Supplementary material for: Internal variability of Earth's energy budget simulated by CMIP5 climate models

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Table S1 : Models and modeling centers for CMIP5 data used

Model Name	Modeling Center (or Group)
ACCESS1.0	Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BOM), Australia
BCC-CSM1-1	Beijing Climate Center, China Meteorological Administration
BCC-CSM1-1M	Beijing Climate Center, China Meteorological Administration
CCSM4	National Center for Atmospheric Research
CESM1-FASTCHEM	Community Earth System Model Contributors
CNRM-CM5	Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancée en Calcul Scientifique
CSIRO-Mk3.6.0	Commonwealth Scientific and Industrial Research Organization in collaboration with Queensland Climate Change Centre of Excellence
CanESM2	Canadian Centre for Climate Modelling and Analysis
GFDL-CM3	NOAA Geophysical Fluid Dynamics Laboratory
GFDL-ESM2G	NOAA Geophysical Fluid Dynamics Laboratory
GFDL-ESM2M	NOAA Geophysical Fluid Dynamics Laboratory
GISS-E2-R	NASA Goddard Institute for Space Studies
HadGEM2-CC	Met Office Hadley Centre
HadGEM2-ES	Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)
IPSL-CM5A-LR	Institut Pierre-Simon Laplace
IPSL-CM5B-LR	Institut Pierre-Simon Laplace
MIROC-ESM	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies
MIROC5	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for nvironmental Studies, and Japan Agency for arine-Earth Science and Technology
MPI-ESM-LR	Max-Planck-Institut für Meteorologie (Max Planck Institute for Meteorology)
MPI-ESM-MR	Max-Planck-Institut für Meteorologie (Max Planck Institute for Meteorology)
MPI-ESM-P	Max-Planck-Institut für Meteorologie (Max Planck Institute for Meteorology)
MRI-CGCM3	Meteorological Research Institute
NorESM1-M	Norwegian Climate Centre
NorESM1-ME	Norwegian Climate Centre

Spatial averaging and integration of CMIP5 model data

Monthly time series of global average surface temperature are computed from monthly two-dimensional fields according to equation (1):

$$GST = \frac{\sum_{i,j} T_{i,j} A_{i,j}}{\sum_{i,j} A_{i,j}} \qquad (1)$$

T is the surface air temperature ("tas") grid cell value at the i-th and j-th horizontal coordinate point. *A* represents the grid cell value as found in the corresponding "areacella" file for each model. The only exception to this was for the model bcc-csm1-1-m, where the information on *A* came from the sister model grid of bcc-csm1-1.

Monthly time series of the net radiation at top-of-atmosphere (TOA) are computed from monthly two-dimensional fields according to equation (2):

$$TOA = \sum_{i,j} ISW_{i,j} A_{i,j} - \sum_{i,j} RSW_{i,j} A_{i,j} - \sum_{i,j} OLW_{i,j} A_{i,j} \qquad (2)$$

ISW is the incoming shortwave radiation at top-of-atmosphere ("rsdt"); *RSW* is the reflected shortwave radiation at top-of-atmosphere ("rsut"); and *OLW* is the outgoing longwave radiation at top-of atmosphere ("rlut"). As for *T* we used the "bcc-csm1-1" grid cell areas when calculating the values for "bcc-csm1-1-m". TOA is then also time integrated so that we are able to track changes in the total Earth system energy content (TE) in Joules.

Monthly time series of ocean heat content for each model level are computed from monthly three-dimensional fields according to equation (3):

$$\Phi_z = \sum_{i,j} \rho C \theta_{i,j,z} V_{i,j,z} \qquad (3)$$

Φ_z is the ocean heat content for each model vertical level, *z*. θ is the potential temperature ("thetao") at that vertical level for the i-th and j-th horizontal coordinate point; *V* represents the grid cell volume as found in the corresponding "volcello" file for each model, where available. *C* is a reference specific heat capacity = 3985 J Kg^{-1} K^{-1}; ρ is a reference density = 1025 kg m^{-3}. For a large number of models there was either no "volcello" file available or the information seemed to be erroneous (e.g. the ocean heat content values were orders of magnitude to large). In either case, we estimated *V* using the model's "areacello" file and multiplied by the nominal vertical level thicknesses, as described in the "thetao" files. This procedure applied to the following models: ACCESS1-0; CanESM2; GFDL-CM3; GFDL-ESM2G; GFDL-ESM2M; GISS-E2-H; GISS-E2-R; IPSL-CM5A-LR; IPSL-CM5A-MR; IPSL-CM5B-LR; NorESM1-M; NorESM1-ME; bcc-csm1-1-m; and bcc-csm1-1.

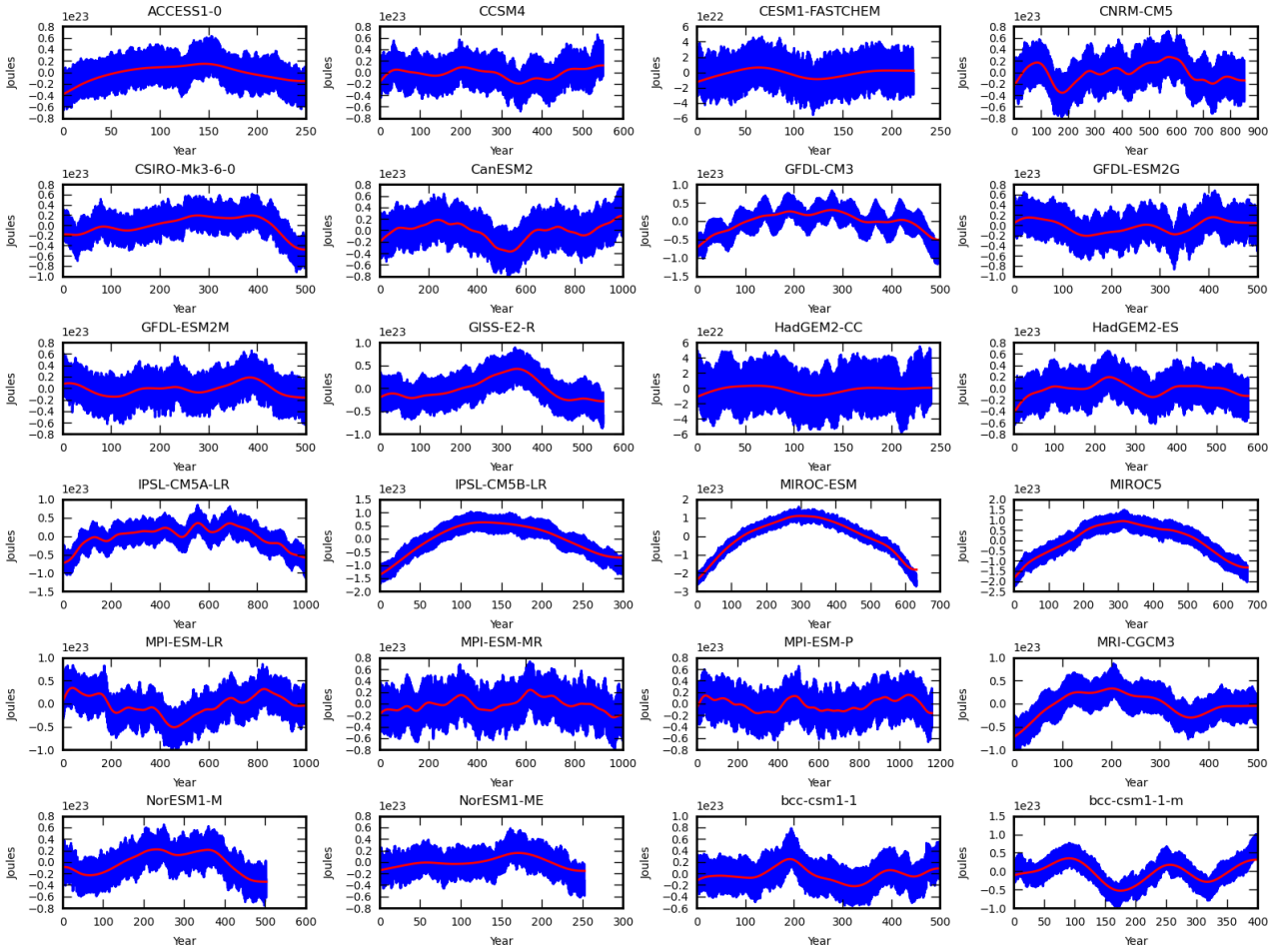

Figure S1: Monthly time series of global ocean heat content after removal of a linear trend (blue). Also show are the 100 year low-passed time series using 2nd order Butterworth filter (red).

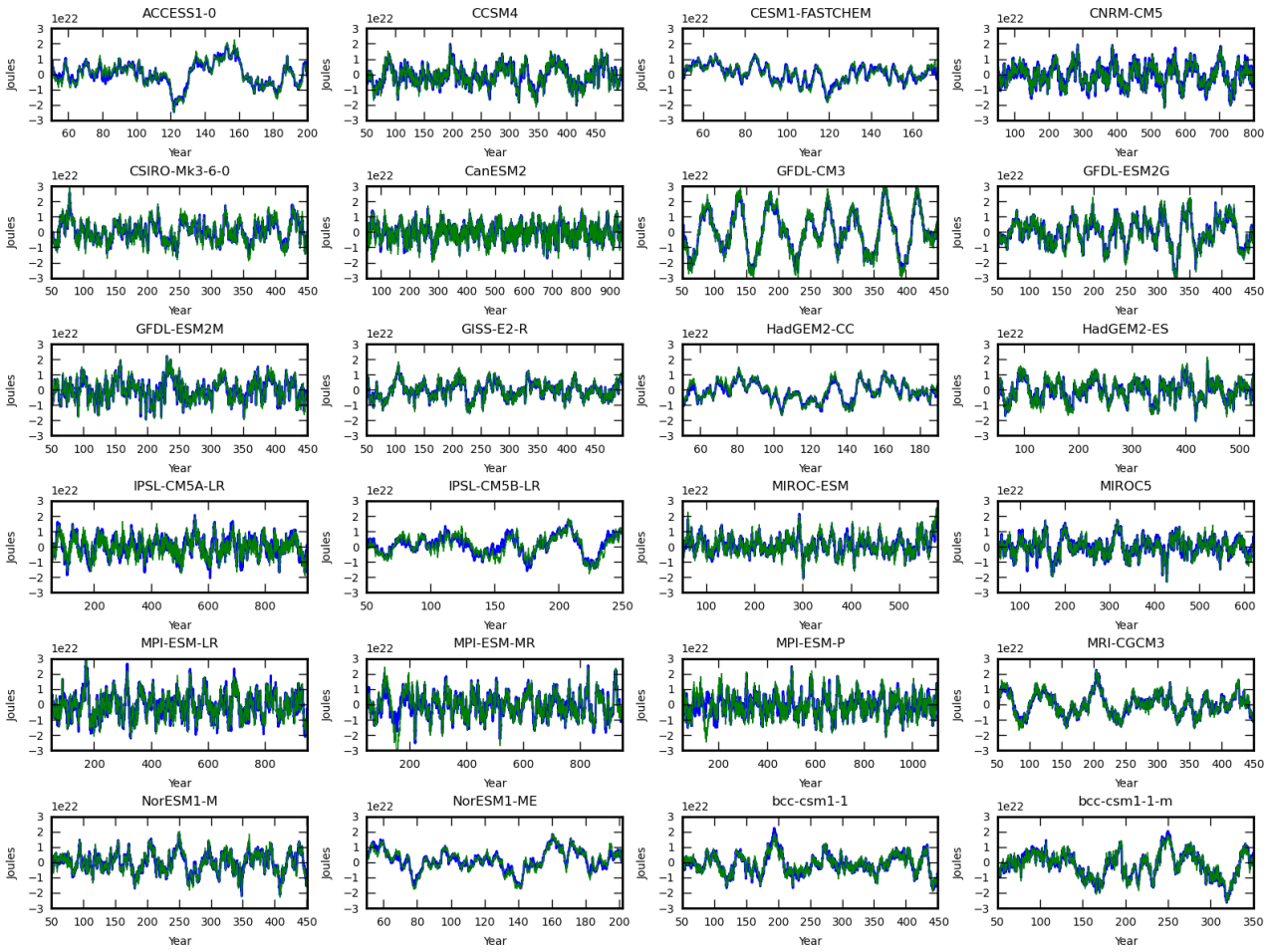

Figure S2: High-passed time series (100 year Butterworth filter) global ocean heat content (blue, thick) and total Earth system energy content (green, thin). To aid the comparison a 0.1e22 offset was added to the green line.

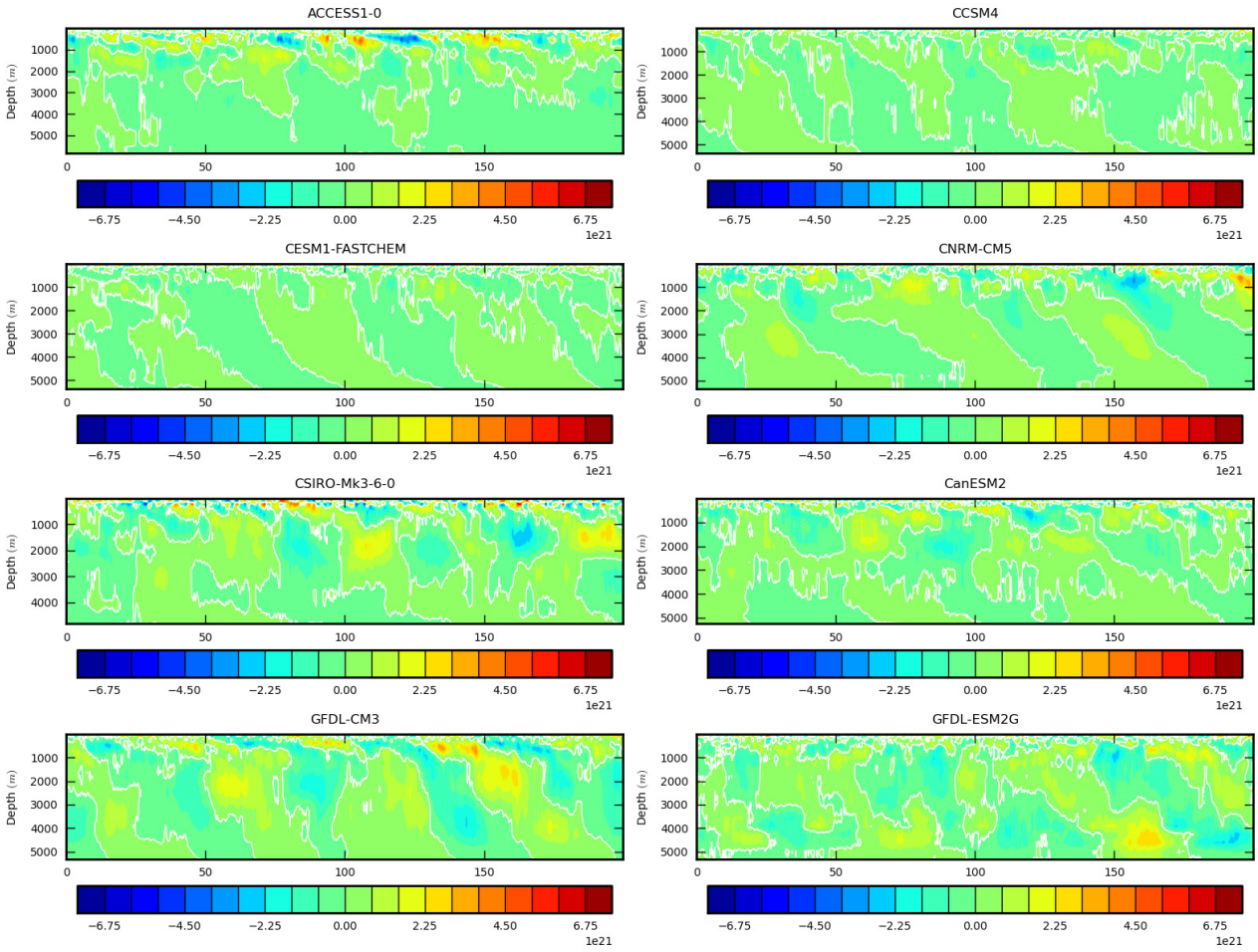

Figure S3: High-passed (100 year Butterworth filter) Hovmöller plots of ocean heat content (Joules) for individual model levels plotted against time in years. The zero contour is indicated in white.

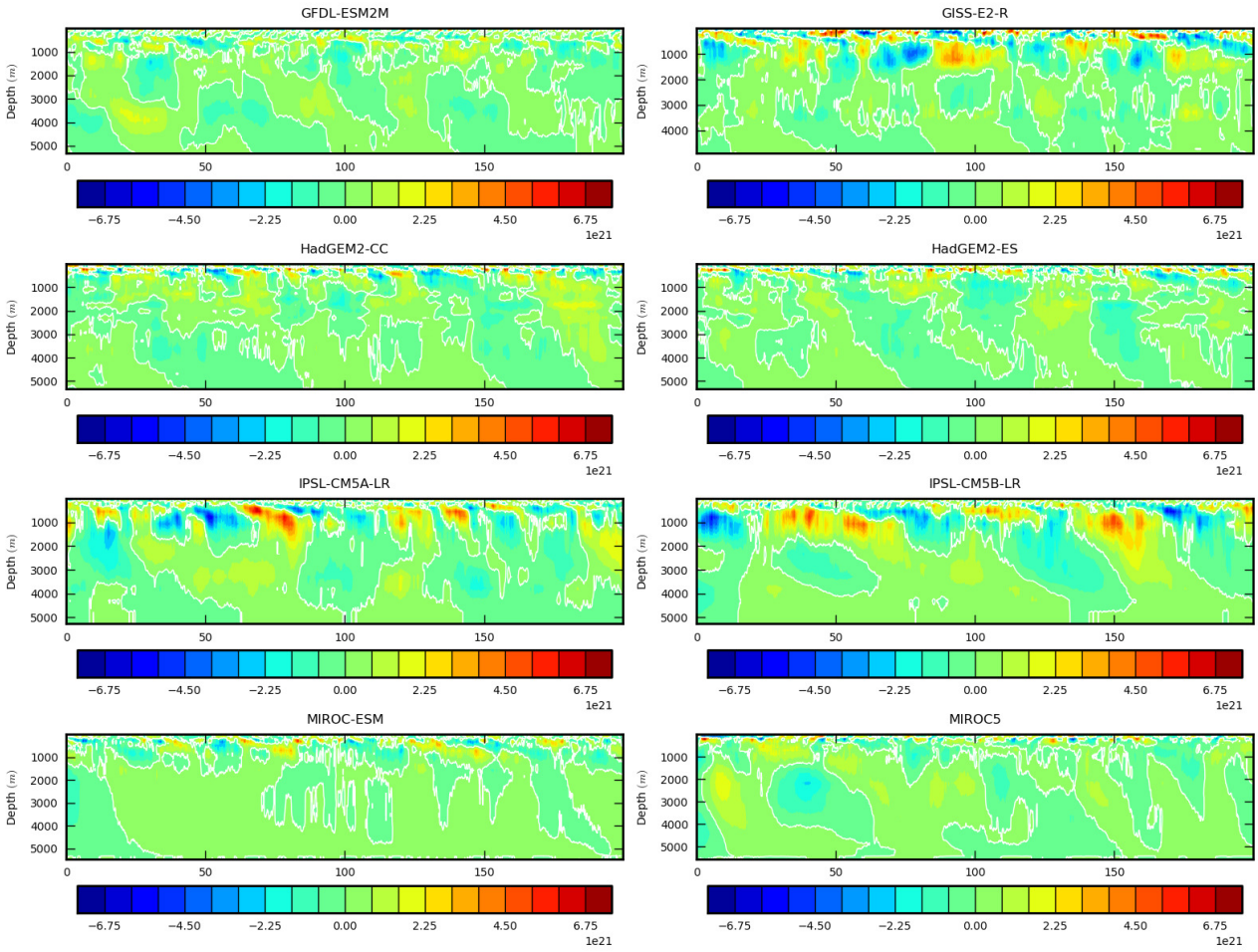

Figure S4: High-passed (100 year Butterworth filter) Hovmöller plots of ocean heat content (Joules) for individual model levels plotted against time in years. The zero contour is indicated in white.

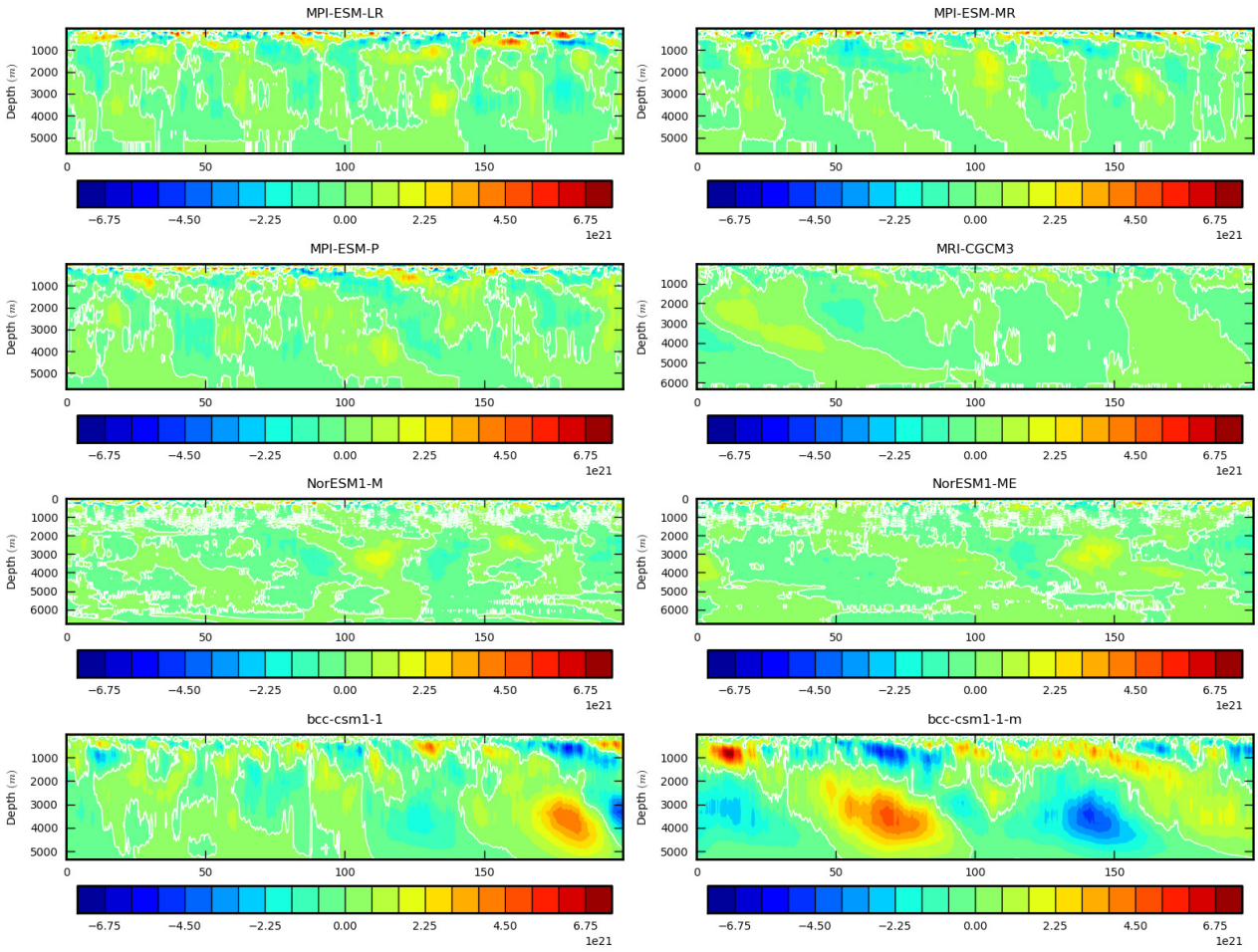

Figure S5: High-passed (100 year Butterworth filter) Hovmöller plots of ocean heat content (Joules) for individual model levels plotted against time in years. The zero contour is indicated in white.