Causes of the billion-dollar drought in North America in 1999 - a verification study

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Introduction

In August and September, 1999 the Toronto Globe and Mail carried the following headlines: "U.S. drought could last into 2000," "Drought crop losses reach $800 million, and "More States may get drought aid." The dry spell that began in July 1998 became the worst drought in a generation to affect states from New England to Kentucky leaving some farmers with 100 per cent losses on crops such as corn, soybeans and hay. States affected in August were as follows: Pennsylvania, Maryland, New Jersey, West Virginia, New York, Delaware and Kentucky. Farm disasters were declared in New York, New Jersey, Pennsylvania, Maryland, West Virginia, Connecticut, Ohio, New Mexico and Arizona.

Monitoring of sea surface temperature anomalies in the Niño-3 region of the east equatorial Pacific for the period September-July 1998/99 revealed weak to moderate La Niña conditions.

In 1969 Bjerknes suggested that regular monitoring of the sea surface temperatures in the tropical east Pacific was indispensable for long-range forecasting in North and South America. Since then hundreds of studies have confirmed his hypotheses. Garnett and Khandekar in 1992 found that El Niño (La Niña) conditions during the summer months tended to favor the spring wheat crop. In 1997 Garnett, Babb and Khandekar substantiated this when they found correlations of +. 59 and +. 56 between Nino-3 SST anomalies in April and May and July rainfall over the Canadian prairies. Hsieh, Benyang and Garnett found a correlation of +. 63 between June and July precipitation and spring wheat yield. A similar El Niño/

La Niña impact is expected south of the Canada/U.S.A. border during the summer months.

U.S.A. Drought in Some Respects Forecast a Year in Advance

Based on La Niña conditions during the fall of 1998 Professor James E. Newman an Emeritius Professor of Purdue University speculated that dry out in 1999 could occur all the way from Texas into Alberta.

According to the U.S. Drought monitor as of September 1999 moderate to extreme drought prevailed from Texas up into the northeast of United States along the Appalachian Mountains. Minor drought was also evident in the northwestern U.S.A.

Drought Its Causes and Effects

In the book Drought Its Causes and Effects by Ivan Ray Tannehill in 1947 (written ten years before the noteworthy 1957/58 El Niño/Southern Oscillation event) Tannehill makes a number of what now seem to be timeless suggestions:

1)"In almost every national (U.S.A.) dry year the Pacific High Pressure is expanded. High Pressure goes with low temperatures, and there is now a suspicion that a relatively cold Pacific causes our desert areas to expand and tends to reduce the rainfall over the nation as a whole."
2)"Thus while we see that the Pacific largely controls the amount of rain which is precipitated over the United States, the Atlantic High controls to some degree the distribution of the rainfall. At times there is a westward extension of this high in the neighborhood of Bermuda. This extension is known as the Bermuda High."
3)"We strongly suspect that the Pacific Ocean is the monster in the back yard which seems to control our national rainfall, exerting a power that is second only to the sun itself."

Along similar lines Jerome Namais (1980) proposed what Daniel Cayan of Scripps Institute of Oceanography has coined the

"Namais Triad" whereby three anticyclones develop one over the Pacific Ocean, one over the Atlantic Ocean and one over continental U.S.A. In 1980 in the Journal of Interdisciplinary History he wrote, "Whatever the mechanism involved, there is some statistical evidence suggesting that dry, warm springs over the plains of the United States tend to be followed by hot, dry summers. Further, hot, dry summers in the plains have a tendency to persist from one year to the next."

As research analyst in the Weather and Crop Surveillance Department of the Canadian Wheat Board the writer observed the "Namais Triad" like patterns in 1980, 1983 and 1988 years of serious drought in North America.

How Did These Three High Pressures Behave in 1999?

In March the Pacific High was pronounced while the Atlantic was non-existent. There was a slight high pressure anomaly south of Hudson Bay.

During April all three high pressures intensified with the Pacific High beginning to encroach over western North America.

During May the Pacific High retreated and weakened while the Atlantic High or its extension the Bermuda High migrated over the Maritimes of Canada.

In June the Pacific High Pressure anomaly vanished while the Atlantic High and its counterpart the Bermuda High intensified over eastern North America. **It appeared that the Bermuda High moved north from its normal position causing the extreme drought in the eastern U.S.A.**

During July the Pacific High Pressure gained some strength while Atlantic and Bermuda High disappeared.

Based on sea surface temperature anomalies at the Niño-3 region during this period La Niña appeared to weaken, strengthen, weaken, strenghten and then weaken in July with the Climate Prediction Center in Washington D.C. rating the event during this period as weak to moderate La Niña event.

Predictions and Verification over the Canadian Prairies

Based on composite analysis published by Garnett et al in 1998, E.R. Garnett speculated in March 1999 at the Canadian Association of Geographers meeting in Lethbridge that dryness problems would occur along the Alberta-Saskatchewan border and Peace River district much like they did in 1998. The techniques presented were suggesting a very cool but dry June and July over the Canadian Prairies.

Similarly the Canadian Institute for Climate Studies in Victoria was suggesting dry conditions in that region of the Canadian Prairies.

By early August it was evident that the Canadian Prairies had experienced a cool and wet June and July with the Canadian spring wheat crop being about two-four weeks late in development. July was about 2°C. cooler than normal over most of the Canadian Prairies. The dryness problems of 1998 persisted in the Peace River District. The region considered to be drought prone (Saskatchewan-Alberta border) experienced 125-200% of normal rainfall during June. The flow over the Pacific North American teleconnection region had been strongly zonal each month since September of 1998.

Forecast for the Winter of 1999/2000

In September during the Prairie Division of the Canadian Association of Geographers Meeting in Winnipeg, La Niña was re establishing itself suggesting that the winter would be cooler than normal with higher than normal precipitation over the Canadian Prairies. It was also suggestive of continuing multiseason multiyear dryness problems in North America.

It was also stated that if this forecast was correct it would have marked the fourth out of five winters that Garnett and Khandekar had forecast over the Canadian Prairies. This forecast was based on the work of Halpert and Ropelewski, 1992. Shabbar and Khandekar, 1996 and the writers experience. The winter of 1998/99 was milder than Garnett had anticipated because of factors related to the Aleutian Low.

Conclusions

1. The drought that affected North America in 1999 was probably the most severe since the 1988 drought.
2. The main causes were La Niña, the North Atlantic Oscillation and its extension the Bermuda High.
3. The Pacific High though dominant in the spring months appeared not to play a major role in the drought as both it and La Niña weakened between spring and summer.
4. The strongest zonal flow in decades over the Pacific North American (PNA) teleconnection index region brought cool, wet conditions to key spring wheat and U.S. corn growing regions of North America.
5. Temperature levels were correctly forecast over the Canadian prairies but June and July rainfall was much greater than anticipated in March.

References

BJERKNES, J., 1969 'Atmospheric teleconnections from the equatorial Pacific' *Mon. Weath. Rev.*, 97: 163-172

GARNETT, E.R. and KHANDEKAR, M.L. 1992 'The impact of large-scale atmospheric circulations and anomalies on Indian monsoon droughts and floods and on world grain yields- a statistical analysis' *Agricultural and Forest Meteorology*, 61: 113-128

GARNETT, E.R., KHANDEKAR, M.L. and BABB, J.C. 1998 'On the utility of ENSO and PNA indices for long-lead forecasting of summer weather over the crop-growing region of the Canadian Prairies' *Theor. Appl. Climatol.* 60: 37-45

HALPERT, M.S. and ROPELEWSKI, C. 1992 'Surface temperature patterns associated with the Southern Oscillation' *Journal of Climate*, 577-593

HSIEH, W. H., BENYANG, T. and GARNETT, E.R., 1999 'Teleconnections between Pacific sea surface temperatures and Canadian prairie wheat yield' *Agricultural and Forest Meteorology*, 209-217

LEFAIVRE, L., KHANDEKAR, M.L. and GARNETT, E.R., 1997 *Proceedings of the Long-range Weather and Crop Forecasting Working Group*, Dorval, Quebec, Canada.

NAMAIS, J. 1980 'Severe drought and recent history' J*ournal of Interdiscilinary History*, X:4 697-712

SHABBAR, A. and KHANDEKAR, M.L. 1996 'The impact of El Niño-Southern Oscillation on the temperature field over Canada' *Atmosphere-Ocean,* Vol.34 No.2

TANNEHILL, I.R. 1947 *Drought, its Causes and Effects,* Princeton, N.J. University Press