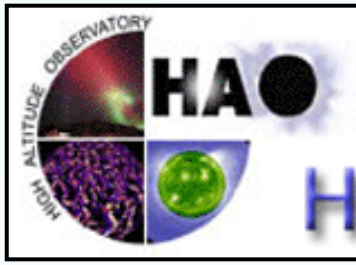


Exploring the Sun and its effects on the Earth's atmosphere and physical environment...

HIGH ALTITUDE OBSERVATORY

Upper Thermospheric Responses to Forcing from Above and Below during 1–10 April 2010: Results from an Ensemble of Numerical Simulations

Maura Hagan, Kathrin Häusler*, Gang Lu

High Altitude Observatory, National Center for Atmospheric Research, Boulder, Colorado

**also at Advanced Study Program, National Center for Atmospheric Research, Boulder, Colorado*

Jeff Forbes, and Xiaoli Zhang

Department of Aerospace Engineering Sciences, University of Colorado, Boulder, Colorado

The National Center for Atmospheric Research is sponsored by the National Science Foundation

April 1-10, 2010 TIME-GCM Simulations

Optimal Simulation:

MERRA lower boundary (ca. 30km) conditions

Optimal Simulation

Modern **E**ra **R**etrospective Analysis for **R**esearch and **A**pplications reanalysis data (3-hourly winds, temperatures, geopotential heights)

AMIE upper boundary forcing after *Lu et al.* [2015]

Assimilative **M**apping of **I**onospheric **E**lectrodynamics

Diagnostic Simulations:

1) Optimal Lower Boundary and Standard Upper Boundary

MERRA forcing ➔ "realistic" tides and planetary waves

GPI (Geophysical Indices) forcing ➔ based on Kp

Standard Simulation

2) Constant Lower Boundary and AMIE Upper Boundary

average MERRA day (3-hourly March–April 2010 MERRA averages

➔ constant tides; no planetary waves

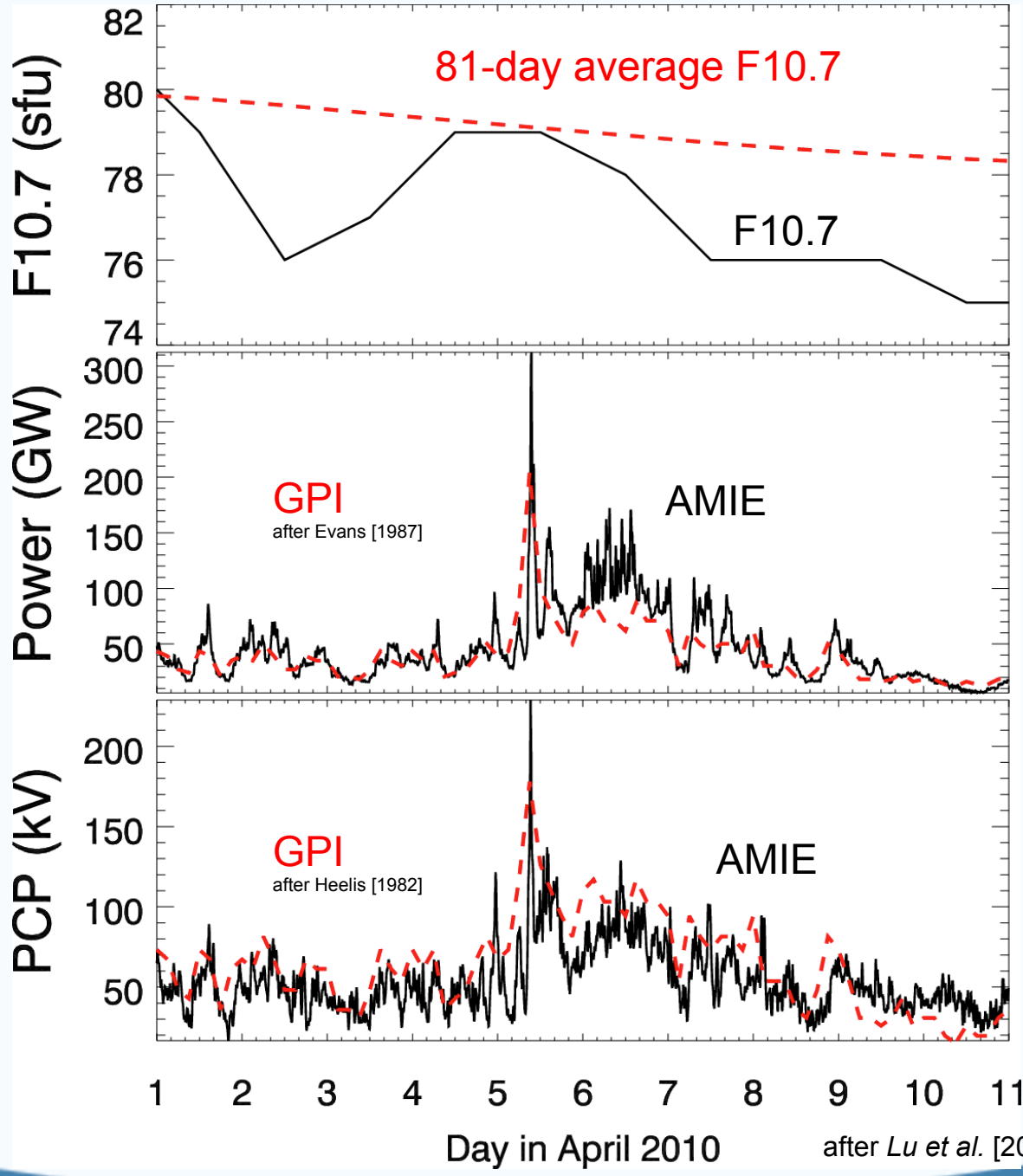
Constant Lower Boundary

3) MERRA Lower Boundary and Constant Upper Boundary

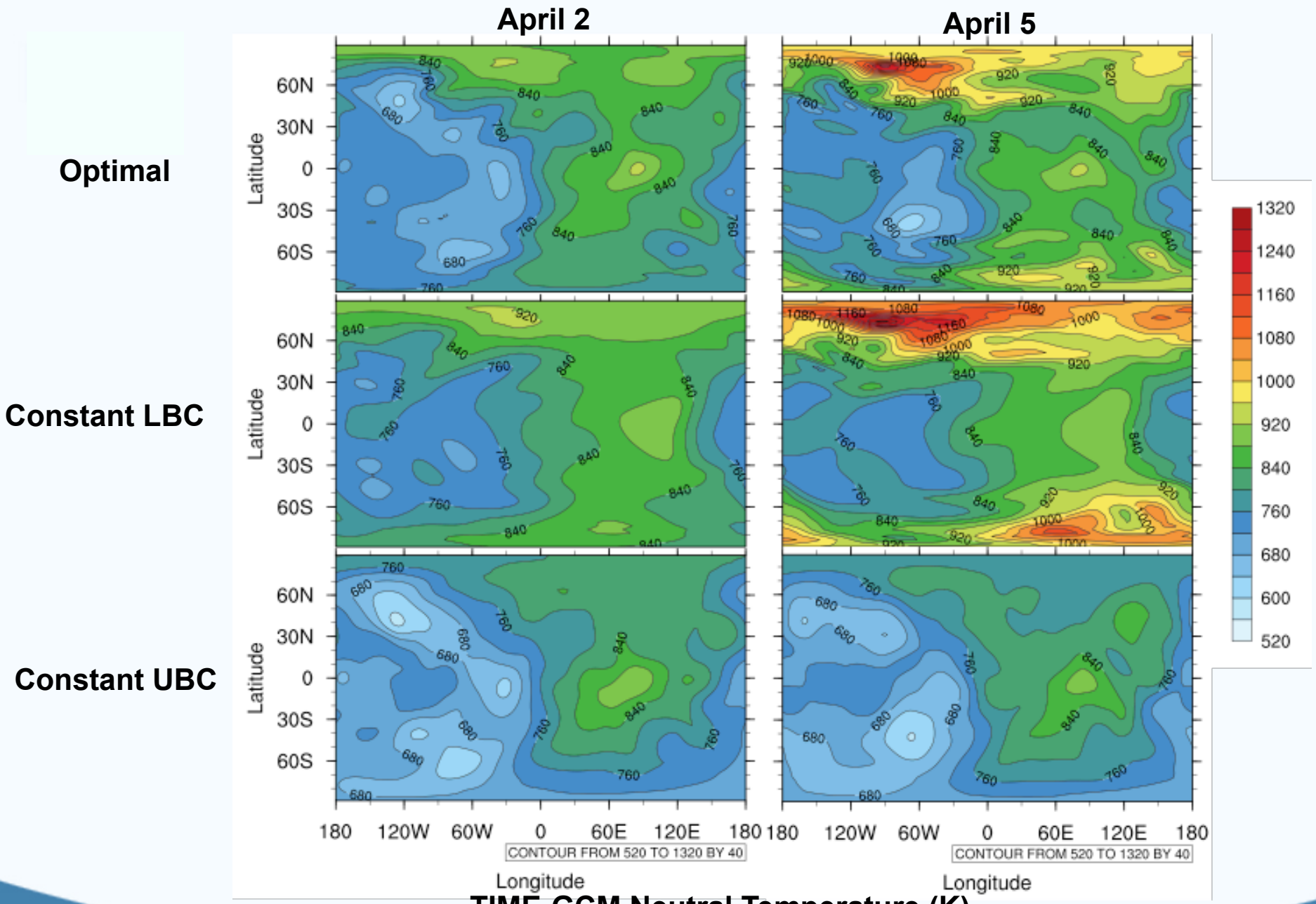
constant quiescent upper boundary ➔ 80 sfu; 8 GW; 30kV

Constant Upper Boundary

Prevailing Conditions and TIME-GCM Upper Boundary Forcing during April 2010

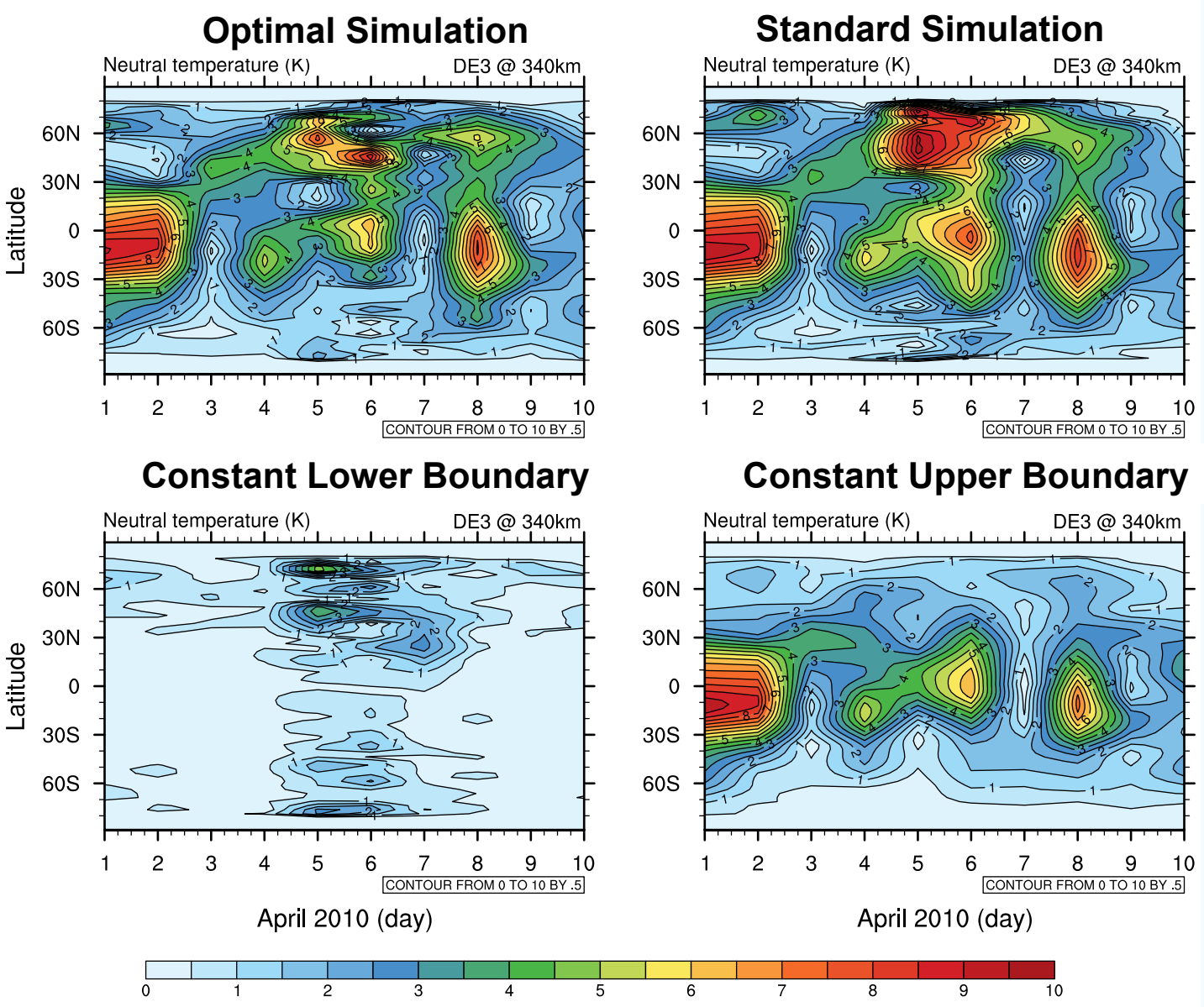


after *Lu et al.* [2015]



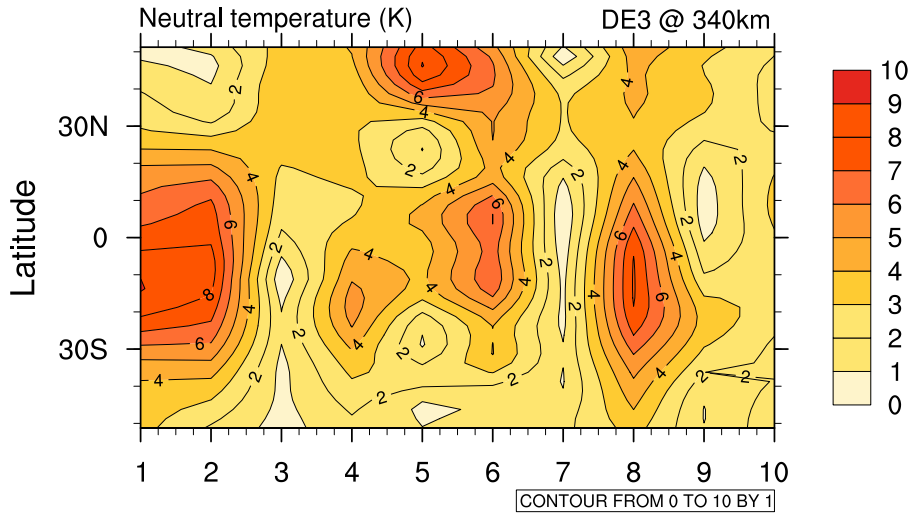
TIME-GCM Neutral Temperature (K)
10:00 UT and 340 km

TIME-GCM DE3 Temperature Amplitudes



TIME-GCM DE3 Temperature Amplitude Differences

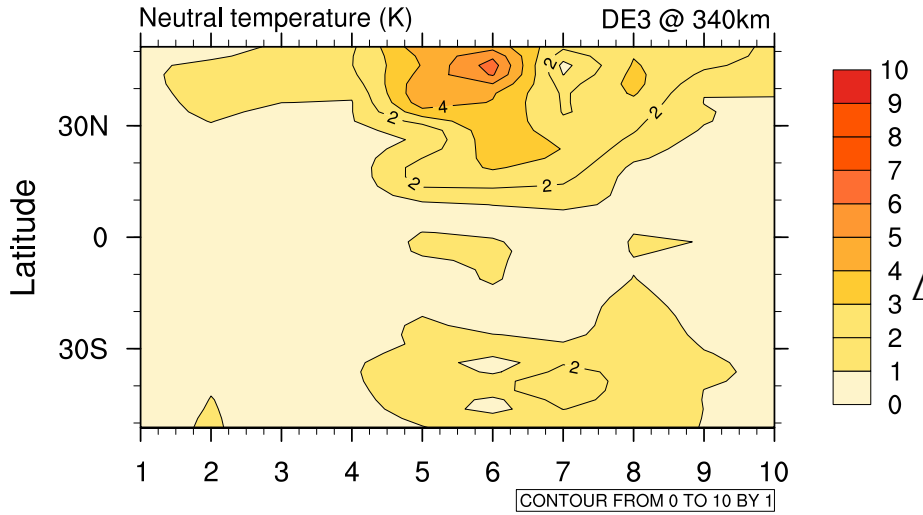
Optimal Simulation - Constant Lower Boundary



Variable Meteorological Forcing:
ΔDE3 ➔ up to 8-9°K at 340km in the tropics

MERRA/AMIE - MERRA/GPI(const)

Optimal Simulation - Constant Upper Boundary

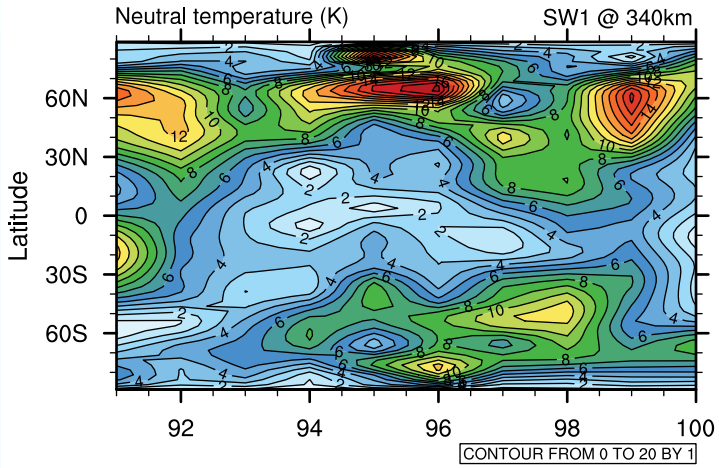


Variable Solar Geomagnetic Forcing:
ΔDE3 ➔ up to 7°K at 340km in the NH

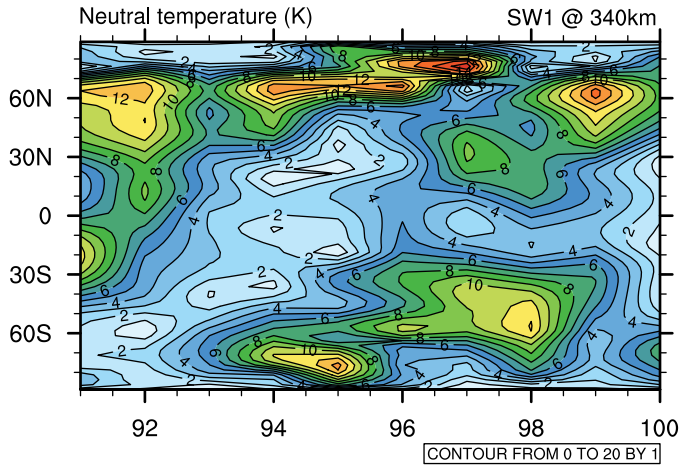
pseudo-tide

TIME-GCM SW1 Temperature Amplitudes

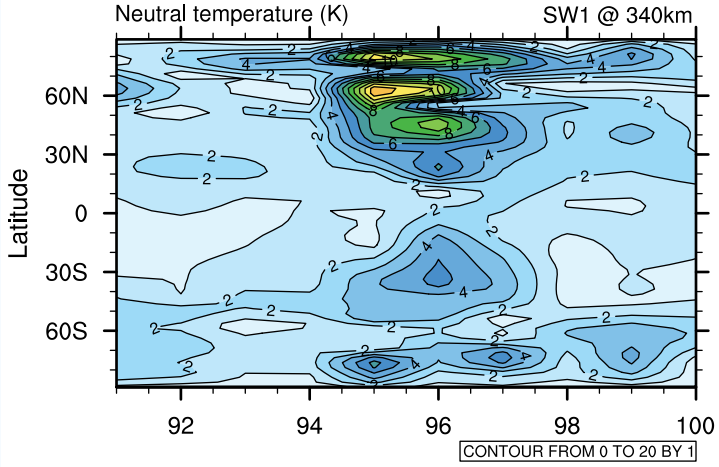
Optimal Simulation



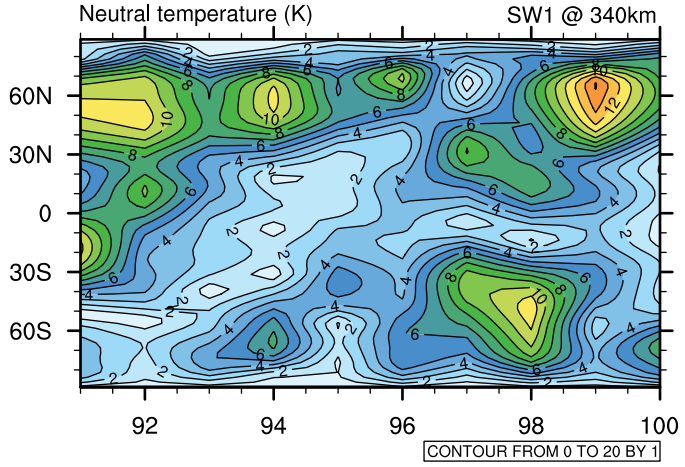
Standard Simulation

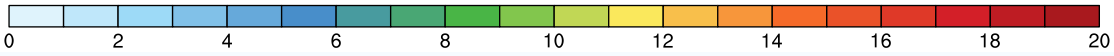


Constant Lower Boundary



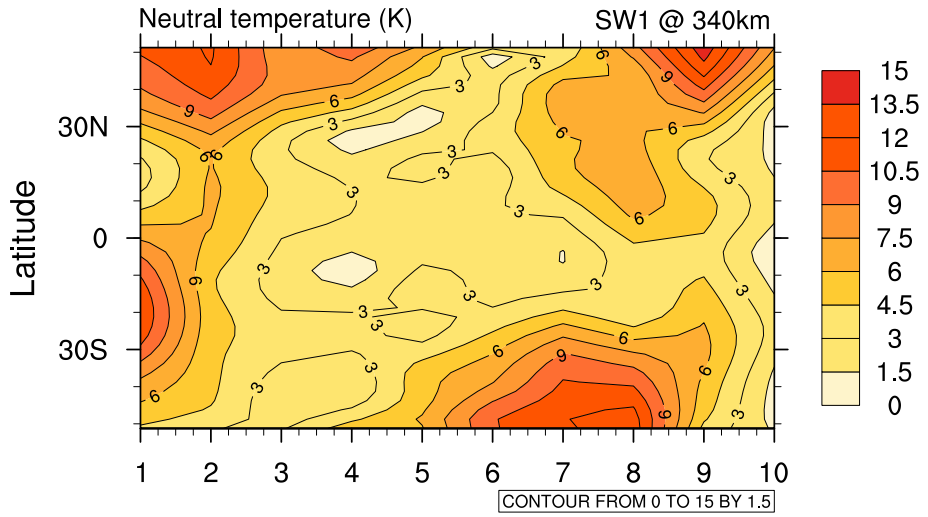
Constant Upper Boundary





TIME-GCM SW1 Temperature Amplitude Differences

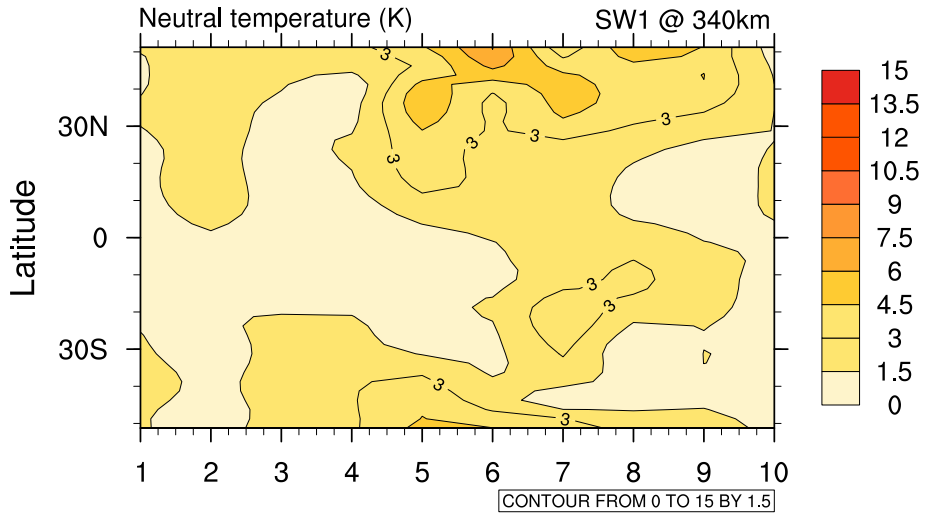
Realistic Simulation - Constant Lower Boundary



Variable Meteorological Forcing:
ΔSW1 ➔ 14°K at 340km

MERRA/AMIE - MERRA/GPI(const)

Realistic Simulation - Constant Upper Boundary

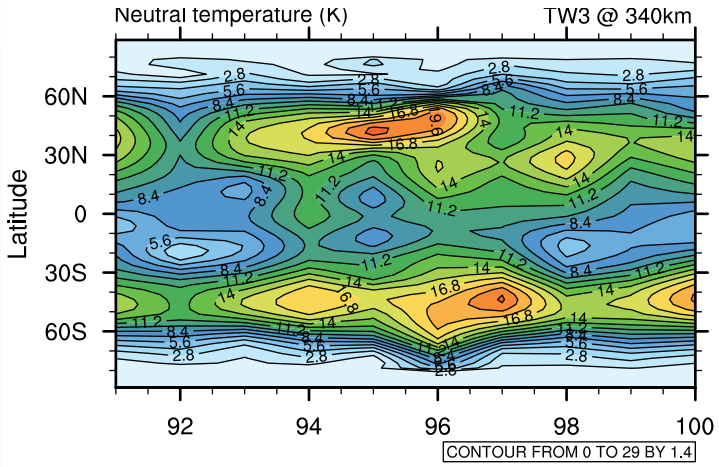


Variable Solar Geomagnetic Forcing:
ΔSW1 ➔ up to 6°K at 340km in the NH

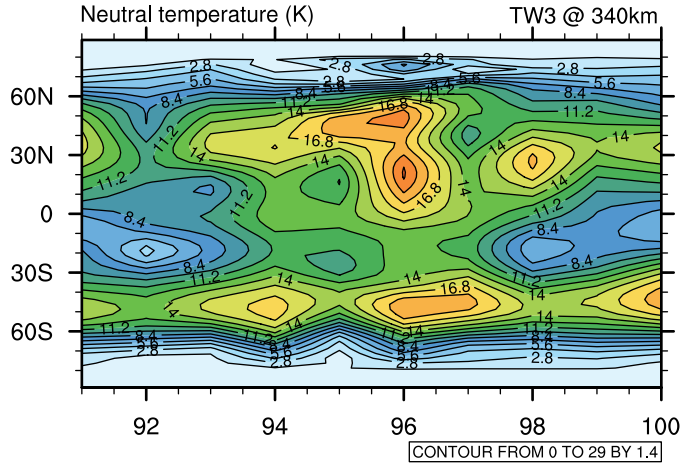
April 2010 (day)

TIME-GCM TW3 Temperature Amplitudes

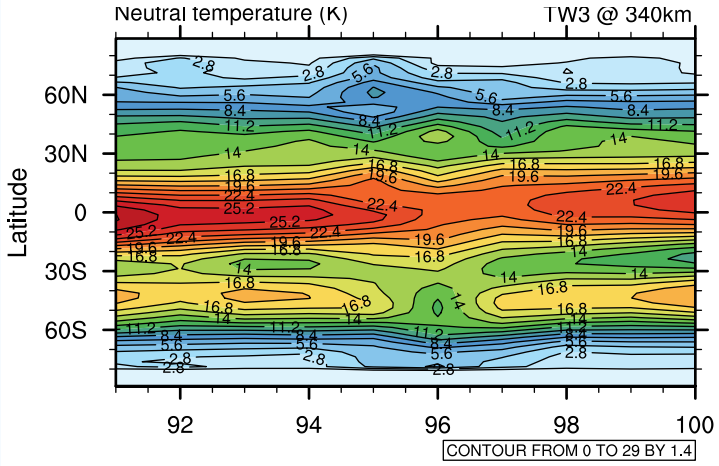
Optimal Simulation



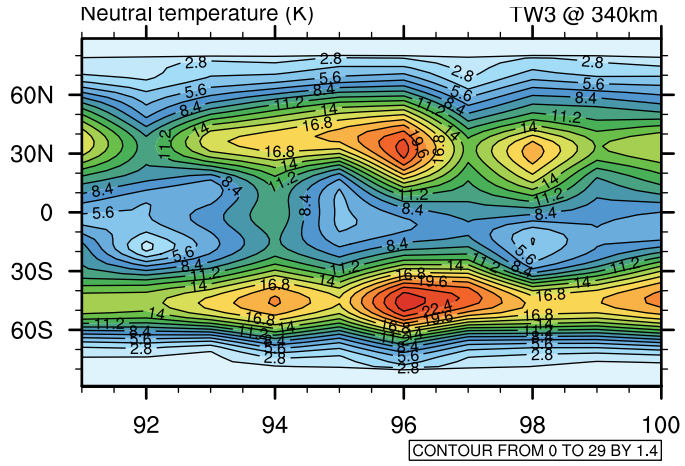
Standard Simulation

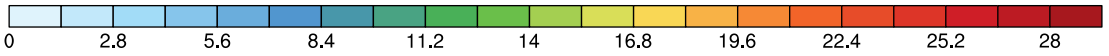


Constant Lower Boundary



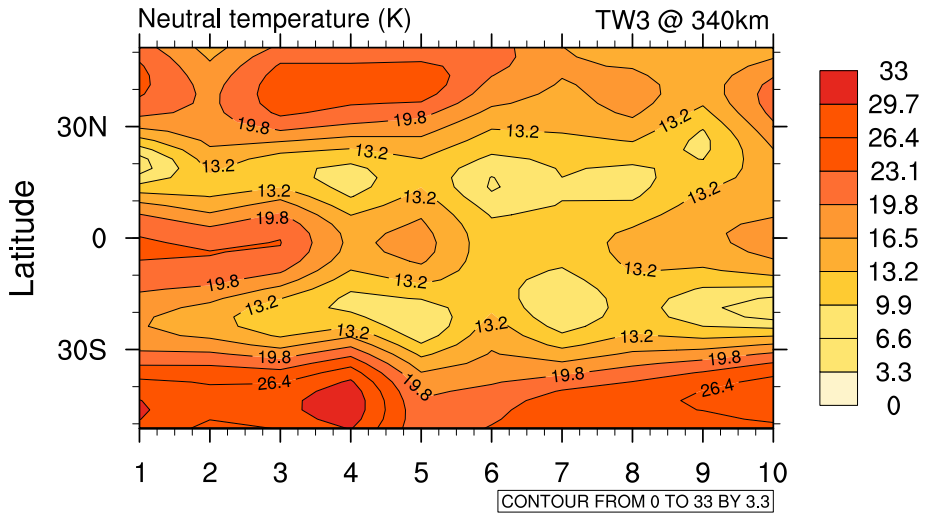
Constant Upper Boundary





TIME-GCM TW3 Temperature Amplitude Differences

Realistic Simulation - Constant Lower Boundary



Variable forcing from below:

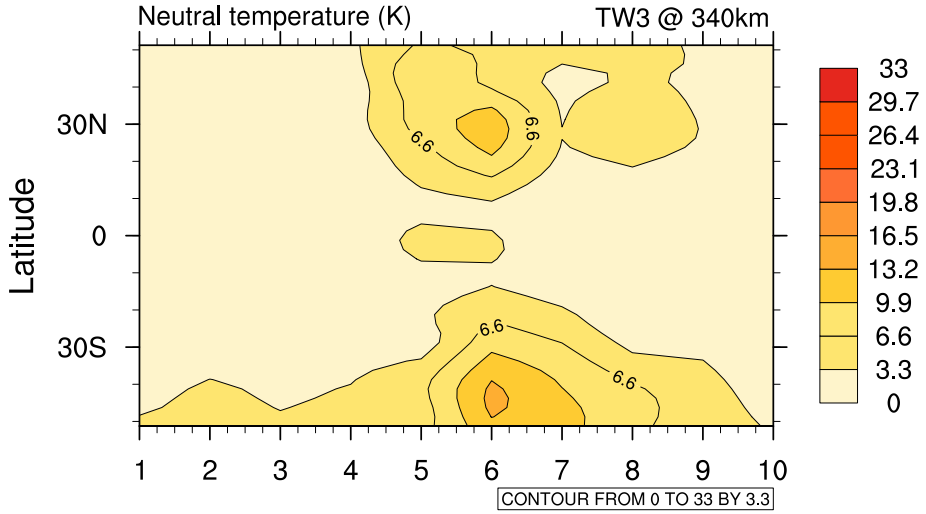
ΔTW3 ➔ up to 30°K at middle latitudes

ΔTW3 ➔ up to 23°K at low latitudes

importance of effects of phase coherence

MERRA/AMIE - MERRA/GPI(const)

Realistic Simulation - Constant Upper Boundary



Variable Solar Geomagnetic Forcing:

ΔTW3 ➔ up to 15°K at 340km in the SH

attributable to in-situ sources

April 2010 (day)

Discussion and Conclusions

TIME-GCM captured the April 5 storm response [*Lu et al.,* 2015]

- GOCE and CHAMP thermospheric winds
- GOCE, CHAMP, and GRACE thermospheric densities
- motivated this study

Longitudinal and temporal response to the solar geomagnetic disturbance

- projects onto TIME-GCM tidal components ➔ pseudo-tides
- adds to the thermospheric tides that originate in the low & middle atmosphere

Nonmigrating pseudo-tides due to the April 5 disturbance

- can be comparable in magnitude to upward propagating counterparts
- largely confined to middle-high latitudes

Strong thermospheric nonmigrating tidal variability during quiescent periods

- attributable to components that propagate upward from below
- underlies the thermospheric response to any solar geomagnetic storm