ATM 622
General Circulation

6. Hadley Circulation

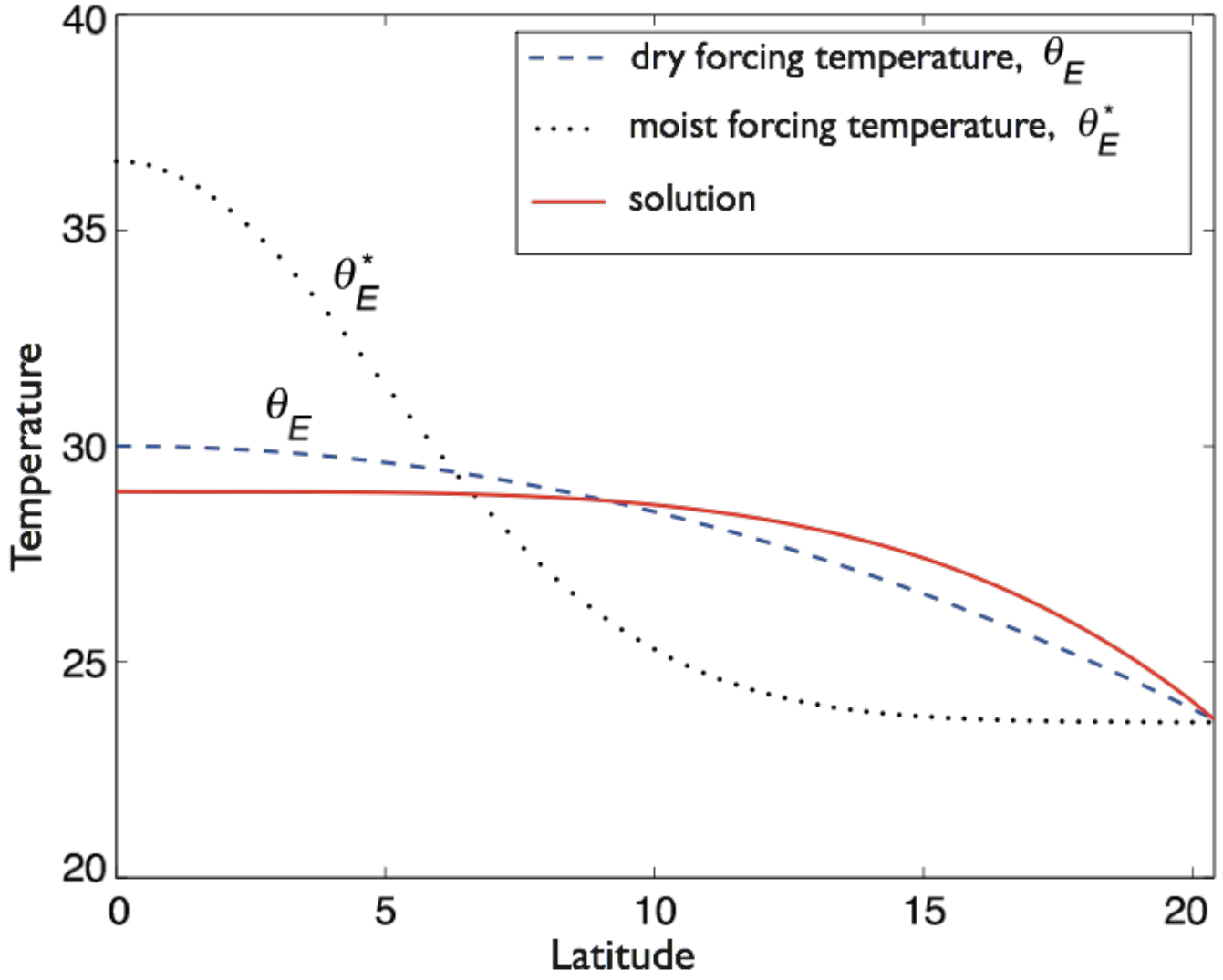


Fig. 11.8 Schema of the effects of moisture on a model of the Hadley Cell. The temperature of the solution (solid line) is the same as that of a dry model, because this is determined from the angular-momentum-conserving wind. The heating distribution (as parametrized by a forcing temperature) is peaked near the equator in the moist case, leading to a more vigorous overturning circulation.

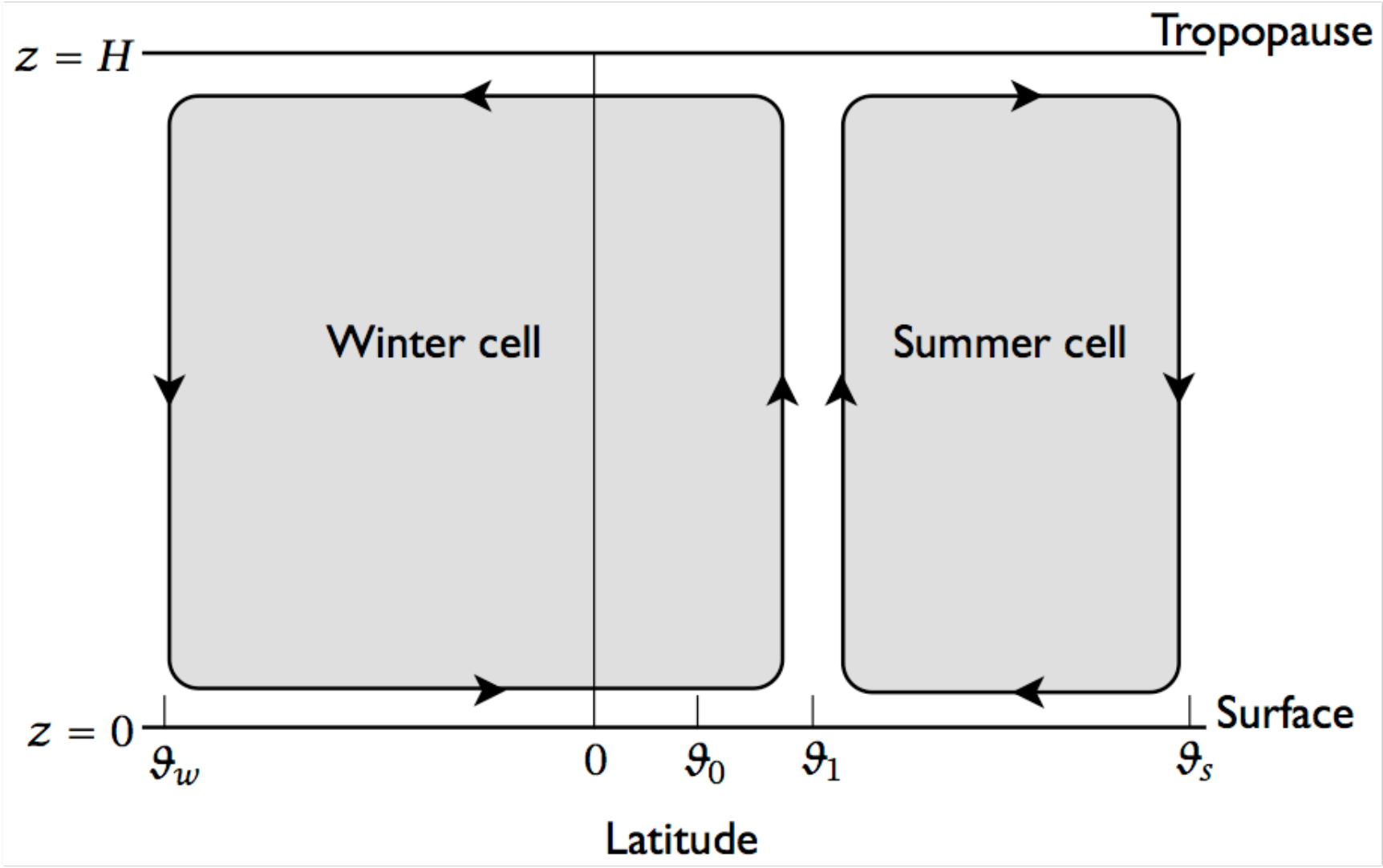


Fig. 11.9 Schematic of a Hadley circulation model when the heating is centred off the equator, at a latitude ϑ_0. The lower level convergence occurs at a latitude ϑ_1 that is not in general equal to ϑ_0. The resulting winter Hadley Cell is stronger and wider than the summer cell.

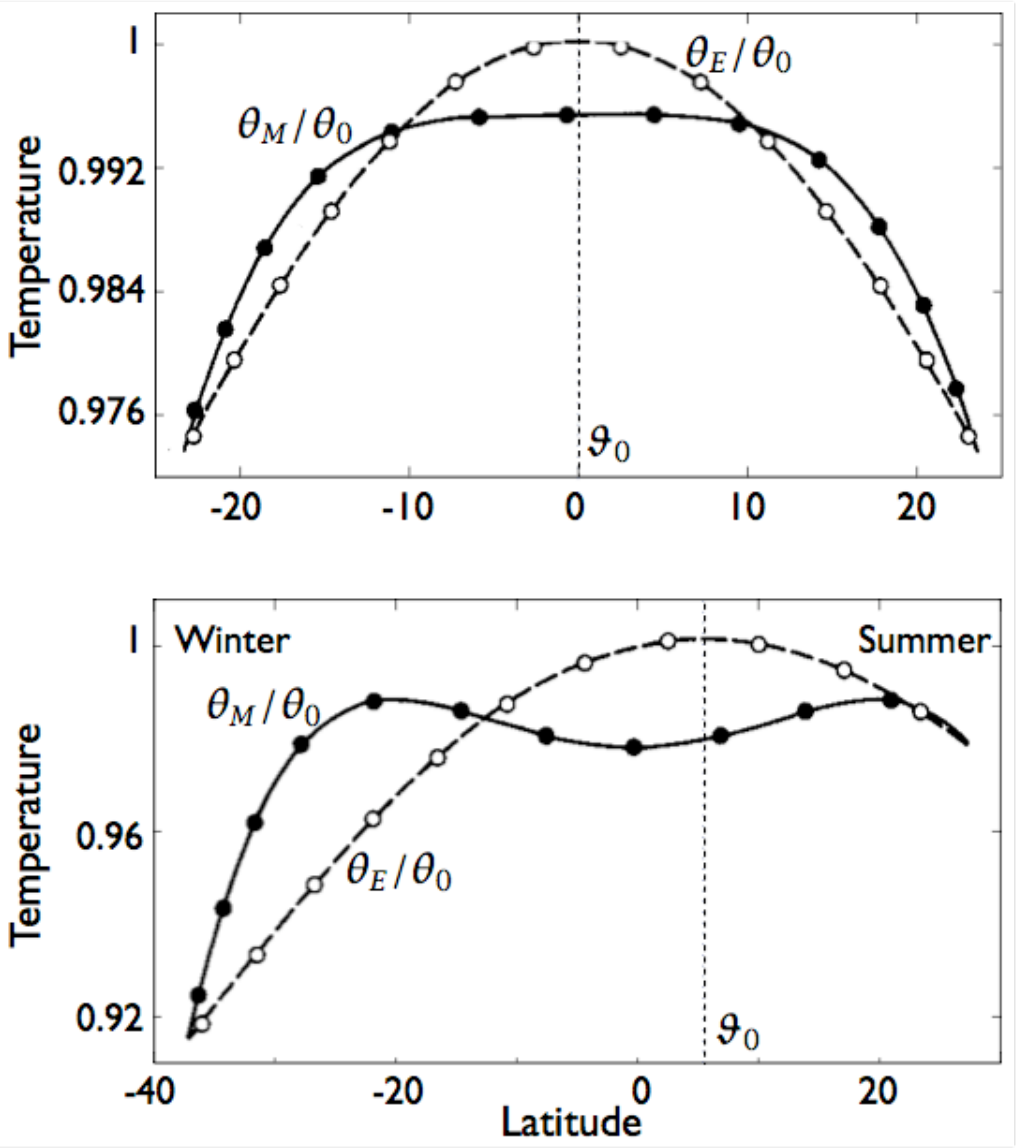
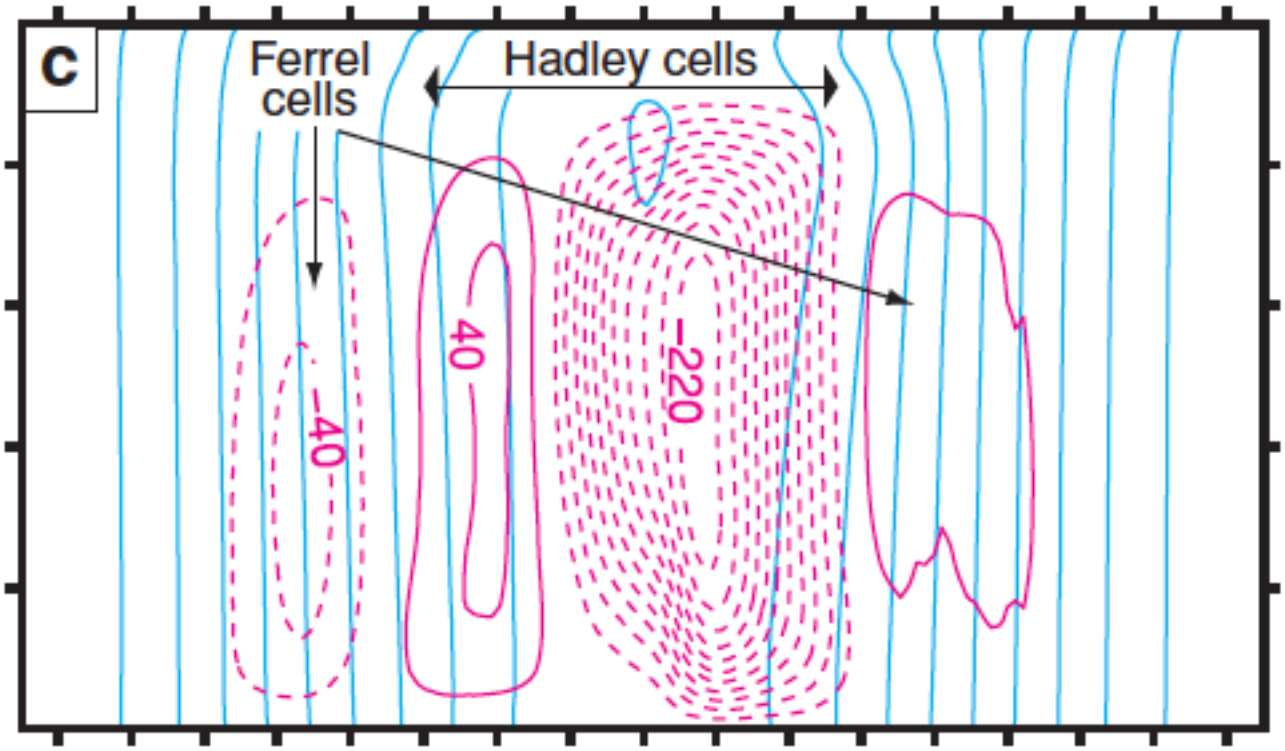


Fig. 11.10 Solutions of the Hadley Cell model with heating centred at the equator ($\vartheta_0 = 0°$, top) and off the equator ($\vartheta_0 = +6°$N, bottom), with $\Delta_H = 1/6$. The dashed line is the radiative equilibrium temperature and the solid line is the angular-momentum-conserving solution. In the lower panel, $\vartheta_1 \approx +18°$, and the circulation is dominated by the cell extending from $+18°$ to $-36°$.[1]



Mass streamfunction and angular momentum (January)

Schneider (2006)

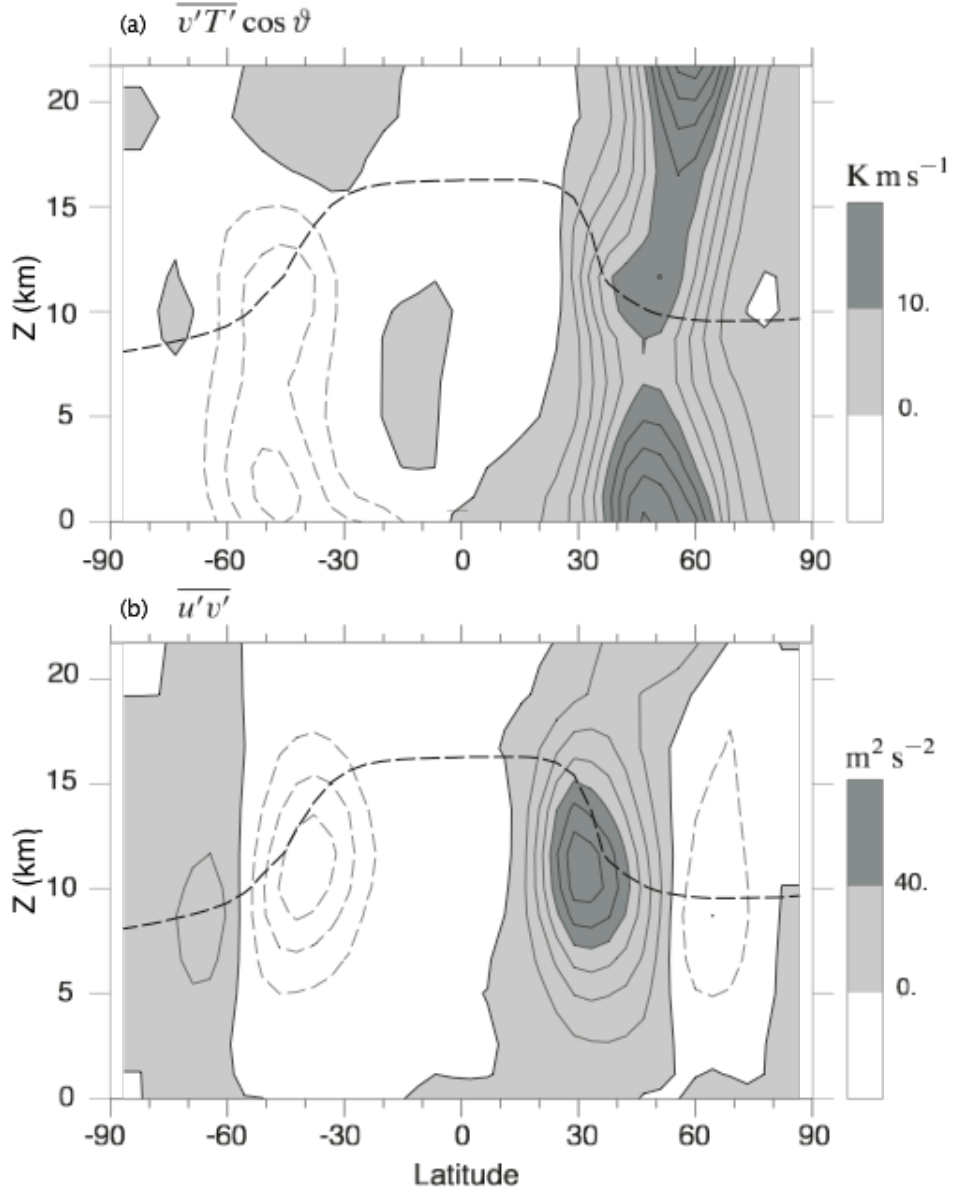


Fig. 11.11 (a) The average meridional eddy heat flux and (b) and the eddy momentum flux in the northern hemisphere winter (DJF). The ordinate is log-pressure, with scale height $H = 7.5$ km. Positive (northward) fluxes are shaded in both cases, and the dashed line marks the thermal tropopause. The eddy heat flux (contour interval 2 K m s^{-1}) is largely polewards, and down the temperature gradient, in both hemispheres. The eddy momentum flux (contour interval 10 m^2 s^{-2}) *converges* in mid-latitudes in the region of the mean jet, and must be upgradient there.[2]

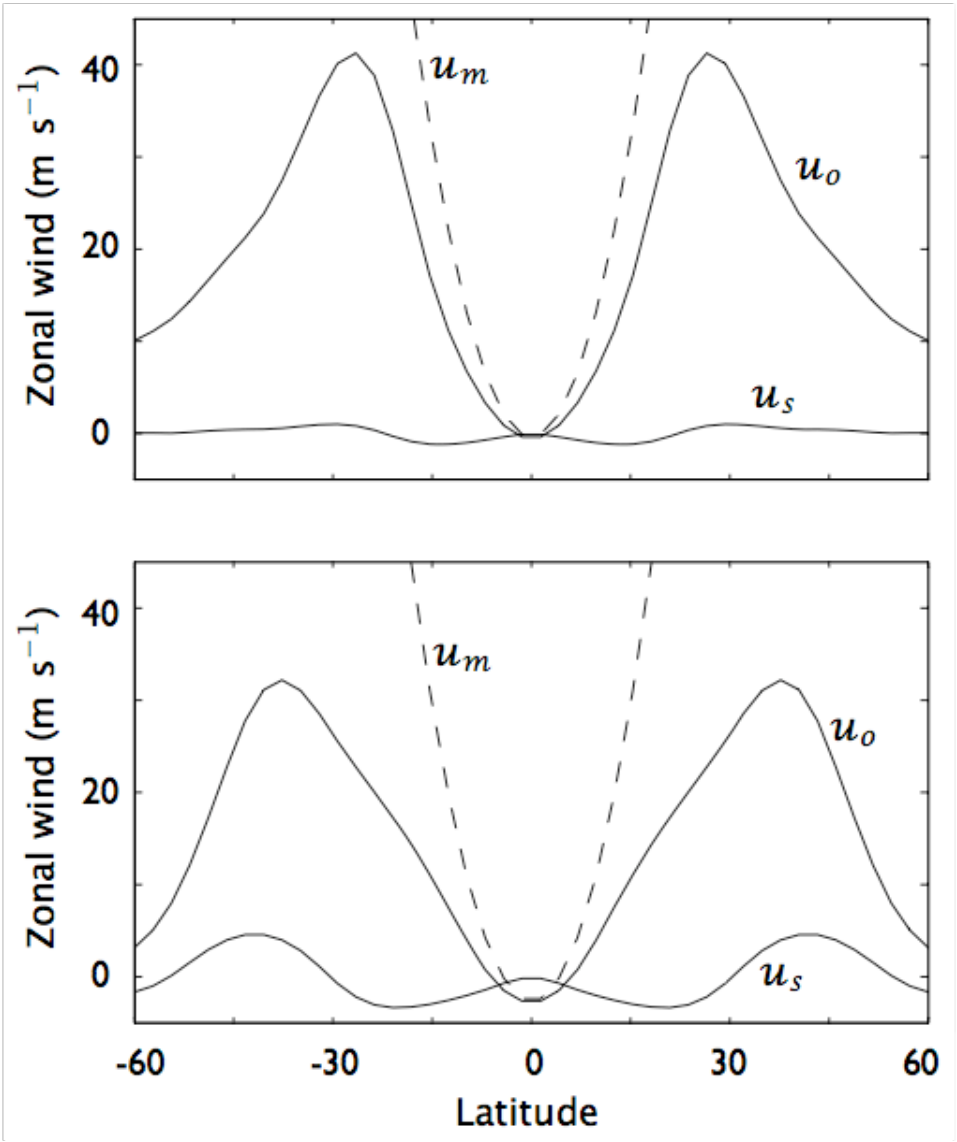


Fig. 11.12 The zonal wind in two numerical simulations. The lower panel is from an idealized dry, three-dimensional atmospheric GCM, and the upper panel is an axisymmetric version of the same model. Plotted are the zonal wind at the level of the Hadley Cell outflow, u_o; the surface wind, u_s; and the angular-momentum-conserving value, u_m.[3]

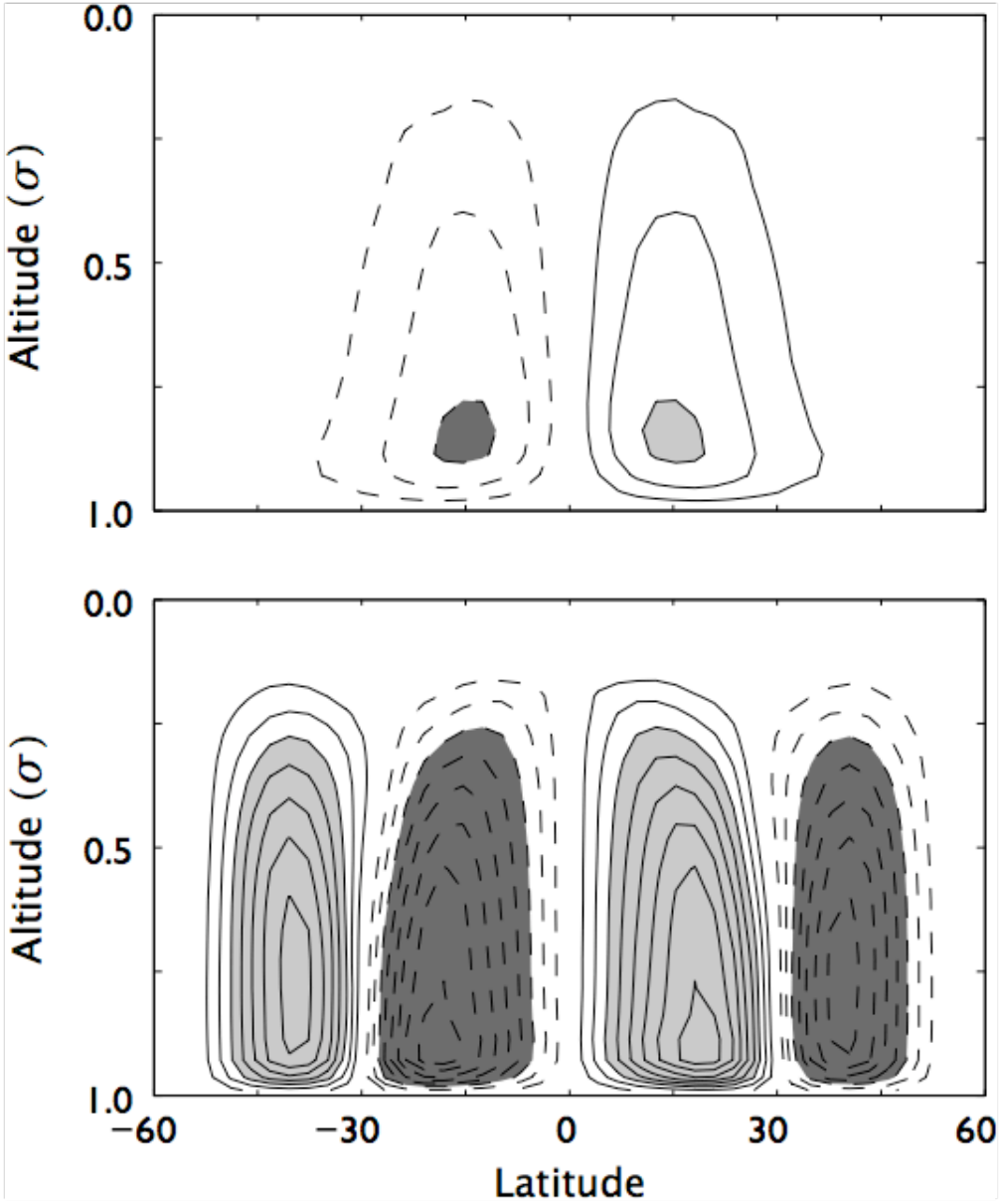
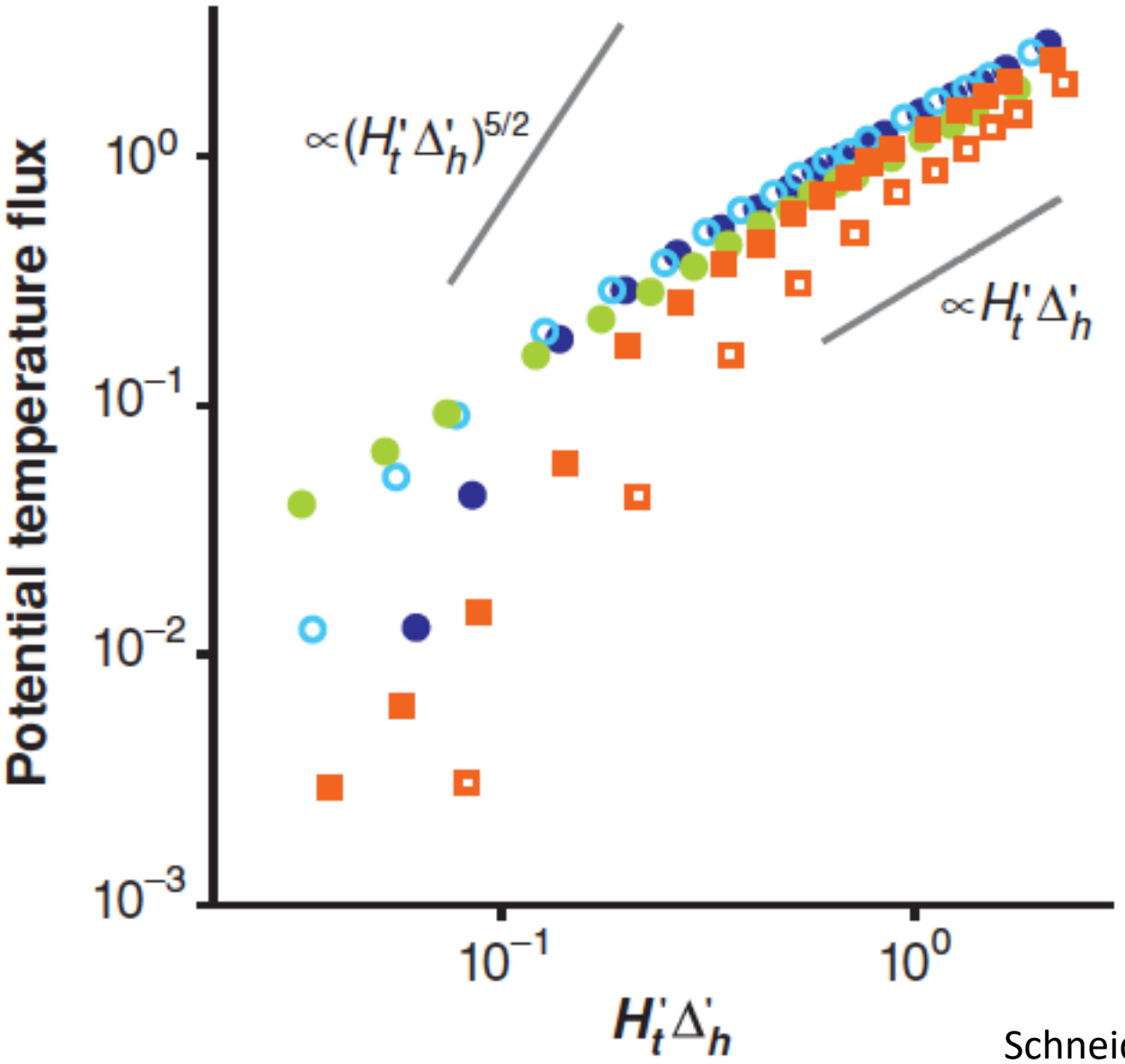
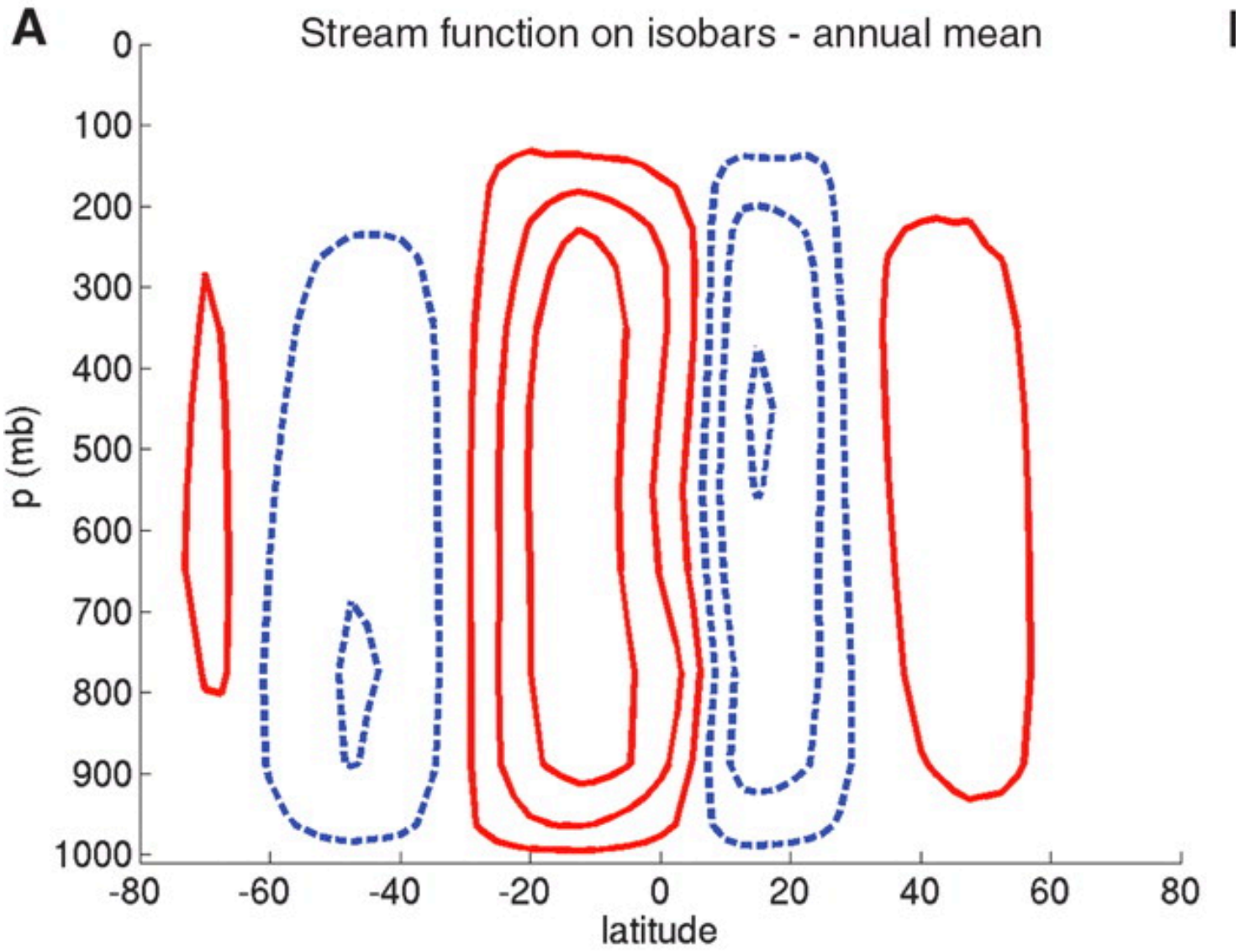


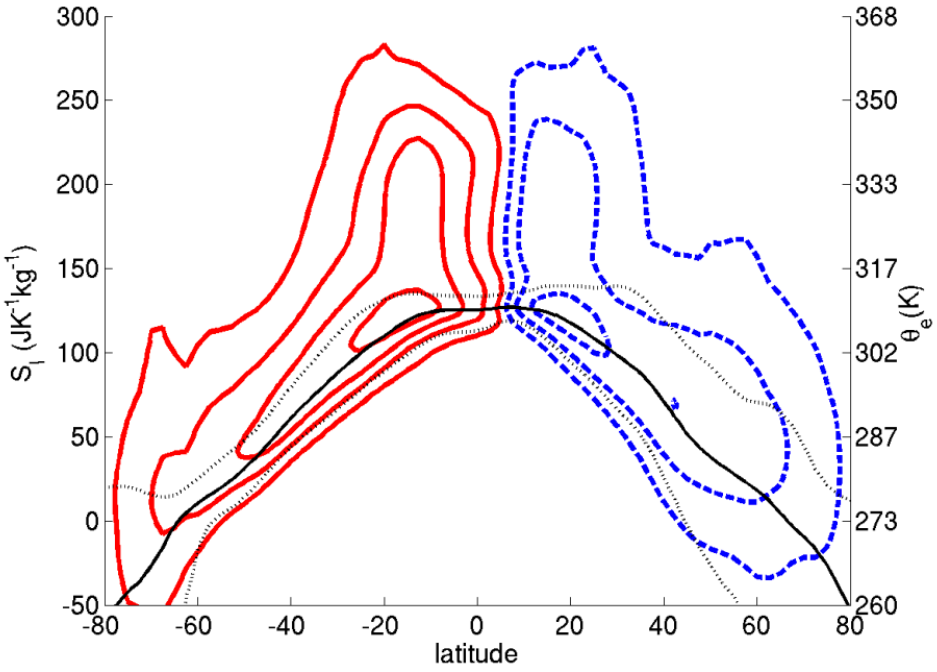
Fig. 11.13 As for Fig. 11.12, but now showing the streamfunction of the overturning circulation. 'Altitude' is $\sigma = p/p_s$, where p_s is surface pressure, and contour interval is 5 Sv (i.e., 5×10^9 kg s^{-1}).



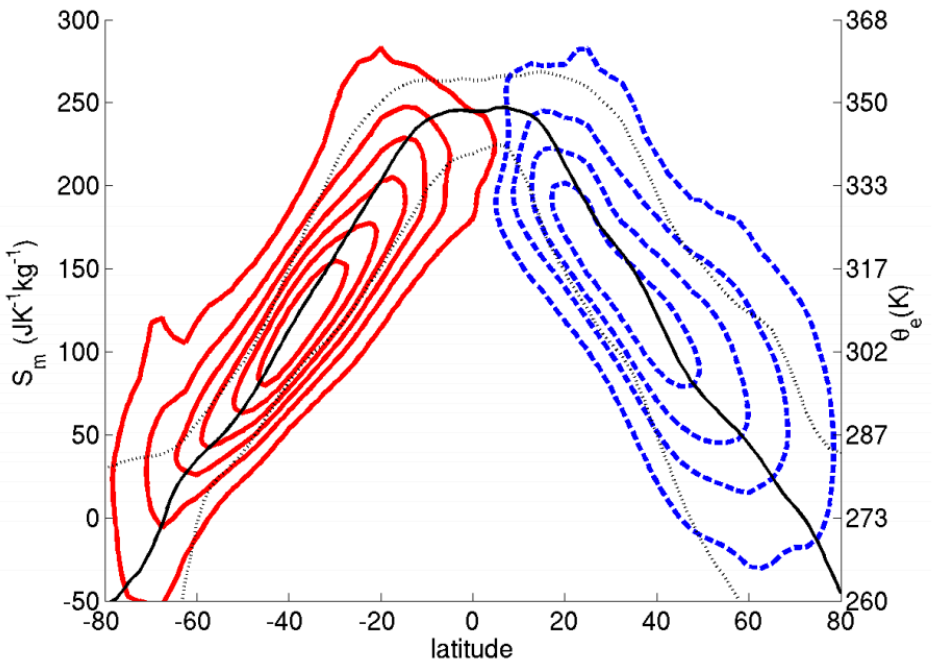
Schneider (2006)


A
Stream function on isobars - annual mean
0
100
200
300
400
500
600
700
800
900
1000
p (mb)
-80
-60
-40
-20
0
20
40
60
80
latitude

Dry Isentropic Stream Function



Moist Isentropic Stream Function



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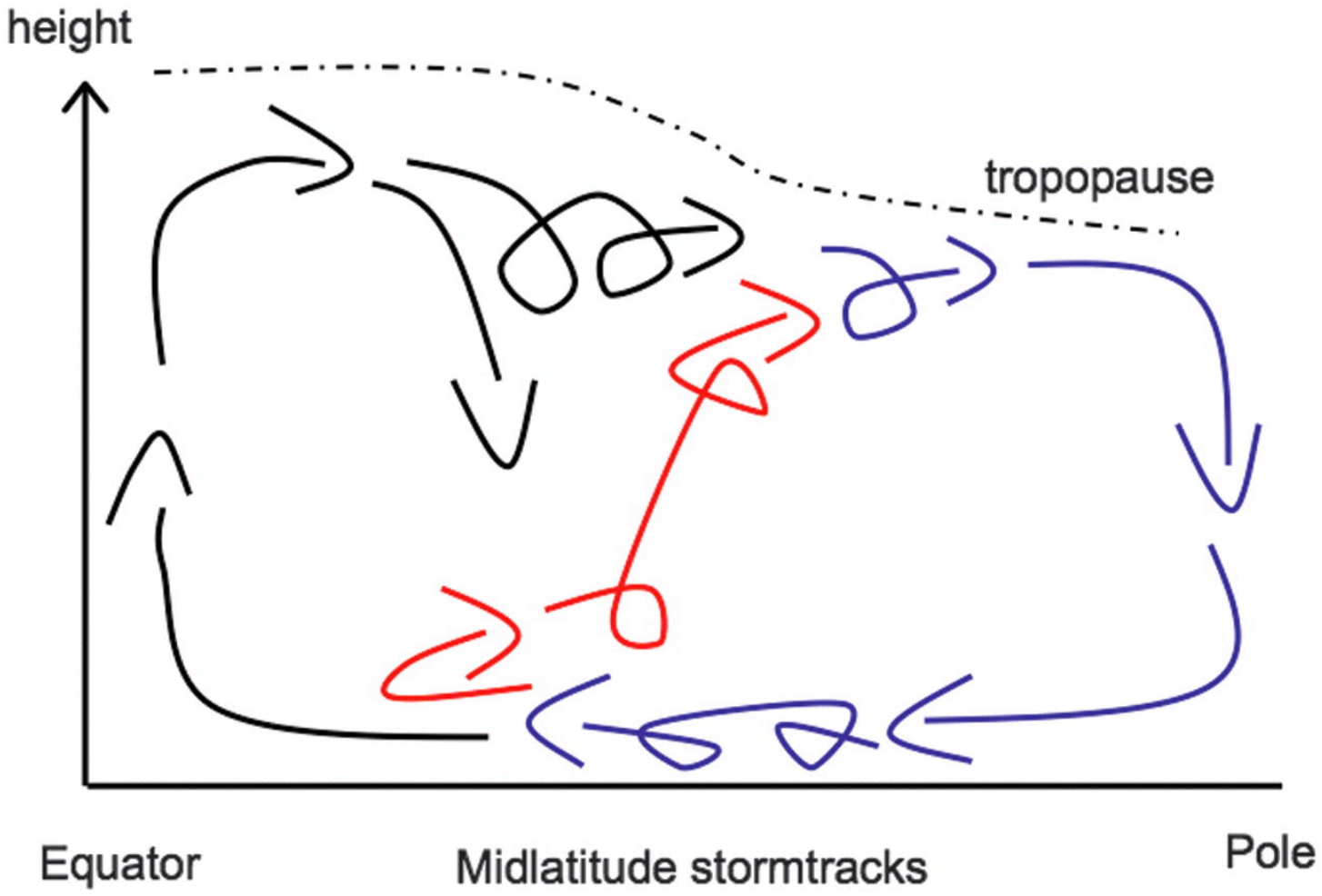

Pauluis et al. 2008