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The first taste of a summer to come? Why Australian beaches are some of the most sensitive in the world to La Niña

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The heavy rain, large waves, strong winds and high tides impacting northern NSW and southeast Queensland this week come with the first significant summer storm event the region has experienced since last February. It has already led to significant flooding and coastal erosion on the Sunshine Coast, Brisbane area and across the border as far south as the mid North NSW Coast, coinciding with high tides, with storm wave conditions expected to remain for the next few days.

Figure 1. *Much of Southeast Queensland and Northern NSW has experienced severe erosion and flooding over the past several days. Source: Adam Head, The Courier-Mail (2020).*

This may be an early taste of Australia's first La Niña summer for almost a decade. At the same time, a new global study, co-authored by Risk Frontiers, provides a timely reminder of just how important La Niña is for the Southeast Australian coast.

Erosion and flooding for Southeast Queensland and Northern NSW

On 14 December, the Brisbane wave buoy, located off North Stradbroke Island, recorded maximum wave heights of over 14 m (~ 45 ft.), with a storm surge exceeding 0.5 m at several gauge sites between Tweed Heads and the Sunshine Coast. Of particular importance with regard to coastal erosion was the storm direction, with waves approaching from the east (Figure 2, right panel), directed at the southern section of beach compartments usually protected from the prevailing south-easterly wave energy by southern headlands.

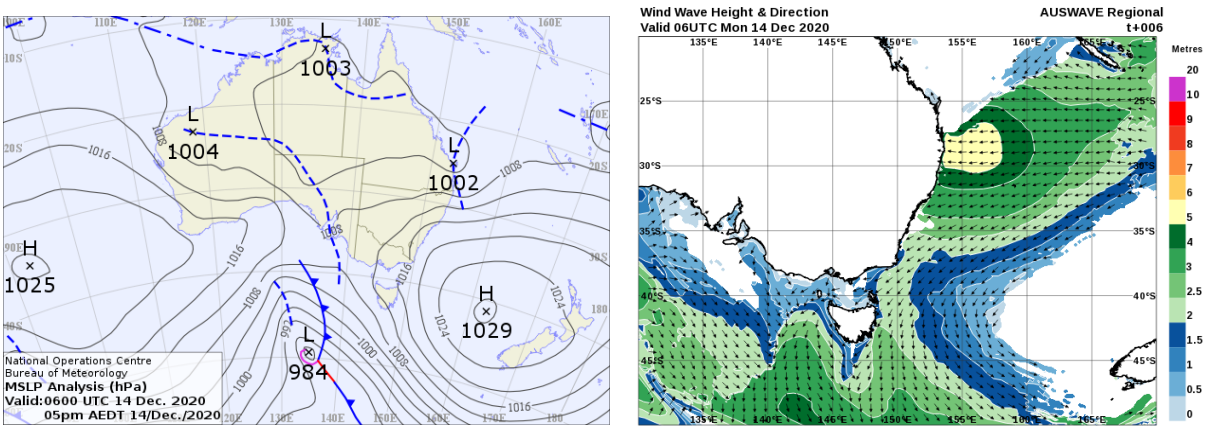

Figure 2. *Synoptic plot (left) and storm wave conditions (right) at 5 pm AEST on 14 December. Note the east to north-east wave direction focused on the Gold Coast / Byron Bay area. Source: BoM (2020).*

Compounding the hazard, storm waves and the surge coincided with the morning spring high tides, with the result that the Highest Astronomical Tide (HAT) level was exceeded in many locations along this stretch of coast, with flooding of low-lying coastal areas occurring simultaneously with storm flows discharging from coastal catchments.

A low developed in the Easterly Dip in a strong blocking high pressure over the Central Tasman Sea (Figure 2, left panel). This low intensified close to the coast and the easterly airstream transported tropical air masses from the Fiji region where two Tropical Cyclones had formed. This onset of Tropical Low and Cyclone formation occurred as the deep equatorial convection associated with the Madden Julian Oscillation migrated westwards into the Coral Sea zone. This typical La Niña weather pattern provides favourable driving conditions for heightened flood and coastal erosion risk east of the Great Dividing Range.

As yet, we have not experienced the full effects of the maturing La Niña event in the Pacific, although this type of event is very much in-phase with what we might expect over the coming summer period. The seasonal forecast is for above-average rainfall along the east coast and heightened cyclone activity, with La Niña conditions expected to peak in January and decay from mid-February.

New study shows Australian beaches are some of the most sensitive in the world to La Niña

A recent paper co-authored by Risk Frontiers with colleagues at the National Autonomous University of Mexico (UNAM), and the Disaster Prevention Research Institute, Kyoto University, Japan, published last week in the Journal of Geophysical Research Oceans, provides a timely indication of just how sensitive the Australian coast is to shifts in El Niño Southern Oscillation (ENSO).

The global coastline was classified into five distinct types, depending on the directional wave climate response to ENSO (Figure 3). Results show that the Australian east coast is one of the most sensitive locations in the world to changes in wave conditions with La Niña, comparable with the west coast of Chile and the east coast of China, returning some of the highest correlation scores with La Niña phases globally (see Odériz et al., 2020).

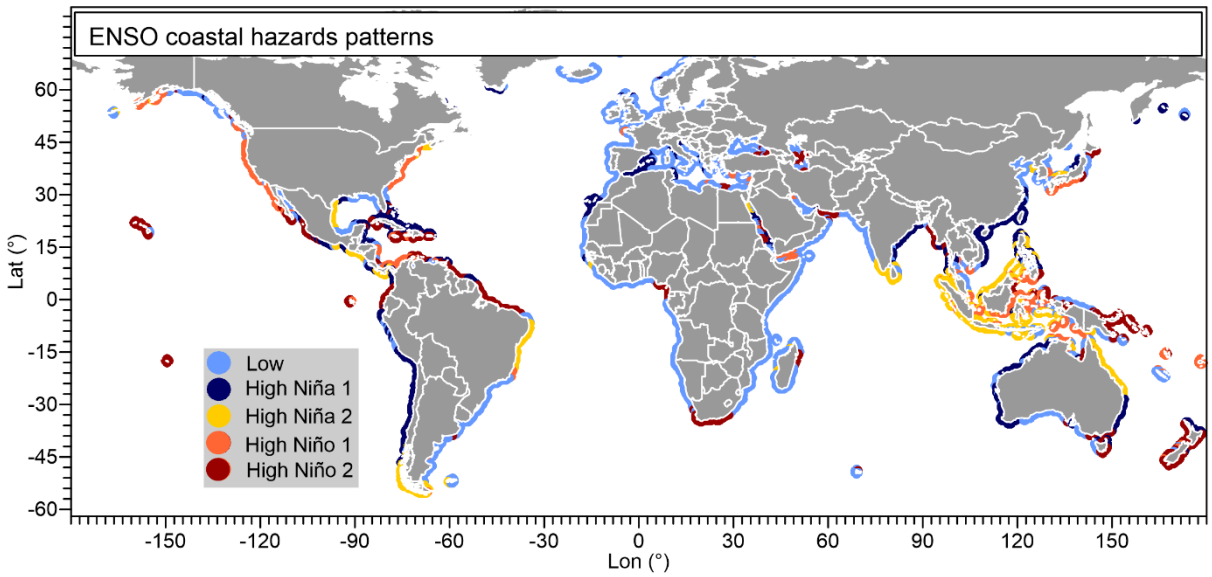

***Figure 3**. Classification of the global coast into five types according to near-coastal wave climate response to El Niño and La Niña. The Southeast Australian coast is classified as "High Niña 1", meaning wave power tends to increase and wave direction rotates anticlockwise (becomes more easterly) during La Niña. High Niña 2 refers to areas where wave power increases and wave direction rotates clockwise during La Niña (such as the Queensland coast). High Niño 1 indicates areas where wave power increases and wave direction rotates anticlockwise during El Niño, and High Niño 2 denotes areas where wave power increases and wave direction rotates clockwise during El Niño. Source: Odériz et al. (2020).*

While coastal practitioners in Australia are already fully aware of the impacts ENSO can have on coastal behaviour, this study puts the Australian experience into a stark global context. It emphasises the importance of inter-annual climate variability, in addition to long-term climate change, for the management and risk quantification of our coastal environments.

Changes to wave direction expected this summer

The study also shows that during the major La Niña events of the past few decades the real change in wave conditions is the direction the waves are coming from rather than change in wave power. In the case of Southeast Australia this is an anticlockwise shift, meaning more waves come from the east and north-east during La Niña rather than the usual south-easterly direction.

This, incidentally, is what we have seen with the current storm event on the north coast – and it is very damaging to the coast. This is because the coastline in Southeast Australia is equilibrated with a predominantly south-easterly wave climate, and when storms come from a direction that is different to this, they can cause a substantial amount of damage.

Our seasonal forecast for December through to February indicates a typical La Niña summer with east to northeast trade winds and the potential for (ex-) Tropical Cyclones or East Coast Lows to form in the Coral Sea and track parallel to the east coast. This means an increase in mean wave direction from the east to north-east.

It's not all about erosion

Over the short term, an east to north-east storm wave direction is generally not good for beaches on the east coast, especially those already in an eroded state.

However, over the long term, storms from this direction can actually have a net constructive effect for beaches, helping to transport sand back to the shoreline that has been sitting offshore in deeper water.

We modelled this process at Byron Bay with colleagues from the NSW Government (Mortlock et al., 2016). Figure 4 shows the change in water currents (top panel) and sand movement (bottom panel) expected with a change in the storm wave direction from the south (S, left panel) to east-north-east (ENE, right panel).

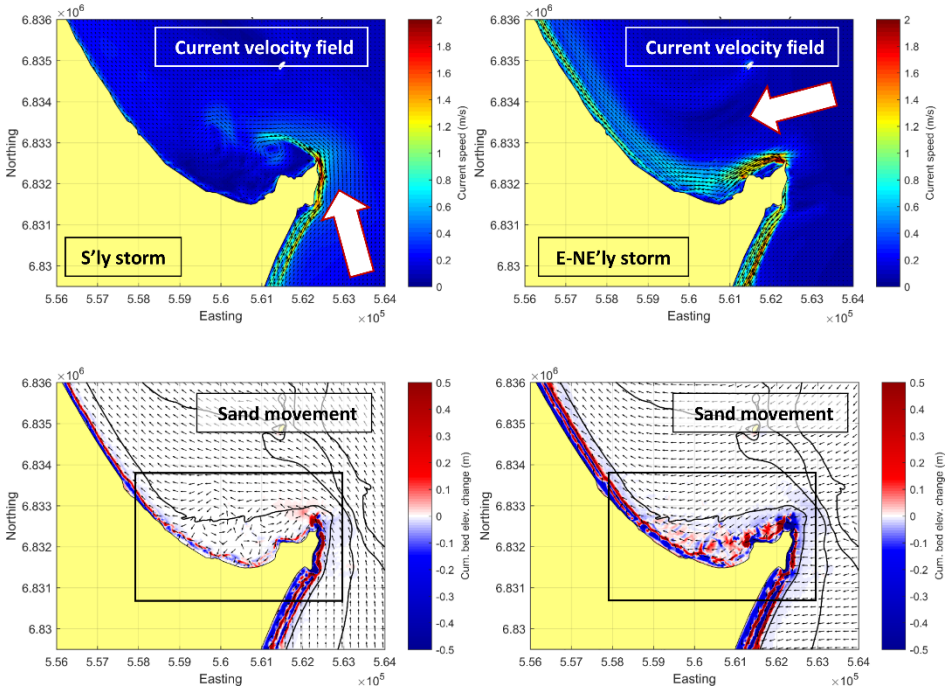

Figure 4. *Modelled current velocity fields (top panel) and sand movement (bottom panel) at Byron Bay for storm wave conditions from the south (4 m wave heights, from 165 °, left panel) and then from the east-north-east (4 m wave heights, from 60 °, right panel). Arrows denote wave direction. Box shows the area from Cape Byron through to Belongil Beach. Source: Mortlock et al. (2016).*

As can be seen, during high wave conditions from the south, sand is pushed northwards along Cape Byron but is then deposited off the Cape in deep water, whereas during high wave conditions from the E-NE, this sand is pushed landward into the southern hook of the embayment. This process is described in detail in Goodwin et al. (2013).

Our recently published study (and others) show that over the past 40 years there has, in fact, been an increase in southerly swell waves along the east coast as the Southern Ocean lows track further poleward and an increase in waves coming from the east as the Tropics expand poleward. The concomitant decrease in south-easterly waves, which are optimal for longshore sand transport

between compartments, has resulted in many embayments like Byron Bay waiting for sand transport. This makes them vulnerable to storm wave erosion like this week.

The line in the sand

With a La Niña summer now upon us, we can expect to see above average flood and erosion risk along the east coast and a shift towards more north-easterly wave conditions. On the north coast of NSW and Southeast Queensland it could go one of two ways this summer – if there is a high storm frequency, beach locations will likely suffer compounding erosion, as has been witnessed this week. If not, and strong trade winds dominate, the longshore spits at the southern end of these beach compartments will weld to the shoreline, widening the beaches. The line in the sand is a fine one.

Either way, Australian beaches appear to be some of the most sensitive in the world to periods of La Niña, highlighting the importance of considering inter-annual climate variability alongside longer-term climate change impacts for quantifying coastal risk.

References

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