Climate Variability and Ground Based Astronomy: The VLT site fights against La Niña

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1 Introduction

Hopes were raised two years ago (The Messenger **89**, Sep.97) to be soon able to forecast observing conditions and thus efficiently adapt accordingly the scheduling of the observing blocks. Importants steps toward this goal were achieved recently with the start of an operational service forecasting precipitable water vapour and cirrus (high altitude) cloud cover for both La Silla and Paranal observatories [1]. This was made possible thanks to the collaboration of Executive Board of the European Center for Medium Range Forecasts (ECMWF) who accepted to distribute twice a day to ESO the Northern Chile output of the global model. The ground level conditions [2] are also extracted from the ECMWF datasets with immediate benefits for observatory operation: bad weather warnings could be issued 72 h in advance during the July snowfalls at La Silla. Once embedded into the Observatory control system, the temperature forecast is due to feed the control loop of the VLT enclosure air conditioning.

These forecast systems still have to be optimized and equipped with a proper user interface taylored to astronomer's expectancies. They might then join established celebrities like the DMD Database Ambient Server, [3] paving the way to modernity for ground based astronomical observing.

2 Unexpected, improbable and yet, real

In this brave new world however, not everything is perfect: as if the task of building a detailed knowledge of our sites was not hard enough, climatic events such as the El Niño-La Niña Oscillation (The Messenger **90**, Dec.97) can turn decade long databases into poorly representative samples. As was reported with UT1 Science Verification (The Messenger **93**, Sep.98), the VLT site started to behave anomalously in August 1998. A re-analysis of the long term meteorological database pointed out an ever increasing frequency of occurrence of bad seeing associated to a formerly quasi unexistent NE wind direction. This contrasting behavior is illustrated in the examples (Fig 1 to 4) as displayed by the Database Ambient Server. While good seeing occurs under undisturbed NNW flow from above the Pacific, this NE wind is coming from land, it is rapid (Fig 5), turbulent, and up to 2 degrees warmer than ambient; Finding its exact origin became a challenging task.

3 Searching for clues

It is commonly stated that observatories are worse when operation starts than they appeared during the preceeding site survey. This is the well known 3σ effect, the most outstanding site being probably at the top of its climatic cycle when it is chosen. This theory did not apply to the VLT site for which we had records since 1983 showing an impressive climatic stability. Therefore, before accusing *The Weather*, a complete investigation was undertaken, starting with manmade causes. In particular

[1] http://www.eso.org/gen-fac/pubs/astclim/forecast/meteo/ERASMUS/
[2] http://www.eso.org/gen-fac/pubs/astclim/forecast/meteo/verification/
[3] http://archive.eso.org/asm/ambient-server/

the chronology of the stresses imposed to the site since the construction of the VLT had started (eg: water sewage, power generation, heat exchanging) were reviewed in collaboration with the VLT staff at Paranal. This, completed by an infrared survey of the surroundings (Fig. 6), confirmed that man made head pollution was orders of magnitude smaller than the phenomenon we were witnessing.

Measurements of the turbulence in the ground layer of the telescope area were then conducted by the University of Nice [4]. The study results delivered in Spring revealed that the first 30 m above ground accounted for only 10% of the total. The turbulence borne by the NE wind was probably extending over one thousand meters or more up in the atmosphere and thus could not have been generated locally.

4 An explanation in view

The inquiry turned then towards synoptic air motion but no obvious correlations could be observed between conditions at Paranal and the output of global models. The answer had to lie just in-between and the picture was slowly taking shape: if apparently stable conditions like the good NNW Paranal wind were based on a fragile equilibrium of energy balance, a slight change in the global circulation could indeed induce noticeable modifications of the wind pattern in continental areas, locally tuned by the mesoscale orography. But, did such a change really occur?

It was then natural to ask the Chilean Meteorologists who kindly and rapidly delivered the report reproduced herewith. This report stating that a weakening of the westerlies was observed during the recent La Niña period constitutes the most plausible explanation todate. Indeed when compared to the last strongest Niño event (1982-1984), the current slowly terminating oscillation has been fairly stronger in its Niña phase (Fig 7) which coïncide with the period of bad seeing at Paranal (July 98 to April 99).

5 And what comes next?

Can we readily assume, looking at Fig 8 that Paranal is on its way to recover its original excellence? hopefully yes, because although the average seeing still reflects some fairly bad events, the best 5 percentile were back into normal over the last two months, just as La Niña was vanishing...

6 Acknowledgements

We would like to thank Myrna Araneda Fuentes, Associate Director of the Department of Climatology of the Direction of Meteorology of Chile who provided the report reproduced herewith and Jose Vergara of the Department of Geophysics of the University of Chile for his helpful advice about mesoscale circulation.

[4] *Report on the GSM Measurement Campaign at the Paranal Observatory, Nov27-Dec20, 1998*; F. Martin et al., Ref: VLT-TRE-UNI-17440-0006

Annex Report (Original in Spanish on MSWord file)
Title: Analysis of the Anomalous Atmospheric Circulation in Northern Chile during 1998
Titulo: Analisis de la circulacion atmosferica anomala en el norte de Chile durante 1998
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In the far north of our country, wind components in the low and middle atmosphere until 700 hPa are normally from the North and from the East (Fig. 1), while above them and up to 100 hPa, West winds are normally prevailing during the whole year (Fig. 2).

It has been noticed that, during the years with La Niña or Antiniño occurrence, changes in the atmospheric circulation are of a global scale, similar to what is recorded during Niño years.

In Niña periods (as is the case since early 1998), the subtropical anticyclone of the South West Pacific which dominates the circulation in our country, becomes more intense and moves a few degrees southwards, resulting in a weakening of the high altitude (westerlies) winds over the far north of the country. To this adds the fact that the circulation on the eastern side of the Andes, which brings air from the Atlantic, becomes more intense from the low altitudes to the high atmosphere, up to the point at which the East component of the wind starts prevailing at high altitudes. This circulation pattern may be persistent enough to be seen on the Antofagasta radiosoundings and is, as previously stated, directly related to La Niña events.

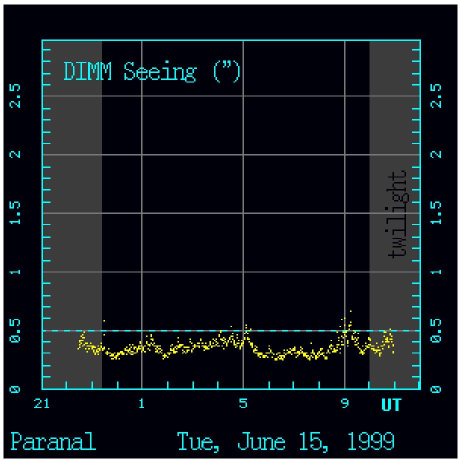

Figure 1: Seeing under Standard Paranal NNW Wind Direction.

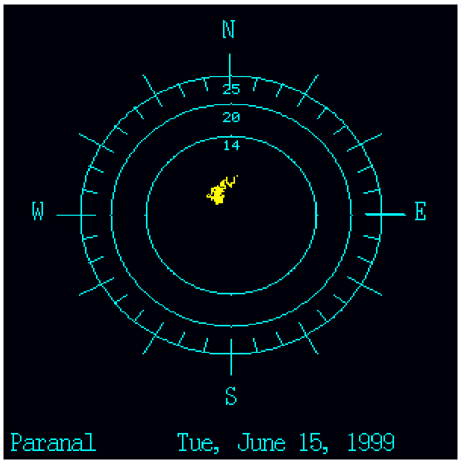

Figure 2: Standard Paranal NNW Wind Direction.

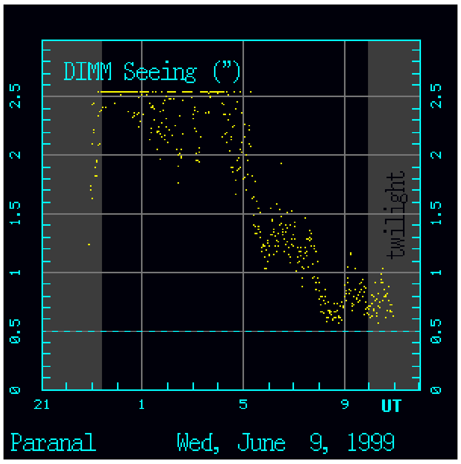

Figure 3: Seeing under Unfrequent Paranal NE Wind Direction (data is truncated for storage purposes).

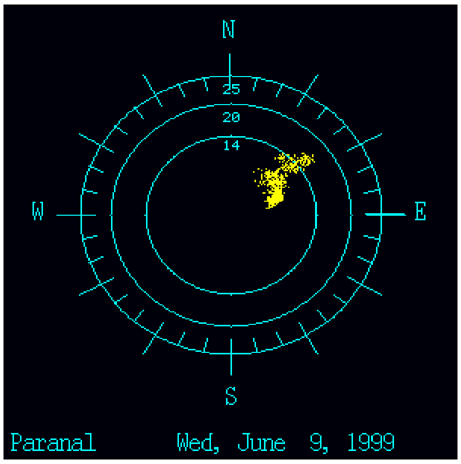

Figure 4: Unfrequent Paranal NE Wind Direction.

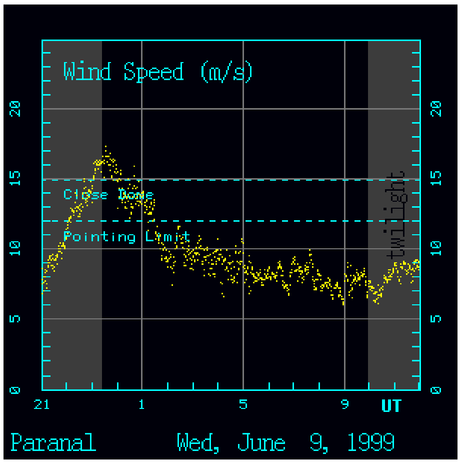

Figure 5: High wind velocities are typical with unfrequent Paranal NE Wind Direction.

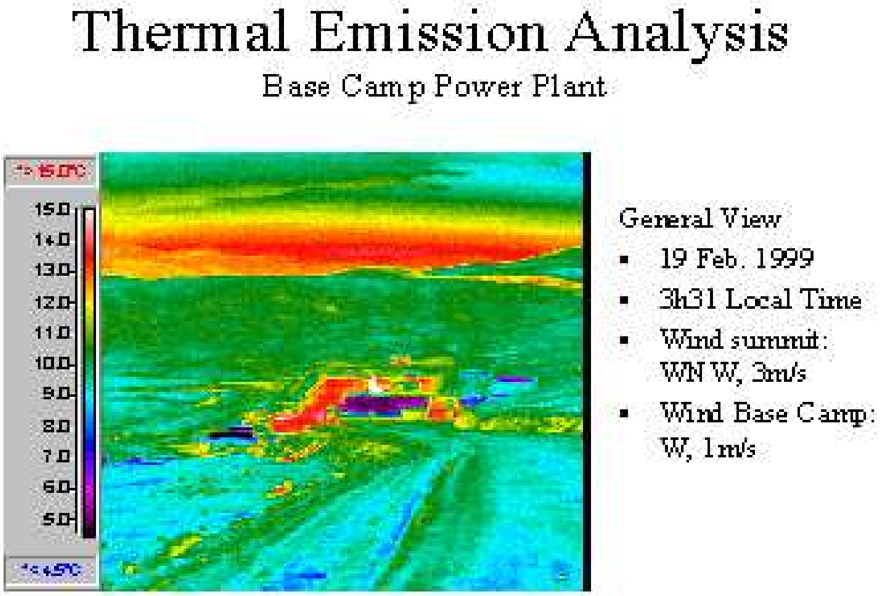

Figure 6: Thermal Infrared image of the VLT basecamp with the hot (white) powerplant plume in the center. These heat sources are located several km to the ESE on the lee side of the mountain. The thermally neutral access road is visible on the foreground. The colour coded temperature scale is qualitative only.

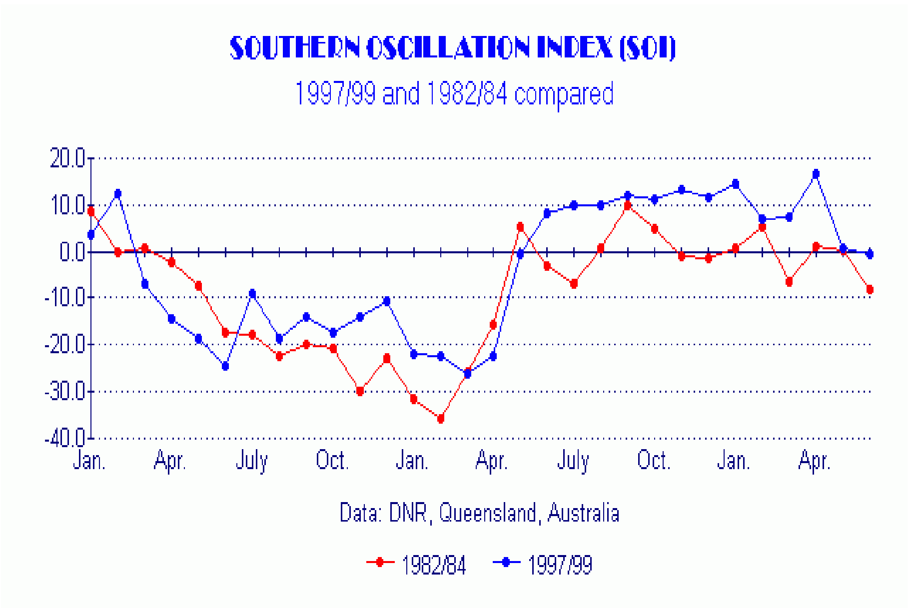

Figure 7: Comparison of the two strongest Niño events. A negative index corresponds to warmer waters (El Niño), a positive index to cooler (La Niña). The 1998-99 Niña period is strongly marked (http://www.vision.net.au/˜daly/elnino.htm).

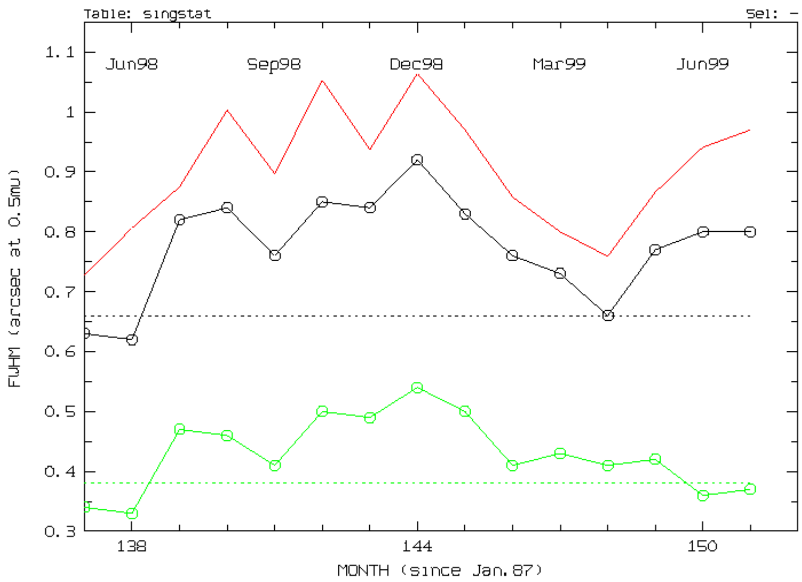

Figure 8: Seeing Statistics at Paranal since UT1 first light: monthly average (red), median (black) and 5th percentile (green). The dashed lines give the respective long term site characteristics. Seeing is reconstructed from DIMM measurements for an equivalent 20 mn exposure, at 0.5μm and at zenith.