



SOIL MOISTURE INFORMATION FOR CENTRAL AMERICA WITH PROJECTIONS FOR THE NEXT THREE DECADES



*Sponsored by the National Oceanic and Atmospheric Administration Office of Global Programs
Produced by the Hydrologic Research Center in December 2001*

Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama constitute the nations of the Central American Isthmus. The volcanic origin of the terrain, and the climatic differences of the Pacific (seasonal rains) and Caribbean coasts (year-round rains), have contributed to the profitable agricultural production of a wide range of crops (corn, beans, sugar, coffee, bananas etc.).

The sustainability of agriculture in the region may be threatened, however, by emerging world market forces, and by current and projected climatic changes. The state-of-the-science coupled global climate model (CGCM2) of the Canadian Climate Centre for Modeling and Analysis estimates increased temperatures and an up to 15% decrease of regional precipitation during the growing season in the first three decades of the 21st Century for an assumed 1% increase of greenhouse gas (GHG) emissions per year. It also projects up to a 10% increase of regional precipitation in the preceding drier months with a significant concurrent increase in precipitation variability (Figure 1).

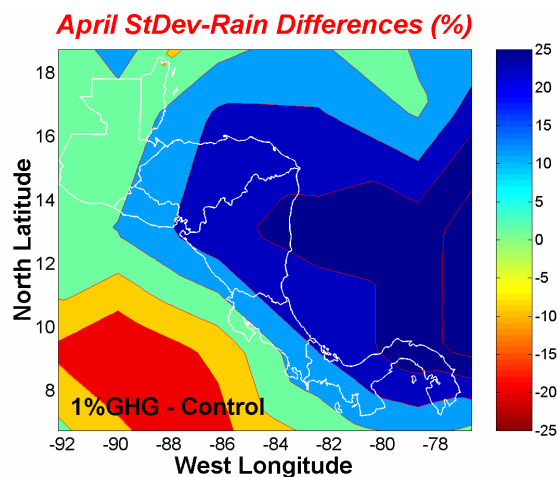


Figure 1. Differences of standard deviation of April precipitation for the period 2001-2030 generated by differences in greenhouse gas emissions. The scenarios are: (a) 1% annual increase in GHGs emissions (1%GHG), and (b) sustained present emissions (Control).

The implications of projected large-scale changes in the long-term average values and variability of renewable water resources for future agricultural productivity may be discerned by estimating soil moisture on hydrologic basin scales.

To assist agricultural and ecological planning and decision making in Central America, the present brochure offers an overview of estimated historical and projected regional monthly soil moisture, taken as an average over a depth of 1 meter from the soil surface and aggregated over 4,000-km² hydrologic basins. The estimates are produced using physically-based numerical models of the land surface processes, spatial digital databases, historical data of monthly precipitation and temperature gridded on a 0.5° grid, and CGCM2 projections of potential future monthly precipitation and temperature forcing, suitably regionalized (Figure 2).

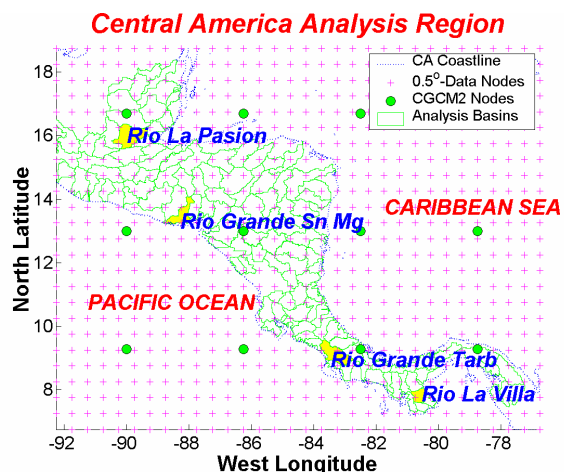


Figure 2: Analysis basins, nodes of historical 0.5° precipitation and temperature data, nodes of CGCM2 data, and basins of model runoff validation (in yellow).

In lieu of direct soil moisture observations in the region, the skill of the land-surface model was validated with monthly runoff from four Central American sites with significant historical record. The land-surface model does have skill in reproducing not only important features of the seasonal cycle of runoff (Table 1 in mm/mo) but also runoff variability (Figure 3) even for extreme cases (in floods and droughts).

Table 1

Validation Site	D-J-F	M-A-M	J-J-A	S-O-N
<i>Rio La Pasion, Guatemala</i>				
Observed	275.9	119.3	462.8	588.5
Simulated	118.1	101.2	423.8	284.1
<i>Rio La Villa, Panama</i>				
Observed	42.9	19.6	78.5	186.3
Simulated	24.4	13.8	94.4	233.8

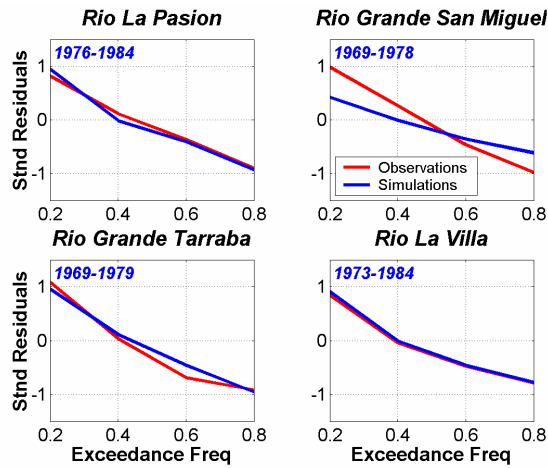


Figure 3. Plots of the frequency of exceeding a certain value of flow standardized residuals for the four validation sites.

The spatial variability of the average degree of soil saturation over the period 1969-1998 is shown in Figure 4 for April, which, on average, is the driest month of the year in the region. There is large spatial variability in Central America soil moisture fractions, with the Pacific coast being generally very dry in April. Analogous maps for other months of the year show that the Caribbean coast is more vulnerable to extreme rainfall events in October when soil moisture is near saturation over large regions.

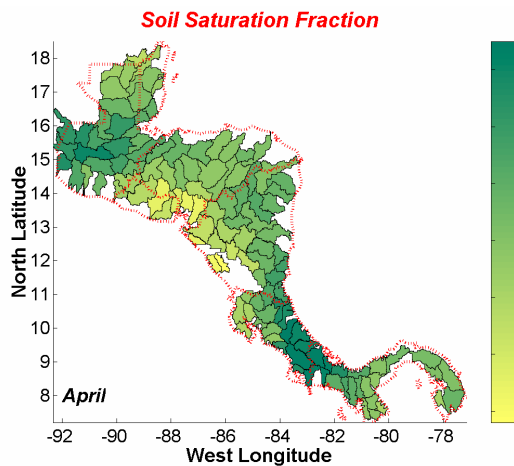


Figure 4. The average April soil saturation fraction as estimated for the period 1969-1998.

A three-member ensemble of large-scale monthly precipitation and temperature simulations from the coupled global climate model CGCM2 was used to quantify potential climate-change impacts in regional soil moisture variability. The analysis procedure accounts for uncertainties due to CGCM2 regional biases and disparity between the scale of the CGCM2 nodes and that of the hydrologic analysis basins (Figure 1). Increase of greenhouse gases by 1% per year with respect to present emissions levels produces modest changes in basin soil saturation fraction throughout the year for the next three decades with an overall increase in regional soil saturation fraction (Figure 5).

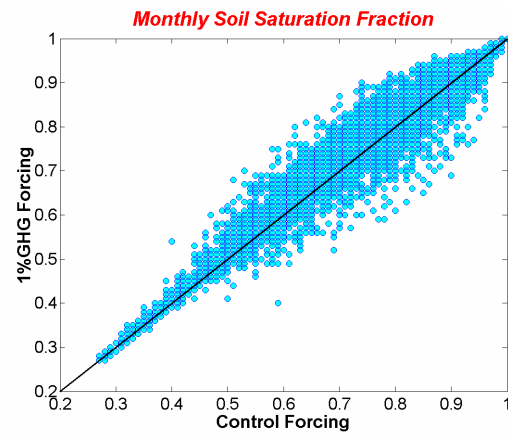


Figure 5. Scatter plot of monthly soil saturation fractions for 1% greenhouse-gas forcing and control scenarios for the period 2001-2030.

The month of April, driest month of the year, shows greatest increases in soil saturation fraction, reaching 5% above the average control levels in several regions of Central America (Figure 6). These levels are comparable to present interannual variability in soil moisture saturation fractions. Thus, on the basis of the CGCM2 results, soil moisture availability is expected to vary within the present levels during the next few decades, with a possible beneficial impact of allowing extension of the growing season earlier than present, mainly in regions of Honduras and Nicaragua. These inferences may be further validated using the same analysis with projections from other state-of-the-science climate models.

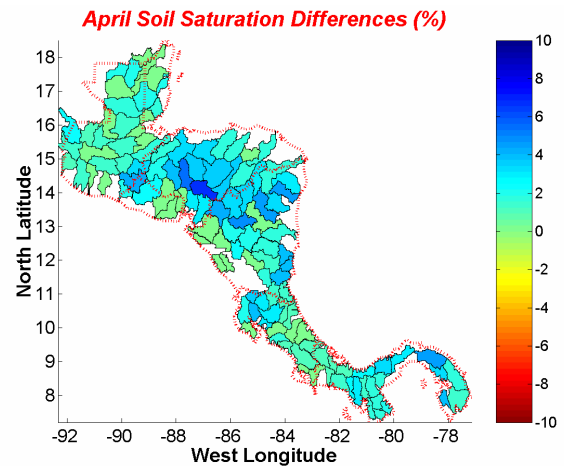


Figure 6. Percent soil saturation fraction differences between the greenhouse-gas-increase and control cases averaged over the period 2001-2030 for the month of April.

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