Journal Club
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Universtität Tübingen

machine learning in climate science

SCIENCE ADVANCES | RESEARCH ARTICLE

CLIMATOLOGY

Emergence of an equatorial mode of climate variability in the Indian Ocean

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DiNezio et al. (2020)

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Tropical ocean SST patterns

DiNezio et al. (2020)

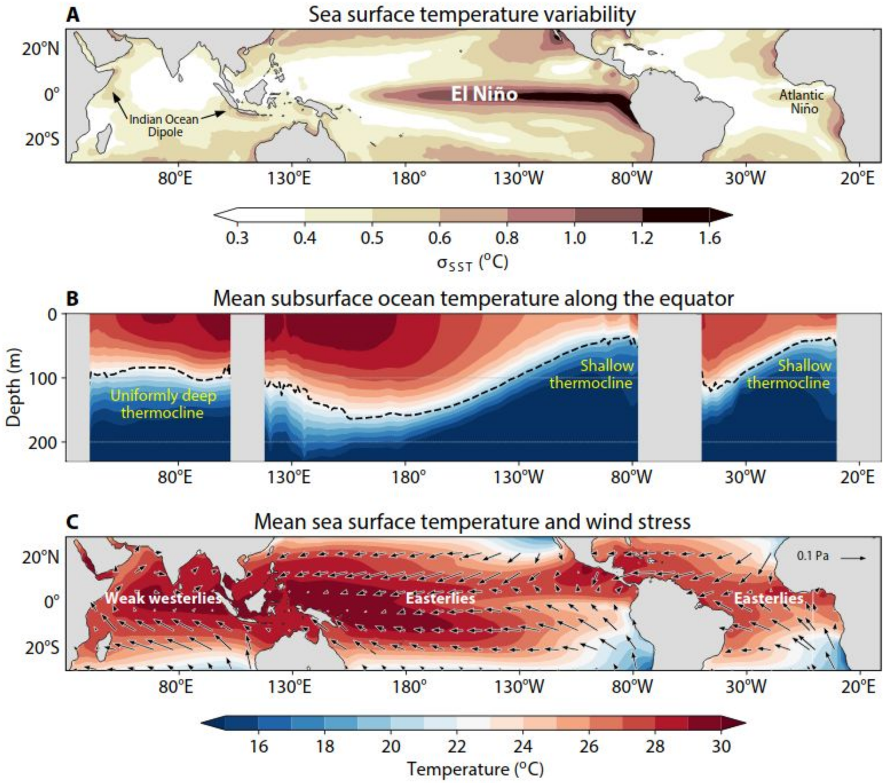
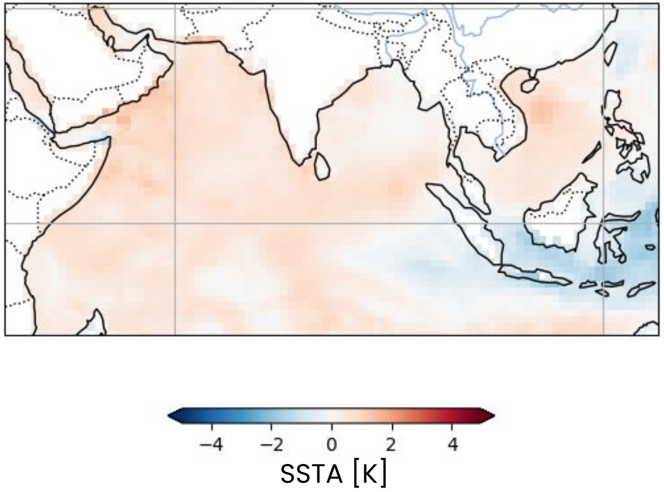


Fig. 1. Observed variability and mean state over the tropical oceans. (**A**) SST variability, (**B**) annual mean subsurface ocean temperature along the equator (5°S to 5°N), and (**C**) annual mean SST (shading) and surface wind stress (vectors). SST variability is computed as the SD of monthly anomalies relative to the monthly mean seasonal cycle. In the tropical oceans, a metric of variability that is dominated by variations occurring on interannual time scales. SST and surface wind stress are from TropFlux (*46*) and subsurface ocean temperature data are from ORAS-S4 (*37*).

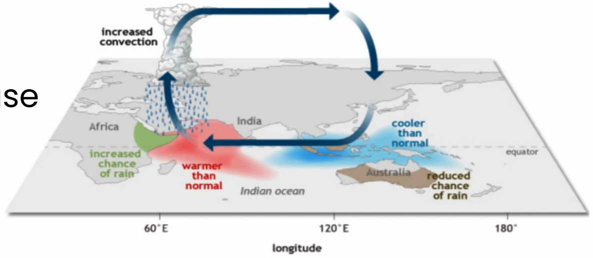
Indian Ocean Dipole

Positive phase of IOD (Oct. 2015)



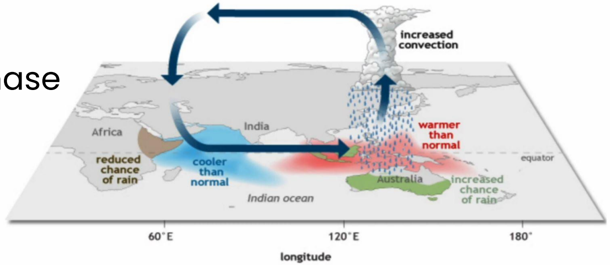
DiNezio et al. (2020)

Positive phase



[NOAA Climate.gov]

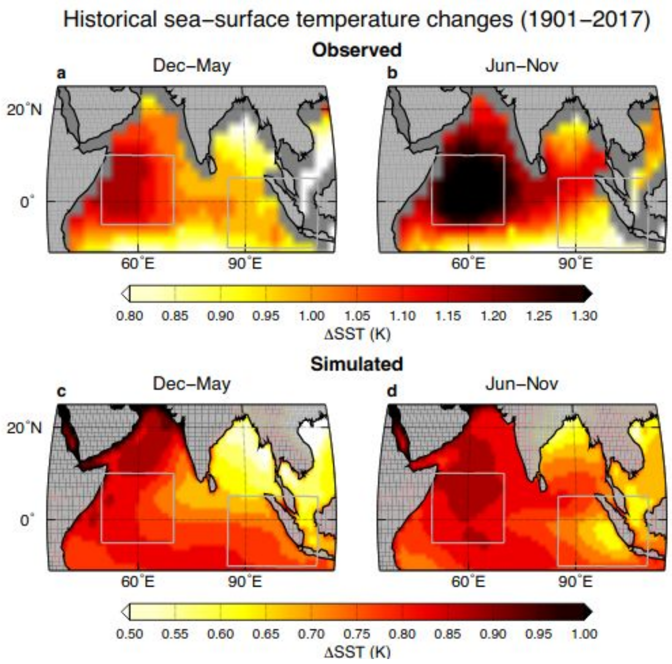
Negative phase



- 2nd mode of SSTA variability in IO
- Occurrence Sep-Oct-Nov
- Lower strength than ENSO or Atlantic Nino

Main question:

How does greenhouse gas emission change SST variability in Indian Ocean?



DiNezio et al. (2020)

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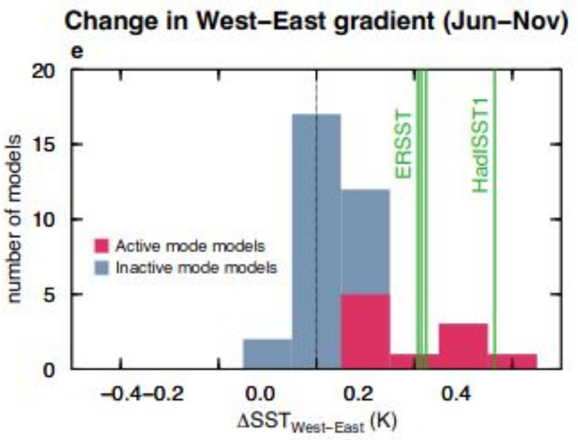
Data and Methods

DiNezio et al. (2020)

Simulations of past and future climate in the IO.

- Coupled Model Intercomparison Project 5 (CMIP5):
  - ➢ run under "business as usual" high emission scenario (RCP8.5)
  - ➢ prediction for the 2050–2100 period
- CESM1 simulation of the Last Glacial Maximum (LGM) around 21 000 years ago



Only some CMIP5 models capture SST changes in the IO.

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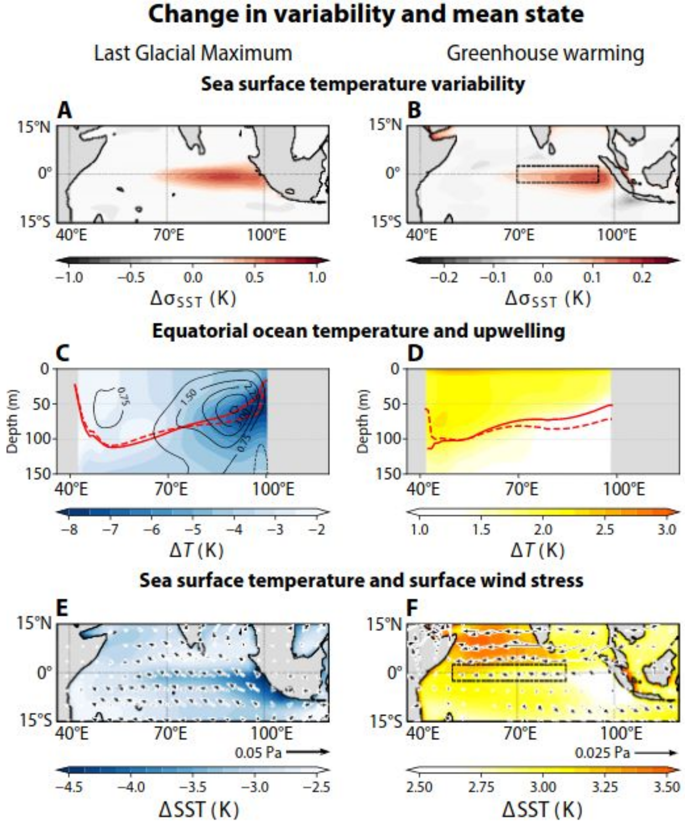
New eastern equatorial IO mode



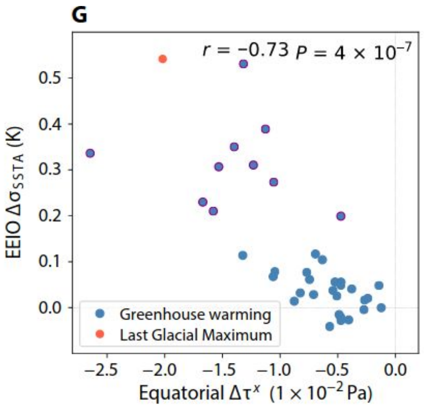


Fig. 2. Simulated changes in IO climate variability and mean state under glacial conditions and greenhouse warming. Changes in (**A** and **B**) SST variability, (**C** and **D**) subsurface ocean temperature (shading, m), vertical velocity (contours, m/day), and (**E** and **F**) SST (shading) and surface wind stress (vectors). Glacial changes (left) are computed from a simulation of LGM relative to a simulation of preindustrial (PI) climate, both performed with the CESM1. Changes under greenhouse warming are computed for the 2050–2100 interval in high-emission scenario [Representative Concentration Pathway 8.5 (RCP8.5)] simulations performed by 36 CMIP5 models relative to the 1850–1950 interval from historical simulations. The changes in variability are computed as the difference in SD of SSTAs during the August-September-October (ASO) season. Changes in mean state are computed for the JAS season. The changes under greenhouse warming are the average among the changes simulated among all 36 CMIP5 models. Dashed and solid red curves in (C) and (D) indicate the depth of thermocline in the reference (PI and historical) and altered (LGM and RCP8.5) climate states, respectively. (**G**) Relationship between changes in SD of SST anomalies in the EEIO (70°E to 95°E, 2.5°S to 2.5°N) during the ASO season and zonal wind stress in the equatorial IO (50°E to 80°E, 2.5°S to 2.5°N) during the JAS season for each model simulated response to greenhouse warming (blue circles) and LGM boundary conditions (red circle). Models with mode activation are outlined in red.

DiNezio et al. (2020)

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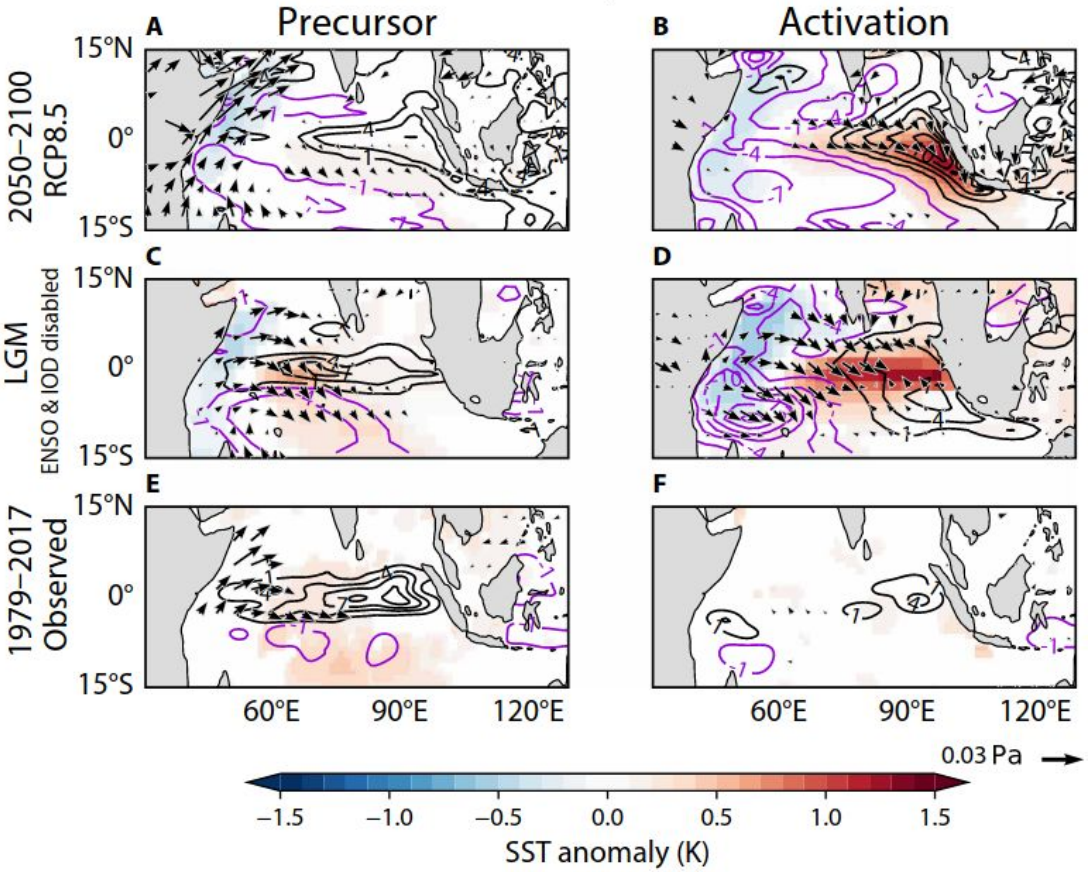
Drivers of the IO equatorial mode



DiNezio et al. (2020)

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Distinct form Indian Ocean Dipole

DiNezio et al. (2020)

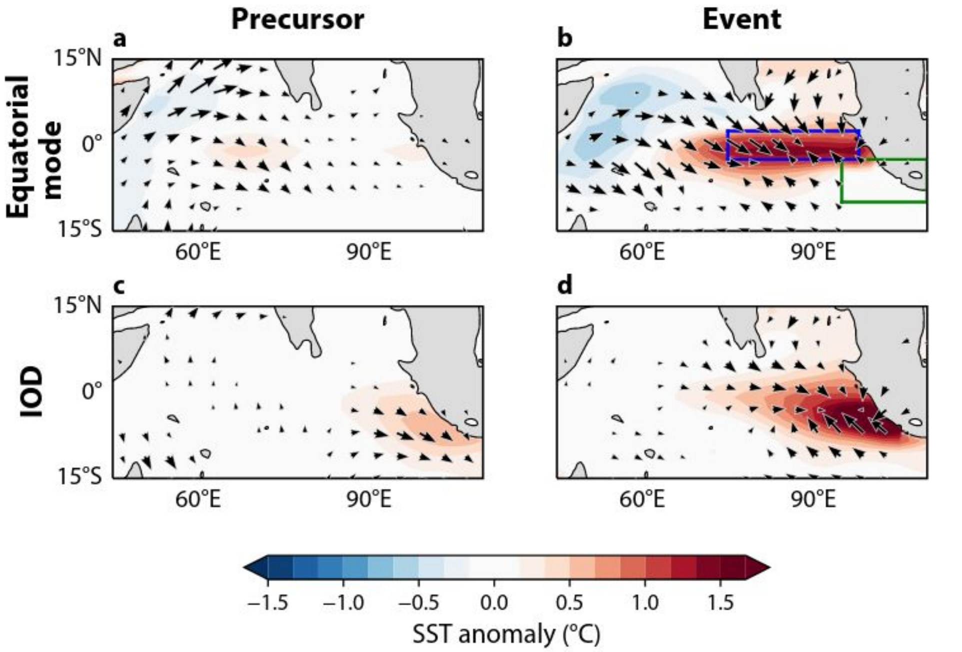

Figure S3 | Modes of variability in the Indian Ocean under altered glacial mean state. Atmospheric precursor (left) and developed (right) sea-surface temperature (shading) and surface wind stress (vectors) anomalies for warm equatorial mode events (top) and Indian Ocean Dipole (IOD, bottom) under Last Glacial Maximum boundary conditions. The events are selected and composited as described in the text using simulations in which the El Niño/Southern Oscillation (ENSO) and the IOD are disabled by restoring SSTs to climatological values in the Niño-3.4 region in the Pacific and southeastern equatorial IO (green box). This methodology allows to isolate the IOD from the equatorial mode.

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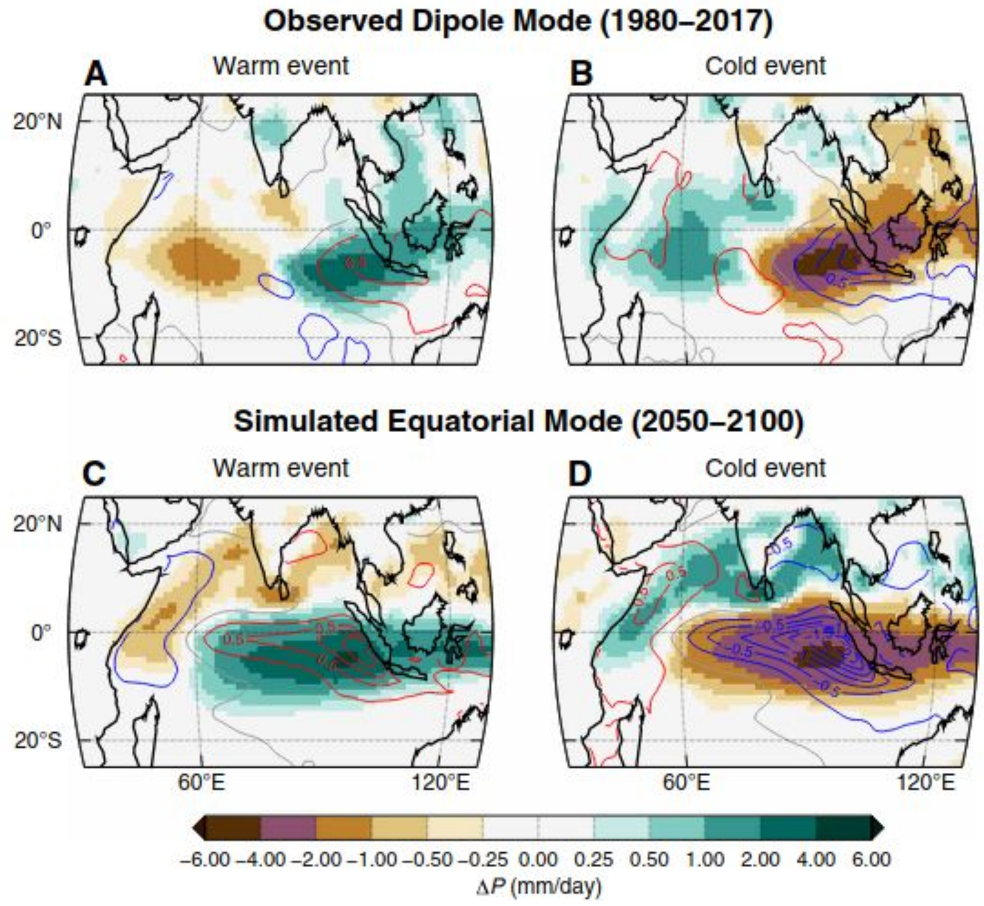
Impact for 2050–2100

- rainfall variability with stronger amplitude
- droughts over the Horn of Africa and Southern India
- increased rainfall over Indonesia and Northern Australia
- CMIP5 predict 4-5 equatorial IO modes per decade



DiNezio et al. (2020)

Take home message

DiNezio et al. (2020)

1. GHG emission may lead to ENSO like mode in the Indian Ocean

2. Climate models allow to disable certain modes of variability

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CO2 concentrations

DiNezio et al. (2020)

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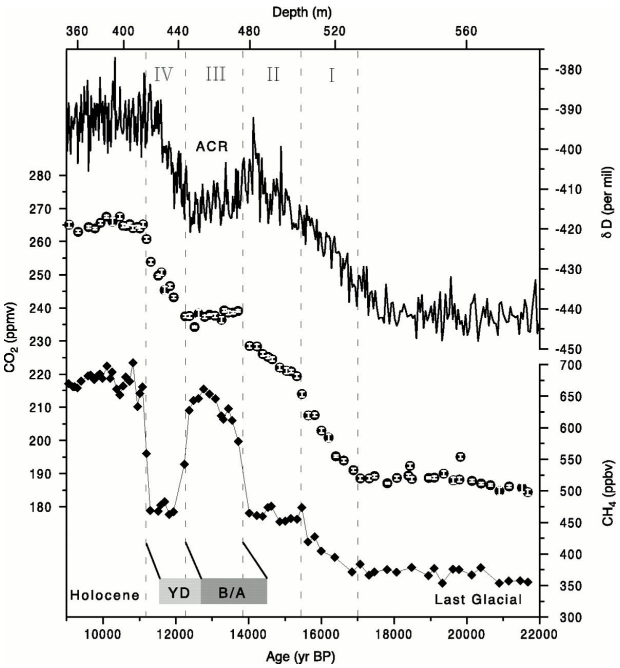
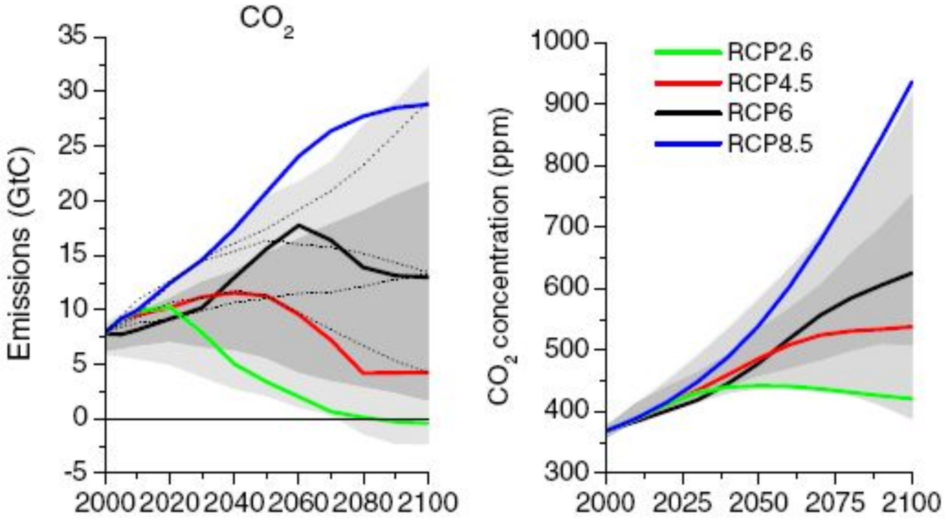
Ice core data Dome C



Monnin et al., Science (2001)

RCP model predictions



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