Vertical heat flux in the Canada Basin inferred from moored instruments.

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Motivations :

- Observational studies have shown that an unprecedented warm anomaly has recently affected the temperature of the Atlantic Water (AW) layer lying at intermediate depth in the Arctic Ocean (McLaughlin et al. 2009)
- In the Eurasian Basin, Polyakov et al. (2010) suggest that the AW warming led to an increase of the vertical heat flux, that may have contributed to the thinning of the sea ice pack.
- ***What did happen in the Canadian Basin when the warm pulse reached the region ?***

Using observations from four profiling moorings, deployed in the interior of the Canada Basin between 2003 and 2011, we quantify the upward diffusive vertical heat flux from the Atlantic Water layer and we examine the sources of temporal and spatial variability for this flux.

BGOS mooring observations :

- Up to 4 moorings deployed and maintained since August 2003 as part of *Beaufort Gyre Observing System*
- Each mooring carries a McLane moored profilers (MMP).
- It returns CTD & ACM profiles between 60 and 2000m

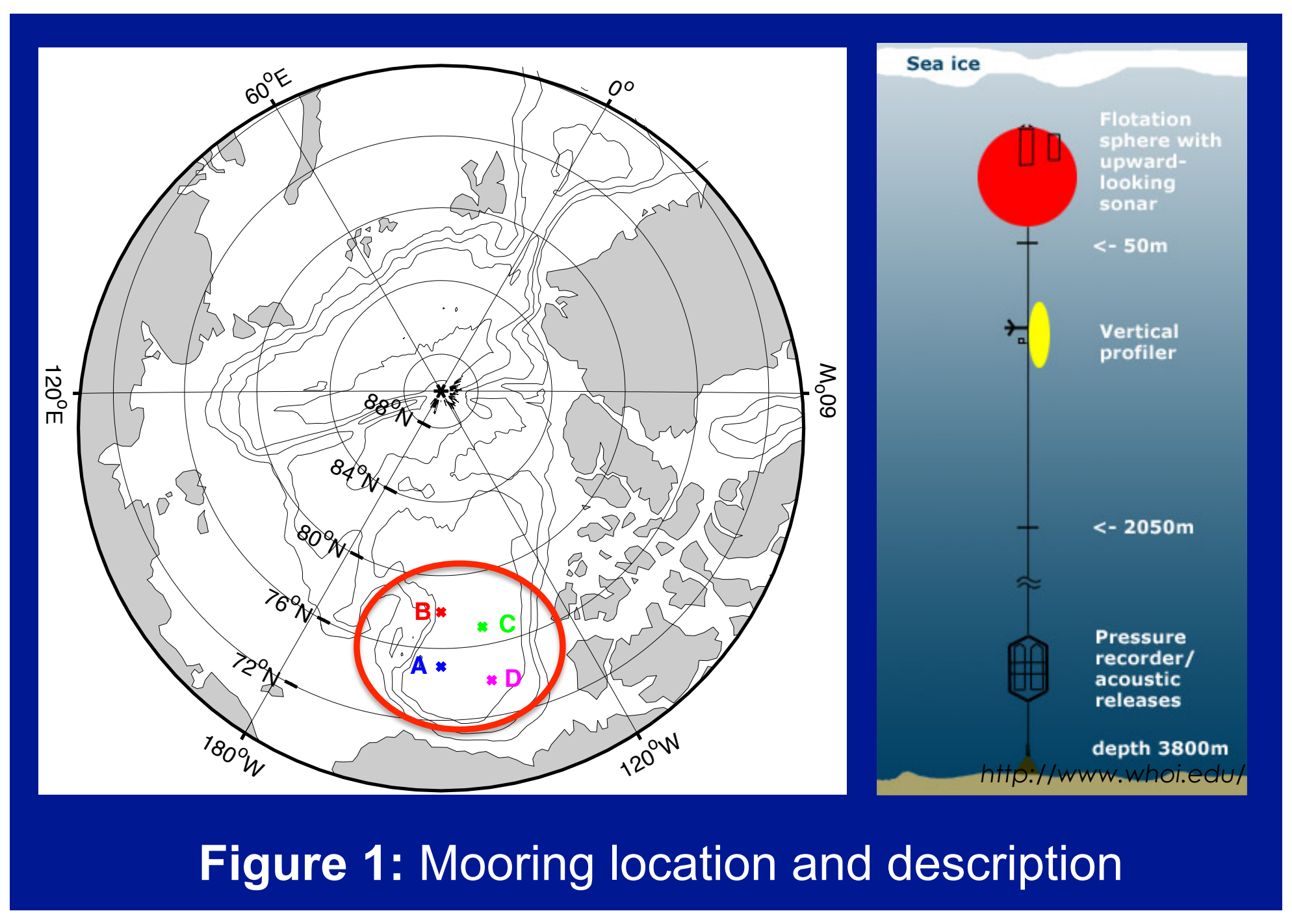

Figure 1: Mooring location and description

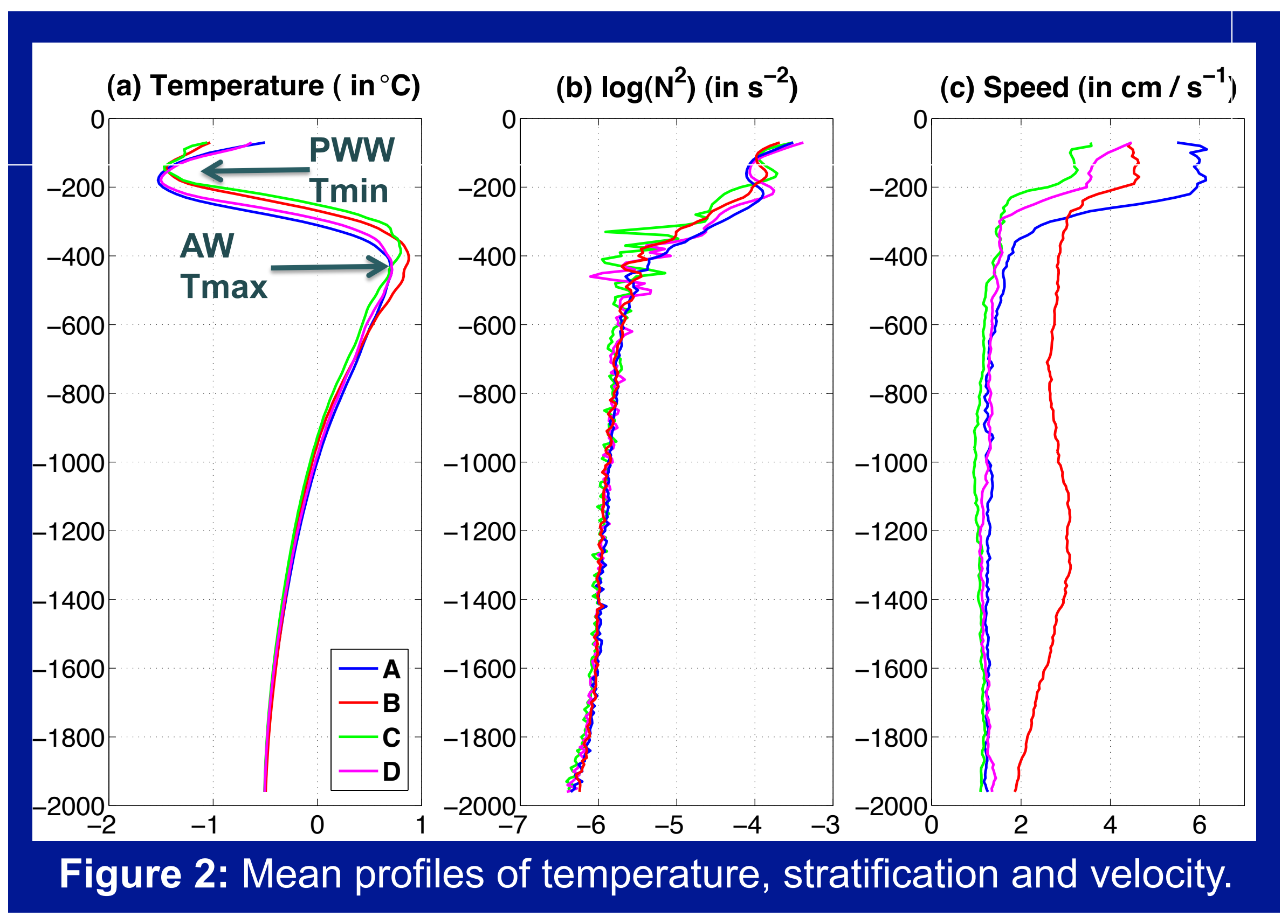

Figure 2: Mean profiles of temperature, stratification and velocity.

Calculation method :

- Vertical heat flux due to diffusion can be expressed as:

$$F_H = \rho_0 C_p Kz \frac{\partial T}{\partial z}$$

- The vertical diffusivity (Kz) is computed as in Guthrie et al. (2013):
  - ✓ Estimated from the fine scale parameterization of *Gregg (1989) and Kunze et al. (2006)*, that accounts for energy dissipation by internal waves breaking.
  - ✓ Values of shear and strain variance are obtained from moving 128-m (i.e. 64 point) segment spectral analysis, calculated every 10m.
- We obtain 1 daily value every 2 days. We focus on the upper part of the water column, above the Atlantic Water (AW) temperature maximum.

Vertical diffusivity and heat flux :

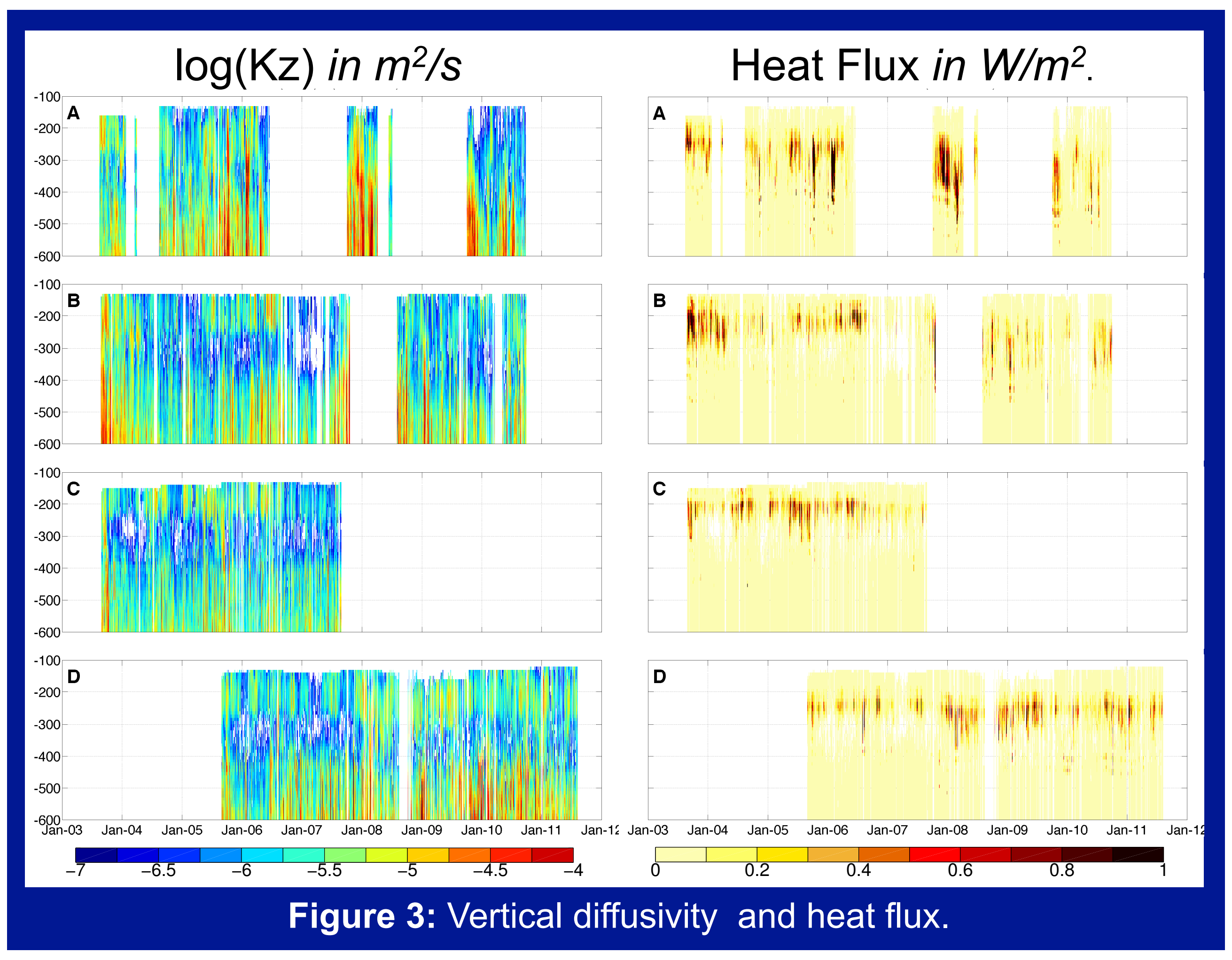

Figure 3: Vertical diffusivity and heat flux.

- We obtain low vertical diffusivity:
  $Kz \sim 10^{-6} – 10^{-5}$ m²/s
  The values are consistent with microstructure measurements performed in the Arctic Ocean.
- On average, the diffusive vertical heat fluxes are small:
  FH ~ 0.1 – 0.3 W/m².
  The maximum heat fluxes are found where the temperature gradient is maximum, i.e., between 200 and 280m (except for mooring A).
- The heat flux exhibits some short events when the values reach up to a few W/m² superimposed on the low background vertical heat fluxes.

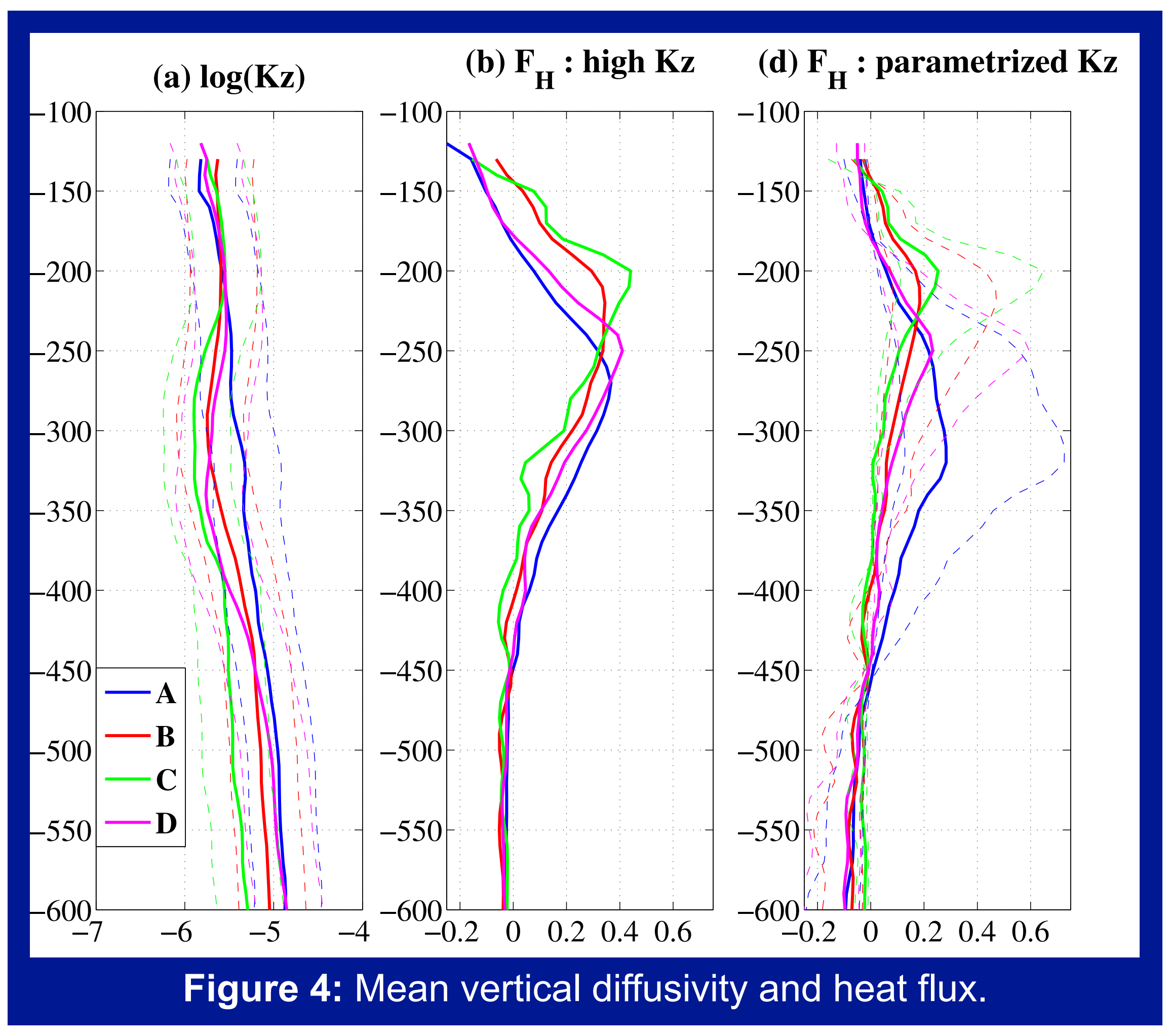

Figure 4: Mean vertical diffusivity and heat flux.

Source of vertical heat flux variability :

Temperature variations :

- The temperatures of the Pacific Winter Water (Tmin) and the Atlantic Water (Tmax) exhibit large variations
- Yet, the resulting vertical heat flux from the AW layer remains roughly constant and small on average.
- The variability of $F_{H\ AW}$ is more driven by the variations of Kz than those of the temperature gradient.

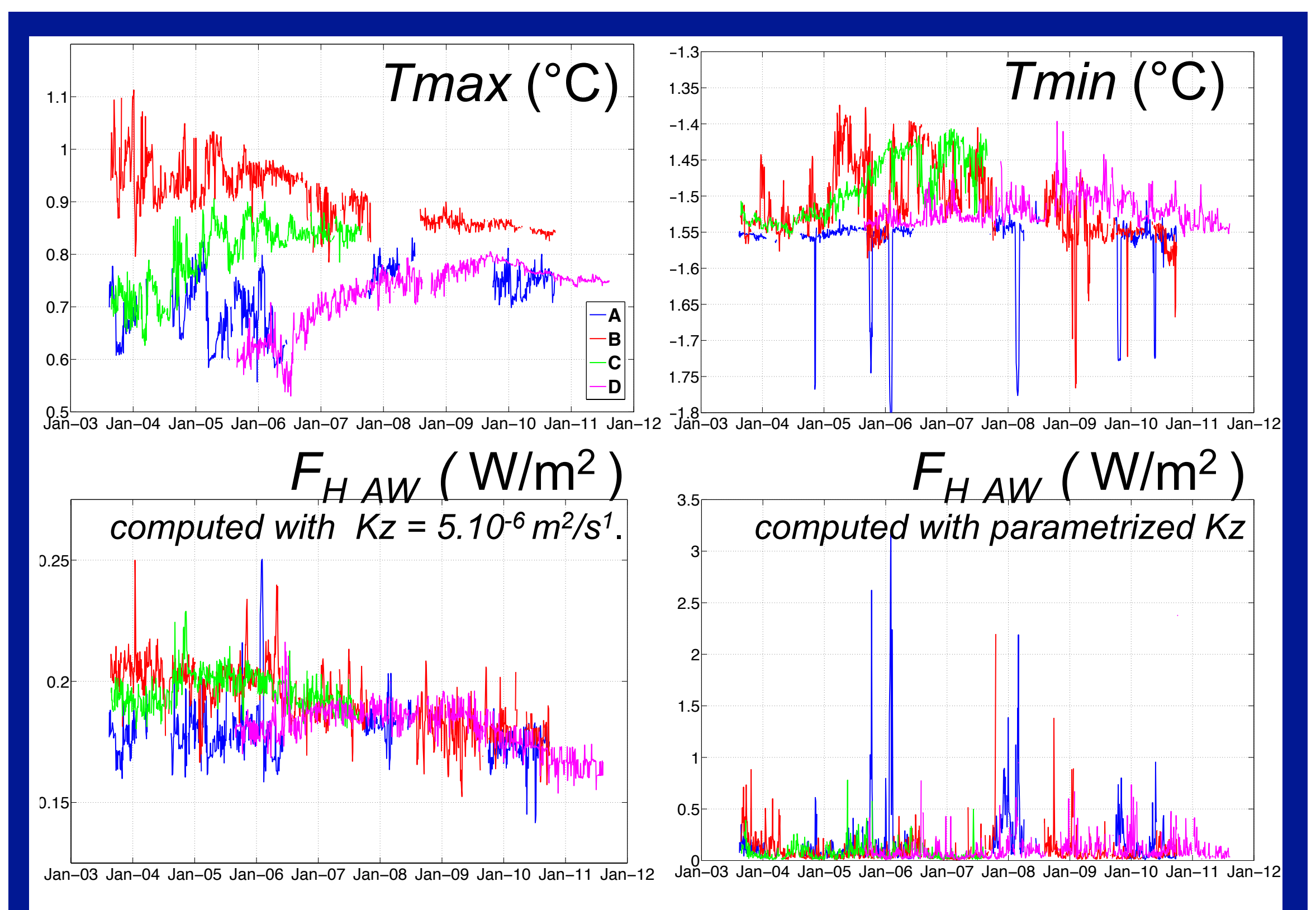

Figure 5: Time series of the PWW and the AW temperatures and the resulting heat flux.

Eddies (mooring A) :

- Mooring A captures several cold core subsurface eddies.
- With a constant Kz, these eddies would yield a 10% increase of $F_{H\ AW}$
- The vertical diffusivity increases in the presence of eddies, yielding vertical heat flux of a few W/m2 during a day or two.

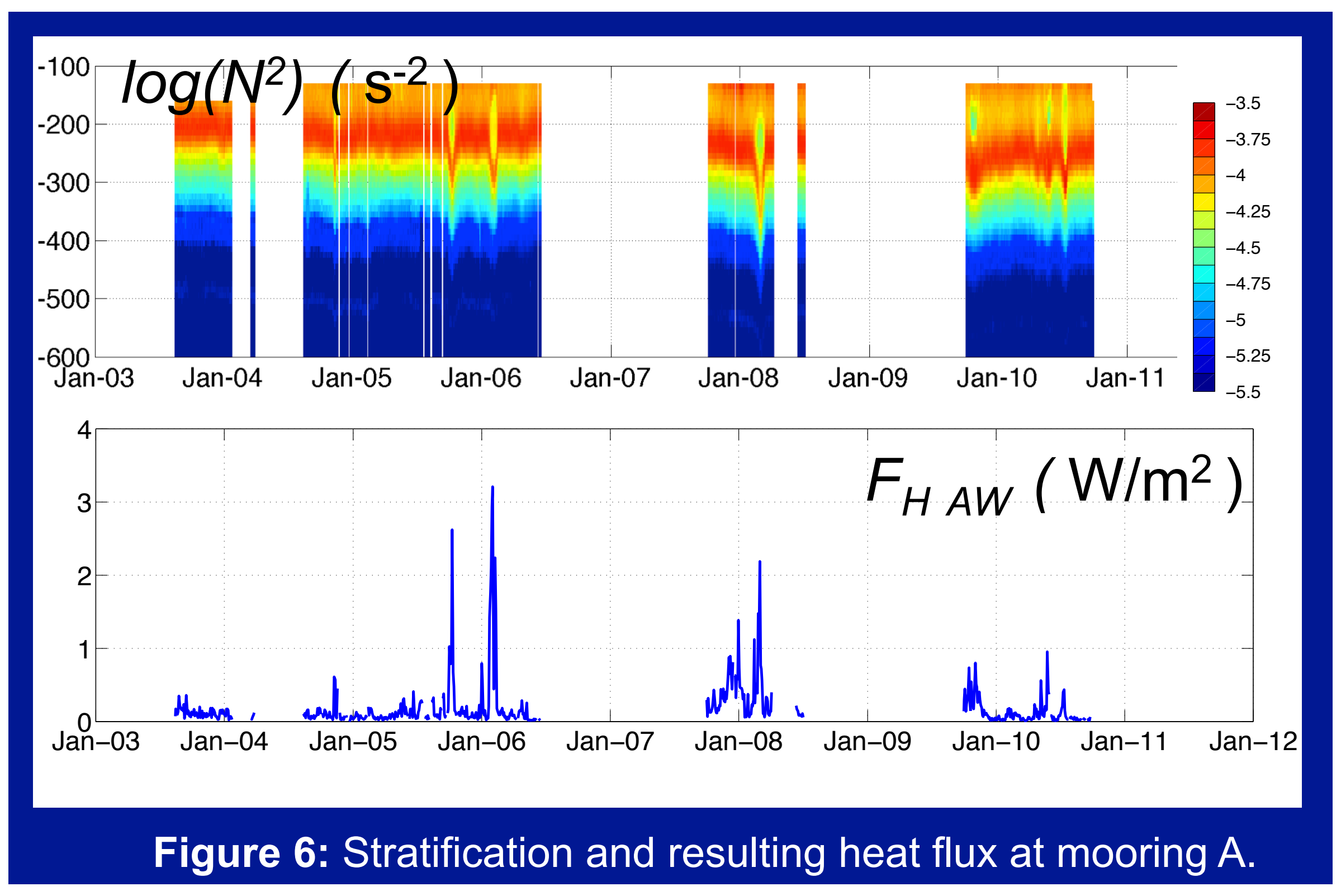

Figure 6: Stratification and resulting heat flux at mooring A.

Summary :

- The vertical heat flux from AW is ~ 0.1 – 0.3 W/m² on average in the interior of the Canada Basin. This is small compared to the 4 W/m² expected from back of the envelope calculation to maintain a steady state.
- The AW temperature variations yield only small variations for the heat flux.
- The presence of cold core eddies is the main source of variability. Their passage can lead to heat flux ~2– 3 W/m² for a day or two.
- Using constant diffusivity of Kz ~ 2 – 3 x 10^{-6} m²/s provides a reasonable estimate of the upward heat flux, although this approximation breaks down in the presence of eddies.

References:
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