



Potential Vorticity Attribution and Causality

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The electrostatic analogy provides a well known paradigm for the concept of potential vorticity (PV) attribution. Just as electric fields can be attributed to electric charges, so are localized PV anomalies thought to induce far-fields of flow and temperature, at least after geostrophic adjustment. Piecewise PV inversion (PPVI) exploits this concept. Idealized examples of PPVI are discussed by selecting isolated anomalies which are inverted to yield the far-field 'caused' by the PV anomaly. The causality of attribution is tested in this study by seeking an unbalanced initial state containing the same PV anomaly but without a far-field from which the balanced state can be attained by geostrophic adjustment. It is shown that the far-field of a balanced axisymmetric PV-anomaly in shallow water, without mean PV-gradients, may evolve from a localized anomaly without a far-field. For the more general example of the electrostatics analogy, namely a three-dimensional spherical PV-anomaly, the initial state has to be non-hydrostatic and needs to exhibit a mass deficit. As this mass deficit cannot be removed during hydrostatic and geostrophic adjustment, it follows that PV attribution does not imply a causal relationship between the far-field of a PV anomaly and the anomaly itself.