Universität Hamburg
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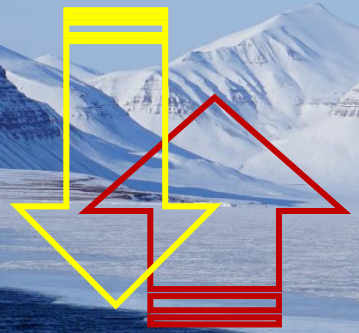
SCHOOL OF INTEGRATED CLIMATE AND EARTH SYSTEM SCIENCES

Long-term evolution of heat fluxes at the Arctic sea-ice edge



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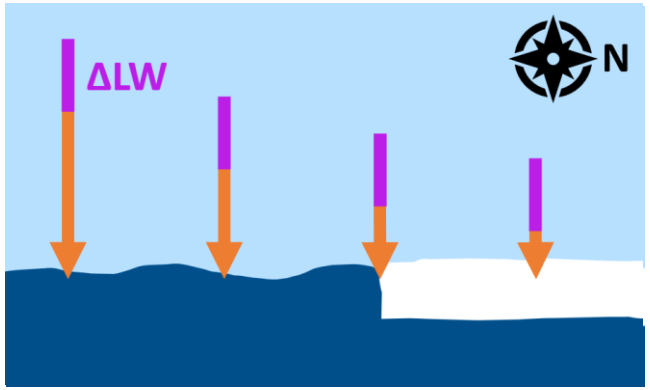
Previous studies



Surface energy budget (SEB):

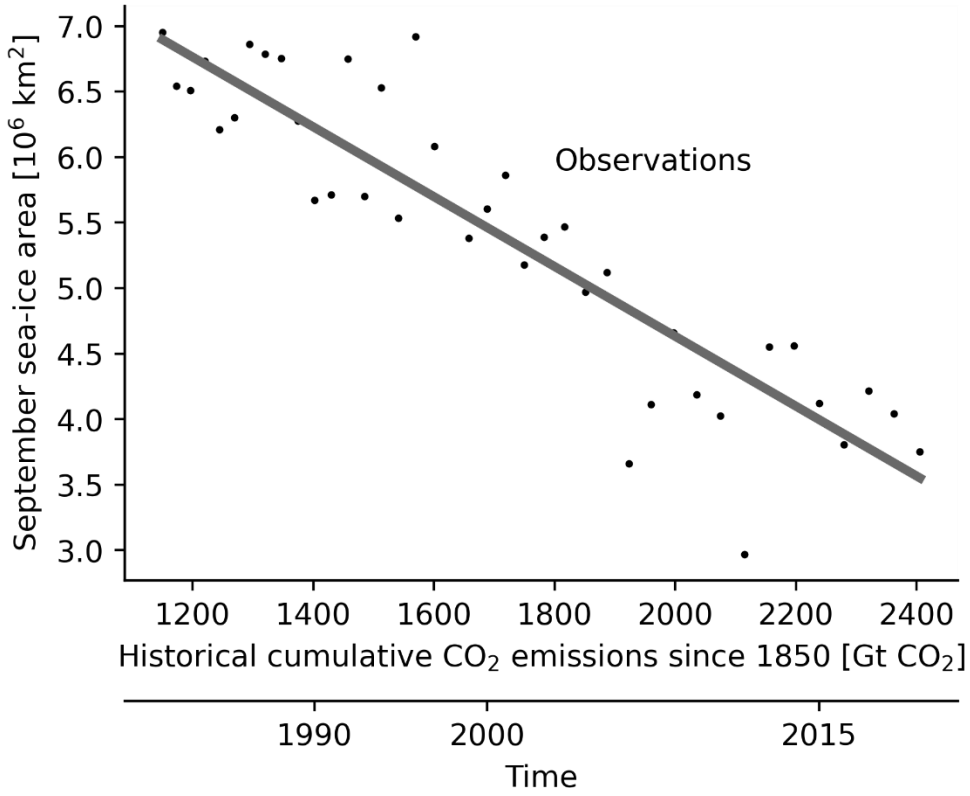
$$SEB = LW\downarrow - LW\uparrow + SW\downarrow - SW\uparrow + latent + sensible + conductive$$

Assumption: SEB stays constant.

$$\Rightarrow \Delta\,SEB = 0 = \Delta\,LW_{in} + \Delta\,SW_{net}$$

Observed Arctic sea-ice loss directly follows anthropogenic CO_2 emission

Dirk Notz[1]* and Julienne Stroeve[2,3]



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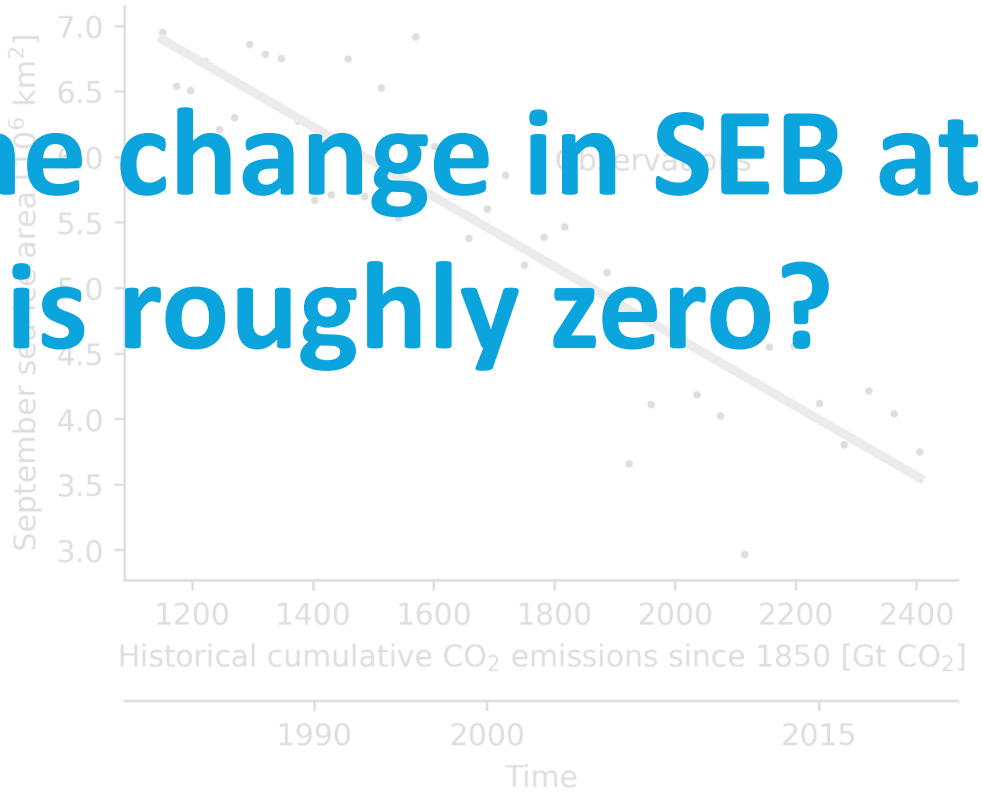
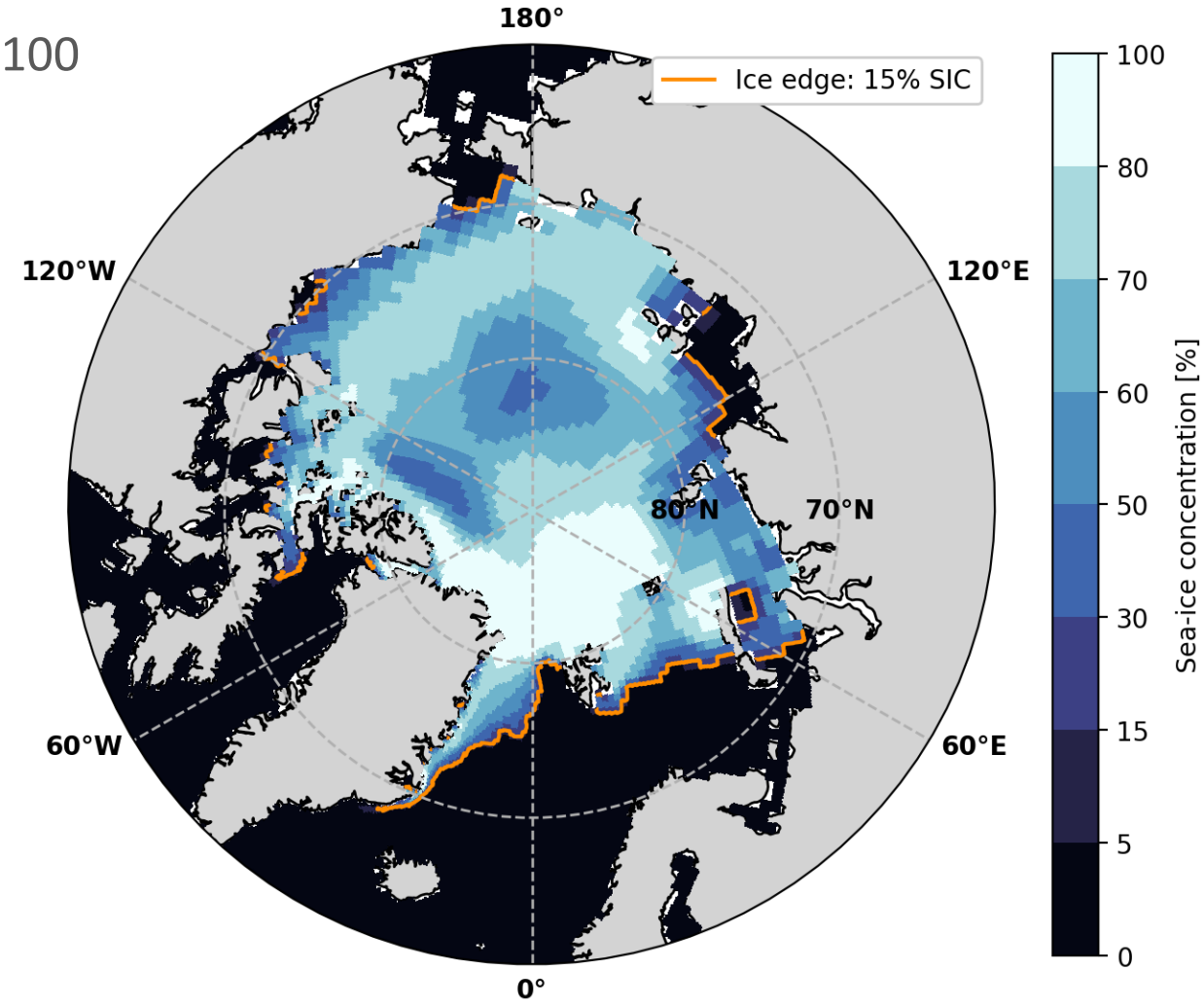


Can we verify that the change in SEB at the moving ice edge is roughly zero?

Sea-ice edge detection

- MPI-ESM1-2-LR (CMIP6), monthly data, 1850 - 2100
- Remap data to regular grid
- Ice edge ≡ 15% sea-ice concentration
- Extract ice edge mask for every September



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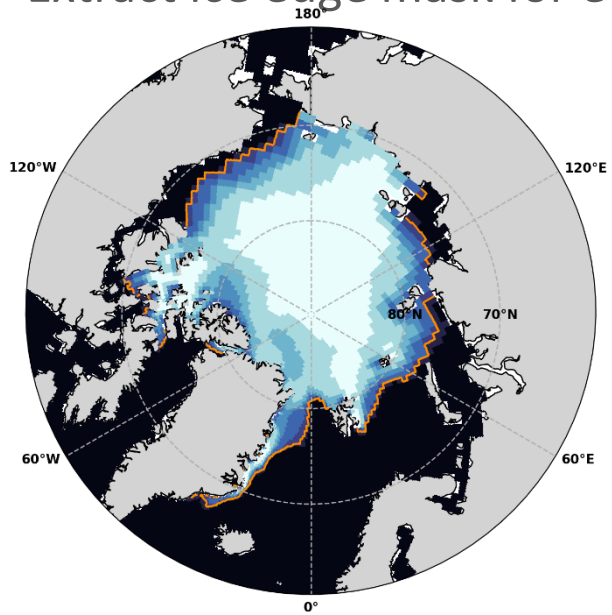
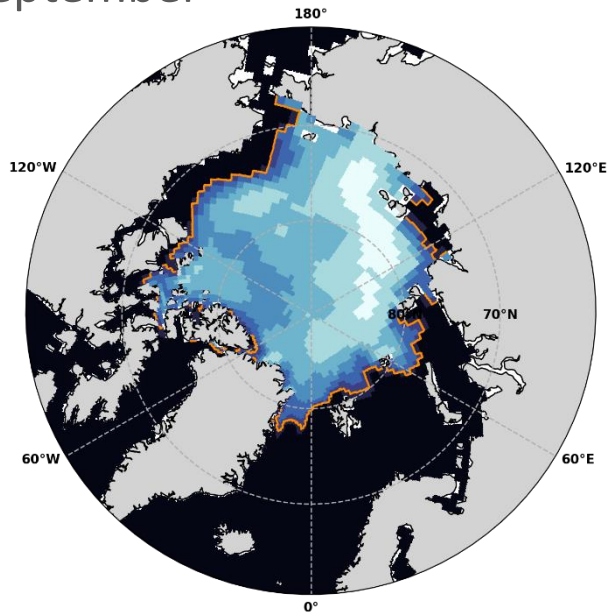
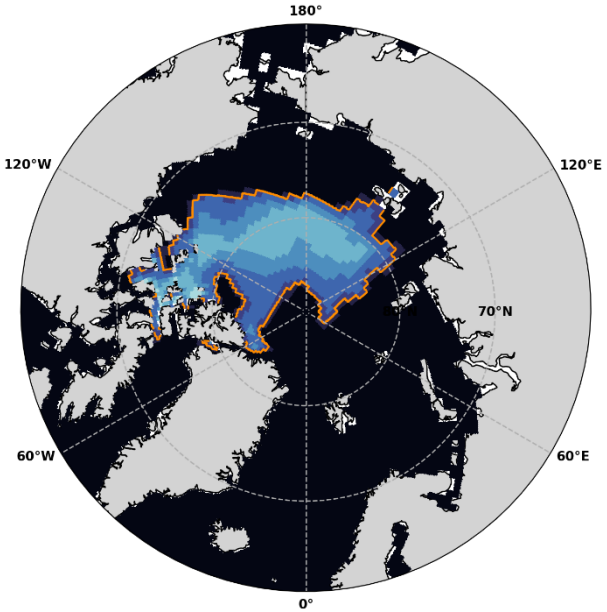


1950

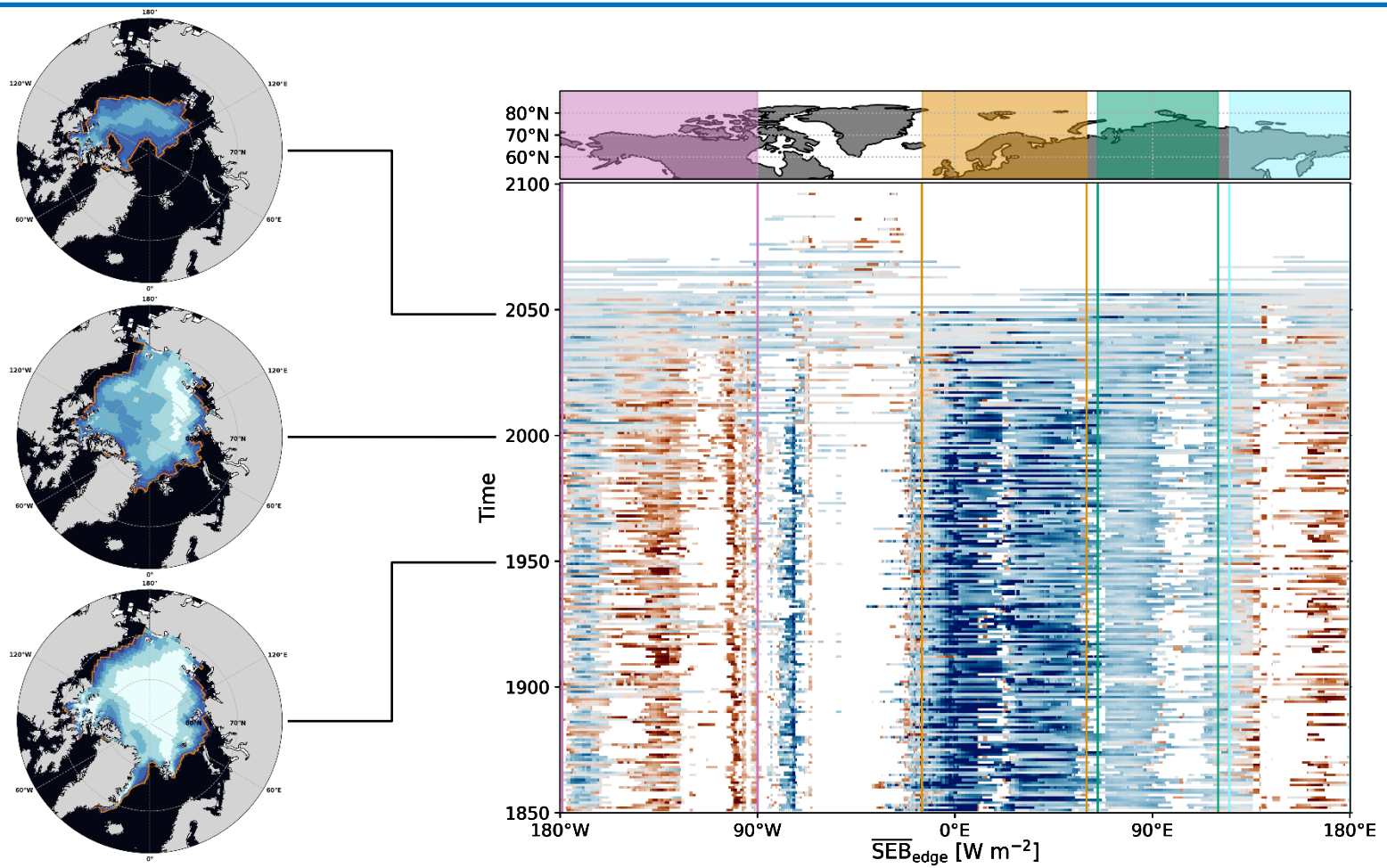


2000



2050

Surface energy budget at the moving sea-ice edge

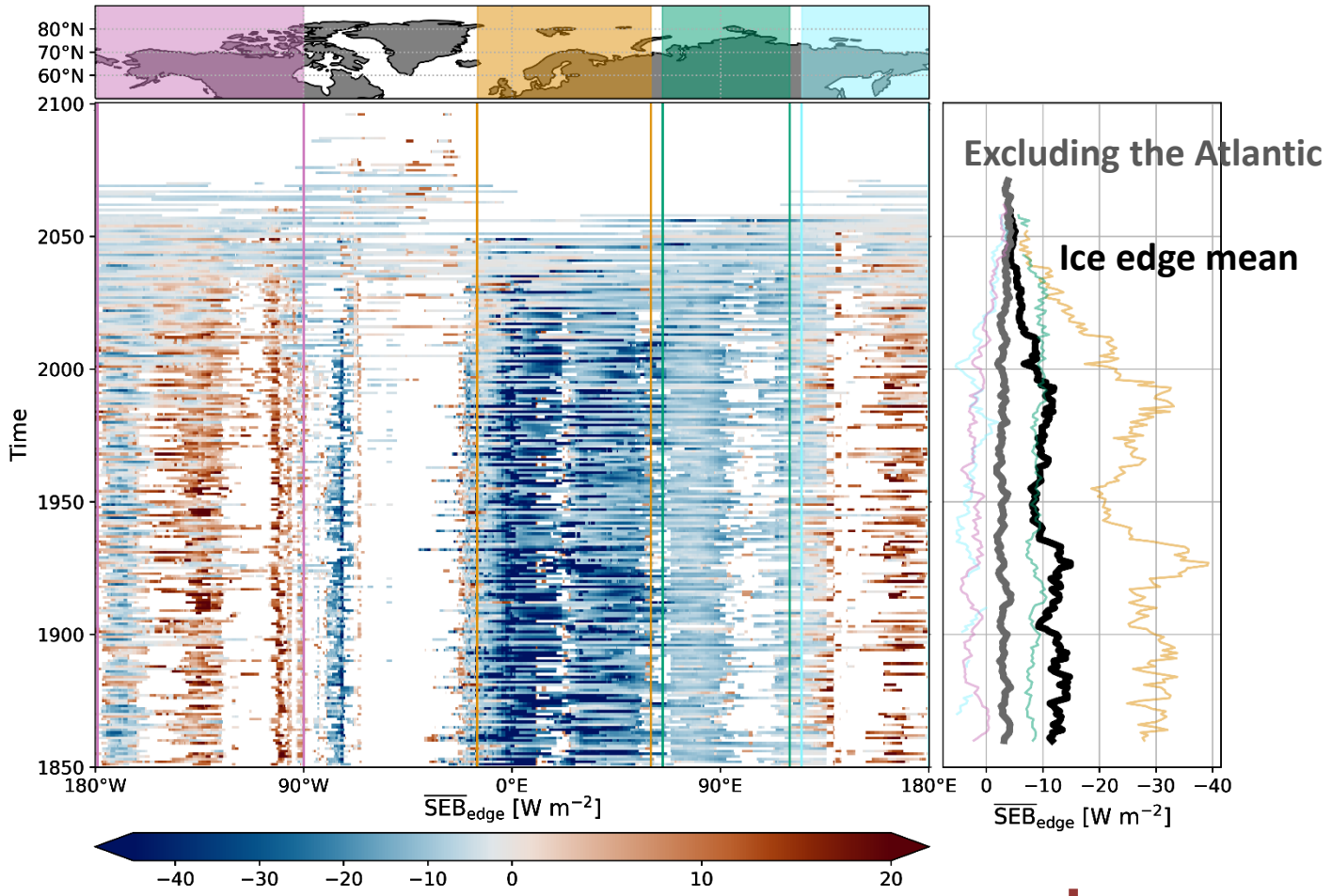


net flux from ice to atmosphere

net flux from atmosphere to ice

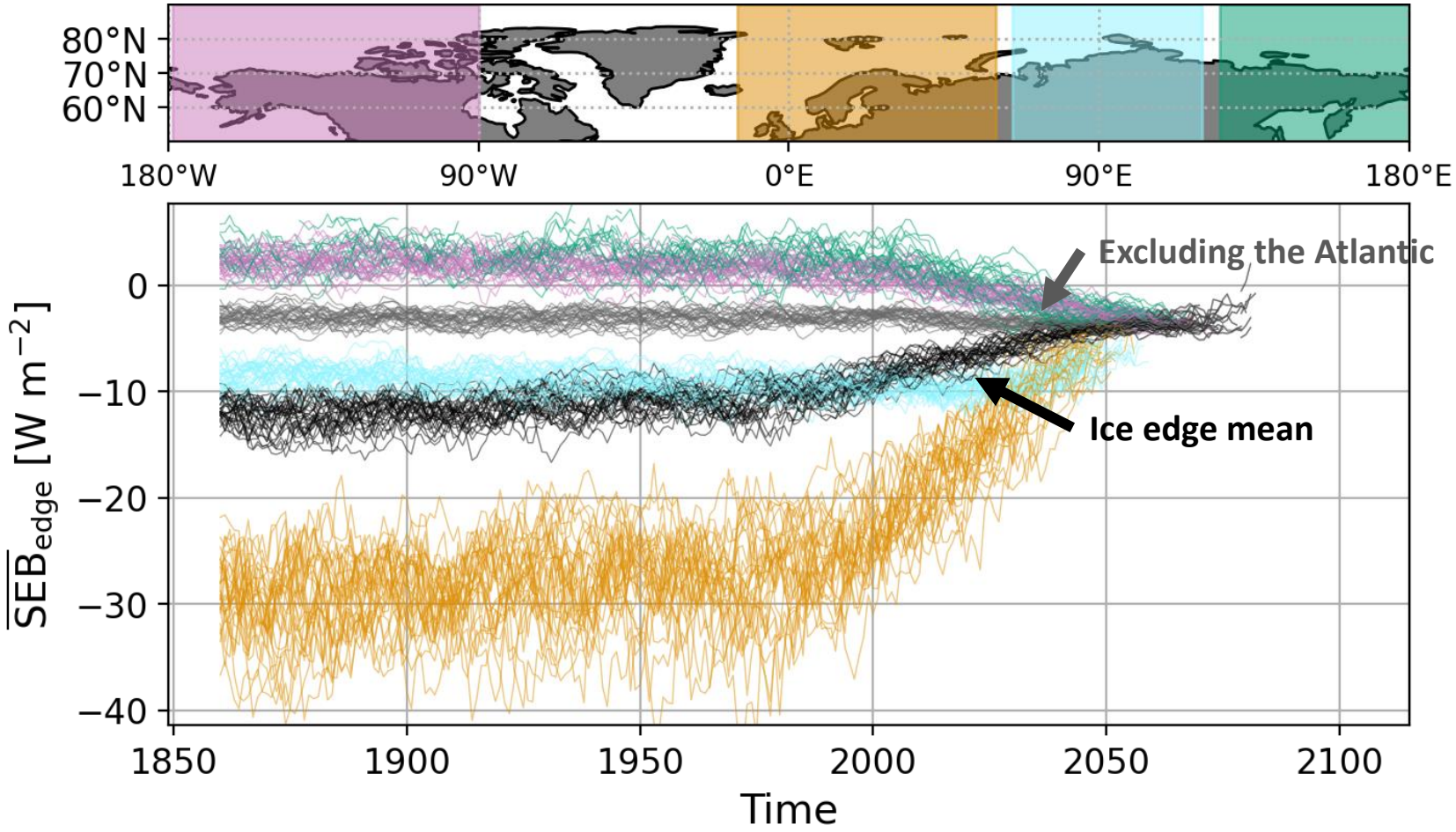
Surface energy budget at the moving sea-ice edge

- Arctic divided into four regions
- SEB is negative in Atlantic
- Largely constant over time except for Atlantic sector



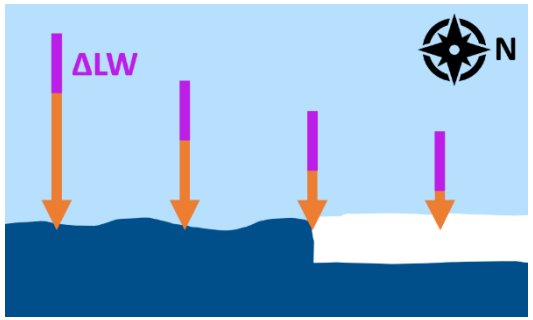
Surface energy budget in different ensemble members

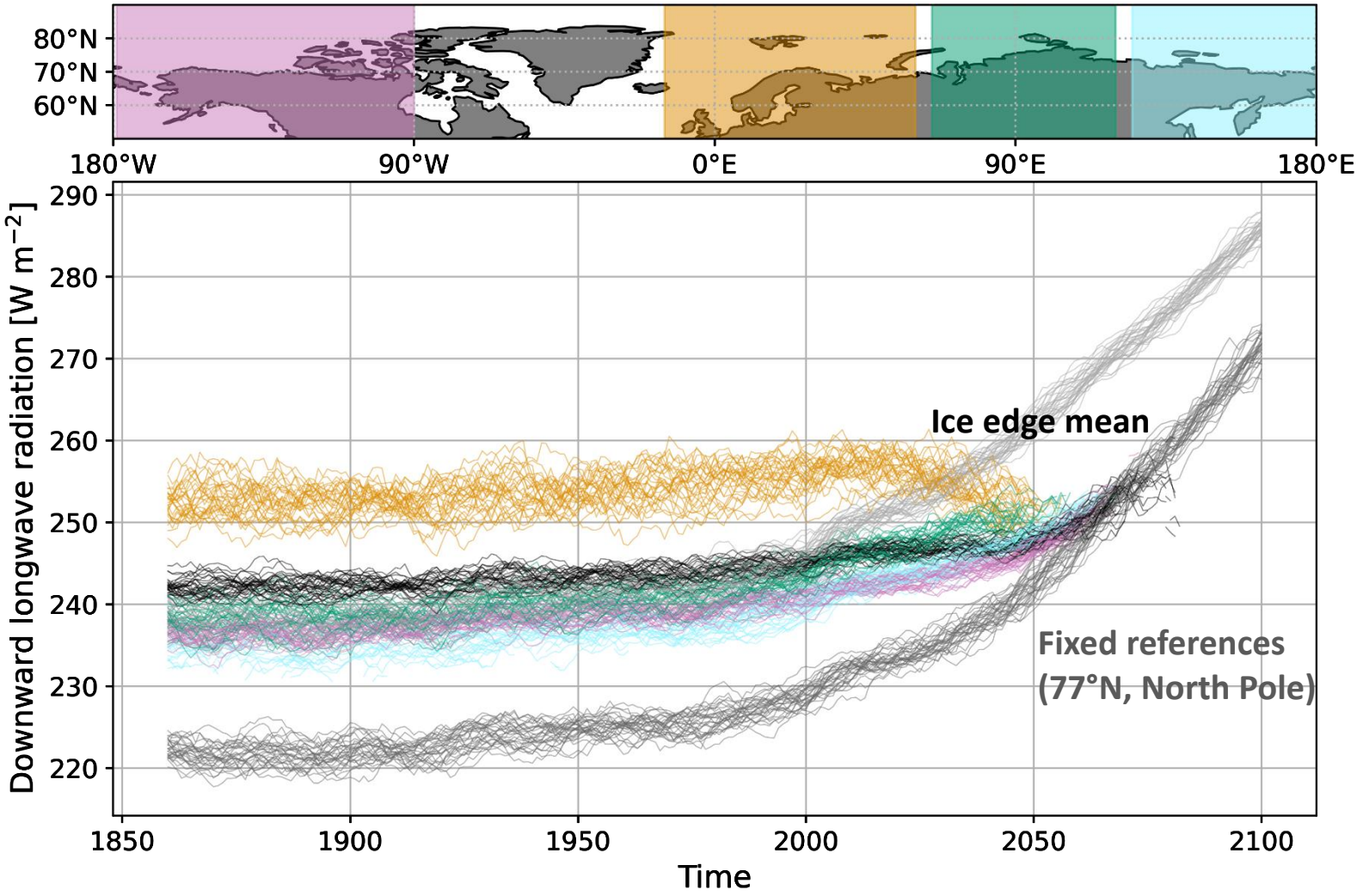
- MPI-ESM: 30 ensemble members
- Consistent features



Downward longwave radiation in different sectors

- LW is the long-term driver of sea-ice evolution
- LW is higher in the Atlantic sector (clouds?)
- Similar evolution for other regions and ice edge mean
- At fixed locations, the downward longwave radiation changes much more than at the ice edge.

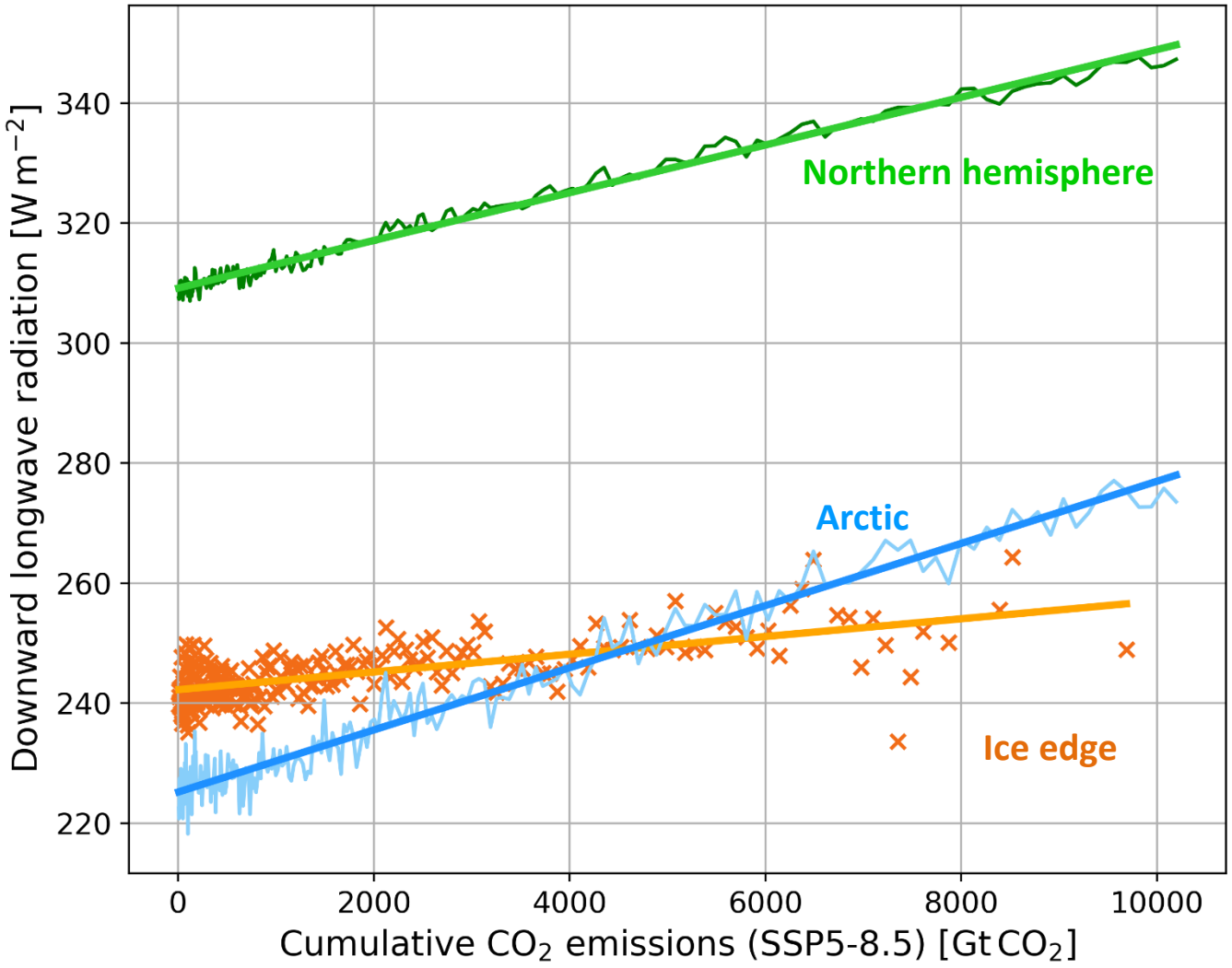




Downward longwave radiation rises much less at the ice edge

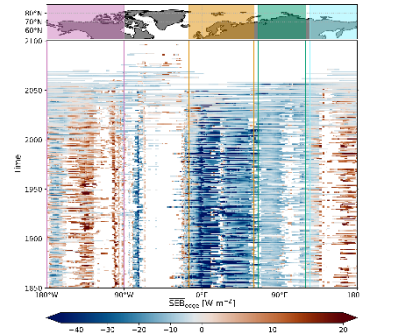
- LW rises linearly with CO_2 emissions across the Arctic (CMIP5: Notz and Stroeve, 2016)
- Similar to Northern hemisphere
- LW rises linearly at the moving ice edge, but much less than elsewhere.
- Possibly “self-compensation” of LW at the ice edge: Ice migrates spatially to regions where LW is lower.

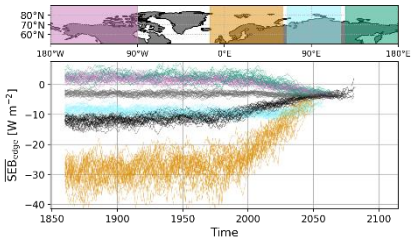
$$\Rightarrow \Delta\,\mathrm{SEB} = 0 = \Delta\,\mathrm{LW_{in}} + \Delta\,\mathrm{SW_{net}}$$

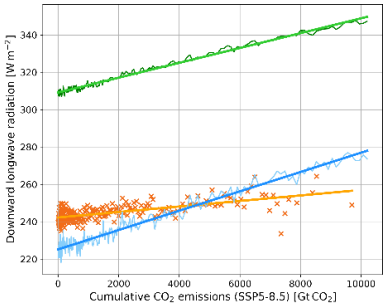


Take-home messages

- As the ice edge moves northwards, the SEB shows little meridional variability but has a high zonal variability along the ice edge at a given time.
  - The Atlantic sector differs from other regions and is highly impacted by oceanic heat fluxes.
  - Excluding the Atlantic, the SEB is roughly constant.
- The findings are consistent across the 30 member ensemble of the MPI-ESM.
- Downward longwave radiation rises much less at the ice edge than across the Arctic / the Northern hemisphere.
  - This might be due to the spatial variability of the LW flux.
  - It is important that models simulate the radiative fluxes correctly.







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