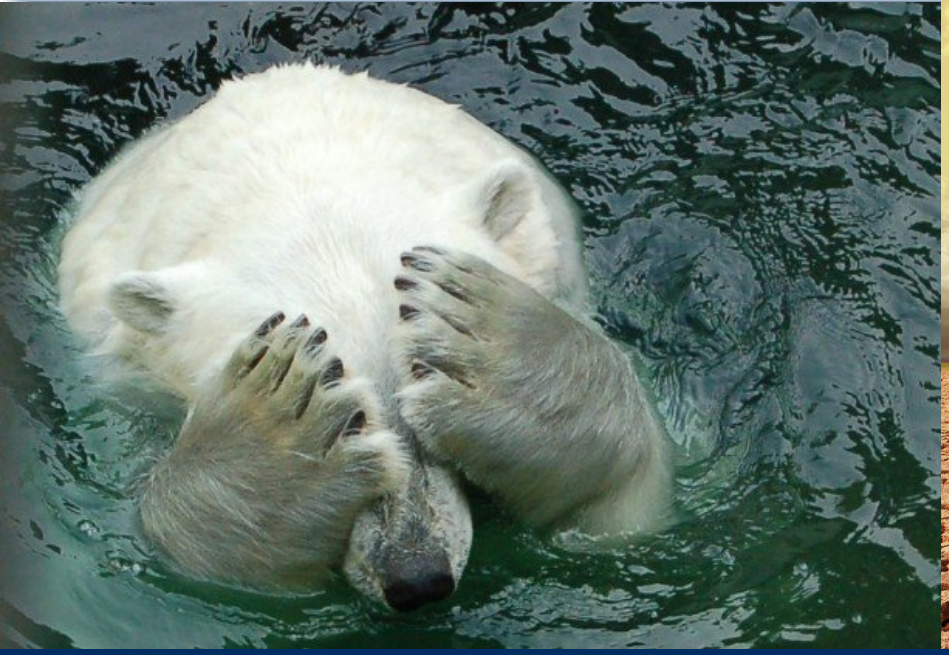


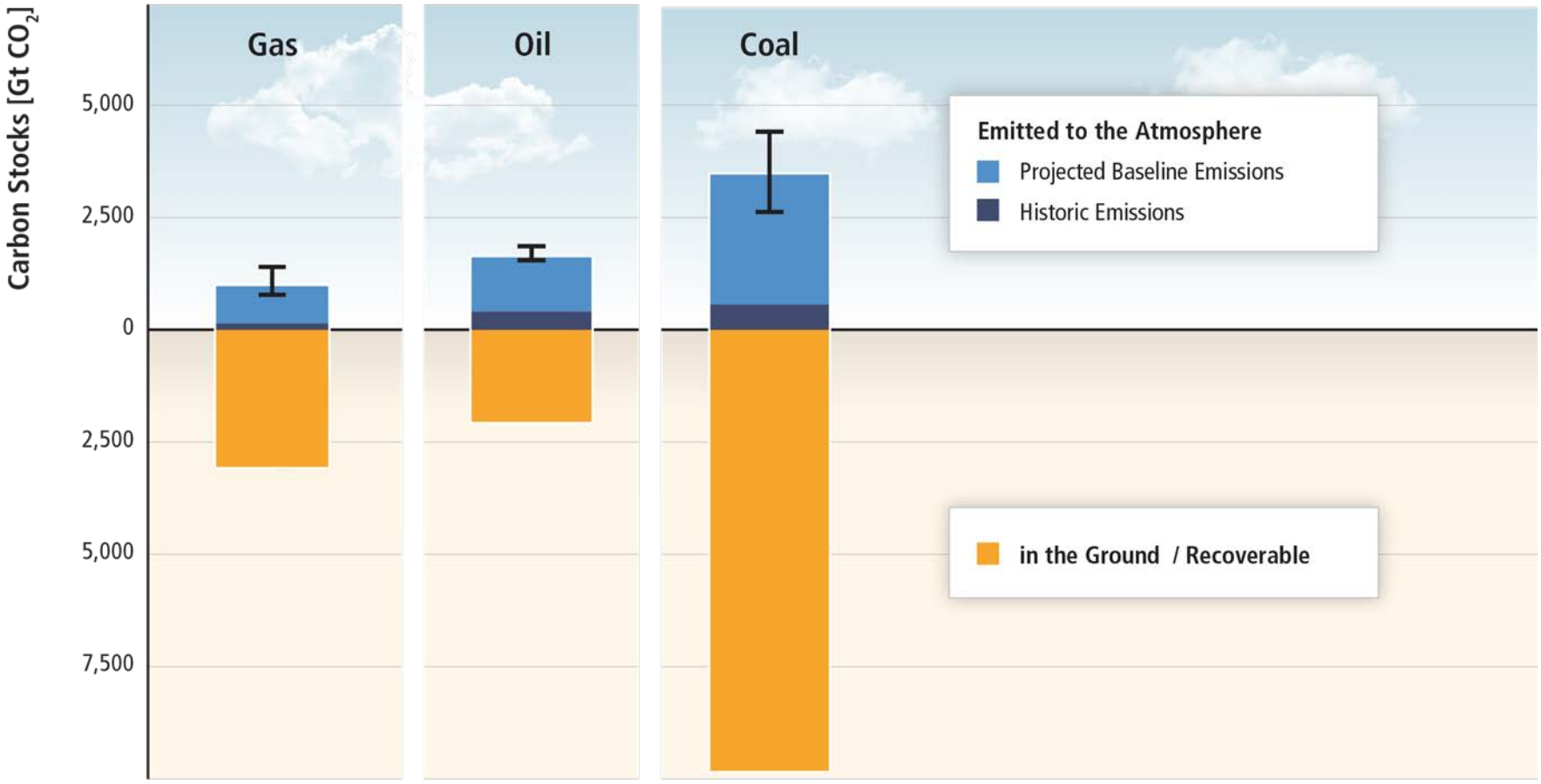
Emission Scenarios for the 21st Century

Sergey Paltsev

Massachusetts Institute of Technology

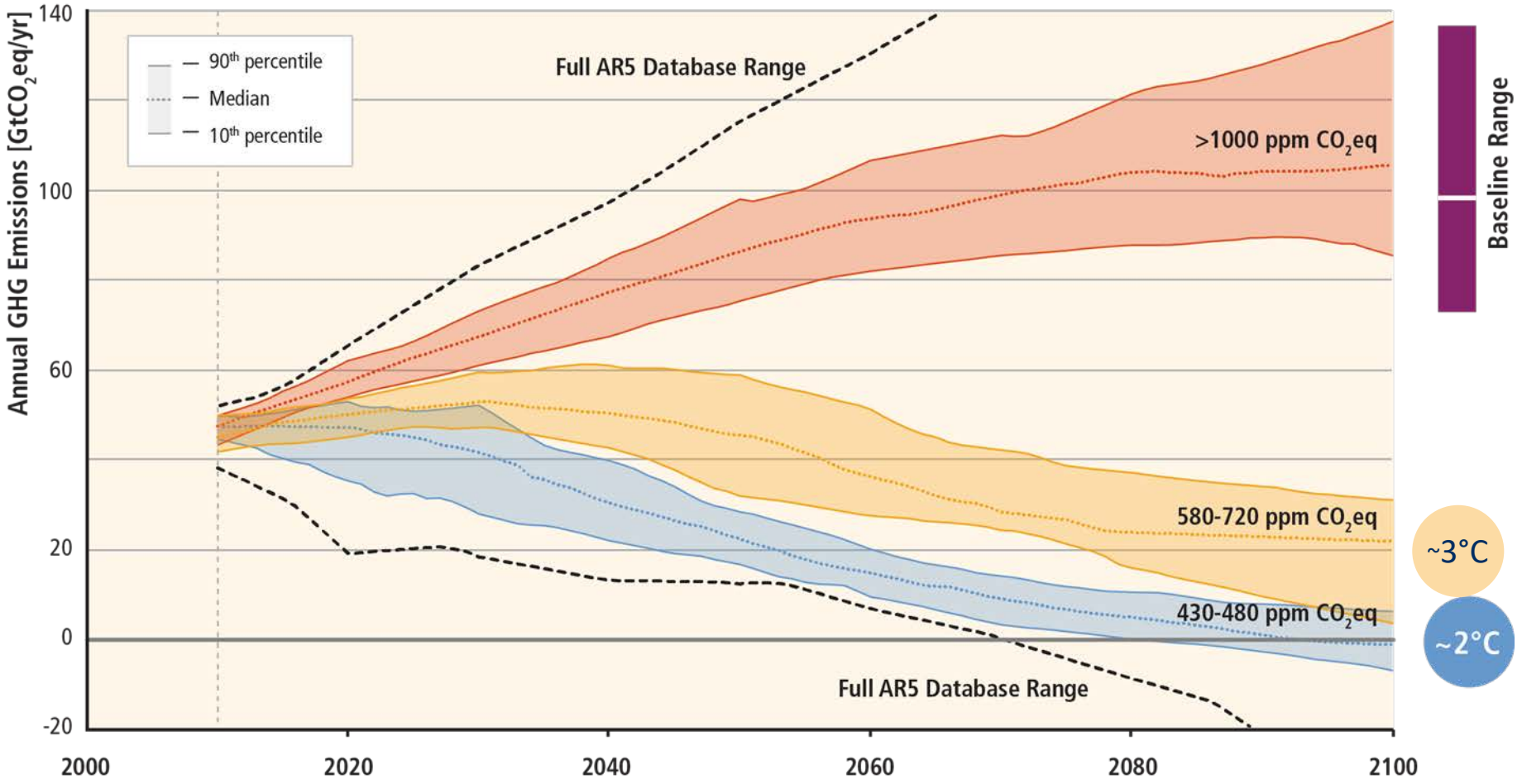
Sunbury, UK
September 25, 2018

Plenty of carbon in the ground



Based on SRREN Figure 1.7

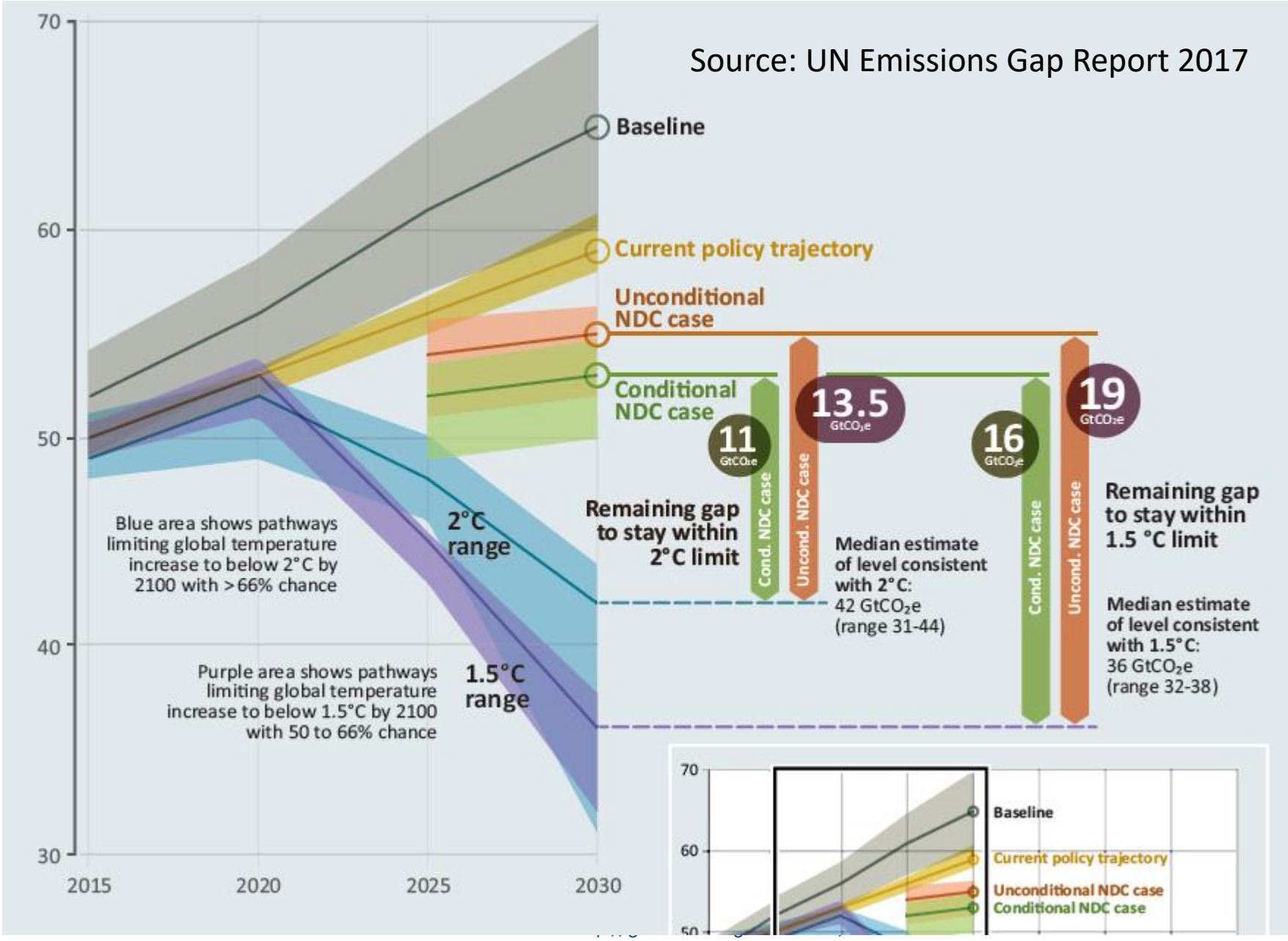
Move to low-carbon energy



Low climate stabilization scenarios are dependent on decarbonization

Based on AR5 WGIII Figure 6.7

2030 Gap


Source: UN Emissions Gap Report 2017
70
60
50
40
30
2015
2020
2025
2030
Baseline
Current policy trajectory
Unconditional NDC case
Conditional NDC case
11 GtCO2e
13.5 GtCO2e
16 GtCO2e
19 GtCO2e
Cond. NDC case
Uncond. NDC case
Cond. NDC case
Uncond. NDC case
Blue area shows pathways limiting global temperature increase to below 2°C by 2100 with >66% chance
2°C range
Remaining gap to stay within 2°C limit
Median estimate of level consistent with 2°C: 42 GtCO2e (range 31-44)
Purple area shows pathways limiting global temperature increase to below 1.5°C by 2100 with 50 to 66% chance
1.5°C range
Remaining gap to stay within 1.5 °C limit
Median estimate of level consistent with 1.5°C: 36 GtCO2e (range 32-38)
70
60
50
Baseline
Current policy trajectory
Unconditional NDC case
Conditional NDC case

Numerous emission scenarios

SRES (2000) – Special Report on Emission Scenarios
A1 (A1T, A1B, A1FI), A2, B1, B2

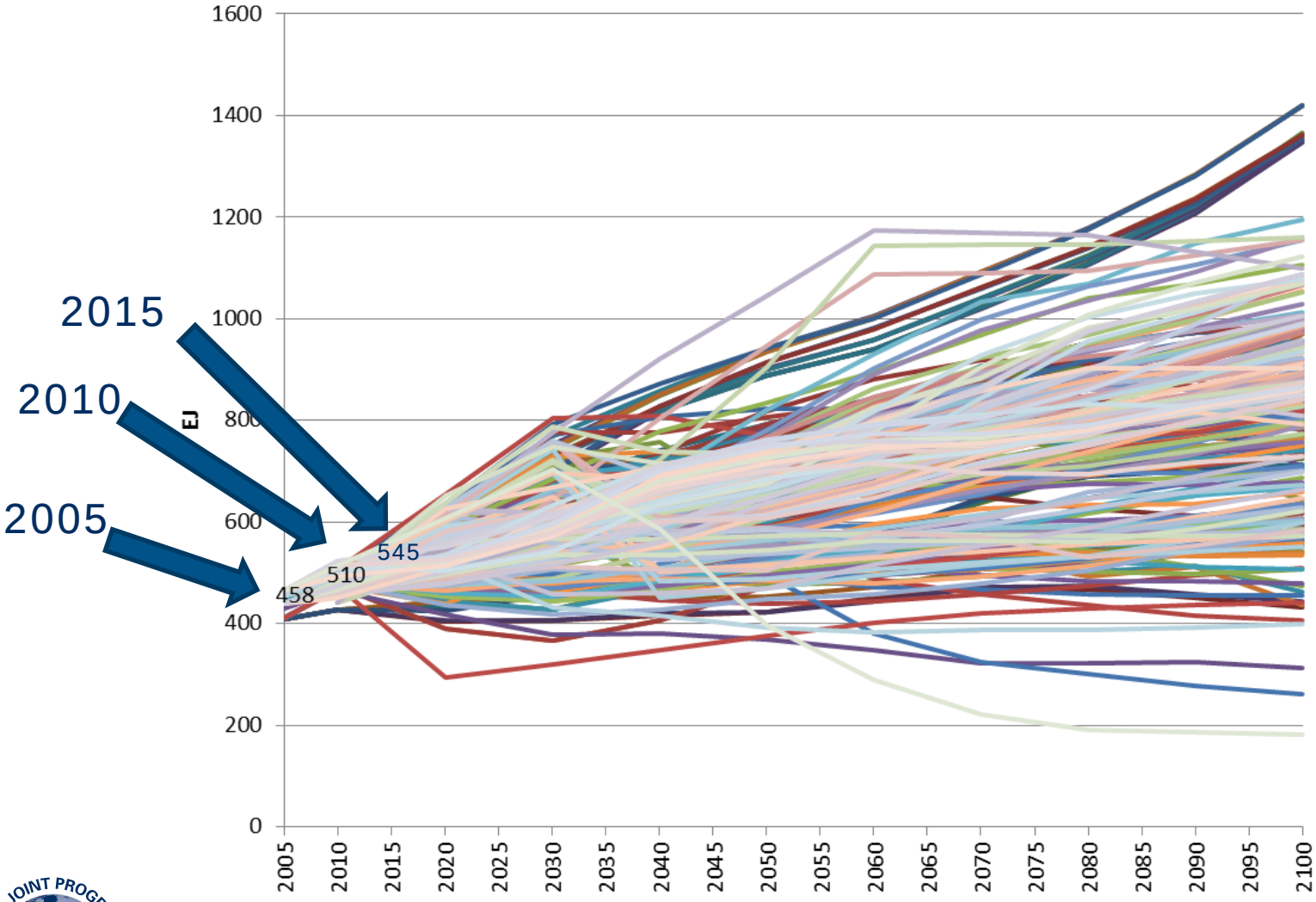
RCP (2009) – Representative Concentration Pathways
RCP8.5, RCP6.0, RCP4.5, RCP2.6
http://www.iiasa.ac.at/web-apps/tnt/RcpDb/

AR5 Database (2014) – 1,184 scenarios
https://tntcat.iiasa.ac.at/AR5DB/

SSP (2016) – Shared Socioeconomic Pathways
SSP1-SSP5
https://tntcat.iiasa.ac.at/SspDb/

Integrated Scenarios
From modeling teams that have both Human System and Earth System Components

2C Scenarios from IPCC AR5: Global Primary Energy



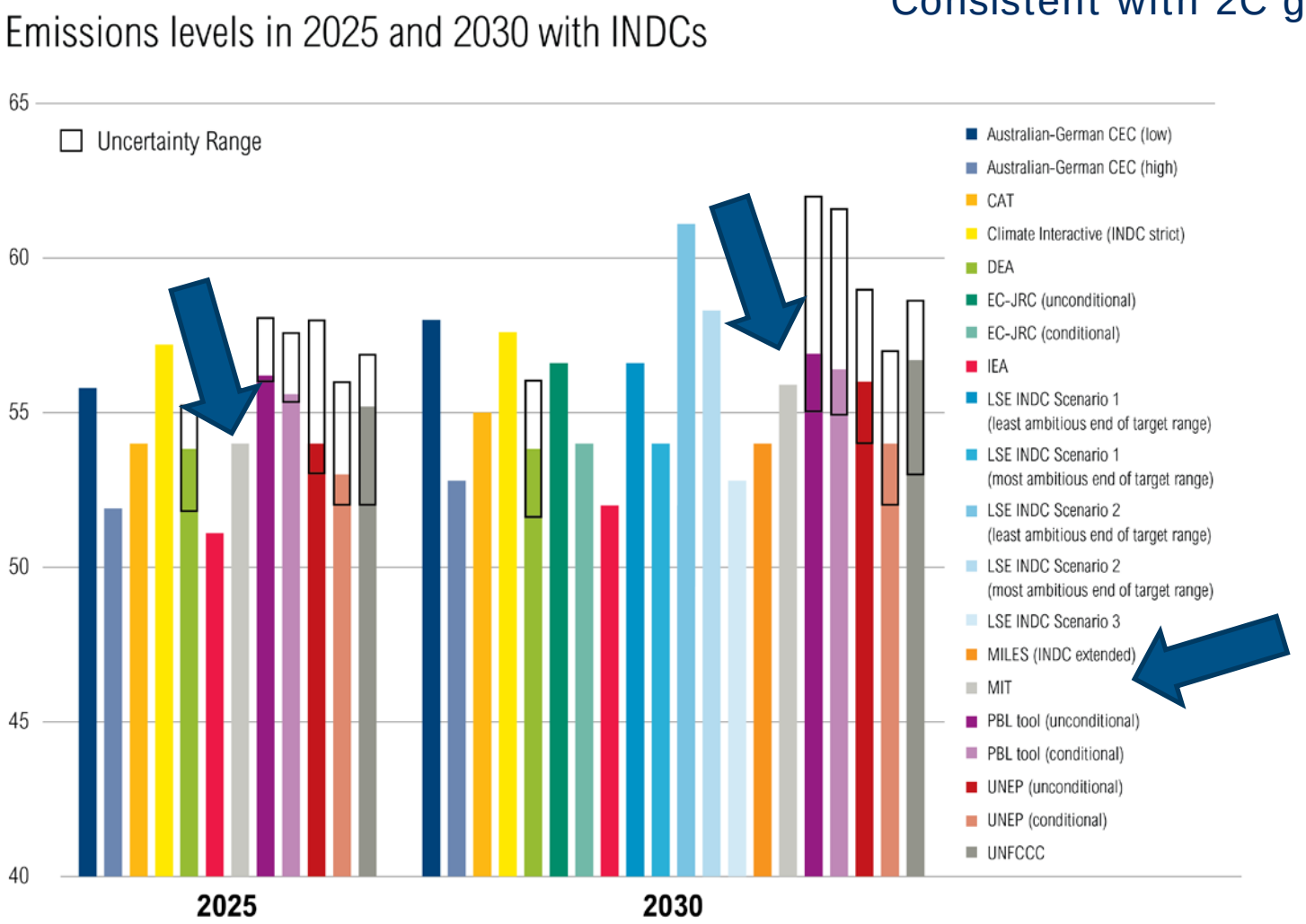
Combining scenarios from different groups

392 of 2C scenarios out of 1,184 total scenarios in AR5

"spaghetti diagram"

GHG Emissions from Proposals for COP-21

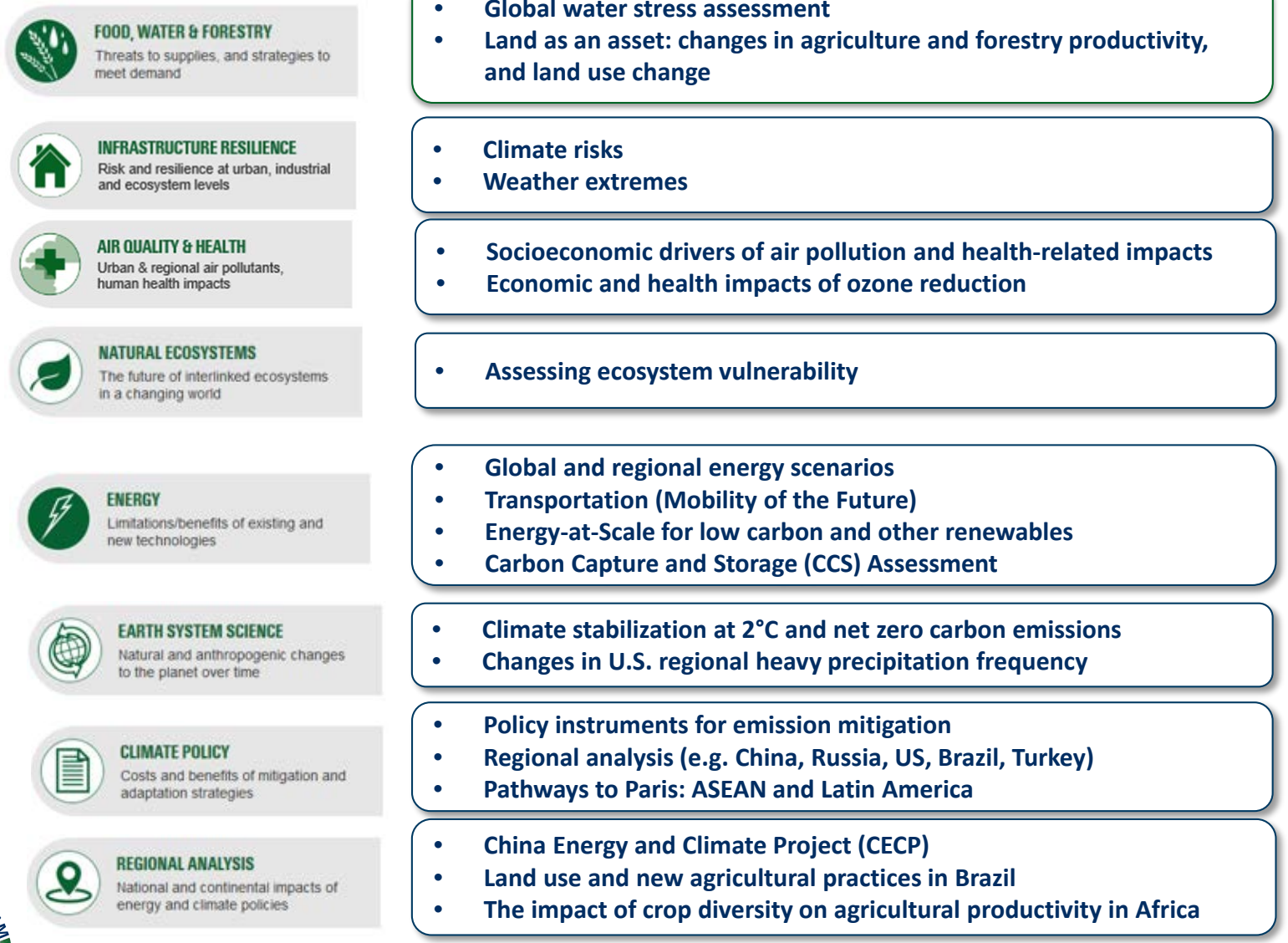
Consistent with 2C goal?



http://bit.ly/indc-temp

WORLD RESOURCES INSTITUTE

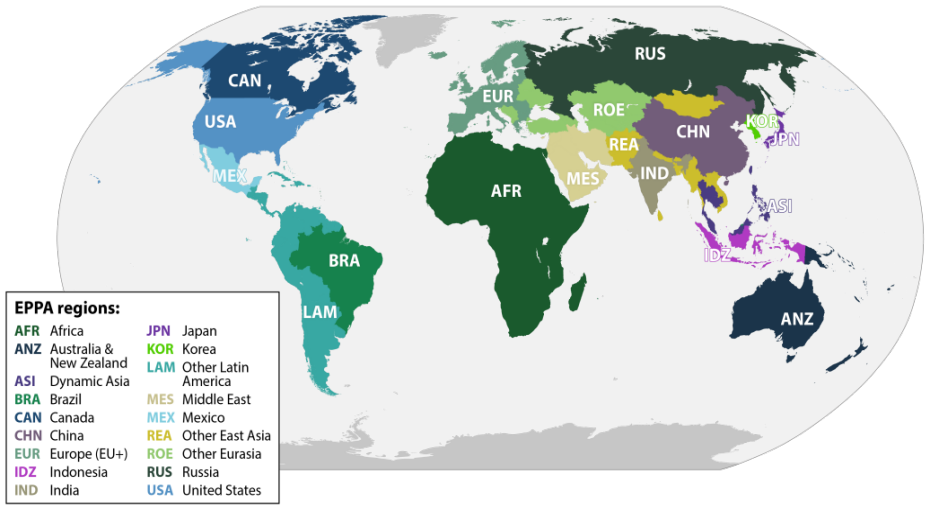
MIT Joint Program Select Research Examples



Tool for Analysis: MIT EPPA Model

Major goals:
Energy, economy, GHG and air pollutants projections.

Representation:
Global coverage,
All sectors of economy.



Non-Energy
- Crops
- Livestock
- Forestry
- Food
- Energy Intensive Ind.
- Manufacturing
- Services
- Industrial Transport
- Household Transport

Energy
- Crude oil
- Refined oil
- Liquid fuel from biomass
- Oil Shale
- Coal
- Natural gas (conv., shale, tight, CBM)
- Electricity
- Synthetic gas (from coal)

Vehicle Types
ICE (gasoline & diesel)
Plug-in Electric
Battery Electric

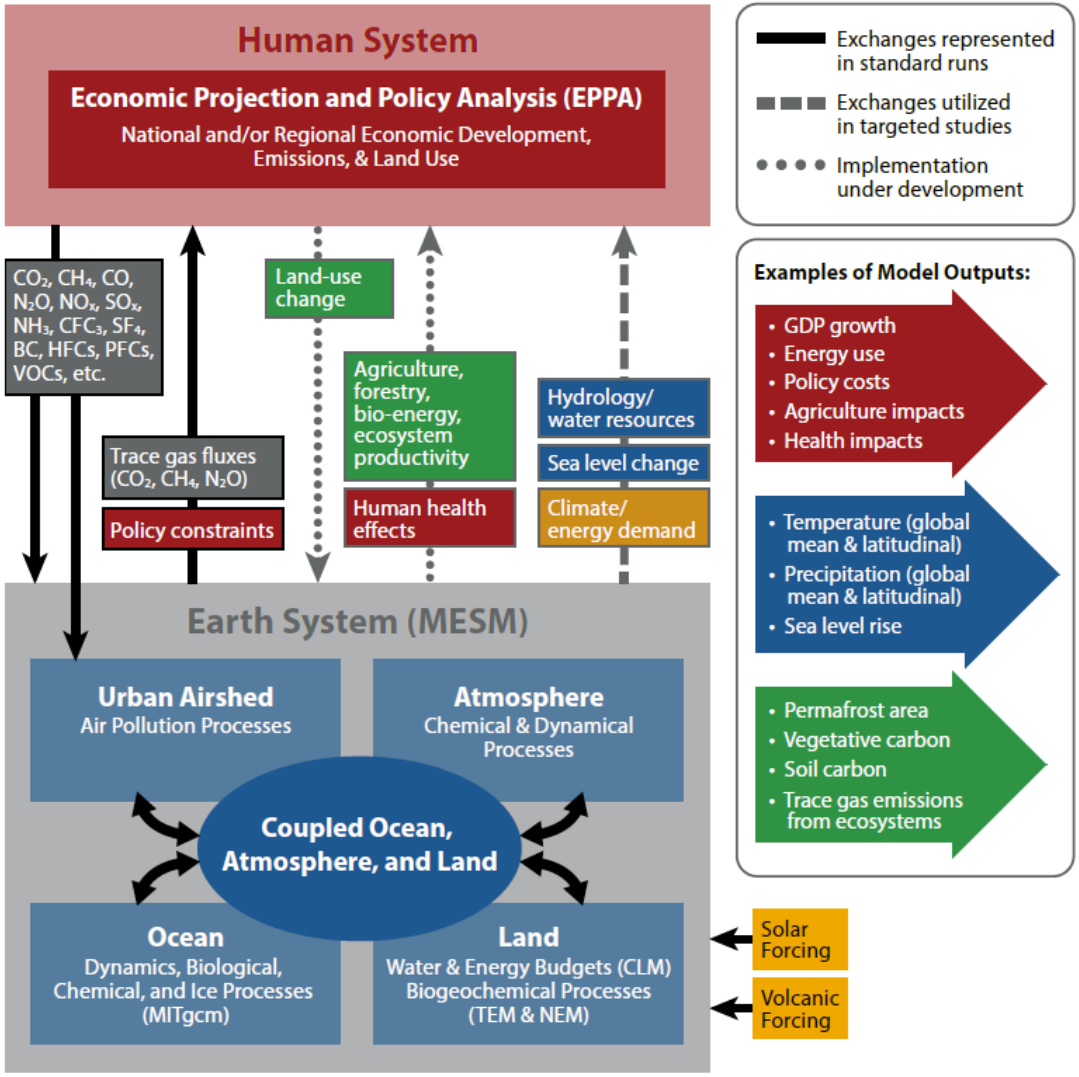
Biofuels
Current generation (Ethanol from Biodiesel)

Advanced biofuel

Technologies Included
Fossil (oil, gas, coal)
Advanced NG (NGCC)
Coal with carbon capture
Gas with carbon capture
Nuclear
Hydro
Wind and solar
Biomass

Features: Theory-based; Prices are endogenous; International Trade; Inter-industry linkages; Distortions (taxes, subsidies, etc); GDP and Welfare effects.
Trade-off: Aggregated representation of technologies.

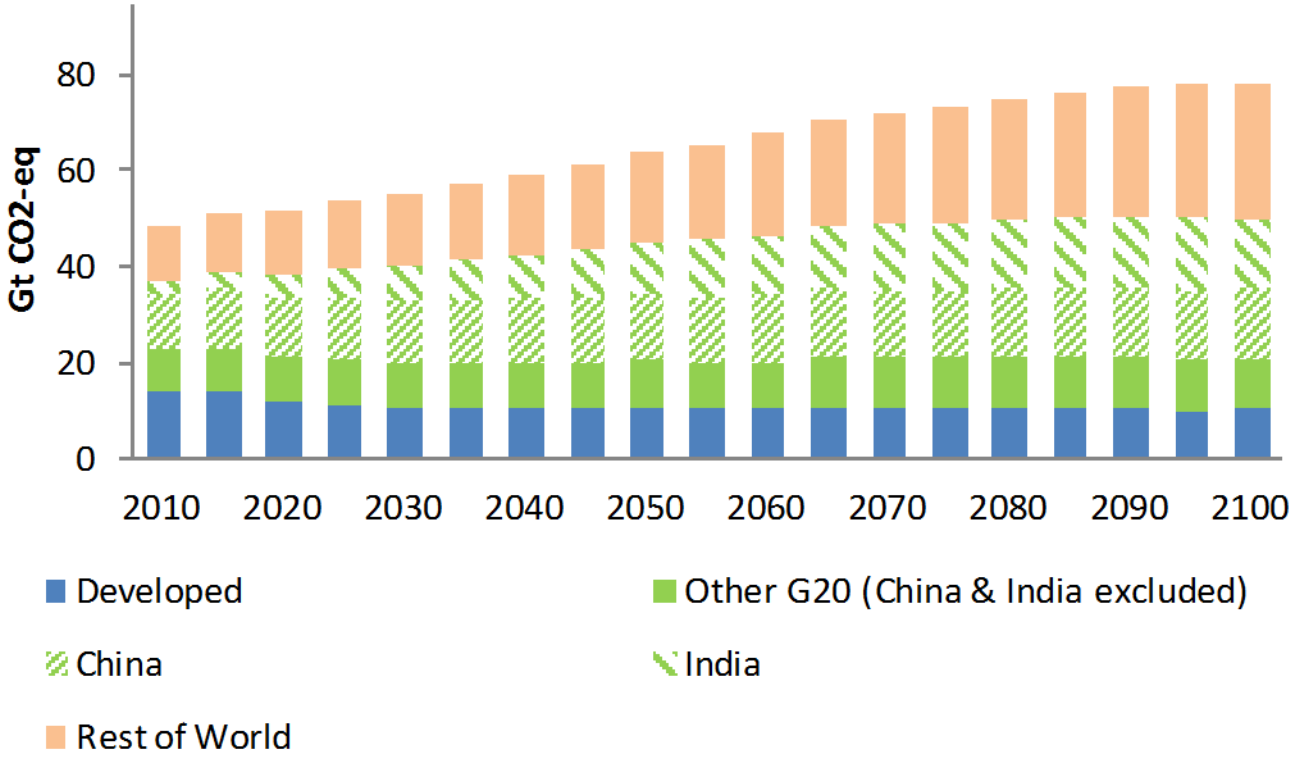
THE MIT INTEGRATED GLOBAL SYSTEM MODEL (IGSM)
Earth and Human System Links



MIT Joint Program Outlooks

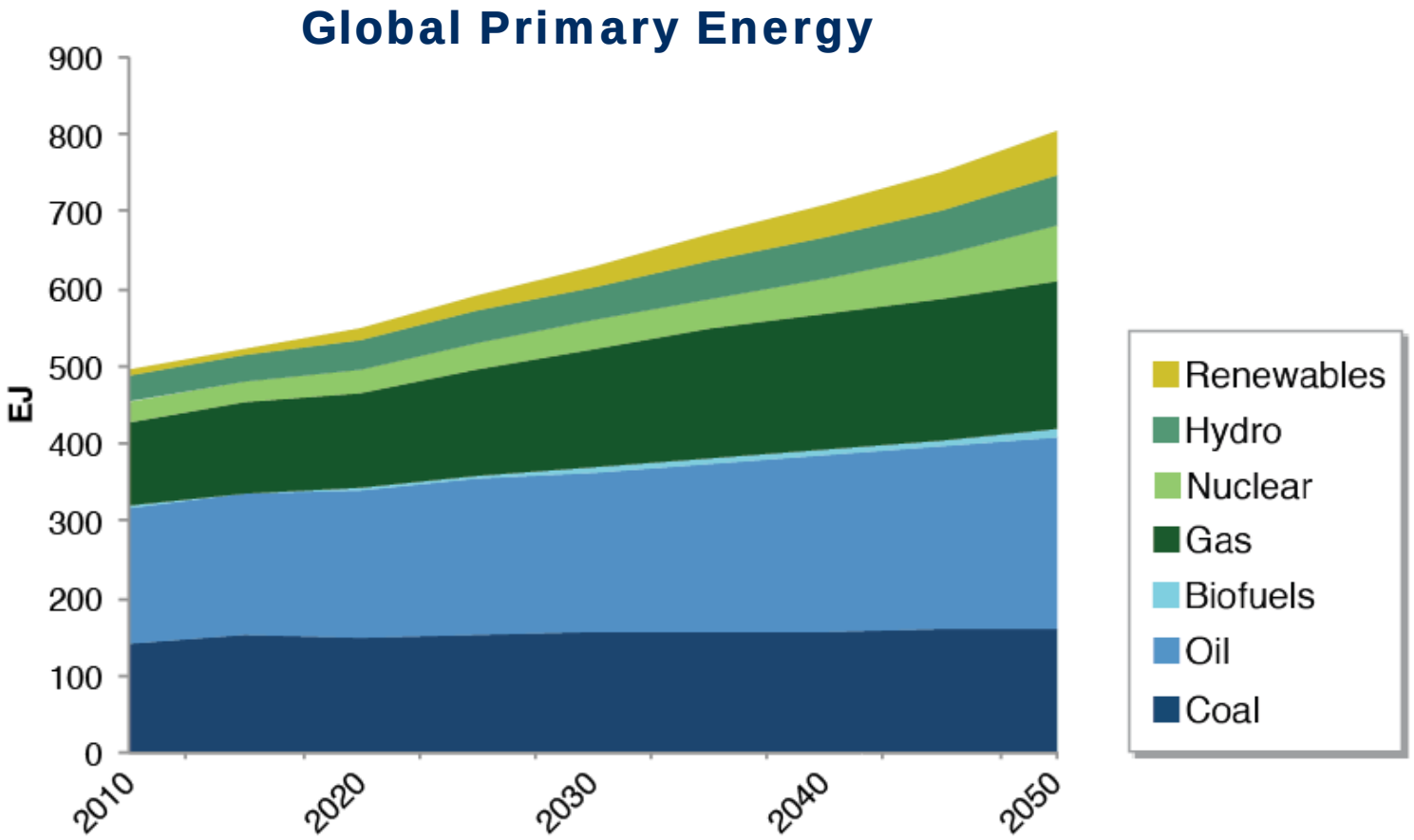
Annual signature publication – in 2016 expanded to food and water

Expected Global GHG Emissions if Paris Pledges are Implemented, but No Further Action



Emissions are flat and declining for most of the G20 (including China) and Developed countries but emissions in India and the Rest of the World would continue to grow.

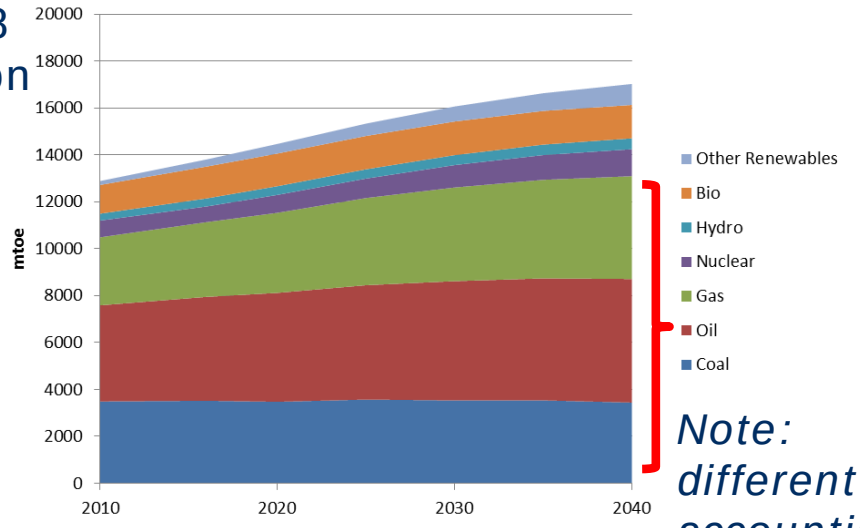
The world remains largely fossil fuel dominated: ~75% but down from ~83% w/o the Paris agreement



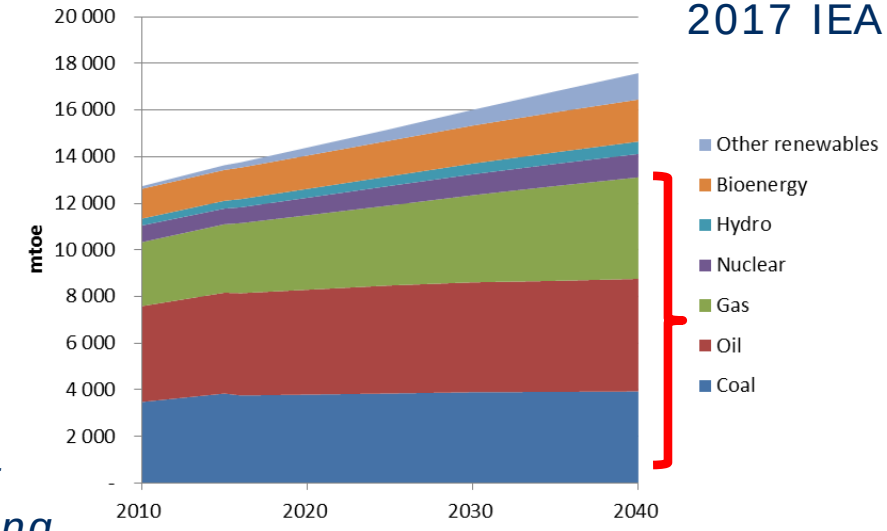
Renewables (8x) and nuclear (3x) expand several fold but not enough to drive out fossil fuels

“Best guesses” – ExxonMobil, BP, “New Policies” – IEA, “Outlook” (draft) – MIT Joint Program

2018 Exxon

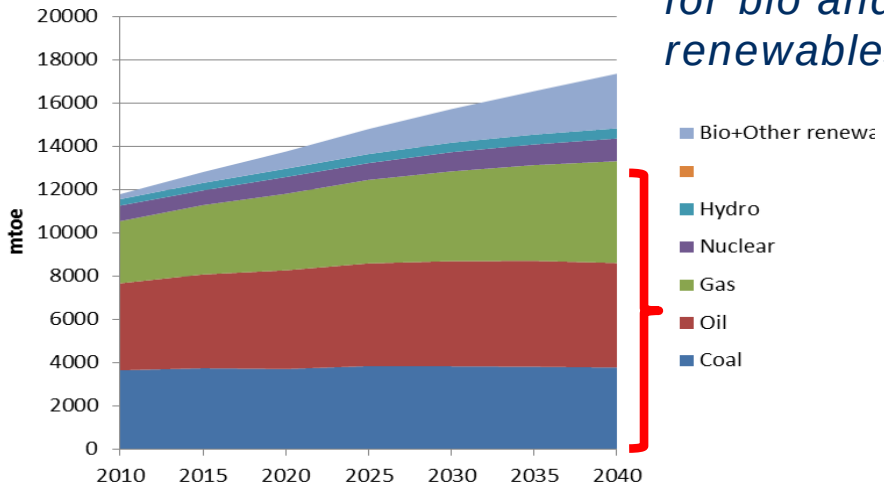


2017 IEA

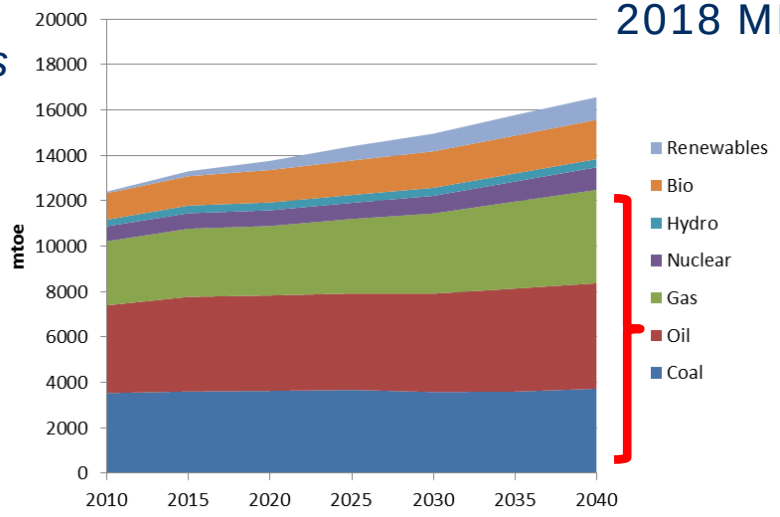


Note: different accounting for bio and renewables

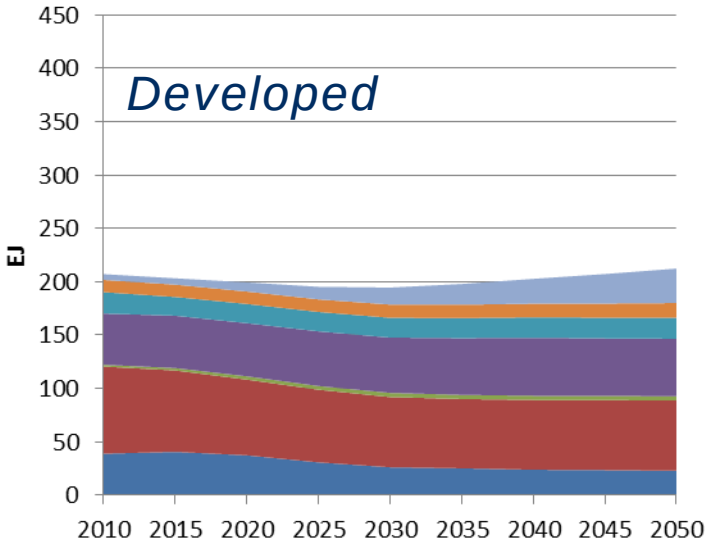
2018 BP

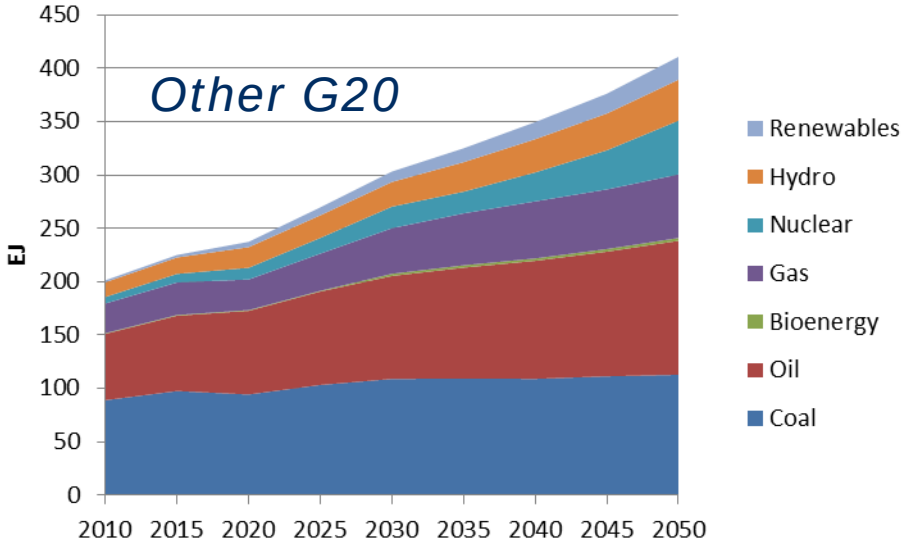


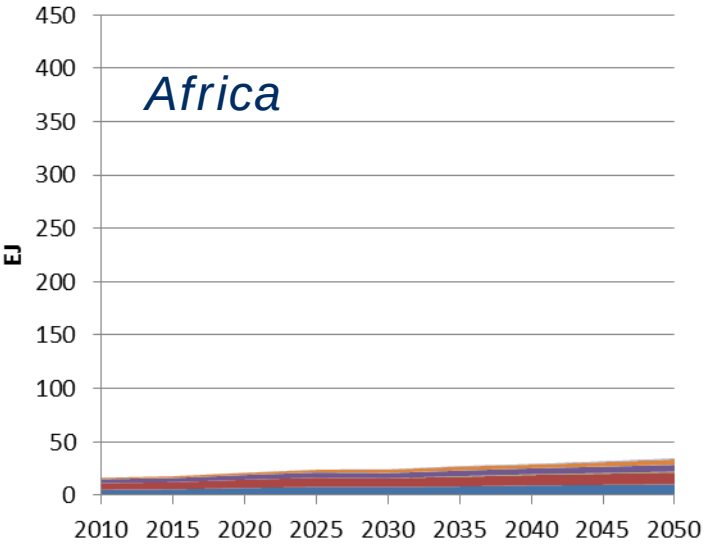
2018 MIT

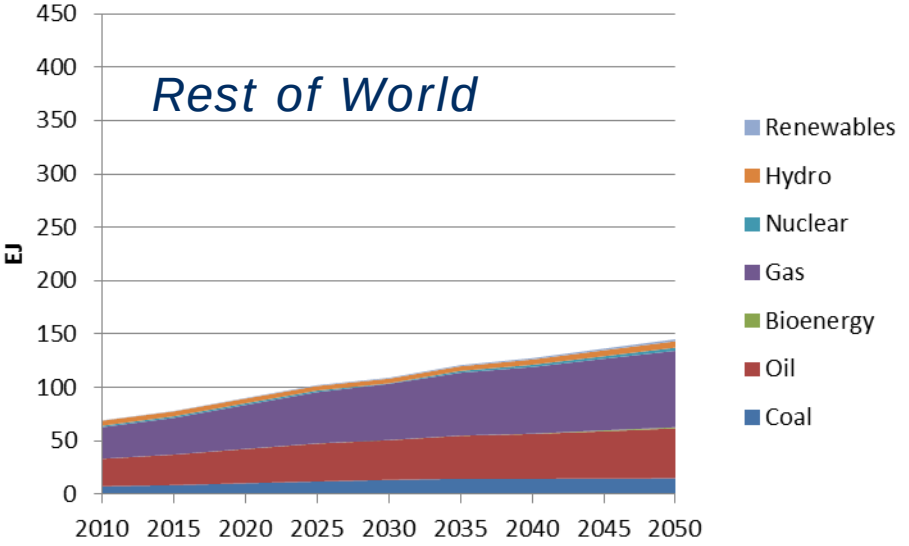


Energy Use by region

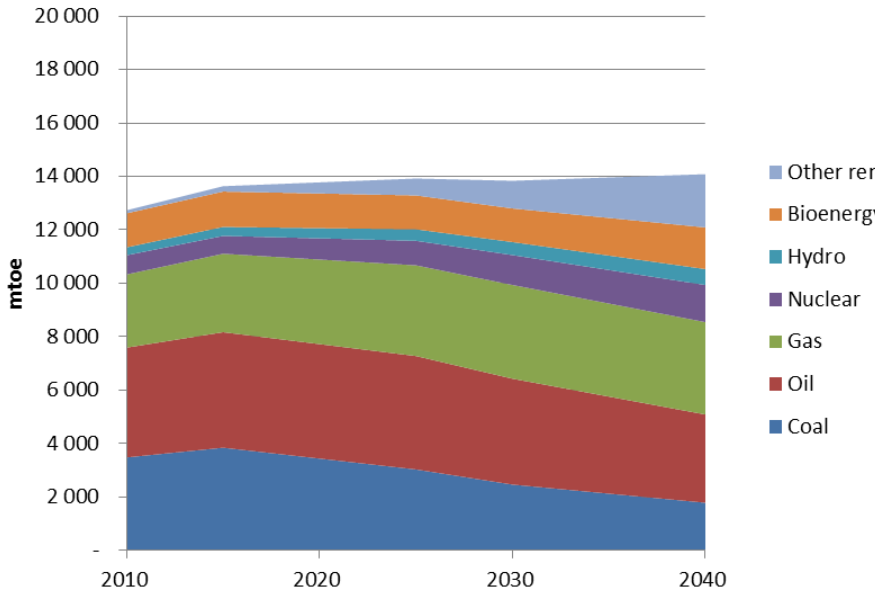




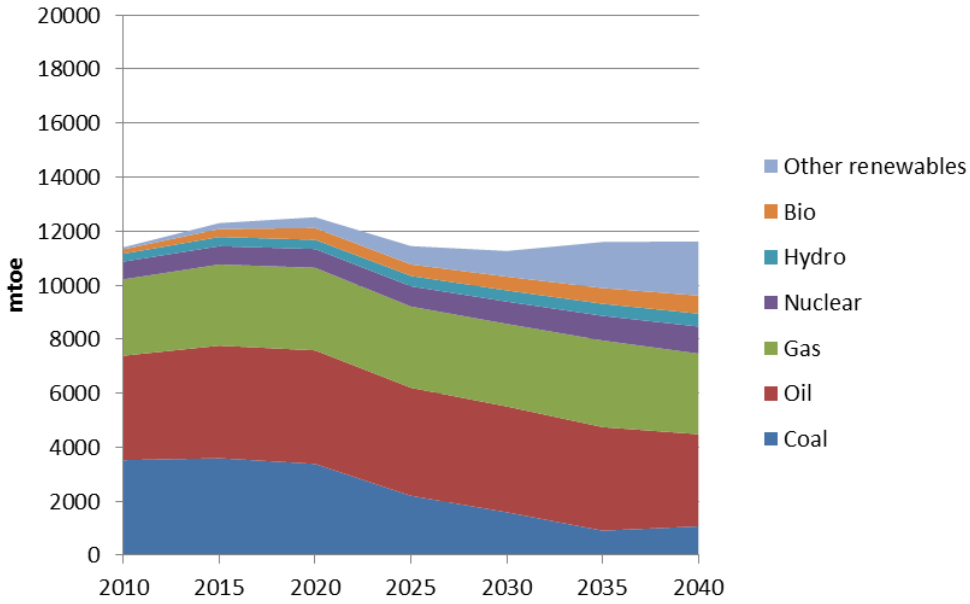




“SDS” – IEA, “2C” (draft) – MIT Joint Program



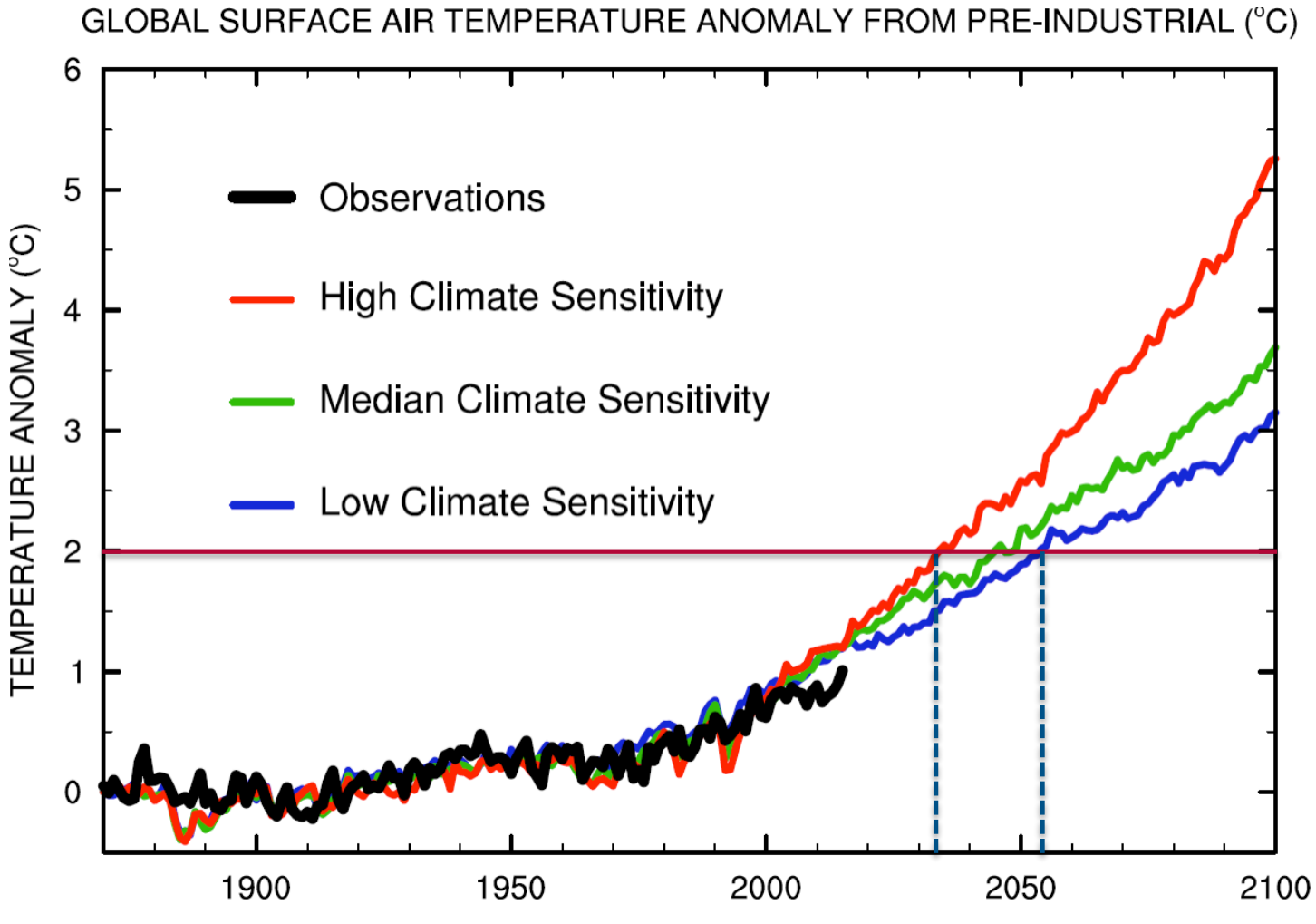
2017 IEA



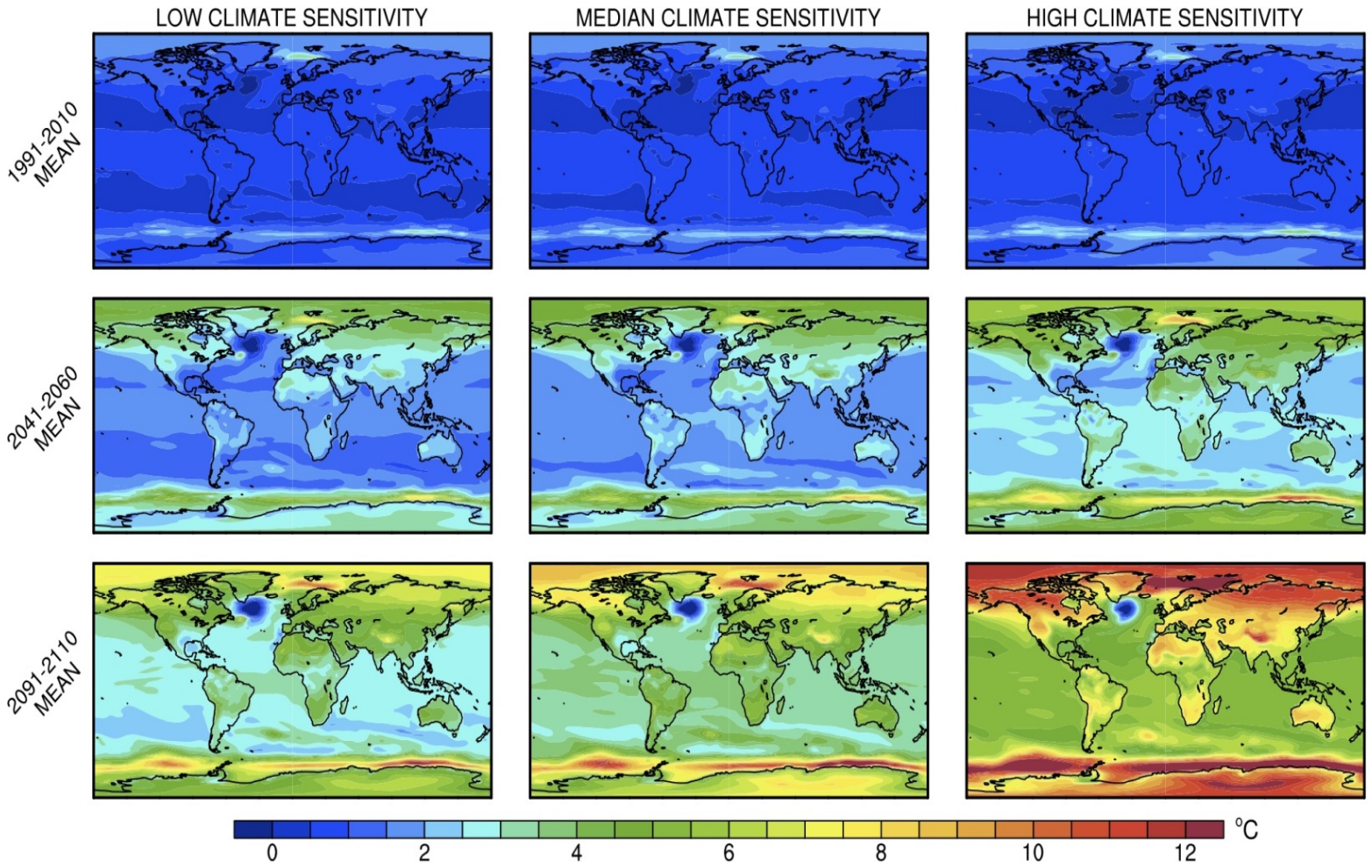
2018 MIT

Traditional biomass is not explicitly represented in the economic model

The current path is not consistent with stabilizing at 2° C



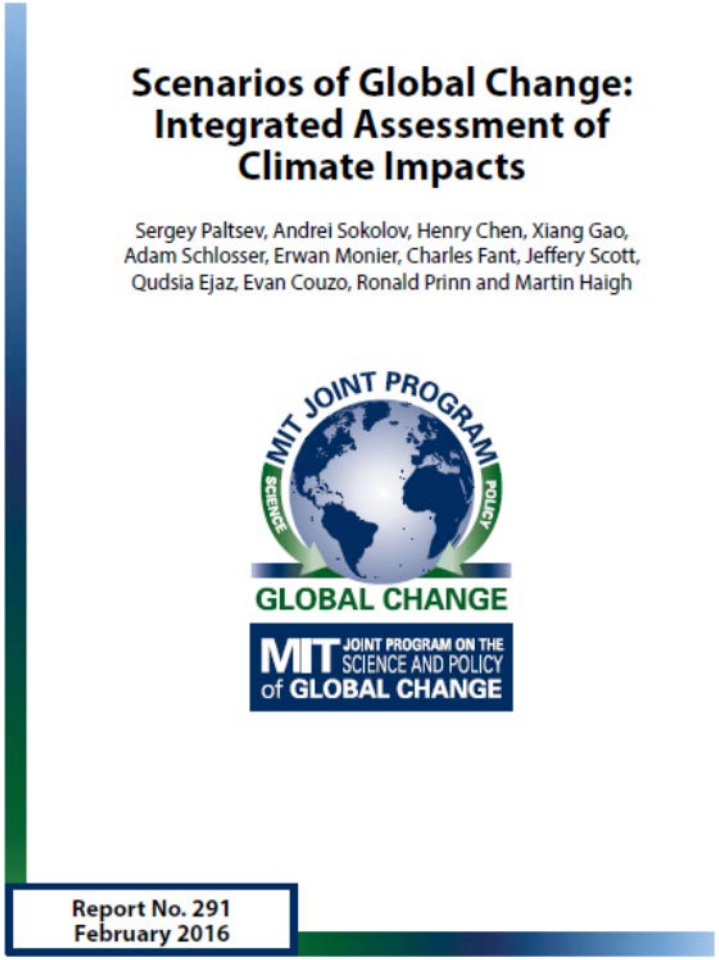
Mean Surface Temperature



Polar regions warming more than the rest of the planet.

Other climate results: see MIT JP Outlook

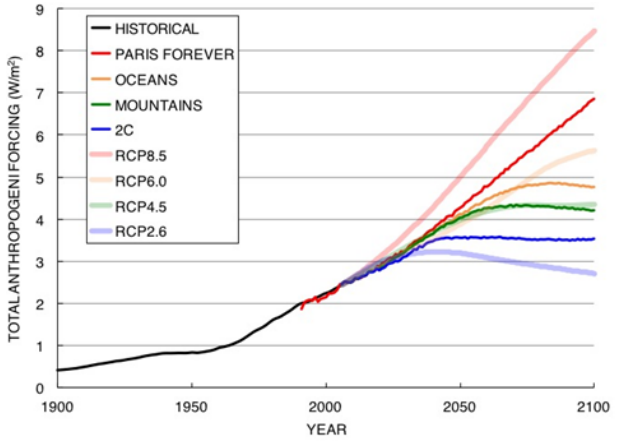
Climate Impacts

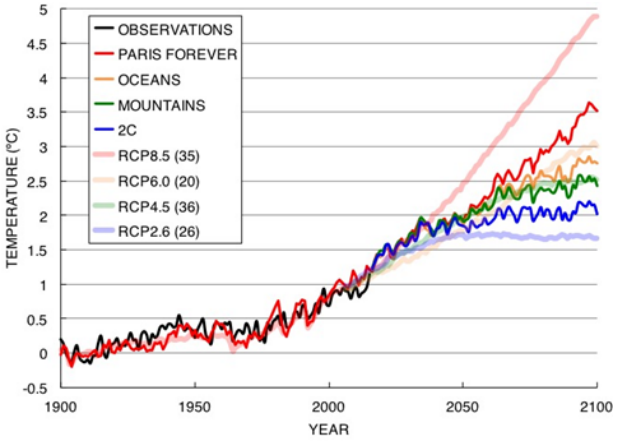


http://globalchange.mit.edu/research/publications/2948

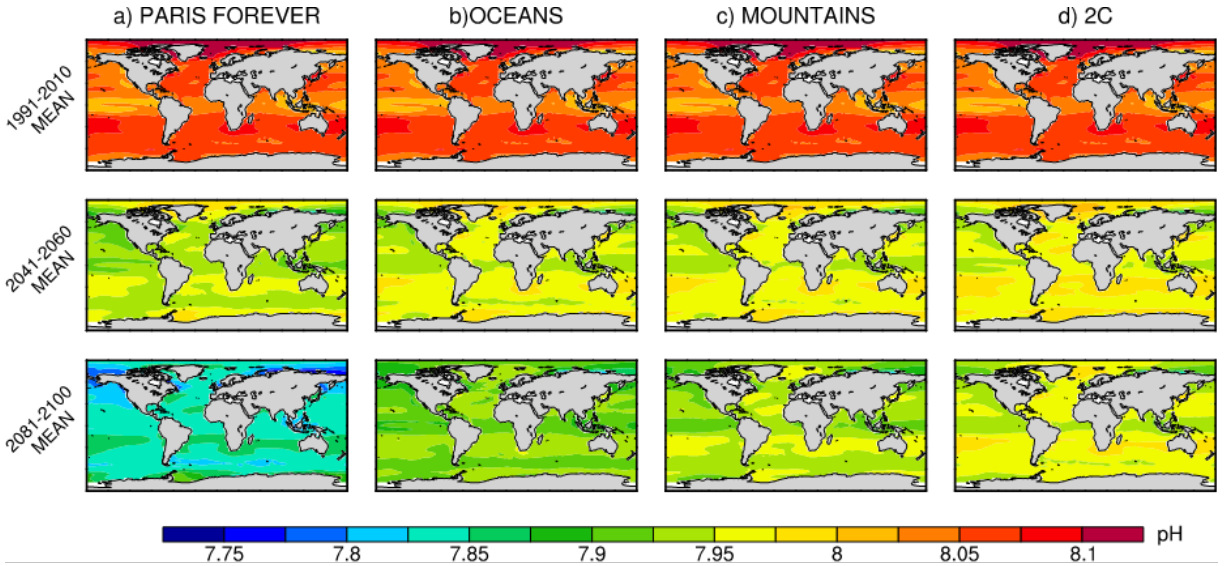
Major Climate Impacts

Radiative Forcing and Temperature



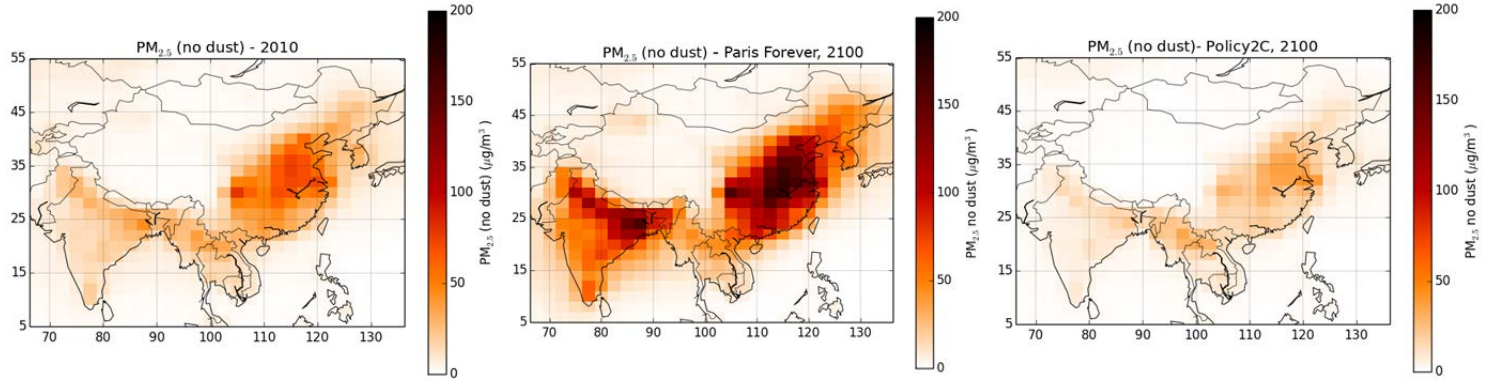


Oceanic Acidity

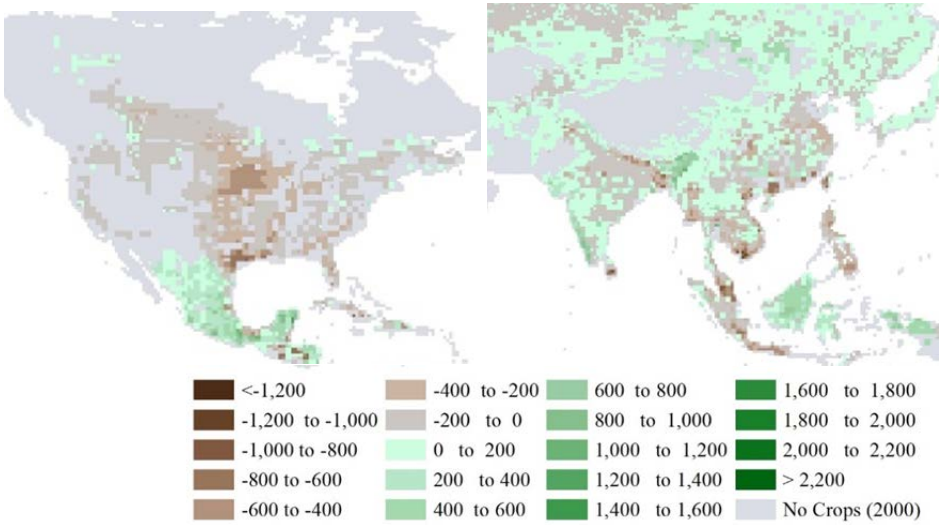


Major Climate Impacts (cont.)

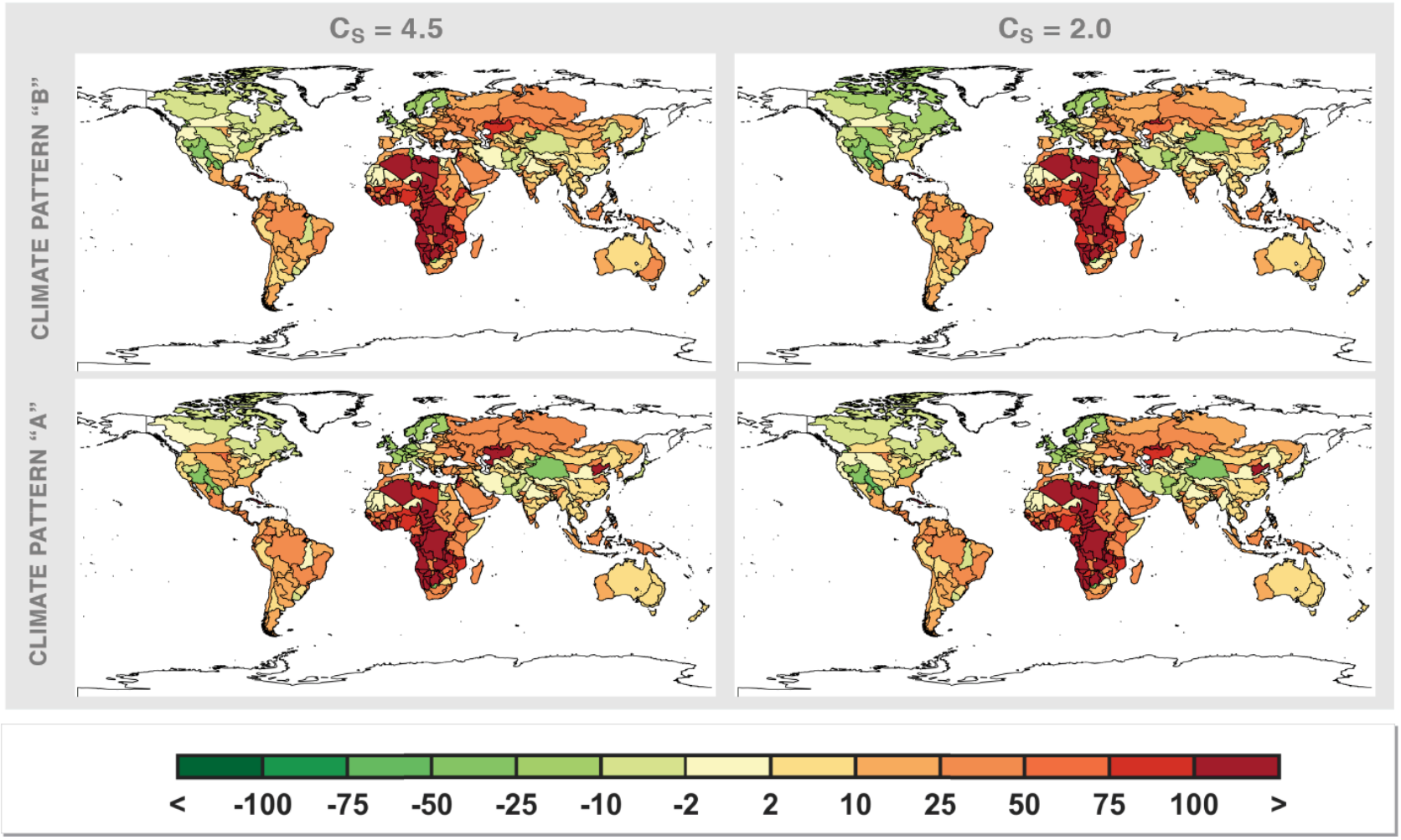
Air Pollution ($PM_{2.5}$ concentrations)



Change in Crop Productivity (2000-2100)

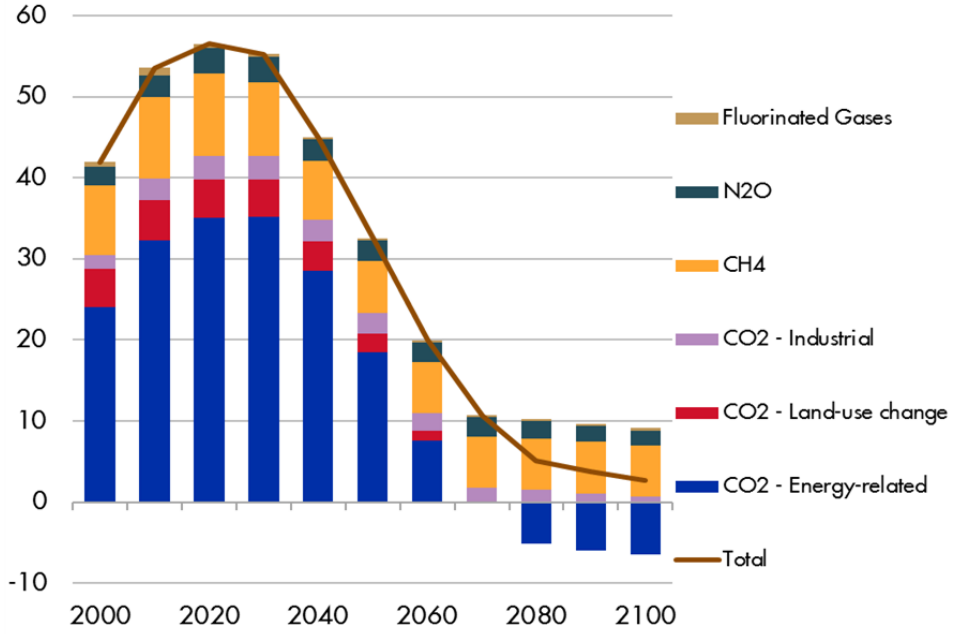


Implications: For 2050 (2041-2060)
(% change in WSI index from present (2001-2020))



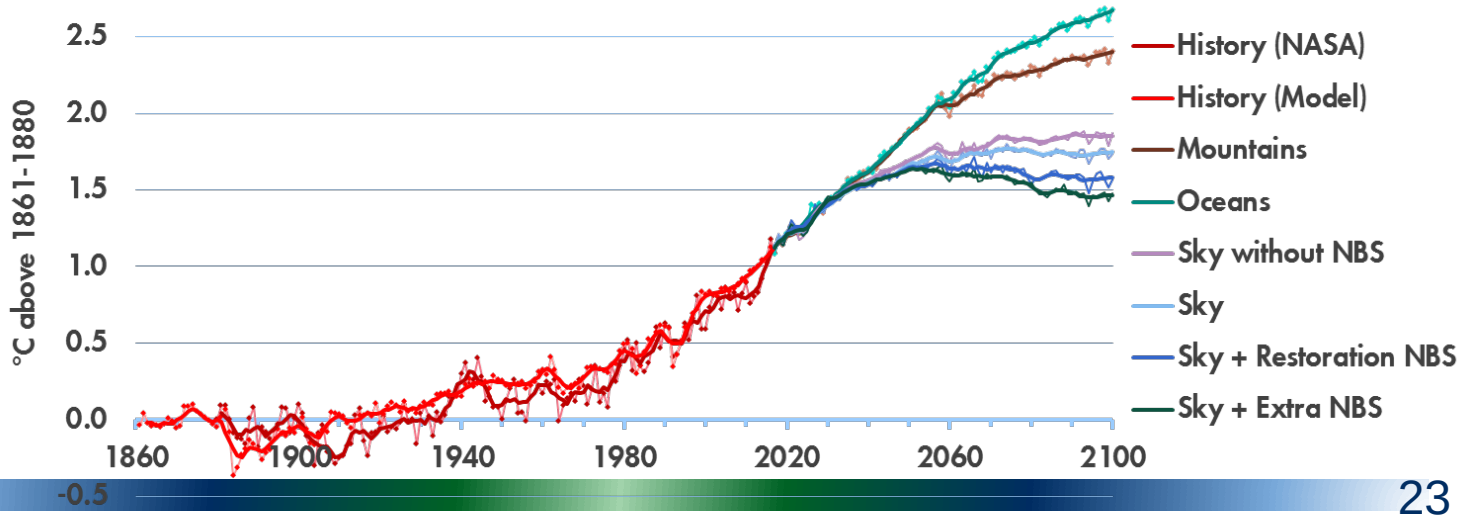
Simulated for two climate patterns (A and B) and two levels of climate sensitivity. Much of stress increase is due to increased demand from growth, but climate often an aggravating factor.

Major energy companies (Shell, BP, Total…) realize the need for a different energy mix



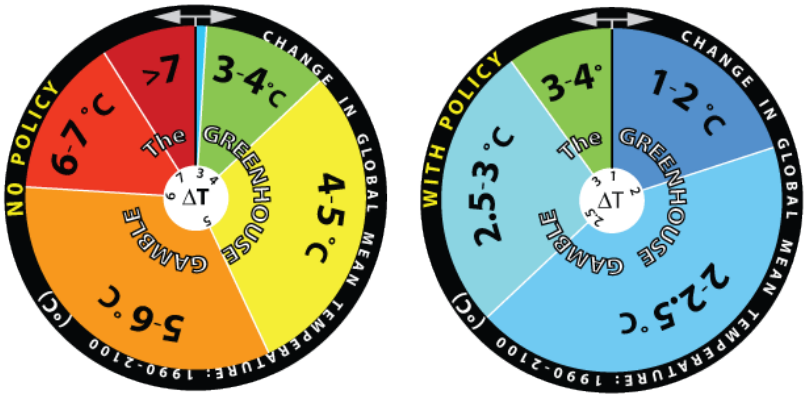
Shell Sky Scenario: Drastic changes in GHG emissions ($GtCO_2$/year)

Temperature Implications of Sky are analyzed by MIT Joint Program (MIT JP Report 330)
https://globalchange.mit.edu/publication/16995



Preparing for Tomorrow Today

- While the world has made progress, much more effort is needed to avoid dangerous climate change.
- The 2025-2030 pledges for the Paris Agreement do not take us very far in the energy transformation ultimately needed to avoid the risk of dangerous warming.
- Even if policy efforts in developed countries are successful in holding emissions constant, the emission increases of other nations – growing and industrializing – will contribute to further increases in greenhouse gas concentrations and climate change.



THE GREENHOUSE GAMBLE

Thank you

Questions or comments?
Please contact Sergey Paltsev at paltsev@mit.edu.

http://globalchange.mit.edu/