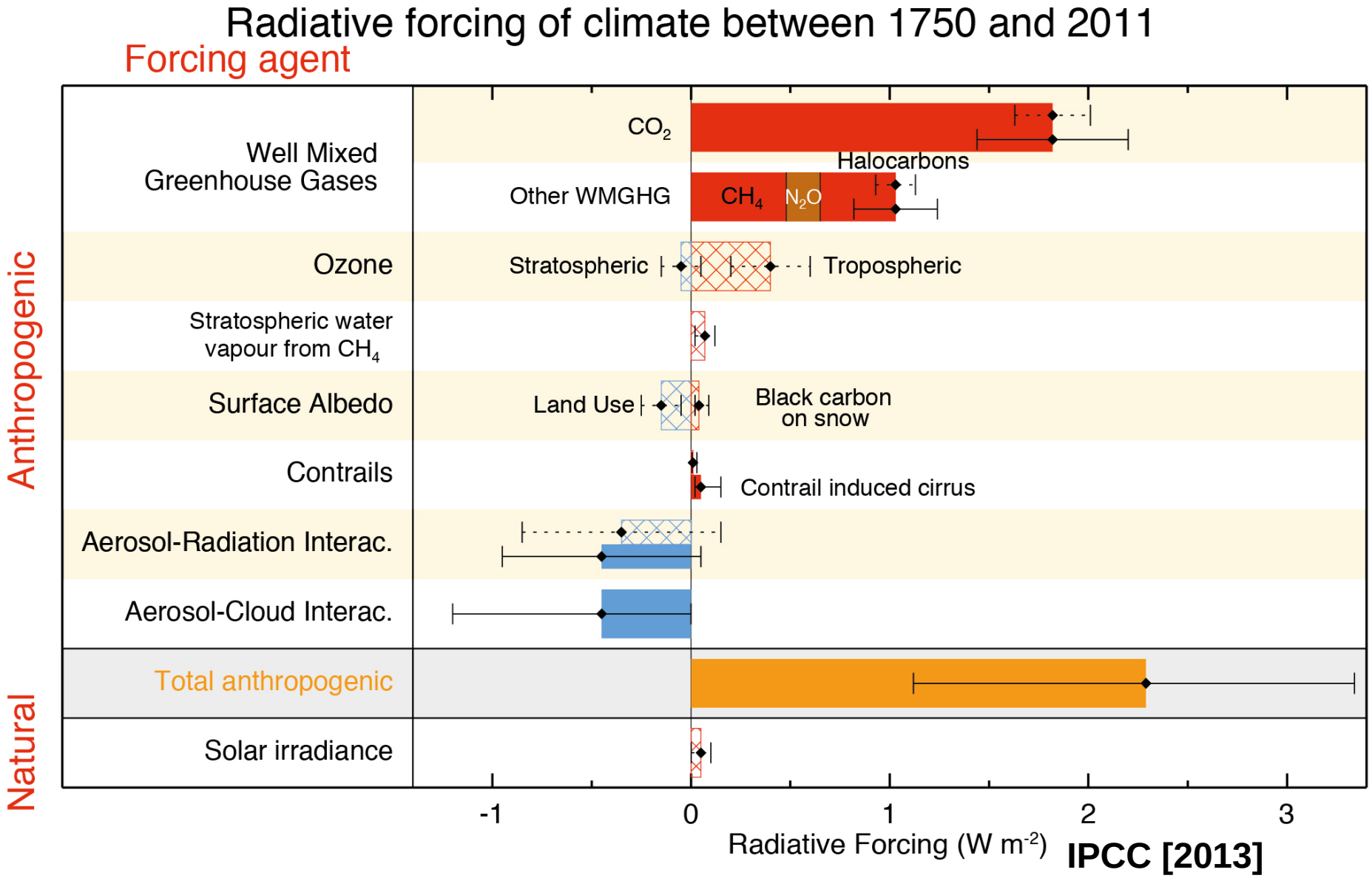
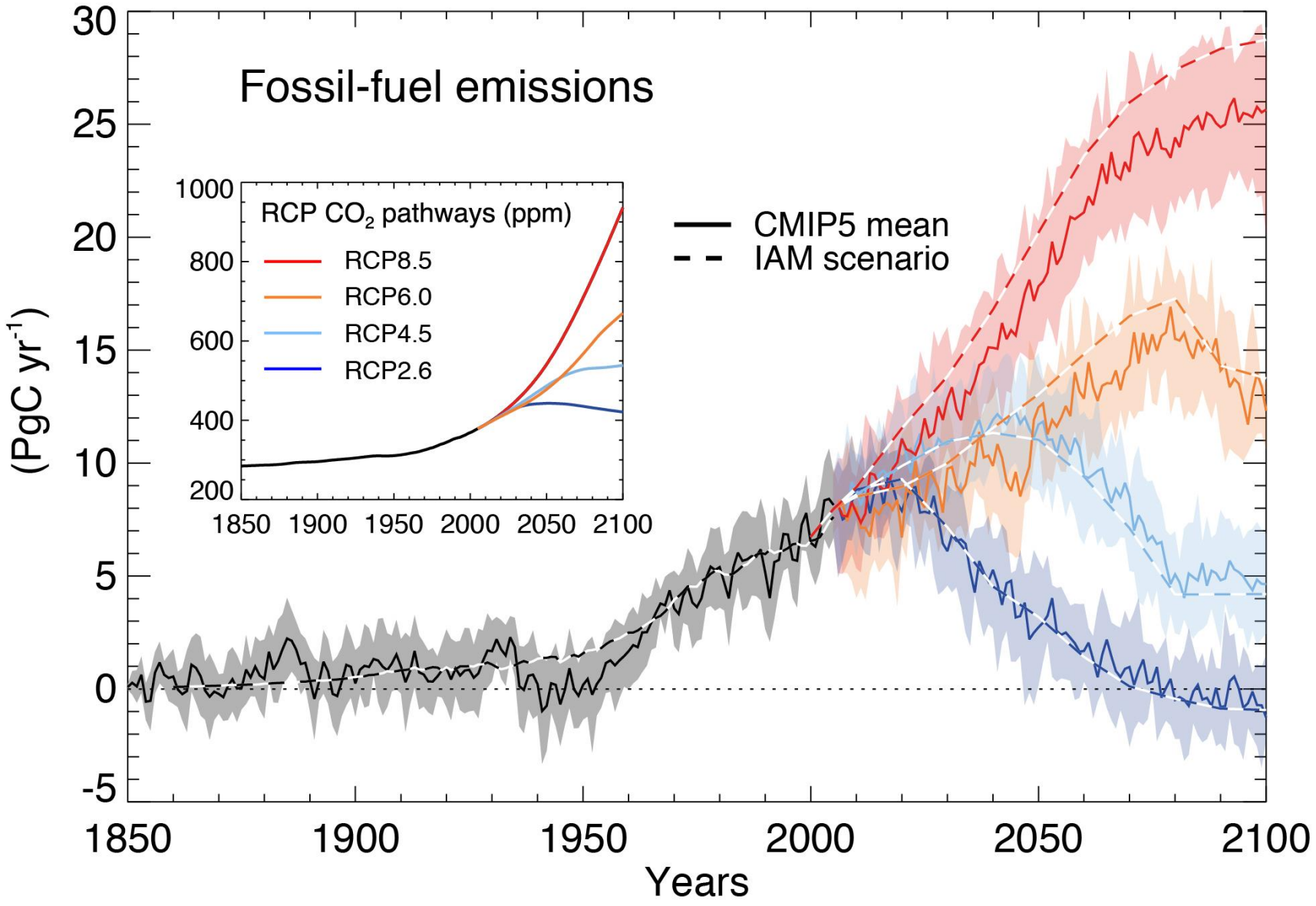
# This Week: Anthropogenic Forcings

- **Aerosol forcings**
- **An example of a global anthropogenic forcing that was mitigated**
- **Expected impacts of GHG forcing (Part 1)**

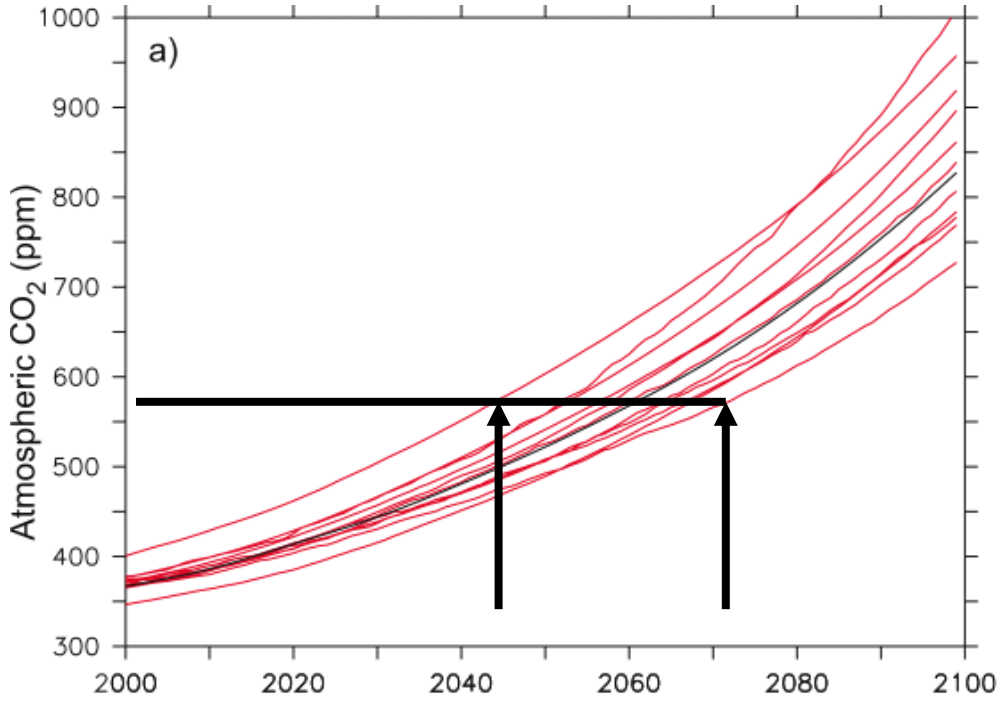
# Anthropogenic Global Radiative Forcing of Climate



# Projections of Future Emissions



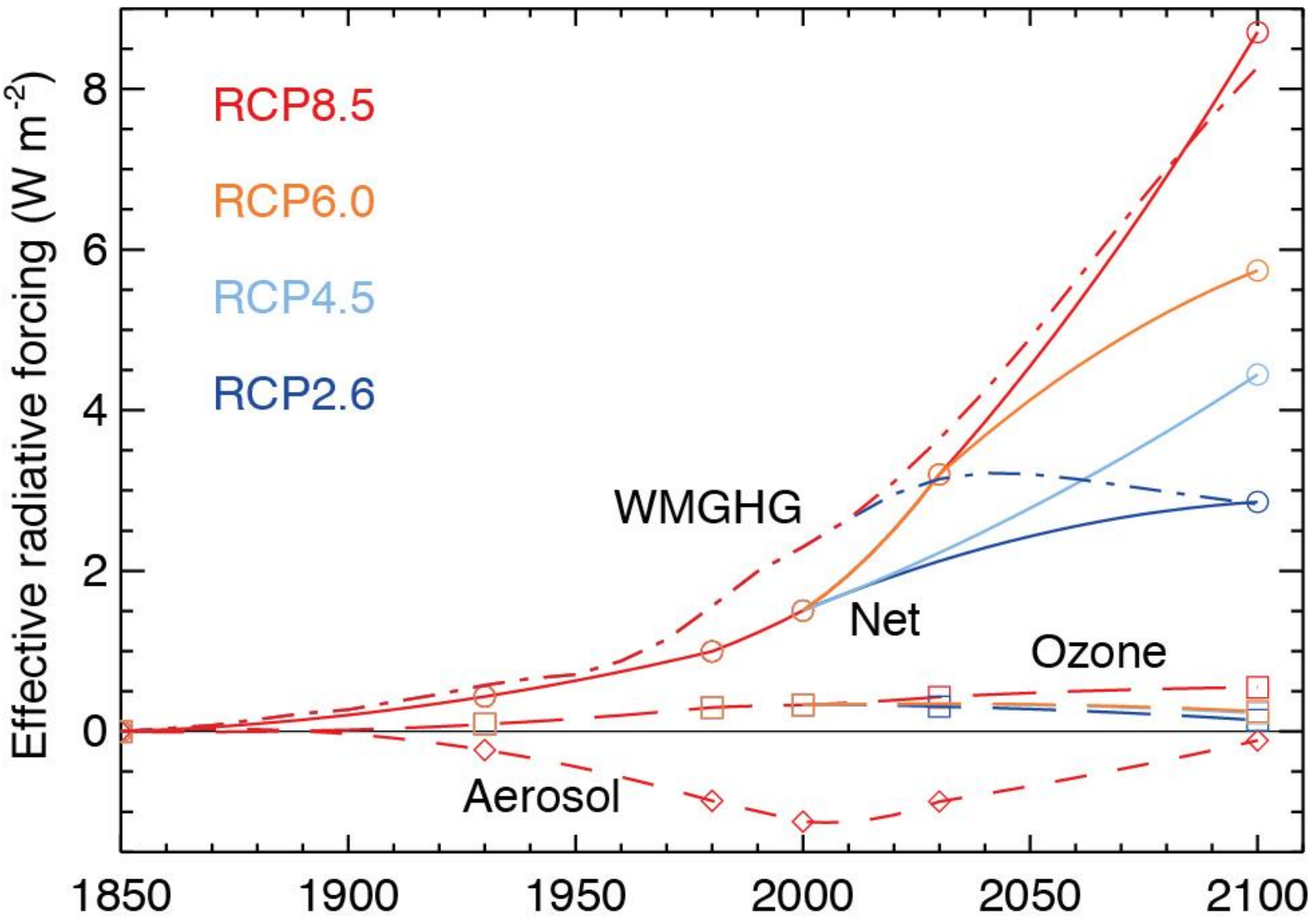
# Future Atmospheric $CO_2$



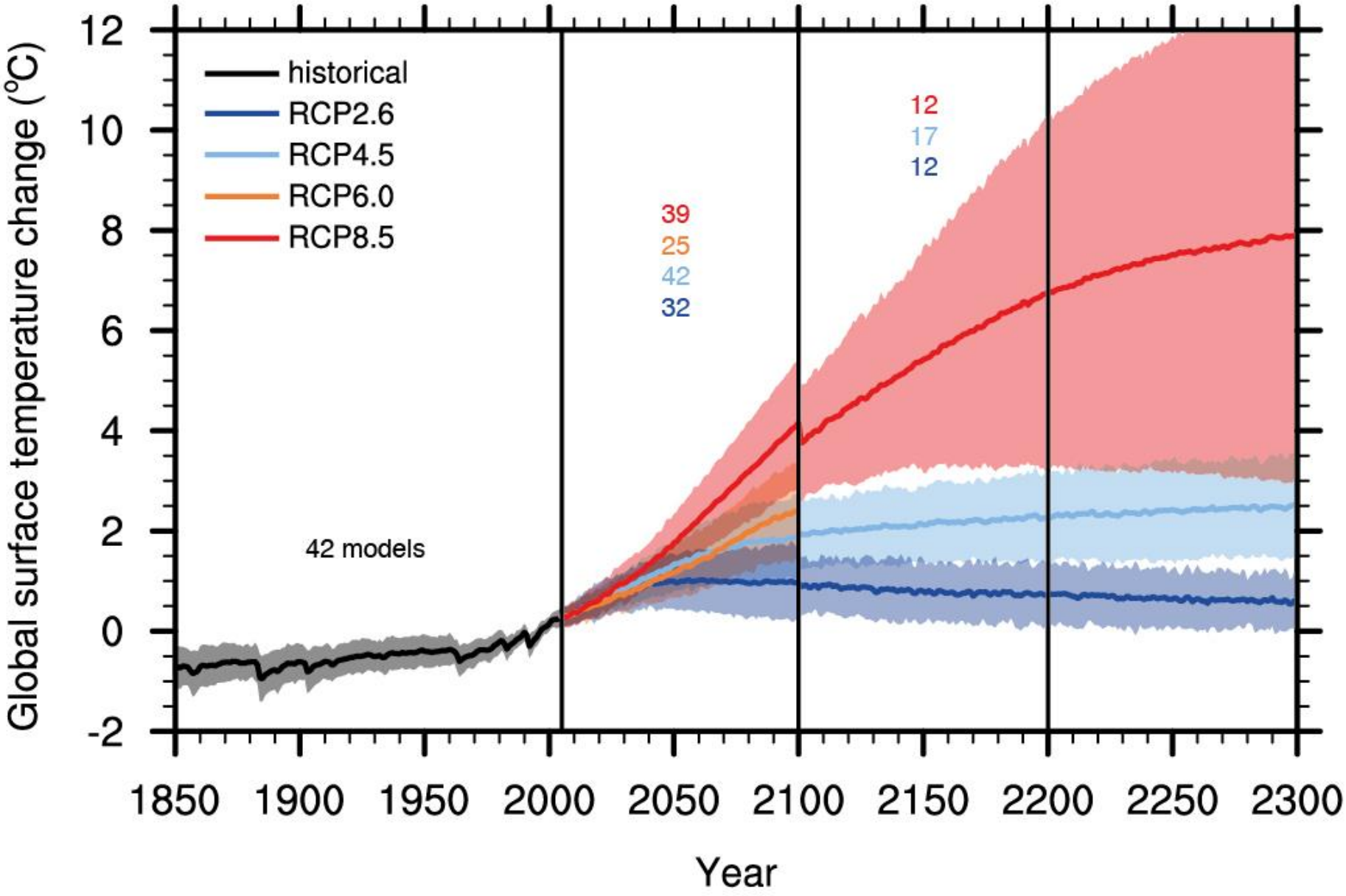

**One emission scenario in many different IPCC models**

**Most models suggest $CO_2$ will be double pre-industrial (2 x 280 ppm) by mid-century**

# Future: Representative Concentration Pathways



# Impact #1: Surface T Increases



# Poll Question

**If all else stayed constant, a doubling of atm. CO2 concentrations alone would increase absorptivity, but only enough to cause 2K increase in surface T for "double CO2" world.**

When poll is active, respond at **PollEv.com/joelathornto254** Text **JOELATHORNTO254** to **22333** once to join

- Clearly climate models can't be trusted.
- Climate models include only negative feedbacks
- Climate models imply positive feedbacks are important

Total Results: 0

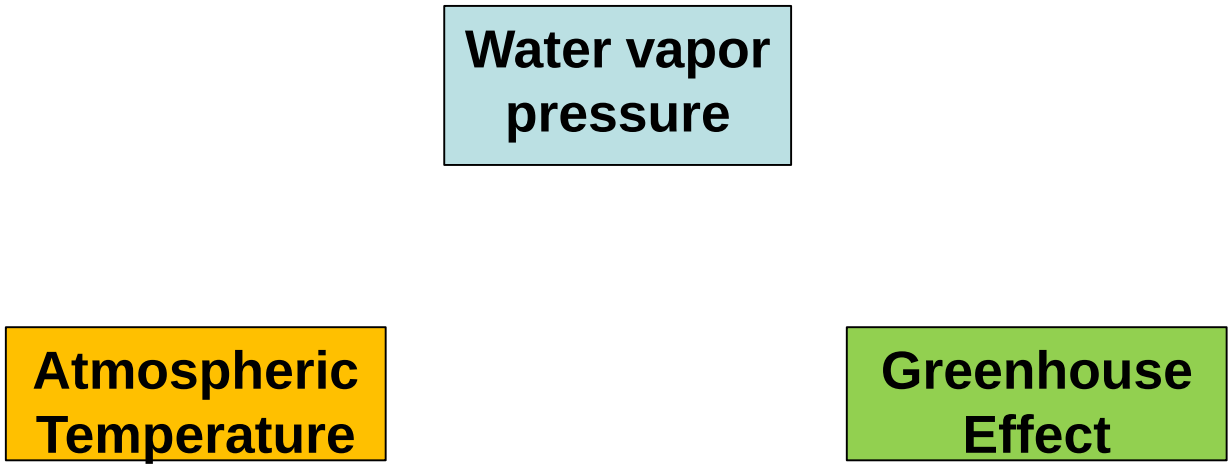
**What is a likely positive feedback operating in climate models on a short timescale that could explain >2K increase with double CO2?**

When poll is active, respond at **PollEv.com/joelathornto254** Text **JOELATHORNTO254** to **22333** once to join

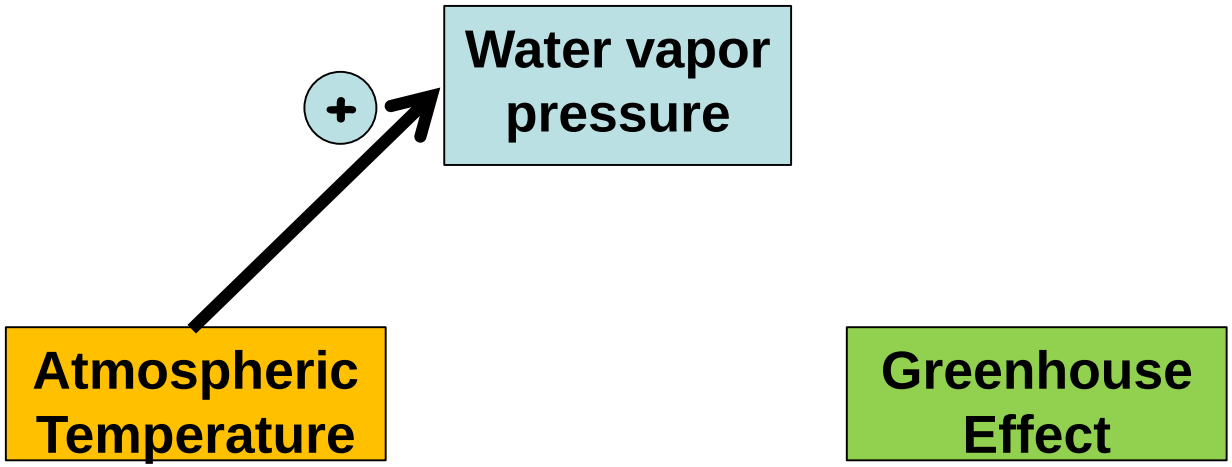
- CO2 – photosynthesis feedback
- Water vapor feedback
- Silicate-weathering feedback

Total Results: 0

# Water Vapor Feedback



# Water Vapor Feedback



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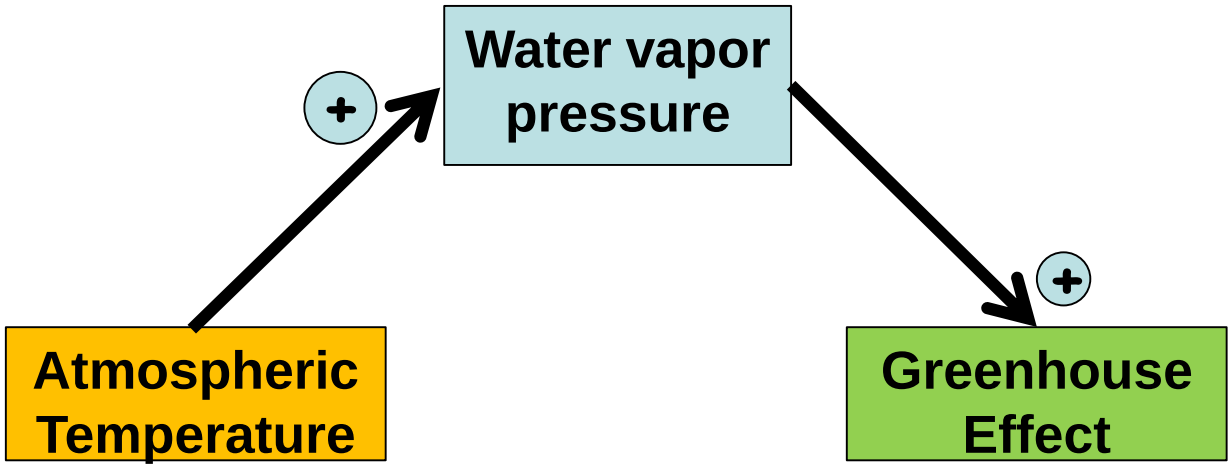
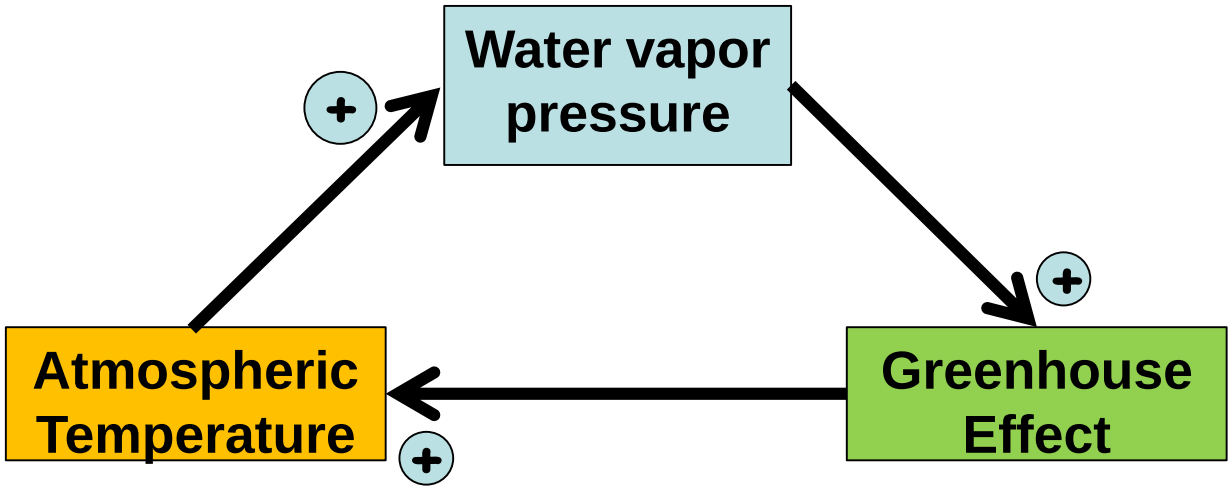


# Water Vapor Feedback

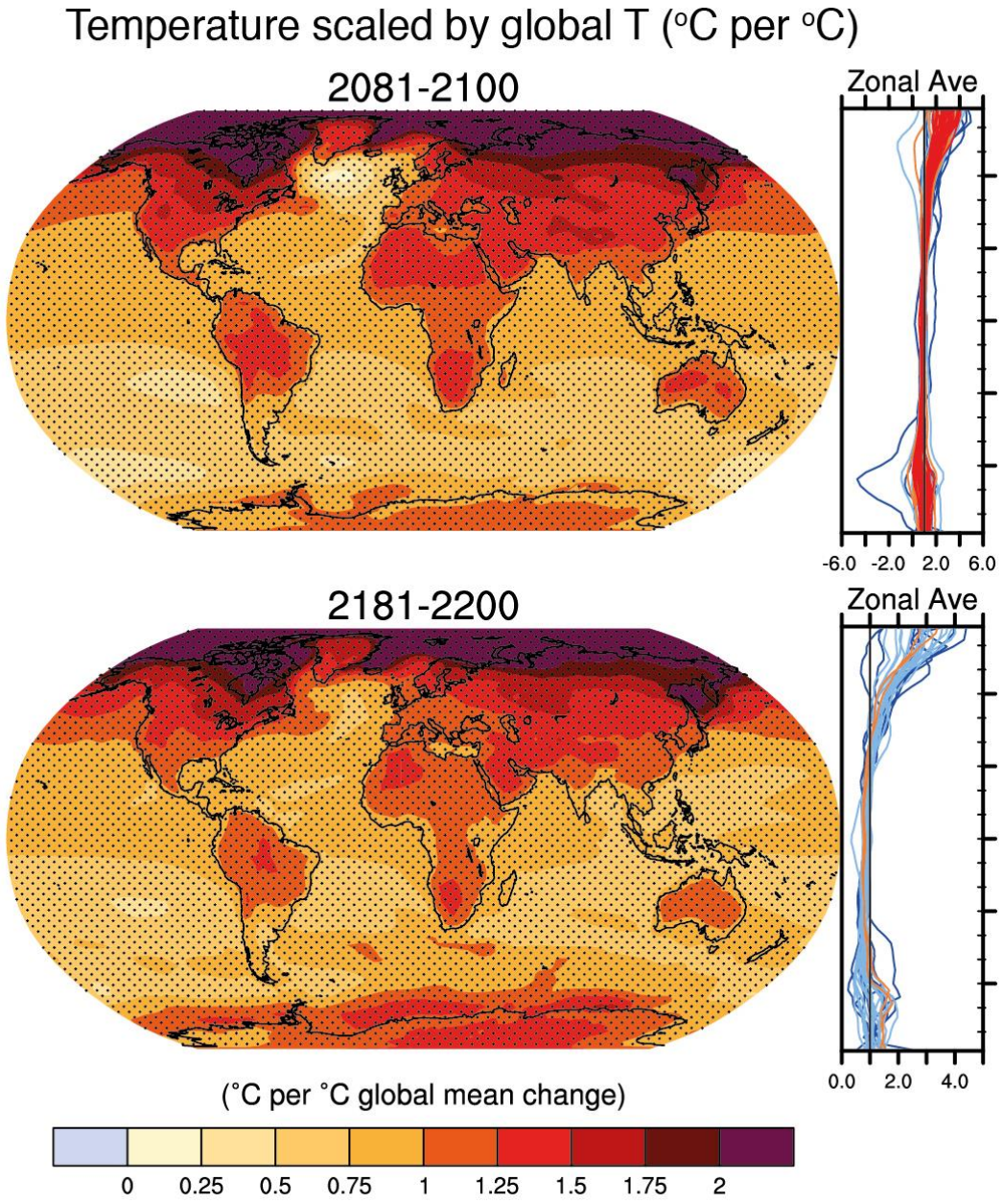



**The amount of water vapor in the atmosphere is a response to the climate**

**Recall: Water vapor residence time is ~ weeks, fast response to changes**

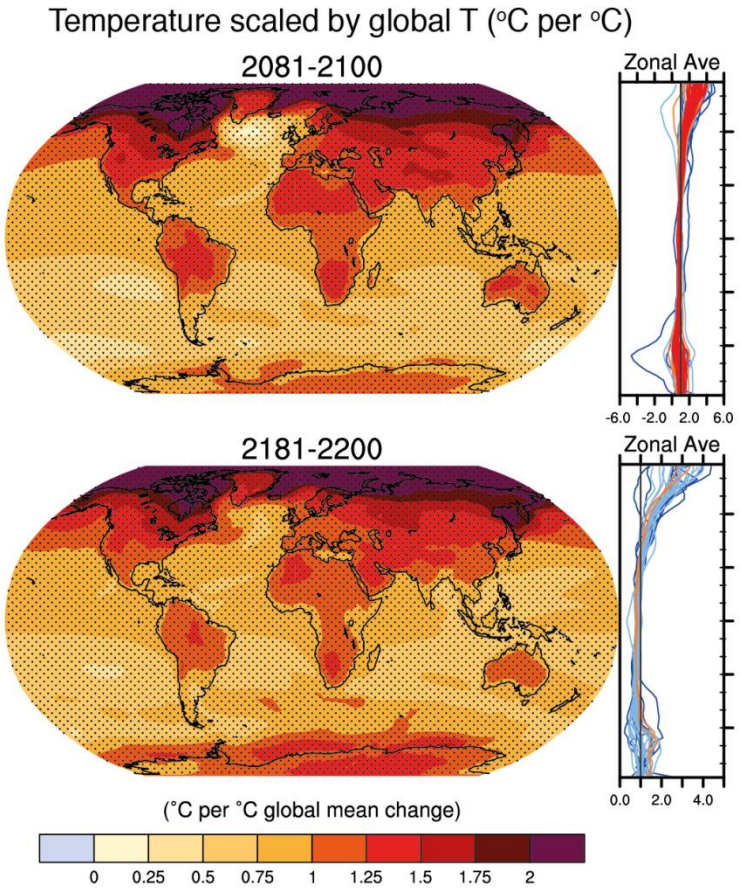
# Impacts: Temperature Increase Not Uniform

- **Land warms more than oceans**
- **Polar "amplification"**



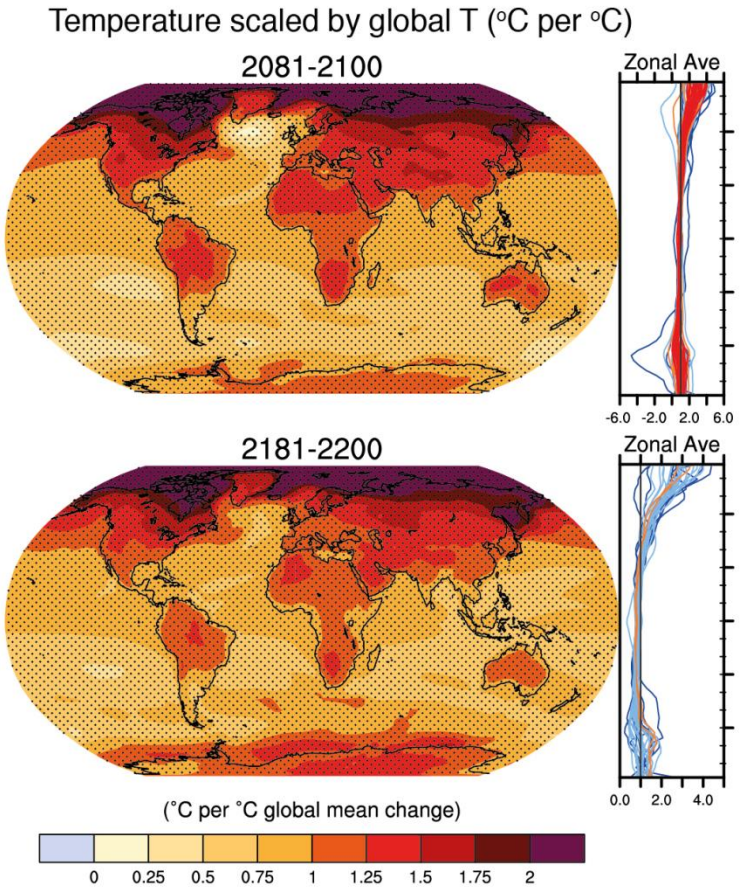
# Impacts: Temperature Increase Not Uniform

- **Land warms more than oceans**
  - **Partly due to different thermal mass and heat capacity**
  - **But more so due to *<u>evaporative cooling</u>* (lack thereof over land)**



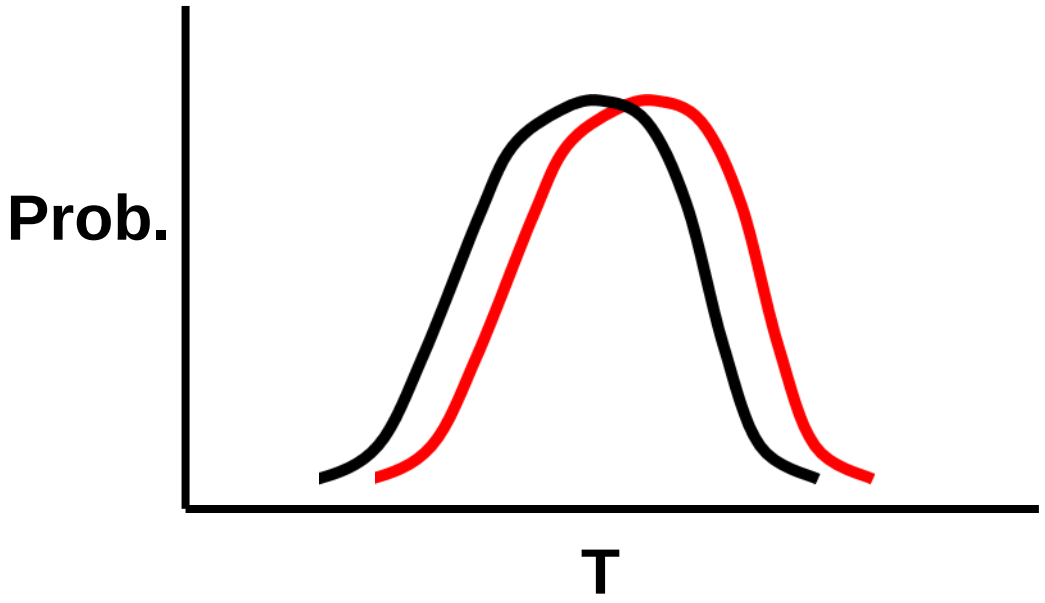
# Impacts: Temperature Increase Not Uniform

- **“Polar Amplification”**
  - **Mostly Arctic amplification**
  - **Partly snow-ice albedo, and increased oceanic and atmospheric (latent) heat transport**

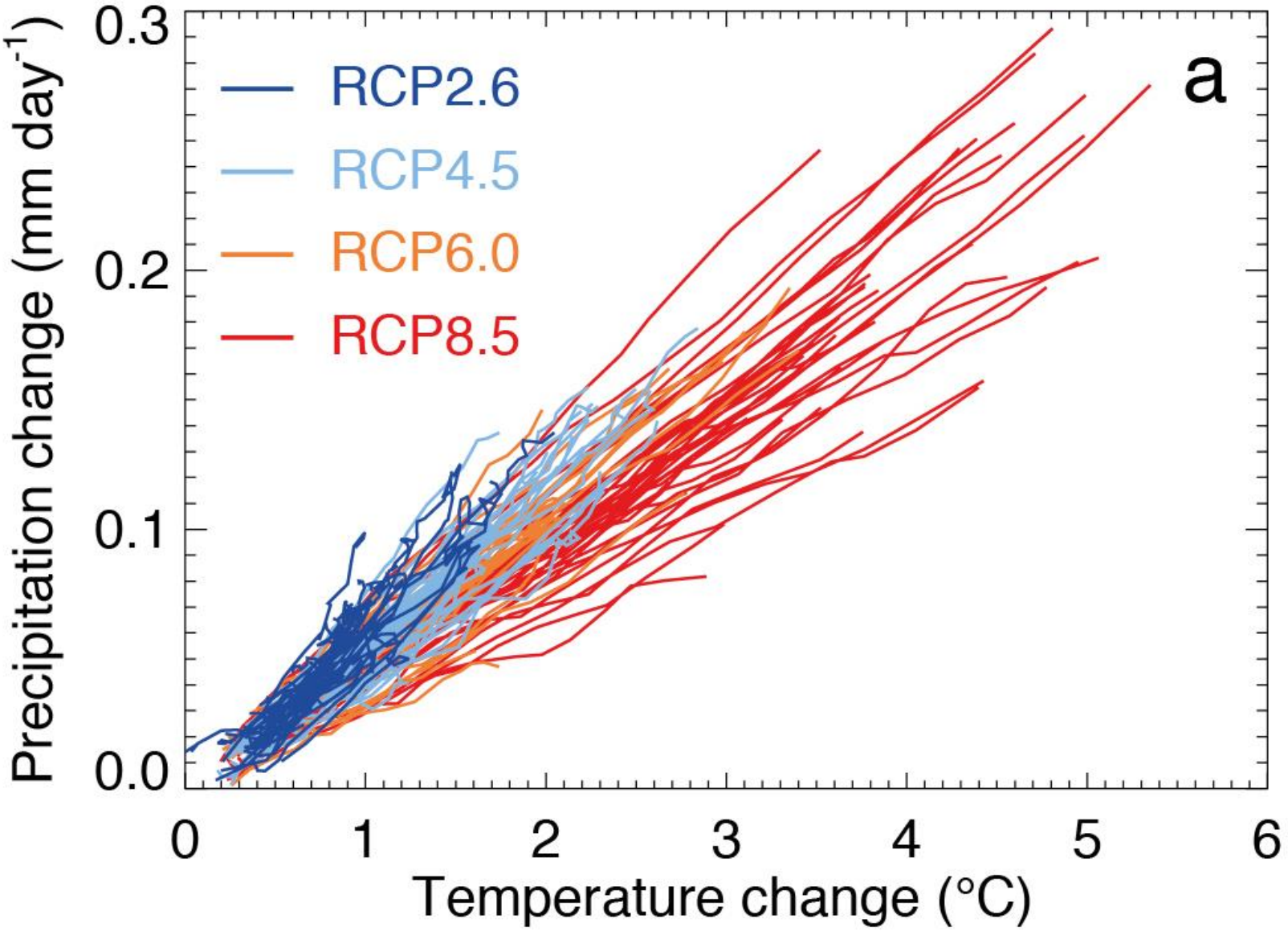


# Temperature Extremes: Distribution shifts

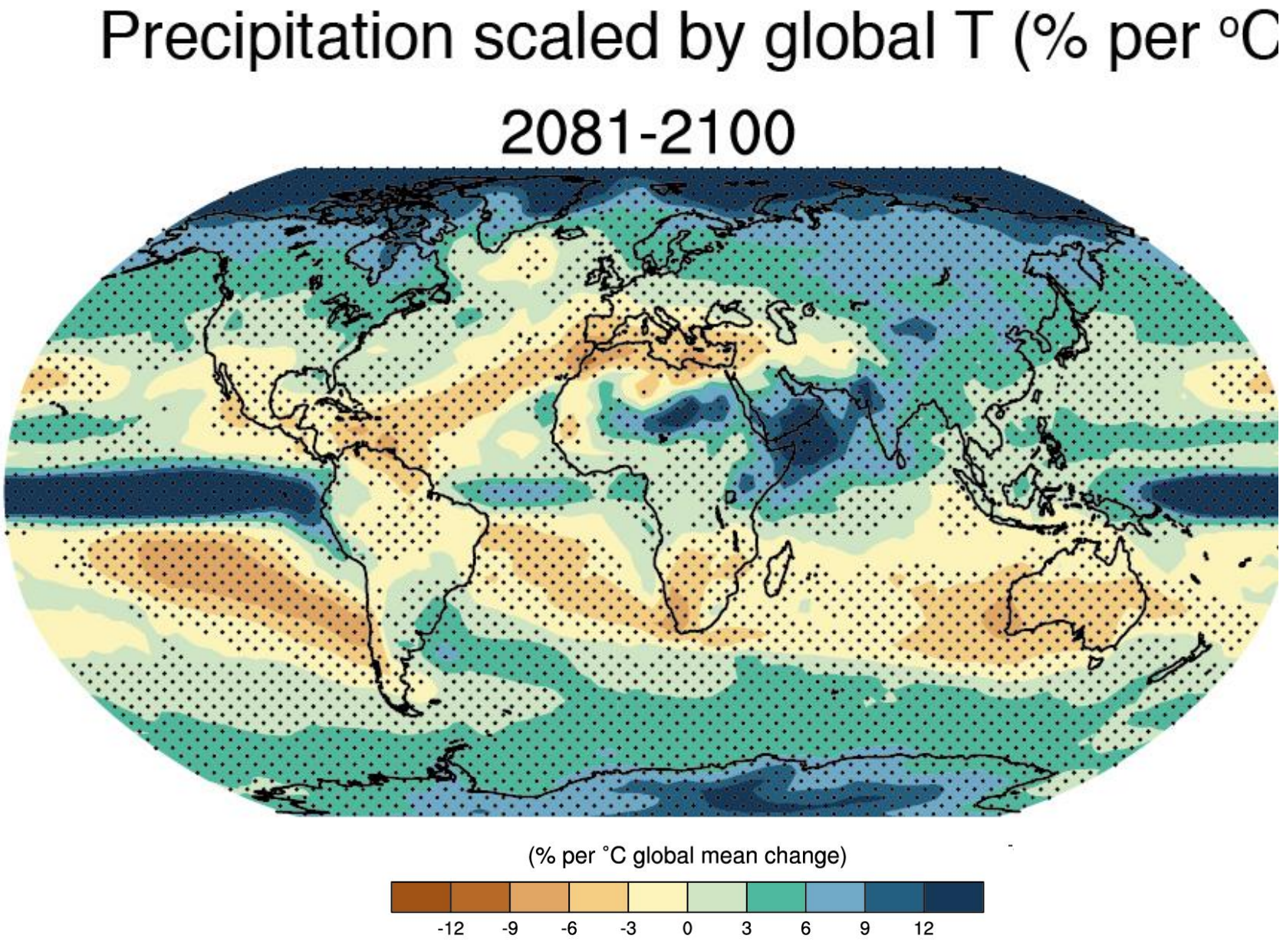
- **Coldest nights get warmer**
- **Warmest days get warmer (more frequent)**
- **Warm nights more often**



# Impact #2: Water Cycle (and Atm. Circulation)



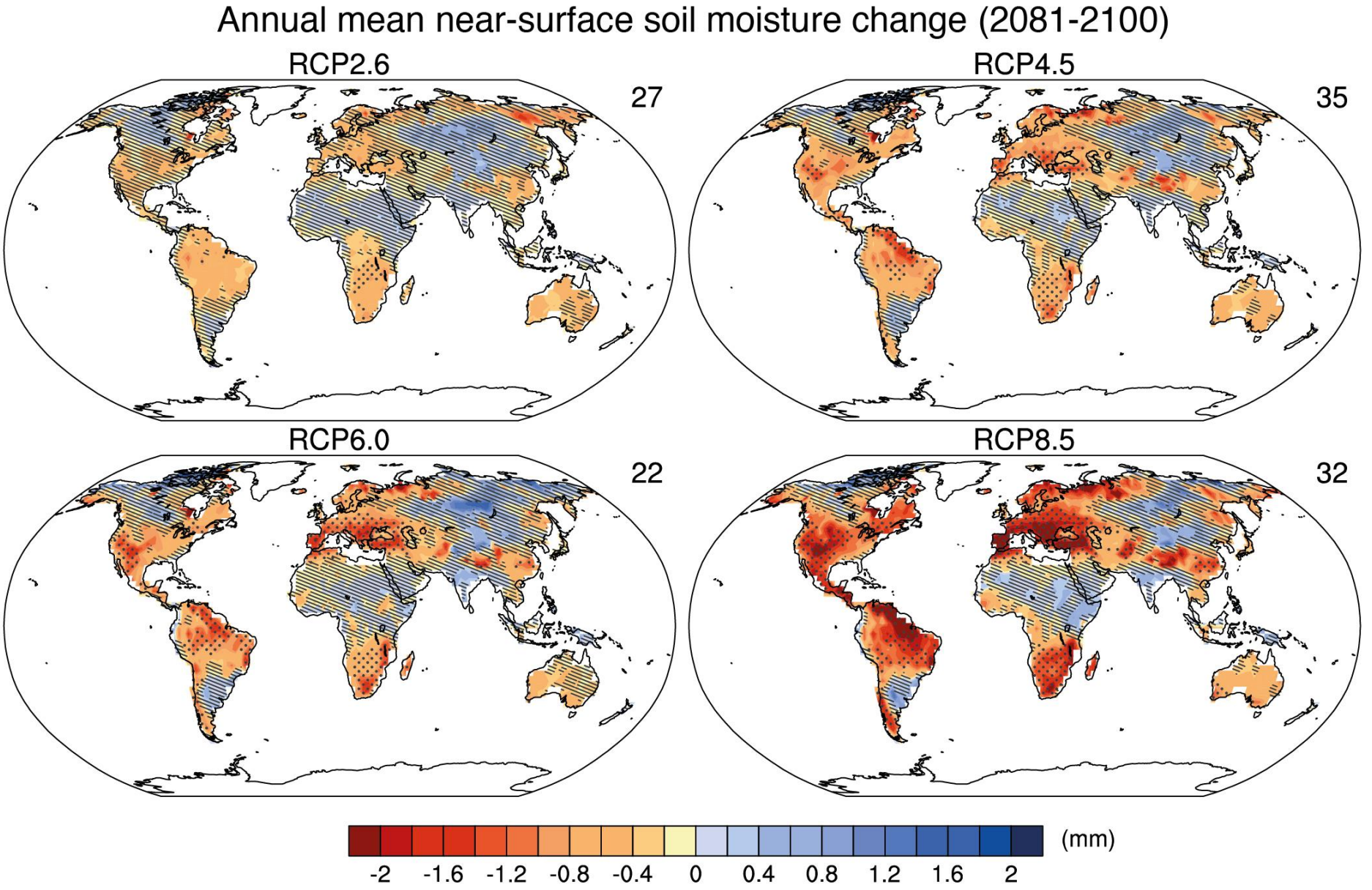
# “Rich Get Richer / Poor Get Poorer”



# “Rich Get Richer / Poor Get Poorer”

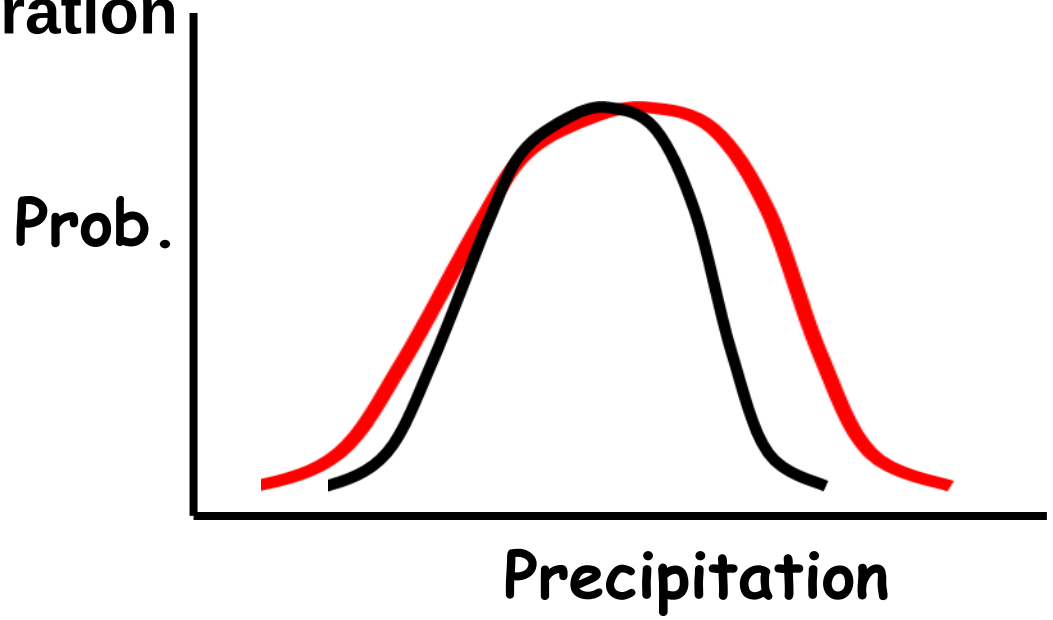
- **Increased water vapor – more water to rain out (where it rains already)**
- **Poleward expansion of Hadley subsiding branches, dries subtropics and into lower mid latitudes**

# Increased evaporation, drier soils

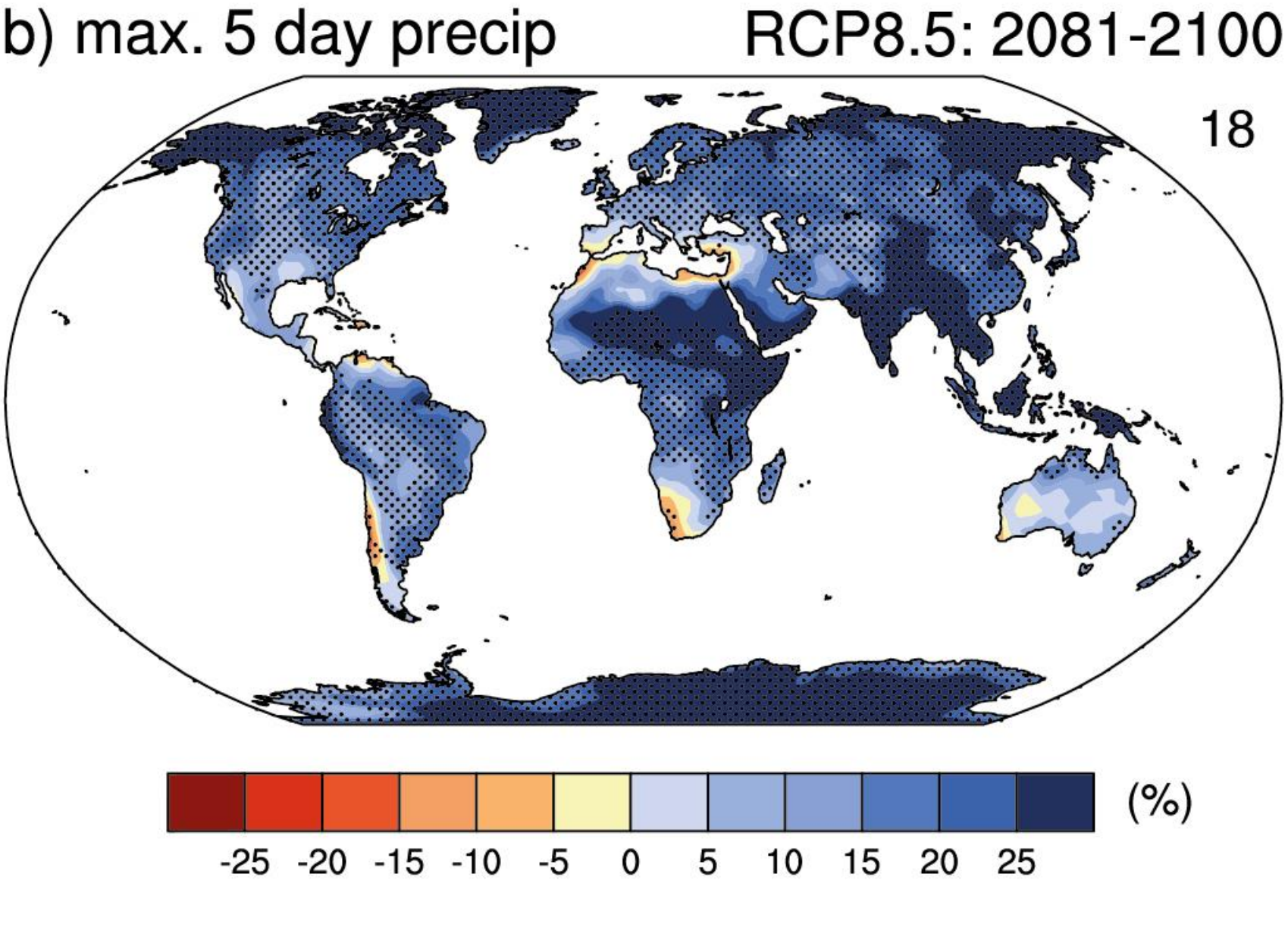


# Hydrologic Cycle Extremes: Distribution shifts

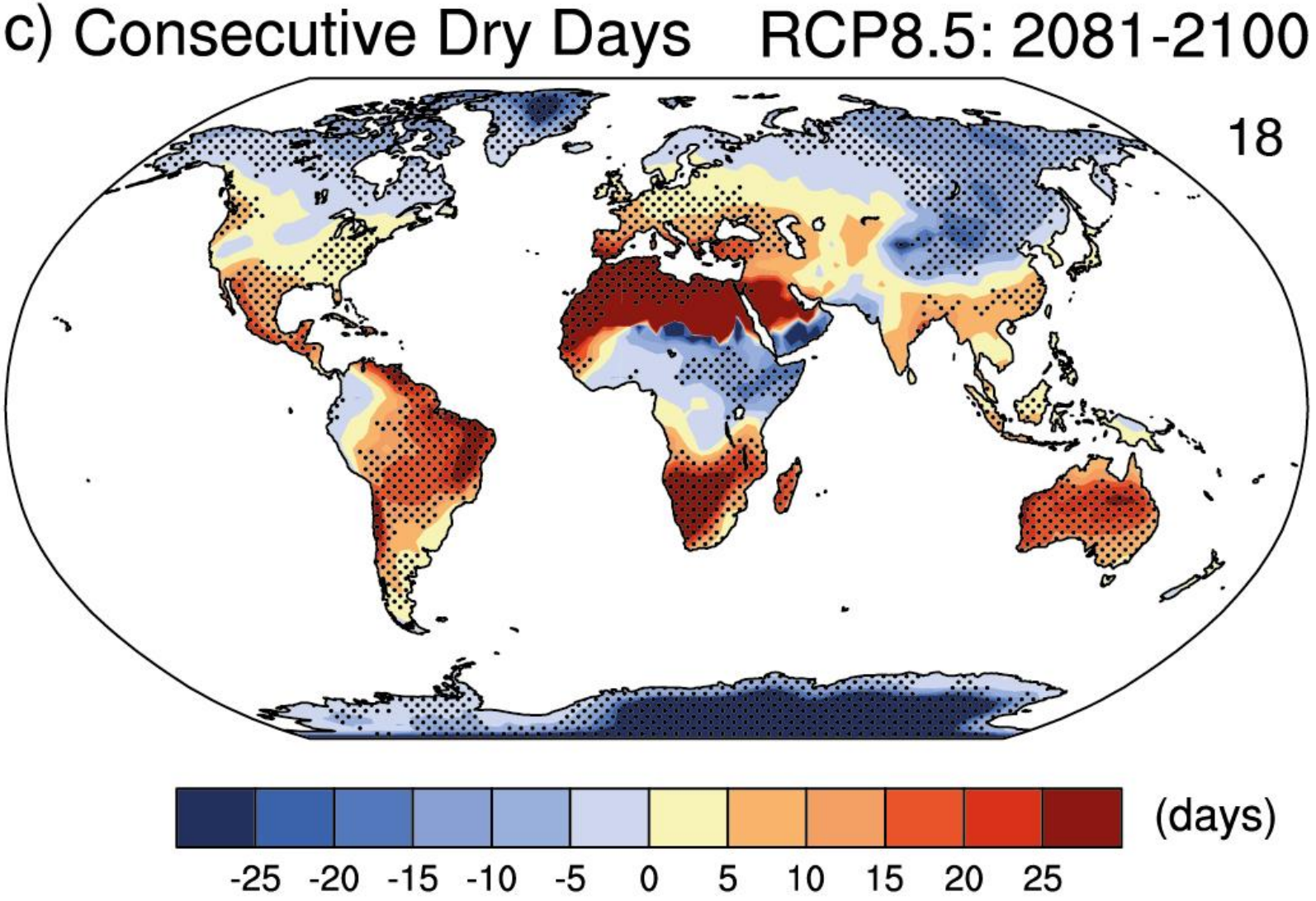
- More water vapor → more intense precipitation events possible
- Increased evaporation can lead to more frequent periods of drought
- Same controls on extremes for average precipitation and evaporation



# Change in Precip Amount on Very Wet Days



# Consecutive Dry Days Increase



# Wetter or Drier??

U.S.

## *New Flood Warning for Houston After Deadly Storms Kill 17*

By REUTERS MAY 27, 2015, 9:33 A.M. E.D.T.

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HOUSTON — The National Weather Service issued a new flash flood warning on Wednesday for Houston as the fourth most-populous U.S. city searched for bodies from deadly storms that turned neighborhoods into lakes.

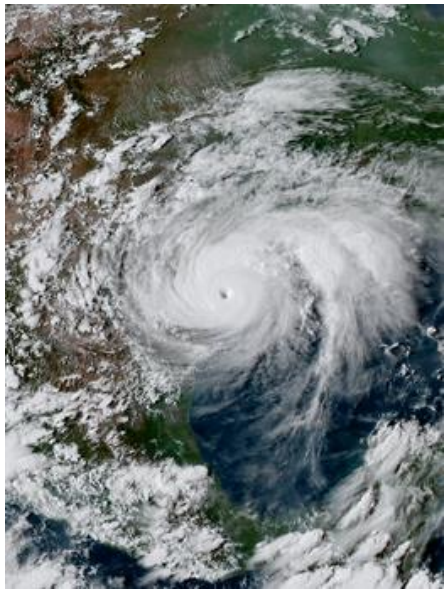


## *Scientists Warn to Expect More Weather Extremes*

By JOHN SCHWARTZ MAY 27. 2015

It was not long ago that the state was dealing with a searing drought. In 2011, the drought was so pronounced that the governor then, Rick Perry, proclaimed three days in April "days of prayer for rain in Texas." Parts of the state began to see the drought ease by 2012, but much of it has remained parched.

# Hurricanes are Extreme Events



**Hurricane Harvey 2017**
**> 4 feet of rain over a few days**

News Release 18-034

## Hurricanes: Stronger, slower, wetter in the future?

**New analysis compares 22 named storms with possible hurricanes of the future**

Will future hurricanes resemble 2017's Jose (top) and Maria? Scientists have new answers.
Credit and Larger Version

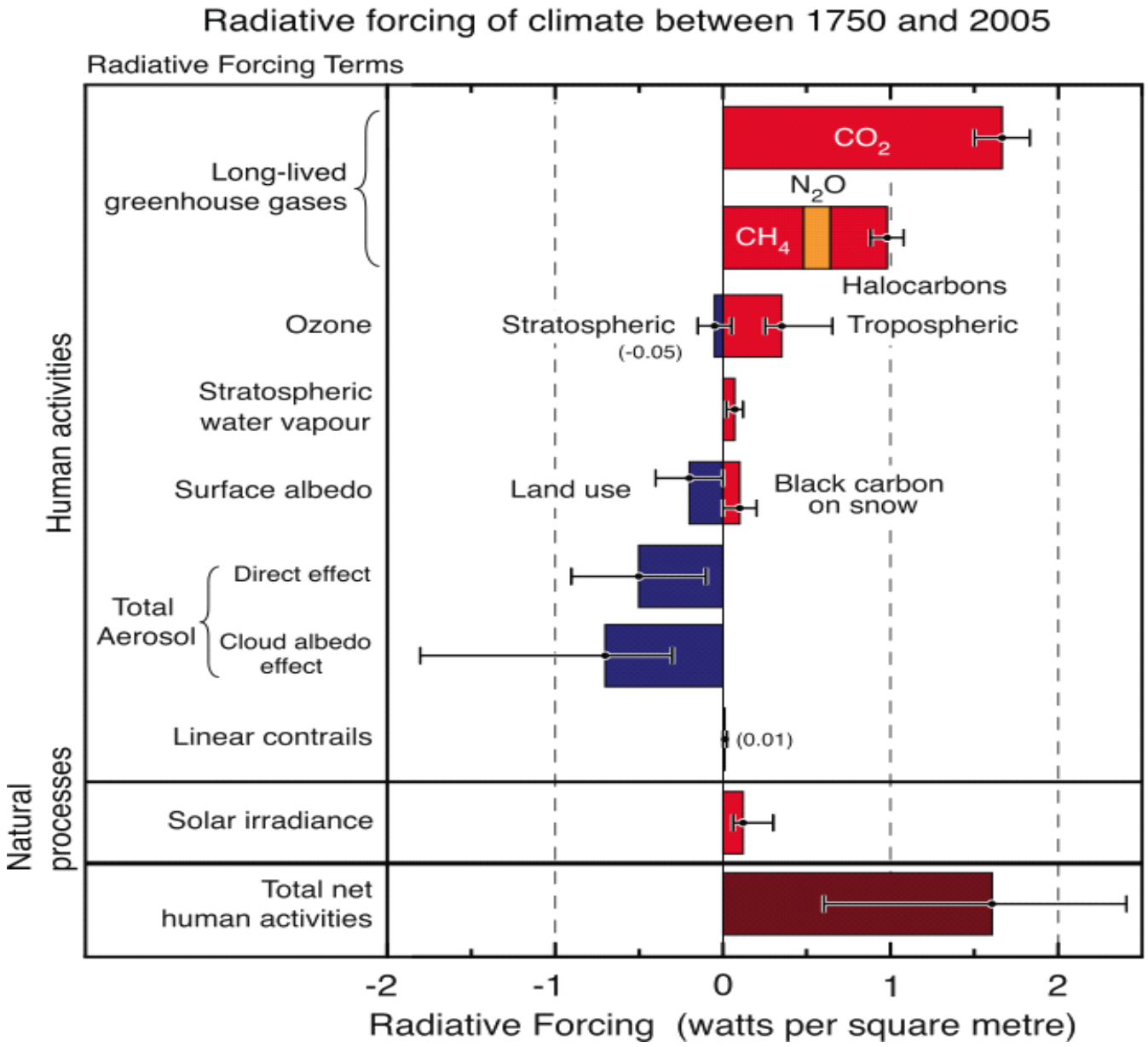
**May 21, 2018**

*Find related stories on NSF's* geosciences risk and resilience interest area.

Scientists have developed a detailed analysis of how 22 recent hurricanes would be different if they formed under the conditions predicted for the late 21st century.

While each storm's transformation would be unique, on balance, the hurricanes would become a little stronger, a little slower-moving, and a lot wetter.

# Anthropogenic Global Radiative Forcing of Climate



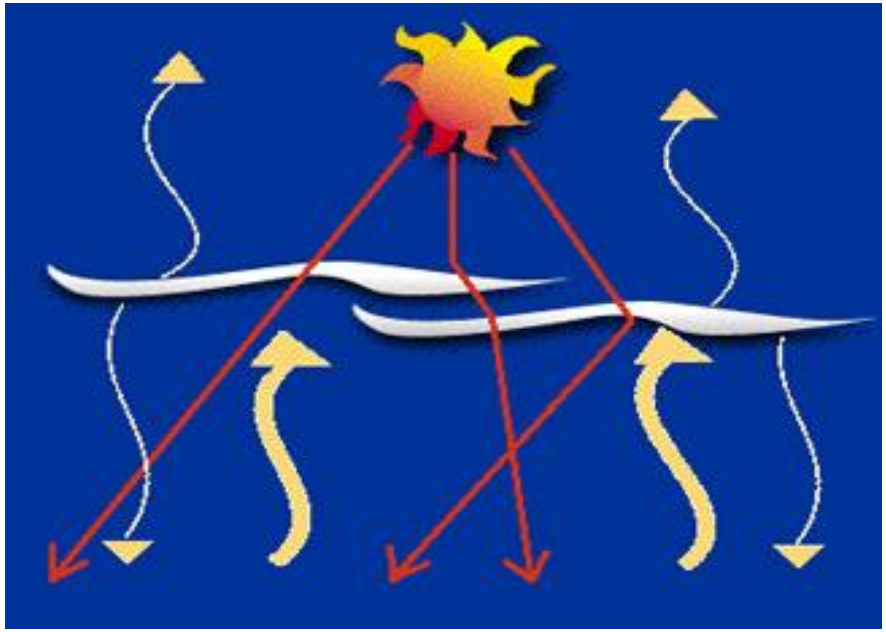

IPCC [2007]

# Cloud Forcings and Feedbacks

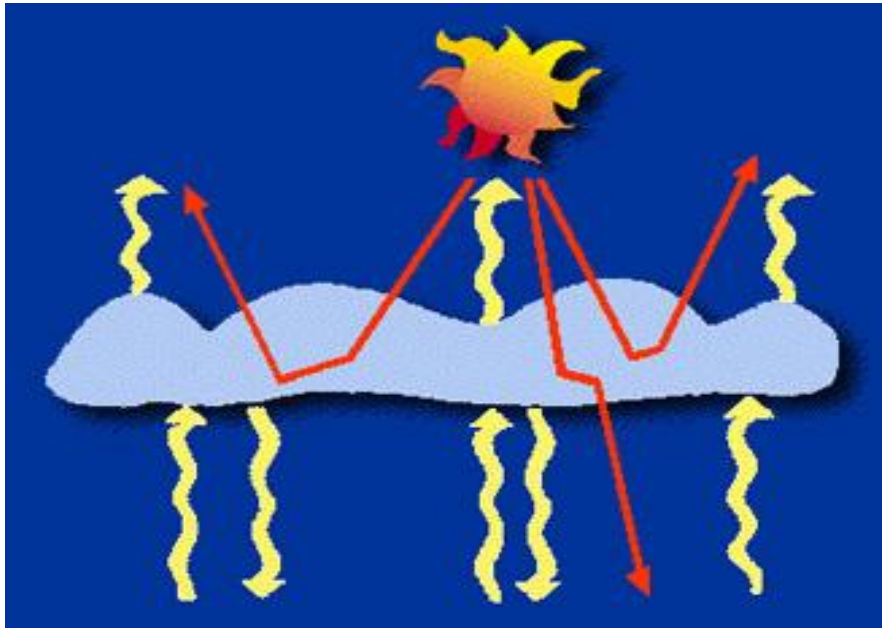
**High altitude thin ice clouds**
**→ Cirrus**

**Low altitude thick clouds**
**→ Stratus**

# Clouds and Climate—a complex problem

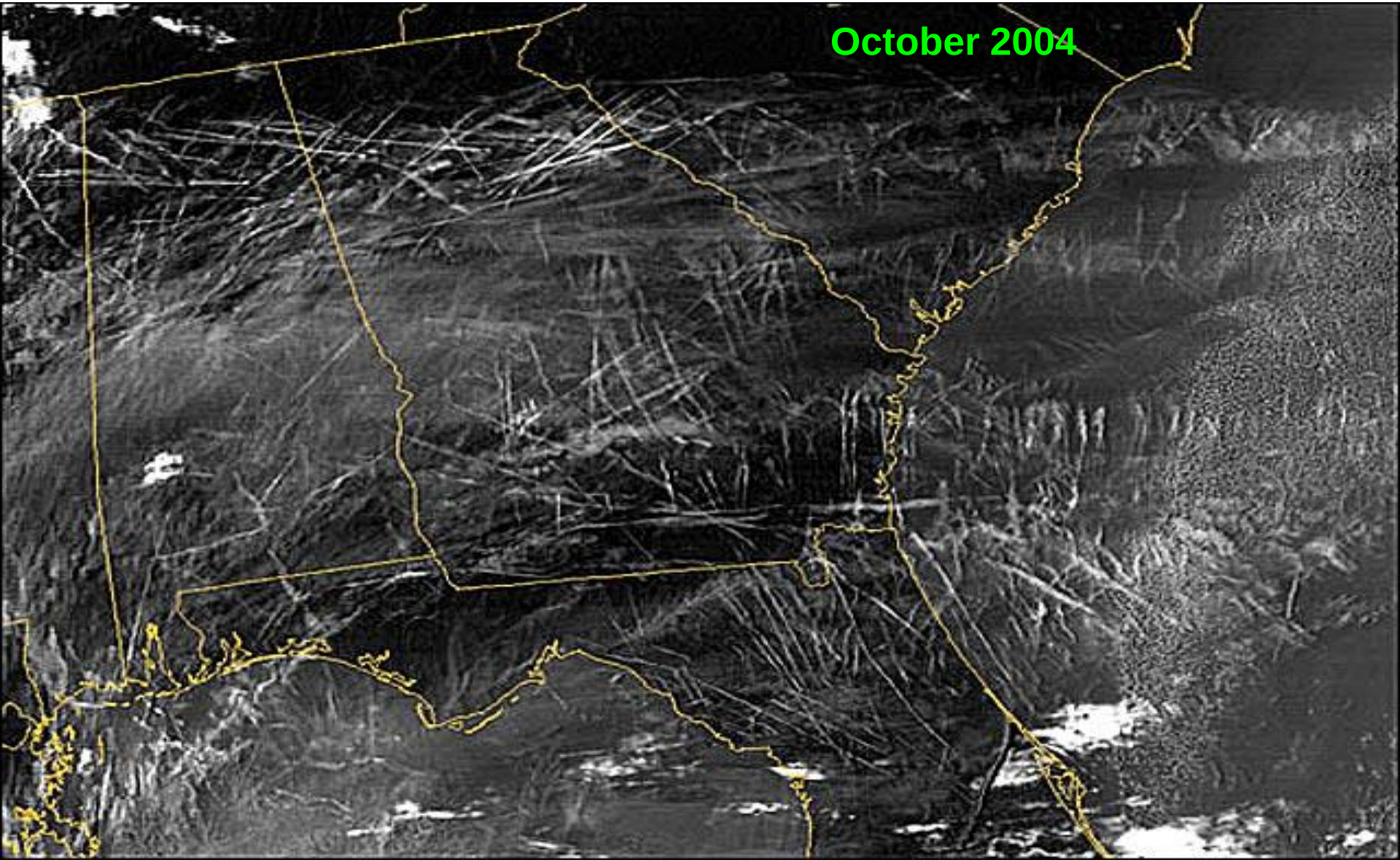


**Cirrus: Not so reflective, but absorb IR and emit at cold T**



**Low Clouds: Reflective, do absorb IR but emit like warm surface.**

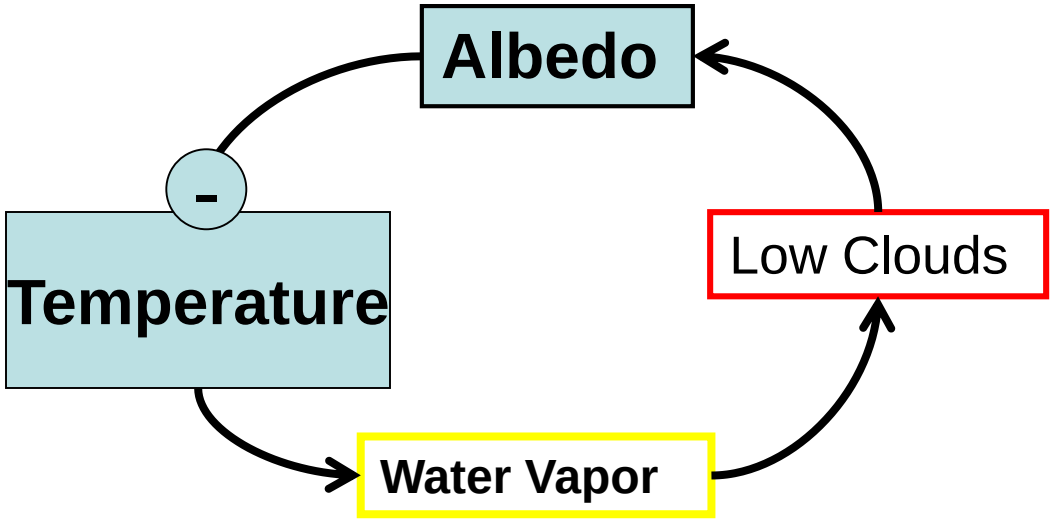
# Aviation Contrails—Positive Forcing



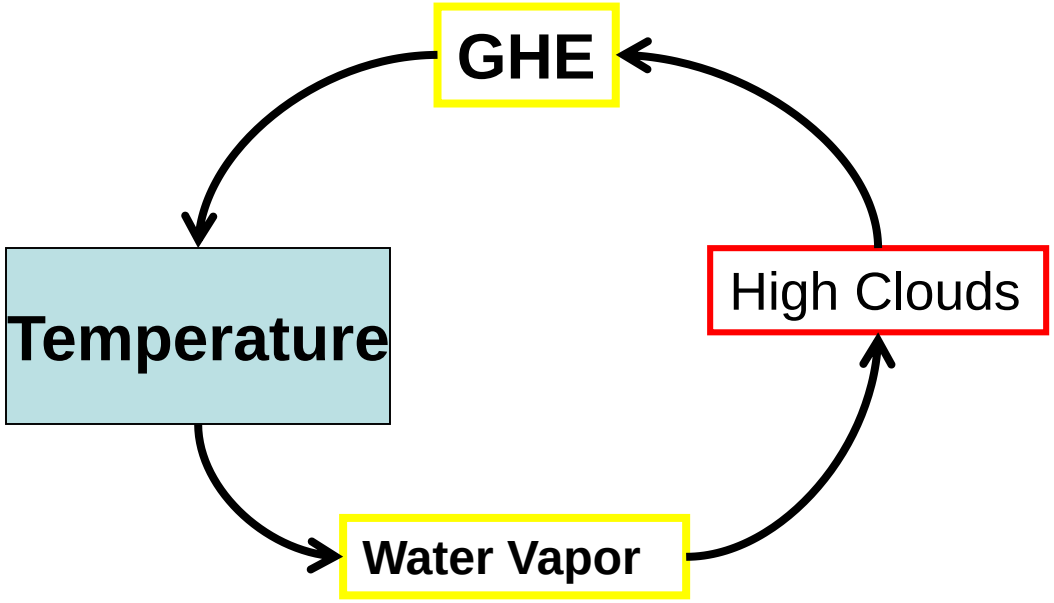
# Clouds and Cloud Feedbacks (two examples)

**Uncertain!**

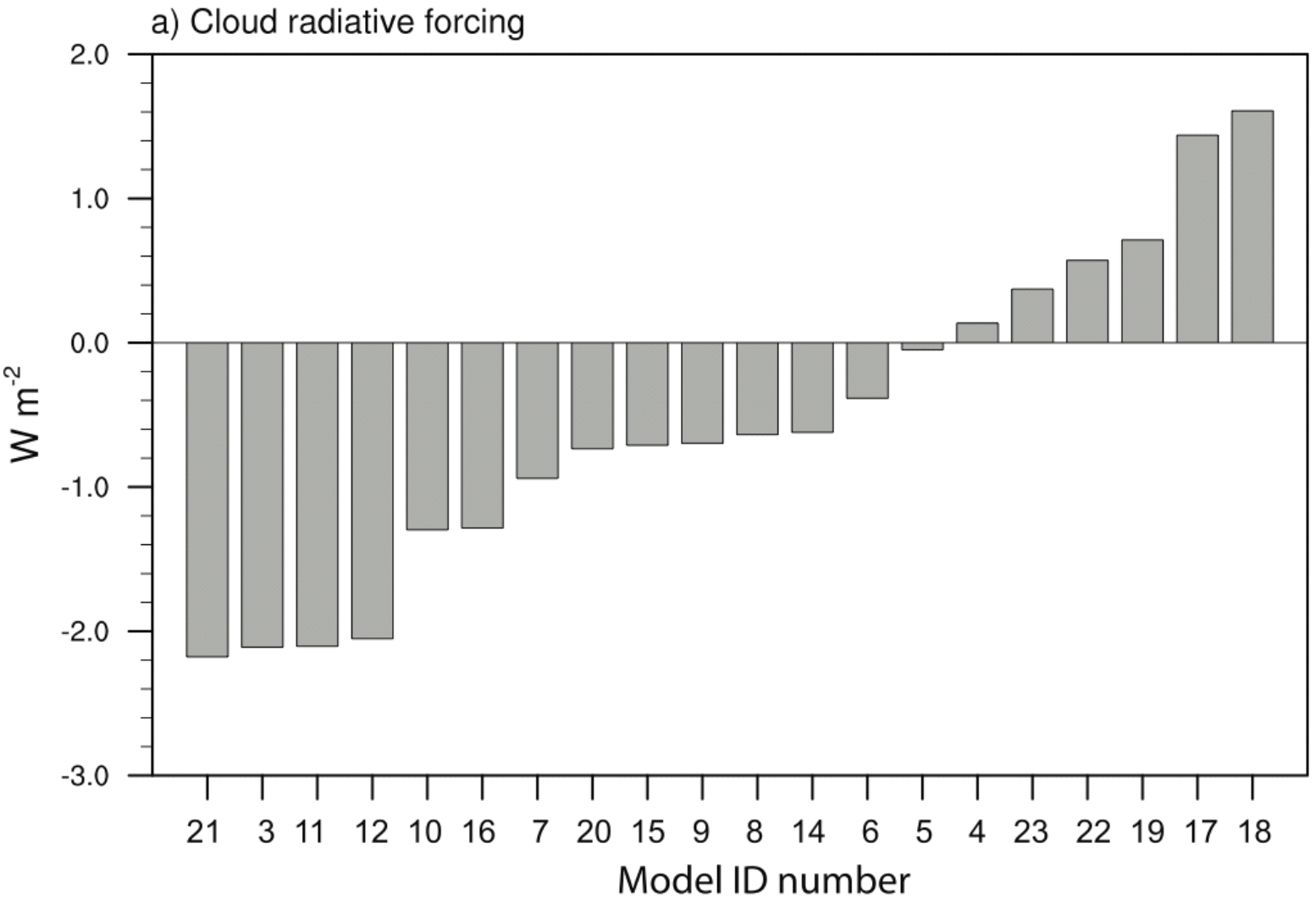
Overall Negative




Overall Positive



# Cloud Forcing Predictions by Different Models




IPCC 2007