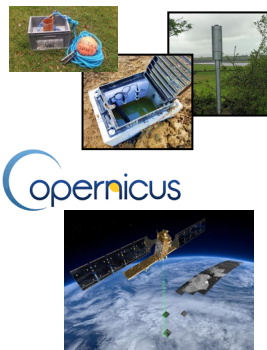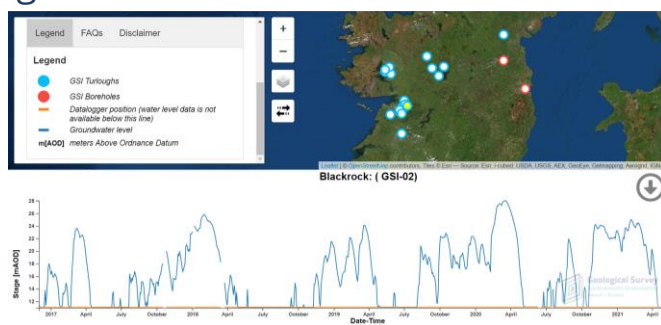# Mapping, Monitoring, Forecasting and Assessing the Impact of Climate Change in Groundwater Systems in Ireland

Joan Campanyà, Ted McCormack, Damien Doherty, Philip Schuler, Monika Kabza, Ellen Mullarkey, Owen Naughton
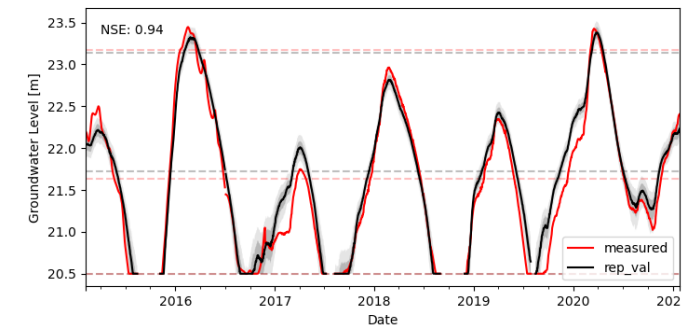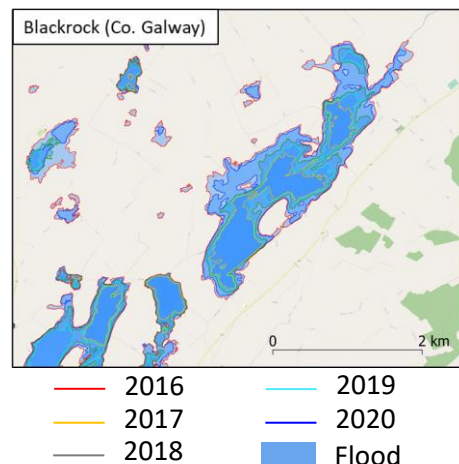
1. Monitoring

gwlevel.ie

2. Modelling

Transfer Functions (API, convolution, reservoir)
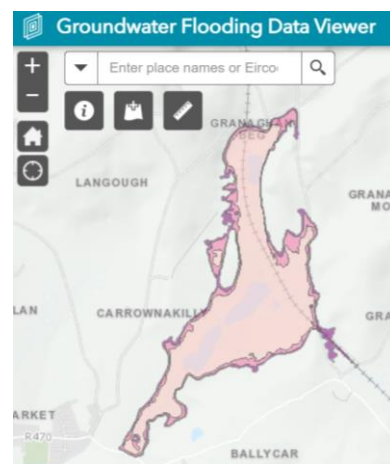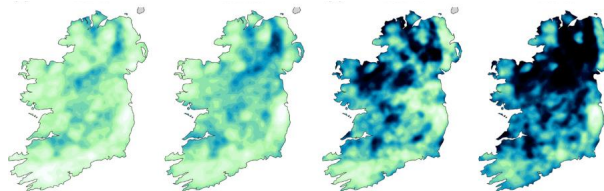

3. Mapping (Sentinel-1)

Historic and seasonal maximum flood extent

Predictive groundwater flood maps
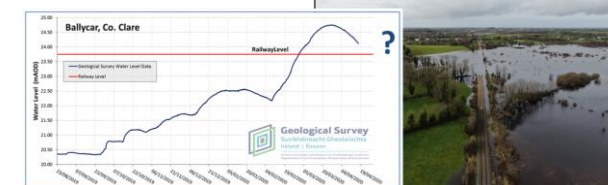

5. Climate Change

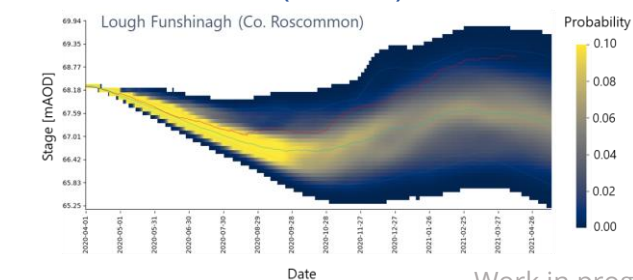Quantify changes in frequency, scale and duration of groundwater floods

Starting in October 2021

4. Forecasting

Short-term (10 days)

Medium-term estimates (months)

Work in progress

Display material

Joan Campanyà, Ted McCormack, Damien Doherty, Philip Schuler, Monika Kabza, Ellen Mullarkey, Owen Naughton

EGU2021

Motivation

Major floods in the Republic of Ireland in recent years: 2009, 2015-16, and 2020

Groundwater Flooding

"Flooding caused by the emergence of water originating from sub-surface permeable strata induced by exceptional and/or prolonged recharge" (Morris 2007)

- Generally requires sustained rainfall over relatively longer durations than other forms of flooding

- Not usually a risk to life

- Discontinuous and difficult to predict

- Can last weeks, or months

Groundwater Flooding

- Primarily occurs on the pure, well-bedded limestones in west and northwest Ireland

- Well-developed karst GW systems

- Low storage and high transmissivity

- Low-lying; high levels of GW-SW interaction

- Poorly understood and often overlooked

Approach

Mapping

Monitoring

Forecasting

GWFlood & GWClimate

Climate Change
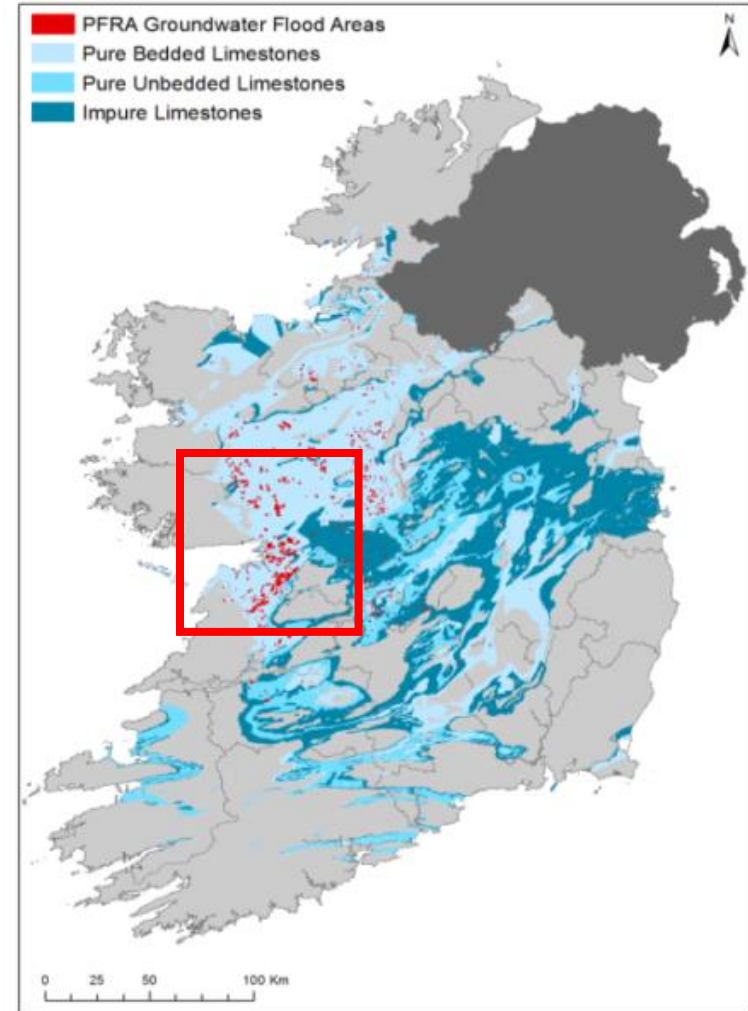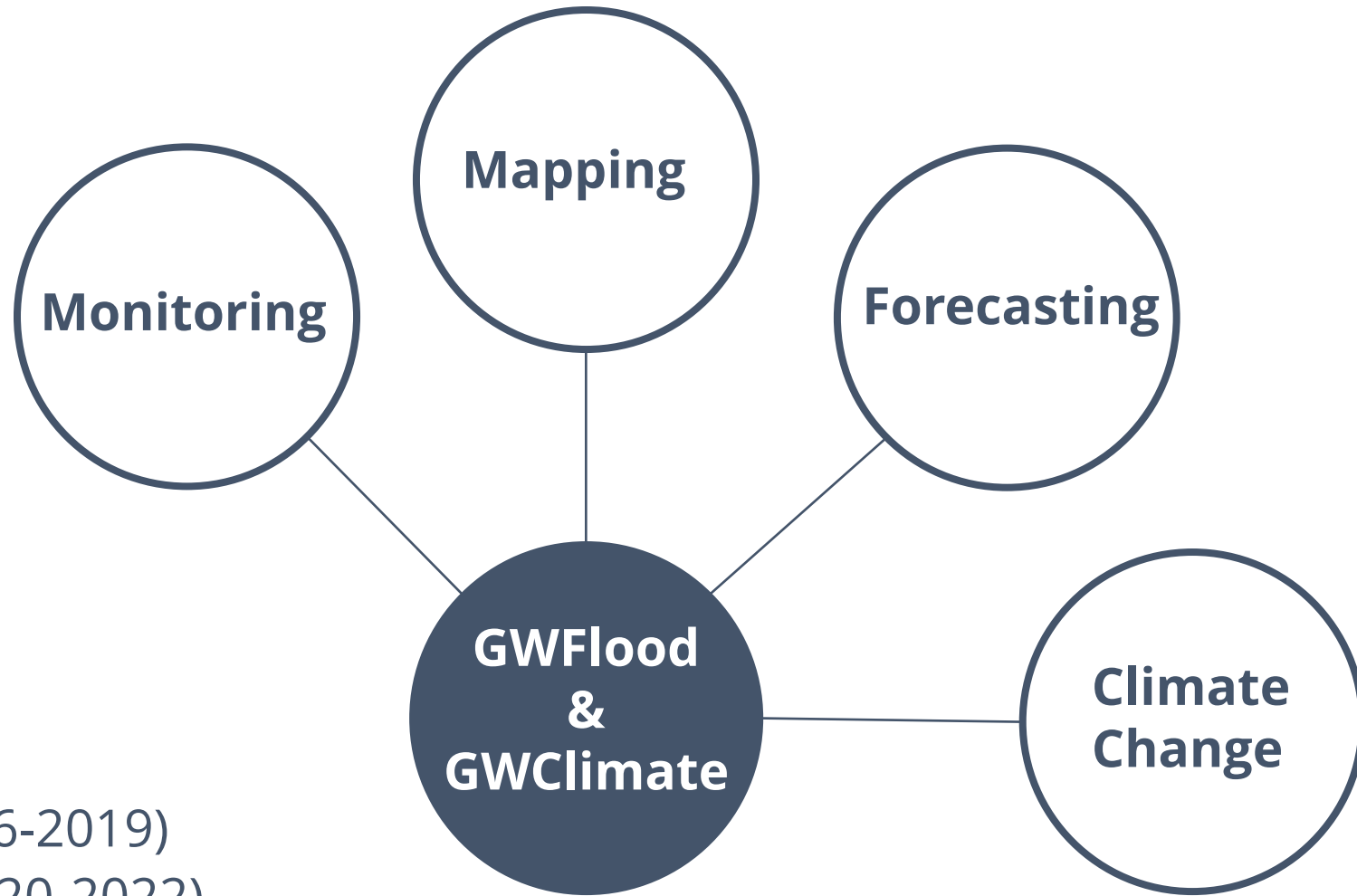
GWFlood (2016-2019)
GWClimate (2020-2022)

Monitoring

Monitoring	
Inputs	Products
- Dataloggers - GPS points - Satellite (Sentinel-1)	Real time hydrographs gwlevel.ie

Monitoring
Observation: in situ

- 65 exploratory sites
- 18 long-term telemetric sites
- 500+ GPS points for validation

Termon South

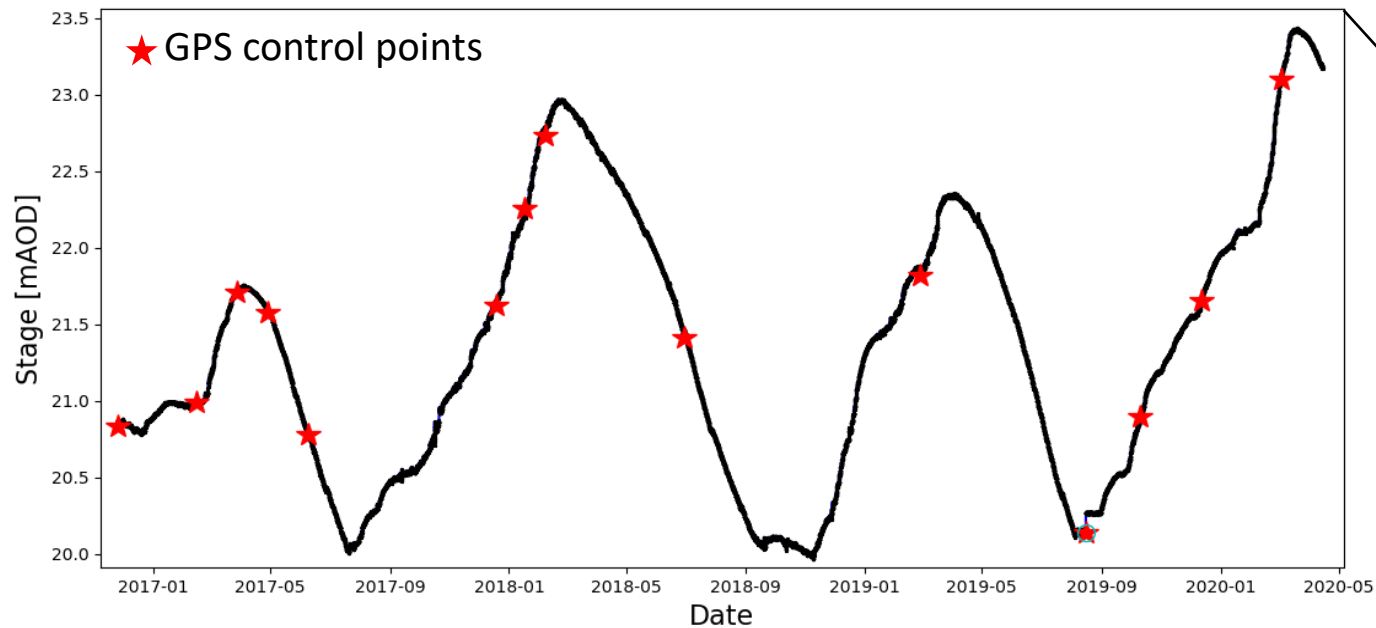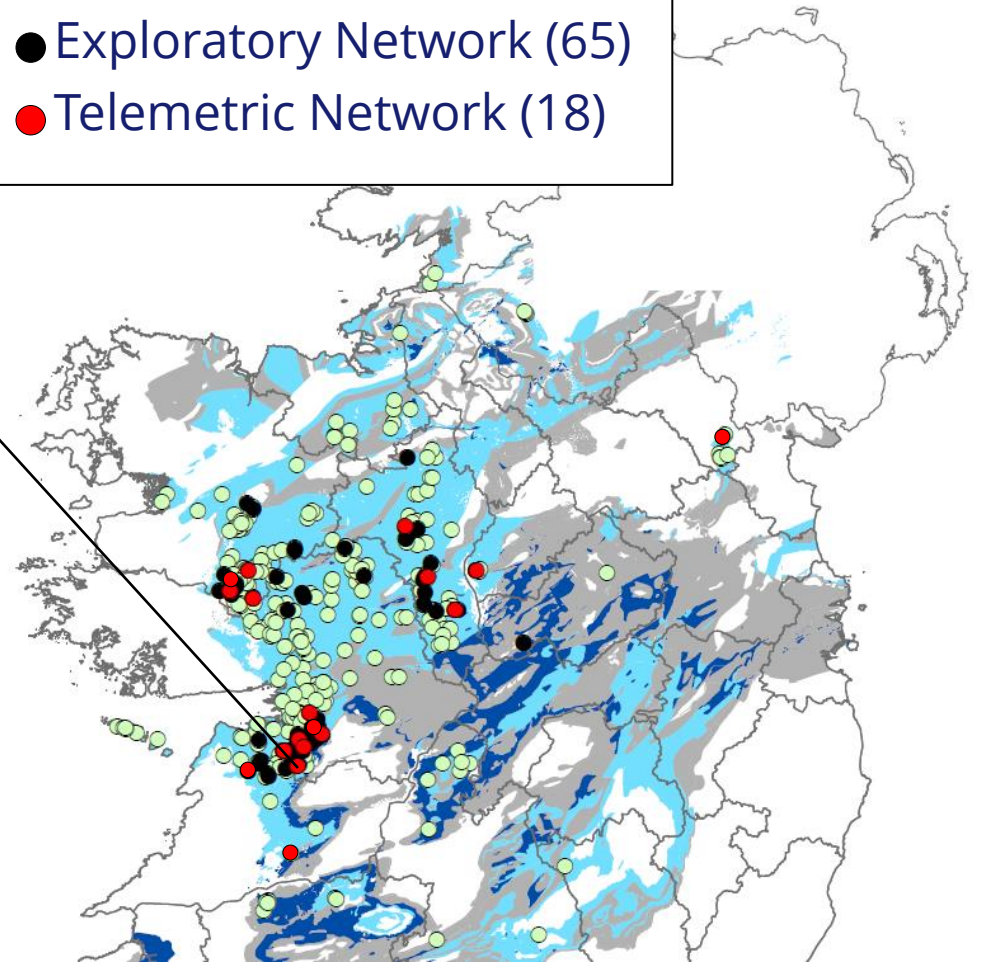# Monitoring
Observation: in situ

There are over 500 karst features that flood

What about the rest?

gwlevel.ie

Blackrock: (GSI-02)
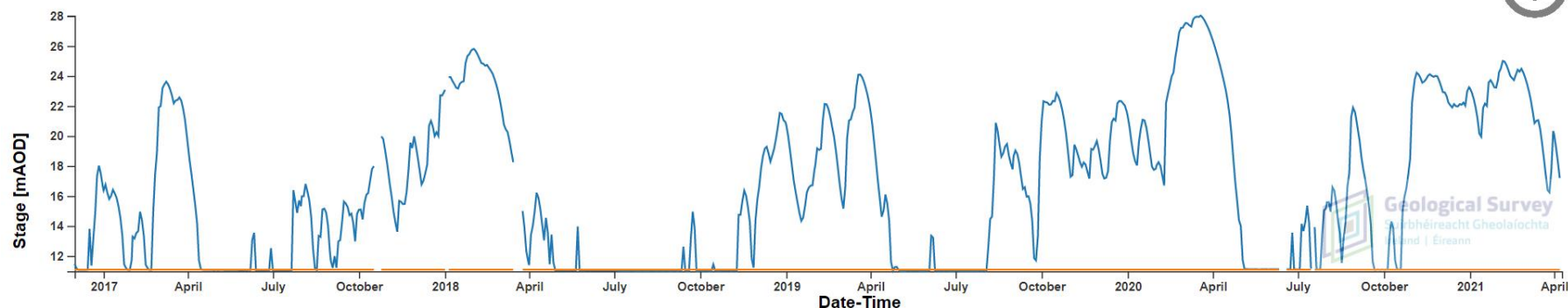
Data available
GSI Telemetric data
- 18 Turloughs
- 3 GSI boreholes

To come
GSI Temporary stations (~50 sites)

Format: csv files

Monitoring
Observation: Remote Sensing

Sentinel-1 Synthetic Aperture Radar (SAR)

- All weather, day and night
- Systematic data collection
- Water detection
- Operational for 2015/2016 floods
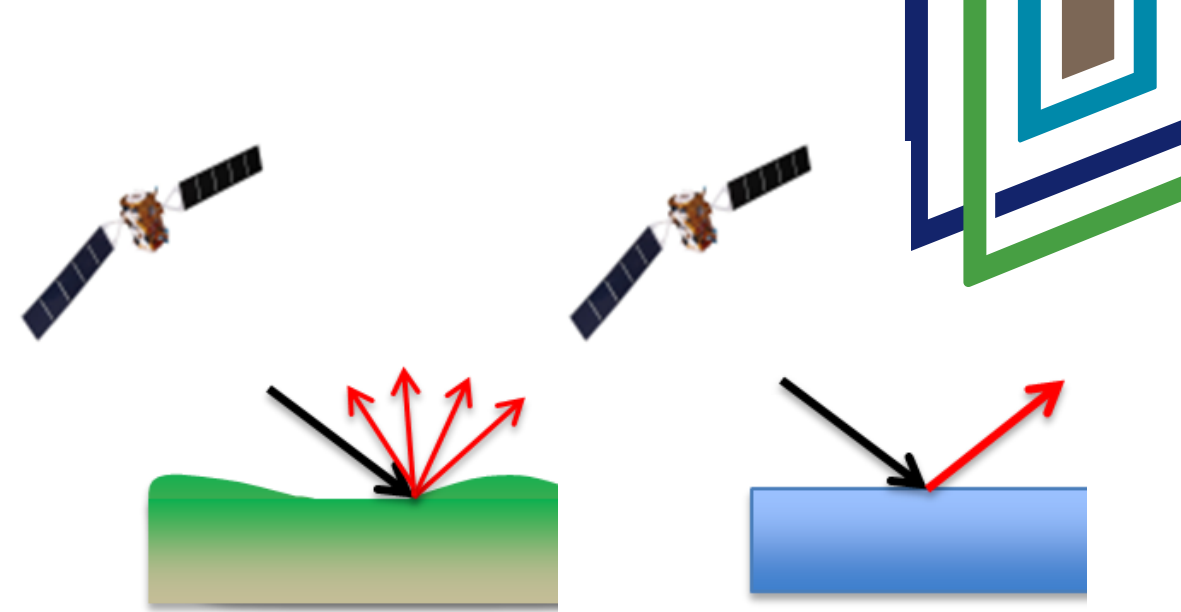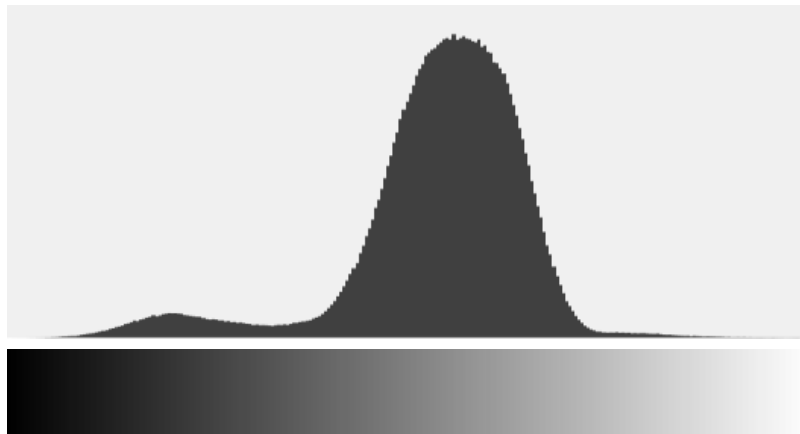
SAR image: high (white) and low (black) backscatter

Monitoring
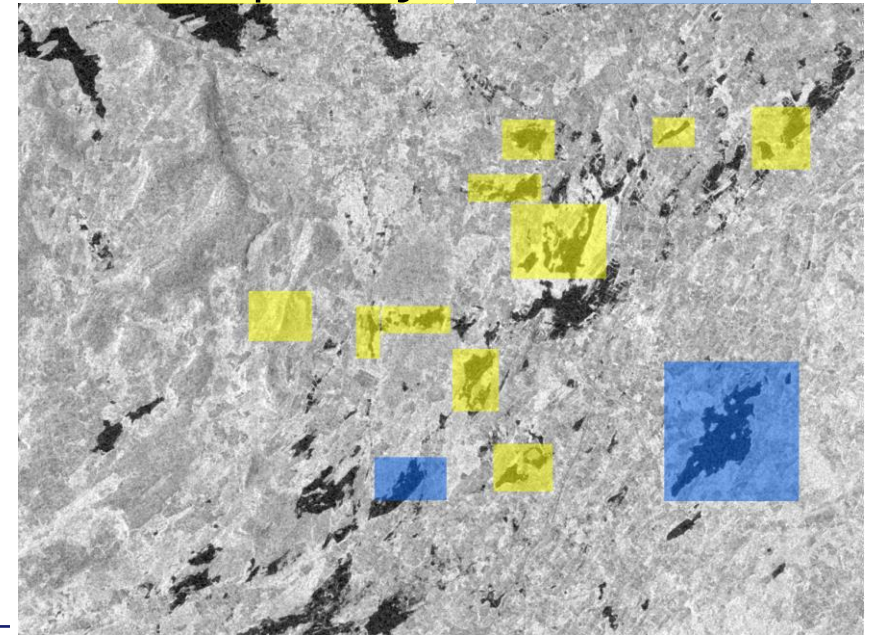## Observation: Remote Sensing

Sentinel-1 Synthetic Aperture Radar (SAR)

- All weather, day and night

- Systematic data collection

- Water detection

- Operational for 2015/2016 floods
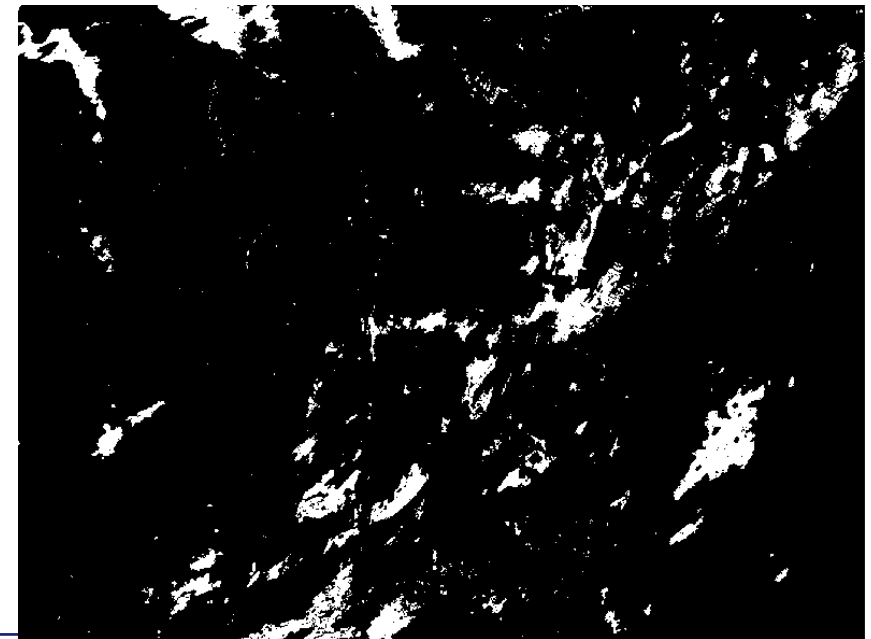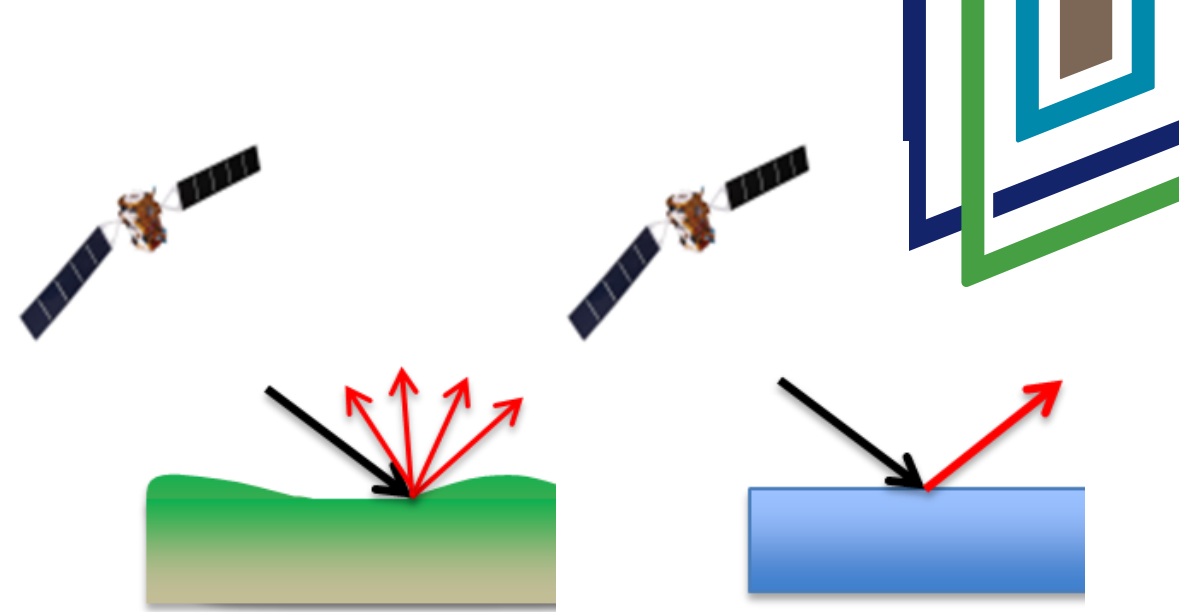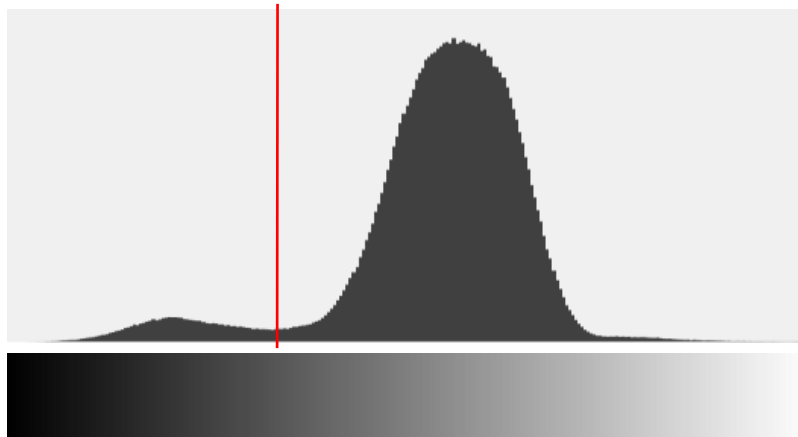
Mask suggesting water (white) and non-water (black)

Monitoring
Observation: Remote Sensing

SAR images
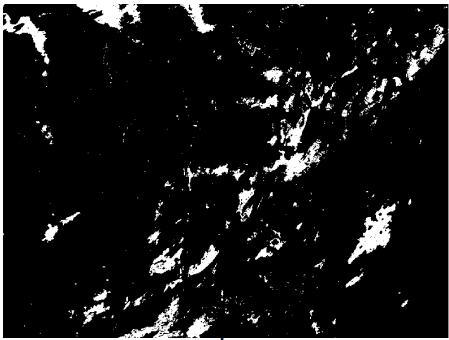
DTM

Groundwater Flood monitoring

GIS Filters
Forestry mask
Rivers and lakes
Fill Difference
...

SAR Generated Hydrographs
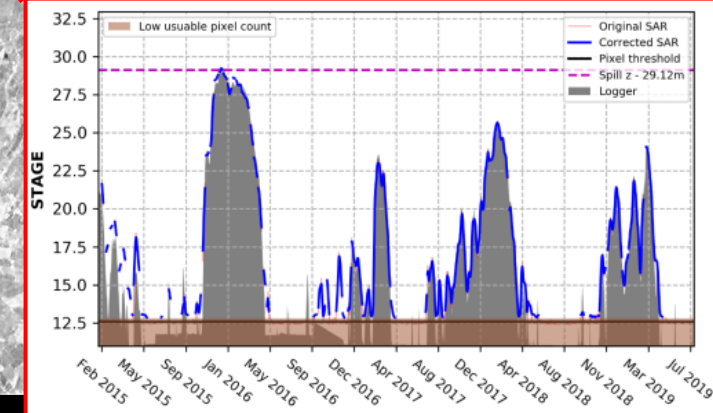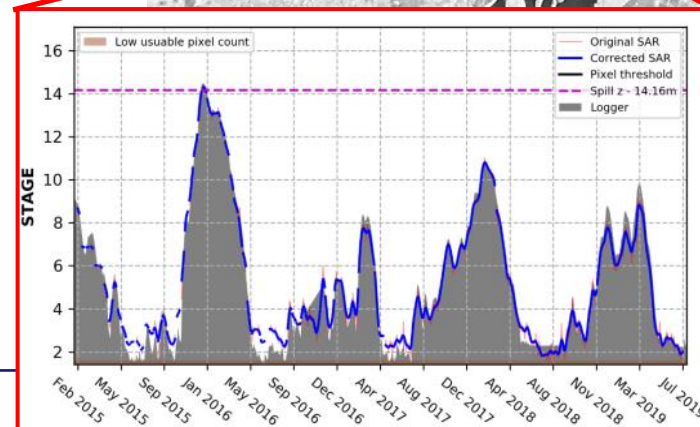
Monitoring
Observation: Remote Sensing

Groundwater Flood monitoring

Accuracy
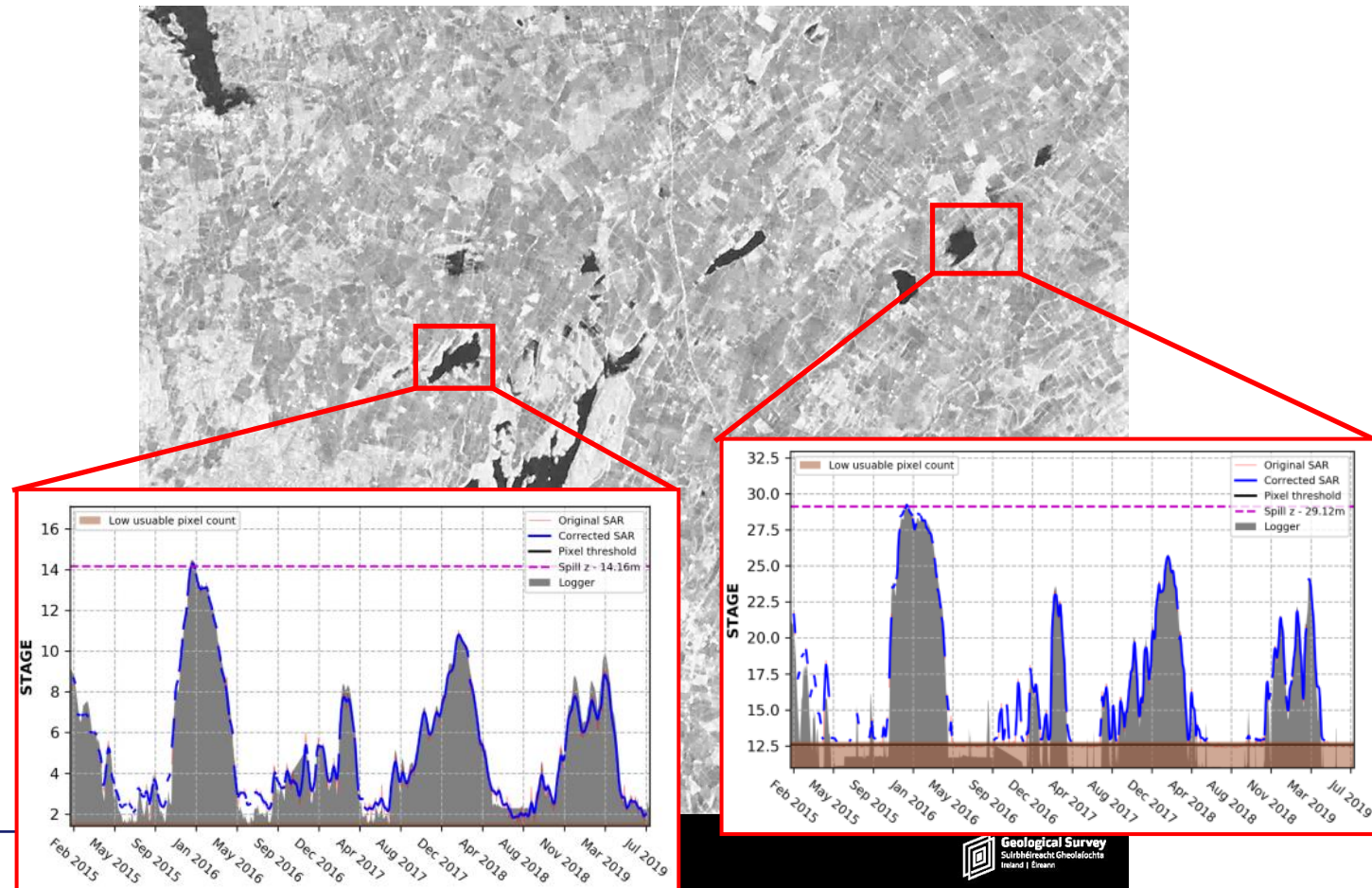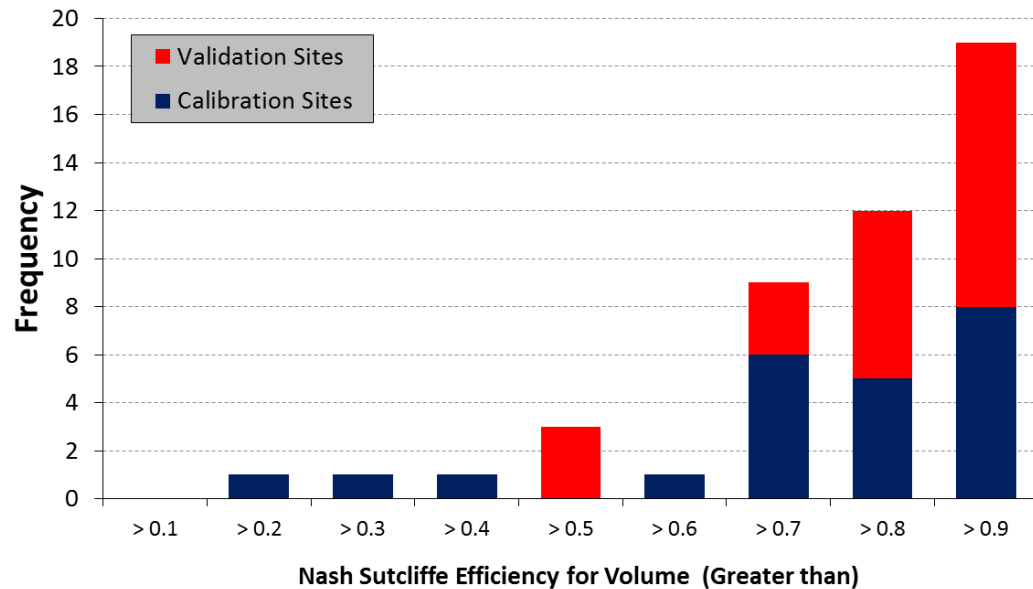
Monitoring
Observation: Remote Sensing
Real time SAR Hydrographs
gwlevel.ie

Monitoring

Ireland 2015-03-01
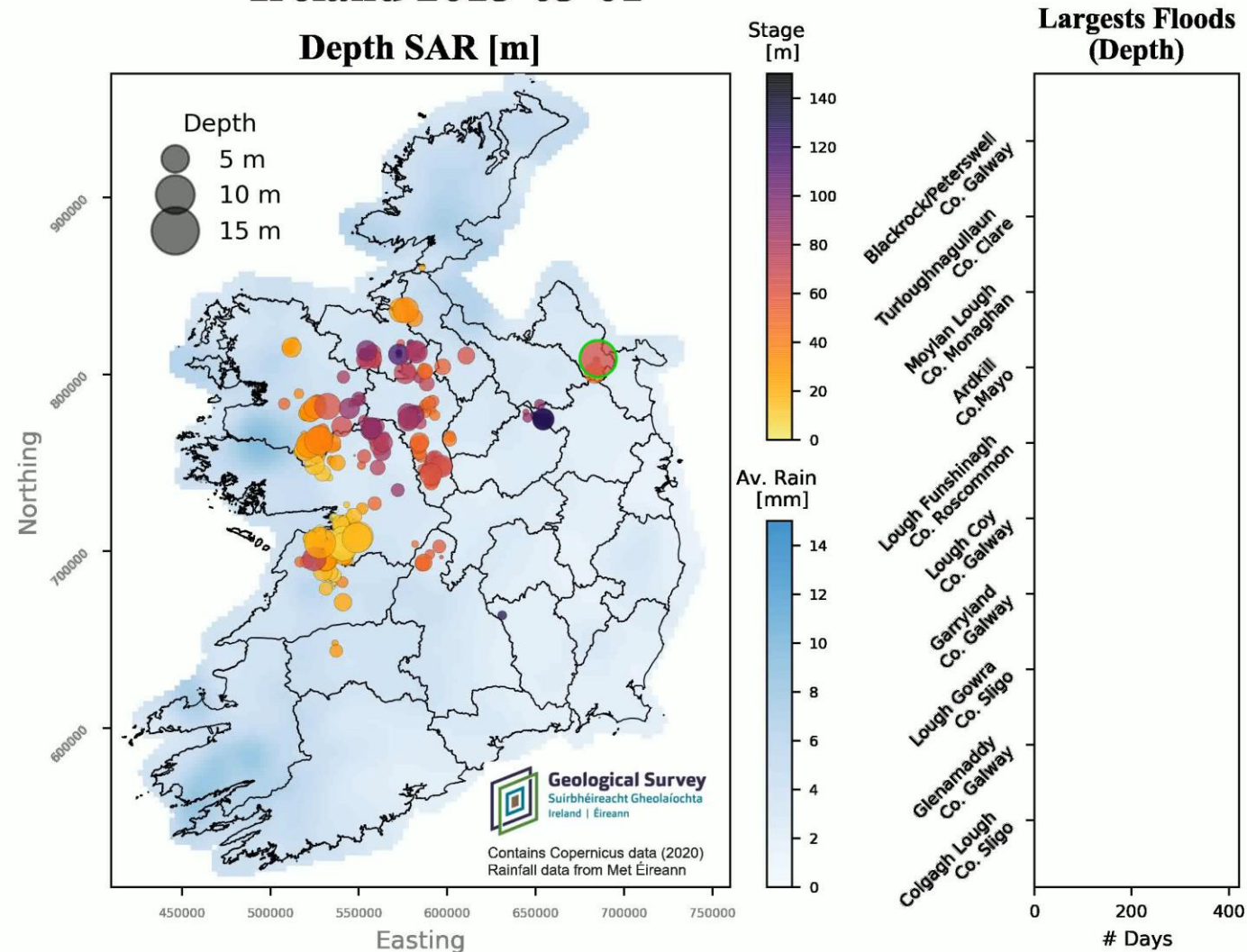
Mapping

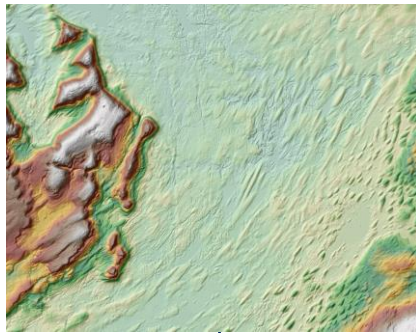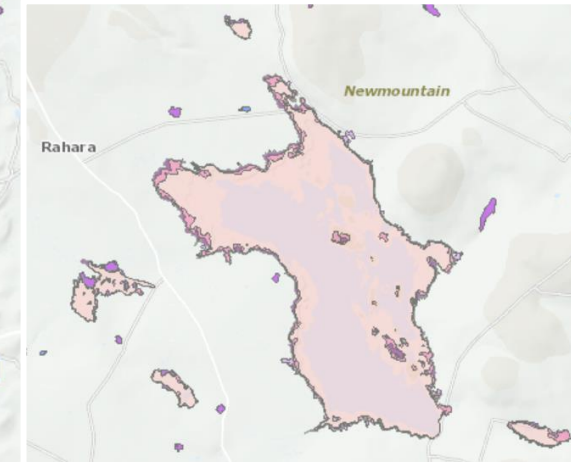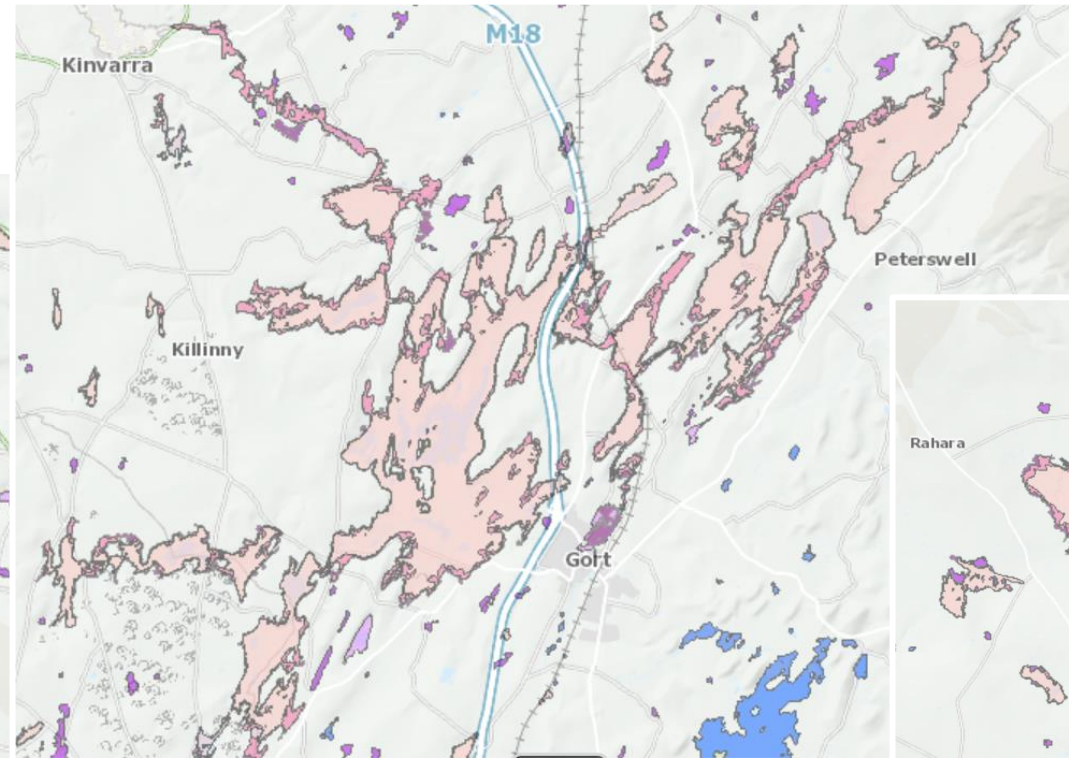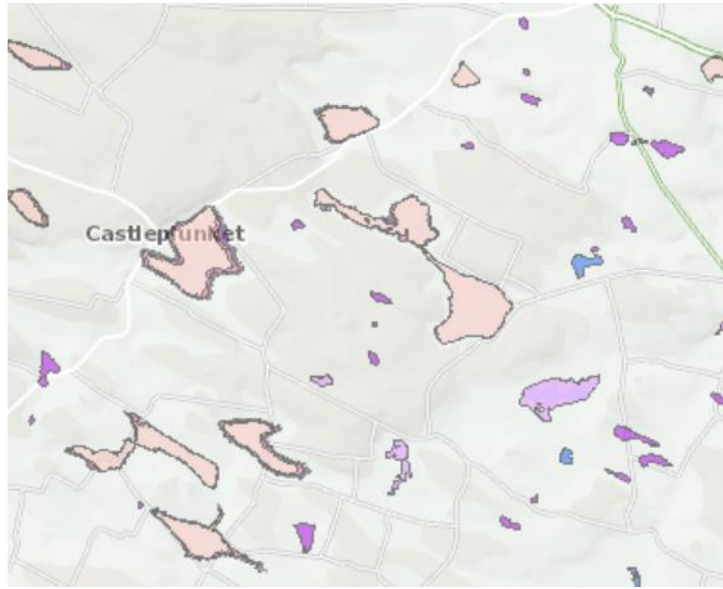| Mapping	
Inputs	**Products**
• Satellite (Sentinel-1) • GIS (filtering) • Dataloggers, GPS, Sentinel2 (Validation) • Hydrological models • Meteorological data	• Maximum Historic Groundwater Flood Map • Seasonal Flood Maps • Predictive Flood Map

Mapping

Stage 0 – Data download from Copernicus Open Access Hub (API)

Stage 1 – Detection

- SAR Processing, Thresholding

Stage 2 – Generate Masks

- Topography, forestry etc.

Stage 3 – Delineation

- Filtering & topographic correction

Stage 4 – Flood Mapping

- Max historic groundwater flood (Dec 2015-Apr 2016 SAR

    & aerial photos) & seasonal flood maps

Stage 5 – Predictive Flood Mapping

- SAR Hydrograph generation & hydraulic modelling
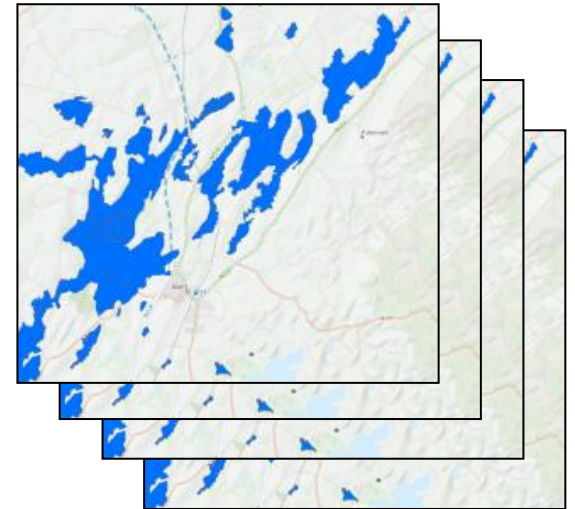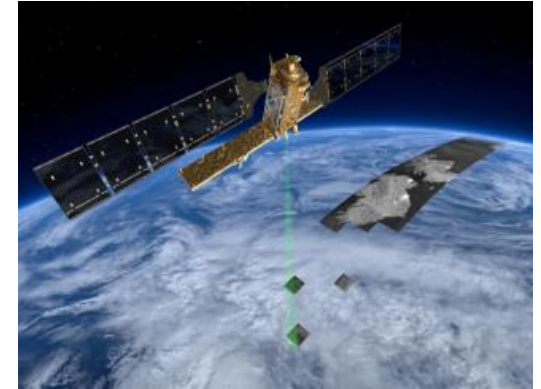
Mapping
Maximum Historic Groundwater Flood Map
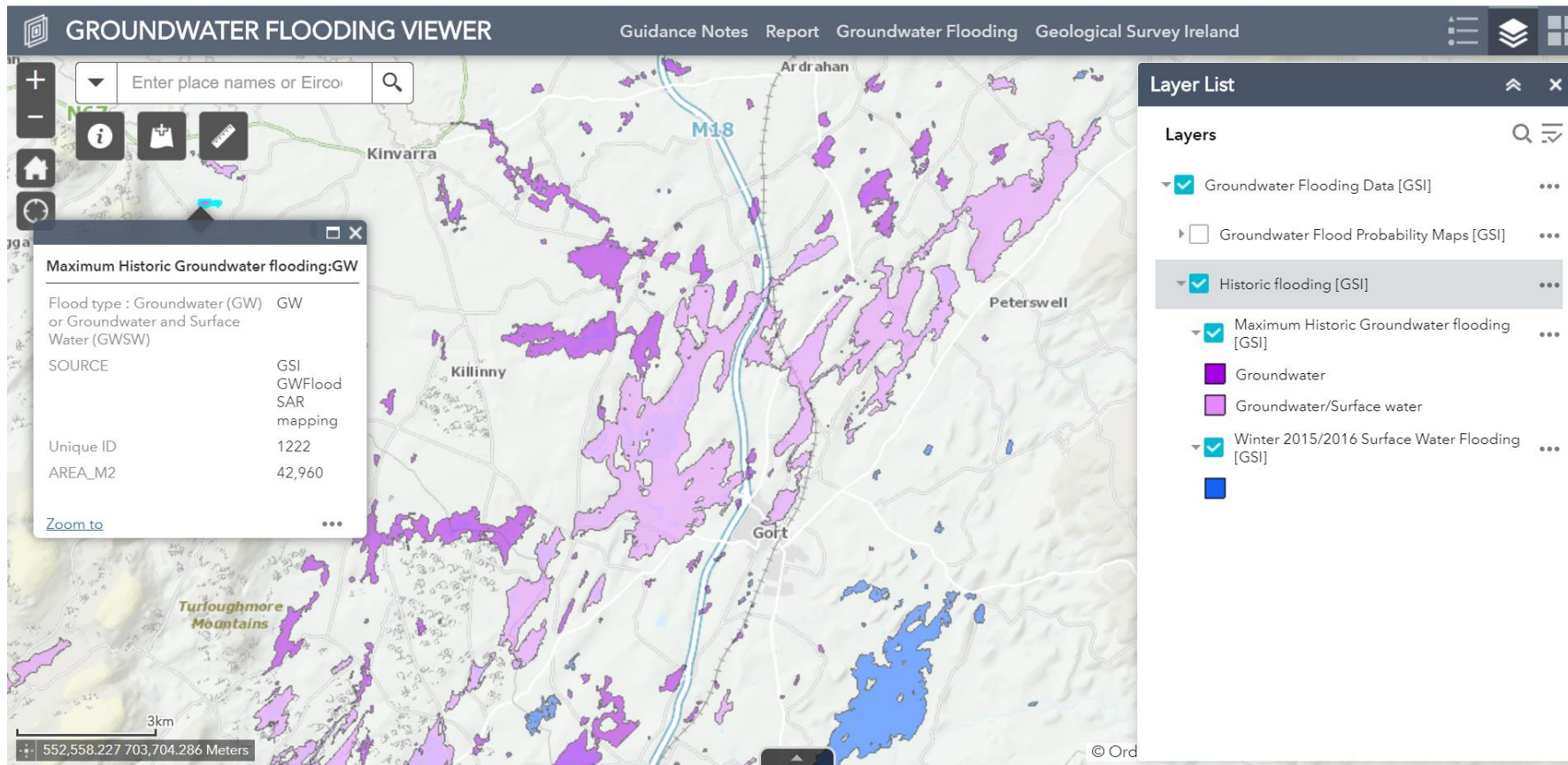
- Maximum flood extent from 2015/2016 Flood event

- Supplementary observed flood data (e.g. aerial photos, local knowledge)

- Surface water flooding also delineated (but not 'peak' floods)

- Flooded area: 283.3 km^2

Maps available at www.gsi.ie

Mapping
Seasonal maximum flood extent maps

Blackrock (Co. Galway)
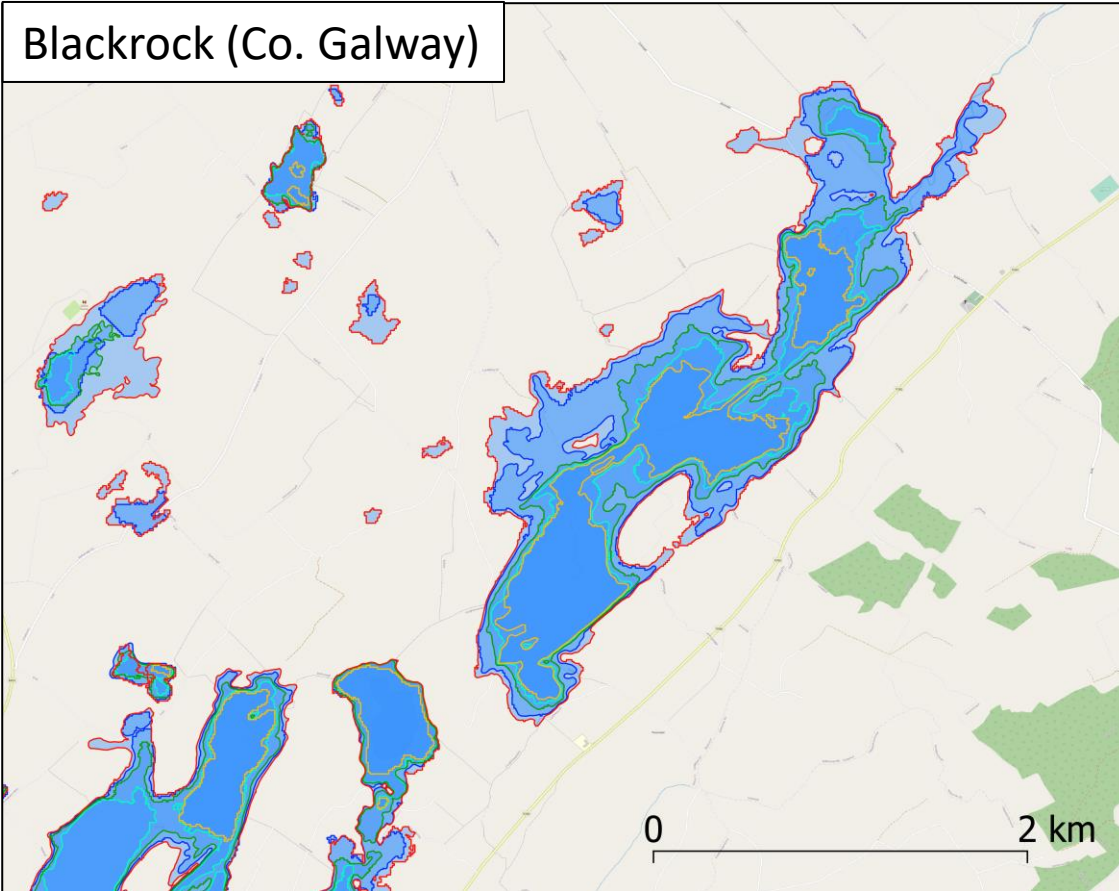
Glenamaddy (Co. Galway)
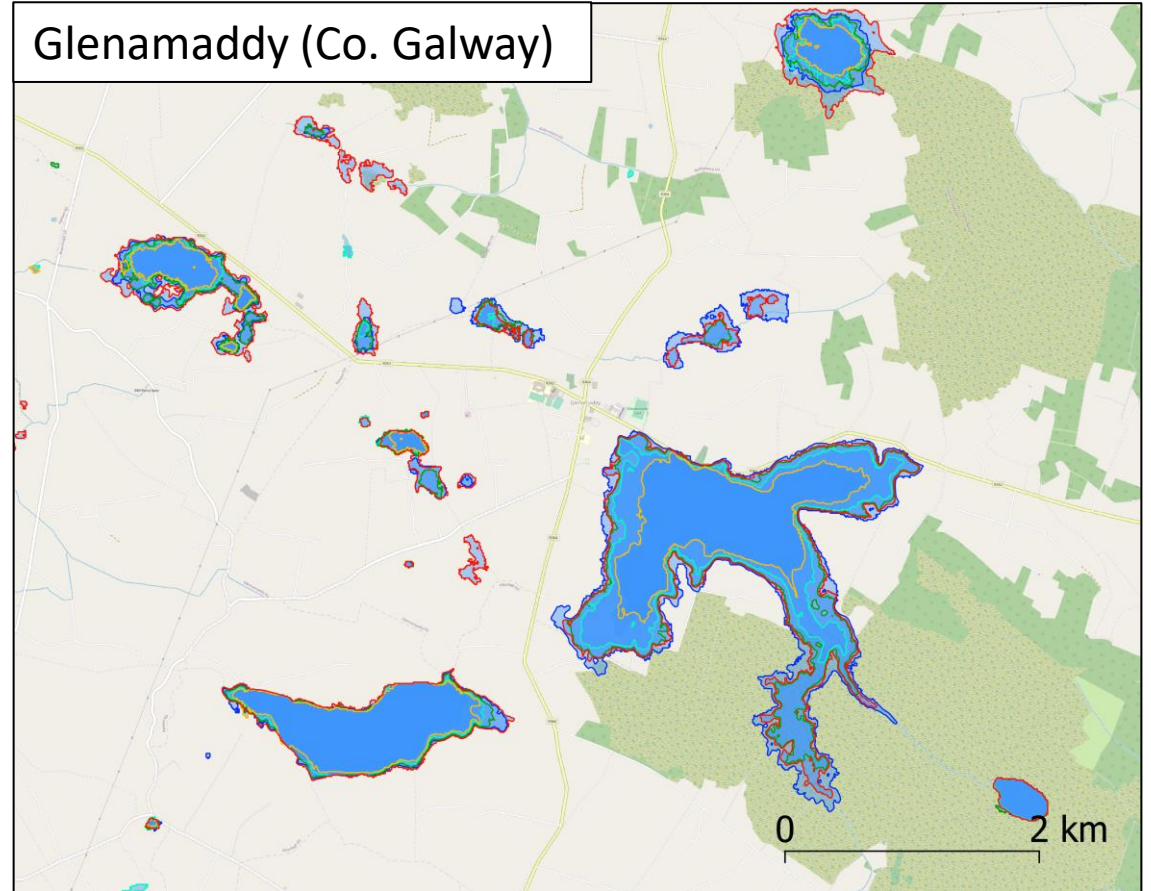
— 2016 — 2017 — 2018 — 2019 — 2020 Flood

Mapping
Predictive Groundwater Flood Map
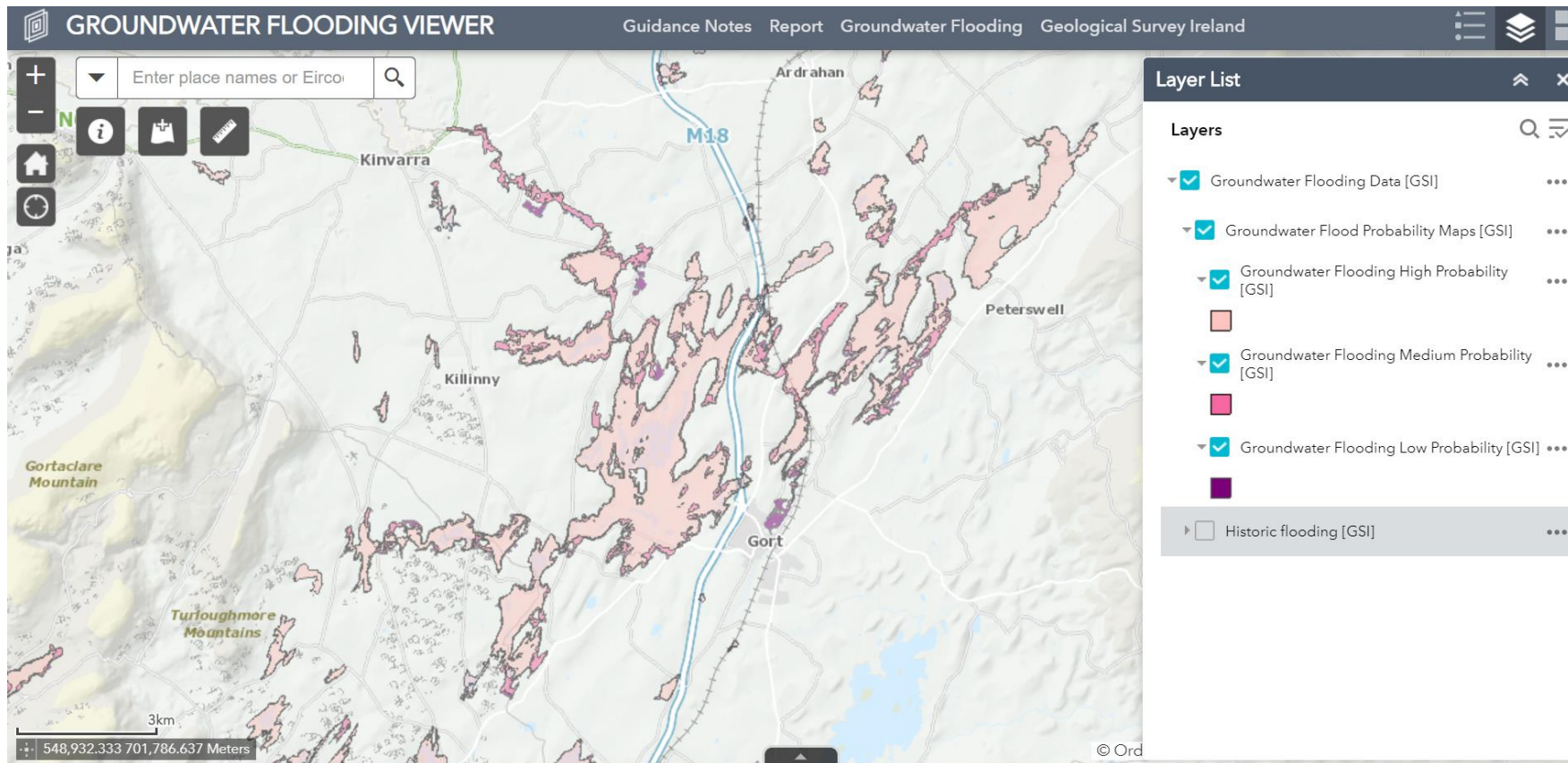
Predictive groundwater flood maps developed using:

- Hydrological models based on SAR hydrographs and rainfall data
- Long term + stochastic generated rainfall data

Results:

- Flood maps for 10, 100 & 1000 year flood
- 440 floods modelled and mapped

Maps available at www.gsi.ie

Forecasting

Ballycar, Co. Clare — Geological Survey Water Level Data
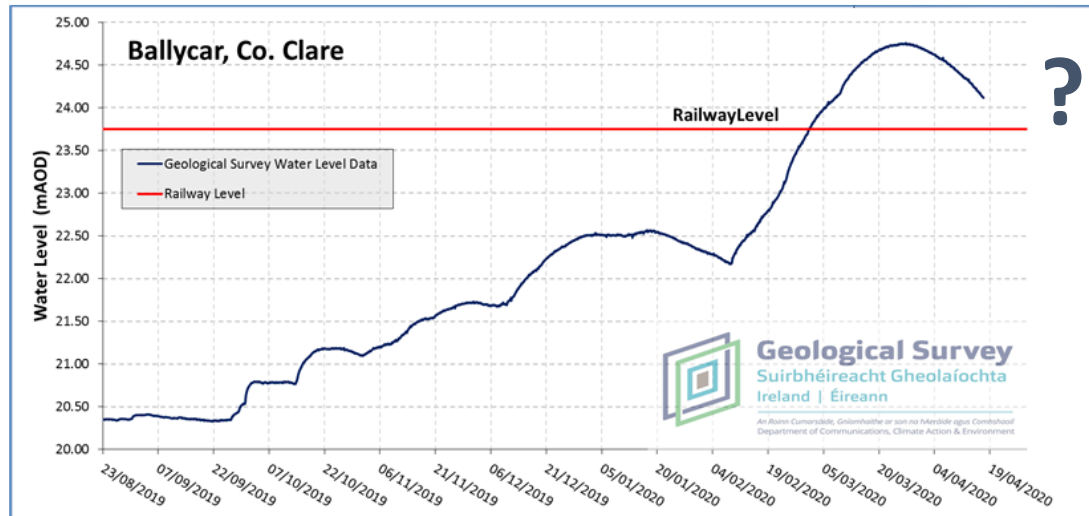
Forecasting	
Inputs	Products
• Hydrographs • Meteorological data • Hydrological models	• Short term forecasting • Medium term estimations

Work in progress…

Forecasting

Short term forecasting

10 days forecast based on:
- ➢ Historic and forecast meteorological data
- ➢ Hydrological models
- ➢ Current groundwater level (hydrographs)
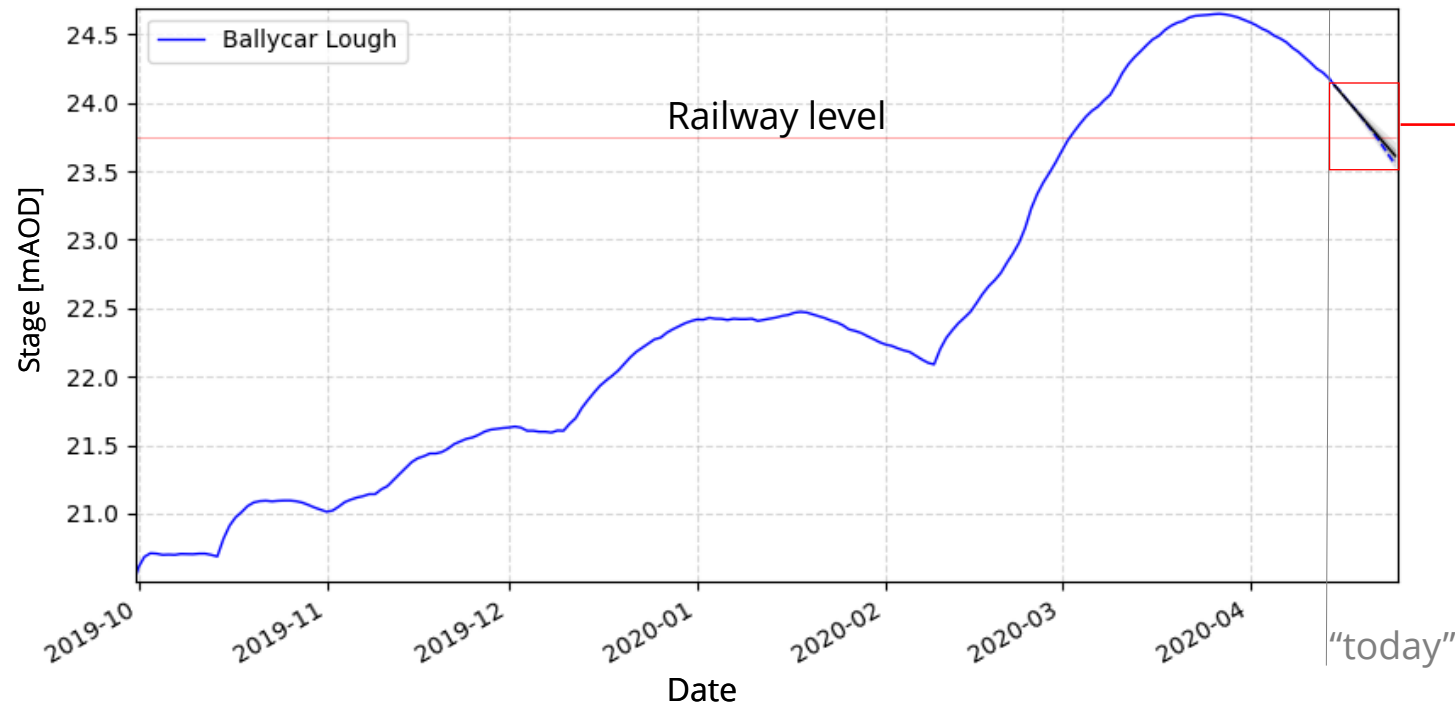
Work in progress…

Forecasting

Medium term estimates

Few months groundwater
level estimates based on:
- ➢ Previous meteorological
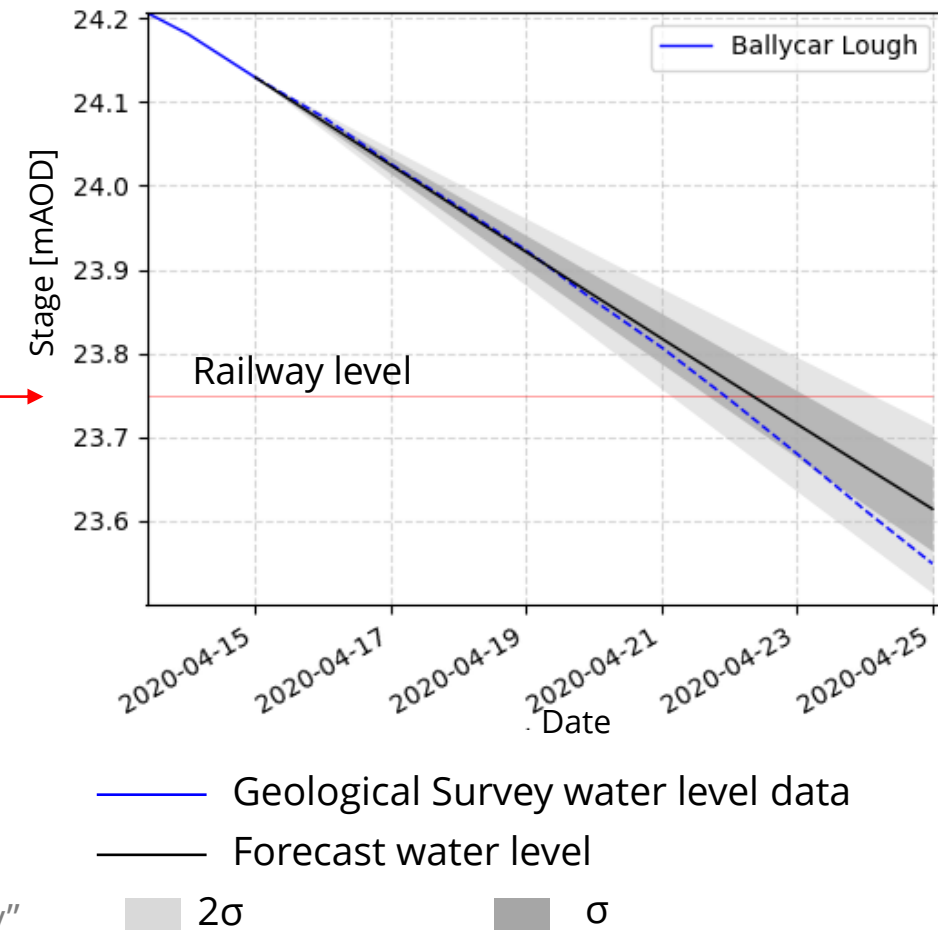 data, since 1941
- ➢ Hydrological models
- ➢ Current groundwater level
  (hydrographs)

Lough Funshinagh (Co. Roscommon)

Stage [mAOD]

max
q95
q75
q50
q25
q05
min

Date

Frequency quantiles — Measured — Probability

0.00 0.02 0.04 0.06 0.08 0.10

Work in progress…

Climate Change

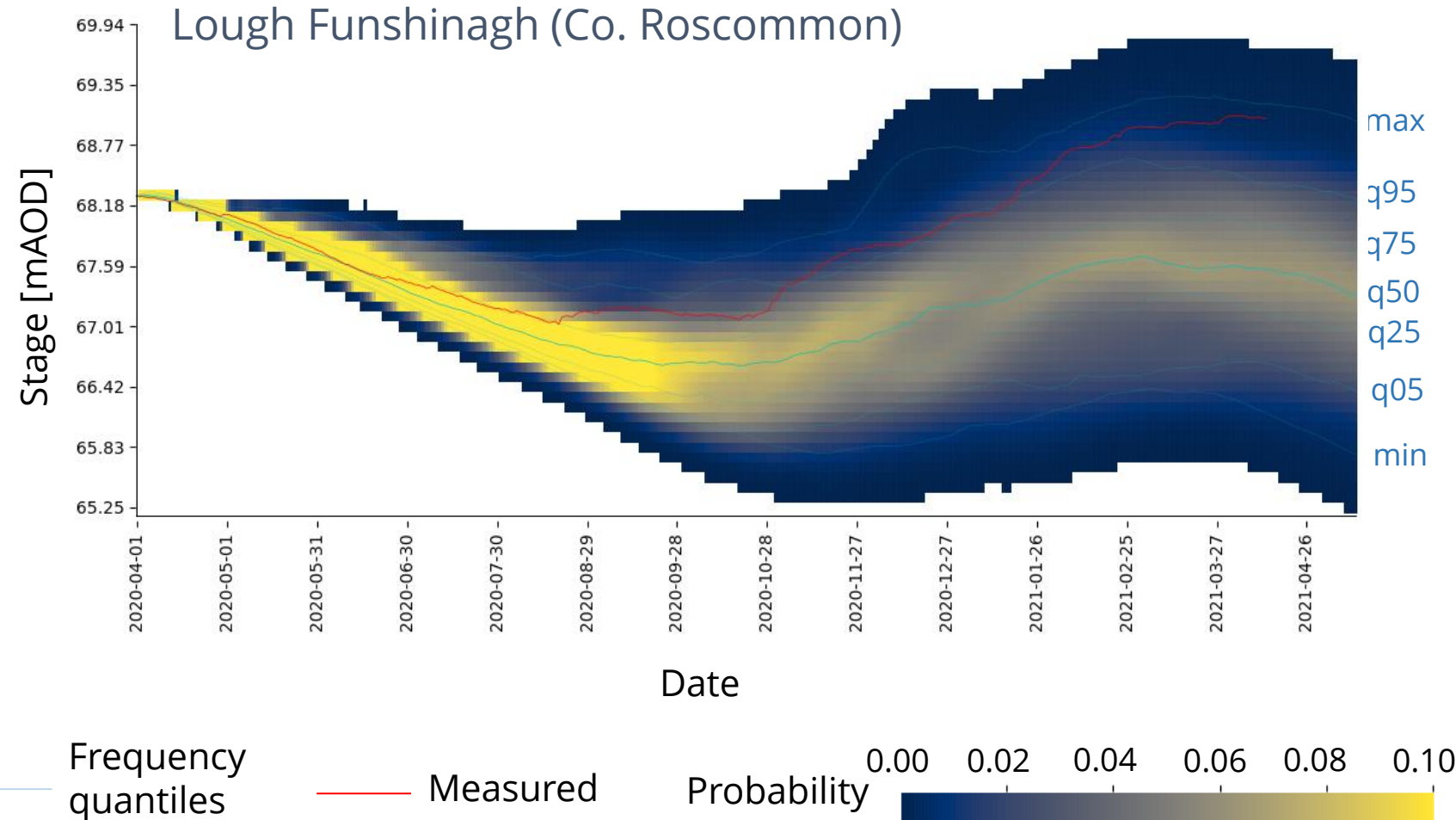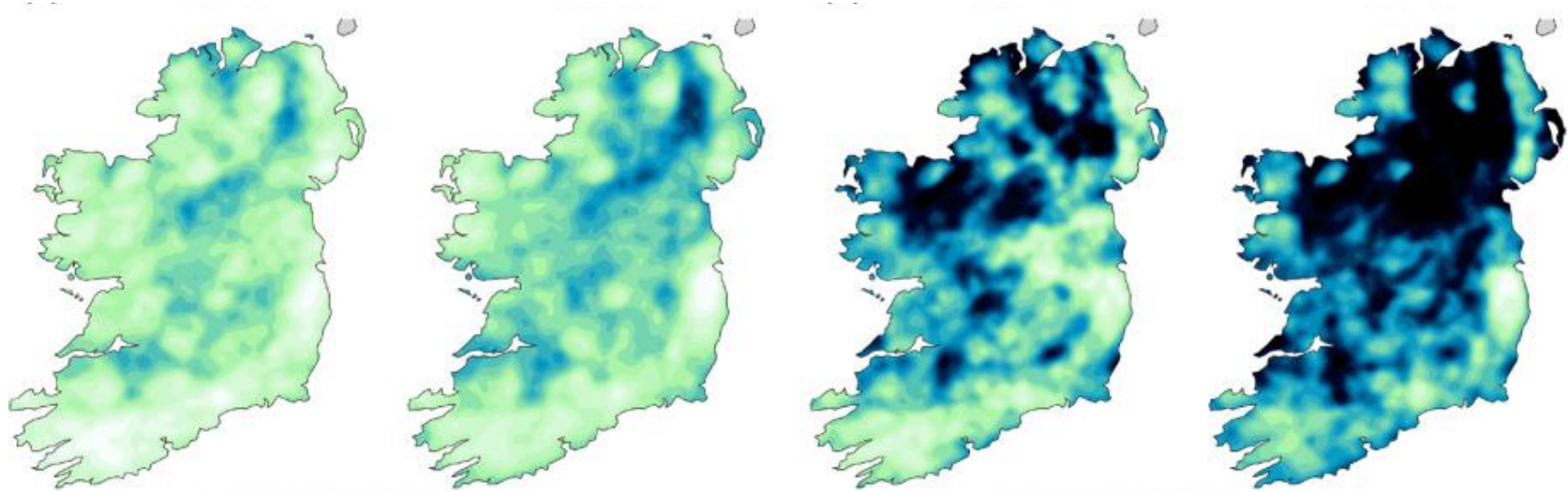| Climate Change	
Inputs	Products
• Hydrological models • Meteorological data and forecast climate models	• Maps quantifying the impact of climate change in groundwater systems

Starting in October

Climate Change

Climate change predictions for Ireland:

➢ Rainfall to increase during winter and autumn and decrease during summer

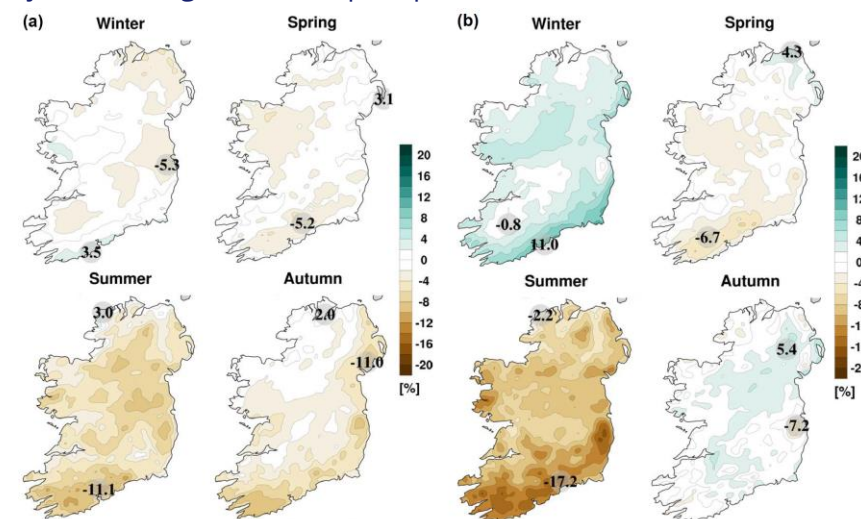➢ Frequencies of heavy rainfall events increase approx. 15%

Climate change scenario modelling
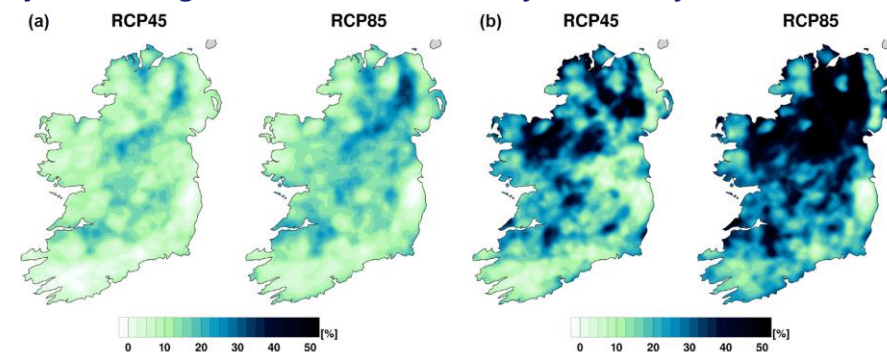
➢ Scenario Led

➢ Scenario Neutral

Quantify impact on groundwater

➢ Potential increases in **frequency**, **scale** and **duration** of groundwater flooding and droughts

Projected changes in mean precipitation RCP4.5(a) and RCP8.5(b)

Projected changes annual wet (a) and very wet (b) days

(Nolan and Flanagan, 2020)

Starting in October

Nolan and Flanagan, 2020. High-resolution Climate Projections for Ireland – A Multimodel Ensemble Approach. EPA report