Appendix A :
Fully-coupled versus atmosphere-only simulations : analysis of the spatial differences.

April 27, 2020

1 Introduction

Here we present global maps of the difference between the fully-coupled and atmosphere-only simulations for various variables.

2 Differences in climate

We analyse here the differences in climate between the fully-coupled and atmosphere-only simulations.

We look at the four groups of experiments for which a fully-coupled and an atmosphere-only simulation exists. These combinations are piControl/piClim-control on 2°x2°, piControl/piClim-control on 1°x1°, historical/histSST on 2°x2° and ssp370/ssp370SST on 2°x2°.

In a first set-up of the atmosphere-only simulations, we have erroneously used a different parameterisation describing the fluxes between the atmospere and ocean than the one used in the fully-coupled experiments. These experiments will be denoted by flux=0. A new set of atmosphere-only simulations has been done with the correct flux parameterisation and is denoted by flux=1.

Finally, one simulation has been done with a setup which is even closer to the fully-coupled experiments. This concerns the temperature field used in the emission parameterisation, and that experiment will be denoted flux=1&ΔDMS.

Table 1 describes the experiments used in the comparison here.

3 Results

We show here global maps of the difference between the atmosphere-only and the fully-coupled experiments, for December-January-February (DJF) and June-July-August (JJA).

For the piControl/piClim-control combinations, we look at the period on which the SST, sea-ice and DMS climatologies are based, i.e., year 1751–1780 for 2°x2°, and years 1351–1380 for 1°x1°.

For the historical/histSST combination we focus on two periods, i.e., 1850–1879 and 1985–2014. For the spp370/ssp370SST, we focus on the period 2071–2100.

Table 1: Overview of the experiments and periods used in the evaluation.

Resolution	Years	Fully coupled	Atmosphere-only		
			flux=0	flux=1	flux=1&ΔDMS
2°x2°	1751–1780	piControl	piClim-control	piClim-control	piClim-control
1°x1°	1351–1380	piControl	–	piClim-control	–
2°x2°	1850–1879	historical	histSST	histSST	–
2°x2°	1985–2014	historical	histSST	histSST	–
2°x2°	2071–2100	ssp370	–	ssp370SST	–

Near-surface (2 m) air temeperature Figures 1 and 2 show the near-surface (2 m) air temperature. Temperature in the Arctic and norhtern high latitudes over land is considerably underestimated in DJF. In JJA, temperatures in the Arctic are overestimated. In the Antarctic, temperatures are underestimated in JJA, especially at the land edge.

The temperature is warmer in flux=0 then in flux=1. The flux=1 simulation seem to perform considerably better than the flux=0 simulations.

Near-surface (2 m) specific humidity Figures 3 and 4 show the near-surface (2 m) specific humidity. The flux=1 simulations perform considerably better than the flux=0 simulations. In general, there is a considerable overestimation in the flux=0 simulations.

Near-surface (10 m) wind Figures 5 and 6 show the near-surface (10 m) wind. The wind is better represented in the flux=1 than in the flux=0 simulations.

Planetary boundary layer height Figures 7 and 8 show the planetary boundary layer height. The boundary layer height is better represented in the flux=1 than in the flux=0 simulations. There is an underestimation of the PBLH in the flux=0 simulations.

TOA imbalance Figures 9 and 10 show the TOA imbalance. In DJF, there is signicant positive bias (incoming) over the Arctic. This imbalance is probably most pronounced over sea-ice. In JJA, this imbalance is even larger, and still manifests itself mainly over sea-ice.

Low cloud fraction Figures 11 and 12 show the low cloud fraction. There is some overestimation in the Arctic and Antarctic in local winter (DJF in the Arctic, JJA in the Antarctic). It is possibly slightly more present at the ice edge. In ssp370/ssp370SST, it is more wide spread over the whole Artic – possibly due to more ice-free regions.

Sea-salt emission strength (mode 1) Figures 13 and 14 show the sea-salt emission strength of mode 1. In the flux=1 simulations, there is an underestimation almost everywhere. The underestimation is strongest in northern high latitudes in DJF, and in southerne high latitudes both in DJF and JJA.

Primary marine organic carbon aerosol emissions Figures 15 and 16 show the primary organic carbon emissions. The impacts observed are very similar to the ones seen for sea-salt (mode 1). In addition, there is now also a locally strong underestimation in northern high latitudes in JJA.

DMS emission strenght Figures 17 and 18 show the DMS emission strength. In flux=0 and flux=1, DMS emissions are continuously underestimated in the tropics, and at mid- to high-latitudes in local summer (JJA in the northern hemisphere, and DJF in the southern hemisphere). Biases are smallest for flux=1&ΔDMS.

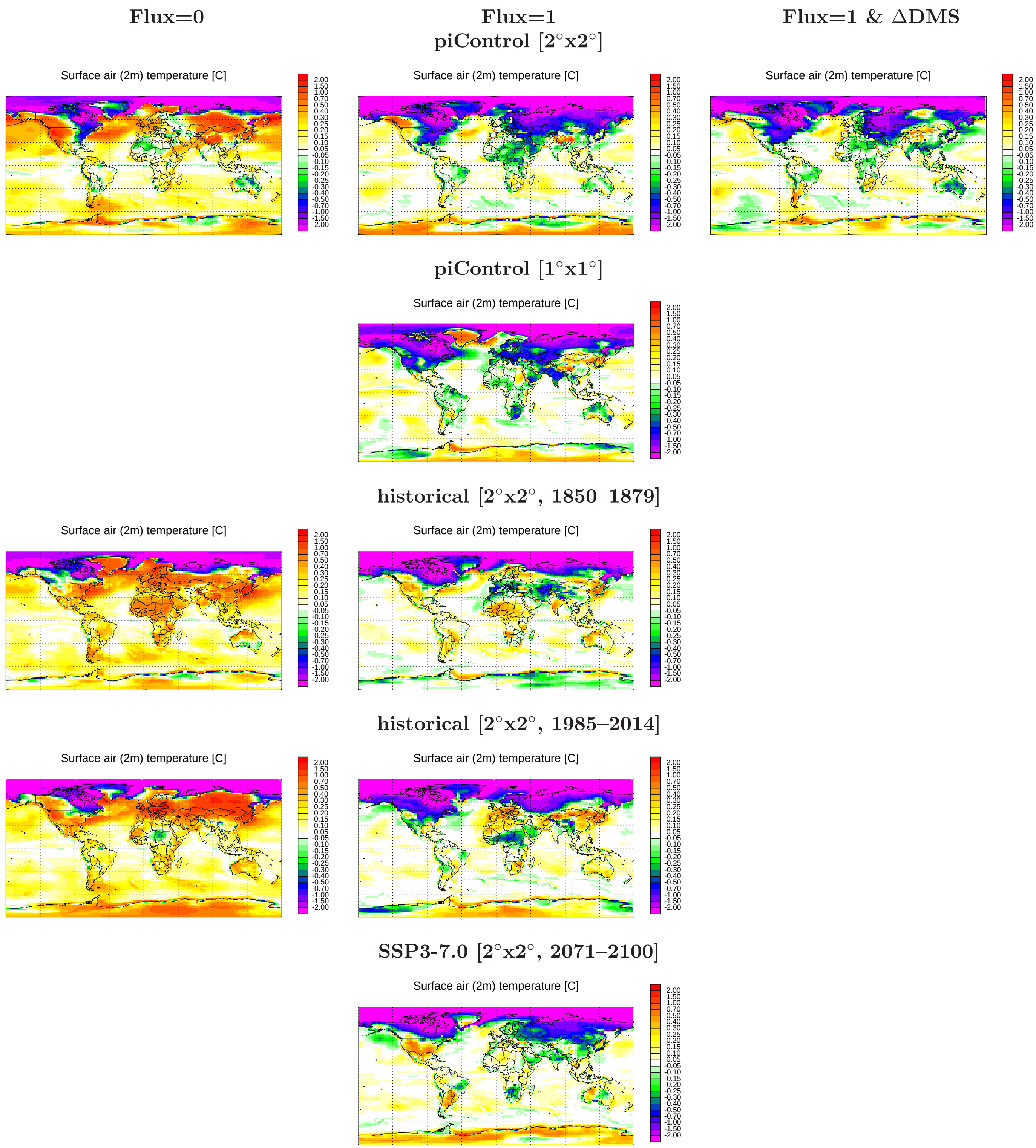

Figure 1: Near-surface (2 m) air temperature : DJF mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

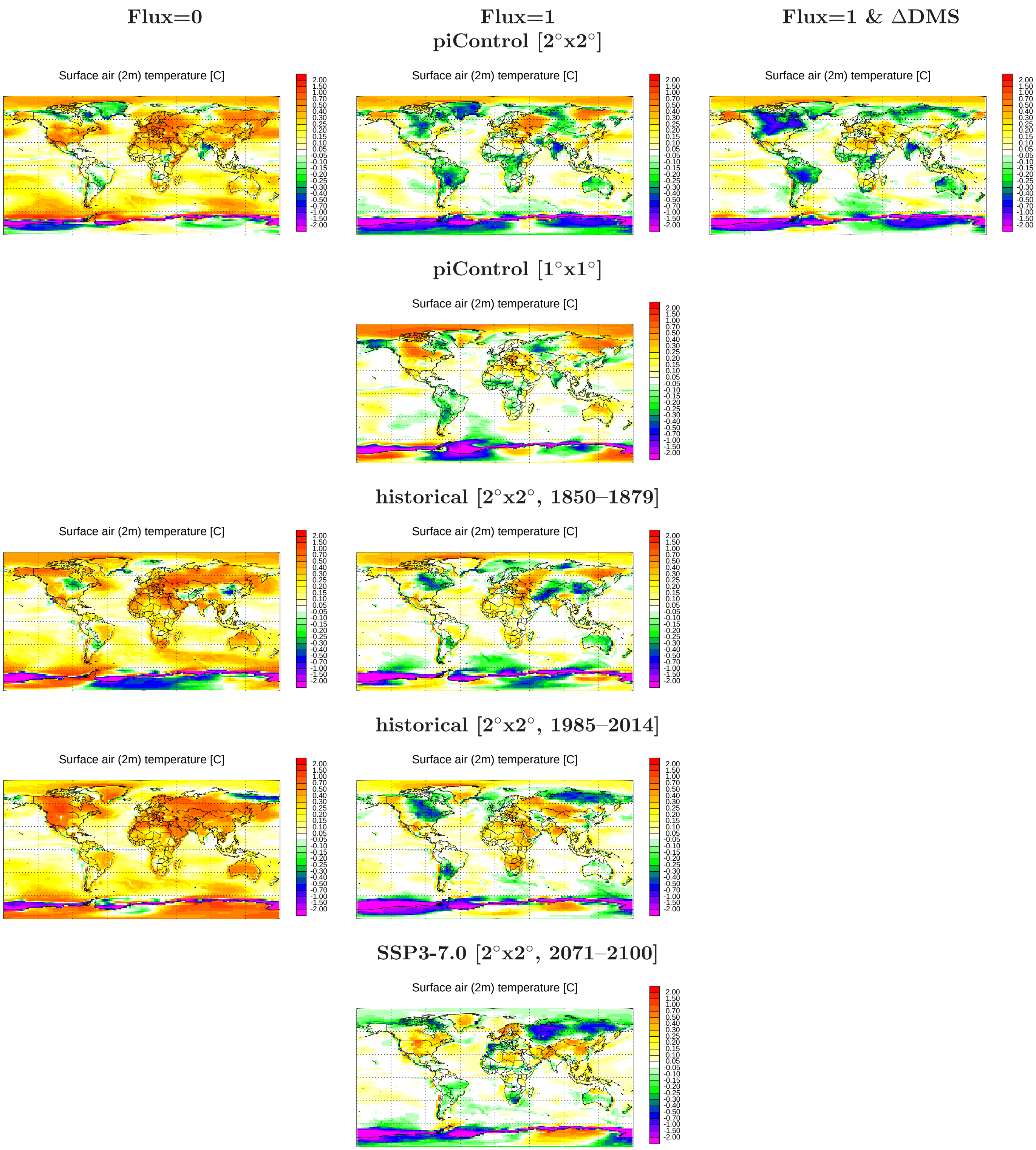

Figure 2: Near-surface (2 m) air temperature : JJA mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

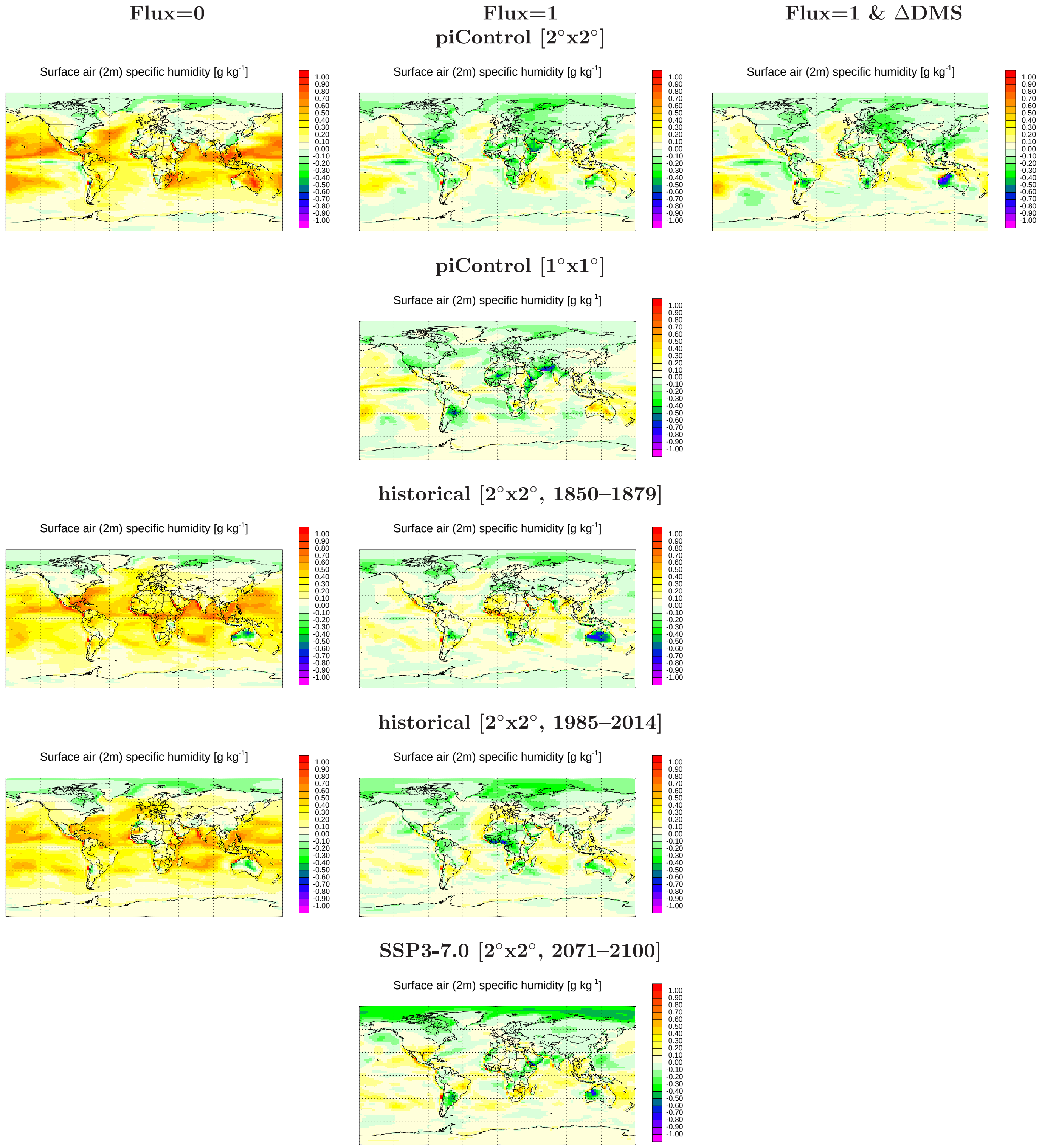

Figure 3: Near-surface (2 m) specific humidity : DJF mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

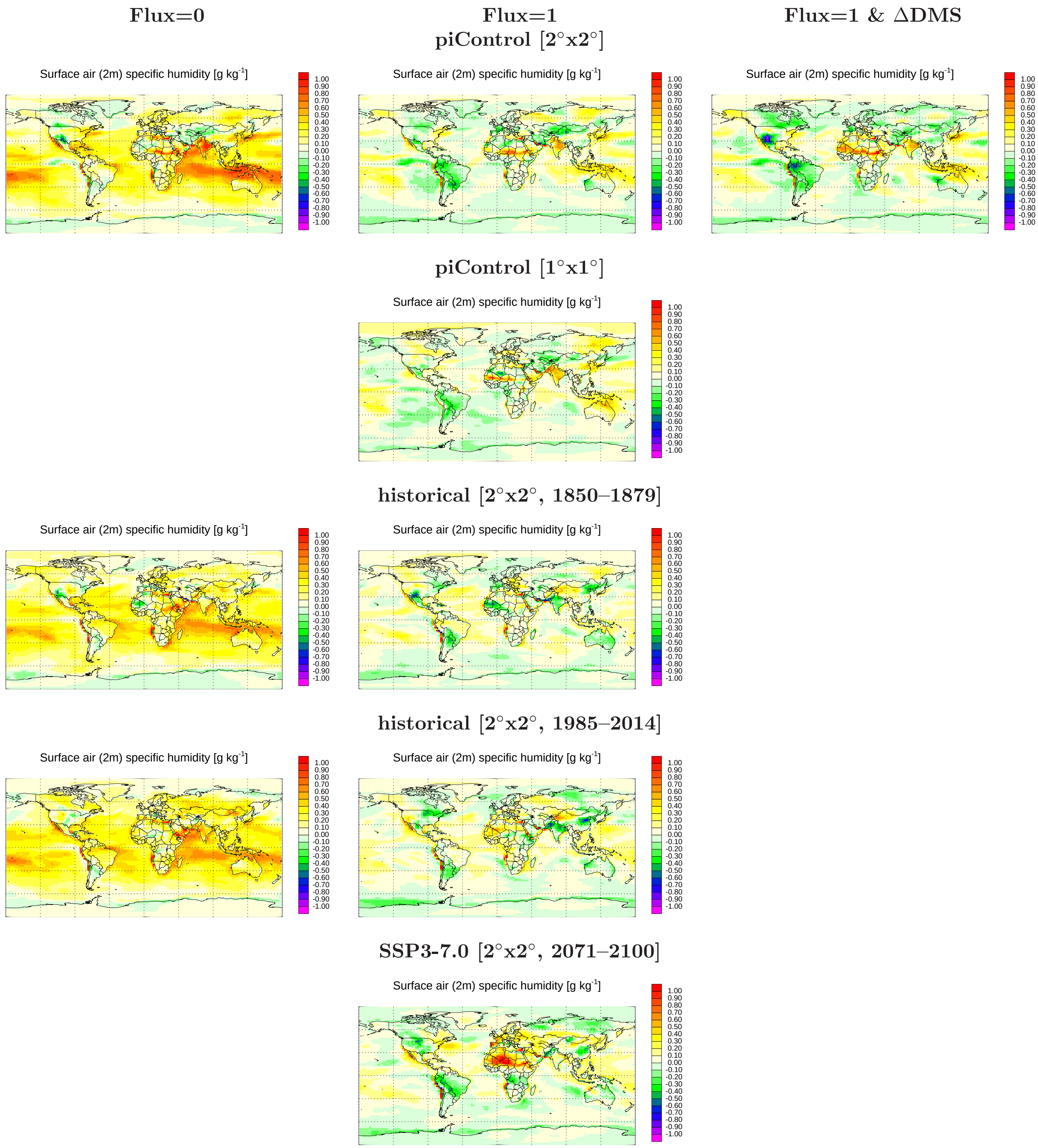

Figure 4: Near-surface (2 m) specific humidity : JJA mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

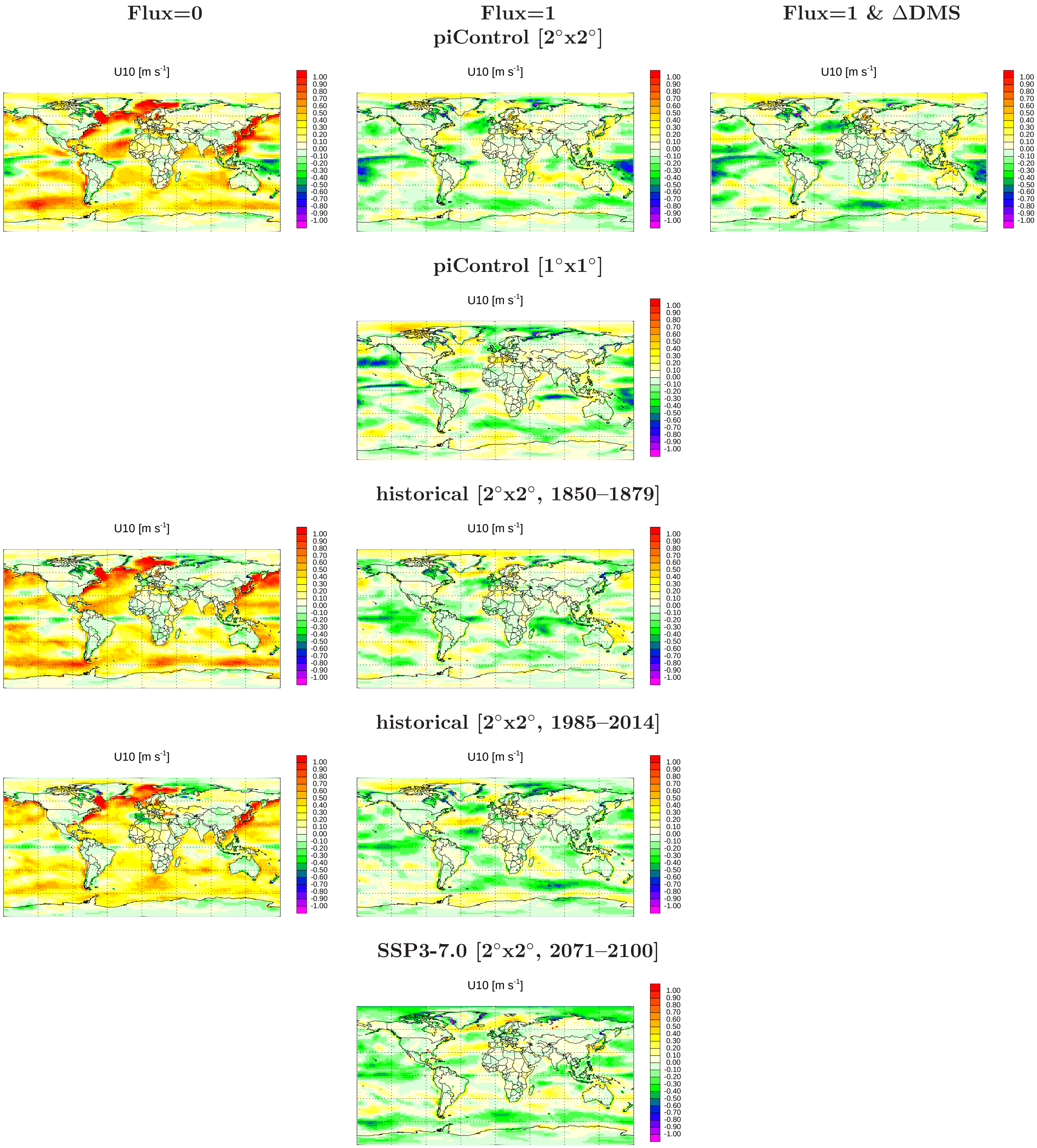

Figure 5: Near-surface (10 m) wind : DJF mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

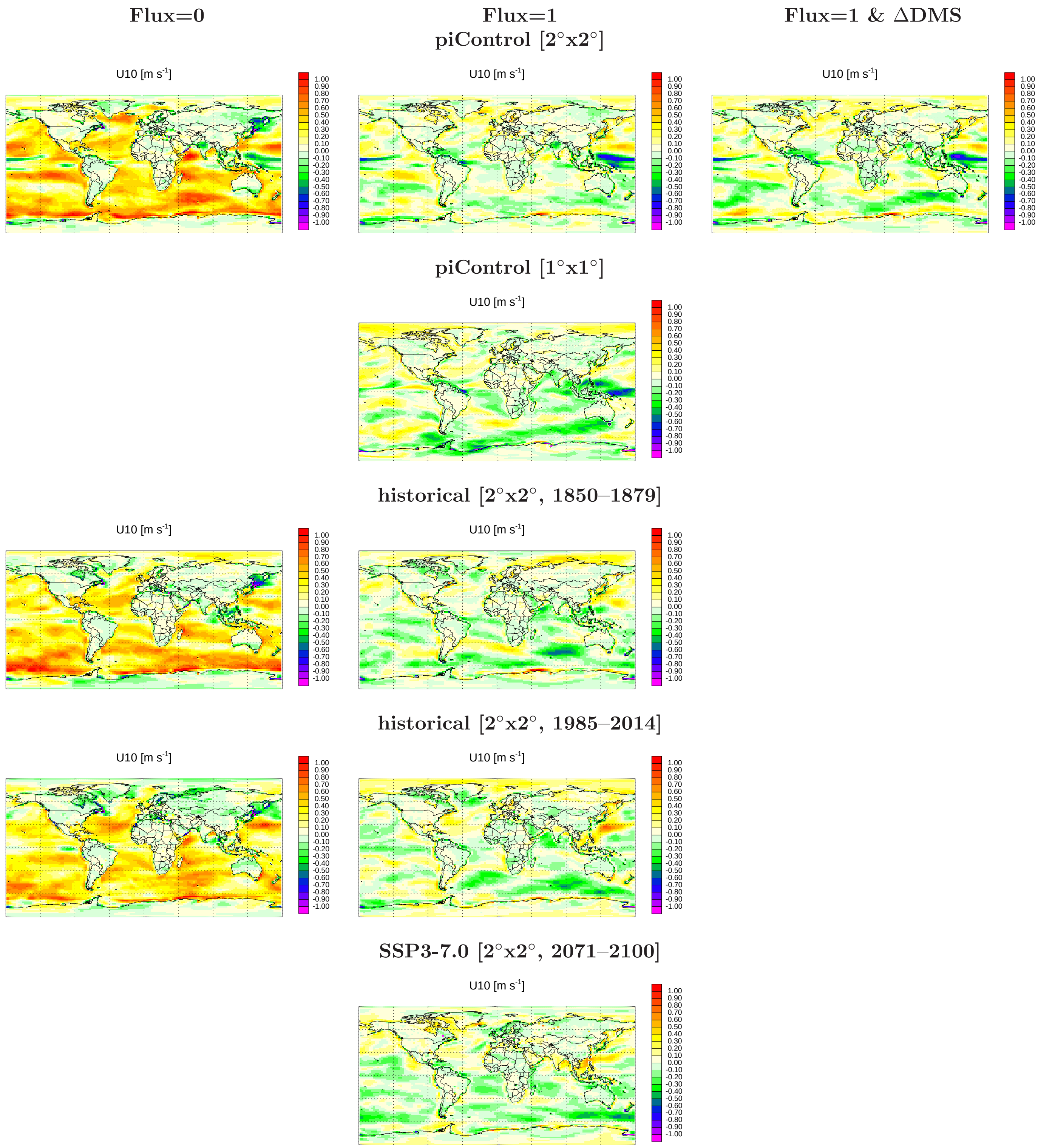

Figure 6: Near-surface (10 m) wind : JJA mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

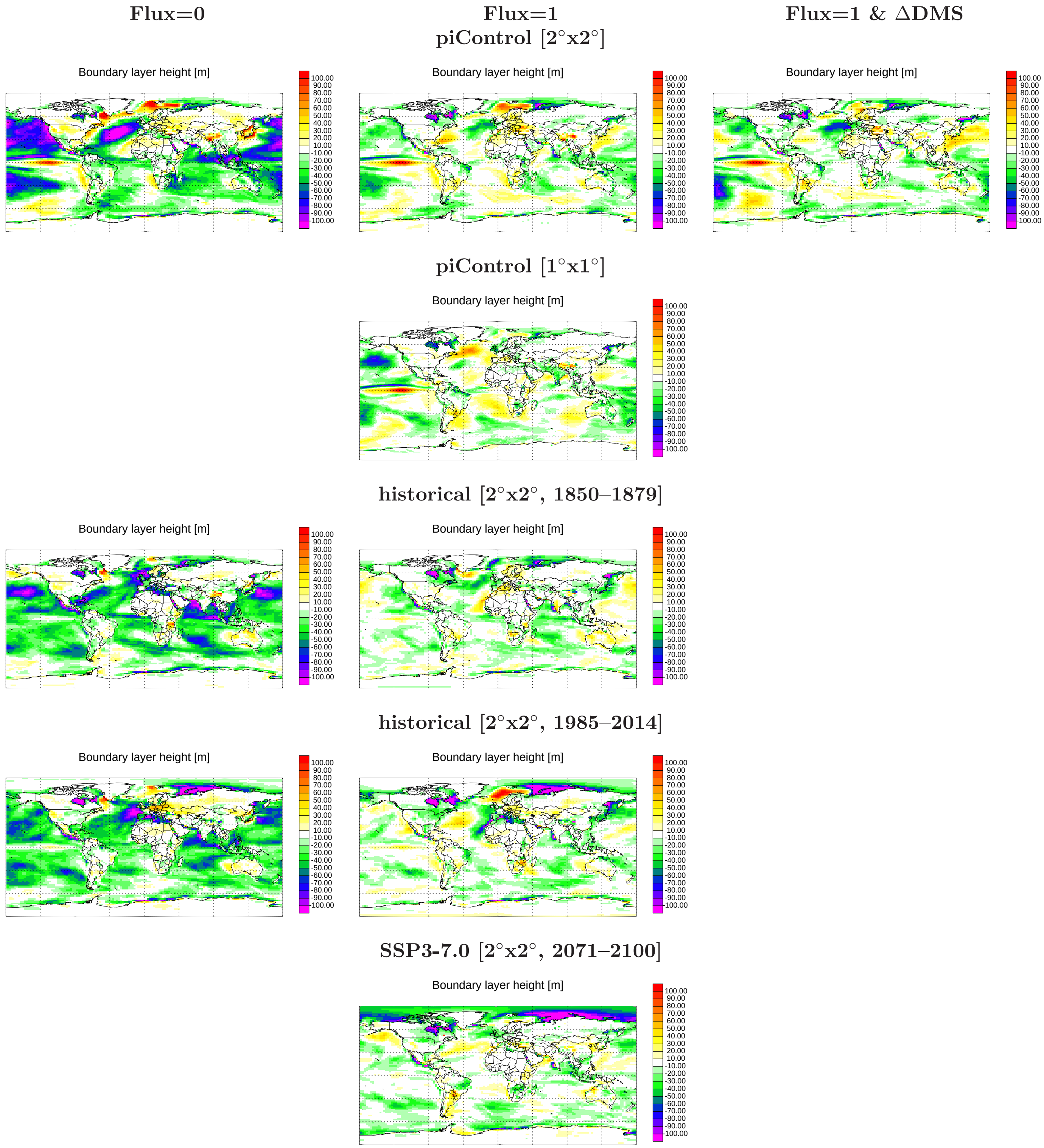

Figure 7: Boundary layer height : DJF mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

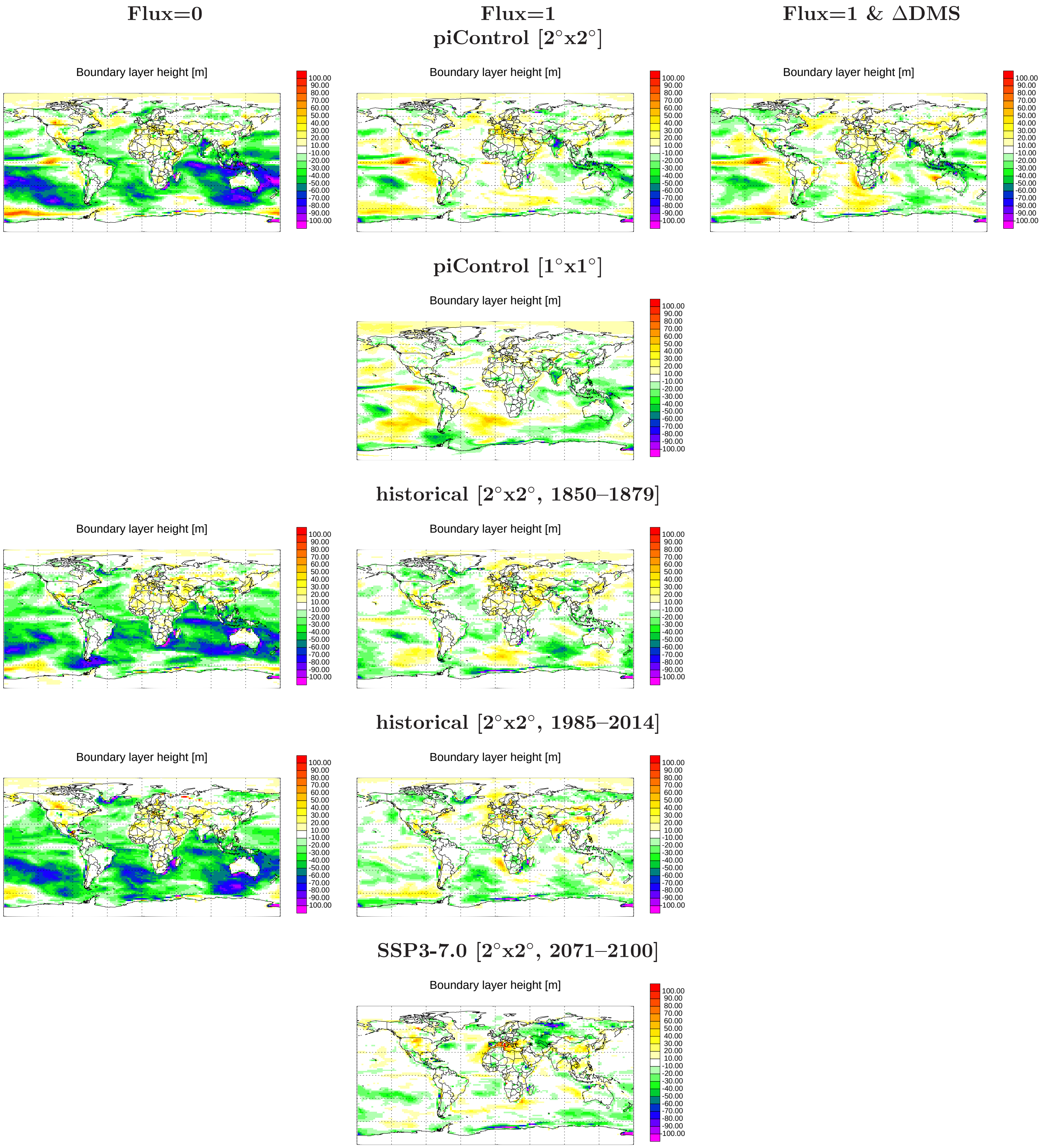

Figure 8: Boundary layer height: JJA mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

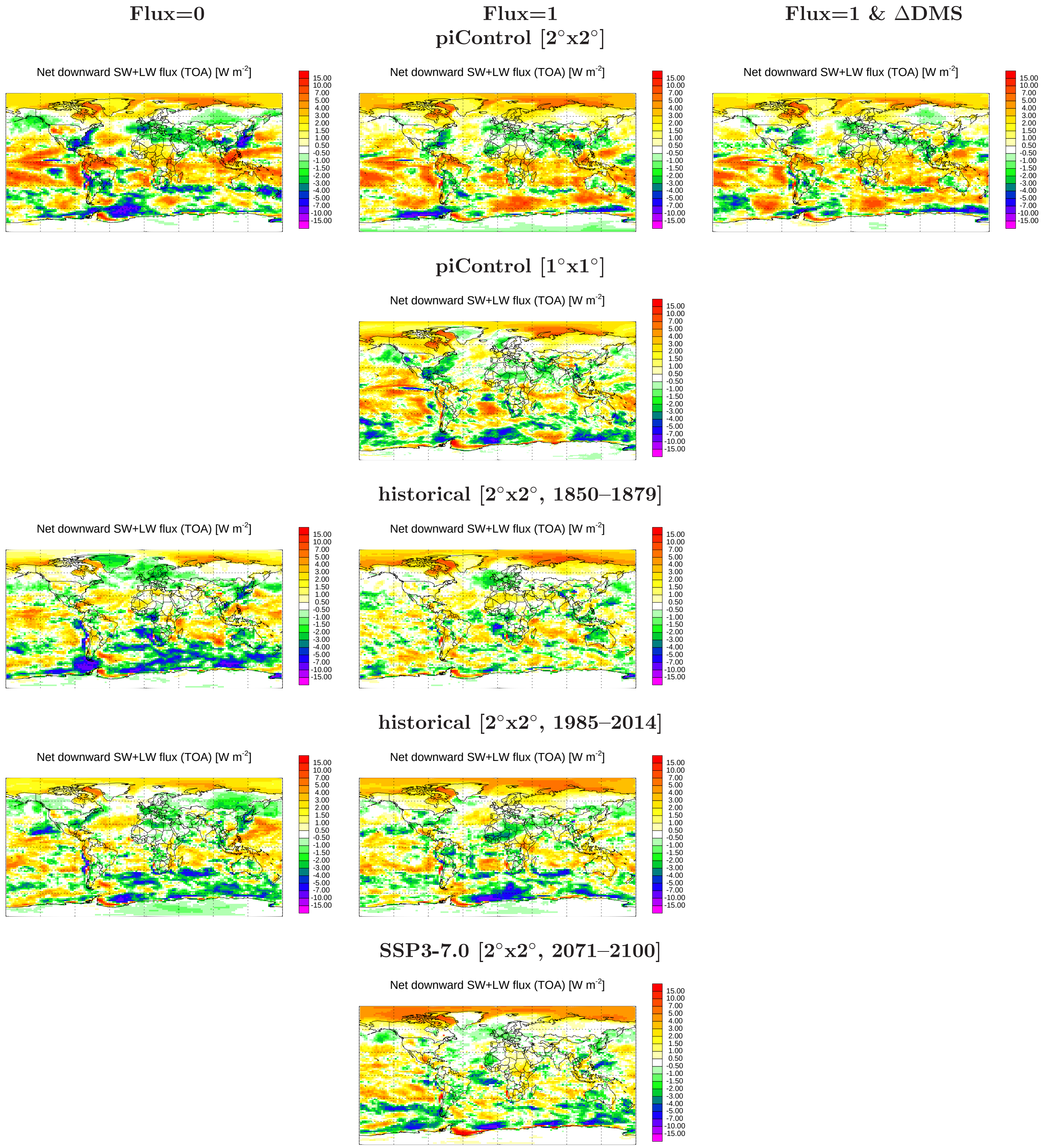

Figure 9: TOA imbalance : DJF mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

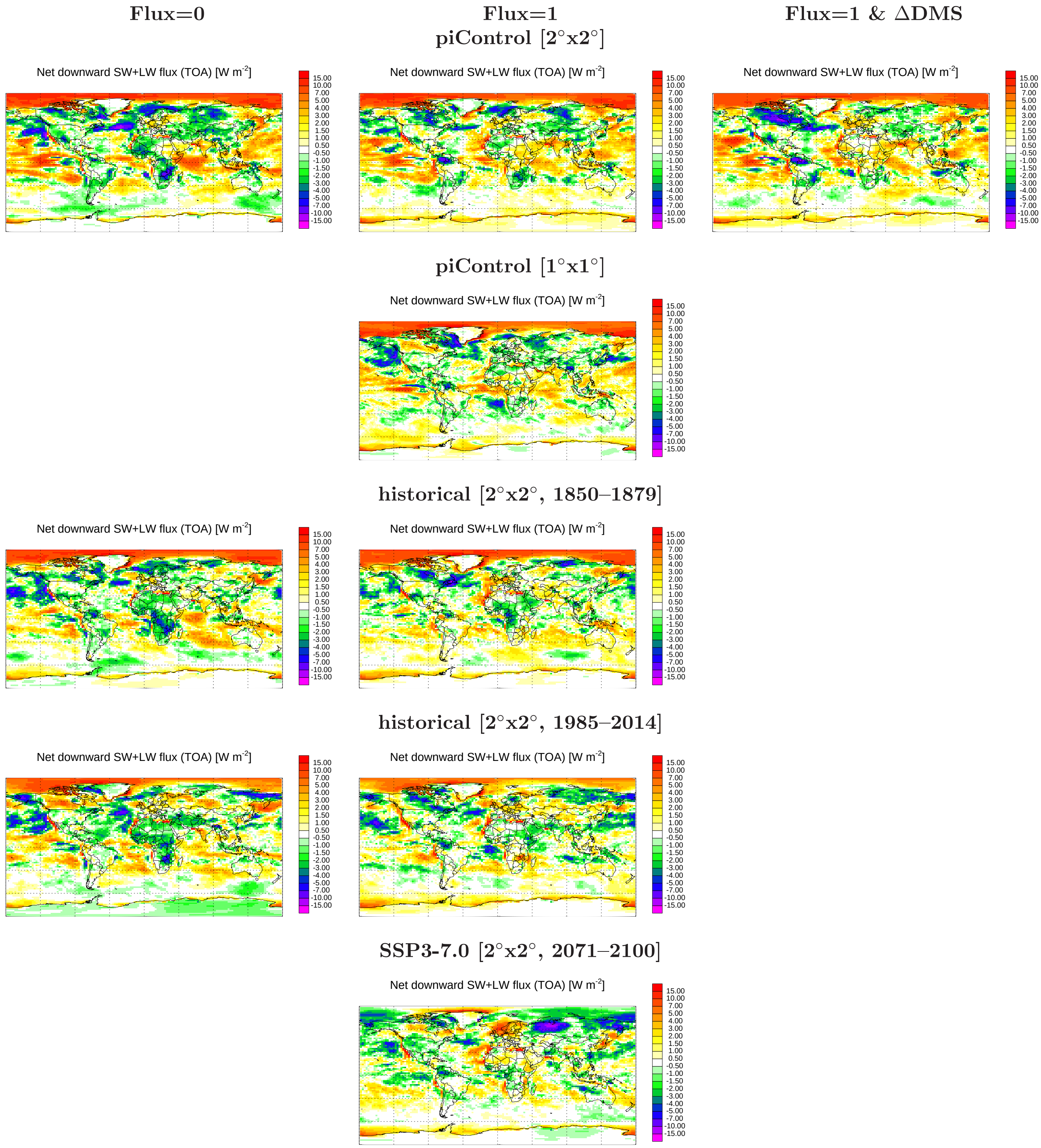

Figure 10: TOA imbalance: JJA mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

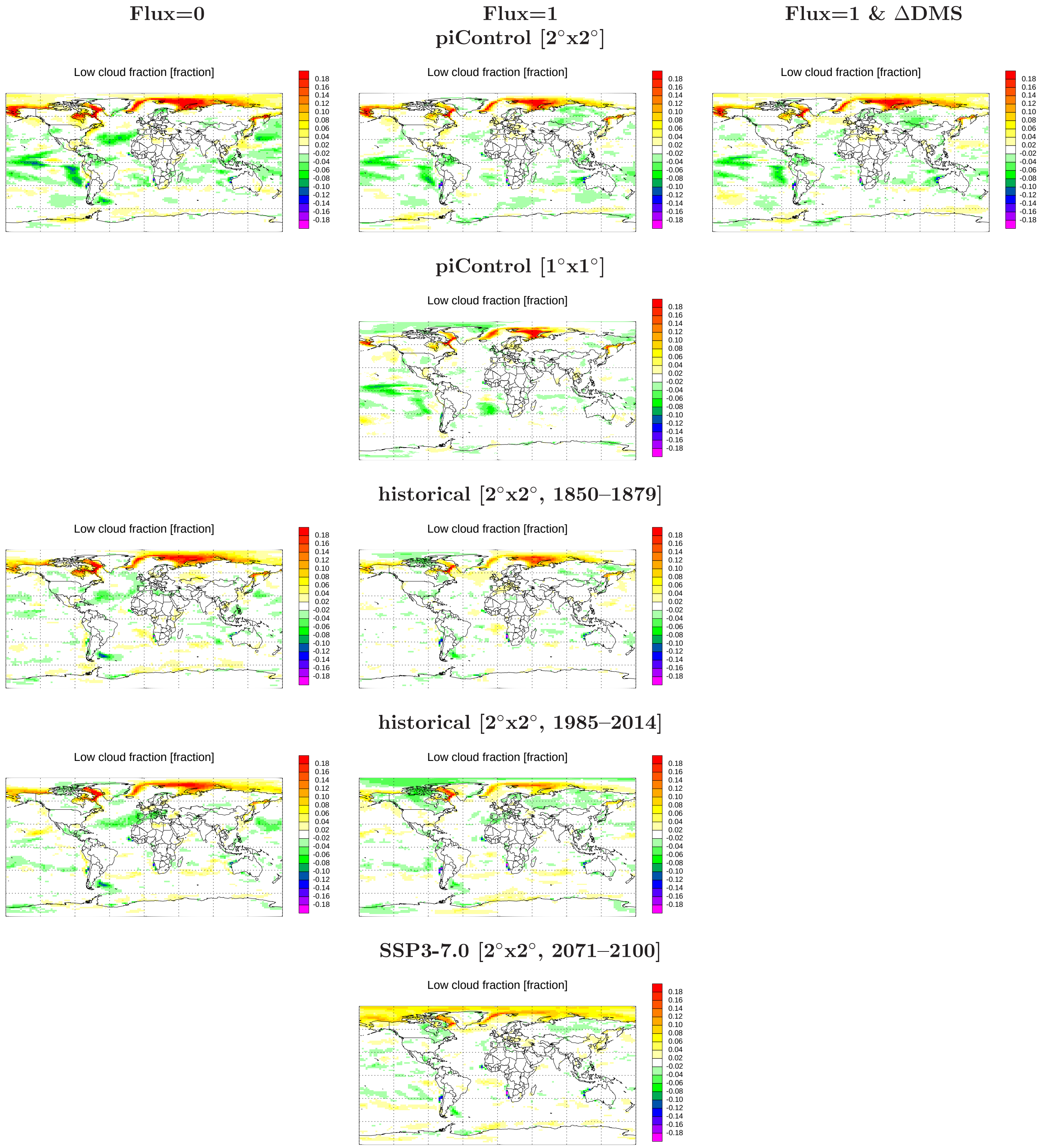

Figure 11: Low cloud cover : DJF mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

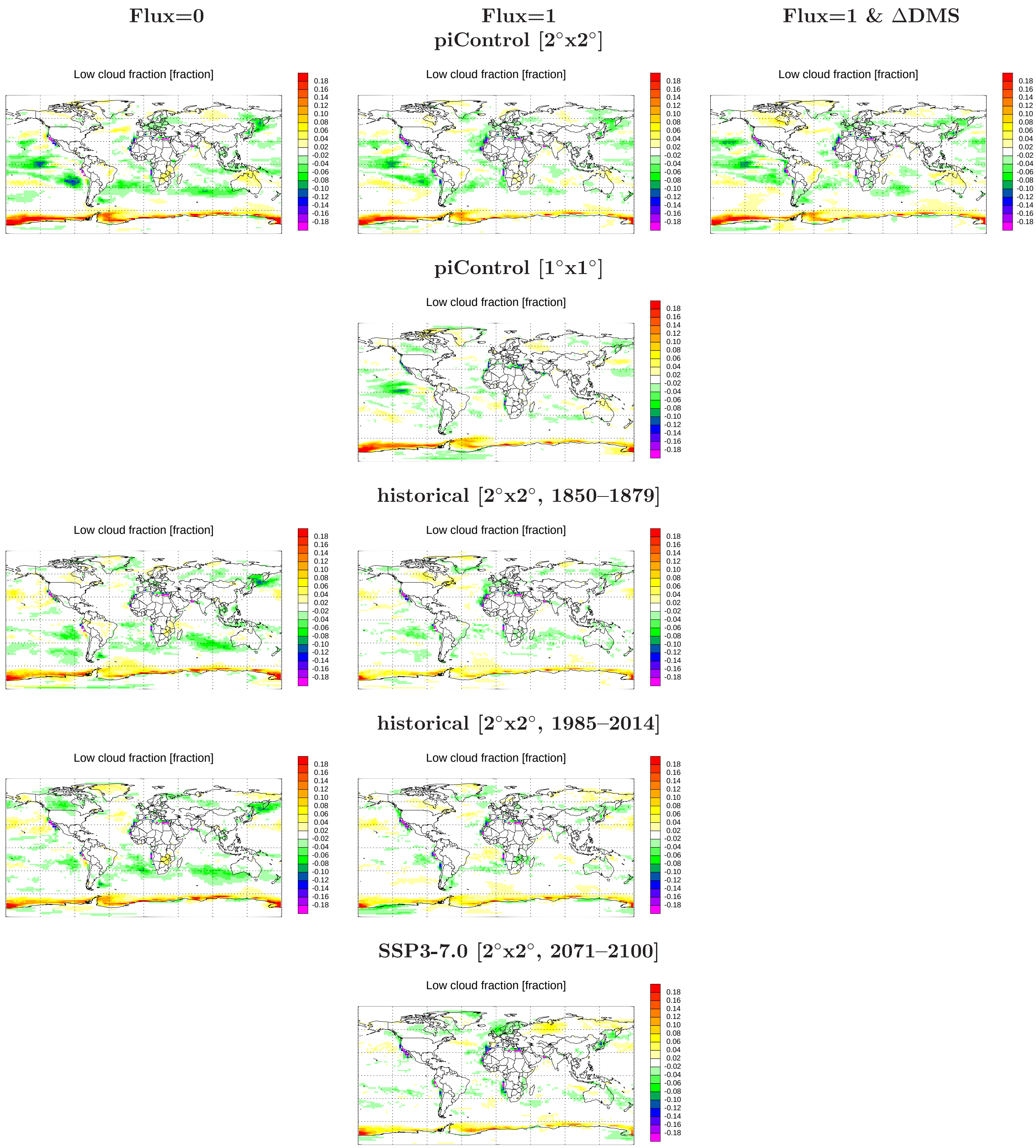

Figure 12: Low cloud cover : JJA mean difference between the atmosphere-only and fully-coupled simulations for piClim-control/piControl on 2°x2°, piClim-control/piControl on 1°x1°, hisSST/historical on 2°x2°, and ssp370SST/ssp370.

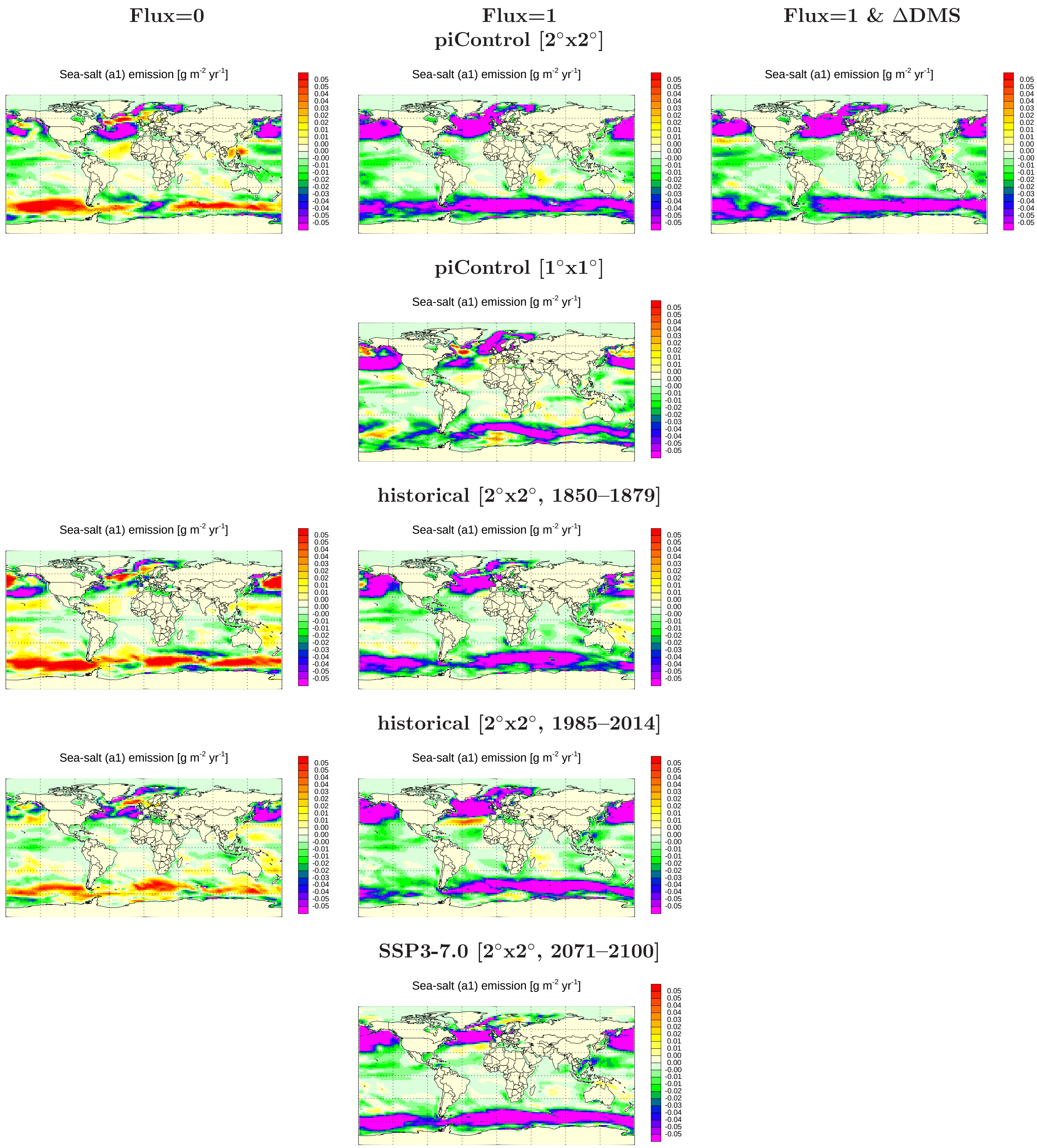

Figure 13: Sea-salt (mode 1) emission strenght in DJF.

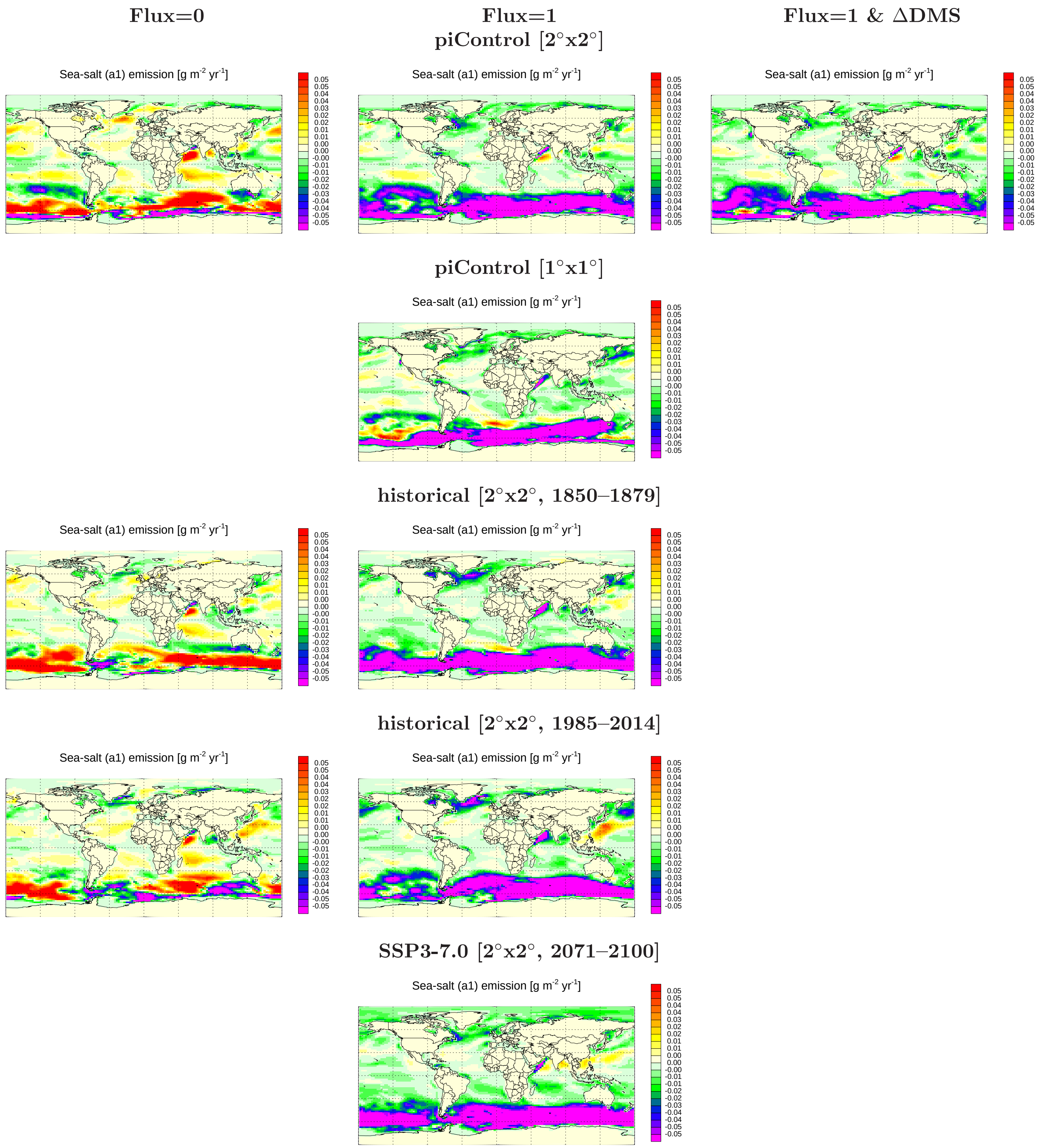

Figure 14: Sea-salt (mode 1) emission strenght in JJA.

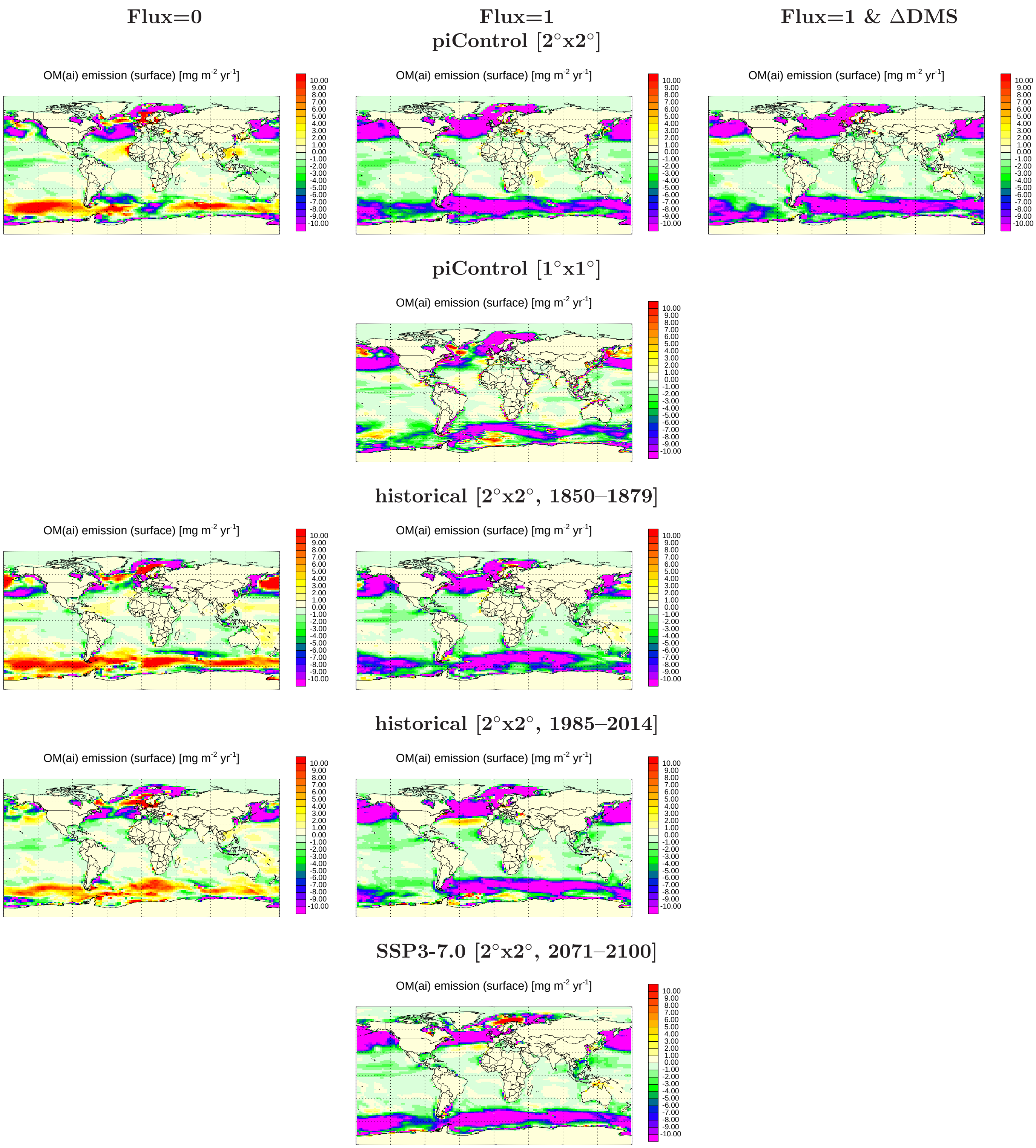

Figure 15: Organic matter emission strenght in DJF.

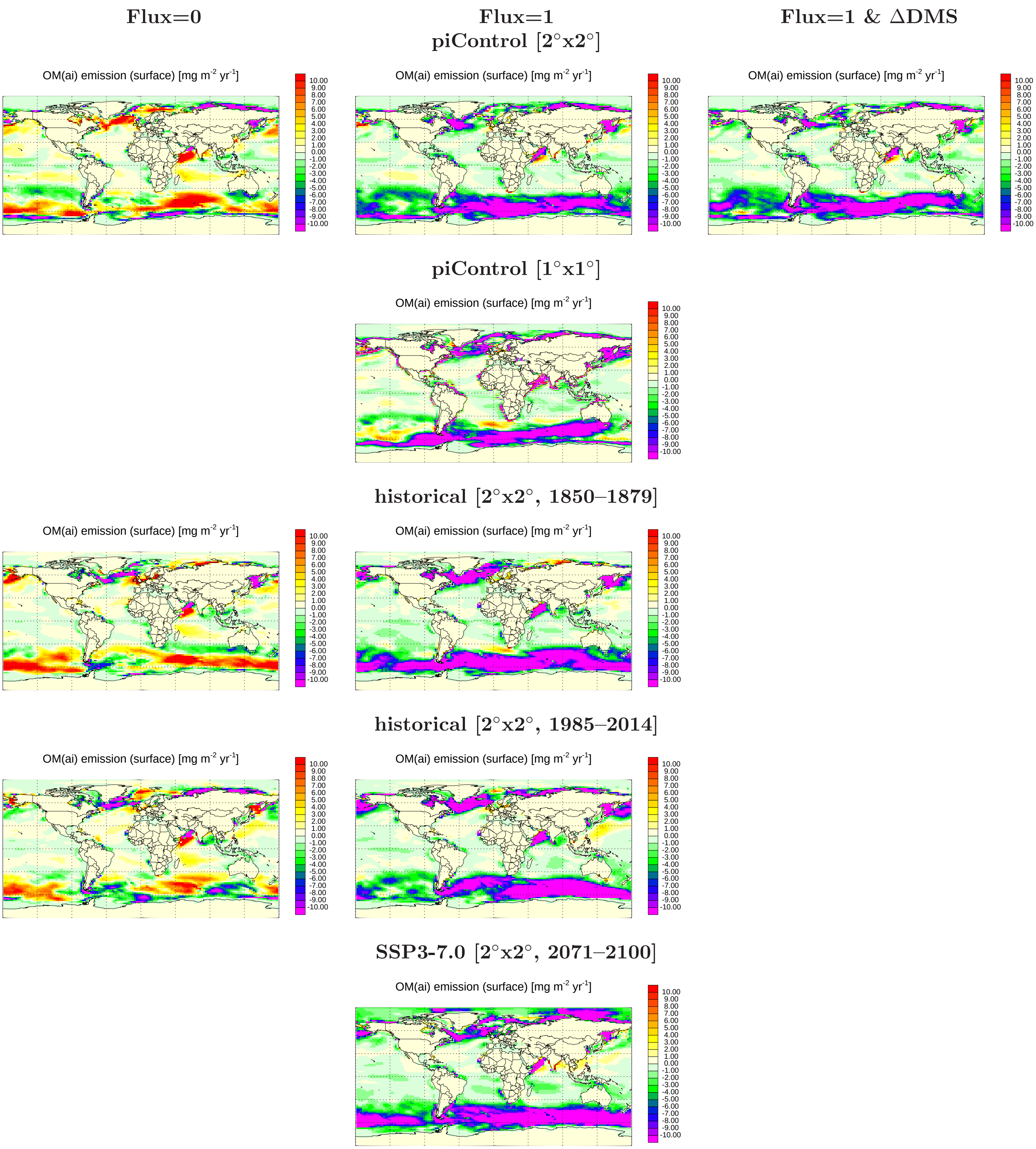

Figure 16: Organic matter emission strenght in JJA.

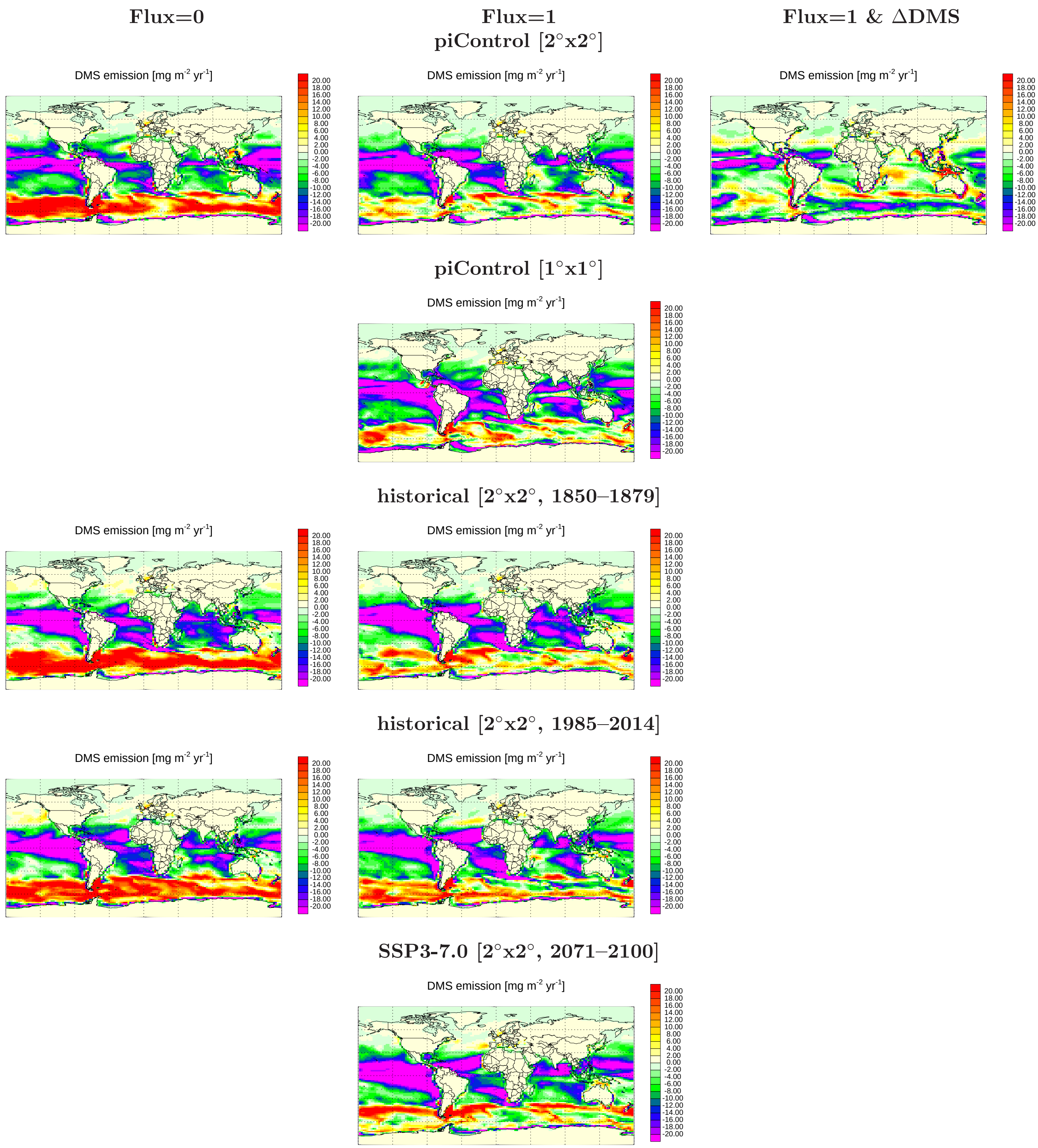

Figure 17: DMS emission strenght in DJF.

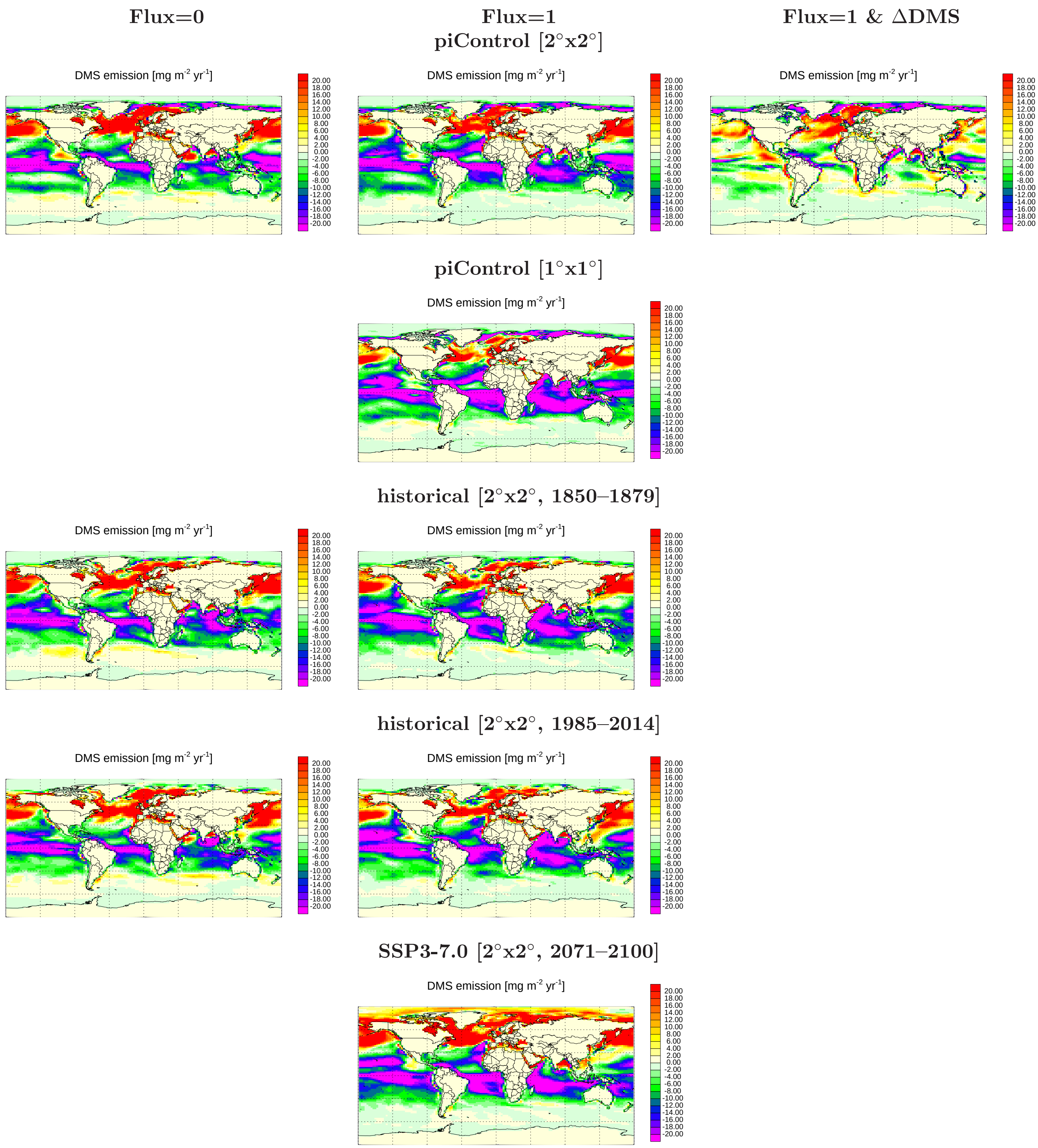

Figure 18: DMS emission strenght in JJA.