Surface Fluxes: Challenges for High Latitudes

NCAR, Boulder, CO - March 17-19

CFL: A year of flux measurements in the Arctic Ocean during IPY.

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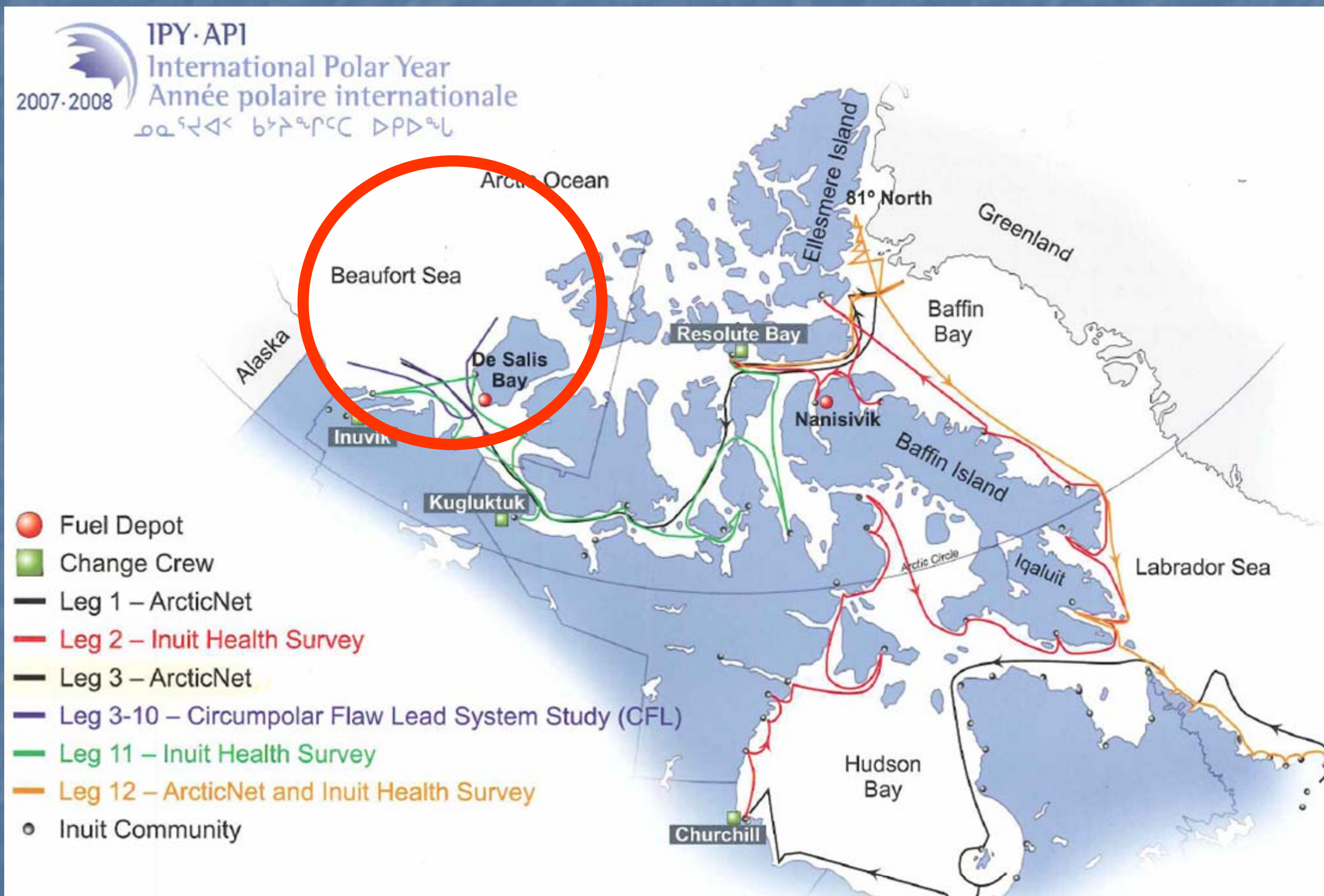
Outline

- IPY and the Circumpolar Flaw Lead System Study
- Gas fluxes - theoretical basis
- Instrumentation on board CCGS Amundsen
- Data acquisition, challenges
- Remarks

Circumpolar Flaw Lead System (CFL)

- Perennial characteristic of the central Arctic
- The Flaw Lead Polynya system is formed when the central pack (which is mobile) moves away from coastal fast ice, opening flaw leads
- Air-sea fluxes are greatly enhanced over leads due to the exposure of open water to the cold arctic air.
- These regions are exceedingly sensitive to physical forcing from both the atmosphere and ocean

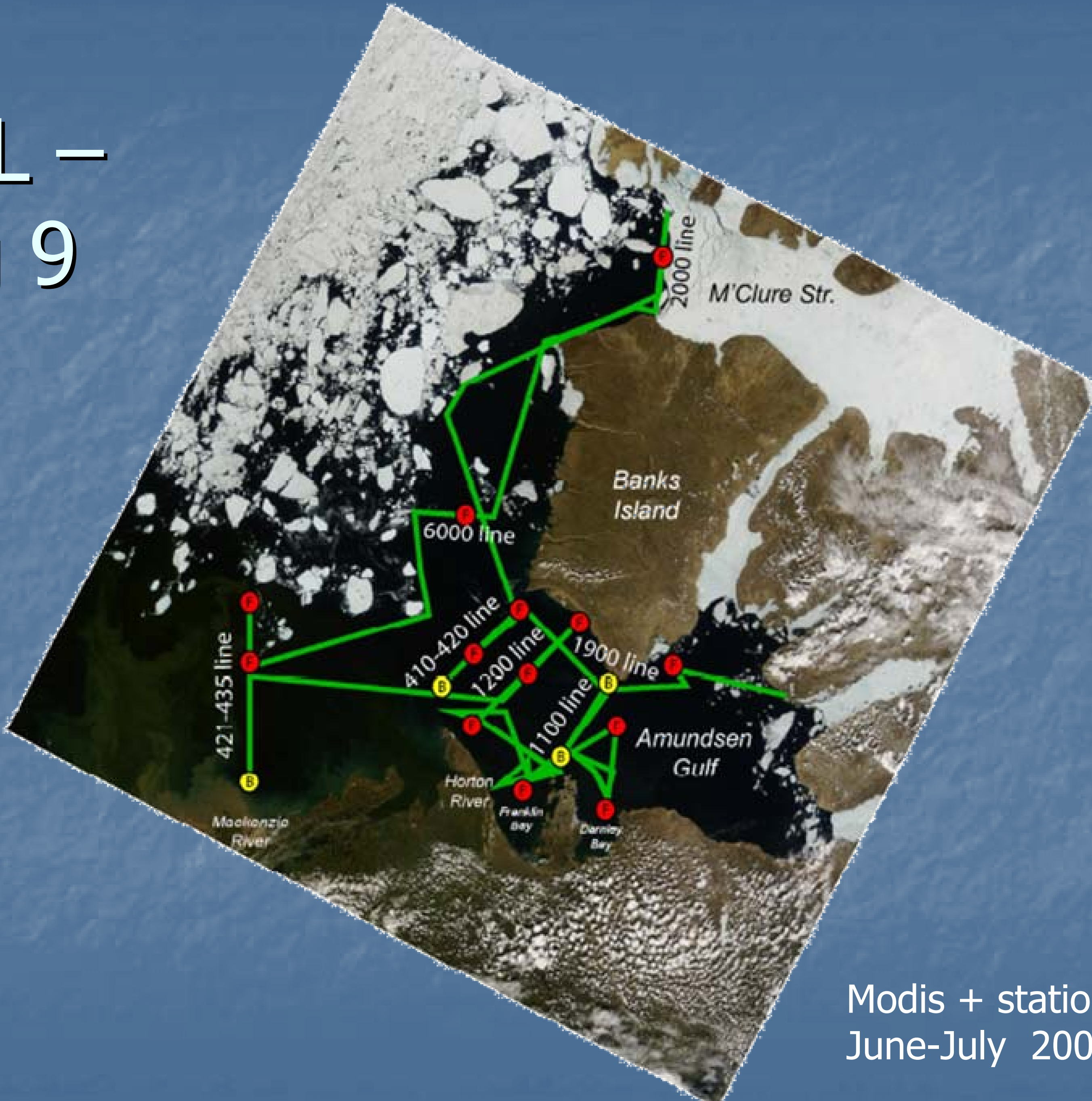
Circumpolar Flaw Lead System Study (CFL)



- Part of a 15-month cruise, on board CCGS Amundsen
- 27 countries participating, 600 people
- 278 discrete stations, 1017 CTD casts, 8,000 ice cores, thousands of box cores, ROV surveys, etc

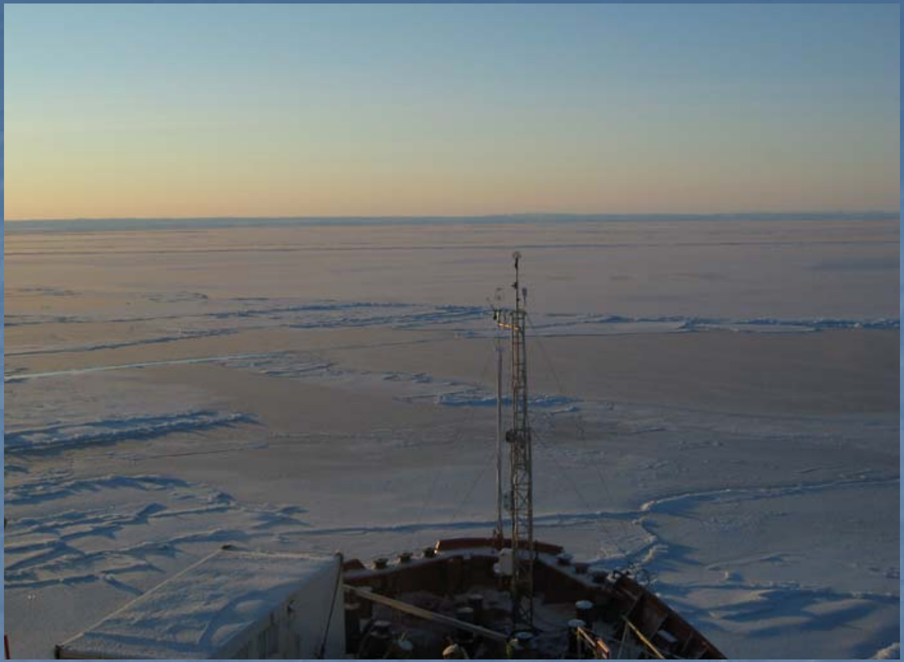
PIs: University of Manitoba (Dave Barber), Gary Stern (DFO)

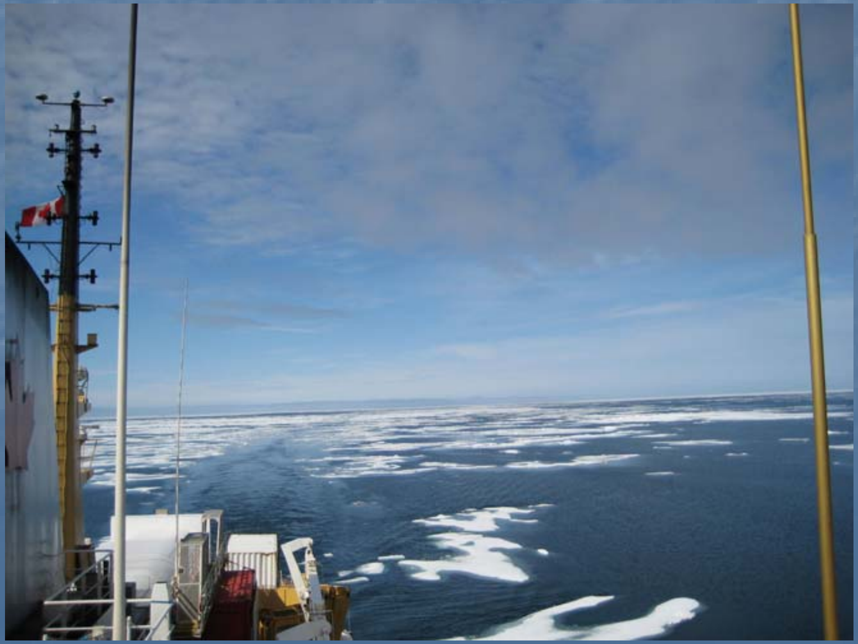
CFL – leg 9



Modis + stations during June-July 2008

Cruise conditions





Leg 3: october 2007
Leg 8: May 2008
Leg 9-10: July 2008

CFL Groups

Team 1 Physical Oceanography
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Team 2 Ocean-sea ice-atmosphere processes
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Team 3 Light, Nutrients and Primary Production
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Team 4 Pelagic and Benthic Foodwebs
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Team 9 Modelling
PI: John Hanesiak, john_hanesiak@umanitoba.ca

Team 10 Traditional Knowledge
PI: Stephanie Meakin, smeakin@ripnet.com

- Gas fluxes
- Heat fluxes
- Momentum fluxes
- Short- and long-wave radiative fluxes

Gas fluxes

$$F = \overline{wc} = -u_* c_* = UC_G(C_w - C_a) = k\,\Delta C$$

Direct covariance

K-theory profiles

Bulk method

k: unique to gas transfer (speed times bulk coeff)

$$F = k\,\alpha\,[\Delta p\mathrm{CO_2}]_{\text{air-water}}$$

- k : gas transfer velocity,
- α : solubility of CO2, function of temperature and salinity
- ΔpCO_2 : difference in partial pressure of CO_2 ocean - atmosphere.

Gas transfer velocity (piston velocity)

$$k = \left(\nu / D\right)^{-n} f\left(U, L\right)$$

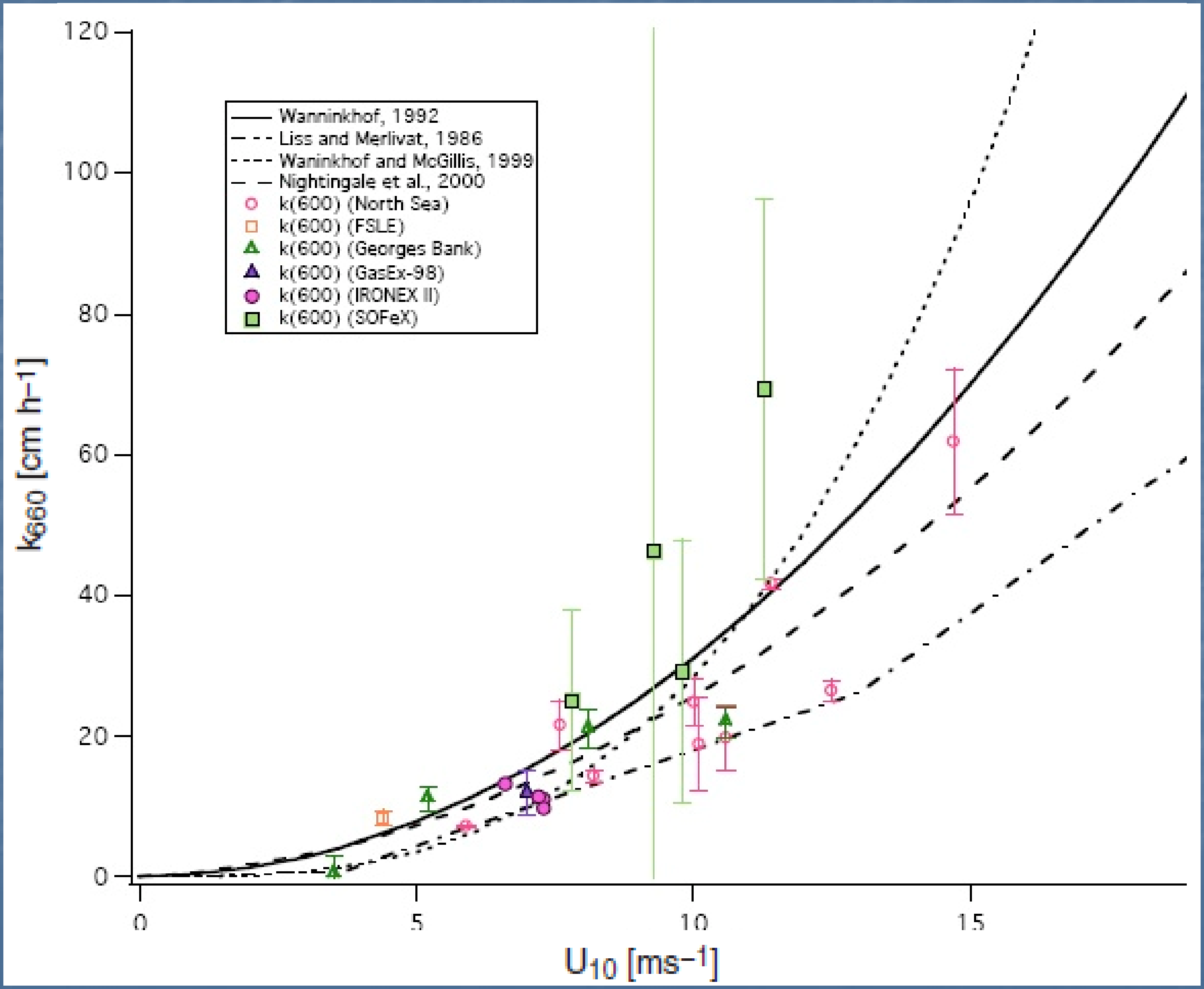
-Function of environmental forcing of water boundary layer
-Function of thermodynamic properties of gas and liquid

$$\nu / D = Sc \approx 100 - 1000$$

Sc varies by a factor 5-6 over oceanic temperature range: gas transfer velocity is a strong function of T

Common practice is to normalize Sc=600 (Schmidt number of CO_2 in fresh water at 20° C) ; Sc=660 idem for sea water

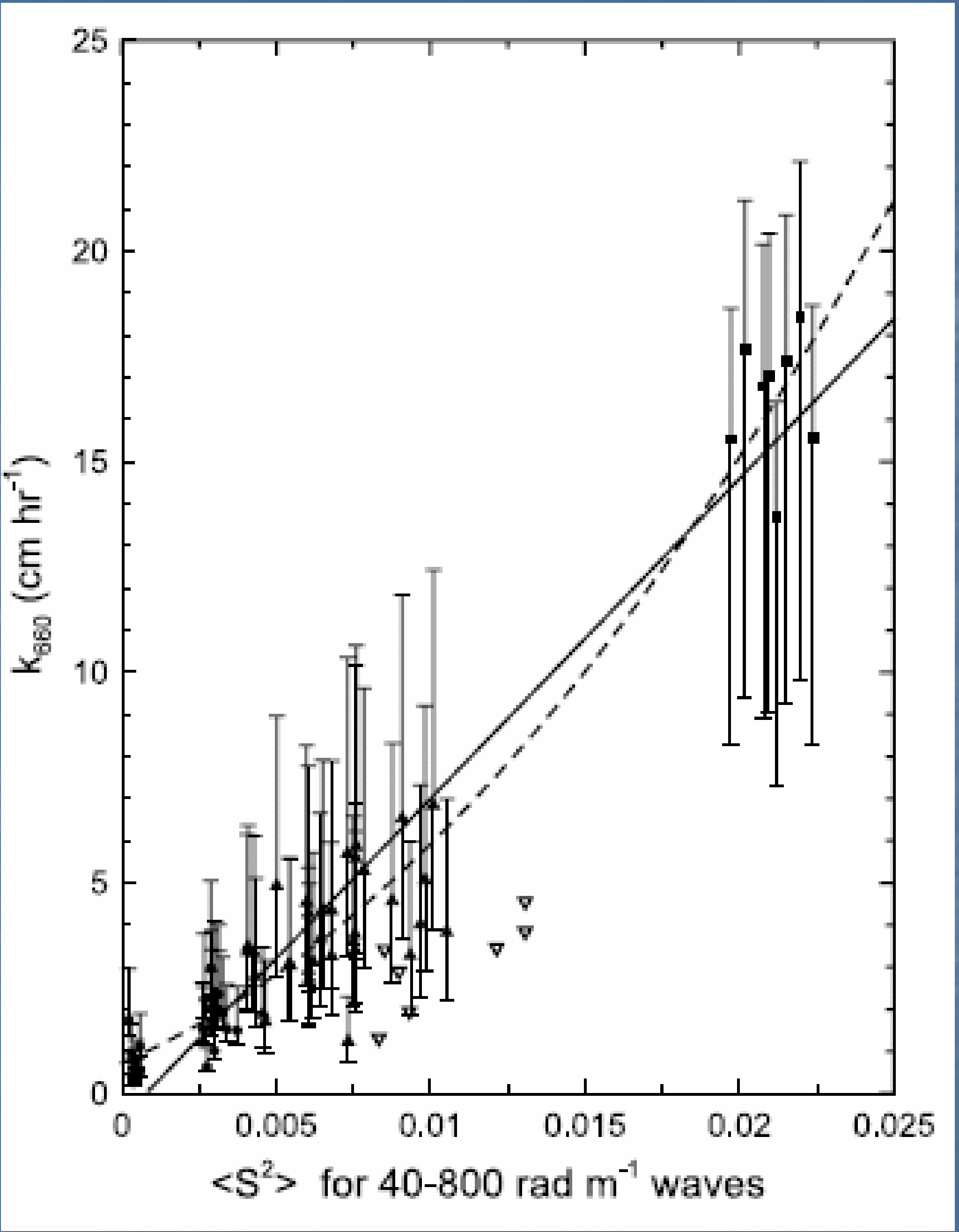
Piston velocity vs wind speed



$k \propto U$

SOGasEx

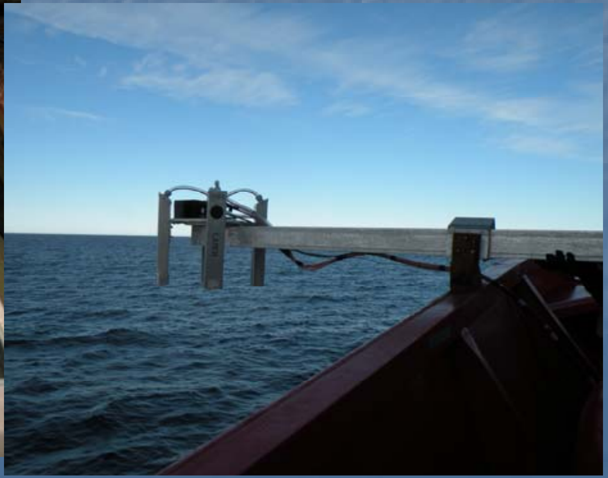
Alternative for k: MSS



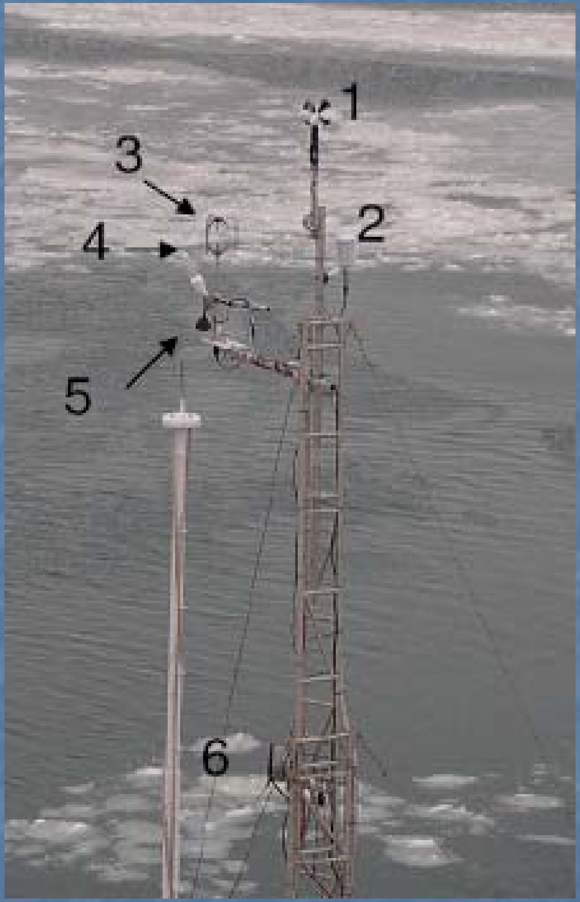
Frew et al 2004

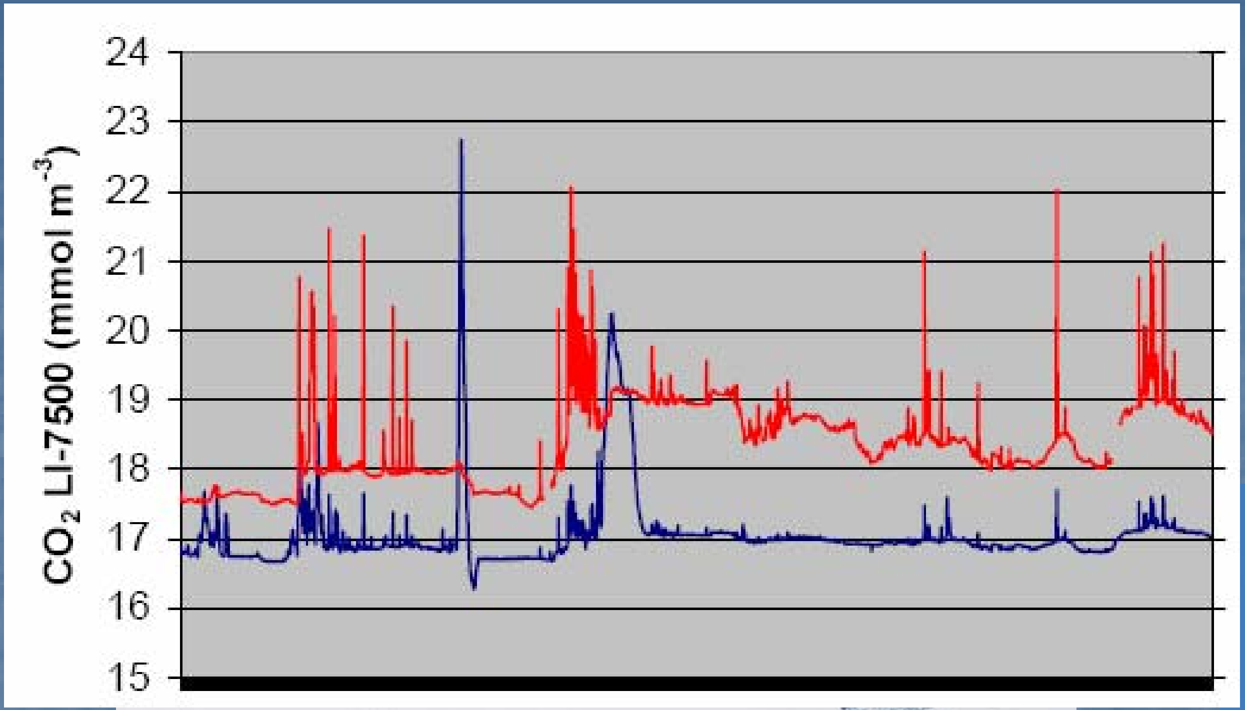
Gas fluxes on board

$$\overline{wc} = k_{660} \, [\Delta pCO_2]_{A-W}$$



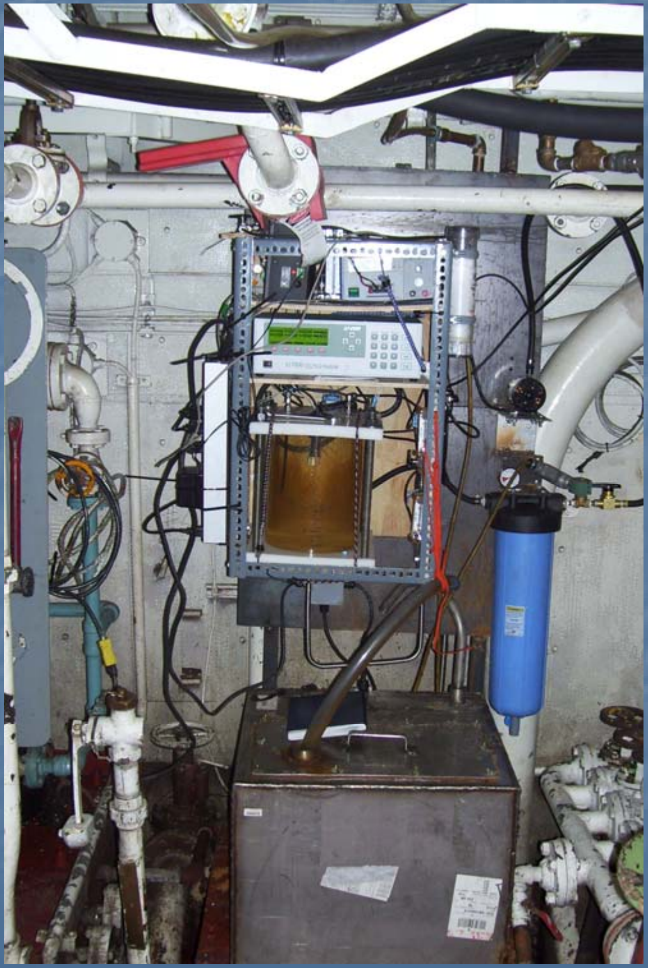
Flux tower

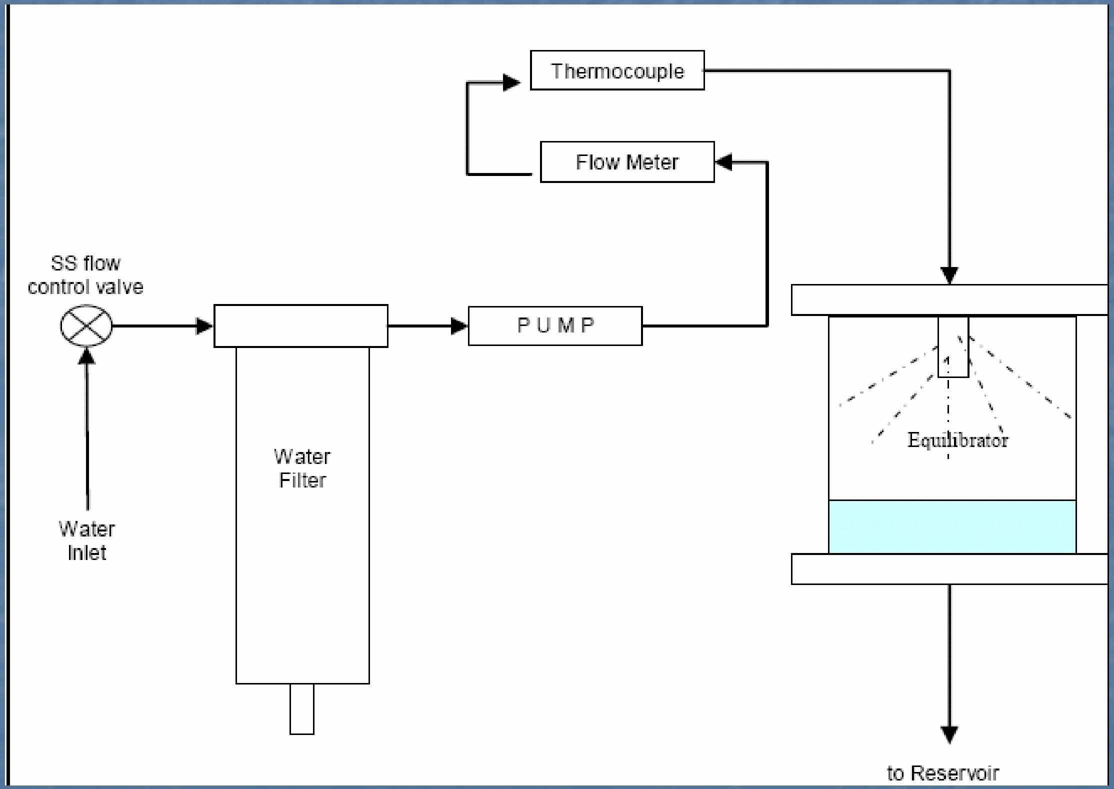



CO_2 LI-7500 (mmol m^{-3})
24
23
22
21
20
19
18
17
16
15

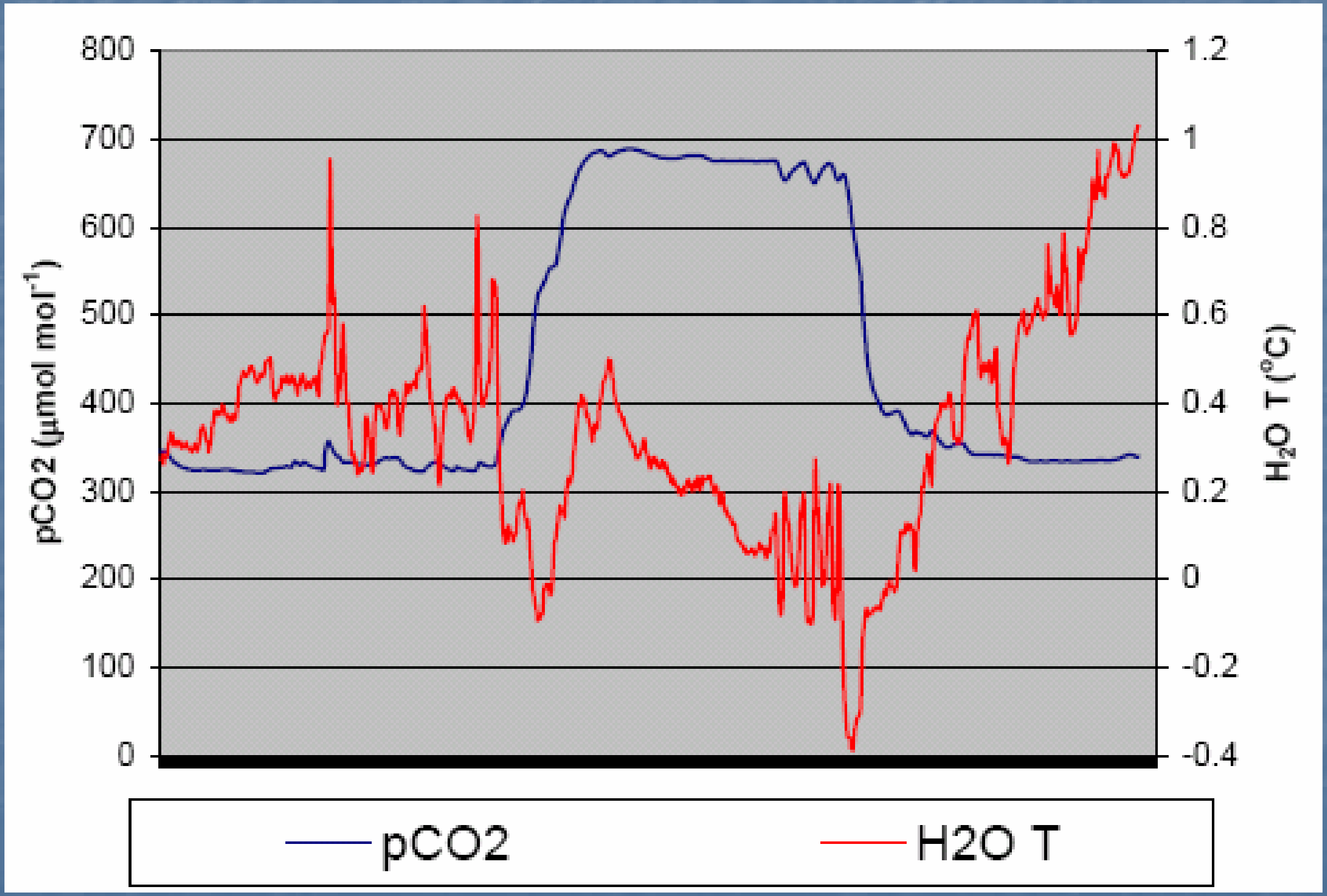

Flow distortion

ΔpCO_2 flow-through system



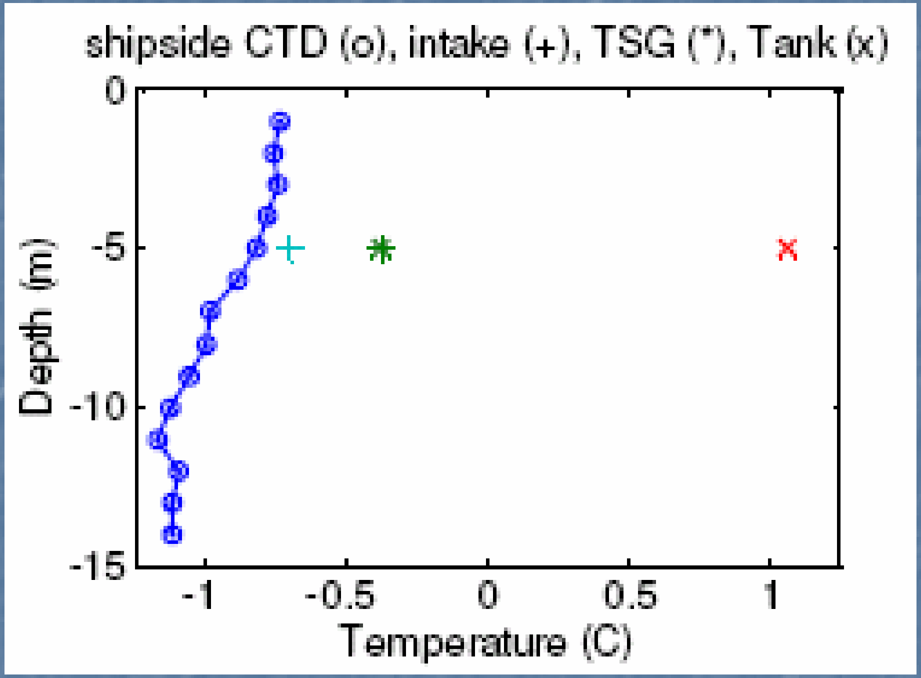


ΔpCO_2

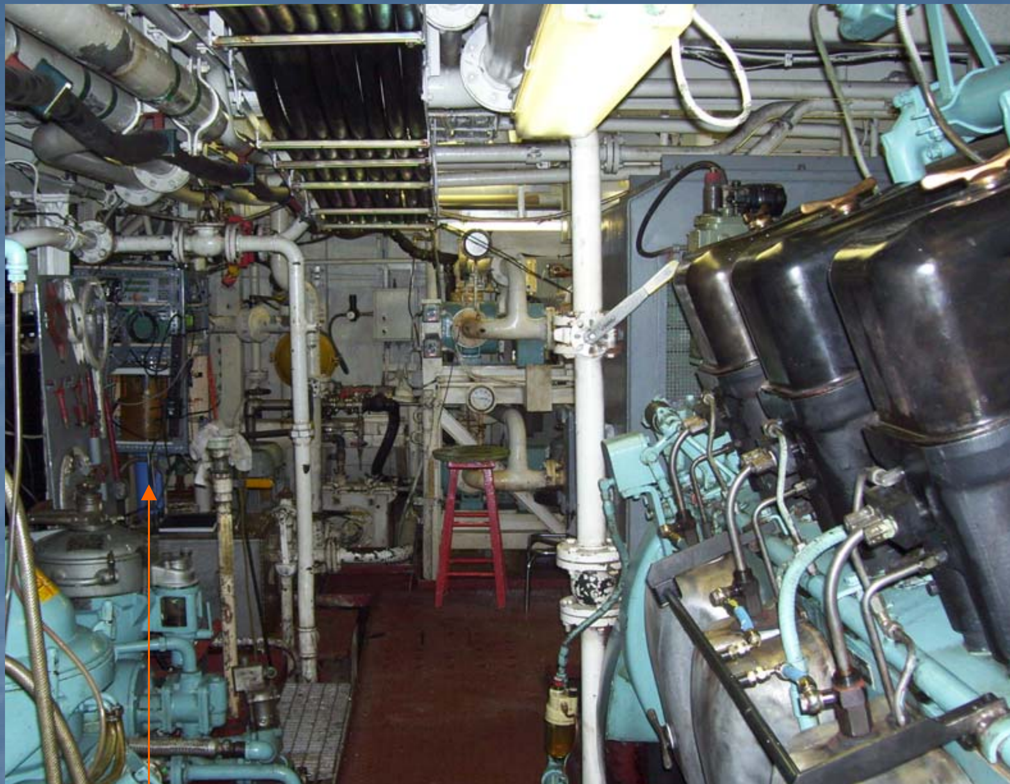


Oct 22nd, 2230 to Oct 23rd, 1640 2007 (UTC) during calibration

ΔpCO_2 System – Temperature corrections



May 27th, 2008 (0506 UTC): water sample difference 30 ppm



System is situated inside engine room

Team 6 – other projects

Co2 fluxes trough ice and brine

Final remarks

- CFL conducted continued measurements over 1.3 years, including different fields of research
  - time variability, different time scale processes
  - surface conditions (roughness)
  - interdisciplinary projects
- Team 6 - Gas Fluxes:
  - atmospheric turbulent fluxes (flux tower) and Co2 content in water in such period
  - 3 legs of waves/slopes measurements (LAWAS) during satellite passages (>100 days)
- Useful for transfer velocity calculations and hence improvement of turbulent fluxes parameterization: upcoming talk, Dr. S Woods


THE END