Flash Floods

Recent developments, changes, challenges and solutions

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Calum Baugh

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ECMWF

Overview of Current ERIC Product

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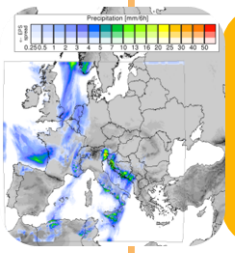
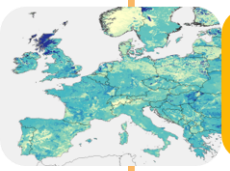
- Implemented since September 2015
- Accumulates runoff on 1 km channel network and compares against thresholds



COSMO-LEPS ensemble precipitation forecast
Twice daily
6-hourly time steps
5 days lead time
7 × 7 km



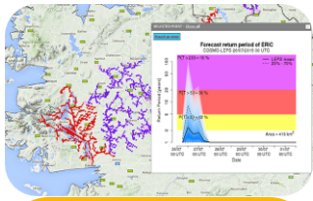
LISFLOOD ensemble soil moisture forecast
5 × 5 km

Surface runoff forecast
1 × 1 km

Accumulated surface runoff
Grid cells with upstream area <2000 km²
6, 12 & 24-hour accumulations

Mean annual maximum
From 19-year climatology
(COSMO-LEPS reforecast)

Maximum accumulated surface runoff
Over all 3 accumulation periods



ERIC flash flood indicators
Twice daily
6-hourly time steps
5 days lead time
1 × 1 km

- Needs to be re-evaluated after each new LISFLOOD calibration

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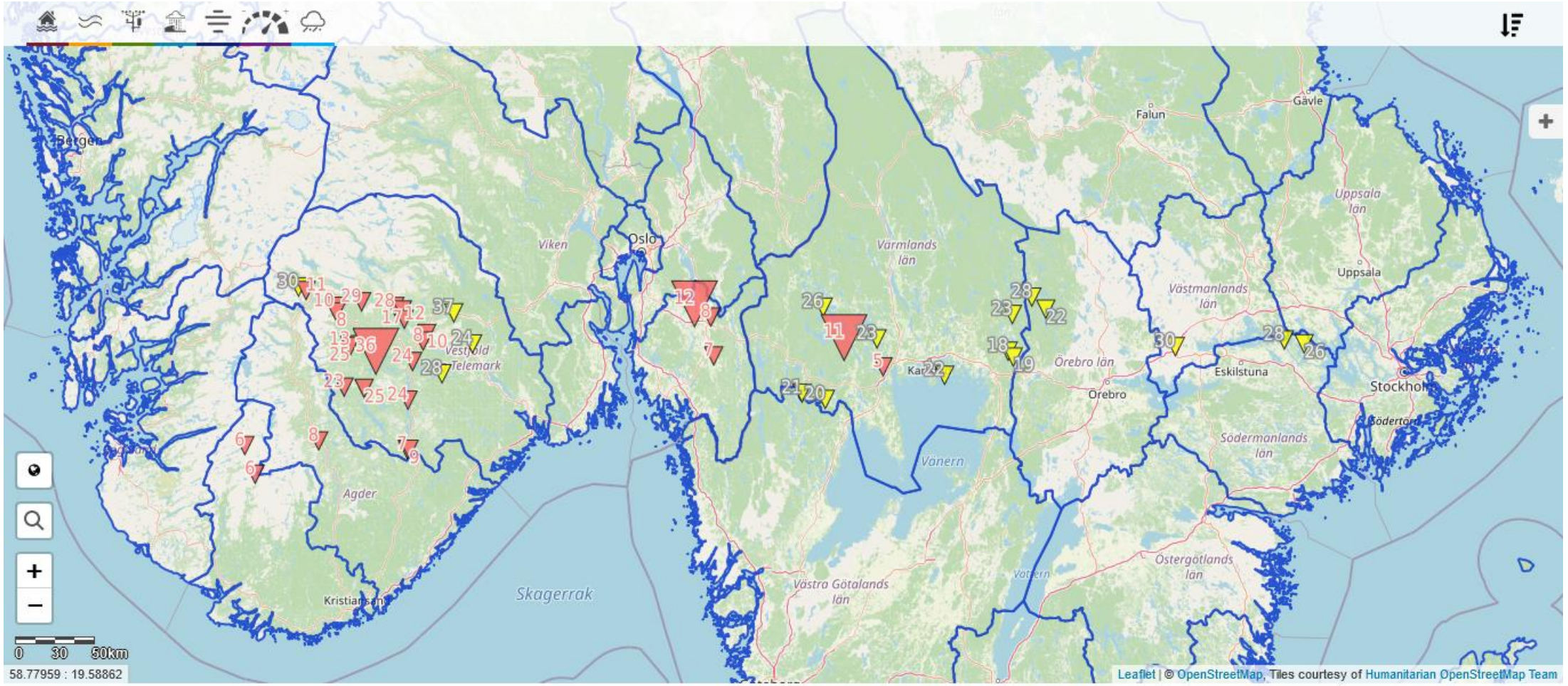
Recent Developments

- Highlight single point per region for issuing a notification



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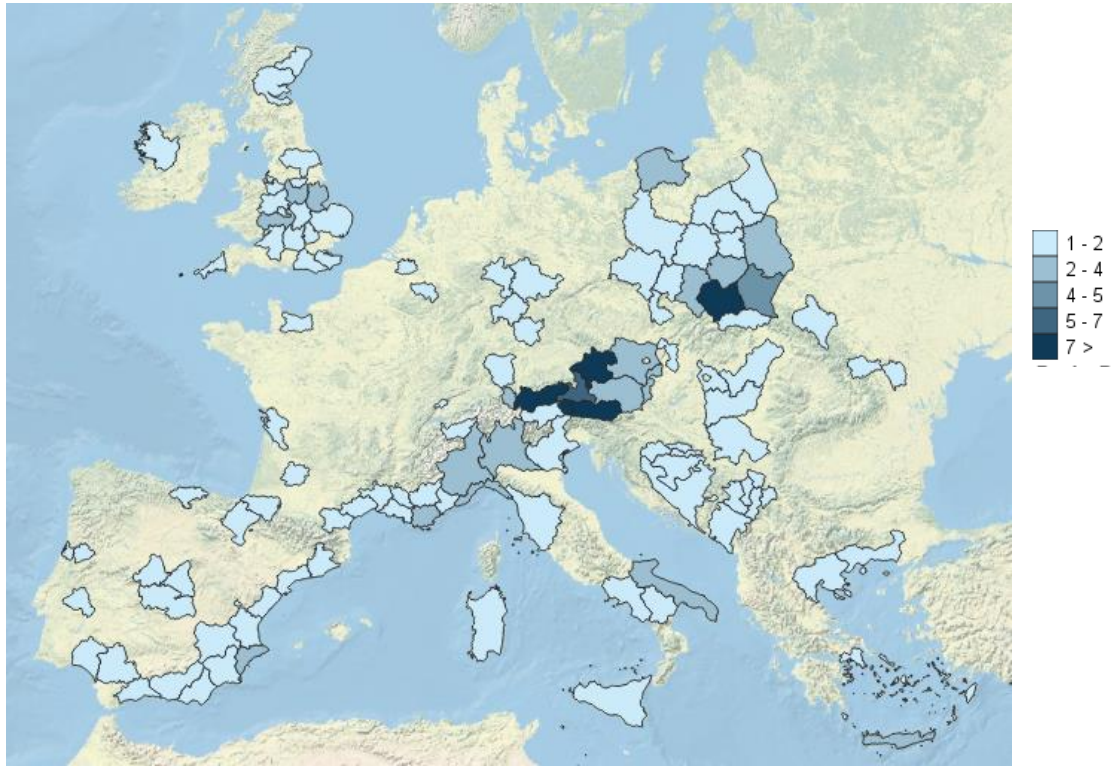
Evaluation of ERIC for EFAS 4.0

- ERIC climatological thresholds recomputed using new EFAS 4.0 6-hourly long term run
- Flash flood notification thresholds recomputed by evaluation against 1 year of observations in 2019

- Observations from FloodList, ESWD, Austrian partner
- 2655 observations, aggregated onto Administration Regions

- Tested different exceedance probability thresholds of 2-, 5- and 20- year return periods to generate ERIC warnings
- Compared the warnings against the observations for different lead times

Total number of flash flood observations per region



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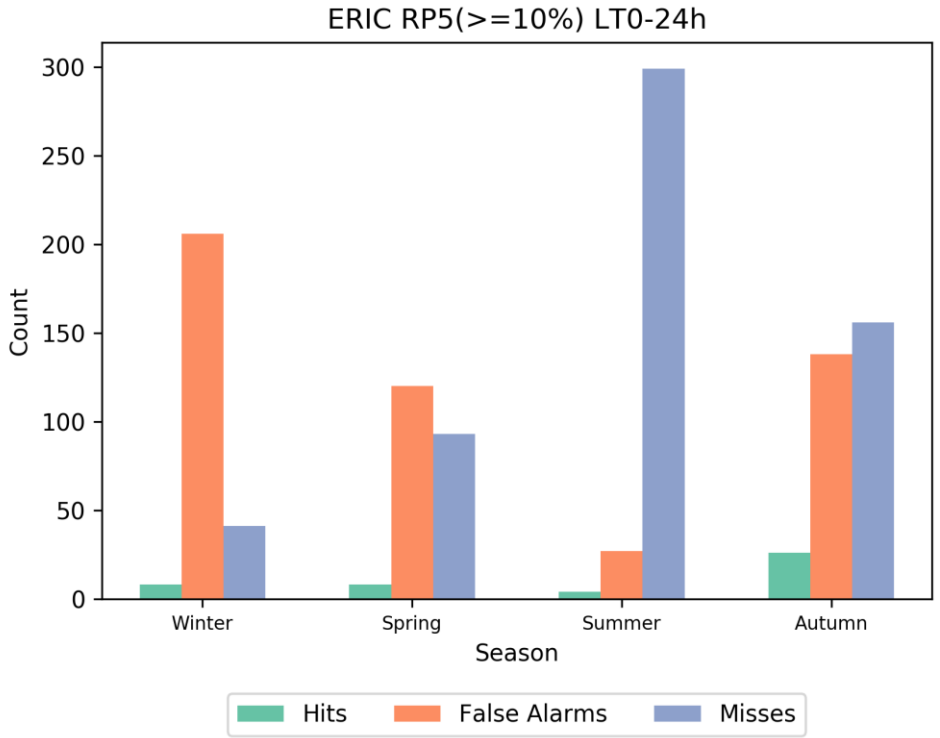
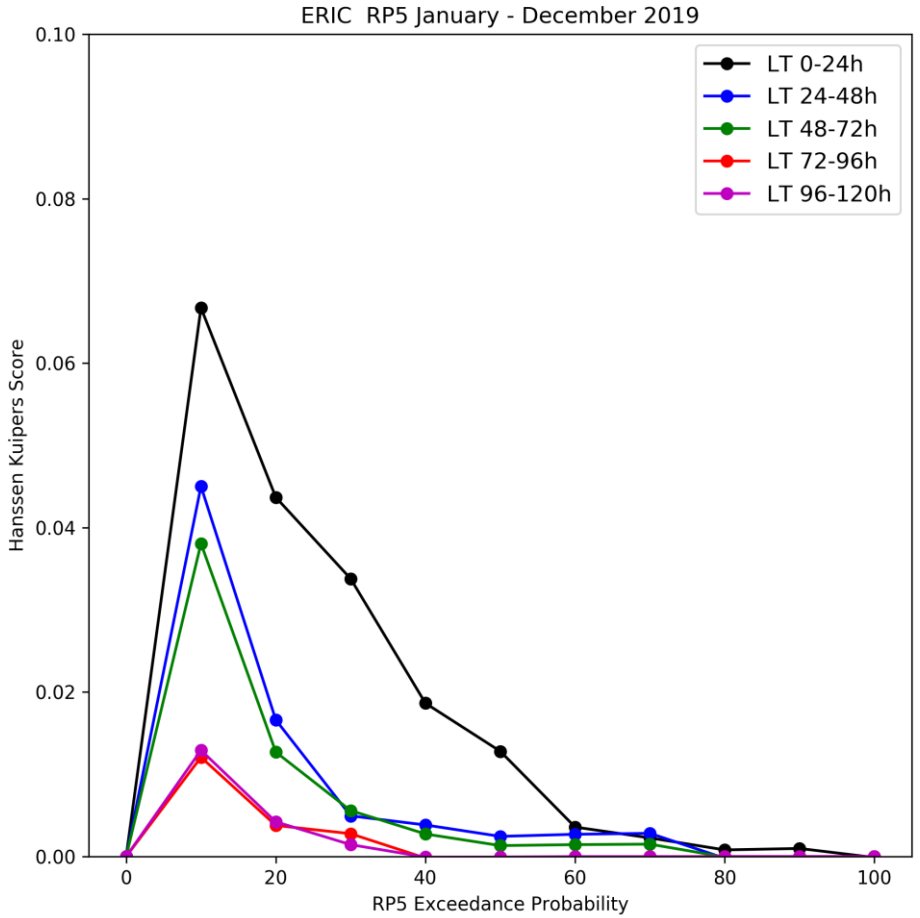
ERIC - Evaluation Results

- Calculated the Hanssen-Kuipers skill metric, shows how well flash flood and non-flash flood events are separated
- Best results at RP5(>=10%)
- Best performance in Autumn, more false alarms in winter, more misses in summer





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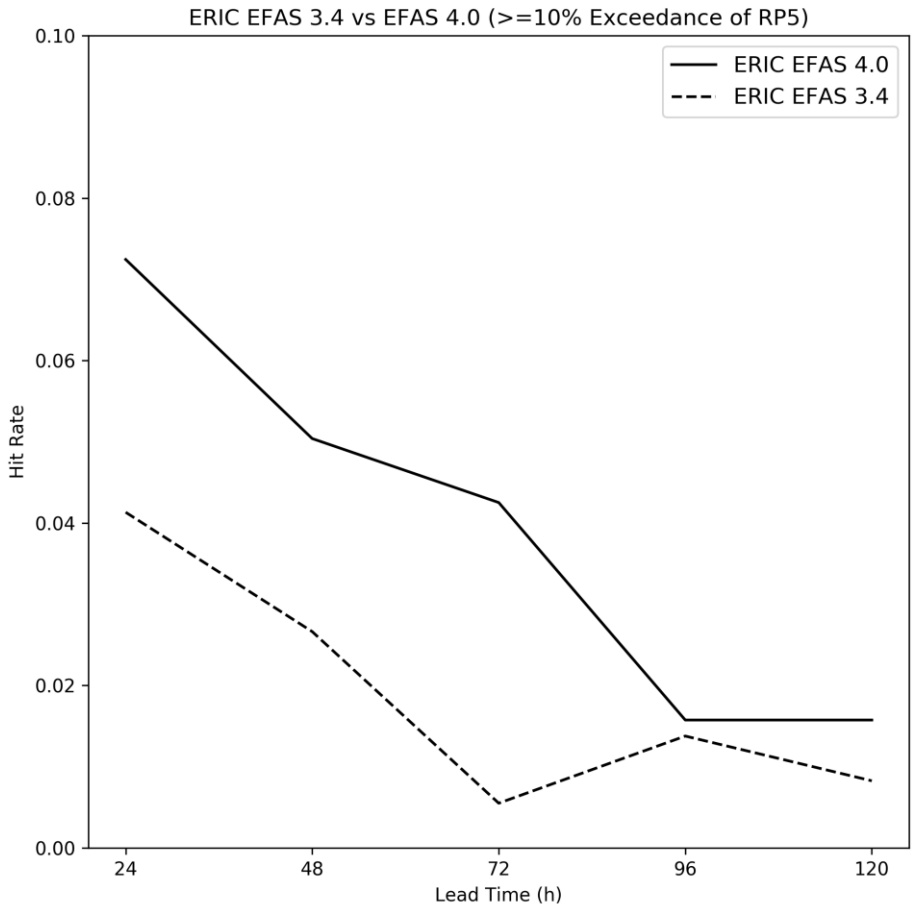
ERIC-Evaluation Conclusions

- Comparison against EFAS 3.4 shows that EFAS 4.0 outperforms at all lead times

- Recommend that flash flood threshold criterion remain unchanged:
  - 10% exceedance probability of 5-year return period
  - Up to lead time of 60 hours (2.5 days)

- For more information see: https://confluence.ecmwf.int/display/COPSRV/EFAS+4.0+ERIC+flash+flood+forecast+skill



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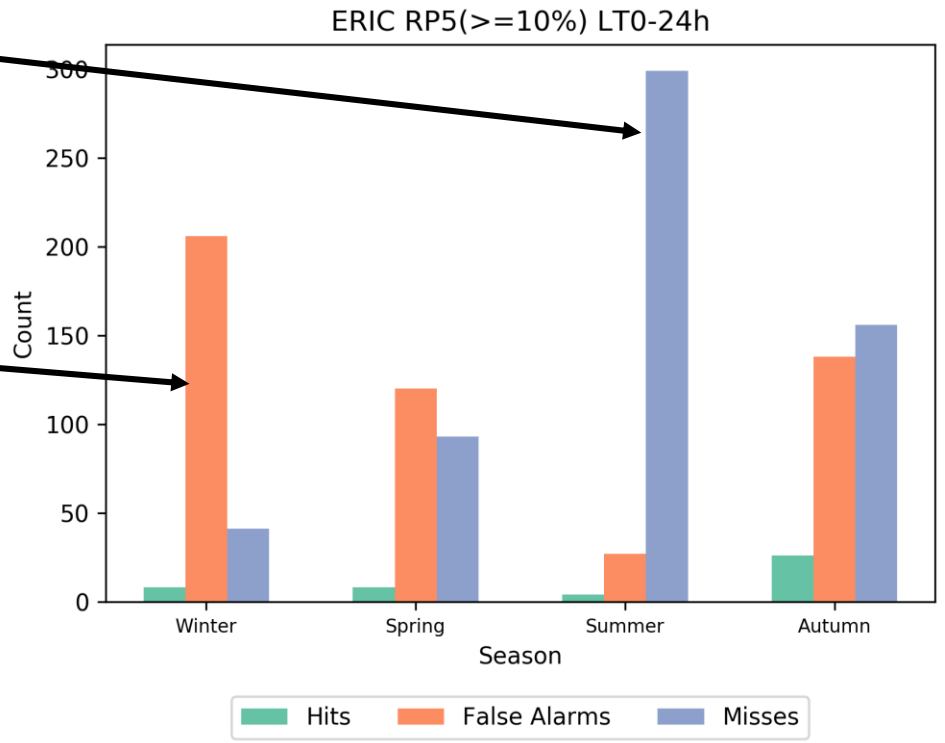
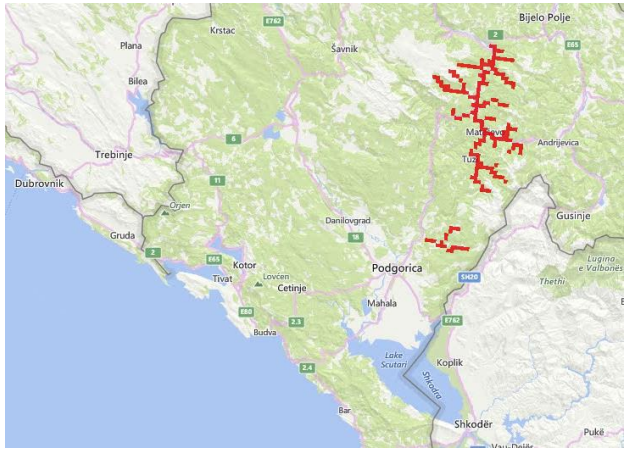
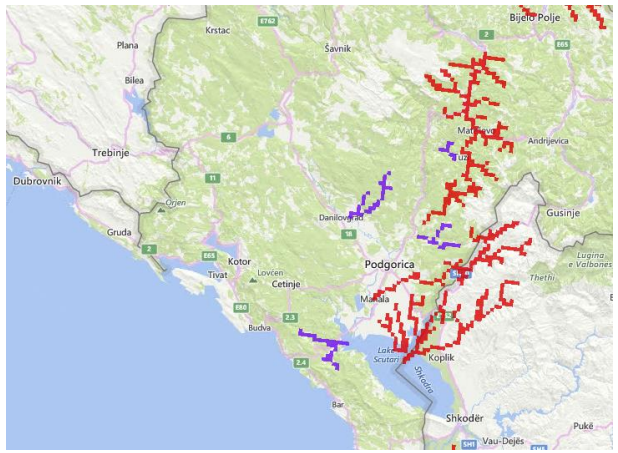
Challenges with ERIC

- Many events are missed
  - e.g. summer convection
- Prevalence of false alarms
  - Setting low exceedance probability threshold
  - Events in winter are not recorded as flash floods
- Persistence of forecast
  - Signal can change between forecasts







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Solutions: How can ERIC be Improved?

1. Better representation of localised extreme rainfall

2. Finer temporal resolution
   - 6 hourly too coarse
   - Flash floods can occur in shorter time scales

3. Forecasts produced more frequently per day
   - Useful for synoptic situations where heavy rain can appear within a few hours

4. Highlight areas where greatest impact
   - Prioritise which areas to focus relief efforts

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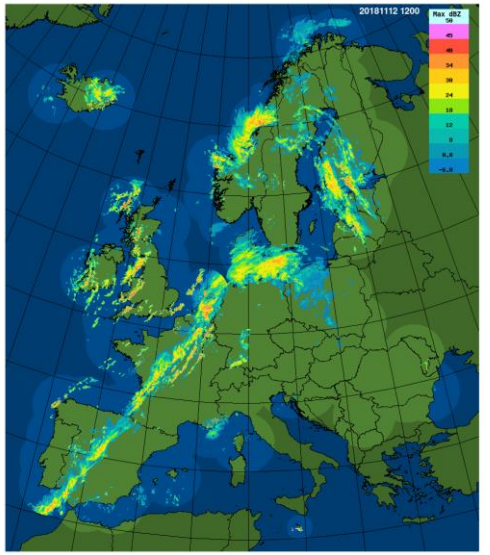
Solutions: TAMIR project

- Use radar rainfall observations from pan-European OPERA consortium
  - 2 km spatial resolution > interpolated to 1 km
  - Observations every 15 minutes
  - Bias corrected to rain gauge observations

- Previous observations used to produce nowcast over the next 6 hours
  - Nowcast produced every hour at hourly resolution

- Nowcasts are blended with ECMWF NWP forecasts to extend forecasts to 5 day lead time
  - Where no radar coverage the NWP are used
  - With greater forecast lead time more weighting given to NWP



Saltikoff *et al.*, 2019
https://doi.org/10.3390/atmos10060320

TAMIR

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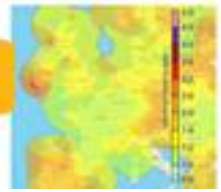
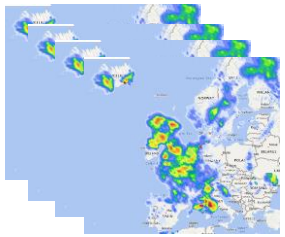
Flash flood prediction chain:

OPERA radar rainfall
1 h accumulation
Every 15 minutes
2 × 2 km

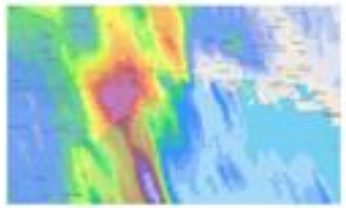


Daily **gauge adjustment**

Nowcasting
Based on Lagrangian Persistence
6 hours lead time

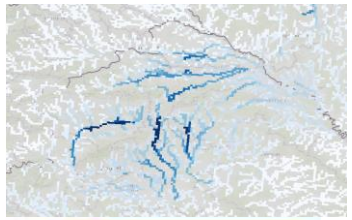


Blending
With ECMWF NWP to 5 days lead time

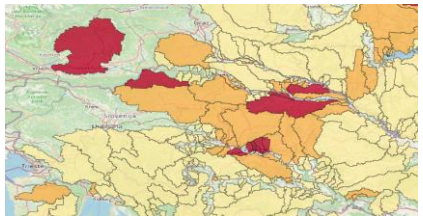


Basin-aggregated rainfall (forecast) accumulation
for 1, 3, 6, 12, 24 hour
1 km drainage grid with upstream areas < 5000 km²

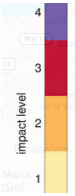
Comparison against **climatological thresholds**



Flash flood hazard, 1 km, hourly, 5 days lead time



Flash flood impact, summary of exposure which is affected



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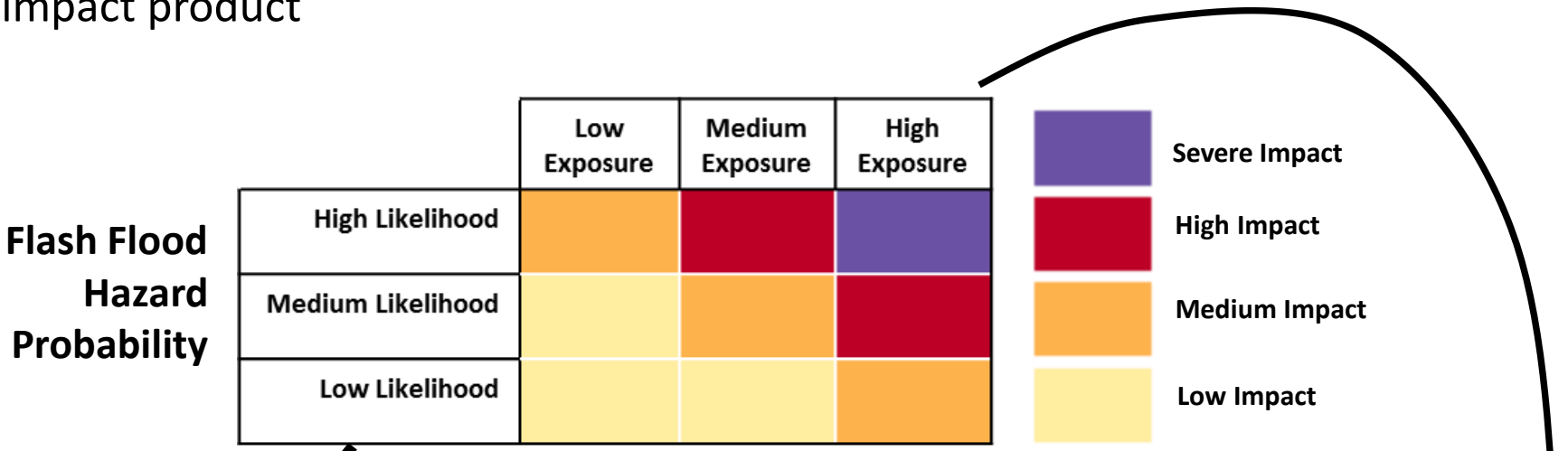
Solutions: Flash Flood Impact

- Impact matrix is used to combine hazard, exposure and vulnerability information into a flood impact product



Hazard Class	Exceedance Probability
High Likelihood	>=75%
Medium Likelihood	20% - 75%
Low Likelihood	5% - 20%

Proposed thresholds

How do we combine different exposure/vulnerability information?

Solutions: Flash Flood Impact

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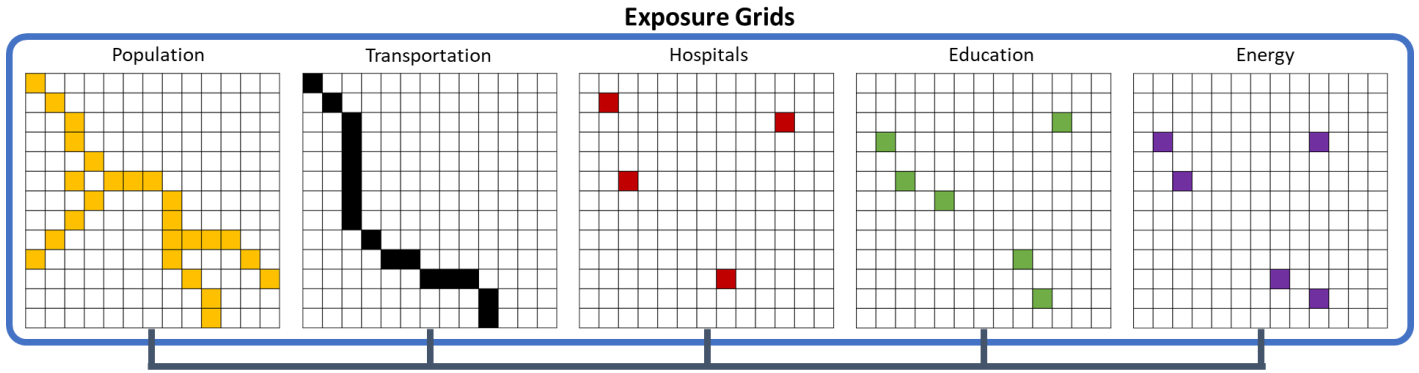
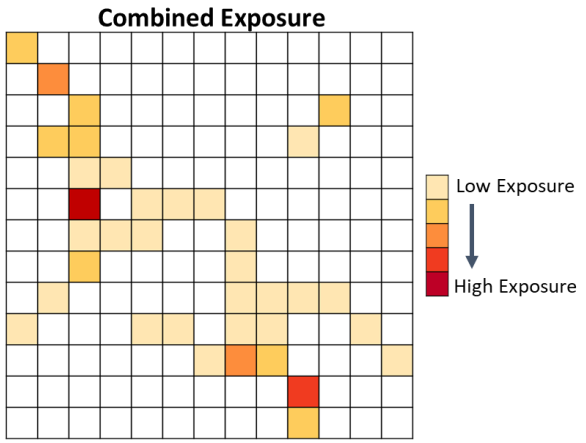
- Themes of exposure information
  - Population
  - Transport
  - Energy
  - Education
  - Health
- What others should we consider?
- Which are the most important?
- Please let us know at the TAMIR user workshop!
  - Online 27th October
  - Registration: https://webropol.com/s/tamirworkshop
  - Agenda: https://www.efas.eu/sites/default/files/2020-07/TAMIR_workshop_invitation.pdf
  - Email: tamir@fmi.fi





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Conclusions

- Current flash flood forecasts are prone to:
  - Issuing false alarms in autumn/winter
  - Missing localised events in the summer
- Spatial and temporal resolution of LISFLOOD forecasts is catching up
- Propose basing flash flood forecasts on blend of radar and NWP
  - Better capture localised events at short range
  - Updated more frequently, higher temporal resolution
- Remaining challenges:
  - Reducing false alarms
    - Including forecasted impacts
  - Evaluation
    - Require as many observations as possible
    - Flash flood feedback form is very valuable

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Q & A - 1

- *Q1 (Nuno Moreira, IPMA, Portugal):* ***ERIC now only uses COSMO-LEPS and Tamir only ECMWF-EPS? Would a multi-model approach enhance the scores?***
- *A1a (Calum Baugh; COMP): The COSMO-LEPS is driven at its boundaries by the ECMWF model itself, so those two models may be quite related to each other, they stand the possibility of other limited area models. The problem is they are too limited to be pan-European. I think it's something to consider, but maybe a bit later.*
- *A1b (Christel Prudhomme, COMP): One issue is the spatial domain of COSMO-LEPS which does not cover the whole of EFAS, but multi-model could be an option to consider for a follow-on project.*

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Q & A - 2

- *C1a (Franz Molé, DWD, Germany): ...**to check the coupling of heavy rain forecasts depending on air mass (cape, shear), could also be a benefit**.*
- *C1b: (Calum Baugh; COMP) We use it like the extreme forecast index, which is a ECMWF product which compares the forecasted ensemble versus model climatology. If you use an ensemble search of ECMWF and even COSMO-LEPS it's still going to struggle to capture these localised events using things like cape. This is something that colleagues of ECMWF have looked into predicting the locations of extreme rainfall and it's actually a product that they're trying now in GloFAS, which identifies the locations of extreme rainfall given the prevalence of things like cape and other meteorological factors. We're going to be monitoring the situation with that product very closely.*
- *C1c (Christel Prudhomme, COMP): Same for other ways of filtering the forecast using Cape, Shear, etc. We might consider it for future research.*