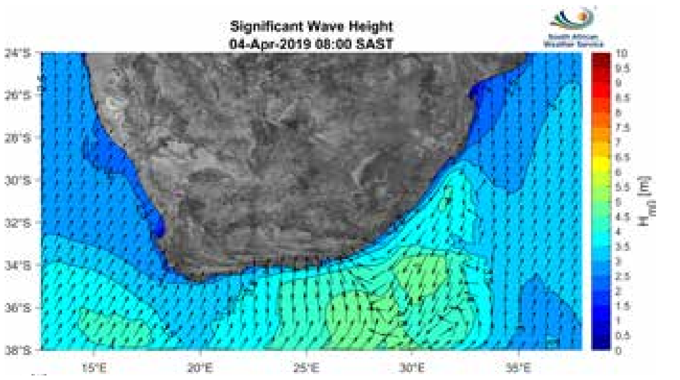
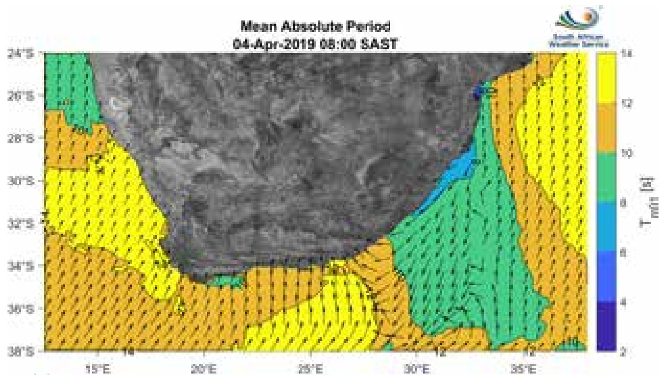
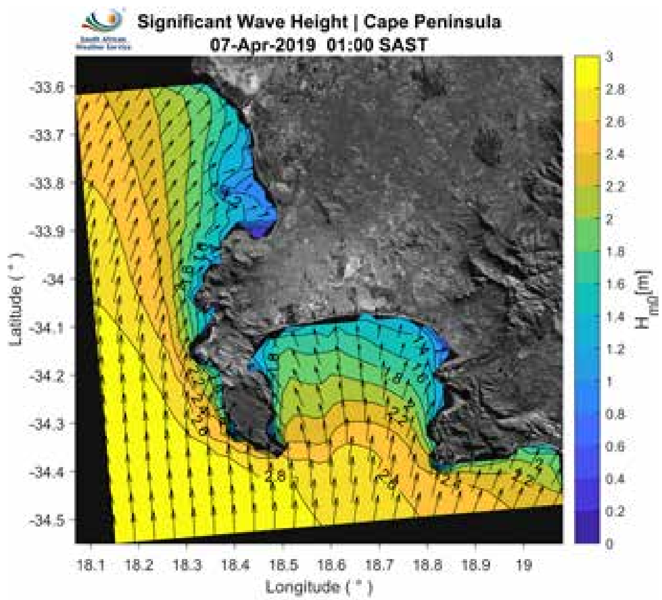
# Marine forecasting

*The Marine Unit of the South African Weather Service forecasts sea conditions for ocean users*




**The wave forecast page on the SAWS Marine Portal has maps showing a regional overview of expected wave conditions. Viewers can press 'play' for an animation of changing conditions over the forthcoming three days. High-resolution wave forecast maps are provided for eight areas around the coast (below).**




At the end of January, the South African Weather Service (SAWS) announced that it had 'gone live' with the country's first locally developed, operational wave-forecasting system. This provides state-of-the-art forecasts for key ocean wave parameters – such as significant wave height, period and direction – free of charge to the South African public. It has been designed with a multitude of users in mind, from surfers and paddlers to small-scale fishermen, from the coastal tourism community to offshore industry.

The new forecasting product is the culmination of extensive research and development by the SAWS Marine Unit's scientists, their aim being to design and implement a wave-forecasting system that is fit for purpose for South Africa's unique oceanographic context. To do this, they focussed on addressing key shortcomings of the global models that users have relied upon until now.

"Global models are adequate for painting a general picture of the open-ocean swell," said Marc de Vos, a researcher in the Marine Unit. "However, inherent technical limitations mean that they cannot accurately describe the wave conditions nearer the coastline, where the vast majority of wave-dependent activity takes place. This is why we have radically raised our model's resolution, as well as the quality of the data which we use to drive it – so that we can actually paint a true picture of the way waves are moving around our coastline in high detail. The model itself is also well suited to both open-ocean and nearshore waves."

The system consists of a regional Simulating Waves Nearshore (SWAN) model with a horizontal resolution of approximately 6 km (1⁄16th of a geographical degree). In key areas around the coastline, additional models are run with resolutions of about 2 km (1⁄48th of a geographical degree). For expert and commercial users, resolutions from 250 m down to 10 m are available for specific areas of interest, to guide operations that are critically dependent on wave conditions.

The wave forecast page on the SAWS Marine Portal shows three-day forecasts as animated maps of Significant Wave Height and Mean Wave Period for the entire South African region. Links to high-resolution (zoomed-in) maps and time-series graphs are provided for Lüderitz, Saldanha, Cape Peninsula, Mossel Bay, Port Elizabeth, East London, Durban and Richards Bay. Since wave period remains constant as waves move into shallower water, the maps better represent a user's experience of the local sea state in nearshore areas than the time-series graphs, which show peak wave period (highest period) as well as wave height and direction.


US Coastguard

Apart from the new wave forecasts, the SAWS Marine Portal also contains the following:

## Forecasts

### Wind

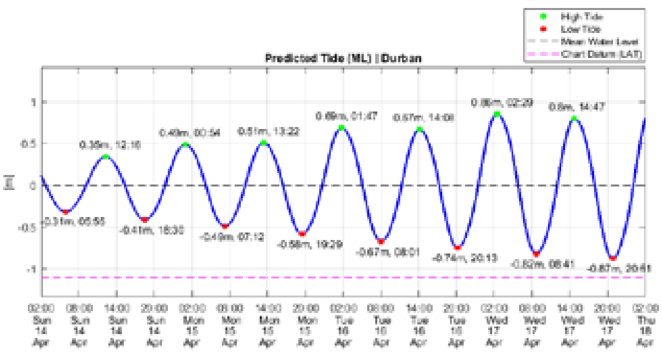
Distant wind systems generate ocean swells, while local winds are a major determinant of sea state, causing a 'flat' or 'choppy' surface depending on wind direction. In some areas, wind drives upwelling, which in turn affects sea surface temperature.

### Storm surge

Storm surge, caused by a combination of strong onshore winds and low atmospheric pressure, results in abnormal volumes of water accumulating against the coastline. It manifests as a raised sea level that can last for several hours, leading to significant coastal flooding.

### Tides

Tide time-series plots, produced from the newly developed SAWS Tidal Model, are available for 39 sites around the coast. These depict the rising and falling of the tides, resulting from the gravitational force of the sun and moon on the ocean as the earth rotates. The time and height above or below mean water level for high and low tide, respectively, are clearly shown.




### SOLAS forecasts

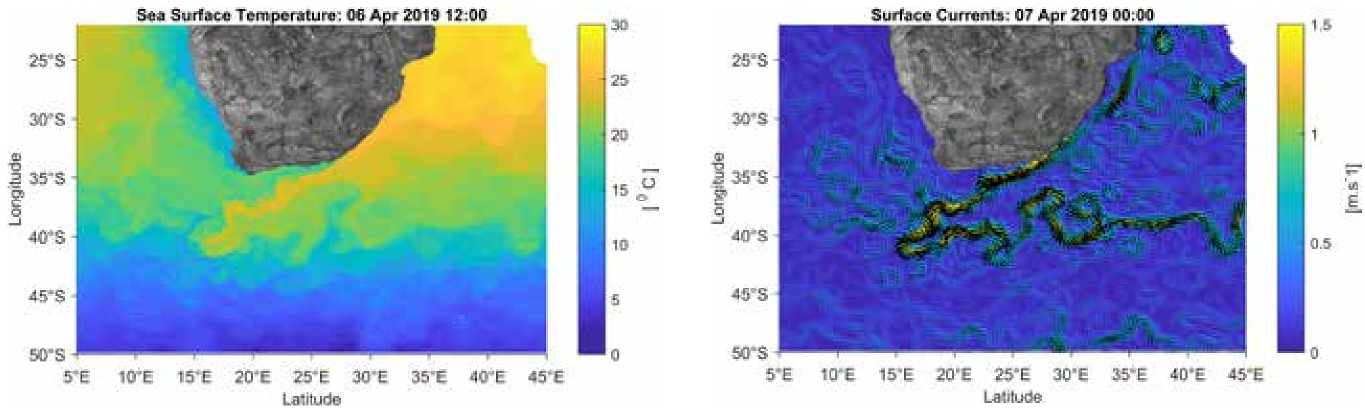
These forecasts, available for both coastal areas and the 'high seas', are a requirement of the International Convention on the Safety Of Life At Sea (SOLAS), the first version of which was adopted in 1914 in response to the *Titanic* disaster. The forecasts are broadcast for shipping purposes, and include information on wind, visibility and sea state, as well as alerts such as warnings of poor visibility due to fog, special weather advisories, or abnormal wave conditions.

## Observations

### Regional sea surface temperature

Sea surface temperature (SST) is a measure of the heat content of the ocean's surface layer. It plays an important role in marine ecology, as well as ocean–atmosphere interaction. For example, a cold ocean along the west coast of South Africa inhibits convection, suppressing rainfall and keeping the adjacent landmass relatively dry, while the warm Agulhas Current along the east coast transfers heat energy to the overlying atmosphere, causing air to rise and condense, and resulting in rainfall that supports lush coastal vegetation.

The depiction of SST on the SAWS Marine Portal is a fusion of *in situ* and satellite data, processed by the Operational Sea Surface Temperature and Ice Analysis (OSTIA) project run by the UK Met Office, and made available courtesy of the EU Copernicus Marine Service.




**The Agulhas Current flowing down the east coast can be clearly seen in these maps generated from satellite data for sea surface temperature and sea surface height. These products are made available to SAWS by the European Copernicus Marine Service.**

### Regional sea surface heights

Sea surface height (or absolute dynamic topography) is a useful measure of the level of the sea surface in relation to a reference level. It provides a useful proxy for the strength of surface currents. Along the east coast of South Africa, for example, a considerable elevation is normally evident due to the strong, south-westward flowing Agulhas Current. The depiction on the SAWS Marine Portal represents a fusion of altimetry data from various satellites, made available by the EU Copernicus Marine Service.

### Regional surface currents

The Agulhas Current can be clearly seen on the depiction of regional surface currents, using data made available by the EU Copernicus Marine Service. Surface currents are derived by applying theoretical formulae to absolute dynamic topography (or sea surface height) data, which are collected by satellite altimeters.

### Coastal sea surface temperature

Dedicated volunteers around the coast record sea temperature with thermometers at the same time and place each day, and submit this to SAWS on a weekly basis. Many organisms in coastal waters are adapted to thrive in a specific range of water temperatures, so this long-term SST dataset is important for monitoring ecosystem health and assessing how coastal ecosystems might be responding to climate change.

### Regional sea level anomalies

Sea level anomalies are deviations from the ocean surface's mean level – in other words, areas of higher or lower sea level relative to a long-term average. These anomalies are useful proxies for eddies that transport heat energy, salt and nutrients around the ocean. Many marine species depend on these eddies, while mariners can use the fast-flowing water around them to save travel time and fuel. Sea level anomalies are derived by subtracting a long-term mean sea surface height from the absolute dynamic topography (or current sea surface height) data, which are collected by satellite altimeters. The data is made available by the EU Copernicus Marine Service.

### Drifting buoys

Each year, the SAWS marine research team deploys 30 to 40 drifting weather buoys, which get carried along by the ocean's surface currents. Their GPS transmitters, SST sensors and air pressure sensors allow real-time insight into key marine meteorological parameters. The data gets incorporated into global weather forecasts to enhance their accuracy, making them a critical element in ensuring navigation safety. The buoys are provided to SAWS annually by the US National Oceanic and Atmospheric Administration (NOAA) to use as part of the Global Drifter Programme.

### Ships

The SAWS Marine Research Unit maintains instrumentation on various research vessels, allowing data collection from areas that are otherwise difficult to reach, such as the Southern Ocean. Personnel are also deployed onboard to conduct routine synoptic surface observations, noting many details about the weather at their given location. Apart from being important for refining weather forecast models and monitoring climate change, this data is often of great value to other researchers working on biological, chemical or physical subjects that may be influenced by local meteorological parameters.

*Visit the SAWS Marine Portal for animated forecasts, observations and other information: http://marine.weathersa.co.za/index.html*

## CURRICULUM CORNER

**GEOGRAPHY GRADE 10**
The atmosphere; Water resources

**GEOGRAPHY GRADE 11**
The atmosphere

**PHYSICAL SCIENCES GRADE 10**
Waves; Chemical systems: hydrosphere

**INFORMATION TECHNOLOGY GRADES 10-12**
Solution development

## *The SAWS Marine Unit explains the process behind marine forecasting*

Geography lessons teach us that the ocean plays a very important role in how the atmosphere forms and functions, while the atmosphere – through strong winds, rain and snow – in turn affects how the ocean behaves. This relationship and its direct implications can be very difficult to understand, and only through very large and dynamic (i.e. ever-changing and constantly updating) models can we begin to do so.

The motion in the atmosphere and oceans is governed by the laws of physics and thermodynamics. The language we use to describe these laws is mathematics. This concept of describing the movement of energy and matter in the oceans and atmosphere mathematically is called modelling, and we can obtain a 'numerical prediction' of what the winds, waves and tides are going to be in future by plugging in known values and getting computers to solve these complicated equations. Forecasting involves using these data together with actual data collected in the field, coupled with local knowledge and experience, to predict the weather for the next seven to 10 days.

To build a forecast model, we divide the area we are interested in into blocks, called grid cells. We then ask the computer to solve a list of equations we learnt about each of those grid cells, given some starting values. If the time for our starting values is T1, we solve the equations to get the conditions at T2. We then plug in the values from T2 to get values for T3 and so on, in each grid cell.

All kinds of considerations go into determining how the air (or water) will move, how big the waves will be or what direction they will travel in, according to these predetermined laws of physics. Some of these change constantly, and others do not. For wave forecasts, for example, we need to give the computer information about the sea floor, which generally changes quite slowly. We also know that wind generates waves, so we will need to feed in some wind data (generated by its own forecast model), and this will need to be updated regularly.

Validation of these models is then with 'real' data, or data observed from well-calibrated, strategically placed observation platforms. For atmospheric data, we need weather stations collecting wind speed and direction, air temperature and humidity, all inputted hourly into the South African Weather Service (SAWS) databases, which in turn are used to update the models and calibrate the hindcast model.

For the oceanographic data, this can be a little more complicated as some observation platforms are delayed time (i.e. their data can only be downloaded and used once they have been retrieved from the ocean), while others that are near-real time (satellite drifters and Argo floats) are not yet fully integrated into forecast models, but are used for validation of hindcast coupled-climate models.

The storm surge, wave and tidal models that have recently been developed by the SAWS Marine Unit are constantly being validated by data collected at sea and from coastal observation stations to ensure accuracy. These models are used to inform forecast offices and warn shipping agencies, disaster managers and any ocean users of potential threats. The primary objective is the safety of life, with the safety of infrastructure being a secondary concern.

Given that sea levels are expected to rise due to climate change and increased ocean warming, the risks storm surges and destructive waves pose in the future will only increase. Society needs to be prepared for this, and the necessary mitigation efforts made, to ensure we are resilient and can adapt with the change. Accurate data and reliable forecasting, as well as good environmental and municipal management, can help reduce the impacts of devastating coastal inundation.

The SAWS Marine Unit draws upon its diverse but complementary skillsets to ensure a continuous, accurate and useful marine service for the South African public. It looks forward to interacting with the academic and coastal engineering sectors, various government agencies, shipping industry stakeholders and other ocean users around our coastline.

*For more information, please contact the Marine Coordinator: tamaryn.morris@weathersa.co.za.*