EGU21-10175, updated on 02 Jul 2022
https://doi.org/10.5194/egusphere-egu21-10175
EGU General Assembly 2021

First model evaluations of height-resolved diurnal water vapour cycles using lidar observations in an Arctic environment

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Atmospheric water vapour is a critical component of both meteorological and climatological processes. It is the dominant gas in the greenhouse effect and its diurnal cycle is an essential component of the hydrological cycle. Diurnal water vapour cycles are complex and are a product of several mechanisms, including (but not necessarily limited to): evapotranspiration, advection, large-scale vertical motion, and precipitation. They are dependent on local geography, as well as latitude. Numerical Weather Prediction (NWP) models rely on high-quality water vapour input to provide accurate forecasts, which is particularly difficult in the Arctic due to its extreme weather and harsh environment. Diurnal water vapour cycle observations are also excellent tools for evaluating NWPs due to their complex nature and dependence on multiple processes. Integrated water vapour (IWV), or total column, diurnal water vapour cycles, usually calculated with Global Navigation Satellite Systems (GNSS) instruments, have been the focus of most previous diurnal WV studies; however, height-resolved diurnal cycles provide a more complete picture of the diurnal mechanisms and include vertical motion, which cannot be discerned via IWV measurements. Differential Absorption Lidars (DIALs) are well suited to providing height-resolved diurnal cycles in the boundary layer due to their high vertical and temporal resolution.

We use the novel Vaisala pre-production DIAL, installed in Iqaluit, Nunavut (63.75 N, 68.55 W), to calculate seasonal height-resolved diurnal WV cycles from 100 m to 1500 m altitude. We also calculate the surface and total column WV diurnal cycles using co-located surface station and GNSS measurements. We find that the first 250 m of the DIAL diurnal cycle magnitudes agree well with the surface station measurements. The phases of the cycle do shift with altitude, and the amplitudes generally increase with altitude. In the summer, all instruments observe a strong 24 hr cycle. As the amount of solar radiation decreases over the year, the 24 hr cycle weakens and the 12 hr cycle begins to dominate in all instruments. While we find a strong correlation between the 24 hr cycle and the solar cycle, we do not observe any correlation between the 12 hr cycle and the solar cycle. Finally, we also compare the DIAL observations to the Environment and Climate Change Canada (ECCC) NWP model. We evaluate both the assimilation of the humidity input and initial water vapour fields, as well as the diurnal cycle over the 24 hour forecast. Future work will include case study comparisons with the Canadian NWP model to assess the model's ability to resolve rapid changes in diurnal water vapour.