LRET Global Networking to Improve Prediction of Extreme Marine Events

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1. Introduction to LRET goals

Marine transportation, oil and gas exploration and exploitation, and the development of coastal infrastructure all depend on the prediction of extreme marine events. For example, efficient marine transportation depends on accurate short-term (1 to 3 days) forecasts of marine winds and surface waves; safe operation of oil and gas operations requires forecasts of extreme currents with the potential to significantly damage offshore platforms; and coastal communities located in low lying areas are dependent on accurate forecasts of storm surges to mitigate the effect of flooding. There is growing evidence that the characteristics of extreme marine events are changing in some regions, and that the problems associated with these events may increase over the next century. To address some of these problems the Lloyd's Register Educational Trust has funded a proposal to establish an international network of researchers from Canada, Australia, the U.K. and Brazil to (a) improve short-term forecasts of extreme marine events, and (b) estimate the frequency of extreme marine events over coming decades with realistic measures of uncertainty. The network will develop new models and statistical methodologies, train graduate students and postdoctoral fellows, and present the results in a way that is useful for scientists, users and the general public.

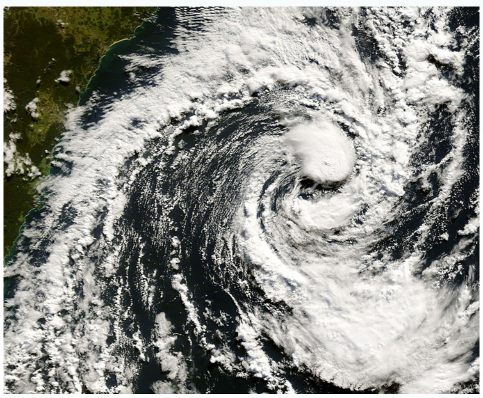

Fig 1: MODIS visible imagery showing an East Coast Low with thunderstorms (vortical hot towers) near the centre and spiral rainbands.

4. Coupled model high-resolution simulations

Using the Coupled Limited Area Model (CLAM; Sandery et al., 2010) down to convective scale resolutions in both the atmosphere and ocean will allow us to investigate both the ocean's influence on an ECL and also an ECL's influence on ocean currents and heat content. CLAM consists of the ACCESS atmospheric model coupled to the MOM4 ocean model using the OASIS coupler.

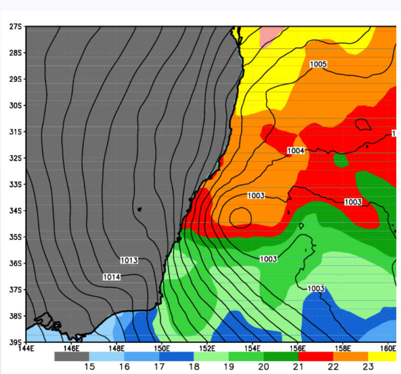

Fig 4. Uncoupled ACCESS-TC with domain shifted for an example ECL; 24 May 2011 SST (colours) and sea level pressure.

References

Sandery, P., G. B. Brassington, A. Craig and T. Pugh, 2010: Impacts of ocean-atmosphere coupling on tropical cyclone intensity change and ocean prediction in the Australian region, *Mon. Wea. Rev.*, 138, 2074–2091.

2. East Coast Lows

The Australian node of the LRET network is currently investigating the formation of Australian East Coast Lows (ECLs). ECLs are low pressure weather systems that can develop rapidly over the oceanic region where the warm East Australian Current (EAC) flows southward. ECLs can produce intense hurricane scale winds and have historically been responsible for major flooding events, damage to coastal infrastructure, and the wrecking of multiple ships.

Fig 2: The Pasha Bulker ran aground during an East Coast Low in June 2007.

ECLs are hybrid systems that can develop rapidly within large scale upper troughs and involve topographic influences and baroclinic processes, but within which deep convection also appears to play a critical role. Not all cut-off lows develop into ECLs indicating this is a necessary but not sufficient condition for ECL development.

The EAC flows southward down the east coast of Australia. Warm sea surface temperatures (SSTs) poleward of Sydney are maintained by transient warm anticyclonic eddies that are shed from the EAC and can become coastally trapped and/or drift southward down the coast on timescales of weeks/months. In contrast to the EAC's warm currents and eddies there exists a narrow strip of cold water along the southern Australian coast as well as transient cold core eddies that lead to areas with strong oceanic temperature gradients.

3. During an ECL where do thunderstorms occur in relation to warm ocean eddies?

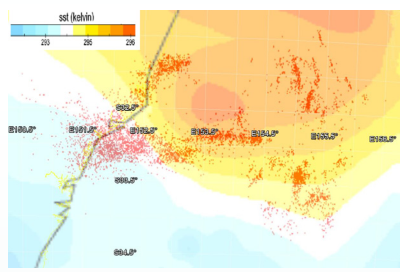

Fig 3: Lightning strikes (red dots) between 1200 UTC, 7 June and 1200 UTC, 8 June, 2007 overlayed on 7 June, 2007 sea surface temperature (K, colour shades).

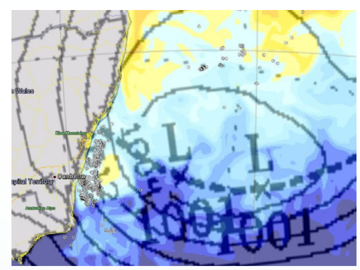

Fig 4: An example plotted using Google Earth of sea level pressure (0000 UTC 20 July 2011) and 24 hour lightning strikes (small circles) overlayed on sea surface temperature

Lightning data is used to determine thunderstorm locations during ECLs. Preliminary analysis indicates a preference for lightning in certain regions of strong SST gradients. If deep convection is initiated along these boundaries in a cyclonically rotating environment then diabatic processes could redistribute potential vorticity and lead to ECL intensification in a manner similar to that hypothesized to occur in tropical cyclones.

5. WRF simulations

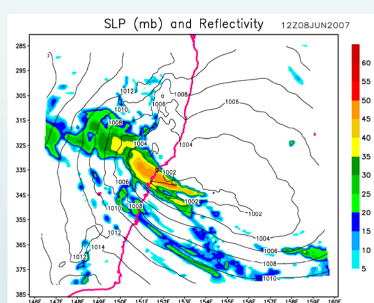

Fig 4. WRF simulated sea level pressure and radar reflectivity for 1200 UTC, 8 June, 2007; the Pasha Bulker case.

WRF simulations have shown their strength in tropical cyclone research and we are using this versatile model to nest down to high resolutions and simulate ECL thunderstorms at convective scales. This should allow analysis of convectively induced potential vorticity redistribution. A preliminary simulation of the Pasha case (Fig. 4) shows the low pressure deepening under regions of strong convection.

6. Conclusion

The objective of the research is to determine if the ocean state can improve forecasts of the formation and location of ECLs as well as to diagnose the dynamical processes responsible for rapid development. Both observational and model data are used in this investigation. High-resolution coupled model simulations of past ECLs should help determine how convective development is related to ocean eddy boundaries, specifically whether these regions of high SST gradients act to trigger mesoscale convective vortices and whether these can then influence the formation and track of the larger ECL. We also intend to study the response of the ocean to the ECL. We are strongly interested in collaborating and discussing these issues with other researchers and forecasters.

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