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Troposphere-Stratosphere Coupling and the Role of Critical Layer Nonlinearity

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There exists a coupling mechanism between the troposphere and the stratosphere, which plays a fundamental role in weather and climate. The coupling is highly complex and rests upon radiative and chemical feedbacks, as well as dynamical coupling by Rossby waves. The troposphere acts as a source of Rossby waves which propagate upwards in to the stratosphere, affecting the zonal mean flow. Rossby waves are also likely to play a significant role in downward communication of information via reflection from the stratosphere in to the troposphere. A mechanism for this reflection could be from a so-called critical layer. A shear flow exhibits a critical layer where the phase speed equals the flow velocity, where viscous and nonlinear effects become important. A wave incident upon a critical layer may be absorbed, reflected or overreflected, whereby the amplitude of the reflected wave is larger than that of the incident wave. In the case of troposphere-stratosphere coupling, the concept of critical layer overreflection is key to understanding atmospheric instability.

Motivated by this, a mathematical framework for understanding the coupling will be presented together with an investigation in to the role of nonlinearity versus viscosity inside the critical layer.