Land Use In the MIT IGSM: The Role of Biofuels and Forests in Mitigating Climate Risks

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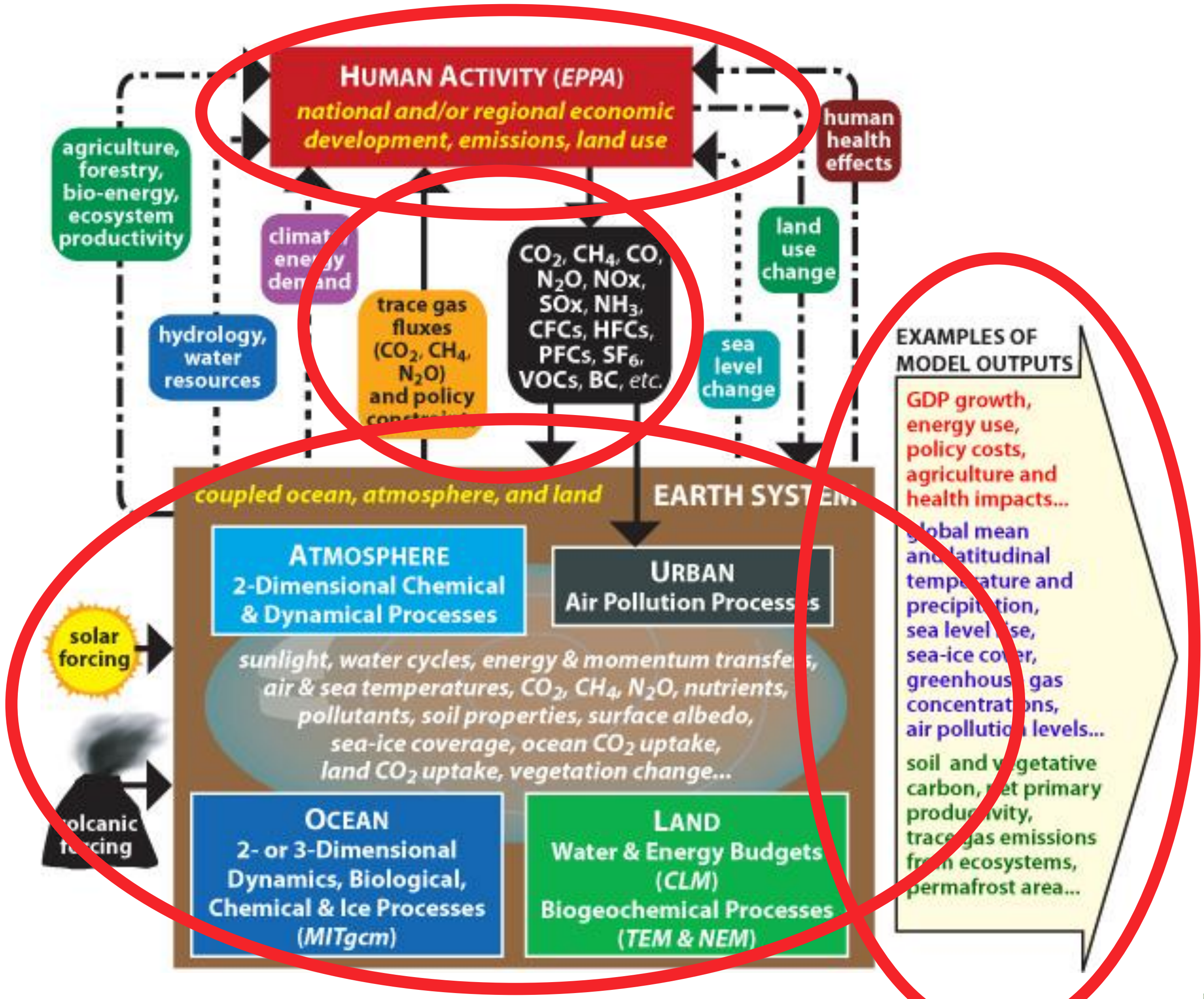
Economic Models of Land Use and Biofuels

Melillo, et al., 2009, Indirect Emissions from Biofuels: How Important?, Science, **326**:1397-99

Gurgel et. al., 2009, Food, Fuel, Forests and the Pricing of Ecosystem Services, ASSA meeting paper, and to be published in the AJAE.

MIT INTEGRATED GLOBAL SYSTEM MODEL



Global Land System Interactions

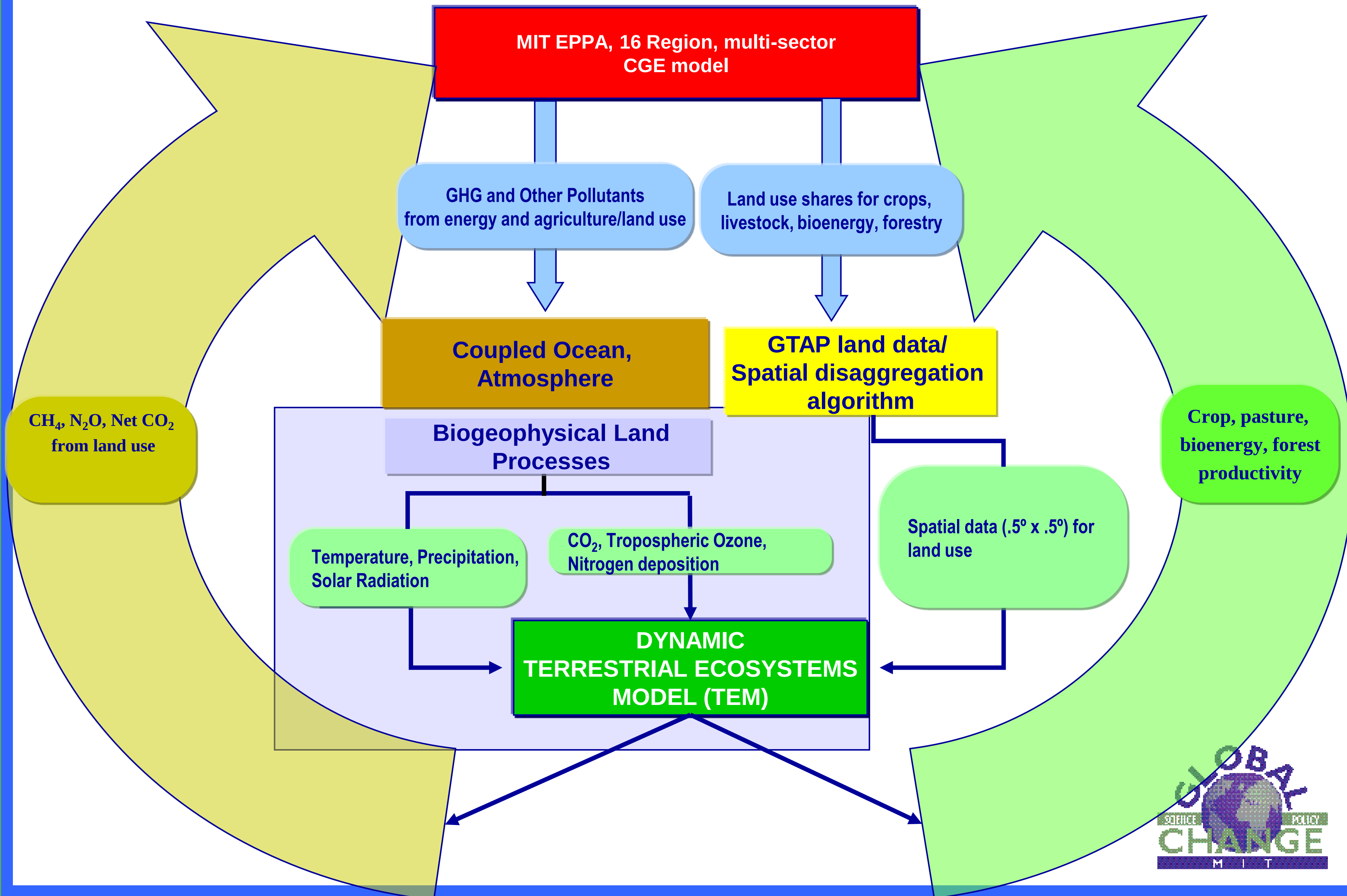


Table 1. Regions, Sectors, and Primary Factors in the EPPA Model

Country or Region	Sectors	Factors
Developed	*Non-Energy*	Capital
United States (USA)	Services (SERV)	Labor
Canada (CAN)	Energy-Intensive (EINT)	*Energy Resources*
Japan (JPN)	Other Industries (OTHR)	Crude Oil
European Union+ (EUR)	Commercial Transp. (TRAN)	Natural Gas
Australia/N.Zealand (ANZ)	Household Transp. (HTRN)	Coal
Former Soviet Union (FSU)	***Other HH Consumption - Recreation***	Oil Shale
Eastern Europe (EET)	**Hunting and Fishing (REHF)**	Nuclear
Developing	**Wildlife Viewing in Reserves (REWV_R)**	Hydro
India (IND)	**Other Wildlife Viewing (REWV_N)**	Wind/Solar
China (CHN)	*Fuels*	***Land***
Indonesia (IDZ)	Coal (COAL)	Cropland
Higher Inc. East Asia (ASI)	Crude Oil (OIL)	Pastureland
Mexico (MEX)	Refined Oil (ROIL)	Managed Forest
Centr. & S. America (LAM)	Natural Gas (GAS)	**Non-Reserved**
Middle East (MES)	Oil from Shale (SYNO)	**Natural Forest**
Africa (AFR)	Synthetic Gas (SYNG)	**Reserved Natural**
Rest of World (ROW)	Liquids from Biomass (B-OIL)	**Forest**
	Electricity Generation	Natural Grassland
	Fossil (ELEC)	Other
	Hydro (HYDR)	
	Nuclear (NUCL)	
	Solar and Wind (SOLW)	
	Biomass (BIOM)	
	Coal with CCS (IGCAP)	
	Adv. gas without CCS (NGCC)	
	Gas with CCS (NGCAP)	
	Agriculture	
	Crops (CROP)	
	Livestock (LIVE)	
	Forest products (FORS)	
	Food Processing (FOOD)	

Expanded SAM—Household “production” sector, leisure

		INTERMEDIATE USE by Production Sectors				*Household Services*		FINAL USE				OUT-
		1	2	...j...	n	hh Prod.	***Labor-Leisure Choice***	Private consum.	Gov't consum.	Invest.	Export	PUT
Domestic Production	1	A						B				C
	2											
	:											
	i											
	n											
Imports	1	D						E				F
	2											
	:											
	i											
	:											
	n											
Leisure							***Leisure***	***Leisure***				
Value added:	-labor	G				***Labor***	***Labor***	***Labor*** H				I
	-capital											
	- natural resources											
INPUT		J										

Biofuels Bioelec Crops Livestock forestry

Environmental health provision

recreation

Unmanaged land, recreation future value

Land for crops, pasture, forestry – productivity affected by environmental change.

Added components are in bold italic.

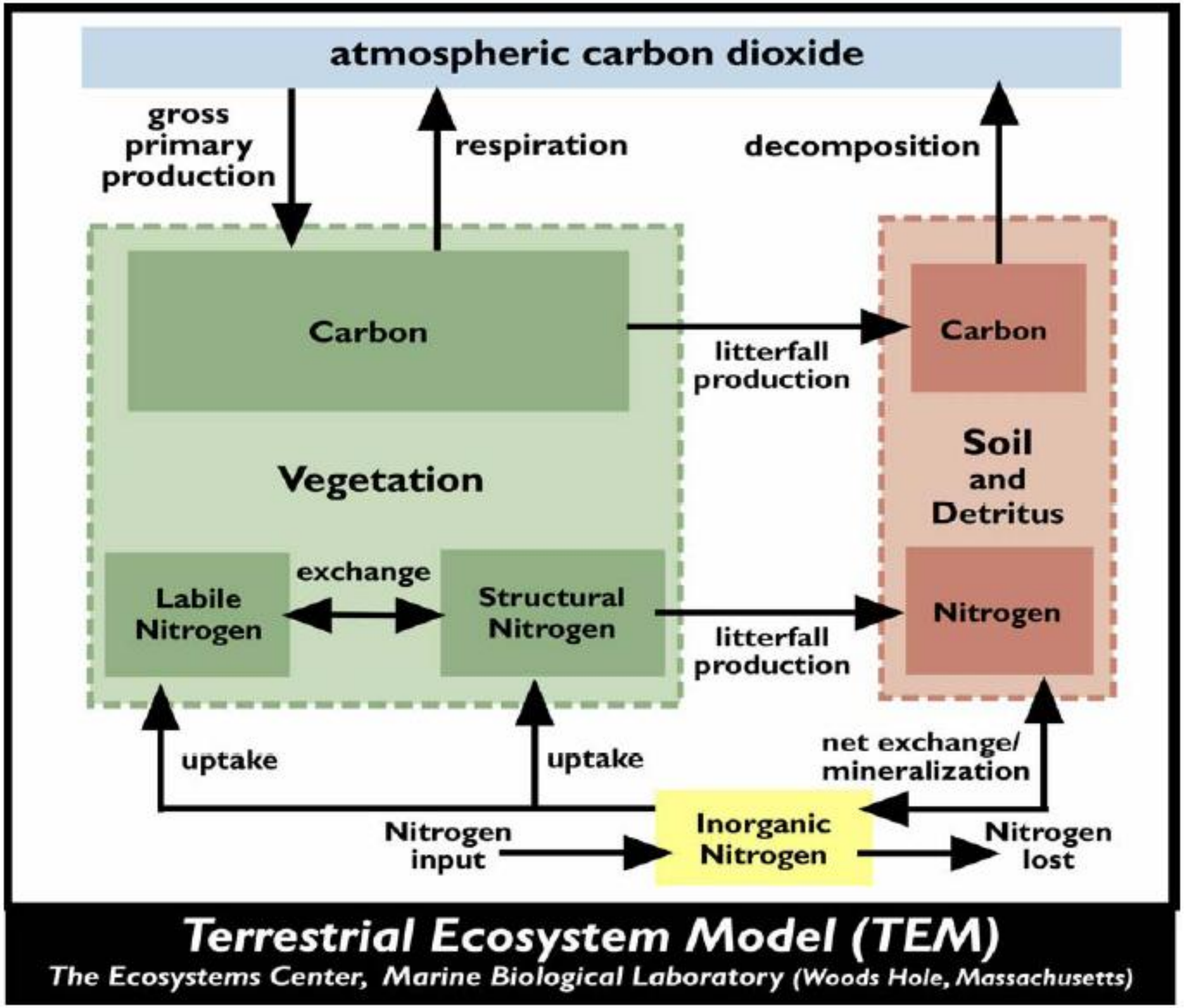


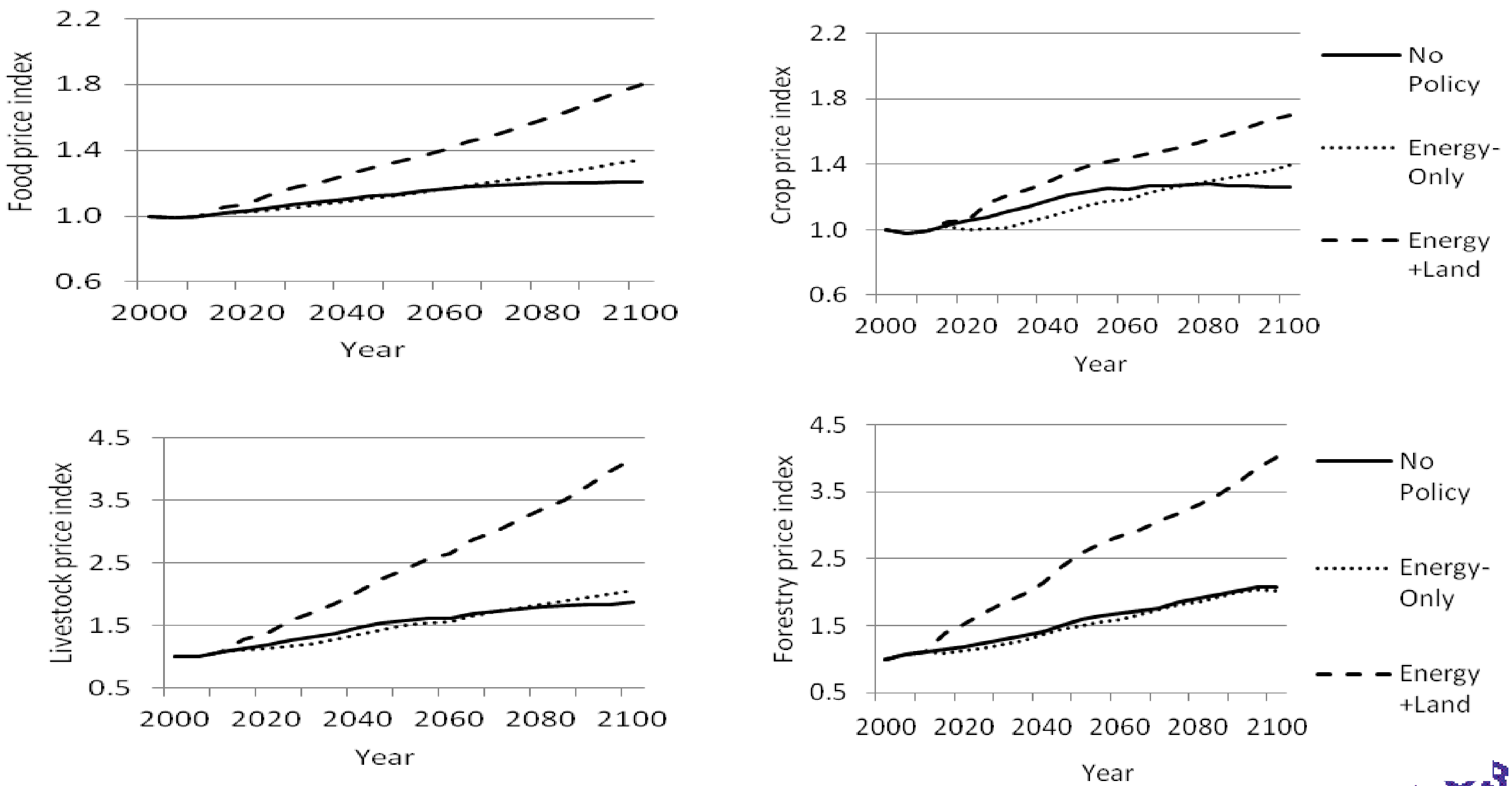
Figure 3.4: Description of the Terrestrial Ecosystem Model (TEM)
Source: The Ecosystems Center, the U.S. Marine Biological Laboratory (MBL).

Monthly,

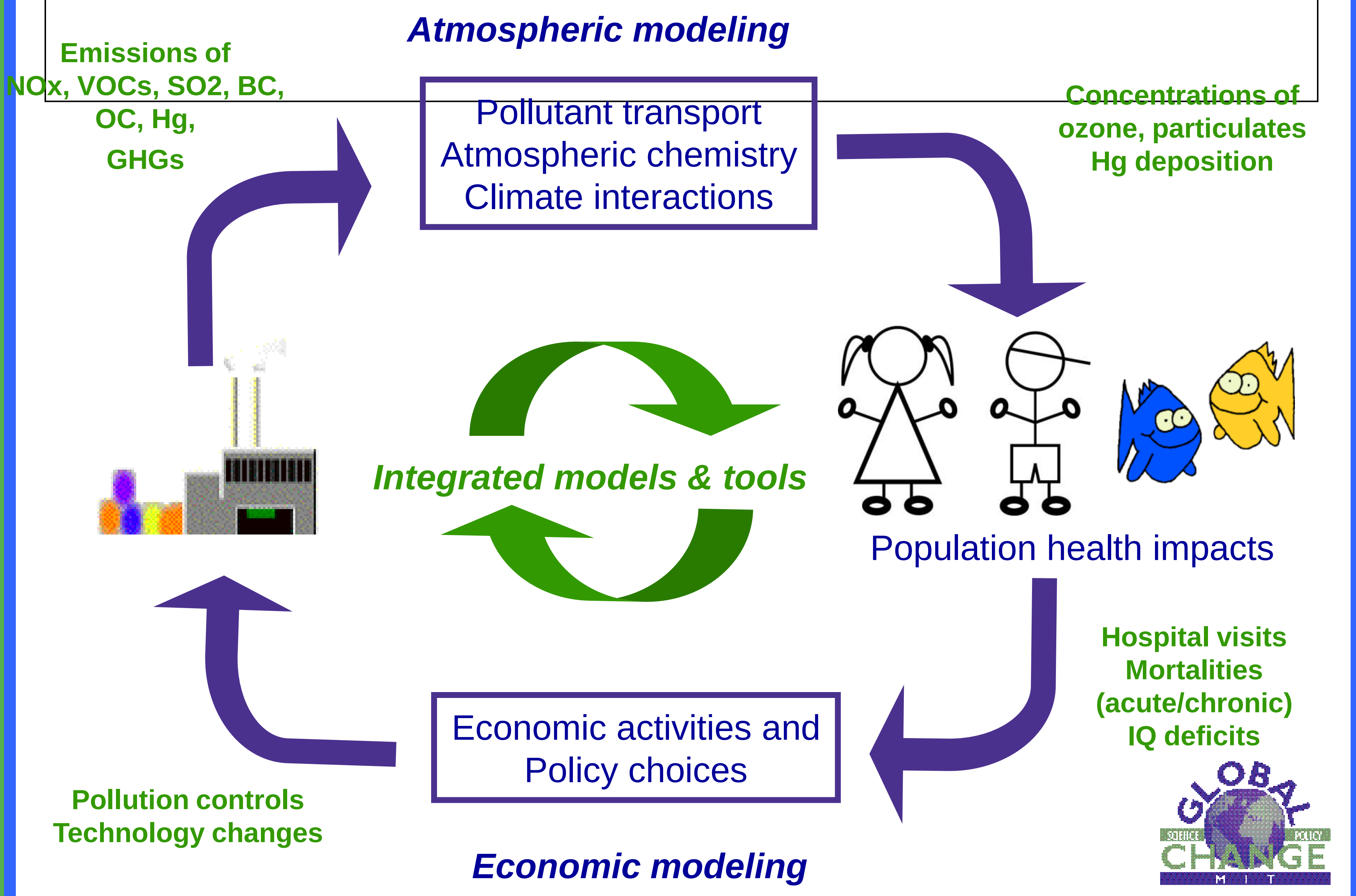
0.5° x 0.5°,

Dynamic soils and vegetation with multiple carbon pools, and multiple harvest carbon pools i.e. forest litter, waste, paper; lumber

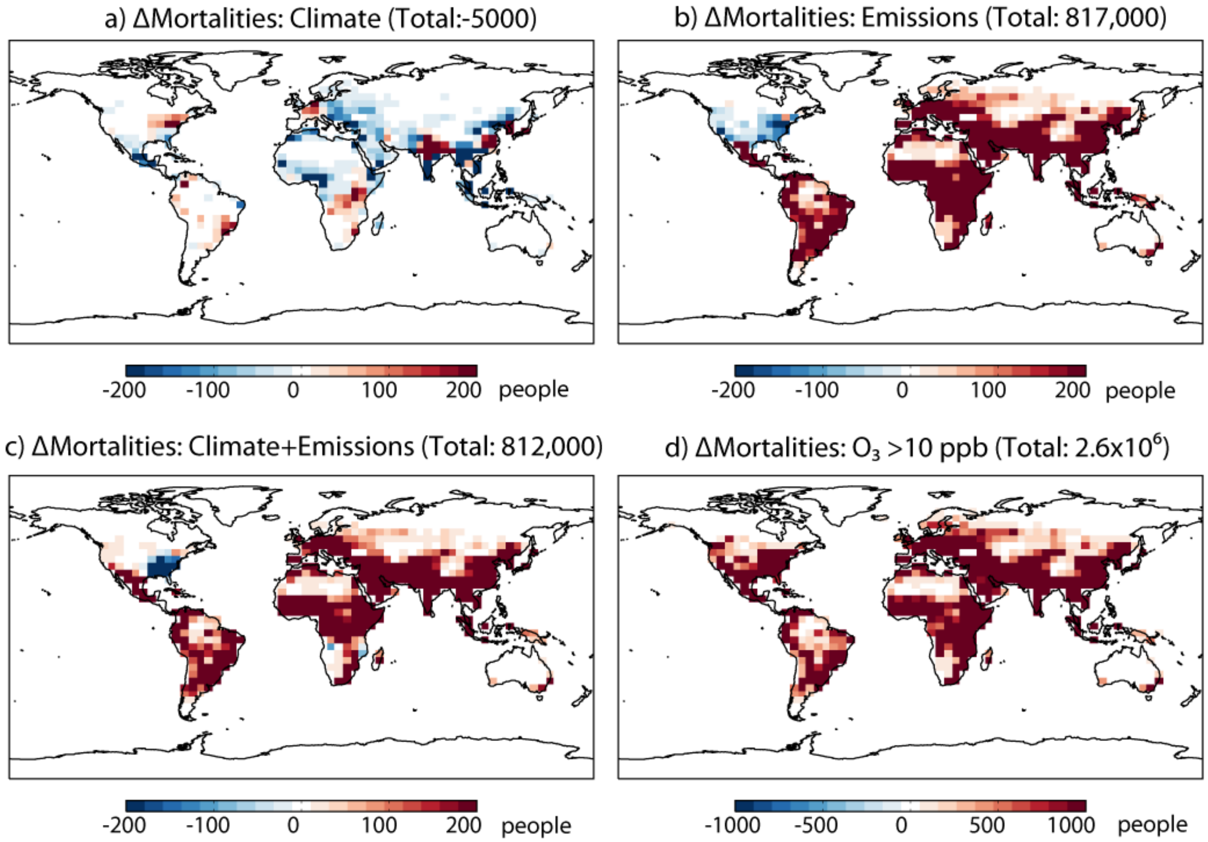
Food, crop, livestock, and forestry price impacts combine impacts of climate change, ozone, competition for land of biofuels, and mitigation cost effects on energy/N_2O/CH_4



FRAMEWORK FOR AIR POLLUTION IMPACTS ANALYSIS



GLOBAL COSTS OF OZONE POLLUTION IN 2050

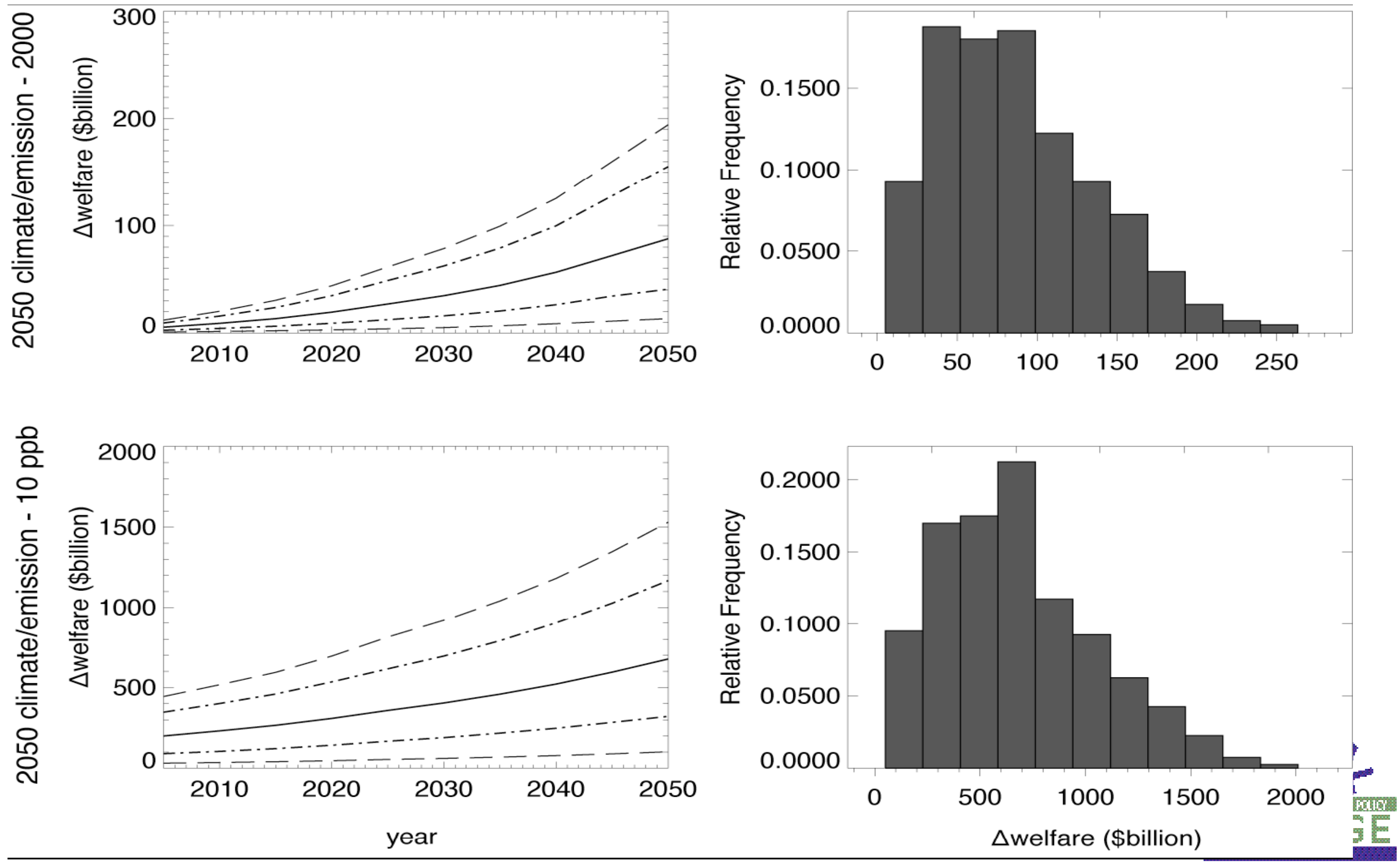


- O_3 from A1B scenario [Wu et al., 2008] to 2050
- Calculate change in welfare due to health impacts of ozone changes, separately for emissions and climate drivers

- 2050 welfare loss from O_3 health impacts, climate only scenario: *€790 million* (year 2000 €)
- 2050 welfare loss from climate+emission changes: *€120 billion*
- 2050 welfare loss from all O_3 above background: *€580 billion*

[*Selin et al*., in prep]

Uncertainty: Due to uncertainty in dose response relationships and economic modeling of impacts.



Uncertainty Analysis: Methodology

Estimate probability distributions for input parameters controlling the emissions and climate projections in IGSM sub-models:

(1) Emissions Uncertainties:
Elasticities of Substitution
GDP Growth (based on Labor Productivity Growth)
Autonomous Energy Efficiency Improvement (AEEI)
Fossil Fuel Resource Availability, Population Growth
Urban Pollutant Trends, Future Energy Technologies
Non-CO_2 Greenhouse Gas Trends, Capital Vintaging

(2) Climate System Response Uncertainties (constrained by observations):
Climate Sensitivity
Rate of Heat uptake by Deep Ocean
Radiative Forcing Strength of Aerosols

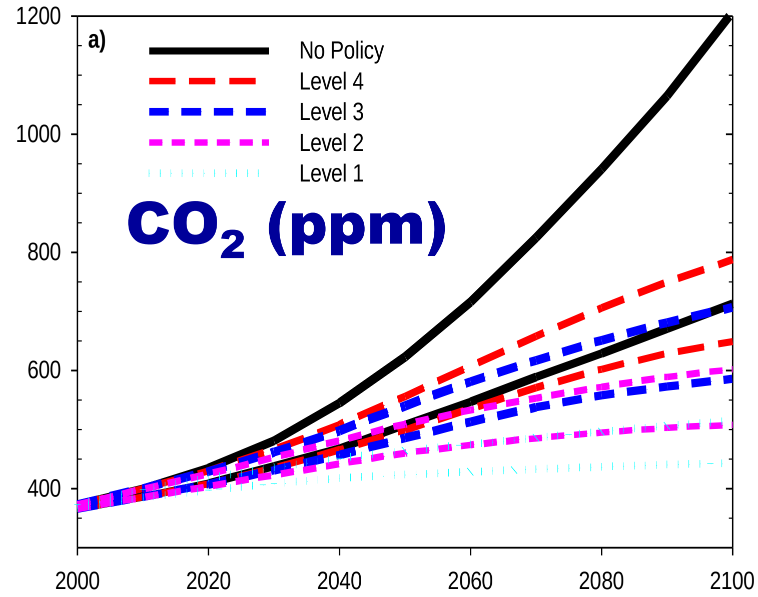
(3) Greenhouse Gas Cycle Uncertainties:
CO_2 Fertilization Effect on Ecosystem Sink
Rate of Carbon Uptake by Deep-Ocean
Trends in Rainfall Frequency on natural CH_4 & N_2O emissions

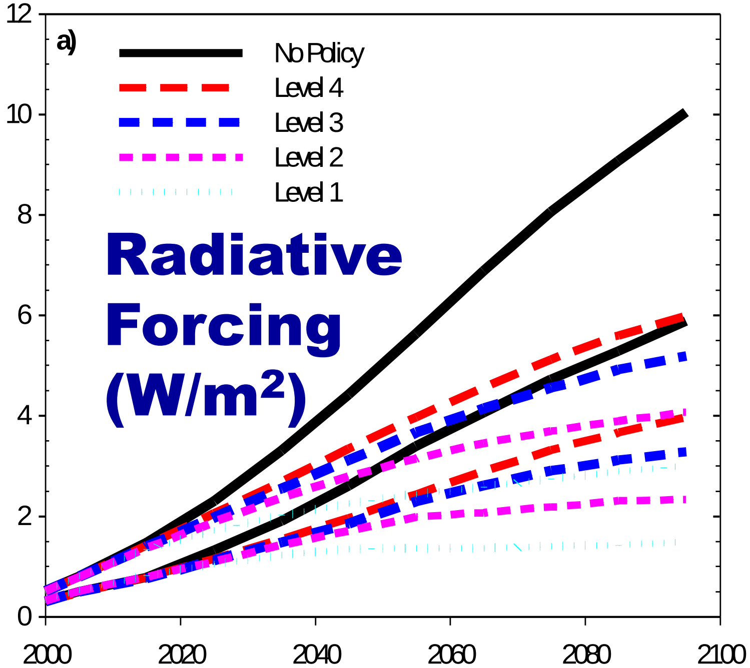
Five Cases indicated by GHG levels (ppm-equivalent CO_2, ppm CO_2 and change in Radiative Forcing relative to ~1990 (W/m^2) in ~2100:

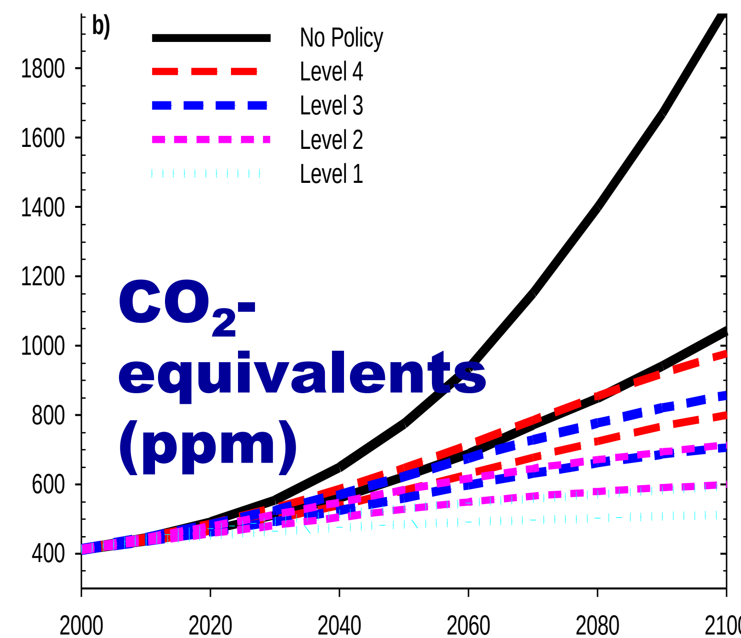
No Policy (1400 ppm CO_2-eq; 870 ppm CO_2; 9.7 W/m^2)
Level 4 (900 ppm CO_2-eq; 710 ppm CO_2; 7.1 W/m^2)
Level 3 (790 ppm CO_2-eq; 640 ppm CO_2; 6.3 W/m^2)
Level 2 (660 ppm CO_2-eq; 560 ppm CO_2; 5.3 W/m^2)
Level 1 (550 ppm CO_2-eq; 480 ppm CO_2; 4.2 W/m^2)

Generate 400 member ensembles (Monte Carlo with Latin Hypercube Sampling) for each case

95% PROBABILITY BOUNDS OF GLOBAL AVERAGE GHG MOLE FRACTIONS AND RADIATIVE FORCING from 1981-2000 to 2090-2100, WITHOUT (1400 ppm-eq CO_2) & WITH A 550, 660, 790 or 900 ppm-eq CO_2 GHG STABILIZATION POLICY?







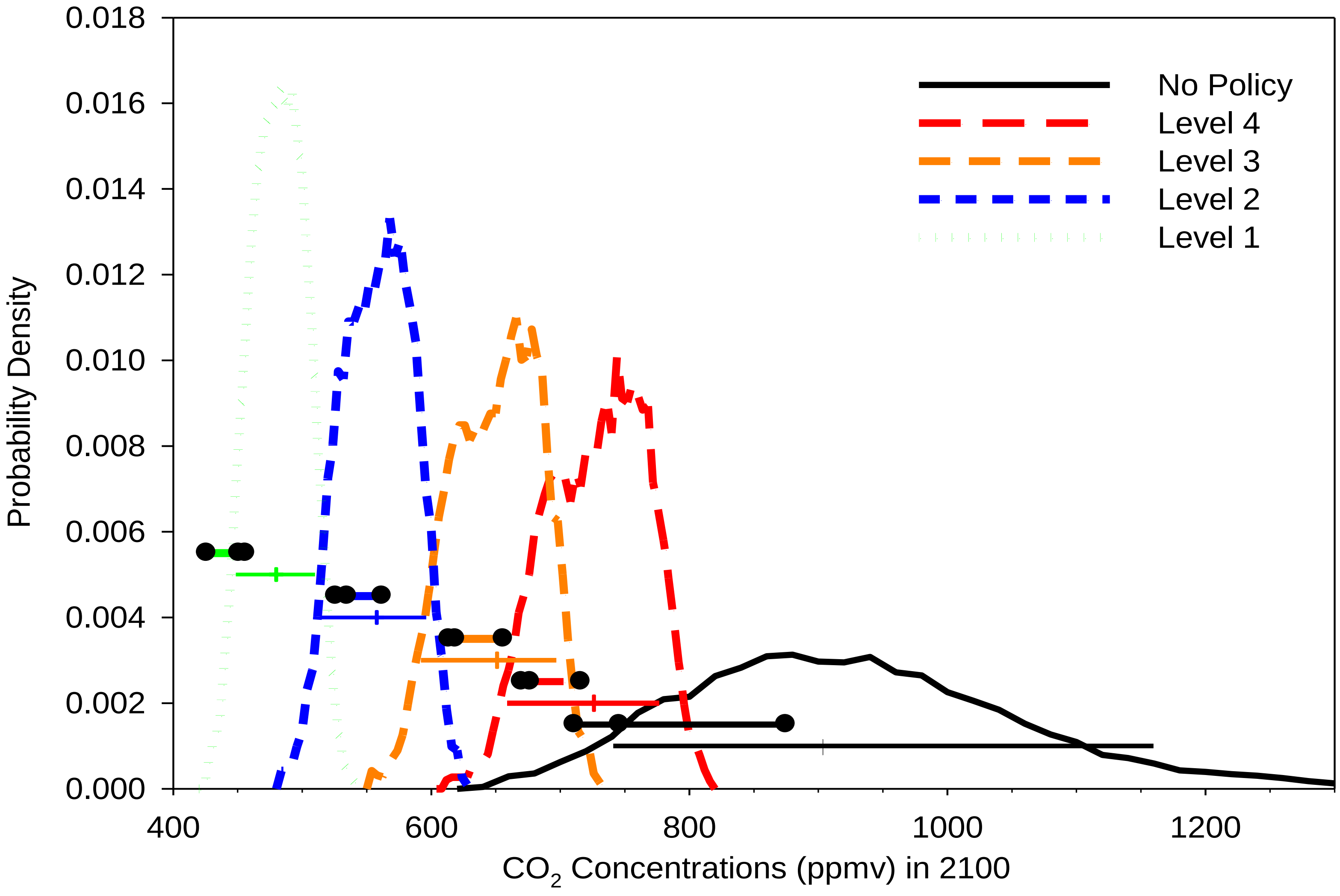
Cumulative PROBABILITY OF GLOBAL AVERAGE SURFACE AIR WARMING from 1981-2000 to 2091-2100, WITHOUT (1400 ppm-eq CO_2) & WITH A 550, 660, 790 or 900 ppm-equivalent CO_2 GHG STABILIZATION POLICY

(Ref: Sokolov et al, Journal of Climate, 2009)

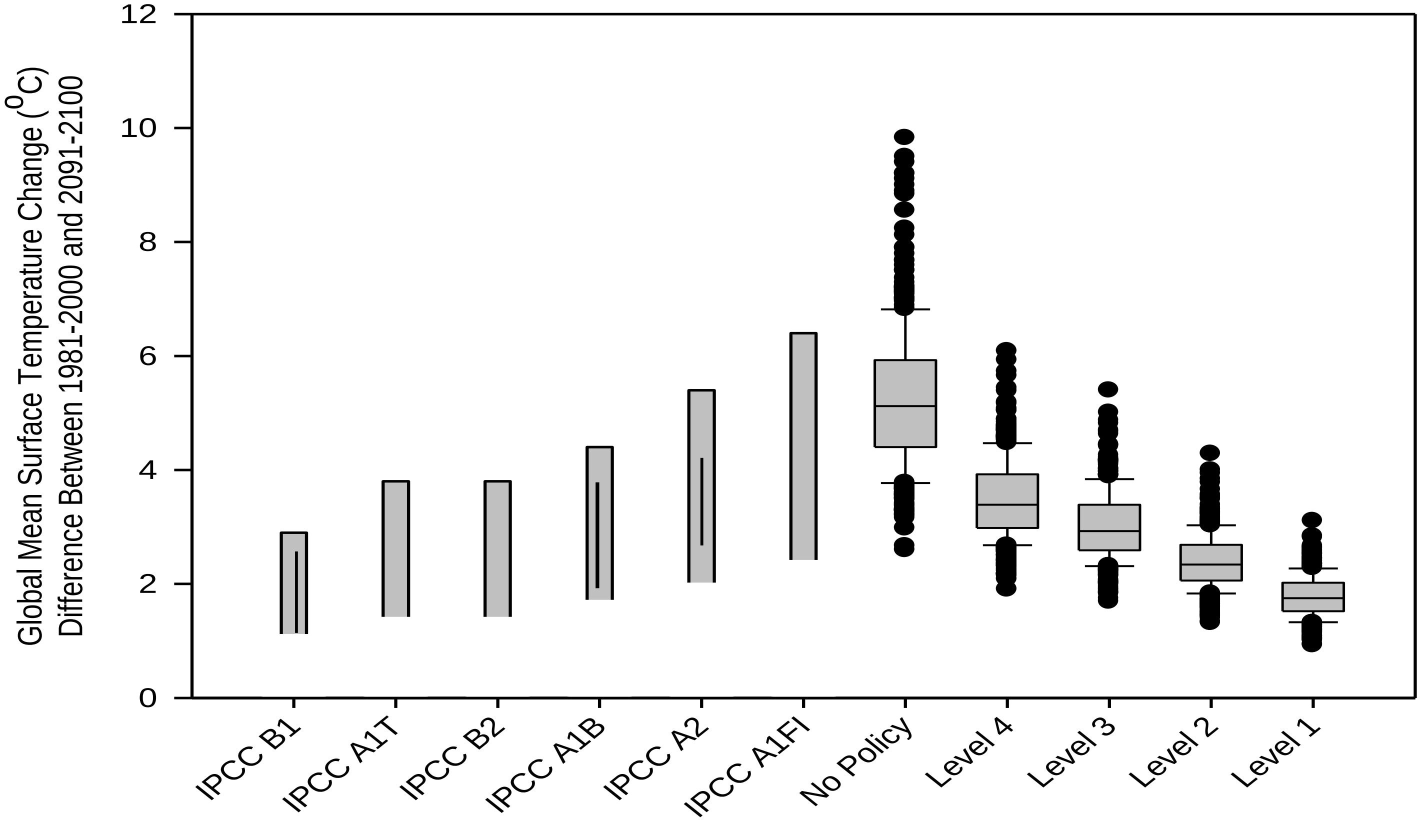
	ΔT > 2°C (*Values relative to 1860/pre-industrial)	ΔT > 4°C	ΔT > 6°C
No Policy at 1400	100%(*100%)	85%	25%
Stabilize at 900 (L4)	100%(*100%)	25%	0.25%
Stabilize at 790 (L3)	97%(100%)	7%	< 0.25%
Stabilize at 660 (L2)	80%(*97%)	0.25%	< 0.25%
Stabilize at 550 (L1)	25%(*80%)	< 0.25%	< 0.25%

GLOBAL SCIENCE POLICY CHANGE MIT

Comparison to Range in CCSP 2.1A



Comparison to IPCC



Global mean temperature change (from 1981-2000 to 2091-2100); IPCC SRES scenarios (Meehl et al. 2007). Grey bars for IPCC results indicate 66% and 90% probability), and solid black line indicates the 5-95% range of AOGCM results (only provided for B1, A1B, and A2). This analysis shown as box plots, where box indicates the 50% range, median, outer whiskers indicate the 5-95% range, dots individual outliers beyond the 95% bounds.

Change in the probability of exceeding illustrative targets for global mean surface temperature change, as measured by the change between the average for 1981-2000 and the average for 2091-2100.