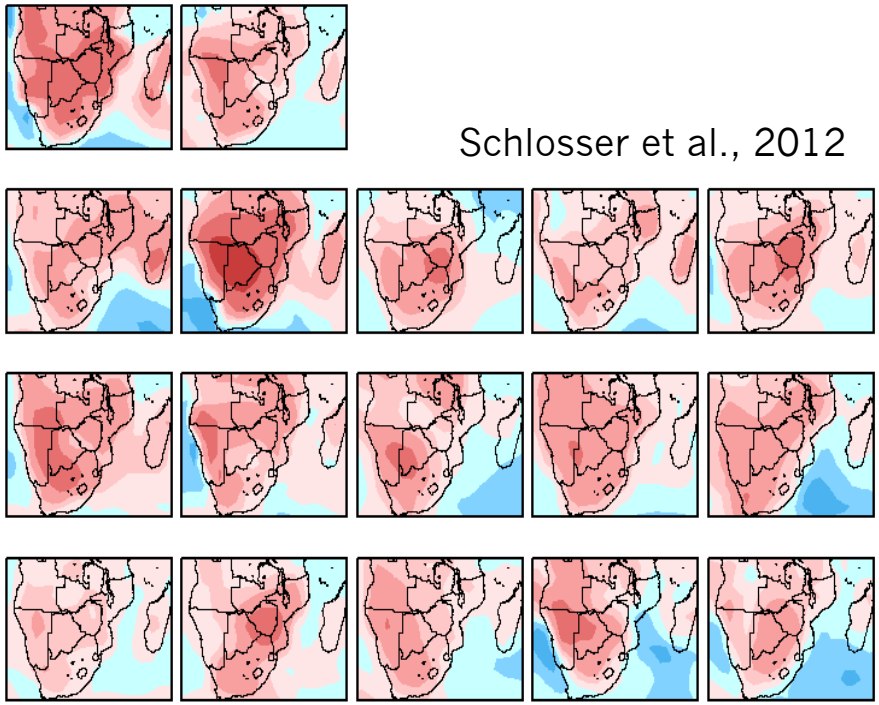
mm/day

10
8
7
6
5
4
3
2
1
0.5
0.25
0.1
0.05

GPCP
OBSERVATIONS

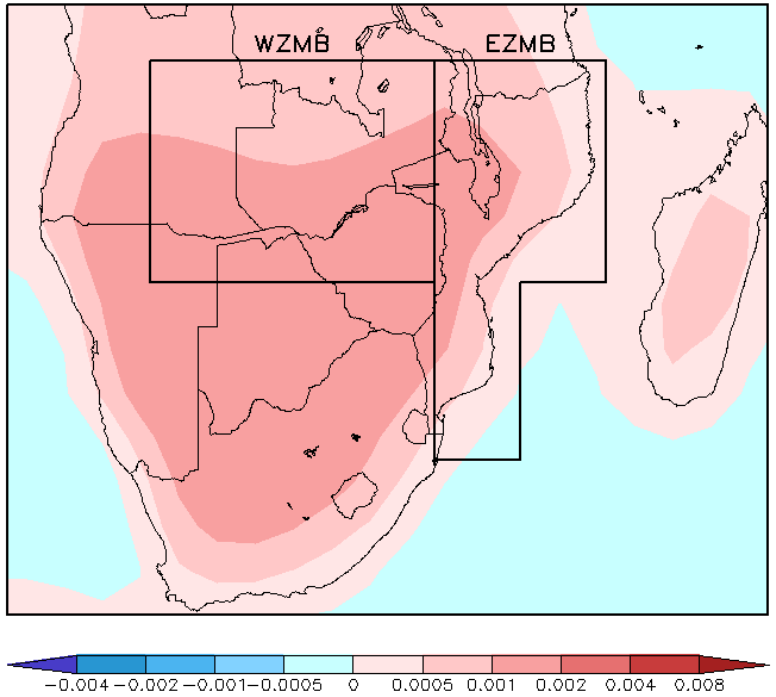
Regional Climate-Change Kernels: DJF Surface-Air Temperature

CMIP3/IPCC Models



Schlosser et al., 2012

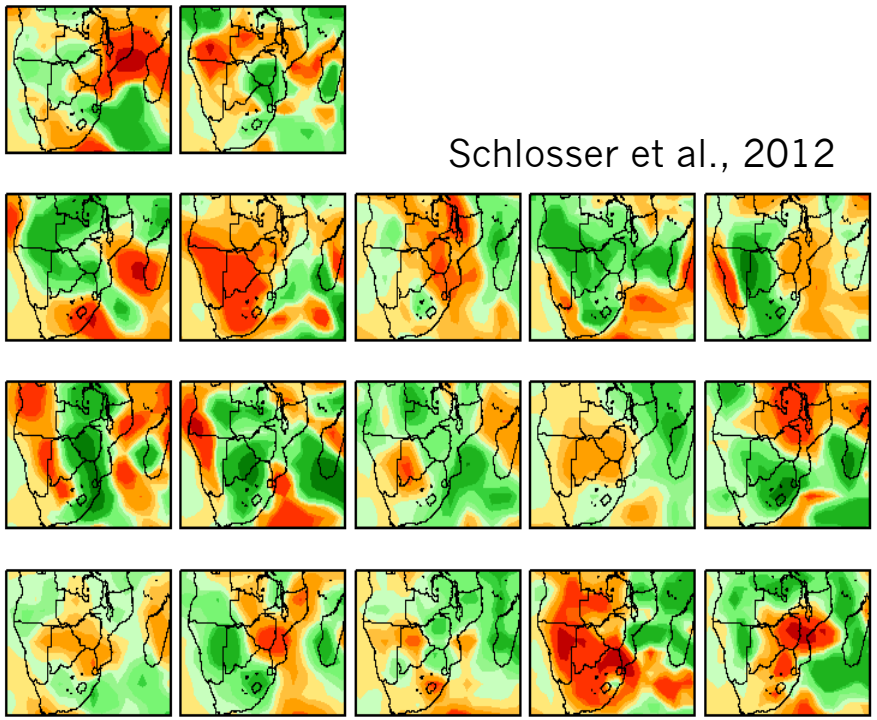
CMIP3/IPCC Model Mean



Climate-change pattern kernels from the IPCC AR4 climate models used to construct hybrid climate-change distributions from the IGSM. Shown are the relative changes in DJF surface-air temperature in response to a unit global temperature increase as a result of anthropogenic greenhouse emissions.

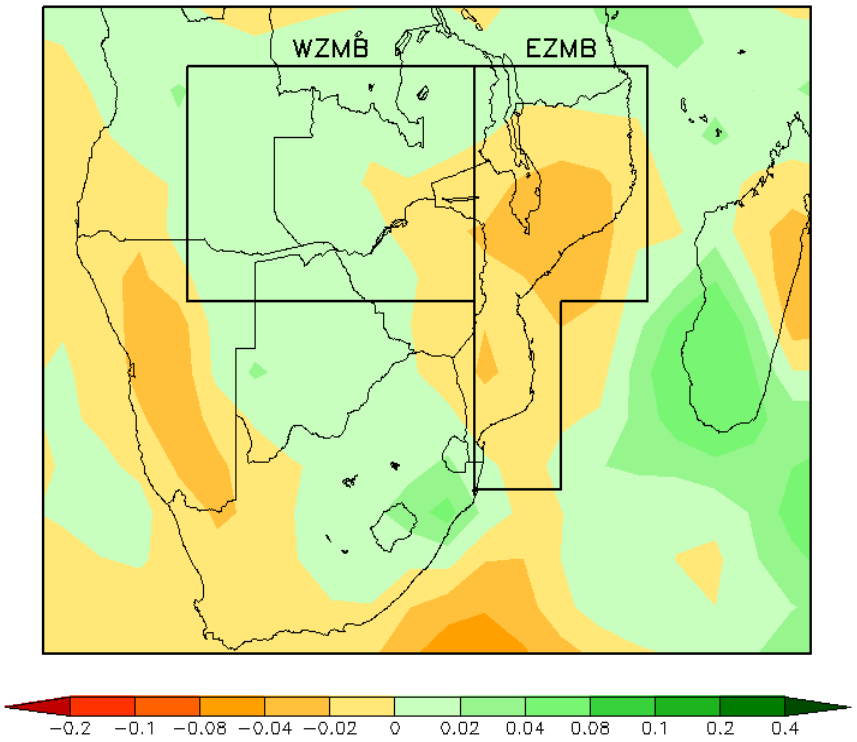
Regional Climate-Change Kernels: DJF Precipitation

CMIP3/IPCC Models



Schlosser et al., 2012

CMIP3/IPCC Model Mean



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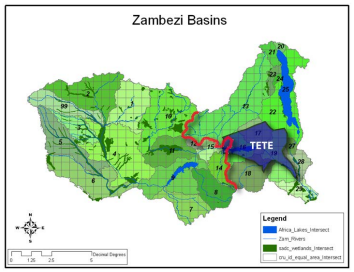
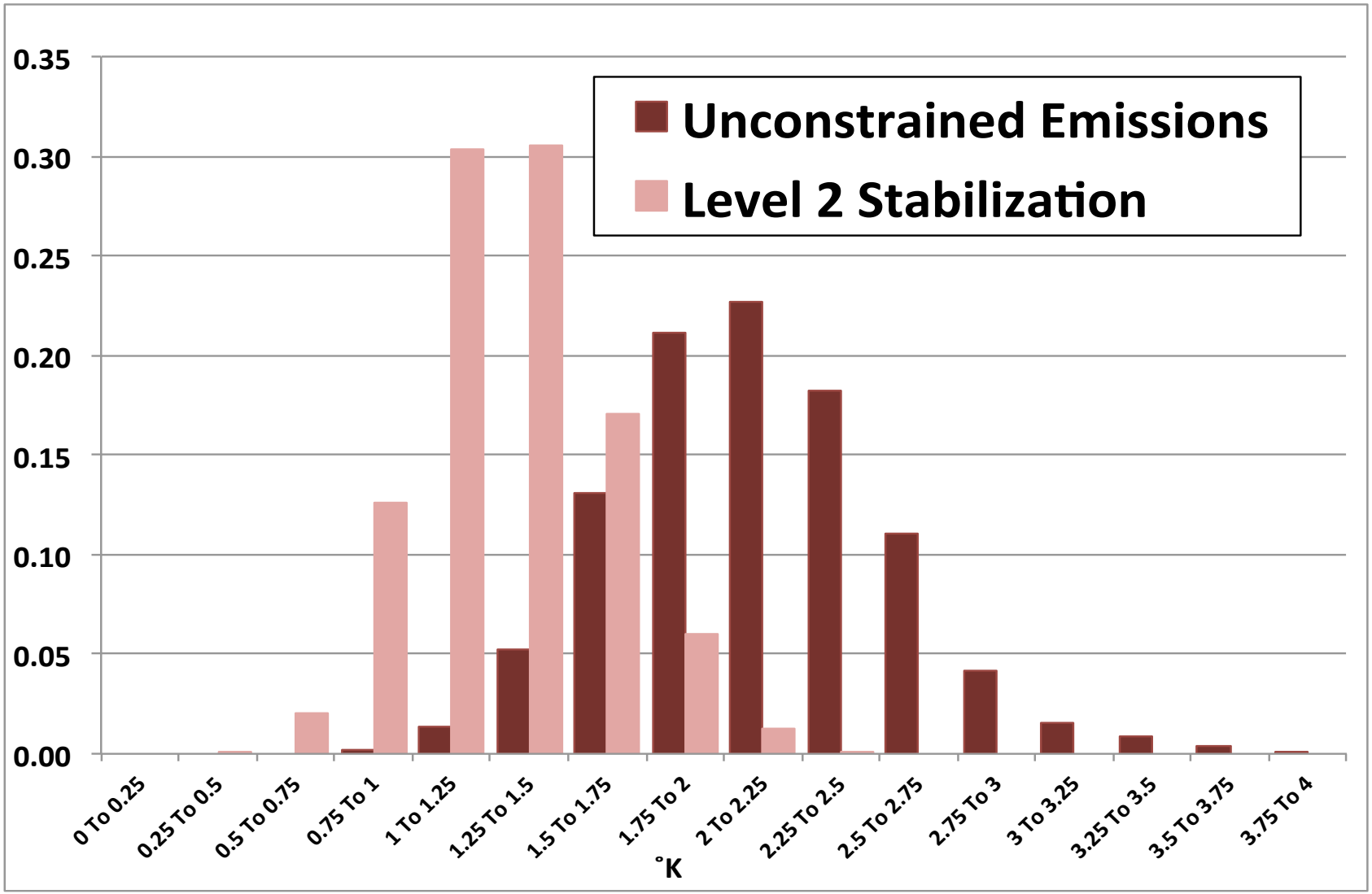
Western Zambezi Frequency Distributions
2050 Decadal Average Surface-Air Temperature Change: Spring





Schlosser et al., 2012

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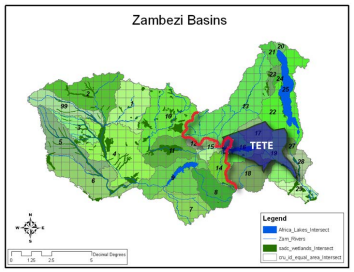

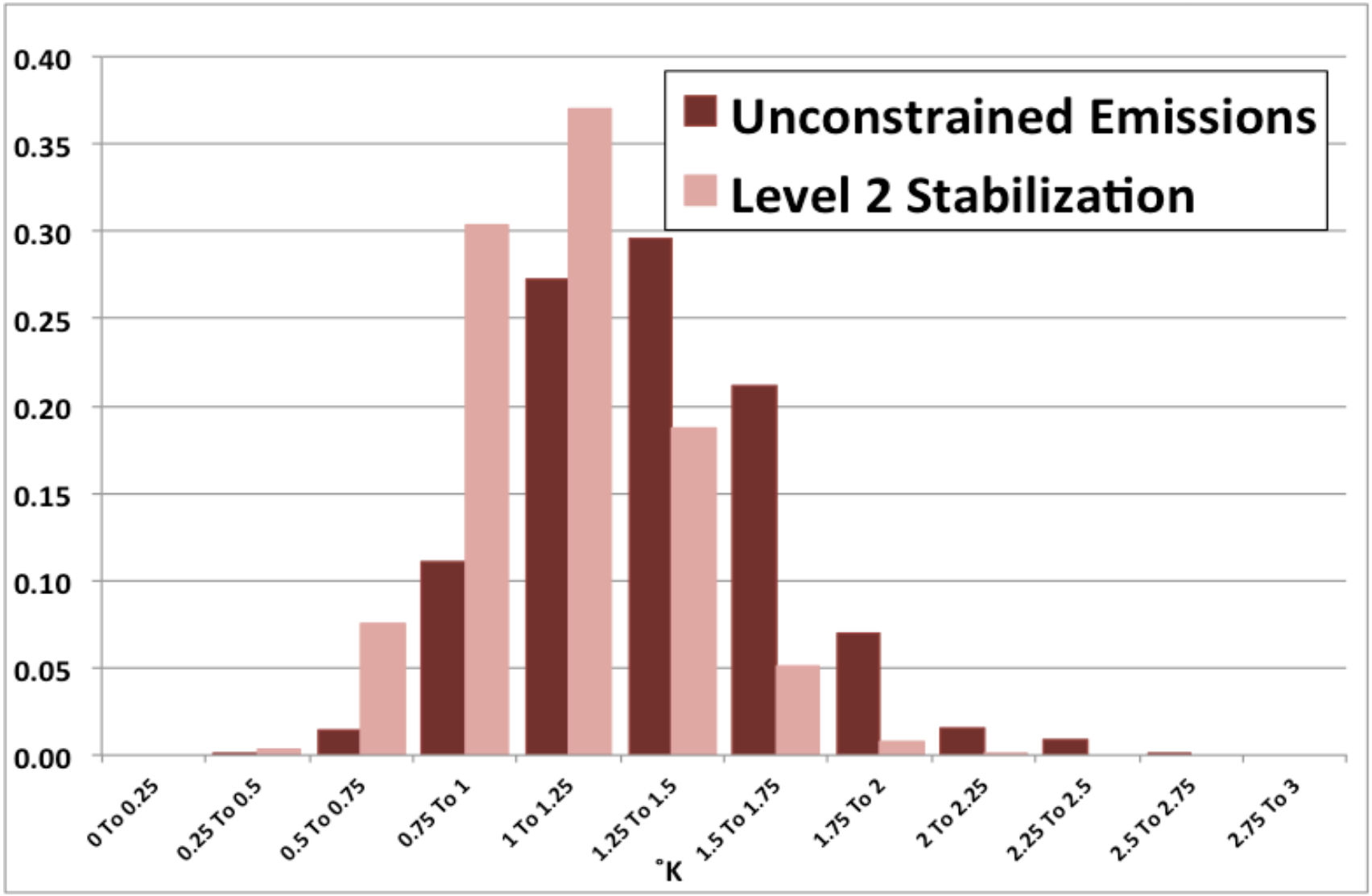

Schlosser et al., 2012

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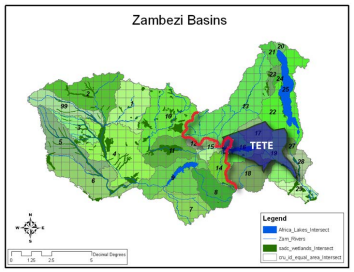

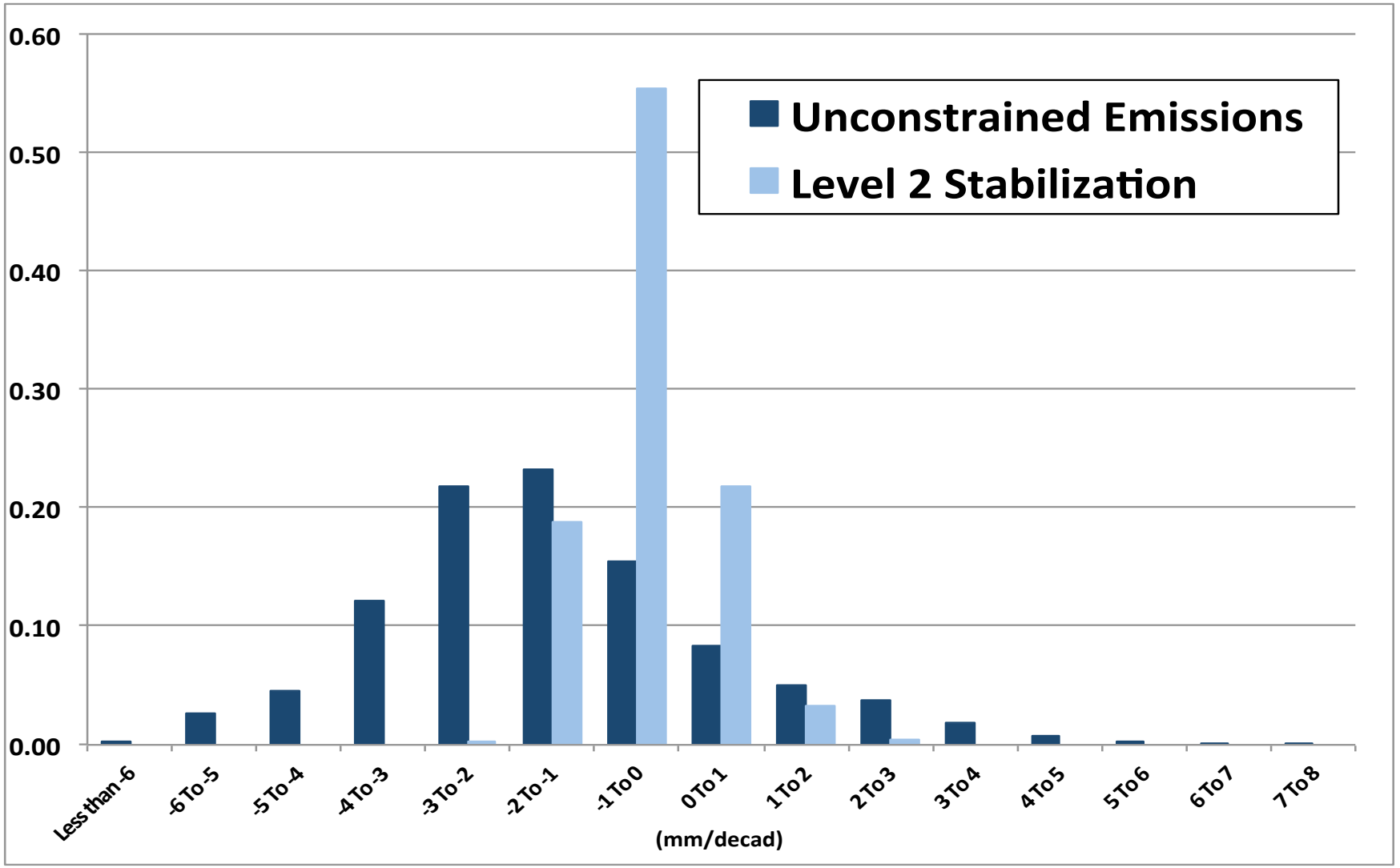

Schlosser et al., 2012

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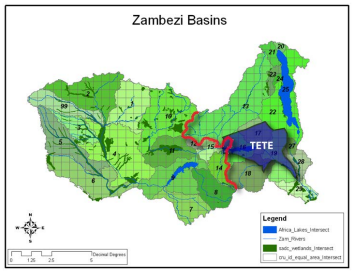

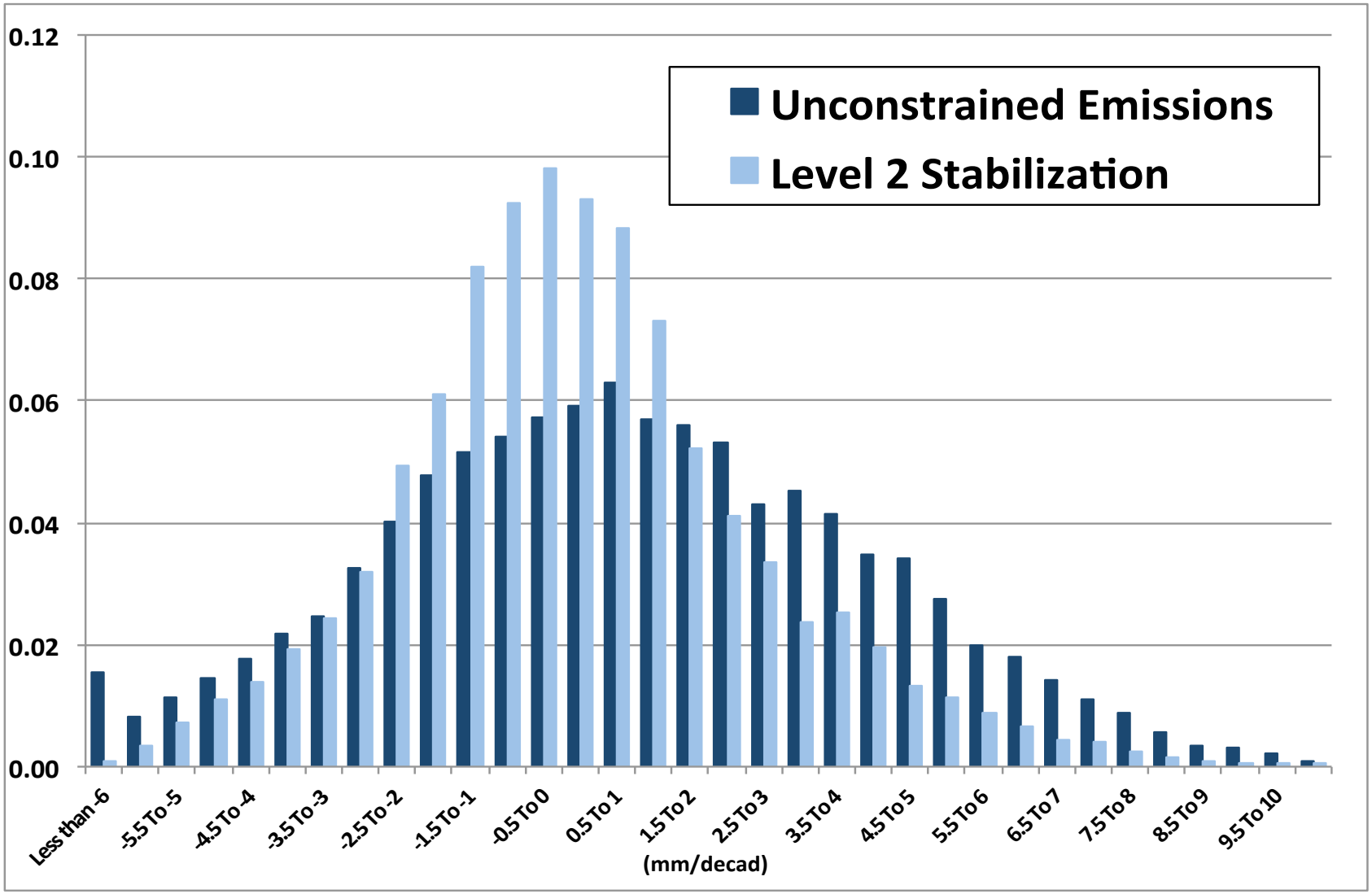

Schlosser et al., 2012

Closing Remarks

- Approach to span plausible outcomes across economic and global-to-regional climate uncertainties.
- Effect of economics and policy is multi-faceted in the climate distributional responses.
  - Seasonality
  - Mode
  - Skewness
- Beyond linearity?
- More details please?...
- THANK YOU!

Results from higher-resolution regional model (right column) compared to its global climate model counterpart.