

Temperature variation which is now known as the Pacific Decadal Oscillation (PDO). The Southern Oscillation Index (SOI) also shows evidence of a shift towards negative phase conditions in 1976/77, which suggests the occurrence of more frequent and/or stronger El Niño events. Intervention Analysis was used to determine the random probabilities of hypothetical changes in the mean coincidental with sign-reversals of the PDO in streamflow records from countries around the Pacific Rim. Available precipitation and streamflow records from Australia and New Zealand were also analyzed. In general, sites located in high northern latitudes present a stronger multidecadal NP signature and are affected by northern hemisphere cold-season climatic processes; consequently, they tend to show evidence of all the climate regime shifts coincidental with the PDO. Sites strongly correlated with ENSO have a tendency to show evidence of the 1976/77 shift. For this reason, the 1976/77 shift is the most widespread among the physical variables around the Pacific Rim.

H32C-02 1550h

**Statistical and Long-Term Characteristics of Southern Oscillation and its Barometric Pressure Data**

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Southern Oscillation (SO) is an atmospheric see-saw phenomenon in tropical Pacific sea level pressure between the eastern and western hemispheres associated with the El Niño and La Niña oceanographic features. The features are known collectively as the El Niño Southern Oscillation (ENSO) phenomenon. There are many research papers on the relationship between SO and hydro-meteorological phenomena. The SO can be measured by a simple index, the Southern Oscillation Index (SOI). The authors have described the chaotic characteristics of SOI and the correlation between SOI and precipitation and temperature data in Fukuoka, Japan. However, the properties of the barometric data from which SOI is derived (i.e. mean sea level pressure data at Tahiti and Darwin) and general statistical characteristics of SO have not been published, as far as the authors know.

We have published autocorrelation and spectral characteristics of SOI, so that in this study, other statistical characteristics of SO and the barometric pressure data as well as the long-term fluctuation characteristics of SO are presented. Firstly, the availability of the monthly mean sea level pressure data at Tahiti and Darwin and the statistics of the monthly pressure data are presented. Next, it is shown that the SO intensity (i.e., cross-correlation between Tahiti and Darwin pressure deviations) has become stronger and stronger since before 1900. The long-term fluctuation of SO intensity discussed statistically. Finally, the frequency characteristics of SOI by magnitude and by month (January-December) are described. We expect that these characteristics will offer useful background information when using SO for other analyses.

H32C-03 1605h

**Has the Frequency of Floods in New Zealand Changed?**

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Almost invariably, flood frequency analysis methods presume that the expected frequency of floods is unchanged from year to year: in statistical terms the series are said to be stationary. In the past, a paucity of long hydrological records and a lack of evidence in any forcing signals have meant that this assumption has rarely been challenged, but with increasing lengths of archived records, it can now be examined.

I report on a study of some of the longest flood records available in New Zealand. In the Bay of Plenty region in the north east of the North Island, the period from 1947-1977 was flood rich, whereas the period since 1978 has been flood poor. Opposite behaviour occurred in the south and west of the South Island: more large floods have occurred since 1978, compared with the period 1947-1977. Two sided t-tests of the mean annual floods (log-transformed) for the two periods and two nonparametric tests (Mann-Whitney U, Krushel-Wallis ANOVA) indicate that flood series for the west and south of the South Island are not stationary, but have

increased since 1978. Large changes in design flood percentiles occur when data from the two periods are compared.

The shifts are also evident in rainfall records. In the south and west of the South Island, increases in annual rainfall typically exceeding 10 percent have occurred, and increases in mean flows exceeding 15 percent are evident. The rainfalls are affected to a limited extent the state of the El Niño Southern Oscillation (ENSO) phenomenon and the mechanism driving the shifts appears to be a change in the relative frequency of El Niño and La Niña episodes since 1978. The change of the ENSO phenomenon is attributed to a change in the state of the Interdecadal Pacific Oscillation, a broadscale phenomenon that affects much of the Pacific Ocean.

These shifts have important consequences for the management of risk in relation to flood hazard and for water resource management. Future work will examine the areal extent of shifts in low flows.

H32C-04 1620h INVITED

**Global Multi-decadal Climate Variability: a Function of Solar Variability?**

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Recent research has revealed marked multi-decadal climate variability in many records in numerous parts of the globe. Much of the observed changes in regional climates have been related to low-frequency changes in mid-latitude Pacific Ocean sea surface temperatures. In this presentation, historic climate and hydrological variability is demonstrated - these historic changes in climate state are marked and correspond to changes in global sea surface temperatures. The following sections explore an alternative approach to understanding the possible influence of natural solar variability on climate states. A disaggregation approach is achieved through the use of a simple non-linear interpretive model. The results indicate that whilst the exact mechanisms controlling multi-decadal variability remain to be identified, significant coherence is observed with changes in solar irradiance. This observation presents many challenges for future global climate modelling efforts.

**H41A WCC: TH-Auditrm Thursday 0830h Hydrology General Posters**

**Presiding:** T S Lowry, Lincoln Environmental; T J Davie, Manaaki Whenua Landcare Research

H41A-01 0830h POSTER

**Site Assessment for Conjunctive Water Use using Analytic Hierarchy Process**

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Conjunctive use of surface and ground water can be a means to augment water availability and improve the overall reliability of water supplies. The issues on the suitability and the priority for conjunctive use depend on various decision-making factors. They include hydrogeologic, environmental, social, and economic attributes. This paper presents a method to assess the suitability of a site for conjunctive use of surface and ground water. It applies the analytic hierarchy process (AHP) in which a complex problem is divided into a number of simpler problems in the form of a decision hierarchy. In it, multiple and even competing objectives are involved and multiple alternatives are available. This paper (1) presents a method that can be used to identify and rank potential areas using AHP; (2) demonstrates the method by presenting a case study; (3) analyzes the effect of varying the relative importance accorded to decision factors.

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H41A-02 0830h POSTER

**Water Accounting as a Decision Support Tool for Assessing Water Use Performance: A Case of Singkarak-Ombilin River Basin in Indonesia**

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Because water is becoming the factor limiting development in many parts of the world, a systematic approach is needed to use water more productively. To address this need, Molden and Sakthivadivel developed a water-accounting procedure for analyzing water use patterns and tradeoffs between users. The procedure treats groundwater and surface water as a single domain. We adapted this procedure to account for ground-water and surface-water components separately, and applied the adapted procedure to the Singkarak-Ombilin River basin, Indonesia, where groundwater is a significant part of the overall water balance. The basin was selected because since 1998, a substantial proportion of water has been withdrawn from Singkarak Lake and diverted out of the basin for use in Singkarak Hydro Electric Power Plant (HEPP), resulting in significant impacts on downstream water users and the lake ecosystem. Based on 15-20 years (1980-1999) of hydrometeorological, land-use, soil, and other relevant data, we developed a simple ground-water balance model to generate hydrogeologic information needed for the water-accounting procedure. Results show that following the Singkarak HEPP operation, the amount of water depletion increases from 59%-81% to 82%-94% of total water supplies in the basin. By considering ground-water components separately, we find a more realistic estimation of water availability could be obtained. Moreover, the new water accounting demonstrates the viability of storing water in a shallow unconfined aquifer during wet periods in order to increase water availability in this basin, where surface-water sources are nearly fully utilized.

H41A-03 0830h POSTER

**Hydrologic Impacts of Institutional Change in Luancheng County, Hebei Province, North China Plain, 1949-2001**

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Water is the most vital and limiting resource in the 350,000 km<sup>2</sup> North China Plain. With all clean surface water allocated, industry, municipalities, rural households, and irrigators are left to compete over a diminishing ground-water resource, even as production continues to increase. As a result, the North China Plain, home to more than 200 million people, now depends upon unsustainable critical agricultural and industrial economy. Streamflow has almost completely ceased, the depth to ground water is declining 1-5 meters annually, salt water is intruding into previously fresh-water aquifers, and in some places the land surface is irreversibly subsiding.

This situation has not occurred suddenly, but rather has developed and perpetuated within an explicit, but dynamic, institutional framework. As cultural institutions evolved, water-use practices and the consequent hydrologic impacts changed accordingly. The causal relationships between institutions and hydrology are especially salient in the North China Plain, where many well-documented social, political, and hydrologic changes occurred over a relatively short time.

Water-table observations, pumping estimates, economic statistics, interviews, and historical maps and chronicles reveal the causal links between hydrologic