Overview of the Mid-Atlantic Gas Emissions Quantification (MAGEQ) Campaign for Stakeholders

U.S. Greenhouse Gas Center
Stakeholder Engagement Team

What is MAGEQ?

MAGEQ is the coordination of independent missions and assets (ground-based, airborne, remote-sensing) to:

- Support and augment observations for synergistic science
- Prototype and cross-validate tiered observing strategies
- Strengthen partnerships between scientists and stakeholders

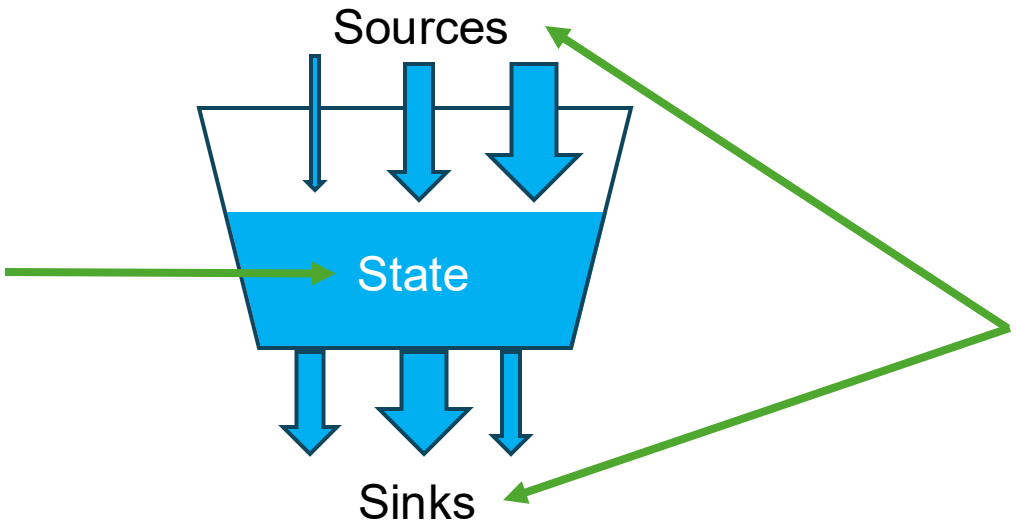
MAGEQ Objectives

1. Demonstrate and compare emission measurements in priority regions – petrochemical, urban, agricultural, and wetland
2. Provide regional context for longer-term ground observations
3. Prototype methodology for scaling from intensive ground and airborne measurements to regional, annual emission estimates
4. Deliver application-ready data to stakeholders

Near term priorities

Longer term opportunities

Normally, we measure this (e.g., gas concentration)



Sometimes, what we really want to know is this (e.g., emission rates)

Aircraft Observations and Ground Partners

Platform	Measurements	PIs
B200-FX in situ	NO_2, HCHO, O_3, CO_2, CH_4, H_2O, CO Eddy covariance fluxes	Glenn Wolfe
P-3 in situ	NO, NO_2, O_3, VOCs (WAS), CO, CO_2, CH_4, N_2O, H_2O, OCS, Aerosol composition and size	Jack Dibb
Twin Otter (TO) in situ + remote	Doppler lidar: wind profiles, PBL height In situ: NO, NO_2, NO_y, O_3, CO, CO_2, CH_4, C_2H_6	Steve Brown Xinrong Ren
G-III remote	MethaneAIR: CH_4 and CO_2 columns HALO: CH_4 column, aerosol profiles, PBL height	Amin Nehrir Steve Wofsy
B200-AV remote	AVIRIS-3: CO2/CH4 enhancements, ecosystem composition and function, water quality	Michael Eastwood Rob Green
A90 remote	G-LiHT: Ecosystem composition, 3D structure and function at meter-scale resolution	Bruck Cook
Ground	Pandora: NO_2 and HCHO columns, profiles TOLNET: O_3 profiles EM-27: CO_2, CH_4 columns NIST Urban testbed DOE CoURAGE NOAA, JHU Mobile Labs	Tom Hanisco John Sullivan Jason St. Clair Anna Karion Ken Davis Pete DiCarlo

JHU

DEPLOYMENT SCHEDULE

	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su
	6/22	6/23	6/24	6/25	6/26	6/27	6/28	6/29	6/30	7/1	7/2	7/3	7/4	7/5	7/6
B200-FX	SARP East							SARP West							
P-3		SARP East						SARP West							
Twin Otter															
B200-AV															
G-III															
A90-GLiHT															

Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th
7/7	7/8	7/9	7/10	7/11	7/12	7/13	7/14	7/15	7/16	7/17	7/18	7/19	7/20	7/21	7/22	7/23	7/24	7/25	7/26	7/27	7/28	7/29	7/30	7/31
VAMOS																								
MAGEQ																								
AIRMAPS/BAQMS																								
																		MAGEQ						
																		APMAC						

Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr
8/1	8/2	8/3	8/4	8/5	8/6	8/7	8/8	8/9	8/10	8/11	8/12	8/13	8/14	8/15
MidFlux														

GDrive: MAGEQ/Operations/MAGEQ Mission Tracking

Fellowship of the Wing

Overlap Periods

Period	B200-FX	P-3	G-III	B200-AV	TO	A90
June 22 – 26	x	x				
July 7 - 15	x	x	x	x	x	
July 16 - 31		x	x	x	x	
August			x			x

B200-FX @ 0.5 – 10 kft
Gases + fluxes
In situ

TO @ 1 – 10 kft
Gases + wind profiler
In situ

P3 @ 0 – 25 kft
Gas + aerosol
In situ

B200-AV @ 28 kft
Atmos + ground
remote sensing

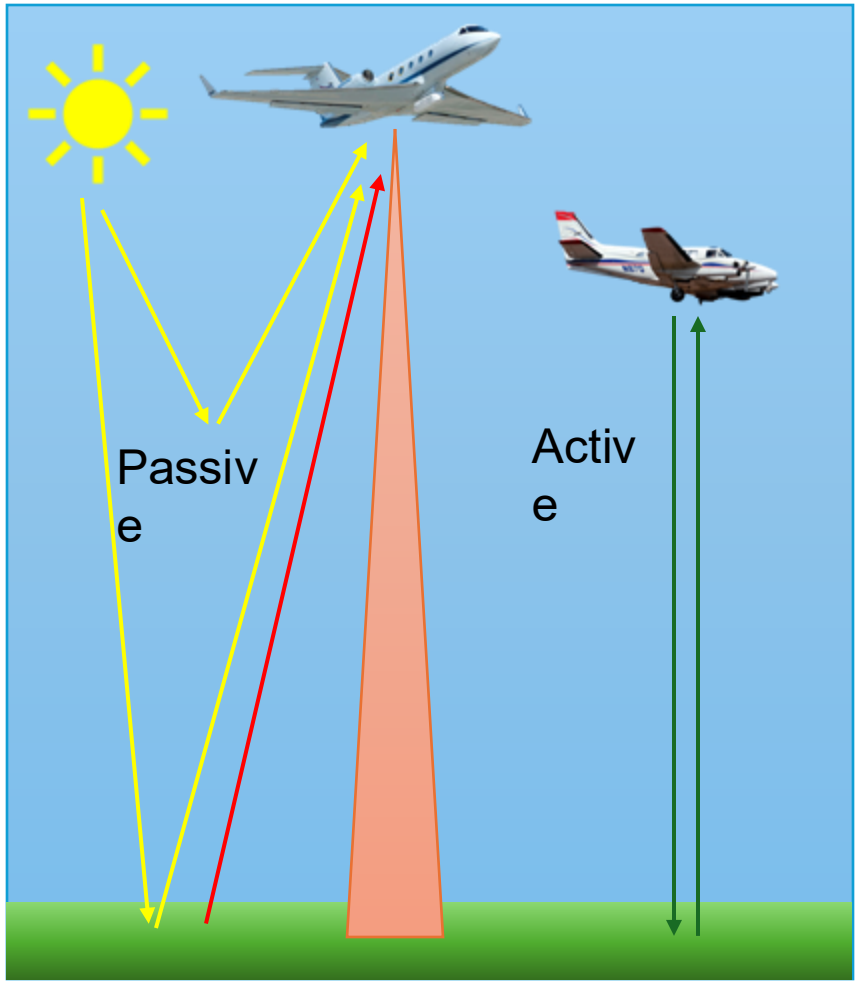
A90 @ 1 kft
Vegetation
remote sensing

GIII @ 42 kft
Atmosphere
remote sensing

Measurement Techniques

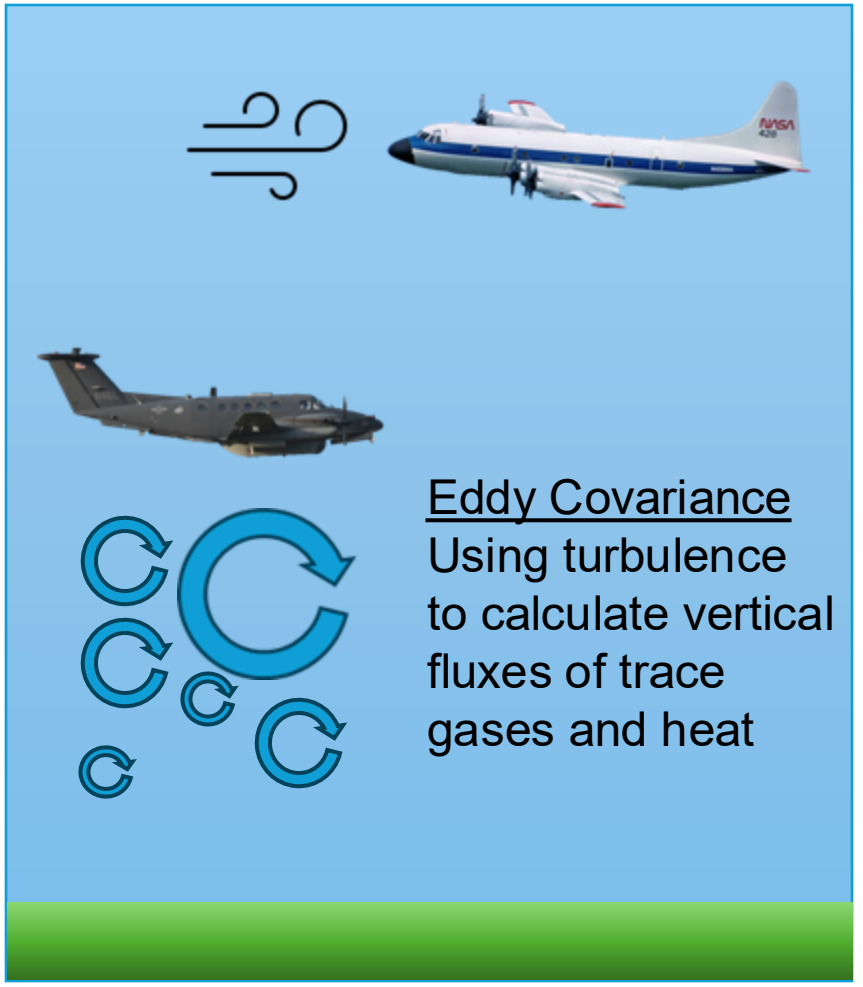
<u>Remote Sensing</u>

Measuring scattered and reflect light (UV, visible, infrared) to infer surface and atmosphere properties



<u>In Situ</u>

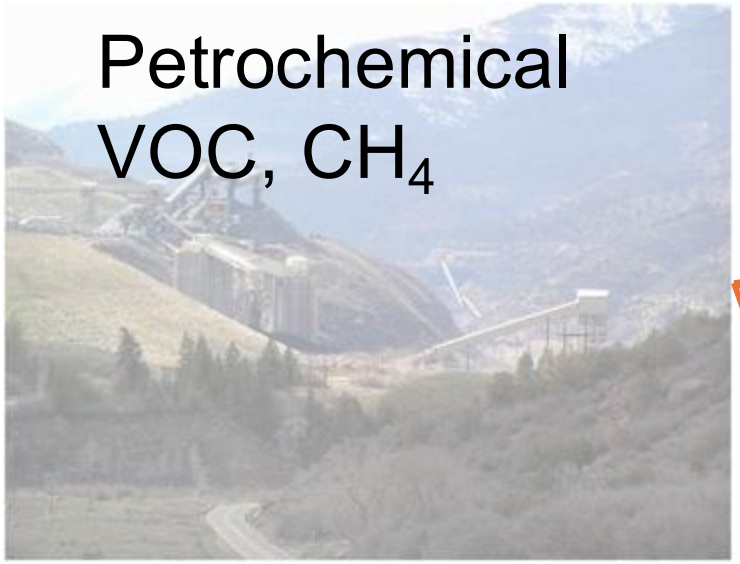
Measuring atmospheric state (gas concentrations, aerosol properties, meteorology) where the plane is



<u>Eddy Covariance</u>

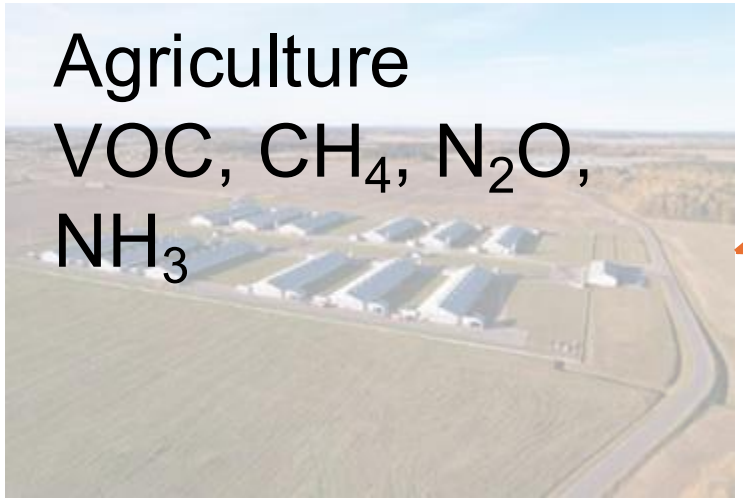
Using turbulence to calculate vertical fluxes of trace gases and heat

Mid-Atlantic Emission Sectors

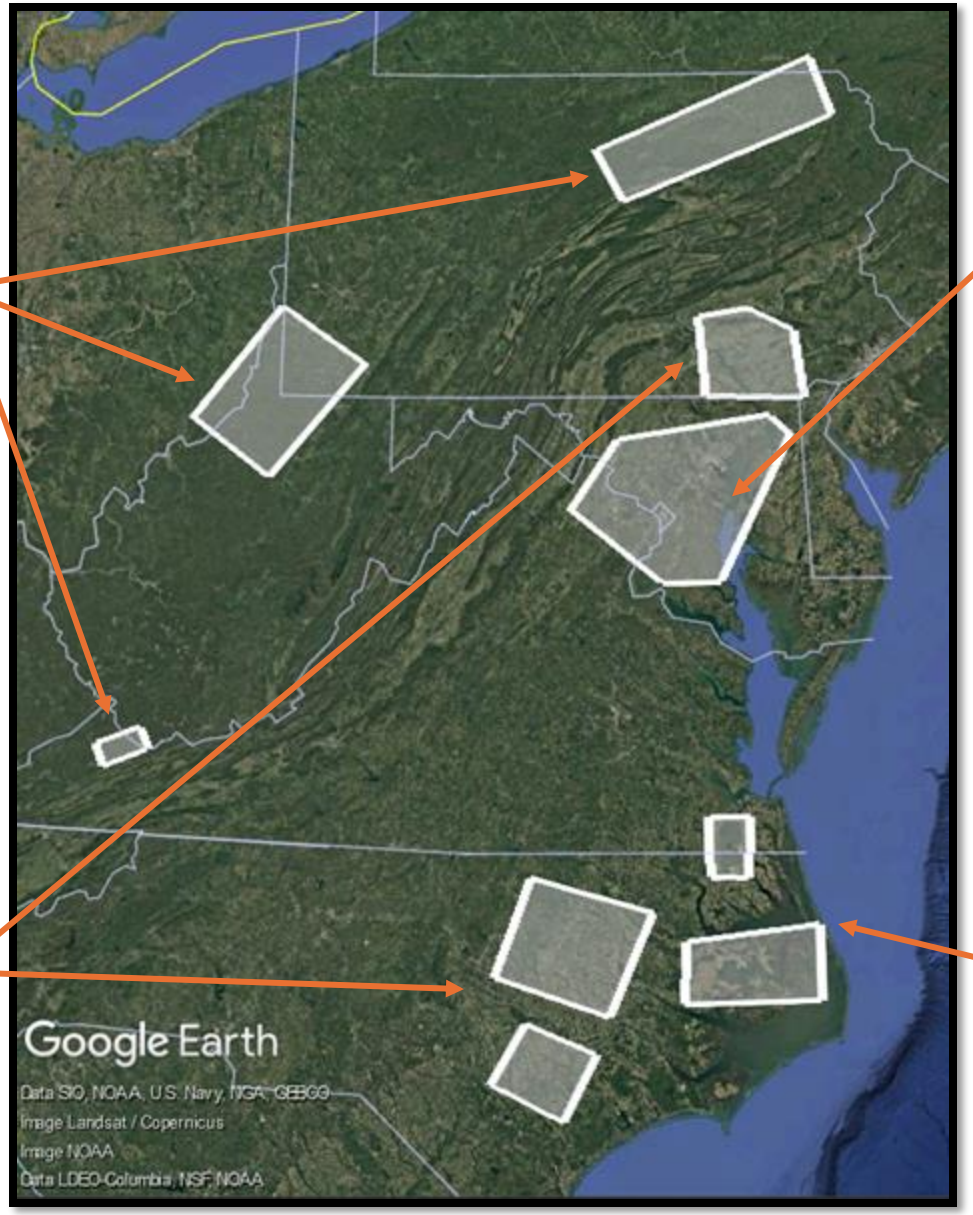


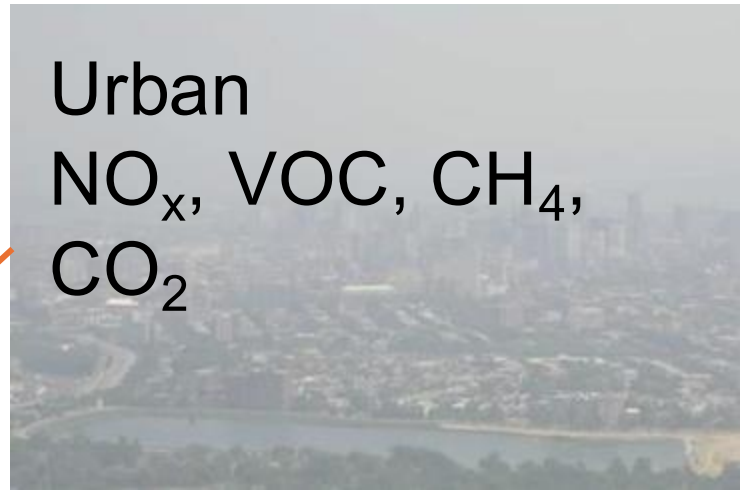
Petrochemical
VOC, CH_4

*VOC = volatile organic compounds



Agriculture
VOC, CH_4, N_2O, NH_3



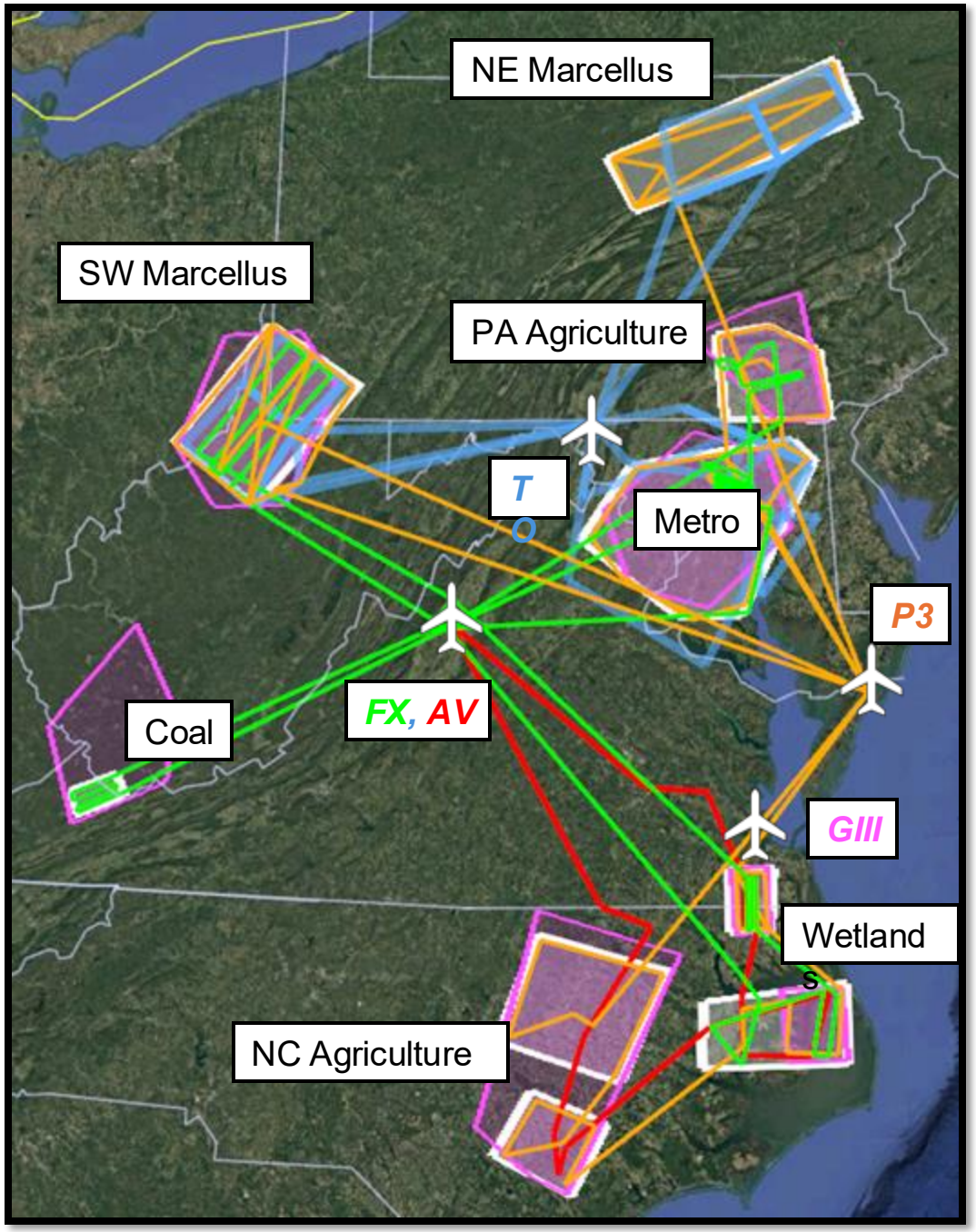


Urban
NO_x, VOC, CH_4, CO_2

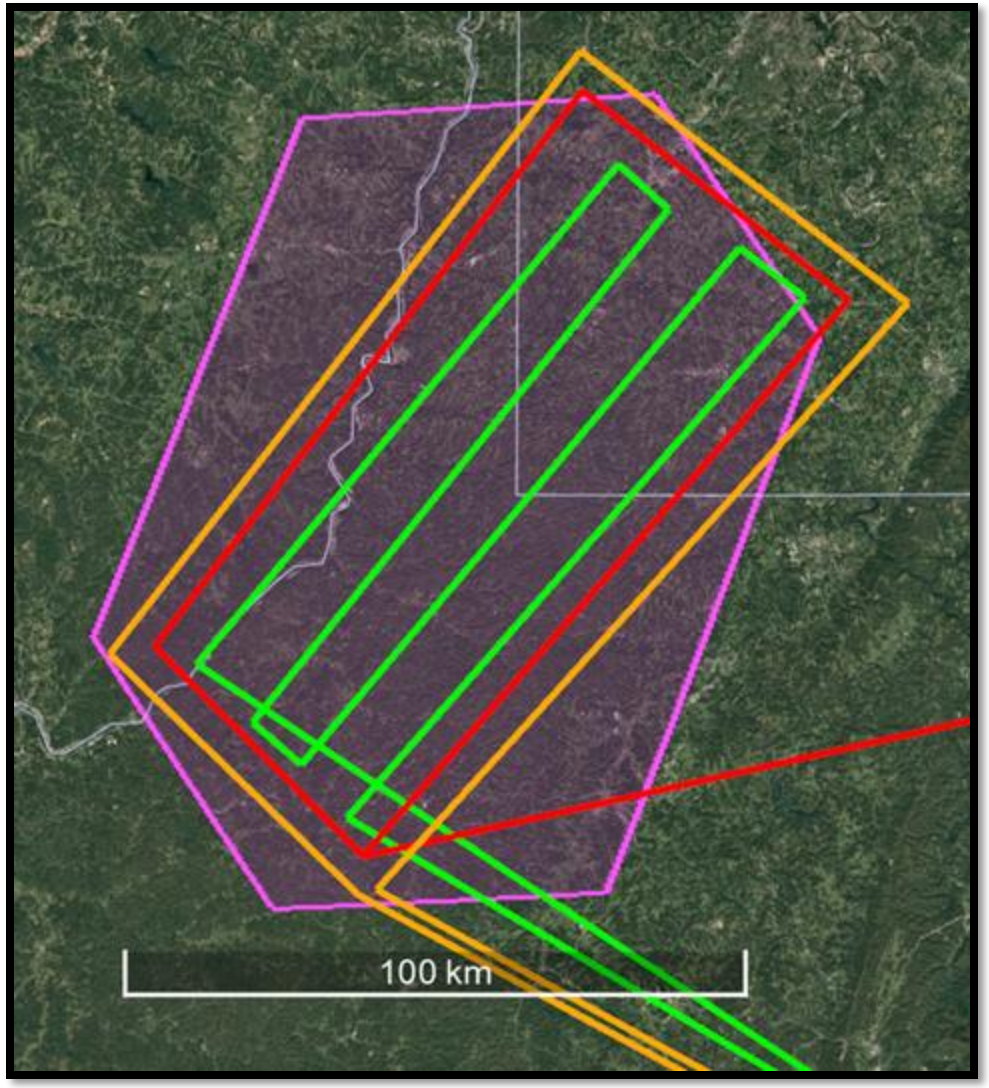
Wetlands
CH_4, CO_2, N_2O

Coordinated Flight Plans

- Areas of interest for MethaneSat (Marcellus and Baltimore) have highest priority because they have the tightest constraints on weather and aircraft operations
- Flight plans align with ground-based observations (CoURAGE, Pandora, EM-27, TOLNET) where feasible
- Most aircraft at different locations
- Not all aircraft will sample all regions



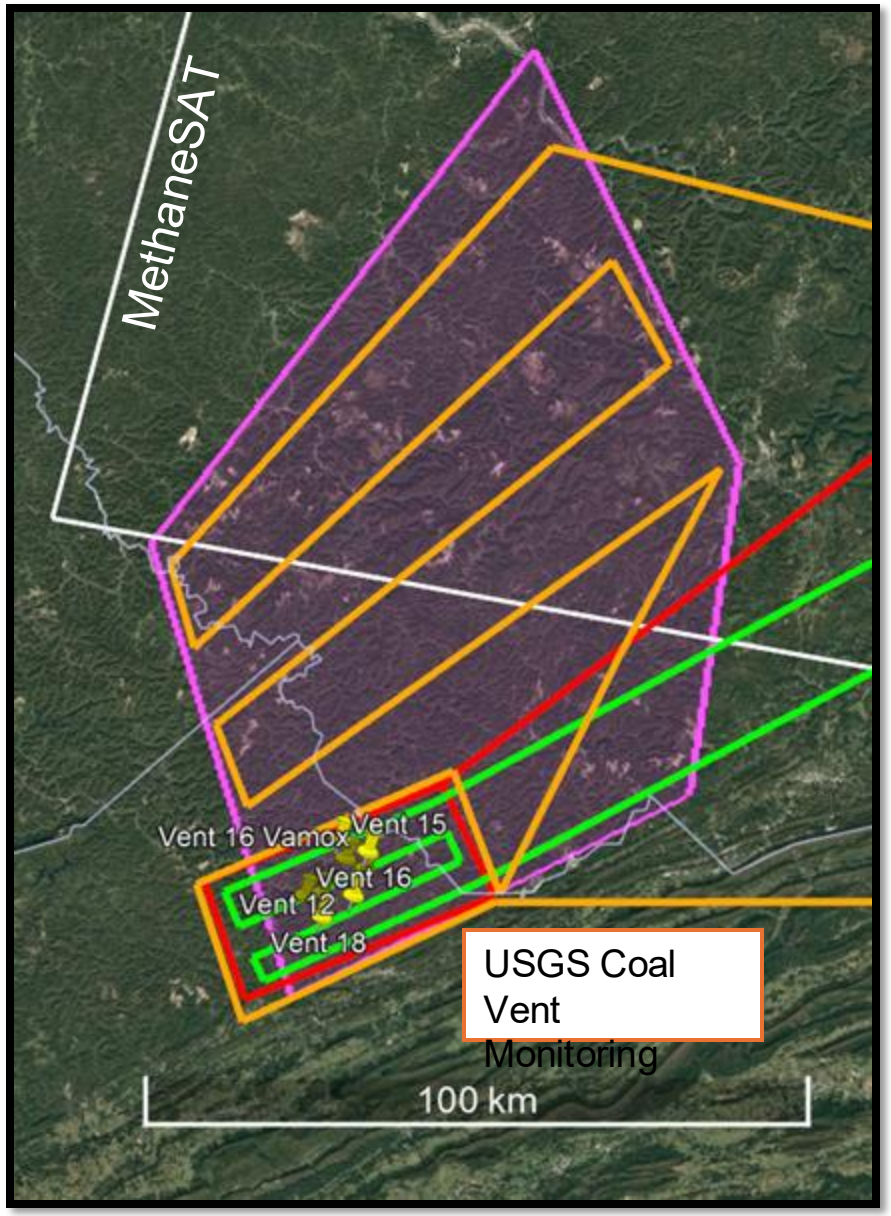
MAGEQ Draft Plan – SW Marcellus



Weather: 2 days of clear sky, E/W winds ideal
Satellites: MethaneSat
Airspace: low challenge

Plane	Pattern	Duration
TO	Circle at 1-6 kft AGL. Vertical profiles to 10 kft AMSL	3.5 h 2 flights/day
GIII	Raster whole region @ 40 kft	5 h 6 flights/ 2 days
FX	Raster @ 500’ AGL, 20 km-long legs at 1000’, 1500’ AGL	4 h 1 flight/day
P3	Circle at 1-3 kft AGL Vertical profiling in the box to 25kft (Locations/frequency?)	4 h 1 flight/day (combine w/another module)
AV	Align with GIII, choose altitude to deconflict	Align with GIII

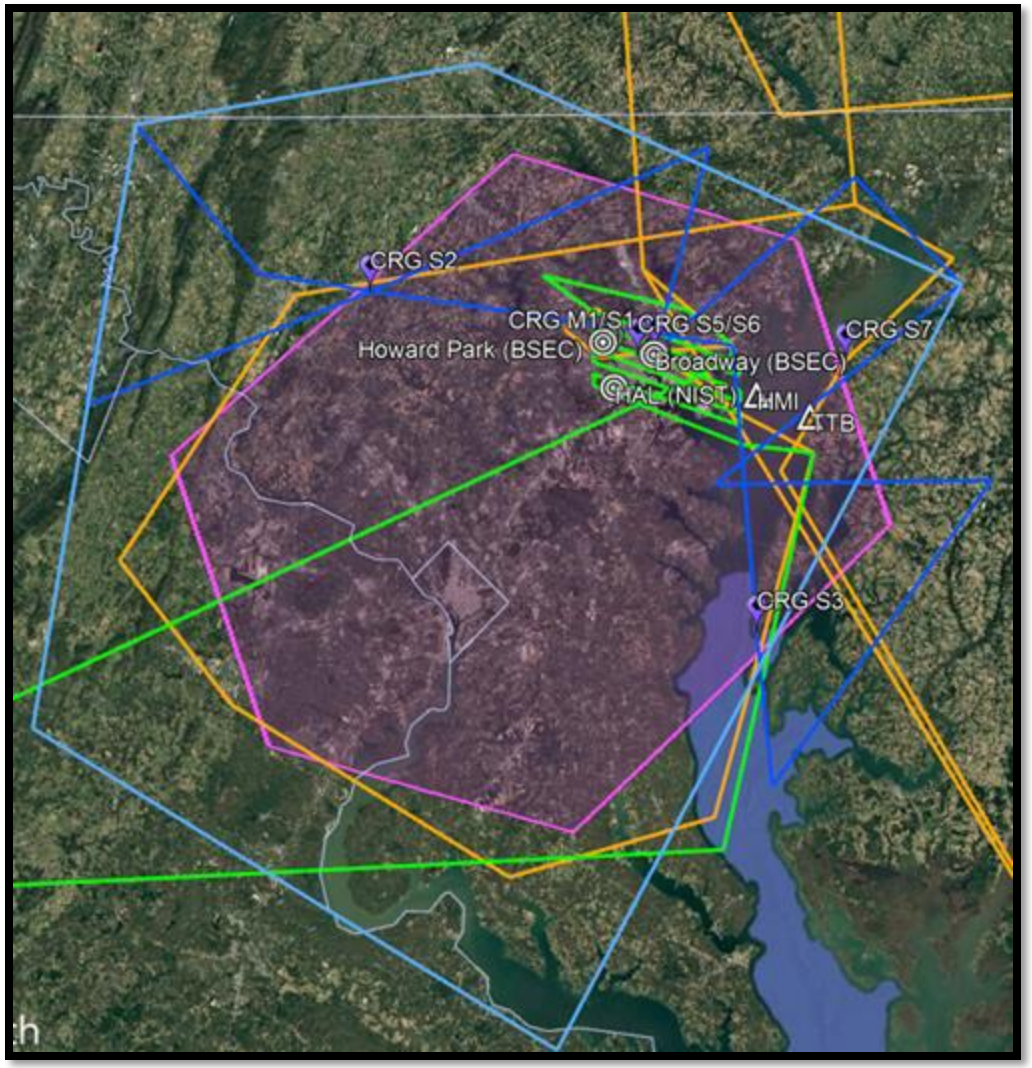
MAGEQ Draft Plan – WV/VA Coal



Weather: clear sky (fair weather Cu OK), N/S winds ideal
Satellites: None planned
Airspace: low challenge

Plane	Pattern	Duration
TO	Circle at 1-6 kft AGL. Vertical profiles to 10 kft AMSL	3 h 1 flight (long transit)
GIII	Raster whole region @ 40 kft	TBD 1 flight
FX	Raster @ 500' AGL	2 h 2 flights
P3	Circle at 1-3 kft AGL Wider area survey in boundary layer Profiling if GIII present	TBD
AV	Align with GIII More dense profiling over vents?	Align with GIII

MAGEQ Baltimore Metro Draft Plan

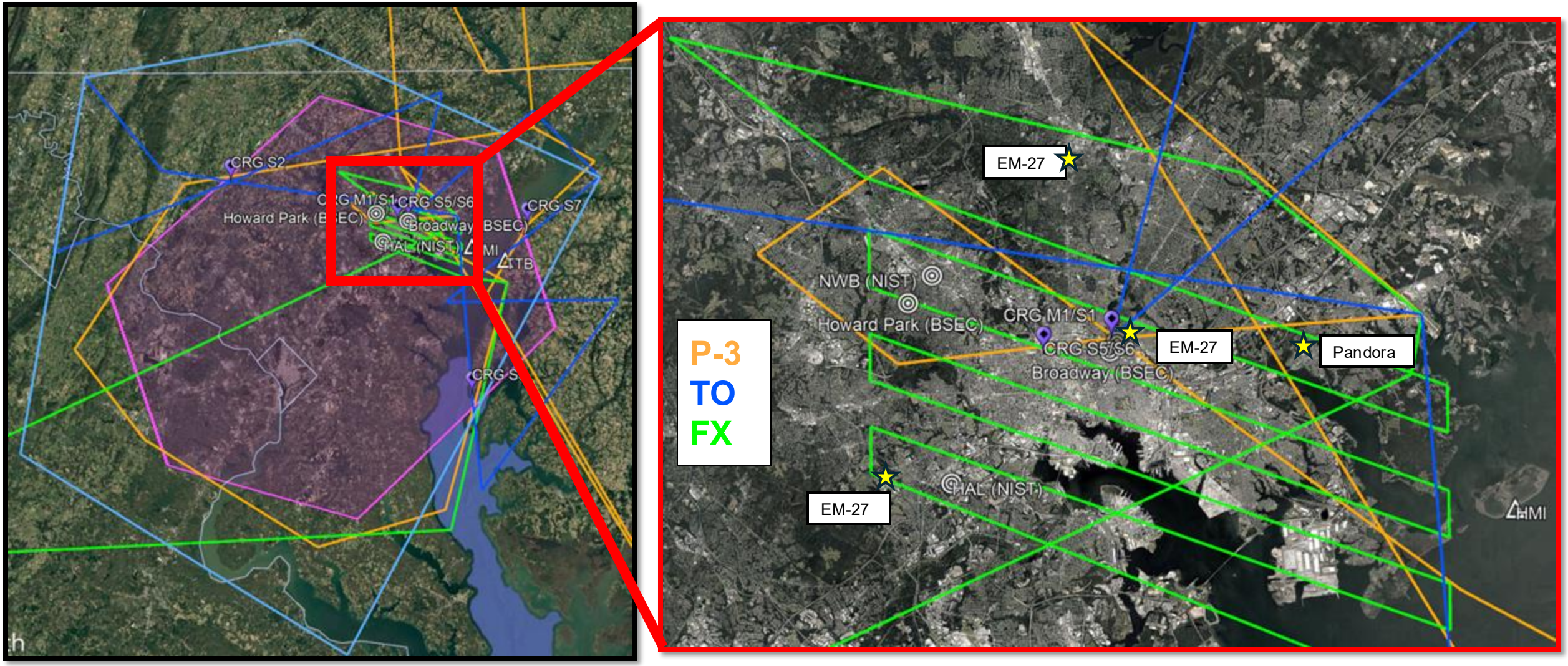


Weather: clear sky or slightly cloudy
Satellites: MethaneSat, TEMPO
Airspace: Very challenging

Plane	Pattern	Duration
TO	Circle region (mass balance) Sample urban plume (air quality)	3.5 h 2 flights/day
GIII AV	Raster whole region	5 h
FX	Raster Baltimore Spirals @ Essex (Pandora)	2.5 h 2 flights / 1 day
P3	Circle region + thru Baltimore low approaches at local airports Spiral @ Towson (EM-27)	8 h (repeat pattern 2x or 3x in one flight)

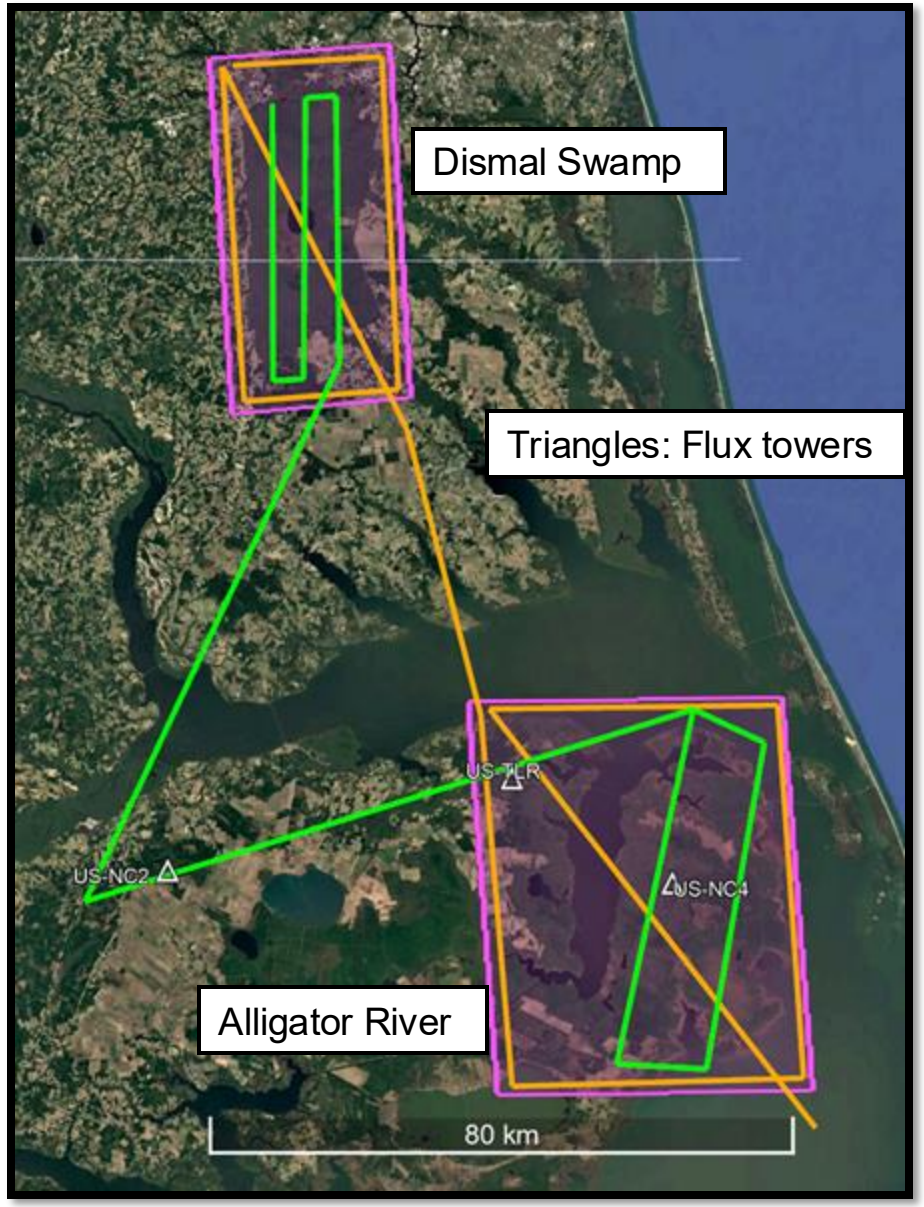
Alignment with ground sites (EM-27, Pandora, CoURAGE, NIST) and where possible

MAGEQ Metro Draft Plan



Alignment with ground sites (EM-27, Pandora, CoURAGE, NIST) and where possible

MAGEQ Draft Plan - Wetlands



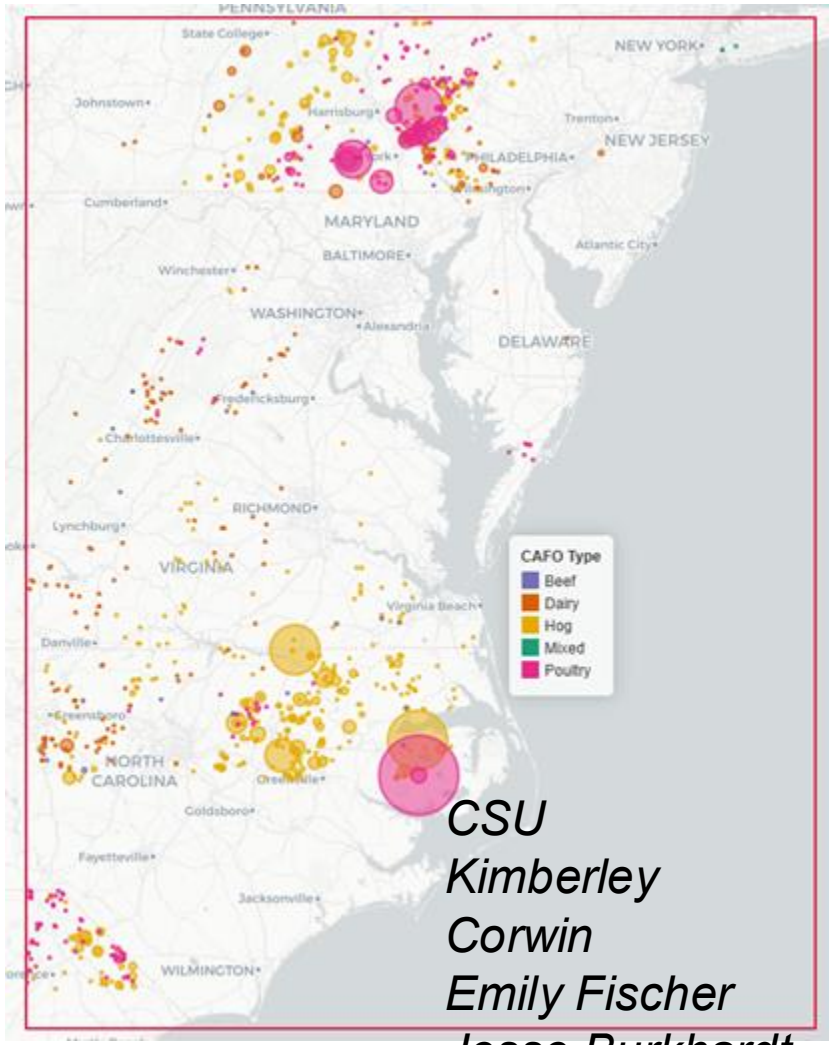
Weather: clear sky (fair weather Cu OK), E/W winds ideal
Satellites: None
Airspace: moderately challenging

Plane	Pattern	Duration
TO	n/a	n/a
GIII	Raster regions @ 40 kft	TBD 1 flight
FX	Raster @ 500' AGL	4 h 1 flight
P3	Circle at 1-3 kft AGL, 3 loops Vertical profiles to 25kft up/downwind Single line through the box @ 1kft	TBD 1 flight (combine with NC Ag)
AV	Align with GIII	Align with GIII

Also, A90 (G-LiHT) could sample these areas in early June

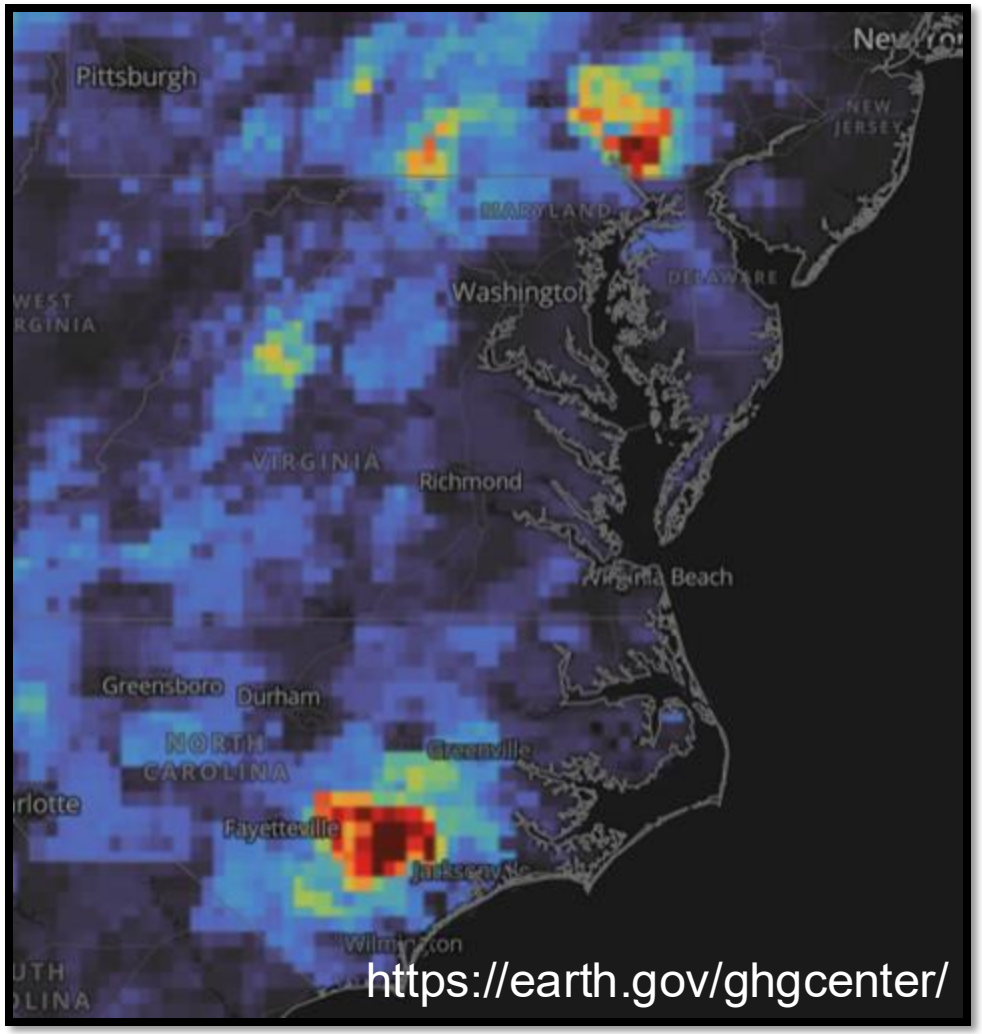
Agriculture – Animal Feeding Operations

AFO location based on permit data, sized by # of animal units (1 AU = 1 cow, 2.5 hogs, or 125 chickens)

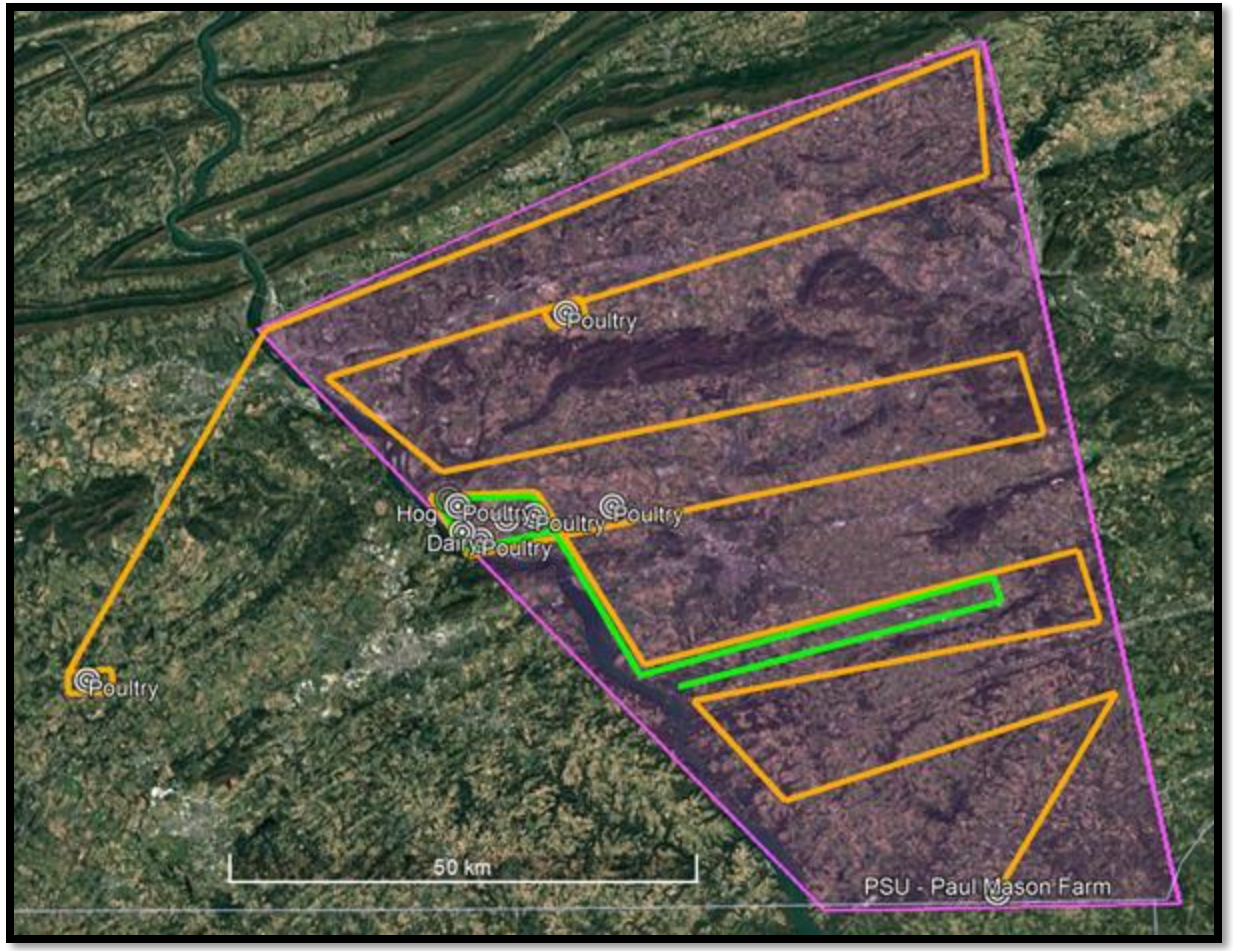


CSU
Kimberley Corwin
Emily Fischer
Jesse Burkhardt

EPA GHG Inventory Total Agricultural Methane Emissions (US GHG Center)



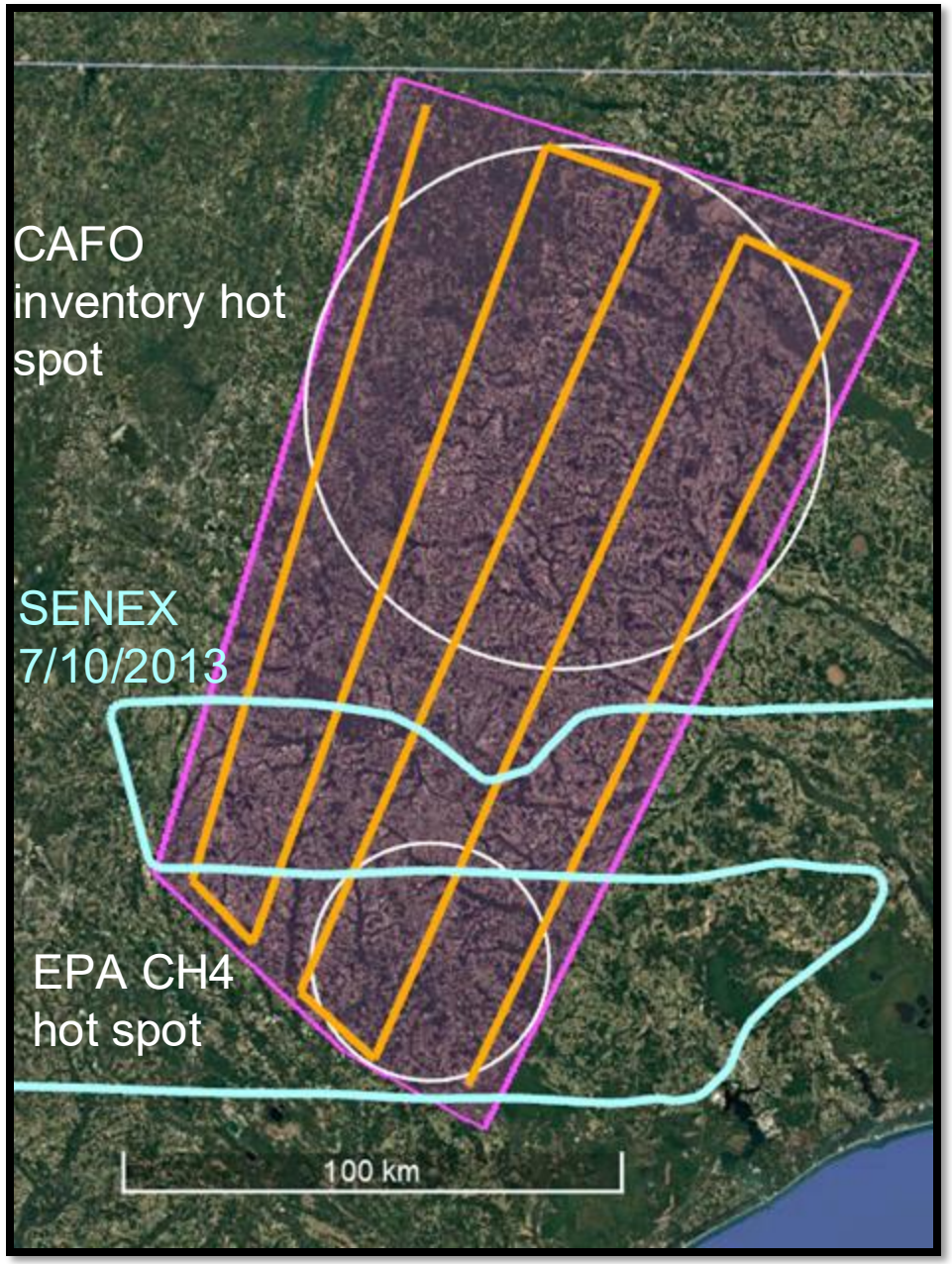
MAGEQ Draft Plan – PA Agriculture



Weather: no precipitation
Satellites: None
Airspace: moderately challenging

Plane	Pattern	Duration
TO	n/a	n/a
GIII	Raster region @ 40 kft	TBD 1 flight
FX	Flux legs south of Lancaster, box budget west of Lancaster	n/a
P3	Area survey circle largest facilities vertical profile if G-III flying	TBD 1-2 flights (do w/ Marcellus)
AV	Align with GIII	Align with GIII

MAGEQ Draft Plan – NC Agriculture



Weather: no precipitation
Satellites: None
Airspace: moderately challenging

Plane	Pattern	Duration
TO	n/a	n/a
GIII	Raster region @ 40 kft	TBD 1 flight
FX	n/a (too far)	n/a
P3	Area survey vertical profile if G-III flying	TBD 1-2 flights (do w/ wetlands)
AV	Align with GIII	Align with GIII

Data Archival and Availability

- Data from each aircraft stored in its own archive, but all archives will be linked through ESPO and/or US GHG website
  - B200-FX: SARP archive (https://www-air.larc.nasa.gov/missions/sarp/index.html)
  - P-3: SARP archive
  - G-III: https://www-air.larc.nasa.gov/missions/apmac/index.html
  - TO: AIRMAPS archive (https://csl.noaa.gov/projects/airmaps/)
  - B200-AV: ORNL DAAC (https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2358)
  - A90: G-LiHT archive (https://glihtdata.gsfc.nasa.gov/)
- Per NASA guidelines, all NASA data will be publicly available once it is finalized, typically 6-12 months after mission end. Preliminary data will be available from PIs upon request
- All data will be standard formats (ICARTT, netCDF, or similar)

Addressing Stakeholder Needs

- Maryland Department of Environment (MDE) and Baltimore Social-Environmental Collaborative (BSEC) require reliable information on pollutant emissions and transport for policy and impact assessments
- Virginia Commonwealth University (VCU) and GSFC researchers are interested in developing carbon budgets for Mid-Atlantic wetlands in support of The Nature Conservancy (TNC) and others
- The U.S. Geological Survey has a vested interest in quantifying methane leaks from active and dormant/abandoned coal mines
- NASA's Student Airborne Research Program (SARP) will fly college interns on some of these aircraft and utilize observations for research projects
- NASA's TEMPO satellite (Tropospheric Emissions: Monitoring of Pollution) requires validation for trace gas columns and emissions estimates

Stakeholders for Science and Applications

- **Air Quality:** Maryland Department of Environment (MDE), Baltimore Social-Environmental Collaborative (BSEC), U.S. Environmental Protection Agency (EPA), NASA TEMPO satellite validation
- **Greenhouse Gases:** U.S. Greenhouse Gas Center partners (NOAA, NASA, NIST, EPA), satellites (MethaneSat, GHGSat, CarbonMapper, OCO), NGOs (ClimateTrace, Climeworks)
- **Ecology and Conservation:** Virginia Commonwealth University, The Nature Conservancy

Stakeholder Plans for MAGEQ

- Stakeholder Mapping & Development of MAGEQ Stakeholder Email List
  - First Order Data Needs
  - Geographic Areas of Interest
  - Need Low-Latency Information
  - Other Feedback / Needs
- MAGEQ Stakeholder Weekly Email Updates
  - Starting on June 27 until mid-August
  - Notes from the (Air)Field
  - Science Focus
  - Plane Spotting (Image of the Week)
  - On the Horizon
  - Get in Touch
  - Feedback Form
- MAGEQ Post-Campaign Stakeholder Plans
  - Monthly meetings to learn about the uses and applications of stakeholders, as well as impact and value of the data collected

Questions?

For email updates: edil.sepulvedacarlo@nasa.gov
For plane tracking: https://airbornescience.nasa.gov/tracker/

US GHG Center Scientists
glenn.m.wolfe@nasa.gov
lesley.e.ott@nasa.gov