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Storm surge and tide interaction: a complete paradigm

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Globally, 200 million people live on coastal floodplains and about $1 trillion worth of assets lie within 1 metre of mean sea level. Any change in the statistics of flood frequency or severity would impact on economic and social systems. It is therefore crucial to understand the physical drivers of extreme storm surges, and to have confidence in datasets used for extreme sea level statistics. Much previous research has focussed on the process of tide-surge interaction, and it is now widely accepted that the physical basis of tide-surge interaction is that a phase shift of the tidal signal represents the effect of the surge on the tide. The second aspect of interaction is that shallow water momentum considerations imply that differing tidal states should modulate surge generation: wind stress should have greater surge-generating potential on lower tides. This has been shown previously by analytical models but not as yet confirmed by fully non-linear models of the continental shelf.

We present results from an operational model of the European shelf that demonstrate that tidal range does have an effect on the surges generated. The cycle-integrated effects of wind stress (i.e. the skew surge) are generally greater when tidal range is low. Our results contradict the absence of any such correlation observed in the complete record of UK tide gauge data. This suggests that whilst the modulating effect of the tide on the skew surge (the time-independent difference between peak prediction and observations) is significant, the difference between individual storms is dominant. This implies that forecasting systems must predict salient detail of the most intense storms. A further implication is that operational models need to simulate tides with acceptable accuracy at all coastal locations. We extend our model analysis to show that the same modulation of storm surges (by tidal conditions) applies to tropical cyclones. We conduct simulations using a mature operational storm surge model in the Bay of Bengal with tropical cyclones from the IBTrACs database; we demonstrate that - just as with the extra-tropical case - higher storm surges on the Bangladesh coastline are generated during smaller tides.