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Scale- and Seasonal-dependent Precipitation Structure from Estonian Radar Composites Using a Poisson-Gamma Model

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Precipitation estimates over the Estonian radar composite domain change with accumulation length, season, and spatial location, yet these dependencies are rarely summarized in a compact way. This matters for comparing products across temporal resolutions and designing downstream applications such as precipitation modelling and nowcasting. Here we characterize precipitation structure using a Poisson-Gamma framework, focusing on the Tweedie variance-mean scaling exponent p as a descriptor of how wet-dry transitions and event-to-event fluctuations vary with aggregation.

Using 4-year radar composites aggregated from sub-hour to daily windows, we estimate p across accumulation lengths and derive seasonal maps that highlight where and when precipitation structure differs. In year-average, p increases with accumulation length across the domain, indicating that longer windows increasingly reflect the combined effect of multiple precipitation episodes within a window, while spatial gradients remain weak compared to the domain-wide shift with aggregation. Seasonal estimates show a consistent ordering, with p highest in summer and lowest in winter, and winter showing a stronger positive dependence on accumulation length. Seasonal maps at 6-24 h reveal clearer organization, including land-sea contrasts and enhanced spatial heterogeneity in warm and autumn seasons, whereas winter fields are smoother with localized marine features. We also compare radar-based behaviour with rain-gauge series at 10-min and 1-h temporal resolutions. Across common accumulation periods, p follows a consistent ordering, with higher values from the higher-temporal-resolution radar composite and lower values from the coarser gauge series, suggesting that temporal scaling influences inferred precipitation structure.

Overall, the study provides a set of figures and maps that summarize how precipitation structure varies with season and accumulation length over the Estonian radar domain. These results offer a baseline for multi-source comparison and for applications where aggregation scale and observing system matter, such as precipitation modelling, verification, and nowcasting-related target design.