Seasonal Changes in the Thermosphere from WACCM-X Future 21st Century Projections

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Motivation

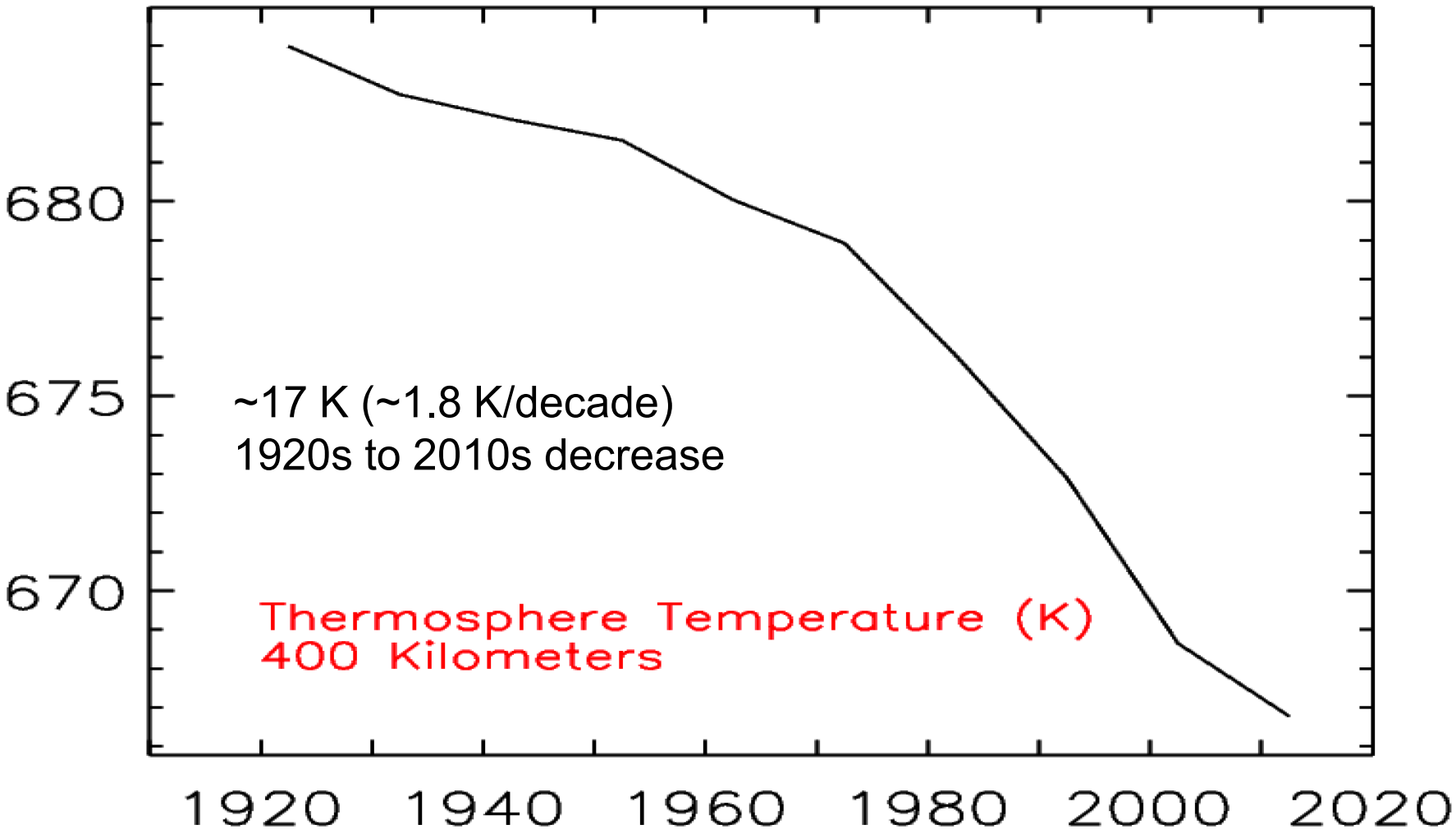
- **WACCM-X - atmospheric configuration of the Community Earth System Model (CESM)**
- **CESM atmospheric configurations CAM and WACCM - fully coupled model projections - IPCC scenarios**
- **WACCM-X fully coupled projections**
  – Challenging/time consuming tuning needed
- **Idealized WACCM-X projections**

Idealized Projections

WACCM-X 21st Century Idealized Simulations:

- **FXHIST compset**
- **Four continuous simulations from 2020 to 2120**
- **IPCC Scenarios SSP1-1.9, SSP2-4.5, SSP3-7.0, SSP5-8.5**
- **Monthly means used to derive seasonal means**
- **Solar minimum quiet conditions, fixed geomagnetic field**
- **Same configuration used for hindcast WACCM-X 20th Century simulations**

Neutral Temperature Time Series – 400 km



McInerney et al., 2024

Previous WACCM -X Projection Scenarios

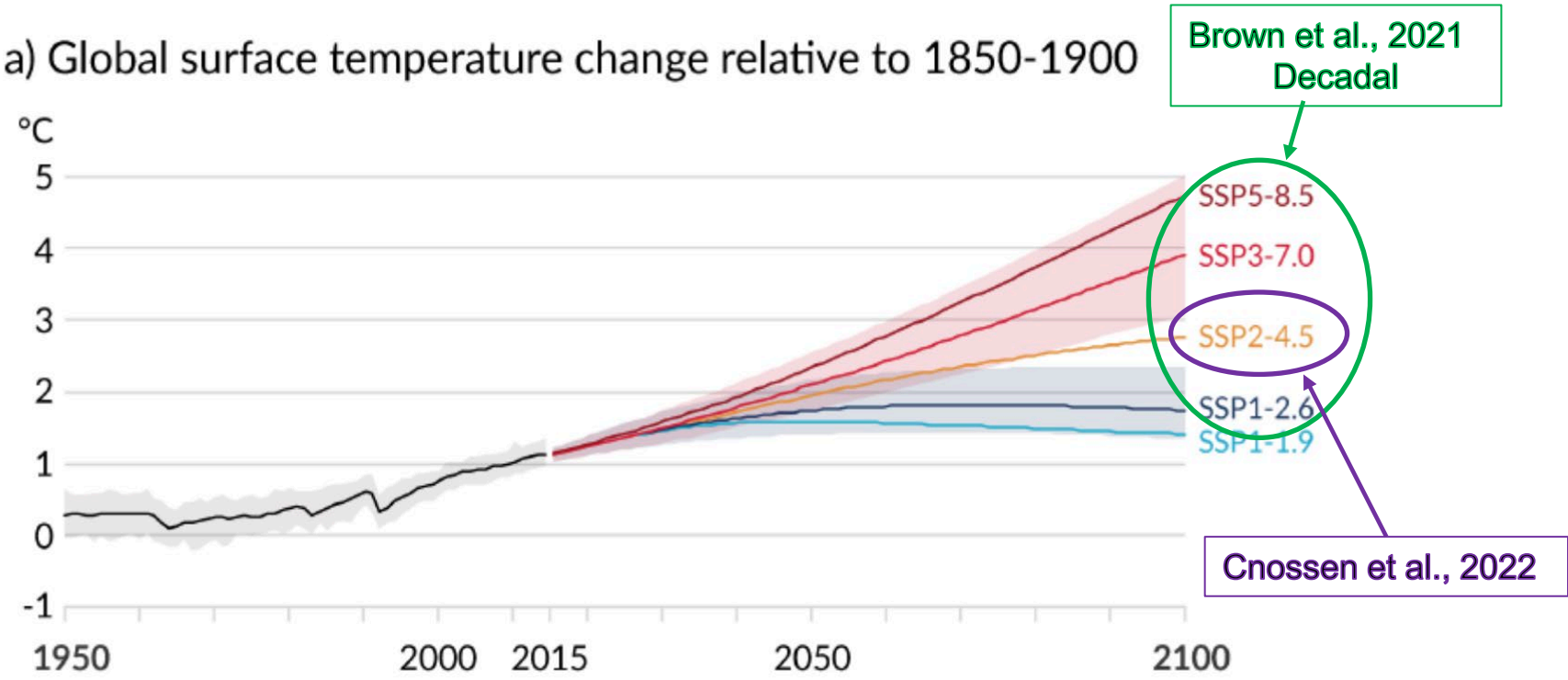
SIXTH ASSESSMENT REPORT
Working Group I – The Physical Science Basis

ipcc INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Human activities affect all the major climate system components, with some responding over decades and others over centuries

Figure SPM.8



This Study Projection Scenarios

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IPCC
INTERGOVERNMENTAL PANEL ON climate change

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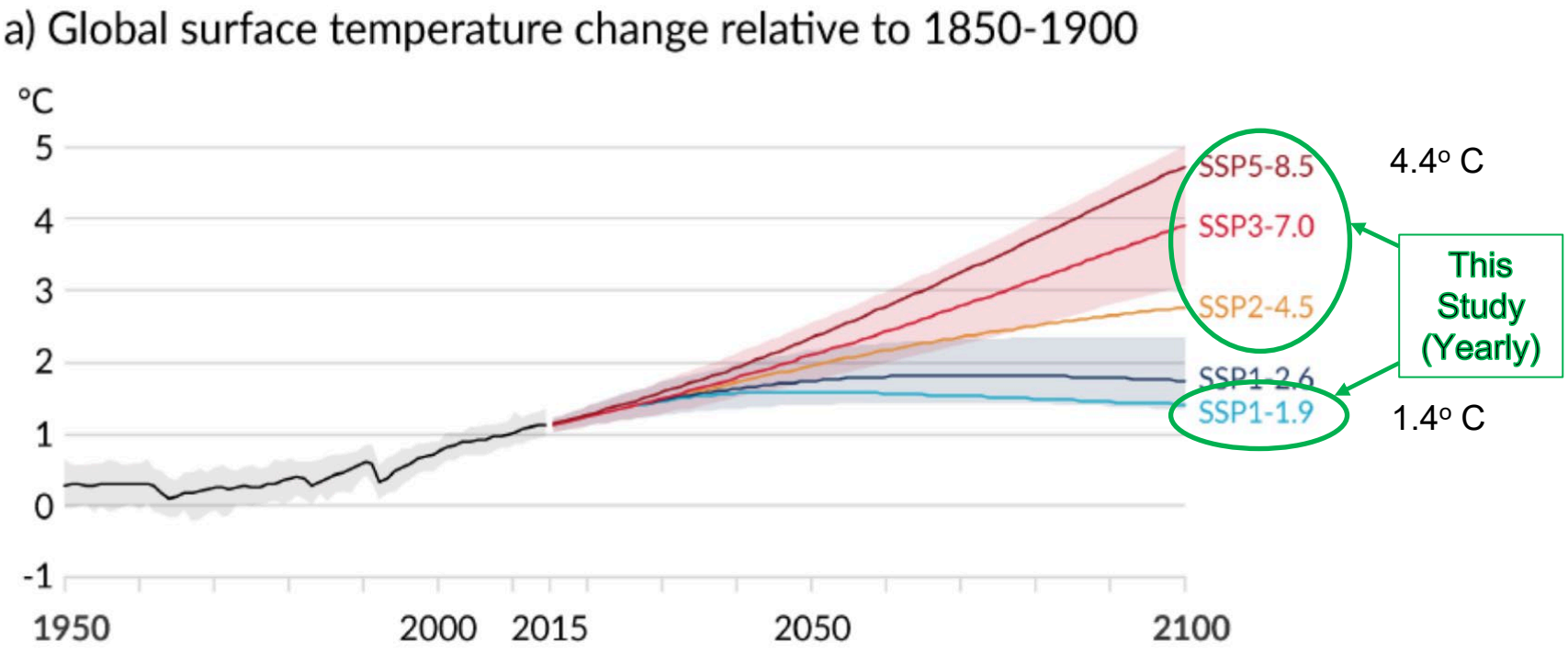
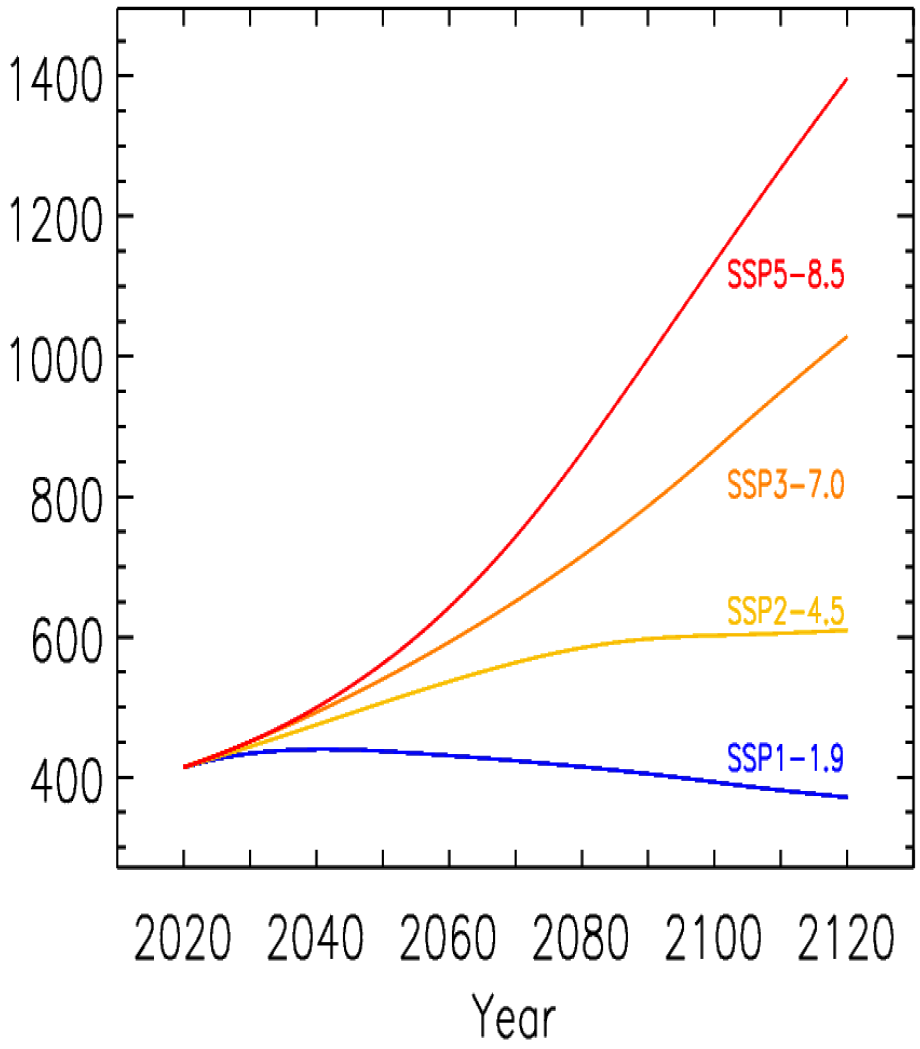
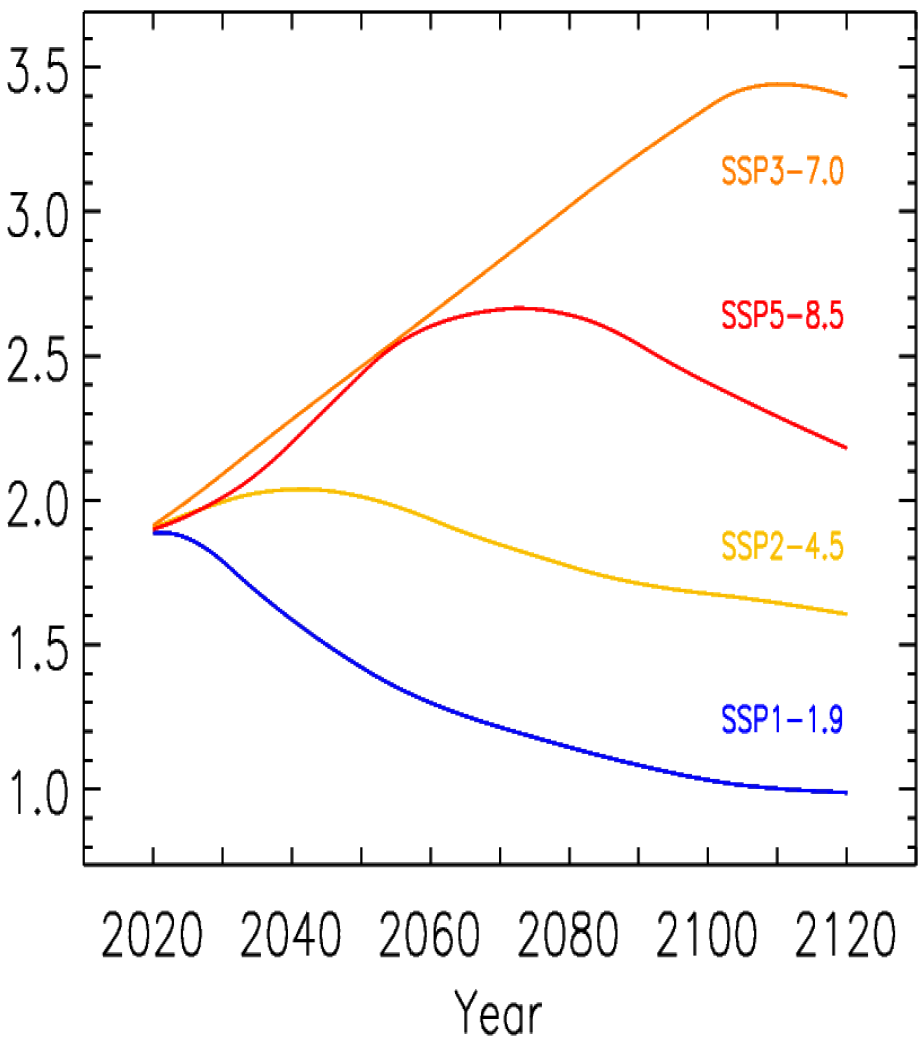
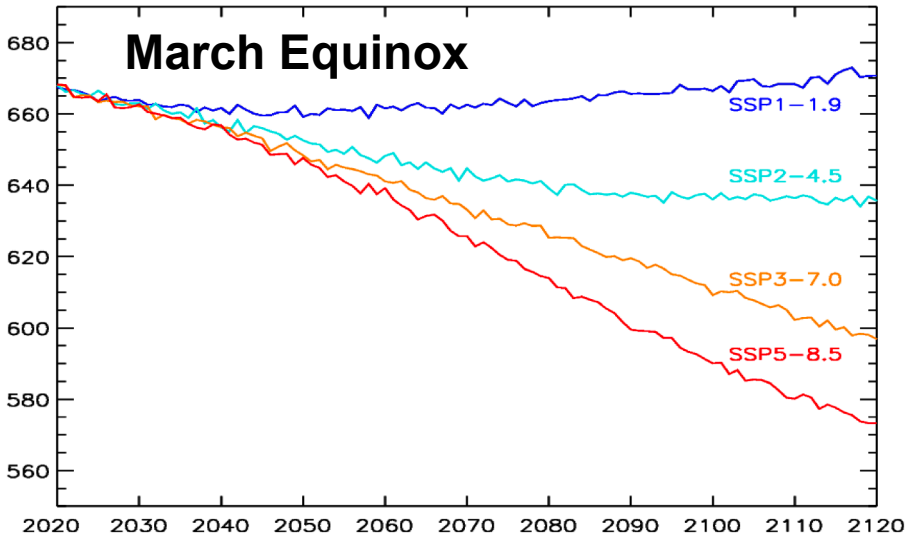


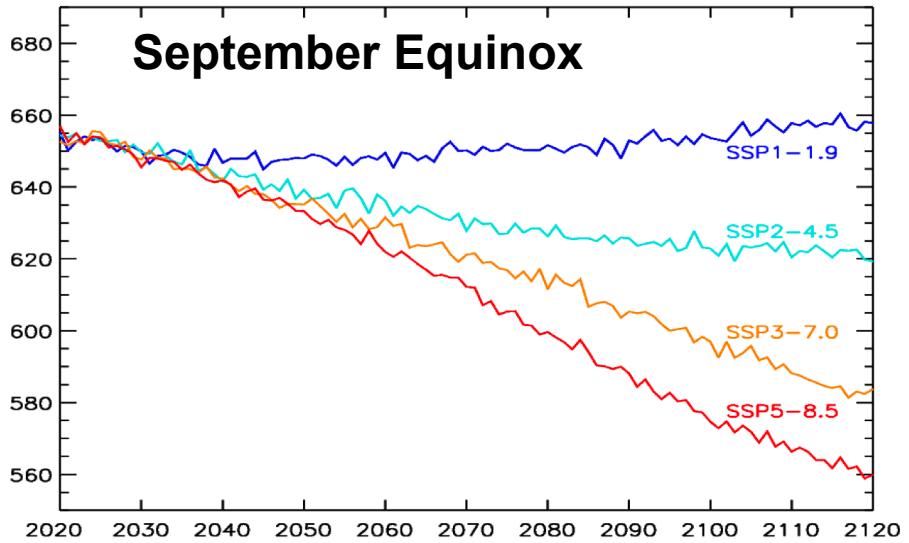
IPCC Scenario CO_2 and CH_4

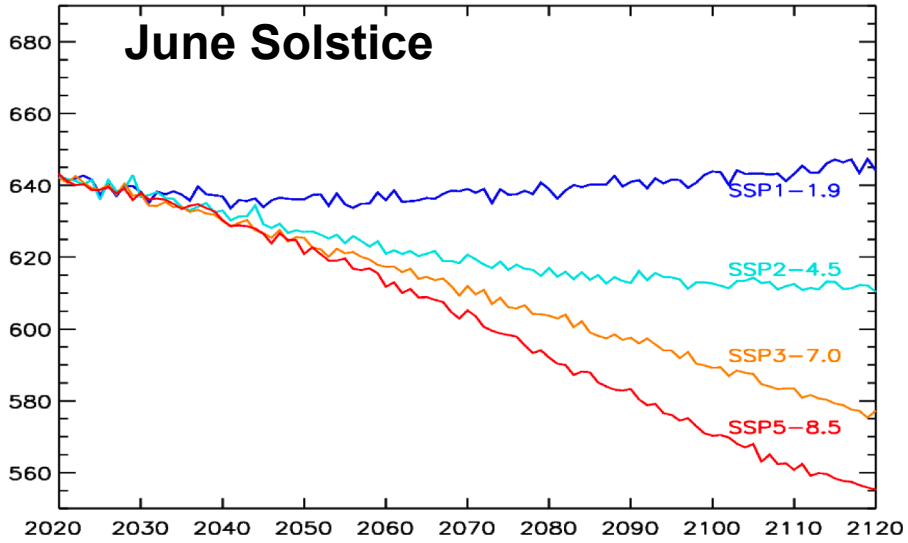


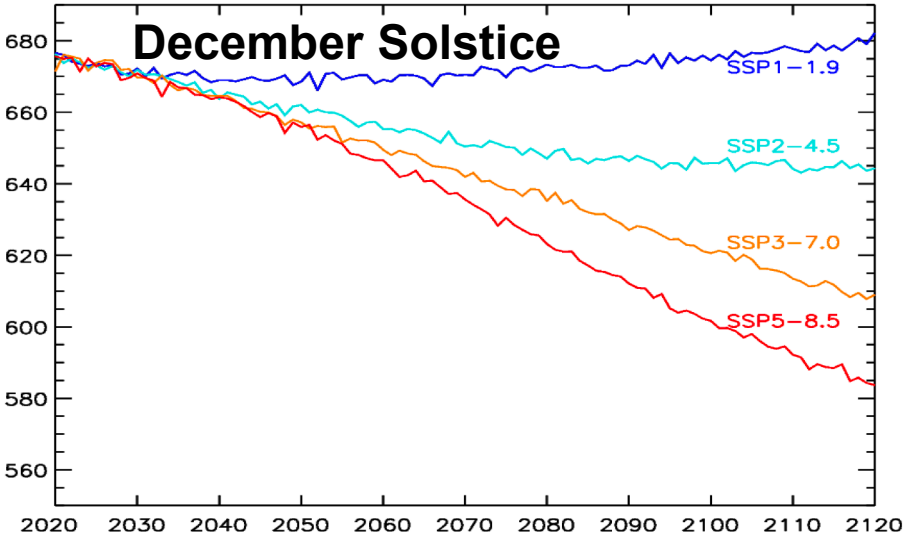


Neutral Temperature Time Series – Equinox/Solstice for IPCC Projections – 300 km

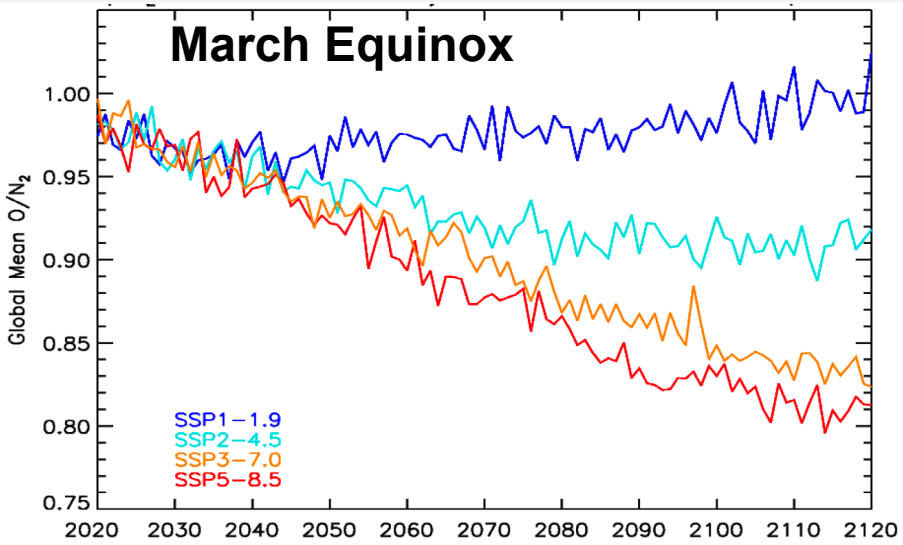


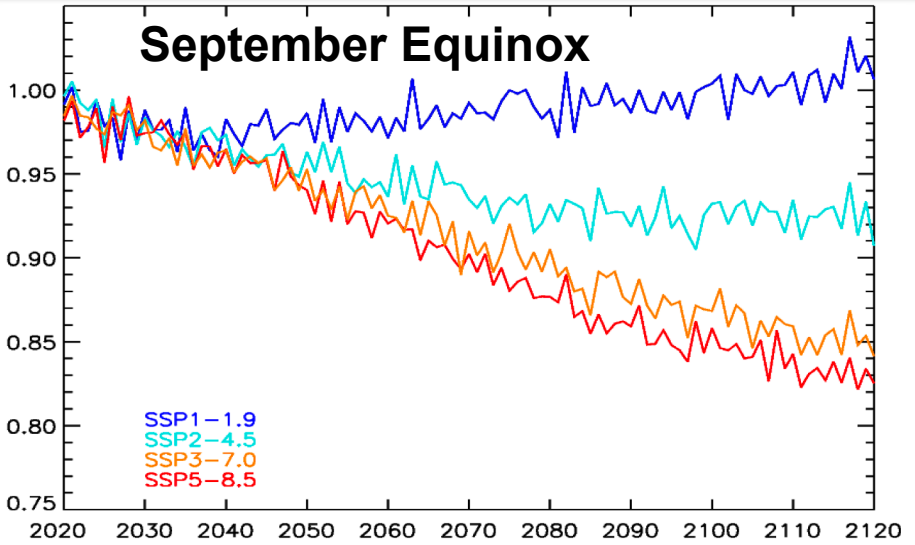


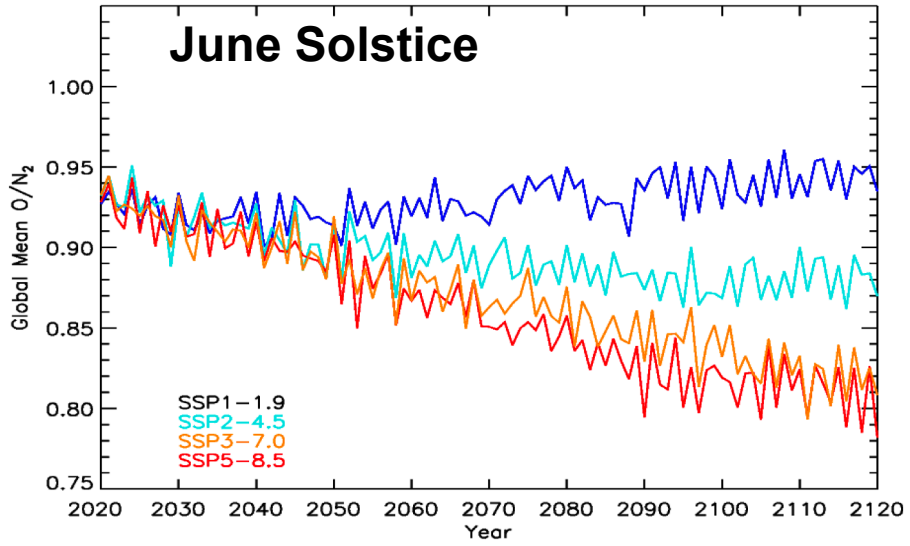


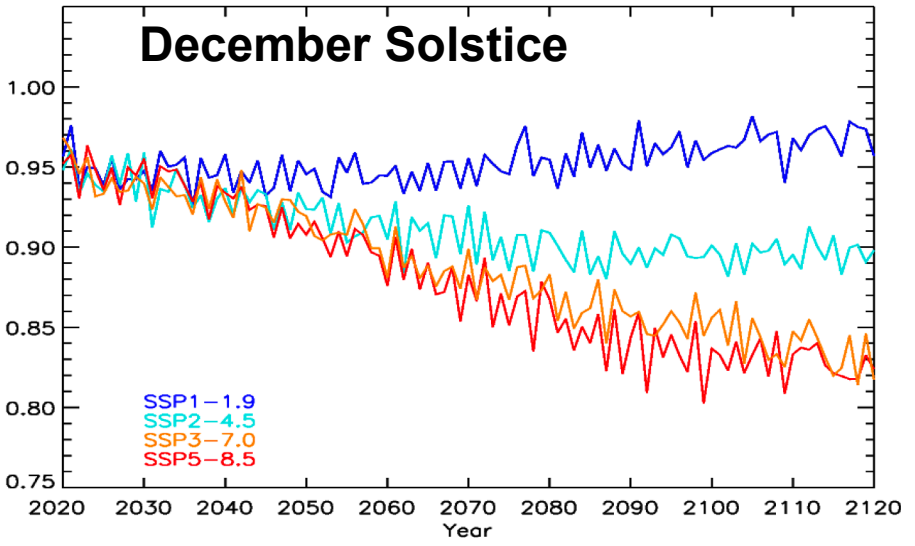


O/N_2 Time Series Equinox/Solstice for IPCC Projections

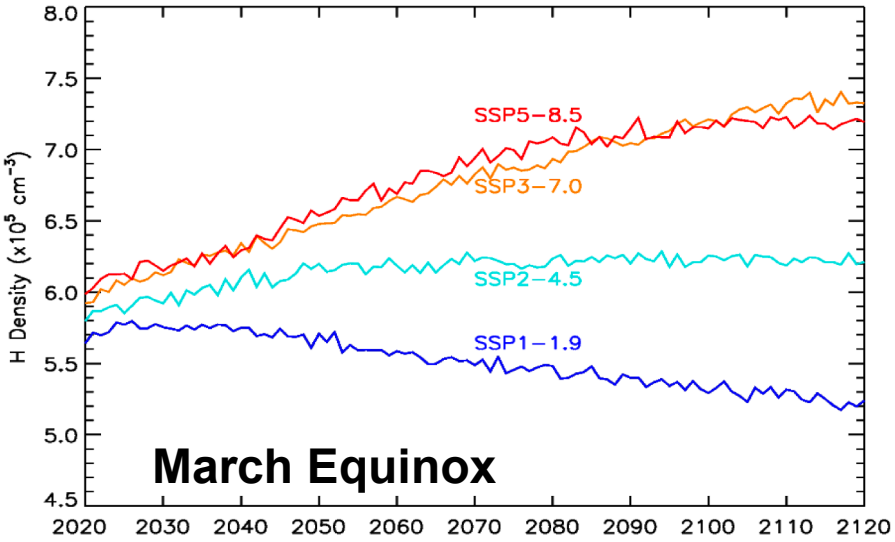


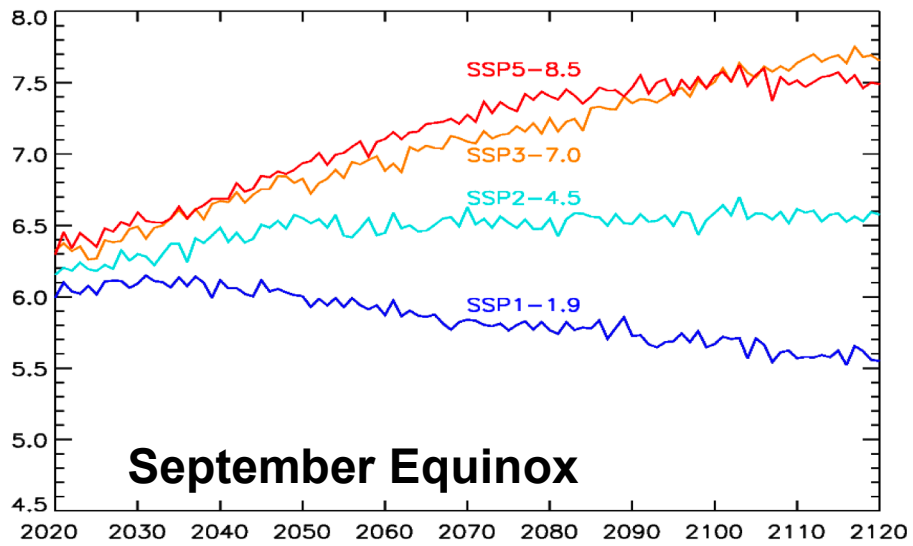


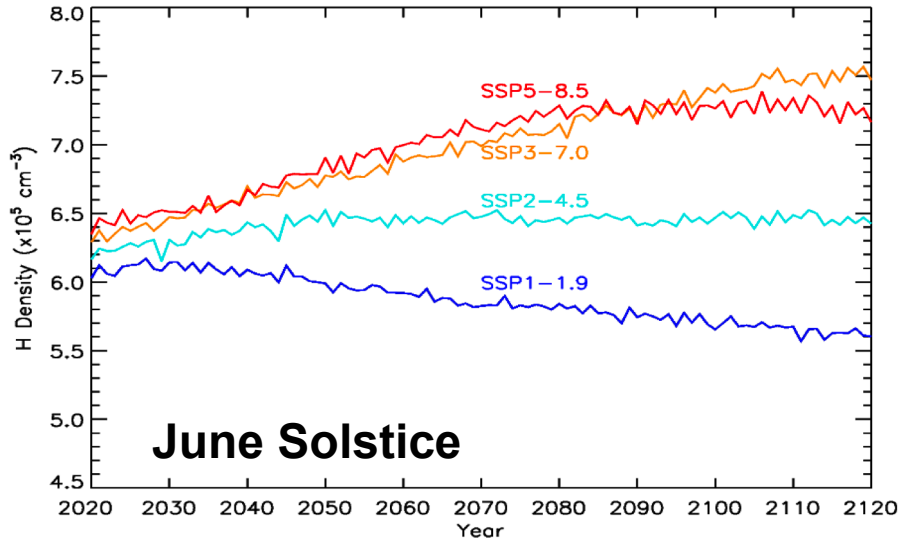


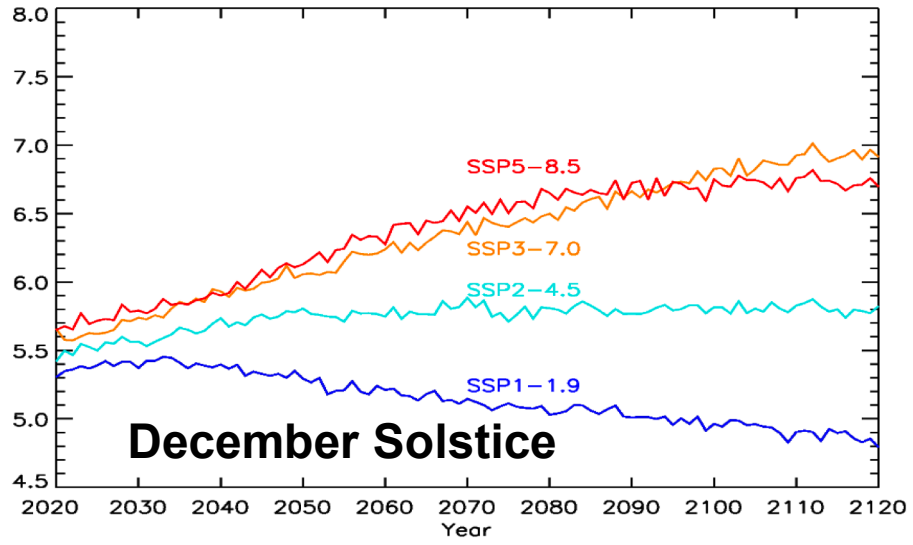


Atomic Hydrogen Time Series Equinox/Solstice for IPCC Projections – 300 km

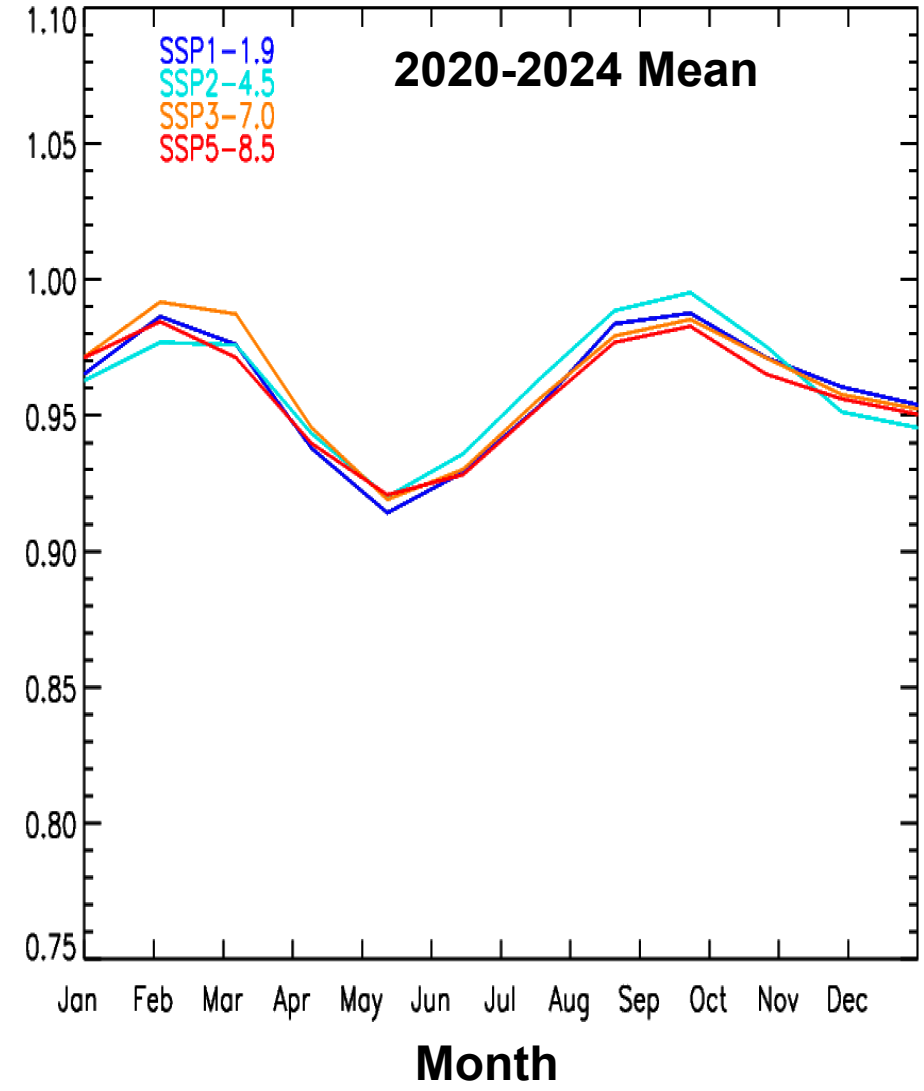


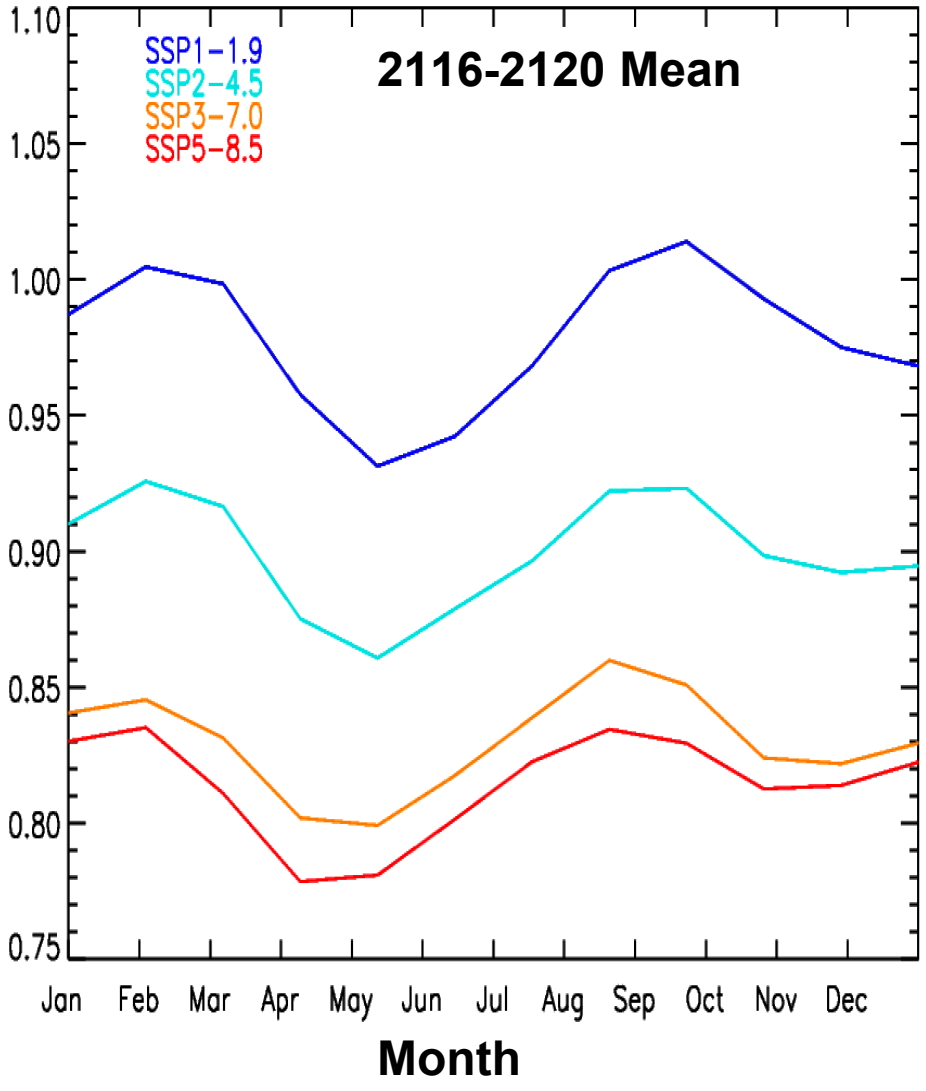




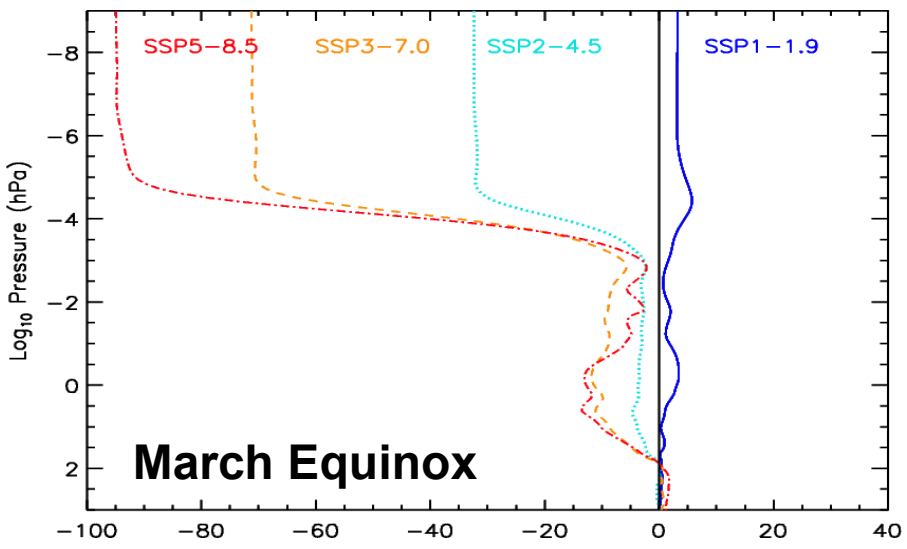


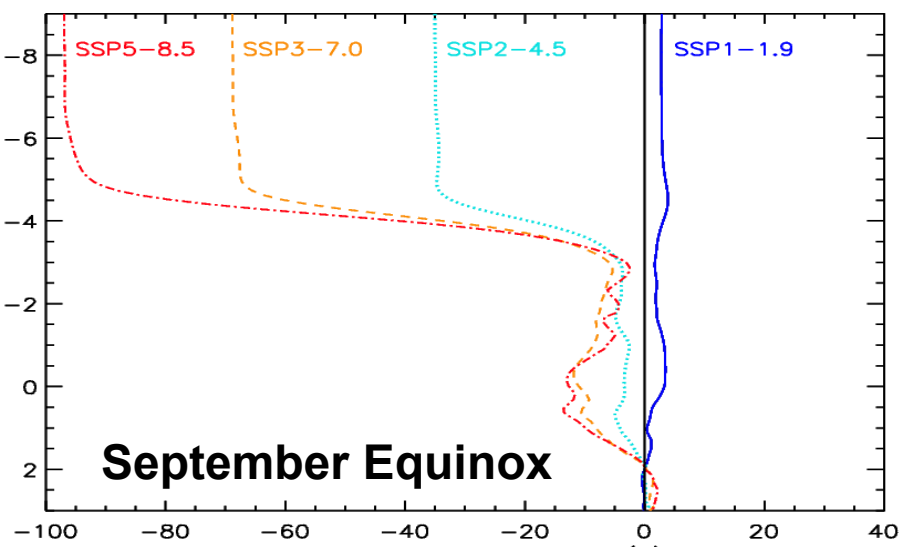
O/N_2 Seasonal Changes – 2020-2024 and 2116-2120 Averages for IPCC Projections

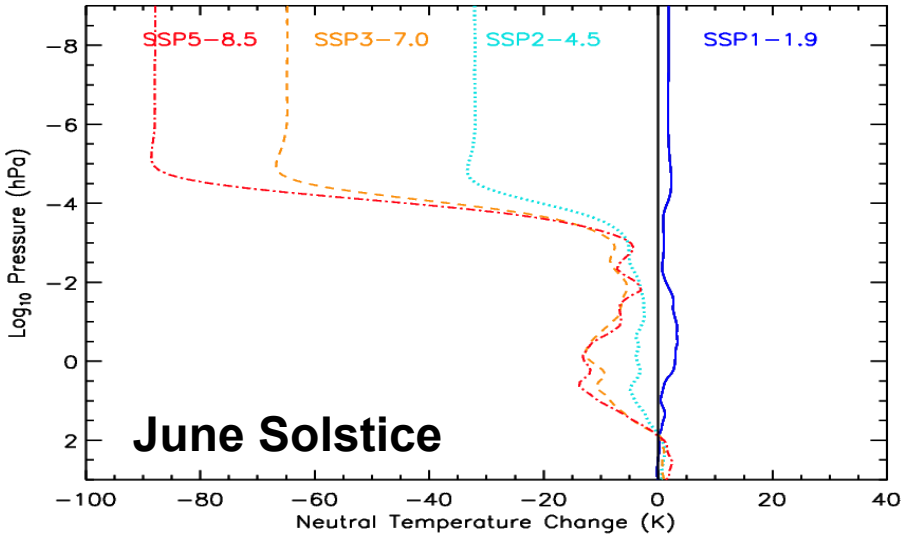


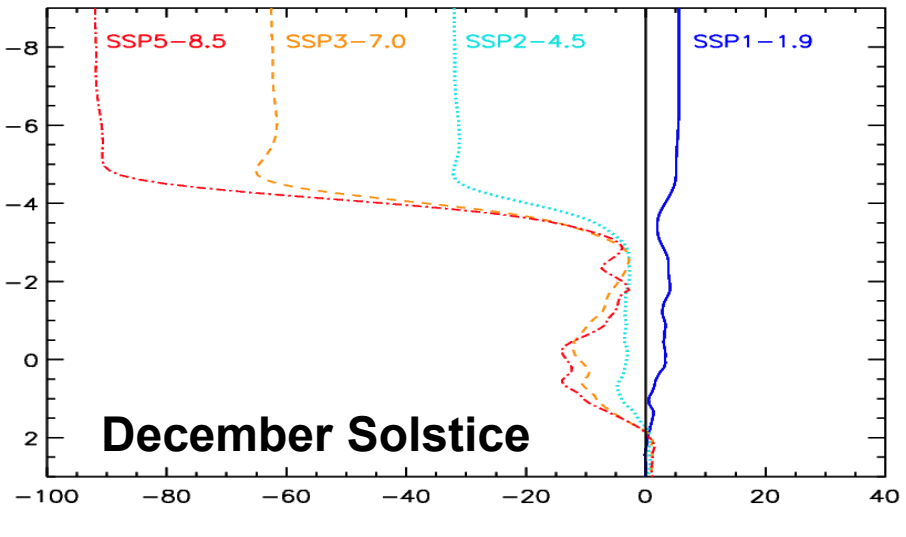


Neutral Temperature Vertical Differences 2120 – 2020 Equinox/Solstice for IPCC Projections

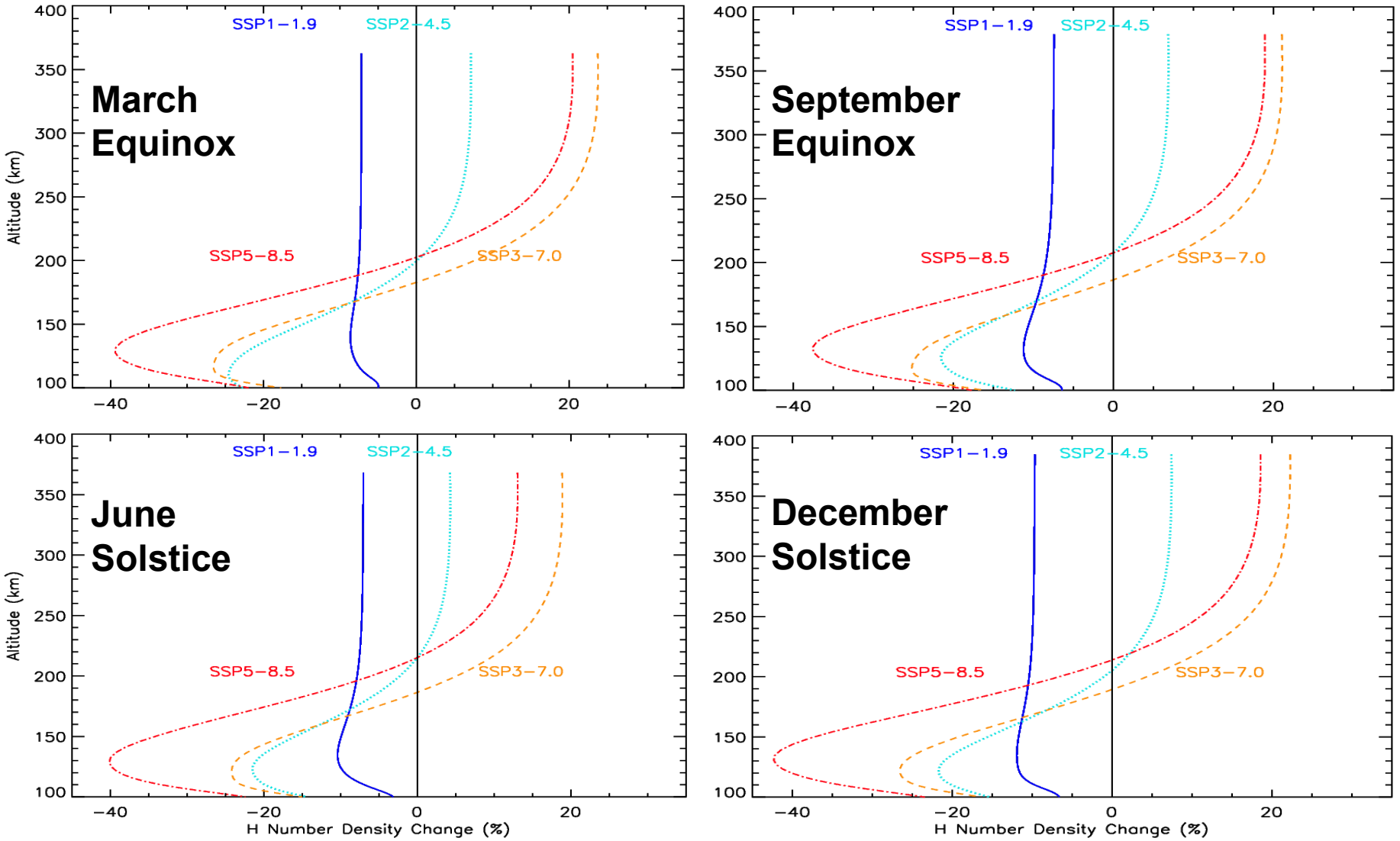




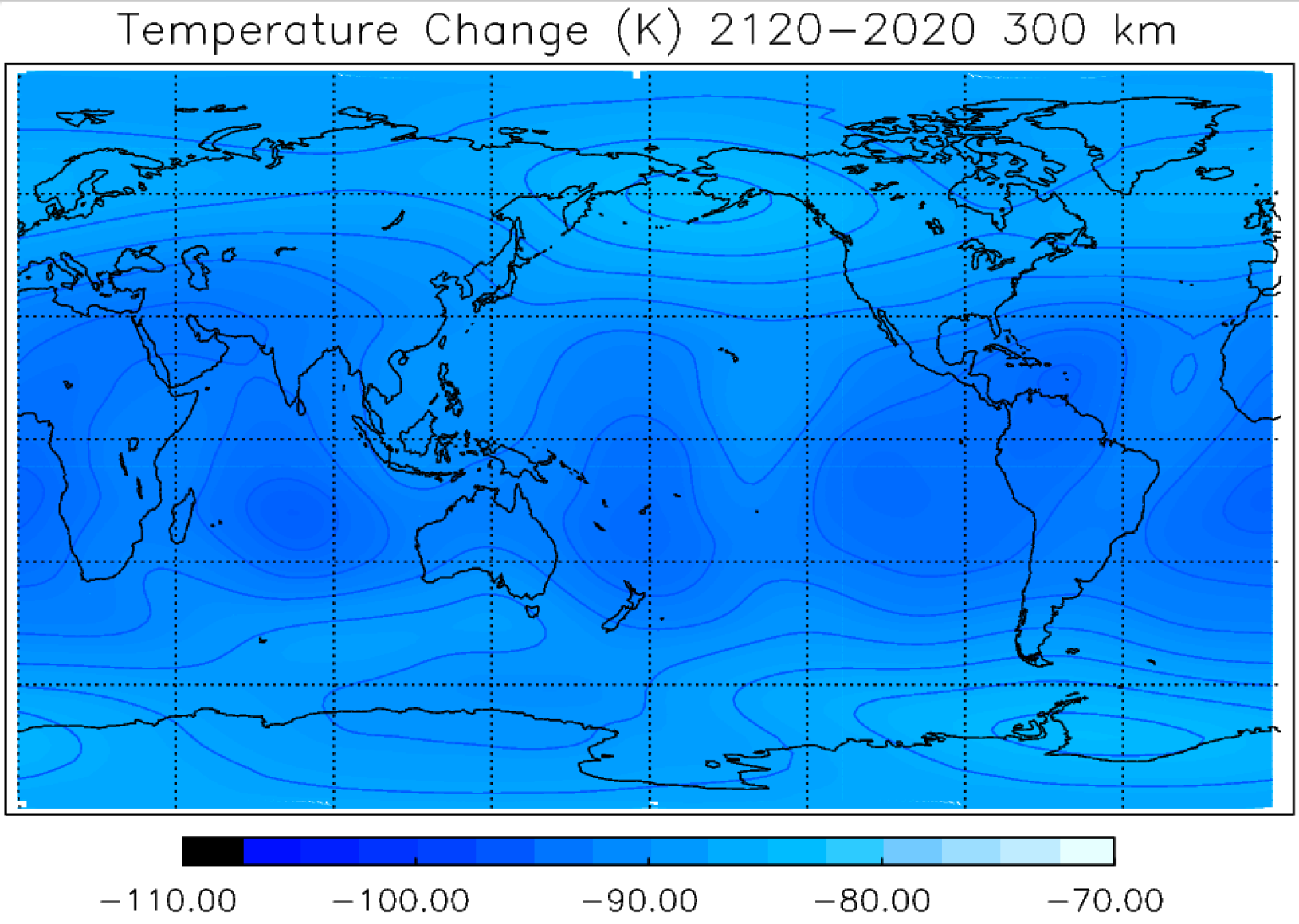




Atomic Hydrogen Vertical Differences 2120 – 2020 Equinox/Solstice for IPCC Projections

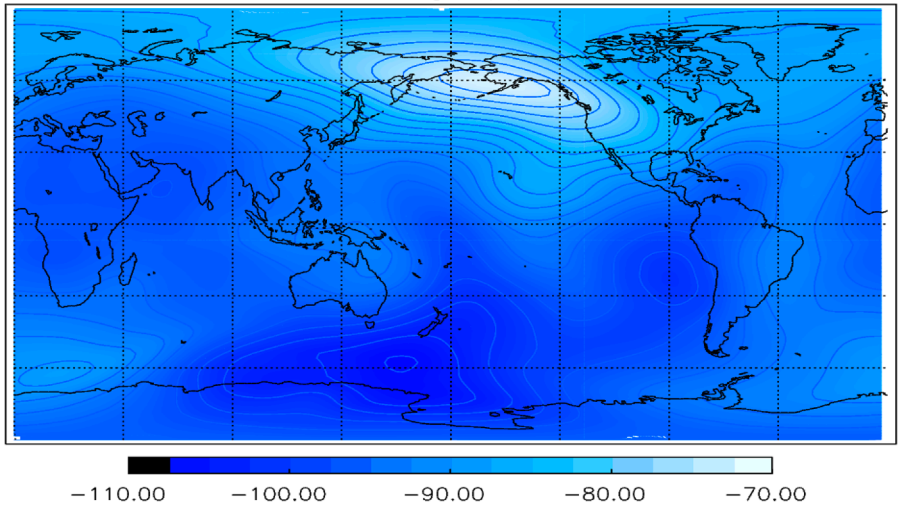


Neutral Temperature Lat/Lon Differences 300 km

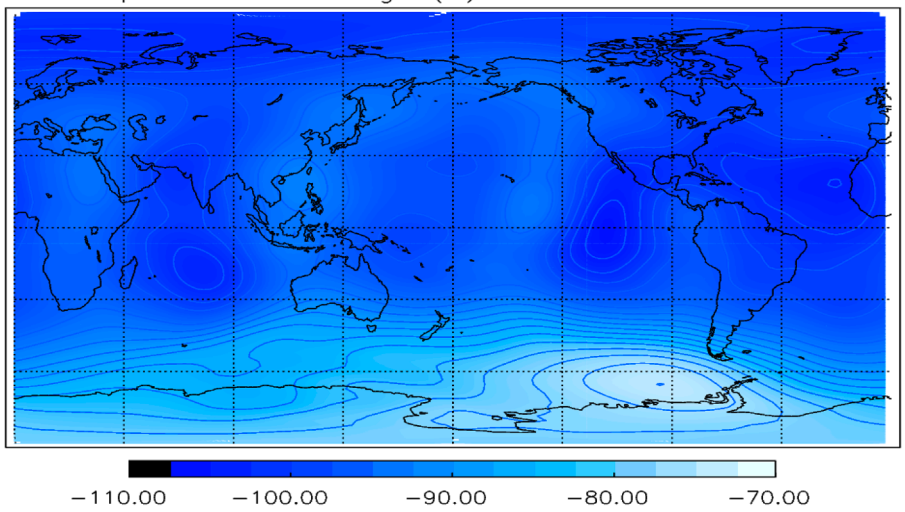


Neutral Temperature Lat/Lon Differences 300 km Equinox/Solstice for IPCC Projections

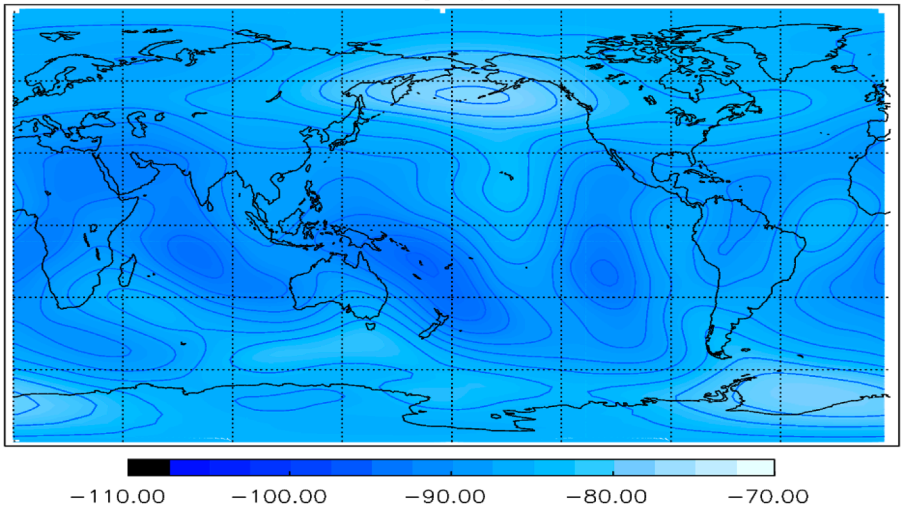
March Temperature Change (K) 2120−2020 300 km



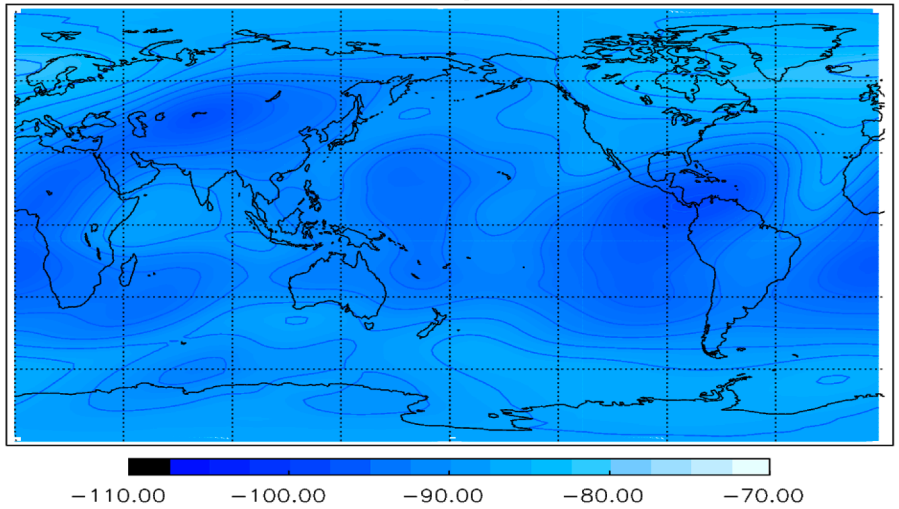
September T Change (K) 2120−2020 300 km



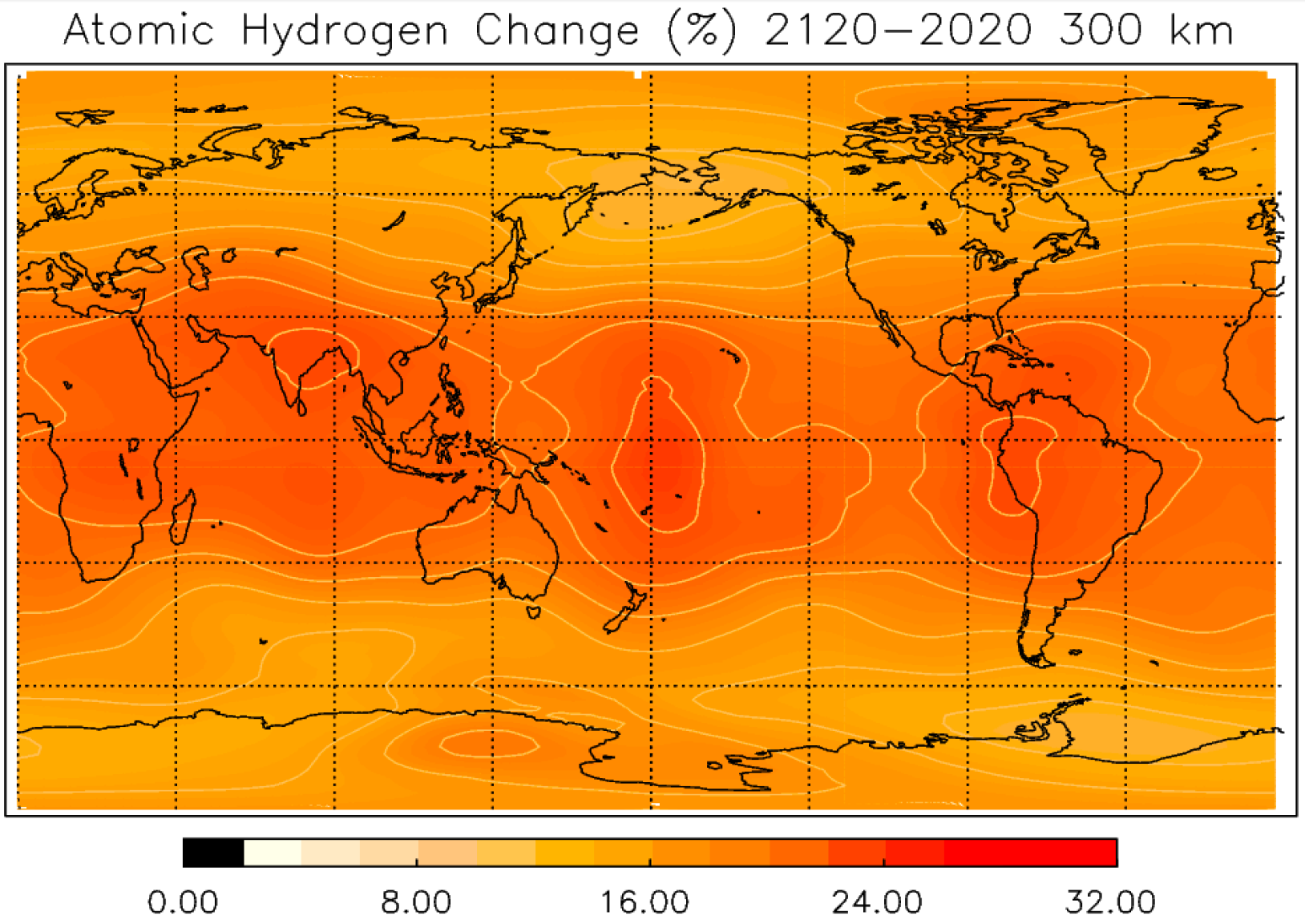
June Temperature Change (K) 2120−2020 300 km



December Temperature Change (K) 2120−2020 300 km

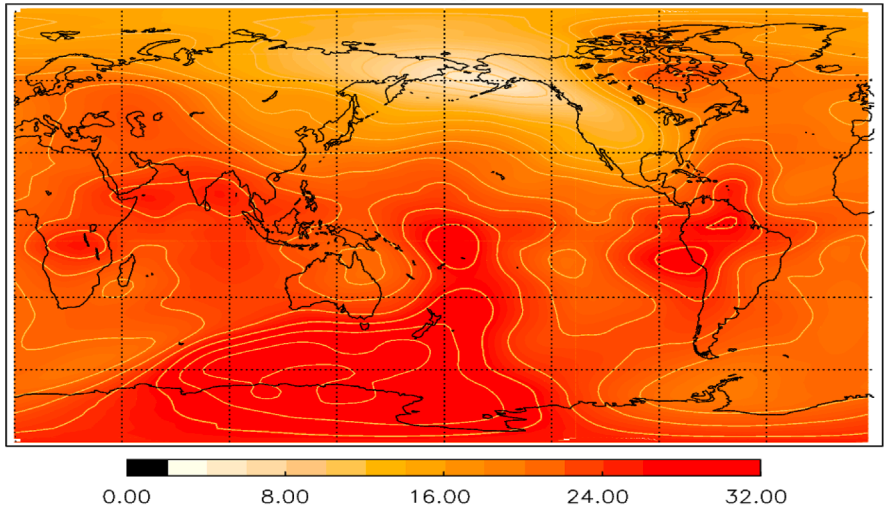


Atomic Hydrogen Lat/Lon Differences 300 km

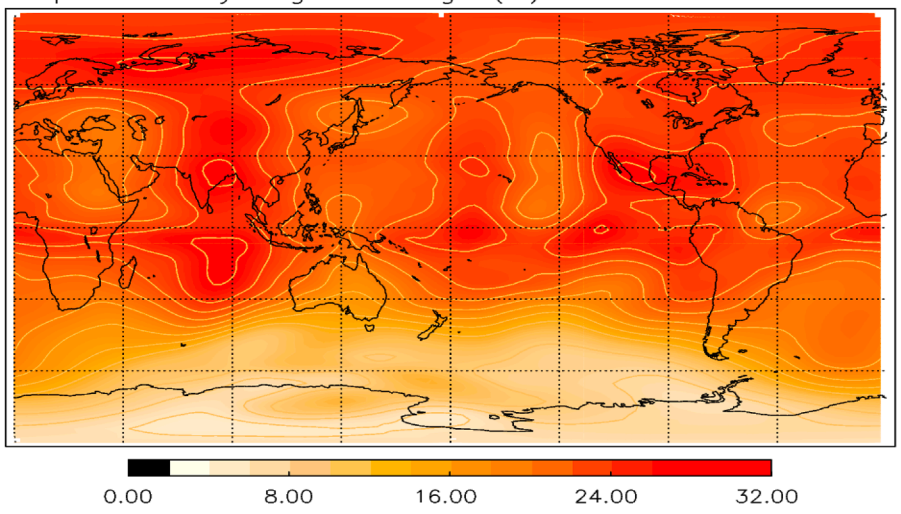


Atomic Hydrogen Lat/Lon Differences 300 km Equinox/Solstice for IPCC Projections

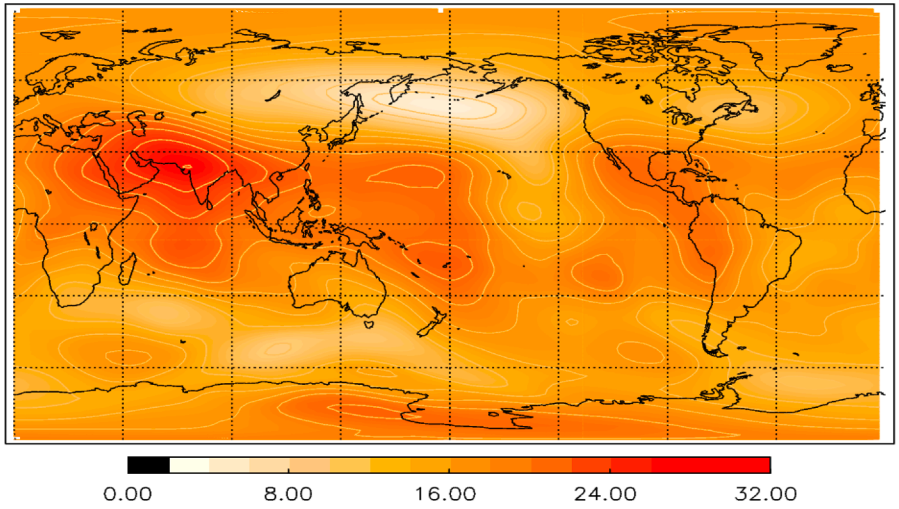
March Atomic Hydrogen Change (%) 2120−2020 300 km



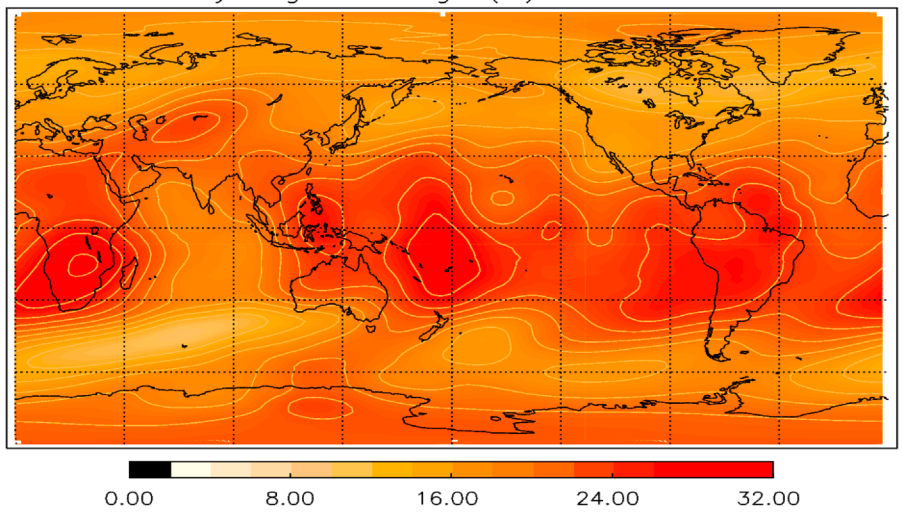
September Hydrogen Change (%) 2120−2020 300 km



June Atomic Hydrogen Change (%) 2120−2020 300 km



December Hydrogen Change (%) 2120−2020 300 km



Seasonal Changes Summary

WACCM-X 21st century IPCC projection simulations:

- **Neutral Temperature**
- **Time series very similar for all seasons**
- **Relatively more global cooling at equinox**
- **Clear geographic dependency of cooling**

- **O/N2**
- **Variability increases more for solstices**
- **Seasonality shifts to earlier in the year**
- **Smaller change between two high emission scenarios**

Seasonal Changes Summary (2)

WACCM-X 21st century IPCC projection simulations:

- **Atomic Hydrogen**
- **Earlier decrease due to CH4 reversal at solstice**
- **June solstice has smaller increases**
- **Clear geographic dependency of increases**

Future work:

- **Comparison to previous WACCM-X projections**
- **Publish results**
- **Fully coupled WACCM-X 7 projections**