E-Rise: earliest detection of sea-level rise accelerations to inform lead time to upgrade/replace coastal flood defence infrastructure

Project details

NERC Grant award number	NE/P009069/1
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Lead institution	University of Southampton
Co-investigators	Francisco Mir Calafat (National Oceanography Centre), Philip Goodwin (University of Southampton), Paolo Cipollini (National Oceanography Centre), Robert Nicholls (University of Southampton)
Project length (including no cost extensions)	15 months
Total funds awarded	£135 949
Industry and other project partners	Environment Agency, HR Wallingford, EDF Energy, Natural Resources Wales
Sectors	Flood and coastal erosion management, flood defences and flood plain management, nuclear
Hazards	High impact, low probability event (H++ scenarios), coastal flooding, sea level rise

Summary

Detecting accelerations in the rate of sea-level rise is not straightforward. However, these forecasts are important for long-term planning for coastal infrastructure and are vital for informing adaptive planning. The aim of this project was to better understand likely lead times for upgrading/replacing coastal defence infrastructure around the UK coast and to assess whether the project team could detect sea-level accelerations earlier to provide sufficient lead time for action. The team developed an active academic and stakeholder group to discuss the issues, challenges and implications relating to detection of sea-level rise and the lead times required to upgrade/replace different types of coastal defence infrastructure. The researchers calculated rates of rise around the UK, before and after accounting for inter-annual variability. They showed that while sea-level rise is accelerating, there is high confidence such levels are below the thresholds currently used for management of the Thames Estuary 2100 plan (Environment Agency, 2012). Finally, the project explored the feasibility of combining *in situ* and satellite-based data with statistical models to develop a toolbox that will help identify timings of future sea-level rise rates and, accordingly, to estimate lead times. This tool will help the Environment Agency to better plan for the future and implement more effective adaptive management pathways.

The challenge or opportunity

Global mean sea levels are rising and the rate of rise is predicted to accelerate. Upgrades to coastal defences will be required to maintain existing flood risk standards. However, this will involve long lead times. There is a need to:

- explore how quickly different sea-level accelerations can be detected, and to compare these with the lead times necessary for upgrading defence infrastructure
- assess whether sea-level accelerations could be detected earlier, extending the lead times available for action.

These issues are important in relation to the adaptive pathway approach for managing increasing flood risk that was pioneered by the Environment Agency (2012) plan. Although the essence of an adaptive management plan is its ability to adapt when needed, it will only be effective if:

- a significant acceleration in sea-level rise is detected and a decision is made in timely manner to move to an alternative pathway
- there is an appropriate lead time to carry out the necessary adaptation.

The science

The E-Rise project built on significant progress made in understanding sea-level accelerations in previous NERC-funded (Rohling, 2015) and other relevant research (Kilsby, 2016). In these earlier projects, researchers showed that detecting accelerations in the rate of sea-level rise is not straightforward, due to the considerable inter-annual variability evident in sea level at regional/local scales, which 'swamps' the smaller underlying acceleration signal. As a result, it could take several decades (for rises up to one metre by 2100) to several years (for rises up to two metres) before discernible accelerations in sea-level rise are detected. These findings showed the need for exploring how quickly different sea-level accelerations can be detected, and to compare these with the lead times that are necessary for upgrading/replacing different defence infrastructure. These issues are particularly important in relation to the adaptive pathway approach for managing increasing flood risk, which is increasingly being used for other defence upgrade schemes around the country and worldwide. The design of the toolbox developed by the researchers was based on a novel approach for assessing sea-level accelerations that the team had previously pioneered, and their improved understanding of the impact of inter-annual variability on sea-level trends.

The innovation

The first phase was to develop a group, to discuss the issues, challenges and implications relating to detection of sea-level accelerations and lead times. Four meetings were held to extensively deliberate about these issues, involving staff from the Environment Agency, EDF Energy, HR Wallingford and Natural Resources Wales.

The second phase was to calculate rates of sea-level acceleration around the UK. Using a novel approach, based on previous research, the team calculated sea-level rise rates before and after accounting for inter-annual variability. Working closely with Environment Agency staff, they compared these rates of rise, to the projections set out by the Environment Agency (2012) plan. The study, which used a new approach for removing the influence of inter-annual variability, is the first to find statistically-significant rates of sea-level rise acceleration around the UK. The key benefit for the Environment Agency is that the results showed that while sea-level rise is accelerating, there is high confidence it is below the thresholds used for management of the plan.

In the third and final phase, the project explored the feasibility of combining *in situ* and satellite-based data with statistical models to develop an innovative web-based toolbox that will help identify timings (with uncertainties) of sea-level rise rates and, accordingly, to estimate lead times. The team are currently using this tool to help the Environment Agency to better plan for the future and adopt more effective and adaptive management pathways, and examine the planning and engineering requirements and their associated lead times for upgrading/replacing the Thames Barrier and associated defences.

The outcome to date (impact or potential impact)

The impact achieved in this project primarily relates to UK policy leadership. A key outcome of E-Rise is the development of a new innovative framework for monitoring sea-level rise accelerations and considering lead times for upgrading coastal defence infrastructure. By accounting for and removing the influence of inter-annual variability in sea-level records, the team have been able to detect accelerations in sea-level rise earlier. The project demonstrated with high confidence and by comparing current rates of rise with the projections set out in the Environment Agency (2012) plan that current rates are below the thresholds of the current pathway of the plan. This has significantly increased the Environment Agency's confidence that it is not yet necessary to move to an alternative pathway and there is appropriate lead time required for future upgrades specific in the plan. The approach will allow the Environment Agency to better monitor change in the future, ensuring that if a significant acceleration in sea-level rise is detected a decision is made in timely manner to move to an alternative pathway. This approach is a major advancement on the sea-level assessment undertaken for the five-year review of the Thames Estuary plan, and results of E-Rise will feed directly into the 10-year review, providing a tangible measure of impact. The adaptive management approach, pioneered in the Thames Estuary plan, is increasingly being used elsewhere in the UK and worldwide. This project also relates to competitive advantages in the UK, as flood risk management is a significant international challenge and the strategic nature of UK expertise is at a premium.

What next?

The researchers will continue to work with the Environment Agency to monitor sea-level accelerations and will assess them with the sea-level analysis component in the 10-year review of the Thames Estuary plan. While E-Rise focused entirely on mean sea level and applications of this for the Thames Barrier and associated defences, changes in other parameters (e.g. tidal range) are also crucial to consider for future management of the Barrier and associated defences. The Thames Estuary 2100 team have recently identified changes in tidal range as a key area for future work. Following, some of the methods applied in E-Rise could be extended to consider changes in tidal range in the Estuary and the implications this would have on the plan. Again, outputs from this will feed into the Environment Agency's more detailed 10-year review that is underway.

Lessons learned, knowledge shared, partnerships formed

If understood components of the inter-annual variability in sea-level records are removed, then accelerations in sea level are likely to become detectable in records much earlier.

The academic team has engaged closely with the partners thought the project. Due to the partnership formed, several of the existing partners have provided their support to related proposal bids. The team is keen to maintain this long-term partnership to generate further beneficial impacts.

Participants and acknowledgements

Katy Francis, James Brand, Tim Reeder, Environment Agency

Hugo Winter, EDF Energy

Ben Gouldby, HR Wallingford

Richard Park, Natural Resources Wales

The E-rise project and tool have and will continue to help us explore and understand how the sea level rise we are monitoring in the Thames Estuary compares to projections and as a result will help to inform our investment decision making for the flood defence system.

Katy Francis

Senior Advisor, Thames Estuary 2100 Team, Environment Agency,

Further information

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Lead institution

UNIVERSITY OF Southampton

Industry partners

Environment Agency

This project was funded through the Environmental Risks to Infrastructure Innovation Programme (ERIIP). Through ERIIP the Natural Environment Research Council (NERC) is enabling collaboration between academia and infrastructure owners and operators to use the latest environmental science to identify, quantify and manage environmental risks.

The five-year, £5m initiative, which is driven by the needs of the business community, is translating the latest research into industry relevant outputs.

For more information please visit: **www.nerc.ac.uk/innovation/activities/infrastructure/envrisks**

ciria

Further information

NERC has contracted CIRIA to support academic–industry collaborations and manage the dissemination of outputs for this programme.

For more information visit: **www.ciria.org/Research/Projects_underway2/NERC.aspx**