New Approach to Estimate Tidal Climatology from Ground- and Space-baced Observations

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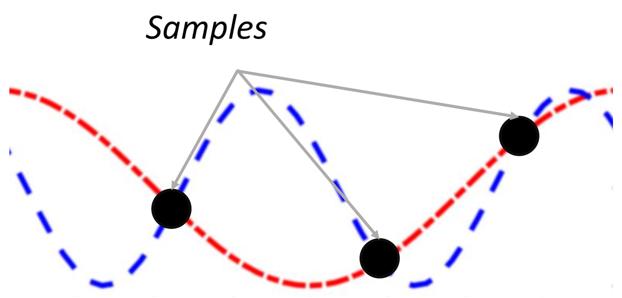
Abstract

This work proposes a new approach to obtain seasonal variations of global tides for the horizontal winds in the mesosphere and lower thermosphere (MLT) region, based on daily tides derived from the global coverage of the TIMED Doppler Interferometer (TIDI) and the local time coverage of a meteor radar chain. The daily variations of different MLT tides are obtained taking advantage of empirical tidal mode (ETM), which is firstly derived from Global Scale Wave Model (GSWM) using Empirical Orthogonal Function (EOF) analysis. ETM displays latitudinal and vertical features of each tidal component in a realistic background atmosphere with dissipation effects. After fitting the observations by ETM day-by-day, the monthly mean of daily fitted results is then used to describe tidal monthly features. Seasonal variations of three major tidal components were found: DW1 in both zonal and meridional winds usually has two maxima around equinoxes; DE3 in zonal winds achieves their maximum in September, while that in meridional winds becomes strongest in February and November. SW2 in zonal winds reaches largest amplitudes in May in the southern hemisphere, and meridional winds has minor peaks in February and November in the northern hemisphere.

Data

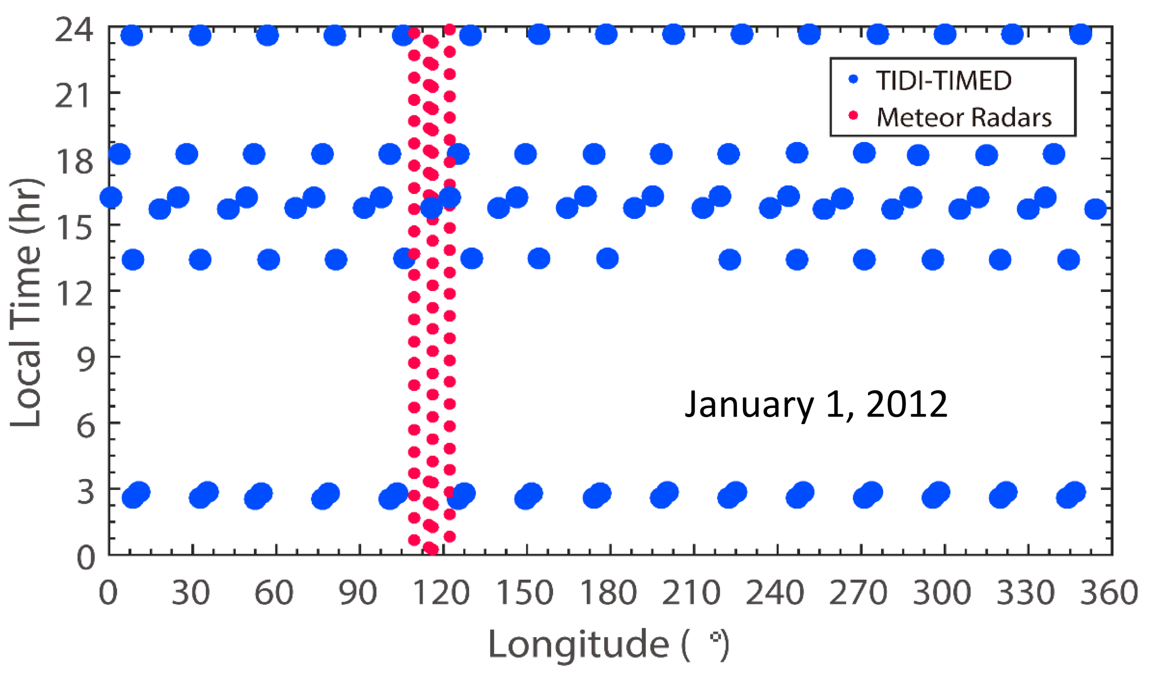
It is hard to distinguish tidal components with ***inadequate*** *observations.*



A good longitudinal coverage results in more reliable zonal wave spectra, and a complete local time coverage leads to a better frequency spectra

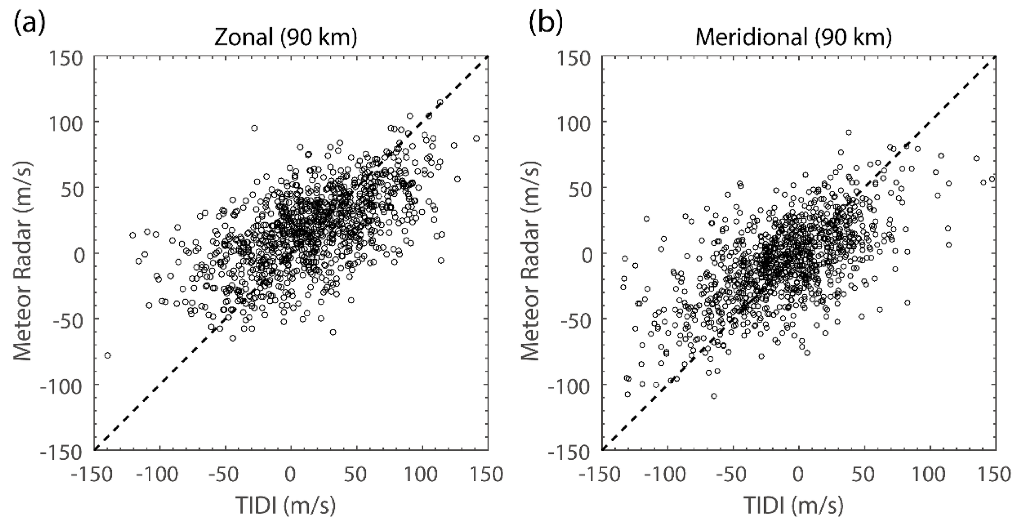
Local time coverage: **meteor radars**

Longitudinal coverage : **TIDI-TIMED**



Meteor radars (SY, BJ, WH, MH) + TIDI-TIMED

Data Comparison



Methodology

Step 1 : Deriving Empirical Tidal Modes (ETMs) from the GSWM

GSWM 09 $[U, V]$ → **EOF analysis** → $[u, v]$

$$\begin{bmatrix} U^f(m,h,\lambda,\varphi) \\ V^f(m,h,\lambda,\varphi) \end{bmatrix} = \sum_{s=-6}^{6} e^{-is\lambda} \left(\sum_{L=sym,asy} \sum_{k=1}^{12} a_{k,L}^{f,s}(m) \begin{bmatrix} u_{k,L}^{f,s}(h,\varphi) \\ v_{k,L}^{f,s}(h,\varphi) \end{bmatrix} \right)$$

Step 2 : Decomposing Observations into ETMs

$$\begin{bmatrix} U_o(d,t,h,\lambda,\varphi) \\ V_o(d,t,h,\lambda,\varphi) \end{bmatrix} = \sum_{f=1}^{2} \sum_{s=-6}^{6} \sum_{L=sym,asy} \sum_{k=1}^{N} \begin{bmatrix} C_{uk,L}^{f,s}(d)\, u_{k,L}^{f,s}(h,\varphi) \\ C_{vk,L}^{f,s}(d)\, v_{k,L}^{f,s}(h,\varphi) \end{bmatrix} e^{i(f\Omega t - s\lambda)}$$

Step 3 : Tidal Amplitudes and Phases, Getting ✔

$$\begin{bmatrix} A_u^{f,s}(d,h,\varphi) \\ A_v^{f,s}(d,h,\varphi) \end{bmatrix} = \sum_{L=sym,asy} \sum_{k=1}^{N} \begin{bmatrix} C_{uk,L}^{f,s}(d)\, u_{k,L}^{f,s}(h,\varphi) \\ C_{vk,L}^{f,s}(d)\, v_{k,L}^{f,s}(h,\varphi) \end{bmatrix}$$

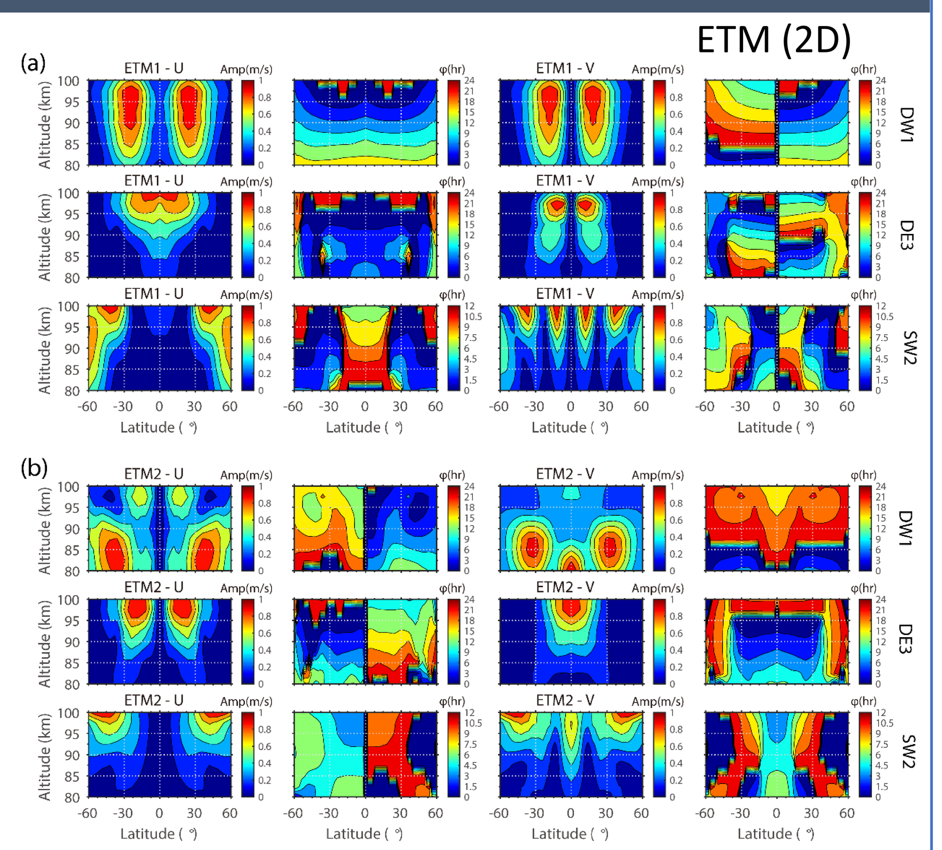
$\left|\langle A_{u,v}^{f,s} \rangle\right|$ Monthly tidal amplitudes

$\tan^{-1}\left(imag\left(\langle A_{u,v}^{f,s}\rangle\right) / real\left(\langle A_{u,v}^{f,s}\rangle\right)\right)$ Monthly tidal phases

Results

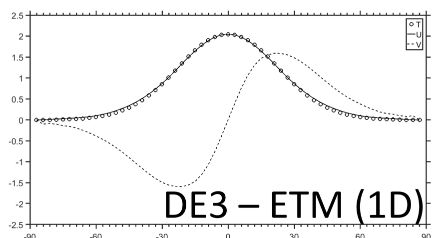
ETM (Examples)

ETM (2D)



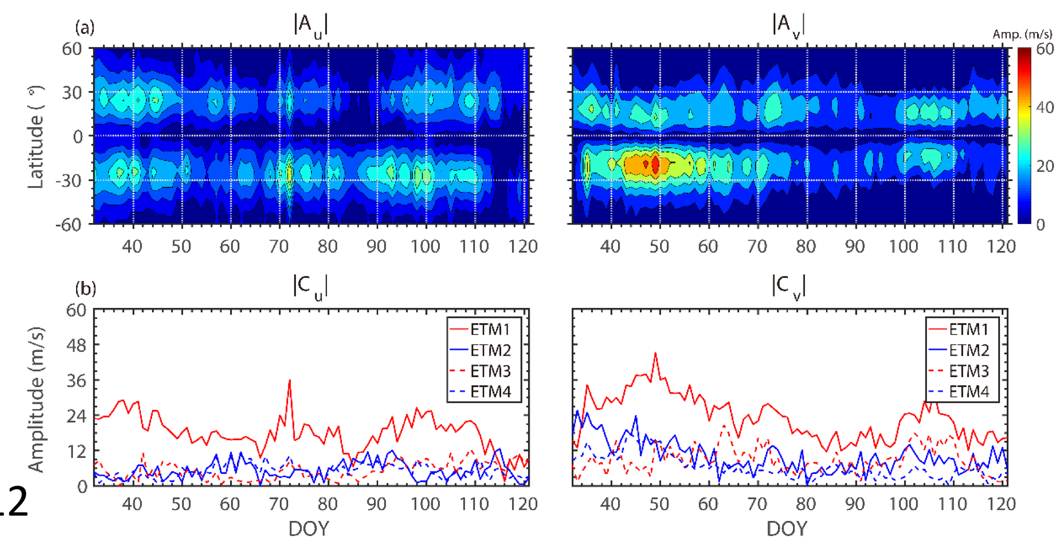
Advantages of ETMs:

- *Fast Convergence*
- *Altitude and Latitude Range are Adjustable*
- *Good Orthogonality*
- *Optional 1-D or 2-D Modes*



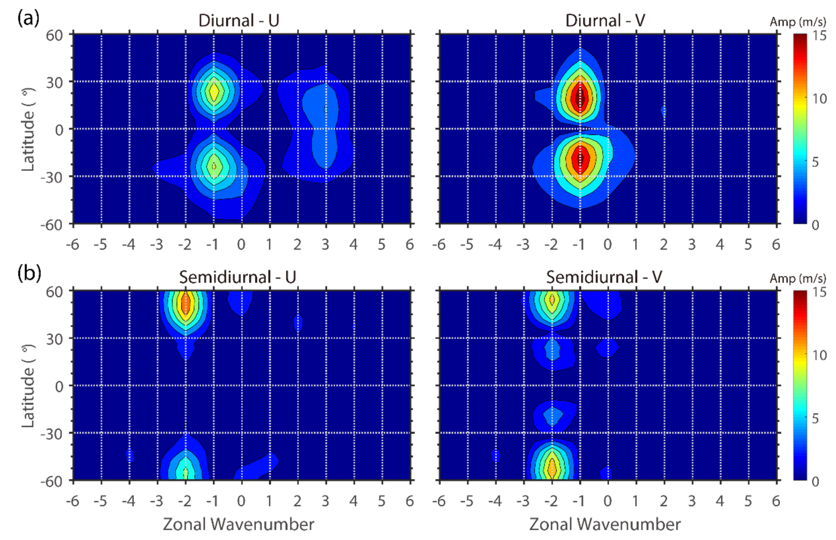
Daily Tides

DW1



Feb-Apr, 2012

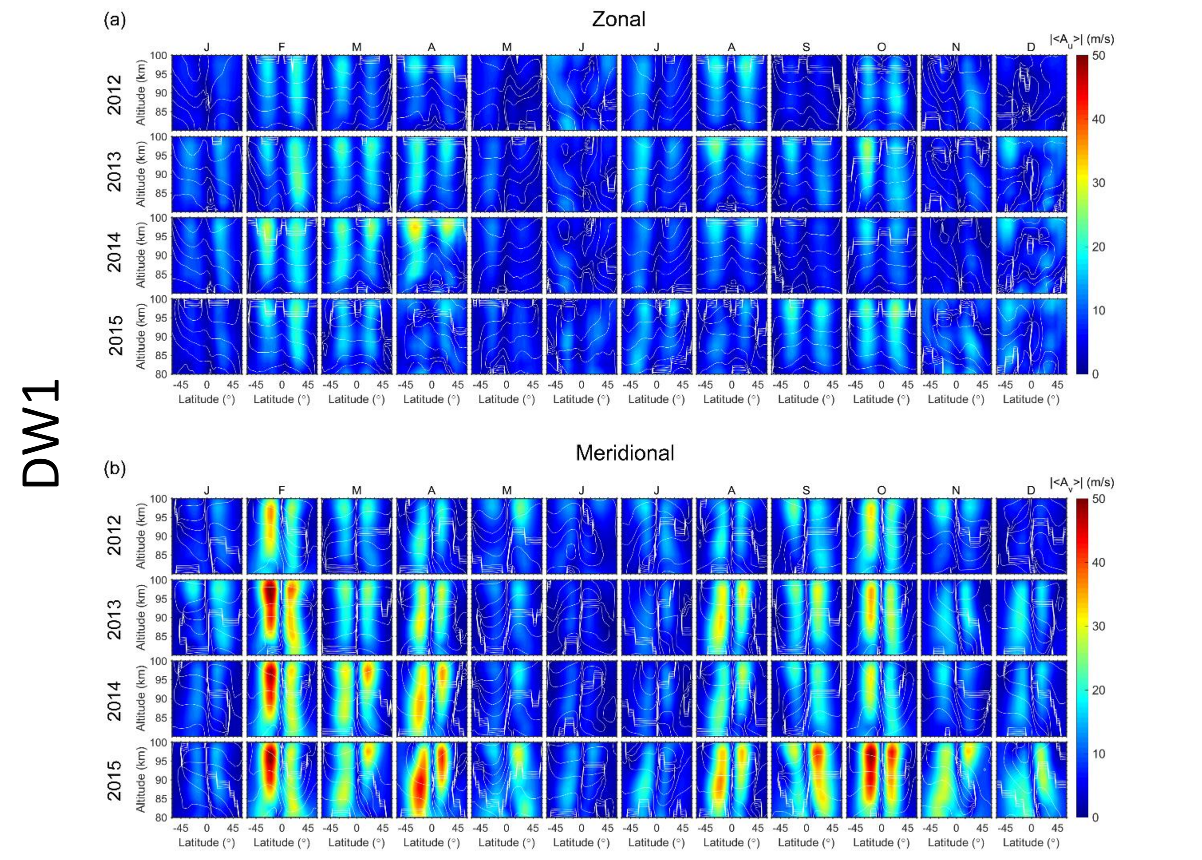
Yearly mean spectra



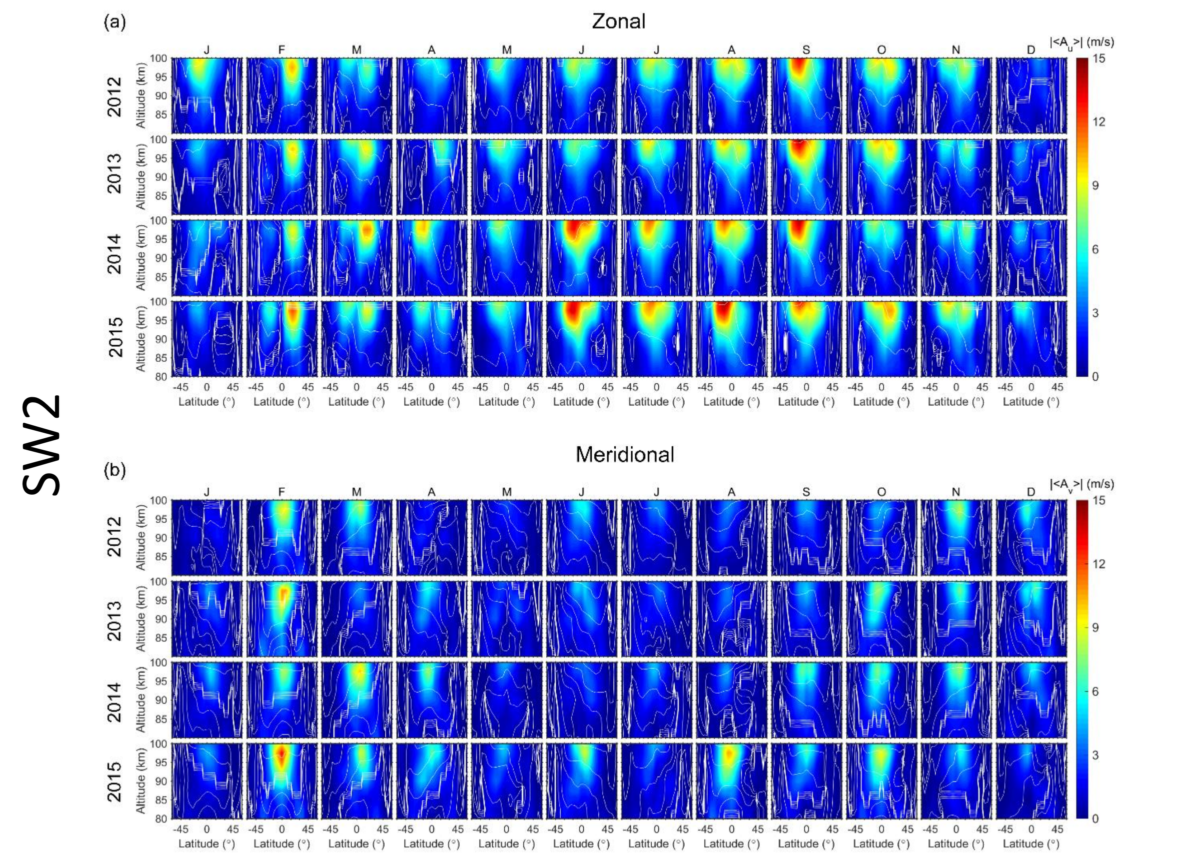
The yearly mean spectra of absolute amplitude of (a) diurnal and (b) semidiurnal tides at 95 km.

Climatology

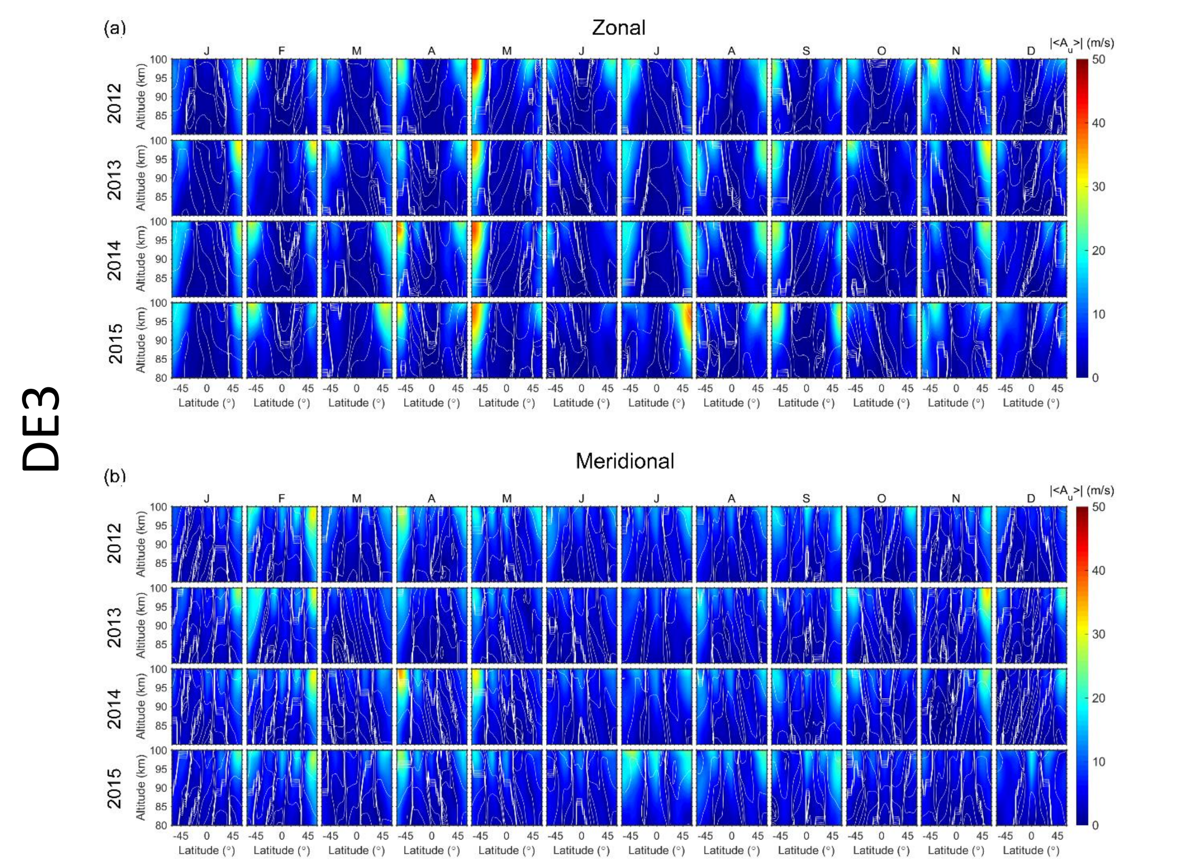
DW1



SW2



DE3



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Zhou et al., 2018, *JGR-Space Physics*