

New Zealand pollen climate reconstructions for three interglacials and their relevance to climate projections for the 21st century

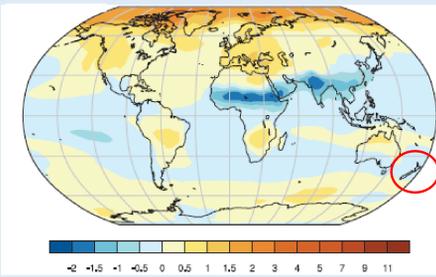
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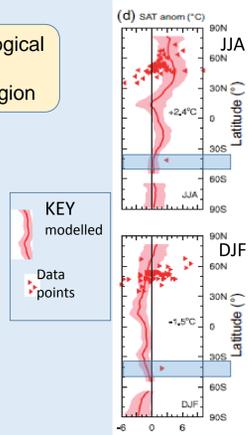
1. Background

- Interglacial thermal optima can give insight into regional biological response in a warmer world
- Data-model comparisons problematic for Southern Ocean region



Last Interglacial simulated annual surface temperature anomaly (°C)
Source: Masson-Delmotte et al (2013) IPCC Fifth Assessment Report

Air temperature anomaly



2. Te Wāhipounamu South West New Zealand

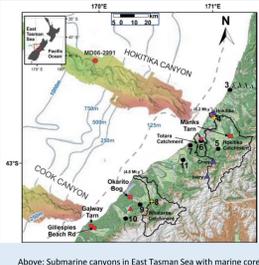
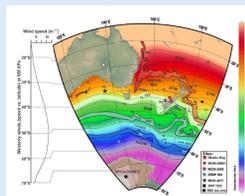


- UNESCO World Heritage Site
- Includes unique New Zealand lowland podocarp forest
- What threats posed by climate change?

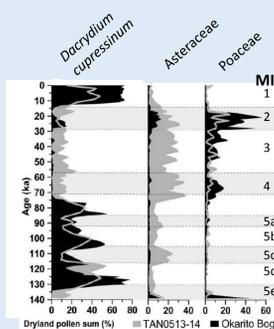
3. Approach

- Hokitika Canyon in east Tasman Sea allows direct land-sea comparison via palynology at a major ocean current boundary (Subtropical Front)
- Here we examine SSTs and pollen-climate reconstruction for MIS 1, 5e, 11

Below: Principal ocean currents, mean annual Sea surface temperatures (SST) and mean westerly wind strength across New Zealand region



Above: Submarine canyons in East Tasman Sea with marine core drill site MD06-2991 and adjacent Westland region showing key on-land pollen sites (red) including Okarito Bog and modern pollen sampling sites (black) (from Ryan, 2017)



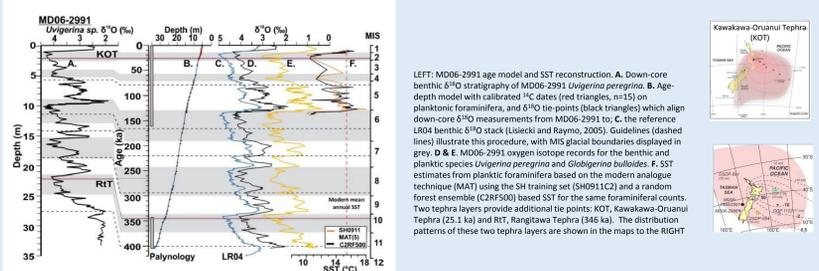
Above: Comparison of pollen percentages for key selected taxa between marine core TANO513-14 from East Tasman Sea and Okarito Bog from adjacent Westland (see map for site locations) (Ryan et al., 2012)

4. Chronology, sea surface temperature reconstructions

- 2 marine cores dated by radiocarbon with tephra and pollen tie points (MIS 1&2) and by comparison with LR04 stack (>MIS 2)
- SSTs determined by Modern Analogue and Random Forest techniques applied to foraminifera assemblages

Site	Early Holocene	MIS 5e	MIS 11c
MD06-2990	-	-	+1.6°C [r]
MD06-2991	+0.8°C [r]	+1.3°C [r]	-
MD06-2986	+0.6°C [ann]	+1.4°C [r], +3.0°C [ann]	+3.6°C [ann]
MD06-2988	-	-	+3.1°C [ann]
MD06-2989	-	-	+3.3°C [ann]

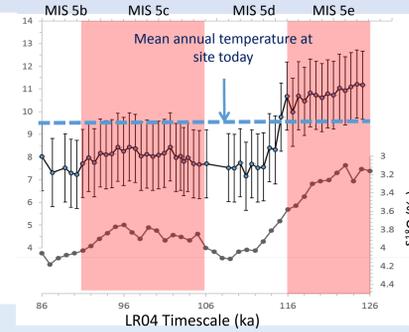
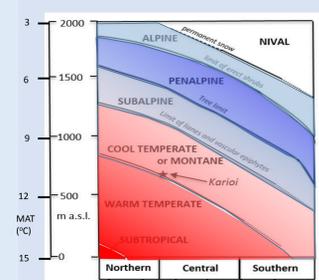
ABOVE: Comparison of RF (°) and ANN (°) foraminiferal and dinocyst (red) based reconstructions of SSTs from marine cores at sites adjacent to South Island New Zealand for the warm interglacials. Sources: Ryan (2017); Prebble et al., 2016



LEFT: MD06-2991 age model and SST reconstruction. A. Down-core benthic $\delta^{18}O$ stratigraphy of MD06-2991 *Uvigerina peregrina*. B. Age-depth model with calibrated ^{14}C dates (red triangles, n=15) on planktonic foraminifera, and $\delta^{18}O$ tie points (black triangles) which align down-core $\delta^{18}O$ measurements from MD06-2991 to; C. the reference LR04 benthic $\delta^{18}O$ stack (Lisiecki and Raymo, 2005). Guidelines (dashed lines) illustrate this procedure, with MIS glacial boundaries displayed in grey. D & E. MD06-2991 oxygen isotope records for the benthic and planktic species *Uvigerina peregrina* and *Globigerina bulloides*. F. SST estimates from planktic foraminifera based on the modern analogue technique (MAT) using the 54 training set (SH9511C2) and a random forest ensemble (C4RF500) based SST for the same foraminiferal counts. Two tephra layers provide additional tie points: KOT, Kawakawa-Ouanuani Tephra (25.1 ka) and RET, Rangitoto Tephra (346 ka). The distribution patterns of these two tephra layers are shown in the maps to the RIGHT

5. Air temperature reconstruction (MIS 5e)

- Few air temperature reconstructions for NZ MIS 5e
- New record from Karioi, central North Island (Newnham et al., submitted, QSR)
- Mean annual temperatures reconstructed by calibration with 'modern' pollen-environment training set (Wilmshurst et al., 2007) corroborated by modern vegetation-climate relationships

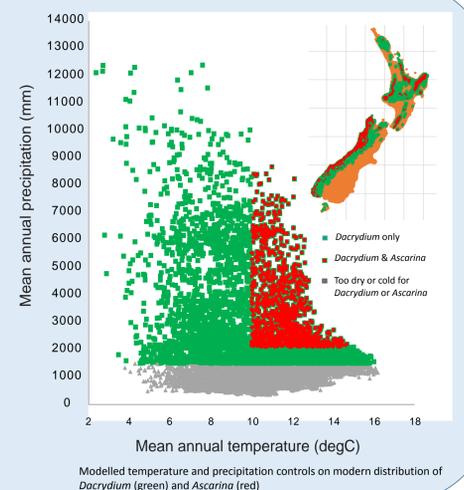


Mean annual temperature reconstructed from the Karioi pollen record using the modern analogue technique compared with the Lisiecki-Raymo (LR04) marine isotope stack. The pollen-temperature reconstructions have standard error of 1.51°C.

6. Two key pollen taxa



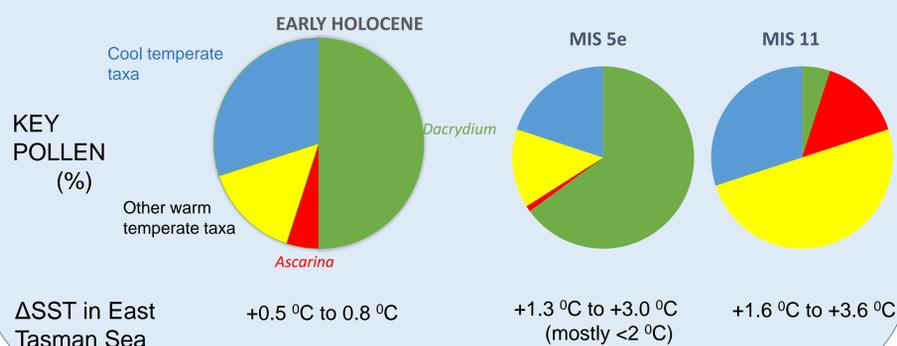
- Dacrydium cupressinum (left, above). Most common, widespread NZ tree with sweet spot in Westland
- Ascarina lucida (right above). Uncommon today, with tropical affinities
- Both species are frost & drought sensitive. But Ascarina copes better with higher temperatures



Modelled temperature and precipitation controls on modern distribution of Dacrydium (green) and Ascarina (red)

7. Key Findings

- Early Holocene and MIS 5e: East Tasman Sea warmer than present but no significant differences observed in pollen records
- MIS 11: SSTs 1.6 – 3.6 °C warmer than present. Significant loss of Dacrydium-dominant podocarp forest in Westland lowlands



8. Conclusions

- Early Holocene, MIS 5e and MIS 11 sea surface and air temperature records indicate warmer than present conditions
- Not simulated in climate models (for 5e)
- MIS 11 biotic response suggests that New Zealand's iconic podocarp rainforest may be under threat with >2°C warming.

References
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