Statistical Modeling of DE3 Tidal Weather in the MLT Region

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Abstract

In this research we attempt to build a model to predict day to day tidal variability of the DE3 using an empirical statistical model based on autoregression (AR). We will present some of the statistical properties of the day-to-day variability of the tide, and the process to build the model to understand and simulate the complex tidal variability from a statistical point of view using Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) temperature observations in the Mesosphere and lower Thermosphere (MLT) region and extended Canadian Middle Atmospheric Model (eCMAM) data.

Research Objective

To examine the statistical properties of the tidal variability and develop a statistical model to forecast total tidal variability.

Results

❖ DE3 Climatology and Weather

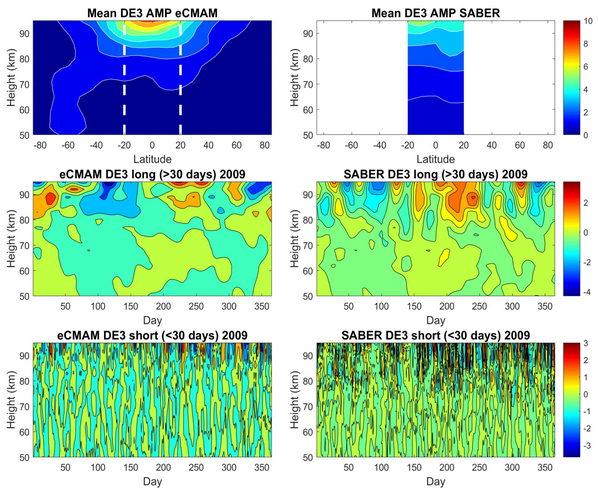


Figure 1: (top) Mean of the DE3 T amplitude from January 2003 to June 2010 as a function of latitude and height. (middle) Long-term anomaly: tidal climatology (>30 days) of DE3 amplitude in 2009 as a function of height at the equator. (bottom) Short-term anomaly: tidal weather (<30 days) of DE3 amplitude in 2009 as a function of height at the equator. The left panel is eCMAM and right is SABER.

❖ Statistical Properties of Tidal Weather

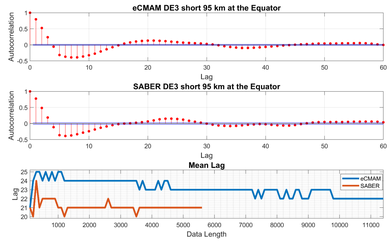


Figure 2: Auto-correlation of the DE3 tidal weather (< 30 days variability) at the Equator and 95 km for eCMAM (top) and SABER (middle). The lag (in days) is determined from day 0 to the next maximum in auto- correlation. (bottom) Mean lag between 40 and 95 km as a function of data length that went into the autocorrelation calculation for eCMAM (blue: 31.5 years = 11496 data points) and SABER (red: 15.5 years = 5600 data points

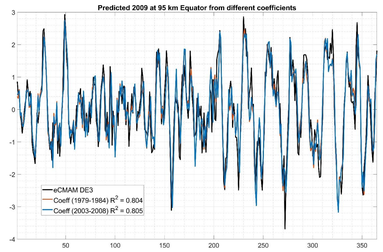
❖ Statistical Model

$$Y_t = C_1 + \sum_{i=1}^{i=23} A_i Y_{t-i} + e_1$$

- Lag is fixed at 23 based on auto-correlation.
- The tidal variability at time t depends on a linear combination of the previous 23 time points.
- There are 24 coefficients that need to be estimated, including C_1, A_i, *where i=1, …23.*

❖ Statistical Model Test, Prediction and Comparison

Figure 3: DE3 tidal weather from eCMAM at 95 km and the equator in 2009 (black line), predicted tidal weather using coefficients estimated from 1979 – 1984 (red line) and 2003 – 2008 (blue line). Both predictions show very similar R-square. The coefficients calculated from the 2000-day window are robust and do not require frequent update.



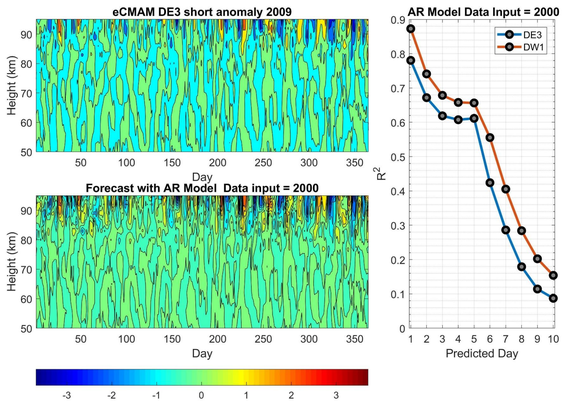


Figure 4. (left top) eCMAM DE3 tidal weather in 2009. (left bottom) Day 1 prediction from a 23-coefficents AR model based on eCMAM input data. (Right) R-square values of prediction as a function of predicted day for DE3 and DW1. DW1 has higher R-square compared to DE3

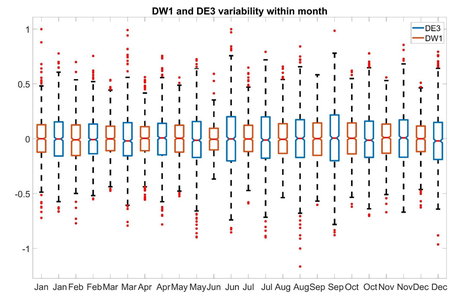


Figure 5: Box-plot shows comparison of DW1 and DE3 tidal weather variability within month.

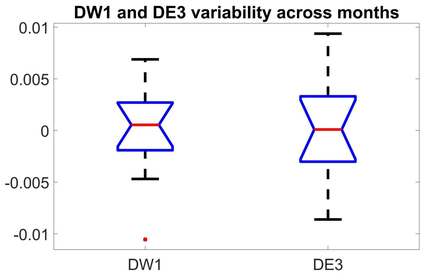


Figure 6: Box-plot shows DE3 tidal weather across months has more variability compared to DW1 tidal weather.

Conclusions

- DE3 and DW1 short term variability is dominated by a quasi 23 day oscillation.
- AR model predict DE3 tidal weather to ~ 80% accuracy and DW1 tidal weather ~ 87% for day -1.
- DE3 tidal weather shows more variability compared to the DW1 tidal weather.
- We intend to further investigate the physical cause for a quasi 23 day oscillation.

Acknowledgment

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

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