Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

**A New Generalized Thermal Wind Equation and its Application to Zonal Flows on the Gas Giant Planets** PHILIP MARCUS, JOSHUA TOLLEFSON, IMKE DE PATER, University of California Berkeley — For baroclinic, rapidly-rotating flows, the Thermal Wind Equation (TWE) describes how the flow varies along the rotation axis as a function of temperature gradients. The TWE works well for many laboratory and atmospheric flows on Earth. We show that the TWE also works well for the zonal (west-to-east) flows $u$ on Jupiter. However, our recent observations of Neptune's zonal flows not only do not fit the TWE, but also have the incorrect "sign." When an atmosphere's longitudinally-averaged temperature is warmer at the equator than at the mid-latitudes, the TWE indicates that $u$ increases with height in the atmosphere. The change in $u$ as a function of height on Neptune has the opposite sign. Here, we show that the high-velocities of $u$ on Neptune make the cyclostrophic terms (i.e., some of the nonlinear terms proportional to $u^2$) large, and these terms are dropped in the standard derivation of the TWE. When the cyclostrophic terms are retained, a more generalized TWE is obtained that both qualitatively and quantitatively agrees with the observations of the change in $u$ as a function of height in Neptune's atmosphere. We show that both the standard and generalized TWE for zonal flows can be extended to the equator despite the fact that the Coriolis force vanishes there.

Philip Marcus
University of California Berkeley

Date submitted: 31 Jul 2015 Electronic form version 1.4