The Ecohydrology and Hydrometeorology Research Group

EcoH2OMe

The EcoH$_2$OMe research group investigate **soil and plant water relations**, and **land surface and atmosphere interactions**, to understand how these interactions in **the critical zone** respond to climate and environmental changes, and the consequences of these responses in **water resources, ecosystem functions, food productivity, and urban climate & environment**. We integrate ***field experiments***, ***remote sensing***, ***environmental tracers***, and ***mathematical modelling*** in our research.

← Here are some examples of EcoH$_2$OMe research

We monitor "blood pressure" and risks of "heart attack" for trees

For a human being, the heart maintains a positive ***blood pressure*** of about 0.2 bar to keep blood circulating in the body. For a tree, negative pressure (called ***water potential***) is maintained so that trees can uptake water from the root-zone soil. To make this happen, water potential in a tree has to be lower than that in soil. Trees use small apertures in leaves (called ***stomata***) in a way very much like how we use a valve to control water flow in a pipe, and meanwhile to adjust water potential in vegetation body. Fig 1 shows part of stem water potential (SWP) data we have collected from a drooping sheoak tree, showing that in some days the tree can have a water potential below -2 MPa (-20 bar !). Actually it can go even lower.

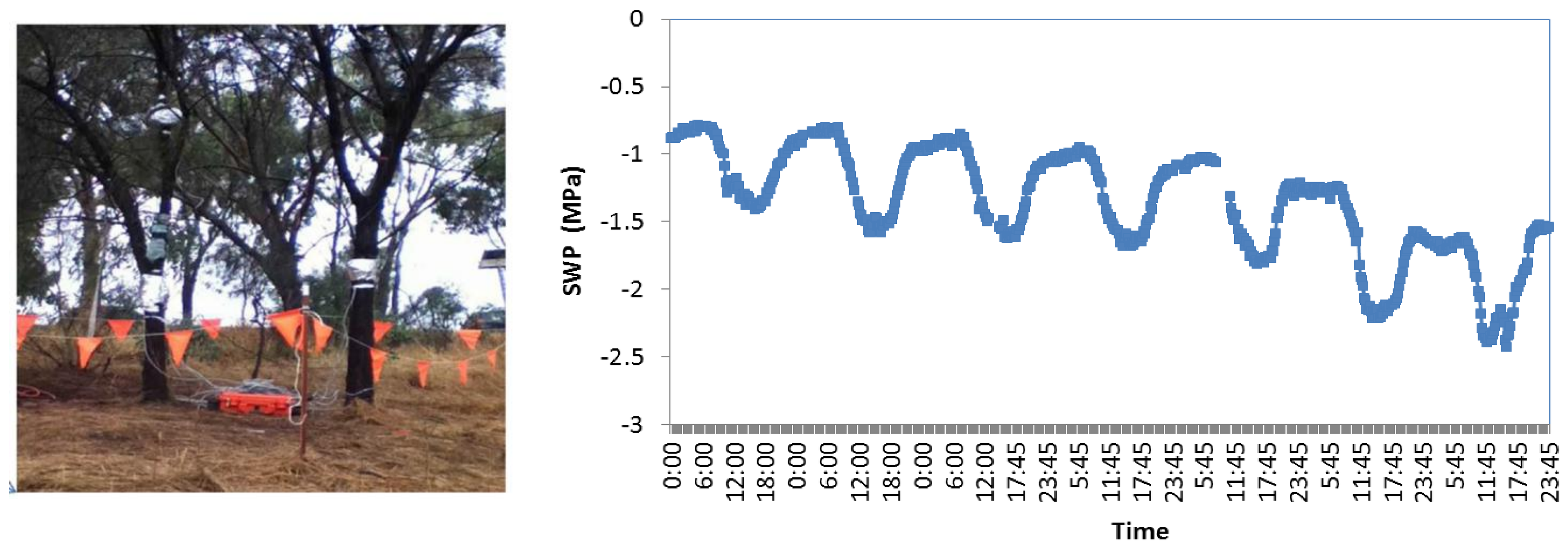

Figure 1. Measured half-hourly stem water potential on a drooping sheoak tree on Flinders University campus.

In a human body, blood flows in arteries and veins. When oxygen-rich blood supply to heart muscle stops due to an artery blockage, a ***heart attack*** occurs. In vascular plants, water forms continuous columns in xylems and slowly moves from roots to leaves driven by a water potential gradient. When air/vapour bubbles form under a low water potential, these liquid water columns in xylem can break (***xylem cavitation***) and stop supplying water for leaves. If this lasts for some time, trees may die.

Nature has played on a continental scale water-storage seesaw in Australia

In Australia, large-scale wetting episodes roughly occurring once every decade lead to imbalance between terrestrial water storage and vegetation cover. Our recent investigation based on remote sensing data revealed an opposite temporal variation pattern of terrestrial water storage between eastern and western Australia. It is characterised by eastern Australia gaining water, while western Australia is losing water, and vice versa. These seesaws are associated with vegetation mediation of soil moisture (Fig 2). This finding has useful implications for management of wildfire risk and water resources in Australia.

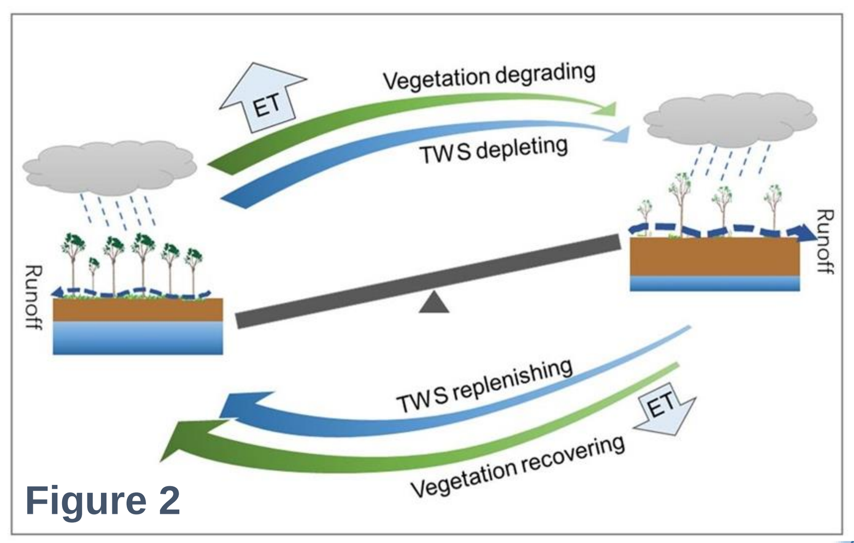

Figure 2

A teleconnection may provide South Australia 7-year lead time for planning

Teleconnections generally refer to linkages between climate anomalies over great distances and with certain time lags. They are useful for predicting climate (e.g., precipitation) variability, and thus can benefit water and agricultural planning. Precipitation teleconnections are often associated with coupled ocean-atmosphere oscillation systems, such as the El Nino and South Oscillation (***ENSO***).

We have found a teleconnection (Fig 3), which provides a seven-year lead time for predicting wet-season precipitation in coastal areas of South Australia (SA). The teleconnection between a positive Antarctic Oscillation (***AAO***) phase and increased SA precipitation, and vice-versa, is very likely realized via three sequential steps in a warm Pacific Decadal Oscillation (***PDO***) phase: a 27-season lag positive correlation between the AAO and sea subsurface potential temperature (SSPT) to the south of SA; a zero-season lag positive correlation between sea surface temperature (***SST***) and SSPT; and a 2-season positive lag correlation between SA precipitation and SST.

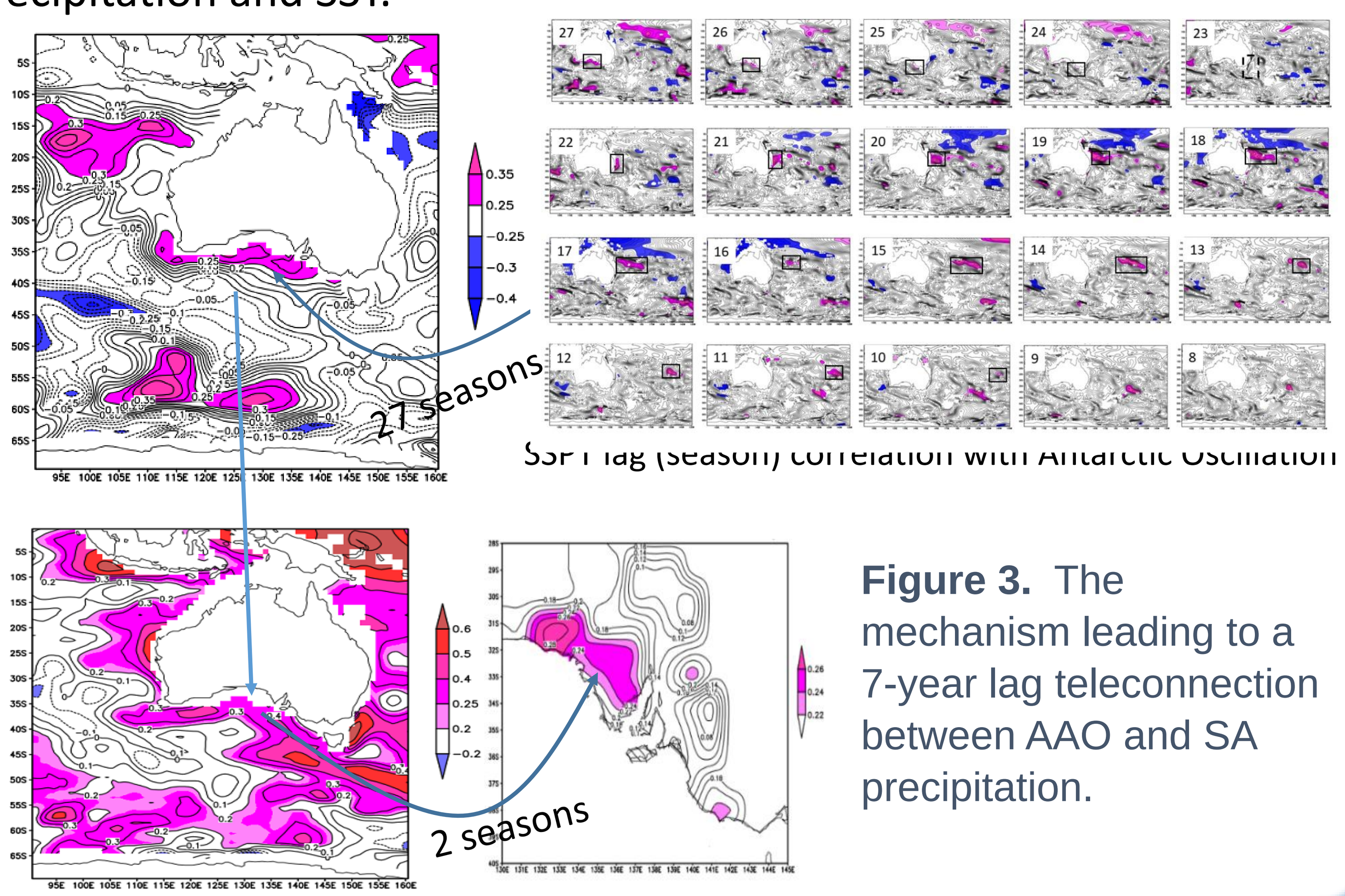

Figure 3. The mechanism leading to a 7-year lag teleconnection between AAO and SA precipitation.

Sea breezes cool summer Adelaide, but lose its power 40 km inland

It is commonly thought that city centres are warmer than the surrounding suburbs and rural areas. This is a phenomenon called urban heat island. Our multiple-year research (Fig 4) has found that Adelaide CBD is not the hottest spot in summer days (hottest in nights!). Unexpectedly the inner southern suburb of Unley emerges as 1^{o} C warmer than the Adelaide CBD and up to 4^{o} C warmer than beach suburbs. Other hot spots appear in Mitcham and the northern council areas of Salisbury, Port Adelaide-Enfield, Tea Tree Gully and Campbelltown. These hot spots are very likely out of reach of sea breeze cooling.

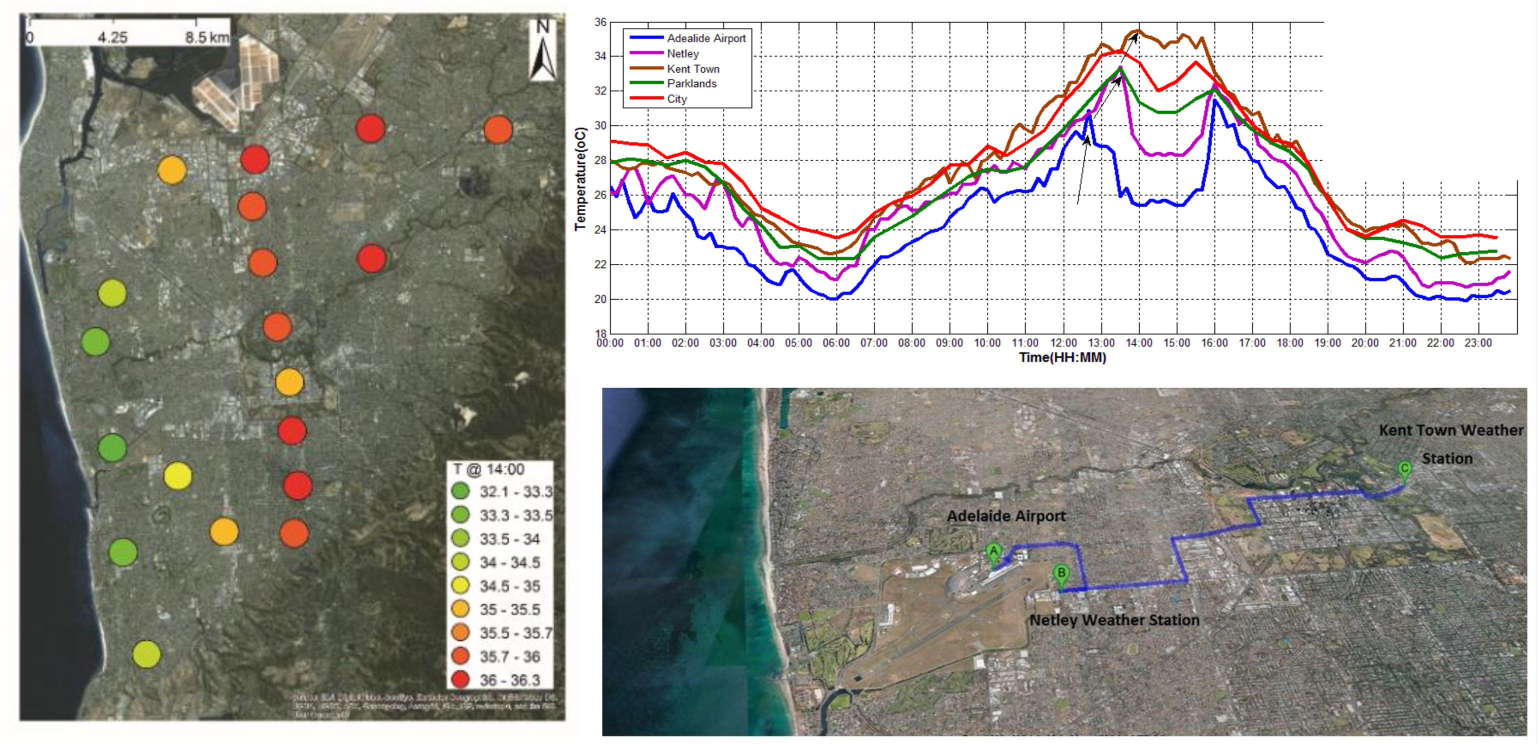

Figure 4. Air temperature at 2 PM averaged over heat wave days in 2011-2013 (left), and the diurnal temperature variations at different locations in a typical sea-breeze day (right).

Sea breezes are an important cooling source in summer. A six-degree cooling is easily observed at the Adelaide airport at the onset of a sea breeze. When a sea breeze progresses inland, it gradually loses its cooling power. Sea breeze cooling power seems to penetrate about 40 km inland in our area. Adelaide CBD is within this distance and benefits from sea breeze cooling. The wider area in the northern Adelaide is around the end of this distance, explains the northern hot spots. Unley and Mitcham are likely in a sea-breeze shadow, which remains to be further investigated.

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