Geographic Patterns in the Lag of Temperature Response to Insolation for El Niño vs. La Niña Conditions

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Abstract

The most important control on the annual cycle of temperature is insolation, with secondary influences from terms related to moisture, yet direct statistical analysis of the moisture-driven modulations (such as El Niño) of the response of temperature to insolation are not available. We have examined one aspect of the relationship between insolation and the instrumental record of maximum daily temperature — the lag between the two — at 252 stations in the western United States. We chose the lag (in days) that maximizes the cross correlation between these two variables. Three stations were chosen from each climate division in 11 western states, at low, intermediate, and high elevations, and 30 years of record (1961-1990) were examined.

We found geographic patterns in lag that reflect the effects of moisture as follows: (1) lag is largest in maritime settings, (2) lag is slightly larger in mountainous than in basin settings, and (3) lag is smaller in semiarid areas. The percentage variance explained by insolation is largest in the continental interior and smallest in maritime settings. The standard deviation of the residual of temperature from the insolation curve is largest in the Pacific Northwest and smallest in the southwestern deserts.

Inter-annual variations also tend to reflect the influence of moisture entrained by the jet streams. For example, the Pacific Northwest tends to be dry when the Southwest is wet, and vice versa, in concert with the positions and strengths of the polar and subtropical jet streams. This pattern of opposition is strongest during extreme phases of the southern oscillation. Stratifying our analysis by years of El Niño and La Niña, we find that during El Niño years lags are largest in the Southwest and during La Niña years, lags are largest in the Northwest. The difference in lag (computed as lag for an El Niño year minus the lag for a La Niña year) is largest in the Southwest and smallest in the Northwest. This difference ranges from about -20 to +30 days, a change of about 100% of normal.

We conclude that the difference in the lag reflects the shift in storm tracks with changing position and strength of the polar and subtropical jet streams. This lag can become a useful diagnostic tool for characterization of climates related to the two conditions.

In: C.M. Isaacs and V.L. Tharp, Editors. 1996. *Proceedings of the Twelfth Annual Pacific Climate (PACLIM) Workshop, May 2-5, 1995.* Interagency Ecological Program, Technical Report 46. California Department of Water Resources.