UNCTAD Intergovernmental Expert Meeting on "Maritime Transport and the Climate Change Challenge"
First Expert Meeting on climate change and maritime transport issues

Aspects of Potential Climate Change Impacts on Ports & Maritime Operations around the Southern African Coast

Marius Rossouw and Andre Theron

CSIR, P O Box 320, Stellenbosch, 7599, South Africa
Email: mrossouw@csir.co.za; atheron@csir.co.za; Tel: 021 888 2400; Fax: 021 888 2693

1. Introduction

The southern African coast plays host to wide range of activities, which include the maritime transport around the coast, fishing, and imports/exports through ports. Furthermore, more than 30% of South Africa's population and about 60% of Mozambique's population currently live at the coast.

Figure 1 presents the outline of the southern African coast showing the major ports. The South African (SA) coastline covers a distance of about 3 000 km. There are seven commercial ports along the SA coast of which four are major ports, with three smaller ports (see Table 1). There are also a number of small fishing harbours along the SA coast. On the western side of southern Africa, along the Nambian coast, there is one major port and one smaller commercial port. The Mozambican coast on the eastern side has two major ports.

Figure 1: Map of southern Africa showing locations of major ports

Table 1: Summary of ports around southern Africa

Country	Port	Main functions	Export/Import Volumes p.a. (2007)
Namibia	Walvis Bay	Containers & fishing	3.9 Mt (0.13 MTEU)
	Lüderitz	Fishing & zinc export	0.5 Mt (0.01 MTEU)
South Africa	Saldanha Bay	Iron ore export	43.7 Mt
	Cape Town	Containers, fishing & repair works	4.1 Mt (0.76 MTEU)
	Mossel Bay	Fishing & export of oil products	1.8 Mt
	Port Elizabeth	Containers, cars & fishing	5.5 Mt (0.42 MTEU)
	East London	Cars & containers	1.8 Mt (0.04 MTEU)
	Durban	Containers & cars, oil import & food	41.9 Mt (2.48 MTEU)
	Richards Bay	Coal export	84.5 Mt
Mozambique	Maputo	Coal, containers & sugar	6.3 Mt (0.10 MTEU)
	Beira	Containers, oil import & fishing	N/A

Mt: Mega-tonnes
MTEU: Million Twenty-foot Equivalent Units

Rossouw, Marius, and A. K. Theron. "Aspects of potential climate change impacts on ports and maritime operations around the Southern African coast." *Proceedings: UNCTAD intergovernmental expert meeting on maritime transport and the climate change challenge, 1st expert meeting on climate change and maritime transport issues, Genève, Switzerland.* 2009.

2. General Weather and Wave Climate of the Southern African Coast

The general weather climate of southern African is influenced by different types of synoptic patterns (MacHutchon, 2006). Waves significantly affecting maritime activities, are generated mainly by passing frontal systems from the southern Atlantic, cut-off low systems along the SA southern to eastern coast and occasionally by tropical cyclones moving down the Mozambican channel.

The wave climate around the SA coast shows clear seasonality and varies in intensity and directionality around the coast. An overview of the annual variation in wave height and period is given in Figure 2, as based on the NCEP model data.

The most severe wave conditions occur on the SA South-west and the South coasts but decreases in magnitude along the West and East coasts. The distribution of wave period remains fairly constant, due to the swell propagating northwards. Wave directions are predominantly South-west but swing more toward a South-south-westerly direction on the East coast.

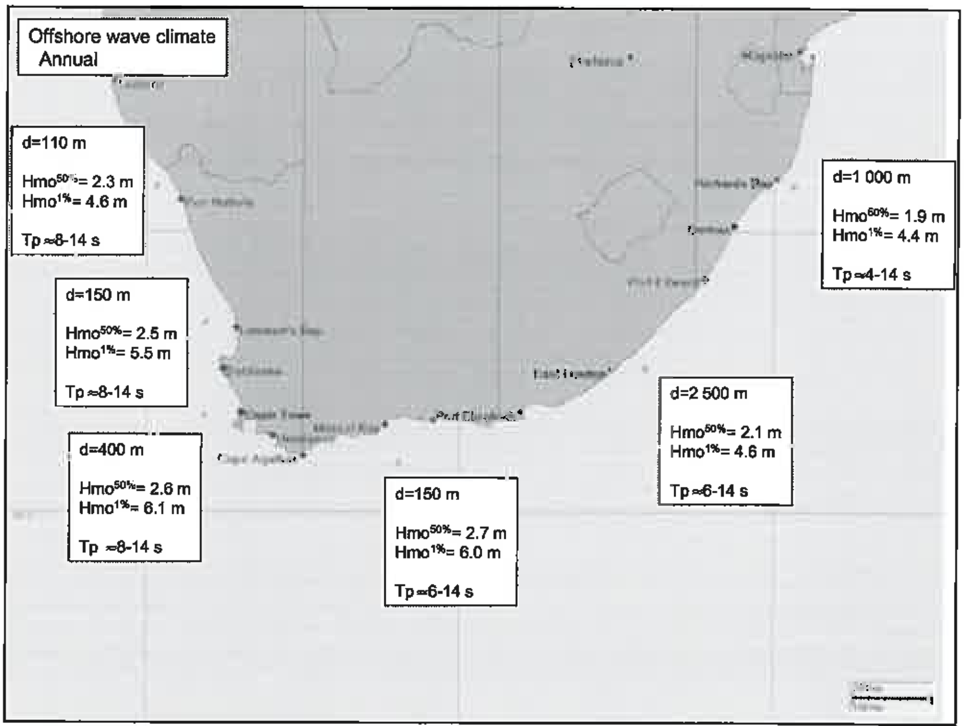

Figure 2: Overview of wave height and period distribution around SA coast

3. Vulnerability to Marine Weather Conditions and Climate Change Effects

The aspects further discussed with regard to the impact of climate change on the marine environment are presented below.

(i) Shipping around the SA coast

The type and number of vessels calling at South African ports on an annual basis are summarised in Table 2. Note that many more vessels pass the South African coast on the shipping route between America and Asia.

Table 2: Summary of large vessels calling at South African ports (2007)

Type of vessel	Number	Main ports
Bulk carriers	2470	Richards Bay, Durban, Saldanha Bay
Oil tankers	1120	Durban
General cargo ships	1350	Durban
Container carriers	3396	Durban, Cape Town, Port Elizabeth
Car carriers	616	Durban, Port Elizabeth, East-London
Fishing trawlers	2985	Mossel Bay, Cape Town

Although ships are generally well-equipped for the severe wave conditions of the southern Atlantic, damage to ships does occur, especially on the South-east coast where the South-westerly waves interact with the strong, opposing, South-west flowing Agulhas current (Figure 3). The wave-current interaction result in an amplification of the waves, which infrequently leads to the creation of a gigantic or freak wave. This wave consists of a long trough, followed by a steep wave front, which can damage vessels severely. From the available literature it appears uncertain at this stage whether climate change effects will significantly strengthen or reduce the

Agulhas current (or increase storminess off the SA southeast coast), and thereby reduce or increase the risk "freak" waves pose to shipping.

Small vessels such as fishing vessels are subjected to lesser extreme conditions, but with a greater chance of loss life. Damage to these vessel are also more frequent. The statistics on casualties for the period 2003 to 2004 are presented in Table 3. During this period, casualties to and on board vessels resulted in 28 deaths of which 20 are linked to small vessels.

Table 3: Statistics on casualties to ships for the period 2003/2004 (SAMSA)

Type of vessel	Fire	Capsize	Grounding	Collision	Vessel sank	Equipment failure	Total
Small vessels	1	10	1	6	4	1	23
SOUTH AFRICAN							
Passenger							
Mining	1		1				2
Harbour Craft			1	1			2
Fishing	4		1	3	1	6	15
FOREIGN							
Cargo	3		1	12			16
TOTAL	9	10	5	22	6	7	59

SAMSA: South African Maritime Safety Authority

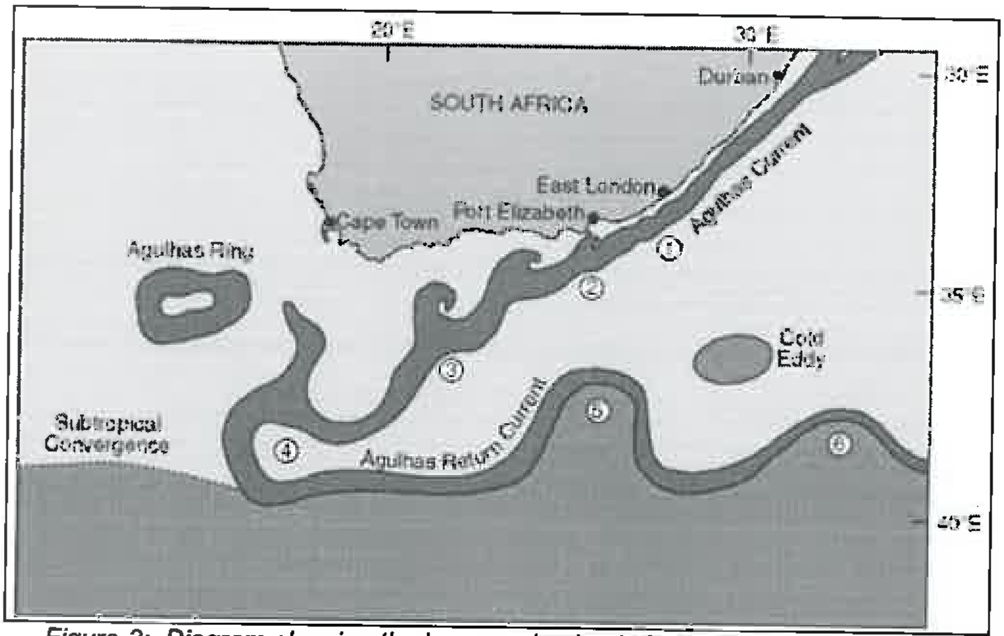

Figure 3: Diagram showing the large scale circulation of the Agulhas current (Lutjeharms and Van Ballegooyen, 1984)

(ii) Port operations

Daily port operations can be directly influenced by adverse wave conditions, which may lead to port closure. Conditions inside a harbour can also become unbearable for large vessels due to the presence of long period waves (wave periods > 100 s), which are generated by the groupiness effect/phenomenon of swell waves. Mooring lines are placed under extreme loading and in some cases, vessel have to leave the port. Thus, the issue of down-time is of concern.

A different example is the Port of Walvis Bay, Namibia (Figure 4). Namibia's main harbour and only deewater port, located at Walvis Bay, is an important national economic hub and regional import/export freight access point for landlocked countries such as Botswana. During seasonal storms, waves wash over the major peninsular sand spit protecting the Port of Walvis Bay. At Baia dos Tigres in southern Angola, natural breaching of a 41 km long sand spit occurred, leaving an 11 km wide gap in the spit, thereby forming an island and destroying safe anchorage. Breaching of the Walvis Peninsula by the sea poses a real threat because the peninsula is so low-lying. Both sea level rise (SLR) and increased sea storminess could greatly increase this risk. A large breach of the Walvis peninsula would have similar disastrous consequences as the Baia dos Tigres breaching.

Figure 4: The vulnerable sandspit that protects the Port of Walvis Bay, Nambia

(iii) Ports and transport infrastructure

- **Mozambique**

Mozambique's main harbours are located at Maputo (a major source of income for the government) and Beira. Statistical analyses of available seawater levels recorded at Maputo and Beira indicate that present annual maximum recorded seawater levels approximately reach the crest of many protective seawalls and revetments. In addition many of these ageing structures are in a state of poor repair. Thus, these port cities are likely to be some of the most problematic areas in Mozambique from a climate change perspective and appropriate local planning and adaptation measures should be initiated in the short-term.

Tropical cyclones is another major threat along the Mozambican coast. About 2 cyclones per year enter the Mozambique channel, while about 1 cyclone per year makes landfall in Mozambique. Strong cyclones, even those that do not make landfall, generate large waves that could potentially impact the local coastline. Climate change projections indicate that cyclones may become more intense. A Third World country such as Mozambique can certainly not afford traditional engineering solutions to wide-scale cyclone or coastal climate change impacts.

- **South Africa**

It is predicted that, due to climate change effects, breakwaters, revetments and sea walls, which protect infrastructure such as harbours (e.g. Figure 5) and residences from direct wave action and under-scouring, will require more maintenance. The longevity of such structures and facilities will also be reduced due to SLR and potential increases in storminess.

(iv) Impact on the coastline adjacent to ports

Taking into account that about 80 % of the southern African coastline comprises sandy shores, erosion is a major area of concern. It is therefore clear that extreme storm events combined with sea level rise will pose an ever increasing threat to the natural coastline and coastal structures.

The coastline north of the Port of Richards Bay is also subject to severe ongoing erosion. Historical erosion rates are higher than 3 m/yr (future rates excluding climate change effects are predicted to be at least 1 m/yr). Despite diligent efforts by the Port of Richards Bay to supply sand to the northern beaches, a great deficit in sand supply to the northern beaches has been built up over the last decades. The shortfall from about the last 20 years is 6 million m^3, while the current annual shortfall in the harbour sand bypassing rate is estimated to be 300 000 to 350 000 m^3/yr. Due to sea level rise (and potential increase in storminess), the erosion rate is expected to accelerate. Thus, climate change is expected to contribute to a particularly dire situation along this coast.

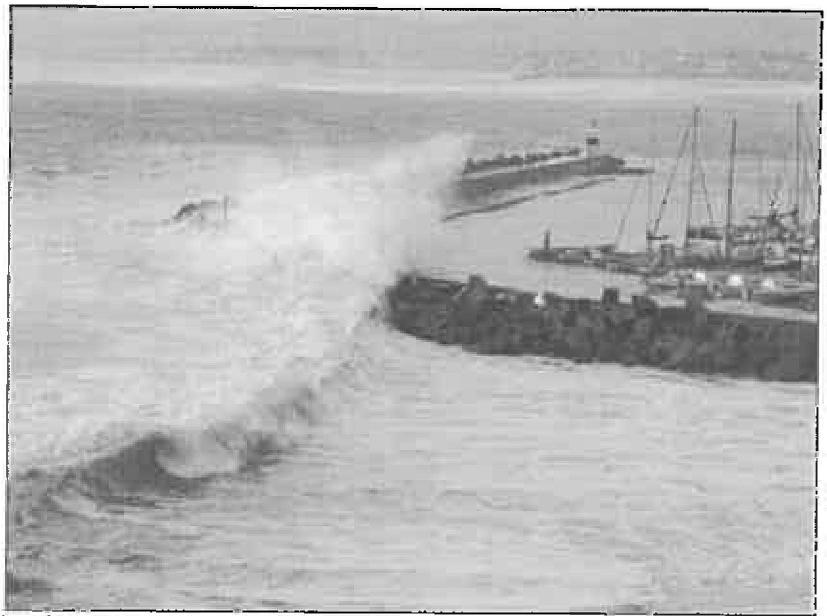

Figure 5: SA example of breakwater barely coping with storm waves at present water levels (Photo: A Theron)

4. Climate Change : Present Studies on SA Wave Climate

It is clear from the previous section that a more severe wave climate and even wind climate will impact negatively on the coast and maritime activities leading to a necessity to predict the future trends in the wave climate. The CSIR is currently involved in studying the effect of climate change on a number of physical and biological aspects in and around South Africa. As part of the study, the wave climate is being evaluated.

The annual mean significant wave height (Hmo) and corresponding standard deviation for the wave data set collected off Richards Bay and the annual mean wave height (Hmo) for the long-term data set, collected offshore of Cape Town, indicate no real increase in severity. This may appear to contradict the findings of the IPCC as present in PIANC (2008). However, these results may indicate the regional aspect of the impact of climate change.

Although the averages appear to remain constant, there seems to be some change in the individual storms. For example, considering the peaks of individual storms during the more extreme winter period (June to August), an increasing trend of about 0.5 m over 14 years is observed (Figure 6). Although this increase is perhaps not significant over this time period, the trend may be indicative of an increase in the storminess over the next few decades.

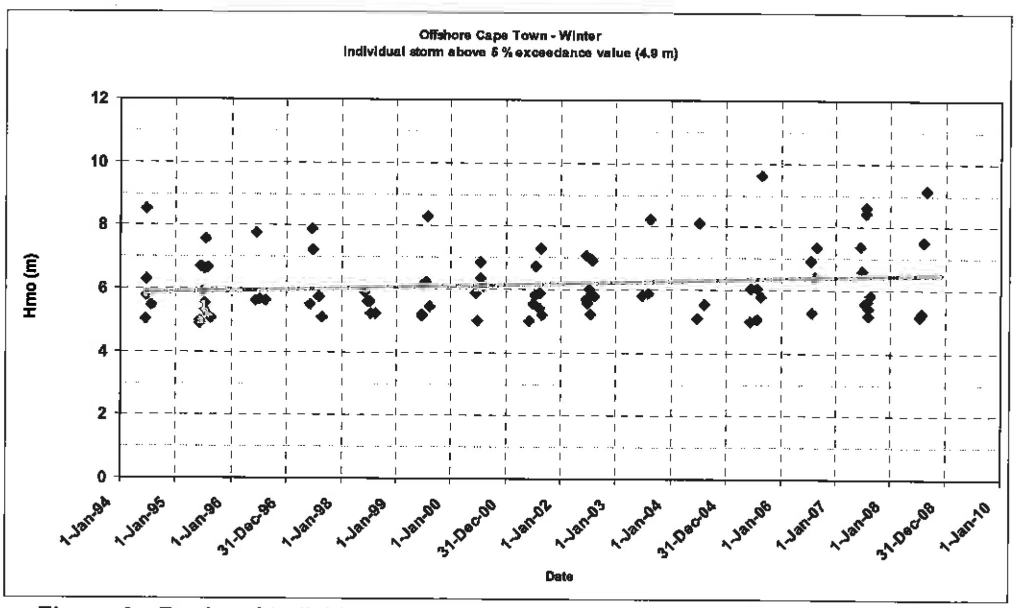

Figure 6: Peaks of individual storms over 14 year-period – offshore Cape Town.

If this trend is indeed true, storminess with regard to intensity, may be on the increase. There are, however, a number of aspects that need further attention. These include:

(i) evaluating similar trends around the entire southern African coastline,
(ii) consider not just the trends in magnitude/intensity but also in frequency of events,
(iii) consider the persistence of these events, i.e. are the duration of storm events increasing or decreasing,
(iv) review the occurrence of cyclones along the SA East coast,
(v) review the trends in energy flux and not just the wave height

The evaluation of these aspects need to be combined with the present estimates of the sea level rise, which will lead to a better understanding of the potential risk of the issues raised in Section 3.

5. Potential Implications and Possible Adaptation Measures for SA Marine Region

A summary of potential impacts and adaptation measures in the SA region, other than those presented in UNCTAD (2008), is given in Table 4. These aspects, as well as those listed in UNCTAD (2008, Table 3), are potential issues to be investigated.

Table 4: Potential impacts and possible adaptation measures for the maritime transport sector

Climate change factor	Potential implications	Adaptation measure
Rising sea levels • Flooding and inundation • Erosion of coastal areas	• Challenge to service reliability and increased dredging, reduced safety and sailing conditions • Changes in water levels in harbours	• Revise quay and wharf levels including infrastructure, e.g. buildings
Extreme weather conditions • Tropical cyclones • Storms • Floods • Increased/decreased precipitation • Wind	• Increased damage to ships as a result of wave-current interaction	• Raising of existing breakwater-structure to counter additional overtopping • Increase monitoring of the state of infrastructure Conditions – e.g. CSIR breakwater monitoring programmes • Strengthen foundations, raising dock and wharf levels – redevelopment programmes • Redesigning new ports • Revising dredging maintenance programmes • Amended beach nourishment programmes • Revision of pilot-transfer operations • Revision in ship mooring operations and equipment in ports • Alterations to ports to compensate for additional wave action (swell induced or long period waves)

6. Conclusions

This paper includes a brief revue of some of the likely physical port and maritime operations related impacts due to expected climate change around the southern African coast. To mitigate these detrimental impacts, research is and should increasingly be directed at an improved understanding of what is happening to our coastline and what is likely to happen as climate change intensifies. Locally applicable methods have to be developed urgently to quantify realistically the impacts of climate change. To mitigate these impacts, we have to understand the adaptation options available to southern African society, which is considerably different from first world approaches, and still largely undefined. Quantitative information is only starting to become available, and the resulting somewhat speculative discussions and predictions presented here are uncertain. Some important potential consequences of global warming on the southern African coast are highlighted, and there is presently a clear and urgent need for improved understanding of these issues and, especially, predictive capabilities.

References

Lutjeharms, JRE, Van Ballegooyen, RC (1984). Topographic control in the Agulhas Current system. Deep-Sea Research, Vol. 31, No. 11.

MacHutchon, KR (2006). The Characterisation of South African Sea Storms. Thesis for the Degree of Master of Science in Civil Engineering, University of Stellenbosch. December 2006.

PIANC (2008). Waterborne transport, ports and waterways: A review of climate change rivers, impacts, responses and mitigation. EnviCom – Task Group 3, PIANC.

UNCTAD (2008). Maritime transport and the climate change challenge. Note by the UNCTAD secretariat. United Nations Conference on Trade and Development. TD/B.C.I/MEM.1.2, 9 December 2008