El Niño Forecast Revisited

by

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1. Background of ENSO Forecast

On 11 January 1999, my paper "Solar Activity Controls El Niño and La Niña" was published on this web site. It included a forecast of the next El Niño around 2002.9 (End of November 2002). As this date is approaching, it seems to be in order to give a short delineation of the background of this forecast for those readers who are interested in an explanation of the general concept, but shun technical details. This all the more so as there are first indications that an El Niño is in the making.

My forecast is exclusively based on cycles of solar activity. This does not conform to the dominating trend in official science. The Third Assessment Report, published by the Intergovernmental Panel on Climate Change (IPCC), continues to underestimate the Sun's role in climate change: "Solar forcing is considerably smaller than the anthropogenic radiative forcings", and its "level of scientific understanding" is "very low", whereas forcing by well-mixed greenhouse gases "continues to enjoy the highest confidence level" as to its scientific understanding. The Third Report considers it "unlikely that natural forcing can explain the warming in the latter half of the 20th century." There are also frequent assertions in the literature that there was only a negligible effect of solar activity on temperature in recent decades.

2. Effect of solar eruptions on climate stronger than variations in irradiance

The IPCC's judgement is based on the observation that the Sun's irradiance changes only by about 0.1 percent during the course of the 11-year sunspot cycle. It turns out to be untenable when the Sun's eruptional activity (energetic flares, coronal mass ejections, eruptive prominences) as well as solar wind contributions by coronal holes are taken into consideration. The total magnetic flux leaving the Sun, dragged out by the solar wind, has risen by a factor of 2.3 since 1901 **(Lockwood et al., 1999)**, while concomitantly global temperature increased by about 0.6°C. The energy in the solar flux is transferred to the near-Earth environment by magnetic reconnection and directly into the atmosphere by charged particles.

Energetic flares increase the Sun's UV radiation by at least 16 percent. Ozone in the stratosphere absorbs this excess energy which causes local warming and circulation disturbances. General circulation models developed by Haigh **(1996)**, Shindell et al. **(1999)**, and Balachandran et al. **(1999)** confirm that circulation changes, initially induced in the stratosphere, can penetrate into the troposphere and influence temperature, air pressure, Hadley circulation, and storm tracks by changing the distribution of large amounts of energy already present in the atmosphere.

3. Forbush events after solar eruptions affect temperature and cloud cover

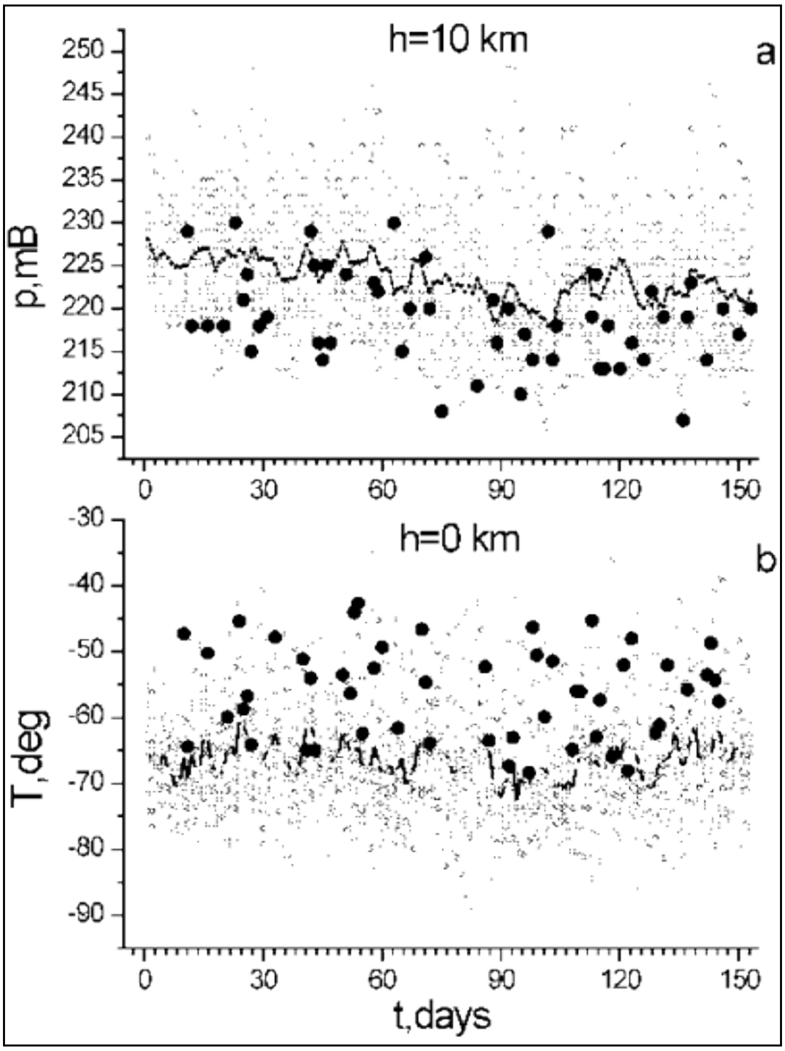

Figure 1

The strongest contributors to the intensity of the solar wind are solar eruptions which create the highest velocities in the solar wind and shock waves that compress and intensify magnetic fields in the solar wind plasma. Indirectly, they modulate the strength of galactic cosmic rays that conceivably have an effect on cloud cover, attributed to cloud seeding by ionized secondary particles **(Svensmark et al., 1997; Pallé Bagó et al., 2000)**

Figure 1 after Egorova et al. **(2000)** provides evidence of this connection. From 1981 to 1991, Egorova, Vovk, and Troshichev **(2000)** observed surface temperature (lower panel) and atmospheric pressure at 10 km altitude (upper panel) at the Russian Antarctic station, Vostok. Tiny open circles indicate superimposed daily observations during the winter season. The solid line describes the 10-winter average. Fat circles mark Forbush events. These are sharp decreases in the intensity of galactic cosmic rays caused by energetic solar flares. As can be seen from Figure 1, temperature was nearly always above the mean after Forbush events, often reaching departures around 20°C.

These 51 experiments performed by Nature and observed by man show a clear connection between solar eruptions, a decrease in cosmic ray intensity, and a strong rise in temperature, not to mention the strong decrease in air pressure. It would be a redundant exercise to assess the statistical significance of this distinct result. It is consistent to assume that the rise in temperature was linked to shrinking cloud cover because of less intense cosmic rays, though the microphysical details of the effect are not yet clear. This link is confirmed by Pudvokin and Veretenenko **(1995)** who observed marked shrinking of local cloud cover by 3 % after Forbush events.

4. Solar eruptions have an impact on tropical circulation

El Niños occur in the tropical Pacific, far away from Antarctica. There is cogent evidence, however, that the Sun's eruptional activity, too, has a strong effect in the tropics. Fig. 2 after Neff et al. **(2001)** shows a strong correlation between solar eruptions, driving the solar wind, and tropical circulation and rainfall. The dark profile represents oxygen isotope variations (^{18}O) in a dated stalagmite from Oman. The ^{18}O record, covering more than 3000 years (9.6 to 6.1 kyr before present), serves as a proxy for change in tropical circulation and monsoon rainfall. The bright ^{14}C profile shows radiocarbon deviations derived from the analysis of dated tree rings. The level of radiocarbon production in the atmosphere depends on the changing strength of cosmic rays. Because of the reverse relationship of cosmic rays with solar activity, the radiocarbon record serves as a proxy of the Sun's activity. Most scientists think that this proxy is related to the activity of sunspots and faculae linked to relatively weak changes in irradiance.

Actually, the radiocarbon data

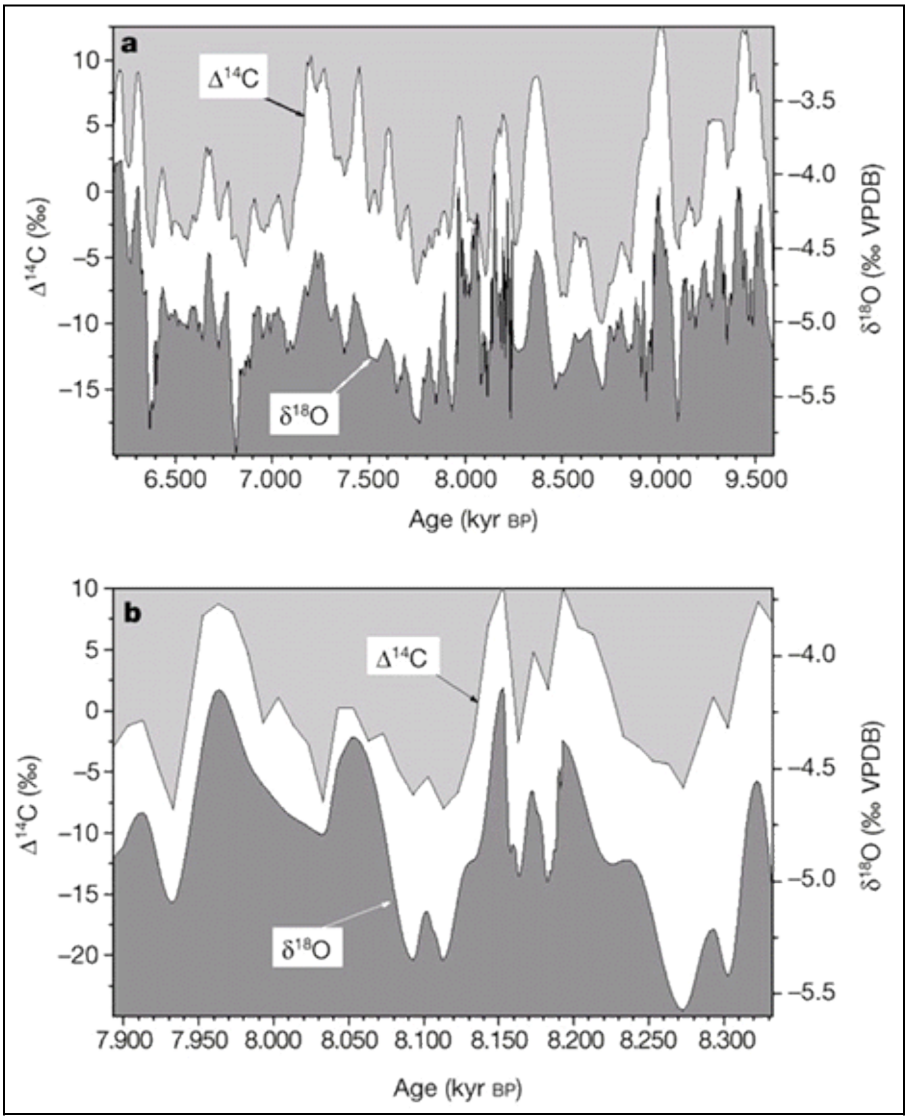

Figure 2

are a proxy of the Sun's eruptional activity driving the solar wind. Energetic solar eruptions do not accumulate around the sunspot maximum. In most cycles they shun the maximum phase and can even occur close to a sunspot minimum.

The upper panel in Fig. 2 covers the whole investigated interval, whereas the lower panel shows the nearly perfect synchronicity in detail.

Lake bottom cores from the Yucatan Peninsula show a similar correlation, covering more than 2000 years, between recurrent droughts and the radiocarbon record linked to the Sun's eruptional activity via cosmic rays **(Hodell et al., 2001)**. These results and many less recent ones document the importance of the Sun's eruptional activity for climate change in the tropics. So it suggests itself to see whether other tropical climate phenomena show similar connections with solar eruptions.

5. Limited lead time of ENSO forecasts based on precursors

Anomalous warming (El Niño) or cooling (La Niña) of surface water in the eastern equatorial Pacific occurs at irregular intervals (2 to 7 years) in conjunction with the Southern Oscillation, a massive see-sawing of atmospheric pressure between the south-eastern and the western tropical Pacific. The coordinated El Niño/Southern Oscillation phenomenon (ENSO), also including La Niña, is the strongest source of natural variability in the global climate system. Anomalies in the global temperature (positive or negative deviations from a defined mean temperature) are primarily driven by ENSO events . Only when explosive volcanic activity intervenes, global temperature is additionally modulated by its cooling effect.

So it is plausible that there are strong links to weather in other world regions. As this might be the key to long-range seasonal forecasts, there is strong interest in precursors that could make it possible to predict ENSO events. The NOAA tripwire open ocean buoy array including deep ocean moorings and surface drifters gives climatologists an early warning of 3 to 12 months of an impending El Niño. Daily observations of changes in sea surface temperature (SST), surface wind, upper ocean thermal structure, and ocean currents enable researchers to develop models that can be tested by experimental forecasts.

It seems to be very difficult, however, to design skilful models that extend the 12-month limit set by the observation of precursors. Zane and Zebiak of the Lamont-Doherty Earth Observatory made the first successful forecast of an El Niño in early 1986, one year ahead of the event, but their model did not predict the strong El Niño in 1997. At present, there exist no physical or statistical models that can skilfully predict ENSO events at lead times longer than 12 months **(Neelin et al., 1998)**.

According to Neelin and Latif **(1998)** weather noise and deterministic chaos, representing the internal variability of the climate system, set the fundamental limits to the lead time. This emphasis on the exclusively internal character of ENSO events is in accordance with the tenet of climatology that

ENSO phenomena are the most spectacular example of a free internal oscillation of the climate system not subjected to external forcing. If it could be shown that this tenet is not tenable because there is external forcing, this would have far reaching consequences for the global warming debate.

6. Eruptive phases in sunspot cycle linked to ENSO events

If there were external forcing, deterministic chaos would not prevent long-range forecasts. Lorenz has emphasized that sensitive dependence on initial conditions and ensuing limited predictability are only valid for processes within the climate system. External periodic or quasi-periodic energy flow can force its rhythm on atmosphere and oceans. Long-term climate effects due to varying solar irradiance, if strong enough, would be a case in point. Investigations into connections between irradiance variations in the course of the 11-year sunspot cycle and changing climate are usually focused on maxima and minima in sunspot activity. It is easy to see that these extrema fail to show a direct relationship with ENSO events.

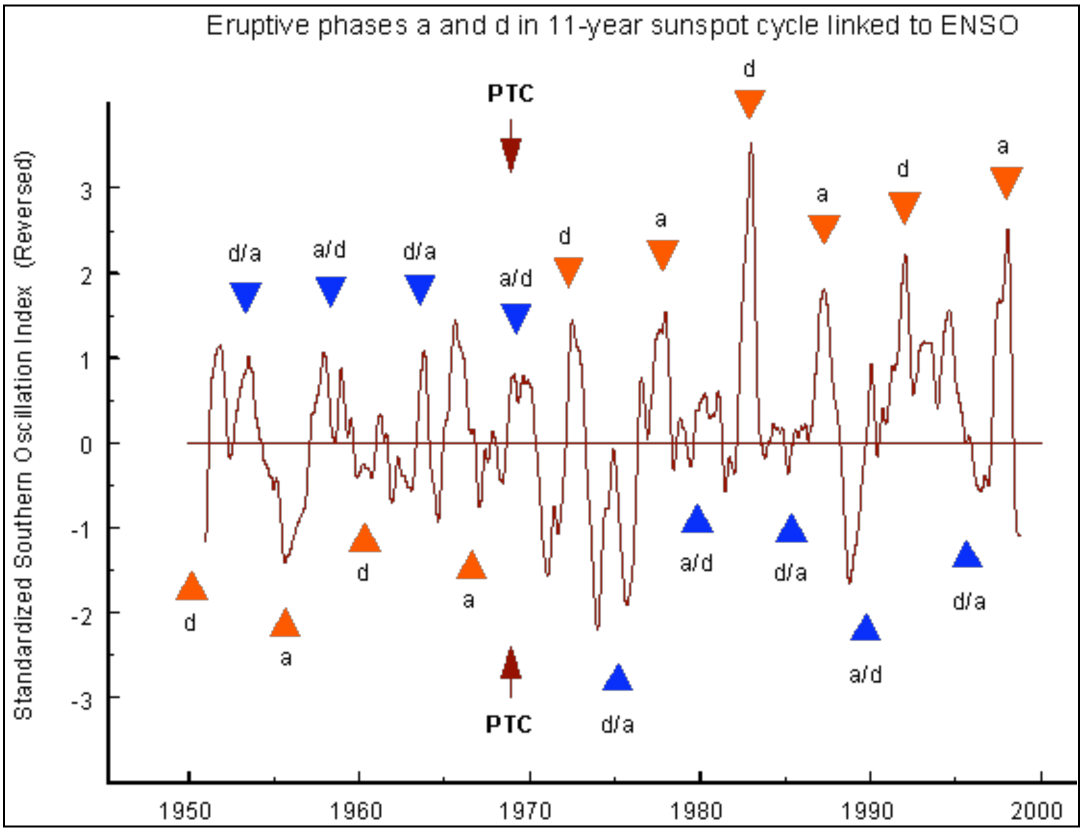

Figure 3

Fig. 3 demonstrates, however, that a close correlation emerges when other phases of the sunspot cycle are examined. The curve shows slightly smoothed standardized monthly data of the SOI, the Southern Oscillation Index, published by the Climate Prediction Center **(1998)**. It measures the pressure gradient across the tropical Pacific which, in turn, is an indicator of equatorial wind variations. Low negative SOI values, indicating El Niños, go along with weaker than normal trade winds over the central Pacific, warmer than normal sea surface temperatures (SST) over the eastern equatorial Pacific, and a reduced westward pressure gradient with changing wind stress values. High positive SOI values indicate La Niña conditions, just the opposite of the El Niño scenario. In Fig. 3 the data are reversed so that strong positive peaks point to El Niños and negative deviations to La Niñas.

After 1970, on the right of the two arrows marked by PTC, red triangles coincide with El Niños and blue triangles with negative deviations. All triangles mark special phases in the 11-year sunspot cycle. This cycle is not symmetric, but skewed to the right. Reliable observations available since 1750 show that the mean rise to the sunspot maximum (4.3 years) is considerably steeper than the decline to the sunspot minimum (6.7 years). The mean ratio of the rising part to the whole 11-year cycle is 0.39.

Nature often repeats proven patterns on different scales. A whole session of the Fall Meeting 2001 of the American Geophysical Union was dedicated to the task to find out how such fractal patterns can be used to make better forecasts. The phases indicated by triangles represent such fractals. The red triangles mark points **a** and **d** which divide the ascending and the descending part of the sunspot cycle such that the ratio 0.39, found in the whole cycle, is again established in the respective parts.

Around phases **a** and **d** we find new maxima, but this time accumulations of solar eruptions, not sunspots. A maximum entropy frequency analysis of monthly SOI data shows that the ratio 0.39 within the investigated parts of the sunspot cycle stands out in the frequency pattern with a significance beyond the 1%-level.

Midpoints between phases **a** and **d** (**a/d** and **d/a**), marked by blue triangles, are farthest away from points **a** and **d**. So it is consistent that they indicate the opposite effect, La Niña instead of El Niño in the range after 1970. Before 1970 everything is reversed. Blue triangles, indicating **a/d** and **d/a**, consistently point to El Niños, and red triangles, marking **a** and **d,** to La Niñas. Such phase reversals can be explained by predictable perturbations in the Sun's dynamics, the same dynamics the sunspot cycle is based on. I have presented many examples of such phase reversals in time series of diverse climate phenomena **(Landscheidt, 1983-2001)**. In an Open Review discussion of the results on this web site, lasting nearly 4 months, I have shown that the connection between phases **a** and **d** and ENSO events goes back to 1868, as far as reliable data are available, and that the phase reversals emerging in this interval are consistently linked to computed perturbations in the Sun's dynamics.

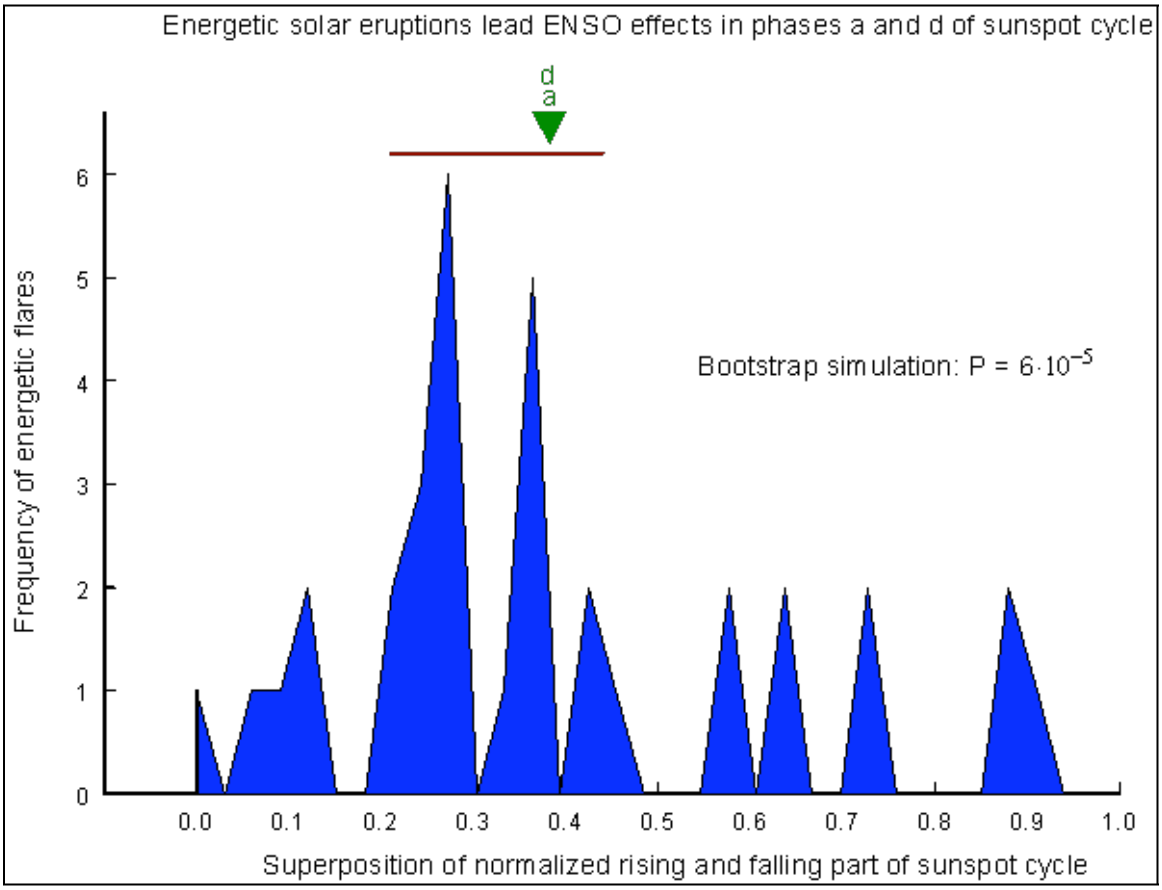

Figure 4

Fig. 4 provides evidence that phases **a** and **d** are actually linked to concentrations of energetic solar eruptions that could explain the climatic effects. It shows the distribution of highly energetic X-ray flares within the respective ascending and descending part of the sunspot cycle. The sample covers all flares X => 6 observed by satellites between 1970 and 1998. These data are available at the National Geophysical Data Center, Boulder. The rising and falling parts of different length were normalized to have equal length 1. Then they were superimposed to make it easy to recognize identical phases. Intense X-ray flares, nearly always accompanied by heavy coronal mass ejections, are geophysically more effective than flares categorized into classes of optical brightness. As many as 19 of the 34 investigated X-ray flares concentrate on the short interval of 0.23 on the unit scale, marked by a horizontal bar at the top left. Only 15 of the flares fall at the remaining large interval covering a range of 0.77 on the unit scale.

The normalized position of points **a** and **d** is marked by a green triangle. The climate effect, observed at **a** and **d** lags the solar eruptions, the conceivable cause. Statistically, the flare accumulation is highly significant. Even when compared with the distribution of mean counts of grouped optical flares, chi-square tests as well as bootstrap re-sampling and randomization tests show that the probability of a false rejection of the sceptic null hypothesis is smaller than P = 0.0001. Highly energetic cosmic ray flares observed between 1942 and 1970 corroborate this result. All events listed by Sakurai **(1974)** were included in the sample except the weakest events with a cosmic ray increase <= 2%. The distribution shows a strong accumulation in the same range. As to potential physical mechanisms that could explain how the Sun's eruptional activity releases El Niños I refer to special publications **(Landscheidt, 1999a, 2000a)**.

The eruptive phases **a** and **d** in the 11-year sunspot cycle are not only related to ENSO events. As I have shown in my paper "Solar Eruptions Linked to North Atlantic Oscillation", published on this web site, they are also linked to maxima and minima of the NAO index. In discussions with Italian hydrologists evidence could be provided that extreme River Po discharges show such a strong connection with phases **a** and **d** that long range forecasts can be based on it.

7. History and evaluation of ENSO forecast

My original ENSO forecast on 11 January 1999, based on the Sun's eruptional activity, was quite simple:

**"The next negative extremum in the SOI, going along with an El Niño,
should occur around 2002.9 (± 0.6 months)
... La Niña conditions should prevail till 2000.1
(decimal notation equivalent to 6 February 2000) and beyond."**

As to La Niña, this forecast with a lead time of at least 13 months turned out correct. La Niña lasted longer than institutes specialized on ENSO predictions had expected though they made use of daily precursor observations and frequently changed their forecasts.

In the Open Review discussion a critic objected that my forecast was not precise enough, did not define El Niños and La Niñas, and did not cover the interval between 2000 and 2002. Though I thought that the scientific community had already presented sufficiently precise definitions of ENSO events, I included such a definition in an even more precise forecast published on 29 March 1999. I also closed the gap between 2000 and 2002 though none of the specialized public institutes had ever made forecasts with such a long lead time.

The extended formulation ran as follows:

"1999.25 - 2000.4: Prevailing La Niña interrupted by neutral conditions (85% probability). 2000.5 - 2002.3: Neutral conditions, no El Niño (85% probability). 2002.55 - 2003.25: Strong El Niño peaking within this period centered on 2002.9 (95% probability). The forecast is based on the Southern Oscillation Index (SOI) published by the Department of Natural Ressources (DNR), Queensland, Australia. It measures the differences in air pressure between Tahiti and Darwin and ranges from about +30 to -30. Conditions are considered neutral when the 90-day average of the SOI stays within the range ±5. A 90-day average beyond this range indicates La Niñas and El Niños."

This wording generally satisfied the critic. When he objected that regarding the interruption of La Niña by neutral conditions I should give a maximum amount of time spent in the neutral range, I answered publicly **"that the neutral range should not cover more than 4 months."** La Niña actually prevailed till end of June 2000, as predicted. There were interruptions by neutral conditions, but they lasted exactly 4 months, as specified in the forecast. The prediction that La Niña would fade away in July 2001 and neutral conditions should develop instead, proved exactly correct though the lead time was as long as 15 months.

From 2000.5 till 2002.3 neutral conditions were expected. They developed from July to mid-October 2000. However, from then on till spring 2001 the neutral phase was interrupted by moderate cool conditions that lasted till mid-March 2001. During a period of 5 months the 90-day average of the SOI was below -5. Some scientists consider this isolated deviation from the already established neutral trend not a real La Niña. As the usual cold tongue along the equator did not form, they attributed the cool period to the Pacific Decadal Oscillation (PDO). I will not jump on this bandwagon, as I have defined neutral phases and ENSO events such that it is clear that there was a deviation from the expected neutral trend. I consider my results as working hypotheses that must be checked by objectively evaluated forecast experiments, the most effective test of the dependability of new results.

This does not mean, however, that this part of my forecast failed. I had omitted the interval between 2000 and 2002 in my forecast of 11 January 1999 because the investigation did not point as reliably to special trends as in other periods. So I gave my extended forecast of La Niña and the ensuing neutral phases, published on 29 March 1999, only a probability of 85%, which means that I expected that 85% of it would turn out right and 15% wrong. Institutes like the Space Environment Center, Boulder, do the same to be able to evaluate their skill at forecasting events in a flexible way. So the length of the forecast periods given a probability of 85% that turned out correct and those that proved wrong should be compared. It is certain that the 90-day average of the SOI will still be in the neutral range in March 2002. Since March 1999 a period of 5 months out of 36 months did not agree with the forecast. The corresponding ratio of 14% is below the expected failure rate of 15%.

8. Outlook

The El Niño forecast has been given the small failure rate of 5%. It remains to be seen whether this forecast with a lead time of nearly 4 years will turn out to be on the point. The auspices are favorable. In January 2002 NOAA's Climate Prediction Center officially announced that warming was being observed over the tropical Pacific which could lead to an El Niño by early spring. The announcement was supported by cloudiness and precipitation over the equatorial central Pacific observed for the first time since the 1997-1998 El Niño episode. On 7 March 2002 there followed an NOAA press release which stated that the evolution towards a warm episode continued during February 2002. Ocean surface temperatures warmed by 2°C in the eastern equatorial Pacific near the South American coast. The rainfall increased in that region. Cold-water anchovies have been replaced by tropical species. NOAA considers it likely that the subsurface and surface warming of the water will continue until early 2003.

The Climate Prediction Center cautioned that the SOI and other atmospheric indices did not yet agree with the warming trend indicated by the reported observations. Meanwhile, this has changed. On 12 March 2002, out of a sudden, the SOI plunged to values below -30. Models based on precursor data did not coherently foresee this development. NOAA's Climate Prediction Center stated in its El Niño/Southern Oscillation (ENSO) Diagnostic Discussion issued on 7 March 2002: "The latest statistical and coupled model predictions show a spread from slightly cooler-than-normal conditions to moderate warm -episode conditions during the remainder of 2002 ... Other techniques indicate that conditions will remain near normal or even return to slightly colder than normal for the remainder of 2002." The Climate Prediction Center's comment on these perplexing discrepancies "All such models have relatively low skill during the transition phases of ENSO" shows clearly that physical models, even if coupling atmosphere and oceans, are not yet able to make dependable long-range forecasts of ENSO events, though they are based on daily observations of precursors and continuously adapt their predictions to the most recent data.

If my El Niño forecast proved correct, this would be the third successful El Niño forecast in a row. The second one had a lead time of 2 years. There are other successful long-range climate forecasts exclusively based on solar activity: End of the Sahelian drought 3 years before the event; the last three extrema in global temperature anomalies; maximum in the Palmer Drought Index around 1999; extreme River Po discharges around 2001.1 etc. **(Landscheidt 1983-2001)**. This is irreconcilable with IPCC's allegation that it is unlikely that natural forcing can explain the warming in the latter half of the 20th century. In declarations for the public, IPCC representatives stress that taxpayer's money will be used to develop better forecasts of climate change. What about making use of those that already exist, even if this means to acknowledge that anthropogenic climate forcing is not as potent as alleged.

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End Note: As proprietor of this website, I can affirm that Dr Theodor Landscheidt's original paper in which he predicted the next El Niño to peak late this year, was indeed published back in January 1999 on this website exactly as he claims above, and has not been altered in any way since then.

Furthermore, participants listed in the Open Review which followed publication of his paper can also attest to the publication date of his original paper. The Open Review itself contains extensive discussion about the predicted dates for the next ENSO events.

Since the El Nino prediction was made over 3 years ahead of the event (the best achievable by models being less than 1 year), it remains only to observe the course of the El Niño that is now unfolding to see if it lives up to his prediction made over 3 years ago. Since Dr Landscheidt wrote the above, the plunge in the SOI toward El Niño has continued apace. Since it is now starting as expected, the probability of his prediction succeeding is now very high.

- John L. Daly 18th March 2002

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