THE SYNERGY OF HISTORY AND EL NIÑO SOUTHERN OSCILLATION FOR ENHANCED DROUGHT AND FLOOD MANAGEMENT

LA SYNERGIE DE L'HISTOIRE ET L'OSCILLATION AUSTRALE EL NIÑO POUR AMÉLIORER LA GESTION DES SÉCHERESSES ET DES INONDATIONS

K. Emami [1]

ABSTRACT

For the first time in human history, the American scientists forecasted extreme floods in California and Florida six months in advance in the summer 1997 by using the teleconnection with El Niño Southern Oscillation (ENSO). In fact, the maximum annual precipitations in a period of 120 years were recorded in 1998. The key ENSO indices have been recorded for periods of more than 100 years and consequently by studying the historical documents for identification and classification of large observed droughts and floods, more extreme events can be used in the models to enhance the forecasting skills. Utilizing the historical documents, large extreme events of Iran in the past 200 years were identified and correlations with ENSO indices were studied. Another study undertaken for six selected basin in Iran, indicated a good teleconnection of strong ENSO events with precipitations in autumn. The historical study supported the teleconnection observed. Currently Iranian authorities are using the ENSO based forecasts and historical correlations for enhanced adaptation to the events associated with very strong El Niño forecasted for fall and winter of 2015.

RÉSUMÉ

Pour la première fois dans l'histoire humaine, les scientifiques américains ont prédis des inondations extrêmes pour l'été 1997 en Californie et en Floride six mois à l'avance, en utilisant la téléconnexion avec El Niño Southern Oscillation (ENSO). De fait, les précipitations annuelles maximales depuis plus 120 ans ont été enregistrées en 1998. Les indices clés d'un phénomène ENSO ont été enregistrés pour une période de plus de 100 ans et par conséquent, en étudiant des documents historiques pour l'identification et la classification des grandes sécheresses et les inondations observées, plus d'événements extrêmes peuvent être utilisés dans les modèles pour améliorer les compétences de prévisions climatiques. Utilisant les documents historiques, de grands événements extrêmes survenus en Iran depuis les 200 dernières années ont été identifiés et des corrélations avec les indices ENSO ont été étudiés. Une autre étude menée sur six bassins sélectionnés en Iran, a indiqué une bonne téléconnexion des forts phénomènes ENSO avec des précipitations en automne. L'étude historique a soutenu la téléconnexion observée. Les autorités iraniennes actuelles sont en train d'utiliser des prévisions basées sur ENSO et des corrélations historiques pour mieux anticiper des événements en lien avec des forts phénomènes El Niño prévus pour l'automne et l'hiver de 2015.

Keywords: Historical droughts – Floods - Climate Forecasting- ENSO – Teleconnection – Iranian basins

[1][Managing Director, KuritKara Consulting Engineers, Tehran, Iran.

1. Introduction

In the long history of mankind, the 21st century would be very distinct from the other centuries and may be considered as the most challenging era for humanity. For the first time in human history, the 21st century is likely to see the end of world population growth. With the current trend of sophistication of technologies, it may be envisioned that by the end of the 21st century even the poorest human beings would enjoy the basic needs of life. Nonetheless reaching this status may involve unimaginable human suffering. Furthermore, according to climate scientists, more floods and droughts would be very likely in 21st century and the people living in poverty would be worst affected by the effects of climate change.

Many scientists and futurists believe that the 21st century is a MAKE or BREAK century. Late James Martin, the IT entrepreneur and founder of The James Martin 21st Century School in Oxford, is among them. He has written 106 books and his last book is "The meaning of the 21st century":

"We are at extraordinary crossroad of human history. Our action or failure to act during the next decades will determine the fate of the earth and the human civilization for centuries to come. This is a MAKE or BREAK century".

The great challenges of 21st century are shown in figure 1. As illustrated in the figure, Water Engineers are involved in more challenges than any other experts.

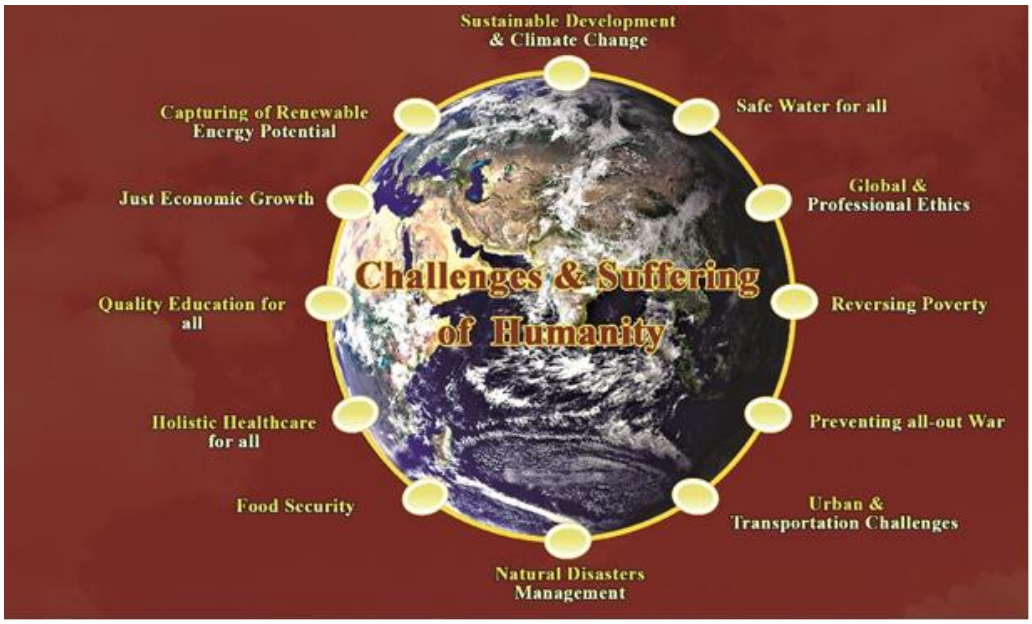

Figure 1: The great Challenges of the 21st century

2. ENSO based climate forecasting

In its simplest explanation, E`l Niño, which occurs every 2 to 7 years, is an abnormal warming of the eastern Pacific waters that interferes with the normal trade wind patterns. The ripple effect from El Niño has been held responsible for everything from droughts in Asia to floods in California. In 1982, scientists began to believe that the El Niño phenomenon and its atmospheric counterpart—this Southern Oscillation—was perhaps the most important mechanism affecting weather patterns on time scales of a season out to a few years. The El Niño Southern Oscillation, or ENSO, is a natural quasi-periodic redistribution of heat in the equatorial Pacific Ocean. In broad terms, ENSO can be characterized as exhibiting one of three phases: warm, cold, and neutral. These phases, in turn, can be characterized by the distribution of sea surface temperatures in the Pacific. During the warm phase, the eastern equatorial Pacific is anomalously warm. The occurrence of this phase is commonly referred to as an El Niño event. During the cold phase, the eastern equatorial Pacific is anomalously cool. Finally, ENSO can exhibit a neutral phase during which the eastern equatorial Pacific is neither anomalously warm nor anomalously cold. Through its effects on atmospheric circulation, ENSO has a significant effect on regional climate on both sides of the Pacific. In many parts of the world, ENSO is the largest source of climate variability on the time scale of 1 to 10 years. In the United States, the clearest ENSO signal occurs in the southeast, where El Niño events are associated with cool, wet winters and warm, dry summers. El Niño events are also associated with reduced tropical storm activity in the Atlantic basin. Precipitation over the western United States is also affected. Since 1877, there have been around 30 El Niño events and 22 cold events. Thus, on average, an El Niño event occurs every 4 years. While the frequency of events fluctuates around this average, there is no evidence of a systematic change in the frequency over the historical period. In 1982, scientists began to believe that the El Niño phenomenon and its atmospheric counterpart—this Southern Oscillation—was perhaps the most important mechanism affecting weather patterns on time scales of a season out to a few years.

When an El Niño develops and unfolds, it changes the prevailing wind patterns over most of the earth. But it changes them in fairly complex ways. The result is that there are certain regions of the world where the effects of El Niño are fairly robust—what we would call robust—that is, you can count on them. The southeast portion of South America will be wetter than usual, in some cases very problematically wetter than usual. The northeast region of South America along the Atlantic coast will suffer drought. It is a very consistent signal. The southeast of the United States is pretty well regularly affected by El Niño (National Climatic Data Center, 1998).

3. ENSO based climate forecasting

The net benefits of a strong El Niño in the U.S. are estimated to be about $15 Billion (Changnon, 1999) and obviously the Climate forecasts have great economical potentials in addition to enhanced water and power management. In the United States alone, the B/C for the forecasting capability proposed by NOAA is about 300 to 1. To quantify ENSO, numerous indices were defined (e.g. SOI, MEI, ONI …)(Glantz, et al., 1991). The records for many of these indices go back to 1800s. On the other hand, the hydrological data of many rivers is mainly recorded in the 20th century. In this context, a study of historical droughts and floods of the last 200 years in Iran was undertaken in 2009. The main objective was to enhance the accuracy of the ENSO based climate models. Numerous historical documents were utilized as shown in Figure 3 and numerous historical floods and droughts were identified and classified as shown in Figure 4 (KuritKara Engineers, 2010).

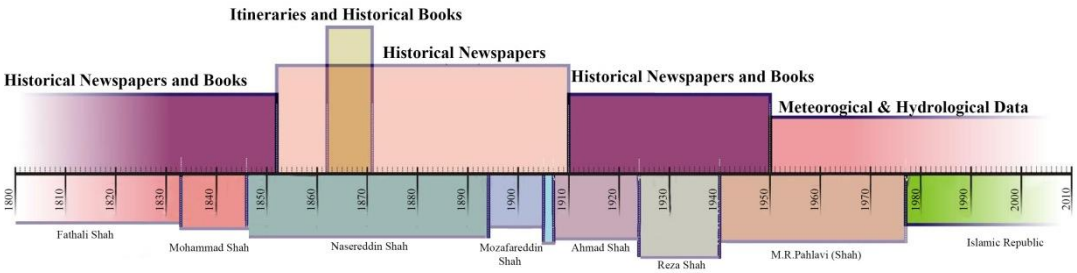

Figure 2: The Historical documents for identification of droughts and floods in Iran

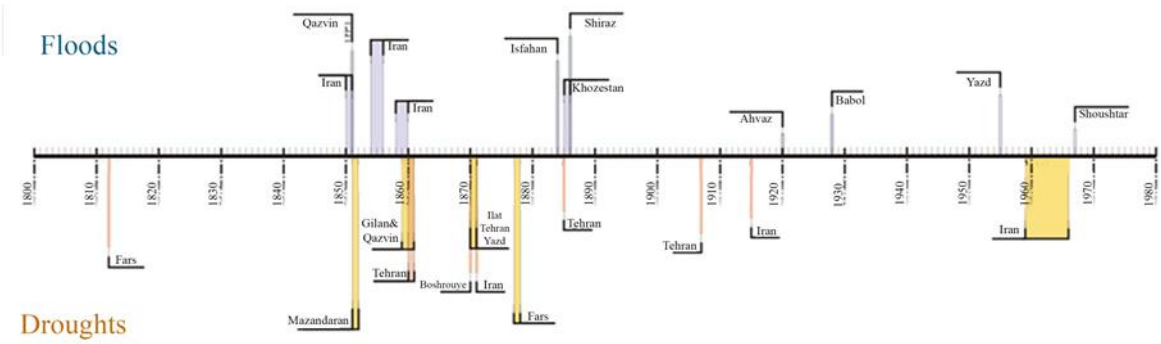

Figure 3: The classified historical droughts and floods of the last 200 years in Iran

3.1 Teleconnection of ENSO with Seasonal precipitation in large basin of Iran

Teleconnection in atmospheric science refers to climate anomalies being related to each other at large distances (typically thousands of kilometers). Most commonly applied to variability on monthly and longer timescales, the name refers to the fact that such correlations suggest that information is propagating between the distant points through the atmosphere. During the early impoundment of the largest dam in Iran (Karkeheh) in 1999, teleconnections between strong La Nina years and dry autumns and strong El Niño years with wet years were discovered by the author (KuritKara Engineers, 2010). In a recent study, the teleconnections of 6 large basins with ENSO were studied. The basins are located in different parts of the country (Figure 4) but a rather similar teleconnection was observed (Figure 5). During strong La Nina years, the selected basin experienced dry autumns. A survey of historical extremes and corresponding ENSO indices supported the teleconnection patterns observed. In this context and in view of very strong El Niño forecasted for the next months, more than long-term average precipitations are forecasted for this autumn in the selected basin which would be beneficial for the water resources of the country. On the other hand, these climate forecasts are being used to enhance vigilance and to reduce the probable casualties and damages in view of increased probability of floods.

Figure 4: The basins used for climate forecasting

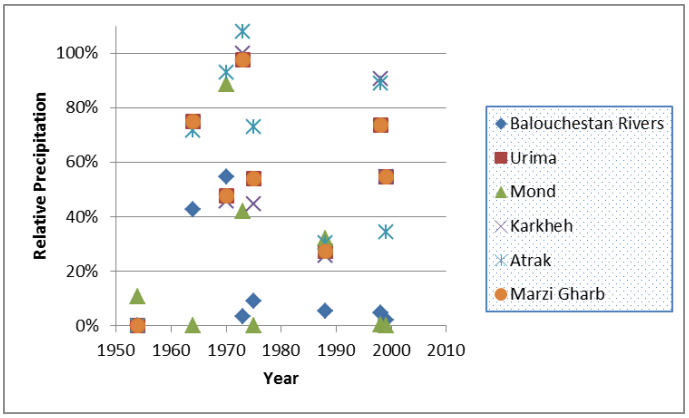

Figure 5: The relative precipitations observed in strong La Nina years compared to the long-term average (100%)

Conclusions

ENSO based climate forecasts can play a key role in efficient water resources management which is related to important challenges of the 21st century. The key ENSO indices have been recorded for periods of more than 100 years and consequently by studying the historical documents for identification and classification of large observed droughts and floods, more extreme events can be used in the models to enhance the forecasting skills. A study undertaken for six selected basin in Iran, indicated a good teleconnection of Strong ENSO events and precipitations in autumn. The historical finding supported the teleconnection observed. These forecasts are currently being used for enhanced adaptation to the events associated with very strong El Niño forecasted for fall and winter of 2015.

REFERENCES

Changnon, S. A., “Impacts of 1997-98 El Nino-Generated weather in the United States”, Bulletin of the American Meteorological Society, Vol. 80, No. 9, Sep 1999.

Glantz, M. H., Katz, R.W., and Nicholls, N. (eds.). Teleconnections linking worldwide climate anomalies: scientific basis and societal impact. Cambridge: Cambridge University Press, 1991.

KuritKara Engineers, “Enhancing the Climate Forecasting Models of Iranian Rivers by Incorporation of Historical Droughts and Floods”, a research undertaken for Iranian Water Resources Management Company, 2010.

National Climatic Data Center, The EL Nino Winter of 97-98, Technical report No. 98-02, April 1998.

U.S. Army Corp of Engineers, “Adaptive Management for Water Resources Planning”. U.S. Corp of Engineers, 2004.

Tong, Jiang; Zhang Qiang, Zhu Deming and Wu Yijin., “Yangtze floods and droughts (China) and teleconnections with ENSO activities (1470–2003)". Quaternary International 144 (2006). pp:29–37.

Lewis S. C. Lewis and A. N. LeGrande, “Stability of ENSO and its tropical Pacific teleconnections” , Climate of the Past Discuss., 11, 1579–1613, 2015.