ASP 2016 Summer Colloquium
Advances in Air Quality Analysis and Prediction

AQ observations introduction

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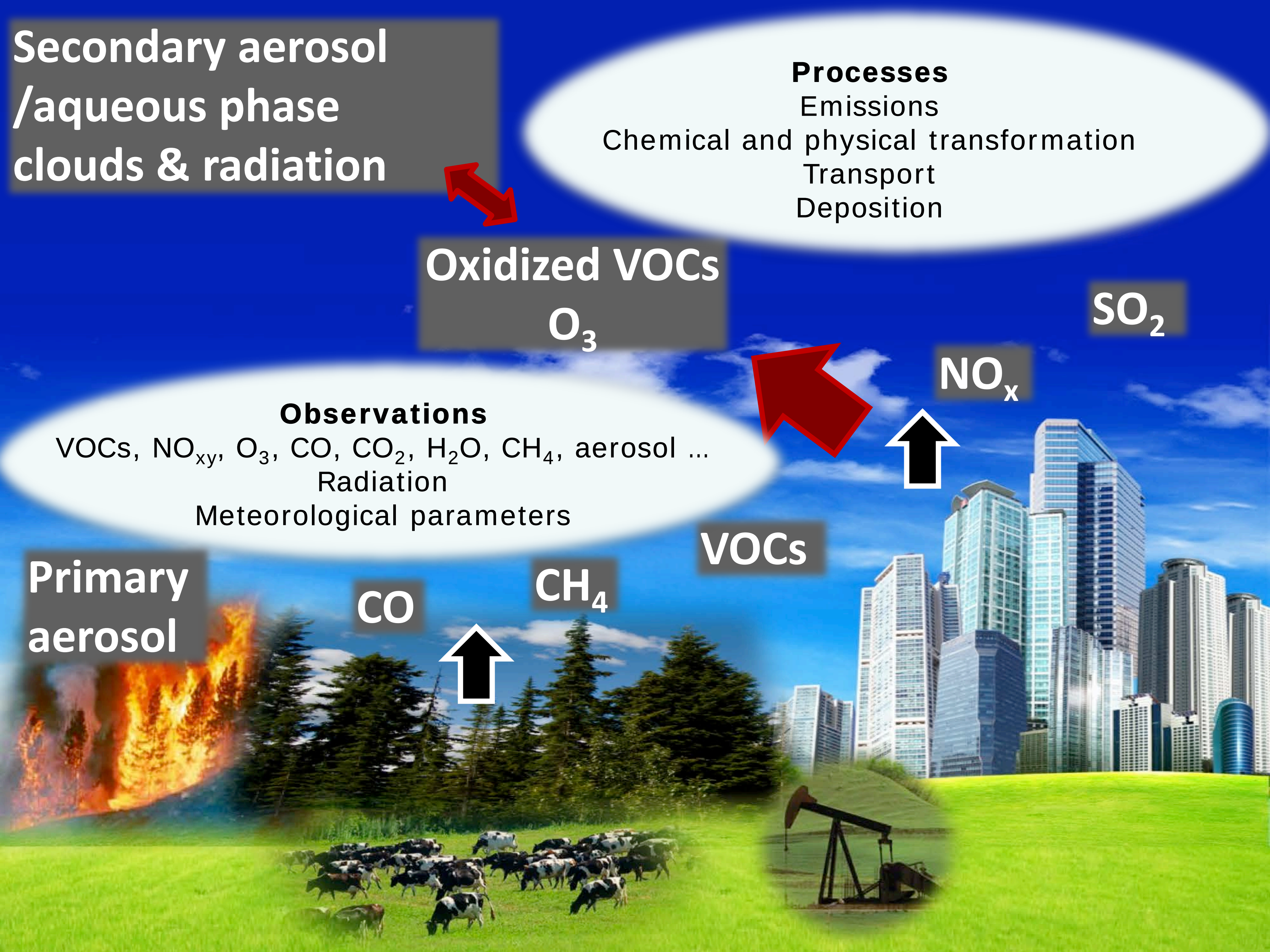
Secondary aerosol /aqueous phase clouds & radiation
Processes
Emissions
Chemical and physical transformation
Transport
Deposition
Oxidized VOCs
O_3
SO_2
NO_x
Observations
VOCs, NO_{xy}, O_3, CO, CO_2, H_2O, CH_4, aerosol …
Radiation
Meteorological parameters
VOCs
Primary aerosol
CO
CH_4

An integrated observing strategy

Air quality observation, modeling, assessment, forecasting and management pose significant challenges to the research community

- *Large spatial variability*: mobile and fixed emission sources and atmospheric dynamics that move pollutants around
- *Large temporal variability*: due to the effect of sunlight, human activities that are schedule driven, weather systems, and the presence of clouds
- *Chemical processing*: pollutant emissions are transformed in the atmosphere

No single observation technique can cover the range of required parameters and spatial and temporal scales

- Observations are integrated together by chemical-transport models operating at different scales to give a unified picture

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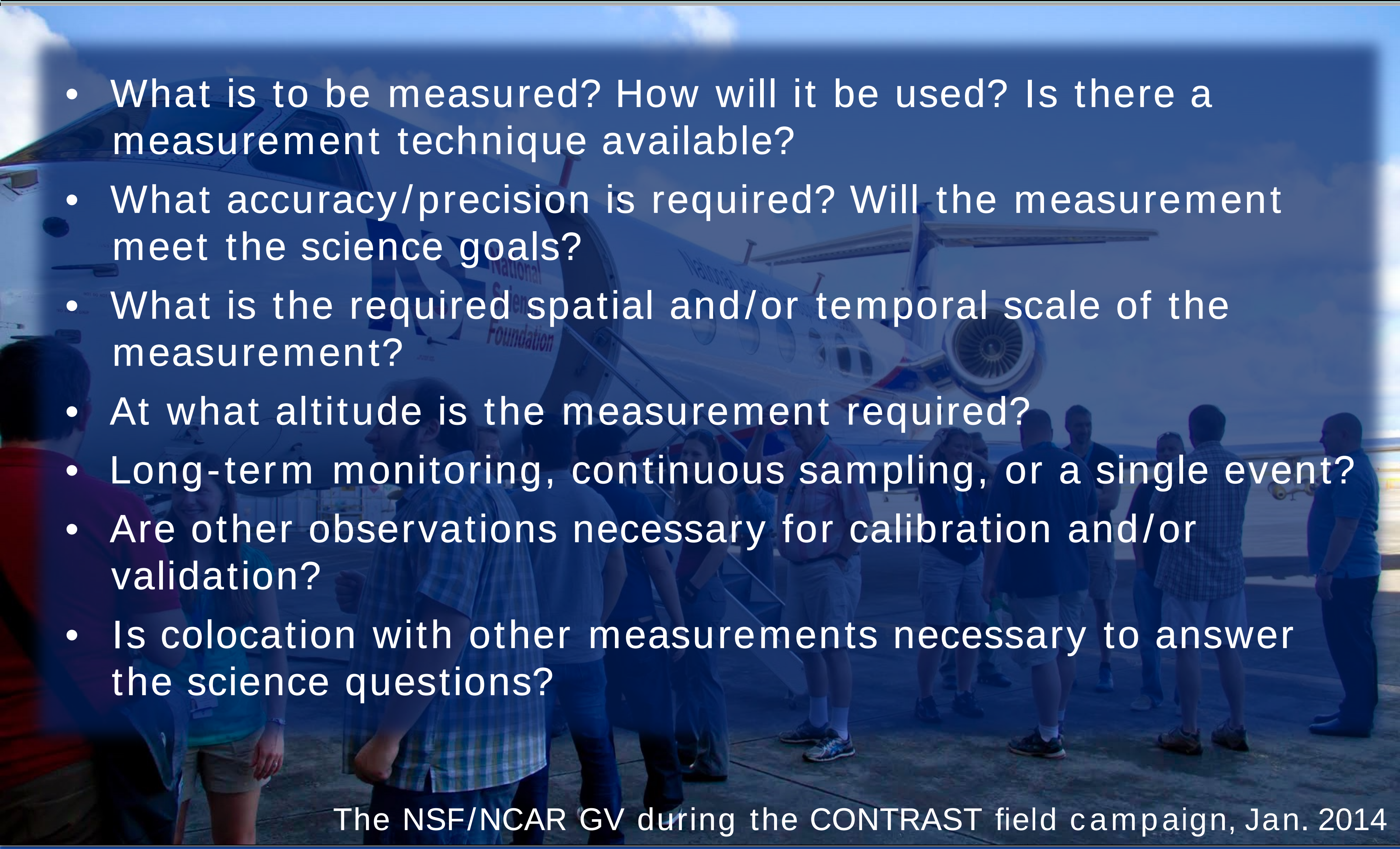
Observational considerations

- What is to be measured? How will it be used? Is there a measurement technique available?
- What accuracy/precision is required? Will the measurement meet the science goals?
- What is the required spatial and/or temporal scale of the measurement?
- At what altitude is the measurement required?
- Long-term monitoring, continuous sampling, or a single event?
- Are other observations necessary for calibration and/or validation?
- Is colocation with other measurements necessary to answer the science questions?



The NSF/NCAR GV during the CONTRAST field campaign, Jan. 2014

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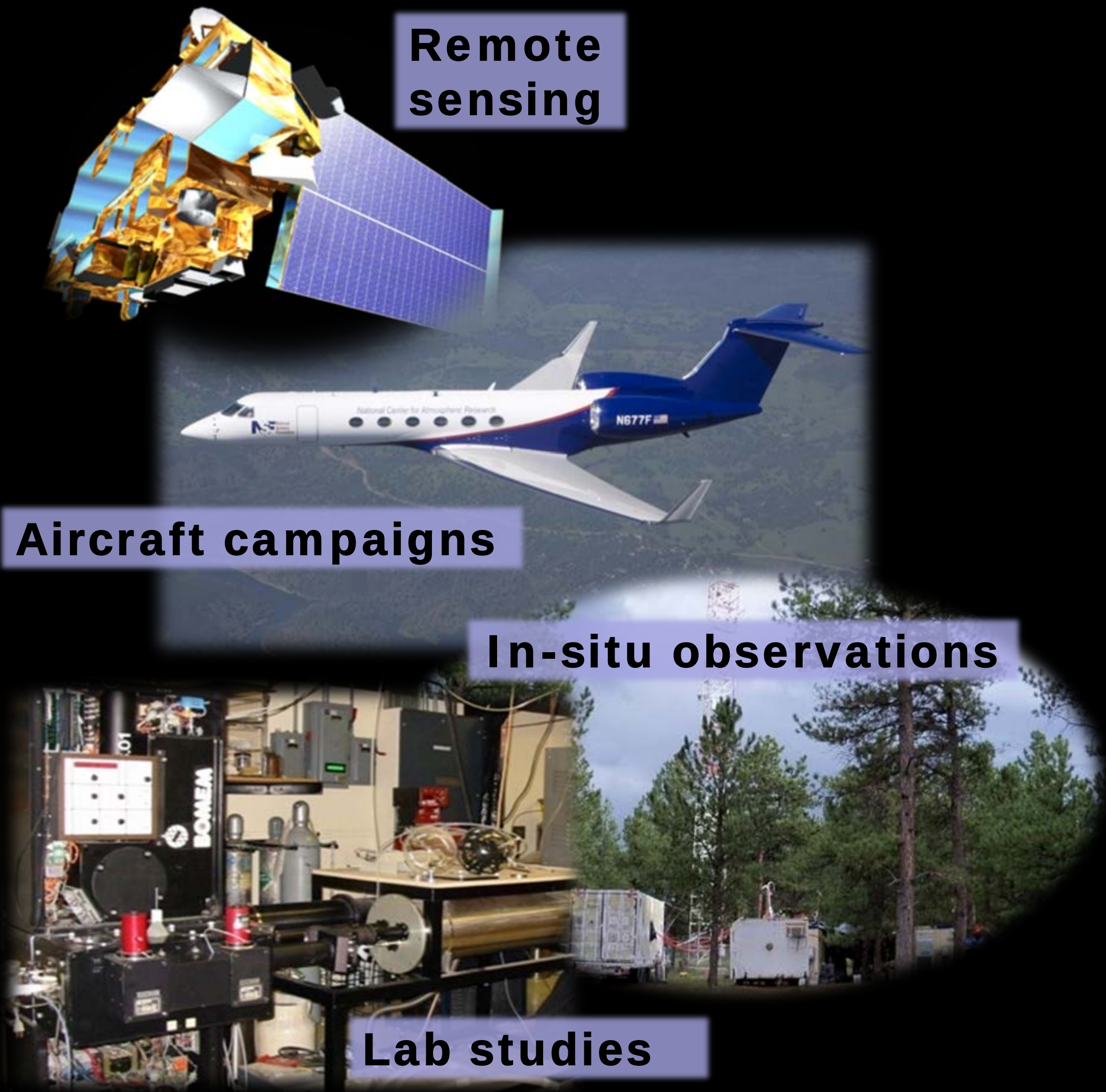
Cross-scale observational capability

Air quality observational activities cover the breadth of spatial scales from laboratory process studies, through groundbased and sub-orbital in situ composition measurements, to satellite remote sensing capability

Cross-scale observational research focuses on developing process-level understanding of the different system components, and their complex couplings and feedbacks



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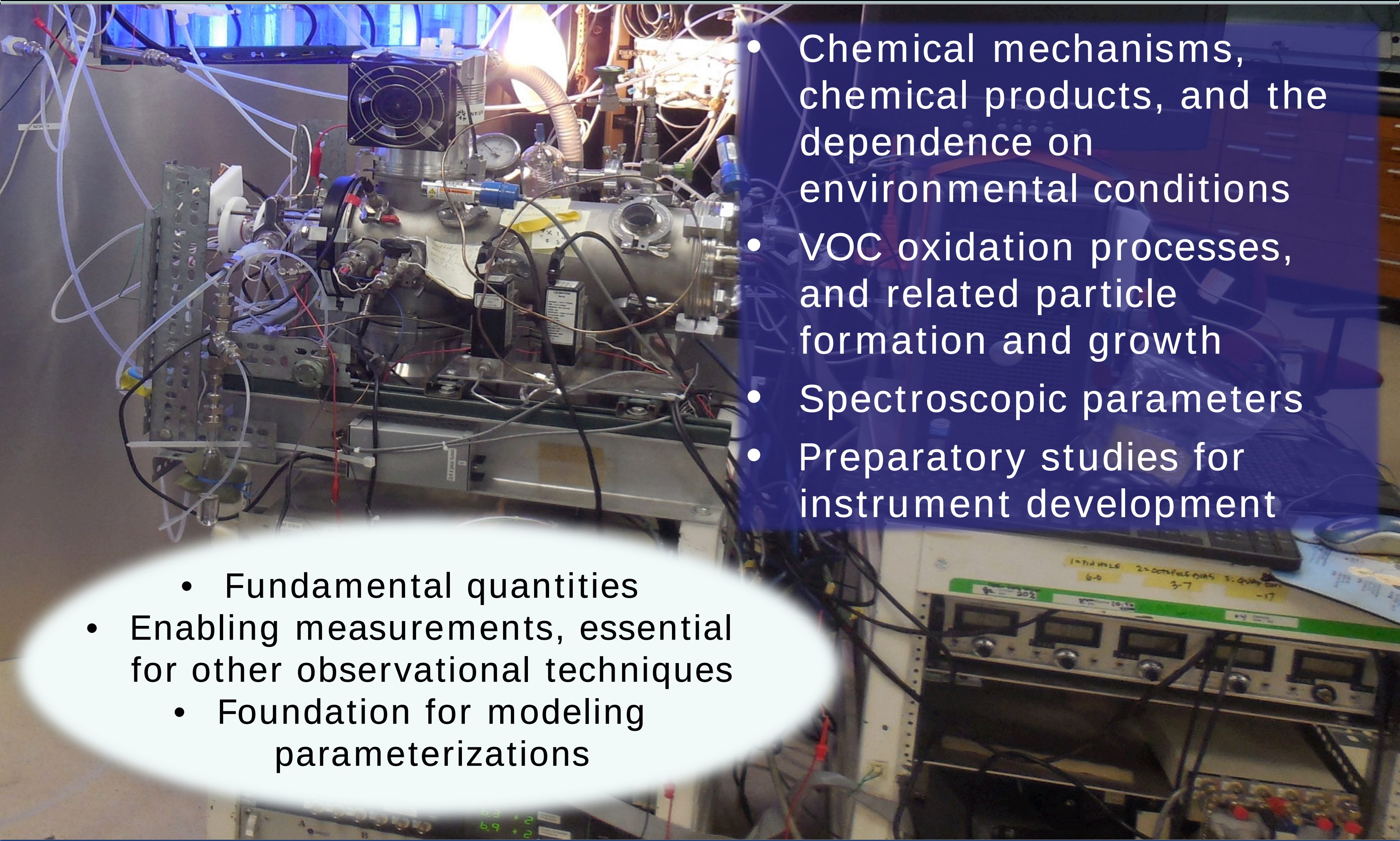
Laboratory measurements



- Chemical mechanisms, chemical products, and the dependence on environmental conditions
- VOC oxidation processes, and related particle formation and growth
- Spectroscopic parameters
- Preparatory studies for instrument development

- Fundamental quantities
- Enabling measurements, essential for other observational techniques
- Foundation for modeling parameterizations

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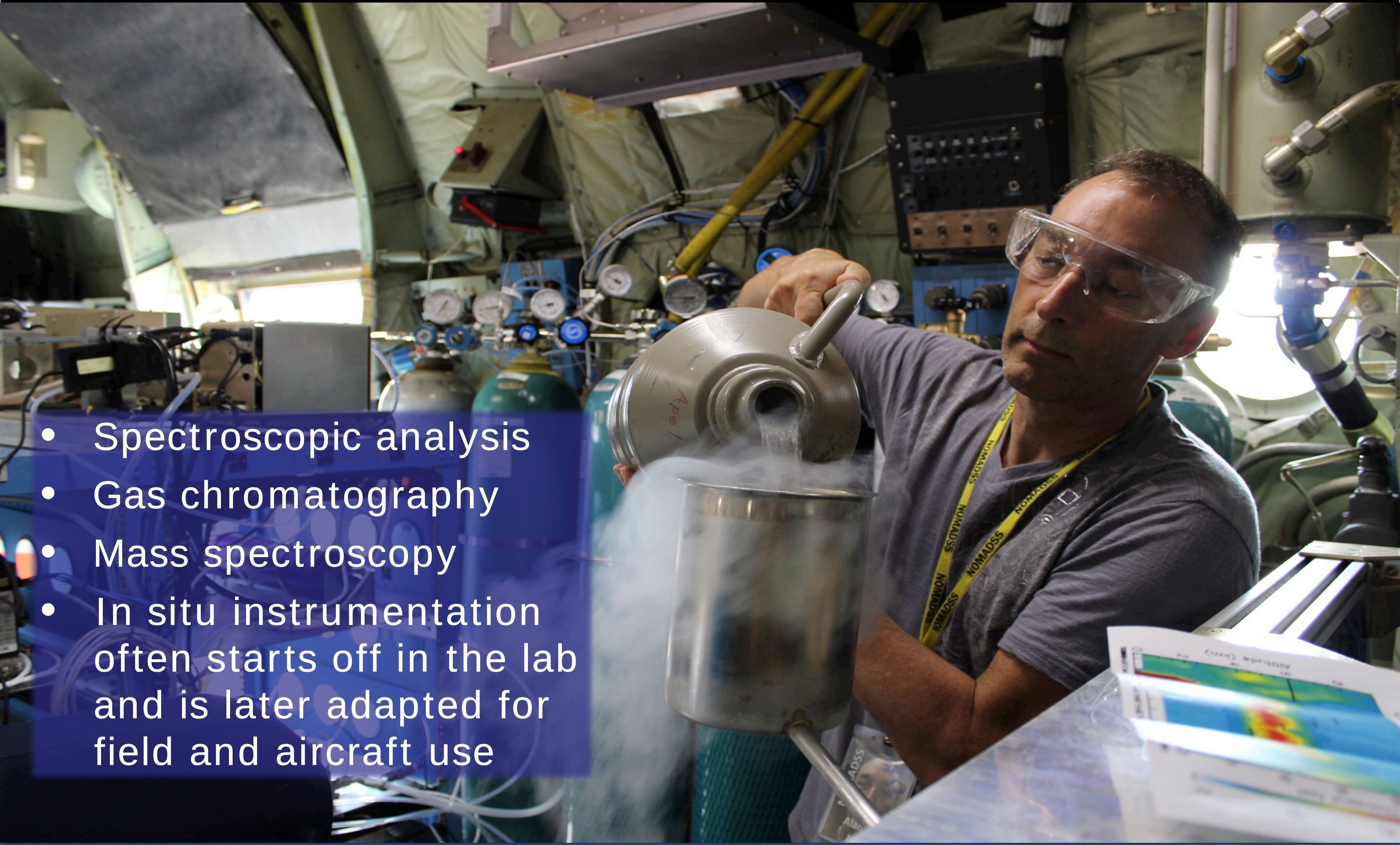
In-situ measurement techniques



- Spectroscopic analysis
- Gas chromatography
- Mass spectroscopy
- In situ instrumentation often starts off in the lab and is later adapted for field and aircraft use

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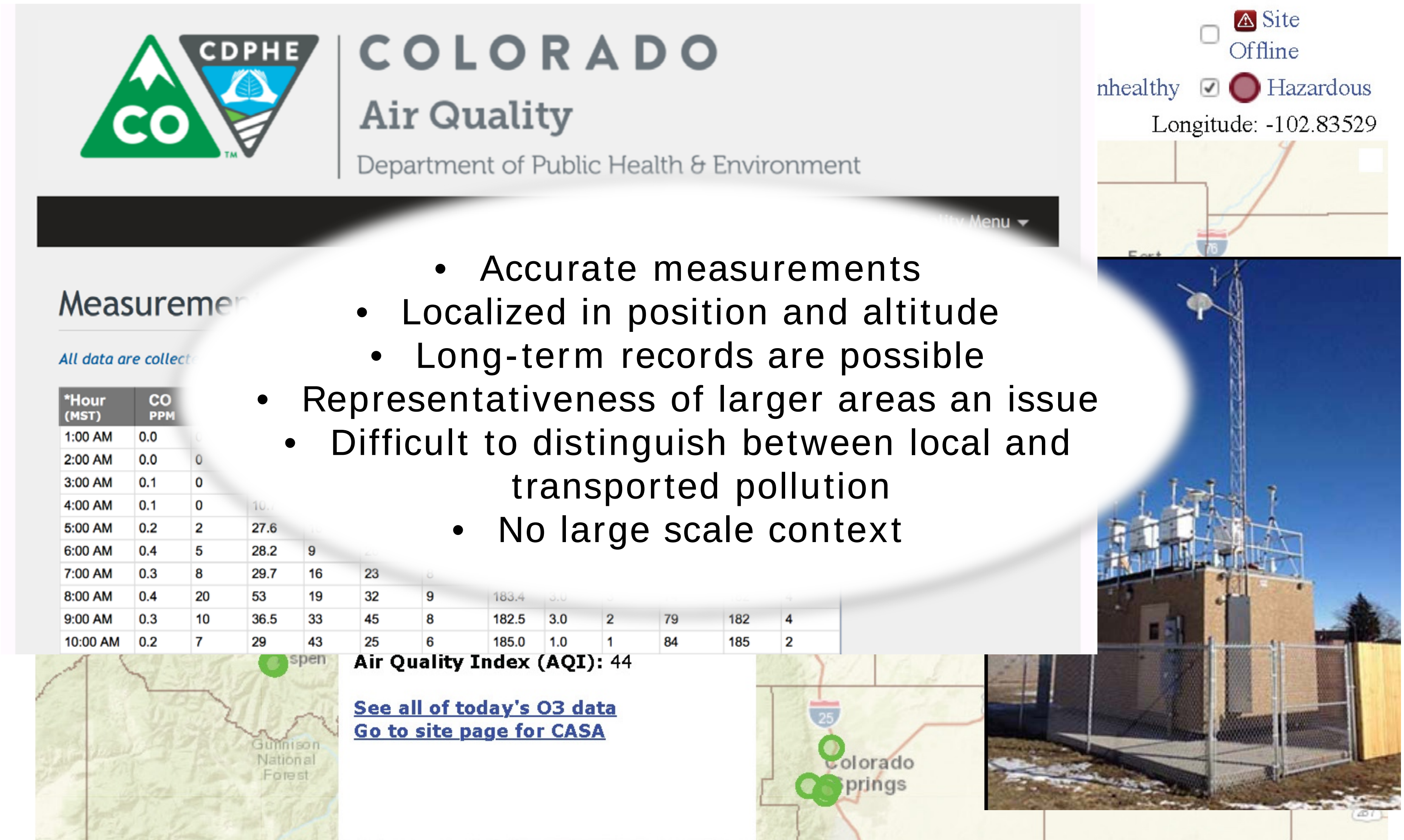
Monitoring



- Accurate measurements
- Localized in position and altitude
- Long-term records are possible
- Representativeness of larger areas an issue
- Difficult to distinguish between local and transported pollution
- No large scale context

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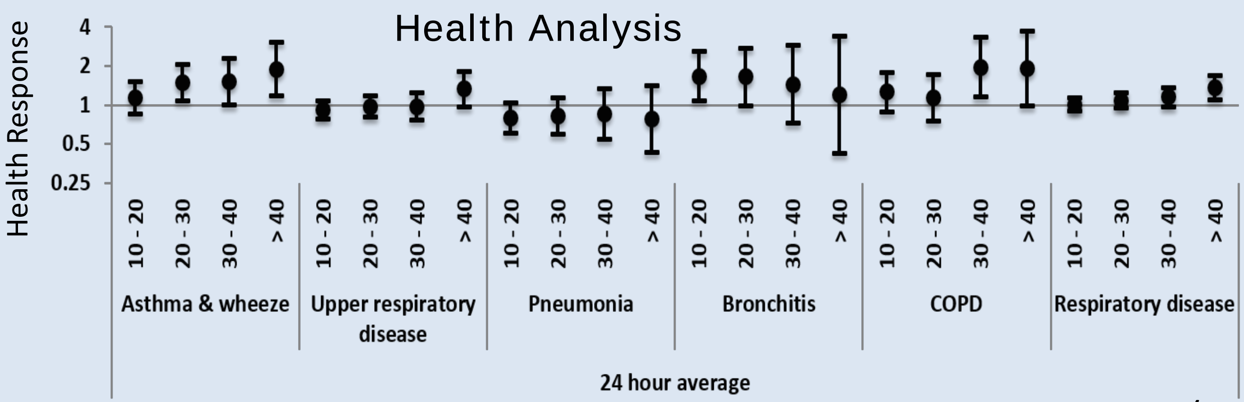
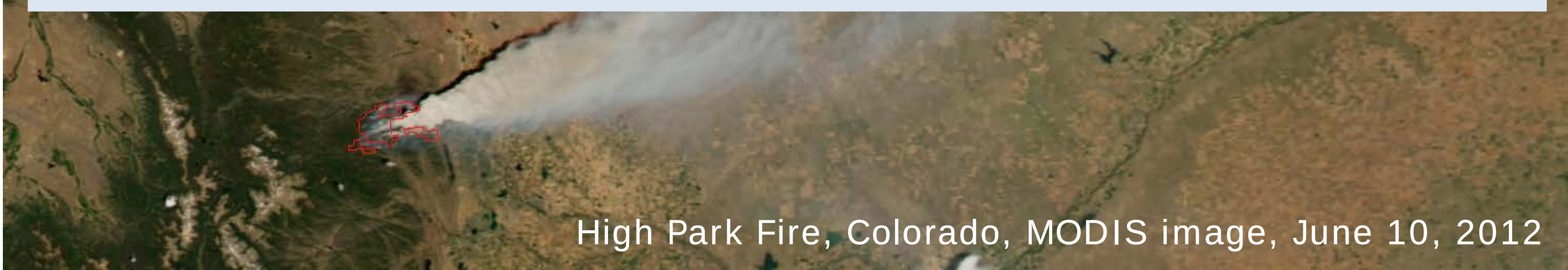
Groundbased monitoring: Wildfires and Health

Case Study: Colorado, Summer 2012

- Collaboration between NCAR, Emory University and CDPHE to explore the relationship of PM2.5 with ED visits and acute hospitalizations for asthma and determine whether wildfire smoke was a contributing factor
- Positive, statistically significant relationships between $PM_{2.5}$ & respiratory disease
- One of first studies to look at concentration-response effects of $PM_{2.5}$ over long-lasting fire period, and to cover a large geographic area

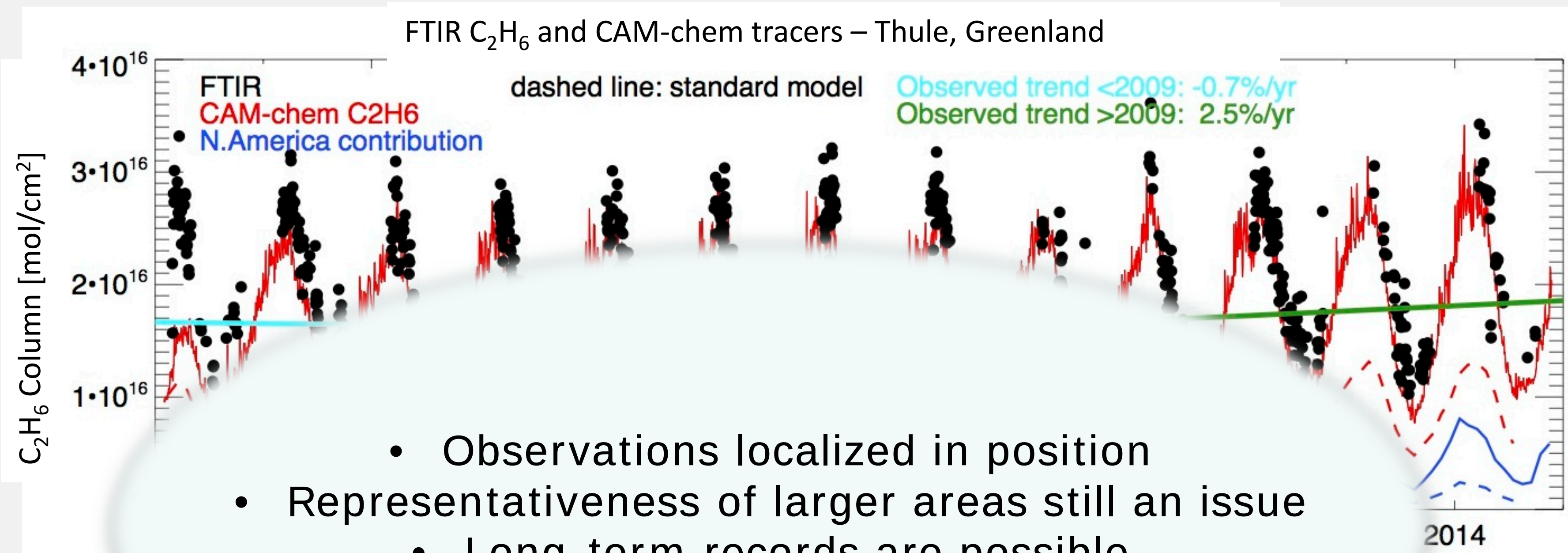


(Strickland et al., to be submitted)



High Park Fire, Colorado, MODIS image, June 10, 2012

Long-term observations document trends



- Observations localized in position
- Representativeness of larger areas still an issue
- Long-term records are possible
- Some altitude information

- Gro… …thane increas… …n in U.S.
- Standard e… …not reproduce these observations so … …based on the data
- The HTAP2 anthropogenic inventory has been doubled globally for all years, and additionally the N. America emissions are increased 0.2 Tg/yr after 2009 [*Franco et al., submitted to Environ. Res. Lett.*]

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Field campaign inspiration & design

- Genesis is often “bottom-up”: Small group of scientists see the need to address a key scientific question
- Typically involves a combination of observational and modeling scientists initiating and leading, motivated by the need to collect breakthrough measurements
- Often a multi-disciplinary problem that involves several communities with multiple goals, capabilities and perspectives
- Final step involves Community Team Building and Engagement: Finding additional key investigators to develop a white paper; holding a community workshop to further develop and refine proposal and campaign ideas

Inside the NSF/NCAR C130 during FRAPPE. Aug. 2014

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Field campaign partnerships

FRAPPÉ: Funded by NSF, State of CO

DISCOVER-AQ: NASA

Provided a comprehensive look at air quality in the Colorado Front Range, an ozone non-attainment area

- NCAR, NSF, Colorado Department for Health and Environment (CDPHE), NASA Airborne Science Program
- Colorado State University (CSU), University of Colorado Boulder, UC Berkeley, UC Irvine, UC Riverside, US Naval Academy, U of Wisconsin, U of Rhode Island, U of Cincinnati, Georgia Tech, GO3 Project, Aerodyne Inc., *and others….*
- Environmental Protection Agency (EPA) Region 8, National Oceanic and Atmospheric Administration (NOAA), National Park Service (NPS), Regional Air Quality Council (RAQC)

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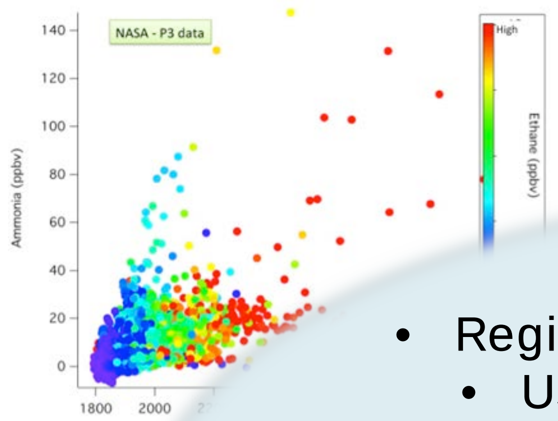
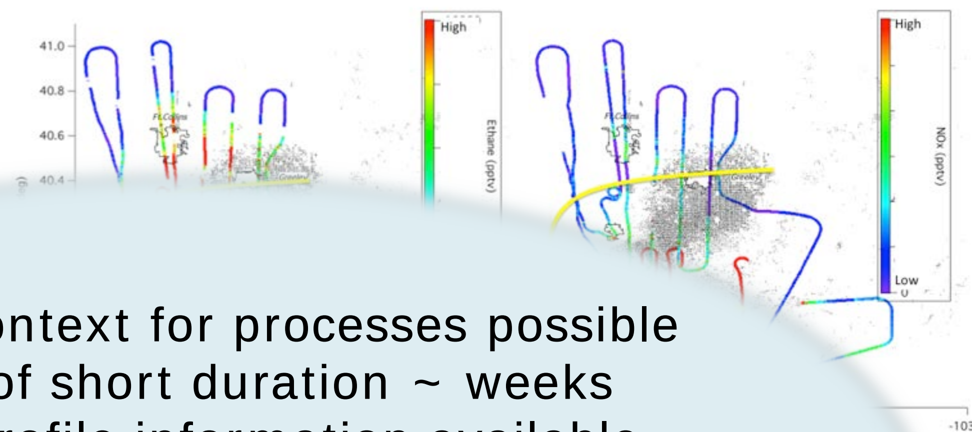
Front Range Air Pollution and Photochemistry Éxperiment

FRAPPÉ (NCAR/NSF/State of Colorado) & DISCOVER-AQ (NASA) collected an unprecedented rich data set on the processes controlling pollution levels in the Colorado Front Range essential to understand:

SOURCES

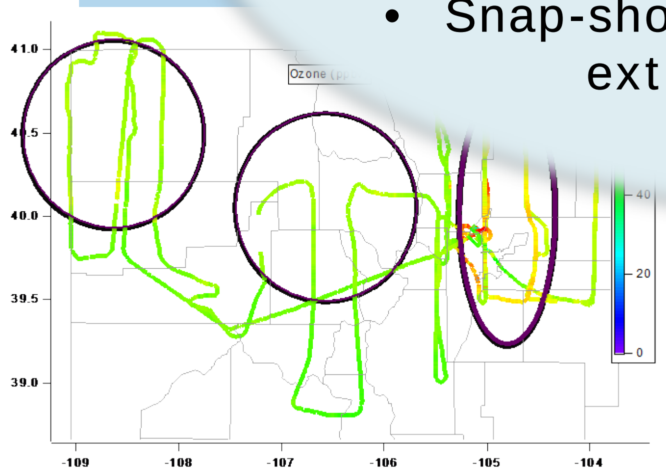


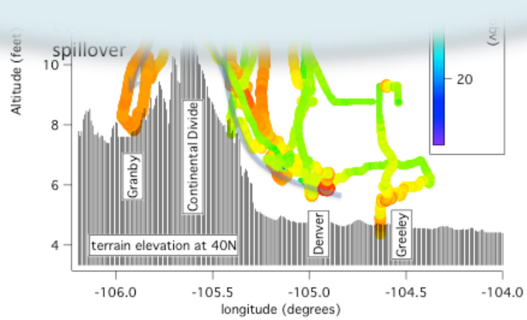
CHEMICAL PROCESSING



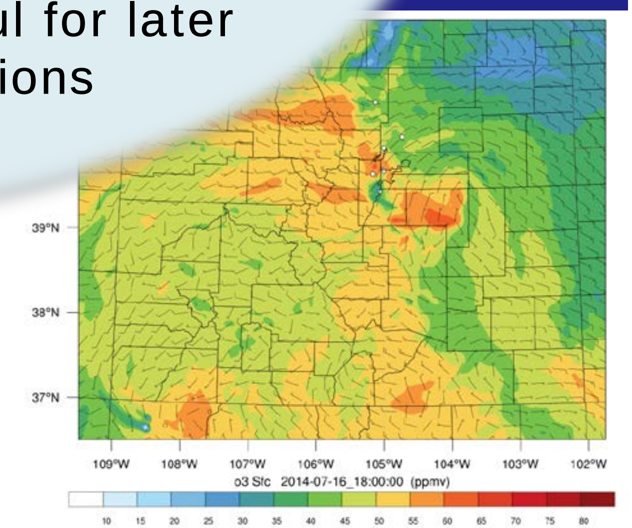
- Regional context for processes possible
- Usually of short duration ~ weeks
- Vertical profile information available
- Excellent opportunity to test an integrated observation system and fully constrain a problem
- Snap-shot in time, hopefully useful for later extrapolation to other situations

BA… CO…

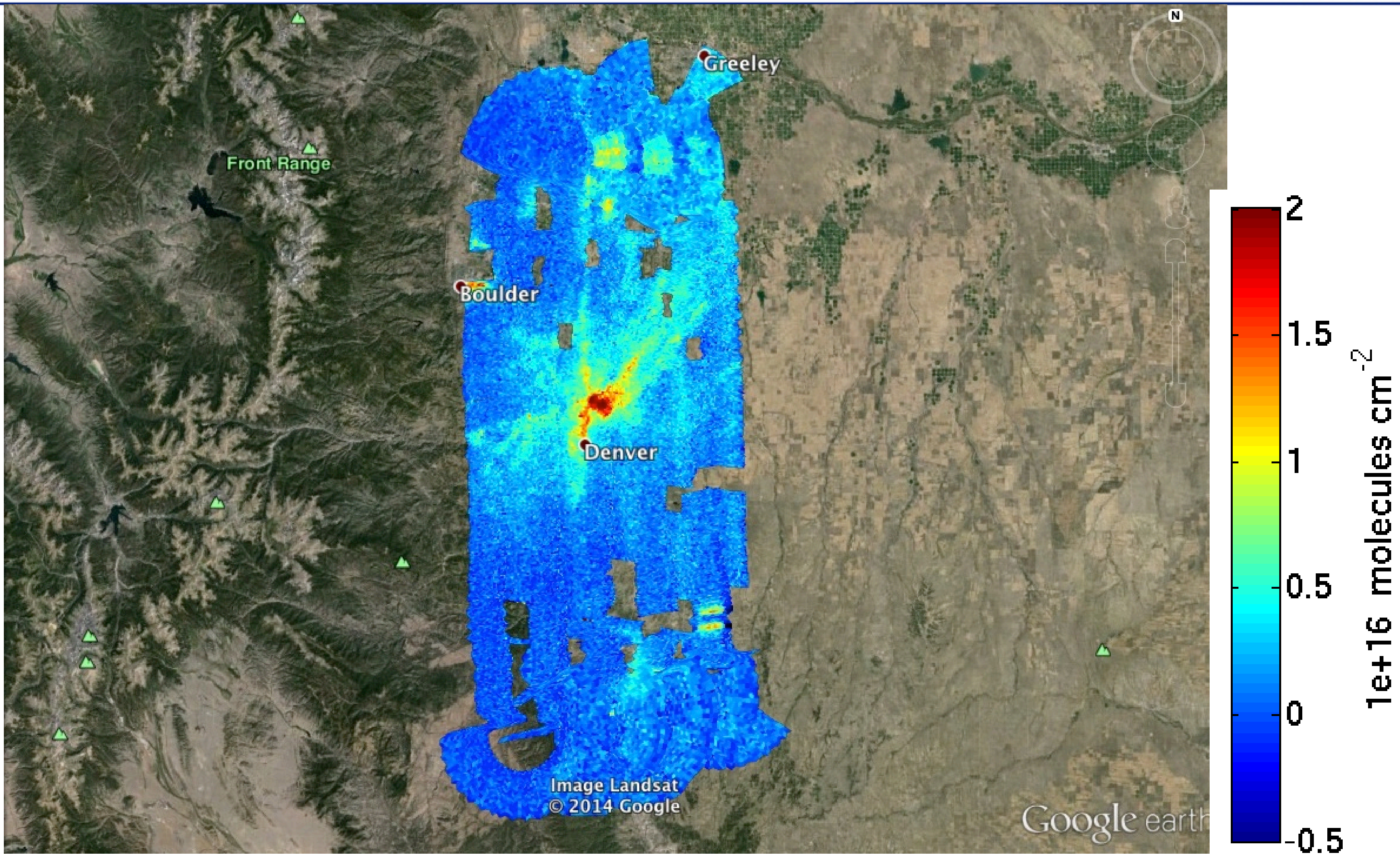




… to much … MODELS



GeoTASO NO_2 Slant Column, 02 August 2014
Morning



Co-added to approx. 500m x 450m

Morning vs. Afternoon

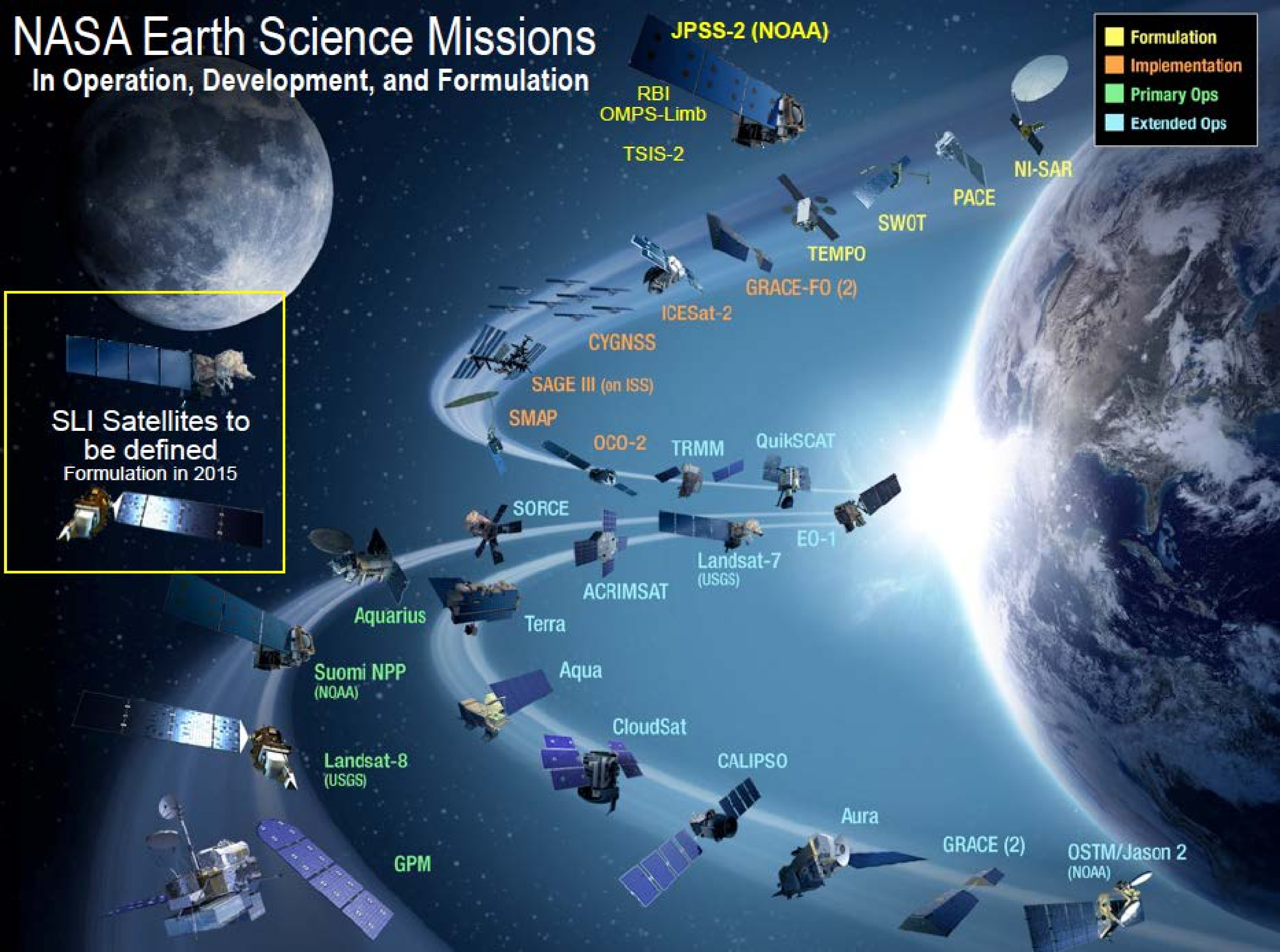
Preliminary data

GeoTASO NO_2 Slant Column, 02 August 2014
Afternoon

Co-added to approx.
500m x 450m

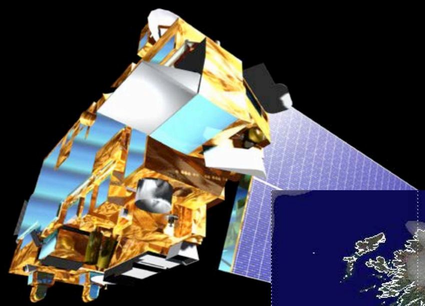
Morning

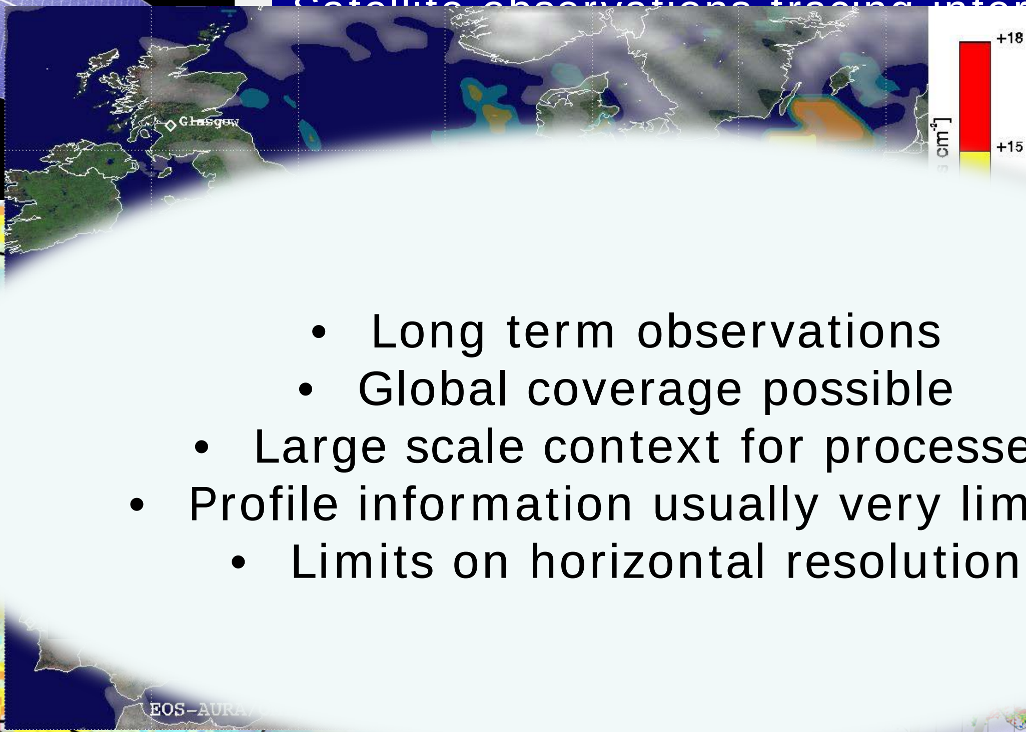
liminary data



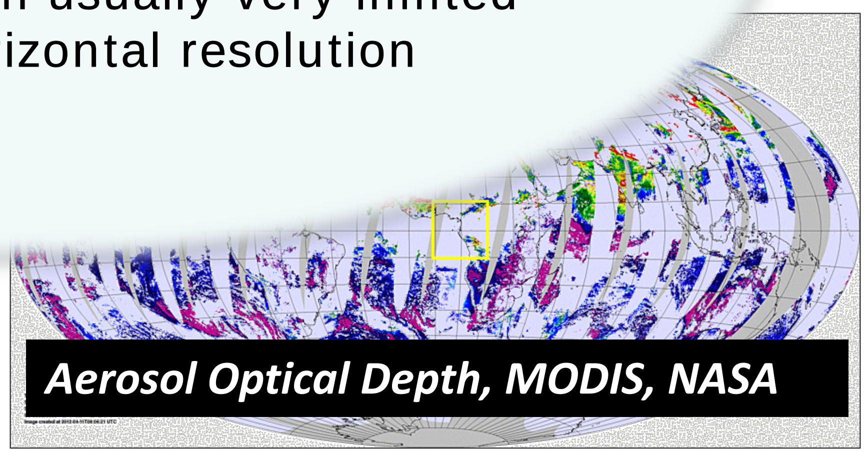
NASA Earth Science Missions
In Operation, Development, and Formulation
Formulation
Implementation
Primary Ops
Extended Ops
JPSS-2 (NOAA)
RBI
OMPS-Limb
TSIS-2
NI-SAR
PACE
SWOT
TEMPO
GRACE-FO (2)
ICESat-2
CYGNSS
SAGE III (on ISS)
SMAP
OCO-2
TRMM
QuikSCAT
SLI Satellites to be defined
Formulation in 2015
SORCE
EO-1
Landsat-7
(USGS)
ACRIMSAT
Aquarius
Terra
Suomi NPP
(NOAA)
Aqua
CloudSat
Landsat-8
(USGS)
CALIPSO
Aura
GPM
GRACE (2)
OSTM/Jason 2
(NOAA)

Observing pollution from Space





- Long term observations
- Global coverage possible
- Large scale context for processes
- Profile information usually very limited
- Limits on horizontal resolution



MEASUREMENTS OF POLLUTION IN THE TROPOSPHERE MOPITT

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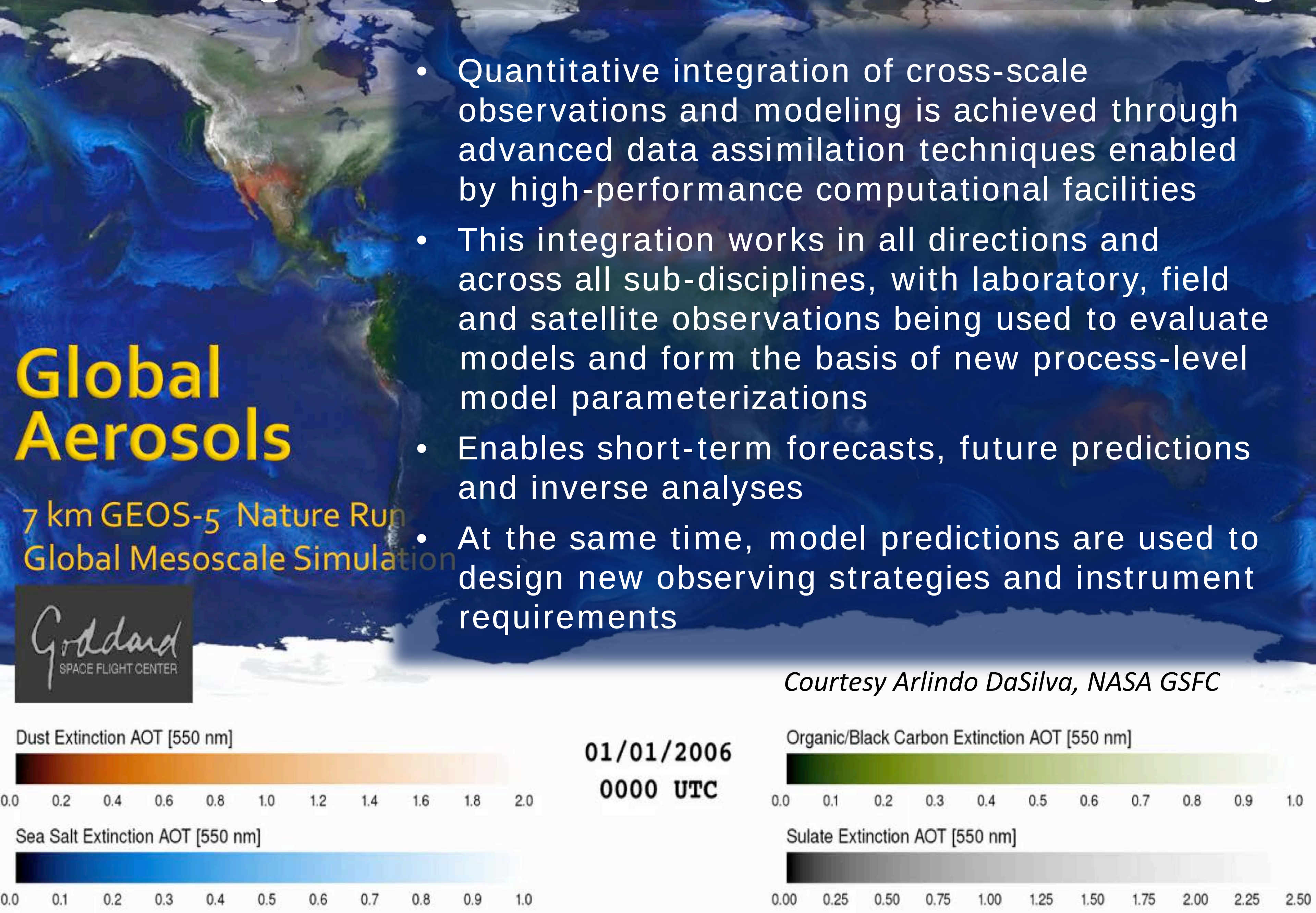
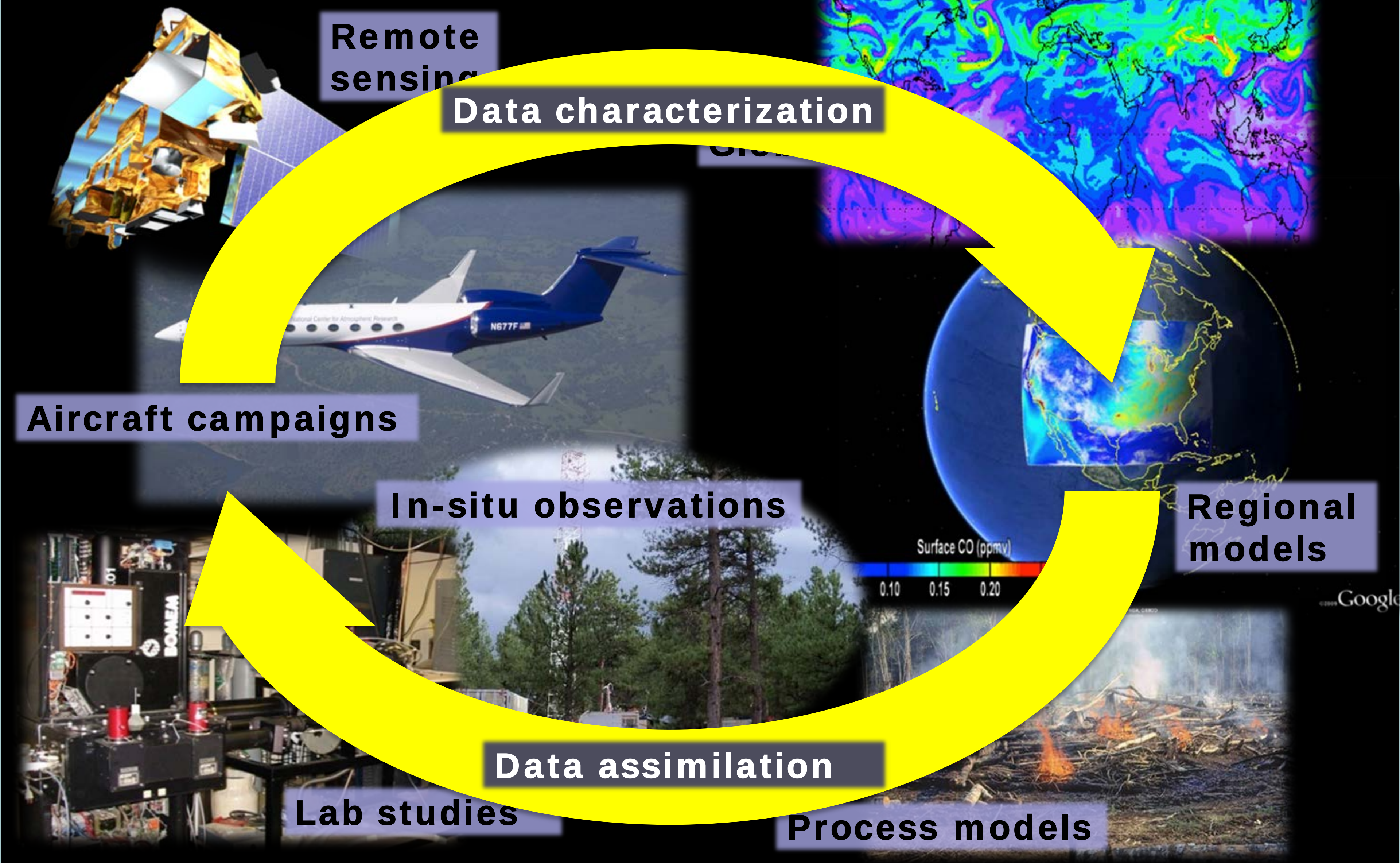
Integration of observations & modeling

- Quantitative integration of cross-scale observations and modeling is achieved through advanced data assimilation techniques enabled by high-performance computational facilities
- This integration works in all directions and across all sub-disciplines, with laboratory, field and satellite observations being used to evaluate models and form the basis of new process-level model parameterizations
- Enables short-term forecasts, future predictions and inverse analyses
- At the same time, model predictions are used to design new observing strategies and instrument requirements



Courtesy Arlindo DaSilva, NASA GSFC

Multidisciplinary science



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Questions

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