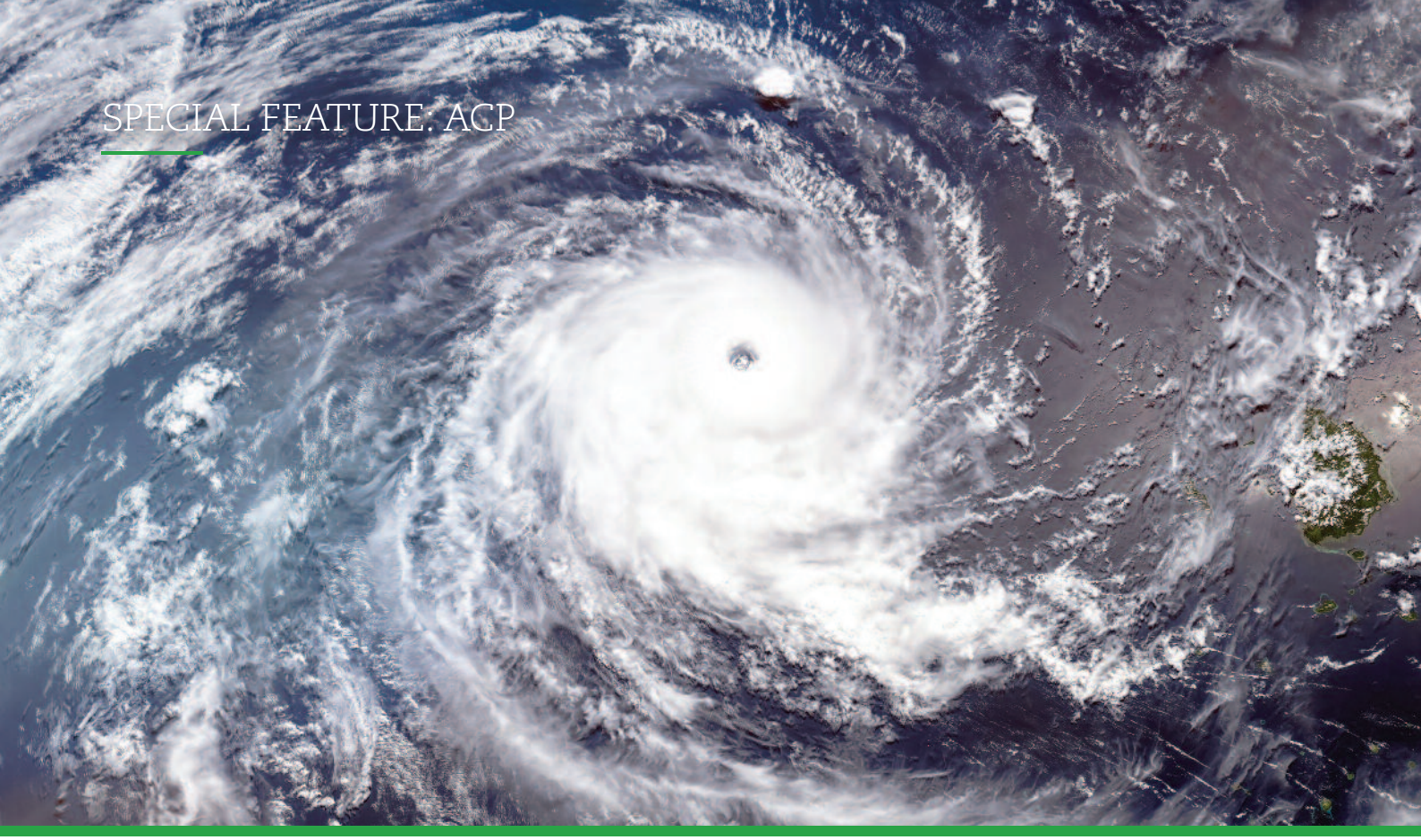

Climate phenomena and catchment water quality

Collaborative TEAGASC research studied the effects of the North Atlantic Oscillation on water quality in Ireland and elsewhere in north-west Europe.

Do climate and weather conditions alter the effectiveness of diffuse pollution measures? Agricultural Catchments Programme (ACP) researchers say they likely do across north-west Europe and may both help and hinder water quality management. The Water Framework Directive requires EU member states to protect all water resources and make improvements where these are needed. Agriculture is a key pressure, mainly due to the risk of phosphorus (P) and nitrogen (N) losses from land, especially during wet weather, and which can lead to water quality problems. In Ireland, measures to reduce these pressures from agriculture are mostly contained in the Nitrates Action Programme and there is an expectation that, as time passes, the measures will have a positive impact on water quality.

But variations in weather conditions may influence how successful these measures are and extremes such as floods and droughts are important to consider.

Climate oscillations

But variations in weather conditions may influence how successful these measures are and extremes such as floods and droughts are important to consider. There are also trends in weather conditions that are linked to longer-term climate systems over the major oceans and these may affect our weather from year to year and over decades. One such climate system is the North Atlantic Oscillation (NAO). This is a difference in atmospheric pressure between the north and mid-Atlantic latitudes and is described by a simple index. In positive phases of the NAO index, weather in north-west Europe is associated with elevated air temperatures in summer and more frequent large rainfall events in winter. The opposite is true when the differences in atmospheric pressure flip to negative phases of the NAO. These phases can grow and diminish over decadal time scales and influence weather patterns over wide areas. Since approximately 2009, the annual average NAO index has sharply increased to a positive phase (**Figure 1**).
As weather conditions influence both soil temperature and the way in which rainwater flows over and through agricultural soils – conditions important for moving nutrients from land to water – we investigated links to the NAO (Mellander *et al.*, 2018). This type of analysis can only be made with a complete dataset of water quality measurements that covers all stages of

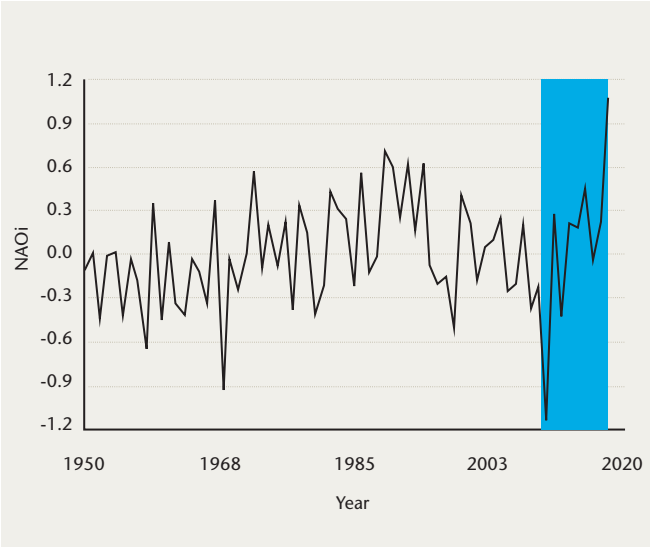

FIGURE 1: The NAO index from the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center. The line shows the annual average NAO index. The shaded area shows the time period the ACP monitored phosphorus and nitrate concentrations in Irish rivers.

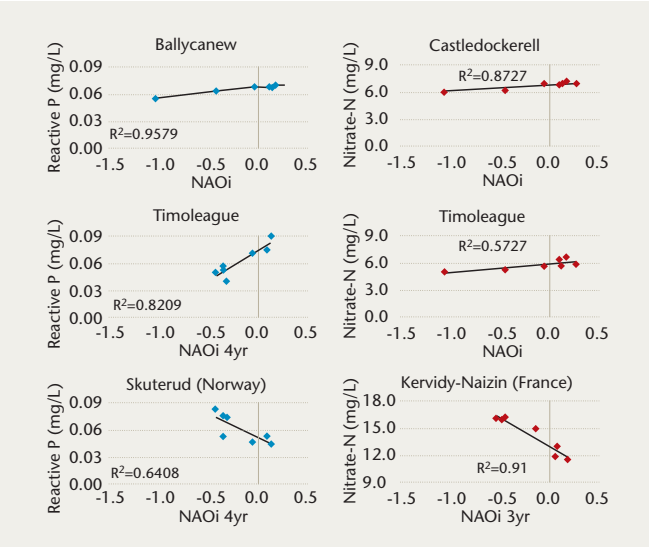

FIGURE 2: Examples of annual averages of reactive phosphorus and nitrate-N concentrations correlated to the annual average, three-year or four-year antecedent moving average North Atlantic Oscillation index (NAOi) for the period 2009-2016 in two different catchment typologies (top four positive correlations; bottom two negative correlations; third typology of catchments with no correlation is not shown).

river flow on annual cycles. The ACP collected these data from six catchments across Ireland at high resolution, and made the analysis over six years from 2009-2015. We included seven other catchment datasets from Norway and France, where there was a similar emphasis on full-data coverage, over the same time period and where weather is also potentially influenced by the NAO.

Results

When P and nitrate concentrations in catchment rivers were compared with the NAO on an annual scale, we found some with positive, some with negative and some with zero correlations, i.e., three typologies (**Figure 2**).

This means that climate has a profound impact on the state of annual river chemical water quality, at least in two catchment typologies. Furthermore, in this period of a positive NAO index, some catchments in north-west Europe may indicate a worsening of water quality (increases in annual concentration) and some may indicate an improvement. Both conditions make the job of assessing the combined influences of land use management more difficult.

The reasons for a strong climate-weather related influence on water quality are likely related to soil and geological factors and how these partition rainfall in runoff – sometimes amplifying runoff pathways into critical source areas and sometimes causing dilution.

From the analysis in this study we propose that shorter-term policy reviews take account of climate factors such as the NAO in order to gain a better understanding of cause and effect between land use, mitigation measures and water quality. This is particularly important as the NAO and other decadal-scale oceanic climate systems are likely to oscillate differently with global climate changes. Integrating catchment typologies into these reviews that account for climate-weather influences will be important and, to be robust, may require further investment in higher temporal resolution water quality monitoring in important or sensitive catchments.

References

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