Seasonal and Local Time Variation of Ionospheric Migrating Tides in 2007-2011 FORMOSAT- 3/COSMIC and TIE-GCM TEC

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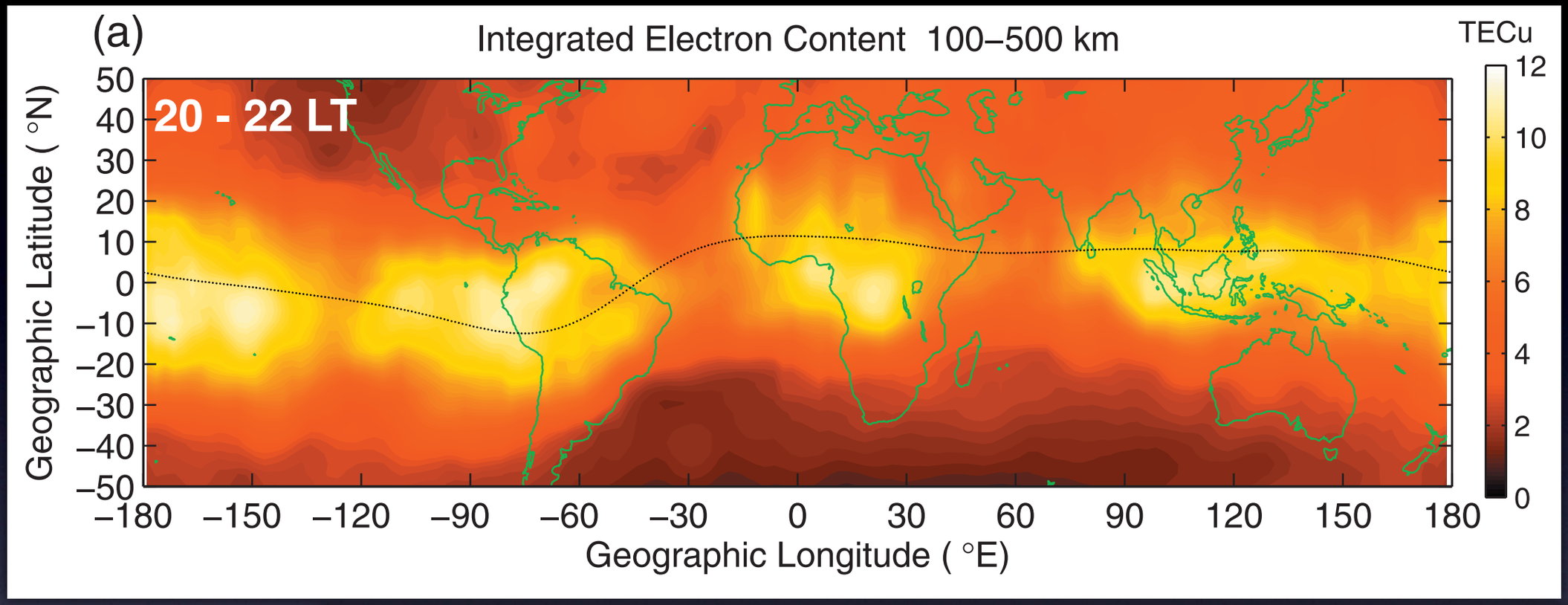
Tides in Constant Local Time

Lin et al., GRL 2007, doi:10.1029/ 2007GL029265



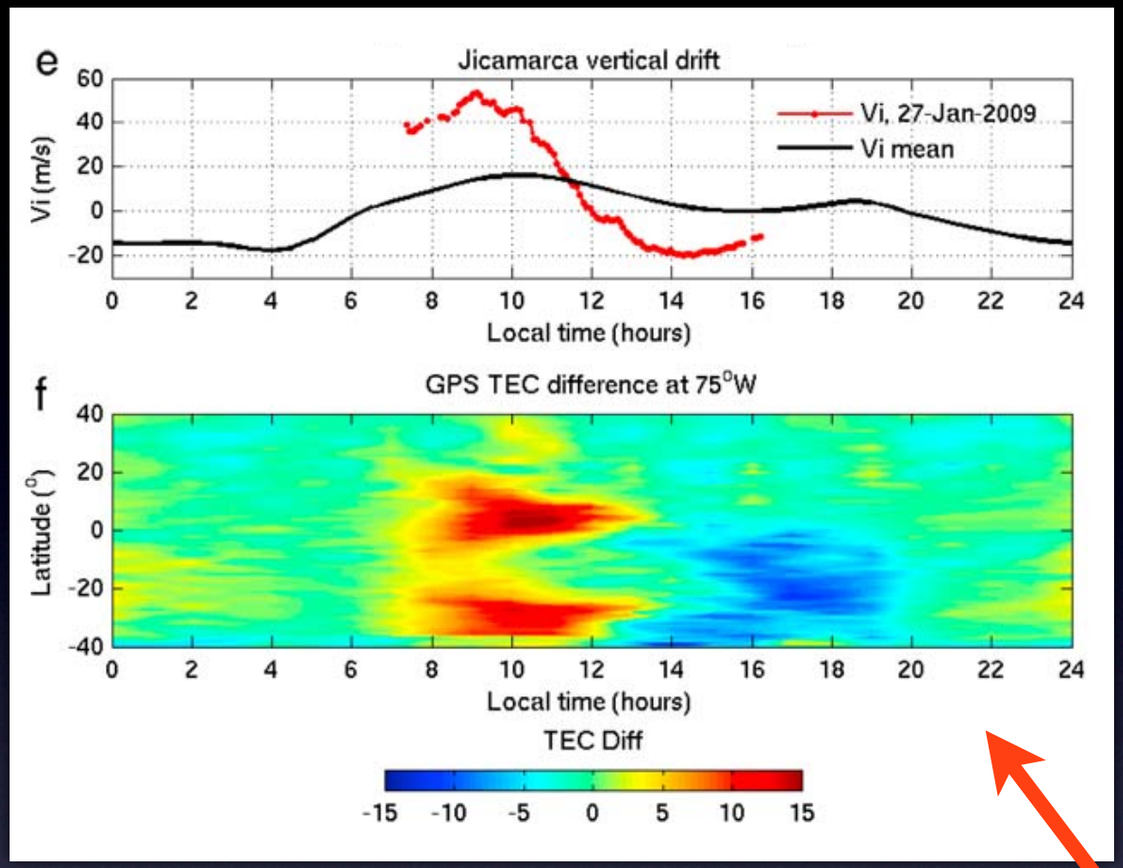
Aliased into as stationary planetary waves

Aliased into zonal mean

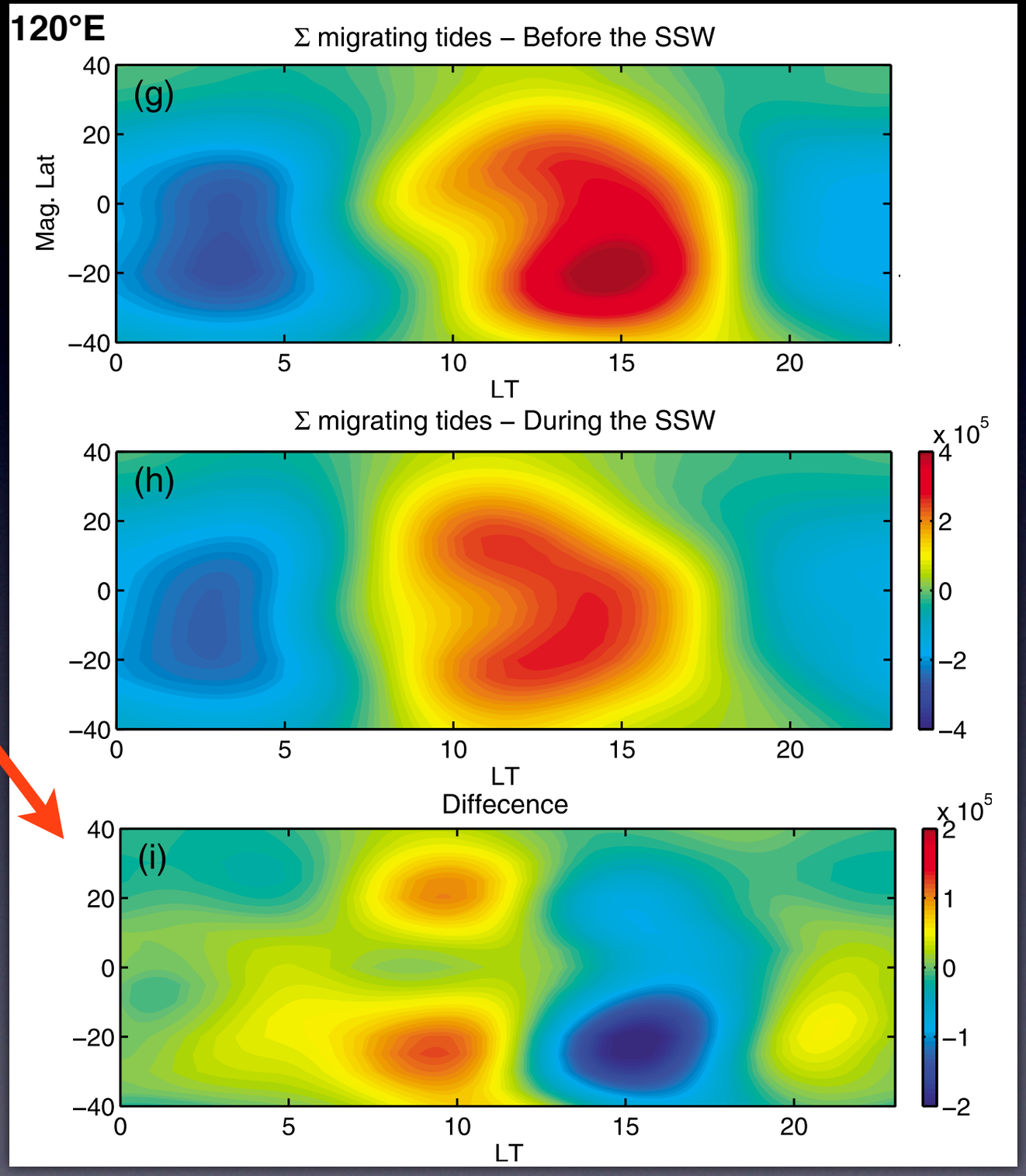
Migrating Tides ($n = -s$):
Sun-synchronous. Identical local time variation at all longitudes (λ).

Nonmigrating Tides ($n \neq -s$):
Non Sun-synchronous. Local time variation changes at different longitudes (λ).

Observations and model results suggest migrating tides drive most ionospheric variability around SSWs.



Goncharenko et al., GRL 2010, doi:10.1029/2010GL043125

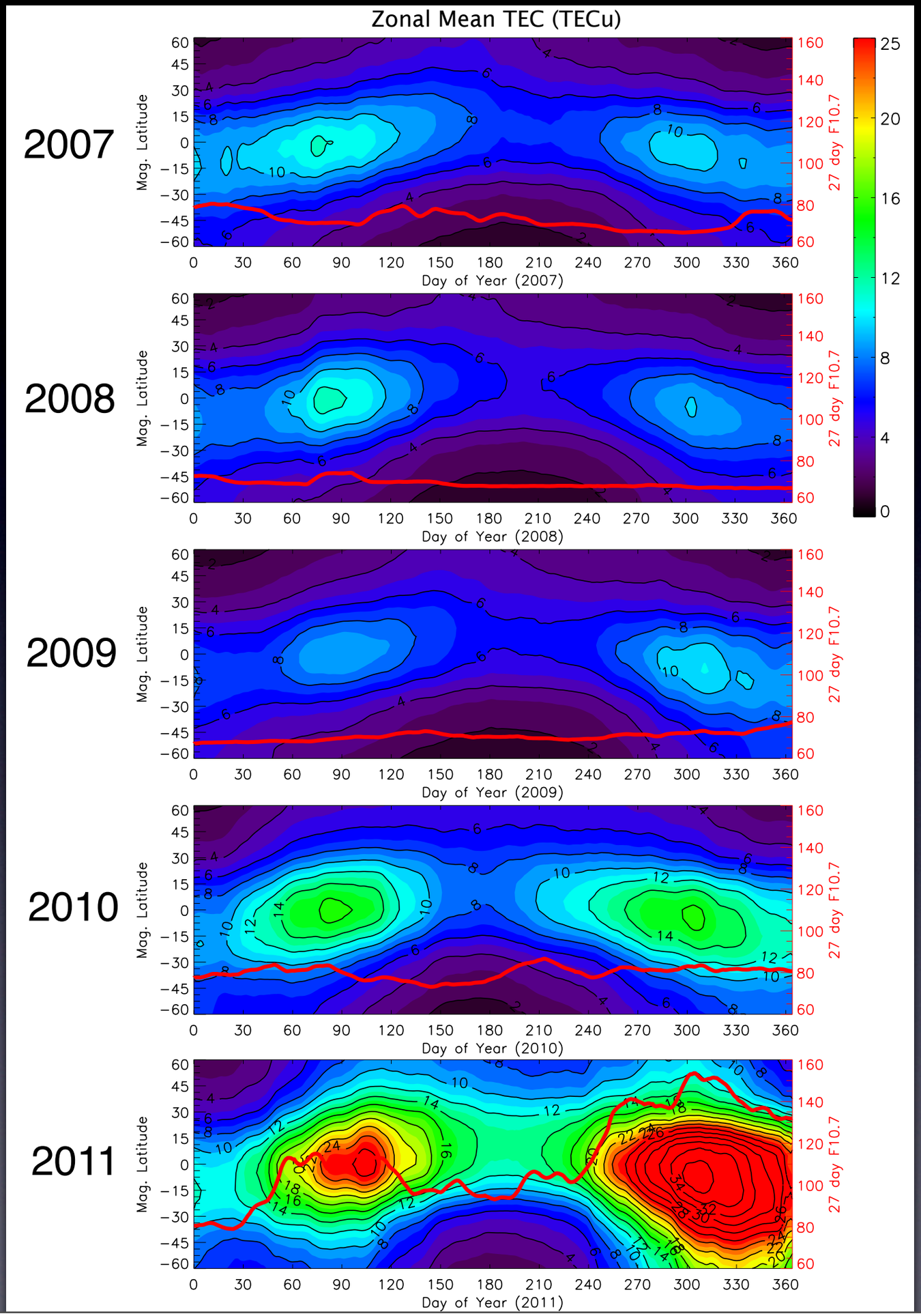


Lin et al., GRL 2012, doi:10.1029/2011GL050248

QUESTIONS:

- What features of ionospheric local time variation correspond to migrating tides in the ionosphere?
- What is the relation between migrating tidal components in the ionosphere and in the MLT?

FORMOSAT-3/COSMIC: Zonal Mean TEC & F10.7

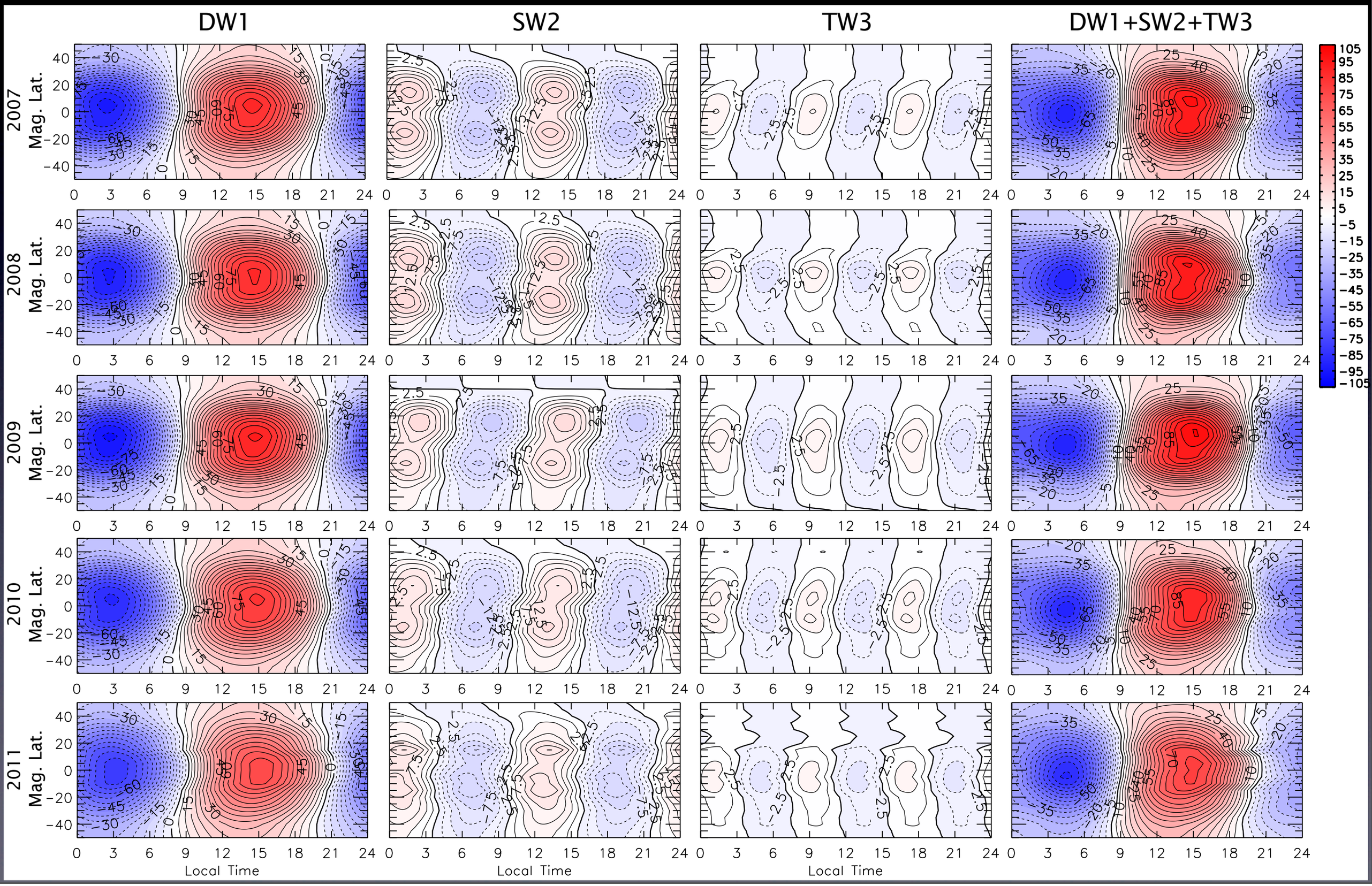


Electron densities from 2007 - 2011 FORMOSAT-3/ COSMIC occultations vertically integrated from 200 - 800 km, and fitted to tidal, SPW, and zonal mean.

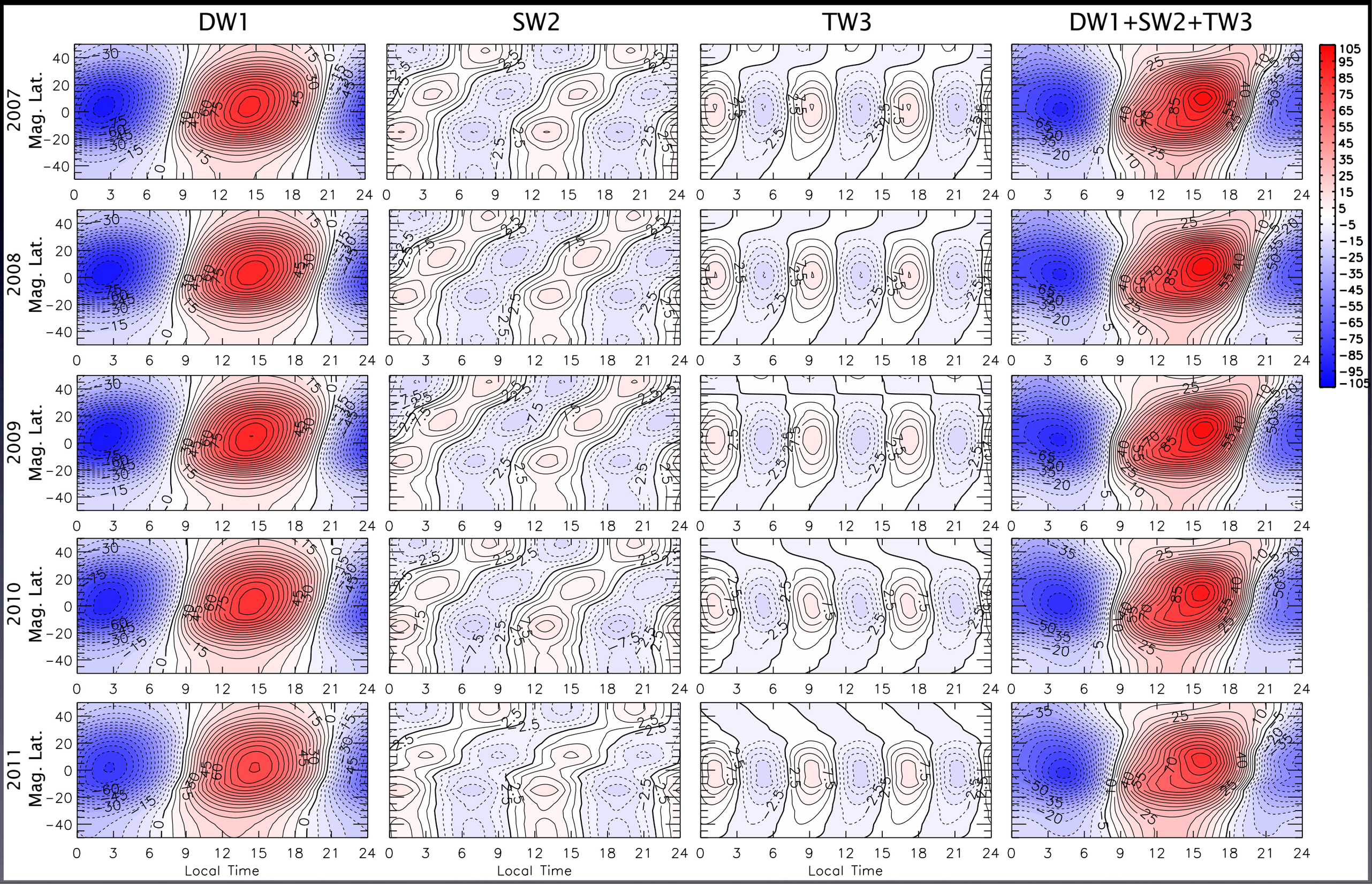
Inter-annually repeating variation, consistent with seasonal composition changes in O/N2 found by previous studies.

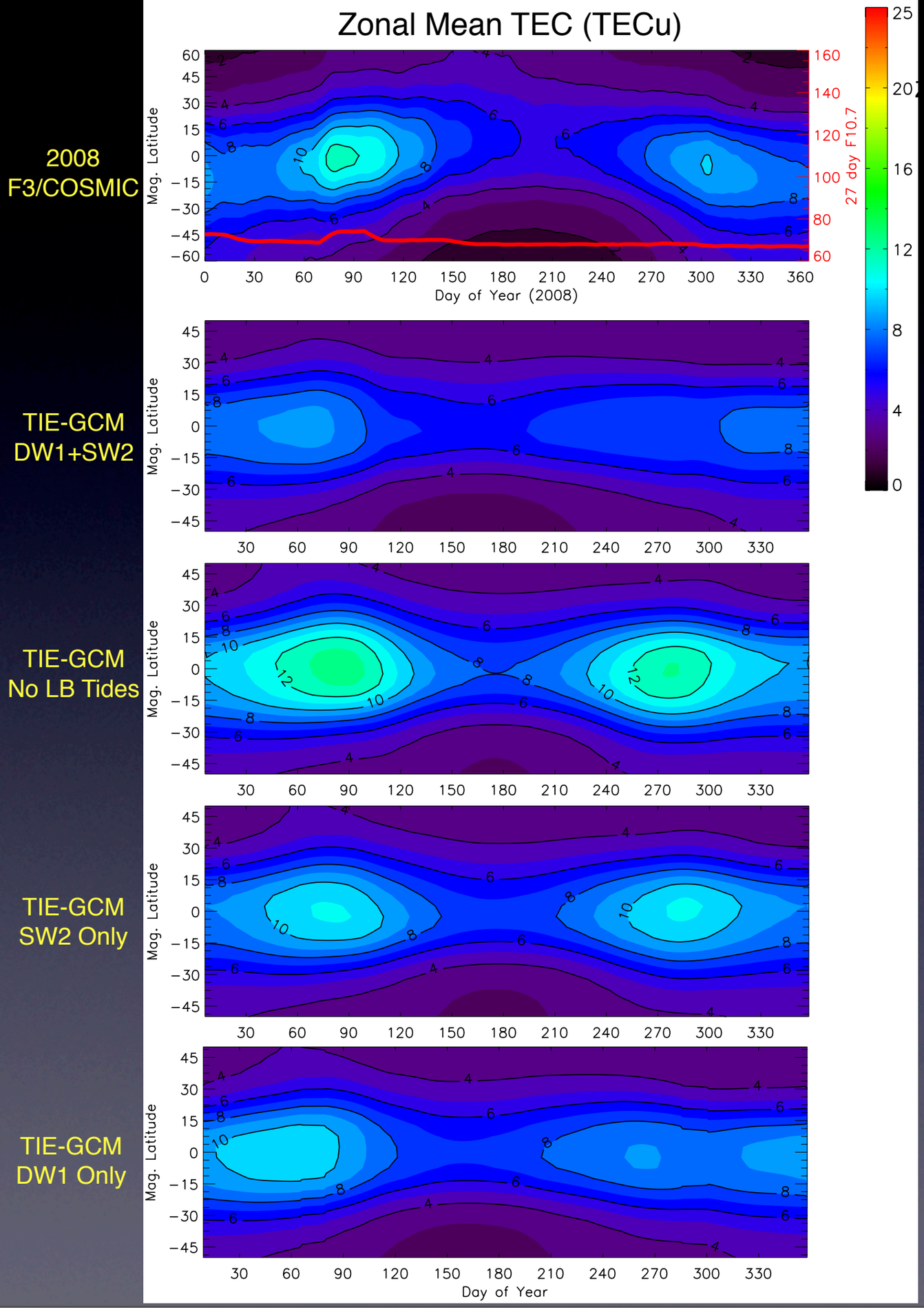
All fitted tidal components show positive relation to zonal mean and F10.7.

FORMOSAT-3/COSMIC: TEC Migrating Tides
Equinox Local Time Variation



FORMOSAT-3/COSMIC: TEC Migrating Tides
Solstice (NH Summer)





TIE-GCM: Migrating Tidal Coupling

Physics based TIE-GCM reproduces most seasonal variability in TECs.

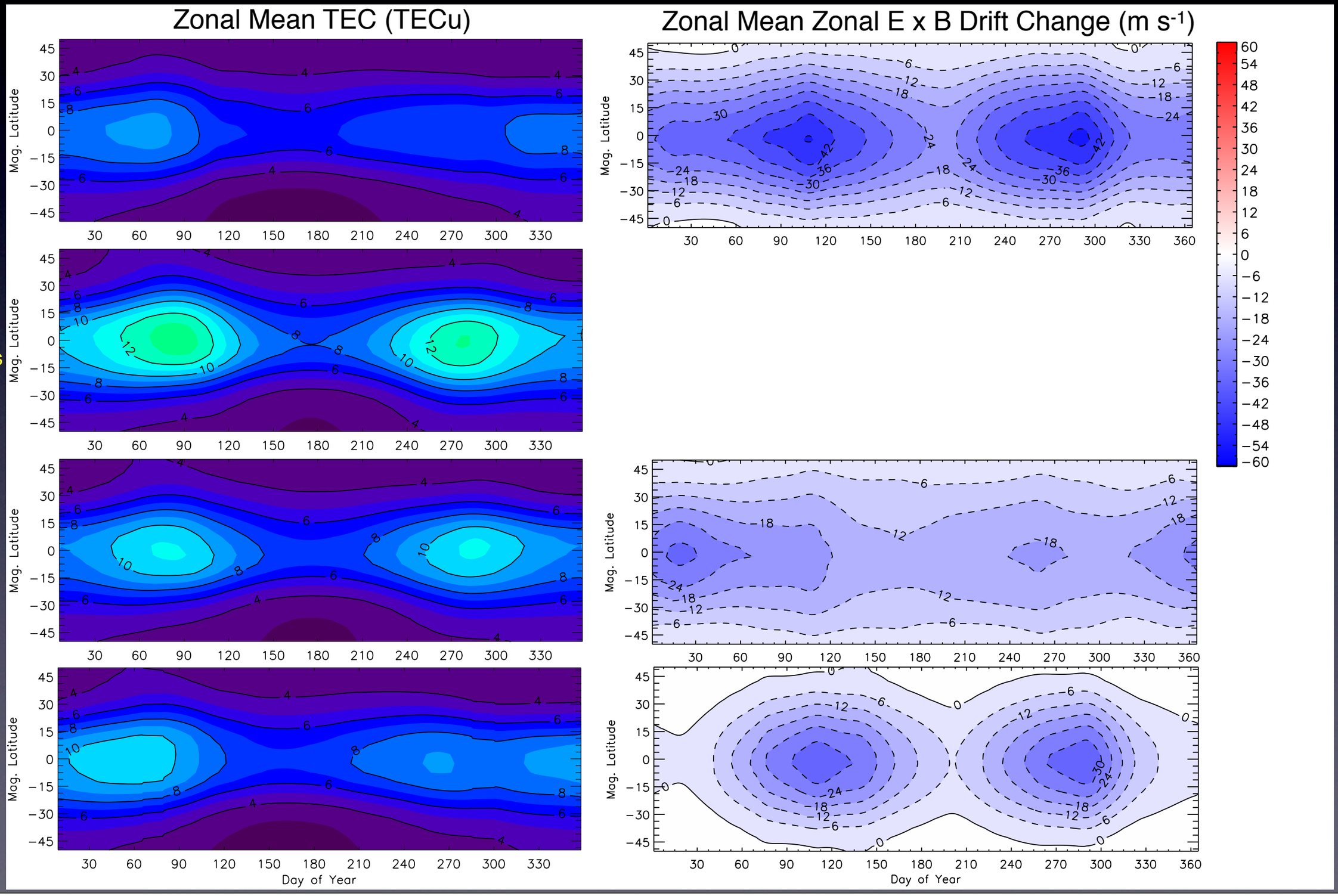
1 year runs of TIE-GCM (F10.7 = 70) to understand relation between migrating tides in neutral middle atmosphere and ionosphere.

TIE-GCM lower boundary (99 km) forced by migrating tide climatology from GSWM:

- DW1 + SW2
- No lower boundary forcing
- SW2 only
- DW1 only

TIE-GCM
Zonal Mean TEC Sensitivity

Zonal mean TEC decreases coincident with enhanced westward E x B drift throughout entire model (vertical and meridional E x B drift changes small).

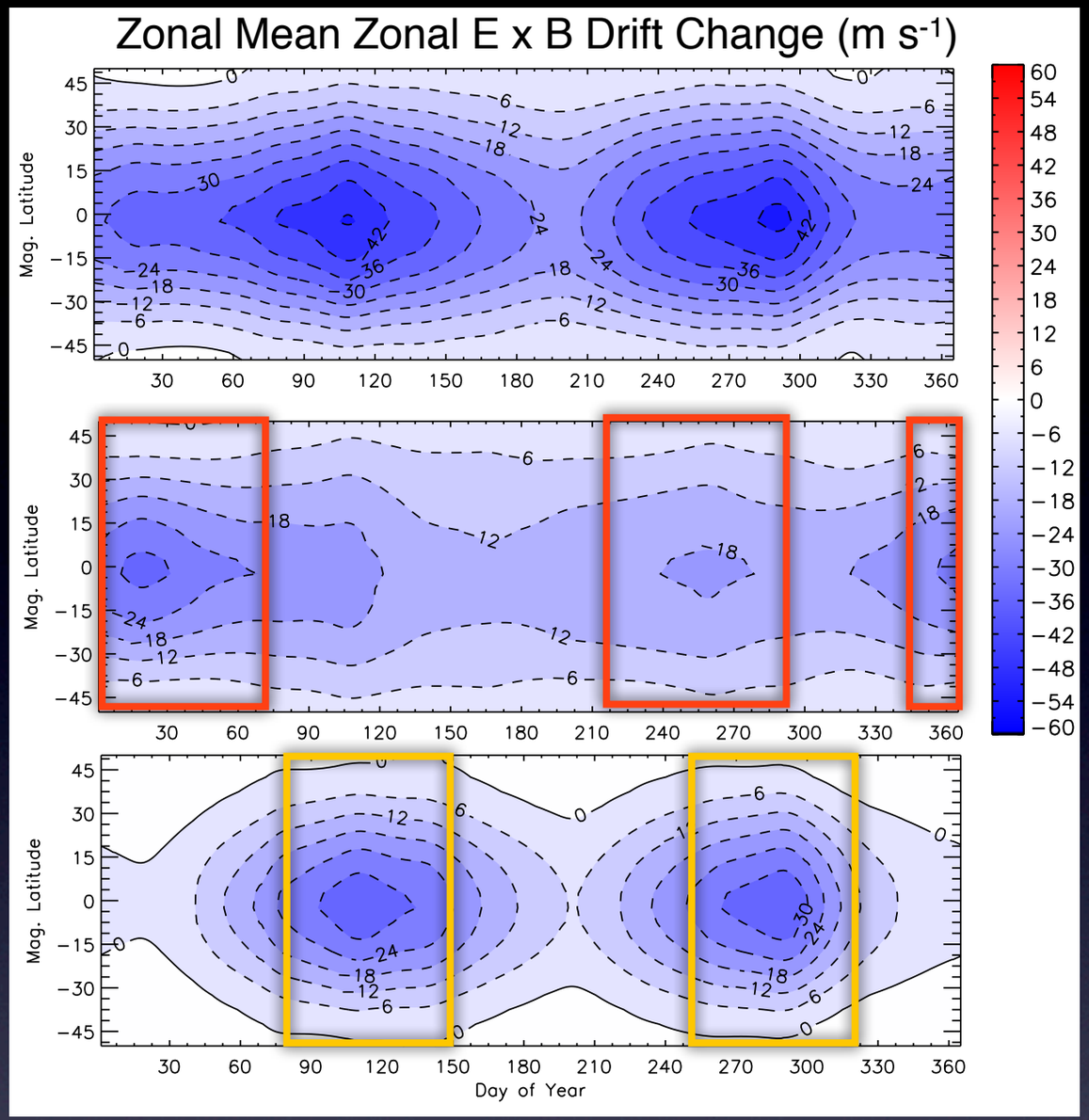


TIE-GCM
Zonal Mean TEC Sensitivity

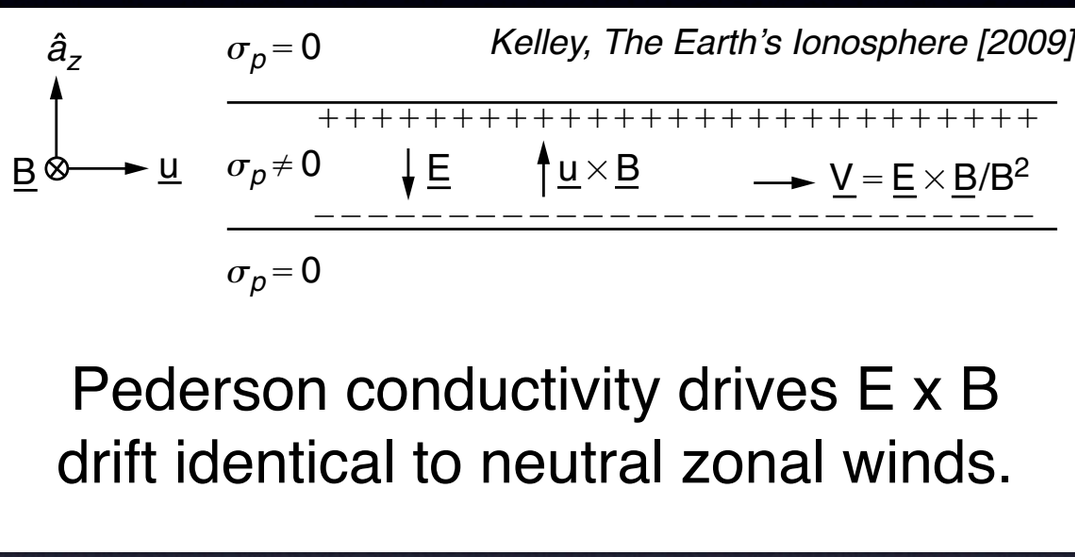
TIE-GCM
DW1+SW2

TIE-GCM
SW2 Only

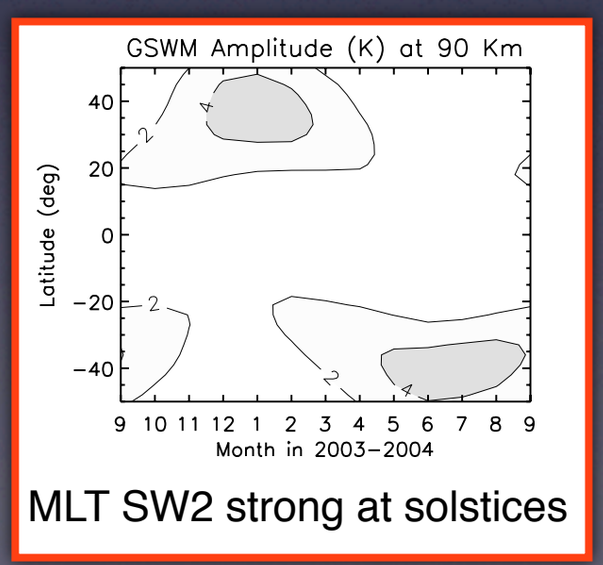
TIE-GCM
DW1 Only



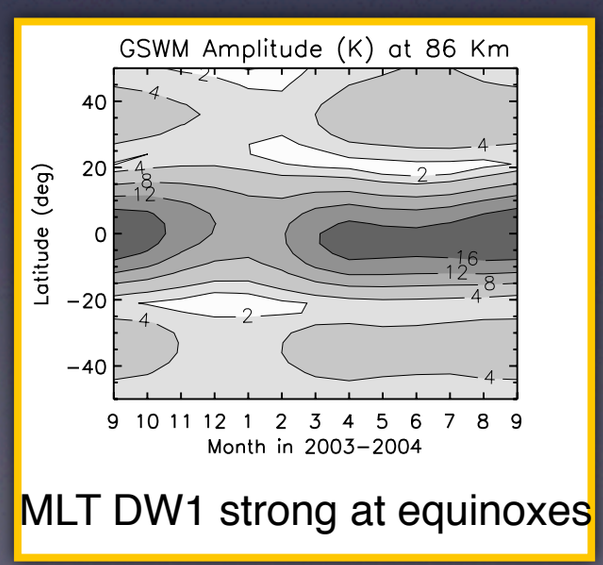
Westward changes in zonal mean E x B drift nearly identical to those resolved in TIE-GCM neutral zonal mean zonal winds



Pederson conductivity drives E x B drift identical to neutral zonal winds.



MLT SW2 strong at solstices



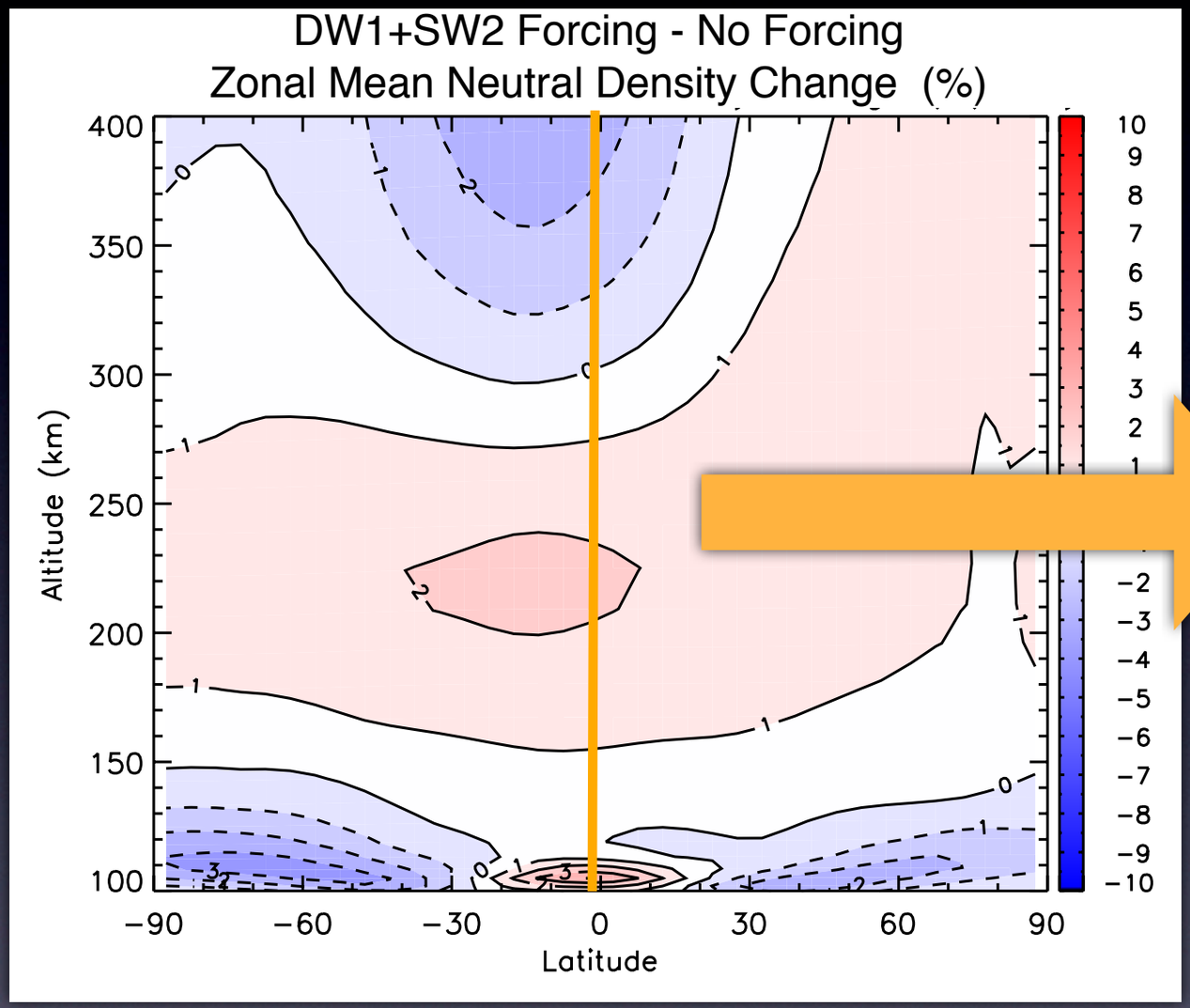
MLT DW1 strong at equinoxes

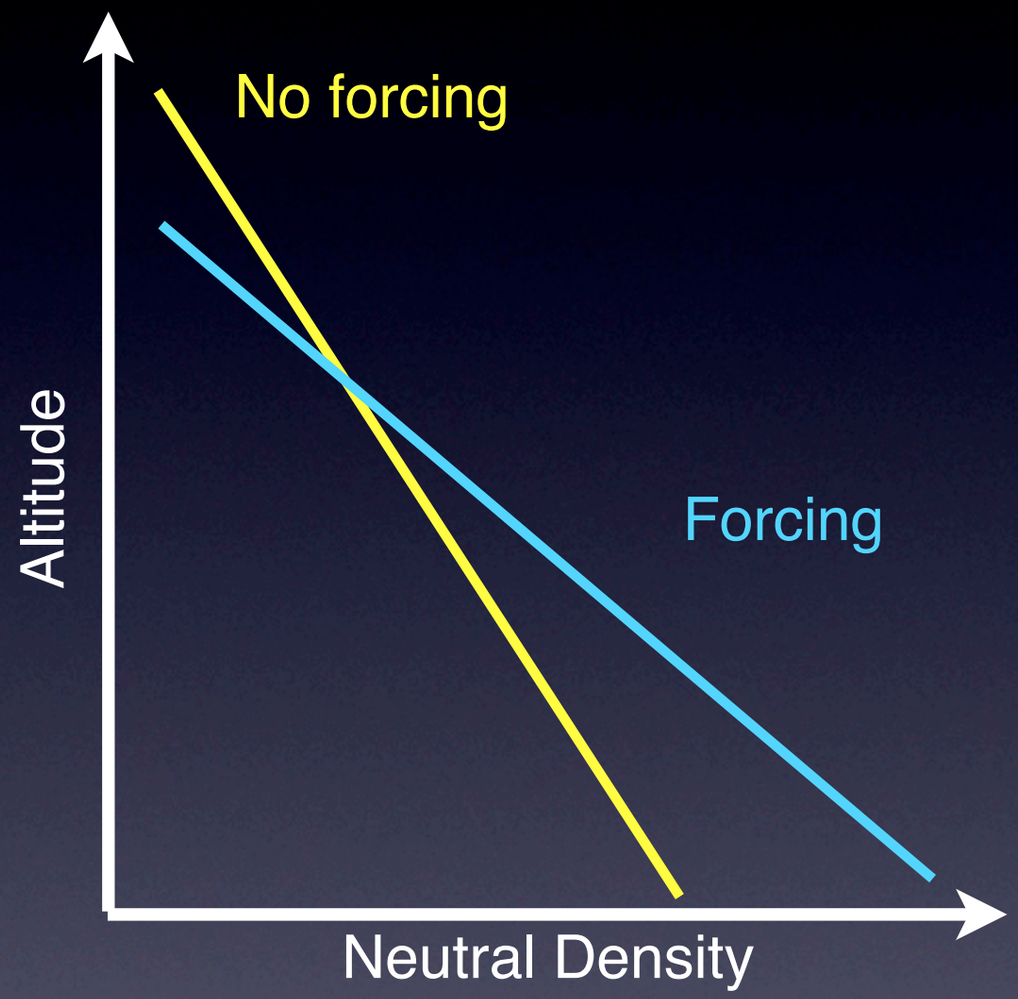
Enhanced westward E x B drift can be attributed to westward forcing on neutral zonal mean zonal winds by migrating tides.

- May result in further changes to neutral thermospheric circulation and composition.
- TEC DW1 morphology nearly identical to zonal mean TECs.

Zhang et al., JGR 2006, doi:10.1029/2005JA011504

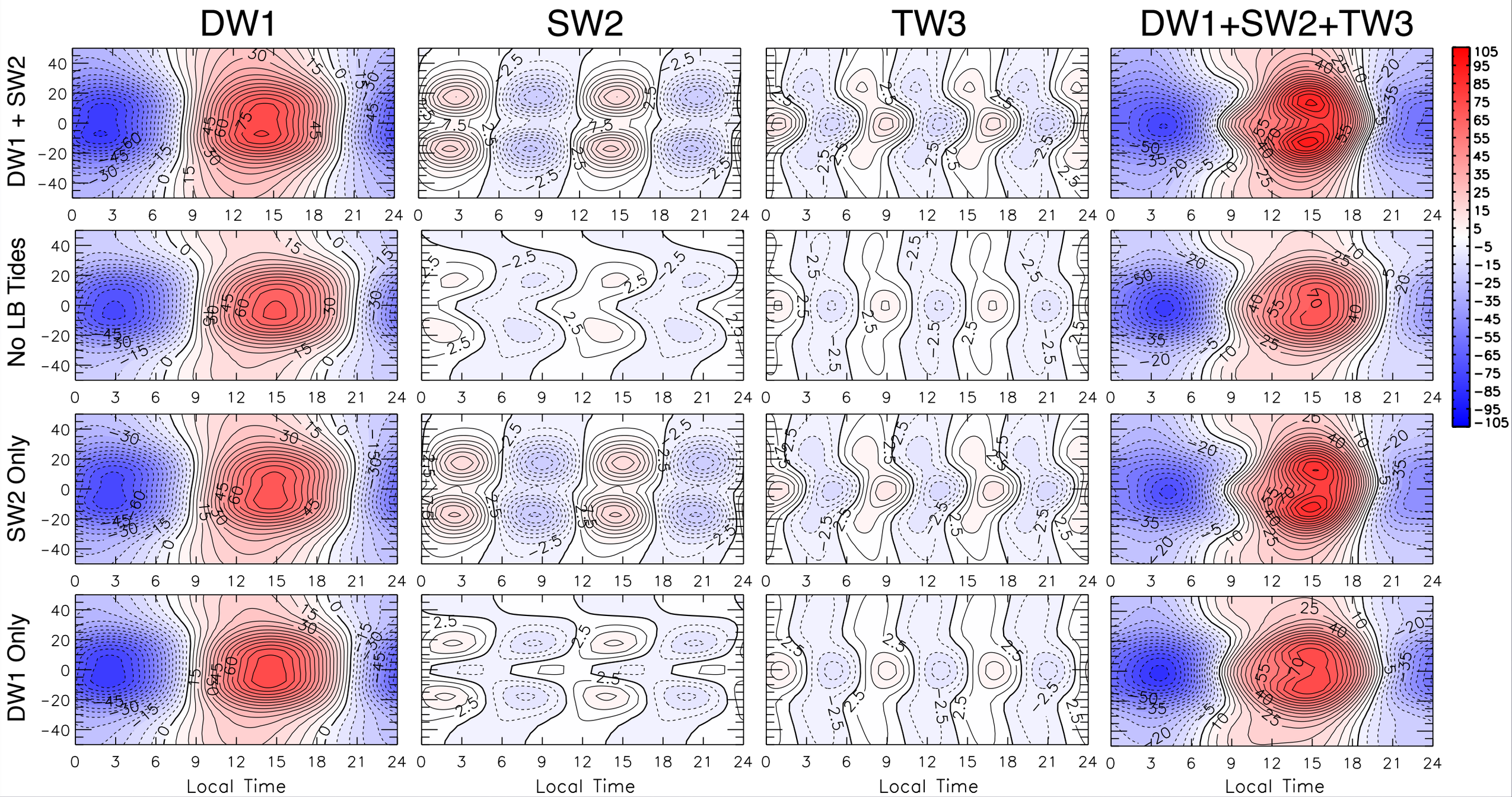
TIE-GCM:
Zonal Mean Neutral Density Sensitivity





Change in zonal mean neutral density due to migrating tidal forcing consistent with contraction of scale height due to decrease of O/N2.

TIE-GCM
Changes to Local Time Variation (Equinox)



In-situ photoionization

EIA crests / equatorial fountain

Equatorial trough

Conclusions

Migrating tides in FORMOSAT-3/COSMIC TECs correspond to specific features of ionospheric local time variation:

TEC Tidal Component	Ionosphere LT Variation Feature	Coupling Mechanism	Coupled To
Zonal Mean	Background	Westward forcing on neutral zonal mean winds	MLT DW1
DW1	Elevated daytime plasma densities	In-situ photoionization	Zonal mean TECs
SW2	EIA crests	Equatorial fountain	MLT SW2
TW3	Equatorial trough between EIAs	In-situ photoionization + nonlinear interaction	MLT SW2

Chang, L.C., C.-H. Lin, J.-Y. Liu, B. Nanan, J. Yue, and J.-T. Lin (2013), Seasonal and Local Time Variation of Ionospheric Migrating Tides in 2007-2011 FORMOSAT-3/COSMIC and TIE-GCM Total Electron Content, *J. Geophys. Res.*, 118, doi:10.1002/jgra.50268.