# Unravelling the Holocene history of the Southern Westerlies: a latitudinal transect of terrestrial (peat) records from the South Indian Ocean

Nathalie Van der Putten[a], Florian Adolphi[b], Anette Mellström[c], Jesper Sjolte[c], Jan-Berend Stuut[d], Raimund Muscheler[c] Elisabeth Michel[e], Cyriel Verbruggen[f], Emmanuel Chapron[g], Jacques-Louis de Beaulieu[h], Svante Björck †

[a] Department of Earth Sciences, Free University Amsterdam, Amsterdam, Netherlands, n.n.l.vanderputten@vu.nl; [b] Alfred Wegener Institute, Bremerhaven, Germany, florian.adolphi@awi.de; [c] Department of Geology, Lund University, Lund, Sweden, anette.mellstrom@gmail.com; jesper.sjolte@geol.lu.se; raimund.muscheler@geol.lu.se; [d]Royal Netherlands Institute for Sea Research (NIOZ),Texel, The Netherlands, Jan-Berend.Stuut@nioz.nl; [e] Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Gif-sur-Yvette, France, elisabeth.michel@lsce.ipsl.fr; [f] Department of Geology and Soil Science, Ghent University, Gent, Belgium, c.verbruggen@ugent.be; [g] Université Toulouse Jean-Jaurès, CNRS, France, emmanuel.chapron@univ-tlse2.fr; [h] IMBE, Aix-en-Provence, France, jacques-louis.debeaulieu@orange.fr

The Southern Hemisphere mid- to high latitudes are strongly influenced by the rain-bearing Southern Hemisphere Westerly winds (SHW), acting on large-scale precipitation and temperature patterns, dictating the climate between the latitudes 30 to 60°S. Changes in the intensity and position of the SHW are believed to control wind-induced upwelling in the Southern Ocean (SO) and hence, the oceanic meridional overturning circulation and atmospheric $CO_2$ variations, during deglacial times, the Holocene as well as in recent times (i.e. Toggweiler, 2009; Moreno et al., 2010, Gruber et al., 2019). However, despite substantial research efforts during the last decades, proxy-based knowledge on the strengthening and/or latitudinal shifts of the SHW is still fragmentary and sometimes contradicting. A prerequisite for reconstructing latitudinal changes in zonal winds is the availability of well-dated terrestrial records that (i) reflect atmospheric conditions and (ii) are situated on a latitudinal transect covering the wind belt. We study the pre-anthropogenic (Holocene) history of the SHW, by investigating a latitudinal transect of peat lands on a series of sub-Antarctic islands in the Indian sector of the SO: from Kerguelen Islands (49°S) located in the core of the modern wind belt, over the Crozet archipelago (46°S), to Amsterdam Island (37°S) at its northern edge. Here we will discuss two case-studies of Holocene SHW changes based on multi-proxy analysis of peat cores [e.g. pollen and plant macrofossil, XRF core-scanning, biogenic silica (BSi)]. The first study is a record for past humidity and windiness changes from the Crozet archipelago (46°S). A shift to wetter and windier conditions occurred about 2800 years ago, caused by a strengthening of the SHW and coinciding with a major decline in solar activity (Homeric minimum). A second study on past humidity and windiness changes originates from Kerguelen Islands (49°S). Accumulation rates in a peat core are very low (~0.1 mm/yr) between 9 and 5.5 kyr BP (thousand years Before Present). From around 5.5 kyr BP onward, a change to more humid conditions caused renewed peat formation prossibly caused by increased SHW influence. Superimposed on this long-term trend, multi-centennial variability was found from about 4 kyr BP onward, showing periods of both (i) higher wind intensity (increased *Azorella selago* pollen and Ti content and (ii) increased humidity (increased *Botryococcus* sp. and BSi percentages) suggesting cyclic SHW intensity changes. This research was partly funded by a grant to Svante Björck who in his later career moved his research interests from Scandinavia and the North Atlantic region to a global perspective applying the unique potential of lacustrine and peat sediments for reconstructing linkages in the global climate system.

## References

Gruber, N., Landschützer, P. & Lovenduski, N. S, 2019: The Variable Southern Ocean Carbon Sink. *Annual Review of Marine Science* 11, 159-186.

Moreno, P. I., Francois, J. P., Moy, C. M. & Villa-Martínez, R., 2010 : Covariability of the Southern Westerlies and atmospheric CO2 during the Holocene. *Geology* 38, 727-730.

Toggweiler, J. R., 2009: Shifting Westerlies. *Science* 323, 1434-1435.