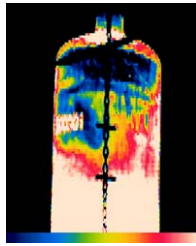


Global Warming: Engineering R/D Needed!



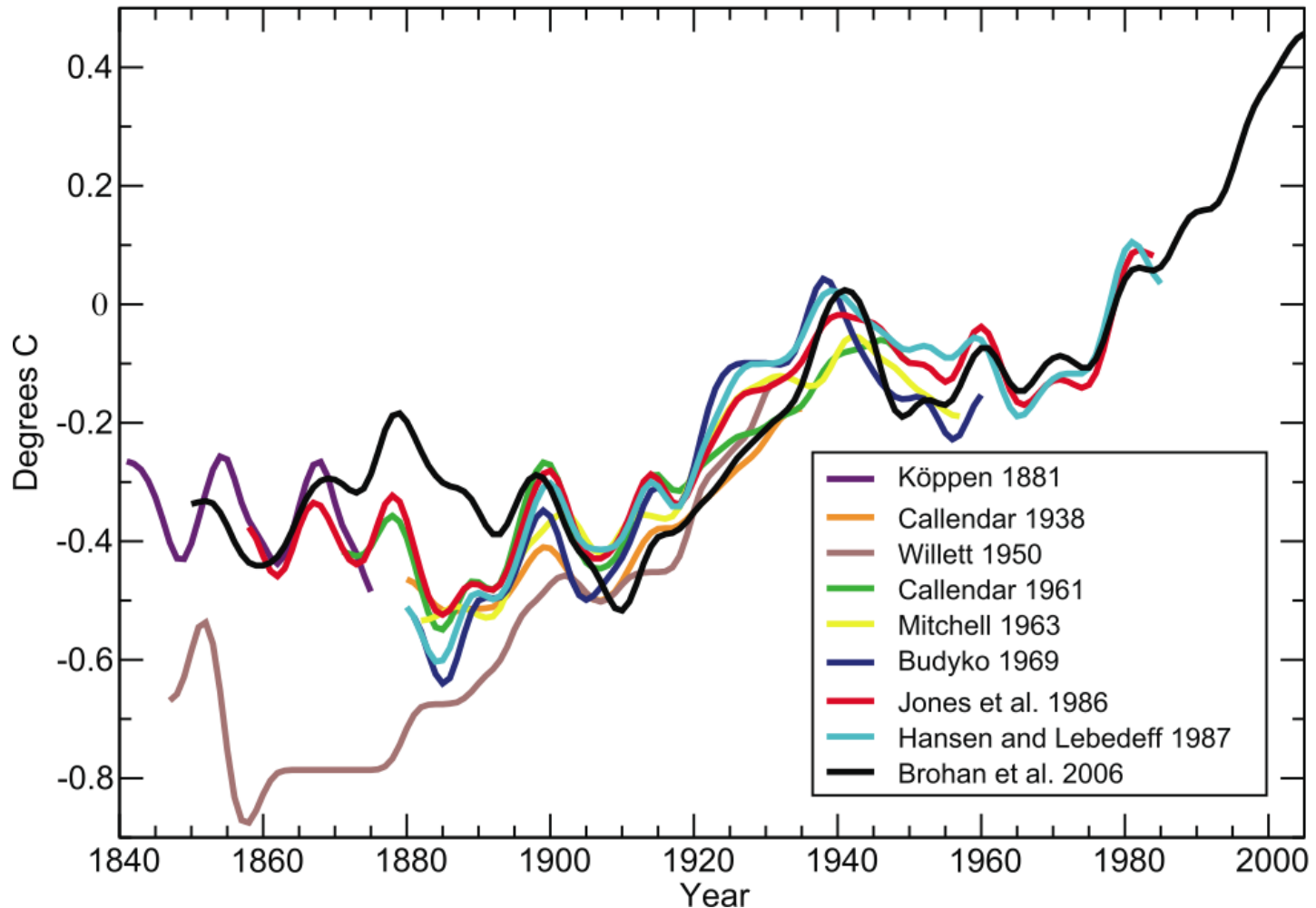
SRNLTM
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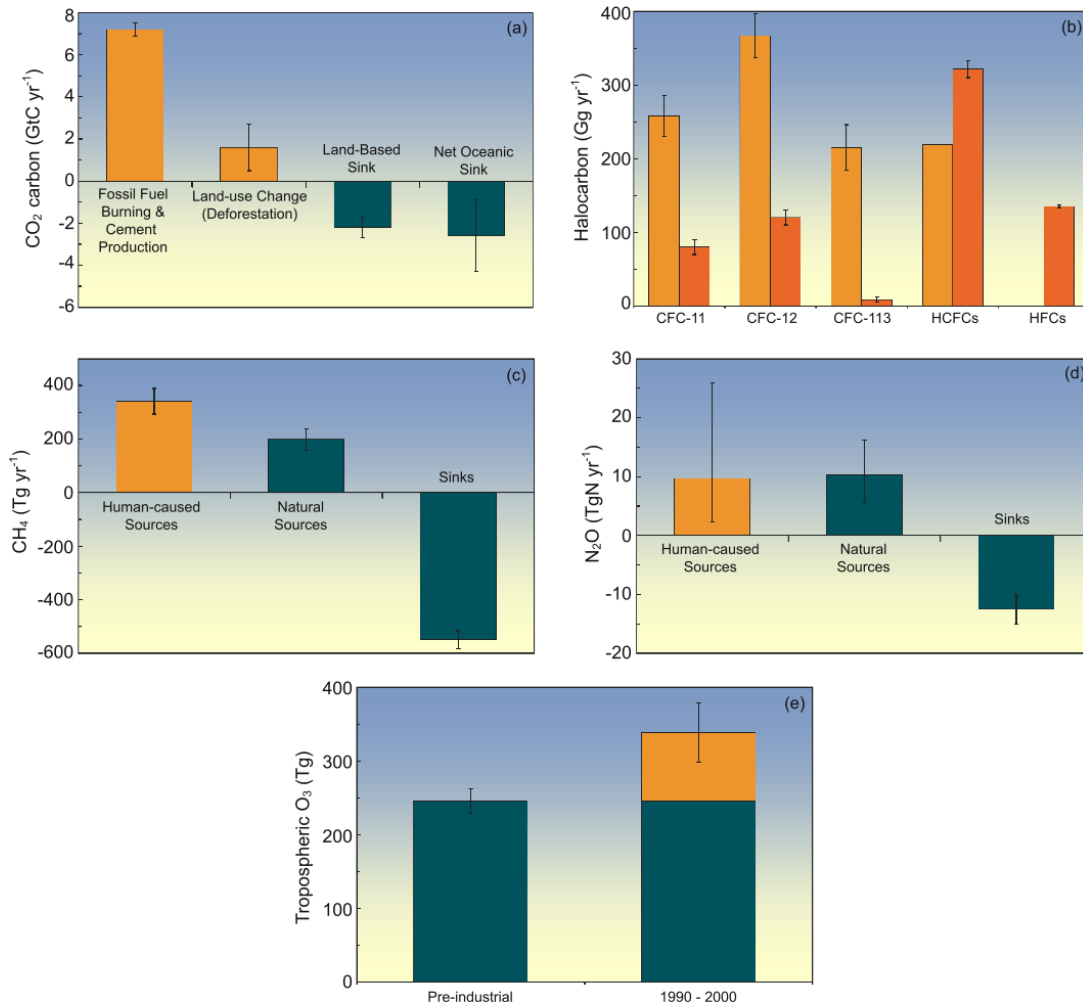
M. John Plodinec
Science Advisor
April 7, 2008

Global warming

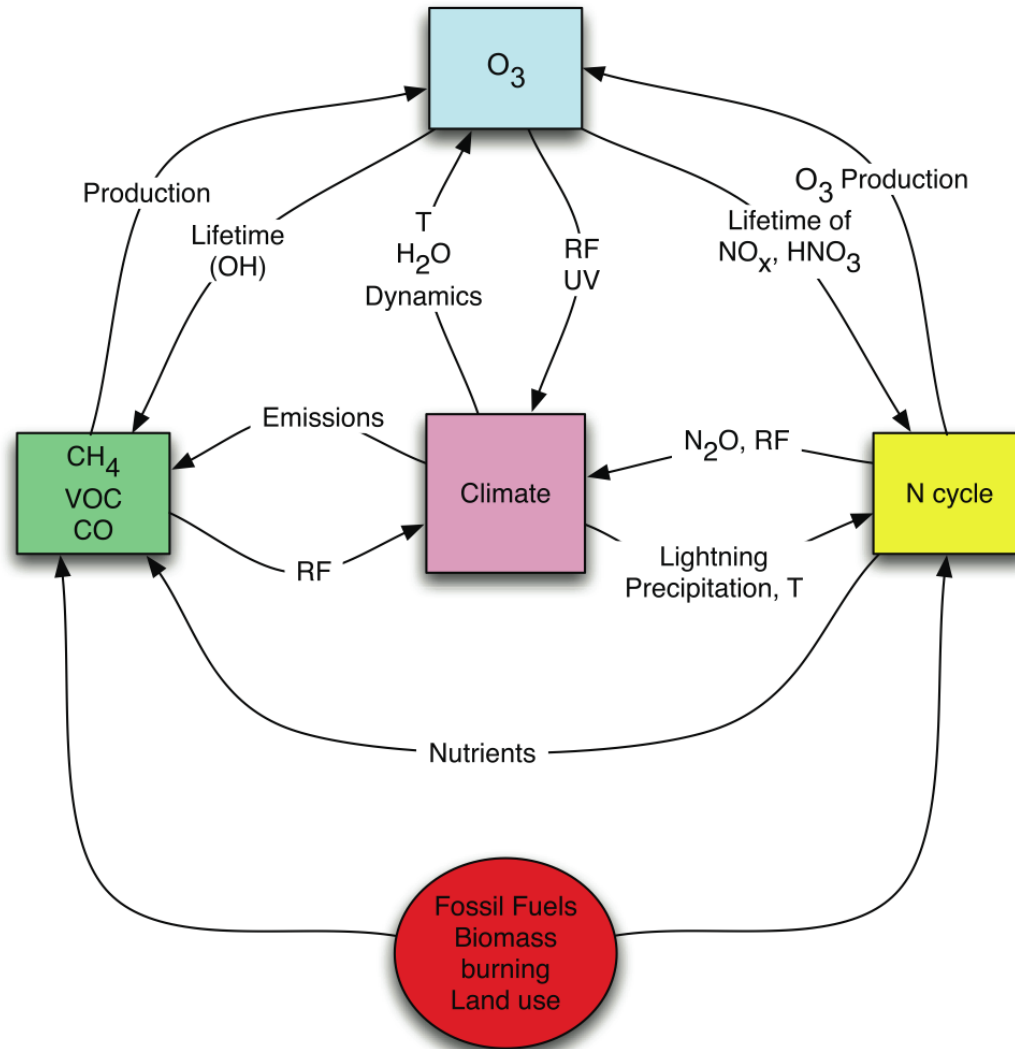
Global Temperature Time Series



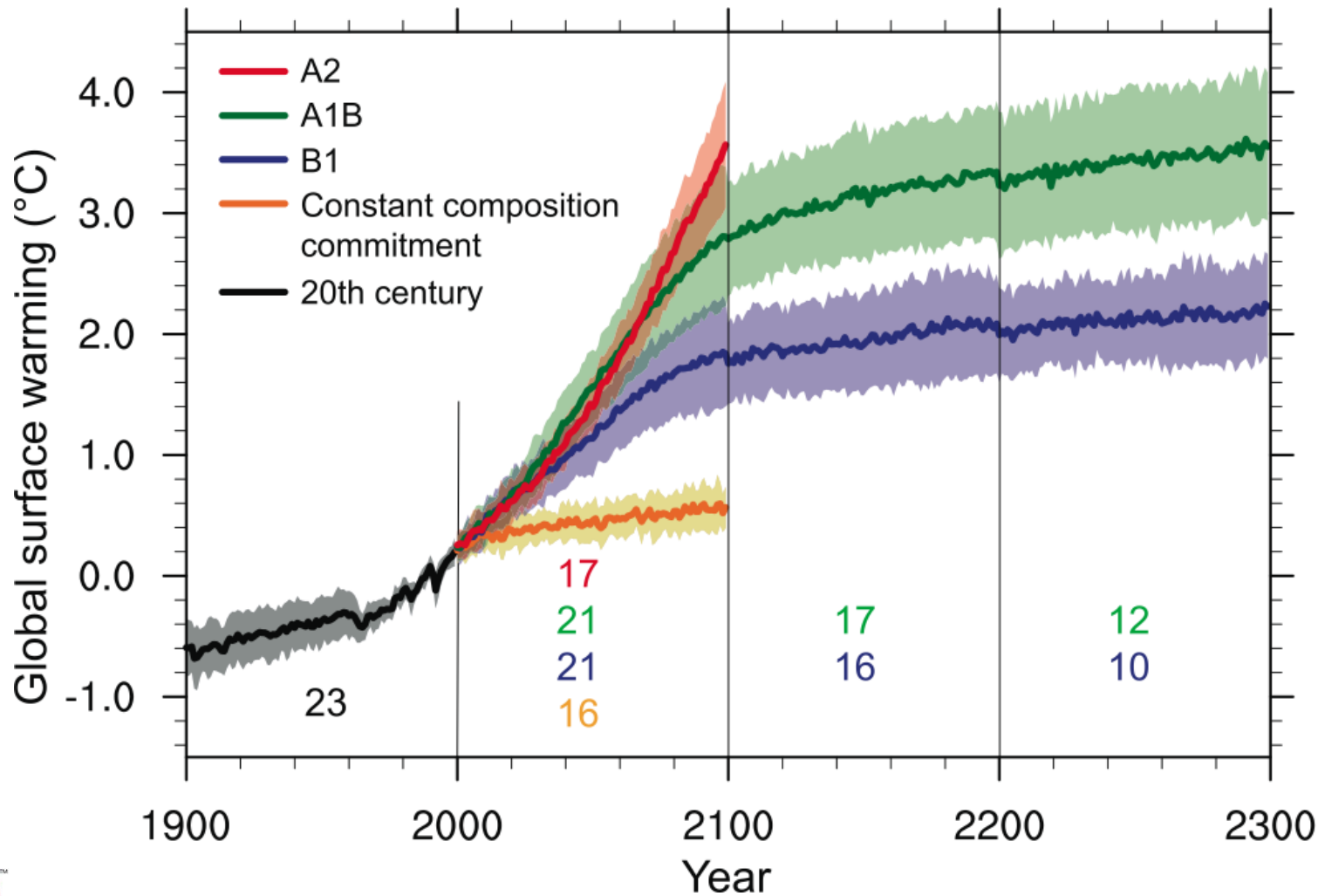
Sources of greenhouse gases



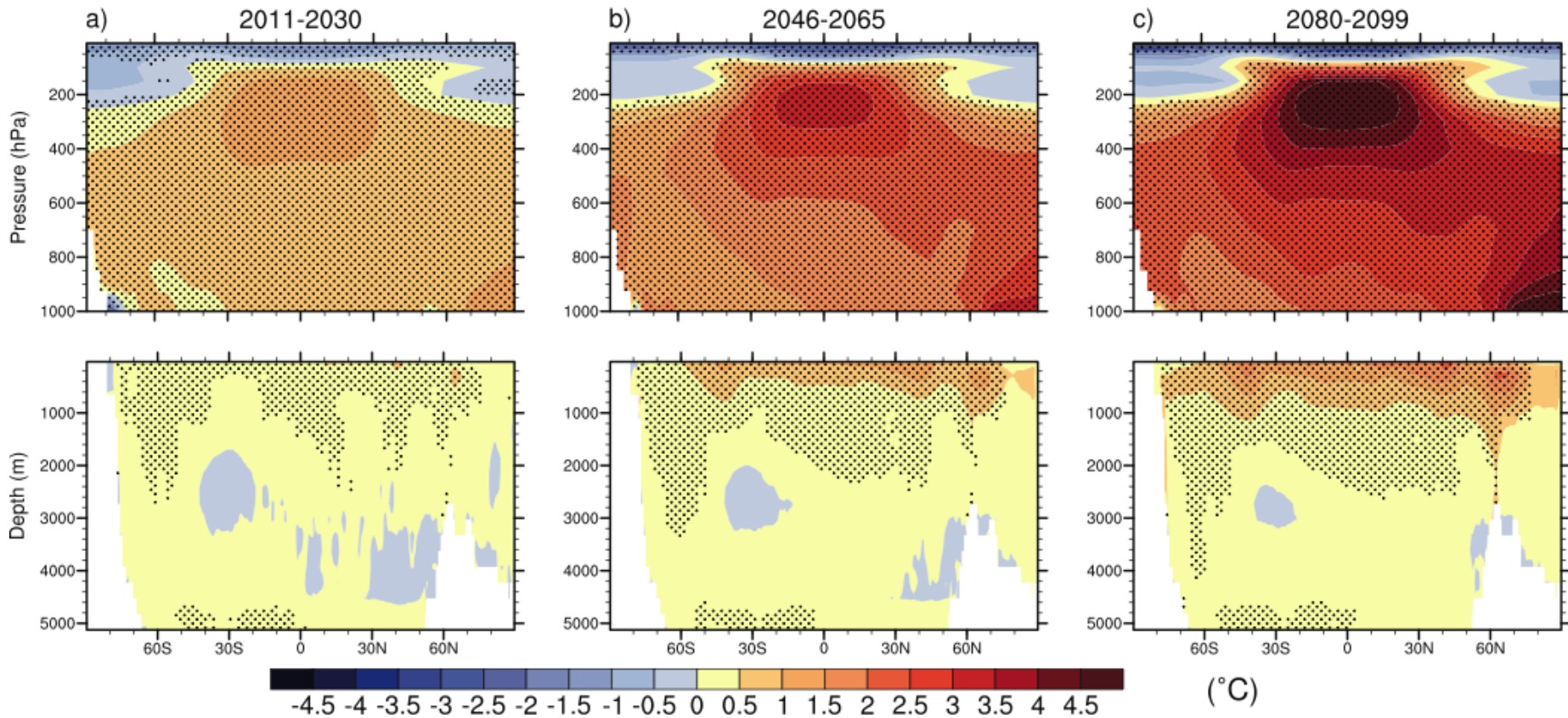
Processes affecting GHGs in atmosphere



GW projections

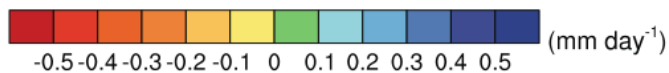
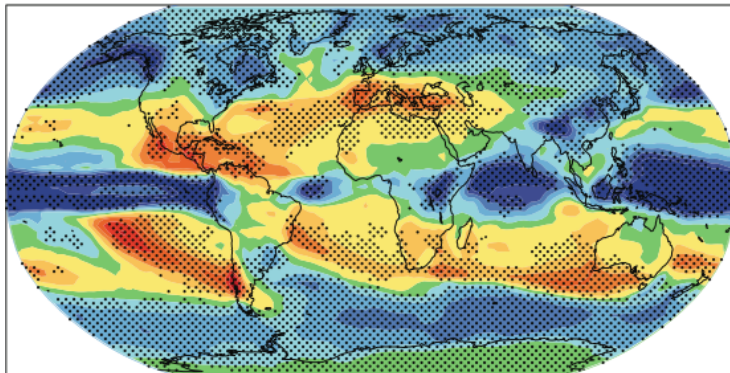


Impacts — temperature changes

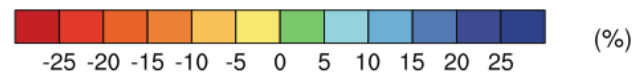
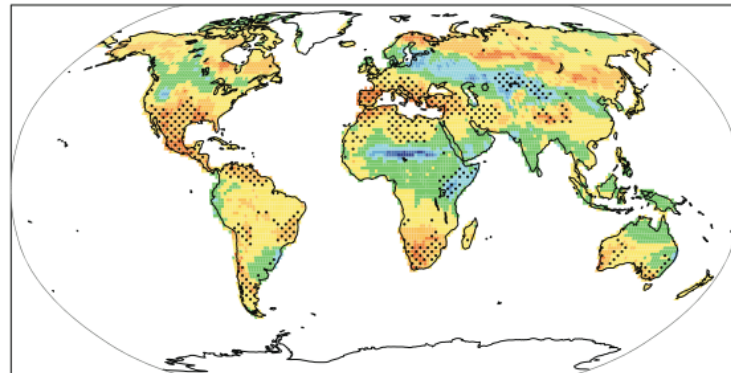


Impacts — water

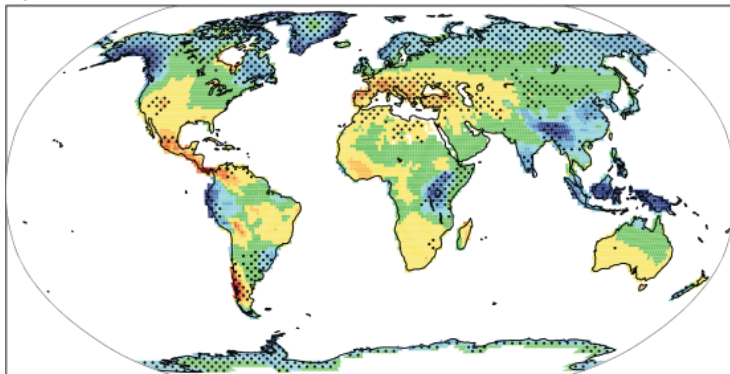
a) Precipitation



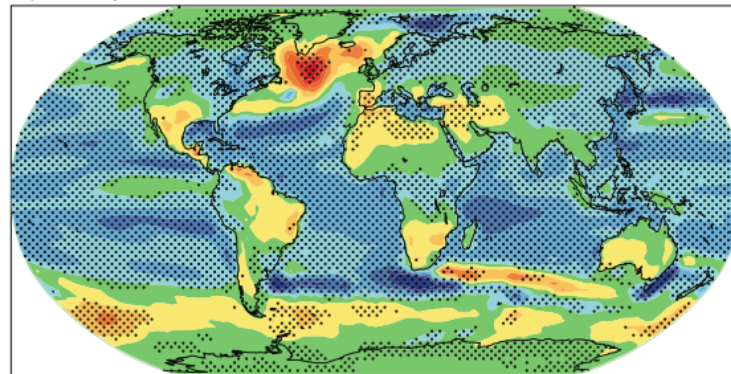
b) Soil moisture



c) Runoff



d) Evaporation



Other impacts

- Falling crop yields in many areas, esp. developing regions
- Extensive risk to coastal areas (e.g., coral reefs)
- Bio-diversity threatened; many species face extinction
- Increased intensity of coastal storms; droughts leading to wildfires
- Health impacts

Accepted conclusions about GW

- It is definitely occurring
- Production of GHGs has increased; most of which is anthropogenic
 - Improving the standard of living of the developing world will lead to huge increases in energy and GHG production
- Production processes involve several coupled mechanisms
- Potential exists for feedback loops to trigger abrupt increases
- In addition to temperature, there will be major impacts on global and regional water cycles

Need for engineering R/D

- Rigorous energy balances
 - From the geologic record, CO₂ increases have always lagged behind temperature rises
 - No evidence proving GHGs are causing GW
 - Period of greatest increase in global temperatures corresponds to period of greatest energy production
 - Need to determine just how important carbon is
- Rigorous carbon balances
- Laboratory and field experiments to test models

Considerations in developing path forward

- 70% of fossil fuel use is for power and heat; 30% for transportation
- From 1900 to 1960, efficiency of electric system increased 5X; from 1960 to now, it has increased less than one percent (currently ~33%)
- In order to stabilize CO₂ levels at 1995 levels by 2050, need to capture as much carbon as was burned as coal in 2000, starting in 2015
- One-sixth of world's population, one-fourth of global economic output, appears vulnerable to water shortages caused by GW

Paths forward

- Mitigation – reduce source term
 - Practically speaking, can reduce rate of increase of temperature and of GHGs, but probably can't reverse
 - Carbon capture and sequestration not ready for prime time
- Adaptation – learn to live in warmed world
- Better anticipate impacts, and ground policy and actions on a firmer basis
 - Precautionary principle would indicate that carbon management should not be undertaken at this time[!]

Engineering R/D to support mitigation

- Carbon sequestration
 - Amine processes suboptimal
 - Membranes coupled with better combustion techniques
 - Bio-processes to convert CO₂ to coal gas or methane
 - CO₂ hydrates
- Processes and products that consume CO₂ or carbon
- In-situ coal burning for power; fuel switching (nuclear, renewables); greater efficiency**
- Low-energy condensers

Adaptation

- Reducing sensitivity to impacts; improving ability to cope with impacts
- Identify vulnerabilities
- Reduce current stresses
- Very little R/D or policy attention to date
 - What's been done is mostly theoretical
 - However, effects are already being seen
 - Mitigating actions will take time to be effective, and may only slow the rates of rise of T and CO₂

Adaptation as a policy option

- World community has recently focused on effects of GW on food, fiber and forestry industries; water availability; human health; and industry/settlement
- Clear that one size does not fit all – even in US will have areas with great droughts and areas with much more rainfall
- Thus, need a variety of developments in order to be able to adapt
- Greatest R/D need is risk assessment

Engineering R/D for adaptation — water

- Reduced water usage in chemical processes and power production
- Improved water desalination technology
- Water demand management
- New techniques for assuring adequate clean water supplies
- Enhanced water distribution systems

Engineering R/D for adaptation — others

- Lower energy heating / cooling systems (e.g., near-surface geothermal, absorption chillers)
- Processes that are much more energy efficient
- Processes that are less likely to have grave consequences if disrupted
- Improved understanding of the implications of substituting wind, solar, biomass for coal
- New products that will lower energy significantly

New products



Summary

- Global warming is real and is already being felt
- Engineering R/D is needed to understand the problem
 - Key issue is carbon vs energy production
- Engineering R/D is needed to support mitigation
 - Esp. carbon management
- Engineering R/D is needed to support adaptation
 - Reducing demands on water supply and getting water where we need it are keys