Climate Dynamics

Supporting Information for:

Dynamical downscaling CMIP6 models over New Zealand: added value of climatology and extremes

Peter B. Gibson[1], Stephen Stuart[1], Abha Sood[1], Dáithí Stone[1], Neelesh Rampal[2], Hamish Lewis[2,3], Ashley Broadbent[1], Marcus Thatcher[4], Olaf Morgenstern[1]

1. National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand
2. National Institute of Water and Atmospheric Research (NIWA), Auckland, New Zealand
3. Department of Physics, University of Auckland, New Zealand
4. Commonwealth Scientific and Industrial Research Organisation (CSIRO) Oceans and Atmosphere, Aspendale, Victoria, Australia

Contents of this file :

- Figures S1 to S17

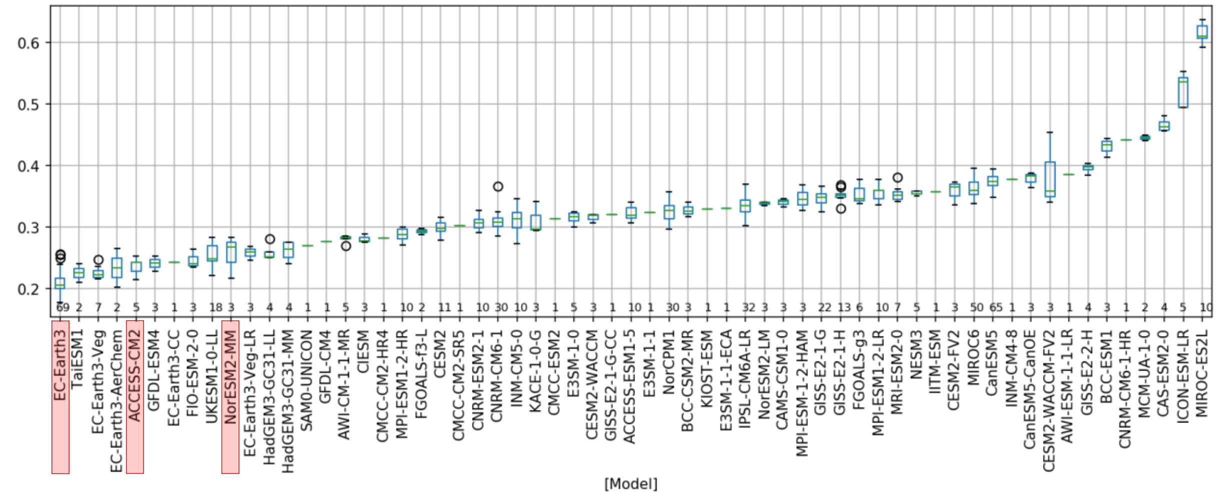

Figure S1: Ranking and selection of GCMs for downscaling with CCAM for the atmospheric nudging simulations. A smaller y-axis value indicates better performance, red shading indicates GCM is selected for downscaling. The box spread for a given model relates to spread across ensemble members, with the number of members evaluated given as a number along the x-axis. Here, the ranking score (unitless) includes a weighted evaluation of various regional circulation, temperature and precipitation indices, their seasonal cycles, teleconnections, and spatial patterns (see Section 2.3 for details).

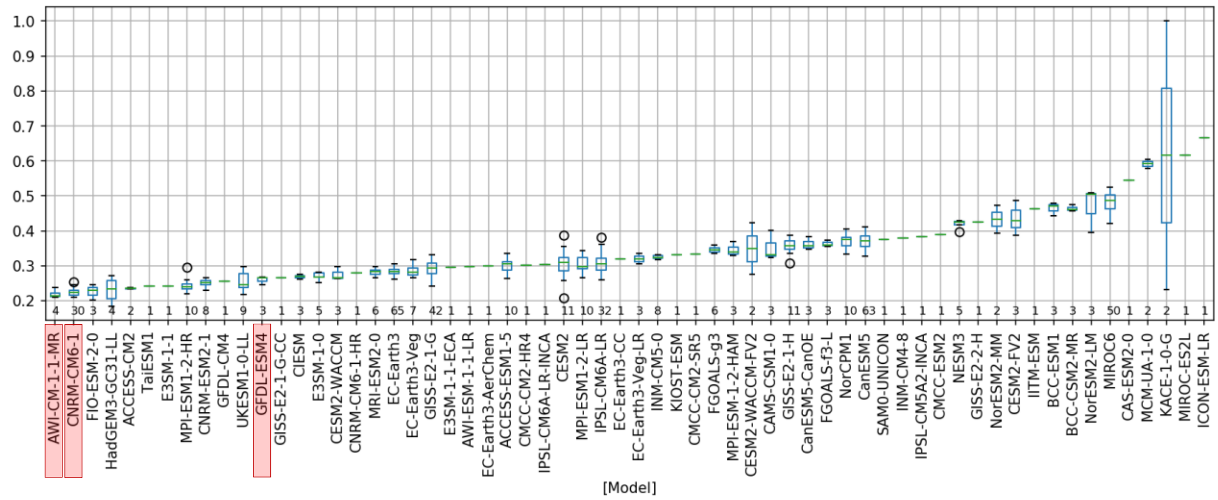

Figure S2: Ranking and selection of GCMs for downscaling with CCAM for the SST/SIC driven simulations. A smaller y-axis value indicates better performance, red shading indicates GCM is selected for downscaling. The box spread for a given model relates to spread across ensemble members, with the number of members evaluated given as a number along the x-axis. Here, the ranking score (unitless) only considers surface air temperature features, including annual, seasonal cycle, interannual standard deviation, and spatial patterns (see Section 2.3 for details).

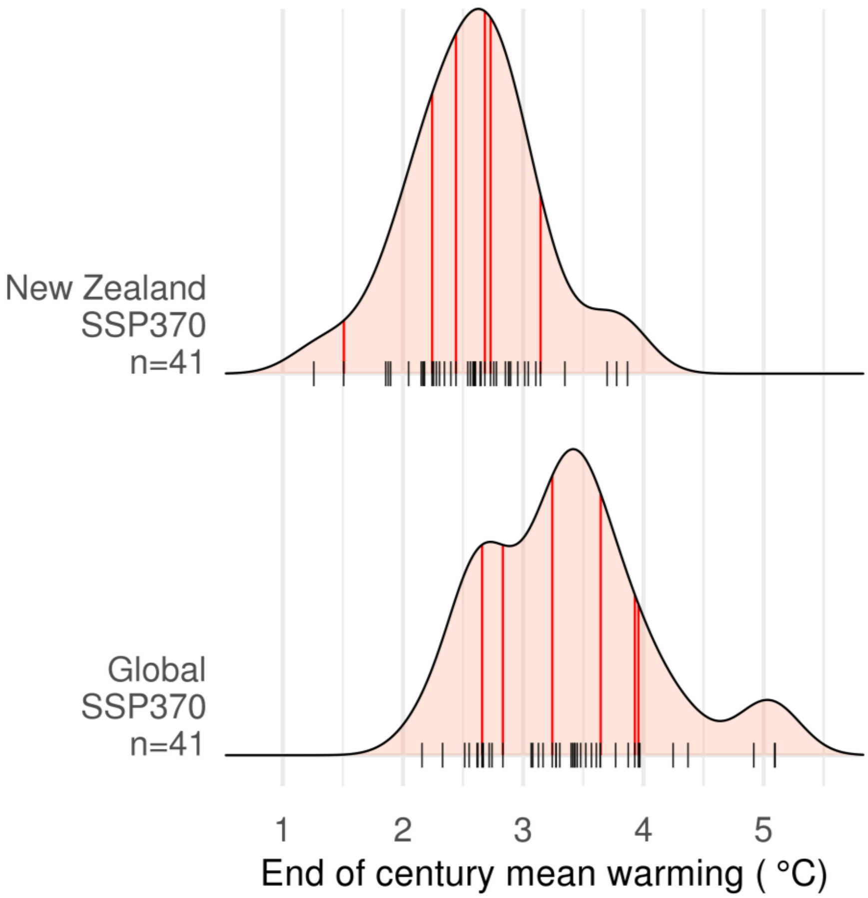

Figure S3: Distribution of CMIP6 end of century near-surface air temperature warming (years 2070-2100 minus 1970-2000) averaged over the New Zealand region (top) and global domain (bottom) under SSP370. The small black vertical lines along the x-axis indicate warming from individual CMIP6 models (n=41), thick red vertical lines indicate warming from the CMIP6 models selected for downscaling (n=6).

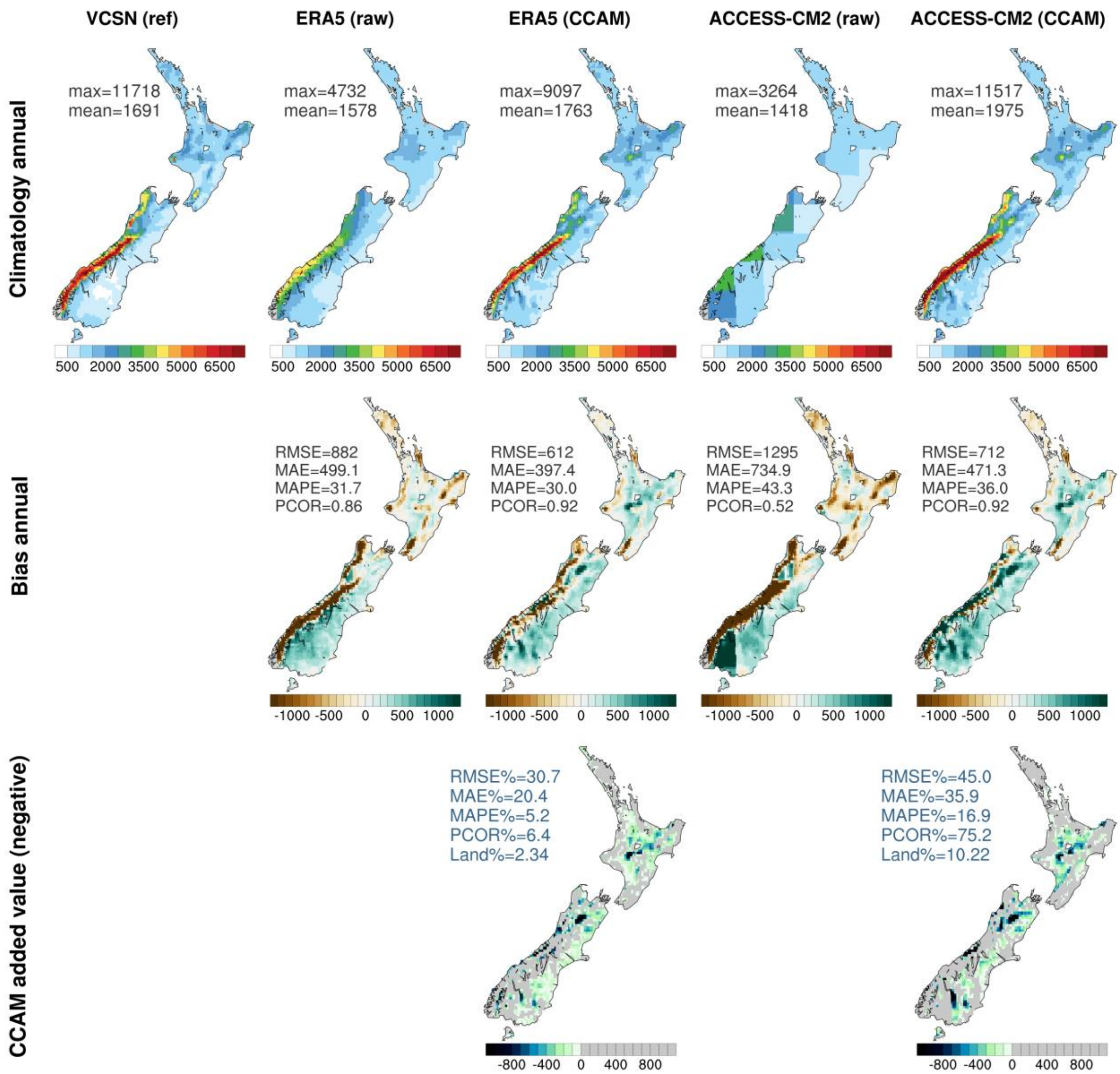

Figure S4: As in Figure 3 (annual mean precipitation climatology) from main manuscript but here shaded values in the bottom row highlight regions of negative added value (i.e. enhanced biases).

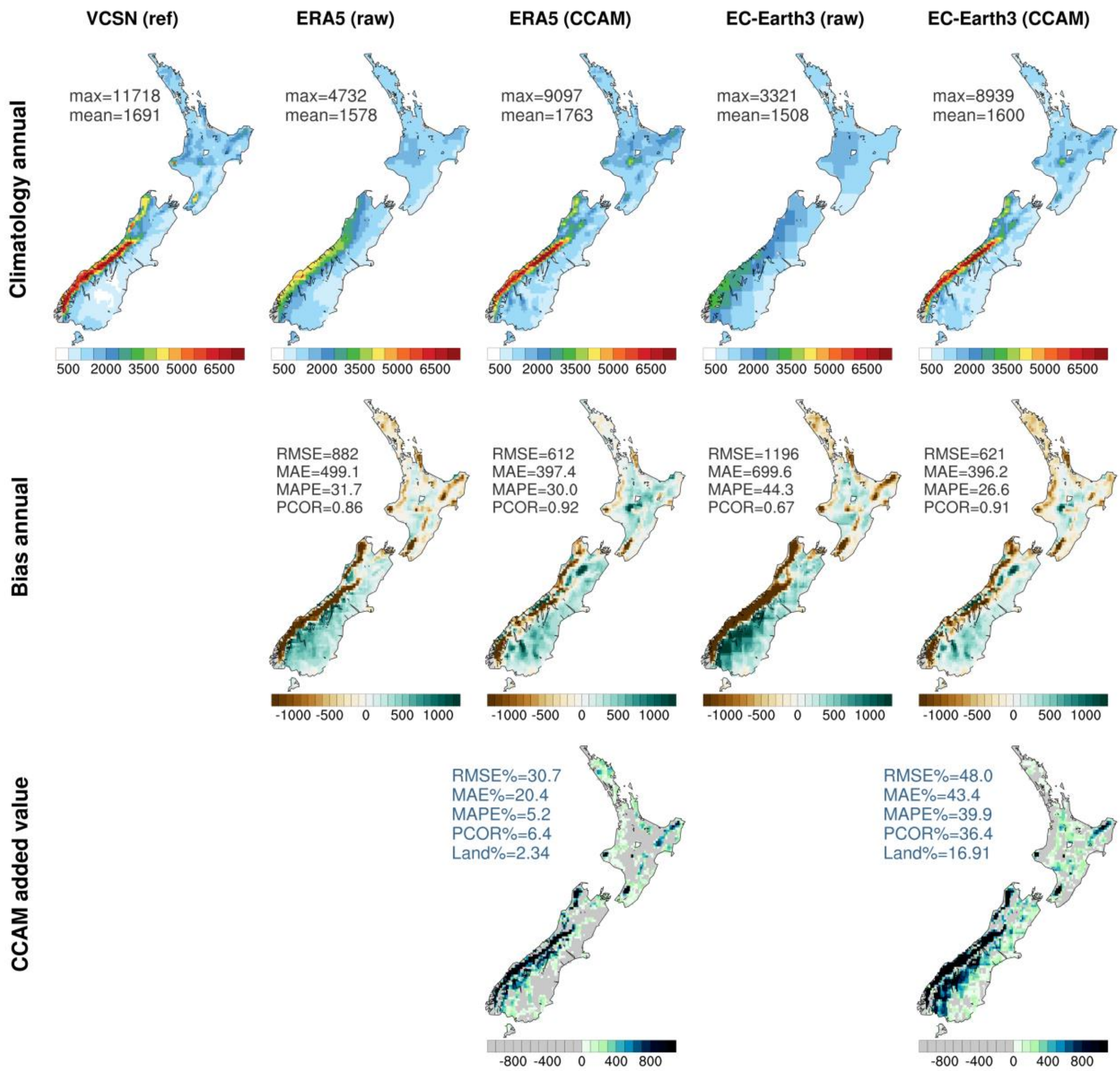

Figure S5: As in Figure 3 from main manuscript but here for annual mean precipitation climatology from downscaling ERA5 and EC-Earth3 with CCAM.

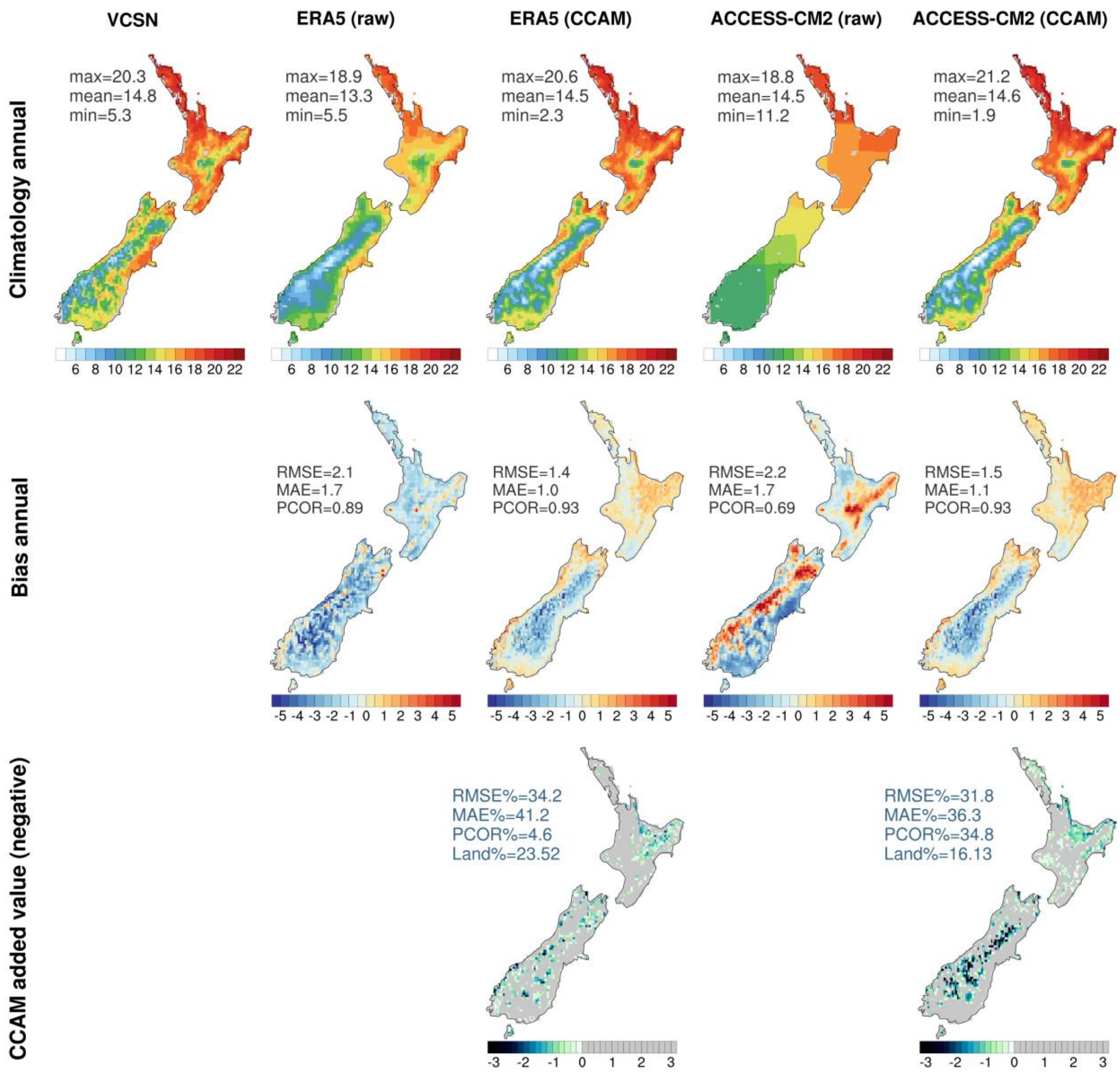

Figure S6: As in Figure 4 (annual mean tasmax) from main manuscript but here shaded values in the bottom row highlight regions of negative added value (i.e. enhanced biases).

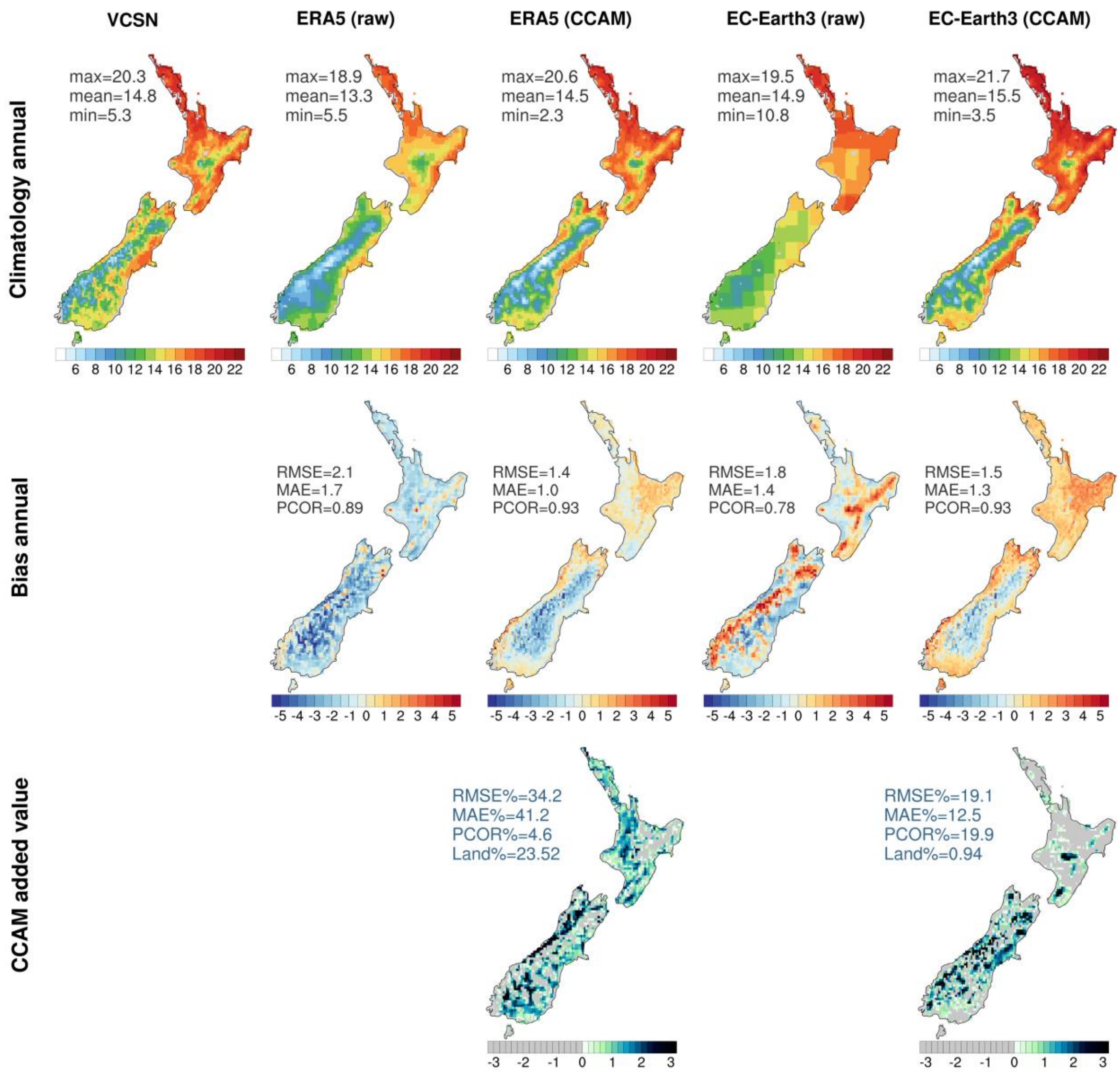

Figure S7: As in Figure 4 from main manuscript but here for annual tasmax climatology from downscaling ERA5 and EC-Earth3 with CCAM.

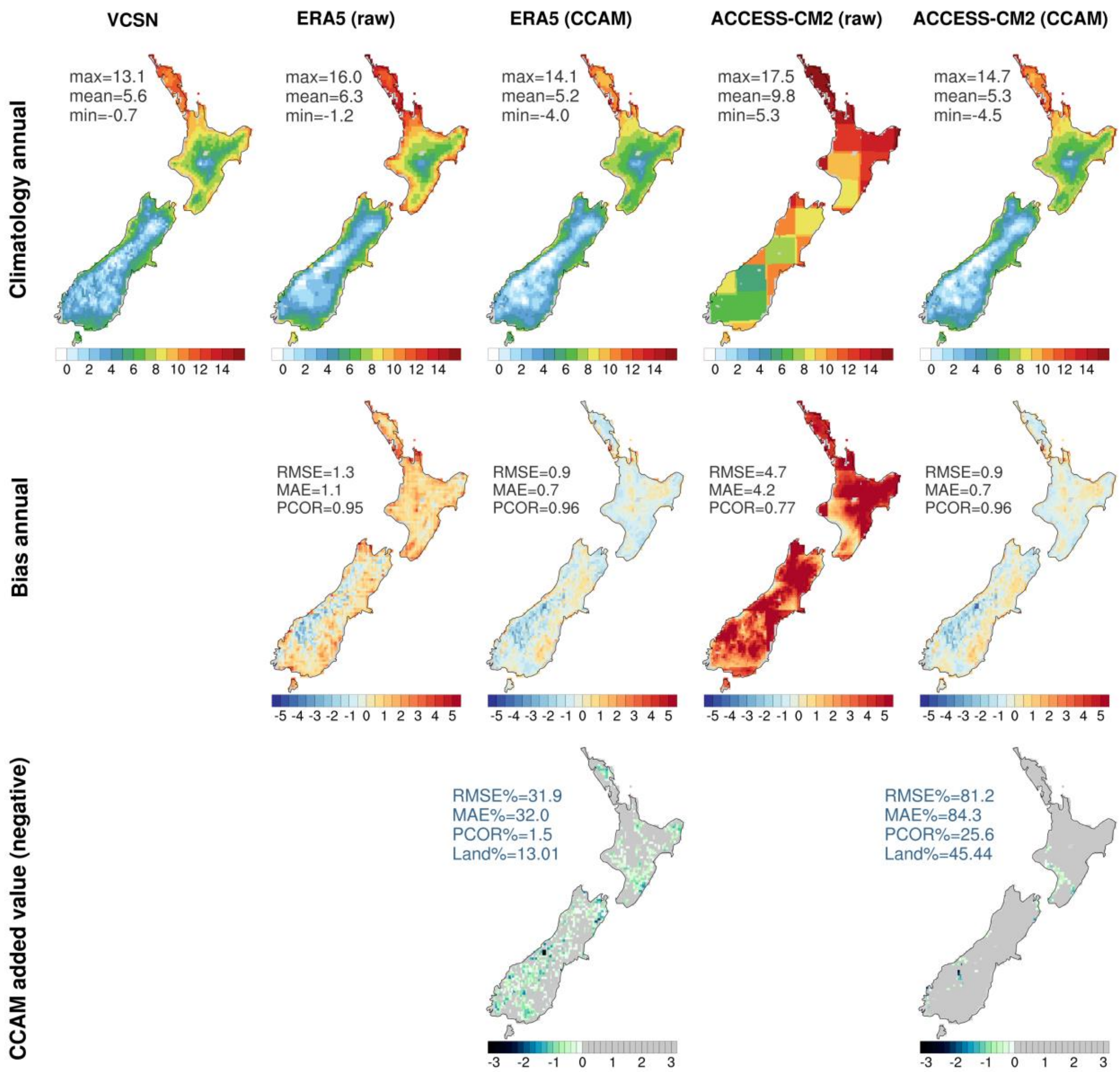

Figure S8: As in Figure 5 (annual mean tasmin) from main manuscript but here shaded values in the bottom row highlight regions of negative added value (i.e. enhanced biases).

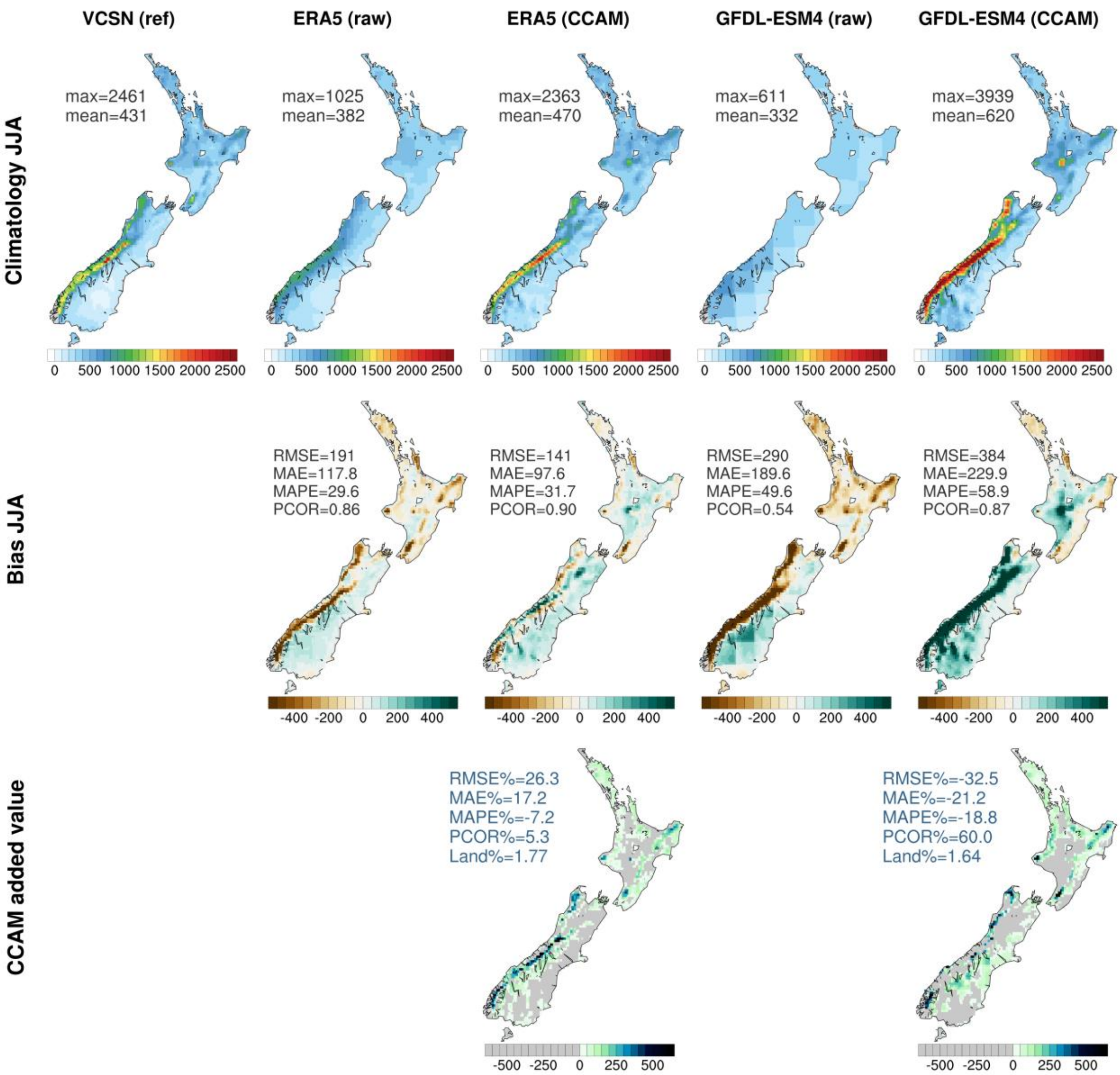

Figure S9: As in Figure 3 from main manuscript but here for winter (June-August) precipitation climatology from downscaling ERA5 and GFDL-ESM4 (SST/SIC-driven) with CCAM.

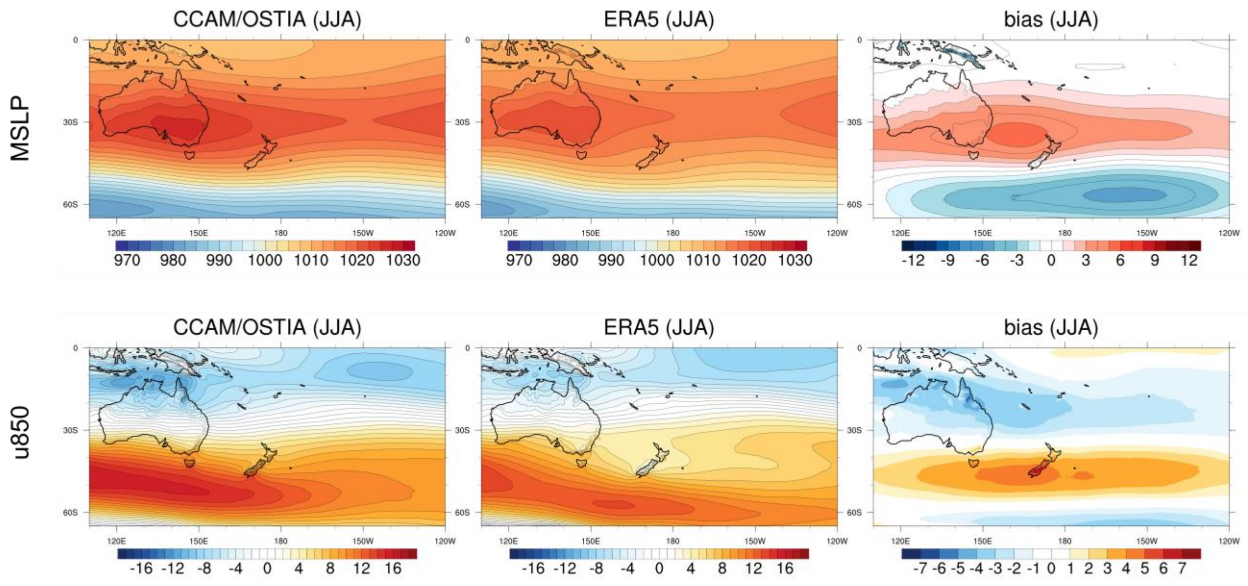

Figure S10: CCAM driven by OSTIA observed SST/SIC from Gibson et al. (2023) with no atmospheric nudging. CCAM shown relative to ERA5 winter (June-August) climatology for: MSLP (top row, units hPa); zonal wind at 850-hPa (bottom row, units m/sec)

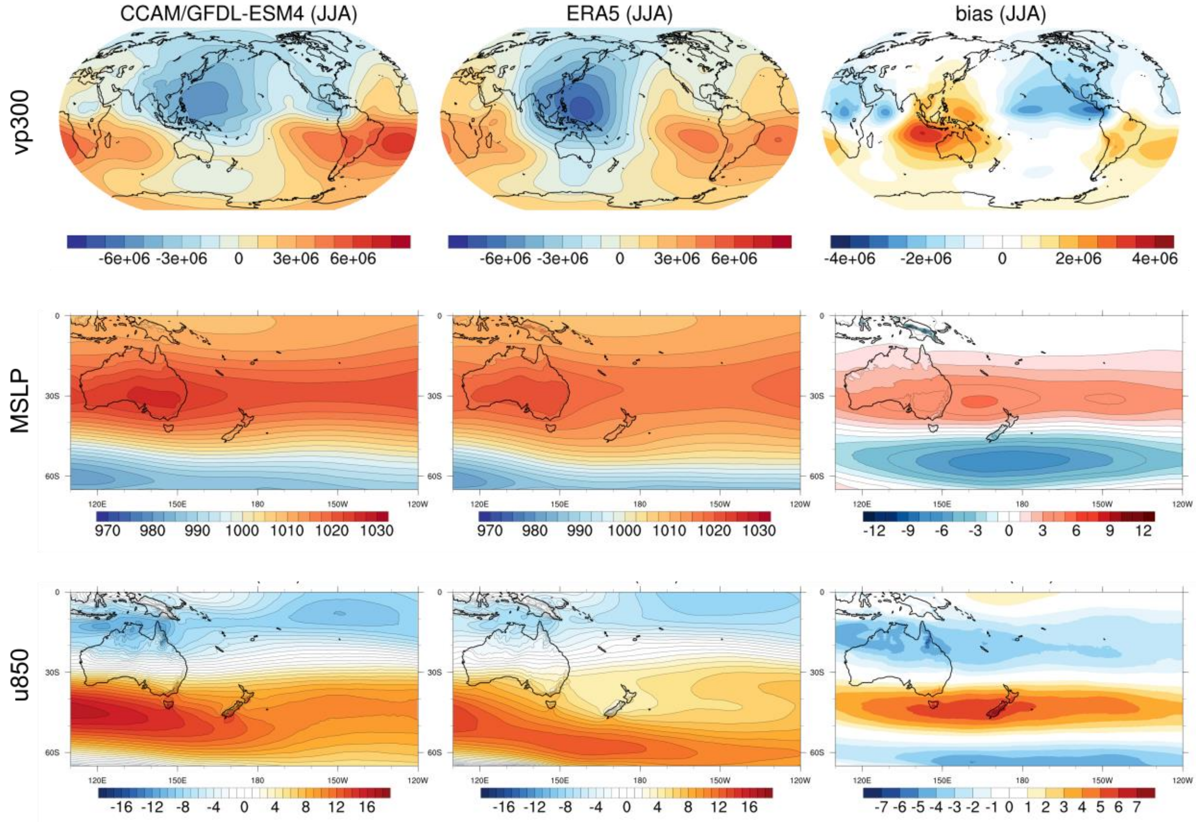

Figure S11: CCAM downscaling GFDL-ESM4 (SST/SIC-driven) relative to ERA5 winter (June-August) climatology for: velocity potential at 300-hPa (top row, units m^2/sec); MSLP (middle row, units hPa); zonal wind at 850-hPa (bottom row, units m/sec)

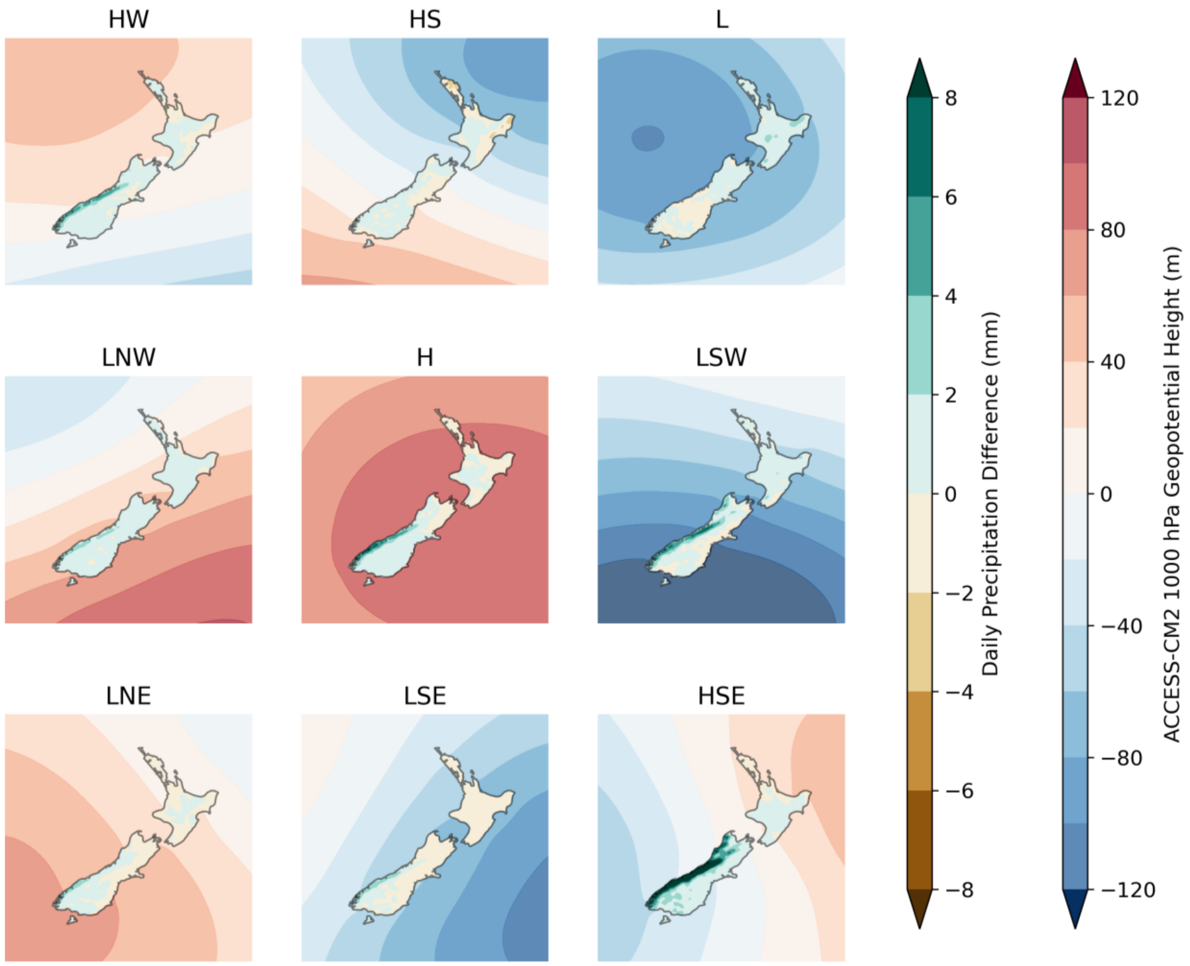

Figure S12: Circulation regimes from ACCESS-CM2 after downscaling with CCAM. The contours show Z1000 while shading over New Zealand shows the differences in regime composite precipitation after downscaling with CCAM between ACCESS-CM2 and ERA5 (ACCES-CM2 minus ERA5)

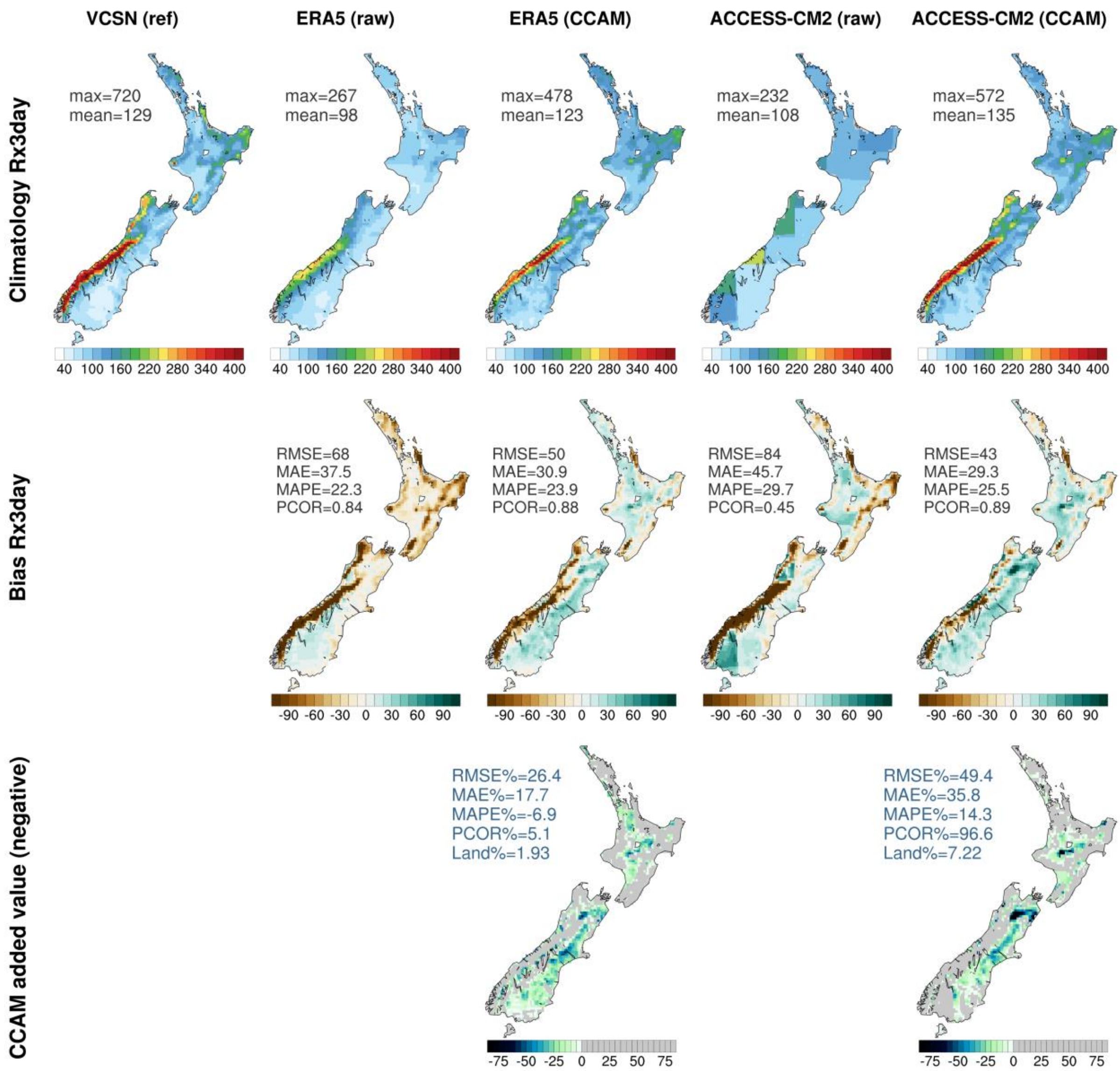

Figure S13: As in Figure 10 (annual Rx3day) from main manuscript but here shaded values in the bottom row highlight regions of negative added value (i.e. enhanced biases).

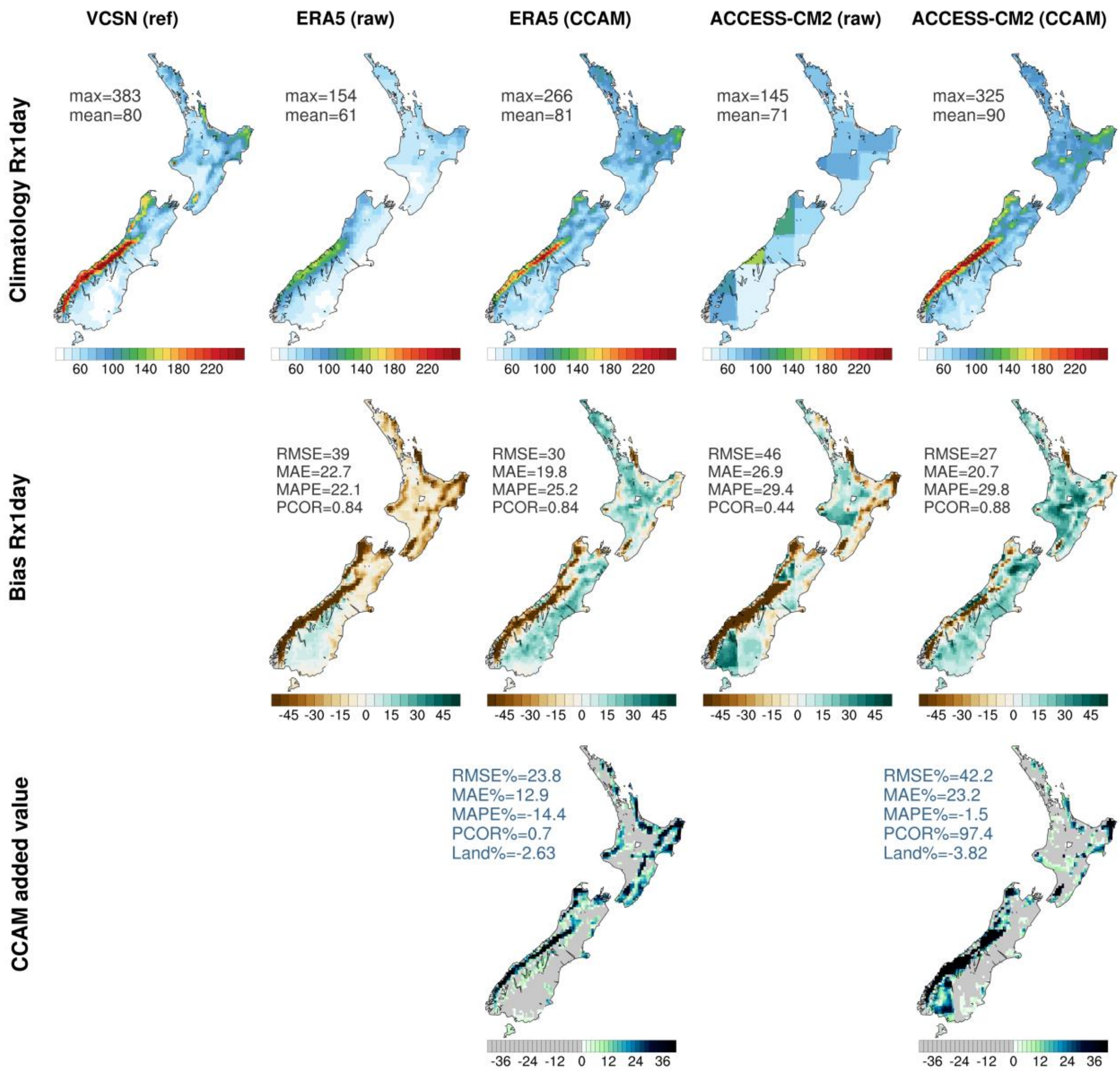

Figure S14: As in Figure 10 from main manuscript but here for annual Rx1day (wettest day of year).

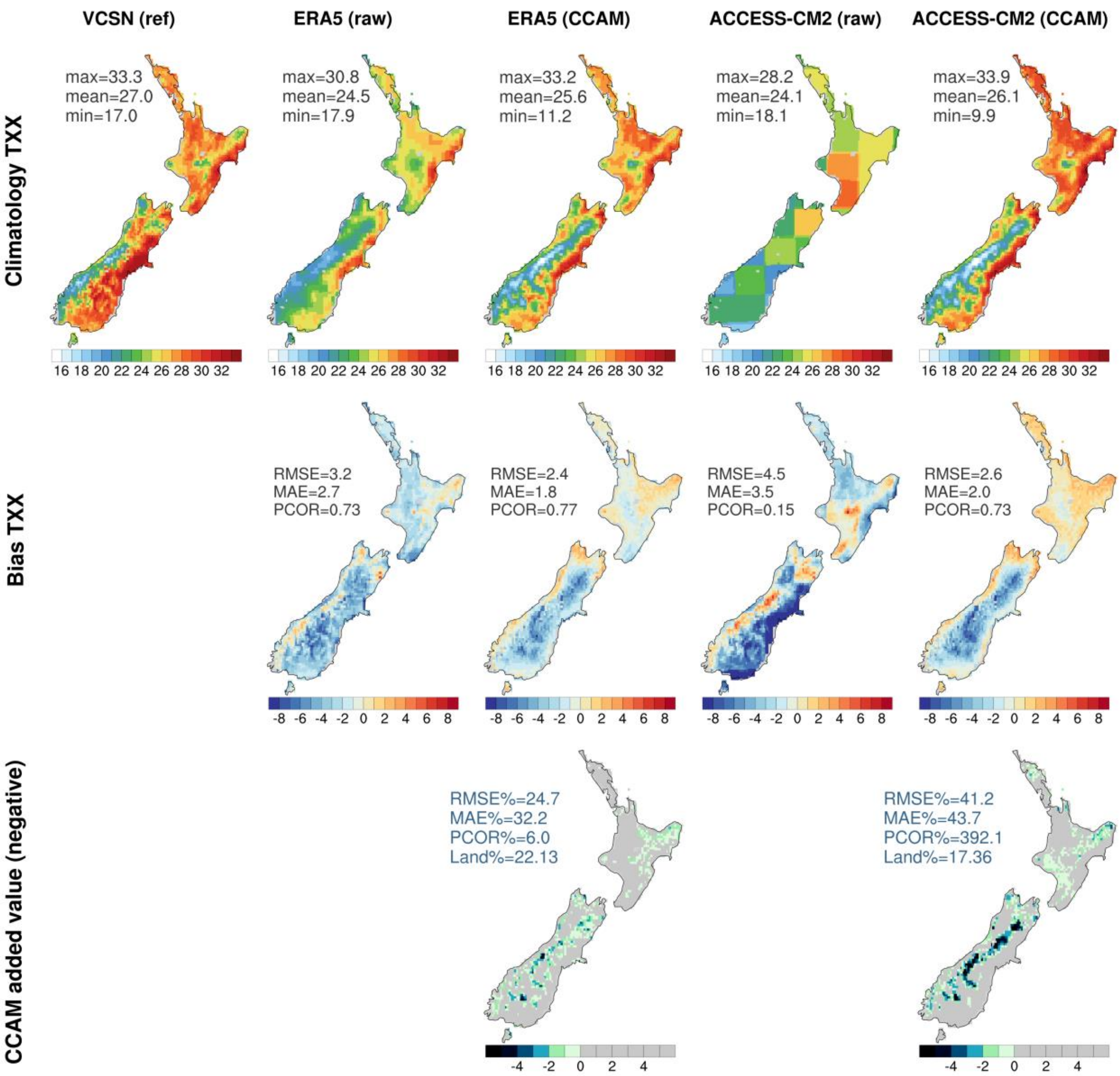

Figure S15: As in Figure 11 (annual TXX) from main manuscript but here shaded values in the bottom row highlight regions of negative added value (i.e. enhanced biases).

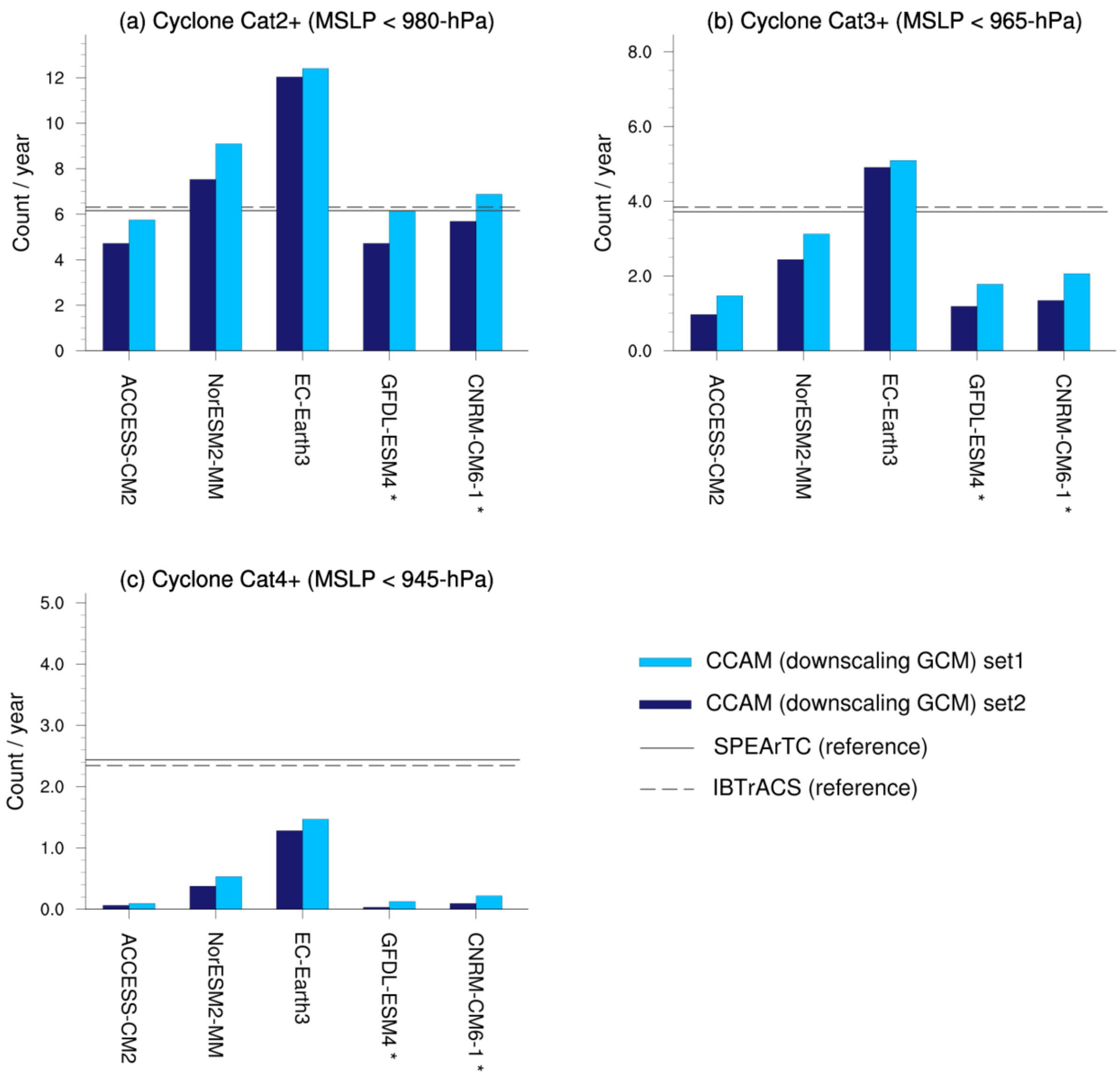

Figure S16: As in Figure 14 but here testing the sensitivity to different sets of tracking parameters from TempestExtremes. Set1 used in Figure 14 is described in Section 2.7. Set2 uses the parameters from Ullrich et al. (2021) described in their Section 3.2. In Set2 the MSLP gradient is defined by an MSLP increase of 200-hPa over 5.5 great circle distance. An additional warm core criteria is imposed based on the gradient of geopotential height thickness. A track must persist for at least 54-hrs, and the maximum distance between subsequent detections is 8.0 degrees.

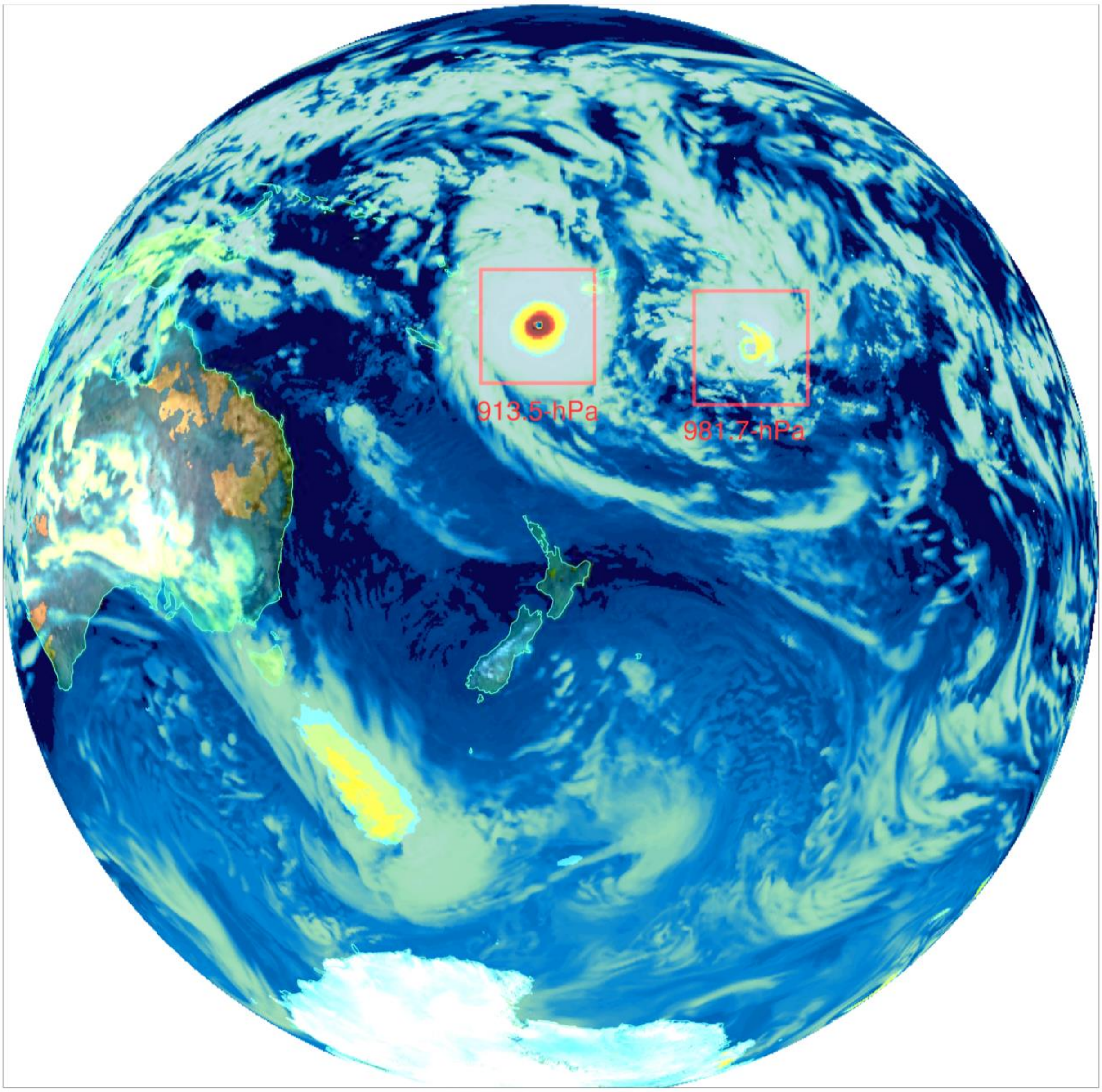

Figure S17: Snapshot of the strongest tropical cyclone (category 5) simulated over the historical period across all downscaled CCAM simulations. Simulated event reached maximum intensity at 1 April 2014 18:00hrs from CCAM downscaling EC-Earth3. Note, since EC-Earth3 is a 'free running' coupled model simulation, this does not correspond to a real-world event in time. During this simulated event the central MSLP reached a track minimum of 913.5-hPa with hourly maximum 10-m surface wind speeds of 72.6 m/sec. White shading shows cloudiness in terms of top of atmosphere outgoing longwave radiation, yellow-red shading shows extreme 10-m wind speeds. Red boxes outline tracked tropical cyclones through TempestExtremes.