Analysis of the frequency-dependent response to wave forcing in the extratropics

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A quasigeostrophic model for the frequency-dependent response of the zonal-mean flow to planetary-wave forcing at Northern Hemisphere (NH) midlatitudes is applied to 4D-Var ECMWF analysis data for six extended winter seasons. The theoretical response is a non-linear function of the frequency of the forcing, the thermal damping time α^{-1}, and a scaling parameter μ which includes the aspect ratio of the meridional to the vertical length scale of the response. Non-linear regression of the calculated response from the analyses onto the theoretical response yields height-dependent estimates for both α^{-1} and μ. The thermal damping time estimated from this dynamical model is about 2 days in the troposphere, 7-10 days in the stratosphere, and 2-4 days in the lower mesosphere. These estimates generally lie within the range of existing estimates, although the values we find for the troposphere are significantly smaller than those calculated in several radiative transfer modeling studies. At most levels, the estimates for μ are significantly lower than can be derived from scaling arguments that apply outside the forcing region. We illustrate with an example how the response of the meridional circulation inside the forcing area can have a higher aspect ratio than the effective response outside the forcing area.