## **SEARCH: Sensitivity of estuaries to climate hazards**

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GFS 0.25<sup>4</sup> Valid: Sat 9 Dec 18:00 UTC

**Overview - Precip, Cloud, Temperature & Pressure** 

0.2 0.6



#### **Flooding globally:**

3 million deaths, >\$1 trillion in economic losses.

## <u>UK</u>:

*Drivers* and *pathways* of flooding poorly understood. Historic flooding is undocumented.

*Impacts:* 1-in-6 properties (3 million) at risk. Annual damages >£540M.

Human health and food security risks, mental health impacts poorly understood.

#### **Future risk:**

- *Drivers:* SLR, sea surface variability, river flows, rainfall, groundwater
- Pathways: land use, water management, defenses, morphology
- *Impacts:* resilience, perceptions, mitigation



## Storm Ciara: Conwy estuary, February 2020 ... the perfect storm?

"Two or more (extreme) events occurring simultaneously that lead to extreme impacts"



 Compound flooding in UK: South UK coasts (2013/14) Cumbria (2015) Conwy (2020)
[Svensson & Jones 2002, 2004, 2006; Hendry et al. 2018]

## Storm Ciara







# Questions

Q1: How likely and how common is compound flooding across Britain? Q2: Can we establish the drivers of flooding and flood thresholds? Q3: How will flood risk change?

**15-min river discharge** data (126 gauges)  $Q_{max} > 50 \text{ m}^3/\text{s}$ 1984 – 2013 (30 yrs)

**15-min sea level** data (27 tide gauges) 1984 – 2013 (30 yrs)





Why use 15-minute data rather than daily mean?



The short windows (<24 hrs) at most sites indicated that for most catchments in Britain sub-daily data is needed to robustly assess the propensity for compound events.

Method: River (Q) peaks over threshold + largest skew surge (S) Kendall's rank correlation; events per season where Q and S > 95<sup>th</sup> percentile



Storm hydrograph window duration (20.25 hrs)



**Lyddon et al. 2022.** Historic spatial patterns of compound flood events in UK estuaries. Reviewed in Estuaries & Coasts

Also: Harrison etal 2021; Robins etal 2021





0 1.5

Kilometers



#### Model calibration against 2021 observations



## Flood validation against 2015-2016 data







#### Conwy - maximum water depths

#### Conwy - flood probability

# Can we establish the drivers of flooding and flood thresholds?



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Clustered events?....

## Is compound flooding likely to change?

- 12 of the 60 km HadGEM3-GC3.0 GCM PPE for RCP8.5 were downscaled to a 2.2 km local Convection Permitting Model.
- Rainfall data were used to force a distributed hydrological model (DECIPHeR) of the **Dyfi Estuary**, (Coxon et al. 2019).
- 10,000 calibration runs forced with observed rain and evap. to simulate hourly discharge. 100 best parameter sets were used with UKCP18 data to simulate baseline, near and far future discharge.

- 12 of the 60 km HadGEM3-GC3.0 GCM PPE for RCP8.5 were applied to 12km regional climate simulations.
- These were used to drive the regional 7 km NEMO AMM7 (1980 – 2080).
- Model simulations are de-tided using a Doodson filter to generate a residual surge.



### *Is compound flooding likely to change? – return periods*



## *Is compound flooding likely to change? – future changes in compound events*



## **Potential groundwater impacts**





Conwy Catchment Area

Properties	Conwy
Catchment Area	345 km <sup>2</sup>
Rainfall (50 years average)	3700mm
Base Flow Index	0.27
Geology	Thick sequence of mudstones
Permeability of Bed Rock	Very low
Superficial deposits	Clay, Alluvium, Till
Groundwater potential of superficial deposits	Moderate
Aquifer systems	Groundwater occurs within shallow weakly permeable aquifers



Geological Map of Wales Source-BGS

## Peak baseflow, runoff and river flow events (1990-2020)



## Summary

#### Historic compound event analysis:

• First sub-daily compound flooding analyses (Lyddon et al. 2022).

#### Inundation modelling:

- Estuary DEMs built at 20-50m res for 13 estuaries (not Thames).
- Full catchment DEMS built for Clyde, Conwy, Dyfi, Humber).
- CAESAR-Lisflood inundation models running for all estuaries.
- CL-groundwater model developed for Dyfi, Conwy, Clyde.
- New method for validation of flooding events (Conwy, Dyfi), paper in-prep
  - New sea-level sensors, Satellite SAR images, inundation records, news articles
- Established tipping points and probabilities of flood drivers in Conwy, Dyfi, Humber (Harrison et al. 2021; Robins et al. 2022)
  - Working on joint-probabilities...

#### Climate change:

- Collated sea-level and river flow projections downscaled from HadGEM3-GC3.0
- Produced future return periods and compound event analysis (paper in-prep)

