Stratospheric Temperature in the North Pole and Iberian Peninsula Rainfall in March

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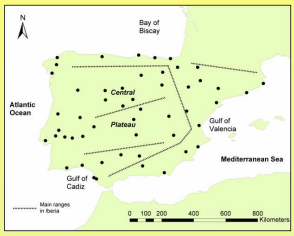
ABSTRACT: The recent negative significant trend of precipitation over most of the Iberian Peninsula is an obvious fact. This study seeks a possible cause of polar vortex behavior in late winter. A reduction of northern polar stratospheric temperatures in March since the end of the seventies might lead to a strengthening of the west winds at high levels (northern annular mode –NAM– high index), and consequently at surface level (Arctic Oscillation index –AOI– increase), by means of a stratosphere-troposphere coupling. During the last two decades, the number of March months with warm stratospheric anomalous temperatures has decreased, but those with a cold and undisturbed vortex have increased. In order to validate the hypothesis, a T-Mode Principal Components Analysis was applied to a daily data grid (NCEP/NCAR reanalysis) at sea level pressure (SLP) over Western Europe for those March months with a positive anomalous temperature in the North Pole (30h-Pa) and for those March months with a negative anomalous one. The circulation patterns obtained are compared with the rainfall anomalies over the Iberian Peninsula. The results validate the hypothesis, as they show that those March months with a very cold middle to low North Pole stratosphere have a strengthening of the westerlies in comparison with those with a warm one. It currently implies a more frequent anticyclone weather type in March over the Iberian Peninsula, which significantly reduces precipitation.

IBERIAN PENINSULA RAINFALL 1951-2000



Monthly trends of Iberian precipitation (standardized value/ decade)

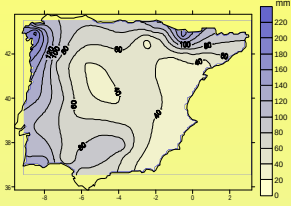
JANUARY	-0.03
FEBRUARY	-0.11
MARCH	-0.26
APRIL	0.04
MAY	0.08
JUNE	-0.09
JULY	0.04
AUGUST	-0.03
SEPTEMBER	-0.02
NOVEMBER	0.01
OCTOBER	0.01
DECEMBER	0.02

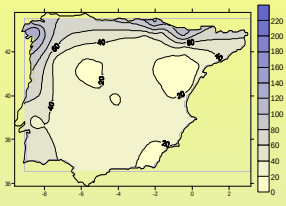
sig. increase
increase
no variation
decrease
sig. decrease

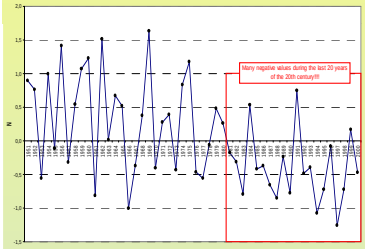
1951-1975

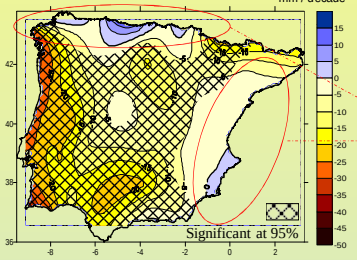
1976-2000

Rainfall mean







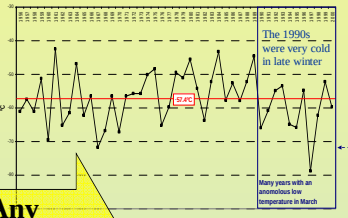


The northern fringe and Eastern Iberia present no significant changes

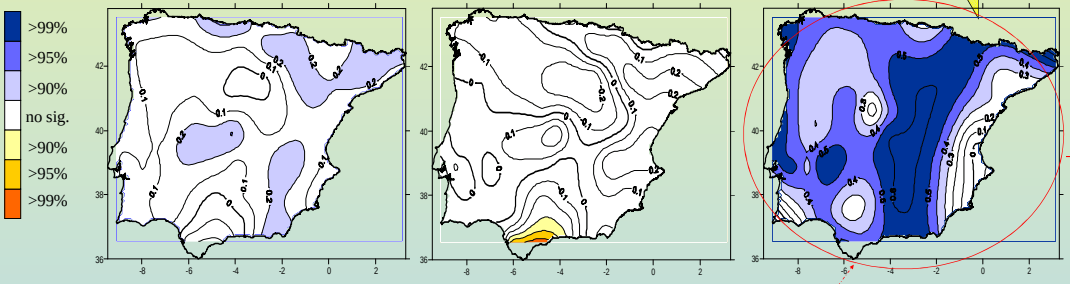
The most outstanding decreases are on the Central Plateau and on the west coast (Portugal and southwestern Galicia)

NORTH POLE TEMPERATURE 30-hPa 1956-2000 *(FU-Berlin)*

ºC / decade	1956-2000	1956-1978	1978-2000
JANUARY	-0.5	2.0	0.5
FEBRUARY	-1.0	-4.0	-3.5
MARCH	=	1.5	-6.0
APRIL	=	3.0	-1.0
MAY	-0.5	1.0	-1.0
JUNE	-0.5	0.5	-1.0
JULY	-0.5	-0.5	-1.5
AUGUST	-0.5	=	-1.5
SEPTEMBER	-0.5	-0.5	-1.5
OCTOBER	-0.5	-1.0	-1.0
NOVEMBER	-1.0	-1.5	=
DECEMBER	=	-1.5	2.0



Any connection?



Spatial distribution of Pearson's correlation coefficients between precipitation and temperature in the North Pole at 30-hPa

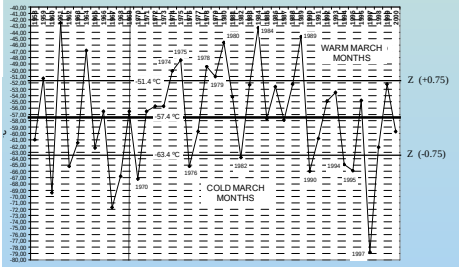
The signal appears as the polar vortex becomes colder and stronger

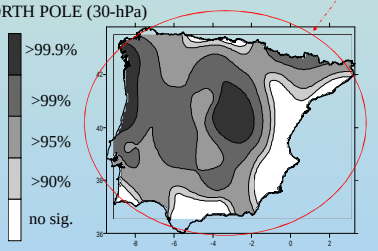
Those rainfall areas that are well correlated with temperature in the North Pole are the ones presenting a significant decrease in precipitation

The Mediterranean fringe shows no relationship with the stratospheric temperature

Both maps are somewhat similar (r = -0.33; >95%)

ANALYSING THE LAST 7 MARCH MONTHS OF THE 20th CENTURY WITH AN ANOMALOUS LOW TEMPERATURE AND THOSE WITH A HIGH ONE IN THE NORTH POLE (30-hPa)



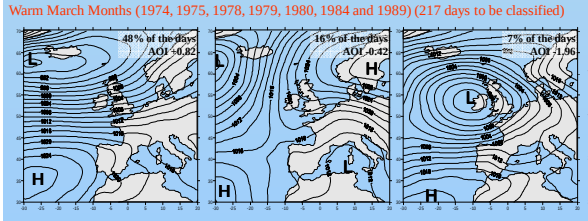


r = 0.60

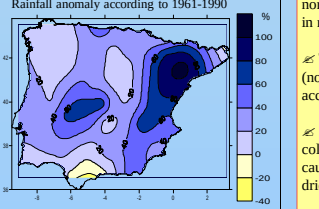
Detection of the areas with a significant mean variation in March rainfall between the years with an anomalous warm stratosphere in the North pole and those with an anomalous cold one

A daily objective synoptic classification was carried out with the use of a T-Mode Principal Components Analysis (PCA) (2.5º×2.5º SLP grid, NCEP/NCAR Reanalysis, Kalnay *et al*., 1996) (Correlation matrix; Rotated –Varimax criterion–)

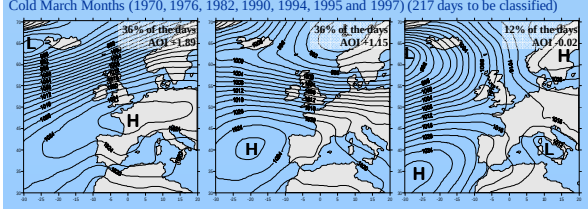
Warm March Months (1974, 1975, 1978, 1979, 1980, 1984 and 1989) (217 days to be classified)



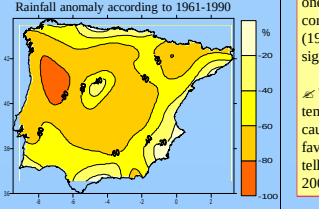
Rainfall anomaly according to 1961-1990



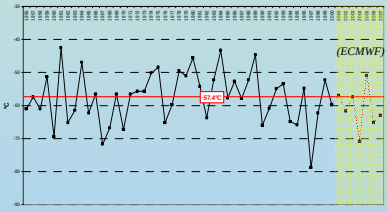
Cold March Months (1970, 1976, 1982, 1990, 1994, 1995 and 1997) (217 days to be classified)



Rainfall anomaly according to 1961-1990



UPDATING THE DATA



Only in 2005 the stratospheric temperature in North Pole was anomalously positive. In 2002 and 2007 it was low, and in 2004 and 2006 extremely low.

MAIN RESULTS TO CONCLUDE

✍ In the years under a **WARM** stratosphere the lows tend to travel on a more southerly track (negative AO phase).

✍ In the years under a **COLD** stratosphere the westerlies are stronger and an anticyclone weather type is established over the Iberian Peninsula. Nevertheless, some north-easterly humid flows are favoured over the eastern fringe, thus avoiding decrease in rainfall over this area.

✍ The AOI and NAOI show a steady increase in late winter (February and March) (not shown). Therefore, for further analyses February should also be taken into account.

✍ No warm March months were detected throughout the 1990s, whereas 4 extreme cold March months took place. The year 1997 was the coldest one ever recorded and caused more than the 80% of the meteorological series to be below 5 mm, and had driest March month of the 2nd half of the 20th century in Iberia.

✍ The map of those areas with a significant mean variation is well correlated with that one presenting Iberian rainfall trends (r = -0.45; >99%). Moreover, it is also well correlated with the one presenting precipitation/ stratospheric temperature 30-hPa (1978-2000) (r = +0.60; >99%). We conclude that it enhances the polar temperature signal in Iberian rainfall.

✍ The rainfall decrease in March over the Iberian Peninsula can be related to the temperature decrease in 30-hPa North Pole. This temperature drop is thought to be caused by the long-lasting undisturbed cold polar vortex. This meteorological situation favours ozone depletion in late winter (Rex et al., 2004; Langematz, 2000). Tim will tell, however, whether it constitutes a real change in circulation (Labitzke and Kunze, 2005).

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