The Boundary Layer and its Response to External Forcing at Summit Station Greenland

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The ICECAPS field program (Integrated Characterization of Energy, Clouds, Atmospheric State and Precipitation at Summit) has operated at Summit Station (over 3000 m ASL) since the spring of 2010 with a broad range of instruments to study the role of clouds and precipitation over the Greenland Ice Sheet (GIS). In addition, a high-resolution minisodar has been operated nearby since 2008 (initially as part of an ice-atmosphere chemical exchange study). The sodar provides detailed views of the thermodynamic structure of the boundary layer from 2 to 160 m above the surface. Several other collaborating programs support additional boundary-layer measurements such as broadband radiation and turbulent flux measurements. The sodar has proven useful in the interpretation of chemical interactions with the snow surface and underlying firn as well as comparisons of boundary layer depth estimators (Van Dam et al, 2013, 2015). In addition it has documented the response of the boundary layer to changing cloud forcing (Shupe et al. 2013). In addition, it has been used to study the wintertime boundary layer with super-cooled fog layers present (Cox et al, 2019). Additional observations have added to an already rich data set, such as those of stable water vapor isotopes (e.g. Berkelhammer et al. 2016).

As in the 2012 melt episode that encompassed nearly the entire ice sheet, atmospheric rivers (ARs) bring moisture from the south along the coasts of Greenland and have been increasing (Mattingly et al., 2018; Neff 2018). We will present a climatology from 2000 to 2012 of ARs some of which are associated with increased transport of moisture from the sub tropics at times in concert with hurricanes and tropical storms that follow the same path. This climatology reveals a distinct low-high pressure pattern spanning from NE Canada to the central Atlantic: the boundary between these systems provides the pathway for moisture to flow from the sub tropics. In this presentation will describe the characteristic cloud/clear skies sequence and accompanying boundary layer structure at Summit Station during these events. A typical sequence is one of ARs trapped along the west coast and then spreading moisture over the GIS in subsequent days.

To understand the origin of the moisture arriving at Summit Station we also carried out back trajectory analyses that show connections to both ARs and extratropical remnants of hurricanes that follow the same path to Greenland. Of particular interest will be the boundary layer behavior during the dramatic melt episodes of June and then July 2019 that had their origins in heat waves off of Africa and over Europe.