USING ISOTOPES TO IMPROVE IMPACT AND HYDROLOGICAL PREDICTIONS OF LAND-SURFACE SCHEMES IN GLOBAL CLIMATE MODELS

K. McGUFFIE
Department of Applied Physics, University of Technology,
Sydney, New South Wales, Australia

A. HENDERSON-SELLERS
Environment Division, Australian Nuclear Science and Technology Organisation,
Menai, New South Wales, Australia

Global climate model (GCM) predictions of the impact of large-scale land-use change date back to 1984 [1] as do the earliest isotopic studies of large-basin hydrology [2]. Despite this coincidence in interest and geography, with both papers focussed on the Amazon, there have been few studies that have tried to exploit isotopic information with the goal of improving climate model simulations of the land-surface. In this paper we analyze isotopic results from the IAEA global data base specifically with the goal of identifying signatures of potential value for improving global and regional climate model simulations of the land-surface.

Evaluation of climate model predictions of the impacts of deforestation of the Amazon has been shown to be of significance by recent results which indicate impacts occurring distant from the Amazon i.e. tele-connections causing climate change elsewhere around the globe. It is suggested that these could be similar in magnitude and extent to the global impacts of ENSO events [3]. Validation of GCM predictions associated with Amazonian deforestation are increasingly urgently required because of the additional effects of other aspects of climate change, particularly synergies occurring between forest removal and greenhouse gas increases, especially CO_2.

Here we examine three decades' distributions of deuterium excess across the Amazon and use the results to evaluate the relative importance of the fractionating (partial evaporation) and non-fractionating (transpiration) processes. These results illuminate GCM scenarios of importance to the regional climate and hydrology: (i) the possible impact of increased stomatal resistance in the rainforest caused by higher levels of atmospheric CO_2 [4]; and (ii) the consequences of the combined effects of deforestation and global warming on the region's climate & hydrology [5].

Conventional observational studies in the Amazon have not been able to assist in distinguishing between appropriate and less valuable simulations of this region to date because most are point-based i.e. in one, or at most two, locations. However, the isotopic data available from the IAEA network has the potential to provide clues about the veracity of regional hydrological simulation of the Amazon (e.g. [6]).

Generally, GCMs predict reductions in precipitation and evaporation as a consequence of deforestation. There is less agreement about the sign of the temperature change although most simulations show a temperature rise. There is also disagreement about the sign of the atmospheric moisture convergence change with about a quarter of the GCM simulations undertaken between 1984 and 2000 predicting an increase in moisture convergence while the others anticipate a decrease (Figure 1). These differences in predicted regional moisture convergence change can be examined using $\delta^{18}O$ and δD data. One widely reported simulation set gives seasonal transpiration and re-evaporated canopy interception budgets different from those derived from isotopic analysis.

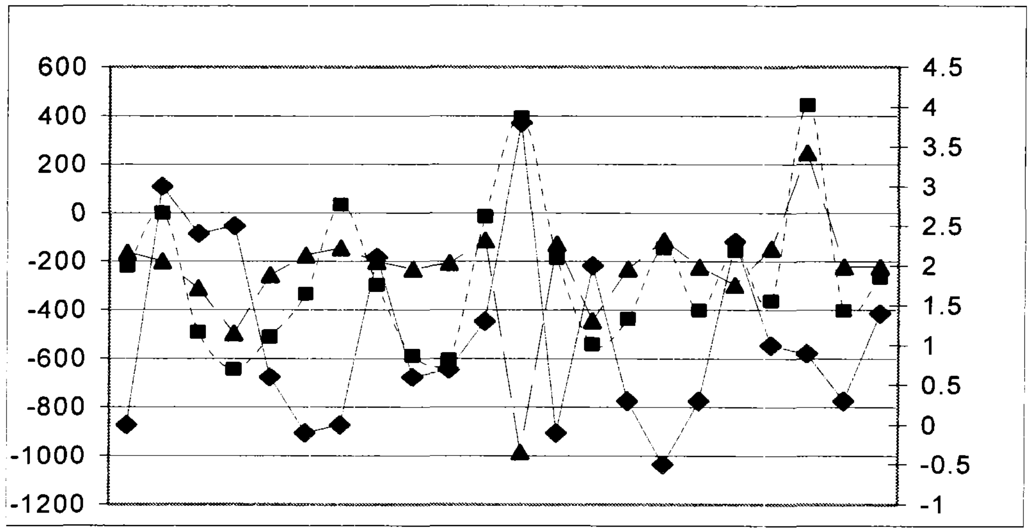

FIG. 1. GCM predicted differences in annual mean Amazonian temperatures (solid with diamonds), precipitation (dotted with squares) and evaporation (dashed with triangles) as a result of simulated deforestation. The right hand scale is in K (temperature) and the left hand scale is in mm (evaporation & precipitation). Points are GCMs from 1984 (left) to 2000 (right). [Note the zero levels are not aligned.]

Our results indicate that the evaporation of moisture intercepted by the canopy is another potential means of evaluating climate model performance. Thus, model estimates of the percentage of intercepted moisture that is evaporated (cf. [7]) can be compared with isotopically-derived fractions. This means that land-surface schemes coupled into modern global climate models and so representing sensitive components of the global hydrological cycle can be evaluated using isotopes.

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