Earth system modelling applied to the Late Cenomanian Plenus Cold Event in the Western Interior Seaway

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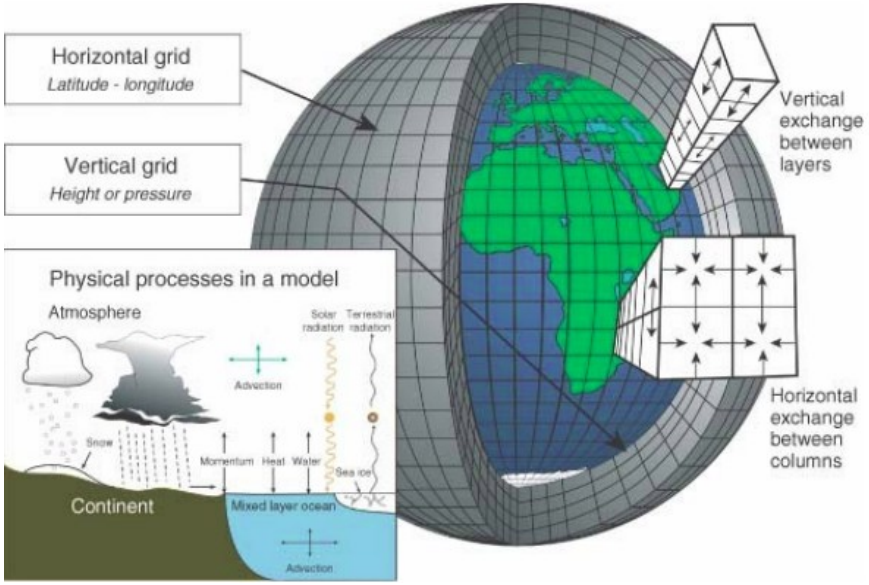
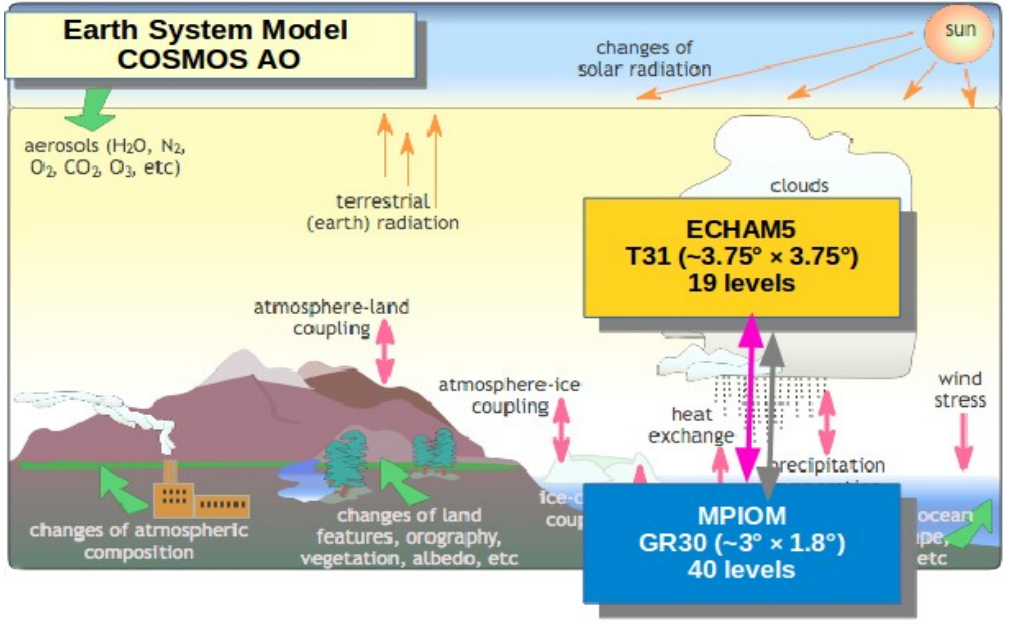


Graphic by Courtney Ritz and Trevor Burnham

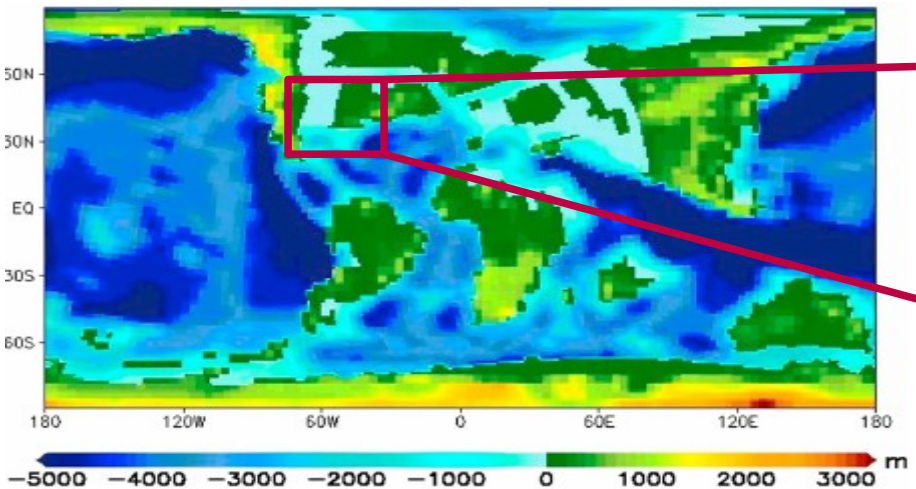


Plenus event

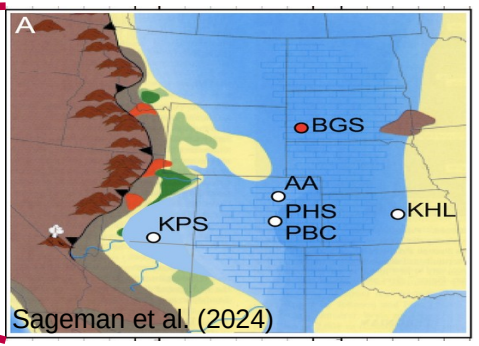
Cooling event within super-greenhouse of Oceanic Anoxic Event 2 (~94 Ma)

However, faunal data from the central to southern part of the WIS provide clear evidence for warm, rather than cool conditions spanning the core Plenus Cold Event (PCE) interval.

Late Cretaceous



Markwick and Valdes (2004)



Sageman et al. (2024)

Plenus event

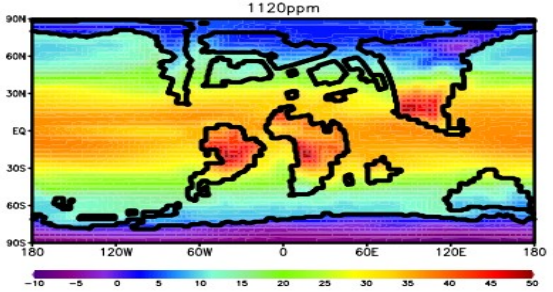
CO_2 level decreased during PCE as indicated for example by stomatal index data

- CO_2 level during OAE2 is estimated to be ~3-5x PI level of 280 ppm;
- CO_2 level during PCE fell at least by ~25% (Jarvis et al. 2011);

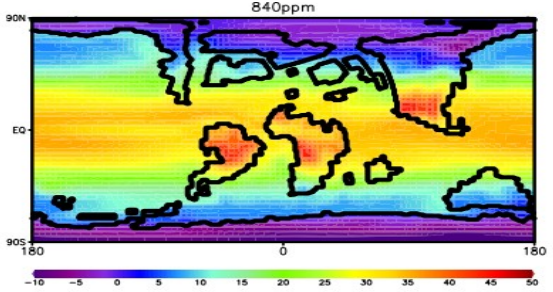
We run three simulations. One with 4x PI CO_2 level representing OAE2 and two with 3x as well as 2x PI CO_2 levels representing PCE. We will compare PCE with OAE by calculating differences (3x – 4x PI and 2x - 4x PI simulations).

Surface Temperature under Different Atmospheric pCO_2 Concentrations

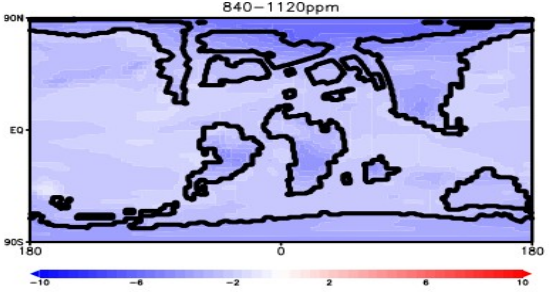
1120ppm



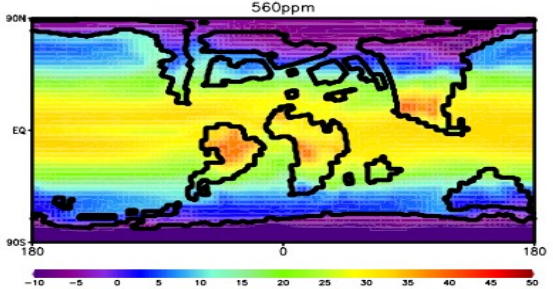
840ppm



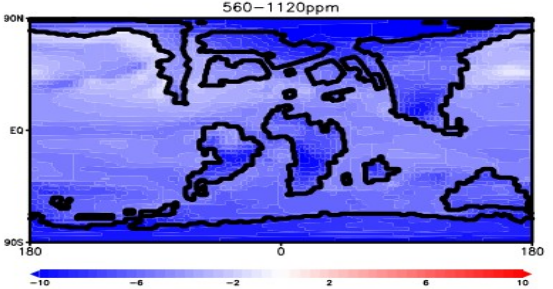
840−1120ppm



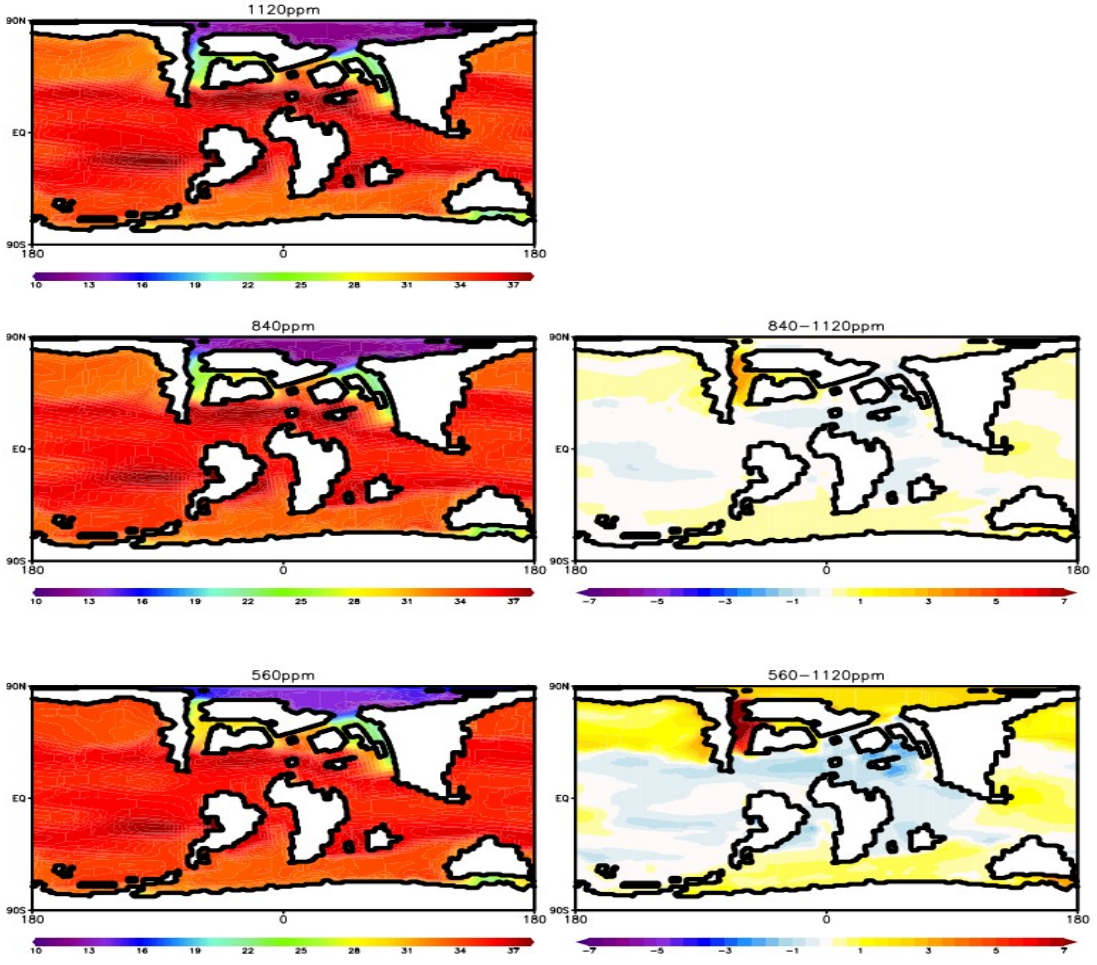
560ppm

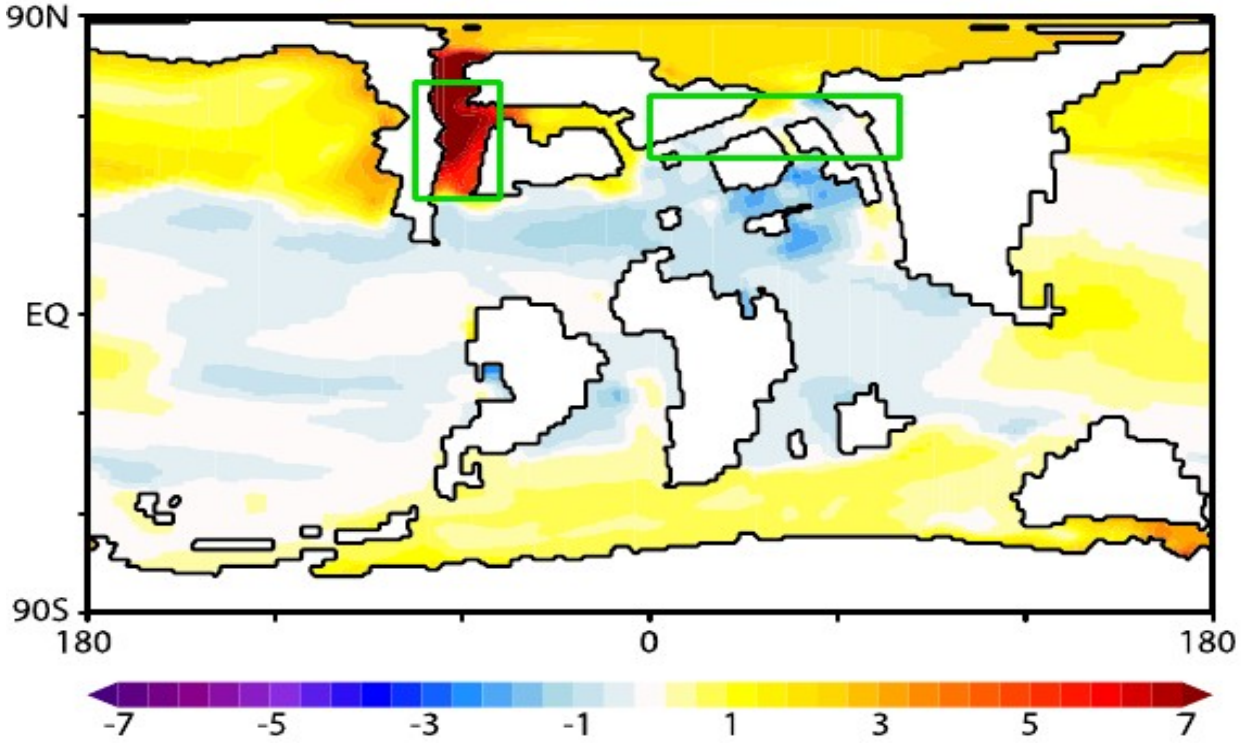


560−1120ppm



Ocean Salinity under Different Atmospheric pCO_2 Concentrations

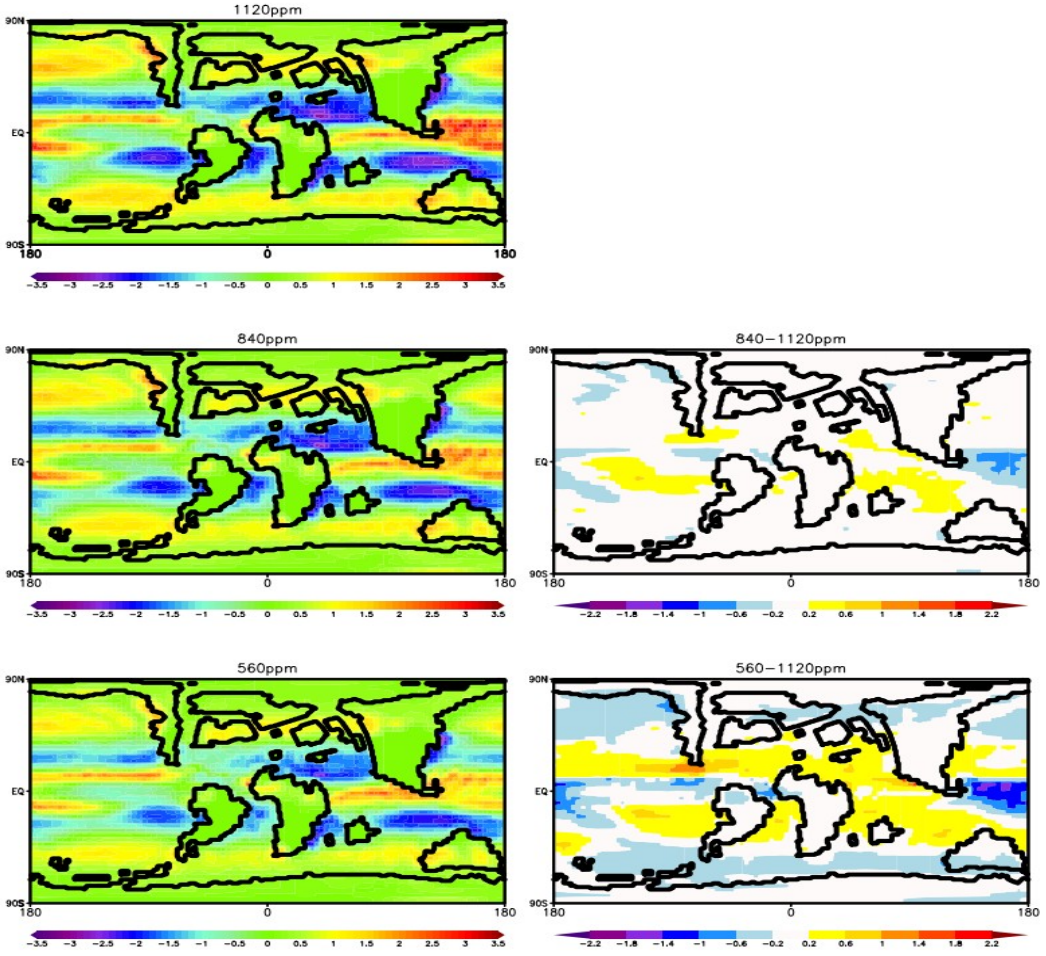




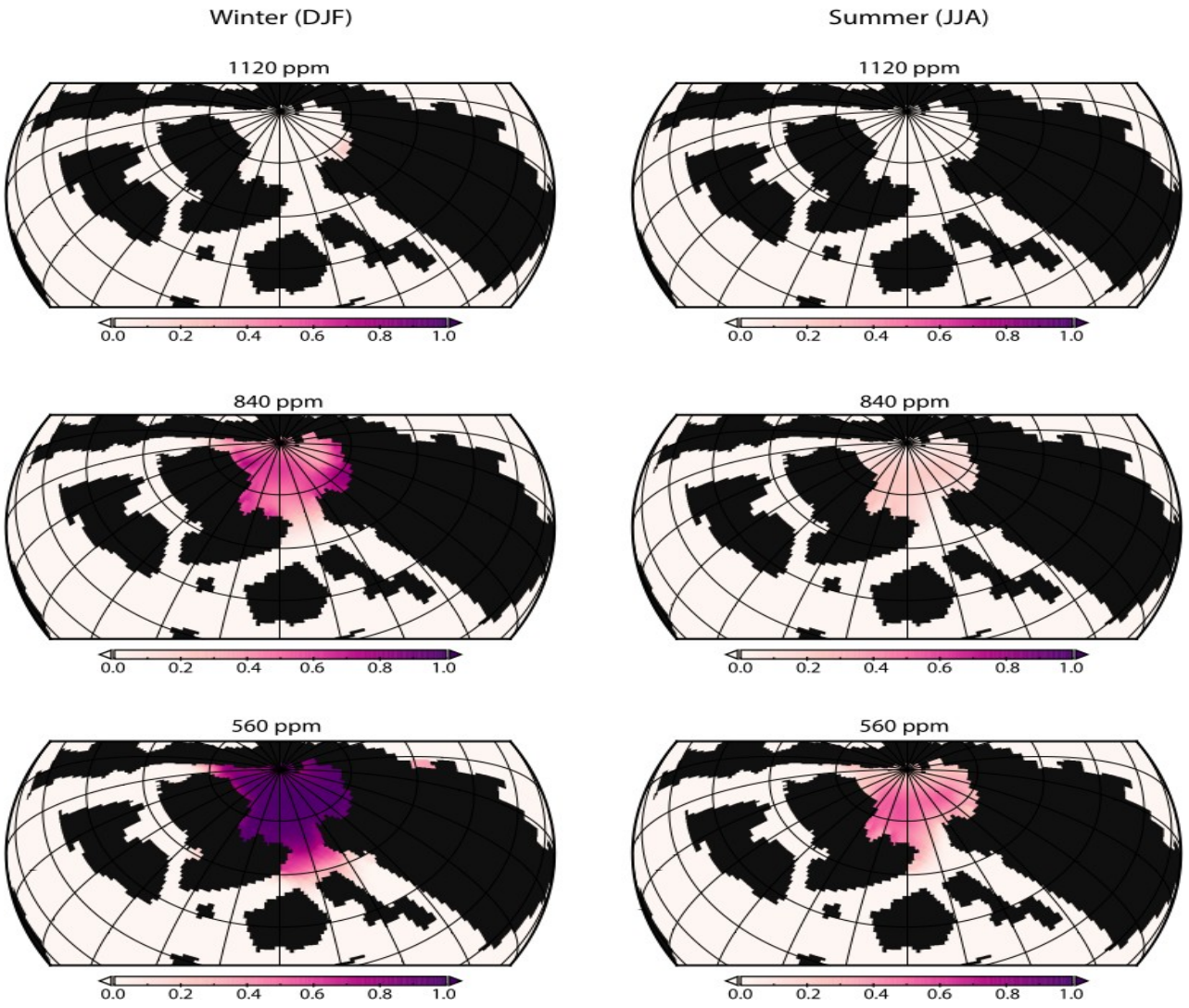
	WIS	Europe
SST (560 ppm-1120 ppm)	-3.5 °C	-6.5 °C
SST vs. GAT	~0.6 × GAT	~1.2 × GAT
SSS (560 ppm-1120 ppm)	~6.3 psu	~-0.1 psu

Why do we observe strong salinity increase and relatively weak cooling in WIS?

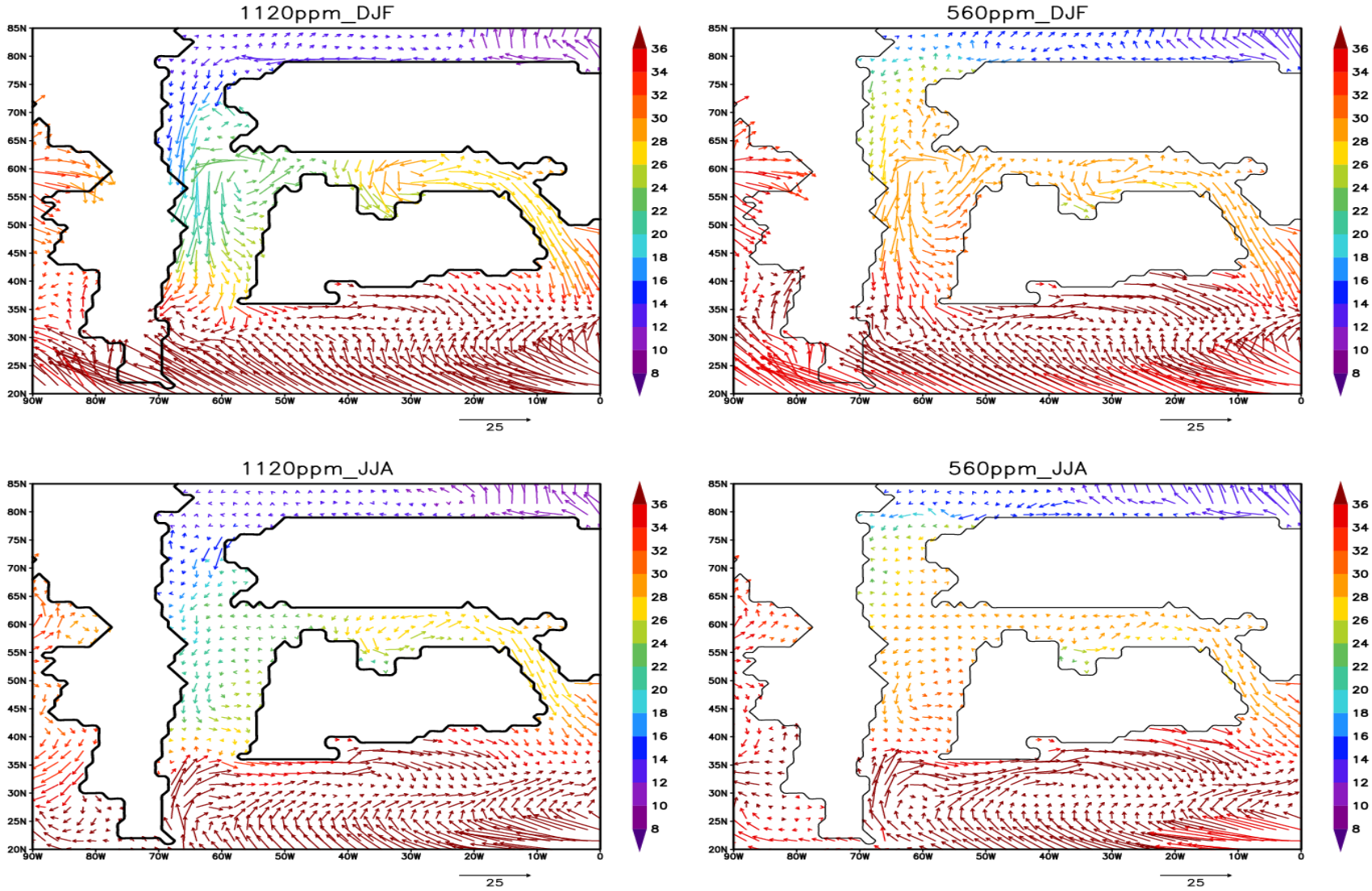
Precipitation minus Evaporation under Different Atmospheric pCO_2 Concentrations



Northern Hemisphere Seasonal Sea Ice Fraction under Different Atmospheric pCO_2 Concentrations



Seasonal surface currents and salinity around WIS for 1120 and 560 ppm simulations



Conclusions

Strong salinity increase and relatively weak cooling in the WIS compared to European domain in the simulation 560 ppm vs. 1120 ppm:

- can't be explained only by direct changes of CO_2 and associated stronger hydrological cycle;
- changes in the ocean circulation due to differences in the sea ice cover support stronger freshening of waters in the WIS from the north in 1120 ppm simulation;
- the greatest changes in ocean circulation are observed during the winter when there are the greatest differences in sea ice cover in the Arctic Ocean (ice-free in 1120, fully ice-covered in 560);
- inflow from the south during summer months supports relatively weak cooling in the WIS in the simulation 560 ppm and incursion of warm-habitat fauna.