GRUAN Task Team on Ancillary Measurements (TTAM) ICM-3 Report

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GRUAN-TTAM Historical

First Contacts:
July 2010

Team Composition (as of today):

Alexander Haefele, MeteoSwiss-Payerne, Microwave and Lidar

Jim Hannigan, NCAR, FTIR

Nik Kampfer, Univ. Bern, Microwave

Thierry Leblanc (co-Chair), NASA-JPL, Lidar

Tony Reale (co-Chair), NOAA-NESDIS, Satellite

Matthias Schneider, (KIT/IMK and ASF), FTIR

Marc Schroder, DWD, Satellite/assimilations

Michael Sommer, DWD, Satellite/assimilations

Dave Whiteman, NASA-GSFC, Lidar

Terms of Reference:
October 2010

GRUAN-TTAM Terms of Reference

1. *Interface with other Expert Teams (e.g., NDACC)*
2. *Evaluate the data products (uncertainty budget etc.) and bring in missing knowledge*
3. *Inventory potential instruments (and interface with other GRUAN-Task Teams if needed)*
4. *Establish campaign rationales for the validation of data from multiple platforms*
5. *Establish a system for the routine collection and display of data from multiple platforms*
6. *Develop guidance on the type and amount of data and associated metadata needed to be stored from the instruments*
7. *Draw conclusions on the suitability of the deployed equipment*
8. *Report to WG-ARO on all above duties*

Now: Ground-based Measurements (Thierry)

followed by: Satellite Instruments (Tony)

Recent Interface With Other Expert Teams

May 2010: Raman Lidar Calibration Workshop

30 attendants (NDACC and beyond), hosted by D. Whiteman, NASA/GSFC

NDACC H_2O lidar measurement accuracy requirements in the UTLS evaluated:
Precision must be better than 50% in UTLS for single profiles

Calibration methods and their accuracy reviewed:
Radiosonde (5%-15%), Total Column (10%-15%), Experimental (7%-20%)

Hybrid method:
Use multiple radiosondes during distant campaigns (e.g., yearly),
and use laboratory lamp between them to monitor calibration stability

Nov. 2010, and ongoing: MWRNet WG Meeting

Aim of the WG:
Register tropospheric MWR, exchange knowledge,
set standards, and harmonize data analysis

Dec. 2010, and ongoing: ISSI Expert Team on Lidar Algorithms

15 attendants, mostly NDACC, Team Lead: T. Leblanc
Definitions of vertical resolution, as reported in NDACC data, reviewed
Uncertainty sources and uncertainty propagation rules reviewed

Team now building conversion tools to NDACC-standardized definitions

Vertical resolution and uncertainties will be reported homogeneously
for all NDACC lidars in 2012

Inventory of Potential Instruments (H_2O)

Lidar:

Routine measurements with UTLS capability (14-20 km):
JPL-Table Mountain (since 2007), UWO-Purple Crow (under re-construction)

Routine Measurements with UT capabilty (8-13 km):
Haute-Provence (since 1999), Rome-Tor Vergata (since 2002), ARM-SGP (since 1999)
Payerne (since 2006?), Lindenberg (?), Mauna Loa (since 2004)

Other routine measurements (altitude range TBD):
Cabaw, Potenza, Beltsville, Eureka

Mobile systems (campaign basis):
ALVICE, STROZ, AT, MARL, ComCAL

Future systems with UTLS capability:
Garmisch-Zugspitze, Maido-Reunion Island

Microwave:

Tropospheric Measurements:
List to be found on MWRNet website

Routine Stratospheric Measurements (30-80 km):
Bern, Seoul, Mauna Loa, Table Mountain, Lauder, Onsala, Andoya, Karlsruhe

Mobile systems: *MIAWARA-C*

Inventory of Potential Instruments (H_2O)

Location of Past and Current FTIR Measurements:

NDACC and TCCON Systems:
Eureka, Ny Alesund, Garmisch, Izana, Reunion Is., Wollongong, Lauder, Arrival Heights

NDACC-only Systems:
Thule, Kiruna, Poker Flat, Harestua, Zugstpitze,Jungfraujoch, Moshiri, Rikubetsu, Toronto, Barcroft, Kitt Peak, Mauna Loa, Addis Ababa, Paramaribo, Svowa

TCCON-only Systems:
Sodankyla, Bialystok, Bremen, Karlsruhe, Orleans, Park Falls, Lamont, Tsukuba, Ascension, Darwin, Eureka

Other:
St Petersburg, Yekateringburg, Tomsk, Bratts Lake, Paris, Egbert, Boulder, Table Mtn, Mexico City, Altzomoni

Data Products and Uncertainty Budgets

Lidar:

NDACC Products:

O_3, T, Aerosols *archived typically on a monthly basis*
H_2O *first archiving date expected in Summer 2011*
No NDACC-standardized uncertainty budget, but data QC made by mandatory intercomparison campaigns

Current estimated uncertainties for H2O:

Systematic Uncertainty: 5% to 10% for Calibration
(using lower tropospheric or toal column meas.)
Random Uncertainty: <1% below 5 km, <10% below 10 km, ~50% above 15 km

Current vertical resolutions used for H2O:

Can be as high as 15-m below 7 km
Degraded to a few 100-meters in the mid-troposphere
degraded up to ~ 2-3 km in the UTLS

ISSI Team on Lidar Algorithms:

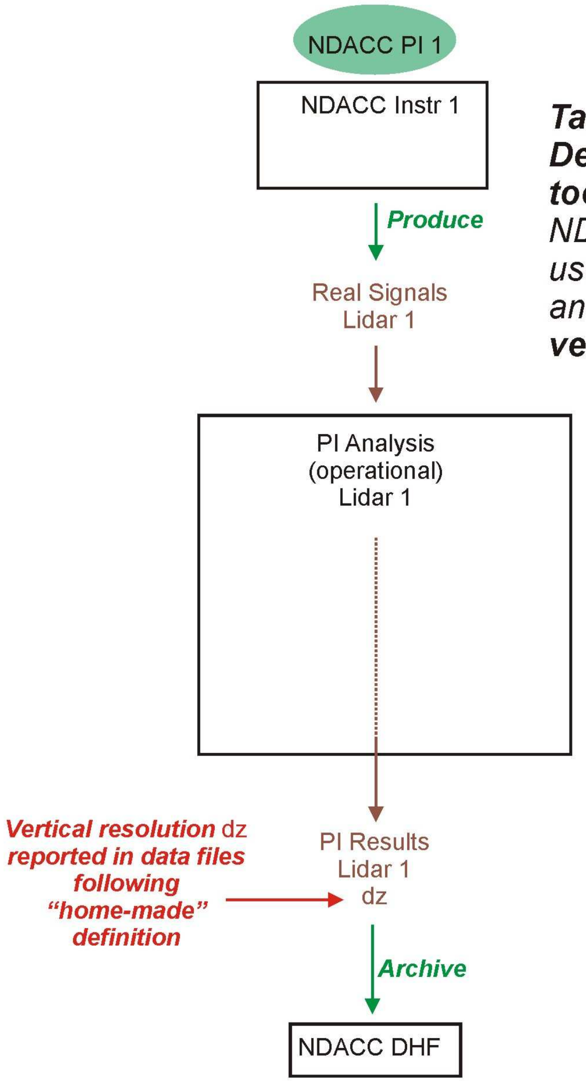
Working towards "NDACC-Standardized" definition of vertical resolution
Working towards "NDACC-Standardized" uncertainty budgets

The International Space Science Insitute (ISSI) 2010 Project

BEFORE ISSI-2010 PROJECT

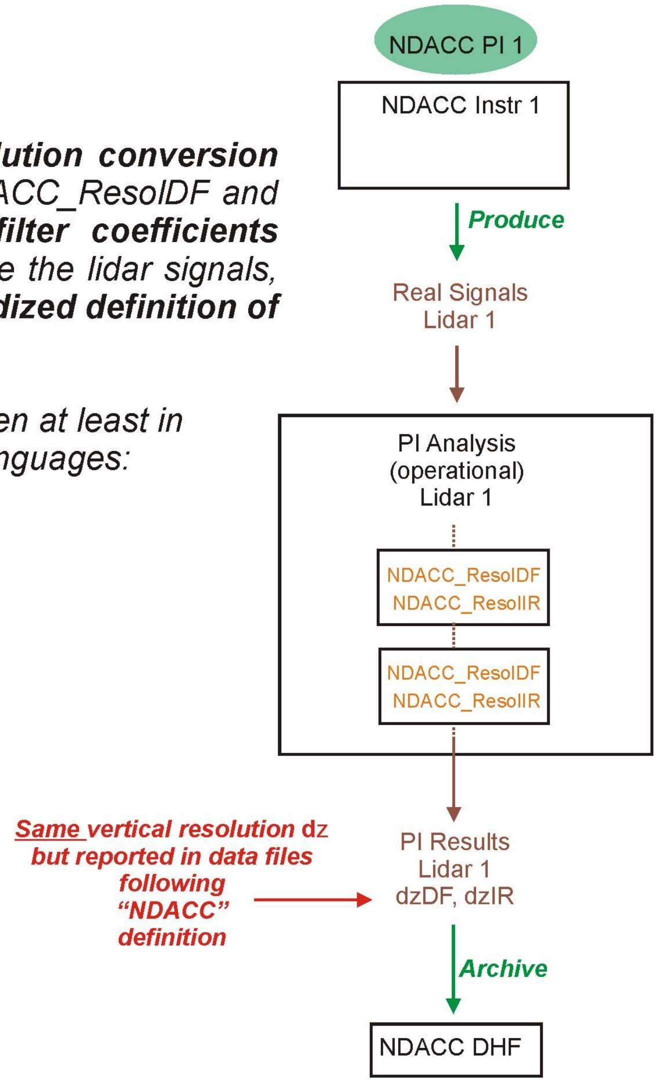
Task 1: Vertical Resolution

AFTER ISSI-2010 PROJECT



Task #1 of ISSI-2010 Project:
Development of a vertical resolution conversion tool. *Two subroutines (called NDACC_ResolDF and NDACC_ResolIR)* ***analyze the filter coefficients*** *used to smooth and/or differentiate the lidar signals, and* ***convert them into a standardized definition of vertical resolution***

These subroutines will be written at least in three different programming languages: IDL, MATLAB, and FORTRAN



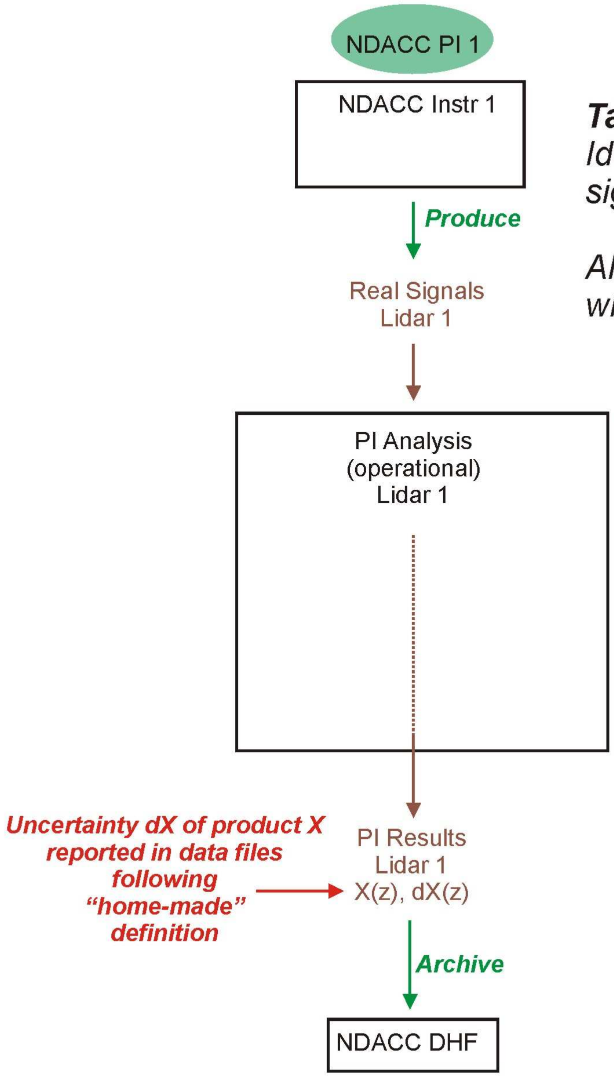
The International Space Science Insitute (ISSI) Expert Team on Lidar Algorithms

Task 2: Uncertainties

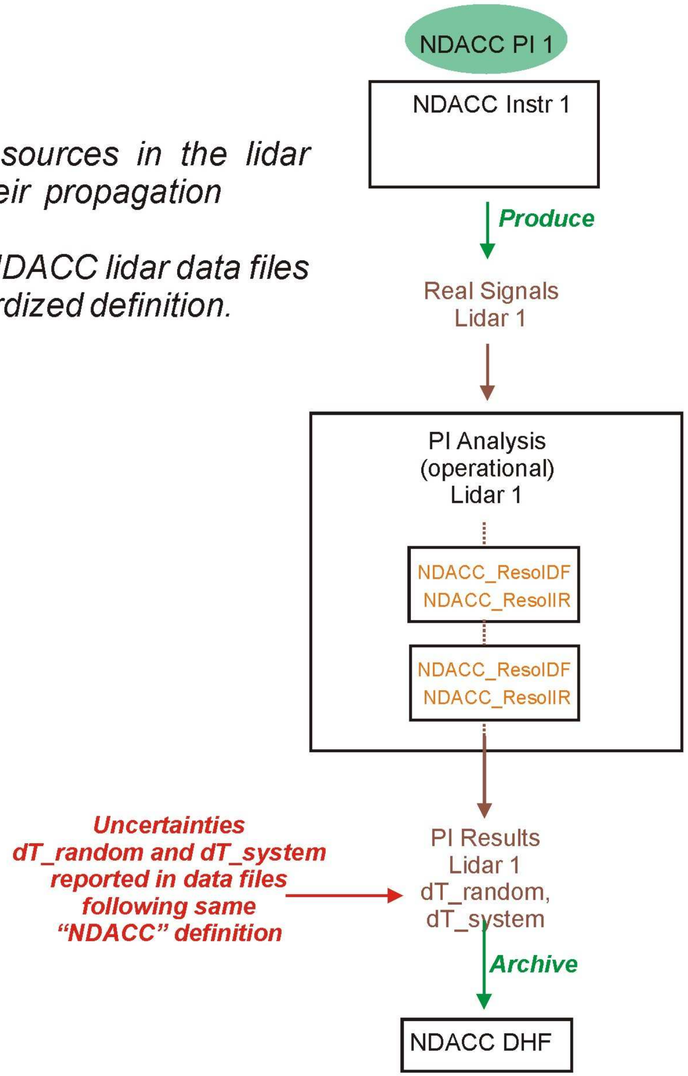
Task #2 of ISSI-2010 project:
Identification of all uncertainty sources in the lidar signals, and standardization of their propagation

All uncertainties reported in the NDACC lidar data files will be based on the same standardized definition.

BEFORE ISSI-2010 PROJECT

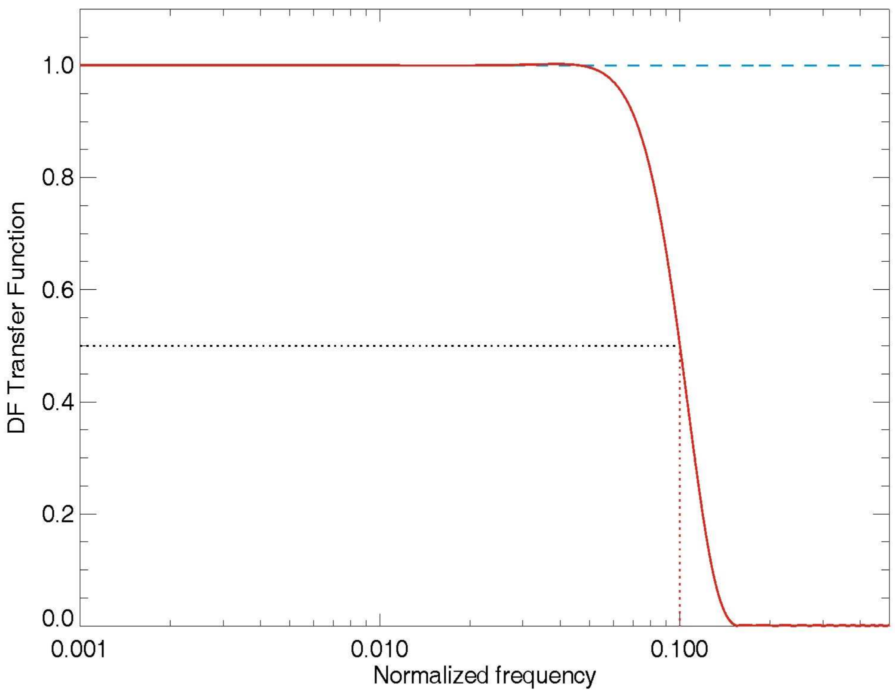


AFTER ISSI-2010 PROJECT



Example (vertical resolution)

Standardized Definition based on Digital Filters (cut-off freq.)

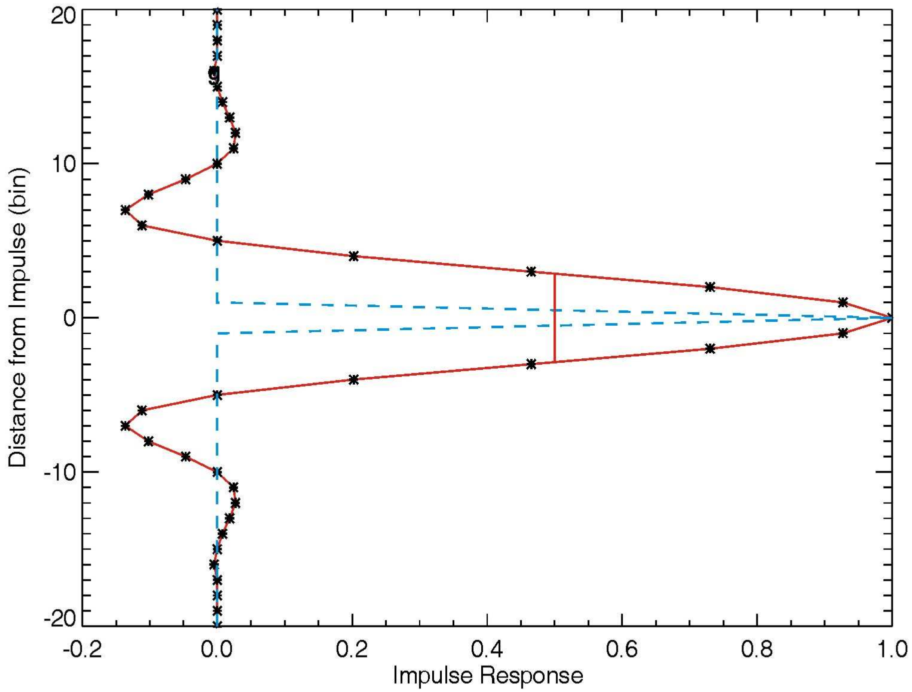


The Input was the set of coefficients of a Hamming filter of full-width 33 pts

The Output is the Transfer Function of the filter, and the calculated cut-off frequency of 0.1 bins^{-1} (the Nyquist frequency is 0.5)

The resulting standardized vertical resolution is: 10 bins

Standardized Definition based on Impulse Response (FWHM)



The Input was the set of coefficients of a Hamming filter of full-width 33 pts

The Output is the Full Width at Half-Max of the Response of the filter to an Impulse (Dirac)

The resulting standardized vertical resolution is: 5.74 bins

Data Products and Uncertainty Budgets

FTIR:

Estimated Uncertainties:
Total column: 1-2% random uncertainty
Tropopsheric profiles: 5-10% random uncertainty

Estimated Vertical Resolution:
~3 km in the lower troposphere
~10 km int eh upper troposphere

NDACC Systems:
No official H2O product archived yet
Usually higher sensitivity than TCCON: Better for UT

MUSICA Project:
H2O retrieval for 10 NDACC FTIR instruments
MUSICA H2O and HDO data will be archived at NDACC

Microwave:

Tropospheric Profilers:
No common data format and no central archive.
That is the purpose of the recent MWRNet WG

Stratospheric Profilers:
Central Data Archive for the NDACC instruments
Optimal Estimator Method of Retrieval, providing uncertanties of 10-15% above 40 km, with a vertical resolution of 10-15 km

Instrument Calibration, Validation

Instrument Calibration (Lidar):

Already covered in previous slides:
Raman Lidar needs calibration. It is done using PTU, FP, or Total Column measurements (operational mode), or it is done experimentally (Research mode)

Instrument Calibration (Microwave):

Absolute Calibration is required. It is done using an external liquid Nitrogen load
A new method using the sky tip measurement is being considered

Instrument Calibration (FTIR):

Self-calibrating technique (DIA), except for the line parameters that depend on laboratory measurements. A review of these parameters is being considered, similar to what was done for O3

Validation Strategies (Lidar):

The use of PTU sondes, and most importantly FP Hygrometers is required
Multiple simultaneous and co-located PTU and FPH launches are commended
*Special treatment in the UTLS is required to avoid the use of fluorescence-contaminated data. See **MOHAVE-2009 on next slides**.*

Validation Strategies (FTIR):

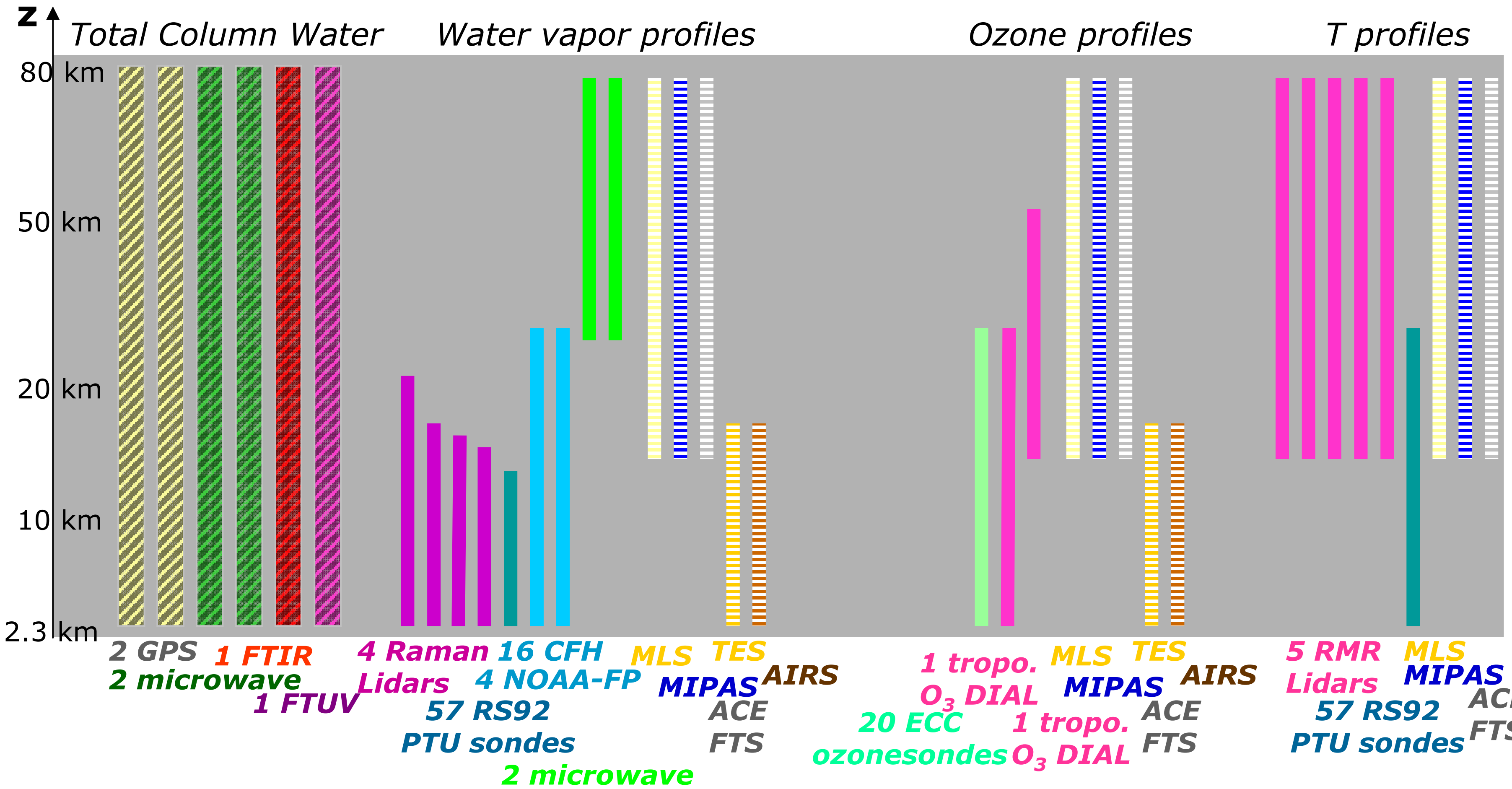
Standard inter-comparisons with PTU and FPH (profiles), and FTIR, GPS and microwave measurements (Total Column)

GRUAN

MOHAVE-2009 Campaign

Where? when? *At JPL-Table Mountain Facility, 11-28 October 2009*

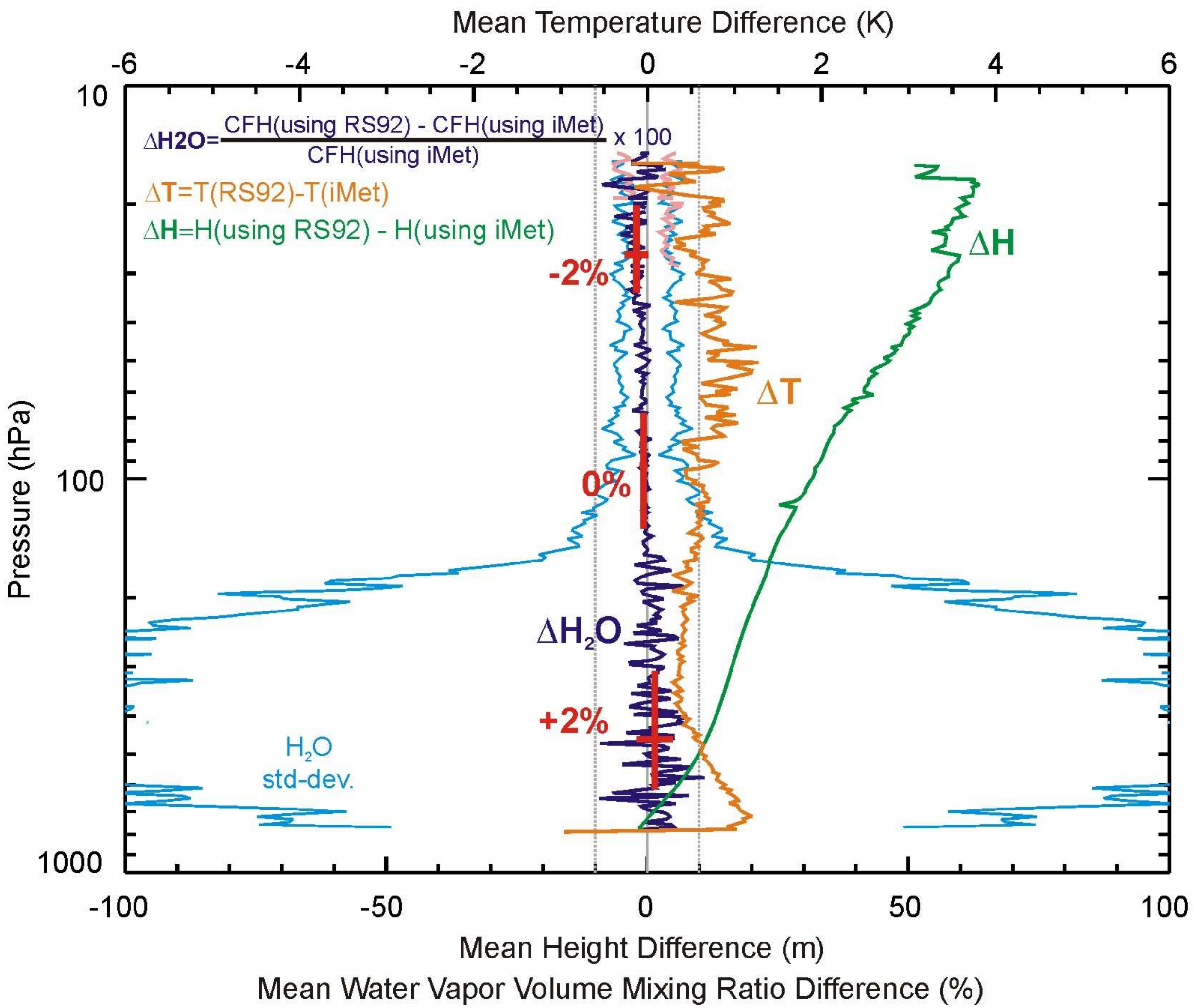
Who?



JPL

MOHAVE-2009 Campaign Results

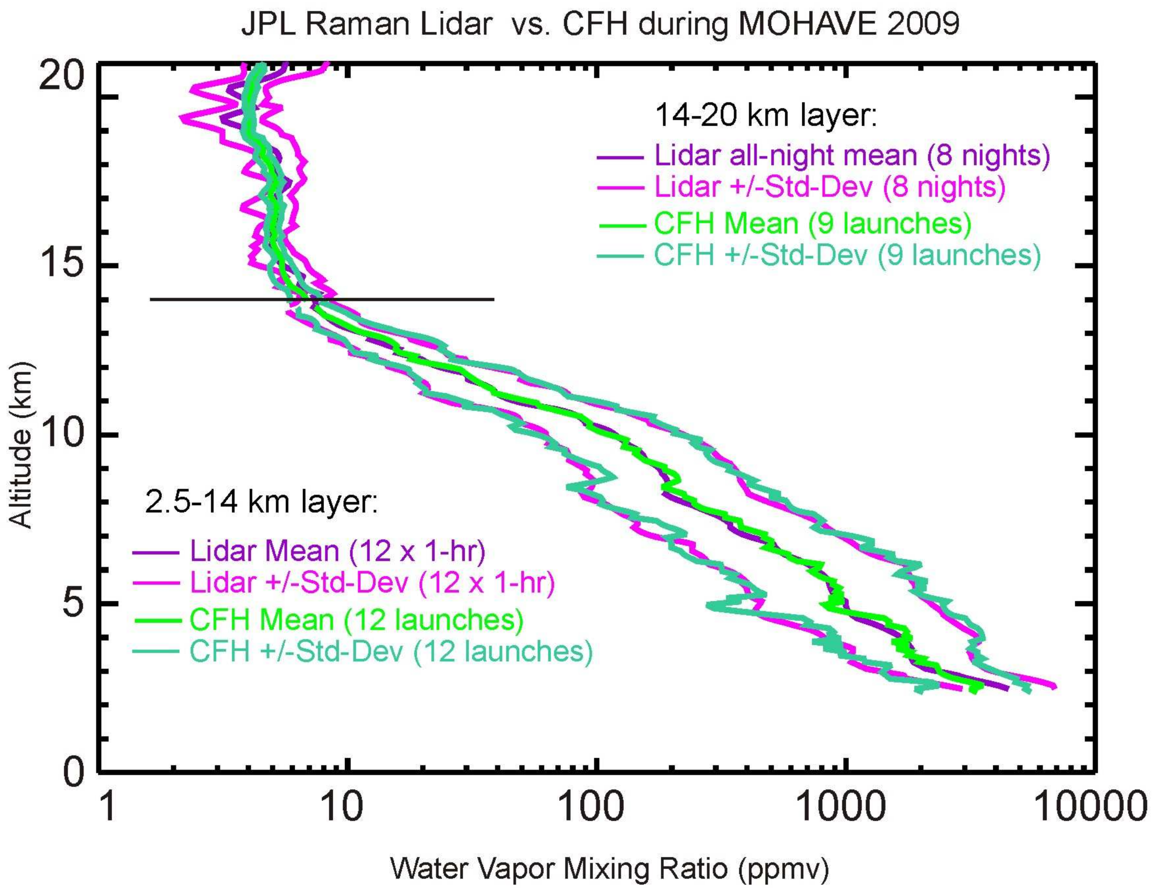
Mean effect on FP-derived water vapor v.m.r. of the P/T systematic differences between RS92 and iMet-1 radiosondes



MOHAVE-2009 Campaign Results

TMF Lidar vs. CFH, Campaign Mean

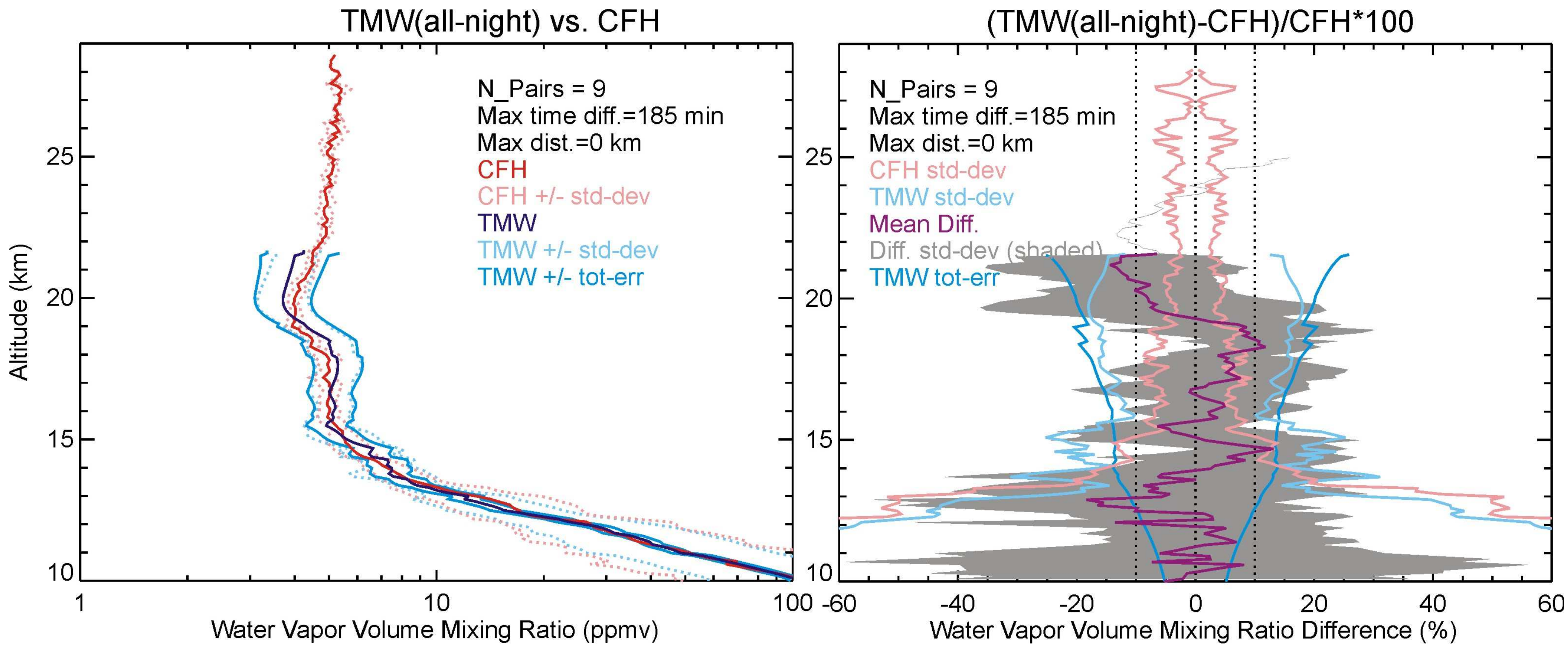
z>14 km: Lidar is integrated all-night (8 nights)
z<14 km: Lidar is integrated for 1 hour starting at launch time (12 launches)



MOHAVE-2009 Campaign Results

TMF Lidar vs. CFH, Campaign Mean, UTLS zoom

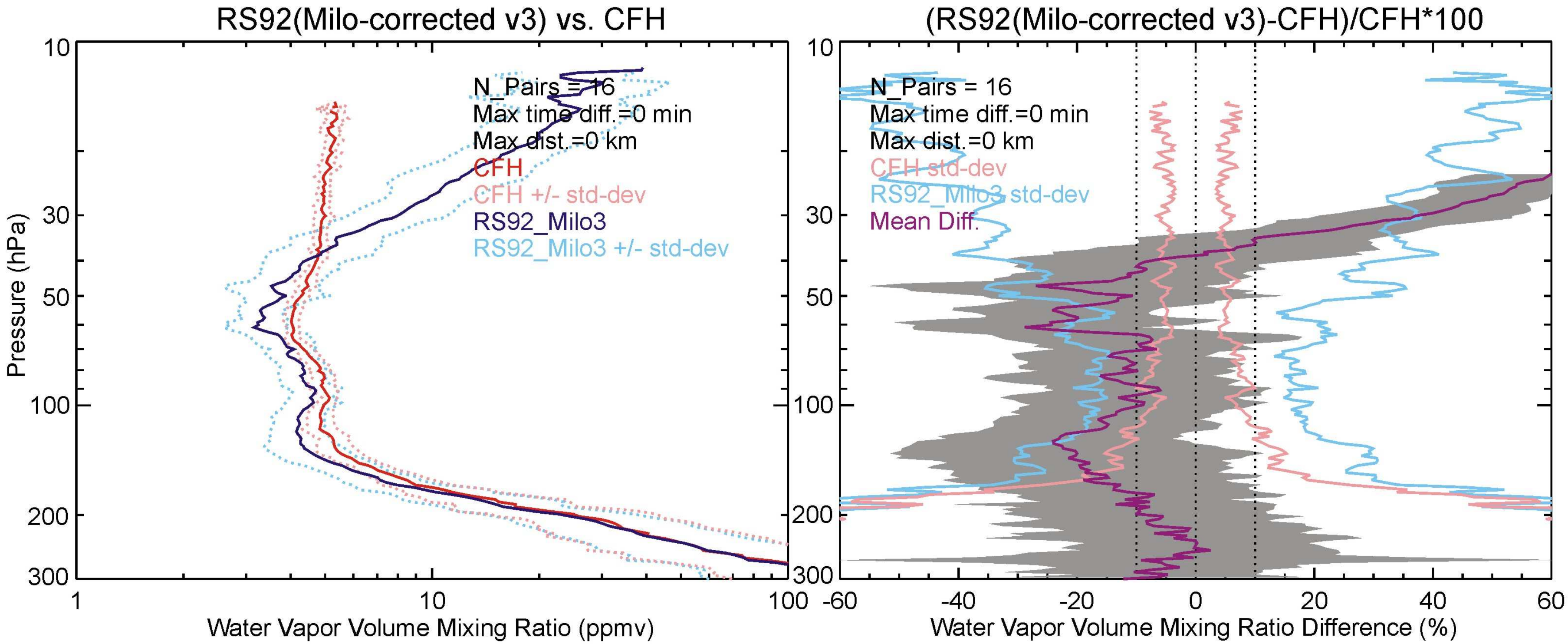
All-night (2 to 8 hours) lidar measurements reach:
- 10 km with 5% random uncertainty
- 13 km with 10% randon uncertainty
- 20 km with 20% random uncertainty (4 times that estimated for CFH)



MOHAVE-2009 Campaign Results

Latest Miloshevich correction (v3, post-Milo[2009]) vs. CFH

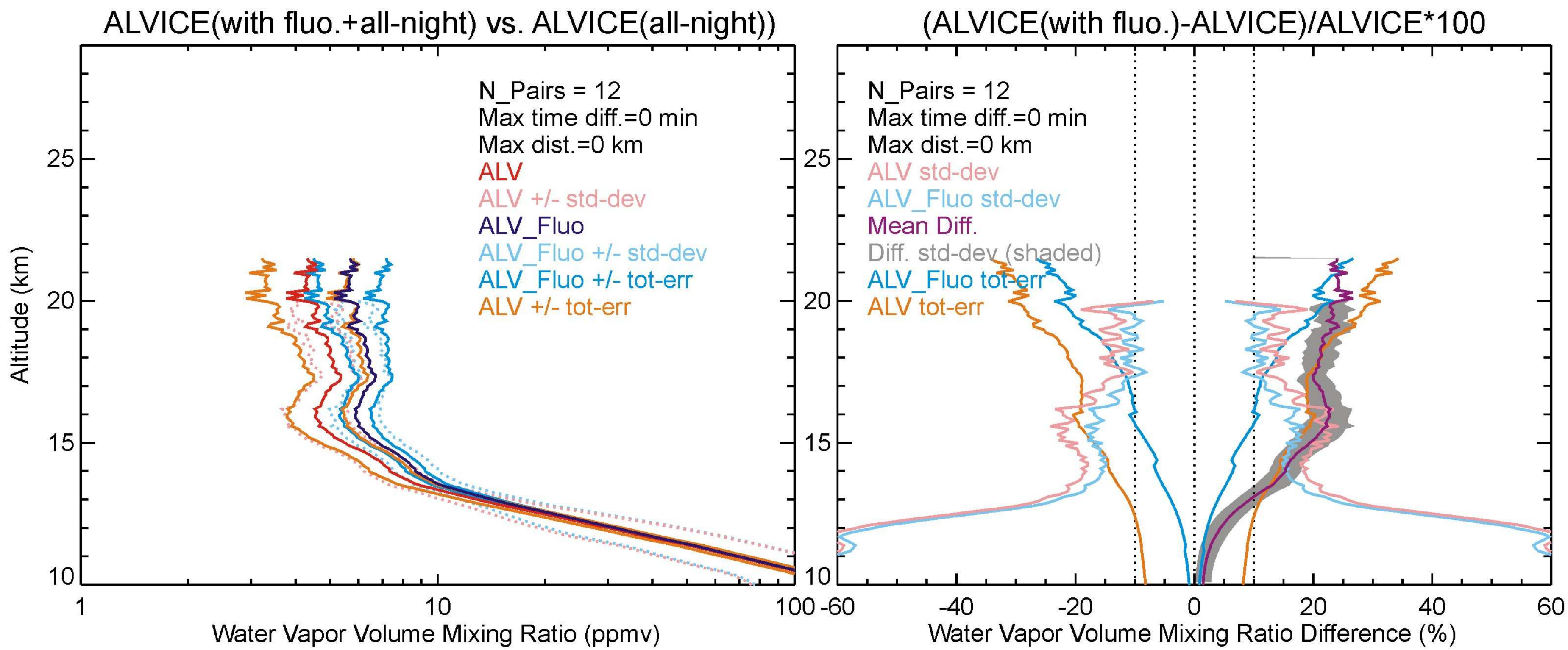
Correction v3 (as opposed to Milo[2009], leads to better profiles in the UTLS, but not above 40 hPa



MOHAVE-2009 Campaign Results

One issue with the Raman Lidar Technique:
ALVICE and STROZ lidars both contaminated by Fluorescence in the UTLS

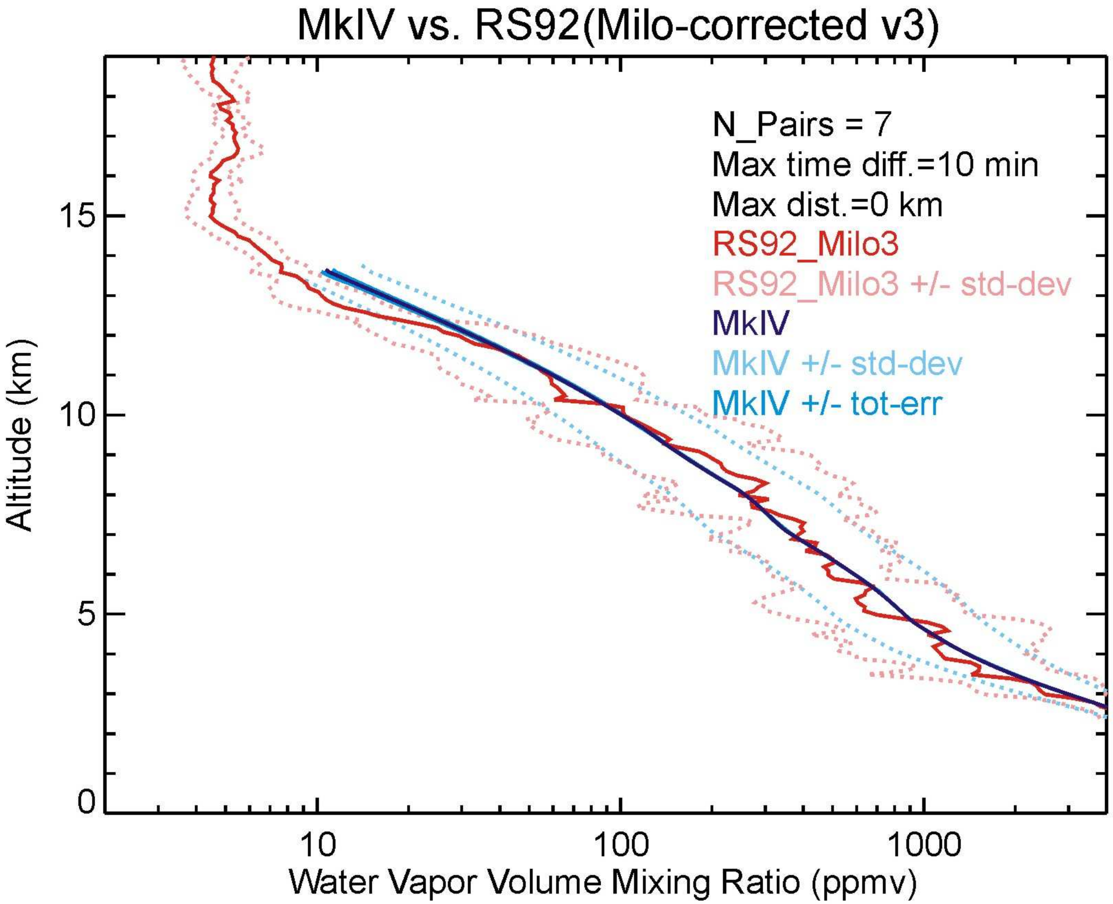
Contamination shows in the form of a constant wet bias in the UTLS
Correction is applicable, but depends on an external source, in this case CFH (equivalent to a "Second Calibration")
In case below, contamination to be corrected reaches 24% of actual signal



MOHAVE-2009 Campaign Results

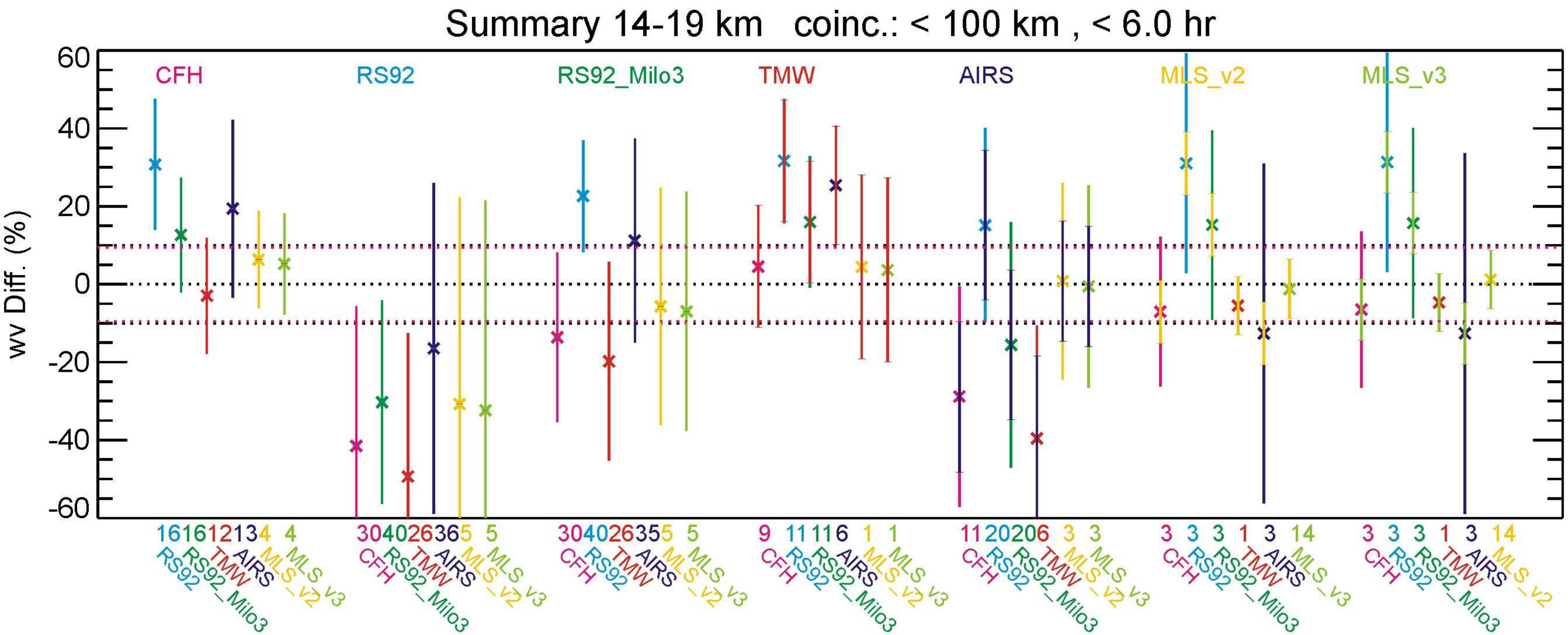
FTIR Profiles vs. RS92 (Milo-corrected v3)

Retrieved by M. Schneider
3 to 4 independent points throughout the troposphere



MOHAVE-2009 Campaign Results

Summary of Mean Differences between 7 different datasets near the tropopause



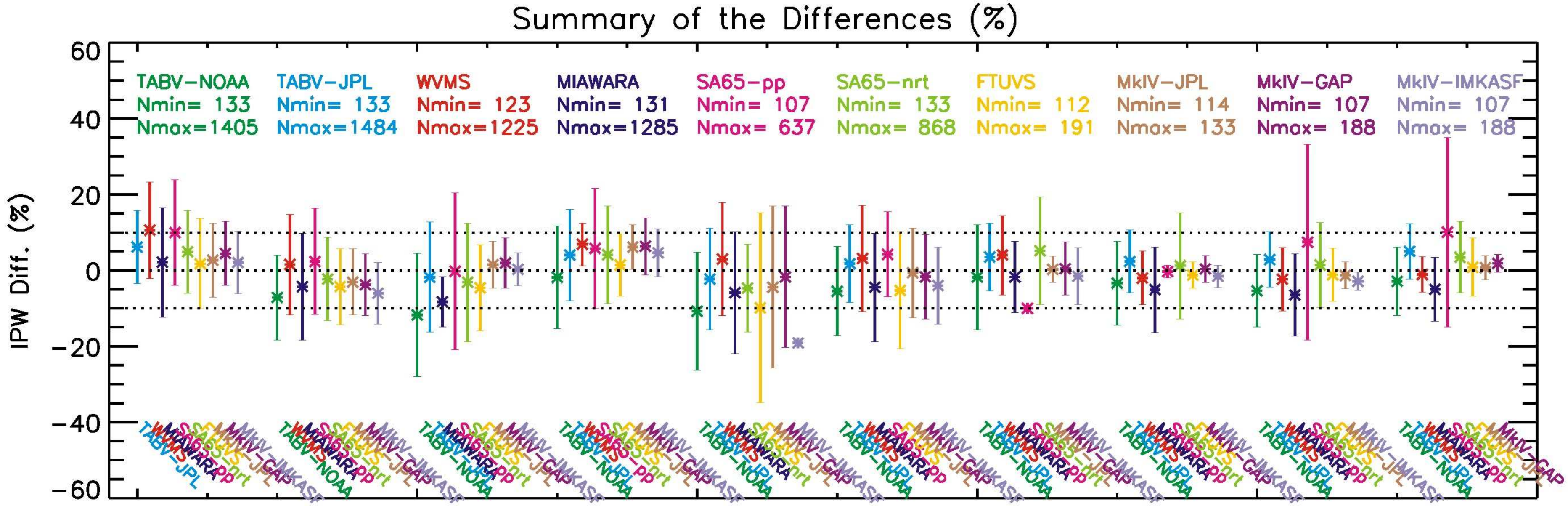
GRUAN

MOHAVE-2009 Campaign Results

Summary of Mean Differences between 10 different Total Precipitable Water datasets

All datasets agree within 10% (~0.5 mm)

Important implications for the long-term stability of the calibration of potential co-located lidars



Special Issue (5-10 papers) on MOHAVE-2009 to be published in AMT in 2011

For more info/results on MOHAVE-2009, visit the website:
http://tmf-lidar.jpl.nasa.gov/campaigns/mohave2009.htm

Other Matters relevant to TTAM ToR

Metadata (FTIR):

NDACC data now archived in HDF format following GEOMS standards
It is expected that the same meta-data standards be used for GRUAN

Definition of Best Measurement Practices (FTIR):

The NDACC/IRWG has Guidelines for Observations amd Retrievals that can be downloaded from:
http://www.acd.ucar.edu/irwg/irwg_info.html/

GRUAN-TTAM Terms of Reference

Satellite Instruments (by Tony)

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Recent Interface With Other Expert Teams

Ongoing: Joint Polar Satellite System (JPSS) Satellite Operational Algorithm Team (SOAT):

Cal-val intensives planned in conjunction with NPP launch of ATMS and CrIs (microwave and FTIR) sensors and derived products

GRUAN site coordination (ARM …) in planned Cal-val a point of interest for ICM-3

NPP Scheduling for intensive Cal/vals pending

NPROVS for routine product validation

Inventory of Potential Instruments (H_2O)

JPSS (afternoon, Oct 2011):
CrIs, ATMS, VIIRS

MetOp (late morning):
HIRS, AVHRR, IASI, AMSU, MHS

NOAA-18, 19 (afternoon):
HIRS, AVHRR, AMSU, MHS

COSMIC … 1500/day

COSMIC-2 (2014) … 8000/day

DMSP SSMIS F16,17

Data Products and Uncertainty Budgets

Satellite:

4.1.6.1.1 *Atmospheric Vertical Moisture Profile (*DOC/*DoD). Water vapor mixing ratio profile throughout the troposphere where moisture is normally measured via radiosonde. (Units: g kg^{-1}).

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	15 km at nadir	1 km
b. Vertical Reporting Interval		
1. Surface to 850 mb	20 mb	5 mb
2. 850 to 100 mb	50 mb	10 mb
c. Mapping Accuracy	5 km	0.5 km
d. Measurement Uncertainty (expressed as percent error of average mixing ratio in 2 km layers)		
Clear:		
1. Surface to 600 mb*	**Greater of 20 % or 0.2 g kg^{-1} (DoD: 25 %)**	10 %
2. 600 mb to 300 mb	Greater of 35 % or 0.1 g kg^{-1}	10 %
3. 300 mb to 100 mb	Greater of 35 % or 0.1 g kg^{-1}	10 %
Cloudy:		
4. Surface to 600 mb*	**Greater of 20 % or 0.2 g kg^{-1} (DoD: 25 %)**	10 %
5. 600 mb to 400 mb	Greater of 40 % or 0.1 gkg^{-1}	10 %
6. 400 mb to 100 mb	Greater of 40 % or 0.1 g kg^{-1}	10 %
e. Latency	156 minutes	15 minutes
f. Refresh	6 hours	3 hours
g. Long-Term Stability**	2%	1%

** Only applies to measurements from CrIS and ATMS.

Data Products and Uncertainty Budgets

Satellite:

4.1.6.1.2 *<u>Atmospheric Vertical Temperature Profile (*DOC/*DoD)</u>. Sampling of temperature at stated intervals throughout the atmosphere.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
1. Clear, nadir	18.5 km	1 km
2. Clear, worst case	100 km	1 km
3. Cloudy, nadir	40 km	1 km
4. Cloudy, worst case	50 km	1 km

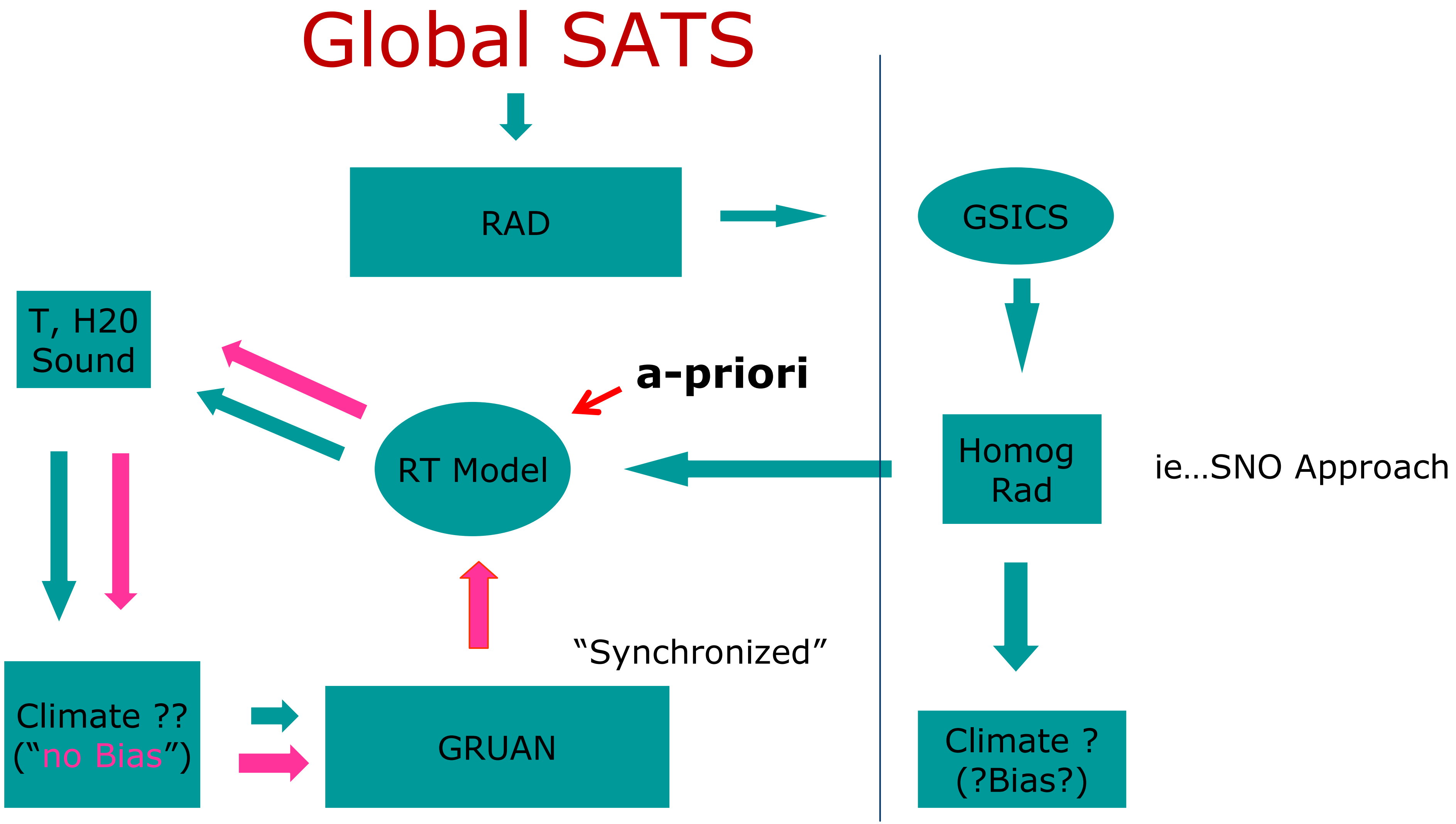
Data Products and Uncertainty Budgets

Satellite: AVTP (continued)

b. Vertical Reporting Interval		
1. Surface to 850 mb	20 mb	10 mb
2. 850 to 300 mb	50 mb	10 mb
3. 300 to 100 mb	25 mb	10 mb
4. 100 to 10 mb	20 mb	10 mb
5. 10 to 1 mb	2 mb	1 mb
6. 1 to 0.1 mb	0.2 mb	0.1 mb
7. 0.1 to 0.01 mb	0.02 mb	.01 mb
c. Mapping Accuracy	5 km	0.5 km
d. Measurement Uncertainty (expressed as error in layer average temperature)**		0.5 K
Clear:		
1. Surface to 300 mb*	**1.6 K per 1 km layer**	
2. 300 mb to 30 mb	1.5 K per 3 km layer	
3. 30 mb to 1 mb	1.5 K per 5 km layer	
4. 1 mb to 0.01 mb	3.5 K per 5 km layer	
Cloudy:		
5. Surface to 700 mb*	**2.5 K per 1 km layer**	
6. 700 mb to 300 mb	1.5 K per 1 km layer	
7. 300 mb to 30 mb	1.5 K per 3 km layer	
8. 30 mb to 1 mb	1.5 K per 5 km layer	
9. 1 mb to 0.01 mb	3.5 K per 5 km layer	
e. Latency	156 minutes	15 minutes
f. Refresh	6 hours	3 hours
g. Long-Term Stability***		
1. Trop. Mean	0.05 K	0.03 K
2. Strat. Mean	0.10 K	0.05 K

** Measurement Uncertainty as specified in 4.1.6.1.2 shall be referenced to the Cloudy Horizontal Cell Size thresholds and objectives as listed under 4.1.6.1.2-3 and 4.1.6.1.2-4.
*** Only applies to measurements from CrIS and ATMS.

Validation Strategies and Results: Satellites

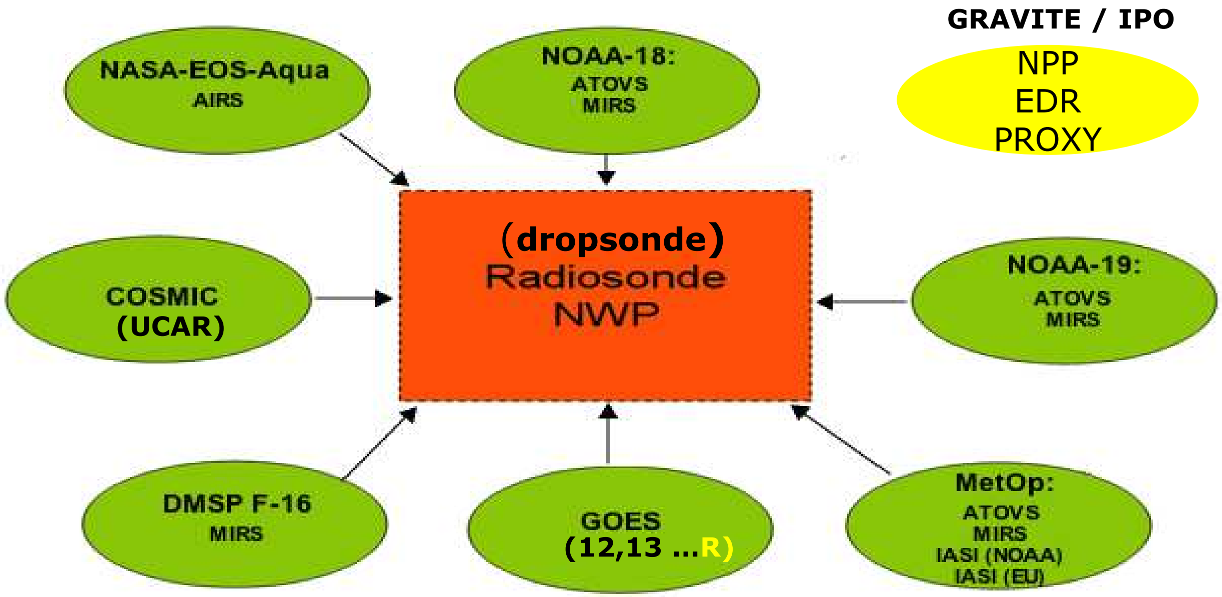


Validation Strategies and Results: Satellites

NPROVS)

Single Closest

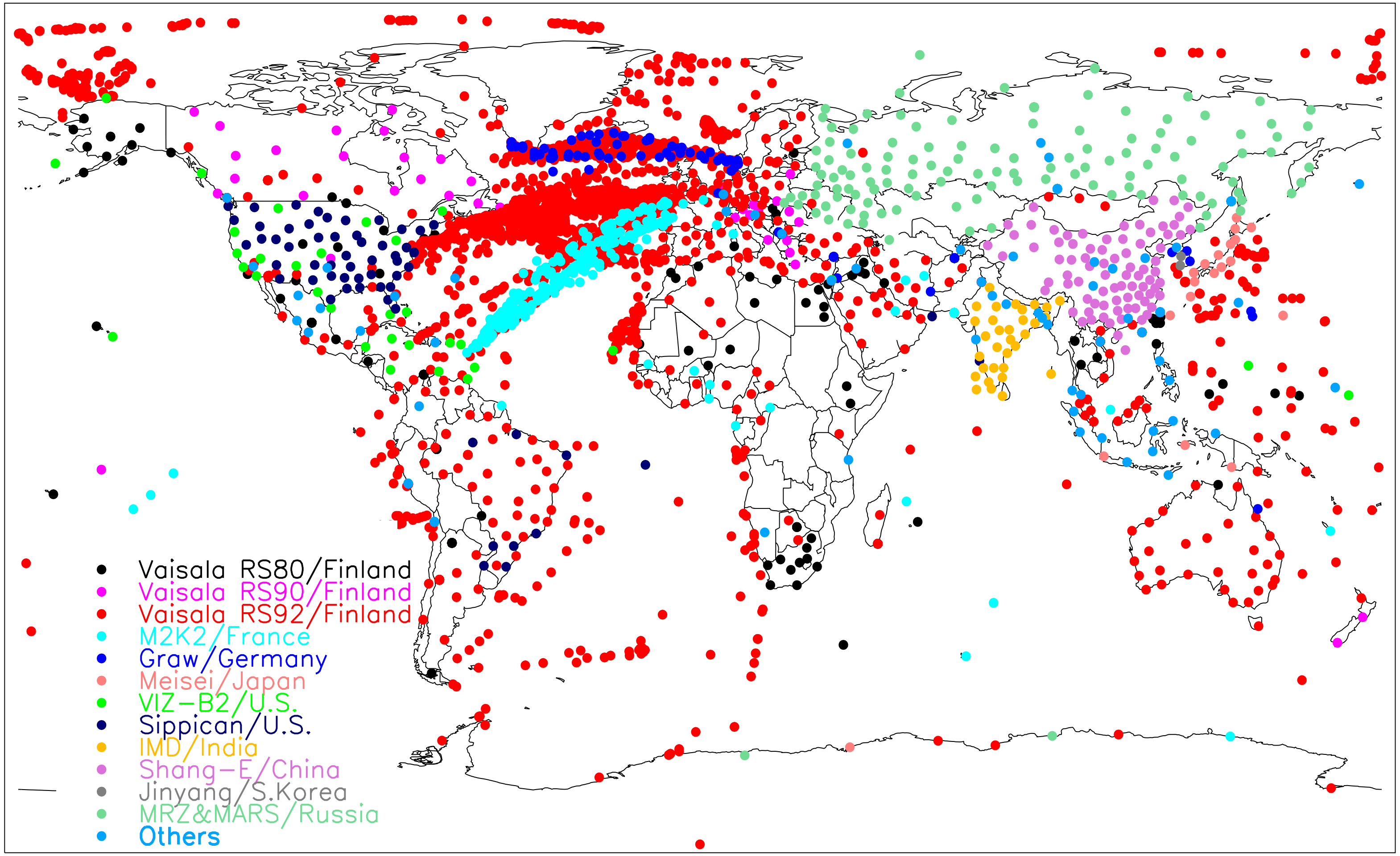
6-hour



250km

Collocated radiosonde and multiple satellite products dataset

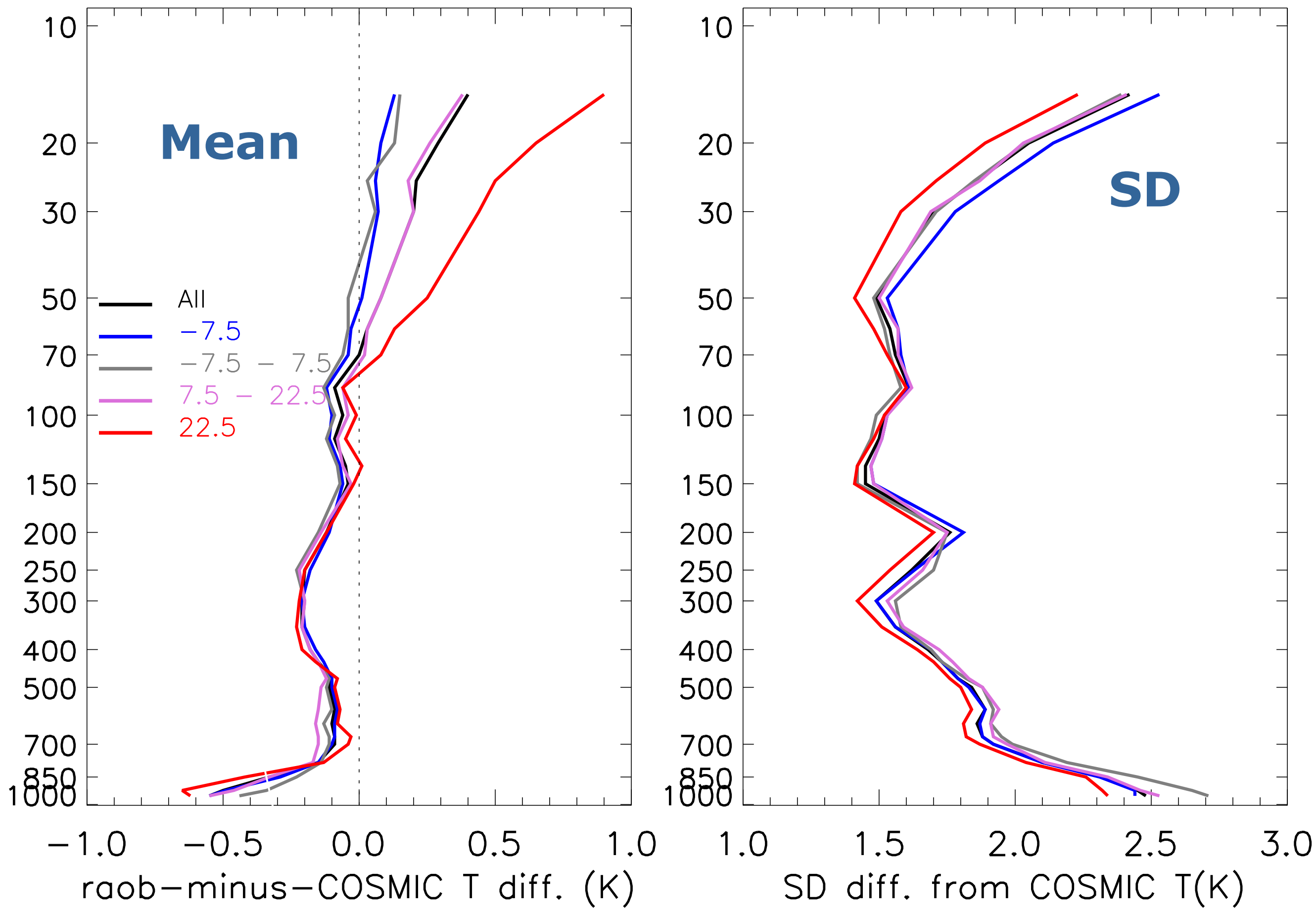
Validation Strategies and Results: Satellites

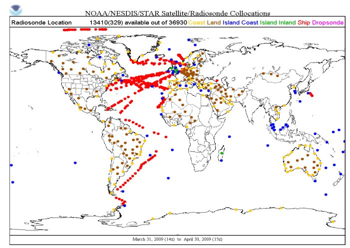


Operational raobs

Validation Strategies and Results: Satellites

Vaisala RS92
(Trad-minus-COSMIC T *)





57,200 profiles

Radiosonde Radiation Correction analysis…

Validation Strategies and Results: Satellites

Time Mismatch Impact per 3 hr

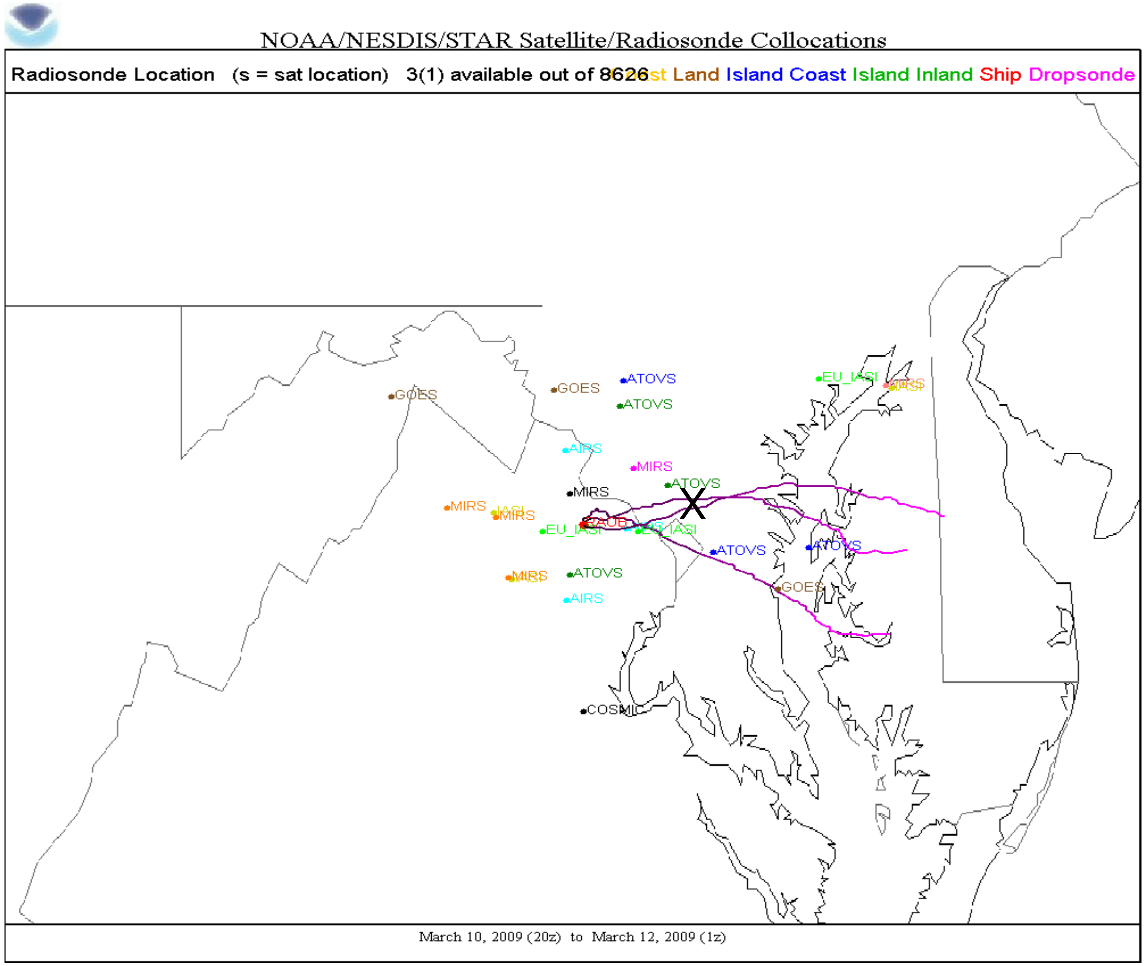
	T (K)	RH (%)	Fractional N (%)
Globe	0.35 (0.042)	3.44 (0.507)	0.33 (0.038)
	0.30 (0.042)		
Mid-high Latitudes	0.40 (0.049)	3.68 (0.549)	0.34 (0.036)
	0.27 (0.053)		
Low Latitudes	0.11 (0.121)	2.45 (0.980)	0.22 (0.095)
	0.47 (0.139)		

SD errors introduced by *time mismatch per 3hr* averaged from 850 hPa to 200 hPa for the troposphere (*and 200 hPa to 10 hPa for the stratosphere T, second row*); values within the parentheses are the standard errors of the estimations; mid-high latitude is poleward 30º

Validation Strategies and Results (Reale/Demoz)

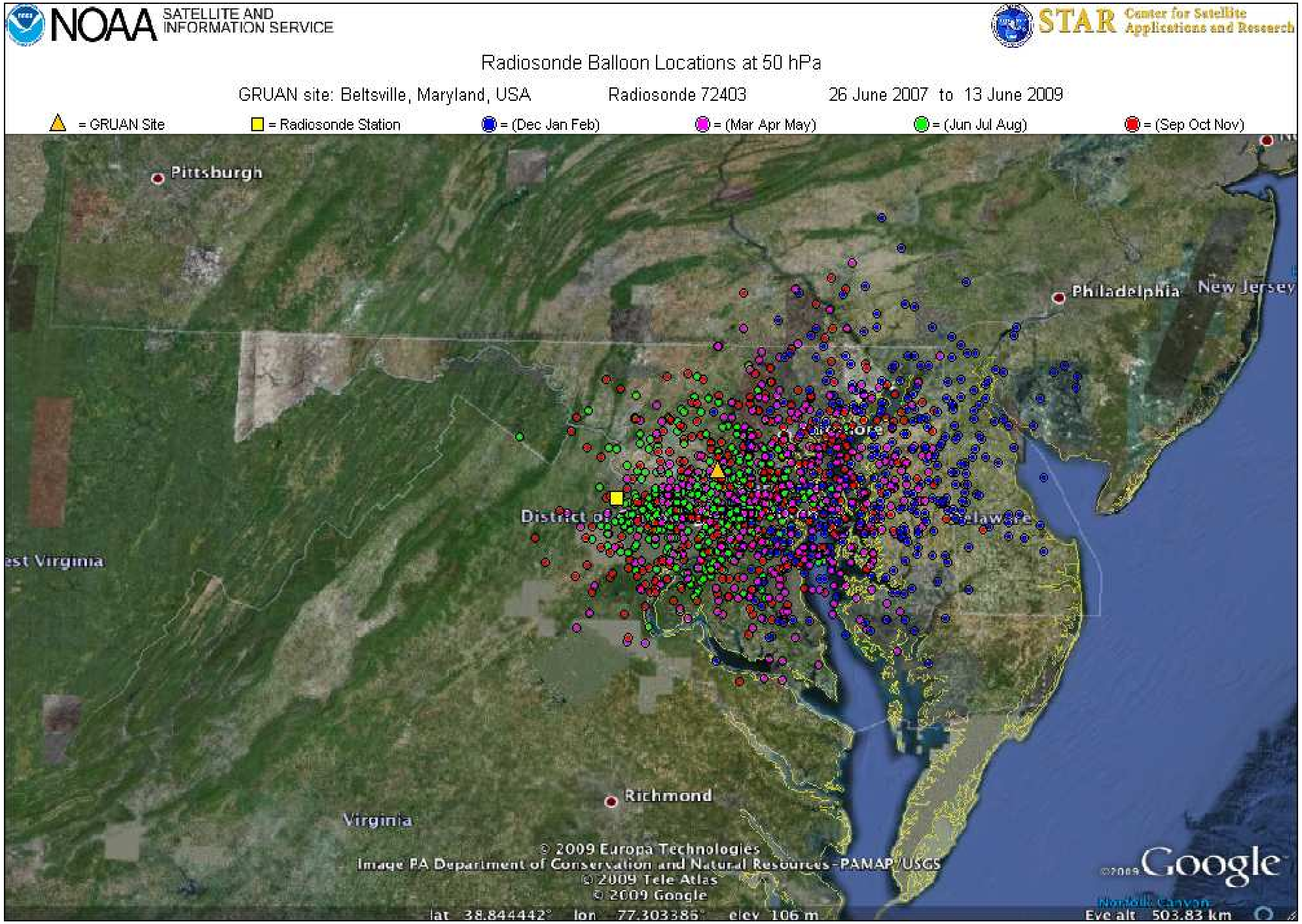
... focused on spatial representativeness of GRUAN sites in climate monitoring and satellite calibration/validation. Specifically on use of available Sterling and Beltsville sondes, ancillary Beltsville data and collocated satellite observations to quantify the spatial domain of Beltsville column and in particular the representation of Sterling sondes for Beltsville ...

extend to other sites in future!



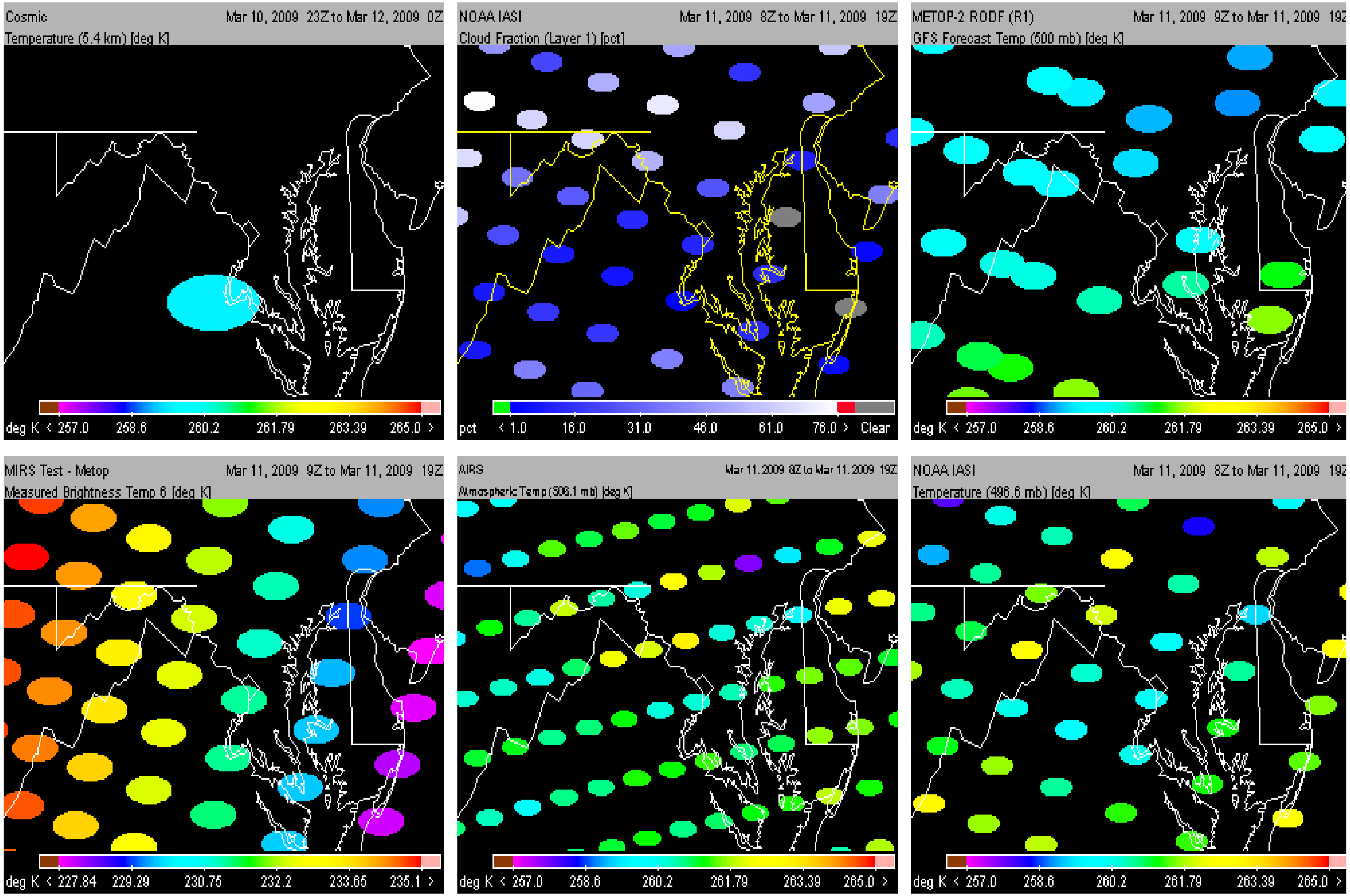
3 consecutive sondes, March 10-12 and drift over **Beltsville**

Validation Strategies and Results (Reale/Demoz)



… at 50mb, peak drift during winter, 200 km, almost to Philadelphia ….

Validation Strategies and Results (Reale/Demoz)



Examples of satellite 500mb T, MWR spectral intervals and footprints

What's Next for GRUAN-TTAM?

Lidar, Microwave, FTIR, and Satellites:

TBD !!