

An overview of J-31 measurements during the INTEX-B/MILAGRO campaign

Phil Russell, Jens Redemann, John Livingston, Qin Zhang, Stephanie Ramirez
Brian Cairns, Charles Gatebe, Omar Torres, Michael King, Lorraine Remer, Brent Holben,

Peter Pilewskie, Sebastian Schmidt,

Rose Dominguez, Warren
Gore, Ralph Kahn, Chris
Hostetler, John Hair, Richard
Ferrare, Edward Browell,
Antony Clarke, Yohei
Shinozuka, Cam McNaughton



Second MILAGRO
Science Meeting
15 May 2007
Mexico City

For INTEX-B/MILAGRO the J-31 was equipped to measure solar energy and how that energy is affected by atmospheric constituents and **Earth's surfaces.**



Because solar energy drives Earth's climate, the J-31 suite of measurements helps show how changing atmospheric and surface properties can change the climate

SCIENCE GOALS, J-31 in INTEX-B/MILAGRO:

Aerosol, Water Vapor, Cloud, & Surface Properties and Radiative Effects

Characterize the distributions, properties, and effects of aerosols and water vapor advecting from Mexico City and biomass fires toward and over the Gulf of Mexico

- Aerosol Optical Depth And Extinction Spectra (354-2138 nm)
- Water Vapor Columns and Profiles
- Aerosol Radiative Impacts: In Clear Sky (Direct Effect) & Via Clouds (Indirect Effect)

Test the ability of Aura, other A-Train & Terra sensors, & airborne lidar to retrieve aerosol, cloud, and water vapor properties

Characterize surface spectral albedo and bidirectional reflectance distribution function (BRDF) to help improve satellite retrievals

Mexico
City

Veracruz

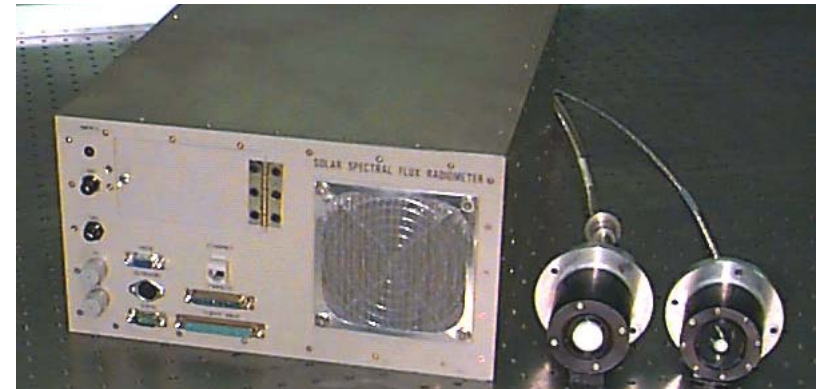
Quantify the relationships between the above and aerosol amount and type

J31 in INTEX-B/MILAGRO: Payload



Ames
Airborne
Tracking
Sun-
photometer
(AATS)

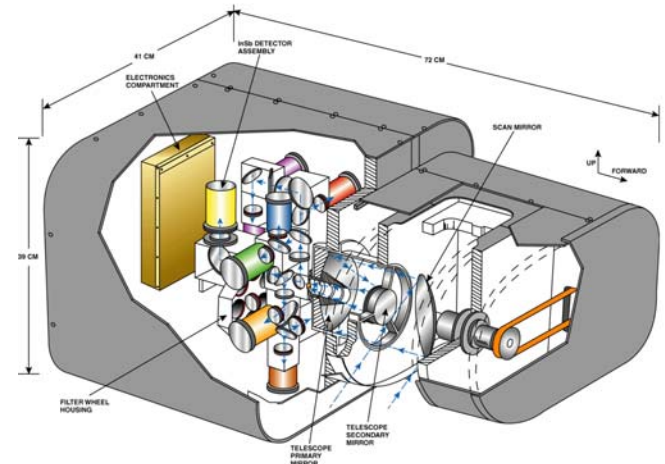
Solar Spectral Flux Radiometer
(SSFR)



Research Scanning Polarimeter
(RSP)



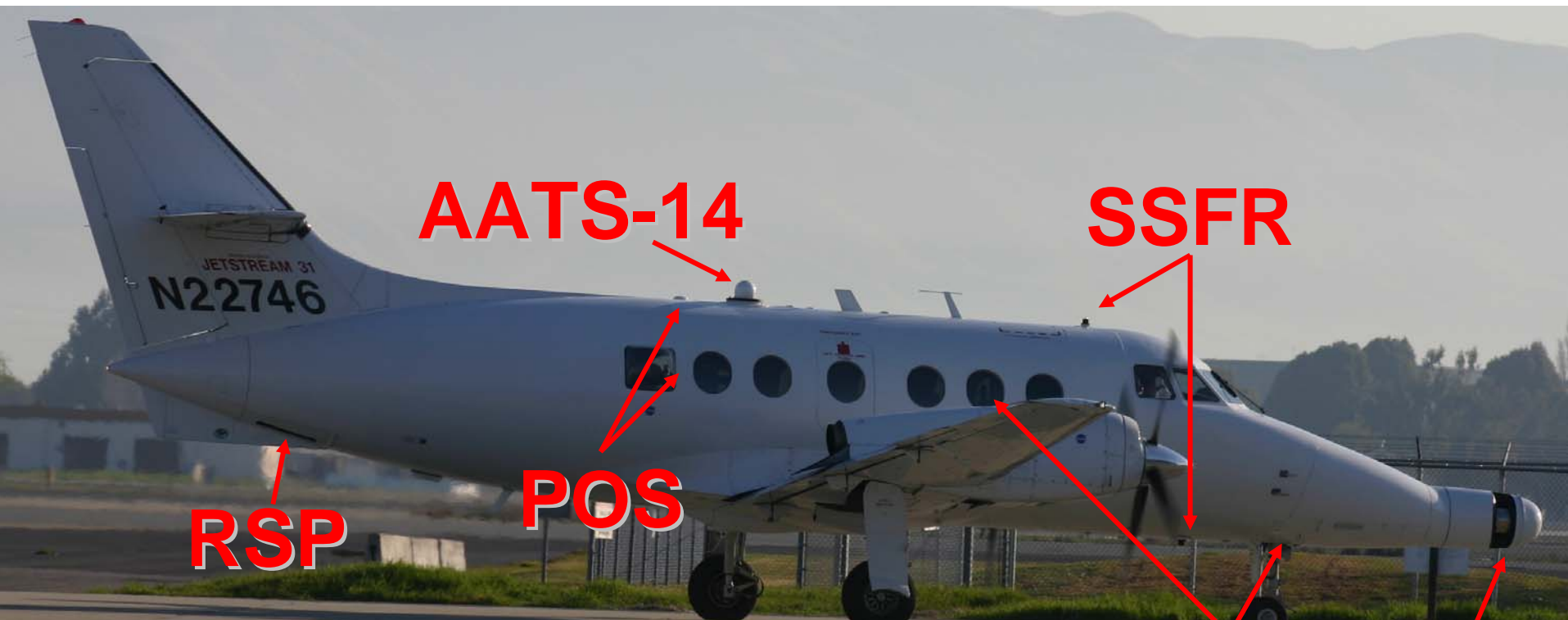
Cloud Absorption Radiometer (CAR)



Position & Orientation System (POS)

Met Sensors & Nav/Met Data System

J31 in INTEX-B/MILAGRO: Instrument Locations



RSP

AATS-14

POS

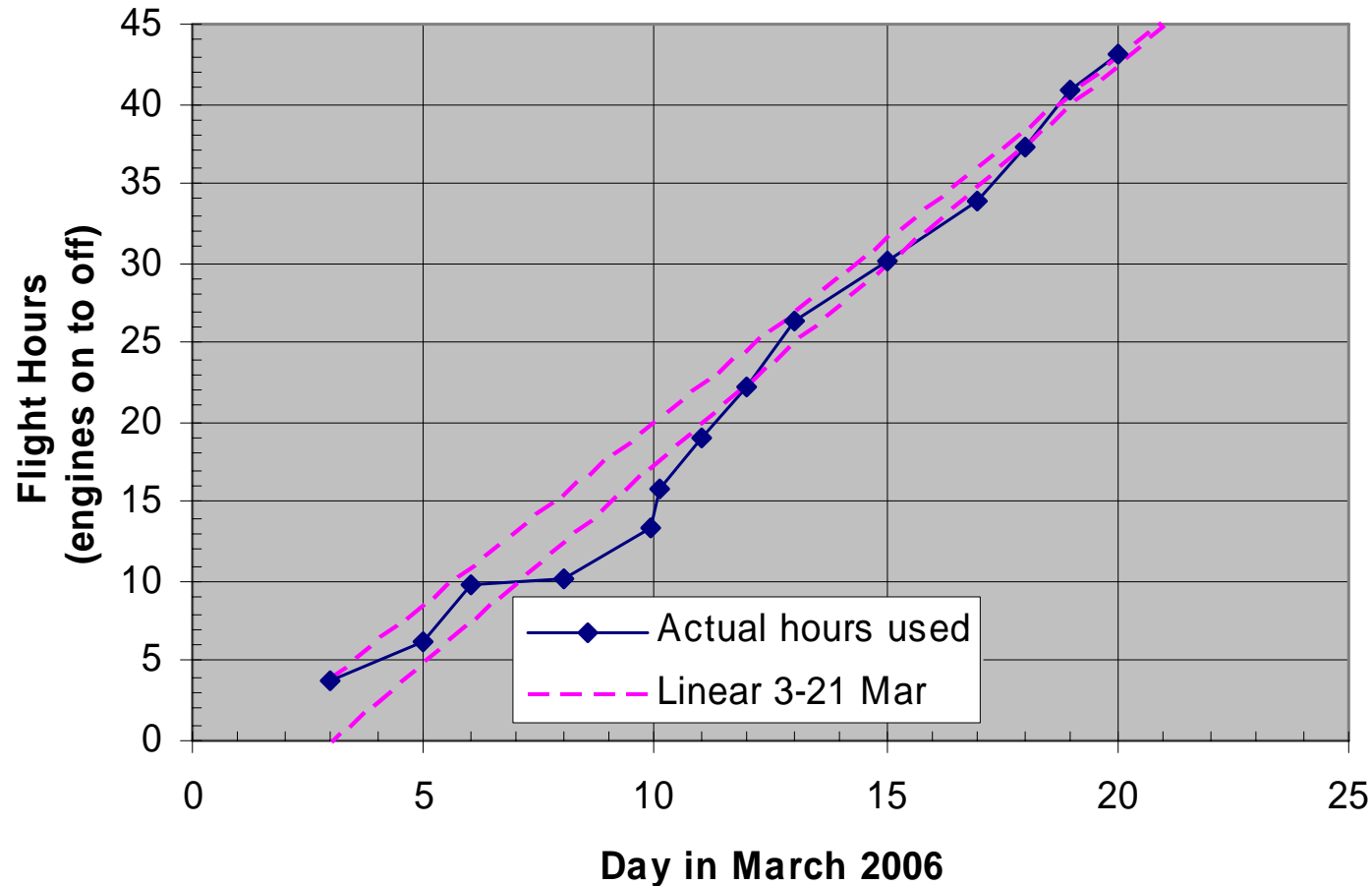
SSFR

NavMet

CAR

To accomplish these goals and objectives we had:

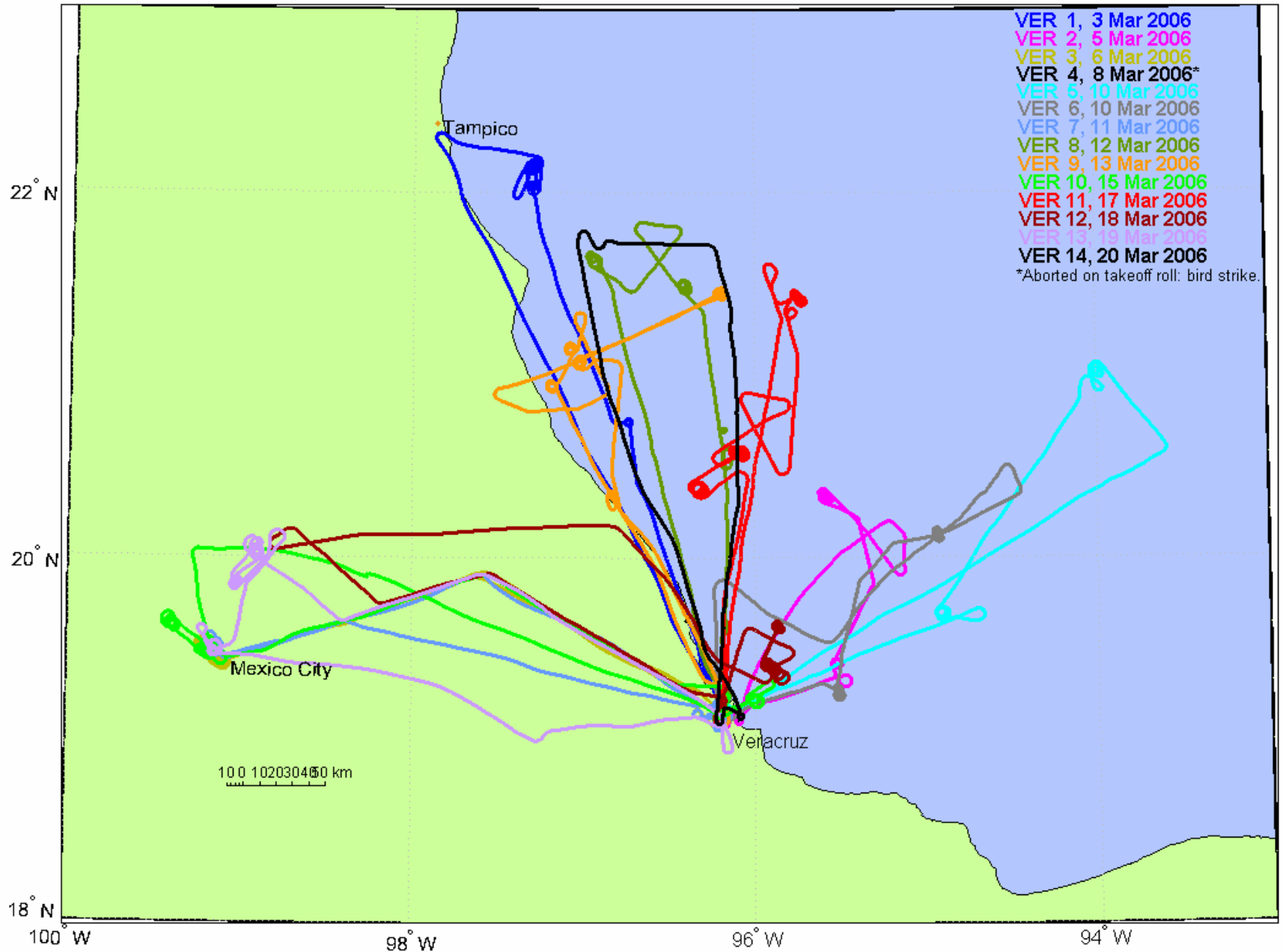
- 19 Days
(3-21 Mar
2006)
- 45 Flight
Hours



A/C & Instruments performed very well

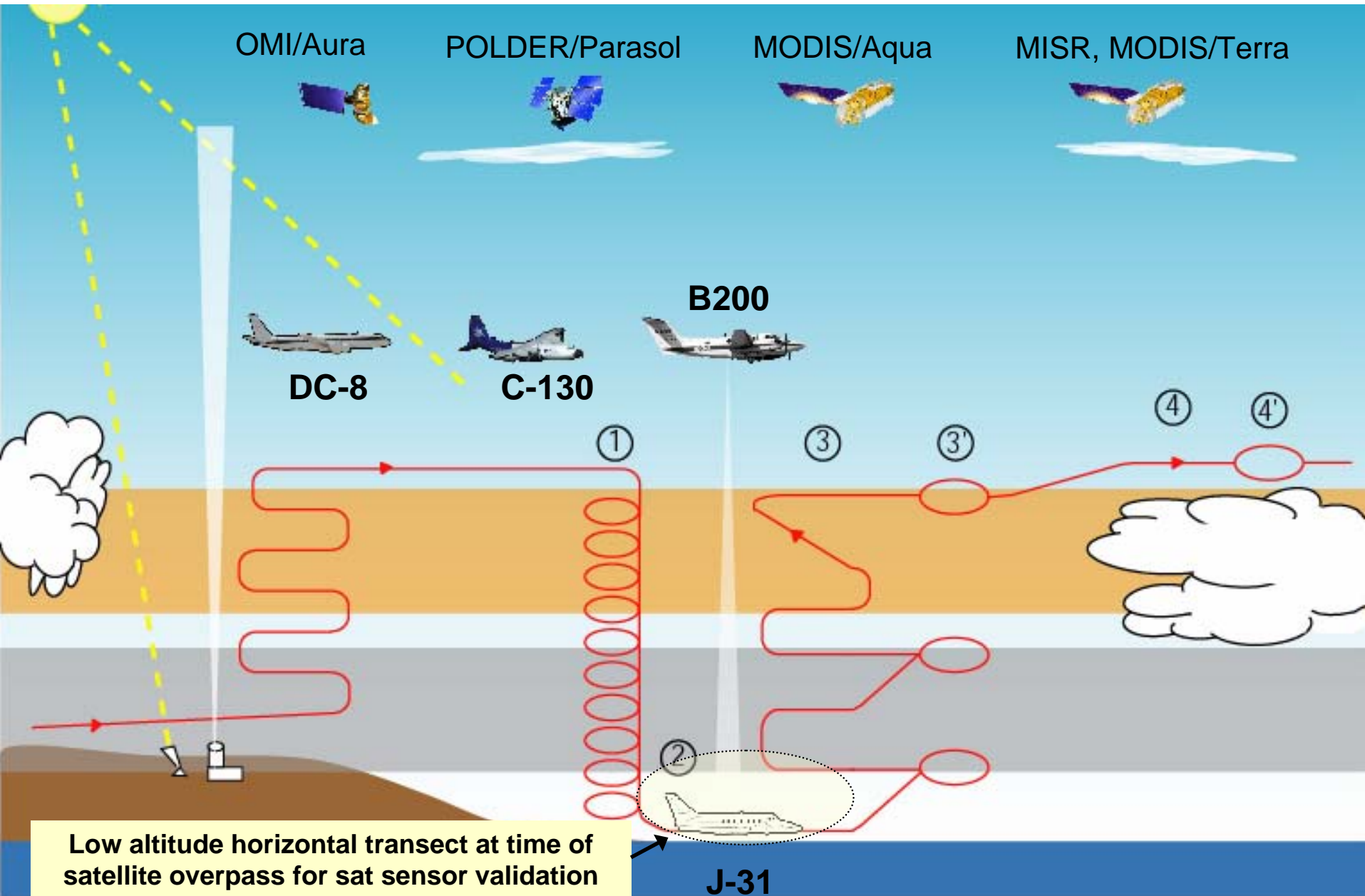
- A/C available to fly every day
- Instruments had very high data capture rates

Flight Tracks, 13 J31 Flights out of Veracruz



J31 flight patterns:

Coordinated satellite, in-situ and radiative missions



25 posters & talks showing J31 INTEX-B/MILAGRO results

- ^{1,2}Cairns et al., Polarimetric remote sensing of aerosols and clouds during MILAGRO
- ¹Clarke et al., Airborne Measurements of Aerosol Size Distributions and Related Physiochemical and Optical Properties During MILAGRO
- ²Ferrare et al., Airborne high spectral resolution lidar measurements of aerosols during MILAGRO
- ^{1,2}Gatebe et al., Airborne Spectral Measurements of Surface-Atmosphere Anisotropy over Different Surfaces in Mexico
- ²Gatebe et al., Retrieval of aerosol and surface BRDF from airborne and ground measurements in Mexico
- ^{1,5}Hair et al., Airborne High Spectral Resolution Measurements of Aerosols from the MILAGRO/INTEX-B Mission
- ¹Kahn et al., MILAGRO/INTEX-B Coordinated Satellite + Sub-orbital Platform Experiments: March 06 & 10, 2006
- ²Kahn et al.: MILAGRO/INTEX-B coordinated satellite + suborbital platform experiments: March 6, 10, and 15, 2006

¹MILAGRO Science Meeting, Boulder, 23-25 Oct 2006

²INTEX-B Data Review Meeting, Virginia Beach, 6-8 Mar 2007

⁵Second MILAGRO Science Meeting, Mexico City, 15-18 May 2007

Cont'd→

25 posters & talks showing J31 INTEX-B/MILAGRO results

- **^{1,2,3}Livingston et al., Aerosol Optical Depths from Airborne Sunphotometry in INTEX-B/MILAGRO as a Validation Tool for the Ozone Monitoring Instrument (OMI) on Aura**
- **⁴Livingston et al., Comparison of airborne sunphotometer and satellite sensor retrievals of aerosol optical depth during MILAGRO/INTEX-B**
- **²Redemann et al., AATS-14 on the J31 in INTEX-B/MILAGRO: Comparisons to data collected by aerosol sensors on Terra, Aqua, and suborbital platforms**
- **^{5,6}Redemann et al., Comparison of airborne sunphotometer and satellite sensor retrievals of aerosol optical depth during MILAGRO/INTEX-B**
- **^{1,2,4,5,6}Russell et al., An overview of J-31 aircraft measurements in the Megacity Initiative—Local and Global Research Observations (MILAGRO) experiment**
- **¹Schmidt et al., Airborne Solar Spectral Irradiance Measurements during the MILAGRO field campaign**
- **⁴Schmidt et al., Airborne Measurements of Aerosol Radiative Forcing, Two-dimensional Surface Albedo, and Flux Divergence during MILAGRO**

¹MILAGRO Science Meeting, Boulder, 23-25 Oct 2006

²INTEX-B Data Review Meeting, Virginia Beach, 6-8 Mar 2007

³Aura Validation & Science Team Meeting, Boulder, xx Sep 2006

⁴EGU General Assembly, Vienna, Austria, 15-20 April 2007

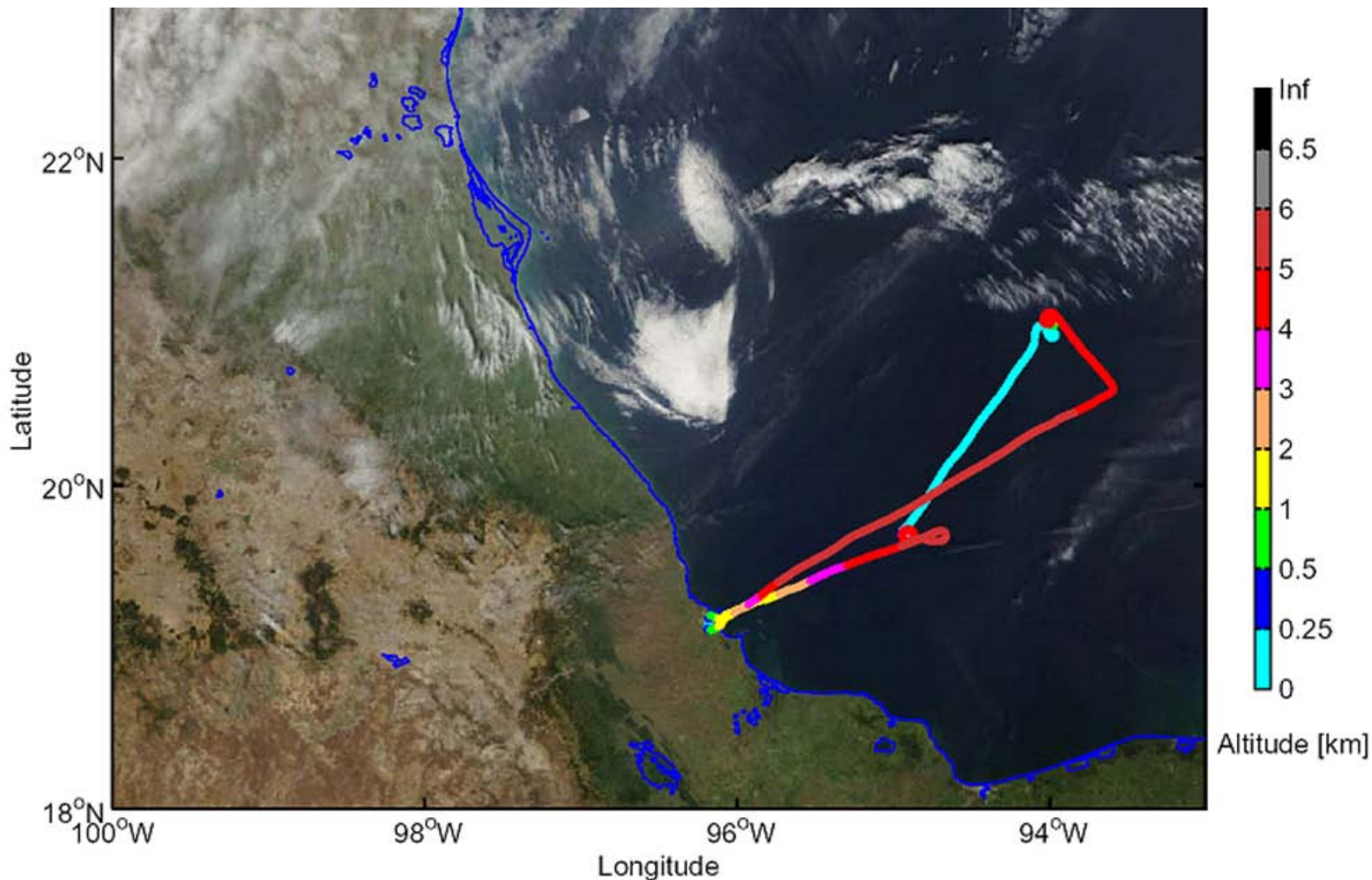
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⁶AGU Joint Assembly, Acapulco, Mexico, 22-25 May 2007

J31 Science Flights out of Veracruz in MILAGRO/INTEX-B

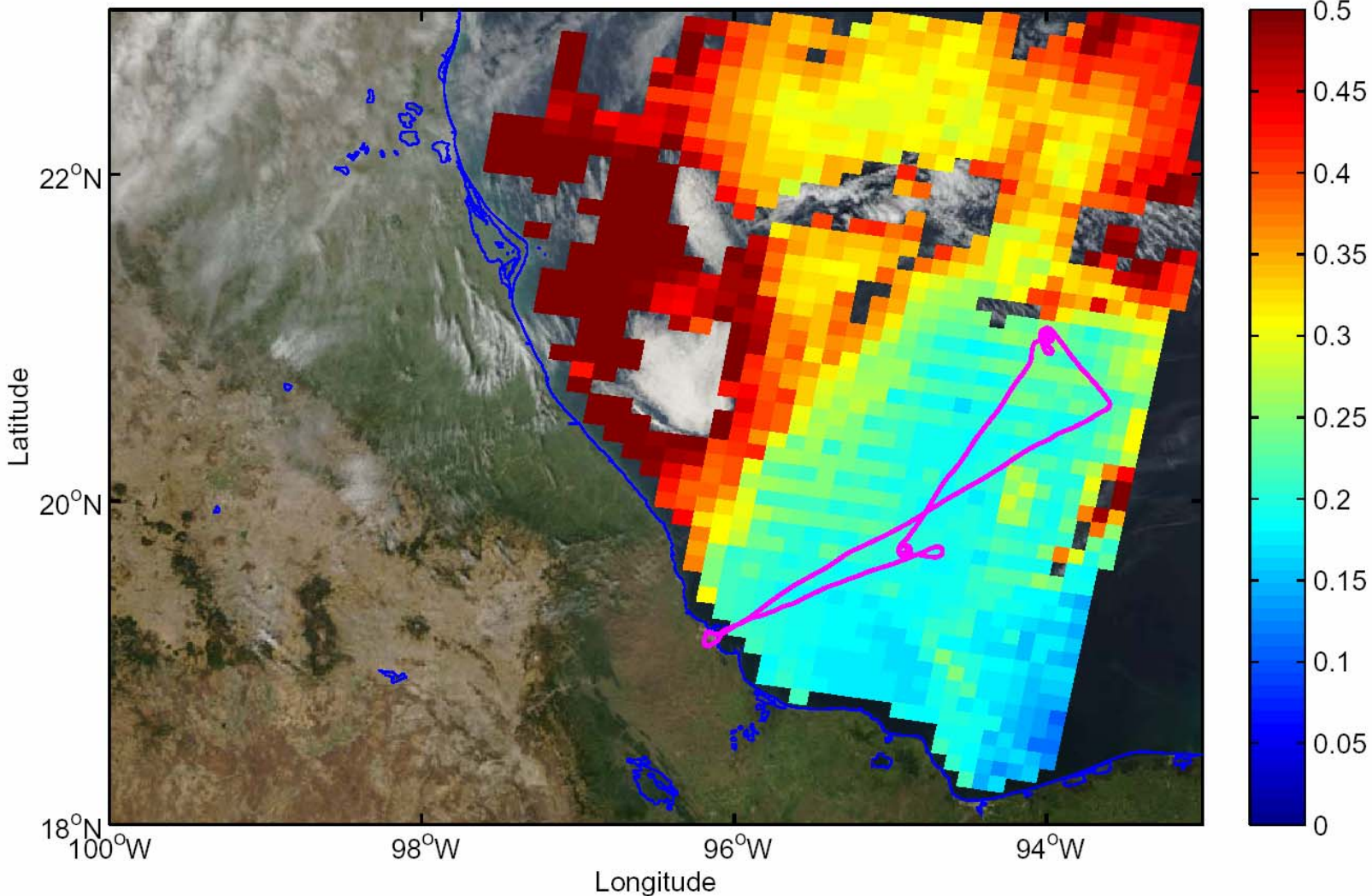
Flt No.	Date, 2006	Track	Comments
VER 01	3 Mar	Gulf of Mexico near VER & Tampico	Terra & A-Train near overpass times, clouds & clear. Profile, RSP legs, CAR circles.
VER 02	5 Mar	Gulf of Mexico NE of VER	Terra , clear. Profile, transects, SSFR fluxes, RSP legs, CAR circles.
VER 03	6 Mar	Mexico City	Terra (MISR LM) , clear. Racetrack stepped profile, SSFR fluxes, RSP legs, CAR racetracks near T0 & airport under King Air .
VER 04	8 Mar	Aborted on takeoff roll: bird strike	
VER 05	10 Mar	Gulf of Mexico NE of VER	Terra (MISR LM + MODIS) , King Air and C-130 . Clear + cirrus. 2 profiles, RSP legs.
VER 06	10 Mar	Gulf of Mexico NE of VER	Aura (OMI) , A-Train in MODIS Aqua glint-free . Profiles , SSFR fluxes, CAR circles, RSP legs
VER 07	11 Mar	Mexico City	CAR circles for urban reflectivity. Profile w 18Z sonde at VER on return.

INTEX-B: 10 Mar 2006 J31 flight track on MODIS-Terra true-color image, ~ 1653 UT



March 10, MISR local mode and MODIS-Terra coincidence over the Gulf of Mexico. Retrieval maps show MODIS-Terra results and J-31 flight track

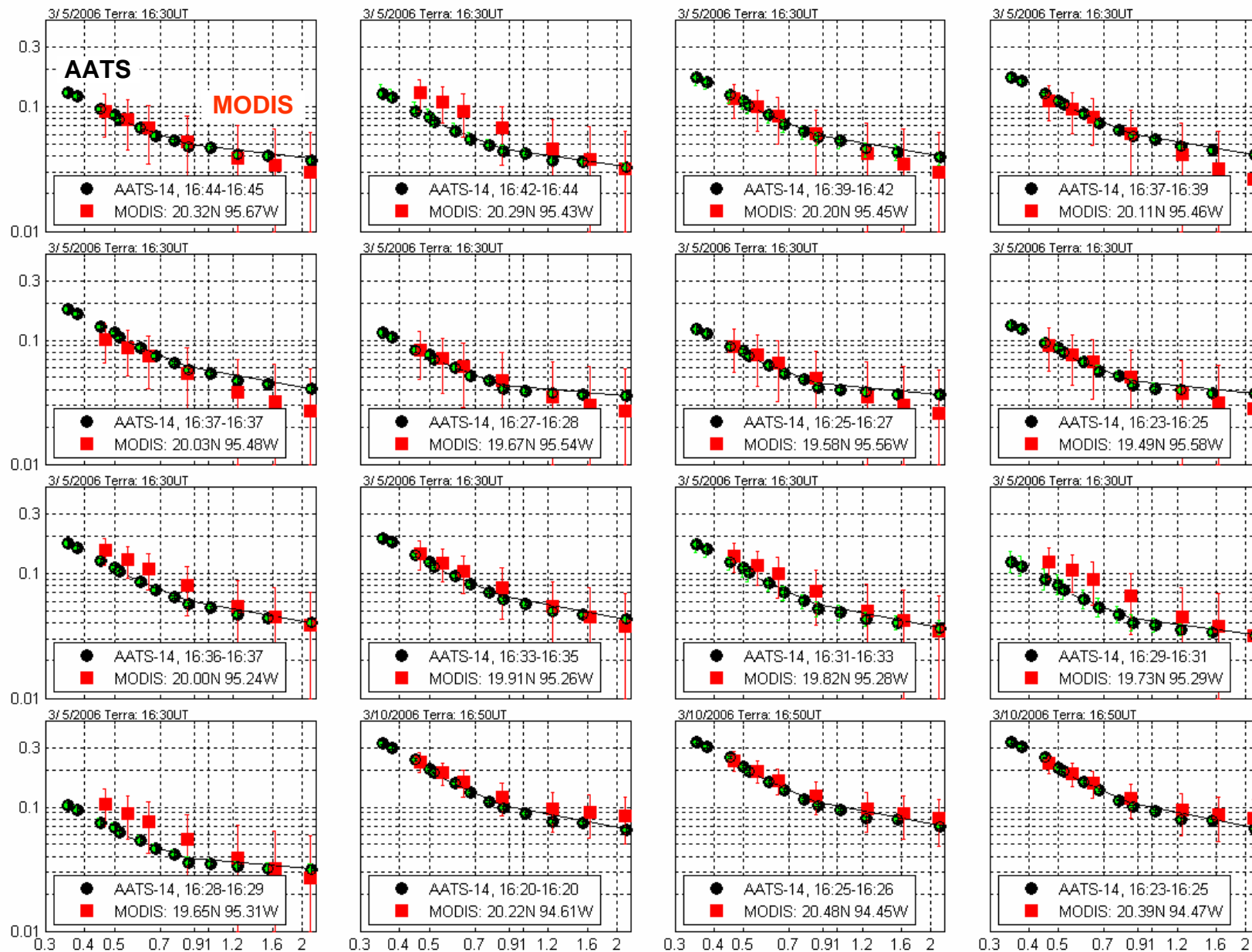
Aerosol optical depth, MODIS, Terra, 069, 03/10/06, UT: 16:50--16:55



[Redemann
et al.]

Full spectrum AOD measurements: AATS vs. MODIS-Terra in MILAGRO

Aerosol Optical Depth



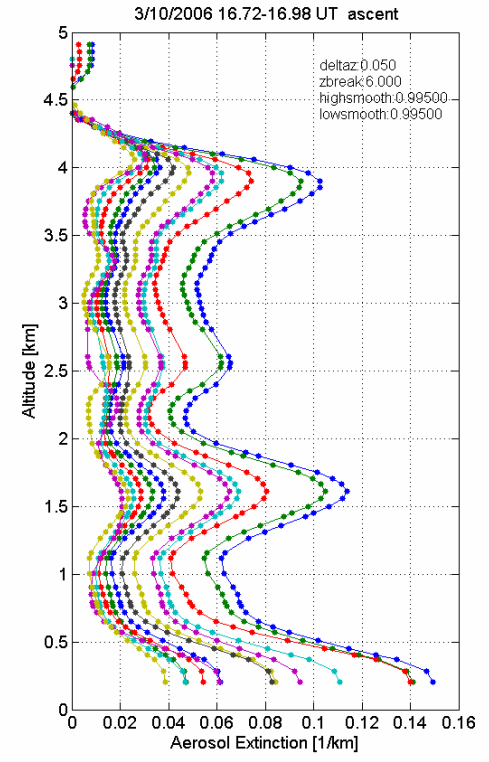
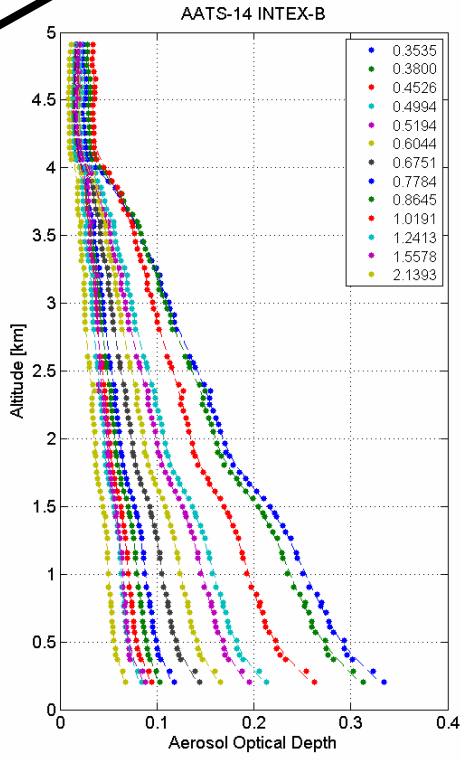
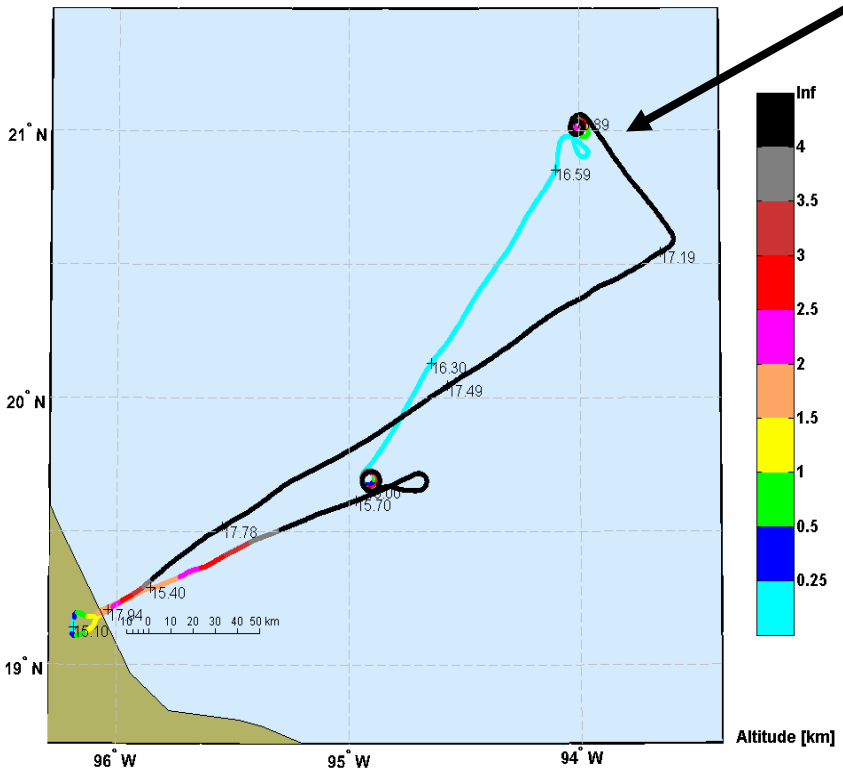
Wavelength (μm)



Comparison of HSRL extinction/AOT with other instruments

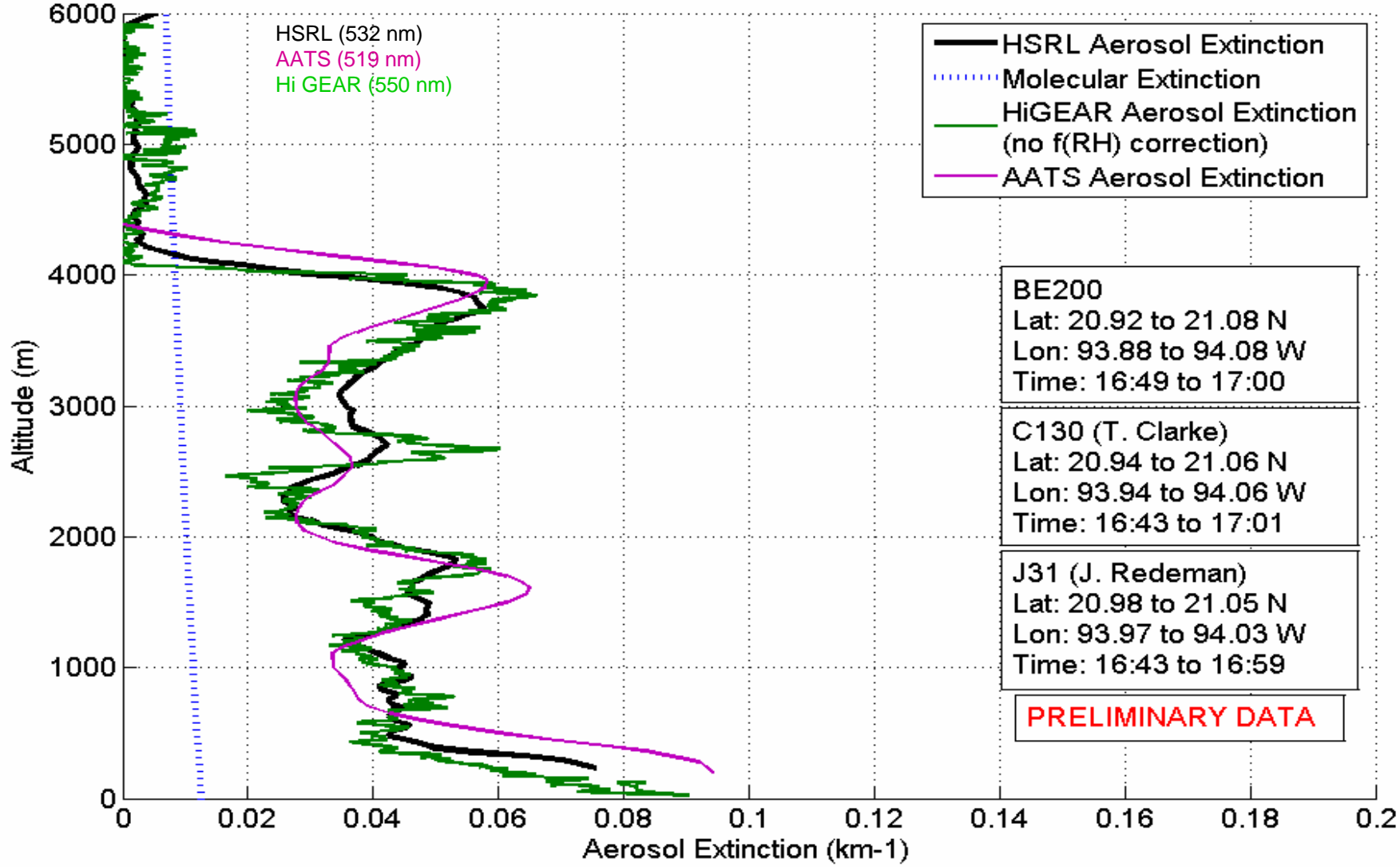
- AATS14 on J-31
 - AATS14 data courtesy of Russell, Redemann, Livingston

Spiral location for J31 & C130



Aerosol extinction comparison from coordinated flights by J31 (AATS), Be200 (HSRL), & C130 (in situ)

MILAGRO March 10, 2006



[Hair et al.]

[Hair, Hostettler, Ferrare, Redemann, Livingston, Clarke, et al.]

J31 Science Flights out of Veracruz in MILAGRO/INTEX-B (cont'd)

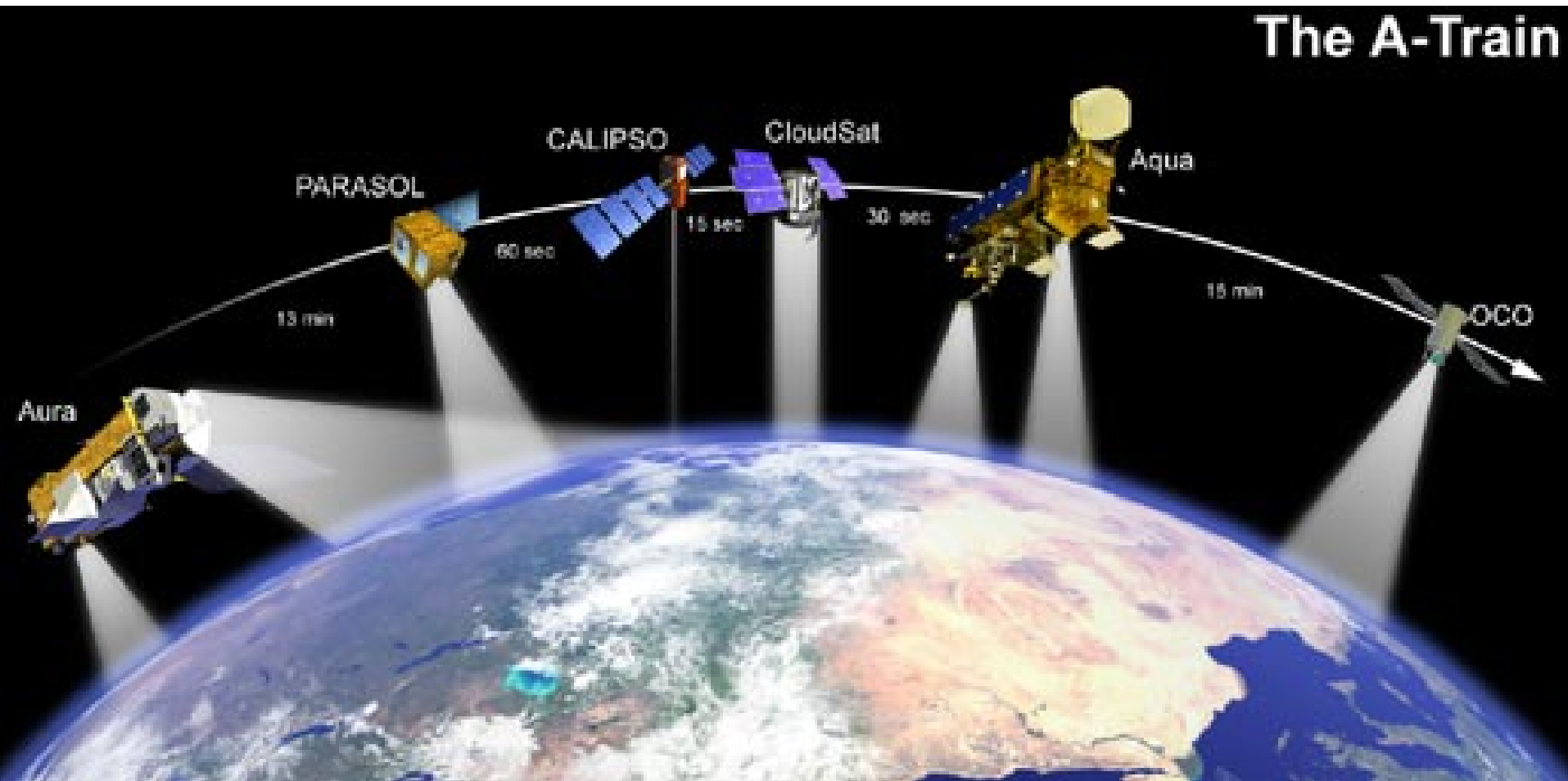
Flt No.	Date, 2006	Track	Comments
VER 08	12 Mar	Gulf of Mexico N of VER	Terra, King Air. Clear + clouds. Profiles, RSP legs. Near AERONET Tampico & Tamihua
VER 09	13 Mar	Gulf of Mexico N of VER	Terra MODIS/Glory glint scenario.
VER 10	15 Mar	Mexico City	Terra (MISR LM), cirrus. Stepped profile, SSFR fluxes, RSP legs, CAR circles at T0 + other point under King Air.
VER 11	17 Mar	Gulf of Mexico N of VER	Aqua, aerosols + cloud experiments. Profiles, SSFR fluxes, RSP legs, CAR circles.
VER 12	18 Mar	Toward Mexico City, then Gulf near VER	Ci over MC caused diversion to Gulf. Profiles, SSFR fluxes, RSP legs, CAR circles w Aqua.
VER 13	19 Mar	T2 & T0 (Mexico City)	Profiles, RSP & SSFR legs with Aqua, POLDER, Aura, DC-8 at T2. Profiles and legs at T0
VER 14	20 Mar	Gulf of Mexico N of VER	H ₂ O sonde comparison on takeoff. Glint experiment scrubbed by Ci.

Photo from DC-8 over Mexico City, 19 Mar 2006

Courtesy of Cam McNaughton



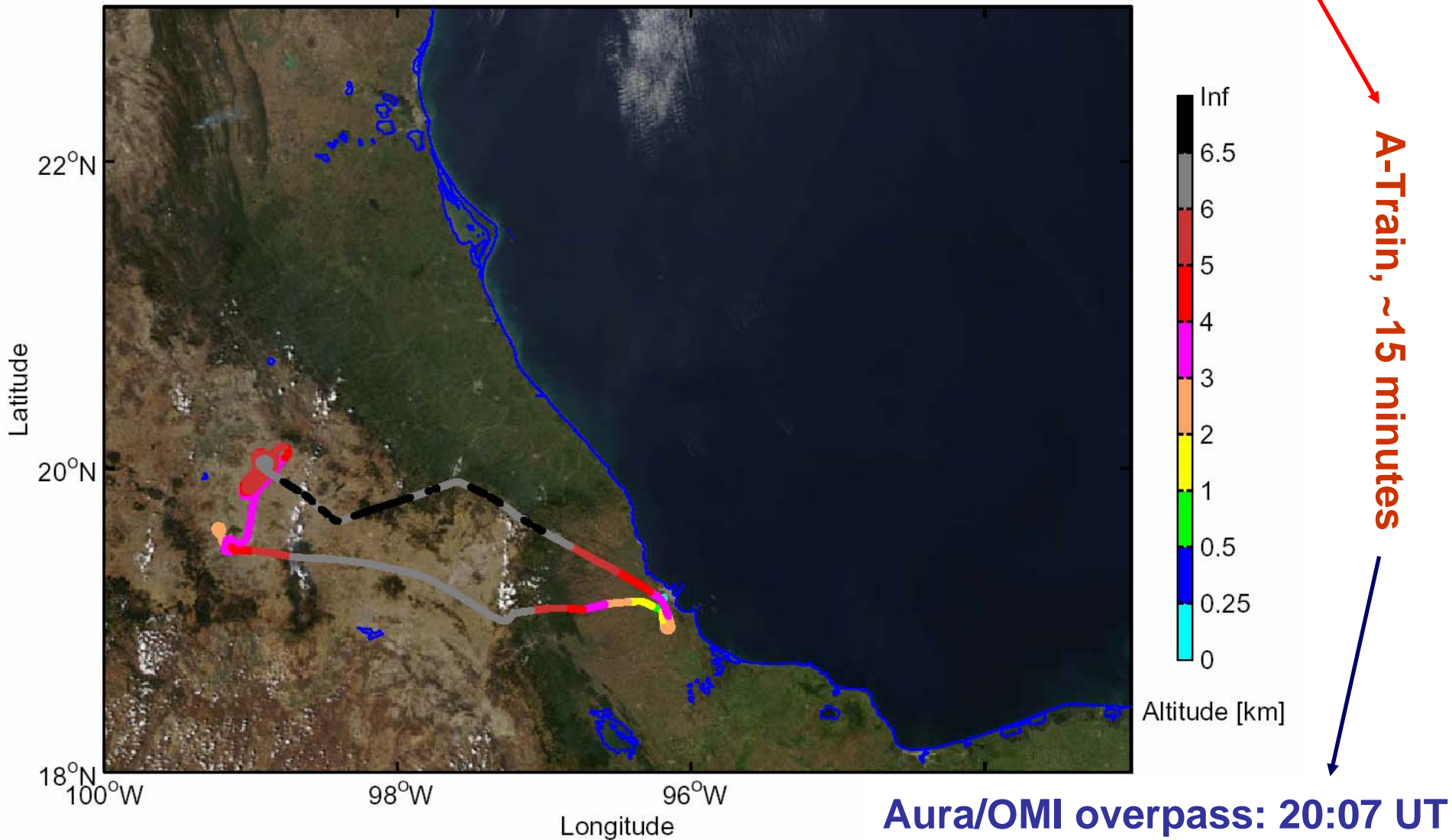
The A-Train is a set of satellites that fly in sequence



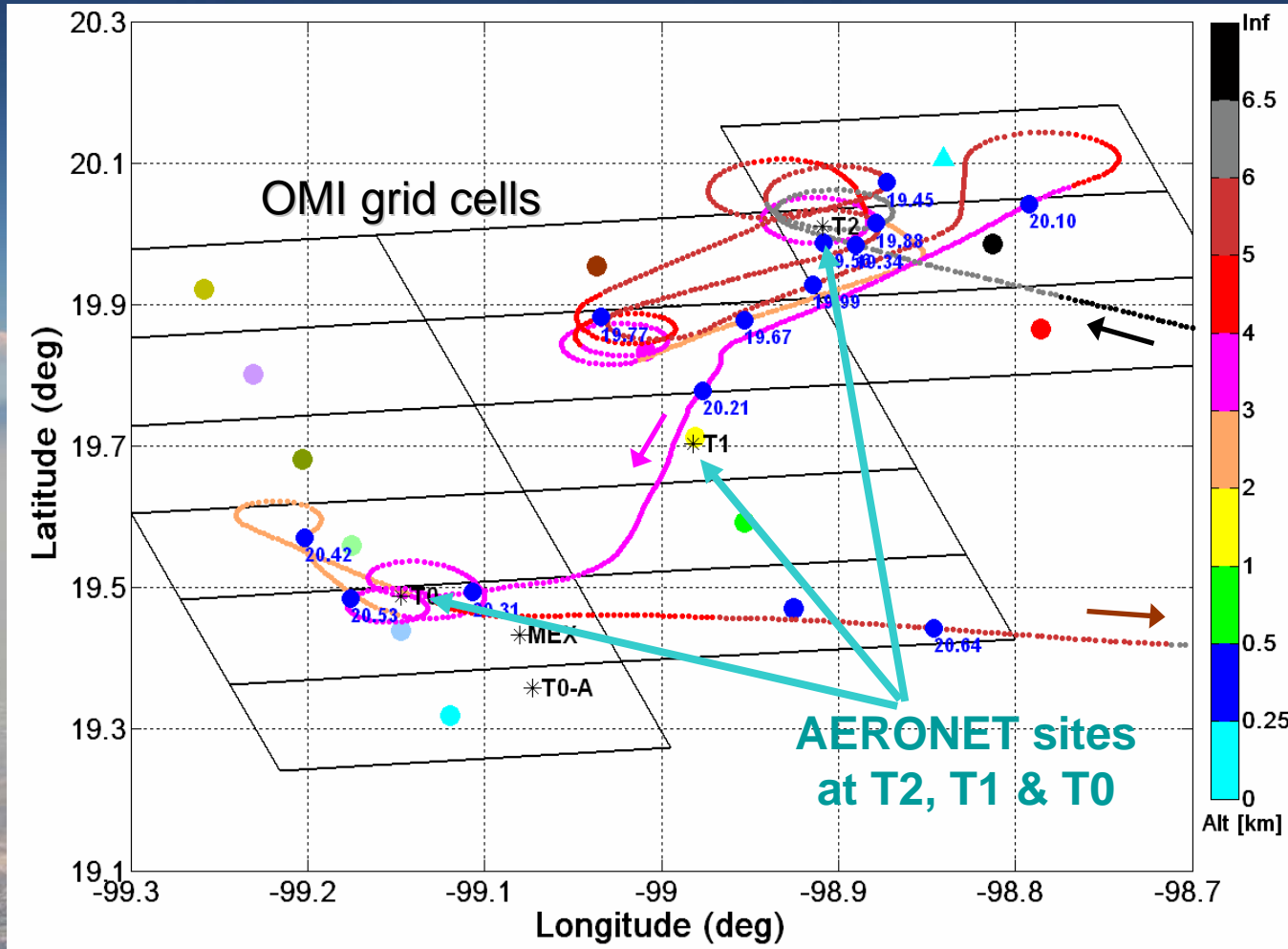
Many J31 flights included legs or profiles under the A-Train or other satellites

19 Mar 2006 J31 flight track on MODIS-Aqua true-color image, ~19:52 UT

True color image,MODIS,Aqua,078,03/19/06,UT:19:50--19:55



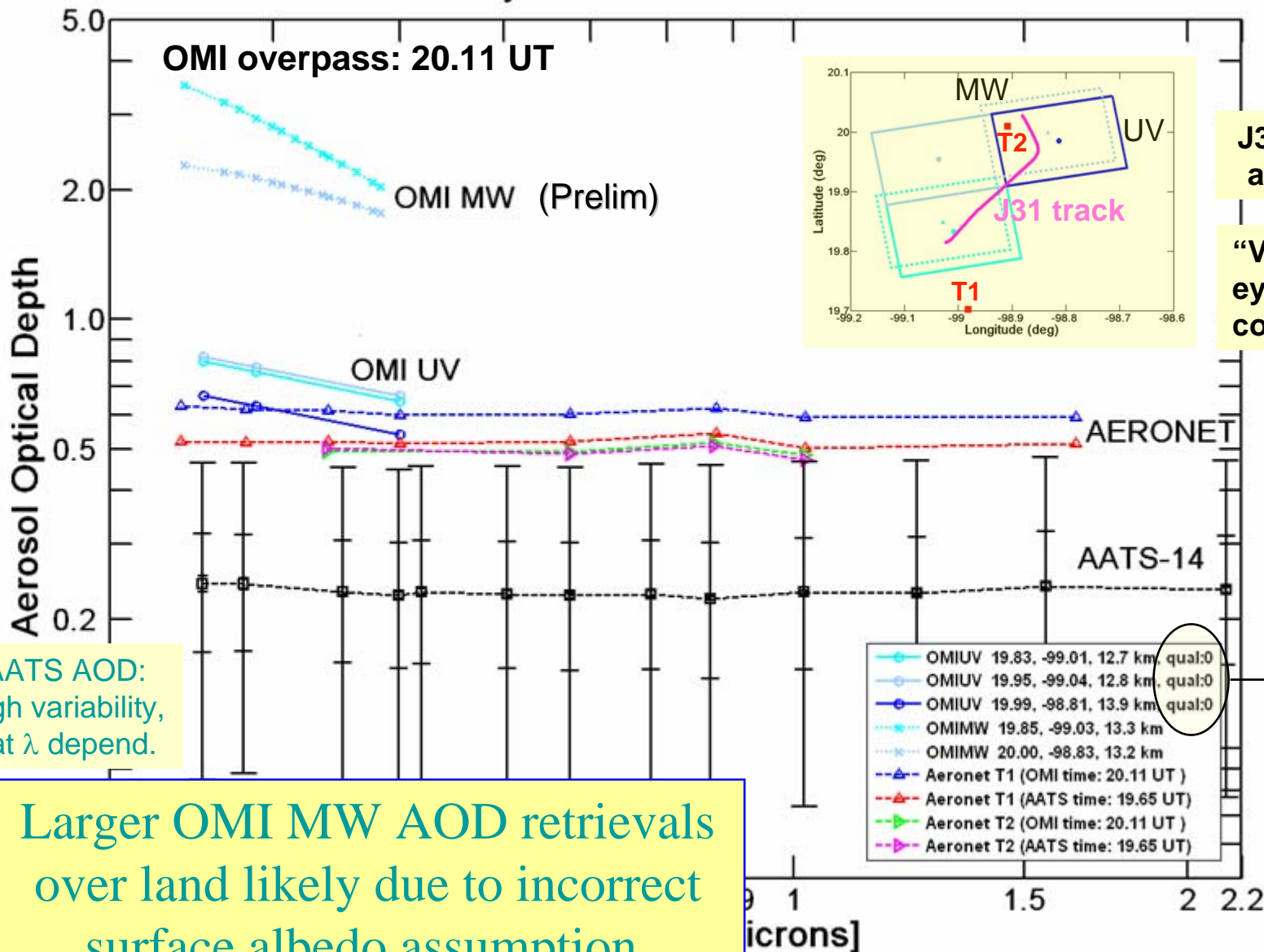
19 March 2006 J31 flight to Mexico City



19 March 2006 (over land)

North of Mexico City 19.60-19.70 UT J31 altitude: 2.96±0.03 km

OMI overpass: 20.11 UT



J31 ~450-750 m above surface

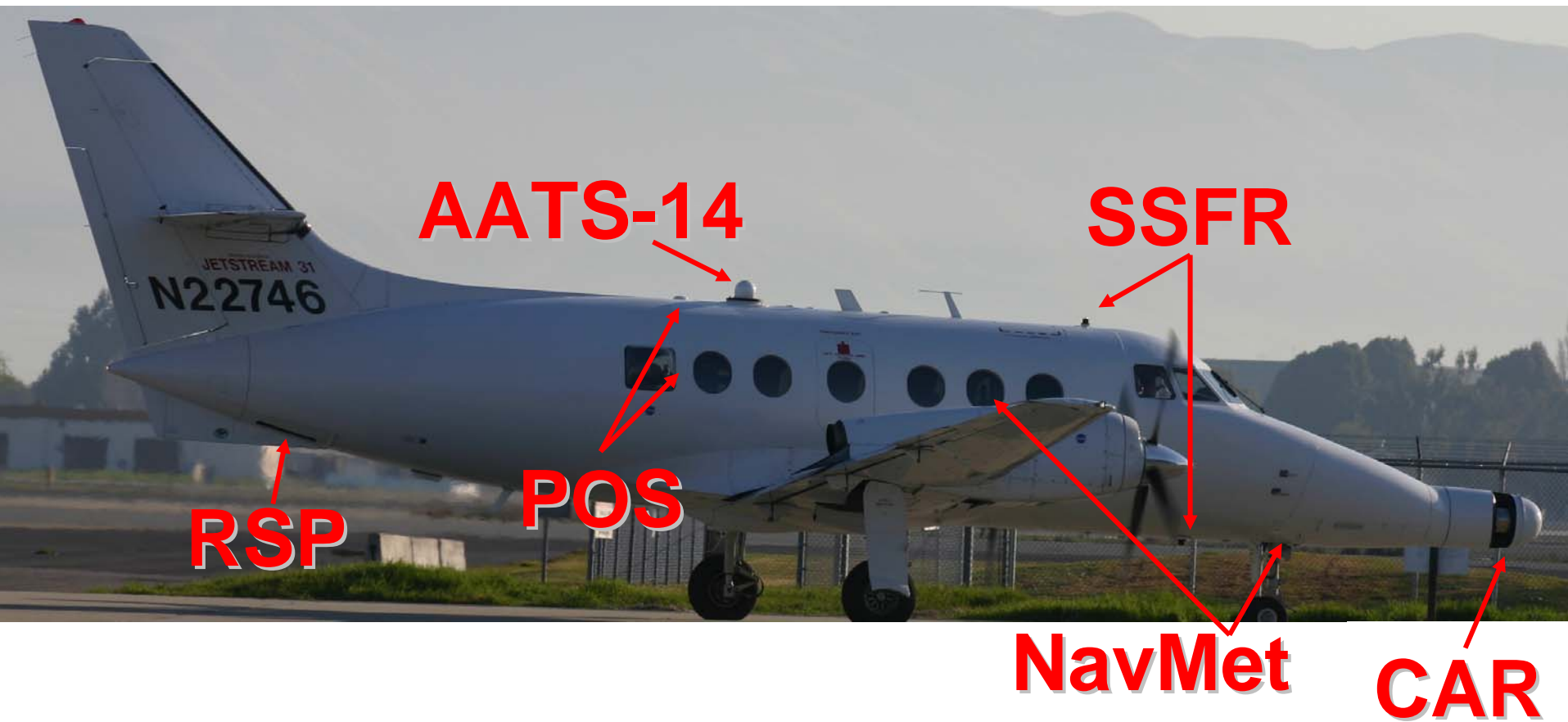
“Visibility poor; eyes burning in cockpit...”

AATS AOD: high variability, flat λ depend.

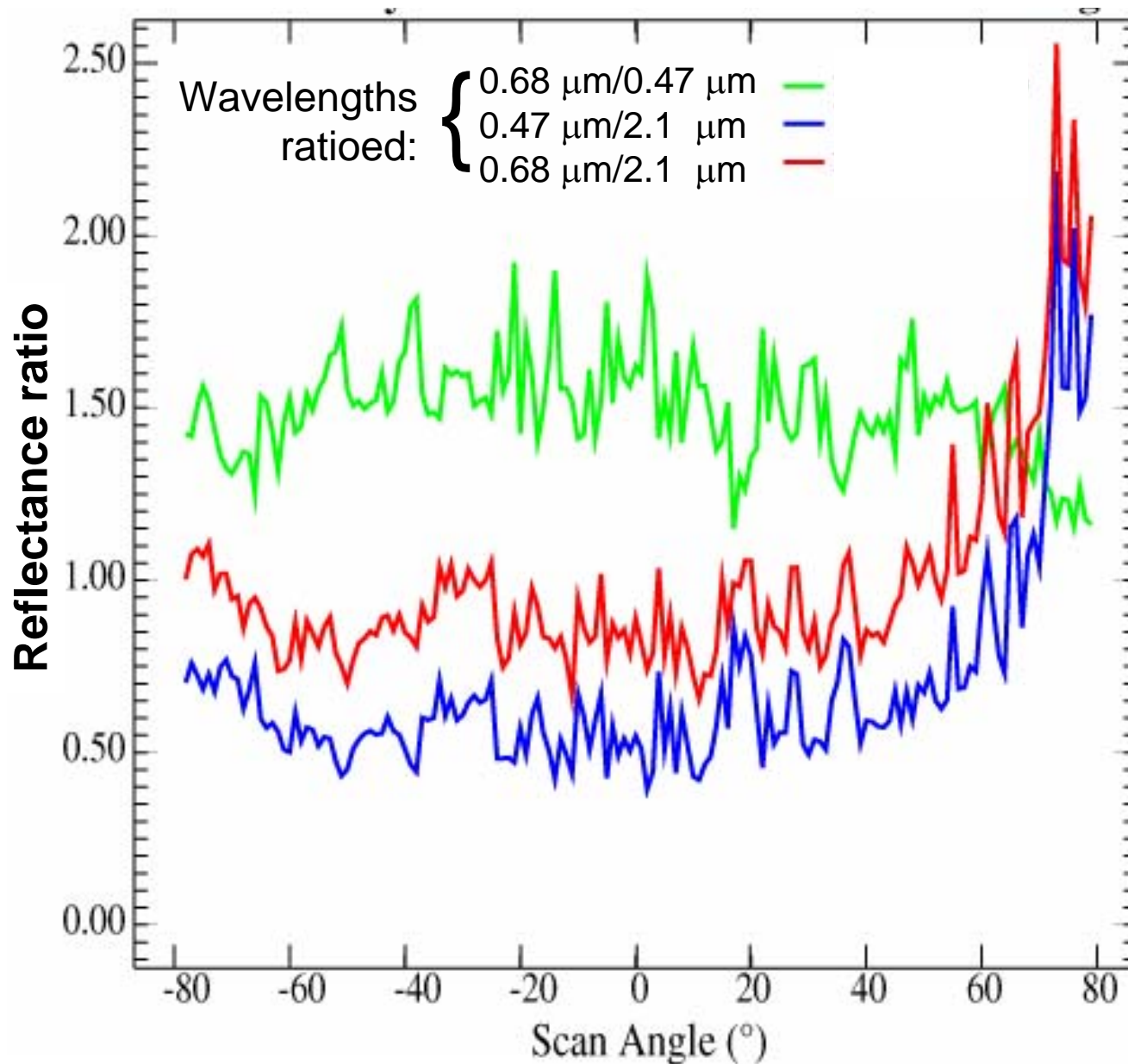
Larger OMI MW AOD retrievals over land likely due to incorrect surface albedo assumption.

highest quality

Other J31 instruments measure surface albedo (SSFR) and BRDF (RSP & CAR)



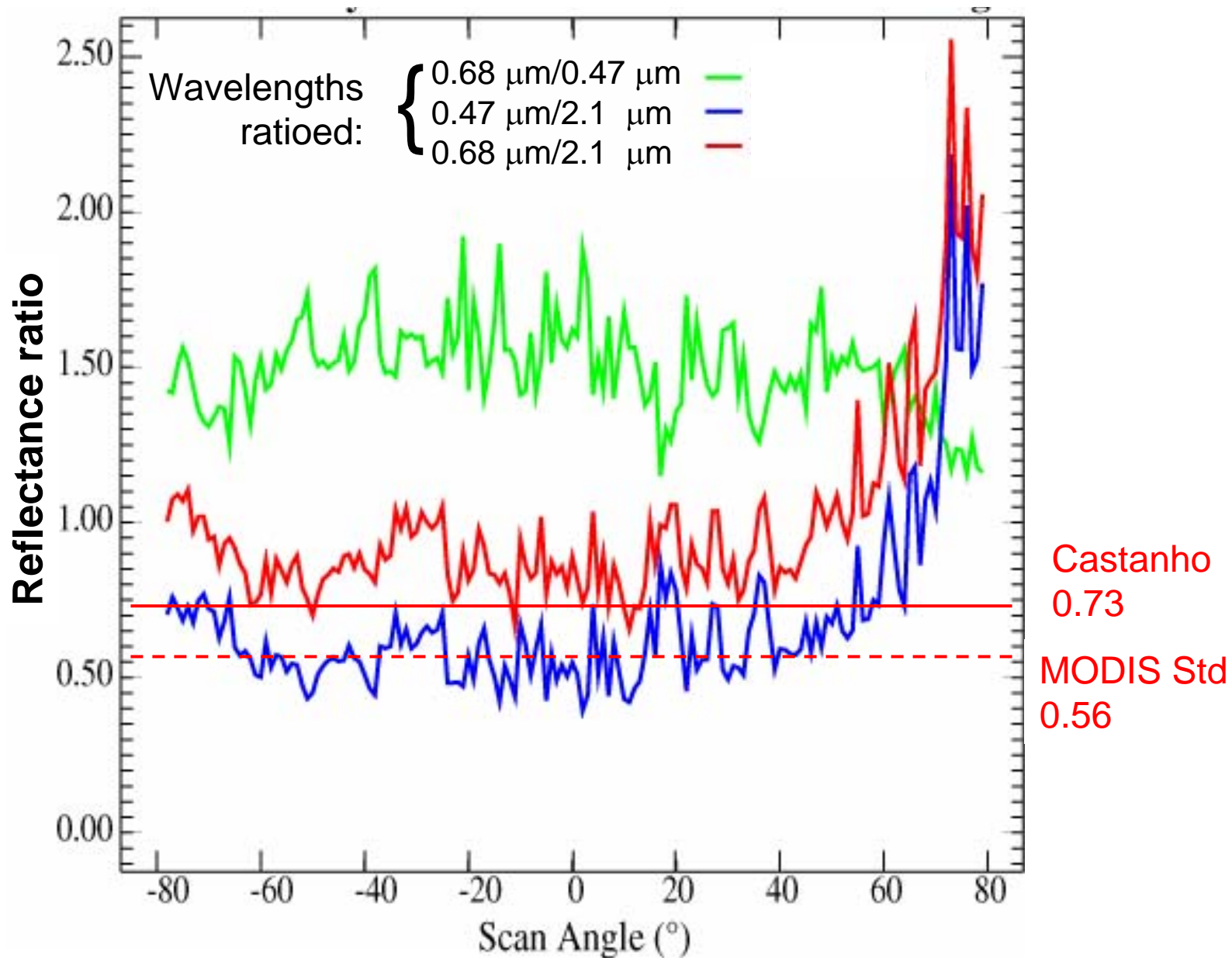
Mexico City BRDF Ratios from CAR on J-31*



*~0.5 km AGL, Principal Plane

Gatebe, King et al.

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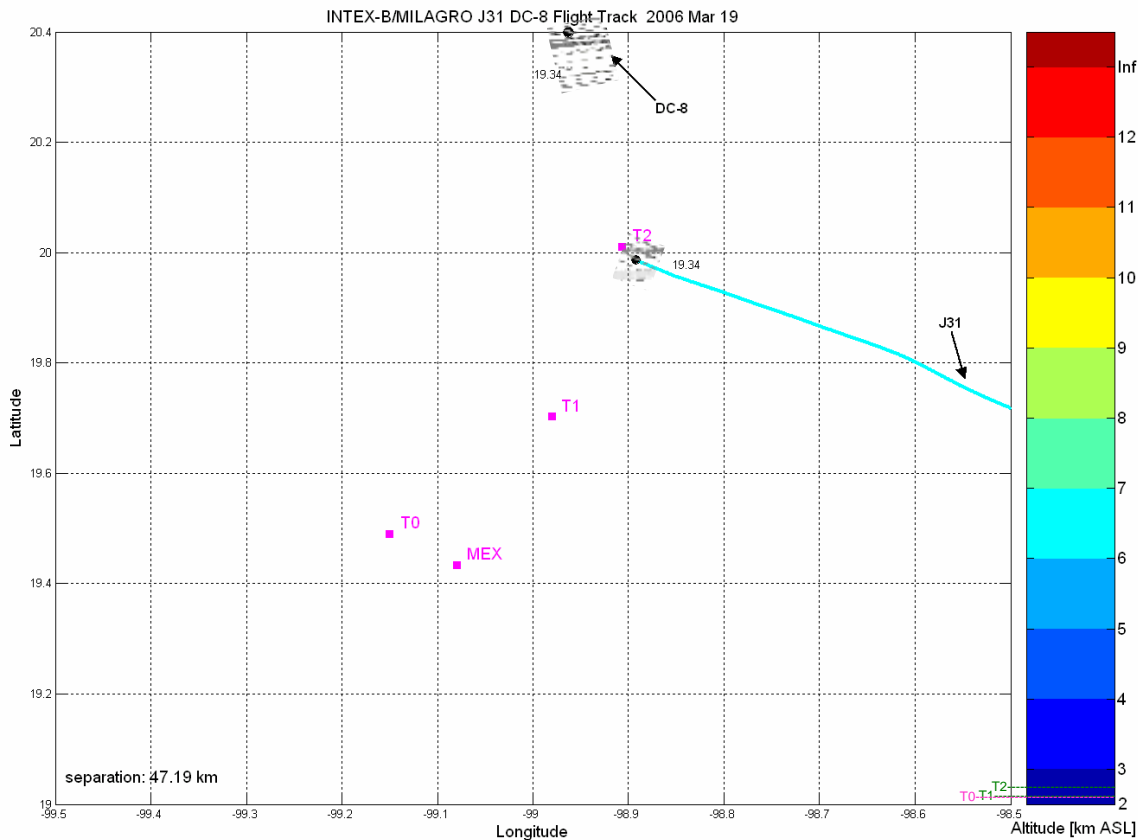
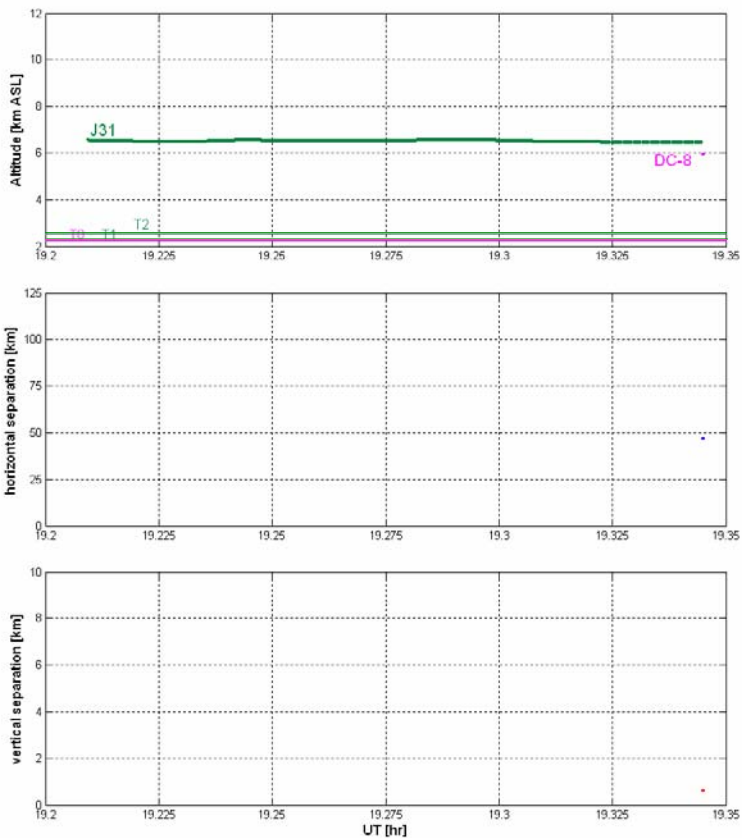
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Gatebe, King et al.

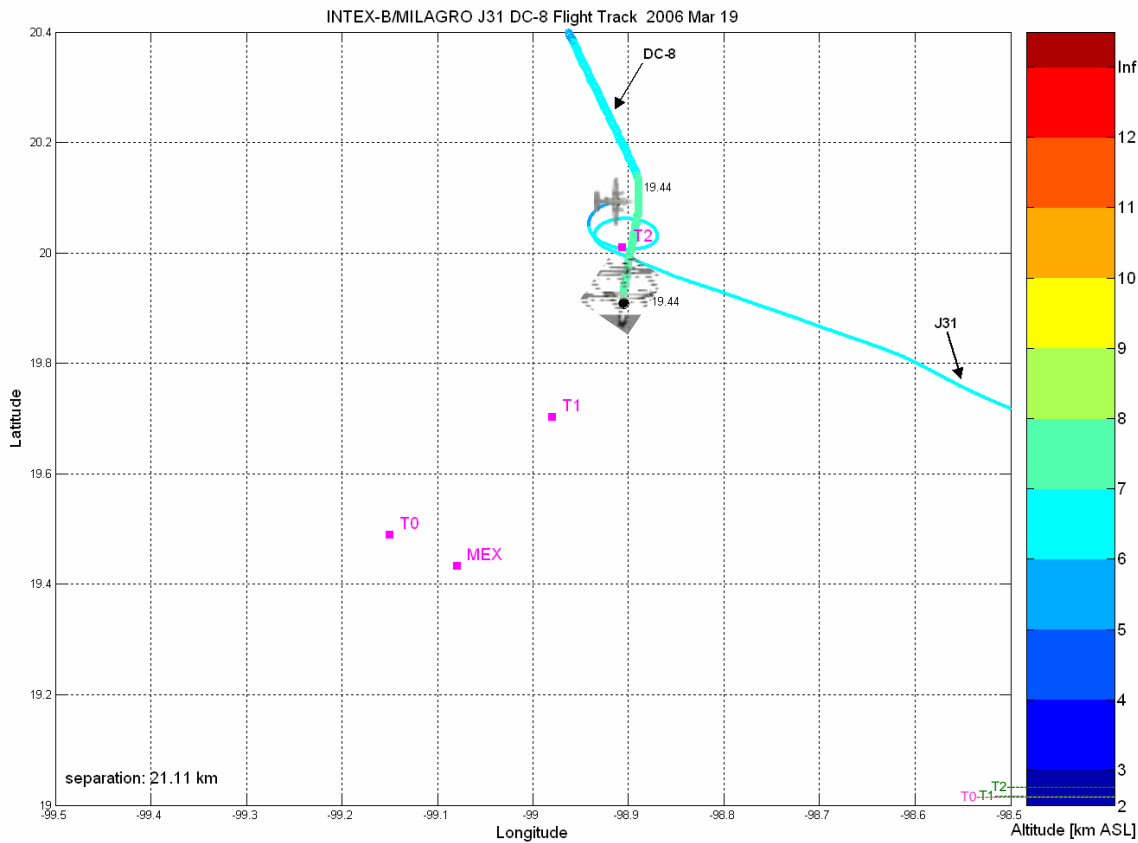
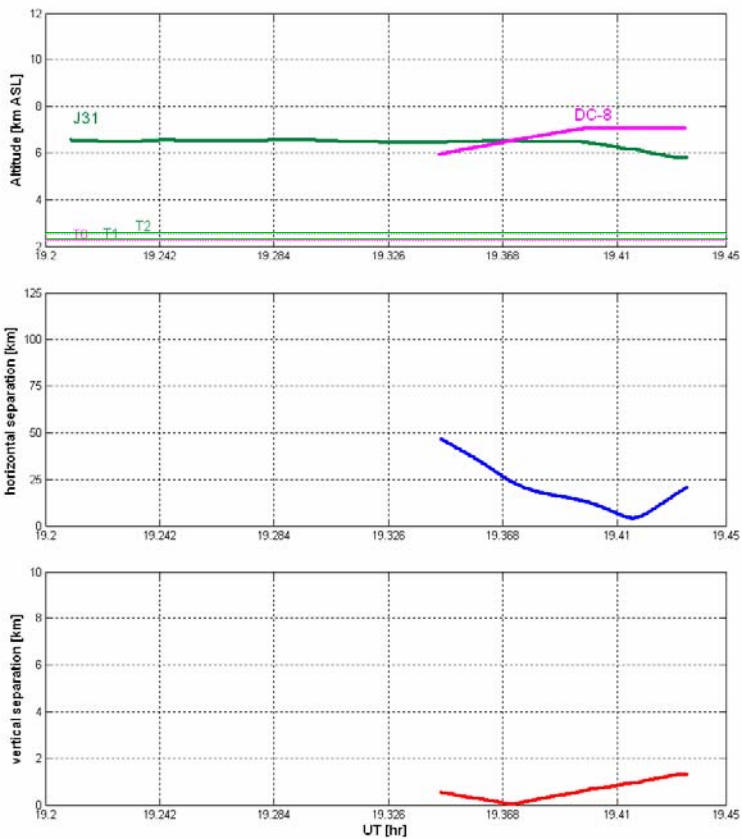
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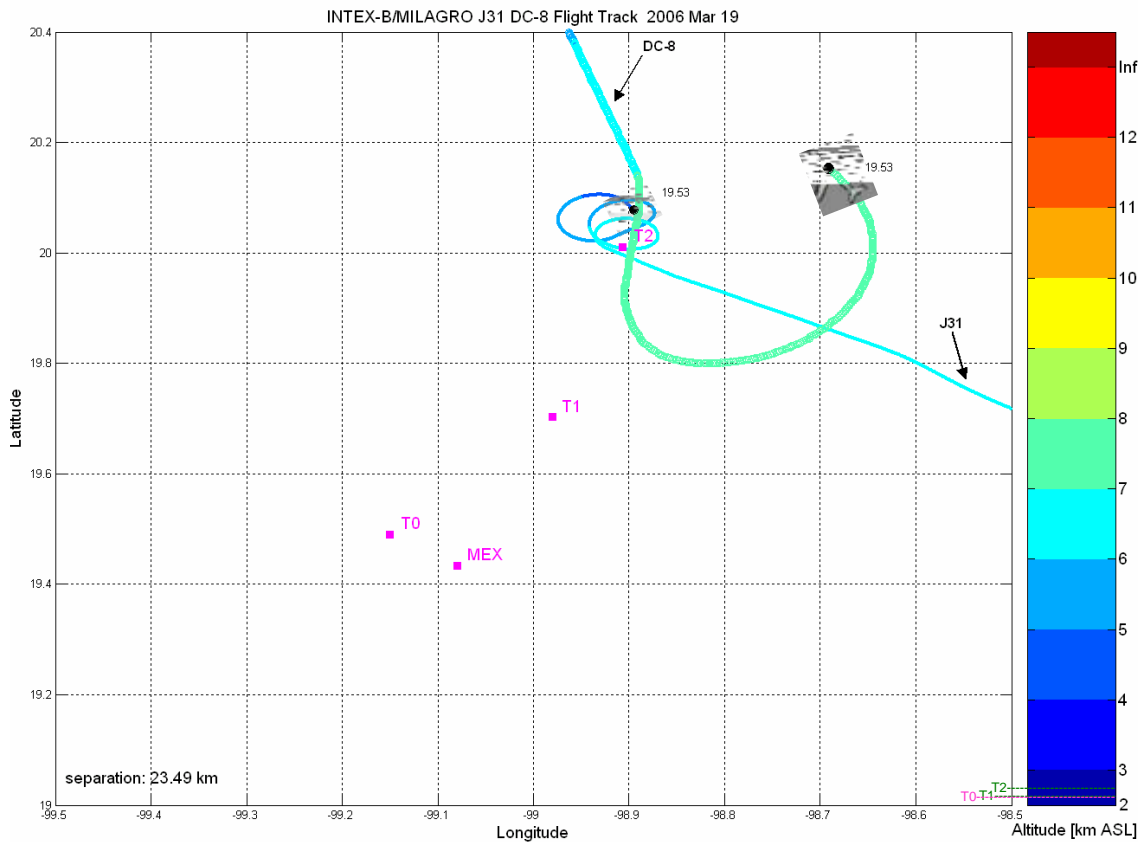
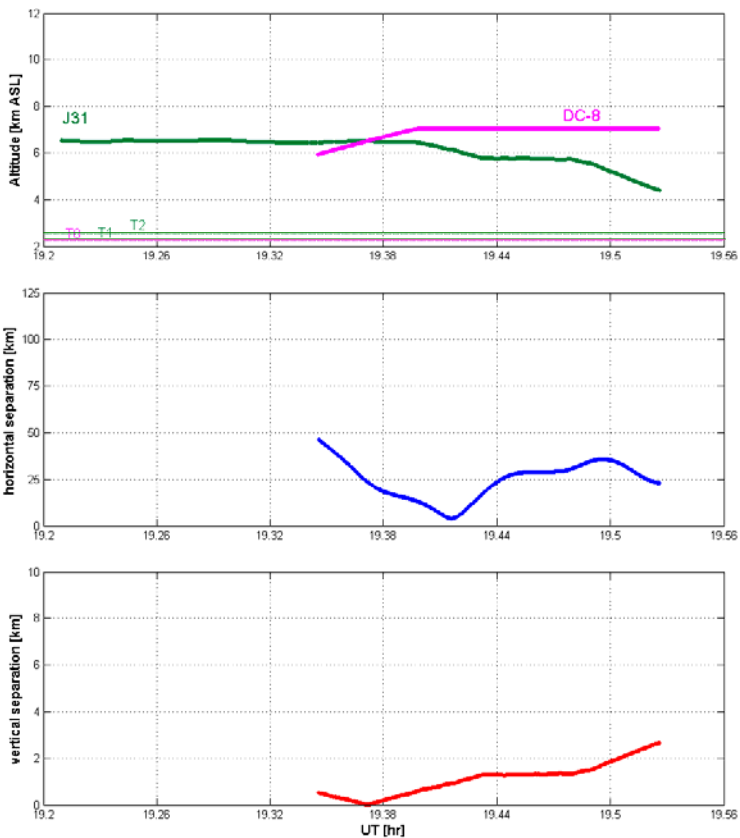
Coordination of DC-8 and J31 Flights, 19 Mar 2006, INTEX-B/MILAGRO



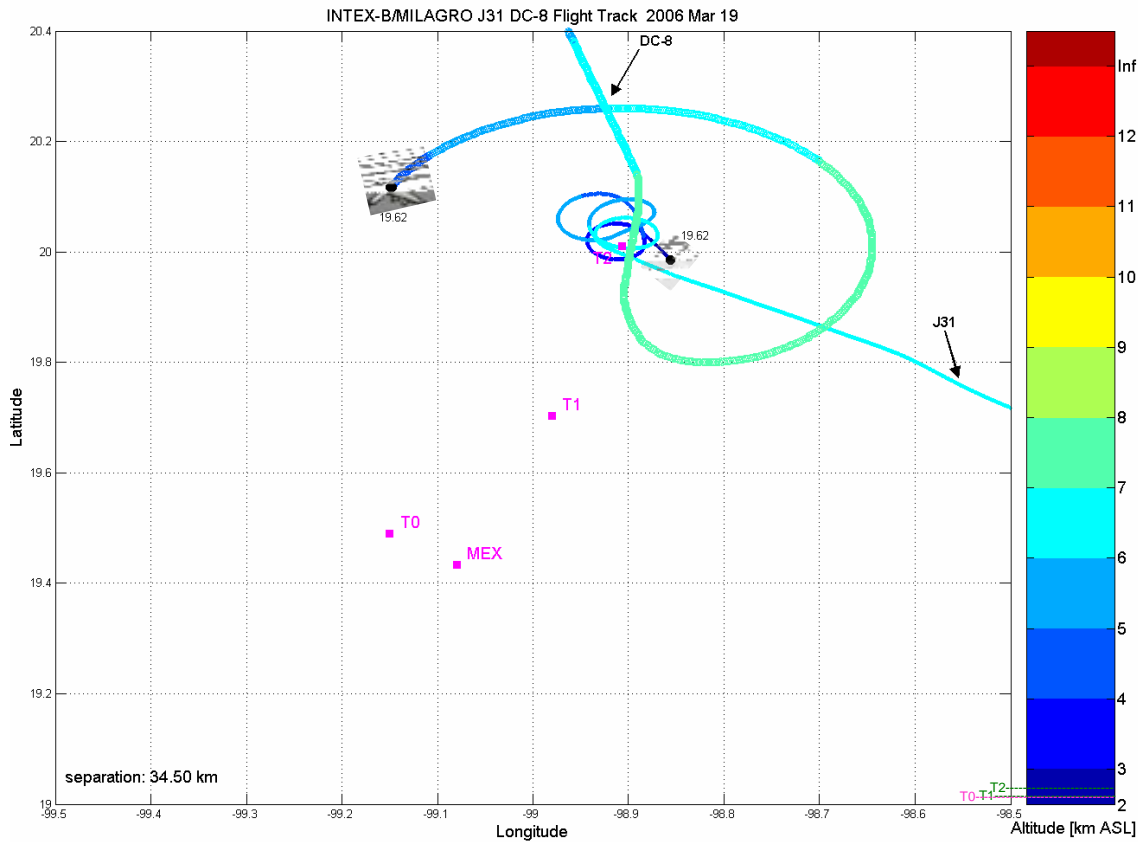
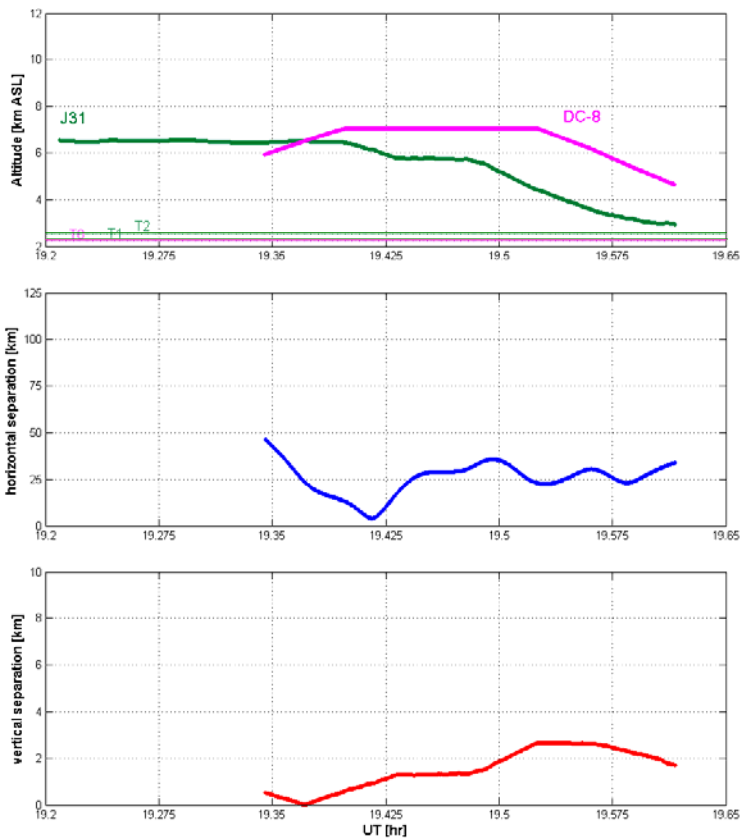
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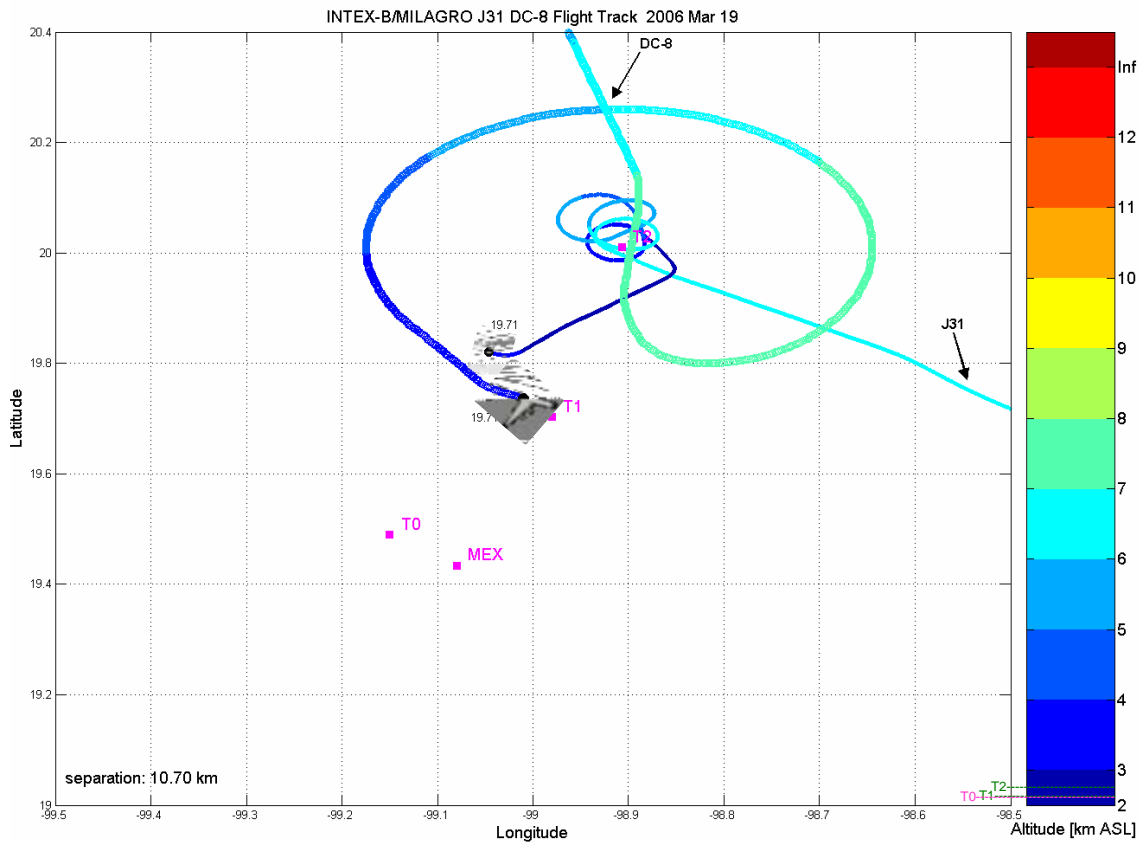
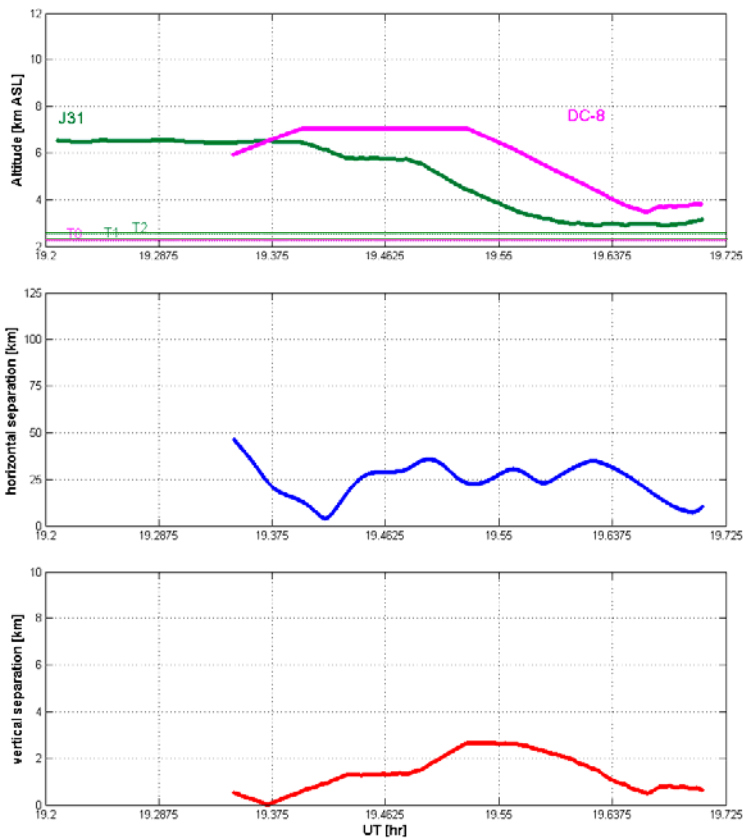
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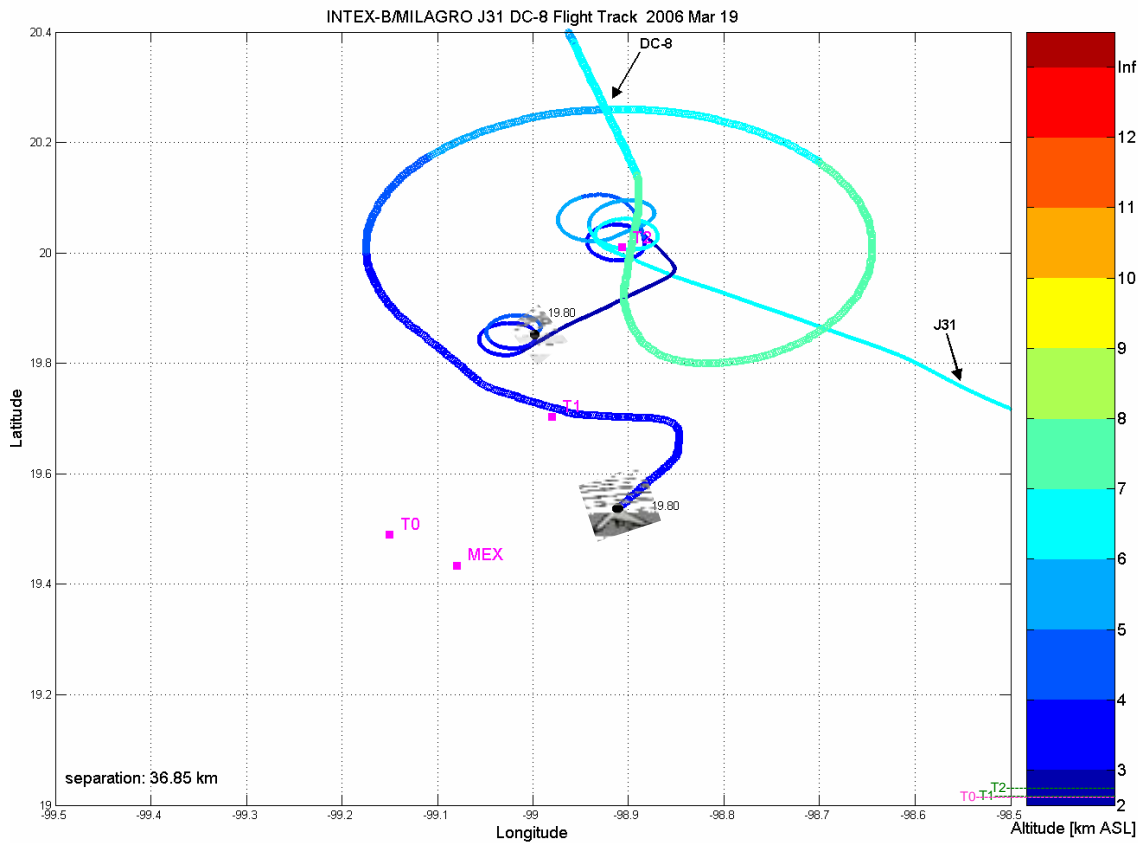
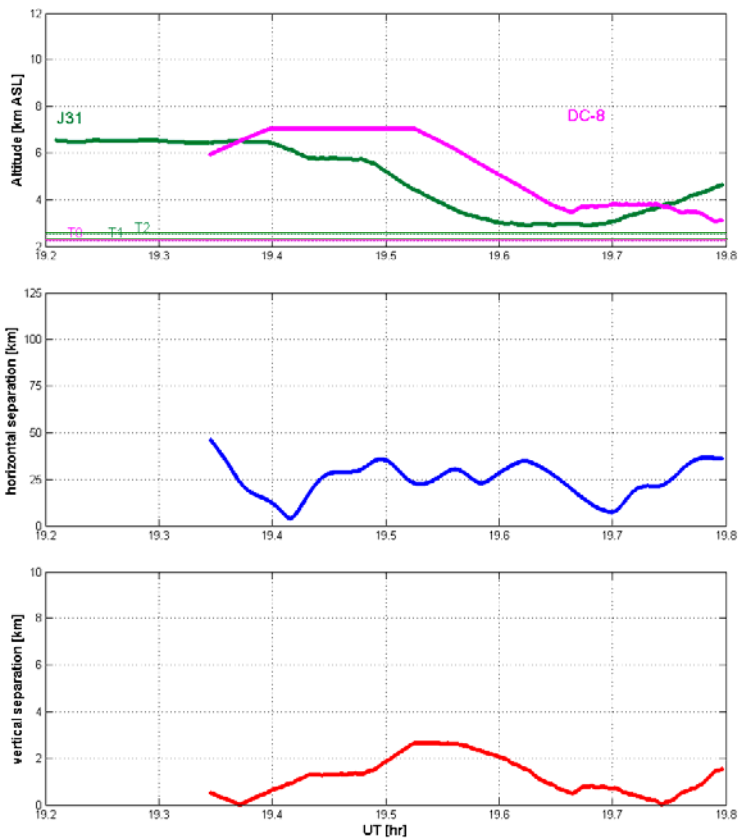
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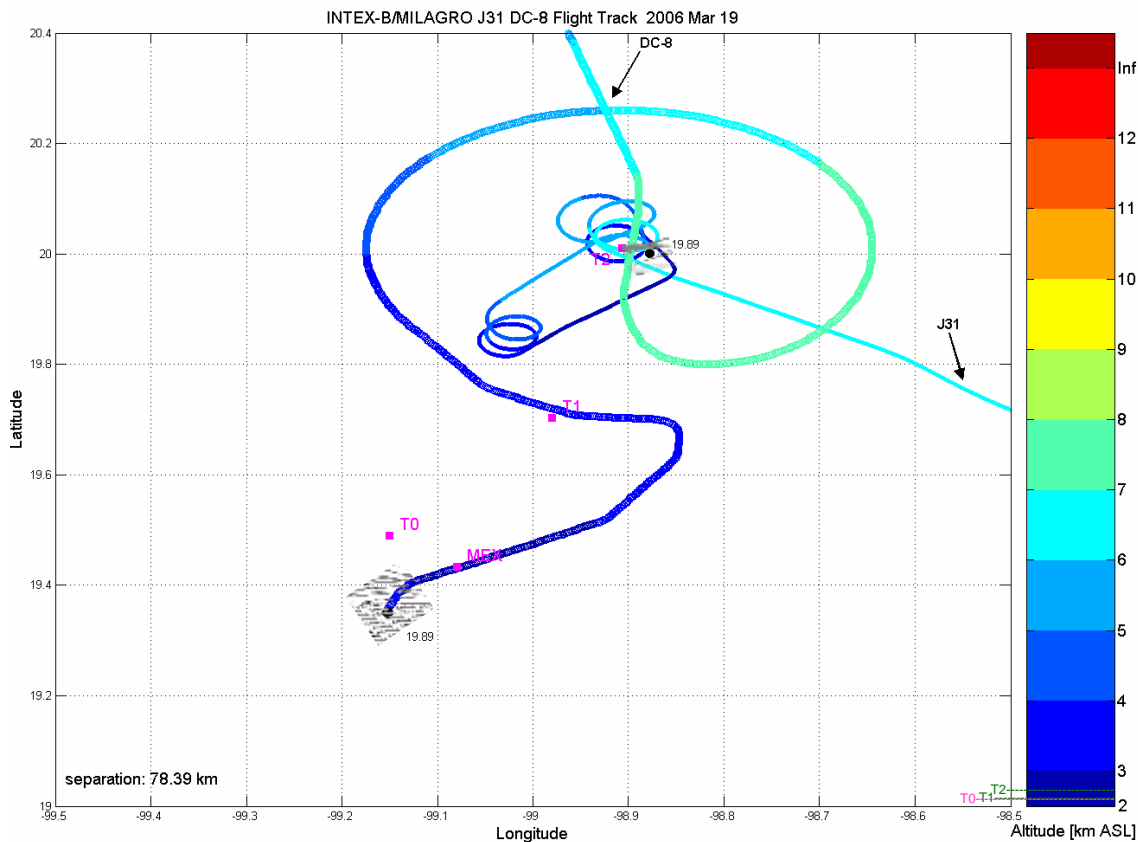
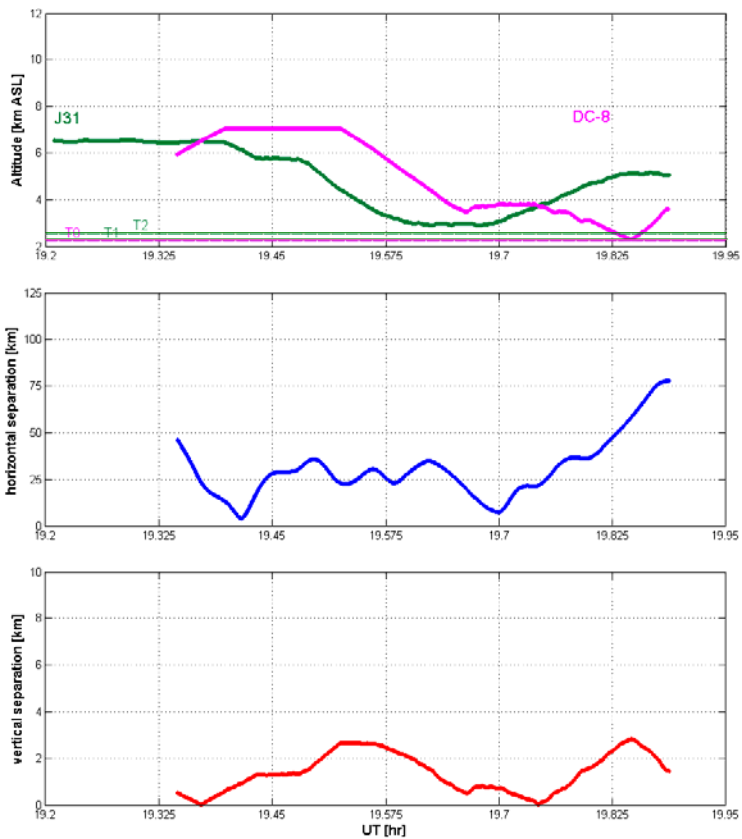
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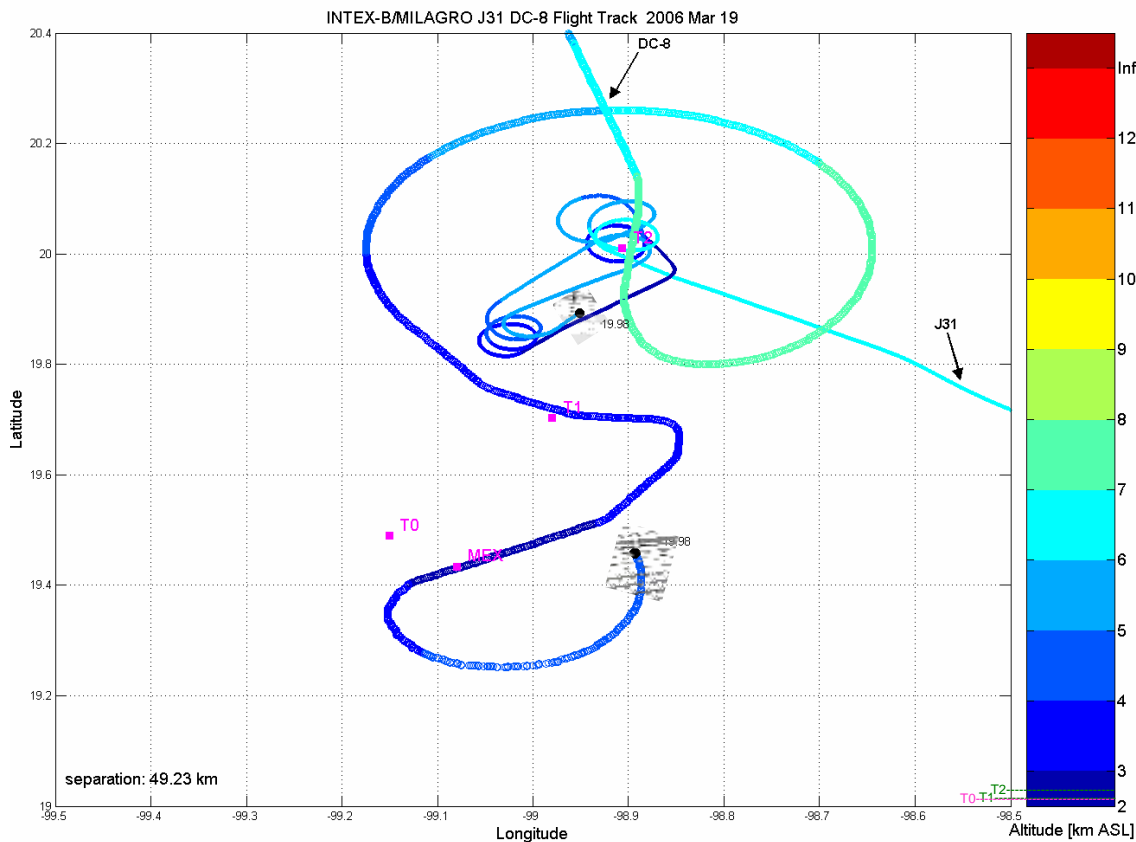
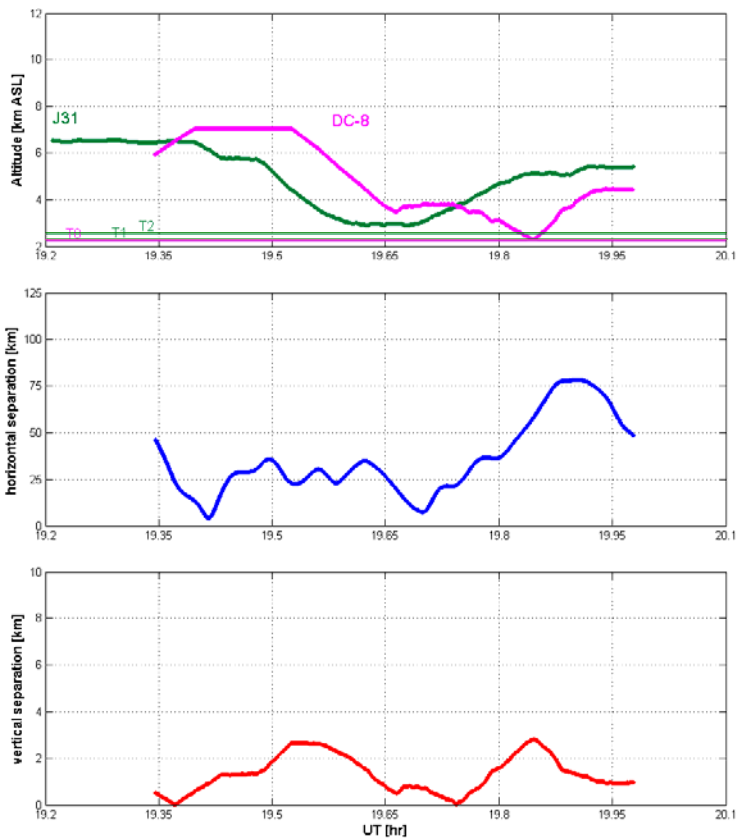
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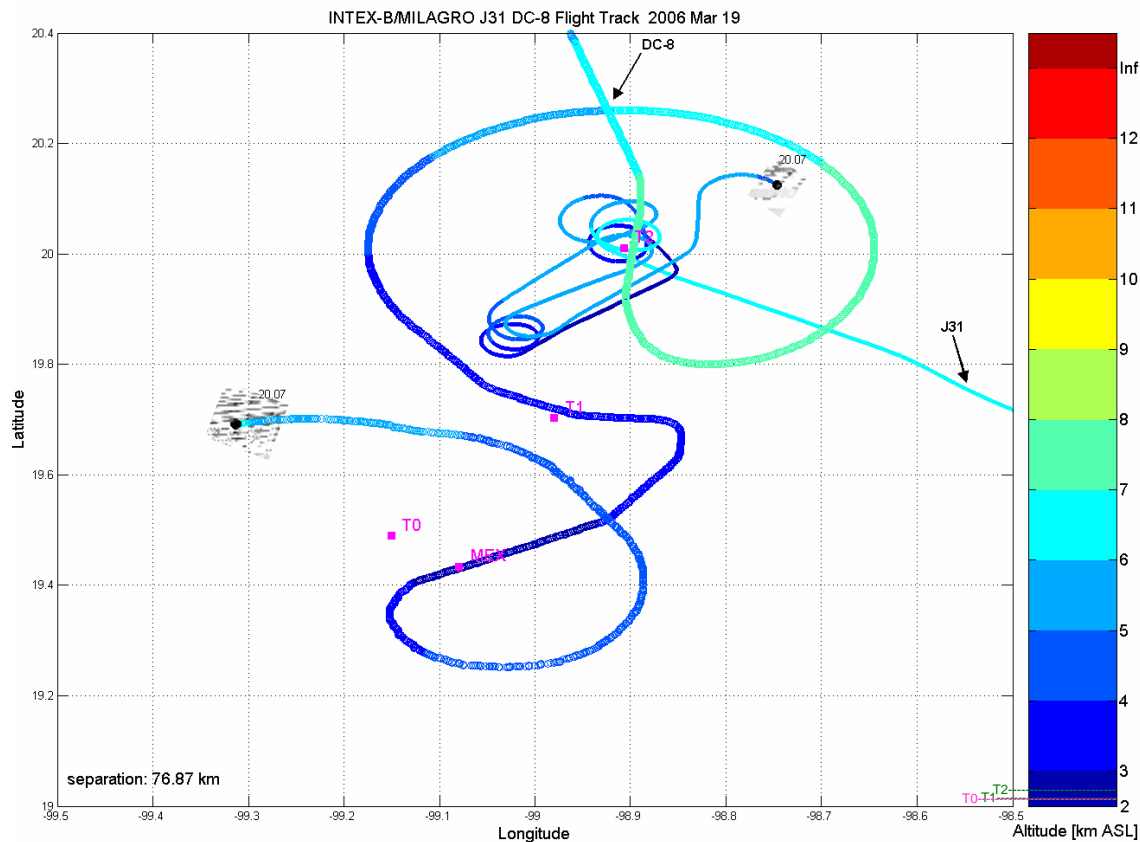
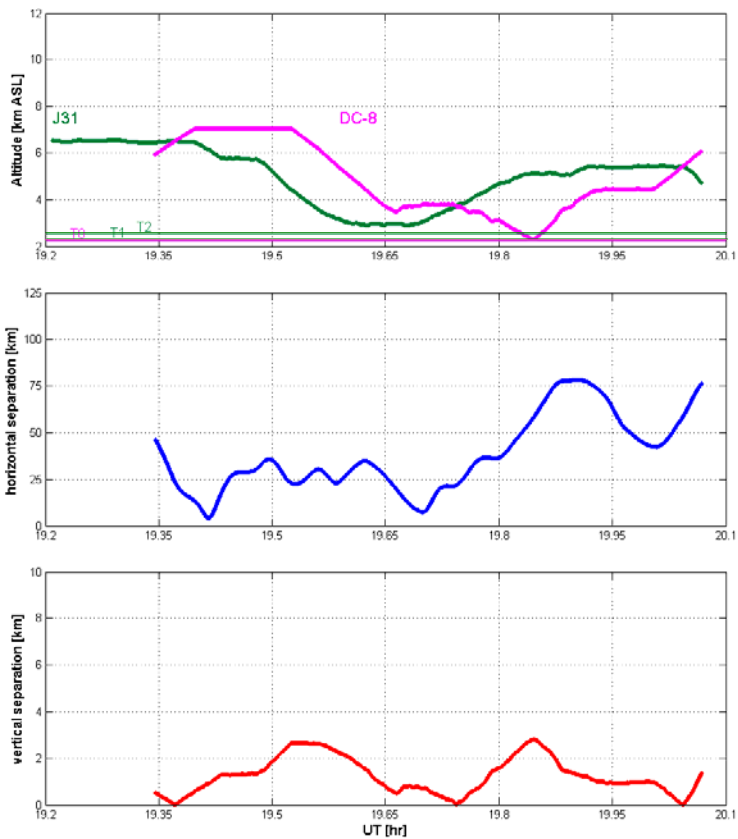
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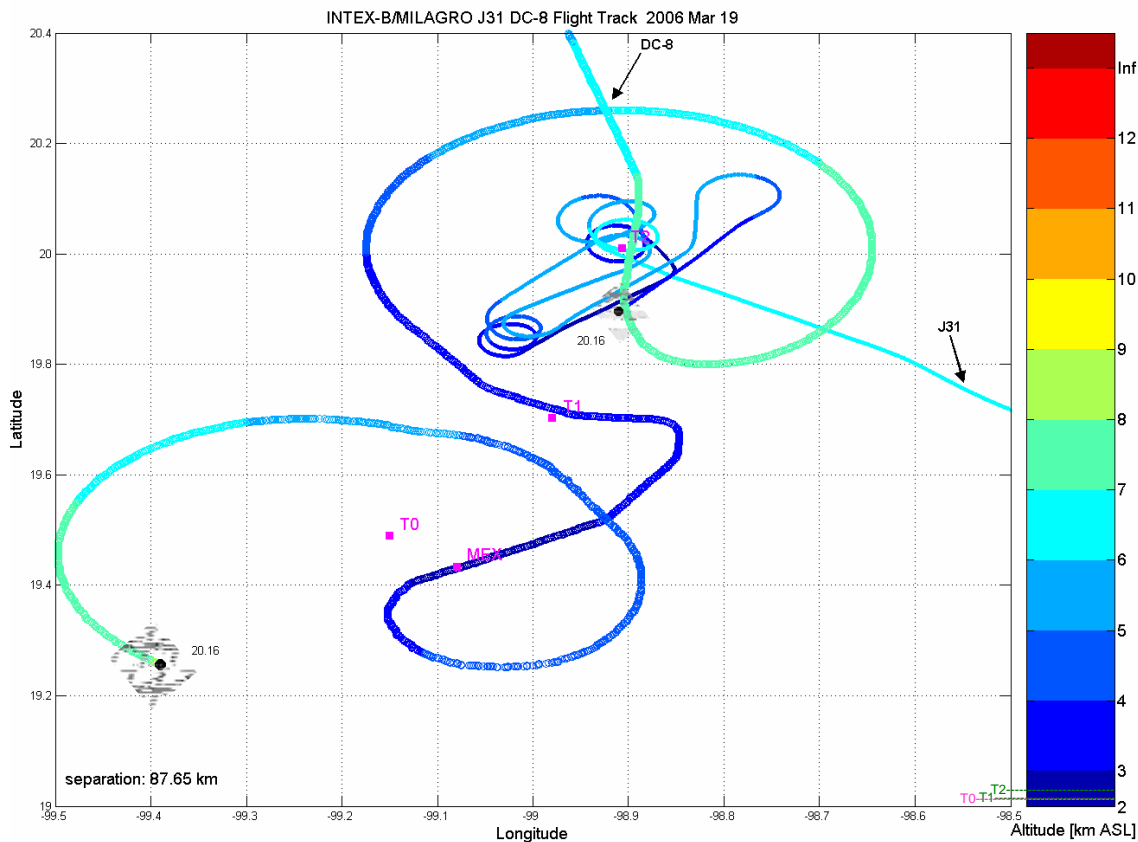
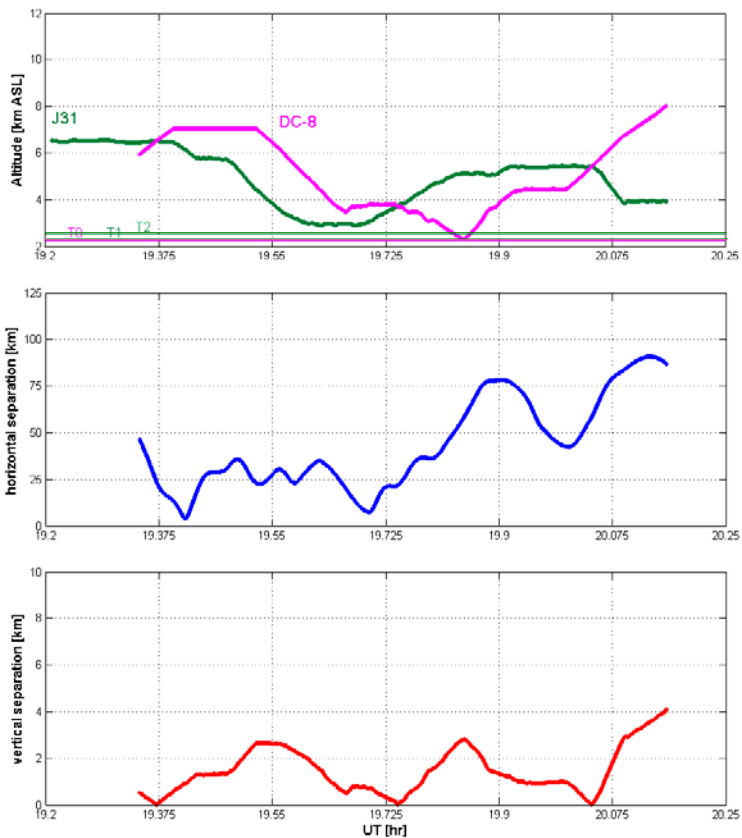
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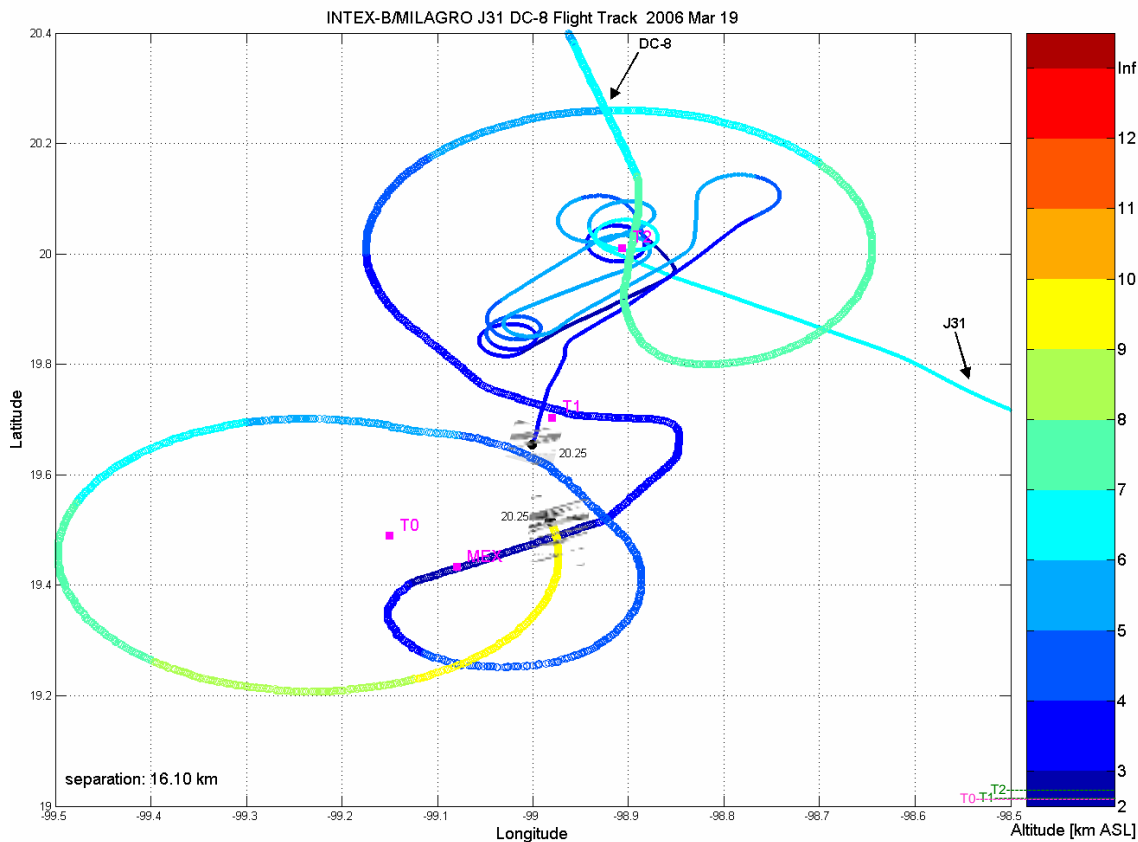
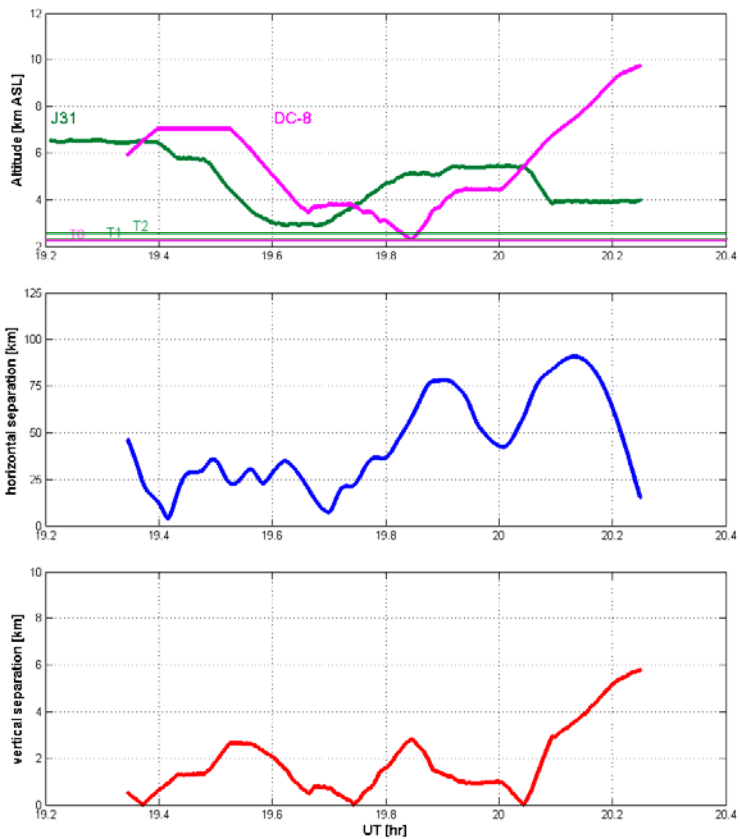
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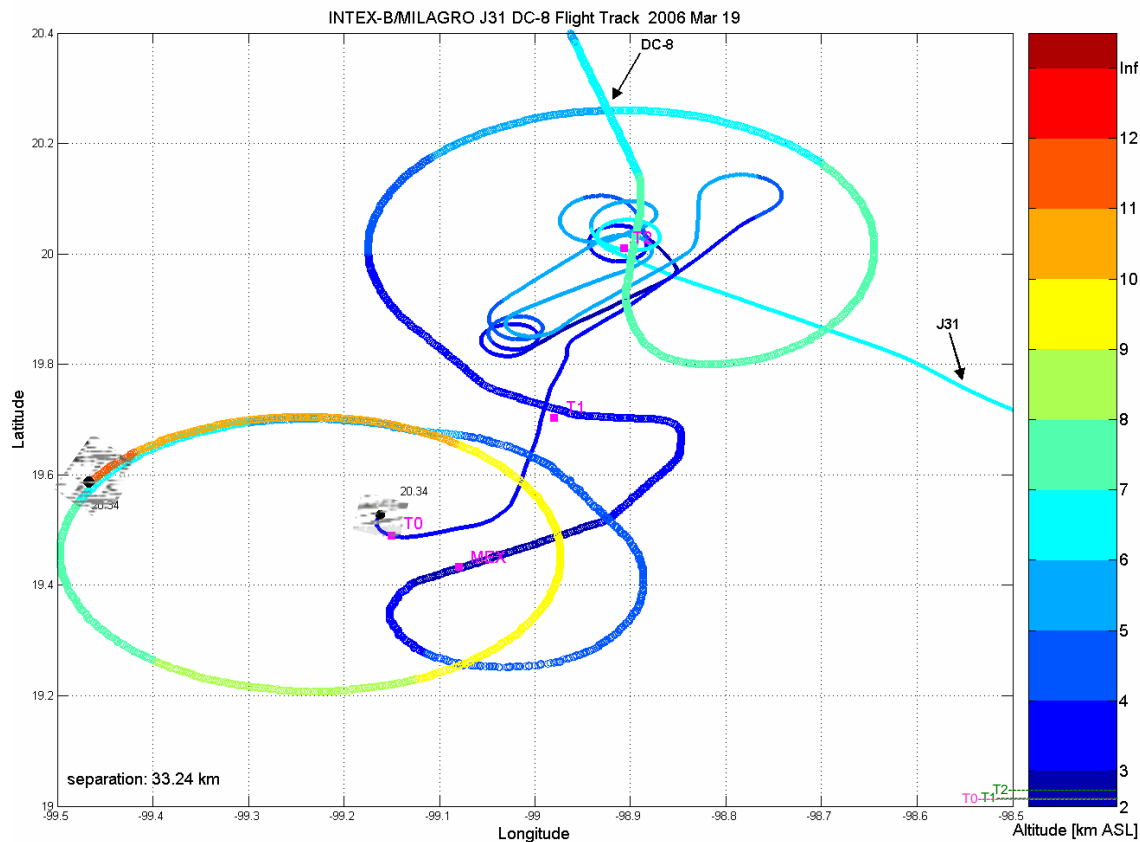
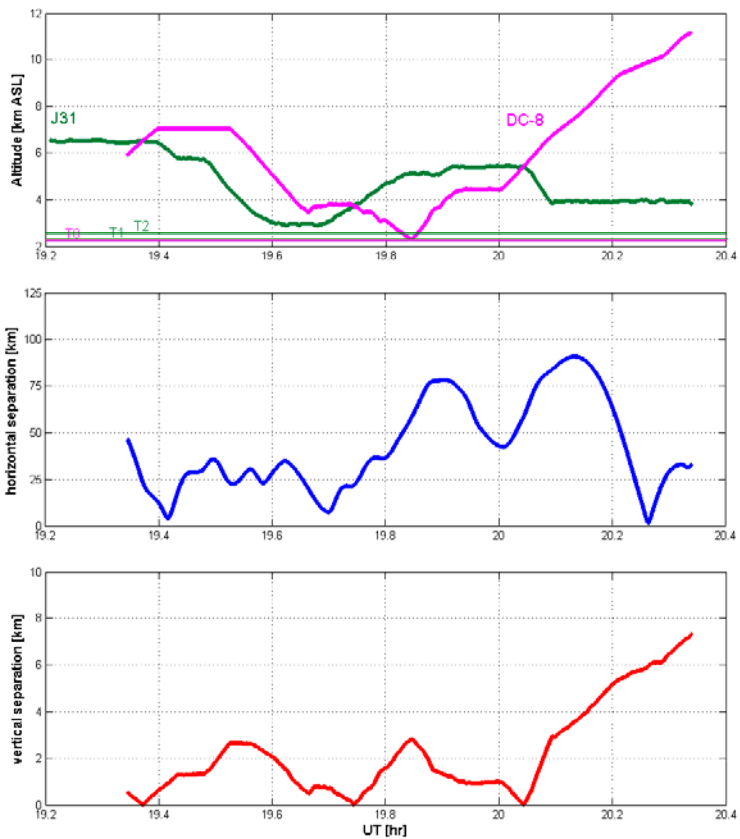
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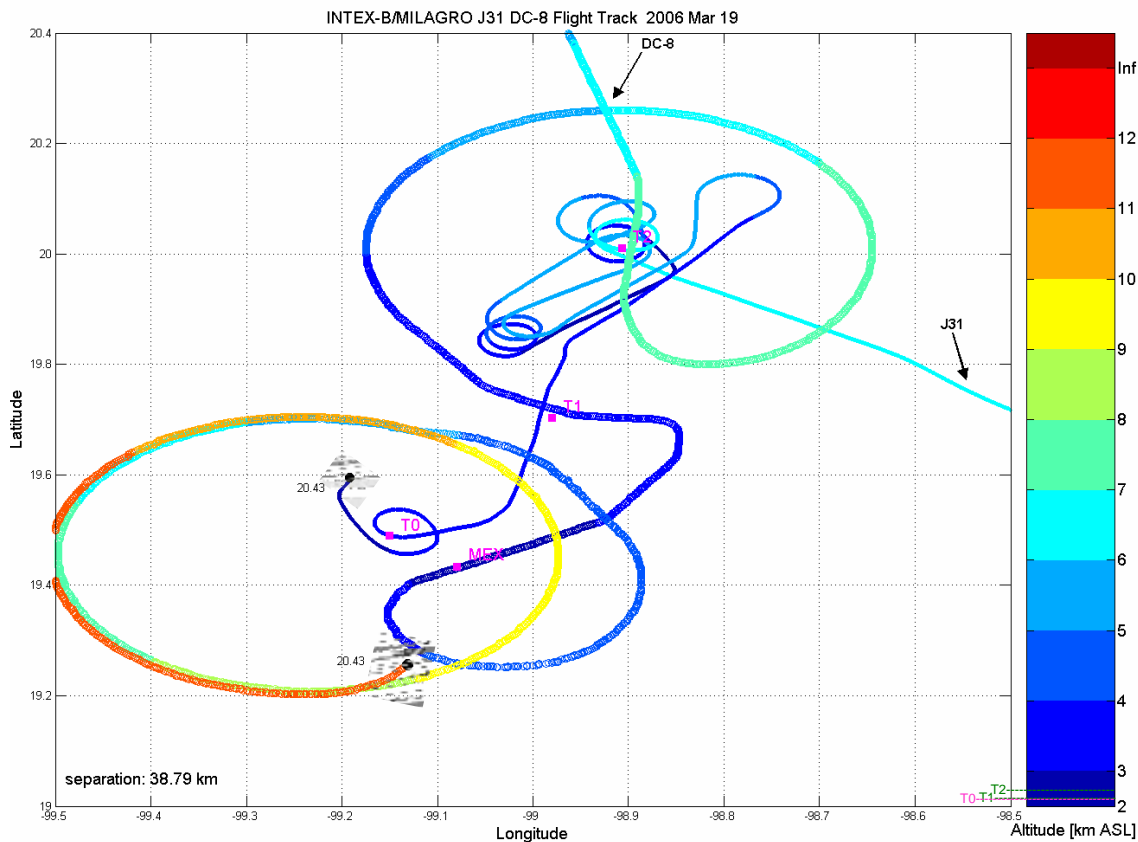
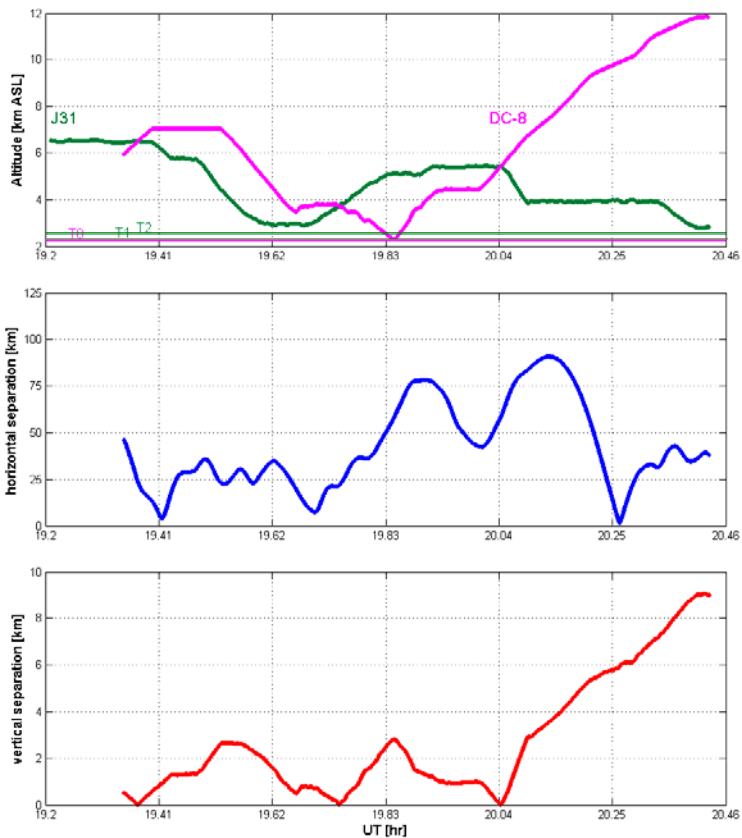
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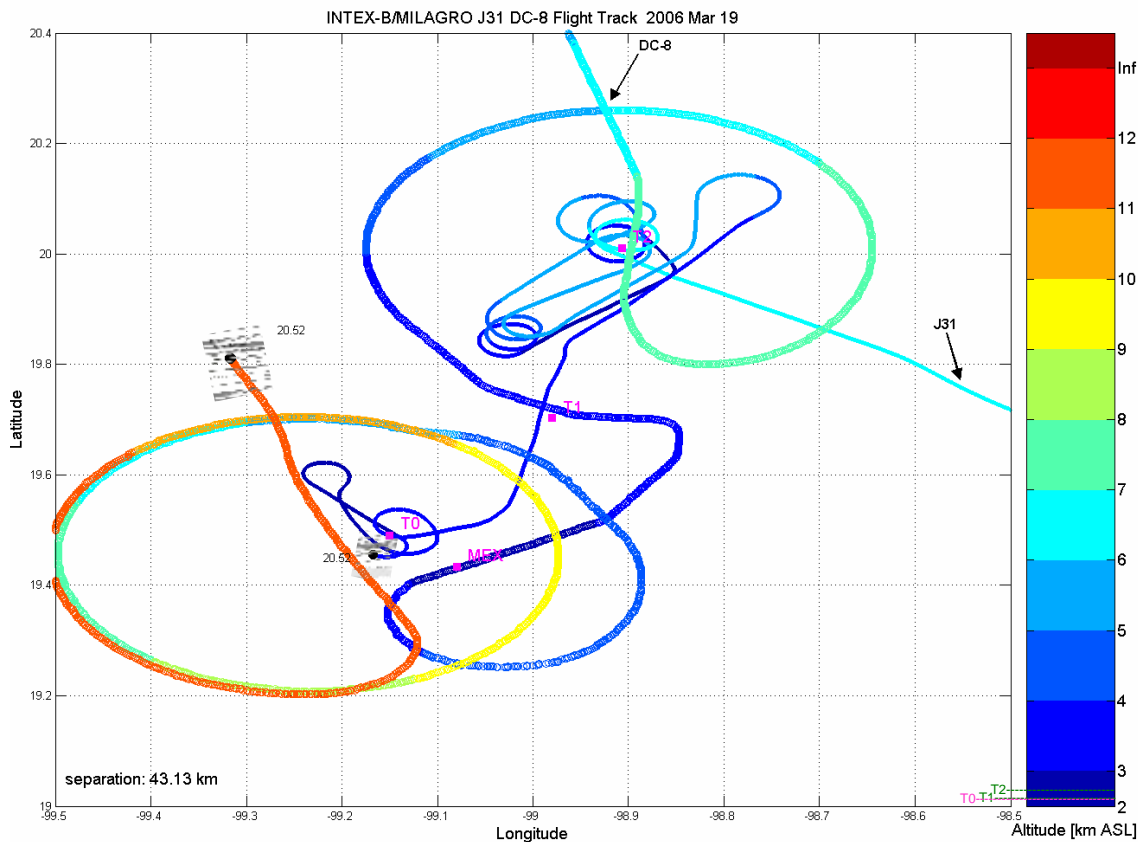
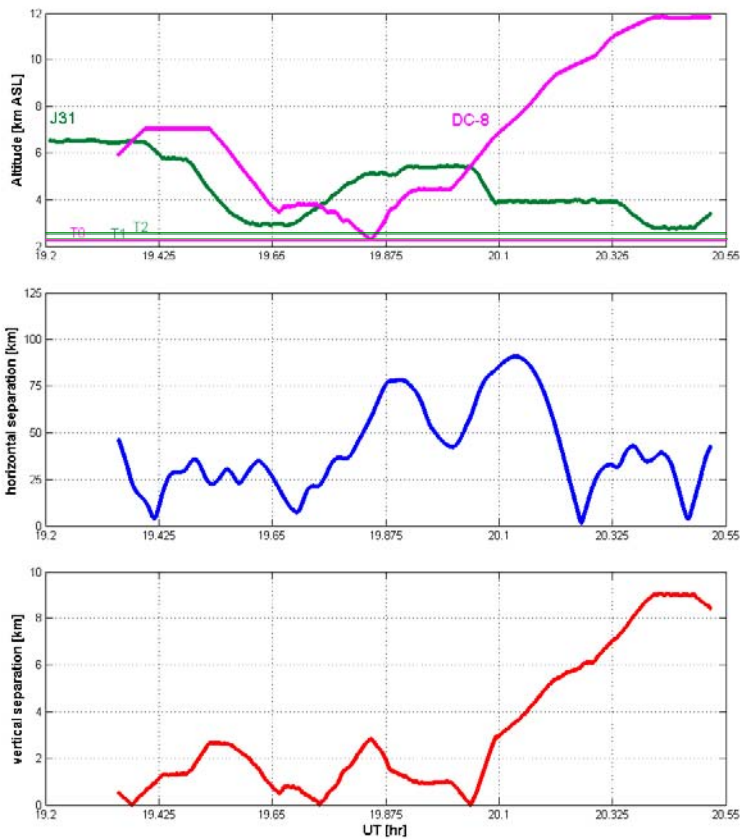
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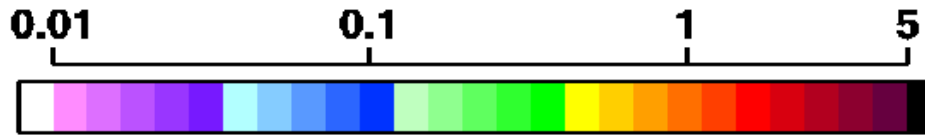
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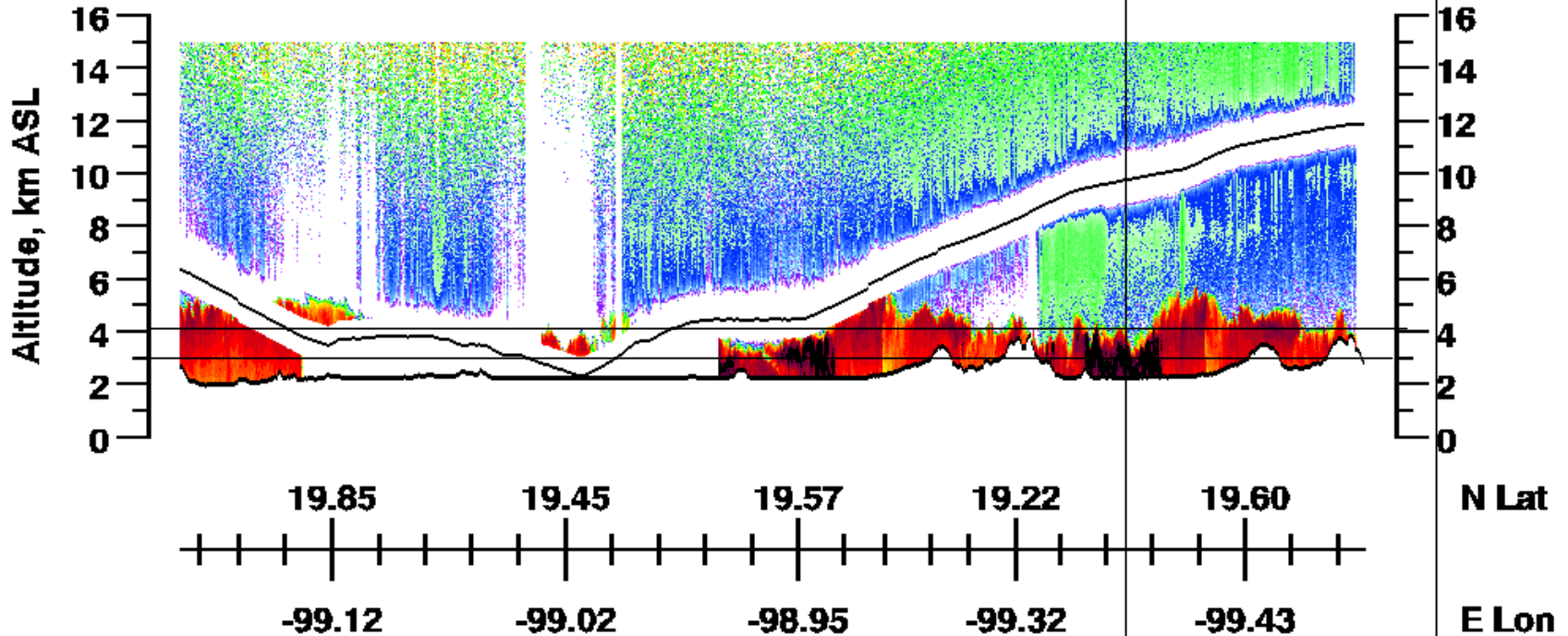
Mexico City Plume 4 / C-130 / TES & OMI
Flight 8

19 Mar 06

Aerosol Scattering Ratio (588 nm)



19:40 19:50 20:00 20:10 20:20 UT



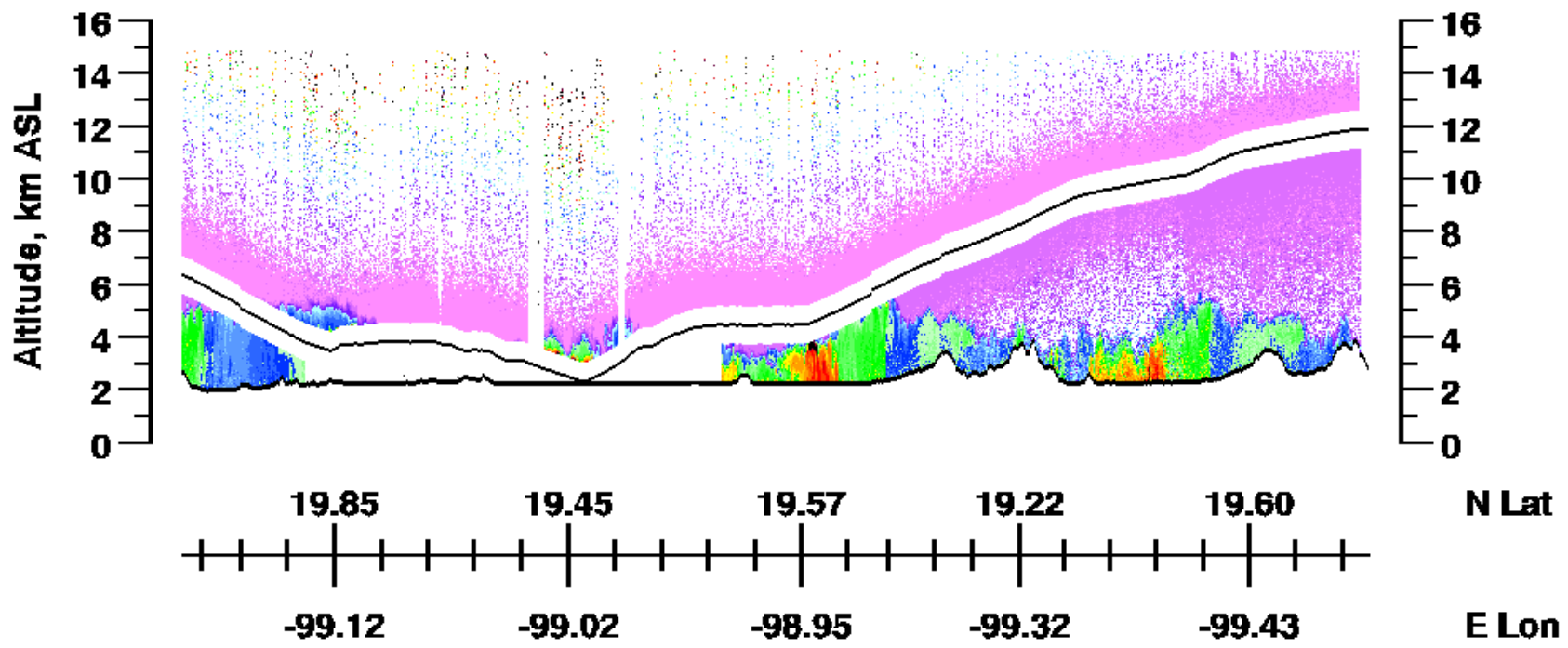
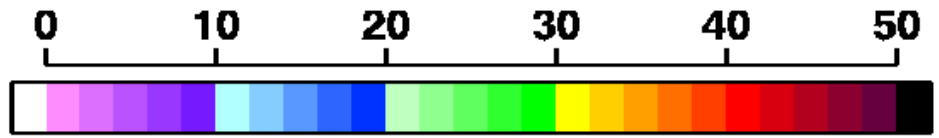
19:25 UT, DC-8 over J31 at T2

E. Browell, J. Hair
et al.

DC-8 over J31 between T1 & T0, 20:15 UT

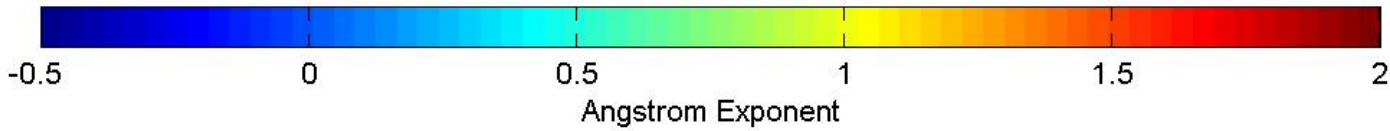
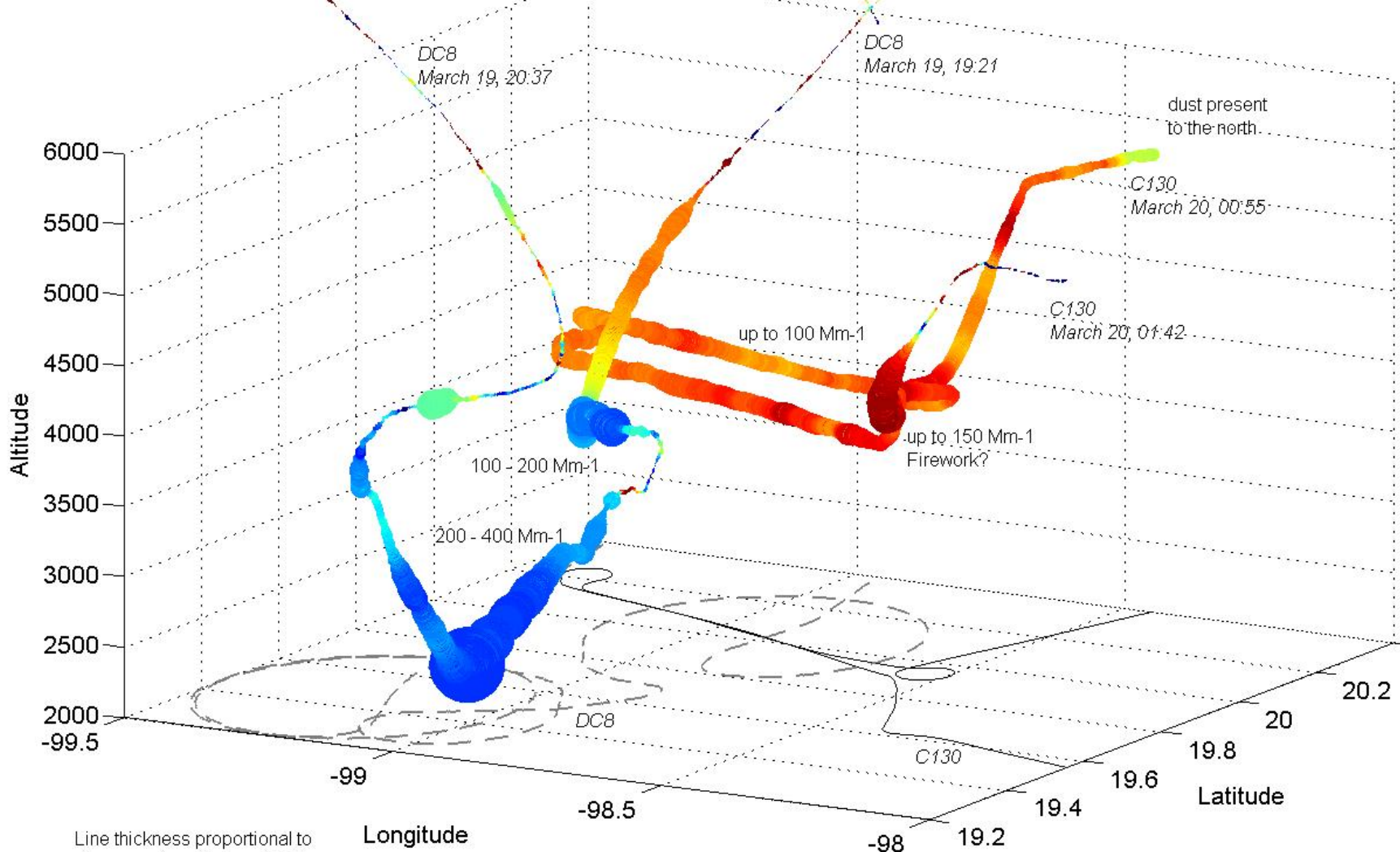
DC-8 over J31 NW of T0, 20:28 UT

Total Depolarization %



Large depolarization suggests dust:
consistent with AOD λ -dep

E. Browell, J. Hair et al.



MIB20060319MexicoCity3d2dflihttrackwormscav2.fig, proplot3d2dflihttrackwormscav2.m, Yohei, 2006-08-01

Clarke, Shinozuka et al.

J31 Collaborations

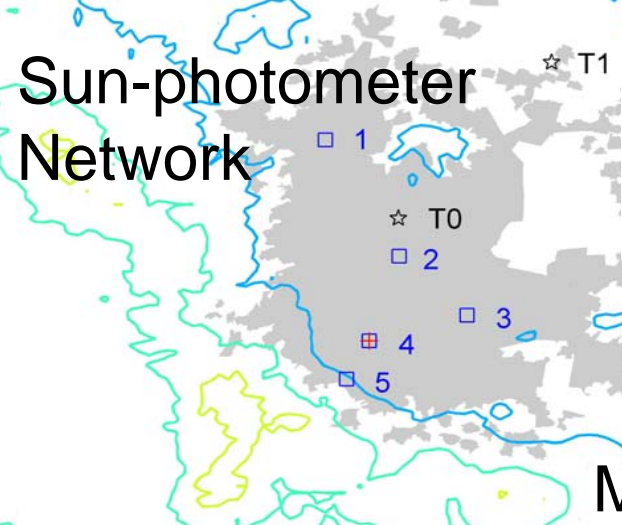
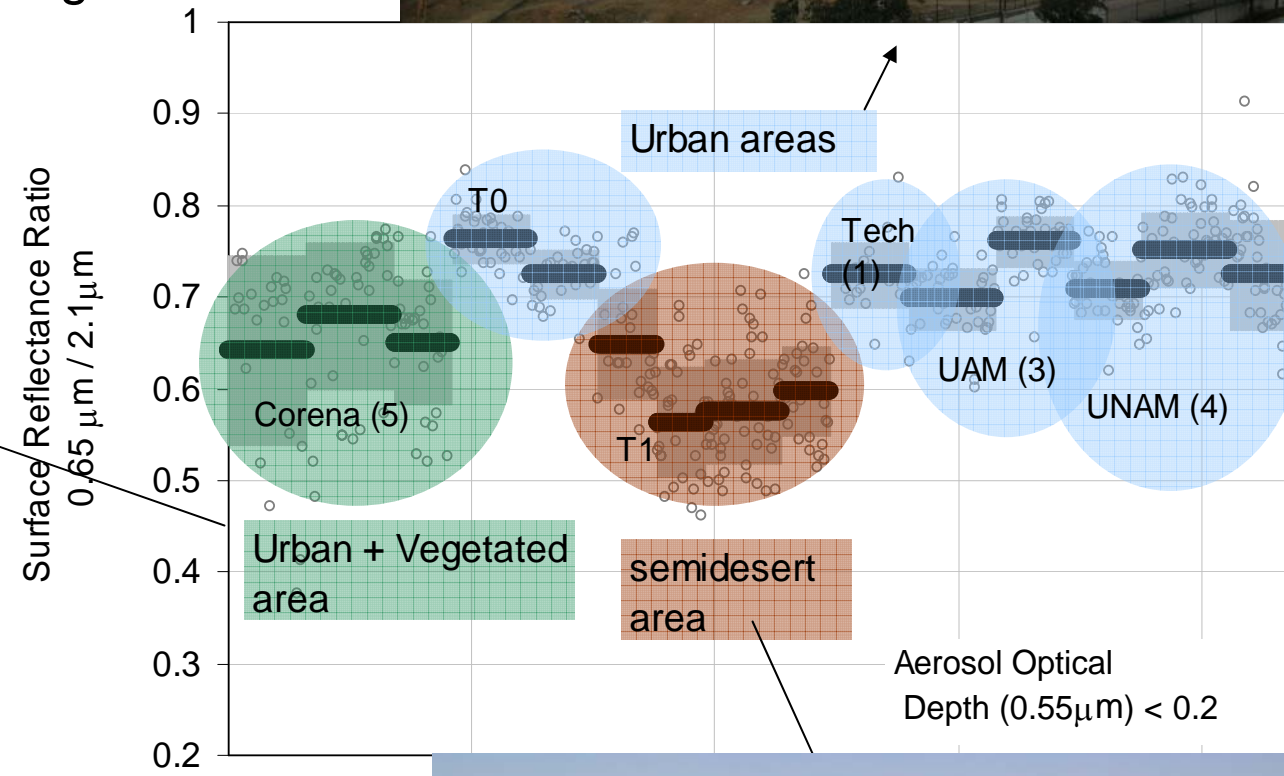
- Current: \longleftrightarrow
- Potential: $\leftarrow - - \rightarrow$

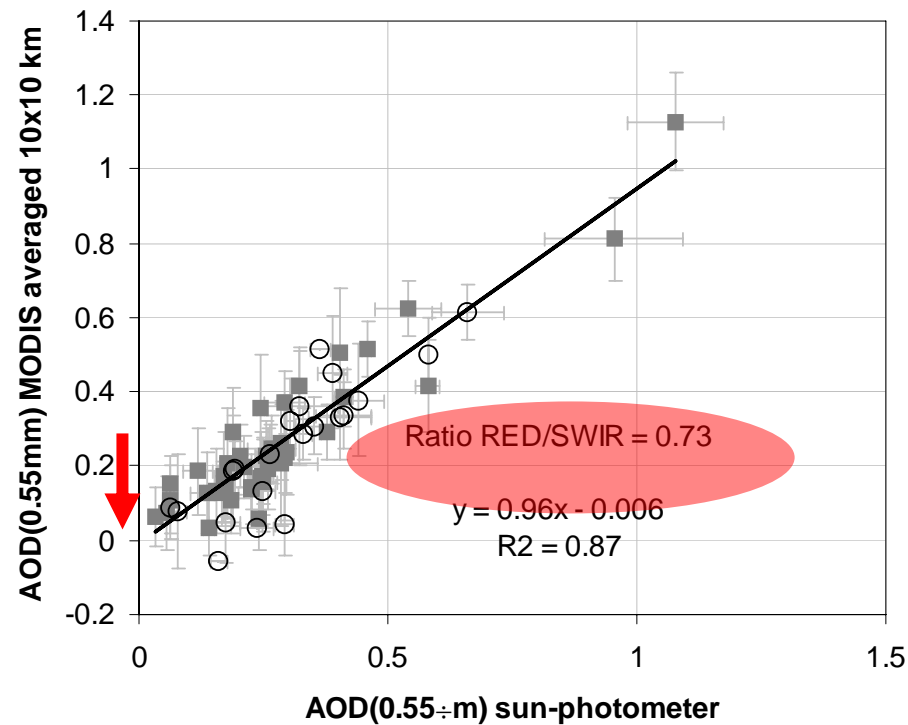
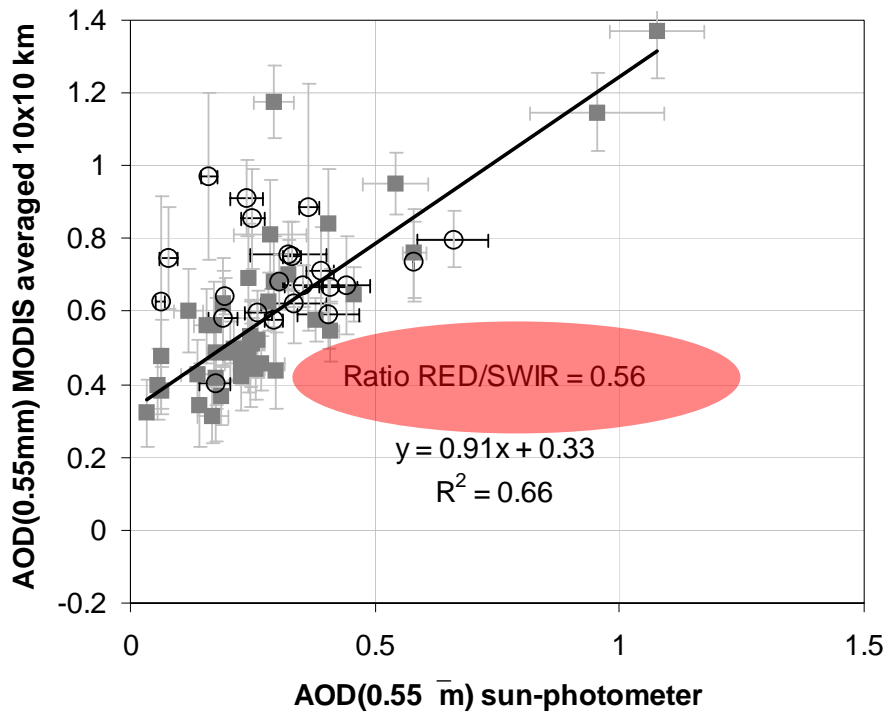


End of Presentation

Remaining Slides are Backup

Surface reflectance ratio between visible and short-wave infrared wavelengths varies as a function of surface cover and scattering angle. The urbanized area in Mexico City shows on average values around 0.73

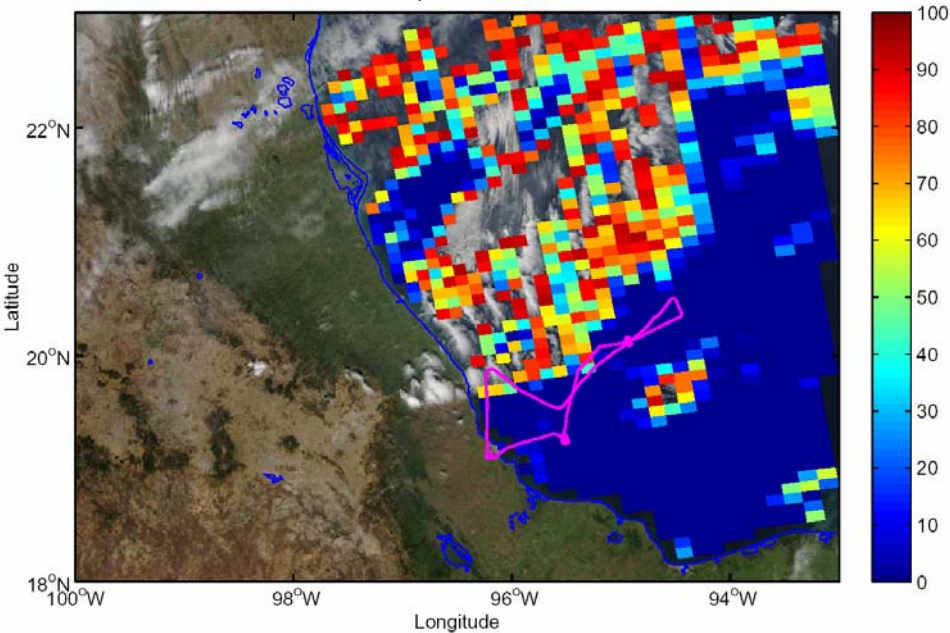




Plots show the MODIS AOD retrieved in this work with 1.5km spatial resolution over Mexico City compared to the sun photometer AOD measurement.

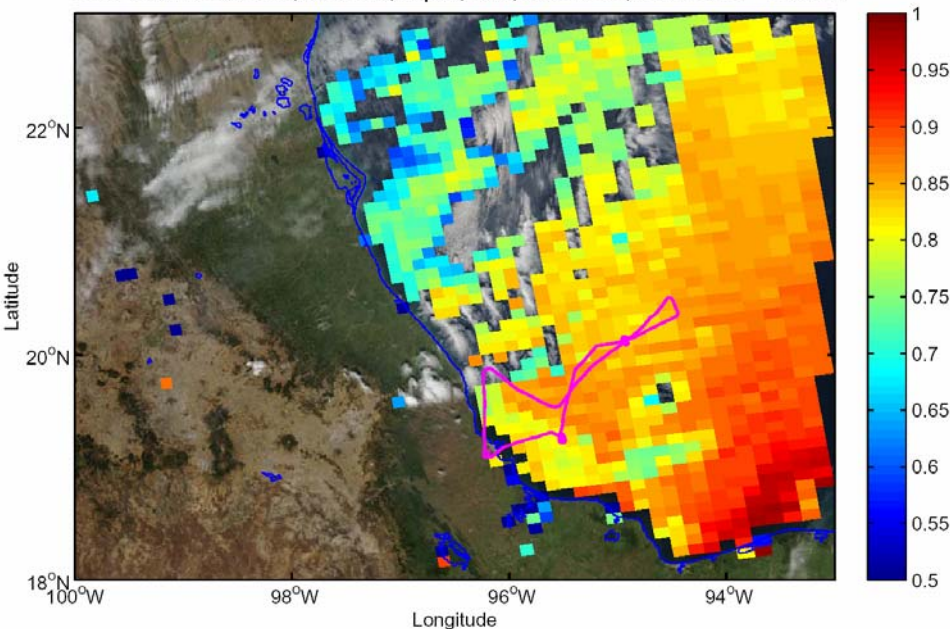
Open dots are data from sun-photometer network/Milagro experiment 2006, and gray squares are data from CIMEL/AERONET from 2002 until 2005. The assumption on the surface reflectance ratio (visible and shortwave infrared wavelengths) makes all difference on the AOD retrieval with MODIS over the Mexico City urban area as shown in these two figures. The surface ratio of 0.73 shows significant improvement on the validation of the retrieval in the urban region.

Fraction of Cloud,MODIS,Aqua,069,03/10/06,UT:19:55--20:00

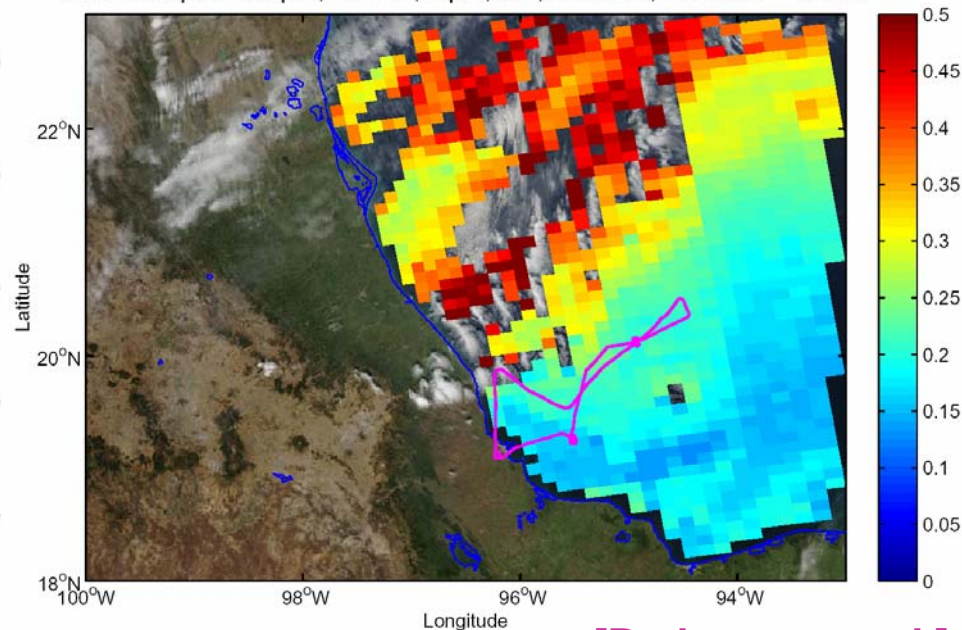


March 10, MODIS-Aqua
over the Gulf of Mexico.
Retrieval maps show
MODIS-Aqua results
and J-31 flight track

Fine mode fraction,MODIS,Aqua,069,03/10/06,UT:19:55--20:00

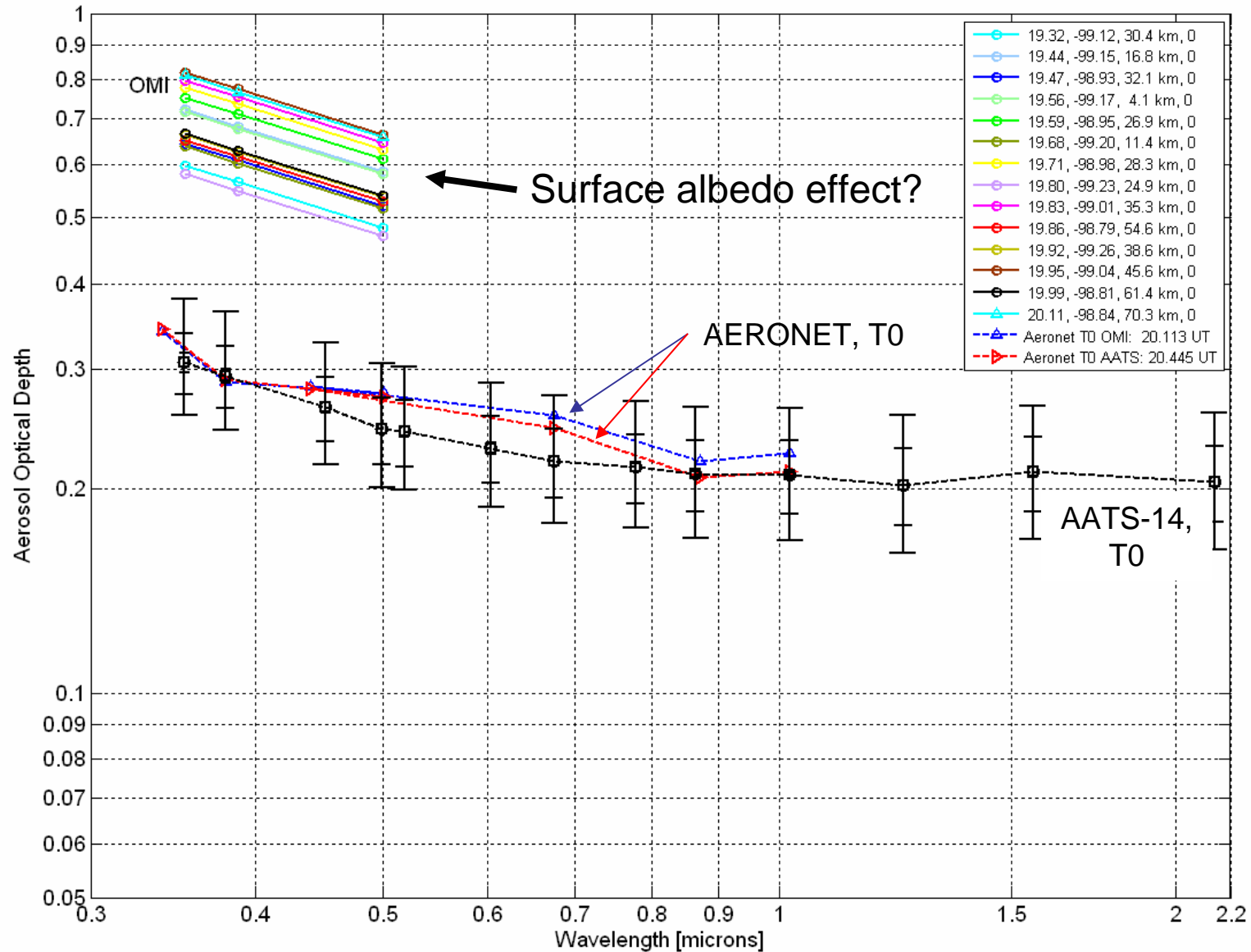


Aerosol optical depth,MODIS,Aqua,069,03/10/06,UT:19:55--20:00

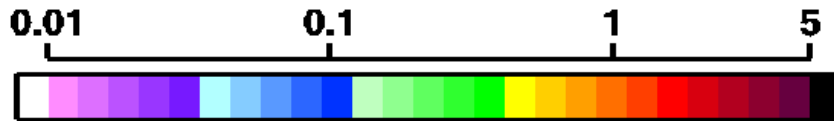


[Redemann et al.]

Comparison of OMI, AATS, & AERONET AOD at T0, 19 Mar 2006



Aerosol Scattering Ratio (588 nm)

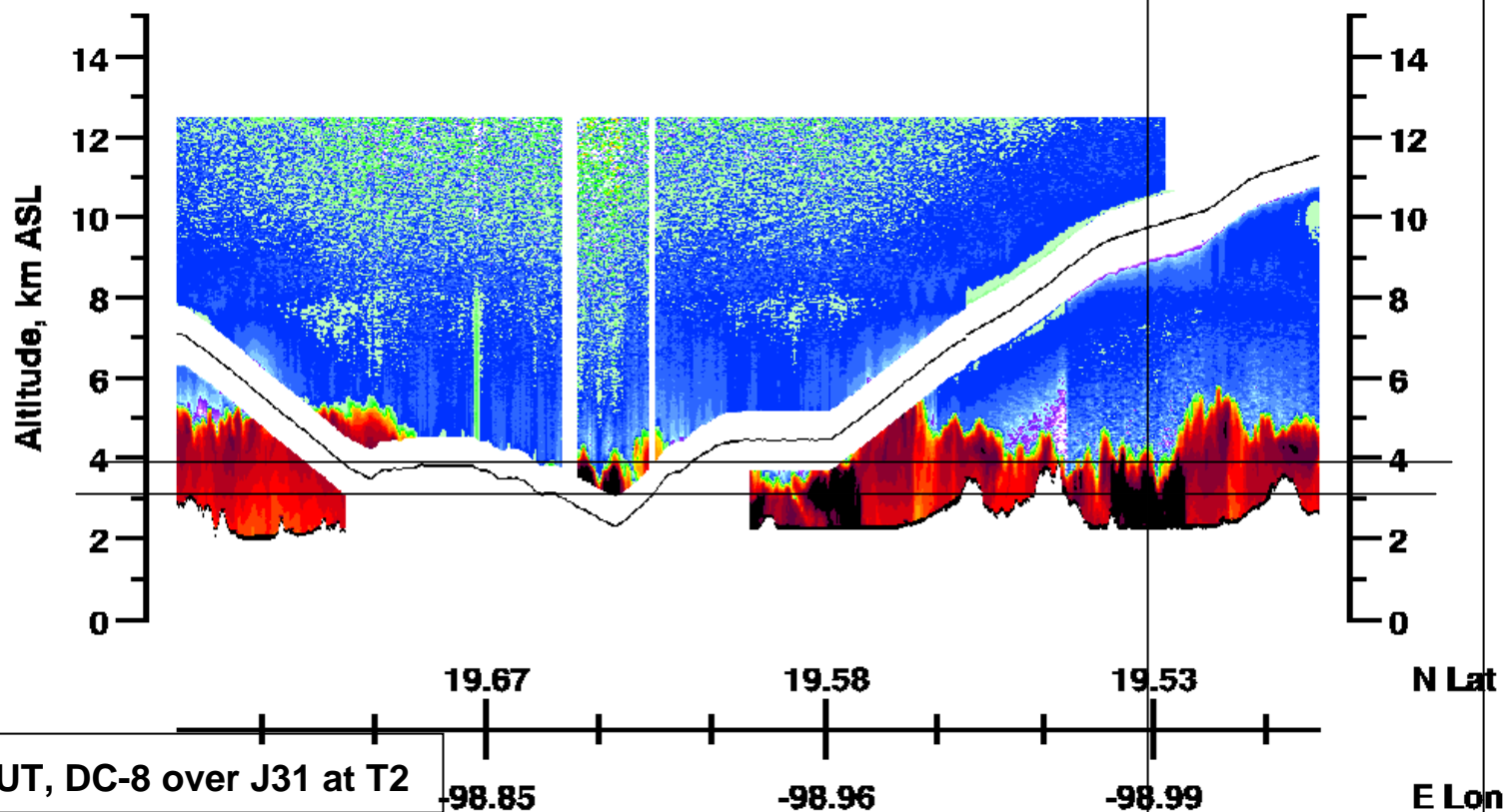


19:45

20:00

20:15

UT



19:25 UT, DC-8 over J31 at T2

DC-8 over J31 between T1 & T0, 20:15 UT

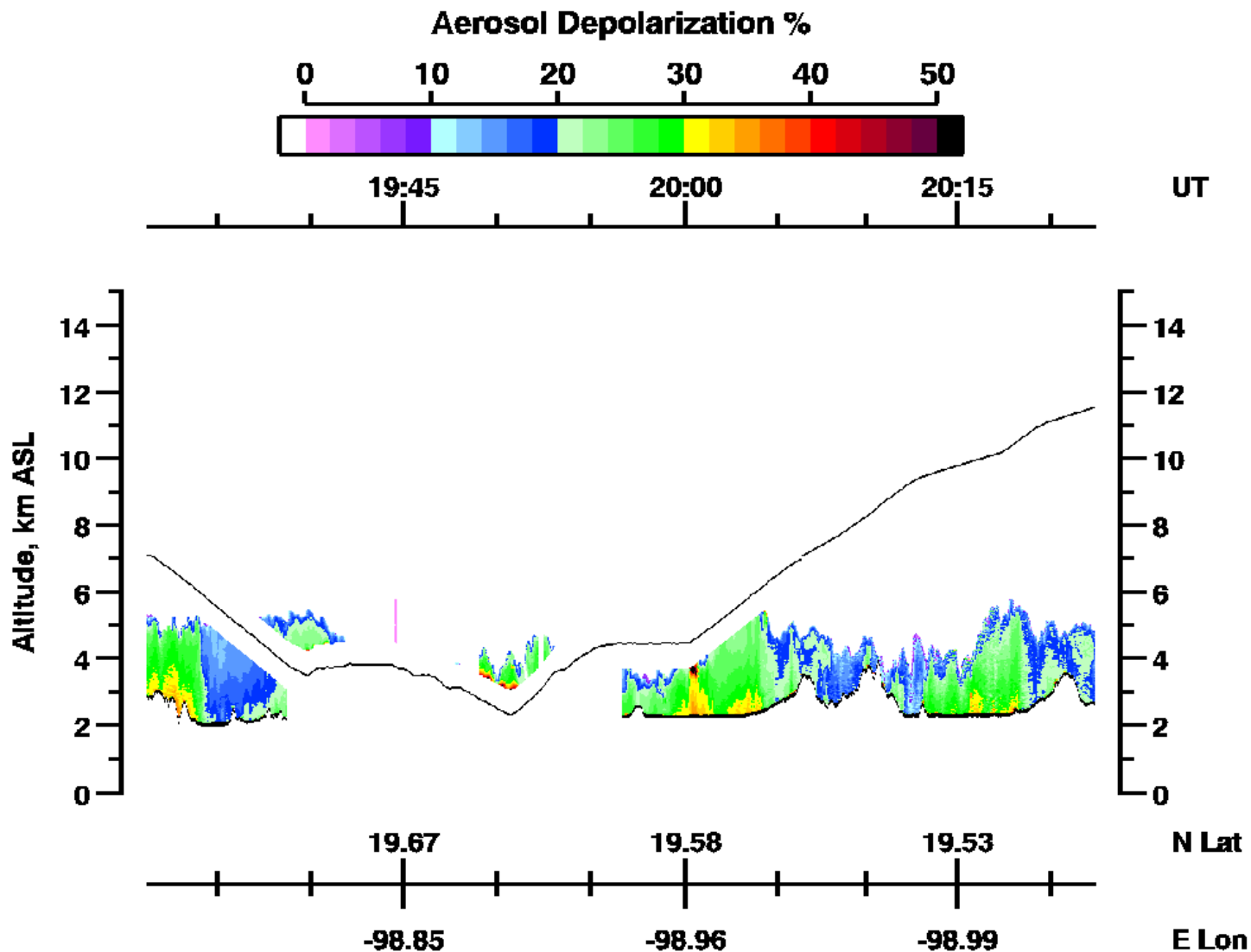
DC-8 over J31 NW of T0, 20:28 UT

J. Hair, E. Browell
et al.

INTEX-B

Mexico City Plume 4 / C-130 / TES & OMI
Flight 8

19 Mar 06



Large depolarization suggests dust:
consistent with AOD λ -dep

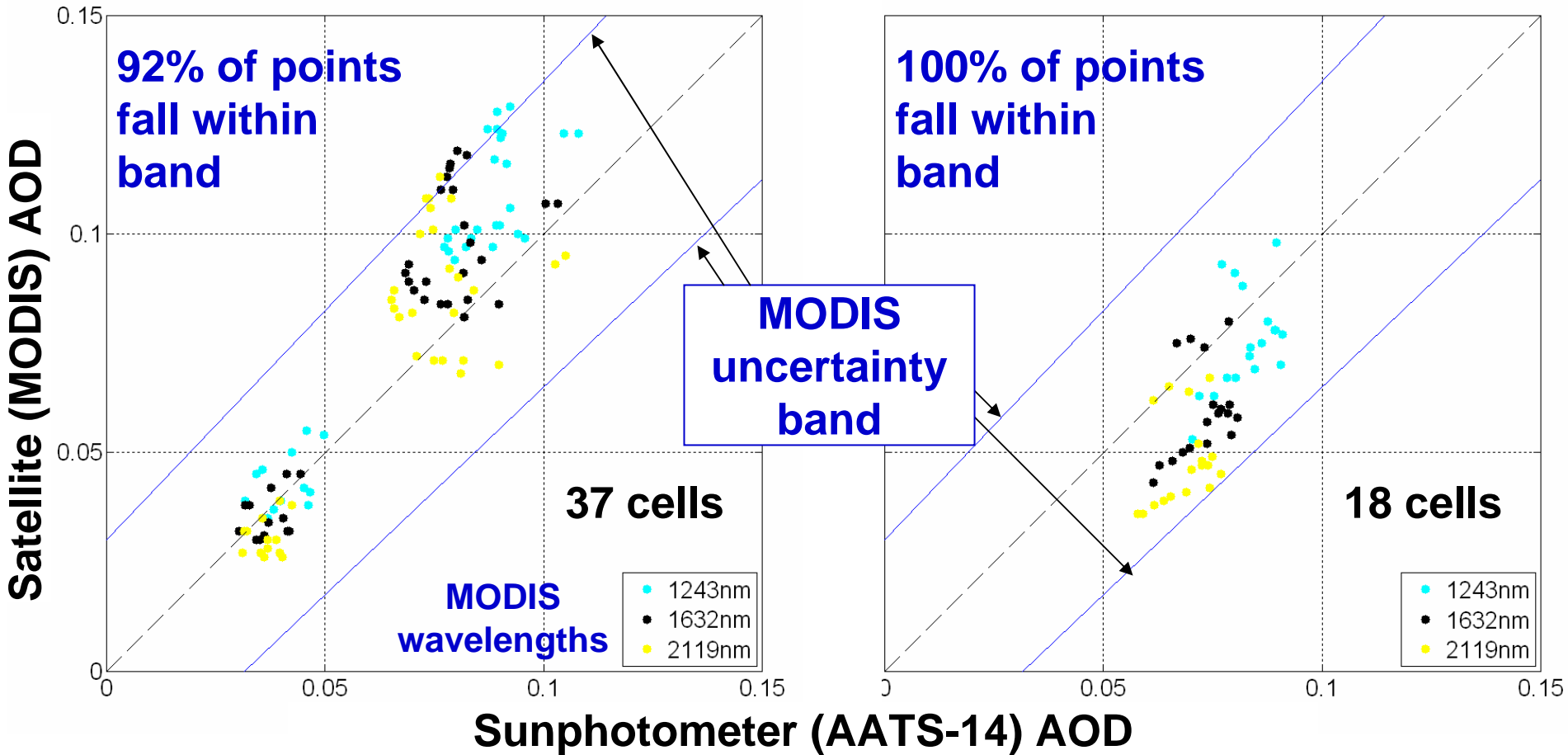
J. Hair, E. Browell et al.

AOD Comparisons, MODIS vs AATS

Gulf of Mexico, INTEX-B/MILAGRO, 2006

MODIS-Terra (March 5, 10, 12)

MODIS-Aqua (March 10, 17)



Agreement at MODIS SWIR wavelengths is better than expected, because the number of points falling within the uncertainty band exceeds 66%, which is the expected fraction if the MODIS uncertainty ($\pm 0.03 \pm 0.05$ AOD) is $\pm 1\sigma$.

