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The nature of moisture at Gobabeb, in the central Namib Desert

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ABSTRACT

This paper reviews the nature of moisture at Gobabeb, Namibia with emphasis on rainfall, and fog. It introduces the observational record produced by the Gobabeb Training and Research Centre and examines nature and cause of the rainfall record from October 1st 1962 to May 30th 2011. Over this period of 17749 days only 381 rainy days produced a total of 1213 mm of rain with an annual average of 25 mm. 2011 has been the wettest year on record also featuring the two most wettest days (March 12th and May the 6th). 1992 has been the driest year with no rain at all. Over the last 3 decades (1979–2009) the number of decadal rain days has decreased from 77 to 56 to 54 days, while total decadal rain amount has increased from 130 mm to 149 mm up to 300 mm. 193 Individual rain events between 1979 and 2009 were linked to synoptic conditions present in the region including the Zaire Air Boundary (ZAB), Tropical Temperate Troughs (TTT), the Angola Low, temperate cold fronts and cut-off lows (850 hgt geopotential height). Cluster analyses in the form of Self Organising Maps (SOMs), suggests that all synoptic states have the potential to produce rain but that the Angolan low dominates with an increase in TTT activity being evident. Fog collection techniques have evolved through time and suggest a range of possible event types, including advected fog, coastal stratus cloud, high stratus cloud, radiation fog and fog drizzle. While each of these has their own meso- and micro-scale synoptic control and may even vary in their bulk and isotopic chemistry, they collectively make a significant moisture contribution to the flora and fauna of the Namib. Additional sources of moisture are gaining appreciation and include the widespread occurrence of hypersaline springs on the Namib gravel plains as well as micro-scale moisture including vapour in desert soils and regolith.

1. Introduction

This paper reviews the synoptic climatology of the sporadic Namib Desert rain, it also examines the various types and uses of persistent fog contributions to the hyper-arid environment and provides an overview of groundwater discharge springs on the Central Namib gravel plains. Using climate records collected over the last 49 years (October 1st 1962 and May 6th 2011), this paper examines the nature, cause and trends of rainfall for the Gobabeb Training and Research Centre (Fig. 1, Lat −23.561116° Lon 15.041341°). The paper also introduces recent studies concerned with soil moisture in the Namib, but it does not cover the ephemeral highland drainage, which has its headwaters in the semi-arid east of the escarpment.

2. Part 1) Rain

2.1. The climatology of the Central Namib

The arid west coast of the southern African subcontinent is rarely disturbed by rain events. Arid regions such as the Namib are the result of dry descending air as part of the Global Hadley Circulation. A strong NE-SW rainfall gradient across southern Africa results in the semi-arid Kalahari and Karoo and ultimately the hyper-arid Namib coast (Fig. 1a). The subsidence associated with the South Atlantic High Pressure (anticyclone), along with the stable air generated by the cold sea surface temperatures, introduces stability which effectively suppresses convection along the

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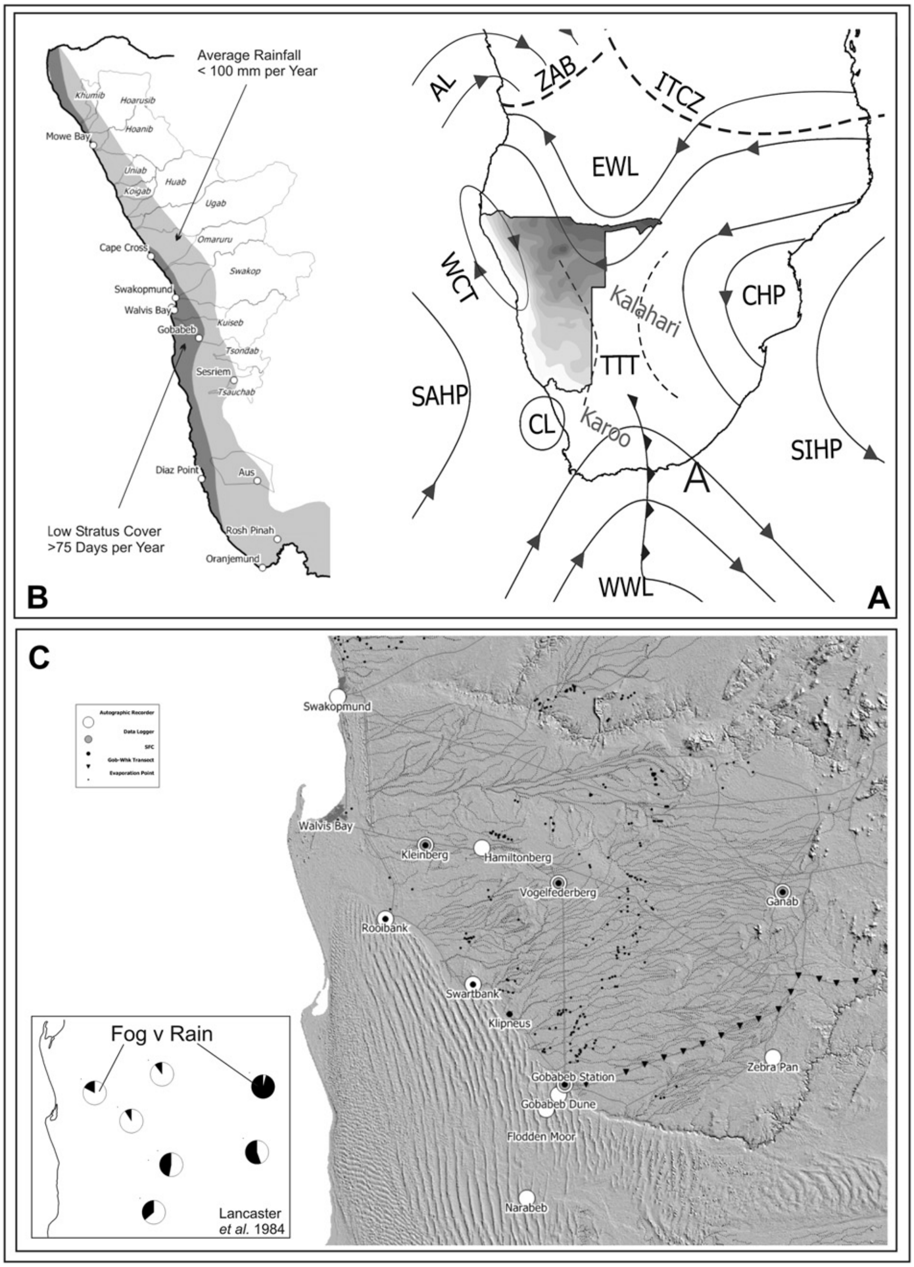

Fig. 1. Top A): Southern African Synoptics and Namibia. Top A) Southern African synoptics which promote Namibian rainfall: Angola Low (AL), Coastal Low (CL), Cold Front (CF), Intertropical Convergence Zone (ITCZ), Tropical Temperate Trough (TTT), West Coast Trough (WCT), Westerly Wave Low (WWL), Zaire Air Boundary (ZAB) and other major pressure system such as the Continental High Pressure (CHP), South Atlantic High Pressure (SAHP), South Indian Ocean High Pressure (SIHP). Modified from Lindesay (1998) and Tyson and Preston-Whyte (2001). (Note rainfall source: Mendelsohn et al., 2003). Top B) Namib Coastline. Coverage of national first order weather stations in the Namib region, location of highland catchments, as well as fog (>75 days) and rain distribution (<100 mm) (Source: Mendelsohn et al., 2003). Bottom C) Central Namib. Map featuring weather stations operated by Gobabeb since 1962, including autographic recorders, data loggers and standard fog collectors (SFC). Saline evaporation points on gravel plain north of the Kuiseb mapped from Landsat imagery using gypsum and halite absorption features. Insert Rain (Solid) v Fog (Clear) from data compiled by Lancaster et al. (1984). (Topography from shaded ASTER GDEM version 1, gravel plain drainage from geological map of Namibia and road pattern modified from Tracks 4 Africa data).

southern African west coast (Logan, 1960; Pietruszka and Seely, 1985) which is further accentuated by a shallow surface temperature inversion.

Rainfall in the region is spatially and temporally highly variable (Mattes and Mason, 1998; Tyson, 1986). Central southern African and in particular Namib rainfall is subject to both inter- and intra-annual variations (Mason and Jury, 1997; Seely, 1978). In fact the coefficient of variation for Namibian rainfall is the greatest in southern Africa, with extreme variability experienced across the central and northern Namib (Mendelsohn et al., 2003; Southgate et al., 1996), where rainfall events are not only highly localized but also of low intensity (Gamble, 1980; Hachfeld and Jűrgens, 2000; Sharon, 1981). Average precipitation in the Namib ranges from 50 to 100 mm in the far south, 5–18 mm in the central Namib and less than 50 mm along the Angolan coast in the north. Furthermore, there is an increase in rainfall from west (~10 mm at the coast) to east (~60 mm at 100 km inland) (Hachfeld and Jűrgens, 2000; Henschel and Seely, 2008; Lancaster et al., 1984;