

## ERRATUM

# Erratum to 'Vortex dynamics of stratospheric sudden warmings: A reanalysis data study using PV contour integral diagnostics'

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There is a sign error in equation (24), and subsequently in equations (27) and (28), in the paper by Kwasniok et al. (2019). These equations correctly read:

$$\sigma \dot{Q} = \mathbf{k} \cdot (\nabla_{\theta} \times \mathbf{F}) + (\zeta_{\theta} + f) \frac{\partial \dot{\theta}}{\partial \theta} - \frac{\partial v}{\partial \theta} \left( \frac{\partial \dot{\theta}}{\partial x} \right)_{\theta} + \frac{\partial u}{\partial \theta} \left( \frac{\partial \dot{\theta}}{\partial y} \right)_{\theta} \quad (24)$$

$$\sigma \dot{Q} - \frac{\partial(\sigma Q \dot{\theta})}{\partial \theta} = \mathbf{k} \cdot \left[ \nabla_{\theta} \times \left( \mathbf{F} - \dot{\theta} \frac{\partial \mathbf{v}}{\partial \theta} \right) \right] \quad (27)$$

$$\frac{\partial C_{Q,\theta}}{\partial t} = Q \mathcal{V}_{Q,\theta} + \oint_{\Gamma_{Q,\theta}} \mathbf{F} \cdot d\mathbf{r} - \oint_{\Gamma_{Q,\theta}} \dot{\theta} \frac{\partial \mathbf{v}}{\partial \theta} \cdot d\mathbf{r} = Q \mathcal{V}_{Q,\theta} + \oint_{\Gamma_{Q,\theta}} \mathbf{F} \cdot d\mathbf{r} - \int_{S_{Q,\theta}} \mathbf{k} \cdot \left[ \nabla_{\theta} \times \left( \dot{\theta} \frac{\partial \mathbf{v}}{\partial \theta} \right) \right] dS \quad (28)$$

Figure 8 is affected by this error. However, we remark that, as argued by Haynes and McIntyre (1987), the diabatic PV flux  $\mathbf{J}_{\dot{\theta}}$  along isentropic surfaces is usually very small in comparison to the flux  $\mathbf{J}_{\mathbf{F}}$  associated with typical gravity wave drag forces  $\mathbf{F}$ . Hence the authors still believe that the two prominent events of removal of circulation from the vortex due to frictional processes visible in Figure 8 between mid-January and mid-February 1979 in the run-up to the SSW are genuine. Also the general comments in the paper on the circulation balance and its use to diagnose frictional processes remain valid.

All of the other results, equations, figures, comments and conclusions of the paper are not affected by this error and remain valid.

The authors would like to apologise for any inconvenience caused.

## ACKNOWLEDGEMENT

The authors would like to thank Zachary Lawrence for pointing out this error.

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## REFERENCES

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- Kwasniok, F., Beaumont, R. and Thuburn, J. (2019) Vortex dynamics of stratospheric sudden warmings: A reanalysis data study using PV contour integral diagnostics. *Quarterly Journal of the Royal Meteorological Society*, 145, 1013–1033.