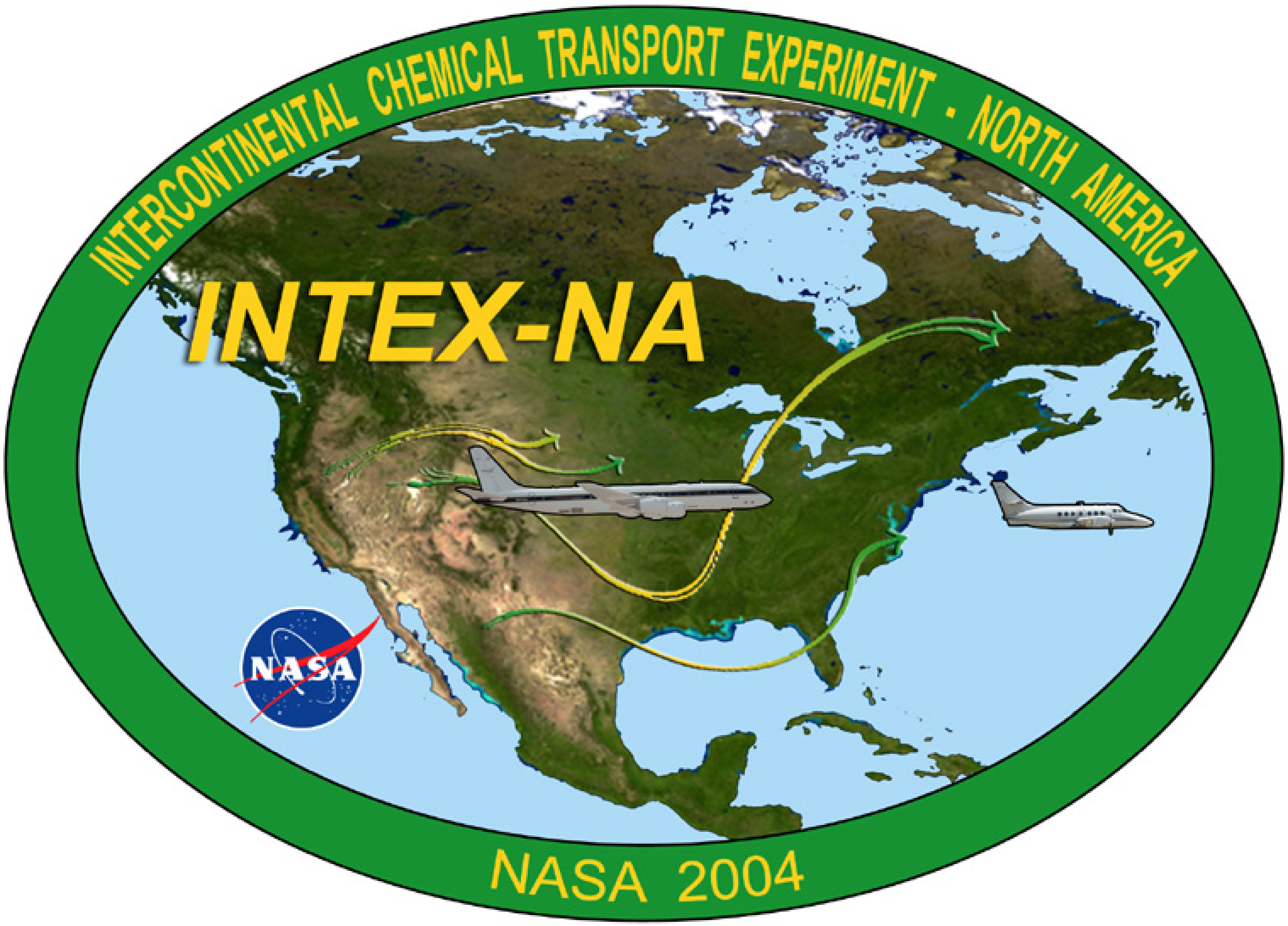
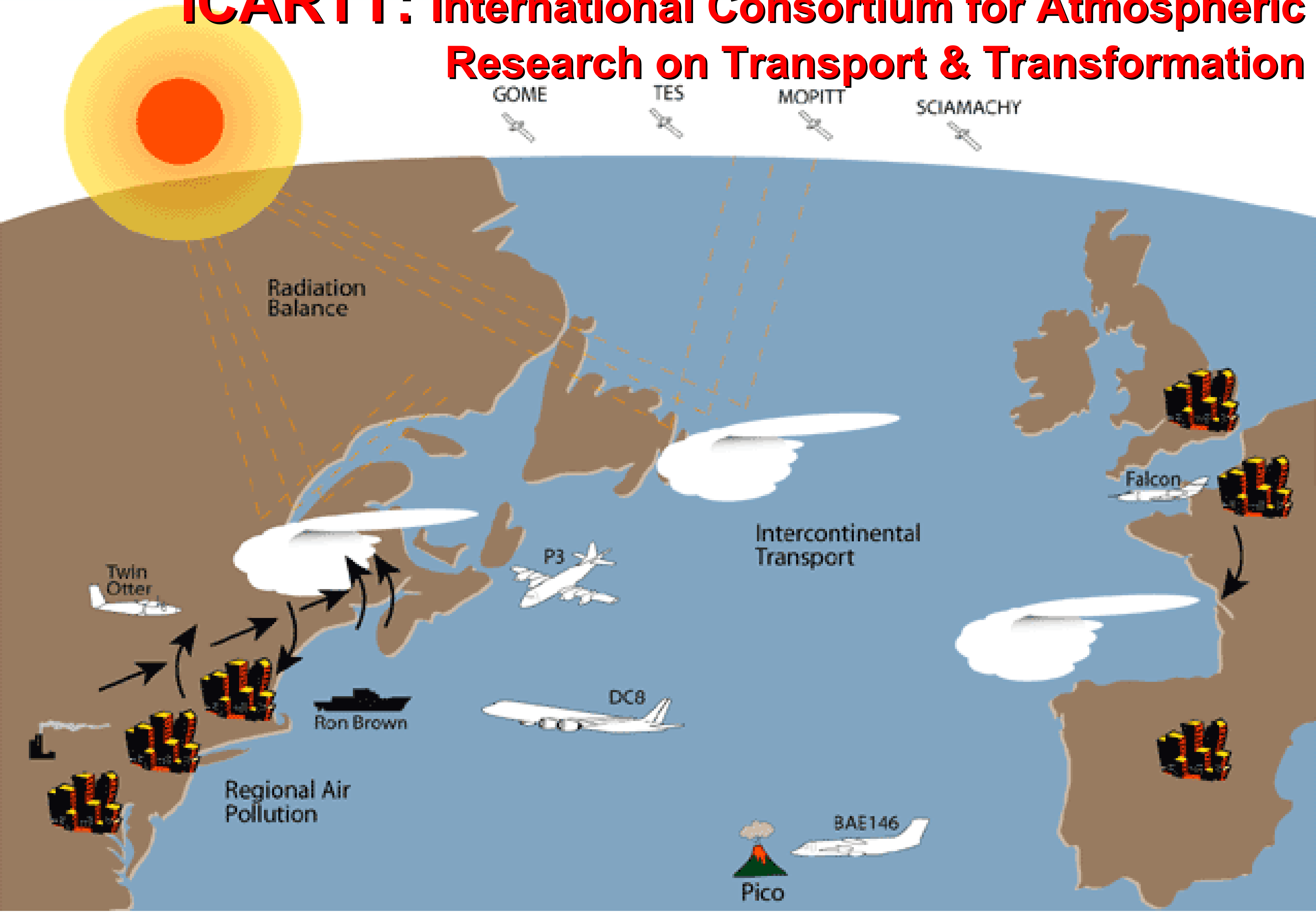
The J31 in INTEX-A / ITCT / ICARTT:
Measurements of Aerosol, Cloud, Water Vapor, and Surface Radiative Properties and Effects

Phil Russell, Peter Pilewskie, John Livingston, Jens Redemann, Beat Schmid, Warren Gore, Jim Eilers, Graham Feingold, Ralph Kahn, Allen Chu, Manfred Wendisch, Trish Quinn, Christoph Senff, Owen Cooper, Andreas Stohl, Cam McNaughton, Tony Clarke, Ed Browell, & Stephanie Ramirez

INTEX Science Team Meeting, Virginia Beach, VA, 29 March-1 April 2005


INTERCONTINENTAL CHEMICAL TRANSPORT EXPERIMENT - NORTH AMERICA
INTEX-NA
NASA
NASA 2004

ICARTT: International Consortium for Atmospheric Research on Transport & Transformation



J31 in INTEX-ITCT – Aerosol Direct & Indirect Radiative Effects

GOALS

Assess the radiative impact of the aerosols advecting from North America out over the Northwestern Atlantic Ocean.

- **–Clear-sky Impact: Aerosol Direct Effect**
- **–Impact Via Clouds: Aerosol Indirect Effect**

Quantify the relationships between those radiative impacts and aerosol amount and type.

Contribute water spectral albedo measurements to help improve satellite aerosol retrievals

INTEX-ITCT-ICARTT Provides a Very Fertile Context For Aerosol-Climate Studies

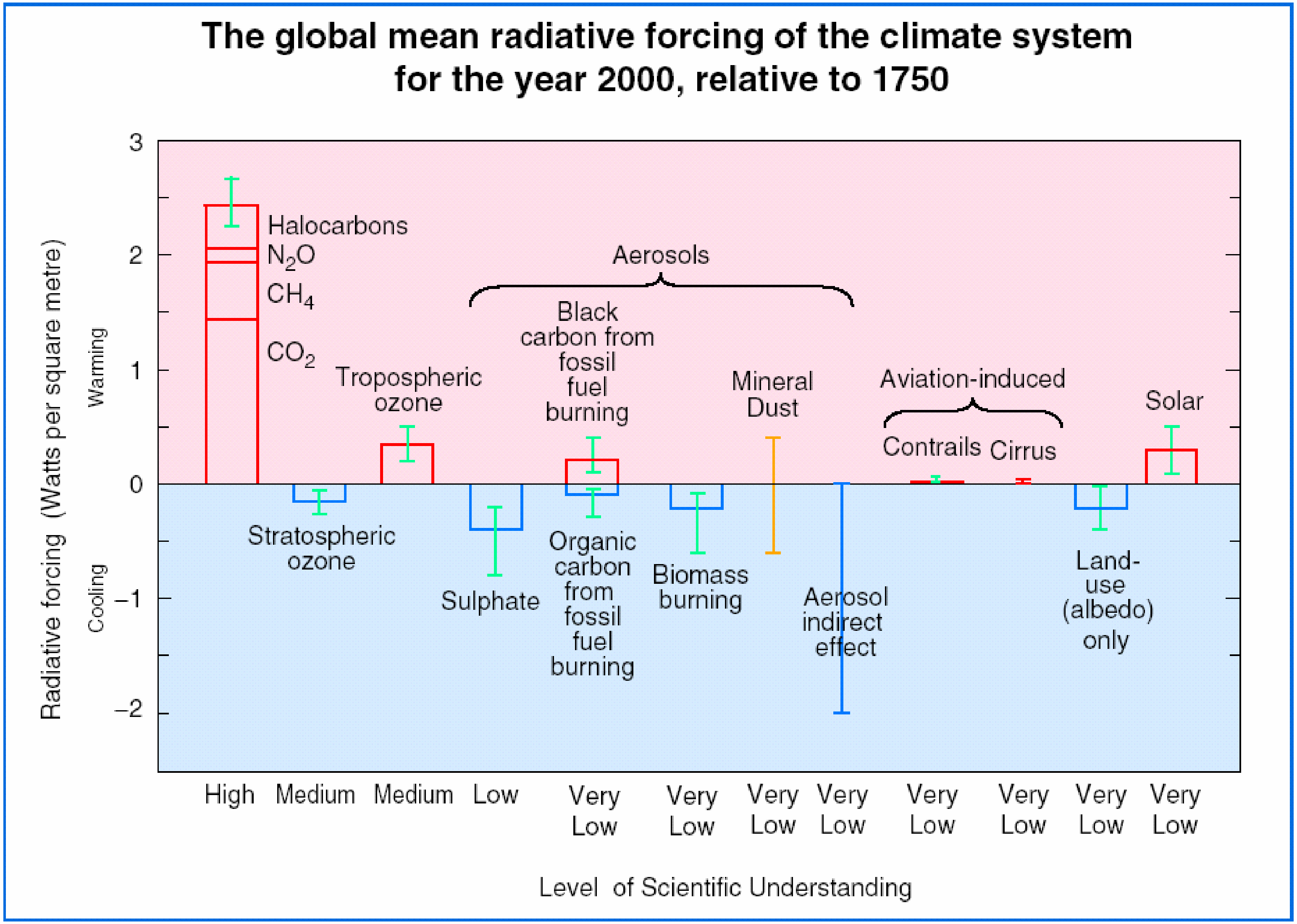
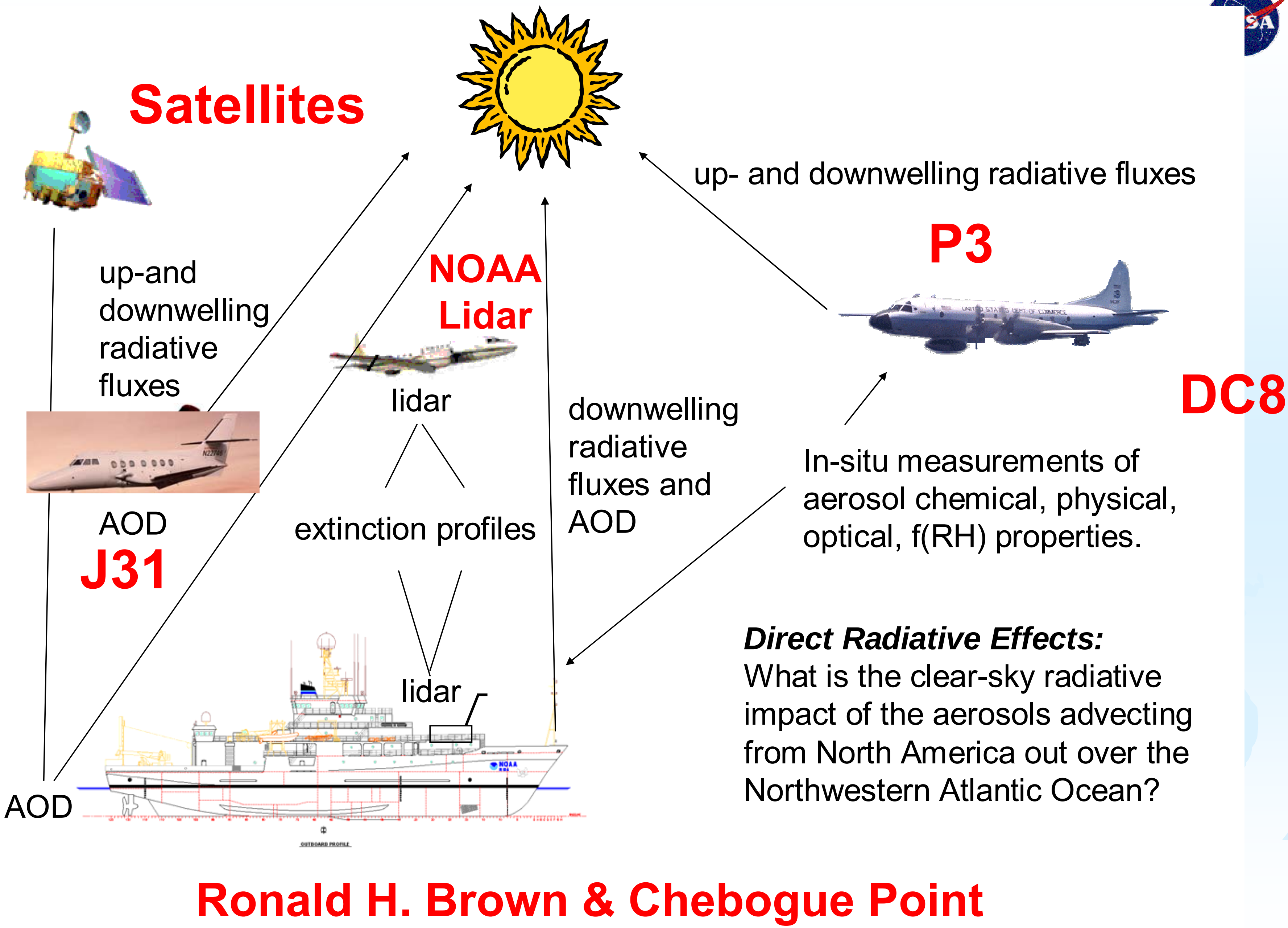


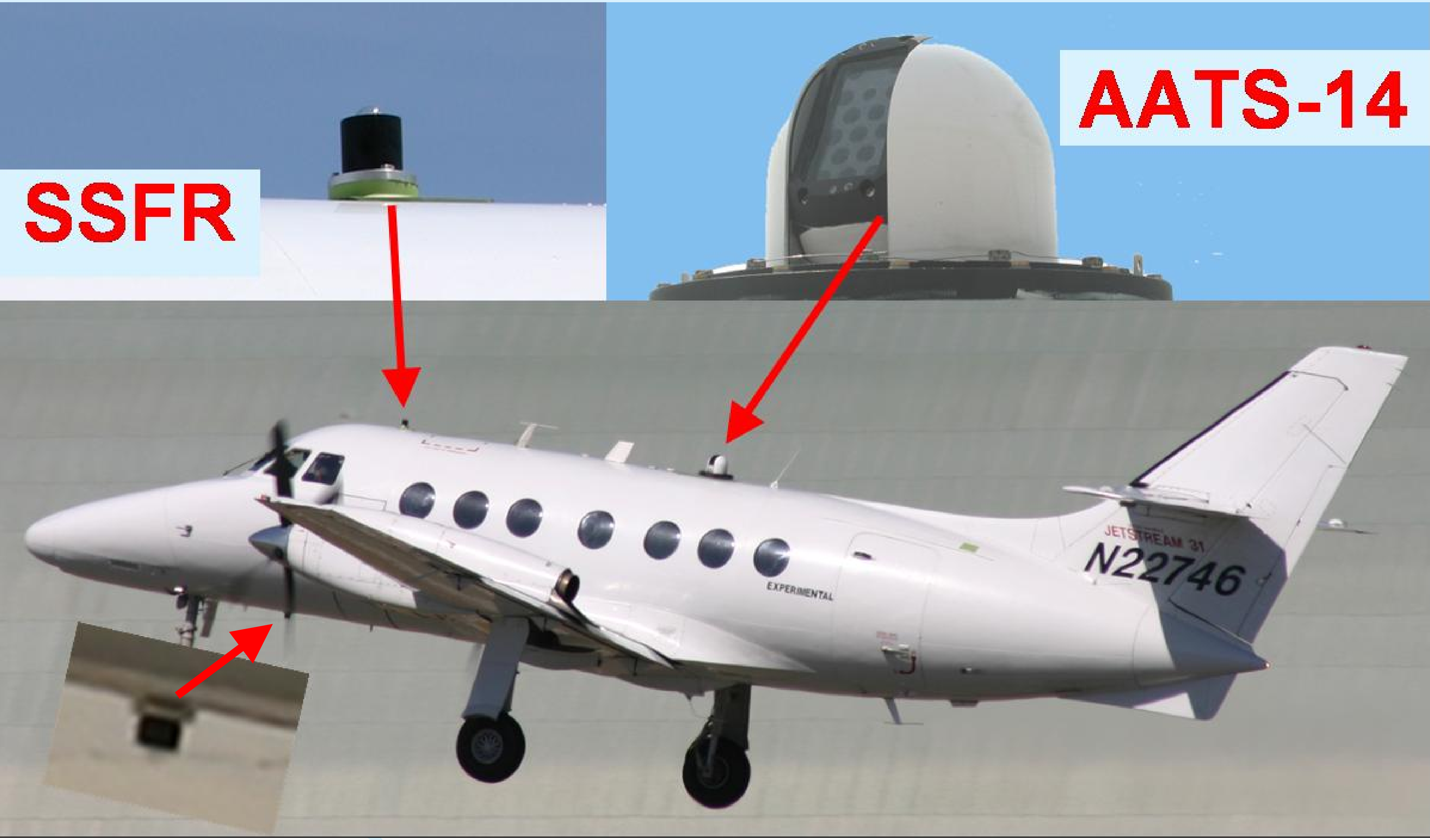
Figure 3: Many external factors force climate change.

- **Nearly All The Important Aerosol Types**

Good Mix of Cloudy & Clear Conditions —Direct & Indirect


Satellites
up- and downwelling radiative fluxes
P3
NOAA
Lidar
up-and
downwelling
radiative
fluxes
lidar
DC8
downwelling
radiative
fluxes and
AOD
In-situ measurements of
aerosol chemical, physical,
optical, f(RH) properties.
AOD
J31
extinction profiles
Direct Radiative Effects:
What is the clear-sky radiative
impact of the aerosols advecting
from North America out over the
Northwestern Atlantic Ocean?
lidar
AOD
Ronald H. Brown & Chebogue Point

Jetstream-31 (J31) in INTEX-ITCT



Jetstream-31 in INTEX-ITCT

- **14-channel Ames Airborne Tracking Sunphotometer (AATS-14)**

Measures: Solar direct-beam transmission, T, at 14 wavelengths, λ, 353-2139 nm

Data products

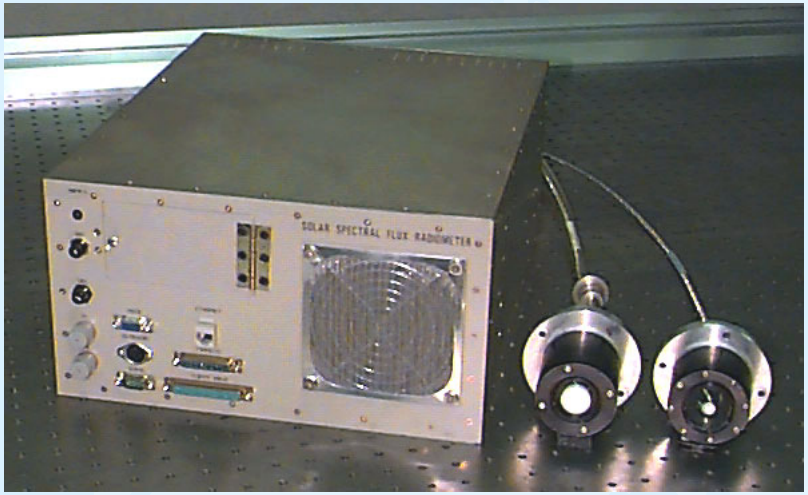
- Aerosol optical depth (AOD) at 13 λ, 353-2139 nm
- Water vapor column content [using T(940 nm)]
- Aerosol extinction, 340-2139 nm
- Water vapor density

} When A/C flies vertical profiles

P. Russell, J31, INTEX Science Team Meeting
Virginia Beach, VA, 29 March-1 April 2005

NASA Ames Solar Spectral Flux Radiometer (SSFR)

- wavelength range: 300 nm to 1700 nm
- spectral resolution ~ 8-12 nm
- simultaneous zenith and nadir viewing
- hemispheric FOV
- Accuracy: ~ 3%; precision: 0.5%
- Missions: FIRE/SHEBA, DOE ARM UAV (1999, 2000, 2002), PRIDE, SAFARI-2000, ACE-Asia, CRYSTAL-FACE, DOE Aerosol IOP



J31 Science Objectives

AATS

- Validate Satellites (AOD spectra, H_2O columns)
- Test Closure (Consistency) among Suborbital Results
- Test Chemical-Transport Models Using AOD Profiles
- Assess Regional Radiative Forcing by Combining Satellite and Suborbital Results

SSFR

- Retrieve cloud droplet radius, optical depth, and liquid water path
- Compare/validate with P-3 MIDAS, P-3 microphysics, satellite retrievals (MODIS), microwave/radar retrievals from the Ron Brown.
- Relate these cloud properties to near-cloud aerosol properties (from other investigators and platforms)
- Provide water spectral albedo measurements to help improve satellite aerosol retrievals

Joint AATS-SSFR

- Study effect of over-cloud AOD on cloud property retrievals by SSFR and satellites
- Derive Spectra of Aerosol Absorbing Fraction (1-SSA) from Spectra of Radiative Flux and AOD.
- Derive Aerosol Radiative Forcing from Simultaneously Measured Radiative Flux and AOD Gradients

The Investment in the J31
(A Catalog Aircraft)

Task	NASA					NOAA
	RSP*	TCP*	SSP*	AA SF*	EOS IDS	ACCP*
Modify J31 for AATS, SSFR, Met, Nav	■	■	■			

***Programs:** **RSP=Rad. Sci., TCP=Trop. Chem., SSP=Suborb. Sci., AASF=Ames Airborne Sens. Facil., ACCP=Atmos. Comp. & Clim.**

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(A Catalog Aircraft)

Task	NASA					NOAA
	RSP*	TCP*	SSP*	AA SF*	EOS IDS	ACCP*
Modify J31 for AATS, SSFR, Met, Nav	■	■	■			
Purchase **Met Sensors** (T, T_d, P_{stat}, P_{tot})	■					

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(A Catalog Aircraft)

Task	NASA					NOAA
	RSP*	TCP*	SSP*	AA SF*	EOS IDS	ACCP*
Modify J31 for AATS, SSFR, Met, Nav	■	■	■			
Purchase **Met Sensors** (T, T_d, P_{stat}, P_{tot})	■					
Borrow **Nav System**				■		
Develop **Met/Nav Data System**	■					




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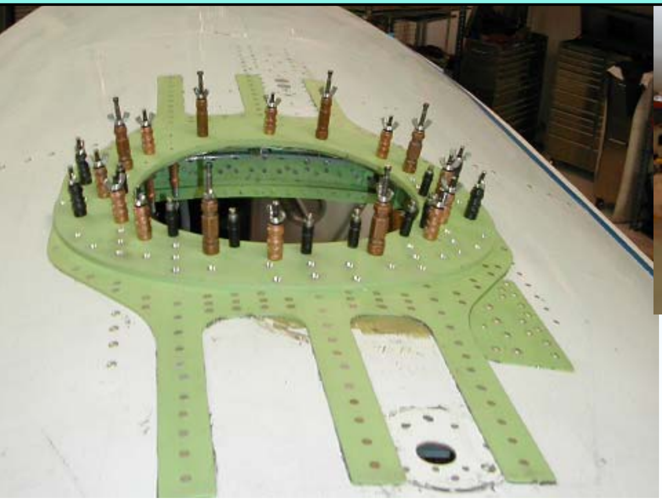
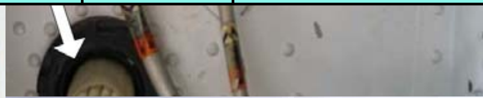
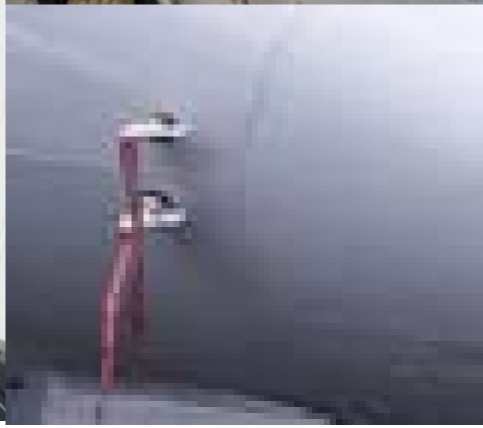
Modify J31 for AATS, SSFR, Met, Nav	■	■	■			
Purchase **Met Sensors** (T, T_d, P_{stat}, P_{tot})	■					
Borrow **Nav System**				■		
Develop **Met/Nav Data System**	■					
Install & Test all above (ground & flight)	■	■	■	■		







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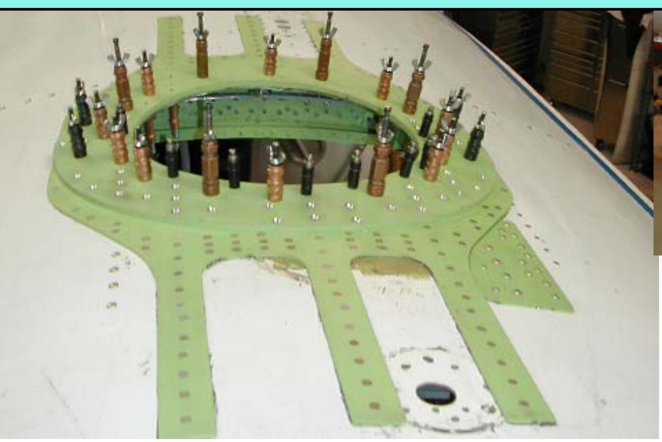
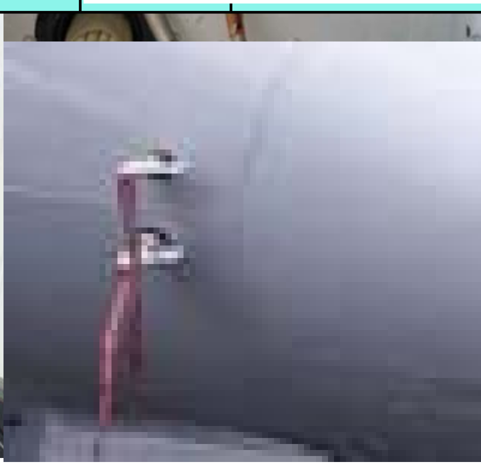
The Investment in the J31
(A Catalog Aircraft)

Task	NASA			
	RSP*	TCP*	SSP*	AA SF*
Modify J31 for AATS, SSFR, Met, Nav	■	■	■	
Purchase **Met Sensors** (T, T_d, P_{stat}, P_{tot})	■			
Borrow **Nav System**				■
Develop **Met/Nav Data System**	■			
Install & Test all above + **Radar Altimeter** (ground & flight)	■	■	■	■

} <6 months!



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(A Catalog Aircraft)

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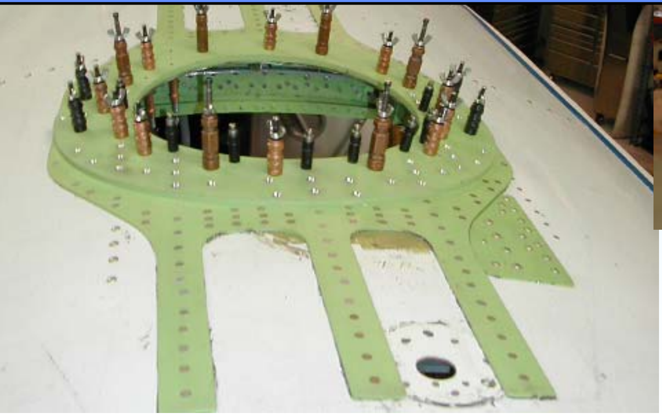
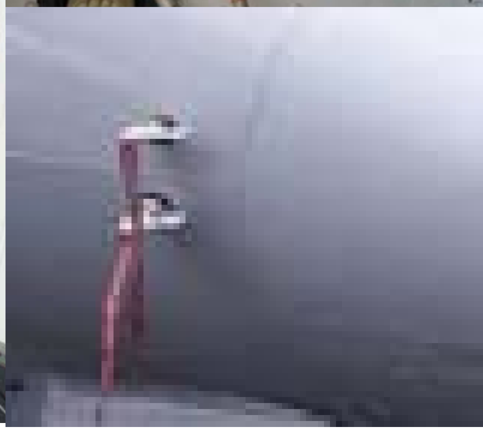
	RSP*	TCP*	SSP*	AA SF*	EOS IDS	ACCP*
Modify J31 for AATS, SSFR, Met, Nav	■	■	■			
Purchase **Met Sensors** (T, T_d, P_{stat}, P_{tot})	■					
Borrow **Nav System**				■		
Develop **Met/Nav Data System**	■					
Install & Test all above (ground & flight)	■	■	■	■		
Deployment, flight hrs, crew travel, …	■	■	■	■		



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The Investment in the J31
(A Catalog Aircraft)

Task	NASA					NOAA
	RSP*	TCP*	SSP*	AA SF*	EOS IDS	ACCP*
Modify J31 for AATS, SSFR, Met, Nav	■	■	■			
Purchase **Met Sensors** (T, T_d, P_{stat}, P_{tot})	■					
Borrow **Nav System**				■		
Develop **Met/Nav Data System**	■					
Install & Test all above (ground & flight)	■	■	■	■		
Deployment, flight hrs, crew travel, …	■	■	■	■		
Measurements						
- AATS (includes MLO calibrations)						■
- SSFR		■				■
Data Reduction & Archival						■

***Programs:** RSP=Rad. Sci., TCP=Trop. Chem., SSP=Suborb. Sci., AASF=Ames Airborne Sens. Facil., ACCP=Atmos. Comp. & Clim. EOS IDS=Earth Obs. Sys. Inter-Disciplinary Science

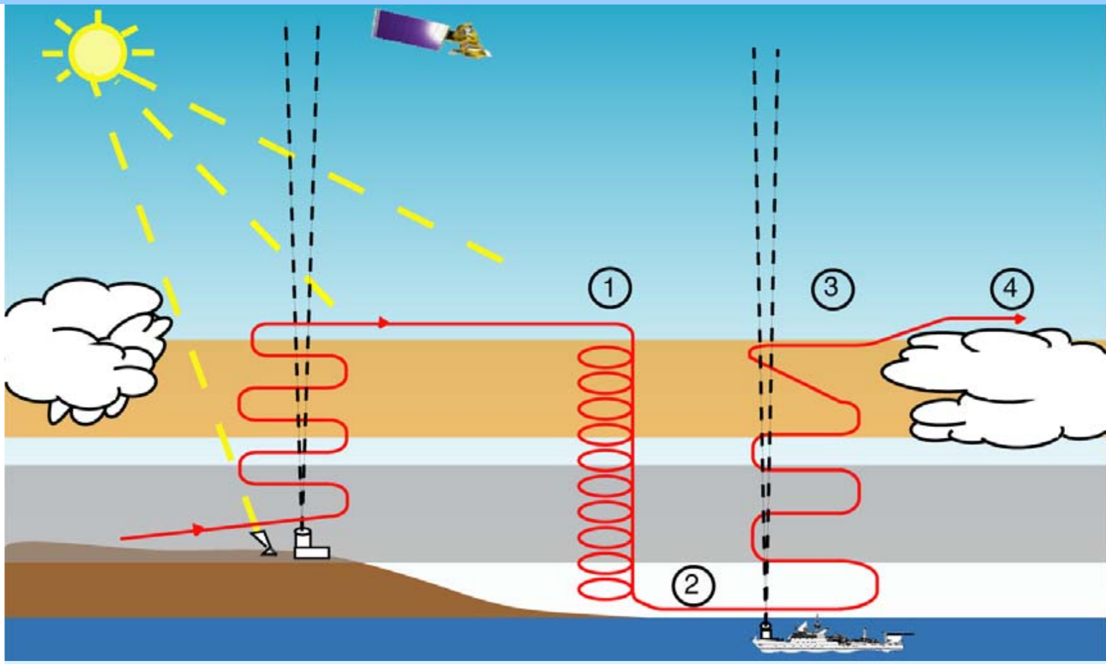
The Investment in the J31
(A Catalog Aircraft)

Task	NASA					NOAA
	RSP*	TCP*	SSP*	AA SF*	EOS IDS	ACCP*
Modify J31 for AATS, SSFR, Met, Nav	■	■	■			
Purchase **Met Sensors** (T, T_d, P_{stat}, P_{tot})	■					
Borrow **Nav System**				■		
Develop **Met/Nav Data System**	■					
Install & Test all above (ground & flight)	■	■	■	■		
Deployment, flight hrs, crew travel, …	■	■	■	■		
Measurements						
- AATS (includes MLO calibrations)						■
- SSFR		■				■
Data Reduction & Archival						■
Integrated Analyses	■				■	

***Programs:** RSP=Rad. Sci., TCP=Trop. Chem., SSP=Suborb. Sci., AASF=Ames Airborne Sens. Facil., ACCP=Atmos. Comp. & Clim. EOS IDS=Earth Obs. Sys. Inter-Disciplinary Science

J31 deployment for INTEX-ITCT/2004

- 19 Science Flights out of Portsmouth, NH, 12 Jul-8 Aug
- 58.4 Flight Hours
- Flights coordinated with satellites Terra & Aqua, Ron Brown & its sondes, DC-3, DC-8, & P-3
- J31, AATS, SSFR, Met, & Nav Systems <u>all performed very well</u>.



(1) Survey Vertical Profile.
(2) Minimum- Altitude Transect.
(3) Parking Garage.
(4) Above-Cloud Transect.

ICARTT J31 Data Workshop

NOAA Aeronomy Lab, Boulder, CO, 9, 10 March 2005

28 Individual Presentations (17 on Day 1, 11 on Day 2)

Most are posted at

ftp://science.arc.nasa.gov/pub/aats/pub/ICARTT/J31WkspPowerPointsforICARTTWebSite/

& soon moving to ICARTT site

Discussion Sessions:

Topic	Leader	Scribe
Navigation & meteorological measurements	Livingston	Pilewskie
Satellite aerosol validation, incl. water-leaving irradiance/albedo spectra	Kahn	Livingston
Aerosol direct radiative forcing	Redemann	Russell
Aerosol transport, evolution, simulation	Russell/Cooper for Stohl	
Clouds & aerosol indirect radiative forcing	Pilewskie	Feingold

ICARTT J31 Data Workshop

NOAA Aeronomy Lab, Boulder, CO, 9, 10 March 2005

Presentations & Discussions on Collaborations

- With Other Platforms (Ron Brown, DC-3, P-3, DC-8)
- With Models
    - -- Transport/evolution
    - -- Regional radiative forcing by assimilating satellite radiances

Discussions of Plans

- Analyses, meetings, publications
- Future missions: Great interest in using J31 or similar platform in INTEX-B

ICARTT J31 Data Workshop

NOAA Aeronomy Lab, Boulder, CO, 9, 10 March 2005

I'll present highlights ordered by discussion topic:

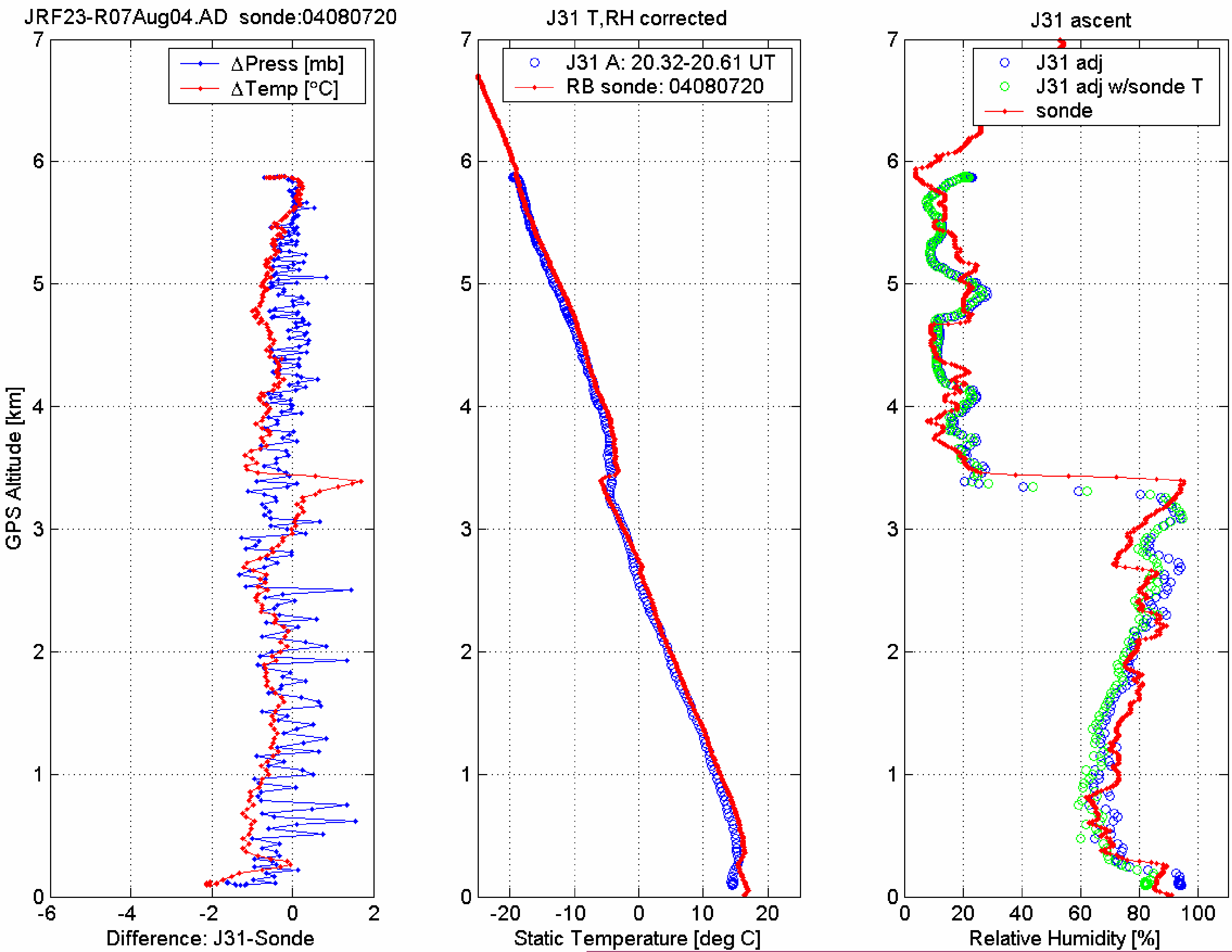
Topic	Leader	Scribe
Navigation & meteorological measurements	Livingston	Pilewskie
Satellite aerosol validation, incl. water-leaving irradiance/albedo spectra	Kahn	Livingston
Aerosol direct radiative forcing	Redemann	Russell
Aerosol transport, evolution, simulation	Russell/Cooper for Stohl	
Clouds & aerosol indirect radiative forcing	Pilewskie	Feingold

JETSTREAM-31 during ICARTT 2004

Table of AATS-14 H2O profiles and Ron Brown radiosonde measurements

Date	J31 Flight	AATS-14			Ron Brown Sonde	mean	comments
		direction	altitude [km]	UT [hr]	UT [hh:mm:ss]	separation [km]	
12-Jul	7	ascent	0.2 - 4.6	18.6 - 18.85	17:05:24	107.5	
					20:43:24	105.1	
15-Jul	8	ascent	2.3-5.6	15.8-16.02	15:32:51	4.0	
16-Jul	9	descent	6.6-0.1	18.90-19.32	19:18:35	22.2	
		ascent	0.1-3.2	19.32-19.43	19:18:35	26.0	
17-Jul	10	ascent	0.1-4.9	14.25-14.5	16:56:22	131.9	
		descent	4.9-0.3	14.5-14.725	11:00:06	47.3	
					16:56:22	91.9	
20-Jul	11	descent	5.3-0.5	15.13-15.41	17:00:00	39.6	
		ascent	0.7-4.5	15.87-16.06	17:00:00	41.3	
21-Jul	12	ascent	0.5-5.3	17.16-17.4	17:00:00	60.9	
		descent	5.6-0.2	17.65-17.93	17:00:00	102.6	
		descent	5.6-0.2	18.86-19.11	17:00:00	82.4	
22-Jul	13	descent	5.3-0.4	14.96-15.22	11:02:00	50.3	
					17:00:00	50.7	
		ascent	0.1-6.7	15.7-16.06	11:02:00	15.4	DC-8 coord
					17:00:00	3.6	
23-Jul	14	descent	5.5-0.1	17.54-17.8	11:06:51	47.1	
		ascent	0.2-2.75	18.18-18.3	11:06:51	23.6	
26-Jul	15	ascent	0-5.9	19.21-19.52	ozonesonde?		
		descent	5.6-0.3	19.64-19.82			
		ascent	0.2-6.4	20.05-20.4			
29-Jul	16	descent	6.4-0.1	14.85-15.23	15:22:46	7.2	
	16	ascent	0.2-7.3	16.4-16.85	17:33:47	62.2	
31-Jul	18	descent	6.6-0.2	17.17-17.47	17:00:19	14.9	DC-3 coord
2-Aug	19	descent	4.5-0.3	14.96-15.21	17:02:57	123.1	
		ascent	0.2-3.9	15.87-16.03	17:02:57	137.0	
		descent	4.0-0.1	16.30-16.52	17:02:57	84.2	
2-Aug	20	descent	6.6-0.1	20.94-21.25	17:02:57	103.9	
		ascent	0.1-6.7	21.59-22.00	17:02:57	22.5	DC-8 coord
3-Aug	21	ascent	0.2-7.0	21.15-21.55	21:35:37	15.9	
7-Aug	22	ascent	0.1-7.1	15.34-15.77	ozonesonde		DC-8/MISR
7-Aug	23	descent	5.9-0.2	20.12-20.32	20:13:00	39.9	
		ascent	0.2-5.9	20.32-20.61	20:13:00	42.9	
8-Aug	24	descent	3.4-0.1	17.35-17.52	17:01:22	62.7	
		ascent	0.2-3.4	17.97-18.17	17:01:22	222.6	
		descent	3.4-0.2	18.27-18.47	17:01:22	150.9	

Livingston



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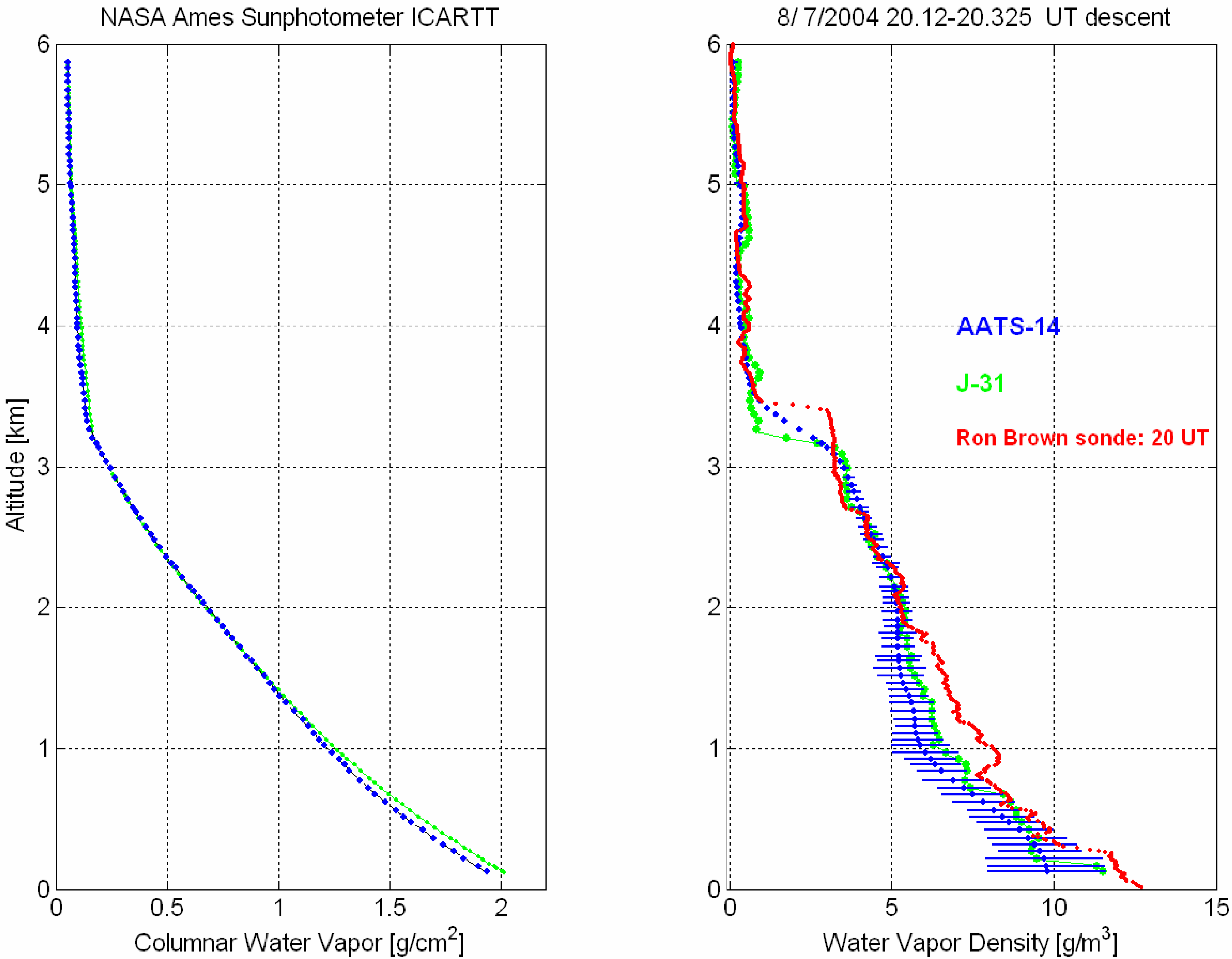
Livingston, Pilewskie, Schmid, …



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Livingston, Schmid, …

ICARTT J31 Data Workshop

NOAA Aeronomy Lab, Boulder, CO, 9, 10 March 2005

Highlights ordered by discussion topic:

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Navigation & meteorological measurements	Livingston	Pilewskie
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Aerosol transport, evolution, simulation	Russell/Cooper for Stohl	
Clouds & aerosol indirect radiative forcing	Pilewskie	Feingold

ICARTT 2004 AATS-14/MODIS Coincidences

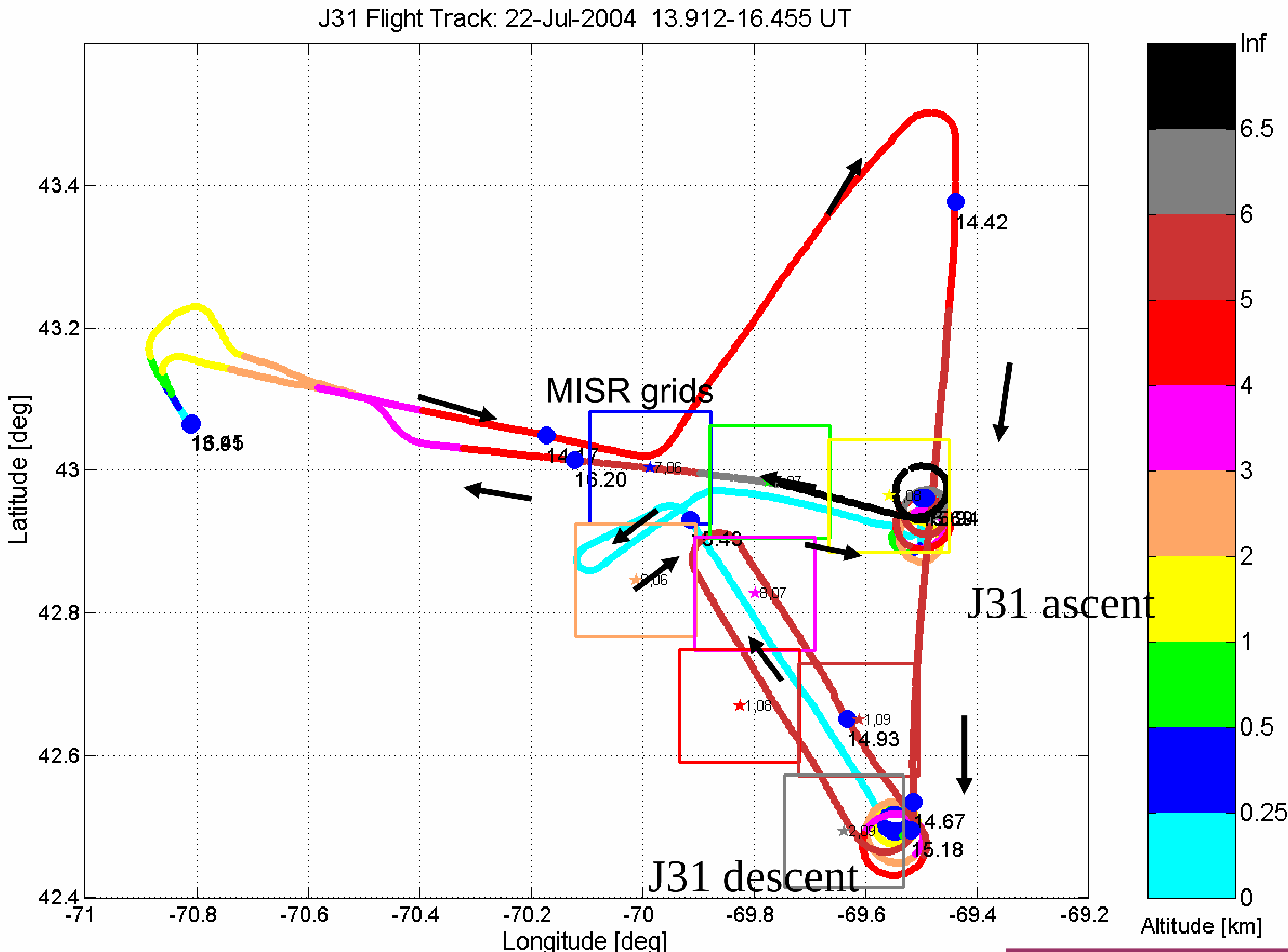
_ Eight cases w/MODIS data

_ July 12, 16, 17, 21, **22**, 23; August 2, 8

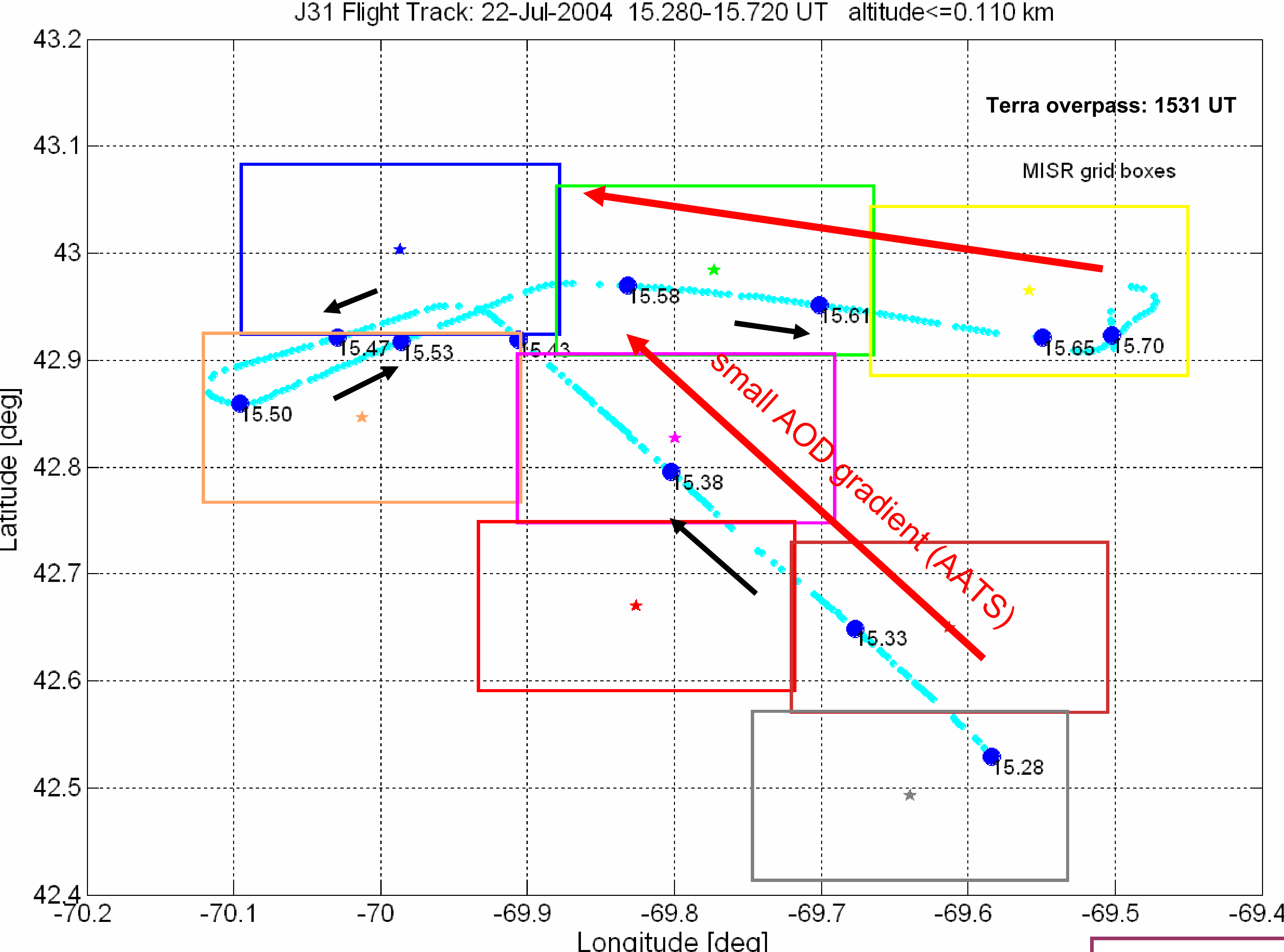
ICARTT 2004 AATS-14/MISR Coincidences

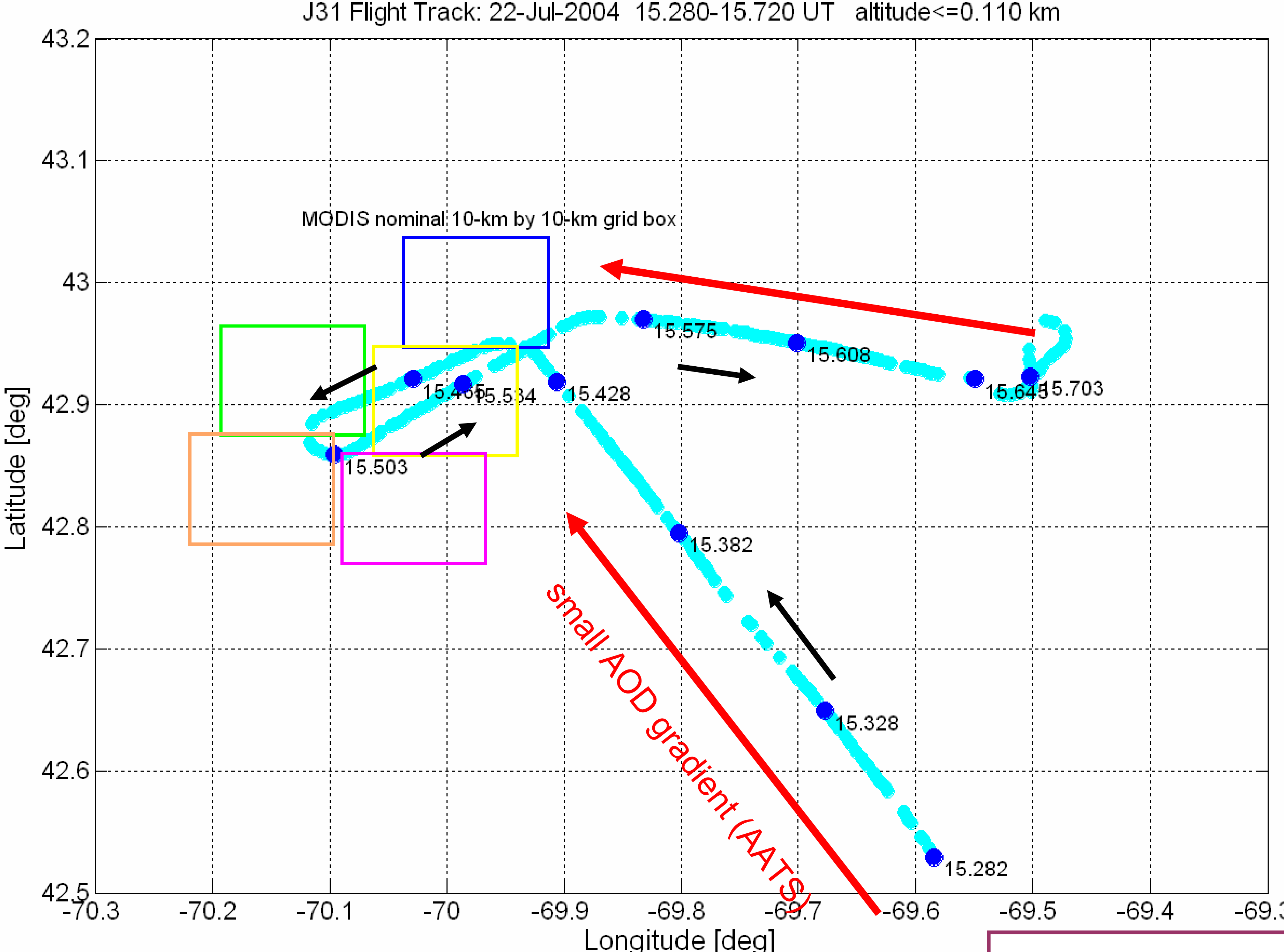
- Four events
- July 20, **22**, 29; August 7

Livingston


J31 Flight Track: 22-Jul-2004 13.912-16.455 UT
Latitude [deg]
Longitude [deg]
43.4
43.2
43
42.8
42.6
42.4
-71
-70.8
-70.6
-70.4
-70.2
-70
-69.8
-69.6
-69.4
-69.2
MISR grids
J31 ascent
J31 descent
14.42
14.17
16.20
14.93
14.67
15.18
Inf
6.5
6
5
4
3
2
1
0.5
0.25
0
Altitude [km]

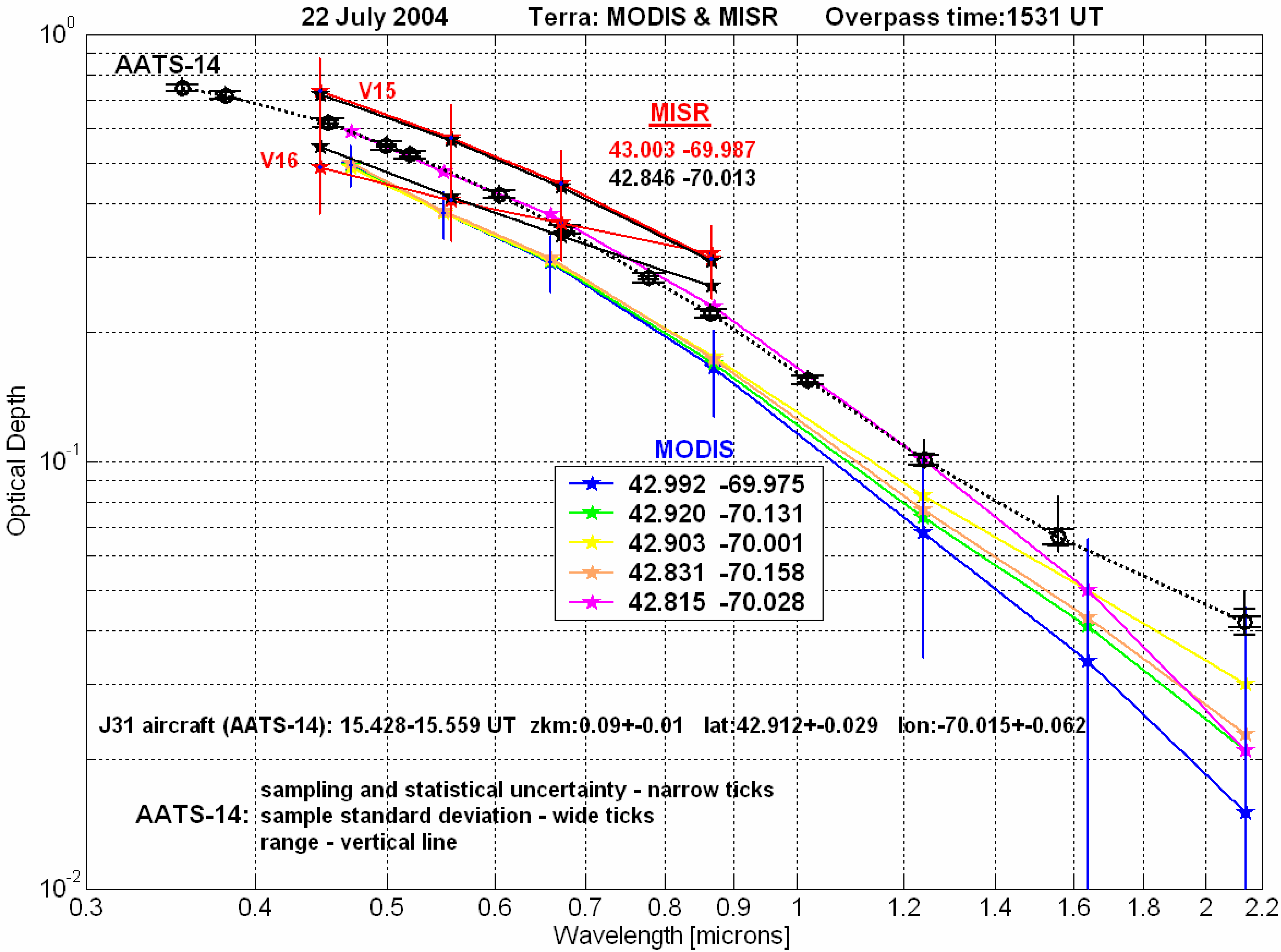
Livingston, ...


J31 Flight Track: 22-Jul-2004 15.280-15.720 UT altitude<=0.110 km
Terra overpass: 1531 UT
MISR grid boxes
small AOD gradient (AATS)
15.28
15.33
15.38
15.43
15.47
15.50
15.53
15.58
15.61
15.65
15.70
Latitude [deg]
Longitude [deg]
43.2
43.1
43
42.9
42.8
42.7
42.6
42.5
42.4
-70.2
-70.1
-70
-69.9
-69.8
-69.7
-69.6
-69.5
-69.4



J31 Flight Track: 22-Jul-2004 15.280-15.720 UT altitude<=0.110 km
MODIS nominal 10-km by 10-km grid box
small AOD gradient (AATS)
15.282
15.328
15.382
15.428
15.465
15.503
15.534
15.575
15.608
15.645
15.703
Latitude [deg]
Longitude [deg]
43.2
43.1
43
42.9
42.8
42.7
42.6
42.5
-70.3
-70.2
-70.1
-70
-69.9
-69.8
-69.7
-69.6
-69.5
-69.4
-69.3

Livingston, …



Livingston, Kahn, Chu, …

MISR *Preliminary* Regional Aerosol Arimass Analysis

July 22, 2004

[MISR Standard Aerosol Product **Version 16**]

- The only relatively cloud-free area is toward the **West Side** of swath (DC-8, J31, Ron Brown)

  -- Mid-visible column **optical depth 0.3 to 0.5**

  -- Mid-visible column **SSA 0.99 ± 0.01**

  -- Column **Angstrom Exponent 0.85 to 1.1** (medium-large particles)

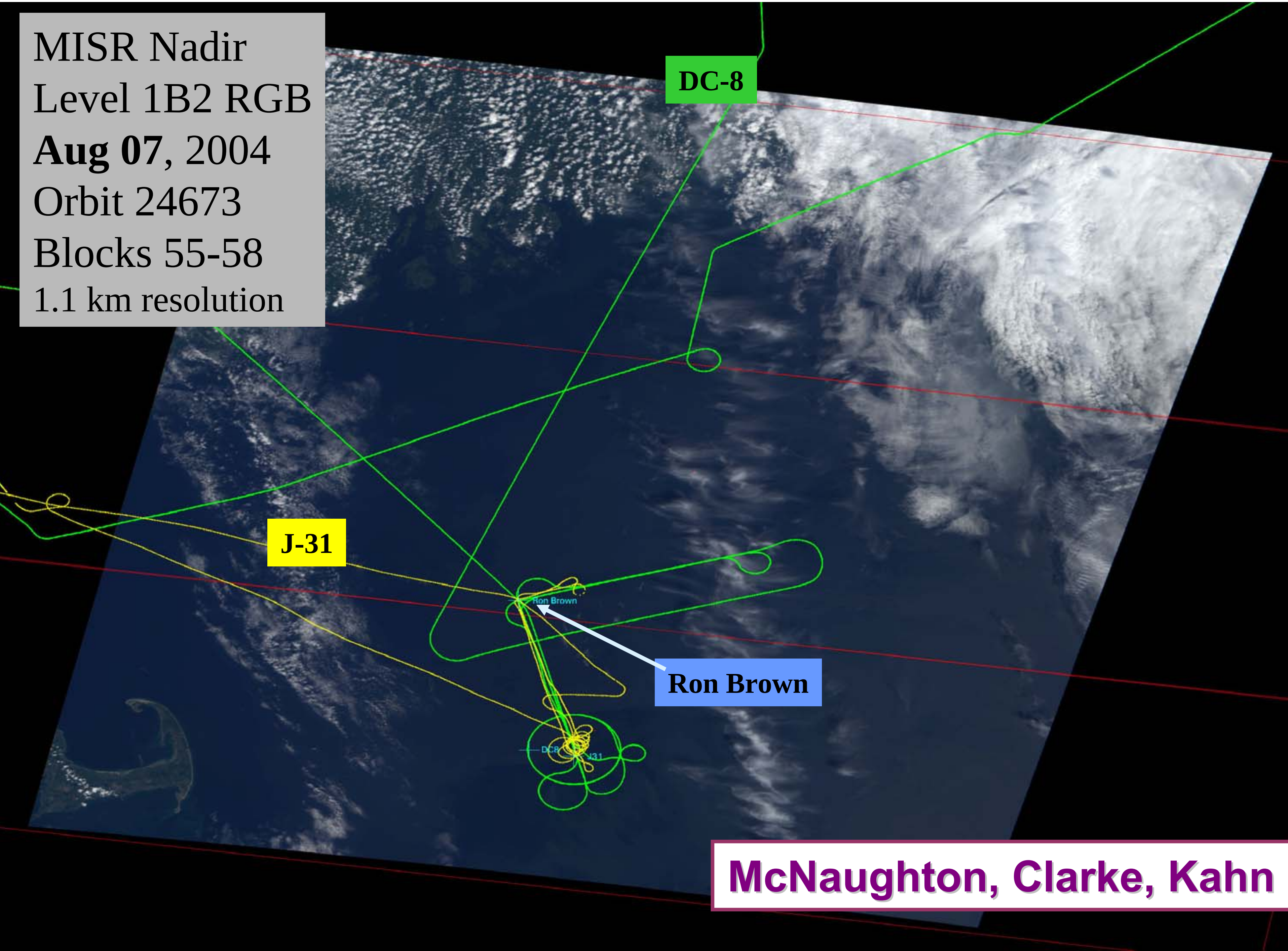
  -- Aerosol **Air Mass fairly uniform**

  -- Mixtures 51 and 54 dominate
  (**tri-modal - spherical, medium-very large, clean + dust**)

- The "dust" may be large, nonspherical, non-absorbing **cirrus**!
  [No cirrus model is included in the V16 Standard MISR Aerosol Retrieval]

- Or it could be **missing medium spherical** clean (larger than 0.26)?
  [The V16 climatology has only 0.06, 0.12, 0.26, and 2.80 spherical particles]

Kahn


MISR Nadir
Level 1B2 RGB
Aug 07, 2004
Orbit 24673
Blocks 55-58
1.1 km resolution
DC-8
J-31
Ron Brown
Ron Brown
McNaughton, Clarke, Kahn

MISR *Preliminary* Aerosol Type Validation

August 07, 2004

[MISR Standard Aerosol Product **Versions 15 and 16; J31 Coincidences**]

Block; Y, X 57; 16, 5	**MISR V15**	**MISR V16**	**AATS** (approx.)
Blue AOT	0.138	0.096	0.10
Green AOT	0.101	0.08	0.064
Red AOT	0.075	0.065	0.043
NIR AOT	0.048	0.052	0.031
Green SSA	0.911	0.99	--
Angstrom Exp.	1.62	0.91	~ 1.6
Successful Mdls.	4, **13**, 14, 15	**54**	--

- **Observations**

-- **AOT**: V16 closer to AATS (Higher SSA → lower AOT)
-- **Angstrom Exp**: V15 closer to AATS (smaller particles → steeper slope)
-- V15 Mixtures: **85% sph_0.12, 15% BC**, the others have some sph_0.26
-- V16 Mixture: **54% sph_0.12, 06% sph_2.8, + 40% med. dust**
-- V15, V16 results similar for nearby pixels

- **Conjectures**

Kahn

-- **Tiny black carbon** (BC) is a poor way to model aerosol absorption here (V15)
-- V16 picks up something **> 0.26 or non-spherical** as dust – Cirrus or med. sph?
-- V16 might add **0.57 or 1.28 spherical** particles to the climatology(?)

Next MISR Validation Steps

- Particle **Sizes** (and **Shapes**) during coincidences –
  - -- Cirrus or medium-spherical particles on July 22, 29, and Aug 07?
    - → DC-8 + further AATS analysis
- Particle **SSA** and **surface albedo** contributions –
  - -- Is retrieved particle SSA correct, or is the surface brighter & SSA lower?
    - → DC-8 + SSFR

Next MISR Regional Analysis Steps

- Complete Particle Property **Validation** for Near-coincidences
- Compare refined **MISR regional retrieval with Aircraft**-observed airmass patterns
- **MISR 2-D Variability** analysis

Kahn

ICARTT J31 Data Workshop

NOAA Aeronomy Lab, Boulder, CO, 9, 10 March 2005

Highlights ordered by discussion topic:

Topic	Leader	Scribe
Navigation & meteorological measurements	Livingston	Pilewskie
Satellite aerosol validation, incl. **water-leaving irradiance/albedo spectra**	Kahn	Livingston
Aerosol direct radiative forcing	Redemann	Russell
Aerosol transport, evolution, simulation	Russell/Cooper for Stohl	
Clouds & aerosol indirect radiative forcing	Pilewskie	Feingold

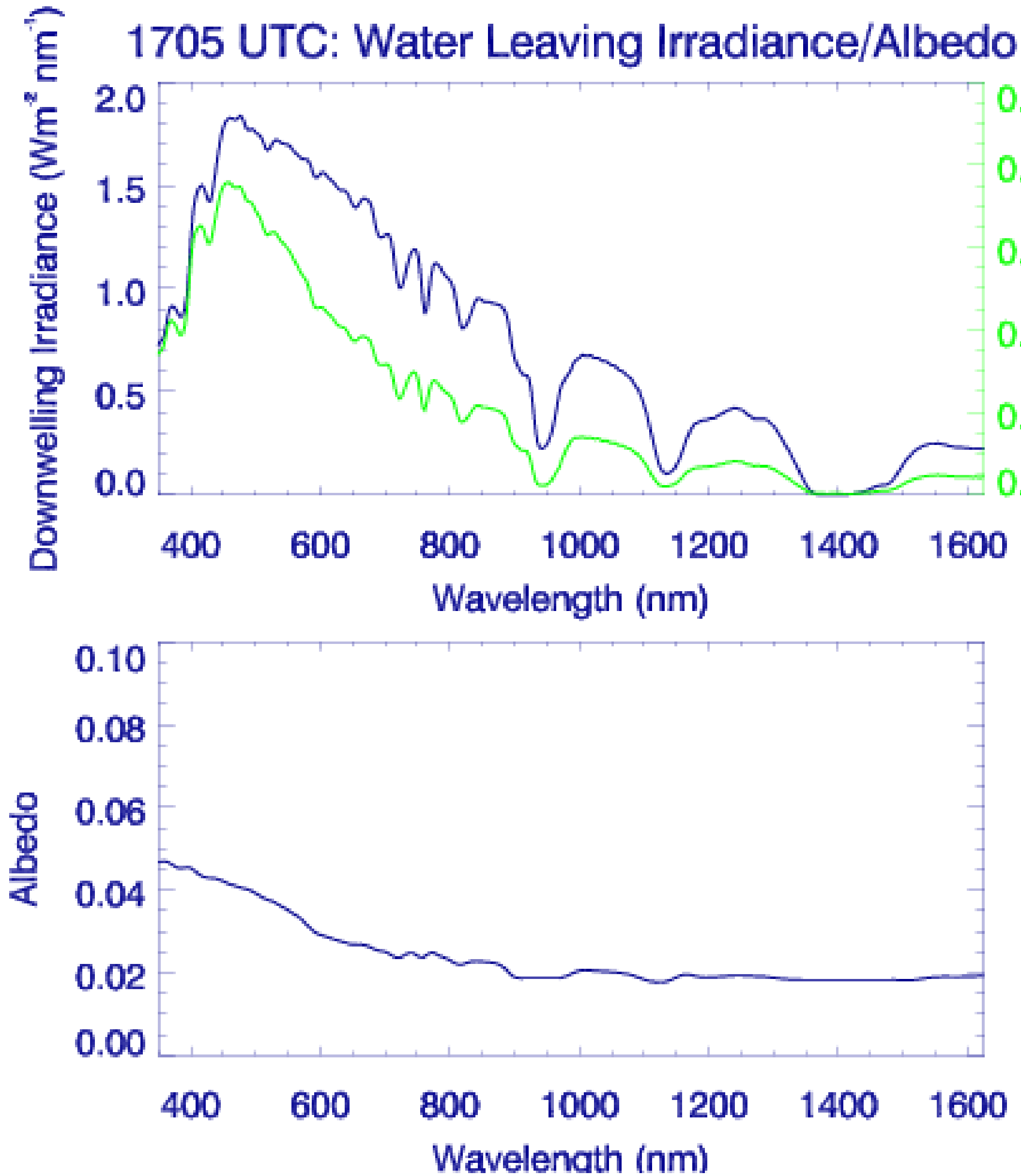
Water-leaving radiance: MISR Validation

- Unless the surface contribution is known: significant uncertainties retrieved aerosol properties
- New algorithm to simultaneously retrieve surface reflectance and aerosol properties self-consistently - validation needed
- Water-leaving radiance is largest uncertainty for small τ_a

Kahn, et al., MISR global aerosol optical depth validation based on two years of coincident AERONET observations, *J. Geophys. Res.*, in press. , 2004.

Pilewskie, Kahn

Water-leaving Irradiance



SSFR albedo spectra show Gulf of Maine water to be very "black", i.e., relatively low levels of chlorophyll-A.

Pilewskie

ICARTT J31 Data Workshop

Room 2A201, NOAA Aeronomy Lab, Boulder, CO

9, 10 March 2005

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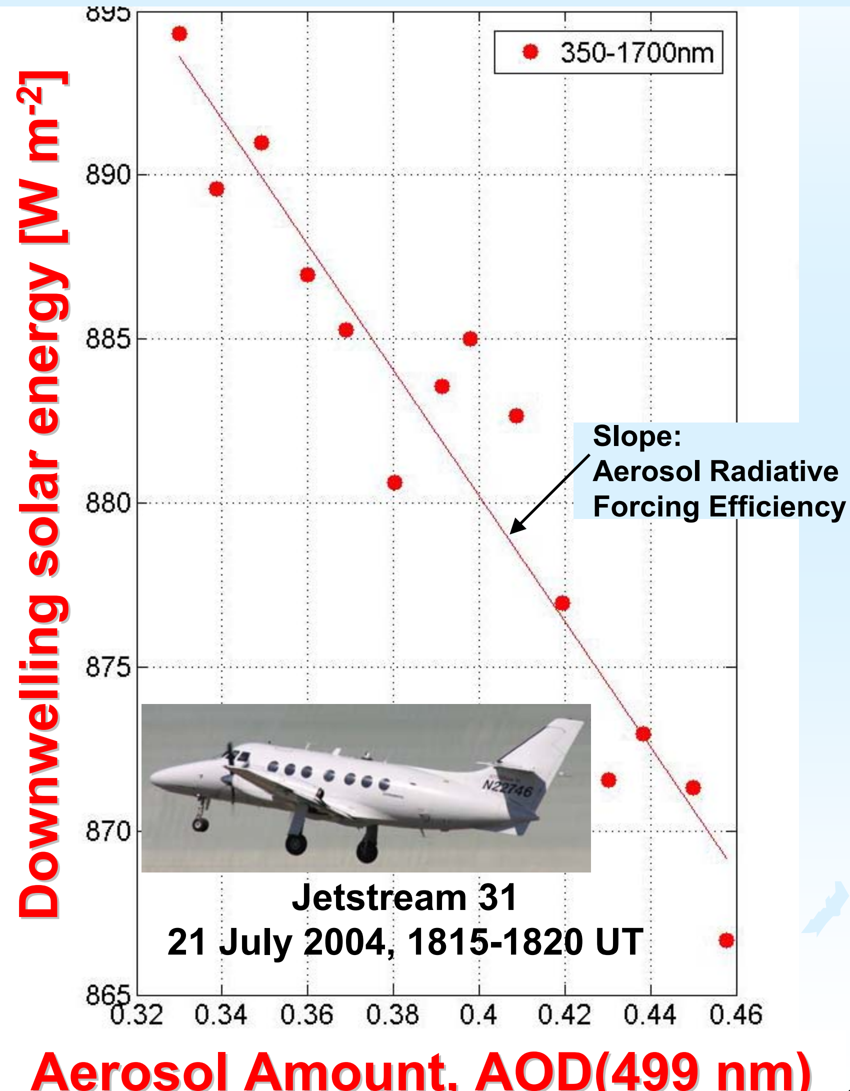
Clouds & aerosol indirect radiative forcing	Pilewskie	Feingold

Climate Change Science in INTEX

Aircraft & Satellite Measurements of Aerosol Effects on the Solar Energy that Drives Climate



Redemann, Pilewskie, ...

ICARTT J31 Data Workshop

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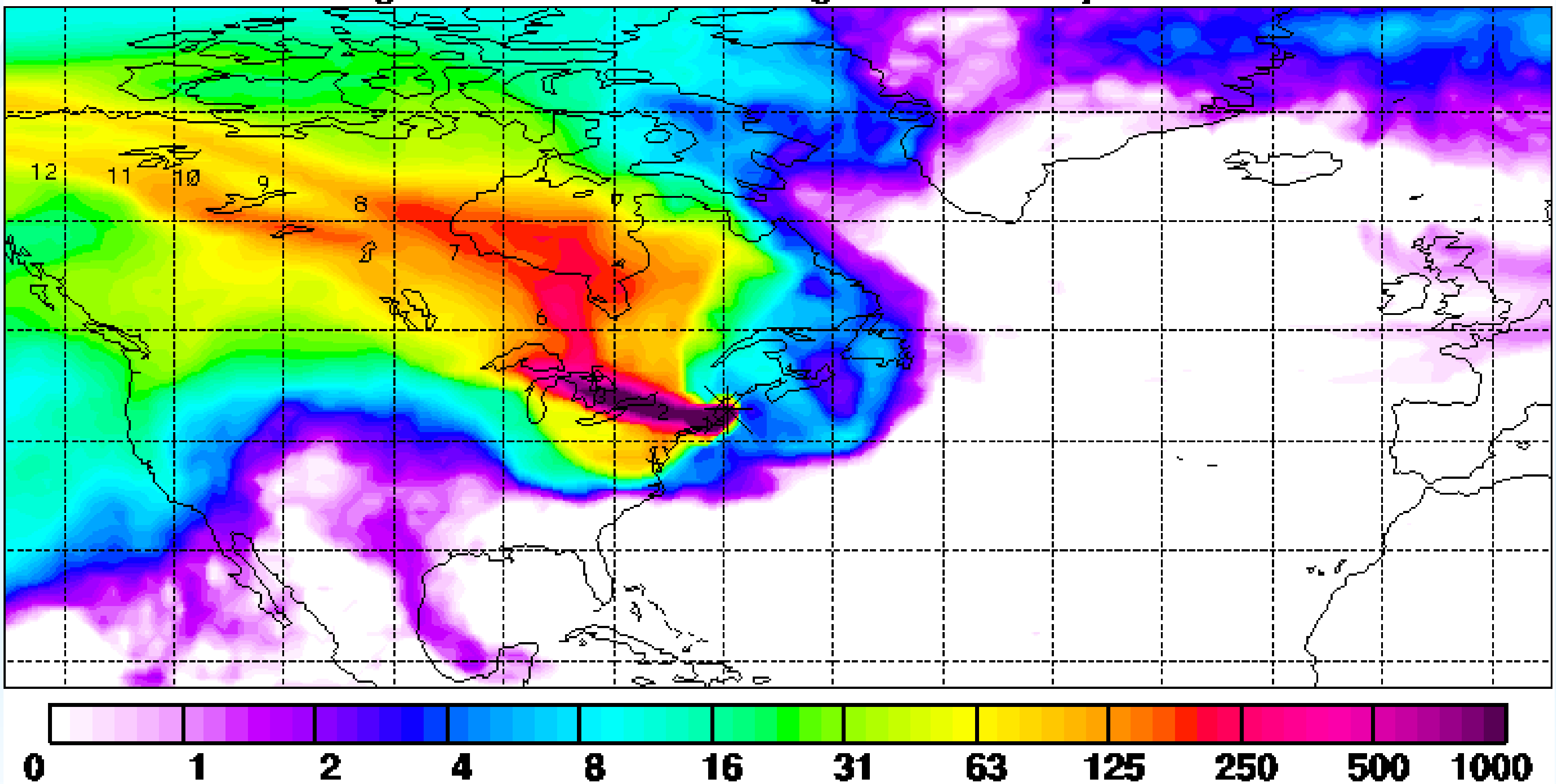
Clouds & aerosol indirect radiative forcing	Pilewskie	Feingold

Column-integrated S-R-Relationship for flight J31_22July_z16

Start time of sampling 20040722.154200 End time of sampling 20040722.160000

Lower release height 750 m Upper release height 1000 m

Meteorological data used is 1x1 deg ECMWF analyses

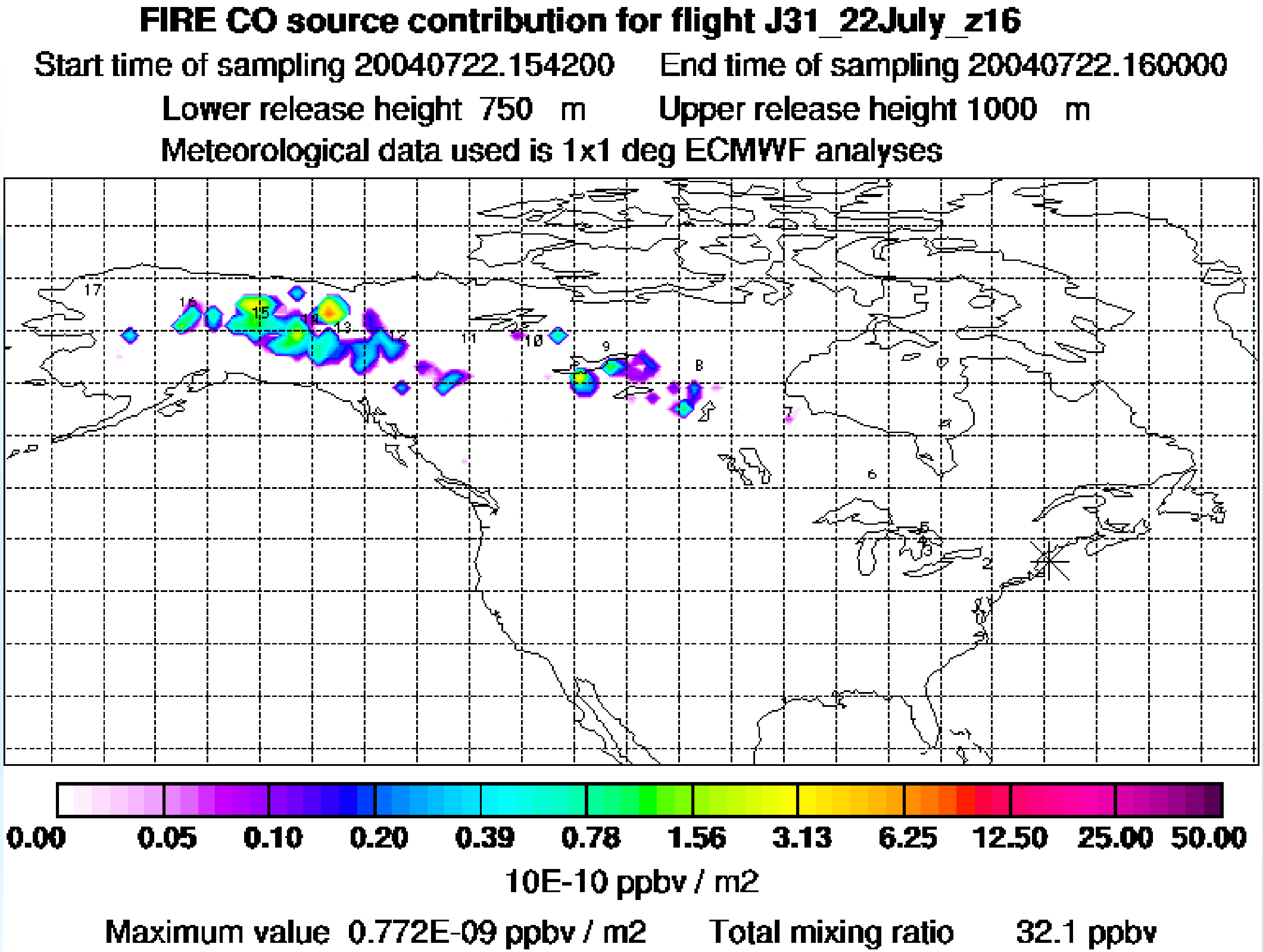


ns m / kg

Maximum value 0.277E+04 ns m / kg

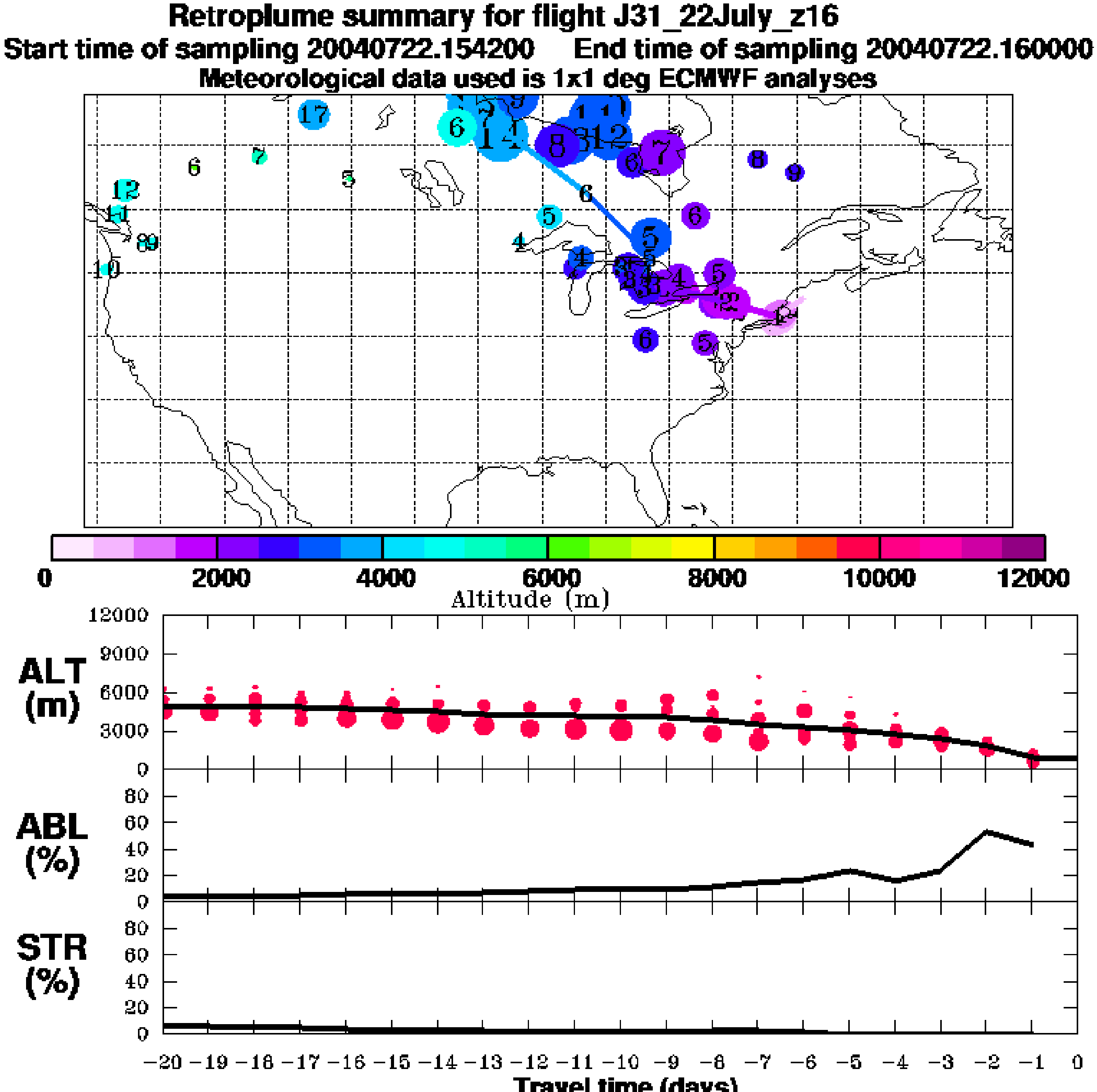
Stohl, Cooper

1x1 degree output resolution

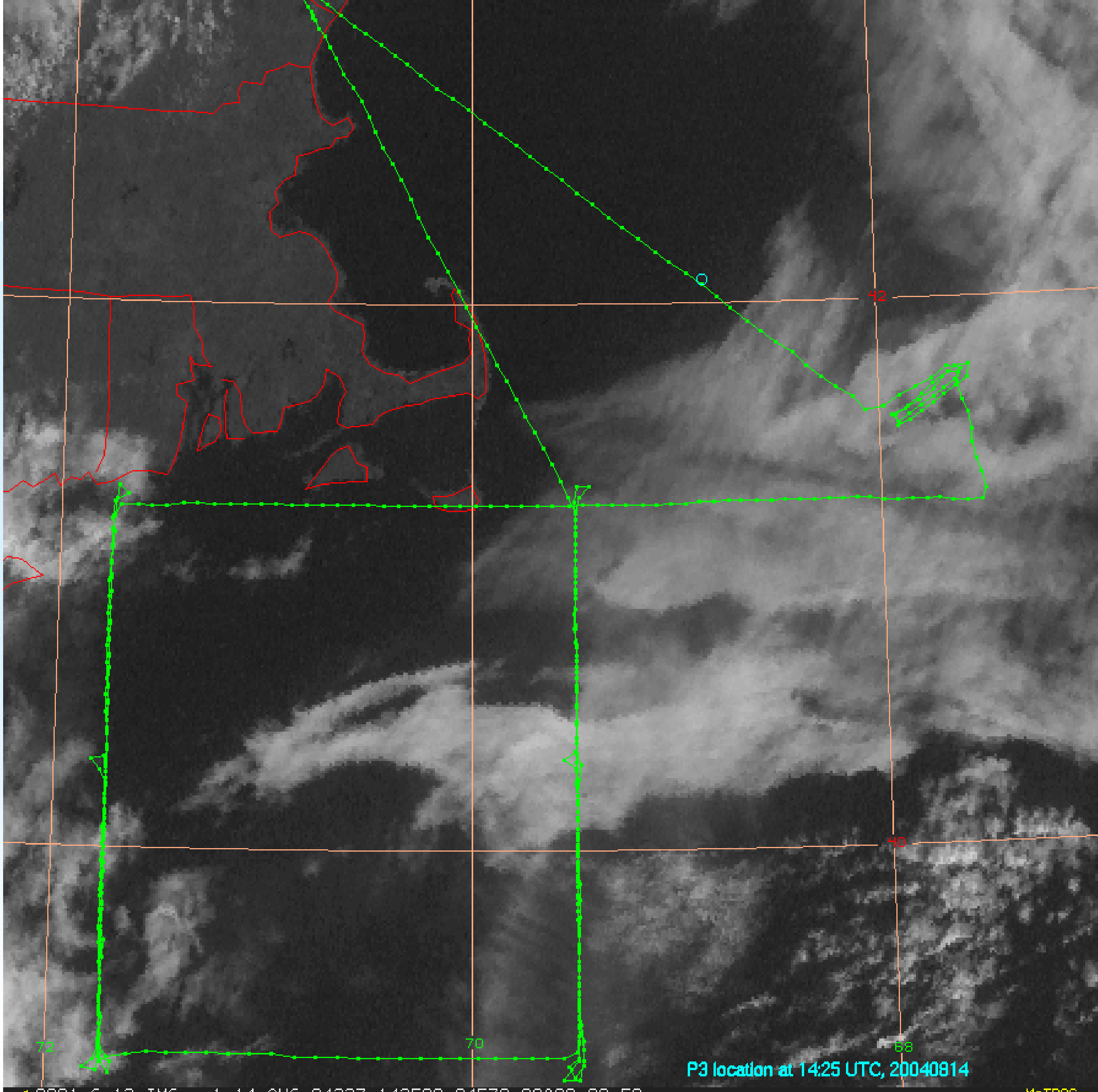


Stohl, Cooper

1x1 degree output resolution



Stohl, Cooper

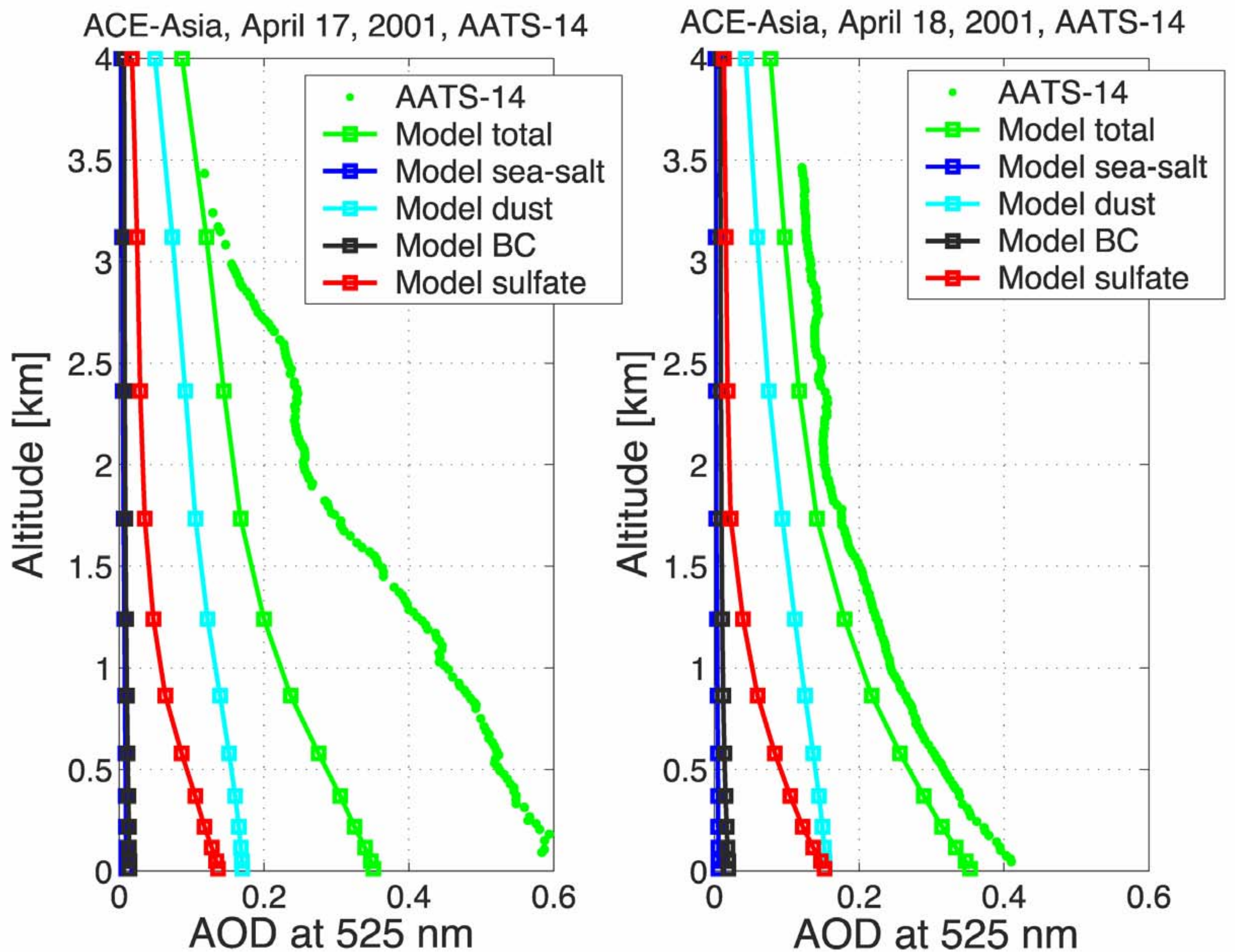

42
40
72
70
68
P3 location at 14:25 UTC, 20040814
1 0001 G-12 IMG 1 14 AUG 04227 142500 04579 09809 00.50
McIDAS

Cooper

Science Plans: Integrated Analyses

- **Satellite Validation**
- **Testing Closure (Consistency) among Suborbital Results**
- **Testing Chemical-Transport Models using AOD profiles**
- **Deriving Aerosol Absorbing Fraction (1-SSA) from Radiative Flux and AOD Spectra**
- **Assessing Regional Radiative Forcing by Combining Satellite and Suborbital Results**

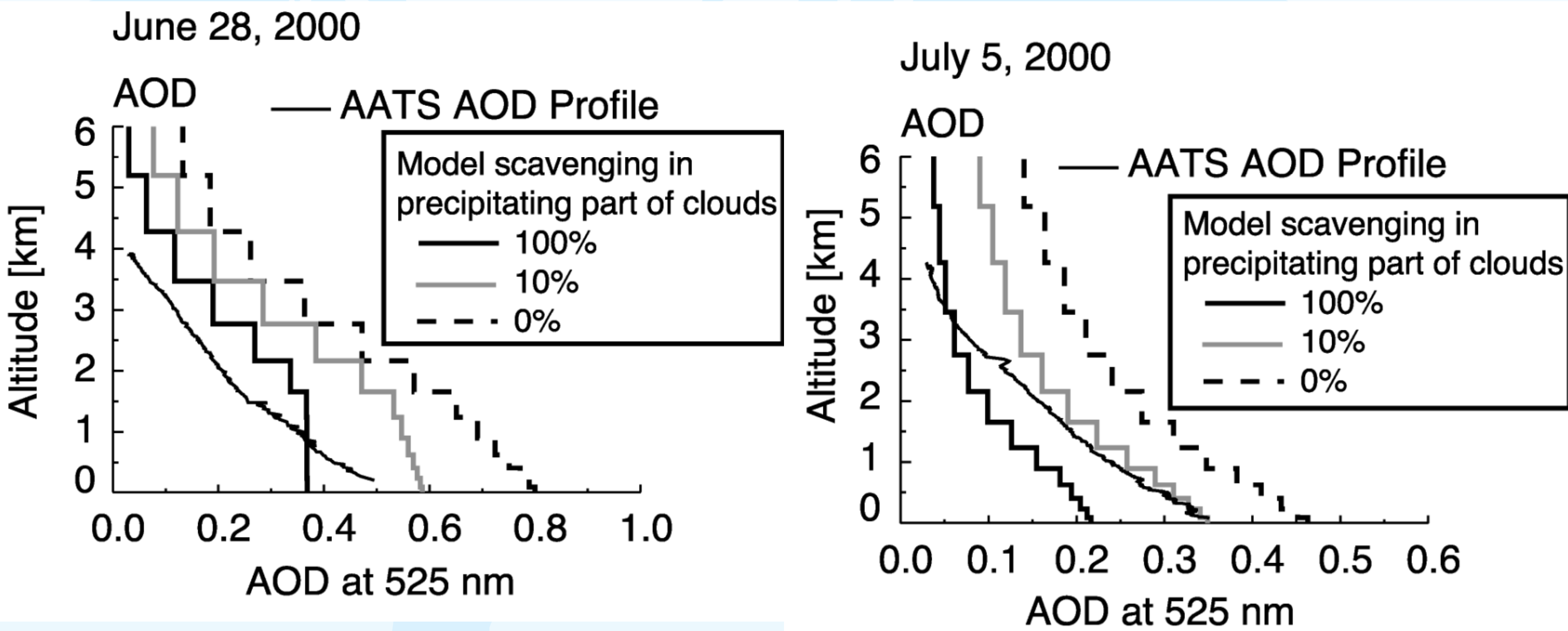
Comparisons of AOD vertical distributions: AATS-14 measurements vs GOCART model



[Redemann, Chin et al.]

Comparisons of AOD vertical distributions: AATS-6 measurements vs CARMA/MATCH model.

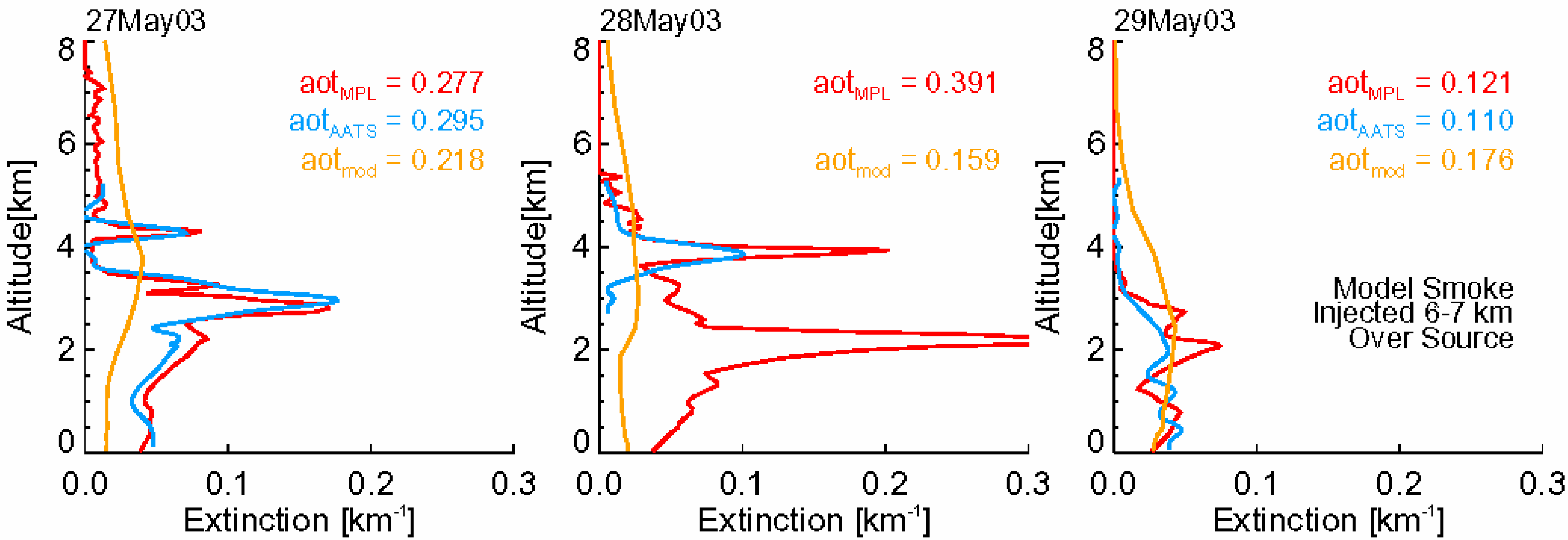
African dust transported to Puerto Rico



Model AOD profiles are labeled by the assumed wet scavenging in the precipitating part of clouds

[Colarco et al., JGR 2003]

Comparisons of AOD vertical distributions: AATS-14 & lidar measurements vs CARMA/MATCH model



Model is of smoke from Siberian fires transported to DOE Southern Great Plains site

[Colarco et al., JGR 2005, submitted]

ICARTT J31 Data Workshop

NOAA Aeronomy Lab, Boulder, CO, 9, 10 March 2005

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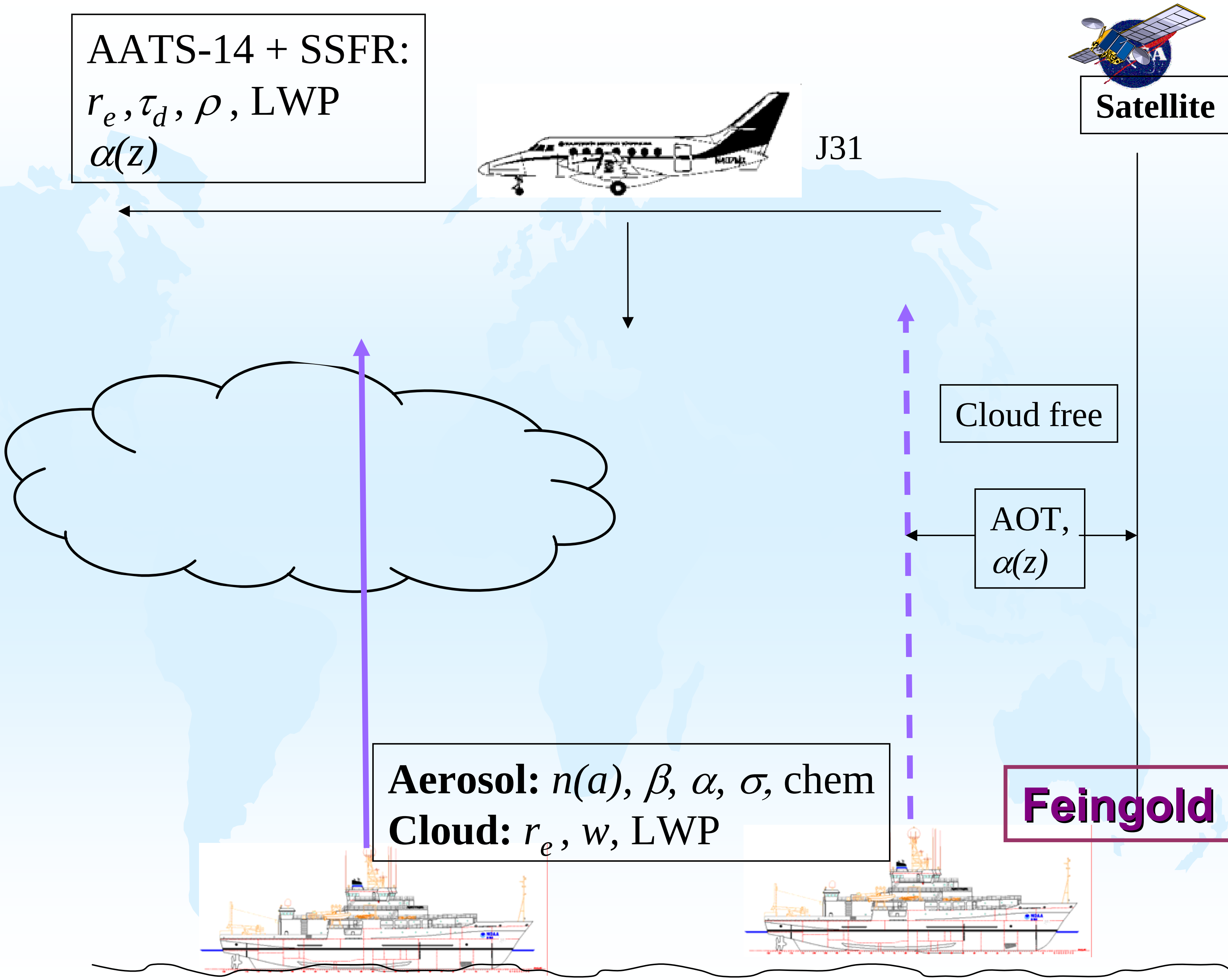
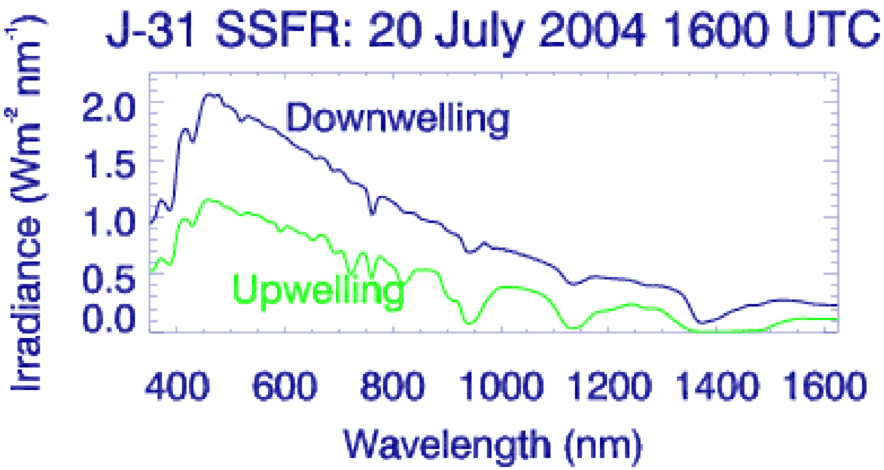
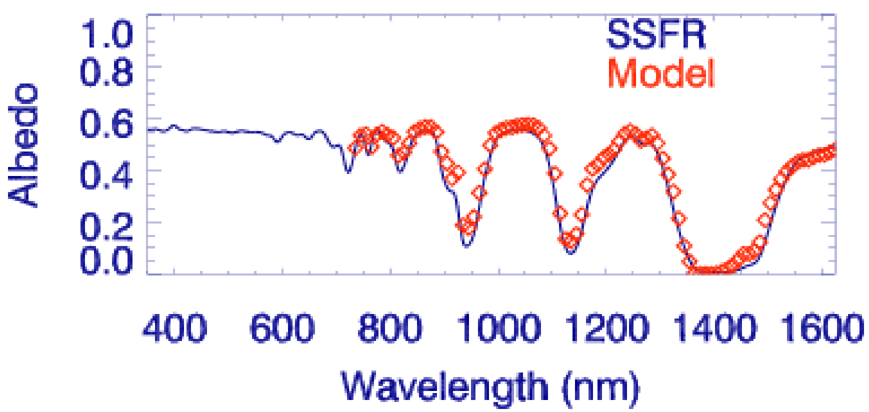
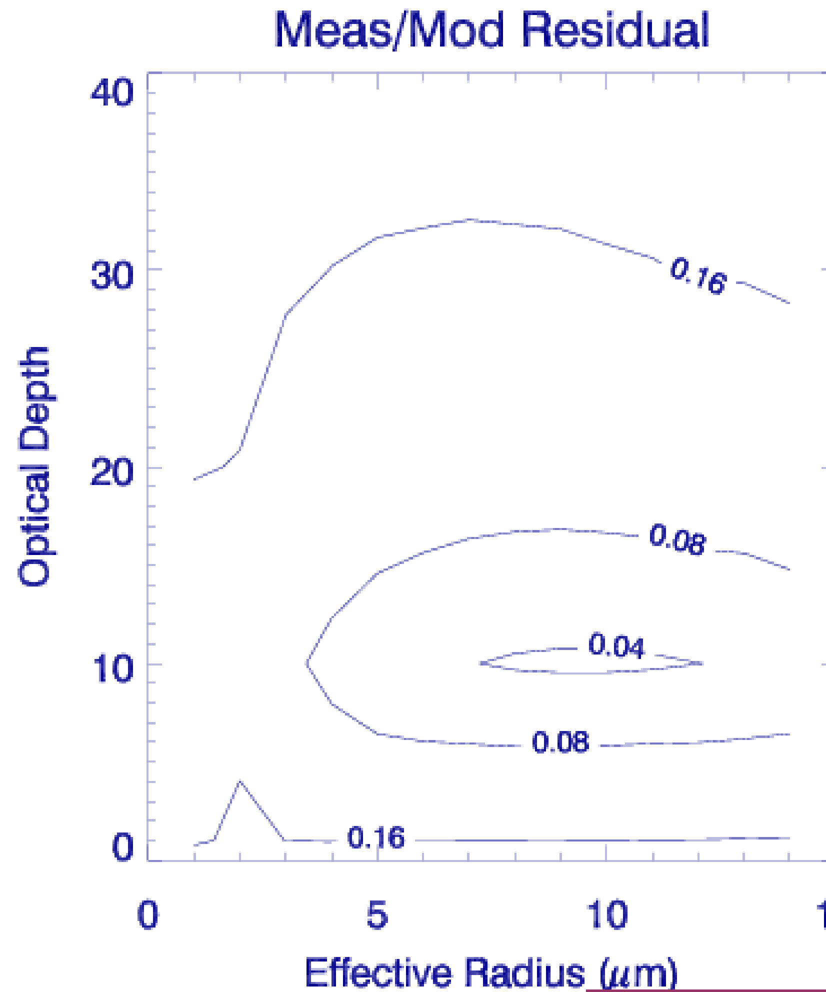

AATS-14 + SSFR:
r_e, τ_d, ρ, LWP
$\alpha(z)$
J31
Satellite
Cloud free
AOT,
$\alpha(z)$
Aerosol: $n(a), \beta, \alpha, \sigma$, chem
Cloud: r_e, w, LWP
Feingold

Cloud Retrievals: J-31







Pilewskie

ICARTT J31 Data Workshop

Room 2A201, NOAA Aeronomy Lab, Boulder, CO

9, 10 March 2005

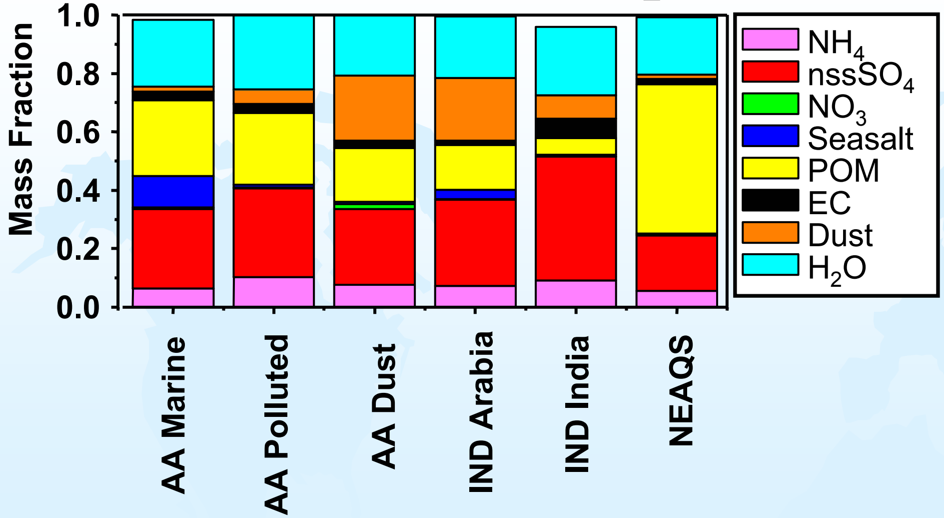
Presentations & Discussions on Collaborations

- With Other Platforms (Ron Brown, DC-3, P-3, DC-8)
- With Models
    - -- Transport/evolution
    - -- Regional radiative forcing by assimilating satellite radiances

Discussions of Plans

- Analyses, meetings, publications
- Future missions: Great interest in using J31 or similar platform in INTEX-B

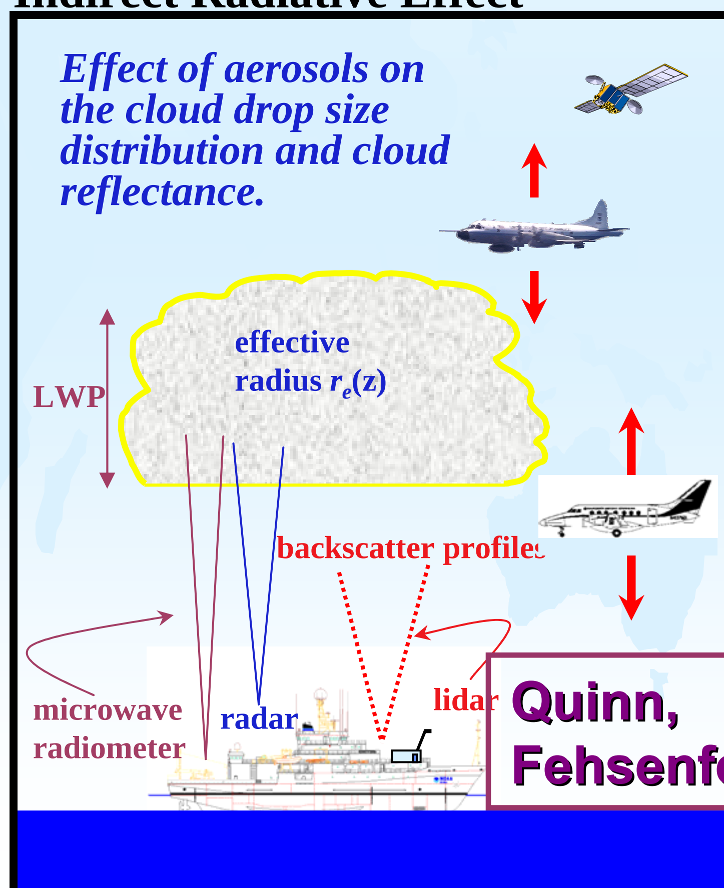
Aerosol Properties and Radiative Effects



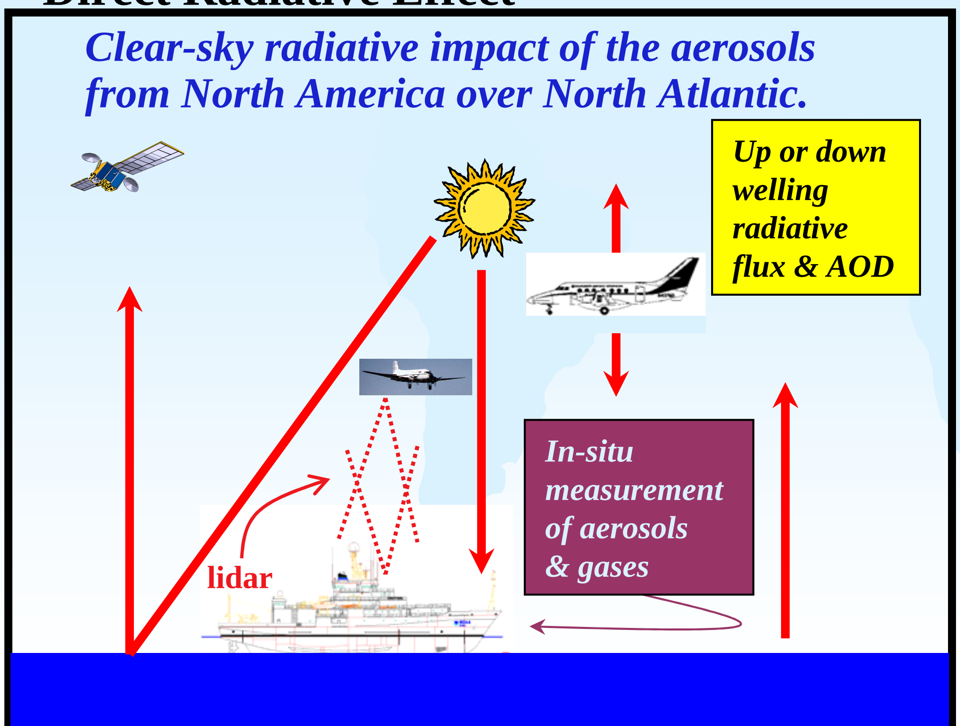
Aerosol Characterization

Characterize the chemical, physical and optical properties of the aerosol particles from North America as they move out over the western North Atlantic and observe how they change. (Various platforms)

Indirect Radiative Effect



Direct Radiative Effect



Quinn, Fehsenfeld

DC-3 / J31 Collaboration

- Two overflights (07/31* & 08/03)
- DC-3 can provide for these flights
  - – Aerosol structure from surface to 2.5 km
  - – Aerosol backscatter and extinction profiles (based on assumption of extinction/backscatter ratio) to 2.5 km
- What would be helpful to us?
  - – Profiles of aerosol extinction (@ 353 nm) from surface to 3 km measured during spirals and parking garage patterns

Senff, Livingston, …

*Cirrus contamination in AATS AOD during profile w DC-3

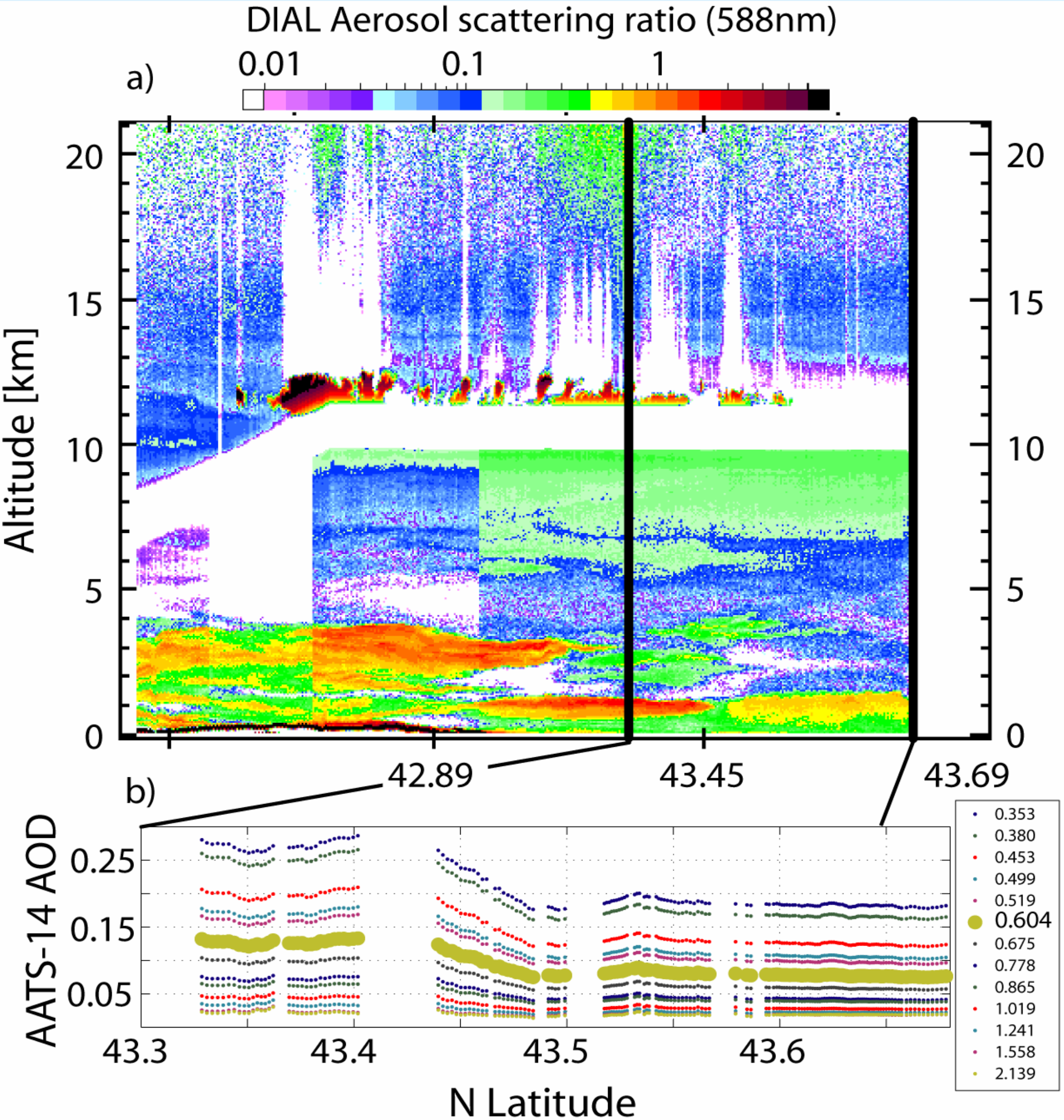
ICARTT J31 Data Workshop

NOAA Aeronomy Lab, Boulder, CO, 9, 10 March 2005

Most Promising Collaborations between J31 & Other ICARTT Platforms

- Ron Brown:
  - -- Sonde T, P, H_2O profiles: Compare to J31 AATS & In situ
  - -- MicroTOPS AOD: Compare to J31 AATS, satellites
  - -- In situ Extinction: Estimate AOD below J31
  - -- In situ SSA: Compare to J31 SSFR/AATS retrievals
  - -- μWave Radiom H_2O: Compare to J31 AATS
  - -- Radar & μWave Cloud R_e: Compare to J31 SSFR
- DC-3: Lidar extinction profile (08/03): Compare to J31 AATS
- P-3: Cloud properties (in situ & remote): Compare to J31 SSFR
- **DC-8:**
  - -- In situ extinction profiles: Compare to J31 AATS
  - -- Lidar extinction: Compare to J31 AATS
  - -- In situ SSA profiles: Compare to J31 layer retrievals
  - -- **+ More ideas from this meeting! (DLH, Cryo Hygro, …)**

DC-8 Lidar (DIAL) underflown by J-31 Sunphotometer (AATS-14) – testbed for A-Train



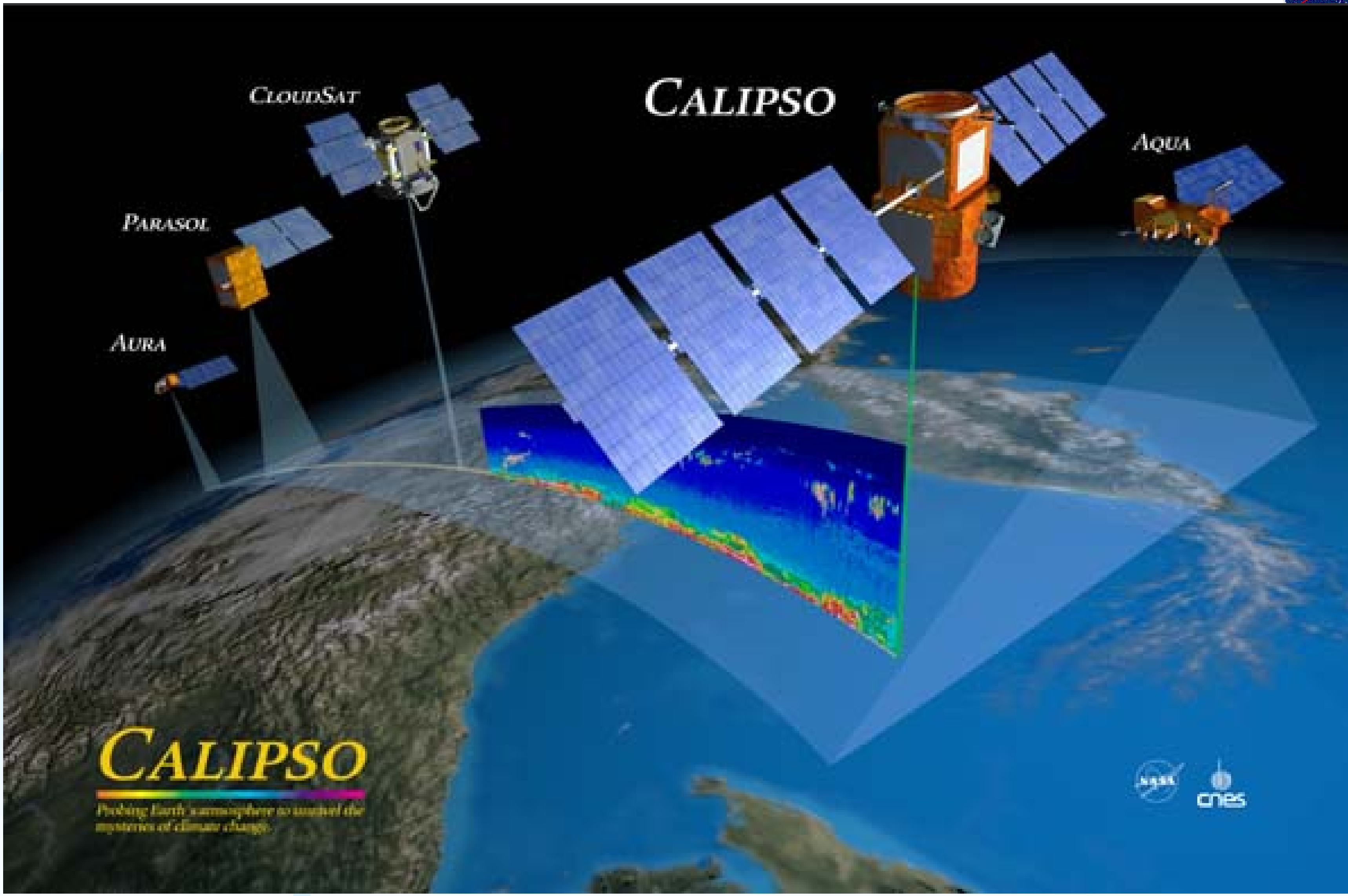
2 Aug 2004

Black vertical lines delimit time and latitude of J31/DC-8 coincidence

AODs are from AATS-14 flying near surface below DC-8

Redemann, Browell

DC-8 DIAL data courtesy of Ed Browell, NASA LaRC


CLOUDSAT
CALIPSO
AQUA
PARASOL
AURA
CALIPSO
Probing Earth's atmosphere to unravel the mysteries of climate change.

ICARTT J31 Data Workshop

NOAA Aeronomy Lab, Boulder, CO, 9, 10 March 2005

Other Promising Collaborations: Between J31 & Models & Satell. Products

- FLEXPART: Identify **origins & history** of radiative forcing aerosols

- O. Cooper GOES images w J31 flight paths: Relate J31 position to clouds

- CTMs in general: Test calcs of **AOD & ext profiles** by comparing to AATS profiles of same

ICARTT J31 Conference & Journal Papers

Presented, Accepted, or Submitted to Conferences:

- **Livingston**, J., et al., **Airborne Sunphotometer and Related Measurements Acquired over the Gulf of Maine During INTEX-ITCT 2004**, American Geophysical Union Fall Meeting, San Francisco, California, December 2004.
- **Livingston** , J., et al., **Coincident airborne sunphotometer and satellite aerosol optical depth measurements during INTEX/ITCT 2004**, European Geophysical Union General Assembly, Vienna, Austria, 24-29 April 2005, accepted.
- **Redemann**, J., et al., **Airborne measurements of direct aerosol radiative forcing in INTEX/ITCT, 2004**, European Geophysical Union General Assembly, Vienna, Austria, 24-29 April 2005, accepted.
- **Russell**, P. B., et al., **Airborne sunphotometer and solar spectral flux radiometer measurements during INTEX/ITCT 2004**, American Meteorological Society Atmospheric Sciences and Air Quality Conference, San Francisco, California, 27-29 April 2005, accepted.
- **Redemann**, J., et al., **Airborne measurements of spectral direct aerosol radiative forcing in INTEX/ITCT, 2004**, Scientific Assembly, International Association for Meteorology and Atmospheric Science, Beijing, China, 2-11 August 2005, submitted.

Planned for Journals:

- **Redemann**, J., P. Pilewskie, P. Russell, S. Howard, J. Pommier, J. Livingston, B.Schmid, W. Gore, J. Eilers, M.Wendisch, **Airborne measurements of spectral direct aerosol radiative forcing - a new aerosol gradient method applied to data collected in INTEX/ITCT, 2004** (planned for *Geophys. Res. Lett*., exact order of authors TBD)
- **Pilewskie**, Livingston, Redemann et al.: **Aerosol layers above clouds—radiative forcing and influence on satellite retrievals of cloud properties.**
- **Livingston**, Schmid, et al.: **Water vapor retrievals by airborne sunphotometer in INTEX/ITCT 2004: Comparisons to aircraft in situ, sonde, and microwave radiometer (and regional climatology?).**
- **Kahn** et al., **INTEX-NA Campaign Validation of Space-based Multi-angle Imaging Derived Aerosol Particle Types** (DC-8, Ron Brown, J31)

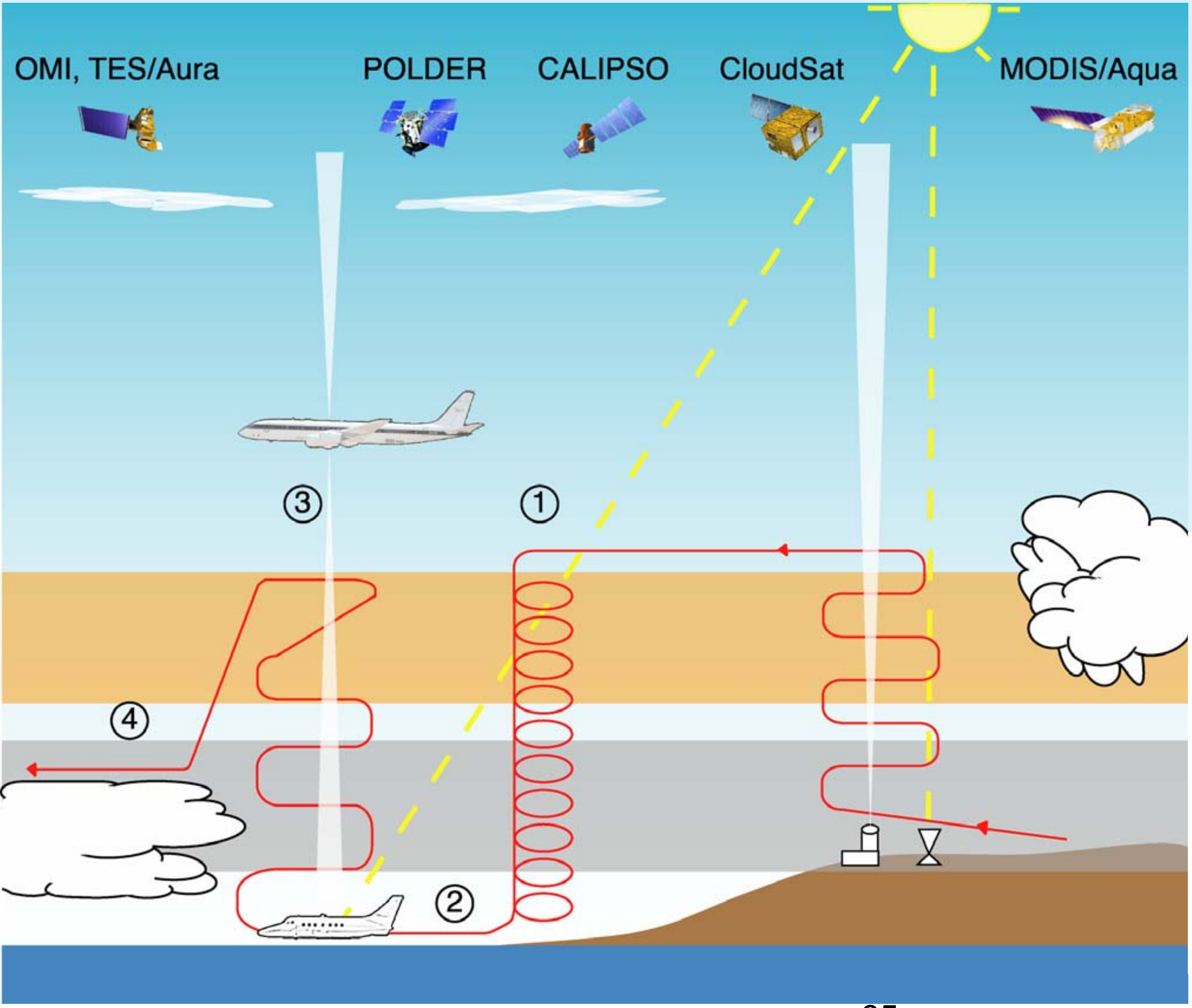
+ Others on integrated analyses currently less defined

- e.g., **Kahn** et al**., 2-D variability (stacked L's)**

Summary & Conclusions

- The investment made in the J31 has produced a very rich data set on aerosol, cloud, & surface optical properties and radiative effects.
- That data set has already produced 5 conference papers (presented, accepted, submitted).
- 4 journal papers currently planned. Integrated analyses, just getting started, are expected to produce many more.
- Comparison of AATS AOD spectra to MISR & MODIS results is providing important insights on improving satellite retrievals and cloud screening.
- SSFR retrievals of cloud r_{eff}, OD, & CWP are being used in studies of aerosol indirect effects.
- >12 cases of AOD gradients have corresponding gradients of radiative flux, suitable for determining aerosol radiative forcing efficiency (next talk, Redemann, Pilewskie et al.)
- SSFR surface albedo spectra show Gulf of Maine water to be very "black", i.e., relatively low levels of chlorophyll-A.
- J31 T & P measurements agree with sondes to ~2 C and ~ 2 mb.
- Archival status: AATS complete. SSFR P-3 complete. SSFR J31 by 3/31.
- The J31 and its INTEX-A payload are well suited to address the radiative-climatic goals of INTEX-B. The J31 team is interested in participating. Our INTEX-B proposal was submitted last fall.

Low-altitude aircraft flight patterns proposed for INTEX-B studies of aerosol radiative effects and satellite validation



(1) Survey Vertical Profile.
(2) Minimum-Altitude Transect.
(3) Stepped Profile ("Parking Garage")
(4) Above-Cloud Transect.

P. Russell, J31, INTEX Science Team Meeting
Virginia Beach, VA, 29 March-1 April 2005

End of Presentation
(Remaining slides are backup)

ICARTT SSFR J-31 Objectives

- **Cloud Remote Sensing and Aerosol Indirect Radiative Forcing**
  - Retrieve cloud droplet radius, optical depth, and liquid water path
  - Compare/validate with P-3 MIDAS, P-3 microphysics, with satellite retrievals (MODIS), microwave/radar retrievals from the Ron Brown.
  - Influence of aerosols on cloud radiative forcing: AATS-14 extinction above cloud, RB lidar extinction below

ICARTT J31 Findings, Cloud/Indirect Effects & Surface Albedo

– 1. a few cases identified for direct comparison between SSFR/MIDAS retrievals of cloud droplet size, cloud optical thickness, and cloud water path; need to compare with in situ (FSSP on P-3) and satellite derived r_e, tau.

– 2. Several (at least 3?) J-31 cases of cloud spectral reflectance measured in regions of enhanced aerosol loading over clouds. Need to be examined in context of direct and indirect radiative forcing and influence on cloud retrievals from space

– 3. Measured water-leaving irradiance in Gulf of NH shows water to be very "black", i.e., relatively low levels of chlorophyll-A.

– 4. Sea surface spectral albedo/water-leaving irradiance needs to be adapted for use with MISR data for constraining low level AOT algorithms; convert to water-leaving radiance via BRDF.

ICARTT SSFR J-31 Objectives

Water-Leaving Irradiance: MISR Validation

- MISR typically uses only the red and near-infrared "dark water" bands for its aerosol retrievals
- Ocean surface reflectance is ***assumed*** negligible in dark bands; not always negligible in the green and the blue, especially for low aerosol optical depth
- MISR team is developing an algorithm to simultaneously retrieve surface reflectance and aerosol properties over shallow polluted waters
- For low aerosol optical depth cases the sea surface albedo contributes the largest uncertainty.

ICARTT SSFR J-31 Objectives

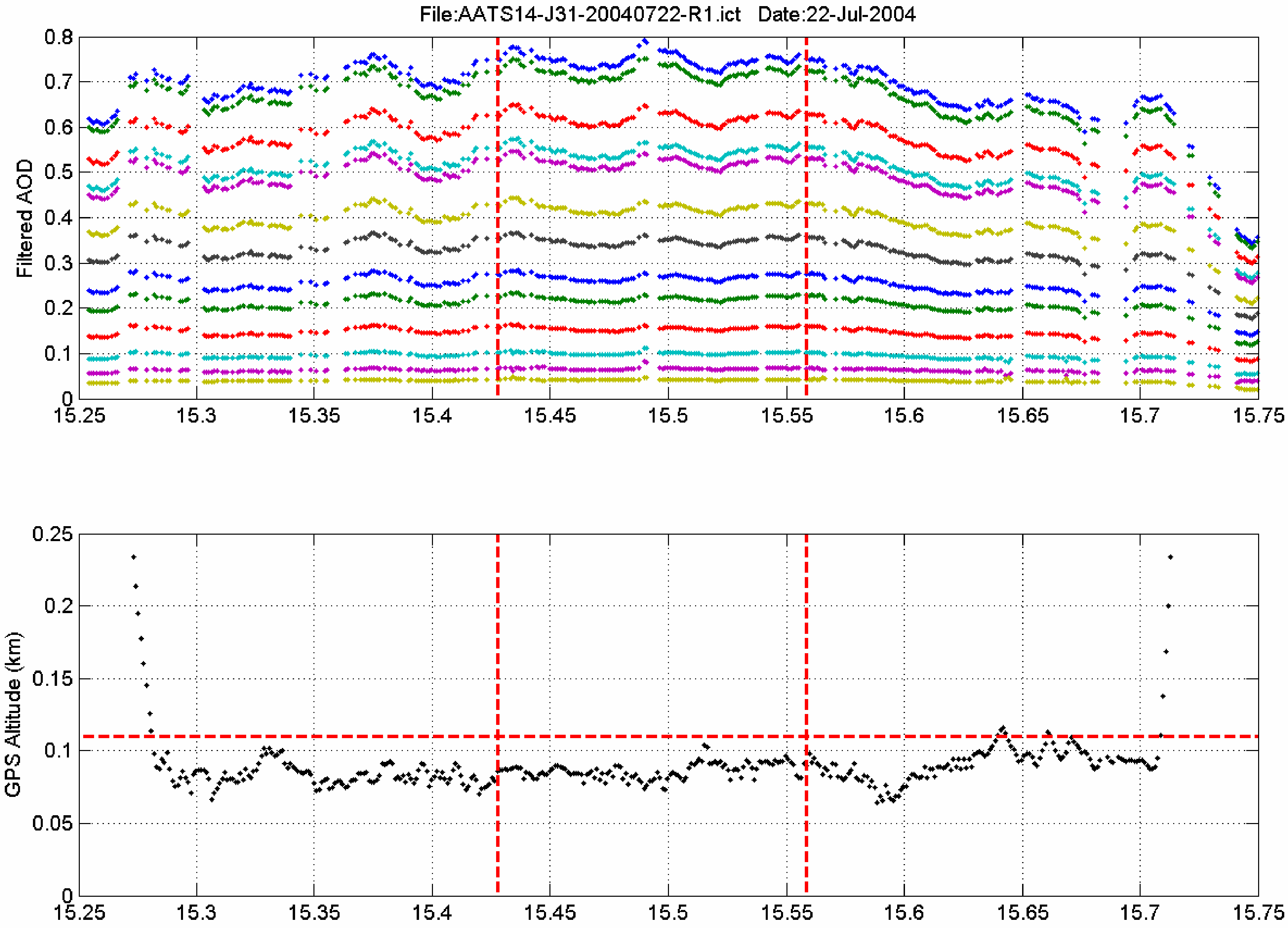
Cloud-Free Column Closure Studies

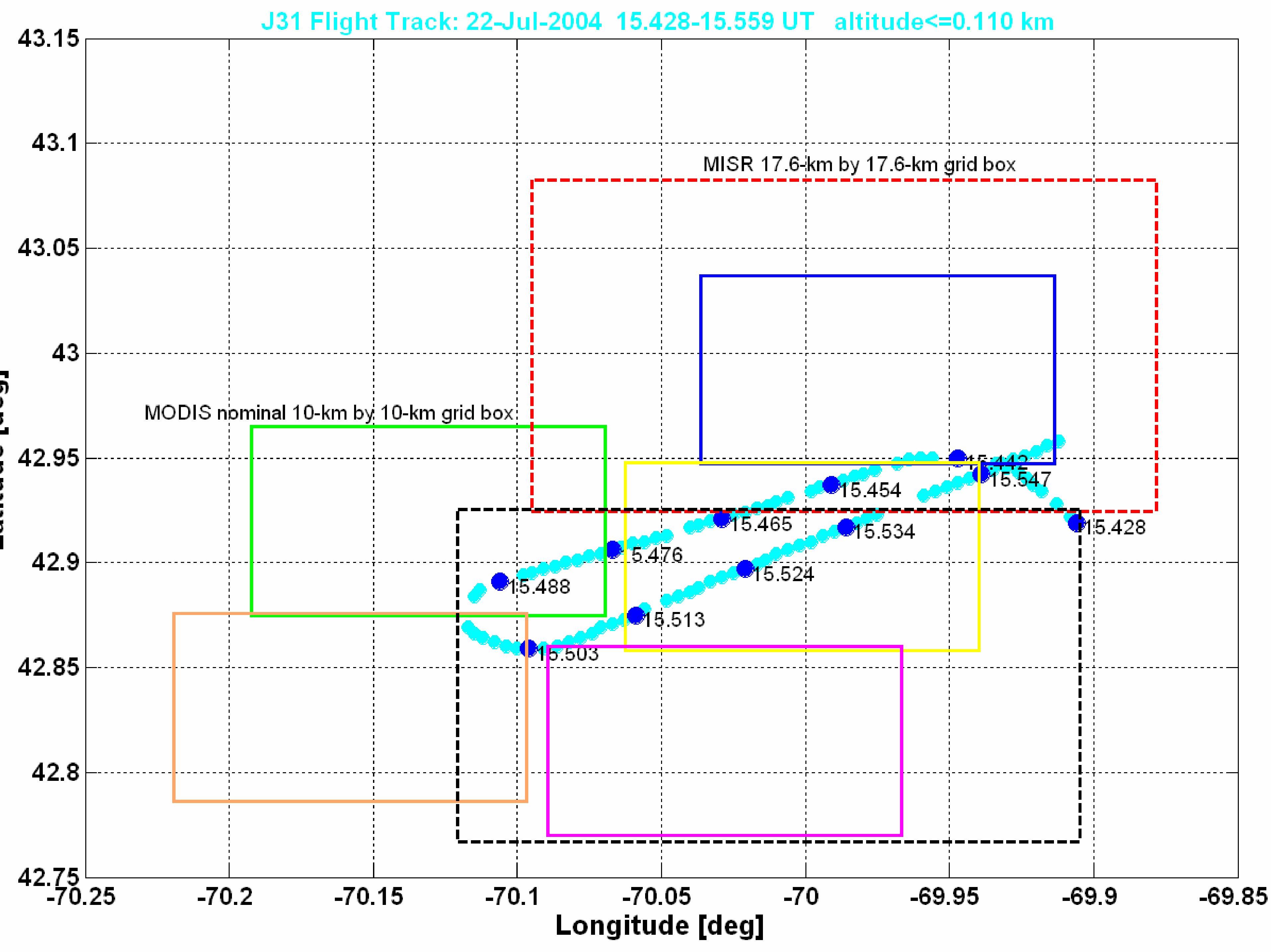
– Measuring spectrally and vertically resolved net solar irradiance → link aerosol radiative effects to optical, microphysical and chemical properties

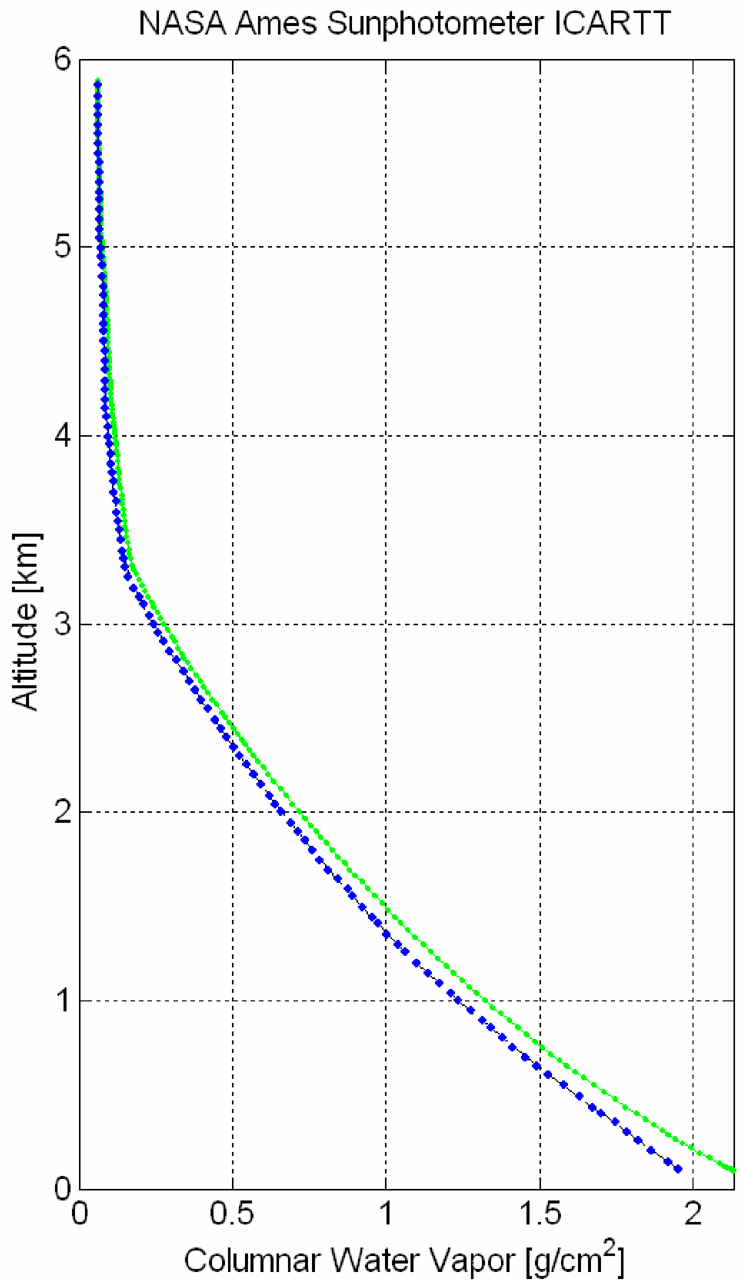
– Determine column solar radiative boundary conditions for modeling studies

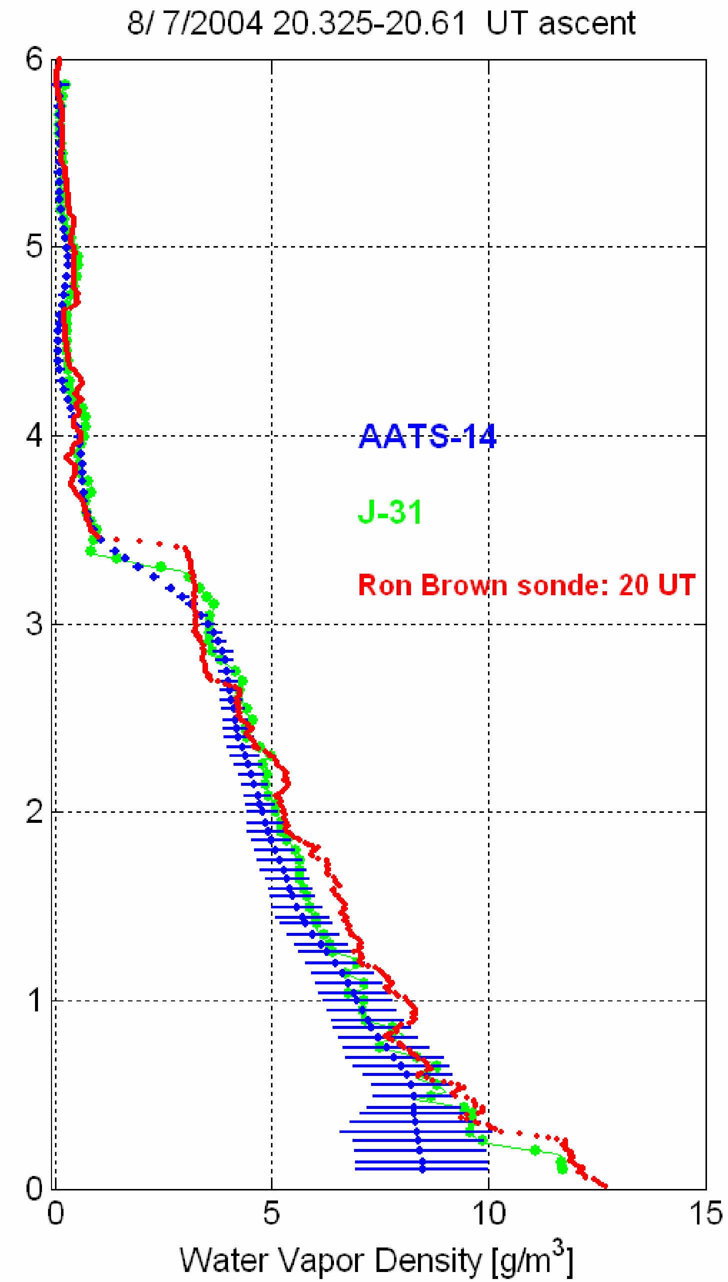
– Combine with AATS-14 aerosol optical depth spectra, derive spectra of aerosol absorption coefficient and single scattering albedo for thick polluted layers.

– Quantify aerosol direct radiative forcing


File:AATS14-J31-20040722-R1.ict Date:22-Jul-2004
Filtered AOD
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
15.25
15.3
15.35
15.4
15.45
15.5
15.55
15.6
15.65
15.7
15.75
GPS Altitude (km)
0.25
0.2
0.15
0.1
0.05
0
15.25
15.3
15.35
15.4
15.45
15.5
15.55
15.6
15.65
15.7
15.75


J31 Flight Track: 22-Jul-2004 15.428-15.559 UT altitude<=0.110 km
MISR 17.6-km by 17.6-km grid box
MODIS nominal 10-km by 10-km grid box
15.442
15.547
15.454
15.465
15.534
15.428
5.476
15.524
15.488
15.513
15.503
43.15
43.1
43.05
43
42.95
42.9
42.85
42.8
42.75
-70.25
-70.2
-70.15
-70.1
-70.05
-70
-69.95
-69.9
-69.85
Longitude [deg]





Livingston, Schmid, …

Table of J31/satellite coincidences during ITCT 2004

DATE	Satellite	Overflight Time	lower left corner	upper right corner	comments	analysis status	
		UT [hhmm]	lat N, lon W [decimal deg]	lat N, lon W [decimal deg]		MODIS	MISR
12-Jul	Aqua	1813	42.95, 69.9	43.1, 69.0		yes	
15-Jul	Aqua	1705	43.1, 69.9	43.2, 69.3		no	
16-Jul	Aqua	1748	42.4, 69.0	43.0, 68.0		yes	
17-Jul	Terra	1513	42.7, 70.7	43.25, 70.0	MISR Path 7; too far east of J31 track	yes	no
20-Jul	Terra	1543	43.05, 69.8	43.3, 69.4	MISR local mode; MODIS unusable	yes/bad	yes
21-Jul	Aqua	1806	43.0, 70.5	43.6, 69.5		yes	
22-Jul	Terra	1531	42.4, 70.2	43.1, 69.4	MISR local mode	yes	yes
23-Jul	Aqua	1754	42.6, 70.2	43.1, 69.95		yes	
29-Jul	Terra	1537	42.5,70.5	43.3 69.5	MISR local mode; MODIS unusable	yes/bad	yes
29-Jul	Aqua	1718	42.5,70.5	43.3 69.5	MODIS unusable	yes/bad	
31-Jul	Terra	1525			no MISR; limited AATS data at low alt	no	no
31-Jul	Aqua	1705			cirrus	no	
2-Aug	Terra	1513	42.3, 70.5	43.2, 69.2	MISR Path 7; too far east of J31 track	yes	no
7-Aug	Terra	1531	41.6, 68.75	42.8, 67.5	MISR (but no LM); MODIS unusable	yes/bad	yes
8-Aug	Aqua	1754	42.65, 70.25	42.85, 67.75		yes	

Livingston

GOALS FOR INTEX-NA MULTI-PLATFORM EXPERIMENT –

- **Provide Column *AOT* and *Particle Property* data to Validate satellite aerosol retrievals and aerosol transport models**

- **Quantify Regional Aerosol Amount and Type *Variability* on ~100 m to 100 km scales**

- **Provide 3-D aerosol physics and chemistry for Closure Tests**

- **Provide 3-D Environmental Snapshots for regional aerosol climatology**

- **Gain experience Coordinating *in situ*, surface, spacecraft aerosol observations**

- **Gain experience performing Integrated, multi-platform analysis**

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Platform Roles in Multi-Platform INTEX-NA Experiment –

- **MISR aboard the EOS-Terra Satellite**
  - -- Instantaneous ***regional*** column-average, 2-D ***AOT***, ***type*** & ***variability***
  - -- Satellite multi-angle aerosol retrieval **validation opportunity**

- **R/V Ron Brown**
  - -- Fixed ***point-of-reference*** and comparison platform for aircraft
  - -- ***Time series*** of column ***AOD***, ***Lidar Profiles***
  - -- Near-surface ***wind vector*** and ***aerosol samples***
  - -- Communicates Profiles and Wind Vectors near-real-time

- **DC-8**
  - -- *In situ* sampling of ***aerosol optics***, ***chemistry***, & ***micro-physics***
  - -- ***Lidar reconnaissance*** of study volume
  - -- Detailed ***characterization of aerosol layers*** along- & across-wind

- **J31**
  - -- Total ***column & height-resolved spectral AOD*** and ***radiative flux***
  - -- ***Surface*** net spectral albedo
  - -- ***Layer definition***, optical closure, lower optical boundary condition

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MISR–Aircraft Coincidences During INTEX-NA
July 15 – August 07, 2004

SITE NAME	DATE	PATH	ORBIT#	UTC	J31#	DC8#
Cont_Shelf,	**Jul 15**	9	24338	15:22	--	08
Gulf_ofMaine	**Jul 20**	12	24411	15:40	11	--
Gulf_ofMaine	**Jul 22**	10	24440	15:28	13	11
Gulf_ofMaine	**Jul 29**	11	24542	15:34	16a	--
Cont_Shelf,	**Aug 02**	7	24600	15:09	--	15
Gulf_ofMaine	**Aug 07****	10	24673	15:28	22	17

**** Golden Day!**

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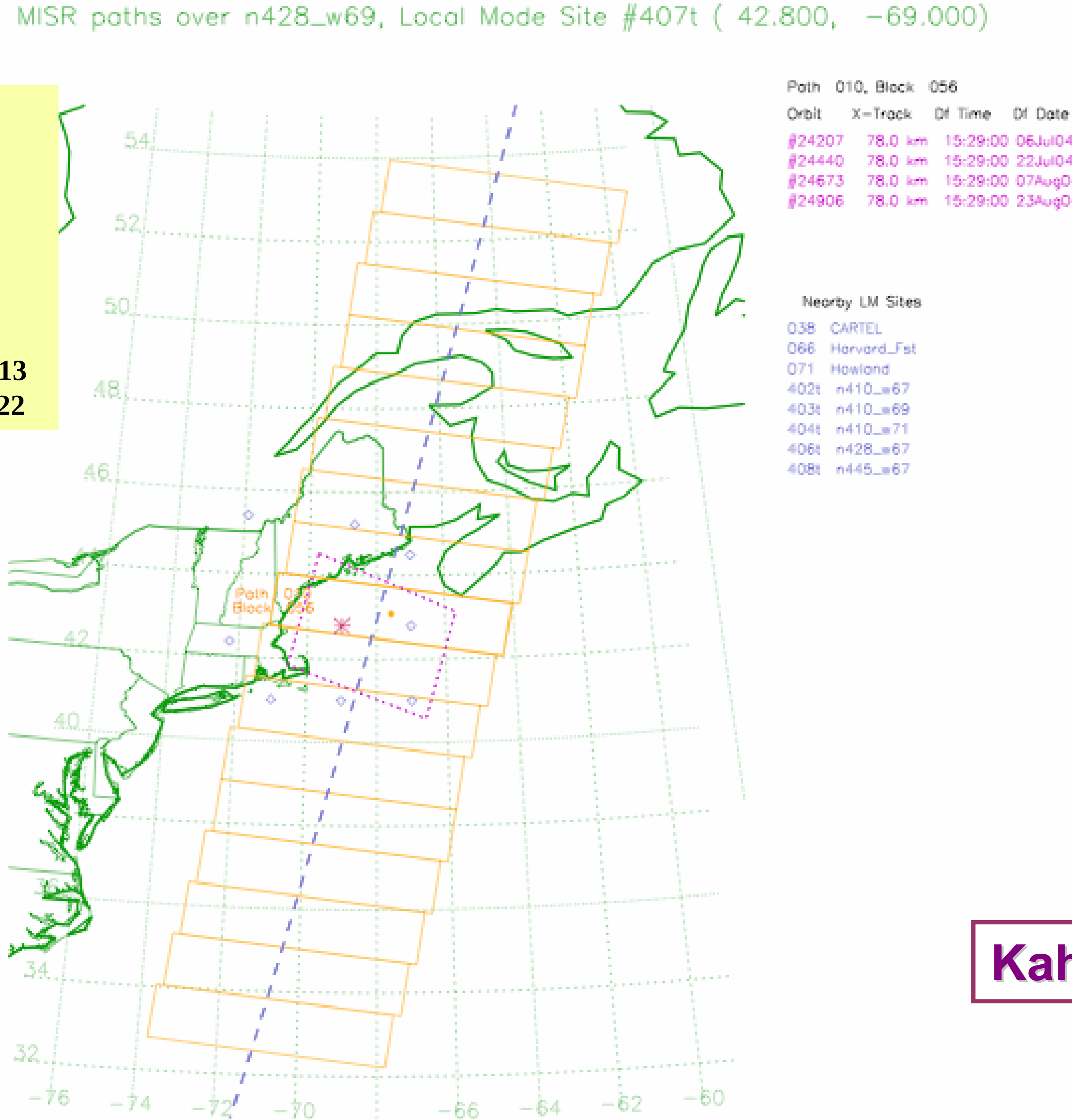
MISR
Coverage Map
Path 010
Blocks 55-58

July 22 -- DC-8 **#11** & J-31 **#13**
Aug 07 -- DC-8 **#17** & J-31 **#22**



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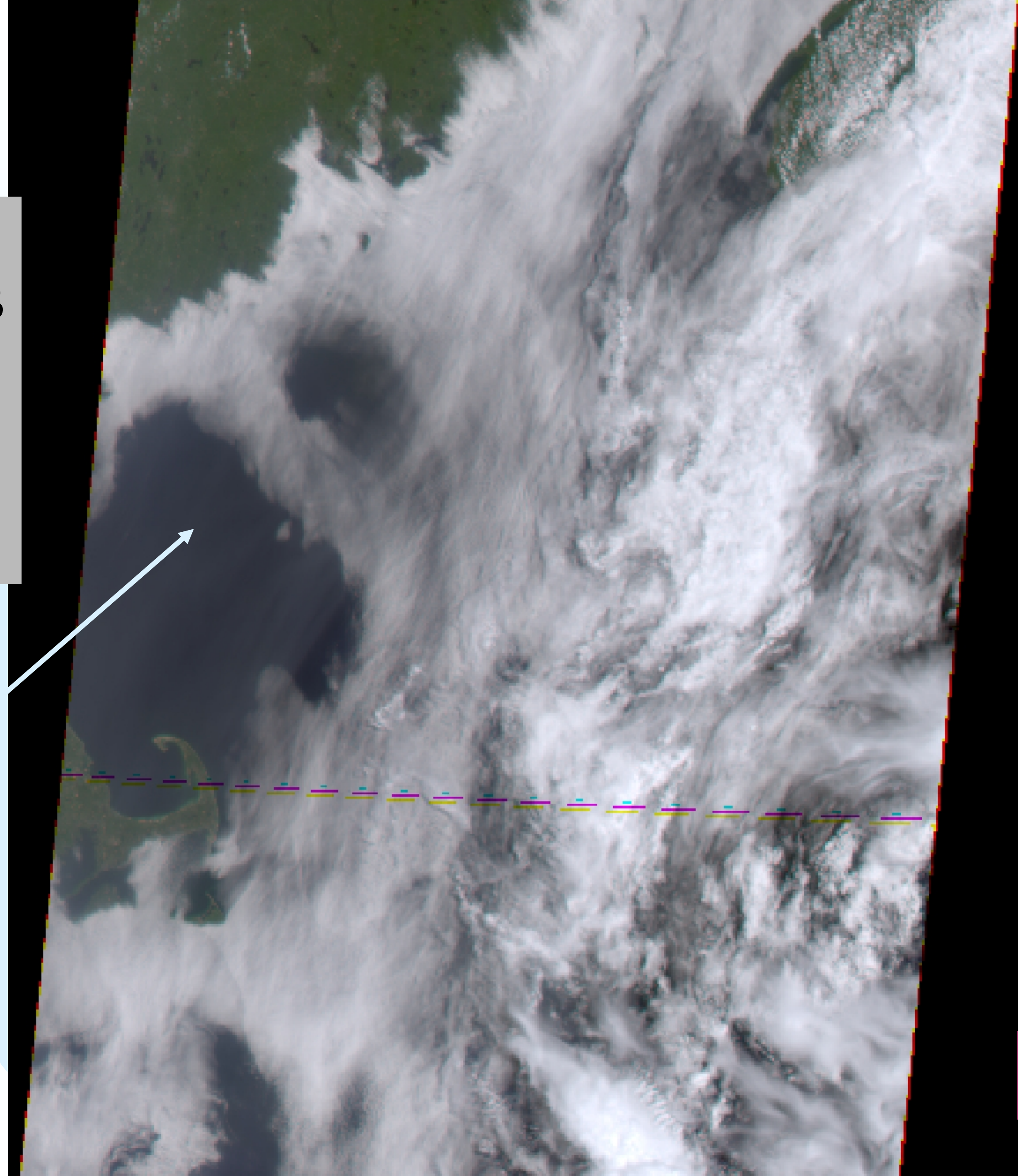
MISR 22 July

- Moderate/large AODs
- small AOD gradient along J31 flight track but outside of MISR grid cell locations

MISR Aa
Level 1B2 RGB
July 22, 2004
Orbit 24440
Blocks 55-58
1.1 km resolution



J-31 at
15:28 UTC

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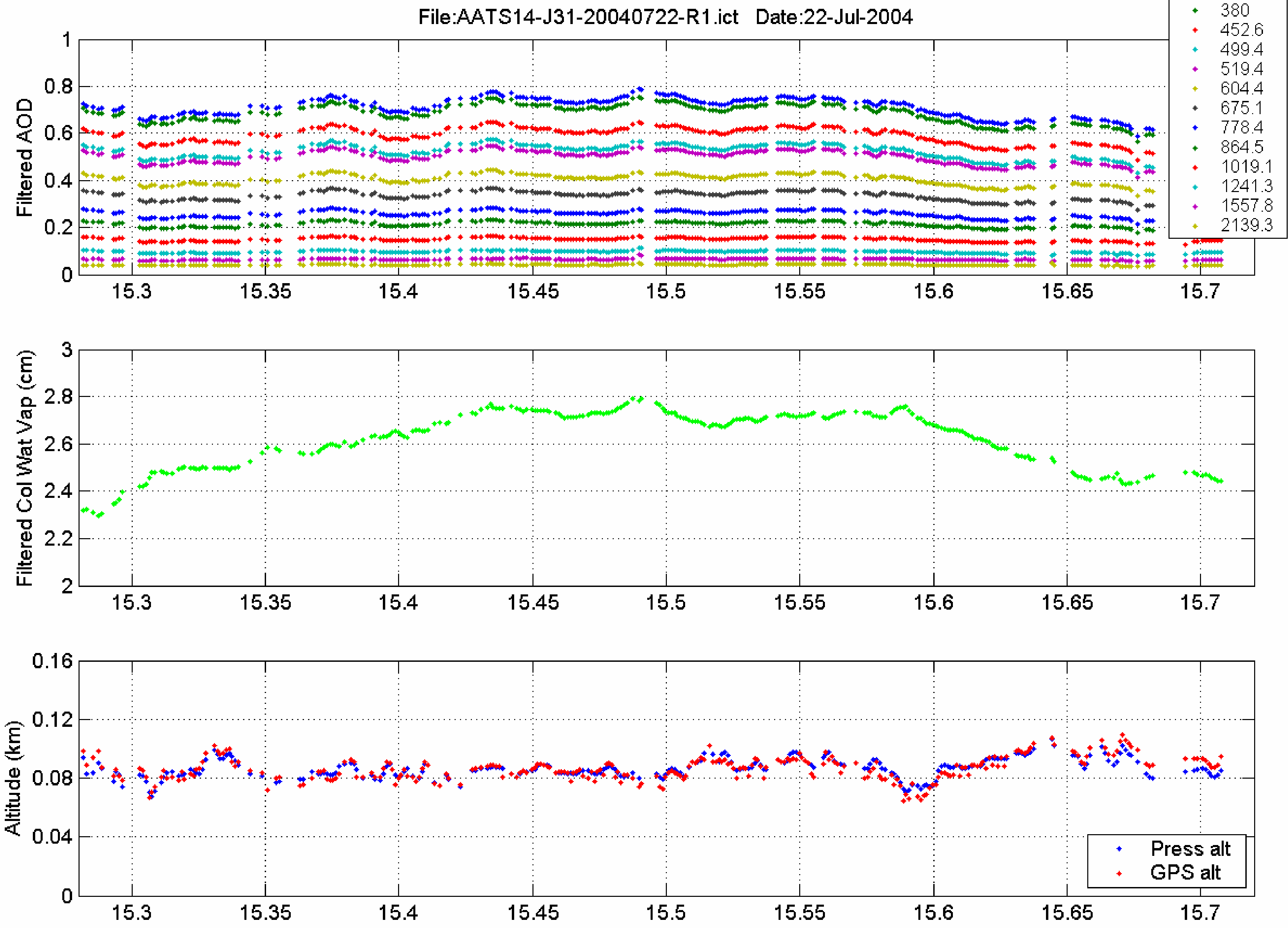
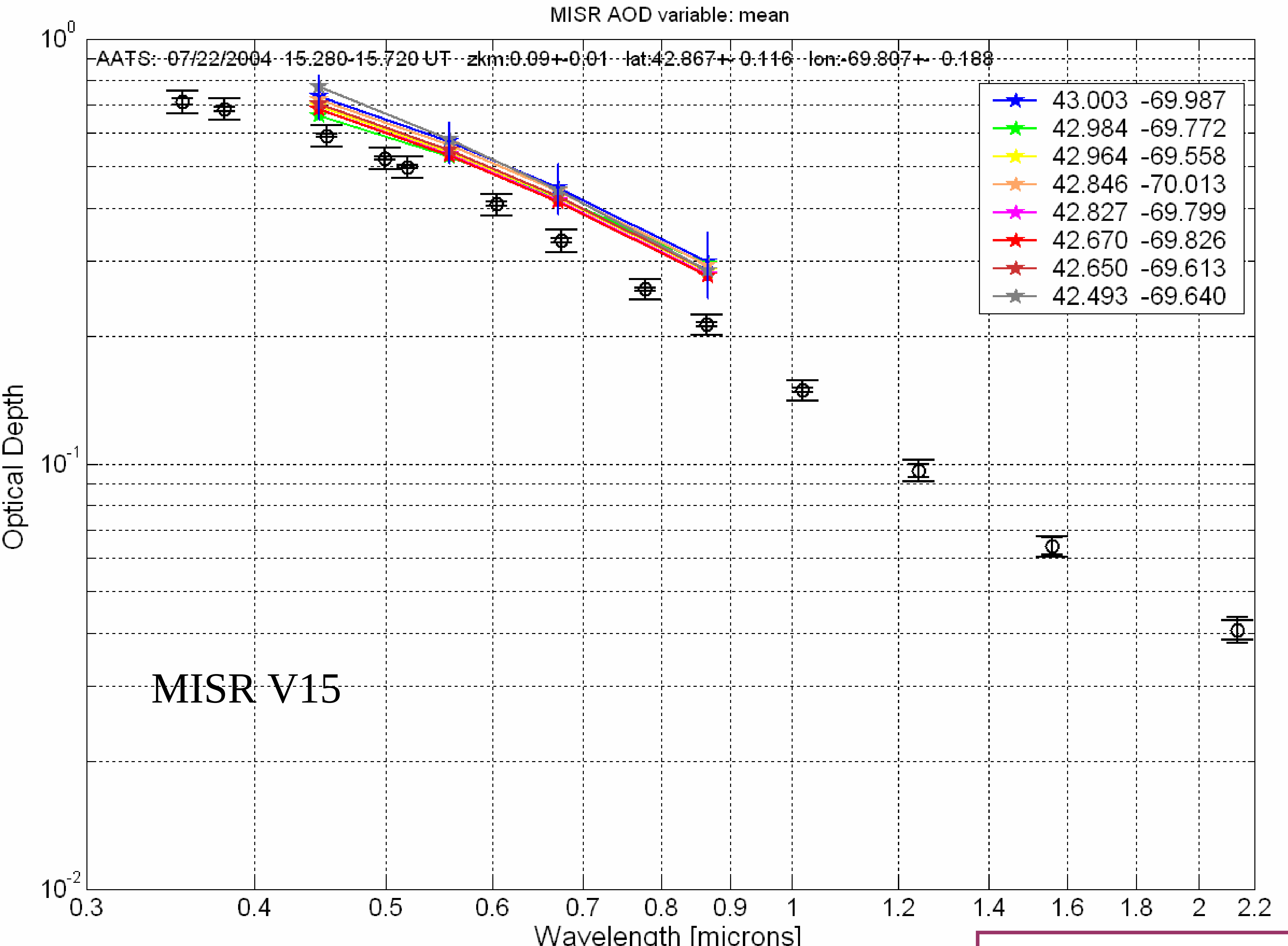
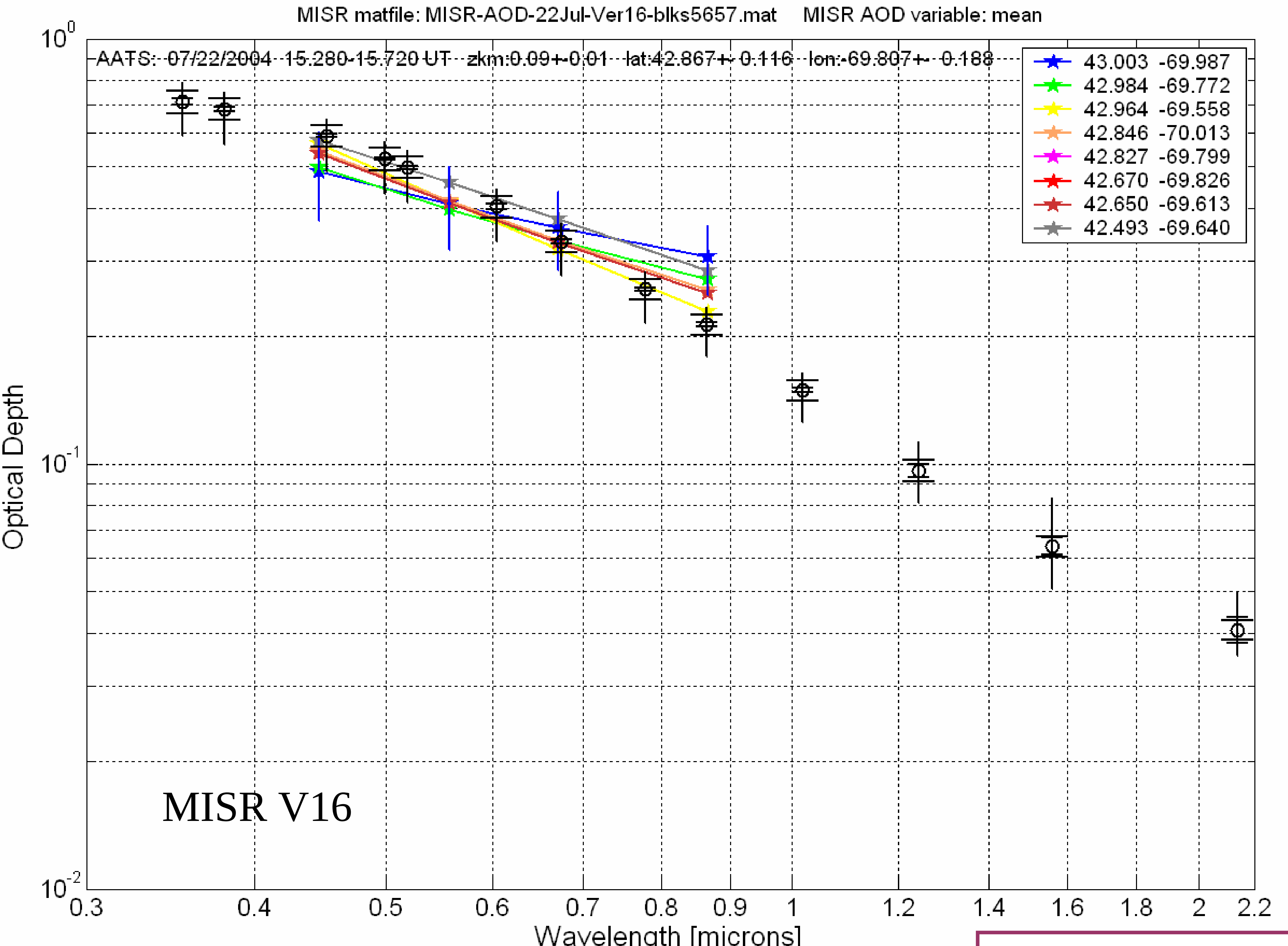

File:AATS14-J31-20040722-R1.ict Date:22-Jul-2004
Filtered AOD
380
452.6
499.4
519.4
604.4
675.1
778.4
864.5
1019.1
1241.3
1557.8
2139.3
Filtered Col Wat Vap (cm)
Altitude (km)
Press alt
GPS alt
15.3
15.35
15.4
15.45
15.5
15.55
15.6
15.65
15.7


MISR AOD variable: mean
AATS: 07/22/2004 15.280-15.720 UT zkm:0.09+-0.01 lat:42.867+- 0.116 lon:-69.807+- 0.188
43.003 -69.987
42.984 -69.772
42.964 -69.558
42.846 -70.013
42.827 -69.799
42.670 -69.826
42.650 -69.613
42.493 -69.640
Optical Depth
Wavelength [microns]
MISR V15


MISR matfile: MISR-AOD-22Jul-Ver16-blks5657.mat MISR AOD variable: mean
AATS: 07/22/2004 15.280-15.720 UT zkm:0.09+-0.01 lat:42.867+- 0.116 lon:-69.807+- 0.188
43.003 -69.987
42.984 -69.772
42.964 -69.558
42.846 -70.013
42.827 -69.799
42.670 -69.826
42.650 -69.613
42.493 -69.640
Optical Depth
Wavelength [microns]
MISR V16

MISR *Preliminary* Aerosol Type Validation
July 22, 2004
[MISR Standard Aerosol Product **Versions 15 and 16**; **J31 Coincidences**]

Block; Y, X 56; 5, 7	**MISR V15**	**MISR V16**	**AATS** (approx.)
Blue AOT	0.735	0.485	0.60
Green AOT	0.573	0.410	0.44
Red AOT	0.447	0.364	0.33
NIR AOT	0.299	0.312	0.21
Green SSA	0.941	0.98	--
Angstrom Exp.	1.37	0.67	~ 1.5
Successful Mdls.	3, 4, **5**, 14, 15	**54**, 57, 63	--

- **Observations**

-- **AOT**: V16 closer to AATS (Higher SSA → lower AOT)
-- **Angstrom Exp**: V15 closer to AATS (smaller particles → steeper slope)
-- V15 Mixtures: **100% sph_0.26**, others have some sph_0.12, sph_0.57, and BC
-- V16 Mixture: **54% sph_0.12, 06% sph_2.8, + 40% med. Dust**; others more dust
-- V15, V16 have similar AOT for nearby pixels; V16 Ang. up to 1.12 nearby

- **Conjectures**

-- **Tiny black carbon** (BC) is a poor way to model aerosol absorption here (V15)
-- V16 picks up something **> 0.26 or non-spherical** as dust – Cirrus or med sph?
-- V16 might add **0.57 or 1.28 spherical** particles to the climatology(?)

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22 July: AATS/MISR/MODIS