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Sheer Instability in a Shallow Water Model with Implication to Venus Atmosphere

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Sheer instability problem in the spherical shallow water system is investigated for three types of wind profiles which are observed at the upper cloud level in Venus. Destabilized Kelvin modes are obtained for all profiles, even when the wind profile is barotropically and inertially stable. The eigenfunctions of these unstable modes are a hybrid of Kelvin modes and continuous modes which have singularity at the critical latitude. Destabilized Rossby-Kelvin modes are also obtained for the barotropically unstable profile with strong jets. When Lamb parameter is large, together with another destabilized gravity modes, these modes have the property of inertial instability modes which are described by the preceding studies on the tropical inertial instability. The destabilizing mechanism of unstable modes is described using resonance theory.

It is found that the angular-momentum flux is equatorward for almost all growing modes obtained in this study; this result is consistent with what the resonance theory predicts. This momentum transport may contribute to the mechanism of producing the super-rotation of the Venus atmosphere based on the meridional circulation. The destabilized Kelvin modes may be considered as a source of the 4-day waves observed in the equatorial region at the cloud top of Venus.

Keywords: Venus; 4-day wave; super-rotation

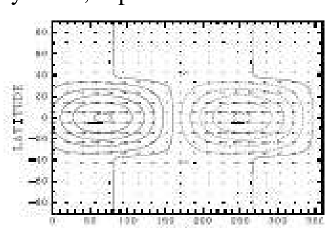

Figure 1: Obtained unstable Kelvin mode which may be a source of the 4-day wave.