

The Earths Eldest at the Frontier of Change

The bristlecone pine story

Annual resolution climate and meteorological signals in Bristlecone Pine Needles.

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I Annual resolution data are obtained from needles of bristlecone pine, *Pinus longaeva*, from the White Mountains, California, USA. The bristlecone pine, living at the tree line in extreme alpine conditions is known for its longevity, some individuals are **the world's oldest non-clonal organisms**.

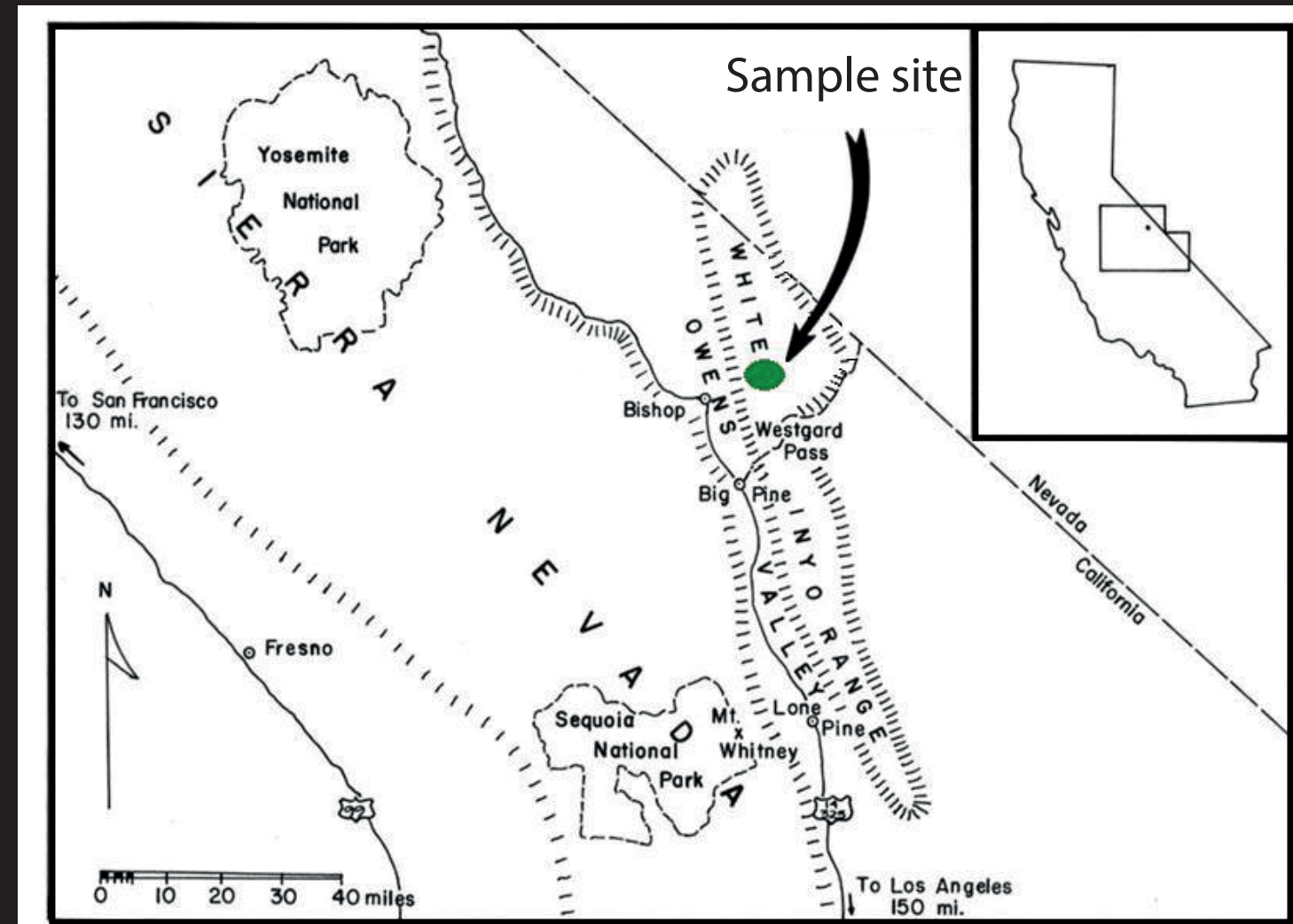


Figure 1: Map of the sample area, in the White Mountains, California, USA.

Adapted from: http://www.geol.ucsb.edu/faculty/sylvester/BIRCH_CREEK/BCpages/BCLOCMAP.html



Figure 2: Bristlecone SHP-610, among used in this study.

Table 1: Sample properties and information.

Name of tree	Location	Time range	Altitude	Situation
SHP 610	Sheep Mountain	1991-2011	3513 m	South-eastern slope, at tree line.
06-950	Sheep Mountain	1994-2011	3512 m	South-eastern slope, at tree line.
06-949	Sheep Mountain	1985-2011	3509 m	South-eastern slope, at tree line.
SWAN 04	Sheep Mountain	1981-2011	3523 m	South-eastern slope, at tree line.
SWAN 09	Sheep Mountain	1993-2011	3326 m	South-eastern slope, 200 m below tree line.
BCP 1	Sheep Mountain	1971-1983	+/- 3500-3515 m	Probably South-eastern slope, at tree line.
BCP 2	Campito Mountain	1968-1983	+/- 3300-3450 m	Probably North-western or North-eastern slope, possibly at tree line.
BCP 3	Sheep Mountain	1971-1983	+/- 3500-3515 m	Probably South-eastern slope, at tree line.

Most samples were taken from very similarly situated trees, at or near the tree line. This is important because of the high degree of environmental variability within a small area. See Table 1 for details of the samples.

IV PDO, the Pacific Decadal Oscillation

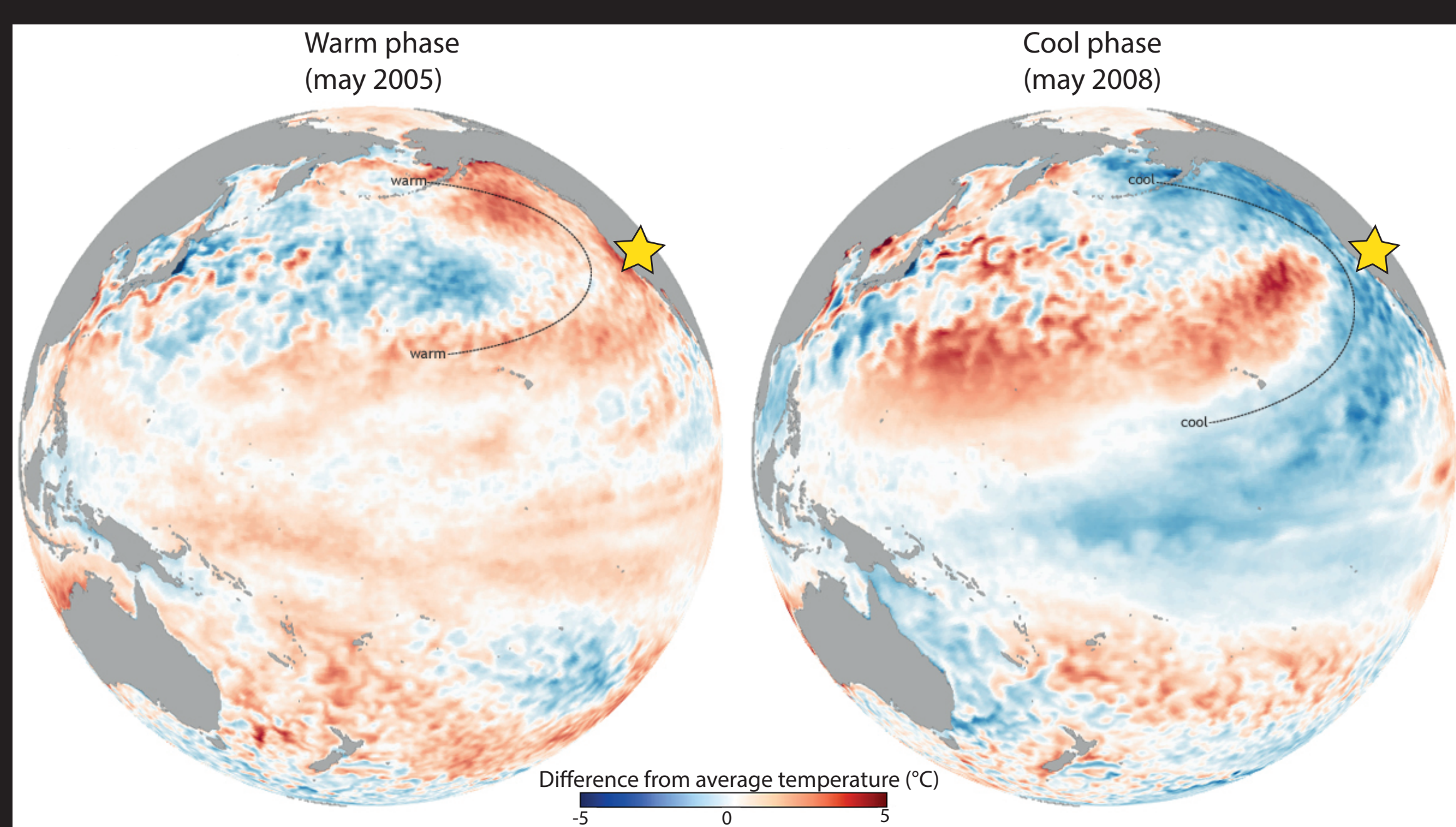


Figure 6: Map of the northern Pacific with SST of the Warm and Cool phases of the PDO. Stars indicate sample area.

Adapted from: http://www.climate.gov/sites/default/files/HR_PDO2005-2008.jpg

The Pacific Decadal Oscillation (PDO) is a monthly sea surface temperature (SST) index representing an oceanic climate system that is of major influence in the northern Pacific region. Its effects are also notable in the study area (White Mountains, CA, USA) by being responsible for temperature and precipitation pattern changes.

II



Figure 3: SWAN 08 branch (representative bristlecone pine twig) shows the distinguishable annual growth of the needles. The needle retention time is up to 40 years.

The Bristlecone pine's suitability for annual resolution studies is unique because the tree holds on to the needles longer than any other plant and the needles grow in fascicles that are clearly distinguishable for each growth year. In the present study a continuous 44 years long series of needle-length have been analyzed. Needle-length has not yet been studied as independent parameter related to long or short term climate variability.

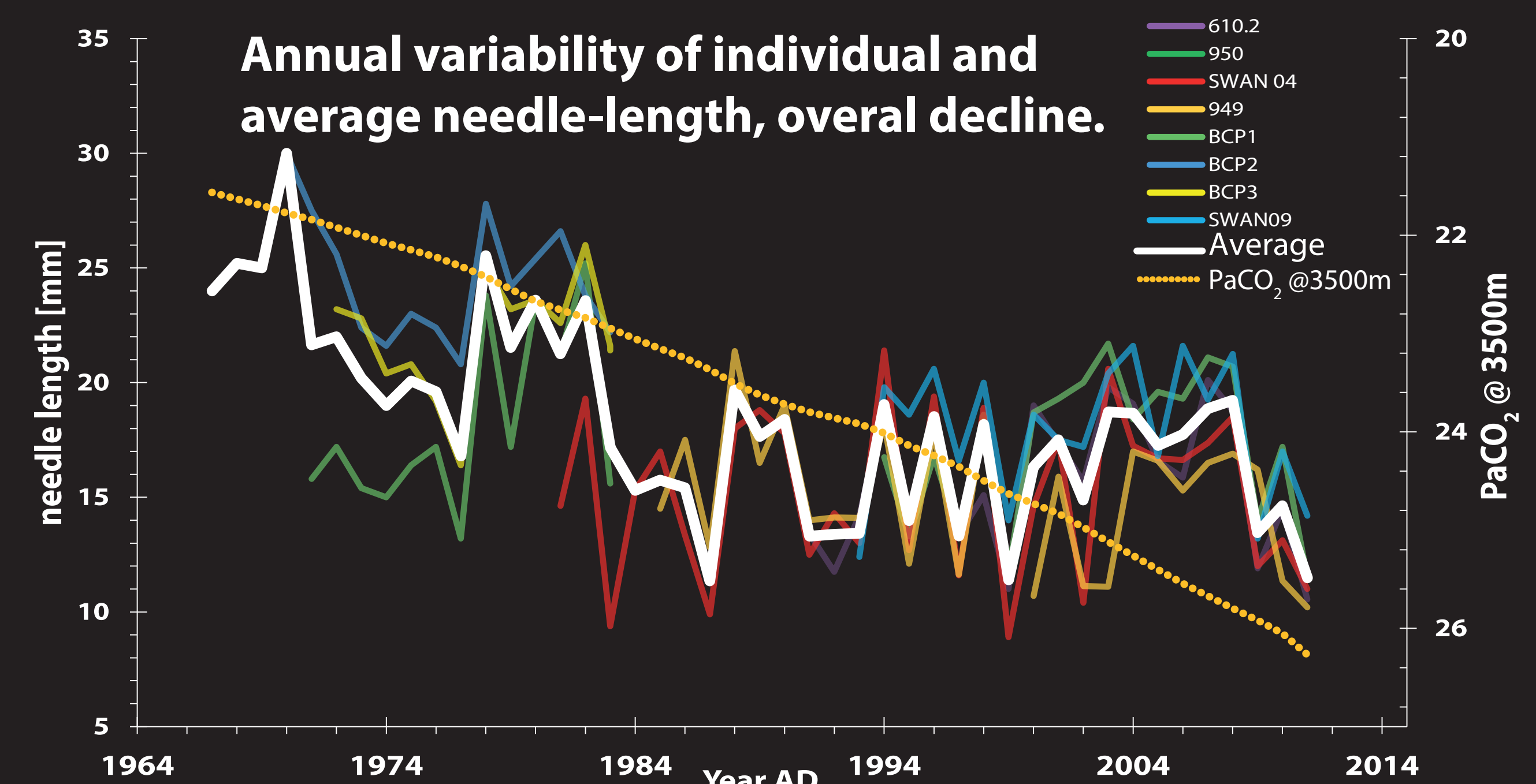


Figure 4: Annual individual needle-lengths and the average, representing the annual variation. Rising atmospheric CO₂ might account for the overall decline.

III

Distinct annual needle-length variations corresponded highly among eight different individual trees that were sampled. In this data-set, two signals can be distinguished, an overall declining trend in needle length and an annual signal. The declining trend provides evidence for a negative relation between atmospheric CO₂ concentration and needle-length.

V

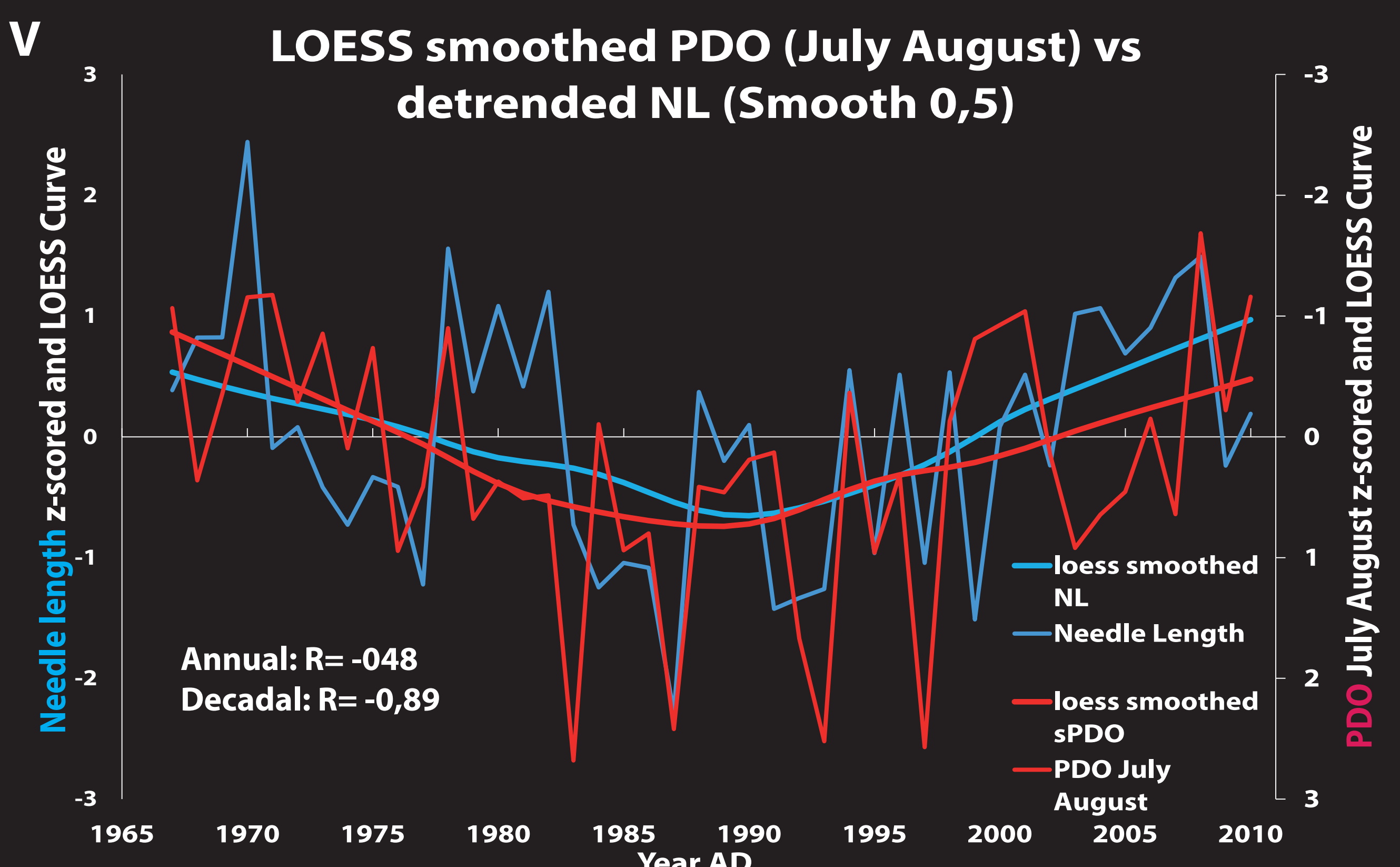


Figure 5: Detrended z-scored needle-length and annual PDO index and detrended (inversed axis), show high annual similarity (R=-0,48). When smoothed, the decadal trend is visible and the correlation is even higher (R=-0,89). PDO index data freely available through the KNMI climate explorer on <http://jisao.washington.edu/pdo/PDO.latest>

The annual variation in needle length might be related to the dominant climate system in the area, the PDO (Pacific Decadal Oscillation) which describes humidity and temperature regimes in the northern Pacific region.

Our results for the first time demonstrate needle-length dependence on CO₂, temperature and humidity on multi decadal to annual timescale.



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