Science and Technology Infusion Climate Bulletin
NOAA's National Weather Service
38th NOAA Annual Climate Diagnostics and Prediction Workshop
College Park, MD, 21-24 October 2013

Jaziku - Statistical Inference Software for the Teleconnections Analysis

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1. Introduction

In geographical terms, Colombia is within the Torrid Zone[1], this means that the temperature decreases with altitude and by the presence of the training Andes mountains, Colombia has a variety of climates. According to Snow J. W. (1976), Colombia "is an island in the middle of three oceans", the author refers to that besides the influence of the Pacific and Caribbean oceans, Colombia receives moisture from the Amazon basin. In the Colombian territory the trade winds converge from north-east and south-east and from the convergence of the trade winds is made a belt of low pressure known as the Intertropical Confluence Zone (ITCZ), which causes large upswings that favor the formation of clouds, causing abundant rainfall. The meridional oscillation of the ITCZ which results in the annual cycle of surface temperatures as a result of insolation effect is the most important physical mechanism to explain the annual cycle of rainfall in Colombia.

However, multiple studies have shown the influence of several phenomena of climate variability in the climate of Colombia (Montealegre 2009) and taking into account that in recent years, multiple studies has reported an increase in the frequency and intensity of these phenomena with the extreme categories, are increasingly the sectors, communities and regions vulnerable to these changes. Consequently it's required to have better and adapted tools, for forecasting changes in the climate of our country and thus help in making decisions for the prevention.

Therefore, currently the seasonal rainfall forecast turns out to be an important item in the planning of the different social and economic sectors of Colombia. As part of the products of working group "Weather and Climate" of the Meteorology branch of the IDEAM (Institute of Hydrology, Meteorology and Environmental Studies - Colombia), is used the composite analysis methodology proposed by National Oceanic and Atmospheric Administration (NOAA)[2], facilitated by Jaziku software.

2. Jaziku

There are multiple methods that can be used for seasonal forecast (such as results of dynamic models, statistical models, *etc.*) and among these, there is a statistic methodology proposed in the article "Creating a Local Climate Product Using Composite Analysis" (by NOAA[2]), this is based in composite analysis. In the original proposal of this methodology are used spread sheets that make this process to be tedious, with possible human errors and impractical for robust studies with many time series, which also produced human errors in the process. Jaziku born as a tool to systematize this process and as the need for own tool and adapted software for own needs but with the advantage of being a free and open source software and therefore can be improved and adapted for different purposes, for example, could be corrected, improved, adapted and implemented by anyone, institutions or weather service.

The Jaziku software was designed to find relationships through composite analysis methodology between the time series of the dependent variables (observed meteorological variable) with the index that represents the phenomenon of climate variability (independent variables)[3].

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[1] Geographic Universal Atlas and Colombia, Oceano Editorial, 1994. ISBN 847764782 8. Barcelona España. 100 pp.
[2] NOAA and UCAR. Creating a local climate product using composite analysis - Print version of webcast - (on line). 1997-2010:COMET Website at http://meted.ucar.edu/, 1997.
[3] Jaziku is statistical inference software for the teleconnections analysis, (version 0.6.1). (2013) IDEAM, Colombia. Jaziku is a free and open source software GPLv3. http://hg.ideam.gov.co:8000/meteorologia/jaziku/summary.

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2.1 Modules

• Data analysis – homogeneity: Evaluates the trend of the series, outliers, multiyear climatology, and several statistics for the time series and presents the results of parametric tests of homogeneity analysis. Such results are for example: Test Mann-Whitney-Wilconxon, F-test or T-test. Respect to the descriptive statistics, are: sample size, minimum, mean, median, standard deviation, kurtosis, coefficient of variation and variance of the series[3].

• Climate: In "Jaziku - climate", the software produces the climatology of the behavior of the dependent variable under the phases associated with the phenomena represented by the independent variable. Generates a series of average values according to the chosen time resolution (Quarter, two months, month, 15days, 10days or 5 days) and generate contingency tables (NOAA and UCAR 1997), which become more probable scenarios of response the dependent variable under the categories (phases) of the phenomenon . Subsequent to the calculation of the most likely scenarios of variation of dependent variable in the module "Jaziku-Climate", the software uses the probability values of the phenomenon represented by the independent variable

• Forecast: In the forecast module is used the total probability theorem to calculate the probability that the dependent variable to be in any category. For these step are required the probabilistic predicted values for each of the categories of the independent variable (which in the case of ENSO are facilitated by physical and statistical models of IRI "International Research Institute for Climate and Society"[4]) and then is used the conditional probability taken of contingency tables (Wilks 1995).

2.2 Software development and program structure

Jaziku run and work only with one file in format csv called "runfile", this file is where are the settings of all options to run Jaziku (see Figure 1). The time series are of dependent an independent variable, are in plain text with the data organized chronologically. Jaziku runs in command line interface (CLI), is developed in Python language[5] with some libraries and software as support to make some statistical formulas (Scipy[6] and Numpy[7]), graphics (Matplotlib[8]), interpolation (HPGL[9]), maps (NCL[10]) and manipulate images (PIL[11]).

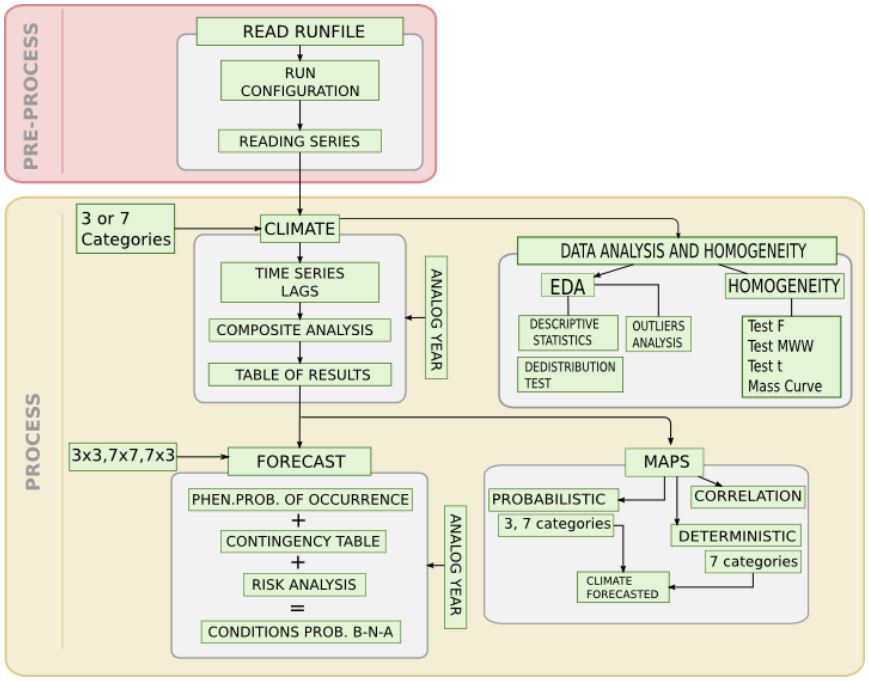

Fig. 1 General scheme of Jaziku run process.

[4] International Research Institute for Climate and Society.
url: http://iri.columbia.edu/climate/ENSO/currentinfo/QuickLook.html.
[5] Python Programming Language, Python Software Foundation, version 2.7. Available at http://www.python.org.
[6] Scipy, Open source scientific tools for Python, License: BSD-new, url: http://www.scipy.org
[7] Numpy, Fundamental package for scientific computing with Python, License: BSD-new, url: http://www.numpy.org.
[8] Matplotlib is a plotting library for Python. License: matplotlib-licence, url: http://matplotlib.org.
[9] HPGL stands for High Performance Geostatistics Library. License: BSD, url: http://hpgl.aoizora.org.
[10] NCL, NCAR Command Language, Copyright (C) 2013 University Corporation for Atmospheric Research. The use of this software is governed by a License Agreement. See http://www.ncl.ucar.edu/ for more details.
[11] PIL, Python Imaging Library, Alex Clark and Contributors, License: PIP-license,
url: http://pillow.readthedocs.org/en/latest/.

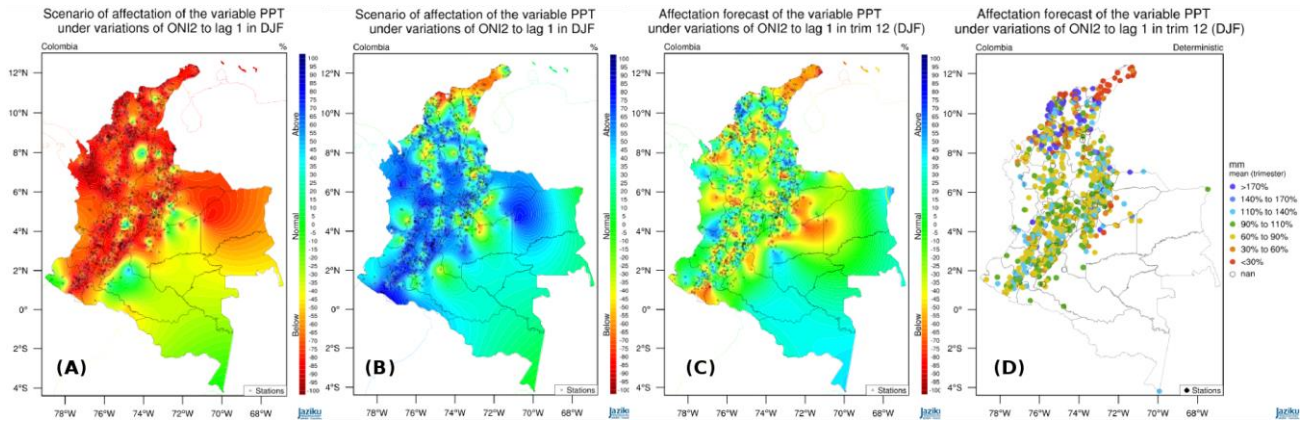

Fig. 2 These are some examples outputs of Jaziku, the first two graphs show the most likely scenarios of rainfall variation under El Niño (A) and La Niña (B) for Colombia. The following two graphs show the special forecast of precipitation for Colombia in the DJF trimester, probabilistic (C) and seven categories (D).

Jaziku is a free and open source software (GPLv3 license), and therefore can be improved and adapted for different purposes, for example, could be corrected, improved, adapted and implemented by anyone, institutions or weather service, but always preserving and respecting the copyright and software licensing agreements.

Jaziku started its development from 2011 and continues being developed. The actual version control system of code of Jaziku is: http:// hg.ideam.gov.co:8000/meteorologia/jaziku/summary. The actual mailing list is: https://groups.google.com/forum/#!forum/jaziku

3. Specific uses and applications

- Currently Jaziku is used for exploratory data analysis, to detect changes in the homogeneity of the time series and analysis of outliers

- Each month the maps of composite analysis results of climate module are used operationally to verify the response of precipitation under the observed conditions the El Niño phenomenon and these are used as the most likely scenarios for risk prediction (Fig. 2, A and B).

- Taking also the results of the composite analysis methodology of climate module, is possible to explore the influence of different climate variability phenomena for specific areas of interest, for example for the agricultural sector or areas of biodiversity protection

- Based on predicted probabilities of IRI models for the El Niño phenomenon and using the forecast module, each month is made a seasonal forecast of rainfall in Colombia (Fig. 2 C and D). These results add to other methodologies (dynamic models and analysis canonical correlation, for example).

- Currently is being explored the skill of the methodology for seasonal forecast of precipitation in Colombia.

4. Conclusions

- Jaziku has helped and facilitated the elaboration of exploratory data analysis, detection of teleconnections and seasonal forecast, so it becomes a tool for multiple applications

- Jaziku even being a young software and still developing, shows great methodological robustness, given the fact that it is based primarily on an existing methodology which has proved very useful in the climatology field.

- Is important for develop of the Jaziku software, to have feedback of its use in other institutions and users.

Acknowledgements. The authors express their gratitude to IDEAM and SIGOT for giving all information necessary for the development of this work, and to Gloria León Aristizabal (Met.), Franklyn Ruíz Murcia (McS. Phy.) and all professionals of the "Weather and Climate group" of IDEAM for their continued feedback and suggestions.

References

Montealegre J. E Bocanegra, 2009: Study of climatic variability of precipitation in Colombia associated with oceanic and atmospheric processes and large-scale meso: Final report of the activities carried out under contract to provide services in IDEAM 022-2009. Institute of Hydrology, Meteorology and Environmental Studies, IDEAM - Directorate of Meteorology, page 54.

Snow, J. W., 1976: The climate of northern South America. Climates of Central and South America, W. Schwerdtfeger, Ed., *Elsevier*, 295–403.

Wilks, D. S., 1995: Statistical methods in the atmospheric sciences: An introduction. *Academic Press*, ISSN 0127519653 9780127519654, 467 pp.