Response of planetary waves and tides to the 2019 Southern Hemisphere SSW and Q2DW enhancement in Jan-Feb 2020 observed by CONDOR meteor radar in Chile and Adelaide meteor radar in Australia

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Abstract

A new multi-static meteor radar (CONDOR) has recently been installed in northern Chile. This CONDOR meteor radar (30.3°S, 70.7°W) and the Adelaide meteor radar (35°S, 138°E) have provided longitudinally spaced observations of the mean winds, tides and planetary waves of the PW-tides interaction cases we present here. We have observed a Quasi-6-Day Wave (Q6DW) enhancement in MLT winds at the middle latitudes (30.3°S, 35°S) during the unusual minor South Hemisphere SSW 2019 by the ground-based meteor radars. Tidal analysis also indicates modulation of the Q6DW w/ amplitude ~15 [m/s] and diurnal tides w/ amplitude ~60 [m/s]. Another case we present here is a dominant Quasi-2-Day Wave (Q2DW) with up to 50 [km/s] amplitude occurring in SH summer 2020 and its interaction with the diurnal and semidiurnal tides. The period of this Q2DW activity changes from ~50hr to ~48hr since Jan 19, which suggests the phase locking mechanism [McCormack et al., 2010]. The 24hr-feature and 12hr-feature show off-phase variations during the Q2DW enhancement time with amplitude of ~40 [m/s].

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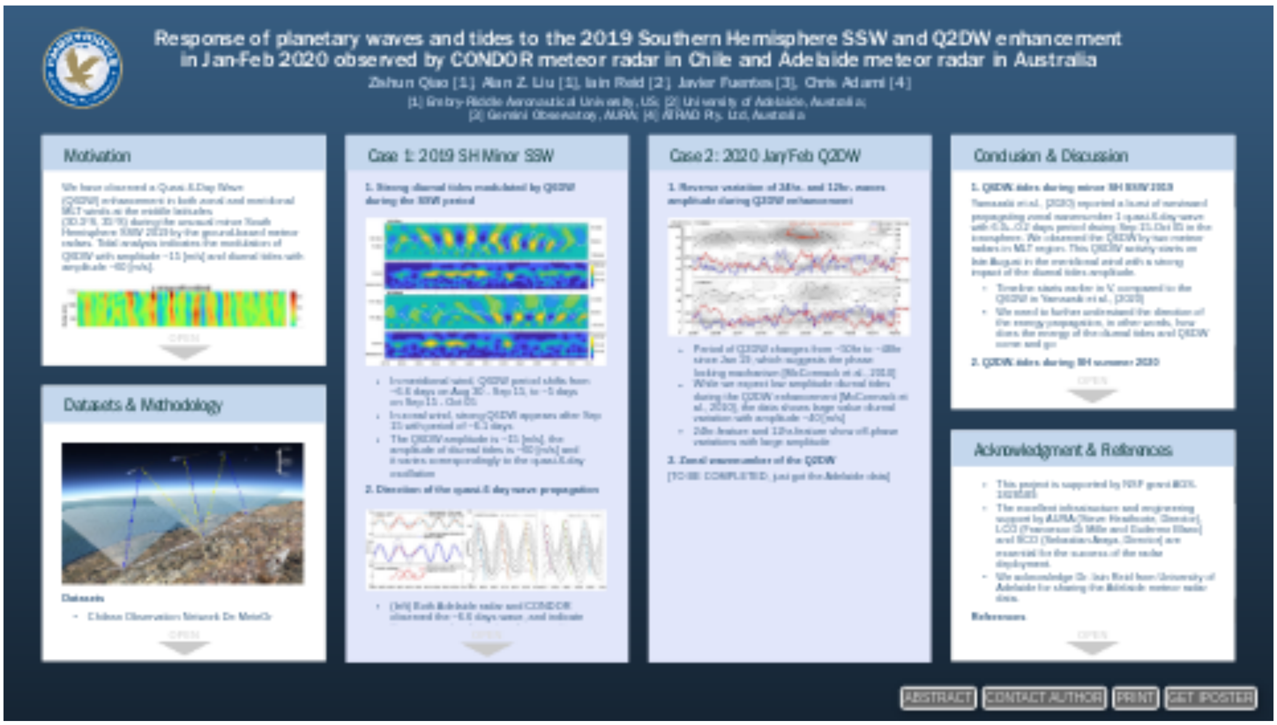

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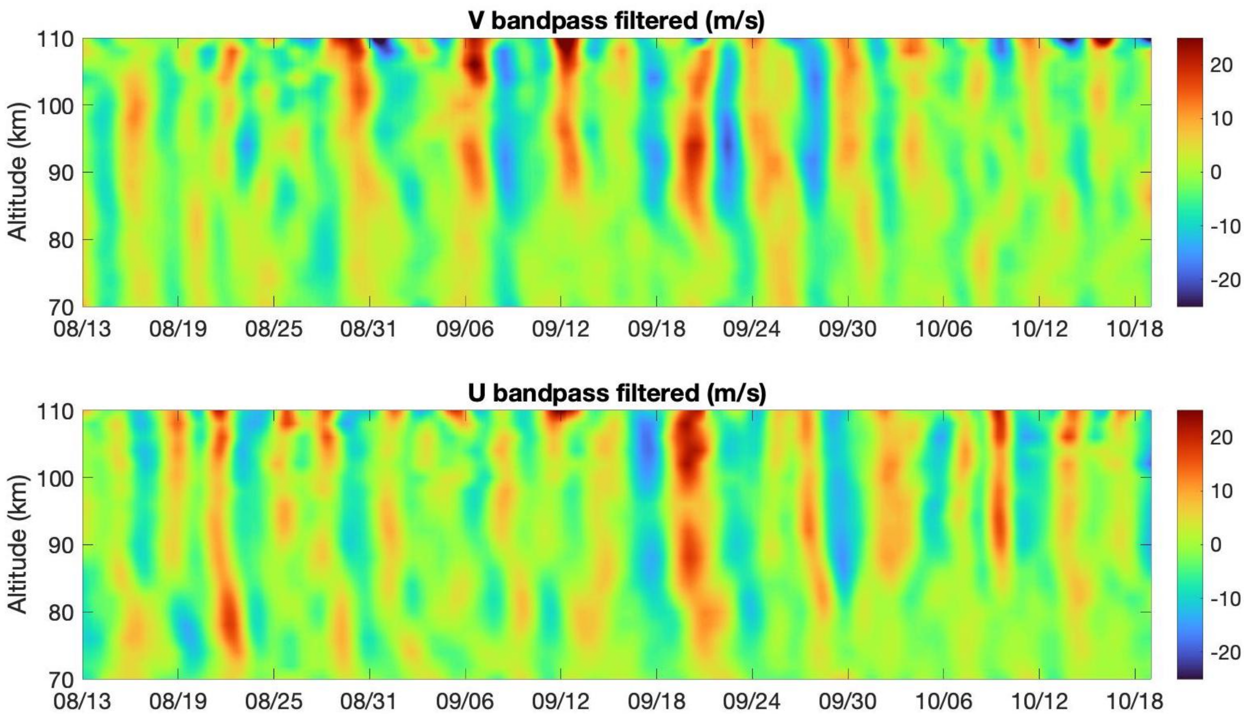
PRESENTED AT:

AGU FALL MEETING
Online Everywhere | 1–17 December 2020

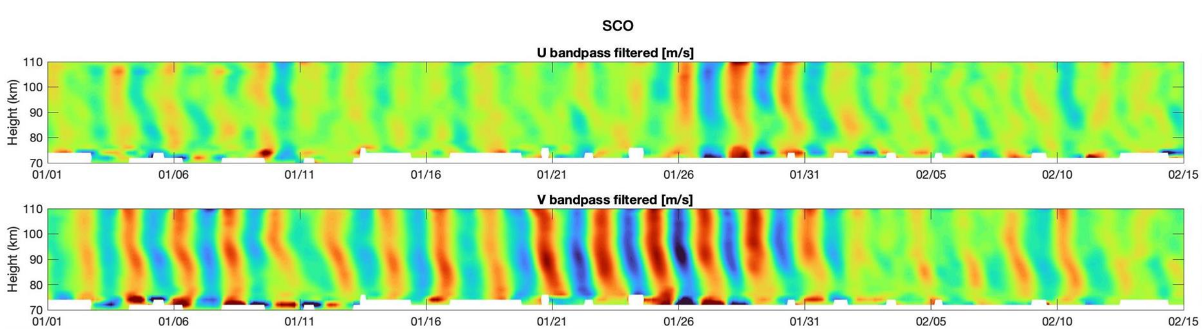
MOTIVATION

We have observed a Quasi-6-Day Wave (Q6DW) enhancement in both zonal and meridional MLT winds at the middle latitudes (30.3°S, 35°S) during the unusual minor South Hemisphere SSW 2019 by the ground-based meteor radars. Tidal analysis indicates a strong modulation of the Q6DW (15m/s amplitude) and the diurnal tides (60m/s amplitude).



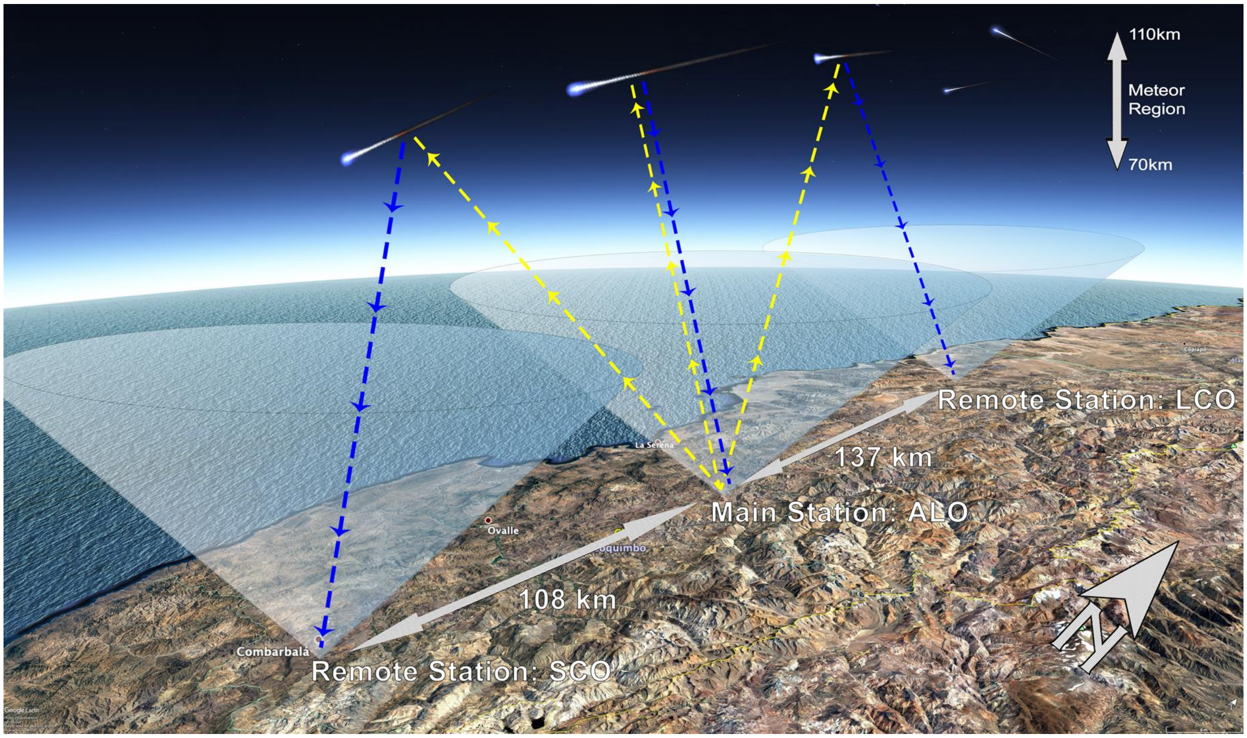
Quasi-6-day wave feature observed in U and V

Another case study we present here is a dominant Quasi-2-Day Wave (Q2DW) with up to 50 [km/s] amplitude occurring in summer 2020 observed by CONDOR meteor radar (30.3°S, 70.7°W) and its interaction with the diurnal and semidiurnal tides. Q2DW enhancement is often reported in summer time south hemisphere and its mechanisms are well studied, however the Q2DW-[1,6] secondary wave amplification presented in McCormack et al., (2010) from its nonlinear interaction with diurnal tides may play different roles in different cases.



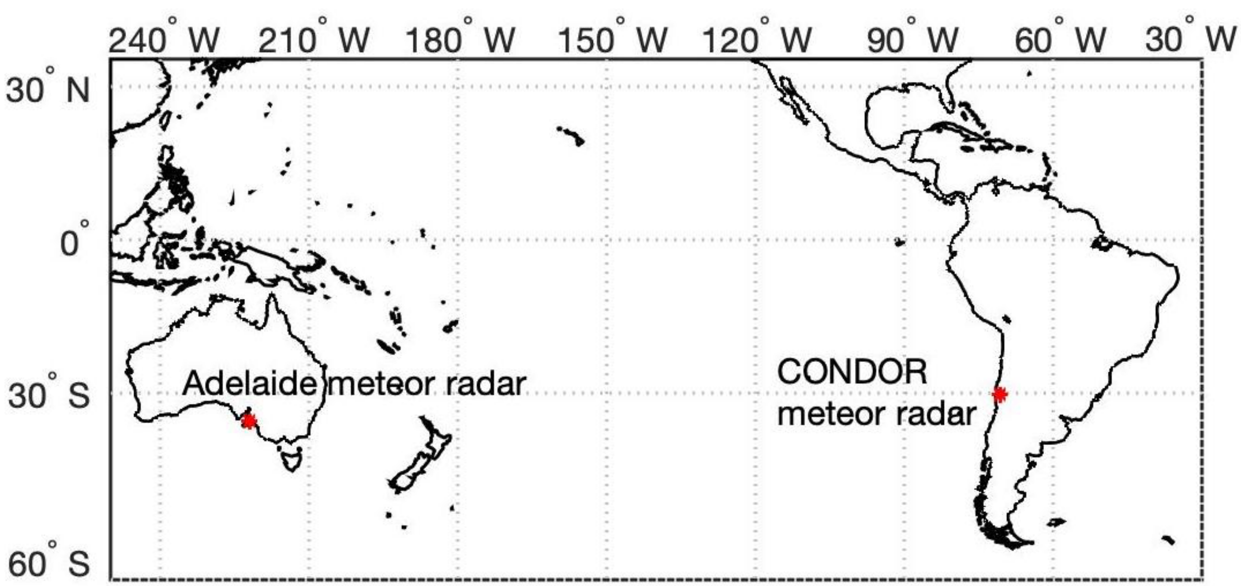
Q2DW enhancement in U and V mean winds, Jan-Feb 2020

DATASETS & METHODOLOGY



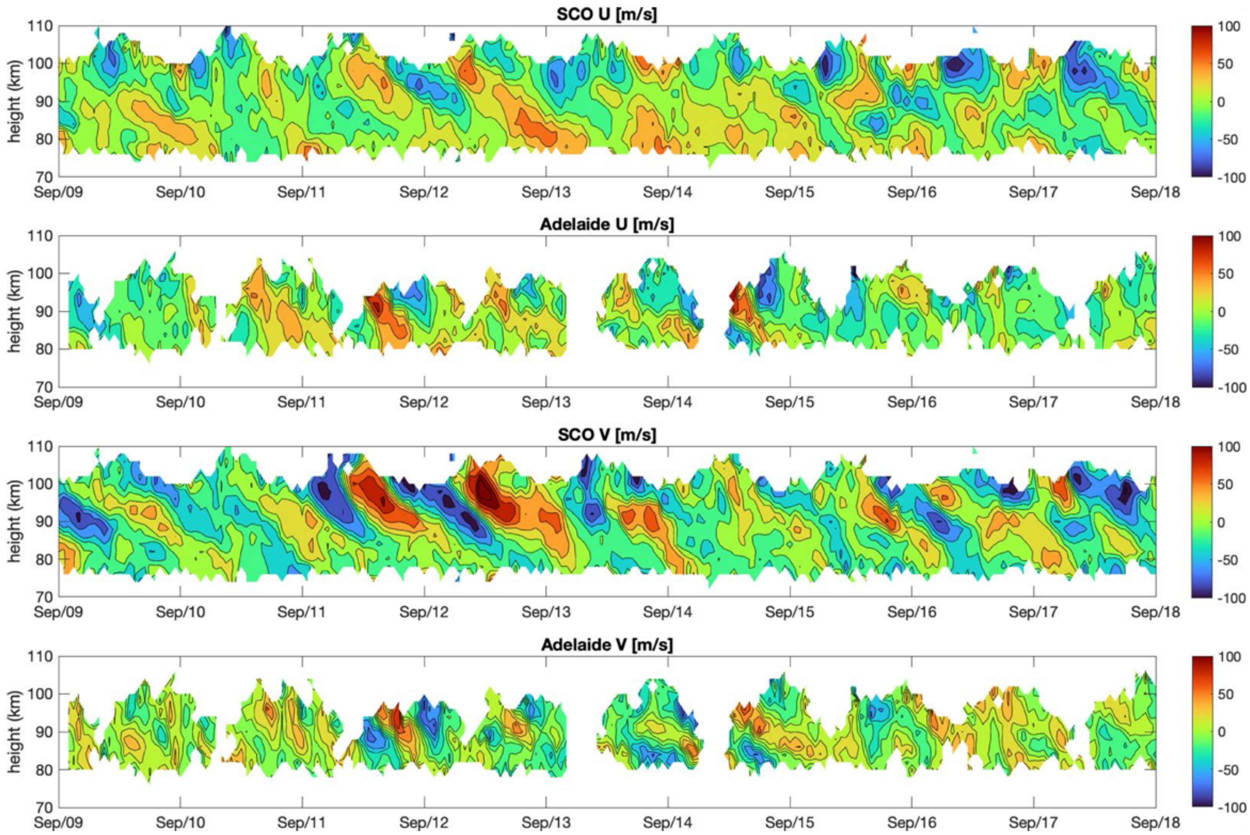
Datasets

- Chilean Observation Network De MeteOr Radars (CONDOR) - A multi static meteor radar system, has been recently installed in northern Chile before the pandemic. The system includes three sites with high meteors detection rate (~30,000 meteor event detections per day per site), which promises good quality of the wind measurements.



- Two PW-tides interaction events are studied by two meteor radars- CONDOR meteor radar (30.3°S, 70.7°W) at Chile and the Adelaide meteor radar (35°S, 138°E) at Australia. They have provided longitudinally spaced (151.75° difference) observations as shown in the figure above.

- 9 days of Adelaide radar wind and 3 months of CONDOR wind has been analyzed for the SSW–Q6DW case
- 20 days of Adelaide radar wind and 40 days of CONDOR wind has been analyzed for the Q2DW case



Meteor radar winds [U,V] during SSW time. SCO is the south site of CONDOR radar system

Methodology

- Continuous wavelet analysis is applied to (i) the Hamming window 4–12 days bandpass filtered wind for the Q6DW phase, amp. and period, and (ii) to the original wind for the amplitude variations of the diurnal/seminal tides
- Q2DW amplitude is fitted from the 1.2–3 days bandpass filtered wind, with equation *Filtered_Wind = A48*cos(2*pi*t/T–phase48) + Residue*
- Tidal components are fitted from the original wind data with equation *Wind = A24*cos(2*pi*t/24–phase24) + A12*cos(2*pi*t/12–phase12) + A8*cos(2*pi*t/8–phase8) + Residue*

CASE 1: 2019 SH MINOR SSW

1. Strong Diurnal tides-Q6DW modulation appears during the SSW period

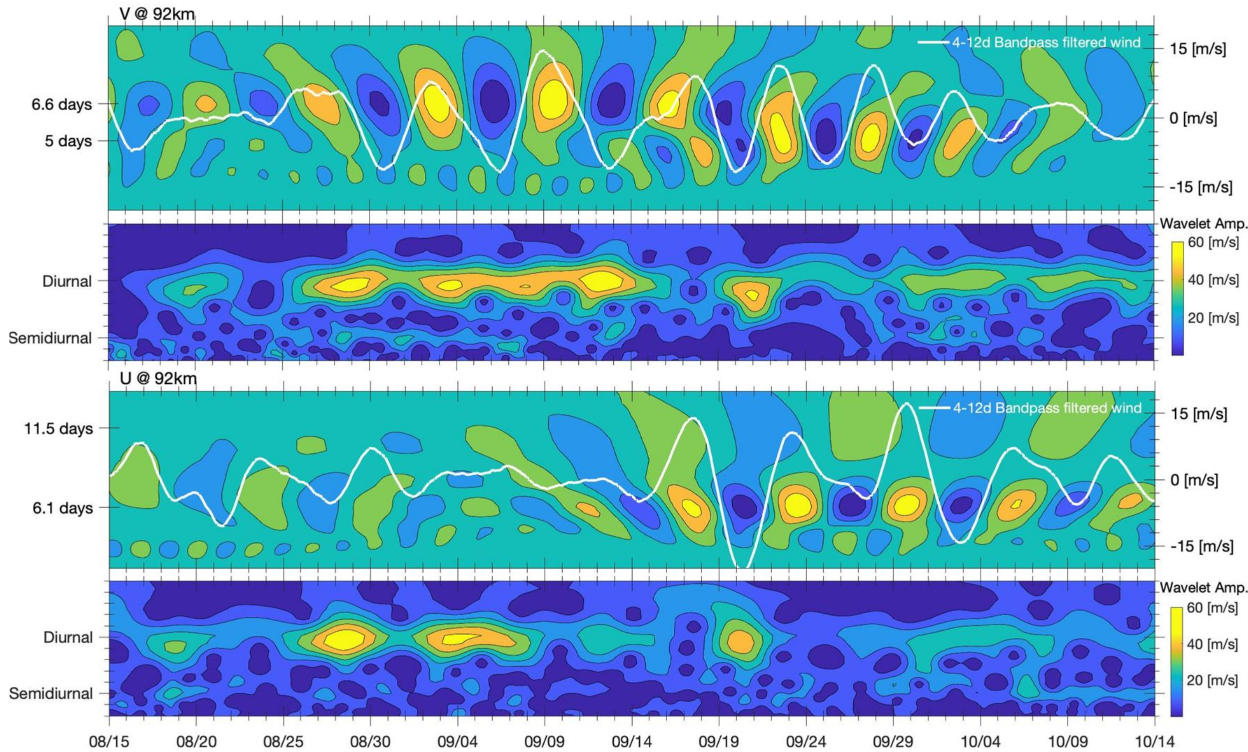
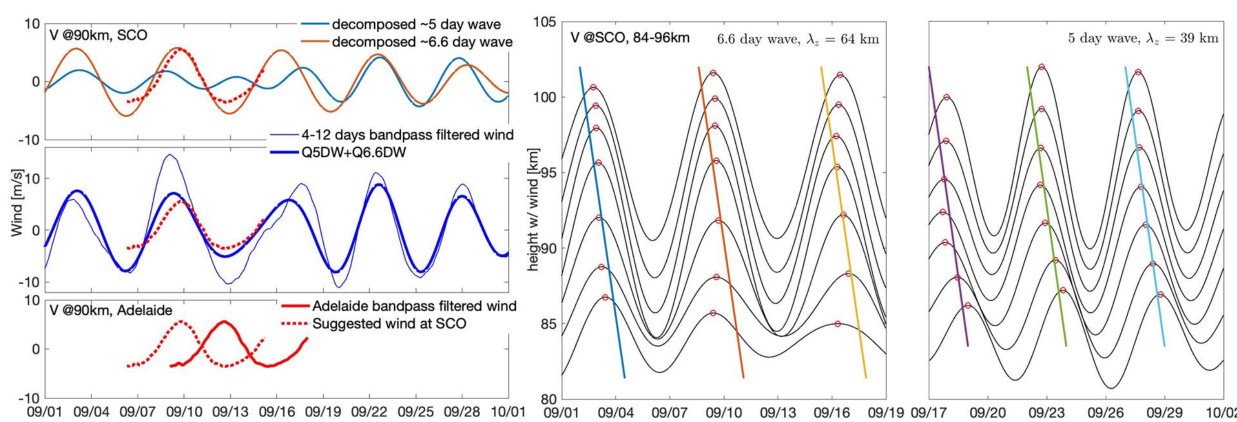


Fig. plot 1&3 show the quasi-6-day wave oscillation while plot 2&4 present the amplitude of tides. This is meant to highlight the temporally corresponding variation.

- In meridional wind, Q6DW period shifts from ~6.6 days on Aug 30 - Sep 15, to ~5 days on Sep 15 - Oct 05
- In zonal wind, strong Q6DW appears after Sep 15 with period of ~6.1 days
- Amplitudes of the Q6DW is ~15 [m/s] and diurnal tide is ~60 [m/s], and diurnal tide varies correspondingly to the quasi-6-day oscillation

2. Propagating direction, wavenumber, and λ_z of the quasi-6 day wave observed by two longitudinally spaced meteor radars (151.75° diff)



- (left) Both Adelaide radar and CONDOR observed the ~6.6 days wave, and indicate the wavenumber 1 westward propagation
- (middle & right) linear fitting the vertical wavelengths of the earlier ~6.6 days wave and the later ~5 days wave in meridional wind. Similar tech also presented in fig 2 of case 2 w/ more details

CASE 2: 2020 JAN/FEB Q2DW

1. Reverse variation of the amplitudes of 24hr- and 12hr- features appears only at 70.7°W, during the Q2DW enhancement time

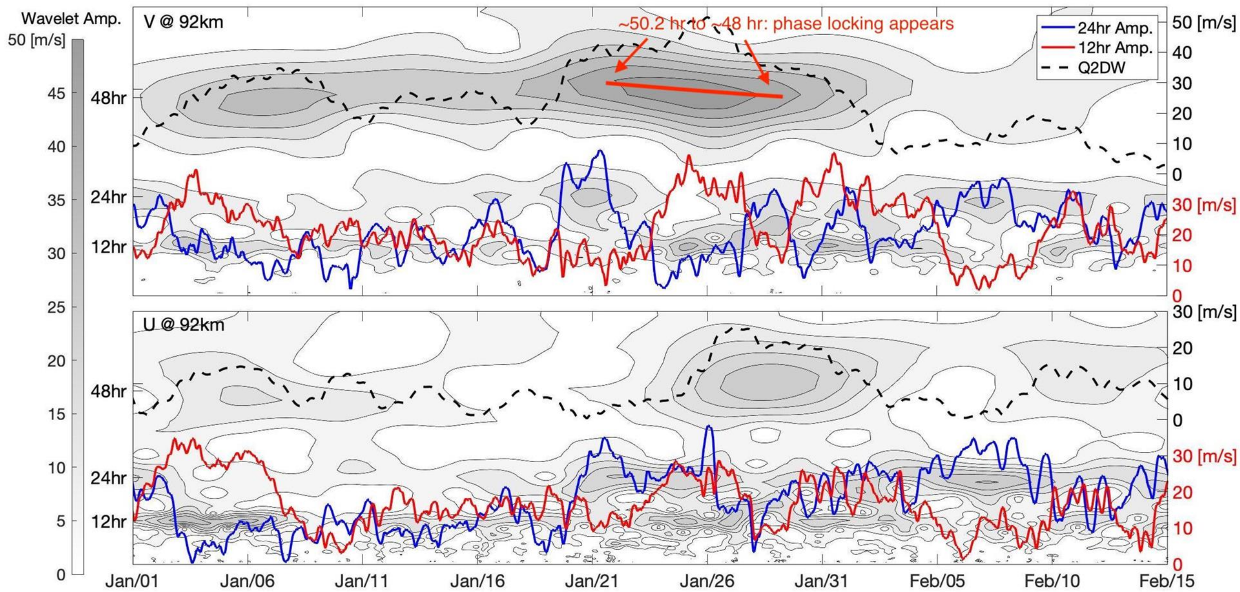
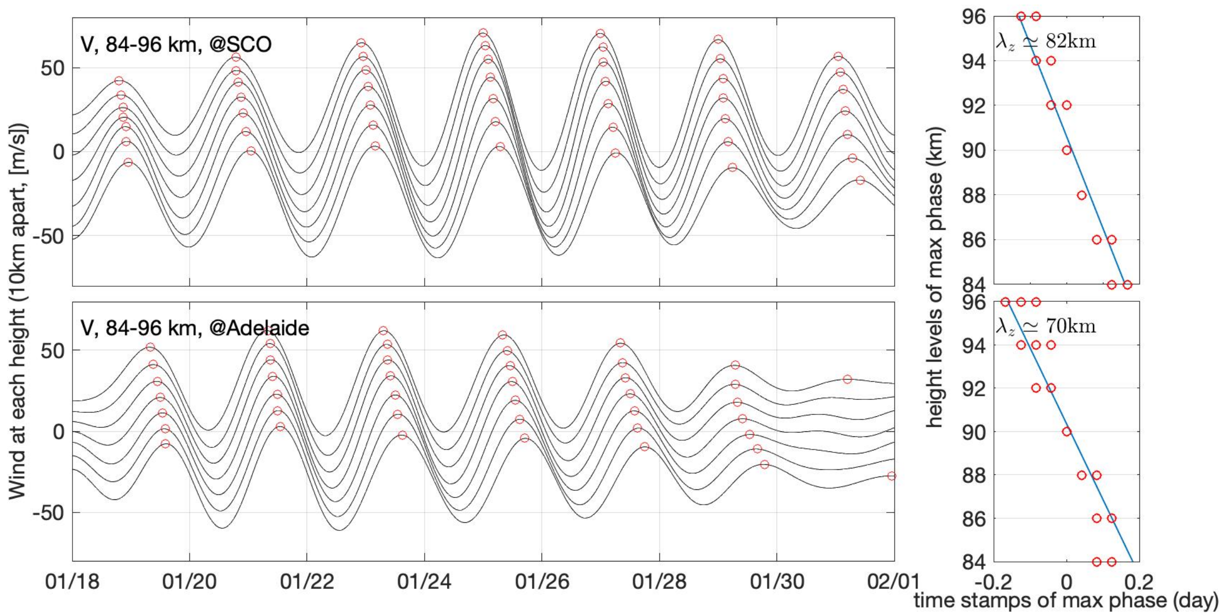


Fig. CONDOR observation of this Q2DW activity

- Q2DW amplitude is ~50[km/s]
- Period of Q2DW changes from ~50hr to ~48hr since Jan 19, suggests the phase locking mechanism discussed in McCormack et al., (2010)
- Large 24hr- and 12hr- features appear with amplitude ~40[m/s], **and vary off-phase**
- While in Adelaide observation, 24hr- and 12hr- features have similar trend and relatively small amplitudes

2. Zonal wavenumber and Vertical wavelength



- Westward wavenumber 3
- Very long vertical wavelength λ_z ~=82km at SCO, 70.7°W
- λ_z ~=70km at Adelaide, 138°E

CONCLUSION & DISCUSSION

1. Q6DW-tides during minor SH SSW 2019

Yamazaki et al., (2020) reported a burst of westward propagating zonal wavenumber 1 quasi-6-day wave with 6.0+-0.2 days period during Sep 15-Oct 05 in the ionosphere. We observed this Q6DW by two meteor radars in MLT region middle altitude (~30°S).

- This Q6DW activity starts on late August in the meridional wind, a couple weeks earlier than the Q6DW studied in Yamazaki et al., (2020)
- A strong impact of the diurnal tides amplitude has been observed. We need to further understand how does the energy of the diurnal tides and Q6DW come and go

2. Q2DW-tides during SH summer 2020

Phase locking (locked to 48hr period) may start occurring on Jan/19 with the Q2DW amplitude amplification. While we expected the small amplitude of [1,1] during the Q2DW amplification (McCormack et al., 2010), diurnal-feature and semidiurnal-feature observed by CONDOR show off-phase variation with amplitude of large values, particularly in the meridional wind.

Is the 24hr-oscillation here the [1,1] or secondary waves like [1,-4] and [1,6]? Possible mechanisms include:

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[1,1]-+[0.5,3]=[0.5,-2],[1.5,4] (i)

[1.5,4]-+[0.5,-2]=[1,6],[2,2] (ii)

[1,6]-[0.5,3]=[0.5,3] (iii)

[2,2]-+[0.5,3]=[1.5,-1],[2.5,5] (i)

[1.5,-1]-+[0.5,3]=[1,-4]+[2,2] (ii)

[2,2]-[1,6]=[1,-4] (iii)
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- We acknowledge Dr. Iain Reid from University of Adelaide for providing Adelaide meteor radar data.

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[1] McCormack, J. P., S. D. Eckermann, K. W. Hoppel, and R. A. Vincent (2010), Amplification of the quasi-two day wave through nonlinear inter- action with the migrating diurnal tide, Geophys. Res. Lett., 37, L16810, doi:10.1029/2010GL043906.

[2] Yamazaki, Y., Matthias, V.,
Miyoshi, Y., Stolle, C., Siddiqui, T., Kervalishvili, G., et al. (2020), September 2019 Antarctic sudden stratospheric warming: Quasi-6-day wave burst and ionospheric effects. Geophys. Res. Lett.Geophysical Research Letters, 47, e2019GL086577.https://doi.org/10.1029/2019GL086577

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