Burst of Unusual Quasi-10 day Wave During the 2019 Southern Sudden Stratospheric Warming

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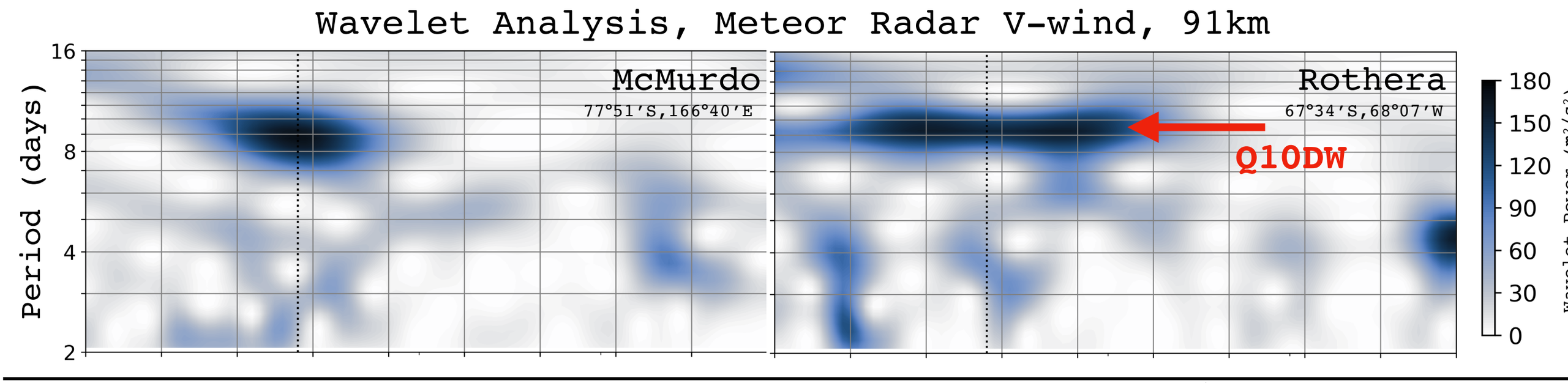
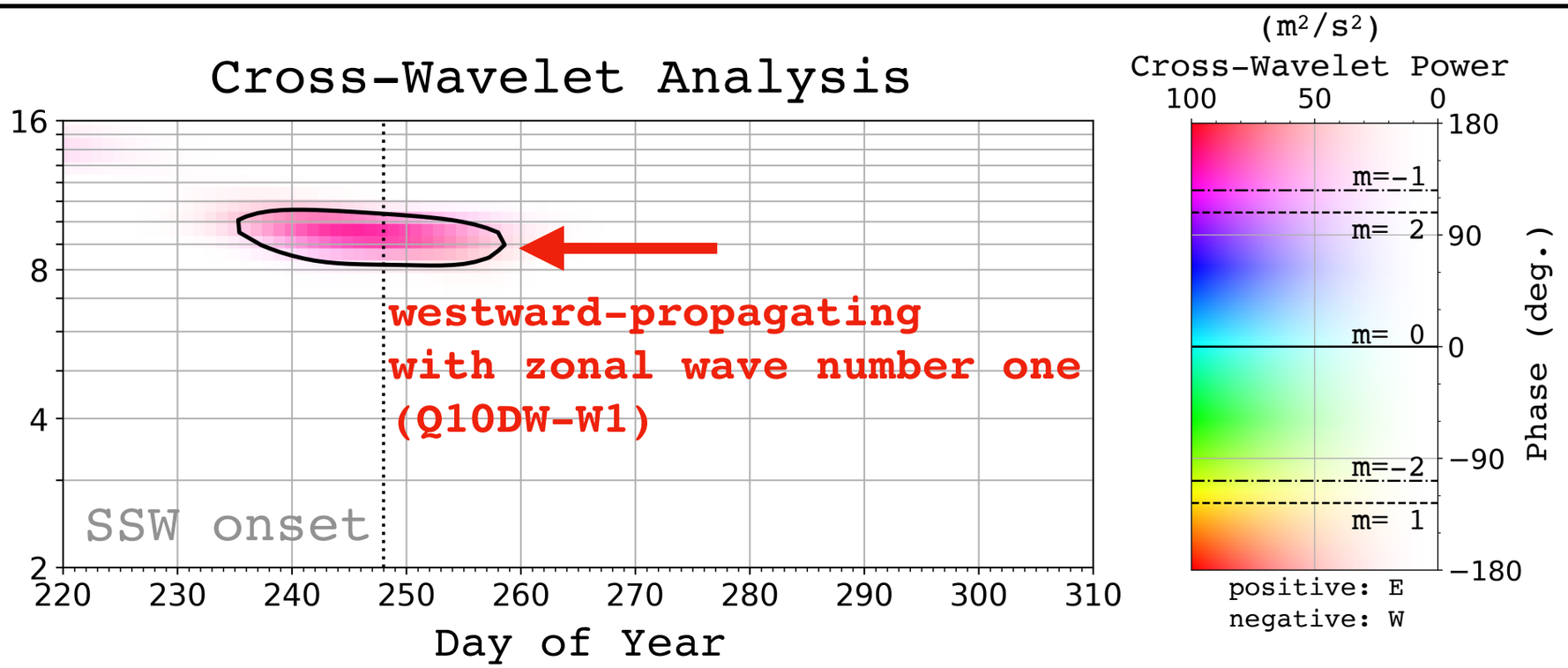
A transient quasi-10-day wave (Q10DW) is present in Antarctica during the 2019 Southern Hemisphere SSW

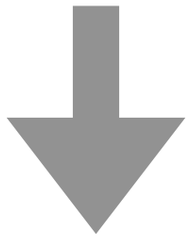




dominant wave number can be resolved through phase-differencing by cross-wavelet analysis between the two stations (He et al., 2018)

Normal mode and instability hypotheses for Rossby-normal mode waves

Initial Forcing	barotropic/baroclinic instabilities in background flow
	waves generated via instability are expected to have a phase speed similar to the background flow



Global Response	waves close to a resonant response of the atmosphere trigger the global response of such normal modes

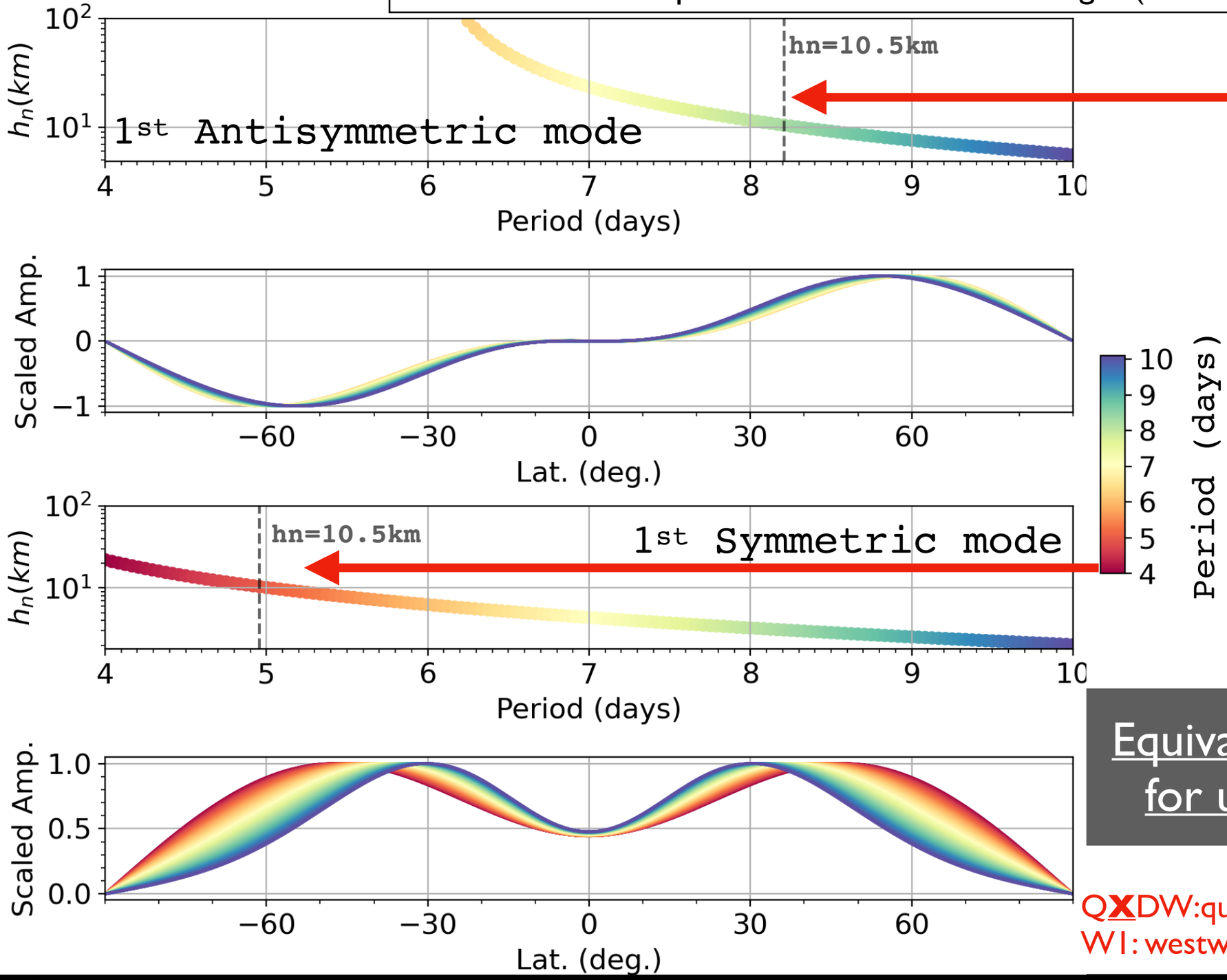
e.g., Q2DW-W3, Q6DW-W1, Q10DW-W1, Q16DW-W1

Q:Quasi, D:day, W:wave, W1: westward-propagating zonal wave number 1

Latitudinal structure of unforced normal mode can be predicted by solving the classical Laplace's tidal equation.

Assumption

- forcing in the vertical structure equation is zero
- isothermal atmosphere -> a constant scale height (H=7.5 km)



Q10DW-W1

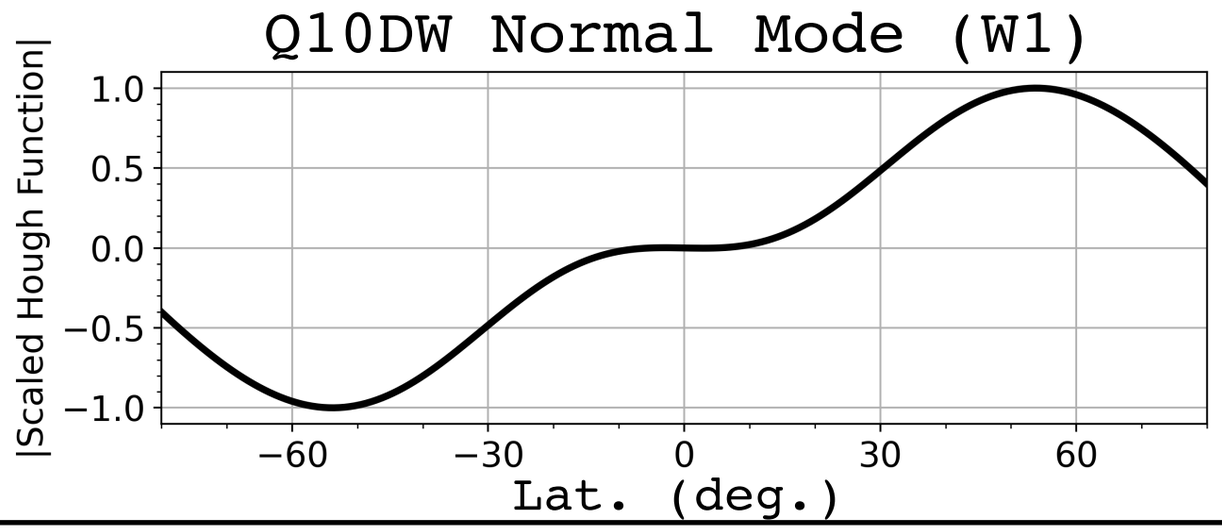
Q6DW-W1

Equivalent Depth(hn)=10.5km for unforced normal mode

QXDW:quasi-X-day wave
W1: westward-propagating zonal wave number 1

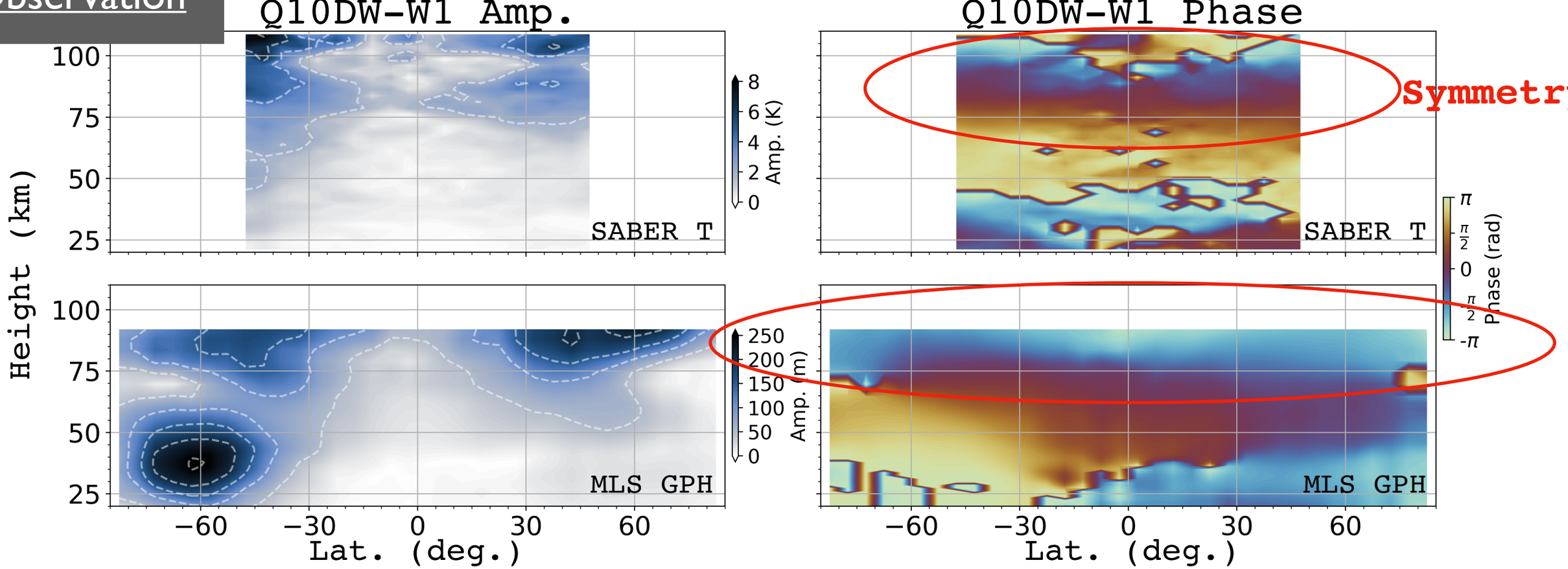
Observed Q10DW-W1 is symmetric, contrary to classical theory which predicts the presence of an unforced normal mode

Theory



Antisymmetry

Observation

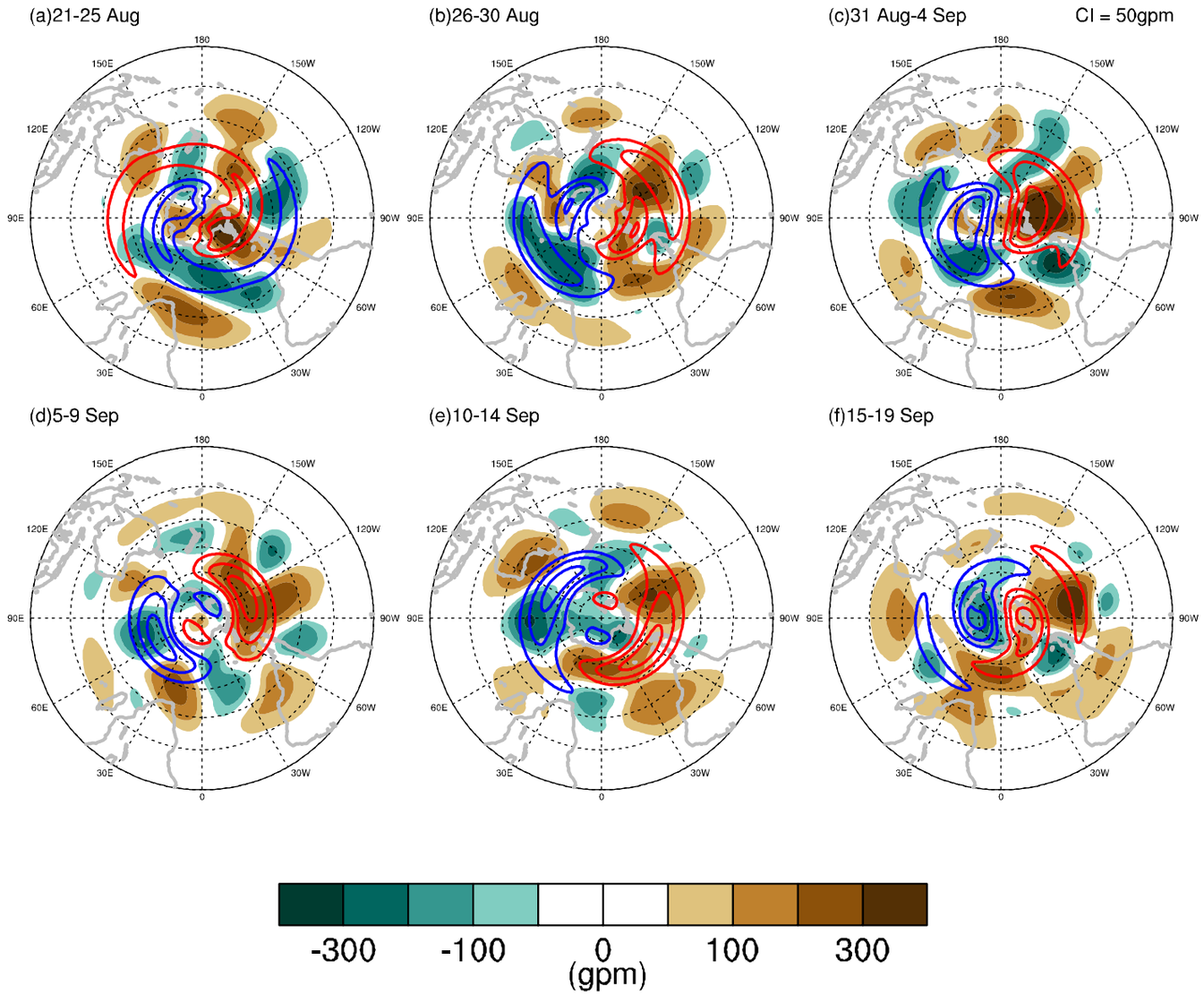


Symmetry

Observed Q10DW-W1 is likely a forced mode.

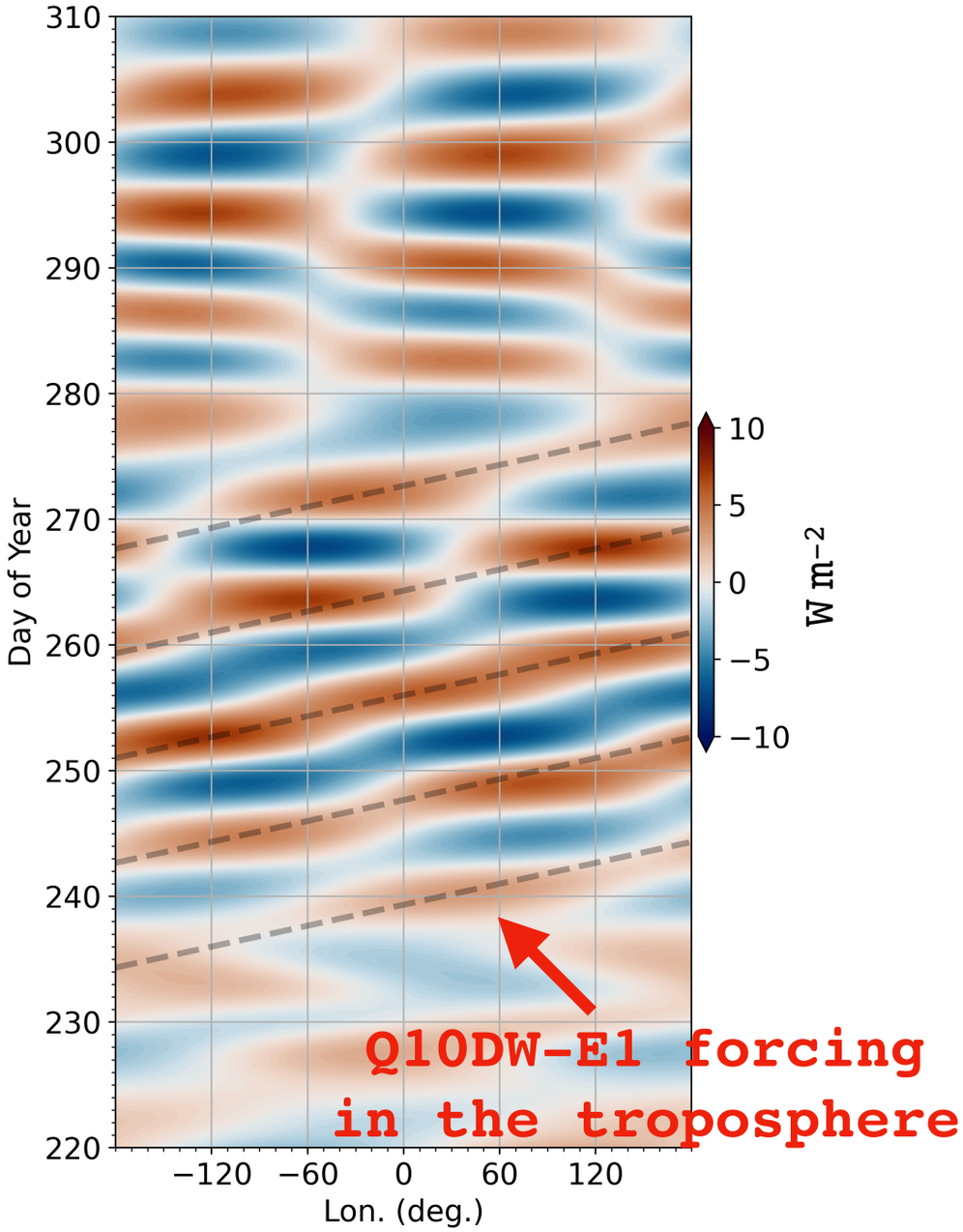
Origin of the forcing of the Q10DW-W1, and the nature of its excitation mechanism are key questions

250-hPa 5-day GPH anomalies (shading, level=50 m)
WN1 component (contour, level=25 m)



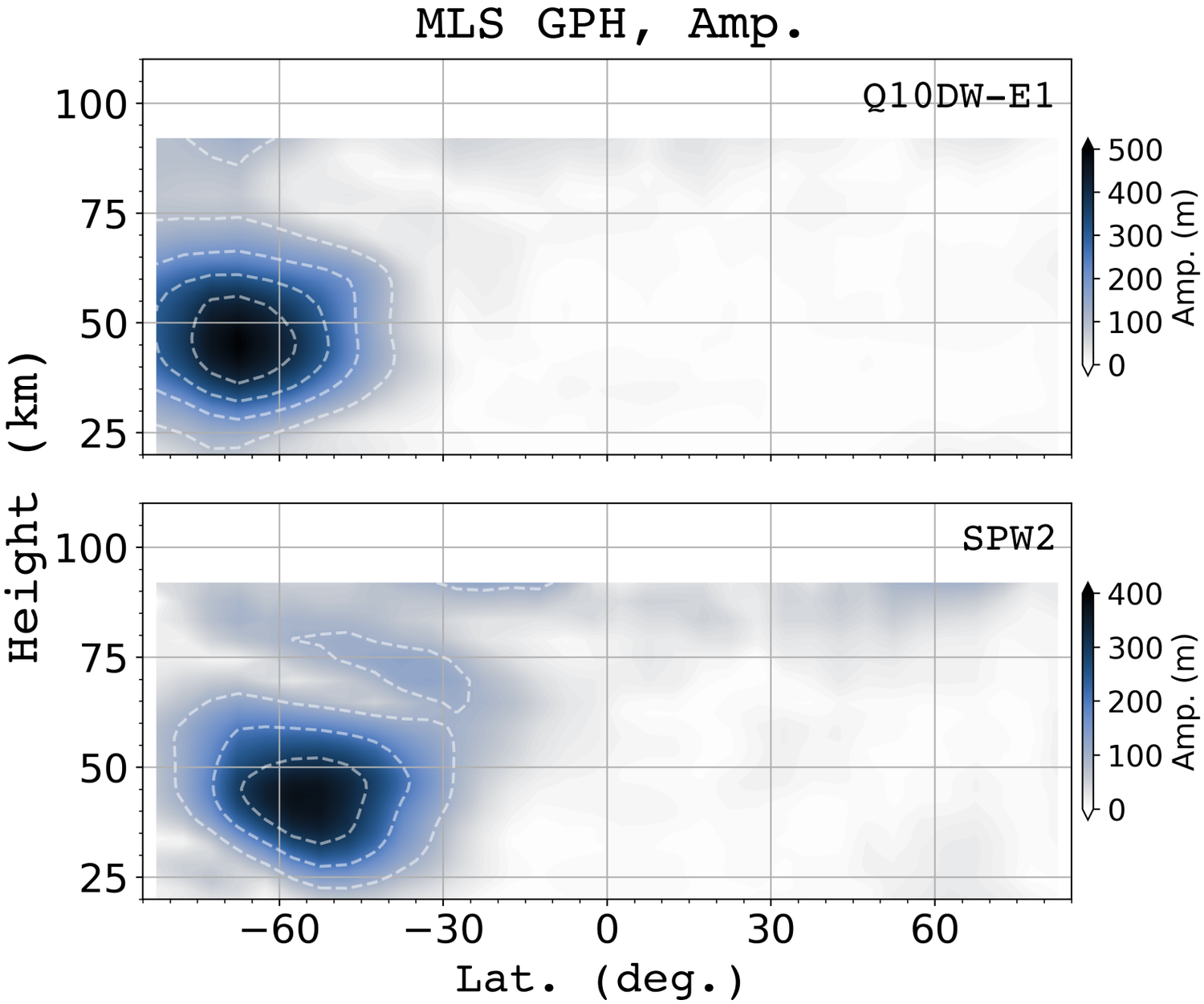
courtesy of Shen et al. (2020)

surface latent energy flux, WN 1
50°S-70°S, bandpass[7-12 days]



Q10DW-E1: Eastward propagating quasi-10 day wave with zonal wave number 1

Q10DW-W1 was forced during the 2019 S. Hemisphere SSW possibly through Q10DW-E1 nonlinear interaction with SPW2



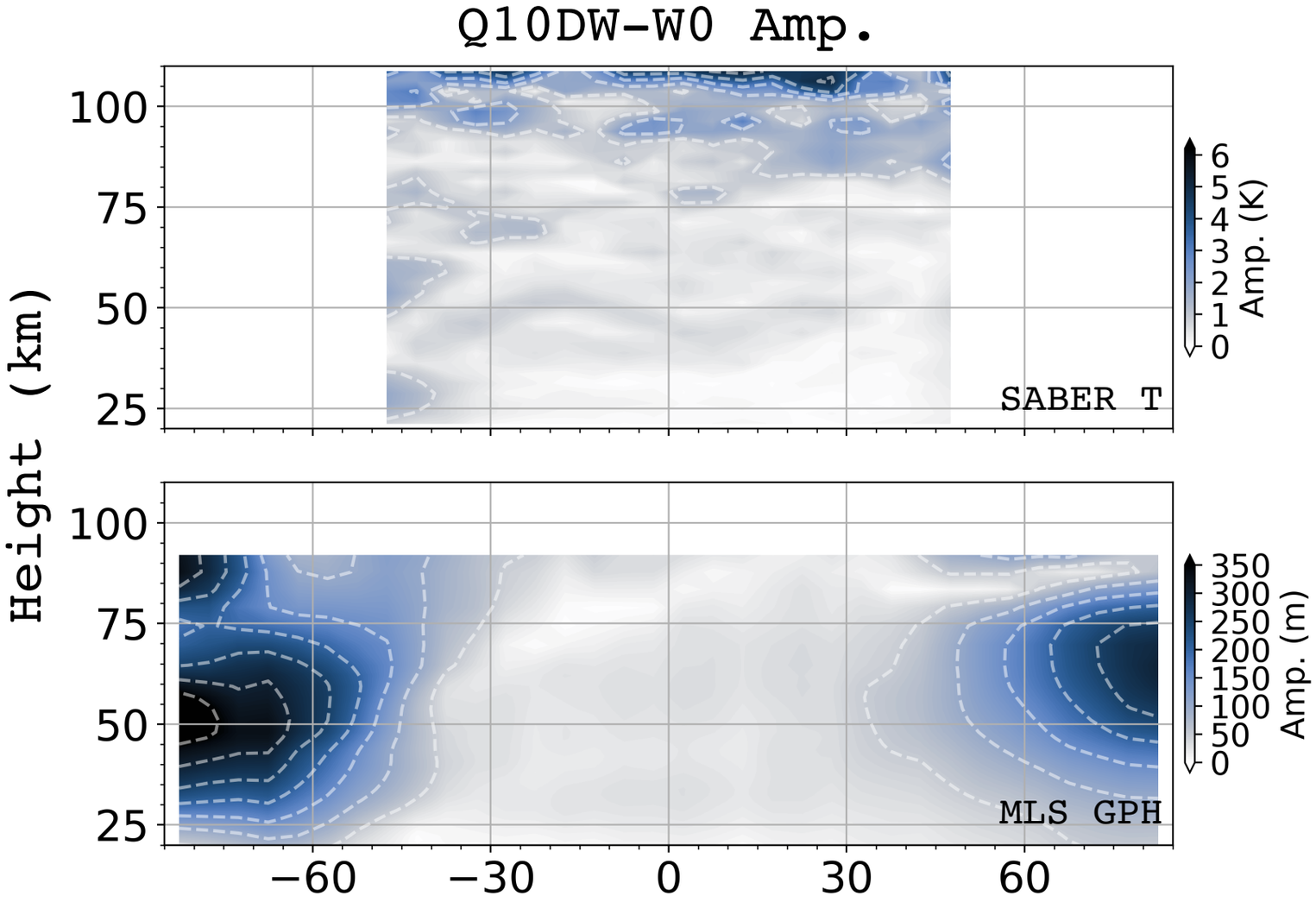
Parent Waves
(1) Q10DW-E1 x SPW2
(2) Q10DW-E1 x SPW1

Nonlinear wave-wave interaction

Child Waves
(1) Q10DW-W1, Q10DW-E3
(2) Q10DW-W0, Q10DW-E2

SPW1: Stationary planetary wave with zonal wave number 1
SPW2: Stationary planetary wave with zonal wave number 2
Q10DW-E1: Eastward propagating quasi-10 day wave with zonal wave number 1

Zonally symmetric Q10DW (Q10DW-S0) was also excited through Q10DW-E1 nonlinear interaction with SPW1



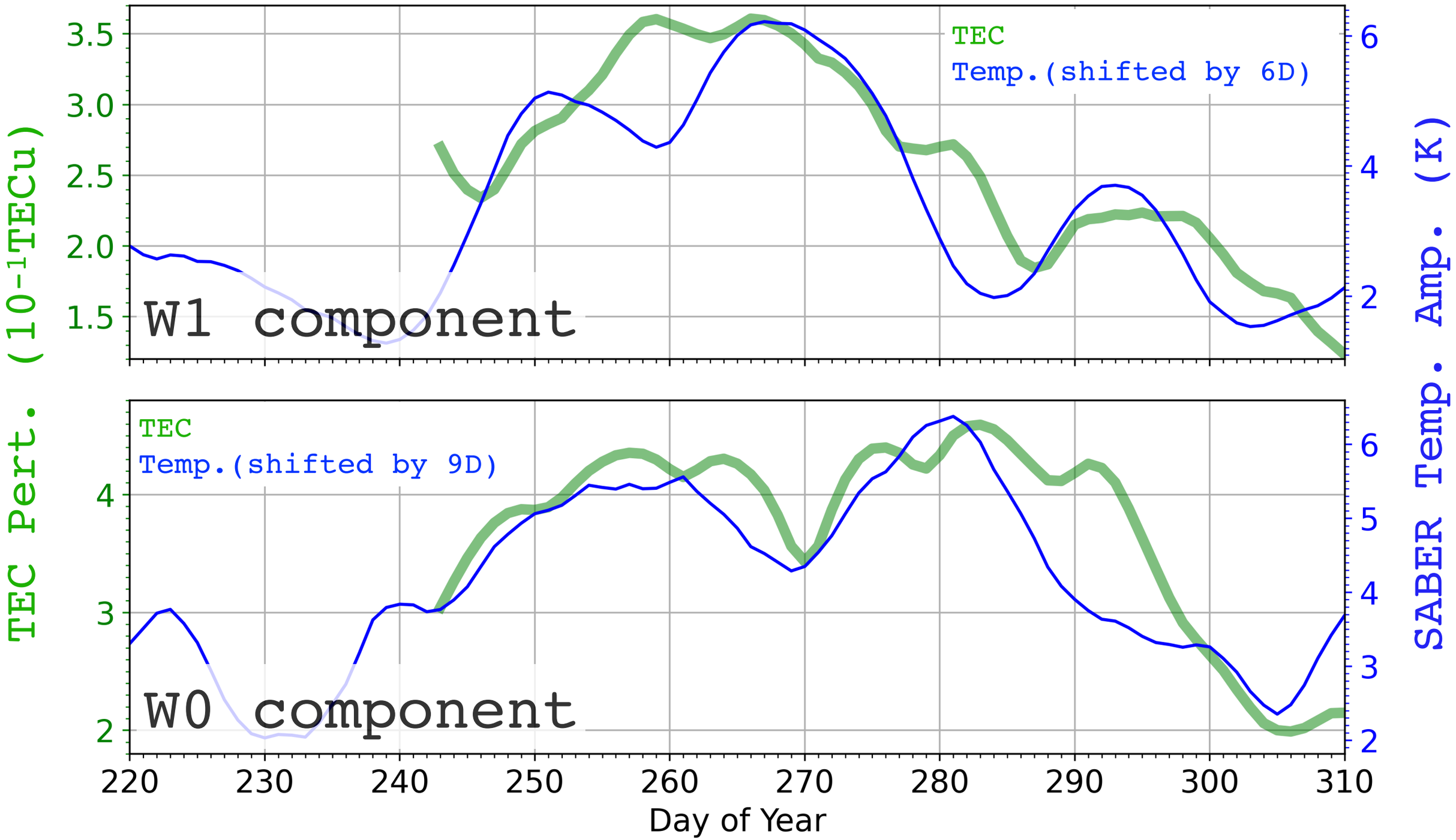
Parent Waves
(1) Q10DW-E1 x SPW2
(2) Q10DW-E1 x SPW1

Nonlinear wave-wave interaction

Child Waves
(1) Q10DW-W1, Q10DW-E3
(2) Q10DW-W0, Q10DW-E2

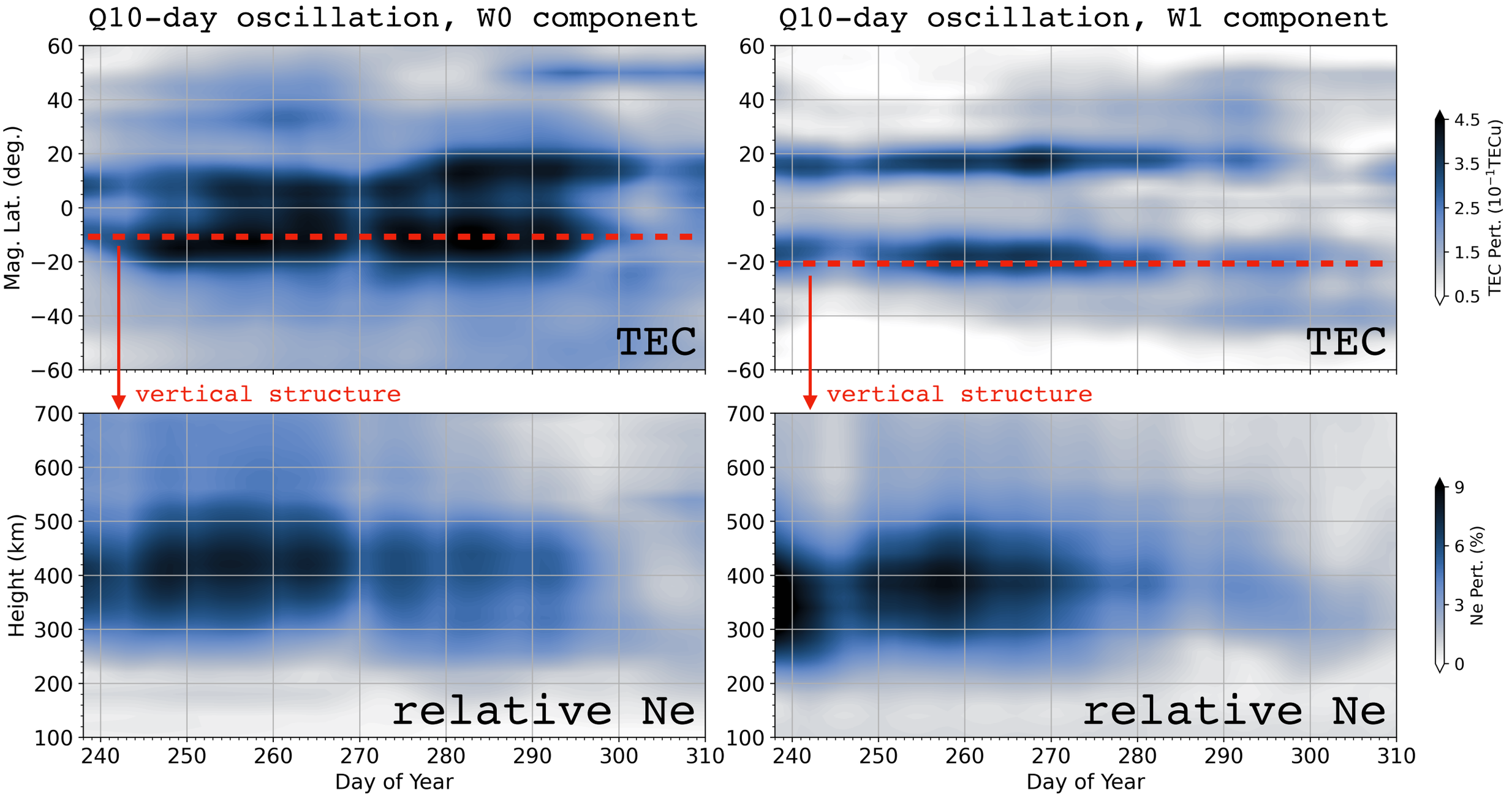
Q10DW-W0: Zonally symmetric quasi-10 day wave (wave number 0)
Q10DW-E1: Eastward propagating quasi-10 day wave with zonal wave number 1
SPW1: Stationary planetary wave with zonal wave number 1
SPW2: Stationary planetary wave with zonal wave number 2

Q10DWs coupled the neutral atmosphere and ionosphere during the 2019 Southern Hemisphere SSW



ionospheric data from Global Ionospheric Specification (Lin et al., 2015, 2017; Lin et al., 2020)

Underlying mechanisms for W0 and W1 quasi-10-day oscillations are different



ionospheric data from Global Ionospheric Specification (Lin et al., 2015, 2017; Lin et al., 2020)

Concluding Remarks

- A symmetric forced Q10DW-W1 occurred during 2019 Southern Hemisphere SSW, contrary to theory which predicts the presence of an antisymmetric normal mode.

- Q10DWs were forced during the 2019 Southern SSW, possibly through Q10DW-E1 nonlinear interactions with SPWs.

- The coherence of temporal variation between atmospheric Q10DWs and ionospheric Q10DOs suggests the Q10DWs can effectively couple the troposphere to the ionosphere.

References

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