Statistical Characteristics of Short-term Tidal Variability of DW1 in eCMAM30 and SABER

Ashan Vitharana[1], Jian Du[1], Jens Oberheide[2], William E. Ward[3]
Department of Physics and Astronomy, University of Louisville, Louisville, KY
Department of Physics, Clemson University, Clemson, SC
Department of Physics, University of New Brunswick, Fredericton, NB, CANADA

ABSTRACT

In this research, we compare the statistical characteristics of DW1 (migrating diurnal tide) short-term variability using data from the extended Canadian Middle Atmosphere Model (eCMAM30) run (1979-2010) and the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument on NASA's TIMED (Thermosphere Ionosphere Mesosphere Energetics Dynamics) satellite. SABER short-term tides are diagnosed with the deconvolution method (Oberheide et al., 2002). Both eCMAM30 and SABER DW1 time series (variability on the order of 5 days) are first fitted to a multiple linear regression model with deterministic inter-annual variability predictors such as ENSO, QBO, Solar Flux (monthly mean values are used for these indices) and 12, 6, 4, 3 months seasonal harmonics. The residue of the time series is further separated into undeterministic long-term variation (> 1 month) and short-term variation (< 1 month). Characteristics of the above predictors, their relative variance, cross-correlations and probability density functions (PDFs) of the short-term tidal variability (< 1 month) were investigated and compared between the two datasets. Many of the statistical properties agree very well between the two datasets. The model should be able to provide some explanations of the physical processes underlying these statistical properties, which is part of our future research.

MOTIVATION

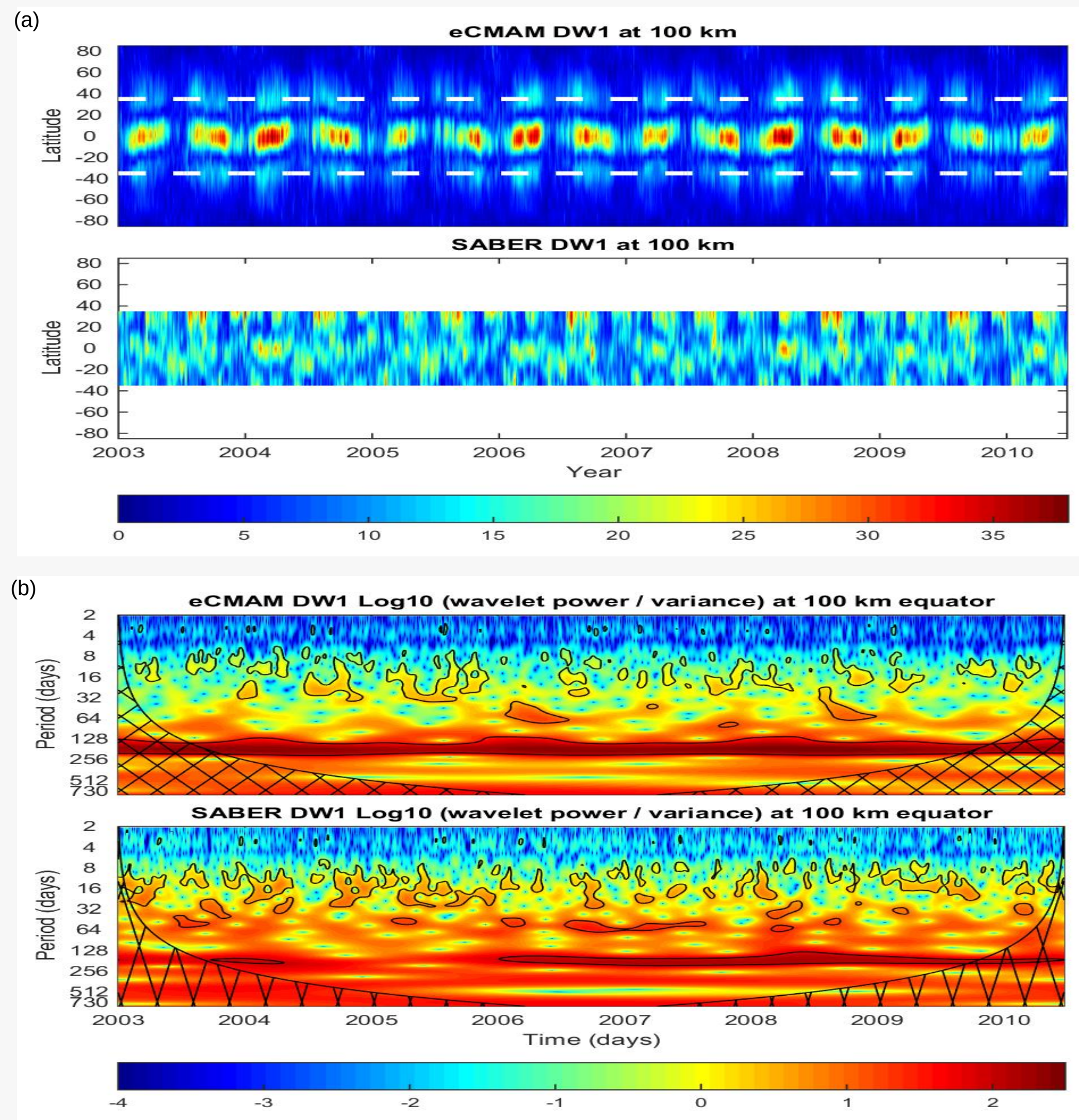

Figure 1: a) eCMAM and SABER DW1 at 100 km from 2003 to 2010 as a function of latitude and time.
b) wavelet analysis of DW1 temporal variability at 100km and the equator for both eCMAM and SABER.

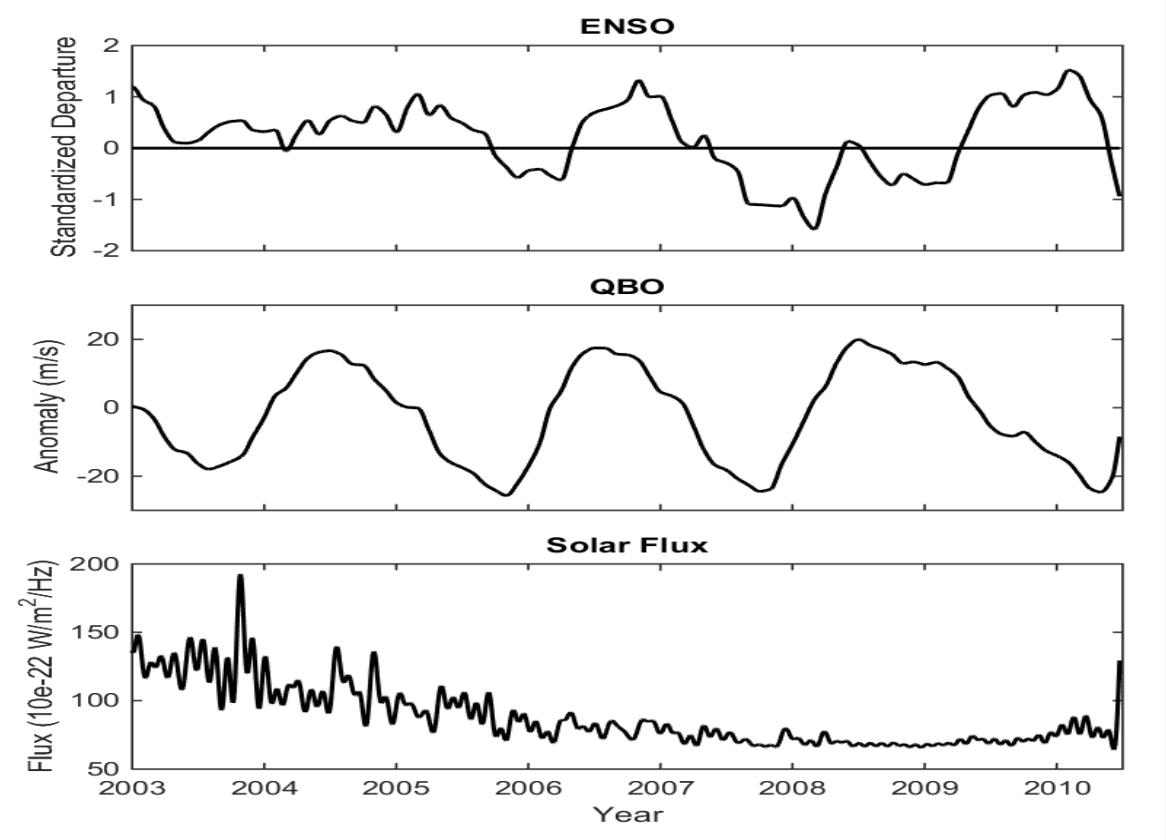

Figure 2: Monthly mean Indices used in the multi-linear regression model: ENSO, QBO, Solar Flux.

$$tide(t)_i = tide_{i0} + \alpha_i(t) + \beta_i E(t) + \chi_i Q(t) + \delta_i S(t) + \sum_{k=1}^{n} a_{i,k}\cos(\omega_k t + b_{i,k}) + \varepsilon_i(t)$$

RESULTS

Section A: Multiple Regression Model

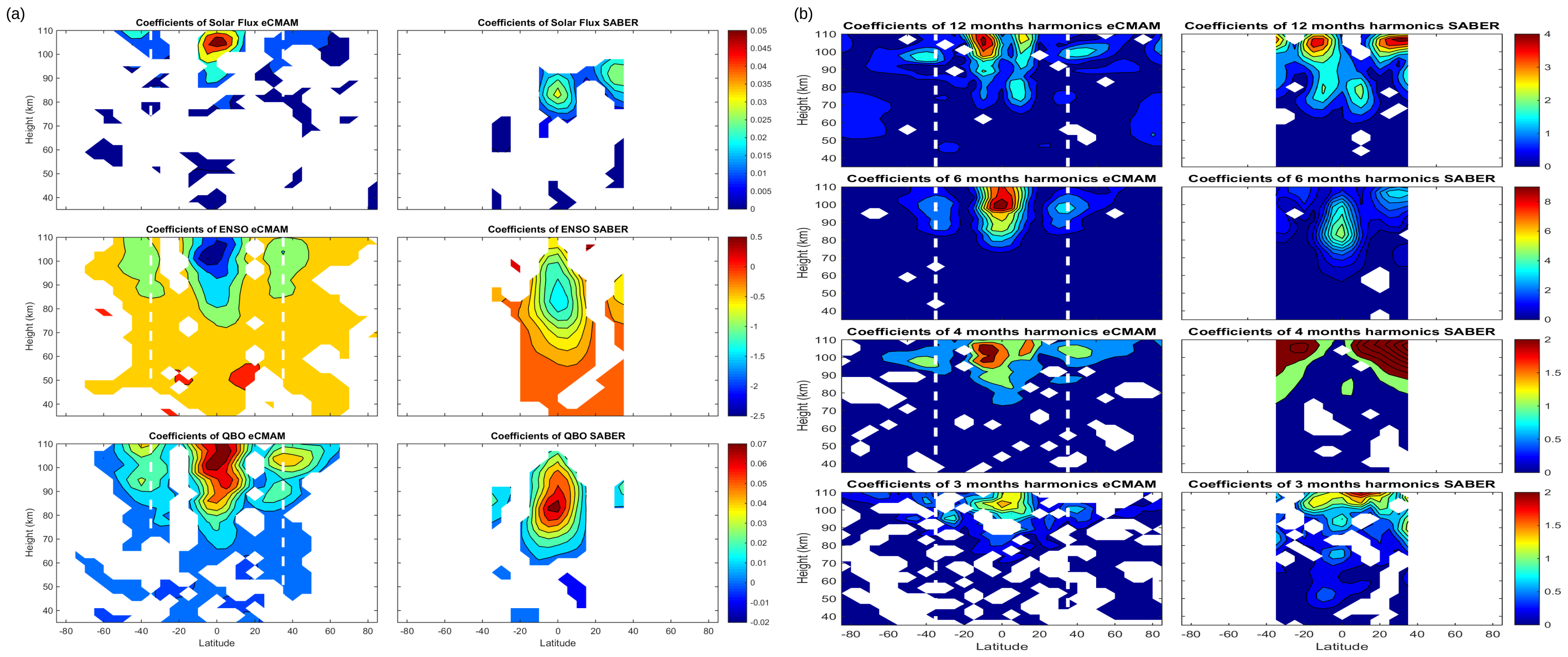

Figure 3: a) Fitting coefficients of tidal variability due to deterministic indices: solar cycle, ENSO, QBO for eCMAM (left) and SABER (right) as a function of height and latitude.
b) Fitting coefficients of tidal variability due to seasonal harmonics: 12, 6, 4, and 3-month variations for eCMAM (left) and SABER (right) as a function of height and latitude.

Section B: Stochastic Part of the Model

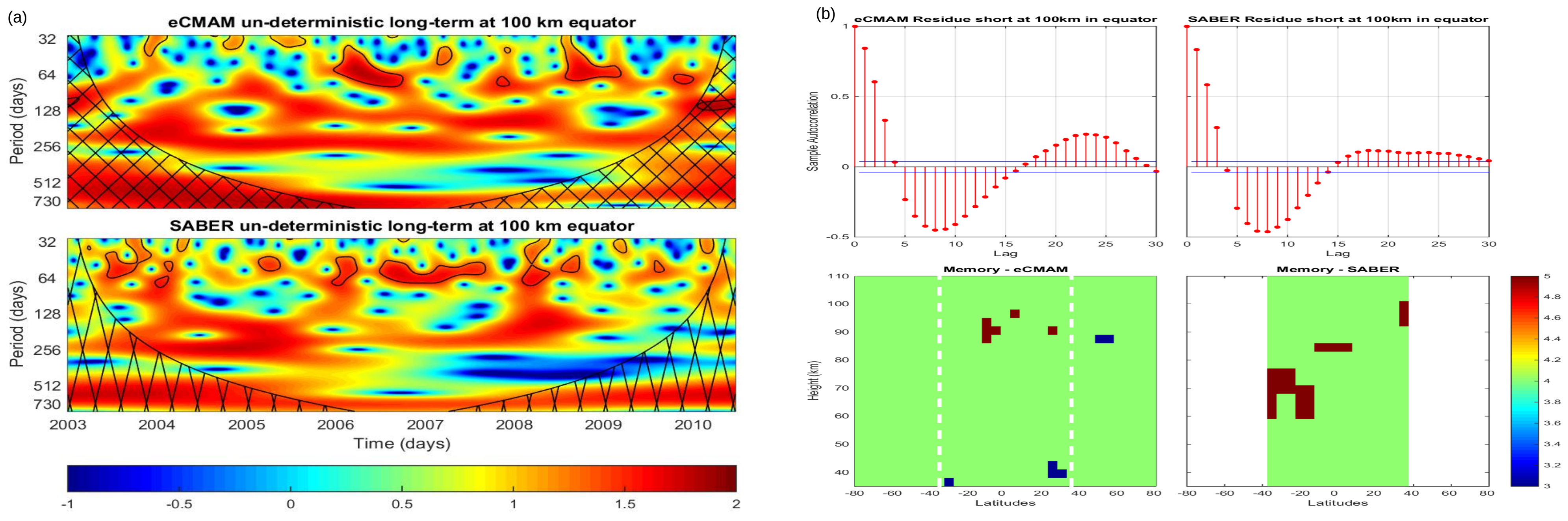

Figure 4: a) Wavelet analysis of Un-deterministic part of the long-term tidal variability in the residue eCMAM (top) and SABER (bottom).
b) Top panel: Self-correlation in time (memory) of short-term tidal variability at the equator and 100 km; Bottom panel: memory of short-term tidal variability as a function of latitude and height for eCMAM (left) and SABER (right).

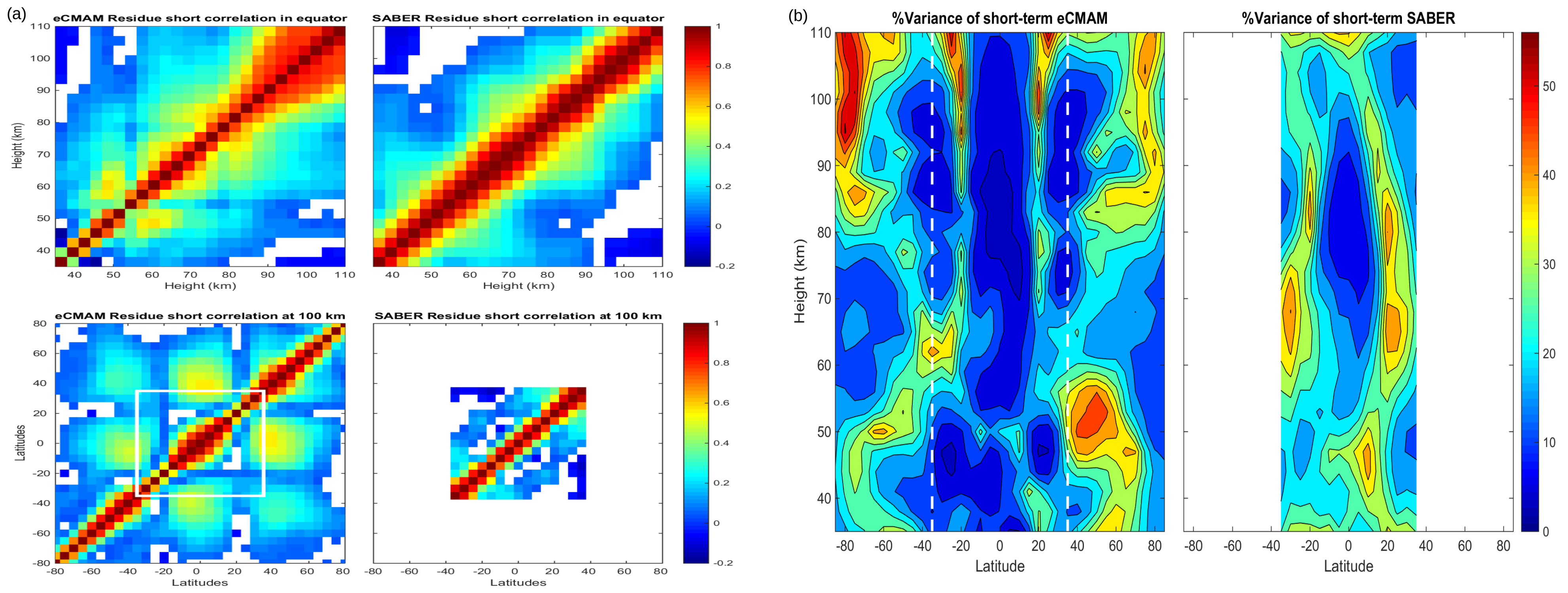

Figure 5 : a) Top panel: Short-term tidal variability correlation with height at the equator for eCMAM (left) and SABER (right); Bottom panel: Short-term tidal variability correlation with latitude at 100 km for eCMAM (left) and SABER (right); b) Relative variance of tidal variability due to short-term variation for eCMAM (left) and SABER (right) as a function of height and latitude.

Section C: Probability Density Functions

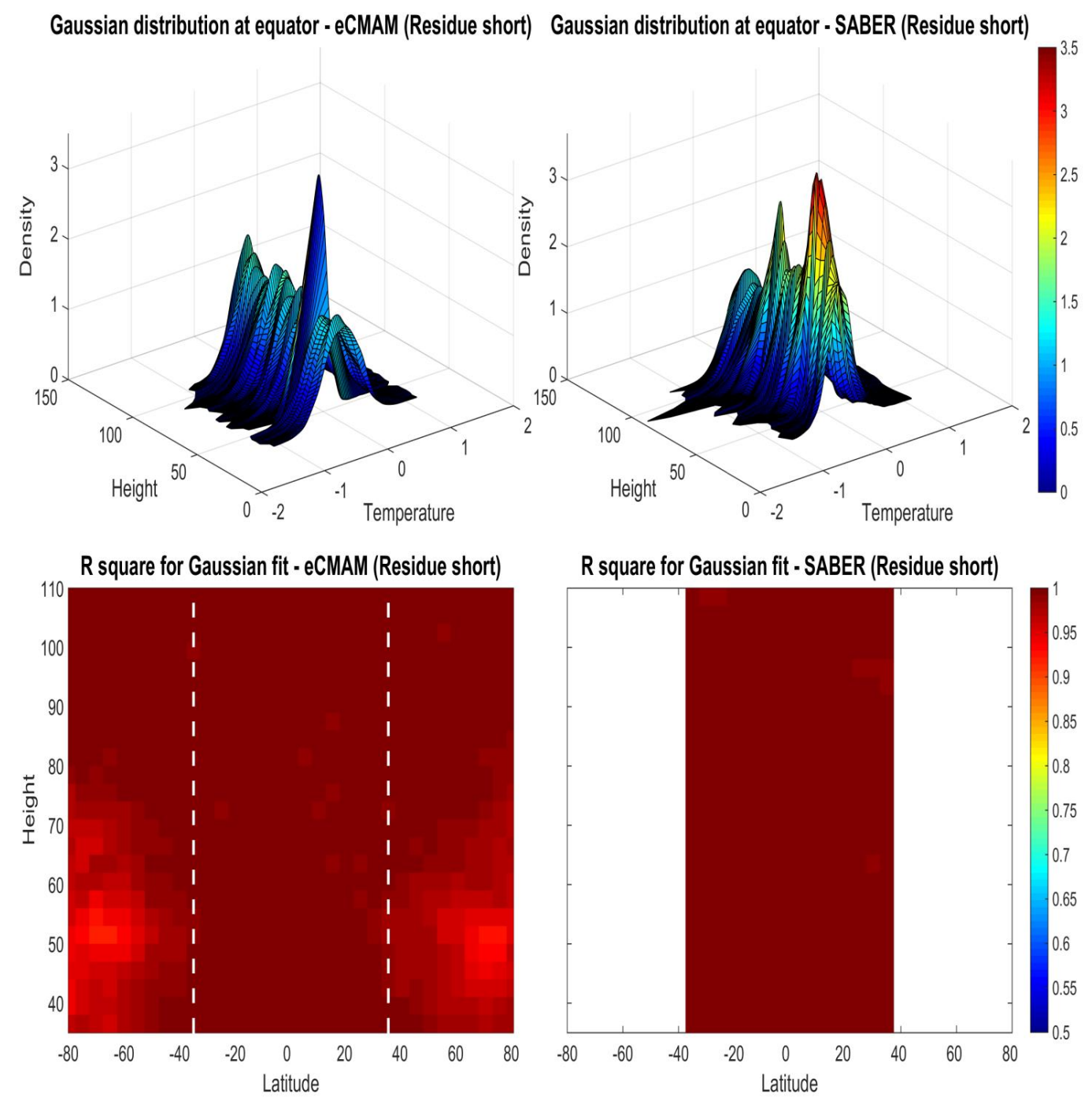

Figure 6: Top panel: Gaussian Fitting of the short-term tidal variability at the equator as a function of height for eCMAM (left) and SABER (right); Bottom panel: R-square value (goodness of fit) as a function of latitude and height for eCMAM (left) and SABER (right).

CONCLUSIONS

All the variables in multiple regression model has well define long-term variabilities and we define these variables as the deterministic part and the residual as the stochastic part of the model. Wavelet analysis of the stochastic part reveals both short and long term (>1 month) variabilities in the residue. These variations are not detained by the long term variabilities.

The short-term tidal variability is not correlated between adjacent latitudes or adjacent days, strong correlation within adjacent heights of only 10 – 20 km. Relative variance of short term is minimum where the DW1 is maximum.

The agreement between the eCMAM and SABER include: correlation with adjacent latitudes, correlation with adjacent heights for short-term tidal variability, self-memory, PDF of short-term tidal variability (Gaussian fit).

We intend to further our investigation by developing time dependent probability density functions (TPDFs) to examine the underlying statistics governing the short-term temporal variability and apply the thermodynamic budget equation to study physical mechanism.

REFERENCES

- Christopher Torrence and Gilbert P. Compo. A practical guide to wavelet analysis.1997.
- N. M. pedatella, J. Oberheide, E. K. Sutton, H. L. Liu, J. L. Anderson, and K. Raeder, Short-term nonmigrating tide variability in the mesosphere, thermosphere, and ionosphere, 10.1002/2016JA022528.
- J. Du, F. Cooper, and S. Fueglistaler, Statistical analysis of global variations of atmospheric relative humidity as observed by AIRS. 10.1029/2012JD017550

ACKNOWLEDGEMENTS

This research is supported by NSF CAREER award 1453943 and NASA grant NO. NNX15AJ02G.

UNIVERSITY OF LOUISVILLE
It's Happening Here.