

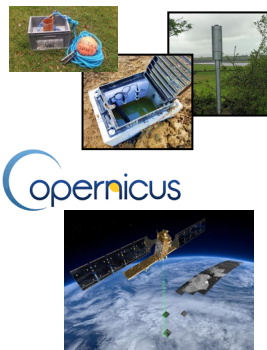
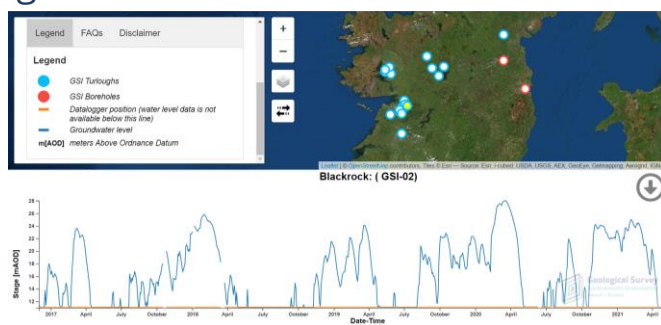


Mapping, Monitoring, Forecasting and Assessing the Impact of Climate Change in Groundwater Systems in Ireland

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

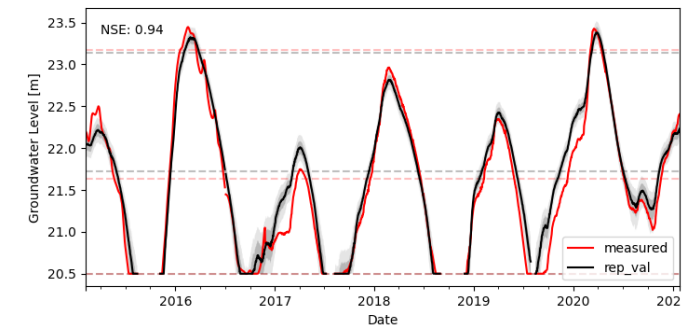
1. Monitoring

gwlevel.ie



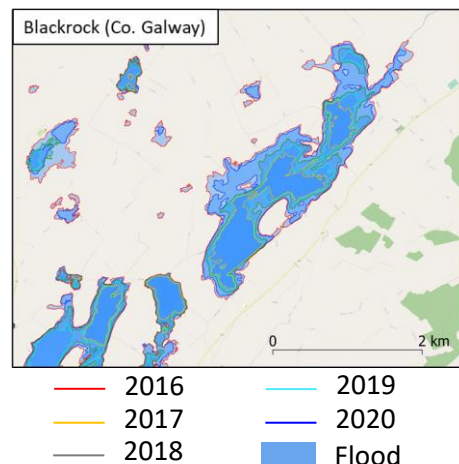
2. Modelling

Transfer Functions (API, convolution, reservoir)

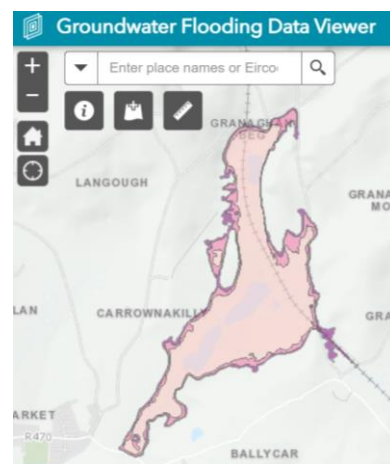


3. Mapping (Sentinel-1)

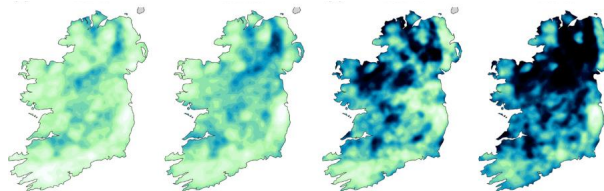
Historic and seasonal maximum flood extent



Predictive groundwater flood maps



5. Climate Change

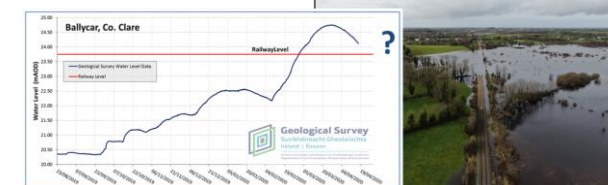


Quantify changes in frequency, scale and duration of groundwater floods

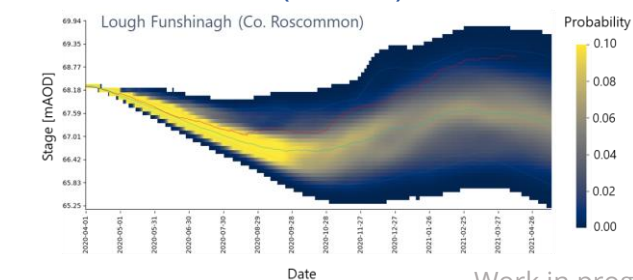
Starting in October 2021

4. Forecasting

Short-term (10 days)



Medium-term estimates (months)



Work in progress



Rialtas na hÉireann
Government of Ireland



INSTITUTE of
TECHNOLOGY
CARLOW
Institiúid Teicneolaíochta Cheatharlach



Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

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

Irish Examiner

HOME > IRELAND



Farmer: Mid-Shannon area 'an absolute sea of water'

Flood waters begin to encroach on the rail line at Mooghaun near Newmarket-on-Fergus forcing Irish Rail to close the Limerick to Ennis line yesterday. Pic: Press 22

By Digital Desk staff



Tuesday, March 03, 2020 - 07:24 AM

THE IRISH TIMES

Mon, Apr 20, 2020

NEWS SPORT BUSINESS OPINION LIFE & STYLE CULTURE

Environment > Climate Change | Heritage & Habitat

Estimated cost from damage following flooding set to reach €100m

Local authorities claim the cost of infrastructural damage and the clean-up is "significantly higher" than the €60 million predicted

© Wed, Jan 20, 2016, 01:00

Sarah Bardon

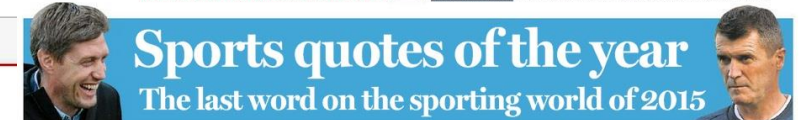


Floods surround a house in the Golden Island area of Athlone. Fianna Fáil claim the budget for flood relief works in 2016 had been cut by 14 per cent. Photograph: Bryan O'Brien/The Irish Times

Irish Independent

IRELAND'S BEST-SELLING DAILY NEWSPAPER

www.independent.ie Thursday 31 December 2015 €2.00 (€1.25 in Northern Ireland)



Sports quotes of the year
The last word on the sporting world of 2015

PLUS: OUR FOOTBALL JURY GIVES ITS VERDICT ON THE WINNERS AND LOSERS OF THE PAST 12 MONTHS

FLOODING CRISIS SPECIAL REPORT, PAGES 2-8

Breaking point



Floodwaters burst through the doors of buildings in Graigueamaneagh, Co. Kilkenny

■ Three more weeks of flooding and rain ■ Emergency crews battle with fatigue ■ Kenny finally set to visit flooded areas

Groundwater Flooding

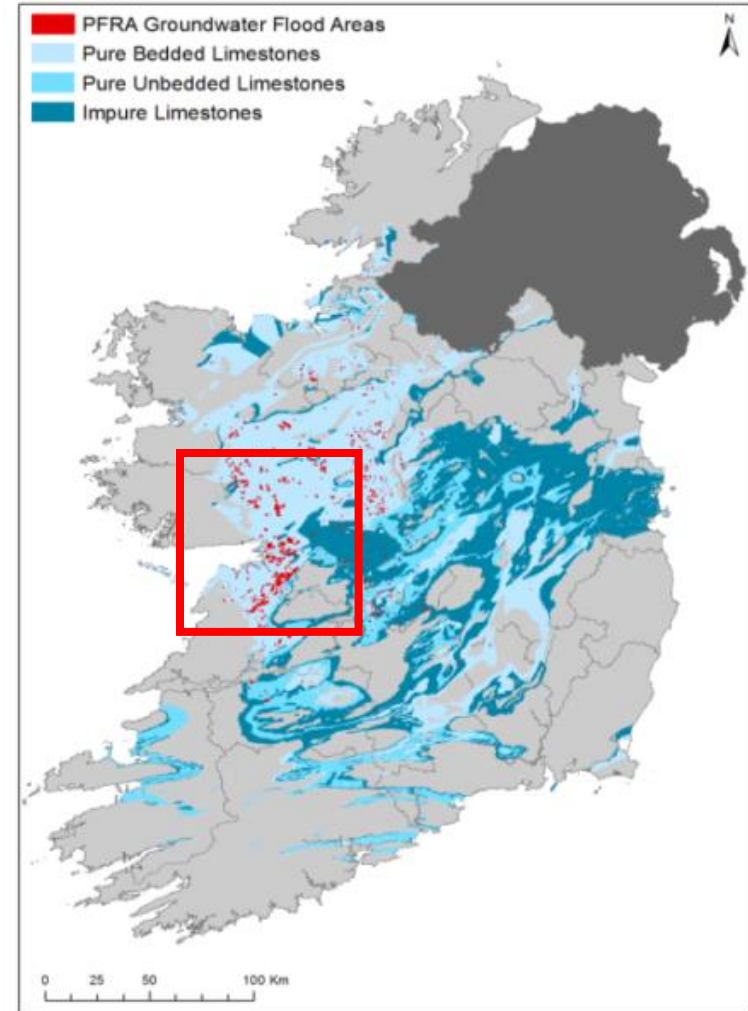
“Flooding caused by the emergence of water originating from sub-surface permeable strata induced by exceptional and/or prolonged recharge” (Morris 2007)

- 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

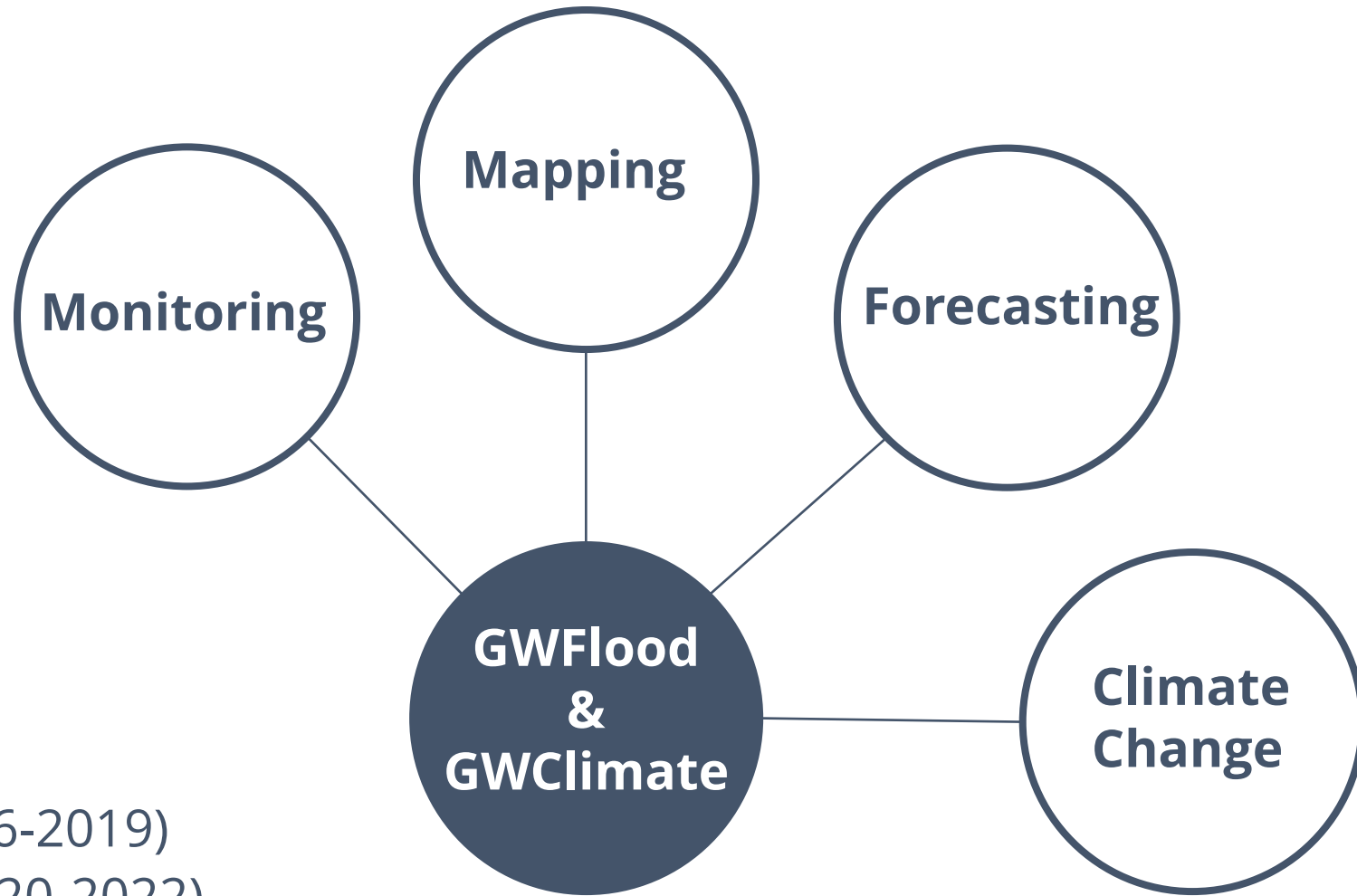


Groundwater Flooding

- 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



GW Flood (2016-2019)
GW Climate (2020-2022)

Monitoring



Monitoring

Inputs

- Dataloggers
- GPS points
- Satellite (Sentinel-1)

Products

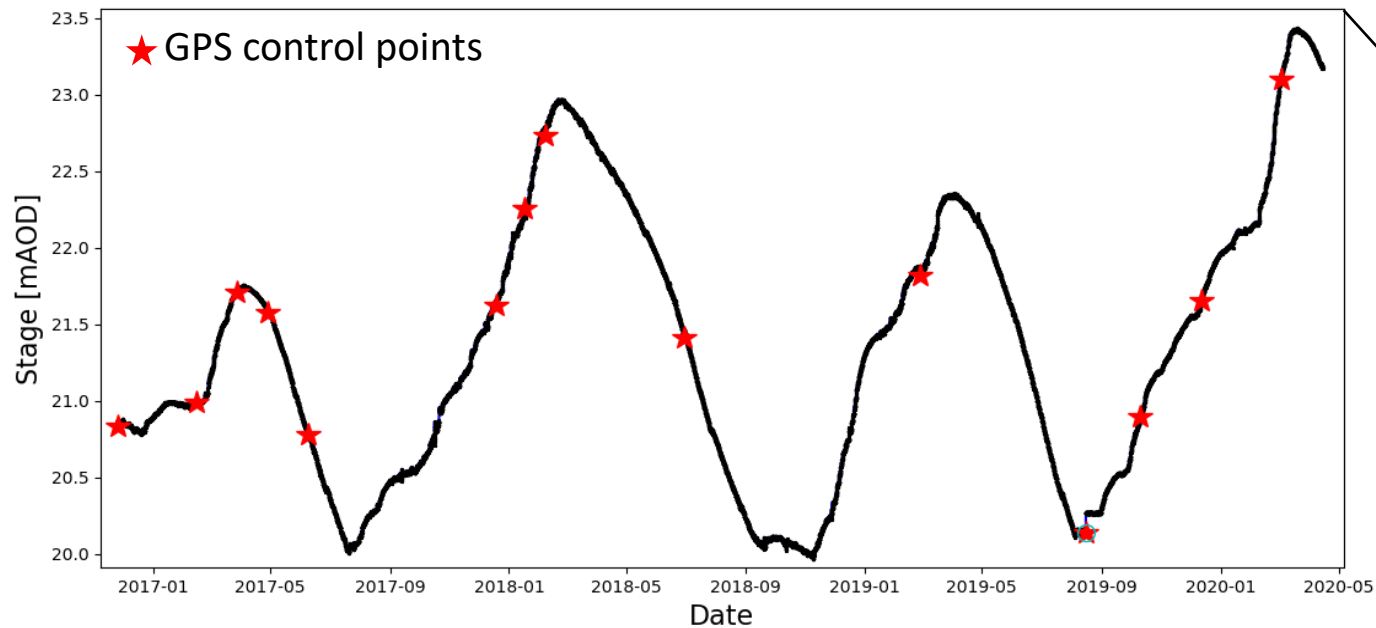
- Real time hydrographs gwlevel.ie

Monitoring

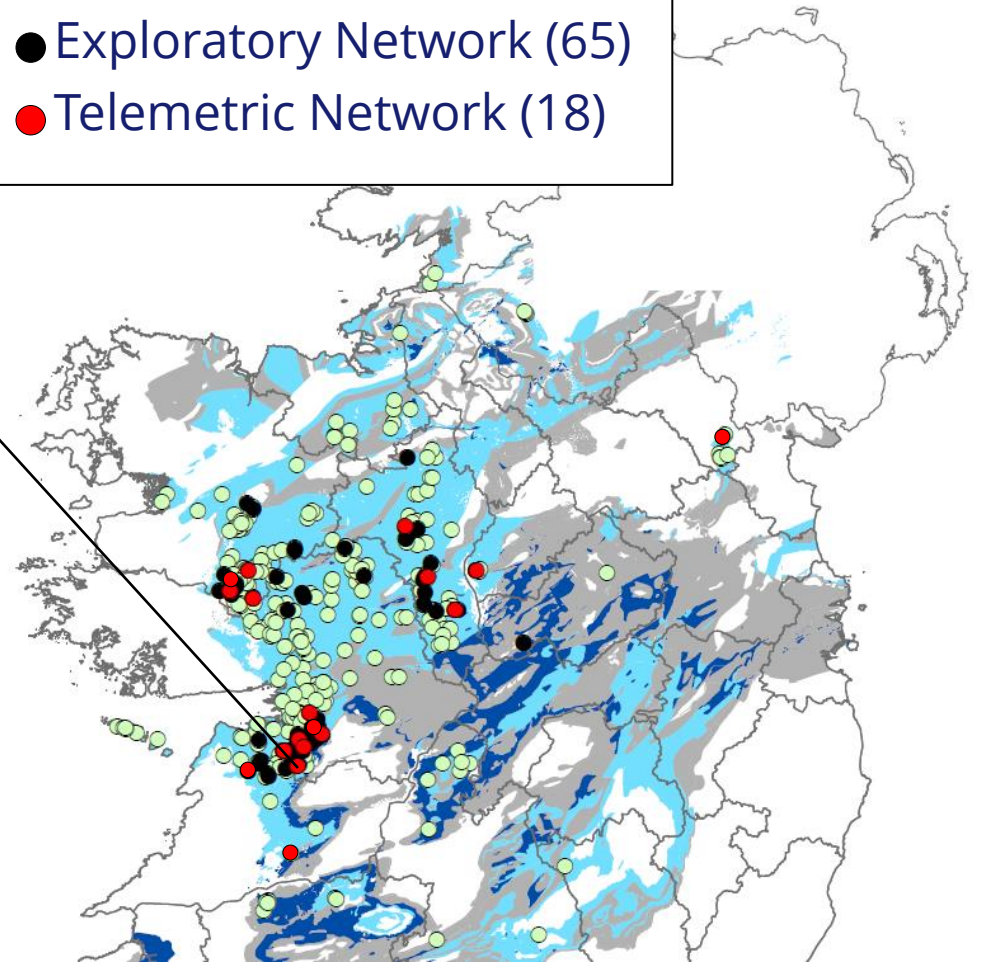
Observation: in situ

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

Termon South



- Potential sites (>500)
- Exploratory Network (65)
- Telemetric Network (18)



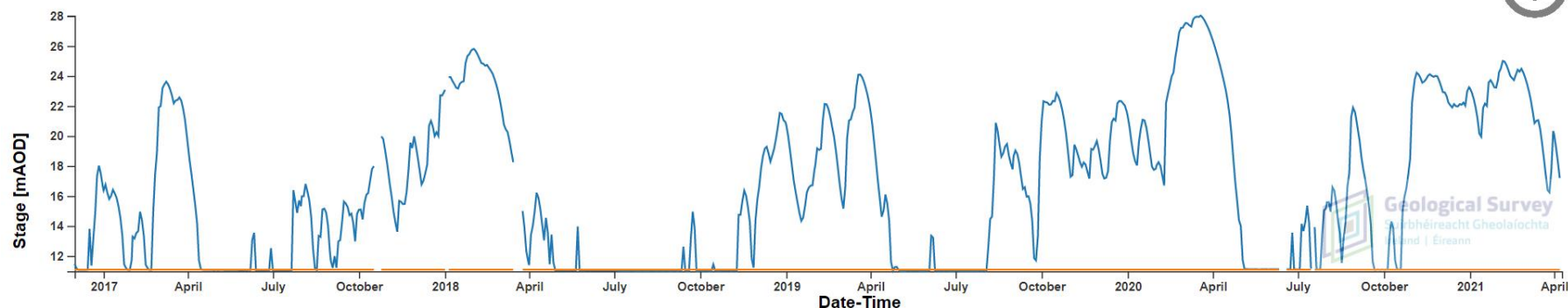
Monitoring

Observation: in situ

There are over 500 karst features that flood

What about the rest?

gwlevel.ie



Data available

GSI Telemetric data

- 18 Turloughs
- 3 GSI boreholes

To come

GSI Temporary stations (~50 sites)

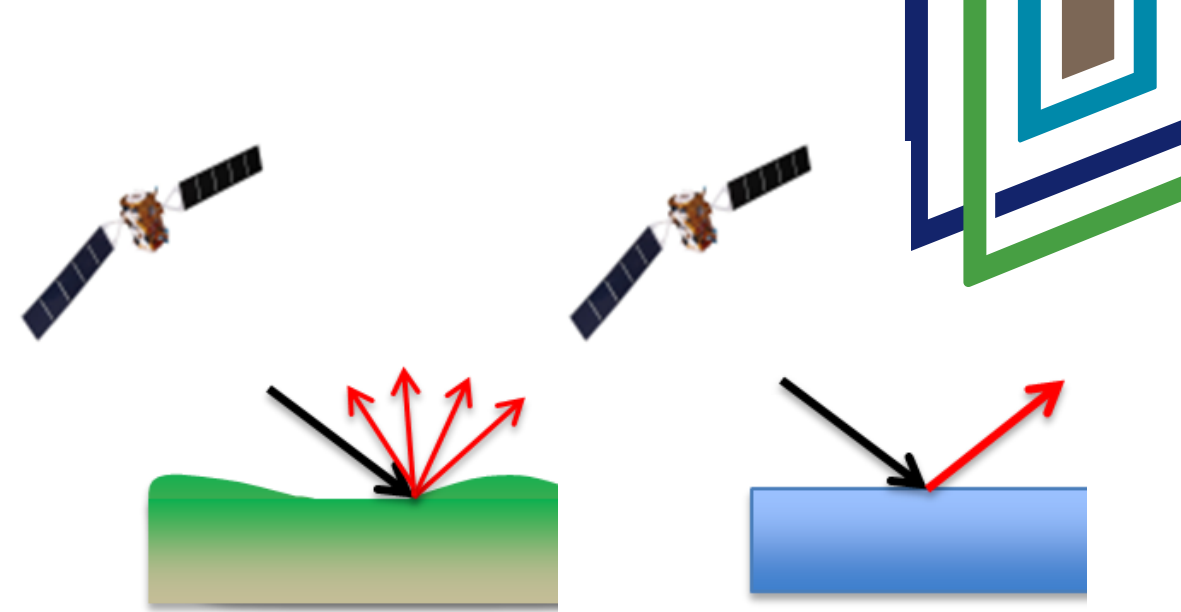
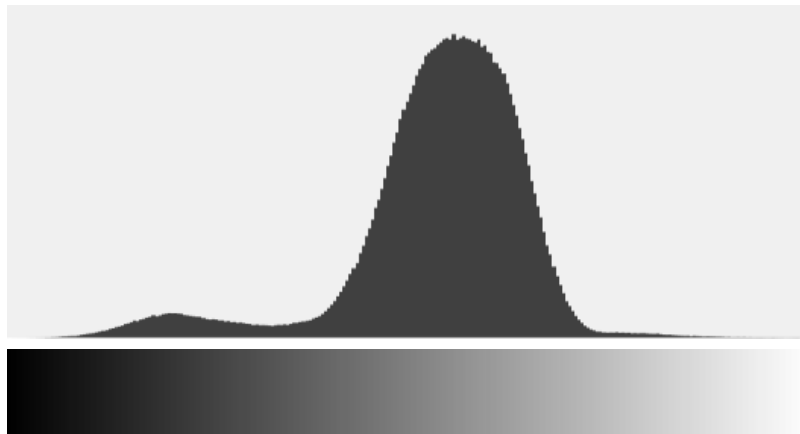
Format: csv files

Monitoring

Observation: Remote Sensing

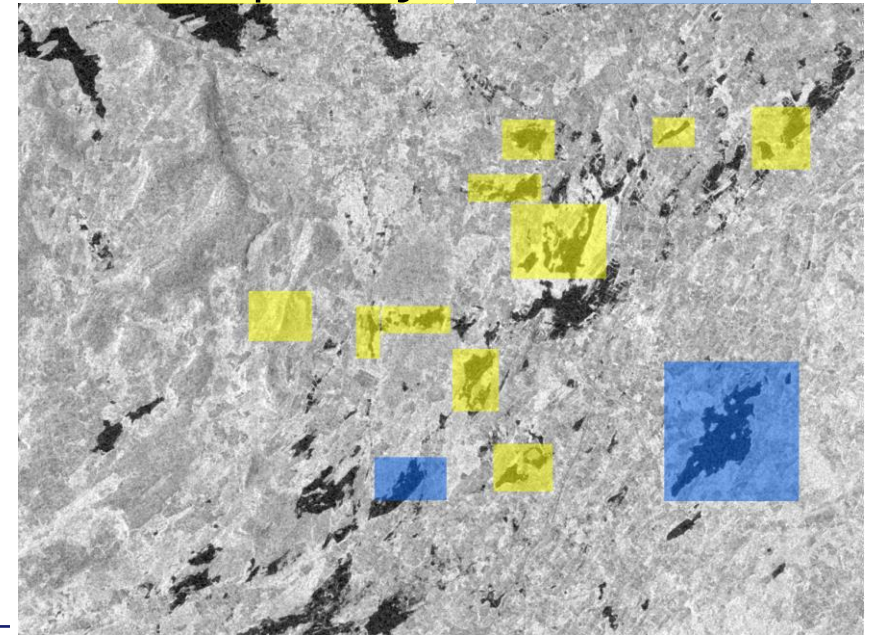
Sentinel-1 Synthetic Aperture Radar (SAR)

- All weather, day and night
- Systematic data collection
- Water detection
- Operational for 2015/2016 floods



Temporary

Permanent



SAR image: high (white) and low (black) backscatter

Monitoring

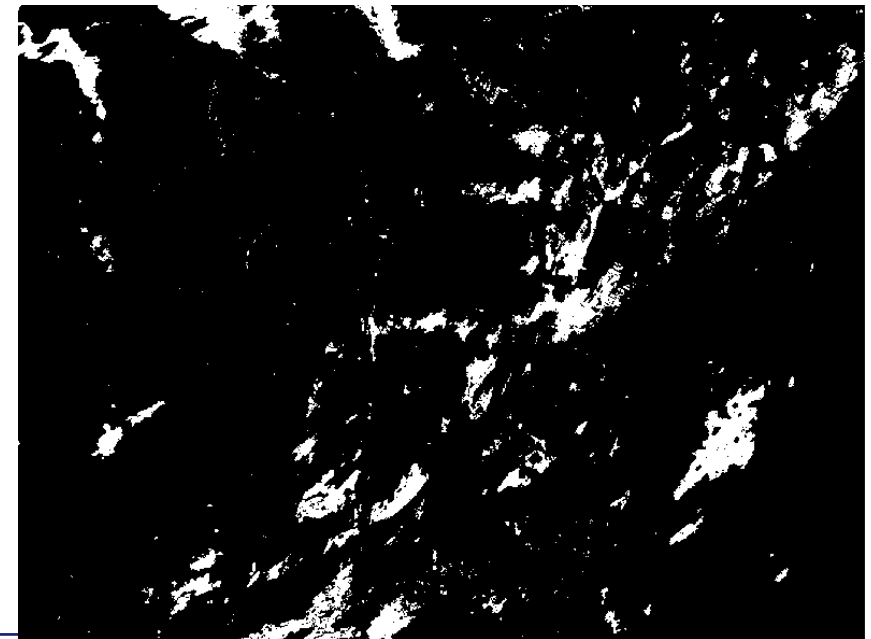
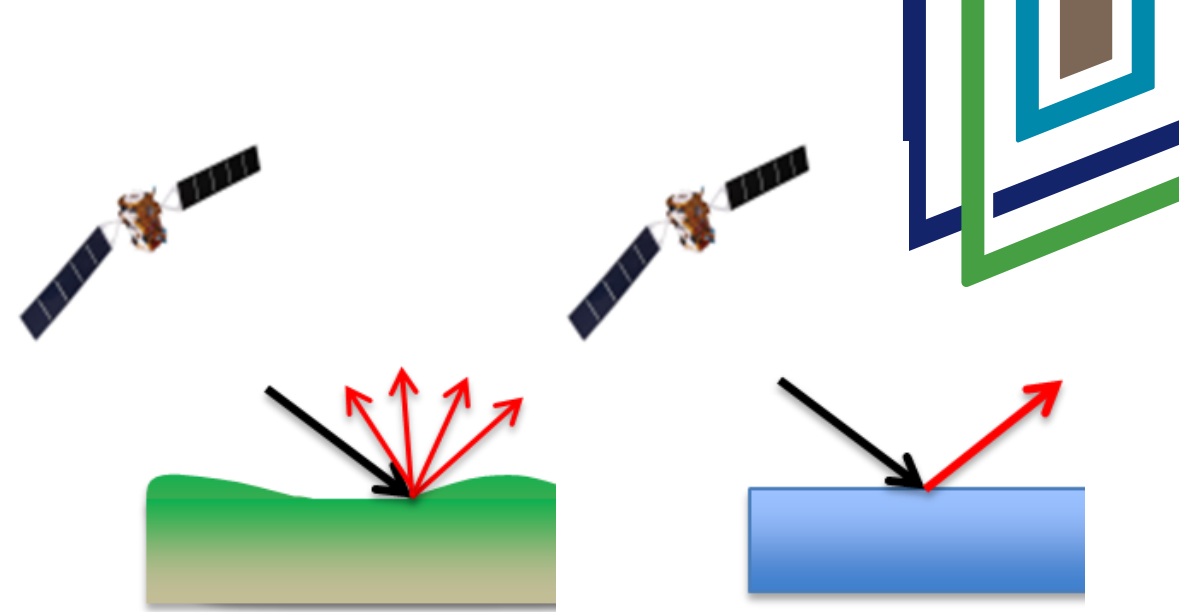
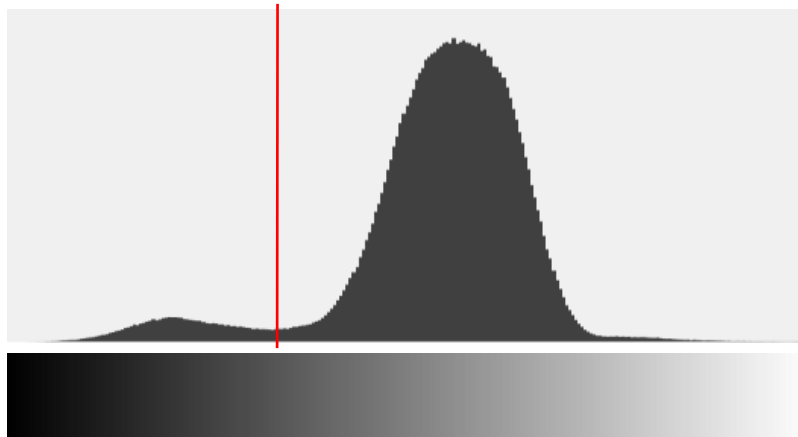
Observation: Remote Sensing

Sentinel-1 Synthetic Aperture Radar (SAR)

- All weather, day and night
- Systematic data collection
- Water detection
- Operational for 2015/2016 floods

Water

Non-water

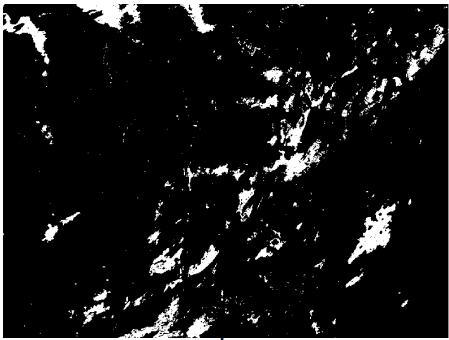


Mask suggesting water (white) and non-water (black)

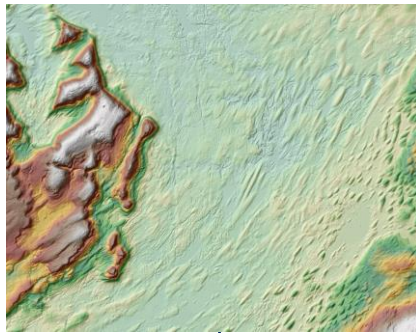
Monitoring

Observation: Remote Sensing

SAR images



DTM



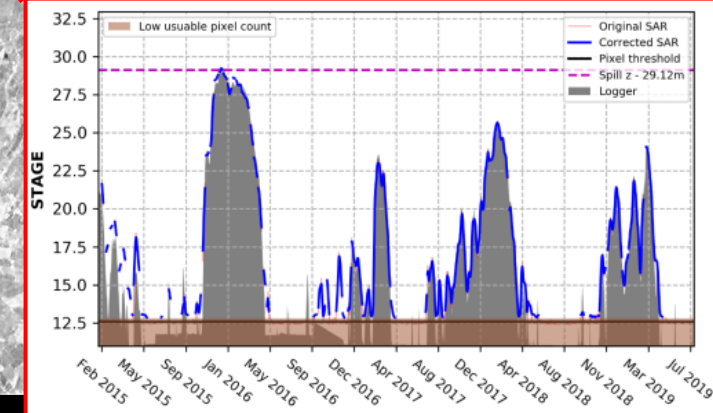
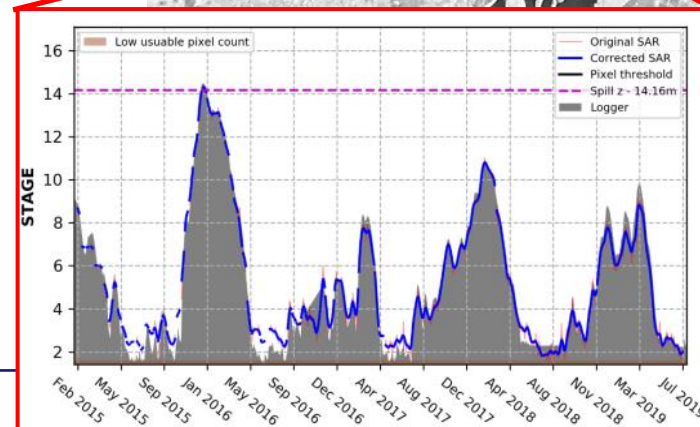
Groundwater Flood monitoring



GIS Filters

Forestry mask
Rivers and lakes
Fill Difference
...

SAR Generated
Hydrographs



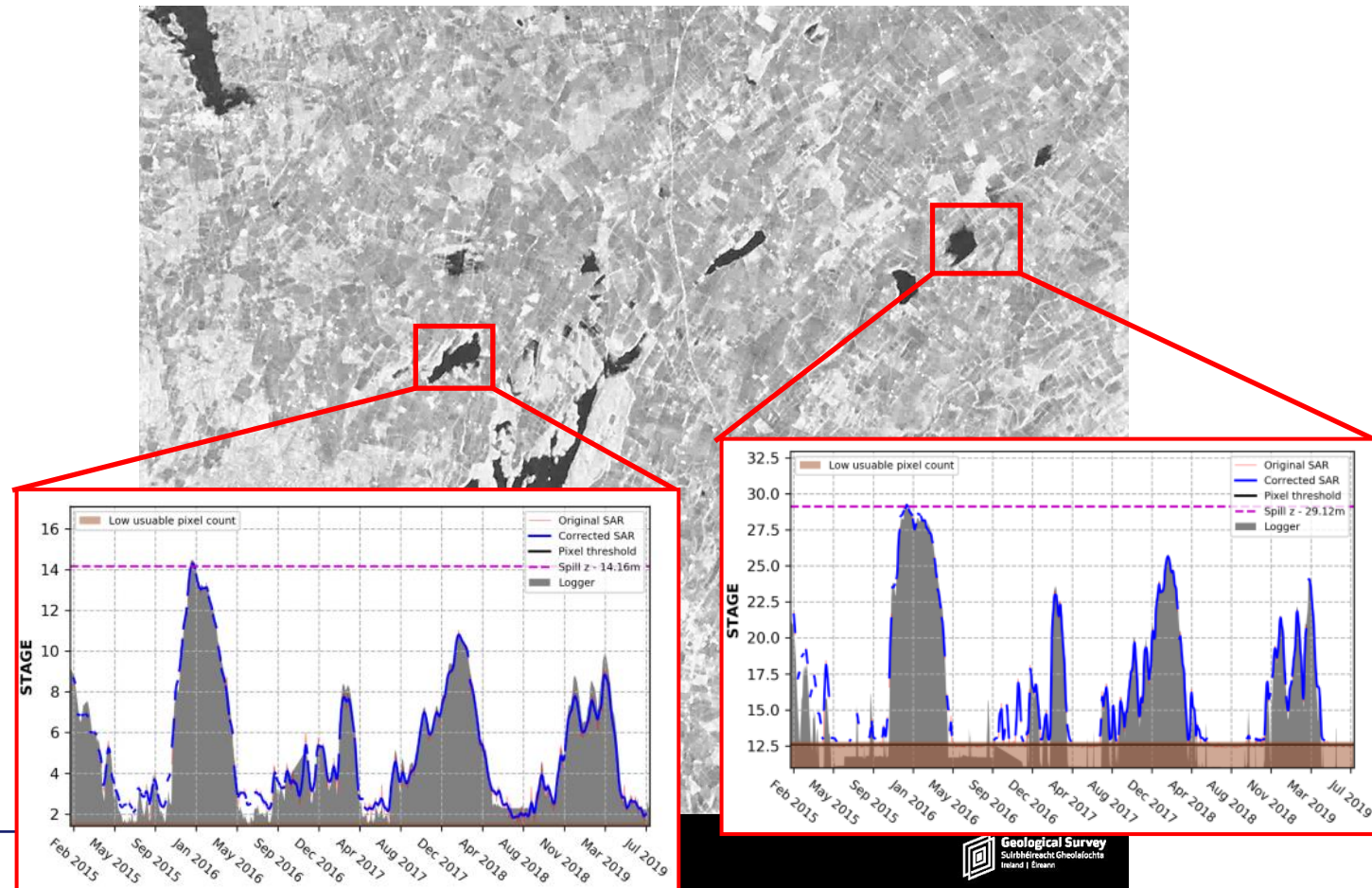
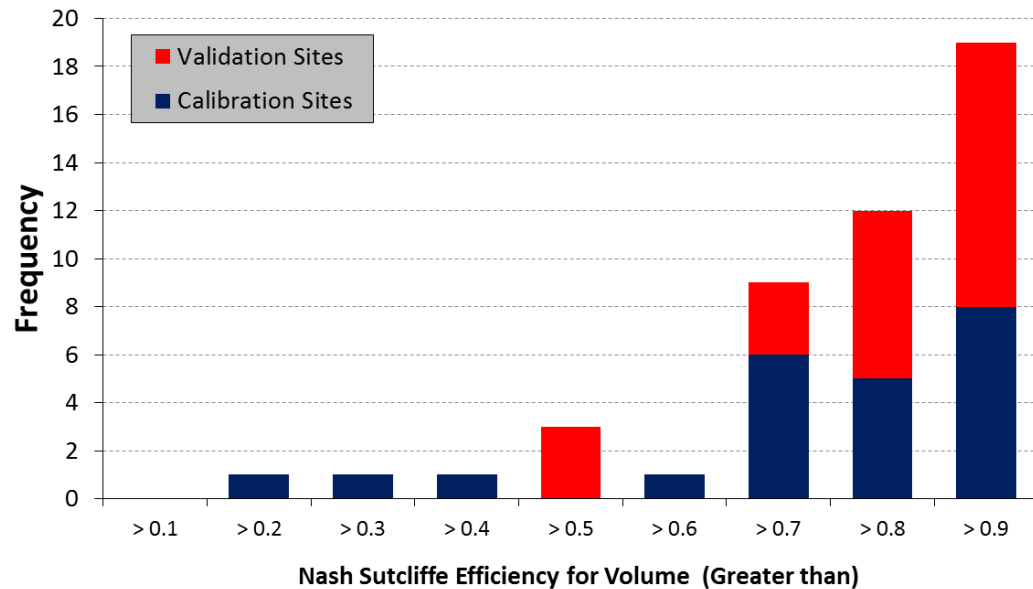
Monitoring

Observation: Remote Sensing



Groundwater Flood monitoring

Accuracy



Monitoring

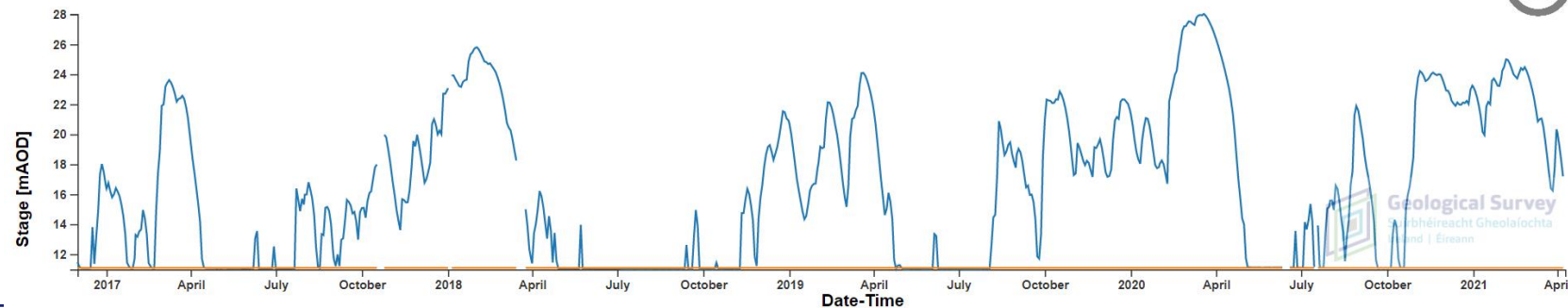
Observation: Remote Sensing

Real time SAR Hydrographs

gwlevel.ie

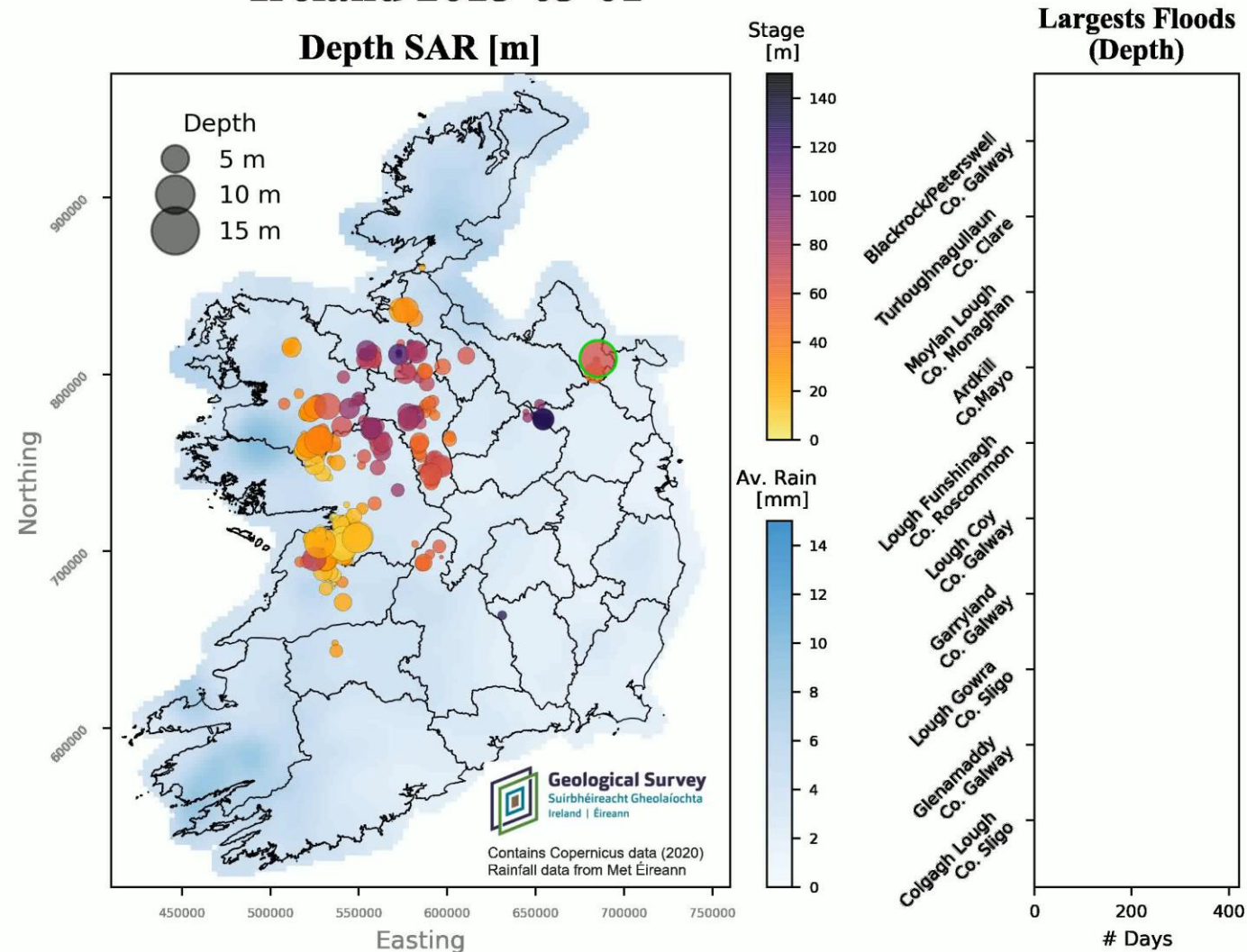


Blackrock: (GSI-02)

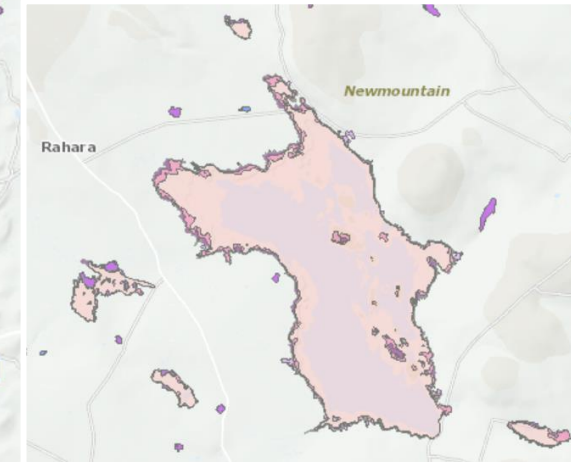
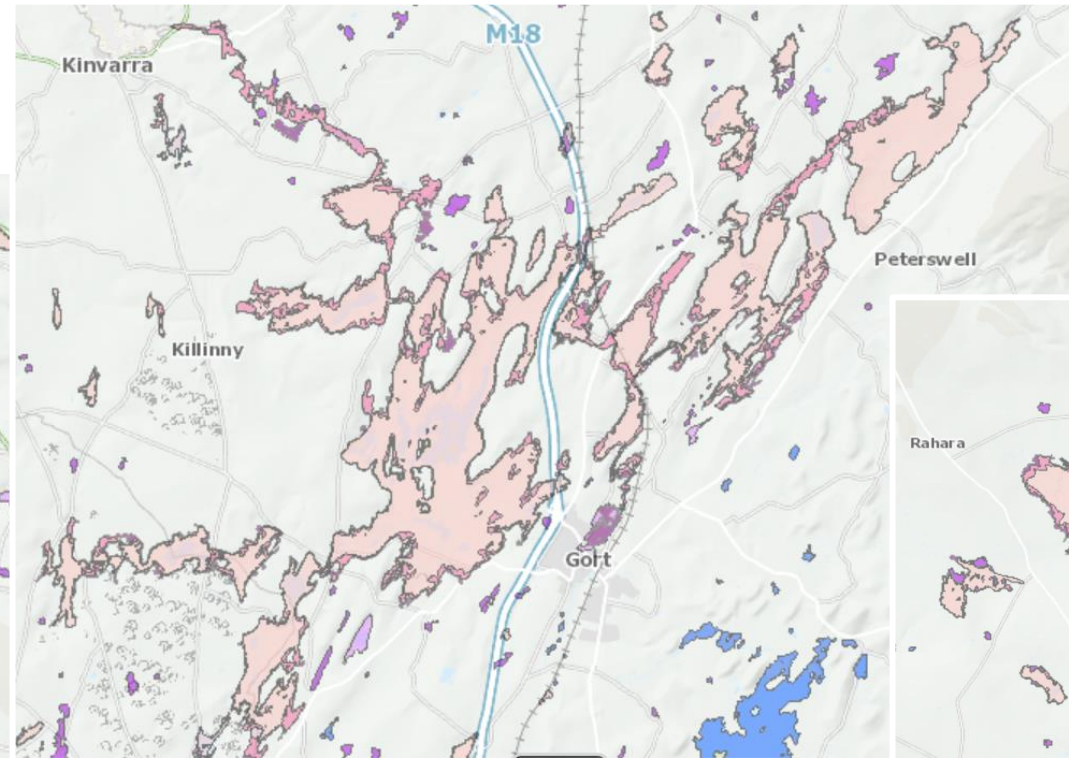
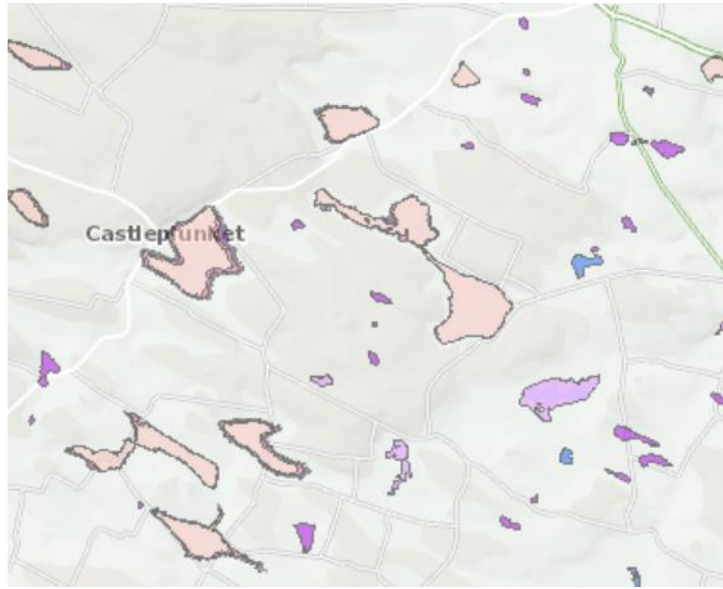


Monitoring

Ireland 2015-03-01



Mapping



Mapping

Inputs

- Satellite (Sentinel-1)
- GIS (filtering)
- Dataloggers, GPS, Sentinel2 (Validation)
- Hydrological models
- Meteorological data

Products

- 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

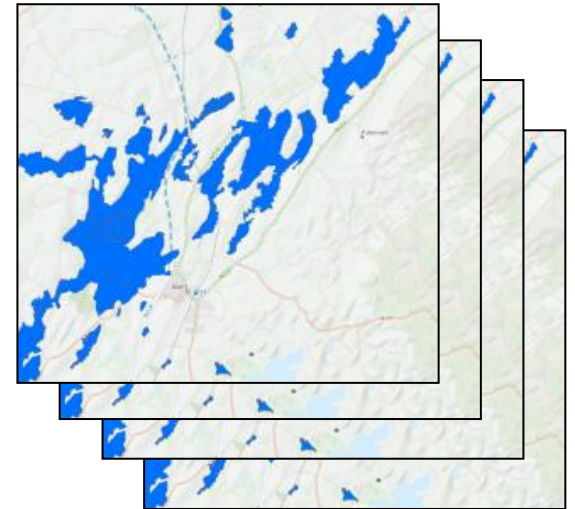
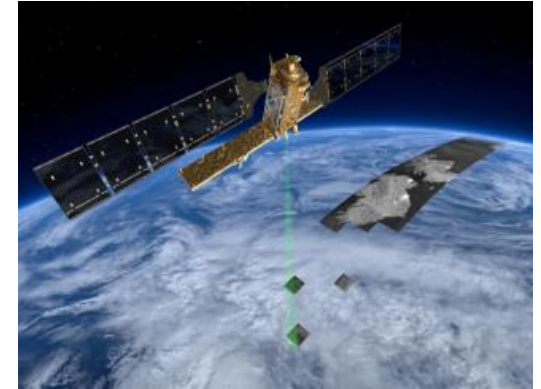
- Filtering & topographic correction

Stage 4 – Flood Mapping

- Max historic groundwater flood (Dec 2015-Apr 2016 SAR
& aerial photos) & seasonal flood maps

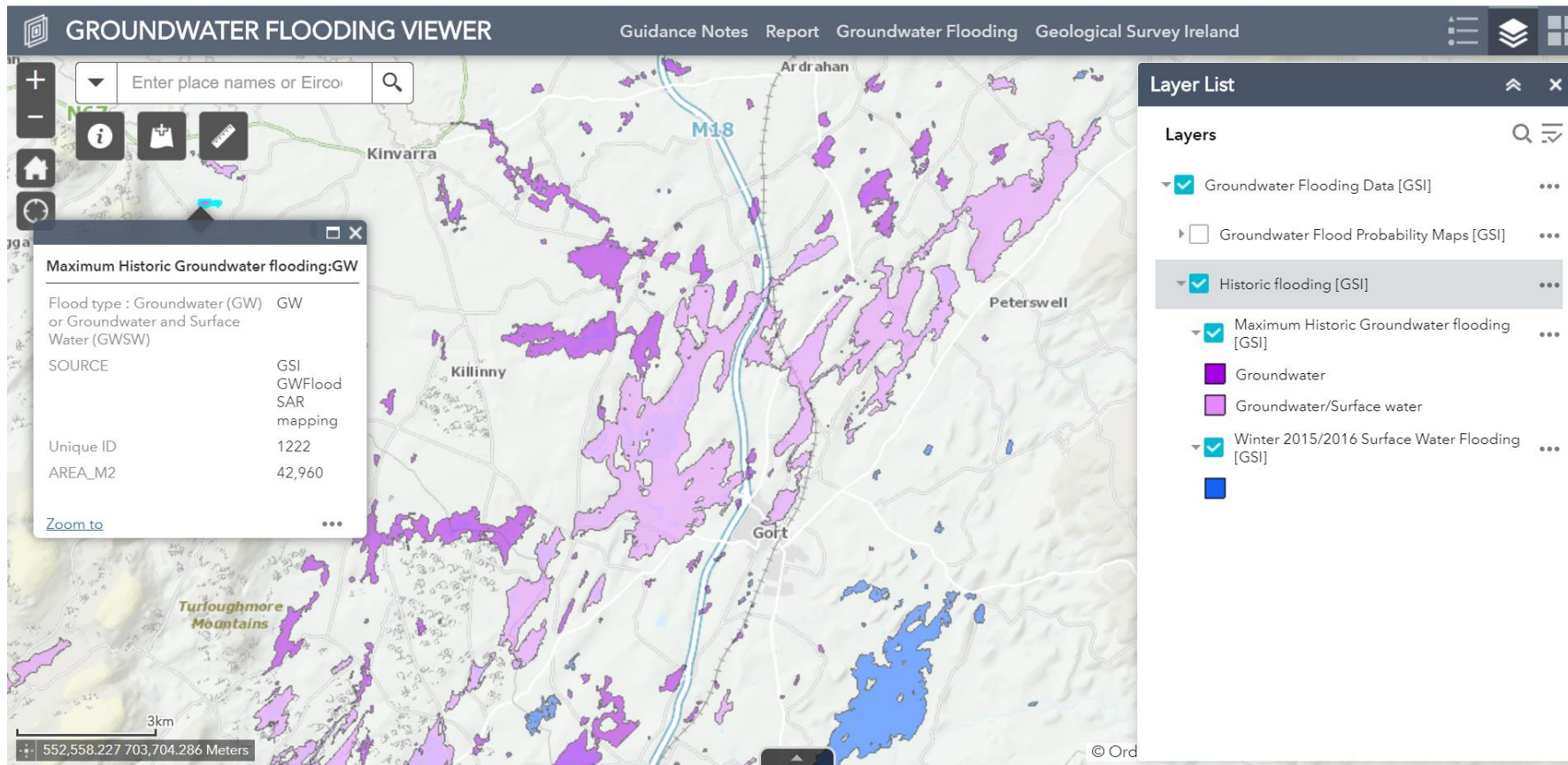
Stage 5 – Predictive Flood Mapping

- 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 km²

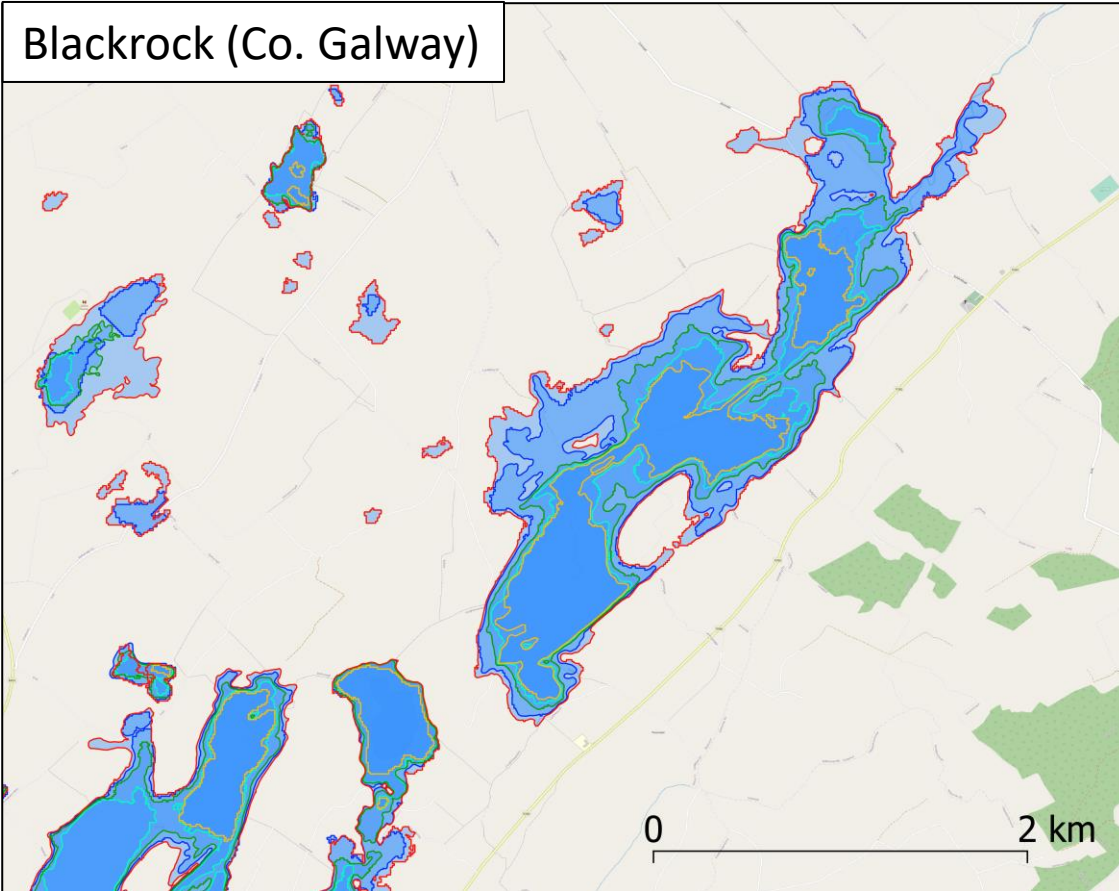
Maps available at www.gsi.ie

Mapping

Seasonal maximum flood extent maps



Blackrock (Co. Galway)

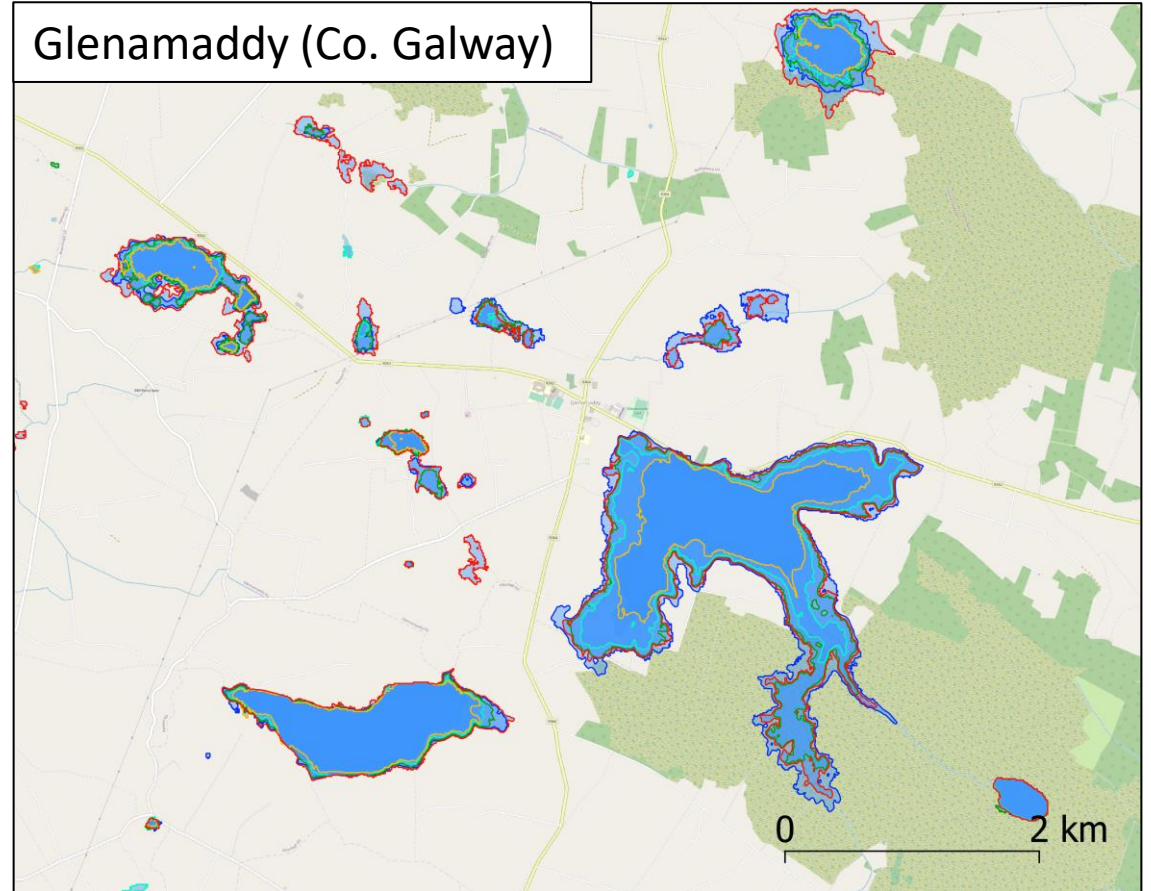


— 2016

— 2017

— 2018

Glenamaddy (Co. Galway)



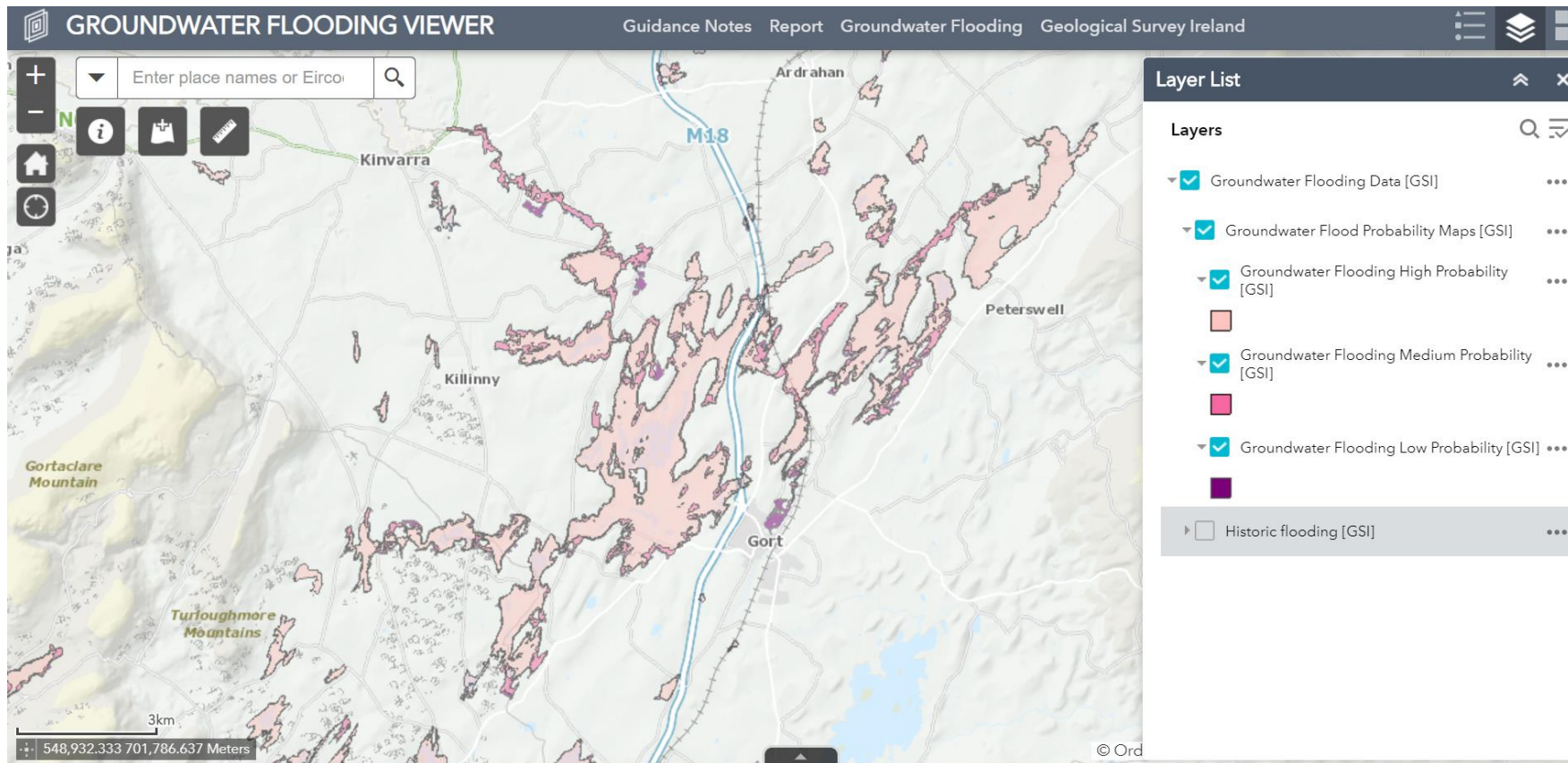
— 2019

— 2020

■ Flood

Mapping

Predictive Groundwater Flood Map



Predictive groundwater flood maps developed using:

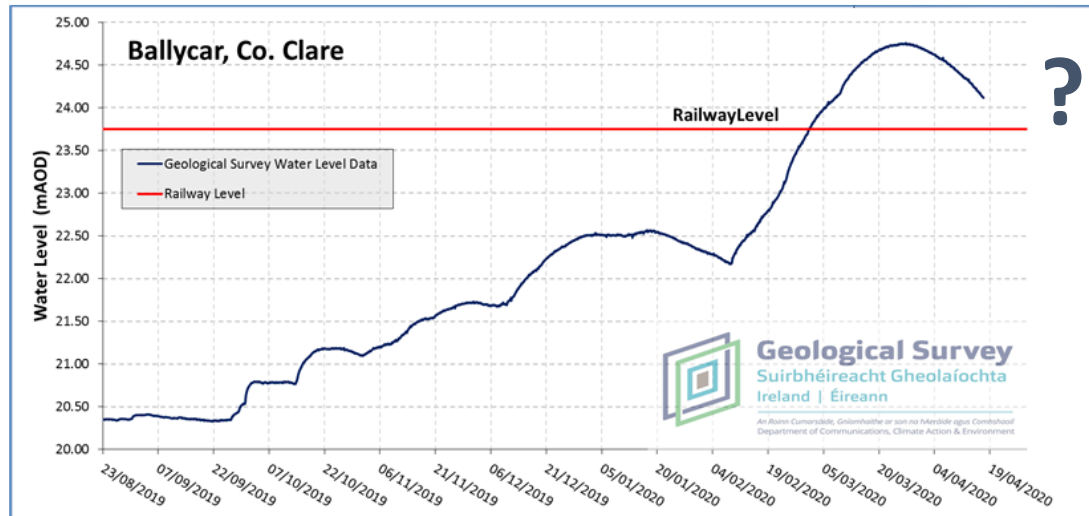
- Hydrological models based on SAR hydrographs and rainfall data
- Long term + stochastic generated rainfall data

Results:

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

Maps available at www.gsi.ie

Forecasting



Forecasting

Inputs

- Hydrographs
- Meteorological data
- Hydrological models

Products

- Short term forecasting
- Medium term estimations

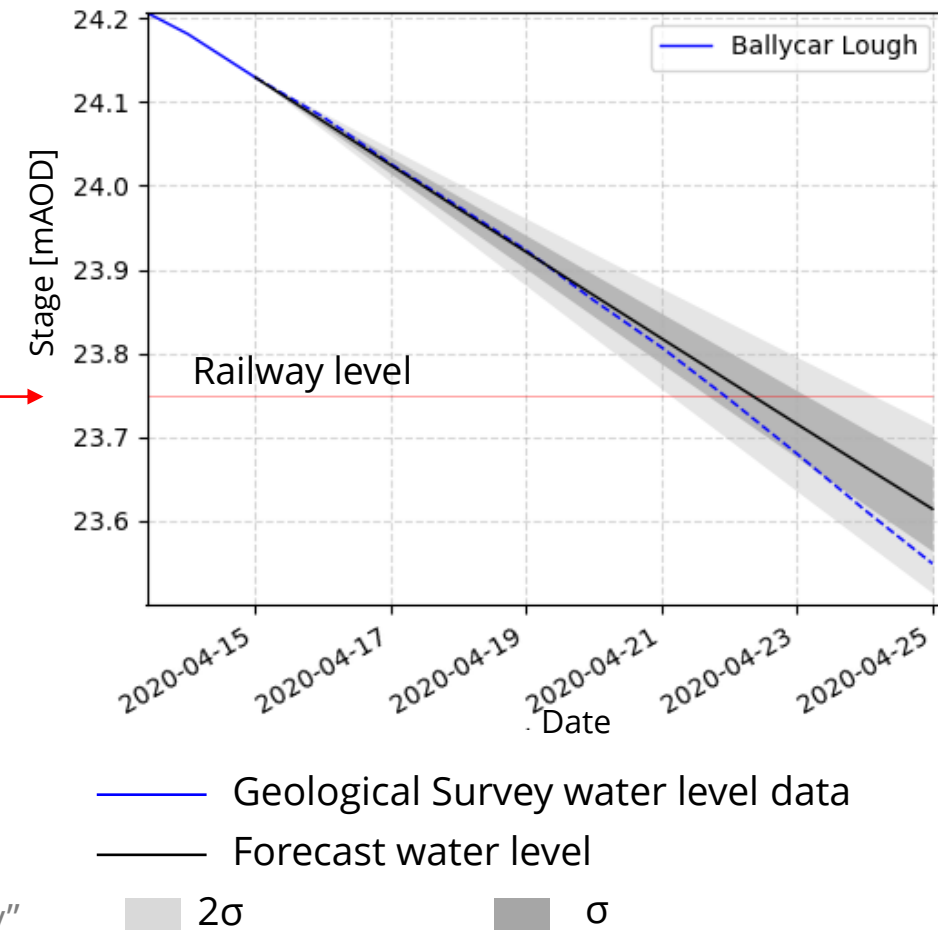
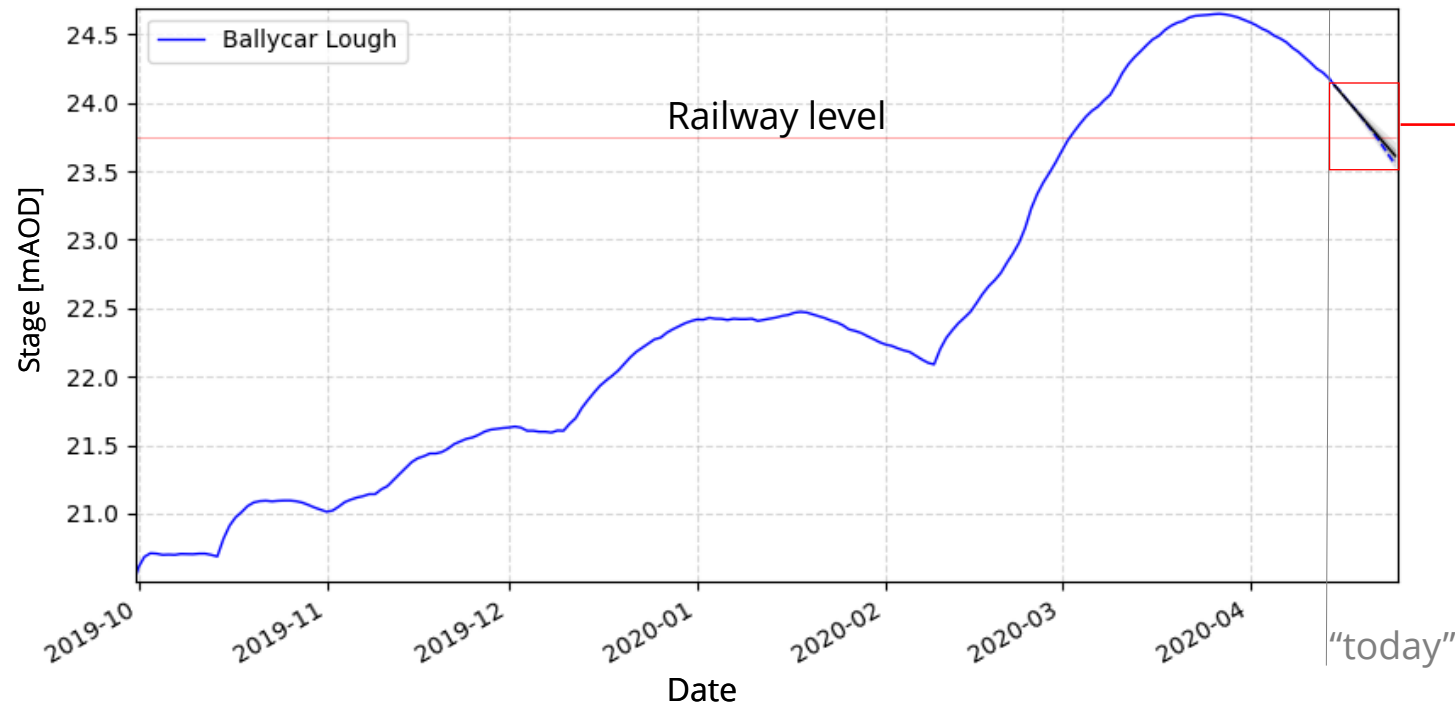
Work in progress...

Forecasting

Short term forecasting

10 days forecast based on:

- Historic and forecast meteorological data
- Hydrological models
- Current groundwater level (hydrographs)



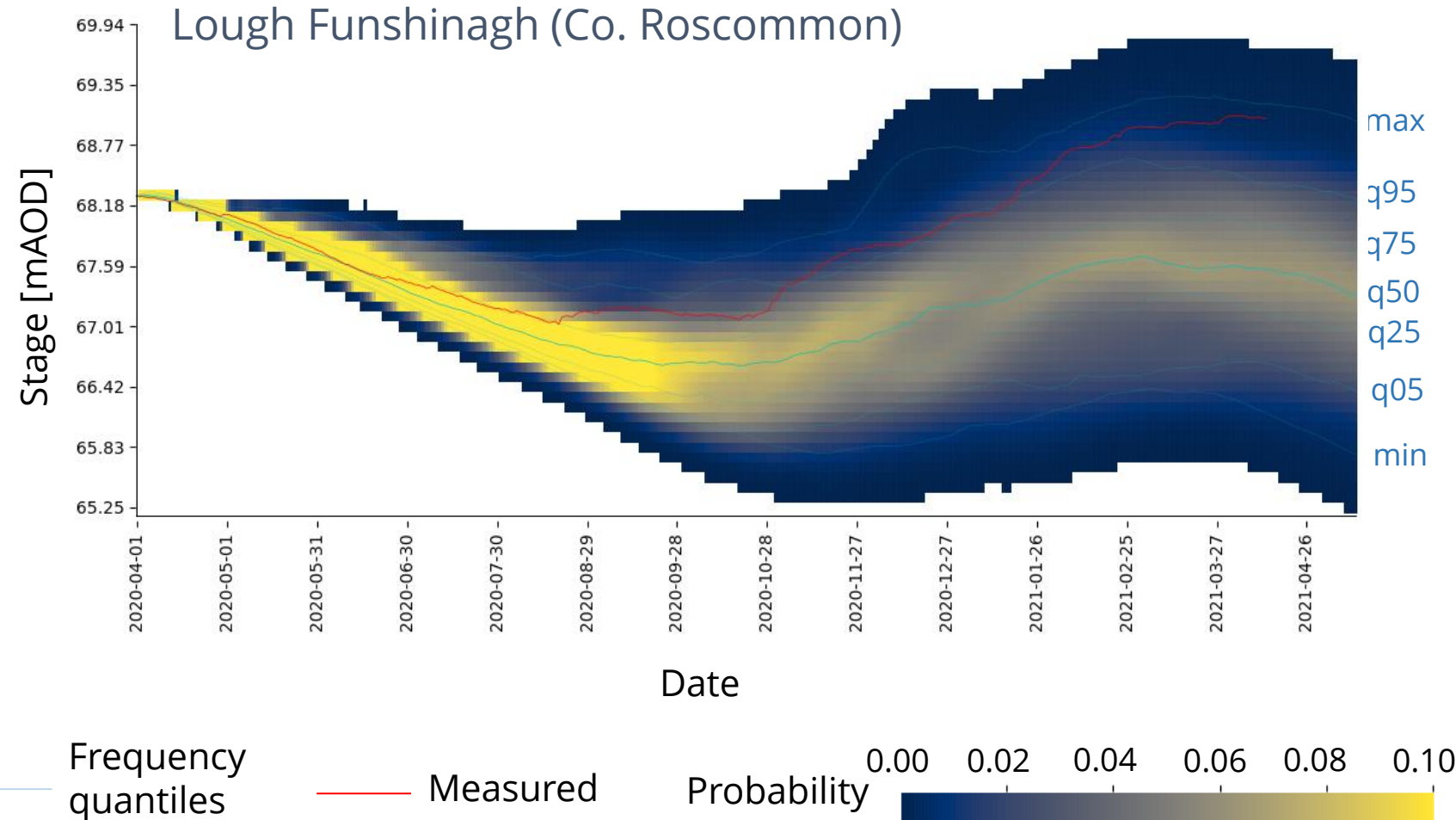
Work in progress...

Forecasting

Medium term estimates

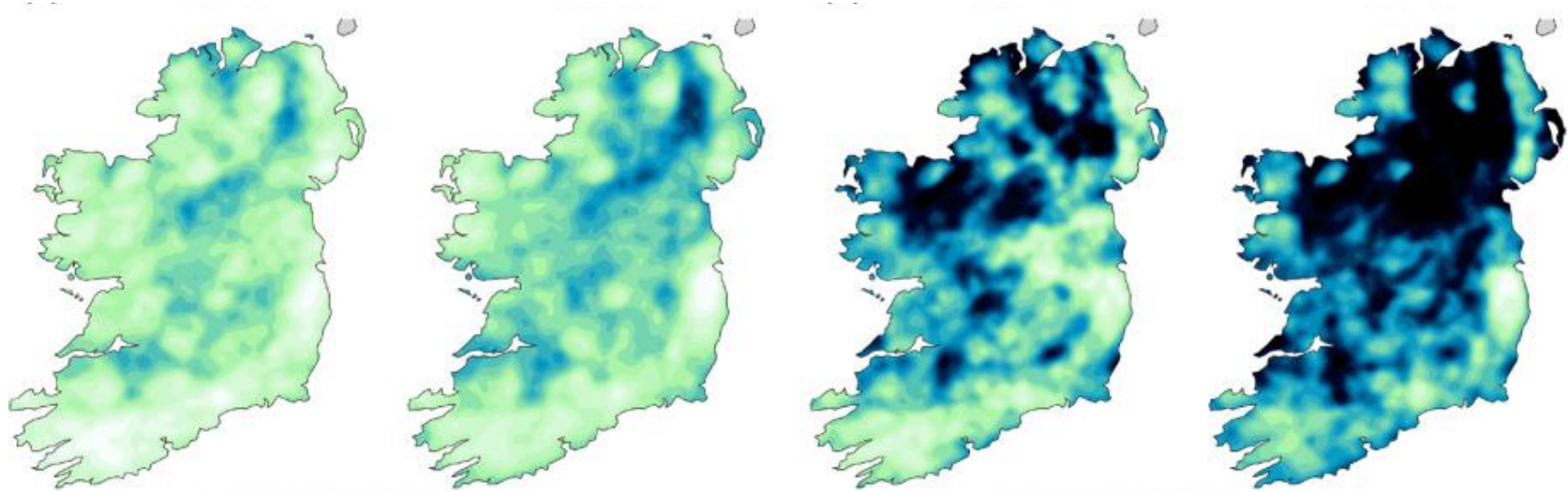
Few months groundwater level estimates based on:

- Previous meteorological data, since 1941
- Hydrological models
- Current groundwater level (hydrographs)



Work in progress...

Climate Change



Climate Change

Inputs

- Hydrological models
- Meteorological data and forecast climate models

Products

- 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%

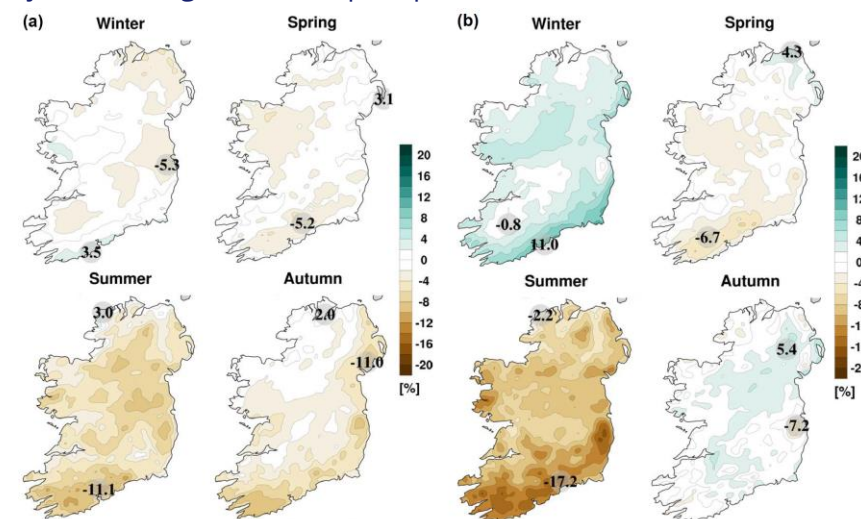
Climate change scenario modelling

- Scenario Led
- Scenario Neutral

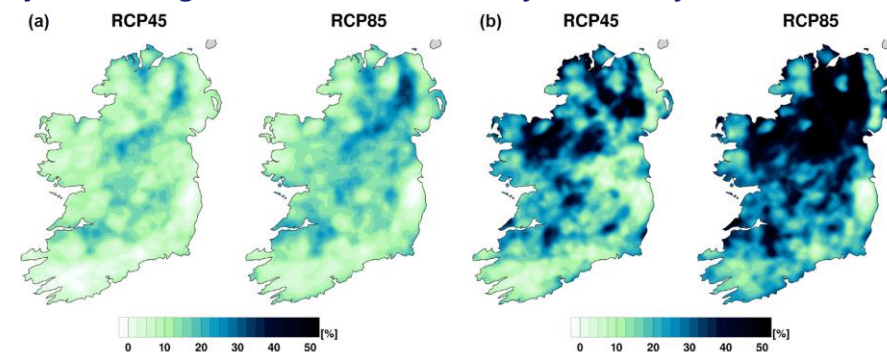
Quantify impact on groundwater

- 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)