GATNDOR - GRUAN Analysis Team for Network Design and Operations Research: status and progress

F. Madonna, A. Fassò, D. Seidel,
J. Wang, P. Thorne, T. Gardiner, D. N. Whiteman,
J. Dykema, G. Bodeker (and all the collaborators)

imaa istituto di metodologie per l'analisi ambientale

Status

Scope

The team performs focused, short-term analyses of existing observations to address specific topics identified by the GRUAN science and management community.

- 3 Topics (Management of change will be no more on the list after ICM-4)
- new topic/scientific question proposed at ICM-3 but not yet volunteers
- Proposal in submission for funding (co-location)
- Enlargement of partnership: needed at this stage but well-focused
- GATNDOR: next year critical

Work Plan 2011-2012

Topic 1: Co-location of Observations

Research Question: How far apart can measurement systems be and yet be considered to effectively sample the same atmospheric column? How far apart can sub-sites be and still be considered a single GRUAN site?

Deliverables available by ICM-4:

a. Toolbox for evaluating co-location issue

b. Draft of a related manuscript

Team leader: Alessandro Fassò (Dian Seidel)

Talk by A. Fassò on Friday morning

Work Plan 2011-2012

Topic 2: Management of Change

Research Question: To better manage changes from one instrument type to another and to accurately merge the two data segments to create a homogeneous time series, what co-incident, independent (i.e. redundant) measurements, how much and what kind of associated metadata, and how much overlap between old and new instruments are needed

Deliverables available by ICM-4:

a. Quantitative assessment (based upon Lindenberg, Tateno, Payerne)
b. Targeting a manuscript

Team leader: Junhong Wang

talk by J. Wang on Friday morning

Work Plan 2011-2012

Topic 3: Quantifying the Value of Complementary Observations

Research Question: How much is measurement uncertainty reduced by having redundant or complementary measurements of a given variable?

Deliverables available by ICM-4:

a. Reccomendation for an optimal observation strategy related to GRUAN phase 1 and 2 (manuscript)

b. Reccomendations for the equipment to operate/acquire at the GRUAN sites

Team leader: Fabio Madonna

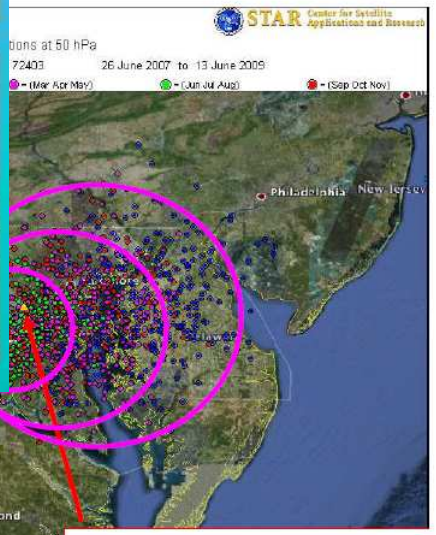
GATNDOR activity

- 3-monthly calls continue (extra-telecon)
- Delivery of the annual workplan
- Link with TT5, document sent to co-chairs
- TT5 (ancillary measures) offered at ICM-3 advice and effort, but not yet cooperation
- Contribution at conferences (e.g WCRP, ITS9)

imaa istituto di metodologie per l'analisi ambientale

Use of measurements

GRUAN stations are highly instrumented sites able to provide redundant measurements.
Cross-checking of redundant measurements for consistency is an essential part of the GRUAN quality assurance procedures.



➔Beltsville/Sterling as a GRUAN-NWS transfer point.

….. at 50mb (~20km)

Sterling: NOAA/NWS Site
IPW: GPS/NOAA
Sonde: RRS (2Xday)

Beltsville: GRUAN site
IPW: GPS/NOAA
MWR: 2 & 39 Channel
Sonde: GRUAN (Wkly)
Raman: HURL/ALVICE

GRUAN ICM3, 28 Feb-4 M

Potential new research topics

1. Covariance matrices: necessary/useful for vertically correlated uncertainties when going to a derived product?
2. Use of GRUAN data (as soon as hystorical RS reprocessing will be available)
3. Checking re-analysis using GRUAN data
4. Impact of co-location uncertainty and sinergetic GRUAN products

Perspectives (to discuss)

- End of 2013, final results from all current topics
- Revitalize GATNDOR activity and recruitment of new volunteers for new topics.
- Proposal for funding of co-location activities (Italy)
- New chair since the next ICM-5

GATNDOR: Quantifying the value of complementary observations for GRUAN operations

Fabio Madonna

Acknowledgements to ARM, Payerne and Potenza Teams

Work Plan 2011-2012

Topic 3: Quantifying the Value of Complementary Observations

Research Question: How much is measurement uncertainty reduced by having redundant or complementary measurements of a given variable?

Deliverables available by ICM-4:

a. Reccomendation for an optimal observation strategy related to GRUAN phase 1 and 2 (manuscript)

b. Reccomendations for the equipment to operate/acquire at the GRUAN sites

Team leader: Fabio Madonna

Outline

- Redundancy concept
- Measurements correlation
- Comparison and impact on RTM
- First remarks on the site equipment

imaa istituto di metodologie per l'analisi ambientale

Reduction of errors

Uncertainty Management theory

This theory contrasts uncertainty reduction theory by identifying reduction as only one of the many actions that people take when uncertainty arises.

Gudykunst (1985) points out that Uncertainty Reduction Theory was formulated to describe the actions and behaviors of middle-class, white strangers in the United States

(From Wikipedia)

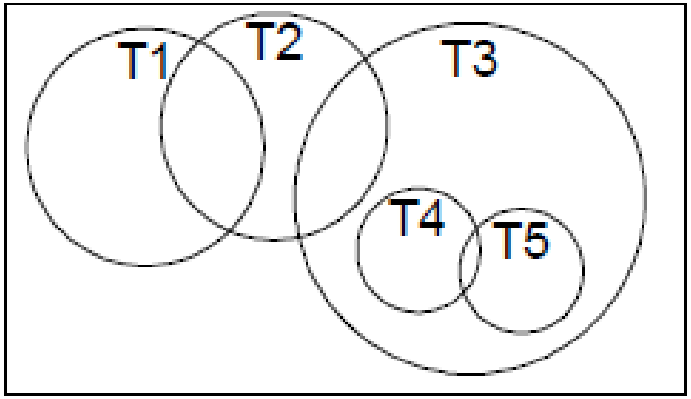
What is redundancy?

- This is the seeming contradiction:
  - Redundancy is something, which is repeated because it is *necessary* to ensure proper operation of some mechanism
  - Redundancy is something, which is *superfluous* because it is not needed or wanted

- Two different aspects of redundancy
  - Independency
  - Duplication

Redundancy metric

- T3, T4 redundant
- T3, T5 redundant
- T1, T2 partial redundant



Evaluation of measurement redundancy

- Several methods exists (correlation, factor analysis, time series, redundancy analysis)

List of “redundant measurements”

In order to have a “triple redundancy” like reported in GRUAN manual, we have to select the follwing sensors

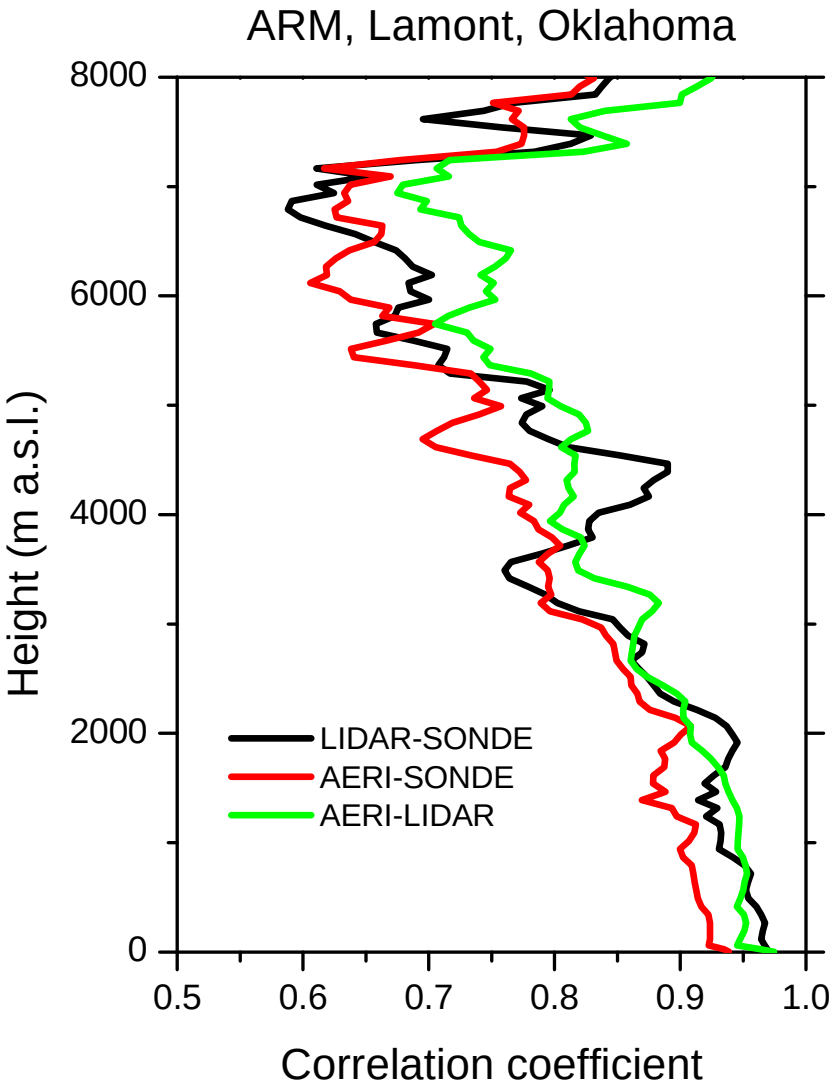
- Humidity
  - Profiling: Sonde (IS), CFH (IS), Raman lidar (A), DIAL (A), MW profiler (P), FTIR (P)
  - Integrated: Sonde (IS), GPS (P), MWR (P), FTIR (P), Lidar (A), Sun photometers (P).

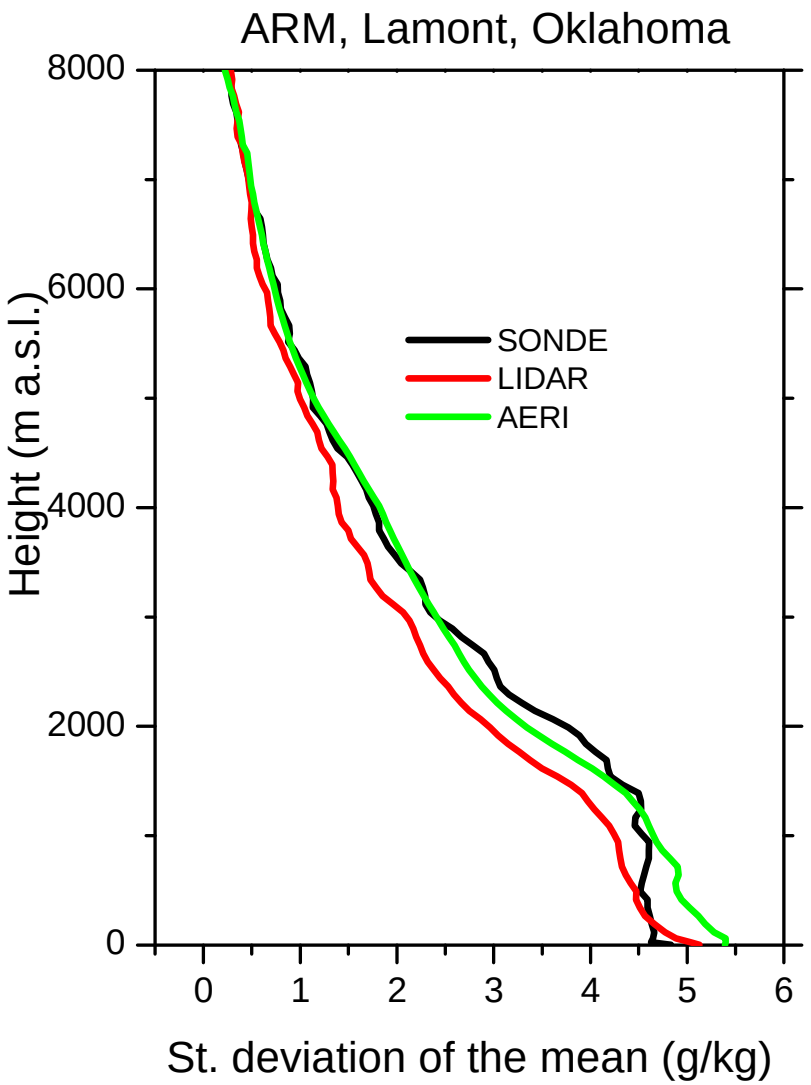
- Temperature

- Profiling: Sonde (IS), CFH (IS), Rotational Raman lidar (A), Rayleigh lidar (A), MW profiler (P), FTIR (P), RASS (A)

Redundancy evaluation: correlation

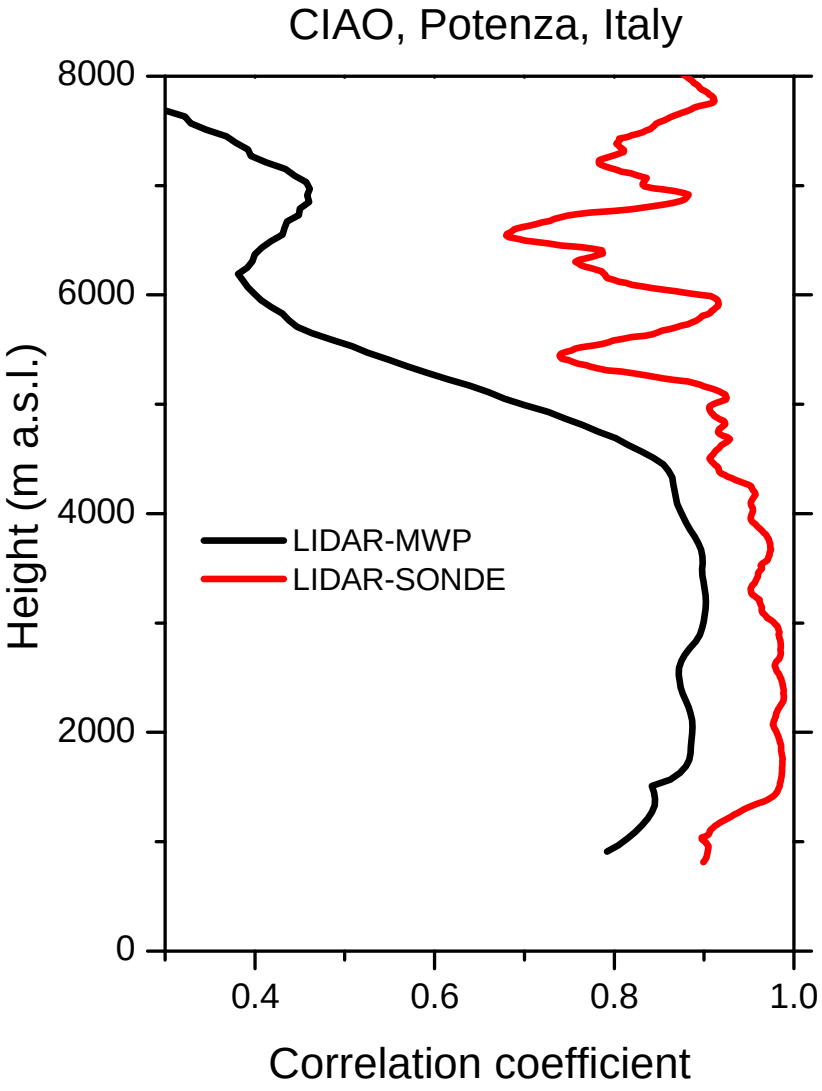
Year 2010, matches with clear sky ad lidar available over 7 km a.s.l.

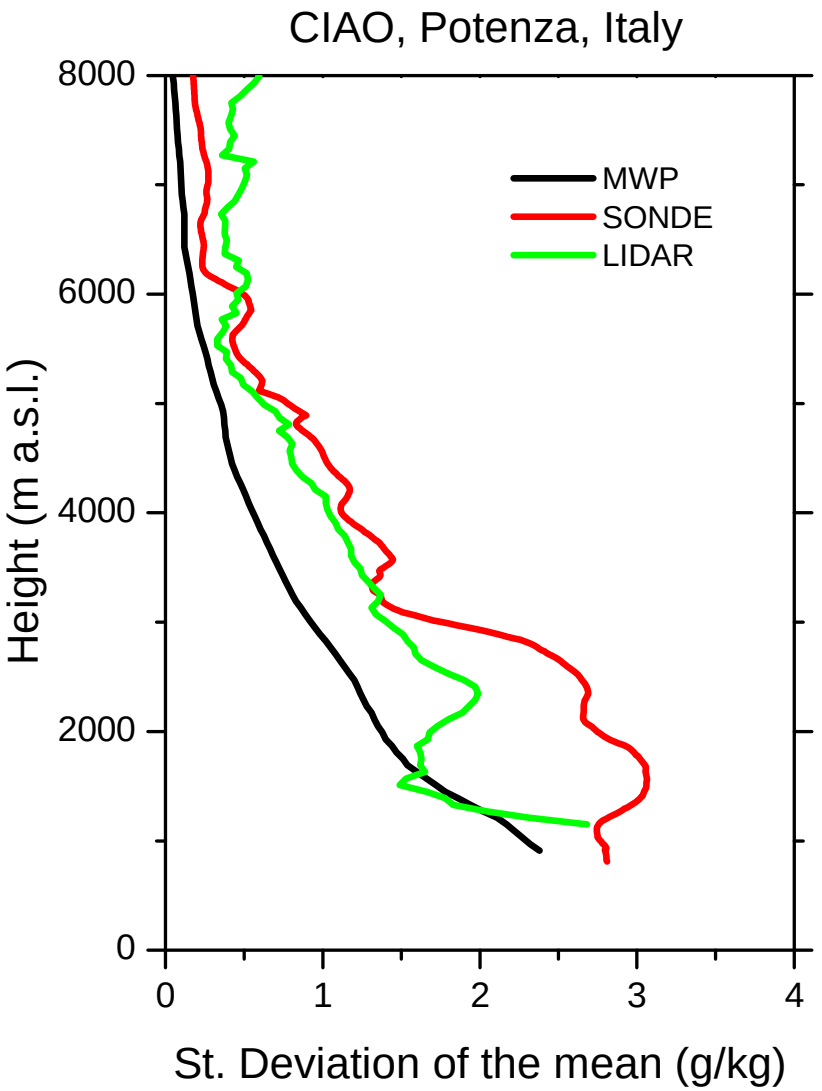




Redundancy evaluation: correlation

Year 2010, matches with clear sky ad lidar available over 7 km a.s.l.





RTM: combined measurement

Along with Raman lidar and sonde profiling measurements, other combinations have been evaluated;

1.MWR – Sonde from ARM VAP program (LSSONDE)

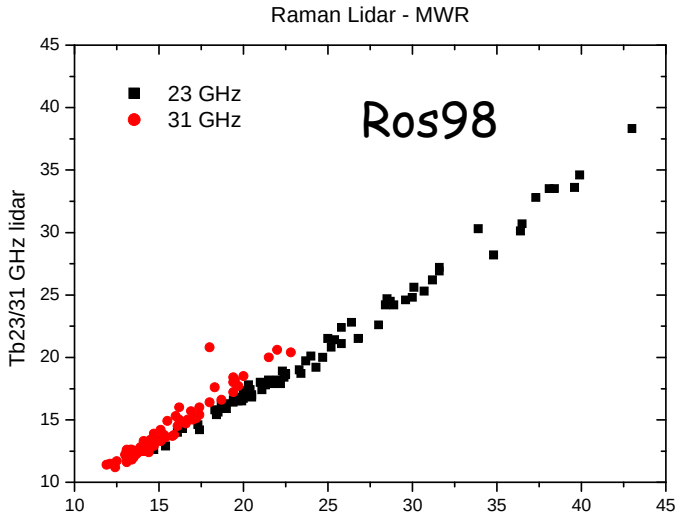
2.Raman lidar – sonde combination using the conditional probability theory (potential reduction of average random error)

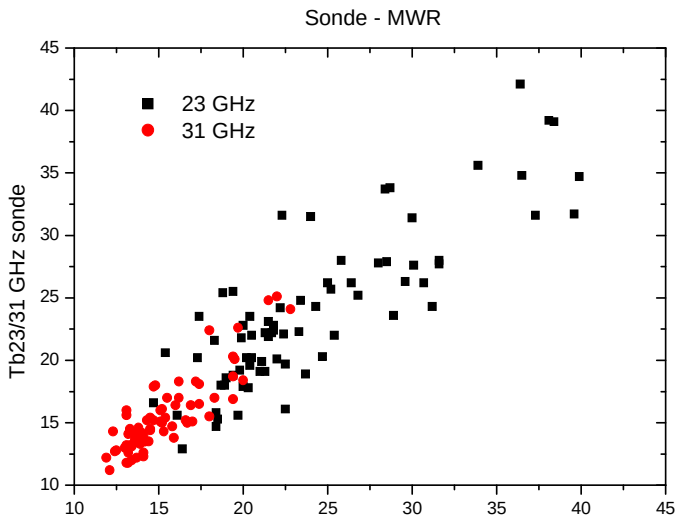
$$f_{X,Y}(x,y) = \frac{1}{2\pi\sqrt{1-\rho^2}} \cdot e^{-(x^2-2\rho xy+y^2)/2(1-\rho^2)}$$

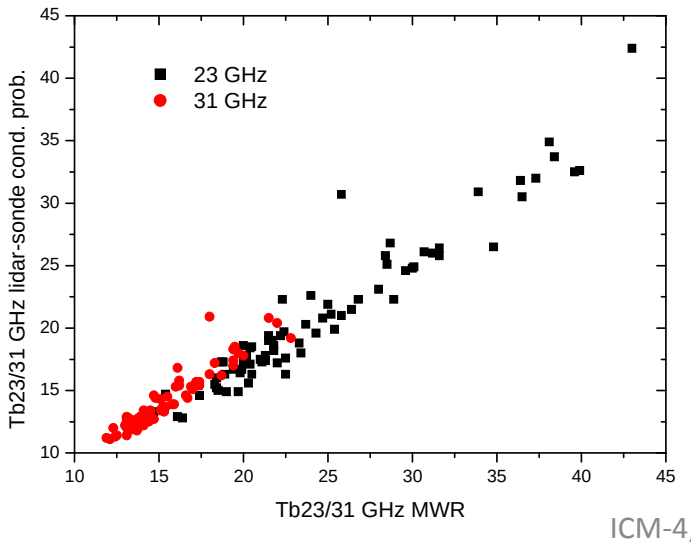
3.Raman lidar – sonde glued with the lidar up to altitude levels where uncertainty exceeds 25 %, using a spline interpolation in between (reduction of co-location impact)

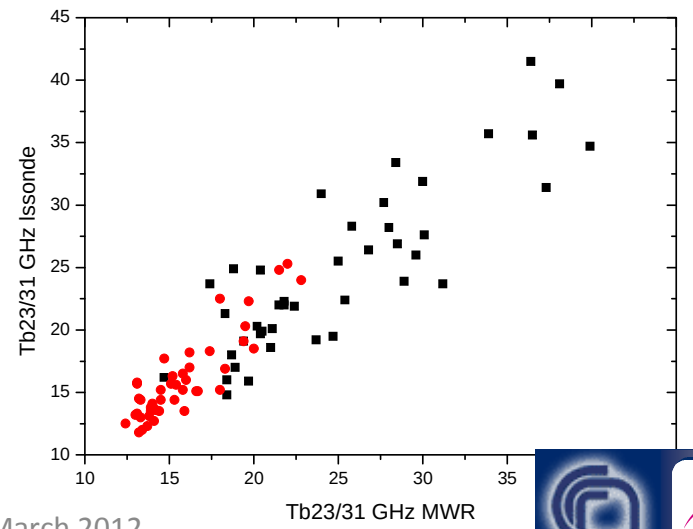
Brightness temperature comparison

Matches with clear sky ad lidar available over 7 km a.s.l.



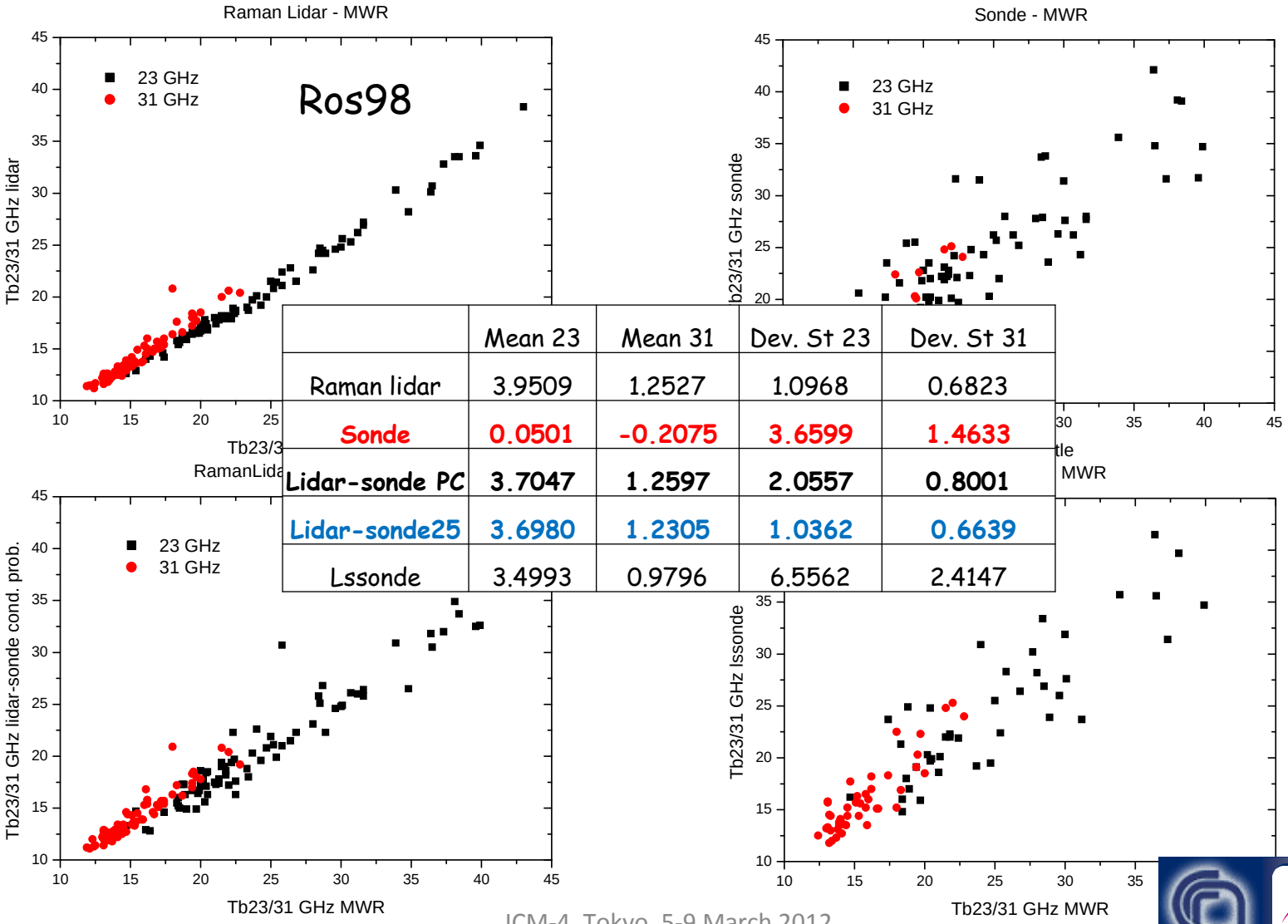






Brightness temperature comparison

Matches with clear sky ad lidar available over 7 km a.s.l.



	Mean 23	Mean 31	Dev. St 23	Dev. St 31
Raman lidar	3.9509	1.2527	1.0968	0.6823
Sonde	0.0501	-0.2075	3.6599	1.4633
Lidar-sonde PC	3.7047	1.2597	2.0557	0.8001
Lidar-sonde25	3.6980	1.2305	1.0362	0.6639
Lssonde	3.4993	0.9796	6.5562	2.4147

Redundant measurements: issues in use of data

- Uncertainty budget

$$\Delta E = \sqrt{\Delta r^2 + \Delta s^2 + \Delta t^2 + \Delta i^2}$$

Δr = observation error, including all the error contributions due to statistical noise, sensor response functions, rounding errors
Δs, Δt = observation representativeness due to space and time co-location, respectively.
Δi = error related to the model used for comparison with observations.

- Instrumental differences, non homogeneity (Very different equipment at the sites but if data available and co-investigated with the sites, potential significant results migth be obtained – TT5)
- Co-location
- Measurement scheduling (TT3)

Redundancy levels

- Indepedent redundancy of measurements (Integration of measurements, e.g. conditional probability)
- Duplication redundancy (e.g for IPWV)
- Sensors calibration/inter-calibration and first guesses (e.g MWR for lidar calibration, sonde for passive profilers)
- Redundancy for filling the gaps and increase time sampling

First remarks

• Recommendations on the equipment

1. Redundancy on humidity vertical profile:
   - Passive profiler redundancy might be useful but dependent on first guesses
   - Redundancy on IPWV:
   - night-time lidar to be compared with GPS for further validation
   - Sun photometer to be tested,
   - Sonde (CFH) not the best solution for IPWV (co-location)
   - Lidar-sonde combination possible solution

• Recommendations on Lidar-sonde combination

1. Conditional probability, 25 % merging and LSSONDE
2. Lidar-Sonde combination solution to investigate for the reduction of both random and co-location uncertainty
3. Impact of sonde spartial drift the RTM (more models to be used)

Analysis to be performed for temperature.

Persectives

- Results and recommendation by ICM-5 (More data from more sites and instruments (retrievals) are needed for coming up with final conclusions Payerne and Potenza data analysis in progress)

- IPWV comparison (Lidar, Sun photometer, GPS, MWR, AERI)

- PCA (eigenvalues and variances): simple routine for redundancy classification.

- Analysis using data from more sites for single technique and combined use of profiling data