

# **INTEX-B & MILAGRO: Airborne observations and satellite validation in 2006**

H. B. Singh, W. H. Brune, **J. H. Crawford**, and D. J. Jacob  
(White paper <http://cloud1.arc.nasa.gov>)

**GOAL: To understand the transport, transformation, & impacts of gases & aerosols on air quality & climate from local to global scales**

- **INTEX-A: Summer 2004**
  - large biosphere emissions
  - active photochemistry
- **INTEX-B: Spring 2006**
  - maximum Asian inflow to NA
  - seasonal contrast

## **MILAGRO**

**MCMA-2006**

**MAX-Mex**

**MIRAGE-Mex**

**INTEX-B/1**

## **INTEX-B**

**INTEX-B/2 (IMPEX)**  
**ITOP**

**Partners: NASA, NSF, DOE, DLR, Mex**

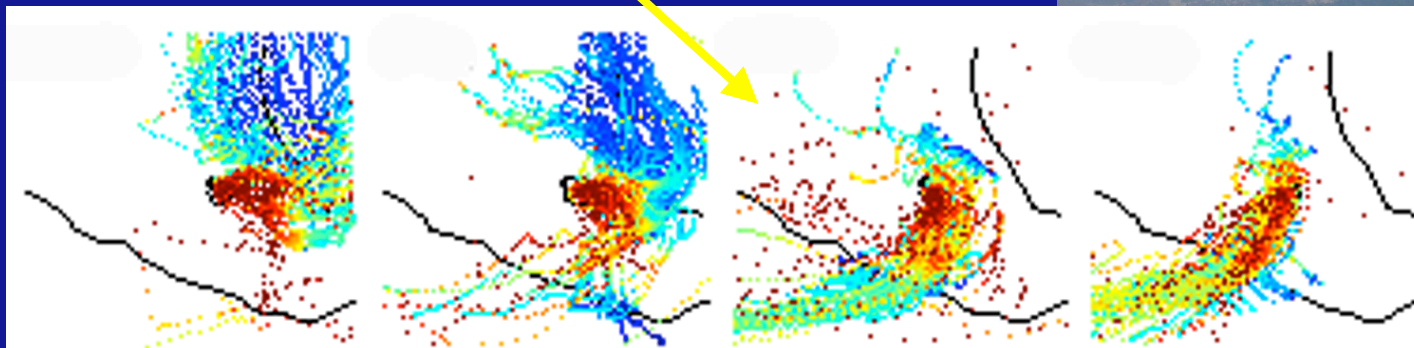
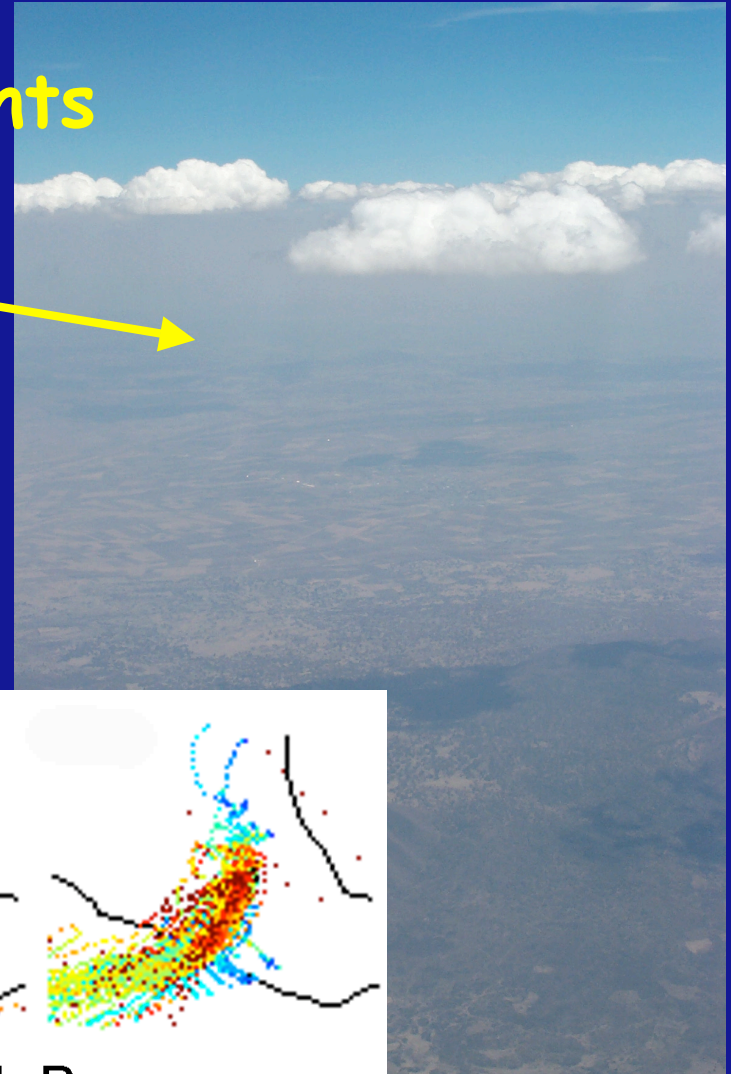
## **INTEX-B/MILAGRO SCIENTIFIC GOALS**

- **Transport & evolution of Asian pollution to NA & beyond - implications for regional air quality & climate**
- **Extent, persistence, & transformation of Mexico City pollution plumes**
- **Validation of satellite observations of tropospheric composition**
- **Mapping of anthropogenic and biogenic emissions**
- **Relating atmospheric composition to sources & sinks**

## Dispersion of MCMA pollutants

Most pollution may be locked in PBL (ground level to 2-4 km AGL).

Horizontal dispersion direction changes with the weather.



Texas Low Pressure >>> Pacific High Pressure

particle trajectory model - noon, 29 April - 2 May 2003

red = fresher; blue = older

(from B. de Foy)

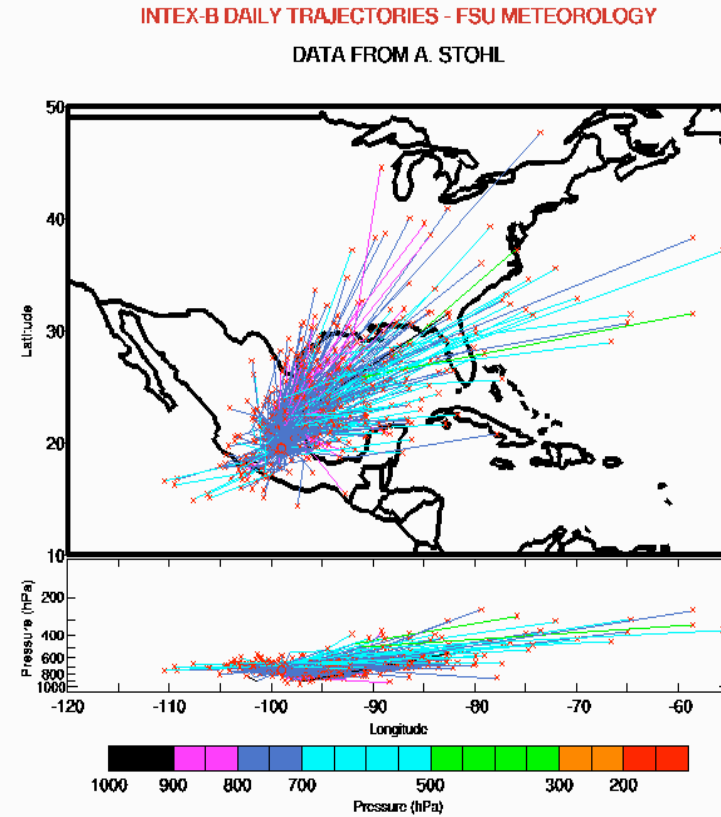
# Where does Mexico City Pollution go?

## 3-Day Forward Trajectories



**March Data for 15 years;  
33% over US**

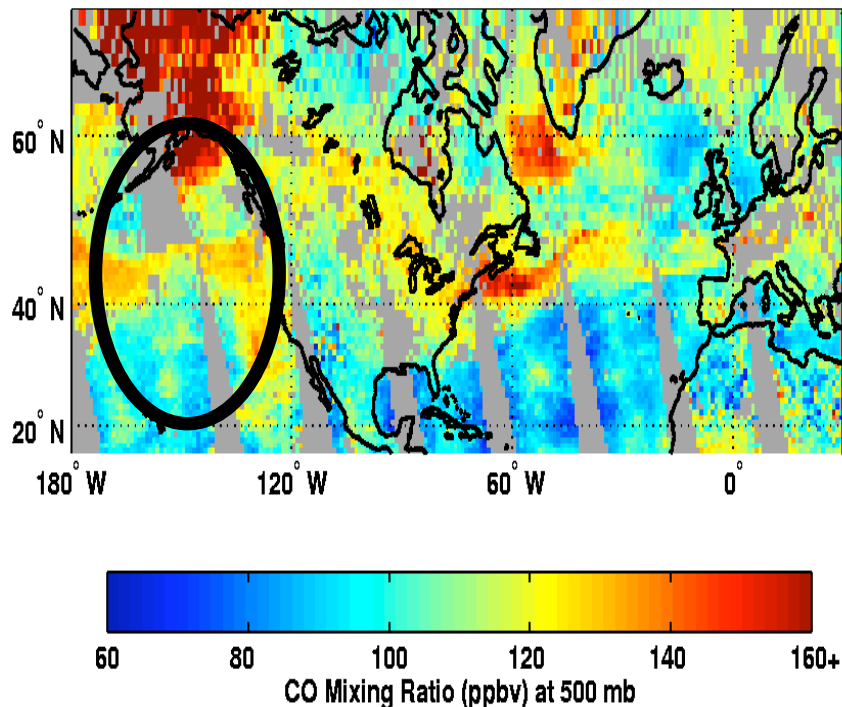
- most in PBL, but some higher?





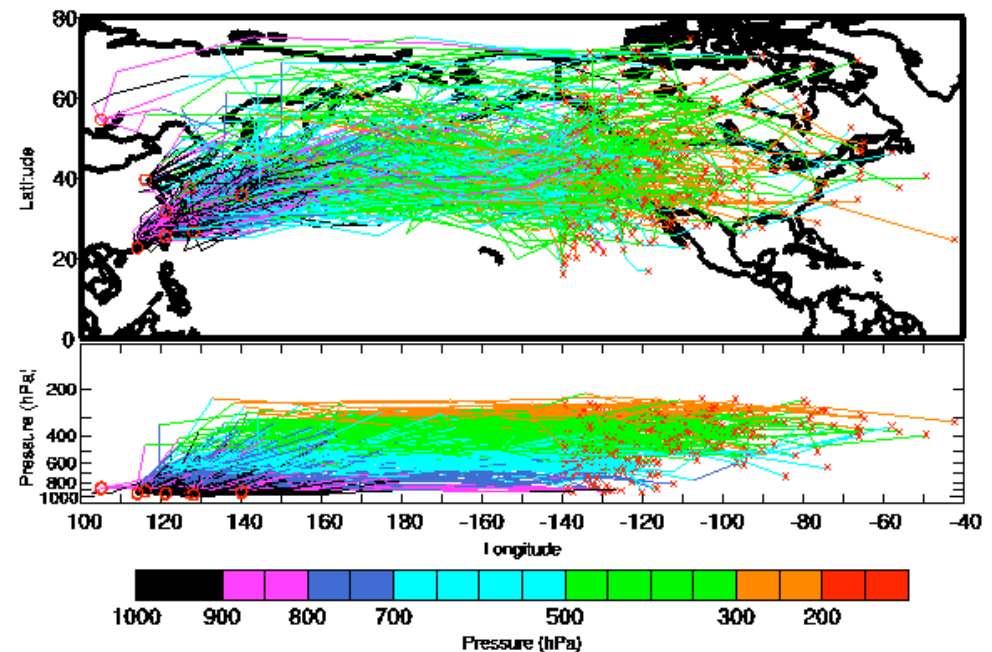
# Is the observed $O_3$ trend of 0.5 ppb/yr due to Asian pollution? - 7-day Forward Asian Trajectories (past 140W)

Local PM (ascending) AIRS CO at 500 mb on 20040701



INTEX-B DAILY TRAJECTORIES - FSU METEOROLOGY

DATA FROM A. STOHL

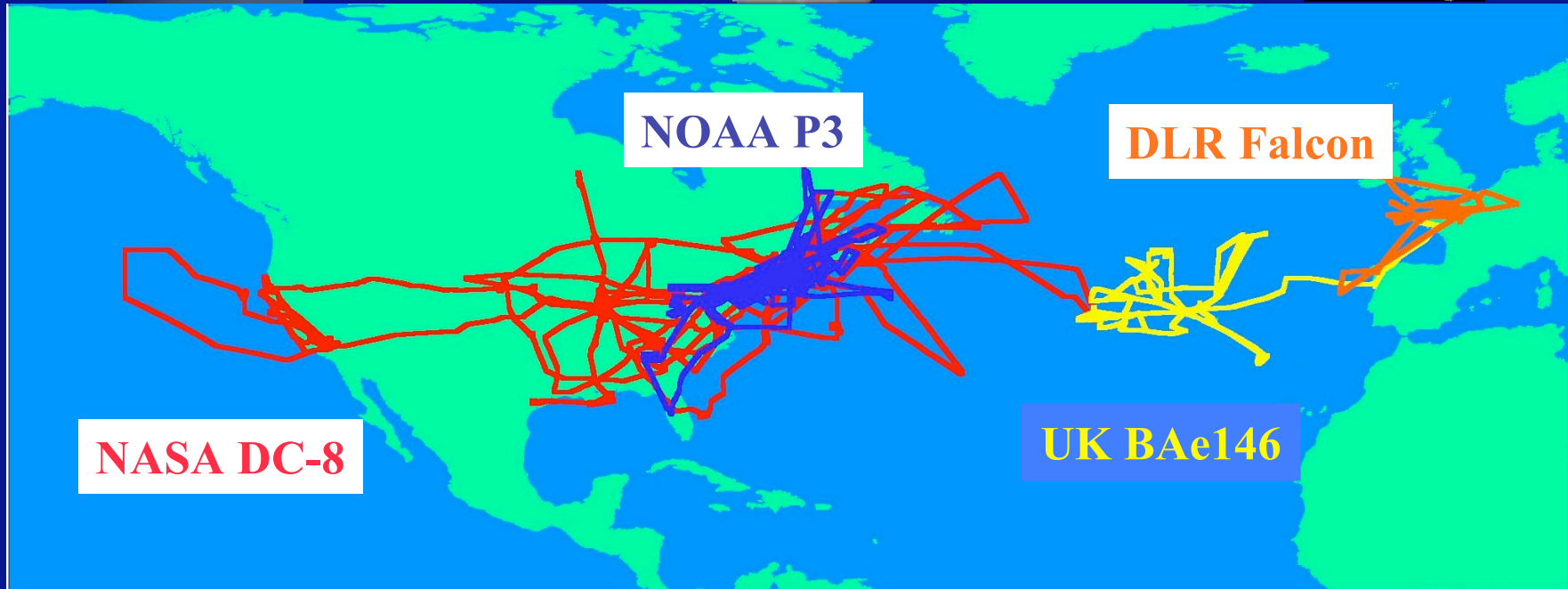
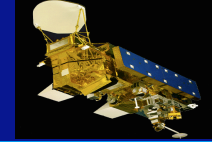


**Major Asian pollution plumes cross about once a week.**

**344 trajectories ~ 10%**

One Trajectory per day released from 500 meters AGL from 8 Asian cities.  
April data, 15 years

# INTEX-B plan patterned after INTEX-A plan



- Inter-comparisons
- Coordinated Science flights
- Sharing of forecasts & data
- Joint publications

# INTEX-B Science Team

**B. Doddridge**  
**TCP Manager, NASA HQ**

**H. Singh, Lead Mission Scientist, NASA ARC**  
**W. Brune, Co-Mission Scientist, Penn State U.**  
**J. Crawford, Co-Mission Scientist, NASA LaRC**  
**D. Jacob, Co-Mission Scientist, Harvard U.**

**Project managers, NASA ARC**  
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**K. Shiffer**

## **DC-8 measurements**

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**M. Avery, NASA LaRC**  
**J. Barrick, NASA LaRC**  
**D. Blake, UC Irvine**  
**E. Browell, NASA LaRC**  
**A. Clarke, Univ. of Hawaii**  
**R. Cohen, UC Berkeley**  
**J. Dibb, U. of New Hampshire**  
**G. Diskin, NASA LaRC**  
**A. Fried, NCAR**  
**B. Heikes, U. of Rhode Island**  
**G. Huey, GIT-EAS**  
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**J. Podolske, NASA ARC**  
**P. Russell, NASA ARC**  
**G. Sachse, NASA LaRC**  
**R. Shetter, NCAR**  
**D. Tan, GIT-EAS**  
**S. Vay, NASA LaRC**

## **Theory and forecasting**

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**D. Edwards, NCAR**  
**H. Fuelberg, FSU**  
**(Mission meteorologist)**  
**W. McMillan, UMBC**  
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**B. Pierce, NASA LaRC**  
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## **Other INTEX-B & Aura**

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**G. Mount, WSU**  
**J-P. Pommereau, Ctr Natl de la Rech. Sci**  
**A. Thompson, Penn State U.**  
**J. Warner, JCET/UMBC**

## **INTEX-B (IMPEX)**

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**J. Jimenez, U. of Colorado**  
**R. Mauldin, NCAR**  
**D. Riemer, U. Miami**  
**R. Weber, GIT-EAS**  
**P. Wennberg, Cal Tech**  
**others supported by NSF / NCAR**

# Main INTEX-B Airborne Platforms

NASA DC-8



NSF C-130



DLR FALCON



DOE G1



NASA J-31





# DLR/Falcon INTEx-B Instrumentation

## \* Chemical Measurements

### Gases:

Nitrogen-  $\text{NO}$ ,  $\text{HNO}_3$ ,  $\text{NO}_y$

Carbon-  $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{CH}_2\text{O}$

Oxidants-  $\text{O}_3$

Sulphur-  $\text{SO}_2$ ,



### Aerosols:

Aerosol size distribution (  $0.004 - 20 \mu\text{m}$  )

volatile/semi-volatile aerosol fraction

\* 5+ missions to coincide with INTEx-B/Part 2

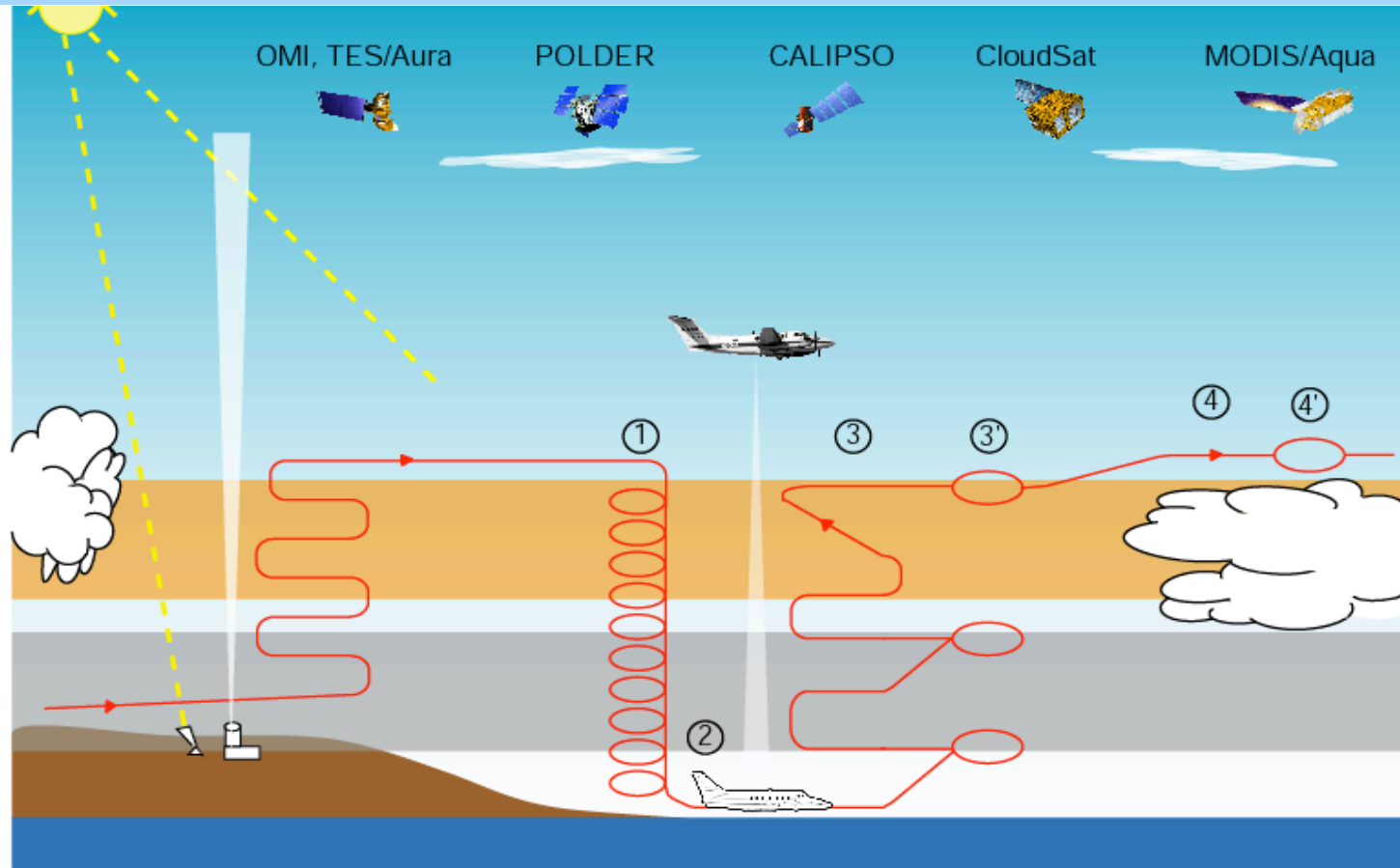


# J31 INTEX-B/MILAGRO Instrumentation



- Sun Photometer (AATS-14): Aerosol optical depth
- Solar Spectral Flux Radiometer (SSFR): Solar flux
- Research Scanning Polarimeter (RSP): Polarization & cloud properties
- Cloud Absorption Radiometer (CAR): Cloud & surface properties

# Flight Patterns Required for J31 Scientific Objectives, INTEx-B/MILAGRO

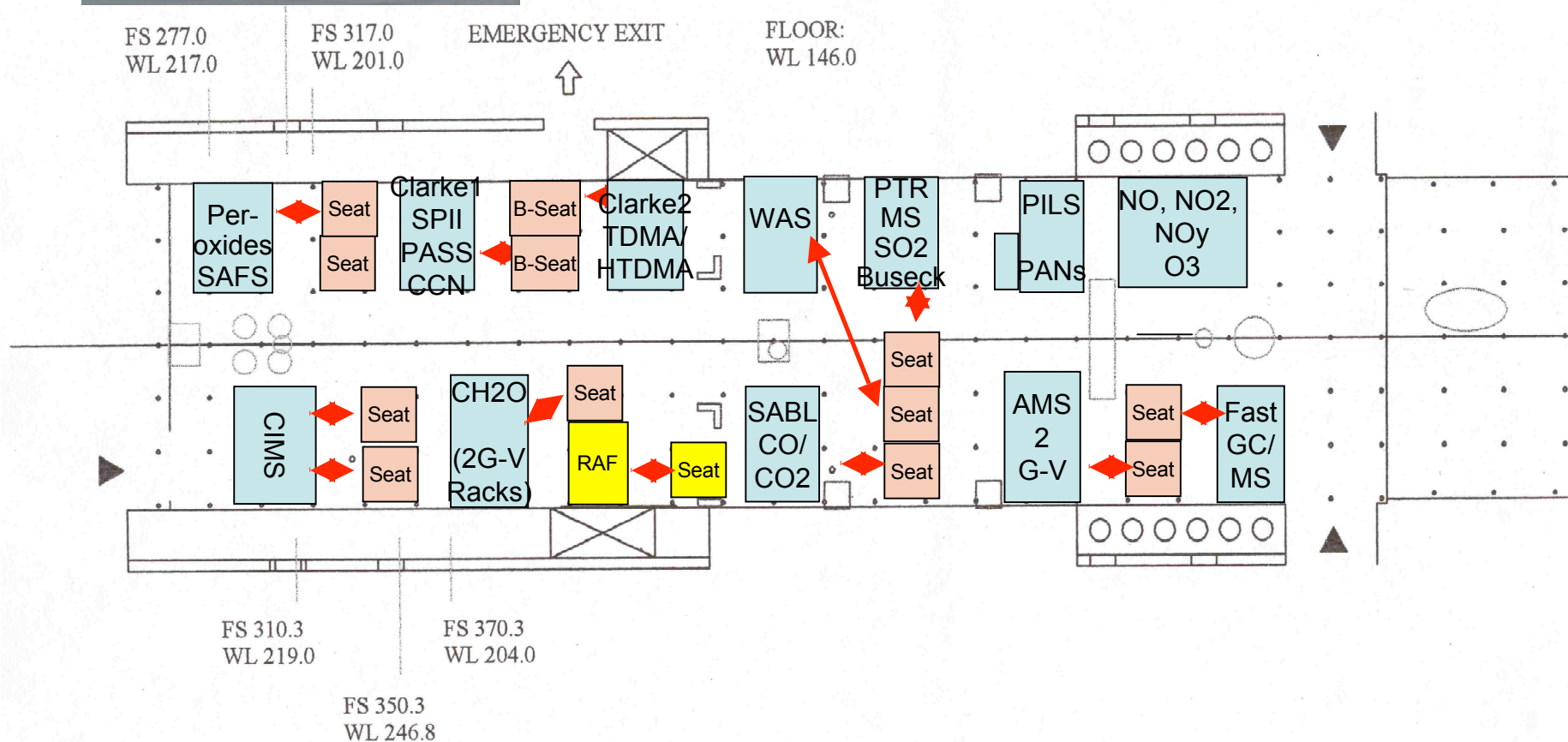


- (1) Survey Vertical Profile. (2) Minimum-Altitude Transect.  
(3) Parking Garage (Stepped Profile). (3') Parking Garage with CAR Orbits.  
(4) Above-Cloud Transect. (4') Above-Cloud CAR Orbit.

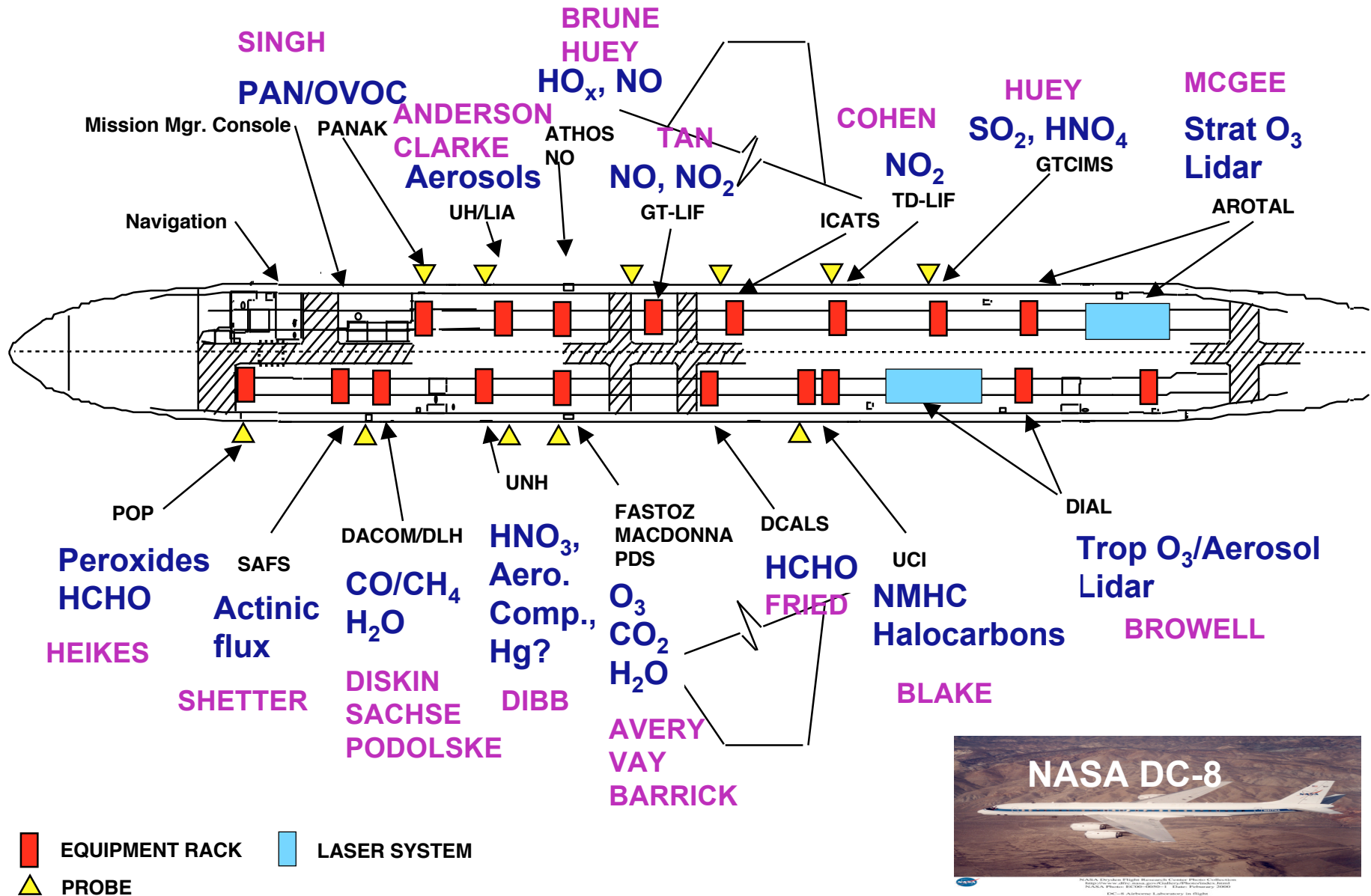


## C-130 LAYOUT FOR MIRAGE

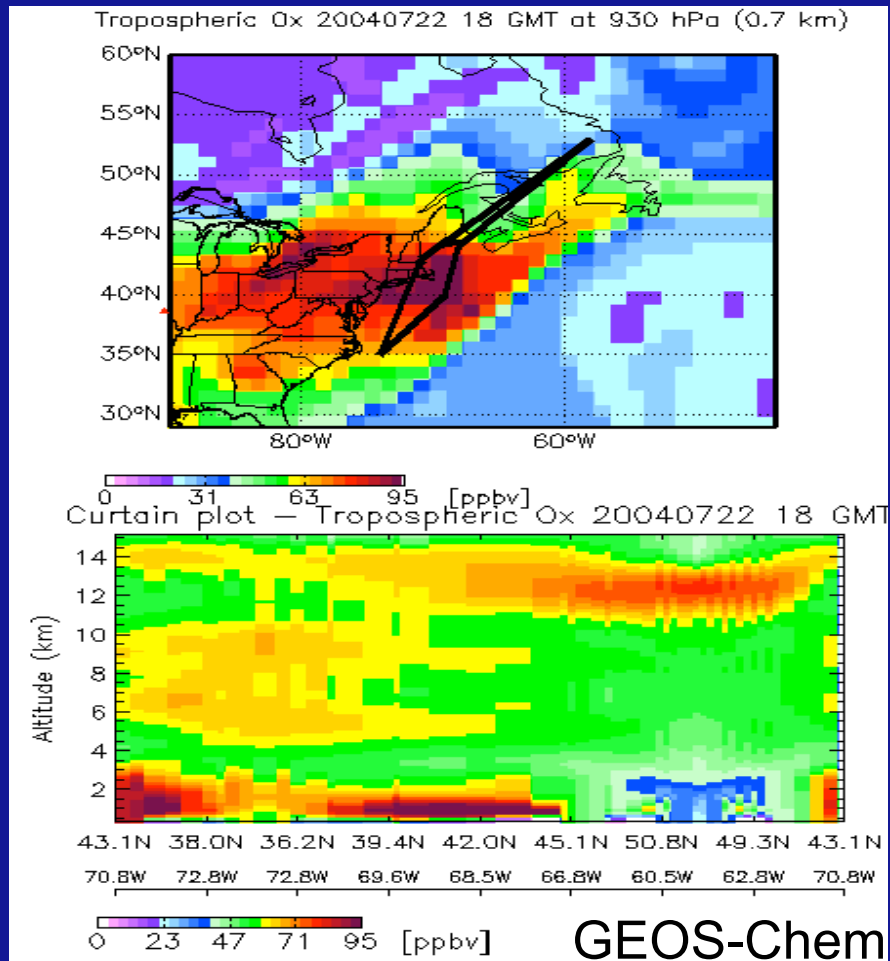
Autonomous instruments:  
NO / NO<sub>y</sub> / O<sub>3</sub>; CO / CO<sub>2</sub>; PANs;  
PILS; WAS; SAFS; SO<sub>2</sub>



# DC-8 INTEx-B Payload



# Forecast Products



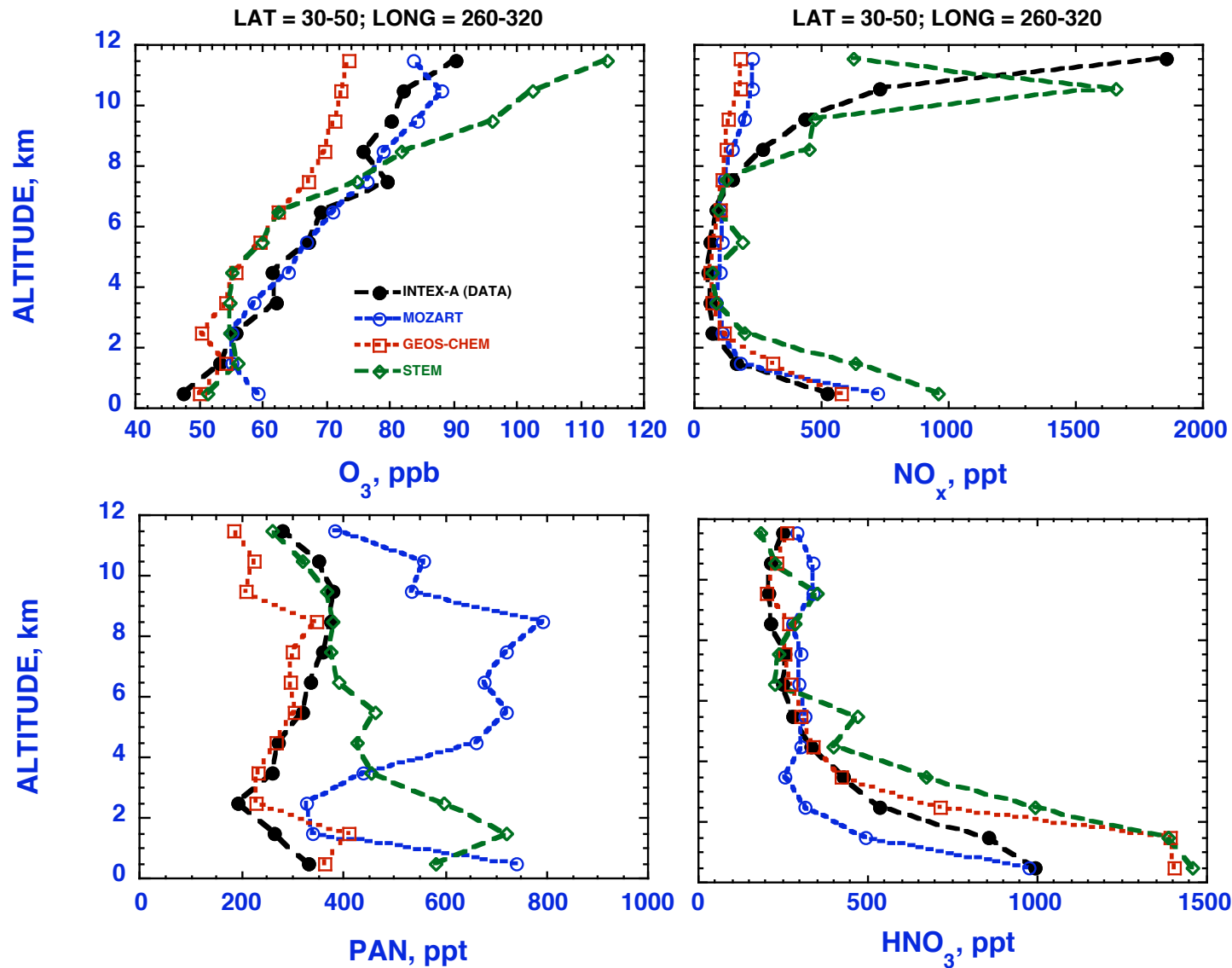
**MET data**  
**Trajectories**  
**Convective influences**

**AIRS CO**  
**MOPITT CO**  
**MODIS Aerosol**

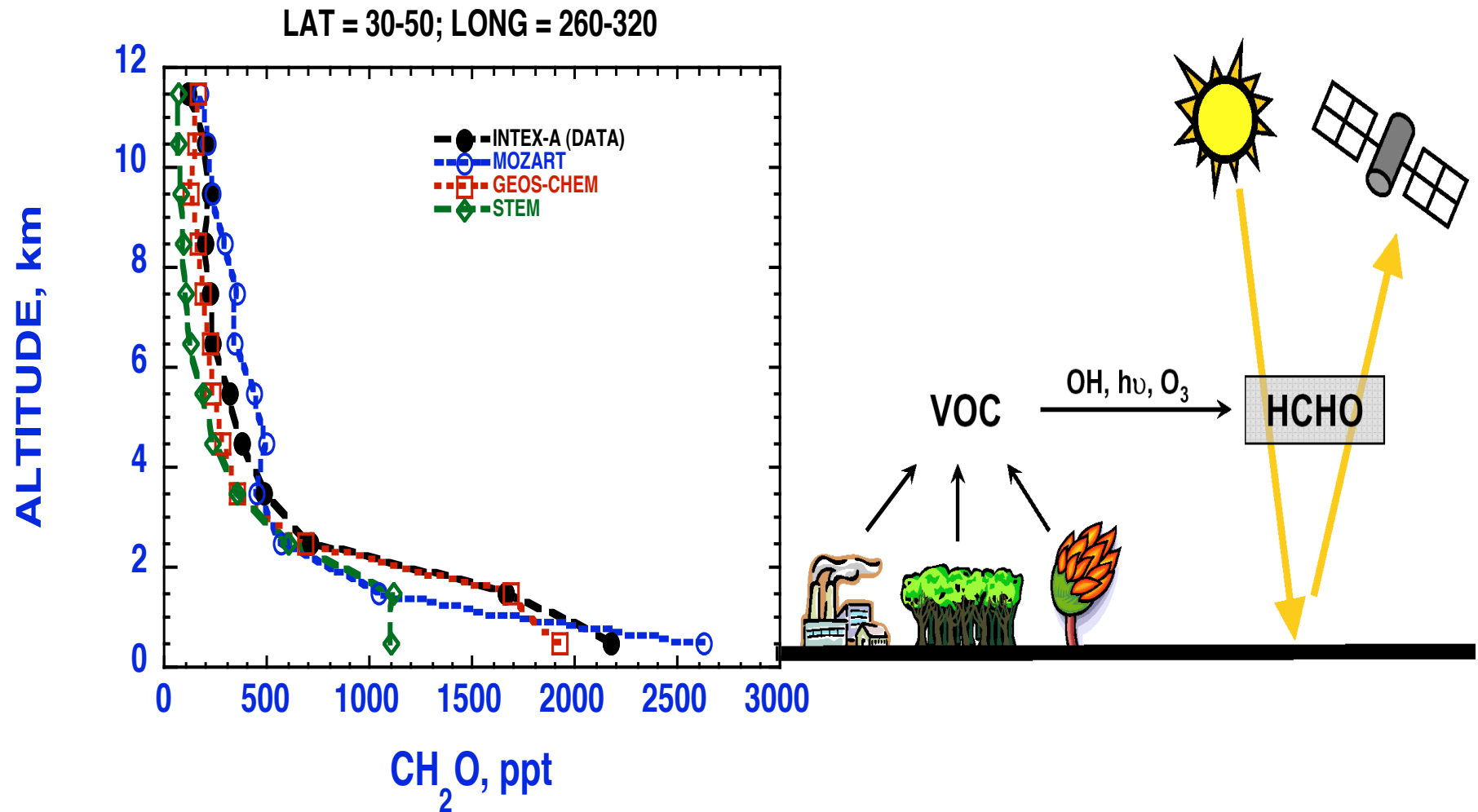
**GEOS-Chem (Harvard)**  
**MOZART (NCAR)**  
**RAQMS (Langley)**  
**STEM/CFORS (U. Iowa)**



# O<sub>3</sub> & Reactive Nitrogen vs models – mixed results

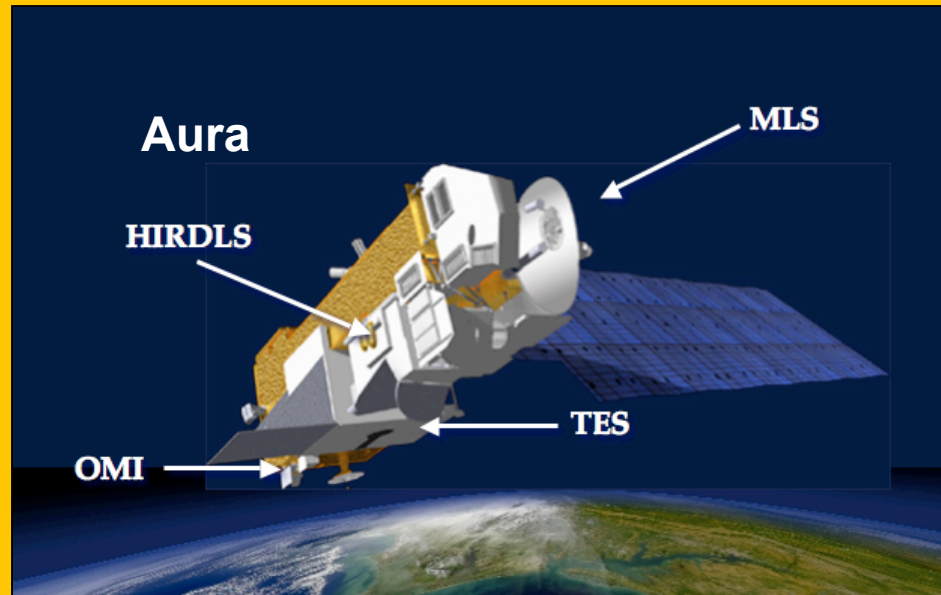


# Formaldehyde and isoprene



Aircraft & satellite observations used with models to understand emissions.

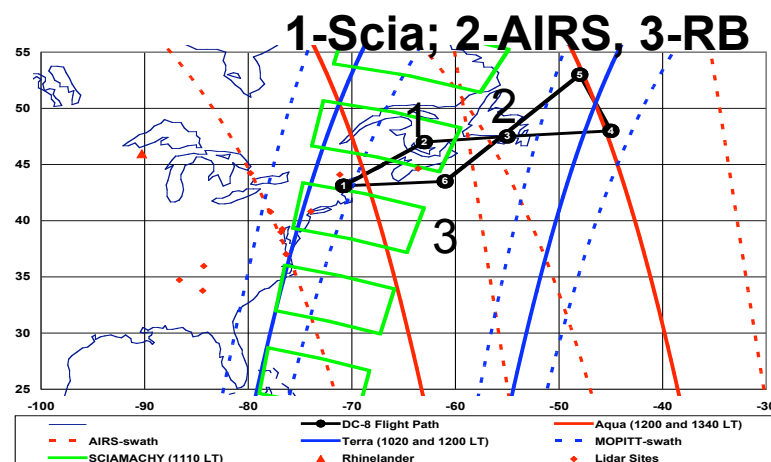
# Satellites



| Satellite Platform*                                                                                  | Instruments                                  | Some key data products                                                                                                                                                    | Vert. resol.                                                      |
|------------------------------------------------------------------------------------------------------|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| <b>Aura:</b><br><a href="http://eos-aura.gsfc.nasa.gov/">http://eos-aura.gsfc.nasa.gov/</a>          | <b>TES</b><br><b>OMI</b><br><b>MLS</b>       | <b>CO, CH<sub>4</sub>, O<sub>3</sub>, HNO<sub>3</sub>, NO<sub>2</sub></b><br><b>O<sub>3</sub>, NO<sub>2</sub>, SO<sub>2</sub>, HCHO</b><br><b>H<sub>2</sub>O, HCN, CO</b> | <b>Trop col./4 km</b><br><b>Trop column</b><br><b>UT/LS</b>       |
| <b>Aqua:</b><br><a href="http://eos-pm.gsfc.nasa.gov/">http://eos-pm.gsfc.nasa.gov/</a>              | <b>MODIS</b><br><b>AIRS</b>                  | <b>Aerosol optical depth</b><br><b>CO</b>                                                                                                                                 | <b>Trop column</b><br><b>Trop col./4 km</b>                       |
| <b>Terra:</b><br><a href="http://eos-am.gsfc.nasa.gov/">http://eos-am.gsfc.nasa.gov/</a>             | <b>MOPITT</b><br><b>MISR</b><br><b>MODIS</b> | <b>CO</b><br><b>Aerosol optical depth</b><br><b>Aerosol optical depth</b>                                                                                                 | <b>Trop col./4 km</b><br><b>Trop column</b><br><b>Trop column</b> |
| <b>Envisat:</b><br><a href="http://envisat.esa.int/">http://envisat.esa.int/</a>                     | <b>SCIAMACHY</b><br><b>MIPAS</b>             | <b>O<sub>3</sub>, NO<sub>2</sub>, CH<sub>2</sub>O</b><br><b>Trace organics</b>                                                                                            | <b>Trop column</b><br><b>UT/LS</b>                                |
| <b>Calipso:</b><br><a href="http://www.calipso.larc.nasa.gov/">http://www.calipso.larc.nasa.gov/</a> | <b>CALIOP</b>                                | <b>Aerosol distribution</b>                                                                                                                                               | <b>High resolution</b>                                            |

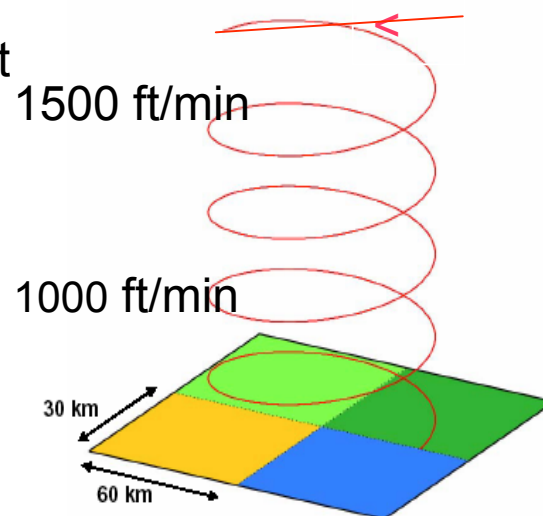
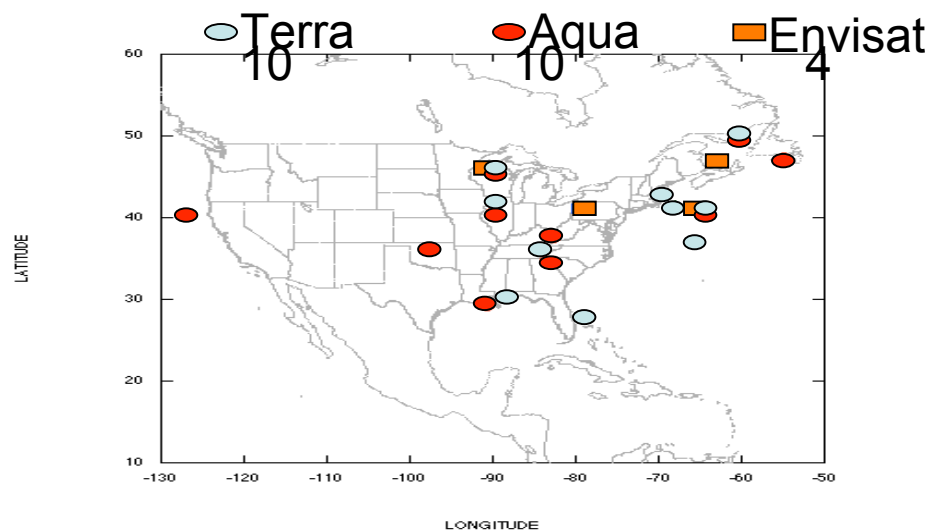
# INTEX-A DC-8 Satellite Validations (MOPITT, MISR, AIRS, SCIAMACHY)

CO  
HCHO  
NO<sub>2</sub>  
SO<sub>2</sub>  
H<sub>2</sub>O  
HCN  
O<sub>3</sub>  
Aerosol  
Organics

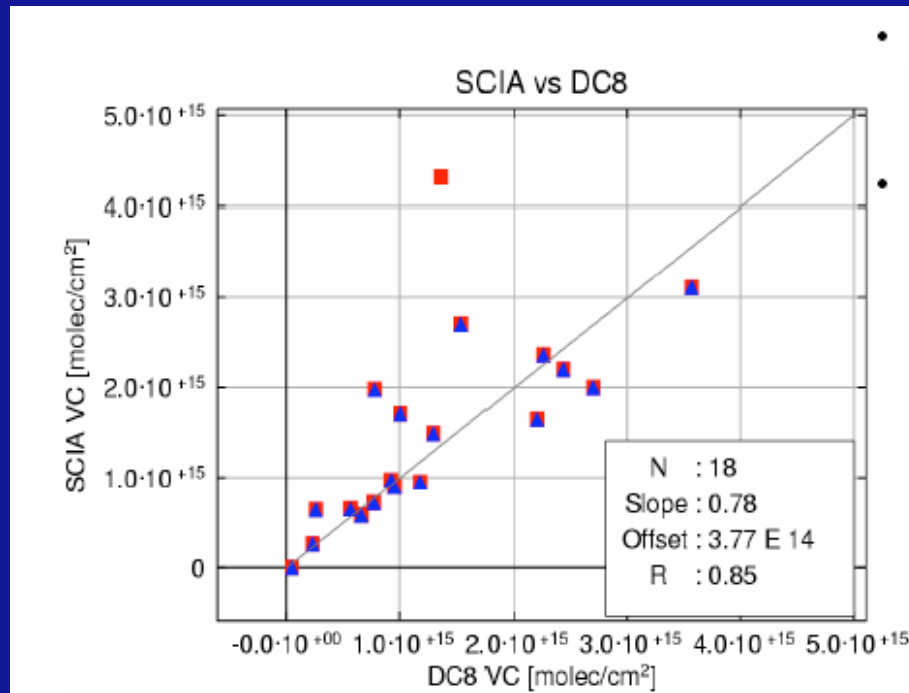


**Profiles:**

- to 11 km
- cloud free
- 15 mi spiral
- 1 hr window



# DC-8/SCIAMACHY Trop Column $\text{NO}_2$

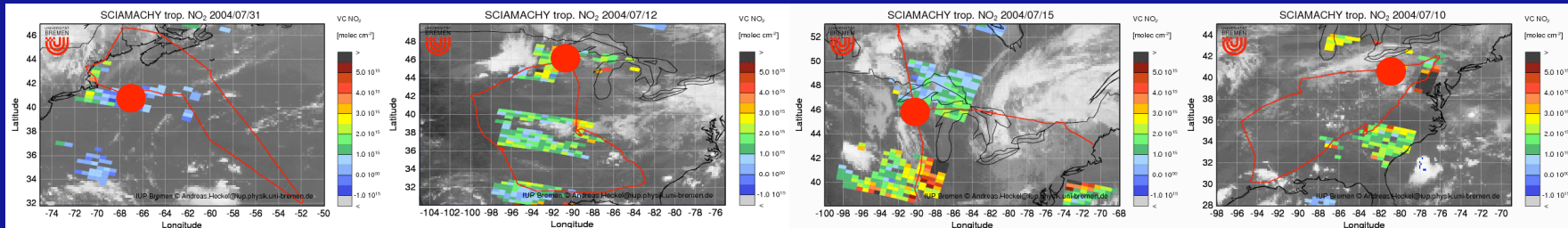
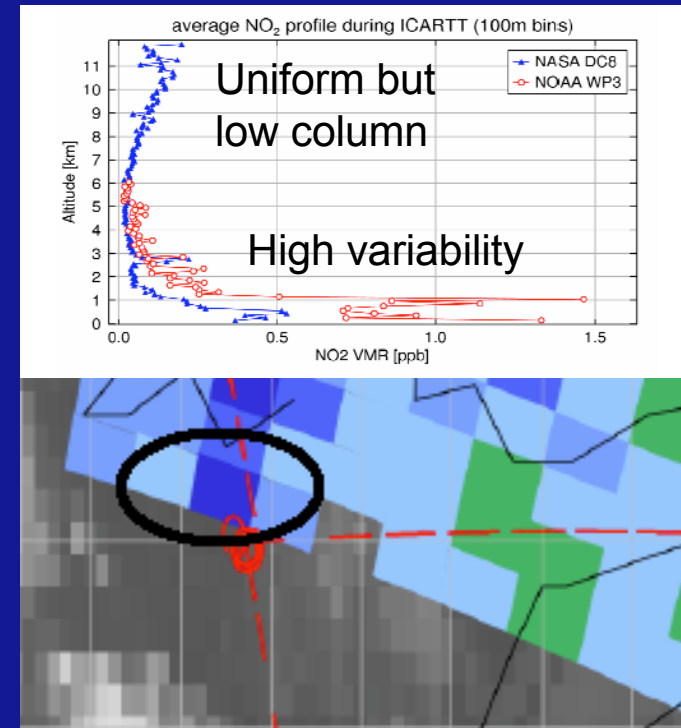


7/31

7/12

7/15

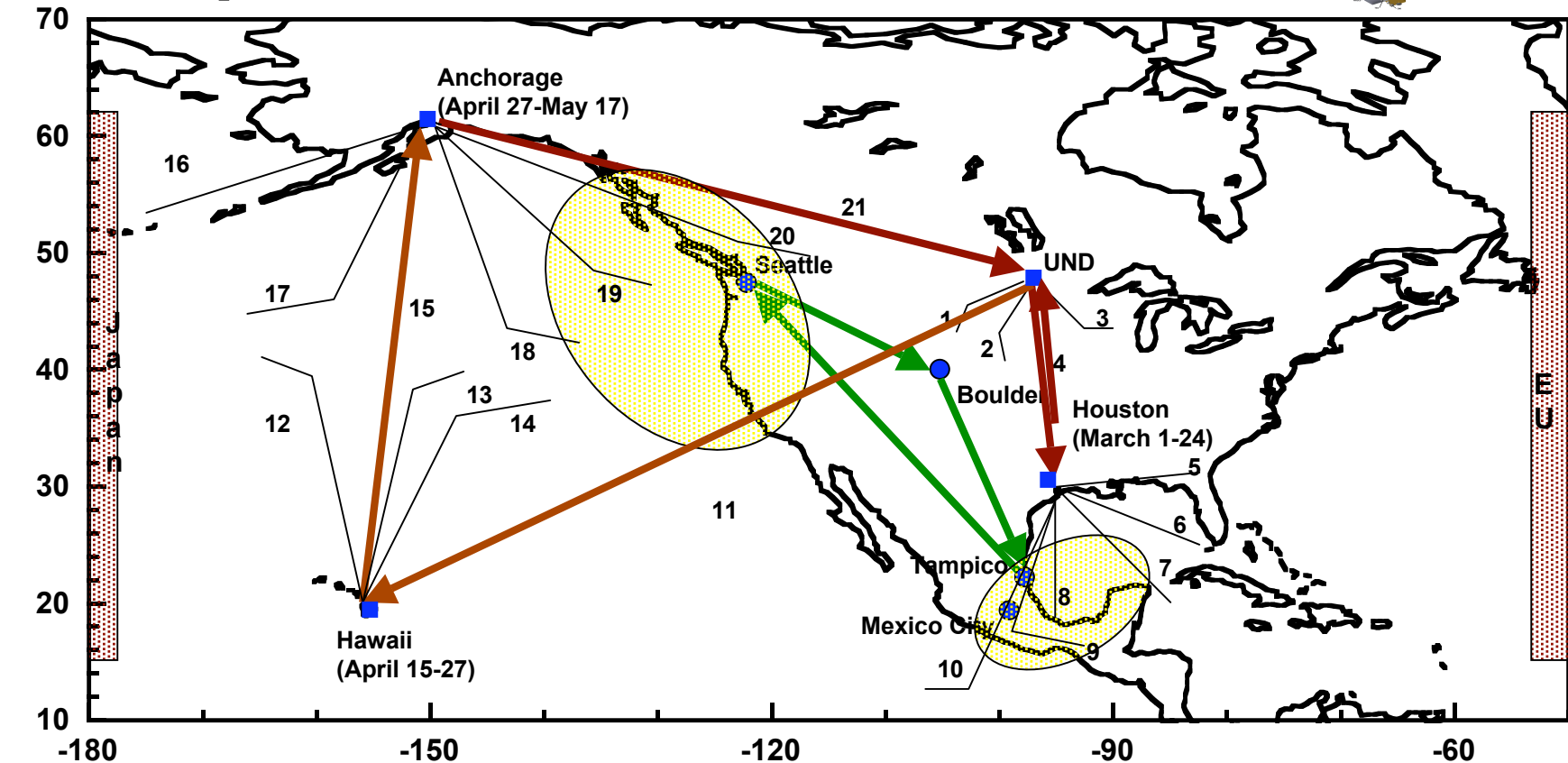
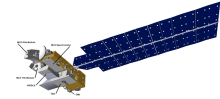
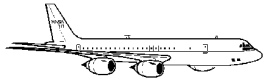
7/10



Heckel et al.



# INTEX-B/MILAGRO Grand Plan for Spring 2006



Nominal C-130 operations

DC-8 transits 

C-130 transits 

DC-8 locals 

**Down period: 25 Mar-10 Apr**

Operations of foreign partners  
(DLR/Falcon-20)



19 flights (140 flight hours):

UND (3 test flights)

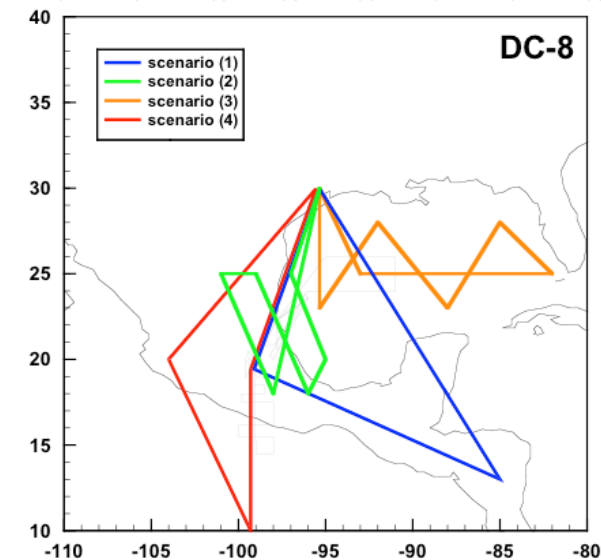
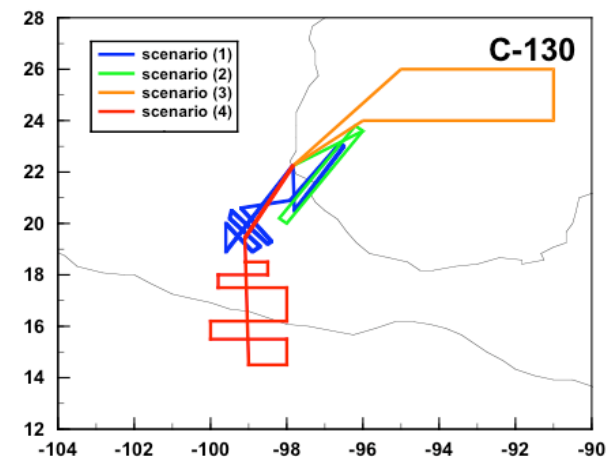
Houston (5 local flights)

Hawaii (3 local flights)

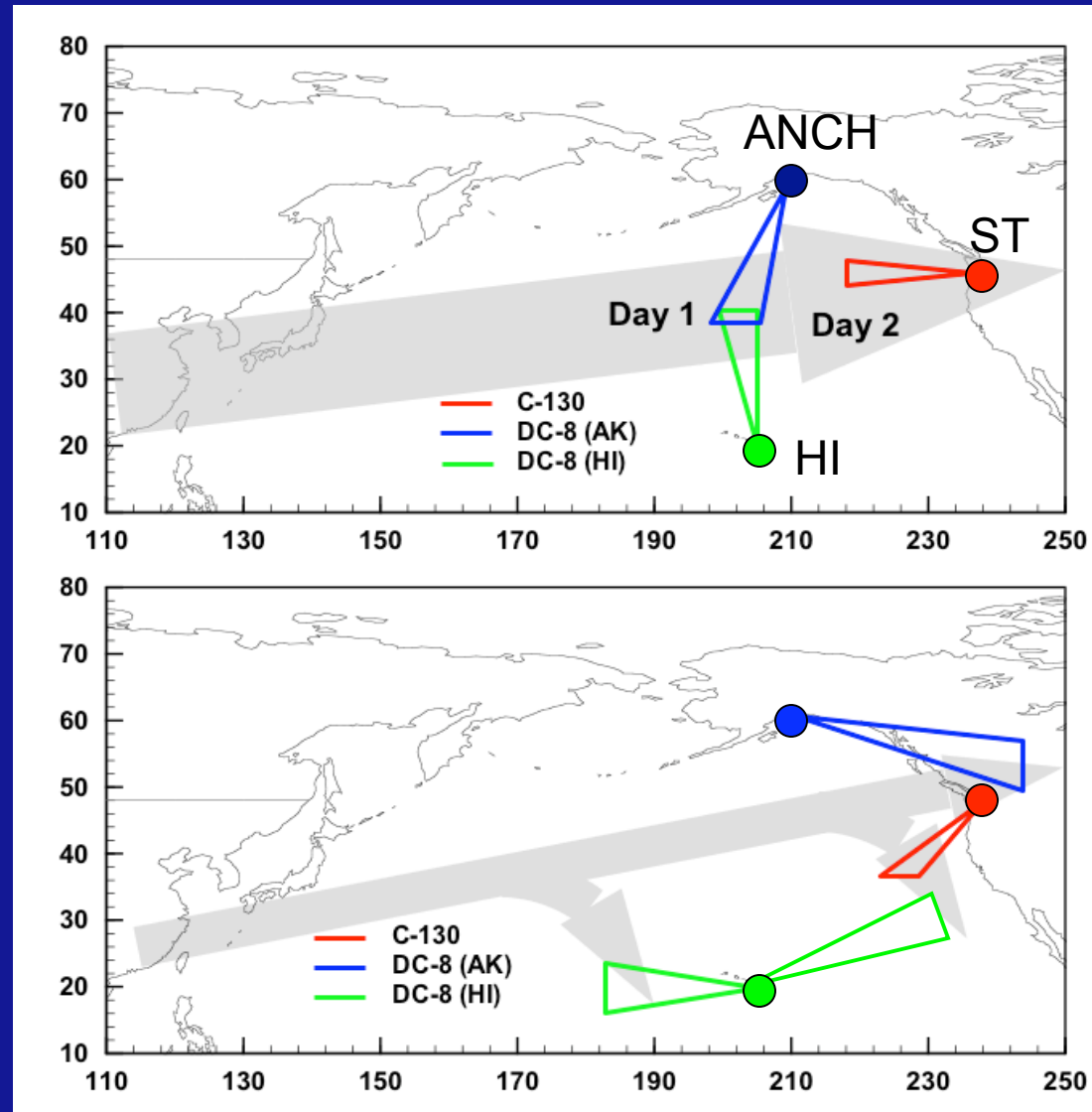
Anchorage (4 local flights)

4 transit flights

# DC-8 & C-130 Coordination in INTEX-B/Part 1



# DC-8 & C-130 Coordination in INTEX-B/Part 2



# INTEX-B/DC8 Schedule\*

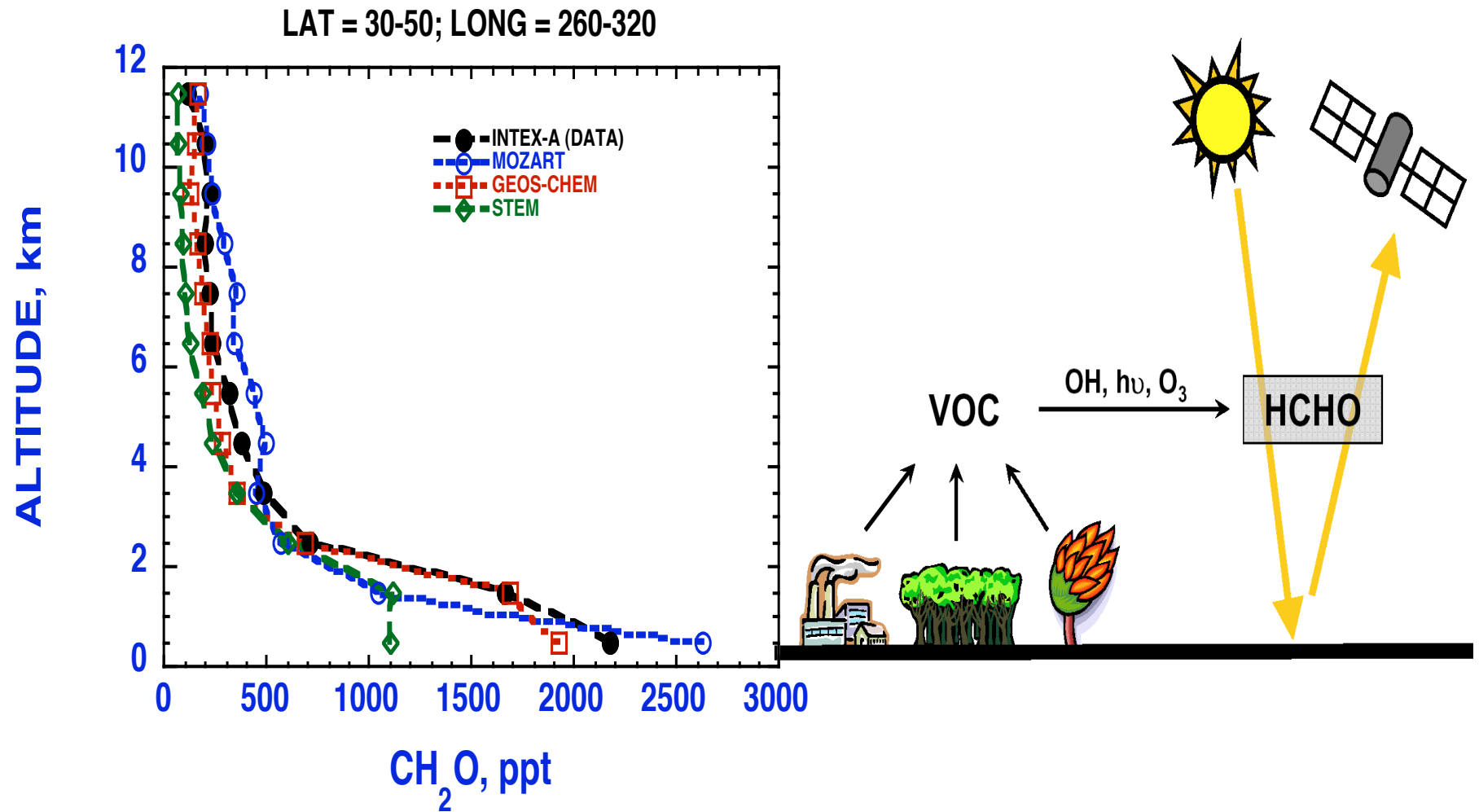
| Location             | Event           | Date (2006) | Flights   | Flight hours |
|----------------------|-----------------|-------------|-----------|--------------|
| UND (Grand Forks)    | Integration     | 1/16-2/16   | 0         | 0            |
| UND                  | Test flights    | 2/17-2/27   | 2         | 8            |
| Transit to Houston   | Transit         | 2/28        | 1         | 4            |
| Houston              | Science Flights | 3/1-3/21    | 5         | 42           |
| Transit to UND       | Transit         | 3/22        | 1         | 4            |
| Break                | Break           | 3/23-4/11   | 0         | 0            |
| UND Prep             | preparation     | 4/12-4/15   | 0         | 0            |
| Transit to Hawaii    | Transit         | 4/16        | 1         | 9            |
| Hawaii               | Science Flights | 4/17-4/28   | 3         | 24           |
| Transit to Anchorage | Transit         | 4/29        | 1         | 8            |
| Anchorage            | Science Flights | 4/30-5/14   | 4         | 35           |
| Transit to UND       | Transit         | 5/15        | 1         | 6            |
|                      |                 |             |           |              |
| <b>Total</b>         |                 |             | <b>19</b> | <b>140</b>   |

\*Additional flight hours, if available, will be use to add 1 flight each at Houston & Anchorage

**End of Presentation**

**Remainder of Slides are Backup**

# Formaldehyde and isoprene





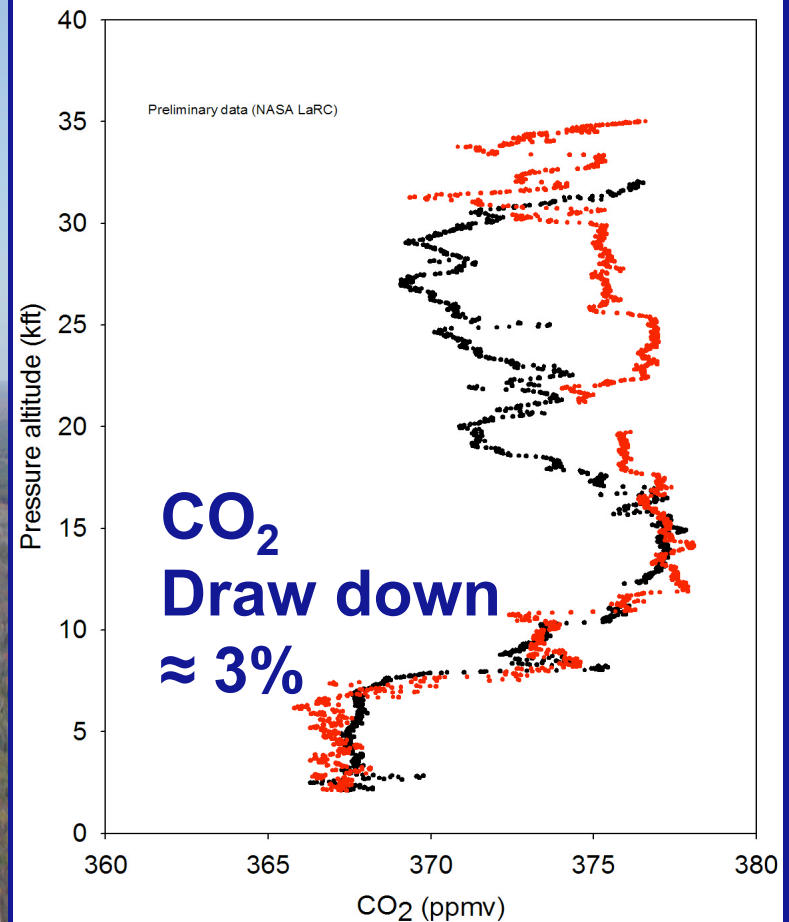
# Carbon Cycle in INTEX-A

**Park Falls, WI [46N, 90W]**

**NASA DC-8 spiral 0.5-33 Kft  
NSF King Air 0.5-25 Kft**

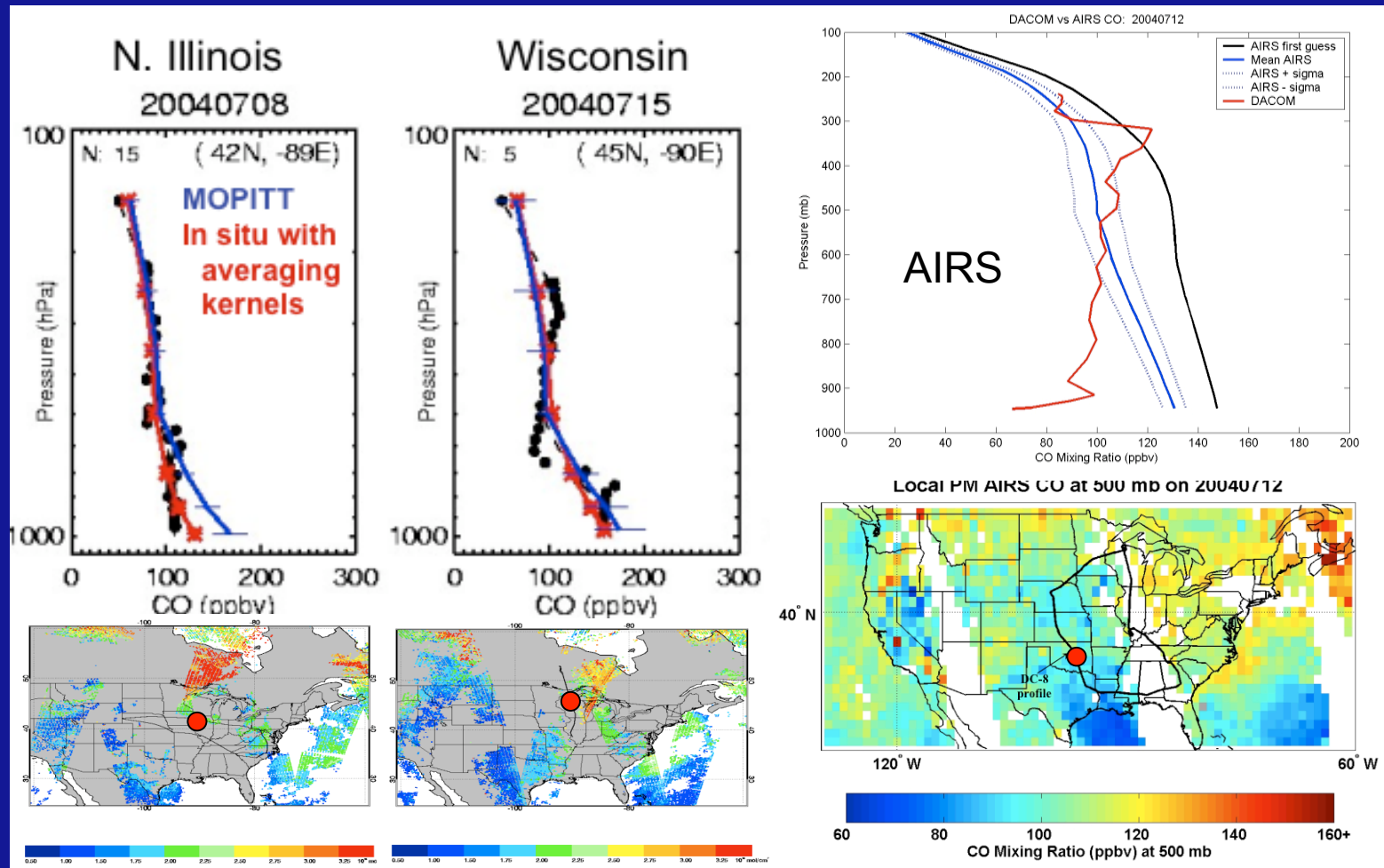
**440 m Tower**

**FTS-CO<sub>2</sub> column**



**S. Vay et al**

# DC-8/MOPITT, AIRS Trop CO



# Emmons/McMillan/Sachse et al

## What we need from the Aura team?

- Satellite tracks and instrument swaths to be integrated with INTEX-B forecasts
- Definition of priorities
  - **Aura instruments?**
  - **along track vs column?**
  - **timed profiles?**
  - **strat/trop balance?**
  - **day/night?**
  - **other satellites?**
- Accommodation of requests from the INTEX-B team (TES step & stare?)

