Day-to-day nonmigrating tide variability simulated by WACCM-X

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Overview

- Motivation
- Numerical Models
- Results
  - Short term DE3 variability in the MLT
  - Variability in the low-latitude ionosphere
- Summary and Conclusions

Outline

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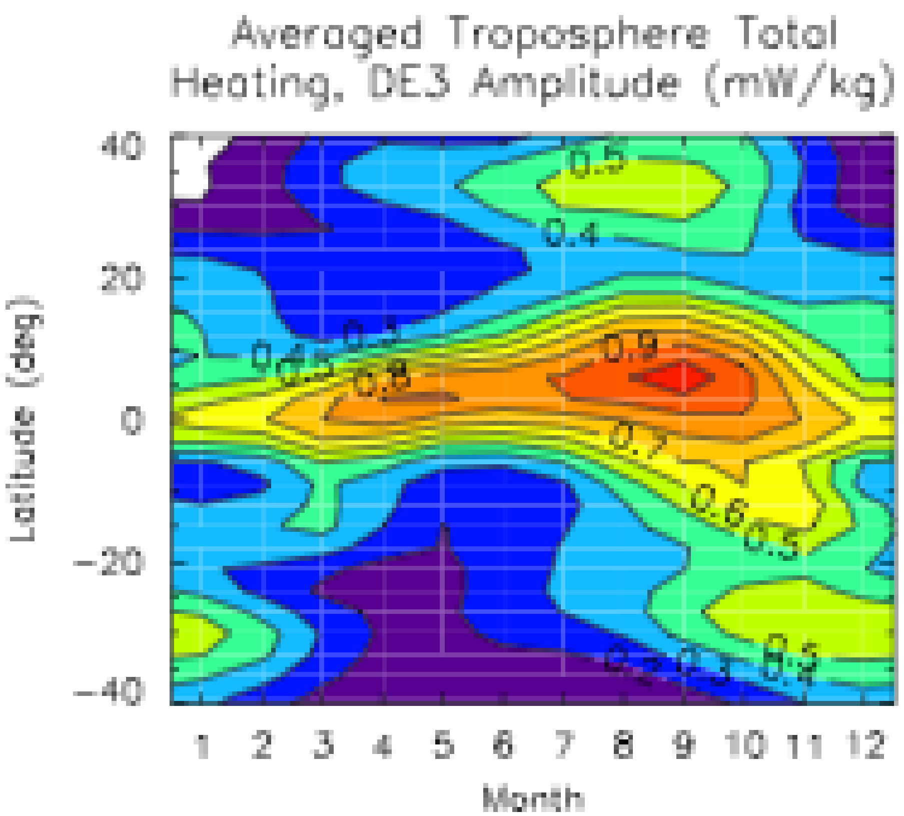
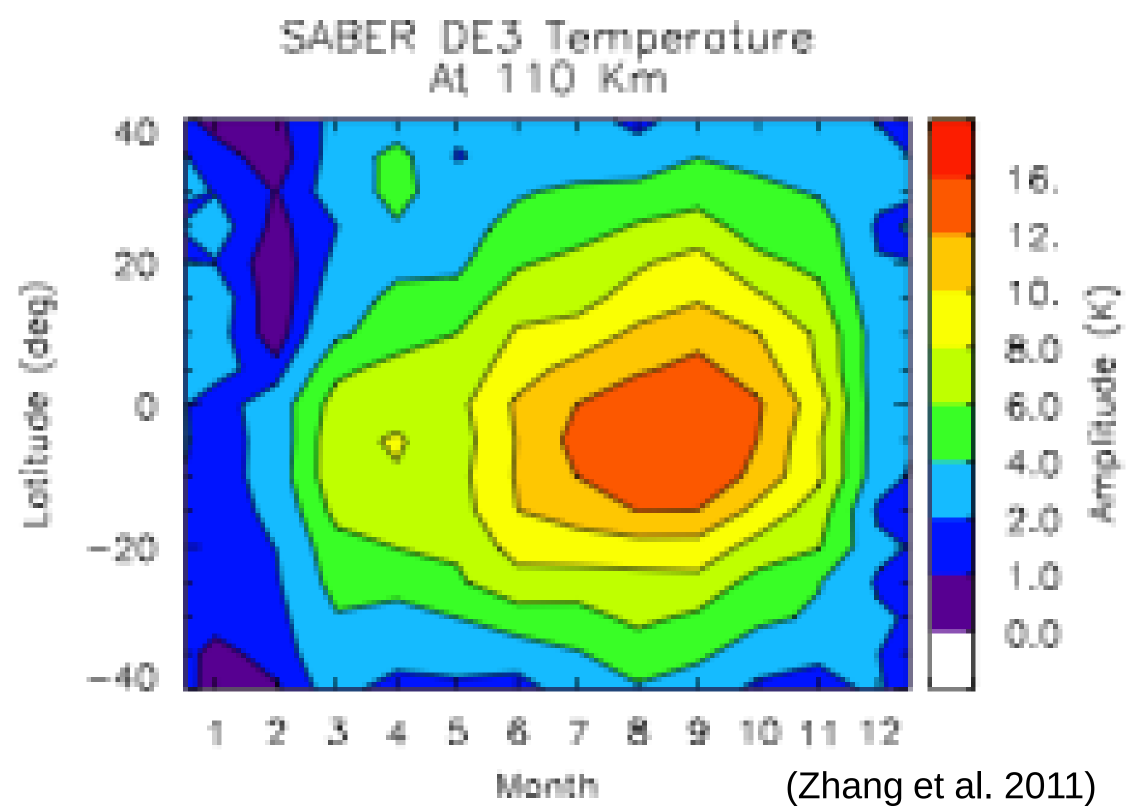
Motivation

- In the mesosphere and lower thermosphere, nonmigrating tides achieve large amplitudes and impact the overall dynamics of the MLT
- Nonmigrating tides are generated by longitudinally invariant sources (i.e. latent heat or ozone) and nonlinear interactions
- The present talk focuses on the diurnal eastward propagating nonmigrating tide with zonal wavenumber-3 (DE3)
  - Generated by tropospheric heating
  - Has significant influence on longitude variability in the ionosphere

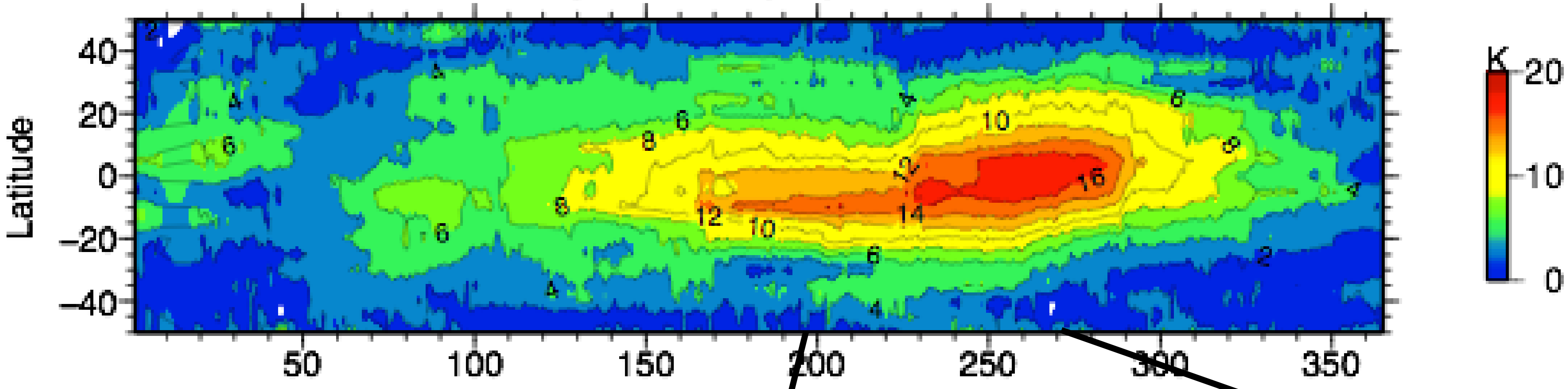




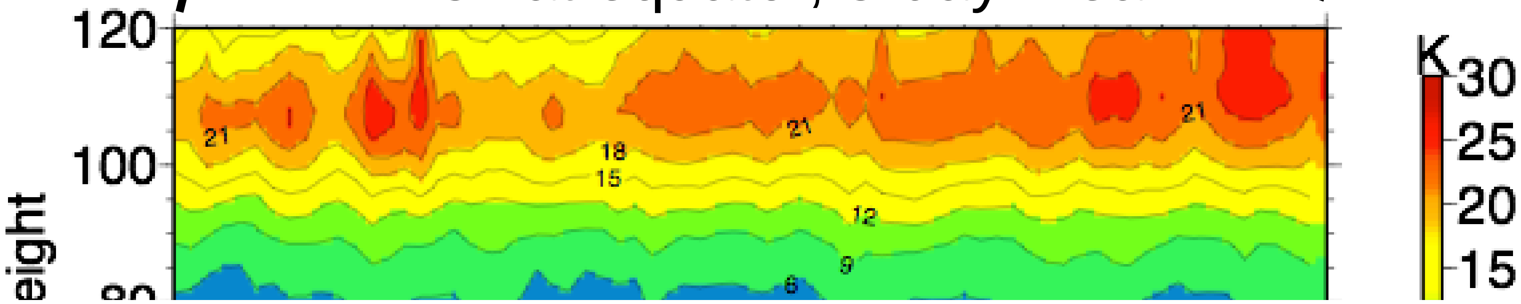
(Zhang et al. 2011)

Studies have primarily focused on seasonal time scales of DE3 variability. Observations indicate that significant short term variations also occur

SABER DE3 at 112km, 60-day mean



“DE3” at equator, 3-day mean



Approximate DE3 by differencing ascending and descending SABER observations and decomposing into wav

10
5
0

Our objective is to illustrate the short-term variability present in the WACCM-X DE3, and develop an understanding of the source of this variability. The consequences of this variability on the ionosphere is also demonstrated.

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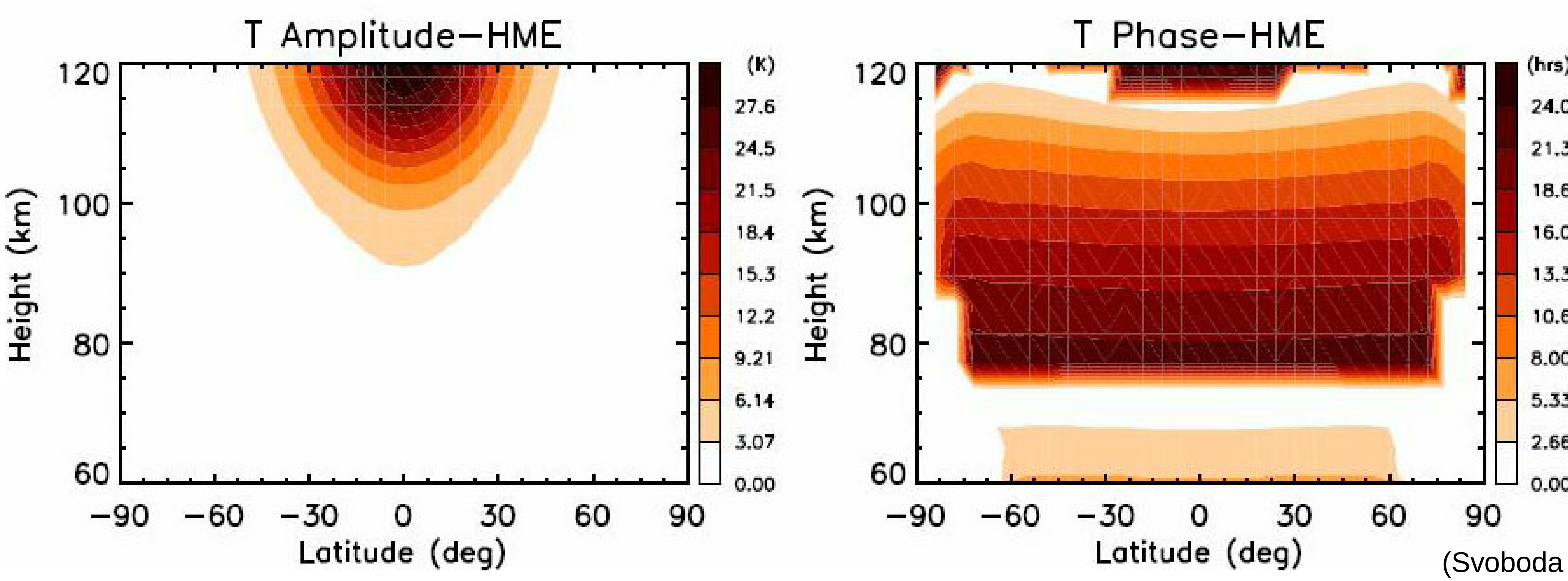
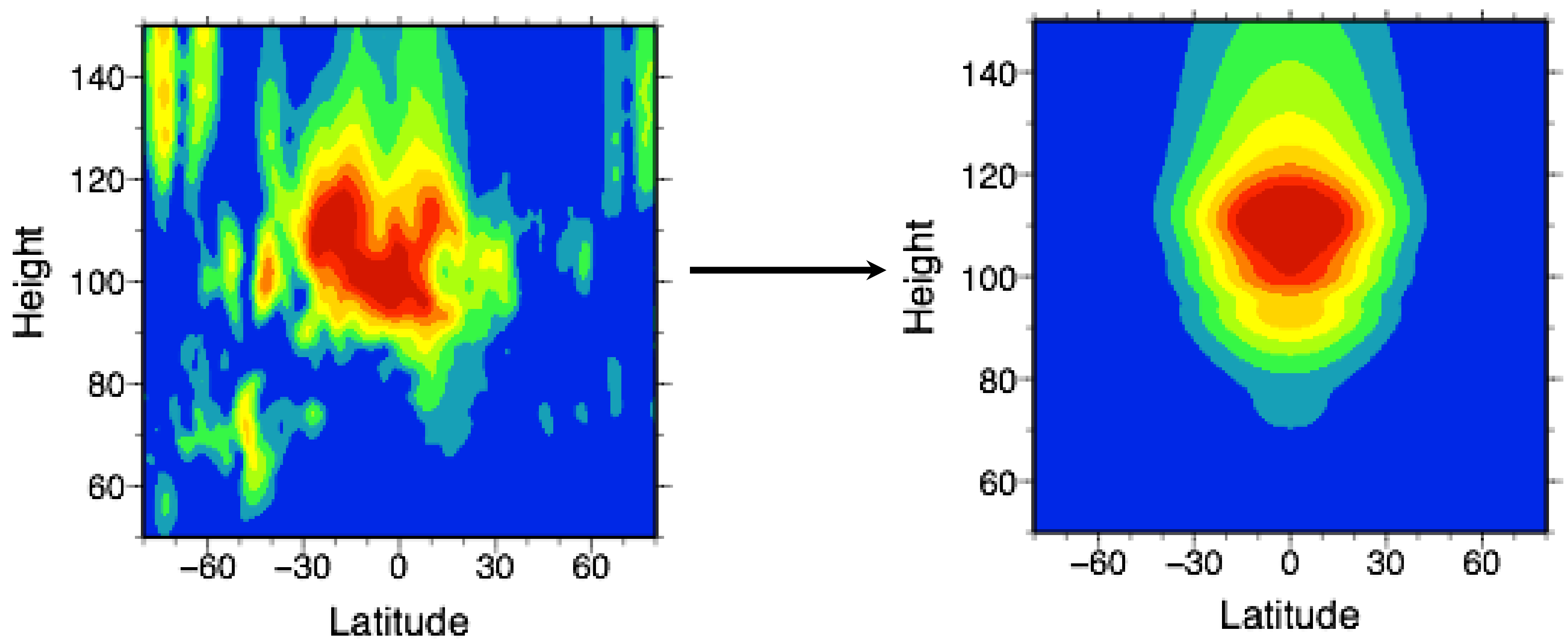
Numerical Models

- DE3 variability is investigated based on three months (Aug.-Oct.) of WACCM-X simulations for solar minimum conditions (F10.7=70)
- The linear Global Scale Wave Model (GSWM) is used to understand the role of source variability by forcing the GSWM with WACCM-X precipitation rates
- Impact on driving day-to-day ionospheric variability is assessed by using the WACCM-X thermosphere to drive the Global Ionosphere Plasmasphere (GIP) model coupled to the electrodynamics portion of the NCAR TIE-GCM

Because of latitudinal variability, throughout the following the results are presented for the DE3 fit to the first symmetric component of the DE3 using the method of Hough Mode Extensions



(Svoboda et al., 2005)



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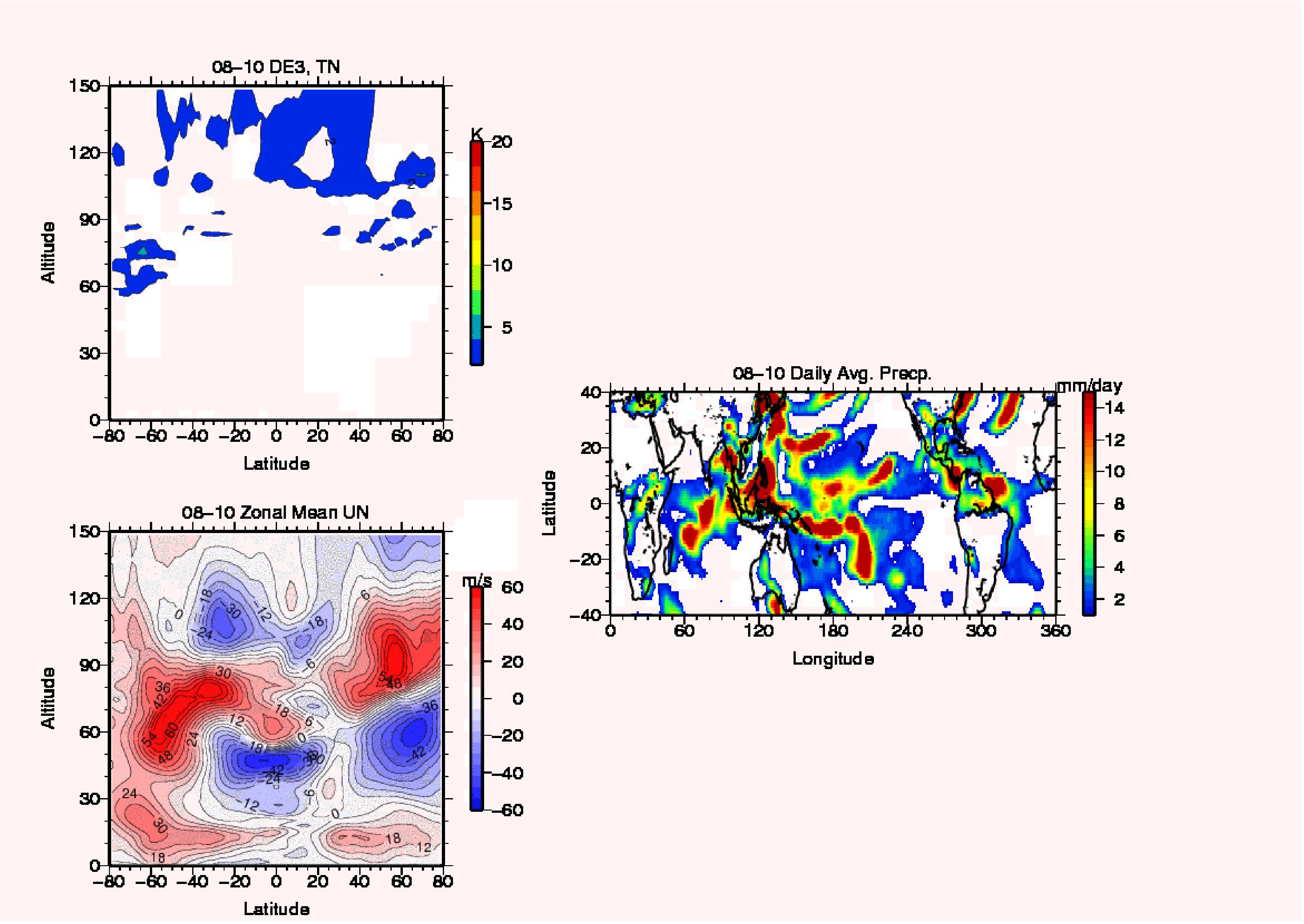
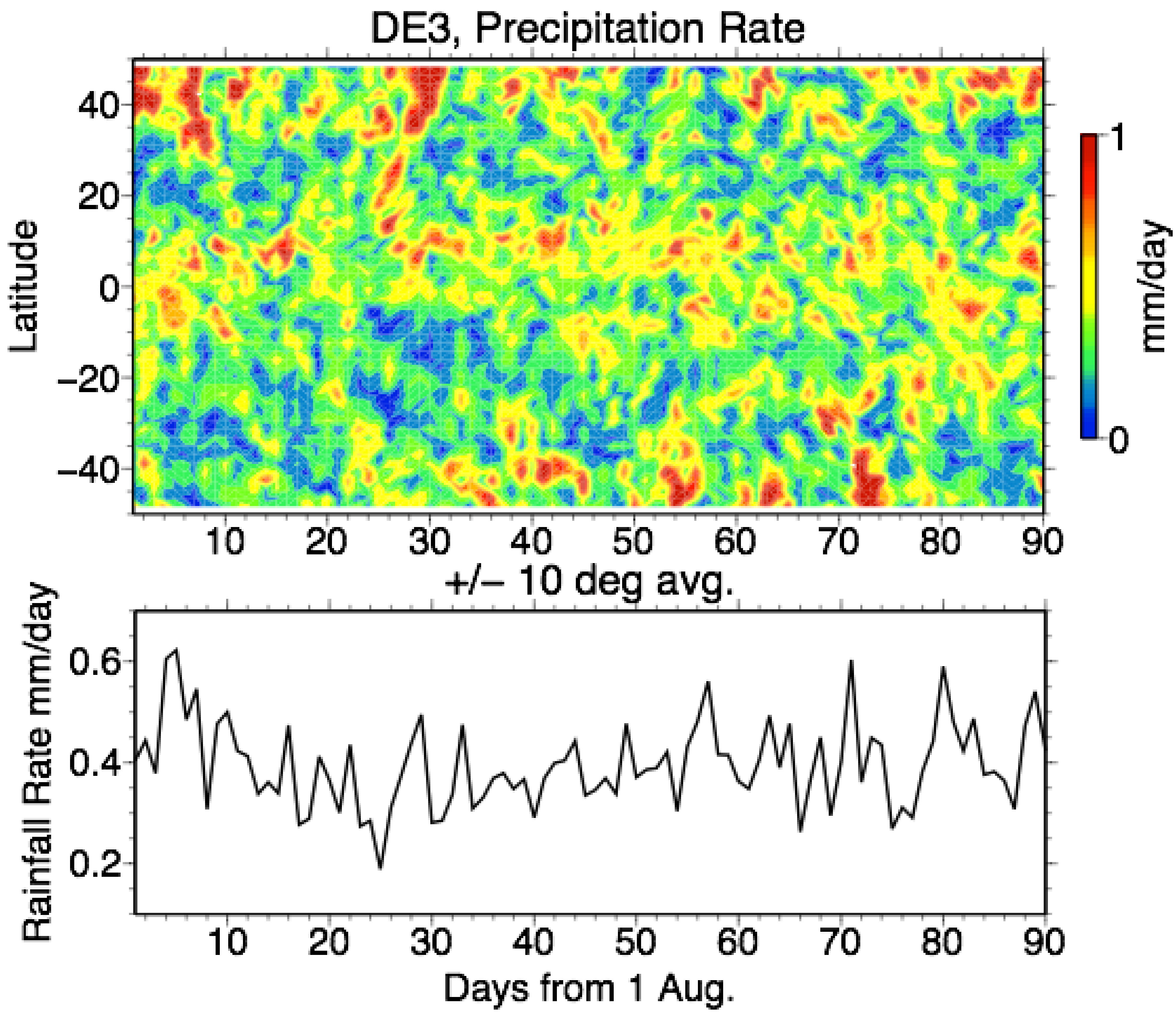
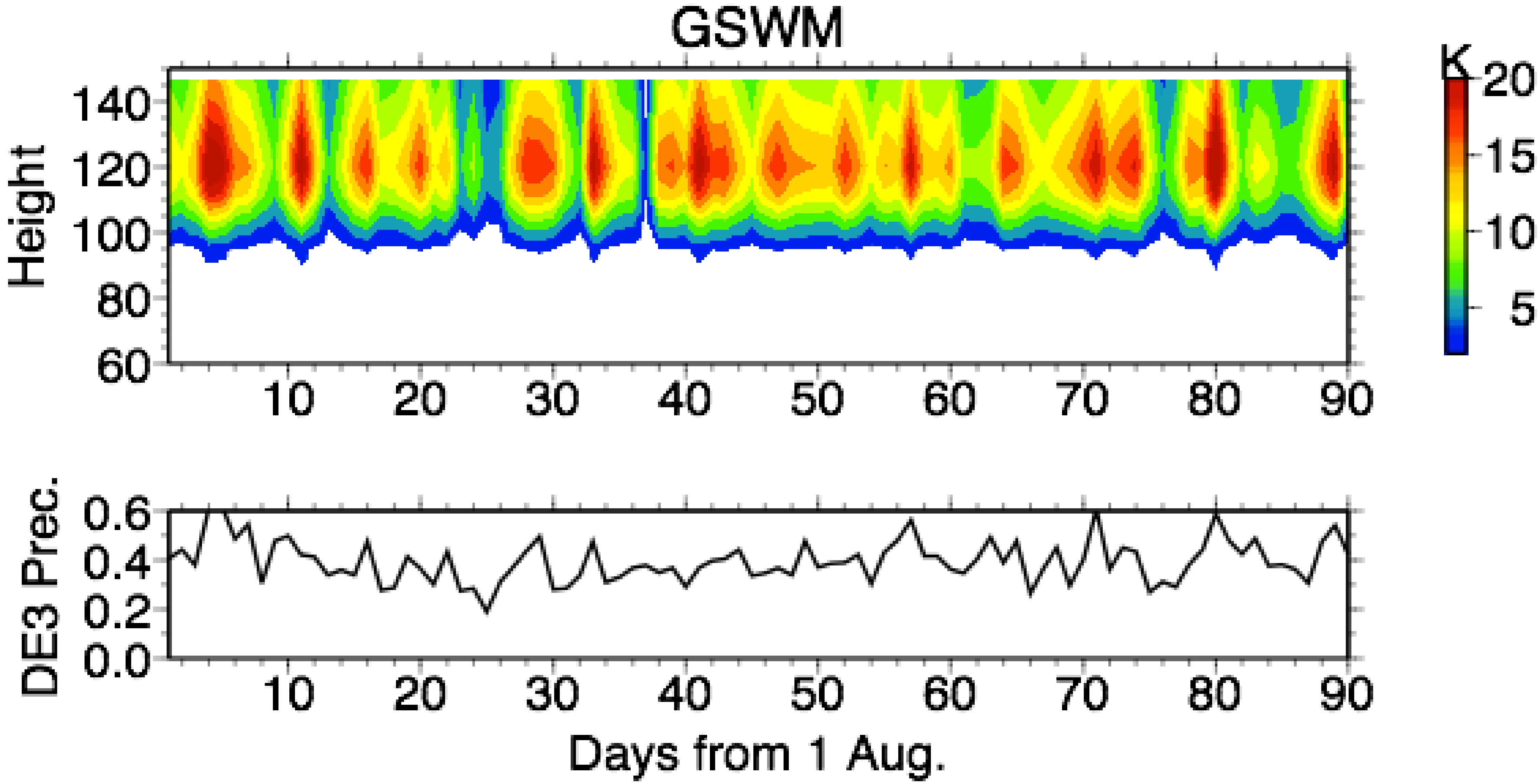
Daily Variability



The tropospheric source of the DE3 in WACCMX is highly variable in both space and time

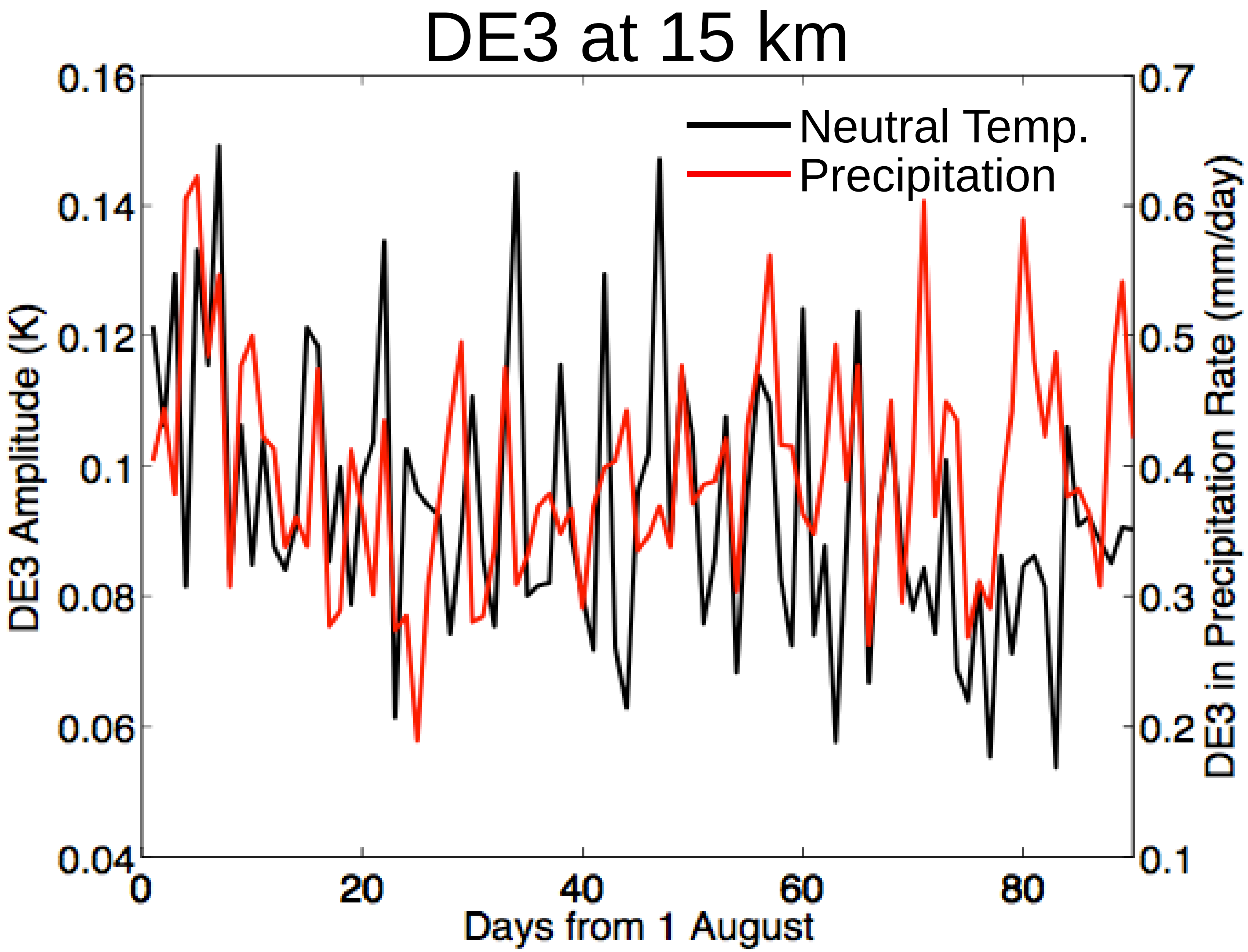


The GSWM simulations considering only source variability demonstrate the significant role that the day-to-day tropospheric variability can have on the MLT



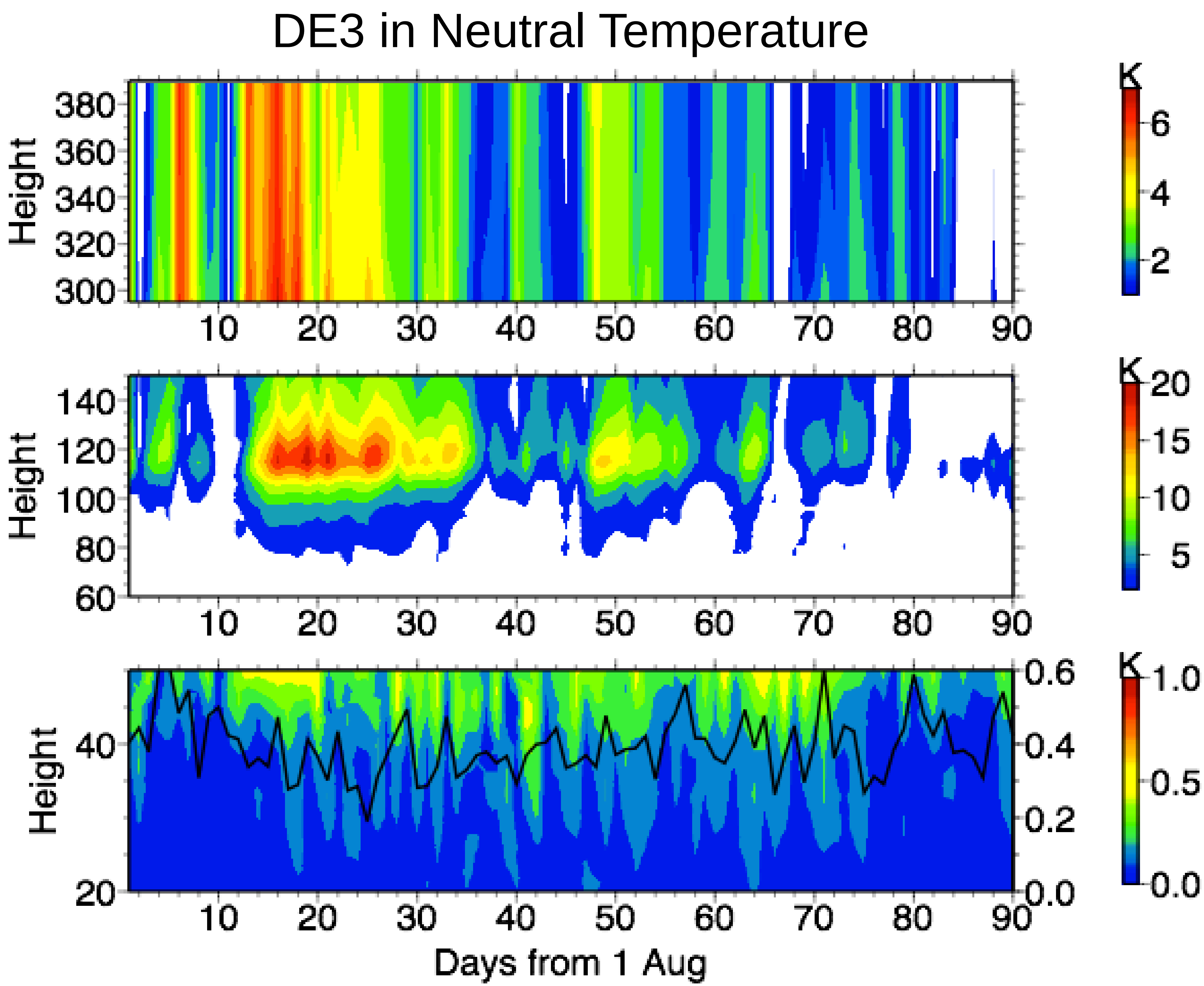
Considerable difference compared to WACCMX results illustrates the role of other processes such as mean winds and nonlinear interactions on the actual variability of tides in the MLT

The variability of the DE3 source in the troposphere generates significant short-term variability in the DE3 at lower altitudes



The latitude and height distribution of the tropospheric heating may be responsible for the lack of direct connection between the DE3 in precipitation and neutral temperature

Correspondence between source variability and variability in the MLT is worse due to the influence of mean winds on tidal propagation and nonlinear interactions



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Ionosphere Variability

Table 1
Possible causes of ionospheric F-layer variability

1. *Solar ionizing radiation*

Solar flares
Solar rotation (27 day) variations
Formation and decay of active regions
Seasonal variation of Sun's declination
Annual variation of Sun–Earth distance
Solar cycle variations (11 and 22 years)
Longer period solar epochs

2. *Solar wind, geomagnetic activity*

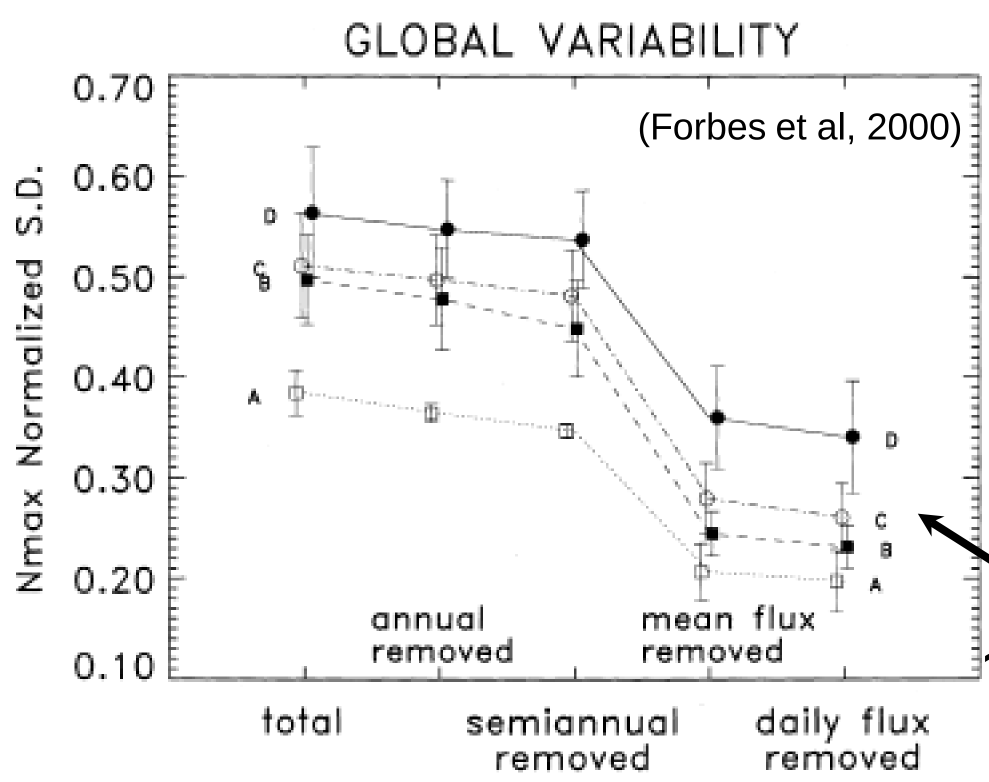
3. *Neutral atmosphere*

Solar and lunar tides: generated within thermosphere or coupled through mesosphere
Acoustic and gravity waves
Planetary waves and 2-day oscillations
Quasi-biennial oscillation
Lower atmosphere weather coupled through mesopause
Surface phenomena: earthquakes, volcanoes

4. *Electrodynamics*

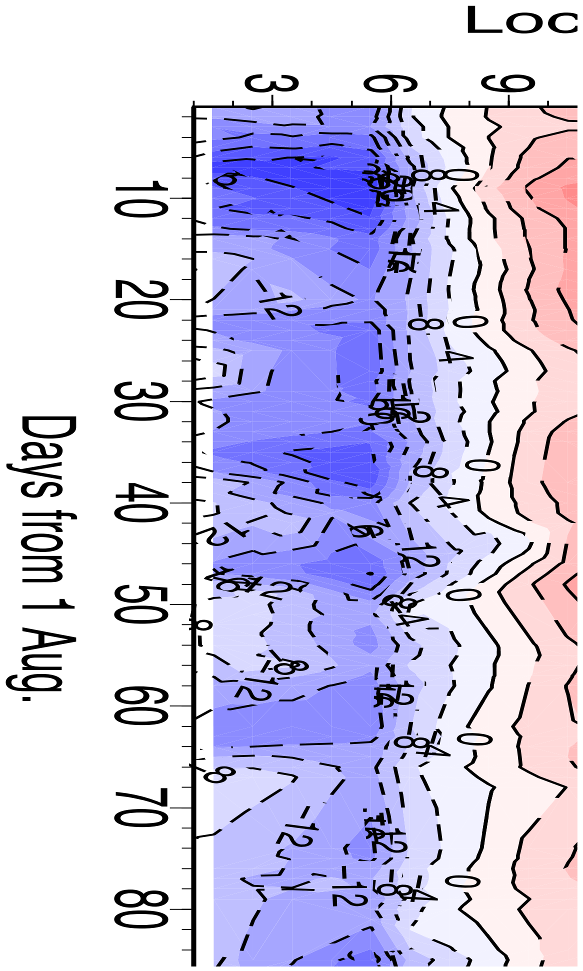
Dynamo 'fountain effect' at low latitudes
Penetration of magnetospheric electric fields
Plasma convection at high latitudes
Field-aligned plasma flows to and from plasmasphere and protonosphere
Electric fields from lightening and sprites

(Rishbeth and Mendillo. 2001)

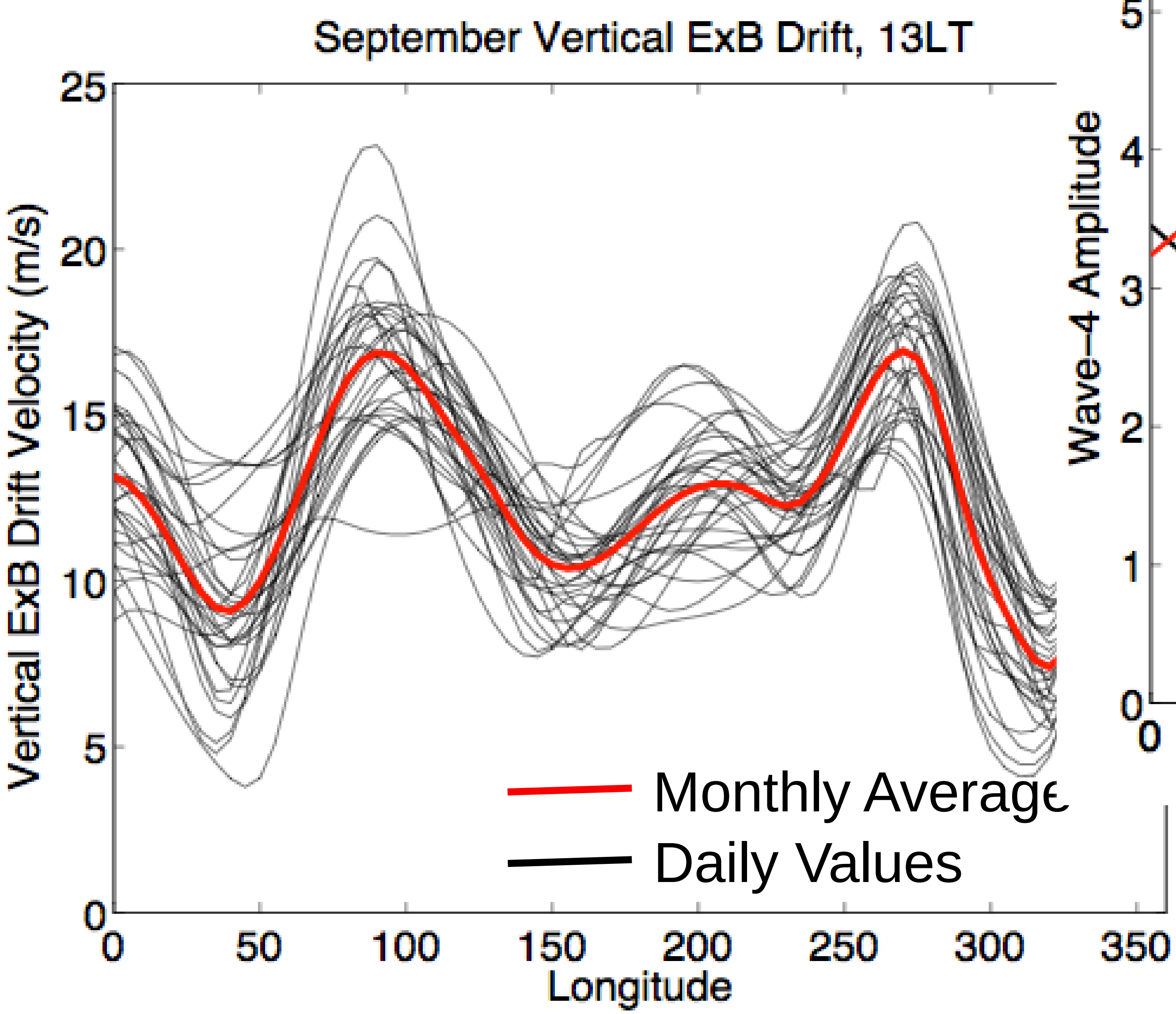


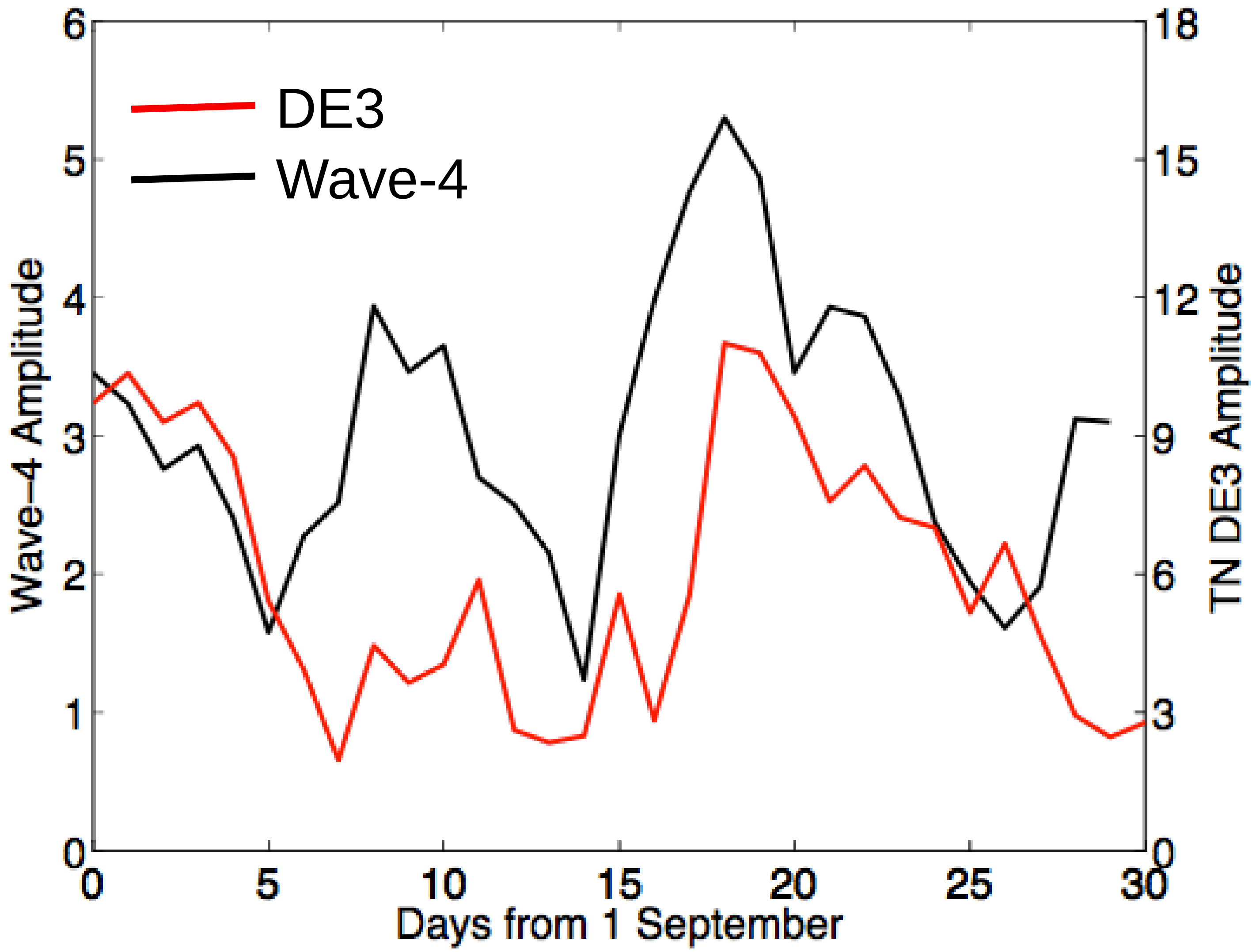
~25-35% "meteorological variability"

WACCM-X/GIP Simulated Variability



The DE3 contributes to the production of a wave-4 longitude structure in the ionosphere. Given the DE3 variability, we expect similar variability in the ionosphere longitude structure





Other waves, such as the SPW4, also contribute to the ionosphere wave-4 longitude structure. One-to-one correspondence between DE3 and wave-4 is therefore not expected.

Summary and Conclusions

- The WACCM-X reveals significant short term variability in the DE3
- A significant portion of the tidal variability in the MLT may be attributed to short term variations in the tropospheric source
- The impact of mean winds on tidal propagation and nonlinear interactions are important for the DE3 variability in the MLT
- Day-to-day thermosphere variability also significantly impacts the ionosphere
- The wave-4 feature in the ionosphere is highly variable and controlled, at least in part, by the DE3 variability
- In the future, we will explore the use of data assimilation to better understand the short term variability that occurs in the MLT