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Relationship between polar stratospheric cloud types and ozone destruction

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Polar stratospheric clouds (PSCs) can appear at a temperature lower than nitric acid trihydrate (NAT) saturation temperature in the polar lower stratosphere. PSCs cause large ozone destruction by heterogeneous reactions on particle surface and denitrification by gravitational sedimentation in the polar spring. PSCs can be classified into three major types (Type Ia, Ib, and II). Type Ia is a solid particle which is comprised of NAT. Type Ib is a liquid particle called supercooled ternary solution (STS) which is composed of HNO_3, H_2SO_4, and H_2O. Type II is water ice particle.

In general, the probability of PSC formation is closely related to the magnitude of chemical ozone loss. However, Terao et al. (2012) showed that the average ozone destruction rate in 1996 and 2000 Arctic winter were different when the average PSC sighting probabilities were similar. As one of the possible reason, we assumed a hypothesis that PSC types may influence the magnitude of ozone destruction. Therefore, we investigated the relationship between PSC types and the ozone destruction rate statistically.

We used the observational data from CALIOP lidar on board the satellite CALIPSO. PSCs observed by CALIOP were categorized into 6 types; i.e. Mix 1, Mix 2, Mix 2-enhanced, Ice, Wave-ice, and STS (Pitts et al. 2007, 2009, 2011). Mix is a PSC type category which contains NAT and STS. We quantified the ozone destruction rate of PSC types observed in 2007 Antarctic winter and in 2009/10 Arctic winter by using a Satellite-Match technique with the observational data of MLS on board the satellite Aura. As a result, it was confirmed that the average ozone destruction rate were different in every PSC type. Especially, the average ozone destruction rate of STS and Mix were larger.

Furthermore, we investigated the relationship between backscatter ratio as an index of particle number density and ozone destruction rate for every PSC type. As a result, it was confirmed that there are positive correlation between backscatter ratio and ozone destruction rate in all PSC types. As a result of the simple linear regression fitting using backscatter ratio as an independent variable, the regression coefficient for Mix PSC is the largest. It is thought that PSCs including NAT and STS have the highest potential for large-scale ozone destruction.

Keywords: Polar stratospheric cloud, Ozone destruction, Satellite-Match technique, CALIPSO