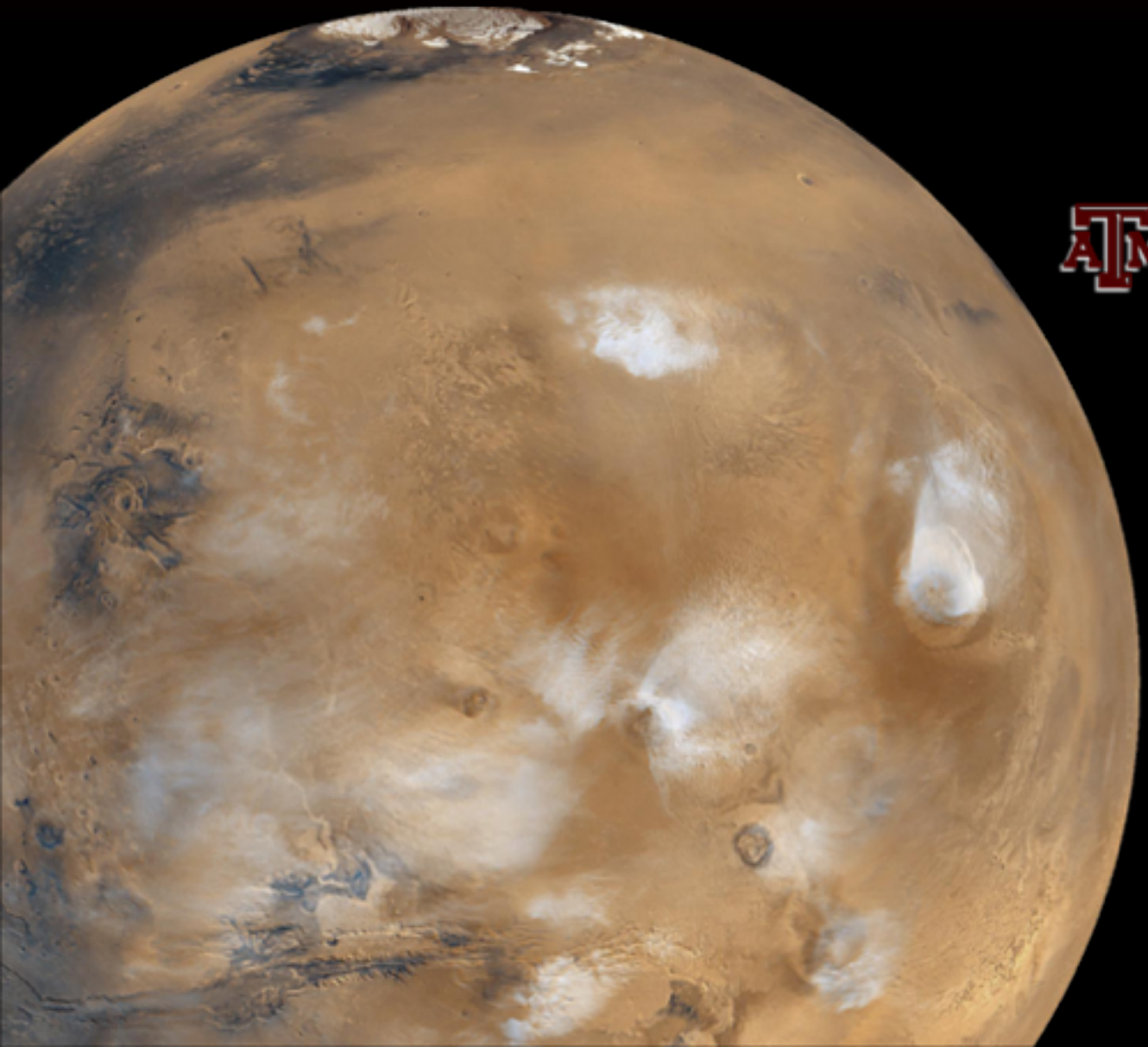
Reduced Baroclinicity During Martian Global Dust Storms



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Background

- Mars Analysis Correction Data Assimilation
  - Retrievals from Thermal Emission Spectrometer on MGS assimilated into a spectral GCM
  - 5x5 degree in horizontal, 25 sigma levels, every 2 hrs for MY24-27 (Montabone, 2011)
- Best for comparing dust scenarios with MY 25 global dust storm

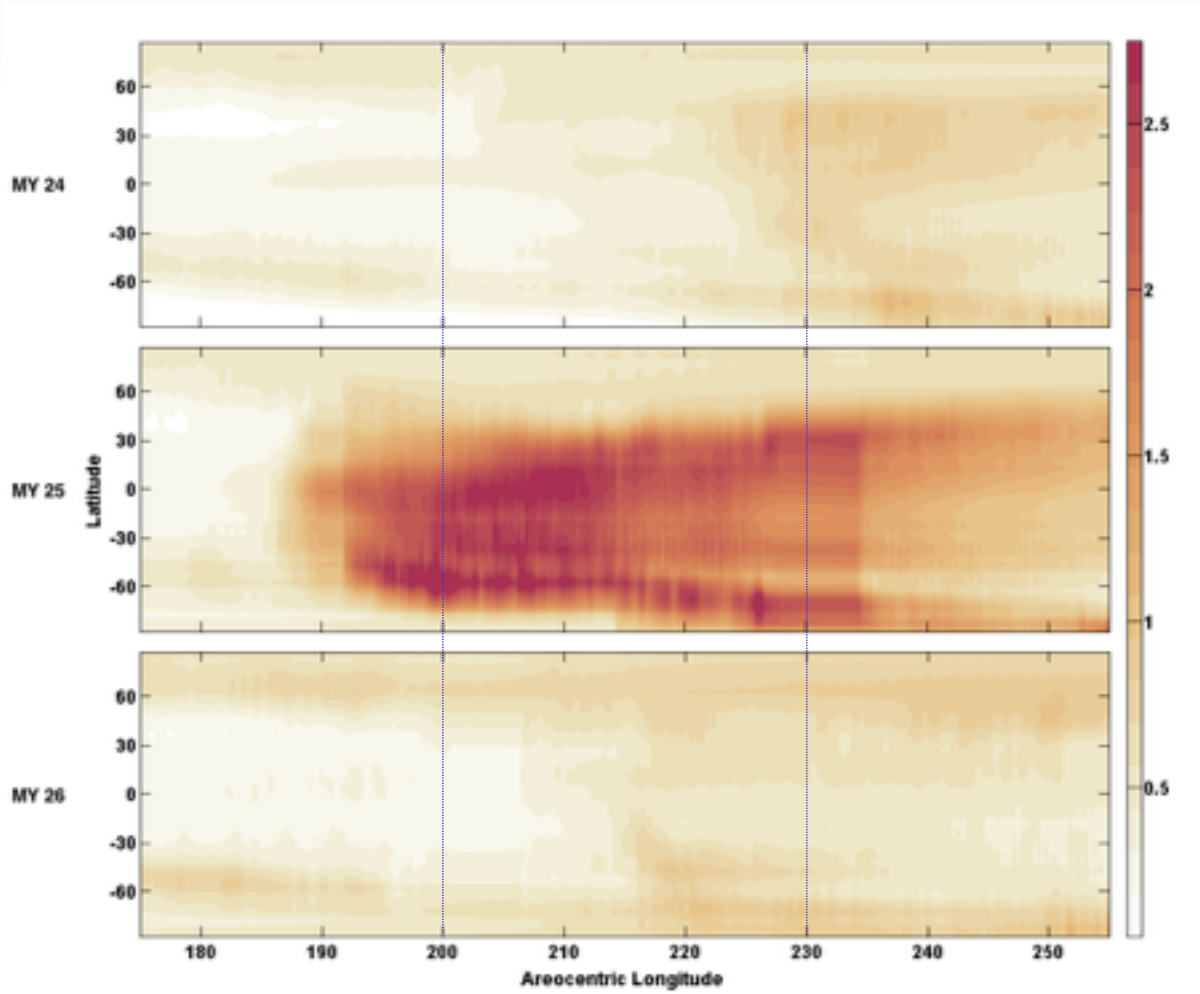


Fig. 1: Column optical depth for $L_s = 175^\circ – 255^\circ$

Eddy Kinetic Energy

$$\frac{\partial}{\partial t}\langle K_e\rangle = -\langle \nabla_3 \cdot \mathbf{v_3} K_e\rangle - \langle \nabla_3 \cdot \mathbf{v_3'}\phi'\rangle - \langle \omega'\alpha'\rangle - \langle \mathbf{v'}\cdot(\mathbf{v_3'}\cdot\nabla_3)\mathbf{v_m} - \mathbf{v'}\cdot\overline{(\mathbf{v_3'}\cdot\nabla_3)\mathbf{v'}}\rangle + \langle Residue\rangle$$

$$\frac{\partial EKE}{\partial t} = etrans + GFC + BCEC + BTEC + residue$$

etrans: eddy kinetic energy advection

GFC: geopotential flux convergence

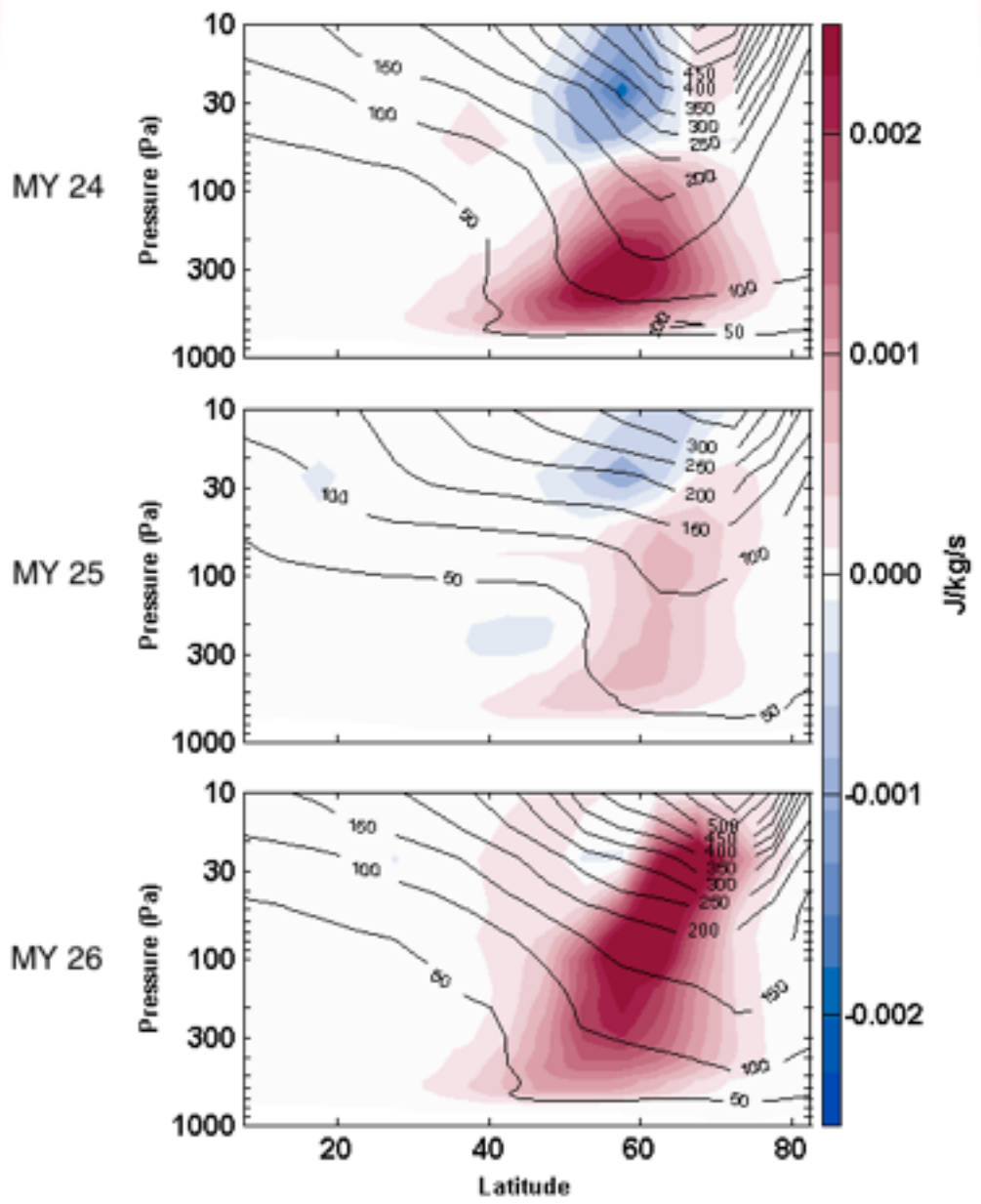
BCEC: baroclinic energy conversion,(+) PE ➔ KE

BTEC: barotropic energy conversion,(+) when KE moved from mean flow to eddies

Residue: $\frac{\partial}{\partial t}\langle K_e\rangle = \mathbf{v'}\cdot\frac{\partial \mathbf{v'}}{\partial t}$

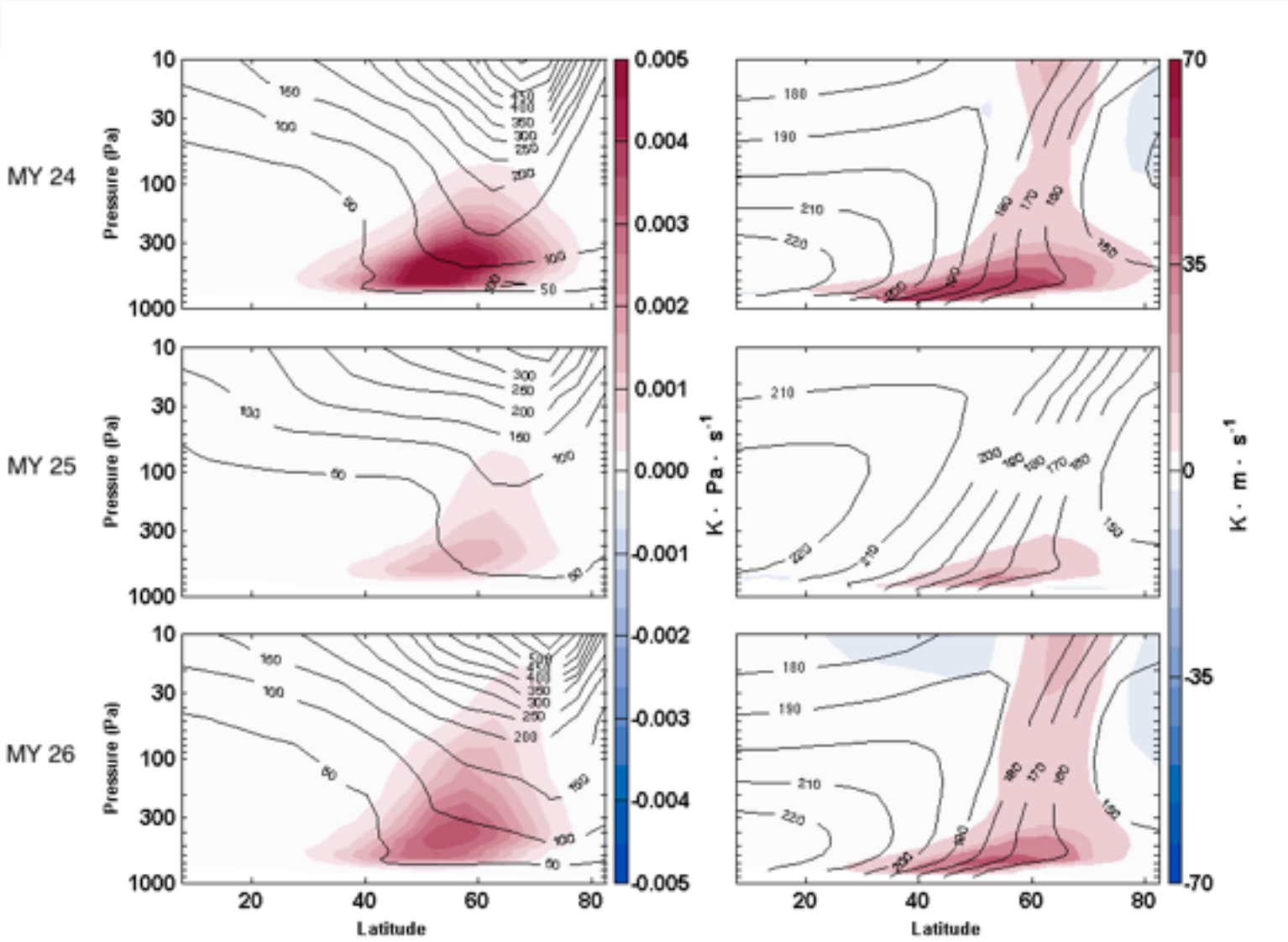
Baroclinic Energy Conversion

Fig. 2: Vertical cross sections of the time-mean ($L_s = 200^\circ - 230^\circ$) zonal mean baroclinic energy conversion. Contours show average EKE (J/kg)



Heat Flux

Fig. 3: Vertical cross sections of the time-mean ($L_s = 200^\circ$ – 230°) of the zonal mean of the vertical heat flux, $-T'\omega'$, (left column) and meridional heat flux, $T'v'$, (right column). Contours show average EKE (J/kg) (left) and temporal mean of temperature (K) (right).



Eady Index

Defined as ratio of vertical shear in zonal wind to Brunt-Väisälä frequency (N) (Hoskins & Valdes, 1990)

$$\sigma = 0.31 f \left(\frac{\partial v}{\partial z} \right) (N)^{-1}$$

$$N = \left(\frac{g}{\theta_{va}} \frac{\partial \theta_{va}}{\partial z} \right)^{\frac{1}{2}}$$

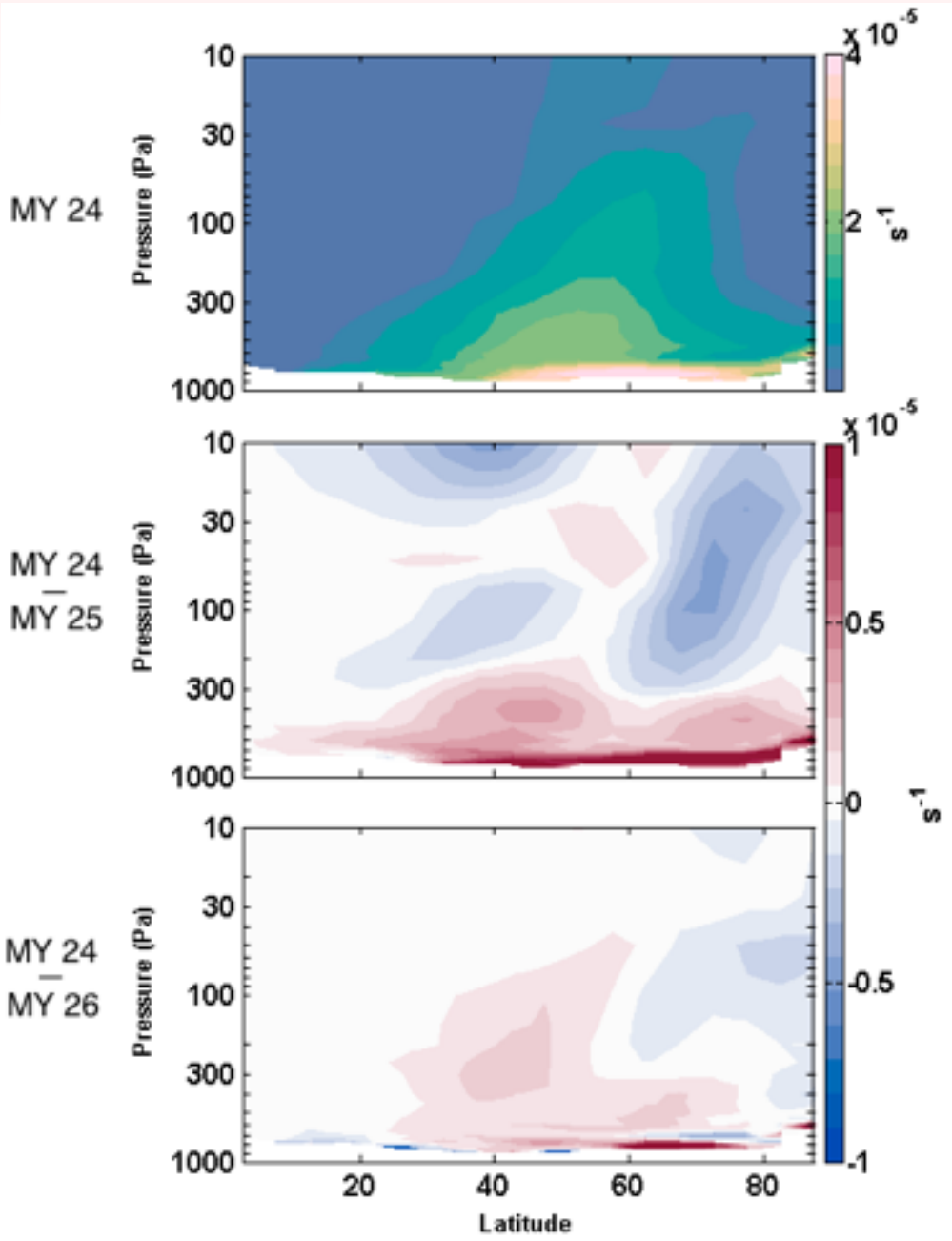


Fig. 4: Vertical cross sections of the time-mean ($L_s = 200^\circ – 230^\circ$) of the zonal mean of the Eady index.

Vertical Profiles

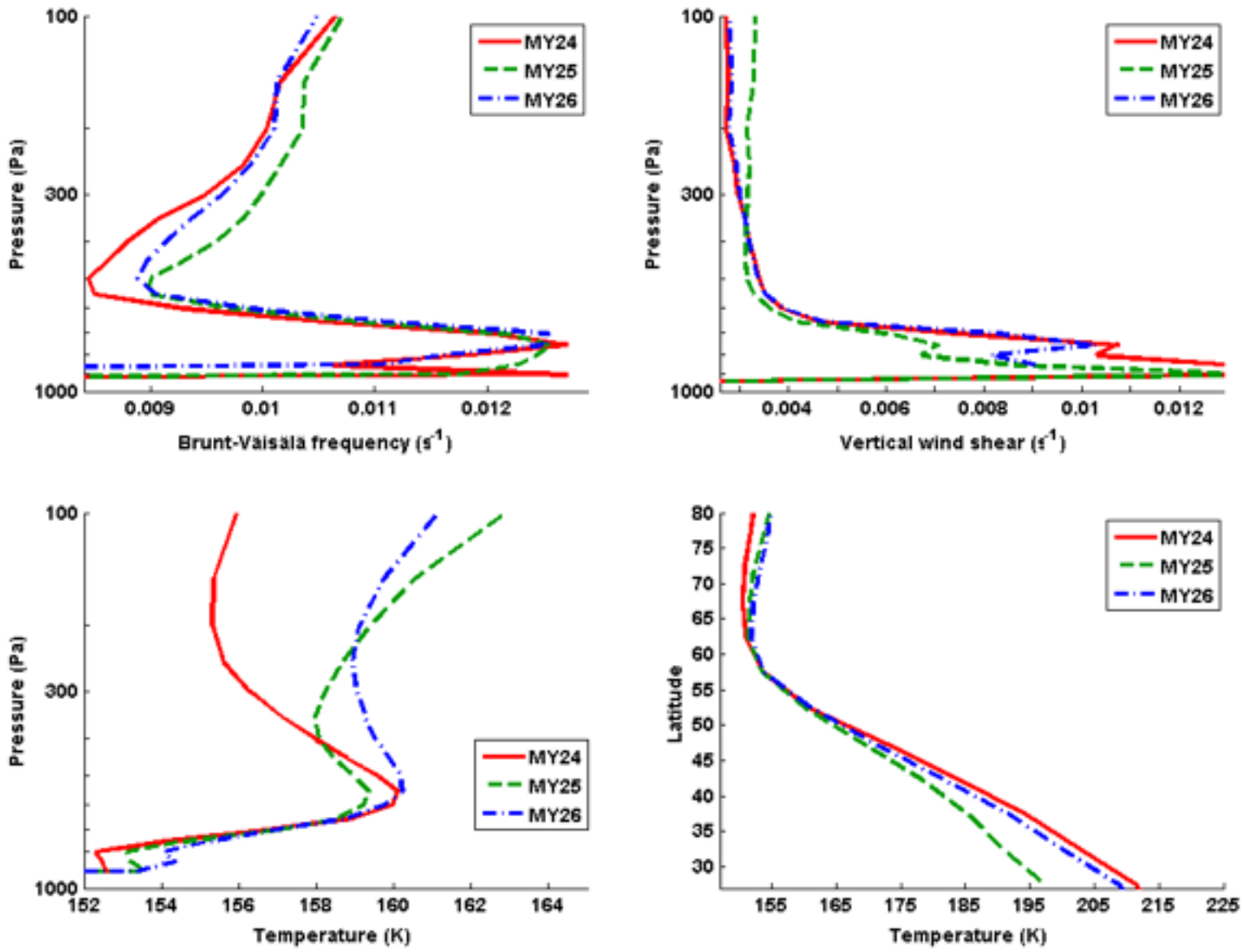



Fig. 5: Brunt-Väisälä frequency (top left), vertical wind shear (top right), and temperature (bottom left) vertical profiles for the time-mean $L_s = 200^\circ - 230^\circ$ of the $57.5^\circ - 82.5^\circ$ N latitude band. Average meridional surface temperature (bottom right) for the time-mean $L_s = 200^\circ - 230^\circ$.