Options and scientific considerations for a field program to investigate air quality in an African megacity

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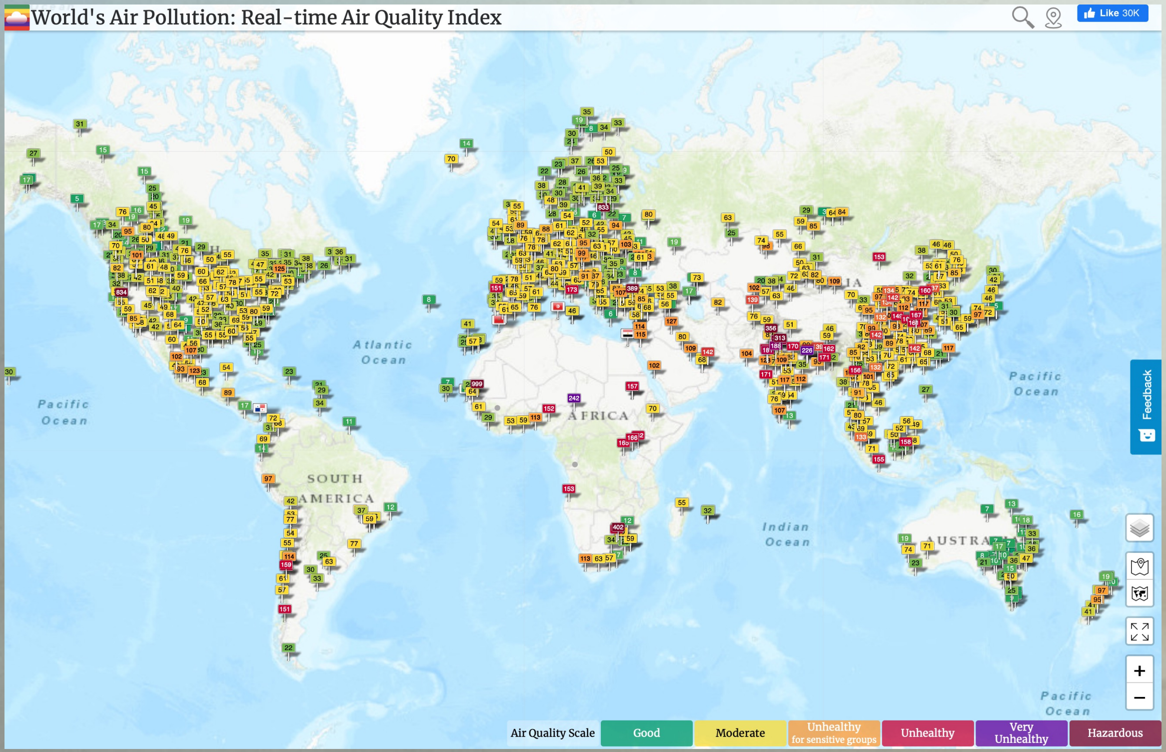
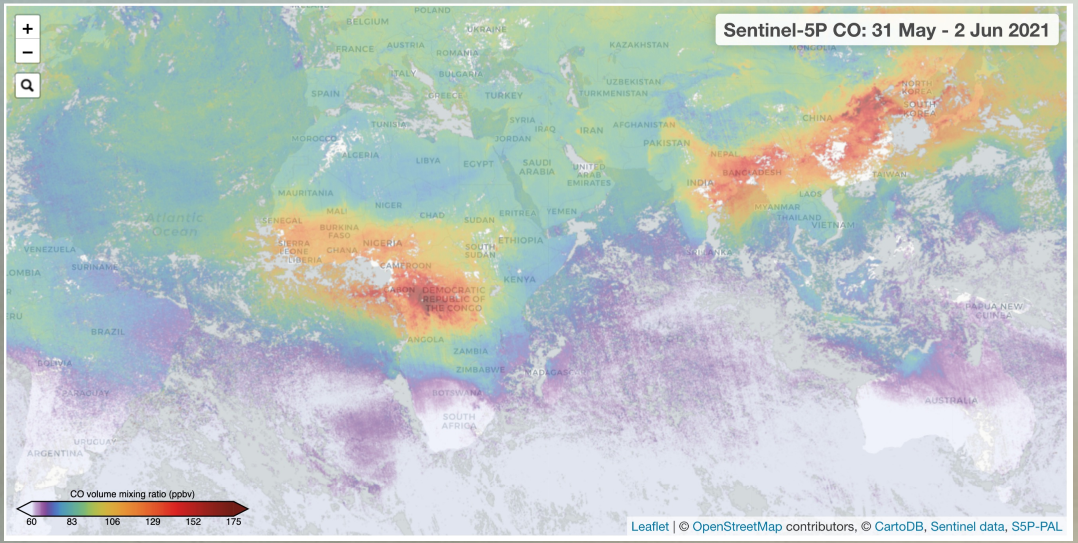
Issues to consider:
Available data is scarce, particularly long-term measurements of photochemical tracers, secondary pollutants and air toxics
Existing data can be hard to access



Issues to consider: There are AQ data records (mostly for ground-based PM) and about 10-15 years worth of satellite data

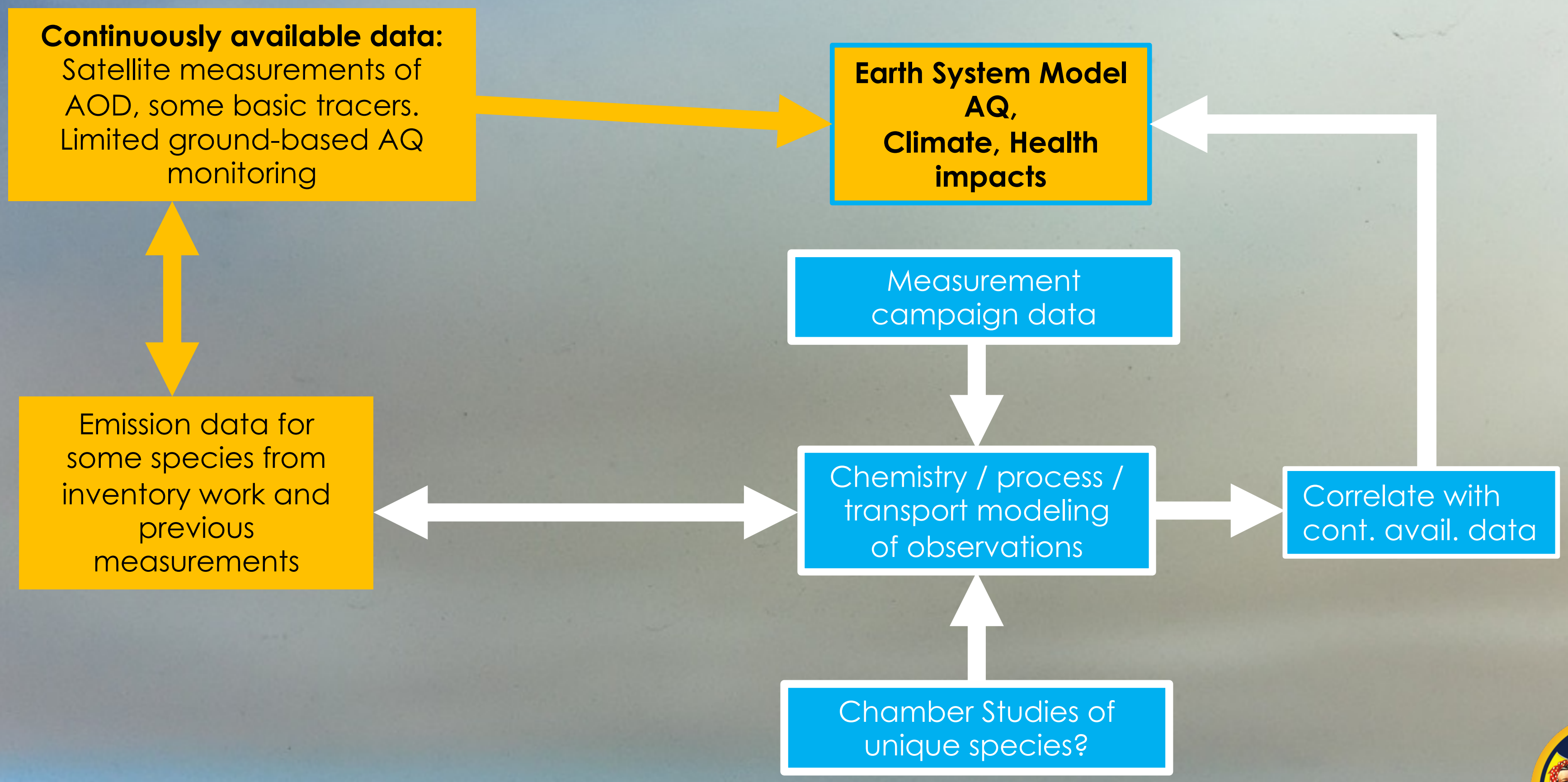


Issues to consider: We do not know enough about specific emissions from particular activities we are "not used to" from our local (or "western") perspective, their extent, emission distribution, atmospheric fate, and interactions with the known photochemistry

- AQ degradation is closely coupled with population growth and trends can exceed 20% per year in some places.

Photos and statistics lifted from Eloise's presentation from Tuesday

We can use campaign and lab data to relate to continuously available data which can be assimilated into 3D models



The strategy for a AQ program in Africa should start with defining the overall scope and time line, and then select and analyze possible deployment sites / regions

- There already are some ongoing programs that can serve as a model or partnership opportunity
  - Accra project - Amherst, ICL, and U Ghana
  - ASAP, SPARTAN, AfricAir, others
  - Columbia U East Africa project
  - EPA / Addis projects
  - NOAA/CIRES **Aircraft study** (GHG)

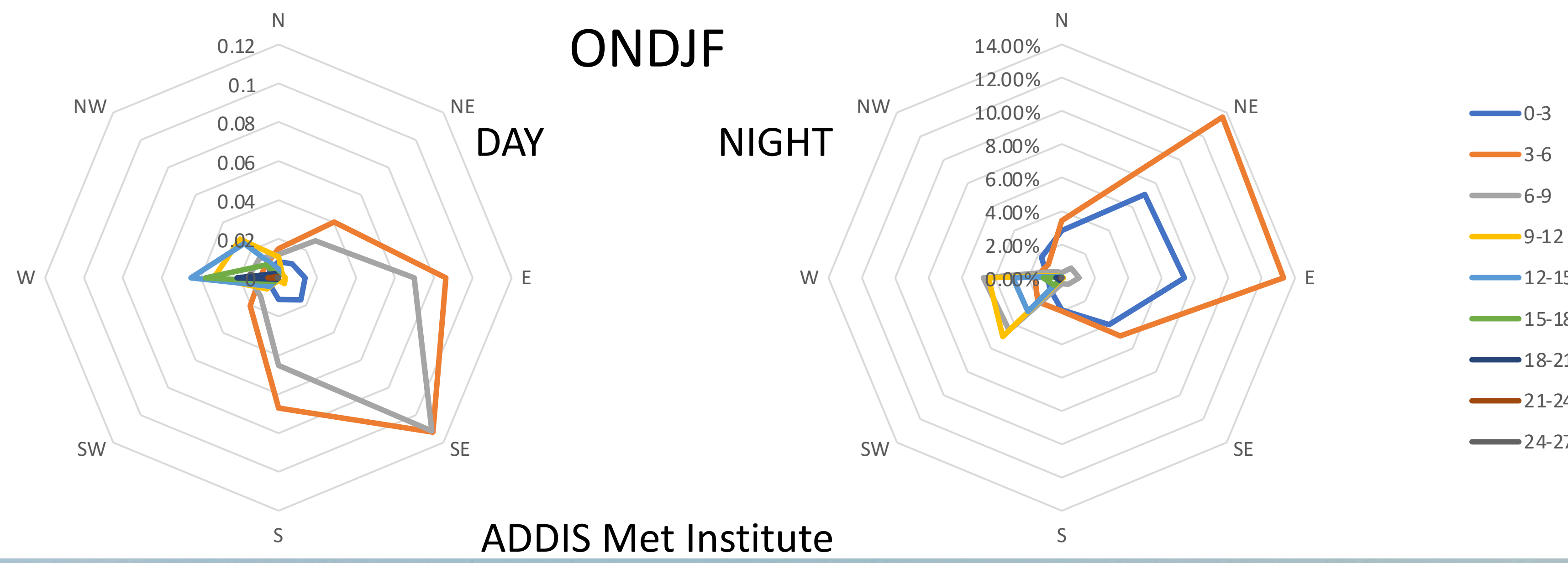
- Most studies based on LCS, satellite data, and modeling
  - Heavy on PM, gas phase limited
  - Limited calibration data, almost all for PM (CAMSnet)

- Satellite data projects / data assimilation / modeling
  - Sentinel 5P (TropOMI)
  - MAIA (JPL) – good example for sat/ground correlation

If we are aiming for a megacity study (starting in one city and expanding from there) we need to first gather all necessary information to be able to run a well informed OSSE* on the target area

*Observing System Simulation Experiment

- Meteorological environment
  - Dry season / wet season / sandstorm season
  - Terrain driven flows
  - Regional transport



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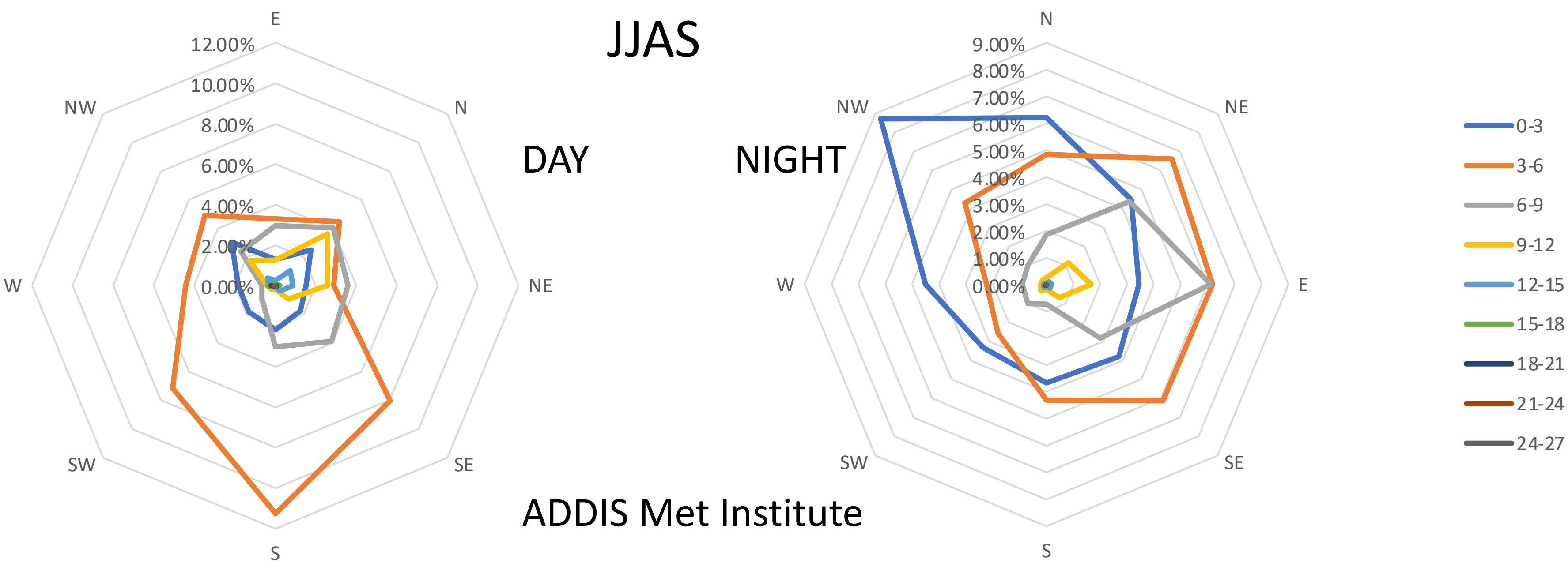

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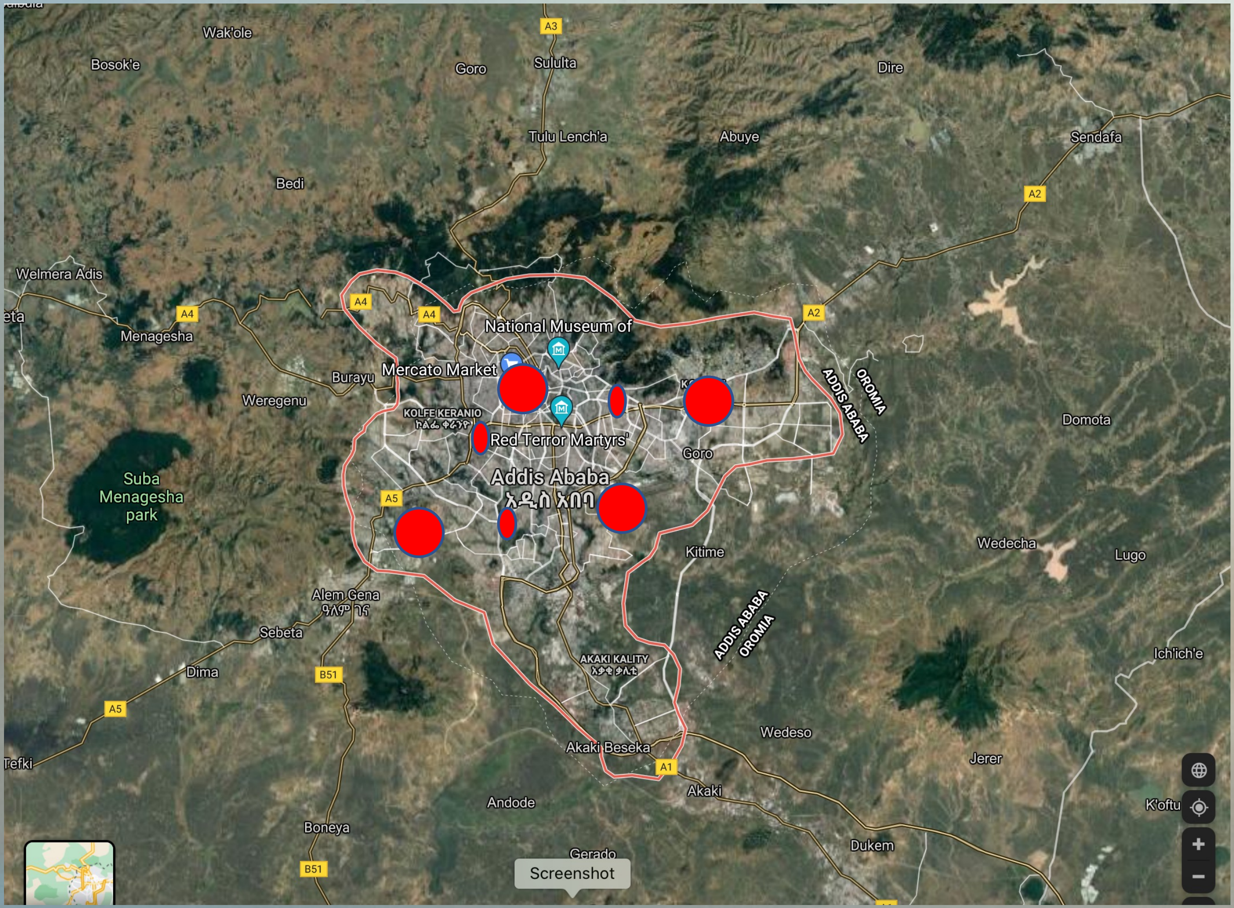

Large sources within the city

- Categorized
- Diurnal variability
- Stack or ground emission?
- How to best characterize?
- Identify tracer footprint

- Maybe start with inventories and compare with local observations

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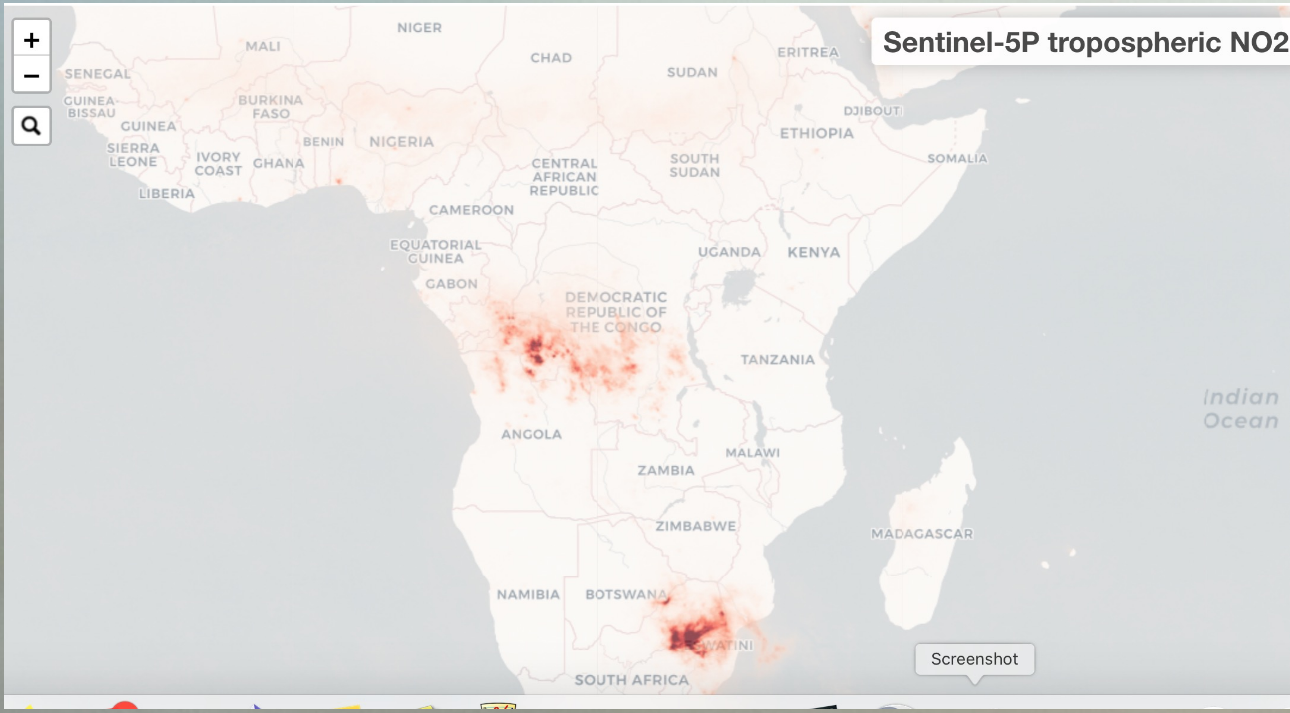
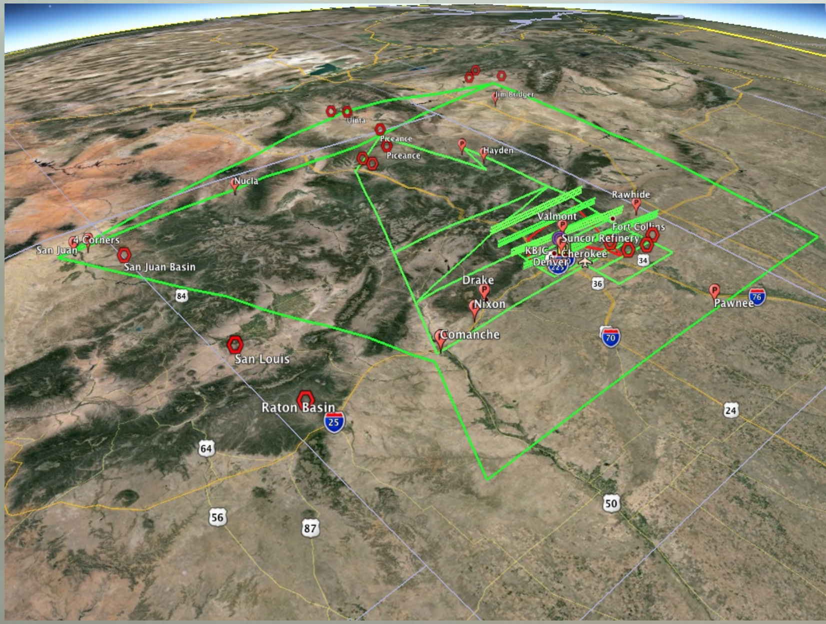
- Regional emissions and transport
  - Biomass burning
  - Power generation
  - LRT
  - Dust
- Some of this can be done with satellite data but emissions could be sporadic



When a study area is identified, and OSSE(s) have been completed, then derive the best strategy to place ground-based measurements (or develop flight plans for aircraft measurements)

- Suggest we start with a reasonable number of **small sensor** packages (20-30)
    - Ozone / Ox
    - CO
    - “VOC”
    - NOx / NO_2
    - **Canister VOC**
    - Boundary layer height ??
- One “reference instrument rack”
    - Centrally located
    - University / Research lab
- Transition to mobile
    - Add in-situ VOC instr.
    - Add aerosol size distr. / physics / composition
    - Toxicity
- Add indoor component
    - From the start?

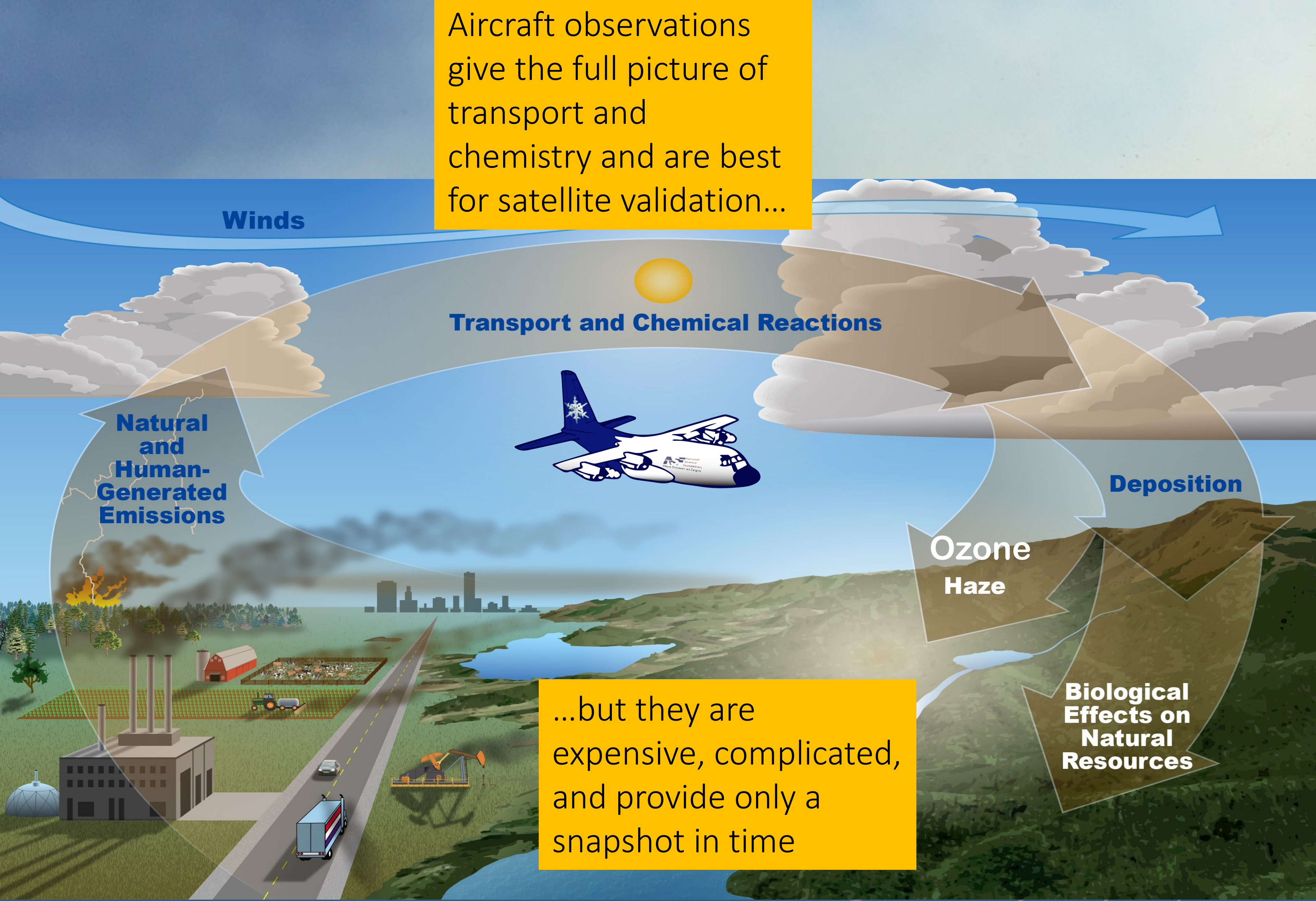


AQ program strategy / sustainability

- Involve all stakeholders
  - Research groups
  - Students
  - Gov't / Regulatory agencies
  - External research groups
  - Schools / Citizen Science

- **Sharing of existing data and ongoing data sets collected!**
  - Establish a central web site / portal for information and data exchange (ASAP excellent example). EOL Field Catalog
- Emphasis on community benefit
- Robust calibration program – long-term reliability of distributed sensors
- Work our way up to enable a targeted aircraft campaign using NSF, NOAA or NASA aircraft

Aircraft observations give the full picture of transport and chemistry and are best for satellite validation…



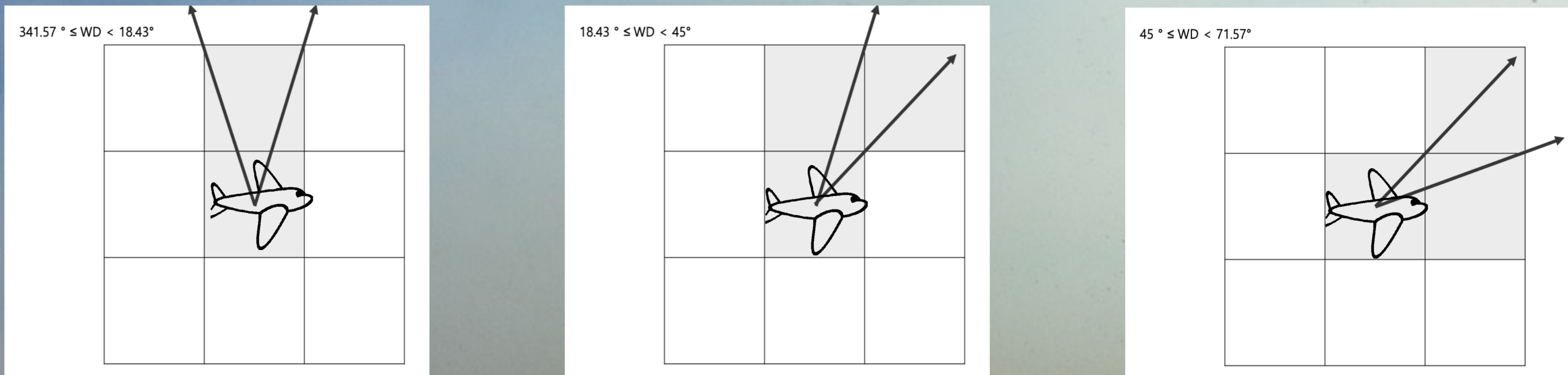
…but they are expensive, complicated, and provide only a snapshot in time

Observing atmospheric chemistry in the wild is best done with aircraft…

- Field measurements are made to provide input / validation for models
- Informing air quality models requires knowing
  - Emissions
  - Transport
  - Chemical evolution
- This is very hard to do from the ground
- While emissions can be determined bottom-up, but often highly uncertain
  - TD measurements require covering large areas
- Transport validation in models requires in-situ measurements of meteorology in space and time
- Investigating the chemistry taking place inside an air mass requires following that air mass while measuring the chemical processes
- Satellite observations are now very good, but number of species (and spatial and vertical resolution) are still limited

THANK YOU

WRF-Chem model results using emission inventory as input were compared with flight data using stringent criteria



- Identify grid boxes for 10-17 LT < 1km agl. Where:
  (1) The contribution of the evaluated emission sector is at least 50%
  (2) Observed and modeled winds are from same sector (10-17 LT, < 1km a.g.l.)
- Compare individual samples with modeled concentrations averaged over each set of grid boxes
- Compare measured and modeled Emission Ratios

Atmospheric Chemistry and Air Quality related field projects I have worked on

~25 airborne

~10 ground-based