An FTIR analyser for simultaneous high precision measurements of CO_2, CH_4, CO, N_2O and $\delta^{13}C$ in CO_2

Comparison with LoFlo and AGAGE measurements at Cape Grim

… and (if there's time) other applications

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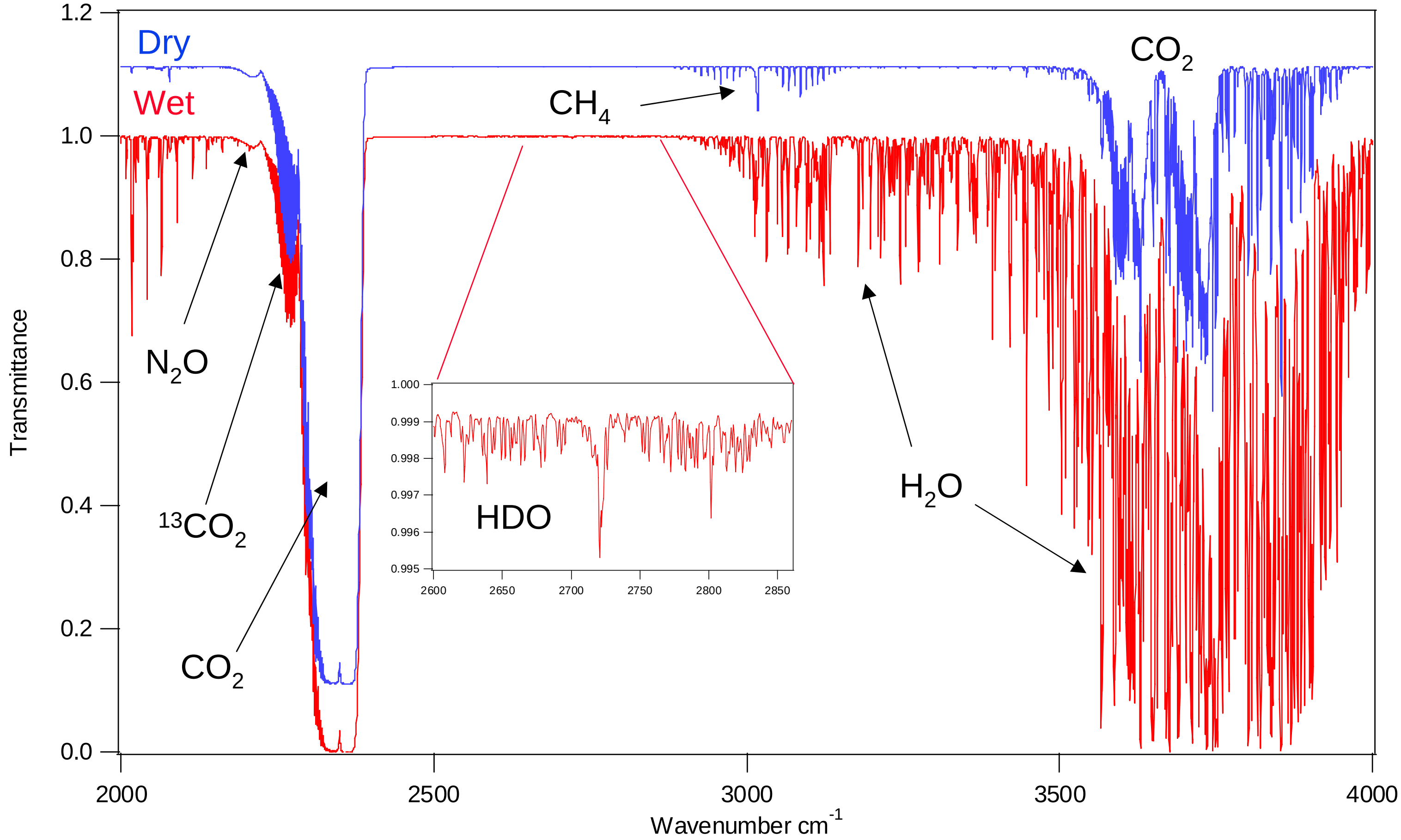
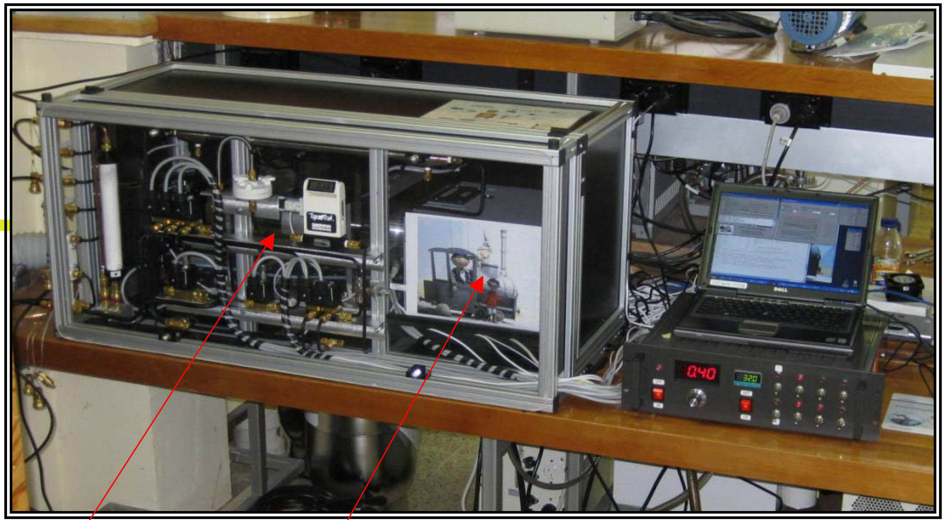
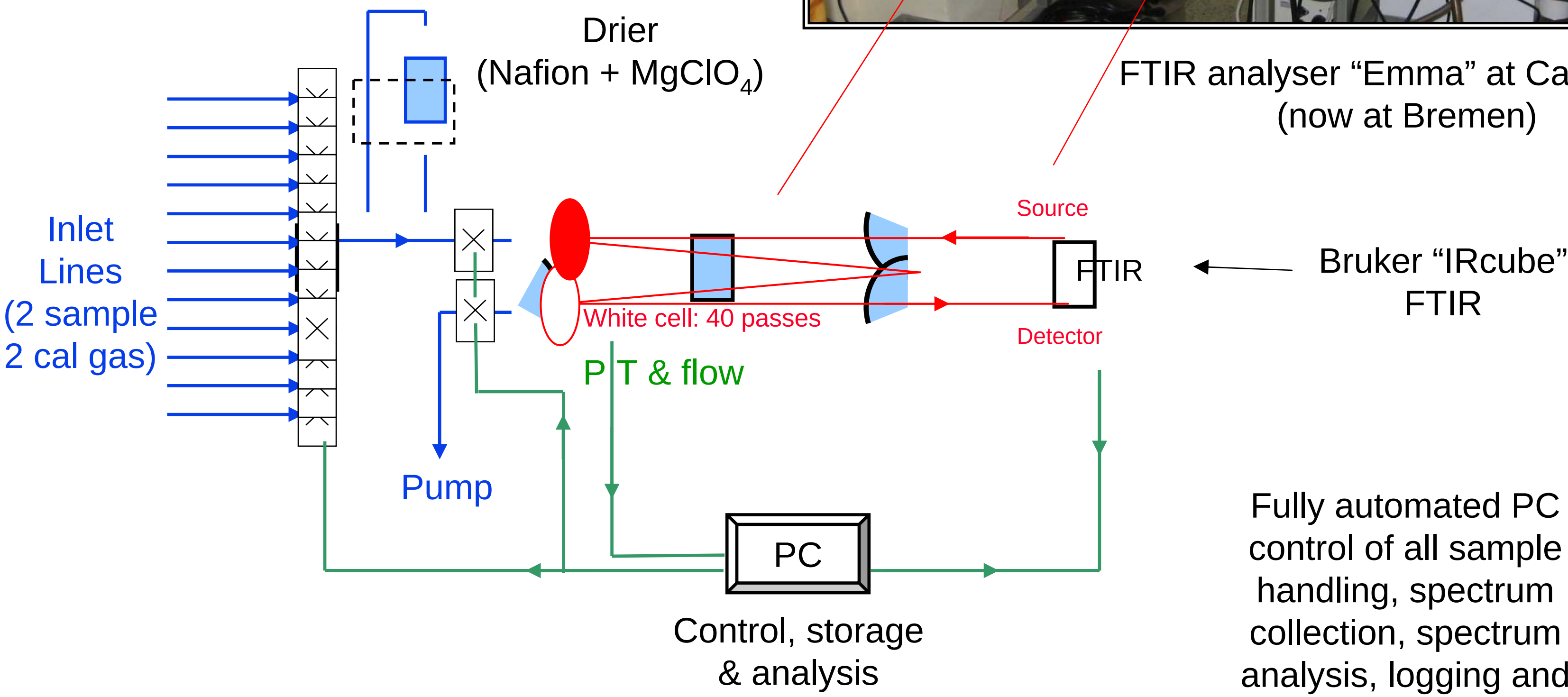
Infrared spectrum of clean air



FTIR
trace gas analyser



FTIR analyser "Emma" at Cape Grim
(now at Bremen)



Fully automated PC control of all sample handling, spectrum collection, spectrum analysis, logging and data storage

Precision - repeatability

- Determined from Allan Variance measurements
- Confirmed in Cape Grim study

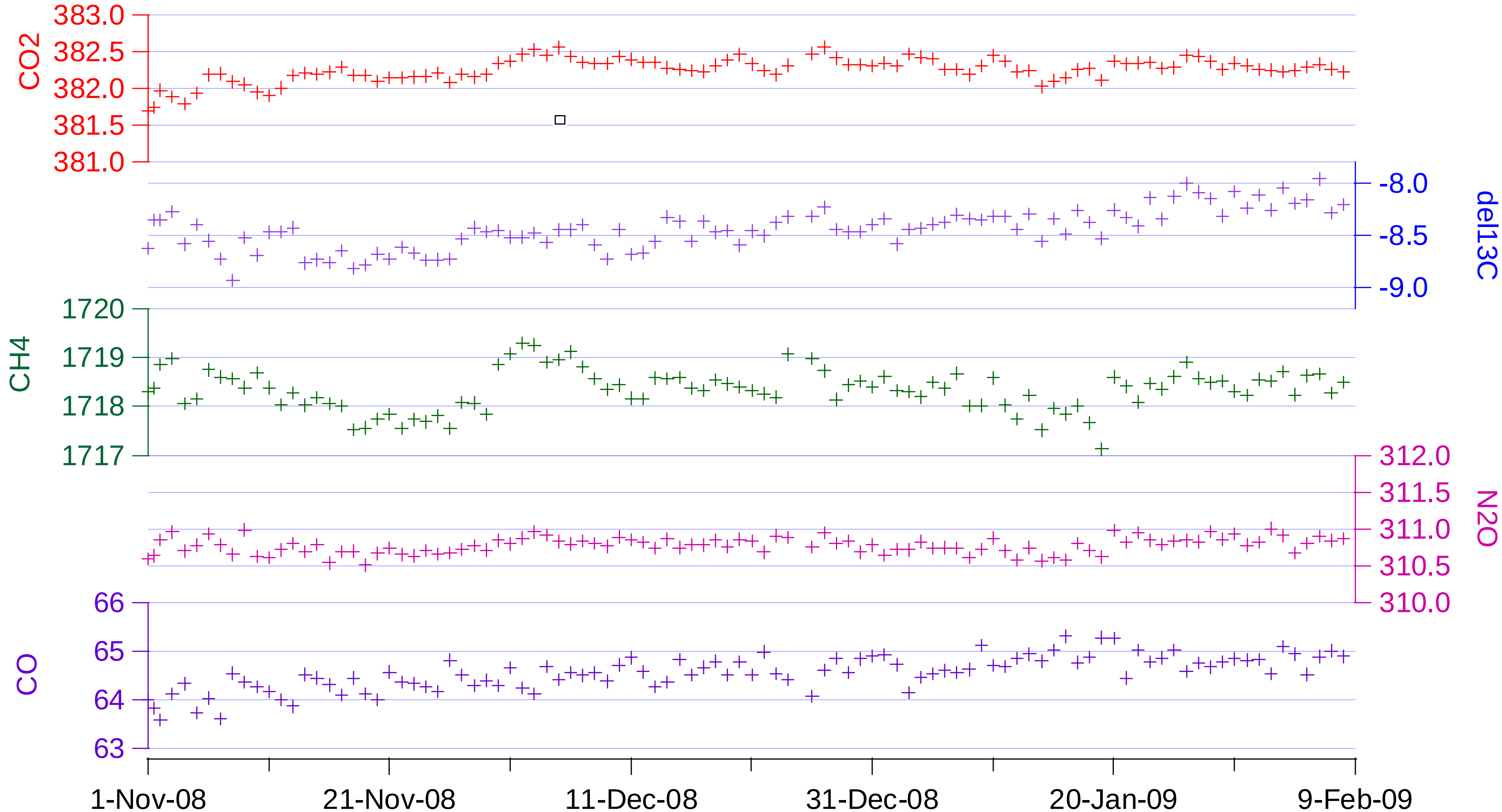
- 1σ repeatability for 10 minute averages:

  - CO_2 0.05 $\mu mol\ mol^{-1}$
  - CH_4 0.2 $nmol\ mol^{-1}$
  - CO 0.2 $nmol\ mol^{-1}$
  - N_2O 0.06 $nmol\ mol^{-1}$
  - $\delta^{13}C$ in CO_2 0.08 ‰

- Accuracy depends on gas standard(s) used

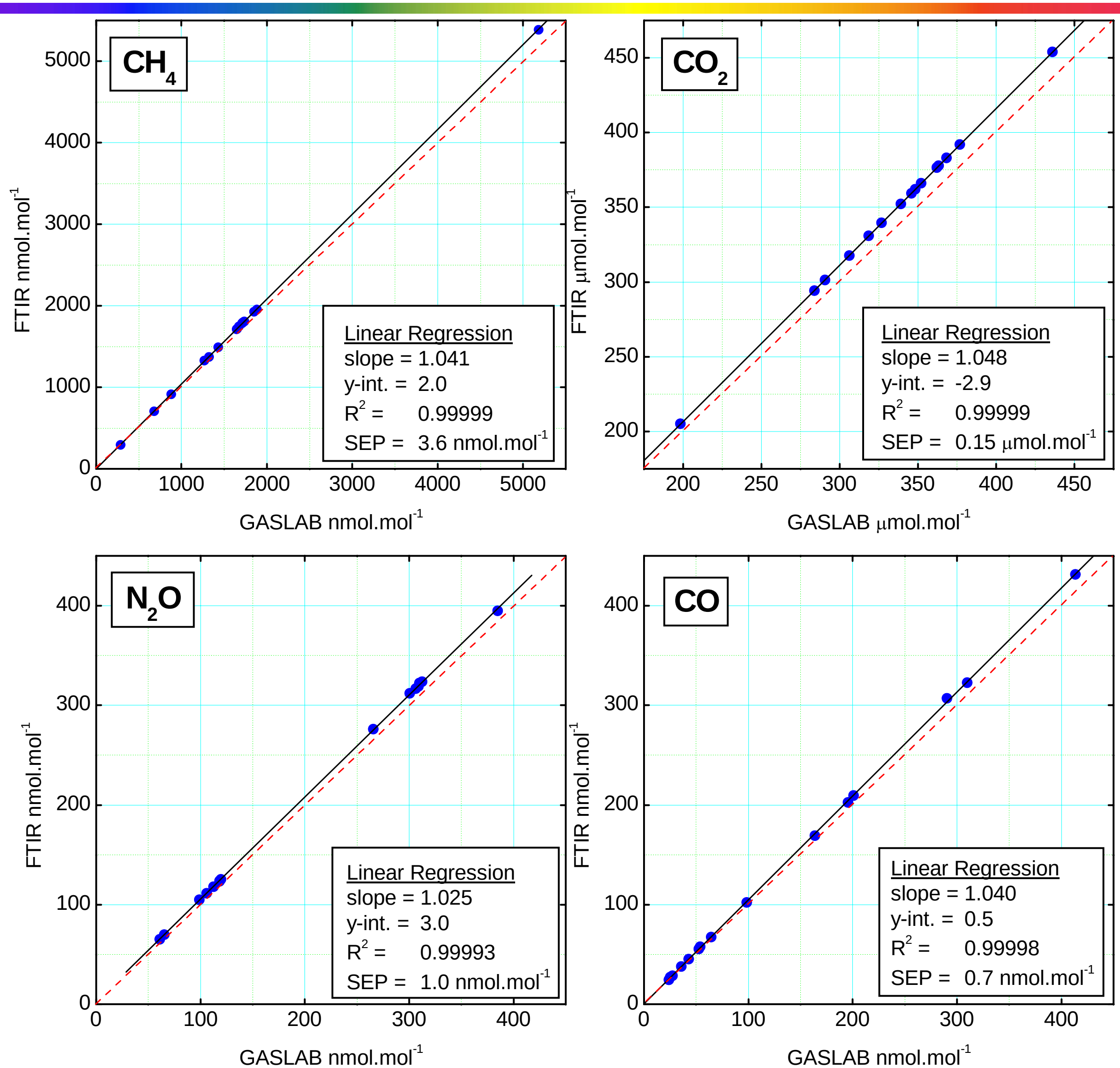
Calibration: stability

110 daily cal.tank measurements at Cape Grim

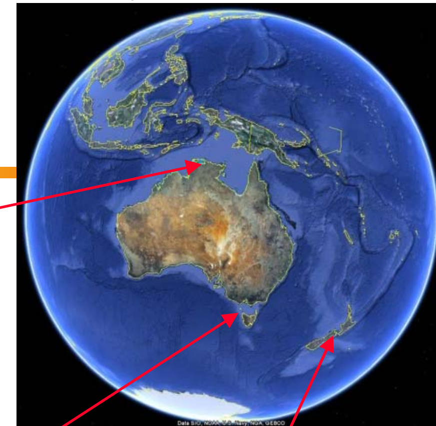


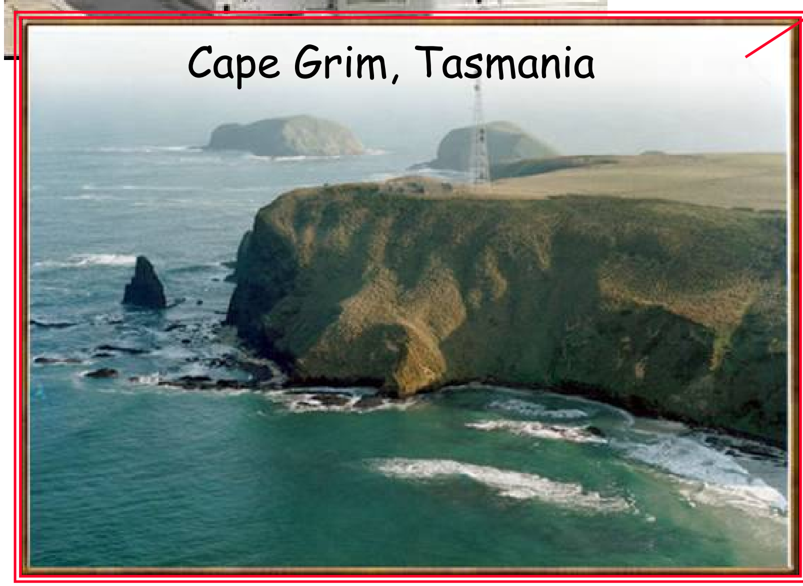
Calibration: linearity

FTIR vs GasLab calibration values (2002), 14 tanks



Cape Grim trial, Oct 2008 – Feb 2009
Continuous air measurements



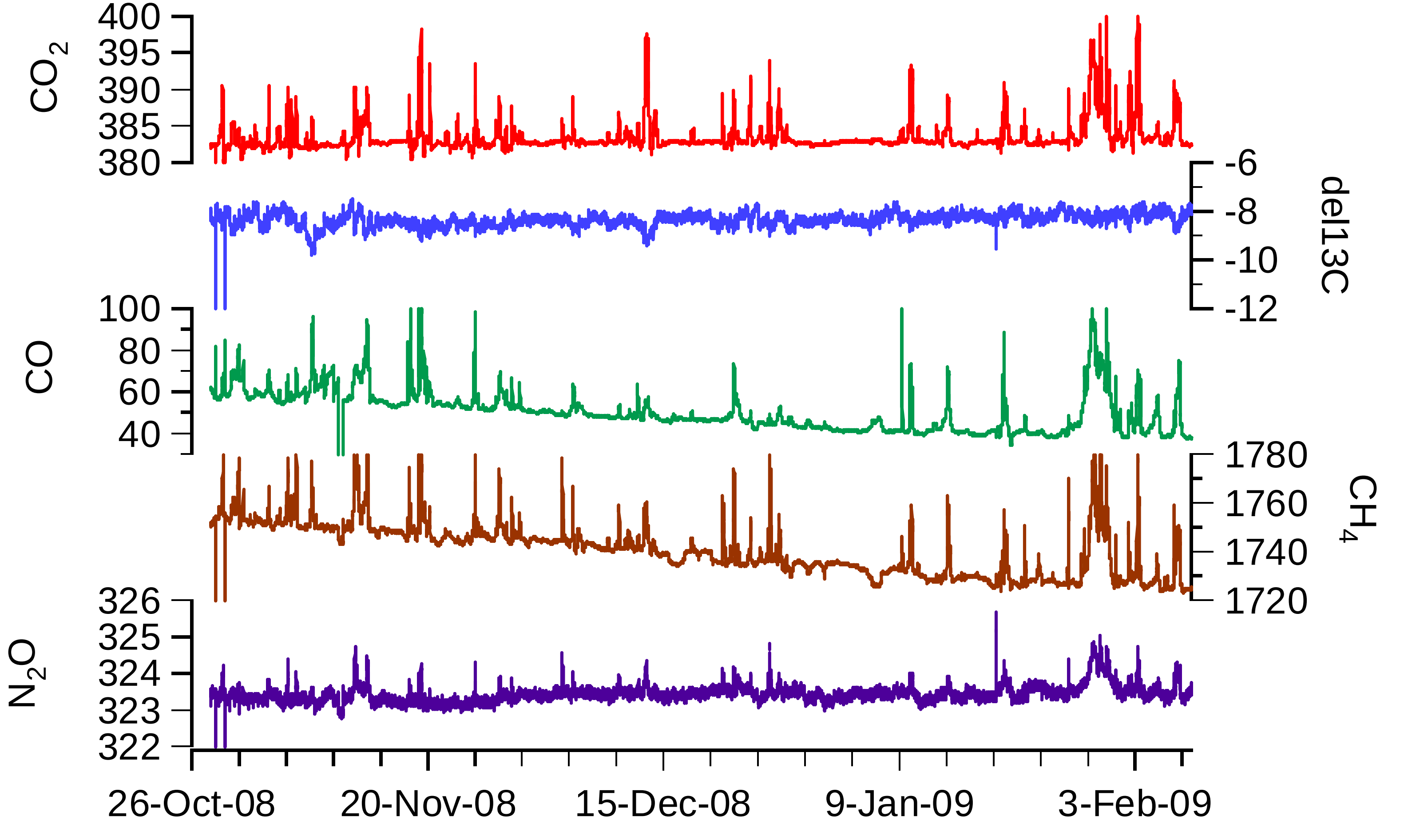


Cape Grim intercomparison

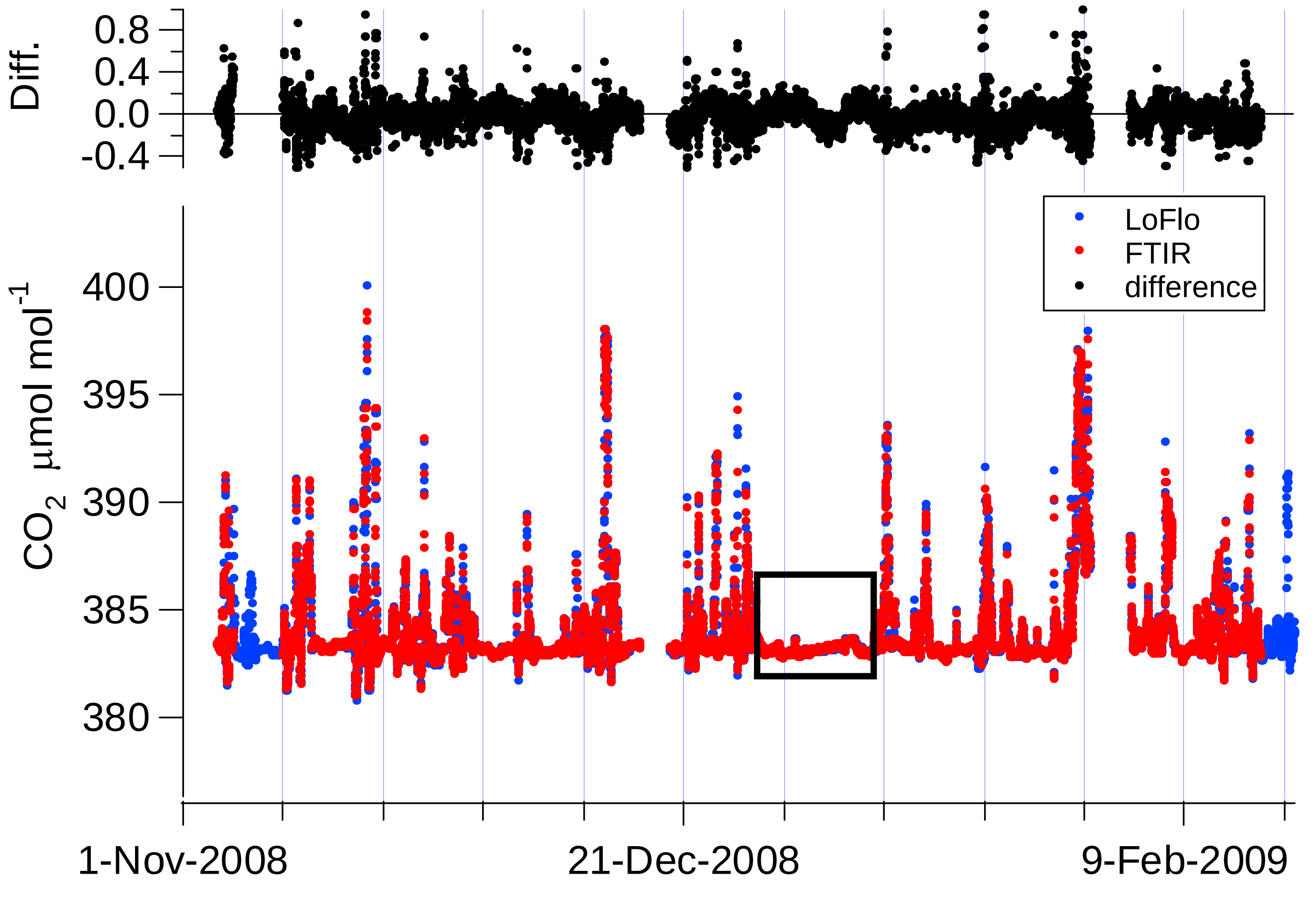
FTIR vs LoFlo (CO_2) and AGAGE-GC (CH_4, CO, N_2O)

- Oct 2008 – Feb 2009, 110 days
- Air drawn continuously at 0.5 L min^{-1} from 70 m tower inlet
  - Parallel to LoFlo and AGAGE inlets
- Continuous real time analysis
  - FTIR measurements are 10 min averages
  - Precision improves with further averaging
  - Comparison values timed/averaged to coincide in time with LoFlo/AGAGE
- Calibration once per day
  - single clean air tank, flask subsamples analysed at GasLAb (awaiting reanalysis)
- Managed over internet to host PC (Windows Remote Desktop)
- Low maintenance, minimal consumables
  - Purge N_2 0.2 L min^{-1}, $MgClO_4$, calibration gas
  - No LN_2, use dried sample air + vacuum for Nafion backflush

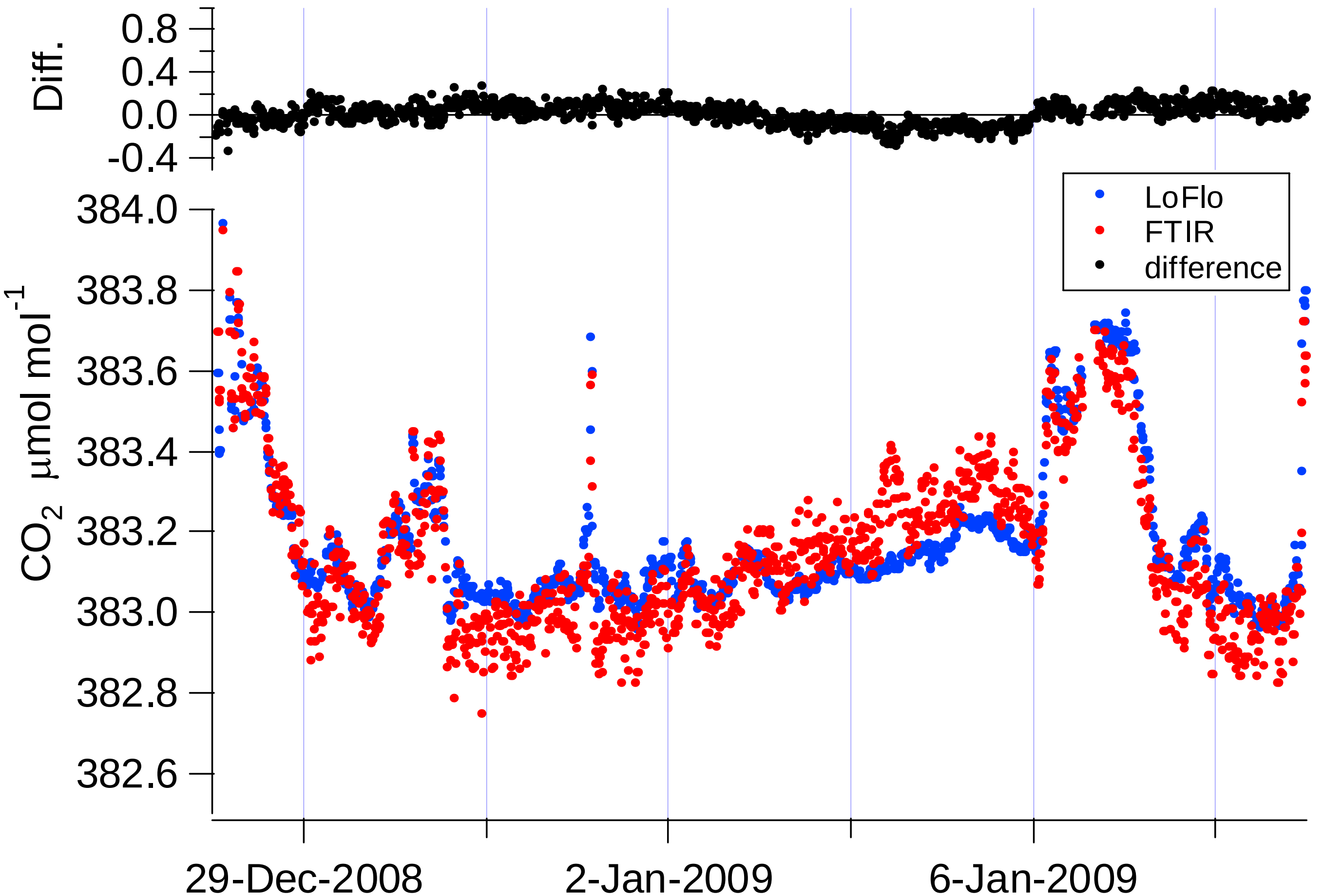
FTIR at Cape Grim - overview



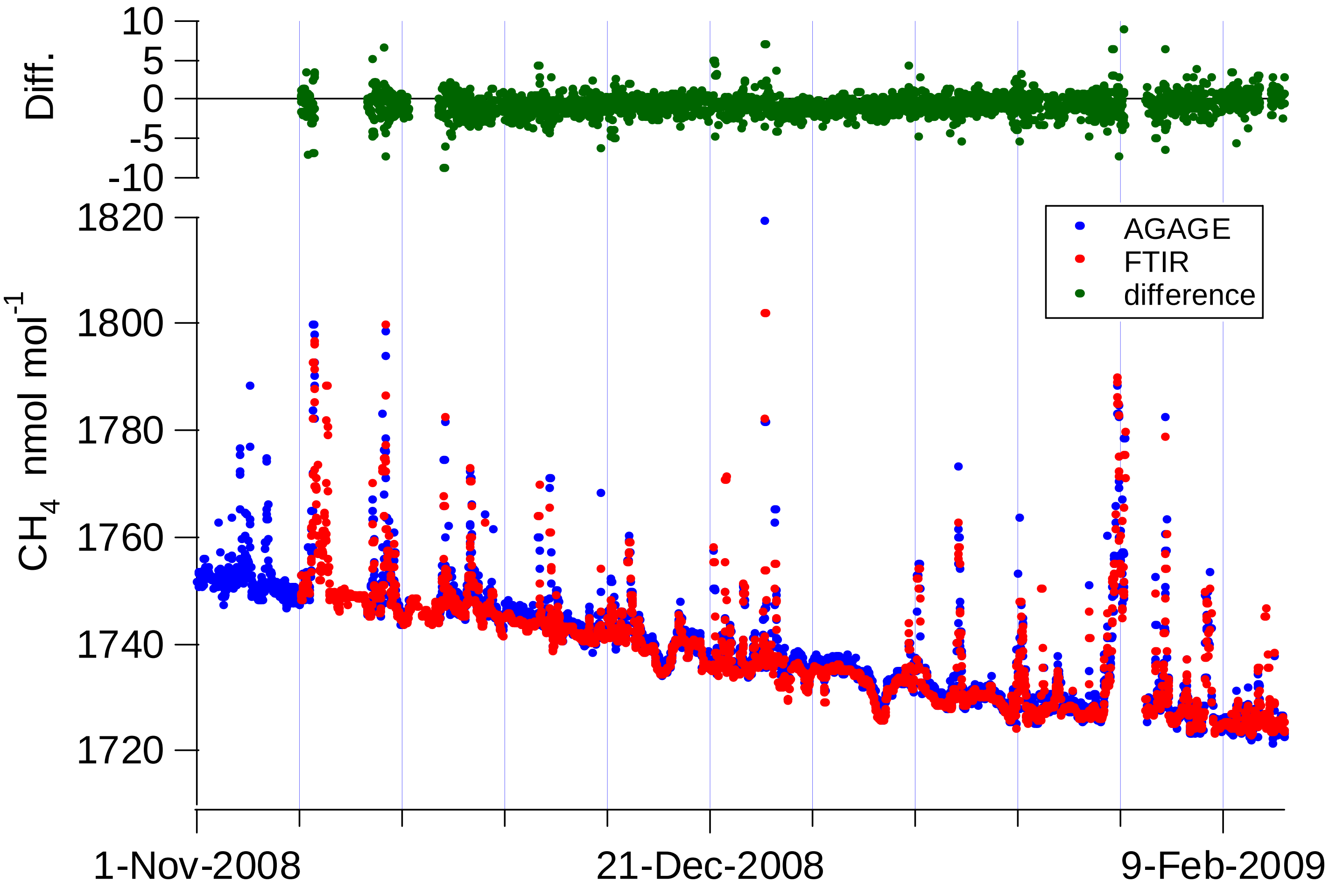
CO_2 : FTIR vs LoFlo



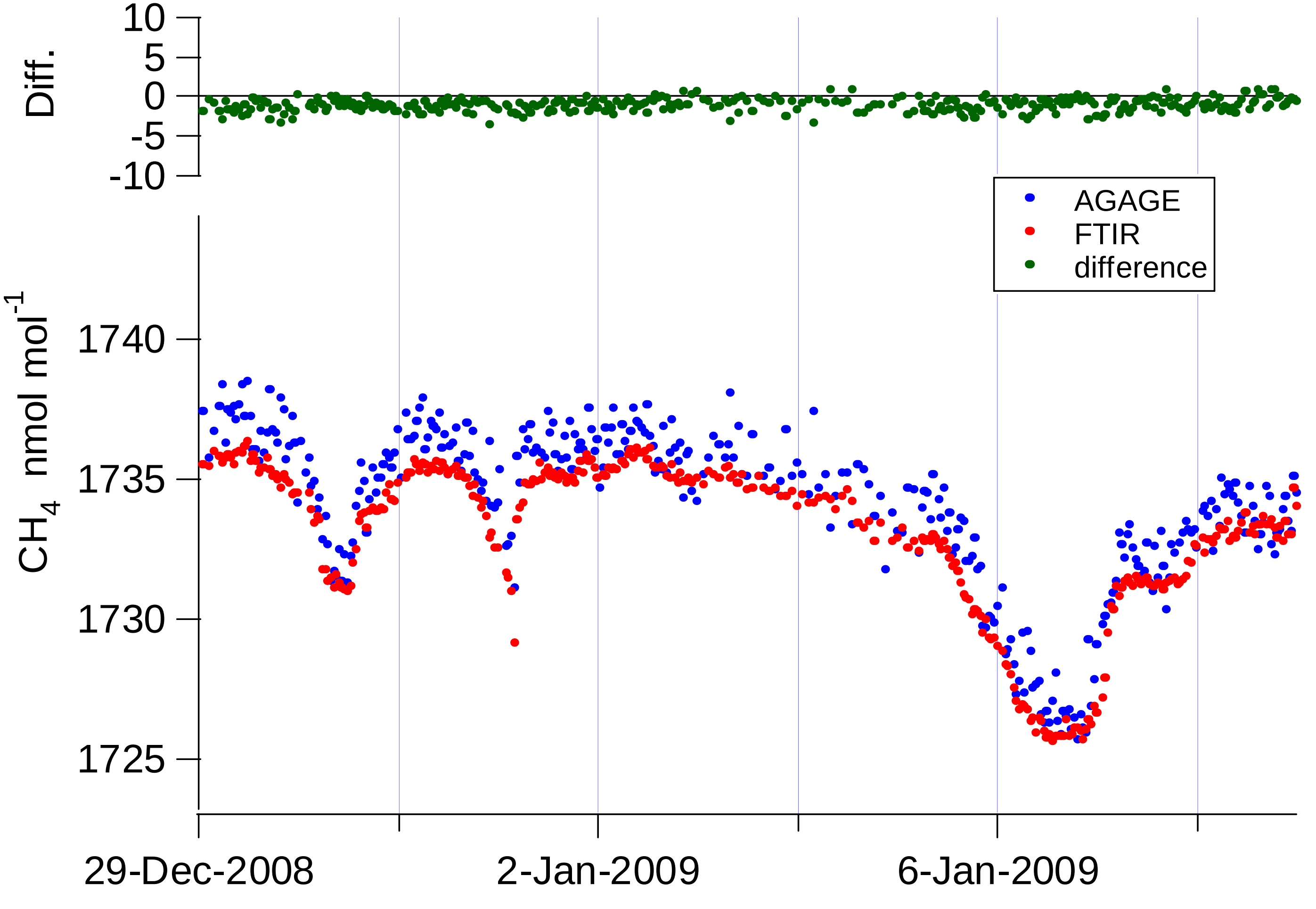
CO_2 : FTIR vs LoFlo



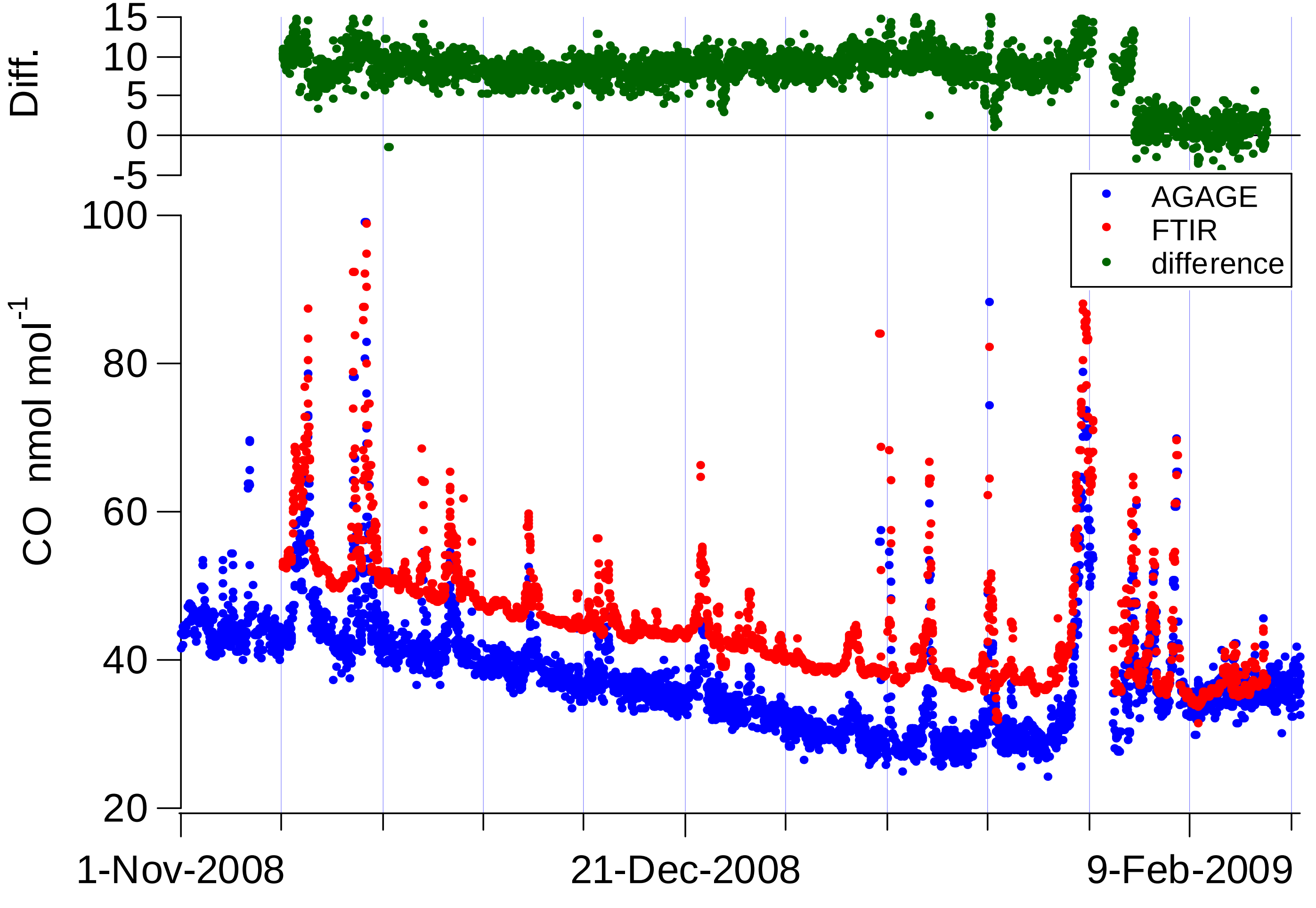
CH_4: FTIR vs AGAGE (GC)



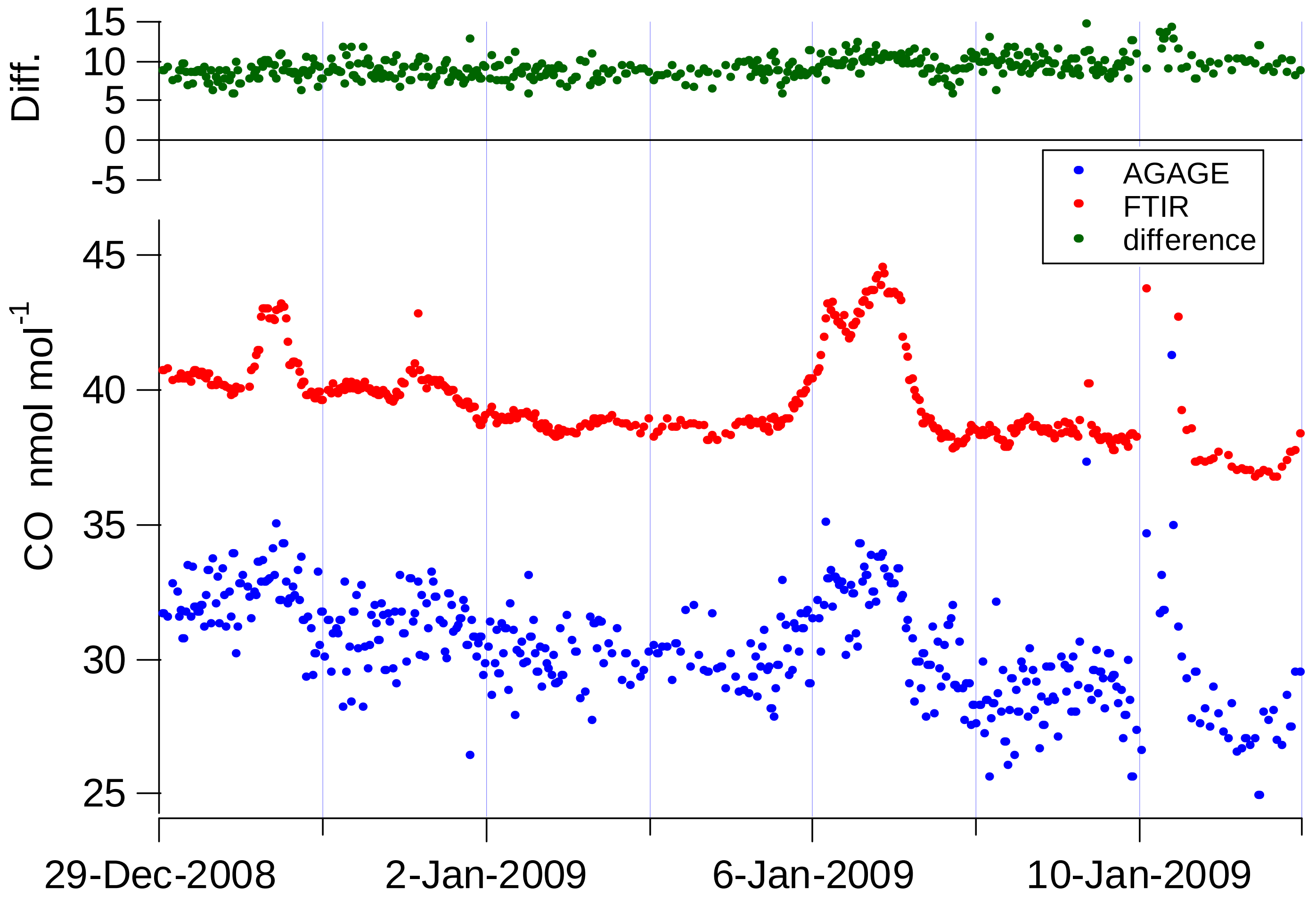
CH_4: FTIR vs AGAGE (GC)



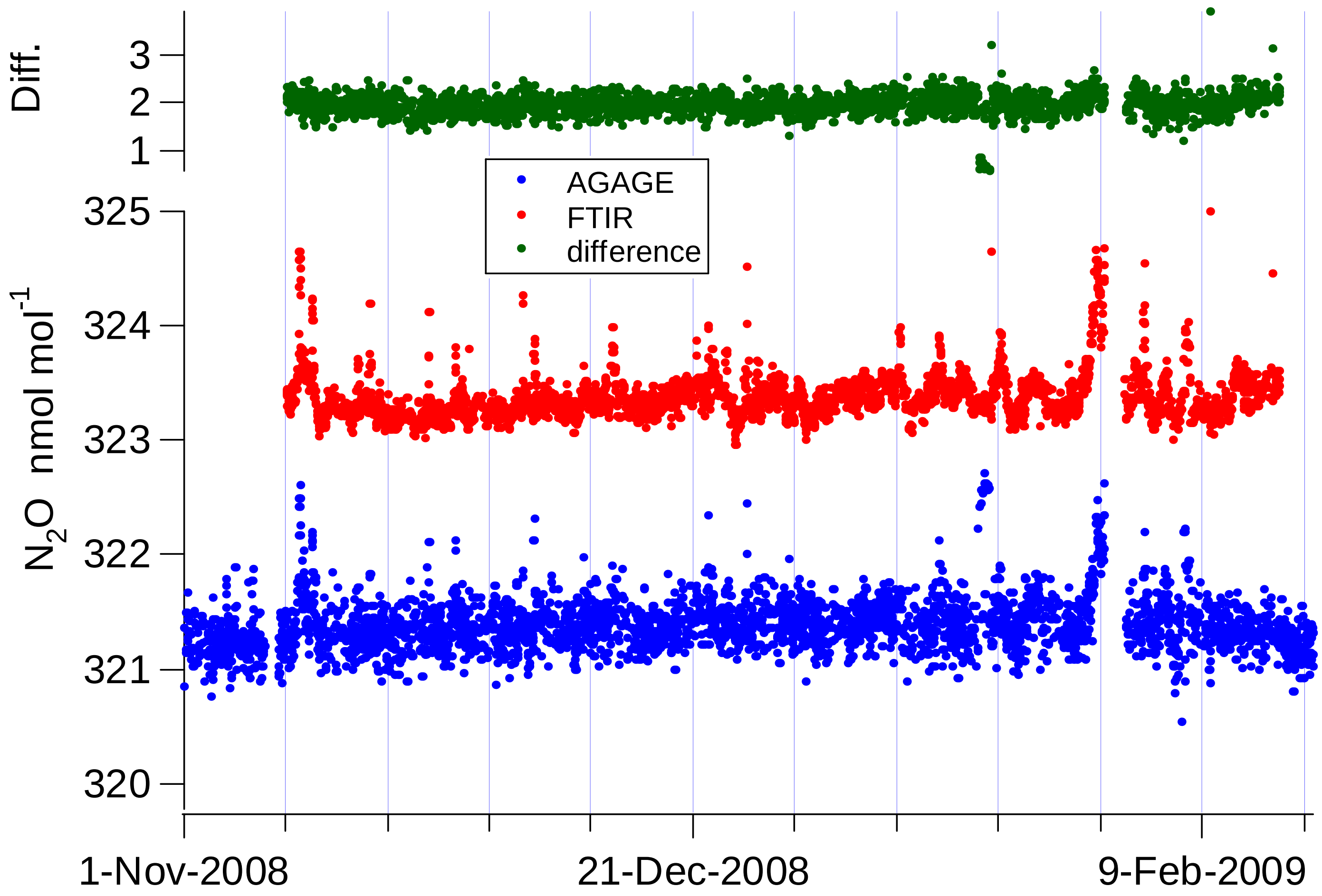
CO: FTIR vs AGAGE (GC)



CO: FTIR vs AGAGE (GC)



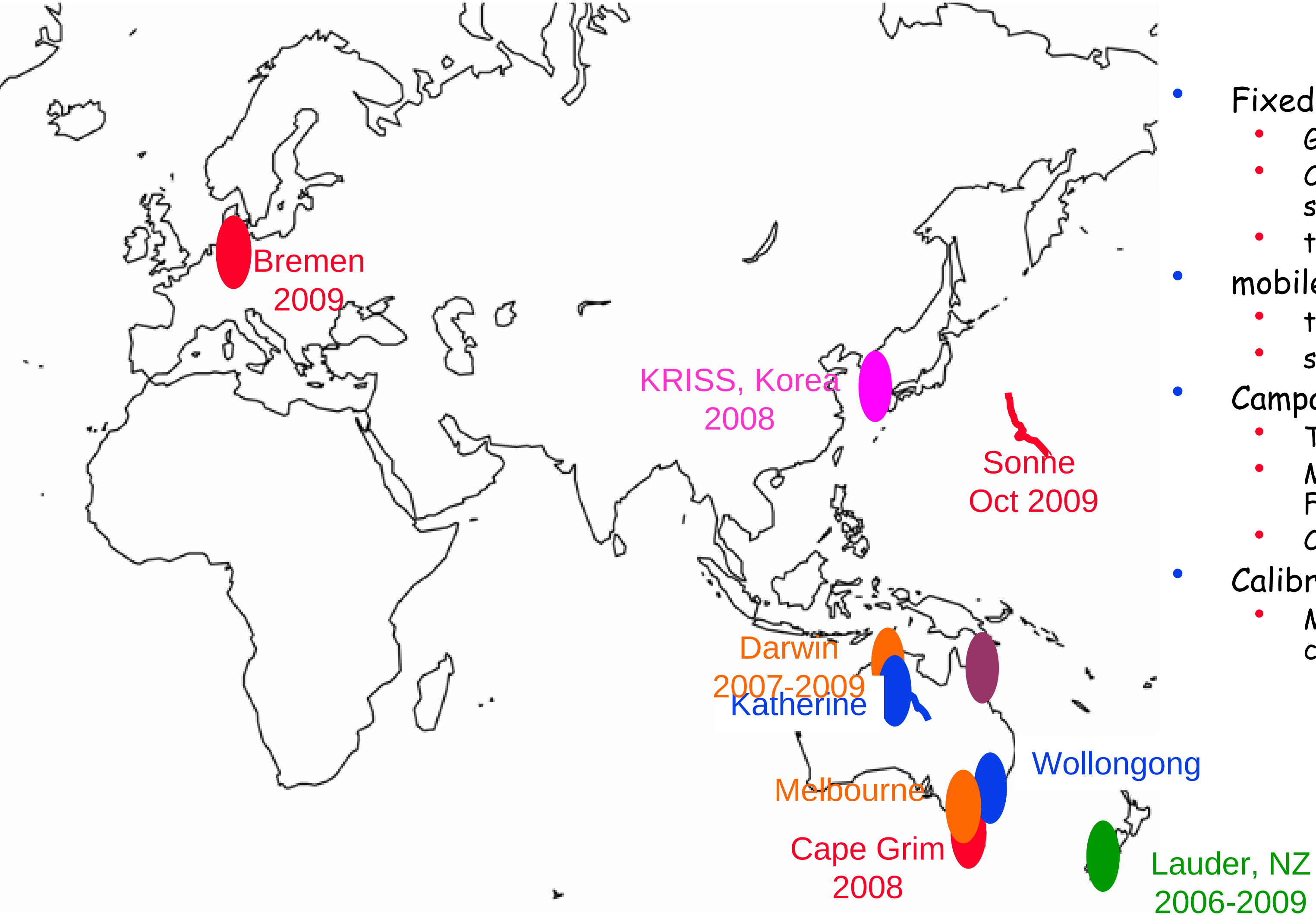
N_2O: FTIR vs AGAGE (GC)



Black Saturday fires, 7 Feb 2009

NOAA HYSPLIT MODEL
Backward trajectories ending at 0900 UTC 07 Feb 09
GDAS Meteorological Data

Some applications
- around (some of) the world



- Fixed stations
  - GAW, ICOS?
  - Characterise new sites
  - towers
- mobile platforms
  - train
  - ship
- Campaigns
  - Tower measurements
  - Micrometeorology - Flux measurements
  - Caves
- Calibration propagation
  - Multi species correlations

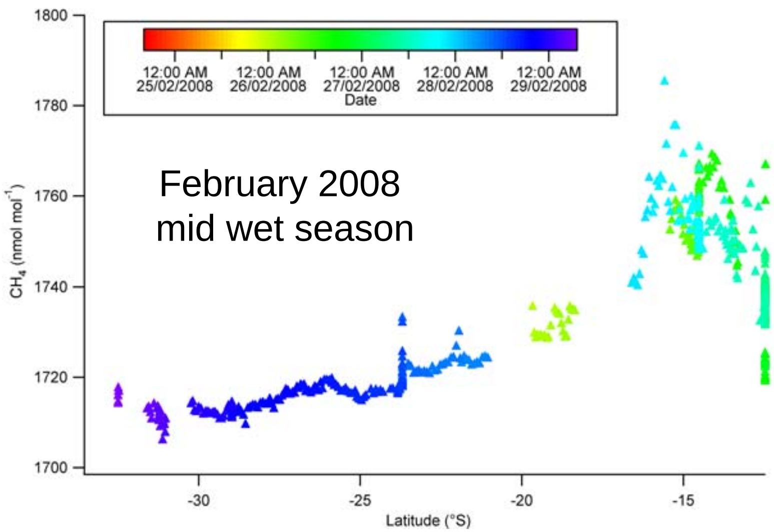
Mobile measurements

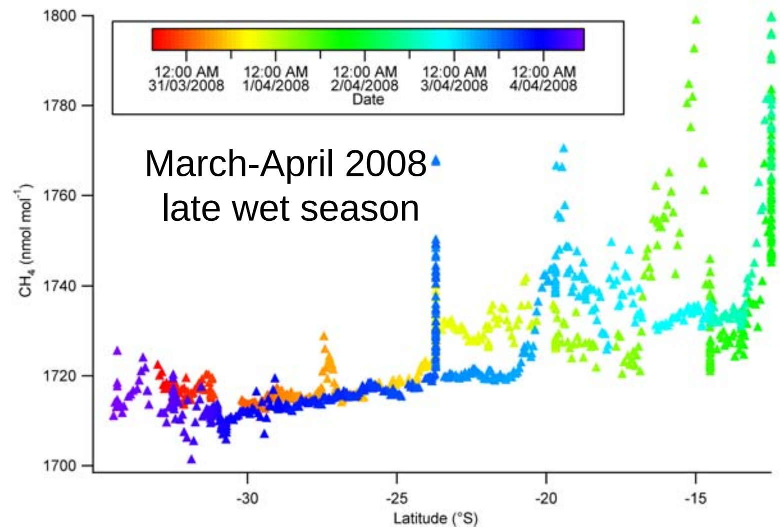
Transects of the Australian continent

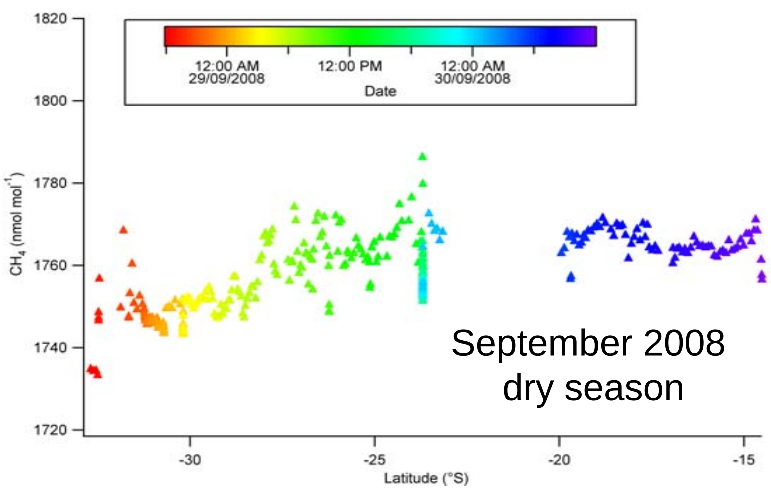
The Ghan

FTIR analyser in luggage van

CH_4 increases in tropical wet season



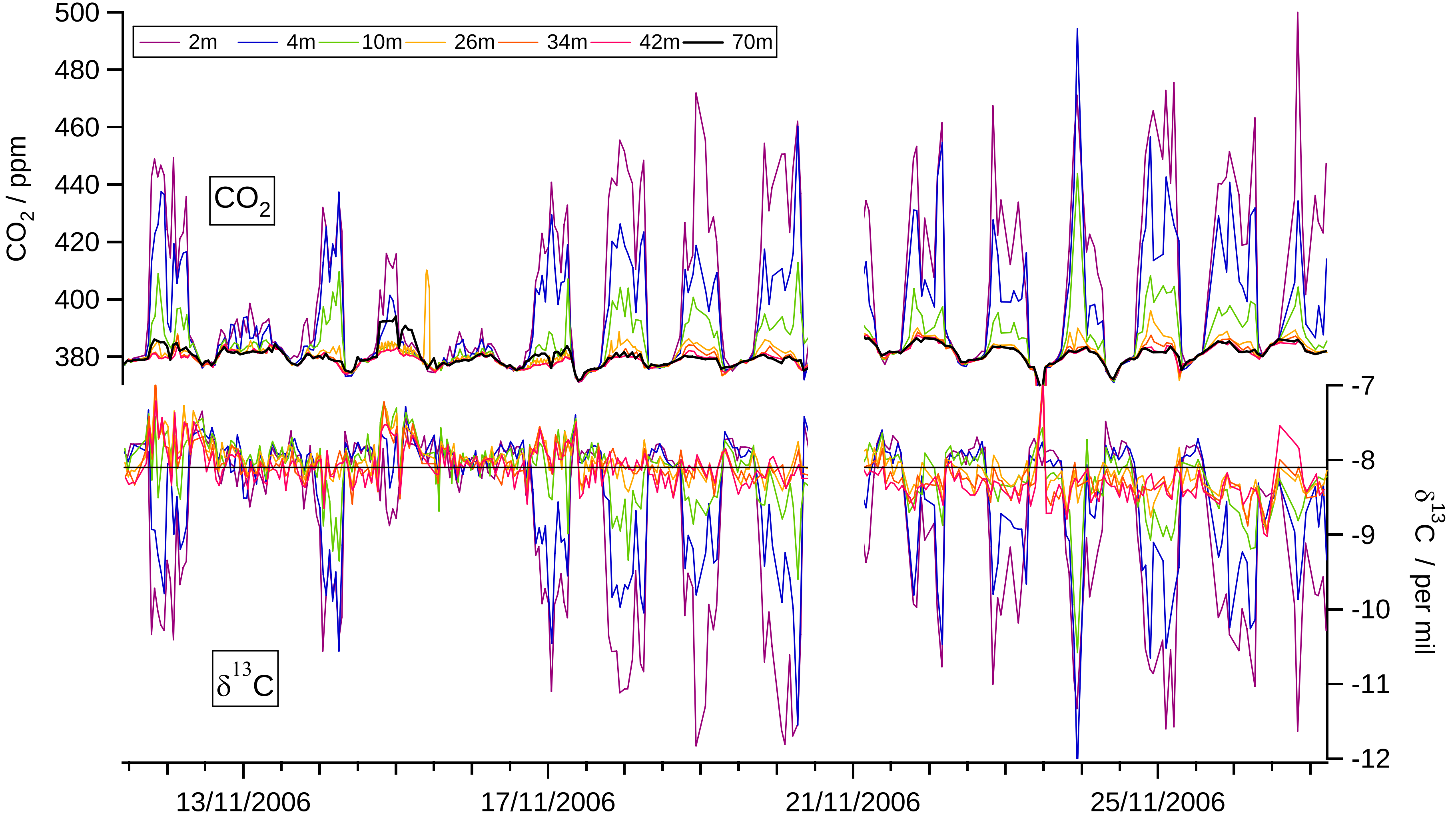




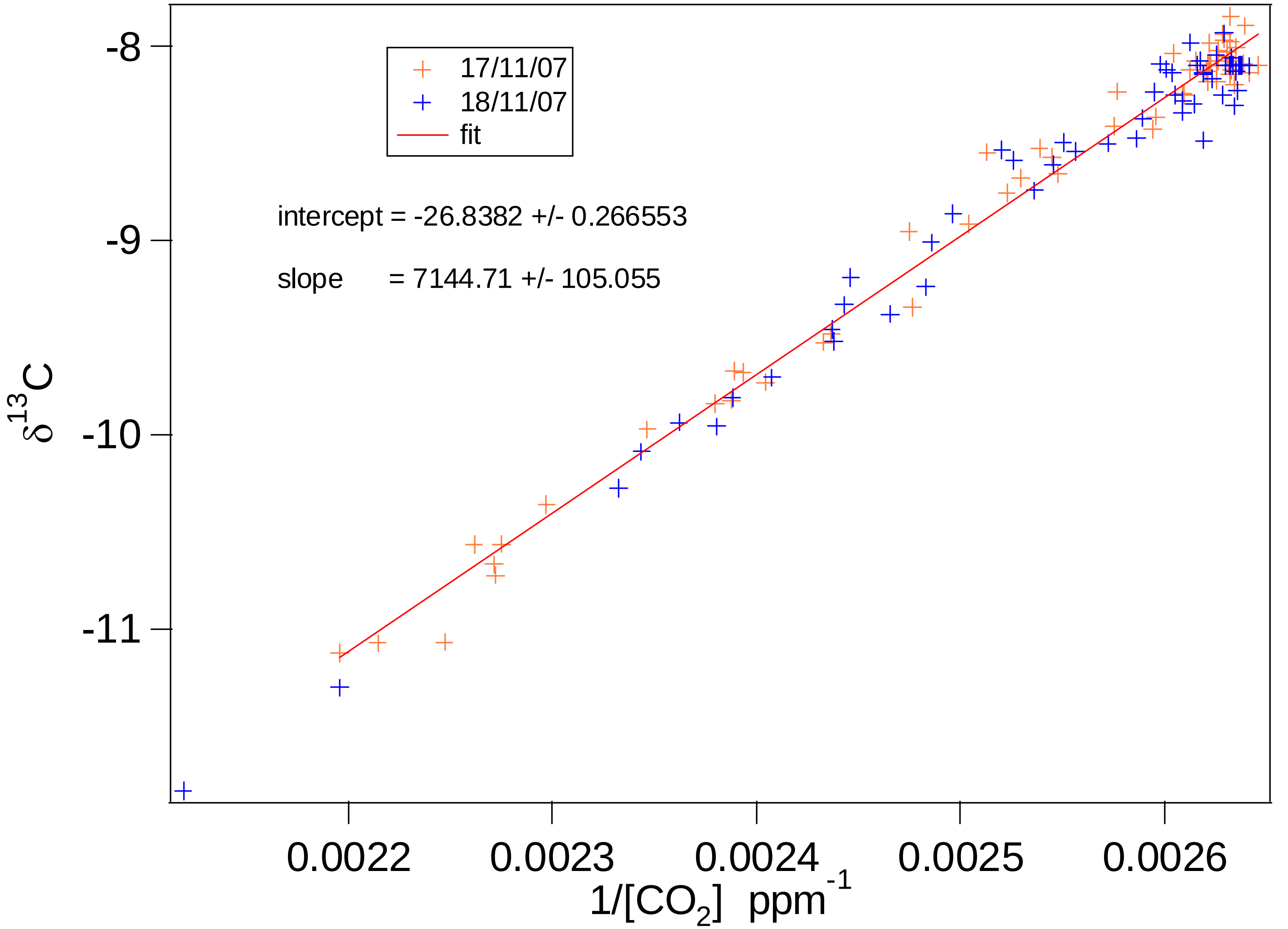
- 40-50 nmol mol^{-1} increase in CH_4 toward equator in wet season
- Due to ephemeral wetlands, + latitudinal gradient
- Ephemeral and permanent wetlands approx. equal annual source strength (~0.4 Tg y^{-1})
- Deutscher et al., JGR submitted 8 Sept 2009

Forest tower profiles:
using trace gas and isotopic fractionation profiles to partition C and H_2O exchange

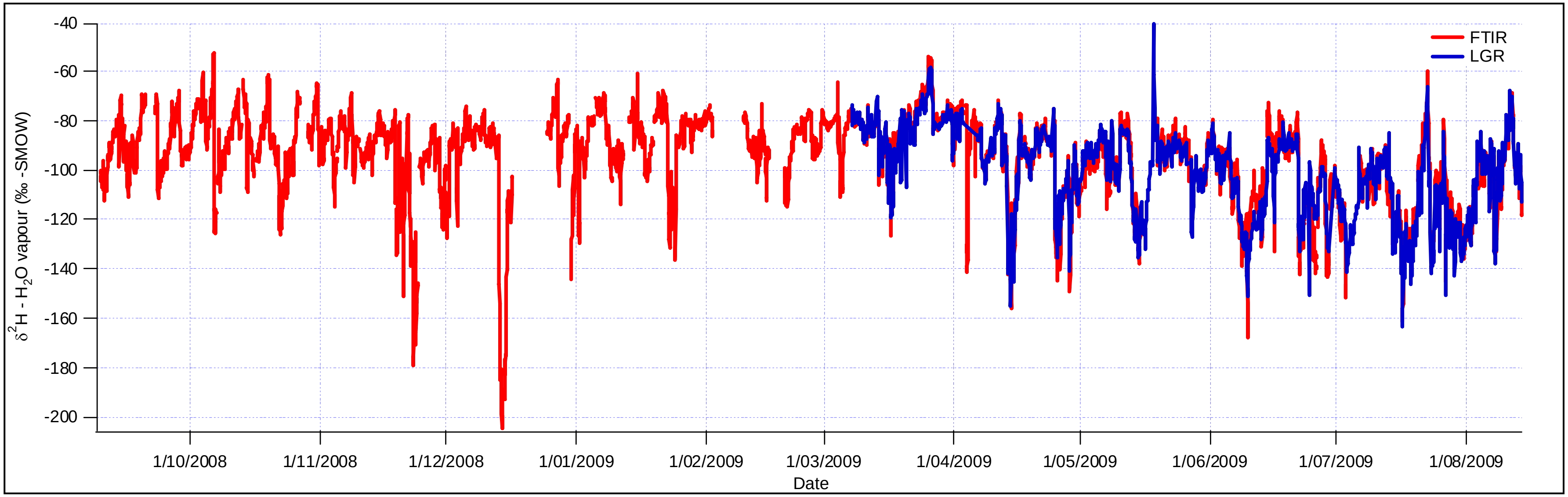
CO_2 and $\delta^{13}C$ - tower profiles 7 heights vs time



CO_2 and $\delta^{13}C$ – night time Keeling plots



Water vapour isotopes
- FTIR vs Los Gatos (Stephen Parkes, ANSTO)



- FTIR calibration against IRMS water standards (undried air)
  - δ^2H in H_2O 1 ‰
  - $\delta^{18}O$ in H_2O 0.4 ‰

FTIR vs laser

FTIR

- Broadband spectrum ☺
  - Multiple components
  - Save spectra - reanalysable
- Thermal source – globar ☹
  - Low brightness
  - => best time resoln. ~ 1 sec
- Mid IR, atmospheric pressure ☺
  - Strong absorption
- Wide spectrum band fit ☺
  - more spectral information
  - Good stability, calib. 1/day

Laser

- Narrowband, single lines
  - Single species or pair (per laser)
- Laser source ☺
  - High brightness
  - => high SNR, fast meas.
- Near IR, low pressure (!QCL) ☹
  - Weak absorption
- Narrow band fit ☹
  - less spectral information
  - Drift, more freq. calib.

Net result: similar precision ☺

- Portable ☹
- More portable ☺

Summary

- Cost effective 5-in-1 analyser for

  CO_2, CH_4, CO, N_2O and $\delta^{13}C$-CO_2

- Simultaneous and continuous analysis
- High precision
  - Accuracy determined by calibration gases
- Good calibration stability & linearity
  - 1 calibration per day, air standard
- Low maintenance and consumables (no LN_2)
- Low "cost of ownership"
- Manage remotely (internet)
- Applications include:
  - Fixed sites (GAW, ICOS?)
  - Mobile platforms – train, ship
  - Tower profiling
  - Micrometeorology and flux measurements
  - Calibration propagation for air standards

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- University of Bremen (the instrument)

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