An El Niño Primer

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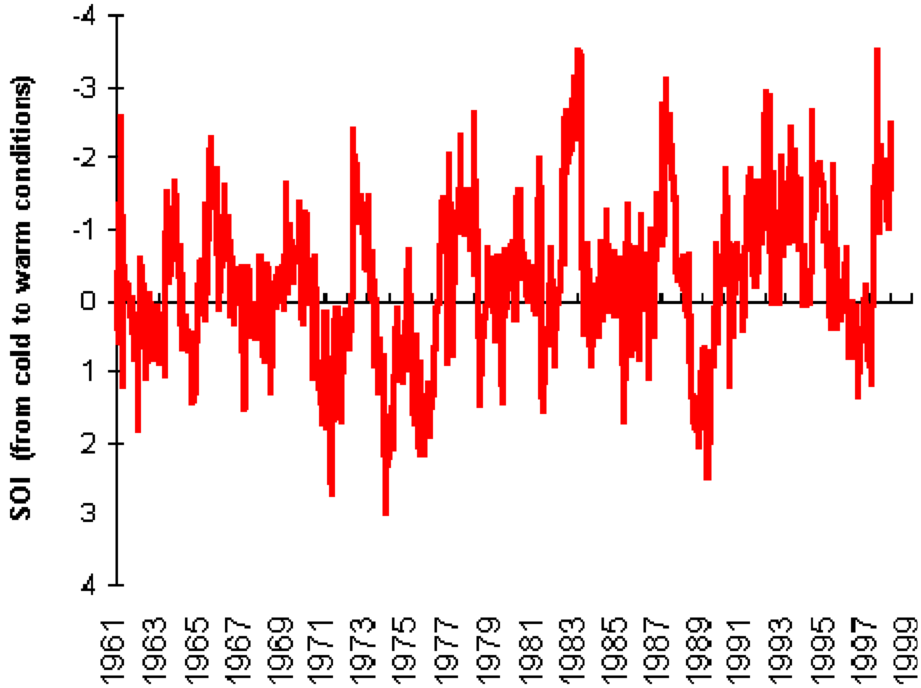
El Niño-Southern Oscillation defined
El Niño is a local warming of surface waters which takes place in the entire equatorial zone of the central and eastern Pacific Ocean off the Peruvian coast and which affects the atmospheric circulation world-wide. It usually peaks around Christmas, hence the name of the phenomenon: El Niño is Spanish for Christ Child). La Niña refers to the "cold" equivalent of El Niño.

Like most atmospheric phenomena, it occurs at more or less regular intervals (pseudo-cycles) and, as such, there is nothing "abnormal" in the occurrence of El Niño. El Niño triggers so much interest for three reasons: it can be modelled, thus forecast; its influence on climate is global, and there is a time lag between the phenomenon itself and many of its most important climatic consequences. Therefore, it can be used for forecasting climate [1].

The Southern Oscillation is an East-West balancing movement of air masses between the Pacific and the Indo-Australian areas. It is associated (roughly synchronised) with typical wind patterns and El Niño, and "measured" by the Southern Oscillation Index (SOI) [2]. El Niño is the oceanic component, while the Southern Oscillation is the atmospheric one. This combination gives rise to the term ENSO. Although there is no perfect correlation between El Niño and the Southern Oscillation for minor variations, large negative values of the SOI are associated with warm events.

As illustrated in figure 1 below, El Niño occurs on average every 4 to 5 years, sometimes less (2 to 3 years), sometimes more (8 to 11 years). The phenomenon proper lasts 12 to 18 months, also a recent very unusual event lasted from mid-1990 to mid-1995 [3]. As indicated, El Niño is a permanent feature of the Pacific ocean; the wording warm event describes an anomalous, unusually warm El Niño. Similarly, there are cold events when the Sea Surface Temperatures (SST) become unusually cold.

Figure 1: **Recent variations of the Southern Oscillation Index**



About the figure: Low (negative) values correspond to the warm phase. The graph was prepared based on time series taken from the Queensland Department of Primary Industries web-site (QDPI, Australia) and the Goddard Distributed Active Archive Center (DAAC, USA). The February 1998 value corresponds to the 30-day period ending on 25 February (given by QDPI). SOI is normalised, i.e. it is the dimensionless deviation from the 1951-80 average expressed in standard deviation units.

It is important to realise that the ENSO phenomenon has always happened and will continue to do so. What has changed recently is a better modelling and understanding of the physics, hence better forecasting and more focused monitoring of ENSO, as well as better world-wide forecasting of the climatic consequences.

Global impacts

There are essentially four sources for ENSO forecasts: the US National Oceanic and Atmospheric Administration (NOAA; see http://www.pmel.noaa.gov/toga-tao/el-nino/forecasts.html#enso), the Australian Bureau of Meteorology (BoM; see http://www.bom.gov.au/bmrc/mrlr/rzk/climfcn3.htm), the Lamont Doherty group at Columbia University (see http://rainbow.ldeo.columbia.edu) and the Centre for Ocean-Land-Atmosphere Studies (COLA/IGES funded by NOAA, NSF, and NASA; see http://grads.iges.org/nino/) A warm event had been forecast for 1997 by one of the climate forecasting Centres in January. However, the agreement between the forecasts could only be reached when the actual warming started to be observed. The models still disagree on details like the intensity, the timing and geographic extension of the SST peak. The warming has now been amply confirmed by satellite observations, moored and floating buoys, deep ocean temperature soundings and sea level analysis.

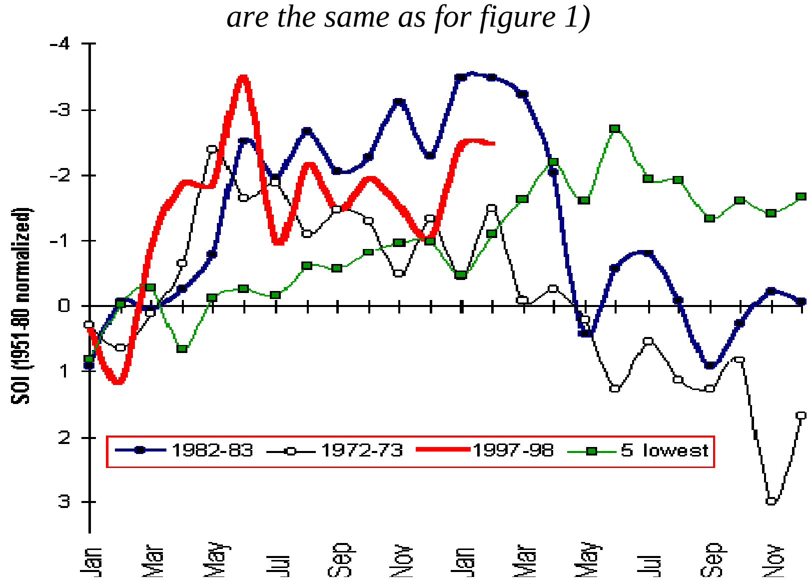
The phenomenon is very visible in figure 2 below, where SOI is compared with some records (1982, 1972), as well as the average of the 5 years of this century (1900 to 1996) which recorded the lowest SOI values. The value indicated for June is among the lowest ever. This behaviour is also very clear in the SST records and various other ENSO indices (see, for instance, under http://www.cdc.noaa.gov/ENSO/enso.current.html).

The current El Niño is exceptional in that it started very early in March-April and because it reached record values during the summer 1997. It actually culminated in June-August but had adopted a more normal pattern in the late months of 1997, seasonally increasing again in December-January and remaining stationary in February 1998. The "previous strongest" El Niño (1982) peaked in March-April but started slower than the current one. The 1972 event (also one of the top 6 for this century) collapsed after July [4]. Therefore, it is very difficult to say exactly how the situation will develop this time. It is clear by now that some extreme weather occurred, though not necessarily where it was expected. On the other hand, some predicted disasters did not occur. Of course, the situation is still developing, and no final conclusions can yet be drawn.

El Niño affects marine fisheries, particularly in the eastern Pacific Ocean where it tends to radically lower the ocean primary production. It is thought to be associated with declines of a number of fish stocks, including the largest fishery that has ever existed on earth, the Peruvian anchoveta fishery, which totally collapsed in conjunction with the 1972 El Niño.

El Niño has different impacts in different parts of the world, sometimes beneficial (for instance, it is believed to suppress hurricanes in the Atlantic), sometimes negative (drought in Southern Africa and Northern Latin America). Some of the possible consequences are illustrated in figure 3 below. Although for many of them the mechanisms are well understood, it should be noted that they are based on the empirical/statistical observation that extreme ENSO has been associated in the past with extreme climatic phenomena. In this context, extreme is taken in a statistical sense, i.e. rare, occurring with a low frequency and usually associated with unusual intensities [5].

Figure 2: **A comparison of the current SOI development with historical data** *(The data used are the same as for figure 1)*



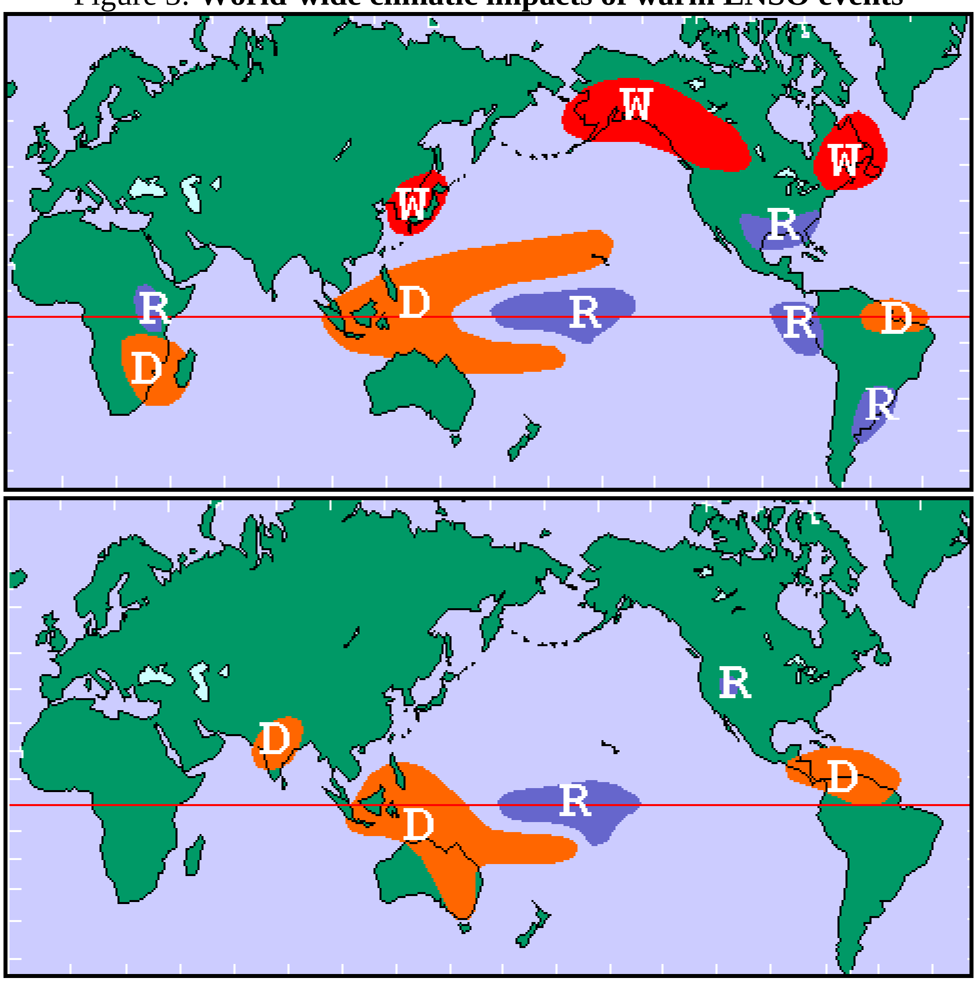
From an agricultural perspective, it is important to remember that the cropping season of the northern tropics falls between April and September, while it coincides with October-March in the southern hemisphere (this excludes all-year moist equatorial areas, the "sub-tropical" Mediterranean areas and winter crops of the temperate climates). It is thus essential to pay attention to the relative timing of the warm events and the crop calendar: the top of figure 3 is thus essentially post-ENSO, while figure 3b coincides with the build-up of high SST (pre-ENSO).

Local impacts

Several WWW sites have assessments of El Niño impacts at a regional and national level. As they have a lot of cross-referencing, it is sometimes difficult to point to the actual source of the data. Some of them are listed below, by continents.

Several WMO members have ENSO information, for instance Brazil, Chile, Colombia, France, UK and the USA. They can be found under http://www.wmo.ch/web-en/member.html; more are added regularly. Meteorology, climatology and geography departments of universities also frequently carry information on ENSO.

Figure 3: **World-wide climatic impacts of warm ENSO events**



About the figure: The upper half (3a) corresponds to the northern hemisphere winter (October to March) and the lower half (3b) covers impacts during April to September. D indicates drought, R stands for unusually high rainfall (not necessarily unusually intense rainfall) and W indicates abnormally warm periods. The figure is modified from two illustrations given by Pacific Marine Environmental Laboratory WWW home page (NOAA, USA).

More details on the situation, by continent

Africa

"Normal" El Niño impacts:

- Southern Africa: dryness coincides with the rainy/growing season, good positive correlation with maize yield (negative impact) in Zimbabwe and South Africa
- East African wetness Oct-Dec coincides with and benefits short season crops
- Sahel: no clear influence due to influence of the Atlantic Ocean

Up-to-date information from the following web-sites:

- http://www.ogp.noaa.gov/enso/africa.html

Asia

"Normal" El Nino impacts:

- India: Dryness corresponds with the SW monsoon, usually associated with reduced rice yields
- Thailand: Negative impact on maize yields. Weak correlation with rice
- Philippines: Dryness corresponds with the NE monsoon season (secondary season), associated with reduced rice yield
- Indonesia: Dryness corresponds with the dry season (a minor growing season)

Up-to-date information from the following web-sites:

- http://www.ogp.noaa.gov/enso/asia.html

Australia

"Normal" El Niño impacts

Generally wet in the North West, but dry in most other parts of the country, particularly the NE (Queensland)

Up-to-date information from the following web-sites:

- http://www.ogp.noaa.gov/enso/australia.html
- http://www.bom.gov.au/climate/ahead/evo.shtml

Latin America

"Normal" El Niño impacts:

- Brazil: Rainy season Jan-Jun. El Niño mainly affects first half of the season, mainly in the Nordeste.
- Ecuador/N. Peru: Heavy rain potential entire rainy season (Nov-Apr)
- Peru/Bolivia: slight tendency for dryness in Dec-Feb

Up-to-date information from the following web-sites:

- http://www.ogp.noaa.gov/enso/latinamerica.html

Pacific Islands

In general, the timing and strengthening observed for this event in recent months has been well ahead of that seen in other warm episodes over recent decades (e.g. since the early 1950s). Although the 1982-83 warm event is still regarded as the strongest this century, the present event has already exceeded it by some measures, and may yet develop into a record-breaking event.

Up-to-date information from the following web-sites:

- http://naulu.soest.hawaii.edu

USA/North America

Up-to-date information from the following web-site:

- http://www.pmel.noaa.gov/toga-tao/el-nino/impacts.html

Notes

1. Climate forecasts, also know as seasonal forecasts differ in many respects from weather forecasts especially as regards the input data, the methods used and the time horizon. Weather forecasts cover up to 10 days, while climate forecasts extend up to one year ahead. Another difference is that climate is defined as average weather, thus a climatic forecast is much less detailed than a weather forecast: only general situations are outlined (i.e. "dry conditions" , "abnormally warm", etc.) in comparison with a reference period.

2. The Southern Oscillation is not unlike the swinging movement of water in a bath tub. It is popular because it is easy to measure as the difference between sea level atmospheric pressures at Darwin (N Australia) and Tahiti (South- Central Pacific), for which there is a long historic record which has greatly facilitated research.

3. This can be considered as one long, chronic, multiple-peaked El Niño or rather as several small ones coming in rapid sequence. What is important is that it lacked the general periodicity of the earlier historical period.

4. There are some marked differences between the current El Niño and the July 1972 event: the SSTs stayed warm throughout 1972 (NINO3 was +2.64 in December, then cooled rapidly in 1973). From an SST viewpoint the collapse was not as rapid as with the SOI, and it is the SST anomalies that provide surplus energy for some climate impacts. NINO3 is currently at +3C and NINO1.2, along the coast is at +4.2C, hence the "feeling" of many experts that the event is not going to disappear rapidly. Note that NINO3 and NINO1.2 correspond to different "sectors" of the central Pacific ocean.

5. One of the consequences is a relative difficulty to achieve good statistical significance. It should further be noted that the frequency is referred to a time period which may differ. For instance, figures 1 and 2 adopt the 1951 to 1980 period as reference. Since warm events have been relatively more frequent after 1980, a more recent reference period would have ranked 1997 as less "extreme". Also, El Niño is only one of the factors that affect global atmospheric circulation and climate. As far as is known, it does not depend on other external forcing. Therefore, there cannot possibly be a "perfect" association between El Niño and climatic impacts. For instance, 1957/58 or 1977/78 had virtually no effect in Southern Africa. Finally, warm events differ in many ways, such as their "position" in the sequence of warm/cold/average SSTs, their absolute magnitude, duration, location, etc.

If you want to learn more:

There is a very large volume of fundamental and applied research on El Niño. Most quoted WWW sites will provide an easy entry point, maybe starting from http://earth.agu.org/revgeophys. For general overviews, also refer to the web site of WMO (http://www.wmo.ch).