Ionosphere Simulated by WACCM-X

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WACCM-X is a whole atmosphere model that extends into the thermosphere and ionosphere.

COSMIC Ne Profile Fitting

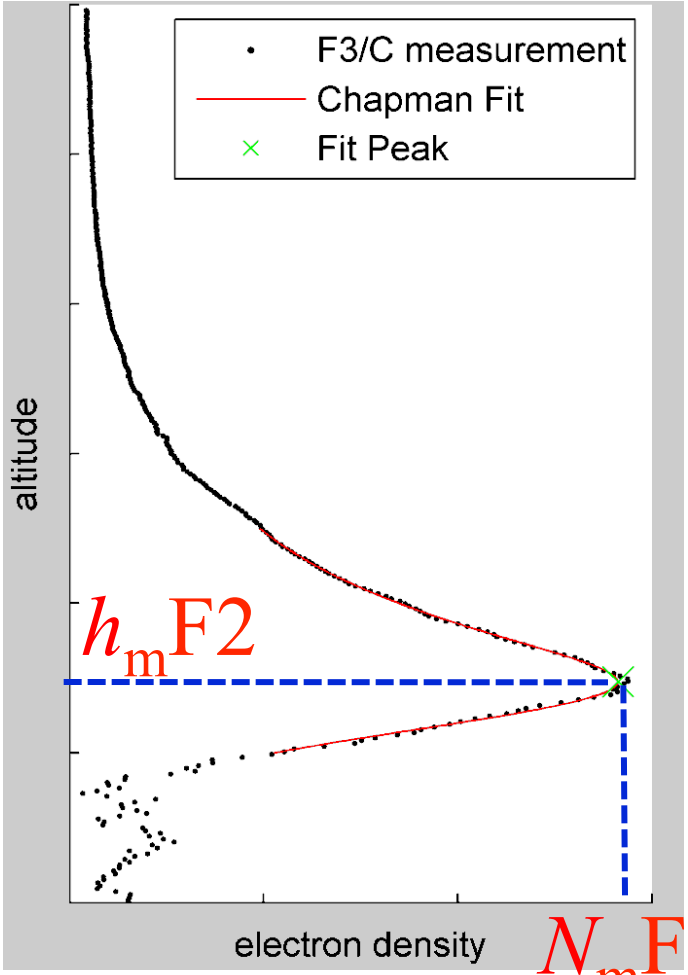
Chapman profile

$$N_e(h) = N_m\mathrm{F}_2 \exp\left\{0.5\left[1 - z - \exp(-z)\right]\right\}$$

$$z = (h - h_m\mathrm{F}_2)\,/\,H(h)$$

Peak parameters:

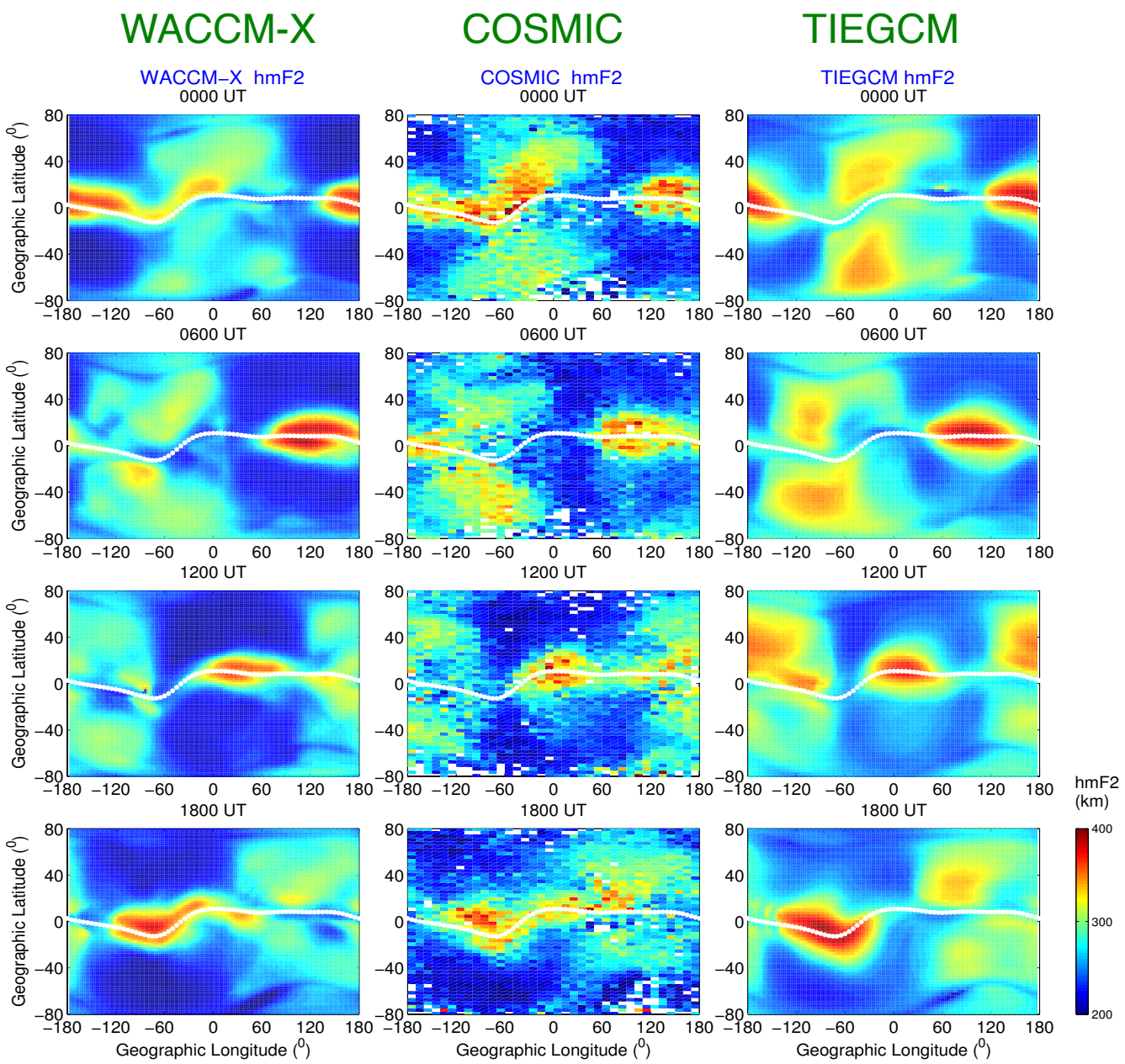
N_mF2 and h_mF2



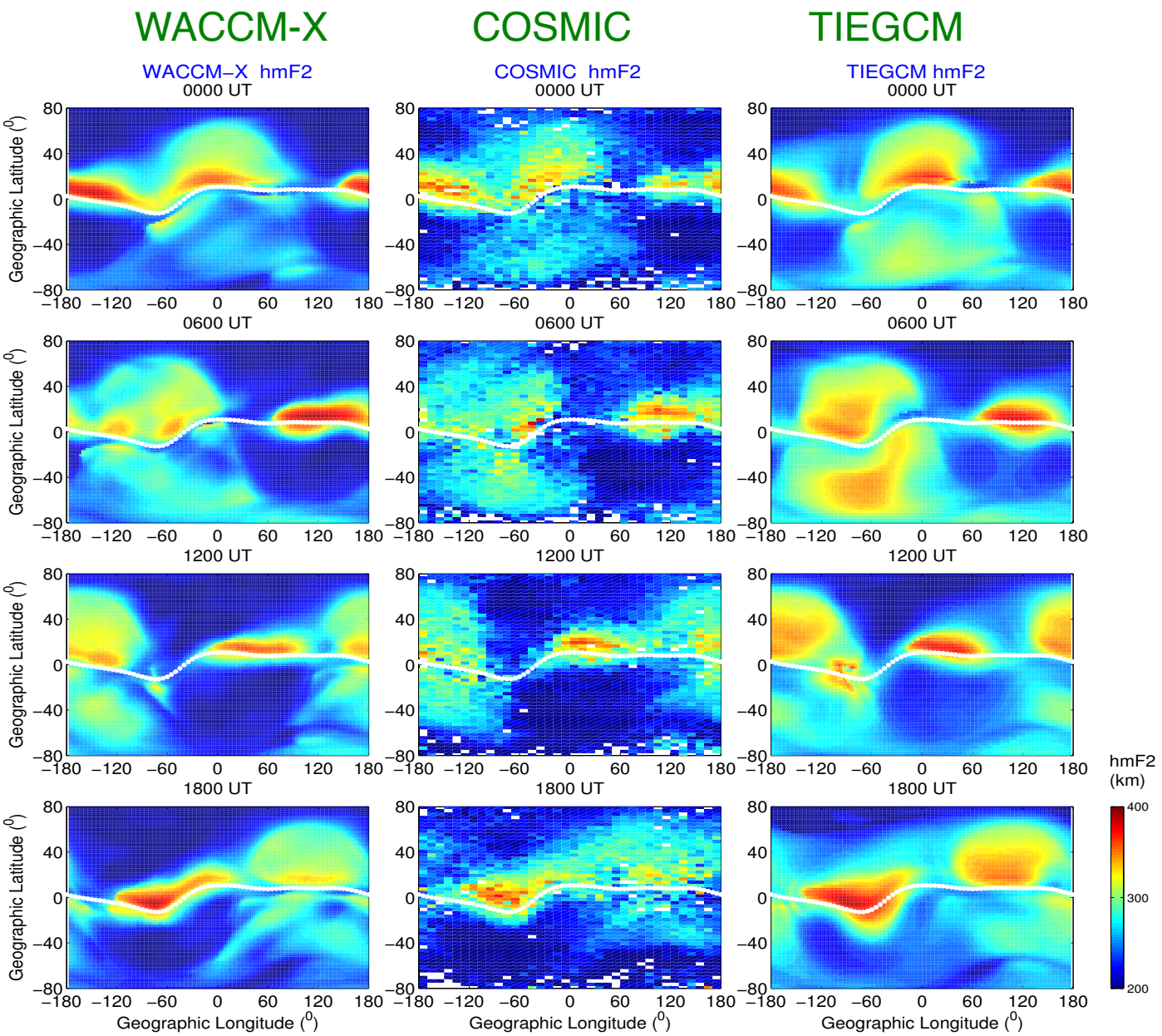
C005.2006.258.03.26.G23

hmF2 in March Equinox

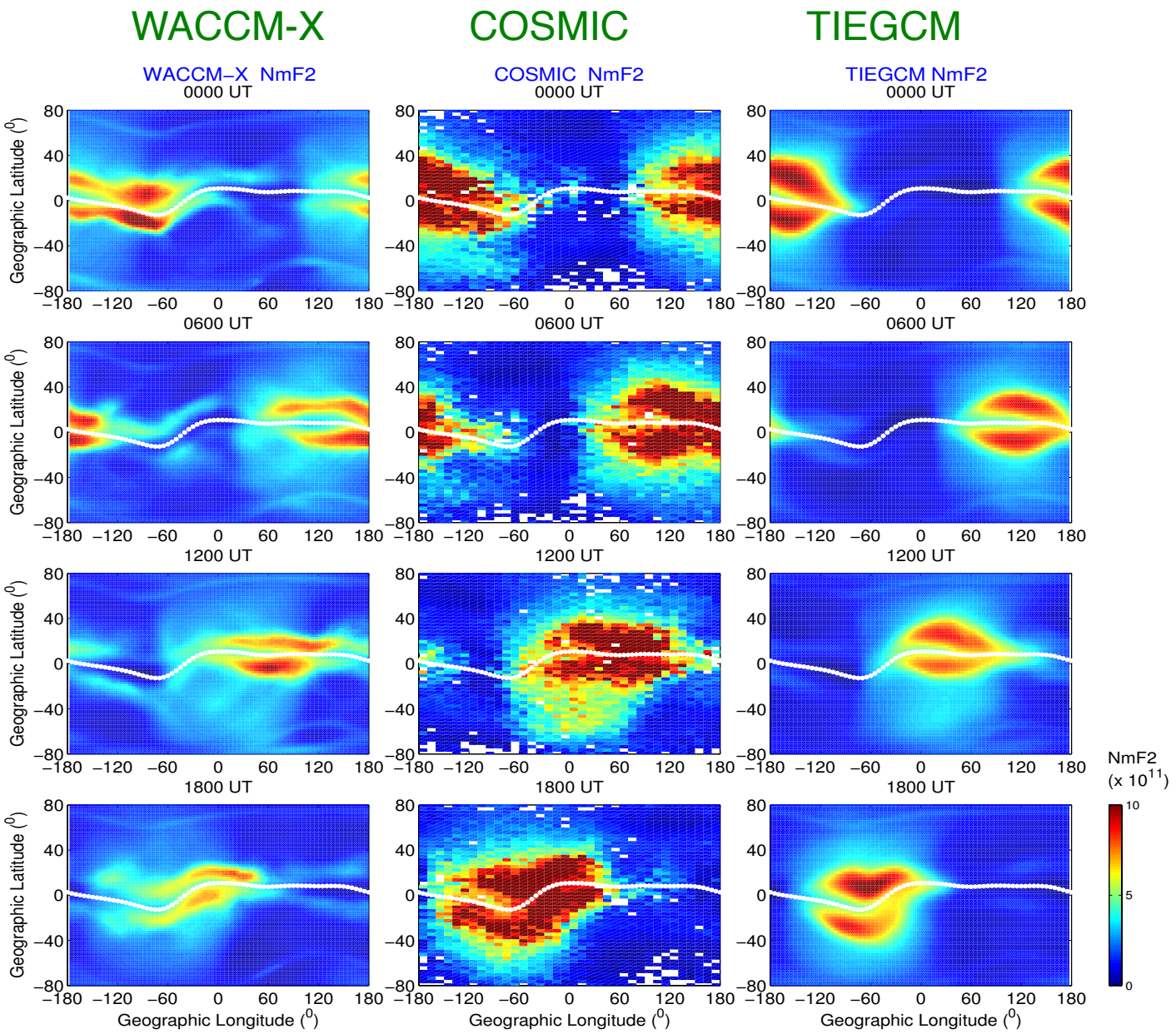
Free Run results



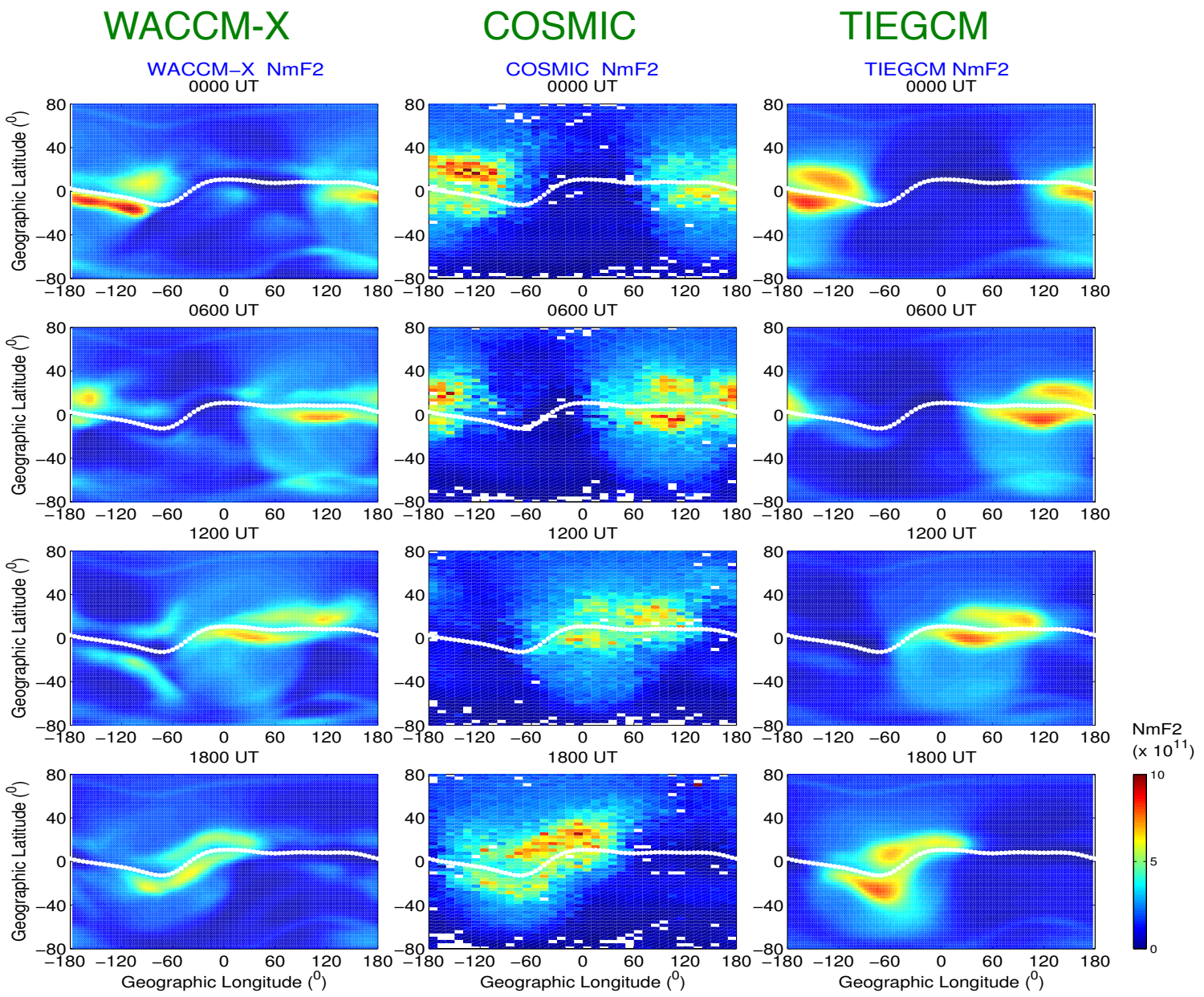
hmF2 in June Solstice



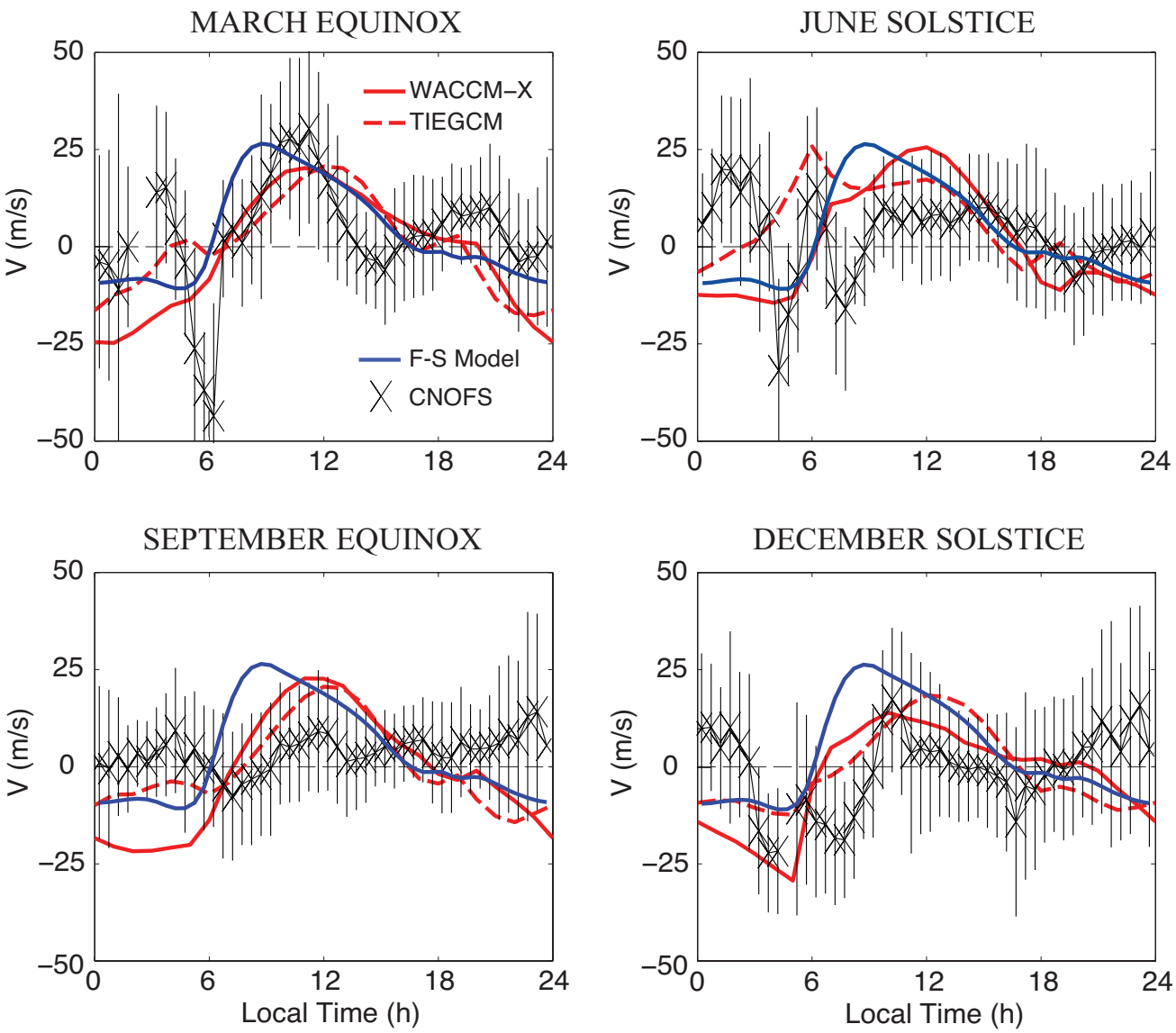
NmF2 in March Equinox



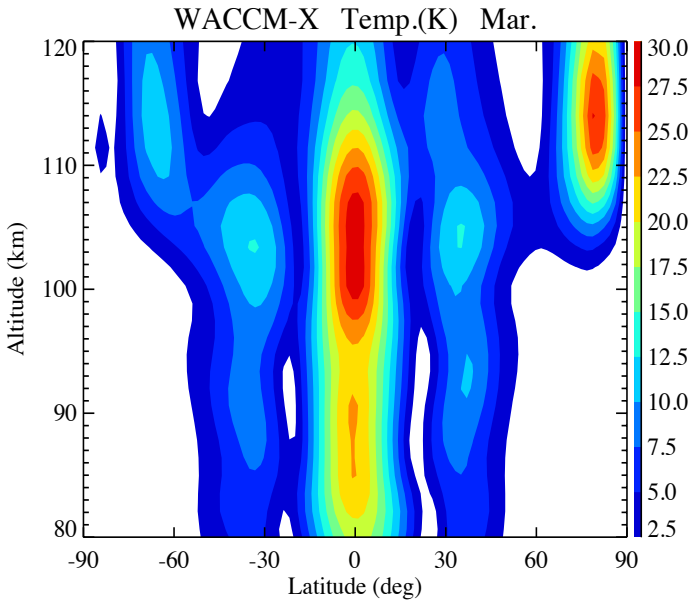
NmF2 in June Solstice

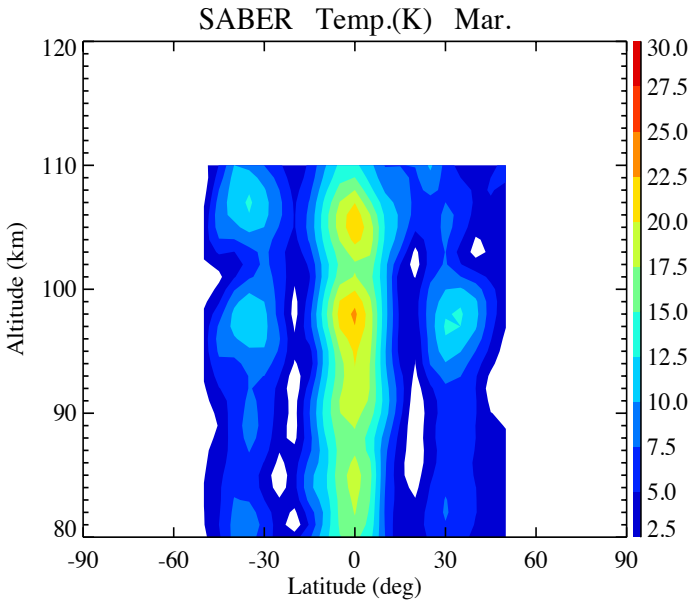


Ionospheric Vertical Drift over Jicamarca



DW1 in March


WACCM-X Temp.(K) Mar.
Altitude (km)
120
110
100
90
80
-90 -60 -30 0 30 60 90
Latitude (deg)
30.0 27.5 25.0 22.5 20.0 17.5 15.0 12.5 10.0 7.5 5.0 2.5


SABER Temp.(K) Mar.
Altitude (km)
120
110
100
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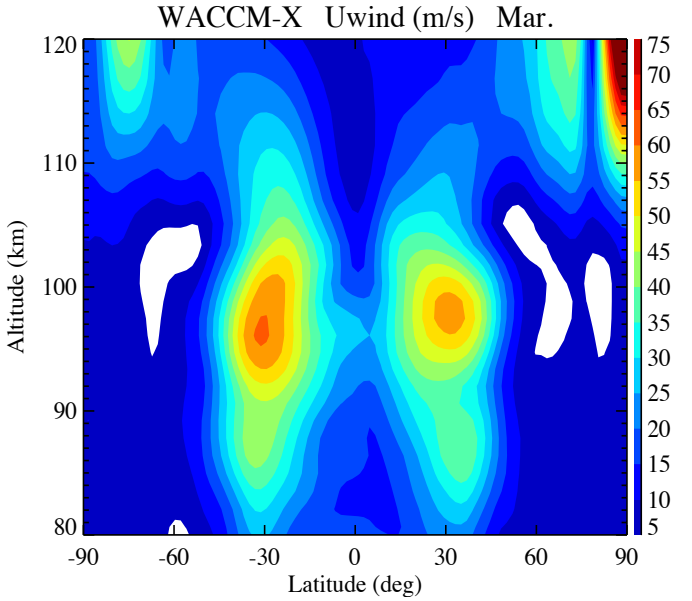
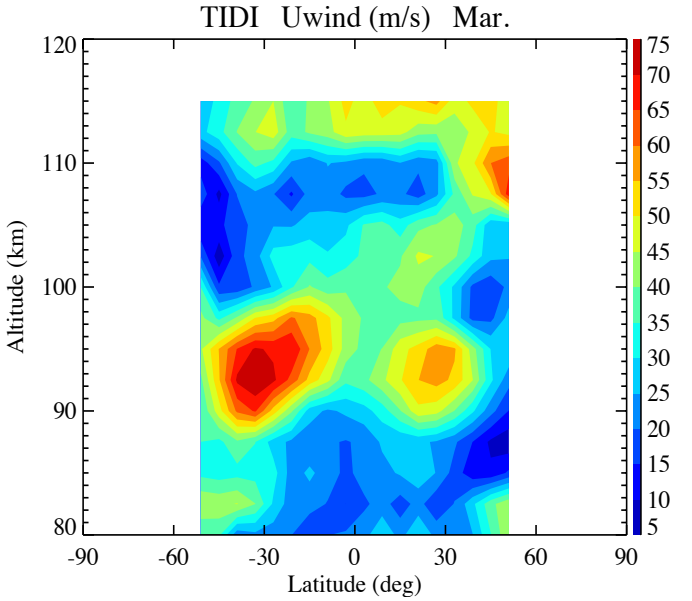
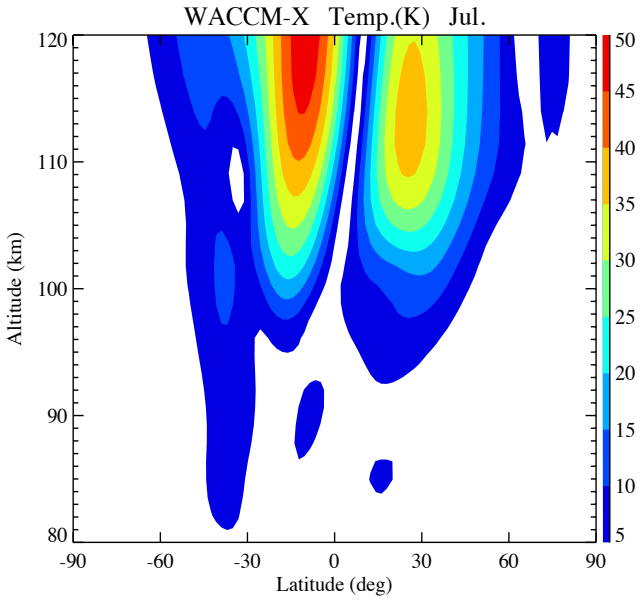
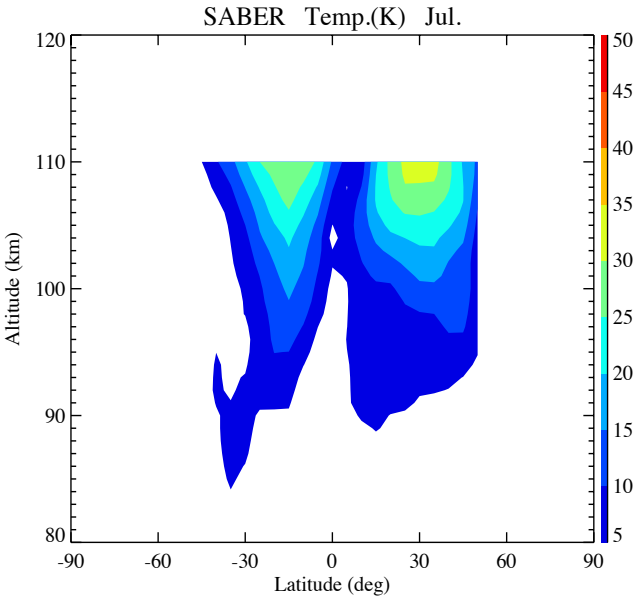
80
-90 -60 -30 0 30 60 90
Latitude (deg)
30.0 27.5 25.0 22.5 20.0 17.5 15.0 12.5 10.0 7.5 5.0 2.5

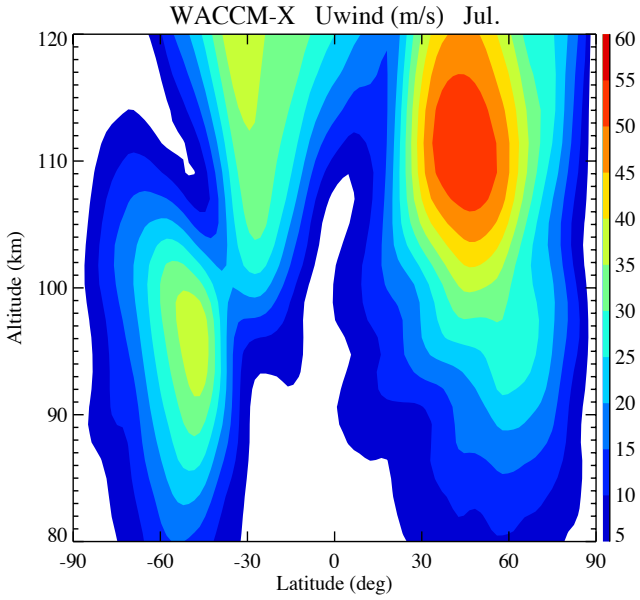

WACCM-X Uwind (m/s) Mar.
Altitude (km)
120
110
100
90
80
-90 -60 -30 0 30 60 90
Latitude (deg)
75 70 65 60 55 50 45 40 35 30 25 20 15 10 5

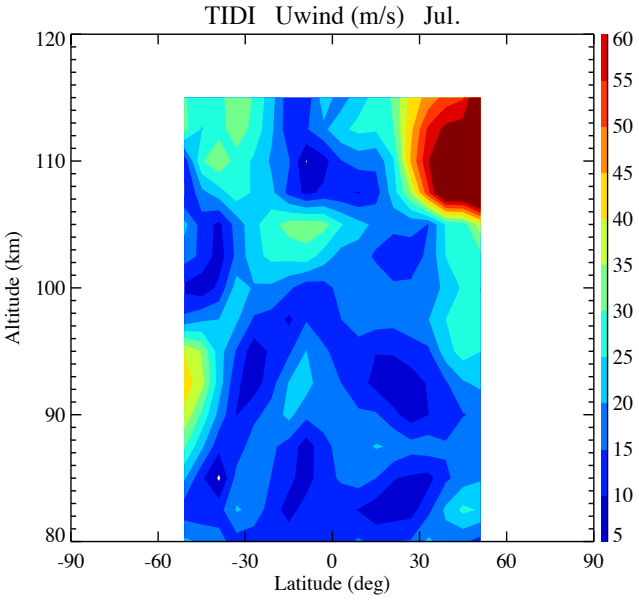

TIDI Uwind (m/s) Mar.
Altitude (km)
120
110
100
90
80
-90 -60 -30 0 30 60 90
Latitude (deg)
75 70 65 60 55 50 45 40 35 30 25 20 15 10 5

SW2 in July

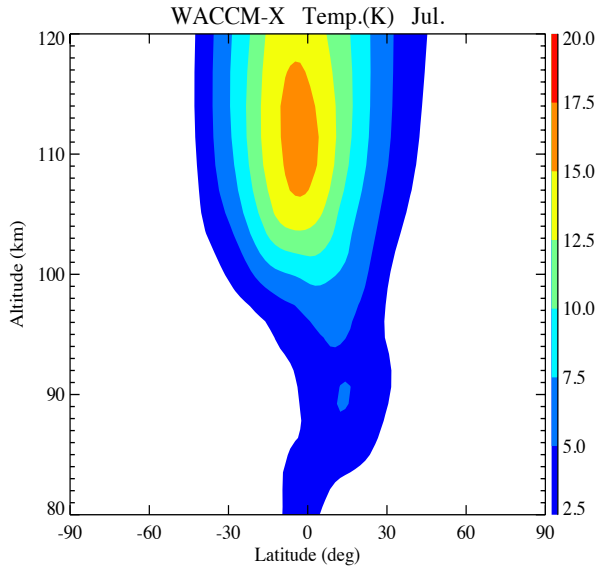

WACCM-X Temp.(K) Jul.
Altitude (km)
Latitude (deg)


SABER Temp.(K) Jul.
Altitude (km)
Latitude (deg)


WACCM-X Uwind (m/s) Jul.
Altitude (km)
Latitude (deg)


TIDI Uwind (m/s) Jul.
Altitude (km)
Latitude (deg)

DE3 in July


WACCM-X Temp.(K) Jul.
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-60
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Latitude (deg)
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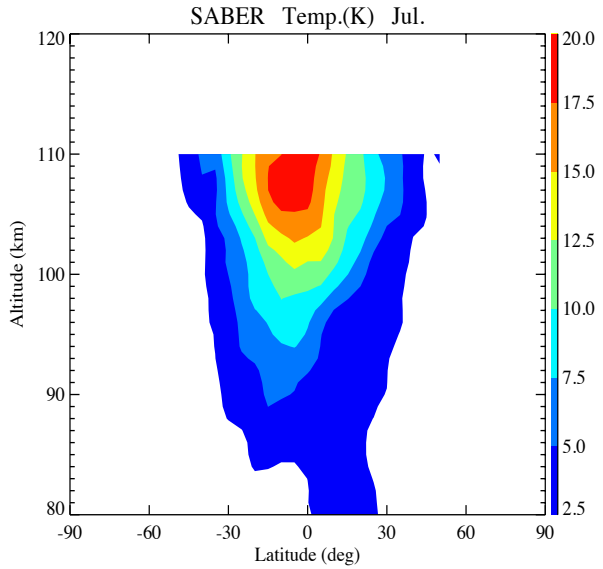
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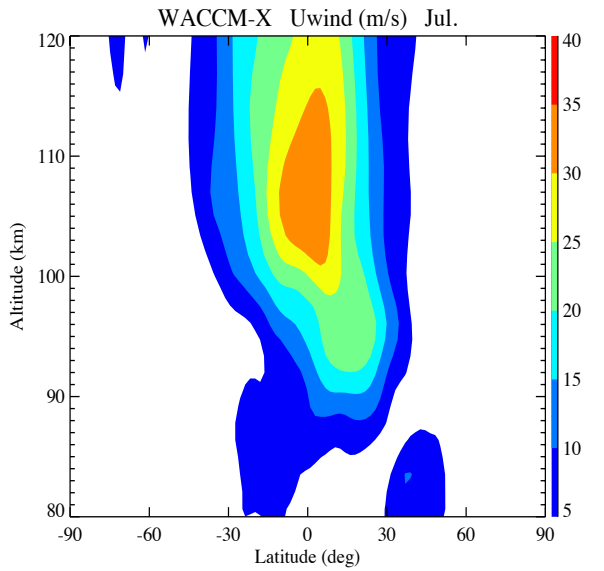
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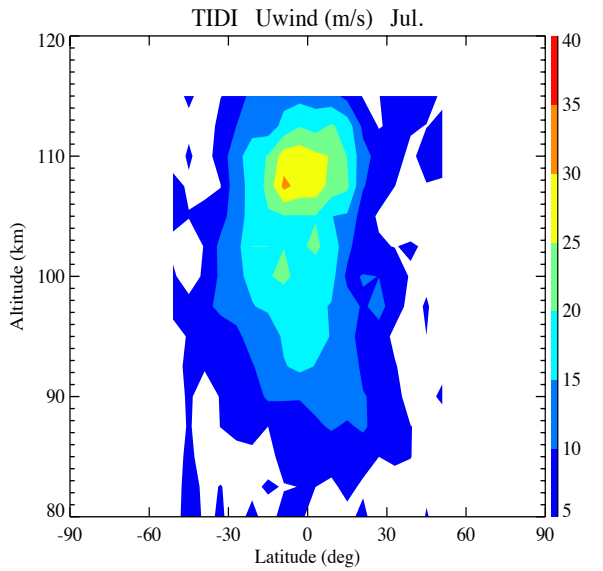
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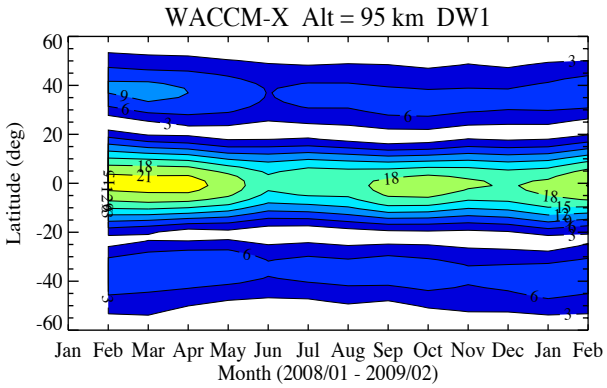
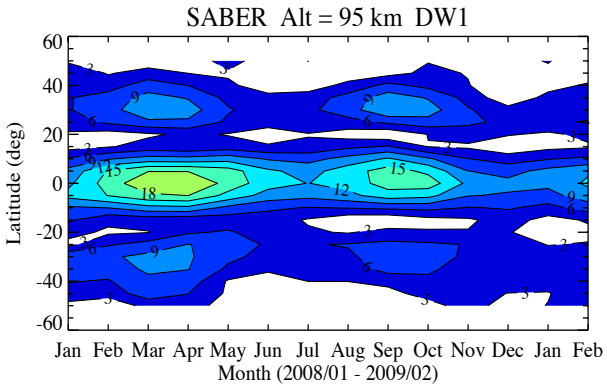
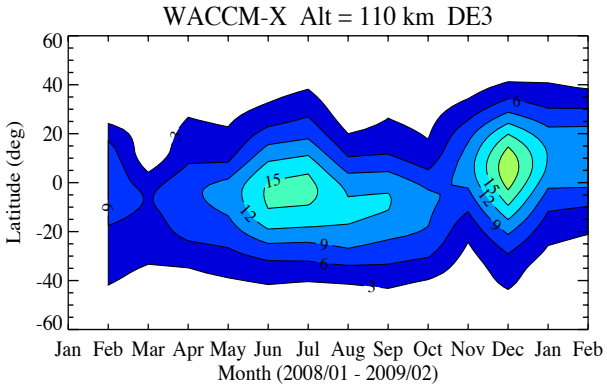
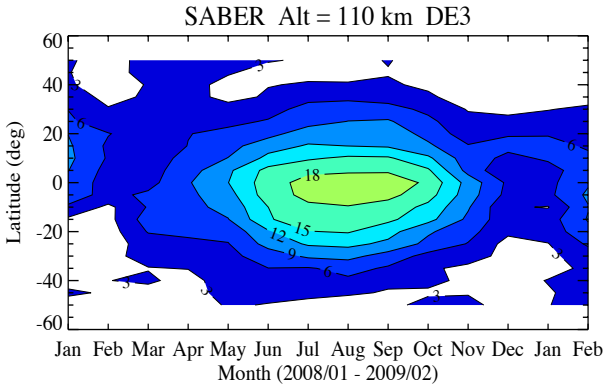
-30
0
30
60
90
Latitude (deg)
40
35
30
25
20
15
10
5

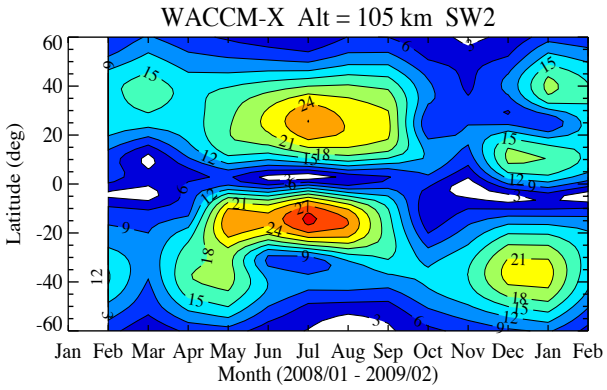
Seasonal Variability of Tides

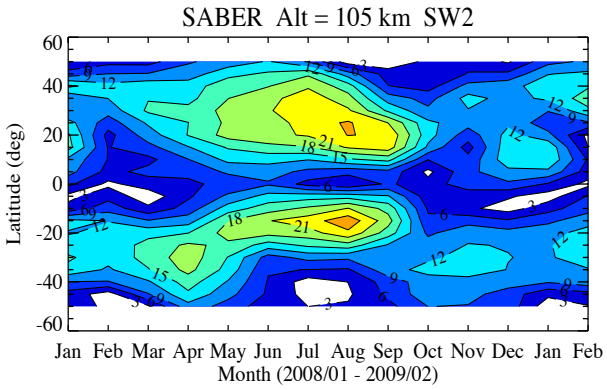












Summary

- **WACCM-X captures the seasonal variability of tides remarkably well, including the diurnal westward harmonic (DW1), semidiurnal westward harmonic (SW2), and diurnal eastward harmonic with zonal wavenumber 3 (DE3).**

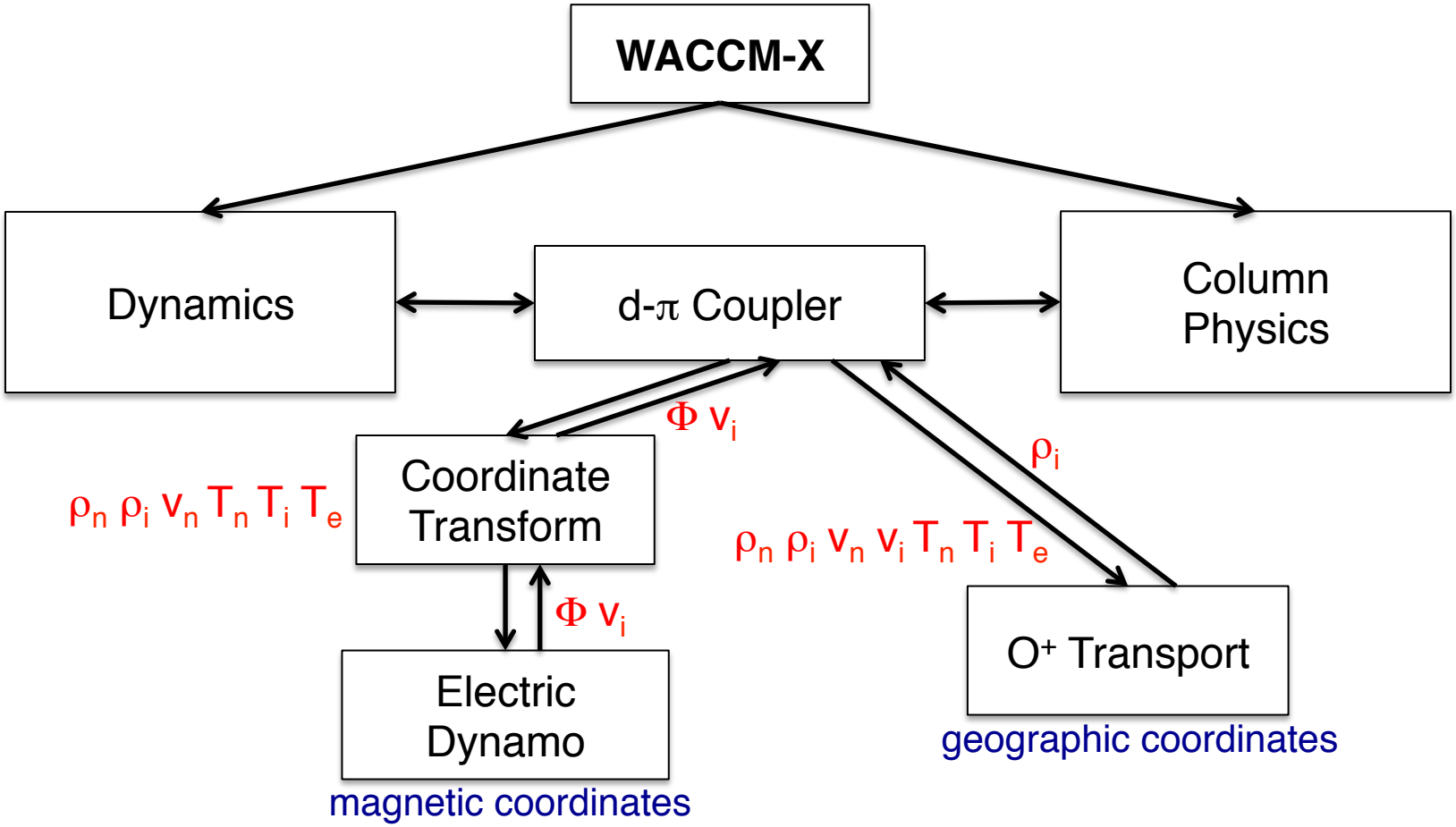
- **Ionosphere climatological features (NmF2 and hmF2) from WACCM-X are in good agreement with the results derived from COSMIC data. WACCM-X predicted NmF2 values are a little bit lower and equatorial ionization anomaly crests are closer to the magnetic equator, relative to COSMIC observations.**

- **Discrepancies exist among WACCM-X, TIEGCM and CNOFS derived vertical ion drifts. CNOFS observed vertical drift exhibit semi- or ter-diurnal variations while models' (WACCM-X and TIEGCM) results are dominated by diurnal variations.**

WACCM and WACCM-X Components and Status

Model Framework	Chemistry	Physics	Physics-X	Resolution
Extension of the NCAR Community Atmosphere Model (CAM) Finite Volume Dynamical Core	MOZART+ Ion Chemistry (~60 species) Fully-interactive with dynamics.	Long wave/short wave/EUV RRTMG IR cooling (LTE/non-LTE) Modal Aerosol CARMA Parameterized GW Major/minor species diffusion (+UBC) Molecular viscosity and thermal conductivity (+UBC) Species dependent Cp, R, m.	Parameterized electric field at high, mid, low latitudes. IGRF geomagnetic field. Auroral processes, ion drag and Joule heating Ion/electron energy equations Ambipolar diffusion Ionospheric dynamo Ion/electron transport Coupling with plasmasphere/ magnetosphere	Horizontal: 1.9° x 2.5° (lat x lon configurable as needed) Vertical: 66 levels (0-140km) 81/125 levels 0-~500km • < 1.0km in Upper Troposphere/ Lower Stratosphere • 1-2 km in strat. • 0.5 scale height in mesosphere/ thermosphere (0.25 scale height in mesosphere/ thermosphere with 125 levels)

Integrating Ionospheric Dynamics



d-π Coupler: dynamics-physics-ionosphere-electrodynamics (D-PIE) coupler
Electric Dynamo: calculates global electric potential resulting from wind-driven ions
ρ: density v: velocity T: temperature n: neutral i: ion e: electron Φ: electric potential