

Short Contribution

An Accidental Result: The Mean 1983 January 500 mb Height Field Significantly Different from its 1967-81 Predecessors

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Abstract:

By means of an objective, multivariate method it is shown that the mean 1983 January northern hemisphere 500 mb height field differs significantly from the series of mean January height fields 1967–81. The difference is likely, at least partly, related to the 1982/83 El Niño event.

Zusammenfassung: Ein unbeabsichtigtes Ergebnis: Das mittlere 500 mb Höhenfeld des Januar 1983 unterscheidet sich in signifikanter Weise von denen der Januare 1967/81

Mit Hilfe eines objektiven, multivariaten Verfahrens wird gezeigt, daß das mittlere 500 mb Höhenfeld des Januar 1983 sich in signifikanter Weise von denen der vorangegangenen Januare 1967/81 unterscheidet. Dieser Unterschied steht wahrscheinlich in Beziehung mit der starken ostpazifisch-äquatorialen Meeresoberflächentemperaturanomalie des Jahres 1982/83 („El Niño“).

Résumé: Le champ moyen d'altitude à 500 mbar en janvier 1983 diffère significativement de ceux de 1967–1981

A l'aide d'une méthode multivariée objective, on montre que le champ d' altitude à 500 mbar sur l' hémisphère nord, en moyenne pour janvier 1983, se distingue de la série de champs moyens de janvier en 1967–1981. Cette différence est probablement liée, du moins en partie, à l'anomalie El Niño de 1982–83.

1 Prologue

In the course of verifying climate simulations with a GCM, we developed as a first step an objective, multivariate strategy to decide whether a certain model-generated, say, monthly mean structure could also originate from a data set based on observations (STORCH and ROECKNER, 1983). Its main elements are a drastical reduction of degrees of freedom by means of an EOF-expansion, a classical χ^2 -test applied to vectors of a few EOF-coefficients and -in case of a significant result-a final univariate analysis to find those patterns which may have caused the rejection of the nullhypothesis “The GCM generated state is not distinguishable from observed ones”. The expectation vector and the covariance matrix used for the χ^2 -test are estimated from observational data. A risk of 5 % is used.

The EOFs are used in this study exclusively to reduce the dimension of the statistical problem. No physical meaning is attached to them. They are not to be identified with physical processes whatsoever. In order to see whether this approach grants a fair test (i.e. whether the probability for an error of the 1st kind is really 5 %), it was applied to some data which are known a-priori to fulfil the nullhypothesis, i.e. simply to some additional observational data. The estimation was done with the observations of the Januaries 1967–81. As additional data the January data of 1982 and 1983 were taken. This data set is clearly independent from the former data set.

The parameter studied are:

$$[\bar{\phi}], [\bar{\phi}^{*2}] \cos \varphi \text{ and } \{\bar{\phi}^*\}$$

where ϕ denotes the daily northern hemisphere 500 mb geopotential height, brackets a zonal mean, an overbar a monthly mean and a $\{\cdot\}$ a meridional 30–60 °N average. Thus, $[\bar{\phi}]$ is the zonal monthly mean, $[\bar{\phi}^{*2}] \cos \varphi$ and $\{\bar{\phi}^*\}$ the zonally averaged variance and the 30–60 °N mean of the stationary disturbances, respectively. The former two parameters are distributed meridionally, the latter is a function of longitude.

Since the nullhypothesis is true, one expects, on the average, a rate of about 5 % erroneous rejections. Because we perform only 6 tests (3 parameters and 2 samples; the parameters are not independent from each other), 0 or 1 rejections are anticipated.

2 The Unexpected Result

The result of this testing is given in the following table, where a star denotes a significant and a bar an insignificant result:

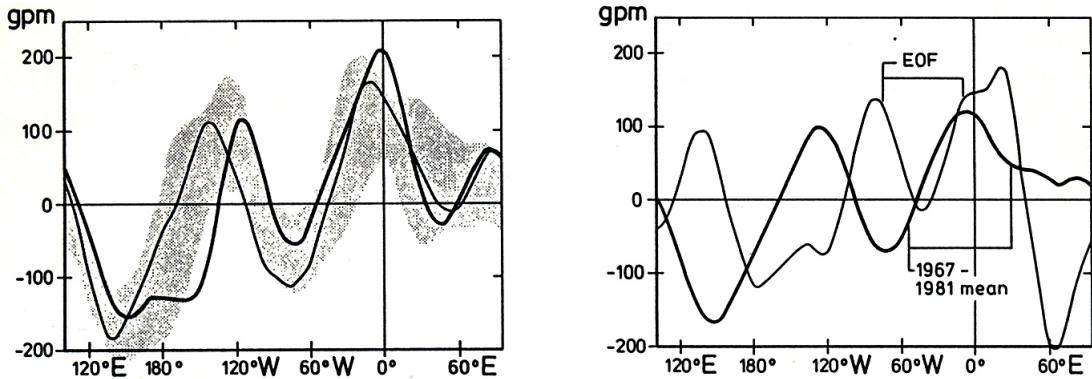
Januaries:	1982	1983
$[\bar{\phi}]$		*
$[\bar{\phi}^{*2}] \cos \varphi$		*
$\{\bar{\phi}^*\}$		*

Actually, the number of rejections is larger than 1, namely 2. The level of significance for the 1983 zonal monthly mean is about 98 %, while that of the zonally distributed quasistationary eddies, $\{\bar{\phi}^*\}$, is far beyond 99.9 %. This result can be interpreted in two ways: Either the test is radical (i.e. it rejects the nullhypothesis more often than 5 %) or the 1983 event is an extraordinary one in view of the sample on which the estimation of the parameters involved in the test procedure is based, i.e. in view of the quasistationary tropospheric circulation of the Januaries 1967–81.

Definitely, this question can be answered with a large sample set only, but one can attempt to analyse why the 1983 pattern is rejected. The univariate analysis yields for the zonal monthly mean $[\bar{\phi}]$ a remarkably large coefficient of EOF1, which describes essentially the north-south contrast. However, one of the Januaries 1967–81 has an even stronger north south contrast. Thus, it might be that this result is really by chance. A detail is an enhanced geostrophic zonal wind at about 20–30 °N.

In case of the 30–60 °N average $\{\bar{\phi}^*\}$ the high level of significance is caused by an extraordinary large coefficient of the EOF shown in Figure 1a. The pattern of this EOF is apparently of wave number 3-type.

In Figure 1b, the curves of $\{\bar{\phi}^*\}$ for 1982 and 1983 are plotted together with the “95 %-tube”. The latter is defined pointwise as that interval containing about 95 % of all states of the 1967–81 data, roughly speaking (see (STORCH and ROECKNER, 1983). As can be deduced from Figure 1b, the 1982



•**Figure 1** Zonally distributed 30-40 °N average of quasistationary 500mb disturbancees, $\{\bar{\phi}^*\}$

Right: EOF which coefficient is extraordinary large in January 1983 and the longyear mean state.
Left: "95 %-tube" (stippled, explanation see text) based on the Januaries 1967–81 and the states of January 1982 (thin line) and 1983 (thick line).

January does not leave the 95 %–tube. However, the 1983 January data does it over the eastern Pacific and at about Greenwich longitude. The comparison with the EOF shown in Figure 1a yields a good coincidence of the extrema of this EOF and the leaving of the tube.

Therefore, we may conclude that the 1983 January mean 500 mb height field is extraordinary with respect to

- 1) a broadening of the Pacific trough to the East for about 30–40° relative to the mean climatology,
- 2) a strong European ridge shifted for about 10° to the East and
- 3) an intense wavenumber 3-type pattern.

These three features can be recognized in Figure 2 showing the hemispheric map of the mean 500 mb height field of January 1983.

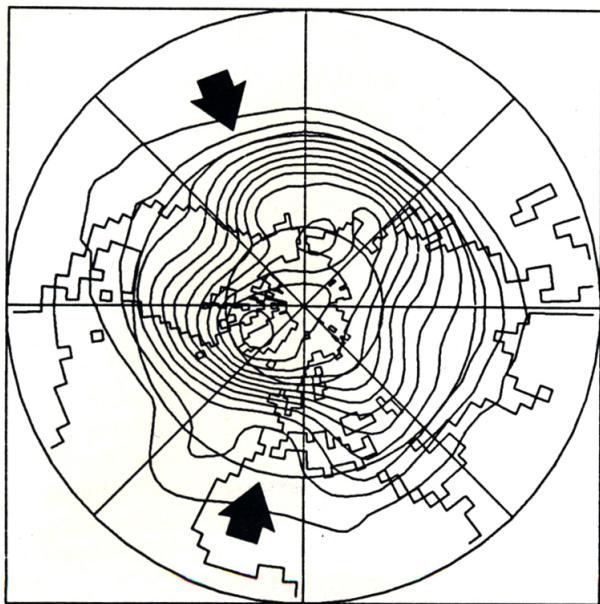
To summarize: The 1983 quasistationary 500mb $\{\bar{\phi}^*\}$ is unusual and the rejection of the null hypothesis does not contradict the test's fairness. On the other hand, the 1982 January was an ordinary one, at least in terms of the statistics used here.

3 Interpretation

The question arises whether the unusual January 1983 circulation is just by chance or if it is caused deterministically by some anomalous forcing.

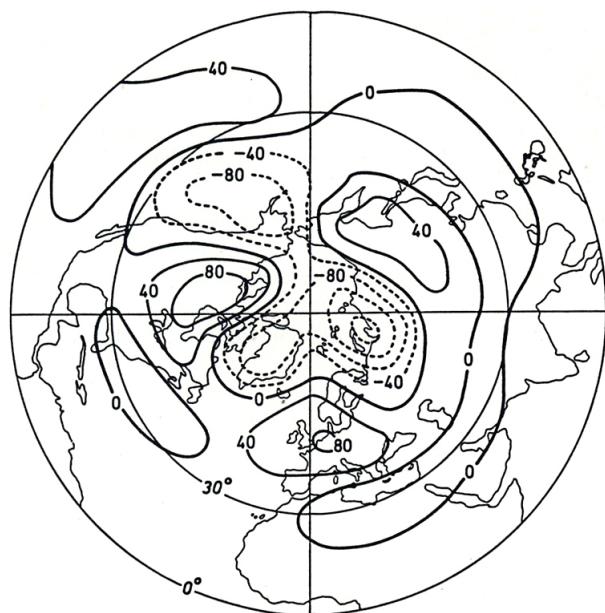
QUIROZ (1983) noted a series of peculiarities of the winter season 1982/83. The most prominent one is the sea surface temperature anomaly in the eastern equatorial Pacific, the "uncommonly strong" El Niño event with maximum anomalies up to 4 °K. Another one is the "record-breaking" strong upper troposphere westerly flow over the east Pacific at 30 °N. These intensified westerlies coincide just with the broadened Pacific trough shown in Figure 2. QUIROZ related this remarkable midlatitudinal circulation pattern to the El Niño SST anomaly.

Indeed, this has been proven with statistical confidence already earlier by CHIU et al. (1981) in an attempt to verify Bjerknes' hypotheses on the atmospheric response to an equatorial SST anomaly. Thus, the Pacific anomaly found by our test strategy is surely caused by the extraordinary equatorial SST distribution.



•Figure 2

Hemispheric map of January 1983 mean 500 mb geopotential hight. The significant patterns are marked by arrows.



•Figure 3

GLAS GCM's response to an El Nino type SST anomaly (300 mb difference control minus SST anomaly run; taken from SHUKLA and WALLACE, 1983).

Now, is the intensification and shifting of the European quasistationary ridge and the strong wave-number 3 structure related to the SST anomaly, too?

QUIROZ also described these two aspects, but he could not ensure that they are linked with the El Niño SST. There is some indication for such a correlation in the paper by SHUKLA and WALLACE (1983): They performed a series of GCM experiments with a normal SST distribution and with an superimposed anomaly similar to that of January 1983. Their 300 mb difference field, which is reprinted here as Figure 3, exhibits the three unusual patterns stated above (namely: broadened Pacific trough, intensified and shifted European ridge, strong wavenumber 3 structure). Preliminary investigations of similar runs integrated with the ECMWF T21 GCM (CUBASCH, 1983) resulted in essentially the same anomaly patterns. A respective paper is under preparation.

A closer look at the basic data set of this study (the DWD analyses of the 500 mb northern hemisphere height field of the Januaries 1967–83) amounts to a further indication of a causal relation between anomalous SST in the eastern equatorial Pacific and the atmospheric flow anomalies described above: An El Niño event was observed not only in 1983 but also in January 1973. The study of the respective statistical parameters gave as results: The EOF coefficient of $\langle \phi^* \rangle$ which was found to be extraordinary large in January 1983, was in January 1973 larger than in all other Januaries besides of 1983. Thus the enhanced wavenumber 3 structure is a common property of both El Niño Januaries. The surprising about January 1973 is that the European quasistationary ridge is well established in contrast to broadening of the Pacific trough. Another mutuality concerns $\langle \phi \rangle$: The coefficient of EOF 1, which was found to be the secondlargest in 1983, is thirdlargest in January 1973.

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