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Differential Geometric Formalism for GFD Coordinate Transformation Applications

This talk will focus on the use and importance of the methods and formalism of differential geometry in geophysical fluid dynamical settings. There are specific applications to work done on residual flows by Young (2012) and some extensions to other systems. The purpose of this is to elucidate the applicability of a more formal and complete use of differential geometric methods in GFD contexts, and particularly in coordinate transformations widely used throughout applications of GFD. Though coordinate transformations are explicitly geometric in nature, the full power of differential geometry is often skimmed over or altogether left out of discussion on the topic. However, to paint a more complete picture of applications of GFD involving coordinate transformations, the formalism can be useful.

In this talk, we go over the common basic ideas and structures in differential geometry such as the metric tensor and derivative operators such as the gradient curl and divergence, and by applying these ideas formally we find a more general framework for changing between various coordinate systems commonly used in literature. To demonstrate our ideas, we extend residual flow work done by Young (2012) both by extending this work to use the full formalism of differential geometry as well as applying Young's thickness-weighted averaging (TWA) formalism to other simple systems in the ocean and atmosphere, all involving coordinate transformations to common GFD quantities. In particular, Young's work depends on the use of a vertical buoyancy coordinate, while our applications replace the horizontal coordinate with potential vorticity.