Northland drought assessment using Standard Precipitation Index

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The Standard Precipitation Index (SPI) is a powerful, flexible index which is commonly used to assess meteorological drought caused by rainfall deficit. New Zealand SPI maps provide a good indication of droughts at national level. However, this information is relatively coarse for Northland where drought severity can be strongly localised. The following article presents some insights from the application of the SPI method to historical drought events in Northland.

Introduction

Drought has a significant impact on Northland farming. It tends to starts slowly, often without warning, and can last for significant periods of time and cover large spatial areas. Drought in Northland has become more frequent and impacts more severe during summer months as a result of increasing temperature and decreasing rain totals.

At least eight severe droughts were recorded in Northland since 1900 (Keyte, 1993 and NIWA, 2010 & 2013). The Northland Avocate (Feb, 2017) reported five droughts have occurred in the past eight years and been of a highly localised nature. The frequency and severity of drought in Northland is projected to continue to increase in the future under a changing climate (NIWA, 2013 & 2016). The research presented in this article represents the first steps of an attempt to develop a regional drought warning system. It involves identifying climatic zones, applying SPI and mapping SPI for severe 1914-15, 1945-46, 1982-83 and 2009-10 drought events.

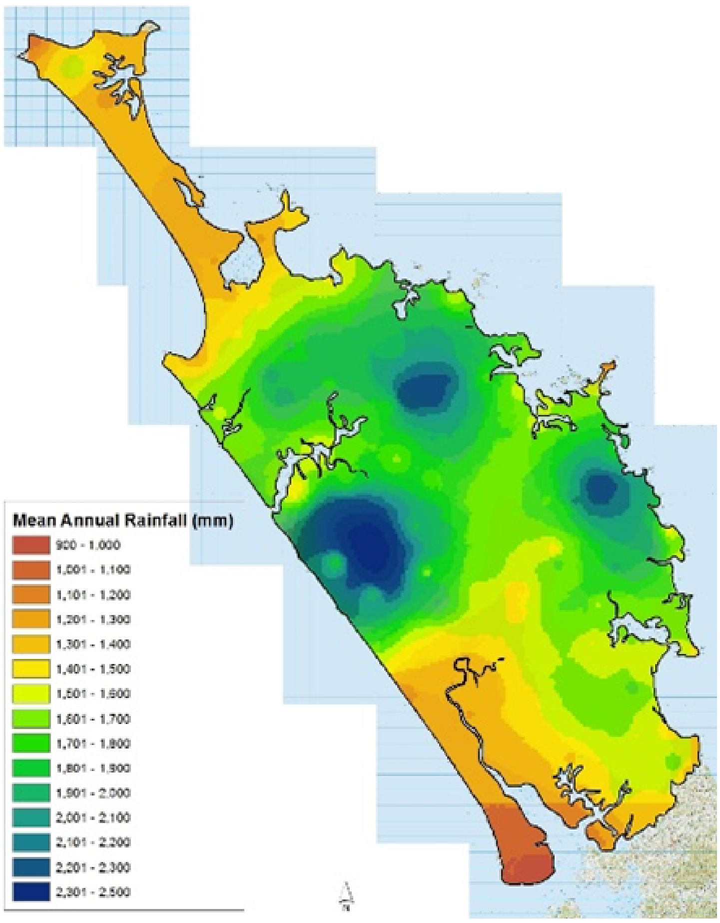
Takou Bay area at the height of drought (left) and a few months later (right) .*Photo: Matt Johnson, NRC*

Input Data

This study used rainfall data from 140 stations owned by NIWA, MetService and NRC for grouping climate zones. Data at a maximum of 40 stations was used for historical drought assessment at regional scale. Daily rainfall data was synthesised in some cases in order to extend the time series beyond gauge operating periods.

Methods and Results

Rainfall in Northland is highly variable leading to the development of localised drought in the region. Hence, the first step was to sub-divide the region into four climate zones based on long-term annual rainfall variability (see map to right). This was done with the aid of ArcGIS Geostatistics. A ratio of 70:70 stations was used for calibration and verification of spatial interpolation process. Rainfall stations could then be selected for further analysis in this study based on achieving representation across the four climate zones.



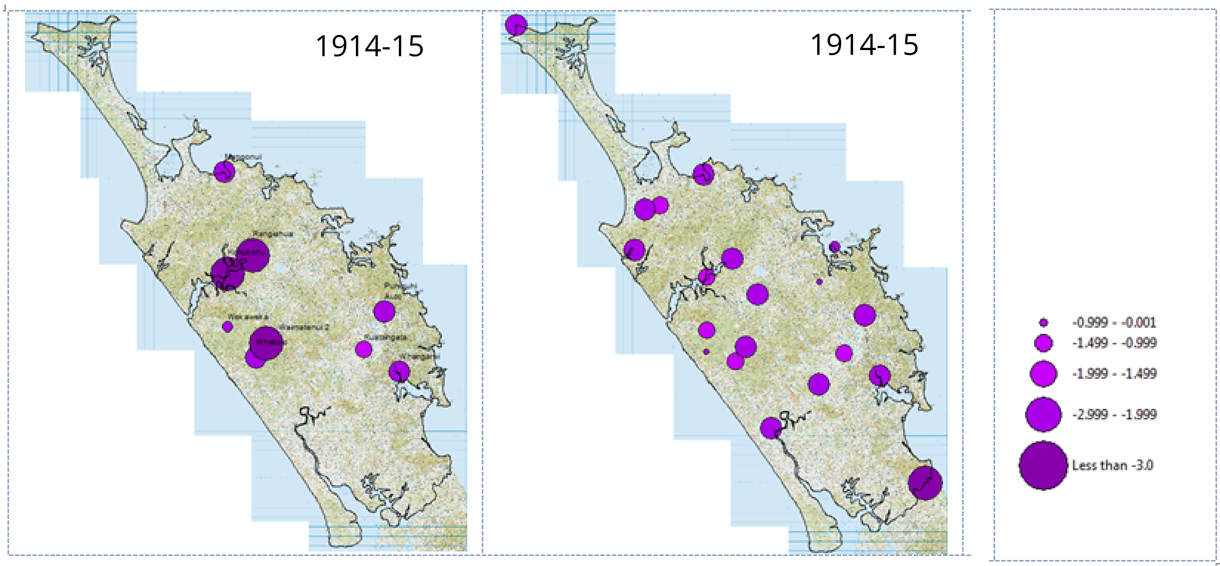
The SPI was introduced by McKee et al. (1993) as a method of measuring drought severity for a particular rain station. The SPI is based on the probability of precipitation for any time scale. The probability of observed precipitation is then transformed into an index. The table below shows how SPI values correspond to categories of drought severity.

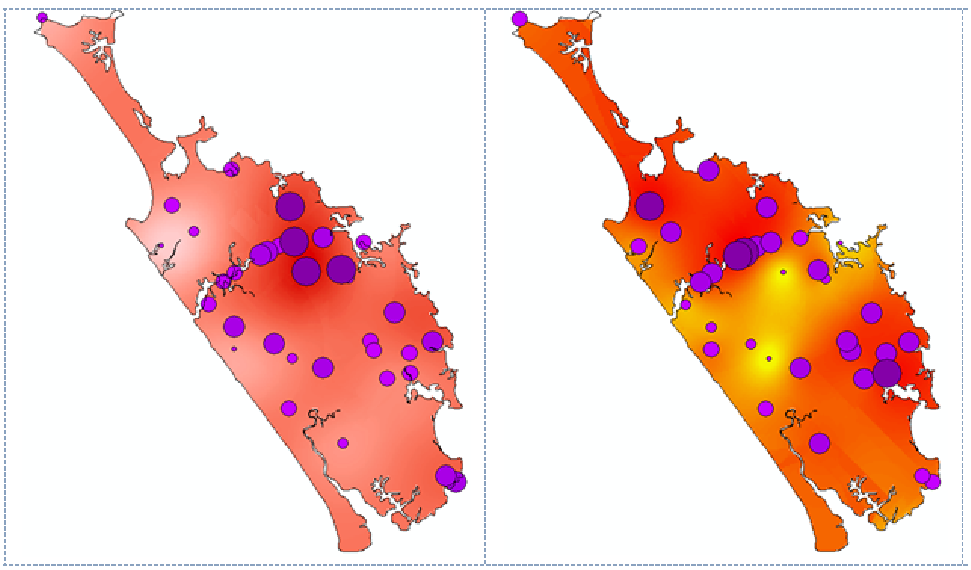
The main advantage of the SPI is that it allows for areas with different rainfall regimes to

[±] 2.00 and above/below	Exceptionally [wet, dry]
[±] 1.60 ÷ 1.99	Extremely [wet, dry]
[±] 1.30 to 1.59	Severely [wet, dry]
[±] 0.80 to 1.29	Moderately [wet, dry]
[±] 0.51 to 0.79	Abnormally [wet, dry]
[±] 0.50	Near normal

be compared. In addition, the SPI provides a method for comparing an area against its own history and giving a normalized value to describe the current rainfall conditions. Through this normalization, rainfall values at different locations can be compared (WMO, 2009). The latest SPI program (SPI_SL_6.exe) developed by the Colorado State University, USA was used in this study. This program provides monthly-based SPI values.

Northland usually experiences 2-3 month droughts with the exception of a six-month drought in 1914-1915. Drought has occurred in spring and summer during El Niño and La Niña. In order to best describe the 1914-15 and 2009-10 drought events, SPI 3 and 6 were computed, respectively. SPI-6 was computed for six consecutive months (from October to February) while SPI-3 was computed for three consecutive months (November - January). Results of these computations were used to develop SPI maps for selected historical drought events shown in the maps below. These station-based SPI maps allow drought intensity at both temporal and spatial scales to be visualised.





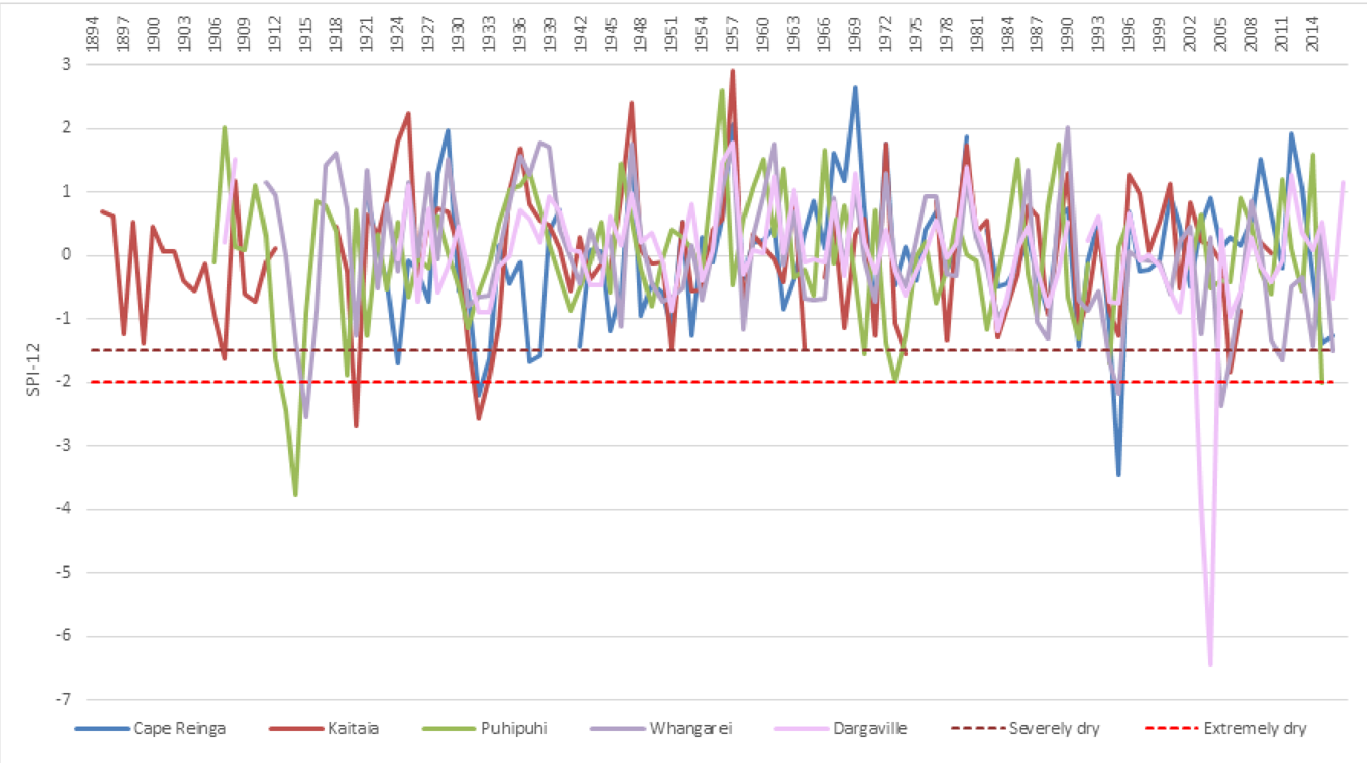
SPI-6 for ONDJFM for year 1914-15 (top left)

SPI-3 for NDJ for years 1945-46 (top right) 1982-83 (bottom left) and 2009-10 (bottom left)

The images on the previous page display some of the general trends of dryness in the region and help to identify the most vulnerable areas to drought. There are a number of obvious features present across the landscape, but the visualization also revealed some apparent errors in the data.

- The most obvious feature in the spatial variability of dryness is a big shift from the west to east coast from early last century (1914-15) to present (2009-10). Also, more areas in the the east are identified as being extremely dry for year 2009-10 (Fig. 3).
- Another noticeable feature is that drought severity relies upon both the magnitude of rainfall deficits and its duration. For example, the 1914-15 drought was caused by both high magnitude rainfall deficits and long duration while the 1982-83 drought was induced by low magnitude rainfall deficits but long duration.

The graph below shows that majority of extreme drought events were prior to 1931 and post-1994 when SPI varies between -1.5 to -3.5 (except for Dargaville in 2004 with the SPI value of -6.44 as an error). At least five droughts have been declared by the Government since 1994, suggesting an increase in drought frequency over the past two decades.



SPI-12 computed for selected rainfall stations

At this time the research has not progressed to the point of ranking the droughts as well as prediction of drought return period. It is also expected that agricultural and hydrological droughts will be integrated in the system when automated network data are available.

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