

Assessing the use of ondemand digital twins in national hydrological models

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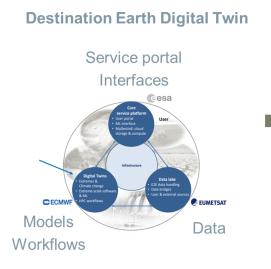


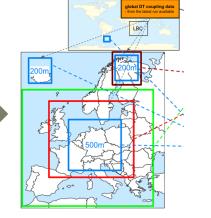
the European Union Destination Earth implemented by CECMWF Cesa EUMETSAT





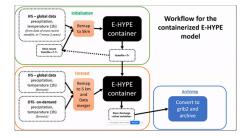
DE_33060: Vision of DestinE for Extreme Flood Events



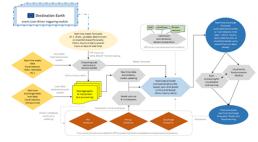


On-demand hyper resolution numerical weather predictions

Path 1: Fully coupled hydro-models



Path 2: Downstream national workflows





Case studies across Europe



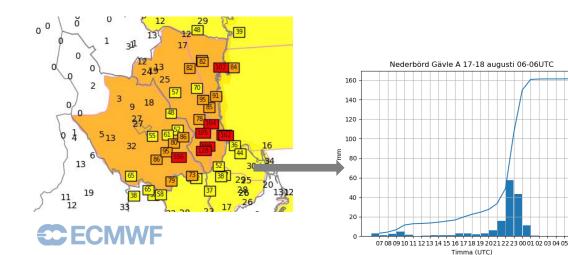
- Nine hydrological forecasting models
- Recent flood events
- Evaluation of DT data in hydrological forecasting
- Participants: SMHI, INRAE, IMO, SHMU, DMI, FMI, NIMH, CHMI, Met Eireann



The Swedish case study – Gävle, August 2021

SMH

- 17th to 18th August 2021
- 160 mm of precipitation in 24 hours, with a peak of 100 mm in 2 hours
- Flooding in the city of Gävle => high impact event
- High flows recorded in two gauging stations, river Testeboån and river Hyttingsån
- Combined event with pluvial and fluvial flooding



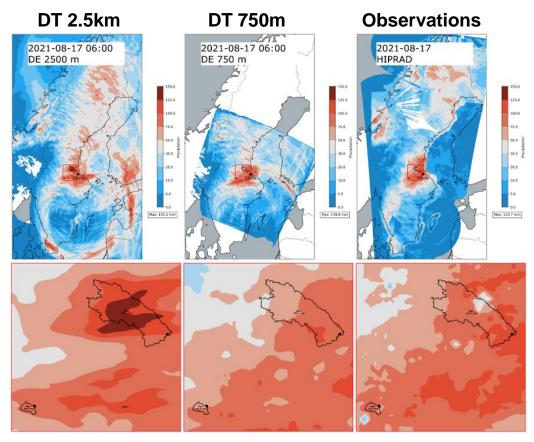


Flooding in Gävle (SvT, 2021)

Meteorological context I



- A well predicted event by the nordic NWP models
- Also predicted in daily scale hydrological models, and warnings were issued
- This means that it is a good case for the on-demandextremes-DT to add value by fine scale details

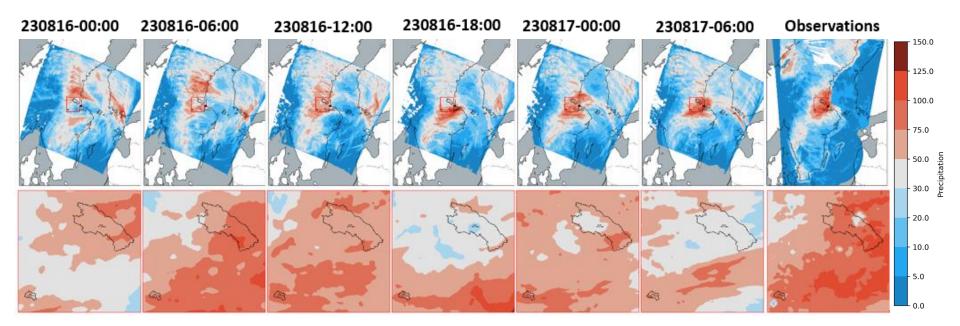




Meteorological context II



72-hour accumulated precipitation forecasts at 750m covering the event (230817-08:00 until 230818-07:00)



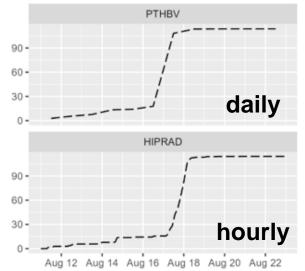


Hydrological response I

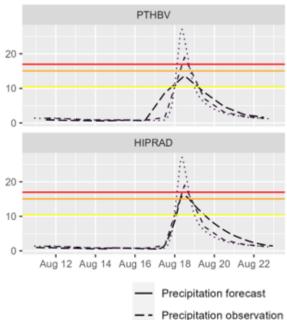


- The S-HYPE national model is operationally run at daily time scale, and in development on hourly
- Daily model underestimates peak and build-up of event
- Hourly model simulates the build-up and peak better, but overestimates the decline
- Total volumes are ok in both cases





River discharge [m³/s]



- ···· Gauged Q, hourly
- Gauged Q, daily

Different forecast times

peak and volume

Initialization of the

All DTs underestimate the

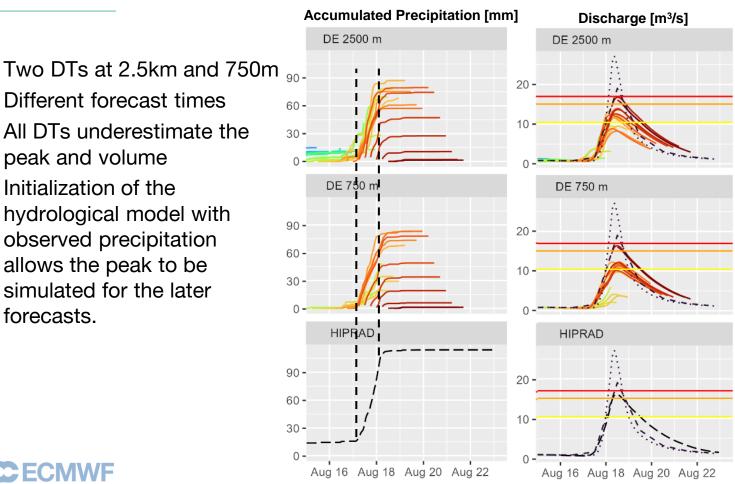
hydrological model with

observed precipitation

allows the peak to be

simulated for the later

Hydrological response II



| _ | Precipitation forecast | | |
|---------------|---------------------------|---|--------------|
| | Precipitation observation | | |
| • • • • | Gauged Q, hourly | | |
| | Gauged Q, daily | | |
| Forecast time | | | |
| — | Aug 11 00:00 | — | Aug 15 06:00 |
| — | Aug 11 06:00 | | Aug 15 12:00 |
| — | Aug 11 12:00 | — | Aug 15 18:00 |
| — | Aug 11 18:00 | — | Aug 16 00:00 |
| — | Aug 12 00:00 | — | Aug 16 06:00 |
| — | Aug 12 06:00 | — | Aug 16 12:00 |
| — | Aug 12 12:00 | — | Aug 16 18:00 |
| - | Aug 12 18:00 | — | Aug 17 00:00 |
| - | Aug 13 00:00 | — | Aug 17 06:00 |
| - | Aug 13 06:00 | — | Aug 17 12:00 |
| - | Aug 13 12:00 | — | Aug 17 18:00 |
| — | Aug 13 18:00 | — | Aug 18 00:00 |
| — | Aug 14 00:00 | — | Aug 18 06:00 |
| - | Aug 14 06:00 | — | Aug 18 12:00 |
| - | Aug 14 12:00 | — | Aug 18 18:00 |
| - | Aug 14 18:00 | — | NA |
| | Aug 15 00:00 | | |
| | | | |

IWF

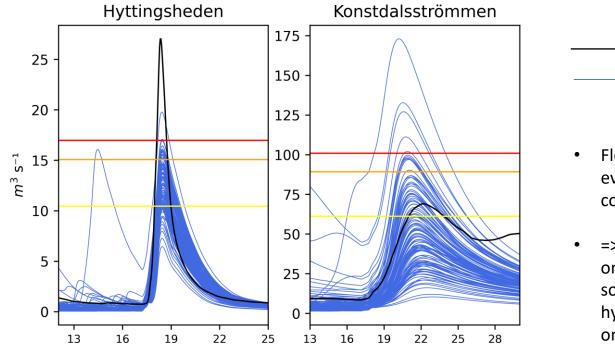
forecasts.

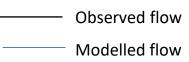
ECMWF

Initial conditions



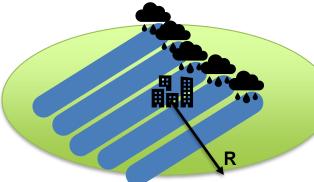
Sensitivity analysis of initial conditions

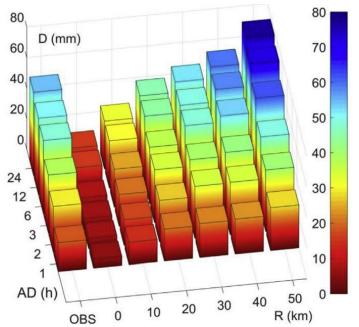




- Flow response of identical rain event under a range of initial conditions
- => Large impact of initial state on response magnitude, something to consider for hydrological forecasts in an on-demand setting

- Cloud burst event in Malmö, Sweden
- Predicted, but not at the right location
- Extend meteo ensemble by displacing the events (changing the coordinates)
- Can be applied to DT, and say something about the probability of an event





Distance-dependent depth-duration analysis in high-resolution hydro-meteorological ensemble forecasting: A case study in Malmö City, Sweden

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Conclusions



- By improving features of convective events (single of embedded), DTs can bring additional local detail which is important for small-scale hydrological and hydraulic forecasting
- Initial conditions strongly affect the hydrological response probabilistic initial conditions, and/or improved real-time observational data needed to improve pan-European model
- Location is very important and ensembles (dynamical and statistical) are needed to assess added value and to give a plausible range of the impacts

