

## Introduction

Precipitation forecasting plays a crucial role in the planning and management of UDS for riverine flood events.

Among the main rainfall data sources (rain gauge stations, rainfall radar stations and weather satellites), satellites are often the most appropriate, however challenging, for exploring new ways to increase lead times in flood forecasting models.

This is particularly relevant for the UK, where severe rainfall events often travel from the Atlantic Ocean undetected by land-based instruments. For these regions, an alternative source of rainfall data for real time flood forecasting, is offered by the GPM (IMERG)\* precipitation estimates.

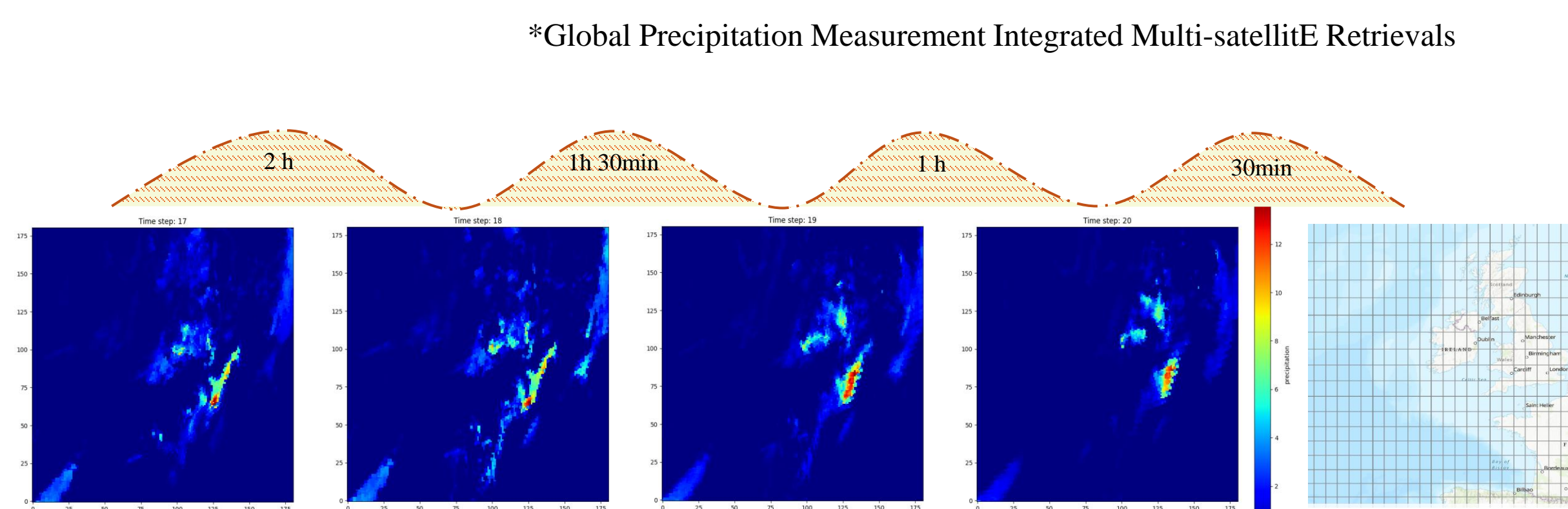


Fig. 1. Weather system movement towards London: Images plotted using rainfall information produce at 30 min interval. Source: GPM - IMERG 06, final run.

However, the adversities lies in monitoring the vast oceanic region near the UK and integrating this extensive amount of data into hydrological or data-driven models. This incurs in significant computational and time constraints. Therefore, identifying key monitoring regions for obtaining these estimates is essential to address these challenges and to effectively use this use for water level forecasting in urban drainage systems (UDS).

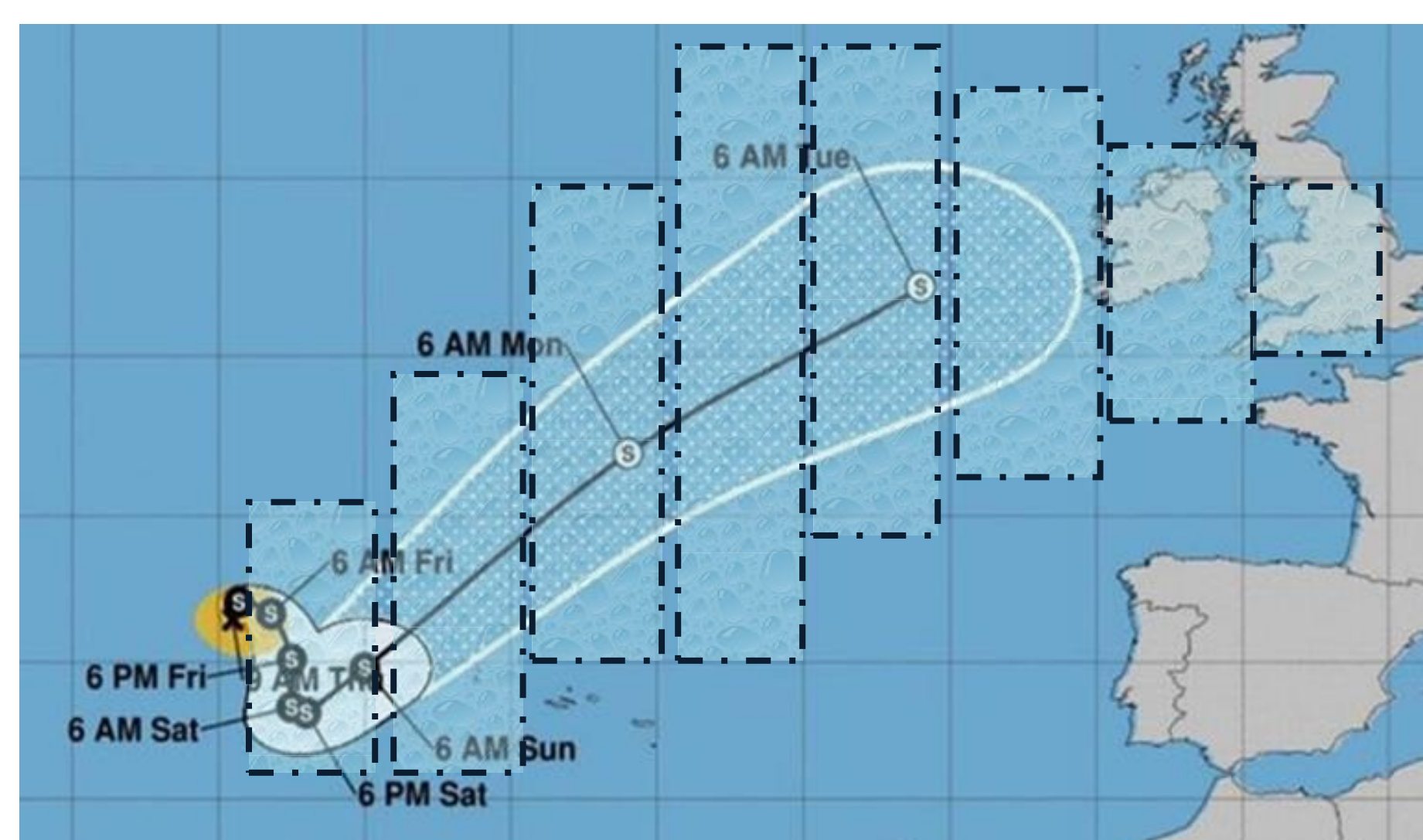


Fig. 2. Representation of the minimal monitoring region required to identify the path, speed and intensity of one weather event generated in the Atlantic ocean

## Methodology

This study introduced an optimized data-driven method streamlining the collection and use of GPM IMERG rainfall estimates for water level forecasting in UDS. We conducted a cross-correlation analysis between water level records in a river and each IMERG data pixel within the selected oceanic area using MATLAB R2023a. The method effectiveness was demonstrated by comparing the performances of selected IMERG pixels and rainfall gauges data on forecasting the river's water level. This methodology aims to identify the most probably path of rainfall from the Atlantic to optimize use of satellite data for flood forecasting models.

## Case study - Data

### Data summary

- Period of data: June 2000 to September 2021
- Time-steps: 374,016
- IMERG data grid: 181 x 181 grid = 37,761 pixels
- Key area: 101 x 181 = 18,281 pixels
- Data processed: 18,282 x 374,016 = 6,837,760,512

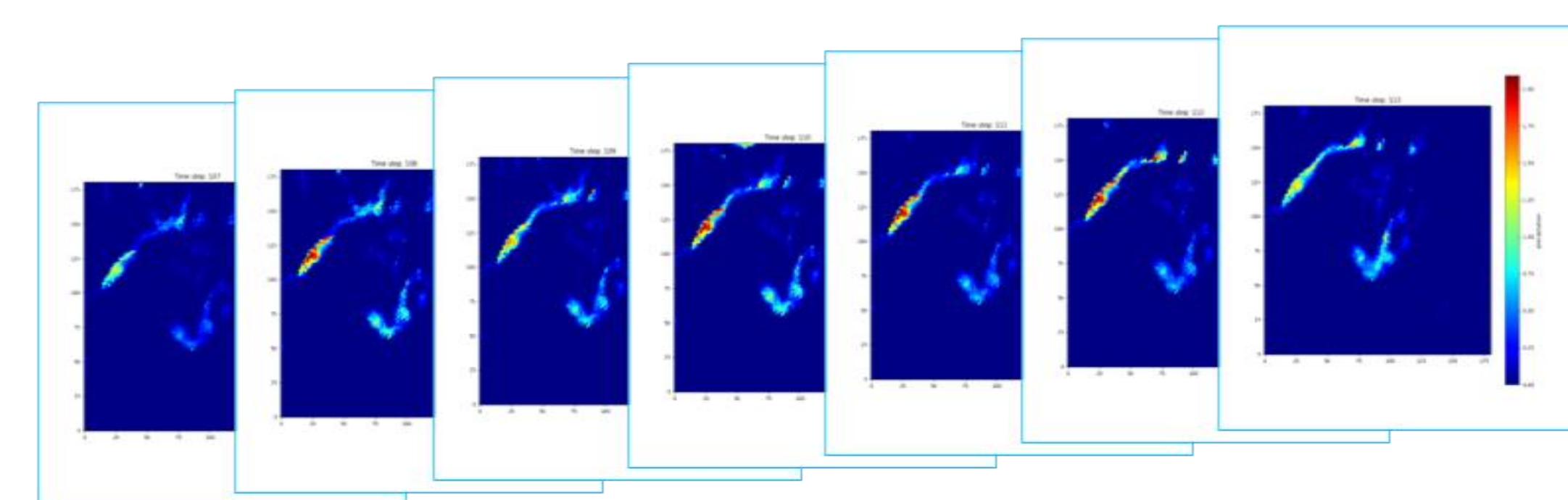


Fig. 3. Representation of the point of hydrological data collection and rainfall information collected from GPM-IMERG 06.

Weather systems reaching the UK typically travel at average speeds of 10 to 30 km/h, with exceptional storms reaching speeds of up to 70 km/h. Also, the processing time to produce near-real-time satellite estimates is at least 4 hours (IMERG early run). This information was taken into account when selecting the region in the Atlantic for data collection to be used in forecasting the water level of a stream near Heathrow in London. The area of interest in the oceanic region extends from 2°W to 20°W and from 42°N to 60°N, while the stream level gauge is located at 51.45°N, 0.45°W. The data spans from June 2001 to September 2021, with readings taken at 30-minute intervals.

## Results

### Cross-correlation results:

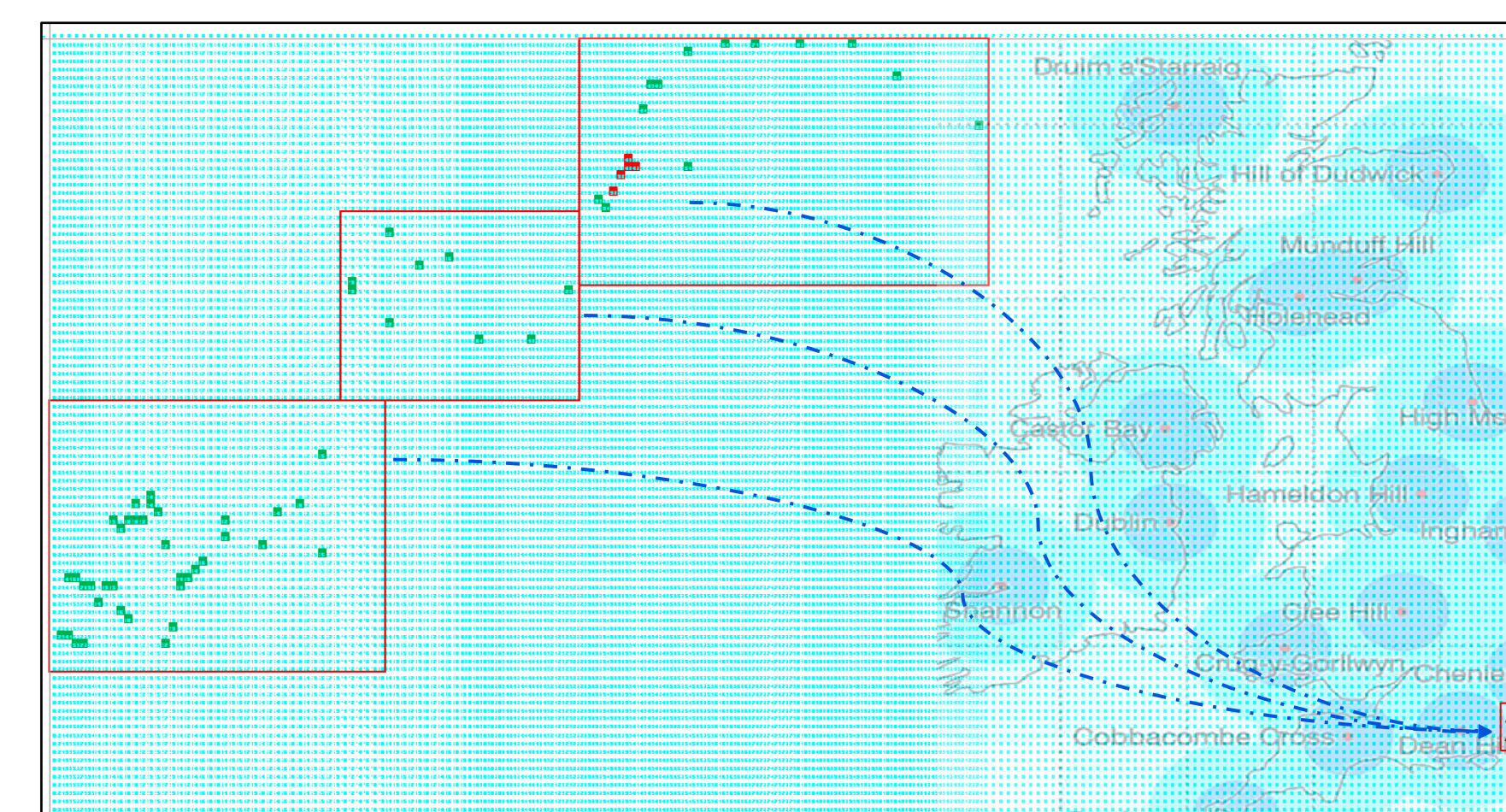
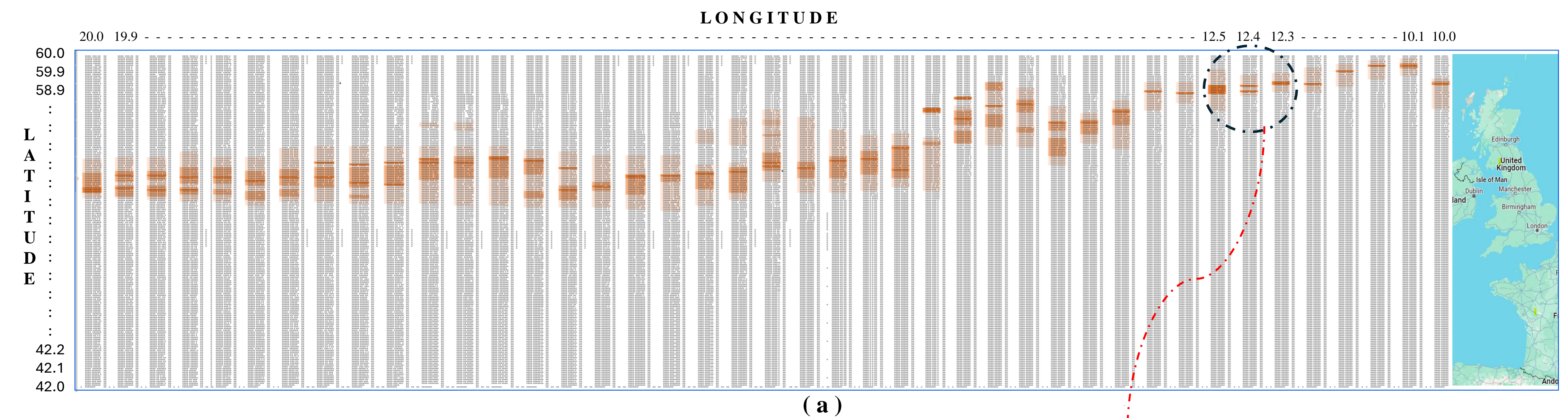


Fig. 3. (a) Correlation results between water level data and each IMERG pixel within the selected. (b) Display of the zones and path of pixels with the highest cross-correlation results with level readings at the X gauge. (c) Zoomed extracted section from figure (a) contained the pixels with highest cross-correlation results.

Pixel	Lat	Lon (-)	Maxcorr /lag	Pixel	Lat	Lon (-)	Maxcorr /lag	Pixel	Lat	Lon (-)	Maxcorr /lag
R13672	57.45	12.55	Max c15: 0.286900 at lag: -33	R13853	57.45	12.45	Max c25: 0.282072 at lag: -33	R14034	57.45	12.35	Max c15: 0.277001 at lag: -34
R13673	57.55	12.55	Max c16: 0.280036 at lag: -32	R13854	57.55	12.45	Max c26: 0.288832 at lag: -32	R14035	57.55	12.35	Max c16: 0.279449 at lag: -33
R13674	57.65	12.55	Max c17: 0.291838 at lag: -32	R13855	57.65	12.45	Max c27: 0.288318 at lag: -32	R14036	57.65	12.35	Max c17: 0.275233 at lag: -33
R13675	57.75	12.55	Max c18: 0.293171 at lag: -32	R13856	57.75	12.45	Max c28: 0.288911 at lag: -32	R14037	57.75	12.35	Max c18: 0.280369 at lag: -33
R13676	57.85	12.55	Max c19: 0.294707 at lag: -31	R13857	57.85	12.45	Max c29: 0.292533 at lag: -32	R14038	57.85	12.35	Max c19: 0.283067 at lag: -32
R13677	57.95	12.55	Max c20: 0.296500 at lag: -31	R13858	57.95	12.45	Max c30: 0.295508 at lag: -32	R14039	57.95	12.35	Max c20: 0.285558 at lag: -32
R13678	58.05	12.55	Max c1: 0.298584 at lag: -31	R13859	58.05	12.45	Max c31: 0.297349 at lag: -31	R14040	58.05	12.35	Max c21: 0.284503 at lag: -31
R13679	58.15	12.55	Max c2: 0.300189 at lag: -31	R13860	58.15	12.45	Max c32: 0.296541 at lag: -31	R14041	58.15	12.35	Max c22: 0.283333 at lag: -31
R13680	58.25	12.55	Max c3: 0.296170 at lag: -31	R13861	58.25	12.45	Max c33: 0.296409 at lag: -31	R14042	58.25	12.35	Max c23: 0.290631 at lag: -31
R13681	58.35	12.55	Max c4: 0.297972 at lag: -30	R13862	58.35	12.45	Max c34: 0.297009 at lag: -30	R14043	58.35	12.35	Max c24: 0.288465 at lag: -30
R13682	58.45	12.55	Max c5: 0.291355 at lag: -30	R13863	58.45	12.45	Max c35: 0.296755 at lag: -30	R14044	58.45	12.35	Max c25: 0.282814 at lag: -30
R13683	58.55	12.55	Max c6: 0.294851 at lag: -29	R13864	58.55	12.45	Max c36: 0.296246 at lag: -30	R14045	58.55	12.35	Max c26: 0.301645 at lag: -30
R13684	58.65	12.55	Max c7: 0.290413 at lag: -29	R13865	58.65	12.45	Max c37: 0.296981 at lag: -29	R14046	58.65	12.35	Max c27: 0.299223 at lag: -29
R13685	58.75	12.55	Max c8: 0.288027 at lag: -29	R13866	58.75	12.45	Max c38: 0.295170 at lag: -29	R14047	58.75	12.35	Max c28: 0.296606 at lag: -29
R13686	58.85	12.55	Max c9: 0.283332 at lag: -29	R13867	58.85	12.45	Max c39: 0.294130 at lag: -29	R14048	58.85	12.35	Max c29: 0.293050 at lag: -29
R13687	58.95	12.55	Max c10: 0.281656 at lag: -28	R13868	58.95	12.45	Max c40: 0.288291 at lag: -28	R14049	58.95	12.35	Max c30: 0.292674 at lag: -29
R13688	59.05	12.55	Max c11: 0.273921 at lag: -28	R13869	59.05	12.45	Max c41: 0.283607 at lag: -28	R14050	59.05	12.35	Max c31: 0.287254 at lag: -28

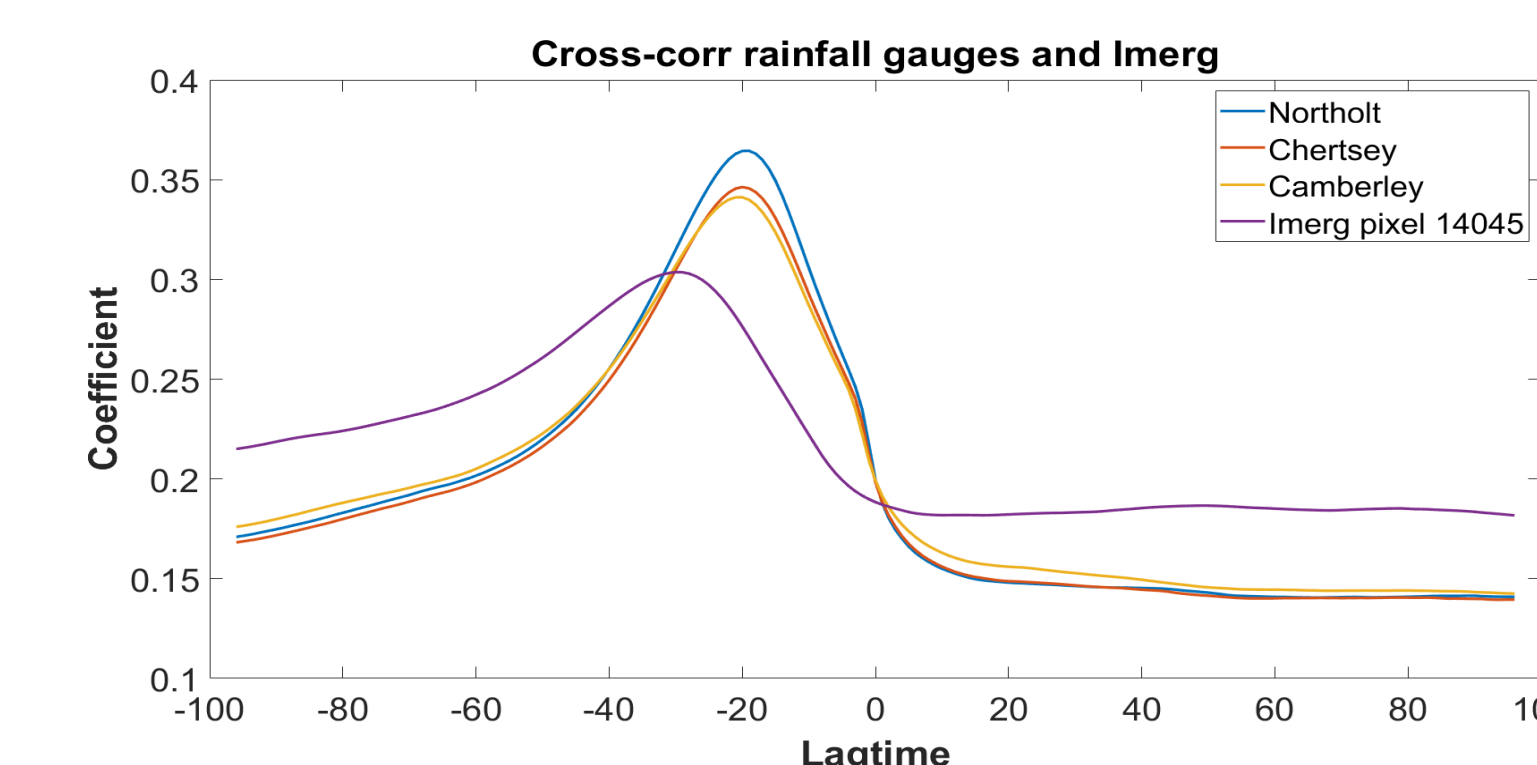


Fig. 4. Comparison between water level correlation with rainfall data from the three local gauges and with IMERG optimum rainfall pixel.

### IMERG rainfall data performance evaluation

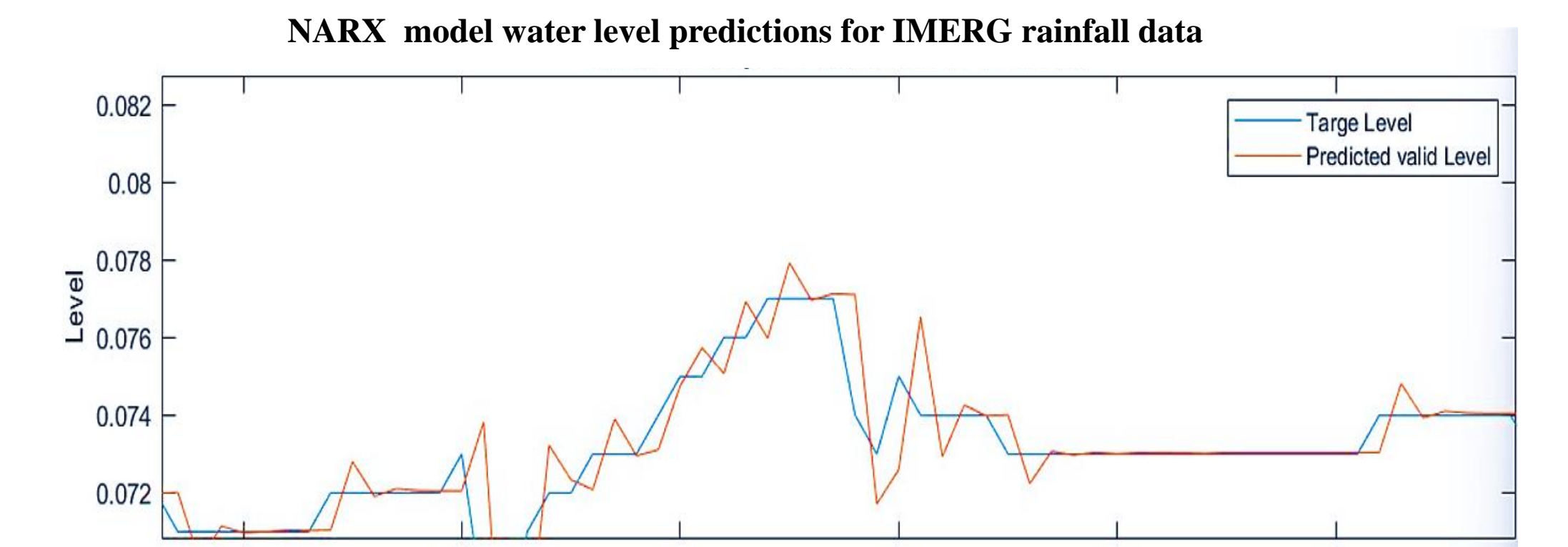


Fig. 5. IMERG rainfall pixel performance for two days-ahead stream level prediction in a NARX model.

## Conclusions and future work

- ✓ This investigation enhances our comprehension of long-distance rainfall pathways towards the UK, which allow the optimization of satellite data collection for data driven forecasting models.
- ✓ It advances a step towards NRT prediction of flood events by enabling the use of satellite data from Oceanic regions in hydrological models.
- ✓ It contributes in reducing the volume of information and processing times in data driven models which will lead to higher speed and lower computational costs.

The next steps of the research looks into the optimization and fine-tune of models to use GPM-IMERG Early Run estimates for near real-time (NRT) predictions