P5.1 THE EFFECT OF MODEL INITIALISED SCATTEROMETER DATA ON THE PREDICTION OF MARITIME CYCLOGENESIS

Lance M. Leslie[1], Milton S. Speer[2] and Robert F. Abbey Jr.[3]

[1] School of Meteorology, The University of Oklahoma, Norman, Oklahoma
[2] National Severe Storms Laboratory, Norman, Oklahoma
[3] Office of Naval Research, Arlington, Virginia, USA

1. INTRODUCTION

The Tasman Sea is a large, historically data sparse area of the Pacific Ocean between New Zealand and the east coast of Australia. It is often subject to synoptic / mesoscale weather systems that threaten life and property at sea or on the coast. These systems range from locally enhanced cold fronts such as the southerly buster of coastal southeastern Australia, low pressure troughs, small explosive low pressure systems near the Australian east coast, to synoptic scale, maritime low pressure systems. They may vary dynamically in intensity and structure across a spectrum that includes both weak or intense cold cored systems to Tropical Cyclones, and the so-called hybrid systems. Hybrid systems are so termed because both subtropical and tropical cyclones can have warm-cored centres with spiral convective rain bands. At this point in time they are determined by their origins in Australia but recently in the US they are recognized as being capable of transforming from one to the other.

In this study we concentrate on the prediction of the latter class of systems, that is, cyclones in open waters that threaten life and property as a result of the combined effects of wind, sea state and swell including both long fetch or storm surge. Quite often these systems at sea are poorly forecast owing to the lack of data used in NWP initialisation. Also, the model predictions usually are poorly verified owing to the lack of observational data. Before the advent of routinely available scatterometer data (archived approximately since August 1999), verification of winds at sea close to the surface relied almost entirely on ships of opportunity. A ten year climatology of Tasman Sea cyclones from 1992 to 2001 reveals a range of the above-mentioned systems. There were 25 systems in total including two explosive lows (or bombs), eleven lows that developed within easterly flow, seven lows that developed on frontal systems, four Tropical Cyclones. One so-called 'hybrid' low pressure system is included in the climatology as a low pressure system that developed within easterly flow.

In summary, there are three aims in this study. The first is to present a simple climatology of Tasman Sea cyclonic systems over the area west of 170E and north of 40S for the period 1992 to 2001. Second, for the hybrid low pressure system we present a synoptic analysis of the lifecycle of the storm from its beginnings as a weak low in the Tasman Sea, to its landfall and eventual dissipation as a major flood event over land. The third aim is to use all available data, augmented by high resolution scatterometer winds, to carry out a series of numerical experiments on the track and structure of the system.

Corresponding author and address: Lance M. Leslie. School of Mathematics, The University of Oklahoma, Norman, OK.
Email:lml@lighthill.maths.unsw.edu.au

2. CLIMATOLOGY

There was a total of 25 systems covering the ten year period with at least one occurring in each month. In Table 1 each system has been broadly categorized according to the synoptic features in which it developed. One each occurred in January and February which were both tropical cyclones (TCs). One other TC occurred in December. There were also four other systems in December making a total of five. There were four systems in May followed by August with three. The major impact on coastal communities was from the March hybrid system and an explosive August east coast low pressure system. The major known impact at sea was on the fleet of December 1998 yacht race in which there were six deaths. The effects on shipping of the sea state and swell of all the 22 systems in the Tasman Sea are important. However, the case study we chose was the March, 2001 hybrid low pressure system, as the rainfall produced over the coastal catchments during the event also resulted in the extra problem of flooding of coastal communities. It is quite conceivable, and, indeed probable, that more of the systems in the first two categories could be regarded as hybrid low pressure systems. However, no attempt has been made to further delineate them as such in this study.

3. CASE STUDY OVERVIEW

In early March, 2001 a low pressure system approached the Australian east coast at approximately latitude 28 deg.S. It made landfall early on March 9 as a cyclonic system equivalent to a category 2 TC in terms of its damage. This kind of event is rare and potentially devastating. At landfall, wind speeds averaged over 50 knots and 24 hr rainfall totals exceeded 400 mm. There is still ongoing discussion whether the system should be re-classified as a named TC, and we hope to contribute to that debate. The extra-tropical lifecycle of the storm was almost one week and its predicted path and intensity were poorly handled by all operational models except the US MRF model, which forecast a weak low to move over the northern New South Wales coast.

4. SYNOPTIC ANALYSIS

On 4 March 2001 a closed, surface low pressure system developed within an easterly trough which was located in the eastern Tasman Sea near 30^0 S 151^0 E. This system was co-located below a cyclonic circulation in the apex of a mid- to upper tropospheric trough. The trough was positively tilted and during 4 March had started to retrogress towards the Australian east coast. The surface low was located under a diffluent region at upper tropospheric levels, which helped maintain weak vertical wind shear above the system. The surface low moved northwest in accordance with the general westerly component of movement of the upper trough. Hence, remaining within its diffluent, weakly, sheared large scale environment the low slowly deepened, even though the upper tropospheric circulation weakened during 6 March, as the upper trough moved west. By 00 UTC 7 March, the surface low was about 250 km east of Brisbane. From here, the low accelerated southwest towards the coast. This path took it over SSTs exceeding 26 deg.C compared to SSTs below 24 deg.C before 7 March. Its rate of intensification also increased. The lowest recorded mean sea level pressure as it made landfall was 997 hPa at Evans Head on the coast.

4. DATA, ANALYSES AND MODEL

The data used was the archived, real-time analyses from the Australian Bureau of Meteorology. These analyses were enhanced by additional high resolution data including: satellite derived winds and high resolution SST fields. Therefore, 4D data assimilation was used to incorporate the additional data. The model used in the simulations is the UNSW HIRES model, run at horizontal resolutions from 20 km down to 5 km and with 32 levels in the vertical.

5. RESULTS

Results show that without the inclusion of scatterometer data in the model initial state, the central pressure of the low gradually weakens in the forecasts and becomes ill-defined in the 24 to 48 hr period. Moreover, the track, while initially forecast to move northwest, as observed, also became ill-defined, as the centre weakened. In contrast, with the inclusion of scatterometer data in the initial state, the sub-tropical cyclone track, intensity and the timing and location of landfall, which was almost four days into the forecast, are very well predicted. The results also show the importance of persistent upper level divergence and weak vertical wind shear for the initial development and intensification of the storm. Other factors such as high resolution SSTs that were used in both experiments appear to have been sufficient for depicting realistic rainfall accumulations along the coast and ranges associated with the onshore circulation from the low pressure system.

6. SUMMARY AND CONCLUSIONS

A simple climatology of cyclonic systems affecting the Tasman Sea between the area west of 170E and north of 40S has been presented. The synoptic analysis of the March 2001 hybrid low pressure has been described.

It was found that using archived real-time data together with the assimilation of additional high resolution scatterometer observations of wind, the track, intensity and rainfall were well predicted for a severe sub-tropical storm. In particular, landfall was predicted up to four days ahead. Finally, our conclusion concerning the classification of the system is that it should indeed be a numbered or named storm, as are similar sub-tropical storms in other parts of the world.

Future work will be extended to predicting the sea state (wave height and swell) or storm surge for some of the climatology cases through the use of an ocean model coupled to the atmospheric model.

Acknowledgements

This research has been sponsored by the US Office of Naval Research Grant N00014-0021-1-0181. One of the authors is supported by a US National Research Council Associateship at the National Severe Storms Laboratory.

Development of system	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Within trough in easterly flow			2		4	2	1				2	3
On a decaying frontal system				1	1			1	1	1		
From wave on frontal system								1				
Explosive low close to coast								1				1
Tropical cyclone	1	1										1

Table 1. Classification of 25 Tasman Sea low pressure systems 1992 to 2001.