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Inertial instability, Rossby wave breaking, and gravity wave activity in the northern hemisphere stratospheric winter 2015/16

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The northern hemisphere winter 2015/16 has attracted much attention in the scientific community due to its extreme Arctic polar vortex which has been identified as the strongest and coldest of the past 68 years. In this paper, we use METOP GPS-radio occultation temperature measurements along with high resolution ECMWF model analyses to study northern hemisphere stratospheric temperature perturbations during this period. In a recent paper by Rapp et al. (2018) the combination of these two data sets has been shown to be suitable for studying stratospheric temperatures and gravity wave fields. It turns out that December 2015 was characterized by large temperature perturbations with amplitudes of up to 10 Kelvin and a vertical wavelengths of about 12-15 km over an extended latitude – longitude range between 35° and 50°N and between 135°W and 45°E. These temperature perturbations occurred as sheets, i.e. they did not show any vertical tilt over the latitude- longitude range where they were observed. This is reminiscent of so-called “pancake“- structures that have previously been observed in several limb sounding temperature data sets. These “pancakes” have been explained as being caused by inertial instability, i.e. an angular momentum imbalance in a rotating fluid. ECMWF analysis fields are used to test whether the structures observed in December 2015 are indeed evidence for inertial instability. In addition, we investigate whether the instability was triggered by Rossby-wave breaking as suggested in previous studies. Finally, we also study the relation between inertial instability and Rossby wave -breaking with coincident gravity wave activity that can be clearly diagnosed from the ECMWF-analyses considering divergence and vertical velocity fields.