論文内容の要旨

Spatial structures and propagation characteristics of coastal trapped waves around Australia

（オーストラリア周りの沿岸捕捉波の空間構造と伝播特性）

氏名　　眞岩　　一幸

Coastal trapped wave (CTW) is defined as the wave in a stratified ocean over sloping topography and propagates along a coast on its left (right) in the southern hemisphere (northern hemisphere). The characteristics of the CTW have a hybrid nature between coastal Kelvin waves [Thompson, 1879] and continental shelf waves [Robinson, 1964] and the wave is mainly excited by alongshore component of winds. A large number of observed evidence for the existence of the CTWs are reported from the coastal area around the world, e.g., [Shoji, 1961; Cutchin and Smith, 1973; Smith, 1978; Brink et al., 1978].

For Australian coasts, the studies of the CTW are initiated by a seminal observational work of Hamon [1962]. Since then, vertical structures and phase speed of the CTW have been locally investigated in detail by several intensive observational studies, such as the Australian Coastal Experiment [Freeland et al., 1986; Church et al., 1986]. These studies, however, treat the waves mainly as the local phenomena along the eastern coast of Australia, and the origin of the waves and behaviour of the waves during their propagation along the coast are not discussed in detail.

In this study, therefore, we investigate the propagation characteristics and structures of the CTWs around Australia from the viewpoint of the continental scale using observed sea level data and results from ocean general circulation models.

The daily mean sea level data at 20 stations around Australia (Fig.1) are obtained from National Tidal Facility of Australia and the University of Hawaii Sea Level Center. The variations of the sea level are dominated by the seasonal variability at the stations located on the northern coast, while

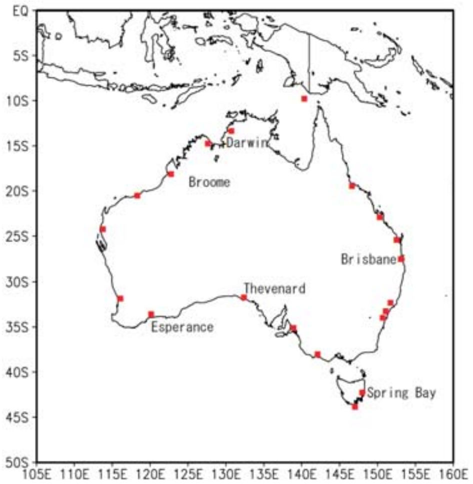

Fig.1; Locations of sea level stations around Australia (Red dots).

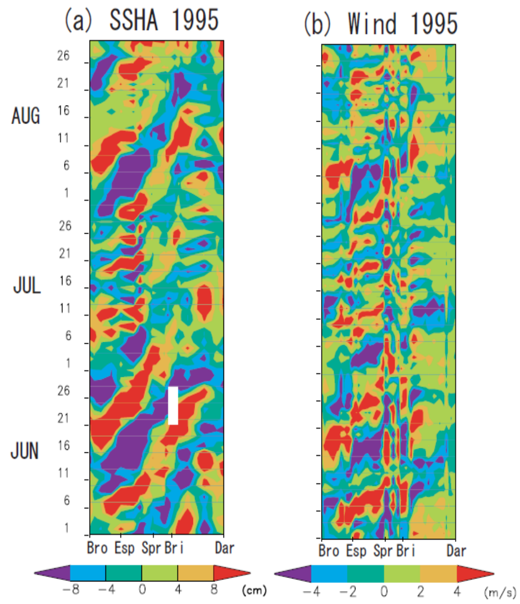

Fig.2: Hovmöller diagram of high-pass filtered (a) sea level anomaly from observation and (b) alongshore component of the wind in 1995. Time spans from 1 June to 31 August (during austral winter). Horizontal axis indicates the distance measured anticlockwise from Broome (northwestern part of Australia) to Wyndham (northern part).

short term variations of the sea level with a period of shorter than one month are dominant along the coast in southwestern, southern and eastern regions. It also turns out that the short term variations show strong seasonality, with large amplitude during austral winter. Since observed data are limited only for 4 years, we focus on the variation with the period shorter than a month.

The high pass filtered sea level variability during the austral winter clearly shows anticlockwise propagation of the sea level signals from the western/southwestern coast to the eastern coast (Fig.2). However, the amplitude of the waves abruptly weakens around Tasmania in many cases. It is found that typical phase speed of the wave differs between southern and eastern coast; the phase speed in the southern coast is faster than 5m/s but it is 2-4 m/s in the eastern coast. Spectrum analyses indicate that dominant time-scale of the variation of the sea level in the southwestern coast is around 10-14 days, which is also a peak in spectrum for alongshore wind variability in the southwestern coast. The association between the two fields is quite high, suggesting the wind forced wave excitation in this region.

To check a possibility for the waves to propagate freely from southwestern region to the eastern coast and to evaluate roles of topographic features on the characteristics of the wave propagation, a regional OGCM around Australia is developed and used for sensitivity studies. The model is based on Princeton Ocean Model, which incorporates a free surface and a terrain-following σ coordinates in the vertical direction. An idealised alongshore wind stress limited only within the southwestern coast with a period of two weeks is applied as a forcing of the coastal waves.

Simulated sea surface height (SSH) variability from results with realistic bottom topography (Control Run) captures the major characteristics obtained from the observed sea level data (Fig.3a). The SSH signal propagates anticlockwise from the southwestern coast to the eastern coasts, with the phase speed of 5.6 m/s and 2.8-3.7 m/s in the southern and eastern coast, respectively. The model also reproduces the weakening of the wave amplitude around Tasmania. In order to explore reasons for the above characteristics of the waves, especially for the change in the phase speed and the amplitude, two sensitivity experiments are conducted with different bottom topography around the southeastern and eastern coasts. In the first experiment, Case 1, a wider continental shelf as in the southern coast is applied to the eastern coast. The phase speed of the waves along the eastern coast increases significantly to the value similar to that in the southern coast (Fig.3b). Modal decomposition of alongshore currents to eigenvalue solutions of the CTWs confirms that the first mode CTW explains more than 60 % of total variability both in the southern and eastern coasts. However, the difference in the width of the continental shelf, the wide shelf in the south and narrow shelf in the east, results in the different phase speed; the narrower the shelf is, the slower the phase speed becomes. In the second experiment, Case 2, the width of the continental shelf in the eastern coast remains narrow as in Control Run, but Tasmania island at the southeastern corner of Australia is removed. In Case 2, the simulated amplitude and the phase speed of the waves are almost the same as in Control run (Fig.3c). It turns out from the two experiments that the narrow continental shelf in the eastern coast is responsible for the relatively slow CTWs and the weakening of the amplitude in the eastern coast.

To examine the behaviour of the CTWs in more realistic conditions, results from a high-resolution ocean general circulation model (OFES) are explored in detail. The OFES results also reproduce the anticlockwise propagation of the CTWs around Australia. Spatial structures of the CTWs, derived from a composite of the simulated positive SSH events, demonstrate that the waves are trapped within about 200 km (80 km) from the coast in the southern (eastern) region with much larger alongshore wavelength of a few thousand kirmetres. The same eigenmode analyses for Control Run of the regional OGCM are applied to the OFES result. It is found that the first CTW mode is dominant both in the southern and eastern coasts, but the phase speed in the southern coast is faster than that in the eastern coast, which is also consistent with the observed results.

However, OFES does indicate the large amplitude responses in the eastern coast in many times, which has strong association with the wind forcing at the southeastern coast of Australia. An additional sensitivity experiment with wind forcing at the southern part of the eastern coast is carried out. The result indicates that the forcing in the eastern coast is necessary for the waves to have the amplitude similar to those observed in the sea level data and simulated in OFES.

The above results from the observed data and the numerical models indicate that the CTWs observed in the eastern coast of Australia can be excited in the southwestern coast by the atmospheric synoptic disturbances and that the propagation characteristics of the CTWs are determined mainly by the width of the continental shelf in the southern and eastern coasts. In addition, the wind forcing in the southern part of the eastern coast plays a key role in strengthening of the amplitude or excitation of the CTWs along the eastern coast of Australia.

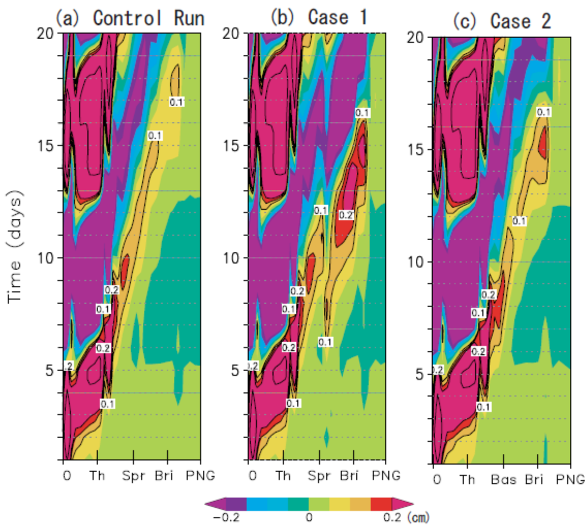

Fig.3: Hovmöller diagram of sea surface height from the results of the numerical experiments for (a) Control Run, (b) Case 1; a wider shelf in the eastern coast and (c) Case 2; without Tasmania island. Horizontal axis indicates the distance measured anticlockwise from a point in the southwestern coast (origin of the wave). A few letters in the horizontal axis denote abbreviations of some locations (refer to Fig.1.)