Low cost sUAS GHG monitoring

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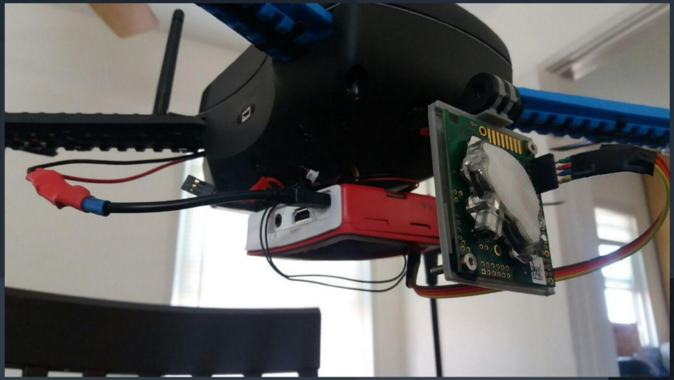

The Federation of Earth Science Information Partners
Fostering connections to make data matter

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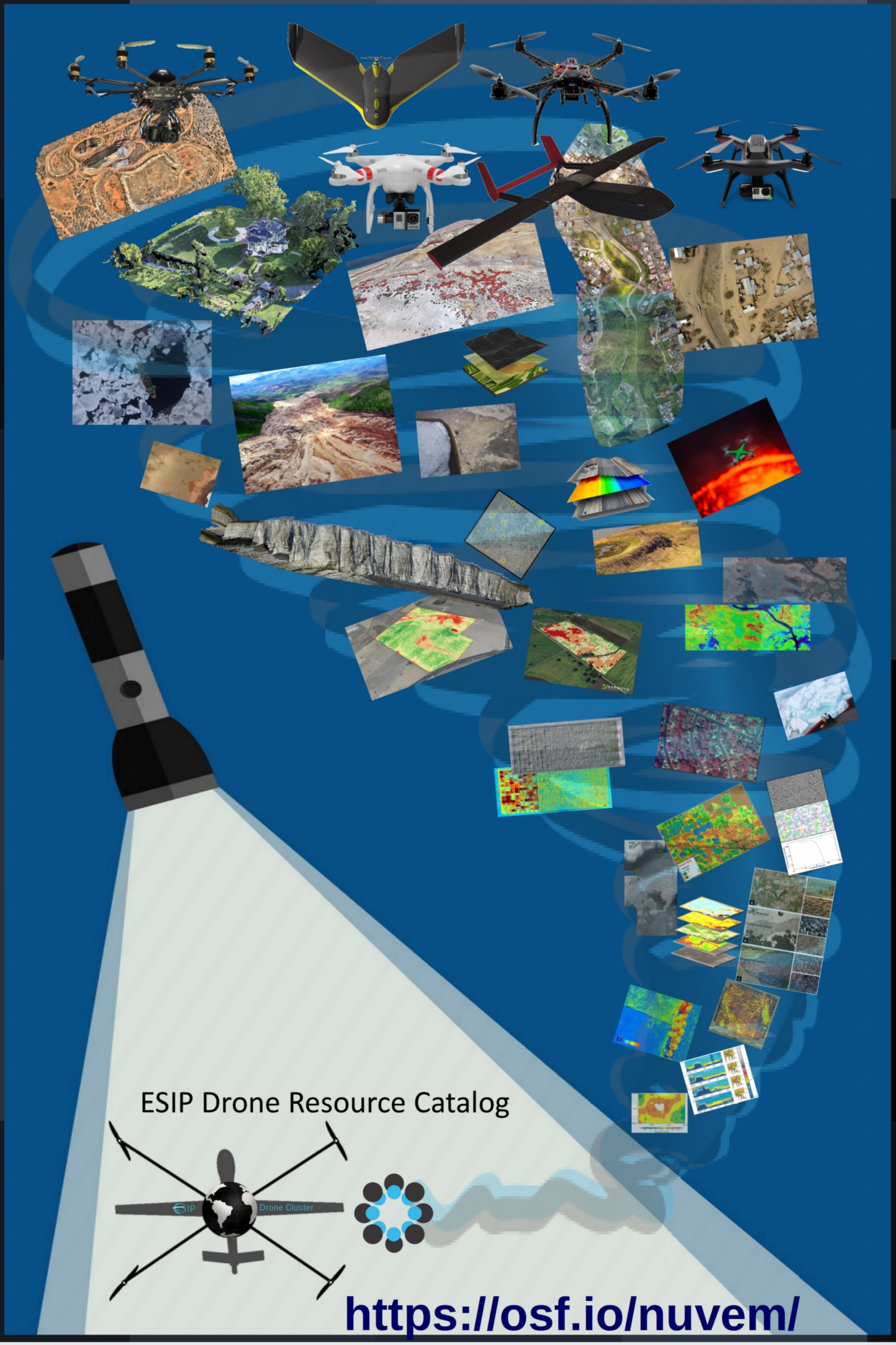
Introduction

- ESIP Drone Cluster
  - Ag GHG monitoring
  - Engineering developments
- Other ongoing work
  - CO_2 sensor platform - Max Planck
  - Climate Systems Analysis Group - UCT
    - Wind speed sampling

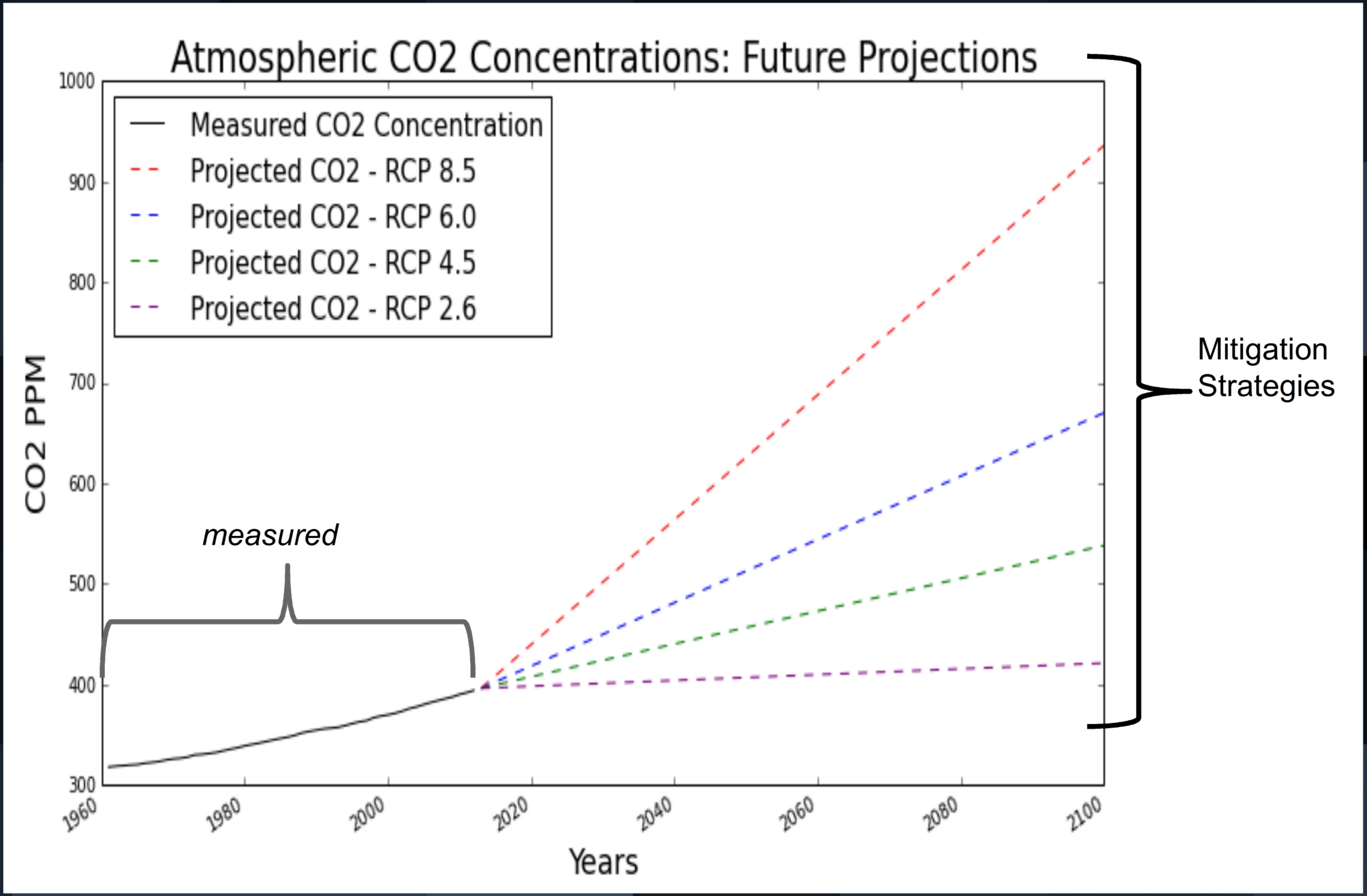
ESIP Drone Cluster

- Earth Science Information Partners (ESIP)
  - NOAA
  - NASA
- Drone Cluster
  - Started June 2015
  - Seed funding
  - Intern
  - Standards



Ag GHG monitoring motivation

Atmospheric Carbon Dioxide Levels Measured and Projected



Ag GHG monitoring motivation

Impact of Agriculture

- Ag produces 19-29% of all GHG emissions [1]
- Ag is the largest (56%) contributor of non-CO2 GHGs [1]

Table 5
Emission coefficient for agricultural residue burning.

Biomass type	CH_4	CO_2	CO	Reference
Emission factor (g/kg)				
Agricultural residue	2.70	1515 ± 177	92 ± 84	[44]
Wheat straw	7.37 ± 2.72		156 ± 22	[45]
Rice straw	5.32 ± 3.08		82 ± 20	[45]
Wheat straw	3.55 ± 2.66	1787 ± 35	28 ± 20	[43]
Wheat stubble			21.1 ± 1.9	[89]
Wheat fire			38.20	[89]
Wheat			44.1 ± 7.4	[89]
Wheat			59.00	[89]
Wheat			35.00	[89]
Cereal waste		1400	35.00	[53]
Wheat residue	2.62–8.97	959–1320	61.1–179	[86]
Wheat residue	0.59–2.04	1540–1615	26–64	[87]
Wheat straw	0.41		34.65	[88]
Default emission ratio				
Agricultural residue	0.01		0.06	[20]

agricultural activity x emissions factor = greenhouse gas estimations!

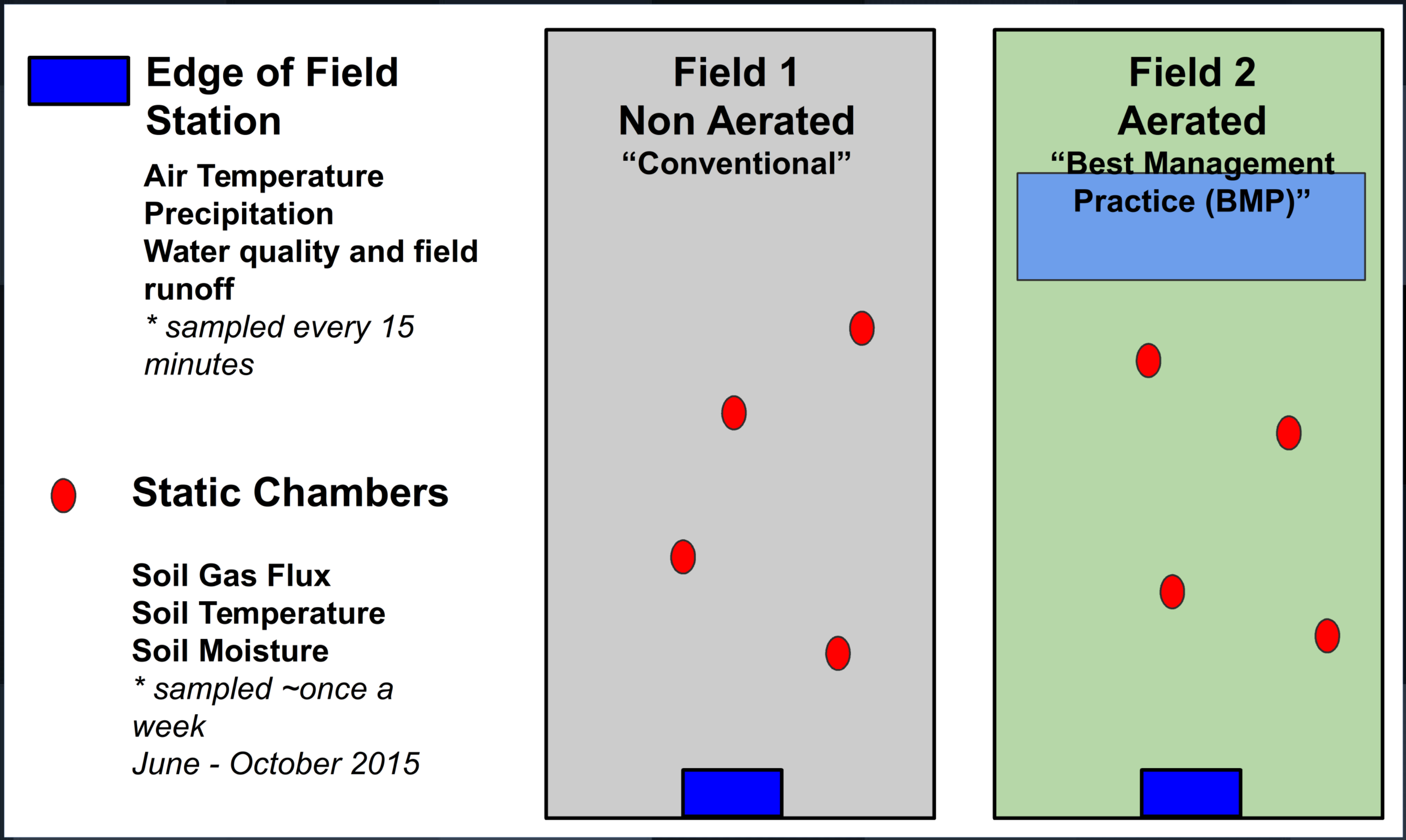
[1] US-EPA 2011, Vermaulen et al 2012

Ag GHG monitoring goals

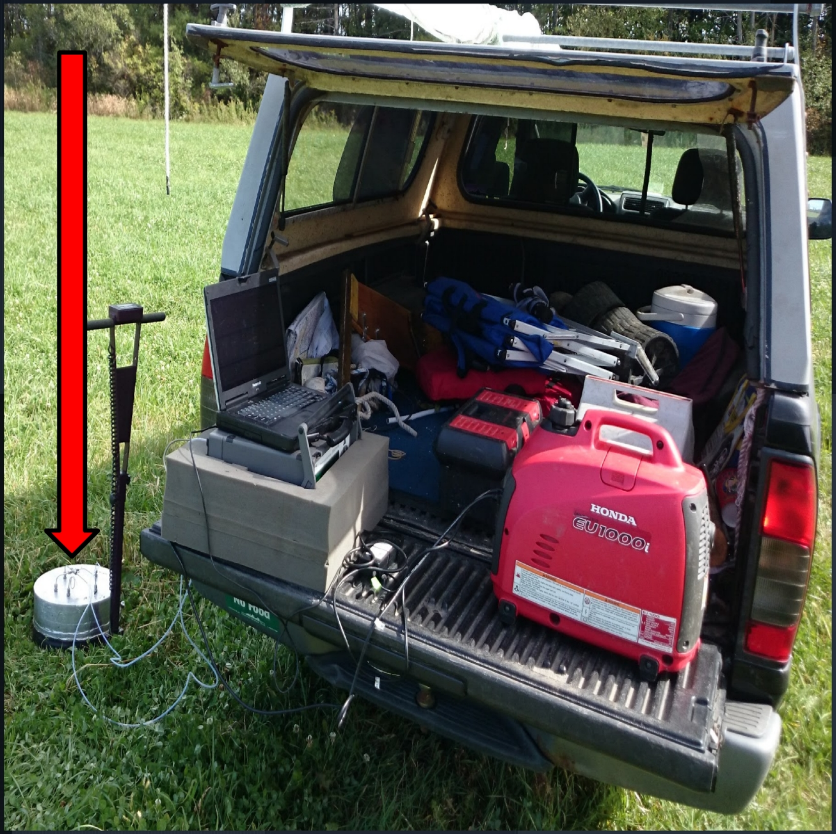
- Low cost (developed and developing world Ag sector)
- Easy to use
- Efficient
- Qualified

Sample area

Monitoring 2 hay fields



Traditional sampling method

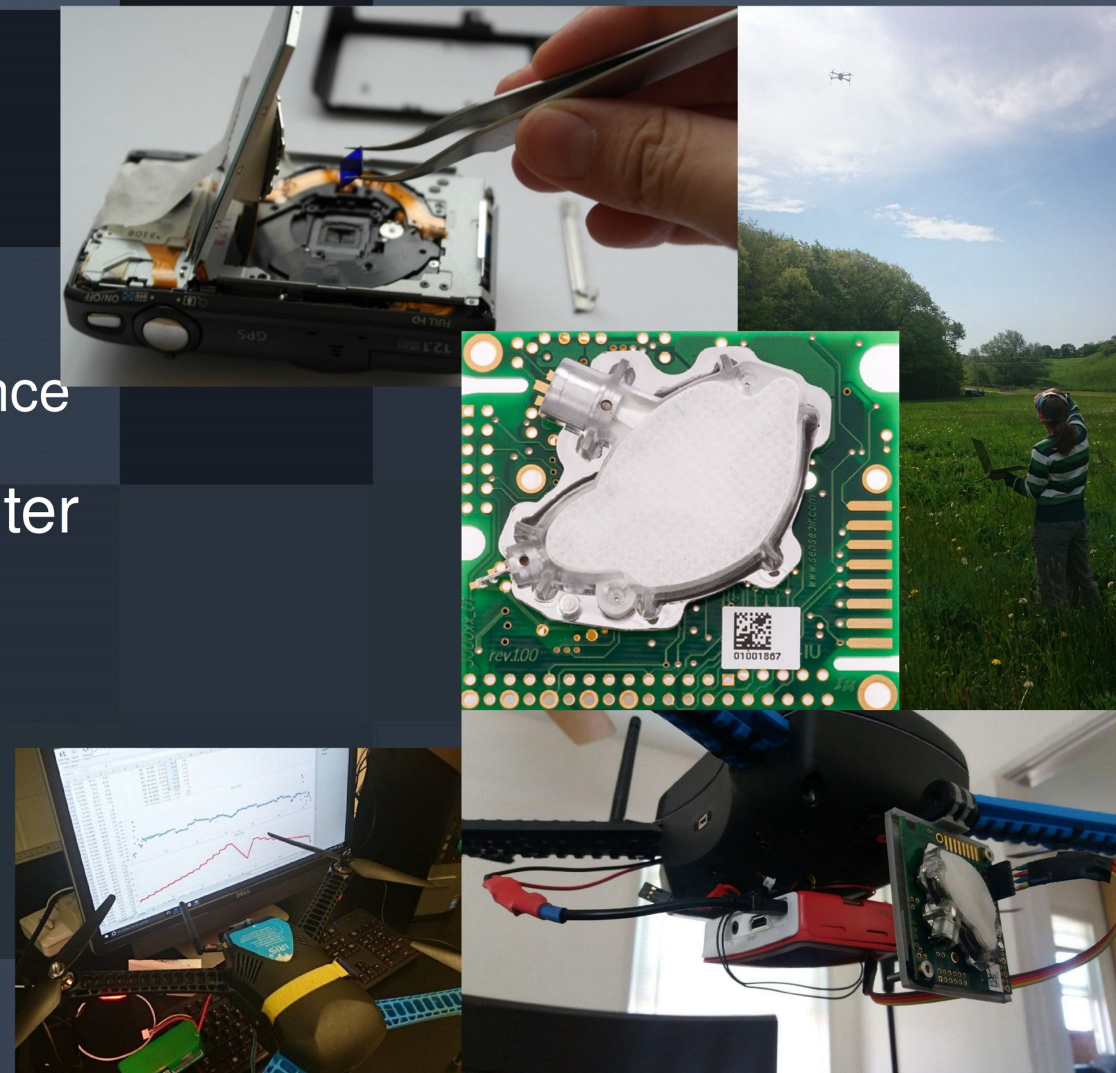


All Day Sampling Is Fun… but…

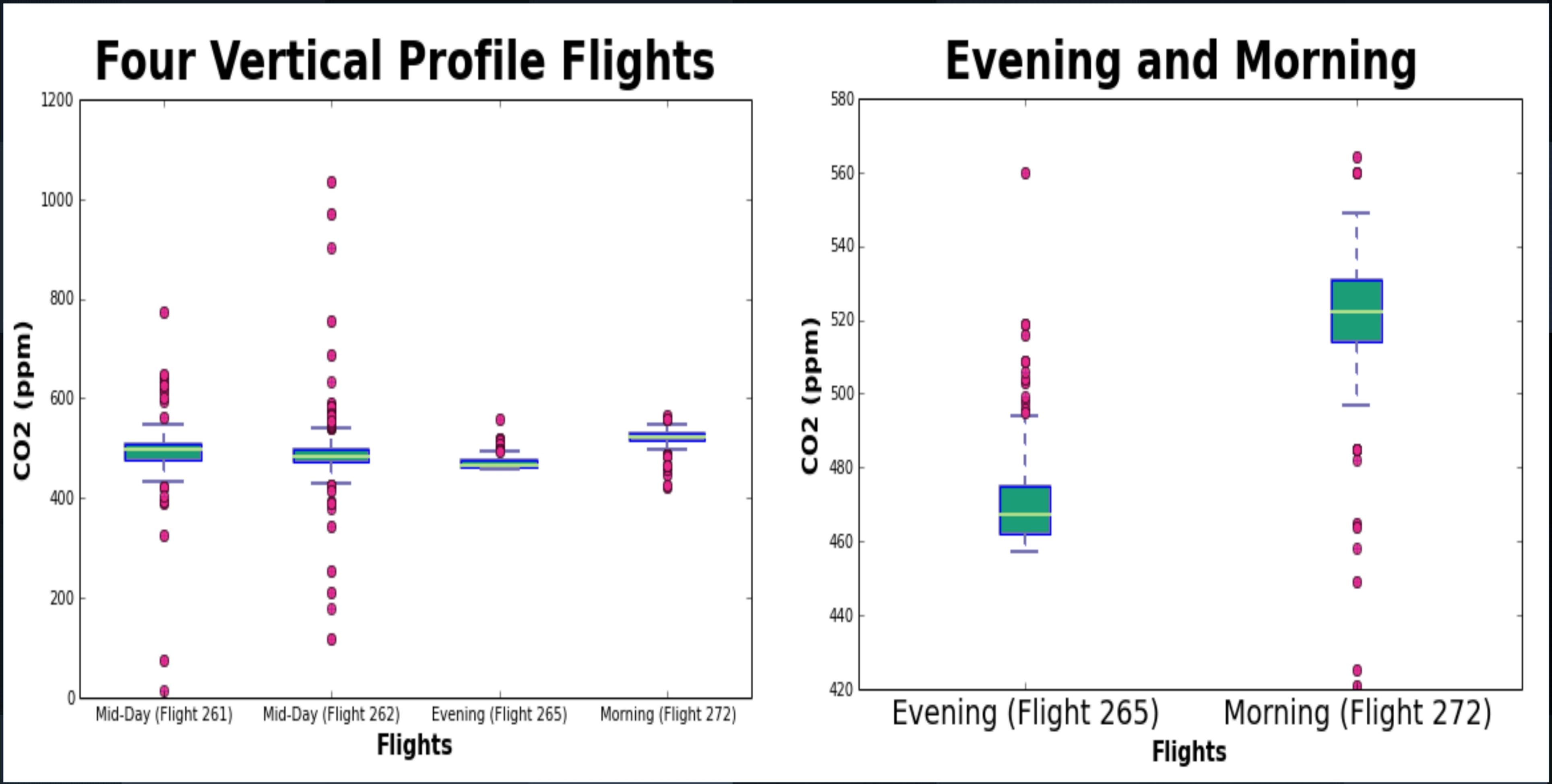
TIME CONSUMING, & expensive

sUAS Campaign1

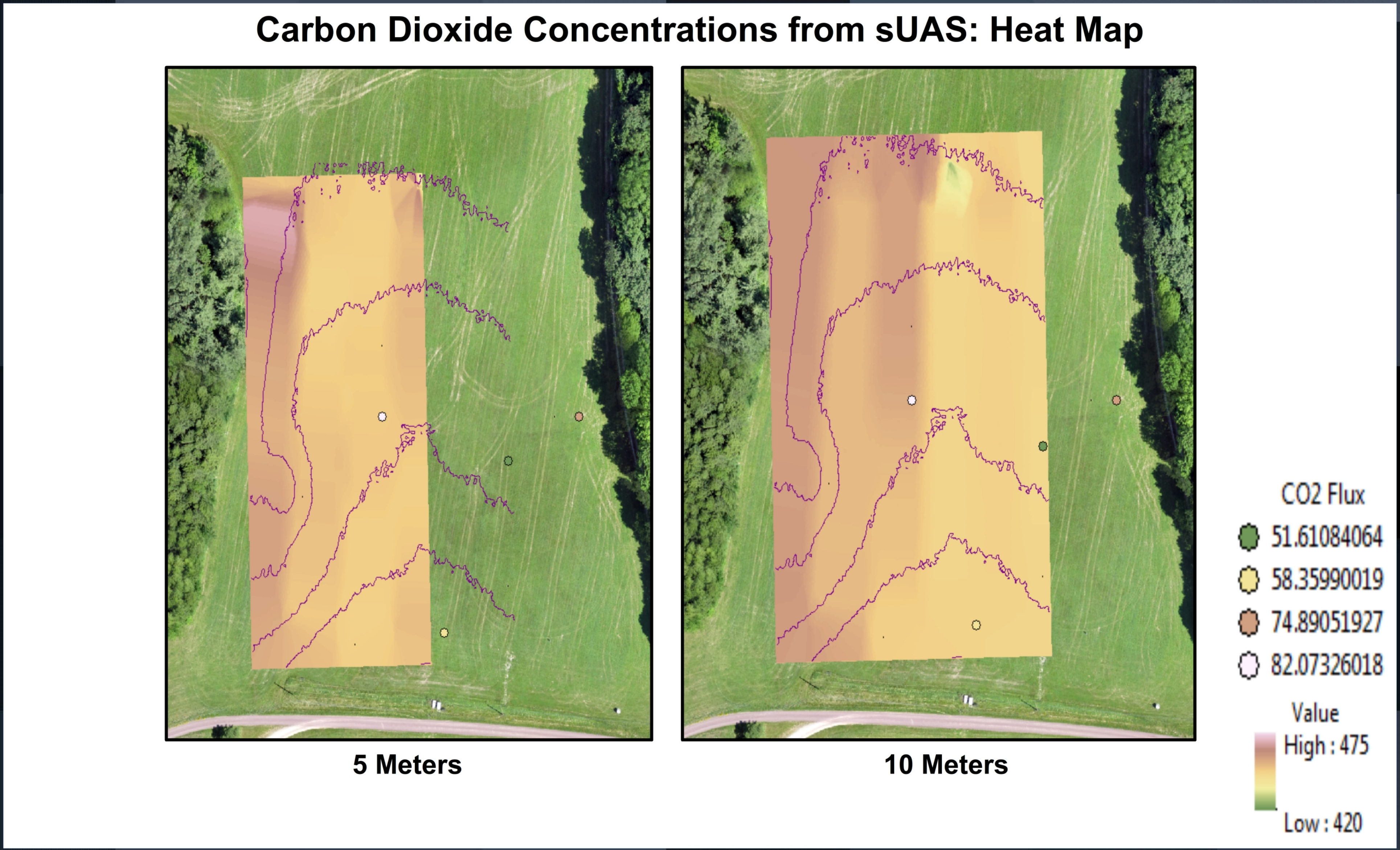
- CO2meter K33 - NDIR
  - +/-30ppm
  - 2Hz
  - Low power, “no maintenance
- Canon S100 + Optical Filter for NIR
  - 12M
  - 198g
  - Modable (NIR)
  - Hackable (CHDK)



sUAS Campaign1



sUAS Campaign1



sUAS Campaign1

Near Infrared Camera Imagery
(Open source drone)

↓

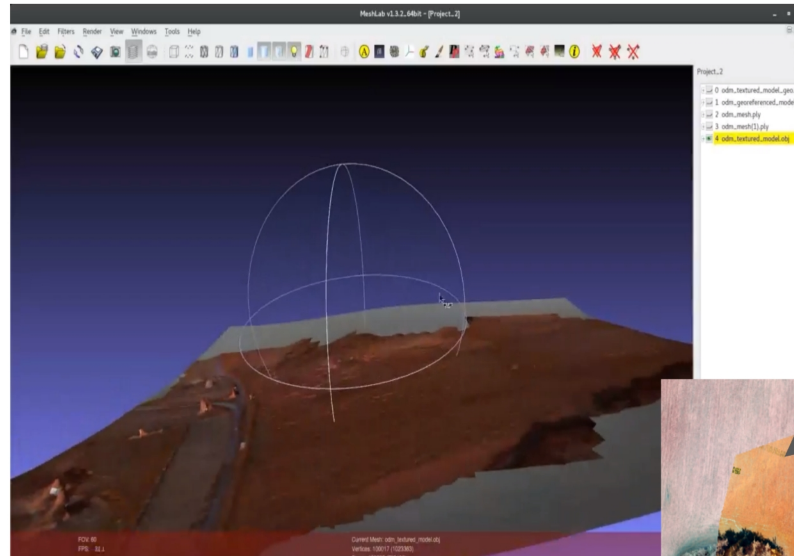
Create mesh and Mosaic
(Open Drone Map)

↓

Visualise textured mesh/point cloud
(Meshlab)

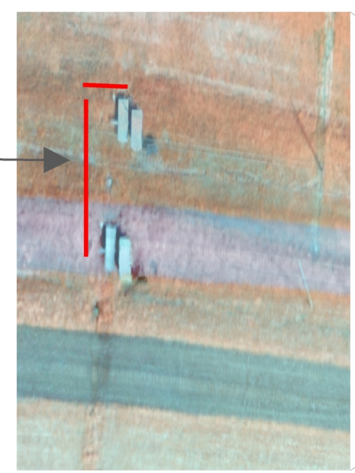
↓

Imagery Analysis!
Digital Elevation Model / NIR
(QGIS)



3D DEM

Offset:
1.3m
7.3m



TimeStamps

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Sensor calibration

- K33 shows good emissions flux rate agreement with Photoacoustic Analyzer (PAS - Picaro),
  - Absolute accuracy is off ~15-30ppm.
- CO_2 Sensor (K-30) needs to be re-calibrated at least every week
  - Possible before each flight
  - Rate of drift test not yet complete
- Temperature, pressure and humidity all need to be measured along with CO_2 and properly accounted for - iMet-XQ UAV

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Engineering outcomes

Open Data Kit flight monitoring

- Open Data Kit [ODK]
  - Aggregate server(Self host/AWS/Gdocs)
  - Customise Excel spreadsheets to create forms
  - Android app

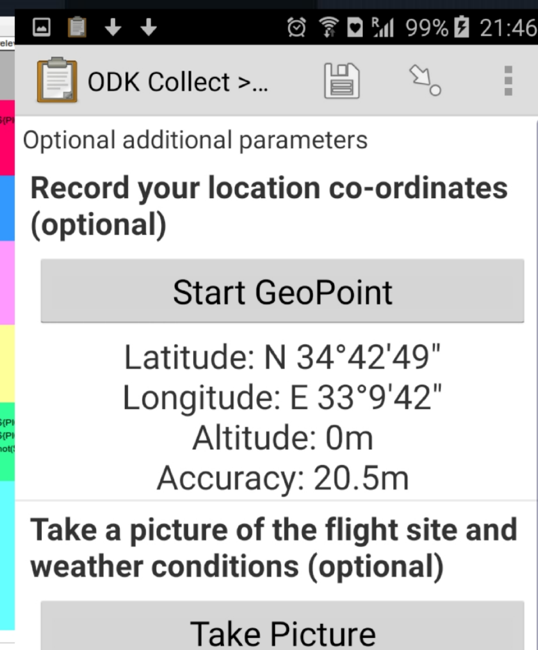
Engineering outcomes

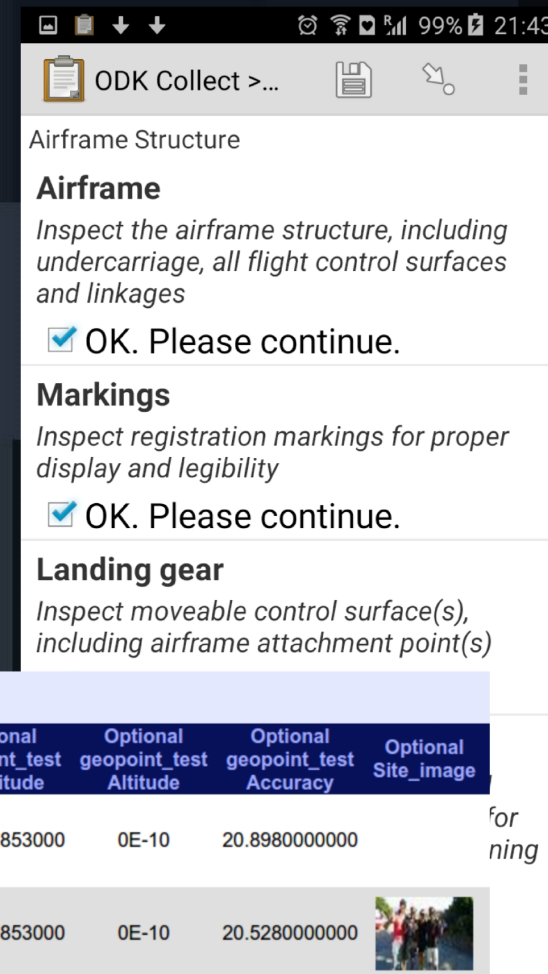
Open Data Kit flight monitoring

- Example forms
  - Preflight checklist multirotor
  - Inter-flight checklist multirotor
  - CO_2 science mission metadata
  - Battery logger
- github.com:r4space/sUAS-ODK-forms.git

Engineering outcomes

Open Data Kit flight monitoring





Previous **PilotLogBook01** Next

	Date	Meta_Time	Device_ID	PIC	Dual_Pilot PIC1	Dual_Pilot CPIC	RPA RPA_type	RPA Engines	Flight Flight_Time	Flight Remark	Optional geopoint_test Latitude	Optional geopoint_test Longitude	Optional geopoint_test Altitude	Optional geopoint_test Accuracy	Optional Site_image
✖	2017-02-21 00:00:00.0	2017-02-21 18:48:46.021	356521077244734	2	Dane	Self	Fixedwing	Multi_engine	0.4000000000	Lesson 5	34.7138000000	33.1616853000	0E-10	20.8980000000	
✖	2017-02-21 00:00:00.0	2017-02-21 18:50:40.33	356521077244734	self			Fixedwing	Single_engine	0.2000000000	Lesson8	34.7138000000	33.1616853000	0E-10	20.5280000000	
✖	2017-02-21 00:00:00.0	2017-02-21 19:12:37.346	356521077244734	self			Multirotor	Single_engine	0.2000000000	CO2 VProfile					

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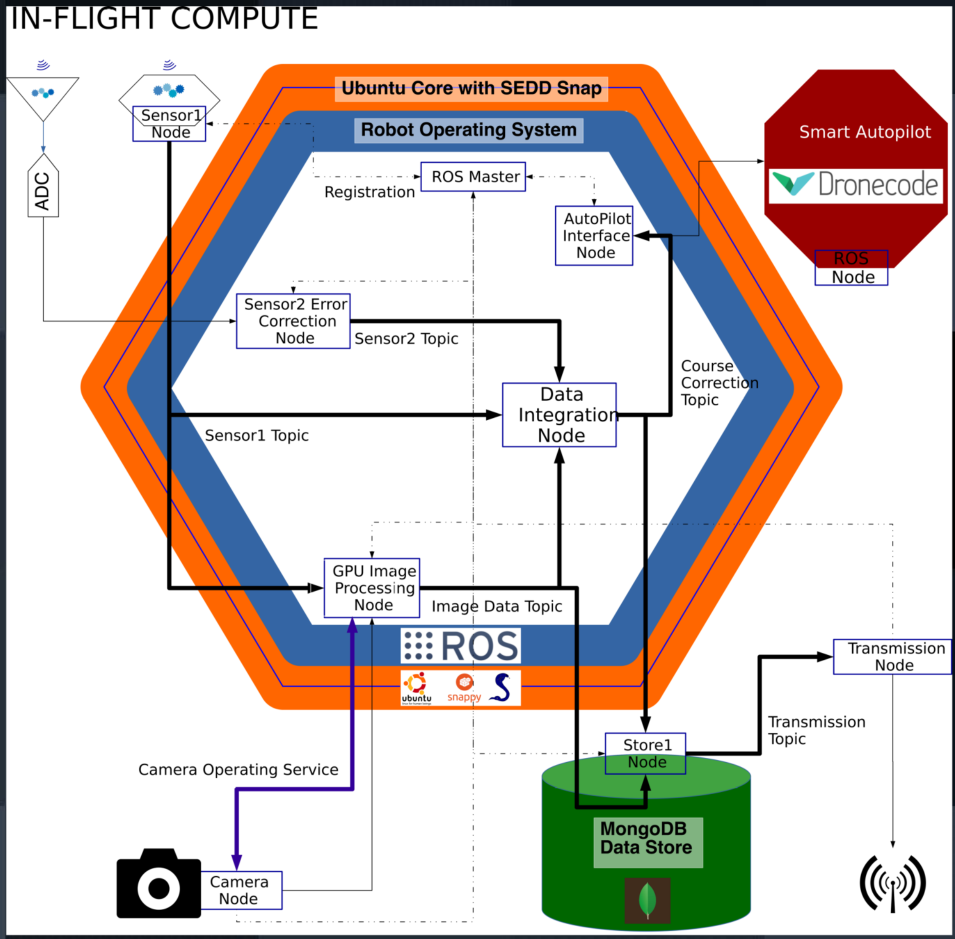
Engineering outcomes

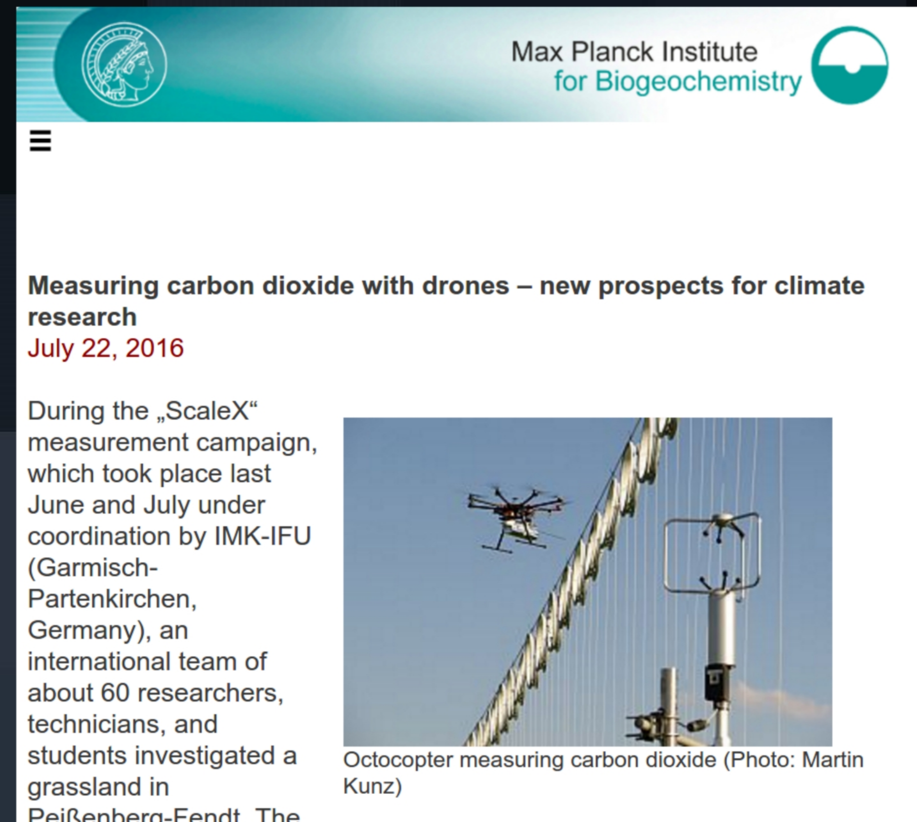
Science Standard Embedded Data infrastructure for Drones

- Ubuntu Snappy
- X-DOMES sensor repository
- ROS
- Ardupilot
- MongoDB
- Open Standards



AMS 2017

- COCAP at the Max Planck Institute for Biogeochemistry
  - CO2 analyser for sUAS
    - 1kg
    - Within 2ppm (2 calibration points per flights)
    - Temperature compensated


Max Planck Institute for Biogeochemistry

Measuring carbon dioxide with drones – new prospects for climate research
July 22, 2016

During the „ScaleX“ measurement campaign, which took place last June and July under coordination by IMK-IFU (Garmisch-Partenkirchen, Germany), an international team of about 60 researchers, technicians, and students investigated a grassland in Peißenberg-Fendt. The

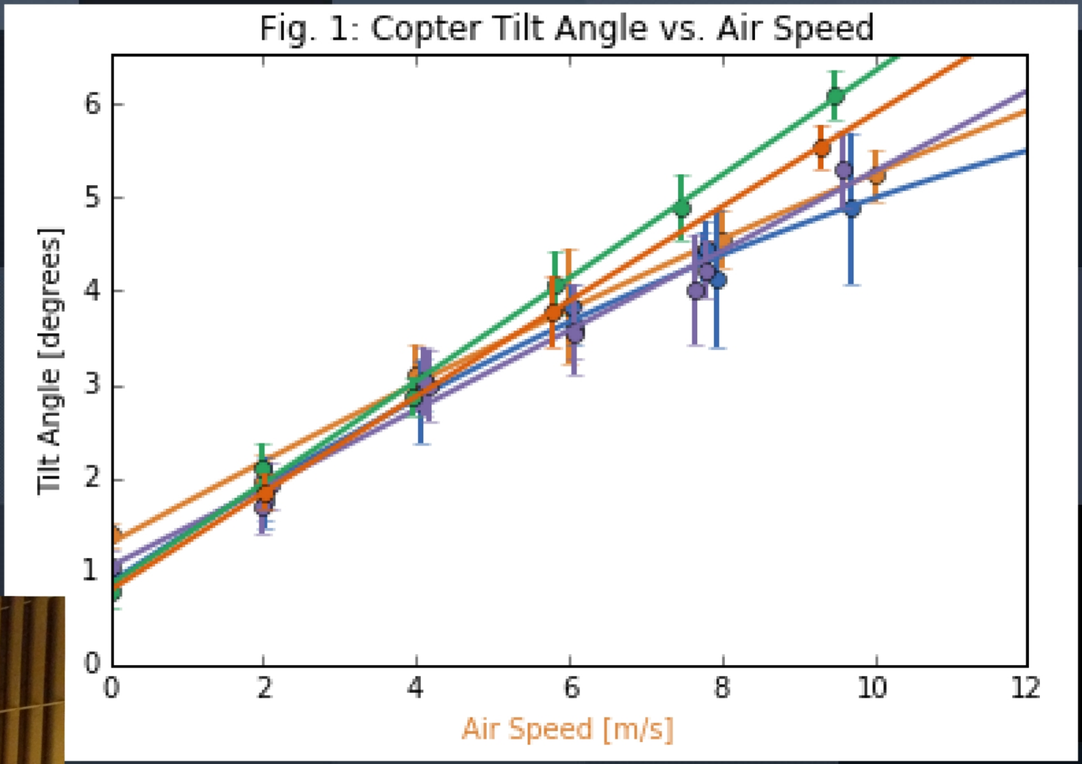
Octocopter measuring carbon dioxide (Photo: Martin Kunz)

https://www.bgc-jena.mpg.de/www/index.php/PublicRelations/NewsSingle?jahr=2016&id=1469104752

Climate Systems Analysis Group

Wind speed

- CSAG – University of Cape Town
  - Wind tunnel callibrated title angle
  - Anticipate ~<1m/s error
    - Error dependant only on IMU and Wind Tunnel error



https://github.com/rodgerduffett/rotmat

CSAG

Conclusions

- GHG sUAS monitoring ...developing…
- Open source is possible
  - Reproducible science
  - Easier to customise
  - Data is yours to publish
    - FAIR data: Finabale, Accessible, Interoperable, Reproducible
  - Lowered costs