Machine learning models for stream level predictions using readings from satellite and ground gauging stations

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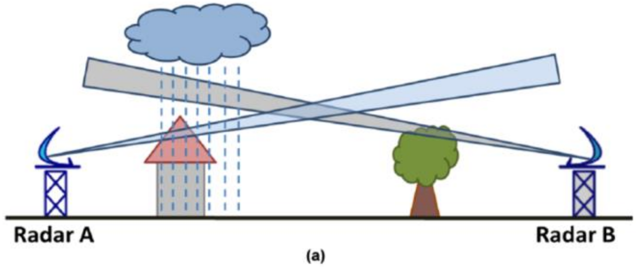
Increasing proactivity of sustainable drainage systems for urban flood reduction

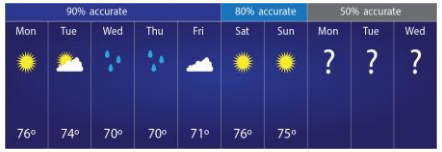
- The biggest challenge for proactive drainage is to increase the lead time of floods forecasting.
- This is particularly difficult due to the rainfall data and modelling intricacies.
- In the UK rainfall often travels from the Atlantic Ocean
- UK's radar network ranges up to 250Km.

Data

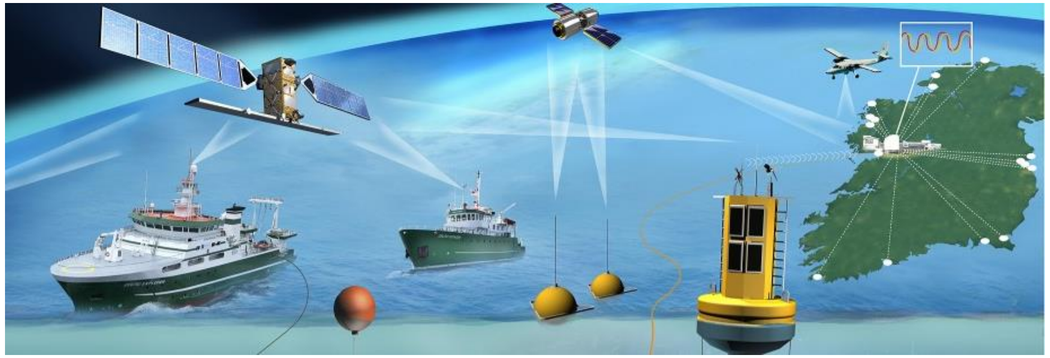
Land instruments limitations



Forecast accuracy

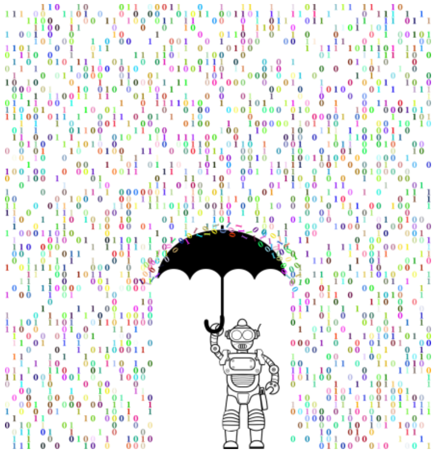


Real time monitoring of ungauged regions

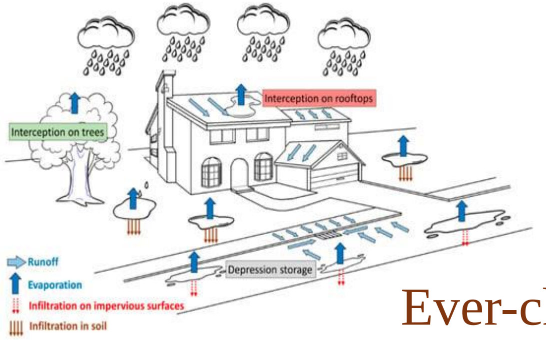


Model

Large datasets



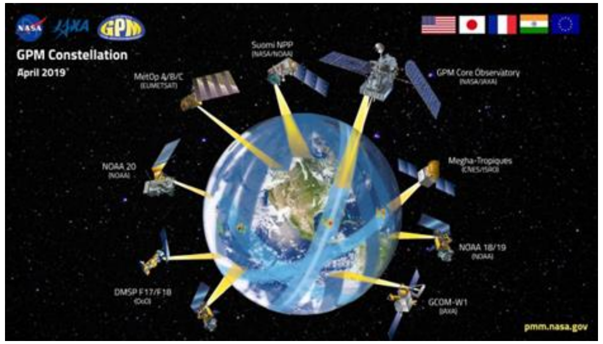
Complex features



Ever-changing urban environment

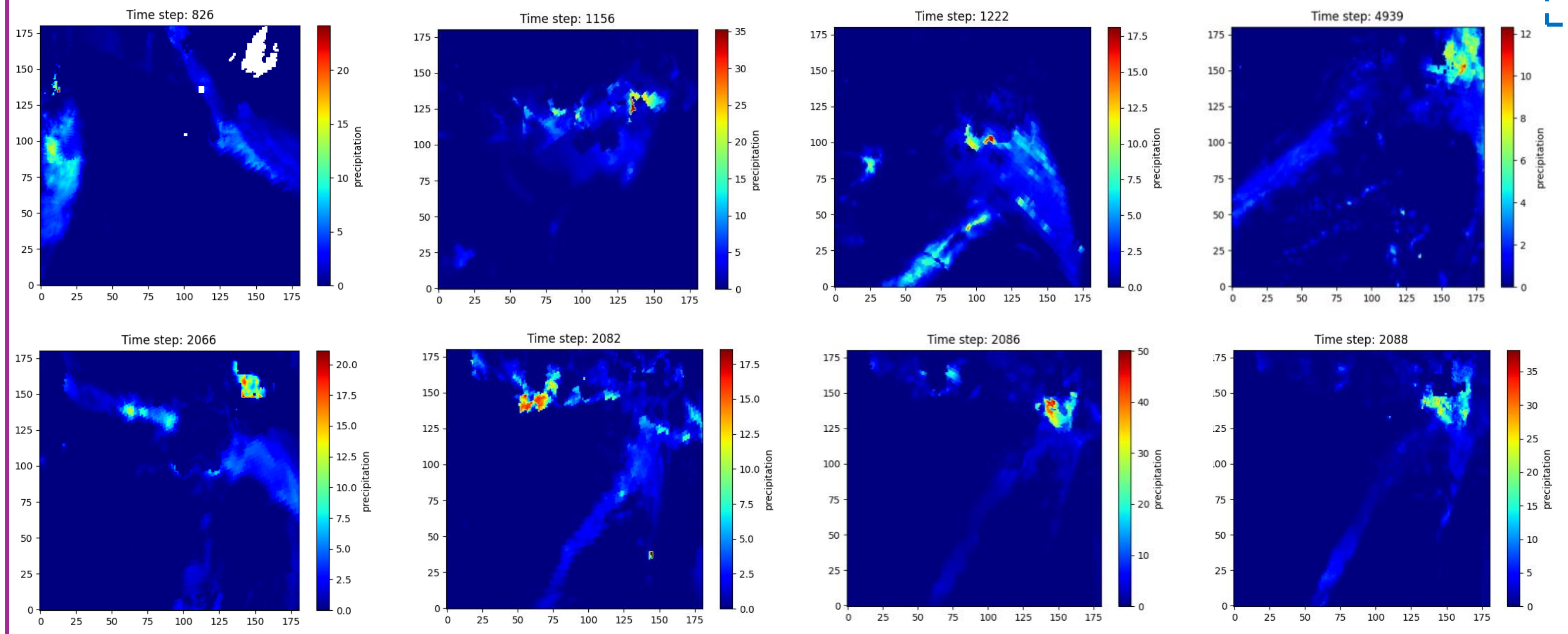
Increasing forecast lead time of flood risk events in London

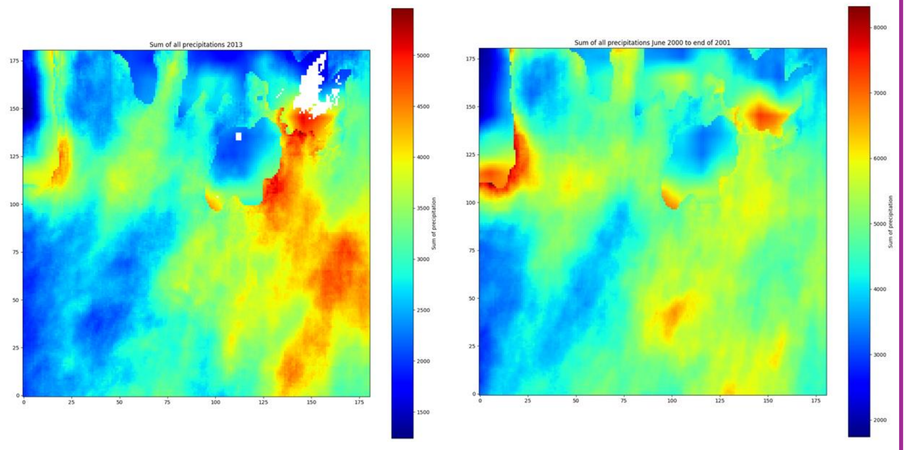
Challenges:
- Monitor an extensive area
- Large data volume
- Long processing time
- Computational expensive
- Discrepancies in datasets



This study's approach to address it:

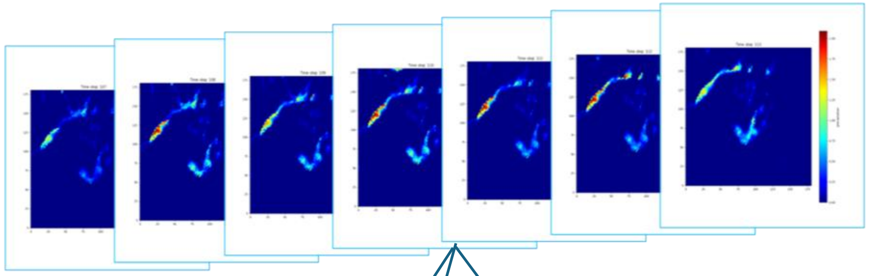
- GPM IMERG as data source in the Atlantic
- Optimized selection of the rainfall dataset excluding pixels not linked to stream level variations
- Selected pixels' data to train machine learning models for stream level forecast
- Pixels processed individually to avoid distortion from zones of discrepancy



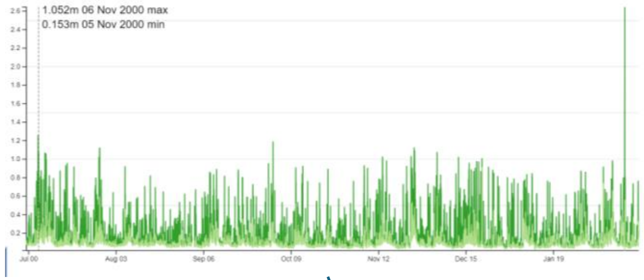


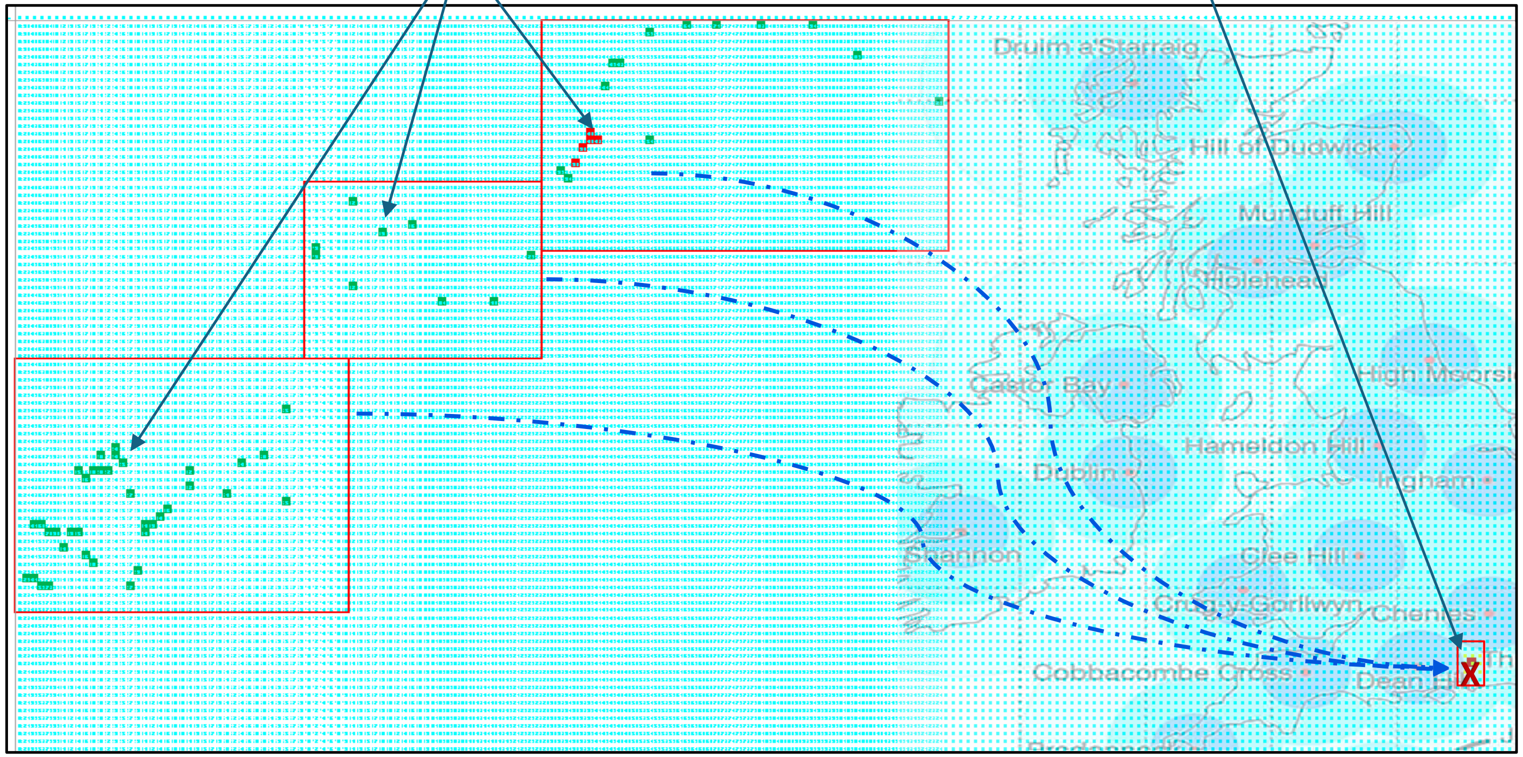
Rainfall data, stream level data and models

IMERG pixel
rainfall timeseries



Stream-level timeseries





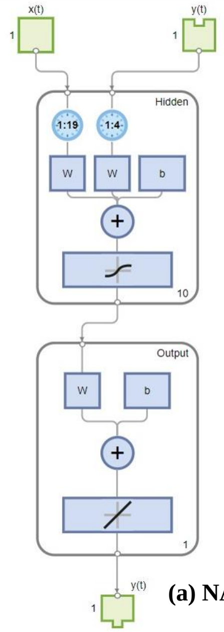
ML models:

IMERG pixels performance was tested by three machine learning models:

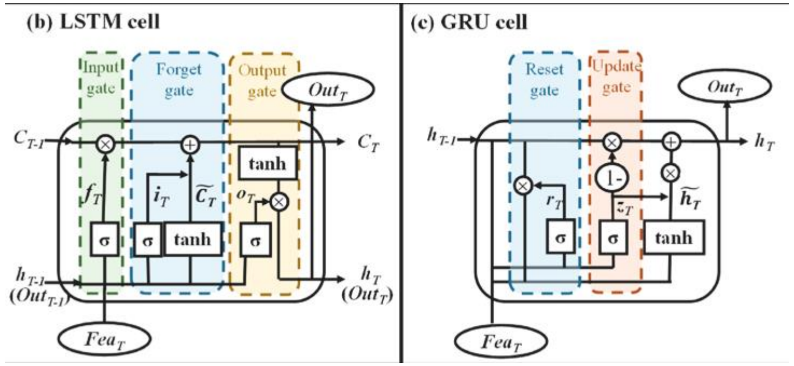
Non-linear regression with exogeneous inputs - NARX

Lon short-term memory - LSTM

Gated recurrent unit - GRU

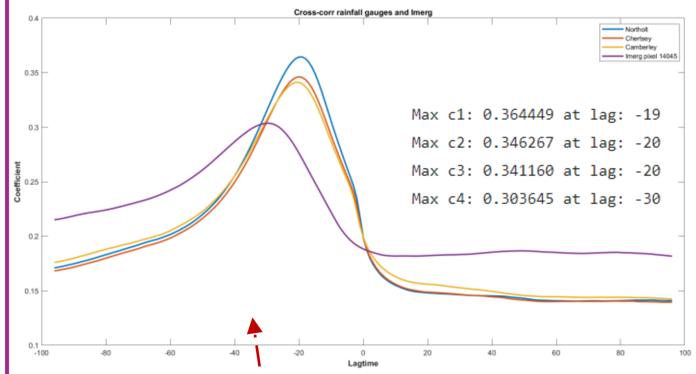


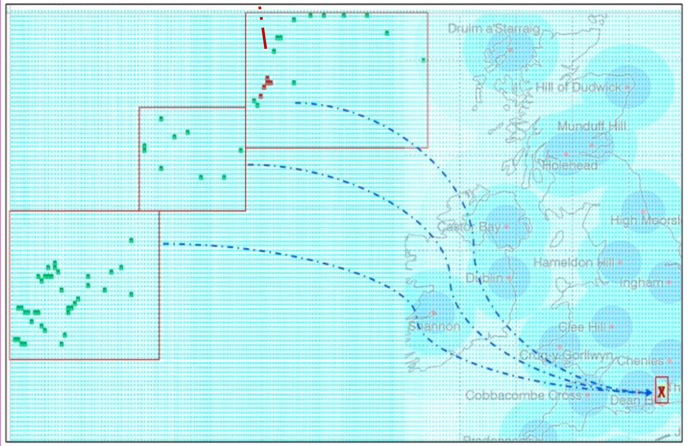
(a) NARX cell



Results

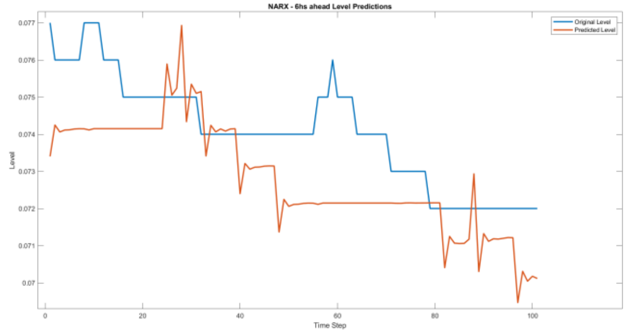
The cross-correlation analyses revealed minimal variance in lags and correlation coefficients between stream level and the IMERG dataset, relative to those between stream level and gauge datasets.

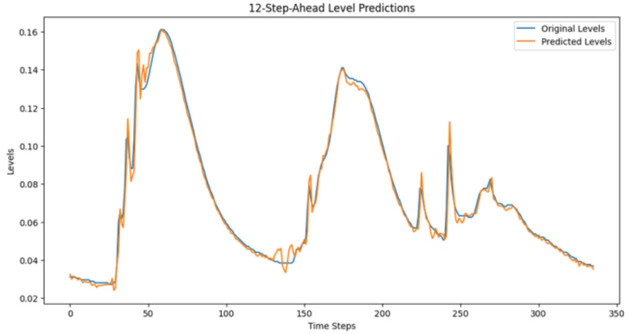


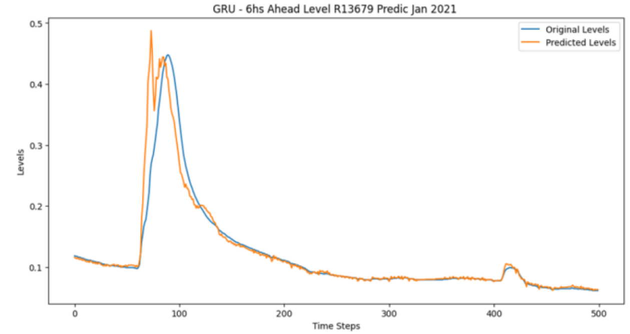


- ✓ NARX model demonstrated high precision in stream level predictions, with MSE values of 1.5×10-5 for gauge data and 1.9×10-5 for IMERG data.
- ✓ LSTM model also produced good predictions, although with higher MSE values of 1.8×10-3 for gauge data and 4.9×10-3 for IMERG data.
- ✓ GRU model showed comparable performance, with MSE values of 1.9×10-3 for gauge data and 5.6×10-3 for IMERG data.

	y_test	y_pred LSTM	y_pred GRU
0	0.031250	0.031459	0.030552
1	0.031250	0.029188	0.027399
2	0.031250	0.031289	0.029401
3	0.031250	0.031253	0.030012
4	0.030449	0.031969	0.030339
...	...	...	...
...	...	...	...
37387	0.069712	0.069604	0.070849
37388	0.068910	0.069157	0.069745
37389	0.068109	0.068251	0.069095
37390	0.067308	0.067444	0.068639
37391	0.067308	0.066689	0.067919







Conclusion

- ✓ The findings demonstrate that all models exhibit satisfactory efficacy, indicating the feasibility of employing machine learning (ML) techniques for stream level prediction solely based on GPM IMERG rainfall and level data.
- ✓ With the integration of satellite rainfall data, we look forward to creating models that can provide predictions with greater lead time to allow for a proactive response with drainage systems.
- ✓ Next, we aim to explore the application of GPM-IMERG Early Run in near real-time (NRT) flood forecasting.

Thank you!

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