A Cloudy Night Again? Blame El Niño!

A Study of the impact of El Niño on the Cloud Cover above ESO Observatories in Chile

M. Sarazin, November 10, 1997

Tropical ocean circulation adjusts itself permanently with respect to tradewinds seasonal fluctuations. For instance in the equatorial pacific, winds in normal regime push warm oceanic surface water towards the western edge of the basin. This generates a slope of the sea level of 40 cm per 10000 km between Australia and South America. By the end of the each year, when the tradewinds weaken the trend is reversed, the pressure is realeased and the ocean recovers a horizontal surface.

Should the tradewinds weaken excessively, the accumulated warm water is not only released towards the East but also far southwards along the Peruvian coast (as shown on Fig. 1 [1], blocking the normal upwelling of cold nutritive deep water in this area and contradicting the northward circulation of the cold Humbolt stream along the Chilean coast. This is the so-called El Niño, named after a Peruvian Christmas festival as it normally take birth in December, near the birthday of the Christ child. This phenomenon creates tremendous sea-atmosphere thermal energy transfers causing heavy precipitations all along the coast of South America and severe draught in Australia for the following year.

The changes in the ocean topography are nowadays monitored by dedicated satellites such as TOPEX-POSEIDON but the history of past El Niños could only be written with meteorological parameters available over long period of time. Meteorologist have found that the difference of pressure at sea level between Tahiti and Darwin (North Australia) could be used to generate an index number fairly representative of the cyclic warming and cooling of the Eastern Pacific [2]. A negative index corresponds to a El Niño while the positive periods (colder water) are named La Niña. This so-called Southern Oscillation Index (SOI), presented on Fig. 2 for the past 14 years, reflects the relative strength of successive events. In particular, it is shown that the current anomaly is not yet as powerful as the devastating 1982-83 event. The object of this study is to analyze the correlation of the SOI with the cloud cover above the observatories of La Silla and Paranal so as to assess the usefulness of the SOI as a tool for the long term planning of the observatory operation. It will be shown that not only the absolute value, but also the relative amplitude of the oscillation are to be taken into account when using the SOI as a predictor of the average clear sky statistics for the year to come.

The database of photometric quality accumulated during the 1983-1990 VLT site survey [3] is continuously maintained by the ESO site monitoring team. The statistics for La Silla [4] are extracted from the observing reports while the monitoring of the Paranal sky is performed by a dedicated staff every two hours along well established rules [5].

The average monthly percentage of photometric nights has been computed for both sites over the length of the database (Fig. 3). The Cloud Cover Anomaly (CCA) is then computed for each month as the relative deviation from these average conditions. It is shown on Fig. 4 and Fig. 5 that the peak to peak variation between surplus and deficit can reach 70% at La Silla and half that value at Paranal. However, the damage is obvious on both sites after conversion into loss of observing time:
the difference in number of available photometric nights during El Niño and La Niña years can amount to 150 nights at La Silla and 100 nights at Paranal.
Inspite of the fact that a fraction (50% at La Silla) of the non-photometric nights can still be used for

[1] Source NOAA: http://www.pmel.noaa.gov/toga-tao/el-nino/home.html

[2] see the WEB page of J.L. Daly at http://www.vision.net.au/~daly/elnino.htm

[3] A. Ardeberg, H. Lindgren, I. Lundström; *La Silla and Paranal: a comparison of photometric qualities* Astron. Astrophys., 230, 518, 1990.

[4] available at http://www.ls.eso.org/lasilla/weather/weather.html

[5] VLT Site Selection Working Group; *Final Report*; November 14, 1990, VLT Report $n^o 62$

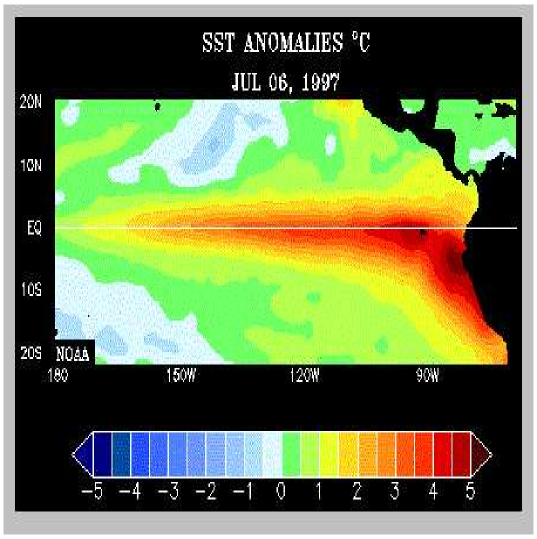

Figure 1: Map of Sea Surface Temperature Anomaly at the heart of an El Niño event. Warm surface waters spread southwards along the Peruvian coast

spectroscopic observations, the efficiency of the observatory is considerably decreased as the location of the patches of sky free of clouds is not known in advance.

The Observatory performance is thus directly related to the CCA and one can imagine that predicting it would allow to better plan heavy operations such as telescope upgrade and also improve the relation of the observatory to the astronomical community. El Niño events are supposed to start in December for a duration of one and a half year. However, a look at the SOI shows that the picture is by far not so clear. While the 1991-92 event has perfectly followed the rule, the 1986-87 had a delayed start but kept nevertheless the nominal duration so that it terminated only at the end of 1992. This phase fluctuation is particularly well reproduced for those two examples on the CCA of both ESO sites. Also the aborted SOI event of December 1989-January 1990 is well visible on the La Silla CCA but less obvious at Paranal. Finally, the softer El Niño of 1994-1995 did not affect Paranal CCA at all, and is burried in the noise of the La Silla CCA. If the strength of an event is reflected by the amplitude of the SOI decrease during the La Niña-El Niño transition, a value larger than 1.5 would be a reasonable limit for deciding of its relevance to astronomy.

In addition to the seasonal weather patterns affecting the Atacama desert [6], the analysis of the SOI-CCA dependency is further complicated by the presence of longer term climatic fluctuations whose period are counted in decades and which have no apparent phase relations with El Niño events. For instance La Silla which has been following since 1992 a positive slope is thus comparatively less affected by the current El Niño than it had been in 1991 when the effects were cumulative.

The SOI is not currently predictable but meteorologists are making progress in the understanding of atmosphere-ocean interaction. As far as ground based astronomy is concerned, the assessment of atmospheric effects has also drastically improved in the past 10 years. Nevertheless, long range forecasts will remain for some time limited to subjective analyses leading to cautious statements of the type:

observing conditions will degrade at ESO observatories in 1998. However, if current El Niño situation persists, conditions at La Silla will probably not reach historic lows of 1987 and 1992.

[6] ESO Internal Workshop on Forecasting Observing Conditions, The Messenger **89**, Sep. 1997, pp 5-10

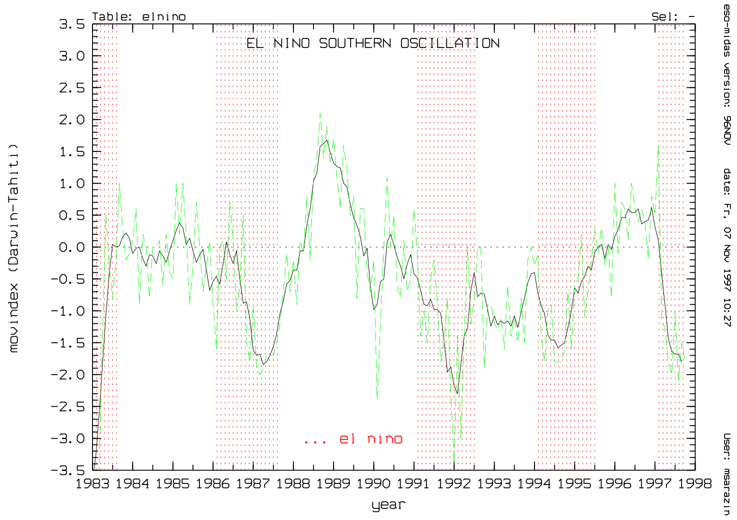

Figure 2: Southern Oscillation Index: the difference of sea level pressure between Darwin and Tahiti as monthly average (green line) and seen through a 5 month wide moving window (black line). Red shadings indicate main past el niño events with the theoretical january occurrence and 18 month duration.

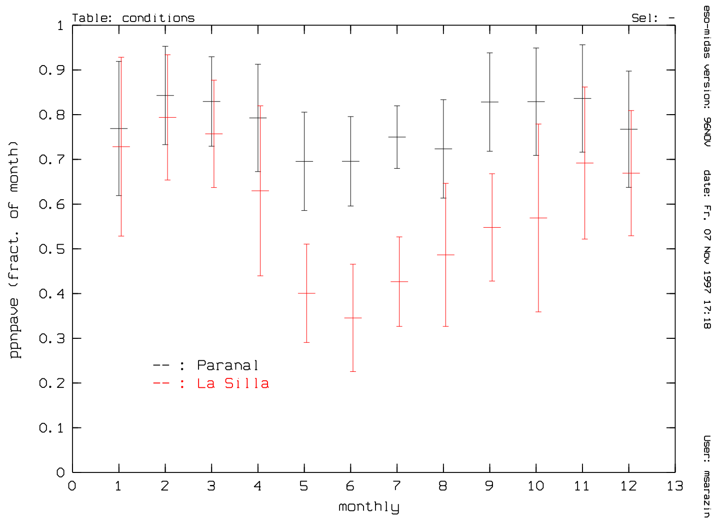

Figure 3: Cloud Cover: the average fraction of available photometric nights as a function of the month of the year at Paranal and La Silla observatories computed over the 14 year long database. The error bars correspond to $\pm$ the rms.

	1984	85	86	87	88	89	90	91	92	93	94	95	96
La Silla	57	59	53	50	66	66	56	53	51	57	58	60	75
Paranal	80	82	80	77	81	78	71	71	69	79	81	83	81

Table 1: Yearly average percentage of photometric nights at ESO sites

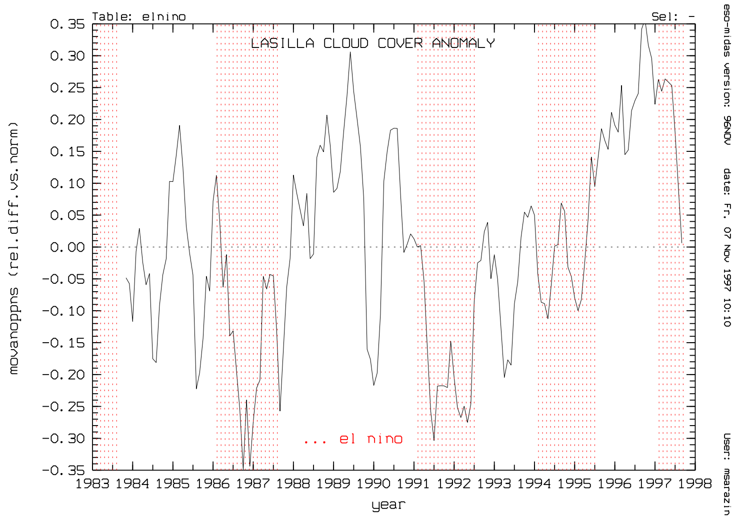

Figure 4: Cloud Cover Anomaly: the relative deviation from the monthly average number of photometric nights at La Silla observatory. seen through a 5 month wide moving window. Red shadings indicate the strongest past el niño events with a theoretical January occurrence and 18 month duration.

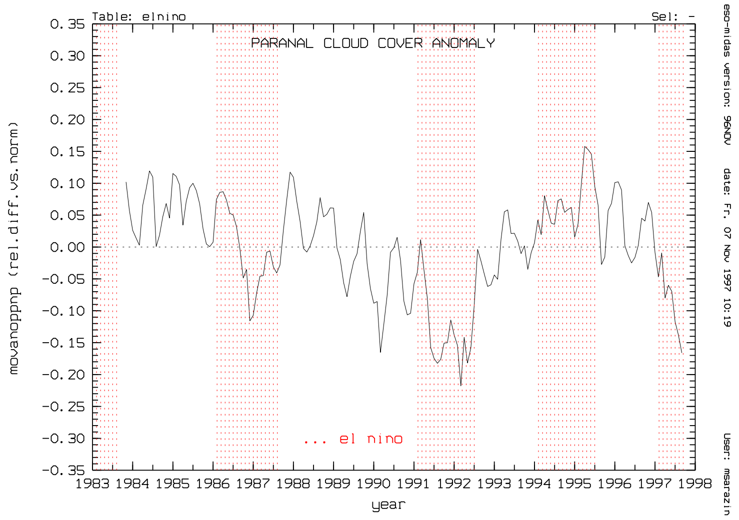

Figure 5: Cloud Cover Anomaly: the relative deviation from the monthly average number of photometric nights at Paranal observatory. seen through a 5 month wide moving window. Red shadings indicate the strongest past el niño events with a theoretical January occurrence and 18 month duration.