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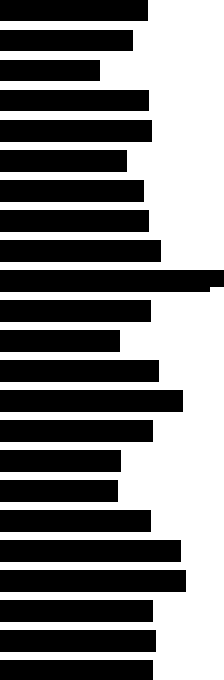
**HYBRID MEETING OF THE ONR EXPERT PANEL ON NATURAL HAZARDS, SUB-PANEL ON METEOROLOGICAL AND FLOODING HAZARDS**

**Wednesday 19 April 2023** - **08:30-16:30**

Windsor House, 50 Victoria St, London SW1H 0TL / Microsoft Teams

**Agenda**

**Attendees**

Professional Lead Civil Engineering and External Hazards Nuclear Safety Inspector

Nuclear Safety Inspector Principal Safety Inspector Nuclear Safety Inspector Nuclear Safety Inspector Nuclear Safety Inspector Nuclear Associate Nuclear Safety Inspector

NR Expert Panel ONR Expert Panel ONR Expert Panel ONR Expert Panel

Climate Change Risk Management (CCRM) Environment Agency

Environment Agency Environment Agency Environment Agency Channel Coastal Observatory

The Engineering Design Institute and Eurocode Panel UK Met Office

UK Met Office Lancaster University

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| --- | --- | --- | --- |
| **Time** | **Item No** | **Item Name** | **Lead** |
| 08:30 | 0 | Gathering |  |
| 09:00 | 1 | Welcome and introductions | ONR |
| 09:15 | 2 | ONR update | ONR |
| 10:00 | 3 | Recent progress on assessing past flooding | CCRM |
| 10:30 | 4 | Break |  |
| Session on extreme ambient temperatures & heat waves | | | |
| 10:45 | 5 | Heatwave impacts on normal operation and | EA |
| 11:15 | 6 | pollution risk across major industries  Changes to weather patterns and extreme events | EP |
| 11:45 | 7 | The July 2022 heatwave & forecasting of future events | UKMO |
| 12:15 | 8 | Lunch |  |

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Session on flooding & coastal morphology changes

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| --- | --- | --- | --- | --- |
| 13:00 | 9 | Spatial and temporal characteristics of compound  flooding around the UK coast | EP |  |
| 13:30 | 10 | Compound Flooding Events | EP |
| 14:00 | 11 | IPCC AR6 Summary | EP |
| 14:30 | 12 | Break |  |  |
| 14:45 | 13 | Shoreline Management Plans | EA |  |
| 15:15 | 14 | National Regional Coastal Monitoring Programme | cco |  |
| 15:45 | 15 | Summary of ONR-RRR-079 | LU |  |
| 16:15 | 16 | Actions and Any Other Business | ONR |  |
| 16:30 | 17 | Thanks and Close | ONR |  |

## ONR Update

ONR opened the meeting and provided an update of regulatory activities relevant to the sub­ panel. ONR re-contracted the Expert Panel on Natural Hazards via a competitive tender process in 2022. The External Hazards technical assessment guide is being updated and an updated version will be published by October 2023. The next Chief Nuclear Inspector's themed inspection is on climate change.

## Recent progress on assessing past flooding

Recent progress with analysis of past flood events was presented. Instrumental river flow records are only available for short timeframes (e.g., decades). UK palaeoflood records reveal flood 'rich' and flood 'poor' periods during the Holocene with abrupt switches in the frequency of significant events, possibly related with climatic changes. Data indicates the second half of the 20th century was flood 'poor' in terms of significant events. Extrapolation from river gauge records alone may underpredict future flood magnitude. Epigraphic flood markers can be used to extend instrumental records. However, they should be combined with sedimentological data and dating techniques to understand temporal geomorphological changes.

A case study for a river catchment was presented showing flood plain elevation has increased through time to its present-day level; if not accounted for historical flood magnitude may be underestimated by up to 30%. Land use change also introduces non-stationarity into the data.

A case study of June 2012 was presented, which was the wettest in England and Wales in record, and amongst the most cyclonic Junes in record. This was possibly related with Arctic amplification and a summer North Atlantic Oscillation index below 0.

## Heatwave impacts on normal operation and pollution risk across major industries

The Environment Agency presented on heatwave impacts across major industrial sectors; this presentation shared learning that may be relevant to the nuclear industry. Case studies were discussed including the effects of heat waves on transport infrastructure. Environmental Permitting Regulations guidance for developing a management system has been updated to focus on an existing requirement to consider climate change. The Environment Agency's ambition is that by 2026 operators of permitted sites (~12,500 regulated by the Environment Agency and Local Authorities) have assessed risks associated with a 4°C rise by 2100, and developed plans to manage risks associated with a 2°c rise by 2050. The Chemical and

Downstream Oil Industries Forum (CDOIF) working group is identifying good practice for climate change adaptation, which may be of interest for ONR.

# Changes to weather patterns and extreme events

The Expert Panel presented on weather and weather patterns in 2022, and their potential relevance with respect to changing weather patterns and adverse events. UK Climate Change Risk Assessment 3 was cited to support the discussion. There have been changes in UK and European maximum temperatures; 9 of the 10 hottest days recorded in the UK occurred since 1990. Adverse weather events were a feature of summer 2022 in UK and Europe and are expected to remain so under the current climate. The statistical significance of high-pressure ‘blocking structures’ with heat wave events was discussed. The El Niño-Southern Oscillation is expected to return in the next few years, which typically causes global mean temperatures to increase. The maximum temperatures observed in the UK in 2022 were high despite it being a la Niña year. Climate sensitivity may be greater than previously considered. Models with high climate sensitivity produce outputs more consistent with the events observed during 2022.

High climate sensitivity implies there could be more global warming in the future with potentially greater climate impacts. Climate tipping points should be considered.

# The July 2022 heatwave & forecasting of future events

The UK Meteorological Office presented learning associated with the July 2022 heatwave event and its use to enhance forecasting of future events. The event was summarised; many long-running meteorological stations measured their hottest day on record. Forecasts for the event gave significant warning (6 days notice of amber warning and 3 days for red). Models had a high predictability for the event and associated temperatures. Event attribution indicates the likelihood of observing such an event in a pre-industrial world is low, and unlikely without climate change. For the 1-day maximum temperatures experienced in July 2022 over central England the return period is estimated at 1 in 1000 years in the current climate. Similar events are likely to become more frequent under future climate scenarios.

# Spatial and temporal characteristics of compound flooding around the UK coast

The Expert Panel presented on example research projects that have analysed the spatial and temporal characteristics of compound flooding. Various case studies were presented:

* The impact of storm clustering and its influence on coastal morphology and defence around the UK coastline.
* Numerical modelling of compound flood events from coastal, fluvial, and pluvial processes at global and regional scales.
* Comp-Flood: Compound flooding in coastal Vietnam.
* Compound flood over coastal area and its impacts in Qiantang Estuary, China.
* Climate Resilience – high-impact storylines and scenarios for risk assessment and planning.
* CHANCE: understanding compound flooding in the past, present and future for North Atlantic coastlines. The project considered changes in the dependence and joint occurrence of flood events as a result of climate change. The project identified different types of spatial surge events, and the inter-annual variability of these events for the UK.
* Impact of climate change on the management, maintenance and operation of storm surge barriers.

# Compound Flooding Events

The Expert Panel presented on compound flood events. Flood impacts can be compounded both spatially and/or temporally (e.g., concurrent hazards affecting a site, multiple sites being affected simultaneously, or a sequence of events affecting a location). Examples compound events were presented. Potential impacts of compound events on infrastructure were discussed including how sequencing of events may have a compounding effect on infrastructure performance. Maintenance and repair windows may be affected by more frequent adverse events.

# IPCC AR6 Summary

The Expert Panel provided a summary of the key findings of the Intergovernmental Panel on Climate Change Sixth Assessment Report (IPCC AR6). Key changes include:

* Updates to temperature rise – higher warming scenarios (e.g., RCP8.5) are now considered less likely but so are very low values.
* Changes in how model projections are used compared with previous assessment reports – e.g., weighting of models based on agreement with observations.
* Changes in the assessment of Equilibrium Climate Sensitivity (ECS) – modelling of southern hemisphere marine clouds increases AR6 ECS. Other contributions remain similar to AR5 (e.g., Planck response and feedbacks). AR6 report gives a "likely" climate sensitivity range of 2.5-4°C, with reduced uncertainty compared with AR5.
* Changes in scenario development.
* Changes in attribution statements (i.e., anthropogenic vs natural variability) – AR6 argues that an unforced climate would probably be cooler and multidecadal variability is very unlikely to be a driver of contemporary warming (i.e., much of the warming is a direct result of best estimate of the human contributions).
* AR6 reporting focuses on those scenarios considered by IPCC to be the least likely (e.g., SSP5-8.5 and RCP8.5) compared with scenarios considered more likely.
* Palaeoclimate gives conflicting results compared with some outputs.
* Uncertainty in Earth System responses (e.g., feedbacks and tipping points).

# Shoreline Management Plans (SMPs)

The Environment Agency presented on shoreline management planning. These plans are long-term, strategic documents setting the flood and coastal erosion risk management of

coastal environments for the next ~100 years split into 3 timescales. They set the management direction based on four overarching policies: Hold the Line, Managed Realignment, No Active Intervention and Advance the Line. There are 22 shoreline management plans covering England and Wales. Since 2019 the Environment Agency has been working on a Shoreline Management Plan refresh project to update the plans and make them more accessible. An online, map-based tool is being developed to host all SMPs around England in one place.

Development is ongoing through 2023.

# National Network of Regional Coastal Monitoring Programmes

The Channel Coastal Observatory presented on the National Network of Regional Coastal Monitoring Programmes. The National Network is part of the UK’s strategic approach to coastal monitoring and understanding associated risks. Various sources of data and information relevant to coastal environments are held by the Channel Coastal Observatory including topographic beach surveys, bathymetry and LiDAR. Data are open access. Analysis

is performed to understand short-term coastal responses to events, such as storms, and also long-term environmental changes. Several case studies were presented.

# Summary of ONR-RRR-079

Lancaster University presented a summary of their research investigating the application of multivariate hazard curves for external hazard contributions. An approach has been developed for quantifying joint events. The PhD thesis includes three peer-reviewed papers that address the methods developed for producing return curves for joint events:

* Development of two novel return curve estimation techniques.
* Accounting for non-stationarity in return curve estimation.
* Tools to evaluate uncertainty and goodness-of-fit when estimating return curves.

The methods introduced by the thesis could allow for a more realistic and robust evaluation of joint events in a non-stationary climate. A summary report will be published to the ONR website with links to the peer-reviewed papers.

# Closing Remarks

ONR thanked the participants and closed the meeting.