2019 Southern Hemispheric SSW triggered Q6DW-Tide-GW interactions observed by meteor radars at 30° S

COUP-9

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Introduction & Motivation

1. 2019 SH Sudden Stratospheric Warming (SSW) is **a rare SH SSW** (NH SSWs occur ~6 times per decade);
2. **Quasi-6-Day Wave (Q6DW) are greater than the average** in Sep., globally observed in the MLT region and ionosphere;
3. **Motivation:** Does this strong **Q6DW** activity impact on **tides** and **Gravity Waves (GW)** propagation?

Data & Methodology

Instruments

Table 1. Specs of two meteor radars used in this work.

	Radar Specs	Site, lat, long, Height	Status during SSW
CONDOR	Freq: 35.15MHz **High power (48kW) & high detection rate (30,000/day/site)**	ALO, 30° S, 71°W, 2520m	From 06/26/2019
		SCO, 31° S, 70°W, 1140m	From 07/14/2019
		LCO, 29° S, 71°W, 2339m	From 02/20/2020
Buckland Park MR	Freq: 55Mhz Power: 18kW	Main, 35°S, 139°E, 302m	ST mode not MLT
		Remote, 35°S, 138°E, 2m	10 days of wind used

Methodology

Input: Meteor radar observations with high temporal & spatial resolution

bipolar distribution coefficient D_α

Line-of-sight velocity

Temperature gradient model [Hocking et al. 1999]

$$T_{radar} = S \cdot \log_{10}\left[e\left(2\frac{dT}{dz} + \frac{mg}{k}\right)\right]$$

$$\frac{dT}{dz} \simeq -1.2, \quad \frac{mg}{k} \simeq 33.2$$

Note that S is the slope of D_α at peak height.

3DVAR: GW dynamics on regional scales [Stober et al., 2021]

$$\Lambda = \Sigma\left((v'_{rad})^2 - (v'_{radm})^2\right)^2$$

Minimize Λ

Get Partially differentiated $u'^2, v'^2, w'^2, u'v', u'w', v'w'$

Q6DW Temp

Time averaged Eliassen-Palm flux

$$\mathbf{F} = \hat{\mathbf{j}}F_y + \hat{\mathbf{k}}F_z$$

$$F_y = -\overline{u'_0 v'_0} = -\frac{1}{2}\Re\{\tilde{u}_{Q6DW}\tilde{v}^*_{Q6DW}\}$$ **Momentum flux**

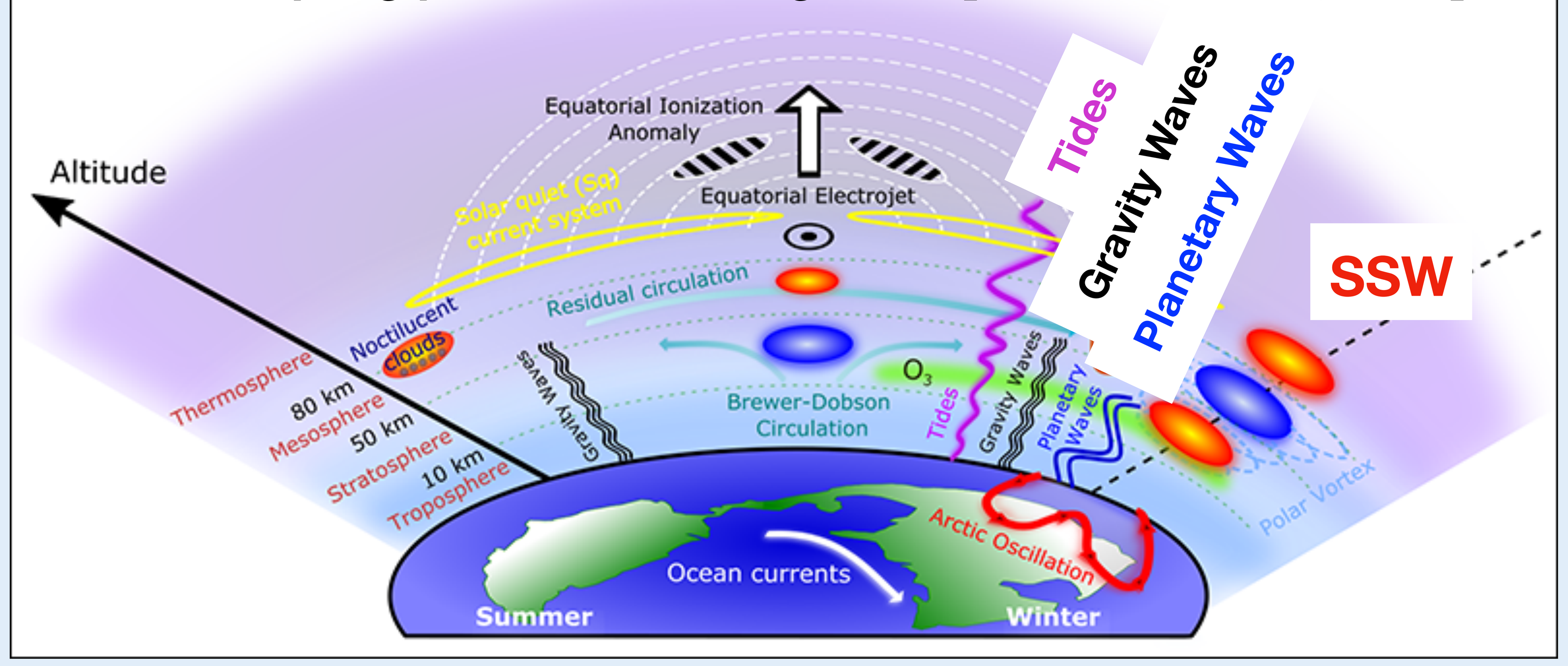
$$F_z = \frac{gf}{N^2}\frac{\overline{\theta'_0 v'_0}}{\theta_S} = \frac{gf}{N^2}\frac{\Re\{\tilde{\theta}_{Q6DW}\tilde{v}^*_{Q6DW}\}}{2\theta_S}$$ **Heat flux**

E-P flux indicates the energy propagation of PWs

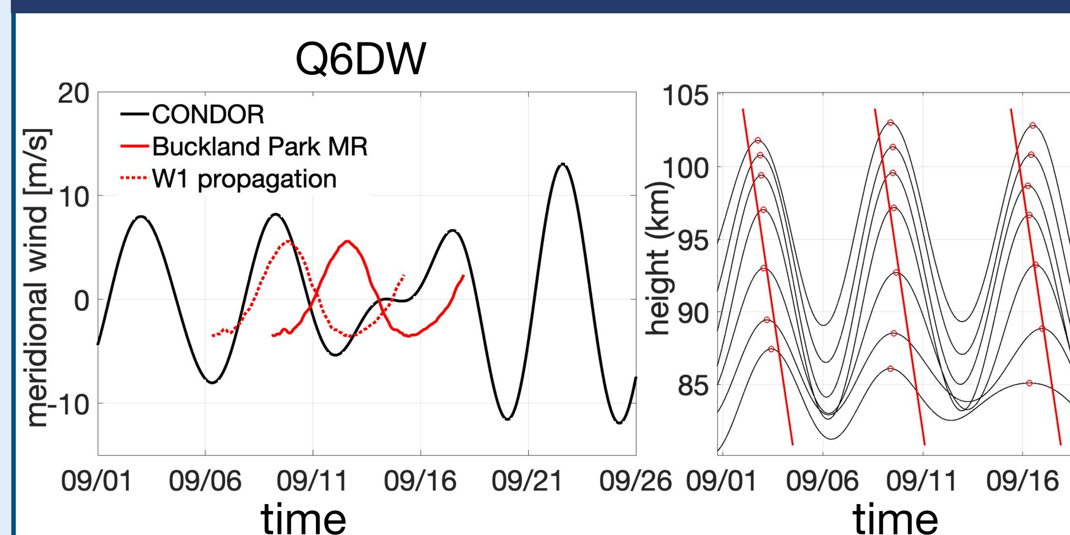
Divergence of E-P flux suggests the energy source/sink.

Compare with SD-WACCM-X simulations

Coupling processes during SSW. [Pedatella et al., 2018]



Result 1: Q6DW Diagnosis

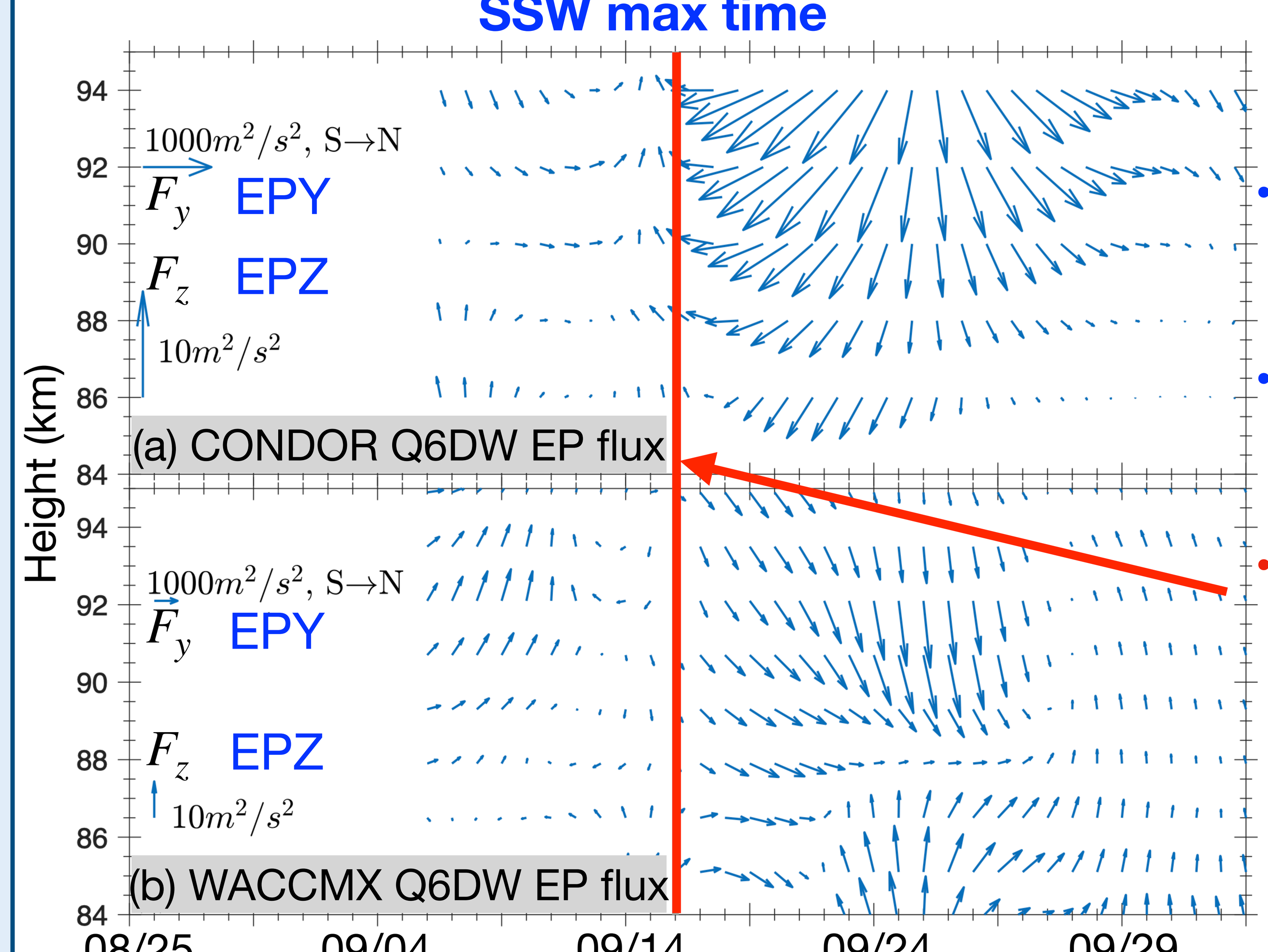


Two meteor radars at same zonal circle

Q6DW parameters
Westward wavenumber 1
Vertical wavelength 64km

Figure 1. 151.75° longitudinally spaced CONDOR and Buckland Park meteor radar winds are combined to diagnose the parameters of Q6DW.

Result 3: Radar & Model Q6DW E-P flux

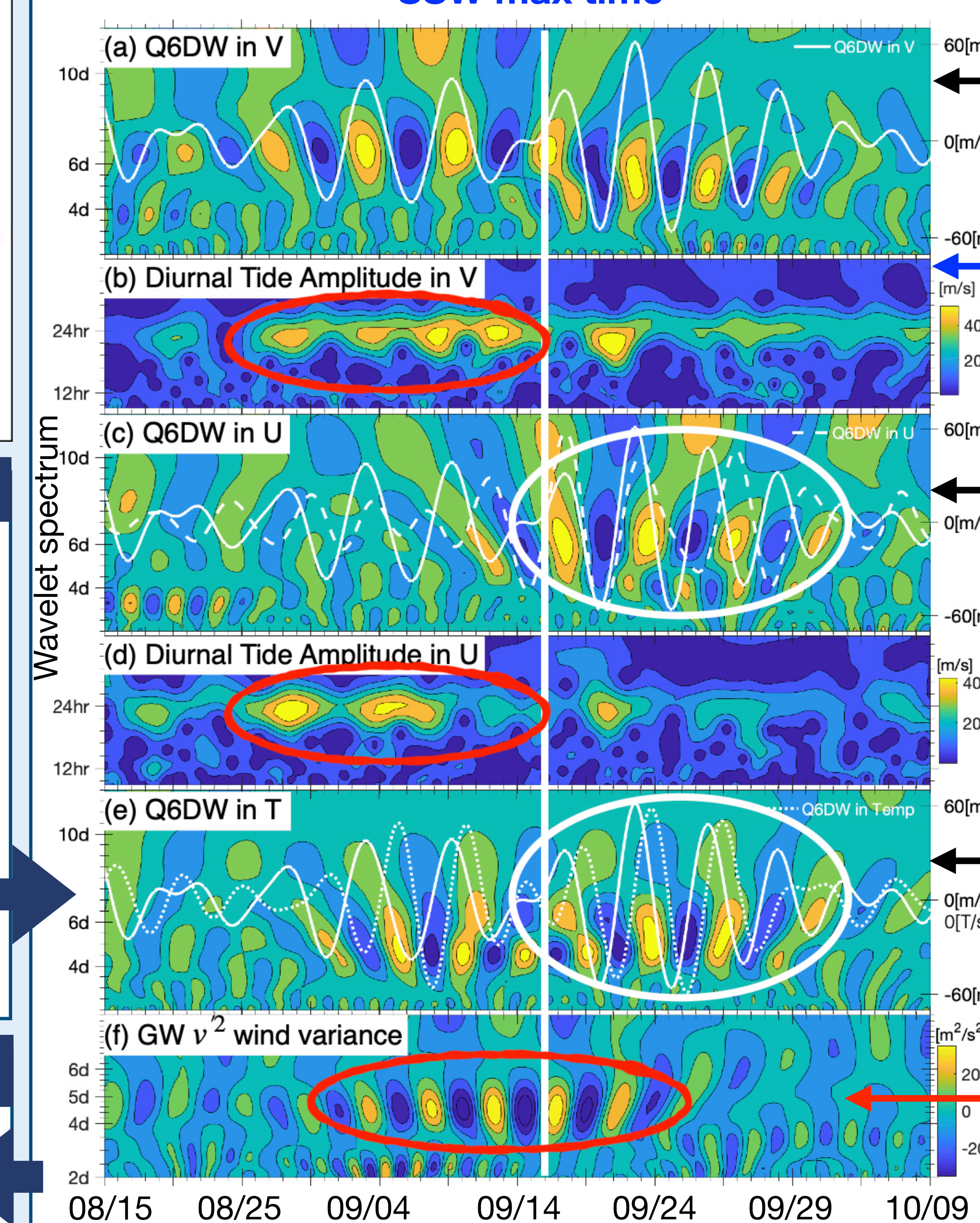


- **Downward EPZ**
- **Time varying EPY**
- **Around Sep16 amplitude enhancement**

Figure 3. Q6DW E-P flux vectors derived from (a) CONDOR observation and (b) SD-WACCM-X simulation.

- First result of meteor radar observed Q6DW E-P flux exhibits a good agreement with simulation.
- Enhancement of the E-P flux suggests potential energy/ momentum deposition in the background atmosphere.

Result 2: Q6DW-Tide-GW interactions



Q6DW is strong before / during / after the SSW max period

Diurnal tide amplified every 6 days

Q6DW momentum flux: southward to northward flux of the westward flow

Equatorward heat flux

Gravity Wave meridional wind variance has a 6-day response

Figure 2. Morse wavelet spectrum of Q6DW in (a) V, (c) U, (e) T; diurnal tide amplitude in (b) V and (d) U; (f) GW variance in meridional wind at 90km.

Conclusion

- A strong W1 Q6DW activity associated with the rare 2019 SH minor SSW is determined by two meteor radars at 30° S.
- Both GW wind variance and diurnal tide amplitude indicate a strong, clear quasi-6-day periodicity in meridional winds.
- First result of meteor radar observed Q6DW E-P flux is presented and exhibits a good agreement with SD-WACCM-X simulation, indicating equatorward heat flux and time varying momentum flux.
- Q6DW-Diurnal Tides-GW interactions in the MLT region may contribute to the reported ionospheric 6-day variability [Yamazaki et al., 2020].
- **The manuscript related to this poster is to be submitted to GRL.**

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