Supplementary Material for "Southern Ocean Carbon and Heat Impact on Climate" by Sallée and co-authors.

The Southern Ocean Carbon and Heat Impact on Climate (SO-CHIC) programme was launched in Nov 2019 for five years. It is funded by European Union's Horizon 2020 research and innovation programme under the call "Addressing knowledge gaps in climate science, in support of IPCC reports". The SO-CHIC programme is composed of a total of 16 organisations led by Sorbonne Université (Paris, France): Alfred Wegener Institut (Bremerhaven, Germany), British Antarctic Survey (Cambridge, UK), CSIR (Cape Town, South Africa), ECOCEANA (Paris, France), European Polar Board (Den Haag, Netherlands), ETHZ (Zurich, Switzerland), ETT (Genoa, Italy), GEOMAR (Kiel, Germany), National Oceanography Centre (Southampton, UK), National University of Ireland (Galway, Ireland), NORCE Norwegian Research Centre (Bergen, Norway), University of Gothenburg (Gothenburg, Sweden), University of Oxford (Oxford, UK), University of Reading (Reading, UK), University of Southampton (Southampton, UK).

The SO-CHIC programme is made up of six research work packages and two management work packages that are strongly interrelated and that have been designed to address Objectives 1–5 (See Fig S2). WP1 addresses air-sea-ice fluxes (Objective 1); WP2 and WP3 tackle the ventilation of the deep ocean by, respectively, upper (surface) and lower (abyssal) pathways (Objective 2 and 3); WP4 tackles the question of abrupt large polynya events (Objective 2); WP5 investigates how the processes (WP1-4) impact the coupled atmosphere–ocean system (Objective 4); WP6 unravels the question of deep Southern Ocean heat and carbon storage (Objectives 1 and 4); WP7 organises data management and connection with climate services (Objective 5); and WP8 comprises management and dissemination and policy advice (Objective 5).

SO-CHIC focus mostly on the Atlantic sector of the Southern Ocean as a natural laboratory both because of its worldwide importance in water-mass formation and because of the already established strong European presence in this sector. Targeted SO-CHIC observations is organised as part of a series of cruises in the region (Fig S3), that are used in a combination with an ambitious modelling efforts (Fig S4).

Further information about SO-CHIC is available from http://www.sochic-h2020.eu/.

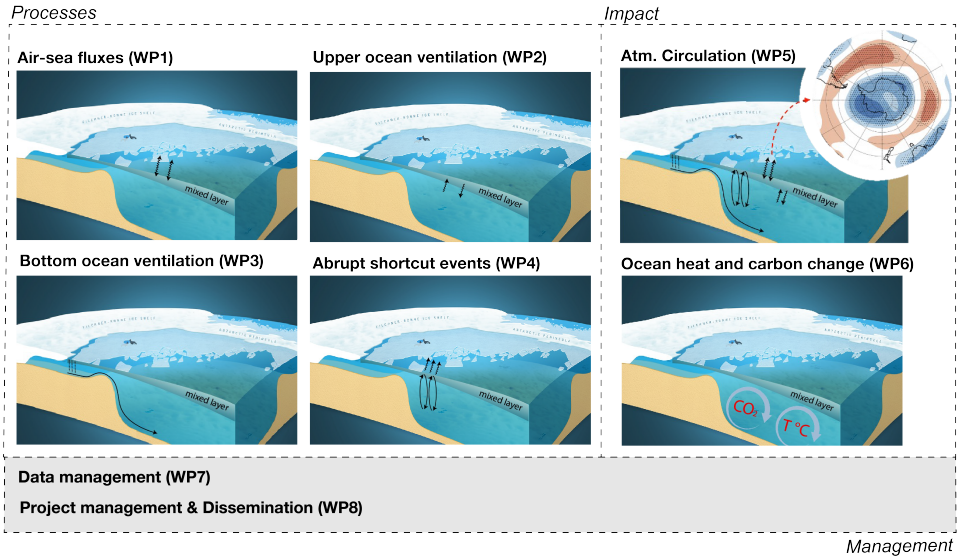

Figure S1. Schematic of the Work Package structure of the SO-CHIC programme. NB: the inset attached to WP5 is a schematic of an anomaly in sea level pressure with no specific scientific sense

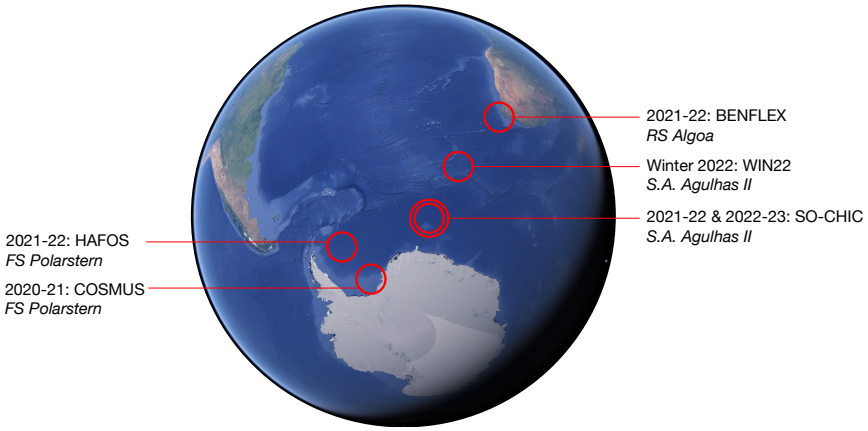

Figure S2. Main cruises that are contributing to the SO-CHIC programme. In austral summer 2020–21, the COSMUS cruise allowed the recovery of a number of moorings feeding in WP3; in summer 2021–22, the BENFLEX cruise dedicated specific efforts to understanding the skin effect for air-sea fluxes of carbon as part of WP1, while the SO-CHIC cruise and the HAFOS cruises deployed and recovered specific observation platforms to address questions in WP1, WP2, WP3 and WP4. In austral winter 2022, the WIN22 cruise collected a unique set of observations (mostly carbonate and water isotopes) in the marginal sea-ice zone. Finally, in summer 2022–23, SO-CHIC will recover instruments while making a last batch of observations around the Maud Rise seamount.

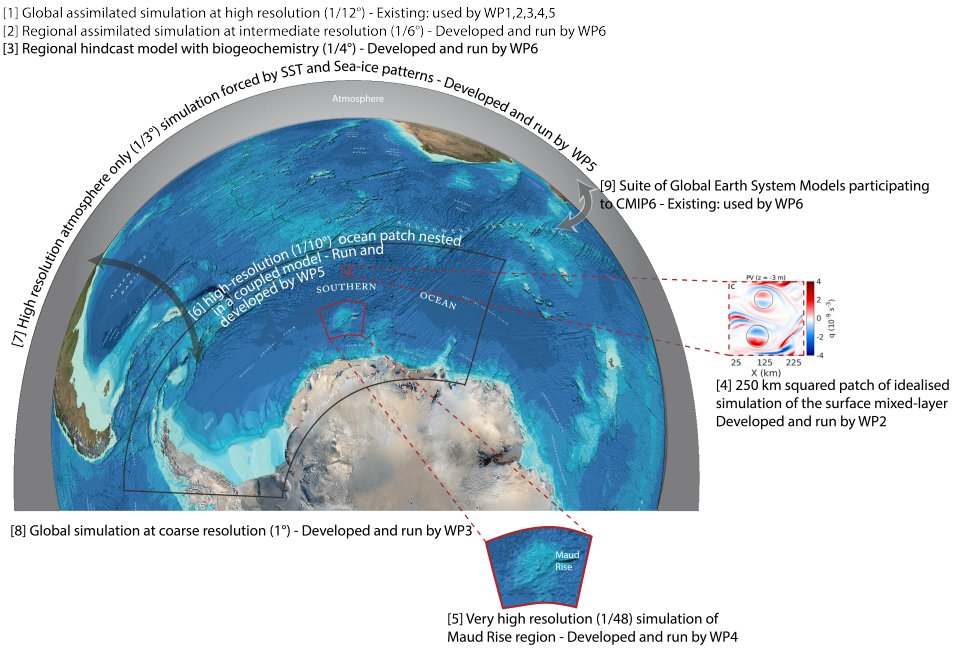

Figure S3. SO-CHIC modelling is composed of a suite of fit-for-purpose model configurations of differing climate components, domain size, and grid resolutions. In order to study a variety of scales, zooms of different complexity are used: one idealised 4°x2° subdomain ocean patch to resolve submesoscale processes (WP2); one realistic high resolution subdomain around Maud Rise is used to resolve small scale processes (1-10 km) associated with open ocean polynya (1/48°; WP4); one nested Weddell Basin high-resolution (1/10°) ocean zoom embedded into a global coupled ocean–atmosphere model is used to investigate climate feedbacks between small-scale processes in the Weddell Basin and the global ocean–atmosphere circulation (WP5). Atmosphere feedback is further explored by forcing a high-resolution global atmospheric model (1/3°) with prescribed sea-surface temperature and sea-ice patterns (WP5). In addition to these small-scale investigations, global-scale propagation and consumption of Antarctic bottom water formed in the Weddell Sea is investigated using a low-resolution (1°) ocean model (WP3). Finally, the suite of CMIP6 models is used to investigate polynya variability in current and new generations of climate models (WP5), as well as to investigate climate-scale seasonal-to-centennial variability of heat and carbon uptake and storage (WP6), with a good understanding of the limitations of such models coming from WP1–5.