



Inter-annual Variations and Trends in Surface Temperature and Precipitation and the Impact of ENSO and Volcanoes

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Inter-annual variations and trends in surface temperature, water vapor and precipitation on both tropical and global scales are examined with data sets spanning the last 30 years. During this period there has been a significant increase in temperature, an associated increase of atmospheric water vapor, but a near zero change in global precipitation. However, there is a significant increase in precipitation over tropical oceans, balanced mainly by a decrease in mid-latitudes, at least in the Northern Hemisphere.

These relations among variables are also examined at the inter-annual scale to understand how they may relate to the long-term change relations. For example, the impact of ENSO and the two major volcanoes during the period have an impact on all three tropical ocean variables (surface temperature, water vapor and precipitation), but when their impact is removed, water vapor is still correlated with temperature, but precipitation is not. Thus we tentatively conclude that precipitation variability over a large domain (tropical oceans), when large-scale dynamic adjustments are eliminated (ENSO impact removed), does not follow surface temperature variations, even though water vapor still does. This relation seems to parallel the relation found in the 30-year trends. Further analysis is presented examining the inter-annual and trend relations on tropical (land + ocean) scale and on the global scale, with similar findings. On the global scale ENSO effects are still apparent in the temperature signal, but not in precipitation. Volcano impacts are evident in both global temperature and precipitation variations. Comparisons with a re-analysis model (MERRA) indicate that the precipitation decreases related to volcanoes are due at least in part to aerosol effects (not simulated in the model) and not only due to surface temperature decreases.