Announcement of a topic for:

x Research ☐
x Seminar Methods ☐
x Master Theses ☐ (please mark one or more)

Topic	Advanced liquid-layer detection in orographic clouds observed during the CORSIPP-SAIL field experiment using VOODOO
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Description	Correct identification of liquid layers in mixed-phase clouds is not trivial but important as cloud liquid influences cloud radiative properties, precipitation formation and -efficiency, and thus cloud lifetime (Morrison et al., 2012; Mülmenstädt et al., 2015). With multisensor retrievals that rely on valid lidar signals, the liquid classification is limited in thick- or multilayer cloud situations due to complete lidar signal attenuation (Illingworth et al., 2007). Recently, advances have been made to improve cloud liquid layer identification by exploiting cloud radar Doppler spectra features with machine-learning approaches (Luke et al., 2010; Kalesse-Los et al., 2022) which were the basis for the open-source tool VOODOO (reVealing supercOOled liquiD beyOnd lidar attenuation; Schimmel et al., 2022). Here we propose to apply VOODOO to clouds in orographic terrain observed during the SAIL experiment in the Colorado Rocky Mountains (https://sail.lbl.gov) from Sep 2021 to June 2023. Specifically, the first step of the Master's work will be to retrain VOODOO on Ka-Band radar data (KAZR) available for the entire field experiment. Statistical analysis of the nearly two-year long data set will be performed and set into context with snowfall rates and synoptic situations etc. Potential further steps include VOODOO-application to W-band radar data obtained with LIMRAD94 (of AG Remsens Arctic) in vertically-pointing mode in Feb – June 2023 and comparison of the liquid retrieval results obtained at both wavelengths as well as determination of the influence of turbulence on liquid layer occurrence.

Literature	Illingworth, A. J., et al., 2007: Cloudnet: Continuous Evaluation of Cloud Profiles in Seven Operational Models Using Ground-Based Observations, B. Am. Meteorol. Soc., https://doi.org/10.1175/BAMS-88-6-883 Kalesse-Los, H., Schimmel, W., Luke, E., and Seifert, P., 2022: Evaluating cloud liquid detection against Cloudnet using cloud radar Doppler spectra in a pre-trained artificial neural network, Atmos. Meas. Tech., https://doi.org/10.5194/amt-15-279-2022 Luke, E. et al, 2010: Detection of supercooled liquid in mixed-phase clouds using radar Doppler spectra, J. Geophys. Res. Atmos., https://doi.org/10.1029/2009JD012884 Morrison, H. et al., 2012: Resilience of persistent Arctic mixed-phase clouds, Nat. Geosci., https://doi.org/10.1038/ngeo1332 Mülmenstädt, J. et al., 2015.: Frequency of occurrence of rain from liquid-, mixed-, and ice-phase clouds derived from A-Train satellite retrievals, GRL, https://doi.org/10.1002/2015GL064604 Schimmel, W., Kalesse-Los, H., Maahn, M., Vogl, T. Foth, A., Saavedra Garfias, P., Seifert, P., 2022: Identifying cloud droplets beyond lidar attenuation from vertically pointing cloud radar observations using artificial neural networks. Atmos. Meas. Techn., https://amt.copernicus.org/articles/15/5343/2022/