

SHAPE Southern Hemisphere Westerly Winds workshop

Auckland NIWA, New Zealand, 28th -29th January 2014

Present: Heidi Roop (GNS, Victoria University Wellington), Steven Phipps (University of New South Wales), Andrew Lorrey (NIWA-Auckland), David Lowe (University of Waikato), Helen Bostock (NIWA-Wellington), Michael Shawn-Fletcher (University of Melbourne), Krystyna Saunders (University of Berne), Marcus Vandergoes (GNS Science) and Chris Moy (University of Otago)

Via Skype: Brian Chase (University of Montpellier) (28th Jan), Maisa Rojas, Fabrice Lambert (Universidad de Chile) (29th Jan)

The aims of the workshop were to:

- discuss the evolution of the Southern Hemisphere Westerly Winds (SHWW) over the SHAPE timescale of 60 ka to present
- keep the momentum going on the proposed SHAPE projects and, in particular, to develop more detailed plans for the proposed publications
- progress a compilation of changes in the SHWW across the Late Glacial – Interglacial Transition (LGIT); one of the key scientific outputs for the first phase of SHAPE.

The first day was spent with everyone giving presentations about their work, or presenting ideas around past changes in the SHWW. The first talk was by Helen Bostock discussing on the use of changes in the Subtropical Front (STF) in the oceans around New Zealand as a proxy for SHWW strength and position. Typically the STF has been defined by the steep gradient in sea surface temperatures (SST), but recent work using satellite SST data has challenged our understanding of using the SST gradient to define the STF (Graham and De Boer, 2013). Strong SST gradients in the west of the major basins are associated with strong currents and a dynamic STF, which does not shift seasonally, while weaker SST gradients are found in the central and eastern parts of the basins, where they shift between summer and winter. The different regions are controlled by different mechanisms. Can we use the SST data from different cores around our region to say something about the SHWW?



Opening discussion lead by Steven Phipps (left) at the SHAPE Auckland SHWW workshop. (L to R: Helen Bostock, Marcus Vandergoes, Michael-Shawn Fletcher, Chris Moy, Heidi Roop)

Brian Chase provided a fascinating overview of some recently published work from Southern Africa (extending from Angola to Cape Town) using a range of different proxies (phytoliths, charcoal, stable isotopes, pollen, ancient DNA) from Hyrax middens (piles of hyrax urine; similar to using speleothems; Chase et al., 2011 Geology; 2013 QSR). The middens are sampled at high resolution providing subdecadal -scale resolution. Nitrogen isotopes indicate changes in moisture patterns, while carbon isotopes suggest changes in the C3 to C4 plants. Together, they suggest that during cooler periods it was wetter and during warmer periods it was drier. This is very different from what global climate models (GCMs) show for this region. Contrary to expectations there is also evidence for an 8.2 ka event and Younger Dryas (YD) in this region rather than an Antarctic Cold Reversal (ACR), suggesting that there must be a strong atmospheric teleconnection to this region from the Northern Hemisphere/North Atlantic.



Brian Chase linking in with the SHWW workshop in Auckland via Skype to discuss his work from hyrax middens and Southern Africa.

Michael-Shawn Fletcher reviewed some of the work that he had done with Patricio Moreno on the SHWW and precipitation using pollen data from South American lake records (Fletcher and Moreno, 2011; 2012). He discussed some new pollen data from Lake Dobson in Tasmania where there is evidence for a local reversal during the LGIT with an increase in grasses at 14.9 ka and then a decrease to a minimum at 14.4 ka, followed by another increase at 14.25 ka. He has been developing pollen temperature calibration for Tasmania, but this has regularly produced some strange temperatures, which he suggests is the result of fire as the main driver of the vegetation as it corresponds to peaks in charcoal, rather than air temperature.

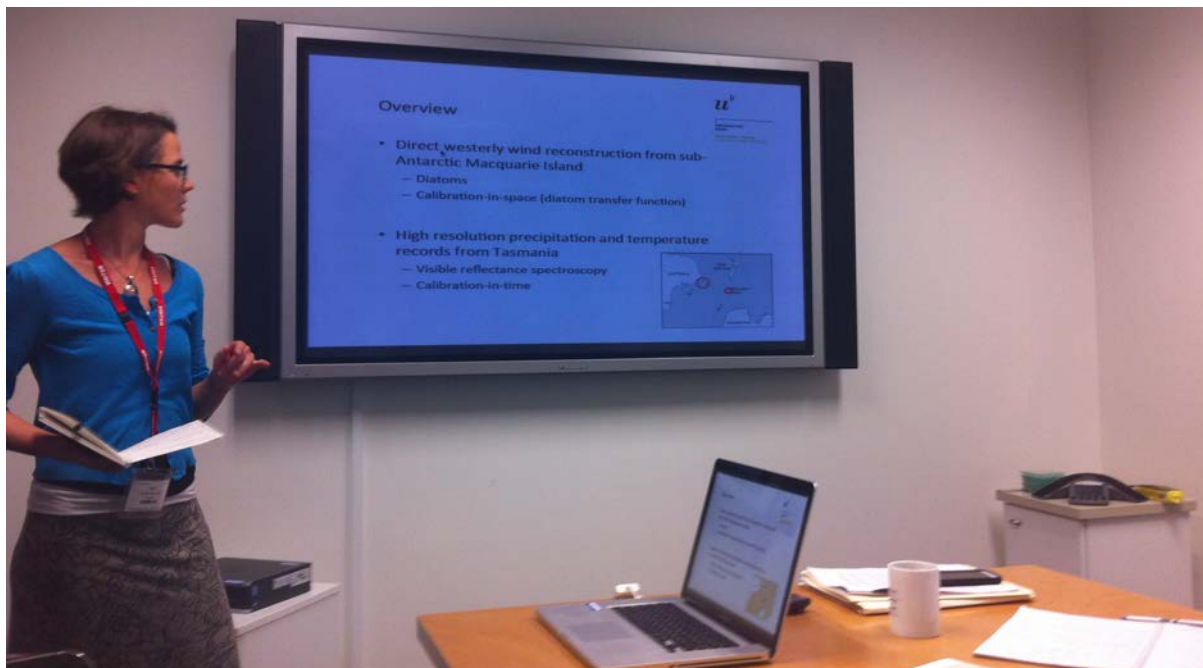


Michael-Shawn Fletcher discusses his westerlies work using South American proxies.

Krystyna Saunders discussed her work from Lake Rebecca in Tasmania, looking at the last 2ka. She has been using some visible reflectance scanning techniques to get some very high resolution data, along with total carbon, total nitrogen, biogenic silica, water content and grain size. By comparing the top part of the core with instrumental records she has been able to develop a calibration to precipitation (Saunders et al., 2012).

She also has some ongoing work on Macquarie and Campbell Islands, which sit in the middle of the SHWW. She is looking for evidence of changes in sea spray in lakes as evidence of changes in the SHWW. Sea spray gets thrown up on to the islands, with a strong gradient from west to east in small lakes. The aim is to reconstruct conductivity (salinity) using diatoms in the lakes back through time. She has been developing a local diatom-conductivity transfer function for each of the islands. Unfortunately the lake sediments from a core on Macquarie Island are relatively low resolution with 110 cm core going back to >16 ka, although the top 20 cm cover the period since European arrival. She needs better dating at the base of the core, but there appears to be a decrease in conductivity at the end of the LGM.

Krystyna is also linked to a project on the Subantarctic Islands lead by Dominic Hodgson from the British Antarctic Survey, with a paper in press right now which reviews our current knowledge of paleoclimate from these islands.



Krystyna Saunders gives a presentation about Southern Hemisphere Westerly Winds from the perspective of small, remote islands in the Southern Ocean.

Marcus Vandergoes discussed the potential to tease out more about precipitation and possible SHWW proxies from pollen records from the lakes and bogs on the east and west coasts of the South Island of New Zealand. This might involve picking some of the more minor, sensitive species as indicators of moisture change. He mentioned a variety of ongoing work on some new lake cores that might provide some insights, including Forks Lagoon on the eastern side of the Alps, near Lake Tekapo, which is bounded by moraines that date to MIS4. This lagoon has no groundwater hydrology

and is therefore completely controlled by rainfall and evaporation. The site is affected by both westerlies and southeasterly winds. The possibility exists of using the ratios of aquatic plants to develop a lake level index for wetter and drier intervals. He also presented work from Boundary Stream Tarn, Eltham Bog and Adelaide Tarn (Ignacio Jarra's PhD – just submitted for publication). There is some possibility for dust work in some of these records.

Heidi Roop presented some of her PhD work on monitoring and short cores from Lake Ohau, testing the climate-varve relationships. Despite the temperate mid-latitude setting there is the right environment to preserve clastic varve formation. Lake Ohau is a relatively small basin which formed around 17.4 ka, with the headwaters at the watershed divide between the west coast and the east coast. There is very little ice in the catchment. Summer rainfall is 2 x greater than in winter and there is a strong correlation between rainfall and inflow into the lake from the monitoring records which go back to 1926. Sediment deposition appears to be strongly controlled by precipitation. The core site near the outflow of the lake exhibits thick summer, dark coloured, coarse grained varves from the river and hyperpycnal flows within the lake, and thinner winter, light coloured, fine grained varves formed by the residual sediment falling out of suspension when the lake is isothermal. Sediment is accumulating at an average of 5mm per year, although there is evidence of some thicker storm deposits. A range of different dating techniques have been undertaken on the 6 m core including ^{137}Cs , ^{210}Pb , ^{14}C on macro fossils, changes in pollen. These have been tested against varve counts by 3 individuals. The short core goes back ~1200 years. She is also testing the potential to use different grainsize and storm bed thicknesses to determine the source/direction of the winds and precipitation using the NOAA model Hysplit. A Marsden project was recently funded to go and retrieve longer cores from the lake, potentially back to 17.4 ka.

Chris Moy presented some work from South America from Lago Guanaco (Moy et al., 2008). This suggests that declining $\delta^{13}\text{C}$ during the Holocene is indicative of decreasing westerly winds during the Holocene, with possible millennial cycles. He also presented some new work that he has been involved with on Lake Von, near Queenstown in New Zealand, where there appears to be a 16 ka record from biomarkers. They have been testing out analysing algal versus terrestrial biomarkers. This could be a good site for further high resolution work.



Chris Moy discussing Holocene SHWW variations and proxies from New Zealand and South America.

Steven Phipps discussed a paper submitted recently by Nerilie Abram (Nature Climate Change), which reconstructs the Southern Annular Mode (SAM) over the last 1000 years and performs a data-model comparison to determine the drivers of past changes. He suggested that SHAPE provides the opportunity to extend this approach to study the evolution of SAM over the past 8ka. He also present analysis of some transient model simulations of the past 8ka, which have been completed as part of Phase 3 of the Paleoclimate Modelling Intercomparison Project (Bakker et al., in review for QSR). Nine models were used, including both intermediate complexity models and full GCMs. Only one of these models has a dynamic ice sheet, and only two have dynamic vegetation. Some of them have been run with accelerated orbital forcing, and most include past changes in greenhouse gases.

The models suggest an intensification and southward migration of the SHWW from 8-0 ka, with an increase in precipitation over the Southern Ocean. Bakker et al. compare the simulated temperatures with a new compilation of proxy data presented within the same special issue of QSR. The opportunity exists for SHAPE to reconstruct changes in the SHWW over the past 8ka, for comparison with the simulated changes.



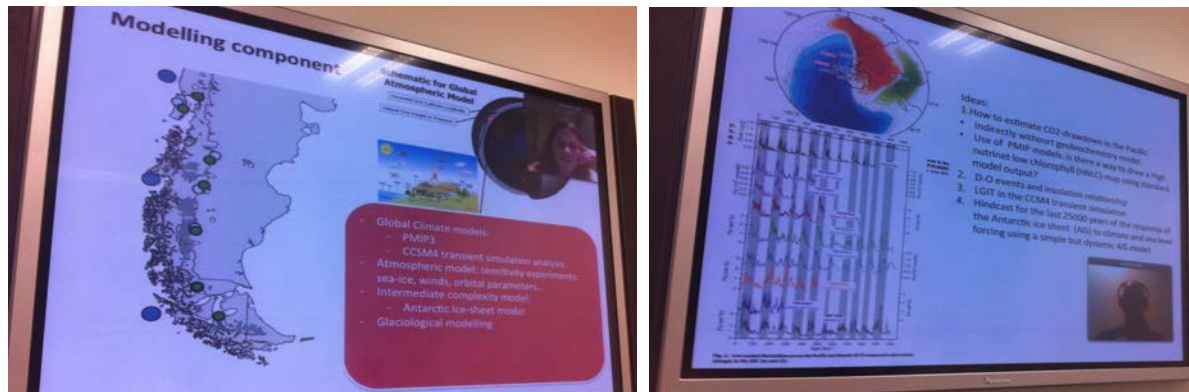
Steven Phipps discusses potential for proxy-model integrations for the SHAPE initiative.

Maisa Rojas gave an overview of their new millennium funded project in Chile looking at SHWW which they will work on for the next 3 years. They have three main questions they hope to address with a multidisciplinary team based in Chile, linking to international work.

Questions?

- How has the coupling between the SWW and CO₂ evolved over the last 25,000 years?
- How did Patagonian glaciers and vegetation respond to climate forcing over the last 25,000 years?
- Do terrestrial and marine paleoclimate archives provide a congruent history of past changes in temperature, SWW circulation and modes of variability?

They will have 4 main focuses: sediment core, lake cores, glacier records and modelling. They will use a range of different proxies including radiocarbon, stable isotopes, tephras, pollen etc. They will compare the proxy results with modelling results from the CCSM4 transient simulation “SynTrace 21” and other PMIP3 models, including both full GCMs and intermediate complexity models which incorporate dust, glacier modelling and Antarctic ice sheet models.



Maisa Rojas(left) and Fabrice Lambert (right) join into the SHAPE SHWW workshop via Skype to discuss their new projects focused on Chilean reconstructions covering the LGM to present.

Fabrice Lambert discussed the recent paper in Science by Frank Lamy (Lamy et al., 2014) where they looked at dust and opal measurements across the Southern Pacific. These were compared to dust models and suggest that the dust in the South Pacific is from Australia/NZ, with 3-4 times greater dust input during the glacials than the interglacials. The Pacific did therefore potentially contribute to CO₂ drawdown. The Australian source didn't change as dramatically as the S. American source. They haven't yet performed geochemical fingerprinting. Rainer Gersonde (who was the voyage leader of the 2010 Polarstern voyage) is presumably looking at the sea ice diatoms to determine the extent and retreat of sea ice between glacials and interglacials from these cores.

Andrew Lorrey also demonstrated PICT to the group as many had not seen the platform at the previous SHAPE meeting in Wellington. PICT can be used to investigate the role of changing synoptic types and their influence on terrestrial proxies, so potentially could be a good tool to look at atmospheric circulation changes and therefore the SHWW. So far PICT has only been trialled in New Zealand for the Little Ice Age, with data from the mid Holocene and the last 2ka currently being entered. It should be relatively easy to develop for Tasmania and South Africa where there is good reanalysis data. However, it will be a little trickier for South America because of the paucity of reanalysis data sets and gridded fields that have a fine spatial resolution (but not impossible). He will probably add further reanalysis fields such as uWind as a proxy for westerly strength and position, and others that might be useful for reconstructing SHWW. There are currently geopotential at 1000hPa and SSTa for the ocean – but perhaps he can try to develop SSH (sea surface heights – a proxy for currents) and productivity/chlorophyll (presumed to be difficult). PICT currently works best in the Holocene, but may work for previous interglacials and potentially has application if add on calculations are incorporated to remove orbital influences on climate anomalies and account for sea level and other boundary condition shifts. That is an ongoing goal to improve tool functionality and application to the wider Quaternary.

The rest of the workshop was spent discussing how to develop some of the ideas that came up during the original SHAPE meeting in September 2013, especially the LGIT paper that is a promised deliverable by 2015, and which is being led by Michael-Shawn Fletcher.

- LGIT - What are the aims of this paper? Looking at the timing of the ecological responses and climate transitions from the LGM all the way through to the Holocene. Focus will probably be on the ecological changes, especially succession of vegetation following the glacial. It is highly likely that the timing of the changes will be asynchronous in different regions and for different proxies. There is also a subquestion about whether the inertia of ecological change after the last termination is significantly disrupted by events like the ACR.

Can we test the Toggweiler hypothesis that the SHWW drive the deglaciation and the different theories of Denton et al., 2010 and Lee et al., 2011? The timing of the deglaciation in the Subantarctic islands has recently been addressed by Dominic Hodgson in a paper in press. The atmospheric circulation patterns suggested by Denton et al. 2010 should be testable using PICT.

- Last 8 ka - There were also discussions around looking at the model versus terrestrial temperature or precipitation proxy data which could have a relationship to SAM – in order to reconstruct SAM over the last 8 ka. PICT could also be used to look at timeslices across this period, for comparison between model and proxy opinions. Steven Phipps will lead this.
- In association with the PAGES 2k Network, the New Zealand last 2K paper will be redone using PICT. Led by Andrew Lorrey.
- Tephra chronology from 30-60 ka – new date for the Rotoehu tephra of 47 ka by Danisik et al. (2012) using U/Th and He dating. Possible help from kauri tree rings across this time period.
- Last 4 ka – trans-Tasman comparison between Tasmania and New Zealand and Subantarctic islands. Probably in SHAPE phase II as the data is still being developed. Led by Krystyna Saunders.

If you are interested in being involved in any of these papers please contact the lead authors mentioned above.

Possible places where SHAPE activities in 2014 and 2015 will take place, for your diary....

- Virtual meetings – Feb 2014 (via Skype or teleconference)
- AQUA conference – June/July 2014 Mildura, Australia
- SHAPE workshop on tools for climate modelling and proxy calibration and interpretation – July 2014 Brisbane, Australia (possible ECR support from SHAPE)?
- SHAPE workshop – Early 2015, Chile
- INQUA Congress – July-August 2015, Nagoya, Japan