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The Met Office Seasonal Forecast for Atlantic Tropical Cyclone Activity in 2023

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1. ABSTRACT

The Met Office has been issuing seasonal forecasts of tropical cyclone (TC) activity in the Atlantic since 2007, based on its seasonal forecast model GloSea. Previous publications have evaluated the skill of the model to predict the variability of Atlantic TC activity (Camp et al., 2015: Camp et al., 2018: Klotzbach et al., 2019).

GloSea forecasts produced during May 2023 showed a high likelihood of above average TC activity in the Atlantic for the following six months, despite forecasting the development of an El Niño, which historically acts to supress activity by generating anomalously high wind shear over the tropical North Atlantic (Gray, 1984). Before issuing a public forecast in late May 2023, further model diagnostics were evaluated to provide an understanding of this unusual forecast. These diagnostics included forecast anomalies of sea-surface temperatures (SSTs), precipitation, sea-level pressure, vertical wind shear and geopotential height. These all gave support to the forecast of most likely above average TC activity for the season ahead. Based on this evidence the GloSea forecast for Atlantic TC activity was issued publicly by the Met Office in late May 2023.

An updated forecast issued in early August reduced the forecast values slightly, but still called for most likely above average activity across the whole season. In the event observed activity in the June-November season was above the 30-year long term average for tropical storm numbers and accumulated cyclone energy index and near to average for hurricanes and major hurricanes. By all these measures observed activity was well above what would normally be seen in an El Niño year. Observed activity was less than the most-likely GloSea forecast values produced in May, but was still within the 70% forecast ranges for most measures of activity.

The GloSea forecasts for Atlantic TC activity are reviewed, including underlying model diagnostics and how these compared to what was observed across the whole 2023 season.

2. GLOSEA FORECAST ISSUED IN MAY 2023

GloSea forecasts for Atlantic tropical storm activity are updated weekly as the season approaches. The forecast for the June-November period produced towards the end of May is published externally on the Met Office web site. Figure 1 shows the GloSea forecast from late May for the June-November 2023. This indicated activity which was well above average for all forecast parameters.

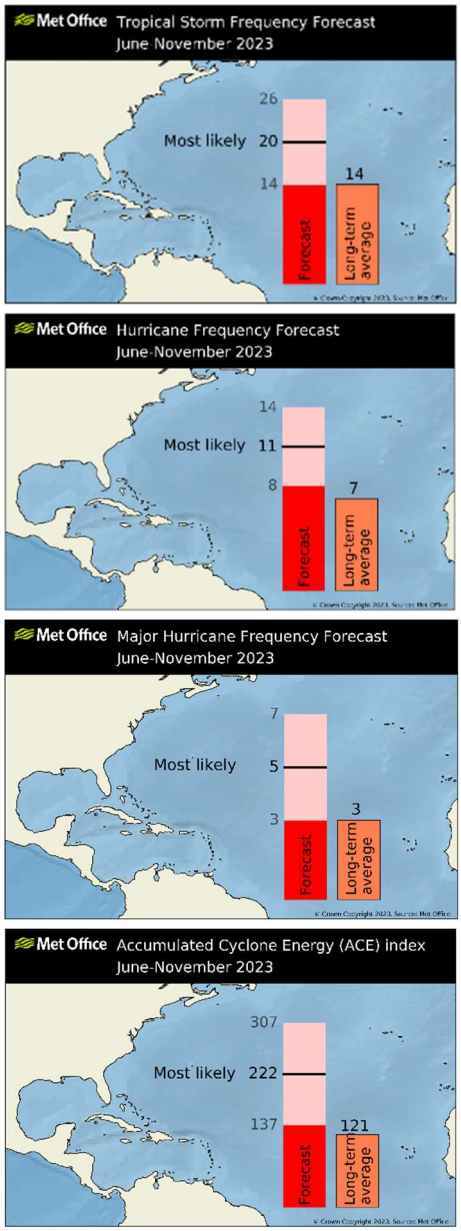

Figure 1.
GloSea North Atlantic forecast issued 26 May 2023 for June-November period.

Figure 2 shows the hindcast skill for forecasts issued in late May based on the 1993-2016 period. The correlation coefficients for tropical storms, hurricanes, major hurricanes and Accumulated Cyclone Energy (ACE) Index were 0.52, 0.67, 0.44 and 0.58 respectively indicating moderate to high skill in forecasts at this range.

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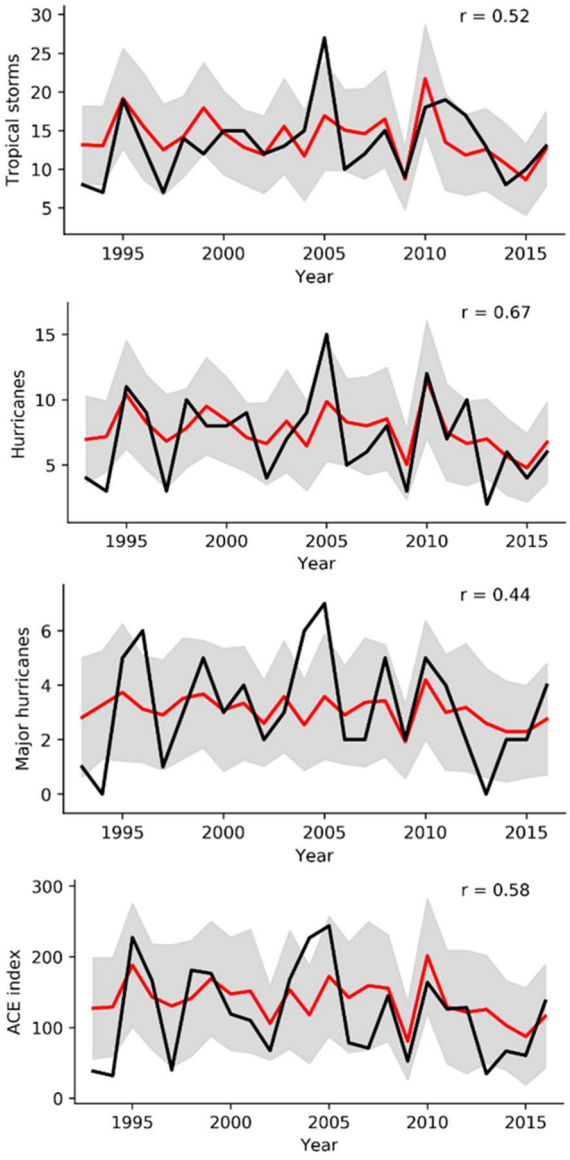

Figure 2.
GloSea North Atlantic forecast skill for late May forecasts based on 1993-2016 hindcast period. Red is GloSea ensemble mean, black is observations, grey +/- one standard deviation.

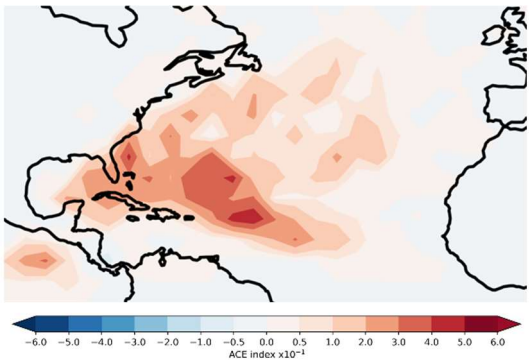

Figure 3.
GloSea late May forecast ACE Index spatial anomalies for the June-November 2023 season

Figure 3 shows the spatial anomaly plots for ACE Index for the late May forecast. This indicates that the above average activity is focused on the Main Development Region (MDR) to the east of the Caribbean and the subtropical seas to the east of the USA. Anomalies were neutral or negative in the Caribbean Sea and the west of the Gulf of Mexico.

The well above average forecast of tropical storm activity was counter to what would be expected given the forecast of El Niño conditions by peak season shown in Figure 4. However, Atlantic SSTs were also forecast to be well above average during the peak season months, as shown in Figure 5, which would act to enhance activity. With these conflicting signals, further diagnostics were examined to gain a better understanding of the forecast tropical storm activity before the forecast was issued publicly.

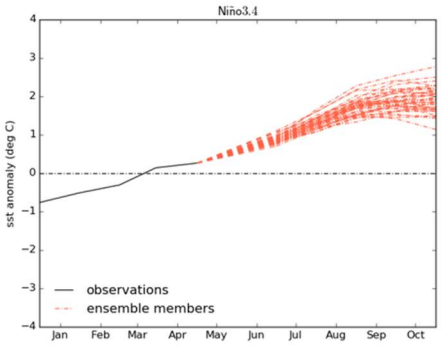

Figure 4.
GloSea May forecast of Niño3.4 Index

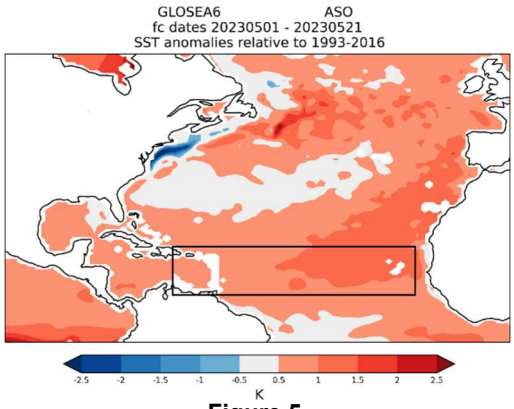

Figure 5.
GloSea May forecast of Atlantic SST anomalies averaged over August-October 2023. Boxed area shows the MDR.

3. ADDITIONAL FORECAST DIAGNOSTICS

El Niño conditions usually have the impact of increasing vertical wind shear over the tropical Atlantic thus supressing the development of TCs (Gray, 1984). However, despite the prediction of an El Niño by peak season (Figure 4), GloSea also predicted low wind shear across a large part of the MDR as shown in Figure 6.

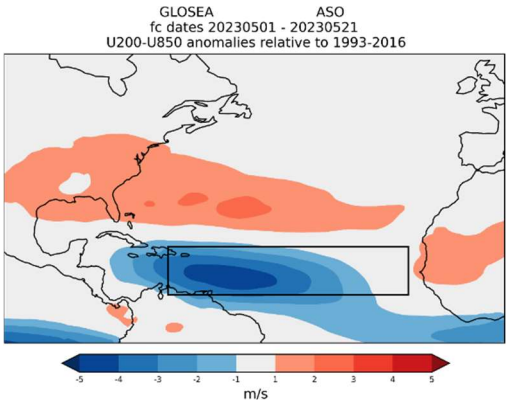

Figure 6.
GloSea May forecast of 850-200 hPa vertical wind shear anomalies averaged over August-October 2023. Boxed area shows the MDR.

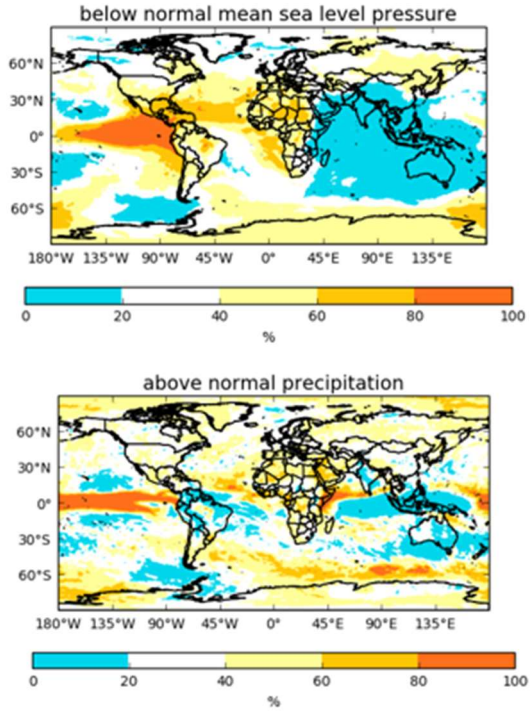

Figure 7.
GloSea May forecasts for August-October 2023.Top: probability of below normal mean sea level pressure. Bottom: probability of above normal precipitation.

Other diagnostics also point towards conditions favouring TC activity in the Atlantic. For example, Figure 7 shows a mid to high probability of below normal sea level pressure across the tropical and subtropical North Atlantic and a high probability of above normal precipitation across the MDR.

A final set of diagnostics shown in Figure 8 also favour enhanced TC activity. GloSea predicted an above normal 2m temperature anomaly across the tropical North Atlantic. The prediction of 500 hPa geopotential height anomaly shows no gradient in the anomalies between the eastern Pacific and Atlantic. This may help explain the lack of El Niño induced Atlantic wind shear. The predicted mean sea-level pressure anomaly is below normal and the positive precipitation anomaly in the MDR suggests enhanced West African monsoon rainfall.

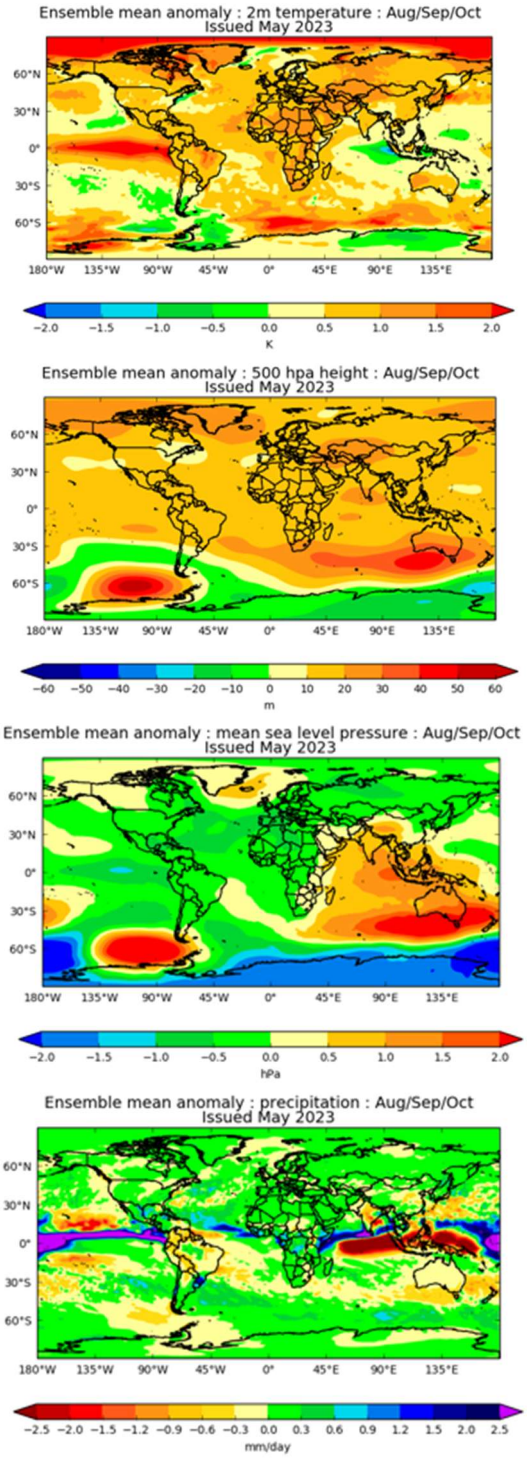

Figure 8.
GloSea May forecast anomalies for August-October 2023. From top to bottom: 2m temperature, 500 hPa geopotential height, mean sea-level pressure, precipitation.

Given that other diagnostics all supported the GloSea forecast of high tropical storm activity, the forecast was published with an accompanying commentary at https://www.metoffice.gov.uk/research/weather/tropica

l-cyclones/seasonal/northatlantic2023may on 26 May 2023.

4. FORECAST VERIFICATION AND ANALYSIS

The final observed activity totals for the June-November period were 19 tropical storms of which seven became hurricanes and three major hurricanes. The ACE Index was 144. These figures compare to the most likely values from the May forecast of 20 tropical storms including 11 hurricanes, five major hurricanes and an ACE Index of 222. The most likely forecast figures were therefore higher than those observed for all parameters except tropical storms, but all were within the 70% forecast range except for the number of hurricanes.

The spatial distribution of TC tracks is shown in Figure 9. This shows that most storms formed east of the Caribbean and turned polewards across the tropical and subtropical Atlantic, tracking over open ocean. Only a small number of storms made landfall. The GloSea forecast spatial anomalies (for ACE Index) shown in Figure 3 indicated that tracks across the open ocean were favoured which matches well with what was observed.

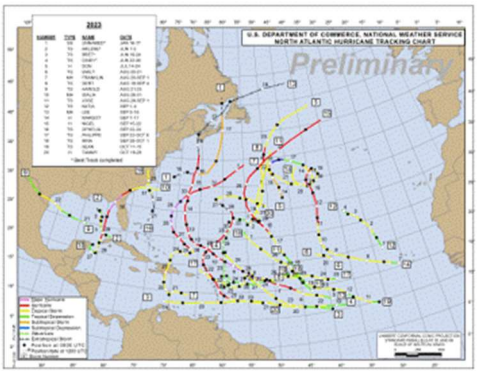

Figure 9.
Observed TC tracks in the Atlantic in 2023

5. ANALYSIS OF WIND SHEAR FORECAST

Although the May GloSea forecast most likely values were above those observed for several parameters, the forecast still gave a good indication of above or near to average activity in an El Niño year when climatologically we would expect below average activity due to increased wind shear in the tropical Atlantic. Thus, it is useful to assess the GloSea forecasts of 850-200 hPa vertical wind shear for the peak season months and how they compared to the ERA5 global reanalysis (Hersbach et al., 2020).

Figure 10 shows the May GloSea forecast of wind shear anomalies for the month of August compared to the corresponding ERA5 analysis. This shows a forecast of below average wind shear in the western MDR (boxed area) and eastern Caribbean Sea. This matches well with the ERA5 analysis.

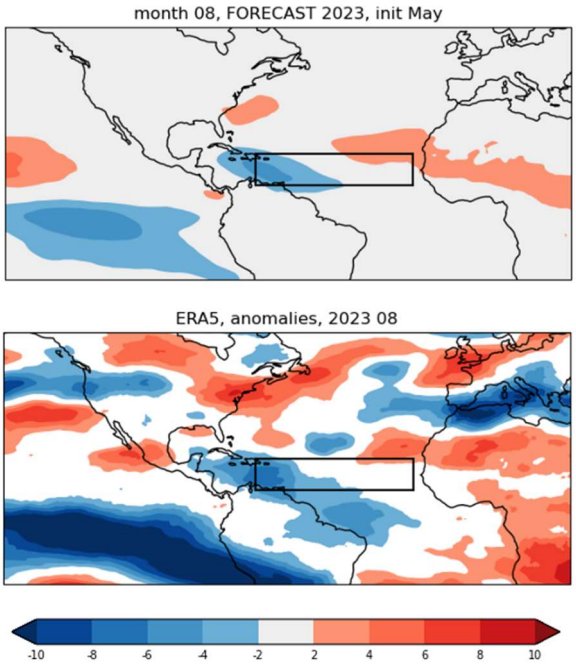

Figure 10.
GloSea May 2023 forecast of **August** wind shear anomalies (top) and ERA5 analysed anomalies (bottom)

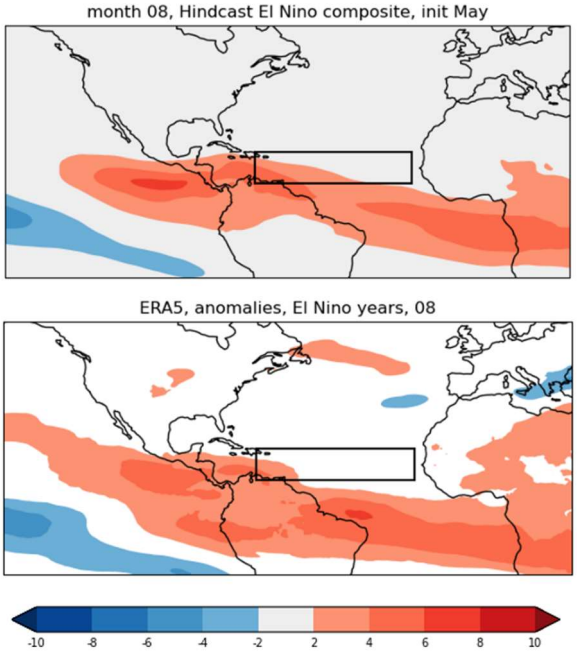

Figure 11.
GloSea hindcast composite of **August** wind shear anomalies initialised in May (top) and corresponding ERA5 anomalies (bottom) in **El Niño** years

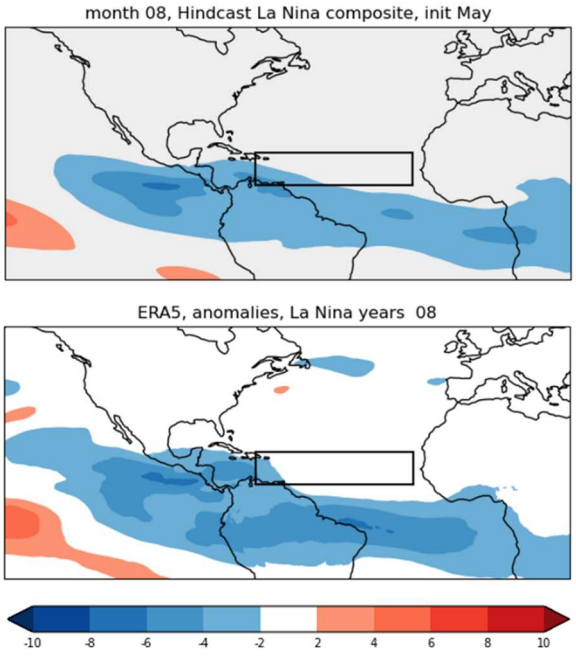

Figure 12.
GloSea hindcast composite of **August** wind shear anomalies initialised in May (top) and corresponding ERA5 analysed anomalies (bottom) in **La Niña** years

To assess how unusual this pattern of wind shear anomalies was for an El Niño year, Figures 11 and 12 show wind shear anomalies for August in GloSea hindcasts initialised in May and the corresponding ERA5 analyses grouped by El Niño and La Niña years. These show that GloSea does a good job in predicting the high wind shear usually seen in the tropical Atlantic and Caribbean in El Niño years and the low wind shear seen in La Niña years. Thus, it was impressive that GloSea was able to predict the unusual combination of El Niño and low wind shear in the tropical Atlantic seen in 2023.

Figures 13-15 are the equivalent to Figures 10-12, but for the month of September instead of August. Again, Figure 13 shows that GloSea predicted the unusual occurrence (for an El Niño year) of low wind shear across the MDR which was verified by the ERA5 reanalysis. Figures 14 and 15 show that in previous El Niño (La Niña) years GloSea correctly predicts high (low) wind shear across parts of the tropical Atlantic and Caribbean Sea in the month of September.

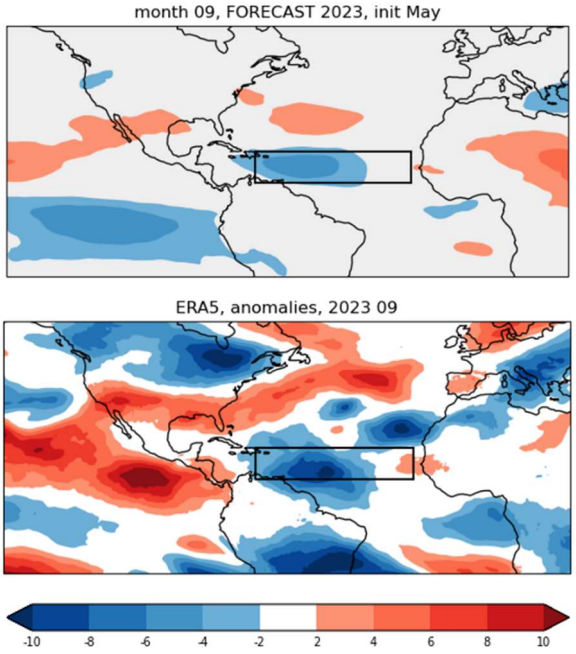

Figure 13.
GloSea May 2023 forecast of **September** wind shear anomalies (top) and ERA5 analysed anomalies (bottom)

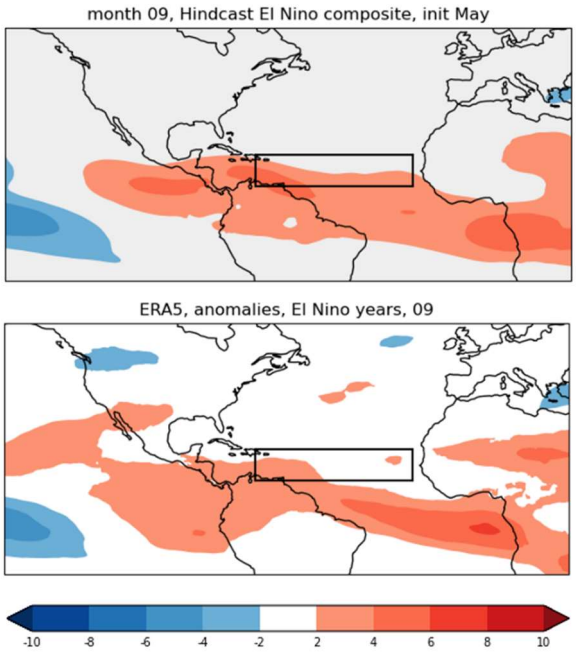

Figure 14.
GloSea hindcast composite of **September** wind shear anomalies initialised in May (top) and corresponding ERA5 anomalies (bottom) in **El Niño** years

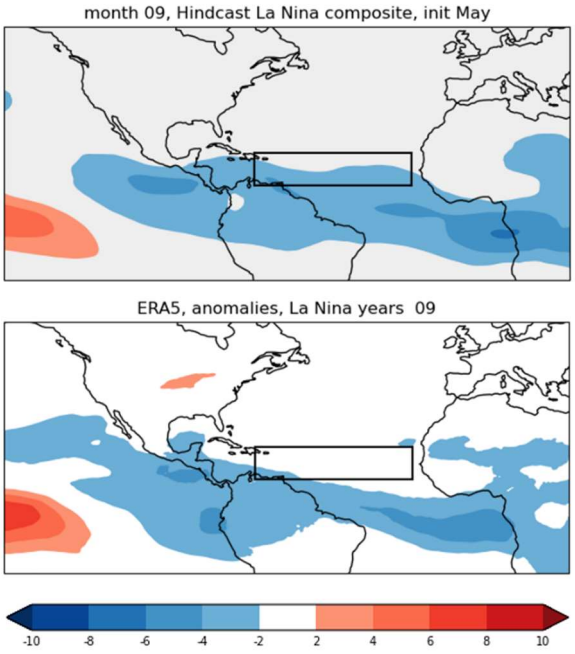

Figure 15.
GloSea hindcast composite of **September** wind shear anomalies initialised in May (top) and corresponding ERA5 analysed anomalies (bottom) in **La Niña** years

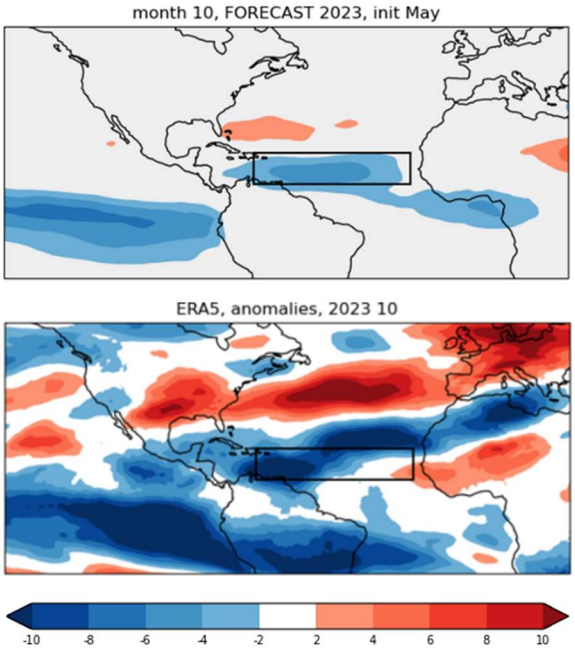

Figure 16.
GloSea May 2023 forecast of **October** wind shear anomalies (top) and ERA5 analysed anomalies (bottom)

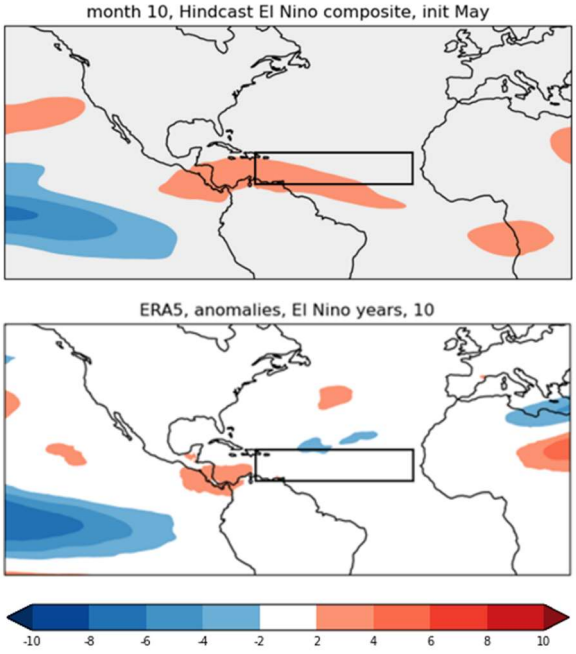

Figure 17.
GloSea hindcast composite of **October** wind shear anomalies initialised in May (top) and corresponding ERA5 anomalies (bottom) in **El Niño** years

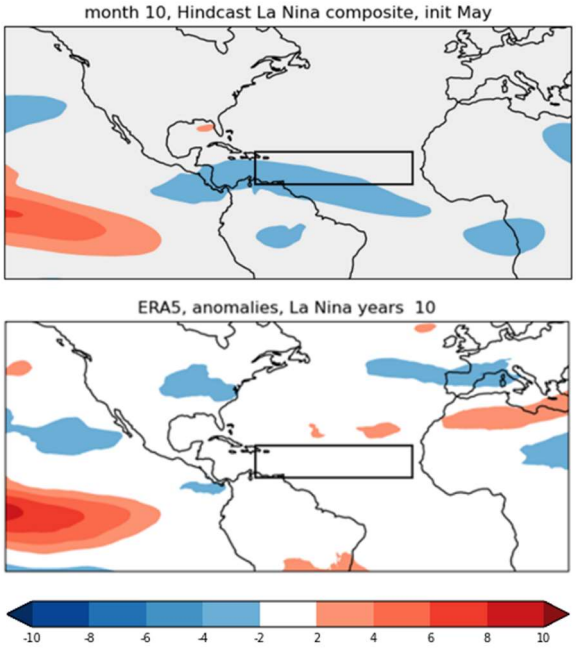

Figure 18.
GloSea hindcast composite of **October** wind shear anomalies initialised in May (top) and corresponding ERA5 analysed anomalies (bottom) in **La Niña** years

Figures 16-18 are the equivalent plots for the month of October. Once again in Figure 16 we see that GloSea predicted low wind shear in the MDR. The ERA5 analysis shows low wind shear occurred over a large part of the MDR. Figures 17 and 18 show that in hindcasts GloSea usually predicts low wind shear across the MDR in El Niño years and high wind shear in La Niña years in the month of October. In contrast to

the months of August and September, ERA5 analyses show that the existence of El Niño or La Niña has less impact on the amount of wind shear observed in October.

Despite the wind shear across the western MDR and Caribbean Sea being low as shown in the ERA5 analysis in Figure 16, TC activity was very limited in October. Tropical Storm Sean formed in the eastern Atlantic and was active for around five days. Tammy formed east of the Caribbean and turned northwards into subtropical Atlantic as a hurricane, briefly reaching category 2 status. There were no tropical storms in the Caribbean Sea or Gulf of Mexico which are the usually favoured regions for activity in October. Colorado State University's end of season report (Klotzbach, 2023) suggested that this lack of activity was due to the presence of mid-level dry air. Given wind shear remained low and SST high, it is possible that TC activity could have continued until late into the season were it not for the presence of this dry mid-level air.

6. SUMMARY

- The GloSea forecast issued publicly in May 2023 called for unusually high TC activity in the Atlantic in 2023 given developing El Niño conditions.
- The El Niño conditions and large Atlantic SST anomalies which occurred were well signalled by the model.
- Forecasts of wind shear, precipitation, surface pressure and geopotential height also all favoured high TC activity during peak season.
- Observed activity was above average as measured by the number of tropical storms and ACE Index and near to average for the number of hurricanes and major hurricanes. Apart from the number of tropical storms, these numbers were not as high as some of the most likely values predicted by the GloSea forecast.
- The GloSea track forecast spatial anomalies matched the predominant observed storm tracks which recurved into the subtropical Atlantic before reaching the Caribbean.
- GloSea correctly predicted the unusual SST and wind shear anomalies during peak season months of August, September and October.
- Anomalously low mid-level moisture in the Caribbean may have curtailed the season, with limited TC activity occurring from October onwards.

7. REFERENCES

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