South Africa's First Operational Storm Surge Forecasting Model in Support of Coastal Disaster Management

… & other high resolution metocean decision support tools

Dr Christo Rautenbach

South African Weather Service
Marine Unit

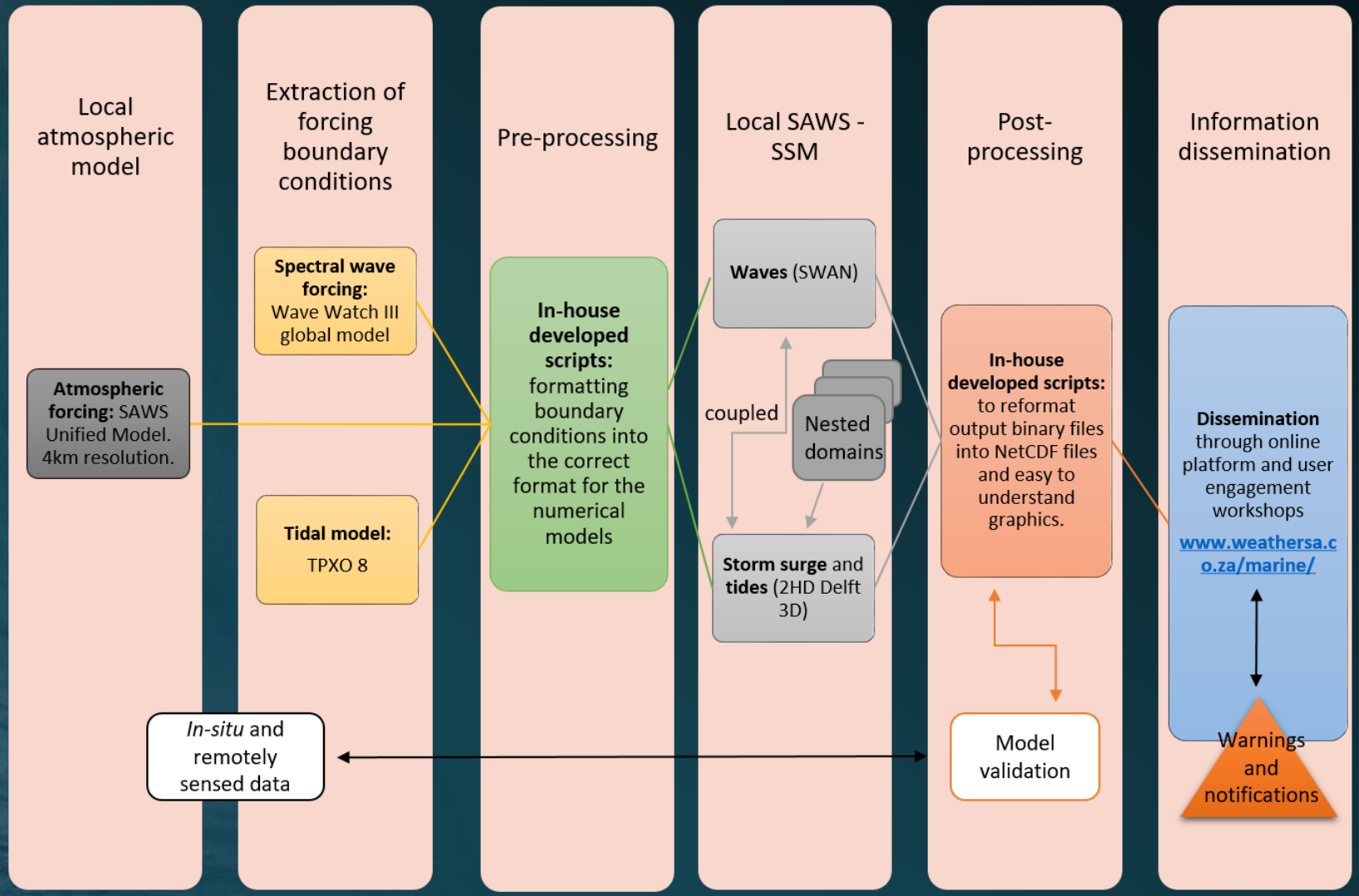
Content Layout

- SAWS Marine Unit
- SAWS Marine Forecasting Framework
- Wave Forecasts
- Tide Forecasts
- Storm Surge Forecasts
- Research – how will climate change affect the coast?
- Research – how do metocean conditions affect coastal safety?

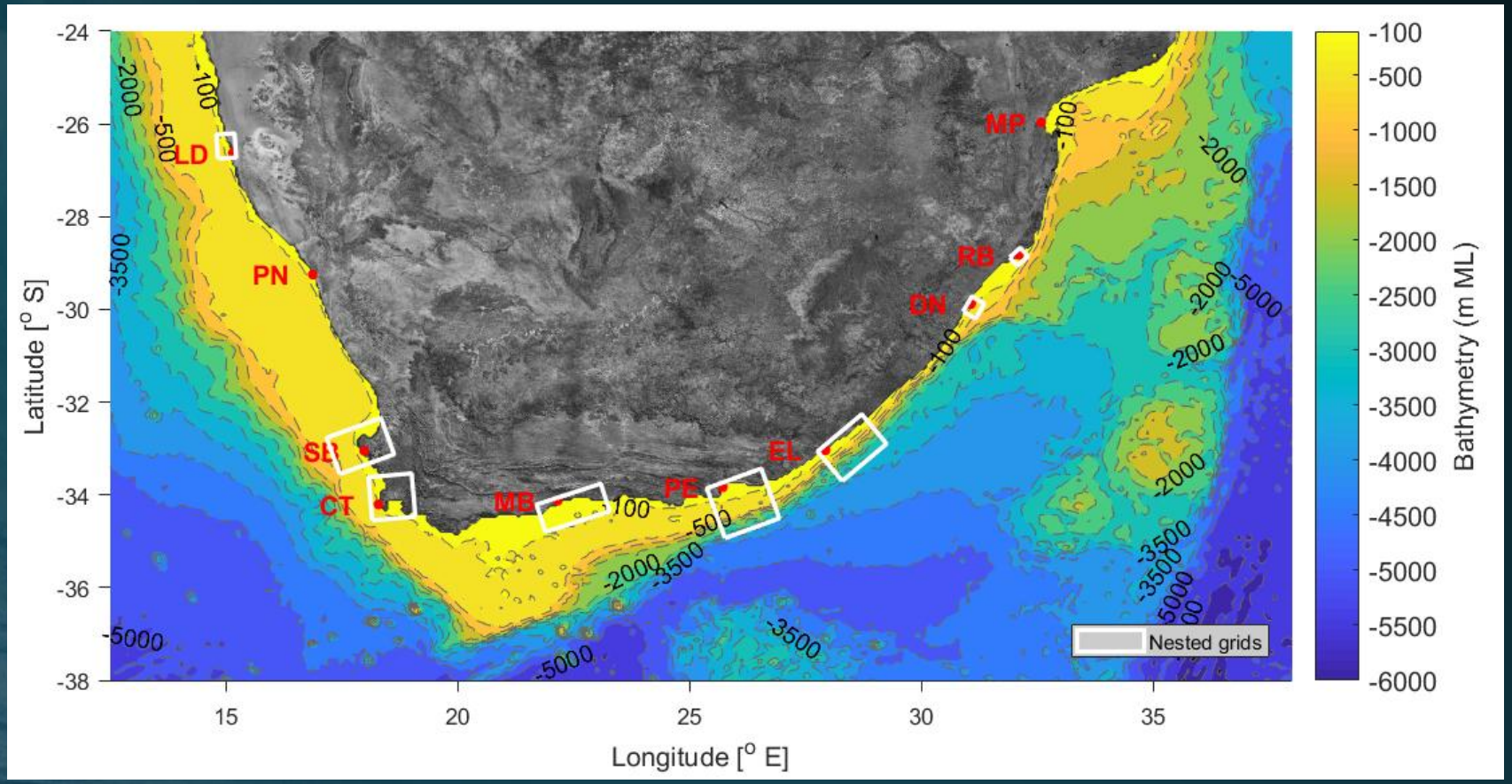
Marine Unit and Marine Master Plan (MMP)

- Around 03/2018, a dedicated **Marine Research Unit** was added to the South African Weather Service (SAWS).
- The development of tools will be based on **applied research** and relevant basic research
- A ***methodology*** is followed where the **science** underpinning the tool developments are **first published (in peer reviewed journals)** and then the tools are rolled out.

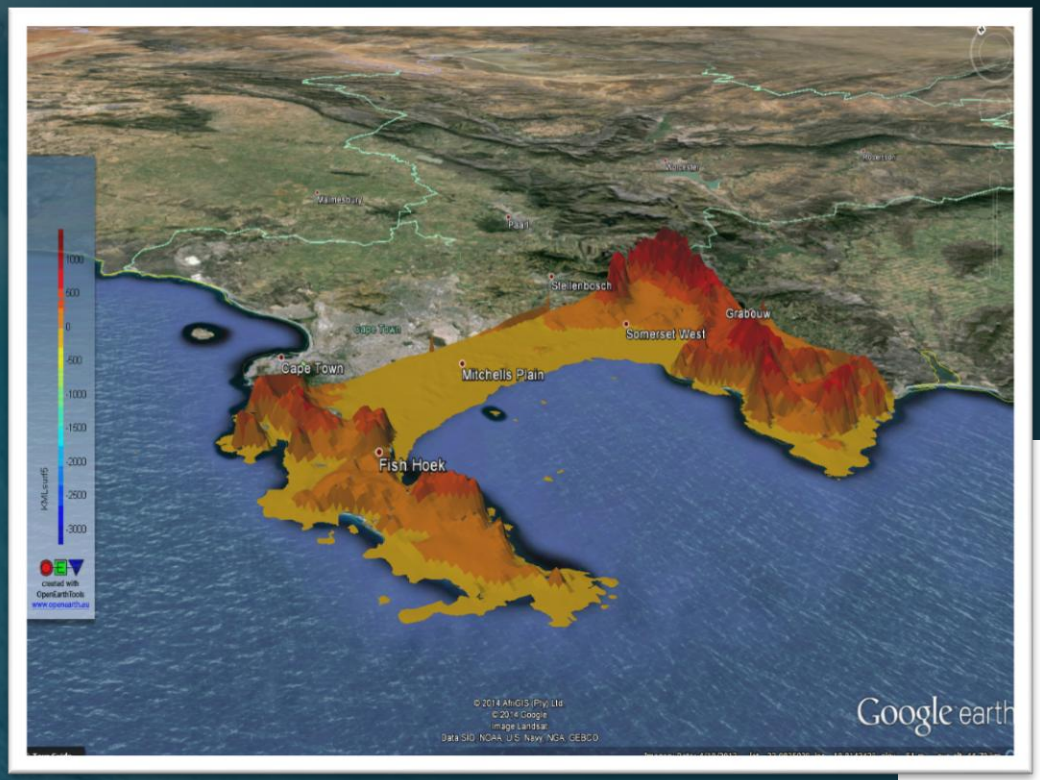
Operational model set-up



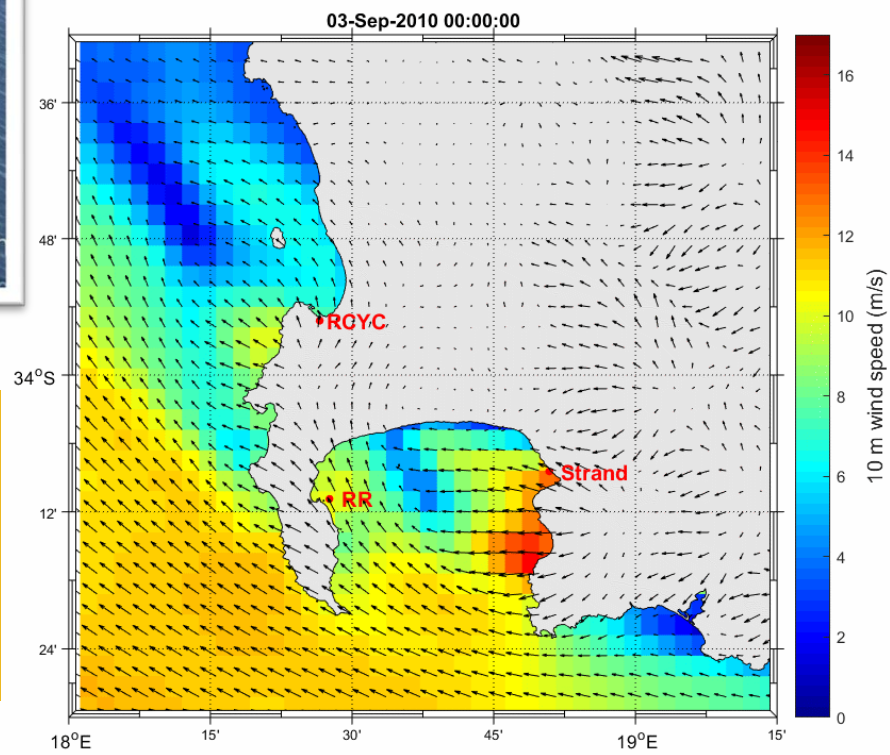
Model coverage and bathymetry



High resolution nests

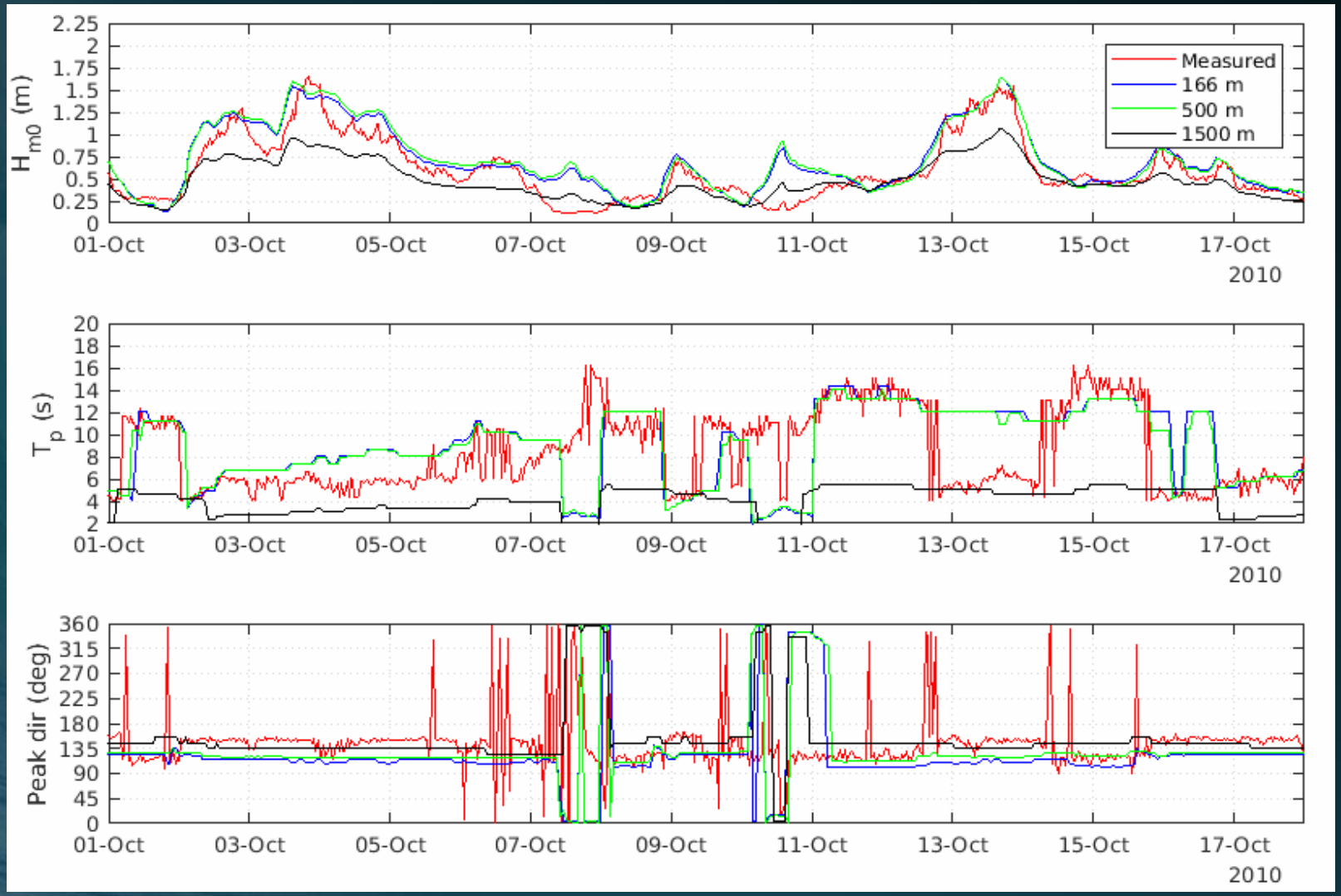


Complex orography causes strong temporal and spatial gradients in local wind forcings.



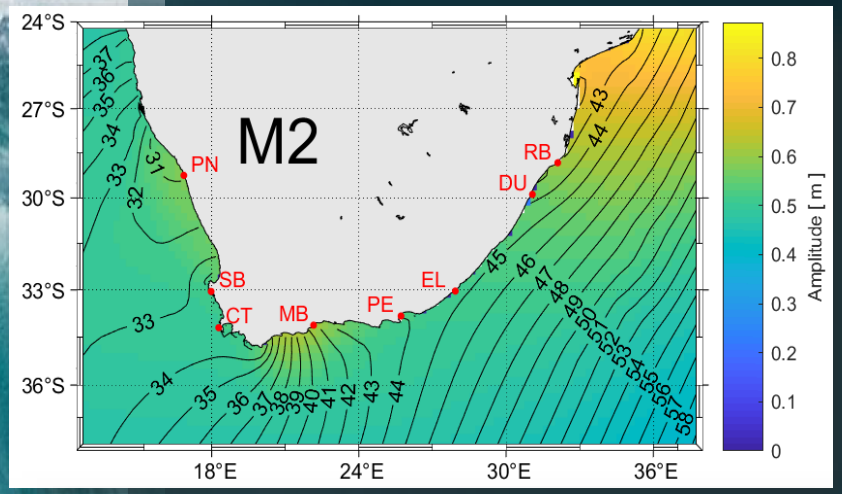
Complex flow and wave patterns emerge in False Bay and Table Bay. Thus lower resolution atmospheric forcings are not an option for accurate flow and wave modelling.

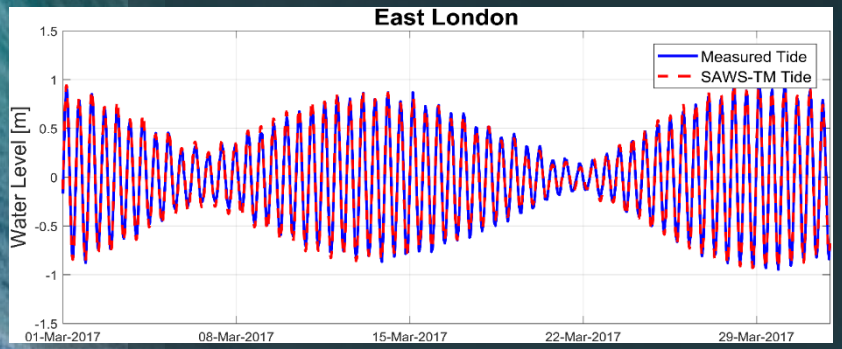
Wave simulation results at Simon's Town

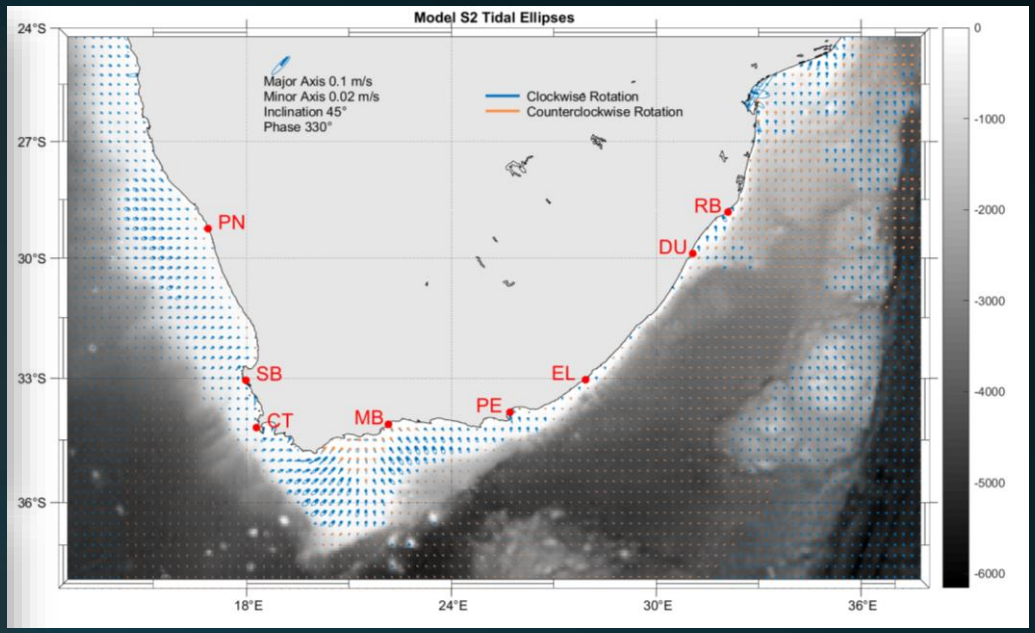


Details to be found in: Williams and Rautenbach (2019), **On the importance of wind generated waves in embayments with complex orographic features – a South African case study.** *Submitted to the Journal of Marine Systems.*

Tidal characteristics of South Africa







Location	CT	ST	MB	PE	EL	DU	RB
RMSE	0.084	0.091	0.098	0.086	0.081	0.090	0.095
Bias	-8.68e-5	-1.78e-3	4.62e-4	4.49e-4	5.88e4	-9.26e-5	8.26e-7
Willmott	0.904	0.894	0.908	0.908	0.911	0.910	0.911

Contents lists available at ScienceDirect

Deep-Sea Research Part I

journal homepage: www.elsevier.com/locate/dsri

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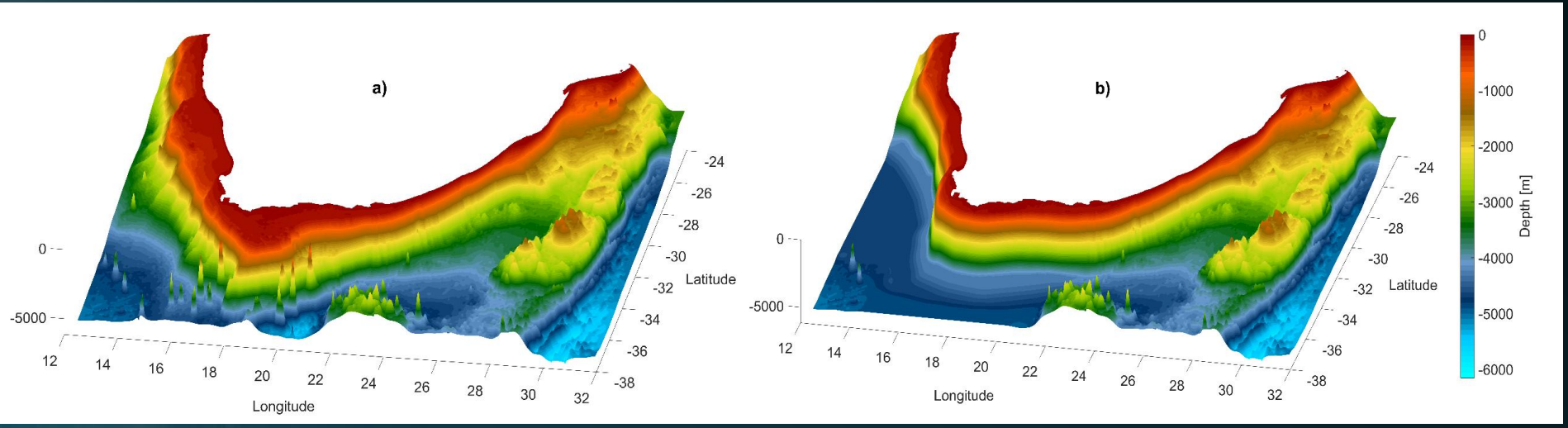
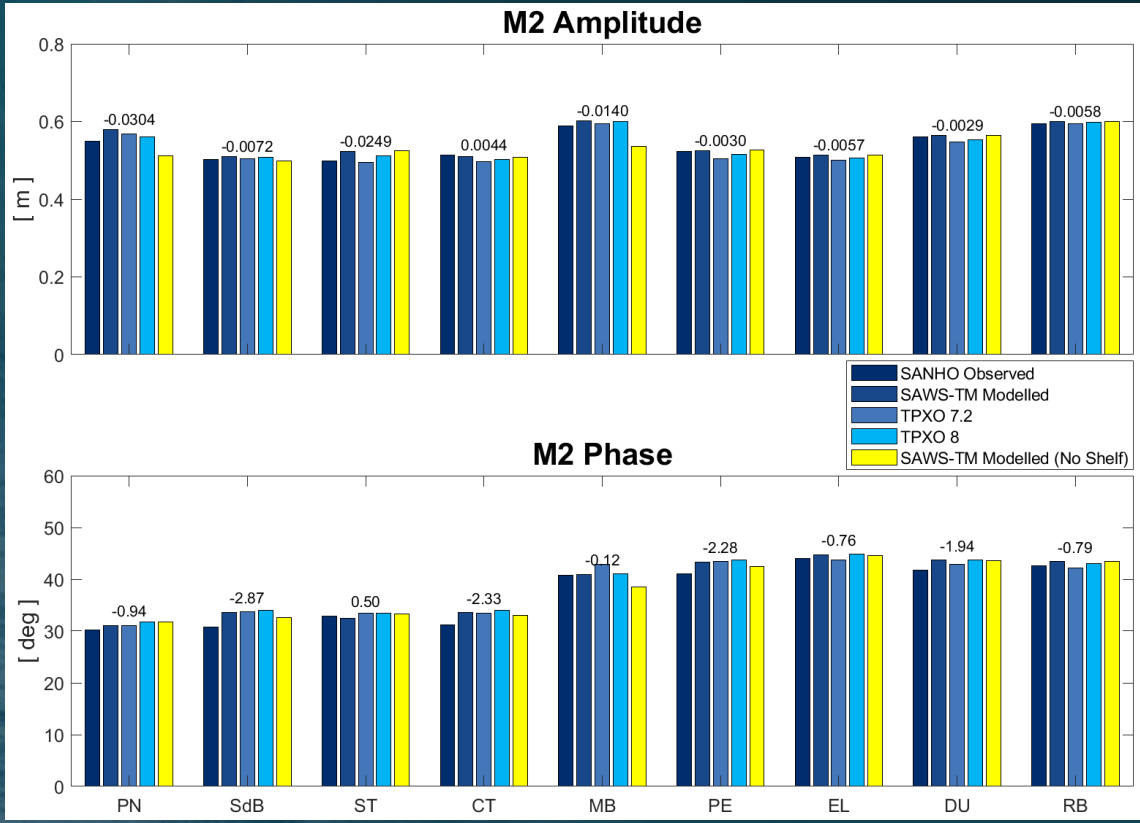
Tidal characteristics of South Africa

Christo Rautenbach[a,b,*], Michael A. Barnes[a], Marc de Vos[a,b,c]

[a] Marine Research Unit, South African Weather Service, Cape Town, South Africa
[b] Department of Oceanography and Marine Research Institute, University of Cape Town, South Africa
[c] National Sea Rescue Institute, Cape Town, South Africa

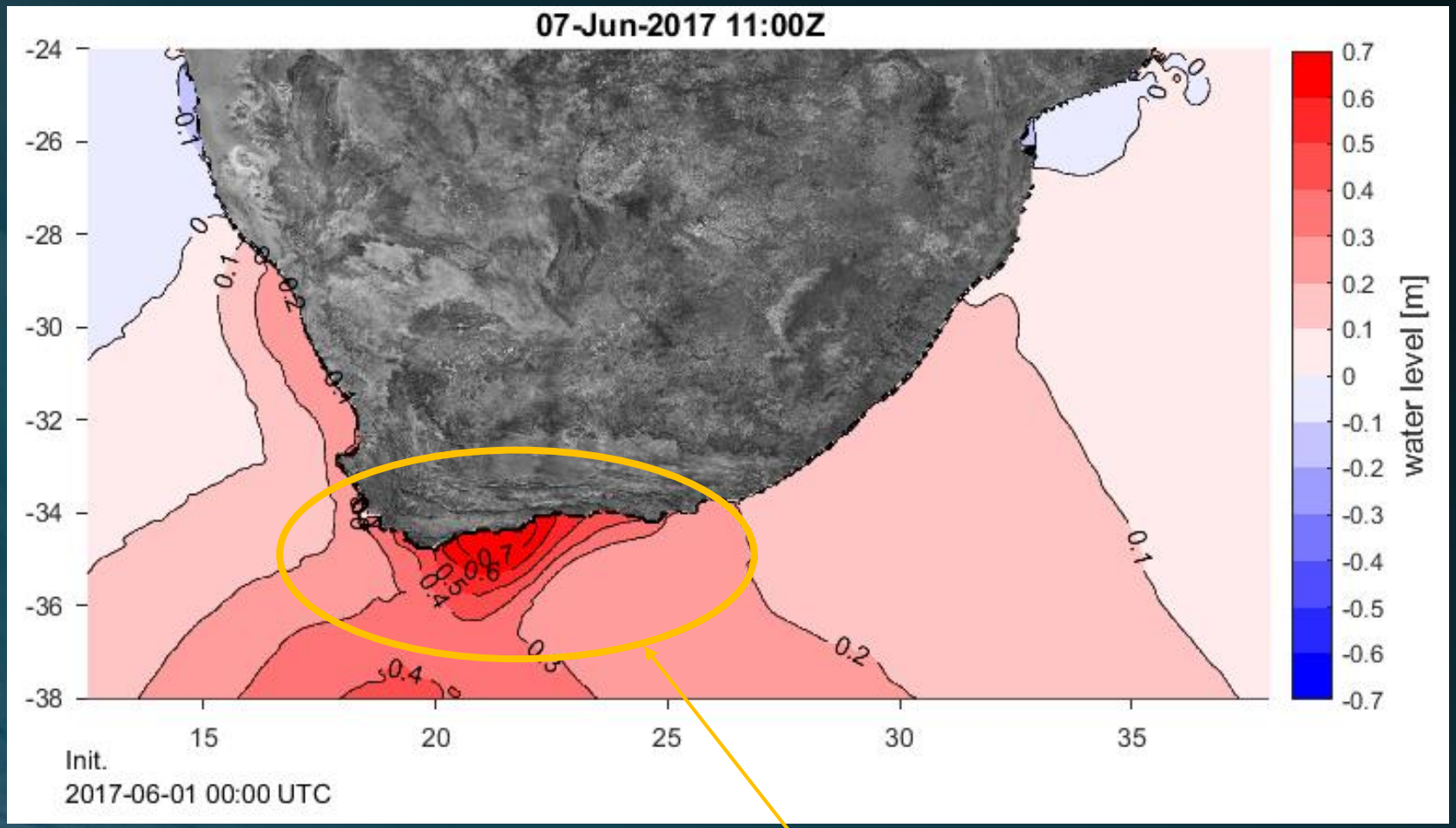
An accurate tide forecast model was the first step towards an accurate storm surge model





The **coastal resonance experiment** revealed that the Agulhas and Namaqua Banks are responsible for the **increasing amplitude** and **phase lags** at Mossel Bay and Port Nolloth.

Storm surge water elevations

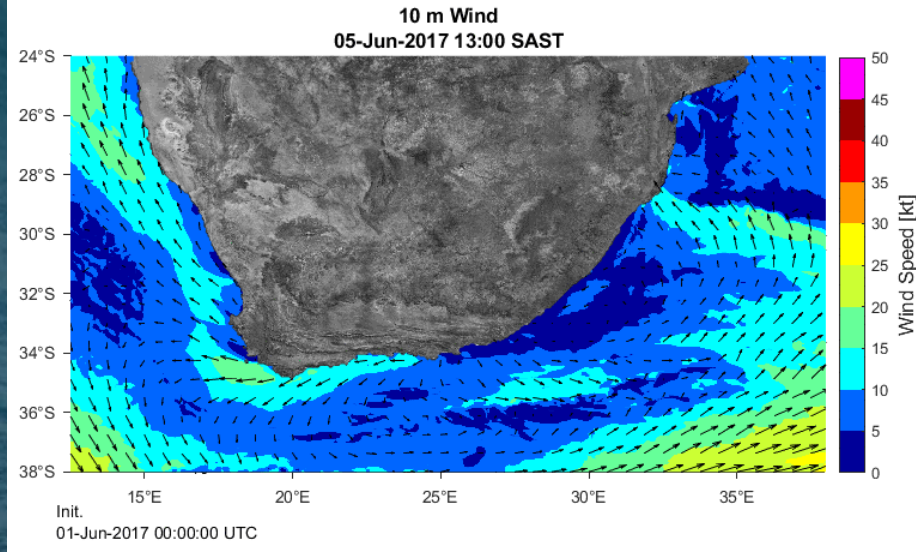


Not coastal semi-diurnal resonance!

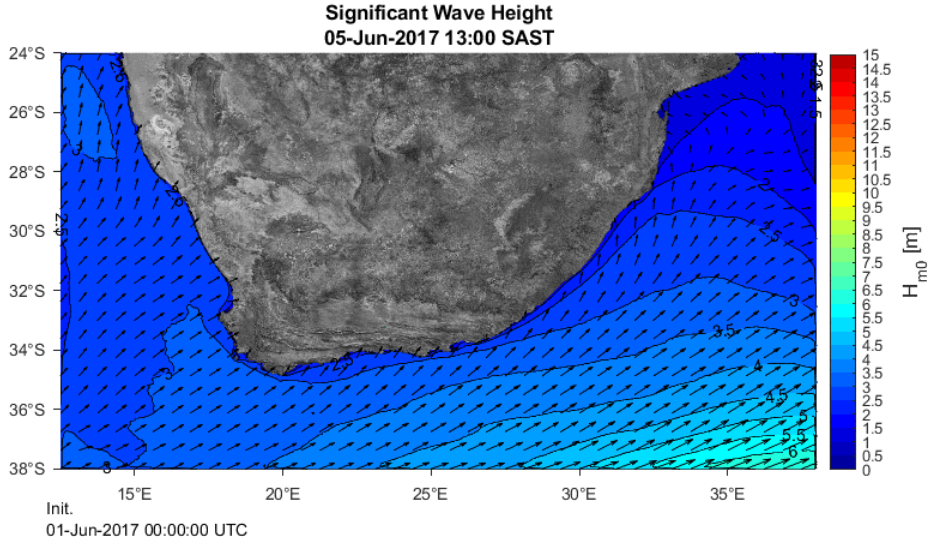
$$\frac{d\eta}{dx} = \frac{\tau_{wind,x}}{\rho g \boldsymbol{h}}$$

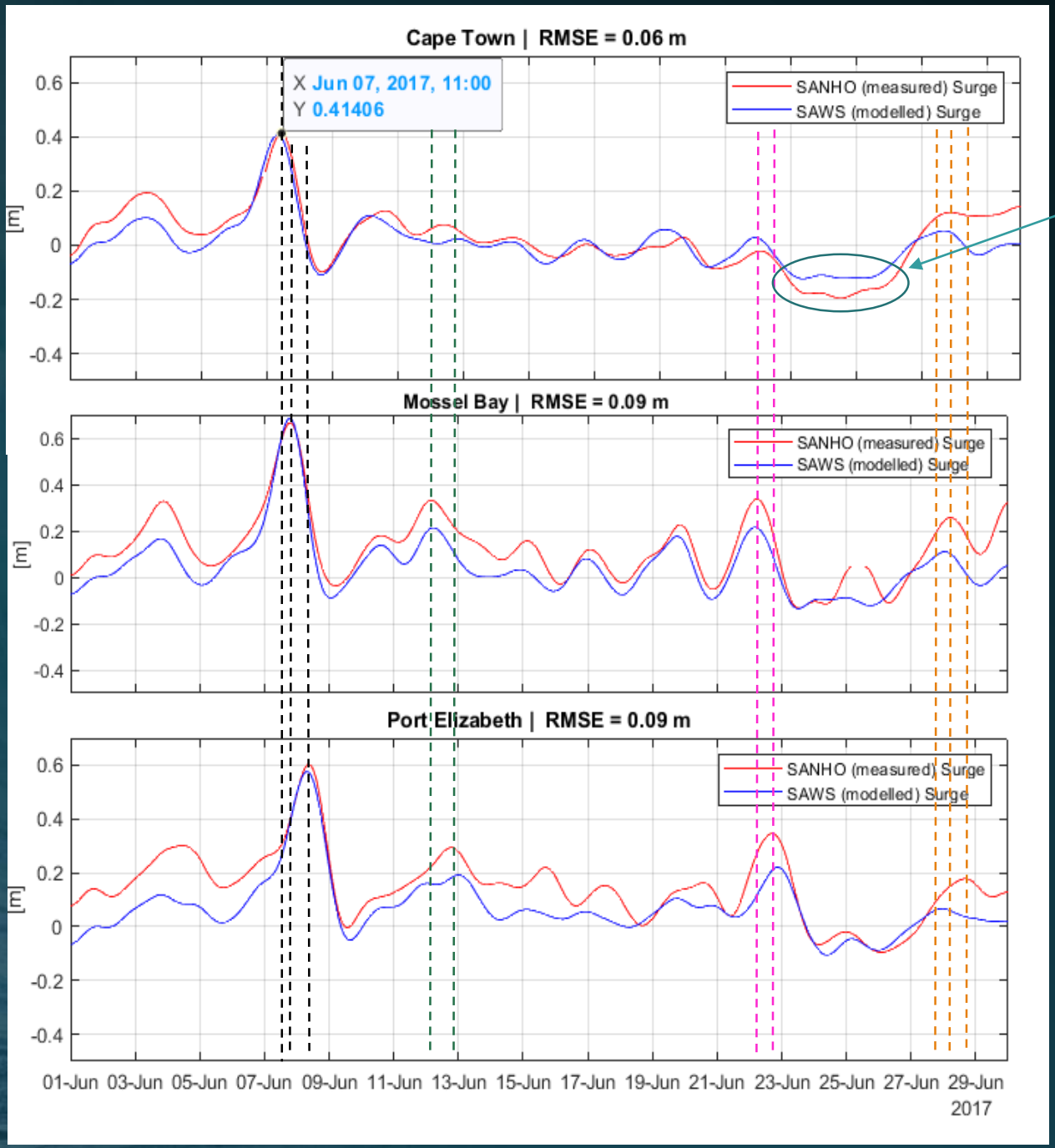
Storm surge calibration – Cape storm 2017

Modelled winds



Modelled waves





Over predicted

CT RMSE: 2,43m/s

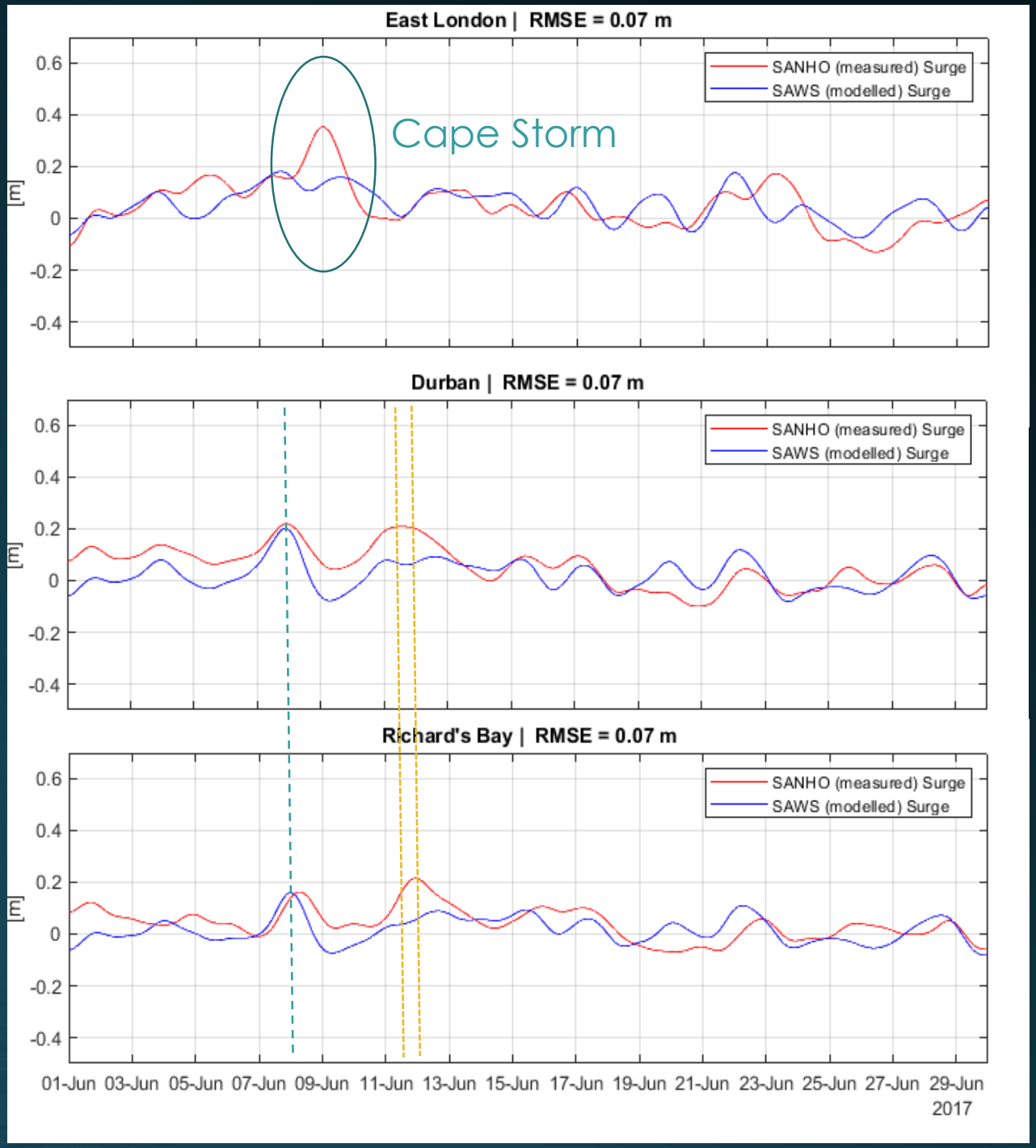
MB RMSE: 3,22m/s

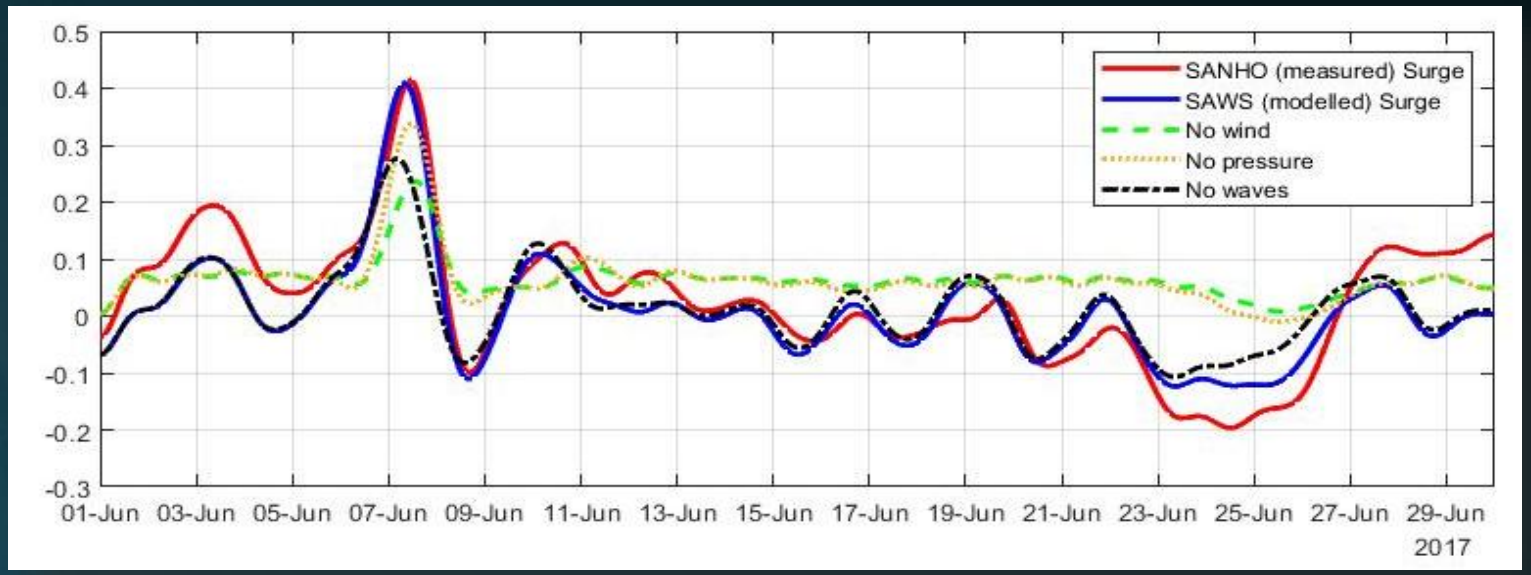
Atmospheric model accuracies

Cape south-west coast

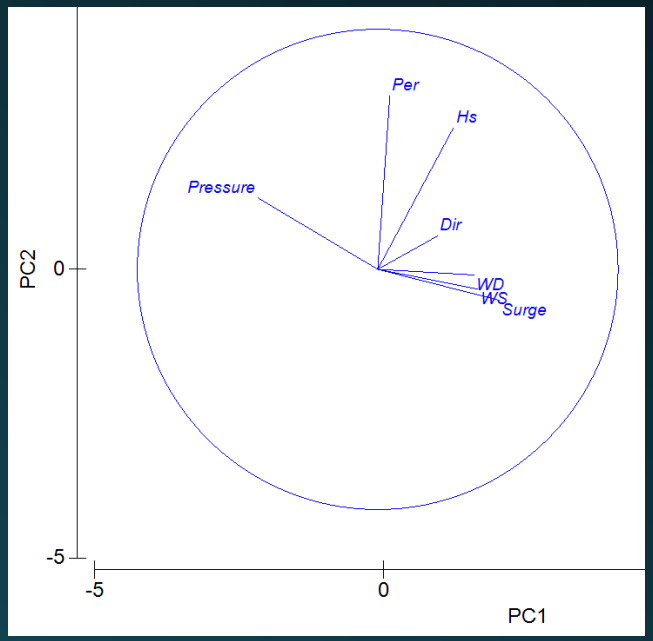
Cape east coast

Durban RMSE: 2,22m/s



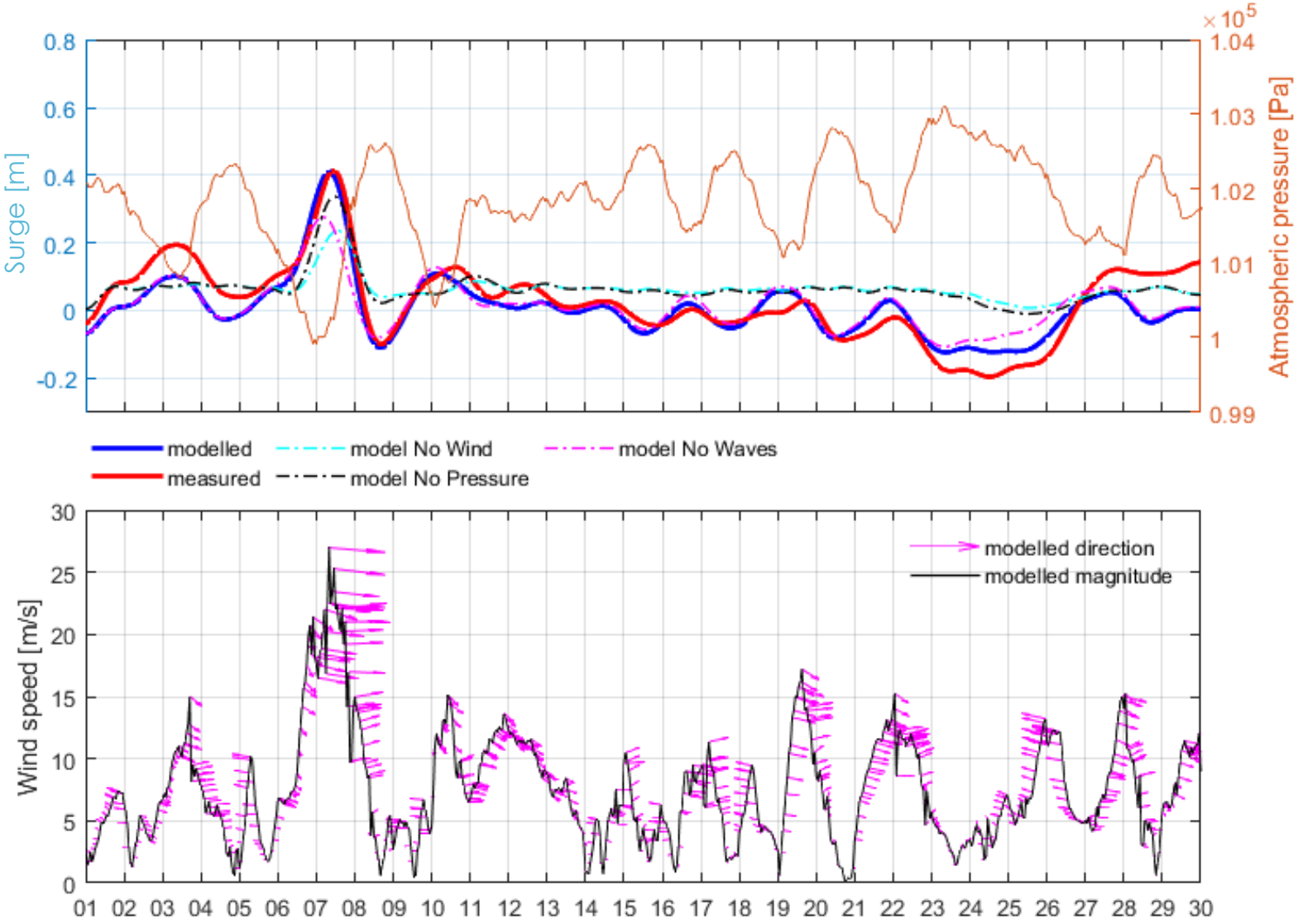


- Without **local atmospheric pressure** **82%** of the storm peak is still described.
- Without **waves** **67%** of the storm peak is still described
- Without **wind** only **52%** of the storm peak is described

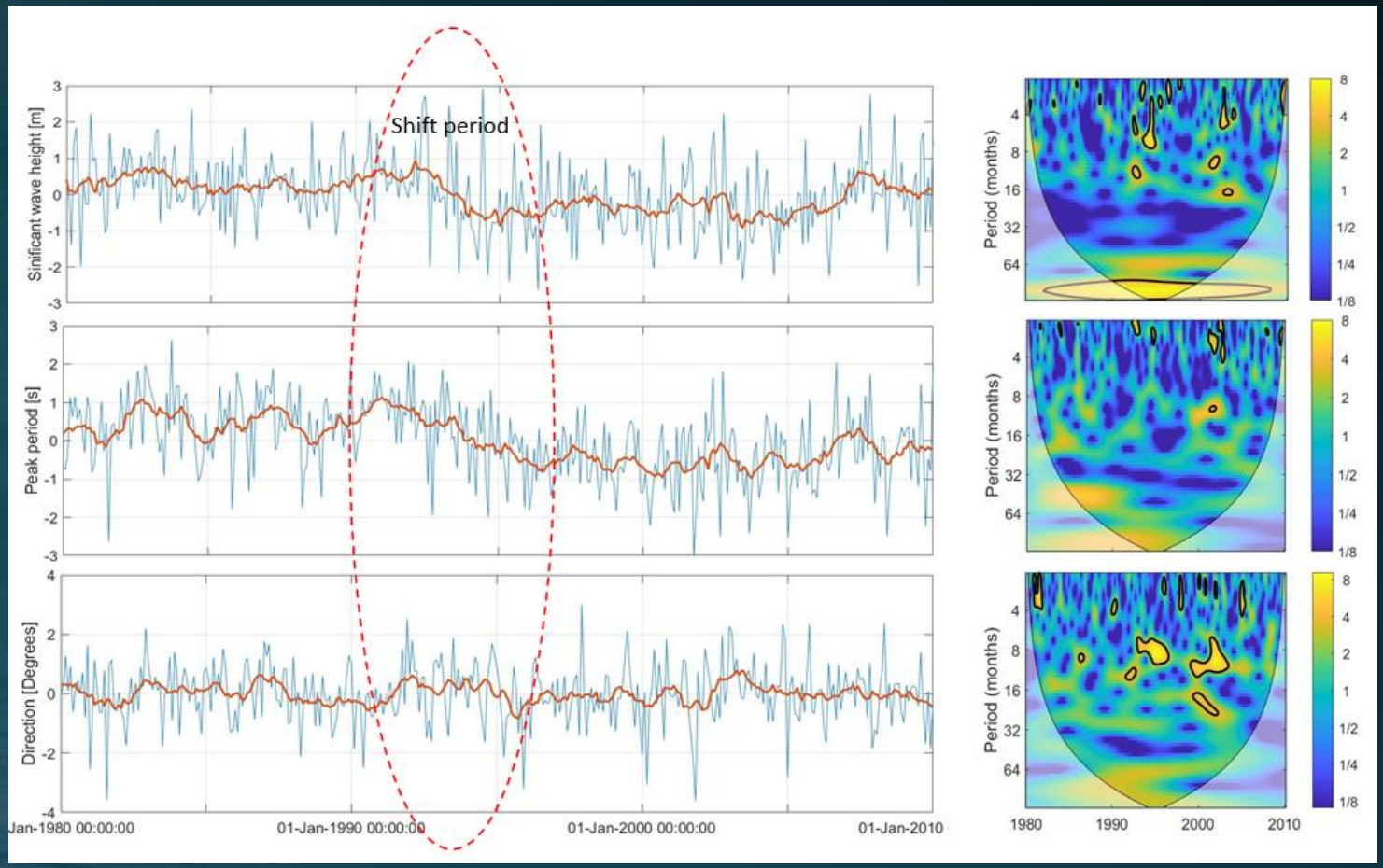


Wind and pressure is needed to capture the annulation in the storm surge signal

Wave set-up only contribute during extreme events and influences the peak timing.

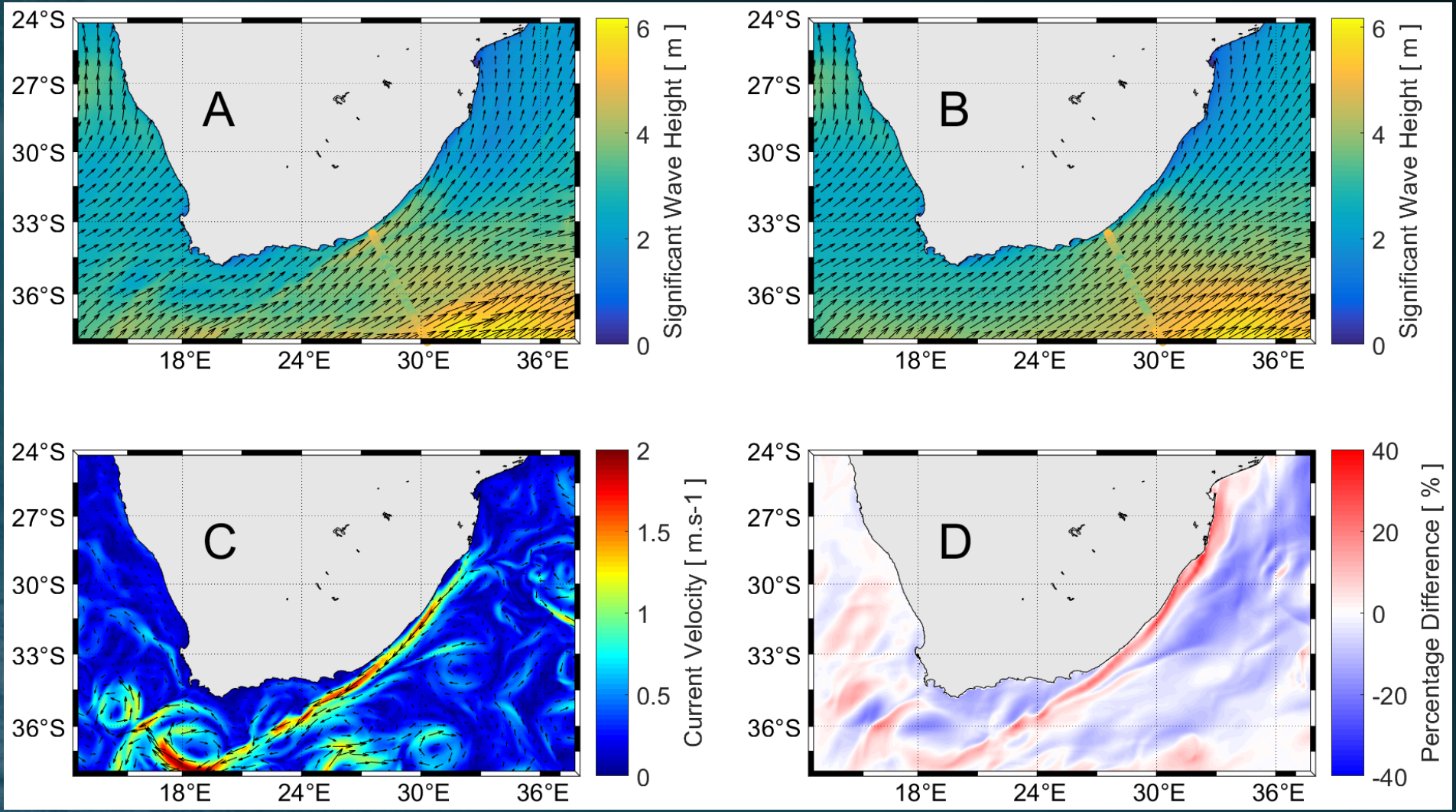

Surge [m]
0.8
0.6
0.4
0.2
0
-0.2
×10^5
1.04
1.03
1.02
1.01
1
0.99
Atmospheric pressure [Pa]
modelled
measured
model No Wind
model No Pressure
model No Waves
Wind speed [m/s]
30
25
20
15
10
5
0
modelled direction
modelled magnitude
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

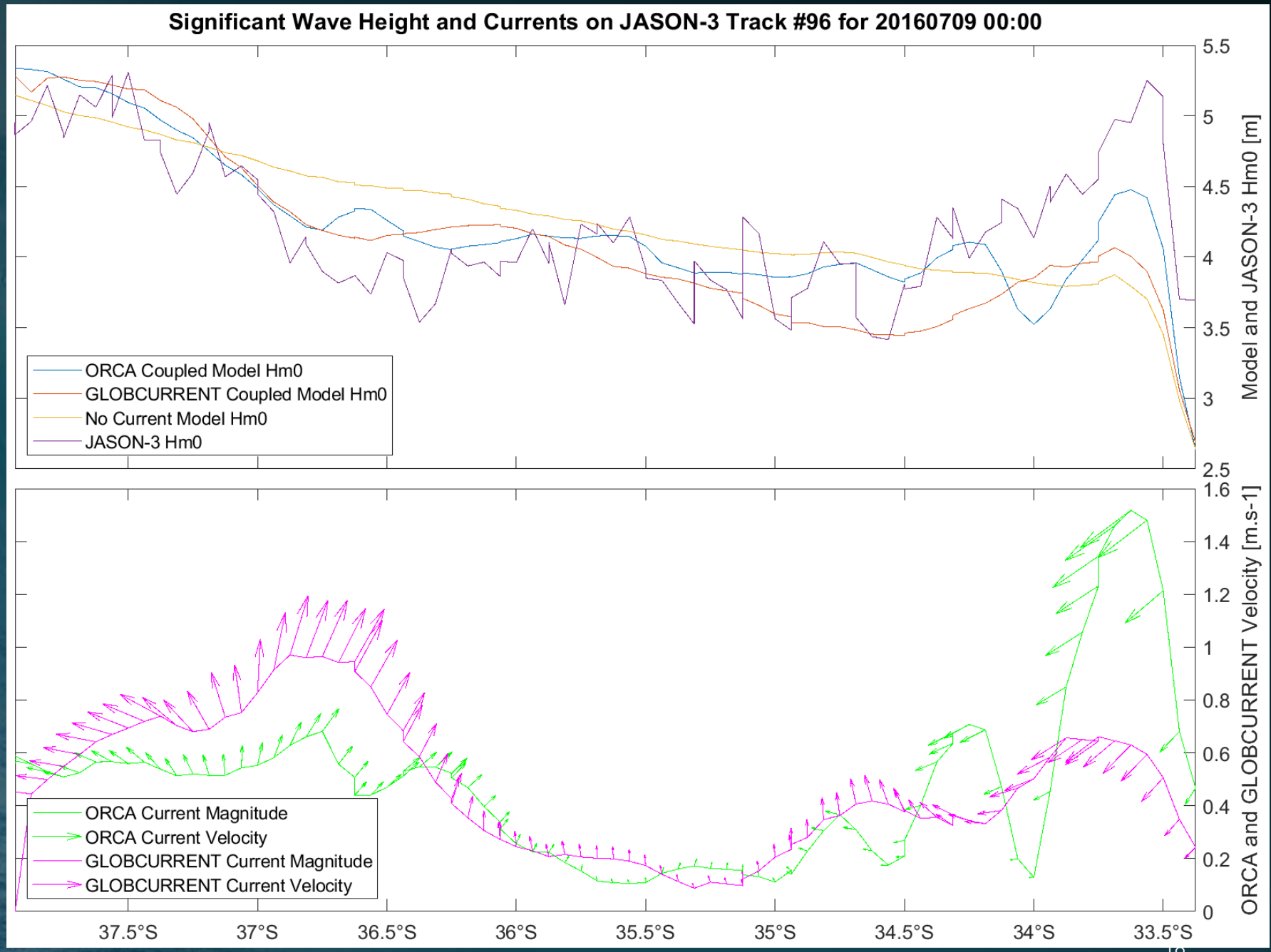
Role of large-scale modes of climate variability



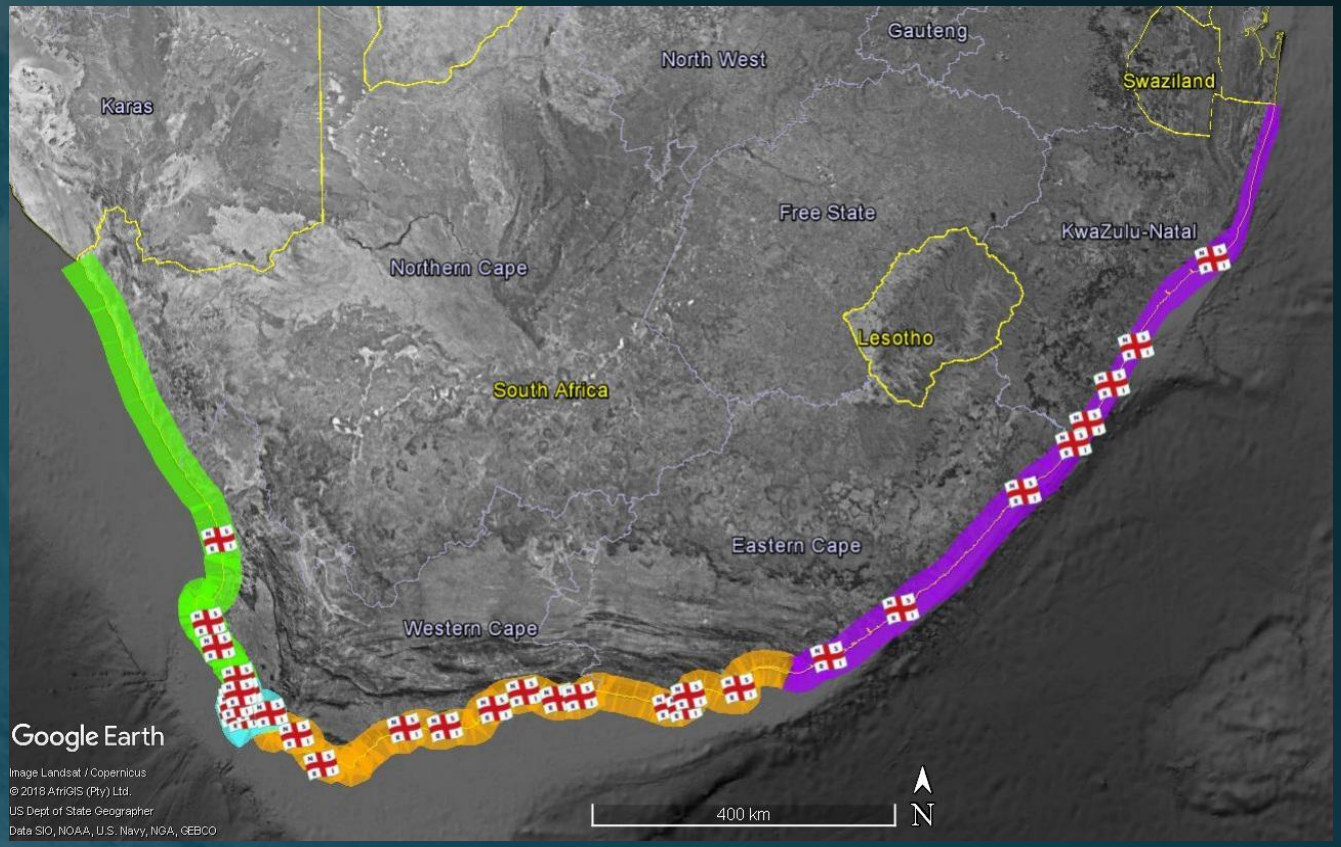
J. Veitch, C. Rautenbach, J. Hermes and C. Reason (2018). *The Cape Point wave record and the role of large-scale modes of climate variability. Journal of Marine Systems, 198, 103185.*

Wave current interactions




Significant Wave Height and Currents on JASON-3 Track #96 for 20160709 00:00
ORCA Coupled Model Hm0
GLOBCURRENT Coupled Model Hm0
No Current Model Hm0
JASON-3 Hm0
Model and JASON-3 Hm0 [m]
5.5
5
4.5
4
3.5
3
2.5
ORCA Current Magnitude
ORCA Current Velocity
GLOBCURRENT Current Magnitude
GLOBCURRENT Current Velocity
ORCA and GLOBCURRENT Velocity [m.s-1]
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
37.5°S
37°S
36.5°S
36°S
35.5°S
35°S
34.5°S
34°S
33.5°S

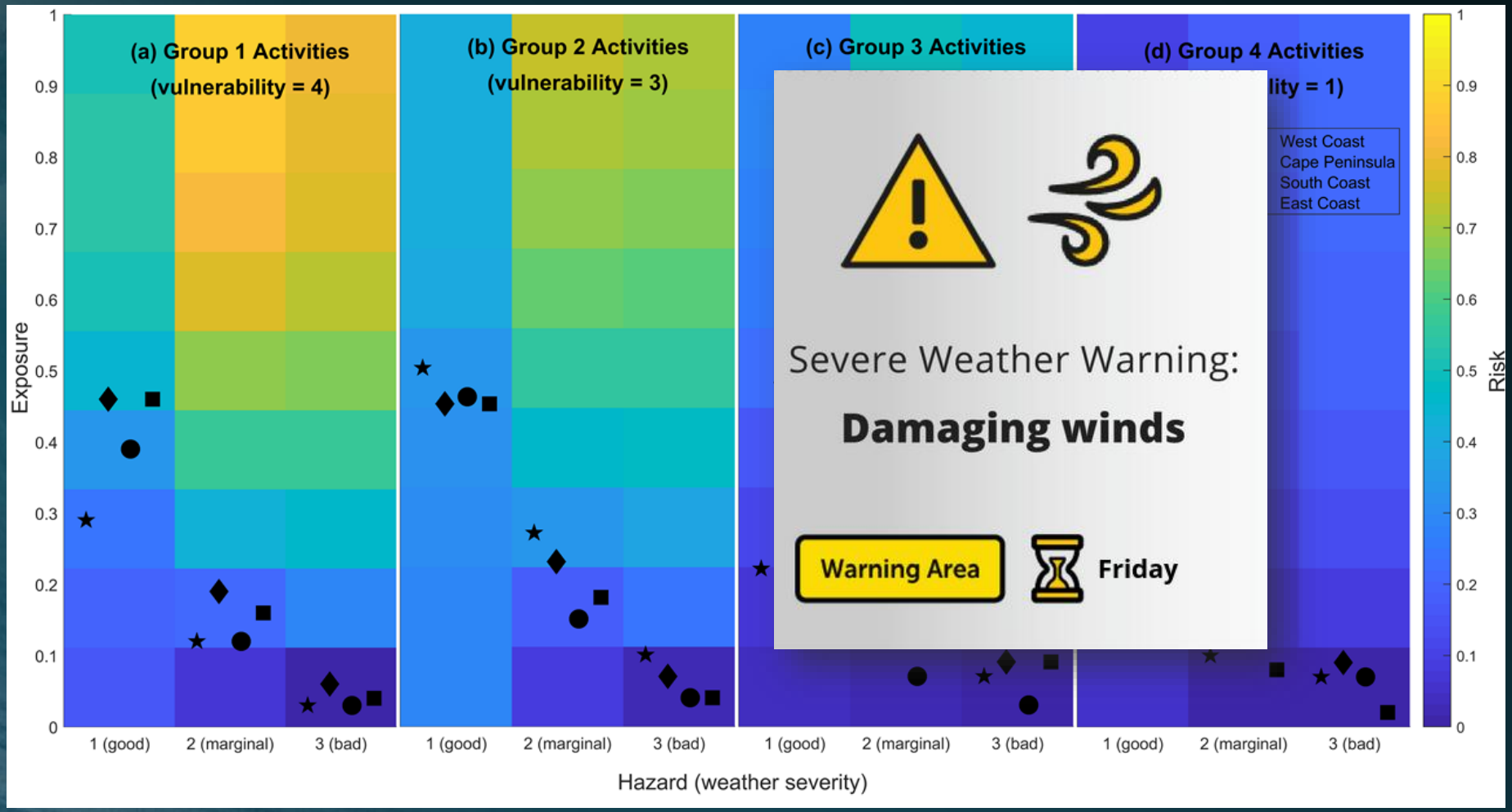
Investigating the connection between metocean conditions and coastal user safety



A map of South Africa showing the 33 **NSRI** stations from which the report dataset draws, as well as coastal sub-regions defined for the purposes of the study.

Classification framework for marine weather conditions		Visibility	Swell (m)	Wind (kt)
Lower Severity ↕ Higher Severity	**Good**	Good	0-2	0-6
	Marginal	Average	2-3	11-27
	Bad	Bad	> 3	> 28

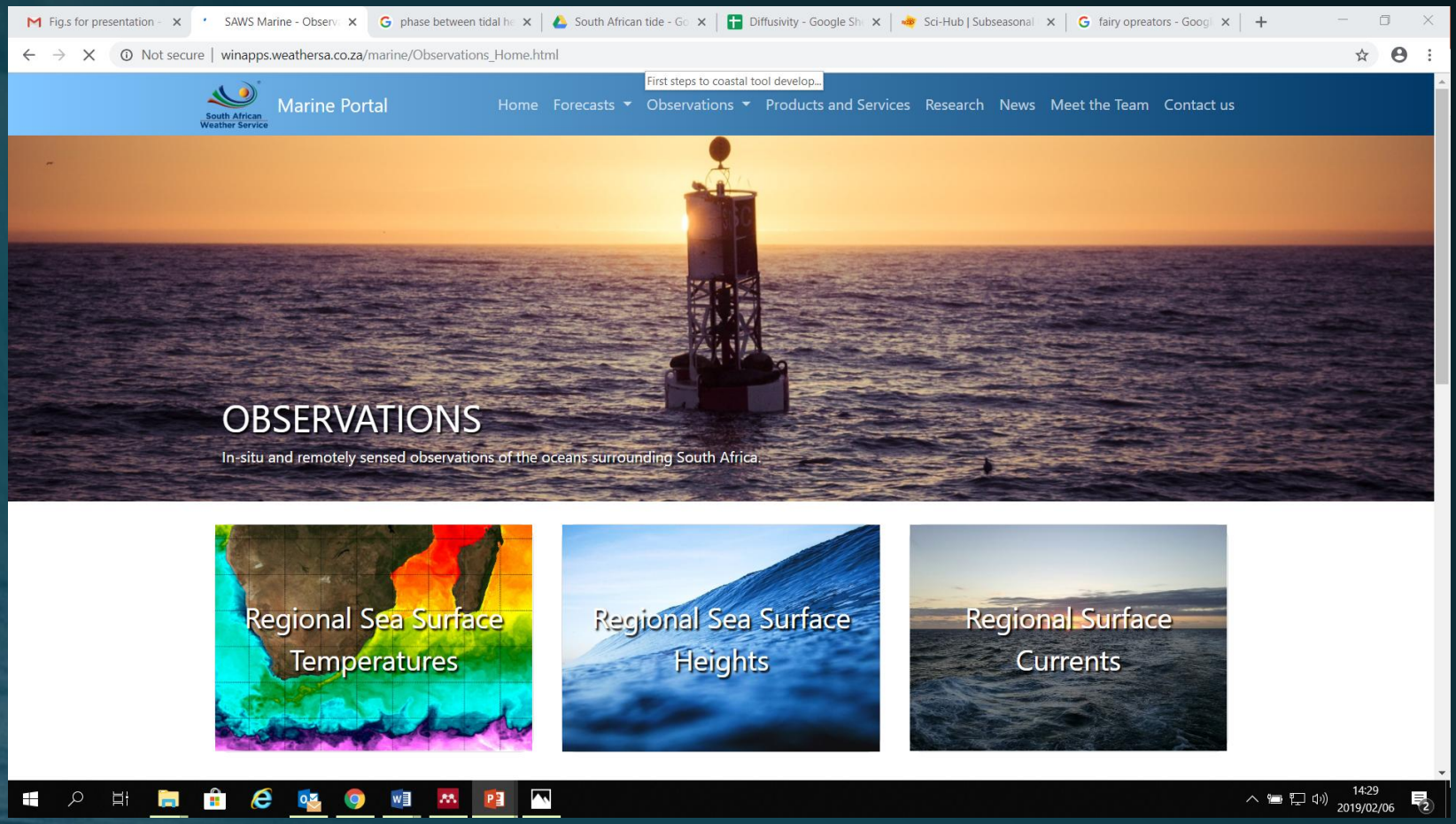
Risk = Hazard × Exposure × Vulnerability



M. De Vos and C. Rautenbach (2019), *Investigating the connection between metocean conditions and coastal user safety: an Analysis of Search and Rescue data*. Journal of Safety Science, 117, pp. 217-228.

Website demo

marine.weathersa.co.za



Thank you for your attention

Rautenbach.Christo@gmail.com

South African Weather Service

Marine Unit