ATMOSPHERIC CIRCULATIONS RELATING TO THE FORMATION OF FOG IN THE CENTRAL NAMIB DESERT, NAMIBIA

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ABSTRACT

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Fog is a regular occurrence in the central Namib Desert of Namibia. Due to its frequency, it not only provides a life support system for many desert-dwelling organisms, but it also has potential to be a harvestable water resource for humans in the area.

The aim of this study is to investigate the nature of these fog events in the central Namib and to analyse potential large-scale controls of the fog formation. The main source of moisture for the fog is the South Atlantic Ocean, and as air is blown towards the land, it cools over the cold Benguela current, causing moisture to precipitate out. The large-scale features that were analysed were therefore related to the characteristics of this cold water upwelling cell, as well as atmospheric circulations leading to onshore winds.

The twelve month period March 1997 - February 1998 was chosen for analysis, and hourly weather data (including fog readings) from three stations across the central Namib were obtained for this period, as well as synoptic charts, relative humidity figures, and details of the cold water upwelling cell. These various characteristics were studied and compared on fog days and non-fog days.

The results reveal that there is not a significant difference between synoptic conditions, upwelling characteristics, or coastal relative humidity on fog days and non-fog days. They do however show that of all the synoptic conditions, coastal lows are the most strongly related to fog events, a result which correlates with those of previous studies. There was also found to be a maximum upwelling extent of 175km over which fog would form. This relates to the presence of coastal lows and the way in which when the upwelling is greater than about 175km, air is forced to circulate over an homogeneously cold surface - thereby preventing it collecting moisture and thus preventing fog formation.

As the large-scale features were found not to be a definitive control of the fog, local scale circulations and features were also analysed. It was found that the local surface heating regime, along with topographic influences, was the dominant control of the wind regime - and synoptic conditions only rarely acted to override these diurnal rhythms. Synoptic conditions are therefore thought not to be as important in the control of weather patterns in the central Namib as previously believed. Local variations are thus very important in determining the type, frequency and seasonality of the fog.

It is noted that these conclusions must be taken as preliminary due to the limited period over which data was taken. Suggestions are made for future studies, including the use of high-resolution satellite images and energy yield analysis.

5. CONCLUSIONS

The aim of this study was to gain a better understanding of the fog in the central Namib desert by analysing not only the nature of, but also the cause of fog events. The results from the investigation have been discussed and explanations, as well as limitations offered. Here, the findings shall be summarised.

The investigation into the cause of the Namib fog was based around three hypotheses, which shall be discussed in turn, below:

1. The first hypothesis was that the synoptic circulation correlating most strongly with fog events would be that dominated by the presence of a coastal low near Walvis Bay. Overall it was found that 34% of fog events related to such conditions, and of all synoptic conditions this was the strongest correlation, albeit marginally so. The hypothesis can therefore be accepted but only in the strictest sense because although the greatest correlation was with coastal lows, it was not strong. This relationship is not as strong as has been found in previous studies, and the explanations offered for this discrepancy are that the synoptic classification system adopted in this study differs slightly from that of previous authors, and that data was taken from too limited a time period to provide a fully representative sample. Not only was the relationship between fog events and coastal lows surprisingly weak, but also the relationship between fog events and cold fronts was surprisingly high in comparison to a previous study. This suggests that Mar 97-Feb 98 experienced unusual climatic conditions, and highlights the need to use a larger data set.

It must be considered however, that no previous studies have compared synoptic conditions of fog and non-fog days. The difference was found not to be significant, implying that

synoptic conditions may be a necessary, but they are not a sufficient condition for fog formation in the central Namib.

2. The second hypothesis was that the cold water upwelling extent would be greater on non-fog days than on fog days when coastal lows were present. Although a difference in the average upwelling extent was found, it was not statistically significant and thus this hypothesis must be rejected. The *maximum* upwelling extent was found to be greater on non-fog days however, and fog appeared not to form when the upwelling reached further than 175km from the coast. This result correlates well with a previous study (Olivier and Stockton, 1989) that stated 200km as the maximum extent of upwelling over which fog will form. This limit is thought to correlate with the maximum diameter of coastal lows, as this would ensure that the air was circulated over an homogeneously cold surface - thus preventing an increase in relative humidity.

3. The third hypothesis stated that the relative humidity would be greater at the coast on fog days than on non-fog days. Of the four coastal stations that were analysed, Walvis Bay, Lüderitz and Orangemund displayed this trend - but the difference was only found to be statistically significant at Lüderitz. This may be explained by the fact that the centre of the upwelling has been identified as being at Lüderitz, and the coastal relative humidity would therefore reflect changes in the upwelling characteristics more so than at other stations. The hypothesis is therefore neither accepted or rejected, as it is only partially true.

The nature of fog events was studied, taking into account seasonality and the causes already discussed. The findings are here summarised:

- Cold fronts and their related fog events were found to have a distinct seasonality,

occurring exclusively in Mar-Sep. This is explained by the seasonal large scale synoptic movements of the westerlies and the South Atlantic anticyclone.

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- The longest lasting fog events were found to be related to cold fronts, and the turbulence and convection associated with their movement across the Namib. These long events (>10 hours) are most common at Vfb where the stabilising effect of the cold current is not as strong as at Klb, and where the altitude and thus orographic influence is greater than at Gob.
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- Although originally assumed that synoptic and other large scale mechanisms were the major control of fog occurrence in the central Namib, it has been shown here that in fact the influence of these mechanisms on fog formation depends not only on their interaction with each other - but also on their interaction with local controls. The dominant control of the wind regime of the region of the central Namib Desert was found to be the diurnal land/sea breeze and thermal gradients, rather than synoptic scale circulation. This diurnal regime is modified by topographical controls such as the Kuiseb valley within which Gob is sited, which acts to channel the wind (and fog) according to its NW/SE orientation. Fog occurs frequently within this diurnal regime, but certain synoptic conditions (coastal lows and cold fronts) appear to alter the wind patterns throughout the region to increase the chance of fog formation - particularly if interacting with conducive upwelling conditions. Thus there are occasions when particularly strong synoptic conditions act to override these surface heating and local topographic controls, and to enhance the chance of fog formation.