Equatorial-PRIMO

(Problems Related to Ionospheric Models and Observations)

- Non-coupled models (GIP, SAMI2, PBMOD, LLIONS, IFM, IPM)
  - March equinox, $F_{10.7}$=120, geomagnetic quiet condition
  - Ne, Te, and Ti are shown in longitude 120°E (to avoid differences in magnetic coordinates)
    - No E×B drift, no neutral wind (Production & Loss)
    - With E×B drift, no neutral wind (P&L, drift, diffusion)
    - With E×B drift and neutral wind (P&L, wind, drift, diffusion)

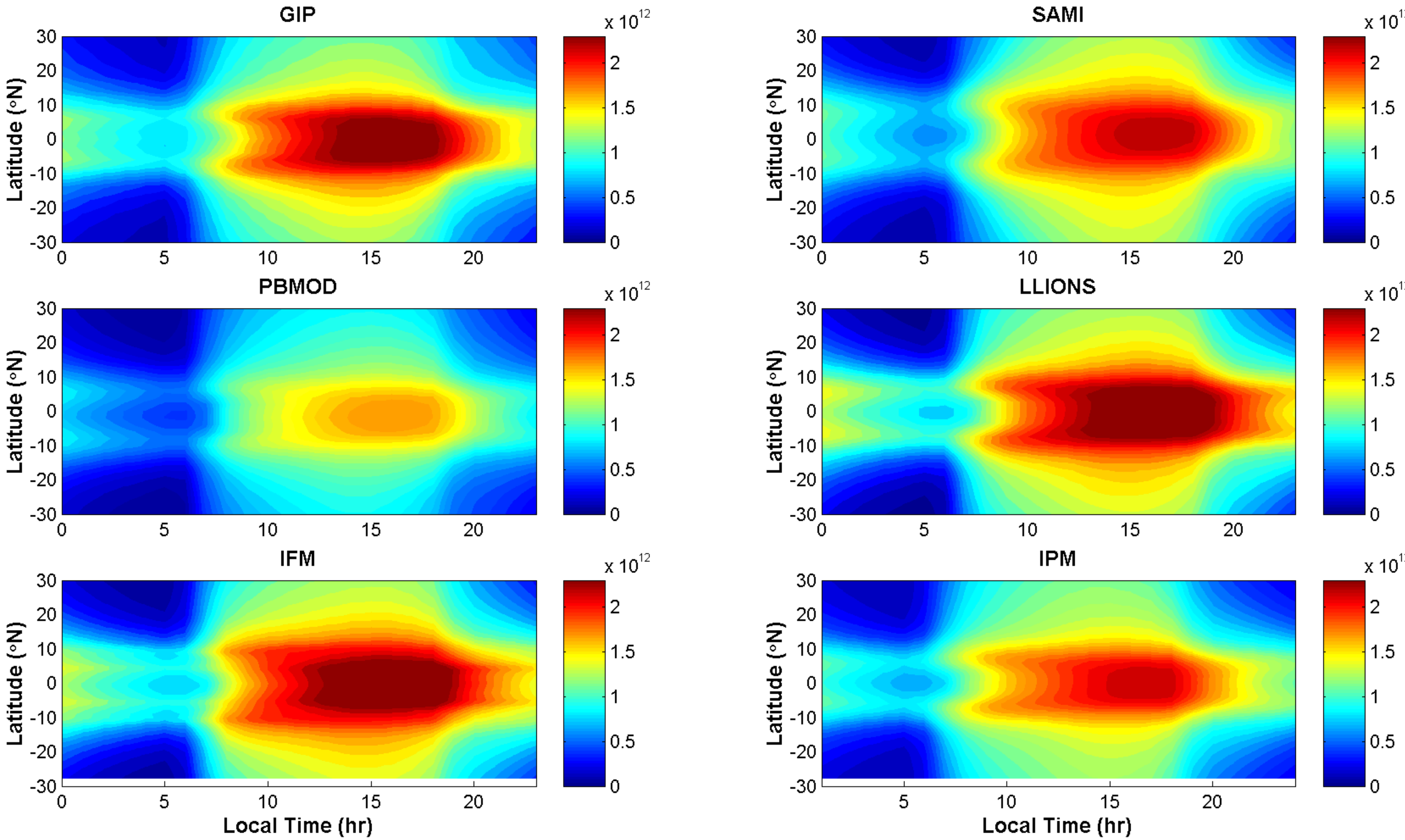
Continuity Equation

$$\frac{\partial N}{\partial t} = \underbrace{q}_{\text{Production}} - \underbrace{\beta(N)}_{\text{Loss}} - \underbrace{\mathrm{div}(N\mathbf{V}_{\parallel})}_{\text{Transport}}$$

- Perpendicular transport ($V_{\perp}$)
  - E×B drift
- Parallel transport ($V_{\parallel}$)
  - Neutral wind effect
  - Plasma diffusion
  - Thermo expansion/contraction
- Zonal transport (neglect here)

Model	Output	Ionosphere Coverage (km)	Thermosphere Coverage (km)	Ionosphere Resolution	Magnetic Coordinate	Photoionization
IFM	Ni (O^+, H^+, NO^+, O_2^+), Ne, Ti, Te	90-1600	MSIS86 HWM93	Various Long: 5°-15° Lat: 2°-5°	Best-fit IGRF dipole for each longitude	EUVAC
IPM	Ni (O^+, H^+, NO^+, O_2^+, He^+,N_2^+, N^+), Ne,Ti, Te	90 - 20,000	NRLMSIS00 HWM93	Lon: 3.75° Lat: 1.0°at mid-lat ; < 1°at low-lat	IGRF	EUVAC
LLIONS	Ni (O^+, H^+, NO^+, O_2^+), Ne, Ti, Te	90-10,000	NRLMSIS00 HWM93	Single longitude Lat: 2°	Best-fit IGRF dipole for longitude	EUVAC
PBMOD	Ni (O^+, H^+, Mol^+), Ne	90 – 4000 (upper end is user selectable)	NRLMSIS00 HWM93	User Selectable (typically Long: 7.5, Lat: 1)	IGRF Apex	Hinteregger Fluxes, Jasperse CSD (1977)
GIP	Ni (O^+, H^+, NO^+, O_2^+, N_2^+, N^+), Ti, Ne, Te	90 - 20,000	NRLMSIS00 HWM93	Long: 4° Lat: 1°	IGRF Apex	Fluxes (Tobiska model) Cross sec. (Torr and Torr, 1982)
SAMI2	Ni(H^+,O^+,He^+,N^+, NO^+,N_2^+,O_2^+), Ti(H^+,O^+,He^+),Te	90 – 20,000	NRLMSIS00 HWM93	Lat: 1 deg	IGRF-like	EUVAC

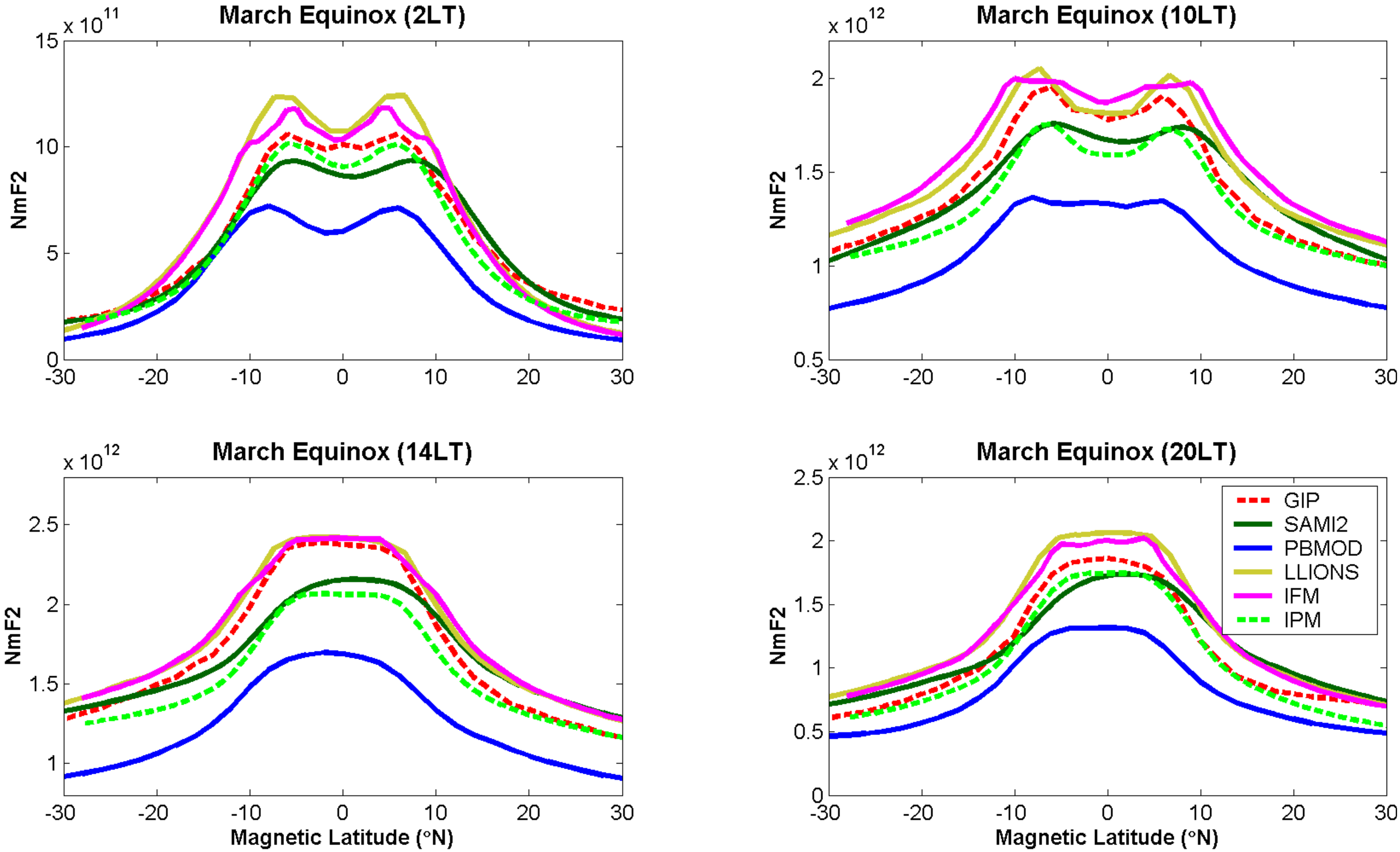
Case 1: No ExB drift, no neutral wind (N_{max}) ➔ Production and Loss



Any nighttime production? Differences in early morning and nighttime

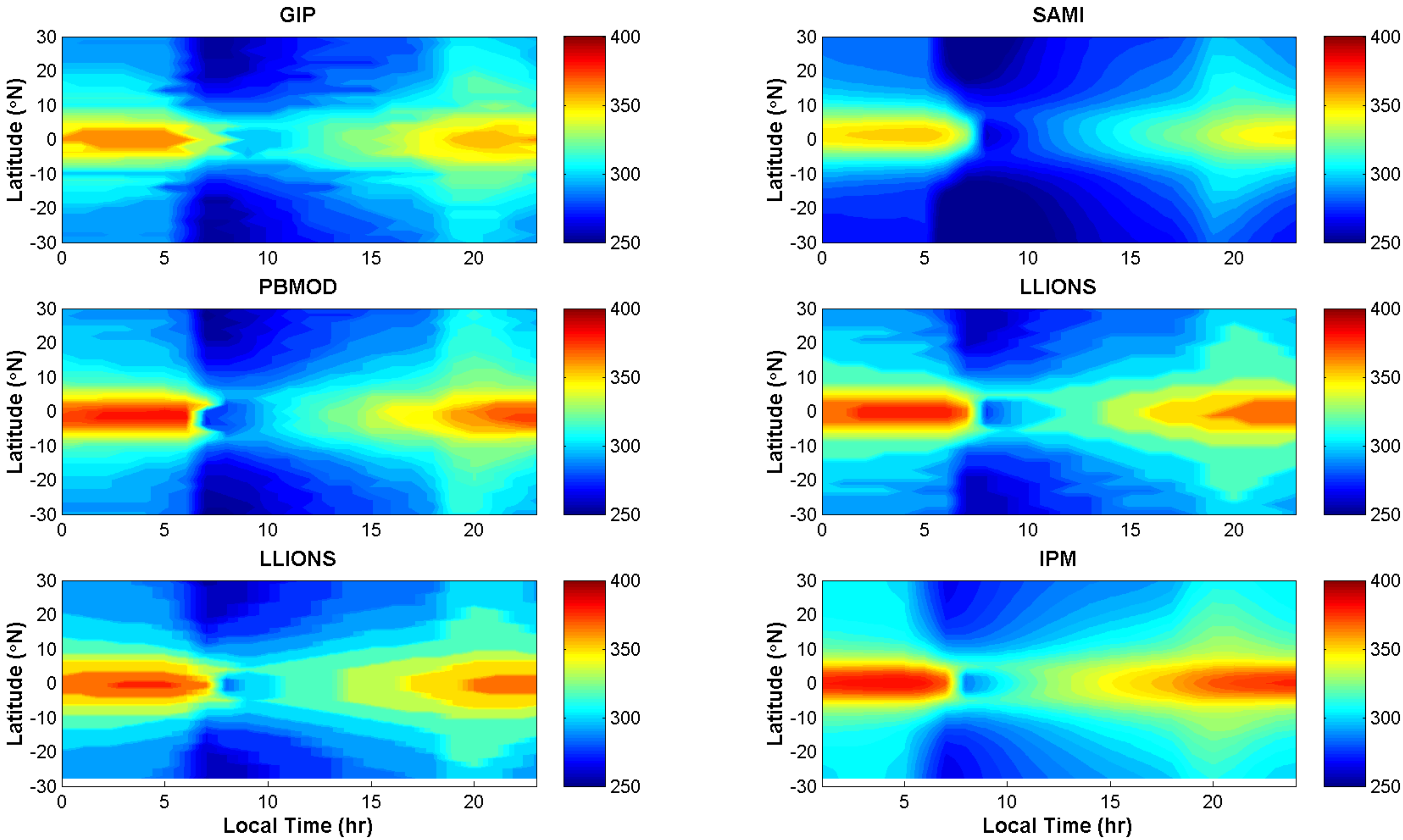
Differences between IFM and IPM?

Case 1: No ExB drift, no neutral wind (N_{max}) ➔ Production and Loss



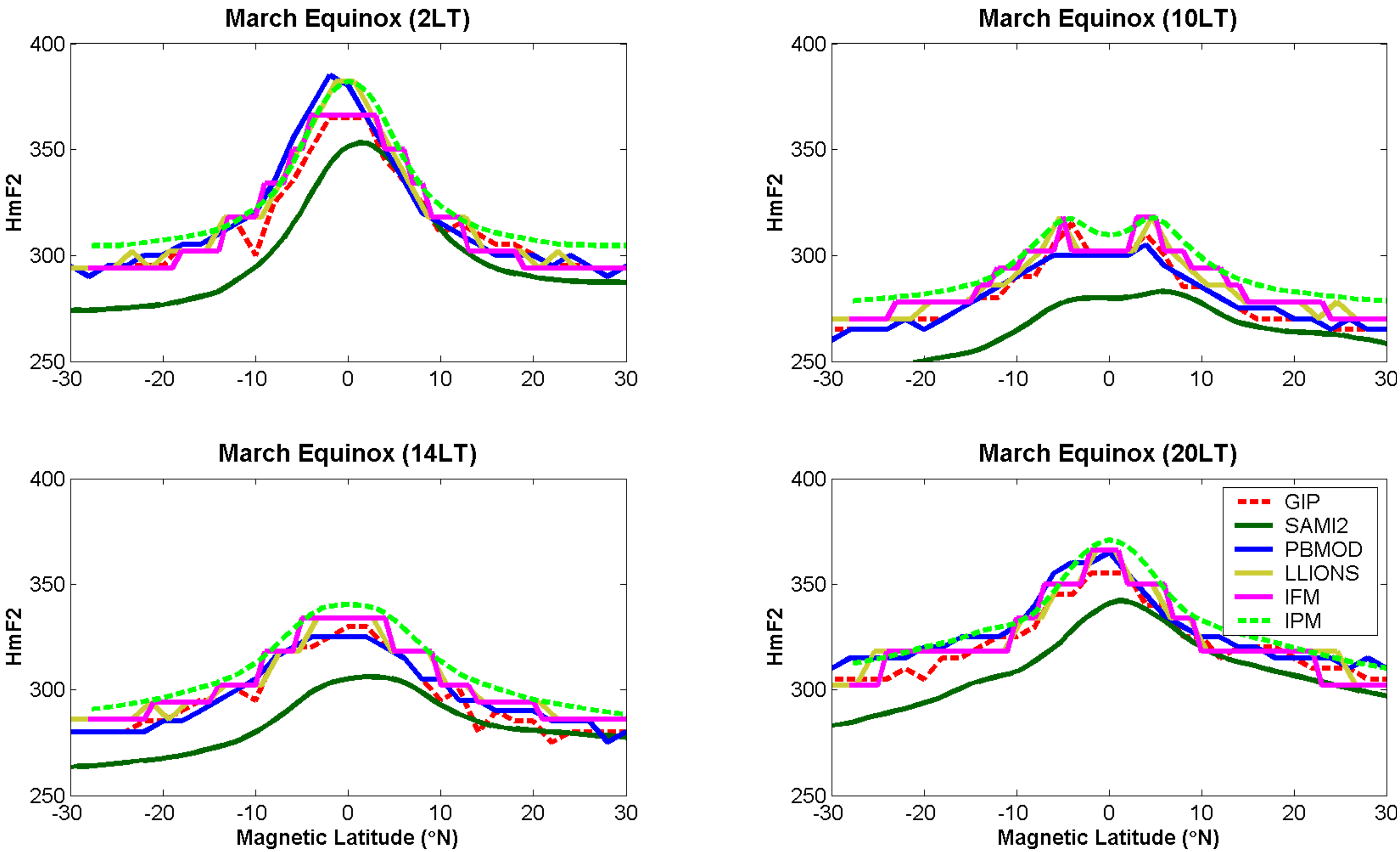
Te in GIP has been changed which significantly reduced the nighttime density

Case 1: No ExB drift, no neutral wind (H_{max}) ➔ Production and Loss



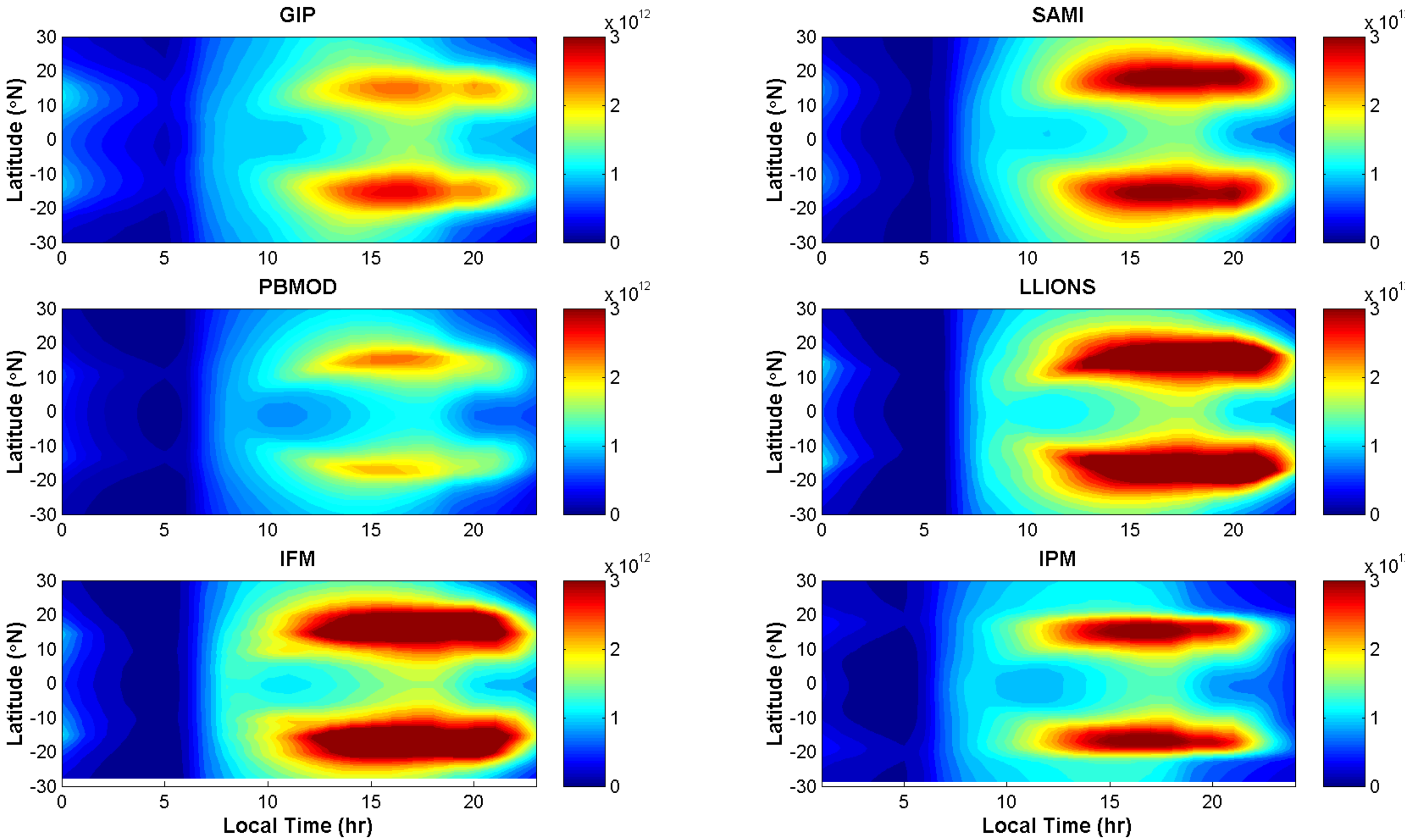
SAMI2 shows the lowest H_{max} in the daytime; IPM shows the highest in the nighttime

Case 1: No ExB drift, no neutral wind (H_{max}) ➔ Production and Loss

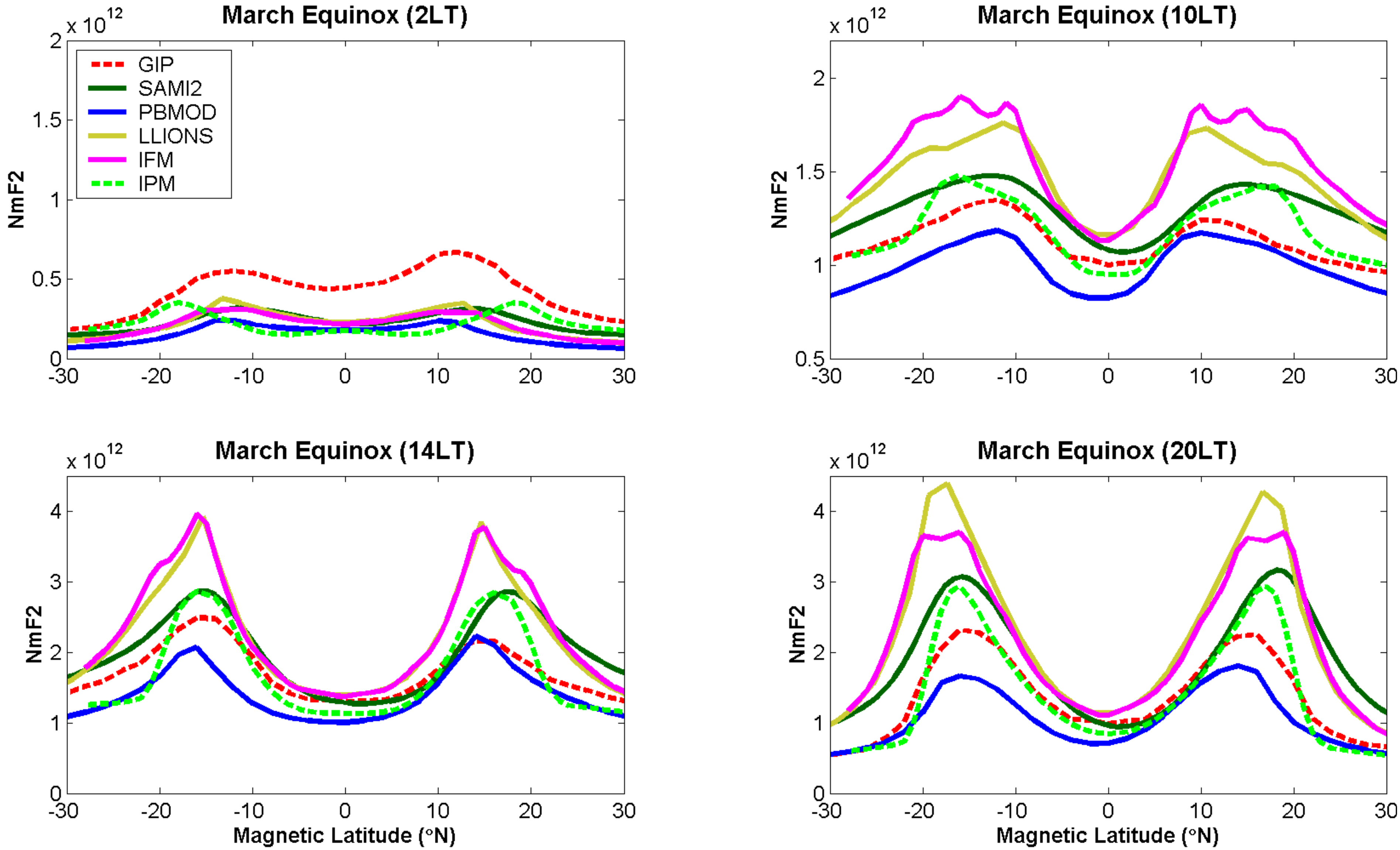


Offset of SAMI2 in latitude?

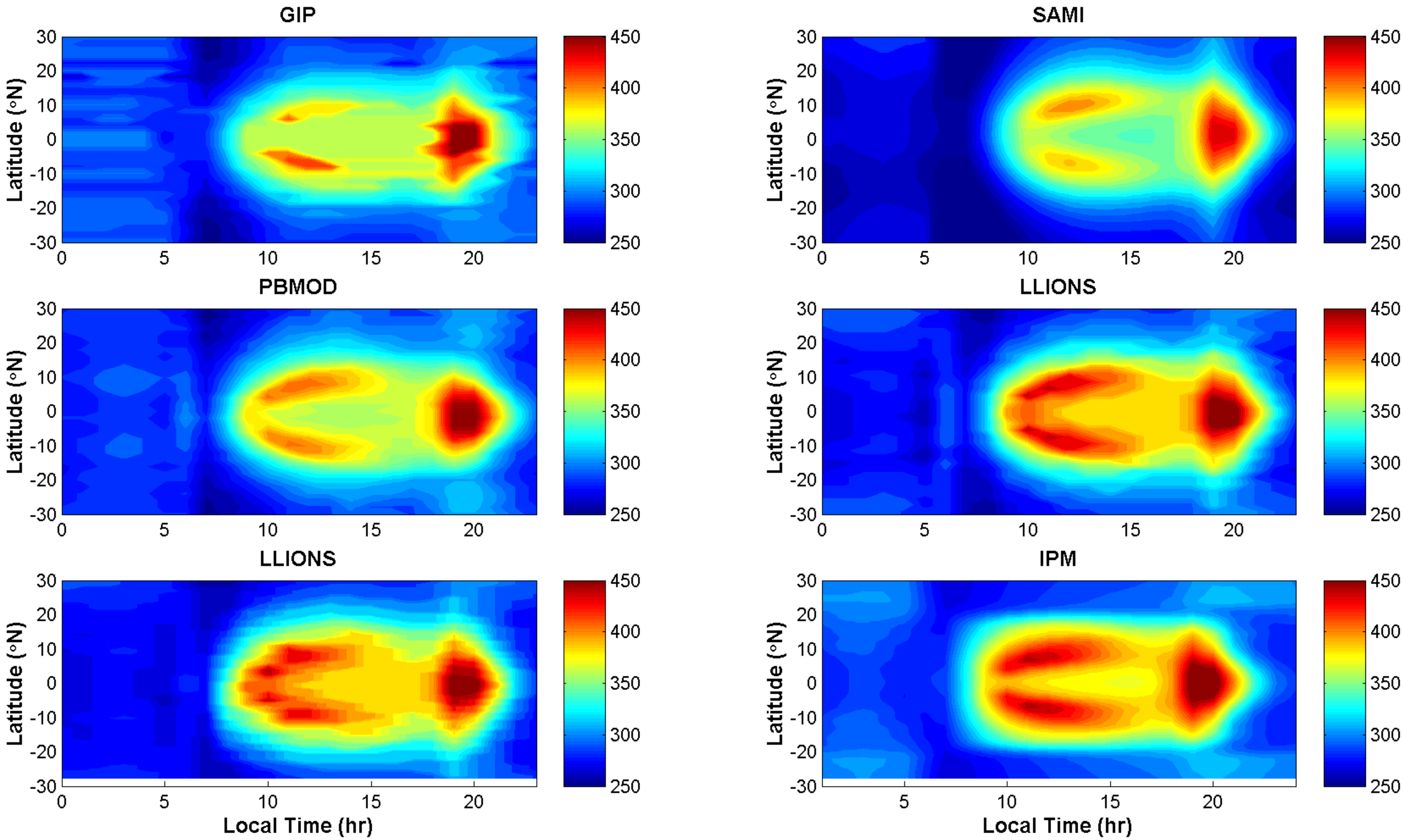
Case 2: With ExB drift, no neutral wind (N_{max}) ➔ P&L, drift, diffusion



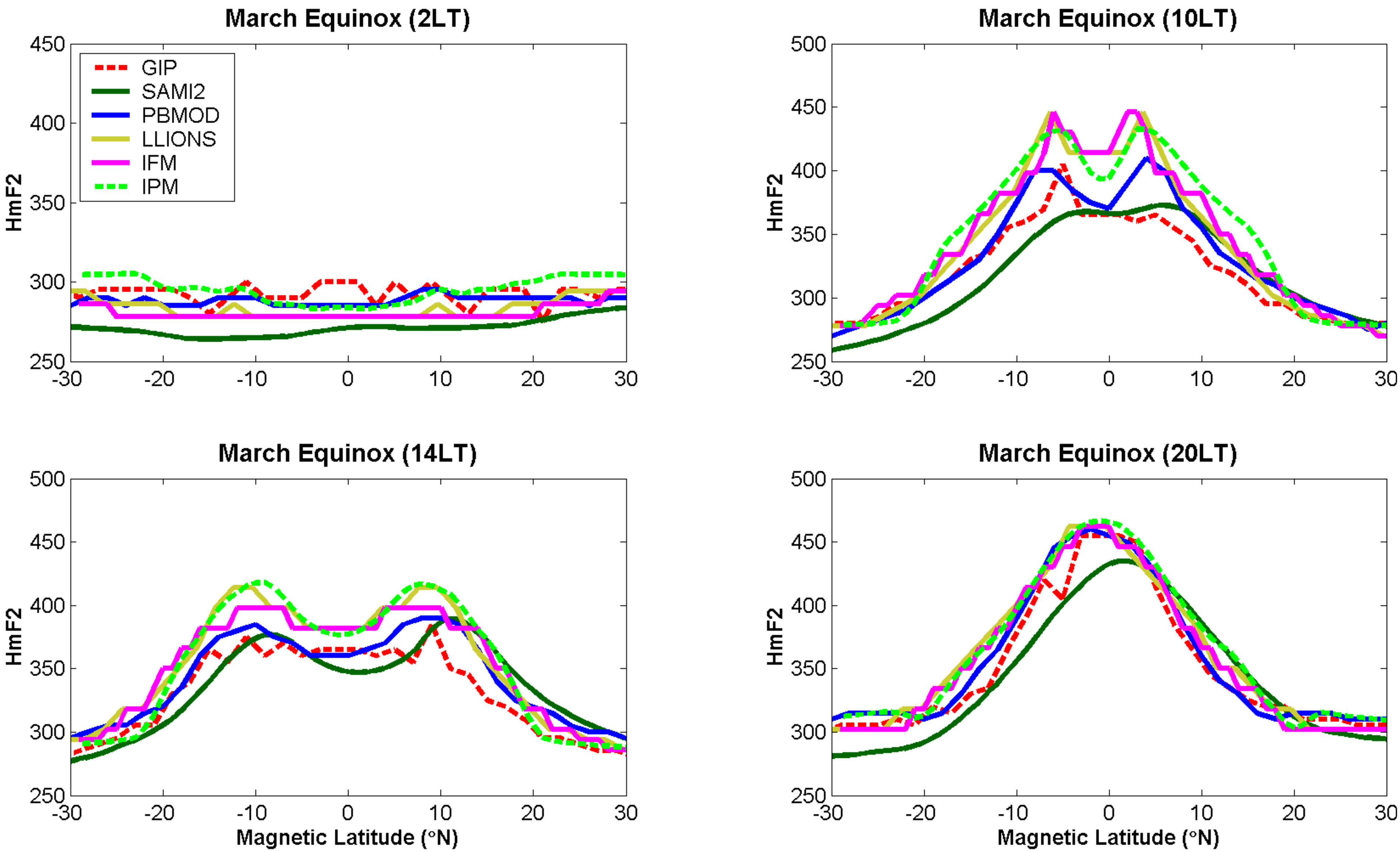
Case 2: With ExB drift, no neutral wind (N_{max}) ➔ P&L, drift, diffusion



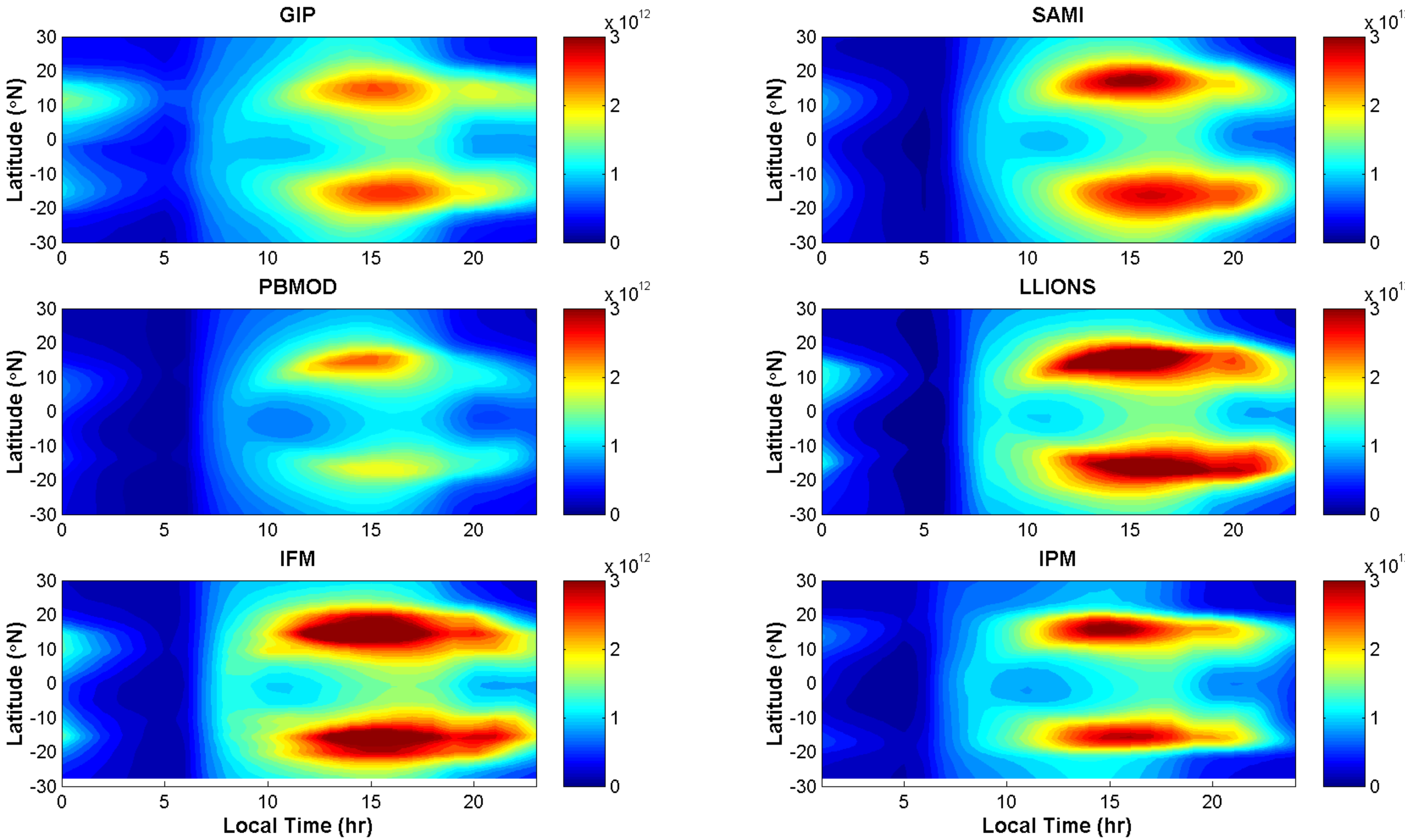
Case 2: With ExB drift, no neutral wind (H_{max}) → P&L, drift, diffusion



Case 2: With ExB drift, no neutral wind (H_{max}) ➔ P&L, drift, diffusion

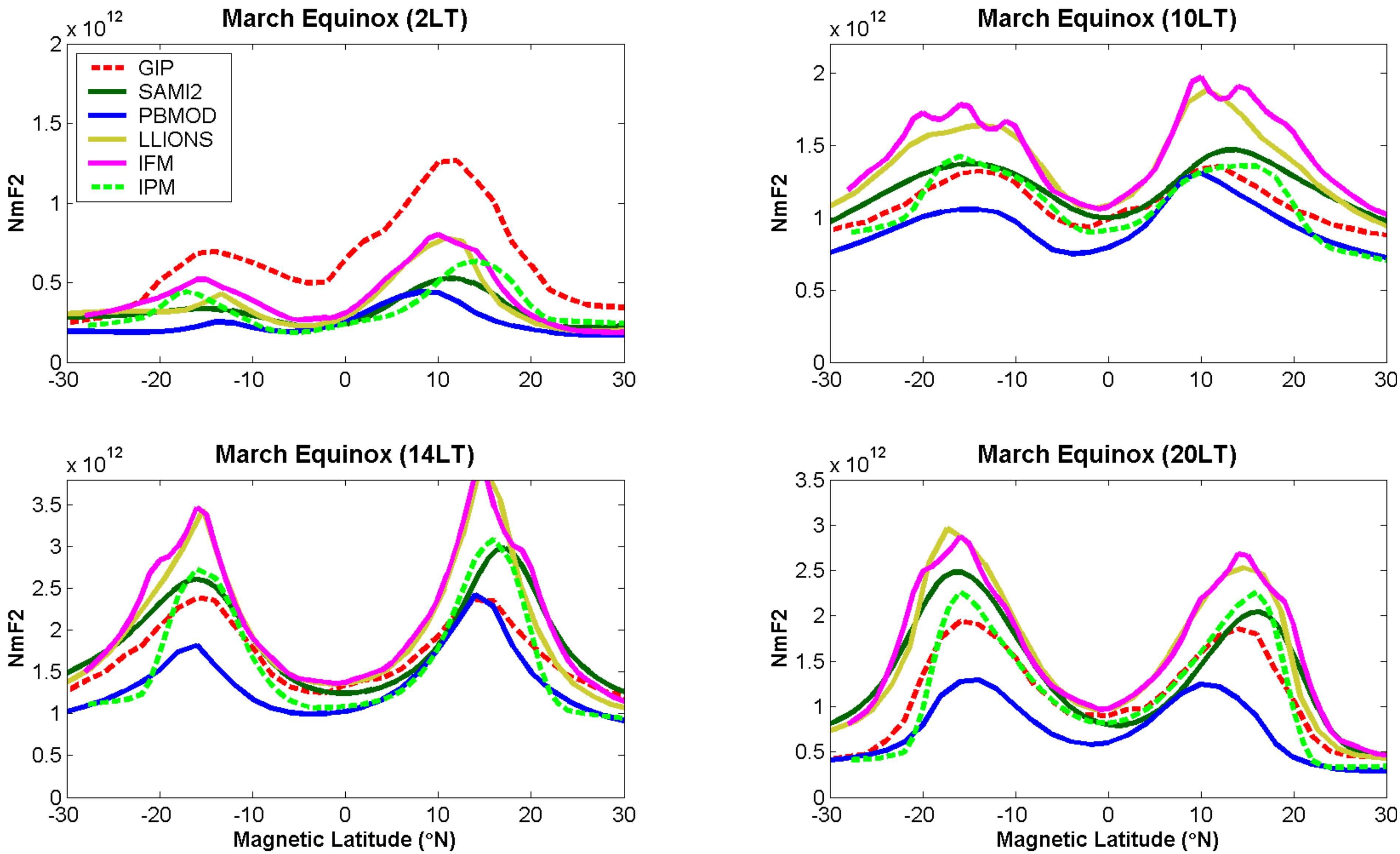


Case 3: With ExB drift and neutral wind (N_{max}) ➔ P&L, wind, drift, diffusion

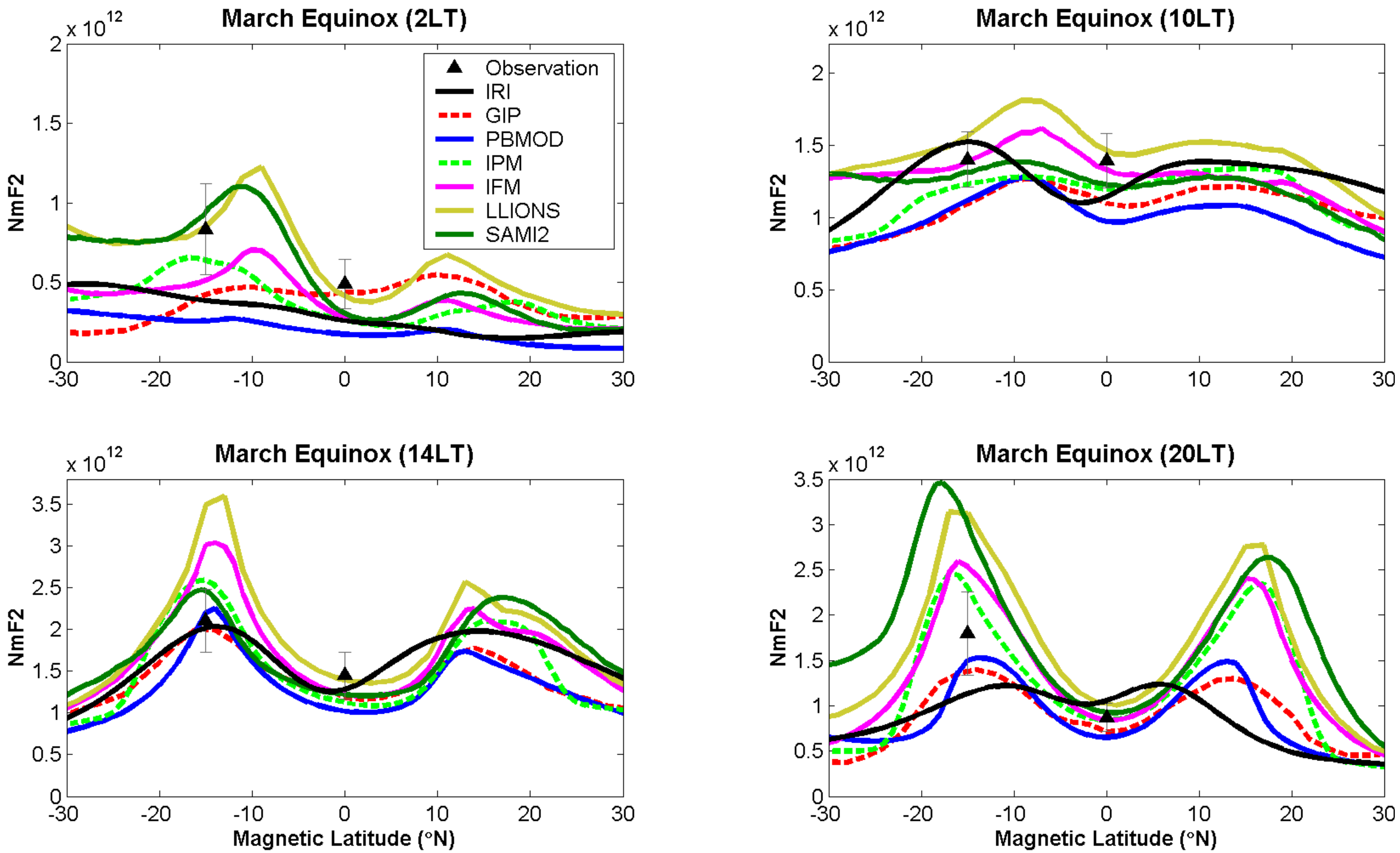


Wind has decrease daytime density and enhance nighttime density

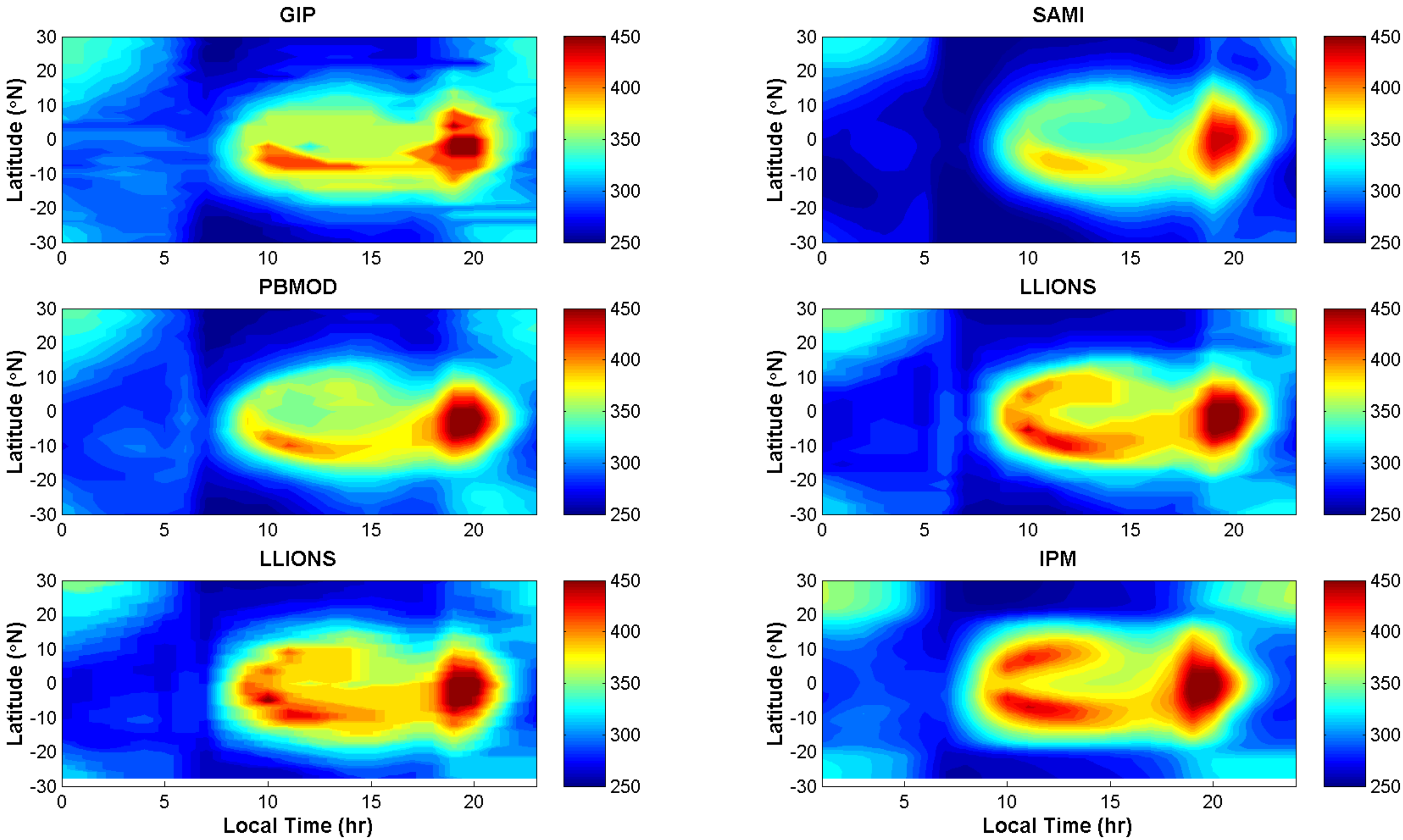
Case 3: With ExB drift and neutral wind (N_{max}) ➔ P&L, wind, drift, diffusion



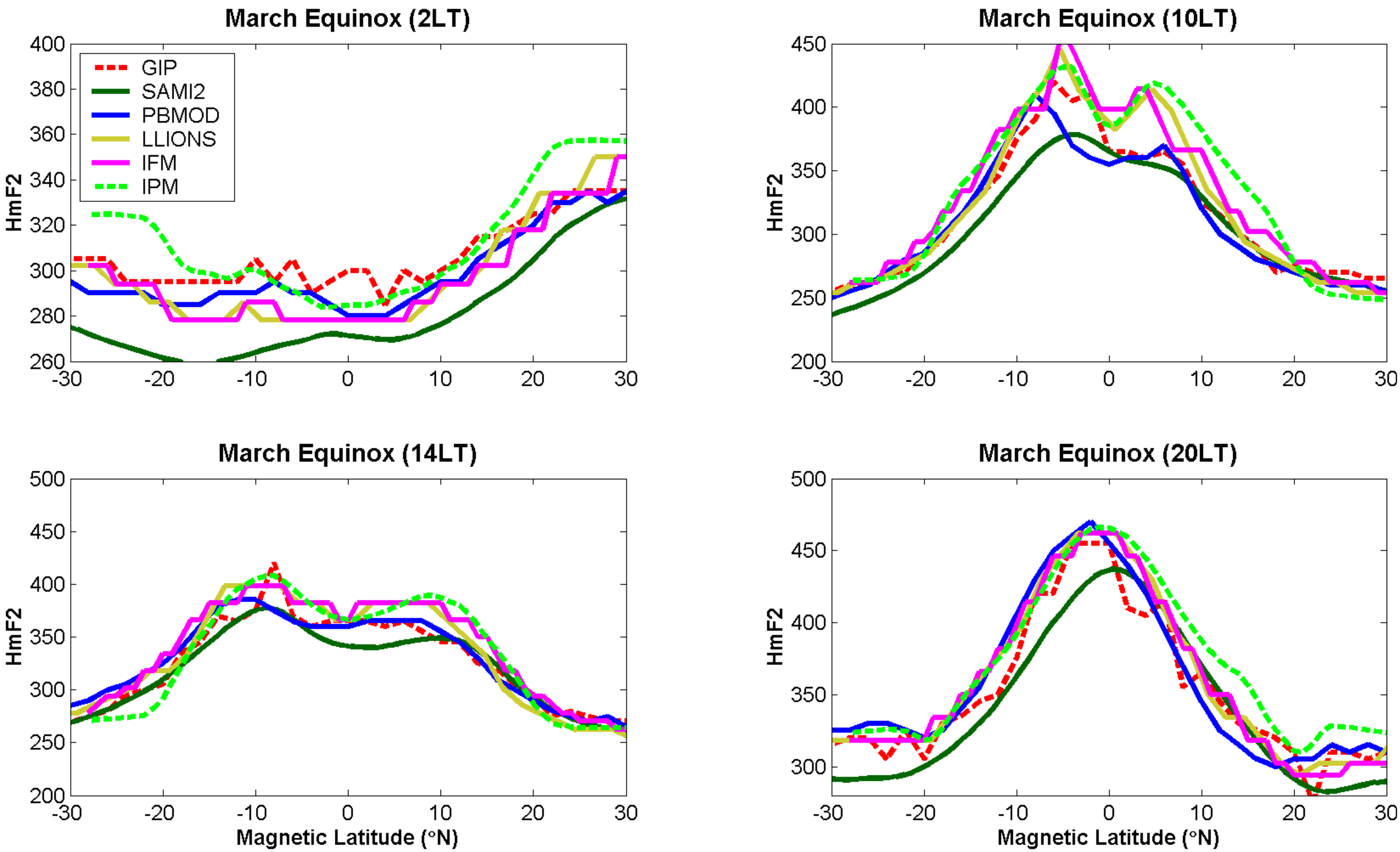
Jicamarca Longitude (Previous results)



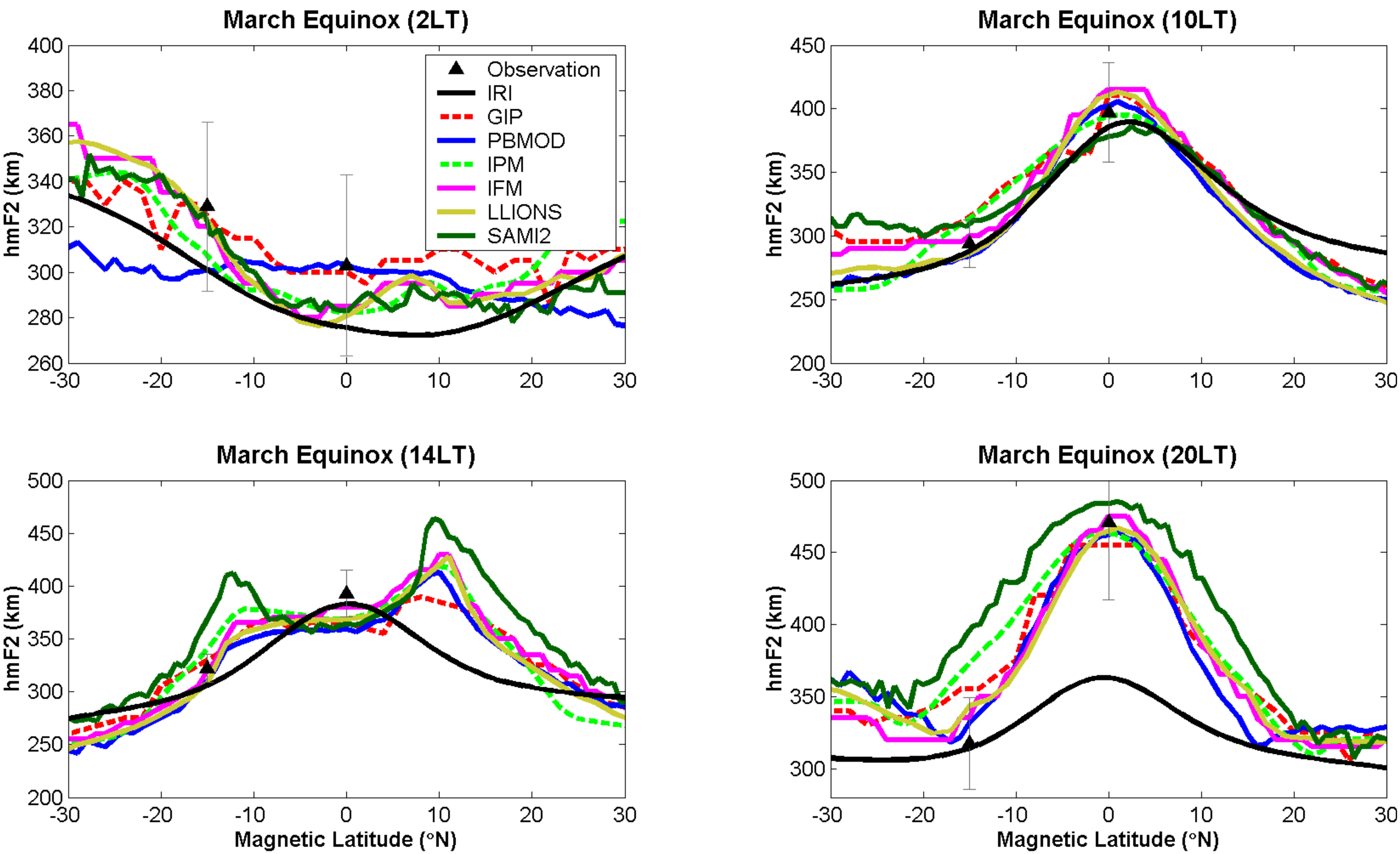
Case 3: With ExB drift and neutral wind (H_{max}) ➔ P&L, wind, drift, diffusion



Case 3: With ExB drift and neutral wind (H_{max}) → P&L, wind, drift, diffusion

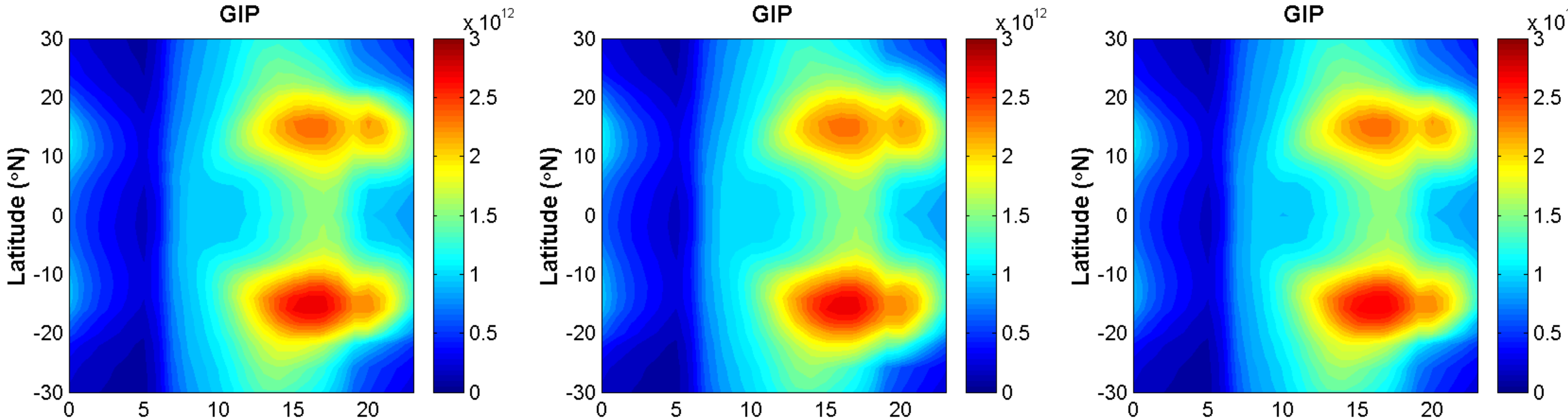


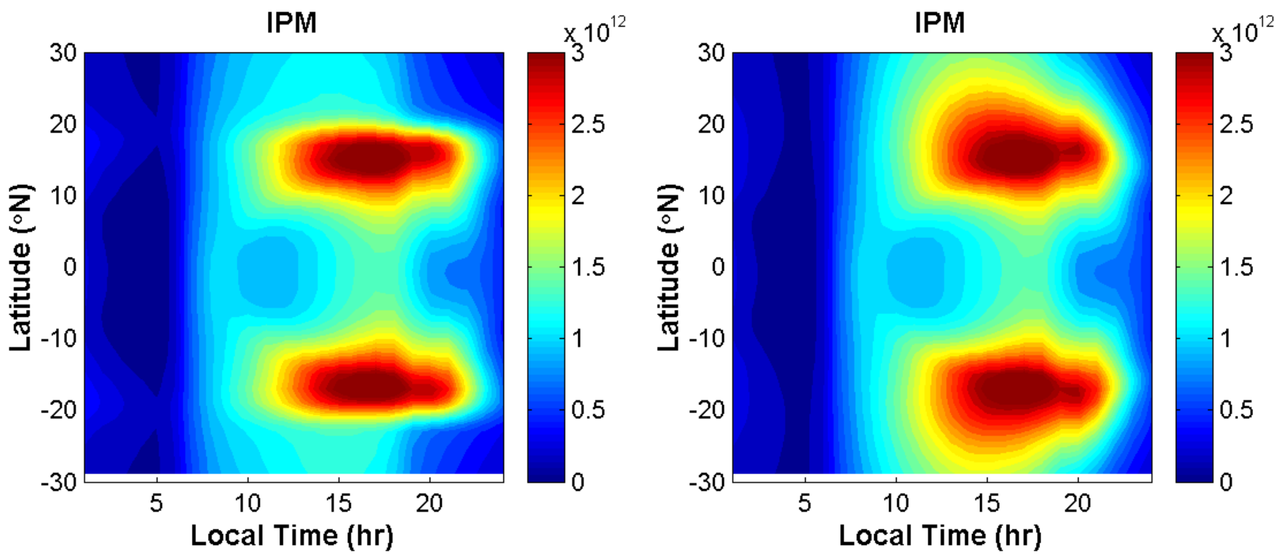
Jicamarca Longitude (Previous results)



Model	Temp Calculation	Height gradient of ExB drift
IFM	Titheridge model for Ti and Te	Different between 2000 and 3000 km Apex altitude.
IPM	Titheridge model for Ti and Te	Drift tappers of between 1000 and 1500 km apex altitude.
LLIONS	Titheridge model for Ti and Te Te=Ti=Tn at ~110km	No graient
PBMOD	Titheridge model for Ti and Te	
GIP	Titheridge model for Te Energy Equ for Ti	0 at 100km 300-1000km F&S >2000km Richmond electric field model between 1000 to 2000km linear interpolation is applied
SAMI2	Ion Temp Equ. Electron Temp Equ.	E x B velocity ramps down to 0 below 150 km with 10 km decay above 150 km F&S with no altitude dependence.

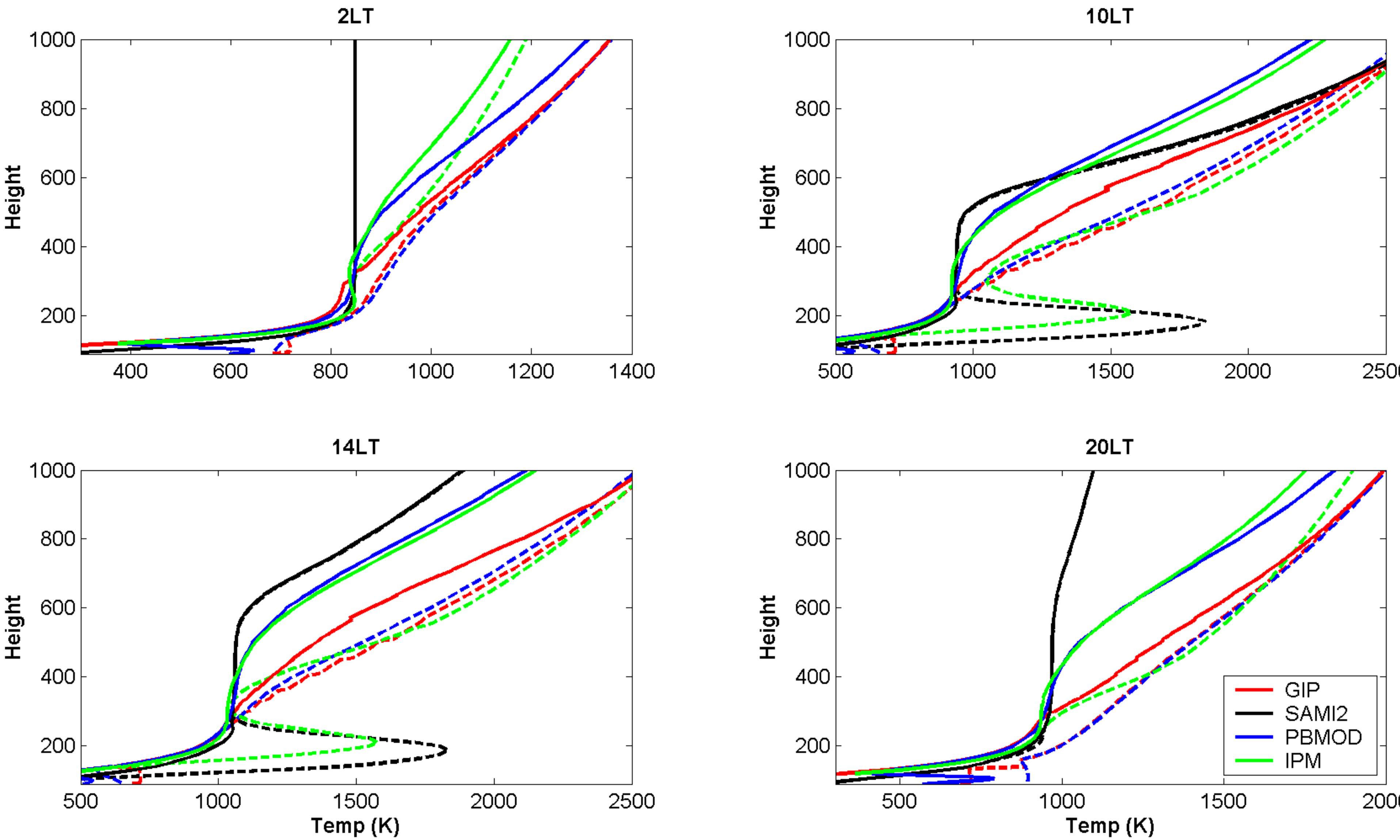
ExB, no wind | **No gradient 1000-2000km** | **No gradient 100-300km**





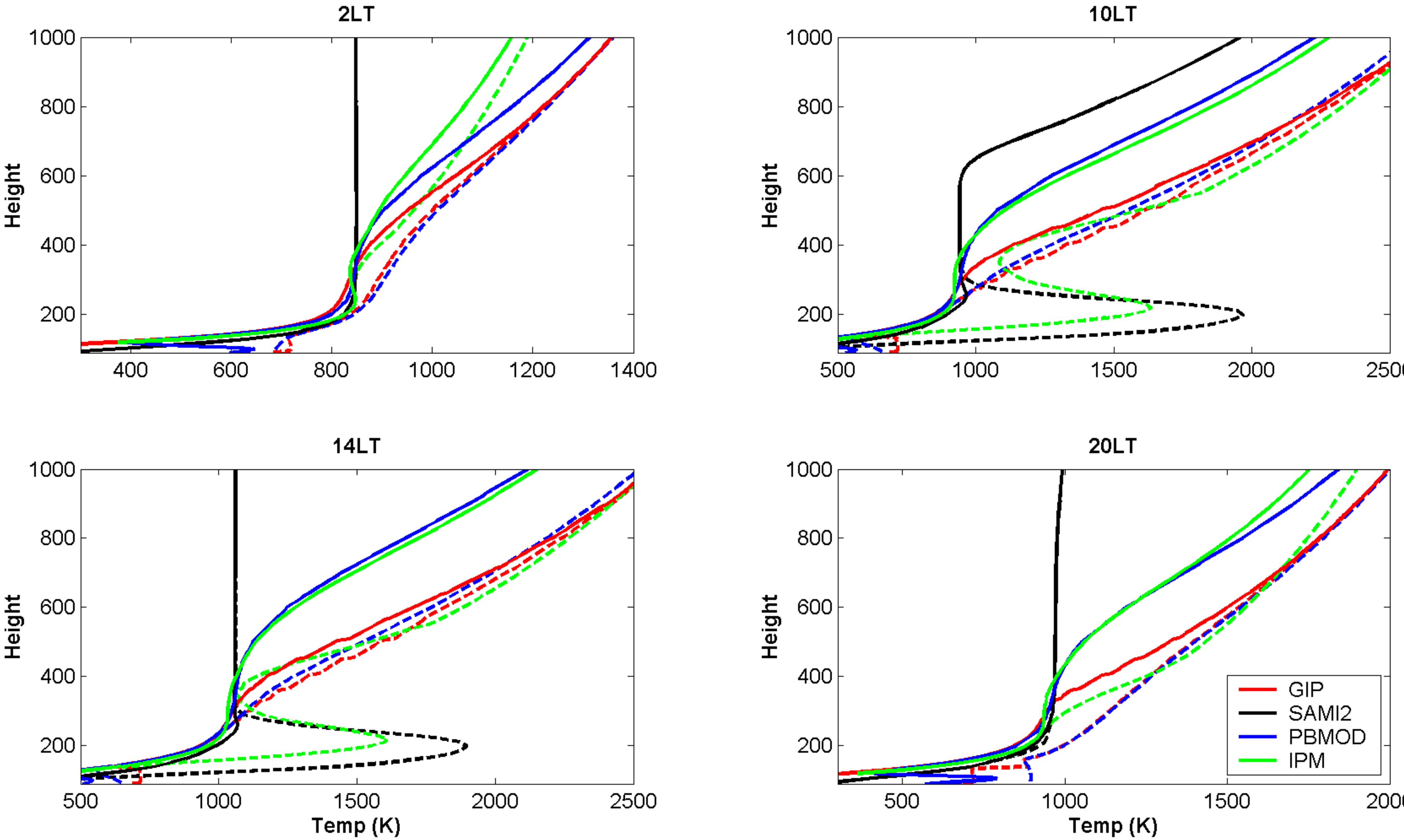
GIP and IPM test runs for height dependent drift input

Temperature: No ExB drift, no neutral wind



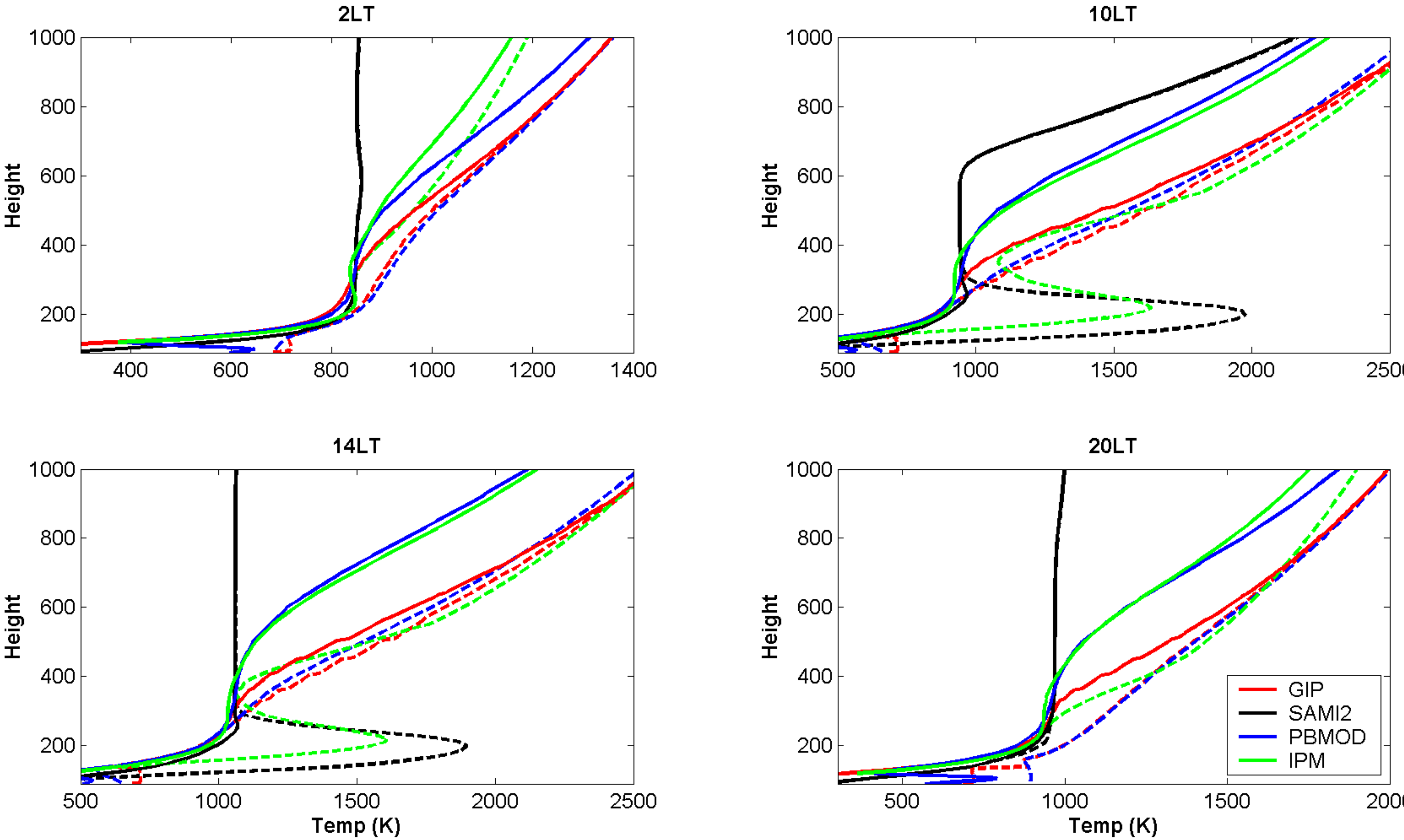
Solid line: Ti (O+) **Dashed line: TE**

Temperature: With ExB drift, no neutral wind



Solid line: Ti (O+) **Dashed line: TE**

Temperature: With ExB drift and neutral wind



Solid line: Ti (O+)

Dashed line: TE

Equation for Ion Neutral Collision Frequency (O-O+)

SAMI2 uses Baily and Balan [1996] in cgs,

$$\nu_{in} = 4.45 \times 10^{-11} n(O) T^{1/2} (1.04 - 0.067 \log_{10} T)^2$$

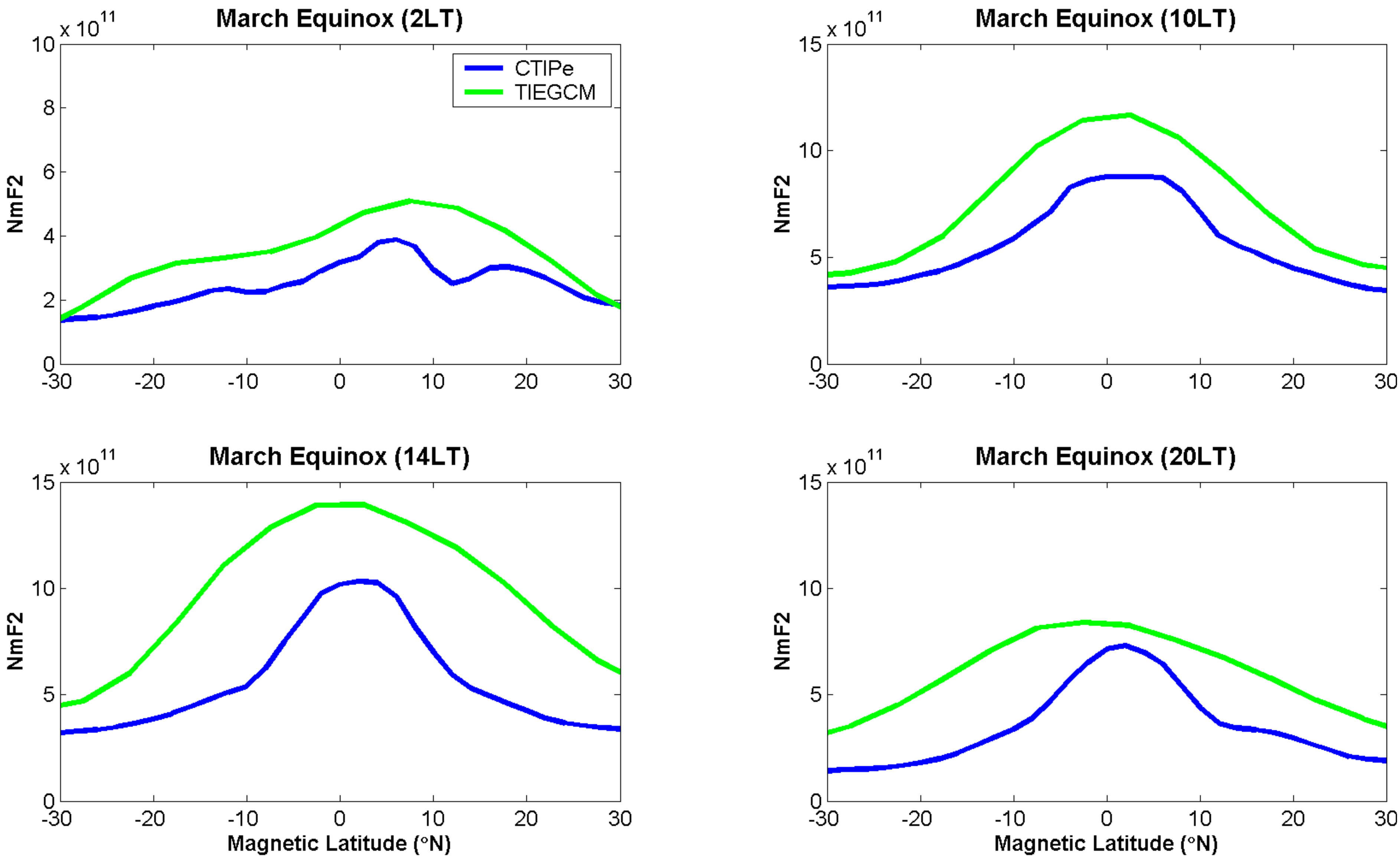
IFM, IPM, LLIONS, and **PBMOD** use Schunk and Nagy [1980] in cgs,

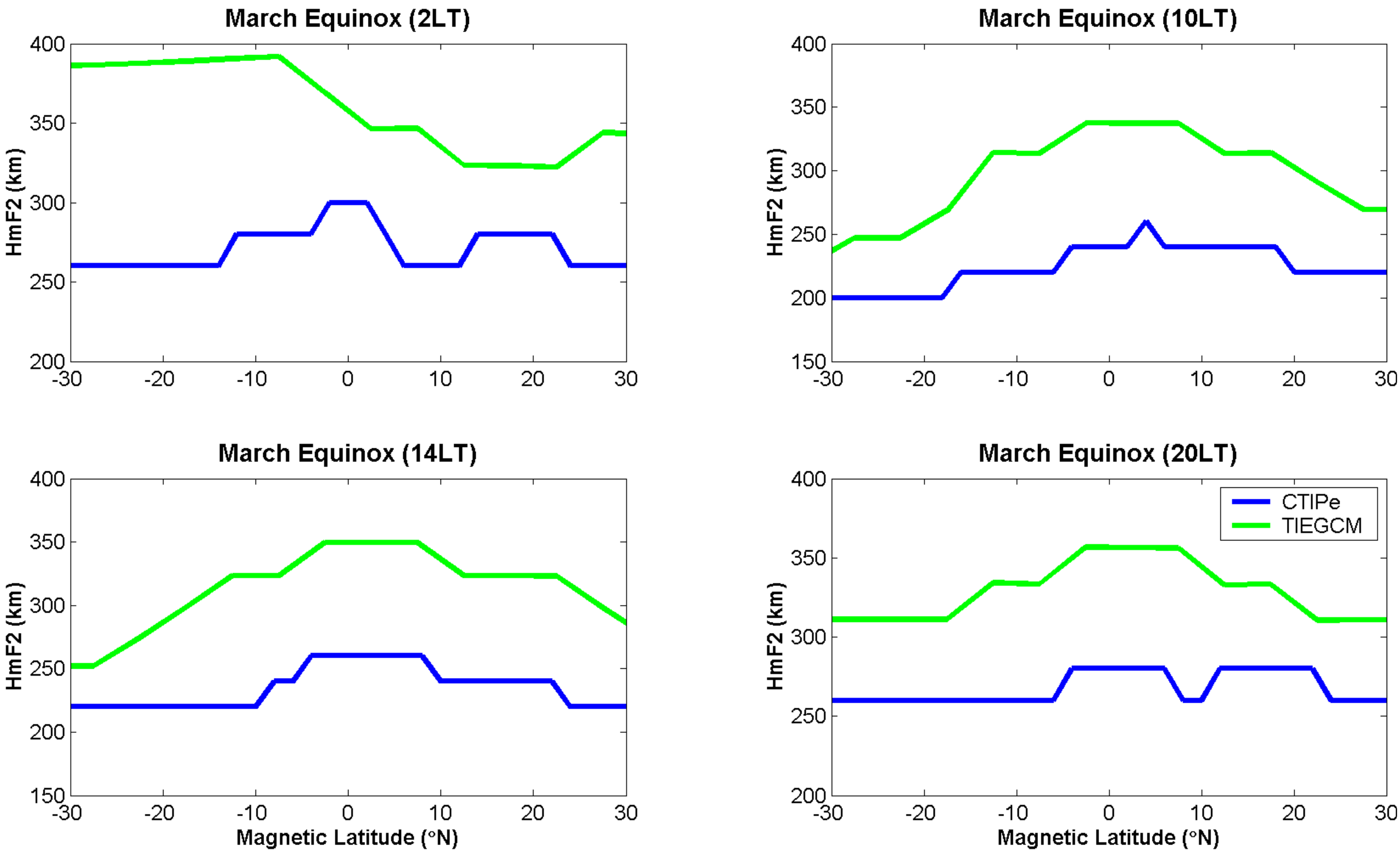
$$\nu_{in} = 3.67 \times 10^{-11} n(O) T^{1/2} (1 - 0.064 \log_{10} T)^2$$

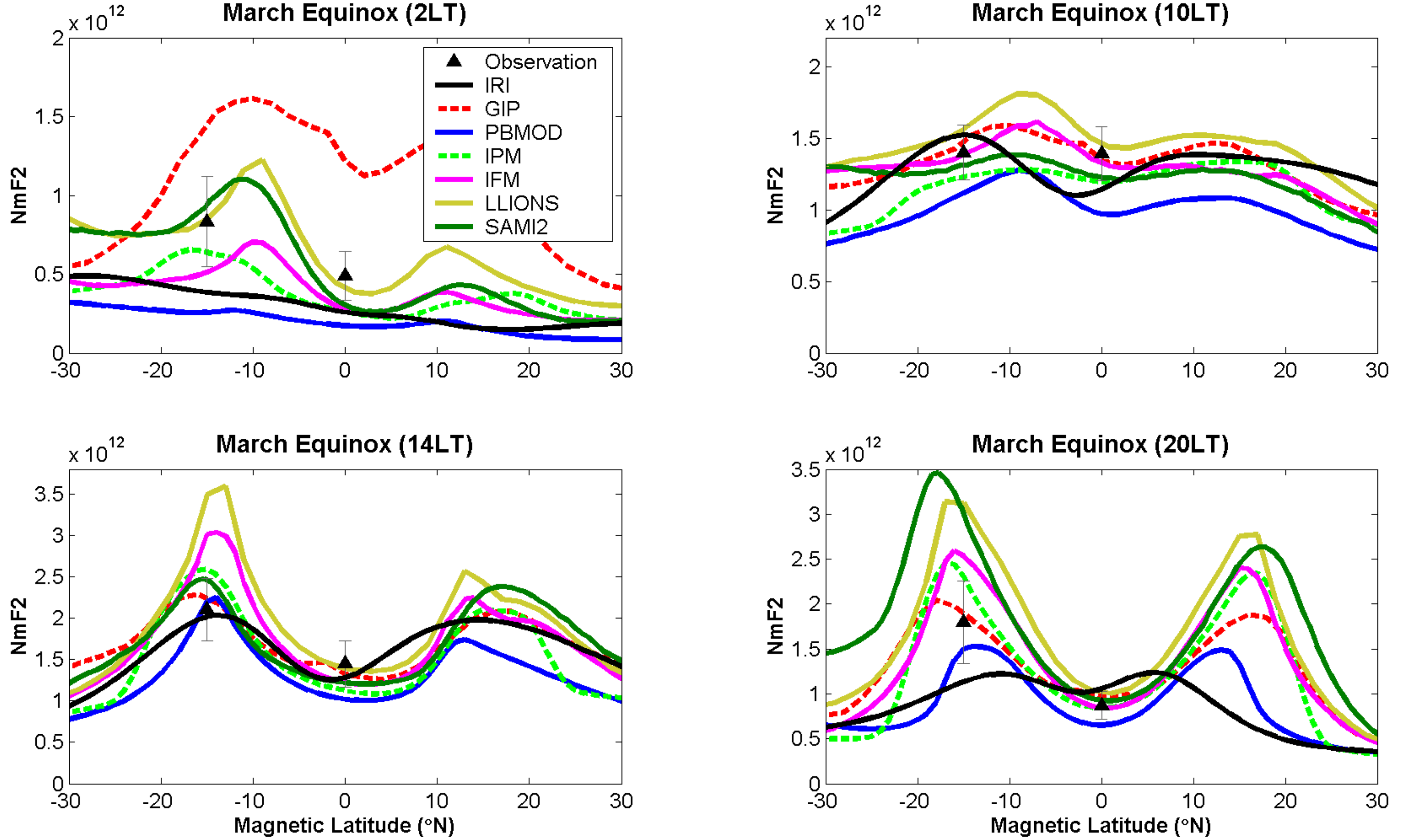
GIP uses Raitt et al. [1975] in MKS,

$$\nu_{in} = 3.42 \times 10^{-17} n(O) T^{1/2} (1.04 - 0.067 \log_{10} T)^2$$

$$T = (T_i + T_n)/2$$


March Equinox (2LT)
March Equinox (10LT)
March Equinox (14LT)
March Equinox (20LT)
x 10^11
NmF2
CTIPe
TIEGCM
Magnetic Latitude (°N)
-30 -20 -10 0 10 20 30
0 2 4 6 8 10
0 5 10 15


March Equinox (2LT)
March Equinox (10LT)
March Equinox (14LT)
March Equinox (20LT)
HmF2 (km)
Magnetic Latitude (°N)
CTIPe
TIEGCM
400
350
300
250
200
150
-30
-20
-10
0
10
20
30



Electron Temperature at Magnetic Equator

LT	IRI	LLIONS	IFM	IPM	SAMI2	GIP	PBMOD
2	956.4	884.9	Same as LLIONS	889.9	832	1295	946.21
10	1326.1	1293.6		1297.7	948	2466	1264.77
14	1273.9	1288.3		1286	1053	2761	1262.29
20	1085.6	1216.8		1255	929	1484	1264.68