Chapter 8: Predictions of Future Climate Change

March ~~23 &~~ 25

8.1. The Factors That Control Emissions

8.2. How These Factors Have Changed in the Past

8.3. Emissions Scenarios

8.4. Predictions of Future Climate

8.5. Is the Climate Predictable?

Terms

Problems

Quiz 4 @ 11:25 am

8.3.1 Factors That Drive Emissions

While we understand factors controlling GHG emission, making factor predictions difficult:

- Future rates of poverty,
- Education for women,
- Availability of health care,
- Views on birth control.
- Policies to decrease GHG emission/abundance.

Impractical to make any single prediction.

Shared Socioeconomic Pathways (SSPs): 5 alternative pathways

8.3. Emissions Scenarios

SSP1: Sustainability. World shifts gradually, but pervasively, toward more environmentally-friendly path. World becomes more equal place, with economic growth in poor countries causing them to close wealth gap with rich world. Population growth is slow, peaking mid-century, and world shifts toward renewable energy.

SSP2: Middle of the road. World follows path in which social, economic, and technological trends similar to the historical patterns.

SSP3: Regional rivalry. Rich get richer, but poor do not, leading to increasing conflict between regions. Nationalism is ascendant. Population growth low in rich countries, but high in poor ones. Consumption is resource-intensive and technological development slow, leading to reliance on high-carbon-intensity fuels like coal.

8.3. Emissions Scenarios

SSP4: Inequality. Like SSP3, world is divided place, but this scenario features more rapid technological development and deployment of energy technologies with low carbon intensities.

SSP5: Fossil-fueled development. World similar to optimistic SSP1 world, but is powered by fossil fuels rather than SSP1 shift toward more sustainable energy. There is emphasis on economic growth rather than sustainability.

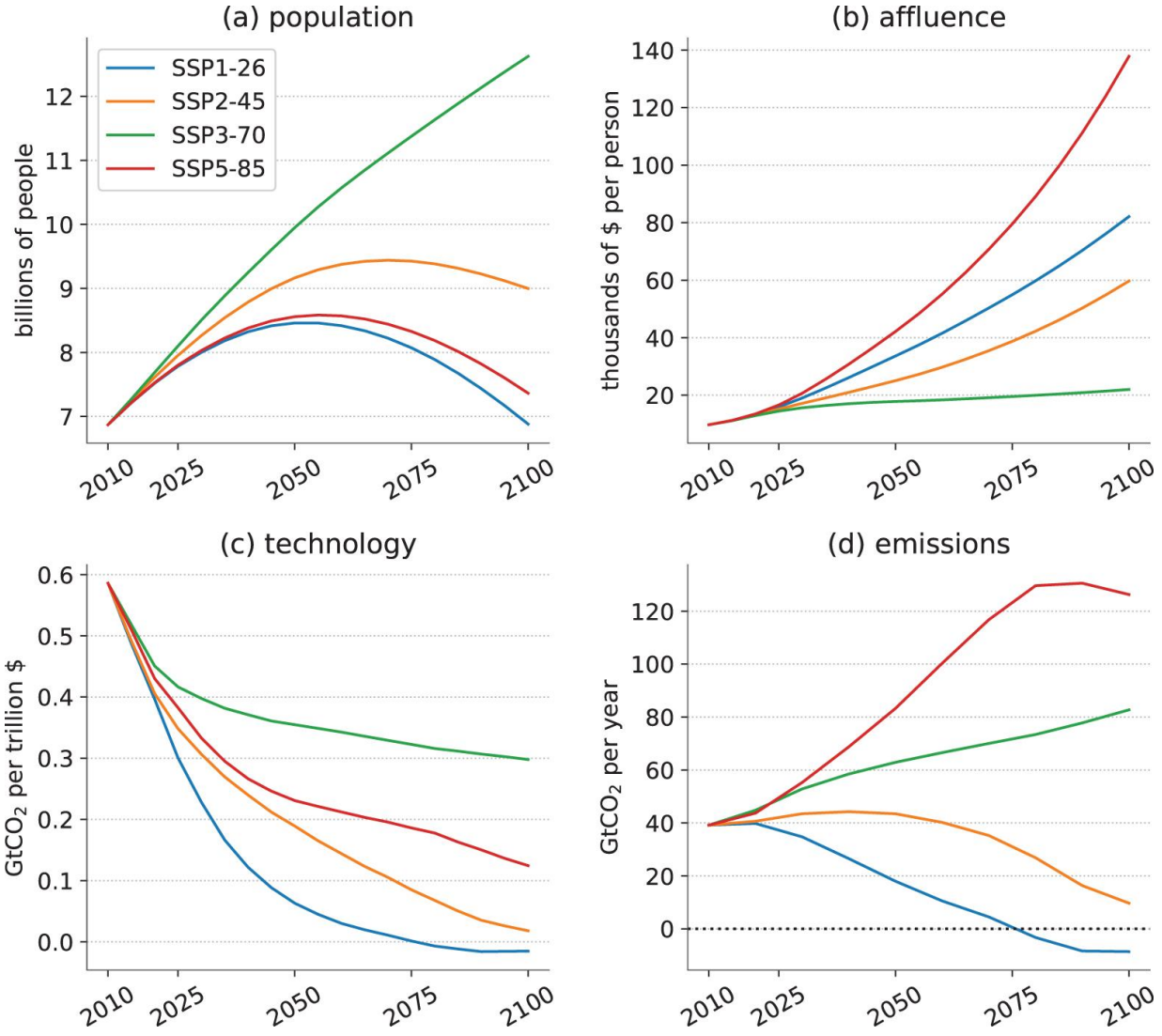

Fig. 8.2: (a) Population (in billions). (b) Affluence ($GDP/pers). (c) Technology term ($GtCO_2$ per trillion $GDP). (d) Emissions of CO_2 ($GtCO_2$/yr).

8.3.1 Factors That Drive Emissions

- Pathway narratives internally consistent: *Population connected to Affluence*.
- Pathways where world's poor become richer (SSP1 and SSP5) feature slower P growth than pathways where poverty maintained (SSP3).
- **Population** peaks mid-century in all SSPs except SSP3 (**Fig. 8.2a**).
- **Affluence increases** in all pathways, but with considerable spread between them (**Fig. 8.2b**).
- **Technology declines** for all pathways over time, with considerable spread (**Fig. 8.2c**):

✓ *Reflects tech used to produce energy, with lower values for more climate-safe energy.*

✓ *Deployment of climate-safe tech takes $, so slowest in poorer SSP3 and fastest in richer SSP1.*

✓ *Affluence <u>not</u> only determinant (e.g., SSP5 affluent, but still relies on fossil fuel).*

8.3.2 Emissions

SSP3 and SSP5 assume **no** effort to address climate change beyond what was already done:

- SSP3 assumes a dirtier world, more reliant on fossil fuel, but poorer, so emissions lower than SSP5.
- SSP3 2100 emissions is ~2x emissions of today (**Fig. 8.2d)**

SSP5 assumes a highest emission pathway, with high growth and reliance on fossil fuel:

- SSP5 2100 emissions = ~126 $GtCO_2$/yr, ~3x emissions of today (**Fig. 8.2d)**

8.3.2 Emissions

SSP1 and SSP2 represent more strenuous efforts to reduce emissions:

SSP2 emissions peak ~2050 and decline after.

SSP1 emission peak around today and declines after with emissions negative ~2075.

8.4. Predictions of Future Climate

8.4.1 Over the Next Century

RF estimates can then be translated into projected ΔT for each scenario by using climate sensitivity& feedbacks **(Eqn. 6.2-6.5)**:

- Despite differences in emissions across scenarios, projected ΔT similar until mid-century (**Fig. 8.4**)
- ΔT of this century largely determined by past emissions and long lifetime of CO_2

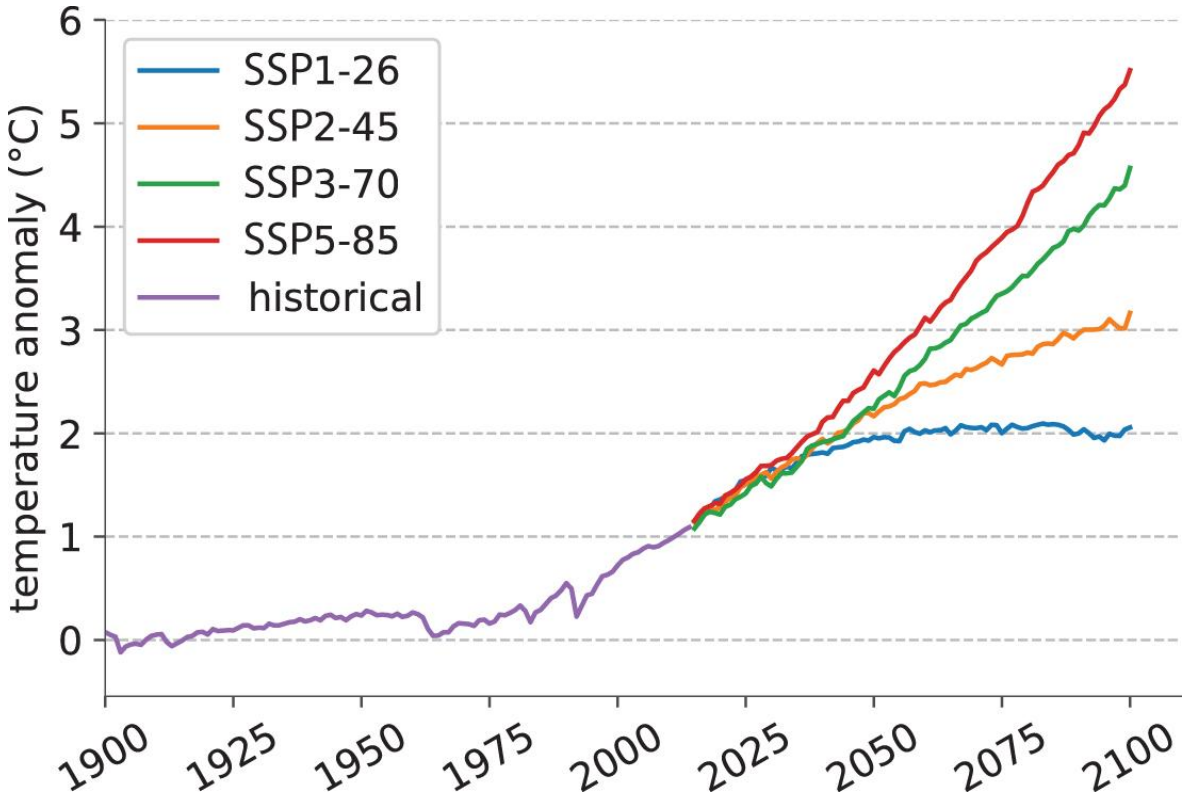

Fig. 8.4: Average of 17 simulations of global and annual average surface T anomaly under 4 emission scenarios. T prior to 2014 from model runs driven by historical forcing.

8.4.2. Climate Change Beyond 2100

- Climate change will not stop in 2100 due to long lifetime of CO_2.
- Of CO_2 emitted today, ~25 % will be in atmosphere several centuries from now and ~100,000 yr to remove all.
- After emissions cease CO_2 abundance declines slowly.
- In 3000 AD, CO_2 abundance still above pre-industrial level ~280 ppm

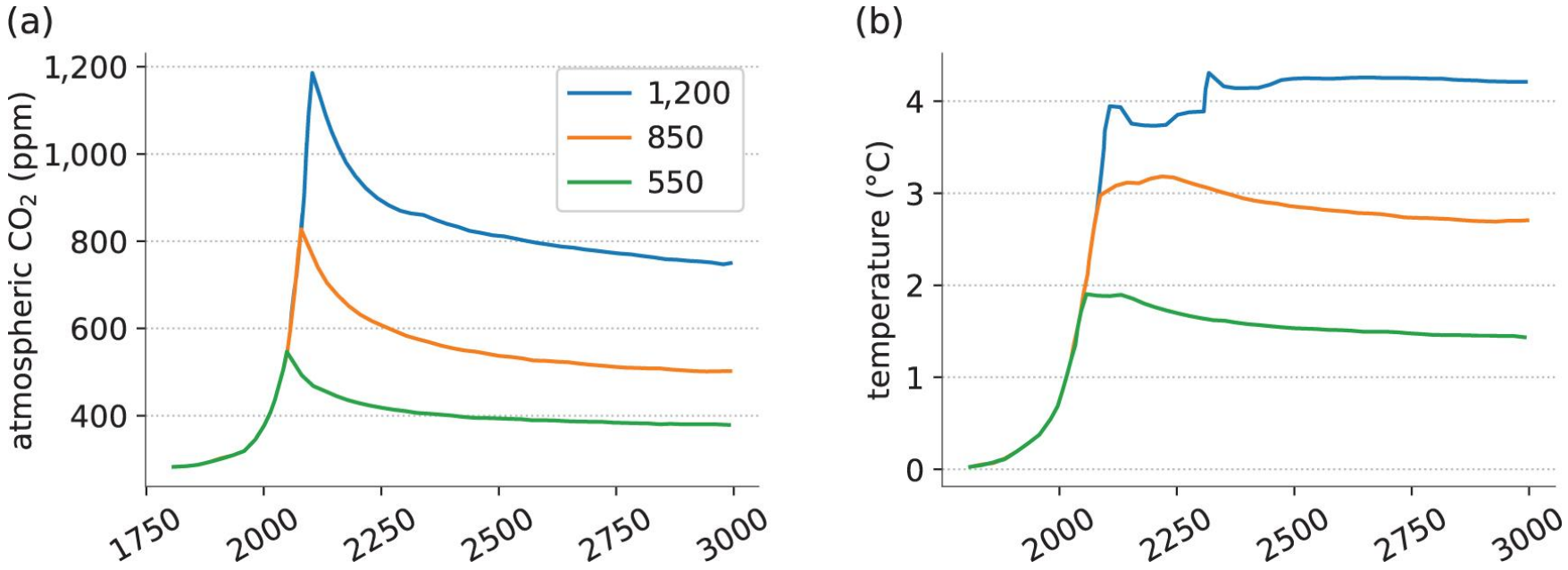

Fig. 8.5: (a) Amount of CO_2 in atmosphere as function of time for next 1000 yr. CO_2 emissions rise at 2%/yr until it hits peak abundance (550, 850, 1200 ppm); then emissions decreased instantly to zero. (b) Temperature time series corresponding to each CO_2 time series.

8.4. Predictions of Future Climate

8.4.2. Climate Change Beyond 2100

Emitting CO_2 this century commits Earth to elevated T for millennia (**Fig. 8.5b**).

Once T rises, reducing emissions will not bring T back down quickly.

Thus, climate change can be considered irreversible over conceivable near term.

8.5. Is the Climate Predictable?

Common criticism: *We can not predict the weather next week, so why does anyone believe predictions of the climate in a hundred years?*

- *It is true that weather predictions only accurate for week or so into future.*
- *However, flaw is direct comparison of weather prediction with climate prediction.*
- *Weather prediction gives exact state of atmosphere at exact time/location.*

8.5. Is the Climate Predictable?

- Climate prediction does not require predicting exact state at exact time/location.
- Rather, is prediction of statistics of weather over regions and time periods of years.
- Our inability to predict complex system (e.g., weather) does not preclude our ability to predict statistics of that system (e.g., climate).
- Weather prediction is “initial value problem.”
  Good prediction requires good knowledge of current state.
- Climate prediction is “boundary value problem.”
  Good prediction requires good knowledge of RF and feedbacks.
- Both types of prediction difficult:
  - ✓ Climate prediction must consider changes to ocean and ice over decades.
  - ✓ Weather prediction can assume these as constant over days.

Ch 8: Predictions of Future Climate Change

8.1. The Factors That Control Emissions
8.2. How These Factors Have Changed in the
8.3. Emissions Scenarios
8.4. Predictions of Future Climate
8.5. Is the Climate Predictable?
Terms
Problems

Quiz 4:

TERMS

Carbon intensity
Emissions scenario
Energy intensity
Greenhouse-gas intensity
Gross domestic product (GDP)
IPAT relation
Shared socioeconomic pathways