Rogue Wave Problem in the Southern African region

Morwakoma M Matabane
Research Scientist

South African Weather Service
ISO 9001 Certified Organisation

Outline

- Background and Motivation
- Rogue Wave Problem: *Southern African Context*
- Ideal Solution

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Background and Motivation

- **Freak wave occurs when the wave height abnormally exceeds the significant wave height by a factor of 2** [*e.g., Draper, 1965; Lyu et al., 2023]*

- **Freak waves can be generated by 3 mechanisms, namely, spatial, dispersive, and nonlinear focusing** [*e.g., Dysthe, 2008; Salonen UCT MSc Dissertation, 2019*]

- **Nonlinear focusing/Modulational instability occurs in deep waters – a phenomenon leading to energy concentration in a narrow–spectrum wave train**. [*e.g., Janssen et al., 2003; Lyu et al., 2023]*

- **Impact of rogue waves** [*e.g., Didenkulova et al., 2023*]:

a) ***Dangerous to vessels*** [e.g., large cruise ships and small fishing boats]

b) ***Damage to oil and gas pipelines and platforms***

c) ***Destroys marine constructions*** [e.g., ports and harbors]

d) ***Fatal to people spending time on sea and fishing***

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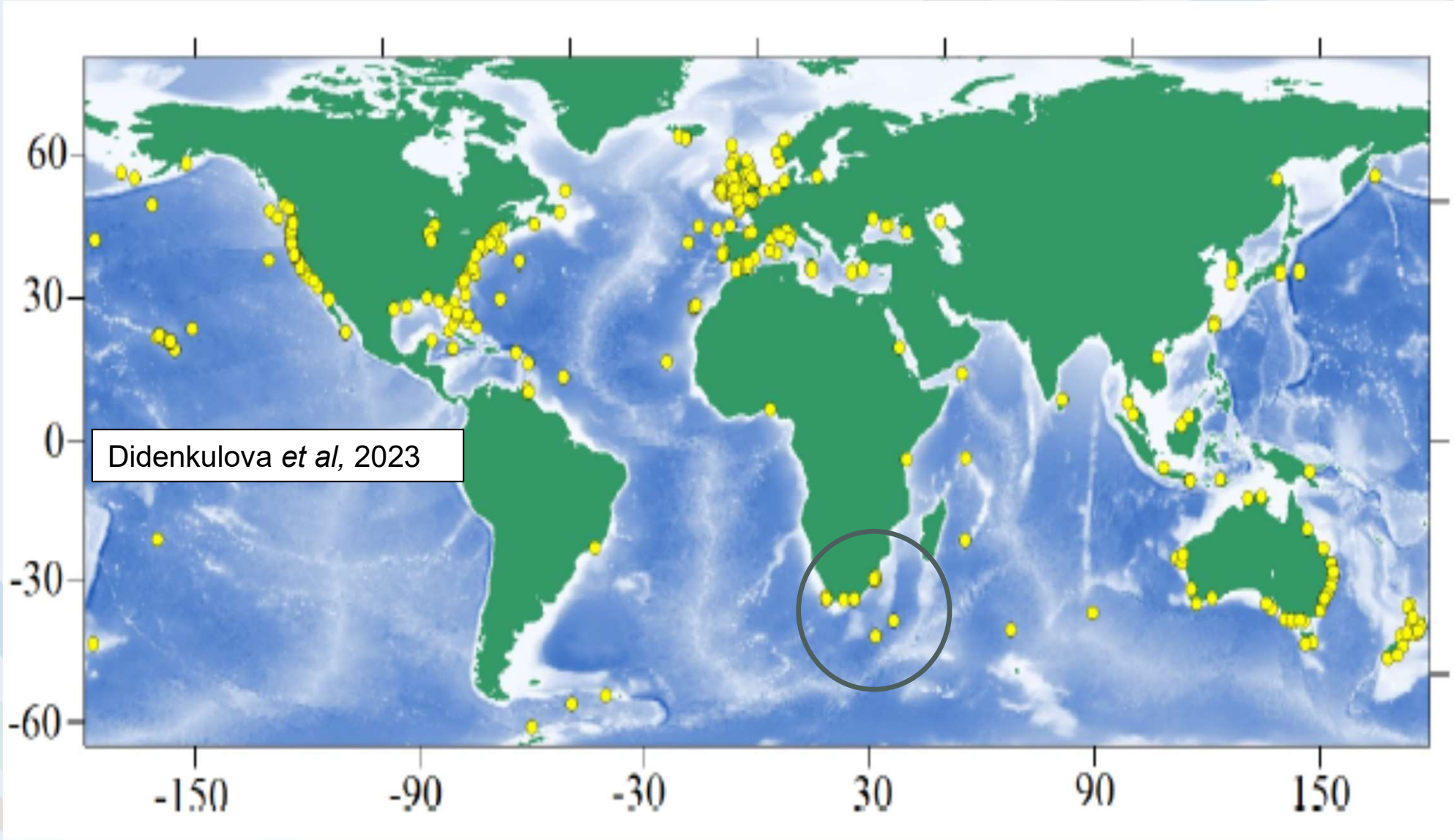
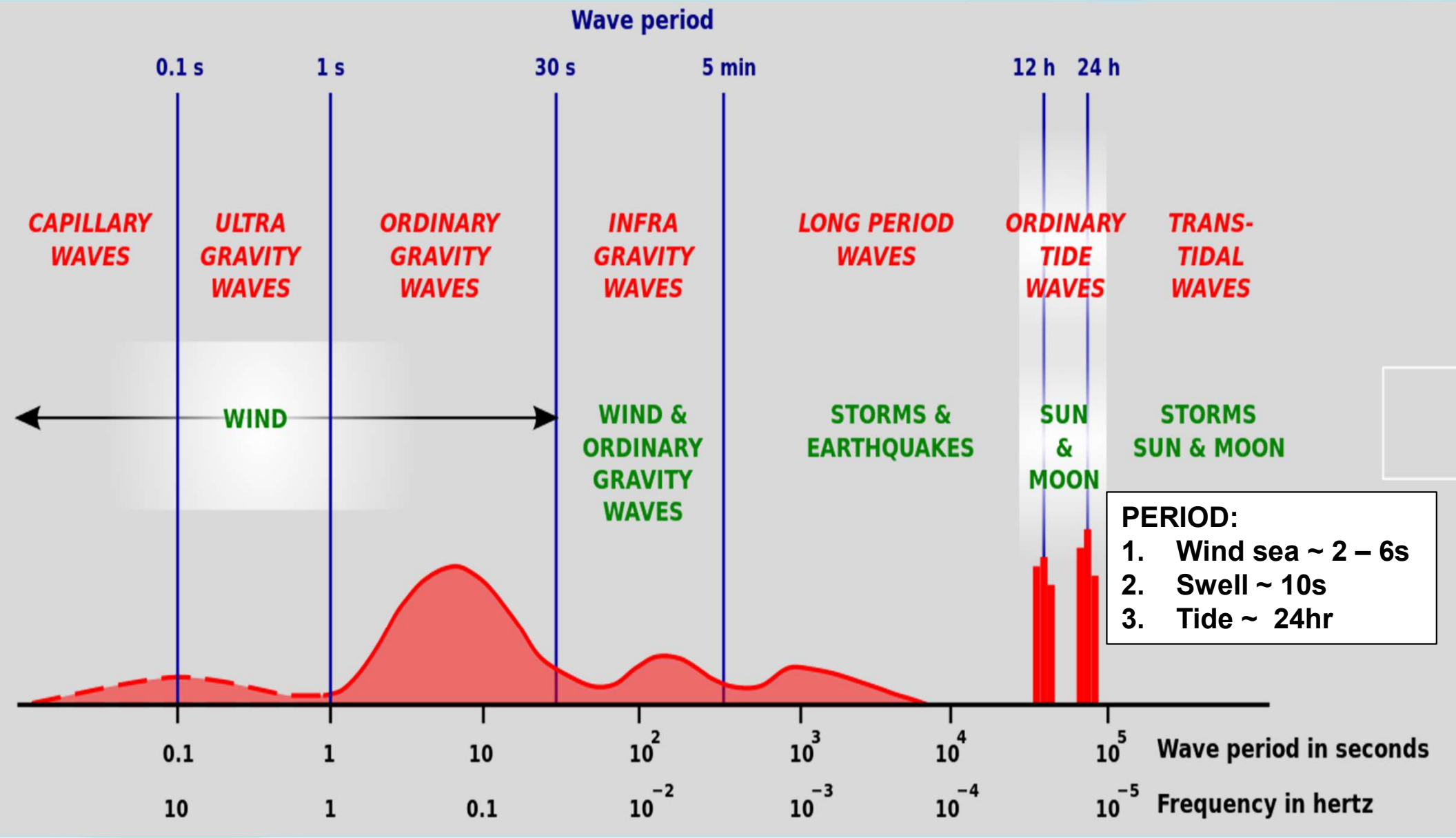
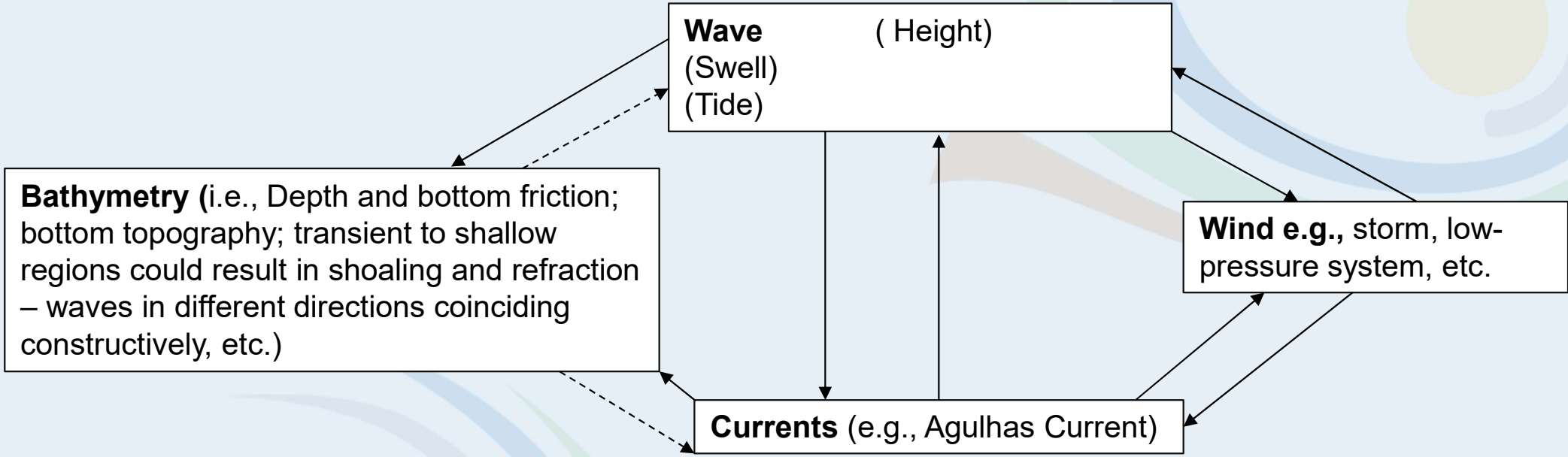
Map of Rogue/Freak wave accidents 2005-2021



Wave: Scaling

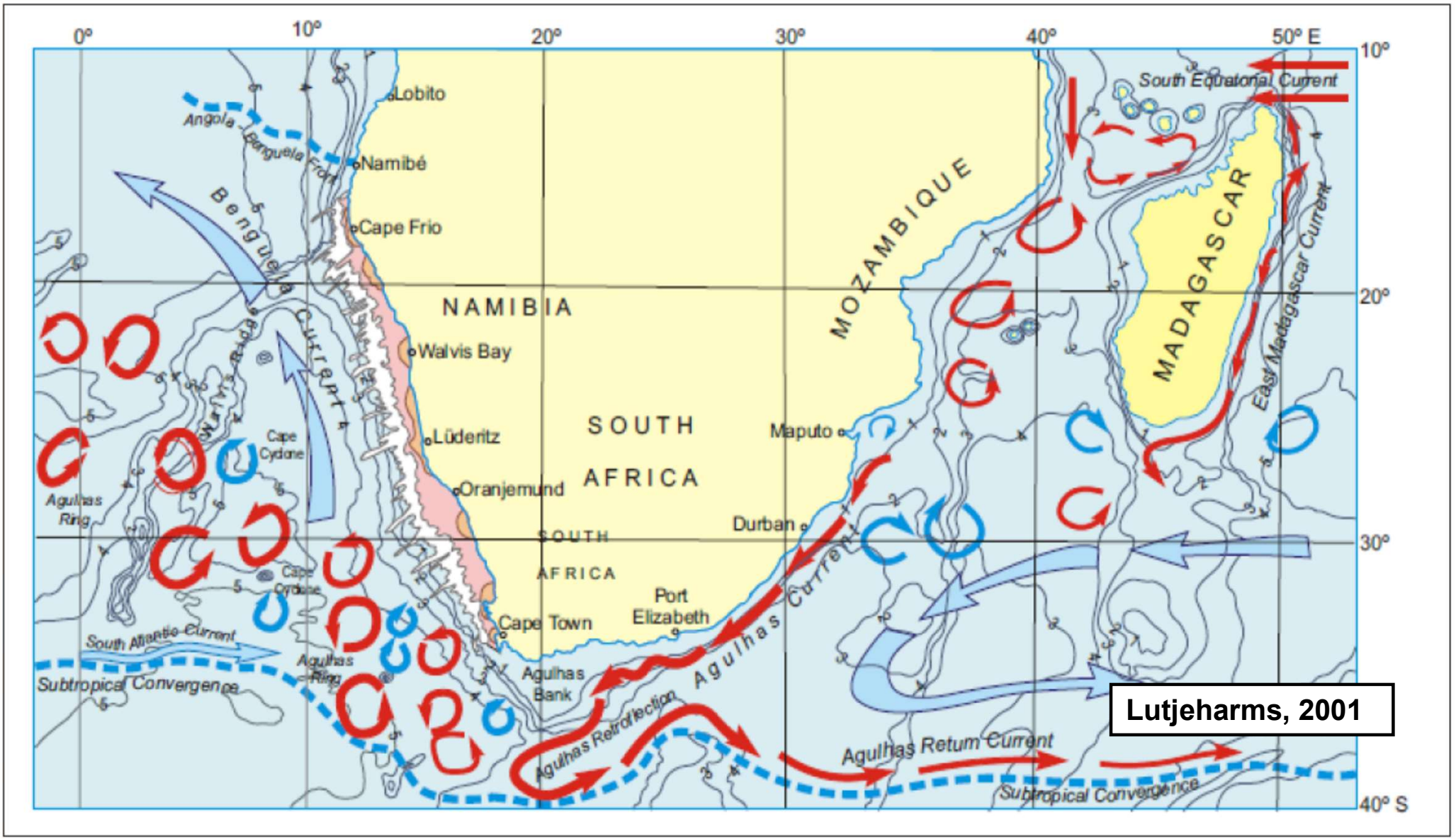


Rogue Wave Problem Overview

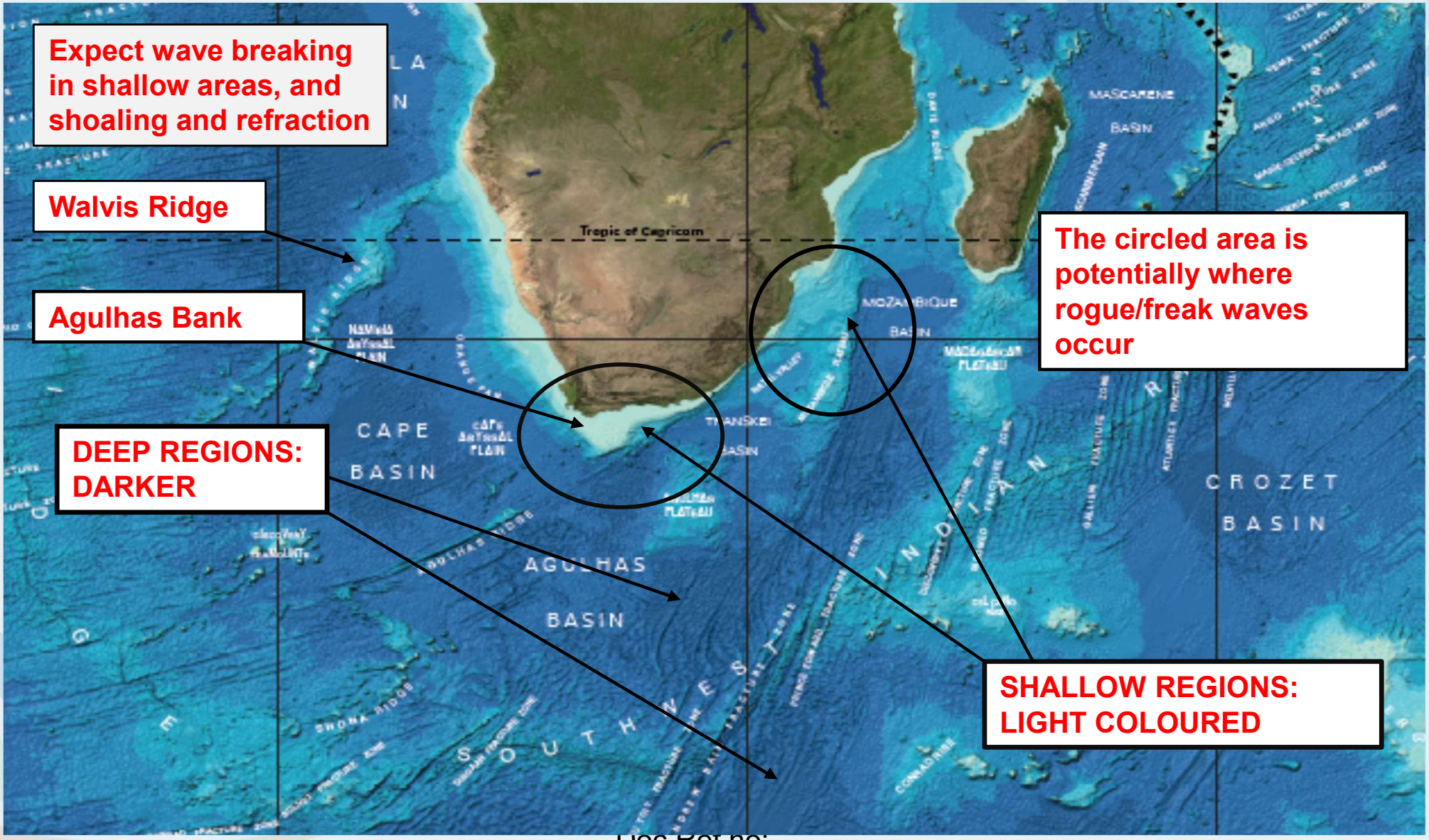


- **Current changes the wave direction, amplitude, and frequency** [*e.g., Villas-Boas and Pizzo, 2021, etc.*]
- **Wave breaking generates currents and turbulence** [*e.g., Villas-Boas and Pizzo, 2021, etc.]*
- **In shallow continental shelves, wave height modulations of up to 20% - 50% have been attributed to tidal currents** [*e.g., Tolman, 1990; Wang and Sheng, 2015*]
- **Following tidal currents corresponds with an increase in wave height of up to 25%** [*e.g., Ho et al., 2023*]
- **Wave height modulation will be reduced if wind and current are in the same direction, leading to smaller waves, and vice versa**. [*e.g., Gemmrich and Garrett, 2012*]
- **Opposing currents could trigger nonlinear instabilities that leads to enhanced wave breaking and potentially more frequent rogue waves** [*e.g., Onorato et al., 2011 – cited from Gemmrich and Garrett, 2012*]

Southern African Context: Agulhas Current System



Bathymetry: GEBCO



Effect of bathymetry, example

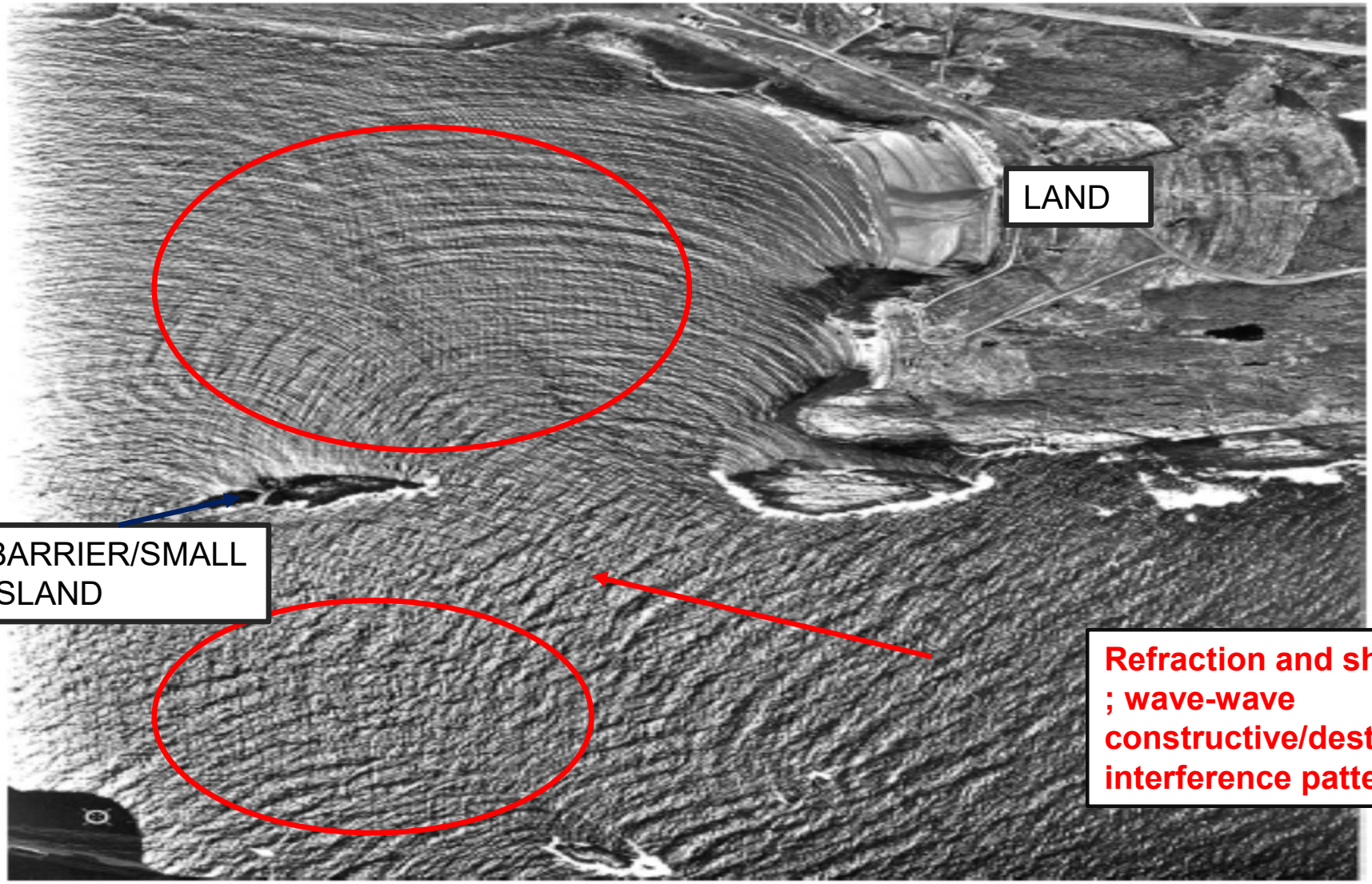


Fig. 3.1 Wave fronts change due to obstacles and variable bathymetry (Dysthe et al. 2005)

Examples of *potential rogue waves*:

Ray Collins Photography

Ideal Solution

- Takes into account both the deep and shallow waters
- Combining rogue wave-focusing mechanisms [e.g., spatial/dispersive/nonlinear] where appropriate
- Address swell/wave-tide-wind-current-depth interaction

Dysthe et al., 2008; Wang et al., 2023; Kharif and Pelinovsky, 2003; Heller et al., 2008; Salonen UCT MSc Dissertation, 2019; White and Fornberg, 1998; Fedele et al., 2016; Didenkulova et al., 2023; Voronovich et al., 2008; Lyu et al., 2023

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