European Union
Civil Protection and
Humanitarian Aid

Smuff

Seamless blending of probabilistic nowcasts and NWP forecast

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Seamless probabilistic multi-source forecasting of heavy rainfall hazards for European flood awareness (SMUFF)

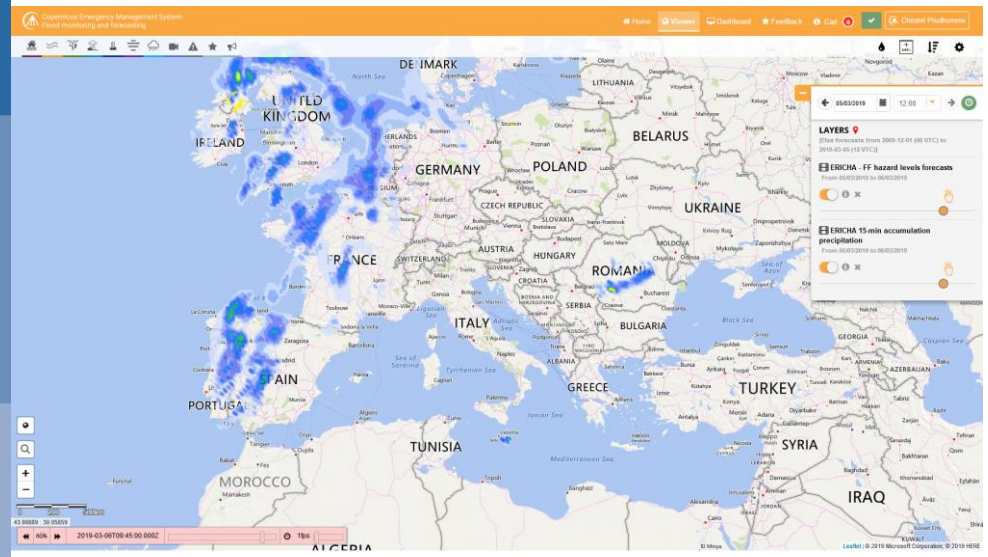
- Tools for assessing and forecasting the hazards and risks induced by intense rainfall and severe storms

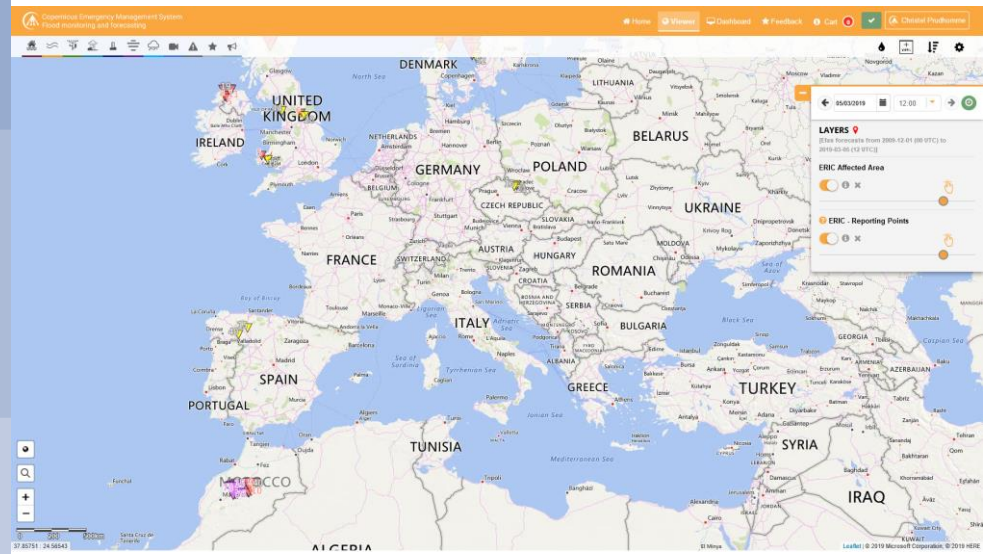
- Project is funded by Union Civil Protection Mechanism
- Following a trilogy of successful projects – HAREN, EDHIT and ERICHA
- Jan 2018- Dec 2019

- Coordinator: Finish Meteorological Institute
- Partners: University Polytechnics of Catalonia, ECMWF, Mikkelin Kaupunki

- Main aim: Rapidly updated, high resolution nowcasts of flash flood hazard within EFAS

Background – EFAS flash flood operational forecasting system

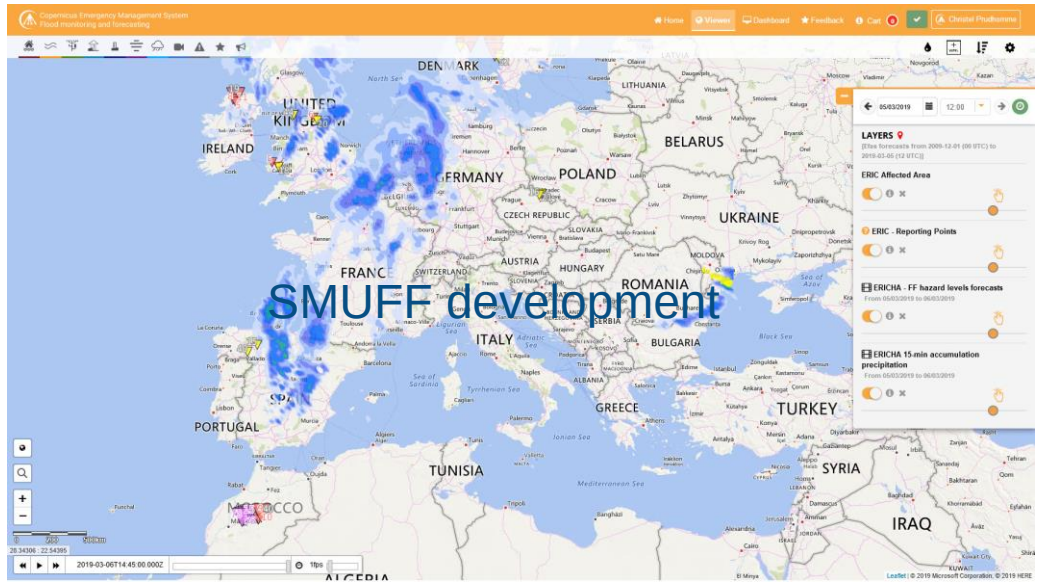




- **ERICHA** – nowcasting 15' to 4 hours [EC Civil Protection Prevention project]
  - Uncorrected Opera radar European coverage
  - Updated every 15 mn up to
  - Total Precipitation + Flood risk area
  - Radar-based deterministic nowcast + flood risk coefficient
  - Thresholds based on MeteoAlert

- **ERIC** – Flash flood indicator next 5 days [JRC]
  - Cosmo-leps European coverage
  - Updated twice daily up to 5 days, no details
  - Flood reporting points + affected areas
  - Probabilistic NWP (Cosmo-leps) + hydrological model + flood risk coefficient
  - Threshold based on reference climatology (model based)

EFAS Flash Flood forecasting Challenges & SMUFF solutions

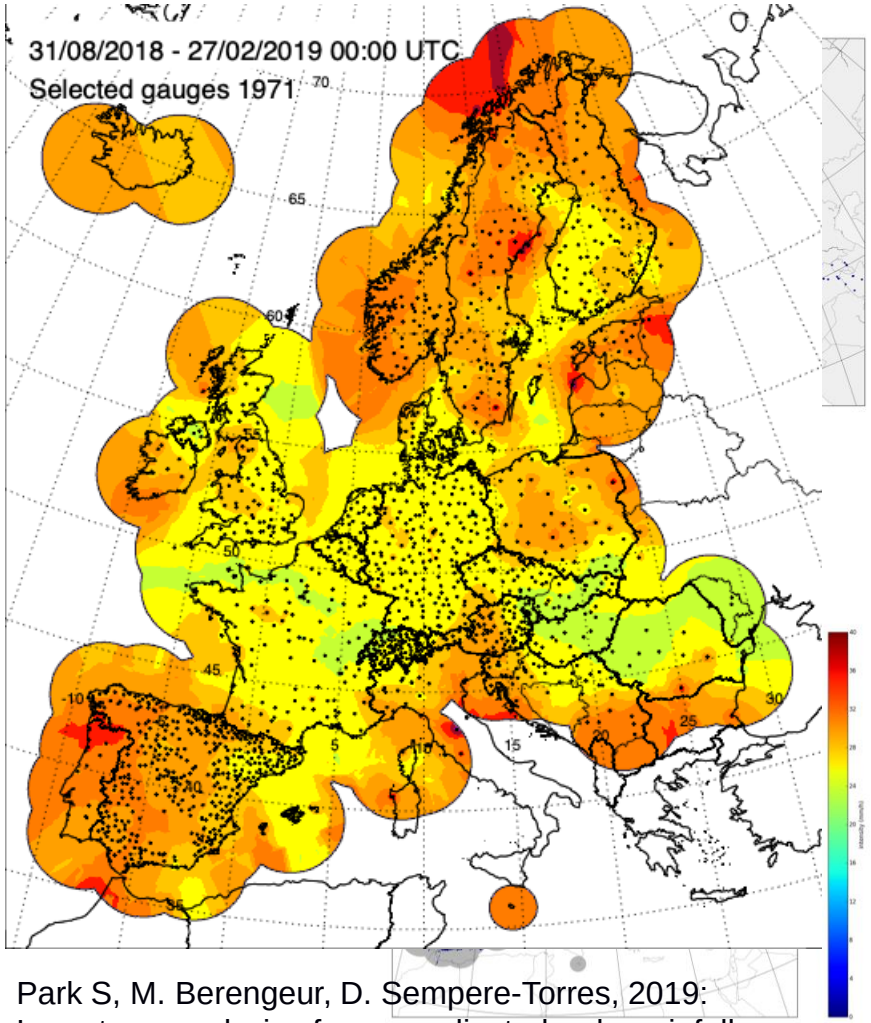


- Limited European coverage -> exclusion of countries e.g. Italy
  - **SMUFF**: radar + satellite merging for extension of geographic coverage
- Precipitation composite from Opera -> systematic errors
  - **SMUFF**: gauge-corrected opera-based precipitation for improved ERICHA forecasts
- Deterministic nowcasting -> no uncertainty/ probability
  - **SMUFF**: ensemble nowcasting for probabilistic forecasts
- Two independent systems -> more complex decision making
  - **SMUFF**: blending of ensemble nowcast & ensemble NWP for seamless, consistent forecast up to 5 days

PERC - Pan-European Radar Composite

- Step 1: Composite consists data from
  - **OPERA** radar network
    - Clutter removal + Bias correction
  - **EUMETSAT** Convective Rainfall Rate (CRR)
    - Bias correction (different for night and day)
  - **Rain fields** based on GLD360 lightning density
    - Bias correction

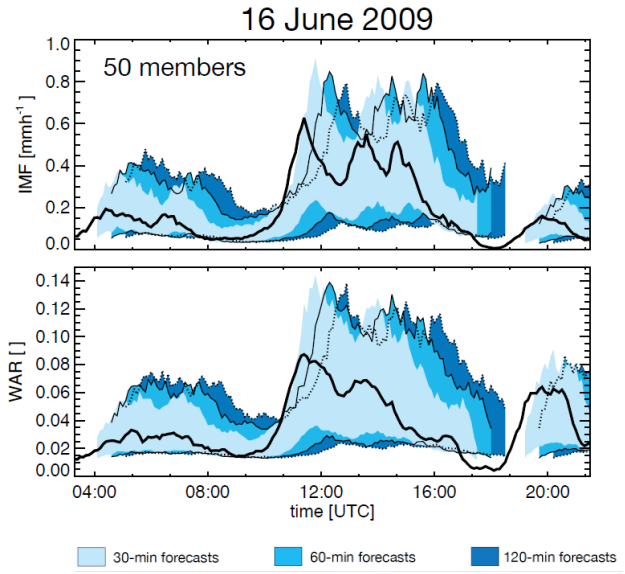
- Step 2: Daily gauge-adjustment of OPERA composite

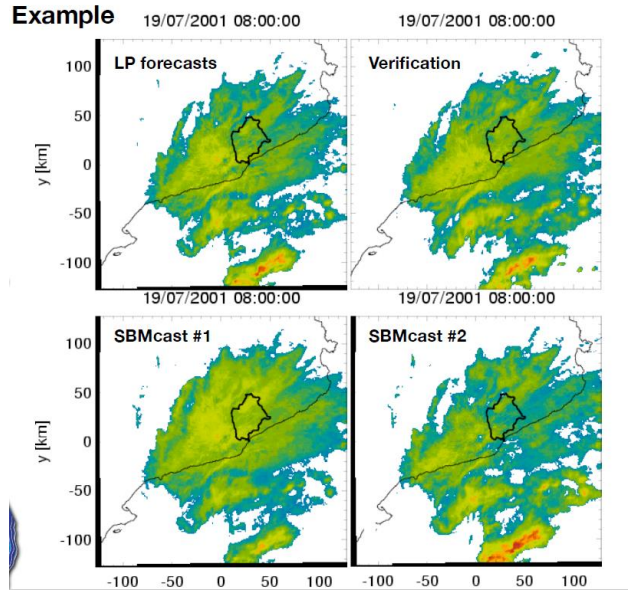


Park S, M. Berengeur, D. Sempere-Torres, 2019: Long-term analysis of gauge adjusted radar rainfall accumulations at European scale, Journal of Hydrology, under review.

Probabilistic radar-based rainfall nowcasts

- Radar-based nowcasting based motion field tracking & extrapolation
- Probabilistic nowcast for the evolution of the rainfall field
- Computationally very expensive
  - Updated every 1 hour.
  - Ensembles size: 20 members.





ECMWF

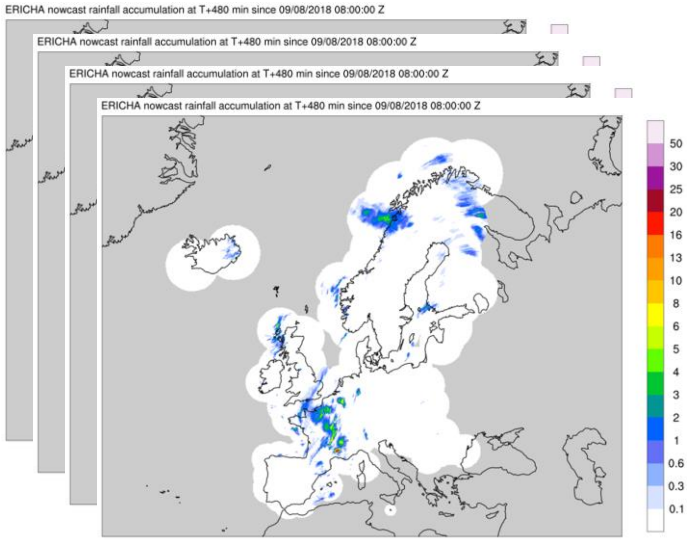
Seamless blending of NWP and nowcast

- Aims to create a seamless ensemble forecast up to 5 days leadtime

- ECMWF-IFS are produced twice daily at 00 and 12 UTC
  - Deterministic forecast @9 km with 10 days lead time, first 90 hours with 1 hour timesteps
  - Ensemble forecasts 50 + 1 members @18km, with 15 days lead time, first 90 hours with 1 hour timesteps

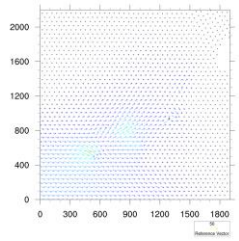
- SWIRLS nowcasting system of the Hong Kong Observatory (Wong et al. 2009)
  - Phase correction (Optical flow method)
  - Intensity calibration by adjusting distribution of accumulated rainfall
  - Merging the adjusted rainfall fields over an 8 hour time window

Blending **ensemble** precipitation nowcast & NWP forecast

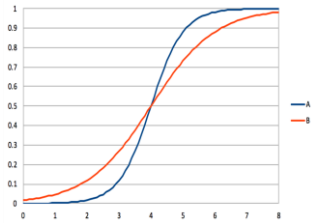


Ensemble Nowcast

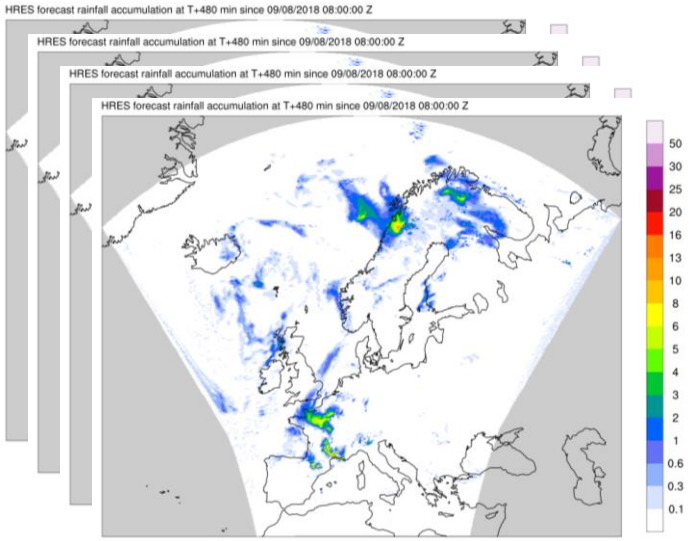
15mn precip total every 15mn up to 8 hrs



Phase correction algorithm



Weighing factor

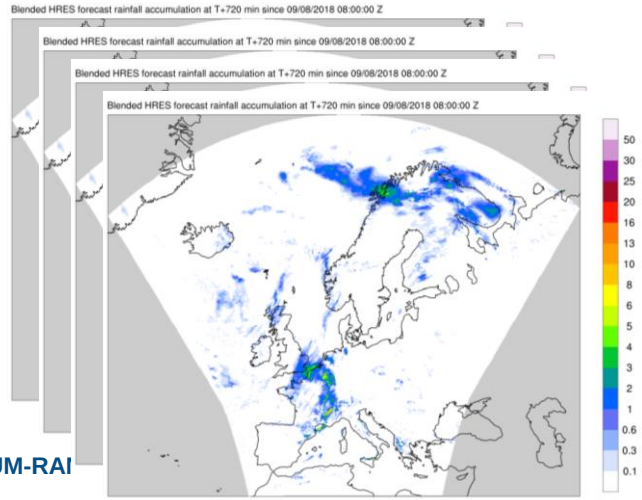


Ensemble NWP

1hr precip total every 6hr up to 5 days

Members searched for similarity in

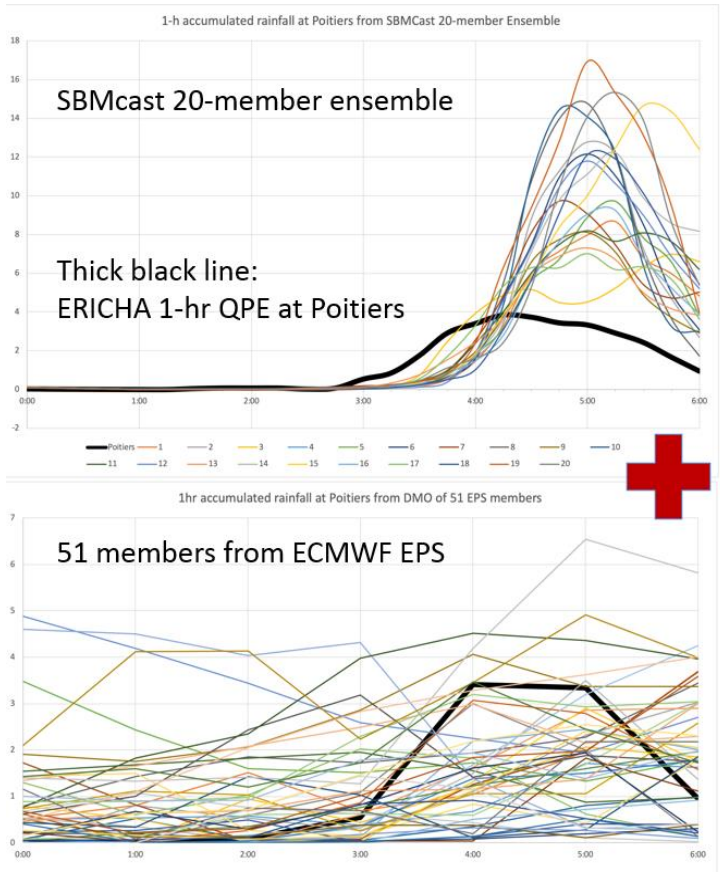
- Precipitation location
- Intensity of 1hr rainfall

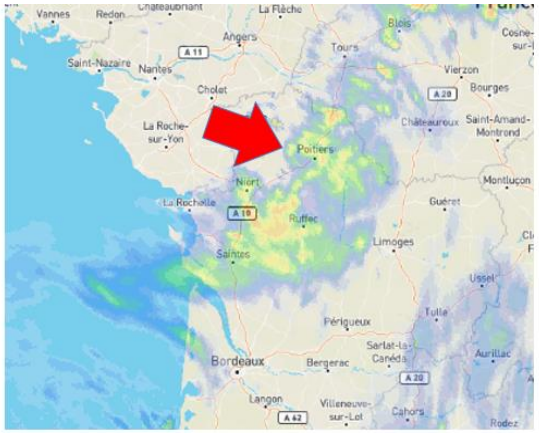


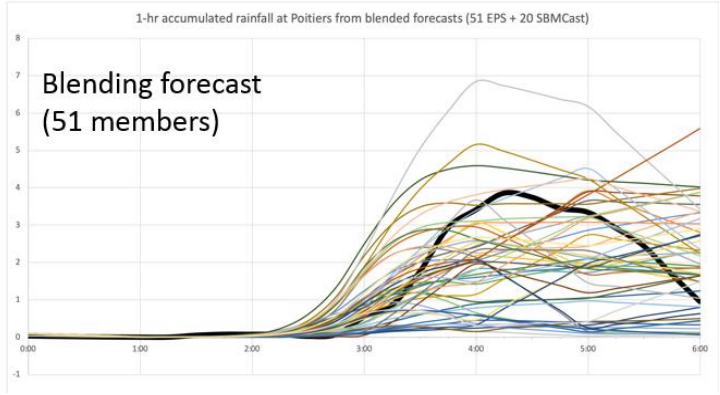
Blended product

Seamless blending of NWP and nowcast

Blending of QPFs from 20-member SBMcast nowcast ensemble with the 50-member of ECMWF EPS is based on maximizing their similarities



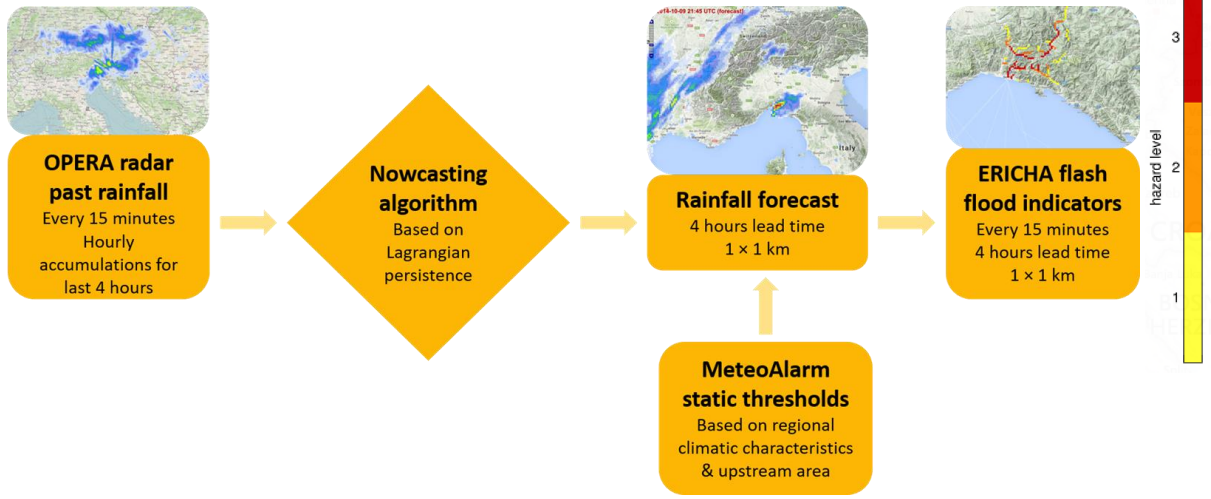




Transforming Rainfall Nowcasts into Flash Flood Hazard Products

Limitations:

- Deterministic only
- Short lead time (4 hours)
- Real world thresholds difficult to exceed when using radar accumulations

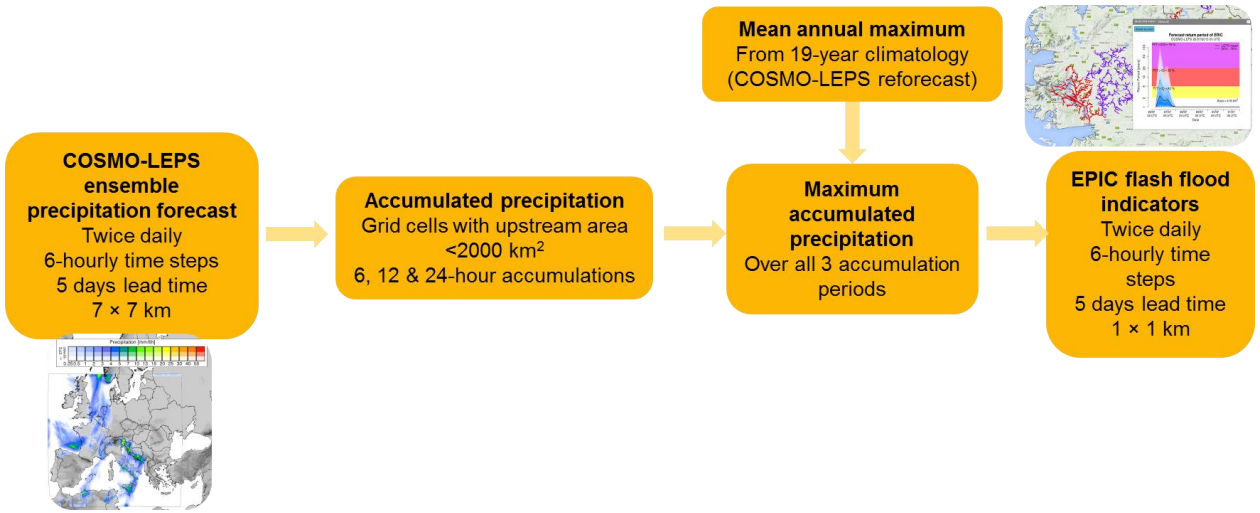


Advantages:

- Probabilistic
- Warnings account for NWP bias

Limitations:

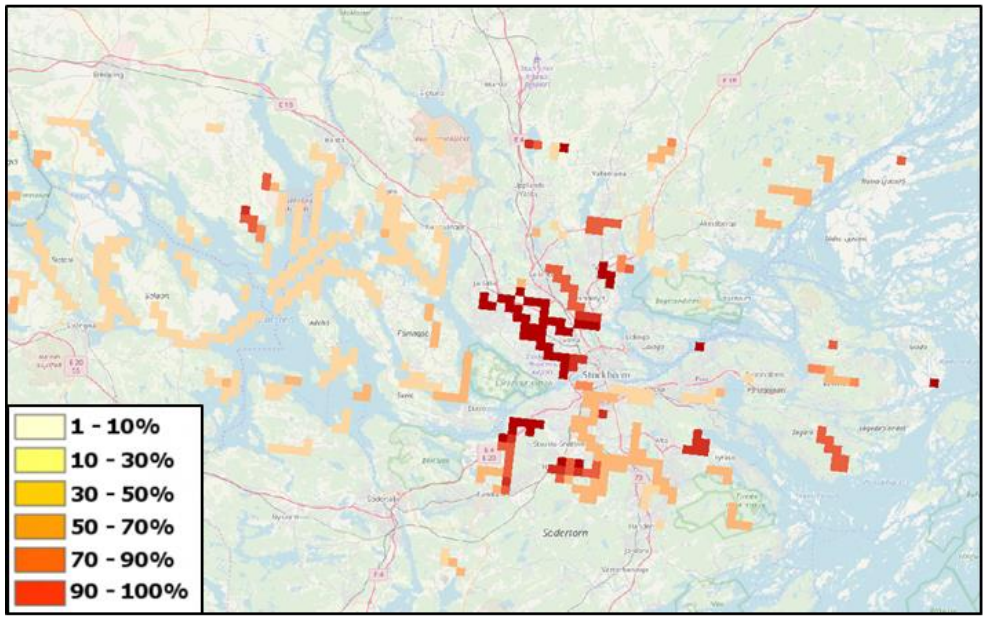
- No short range detail for first 4 hours



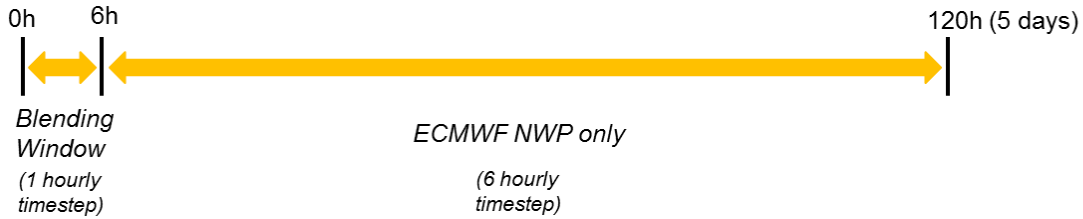
Transforming Rainfall Nowcasts into Flash Flood Hazard Products

- Combine ERICHA and EPIC methodologies
  - **Input:** Probabilistic information from the blended forecast
  - **Output:**Probabilistic flash flood hazard nowcasts
  - Extended lead time up to 5 days (whilst preserving detail in first 4 hours)
  - Warnings not affected by bias

Probabilistic product:



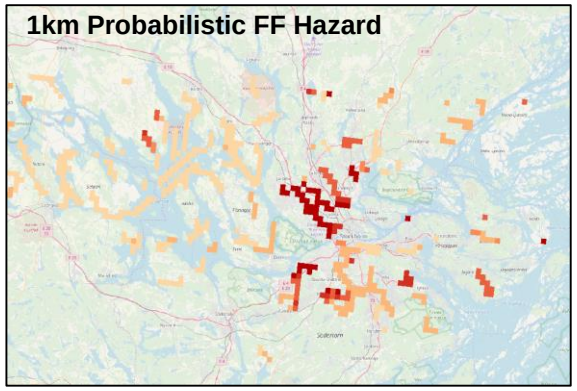
- At each timestep show probability of exceeding mean annual maximum

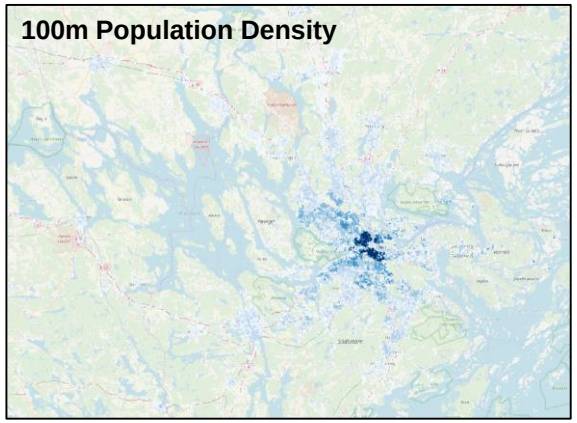


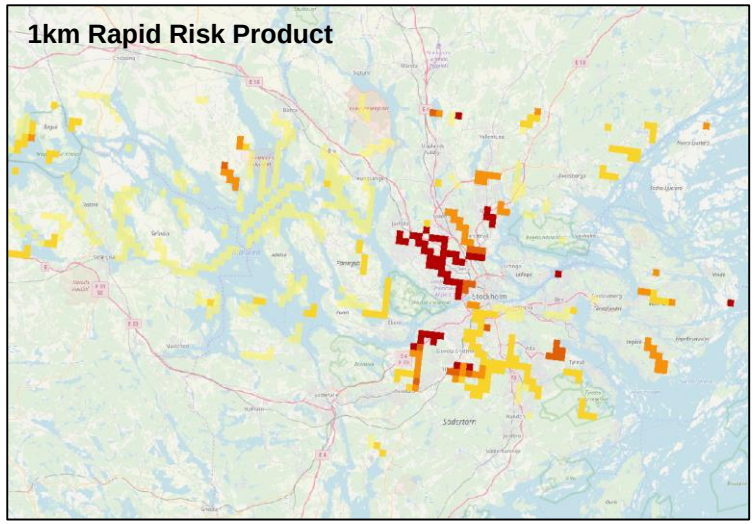
Simplified Rapid Risk Forecasts

- Currently no way of knowing which locations will have the most impact
- Population density is a key driver

> Intersect probabilistic flash flood hazard with population density







Conclusions and future aspects

- SMUFF develops tools for assessing and forecasting pan-European hazards induced by severe storms and flash floods

- The project focus on
  - probabilistic nowcasting of convective storms that cause hazards in urban areas
  - providing a continuous hazard forecasting horizon by seamlessly integrating the nowcasts of precipitation with the NWP outputs of ECMWF
  - developing tools to characterize the uncertainty affecting the different components of the hazard forecasting algorithms

- The SMUFF products will be integrated into new layers on the ERICHA/SMUFF platform and provided for EFAS

- Future plans are to improve the risk assessment and consider precipitation type in the precipitation forecasting.

ECMWF
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European Union
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Thank you

Operational challenges

- **Time step**
  - 15mns OK for nowcasting; not appropriate after 8 hours
- **Number of ensemble members**
  - 20 x 51 combinations too costly
  - Sub-sampling of most common features -> 51 members up to 5 days
- **Spatial resolution**
  - 1km nowcast OK; 1km NWP not appropriate
  - Change file formats / resolution too complex for downstream applications (e.g. flash flood transformation)
- **Code efficiency and archiving**
  - 15mn update -> volume too high for archiving