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Changes in atmospheric composition discerned from long-term NDACC measurements: evolution of the winter stratosphere from Thule, Greenland, and the exceptional winters of 2008-2009 and 2010-2011.

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Several instruments are operational at Thule Air Base (76.5oN, 68.8oW) as part of the Network for Detection of Atmospheric Composition Change. A lidar was installed in 1990 and has been operational particularly during the winter season. Lidar measurements are used to derive the aerosol backscatter ratio between about 10 and 35 km, and the atmospheric temperature (T) profile from 25 up to 70 km, with a resolution of 150 m. A ground-based millimeter-wave spectrometer (GBMS) was installed at Thule in 2001, and has been operational during the winter seasons of 2001-2003 and 2009-2011. The GBMS permits to derive the atmospheric concentration profiles of different chemical species, such as O3, CO, N2O, and HNO3, between about 15 and 80 km at a resolution of 6-8 km. The Arctic winter stratosphere is characterized by a high variability, and detection of trends is particularly difficult. The evolution of the vortex and the temperatures in the lower stratosphere has a large impact on formation of Polar Stratospheric Clouds (PSC) and on the stratosphere chemical evolution. Coldest winters occurred in 1999-2000, and 2004-2005. Intensive measurement campaigns were conducted at Thule Air Base during winters 2008-2009 and 2010-2011. These two winters have been deeply different in their thermal, dynamical and chemical evolution. The 2008-2009 Arctic winter has been characterized by the most intense Sudden Stratospheric Warming (SSW) event ever observed, and the maximum of this warming was detected over Greenland. Thus, ground-based observations of the thermal structure and chemical composition of the middle atmosphere from the station at Thule Air Base have permitted to show the evolution of the phenomenon and its interactions with the dynamical structure of the polar vortex in the region of maximum warming. On the contrary, the 2010-2011 has been a very cold winter, and polar stratospheric clouds have been detected by lidar from mid-February to mid-March at Thule Air Base. This very cold winter, together with the massive formation of PSCs, has caused the record stratospheric ozone loss that is occurring in spring 2011 in the Arctic. In this study, we will present a summary of the measurements of the thermal and chemical stratospheric structure obtained at Thule Air Base between 1990 and 2011, with special attention to the two winters of 2008-2009 and 2010-2011.