Use of automated systems to measure greenhouse gas emissions from boreal reservoirs in Manitoba and Québec, Canada.

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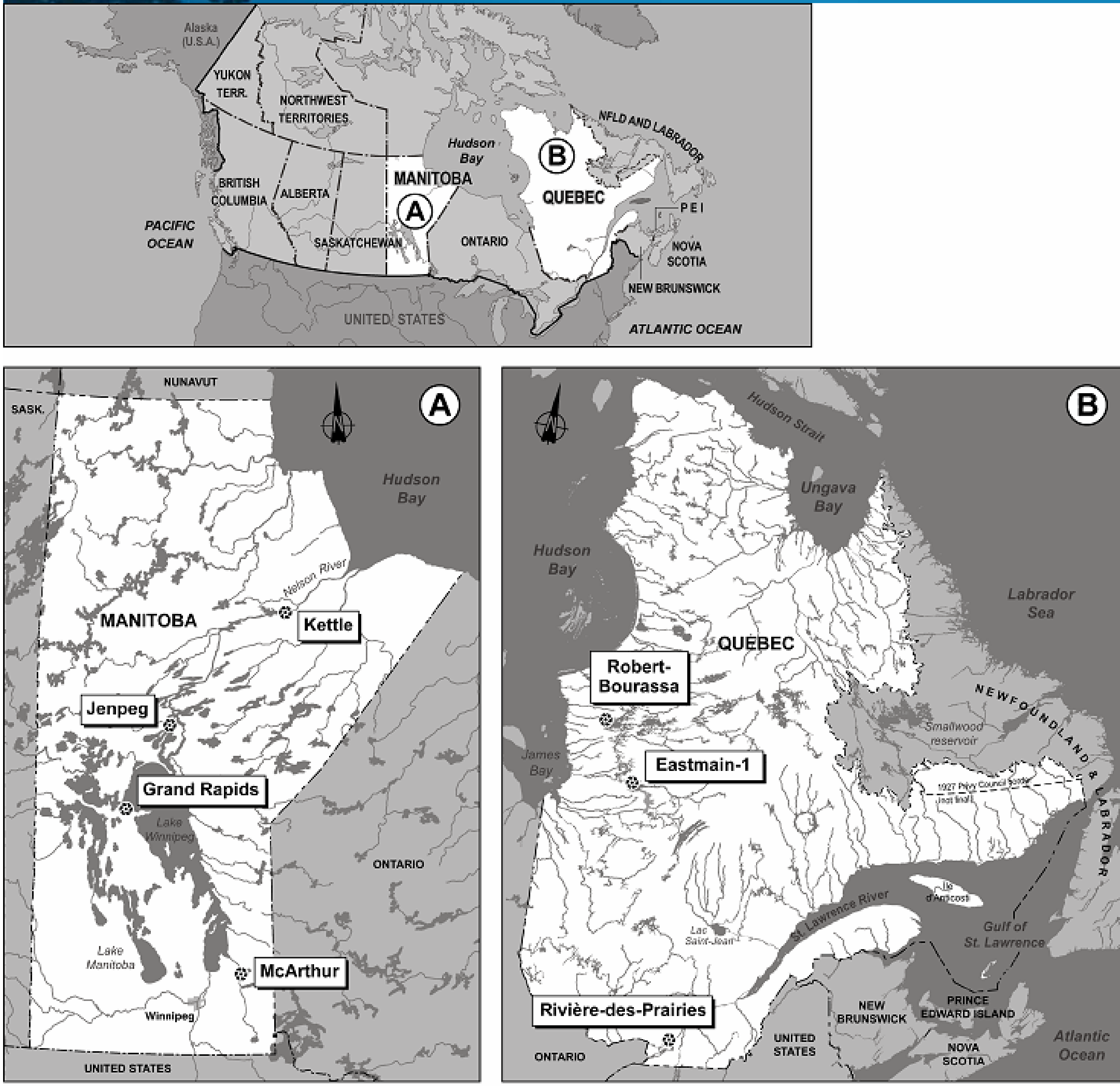
Introduction

- Growing worldwide concern to determine the contribution of freshwater reservoirs to the increase of GHGs in the atmosphere
  - Part of this concern is related to understand uncertainties in measuring representative GHG fluxes
- Moreover, evaluation of net GHG emissions from reservoirs is becoming more and more crucial
  - To ensure accurate comparison of energy production methods
  - To evaluate carbon credits
  - To determine national inventories (IPCC)

Today's talk

- New automated system designed by DFO
  - Ray Hesslein
  - Morris Holoka
- Few versions of this system around the world
  - Most of them are designed for onboard ocean CO_2 monitoring
  - One design for GS

Studied regions



GES_cm_161_081024a.fh9

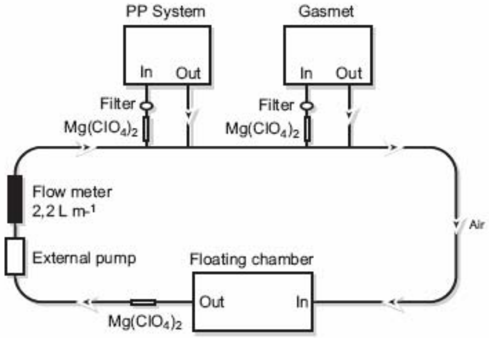
- MH: since 2003
- 4 monitoring stations
- HQ: since 2006
- 3 monitoring stations
- Comparison with traditional field campaign results

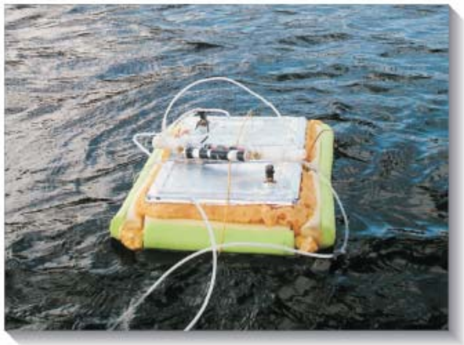
Floating chamber campaign

- **Expensive**
  - **Many measurements are required to adequately represent an ecosystem's emissions**
  - **Analysers are expensive and not designed for field measurements and frequent transportation**

- **Data from FC campaigns are a snapshot of what happens during the whole year**

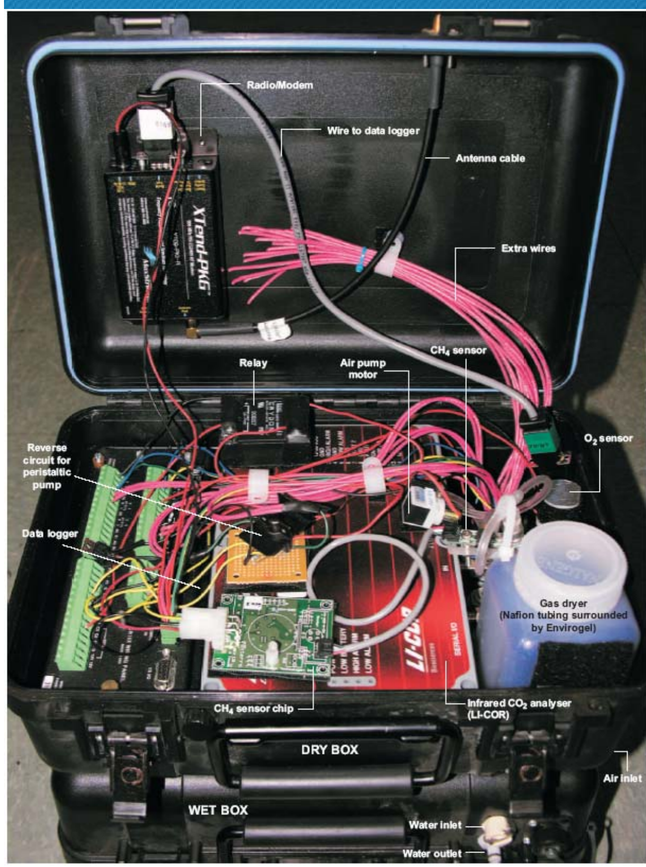
- **Advantage of being adapted for spatial variability measurements**



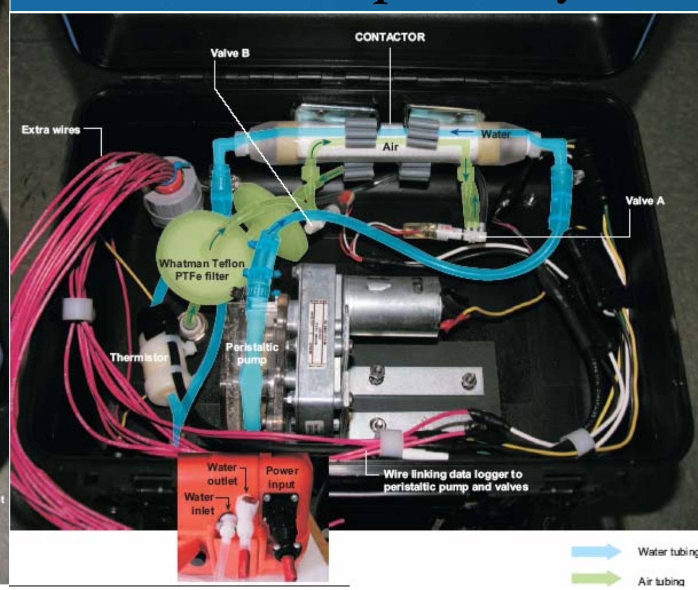


Automated system

- Increase the frequency of measurement by providing time series
- More accurately document temporal variations throughout the year
- Reduce field work requirements

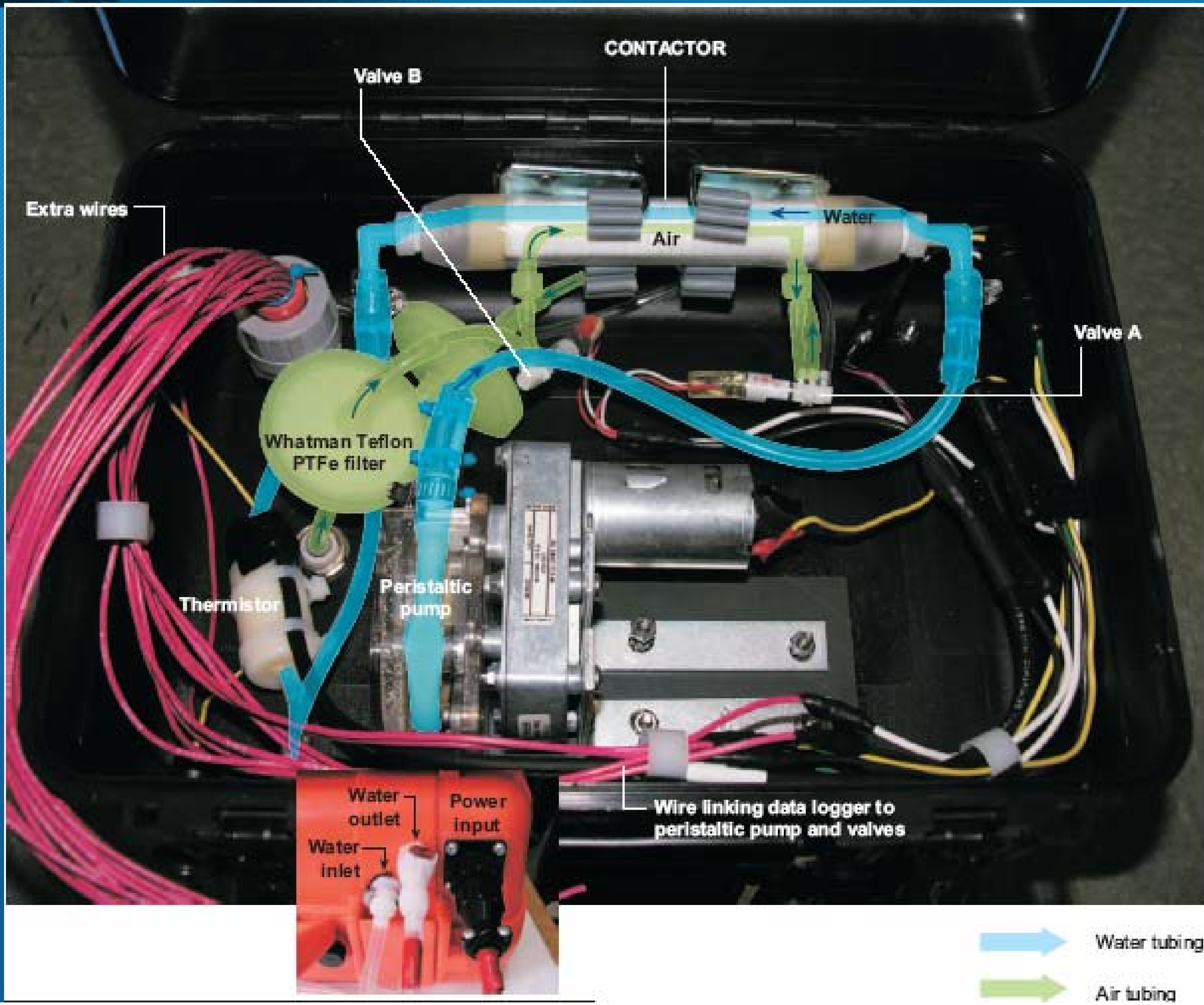


- Reduced costs
  - For example for the cost of a 2 week FC campaign = one GS equipped with an AS and provide year-round data

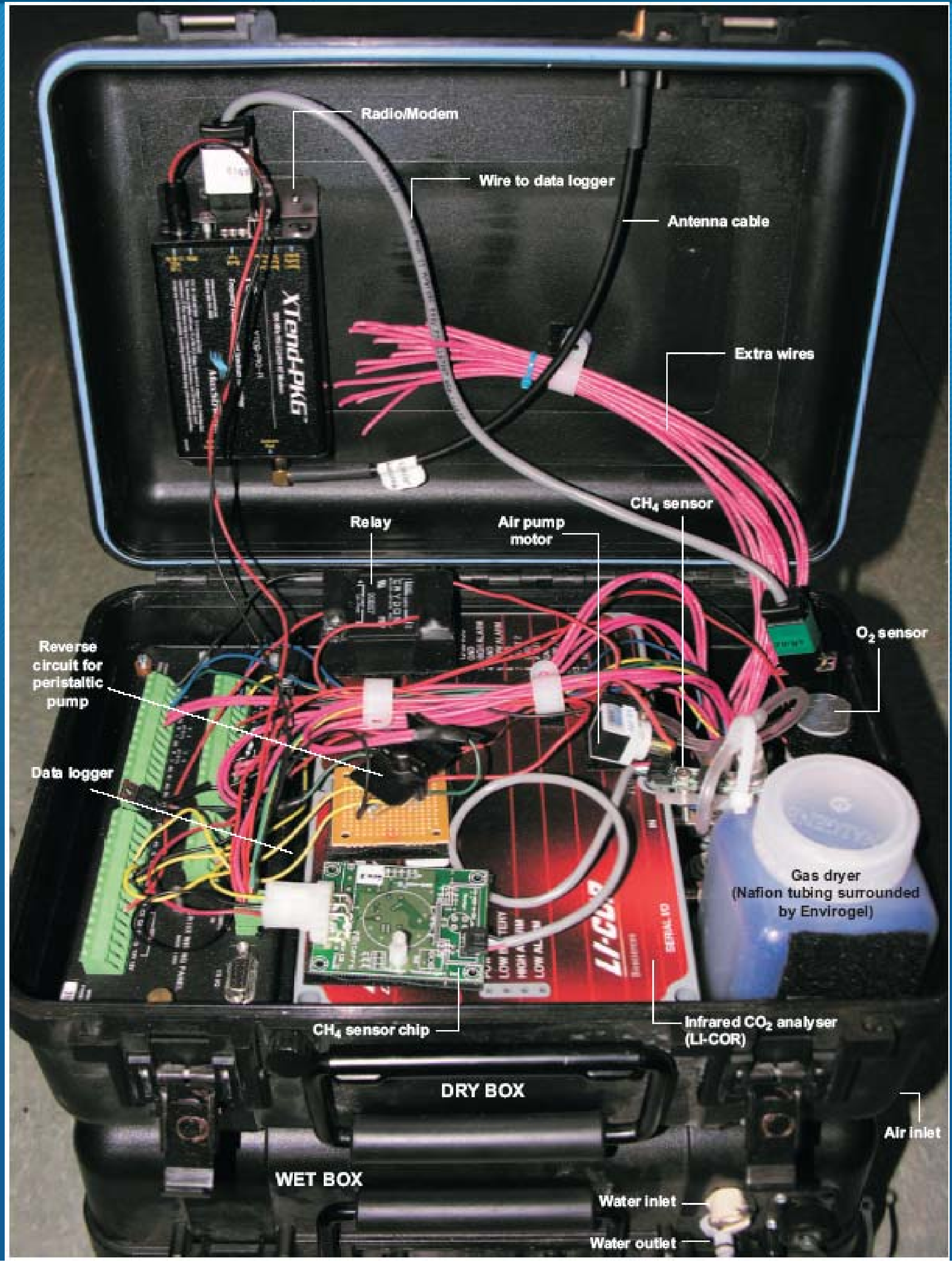


- More stations can be installed on buoys or floating decks

Wet Box


CONTACTOR
Valve B
Extra wires
Water
Air
Valve A
Whatman Teflon
PTFe filter
Thermistor
Peristaltic
pump
Water
outlet
Power
input
Water
inlet
Wire linking data logger to
peristaltic pump and valves
Water tubing
Air tubing

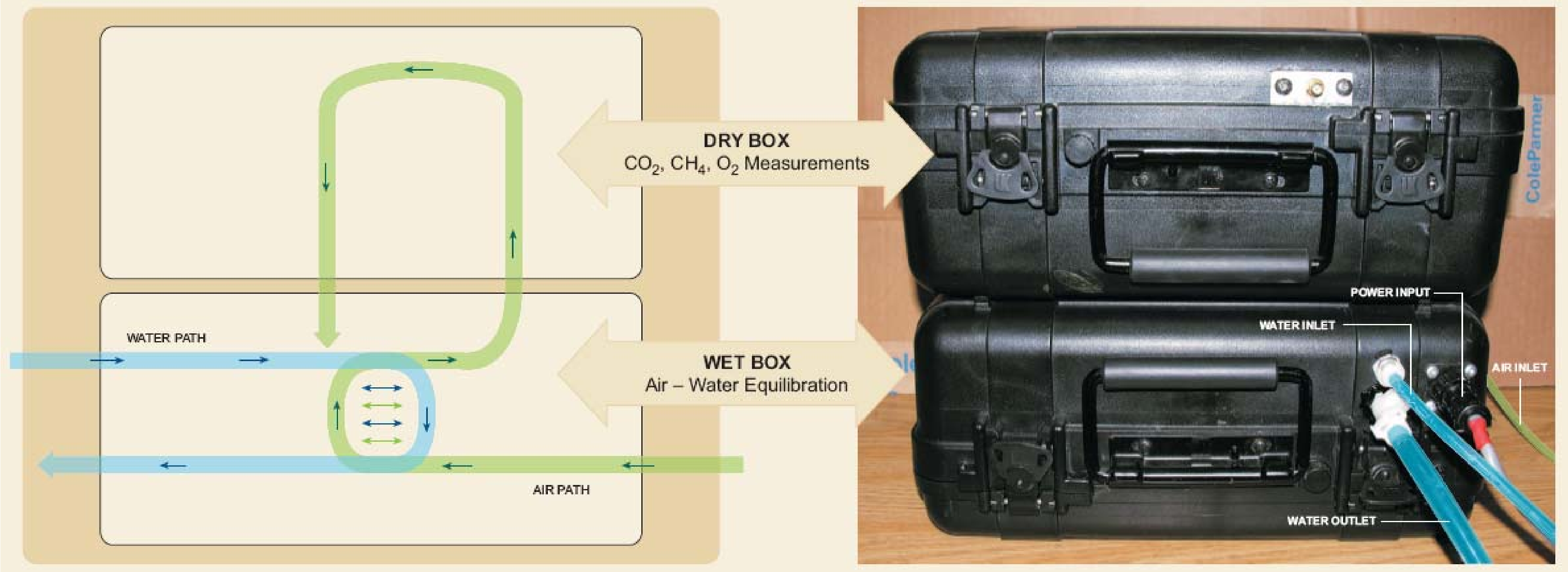
Dry Box



Radio/Modem
Wire to data logger
Antenna cable
Extra wires
CH$_4$ sensor
Relay
Air pump motor
O$_2$ sensor
Reverse circuit for peristaltic pump
Data logger
Gas dryer (Nafion tubing surrounded by Envirogel)
CH$_4$ sensor chip
Infrared CO$_2$ analyser (LI-COR)
DRY BOX
Air inlet
WET BOX
Water inlet
Water outlet

Automated system

- While in monitoring mode, the device activates once every 3 hours
- The monitoring cycle takes 22 minutes
  - 20 minutes cycle in water
  - 2 minutes cycle in air
- Water temperature is also recorded



Flux calculation from dissolved gas partial pressures

Thin Boundary Layer equation

$$Flux = k_x(C_{water} - C_{air})$$

Gas exchange coefficient from Cole and Caraco, 1998

$$k_{600} = 2.07 + (0.215 \times U_{10}^{1.7})$$

Wind speed obtained from Environnement Canada Website

Continuous measurements

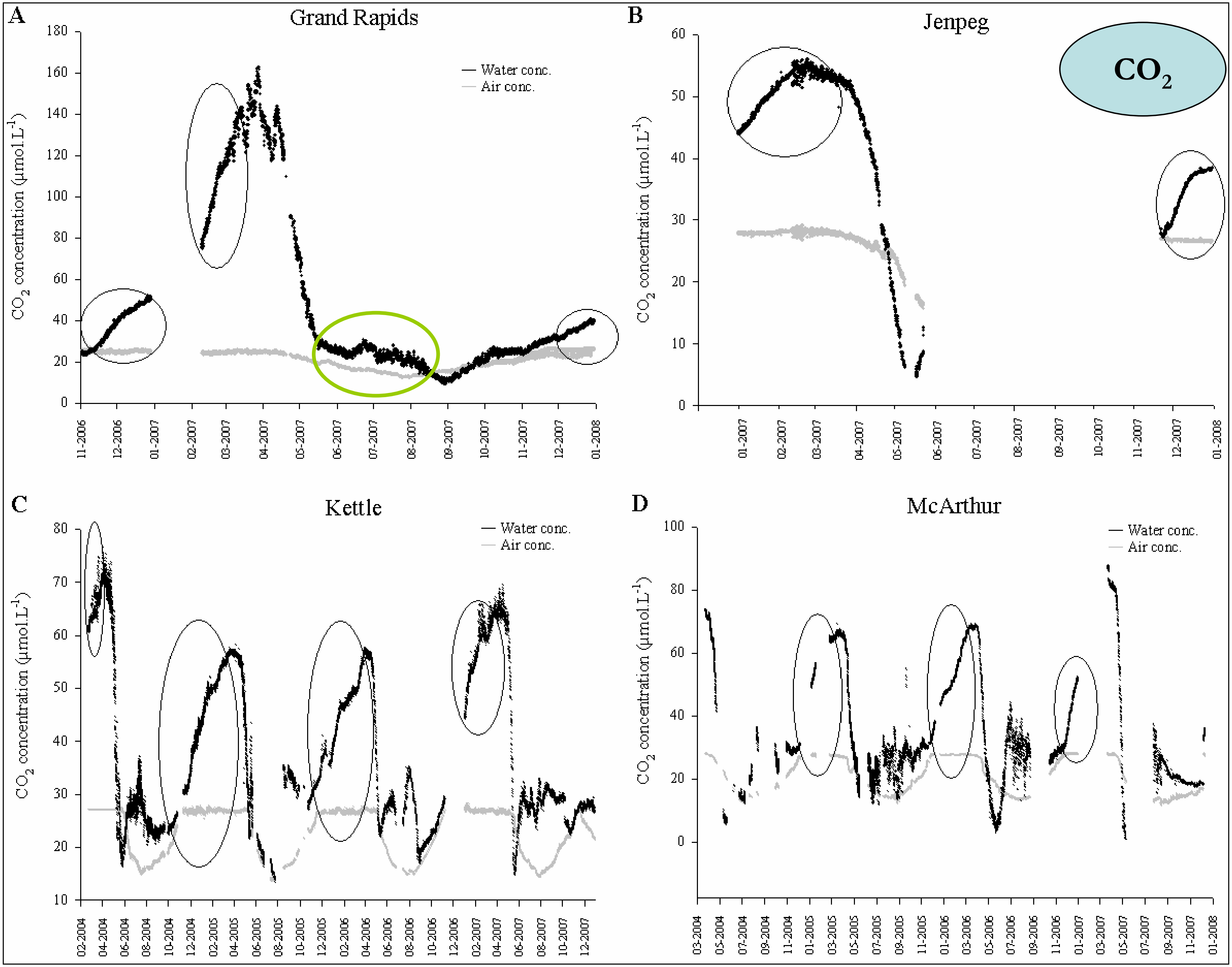
Partial pressures → concentrations

$$CO_2wc = K_H * CO_2wp$$

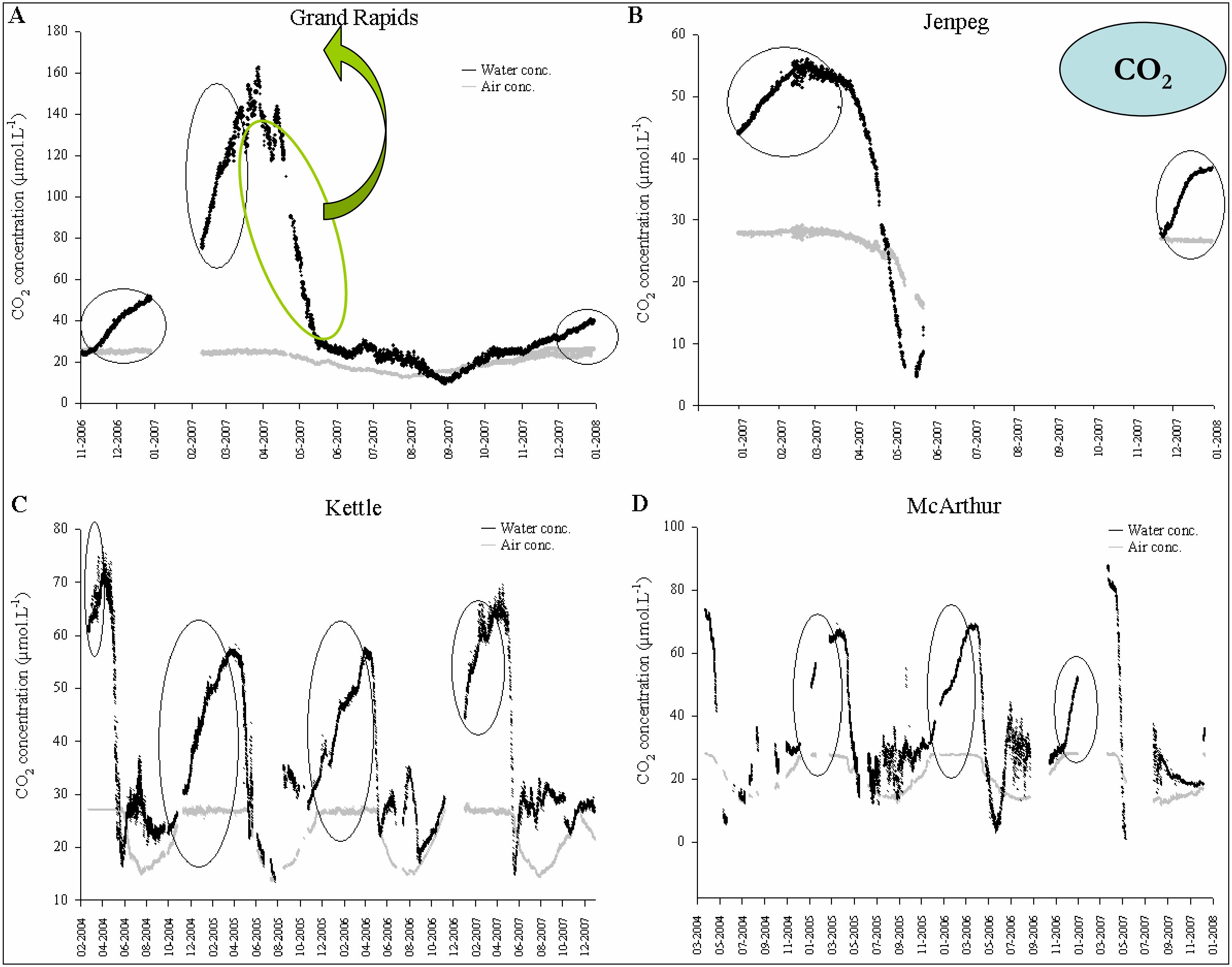
Henry's Law

Constants

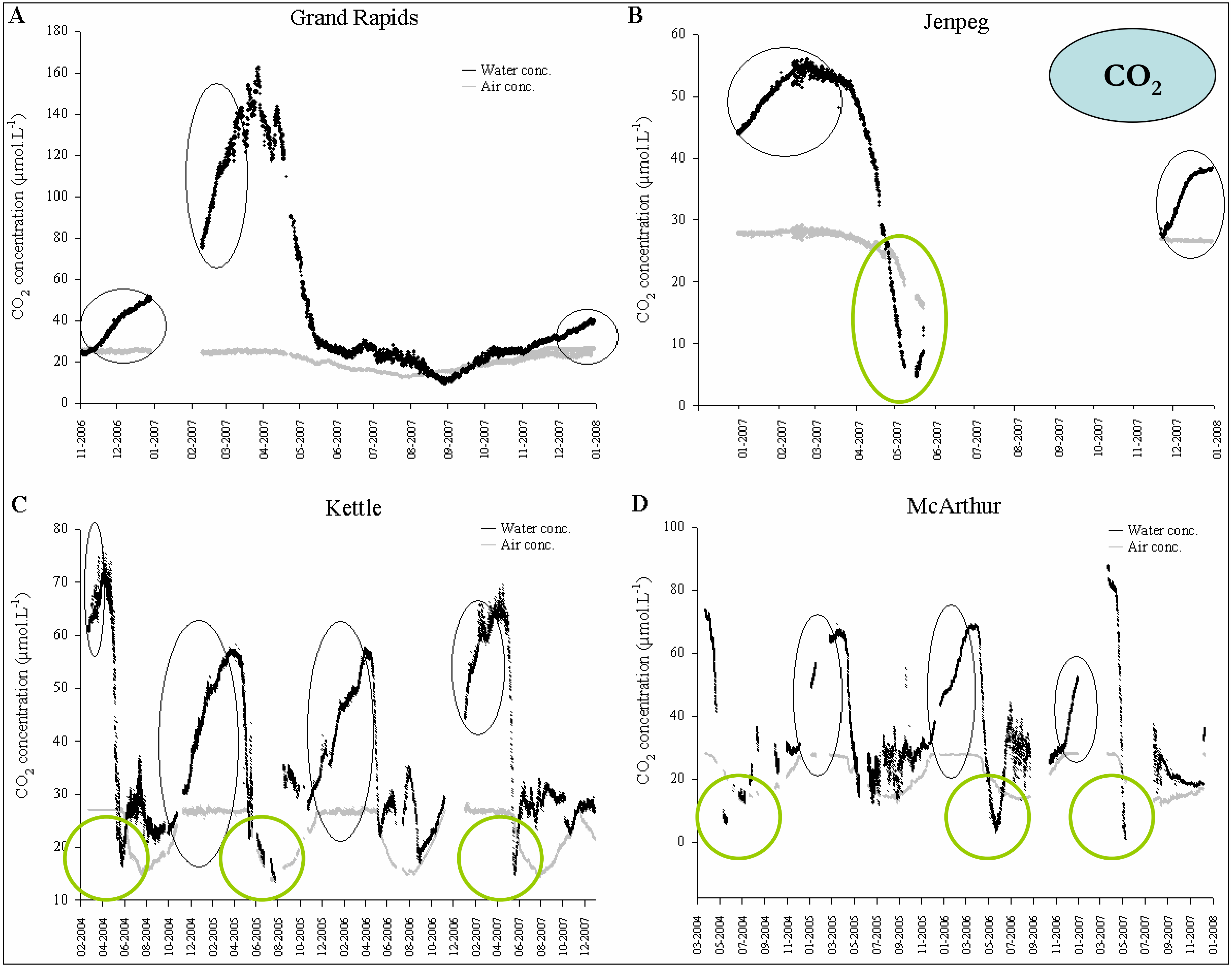
- **383 µatm for pCO_2**
- **1.745 µatm for pCH_4**



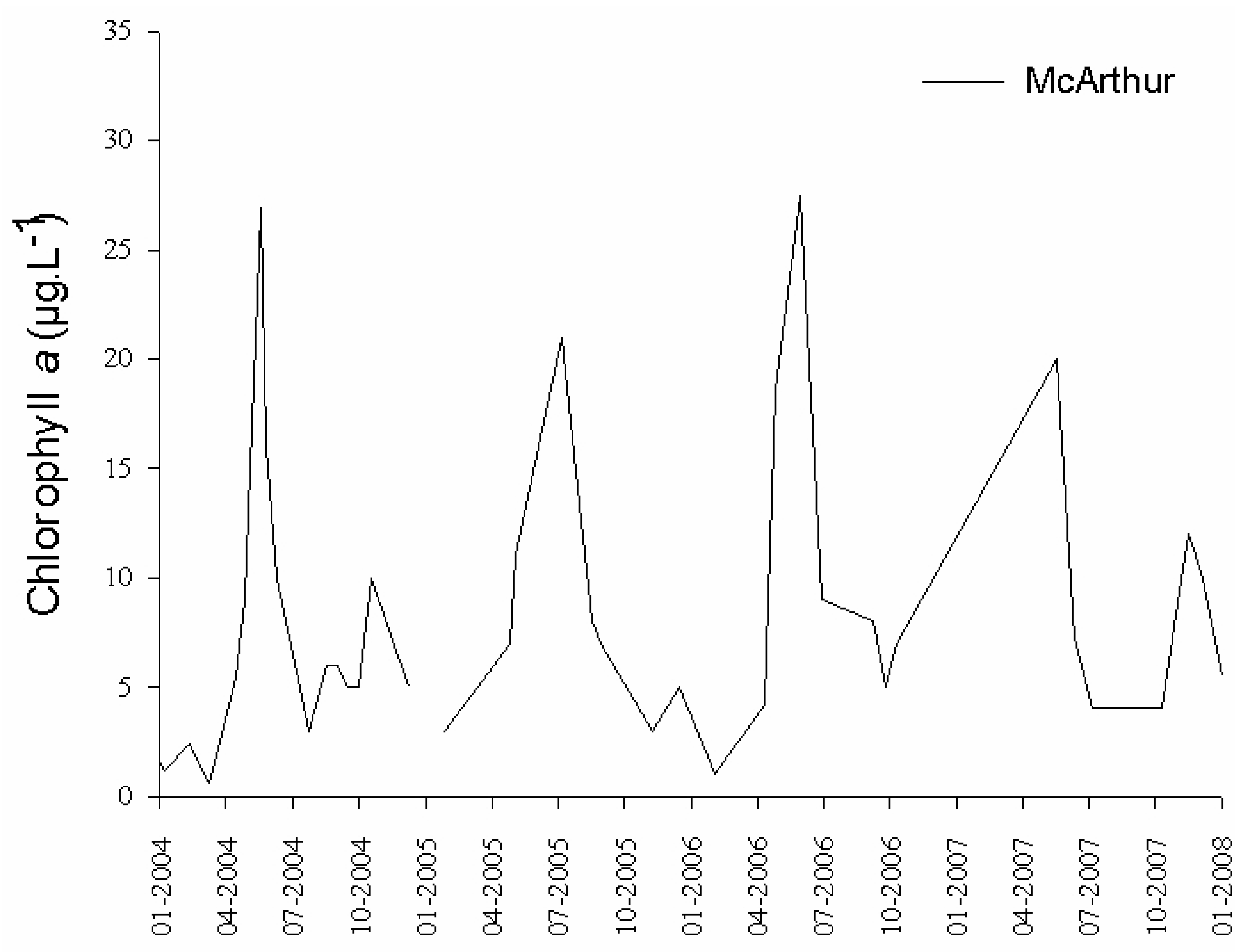
A
Grand Rapids
Water conc.
Air conc.
CO_2 concentration (µmol.L^{-1})
B
Jenpeg
CO_2
C
Kettle
D
McArthur

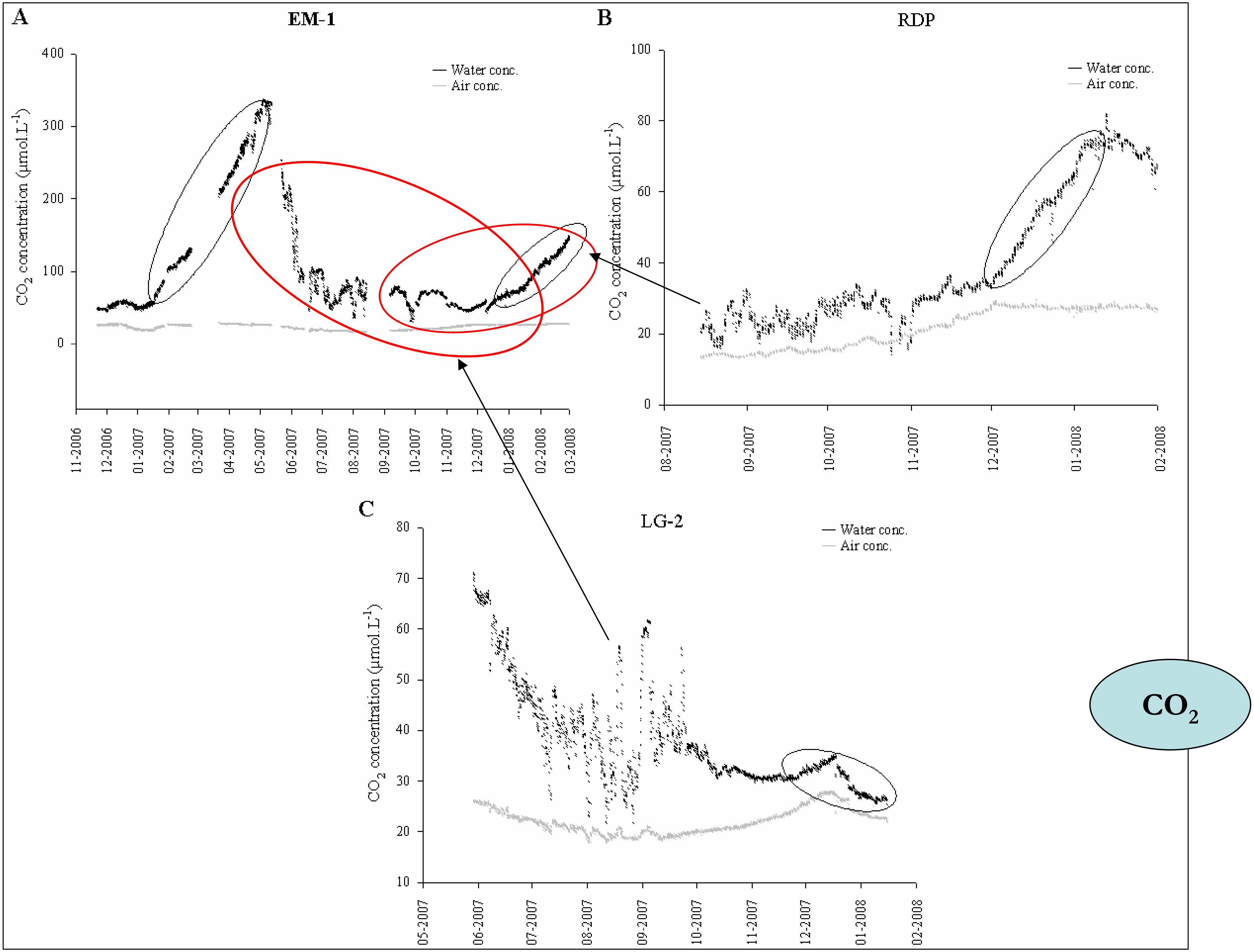


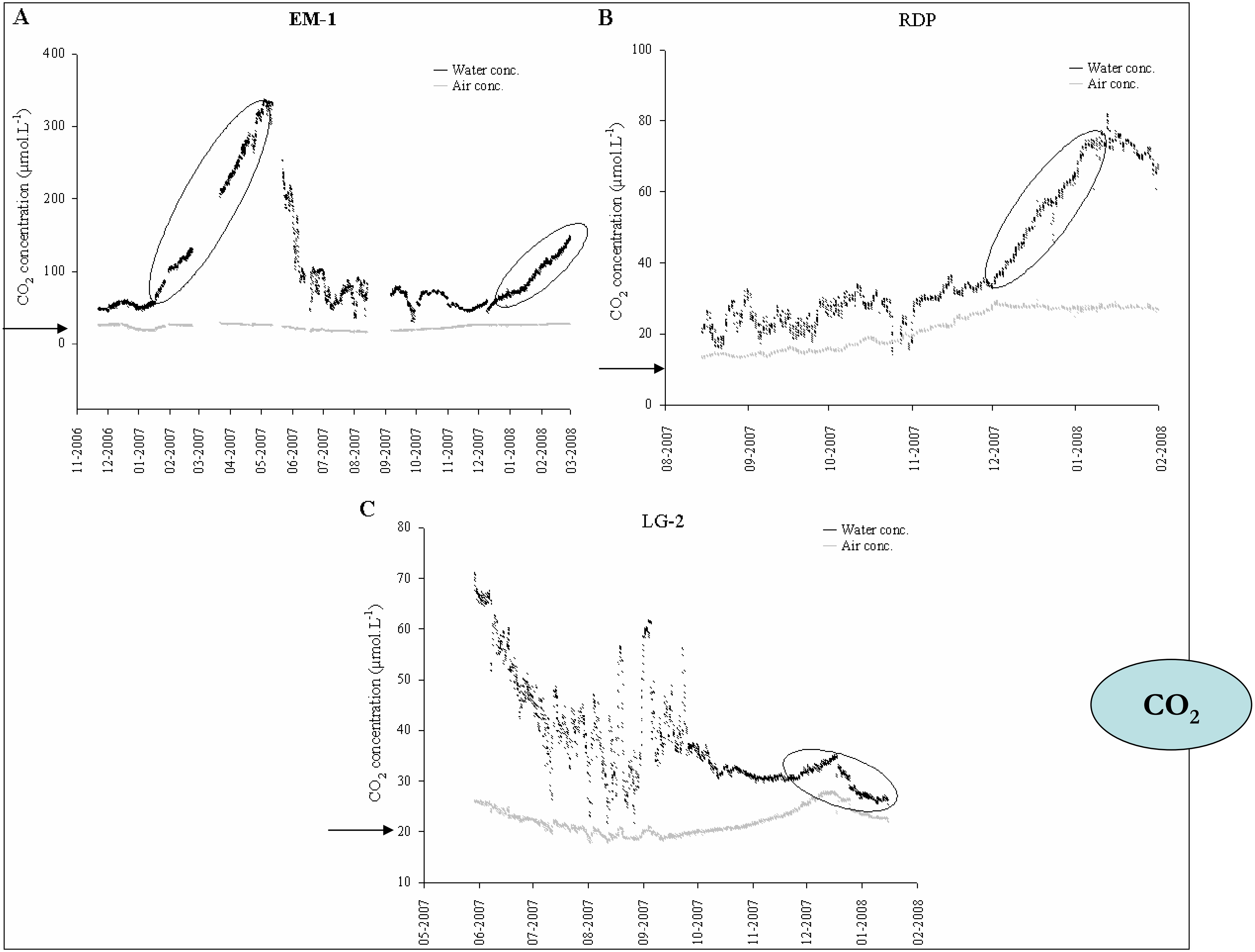
A
Grand Rapids
Water conc.
Air conc.
CO2 concentration (µmol.L-1)
B
Jenpeg
CO2
C
Kettle
D
McArthur



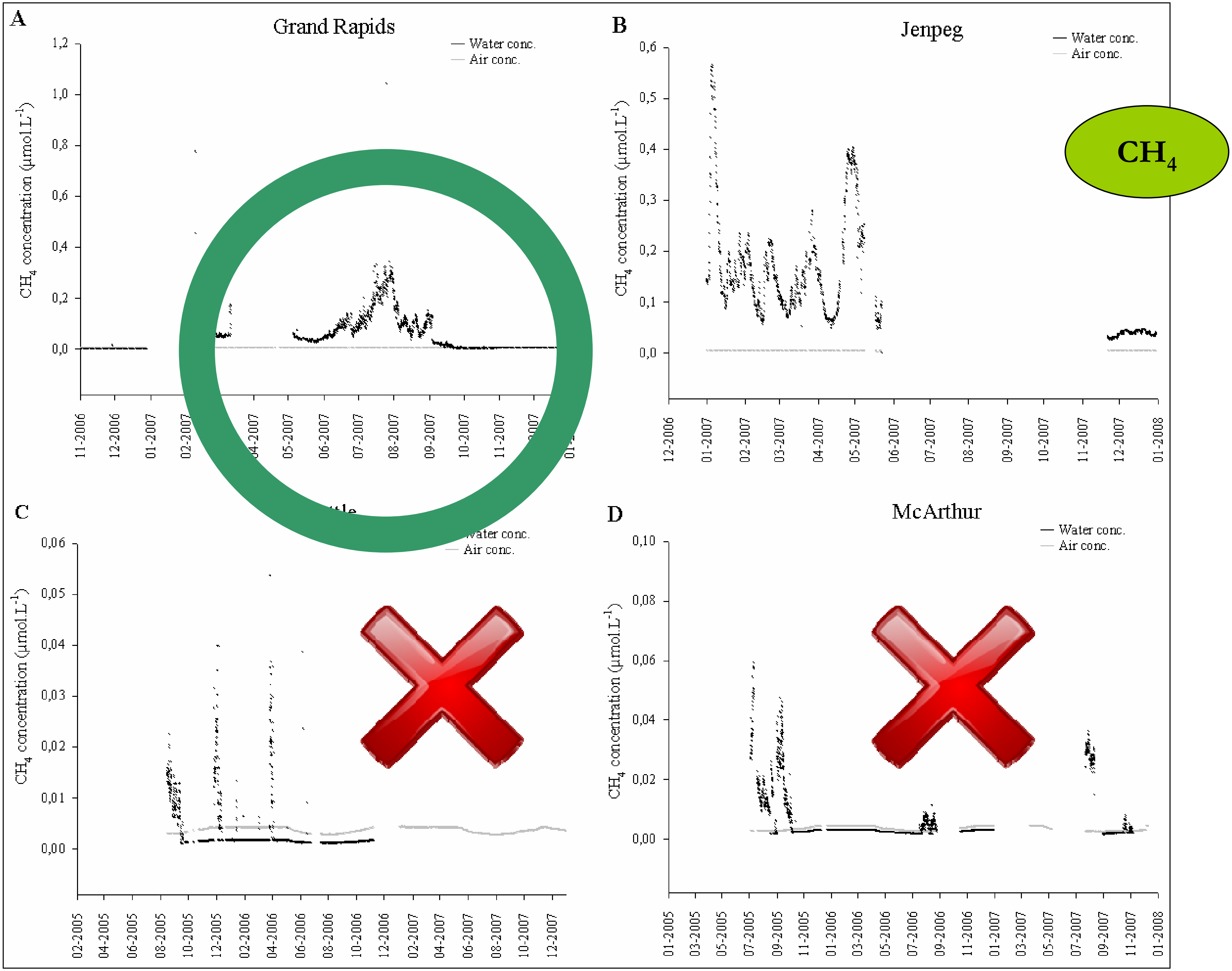
A
Grand Rapids
Water conc.
Air conc.
CO_2 concentration (µmol.L^{-1})
B
Jenpeg
CO_2
C
Kettle
D
McArthur


35
30
25
20
15
10
5
0
Chlorophyll a (µg.L-1)
McArthur
01-2004
04-2004
07-2004
10-2004
01-2005
04-2005
07-2005
10-2005
01-2006
04-2006
07-2006
10-2006
01-2007
04-2007
07-2007
10-2007
01-2008

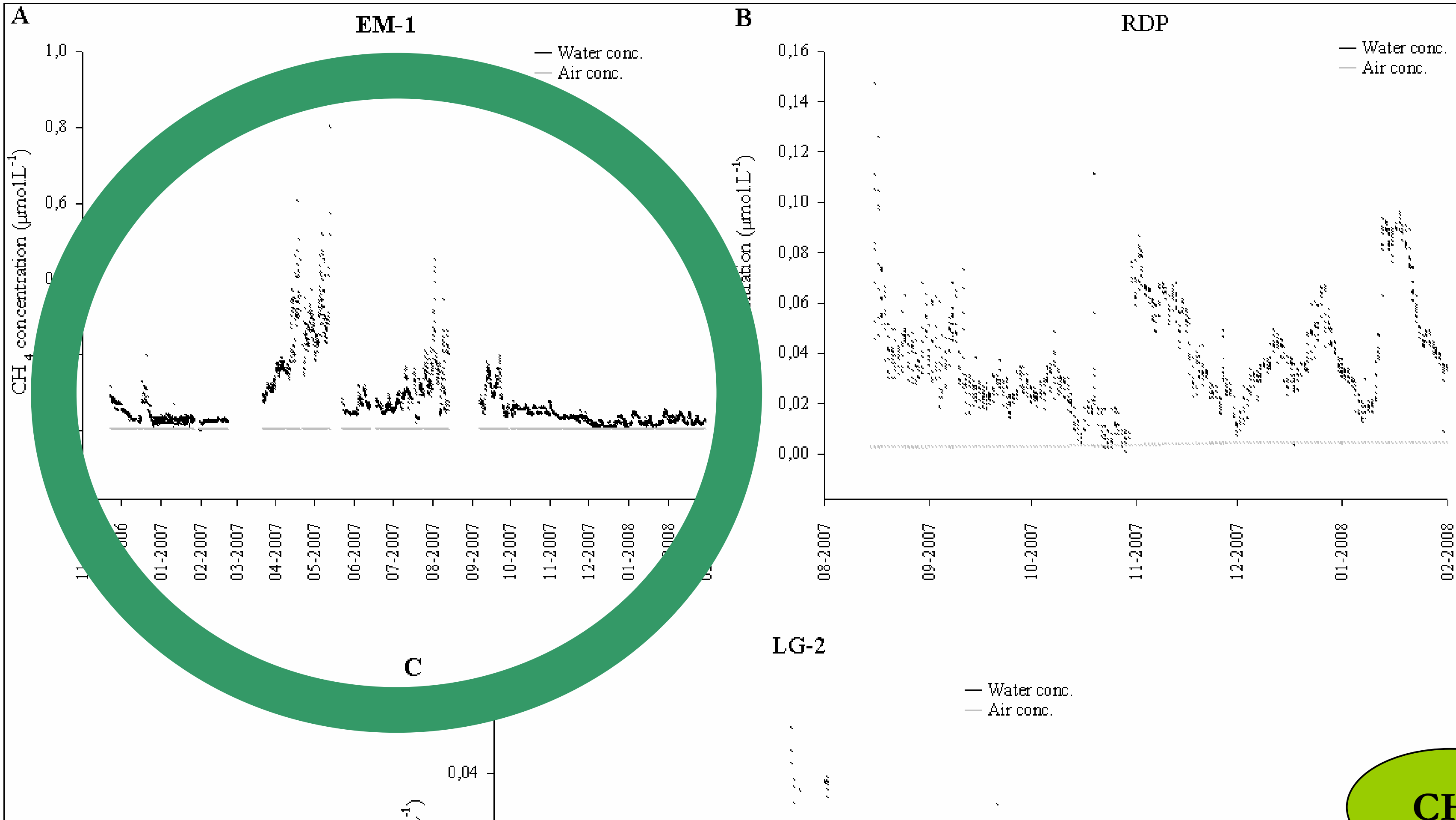

A
EM-1
B
RDP
C
LG-2
Water conc.
Air conc.
CO2 concentration (µmol.L-1)
CO2



A
EM-1
B
RDP
C
LG-2
Water conc.
Air conc.
CO2 concentration (µmol.L-1)
CO2

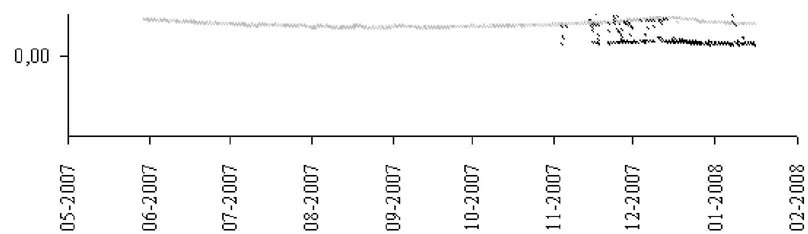


A
Grand Rapids
Water conc.
Air conc.
CH4 concentration (µmol.L-1)
B
Jenpeg
Water conc.
Air conc.
CH4
C
Water conc.
Air conc.
D
McArthur
Water conc.
Air conc.



CH_4

- No CH_4 increase under ice
  - Lower production rate due to cold temperature
  - CH_4 oxidation

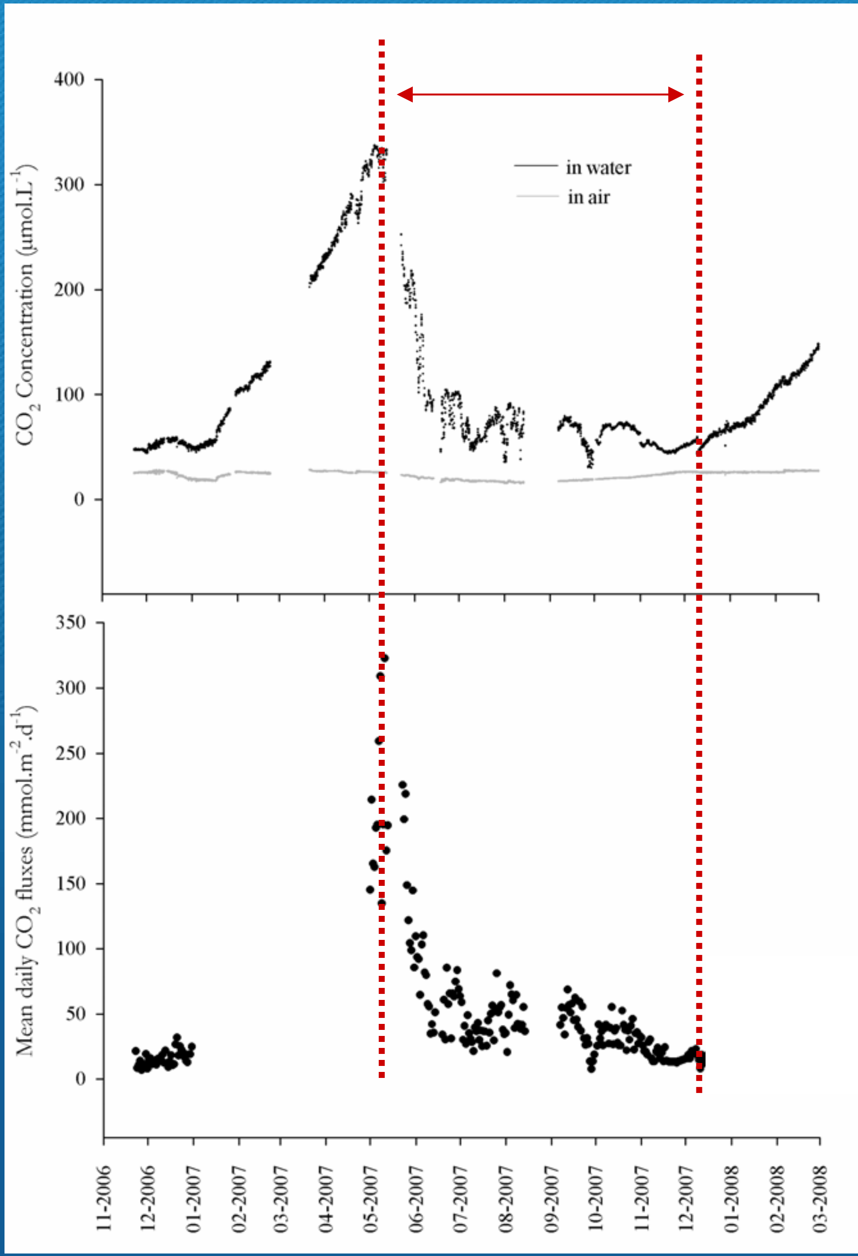


Total annual emissions:

Ex: CO_2 at EM-1 in 2007

Concentrations

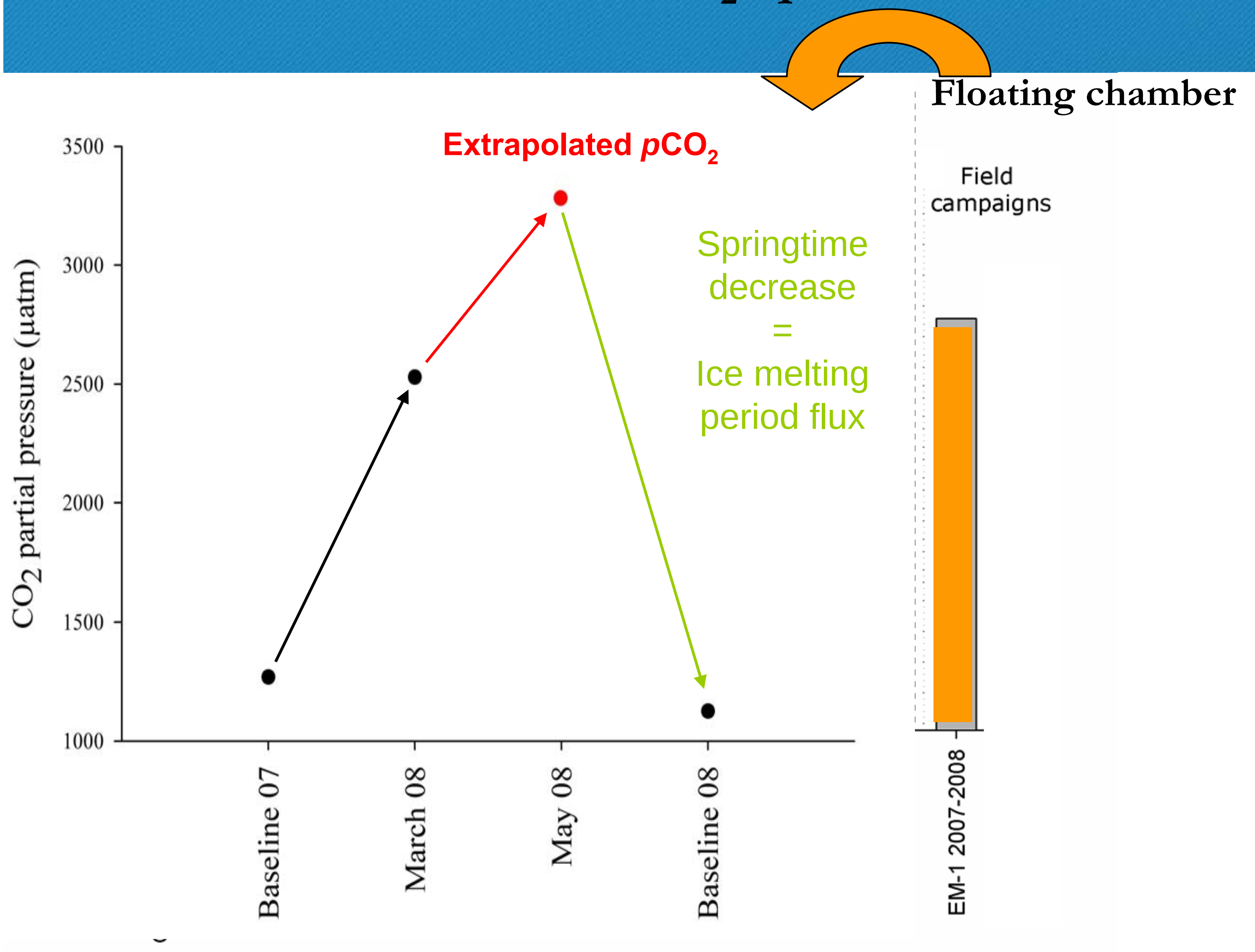
Fluxes



Total annual emissions =
Σ daily fluxes
during the ice free period

Results

Total annual emissions in CO_2eq: $GHGFlux = CO_2\,flux + 23 * (CH_4\,flux)$



Conclusion

ADVANTAGES

- **Adequate technique to document temporal variations**
  - magnitude of CO_2 accumulation under ice cover
- **Allow the calculation of a total annual GHG emission**
  - use of single automated systems inside generating stations = multiple field campaigns
- **Much more cost effective than discrete field campaigns**

Conclusion

DISADVANTAGES

- **Experimental design**
- **Regular maintenance require (each 2 months)**
- **CH_4 sensor accuracy questionable**

Conclusion

FUTURE DEVELOPMENTS

- **New CH_4 sensor are being tested (semi-conductor technology; METS, Franatech)**
- **Will test laser diode CO_2 and CH_4 sensor this spring**
- **Automated system on the way of being commercialized**

Questions?