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How can the polar dome be identified in meteorological analysis model data?

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The thermal stratification of the lower atmosphere at high latitudes causes an isolation of polar regions from lower latitudes. A transport barrier establishes in the region where isentropic surfaces slope upward from near surface to higher altitudes. This barrier is also known as the polar dome. For adiabatic flow the transport of air masses from midlatitudes into high latitudes occurs almost along the isentropic surfaces. Only diabatic processes related to clouds, radiation, or turbulence can foster a transport across the barrier. Such processes can be identified by the material rate of change of potential temperature which have to occur in the vicinity of the polar dome. Thus, to identify regions of exchange, it is first crucial to know where the transport barrier is located. The question arises then which meteorological variables may be suited to identify the location of this transport barrier. A second question is how the shape of the polar dome changes during different time periods of the year?

For this we use gridded analysis model data from the European Center for Medium-Range Weather Forecast (ECMWF) with high spatial resolution for several time periods during 2014 and 2015. Especially, we focus on time periods during spring and summer when extensive in-situ measurement campaigns took place in the high Arctic. We define four metrics to identify the location, i.e. the latitude, of the transport barrier at various altitudes, e.g., the surface or a surface of constant pressure in the lower troposphere. These metrics are based on (1) a constant value of potential temperature that intersects a given altitude, (2) the strongest gradient of potential temperature on a given altitude level, and (3) the relative difference between equivalent potential temperature and potential temperature at the surface. The last metric is based on a Lagrangian analysis for which ten days forward and backward trajectories are calculated, starting at each grid point between 45 degree N and the North Pole at given altitudes. For each metric we present the location of the polar dome during the chosen time periods. We further discuss the differences between the various methods and present advantages and disadvantages of the individual metrics.