However, it is a syllogistic fallacy to conclude that the record precipitation was caused by the NAO, since other circulation patterns are known to have stronger influences on the storm track in this region. Historical data shows that the NAO accounts for only 5.4% of the variance in precipitation — its influence is predominantly over northwestern parts of the UK (Supplementary Fig. 2), where flooding was unexceptional in 2013/14. Conversely, a pressure pattern with a low to the west of Scotland rather than over Iceland (Supplementary Fig. 1c) accounts for 80% of the variance in precipitation in southern England and had an exceptionally low index in 2013/14. Hence, despite precipitation in the region being a small area-average, there does appear to be a highly correlated atmospheric driver, which is substantially different from the NAO. This is not surprising, because previous studies have shown that combinations/mixtures of several major modes/regimes are required to adequately describe local storminess (refs 2,3, for example).

Similarly, we find in end-to-end analyses that a positive AMO index on average was associated with slightly less rain in southwestern England. There is no empirical or published evidence of Indonesian sea surface temperature (or rainfall) nor the QBO nor solar activity (including lags) affecting rainfall in southern England.

Previous studies of observational data have found no evidence for more persistent flow regimes due to Arctic sea-ice melting[4], and there is no evidence of an influence in western Europe even in a large ensemble of simulations with one climate model[5]. Details can be found in the Supplementary Information.

To conclude, due to the lack of any strong associations with precipitation in southern England, we find it difficult to believe that any of the proposed drivers could have been responsible for the extreme event in winter 2013/14. Even a multiple linear regression model containing all the drivers shown in Fig. 1 explains only 5.5% of the total variance in precipitation. Furthermore, Huntingford *et al.*[1] fail to mention in the 'Weather and climate change drivers' section other more relevant drivers — such as more appropriate atmospheric circulation patterns and atmospheric moisture content, which has risen due to global warming[6,7]. Exceptional flood events are often strongly localized in space and so can be expected to have drivers that depend on the specific target region rather than large-scale modes of variability. ❐

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Additional information

Supplementary information is available in the online version version of the paper.

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Reply to 'Drivers of the 2013/14 winter floods in the UK'

Huntingford *et al.* reply — Our Perspective[1] on the potential factors in the UK floods of December, January and February 2013/14 (DJF1314) discusses potential links between remote drivers in the climate system, Atlantic atmospheric circulation and storminess and UK precipitation. Based on a correlational analysis, van Oldenborgh *et al.*[2] are critical of these links, arguing for instance that winter rainfall amounts for parts of the UK have only a correlation of 0.23 when compared with the North Atlantic Oscillation (NAO). The disagreement is essentially one of spatial scale: their arguments are based on a particularly localized measure of rainfall for southern England, rather than the Atlantic atmospheric circulation or more UK-wide precipitation and river flows that we discussed.

We agree with van Oldenborgh *et al.*[2] that the scale-dependence of the response to remote drivers has important practical implications: if the response to a particular driver is only evident on very large scales, and not at the scale of a river catchment, then its utility may be quite limited in terms of analysis and prediction of specific flood events. Improved understanding of the role of remote drivers in the overall synoptic situation in DJF1314 may, nevertheless, provide improved warnings for flood-prone areas. This is valid, even if it does not translate into a substantial improvement in a simple correlation skill for local rainfall.

van Oldenborgh *et al.* question our use of the NAO index when discussing DJF1314, arguing that other pressure patterns are better related to rainfall in the UK. While we agree that the observed sea-level pressure pattern from last winter is not simply characterized by the NAO, the sea-level pressure NAO index for winter 2013/14 was ~12hPa (1.5 standard deviations) above normal. This is an atmospheric pattern that is known to emerge in response to a multitude of external climate drivers, including those discussed in our Perspective and the references therein.

Interactions between drivers can also result in relationships being obscured in correlation analyses. As an example (albeit not specifically relevant to DJF1314), El Niño is well established as a particularly strong driver of the global climate state[3] with recently verified influence on northern European winter climate[4,5] yet it occurs only episodically, every five years or so. In the years when El Niño is inactive, the atmospheric circulation will continue to vary due to internal fluctuations and external drivers. A correlation across all years can therefore easily mask the influence of El Niño in the years when it is active. For many of the drivers we highlighted, multiple modelling and observational studies show statistically significant influences on Atlantic–European surface climate when they are active.

Our Perspective reviews the enormous literature that relates particular phases and drivers of the Earth system to Atlantic circulation and hence to the risk of extreme rainfall in the UK. Many of these drivers appear to have been contributing to a large-scale synoptic situation conducive to flooding in the UK in DJF1314. We remain confident that improved modelling of such drivers will improve our ability to interpret and predict both long-term and year-to-year variations in flood risk. However, we are particularly careful in our Perspective article not to attribute DJF1314 rainfall events to any specific driver. Instead, the purpose of our study was to highlight that it is important to correctly model known teleconnections to Atlantic circulation if we are to understand and predict changing flood risks. That said, as van Oldenborgh *et al.*[2] correctly note, an ability to predict flood risk should not be confused with capability to predict individual flood events: the enormous importance of chance should always be acknowledged in any discussion of our chaotic weather. ❐

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CORRESPONDENCE:

Tidal river management in Bangladesh

To the Editor — The study by Auerbach *et al.*[1] advances understanding of the drivers of flood risk in natural and embanked regions of the coastal and tidal regions of Bangladesh. The quantification of sedimentation rates and how effectively periodic opening and closing of polders may result in elevation recovery is valuable in the context of reducing the vulnerability of coastal Bangladesh to flooding in the twenty-first century.

However, we are surprised at the authors' apparent lack of awareness of the long-practiced protocol called tidal river management (TRM) and its successful implementation for over a decade in coastal Bangladesh[2,3]. TRM involves the periodic cutting and closing of polders to accelerate land accretion (or reclamation). TRM as a concept has been around since the 1990s and has been practised or analysed by many local stakeholder entities such as the Institute of Water Modelling of Bangladesh for elevation recovery in several (embanked) regions in coastal Bangladesh. Thus, the management strategy advocated by Auerbach *et al.*[1] is not so innovative.

In summary, we commend the authors' quantitative work on understanding flood risk on embanked polder regions. However, the Letter could be more cognizant of previous studies and could have benefited by learning from local wisdom to potentially make their research more useful to the local stakeholders[4]. ❐

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Reply to 'Tidal river management in Bangladesh'

Auerbach *et al.* reply — We appreciate the opportunity to address tidal river management (TRM), as raised by Hossain and colleagues[1]. We are aware of TRM but made the decision not to include it in our Letter[2] on flood risk on the Ganges-Brahmaputra tidal delta plain for the following reasons.

First, our Letter[2] concerns a major disaster that displaced >100,000 people and flooded an anthropogenically degraded landscape for nearly two years. These circumstances, and our finding that decimetres of sandy, saline sediment unsuitable for agriculture were deposited, do not lead to a simple endorsement of TRM.

Second, TRM presents neither a simple engineering solution nor one that is socially or politically straightforward. Beyond the TRM implementations noted by Hossain and colleagues[1], there have been well-documented failures resulting from both engineering challenges[3] and lack of proper social discourse[4]. Although these occurrences do not discount the potential benefits of TRM[5–7], they do preclude an unqualified prescription in the context of our Letter.

Third, sites where TRM has been used lie >50 km inland of Polder 32 — where the physical environment is considerably different, with reduced tidal energy and less saline surface waters. Furthermore, the area of TRM test sites is about a third of the size of Polder 32, and together these areas comprise <1% of the 5,000 km² of southwest Bangladesh. Thus to consider the application of TRM across the region is premature.