A Cloudy Night Again? Blame El Niño!

A STUDY OF THE IMPACT OF EL NIÑO ON THE CLOUD COVER ABOVE ESO OBSERVATORIES IN CHILE

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Tropical ocean circulation adjusts itself permanently with respect to trade winds 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 10,000 km between Australia and South America. By the end of the year, when the trade winds weaken, the trend is reversed, the pressure is released and the ocean recovers a horizontal surface.

Should the trade winds weaken excessively, the accumulated warm water is not only released towards the east but also far southwards along the Peruvian coast as shown in Figure 1, blocking the normal upwelling of cold nutritive deep water in this area and contradicting the northward circulation of the cold Humboldt Stream along the Chilean coast. This is the so-called El Niño (named after a Peruvian Christmas festival) because it normally starts 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 during 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 periods 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 an El Niño while the positive periods (colder water) are named La Niña. This so-called Southern Oscillation Index (SOI), presented in Figure 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 analyse 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

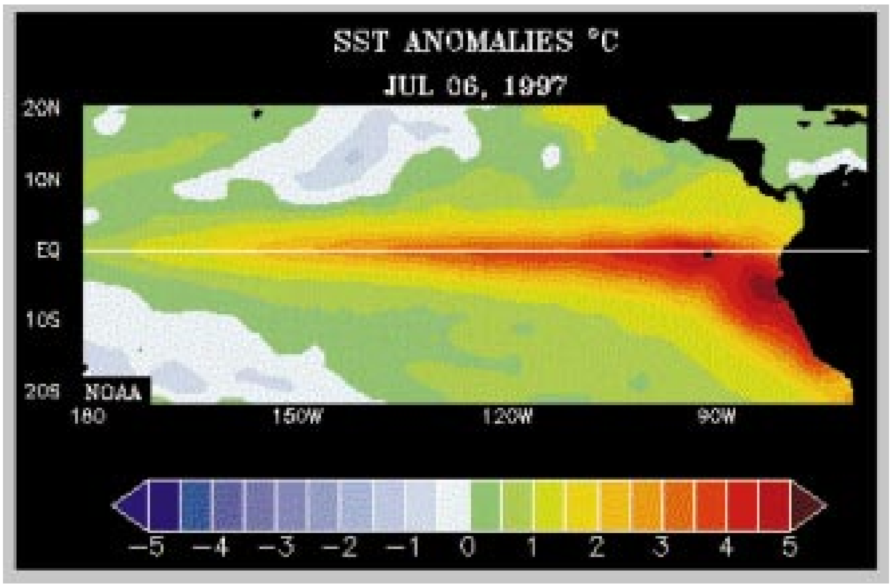

Figure 1: Map of Sea Surface Temperature Anomaly at the heart of an El Niño event. Warm surface waters spread southwards along the Peruvian coast.[1]

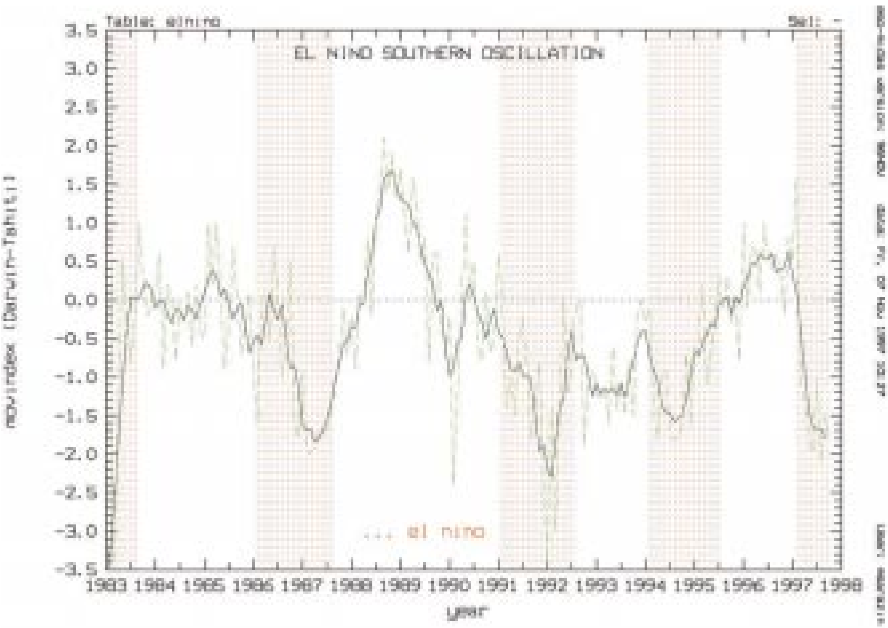

Figure 2: Southern Oscillation Index: the difference of sea level pressure between Darwin and Tahiti as monthly average (green line) and seen through a 5-month wide moving window (black line). Red shadings indicate main past El Niño events with the theoretical January occurrence and 18 months duration.

[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.html

[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 No. 62.

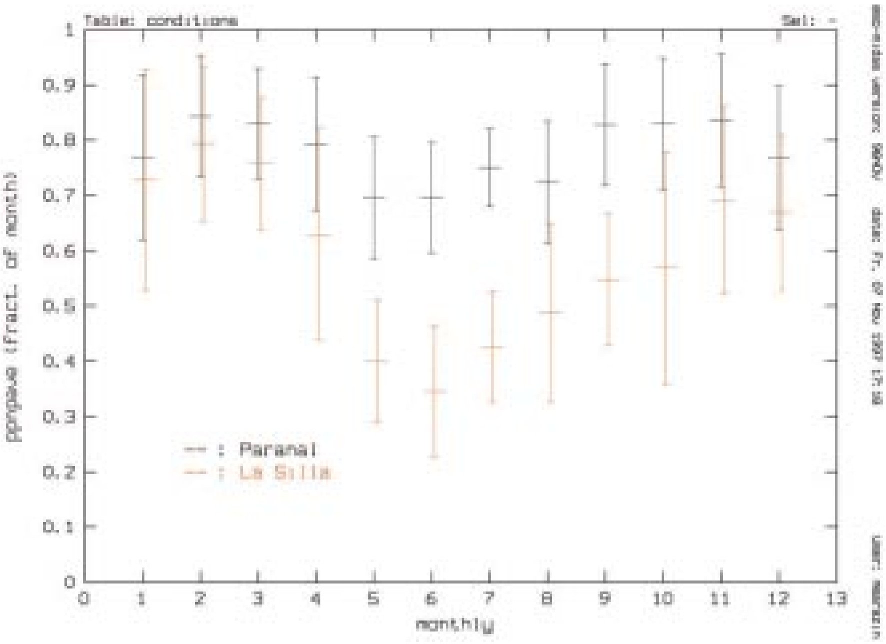

Figure 3: Cloud Cover: the average fraction of available photometric nights as a function of the month of the year at Paranal and La Silla observatories computed over the 14-year-long database. The error bars correspond to ± the rms. ◄

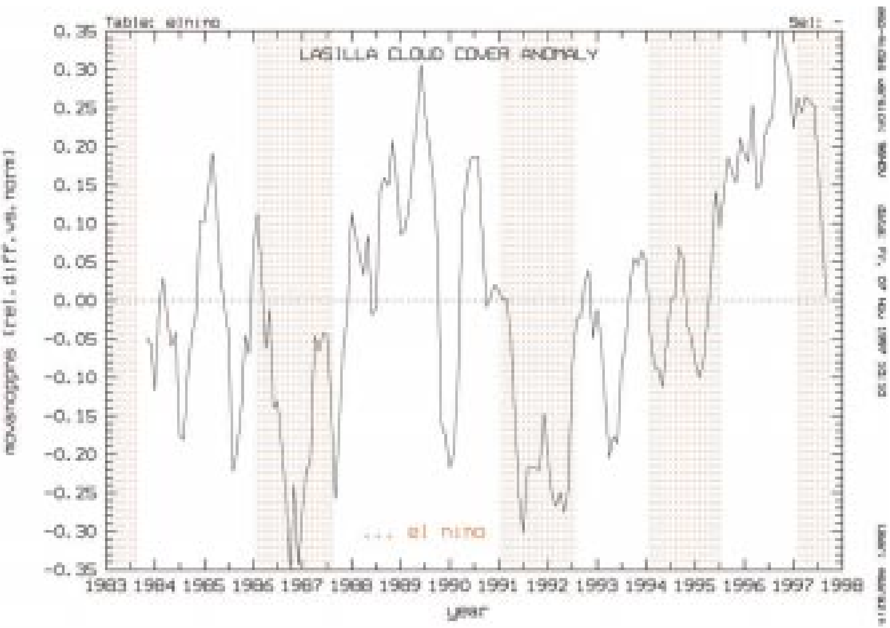

Figure 4: Cloud Cover Anomaly: the relative deviation from the monthly average number of photometric nights at La Silla observatory, seen through a 5-month-wide moving window. Red shadings indicate the strongest past El Niño events with a theoretical January occurrence and 18 month duration. ▼

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 in Figures 4 and 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 90 nights at La Silla and 50 nights at Paranal.

In spite of the fact that a fraction (50% at La Silla) of the non-photometric nights can still be used for 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 it is easy to imagine that predicting it would allow to better plan heavy operations, such as telescope upgrade, and also to inform 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 (Fig. 2) 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 1987. This phase fluctuation is particularly well reproduced for those two examples on the CCA of La Silla. 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 1994/95 did not affect Paranal CCA at all, and is buried 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 reason-

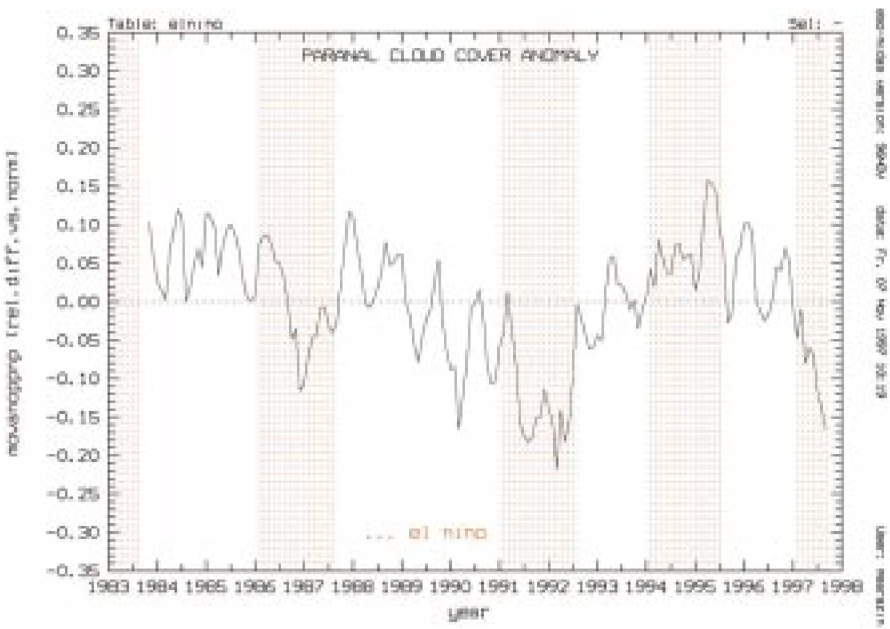

Figure 5: Cloud Cover Anomaly: the relative deviation from the monthly average number of photometric nights at Paranal observatory, seen through a 5-month-wide moving window. Red shadings indicate the strongest past El Niño events with a theoretical January occurrence and 18 month duration. ►

	1984	85	86	87	88	89	90	91	92	93	94	95	96	1984–1996
La Silla	57	59	53	50	66	66	56	53	51	57	58	60	75	58.5
Paranal	80	82	80	77	81	78	71	71	69	79	81	83	81	77.9

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

able 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 periods 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 the 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, Sept. 1997, pp. 5–10.

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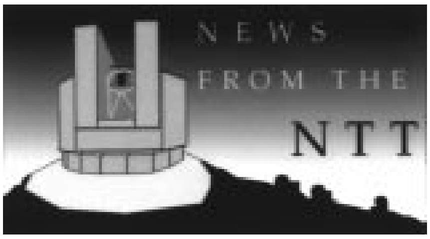

NEWS FROM THE NTT

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The NTT has, at the time when this is written, been back into operations for 4 months. Emphasis during that period has been laid on stabilising the control system and developing an operational model. Accordingly, there has been virtually no technical intervention except for fixing problems or improving the robustness, in strong contrast with the upheaval of the Big-Bang year during which most of the control system had been replaced.

The Operational Model

Two modes of operations are currently supported at the NTT: service and classical.

Service observations are performed by the NTT support astronomers according to the schedule defined by the User Support Group (USG) of the Data Management Division (DMD). The latter is established according to the OPC recommendations and is supplied to the NTT Team under the form of Observation Blocks (OBs) which reside in a database.[1] The OBs, each of which fully describes an observation, have been defined generally well before they are scheduled by the PIs of the selected programmes, using the Phase 2 Proposal Preparation (P2PP) tool. The OBs are assembled into a schedule by the Observing Tool (OT), which is the interface between the database and the High-Level Observing Software (HOS) running on the acquisition workstation.

During the second half of Period 59 (that is, for observations to be performed until the beginning of October), PIs had to travel to the ESO headquarters in Garching to run P2PP to prepare their OBs. As of its version 1.0, released by the USG in September, P2PP has started to be distributed outside ESO, and applicants who have been allocated observations in service mode with the NTT now have the possibility to install this software on their own computers and to carry out the phase 2 preparation in their home institutes. This is done with the support of the USG, which answers questions and to which possible problem reports must be addressed.

Essentially the same scheme is followed for classical observations. Visiting astronomers are invited to come to La Silla two days before the beginning of their run, to prepare the bulk of their OBs on the La Silla off-line computing system before the start of their observations. This step is carried out with the help of the NTT support astronomers. P2PP is also run at the NTT during observation to perform last-minute modifications of the OBs.

Classical observers can, of course, also get the P2PP software from ESO and use it to prepare their OBs at home. However, ESO does not have the means to provide on-line support for that case, so that questions and problems that might arise at that stage will have to be solved upon arrival of the visiting astronomer on La Silla.

A calibration plan defined jointly by the USG and the NTT Team is executed by the latter on a daily basis, so as to guarantee that all the data that are taken can later be calibrated in a standard manner. The use of P2PP and the regular execution of the calibration plan guarantee that the data coming out of the NTT are suitable for archive research. As a matter of fact, all the data taken are systematically archived.

The archiving process is still very much in the same transitional status as reported in the previous issue of *The Messenger*, as far as the automatic archiving software is concerned. However, on the operational side, significant progress has been achieved on at least two aspects. One is the implementation of a (temporary) tool to transfer in real time the data obtained during service observing to an archive machine in the ESO Garching headquarters, in order to speed up delivery to the investigators by the USG. On the other hand, on-site production of the CD ROMs on which the data are eventually archived has begun on La Silla.

System Performance

Overall, the telescope and instruments have performed very smoothly since the return into operation. There has been only a very small number of failures of the new control system, and they could in general be fixed in a minimum time. Accordingly, the overall technical downtime has been low. However two problems of more importance were

[1]The concept of OB has already been described on various occasions in previous issues of *The Messenger* (see e.g. the NTT News in the last issue).