Survey of air-ice-ocean carbon dioxide exchanges over Arctic sea ice

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- There are evidences that, in some conditions, sea-ice can be permeable to gas exchange and that CO_2 gradients exist between the brines and the atmosphere.

- Ice-covered oceanic zones are not taken into account in the current ocean CO_2 budget estimations

Overvie … a-ice

- Previous direc … complete

Reference					te	location
Semiletov et al., 2					ne 02	Barrow, Alaska
Zemelink et al., 20					ce er 04	Weddell Sea
Delille et al., 2007						Weddell Sea

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⇒ Main goals of this survey

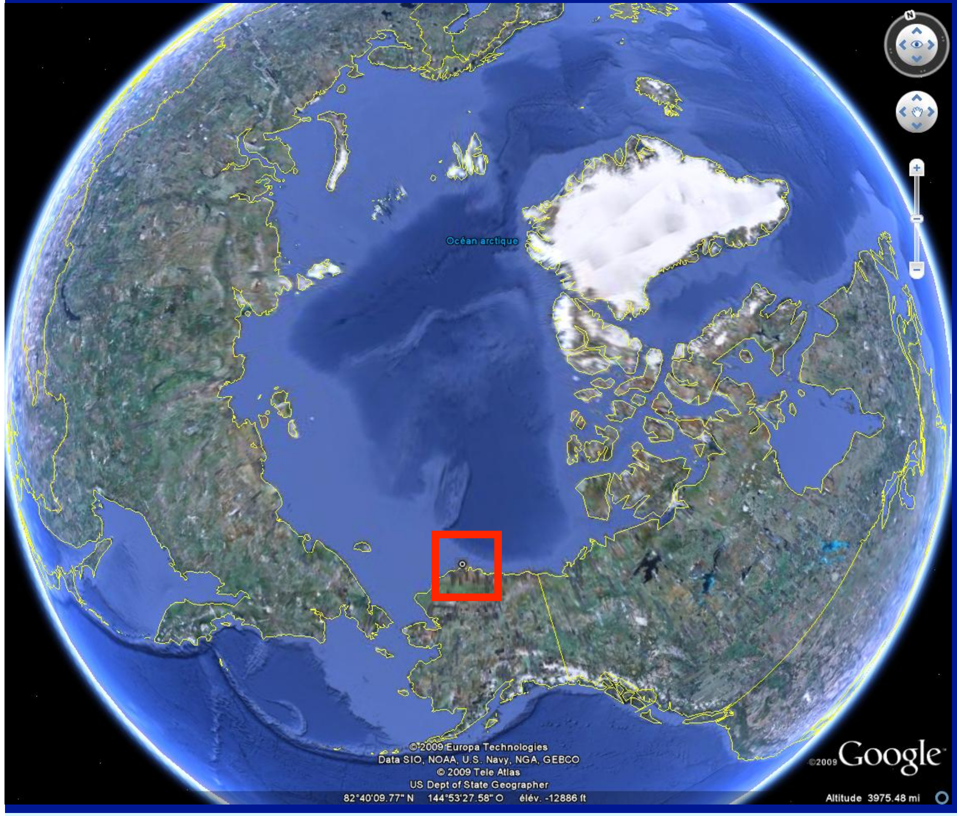
- to robustly track CO2 exchange between land-fast sea-ice and the atmosphere during the winter and spring season
- to analyse these fluxes in respect with physical and biochemical properties of sea-ice
- to produce a CO2 budget for sea-ice

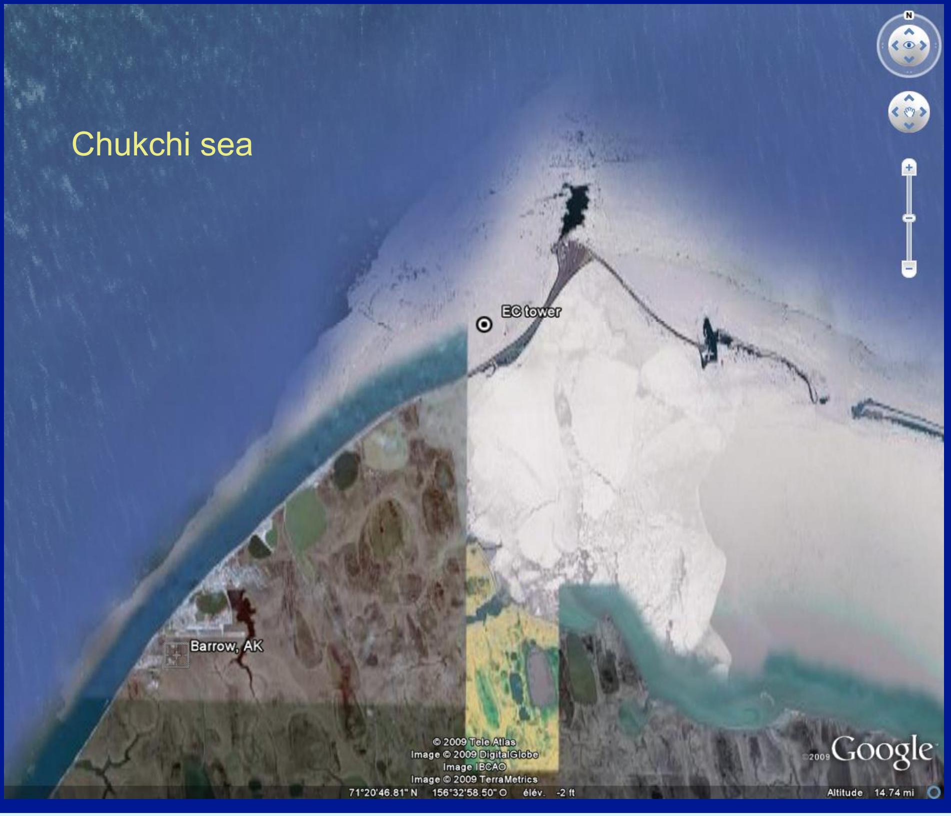
Site

Flat first-year land-fast sea-ice near Barrow (Alaska), 1 km off the coast.

The source area for EC measurements at 2.8 m was well within the boundaries of the floe.

Duration: from the end of January 2009 to the beginning of June 2009, before ice break-up.





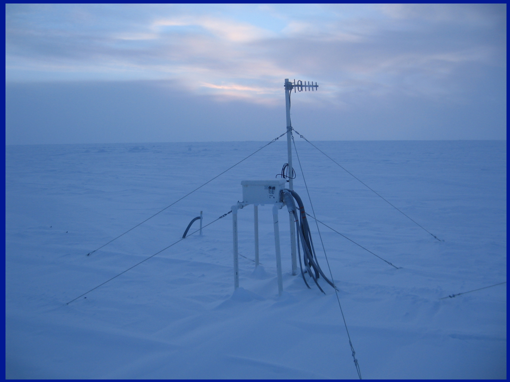
Experimental setup: main characteristics

Micro-meteorological mast (eddycovariance)

CO_2 sampling	: 10Hz	Standard methodology for flux computation
IRGA	: 1 LiCor 7000	- closed path CO_2 analyser
Sonics	: 1 Csat3	- detection limit
Measurement height	: 2.8 m	
Data acquisition	: CR3000	

The micro-met. final dataset consisted 45 days of reliable CO2 flux data

Automatic mass balance station

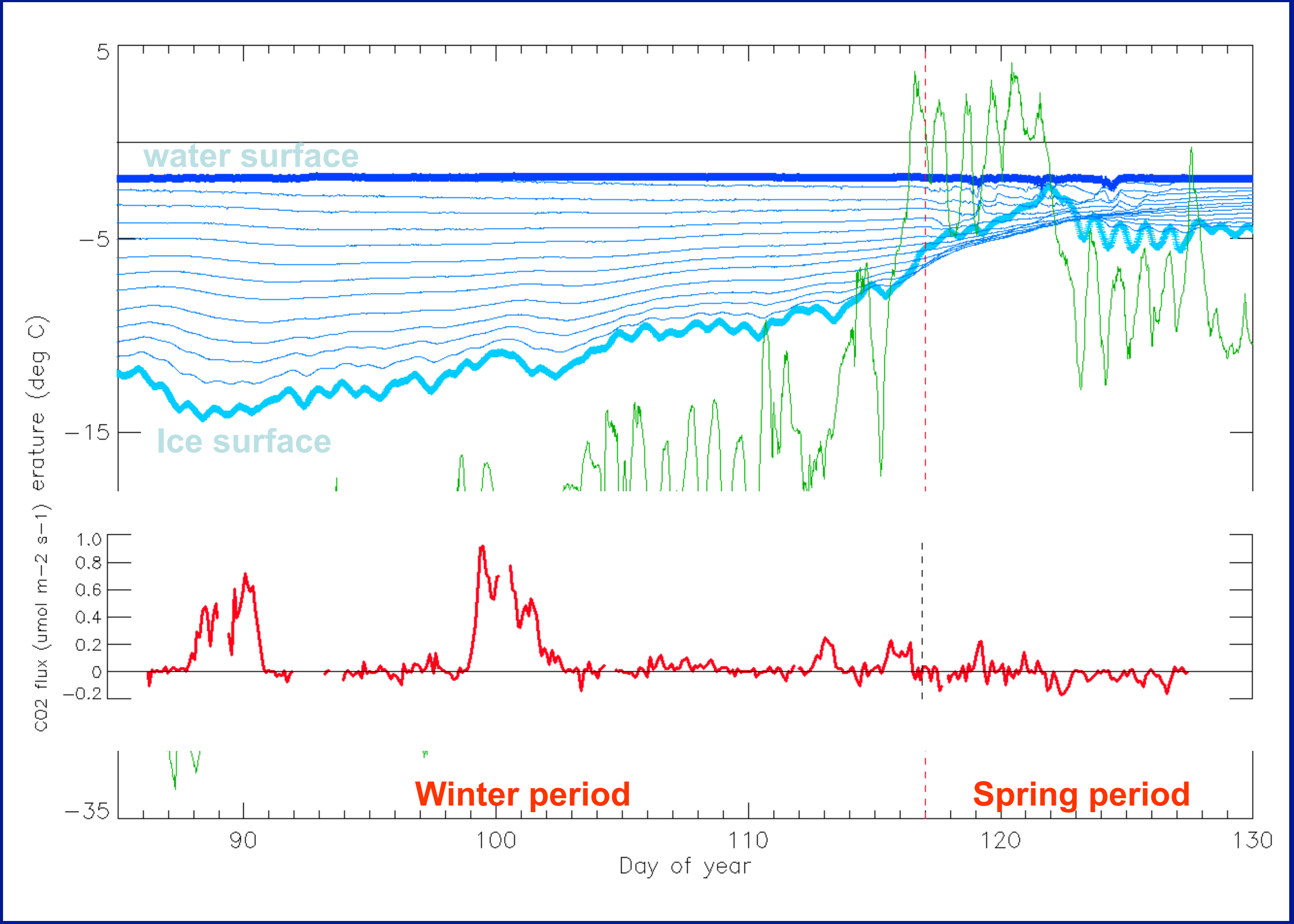


- Ice temperature and thickness
- Air temperature and humidity
- Snow depth
- Water temperature and depth

Ice coring (10 stations)

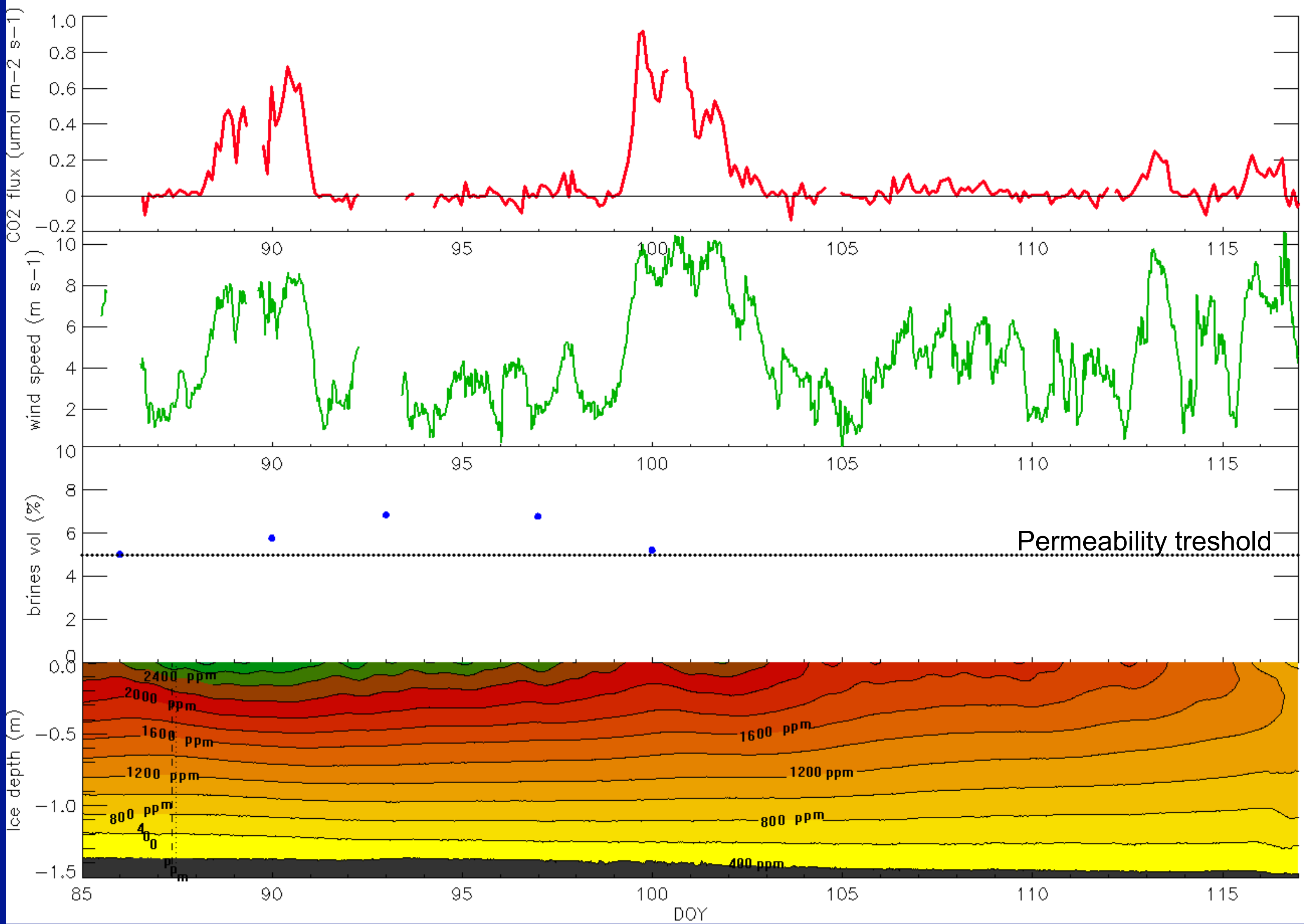
- Brines pCO_2
- Brines POC
- DIC, Alkalinity
- Chlorophyll a
- Ice texture

Ice temperature profile

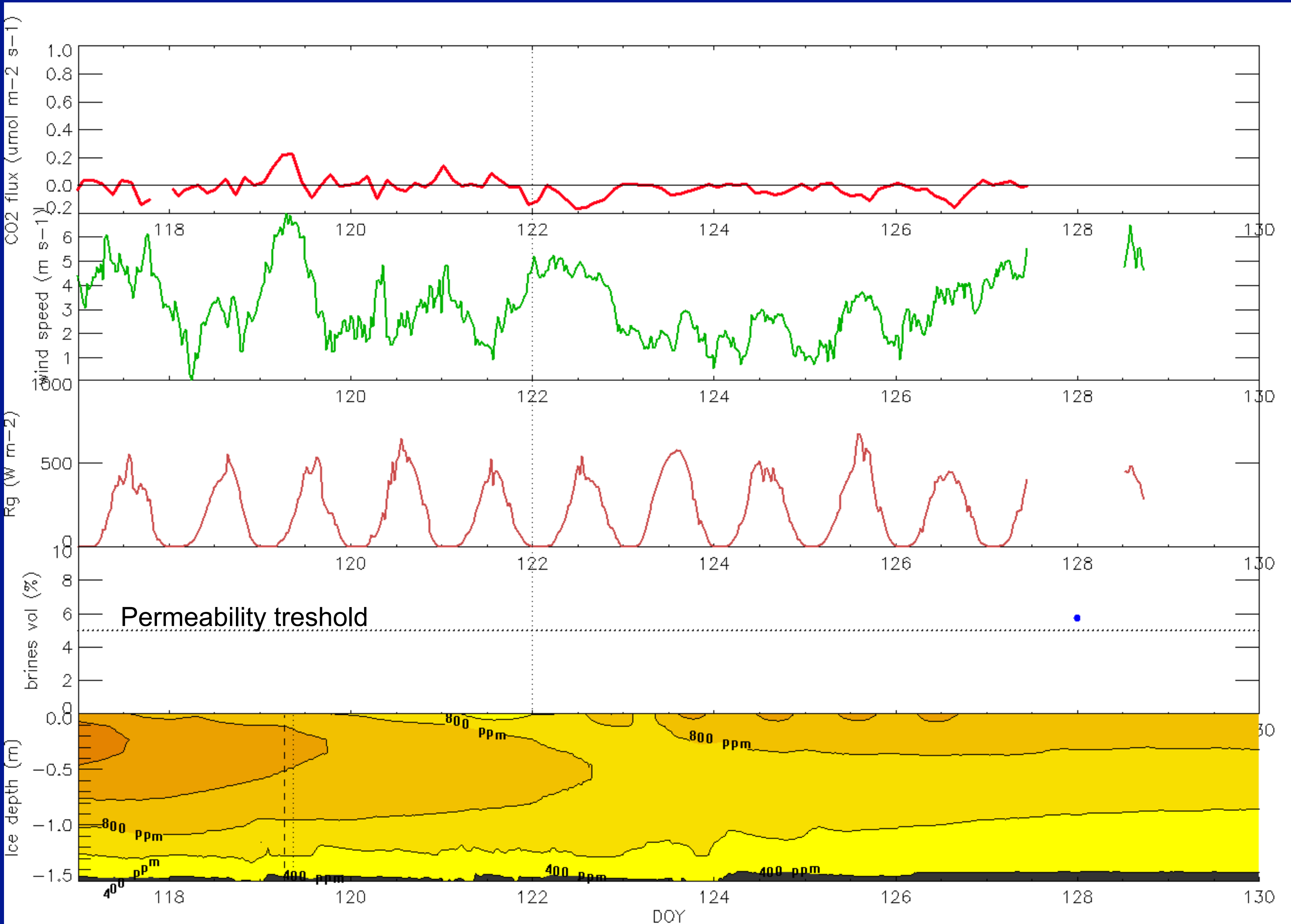


Around day 117, onset of substantial convection throughout much of the ice column as the ice warms and allows forced convection (due to the hydraulic head of the brine above freeboard level) to occur.

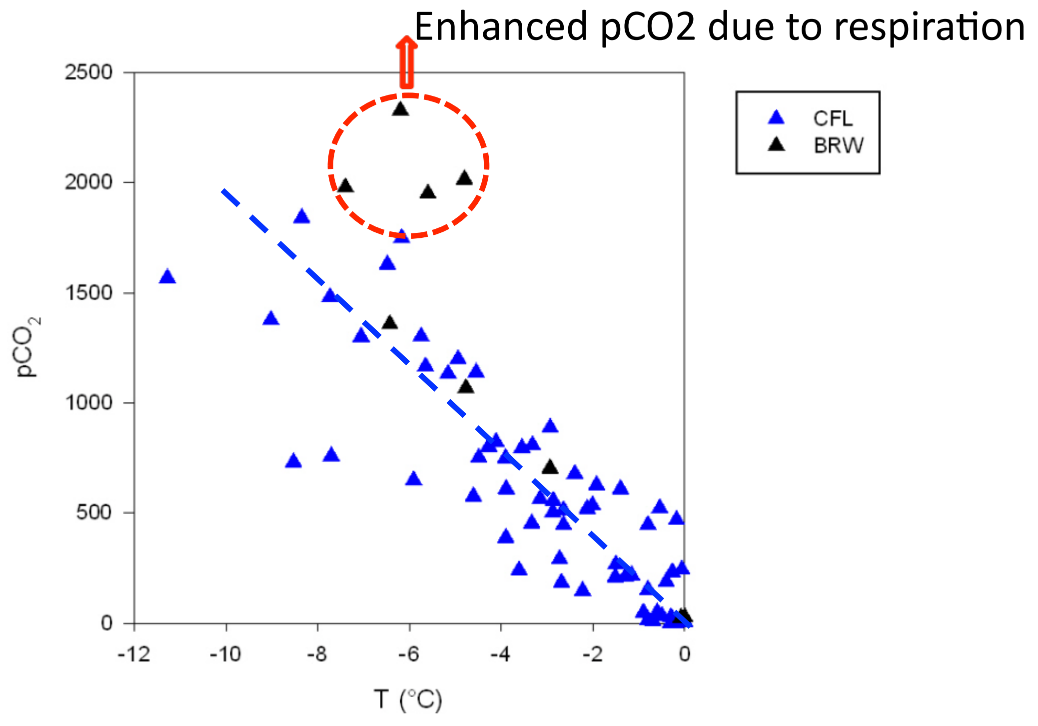
“Winter” regime



"Spring" regime



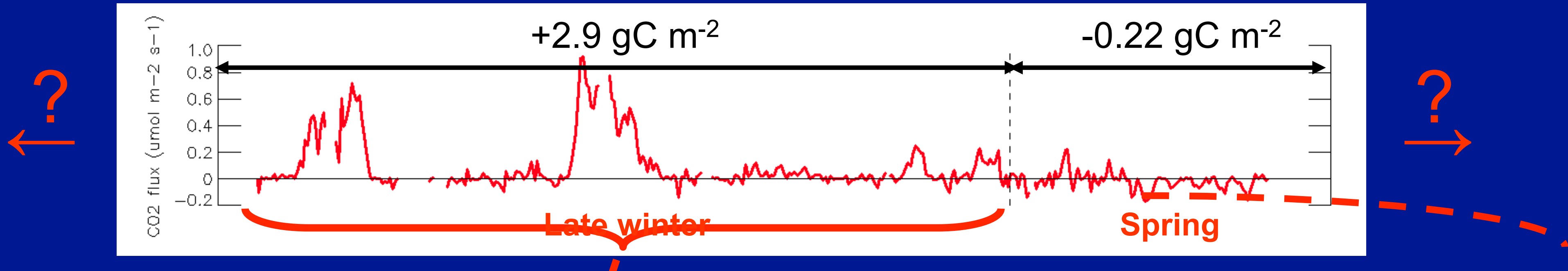
pCO_2-T° relationship

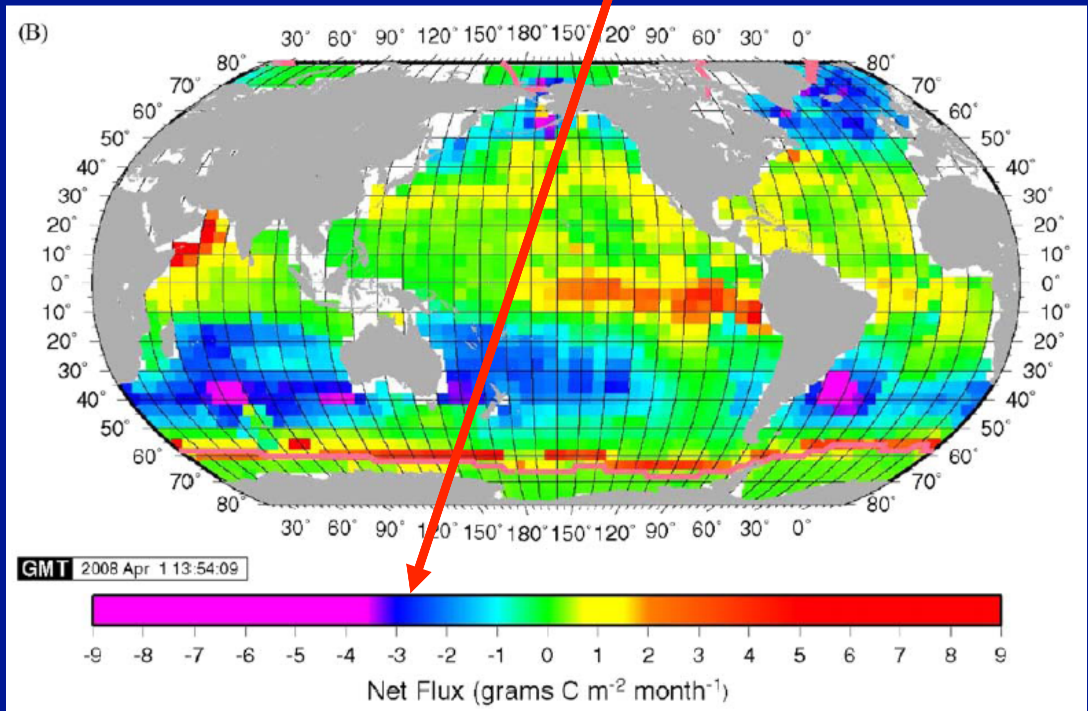


Arctic pCO_2-T° relationship

- Huge uncertainties on this pCO_2-T extrapolation for the ice top layer in Barrow
- We probably underestimate pCO_2 in the top layer in winter and overestimate pCO_2 in spring

Carbon budget





Takahashi, T. et al., in press

Summary

- We observed conspicuous CO_2 flux events qualitatively linked to ice permeability and pCO_2 of the brines

    - in late winter, prior to the start of the internal processes that can lead to brines pCO_2 reduction, sea-ice was a source

    - in the beginning of spring, sea-ice shifted to a sink 5 days after the warming period started

Are these fluxes significant in the carbon budget of the polar oceans ?

- The order of magnitude of the measured fluxes, integrated on the whole sea-ice cover of Arctic ocean would lead to a significant contribution but we catched only a short part of the year and so it's difficult to make a budget on the sea-ice life cycle.


Thank you for your attention
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