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Identification of Synchronicity in Deterministic Chaotic Attractors for the Downscaling Process in the Bogotá River Basin

Santiago Duarte[1,2], Gerald Corzo[1], and Germán Santos[3]
[1]IHE-DELFT Institute for Water Education - P.O. Box 3015, 2601 DA Delft, The Netherlands
[2]Delft University of Technology, Water Resources Section, Delft, the Netherlands
[3]Escuela Colombiana de Ingeniería Julio Garavito, AK.45 No.205-59 +57(1) 668 3600, Bogotá, Colombia

Bogotá's River Basin, it's an important basin in Cundinamarca, Colombia's central region. Due to the complexity of the dynamical climatic system in tropical regions, can be difficult to predict and use the information of GCMs at the basin scale. This region is especially influenced by ENSO and non-linear climatic oscillation phenomena. Furthermore, considering that climatic processes are essentially non-linear and possibly chaotic, it may reduce the effectiveness of downscaling techniques in this region.

In this study, we try to apply chaotic downscaling to see if we could identify synchronicity that will allow us to better predict. It was possible to identify clearly the best time aggregation that can capture at the best the maximum relations between the variables at different spatial scales. Aside this research proposes a new combination of multiple attractors. Few analyses have been made to evaluate the existence of synchronicity between two or more attractors. And less analysis has considered the chaotic behaviour in attractors derived from climatic time series at different spatial scales.

Thus, we evaluate general synchronization between multiple attractors of various climate time series. The Mutual False Nearest Neighbours parameter (MFNN) is used to test the "Synchronicity Level" (existence of any type of synchronization) between two different attractors. Two climatic variables were selected for the analysis: Precipitation and Temperature. Likewise, two information sources are used: At the basin scale, local climatic-gauge stations with daily data and at global scale, the output of the MPI-ESM-MR model with a spatial resolution of 1.875°x1.875° for both climatic variables (1850-2005). In the downscaling process, two RCP (Representative Concentration Pathways) scenarios are used, RCP 4.5 and RCP 8.5.

For the attractor's reconstruction, the time-delay is obtained through the Autocorrelation and the Mutual Information functions. The False Nearest Neighbors method (FNN) allowed finding the embedding dimension to unfold the attractor. This information was used to identify deterministic chaos at different times (e.g. 1, 2, 3 and 5 days) and spatial scales using the Lyapunov exponents. These results were used to test the synchronicity between the various chaotic attractor's sets using the MFNN method and time-delay relations. An optimization function was used to find the attractor's distance relation that increases the synchronicity between the attractors. These results

provided the potential of synchronicity in chaotic attractors to improve rainfall and temperature downscaling results at aggregated daily-time steps. Knowledge of loss information related to multiple reconstructed attractors can provide a better construction of downscaling models. This is new information for the downscaling process. Furthermore, synchronicity can improve the selection of neighbours for nearest-neighbours methods looking at the behaviour of synchronized attractors. This analysis can also allow the classification of unique patterns and relationships between climatic variables at different temporal and spatial scales.