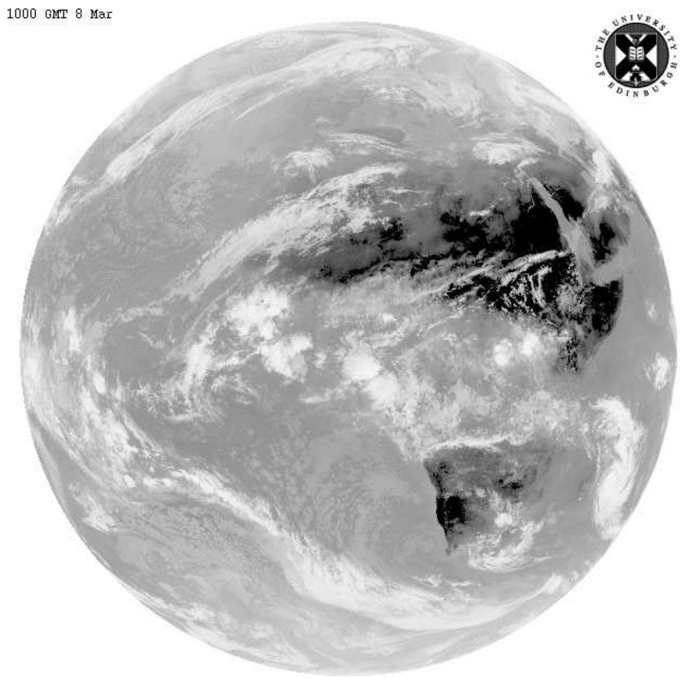


# Technical Note on Namibian Gamsberg site [1]

## Part I: General Climatology

M. Sarazin April 24, 1994

[1]Namibia is shown on this Meteosat IR image as the only cloud free area in the southern part of Africa on March 8, 1994.

# Contents

# 1 Introduction

This document summarizes our current knowledge of the scientific qualities of Gamsberg Namibian site for astronomical observing. On the basis of available data, Gamsberg is compared to the VLT site of Paranal whenever possible. Additional measurements are proposed in view of assessing the suitability of Gamsberg as a backup solution for the VLT in case ESO would be prohibited to resume construction in Chile.

When the Max Planck Institute für Astronomie was founded in 1969 began immediately a search for sites in both hemispheres for several telescopes to be built during the decades to come. For the Southern hemisphere a 2.2 m telescope was planned. The survey rapidly focused on Chile, where ESO was already operating La Silla and Namibia, where a single site drew the attention of the astronomers, the Gamsberg impressive table mountain which could easily be seen from the main road several tens of kilometers away.

The Gamsberg survey started in 1970 under the impulse of Pr. Elsässer and was conducted by Dr. Th. Neckel who registered an extensive set of meteorological informations until 1975. In January 1971 Max-Planck Society became owner of the 239 hectare composing the Gamsberg plateau and negotiated a Right of Way Agreement with the neighboring farmer to get access from the public district road. A rudimentary access road to the top was built as well as a modest but complete infrastructure. This allowed to realize professional astronomical observations between 1973 and 1975 with a 50 cm photometric telescope which confirmed the excellent photometric quality of the Gamsberg sky ([Klare 1977]).

The political situation in Namibia did not improve and time came when the 2.2 m telescope was ready for shipment. The U.N.O economic sanctions against South Africa were prohibiting any investment in that part of the world and the decision was thus taken in January 1982 to erect the telescope at La Silla. Since then, Gamsberg infrastructure was maintained in a correct shape but few observations were made.

# 2 Comparison of Chile and Namibia

## 2.1 Economy

After years of turmoil and political uncertainties, Namibia reached independence in 1990 and is now considered as a stable democracy. This country presents however large discrepancies with Chile shown on Table 1 which certainly have to be considered in a later stage for logistics, construction and operation of a modern observatory.

## 2.2 Geography and general climatology

The western coast of Namibia and the Namib desert present striking similarities with the coastal conditions at the latitude of the Atacama desert. In addition, the situation of Gamsberg is similar to Paranal with the exception of a greater distance from the coast and a much larger size as shown on Table 2 and on the map in Annex 1.

The Gamsberg upper air conditions are more favorable with a slower mean wind velocity at 200 mB. On the other hand, at lower altitude, the inversion layer determining the cloud cover is probaly less stable due to a higher sea surface temperature, thus possibly allowing coastal clouds to reach the summit.

### 2.3 Seismicity

As shown on Fig. 1 summarizing the major seismic events recorded in Africa between 1970 and 1992, Namibia and in particular the Namib desert appear in a much better situation than Northern Chile.

## 3 Local climatology

### 3.1 Topography

The topography of Gamsberg is absolutely unique by the flatness of the plateau and its size as shown in Annex 2. It is believed ([Seelenbinder 93] that the landscape was covered by sand dunes during the Jurassic period (170-120 million years ago, which eventually turned into quarzitic layers. These were destroyed by erosion everywhere but in a few granitic intrusions which protected them. This is the case of Gamsberg and also of its neighbor, a plateau the size of Paranal named *Klein Gamsberg*, 3 km to the NE, at the same altitude.

### 3.2 Wind

From measurements taken 2 m above ground, Gamsberg appears considerably less windy than Paranal and still presents a similar wind pattern about 80% of the time included in a 180 degrees angle. The Gamsberg prevailing direction is from the coast with no major obstacle at the same altitude as the site.

A cone shaped summit creates a local overspeed at ground level. For that reason, the hill-top wind height profile at Paranal is such as the velocity at 2 m above ground is similar to the 10 m value. In the Gamsberg case, the dimensions of the flat plate are large enough so that the flow at the center can be considered as undisturbed. The theory tells that the wind height profile is such that the velocity at 10 m height is 1.4 times higher than at 2 m. A limited set of measurements made at Gamsberg on a 40 m high tower found a 1.8 times increase from 2 m to 40 m. This result is in agreement with the undisturbed flow hypothesis.

It is thus expected that the wind velocity at 10 m height (VLT M1 level) would be equal to 5.6 m/s on a yearly average against 7.7 m/s at Paranal before flattening. Moreover, Gamsberg wind velocity do not show noticeable seasonal trends.

### 3.3 Temperature

Generally speaking, the temperature is a few degrees higher at Gamsberg than at Paranal. Daily temperature variations show a strong seasonal trend at Gamsberg, increasing during the rain season (Fig. 2). The day to night temperature amplitude is much larger at Gamsberg than at Paranal, in particular during austral summer (Fig. 3).

### 3.4 Relative humidity

The Gamsberg relative humidity was measured at 2 m height with a thermo-hygrograph with hair measuring element. Such a device is limited to values higher then 5% and thus not adapted to dry sites. The Gamsberg statistics are thus probably slightly overestimated during the dry season when monthly averages between 20 and 30% have been recorded (compared to 10% at Paranal). The average for summer months is around 50% with the exception of periods of heavy rains like January 1974 (80% humidity and 220 mm rain).

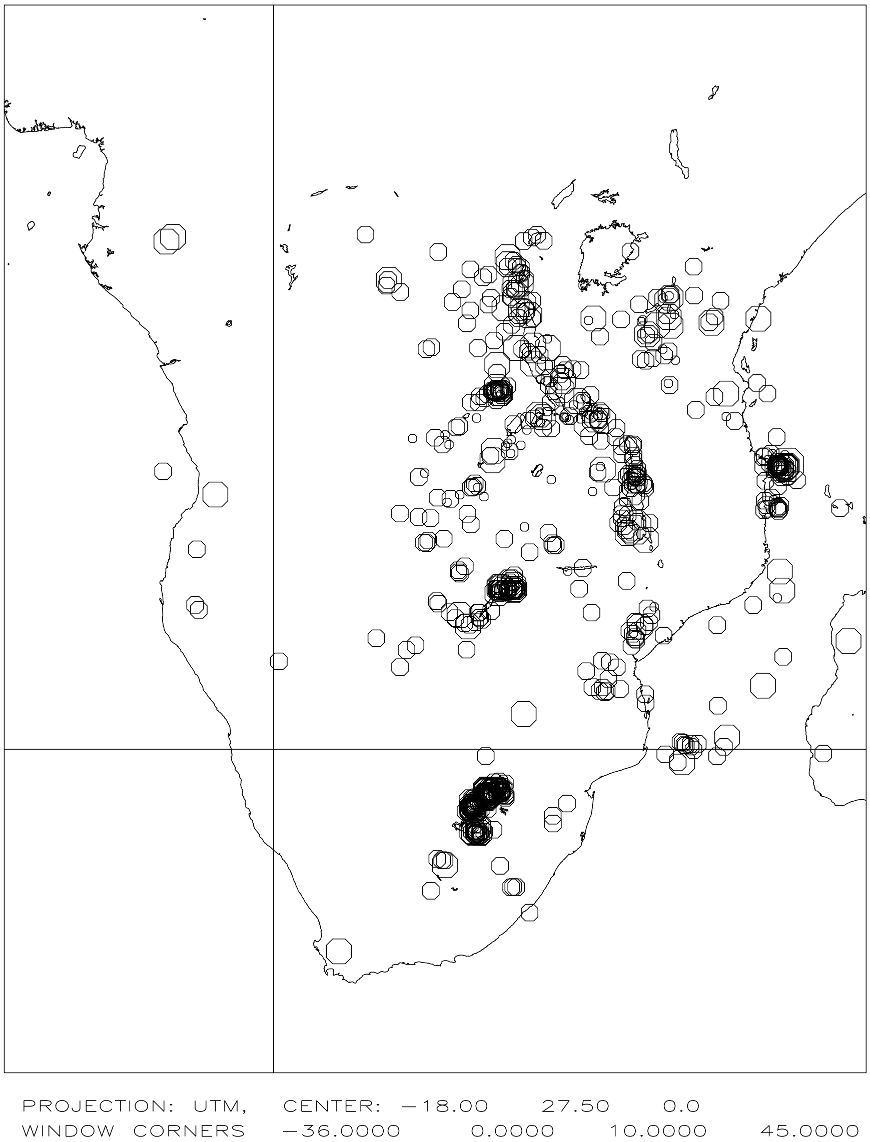


Figure 1: Location of the hypocenters of the major seismic events (Magnitude $4.0 \leq M \leq 6.4$ down to 30 km depth) recorded in Africa between 1970 and 1992 (Courtesy Dr. Luis Riverra, EOPGS, Strasbourg).

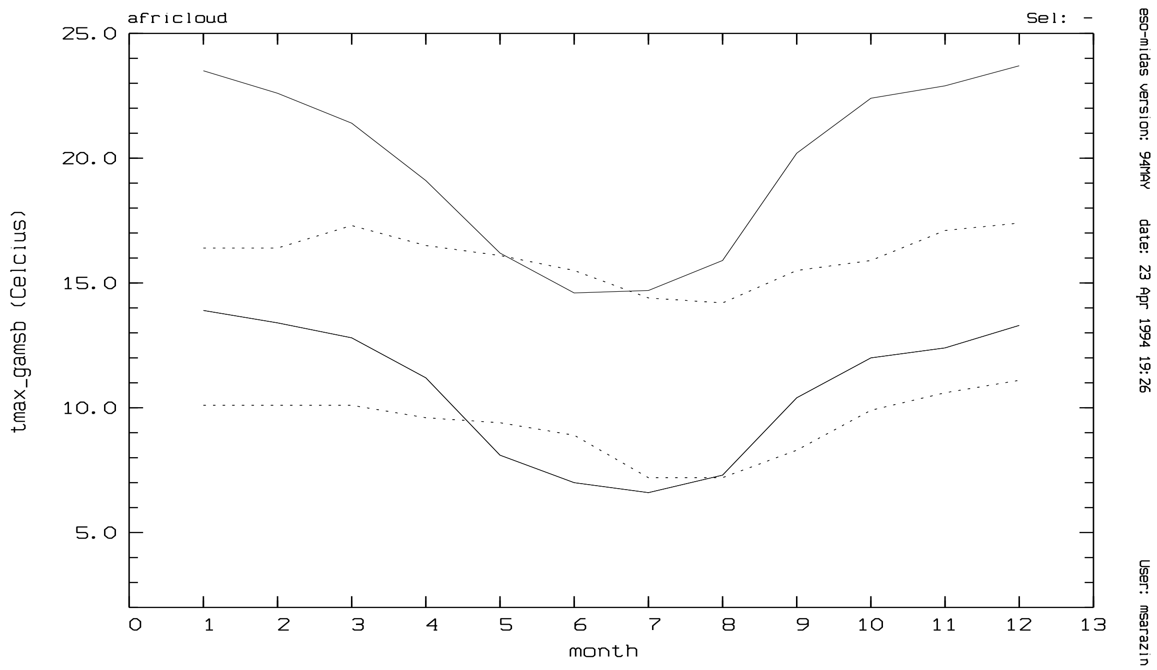


Figure 2: Comparison of Gamsberg statistics of monthly average of daily temperature extrema (full line, Sep. 1970-Dec. 1975) with Paranal similar measurements (dotted line, 1985-1986).

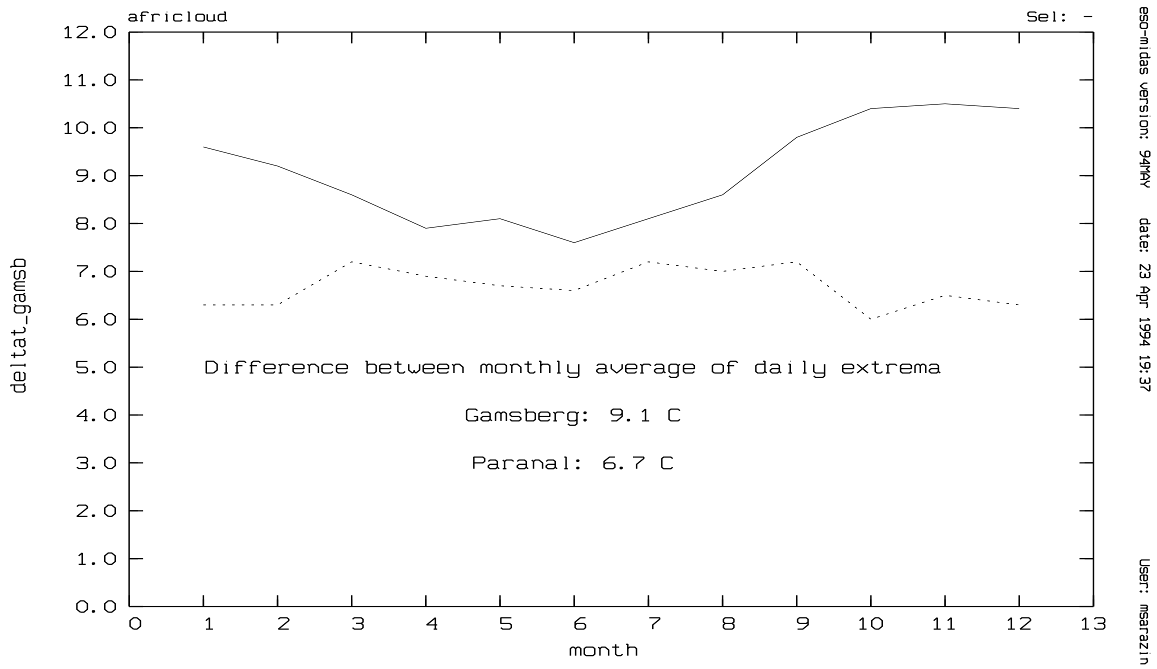


Figure 3: Comparison of Gamsberg statistics of the difference between monthly average of daily temperature extrema (full line, Sep. 1970-Dec. 1975) with Paranal similar measurements (dotted line, 1985-1986).

### 3.5 Cloudiness

The only available statistics for daytime are for the capital city Windhoek, 130 km East from Gamsberg. The Windhoek sunshine statistics are compared with the percentage of photometric days at Paranal on Figure 4. The criteria of photometric days used for Paranal is probably more restrictive since it excludes also days with thin cirrhus clouds.

As for nighttime, it is shown on Figure 5 that with only an average of 197 photometric nights per year (the best year gave 216 and the worst 168, between 1970 and 1975), Gamsberg suffers from a strong seasonal cycle. Rain showers or storms may occur from October to April, with a maximum of chance during January and February. The La Silla nighttime statistics used in [Elsässer 71b] give slightly better results although the difference would decrease if one correct for the length of the astronomical night (varying from 7.5 hours in Summer to 10.6 hours in winter when Gamsberg is at its best). However, La Silla is clearly better than Gamsberg in terms of spectroscopic nights (Table 2).

## 4 Proposed measurements

### 4.1 Guidelines

Completing our knowledge of the scientific qualities of Gamsberg with regards to astronomical observing is a task which goes beyond the only interest of ESO-VLT. The world astronomical community will benefit from this work and if it happens that the results of seeing measurements place Gamsberg among the high ranking sites worldwide, the outstanding topography of this site would without doubt create a credible alternative to existing southern observatories for the coming century.

### 4.2 Seeing

Attempts at monitoring image motion lead to quite comparable results between Gamsberg and La Silla. However the method used in [Elsässer 71b], like others used at that time, cannot be used to determine with accuracy the image quality a large telescope would provide, in particular with regards to the period of excellence (Full Width at Half Maximum smaller than 0.5 arcsec) which made the reputation of Paranal.

It is thus proposed to move to Gamsberg one of the DIMM monitors currently in use in Chile. The preparation of the logistics for such a campaign implied a first visit to the site which took place from 8 to 15 April under the guidance of Dr. Th. Neckel, representing Max Planck Institute for Astronomy (Heidelberg), the owner of Gamsberg mountain top.

Plans have been made for a short term campaign (6 weeks from July 15 to August 31 1994) with a possibility of extension to a full year if deemed necessary, as described in Annex 3.

### 4.3 Water Vapour

Precipitable water vapour was never monitored during the previous Gamsberg site survey. One of the Kitt Peak infrared radiometers currently operated at Paranal will be transported from Chile to Gamsberg together with the DIMM. In addition, the complete upper air data set from radiosoundings regularly launched from Windhoek have been ordered for a more detailed comparison with the Antofagasta data set.

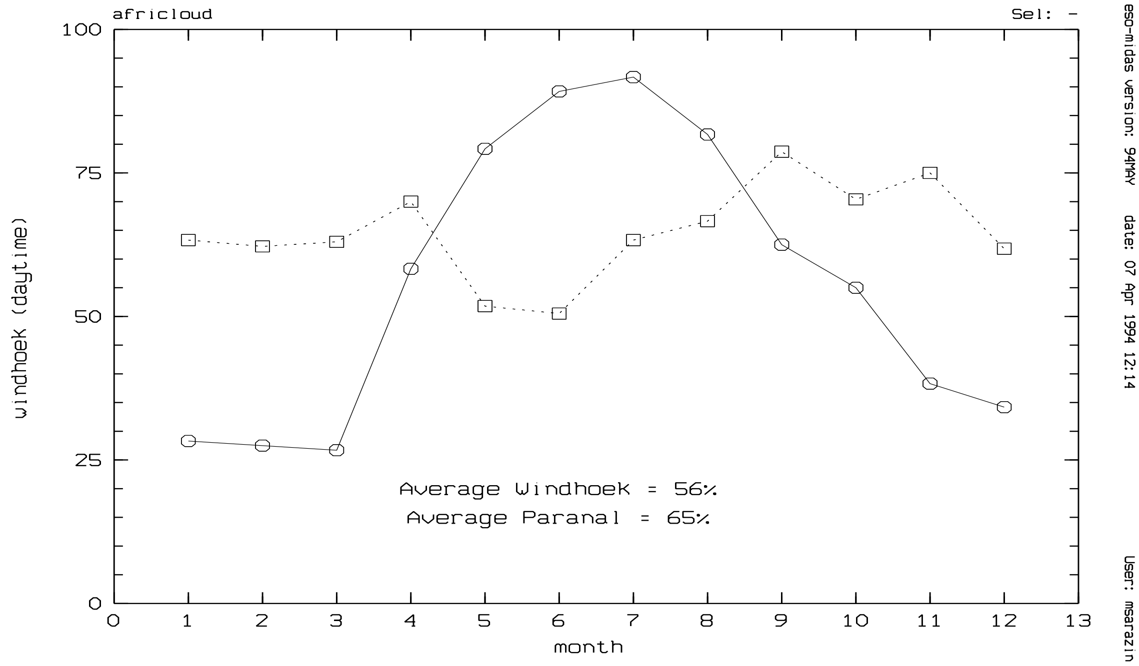


Figure 4: Comparison of Windhoek sunshine statistics (days with more than 90% of possible sunshine duration, full line, circles, 1960-1970) with Paranal statistics of photometric days (dotted line, squares, 1983-1989).

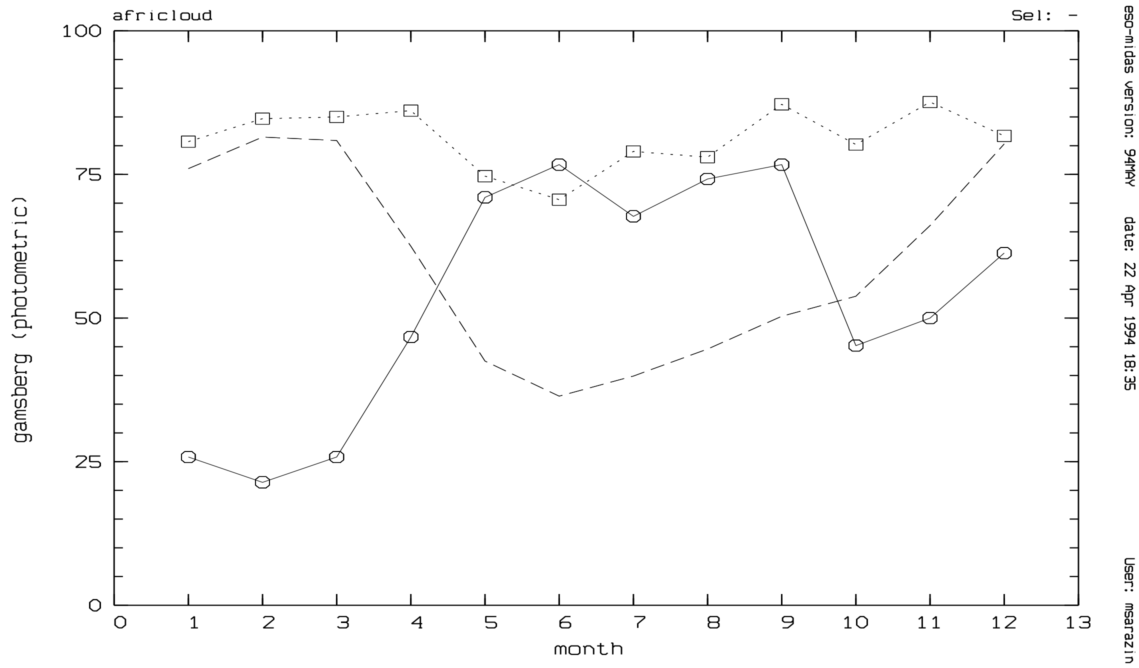


Figure 5: Comparison of Gamsberg statistics of photometric nights (full line, triangles, Sep. 1970-Dec. 1975) with Paranal (dotted line, squares, 1983-1989) and La Silla statistics of photometric nights (dashed line, 1965-1972). The respective yearly averages amount to 54, 81 and 58 percent.

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| Parameter | Unit | Country | |
|---|---|---|---|
| | | CHILE | NAMIBIA |
| Area | $km^2$ | 756945 | 824290 |
| Total population | million | 13.6 (1982) | 1.5 (1991) |
| Density | inh./$km^2$ | 18.0 | 1.8 |
| Urban population | % | 86 | 28 |
| Capital | | Santiago | Windhoek |
| Population | thousand | 4132 | 150 |
| Distance from Europe | flight hours | 16 | 9.5 |
| Time difference with ESO HQ | Winter,Summer (hours) | -4,-6 | +1,-1 |
| Human Development * | United Nations index (max=1) | 0.864 | 0.289 |
| Illiteracy | % | 6.6 | 60 |
| Infant mortality | per thousand births | 19 | 97 |
| Life expectancy | years | 72 | 59 |
| Number of physicians | per 1000 inh. | 0.46 | 0.26 |
| Brutto internal product | US$ per inh. | 2444 | 1120 |

Table 1: Comparison of geophysical situation of Chile and Namibia.

(*) the human development index was set-up in 1990 by the UN to obtain a better picture of the state of welfare reached by a population than with the usual reference to GNP per capita. It combines the life expectancy, the illiteracy and the average number of school years, and the GNP per capita corrected from purchasing power differences between countries. The maximum value of the index is unity, representing a country reaching for all criteria the maximum observed worldwide.

| Parameter | Unit | Site | |
|---|---|---|---|
| | | PARANAL | GAMSBERG |
| GEOGRAPHY | | | |
| Land property | status | concession to ESO | owner Max-Planck-Ins. |
| Latitude | degrees | 24.6 S | 23.3 S |
| Longitude | degrees | 70.4 W | 16.2 E |
| Distance to nearest city | km (car drive) | 140 (2 h) | 157 (2-3 h) |
| Altitude | m above sea level | 2630 | 2350 |
| Shape | | peak | table mountain |
| Flat area | largest dimension (m) | 250x150 | 3000x1500 |
| Height abv. surrounding | in main wind direction | 600 | 1000 |
| Distance to coast | as a bird fly (km) | 12, West | 200, West |
| GENERAL CLIMATOLOGY | | | |
| Ocean coastal current | cold equatorward | Humbolt | Benguela |
| Ocean surface Temperature | annual mean (C) | 14 | 16 |
| " | January-July difference | 4 | 3 |
| 200-mb zonal wind component | annual mean (m/s) | 25 | 20 |
| " | January-July difference | -30 | -20 |
| LOCAL CLIMATOLOGY | | | |
| Spectroscopic Nights | % | 90 (82 at La Silla) | 63 |
| Photometric Nights | % | 81 (58 at La Silla) | 54 |
| Photometric Days | % | 65 | 56 (Windhoek) |
| Relative Humidity | % Winter/Summer | 10/25 | 25/50 |
| Air temperature | yearly average (C) | 12.7 | 15.3 |
| " | min, max (C) | -8, 22 | -3, 30 |
| " | diurnal variation (C) | 6.7 | 9.1 |
| " | nocturnal variation (C) | 1.3 (6h) ,2.8 (12h) | 3.2 (10h) |
| Predominant wind | from dir. $\pm 90^{o}$, % | NNW, 80 | NW, 74 |
| Velocity (height) | m/s (m above ground) | 7.7 (10) | 4 (2) |
| Nighttime wind speed | % lower than 10 m/s | 75 (87 at La Silla) | 90 |
| " | % lower than 5 m/s | 35 (52 at La Silla) | 60 |

Table 2: Comparison of characteristics of Paranal and Gamsberg, according to [Elsässer 71a], [Elsässer 71b], [Birkle 76], [Peixoto 92], [Vlt 90], [Vlt 91], [Vlt 92], [Neckel 82], [Neckel 94].