Physical phenology of air-sea heat budget for the Beaufort Sea autumn freeze-up

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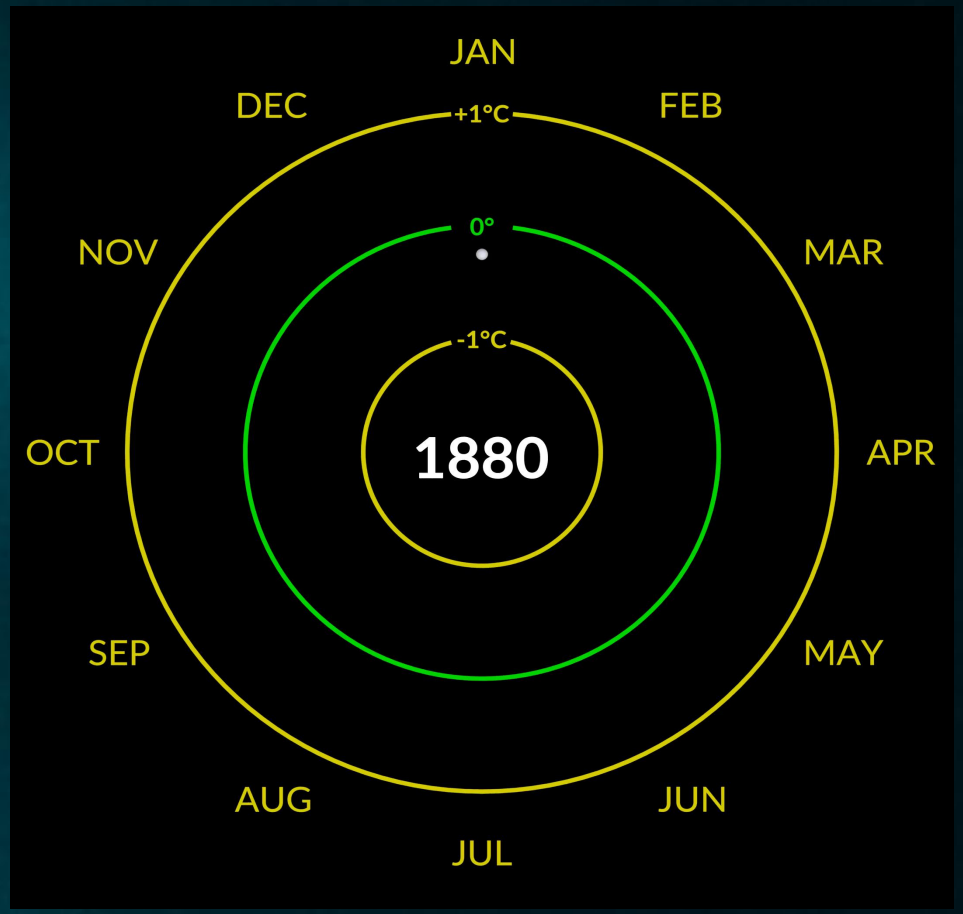
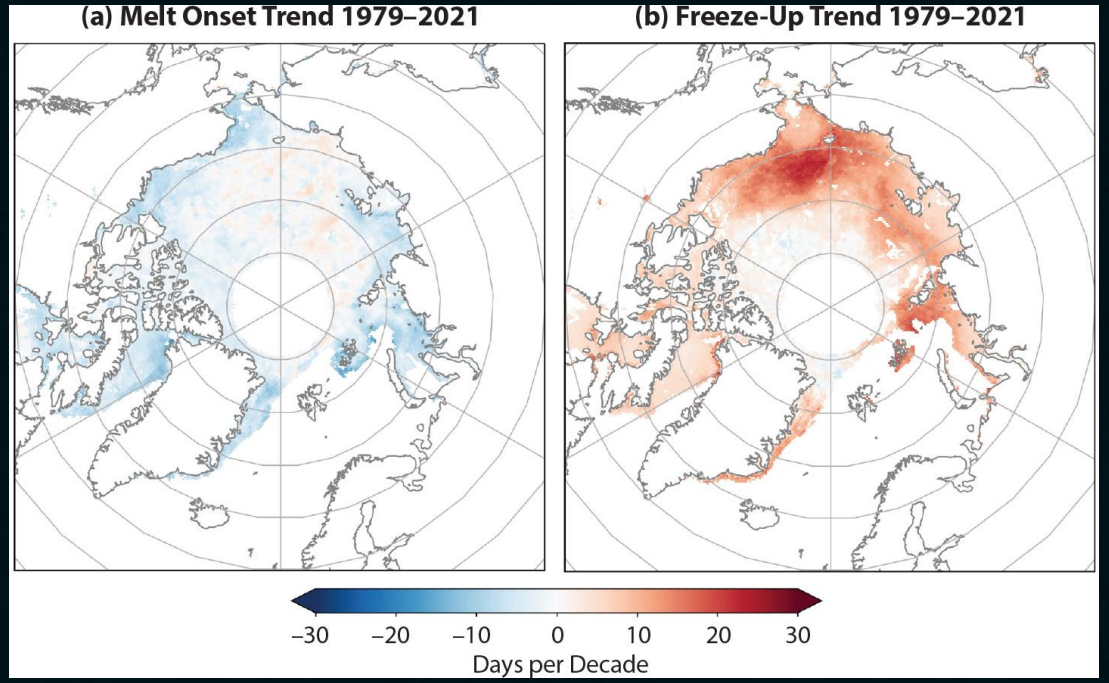
Arctic freeze–up trends

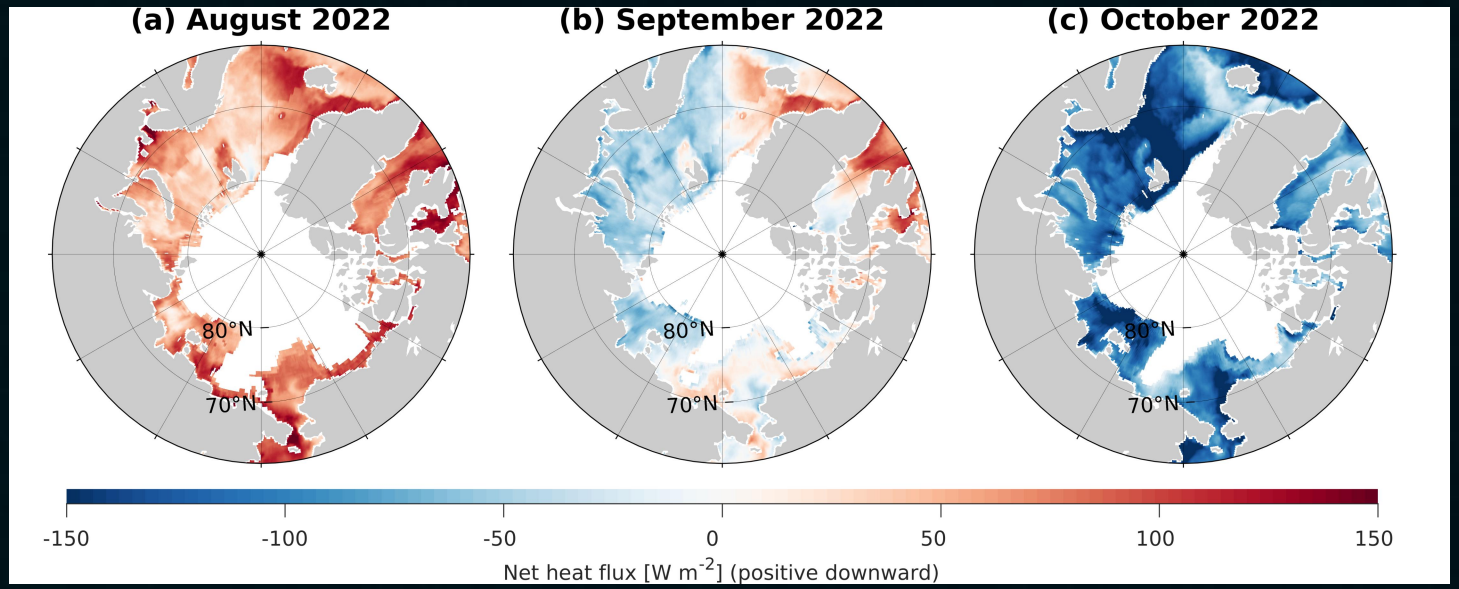
NASA climate spiral 1880–2022





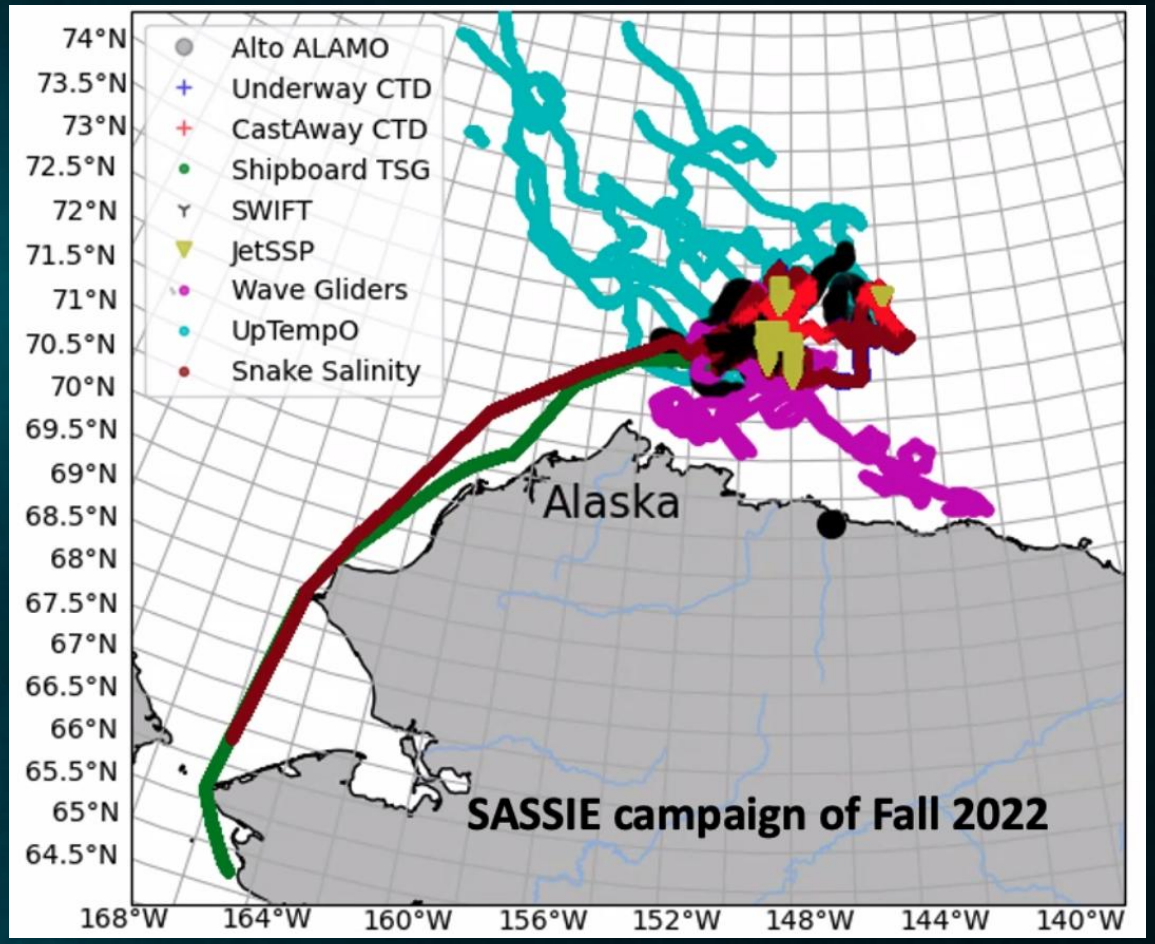
Meier and Stroeve, 2022

Net heat flux (positive downward)

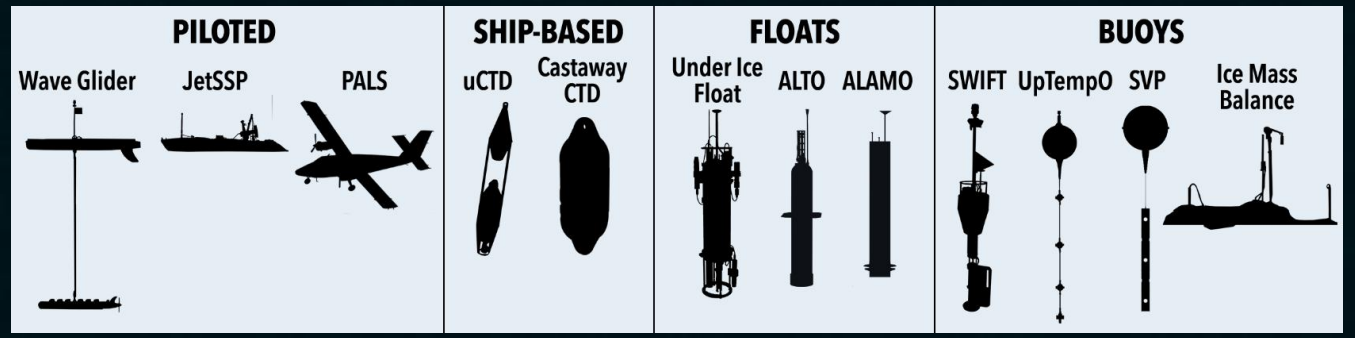


The 2022 SASSIE campaign

Spatial distribution of in–situ measurements for SASSIE 2022 campaign



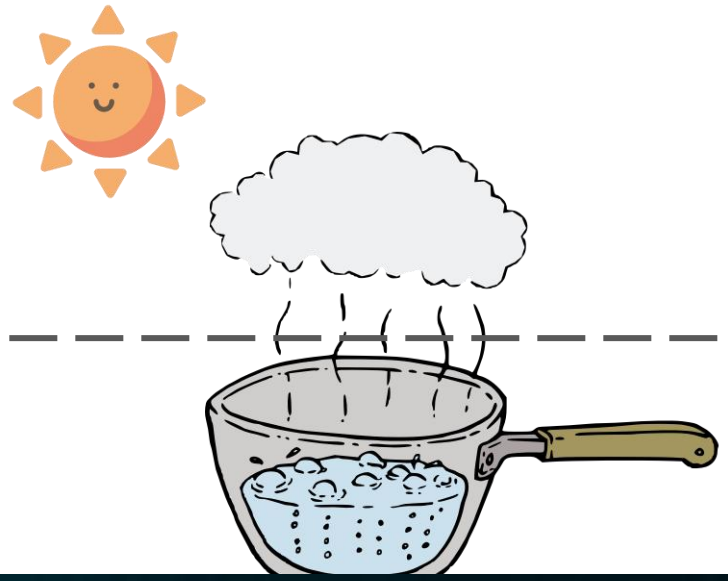
- In–situ dataset from 12 or more instruments of SASSIE campaign during Fall of 2022



- Meteorology: 2 masts, barometer and radiometer
- Sea ice products are from: AMSR product and National Weather Service Alaska Sea Ice product (Astrid et al. 2023)
- Satellite–based/reanalyses data for comparison of air–sea heat fluxes
  - ERA5 (ECMWF)
  - MERRA–2 (NASA)
  - CFSv2 (NOAA NCEP)
  - OAFlux2 (COARE algorithm+CERES as radiation)

How to quantify heat budget?

Question: Is the ocean or atmosphere the volume box for calculating air–sea heat flux?



1) **Conduction**: direct exchange of kinetic energy of particles through the boundary
2) **Convection**: depends on movement of mass
3) **Radiation**: electromagnetic
4) **Evaporation**: phase change, then convection

2D Method (more direct)

$$MHT = \int_{lon_1}^{lon_2} \rho c_p h T v \, dx$$

3D method (control volume)

Heat budget: $\frac{\partial T}{\partial t} + \vec{u} \bullet \nabla T = (k_v T_z)_z$ + lateral "eddy" diffusion

× ρc_p and integrate over volume

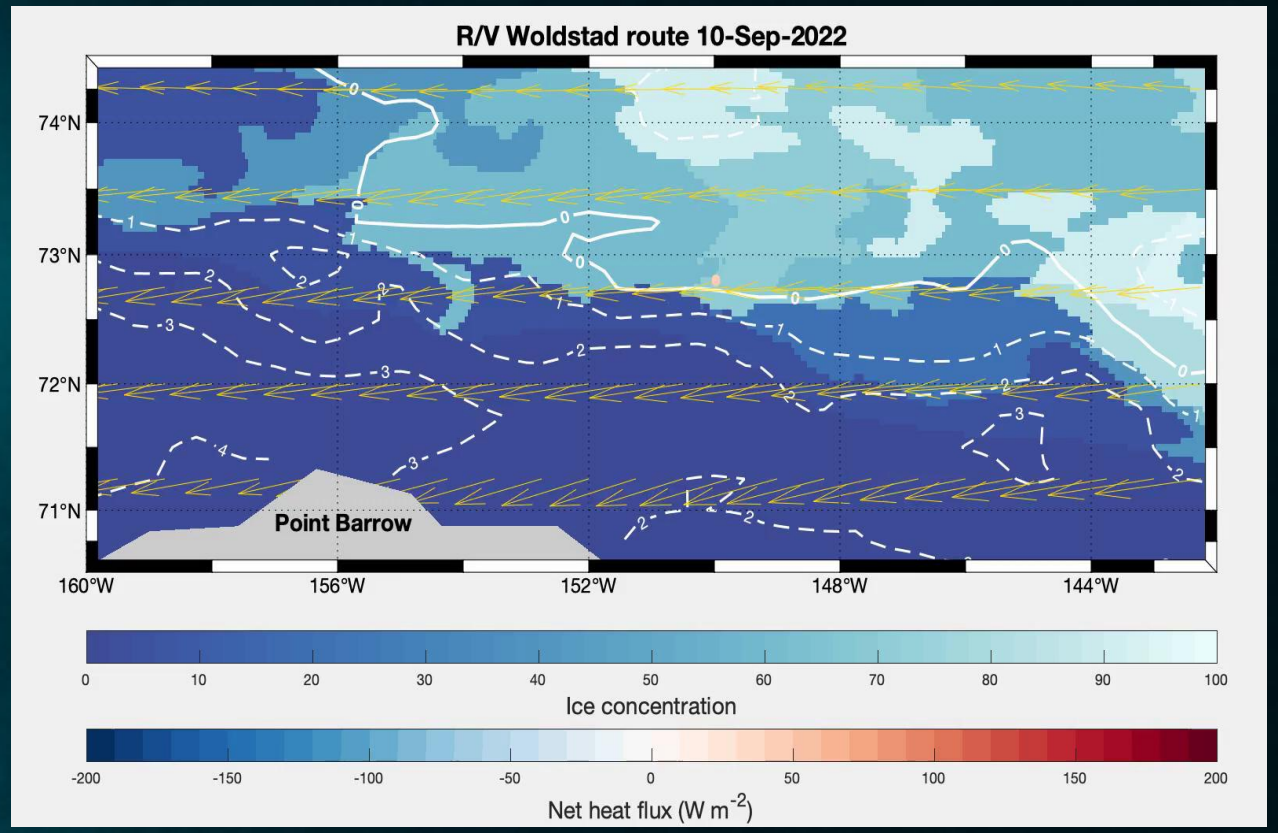
$$\int \rho c_p \frac{\partial T}{\partial t} dV + \int \rho c_p \vec{u} \bullet \nabla T dV = \int \rho c_p (k_v T_z)_z dV$$

$$\iint \rho c_p k_v T_z \Big|_{Bot}^{Top} dx dy$$

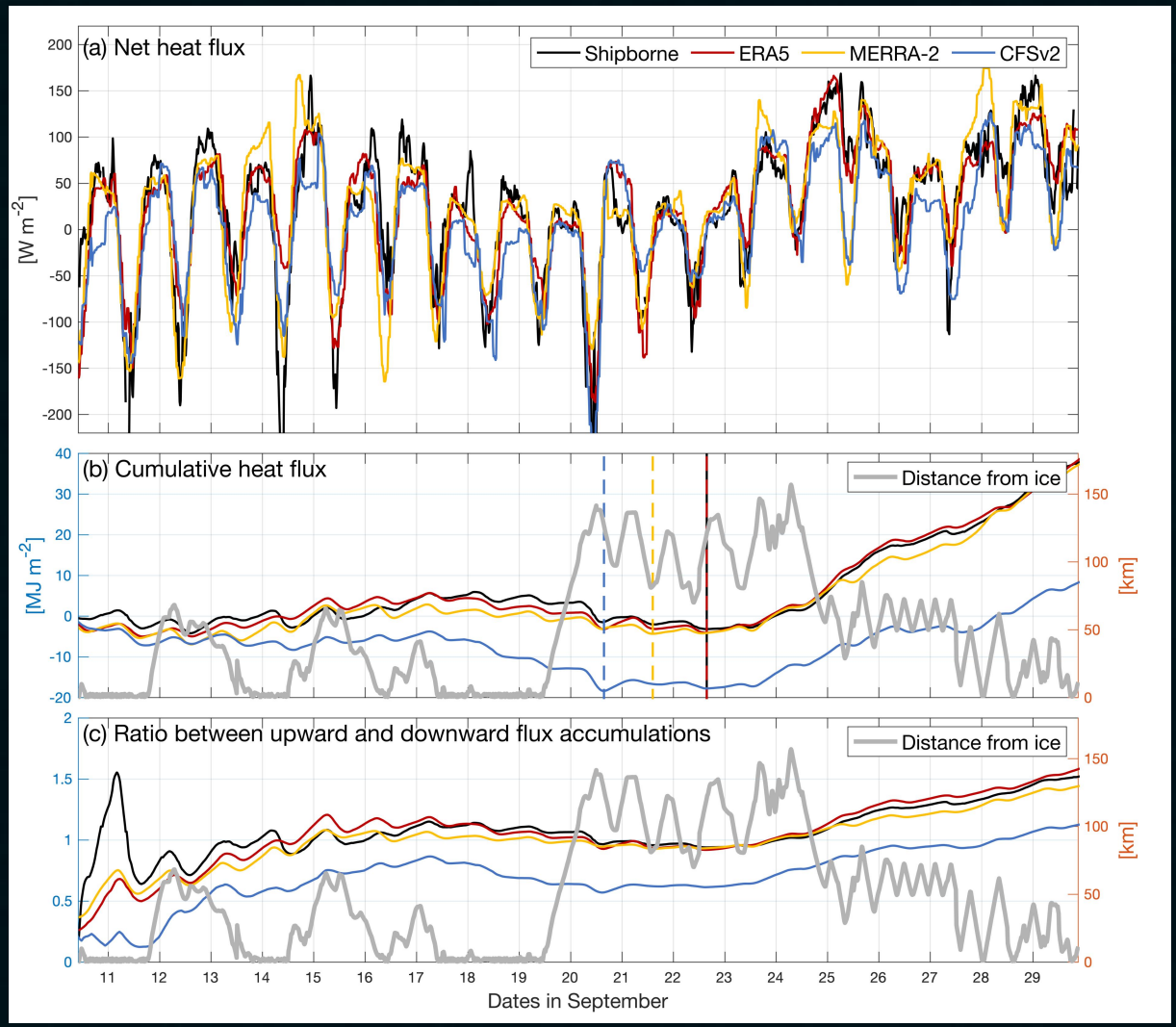
$$\iint F_s dx dy$$

Comparison with reanalyses on air–sea exchange

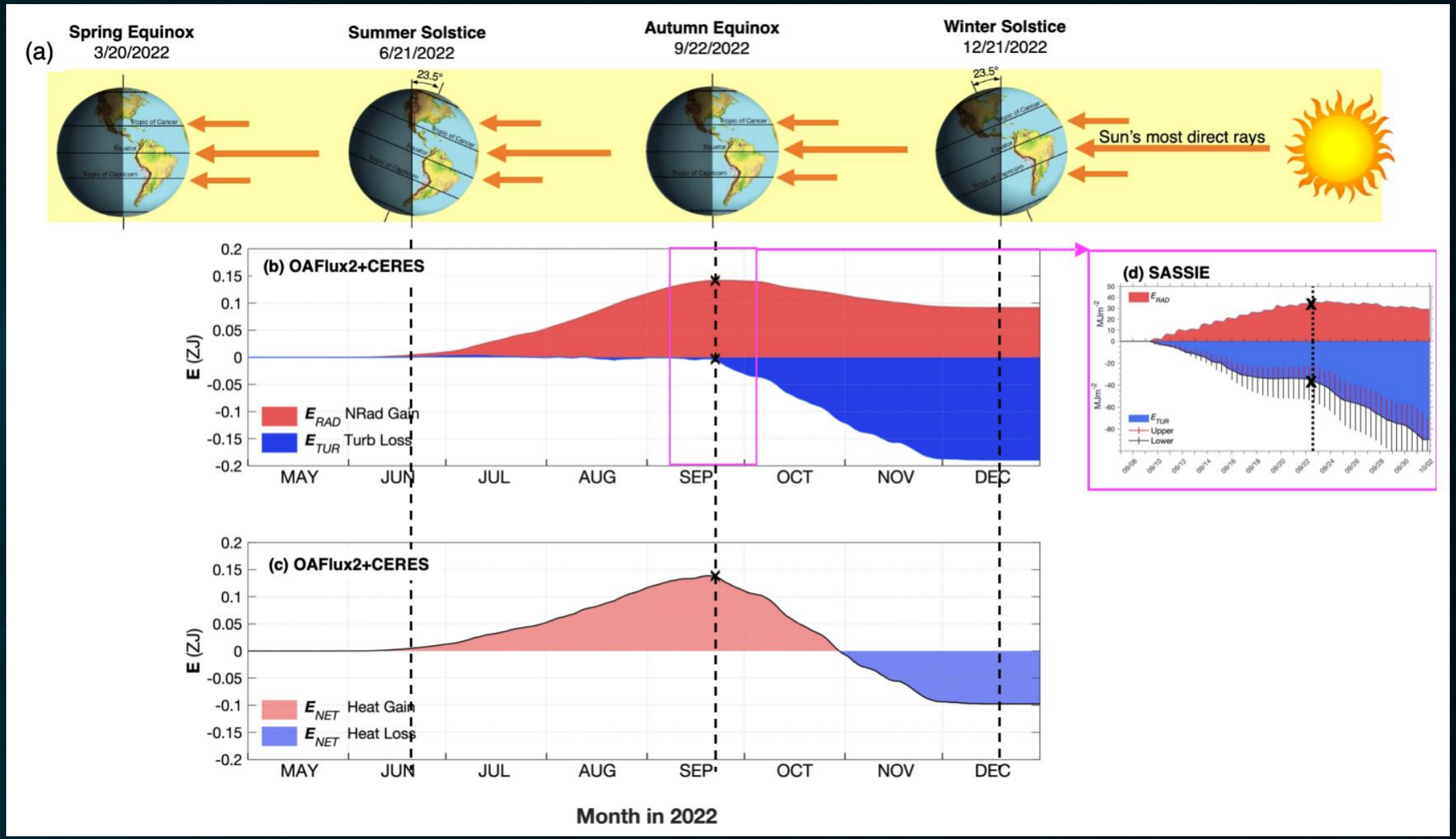
Net heat flux along the ship track
(positive upward)



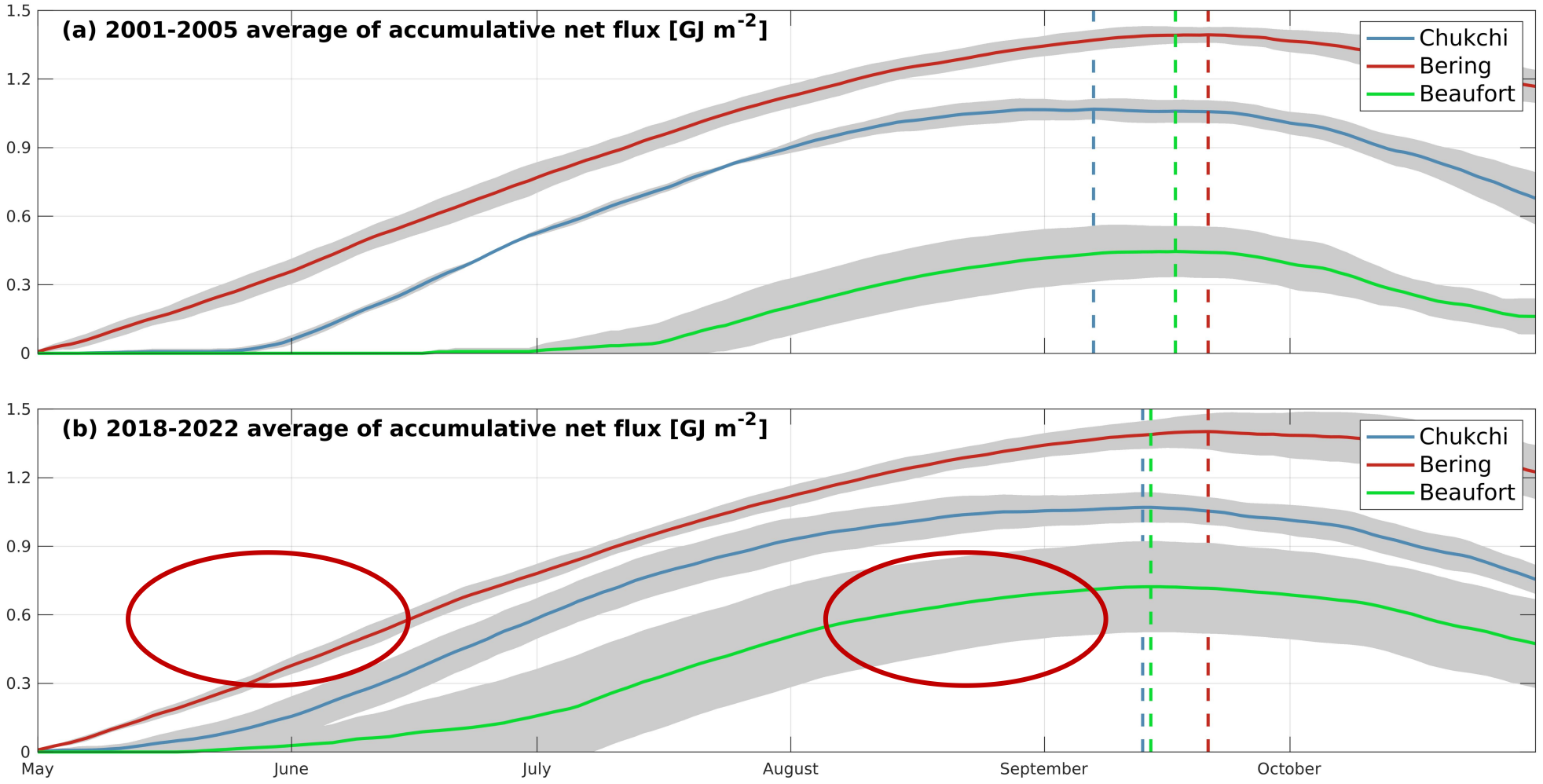
Shortwave, Longwave, sensible and latent
components for 1 cruise + 3 reanalyses



Air–sea heat flux accummulation



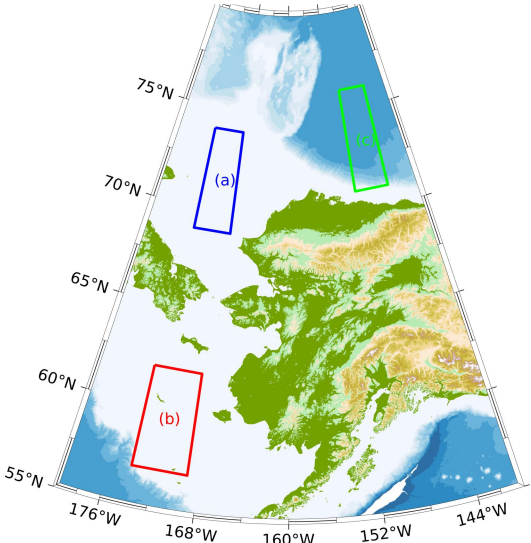
32-year summer air-sea heat flux



1) ERA5 radiation + ERA5 turbulent heat flux

2) CERES radiation + COARE turbulent heat flux (ERA5 meteorologies)

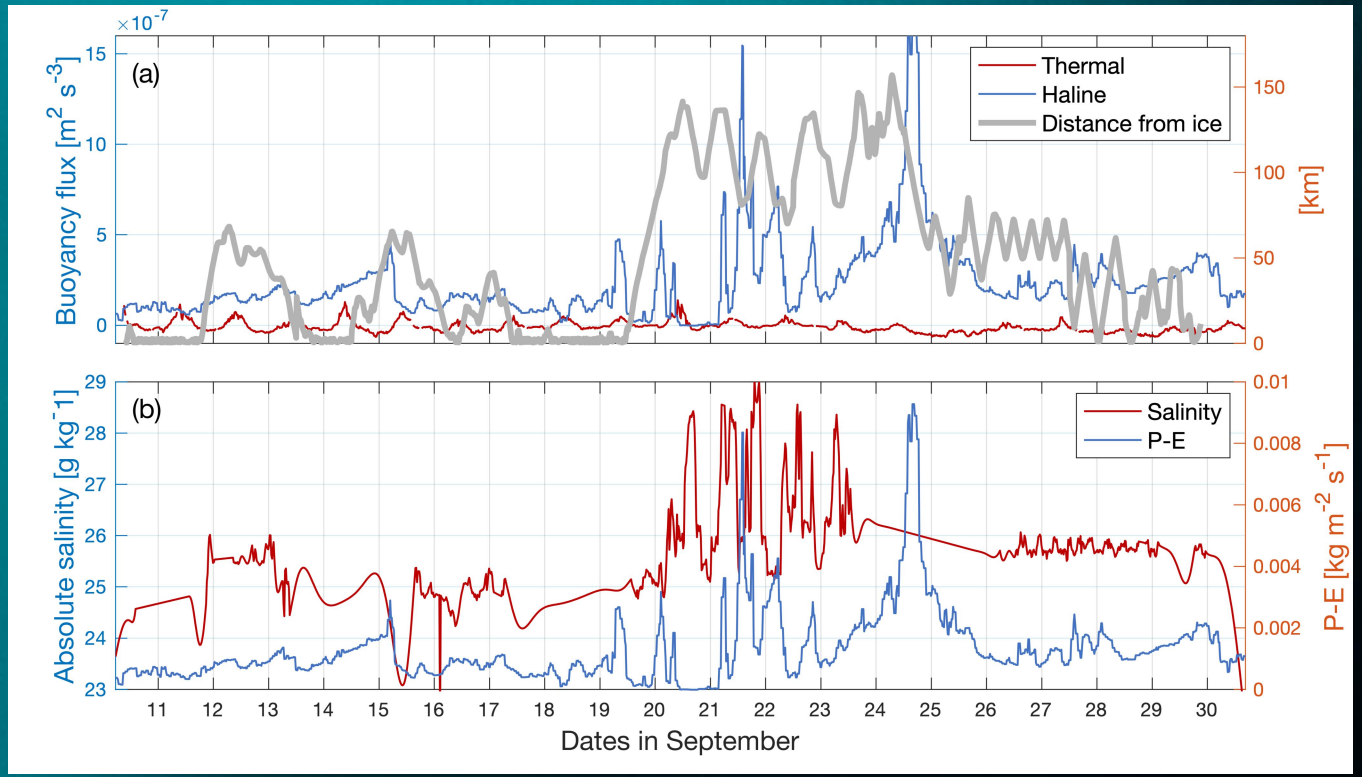
(a) Chukchi
(b) Bering
(c) Beaufort



Take home message

1. Net air–sea heat budget of Beaufort Sea autumn transition follows the Earth's orbital motion around the Sun.

2. Various methods/mindsets in air–sea turbulent heat flux calculations lead to different transitional dates of ocean receiving heat to releasing it.



3. A separation of different freshwater forcings/components is important!