Long-Range Forecast of U.S. Drought Based on Solar Activity

by **Dr Theodor Landscheidt**

Schroeter Institute for Research in Cycles of Solar Activity
Klammerfelsweg 5, 93449 Waldmuenchen, Germany

th.landscheidt@t-online.de

1. Introduction

Drought occurs if there is lack or insufficiency of rain for an extended period which causes a considerable hydrologic imbalance and, consequently, water shortages, crop damage, streamflow reduction, and depletion of groundwater and soil moisture. Drought is the most serious physical hazard to agriculture. In the U.S., the "dust bowl" droughts of the 1930s and 1950s are the most severe examples of the devastating effect of extended periods of dryness. In the 1930s, drought virtually covered the entire Plains for almost a decade. Many crops were damaged by deficient rainfall, high temperatures, high winds, insect infestations, and dust storms.

The resulting agricultural depression contributed to the Great Depression's bank closures, business losses, and increased unemployment. These hardships sent economic and social ripples throughout the country. Millions of people migrated from the drought areas in search of work, which resulted in conflicts between the newcomers and the longer-established residents and overburdened relief and health agencies.

Understandably, such conditions were a strong motive for monitoring, mitigating, and predicting drought. Diverse drought indices have been developed and the **National Drought Mitigation Center** (NDMC) offers advice in planning for drought. NOAA's **Climate Prediction Center** and the **U.S. Drought Monitor** as well as many other institutions publish assessments of the current conditions and seasonal outlooks.

The immediate cause of drought is the predominant sinking motion of air that results in compressional warming or high pressure, which inhibits cloud formation and results in less precipitation. Prolonged droughts occur when large-scale anomalies in atmospheric circulation patterns persist for months, seasons, or even longer. The extreme drought that affected the Unites States and Canada during 1988 was caused by the persistence of a large-scale circulation anomaly.

There are many variables that may cause such anomalies: air-sea interactions, soil moisture, land surface processes, topography, internal dynamics, and the accumulated influence of dynamically unstable synoptic weather systems at the global scale. According to the National Drought Mitigation Center **(2003)**, even scientists making use of General Circulation Models are no match for this complexity. They do not know how to predict drought a month or more in advance for most locations. Especially in the extra-tropical regions, current long-range forecasts are of very limited reliability. In the tropics, empirical relationships have been found between precipitation and ENSO events, but few such teleconnections have been confirmed above latitude 30° N.

2. Long solar motion cycle and U.S. drought

So it is a notable step forward that the sun's varying activity offers a means to predict U.S. drought many years before the respective event. I have shown that ENSO events, the North Atlantic

Oscillation (NAO), the Pacific Decadal Oscillation (PDO), extrema in global temperature anomalies, drought in Africa, and European floods are linked to cycles in the sun's orbital motion around the center of mass of the solar system **(Landscheidt, 1983-2003)**. Figure 1 demonstrates that such a relationship also exists between U.S. drought and solar cycles.

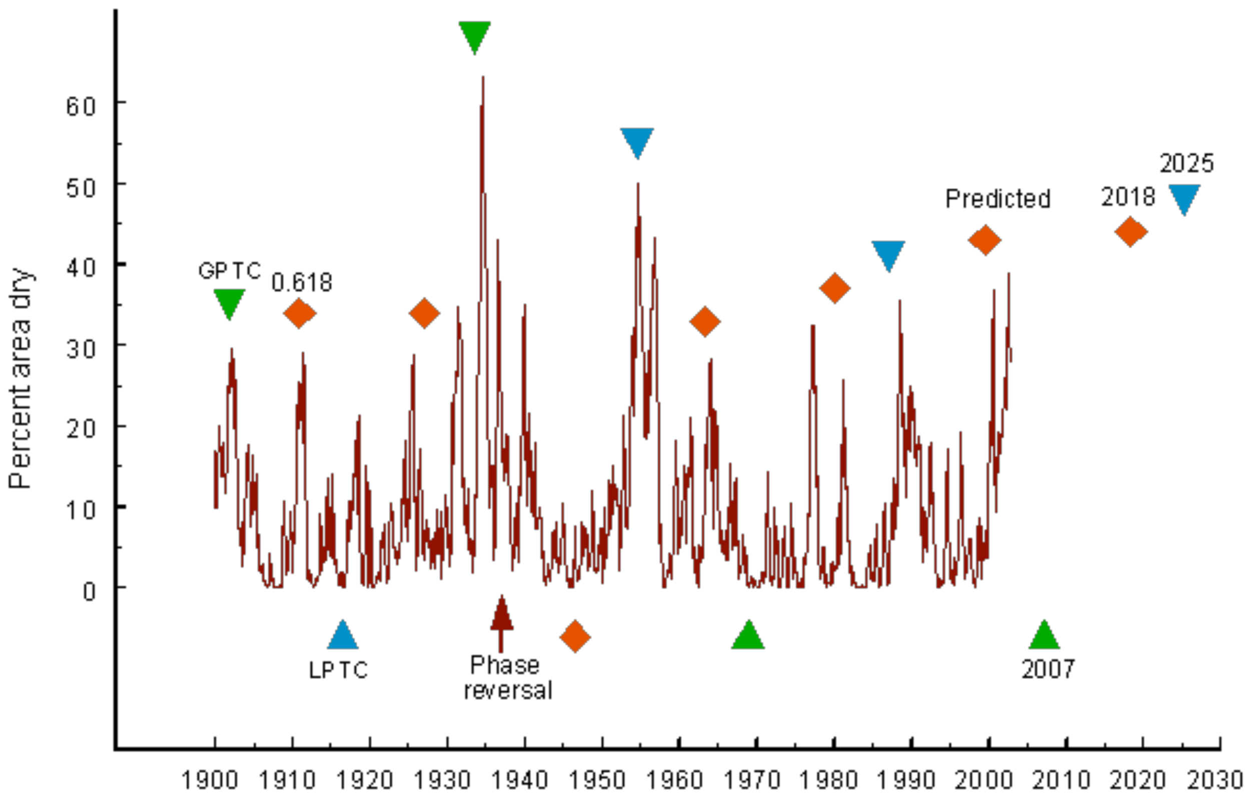

Figure 1

The brown curve represents the raw monthly values of the Palmer Drought Severity Index (PDSI) for 1900 to 2001 **(NCDC, 2003)**. This index was devised by Palmer **(1965)** to indicate the severity of dry and wet spells over the contiguous U.S. It uses monthly temperature and precipitation data and the Available Water Content (AWC) of the soil, also called soil-water holding capacity. It is based on the supply-and-demand concept of the water balance equation, taking into account more than just the precipitation deficit at specific locations. It is standardized to local climate, so that it can be applied to any part of the country to demonstrate relative drought and rainfall conditions. The U.S. Department of Agriculture uses it to determine when to grant emergency drought assistance. Palmer values lag emerging droughts by several months, but respond reliably to weather conditions that have been abnormally dry or wet. The vertical scale in Figure 1 indicates the percentage of the U.S area affected by moderate to extreme drought. In 1934 the PDSI reached a maximum value of 63 percent.

The green and blue triangles in Figure 1 mark special phases in solar motion cycles that can be computed. Such cycles have been used to forecast ENSO events, the North Atlantic Oscillation (NAO), the Pacific Decadal Oscillation (PDO), extrema in global temperature anomalies, African droughts, and European floods **(Landscheidt, 1983-2003)**. By now, these forecasts have turned out correct without exception. Strangely, this has not sent any ripples throughout official science though it is a proclaimed aim of scientific endeavour to make human life easier by dependable forecasts.

The rate of change of the sun's orbital angular momentum *L*, the rotary force d*L*/d*t* driving the sun's orbital motion (torque), forms a torque cycle with a mean length of 16 years **(Landscheidt, 2001 a,b)**. Perturbations in the sinusoidal course of this cycle recur at quasi-periodical intervals and mark zero phases of a perturbation cycle (PC) with a mean length of 35.8 years. As to details, I refer to Figure 2 in my on-line paper "Solar Eruptions Linked to North Atlantic Oscillation" **(Landscheidt, 2001 a)**. In Figure 1 presented here, zero phases of the PC are marked by green triangles and the label GPTC (Greatest perturbation in the torque cycle). Blue triangles labelled LPTC (Least perturbation in the torque cycle) mark phases of minimal perturbation.

I have shown that these phases indicate the peaks of warm PDO regimes and the coolest phases of cold PDO regimes **(Landscheidt, 2001 b)**. In Figure 1 they are closely linked to extended dry and wet spells. Obviously, there is a phase reversal in the connection just after the PDSI had reached an exceptionally high value of 63 percent in 1934. The instability inherent in these conditions seems to have contributed to the phase reversal, a phenomenon often observed in solar-terrestrial cycles. Before the phase reversal, GPTC (green triangle) coincided with drought conditions and LPTC (blue triangle) with wet conditions. In the latter case, this is easier to see in Figure 2 with data subjected to 4-year moving window Gaussian kernel smoothing **(Lorczak)**.

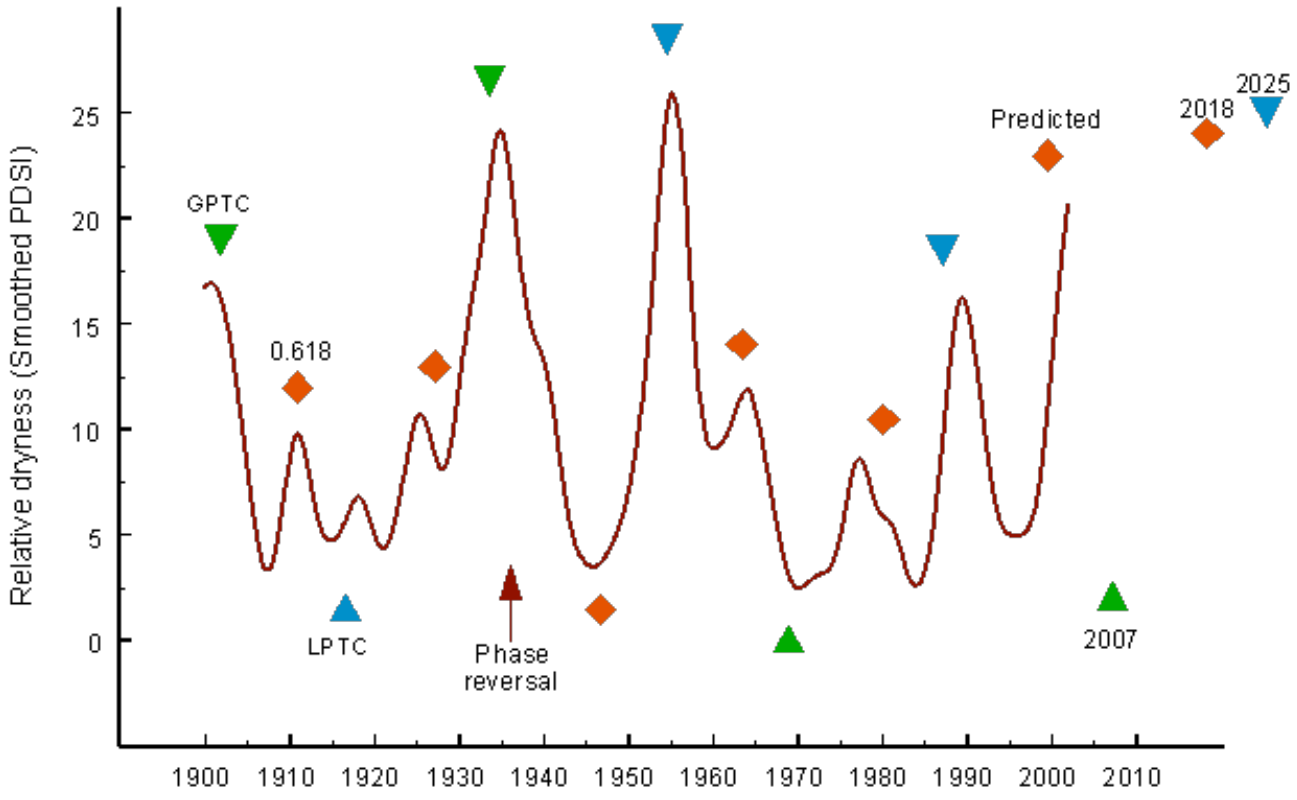

Figure 2

After the drought peak in 1934 the relationship is reversed. Now LPTCs (blue triangles) consistently go along with drought peaks and GPTCs (green triangles) with wet periods. This pattern has been stable since 1934 and should continue to be stable for many decades as it is modulated by a cycle of 179 years **(Landscheidt, 1998 b)**. So the next extended wet period should begin around 2007 and last about 7 to 8 years, as can be derived from Figure 1. A draught peak, indicated by LPTC (blue triangle) is to be expected from 2025 on and should last about five years.

3. Parameter *P* as predictor of Palmer-extrema

Additional indicators of periods of moderate or extreme dryness or wetness are special solar phases marked by red diamonds. Before 1934 they went along with drought periods. The first phase after 1934 showed the same reversal as the other indicators and marked a period of extended wetness. Afterwards, however, the phases indicated by red diamonds returned to the mode before 1934. After this stabilization I predicted in 1995, while wet conditions prevailed, that the next period of draught would begin in 1999 **(Landscheidt, 1995 b)**.

Just this happened, as can be seen from Figure 1. In spring 1998 the Palmer percentage was still at zero. Towards the end of 1999 it reached already 14 percent. In summer 2000 the high value of 36 percent was observed, and in 2002 nearly 39 percent of the area of the contiguous U.S. was affected by moderate to extreme drought.

When the consecutive intervals between GPTCs and LPTCs are normalized to 1, the phases in question (red diamonds) fall at 0.618 in between. The parameter 0.618 (*P*) is of fundamental importance as it is a regulator of stability in dynamical systems of all kinds from atoms and molecules to planetary systems **(Siegel, 1942; Arnol'd, 1963; Moser, 1973; Kolmogorov, 1979; MacKay, 1987; Child, 1993)**. *P* determines the ideal ratio of the length of the rising and the sinking branch of the 11-year sunspot cycle, but also of longer and shorter cycles of solar activity. Figure 3 presents an example, the function of *P* in the torque cycle, mentioned above, as an indicator of maxima in global temperature anomalies.

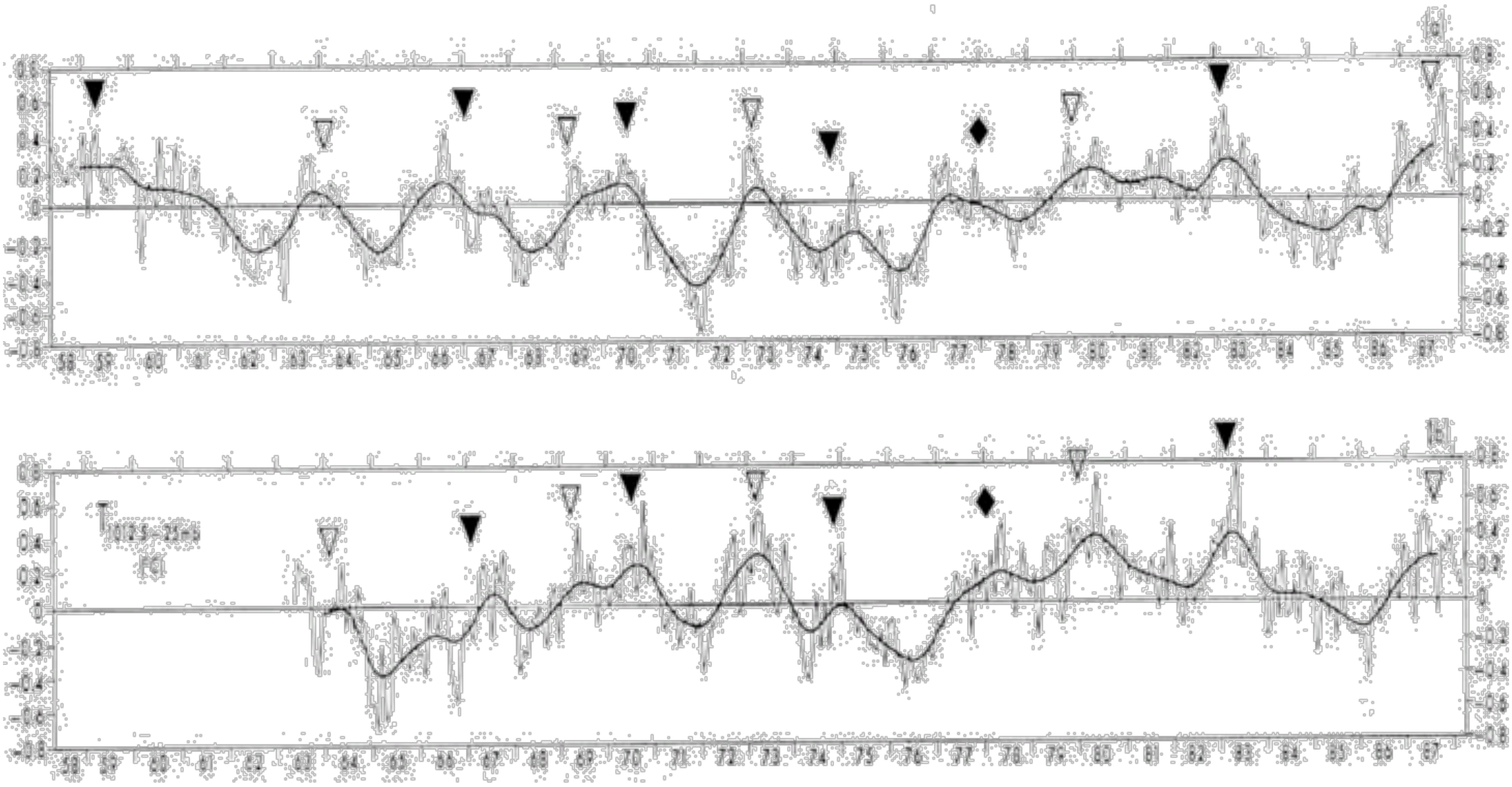

Figure 3

Figure 3 after Peixoto and Oort **(1992)** shows monthly atmospheric temperature anomalies (°C) averaged over the Northern (top) and Southern (bottom) hemispheric mass between the surface and 25-km height based on radiosonde measurements. The anomalies are taken with respect to the 1963 -1973 mean conditions. The smoothed curves are based on 15-month Gaussian type filtered values. The filled triangles mark zero phases in the torque cycle and the open triangles the parameter *P* between consecutive zero phases.

Obviously, the maxima of the anomalies are consistently coeval with the zero phases in the torque cycle and *P*. Though the intervals between the consecutive zero phases show large variations in length, the match is of satisfying precision. As far as there are deviations they merely amount to a few months. The last five extrema in the temperature anomalies were correctly forecast on this basis **(Landscheidt, 2000 a)**.

The epoch of the next *P*-phase between GPTC in 2007.2 and LPTC in 2025.4 is 2018.4. As indicated in Figure 1, another Palmer-maximum is to be expected around this date. As the relationship is based on astronomical data that can be computed, the forecast could be extended farther into the future, but who would check such predictions?

4. Background and outlook

The empirical relationship, presented here, would have a practical value even if there were no theoretical background. Many practices in meteorology are on this heuristic level. Yet there are hundreds of observations which show that within a few days after energetic solar eruptions (flares, coronal mass ejections, and eruptive prominences) there are diverse meteorological responses of considerable strength **(Balachandran et al., 1999; Bossolasco et al., 1973; Bucha, 1983; Cliver et al., 1998;**

Egorova et al., 2000; Haigh, 1996; Herman and Goldberg, 1978; Landscheidt, 1983-2003; Lockwood et al., 1999; Neubauer, 1983; Markson and Muir, 1980; Palle Bago and Butler, 2000; Prohaska and Willett, 1983; Reiter, 1983; Scherhag, 1952; Schuurmans, 1979; Shindell et al., 1999; Sykora et al., 2000; Yu, 2002).

Such eruptions accumulate around crucial phases of solar motion cycles so that they can be predicted. A long-range forecast experiment on this basis, covering six years, was checked by astronomers and the Space Environment Center, Boulder. It reached a hit rate of more than 90 percent though solar eruptions occur at quite irregular intervals **(Landscheidt, 2000 a)**.

Radiocarbon deviations derived from the analysis of dated tree rings serve as a proxy for the varying intensity of the sun's eruptional activity. Comparison with proxy data for climate show a close covariation for thousands of years **(Beer and Joos, 1994; Hodell et al., 2001; Neff et al., 2001; van Geel et al., 1999; Wigley, 1988)**.

Similar relationships were also established between the variable length of the 11-year sunspot cycle as a coarse proxy for the intensity and frequency of solar eruptions and temperature on earth **(Butler, 1996; Friis-Christensen and Lassen, 1991; Lassen and Friis-Christensen, 1995)**.

Contrary to the assertions of IPCC scientists, there are several physical models that could explain the effect of solar eruptions on climate **(Balachandran et al., 1999; Bucha, 1983; Herman and Goldberg, 1978; Hoyt and Schatten, 1997; Neubauer, 1983; Markson and Muir, 1980; Shindell et al., 1999; Tinsley, 2000; Tinsley and Yu, 2002)**. Some of them were published decades ago.

So, there is hope of a more detailed cause and effect explanation as soon as the still rudimentary theories of solar activity and climate change reach a more mature stage of development. Anyway, the correct forecast of the U.S. drought beginning in 1999 and a dozen of further successful climate forecasts, exclusively based on solar activity, show already now that the IPCC's claim that there has only been a negligible solar effect on climate change in recent decades is not tenable. Ironically, just drought, the greatest threat attributed to alleged man-made global warming, has turned out to be regulated by variations in the sun's eruptional activity.

Postscript by John L. Daly:

Dr Theodor Landscheidt claimed several times in the above paper that he had successfully predicted key climatic events (such as the current El Niño) years before the actual events, making reference to papers currently archived on this website and to other papers he has published elsewhere.

I can certify that the papers he refers to were indeed published on this site on the dates indicated and that his forward predictions made on this website to events that have now already happened were indeed made well ahead of their time, just as he says they were. In particular, he predicted the current El Niño 3½ years in advance, in a paper published on this website in January 1999. I can therefore fully confirm the authenticity of that prediction, as can the many expert reviewers who participated in the subsequent open review in 1999.

John L. Daly
proprietor of `Still Waiting for Greenhouse'

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