Modeling Study of Day-to-Day Variability of Migrating Diurnal Tide

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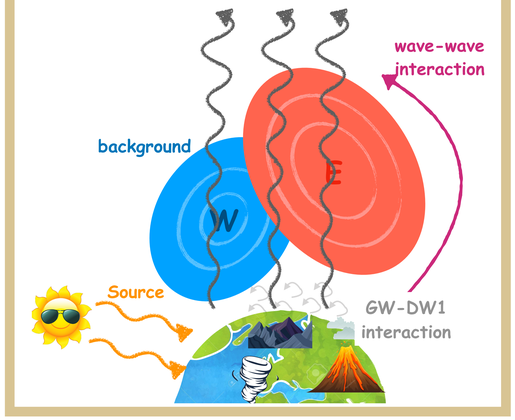
Science Goal

Determine potential causes driving the day-to-day variability of DW1, including wave source, mean state, and the gravity wave.

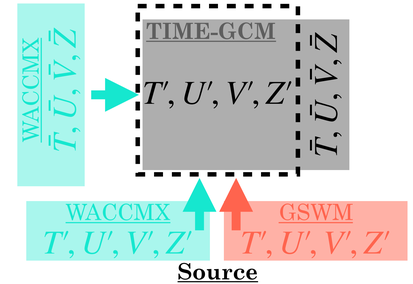
Migrating Diurnal Tide (DW1) Day-To-Day Variability

- Observations from both ground and space provide strong evidence that the DW1 undergoes significant day-to-day changes.
- Modeling studies [Liu, 2013] have also indicated that the DW1 can vary upwards of 100% from one day to the next.
- Limitations of both ground-based and satellite-based techniques have prevented the explicit estimation of the DW1 on a global scale without significant assumptions until recently [Nguyen and Palo, 2013]. As a result, the short-term variability of the DW1 is not well understood.

Potential Causes of DW1 Day-to-Day Variability



Simulations



Source

For source
WACCMX v.s. GSWM

For background
Nudged run v.s. default

Thermodynamic Equation

$$\frac{\partial T}{\partial t} = -\vec{V}\cdot\nabla T + \frac{RT}{C_p m}\omega + F_{GW,T} + F_{diff} + F_{K_{T,z}} + Q - L$$

Momentum Equation

$$\frac{\partial u}{\partial t} = fv - \frac{1}{a\cos\phi}\frac{\partial \Phi}{\partial \lambda} - \vec{V}\cdot\nabla u + \frac{uv}{a}\tan\phi + F_{GW,x} + F_{other,x}$$

$$\frac{\partial v}{\partial t} = -fu - \frac{1}{a}\frac{\partial \Phi}{\partial \phi} - \vec{V}\cdot\nabla v - \frac{u^2}{a}\tan\phi + F_{GW,y} + F_{other,y}$$

GW related

background related

Reynolds Decomposition: $T = \bar{T} + T', u = \bar{u} + u', v = \bar{v} + v', \Phi = \bar{\Phi} + \Phi'$

Nudged Run: $\bar{T} = \bar{T}_{\text{WACCMX}}, \bar{u} = \bar{u}_{\text{WACCMX}}, \bar{v} = \bar{v}_{\text{WACCMX}}, \bar{\Phi} = \bar{\Phi}_{\text{WACCMX}}$

Acknowledgements

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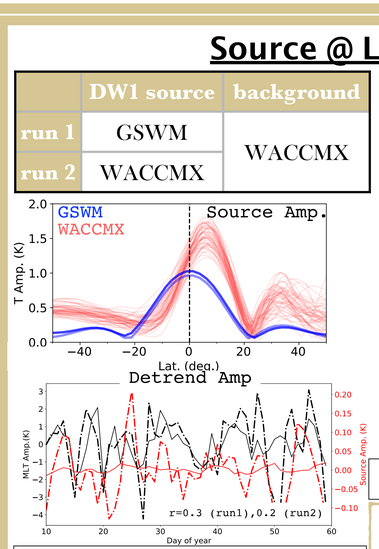
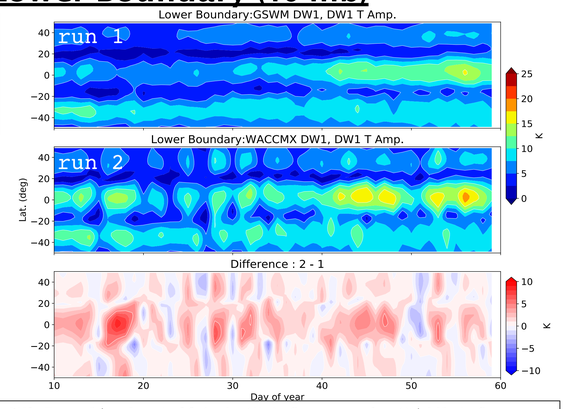
Source @ Lower Boundary (10 mb)

	DW1 source	background
run 1	GSWM	WACCMX
run 2	WACCMX	



(Up) Daily DW1 T amplitude at model lower boundary. (Bottom) DW1 peak amplitude detrended by 10-day running mean at (red) 10 mb and (black) lower thermosphere. (Solid) From run 1. (Dash) From run 2.

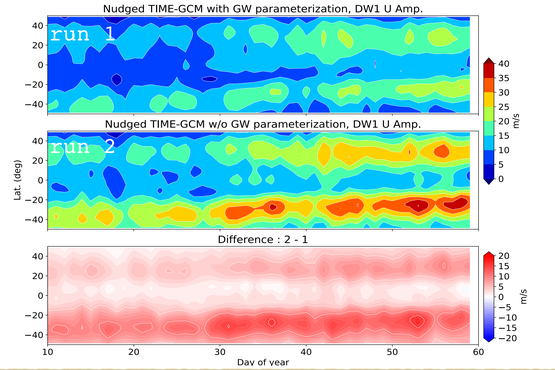


DW1 T amplitude at 10^{-4} mb (Up) from run 1. (Middle) from run 2. (Bottom) Amplitude difference. (run 2 – run 1).

Statistic analysis shows the source amplitude only has small correlation with MLT DW1. Source variability cannot fully explain the DW1 day-to-day variability at MLT region.

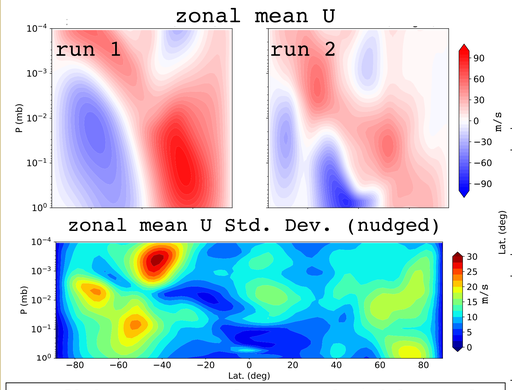
GW-DW1 Interaction

	GW scheme	DW1 source	background
run 1	on	GSWM	WACCMX
run 2	off		



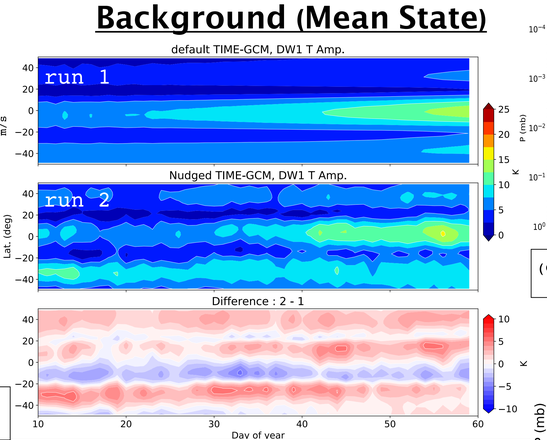
Breaking GW stress can interact with DW1 and tends to suppress the DW1 amplitude.

Background (Mean State)



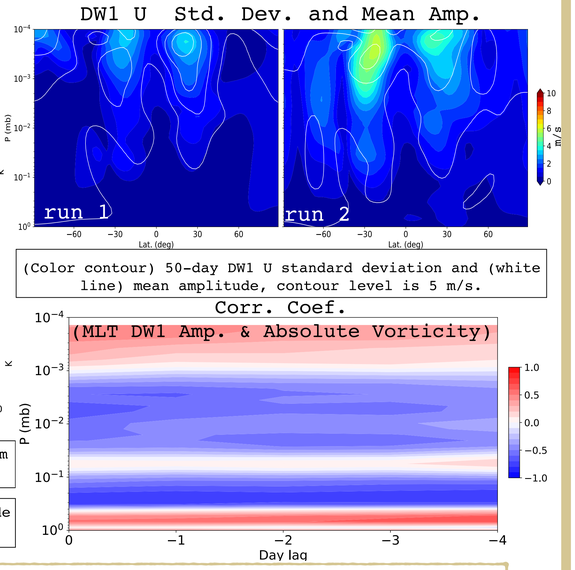
(Up) 50-day average zonal mean zonal wind from (Left) run 1 and (Right) run 2. (Bottom) zonal mean zonal wind standard deviation from run 2.

	DW1 source	background
run 1	GSWM	default run
run 2		nudged by WACCMX



DW1 T amplitude at 10^{-4} mb (Up) from run 1. (Middle) from run 2. (Bottom) Amplitude difference. (run 2 - run 1).

(Right) Correlation coefficient between MLT DW1 amplitude and R (R=absolute vorticity/Coriolis vorticity).



Smaller absolute vorticity can be analogous to slow down the Earth 's rotation rate and can broaden the equatorial wave guide for DW1 propagation. Mean state is essential to the DW1 day-to-day variability. (Propagation condition changes)

Summary

- We found that the day-to-day variability of the mean state plays a major role in driving the DW1 short-term variability. The daily change of DW1 amplitude can be up to 50%, and the horizontal structure is also sensitive to the mean state.
- The wave source variability plays a secondary role in driving DW1 variability, which is consistent with previous studies. It can cause 15 to 30 % variation to the DW1 amplitude.
- The GW-DW1 interaction can suppress 50% of the DW1 amplitude, suggesting the day-to-day variability of GW activity might also play a secondary role to the day-to-day variability of DW1 amplitude and horizontal structure.