Preliminary Results Combining Ground-based RAMAN Lidar and NAST-I Airborne Spectrometer to Describe the Evolution of a Cirrus Cloud – EAQUATE, ITALY 2004

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1. INTRODUCTION: ITALIAN EAQUATE CAMPAIGN

The EAQUATE campaign was designed to study the atmosphere using aircraft and ground based instruments, demonstrating the benefit of these measurements in validating hyper-spectral satellite sounding observations. The first phase took place in Italy (5th - 10th September 2004) and the second phase in the UK (13th - 22nd September 2004). The Protea high altitude aircraft participated in both campaigns, providing measurements from the NAST thermal infrared interferometer and microwave radiometer, the Scanning HIRLAM-RAMAN Lidar, and the micro-MAPS CO sensor. The Italian phase, funded by the Integrated Program Office and by the Province of Benevento, was carried out as part of an international collaboration between NASA Langley Research Center, University of Wisconsin, the Istituto di Metodologie per l’Analisi Ambientale (IMA-CNRL), the Mediterranean Agency for Remote Sensing (MARS) and the Universities of Basilicata and Napoli. The experiment involved a range of ground based remote sensing instruments (lidars, microwave radiometer, infrared interferometer, ceilometer) as well as an Earth Observing System Direct Readout Station. A radiative system has provided conventional profiles. The aircraft was based at the military side of the Napoli Capodichino airport. Aircraft and crew were hosted by the V GMV of the Italian airforce. Four flights were successfully completed with two different AQUA overpasses. The aircraft flew over the Napoli, Potenza and Titone studies through the campaign allowing the collection of coincident aircraft and in-situ observations [http://metresearch.net/eaquate/Homepage.html].

2. EXPERIMENTAL CONDITIONS: SEPTEMBER 6th 2004

Flight track and Potenza location are reported on the right, also the SEVIRI image is almost time-dependent.

3. GROUND BASE AND AIRBORNE SENSORS

4. WORK PLAN AND GOALS:

• To co-locate and jointly process data coming out from a range of different sensors (Radiosondes/Raman-lidar/NAST-I interferometer).
• To evaluate the relevance of the lidar information in clear and cloud sky conditions.
• To simulate very high spectral resolution radiometric information (at different viewing angles) by using a LIM Multiple Scattering code and to investigate the consistence between measured/modelled radiations in presence of ice clouds.
• To arrange a temporal sequence of the cloud cooling rates. Evaluate the importance of the combined lidar – spectrometer information in predicting the evolution of a cirrus cloud.
• To push down the basis for a full study of a cirrus cloud evolution accounting for the dynamics and microphysics.

5. DATA

The upper left panel shows the NAST-I interferometer, the SCFIR, Raman interferometer and the micro-MAPS CO sensor. The cloud effect is evident both in and out the cloud layers. A sensible gradient between cloud top and bottom is developed only in the presence of ice clouds.

6. METHODOLOGY:

Line-by-line computations are performed to obtain high resolution optical depths for the major gas absorbers. The radiosonde temperature profile is used to characterise the atmosphere below flight level during the 4 overpasses. The water vapour mixing ratio profile is obtained from the lidar measurements when the associated percentage errors are less than 50 %. The radiosonde mixing ratio profiles are used to fill the lower boundary region (600 m above the lid) and the lidar data affected by large uncertainties. The rest of the atmospheric column above is determined from the 18 IR channels of the LIF lidar used for concentration profiles for the other molecules (CO₂, O₃, CO, CH₄, NO₂, SO₂, N₂O, CO₂, N₂O, CFC, CCLF and CCL) are also taken from the USH. The number of levels used for the computation is 94.

Line-by-line computations of the layers optical depths are performed using HARTCODE. Single scattering properties for the cloud layers are generated assuming that ice particles are hexagonal columns. The cloud optical depths, altitudes and geometrical thickness for the 4 overpasses are determined by the radiative measurements of extinction and backscattering coefficients. The radiative transfer calculations are performed using the RT3 code, based on adding and doubling method to handle multiple scattering conditions. The code is interfaced with the gas and particulate optical depth databases. To simulate accurate interferometric measurements, high spectral resolution radiance are convolved with the appropriate instrumental function. Since the percentage error of the difference between the simulated interferometric measurements and the NAST-I data (in all the 4 overpasses) is almost less than 4% almost all over the spectrum, fluxes and heating rates have been computed at all levels.

7. RESULTS AND COMMENTS

Up and downwelling fluxes and cooling rates are computed at all levels and at every 0.05 cm⁻¹ for every NAST-I overpass of the Potenza region. The results are shown in the four panels below on the left. During the first overpass the cloud is made of two very similar cirrus clouds. A sensible gradient between cloud top and bottom is developed only in the first example. The total cooling rates show how the radiative forcing seems to be insufficient to explain the complete cloud dissipation.

The total cooling rates computed for the 4 Protea overpasses over the cirrus cloud. The cloud effect is evident both in and out the cloud layers. A sensible gradient between cloud top and bottom is developed only in the first example. The total cooling rates show how the radiative forcing seems to be insufficient to explain the complete cloud dissipation.

8. FUTURE

For the case study under study the radiative energy balance does not justify the whole ice cloud sublimation. Microphysics and chemistry need to be accounted for an exhaustive study of a cirrus cloud evolution.

More lidar information can be used to constrain the simulation (profile of the extinction coefficient, entrainment to backscatter, temperature profiles) and new cloud particle parametrisations are required to improve the consistency between the solar (laser) and infrared (interferometer) wavelengths.

PARTECIPATING INSTITUTES

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International TOVS Study Conference, 14th, ITSC-14, Beijing, China, 25-31 May 2005.
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,
Cooperative Institute for Meteorological Satellite Studies, 2005.