Combined cloud radar and lidar aerosol observations in Potenza, southern Italy

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Introduction

Which is the problem?

Giant and **ultragiant aerosols** (r > 5 μm) distribution and importance for global meteorology and climate through **warm rain** processes and **ice nucleation** is not well known. They expedit warm rain processes by acting as **GCCN** (Giant Cloud Condensation Nuclei[1-3]) and are efficient **IN** (Ice Nuclei), increasing the ice formation temperature.

What can we do?

Combine different instruments aerosol measurements:

- **Lidar** and sun photometer are used to retrieve aerosol microphysical properties between 100 nm and few μm[4] in absence of thick clouds
- **Cloud radar** can detect giant and ultragiant aerosols[5]

How do we do it?

- Establishing an **aerosol detection** methodology with the **cloud radar**
- Analysing **lidar simultaneous measurements** and retrieving their size distributions by lidar inversion codes
- Creating an **effective radius** radar **inversion** code
- Using the **lidar-radar synergy** to obtain the aerosol effective radius

Where?

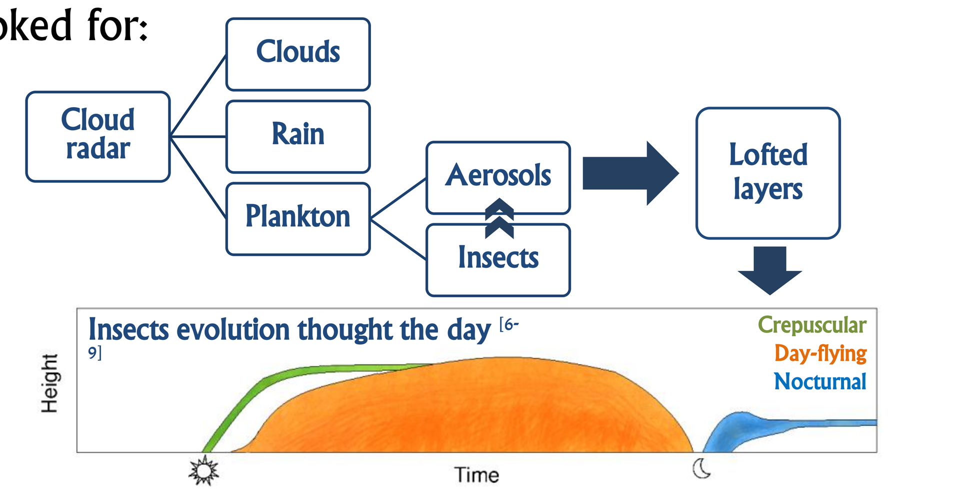
Aim

Enlarge the range where aerosols can be observed and their microphysical properties characterized

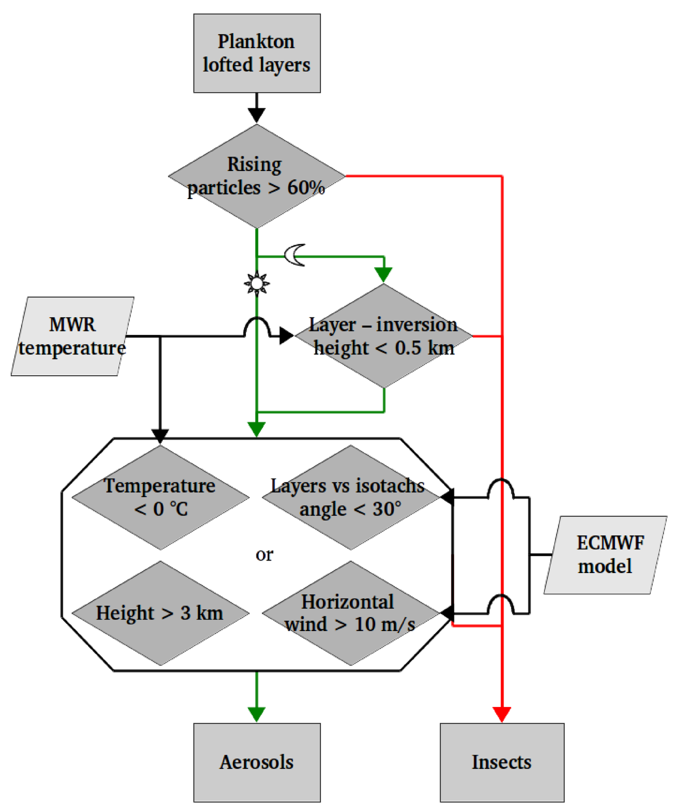
Methodology

Aerosol detection with a cloud radar

1. Lofted plankton layers respect to the insects are looked for:



2. Using the knowledge from several entomology studies[6,10-14], the layers are classified:



Lidar simultaneous measurements

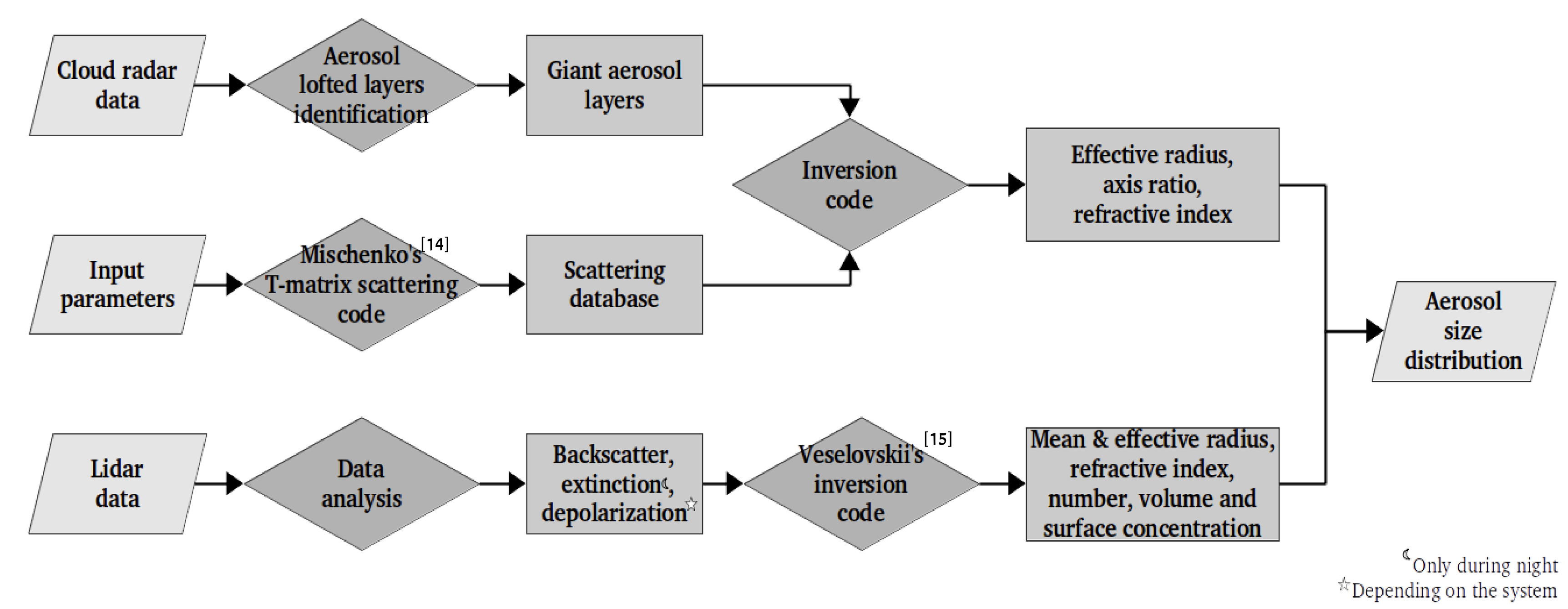
Raman lidars (Nd-Yag) emit at 355, 532 and 1064 nm and receive the elastic backscattered light at the same wavelengths and the Raman backscattered light at 387 (N_2), 407 (H_2O_v) and 607 nm (N_2).

By analysing the measured signals, the extensive and intensive parameters are obtained. The first depend on the particle concentration, while the second on the particle type.

Extensive	Intensive
Backscatter (β)	Lidar ratio (S)
Extinction (α)	Ångström exponent (Å)
	Depolarization (δ)

Effective radius retrieval

Cloud radar and lidar measure the signal backscattered by different targets ($\lambda_{radar} >> \lambda_{lidar}$), and the particle size retrieval cannot be jointly done. For the radar, a look-up reflectivity and LDR table was build with a T-matrix scattering code and is consulted to obtain the most probable particle size, shape and refractive index. For the lidar, an already existing inversion code is used. Then, the inverted size parameters from both instruments are combined.



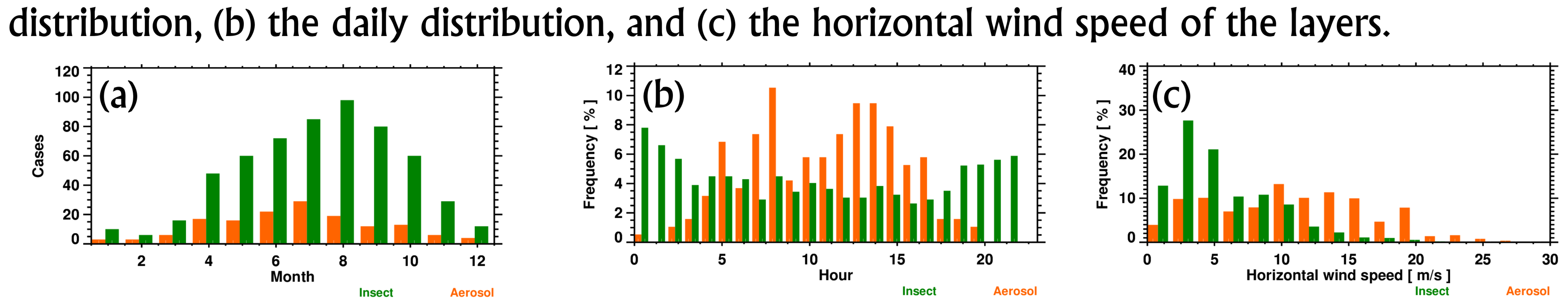
Only during night
Depending on the system

Results

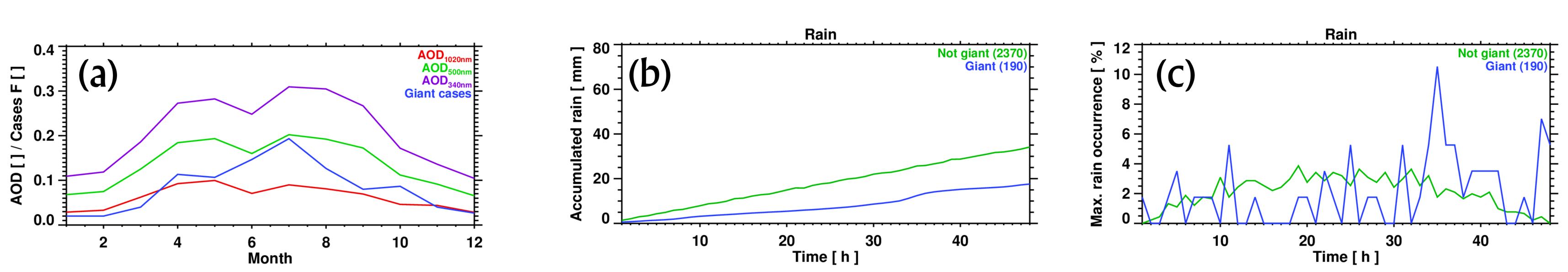
Cloud radar aerosol dataset

The application of the new methodology to the period March 2009 – June 2015 resulted in the identification of **150 aerosol** and **576 insect lofted layers**.

Some general statistics of these layers are shown in the next histograms: (a) the monthly distribution, (b) the daily distribution, and (c) the horizontal wind speed of the layers.



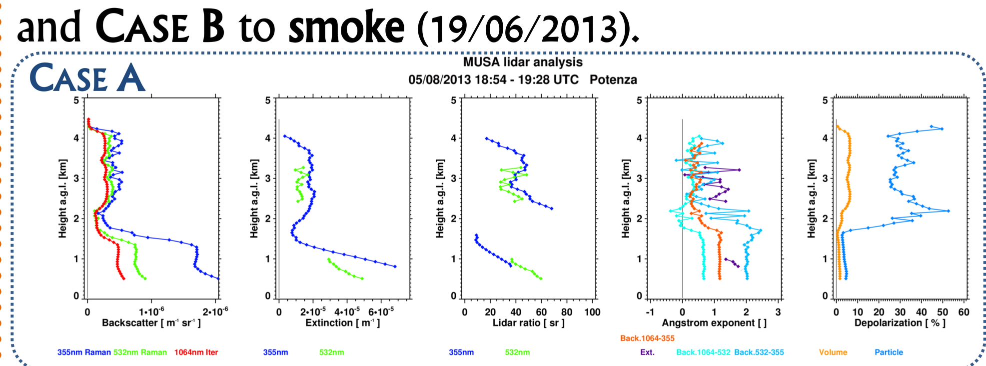
The effects of giant aerosols in (a) AOD and (b) accumulated and (c) maximum precipitation:



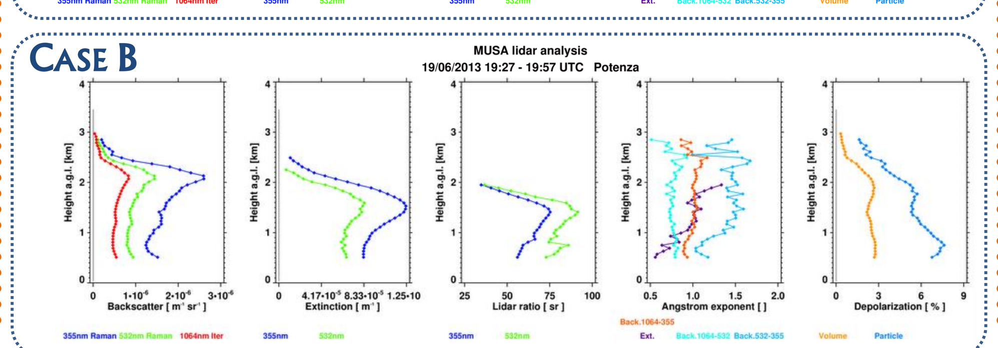
Lidar simultaneous measurements analysis

The lidar measurements simultaneous to giant aerosols observations were analyzed. Two examples are shown: **Case A** corresponds to **dust** (08/05/2013) and **Case B** to **smoke** (19/06/2013).

CASE A



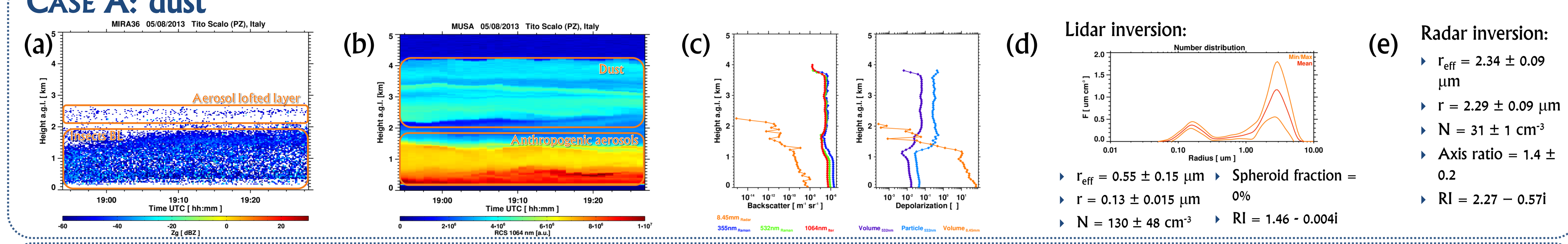
CASE B



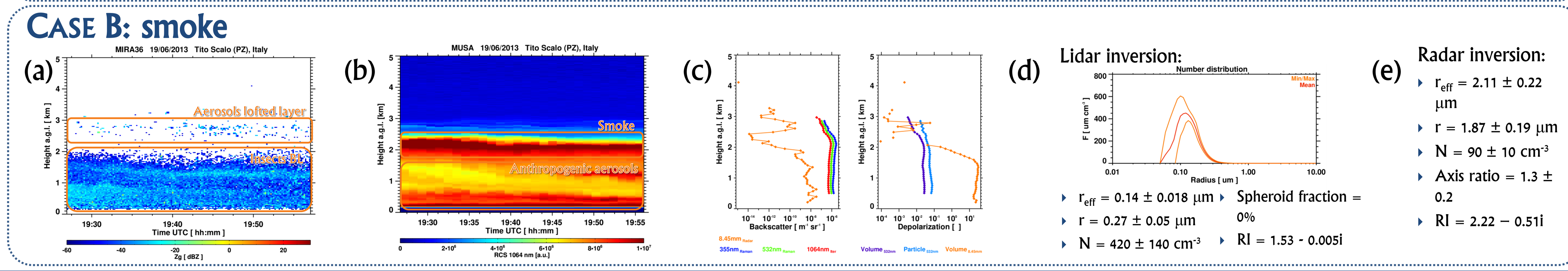
Lidar and cloud radar synergy

The time-range evolutions of (a) the radar reflectivity and (b) the lidar Range Corrected Signal (RCS) at 1064 nm, (c) the backscatter profiles, (d) the lidar size distribution and (e) the radar effective radius are the following:

CASE A: dust



CASE B: smoke



Conclusions

Clour radar aerosol observation

- **Giant aerosols** can be **observed** with a cloud radar
- **Entomology criteria** are appropriate to discriminate aerosols and insects
- Large number of layers detected (**~ 20/year**)
- The **size range** where aerosols can be observed is **enlarged**

Giant aerosol effects

- The **AOD seasonal evolution** is in accordance with aerosol observations
- The **precipitation life cycle** is modified: lower accumulation and more probability of intense rainfall, occurring preferentially ~1½ days after the observation

Synergy

- The **particles observed** by the two instruments are **different**
- The size distribution (lidar) and the effective radius (radar) can be retrieved by **inversion methods**
- Their merging is currently under investigation to obtain the **enlarged size distributions**

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37th Conference on Radar Meteorology, 14-18 Sept. 2015, Norman, OK

Acknowledgements: The financial support by the European Community's 7th Framework Programme under **ACTRIS** Grant Agreement n. 262254 and **ITaRS** Grant Agreement n. 289923 and by the national project "Programma Operativo Nazionale (**PON**) Regione Basilicata 2000/2006" are gratefully acknowledged.