university of groningen / faculty of science and engineering / centre for isotope research

Update on Groningen COS work

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WAGENINGEN UR

European Research Council
Established by the European Commission

Groningen ongoing COS work

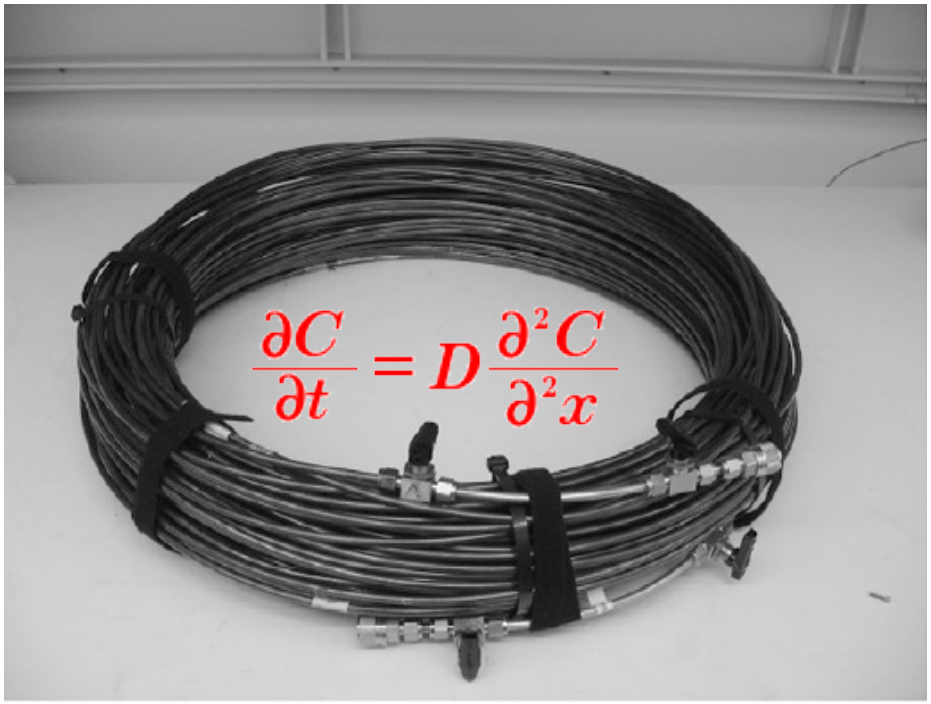
- AirCore COS observations (COS-OCS)
- Sources and sinks of COS in the Netherlands (the last chapter of PhD thesis Linda Kooijmans)

PhD or Postdoc vacancy (COS-OCS, to be filled, hopefully Aug-Sep, 2020)

Ongoing master projects on COS

- Alessandro Zanchetta (Anthropogenic sources of COS in Groningen)
- Sander Leuning (Test of O_3 on COS measurements)
- Charlotte Tabak (AirCore + LISA for Hemera COS balloon measurements Kiruna Sep 2020)

AirCore measurements

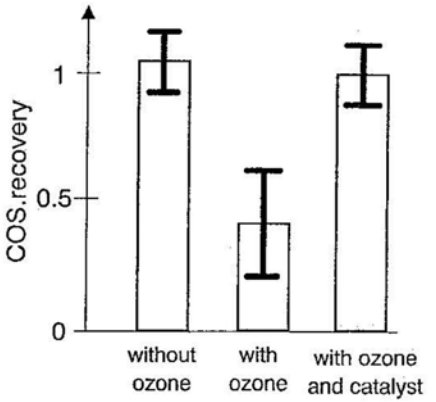


The 152 m–long AirCore, *[Karion et al. 2010]*
More recently, [Membrive et al. 2017], [Engel et al., 2017], [Andersen et al., 2018]

Towards AirCore measurements of COS profiles

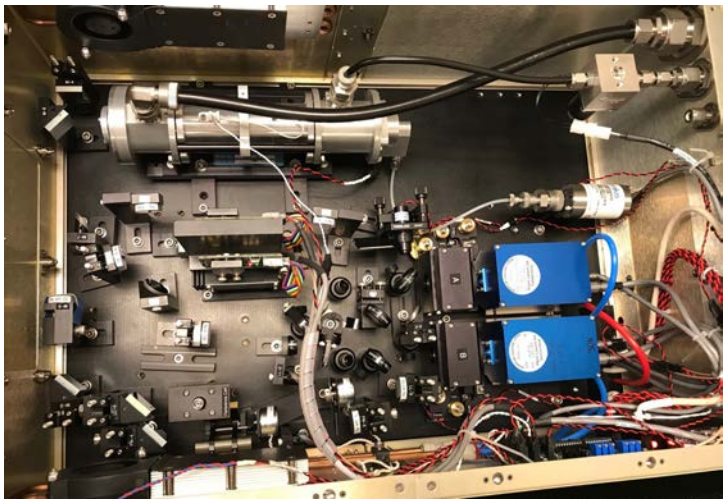
- Sample analysis
  - Analyzer
    - precision vs. sample size (a total of ~ 1L)
  - Accuracy
    - Stability of the analysis
    - Calibration scale i.e. the NOAA COS scale

- AirCore Sampling Cryogenic
  - Potential contamination of COS
  - Potential effects of atmospheric ozone, especially in the stratosphere



Engel et al., 1994 for cryogenic whole air sampler

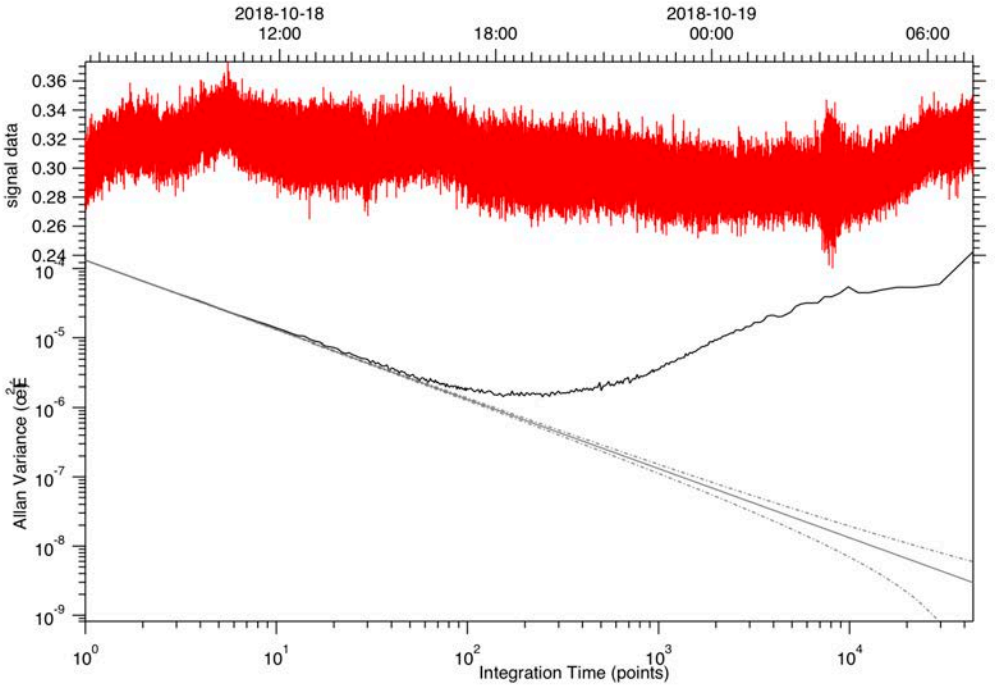
Analyzer: Small-cell Dual QCLS COS/N_2O/CH_4/CO_2/CO/H_2O



Aerodyne Research Inc.

Cell volume	150 mL
Optical Path length	36 m
Pressure	40 – 60 Torr

Effective Cell Volume at 50 Torr: ~ 10 mL



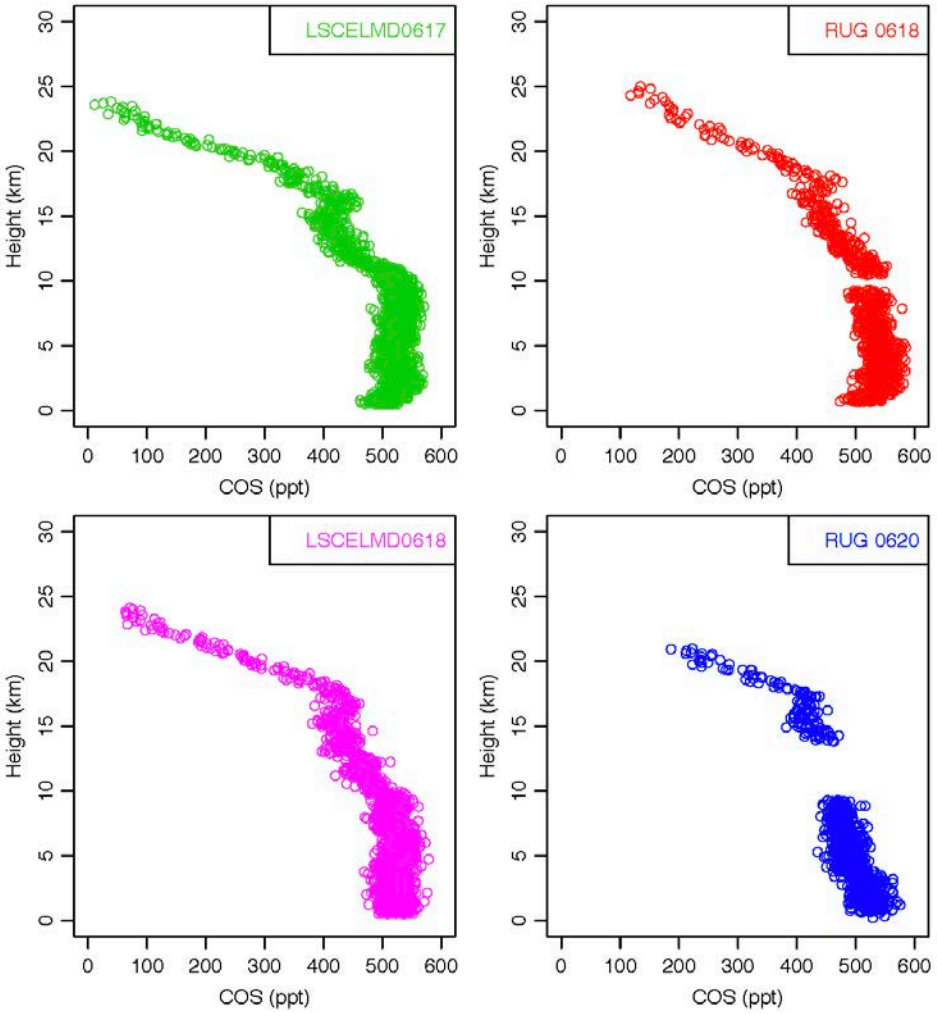
Species	COS (ppt)	N_2O (ppb)	CO_2 (ppm)	CH_4 (ppb)	CO (ppb)	H_2O (ppm)
1-sigma	~ 12	0.1	0.08	0.45	0.65	7.2

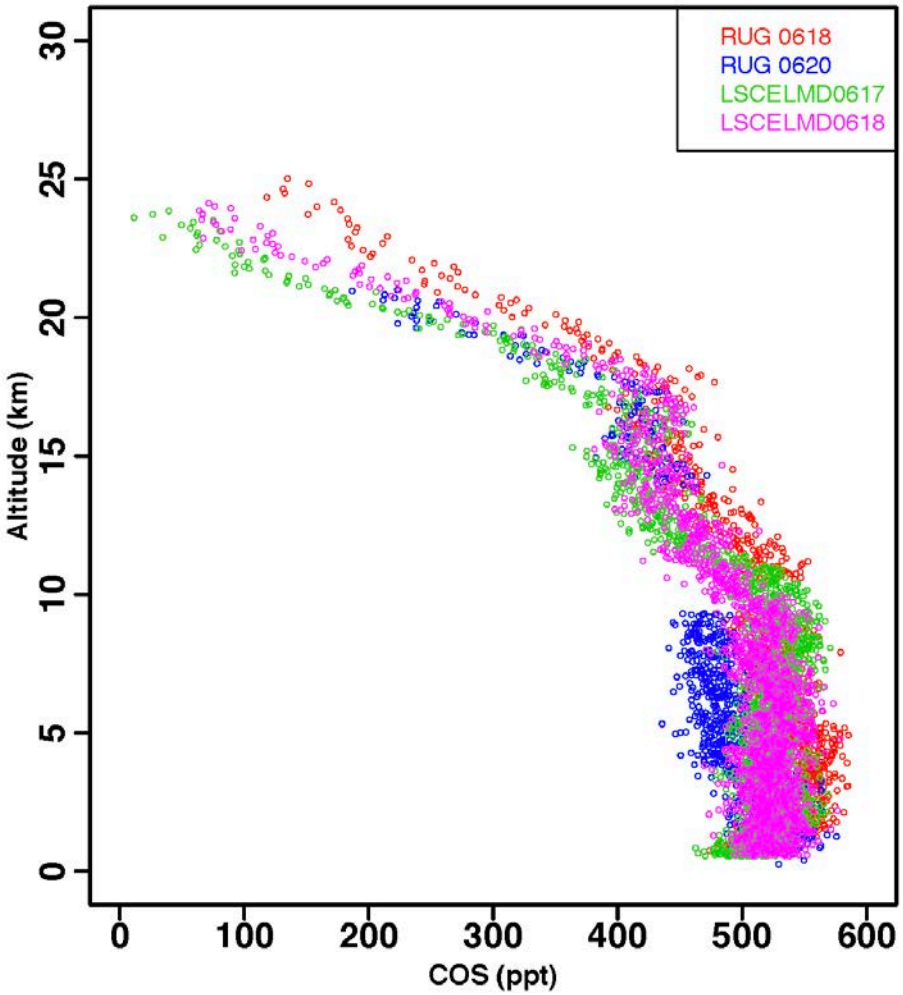
The RINGO AirCore Campaigns

- **June 10 – 21 2019**

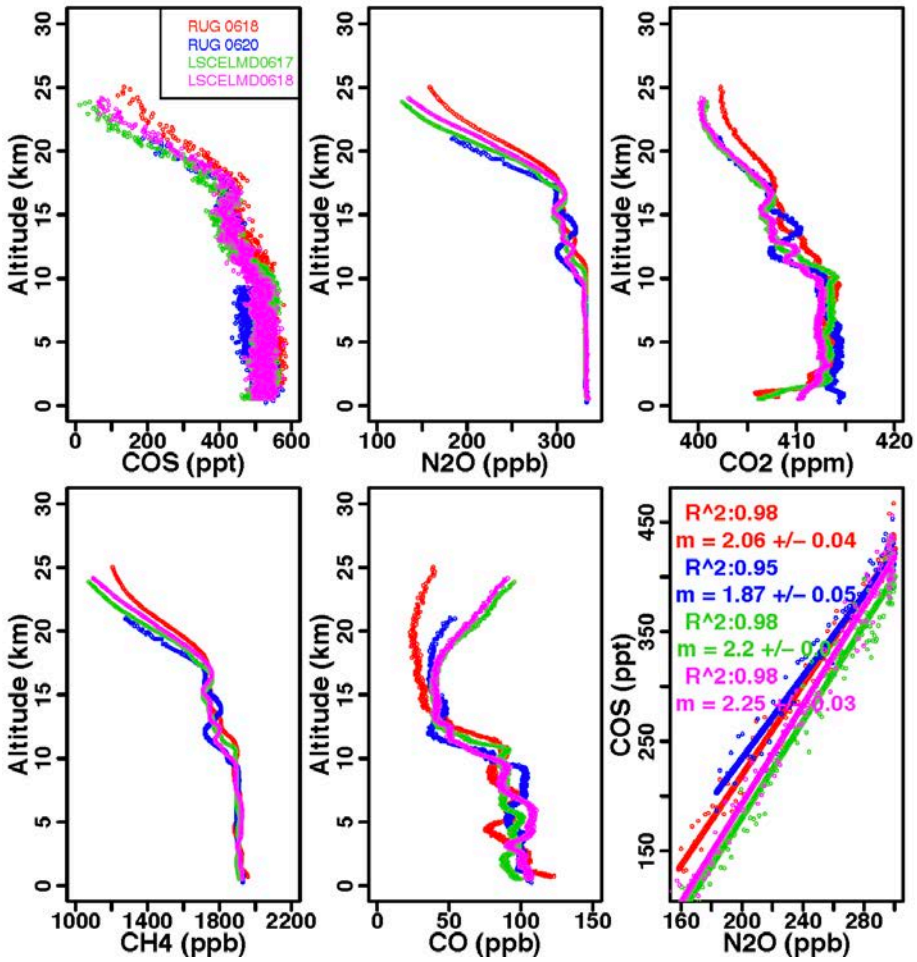
Next to TCCON/NDACC

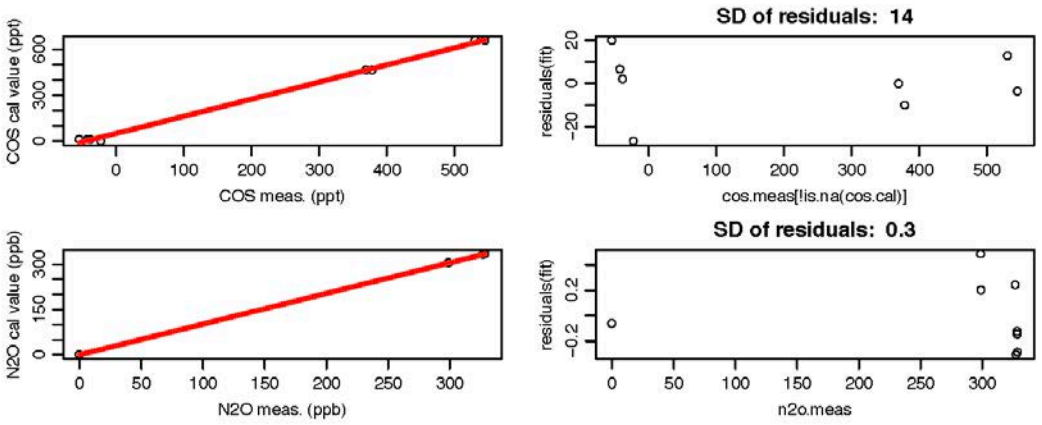
First preliminary AirCore COS profiles near Trainou





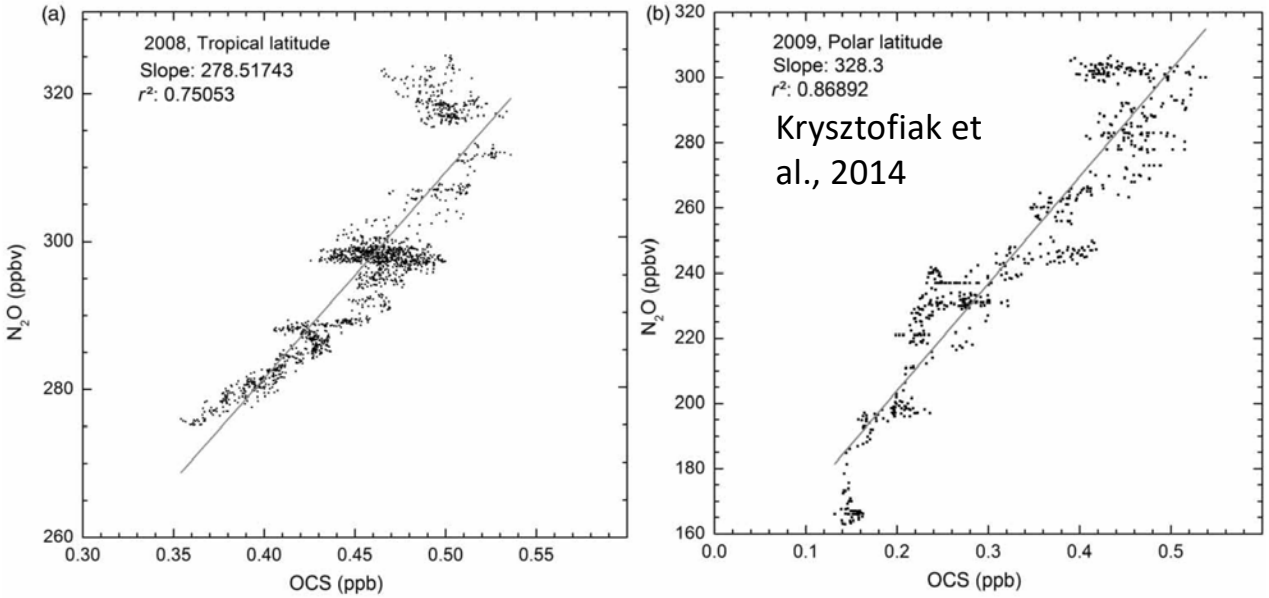
First preliminary AirCore COS profiles near Trainou





	SD COS Res. (ppt)	SD N2O Res. (ppb)	SD CO2 Res. (ppm)	SD CH4 Res. (ppb)	SD CO Res. (ppb)
RUG 0618	23	0.6	2.4	2.8	2.6
RUG 0620	18	0.3	0.7	0.9	2.9
LSCELMD0617	14	0.3	0.2	0.9	0.7
LSCELMD0618	10	0.2	0.1	1.4	0.7

Comparisons with Previous Measurements



COS/N_2O Krysztofiak et al. 2014

- Polar 3.0 ppt/ppb (R^2: 0.87)
- Tropical 3.6 ppt/ppb (R^2: 0.75)

AirCore COS/N_2O 2019

- Mid-latitude 2.10 +/- 0.17 ppt/ppb (R^2: 0.98)

Atmospheric monitoring station Lutjewad

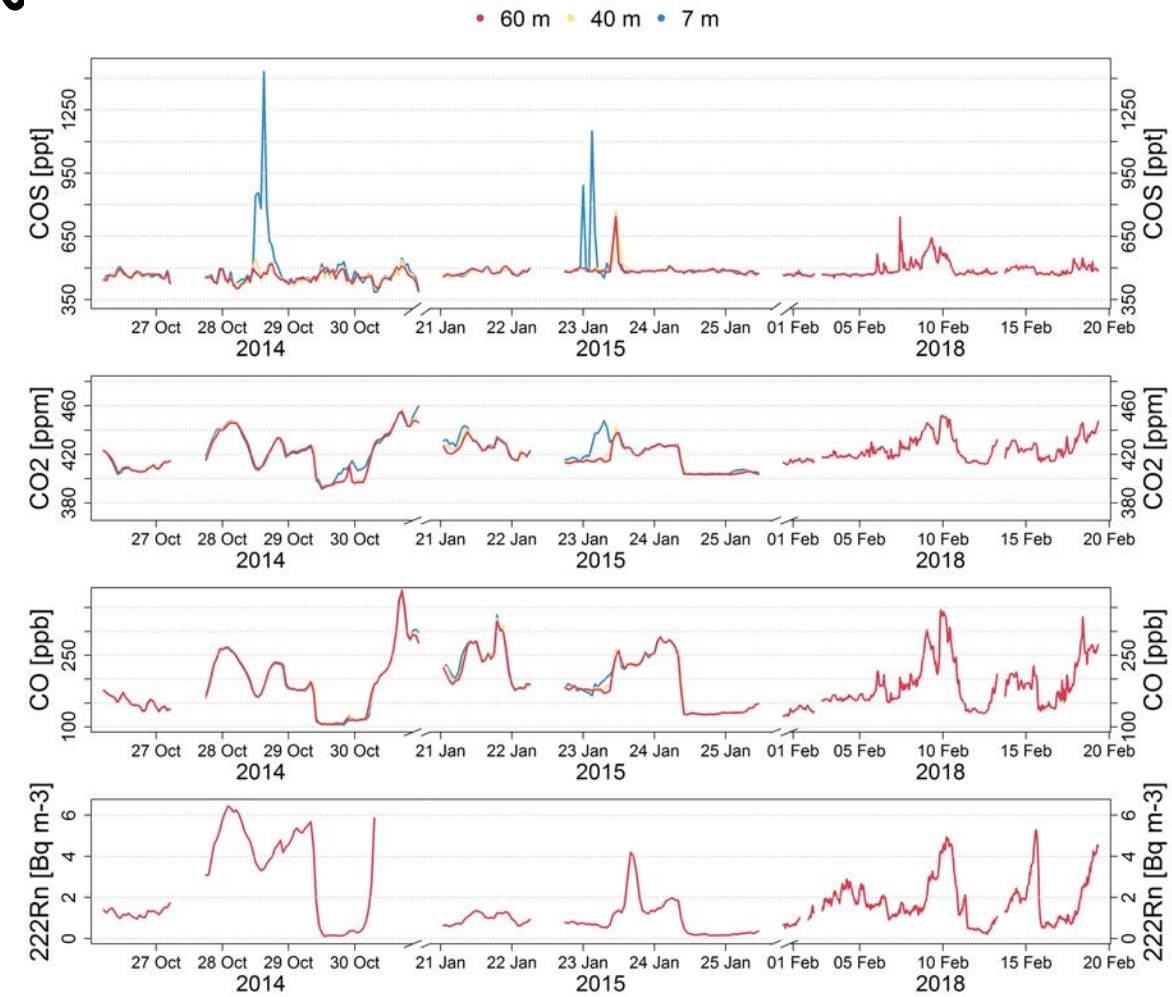
60 meter tall tower

Continuous measurements:
$[CO_2]$, $[CH_4]$, $[CO]$, $[N_2O]$,
$[SF_6]$, 14-days $^{14}CO_2$,
Recently $[O_2/N_2]$, COS

Flask sample measurements:
$[CO_2]$, $[CH_4]$, $[CO]$
$\delta^{13}C$, $\delta^{18}O$, $\Delta^{14}C$ in CO_2
O_2/N_2, Ar/N_2, COS

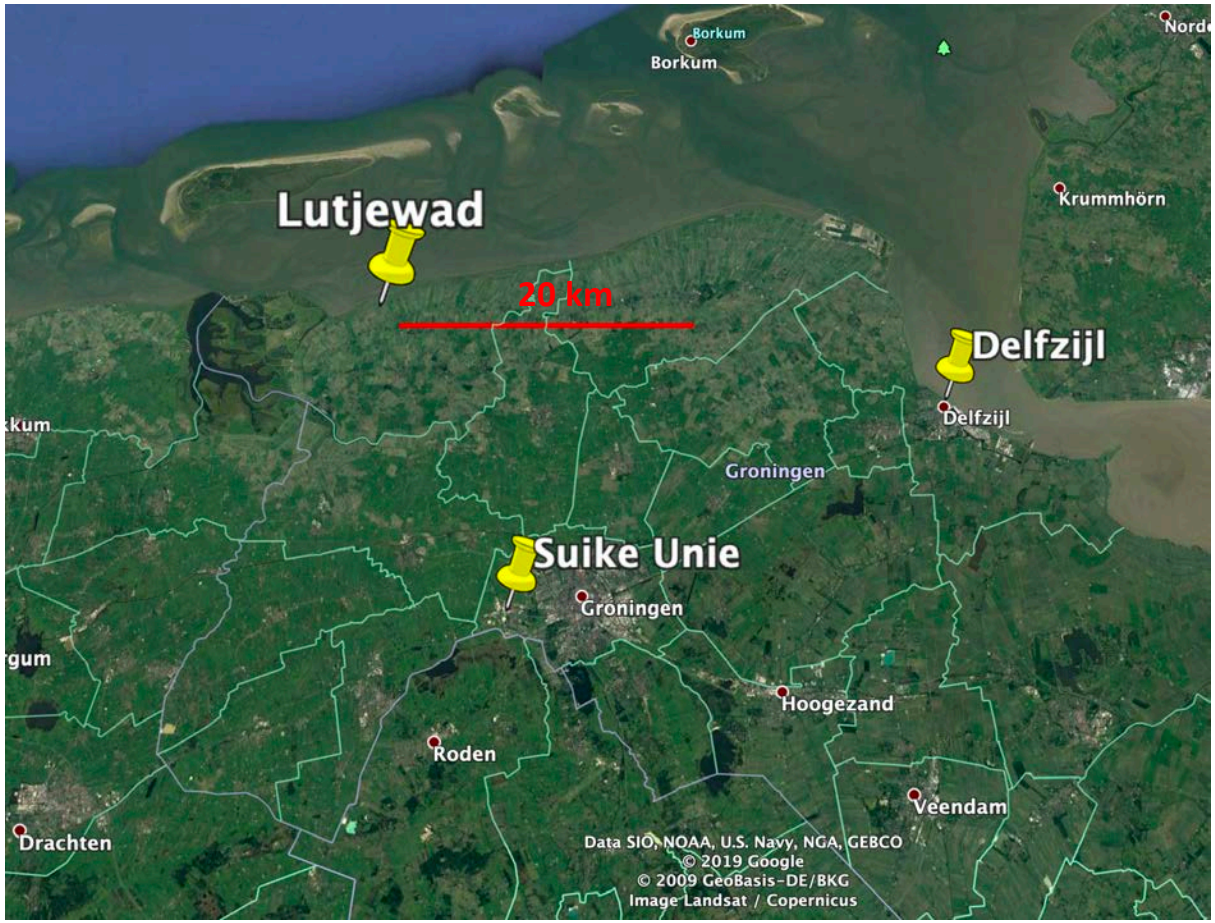
And: Radon, Meteorology continuous

Lutjewad enhanced COS measurements



Kooijmans PhD thesis

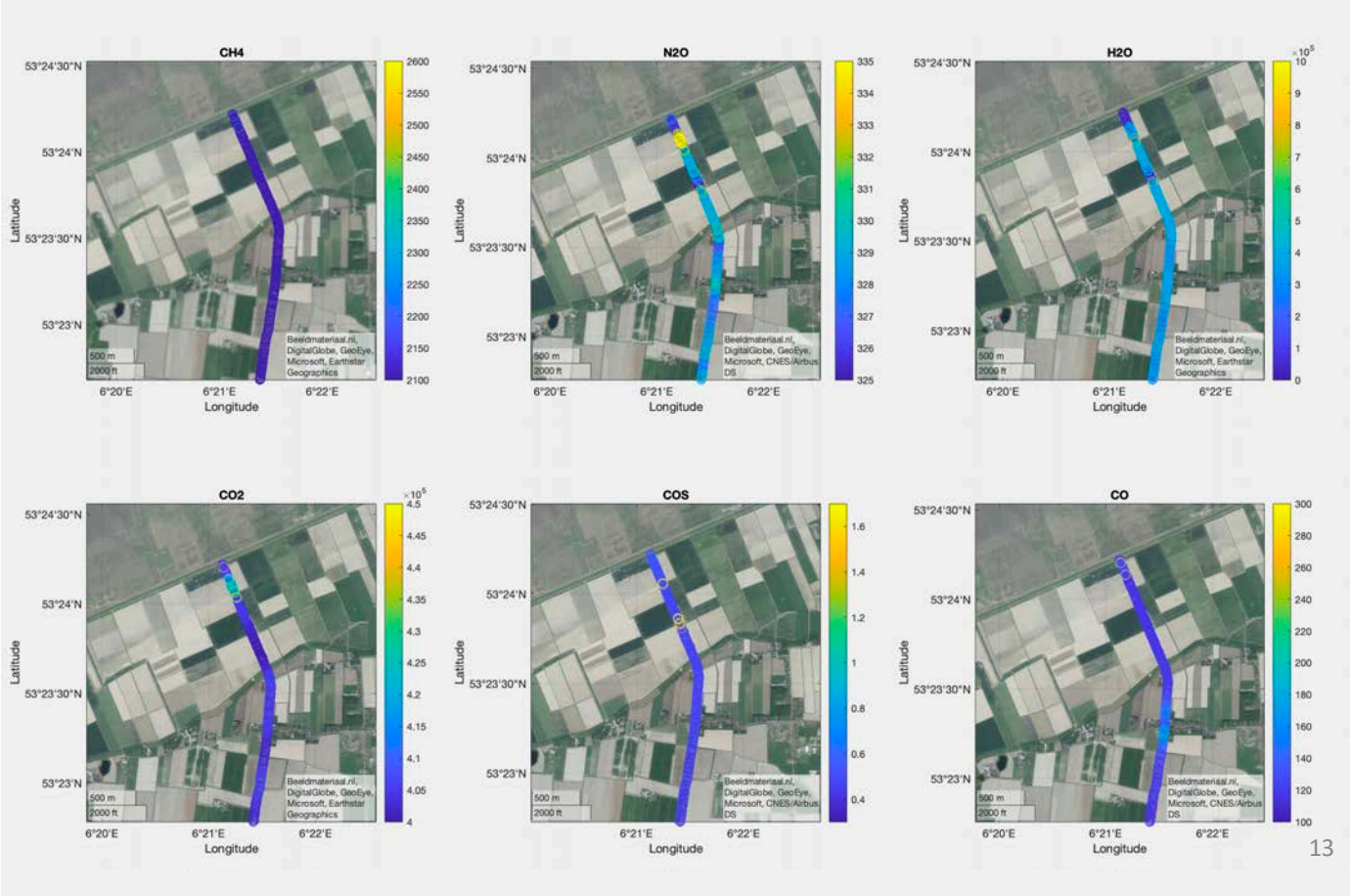
Mobile van COS measurements Groningen province



- Lutjewad
  - Ploughing
- Delfzijl
  - Indurstrial
- Suike Unie
  - Sugar production

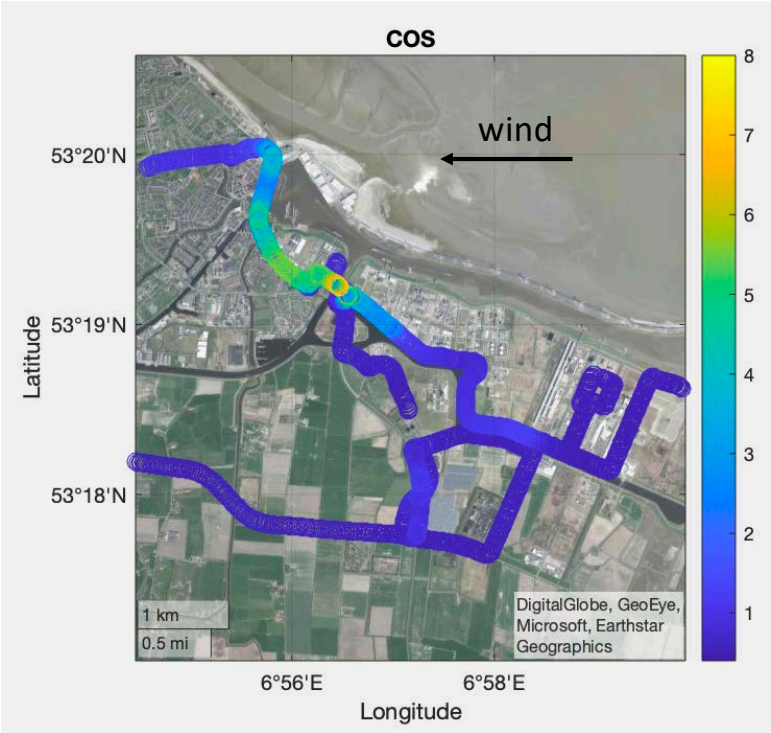
Lutjewad ploughing

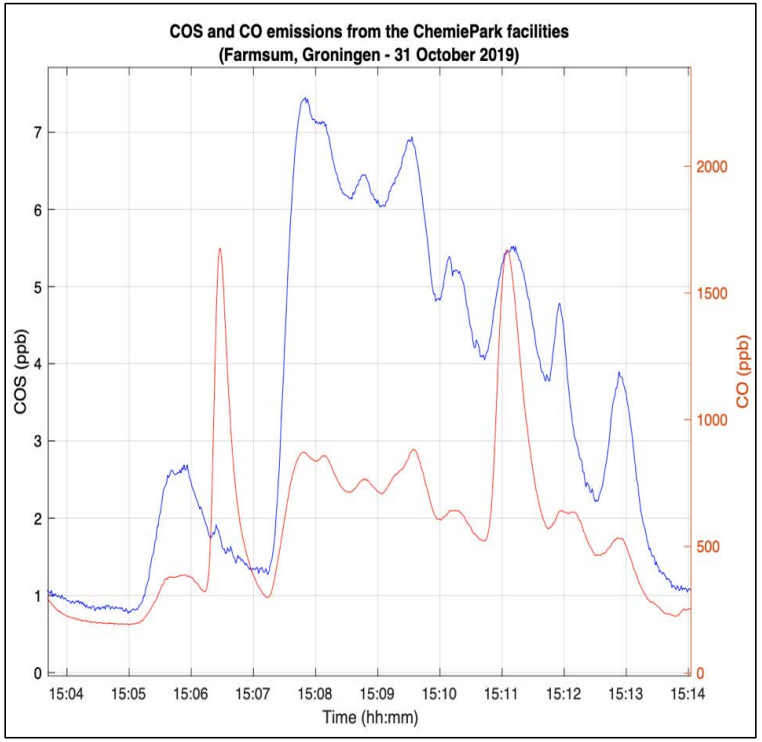
Oct 29 2019: Lutjewad



- No COS enhancements observed, but enhanced N_2O and CO_2

Delfzijl Industrial



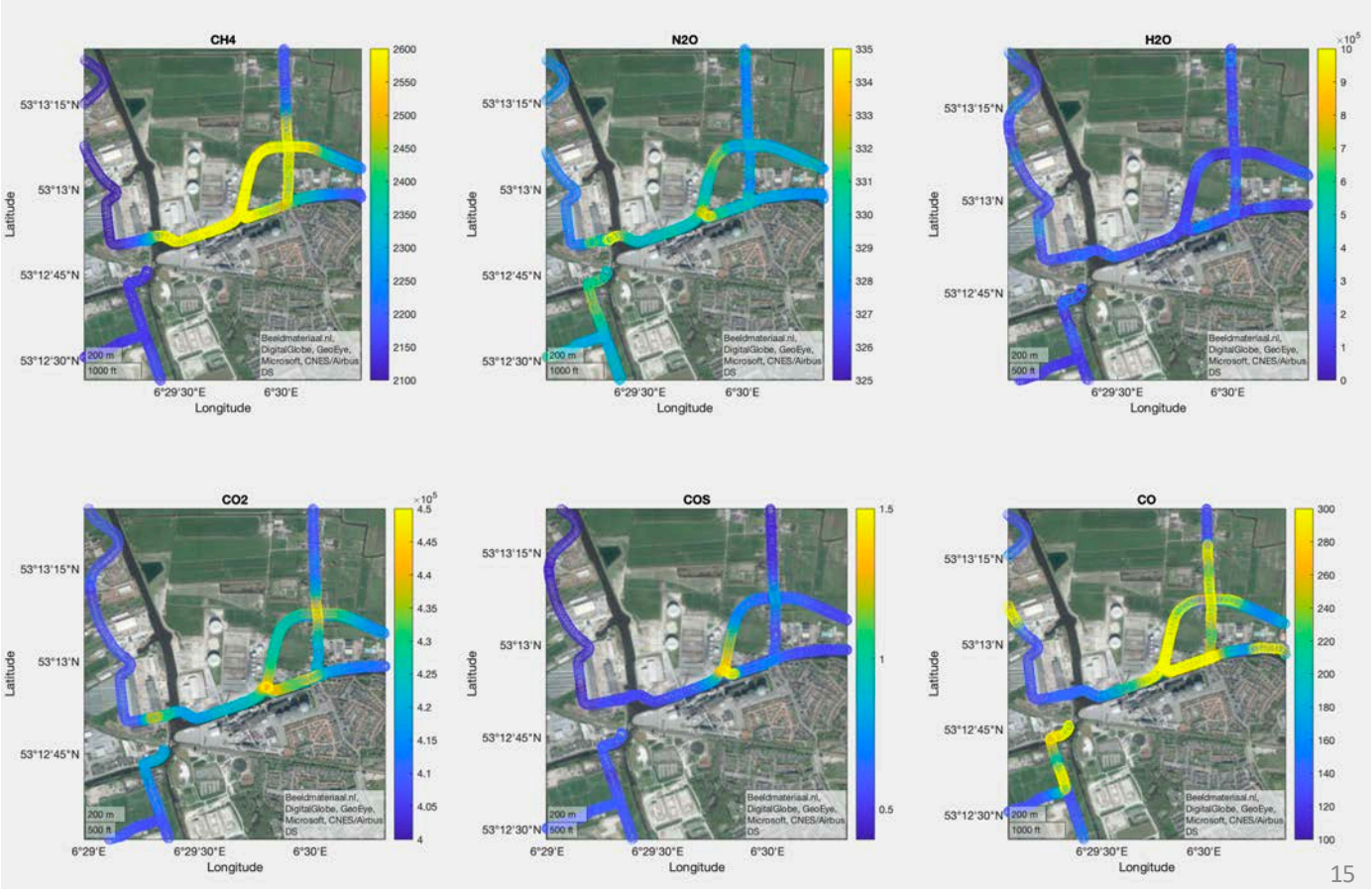


- High correlation with CO, with a ratio of 9.6 ppt(COS)/ppb(CO)

  Sources: Combined heat and power plant; metal smelting; Alloys production, waste and soil treatment; Bio-methanol production

Suiker Unie

Oct 15 2019:
SuikerUnie (Hoogkerk)



- COS enhancements observed, as well as significant CH_4 enhancements, but not colocated

RINGO 2019 Trainou Flight Overview

	Day 1 (Jun 11)		Day 2 (Jun 12)		Day 3 (Jun 16)		Day 4 (Jun 17)		Day 5 (Jun 18)		Day 6 (Jun 20)		Day 7 (Jun 21)
1	LSCE/LMD	3	GUF	6	FMI	9	GUF	15	GUF	21	LSCE/LMD	24	Ubern
2	NOAA	4	RUG , NOAA	7	FZJ	10	RUG, NOAA	16	RUG, NOAA	22	RUG, NOAA	25	NOAA
		5	Ubern	8	UBern	11	LISA	17	LISA	23	LISA	26	LSCE
						12	LSCE/LMD	18	LSCE/LMD			27	Amulse
						13	LSCE/RUG	19	LSCE/RUG				
						14	FMI	20	FZJ				

AirCores for COS

Date	Flt#	Payload	Analyzer	Species	Comments
20190617	13	LMD/LSCE	Aerodyne QCLS	COS, N_2O, CO_2, CH_4, CO	Sampling no dryer; Analysis with a dryer
20190618	16	RUG	Aerodyne QCLS	COS, N_2O, CO_2, CH_4, CO	Sampling WITH a dryer; Analysis no dryer
20190618	18	LMD/LSCE	Aerodyne QCLS	COS, N_2O, CO_2, CH_4, CO	Sampling no dryer; Analysis with a dryer
20190620	22	RUG	Aerodyne QCLS	COS, N_2O, CO_2, CH_4, CO	Sampling no dryer; Analysis with a dryer

Measurements using QCLS

Aerodyne QCLS:

– sensitive to inlet pressure variations, e.g. gas switching

– pressure control is very precise, but very slow (…)

AirCore Applications:

– low and constant sample flow rate (~50 ml/min)

– stable instrument performance during gas switching and analysis

– multiple-point calibrations of the instrument

Frontend: sample handling system

Besides this:

– high temperature sensitivity

– field deployment

Flightcase: Mobile platform

In addition:

sensitive to variations of ambient concentrations

Flushing the optics using N_2

COS Groningen staff and work overview

1. Former PhDs
   - Linda Kooijmans (2014.01-2018.06)
     - ✓ QCLS instrumentation humid air measurements, Kooijmans et al., 2016
     - ✓ Canopy COS nighttime uptake, Kooijmans et al., 2017
     - ✓ Season-long continuous LRU, Kooijmans et al, 2019
     - ❖ Sources and sinks of COS in the Netherlands
   - Wei He (PhD, 2014.05 – 2016.04)
     - CTDAS-Lagrange model development, He et al., 2018
     - ❖ CTDAS-Lagrange COS, not finished
2. Former Postdocs
   - Ivar van der Velde (2015.09-2016.05), CTDAS-Lagrange
   - Steven van Heuvan (COS-OCS, 2018.06 - 2019.03; scientific engineer 2019.04 -)
     - ✓ Built a frontend analysis system and a mobile platform for dual laser QCLS
3. Ongoing master students
   - Alessandro Zanchetta (Anthropogenic sources of COS in the Groningen province)
   - Sander Leuning (Test of O_3 on COS measurements)
   - Charlotte Tabak (AirCore + LISA for the Hemera balloon campaign Kiruna Sep 2020)
4. PhD or Postdoc vacancy (COS-OCS, to be filled, hopefully Aug-Sep, 2020)
   - ❖ AirCore COS observations