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Modeling water, land, and energy interactions in GCAM - a water focus

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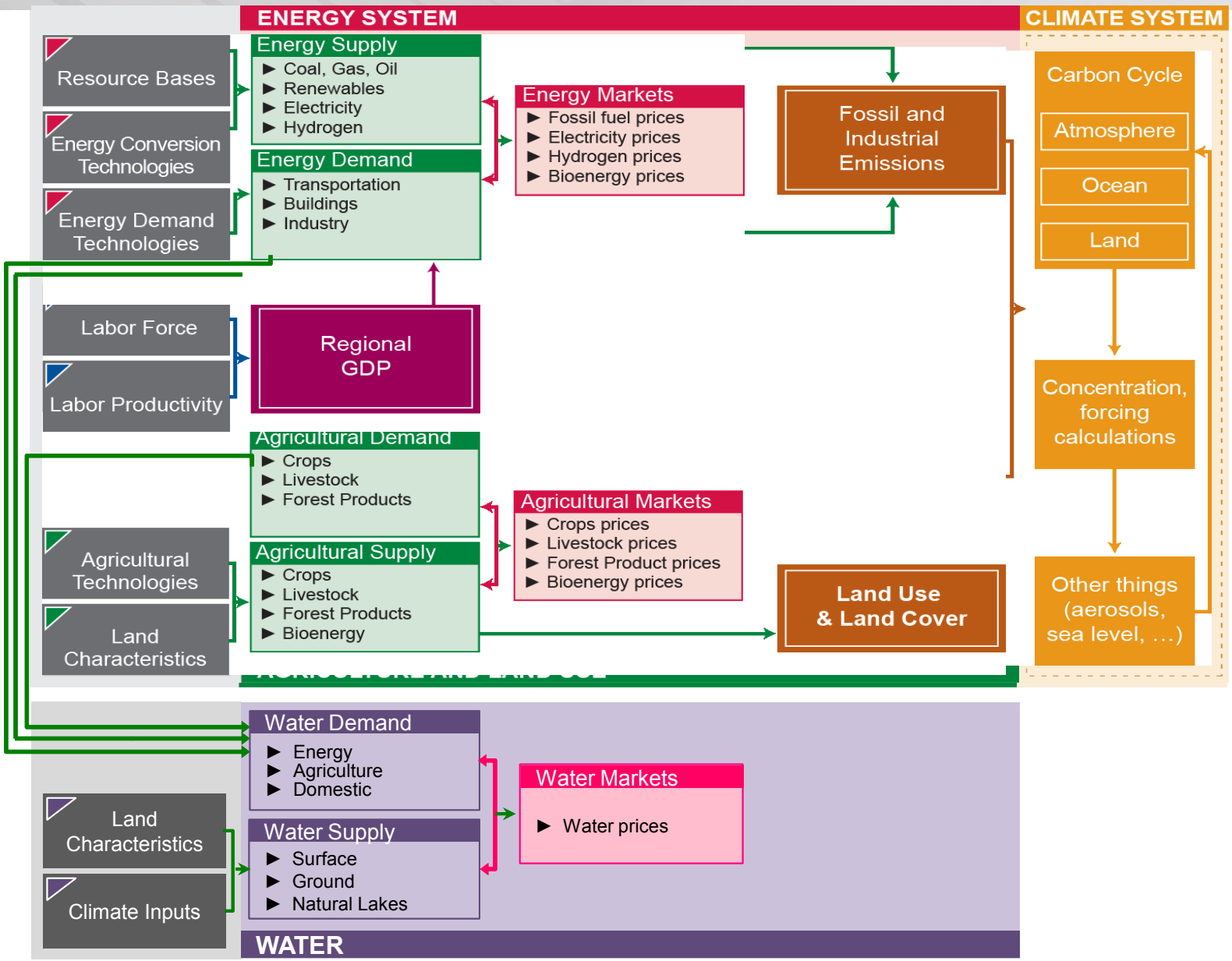
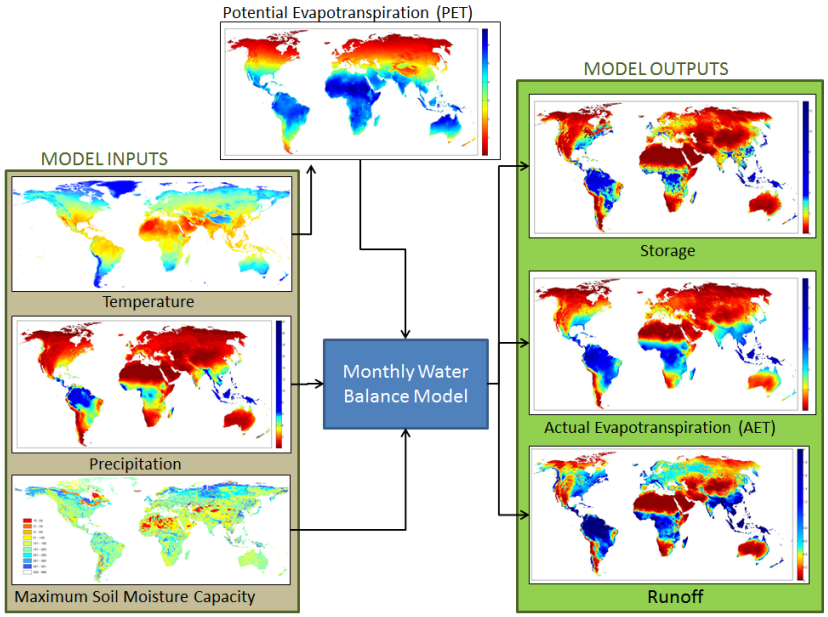
The 5th Annual IAMC Annual Meeting, Utrecht, Netherlands,

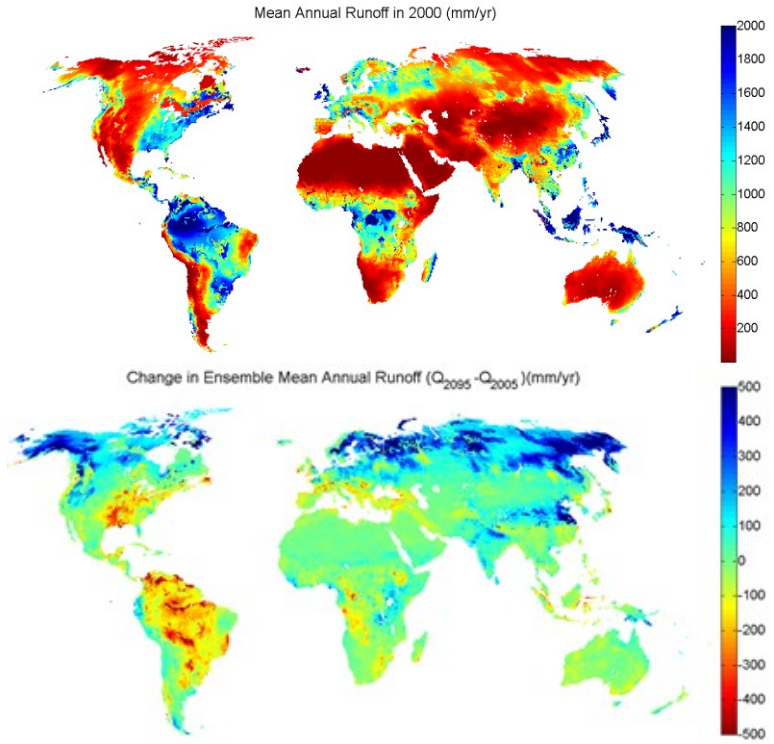
Monday, November 12, 2012

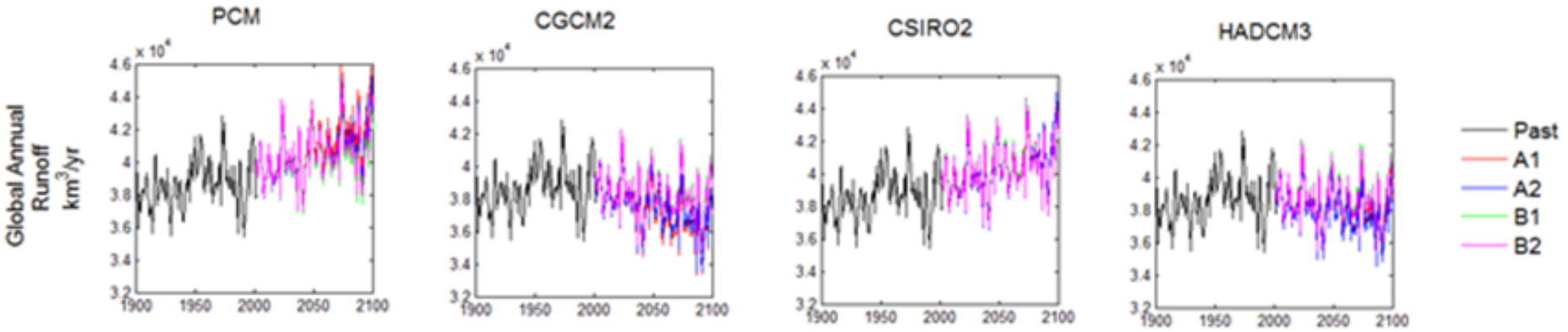
Incorporating Water in GCAM - The links to land and energy



Water Supply – A Global Hydrologic Model

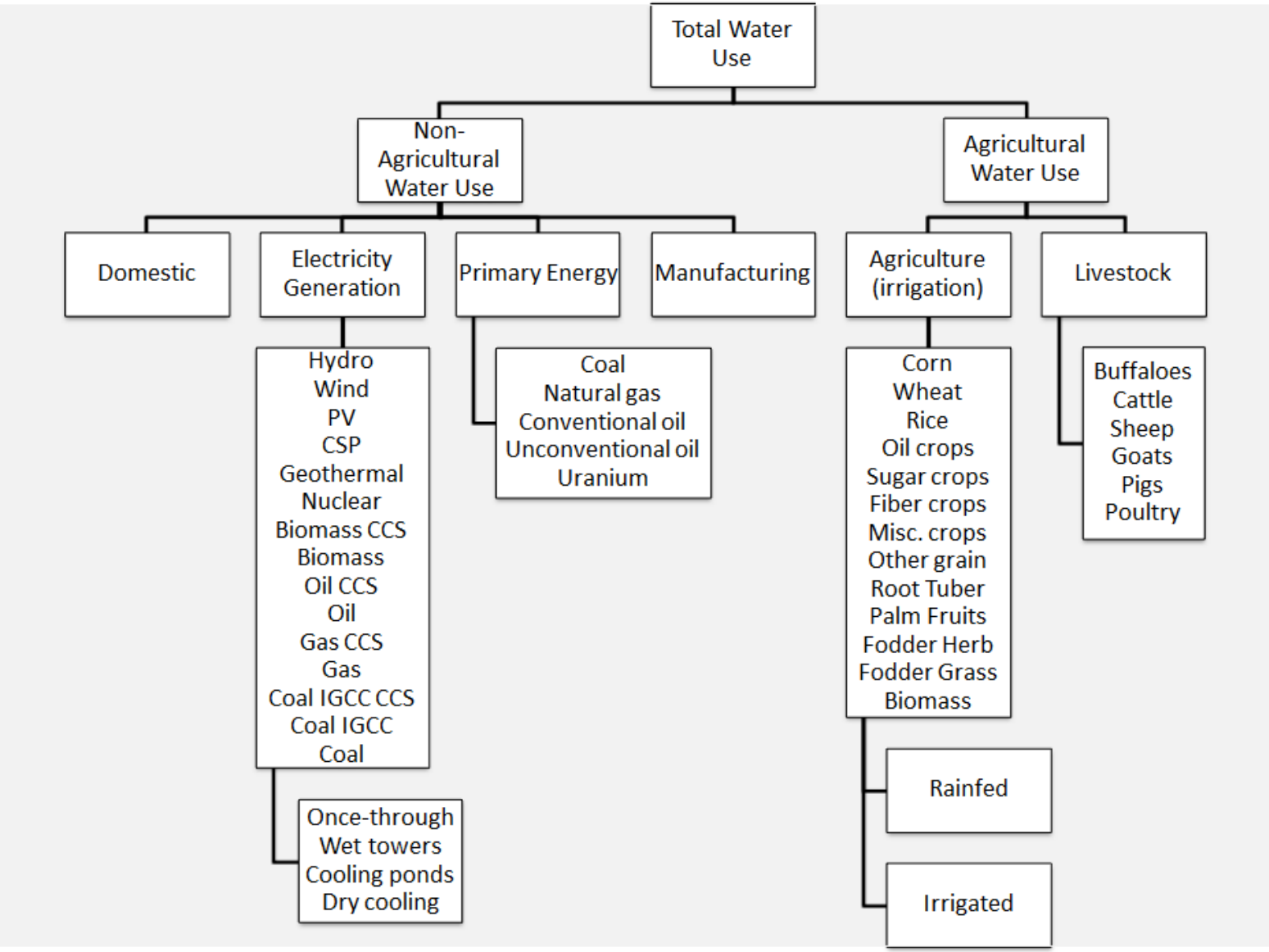






Climatic Research Unit (CRU), University of East Anglia

Representation of all Components of the Water Demand Sectors in GCAM



Estimates of Global Water Demands in 2005 & 2095

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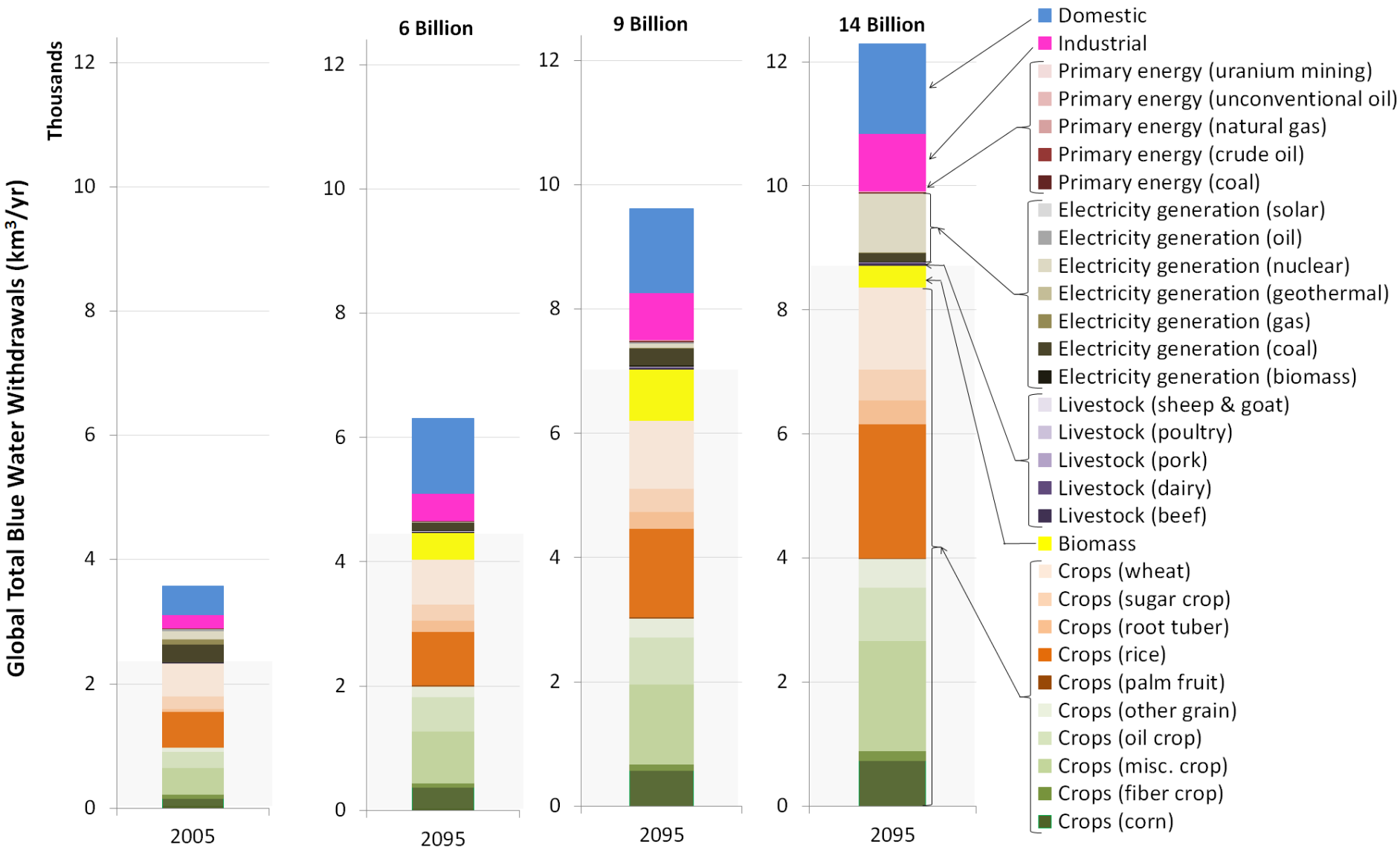
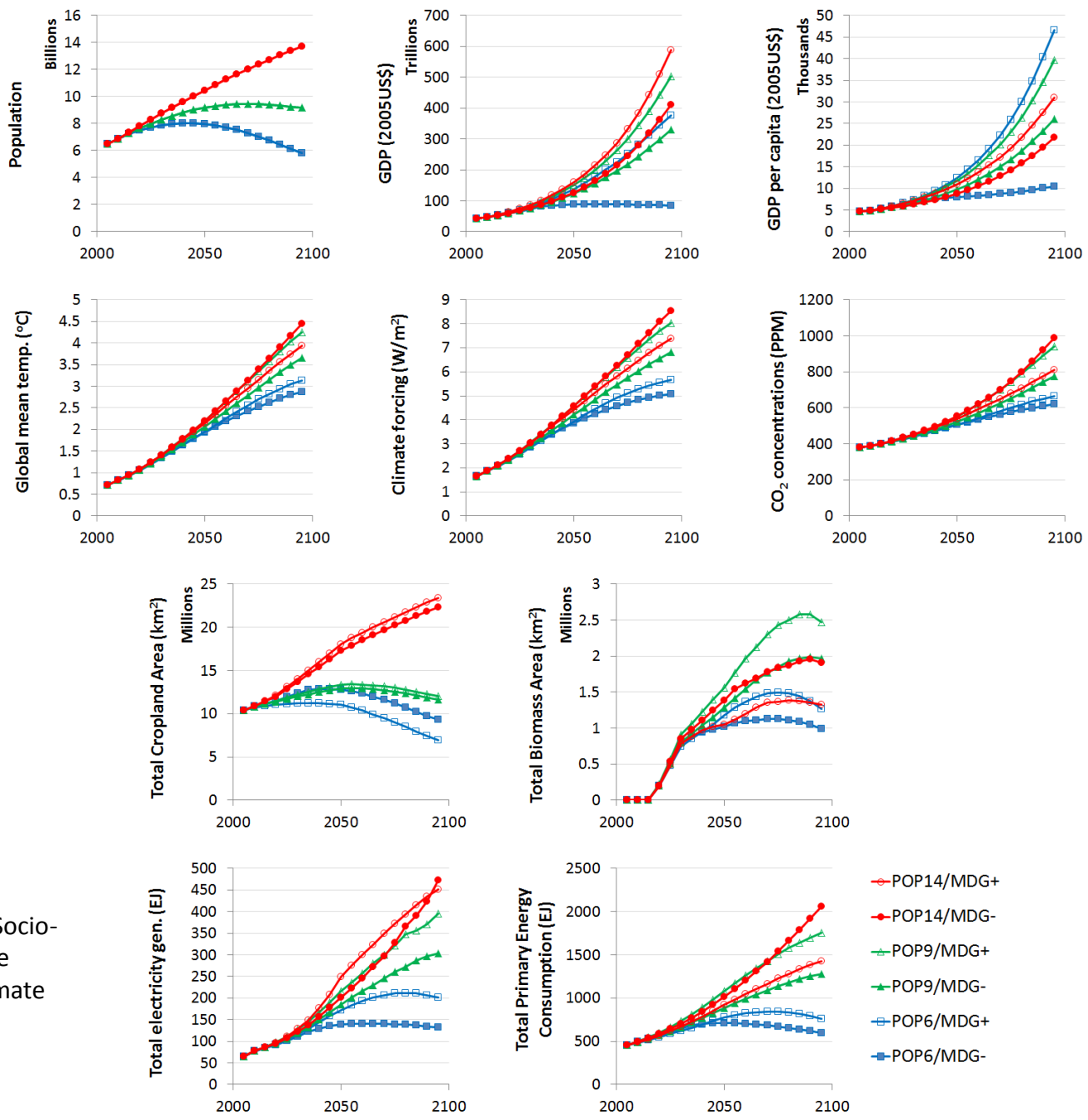


Global water demands by sector in years 2005 and 2095 (under three alternative scenarios with variations in technology, income, & population)

Socioeconomic Scenarios

SIX SCENARIOS:

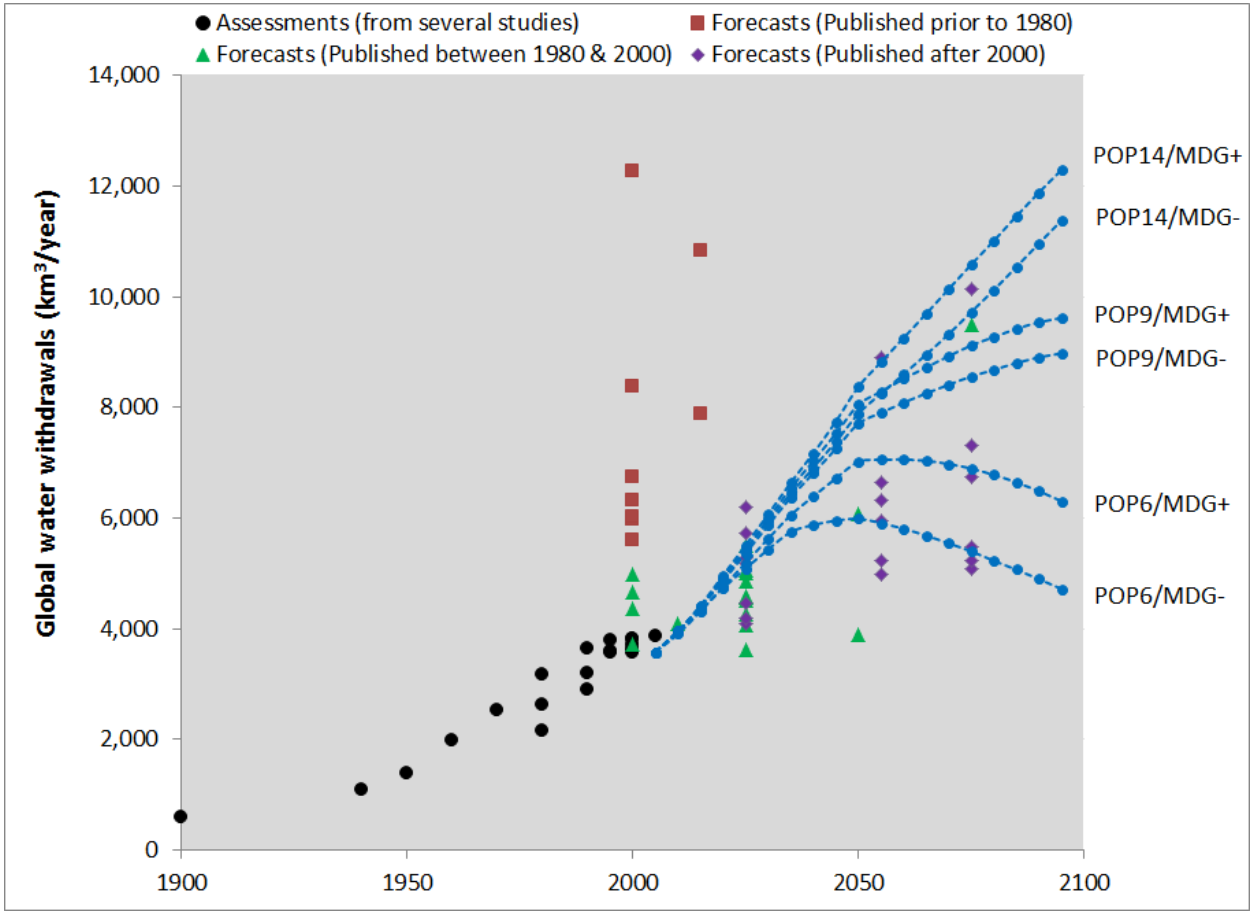
1. Collapse (POP6/MDG-)
2. Sustainability and Equity (POP6/MDG+)
3. Muddling Through (POP9/MDG-)
4. Consumerism (POP9/MDG+)
5. Crowded Chaos (POP14/MDG-)
6. Social Conservatism (POP14/MDG+)



Eom, J., et al. (2012), Scenarios of Future Socio-economics, Energy, Land Use and Radiative Forcing, in Robert G. Watt, Energy and Climate Change, In Preparation, edited.

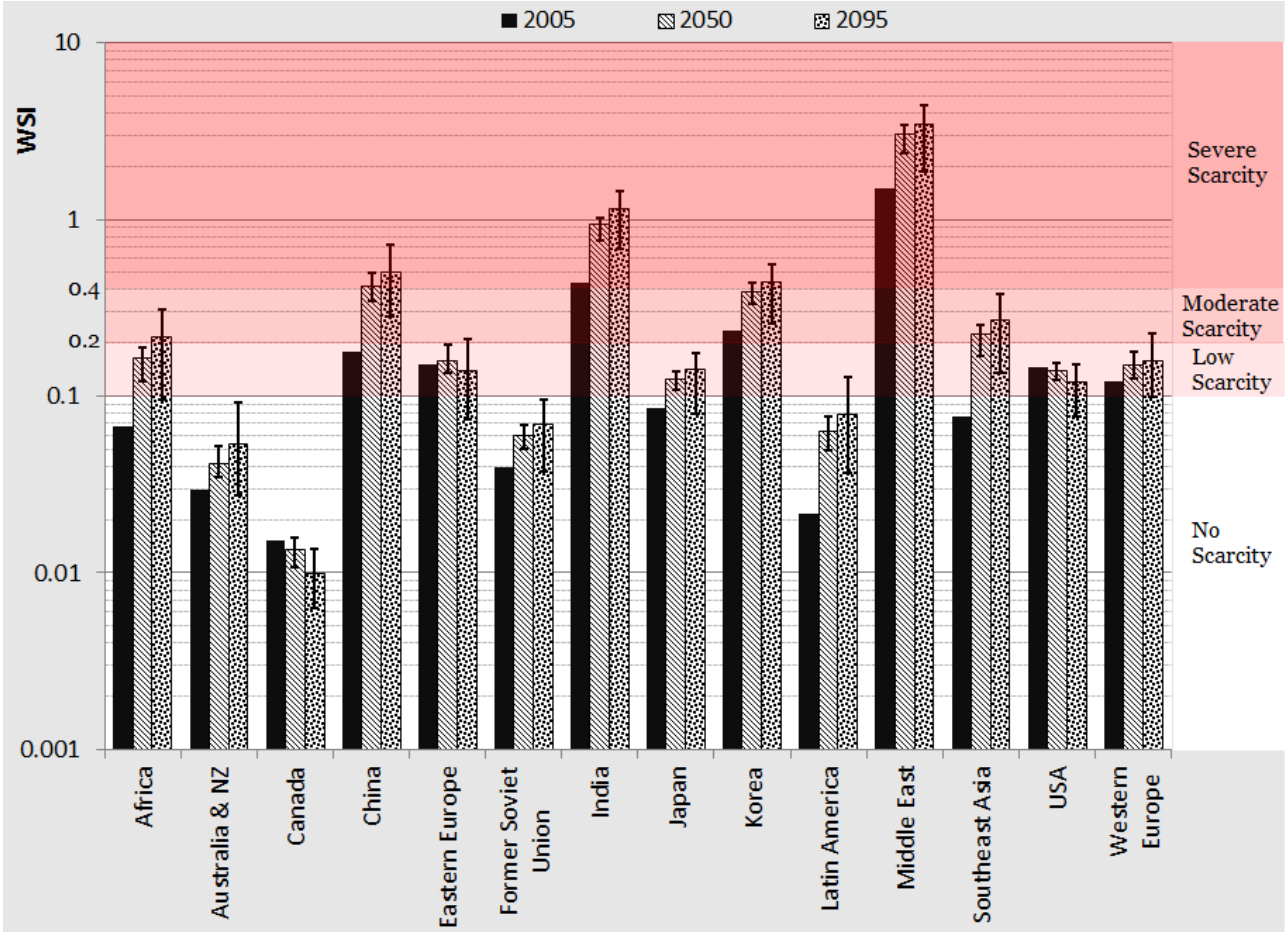
Comparison among the six scenarios with respect to socioeconomics (e.g.: population, GDP and per capita income), climatic variables (e.g.: ΔT, radiative forcings, & CO2 concentration), land (e.g.: cropland area, biomass area), & energy (e.g.: electricity generation, & primary energy consumption) assumptions

Global Water Withdrawals vs. Literature Estimates of Water Use



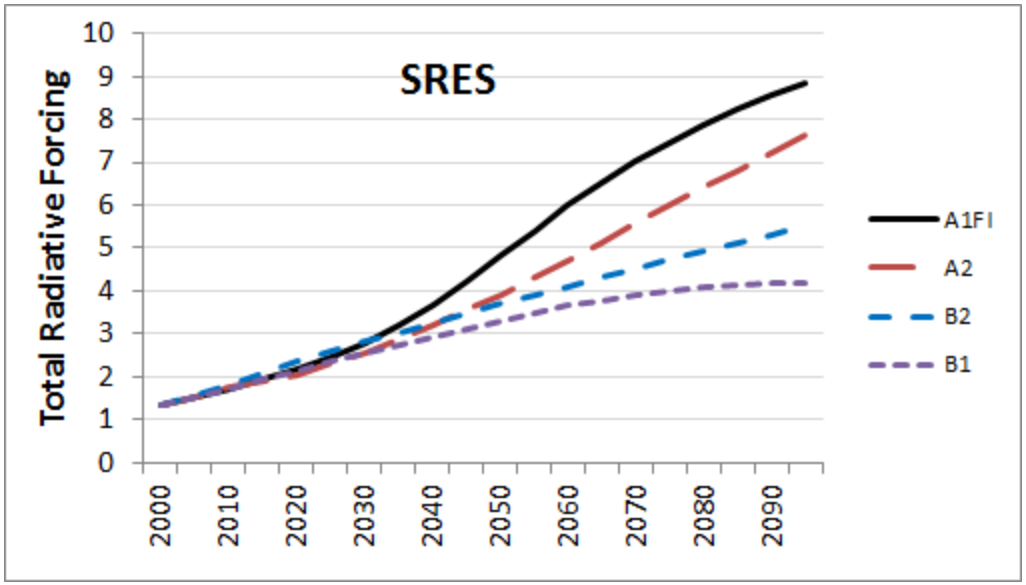
Sources: Gleick 2003 (and references therein), Falkenmark & Rockström, 2000, Alcamo et al. 2003a, Alcamo et al. 2003b, Shiklomanov & Rodda, 2003, Alcamo et al., 2007, Shen et al. 2008, Wada et al., 2011, and AQUASTAT 2011

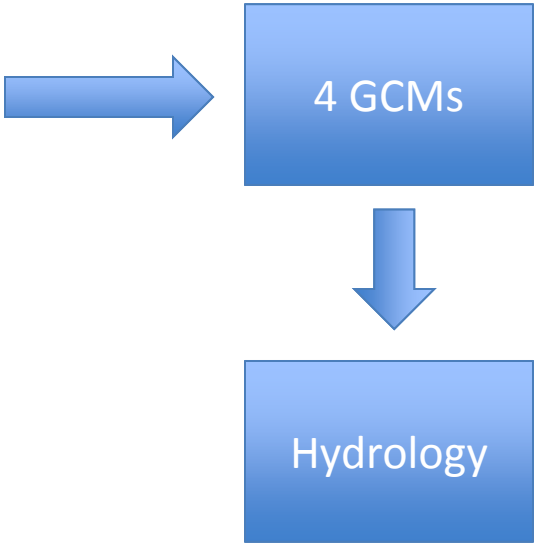
Preliminary Assessment of Water Scarcity



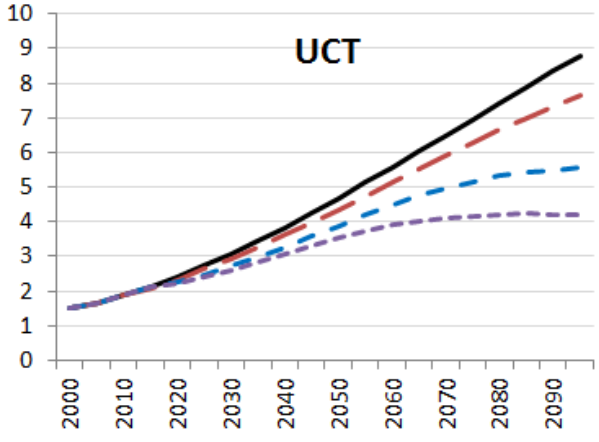
Water scarcity in years 2005, 2050, and 2095 at the 14-GCAM regions due to changing water demands; total water supply (renewable water + desalinated water) are assumed fixed to 2005 levels to capture the effect of demand projection alone on water scarcity; the error-bars represent the range of values based on the six SSP scenarios; WSI values above 0.4 are considered severely stressed regions

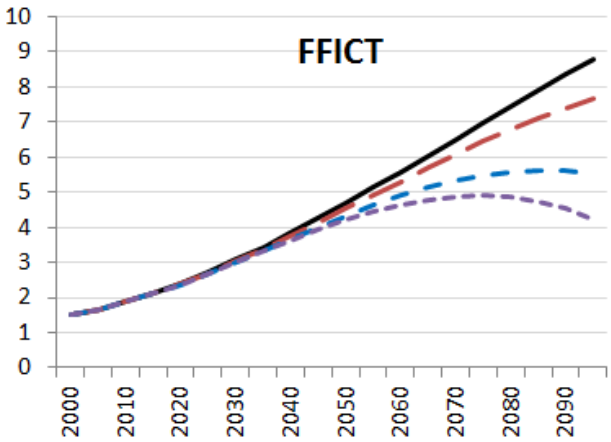
Consistent World of Water Demand & Supply in GCAM

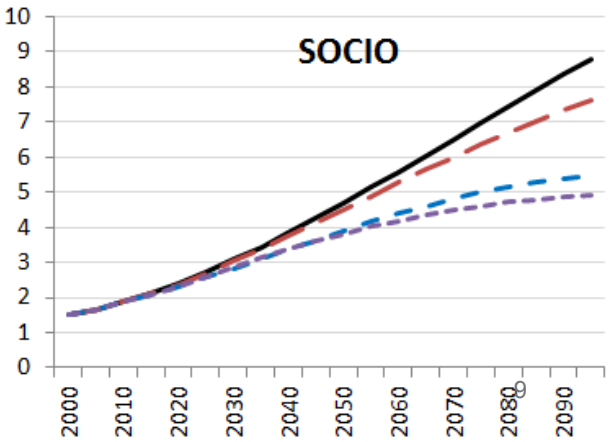




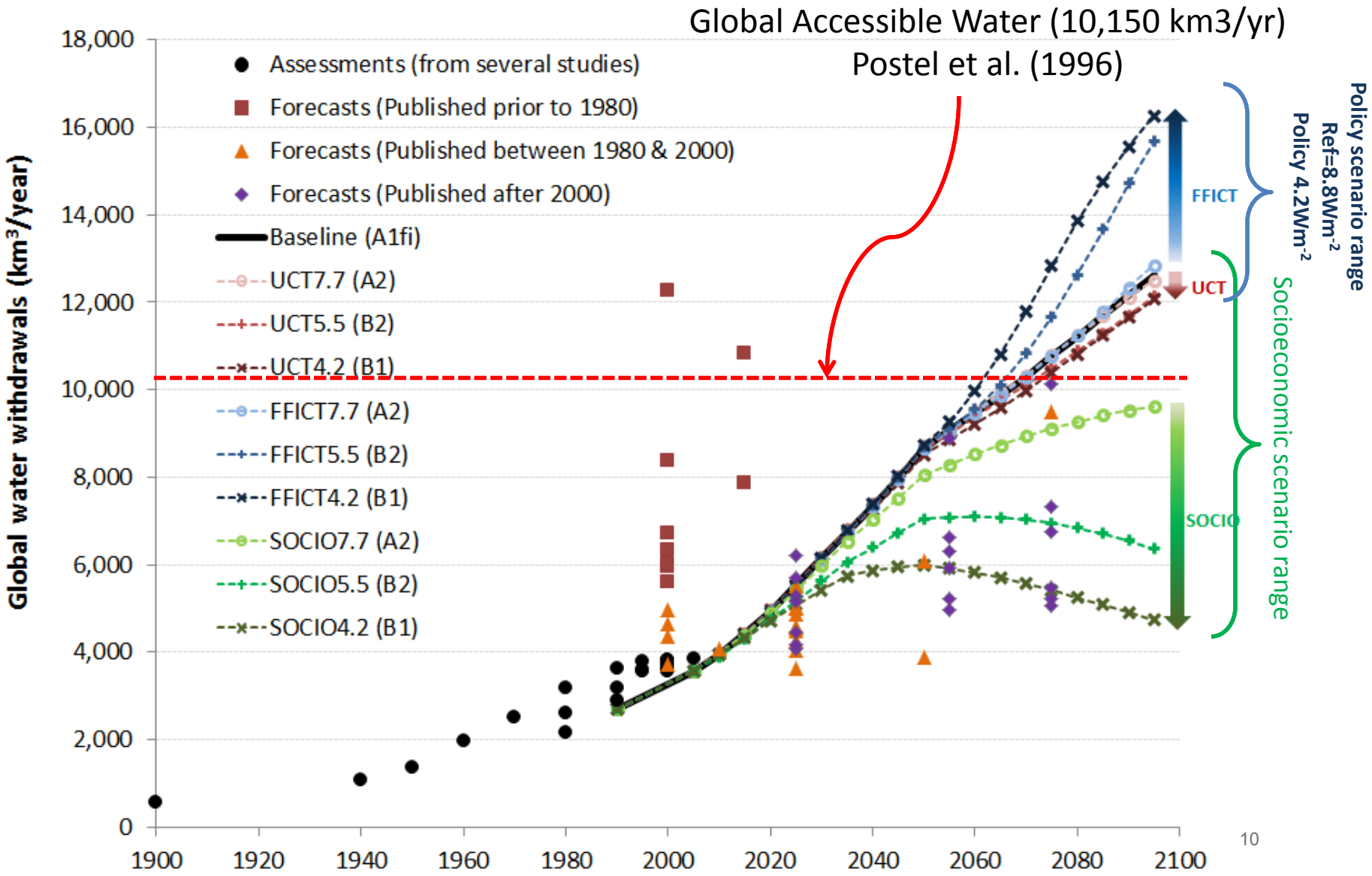
Force GCAM to reproduce the above radiative forcing pathways using:







Future Global Water Demands



Impact Assessment: Water Scarcity

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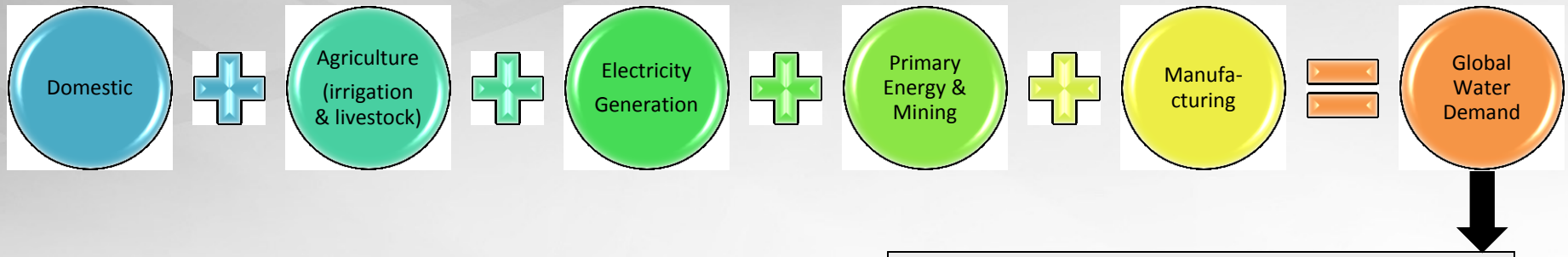
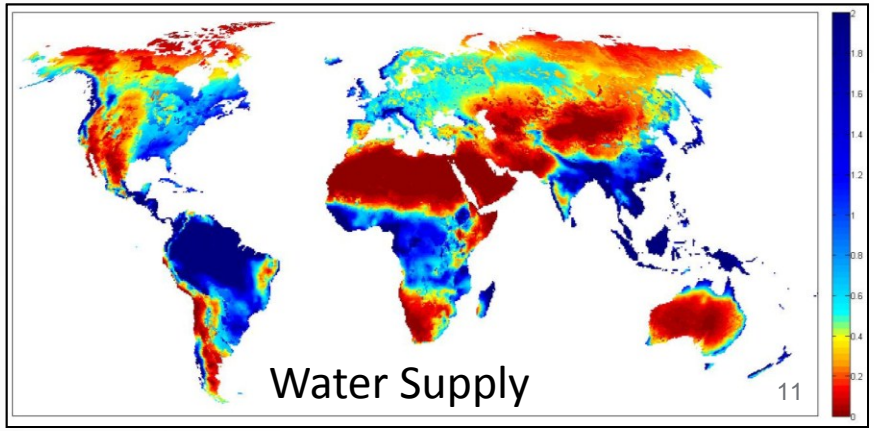
For a given climate mitigation policy scenario & particular year:



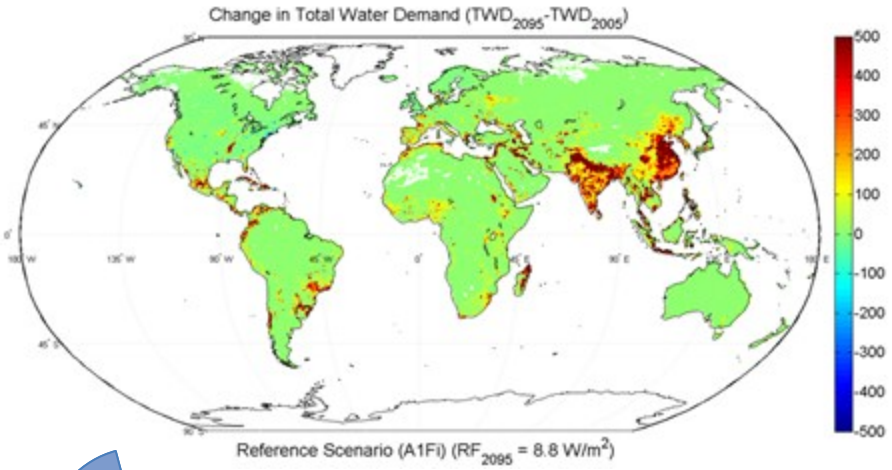
Global gridded-map of total water demands

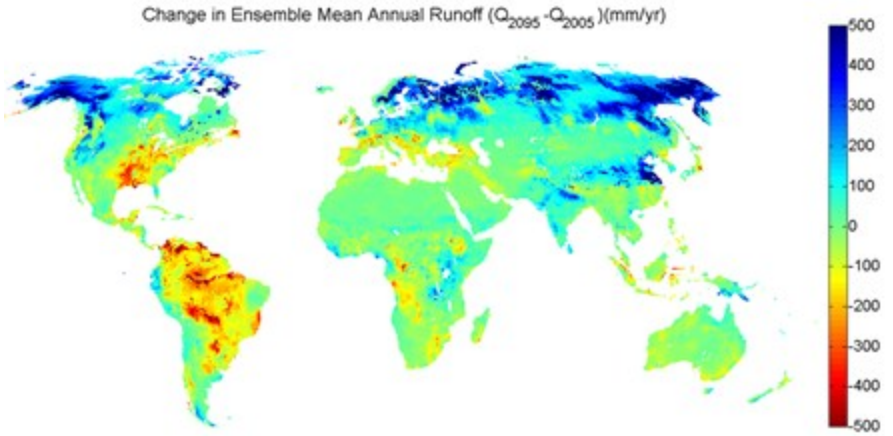
Requirement: Downscale demands to grid scale

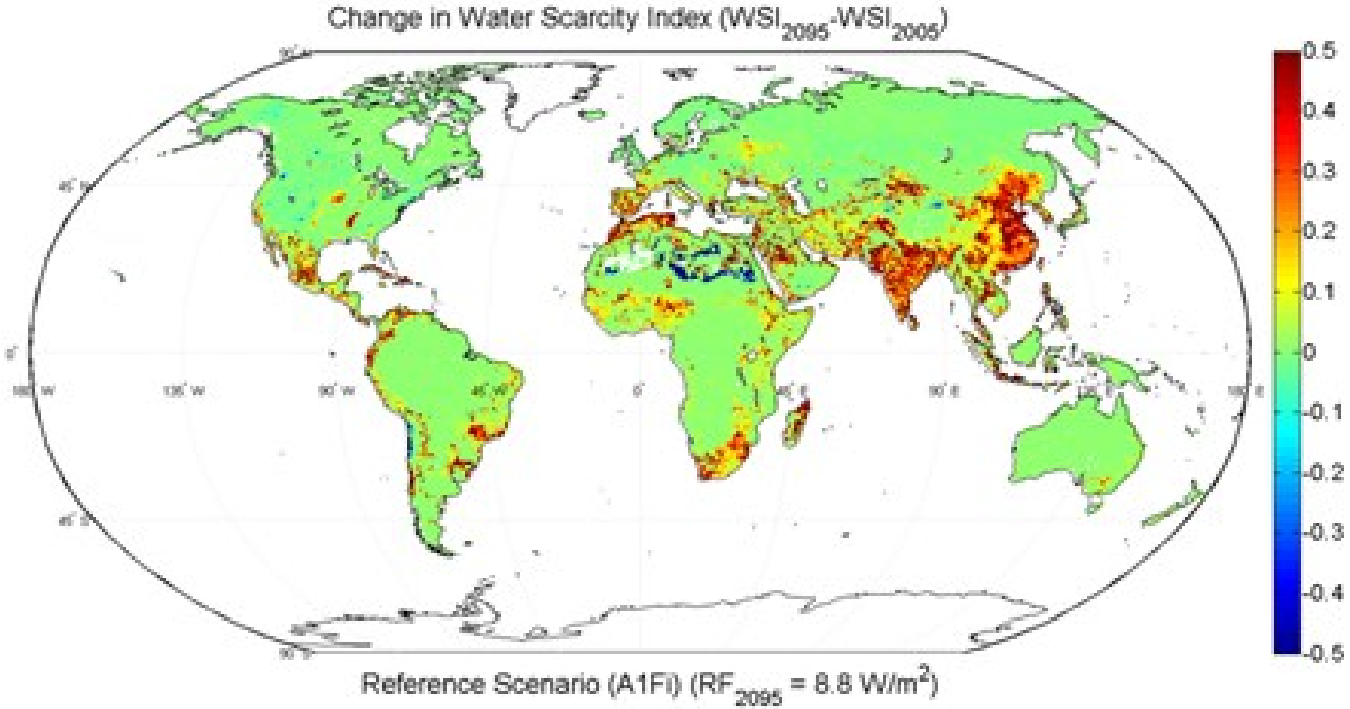
Severe Stress:
0.4 ≤ WSI
Moderate Stress:
0.2 ≤ WSI < 0.4
Low Stress:
0.1 ≤ WSI < 0.2
No Stress:
WSI < 0.1



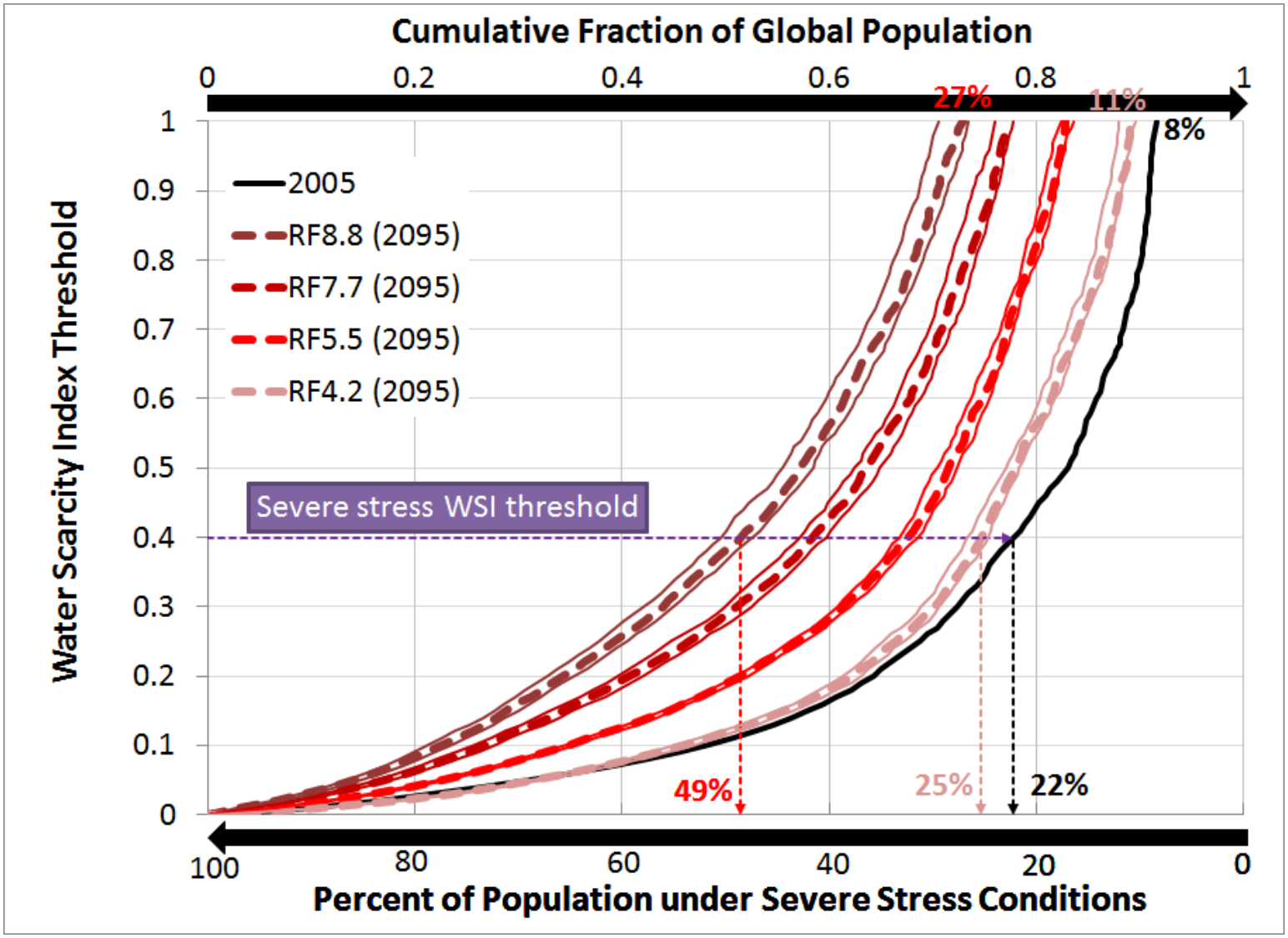
Change in Water Scarcity







The Effects of Socioeconomic Drivers on Water Scarcity in 2095



Shifts in the Cumulative Density Function of Global Population in 2095

Experiments

Baseline: current demands and current climate conditions in year 2005

	Baseline
Fixed	$Climate_{2005}$
Fixed	$Demand_{2005}$

The effect of climate change alone

	B1 (RF4.2)	B2 (RF5.5)	A2 (RF7.7)	A1Fi (RF8.8)
Variable	$Climate_{2095, B1}$	$Climate_{2095, B2}$	$Climate_{2095, A2}$	$Climate_{2095, A1Fi}$
Fixed	$Demand_{2005}$	$Demand_{2005}$	$Demand_{2005}$	$Demand_{2005}$

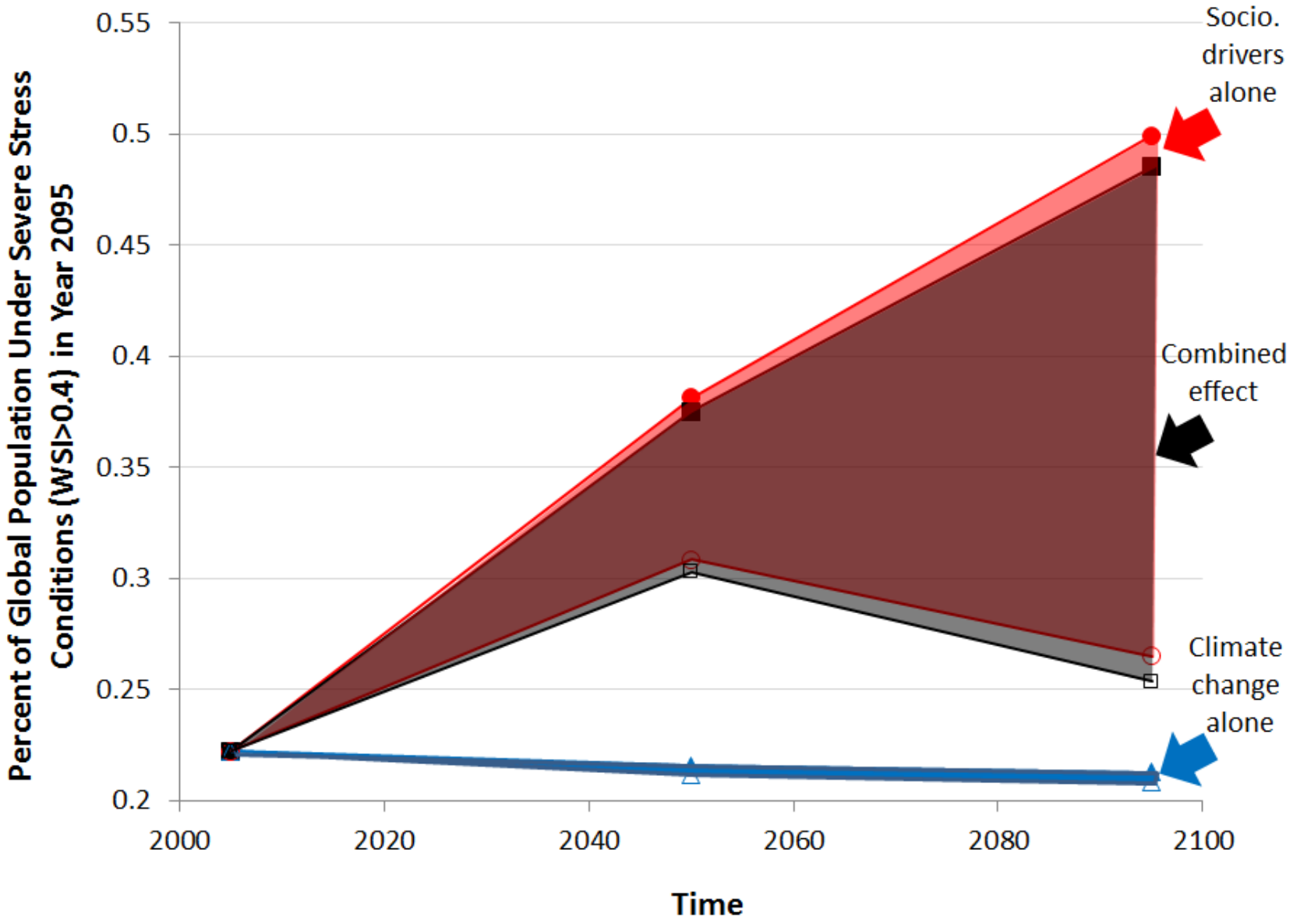
The effect of socioeconomic drivers alone

	B1 (RF4.2)	B2 (RF5.5)	A2 (RF7.7)	A1Fi (RF8.8)
Fixed	$Climate_{2005}$	$Climate_{2005}$	$Climate_{2005}$	$Climate_{2005}$
Variable	$Demand_{2095, 6-}$	$Demand_{2095, 6+}$	$Demand_{2095, 9+}$	$Demand_{2095, 14-}$

The effects of climate change and socioeconomic drivers together

	B1 (RF4.2)	B2 (RF5.5)	A2 (RF7.7)	A1Fi (RF8.8)
Variable	$Climate_{2095, B1}$	$Climate_{2095, B2}$	$Climate_{2095, A2}$	$Climate_{2095, A1Fi}$
Variable	$Demand_{2095, 6-}$	$Demand_{2095, 6+}$	$Demand_{2095, 9+}$	$Demand_{2095, 14-}$

Climate Change Vs. Socioeconomic Drivers



Climate Change Vs. Socioeconomic Drivers
Basin Scale

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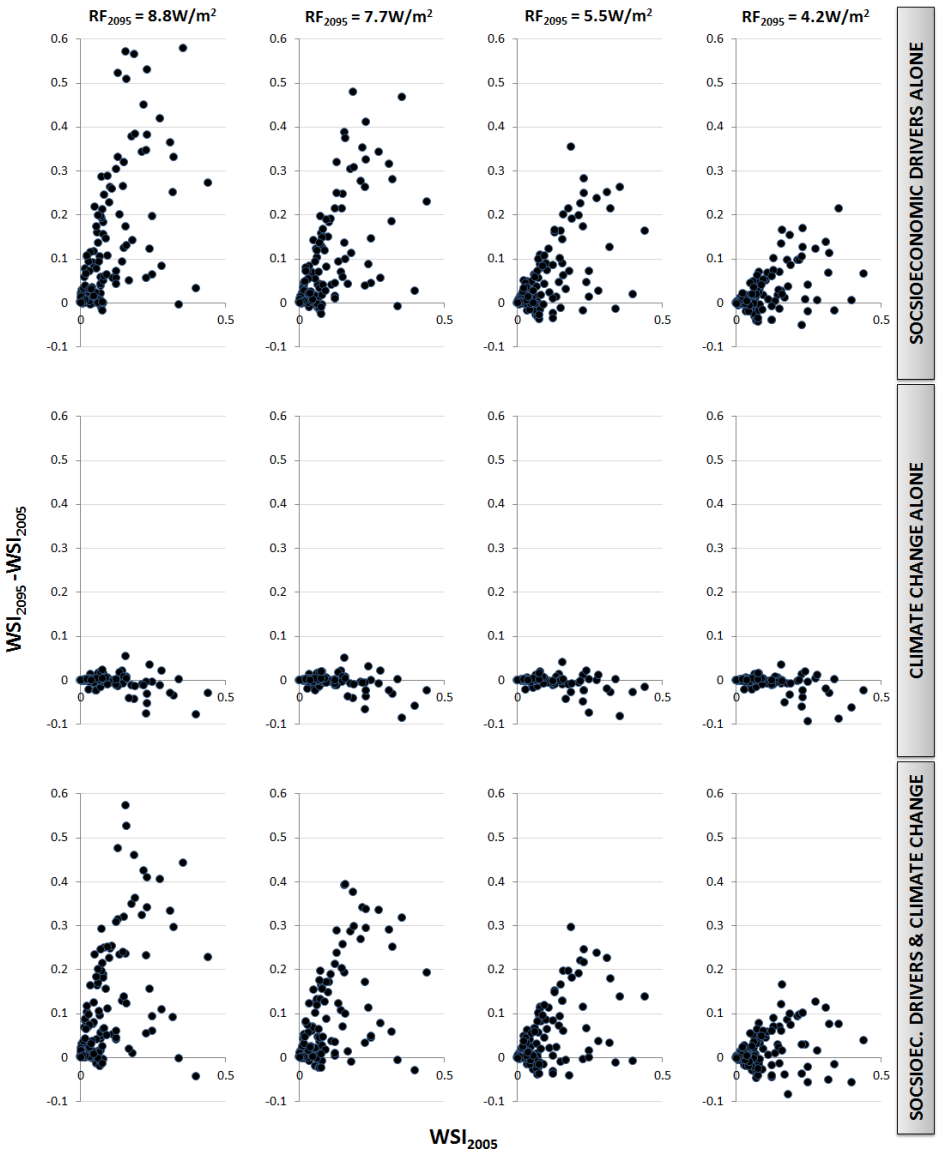

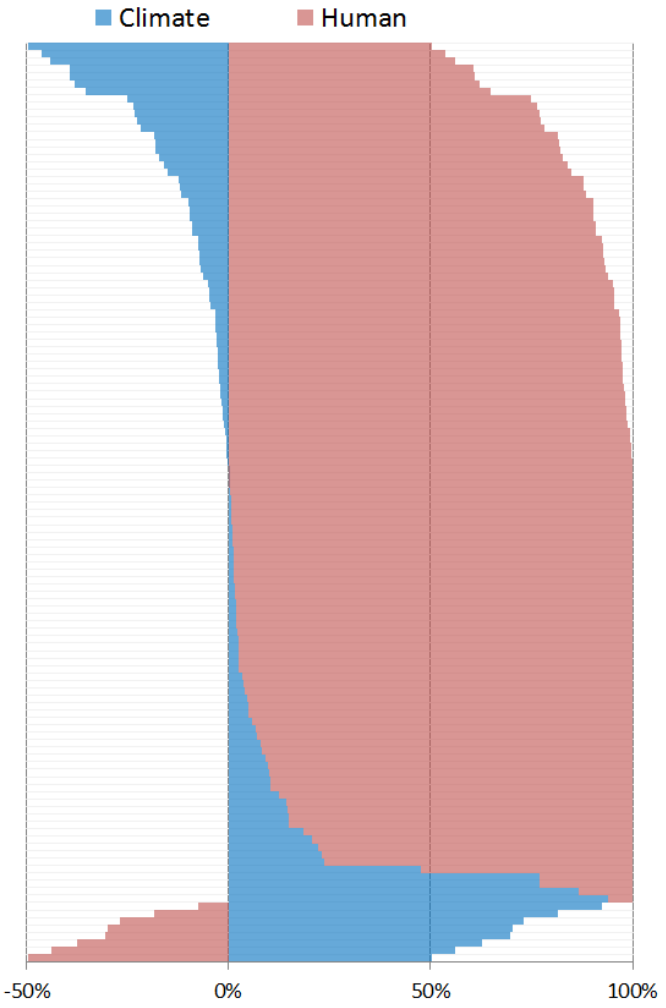

Distribution of the range of the change (2005 to 2095) in average share of population living under water scarcity by water basin.

Future Research Directions

- Allocating water among competing water users and technology choices (two-way feedback)
- Climate change impacts on water demands
- Enhance the existing representations of the global hydrologic model and demand sectors in GCAM
- Accounting for non-renewable water sources, e.g., desalinated water and non-renewable (fossil) groundwater

QUESTIONS!

References

- Hejazi, Mohamad I., Jae Edmonds, and Vaibhav Chaturvedi (***in press***). Global irrigation demand – A holistic approach, *Journal of Irrigation & Drainage Systems Engineering*.
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