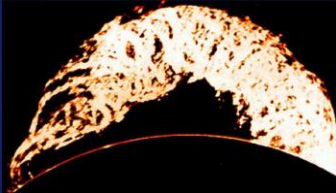
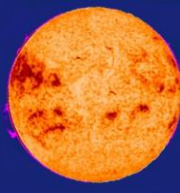
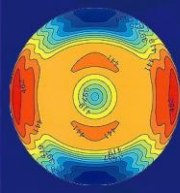


**HAO** ●



# ***Model-Data Comparison of Thermospheric Neutral Density***

Liying Qian, Stanley C. Solomon

High Altitude Observatory, National Center for Atmospheric Research

# **Model-Data Comparison of Neutral Density: Temporal and Spatial Variations**

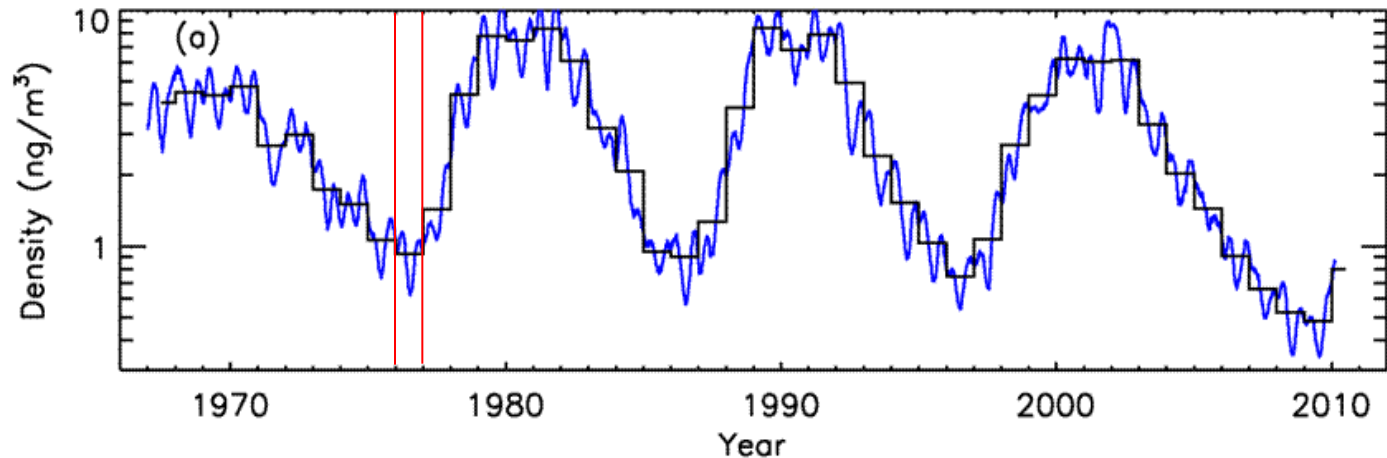
Temporal variation: Abrupt changes, diurnal variation, multi-day variation, solar-rotational variation, annual/semiannual variation, solar-cycle variation, long-term trends

Spatial Variation: Latitudinal and longitudinal variation, variation with altitude.

- Model
  - NCAR TIE-GCM, TIME-GCM, MSIS00
- Data
  - Global-mean density at fixed altitudes (John Emmert, Naval Research Laboratory, *Emmert, 2009*)
  - CHAMP/GRACE (<http://sisko.colorado.edu/sutton/data.html>, *Sutton et al., 2005*)
  - Density at perigees of individual satellites (Bruce Bowman, Air Force Space Command, *Bowman et al., 2004*)

# Annual/Semiannual variation of thermospheric density and composition

Global-mean density at 400 km (*Emmert, 2009*)

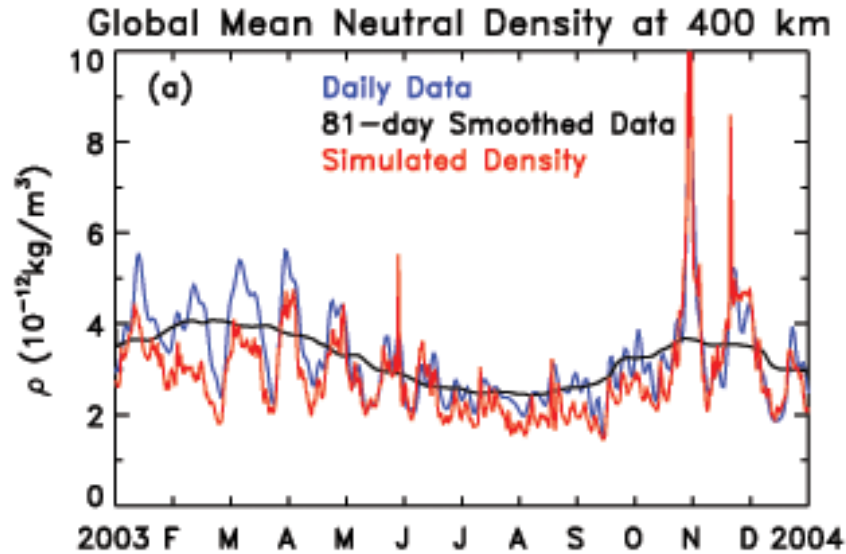


We proposed a lower atmospheric forcing mechanism [*Qian et al., 2009*]:

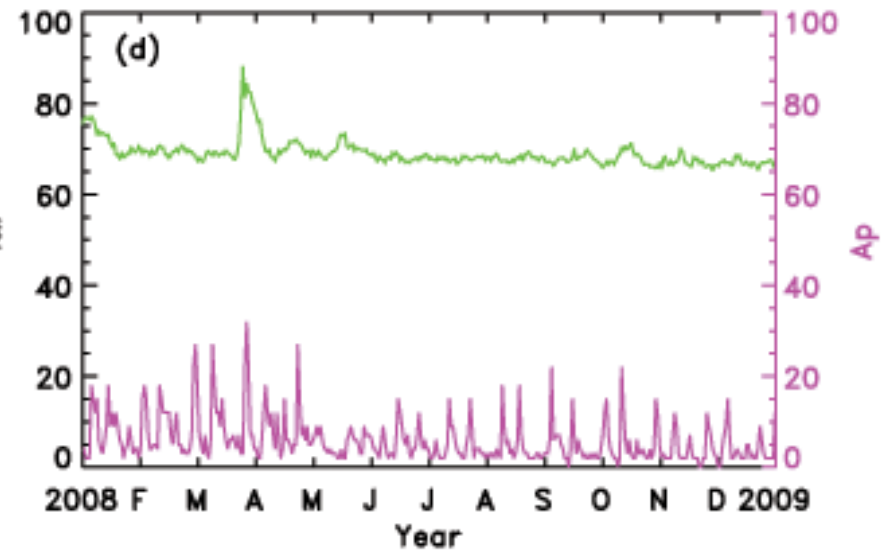
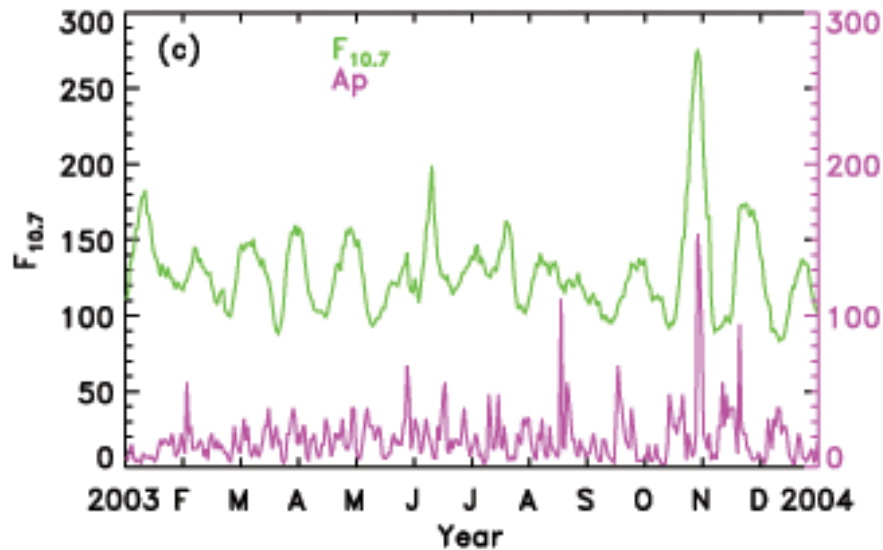
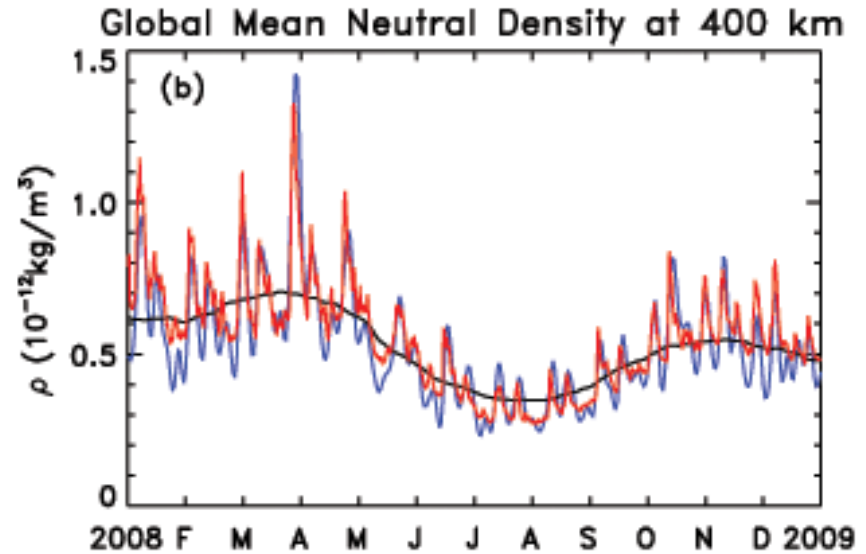
- Gravity wave breaking causes changes in eddy mixing;
- Increased eddy diffusion increases the downward transport of O to the mesopause where it recombines;
- Composition change in the lower thermosphere is propagated throughout the thermosphere by molecular diffusion.

# Density at Solar Maximum and Minimum

2003

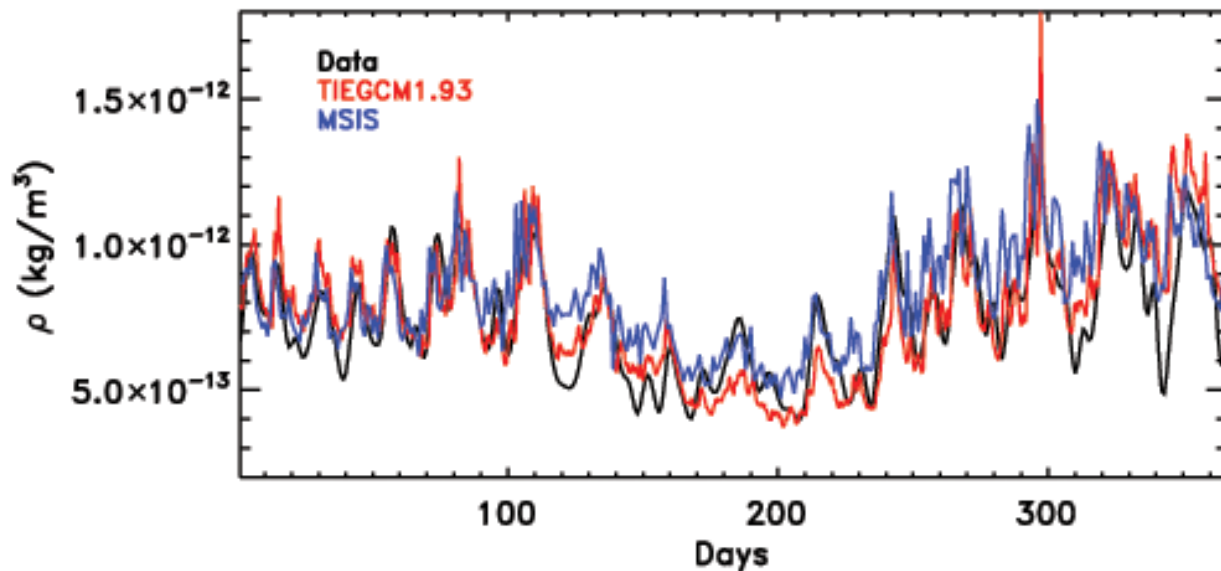


2008

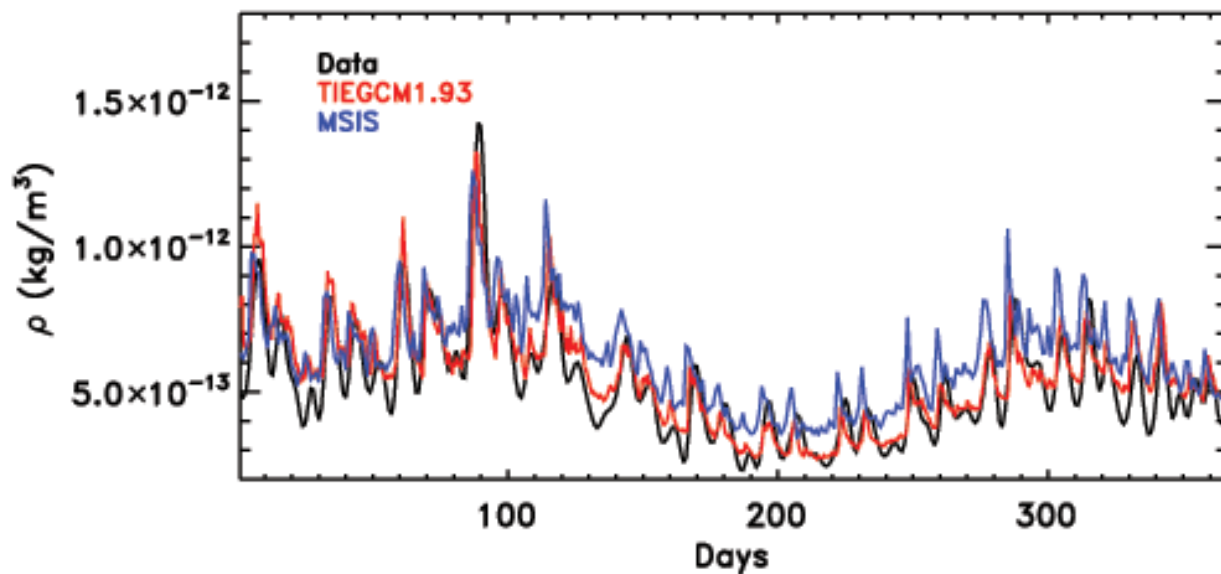


# Density at the two most Recent solar Minima

1996



2008



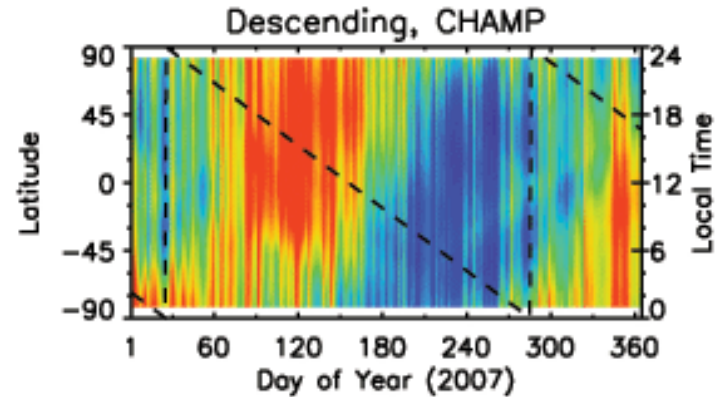
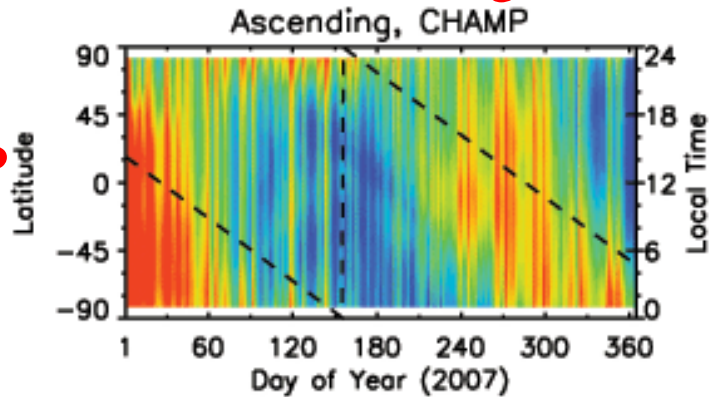
*Solomon et al., 2011,  
JGR*

# Neutral Density, 2007

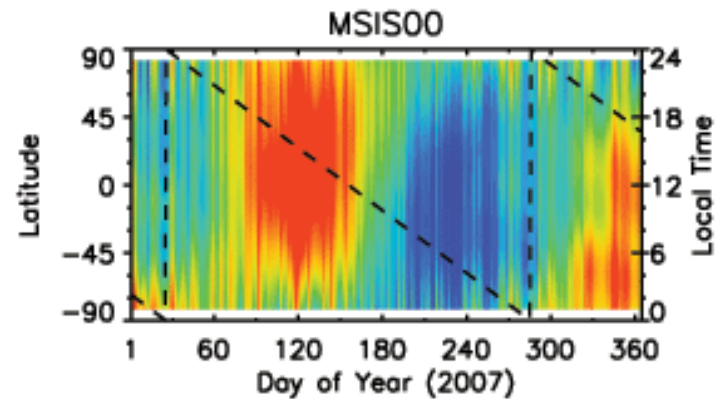
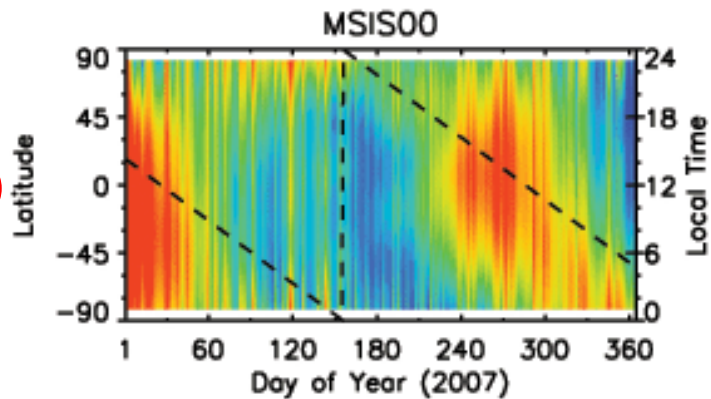
Ascending

Descending

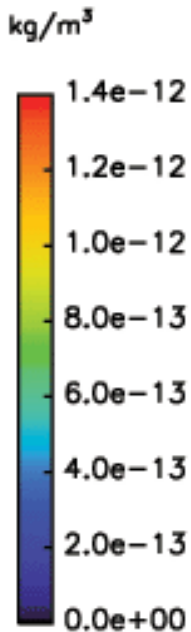
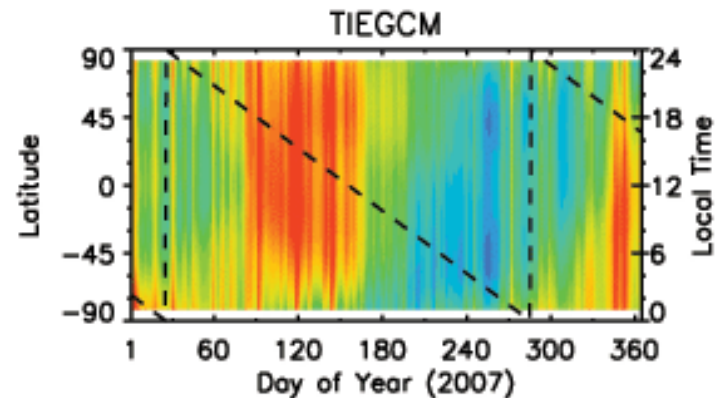
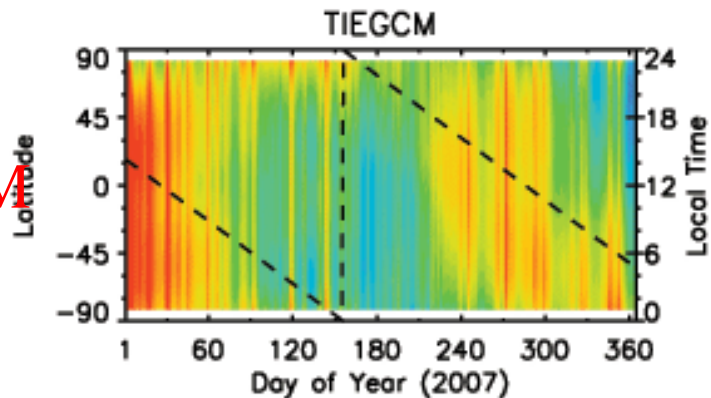
CHAMP



MSIS00

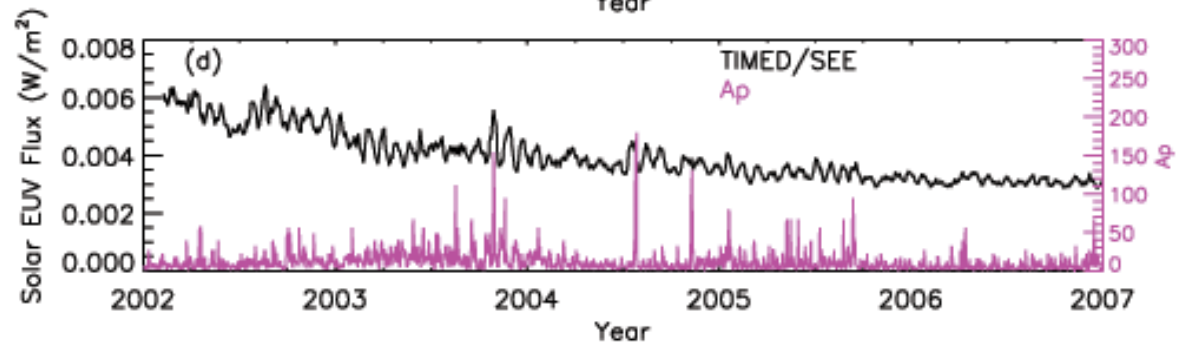
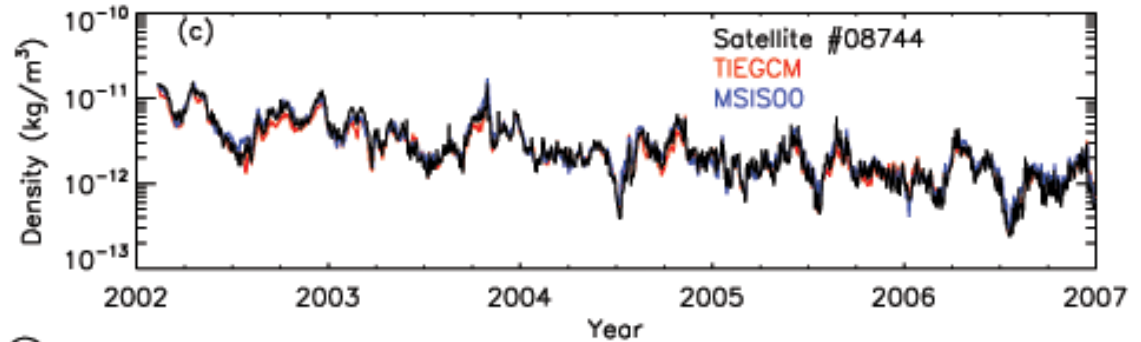
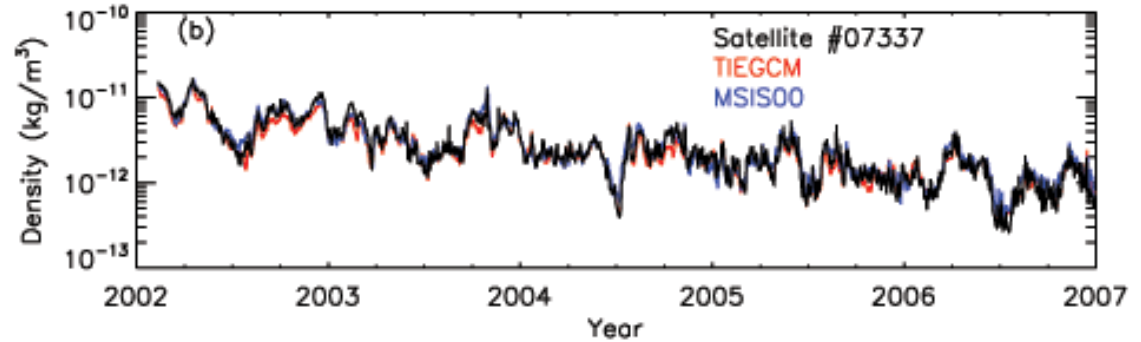
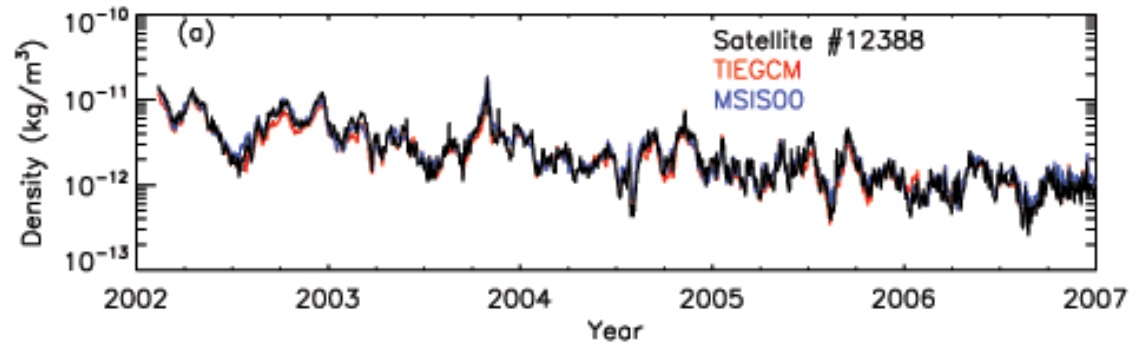


TIE-GCM

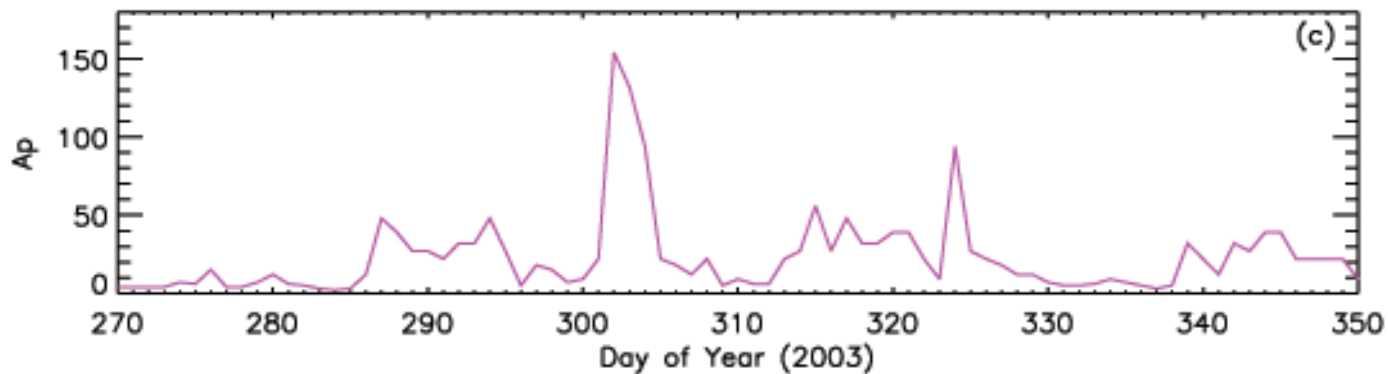
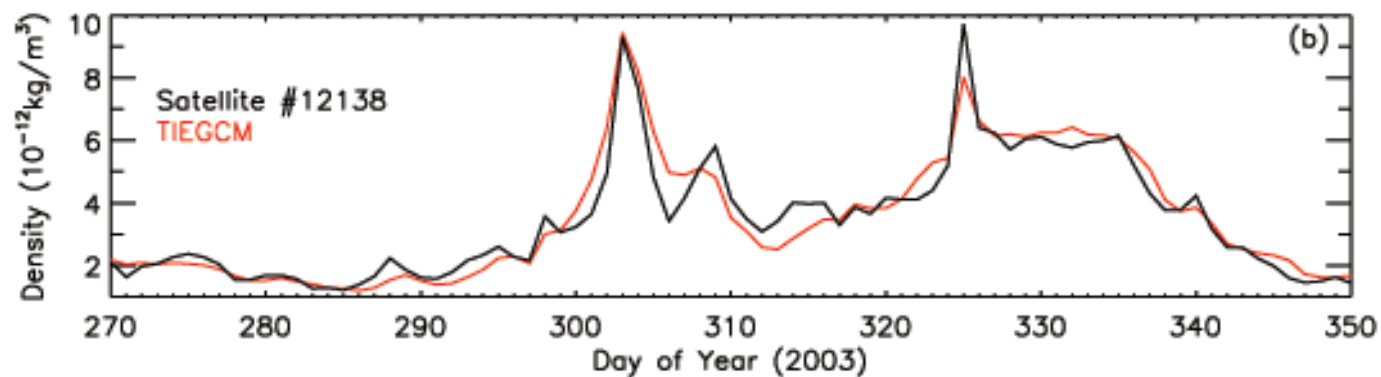
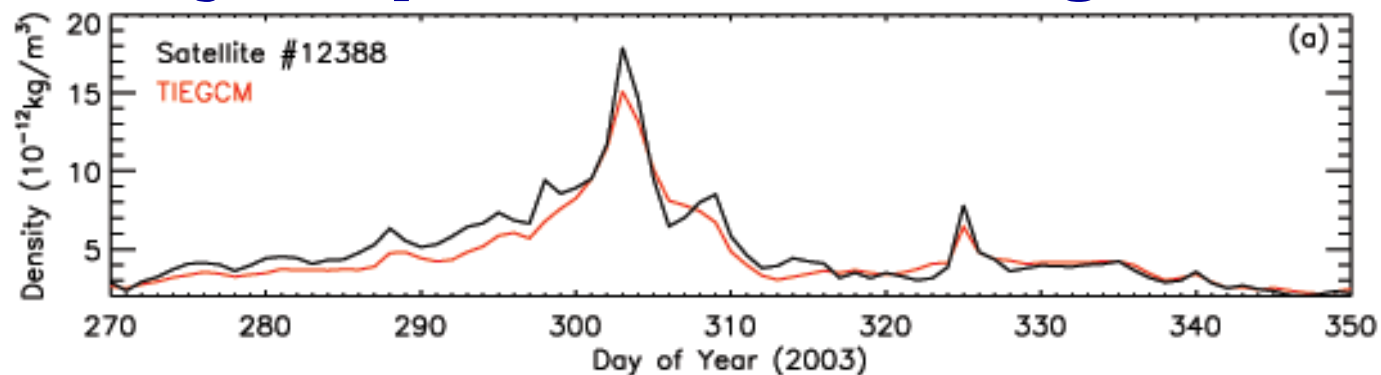


# Solar Cycle Variation

Qian et al., 2009, JGR



# Density response to Geomagnetic Storm



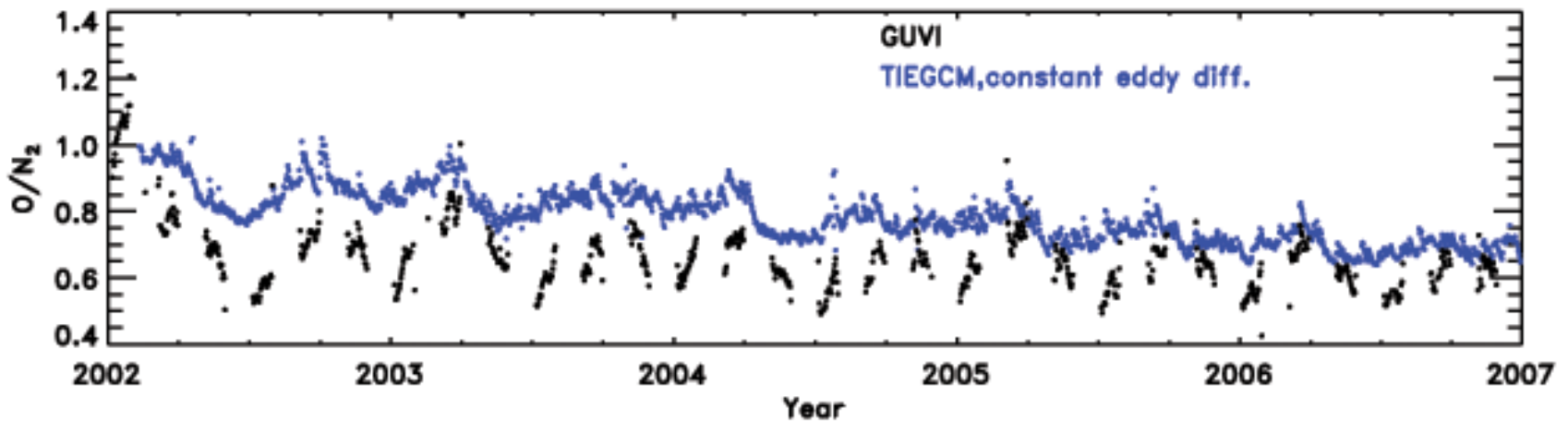
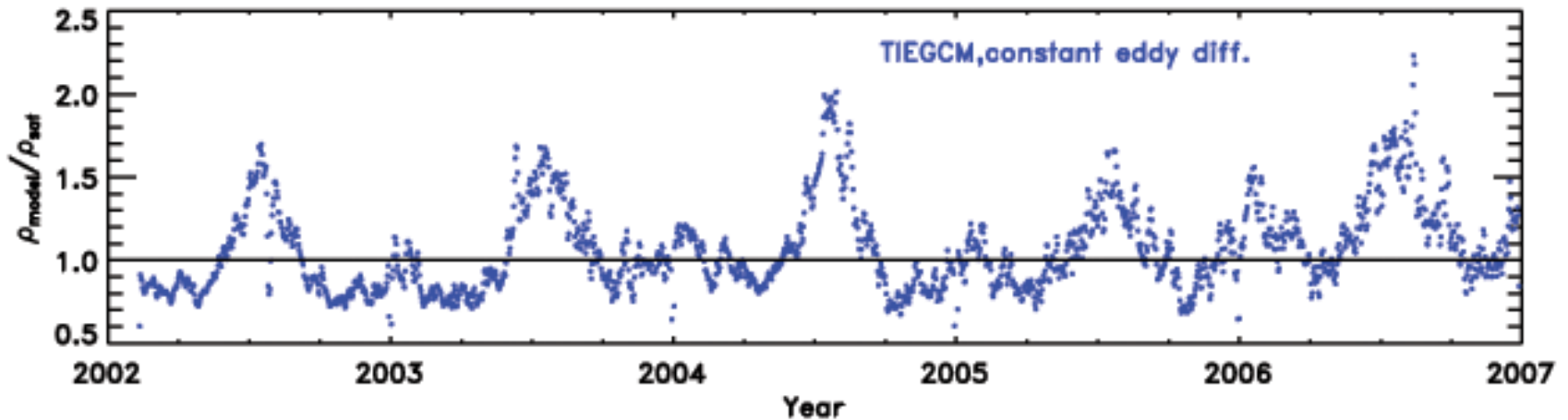


# ***Summary***

- The three density data sets provide us neutral density and its temporal variation on time scales ranging from abrupt changes to decadal long-term changes, as well as its spatial variations;
- Simulated density is in agreement with the data in terms of the solar cycle variation; density at solar minimum and maximum, including the annual/semiannual variation, solar-rotational variation, and shorter-term variation responding to geomagnetic forcing, at these solar activity levels;
- Model-data comparison helps to identify and understand physical mechanisms that drive the observed phenomena.

***Back up Slides***

# ***Annual/Semiannual variation of thermospheric density and composition***



# Seasonal variation of thermospheric density and composition-2

