AKADEMIA GÓRNICZO-HUTNICZA
IM. STANISŁAWA STASZICA W KRAKOWIE

COAL TO CLEAN ENERGY POLICY

MRV – what do we truly know?

Metrology perspective

Jarek Necki
Dep. of Physics and Applied Computer Science
AGH – University of Science and Technology

Anatoli Smirnov
Sabina Assan

EMBER

Methane Mondays UNECE virtual 21.02.2022

MRV – what do we know?

Metrology perspective

Emissions

CH_4 area flux (kg/(m^{2}h))

CH_4 release rate (kg/h)

CH_4 mole fraction (ppm)

CH_4 release (kg)

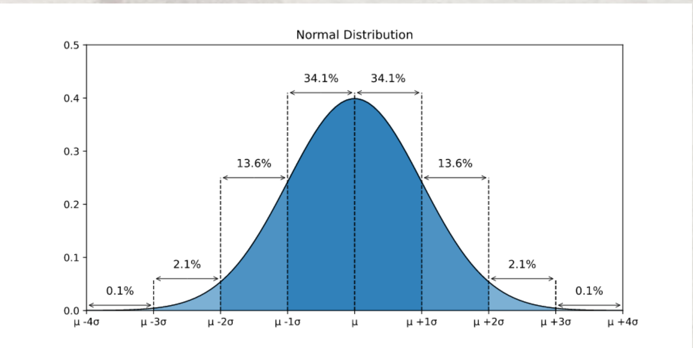
CH_4 concentration (kg/m^3)

CH_4 mixing ratio (%)

Each variable – measurement result X – is obtained with uncertainty u(X)

e.g. C = 1.2%   u(C) = 0.2%

In most cases it means that there is a 68% Chance that real value of C is between 1% and 1.4%
But still, there is 1/6 Chance that the mixing ratio is higher



M R V – what do we know?

Metrology perspective

CH_4 measurements – Precision accuracy

$$CH_4(t_i) = C(t_i)\text{Flow\_rate}(t_i)$$



Pellistor and semiconductor

https://www.draeger.com

- If, $C(t_i)$=0.3%, $F\_r(t_i)$=10000m^3/min and u(C)=0.1% and u(F_r)=100m^3/min then:
  $CH_4(t_i)$=30m^3/min , $u(CH_4(t_i))$=10m^3/min
  when aggregated to yearly **CH_4(year)=11±8kt**
  what means that any declared reduction by 20% can be true only with 50% chance!

U(C)= 0.1%

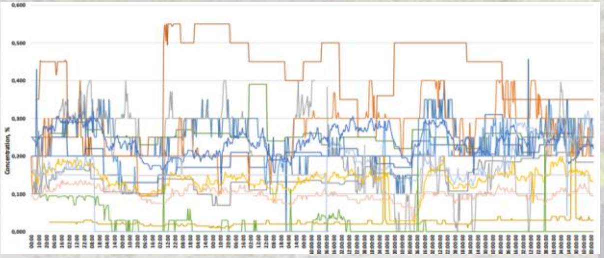
MRV – what do we know?

Metrology perspective

Uncertainty

- **What does affect the uncertainty ?**

Variability Precision Accuracy Conditions



Representativeness in time and space ?

EMBER
COAL TO CLEAN ENERGY POLICY

AGH

MRV – what do we know?

Metrology perspective

- **Different methodology for:**

Dusty

Space integration

Supersaturation, high CO_2

Incidental emissions

APEX requirements

Low mole fractions (2-200ppm)

VAM mixing ratio 0 – 2%

DM mixing ratio 40 – 100%

EMBER
COAL TO CLEAN ENERGY POLICY

AGH

MRV – what do we know?

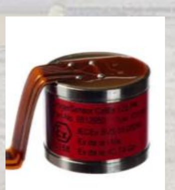
Metrology perspective

Measurements techniques

Catalytic ; Semiconductor; Optical:

DAS, TDLAS, DIAL, OGI, CEAS:

CRDS,
ICOS,
OFCEAS,...



Closed path TDLAS

Open path TDLAS

Wojcik, M., Crowther, B., Lemon, R., Valupadas, P., Fu, L., Leung, B., … Chambers, A. (2015). *Development of differential absorption lidar (DIAL) for detection of CO2, CH4and PM in Alberta. Advanced Environmental, Chemical, and Biological Sensing Technologies XII.* doi:10.1117/12.2176984

MRV – what do we know?

Metrology perspective

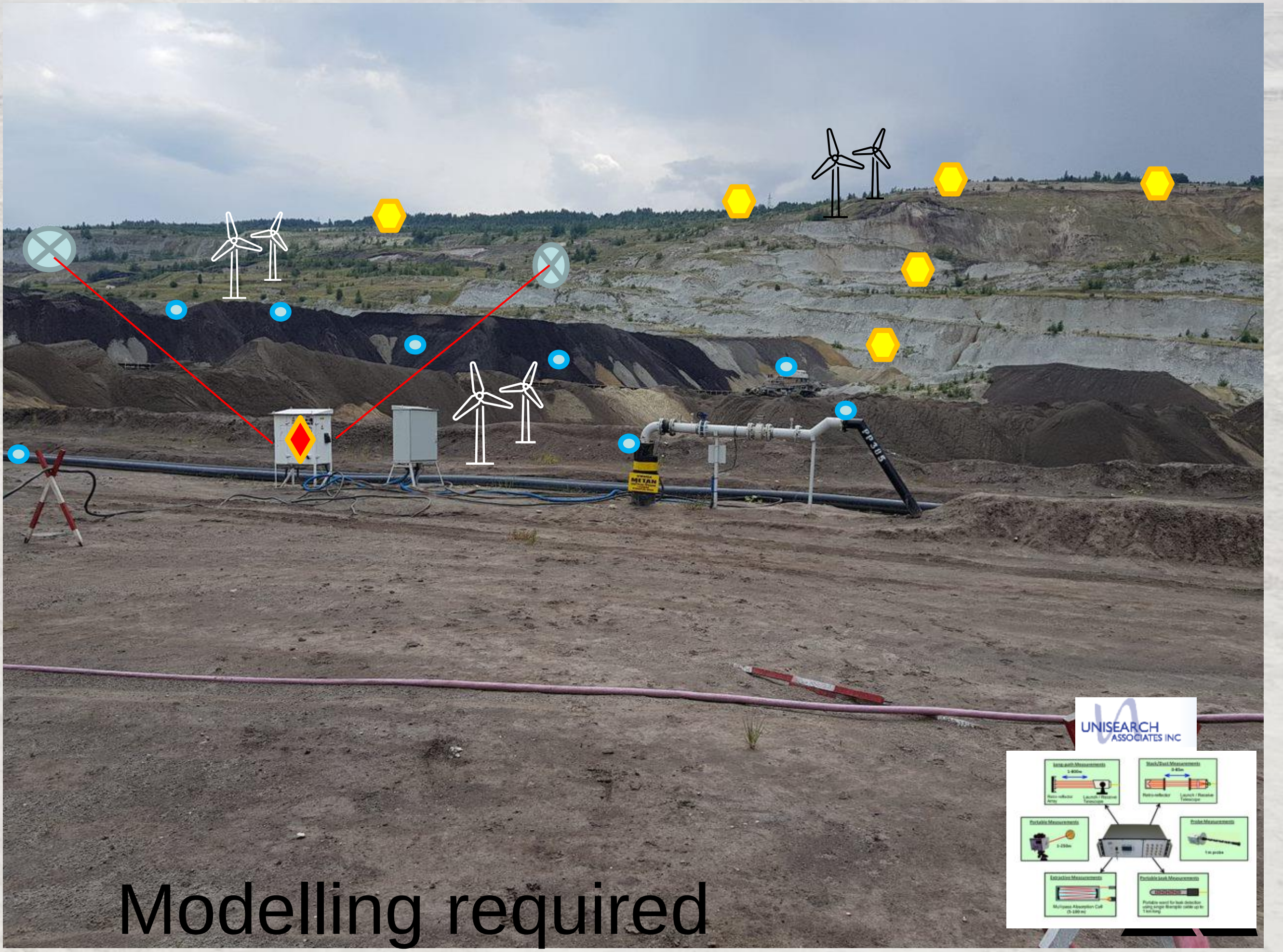
20kUSD

- **What is available?**

TDLAS – open path
1pcs
Retroreflectors
5 pcs

Low cost DAS
10pcs
with bLM or IGM

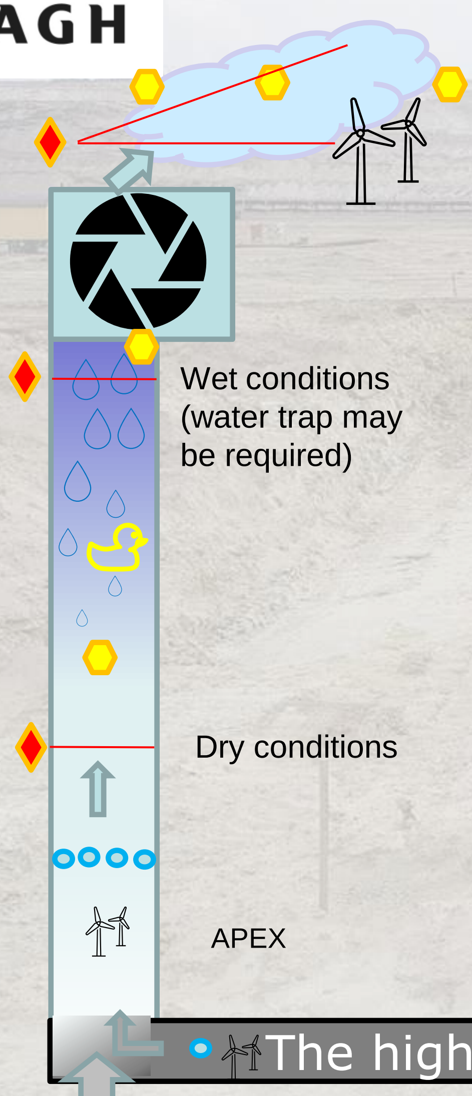
Low cost
Semiconductor Sensor
100 pcs
Anemometers 3D



MRV – what do we know?

Metrology perspective

- **Where can we measure?**



TDLAS – open path 1pcs
Retroreflectors 1 pcs

Low cost DAS 3pcs
with bLM or IGM
Anemometers 3D (lowest level and outside)

Low cost Semiconductor Sensor 10 pcs

Anemometers or Pitot tubes

Tracer release (ocassionally)

The highest gallery input

MRV – what do we know?

Metrology perspective

- **Models**

Wherever we can't do direct measurements

Lagrangian models
bLS
Follows the single particles

good for point receptor

Gaussian models
IGM
Follows the whole plume (averaged)

good for open path analyser

Mass balance
MB
Counts the mass

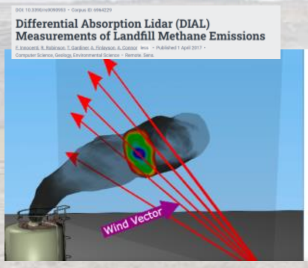
good for airborne platforms or DIAL

https://www.starspost.com/not-good-to-breathe-in-la-palma-volcano-erupts-again-with-dangerous-gas-plume/

MRV – what do we know?

Metrology perspective

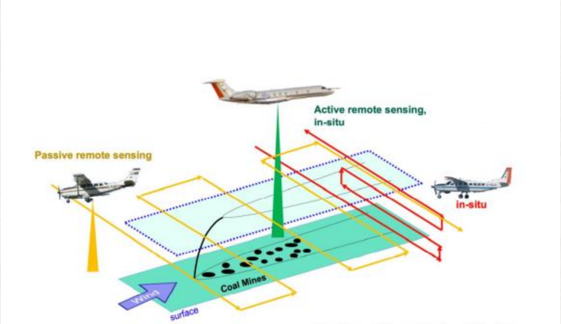
- **<u>Verification</u>**




DIAL (lidar) 0.4M$ one per country



CEAS (light, MIR) 40k$ one per institution



DIAL,CEAS (heavy, MIR), OGS (SWIR) ?$ few per continent

CEAS (mobile, MIR,SWIR)

60k$ one per institution