12th European Conference on Severe Storms
Utrecht, Netherlands – 17 to 21 November 2025

Probabilistic Localized Radar-Based Nowcasting of Flood-Inducing Rainfall Events

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P52: ECSS2025-117

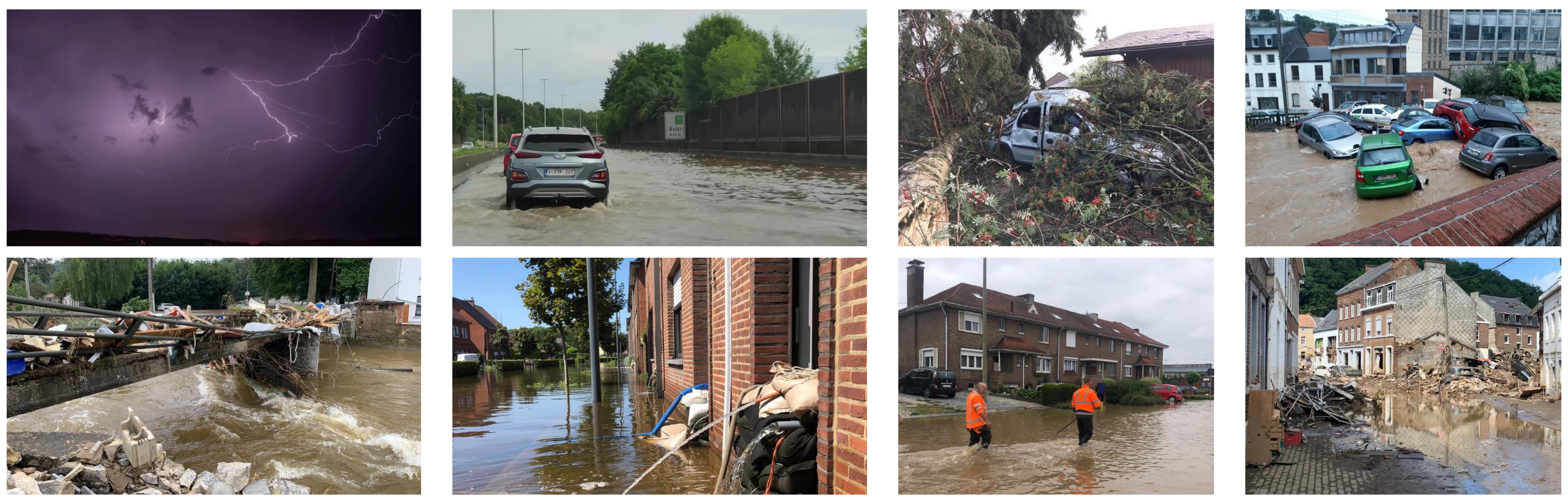
Introduction

Accurate **rainfall nowcasts** are essential for **flood early warning systems** in extreme events. In addition, developing **probabilistic ensemble forecasts** can provide an **uncertainty** range, supporting better **risk management** and response planning.

Traditional rainfall nowcasting techniques, such as Lagrangian persistence, are not able to predict the **growth and decay of precipitation**. To address these limitations, methods like STEPS [1,2], ANVIL [3], and SPROG-LOC [4] have been developed. These methods involve **spectral decomposition** of **rainfall (R)** or **Vertically Integrated Liquid (VIL)**, **autoregressive (AR) or AR integrated (ARI) model**, **localization**, and **stochastic perturbations** to improve the accuracy of nowcasts.

Building on these methods, we propose **Short-Term Autoregressive Nowcasting (STAN)** [SLAN], a novel **probabilistic** [deterministic] integrated approach designed to improve nowcasting performance in **convective** cases, incorporating improvements such as **adaptive localization**, and **post-processing** considering **VIL and rainfall**.

Impact of Analyzed Events



News and Videos for Events in 04/07/2021 15/07/2021

Historical Flood Events in Belgium

Methodology

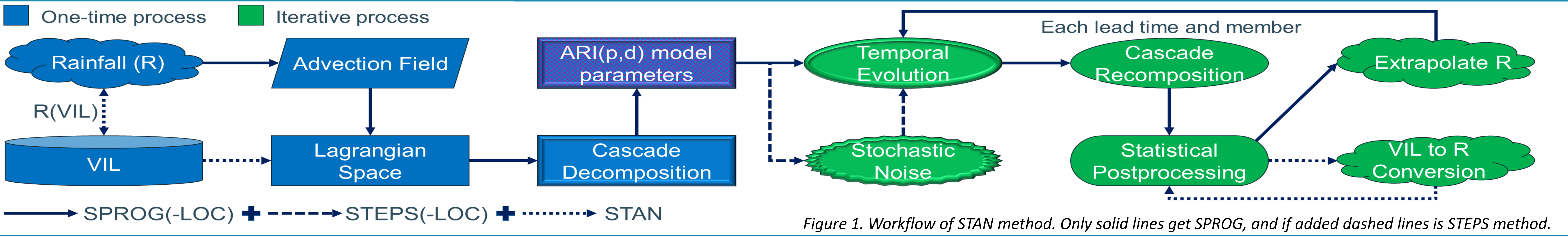


Figure 1. Workflow of STAN method. Only solid lines get SPROG, and if added dashed lines is STEPS method.

Results

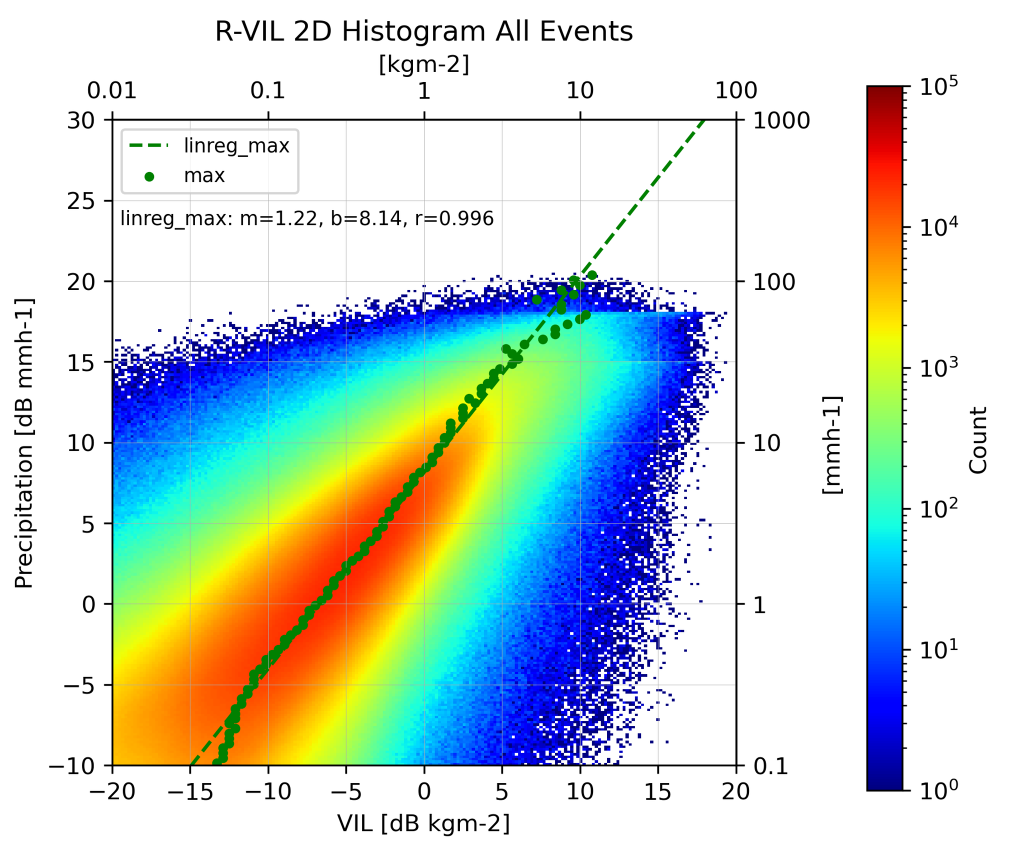


Figure 2. R-VIL Relation (in dB) for pixel-to-pixel comparison and 10 analyzed rainfall events. Linear regression parameters of maximum count (linreg_max) are used when there are no R-VIL values in last observation for STAN method.

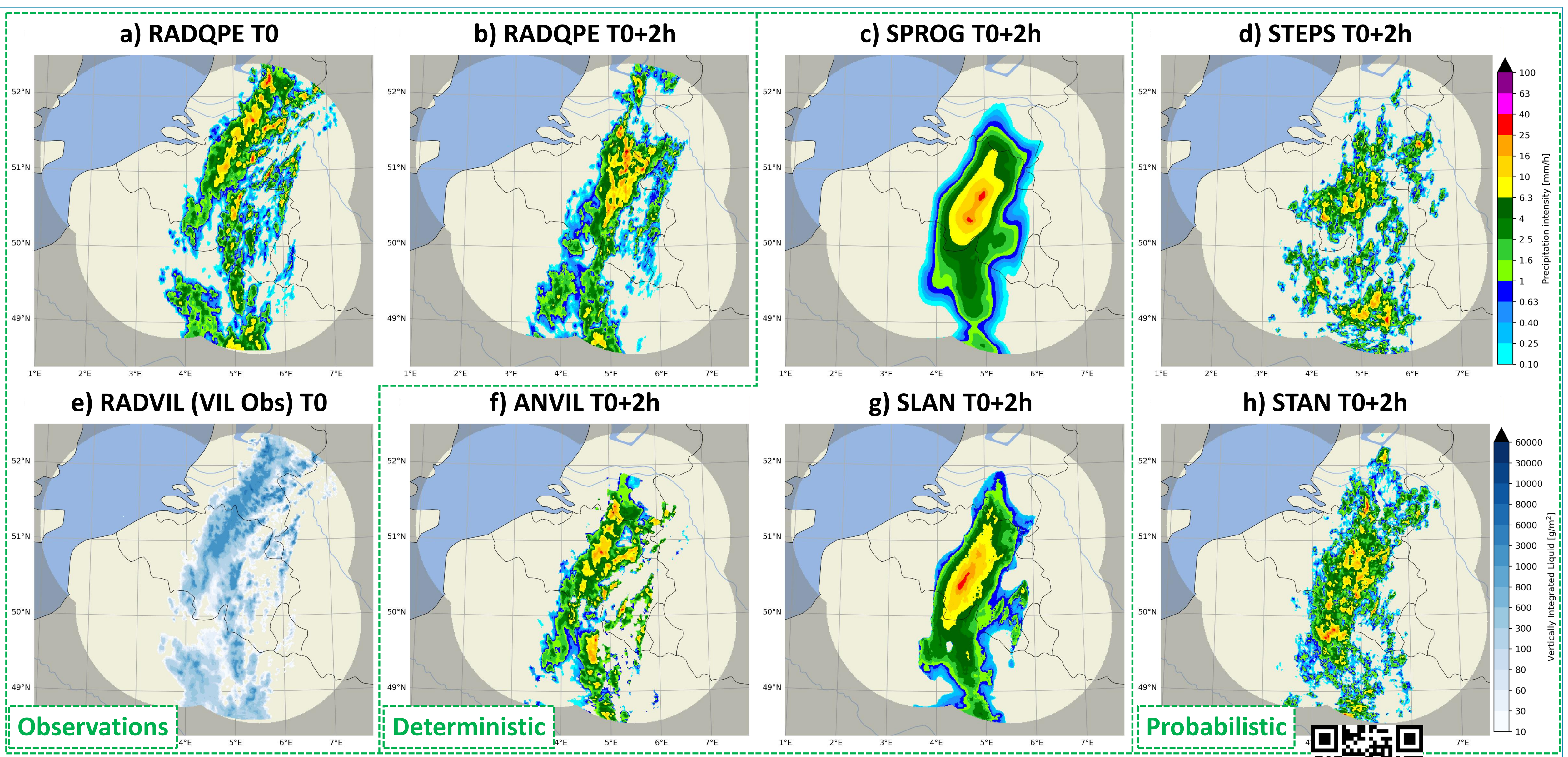


Figure 3. (a) RADQPE (R Obs) and (e) RADVIL (VIL Obs) for T0 at 1 a.m. on 15/07/2021 compared to (b) RADQPE (R Obs), (c) SPROG, (d) STEPS (1 member), (f) ANVIL, (g) SLAN and (h) STAN (1 member) nowcasting methods at 2 h lead time (3 a.m. on 15/07/2021).

Scan me to see Animation

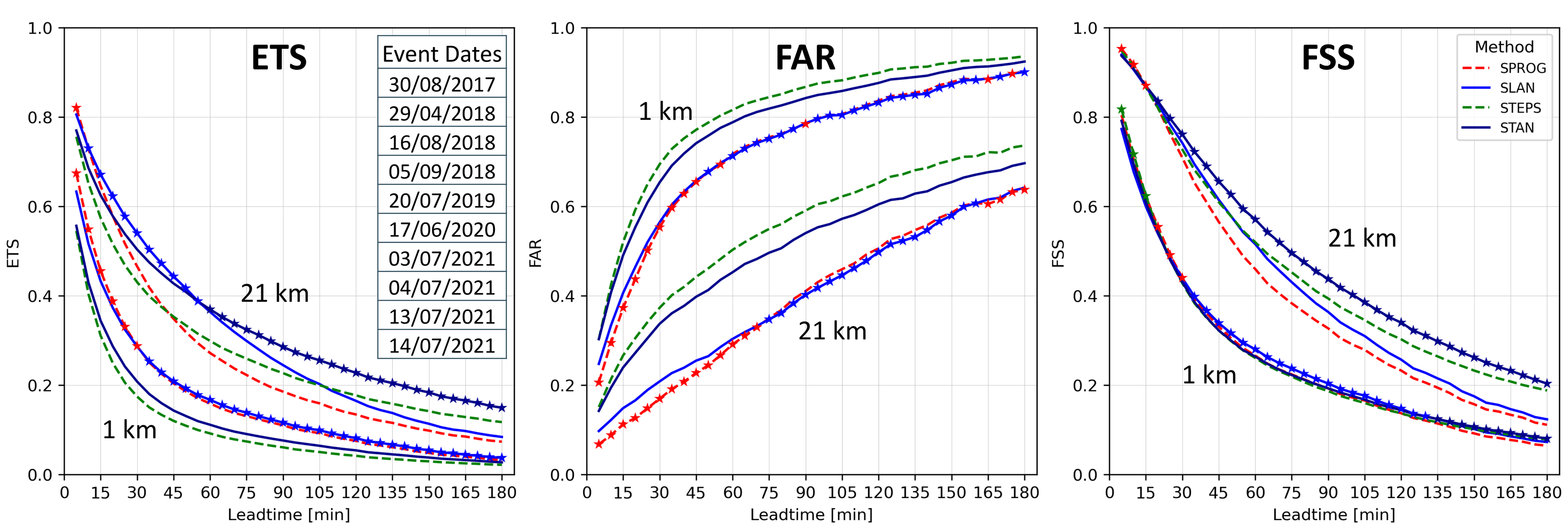


Figure 4. ETS, FAR and FSS for threshold ≥ 5 mm/h and window sizes of 1 and 21 km averaged over 10 rainfall events for deterministic (SPROG and SLAN), and probabilistic (STEPS and STAN) nowcasting methods.

Conclusions

- **STAN** nowcasts usually yield **better results** than STEPS in ETS, POD, FAR, and FSS for **high thresholds** ≥ 5 mm/h, similar for ≥ 1 mm/h, and worse for ≥ 0.1 mm/h.
- STAN can **model growth and decay** of rainfall from initial non-dry pixels, and growth of convective cells from dry pixels is simulated with **stochastic noise**.
- **VIL** can serve as a **proxy for rainfall**, especially for **convective** events, with accuracy expected to improve through better QPE, VIL estimation and R–VIL relationship.

References

[1] Seed, A. W., C. E. Pierce, and K. Norman (2013), Formulation and evaluation of a scale decomposition-based stochastic precipitation nowcast scheme, *Water Resour. Res., vol.* 49, pp. 6624–6641.
[2] Pulkkinen, S., Nerini, D., Pérez Hortal, A. A., Velasco-Forero, C., Seed, A., Germann, U., and Foresti, L. (2019), Pysteps: an open-source Python library for probabilistic precipitation nowcasting (v1.0), *Geosci. Model Dev.*, vol. 12, pp. 4185–4219.
[3] S. Pulkkinen, V. Chandrasekar, A. von Lerber and A. -M. Harri (2020), Nowcasting of Convective Rainfall Using Volumetric Radar Observations, *IEEE Transactions on Geoscience and Remote Sensing*, vol. 58, no. 11, pp. 7845-7859.
[4] R. Reinoso-Rondinel, M. Rempel, M. Schultze and S. Trömel (2022), Nationwide Radar-Based Precipitation Nowcasting—A Localization Filtering Approach and its Application for Germany, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 15, pp. 1670-1691.