Tropopause Evolution in a Rapidly Intensifying Tropical Cyclone: A Static Stability Budget Analysis

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ABSTRACT

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1. Introduction

2. Model Setup

Put description of Fig. 1 in this section. Don't forget to mention 1-2-1 smoother.

3. Budget Computation

4. Results

a. Static stability evolution

The simulated static stability evolution closely follows that observed in Hurricane Patricia (2015; Duran and Molinari 2018). The average N^2 over the first day of the simulation (Fig. 2a) indicates the presence of a static stability maximum about 400 m above the cold-point tropopause. This lower-stratospheric stable layer had begun to erode during the initial spin-up period, with the maximum destabilitzation occurring at the innermost radii. This decrease in static stability continued into the second day of the simulation (Fig. 2b) as the storm intensified to hurricane strength (Fig. 1). Destabilization was particularly pronounced over the developing eye, where the time-mean cold-point tropopause height increased by up to 400 m compared to the previous day. Over the developing eyewall and outer rainband regions, meanwhile, the time-mean tropopause height remained nearly constant. During the third day of the simulation (Fig. 2c), static stability over the eye region continued to decrease, and the cold-point tropopause height rose to 18.3 km at the storm center. The tropopause sloped sharply downward over the innermost radii, reaching the 16.4-km level near the 50-km radius. This local minimum in tropopause height corresponded to the eyewall region, where upper-tropospheric static stability increased during this time period. Outside of the eyewall region, static stability began to increase in the layer immediately overlying the cold-point tropopause. This stable layer sloped upward with radius, which corresponded to an upward-sloping tropopause radially outside of the eywall region. Over the next 24 hours (Fig. 2d), as the storm's maximum 10-m wind speed leveled off near 80 m s^{-1} (Fig. 1), the upper-tropospheric static stability within the eyewall region continued to strengthen, along with the static stability within the lower stratosphere radially outside of the eyewall. As the stable layer strengthened, its altitude rose slightly, which corresponded to a slight increase in tropopause height outside of the eyewall during this period. Within the upper troposphere radially outside of the eyewall, meanwhile, static stability decreased such that it was nearly neutral in a thin layer between the 120- and 150-km radii. The eye region likewise continued to destabilize, and the cold-point tropopause height increased to a level above 18.5 km.

b. Potential temperature budget analysis

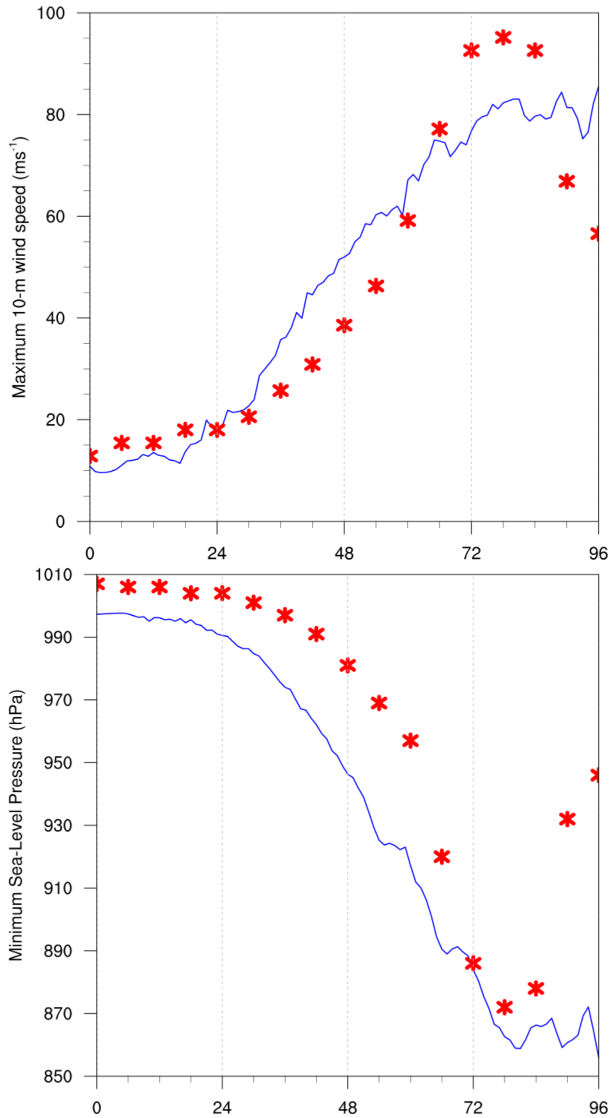
The left column of Fig. 4 depicts 24-hour changes in N^2 over each of the four days of the simulation. These represent bulk changes computed by subtracting the instantaneous N^2 at the initial time from the instantaneous N^2 at the final time. The middle column of Fig. 4 represents the change in N^2 computed using Eq. XXX and the process described in Section 3. The residual between these two computations (Fig. 4, right column) is much smaller than the change in N^2, meaning that the budget peforms well within the analysis domain.

Acknowledgments. Start acknowledgments here.

References

Duran, P., and J. Molinari, 2018: Dramatic tropopause variability during the rapid intensification of hurricane patricia (2015). *Mon. Wea. Rev.*, **XXX (X)**, XXX–XXX.

LIST OF FIGURES



67 FIG. 1. The maximum 10-m wind speed (top panel; m s^{-2}) and minimum sea-level pressure (bottom panel;
68 hPa) in the simulated storm (blue lines) and from Hurricane Patricia's best track (red stars).

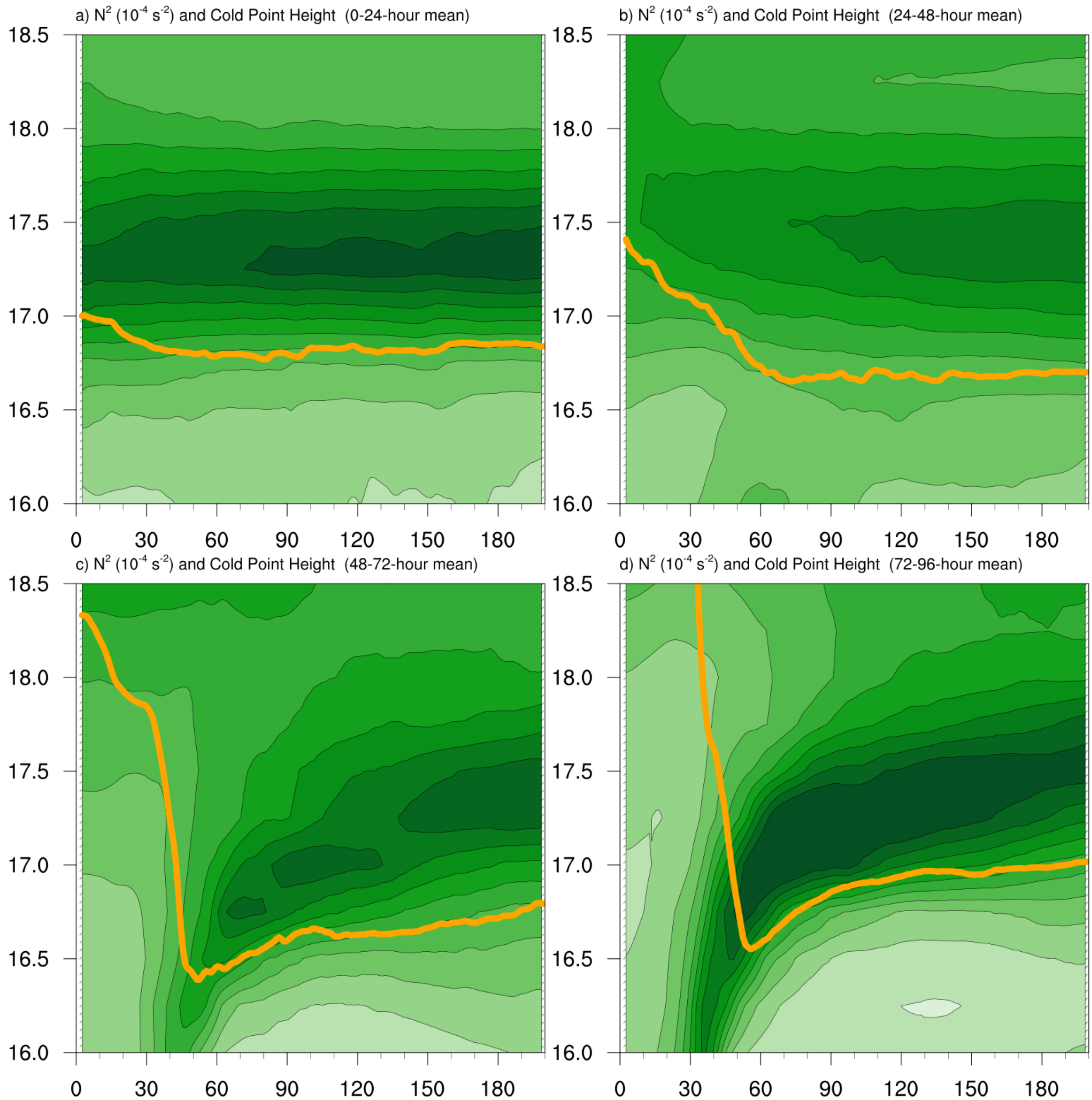


FIG. 2. Twenty-four-hour averages of squared Brunt-Väisälä frequency (10^{-4} s^{-2}) over the first four days of the simulation. Orange lines represent the cold-point tropopause computed from the mean temperature field over the same time periods.

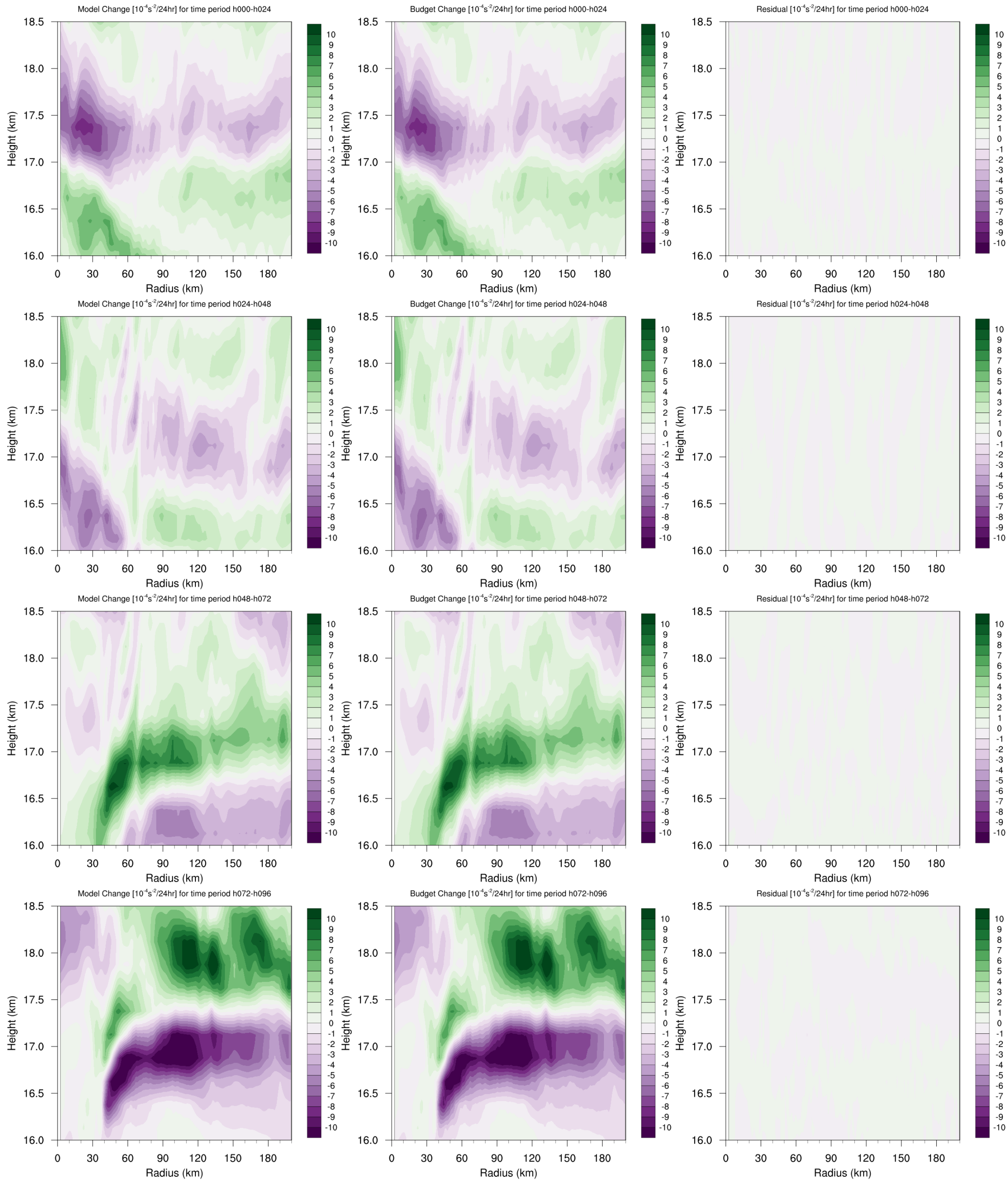


FIG. 3. Left panels: Twenty-four-hour changes in squared Brunt-Väisälä frequency (10^{-4} s^{-2}) over (a) 0-24 hours, (b) 24-48 hours, (c) 48-72 hours, (d) 72-96 hours. Middle Panels: The N^2 change over the same time periods computed using Eq. XXX. Right Panels: The budget residual over the same time periods, computed by subtracting the budget change (middle column) from the model change (left column).

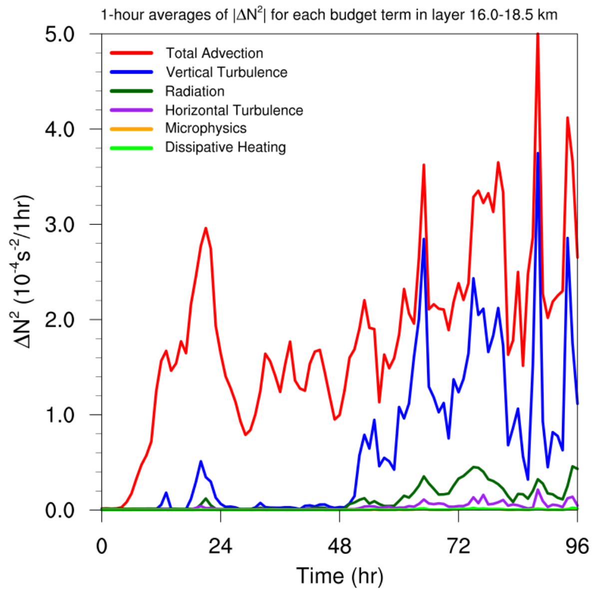


FIG. 4. Time series of the contribution of each of the budget terms to the squared Brunt-Väisälä frequency (10^{-4} s^{-2}) tendency. For each budget term, the absolute value of the N^2 tendency is averaged both temporally and spatially over 1-hour periods, using output every minute, and within the radius-height domain depicted in Fig. 4.