

A new portable infrared laser spectrometer for field measurements of N₂O & CH₄ emissions.

Agnès Grossel ^a, C. Guimbaud ^b, C. Robert ^b, B. Nicoullaud ^a, C. Hénault ^a, G. Richard.

a.UR Sol, INRA, Orléans

b.LPC2E, CNRS, Orléans

The « SPIRIT » instrument

Spectromètre IR *in situ* troposphérique

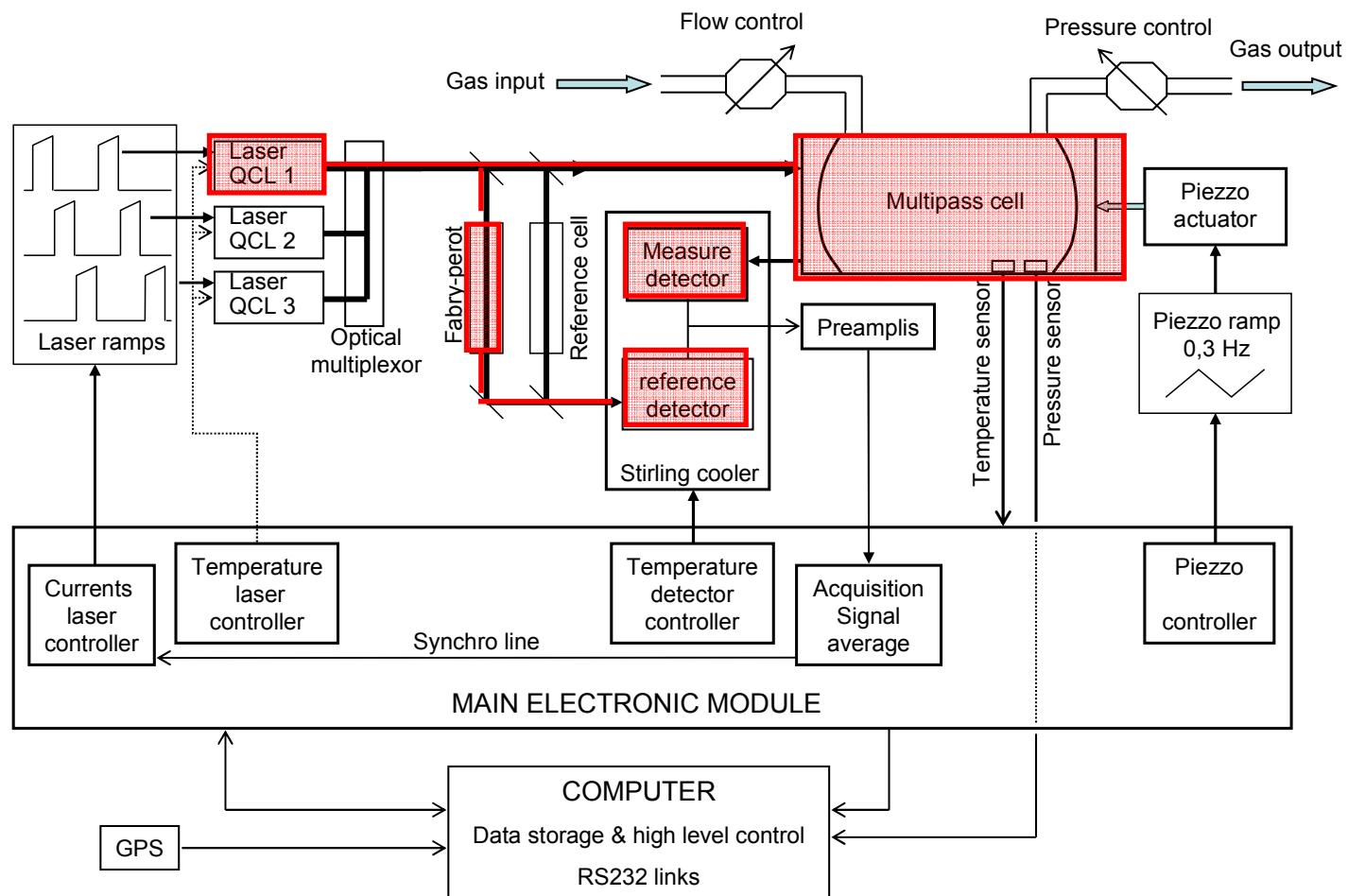
- QCL spectrometer

Laboratory-built : LPC2E (laboratory of physics and chemistry for the atmosphere and space).

Selective detection of CH₄ and N₂O (~8 μm), strong greenhouse gases

Applications to the detection of N₂O emissions from croplands

Schematics



Instrumental set-up

① IR laser source : QCL

High spectral resolution (laser line
 $< 5\text{MHz}$)

High power : multiple reflexions in
the cell

② Multi-pass cell

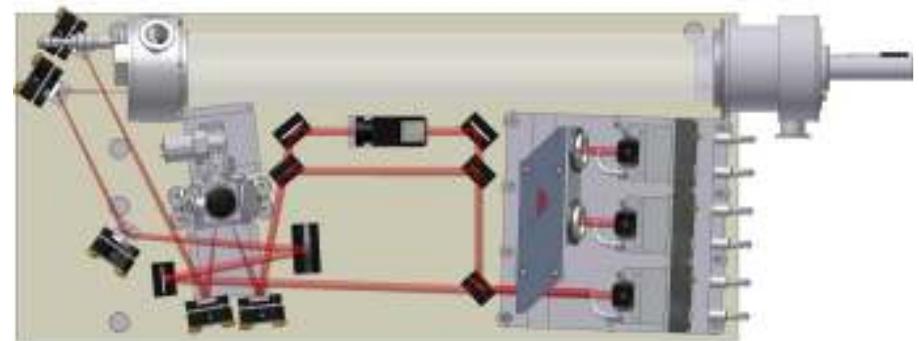
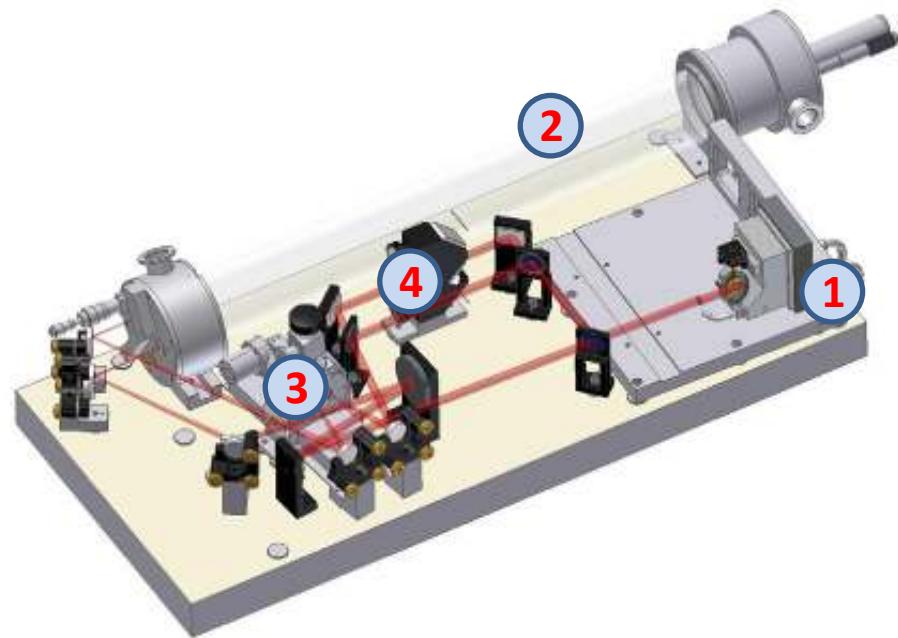
144 m optical path

③ IR detectors

Stirling cycle cooled detectors
(130K)

④ FP etalon

Wavelength etalon for the spectra
fit



The optical cell

- Absorption can be enhanced by long optical path
=> Use of multi-path cells
- Most common cells : White, Herriott, astigmatic Herriott
- **SPIRIT : special design, generalization of previous cells.**

Patents :

France (05/08396) and International (WO 2007/017570 A1)

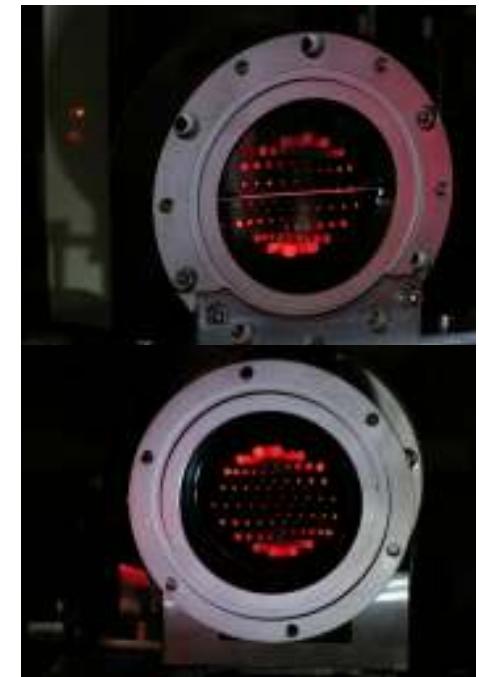
3 spherical mirrors

Advantages :

Compactness, high path

Simple to adjust *in situ* (rotation of a single mirror)

Excellent opto-mechanical stability.



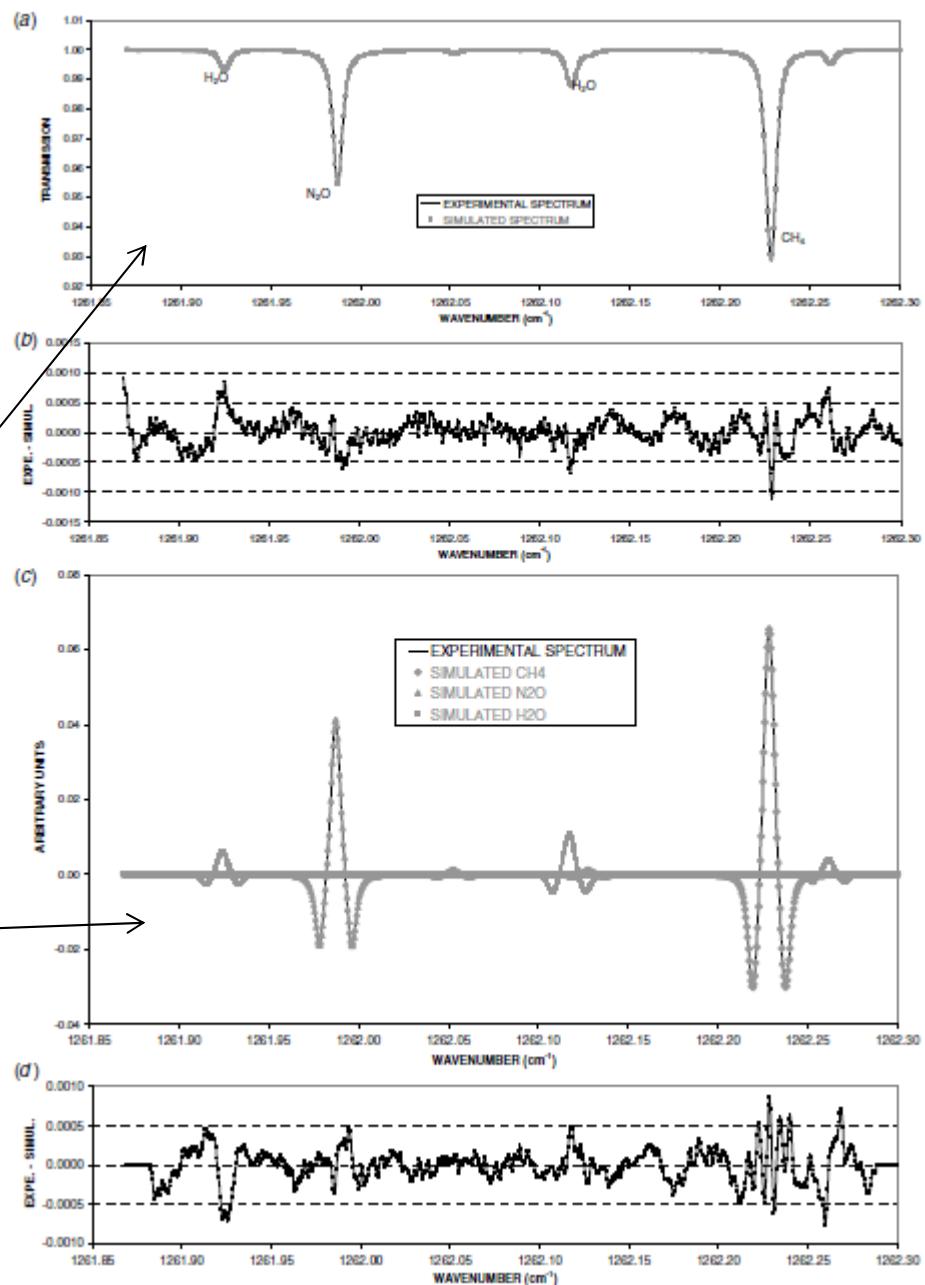
Spectra

- QCL $\sim 7.8 \mu\text{m} \leftrightarrow 1260 \text{ cm}^{-1}$

Simultaneous N_2O and CH_4 measurements

Direct spectrum

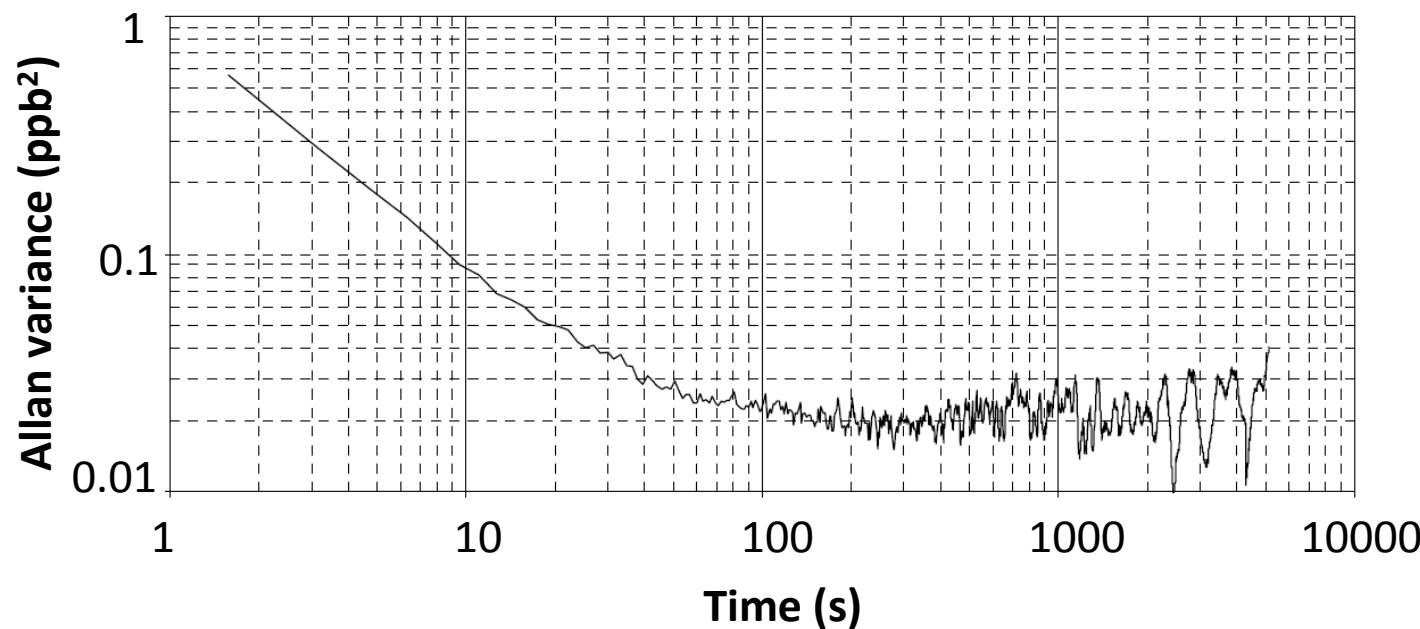
Second derivative



Instrumental achievement

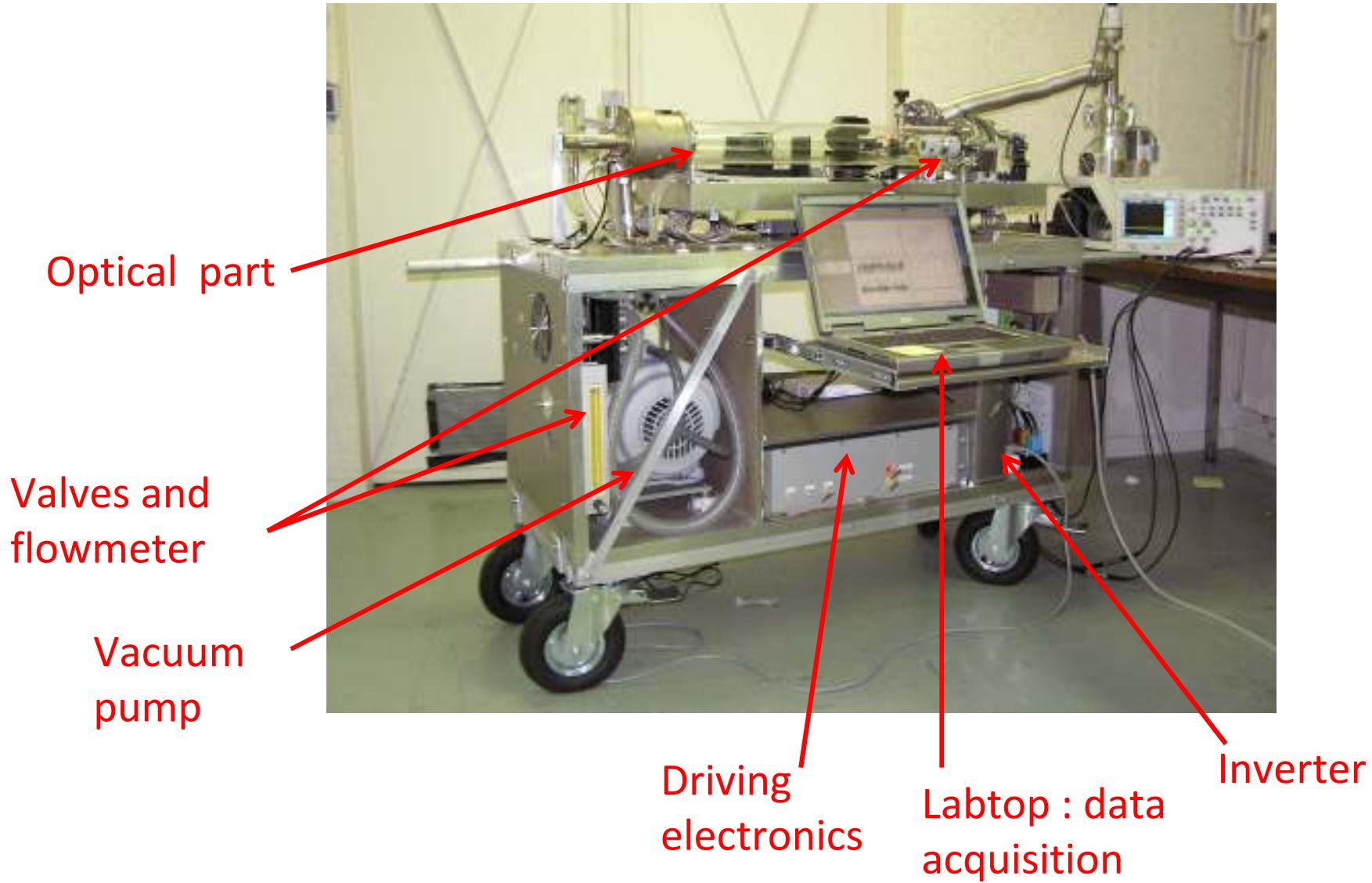
- At 0.7 Hz, theoretical absorption resolution $1.5 \cdot 10^{-5}, 10^{-4}$ achieved.
⇒ 0.6 ppb of N₂O and 4 ppb of CH₄ (1σ)

Allan variance : 0.13 ppb of N₂O and 0.62 ppb of CH₄ in 250 s.



Guimbaud et al, Measurement Science and Technology, 2011

The whole set-up

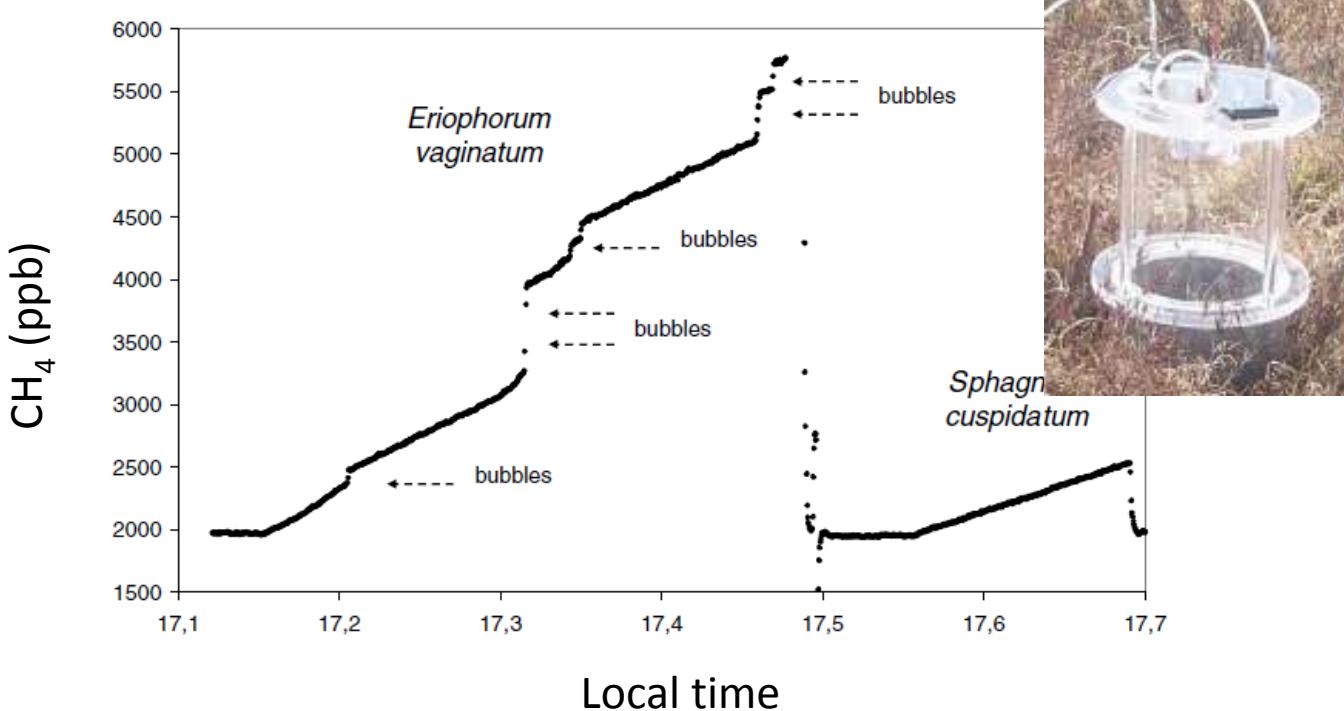


Some applications...

1. CH_4 emissions from peatlands (LPC2E)

Objective : study of climate change and anthropic perturbation on the carbon sink function of peatland

Experimental sites : La Guette (Centre France) :
Frasne (Doubs, France)



La Guette peatland,
Centre France



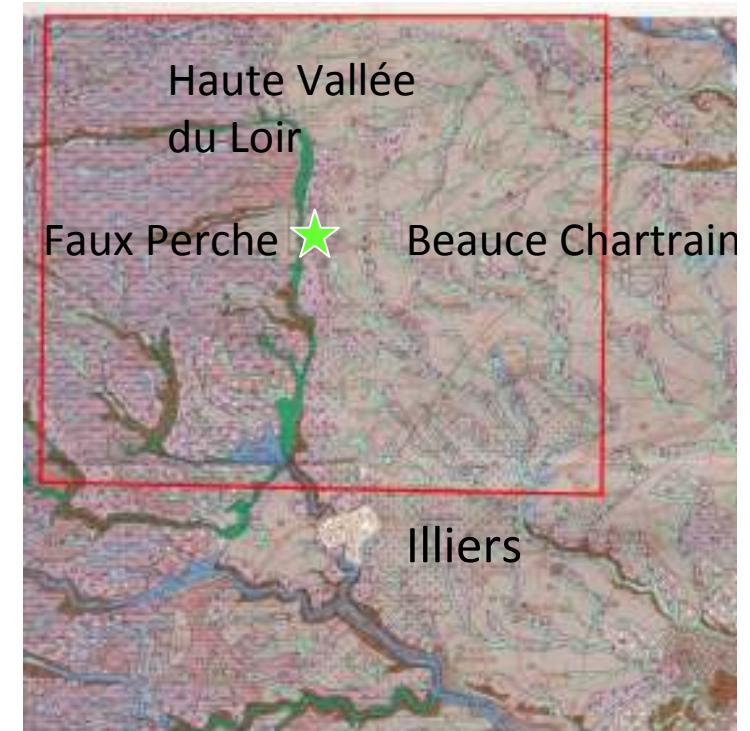
Agricultural studies

2. N₂O emissions from agricultural soils (INRA, Soil Science Lab).

Objective : study of the spatial variability of N₂O emissions

Experimental site : OS² (Observatoire spatialisé Orléanais des Sols) = croplands, Centre France

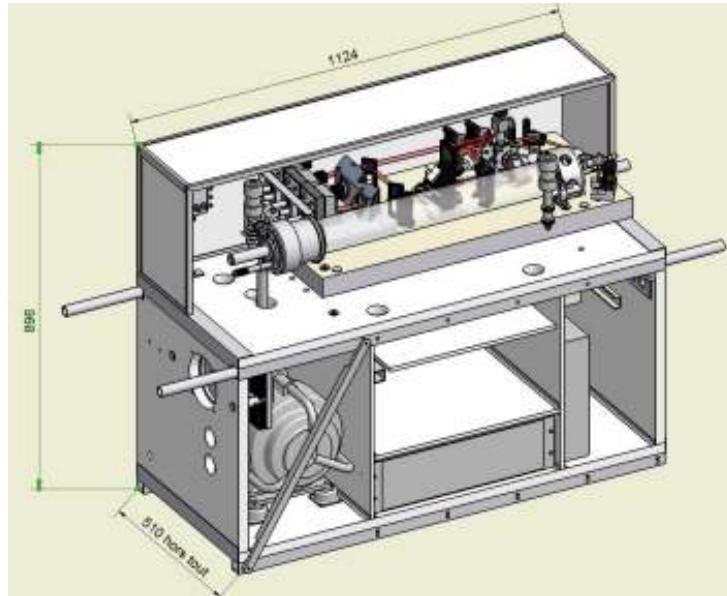
Loamy soils



The INRA SPIRIT

the second instrument

- More compact: 51*112*90 cm
- Optical cell length : 64.5 cm (usual optical path
117 m)
- Cell width : 8 cm \Leftrightarrow 3.2L
- powered in the field with a generator



Flux measurements techniques

- **Chambers**

Minimum measurable flux estimated with

1.2ppb (2σ) error on N_2O , **6 minutes**

accumulation and a **15 cm chamber**

height : $0.5 \text{ g.N.N}_2\text{O.ha}^{-1}.d^{-1}$ or $0.57 \text{ g.N.N}_2\text{O.m}^{-2}.s^{-1}$

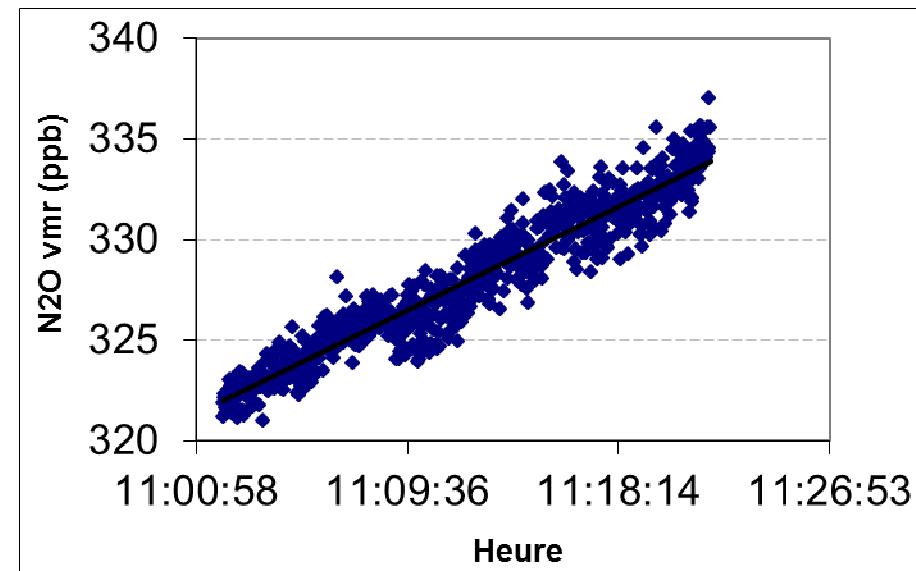


Air inlet and
outlet



- **Fast box**

Minimum flux $\sim 2 \text{ g.N.N}_2\text{O.ha}^{-1}.d^{-1}$



Thank you for your attention



And also thanks :

**To the whole LPC2E team who built up the instrument
And to the technical team of UR Sol (INRA)**

This work has been funded by the INRA Institute, the region Centre of France and the FEDER (CPER 2007-2013).