Overturning at Fram Strait & Barents Sea Opening and connections to OHT in CESM2-LE

Dylan Oldenburg

Why look at MOC at Fram Strait/Barents Sea Opening?

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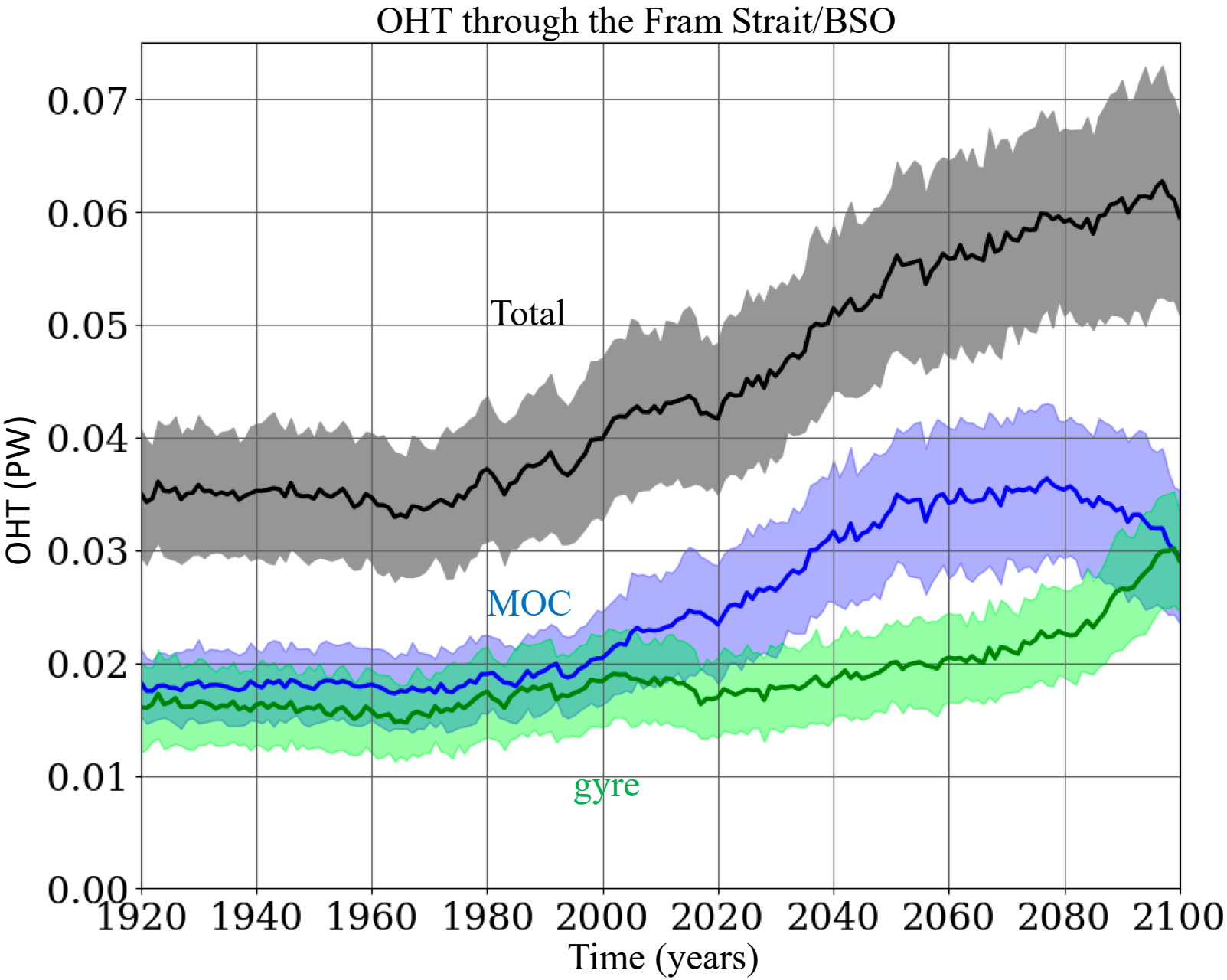

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  - Can more easily separate internal vs climate-forced variability
  - Focus on years 1920-2100

Calculate overturning in density coordinates

$$\Psi(\sigma) = -\int_{x_s}^{x_e}\int_{\sigma_{max}}^{\sigma_{min}} v(x,\sigma)d\sigma dx$$

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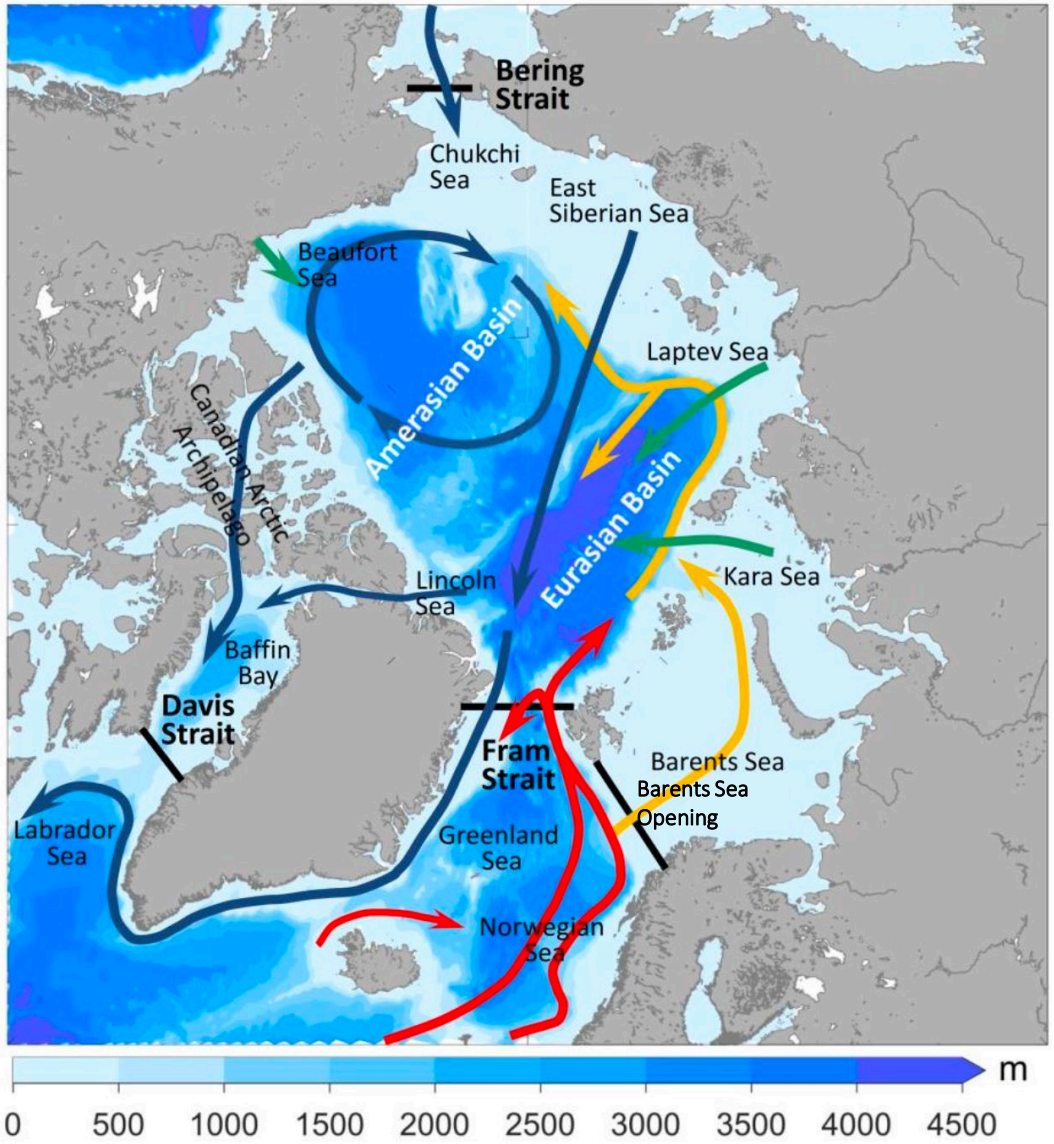
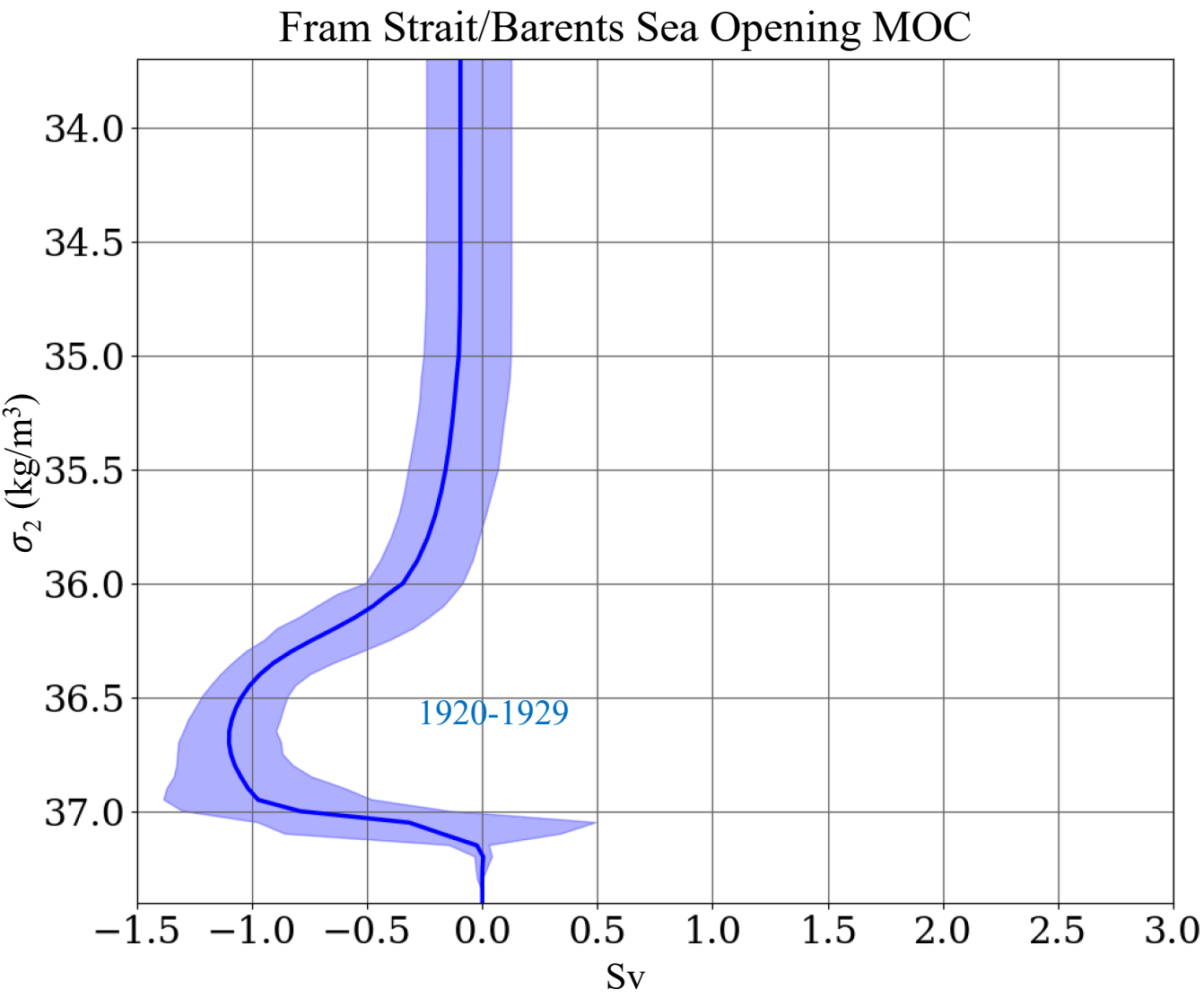
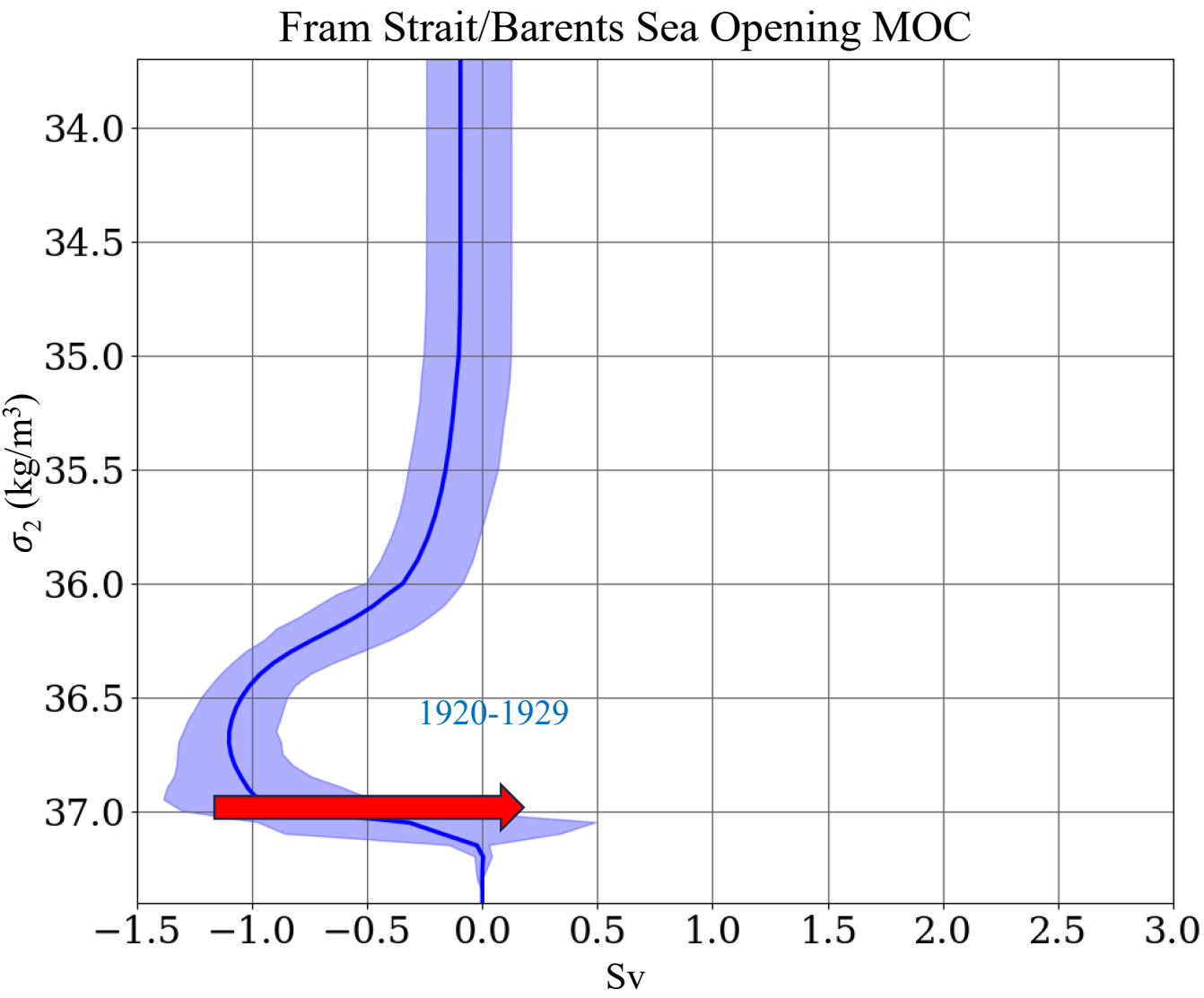



Fram Strait/Barents Sea Opening MOC
34.0
34.5
35.0
35.5
36.0
36.5
37.0
σ_2 (kg/m^3)
1920-1929
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Sv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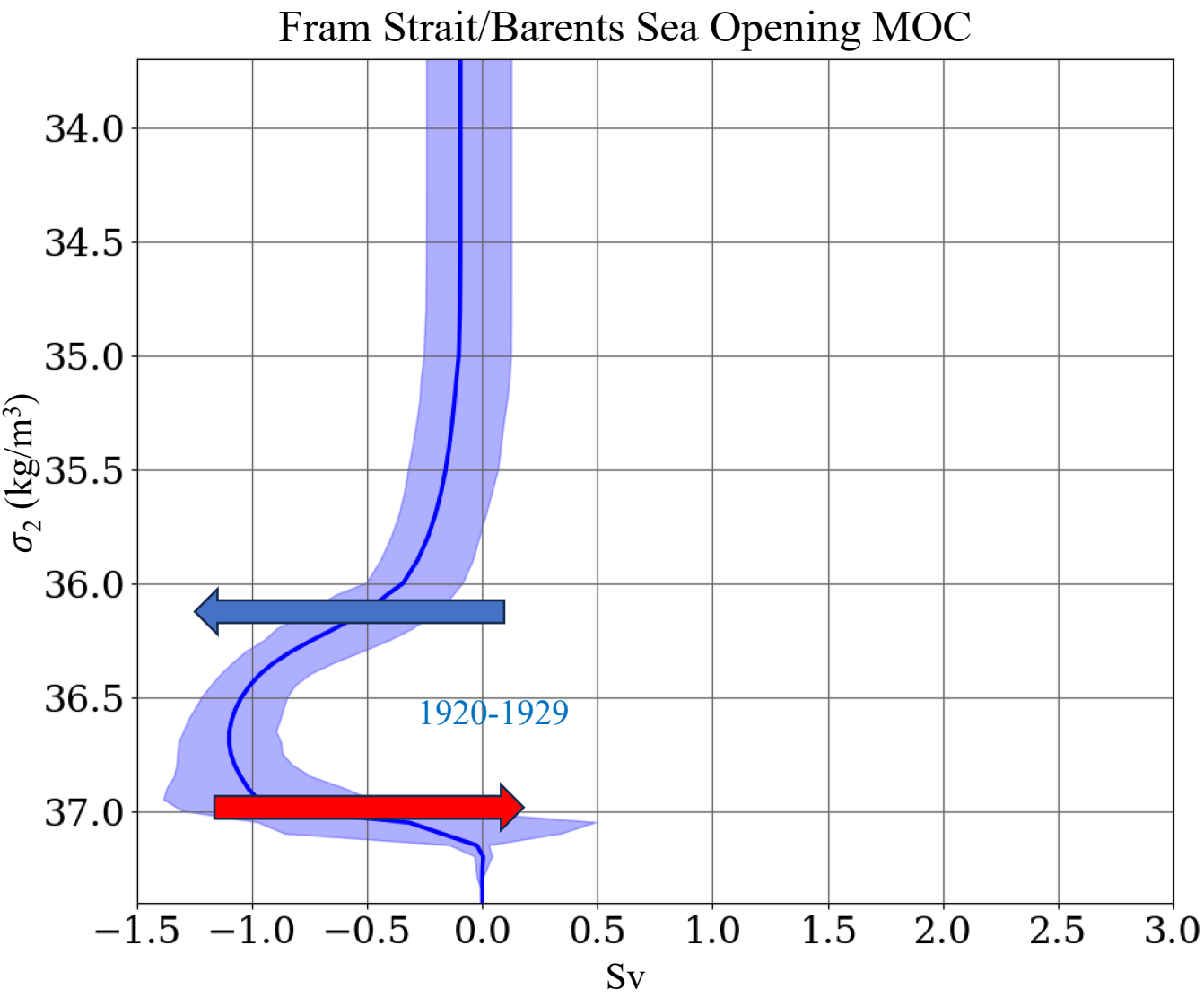
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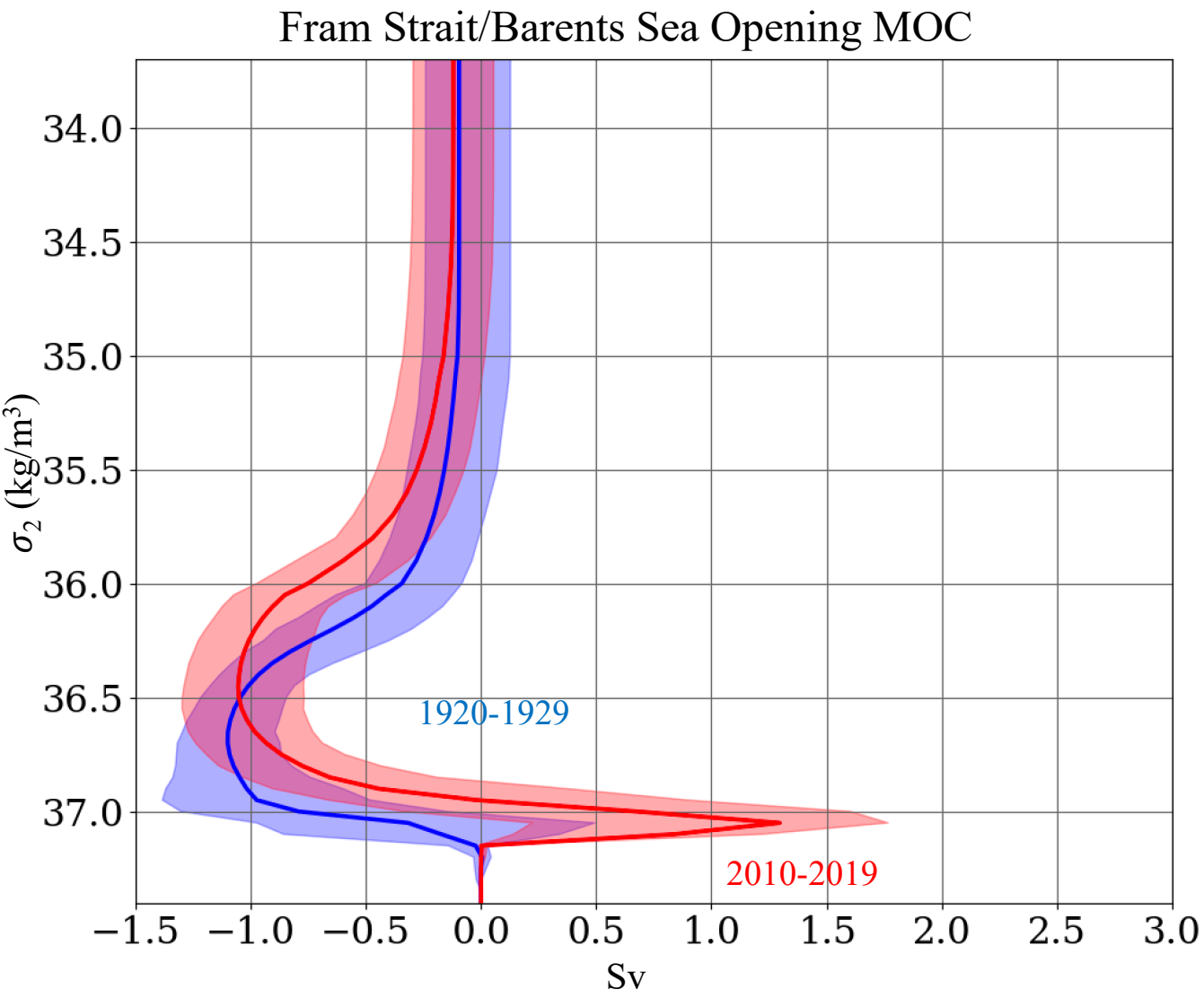
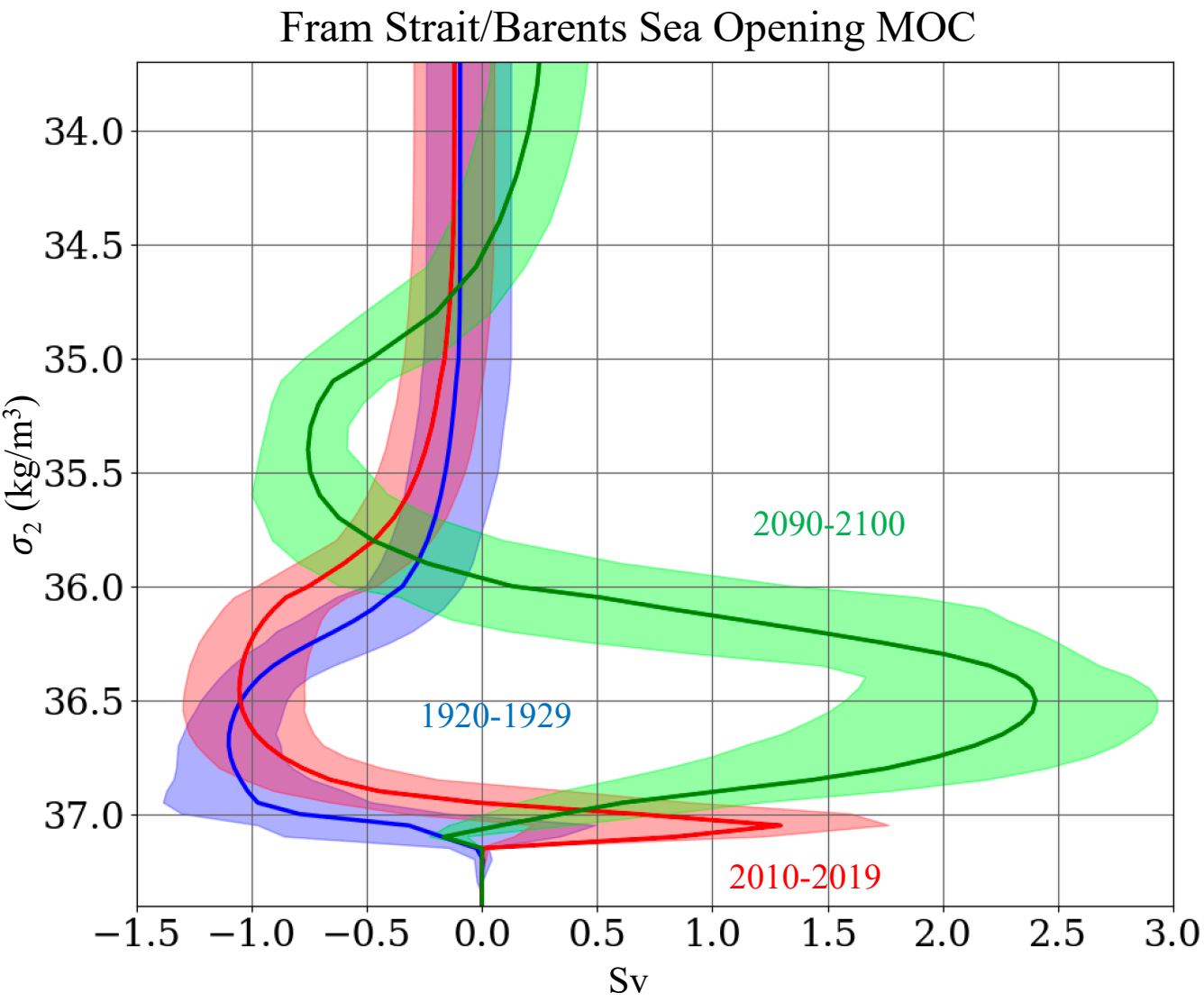

Fram Strait/Barents Sea Opening MOC
34.0
34.5
35.0
35.5
36.0
36.5
37.0
σ_2 (kg/m^3)
1920-1929
2010-2019
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Sv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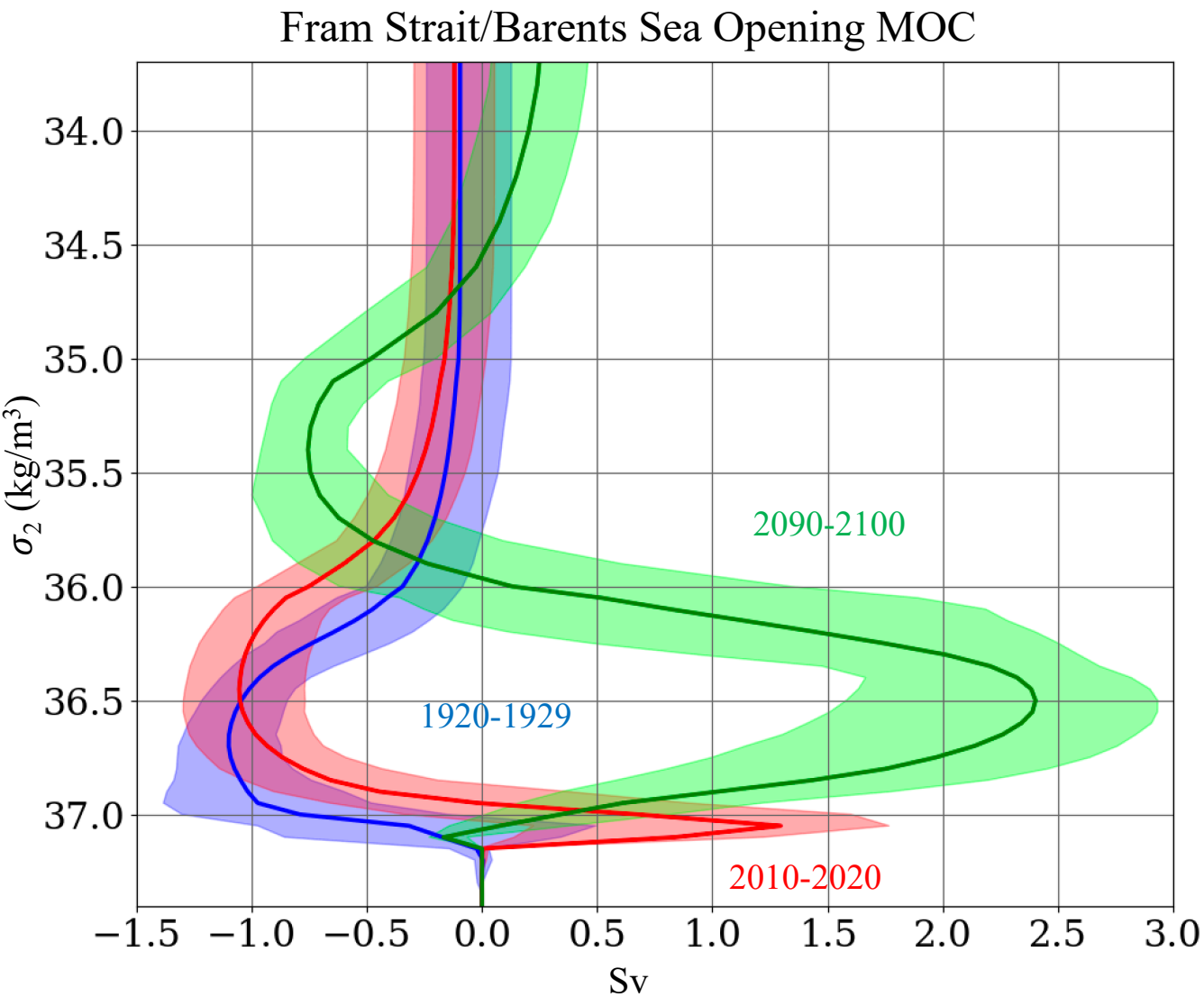
34.0
34.5
35.0
35.5
36.0
36.5
37.0
σ_2 (kg/m^3)
2090-2100
1920-1929
2010-2019
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Sv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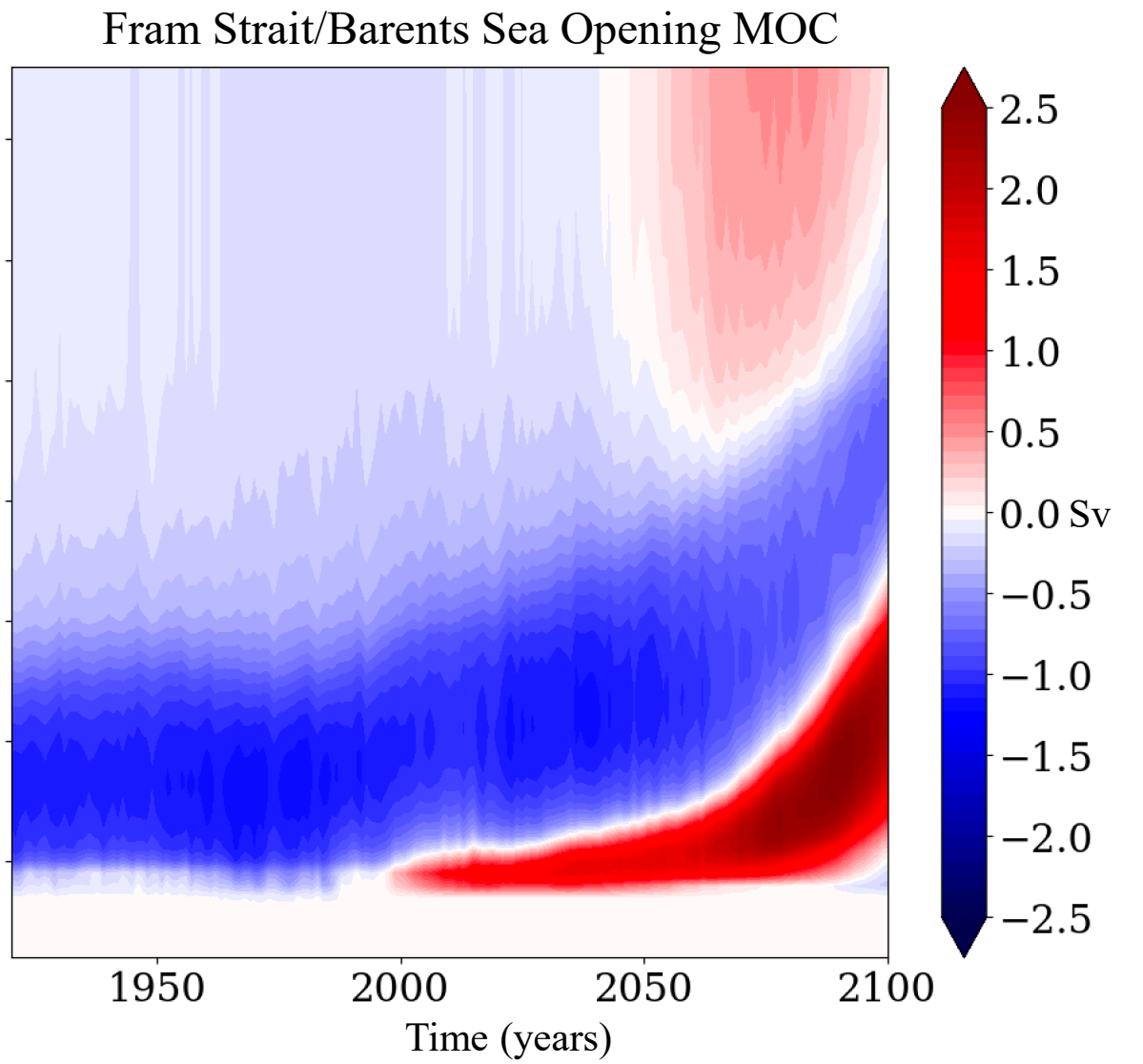
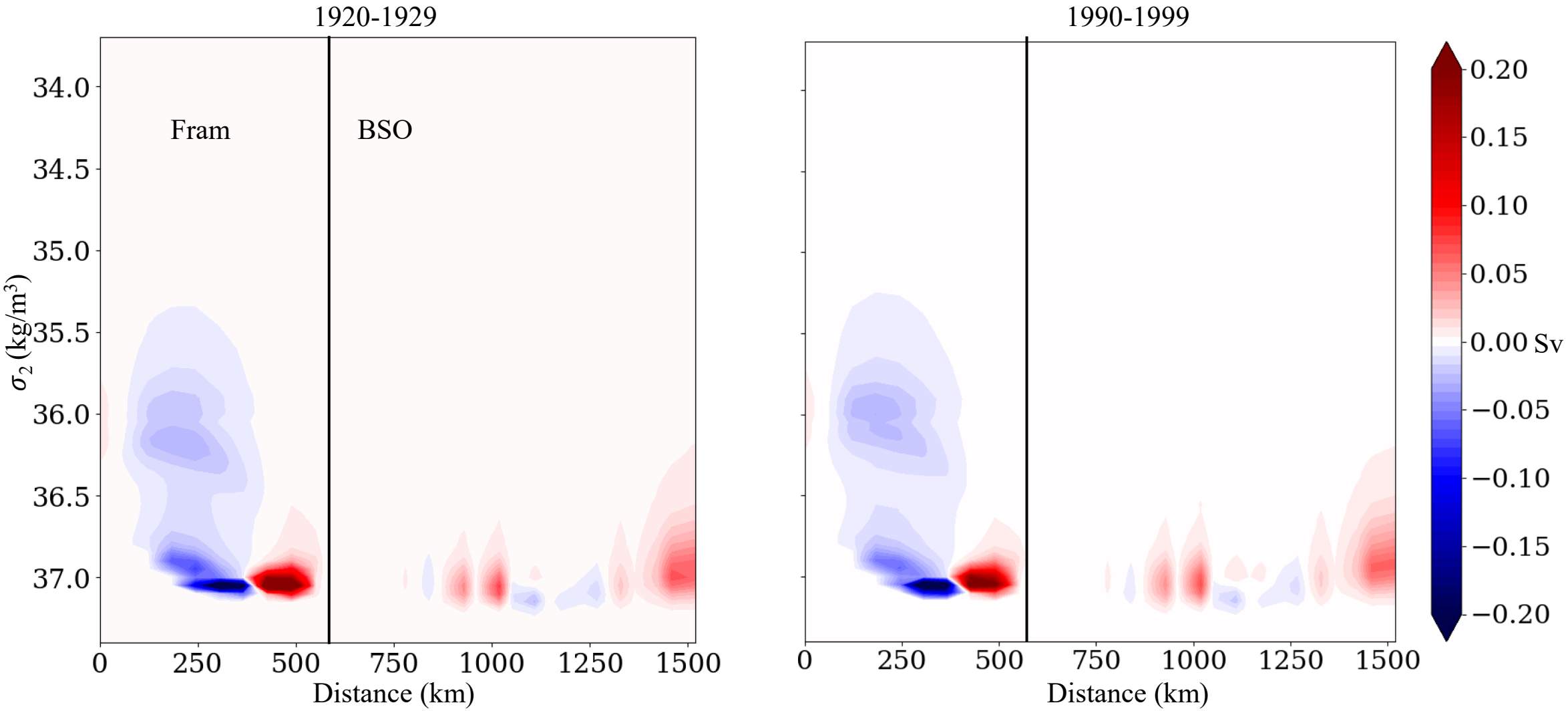
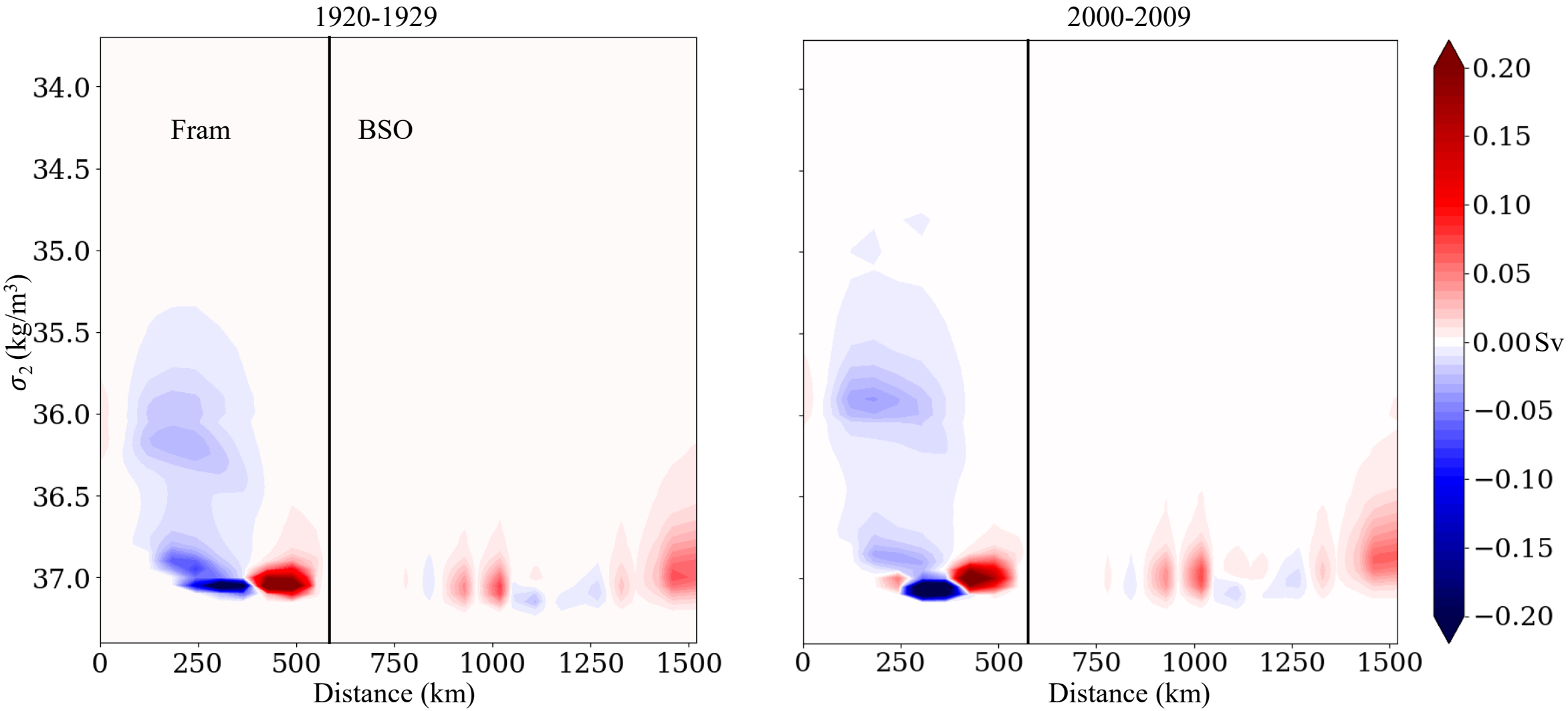
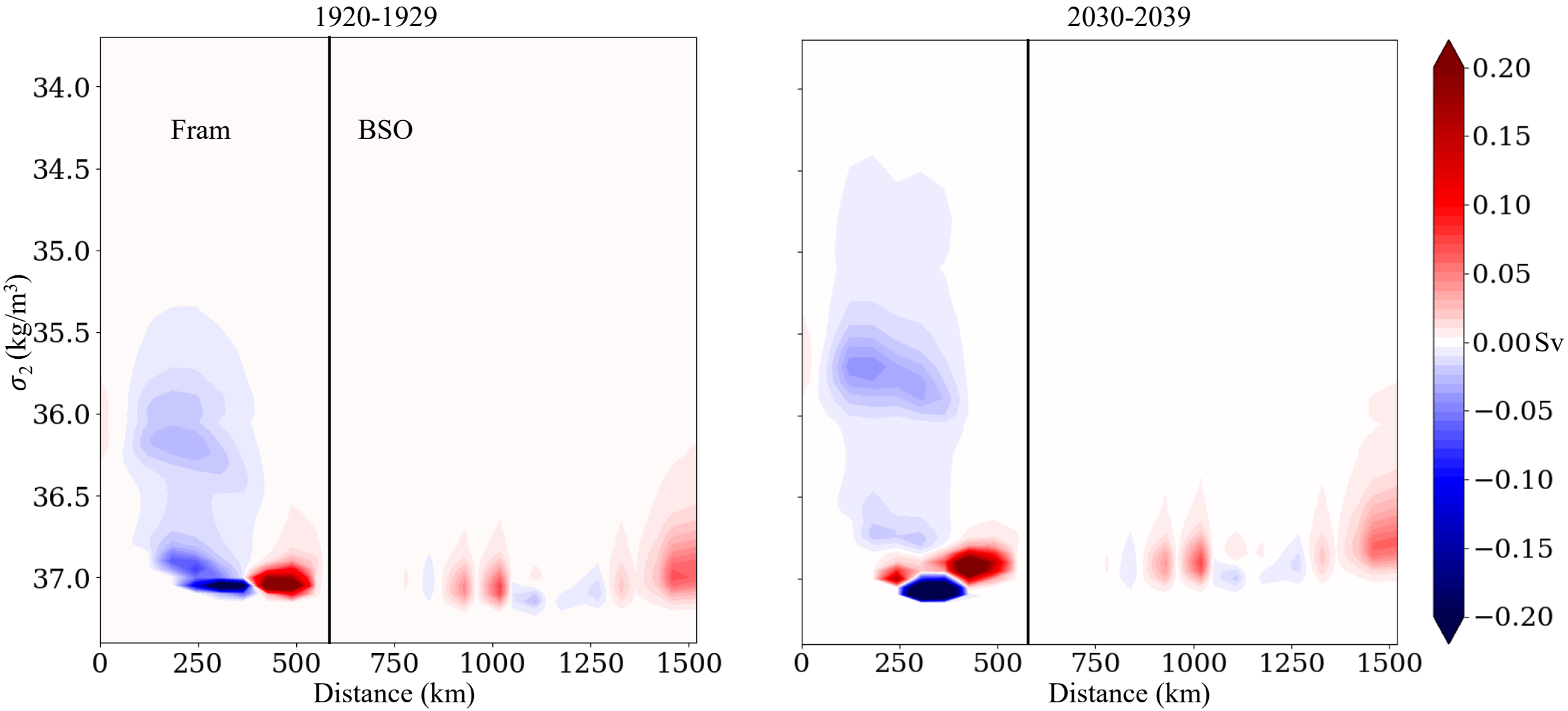
34.0
34.5
35.0
35.5
36.0
36.5
37.0
σ_2 (kg/m^3)
2090-2100
1920-1929
2010-2020
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Sv


Fram Strait/Barents Sea Opening MOC
1950
2000
2050
2100
Time (years)
2.5
2.0
1.5
1.0
0.5
0.0 Sv
−0.5
−1.0
−1.5
−2.0
−2.5


Volume flux in density space
1920-1929
1990-1999
Fram
BSO
34.0
34.5
35.0
35.5
36.0
36.5
37.0
σ_2 (kg/m^3)
0
250
500
750
1000
1250
1500
Distance (km)
0.20
0.15
0.10
0.05
0.00 Sv
−0.05
−0.10
−0.15
−0.20


Volume flux in density space
1920-1929
2000-2009
Fram
BSO
34.0
34.5
35.0
35.5
36.0
36.5
37.0
σ_2 (kg/m^3)
0
250
500
750
1000
1250
1500
Distance (km)
0.20
0.15
0.10
0.05
0.00
Sv
−0.05
−0.10
−0.15
−0.20


Volume flux in density space
1920-1929
2030-2039
Fram
BSO
34.0
34.5
35.0
35.5
36.0
36.5
37.0
σ_2 (kg/m^3)
0
250
500
750
1000
1250
1500
Distance (km)
0.20
0.15
0.10
0.05
0.00
Sv
−0.05
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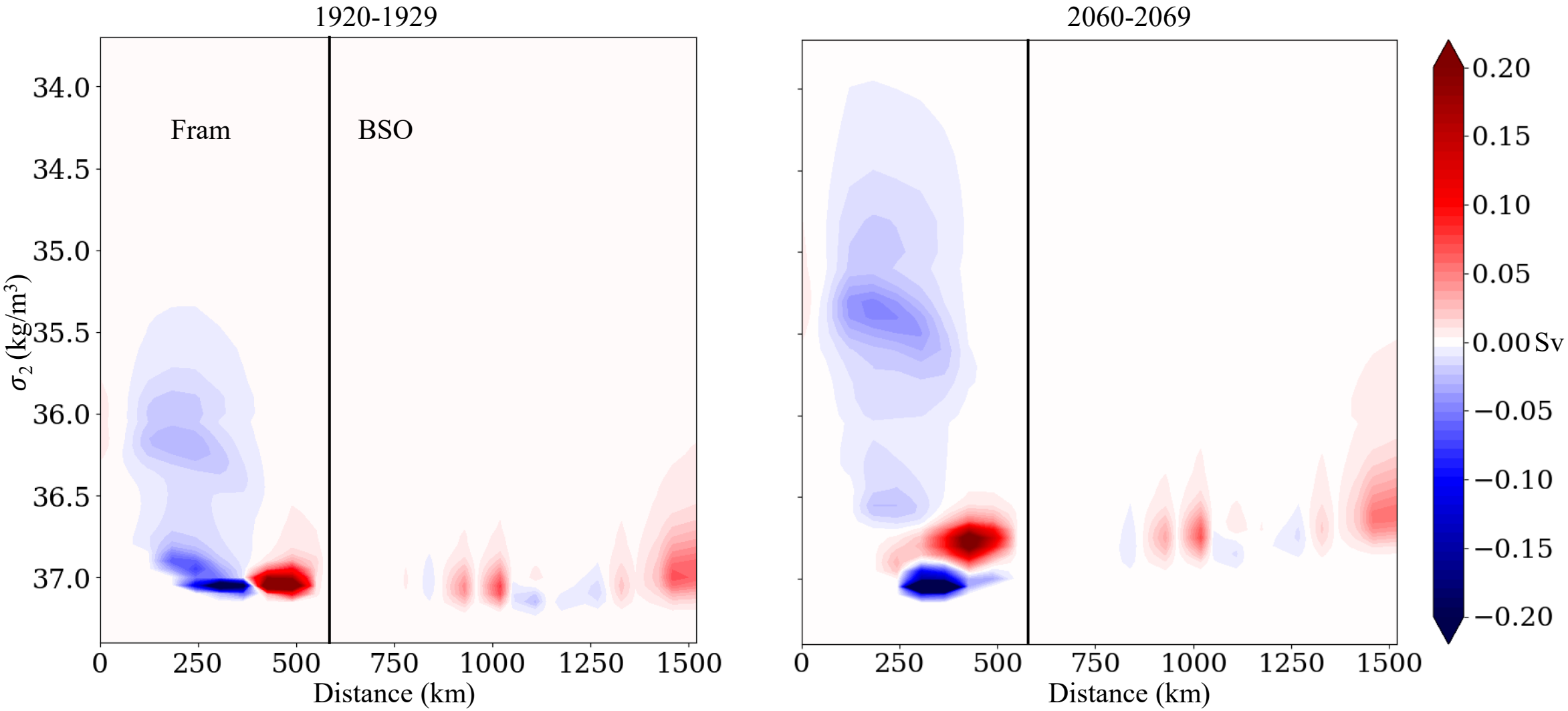
−0.20


Volume flux in density space
1920-1929
2060-2069
Fram
BSO
34.0
34.5
35.0
35.5
36.0
36.5
37.0
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250
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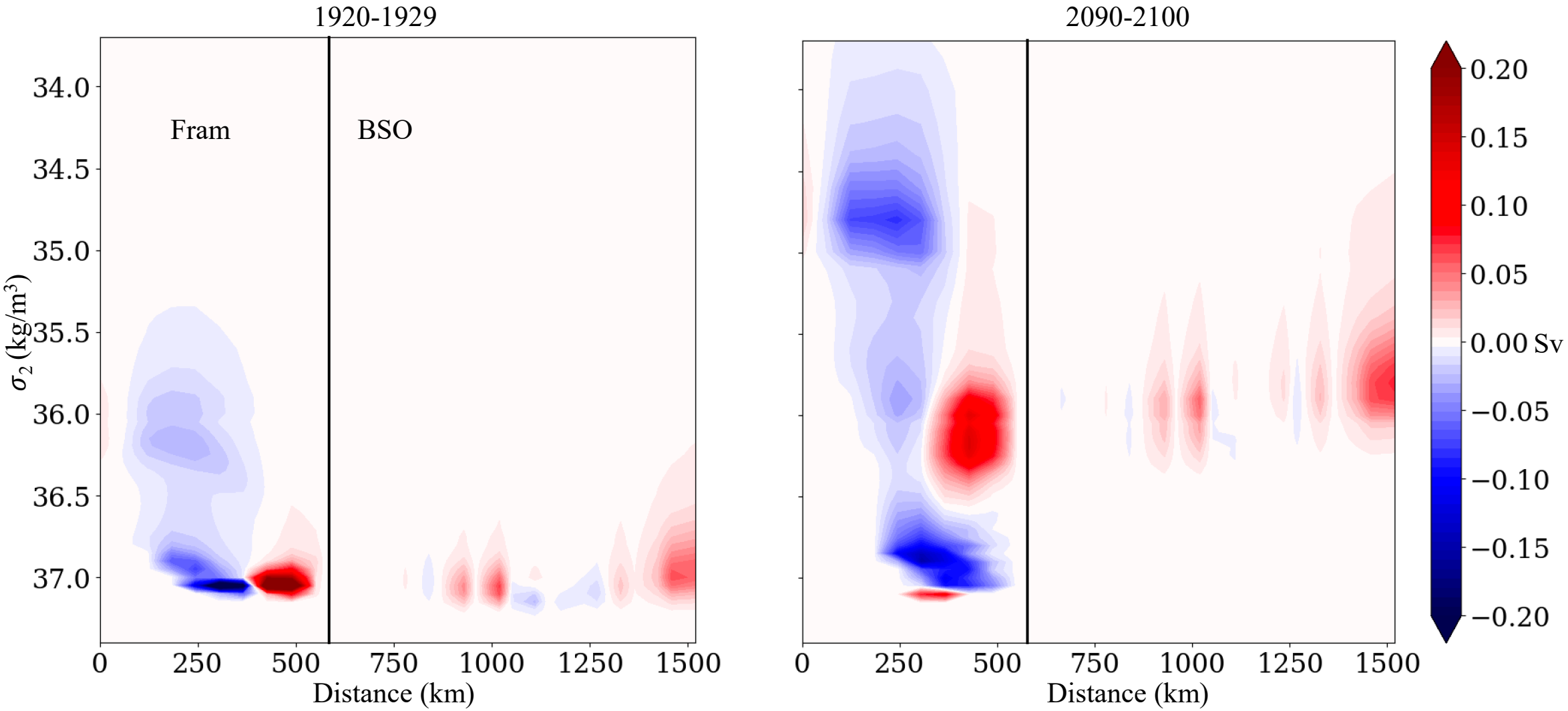
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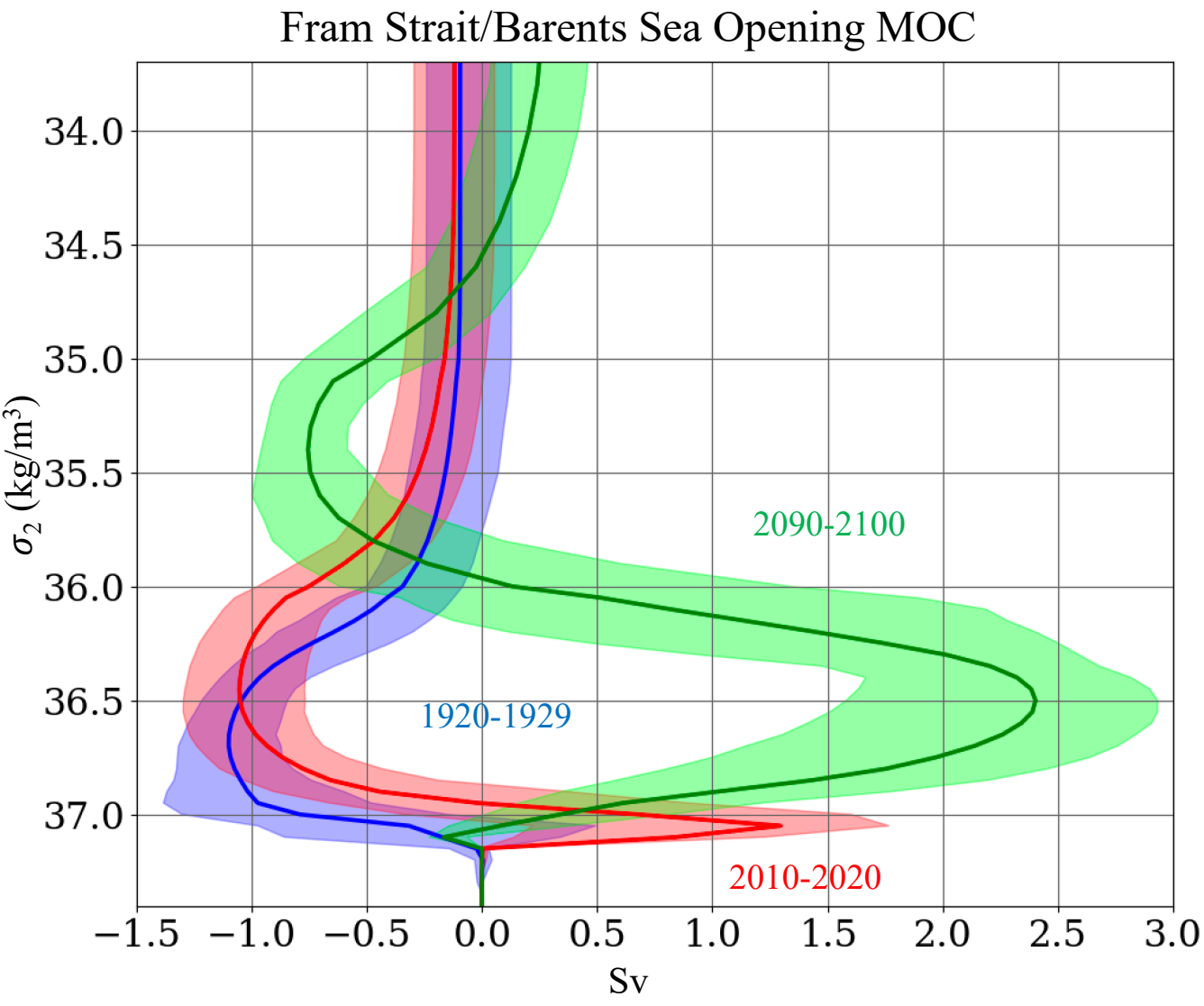
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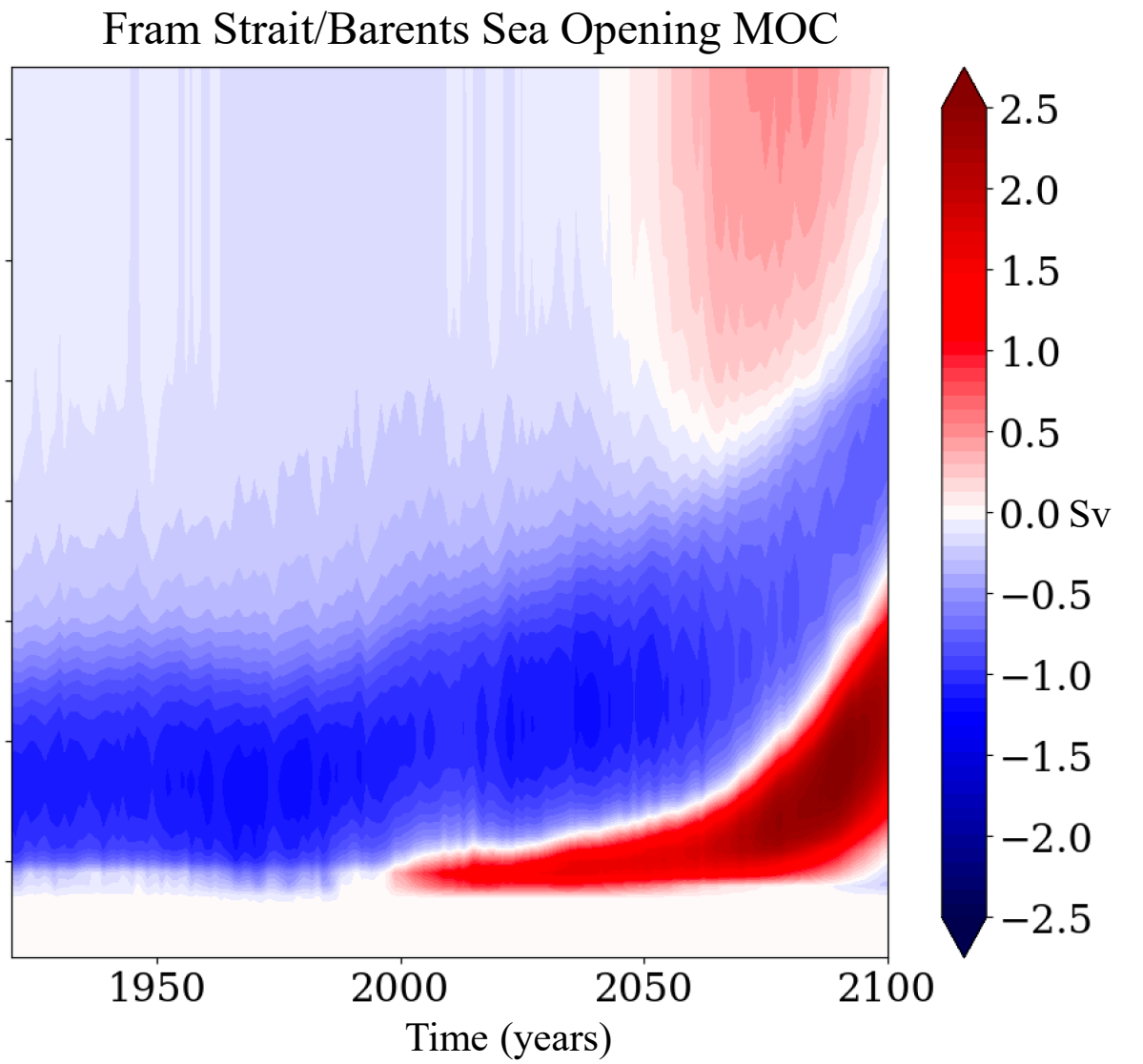
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2000
2050
2100
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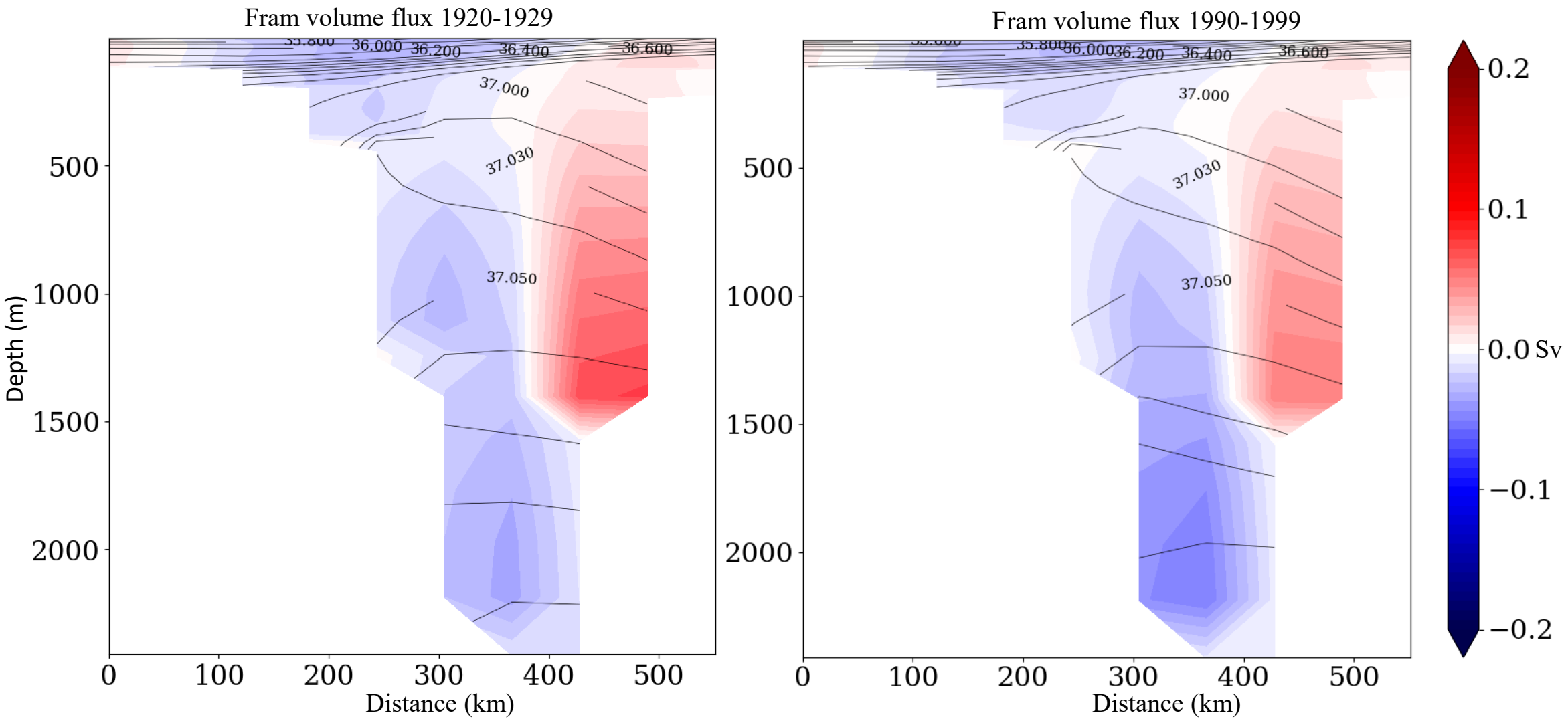
1.5
1.0
0.5
0.0 Sv
−0.5
−1.0
−1.5
−2.0
−2.5

CESM2-LENS: Fram Strait flow structure changes



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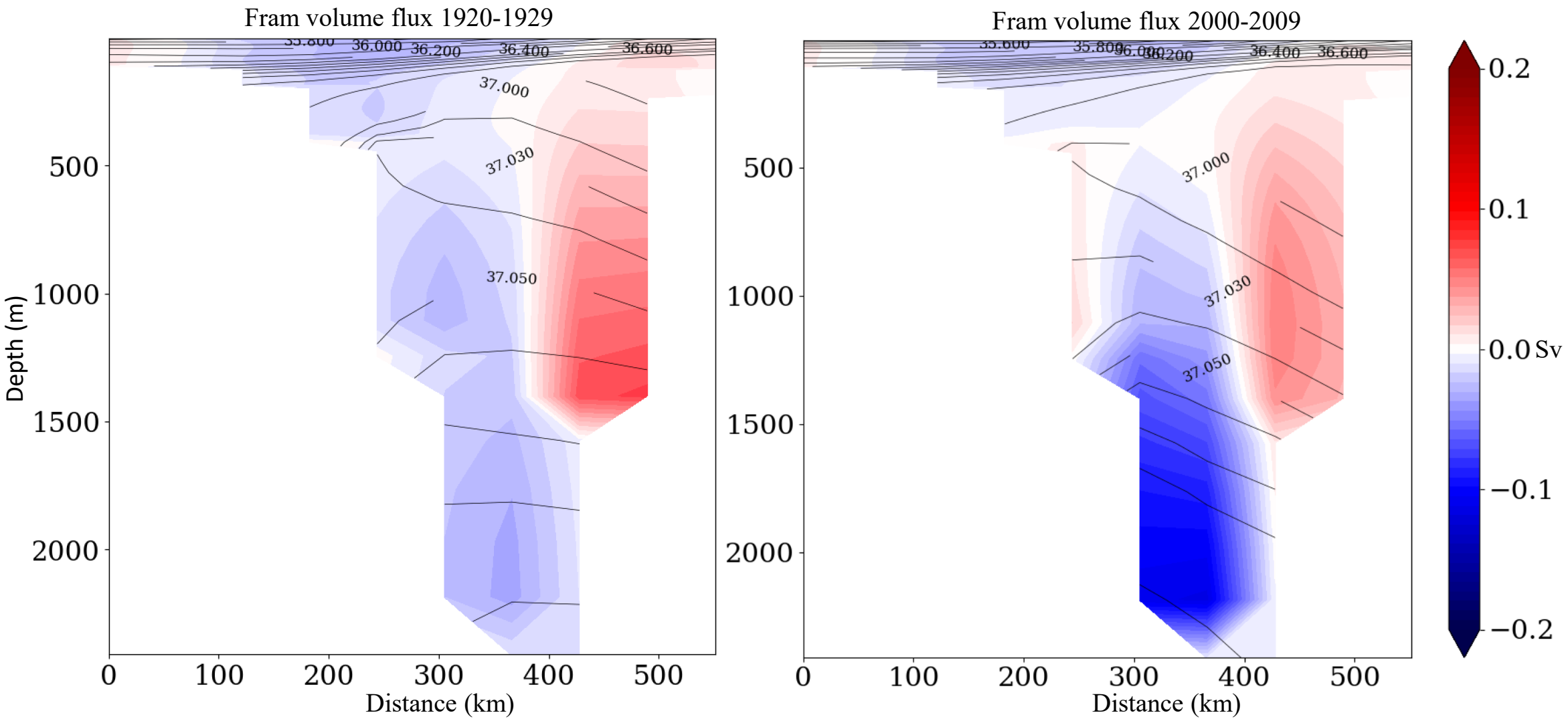

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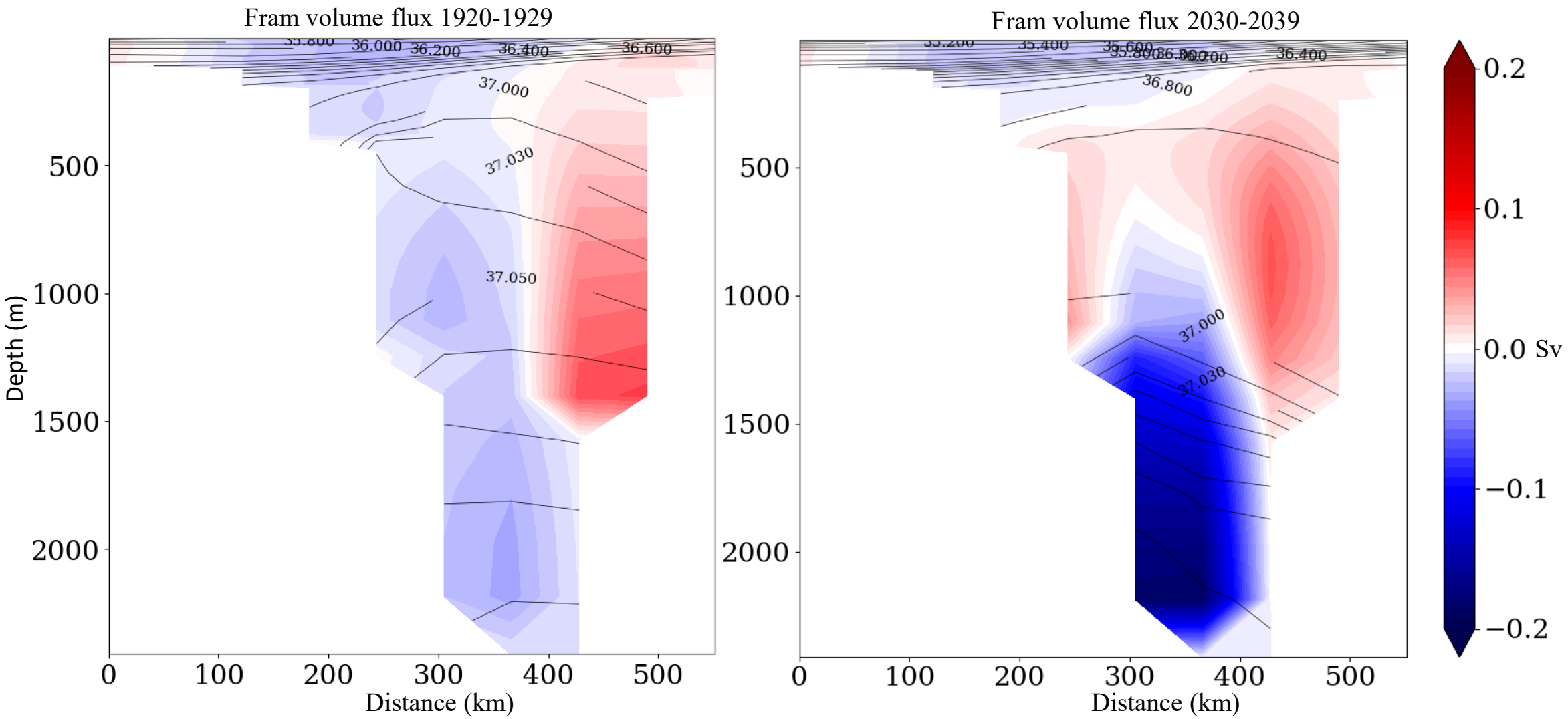

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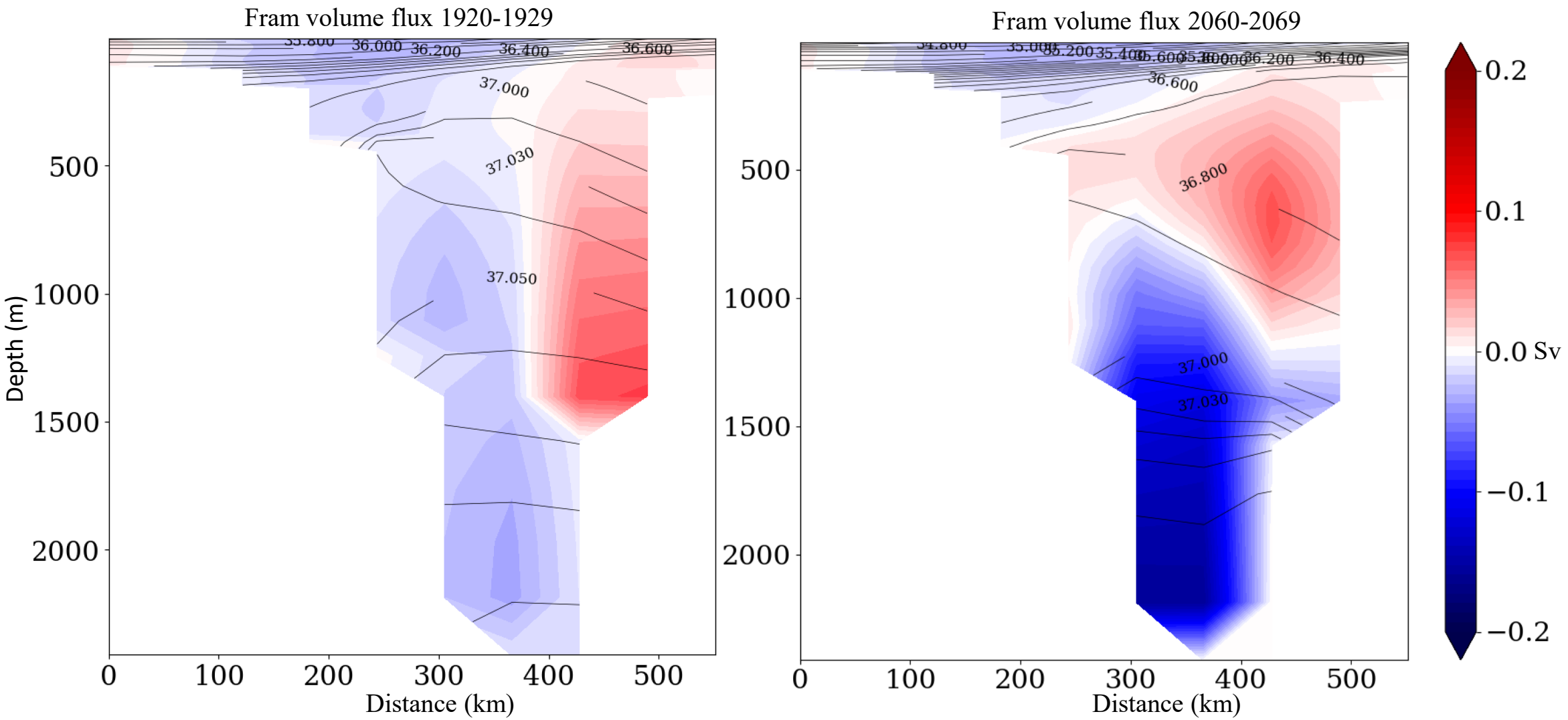

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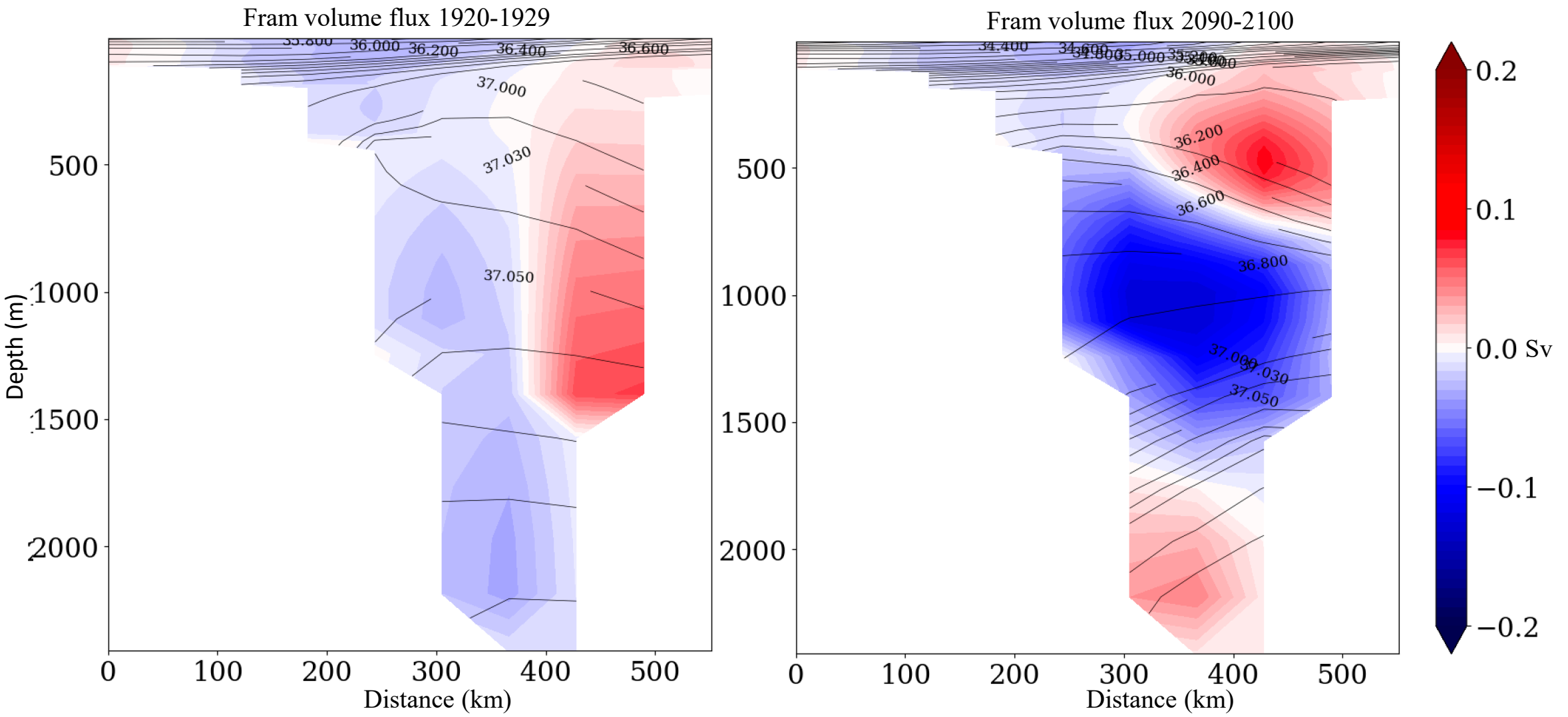

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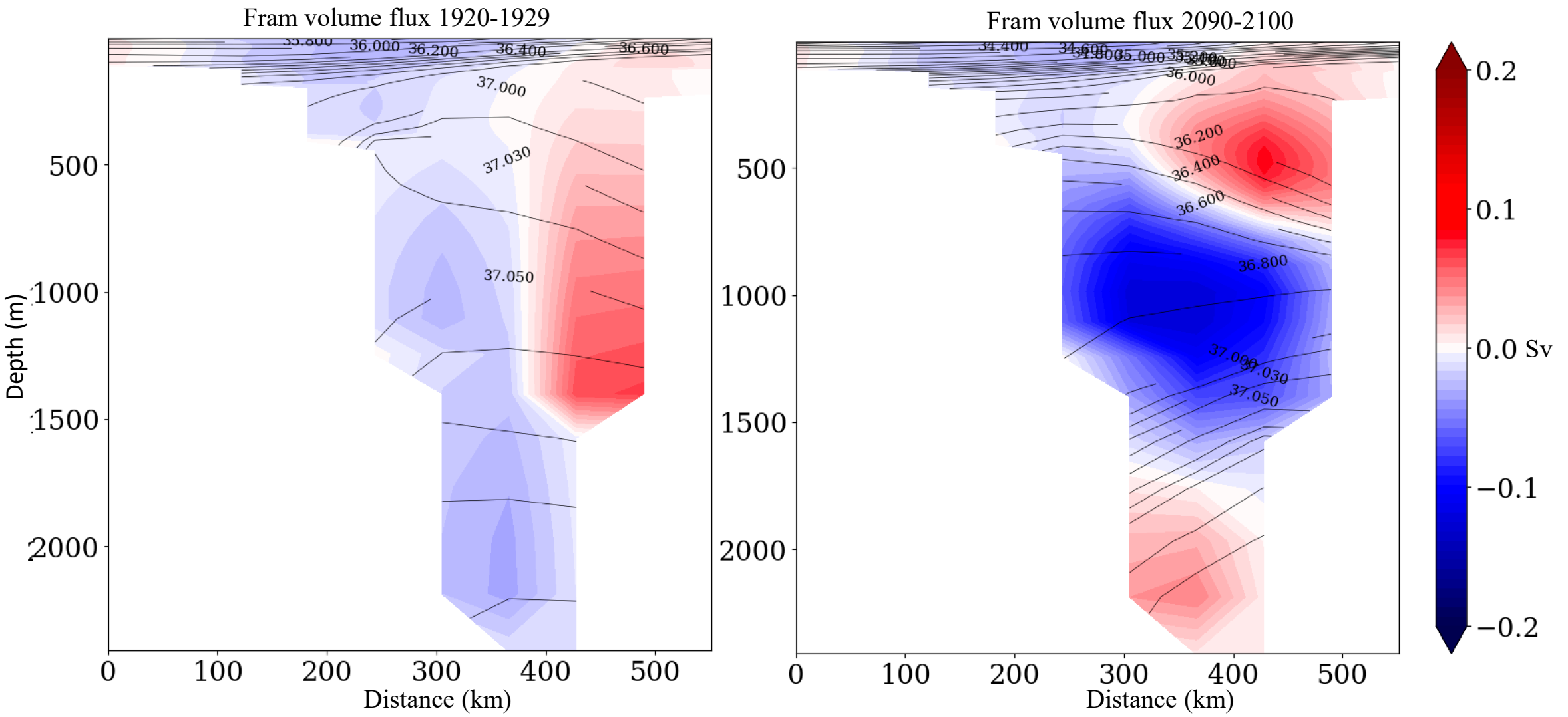

Computing surface forced water mass transformation (WMT)

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$$F_T = \alpha c_w^{-1} Q_H$$

Langehaug et al. (2012)

Thermal expansion coefficient

Heat capacity

Air-sea heat flux

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Haline contraction coefficient

Surface salinity

Freshwater flux

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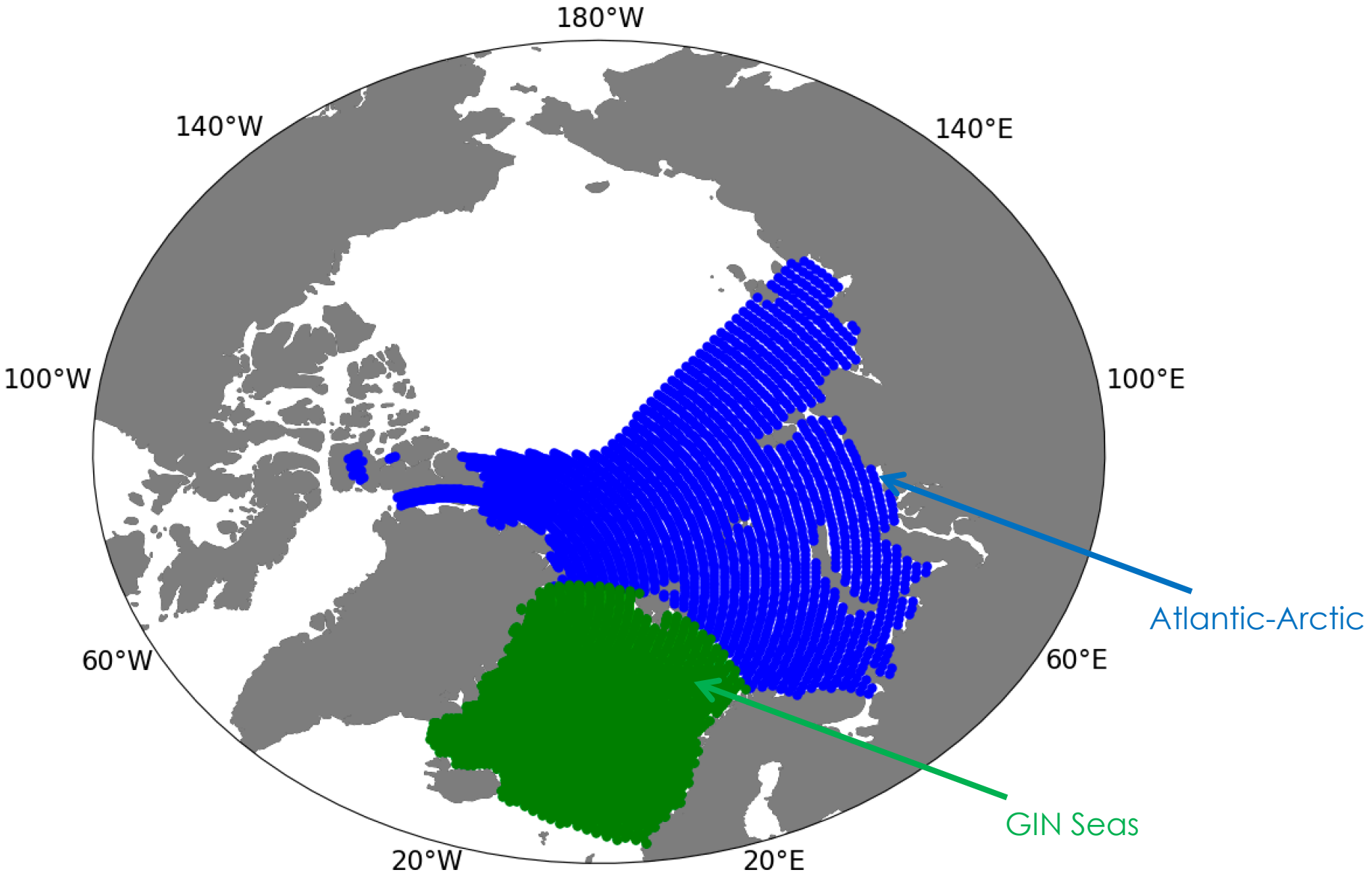
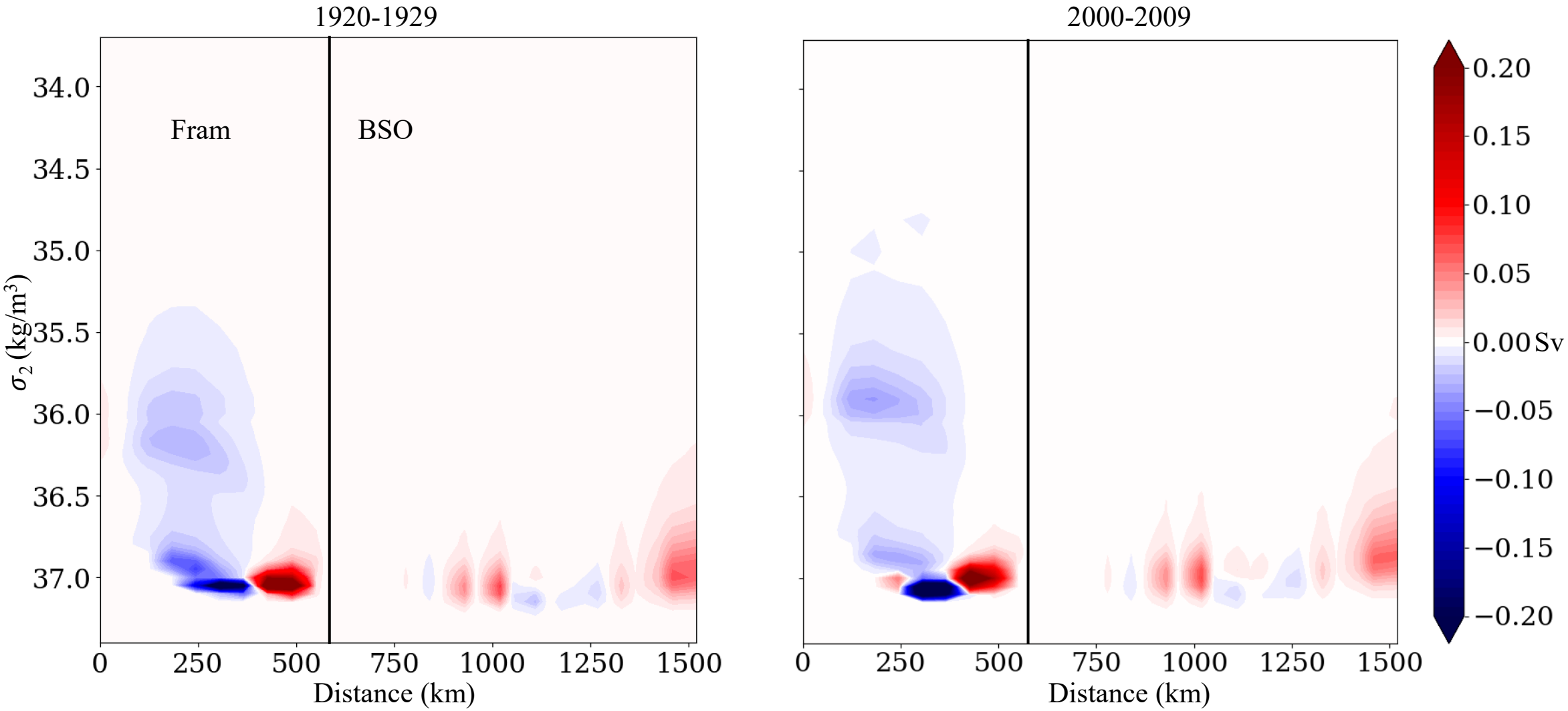
Langehaug et al. (2012)

$$D = F_T + F_S$$

$$F(\sigma) = \lim_{\Delta\sigma \to 0} \frac{1}{\Delta\sigma} \int_{\sigma}^{\sigma+\Delta\sigma} D \; dA$$

Computing surface forced water mass transformation (WMT)

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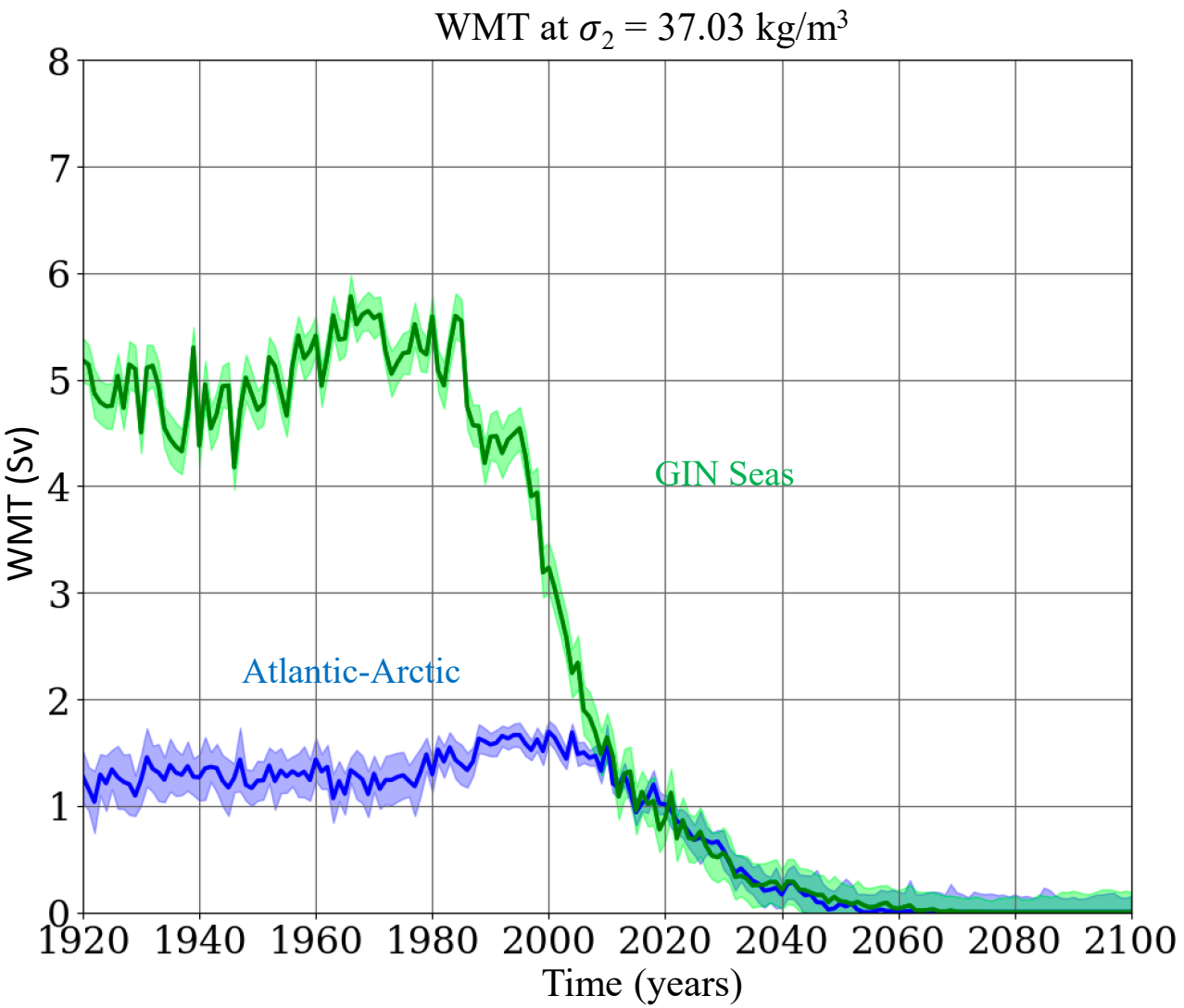
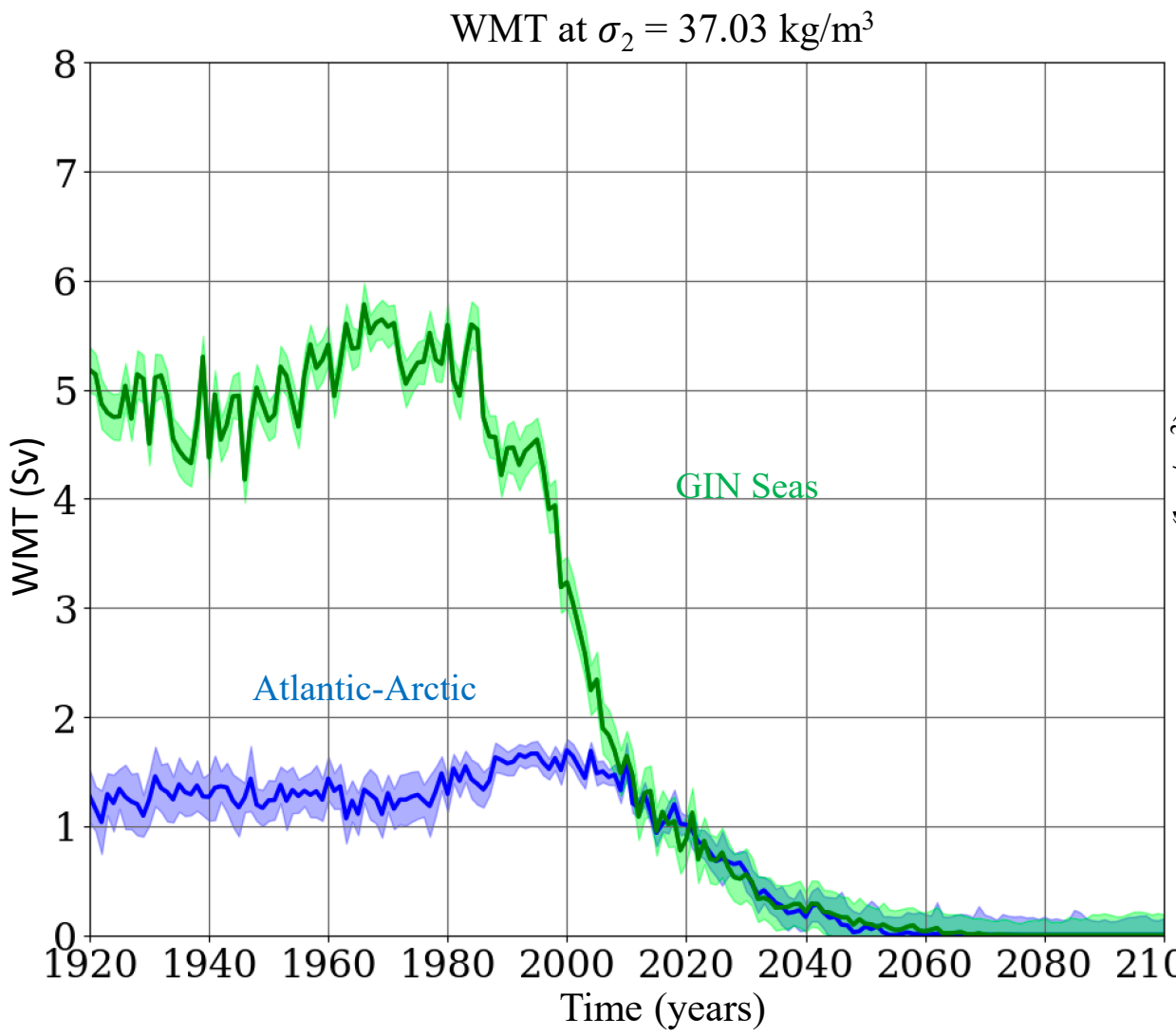
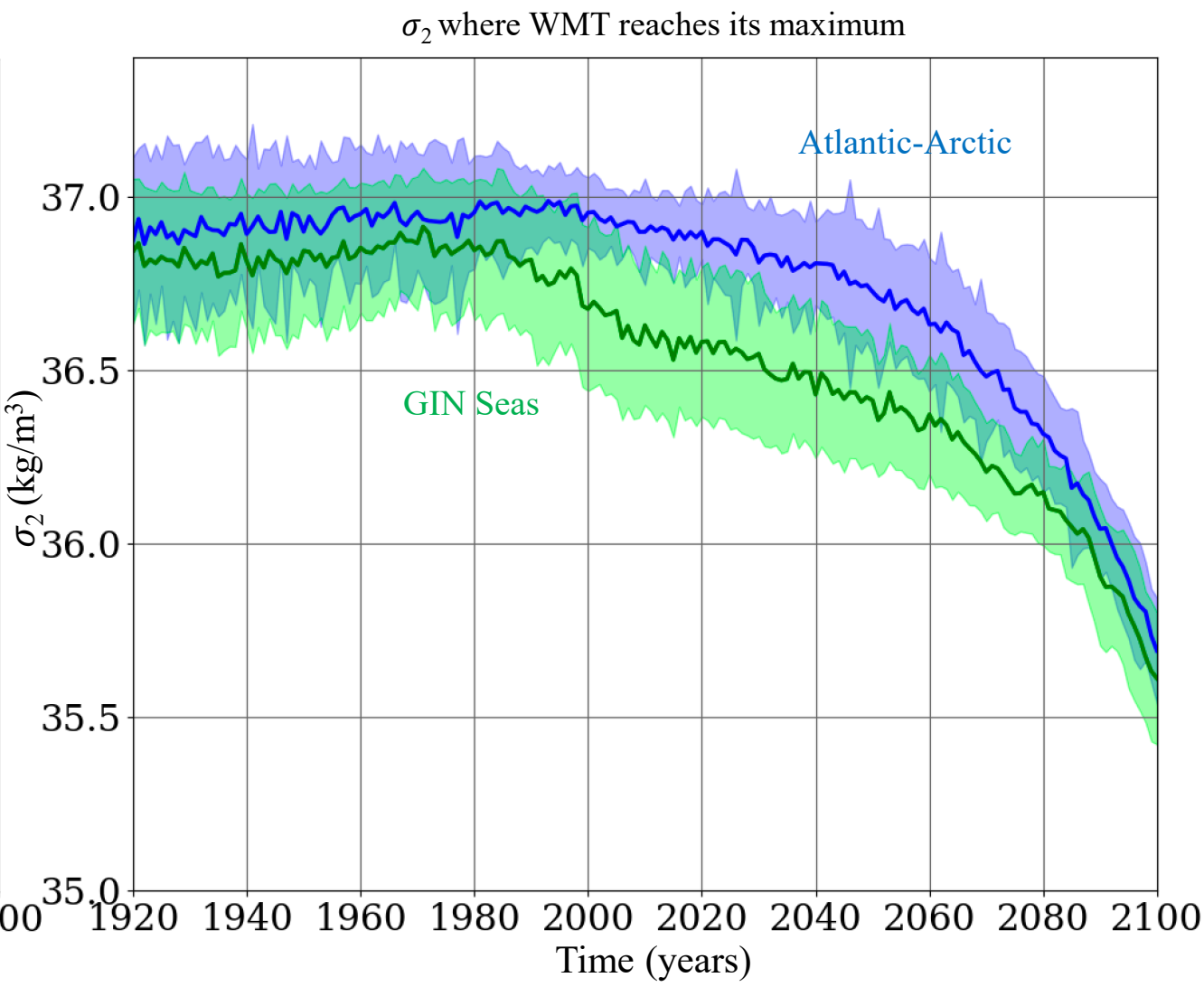
0.15
0.10
0.05
0.00
Sv
−0.05
−0.10
−0.15
−0.20

WMT at high density classes declines rapidly in GIN Seas



WMT in GIN Seas shifts to much lower densities starting in 1980s





Conclusions

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- This MOC pattern change is linked to warming of Atlantic inflow outpacing warming of Arctic outflow
- However, not clear why there is a dramatic flow pattern shift in deep part of Fram Strait

The end

- Thank you!