Projecting Energy and Climate for the 21st Century: MIT Joint Program Outlook

Sergey Paltsev

Massachusetts Institute of Technology

Briefing at U.S. Energy Association

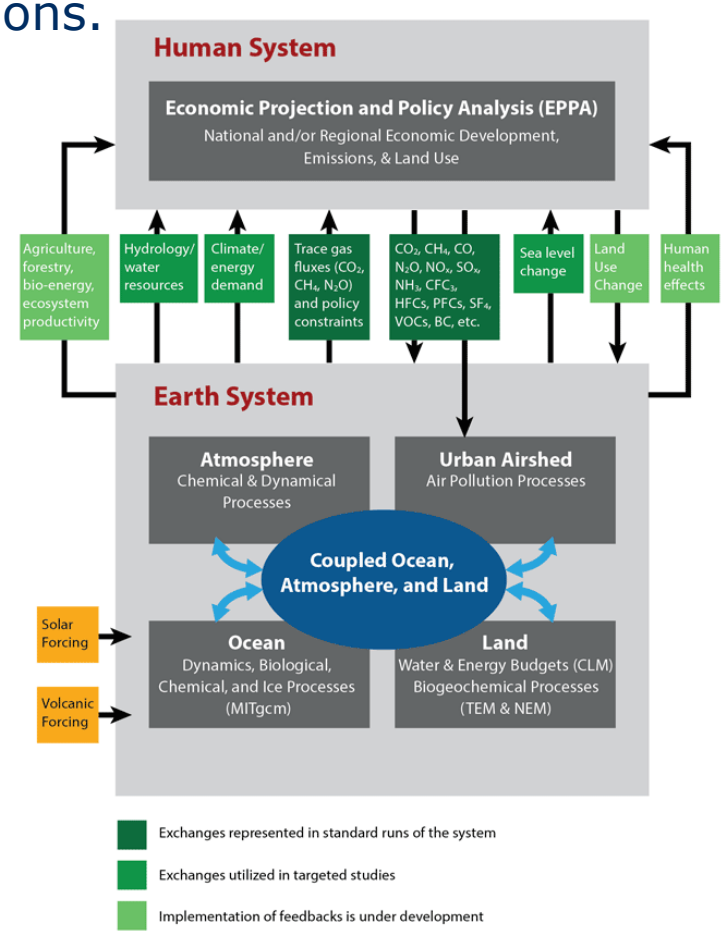
Washington, DC
June 30, 2015

Setting

Annual outlook at the world's current development path and the associated energy and climate implications.

It uses MIT IGSM: economic, energy, land use, emissions projections from the EPPA model; climate projections from the MESM.

It incorporates our assessment of the current emission pledges and shows how far these pledges take us, and what is at risk if we fail to push beyond these goals.



Available at:

http://globalchange.mit.edu/research/publications/other/outlook

MIT JP Outlook

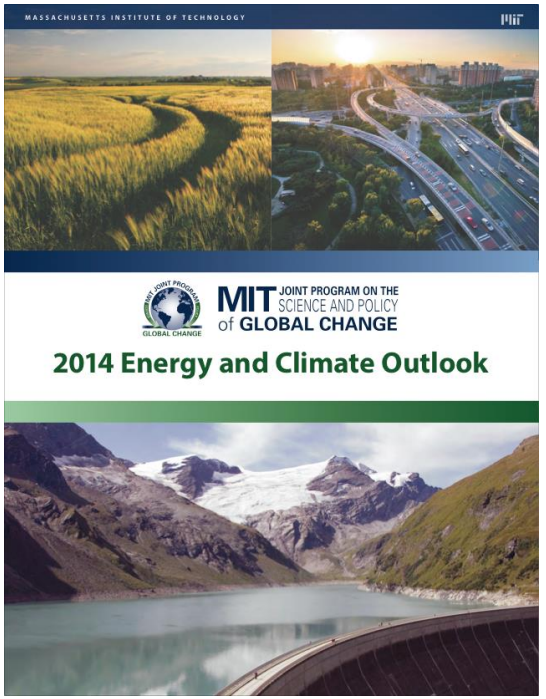
MIT JP Outlooks are issued annually from 2012.

This presentation focuses on the 2014 edition of the Outlook, with some preview of the 2015 Outlook results.

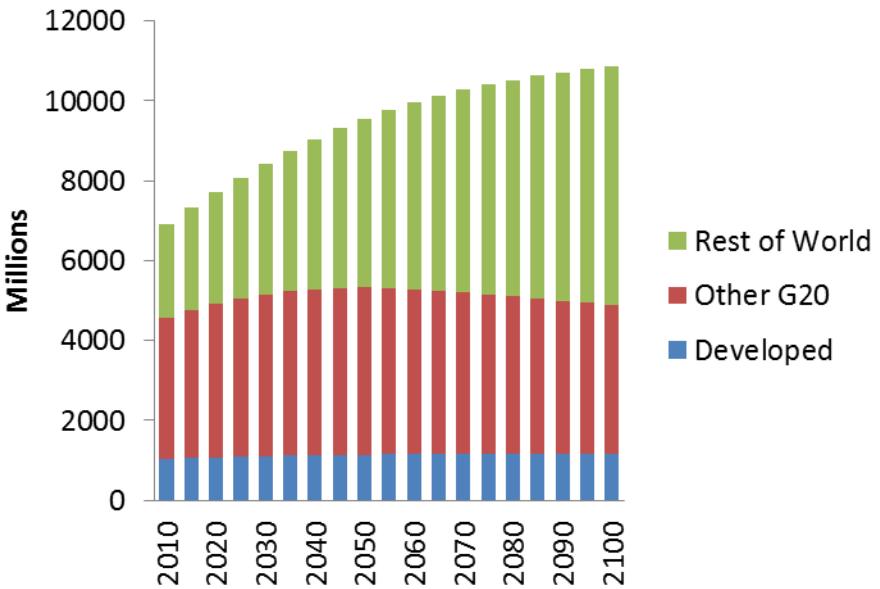
Outlook reports results for 3 broad groups:

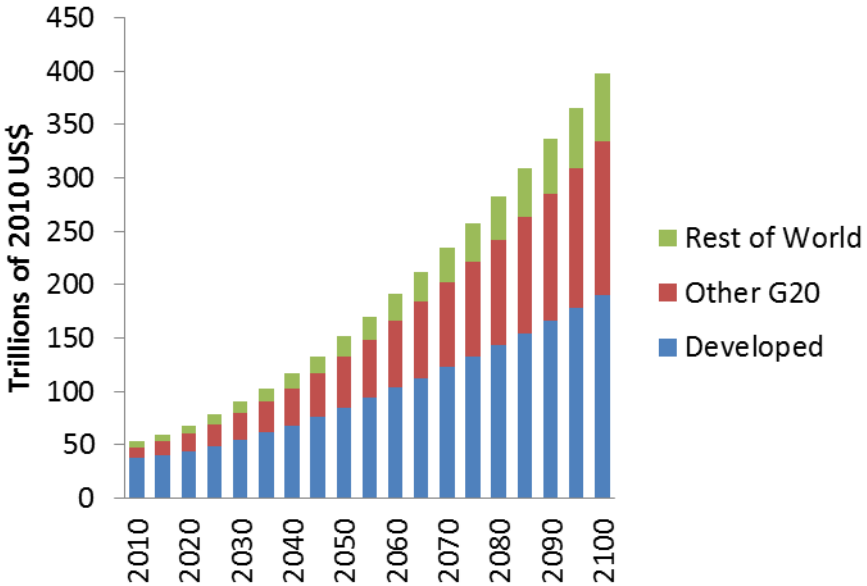
- Developed countries (USA, Canada, Europe, Japan, Australia and New Zealand)
- Other G20 nations (China, India, Russia, Brazil, Mexico, and several fast-growing Asian economies)
- The rest of the world

Supplementary Excel file provides major energy and economic outputs for 16 regions up to 2050.



Population and GDP

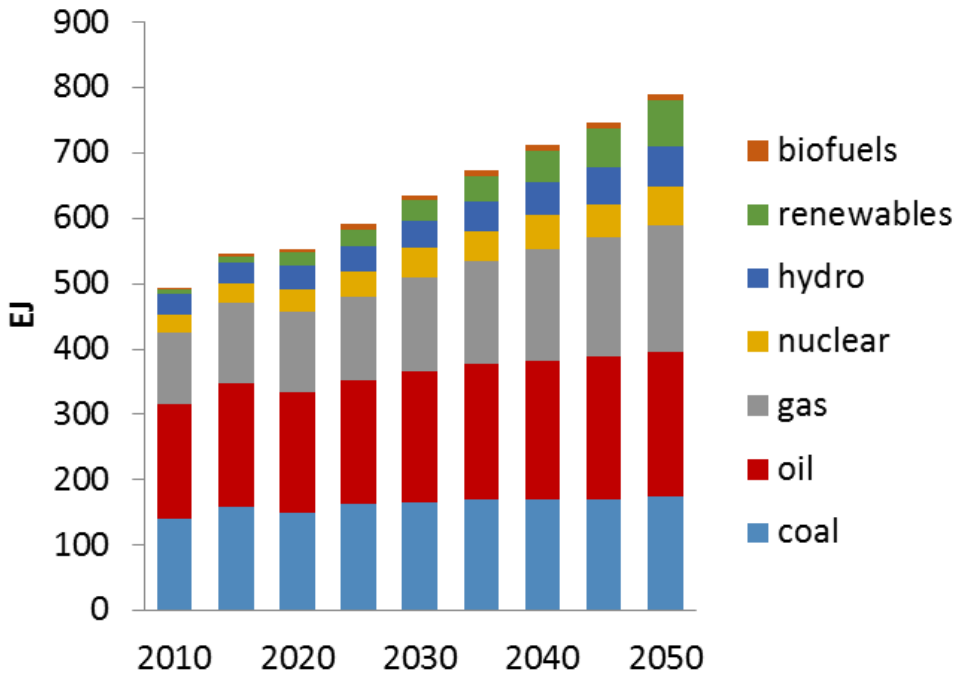




World population is projected to reach 10.8 billion by 2100 (based on UN, 2013). Global GDP will grow 7.5 times between 2010 and 2100 (real GDP growth= 2.3%).

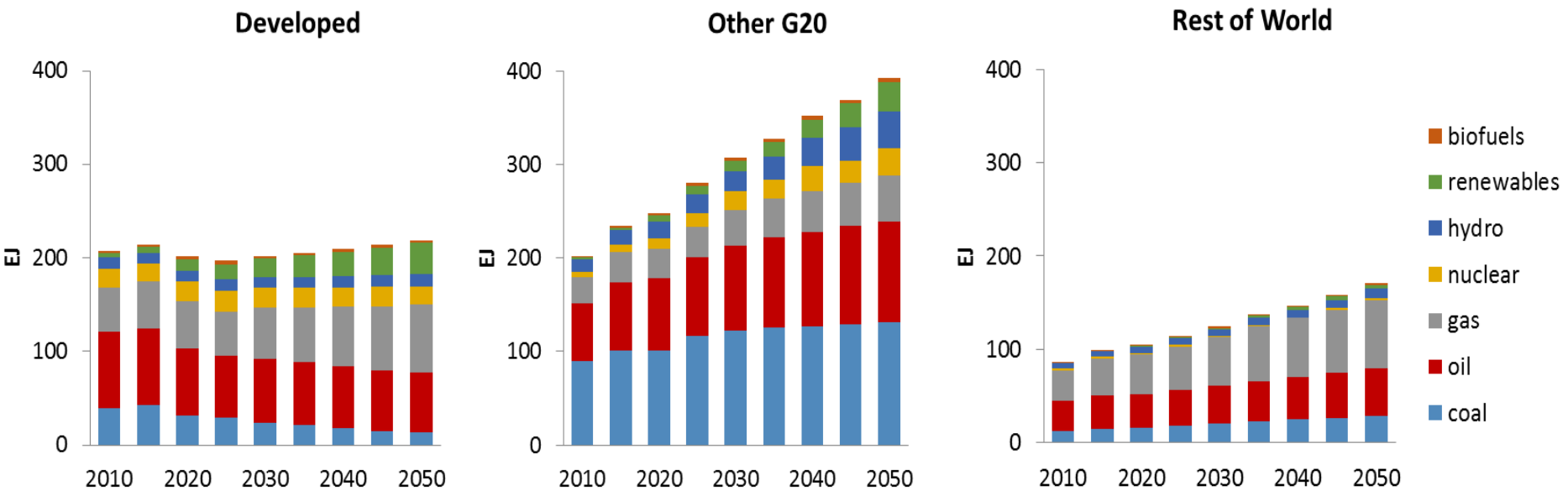
Per capita income: growth in all regions, income in developing regions is still well below that of developed countries.

Global Energy Use



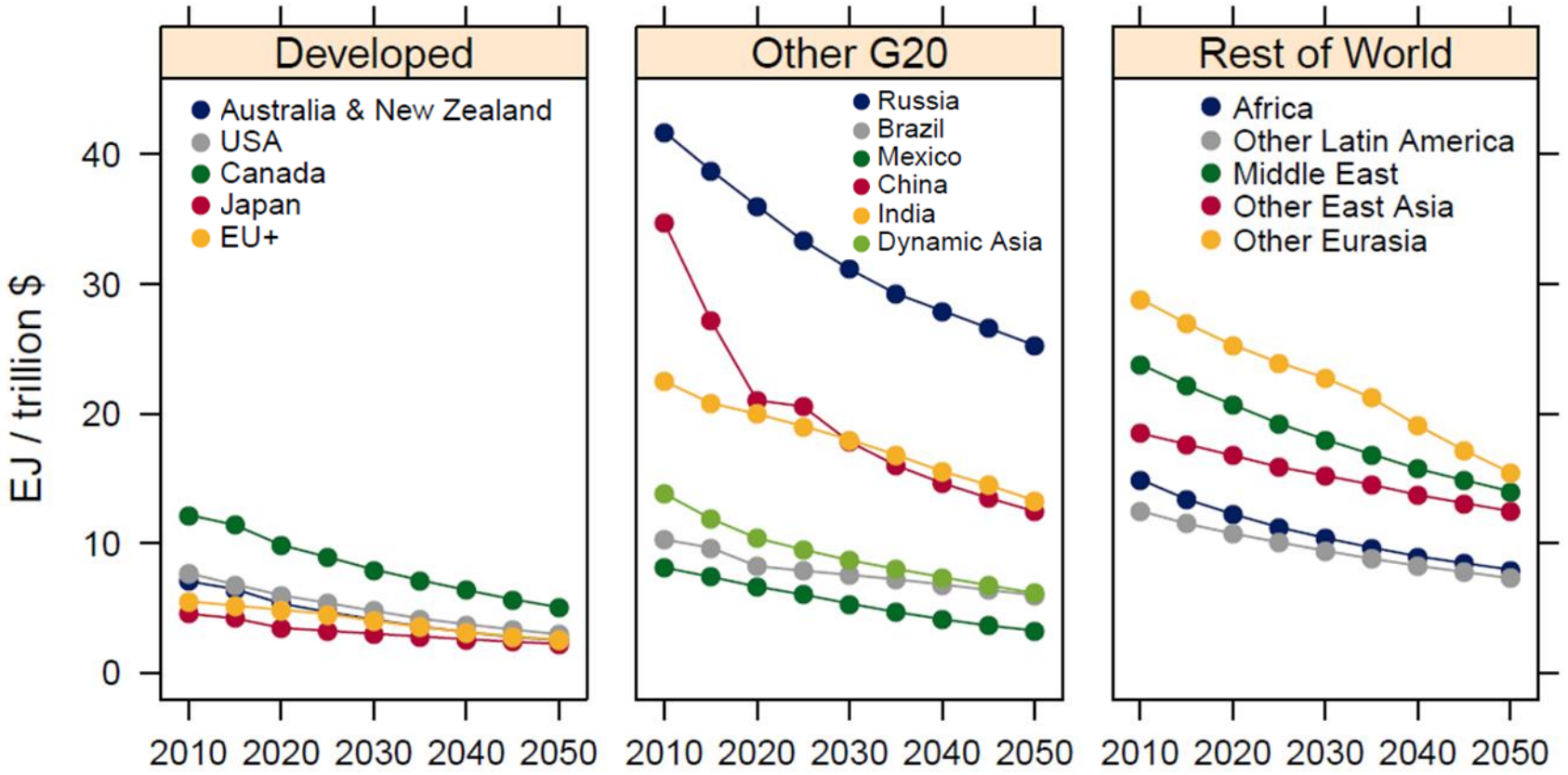
- As population and incomes increase, energy needs and desires will increase – almost doubling energy use by 2050.
- Most energy (~75%) will come from the same sources currently utilized: coal, oil and natural gas.
- There is an abundance of fossil fuel resources:
  - Coal ~180,000 EJ
  - Oil ~ 35,000 EJ
  - Gas ~ 29,000 EJ
- By 2050 fossil resources remain plentiful- their cumulative use to 2050 is:
  - Coal ~8,000 EJ
  - Oil ~ 9,000 EJ
  - Gas ~ 7,000 EJ

Energy Use by Major Group



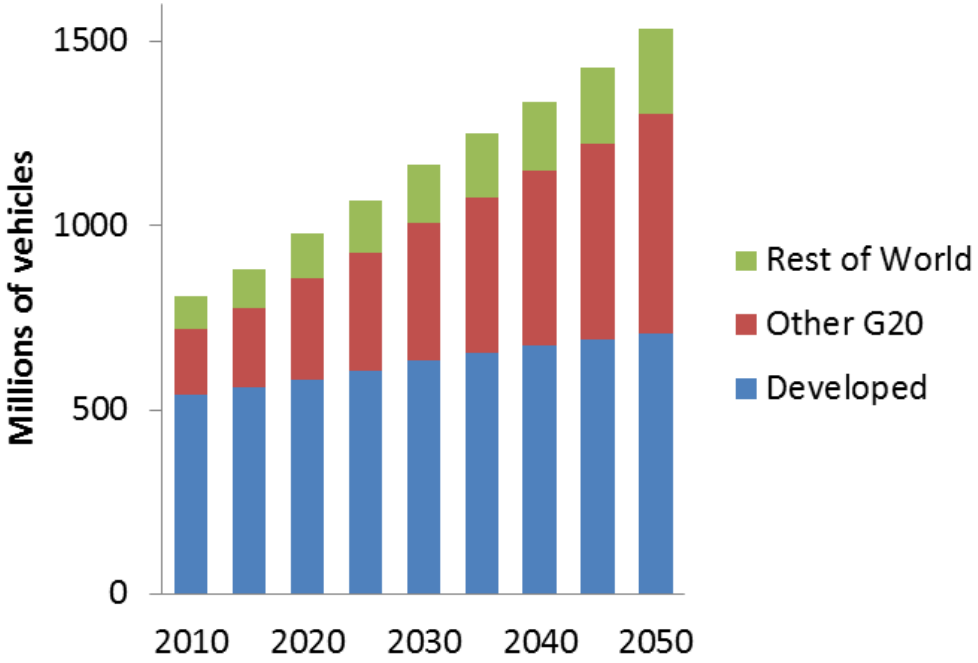
- Renewables will increase mostly in developed countries and other G20.
- Nuclear and hydropower will increase mostly in developing nations, but not significantly without mandate or policy changes.
- Energy use overall stabilizes in developed countries, grows substantially in other G20 nations (to ≈500 EJ), and grows in the rest of the world to about what is used presently by the developed world.

Energy Intensity by Region



While energy consumption will increase over time, energy use per unit of GDP generally decreases about 40% from 2010 to 2050. This reflects the improvement in energy-efficiency and rising energy prices caused by resource depletion and carbon policies.

Vehicle Stock

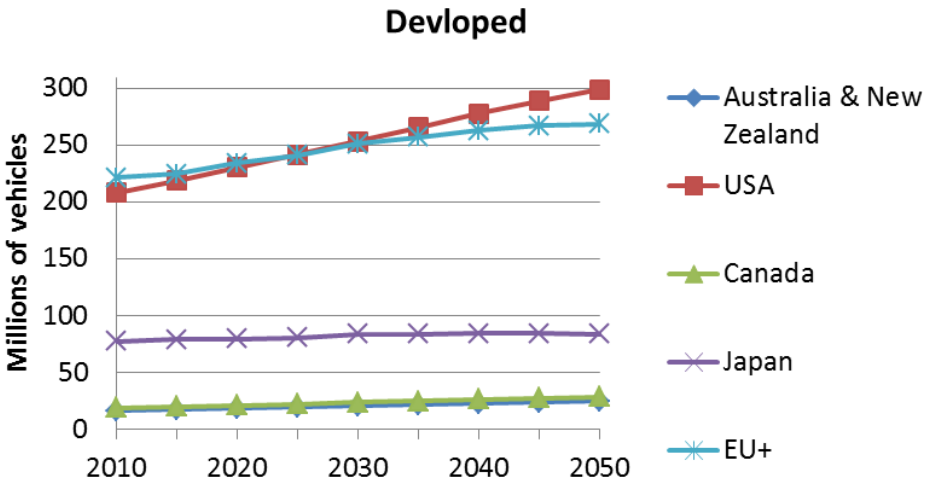


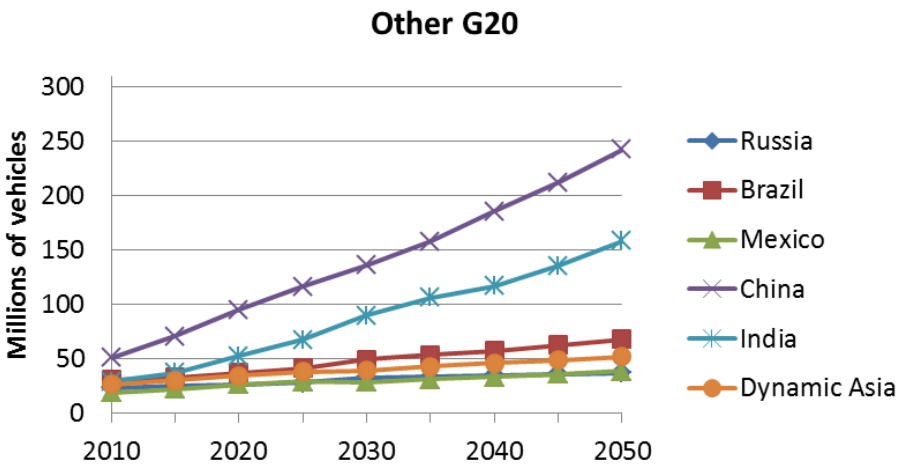
Private Cars and Light Trucks

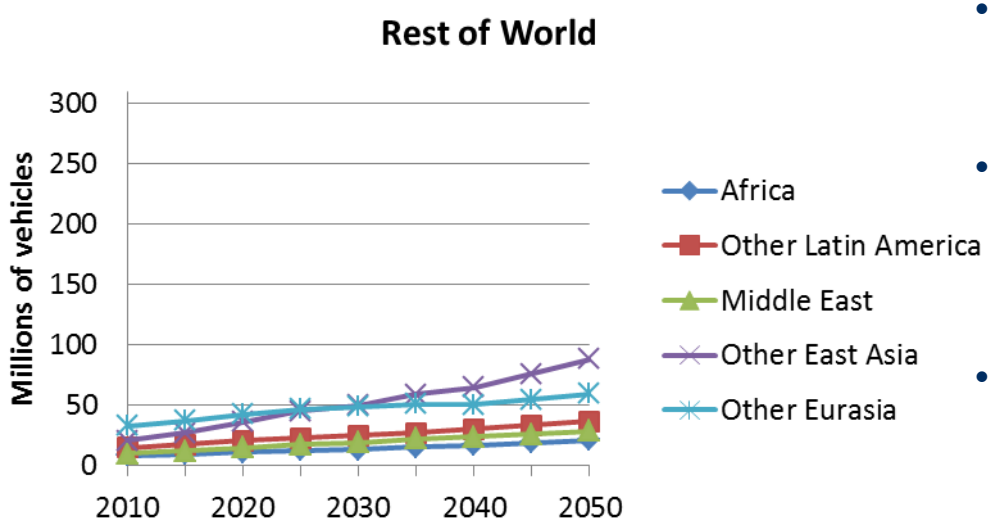
As population grows, vehicle use increases – doubling globally by 2050 and growing by about 3.3 times in other G20 nations (i.e. China and India) where population and incomes grow rapidly.

Transport emissions increase about 60% from 2010 to 2050 (rising from 6 Gt CO_2 to about 9.6 Gt). However, the share of total CO_2 emissions from transport is about the same in 2010 and 2050 (around 20%).

Vehicle Stock by Region

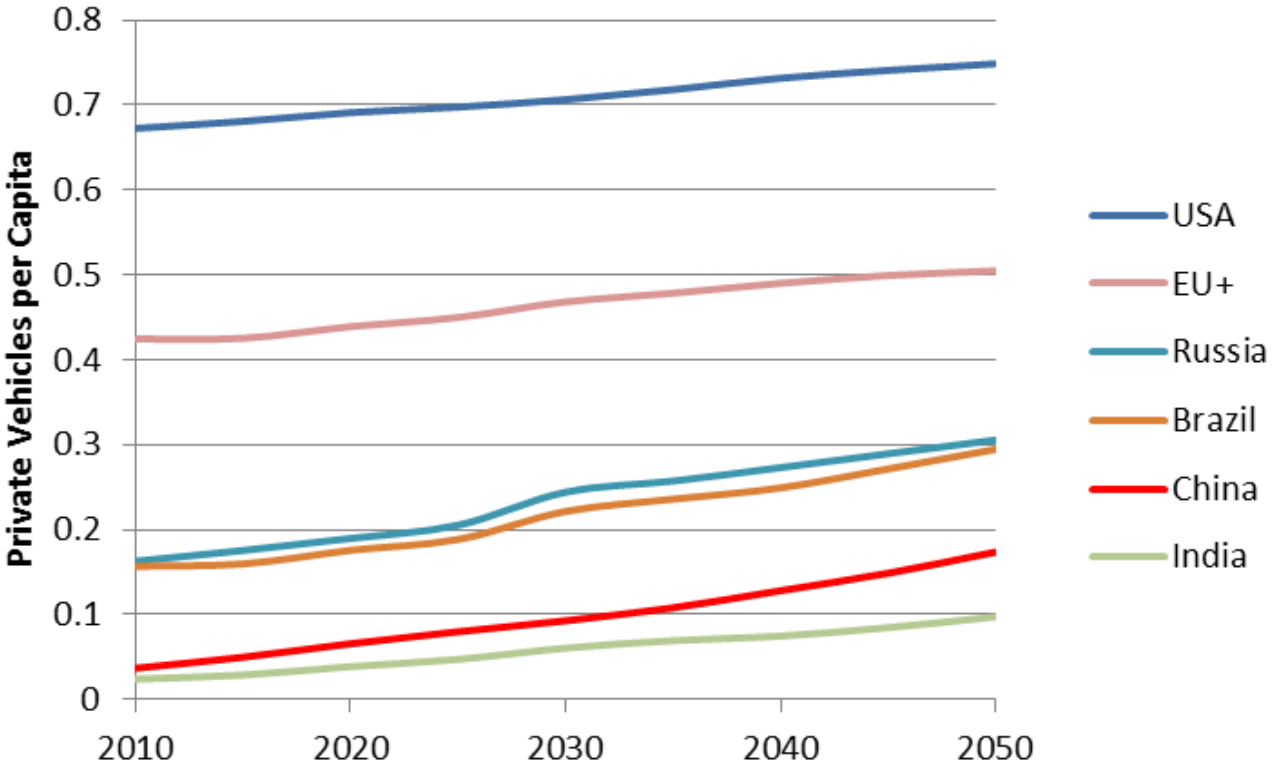






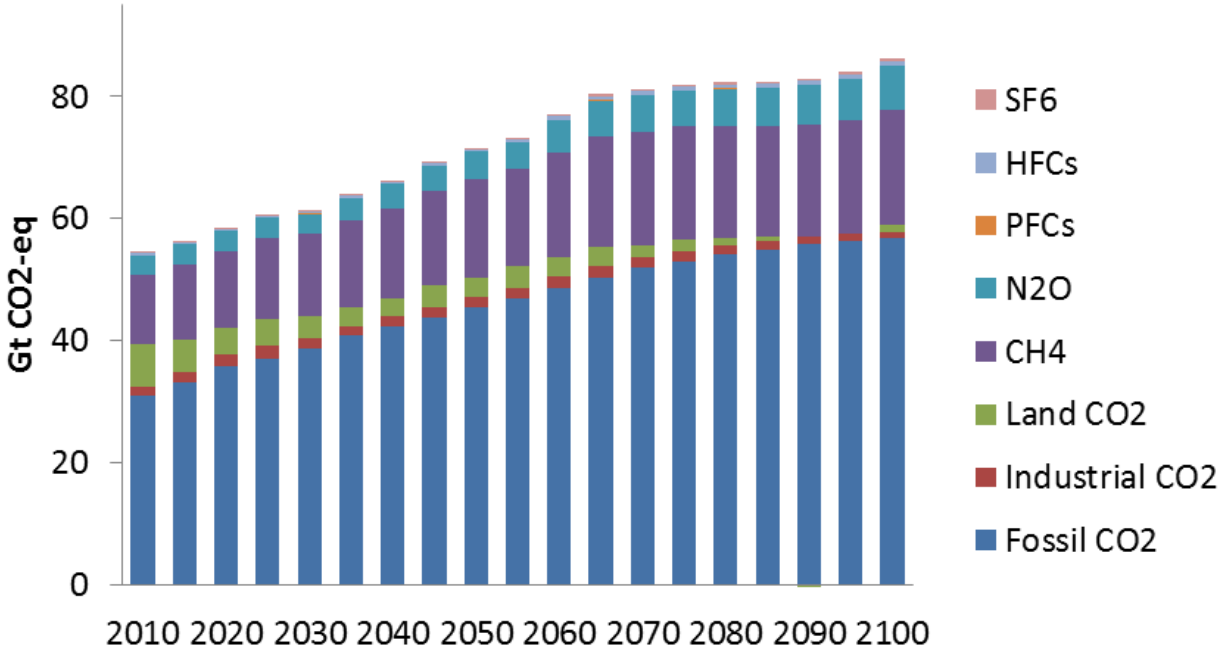
- Vehicle use in developed countries will grow slightly.
- Significantly more automobiles will be in other G20 nations by 2050.
- Vehicle use in the rest of the world is projected to rise moderately to more than double present-day levels by 2050.

Vehicle Ownership per Capita



While total number of cars in China and India approaches the total number of cars in the U.S. and the E.U., car ownership per capita is lower in China and India. In 2050: 0.75 cars/person in U.S., 0.5 – in E.U., 0.17 - in China, 0.1 – in India.

Global Greenhouse Gas Emissions

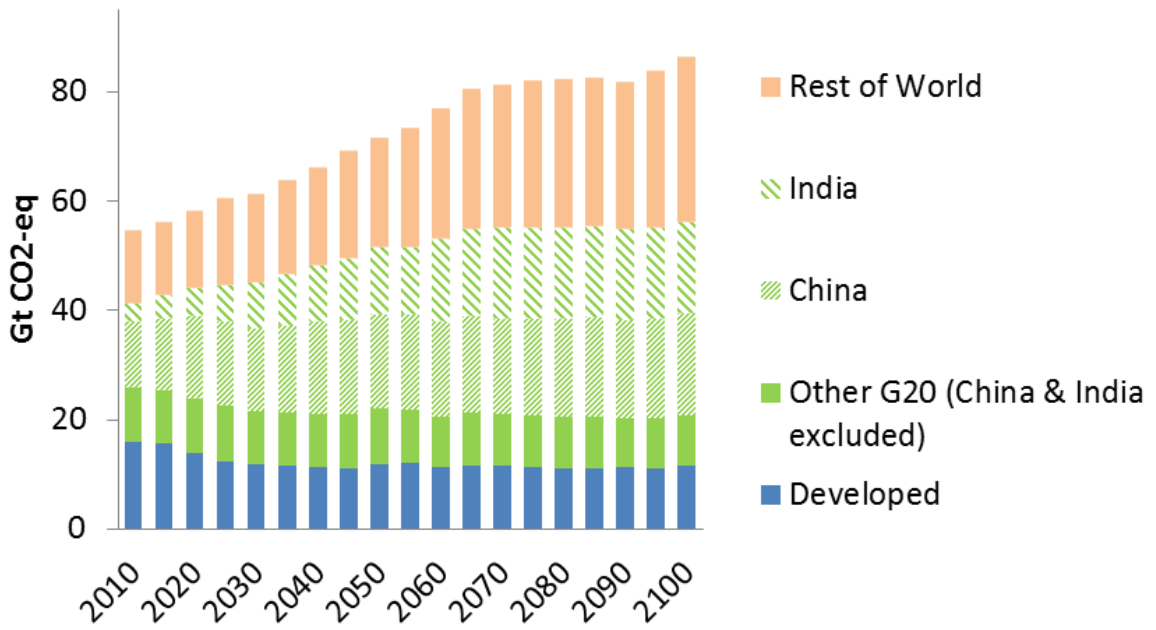


With more power plants and industrial activity, more cars and trucks on the road, and more cropland and livestock, most sources of GHGs will grow.

Fossil fuel CO2 emissions will continue to constitute about 2/3 of total emissions

➡ Due mostly to uncontrolled emissions from agriculture, energy production and other industrial activities.

GHG Emissions by Major Group



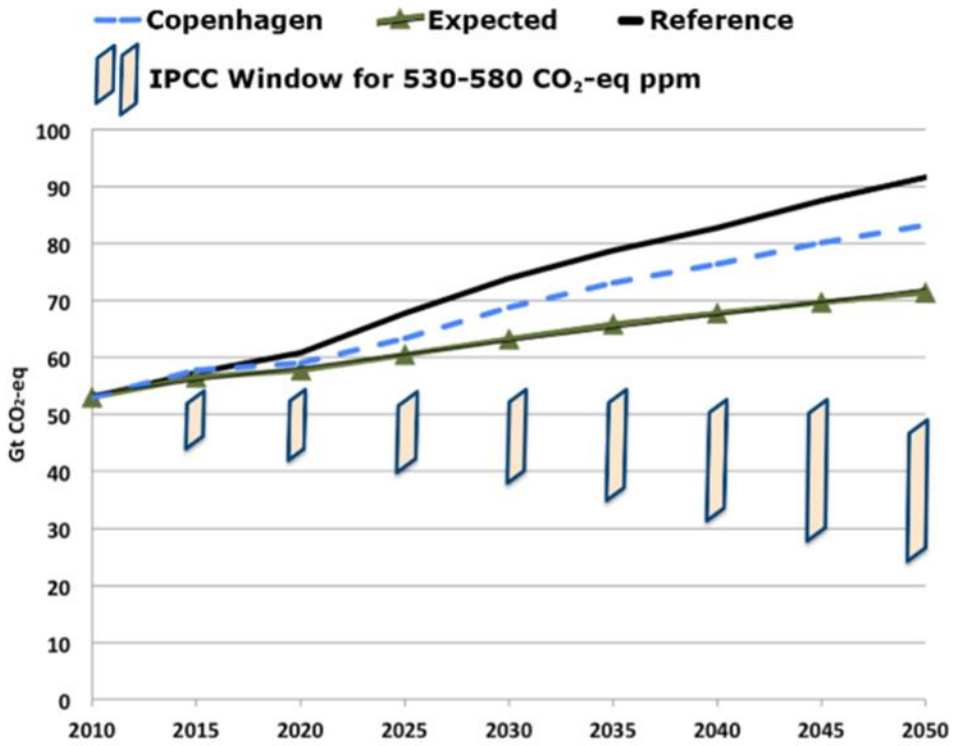
Emissions in developed countries decrease ≈10% in the near term (b/c of pledges), then remain constant after 2030.

Slow growth in emissions in other G20 nations, but unless targets are extended, emissions increase 100% over the century

➡ contributing ≈55% of global emissions by 2100.

Due to population growth and the absence of climate policy, the rest of the world's emissions more than double by 2100.

Expectations for COP Meeting in Paris



An agreement likely achievable at COP-21 in Paris in November 2015 will decrease a growth in GHG emissions.

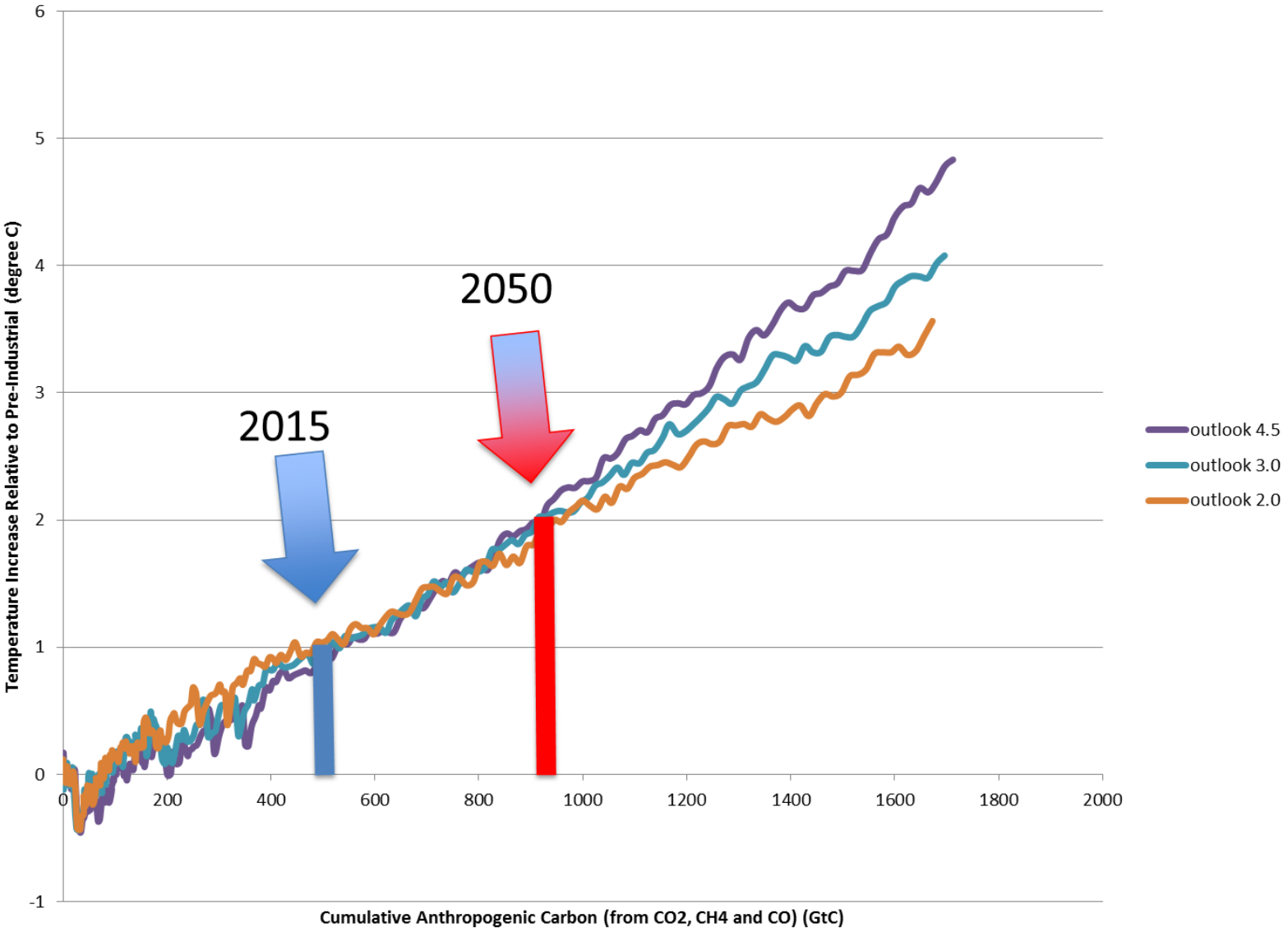
Not consistent with 2C target.

530-580 CO2-eq (RCP4.5) are consistent with a median global temperature increase of 1.8C over this century (2.6C above the pre-industrial level).

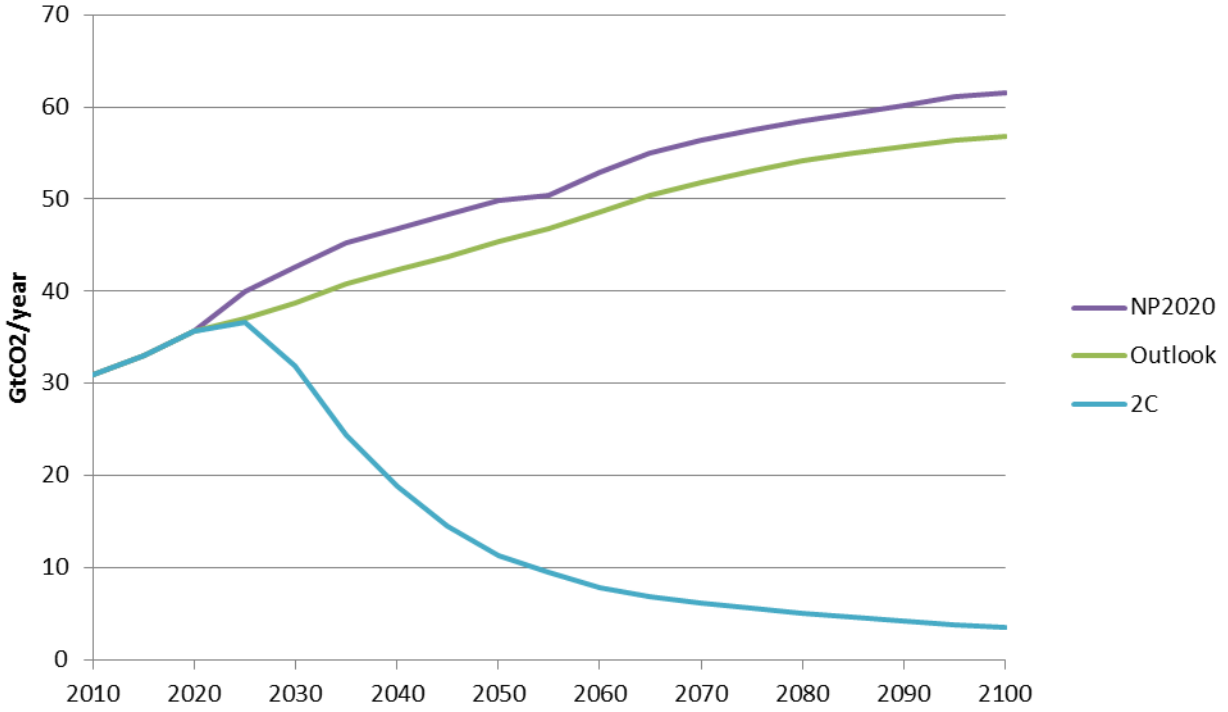
Need for the follow-up steps.

More information at:
http://globalchange.mit.edu/research/publications/2835

Carbon Budget



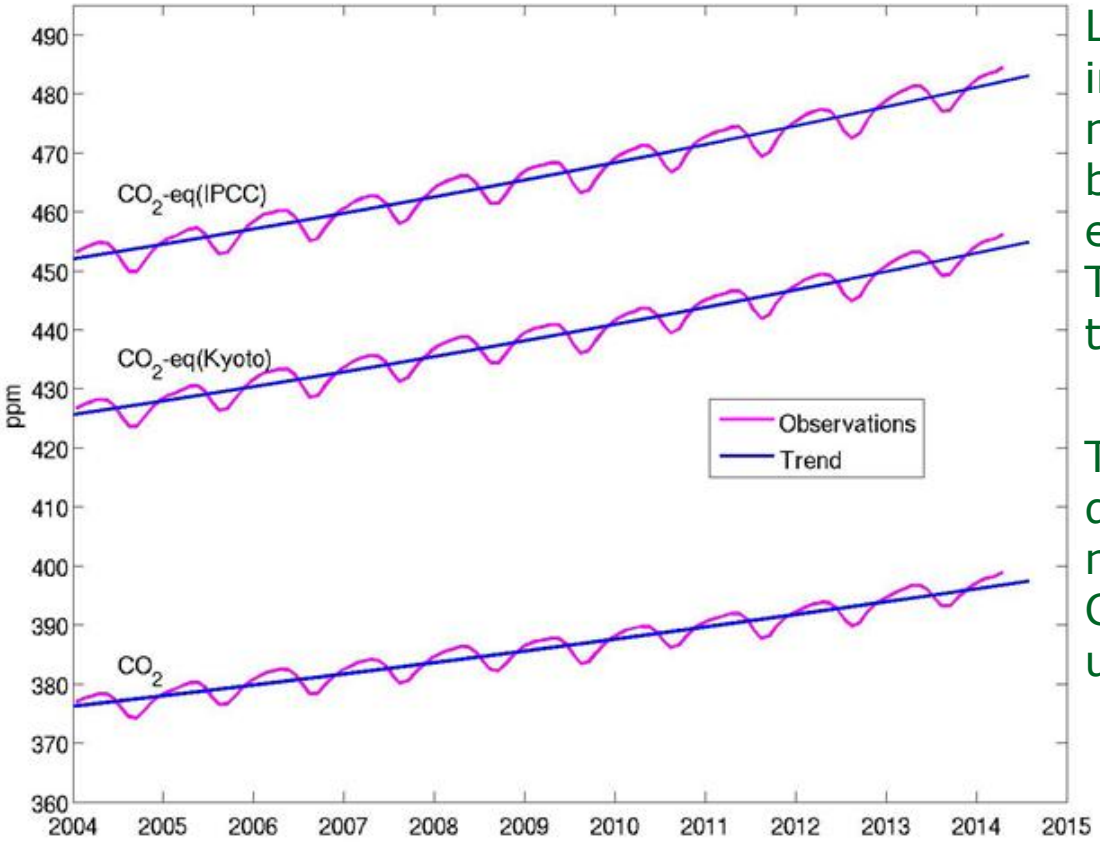
Need for Additional Actions



"Net zero": no requirement for zero anthropogenic emissions by 2050 (or by 2100) because of (mostly) ocean and land sinks.

2C stabilization is costly and requires substantial energy system transformation.

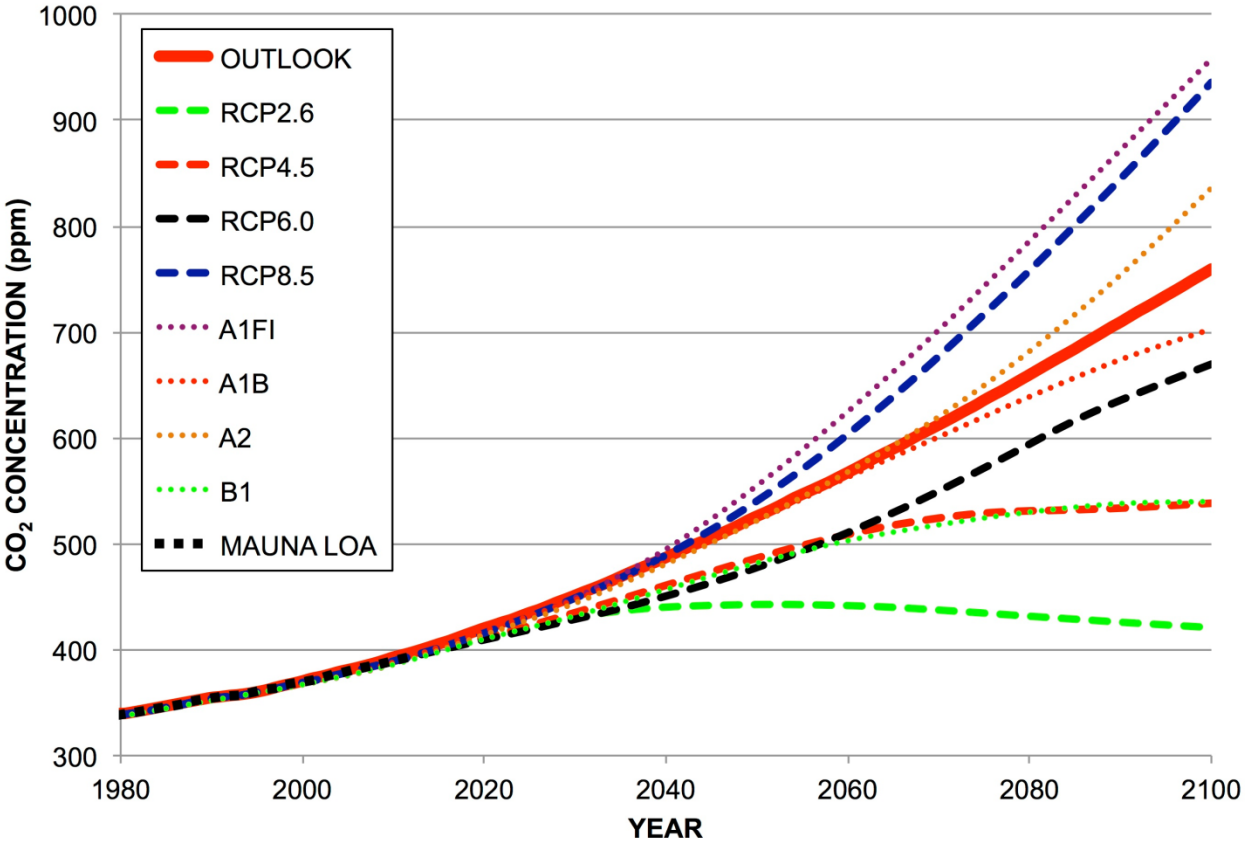
Current Greenhouse Gas Concentrations



Looking at the GHG concentrations in our atmosphere, it shows that to meet the climate goals discussed broadly amongst nations, global emissions need to peak very soon. This chart shows that will not be the case.

The well-known seasonal cycle, due largely to strong effects of northern hemisphere vegetation on CO2, is smoothed to show the underlying trend.

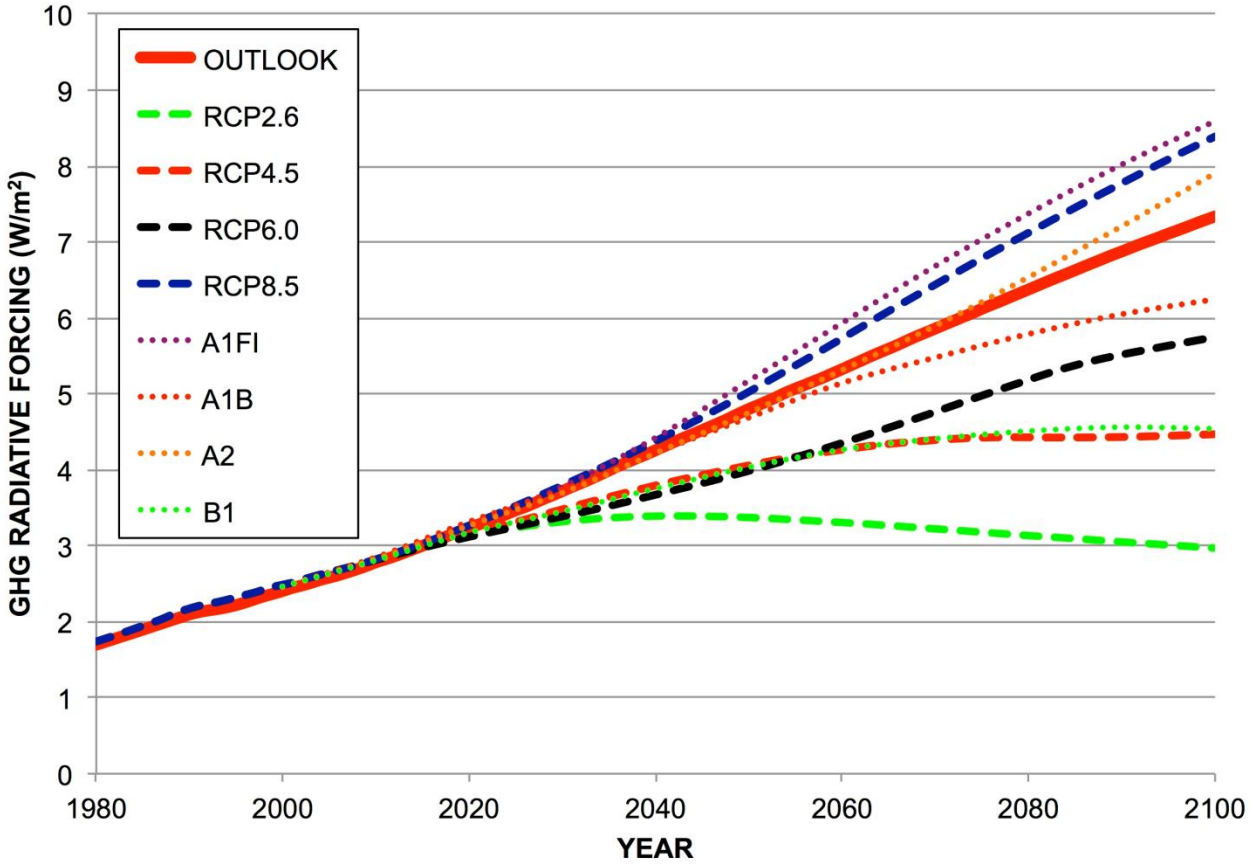
CO_2 Concentrations



Future concentrations of CO2 will rise substantially as emissions rise: approach 750 ppm by 2100 and continue to rise.

Outlook scenario lies between the SRES scenarios A2 and A1B, and between the RCP scenarios RCP6.0 and RCP8.5.

GHG Radiative Forcing



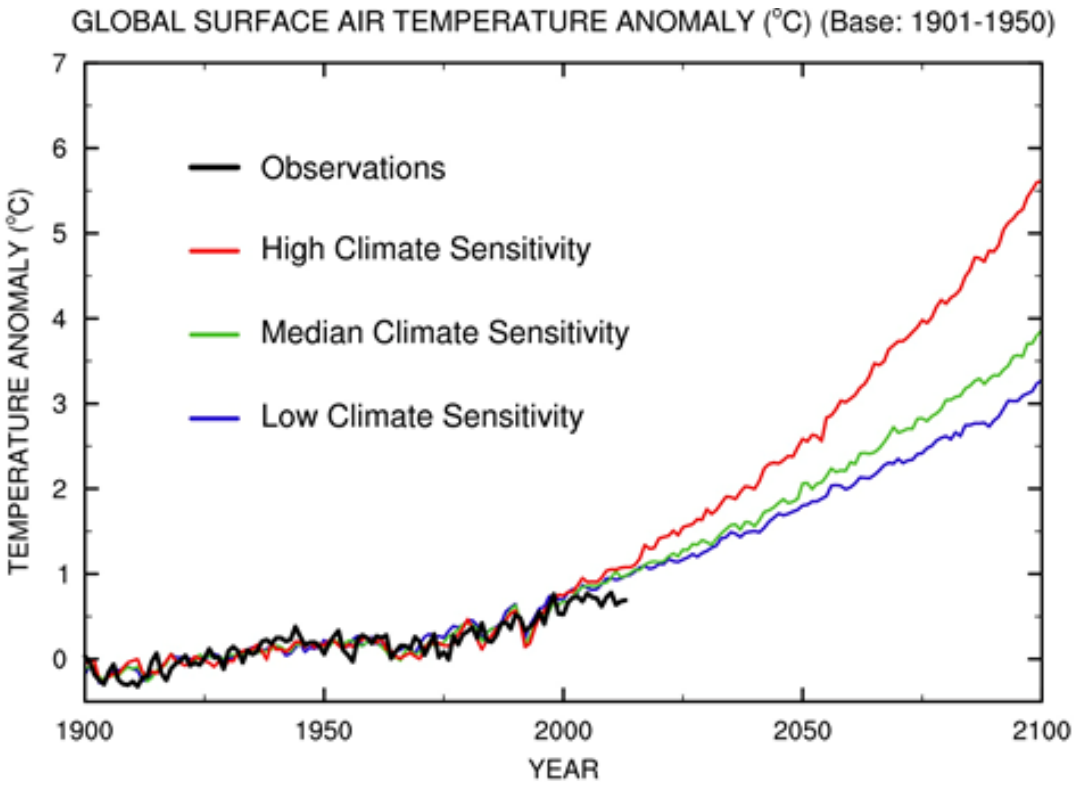
GHG radiative forcing continues to increase: reaches 7.5 W/m^2 from about 3 W/m^2 in 2015.

Outlook scenario lies between the SRES scenarios A2 and A1B, and between the RCP scenarios RCP6.0 and RCP8.5.

Climate Sensitivity

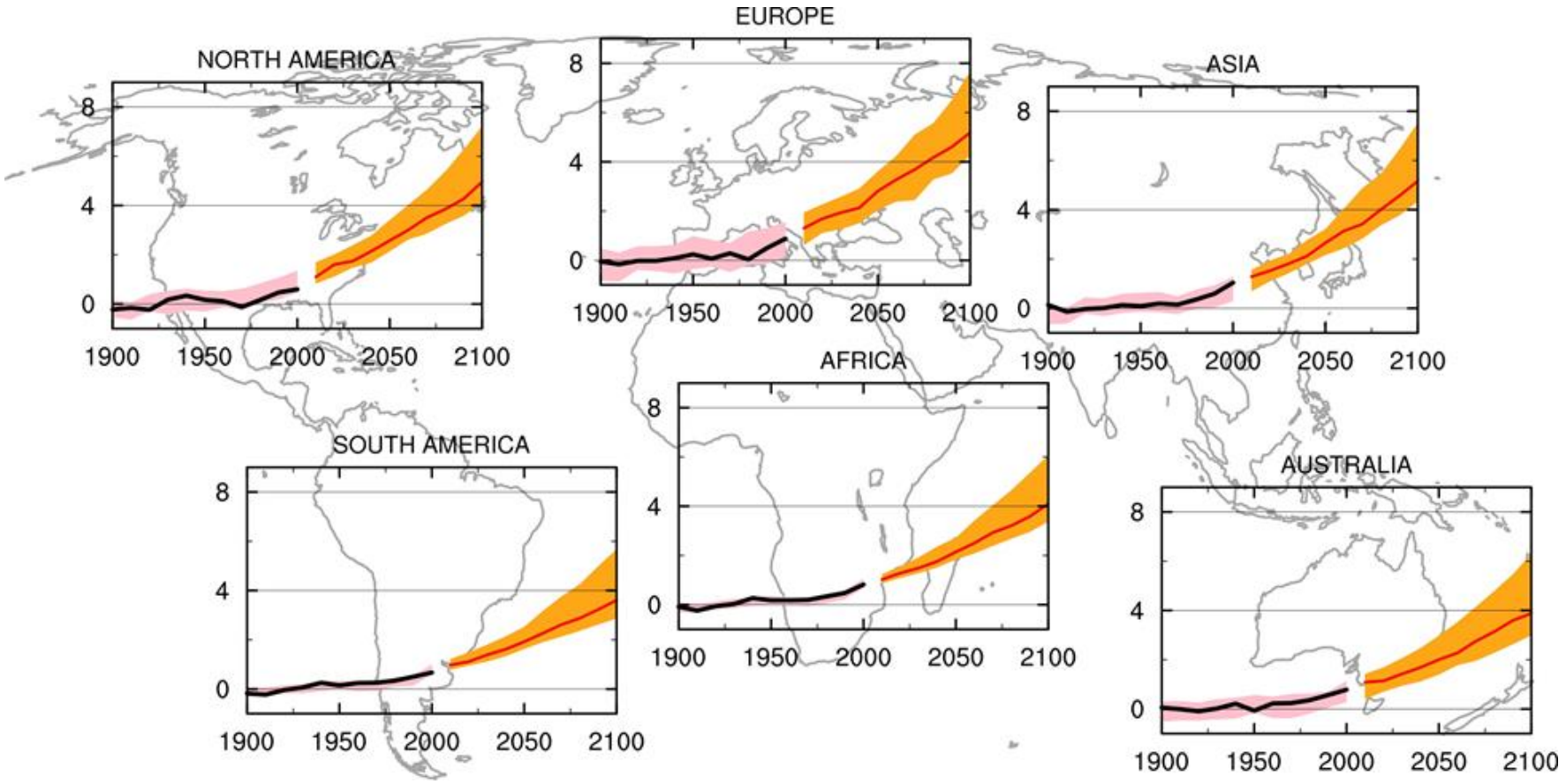
- Because Climate Sensitivity (CS) is uncertain, we developed 3 climate scenarios that capture the uncertainty in the Earth's response to the cooling from aerosols and warming from greenhouse gases, corresponding to CS=2°C (low), CS=2.5°C (median), and CS=4.5°C (high).

Temperature Increase



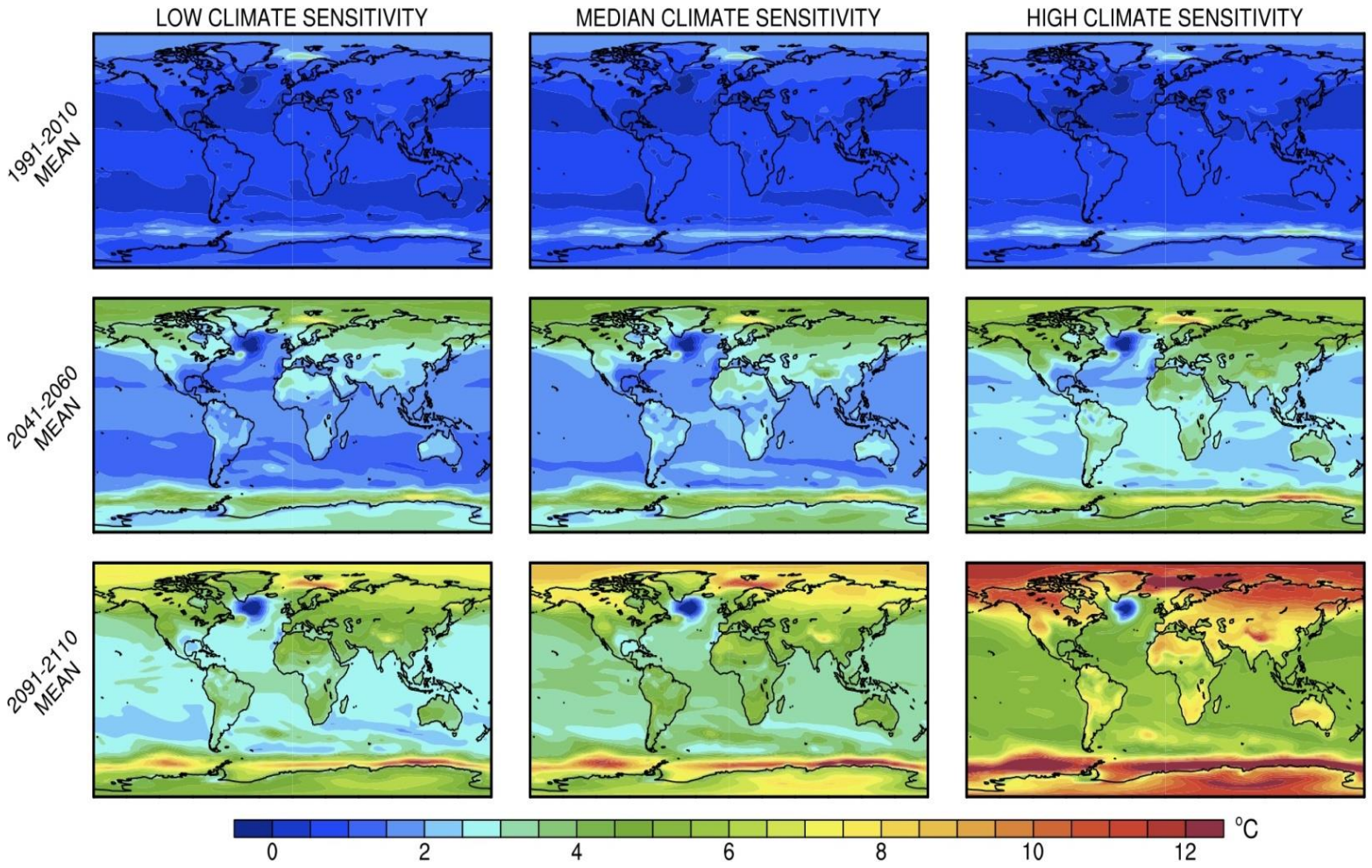
Using the previous 3 scenarios, by 2100 the mean global temperature is projected to increase from about 1 degree Celsius in 2010 to **3.2 to 5.6** degrees Celsius by 2100 (relative to the mean temperature in 1901-1950)

Regional Temperature Change



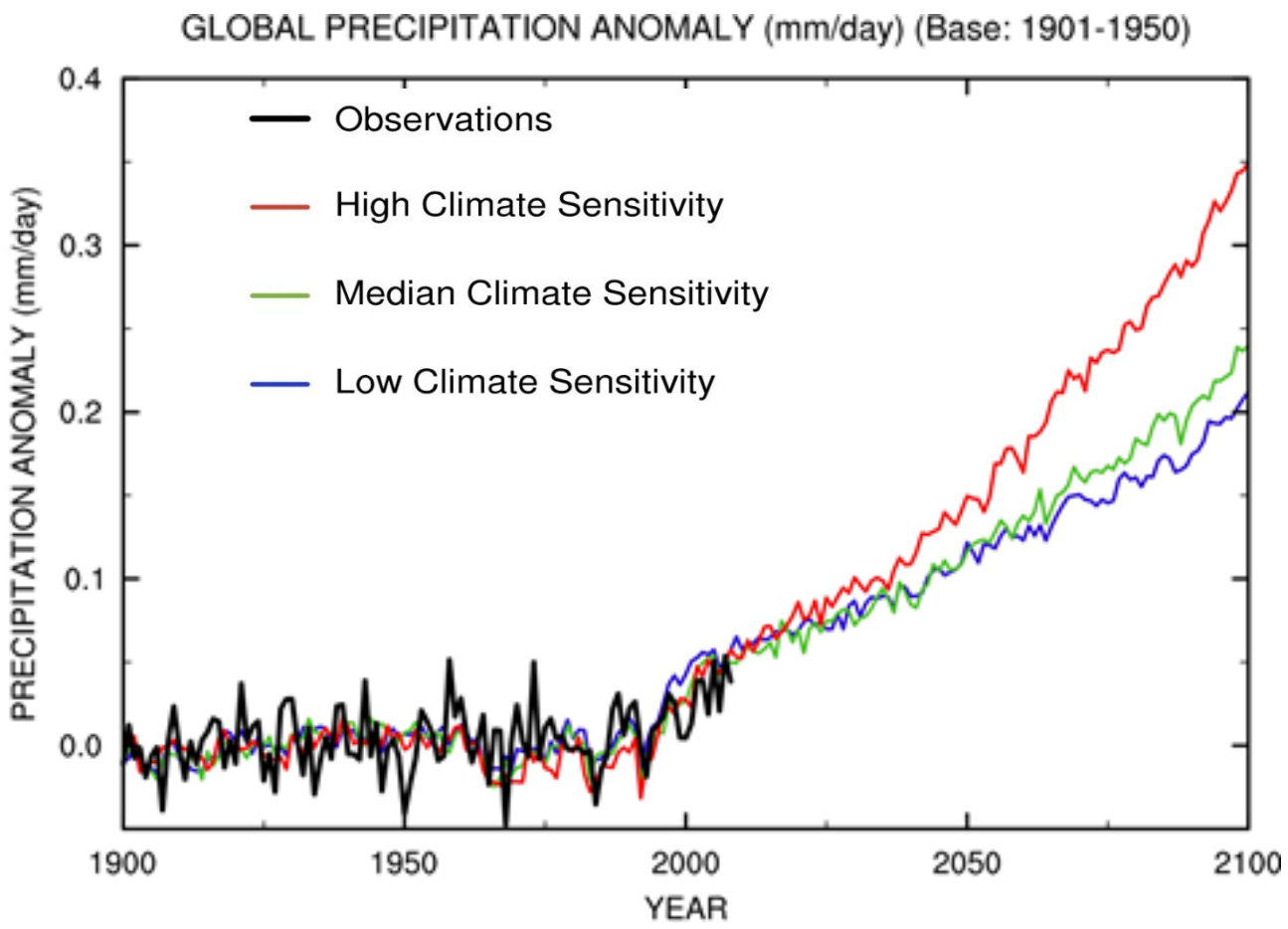
By 2100 temperature increases in North America, Europe, and Asia exceed those in Africa, Australia, and South America.

Mean Surface Temperature



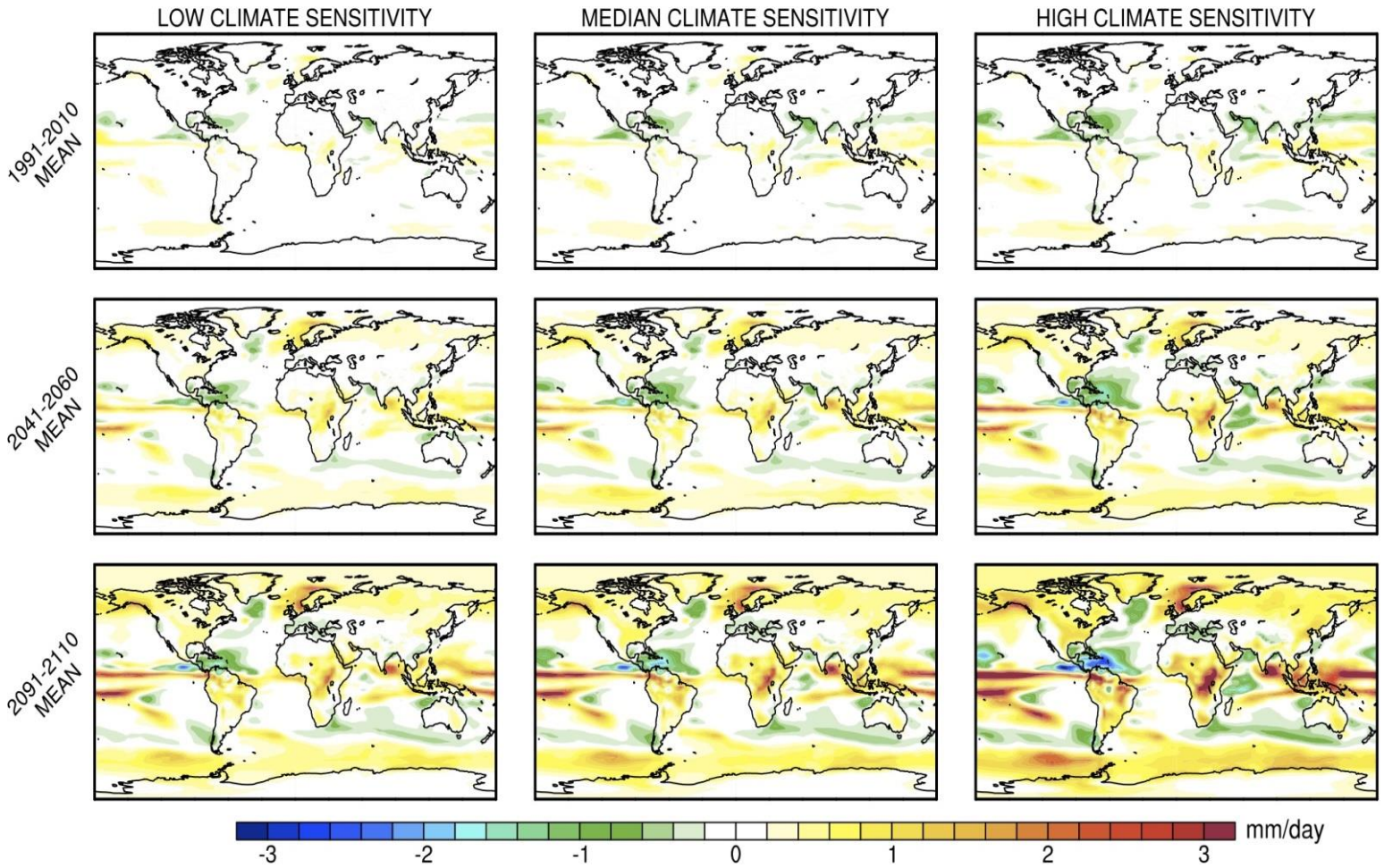
Polar regions warming more than the rest of the planet.

Precipitation



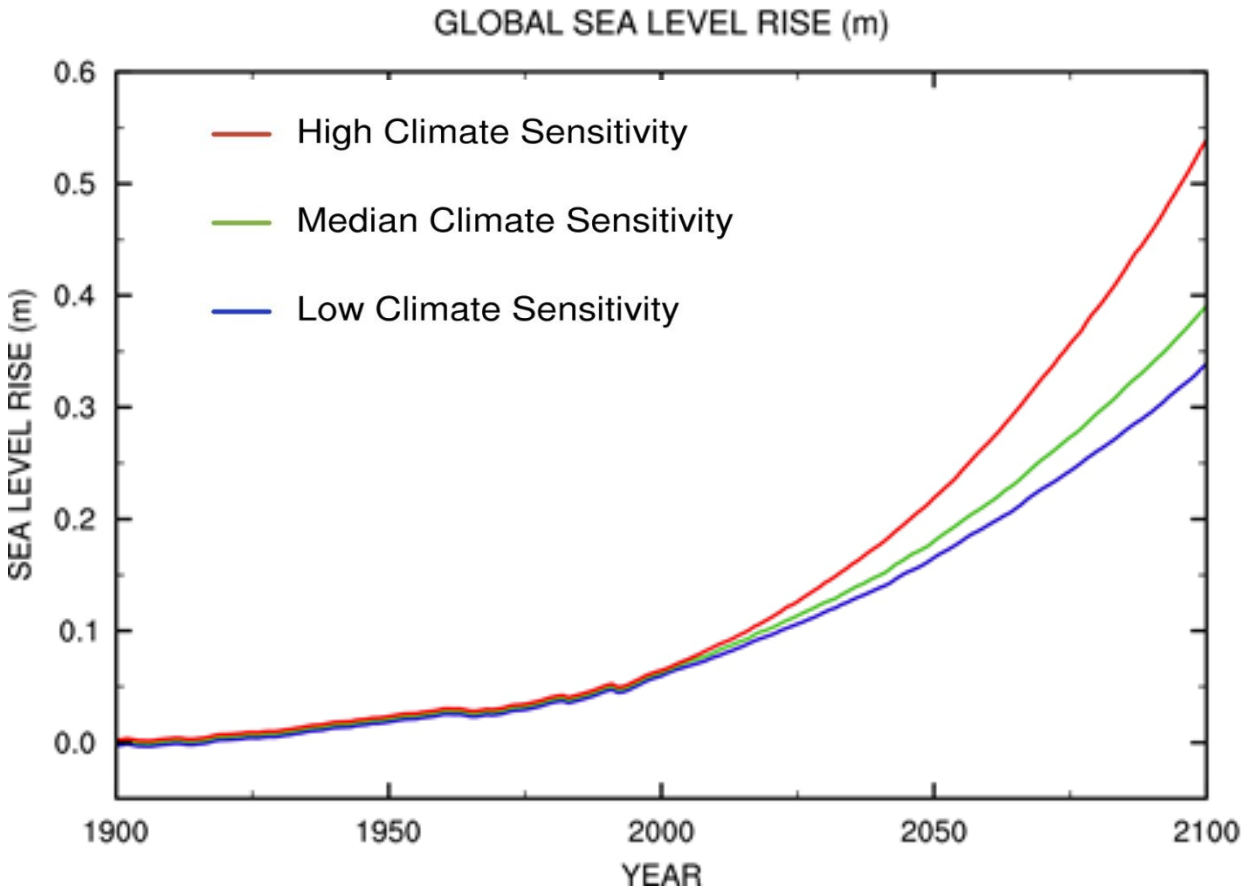
Projected increase in global precipitation anomaly from 0.05 mm/day in 2010 to a range of 0.21-0.35 mm/day in 2100.

Precipitation



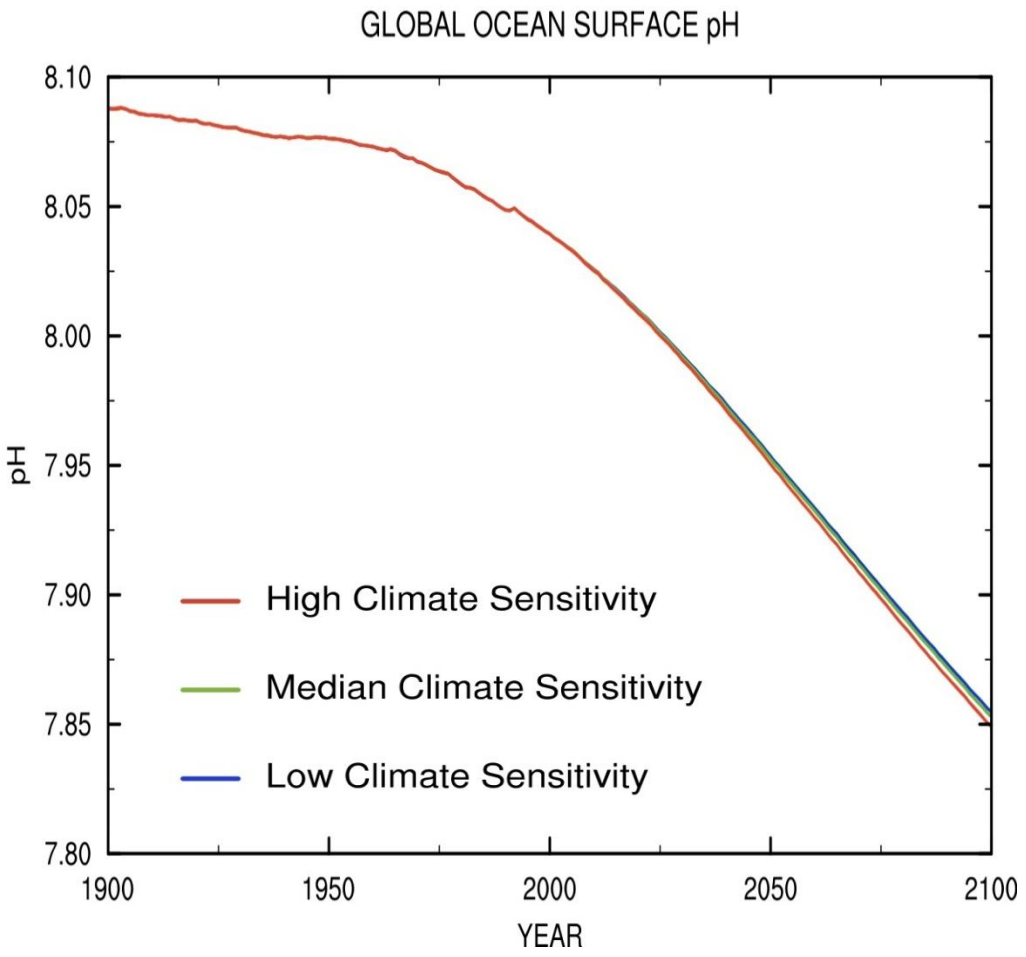
Geographic patterns vary with some areas (e.g., Indonesia) projected to become wetter and some areas (e.g., The Caribbean) projected to become drier.

Sea Level Rise



Projected increase in global sea level rise due to thermal expansion from 0.1m in 2010 to a range of 0.34-0.54 m in 2100.

Ocean Acidity



As CO2 concentrations increase, oceans become more acidic (measured by seawater pH, lower pH= higher acidity).

Today: pH= 8.05

Oceans are absorbing about 1/3 of the CO2 emitted.

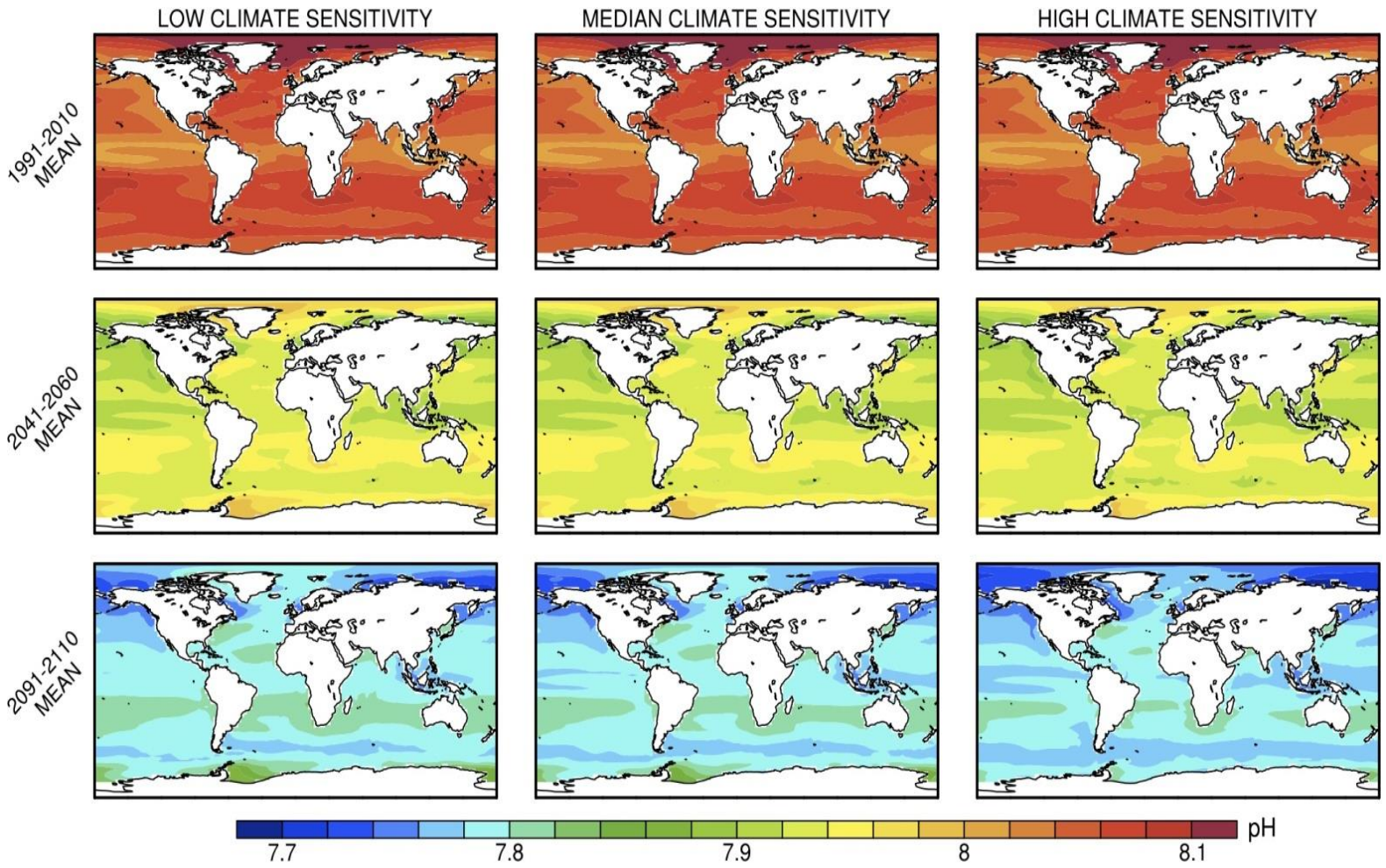
➡0.1 pH drop since pre-industrial times.

2100 and Beyond:

➡ drop of 0.2 pH to 7.85pH strongly affecting marine organisms.

➡Corals are likely to cease to exist with 7.7pH.

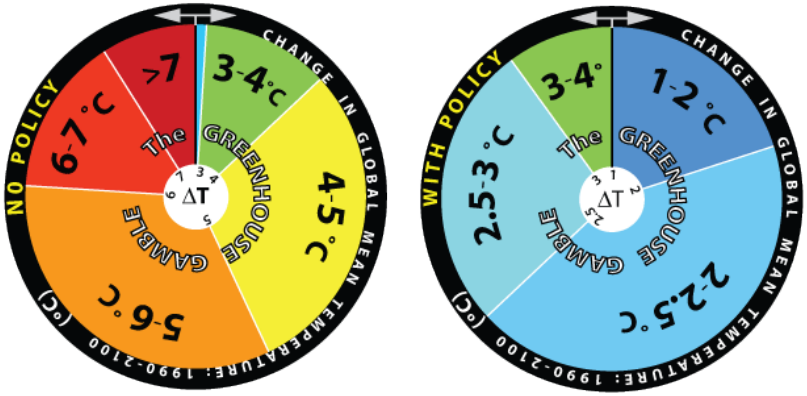
Ocean Acidity



By 2100 most locations are projected to reach the levels of 7.7-7.85 pH.

Preparing for Tomorrow Today

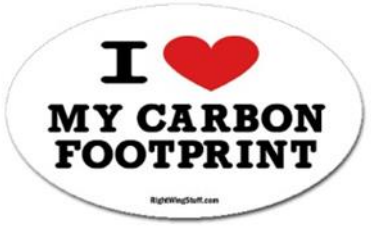
- While the world has made progress, much more effort is needed to avoid dangerous climate change.
- The expected agreement in Paris (COP-21) does not take us very far in the energy transformation ultimately needed to avoid the risk of dangerous warming.
- Even if policy efforts in developed countries 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/