Inferring Future Changes in ENSO Teleconnections

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The Problem

- Want to project future changes in ENSO variability and predictability caused by increasing greenhouse gases.
- CGCMs have large biases in simulations of the tropical mean climate and variability for the current climate.
- Therefore, future projections of changes in tropical climate and tropical climate variability, and impacts on midlatitude climate from these models are suspect.

Interim Solution

- Examine the effect projected changes in GHG and SST climatology would have on current climate teleconnections.

- Method
  - Superpose future changes of SST and GHG from IPCC AR4 runs on observed time varying 20th century forcing (SST, sea ice, GHG, aerosols, …) AGCM/LSM “IAMIP” runs.
    - Sea ice unchanged (not consistent with future SST)
  - Time varying tropical SST variability and external forcing as observed for 1950-1999.
    - Realistic structure of tropical annual mean and annual cycle of SST are assured.
    - Realistic ENSO evolution and structure are assured.
  - Shortcomings of this approach are obvious, as are the advantages

Related Papers

- Sexton et al, 2003: **Design and analysis of climate model experiments for the efficient estimation of anthropogenic signals**. *J. Climate.*

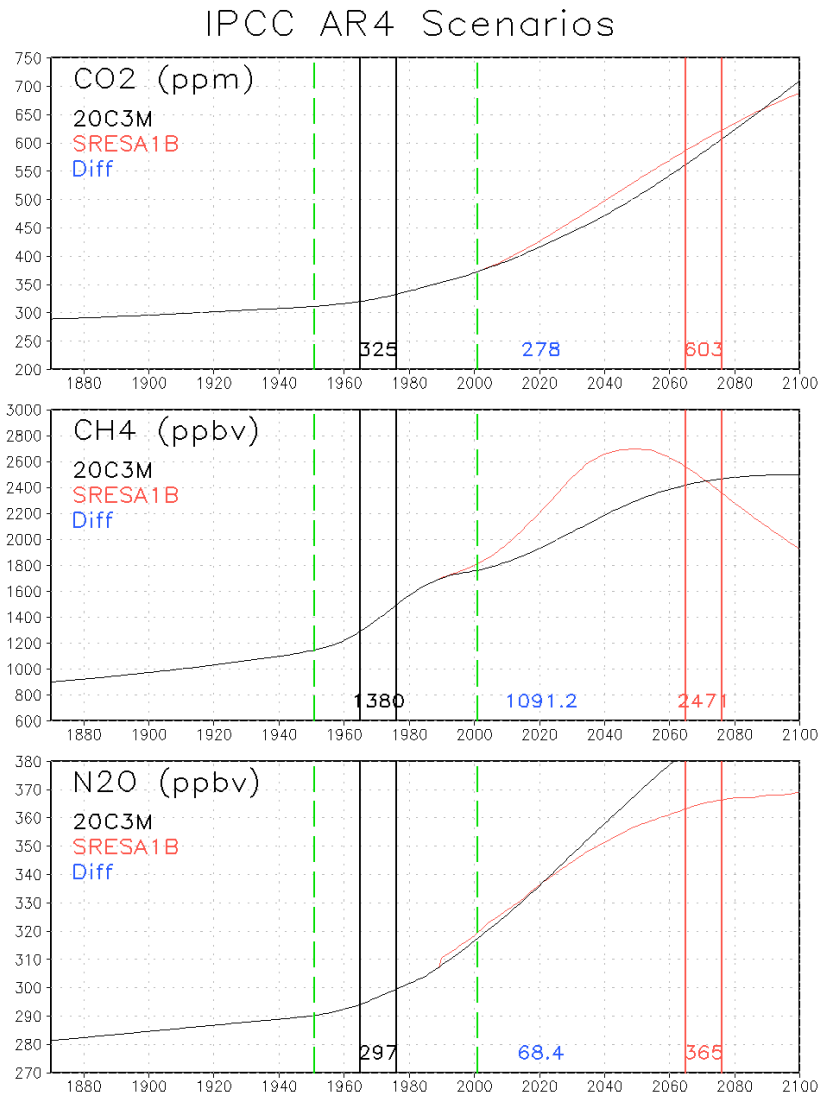
- Deser and Phillips, 2008: **Atmospheric Circulation Trends, 1950-2000: The Relative Roles of Oceanic and Atmospheric Radiative Forcing.** *J. Climate.*

- Campo and Sardeshmukh, 2008, **Oceanic Influences on Recent Continental Warming**. *Climate Dyn*. (submitted).

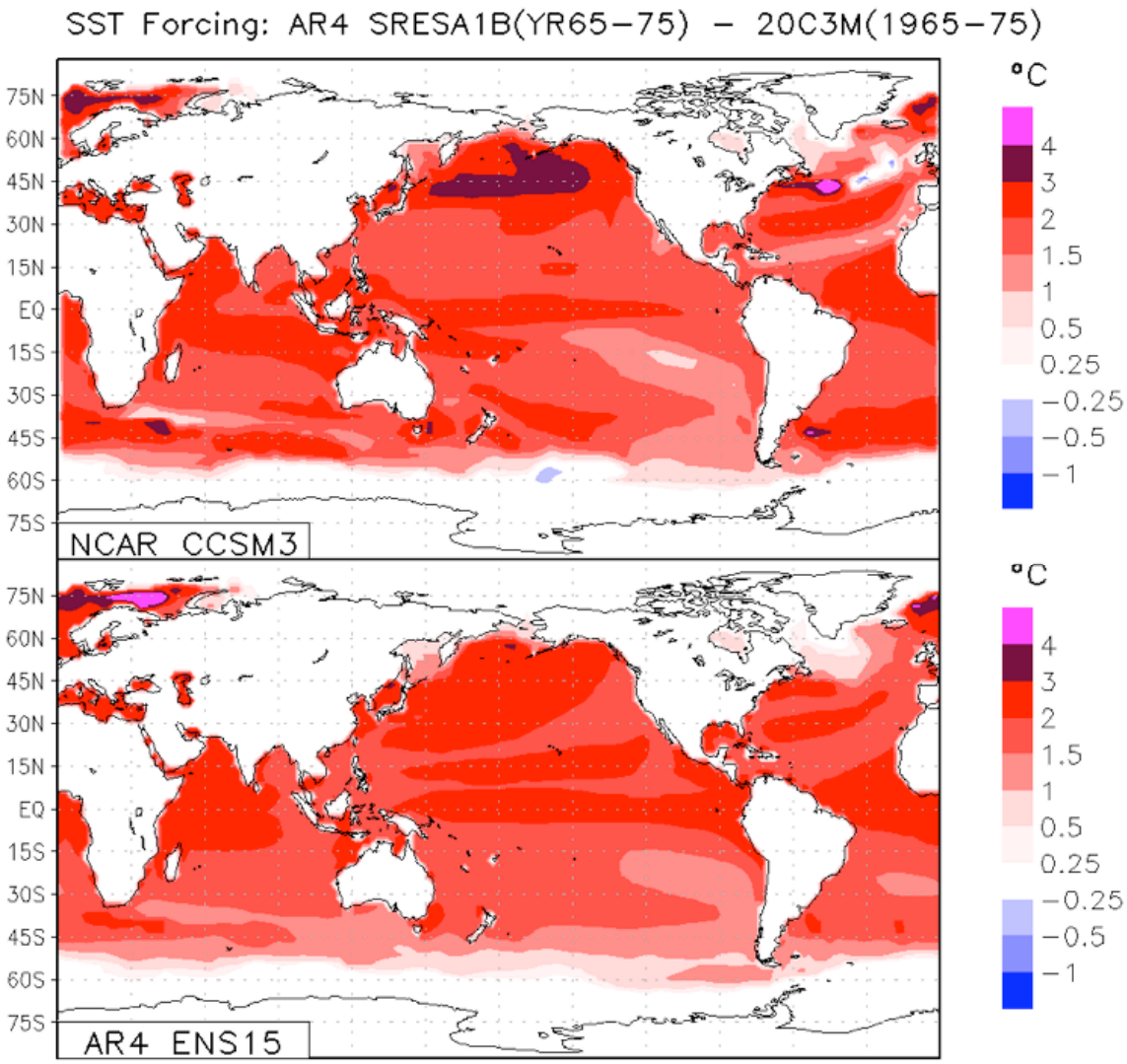
Details

- 21st century
  - IPCC AR4 SST differences
    - Monthly means (2065 to 2075)-(1965 to1975)
      - (1965 to 1975) from 20C3M
      - (2065 to 2075) from A1b
  - GHG: A1b(2065 to 2075)-20C3M(1965 to1975)
- Control run IAMIP ensemble 1951-2000
  - Deser and Phillips, 2008, J. Climate
- All results from 5 member ensembles (x2) of 50 year runs

20C3M/A1B Forcing



Annual Mean ΔSST

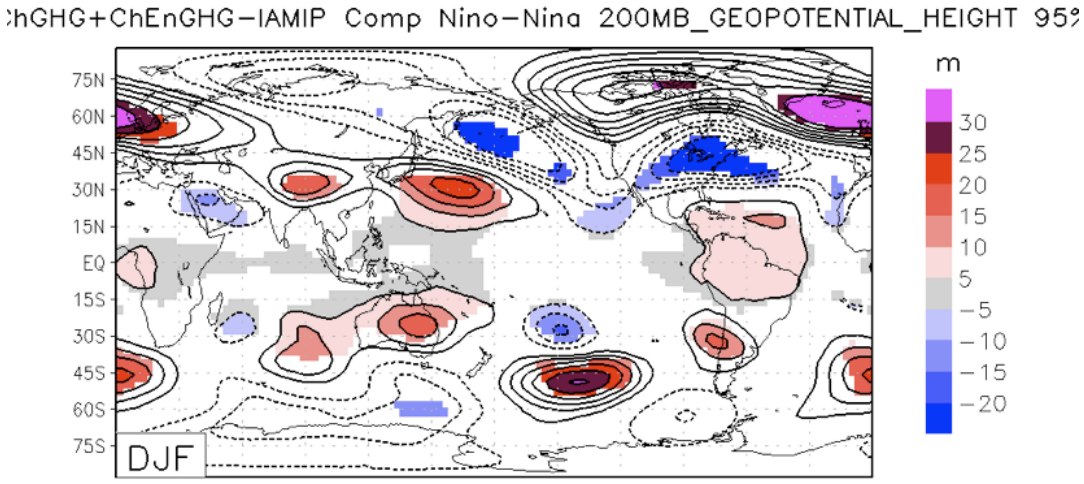


ENSO Composites

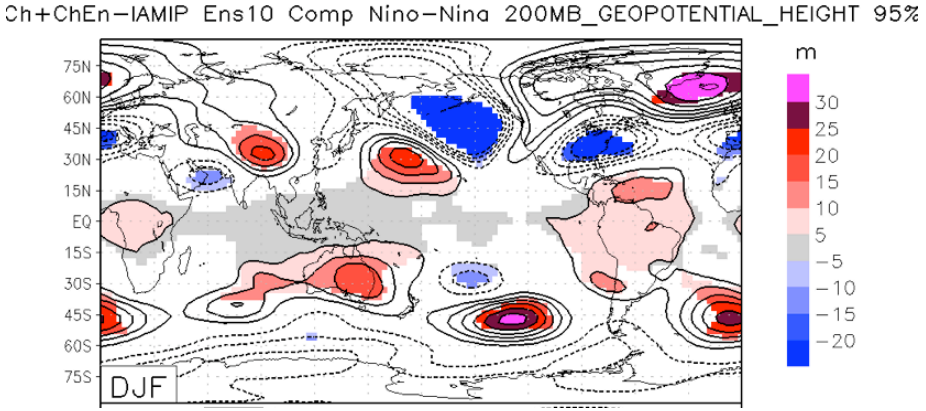
- El Niño years (mature Decembers)
  - 1957, 1965, 1972, 1977, 1982, 1987, 1991, 1992, 1994, 1997
- La Niña years (mature Decembers)
  - 1955, 1956, 1964, 1970, 1971, 1973, 1974, 1975, 1988, 1998

Changes in Z200 ENSO Teleconnections

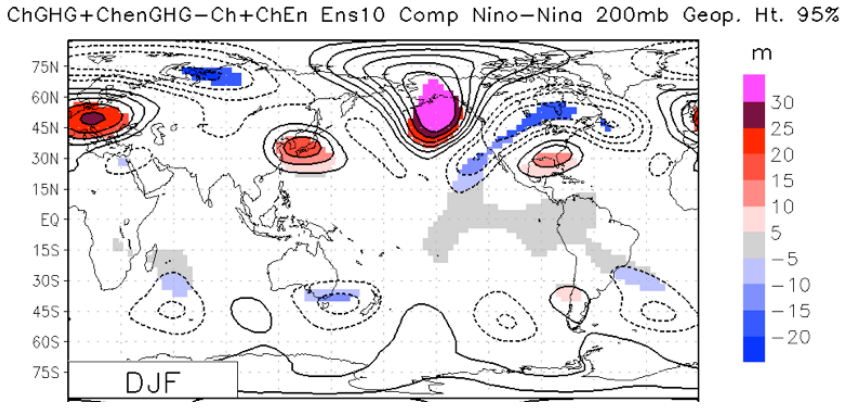
From ΔSST+ ΔGHG



From ΔSST

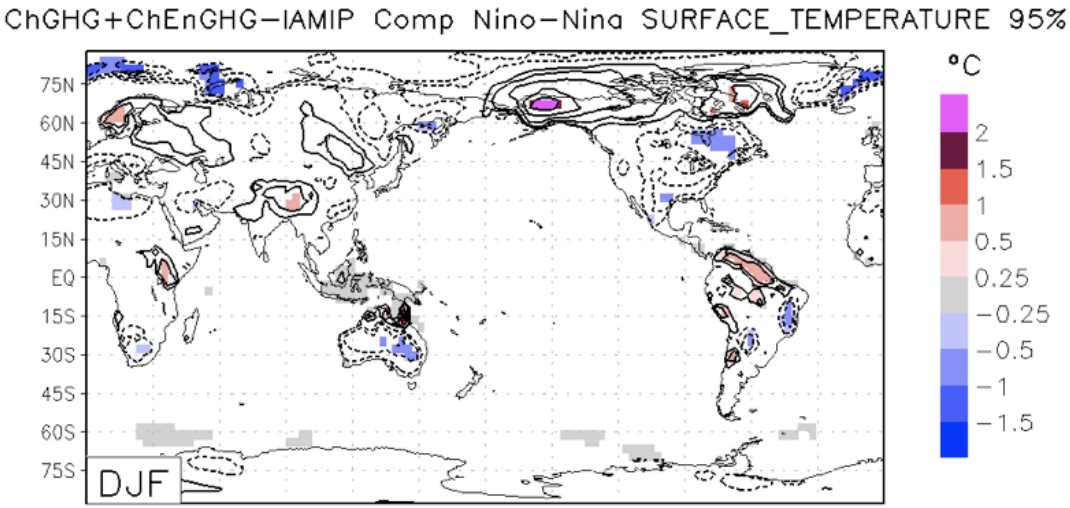


From ΔGHG

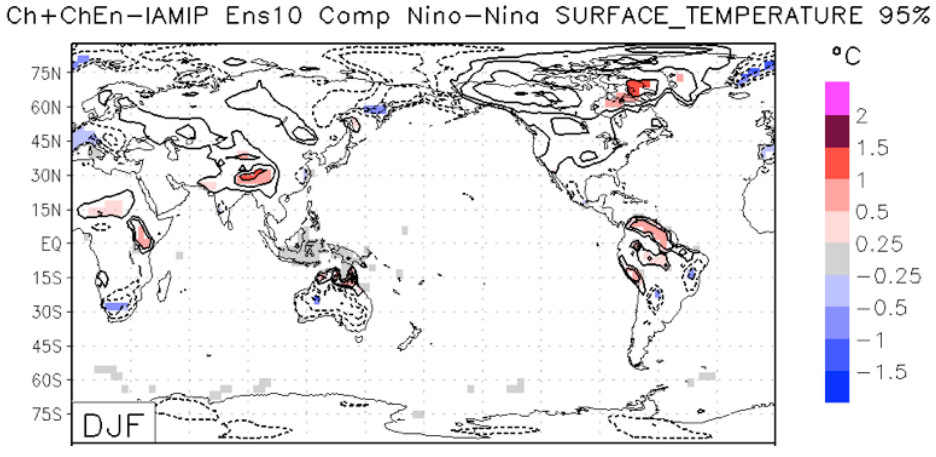


Changes in Ts ENSO Teleconnections

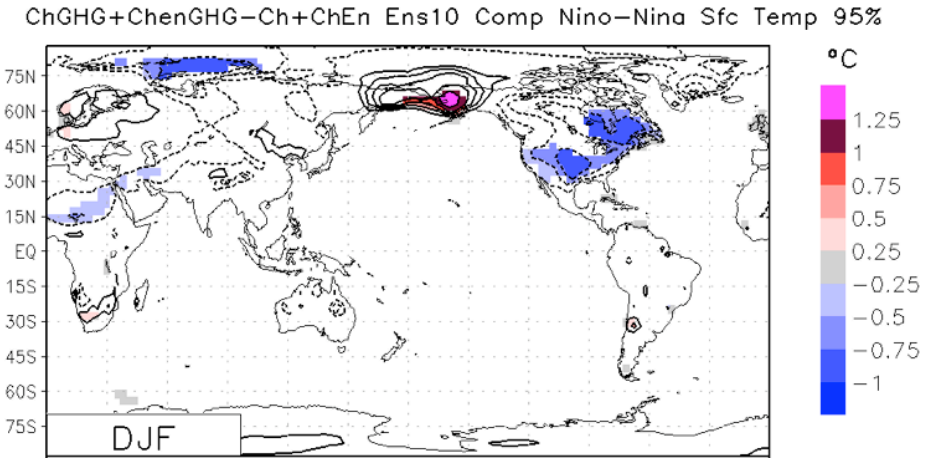
From ΔSST+ ΔGHG



From ΔSST



From ΔGHG

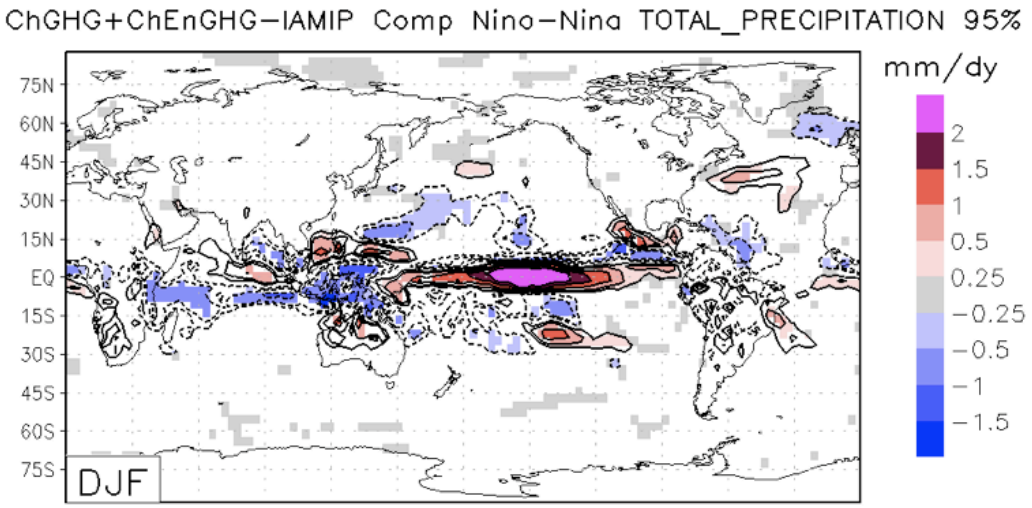


Diagnosis of Changes in ENSO Teleconnections

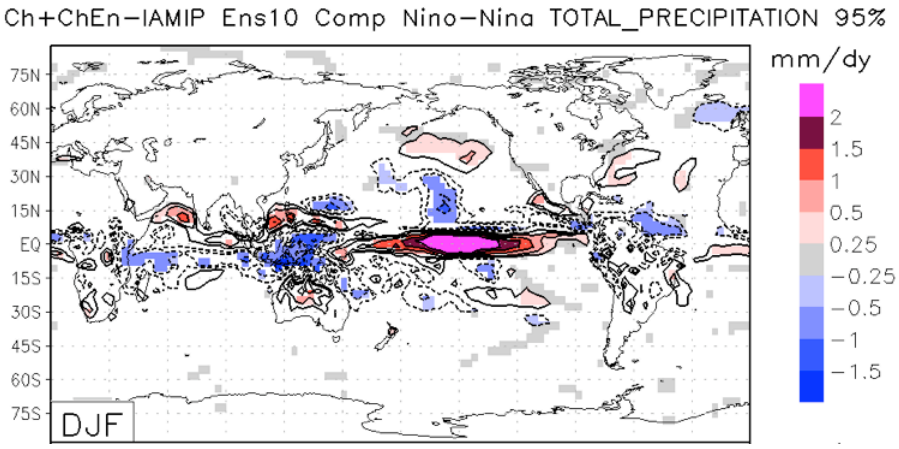
- Structural diagnosis: ΔSST forcing vs. ΔGHG forcing
- Dynamical diagnosis:
  - Change in forcing inferred from change in El Nino minus La Nina precipitation
    - Attribute to changes in climatological SST, GHG
  - Change in wave transmission properties due to changes in the waveguide
    - Attribute to changes in climatological SST, GHG

Δ Precip Forcing of ENSO Teleconnections

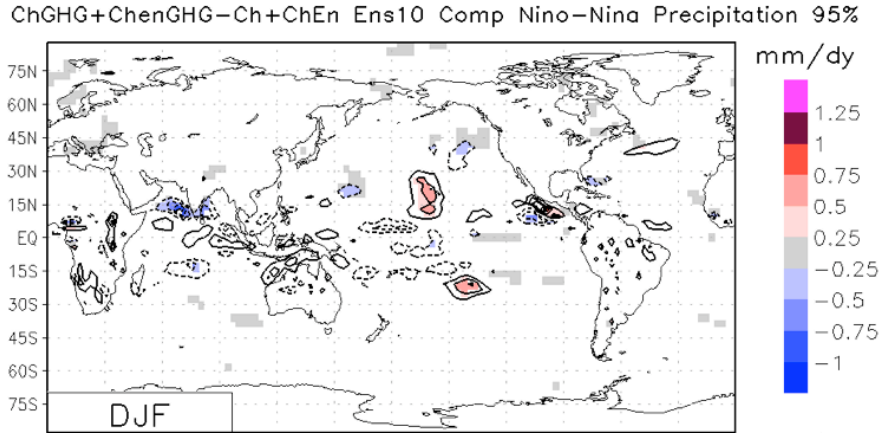
From ΔSST+ ΔGHG



From ΔSST

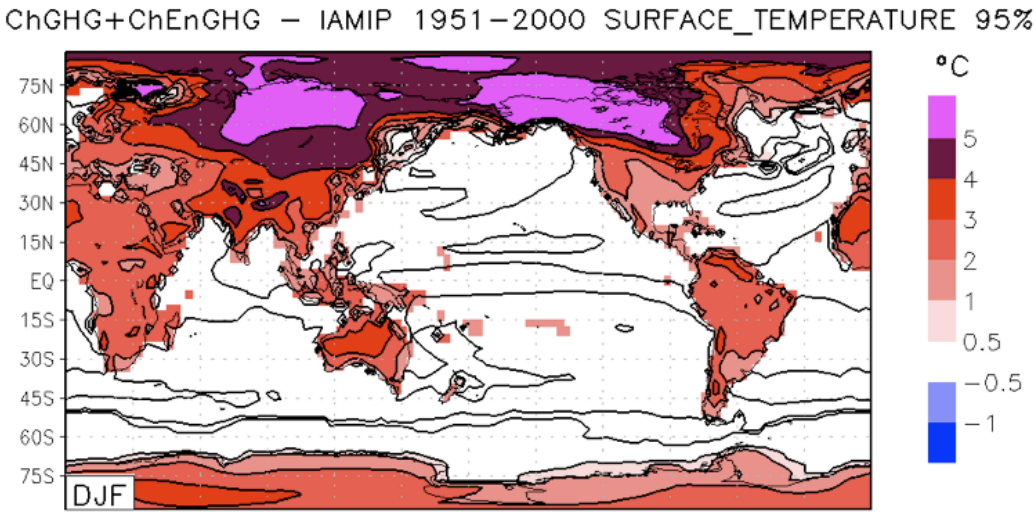


From ΔGHG

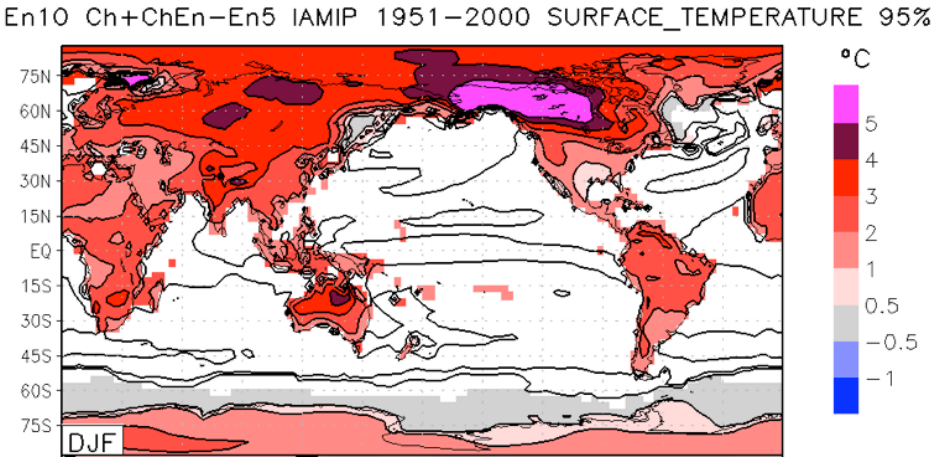


Δ Ts Climatology

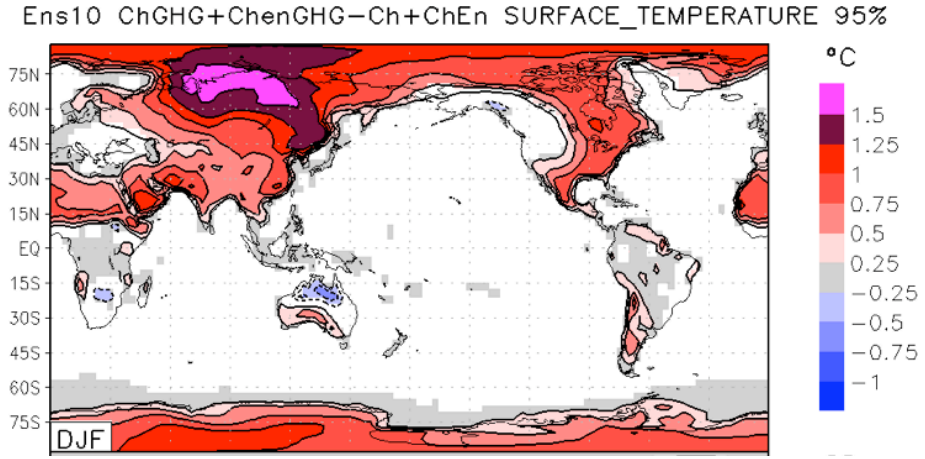
From ΔSST+ ΔGHG



From ΔSST



From ΔGHG



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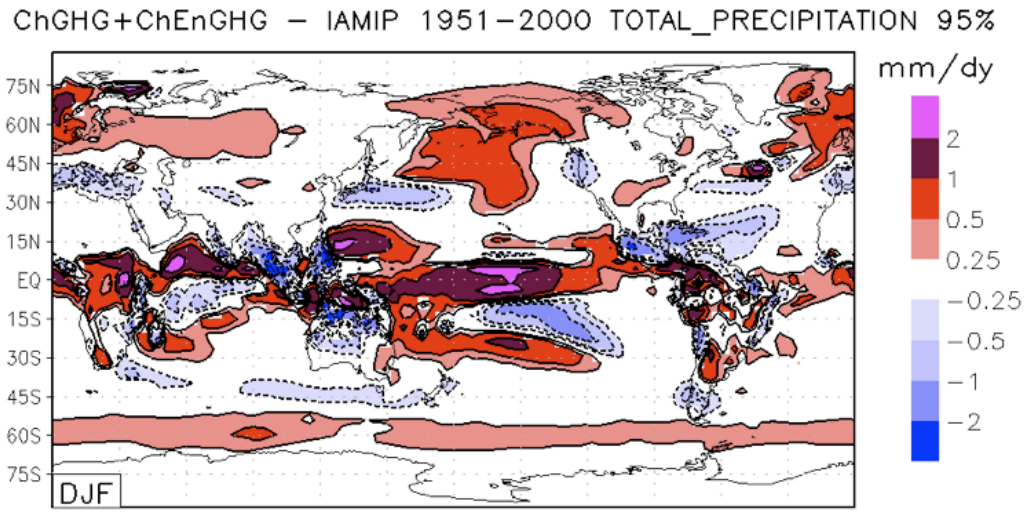
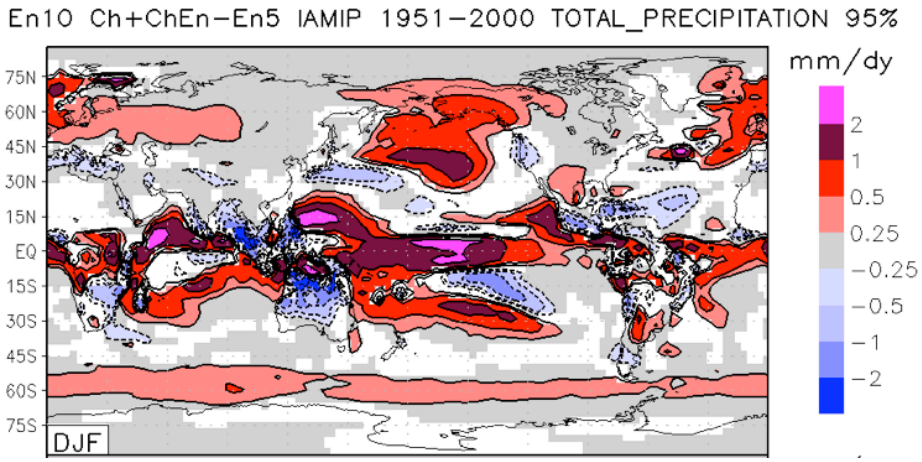
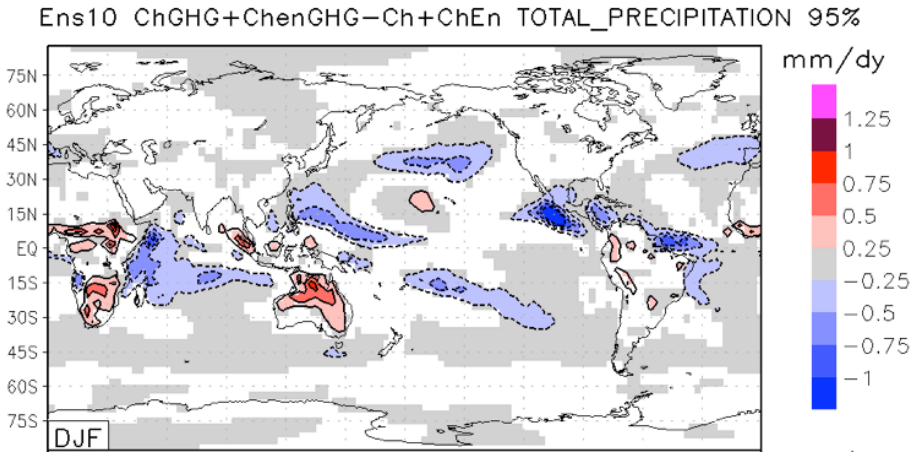


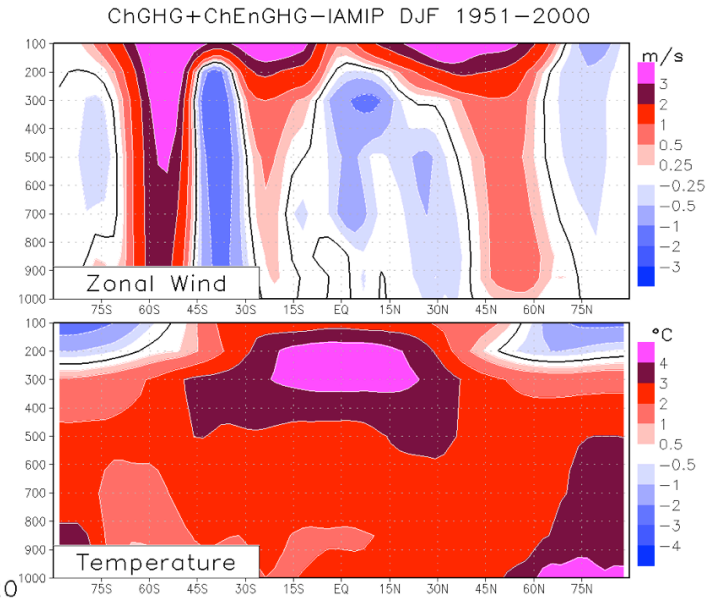
From ΔSST



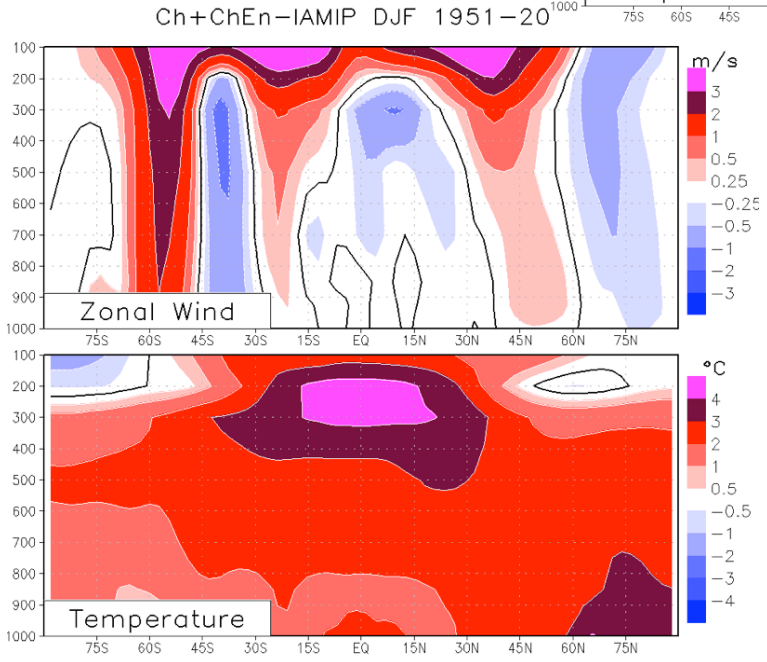
From ΔGHG



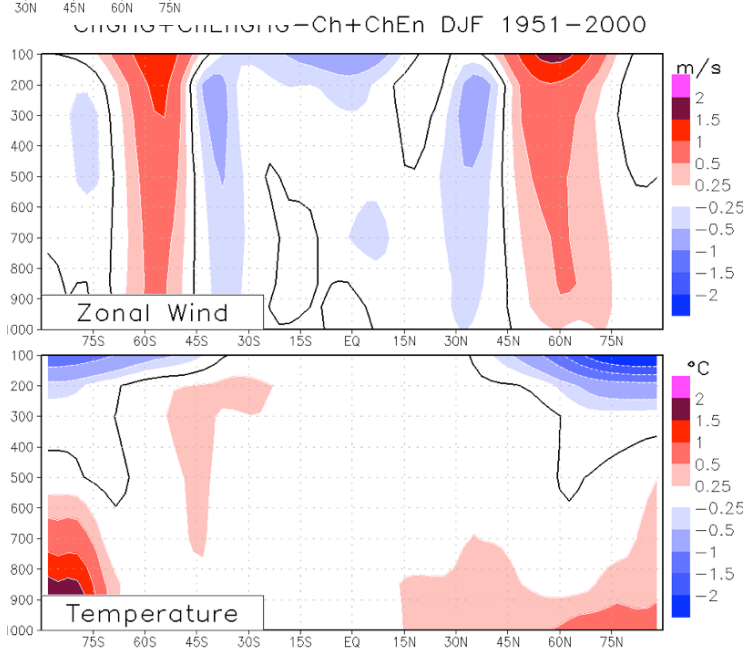
Δ Zonal Mean U, T Climatology DJF



From ΔSST+ ΔGHG



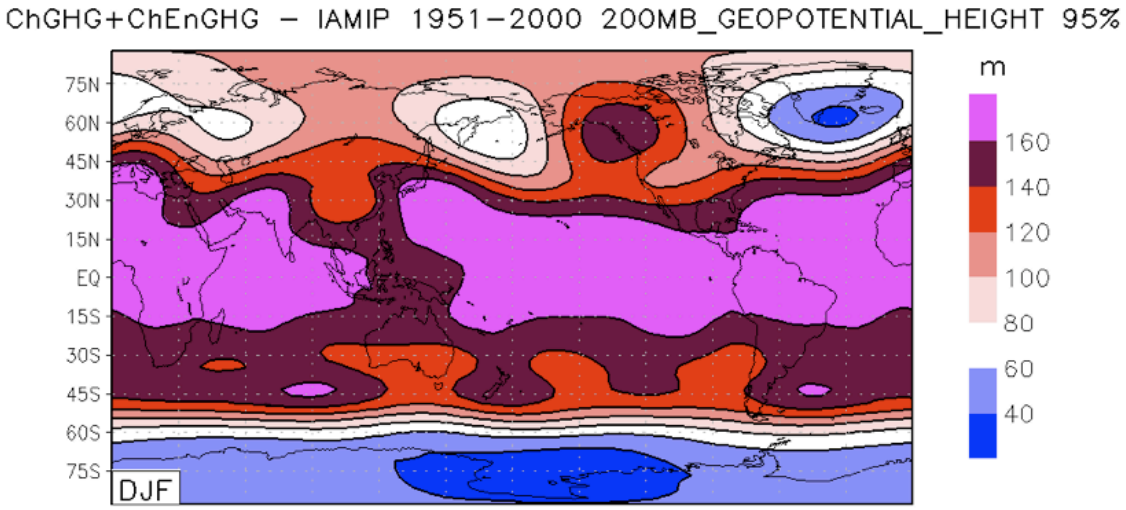
From ΔSST



From ΔGHG

Δ Z200 Climatology

From ΔSST+ ΔGHG



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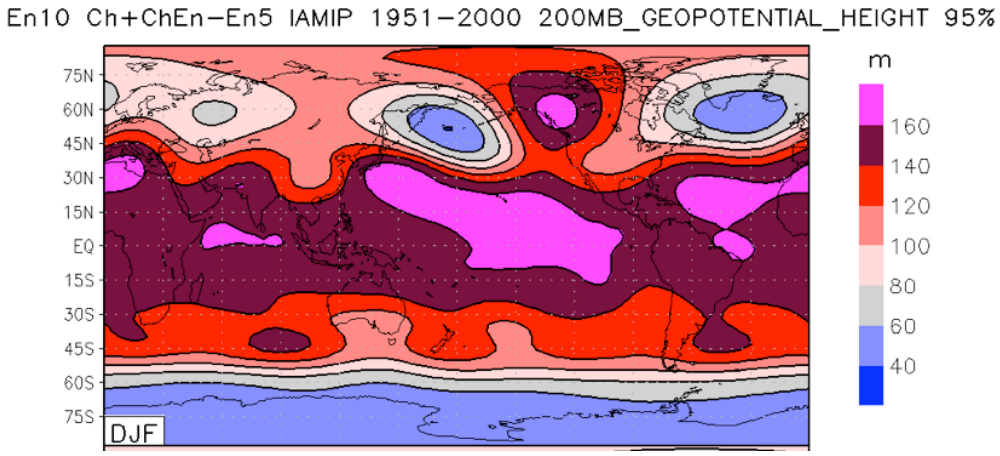
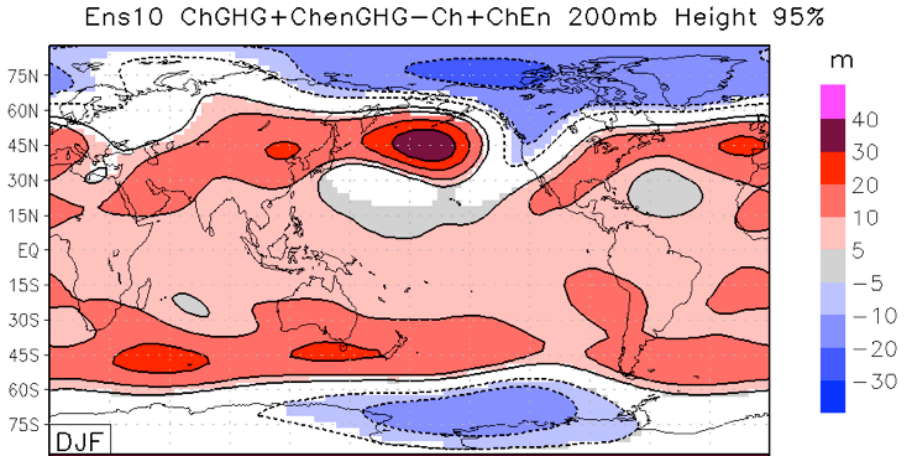


From ΔGHG

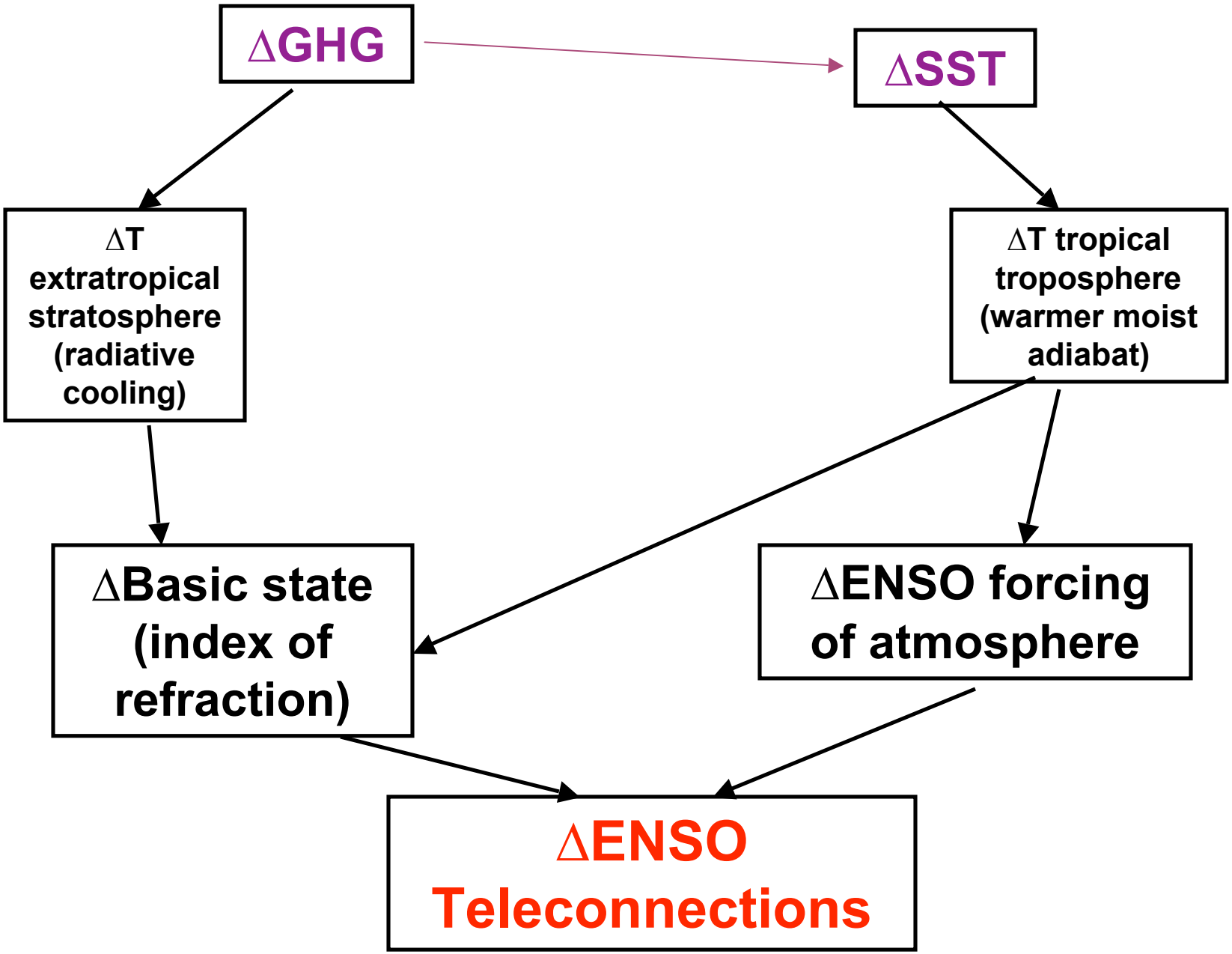


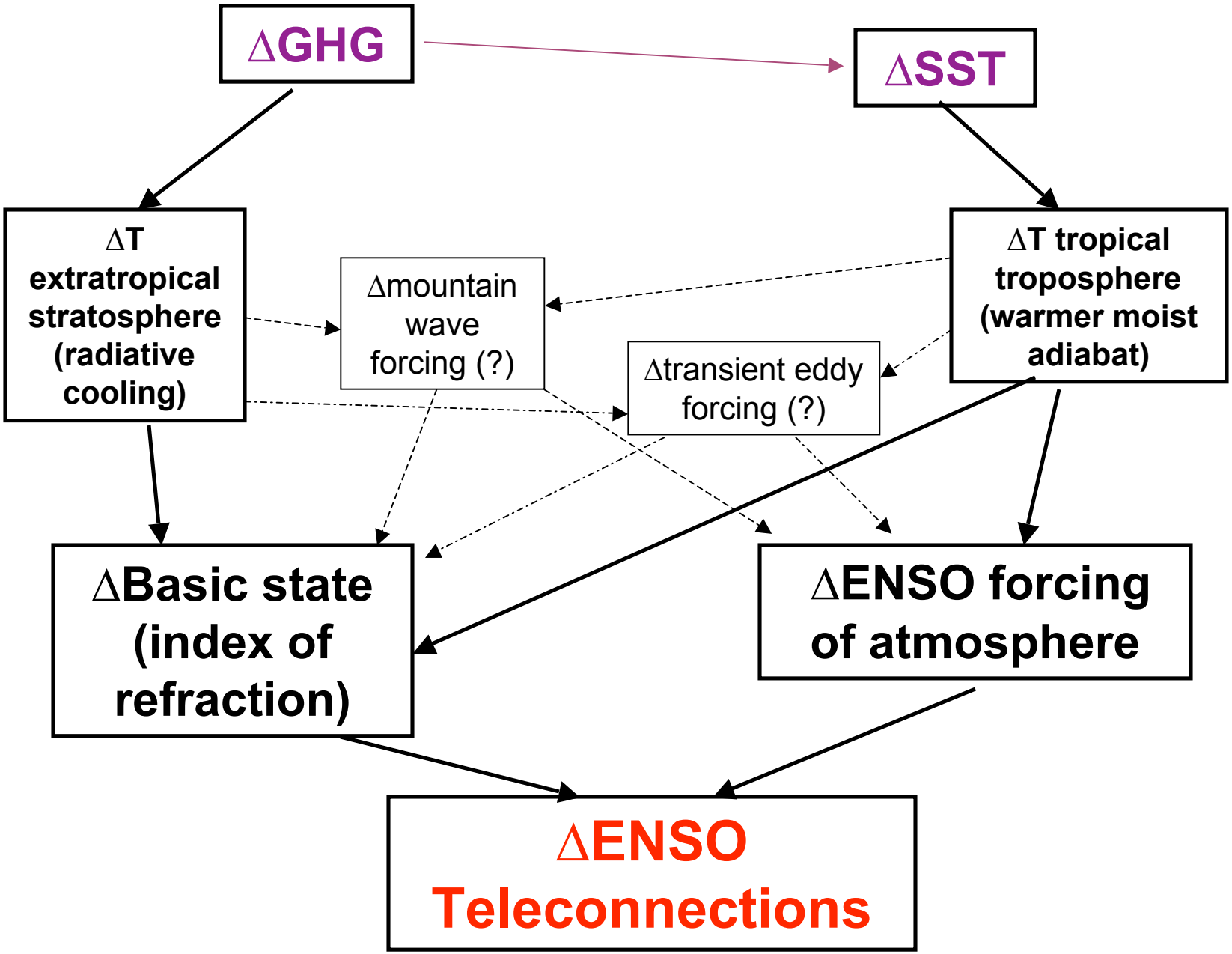
Discussion

- Changes in ENSO teleconnections in 21st century are due to:
  - Changes in tropical heating distribution and intensity asssociated with changes in tropical SST
  - Changes in wave propagation characteristics of mean state

Changes in Basic State

- Changes in zonal mean jets
  - Intensification of jets from intensified ITCZ + zonal mean/Hadley circulation dynamics
  - Intensification/poleward dispacement of jets from GHG polar stratospheric cooling
- Changes in stationary waves
  - Intensification of stationary waves from (tropical) mean SST teleconnections
  - High latitude influence on stationary waves from GHG


ΔGHG
ΔSST
ΔT extratropical stratosphere (radiative cooling)
ΔT tropical troposphere (warmer moist adiabat)
ΔBasic state (index of refraction)
ΔENSO forcing of atmosphere
ΔENSO Teleconnections


ΔGHG
ΔSST
ΔT extratropical stratosphere (radiative cooling)
Δmountain wave forcing (?)
ΔT tropical troposphere (warmer moist adiabat)
Δtransient eddy forcing (?)
ΔBasic state (index of refraction)
ΔENSO forcing of atmosphere
ΔENSO Teleconnections