Tree Growth and the Westerlies in the Southern Hemisphere

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Understanding the causes of variability in the Southern Hemisphere circumpolar westerlies is hampered by short instrumental observations that barely exceed 50-60 years in most cases. Long tree-ring records from appropriate SH land areas have been used to successfully bridge this knowledge gap. An early highly successful, yet rarely cited, example is the work of Ricardo Villalba and others published in 1997 in which a tree-ring reconstruction of the Trans-Polar Index (TPI) was described. The TPI, originally based on the pressure difference between between Hobart, Tasmania (43 °S 147 °E) and Stanley, South Atlantic Ocean (52 °S 58 °W), was proposed by Pittock (1980) to measure the eccentricity of the polar vortex around the South Pole. When the TPI is positive the subtropical anticyclones and the westerlies are displaced further south in the Australian-New Zealand sector. In contrast, in the South American-South African sector, the subtropical anticyclone and the westerlies will be shifted towards the equator resulting in major precipitation and temperature variations in the affected regions. Climatically sensitive chronologies from Tierra del Fuego (54-55°) and New Zealand (39-47°) were used to develop a verifiable reconstruction of the Austral summer TPI (STPI) back to 1745. It revealed persistent multi-decadal variations in STPI, with most of the 19th century locked into a negative index phase. In turn, the reconstruction was found to be strongly coherent with the Southern Oscillation Index (SOI), an unexpected finding at the time. More recent work by Villalba and others have now used a much denser grid of tree-ring chronologies from Tasmania-New Zealand and South America to directly reconstruct an index of the summer Southern Annual Mode (SAM), essentially a measure of the pressure gradient between Southern Hemisphere mid and high latitudes. In this case, tree-ring-based reconstructions of summer SAM indices suggest that the high frequency of the positive phase SAM since the 1950s is unprecedented in the past 600 years, most likely reflecting the impact of polar stratospheric ozone depletion.