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A stochastic modeling approach to investigate a possible hydrological strengthening mechanism of climate change

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The question about climate change influence over hydrological regime of Andean Colombian region is touched upon. An approach is developed that first, revise the base line reported by hydrometeorological stations, establishes significant trends, tele-connections and seculars cycles and then derives, theoretically and by means of adaptive operators and genetic algorithms, a deterministic kernel to describe the monthly and annual water balance dynamics, conforming a three dimensional phase space (Rainfall-Evaporation-Runoff) that is afterward described through a vector Langevin equation, dynamics of which are then studied through a multidimensional numeric solution of the corresponding Fokker-Planck-Kolmogorov (FPK) equation. Numeric experiments show some evidence about the existence of a hydrological strengthening mechanism of the global warming process. The strengthening mechanism is driven by the dependency of the albedo with the basin surface moisture content and by the non-linear relationship of the outgoing thermal radiation with temperature. Mentioned mechanism can lead to a chaotic dynamic of soil moisture contents, air temperature and, as a consequence, to disequilibrium of the hydrosphere process. Derived deterministic kernels (through adaptive operators and genetic algorithms) are also compared and agree well with theoretically derived kernels. The level of agreement is analyzed and recommendations given to select a kernel to setup the process Langevin equation. For this equation a Fokker-Planck-Kolmogorov equation is proposed and solved using bidirectional weighted finite differences and CUDA programming techniques. We analyzed the stability of the numeric algorithm and proposed a Courant-Friedrichs-Levy (CFL) condition to ensure its stability. Boundary and initial conditions are derived from the current regime. Climate change and land use perturbations are introduced to study how they will affect the probabilistic patterns of different hydrological characteristics (maximal, minimal and mean runoff). As perturbation vector we used obtained trends and also official Colombian climate change scenarios. Projected hydrological scenarios are used to build water pressure indexes that are compared with the same indexes for the current hydro-climatic conditions. The results show that the hydrological strengthening mechanism, in tandem with the demographic dynamics, could exacerbate hydrological consequences of global warming process accelerating the warming process itself.