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Cloud ice water path (IWP) observed by Aura MLS

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Clouds play an important role in atmospheric radiative and hydrological processes. Extratropical clouds are especially difficult to characterize and understand because both liquid and ice phases are present at sub-freezing temperatures. Millimeter and submillimeter-wave radiometry can measure the ice content of mixed-phase clouds through the scattering signatures of ice crystals. Compared to nadir techniques, limb sounding has better sensitivity to clouds of low ice content and depends little on surface emissivity and atmospheric temperature. In this paper we present initial IWP results measured by Aura MLS (Microwave Limb Sounder) at 118-640 GHz frequencies with emphases on seasonal variations in the extratropics. Compared to AMSU (Advanced Microwave Sounding Unit) measurements, MLS monthly IWP maps reveal more cloud ice at mid-latitudes. In addition, AMSU tends to have false cloud detection over ice and snow surfaces where MLS cloud signatures remain robust as limb radiances do not see the surface. Among most interesting features in the MLS IWP observations are the enhanced cloud ice over the North Atlantic, the North Pacific, and the Tibetan Plateau in the Northern Hemisphere, and over the South Indian Ocean and the South Pacific in the Southern Hemisphere. Cloud ice over the North Pacific exhibits a maximum in December whereas the North Atlantic experiences a large amount of cloud ice from January to March. MLS IWP over the Tibetan Plateau shows maxima in April-May and July. The April-May peak in MLS data agrees well with the seasonal variation of MODIS high-cloud reflectance. However, the July maximum is not seen by the MODIS reflectance and contributed mostly by deep convective clouds, based on MLS multi-frequency measurements. In the Southern Hemisphere, maximum cloud ice is found in May over the South Indian Ocean and in July-August over the South Pacific. MLS radiances at different tangent heights can be used to dis-

criminate cloud ice columns above different heights. We find that seasonal variations of cloud ice at higher altitudes can differ significantly from those at lower altitudes.