

Corrigendum and addendum: a balanced axisymmetric vortex in a compressible atmosphere

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ABSTRACT

An error in the calculation by the author of a balanced axisymmetric vortex in a compressible atmosphere is corrected. While the corrected solutions are qualitatively similar to the earlier ones there are some quantitative differences that should be recorded. In particular, the anomalously cold surface temperatures predicted by the earlier calculations are reduced, but the corrected ones would still be large enough to explain at least some of the observed near-surface cooling in tropical cyclones.

1. Introduction

In a recent paper (Smith, 2006, hereafter S06), I described an accurate method to calculate the balanced density field of an axisymmetric vortex in a compressible atmosphere in various coordinate systems, given the tangential wind speed as a function of height and the vertical density profile at large radius. I showed, *inter alia*, that a baroclinic vortex in which the wind speed decreases with height has a cold core at low levels, including the surface, although it is warm cored aloft. Observations have shown an increase in the air-sea temperature difference in the inner-core region of a tropical cyclone on the order of 5 °C (e.g. Korelov et al., 1994; Pudov, 2000), a feature that has been attributed primarily to the evaporation of sea spray in the region of strong wind speeds (see e.g. Fairall et al., 1995, and references therein.). While not discounting the importance of this mechanism, the results I presented offered an alternative and simpler explanation. Shortly after my paper was published I discovered that the Runge-Kutta subroutine used to integrate the equations contained a small error, which makes quantitative changes to the solutions. Then the important questions arise: how are the surface temperature reductions changed and are these still sufficient to account for a significant fraction of the observed cooling in tropical cyclones? In this paper, I show the corrected solution and explore the surface temperature reduction for a range of tropical-cyclone-strength vortices.

2. The corrected solution

Figure 1 shows the density and perturbation temperature fields for a vortex with a maximum tangential wind speed of 40 m

s⁻¹ at a radius of 40 km, reducing sinusoidally to zero at a height of 16 km. Panel (a) shows also the isotachs of tangential wind speed, which is essentially that shown in fig. 2 of S06. The two panels of Fig. 1 should be compared with figs. 2b and 3b of S06. The lowering of the isochores near the vortex axis in Fig. 1a is a little less than in fig. 2b of S06 and the depth of negative temperature perturbation in Fig. 1b is reduced accordingly. In particular, the temperature perturbation at the surface is less than 2 °C at the vortex axis in the corrected calculation compared with nearly 5 °C in fig. 3b of S06. The question then arises: to what extent is such a reduction in temperature typical? Since a vortex with a tangential wind speed maximum of 40 m s⁻¹ is only category 2 on the Saffir-Simpson scale (see Simpson and Riehl, 1981), what would be the temperature reduction in a category 5 storm with wind speeds of more than 69 m s⁻¹?

3. Surface temperature reduction

Figure 2 shows the surface temperature perturbation in the innermost 100 km for a vortex with the same profiles as in S06, but for various values of maximum tangential wind speed, $v_{\max}$, and radii at which they occur, $r_{\max}$. In general the maximum magnitude of the temperature perturbation lies in the range 2–4 °C and increases with increasing $v_{\max}$. Moreover, the range of radii at which there is a significant temperature reduction increases as $r_{\max}$ increases.

4. Conclusions

The corrected solutions are qualitatively similar to those presented earlier, but there are modest quantitative differences leading to smaller surface temperature perturbations in the vortex core. However, the results still indicate that the low-level cold-core structure of a balanced, tropical-cyclone-like vortex could explain, at least in part, the increased air-sea temperature

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