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Coupling MAR (Modèle Atmosphérique Régional) with PISM (Parallel Ice Sheet Model) mitigates the positive melt–elevation feedback

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Random years (2091-2100) sampled until 2200							
Runned year	Original year	Runned year	Original year	Runned year	Original year	Runned year	Original year
2101	2096	**2126**	2091	**2151**	2097	**2176**	2095
2102	2091	**2127**	2097	**2152**	2097	**2177**	2091
2103	2095	**2128**	2095	**2153**	2097	**2178**	2099
2104	2094	**2129**	2093	**2154**	2099	**2179**	2093
2105	2098	**2130**	2096	**2155**	2091	**2180**	2095
2106	2098	**2131**	2100	**2156**	2091	**2181**	2098
2107	2098	**2132**	2091	**2157**	2096	**2182**	2099
2108	2095	**2133**	2098	**2158**	2093	**2183**	2092
2109	2100	**2134**	2095	**2159**	2096	**2184**	2096
2110	2092	**2135**	2094	**2160**	2095	**2185**	2098
2111	2091	**2136**	2095	**2161**	2094	**2186**	2093
2112	2096	**2137**	2094	**2162**	2096	**2187**	2097
2113	2099	**2138**	2092	**2163**	2100	**2188**	2093
2114	2091	**2139**	2091	**2164**	2092	**2189**	2098
2115	2093	**2140**	2093	**2165**	2093	**2190**	2093
2116	2099	**2141**	2095	**2166**	2098	**2191**	2099
2117	2100	**2142**	2093	**2167**	2091	**2192**	2091
2118	2092	**2143**	2099	**2168**	2092	**2193**	2099
2119	2094	**2144**	2093	**2169**	2098	**2194**	2098
2120	2092	**2145**	2094	**2170**	2094	**2195**	2095
2121	2098	**2146**	2092	**2171**	2093	**2196**	2091
2122	2100	**2147**	2092	**2172**	2097	**2197**	2096
2123	2099	**2148**	2093	**2173**	2096	**2198**	2096
2124	2091	**2149**	2095	**2174**	2092	**2199**	2095
2125	2095	**2150**	2097	**2175**	2092	**2200**	2094

Table S1. Random years from CESM2 (2091-2200) sampled until 2200 to extend the large-scale forcing field for MAR.

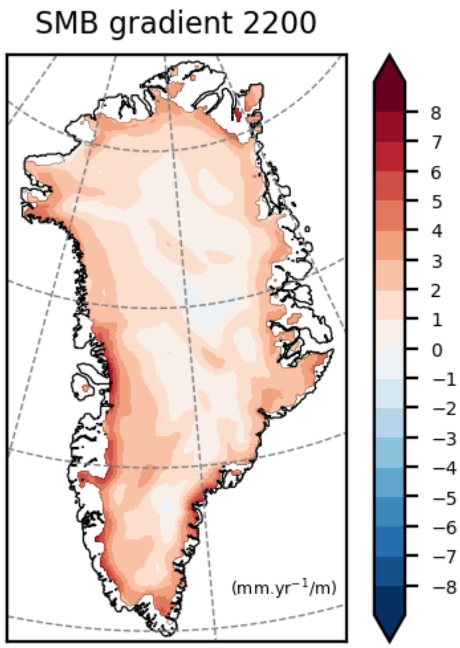

Figure S1. Surface mass balance (SMB) gradients ($mm.yr^{-1}/m$) in 2200 as calculated by the offline correction (Franco et al., 2012) over the PISM-4.5 km grid and considering the SMB and surface elevation from the 9 nearest grid-cells of the MAR-25 km grid.

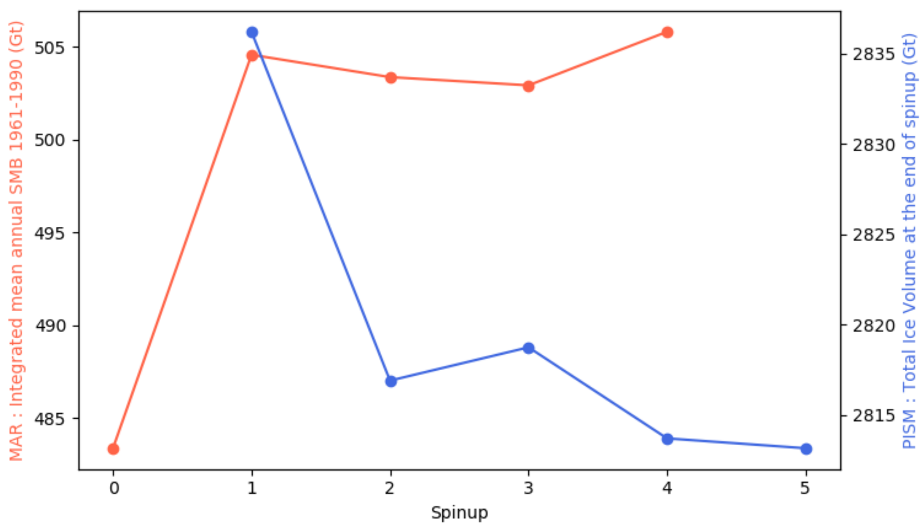

Figure S2. Spinup simulations results of SMB in red (MAR), and of MB in blue (PISM).

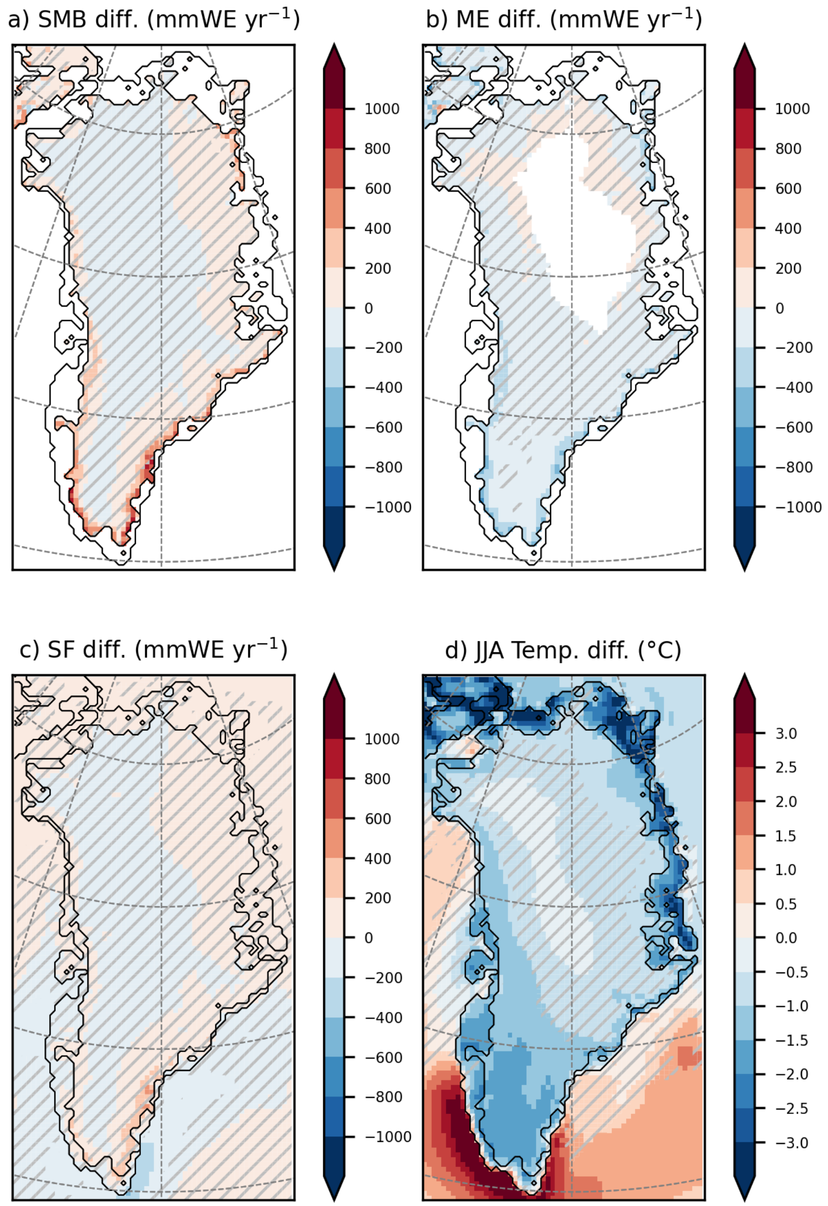

Figure S3. Evaluation of MAR-CESM2 compare to MAR-ERA5 over the reference period 1961-1990 with the initialised topography from the coupling between MAR and PISM through differences of the 4 main variables: a) the surface mass balance (SMB, mmWE yr^{-1})), b) melt (ME, mmWE yr^{-1}), c) snowfall (SF, mmWE yr^{-1}) and d) summer temperatures (JJA Temp., °C). Non-significant (smaller than the inter-annual variability) differences are hatched.

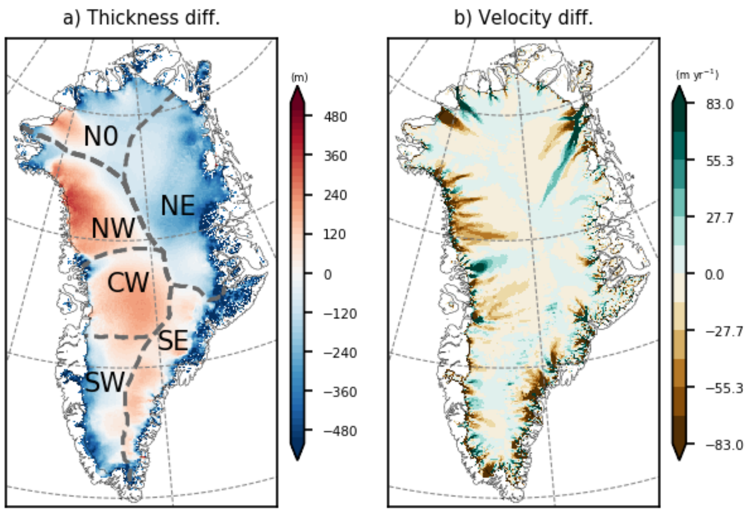

Figure S4. Difference of observational data sets - model spinup for a) thickness and b) velocity. For the ice thickness observation, the BedMachineV3 data set (Morlighem et al., 2017) was used. For spinup and observational data set only values with thicknesses >= 1 m were considered to display the thickness differences and calculate the root mean square error (RMSE) of 224.02 m. The differences of the surface velocities are given by comparing the model spinup to the observational data set (Joughin et al., 2018) with velocity fields averaged over the years 1995–2015. The RMSE for the velocity fields yields 113.53 ms^{-1}. Basins are adjusted following Rignot and Mouginot (2012)

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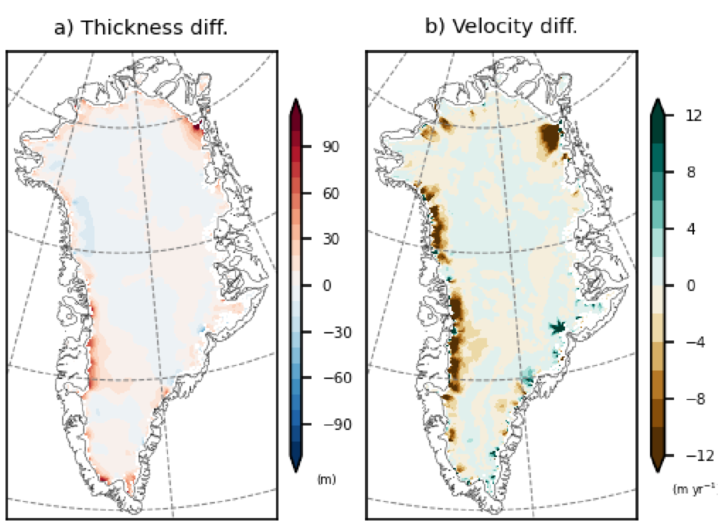

Figure S5. Differences in the year 2200 of MAR-PISM 2-way coupling (MAPI-2w) minus 1-way experiment (MAPI-1w) for a) thickness (m) and b) surface velcotites ($m\,yr^{-1}$).

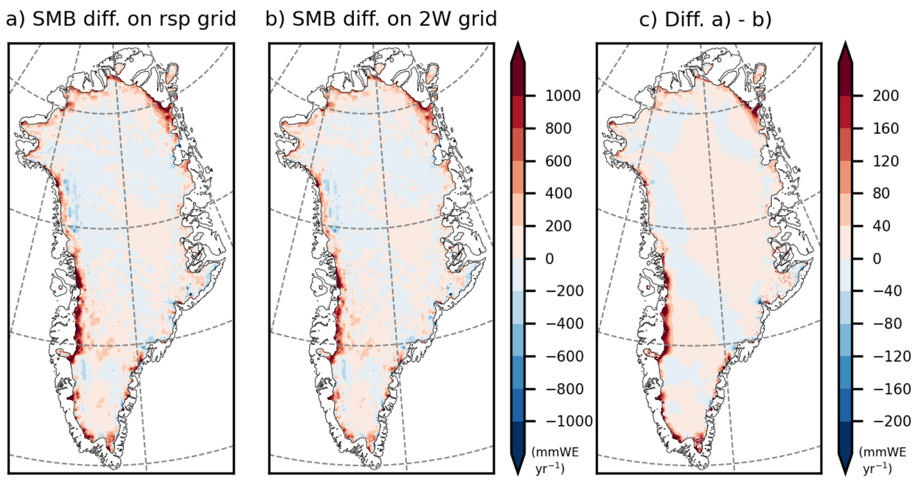

Figure S6. a) SMB differences in 2171-2200 between MAPI-1w and MAPI-2w interpolated on their respective PISM topography (mmWE yr^{-1}). b) Same as a) but both interpolated on the same topography of PISM from MAPI-2w. c) Differences between a) and b).

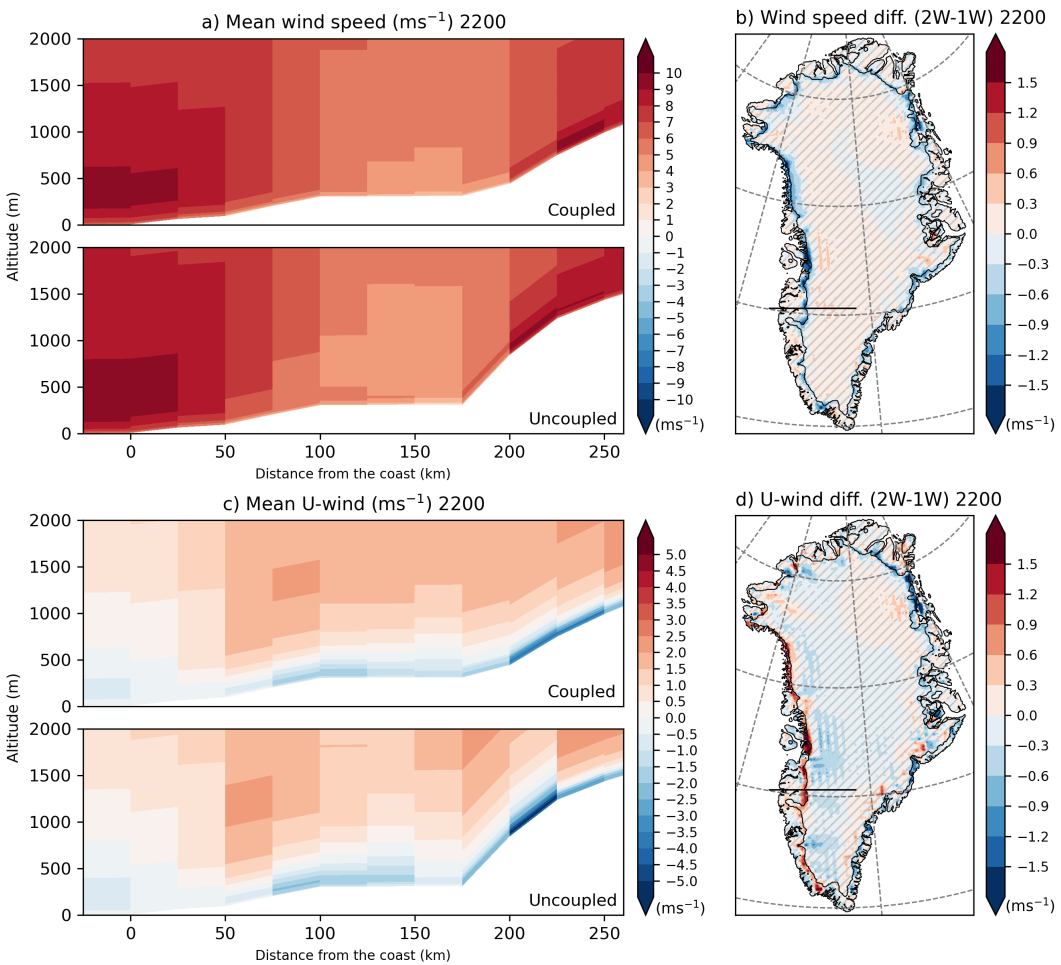

Figure S7. a) Cross sections along 66.64–67.35 ° N of mean wind speed (ms^{-1}) of Greenland in 2200. Upper cross-sections are represented over the coupled-topography of MAR in MAPI-2w experiment (coupled). Lower cross-sections are represented over the uncoupled-topography of MAR in MAPI-0w or -1w experiment (uncoupled). b) Wind speed differences (ms^{-1}) between MAPI-1w and MAPI-2w experiments in 2200. Non-significant differences (lower than the interannual variability over 2171 – 2200) are hatched. The black line situates the cross section in a). c) and d) are the same than a) and b) for the U-wind component (west-east, positive eastward, ms^{-1}).

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