Water and Climate

Quantifying Risks & Uncertainty
An Intermediate Approach with an Integrated Assessment Model Framework

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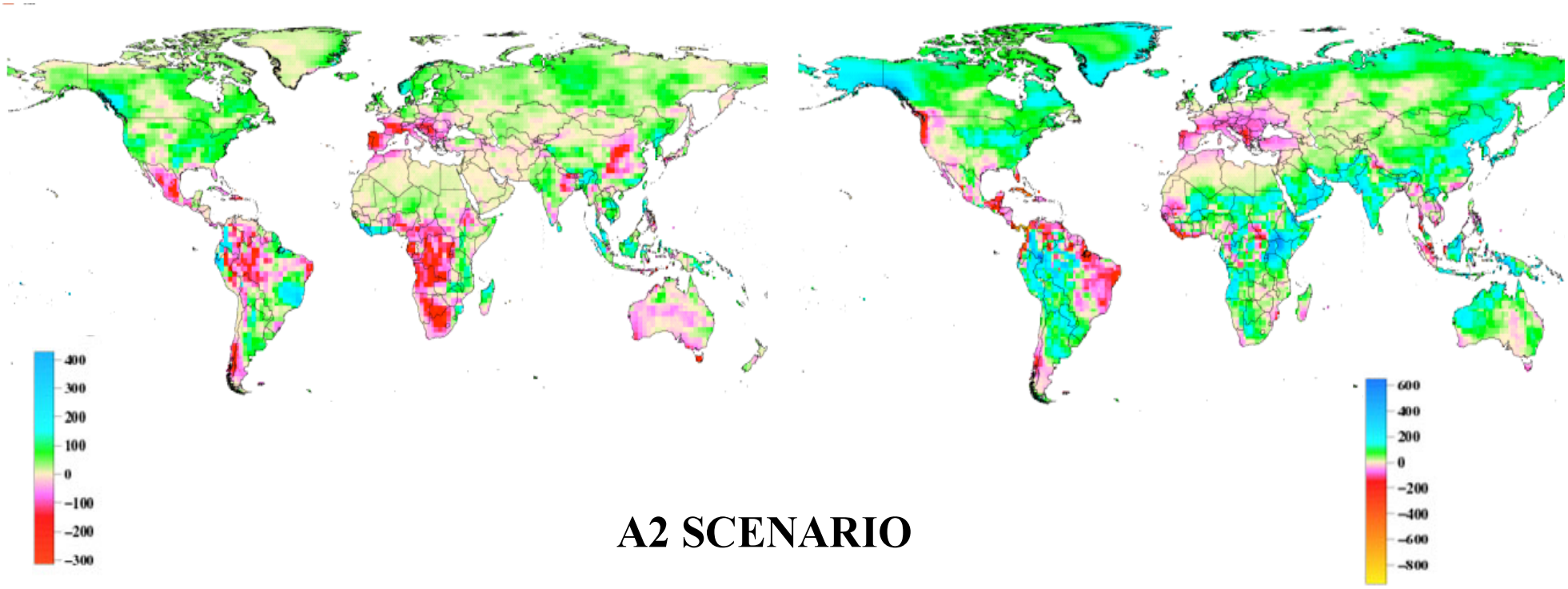
Adapt to what? – Global Wet and Dry

Change in average annual precipitation, 2000 – 2050

CSIRO (DRY) **NCAR (WET)**



A2 SCENARIO

Two extreme GCMs used to estimate range of costs

IGSM Scenarios

(Sokolov et al., 2009, and Webster et al., 2010)

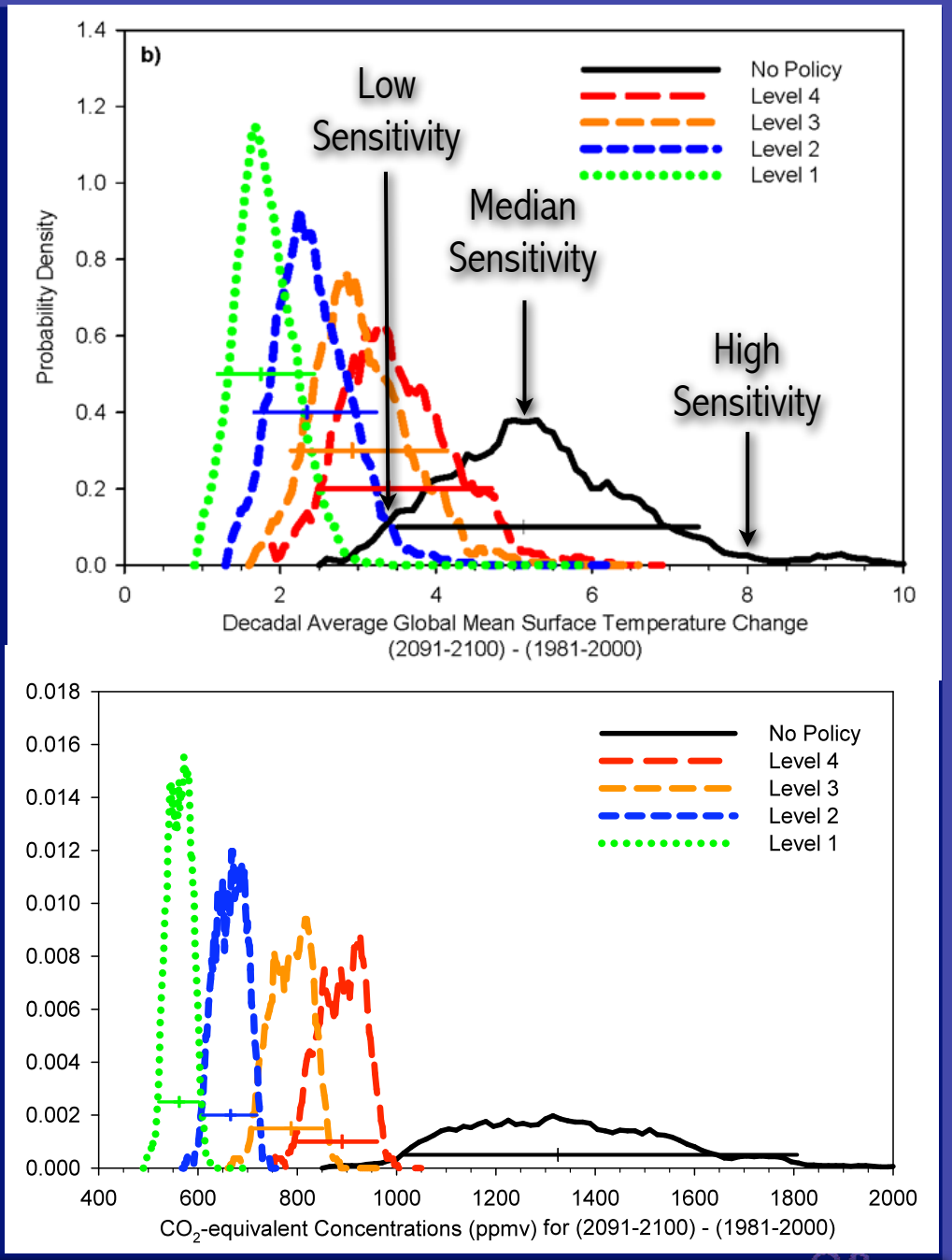
No Policy (Reference):

- Climate & EPPA samples

Policy Scenarios:

Representative Concentration Pathways (RCPs)

- U.S. CCSP Level 4
- U.S. CCSP Level 3
- U.S. CCSP Level 2
- U.S. CCSP Level 1



Run 400 member ensembles using Latin hypercube sampling for each policy

Methodology, Philosophy, Proof of Effort

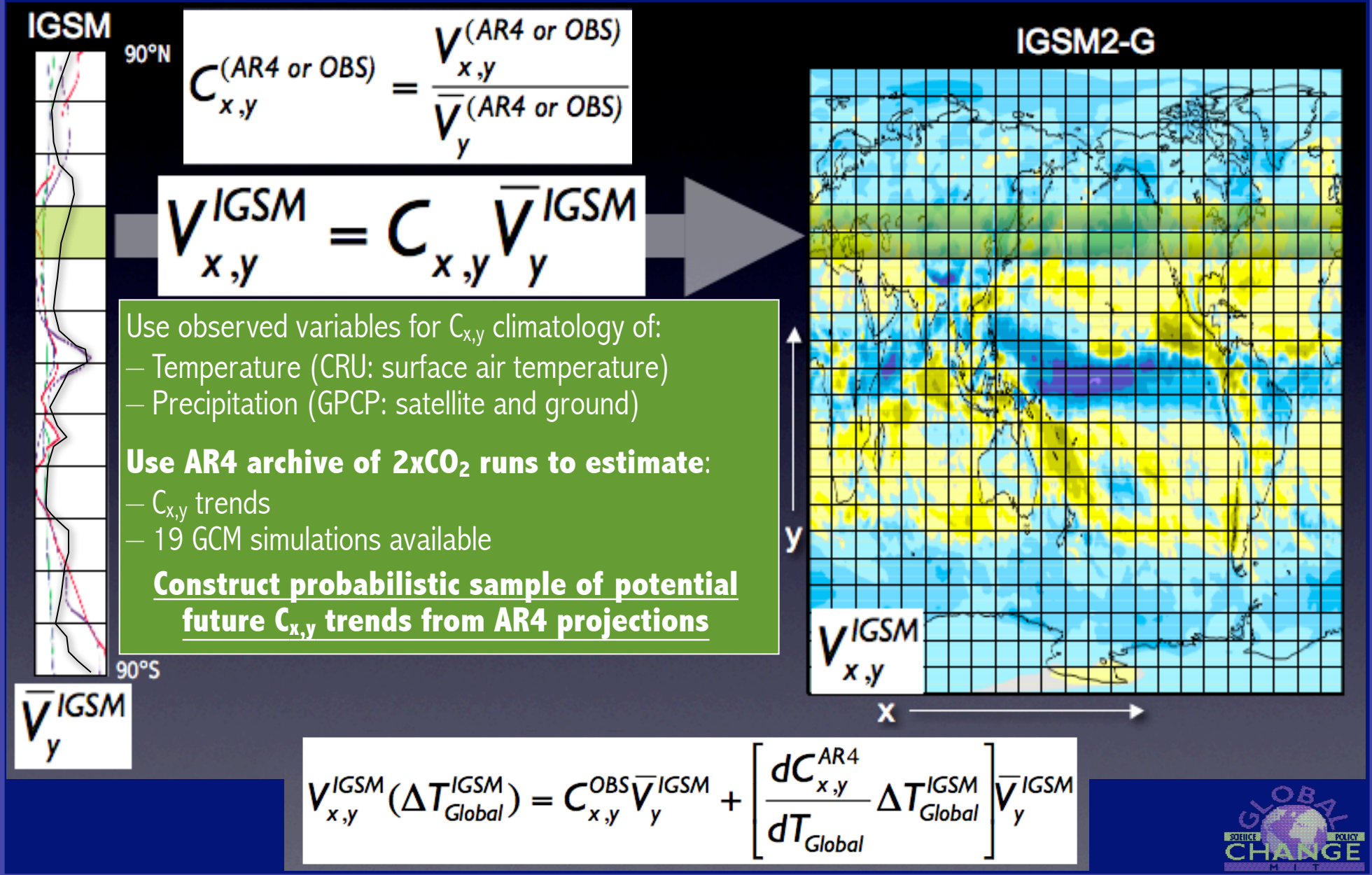
- Extrapolation: of GCM patterns - how to characterize?
  - Methods out there... So where's the quantum leap?
- Consistency:
  - Do the IGSM and GCMs agree on the zonal trends?
- Plausibility:
  - Can/should we filter out certain GCMs, how?
    - Impact on resulting regional PDFs?
- Provisional application to water-resource risks

Methods to Get 3D from (≤)2D

- 0-order: Assume no change in patterns from climatology
- 0.5-order: Pick one GCM and run with it… but which one do you believe more?
- 0.75-order: Take the average of some GCMs… Smooth out Peaks (High Risk)
- 1st-order: Consider "all" equally plausible.
  - SCENGEN: Similar… driven by MAGICC (0-order global energy balance model)
  - COSMIC: Pick GCM, C_S (climate scaling factor), and emissions scenario (both GHG and sulphate), done by country
  - MERGE: Based on 1D damage functions
    - These methods are 1D (i.e. global) to 3D… and no feedbacks.
- **1.5-order: Filtered selection (zonally-based for IGSM)**
- 2nd-order: Probabilistic-conditional selection w/ time-varying elasticities.
- "3rd-order": Explicit regional climate change probability via 3D GCM or RCM.

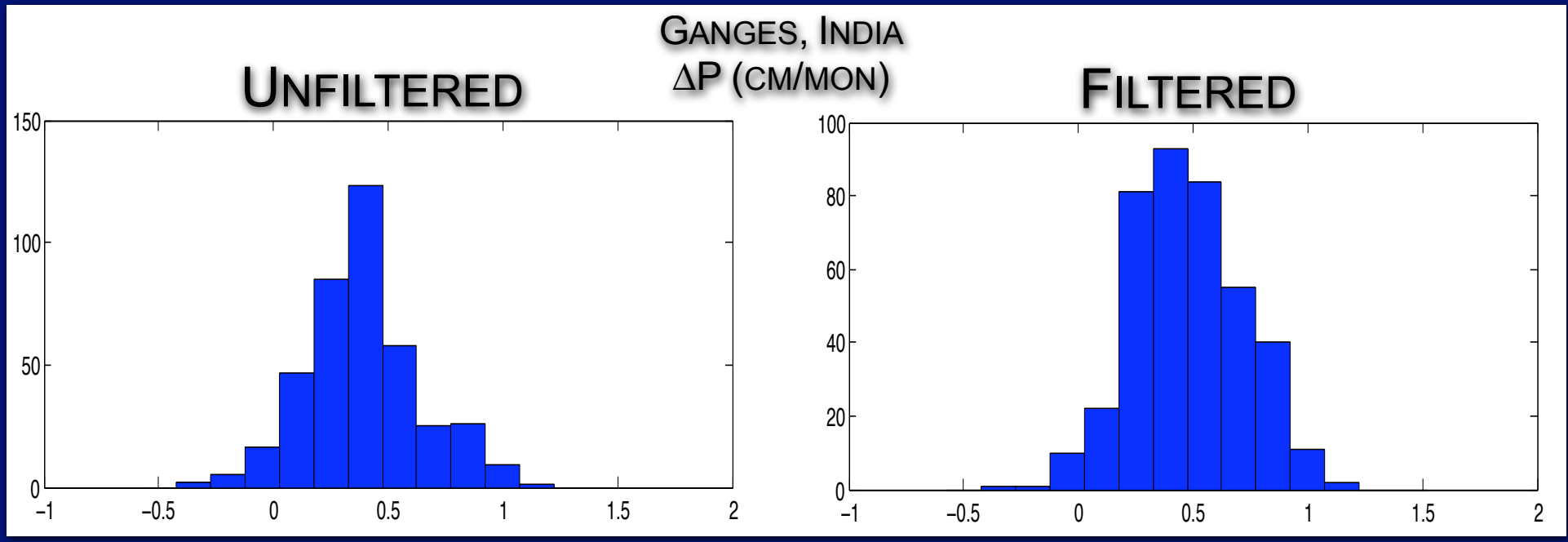
Groups doing somewhere between 0 and 1st-order

Merging Regional Climate Uncertainty in the IGSM Framework

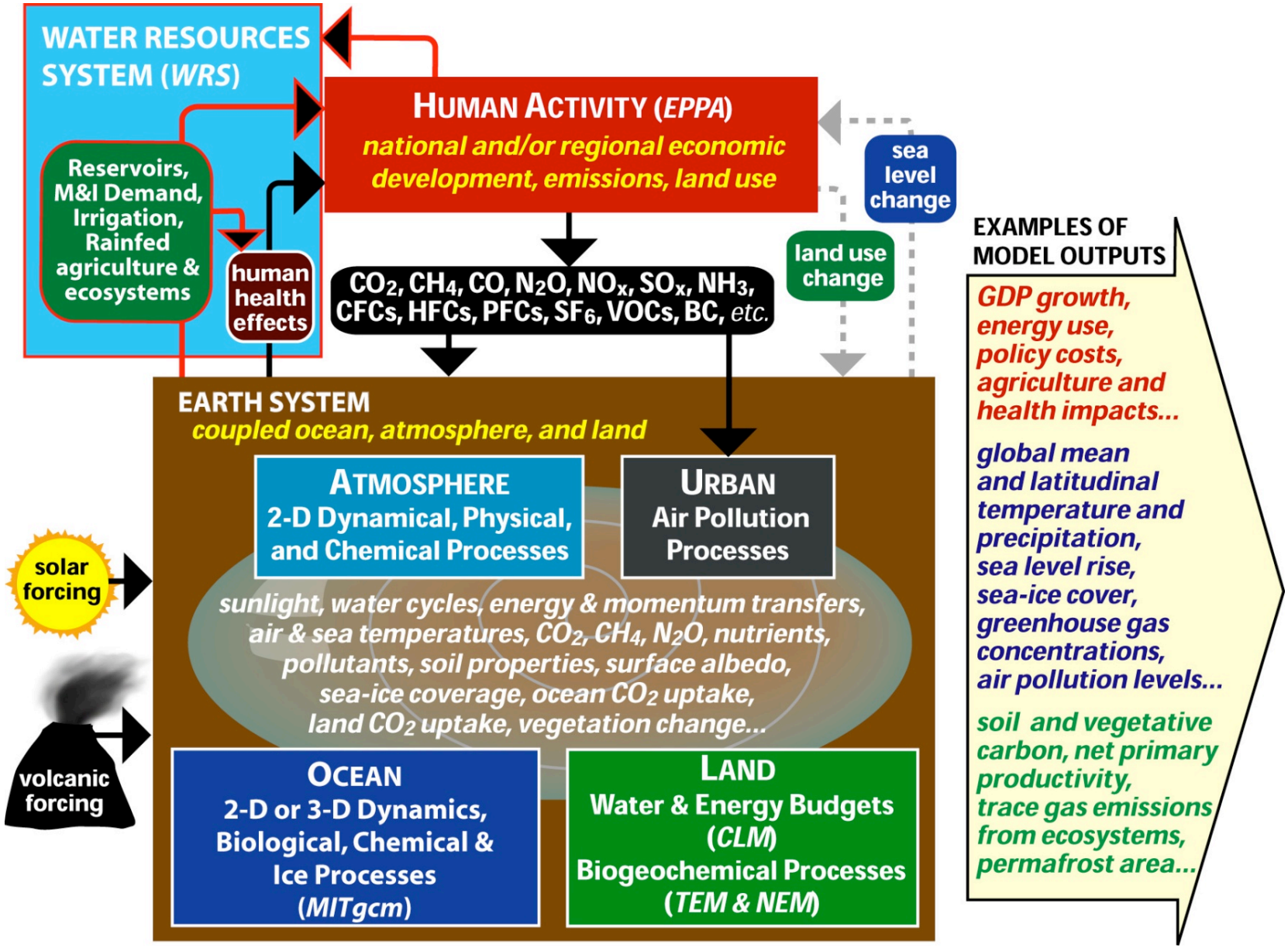


Selection & Filtering of GCM Patterns

- Initially, all GCM patterns assumed equally probable.
- Filtering Philosophy: Cannot fuse a GCM pattern whose zonal trends do not match the IGSM.
  - Doesn't necessarily indicate GCM is "wrong" - just not consistent
  - Tested criterion on a seasonal and annual basis.

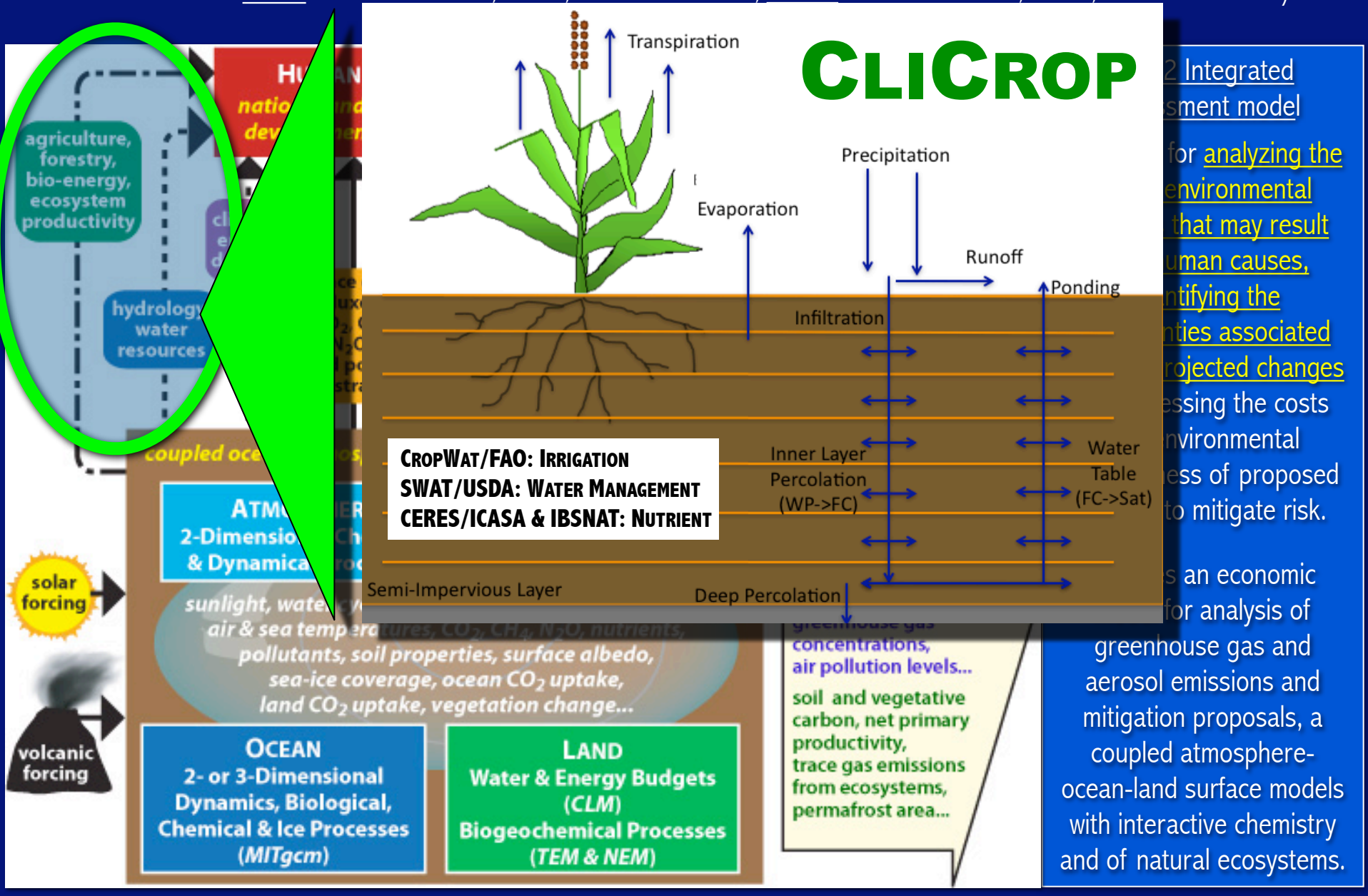


Water Resource System in IGSM



THE MIT INTEGRATED GLOBAL SYSTEM MODEL VERSION 2

(IGSM2: SOKOLOV ET AL., 2005, JP REPORT #124 EPPA: PALTSEV ET AL. 2005, JP REPORT #125 LAND: SCHLOSSER ET AL., 2007 JP REPORT #147 OCEAN: DUTKIEWICZ ET AL., 2005, JP REPORT #122, URBAN: COHEN AND PRINN, 2009, JP REPORT #181)



2 Integrated
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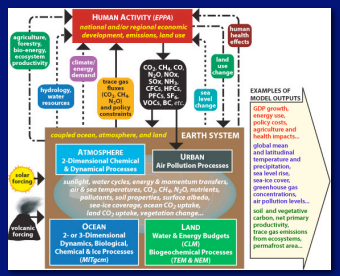
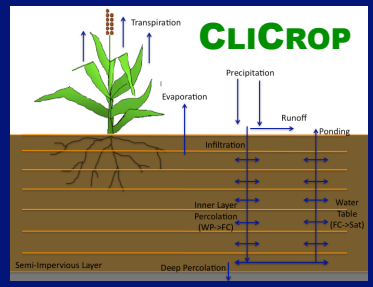
to mitigate risk.

s an economic
for analysis of
greenhouse gas and
aerosol emissions and
mitigation proposals, a
coupled atmosphere-
ocean-land surface models
with interactive chemistry
and of natural ecosystems.



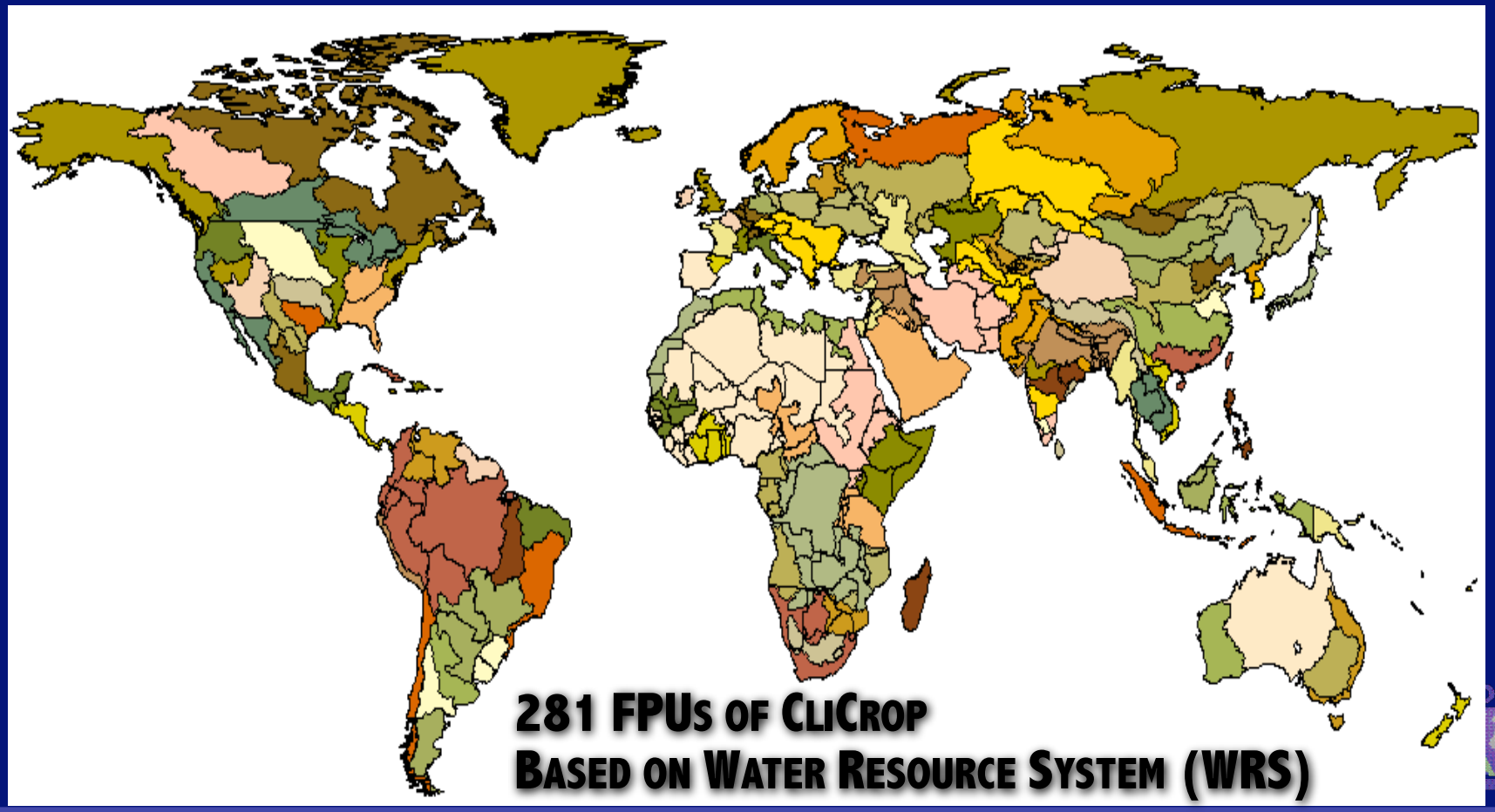
Simulation Experiments
IGSM-CliCrop



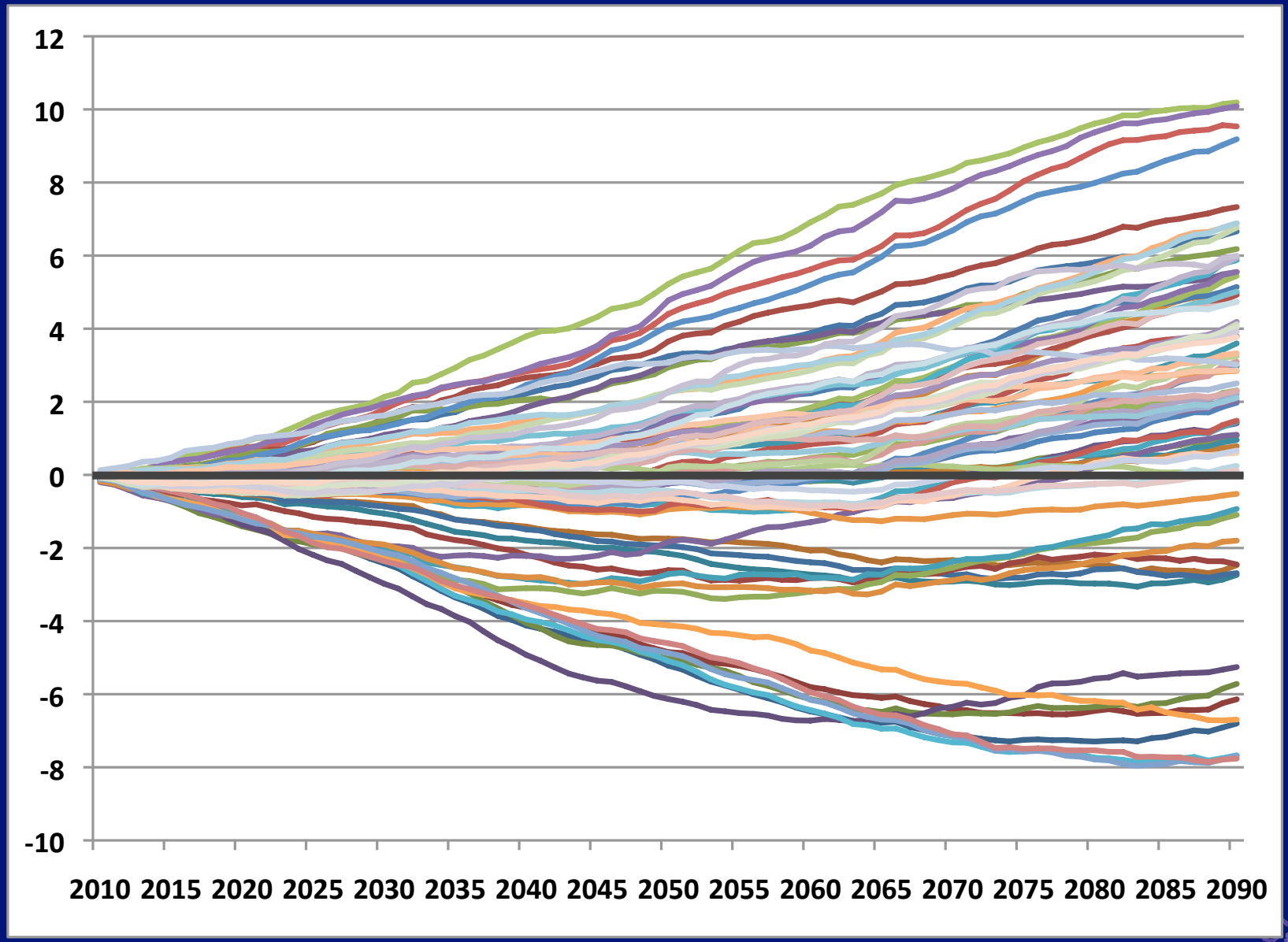
- IGSM2 "No Policy" ensembles (with 400 members) considered.
- Each GCM assumed equal plausibility (random pick of filtered GCMs).
- CliCrop run globally at 2° x 2° spatial resolution.
- Simulation Period: 2000-2100 (using the IGSM2 projections).
- CliCrop simulations executed for maize. Other crops will follow.
- Total area of rainfed and irrigated crops kept constant in time.
- Changes in agricultural technology not considered in this exercise.

Aggregate CliCrop Food Producing Units (FPUs)

- Preliminary Analysis/Results for two large agriculture FPUs:
  - **India Ganges: One of largest irrigated crop areas**
  - **South Africa East/West Cape : One of largest rain fed crop areas**
  - **Nile/Ethiopia and Missouri River Basin**

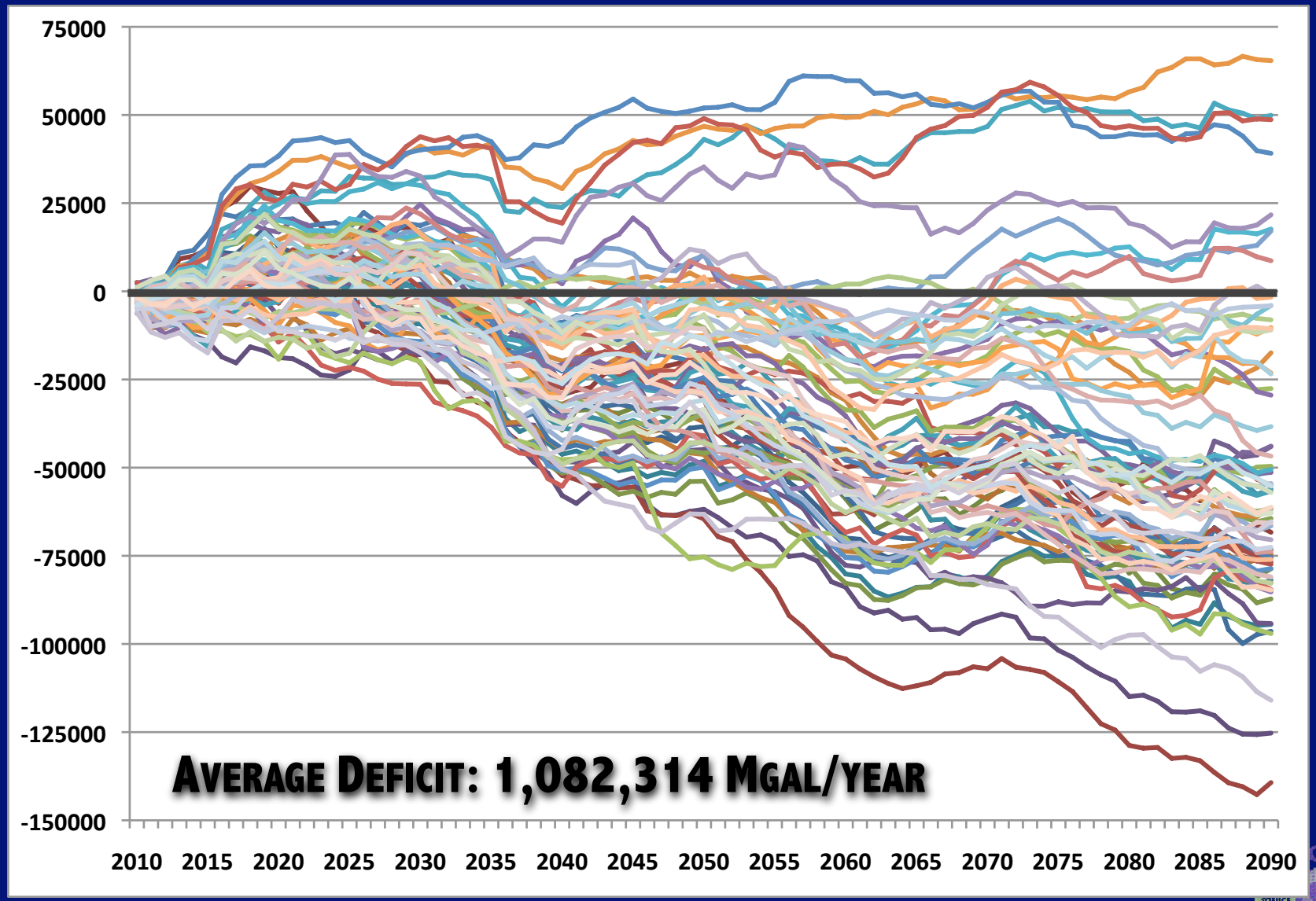


South Africa: Change in Rain Fed Maize Yield (%)



India Ganges

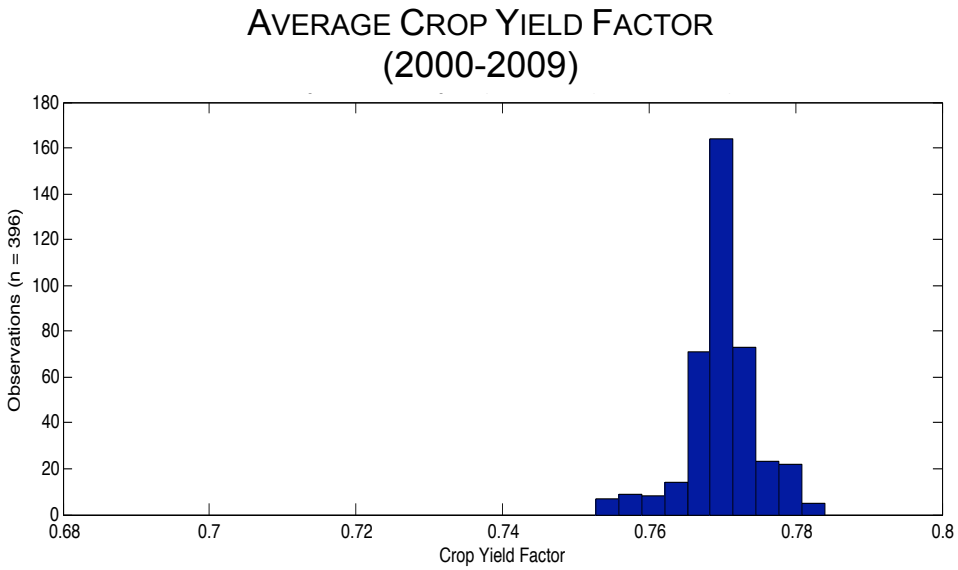
Change in Irrigation Deficit (10^6 Gal/Year)

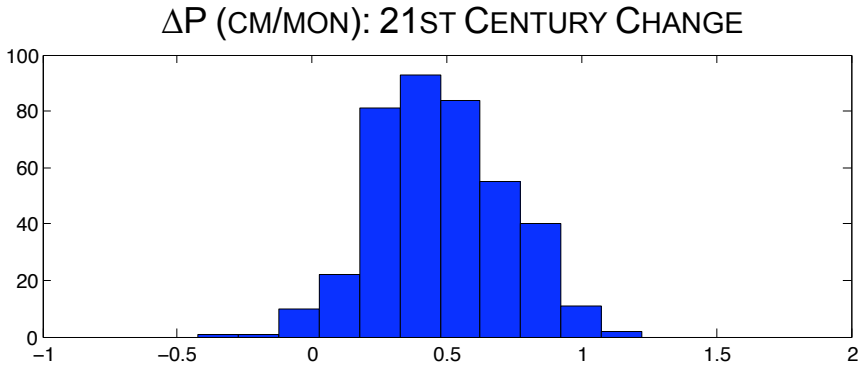


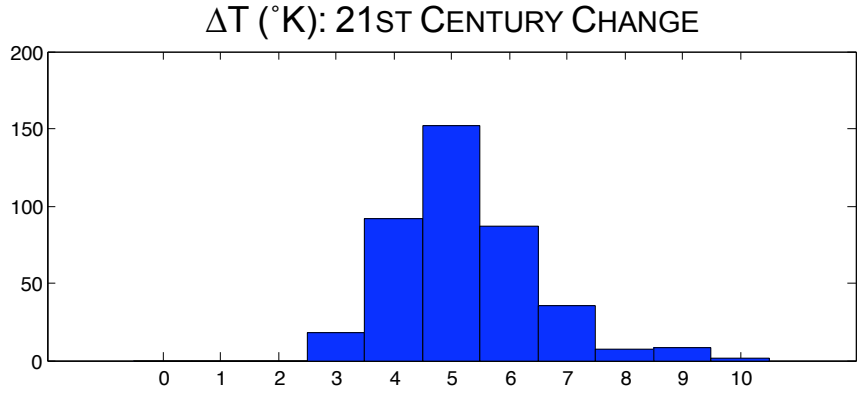
LMWG/BGCWG Meeting, Feb. 9, 2010

PDFs of Changes

Ganges, India

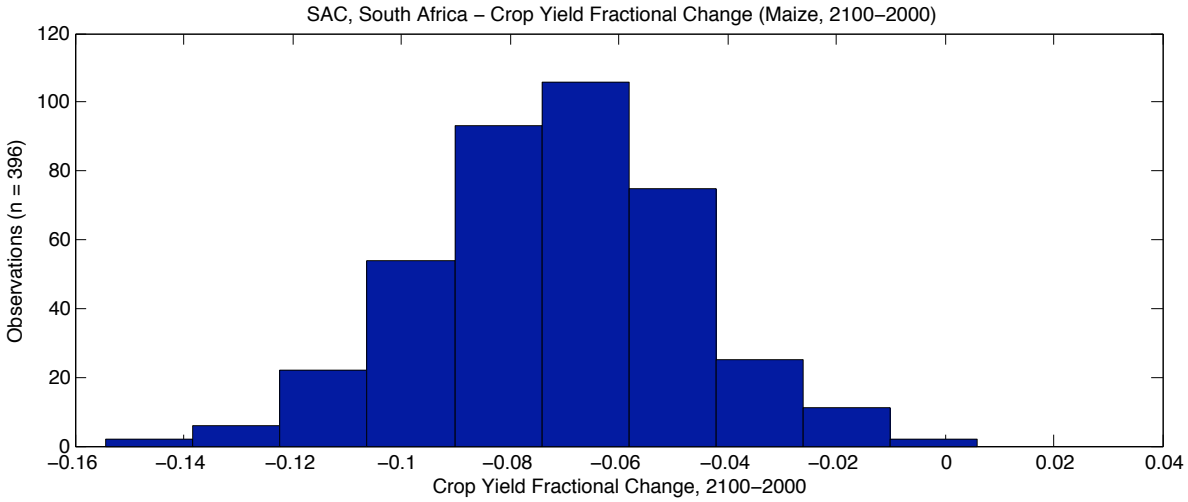


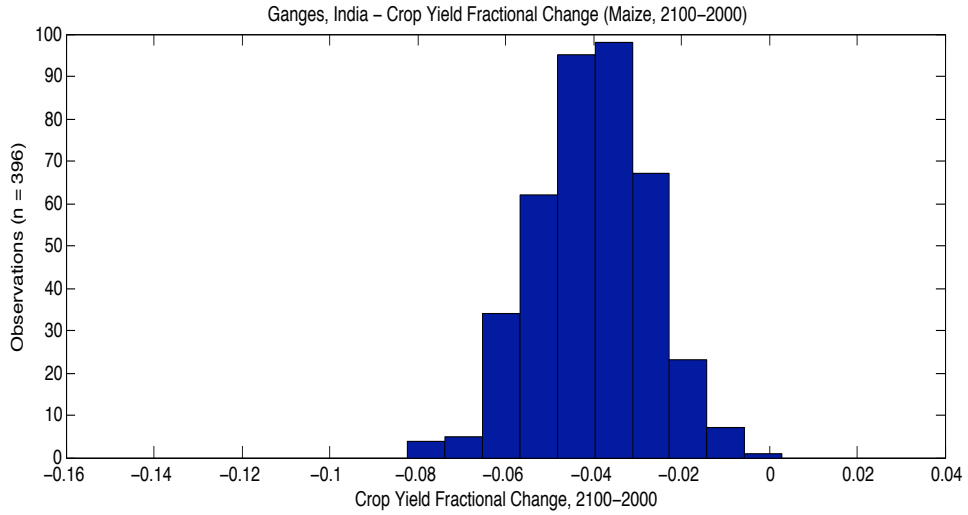


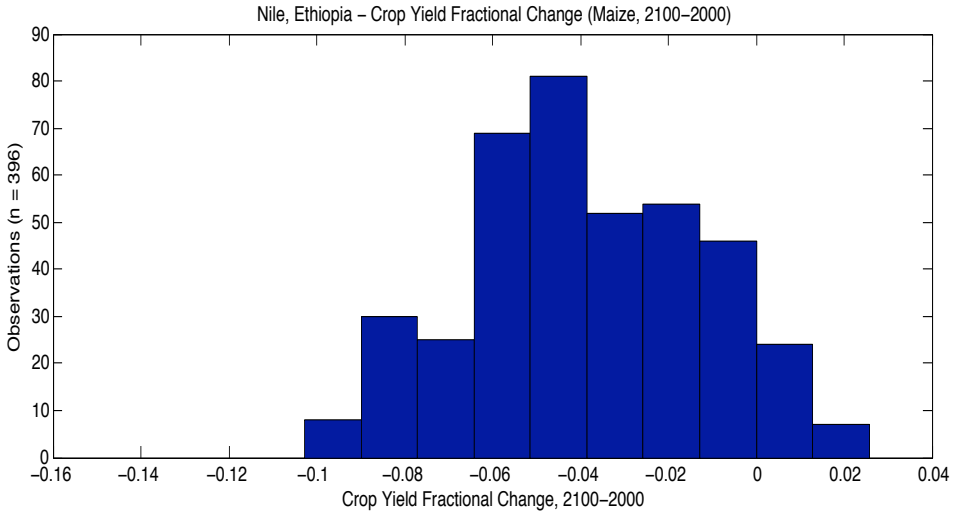


- Which wins out for Ganges, increased P or increased T?

PDFs of Crop Yield Change







Closing Remarks

- In these preliminary runs with the extrapolated no-policy, we see trend reversals in crop (for now, maize) productivity & irrigation demand
- PDFs show that ΔT's win out over ΔP's for basins considered.
- Near term:
  - Refine Hybrid Regional PDFs of ΔT's and ΔP's
  - Expand crops and link public, industrial, hydroelectric water
  - Ensembles (IGSM Policy Plus GCM patterns)
- Land Use Change:
  - Renewables (NREL) and Biofuels at Large-Scale