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Ground-Based Observations of Secondary Ice Production: A Case Study Showing Droplet Fragmentation during Refreezing Rain

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The discrepancy between the concentration of ice nucleating particles and ice in the atmosphere, which can reach up to several orders of magnitude, indicates the importance of secondary ice formation and has led to the suggestion of several secondary ice processes (SIPs). Despite their recognized importance, SIPs remain insufficiently quantified and parameterized in atmospheric models. Some SIPs are entirely theoretical, while others have been demonstrated in laboratory settings. One SIP is droplet fragmentation, where the freezing of liquid droplets leads to the formation of small ice splinters as the droplets shatter. Laboratory studies indicate that this process operates effectively over a broad temperature range, particularly with larger droplets. However, like many secondary ice processes, it is challenging to observe and quantify in natural environments.

Ground-based in situ precipitation measurements provide a viable method for studying these phenomena, offering direct measurements over extended periods with minimal disruption. This approach captures a wide variety of microphysical scenarios and facilitates real-time monitoring of changes in hydrometeor characteristics.

This talk presents a case of refreezing rain recorded in Hyytiälä, Finland, which indicated secondary ice production through droplet fragmentation. An analysis using ground-based in-situ data from the third generation of the Video in Situ Snowfall sensor, combined with the spectral linear depolarization ratio from W-band cloud radar measurements supported this hypothesis. Multiple modes of droplet fragmentation that were identified through in situ imagery, accompanied by a significant increase in ice particle concentration will be shown. Further, we will quantify and characterize the hydrometeors affected by freezing and shattering, as well as SIP particles produced during the event.

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Session

Enhancing Process Understanding: New observations for modeling and parameterization development

Preferred Contribution Type

Oral Presentation

Presenting Author

Nils Pfeifer

Email Address of Presenting Author

nils.pfeifer@uni-leipzig.de

Affiliation of Presenting Author

Leipzig Institute for Meteorology (LIM), Leipzig University, Leipzig, Germany

Address of Presenting Author

Nils Pfeifer, Universität Leipzig, Stephanstraße 3, 04103 Leipzig

Author: PFEIFER, Nils (Leipzig Institute for Meteorology (LIM), Leipzig University, Leipzig, Germany)

Co-authors: Mr MOM, Bernd (Institute for Atmospheric and Earth System Research/Physics, Faculty of Science, University of Helsinki, Helsinki, Finland); Prof. MOISSEEV, Dmitri (Institute for Atmospheric and Earth System Research/Physics, Faculty of Science, University of Helsinki, Helsinki, Finland); MAAHN, Maximilian (Leipzig Institute for Meteorology (LIM), Leipzig University, Leipzig, Germany)

Presenter: PFEIFER, Nils (Leipzig Institute for Meteorology (LIM), Leipzig University, Leipzig, Germany)