H431 - 1341

Exploring the Effects of Climate Oscillations on the Hydroclimatology of a Regulated River Basin

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I. INTRODUCTION

Climate and hydrology create an intricately coupled system, as large-scale atmospheric and oceanic oscillations produce shifts in precipitation, air temperature, soil moisture, and runoff. Drastic and persistent changes in these variables may alter the likelihood of extreme events or cause changes in the form of seasonal precipitation. Detection of consistent phases of these natural oscillations and attribution of hydrologic anomalies to these phases are fundamental to understanding future climate change, both natural and anthropogenic, and managing water resources. The Columbia River Basin is highly regulated, making it difficult to identify oceanic and atmospheric oscillation signals in streamflow. Annual mean runoff anomalies and the associated soil moisture tendency are generally constrained to be the same sign in the absence of anthropogenic effects. Therefore, drought indices may provide information on modes of large-scale oscillations.

II. BASIN DESCRIPTION

❑ The Columbia River Basin is located primarily in 4 states and 1 Canadian province:

- Oregon
- Washington
- Idaho
- Montana
- British Columbia.

❑ The Basin's climate is partly continental and partly marine.

❑ The Basin contains diverse landforms, including:

- Mountains
- Arid Plateaus
- River Valleys
- Rolling Uplands
- Deep Gorges.

Figure 1: Columbia River Basin

http://en.wikipedia.org/wiki/File:Columbiarivermap.png

III. RESEARCH QUESTIONS

1. What quantifiable relationships exist between the periodic anomalies that exist in the atmosphere-ocean system of the Pacific Ocean and the monthly PDSI in the Columbia River Basin?

2. How can we understand the influence of large-scale atmosphere-ocean oscillations on natural streamflow through drought indices such as the PDSI?

IV.METHODS

❑ Collect monthly PDSI data from January 1895 through December 2010, as calculated by the National Climatic Data Center.

❑ Filter data using high-pass filters with cutoff frequencies of 1/70 and 1/25 and compute continuous periodograms.

❑ Compute the power spectral density (psd) and determine the contributions of three ranges of frequencies – 1 cycle/3-7 years, 1 cycle/9-12 years, and 1 cycle/12-25 years [1] – to the total variance.

V. SPECTRAL ANALYSIS RESULTS

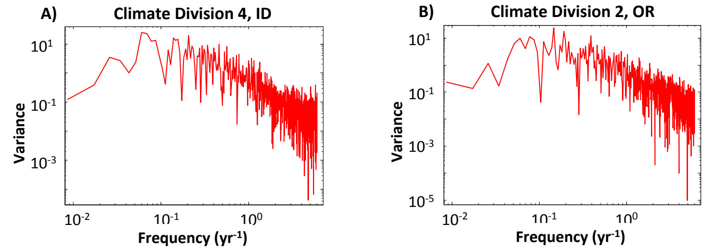

Figure 2: Continuous periodogram of filtered monthly PDSI data for A) Climate Division 4 of Idaho, and B) Climate Division 2 of Oregon. Data were filtered using a cutoff frequency of 1/70.

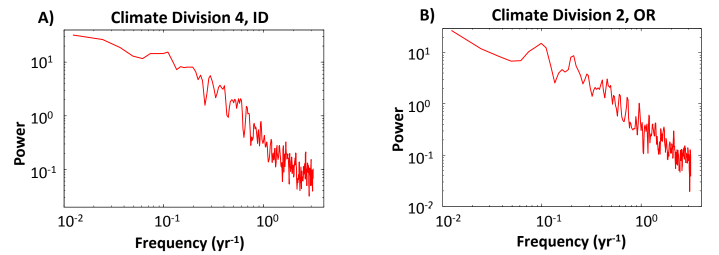

Figure 3: Power spectral density of monthly PDSI data for A) Climate Division 4 of Idaho, and B) Climate Division 2 of Oregon. The power spectral densities were calculated using Welch's method.

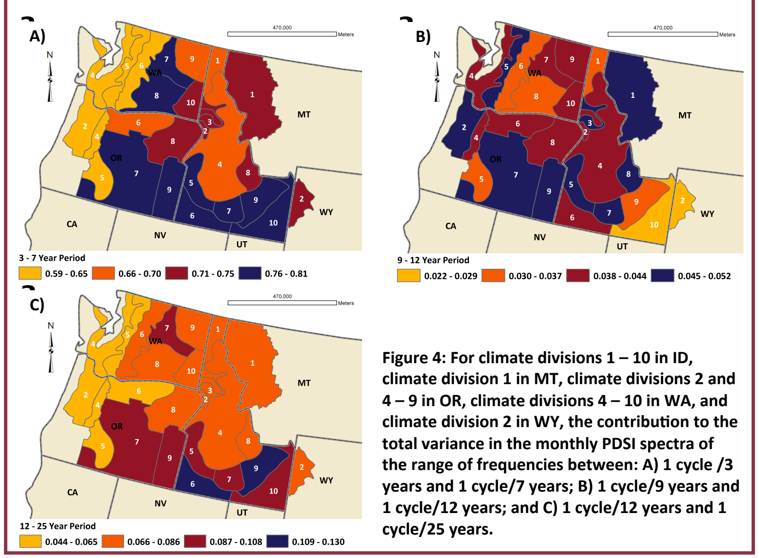

Figure 4: For climate divisions 1 – 10 in ID, climate division 1 in MT, climate divisions 2 and 4 – 9 in OR, climate divisions 4 – 10 in WA, and climate division 2 in WY, the contribution to the total variance in the monthly PDSI spectra of the range of frequencies between: A) 1 cycle /3 years and 1 cycle/7 years; B) 1 cycle/9 years and 1 cycle/12 years; and C) 1 cycle/12 years and 1 cycle/25 years.

VI. DISCUSSION

❑ **Identifiable Frequencies**

- There are at least two dominant peaks within the continuous periodograms and power spectral densities of most climate divisions (Figures 2 and 3).
  - These peaks occur over two ranges of frequencies, approximately 0.06 to 0.09 and 0.125 to 0.2 (11 – 17 year period and 5 – 8 year period).
- For several climate divisions, other, smaller peaks can be identified within the continuous periodograms.
  - These peaks occur around frequencies of 0.1, 0.3 and 0.5 (periods of 10 years, 3 years, and 2 years).
- These frequencies correspond to periods similar to those of the El Niño Southern Oscillation (ENSO), the Quasi-Decadal Oscillation (QDO), and the Interdecadal Pacific Oscillation (IPO).

❑ **Spatial Trends in Power associated with Frequency Bands**

- For most climate divisions, most of the variance can be explained by frequencies with periods between 3 and 7 years (Figure 4).
- The power associated with frequencies similar to that of ENSO increases east of the Cascade Range, in the interior of the Basin (Figure 4).
- The power associated with frequencies similar to that of the IPO follows a similar pattern, increasing in the interior of the Basin (Figure 4).
- The power associated with frequencies similar to that of the QDO show no general pattern, with the power magnitudes being relatively small for all climate divisions within the Basin Figure 4.

VII. IMPLICATIONS

We may be able to understand the natural climate variability in regulated streamflow through examining the PDSI of the drainage basin. Tree ring reconstructions of PDSI have been shown to be correlated with the PDO in the western United States [2]. Similarly, shifts in mean Columbia Basin runoff have been shown to follow a constructive and destructive phasing of ENSO and PDO events [3, 4]. It is useful then to consider the relationships between drought indices and large ocean-atmosphere oscillations, as we may gain a different perspective on natural streamflow variability within a regulated river basin.

VIII. ACKNOWLEDGEMENTS

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