9.11 OPTICAL FLOW MODELS BENCHMARKING FOR RADAR-BASED PRECIPITATION NOWCASTING

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Precipitation nowcasting is crucial for early warning of hazardous events at small spatiotemporal scales (tens of kilometers, lead times of a few hours). It has been shown that nowcasting systems, if operationalized, are both efficient and effective in reducing economic and human losses caused by heavy rainfall.

We have developed and benchmarked two classes of parsimonious precipitation nowcasting models based on gridded radar data and optical flow algorithms. The Python implementation of these algorithms is entirely based on open source software libraries, notably OpenCV, NumPy, SciPy, Scikit-learn, Scikit-image, and wradlib.

The first class ("sparse" optical flow) employs a continuous stack of feature detection, tracking, and extrapolation techniques followed by a spatial transformation routine based on image warping. The second class (dense optical flow) derives a full velocity field which is then used to compute the precipitation field displacement. Each model class consists of several variants with regard to the treatment of extrapolation and field displacement. We used the German Weather Services (DWD) RY radar composite product which provides estimates of instantaneous rainfall intensity at 5 minute intervals on a 1 km regular grid for a 900 km by 900 km domain.

For our benchmarking experiment, we used the following set up:

- nowcast lead time: one hour at 5 min intervals
- 11 events during summer periods of 2016 and 2017, that cover different durations, spatial coverage, precipitation intensities, and convection types
- two "sparse" optical flow model modifications that differ with regard to the temporal extrapolation of detected features
- two dense optical flow model modifications that differ with regard to the advection technique
- primitive benchmark model based on the Eulerian persistence
- DWD operational nowcasting model (RADVOR), namely the RV product, as advanced benchmark (5 minute intervals, 1 km resolution, 2 hours lead time)
- mean absolute error (MAE) and critical success index (CSI) with different thresholds for forecast verification

Results show that the use of standard optical flow techniques for extracting relevant information about precipitation field movement provides a firm basis for radar-based precipitation nowcasting. All models show significant skill over persistence. The dense optical flow model class shows comparable results with the

RADVOR operational model baseline. Nevertheless, heavy rainfall nowcasting for the lead times longer than 30 minutes is still the most challenging task for every model.

The computational time for one forecast at one hour lead time varies from 20 sec to 150 sec on a standard office computer for a "sparse" and dense optical flow model classes respectively. The overall performance in combination with the open source implementation allows for immediate application in different contexts, and a reliable baseline for developing more advanced models.