

Seamless Integrated Rainfall Forecasts using Nowcasting and NWP-Ensembles

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Introduction and Motivation

- Improvement of short-term rainfall forecasts required due to many flood events in recent years
- Numerical Weather Prediction (NWP)
 - ICON-D2-RUC
 - Update rate: 1 h
- Nowcasting (STEPS)
 - Short-Term Ensemble Prediction System
 - Update rate: 5 min
- Objective: Provide rainfall and radar reflectivity forecasts for the next 12 h by a seamless transition from Nowcasting to NWP
- Resulting forecast product: INTENSE (INTegration of ENSembles of NWP and Extrapolation)





Methodology



DVD implementation of STEPS (Short-Term Ensemble Prediction System, Seed 2003)

Advection forecast by optical flow extrapolation



Spatial decomposition by FFT algorithm and a bandpass filter in the Fourier space



Generation of scale-dependend noise defined by first order AR process: $X_t = \Phi X_{t-1} + \varepsilon_t$



Sprative Combination Procedure:

- Extrapolation: Apply STEPS
- Correction: Localized Transition to NWP inspired by the Ensemble Kalman Filter Approach (Nerini et al 2019)
 - (1) Thresholding of rainfall fields
 - (2) Preprocessing regarding skewness and spatial intermittency
 - (3) Pixelwise calculation of ensemble variance
 - (4) Spatial smoothing using a box filter
 - (5) Field of adjustment coefficients: $C = \frac{\sigma_{ext}^2}{\sigma_{ext}^2 + \sigma_{NWP}^2}$
 - (6) Correction: $X_{Extrapol} = X_{Extrapol} + C (Z_{NWV} X_{Extrapol})$
 - (7) Adjust rainfall histogram by quantile mapping







DWD

Example: 29th May 2016



Rainfall Sum 1 h: Member 1



Reflectivity: Member 1



Example: 29th May 2016

Replace no rainfall values (Idea from Atencia et al. 2020)

- Obtain ensemble rainfall mask (at least 1 member with more than 2 dBZ)
- For each member: obtain specific rainfall mask
- Fit truncated normal distribution to rainfall values
- Calculate distance to nearest rainfall pixel for each no-rainfall pixel
- Map distances to the truncated tail of the reflectivity distribution









Deutscher Wetterdienst Wetter und Klima aus einer Hand

DWD

Example: 29th May 2016







DWD

Example: 29th May 2016



Rainfall Sum 1 h Exceedance Probability for 15 mm

Rainfall Sum 1 h: 11 km Box Maximum Exceedance Probability for 15 mm

90.00

80.00

60.00

50.00 2

40.00

30.00

20.00

10.00



Ensemble Spread Rainfall Sum 1 h Interquartile Range (75th – 25th Percentile)



Verification



- Fraction Skill Score (FSS) for Reflectivity Forecast
- 27.05.2016 to 28.06.2016, 1h Inits



Verification



Reliability Diagrams and ROC Curves for Reflectivity





Current Status and Outlook

- Real-time test and evaluation operations
 - Evaluation at ESSL-Testbed
 - \rightarrow Evaluation for severe weather situations by DWD forecasters
- Goal: Become with pre-operational with INTENSE until 12/2025
- \rightarrow Further tuning and objective verification
- Consider feedback from flood forecasting institutions
- Methodological improvement: Consider NWP skill in addition to NWP spread
- Use of gauge-adjusted rainfall input

References

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