OSCAR (Observation System for Climate Application at Regional scale)

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Outline

- OSCAR project: objectives and products
- Instrument design
- Scattered sunlight by dust
- Scattered sunlight by clouds

Objectives

OSCAR is a project funded under the FESR 2007-2013 program

Specific objectives of the project are:

► Design and of a low-cost prototype able to provide integrated measurements for the quantification of the impact of climate variability on surface radiation

► Development of a methodology for the estimation of the impact of climate variability on surface radiation using the integration of the observations provided by prototype.

► Study of correlation between the surface radiation, precipitation and aerosols transport.

Partners:

Coordinator: Consiglio Nazionale delle Ricerche – Istituto di Metodologie per l'Analisi Ambientale (CNR-IMAA), PI Dr. Fabio Madonna

Partnership: Finnish Meteorological Institute (FMI), PI Dr. Ewan O'Connor (Cloudnet models)

October 2013 – April 2015

Objectives

Provide an observation low cost station, mobile, 2-D scanning for monitoring the climate at a regional scale

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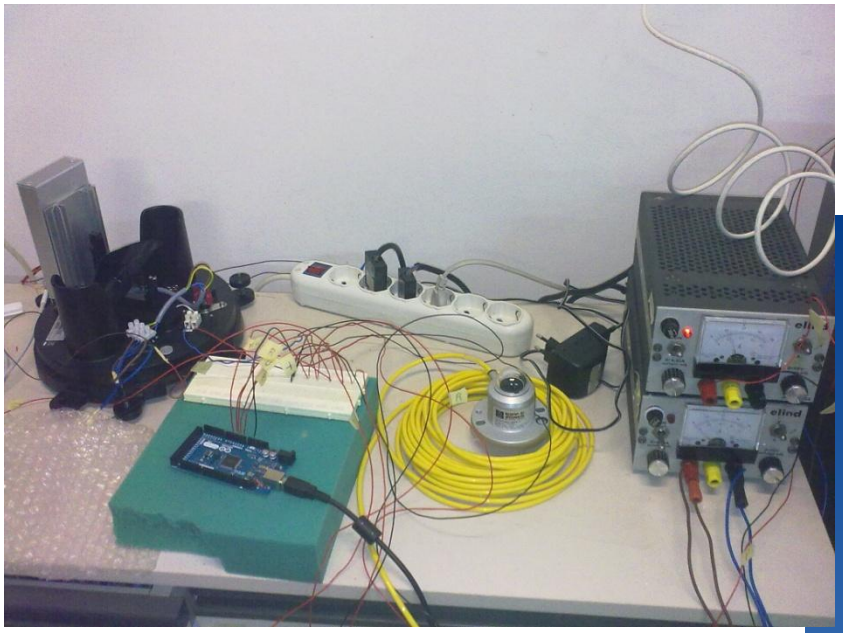
OSCAR prototype

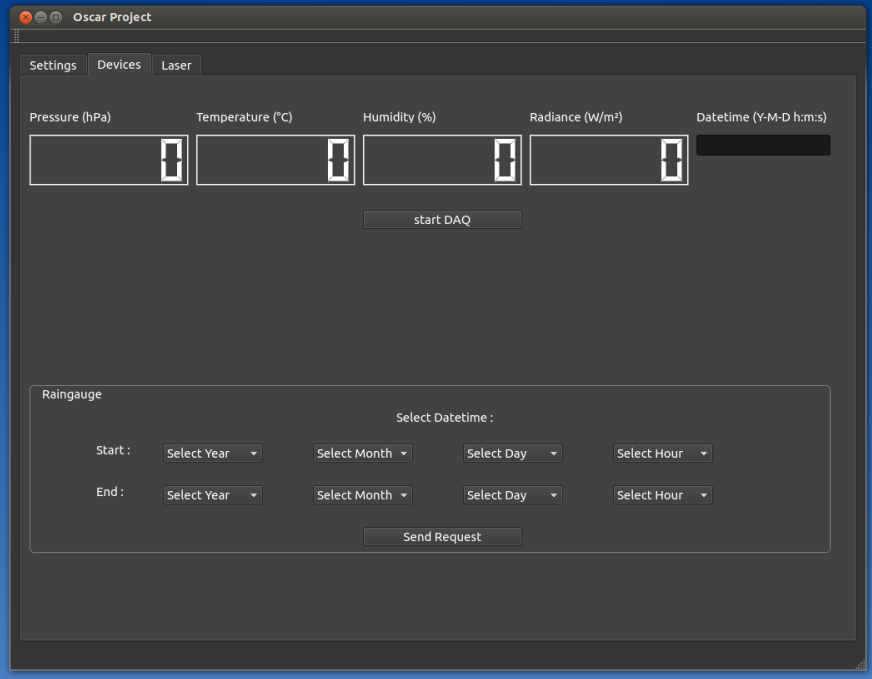
Controlled using technologies such as mini-PC, smartphone or tablet (locally and remotely). Suitable for monitoring networks at a regional scale, also run by not scientific agencies.

work in progress....



System test and electronic design

Interface of the software data acquisition



Products

Development of a methodology for estimating the impact of climate variability on the amount of surface radiation using the integration of the observations provided by the integrated prototype system. The minimum set of variables needed for this study will identified.

A few of the variables relevant to the study are:

- Cloud fraction
- Cloud height
- Cloud frequency
- Integrated water vapor
- Solar irradiance at the ground
- Aerosol optical depth
- Backscatter coefficient
- Visibility (fog)
- Accumulated amount of precipitation
- Meteorological surface parameters
- Radiative forcing BOA

Other variables will be studied and incorporated as a result of a preliminary evaluation of their relevance.

Motivation: Energy & Atmosphere

- Study of the techniques for using solar energy implies the knowledge of nature, ecosystem, biological factors and local climate.

- Climate change, both at global and regional scales, require a continuous monitoring of wind and solar radiation fields.

- Clouds, fog, water vapor, and the presence of large concentrations of **dust** can significantly affect the way to exploit the solar energy. Therefore, a quantitative characterization of the impact of climate variability at the regional scale is needed to increase the efficiency and sustainability of the energy system.

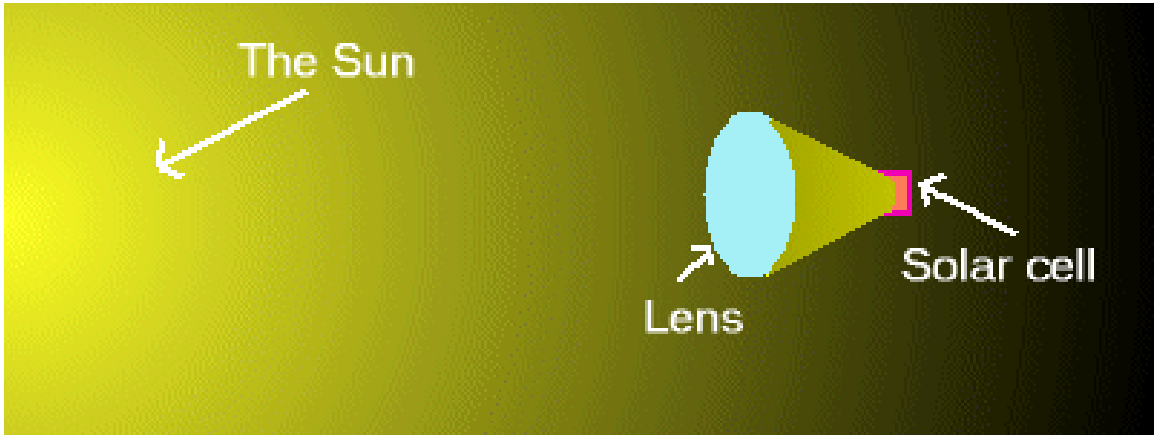
Direct vs diffuse

OSCAR project aims at providing a system able to cidentify the contribution of aerosol and clouds due to both the direct and the diffuse components of the solar radiation

- Diffuse sky radiation is solar radiation reaching the Earth's surface after having been scattered from the direct solar beam by molecules or suspensoids in the atmosphere.
- Sky radiation is approximately 25% of the incident radiation when the sun is high in the sky, depending on the amount of dust and haze in the atmosphere.
- About two-thirds of the sky radiation ultimately reaches the earth as diffuse sky radiation.

Solar concentrator

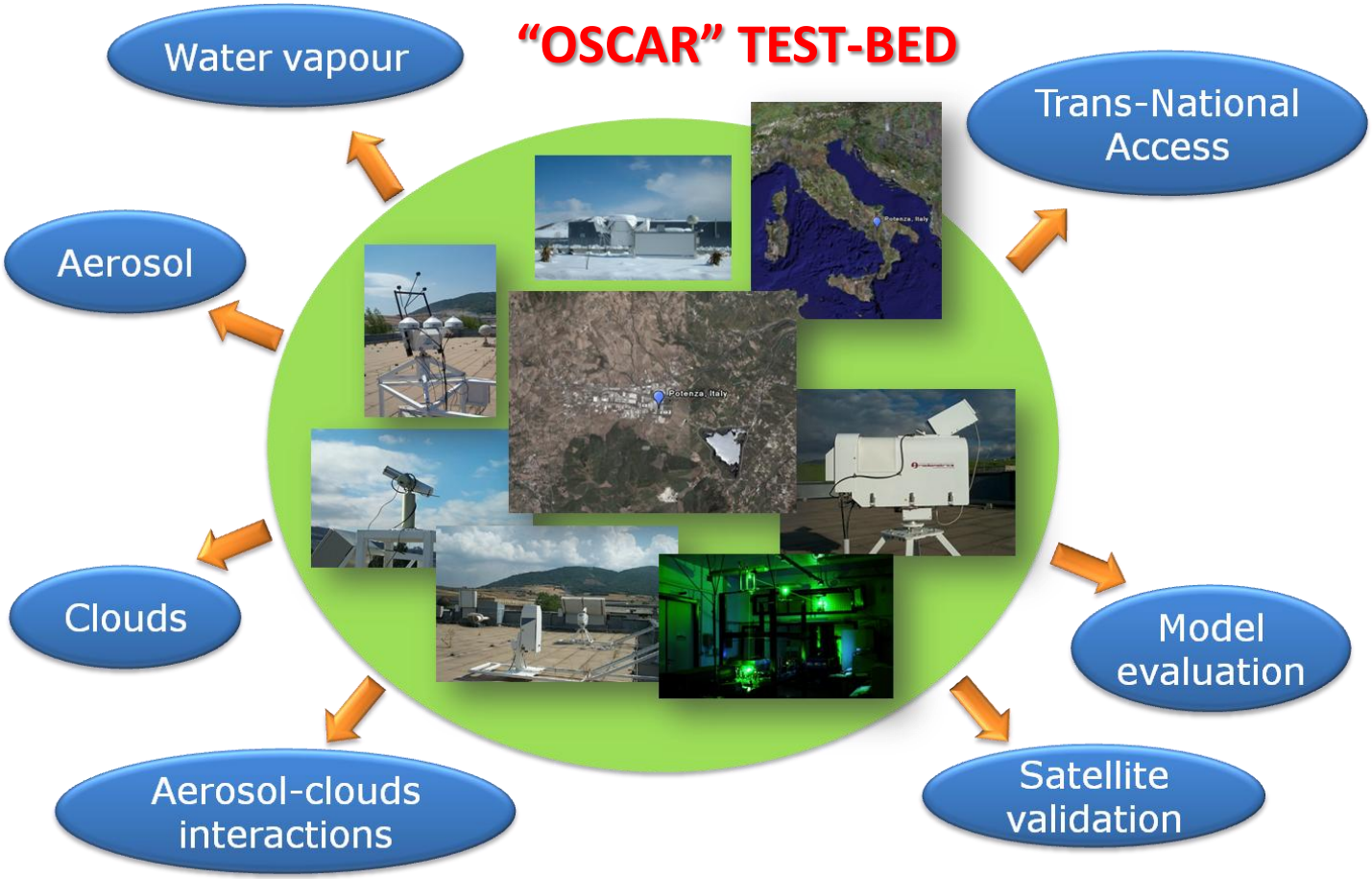
…and new technologies can better exploit also the scattered sunlight.



- A solar concentrator uses lenses, called Fresnel lenses, which take a large area of sunlight and direct it towards a specific spot by bending the rays of light and focusing them.
- Fresnel lenses are shaped like a dart board, with concentric rings of prisms around a lens that's a magnifying glass. All of these features let them focus scattered light from the Sun into a tight beam.
- Solar concentrators put one of these lenses on top of every solar cell. This makes much more focused light come to each solar cell, making the cells vastly more efficient.

CNR-IMAA Atmospheric Observatory (CIAO)

Basilicata 2007 | 2013



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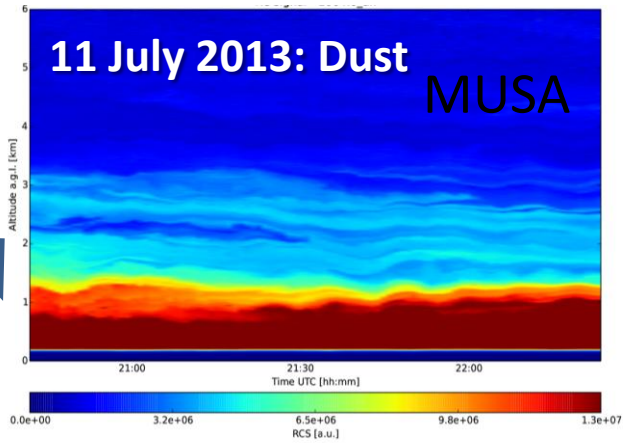
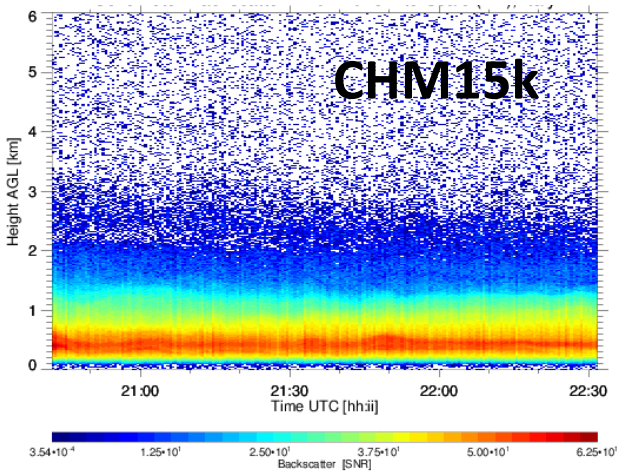
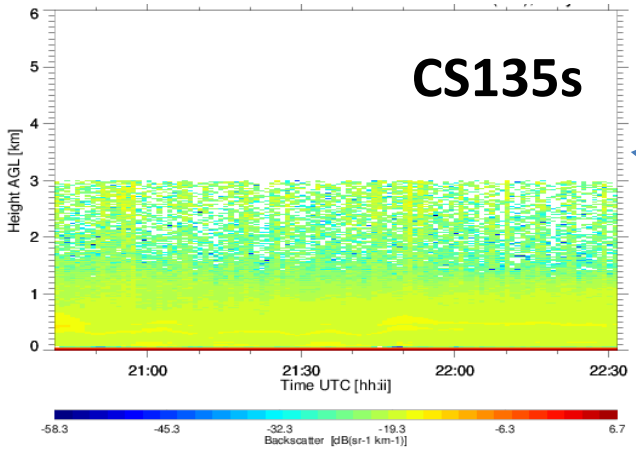
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

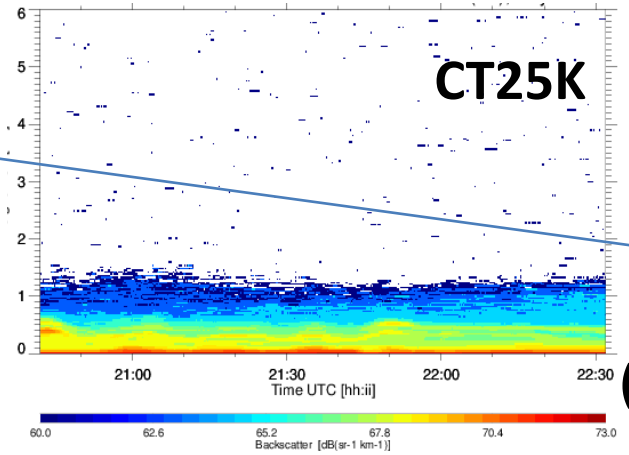
Sensor comparison



LIDAR

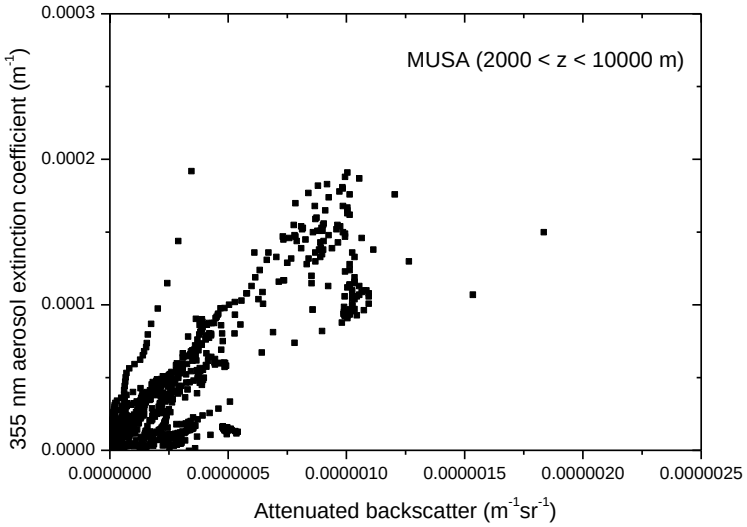


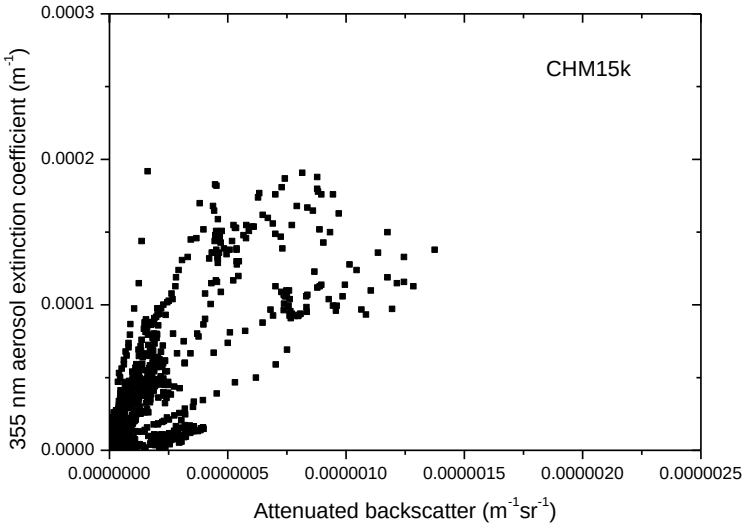




CEIMOLETERS (raw products)

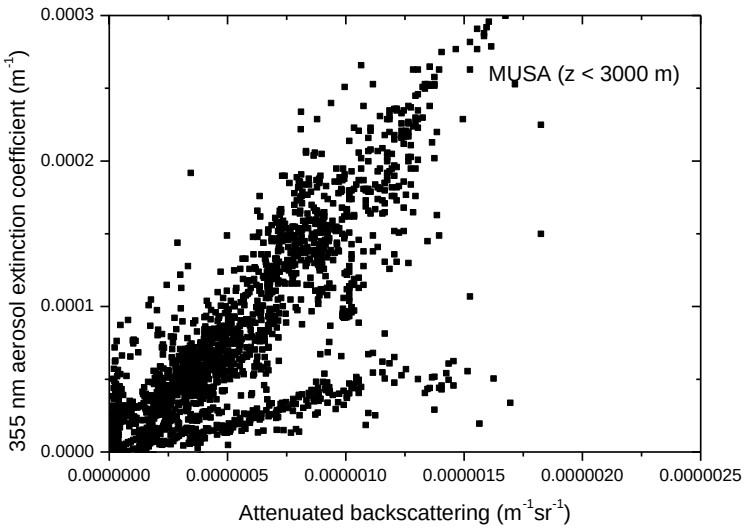
Sensor comparison

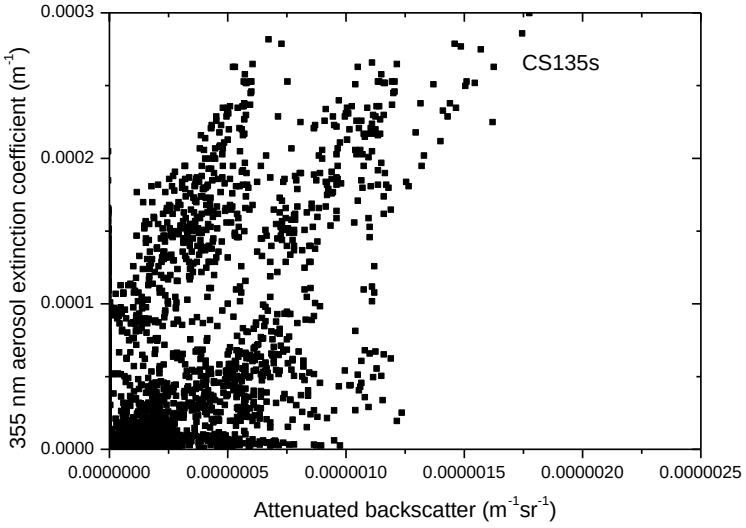




Comparison of different lidar technologies shows that diode or diode-pumped laser based ceilometers cannot be sufficient to monitor in a reliable way all the aerosol layers, at all the altitude levels, and at all the aerosol optical thickness values.

Sensor comparison





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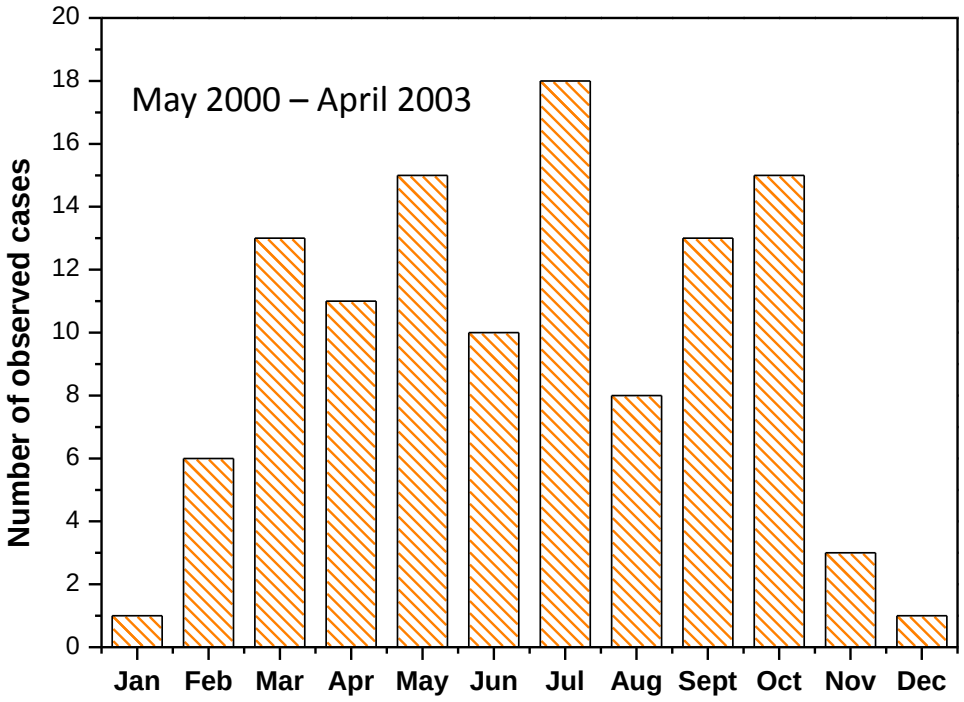
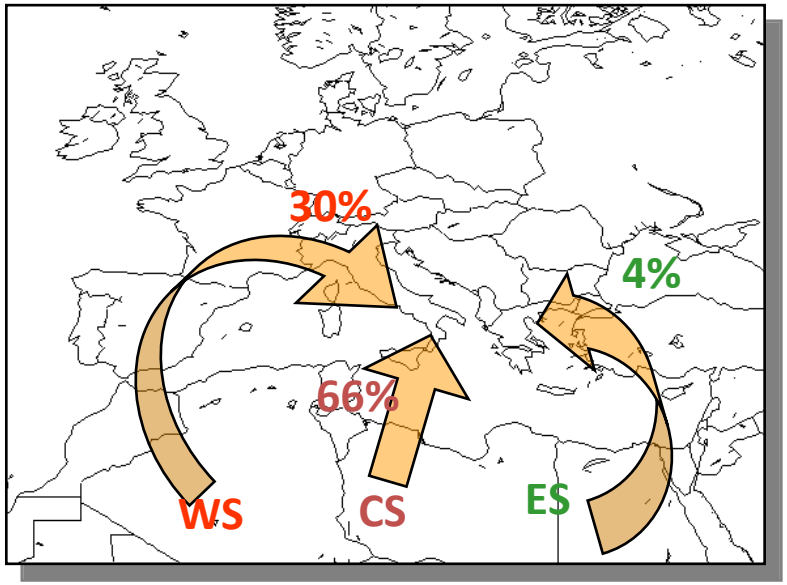
Dust climatology

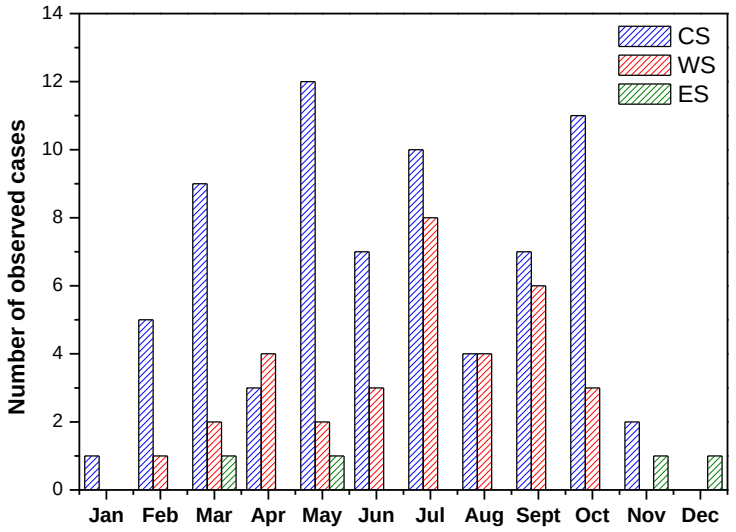


Mona et al., 2006

In about 35 days per year, Saharan dust layers are observed at CIAO site.
During summer, more Saharan dust observations are collected.
Cases are typically identified using multi-wavelength Raman lidar observations and Lagrangian back-trajectory models

Dust climatology





More WS occurrences during summer.
During spring, dust comes mainly from CS.

AERONET data

To study both the direct and diffuse component of the solar radiattion we are using:

►aerosol radiative forcing calcaulted by AERONET as a function of aerosol optical properties (dust cases have been identified using the lidar processing).

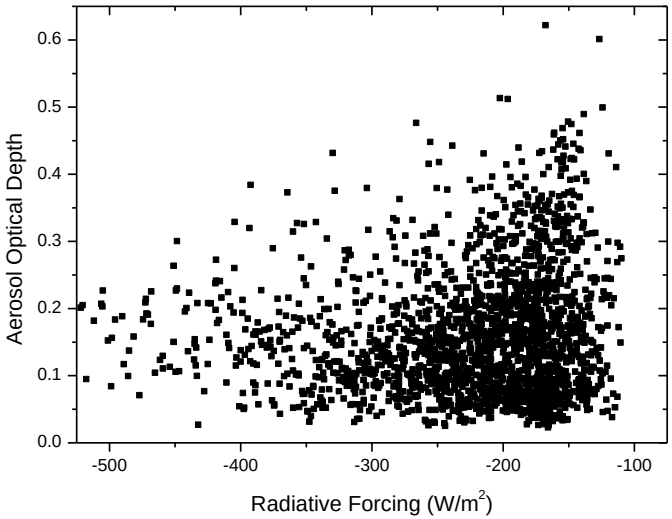
►sky radiation (almucantar and principal plane scenarios) from AERONET to study the diffused solar radaition as a function of the angle range.

Final objectives:

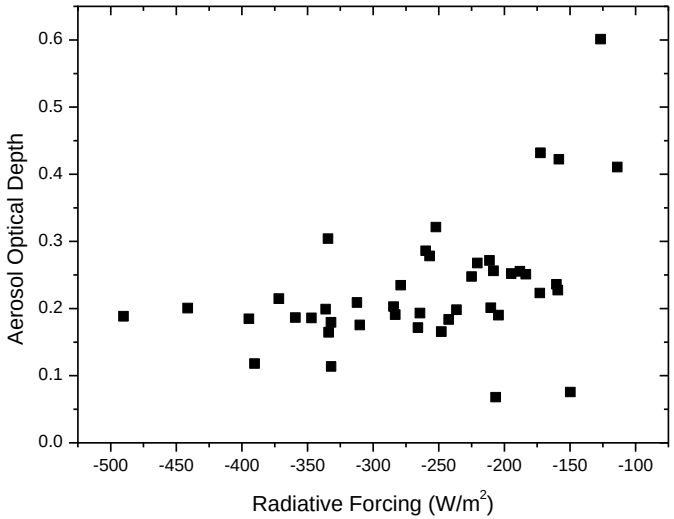
1. To desing the OSCAR protoype with a scanning capability in a minimum angle range
2. To provide the manufacturer of solar tools with recommendations about the possible acceptance angle the solar installations could use and to exploit the sky radiation.

Radiative forcing BOA

AERONET data from CIMEL sunphotometer operational at CIAO



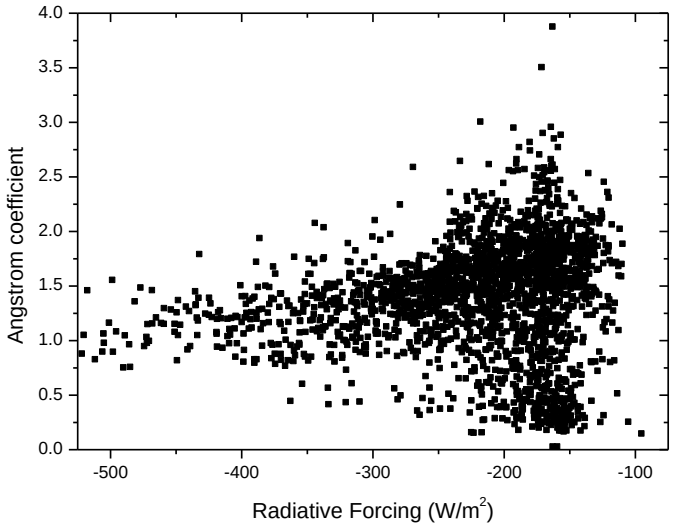
Climatology



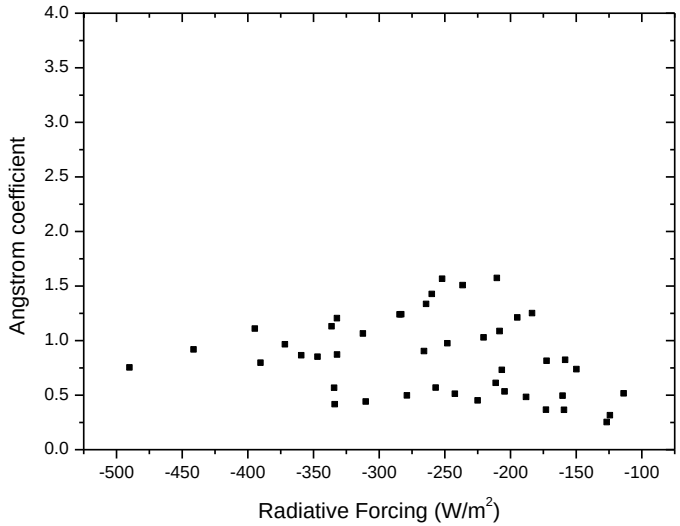
Dust cases (in the period 2009-2013)
Only those with simultaneous lidar and AERONET measurements

Radiative forcing BOA

AERONET data from CIMEL sunphotometer operational at CIAO



Climatology

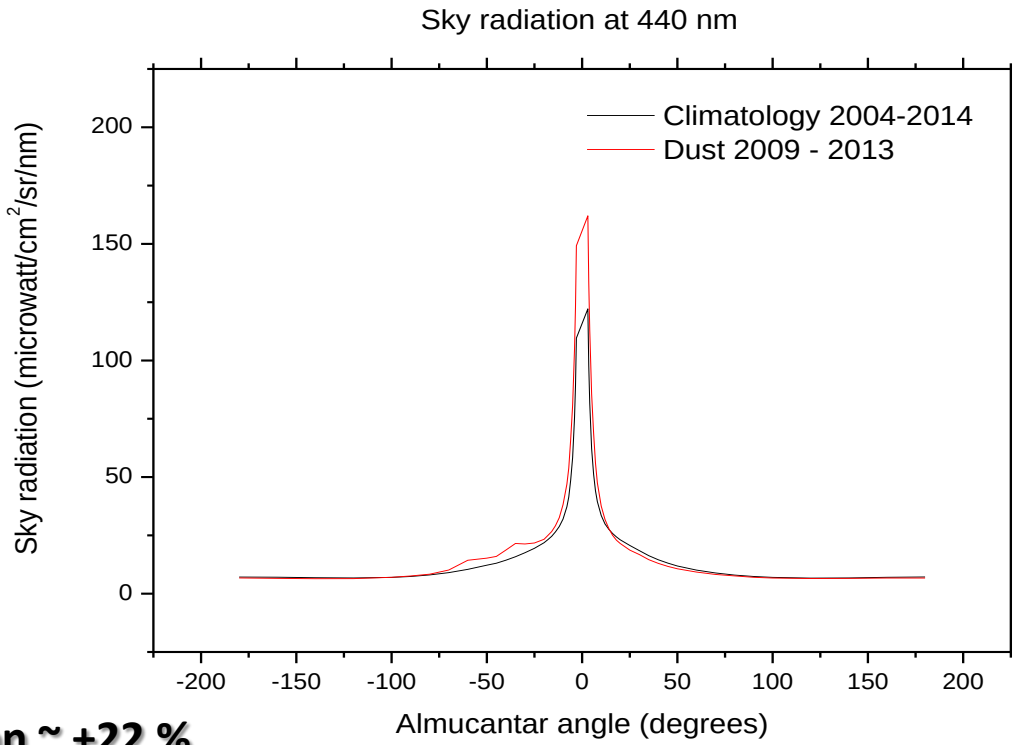


Dust cases (in the period 2009-2013)
Only those with simultaneous lidar and AERONET measurements

Dust have a pretty variable impact on the radiative balance. AOD and Angstrom coefficient show no precise correlation with the radiative forcing BOA.

Diffuse radiation Almucantar

AERONET data from CIMEL sunphotometer operational at CIAO

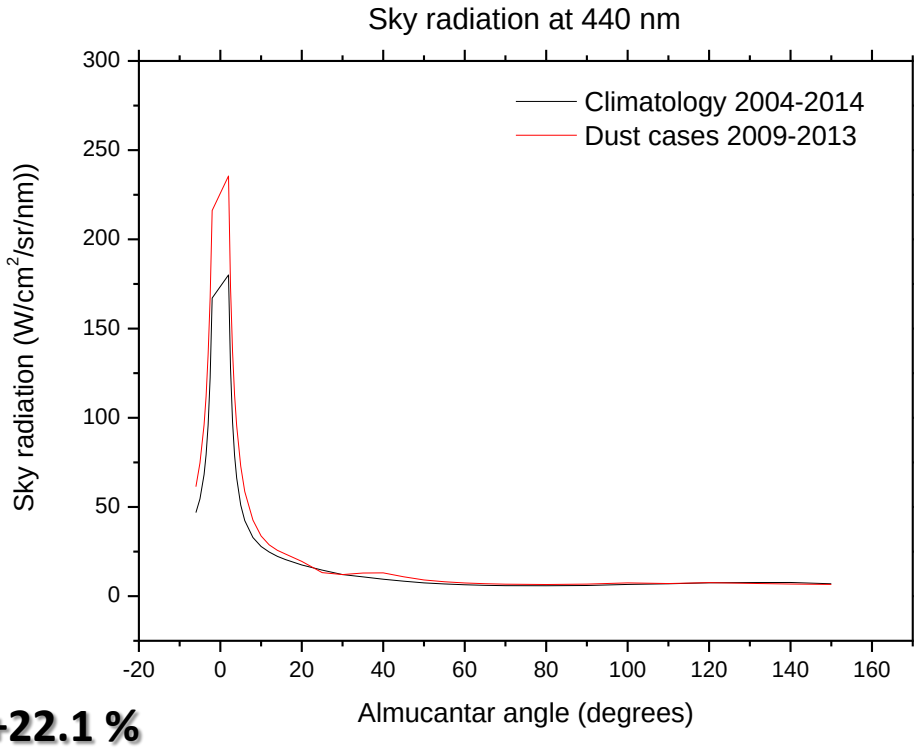


Dust sky radiation ~ +22 %

Average AOD = 0.16 Dust AOD = 0.23

Diffuse radiation PPLAN

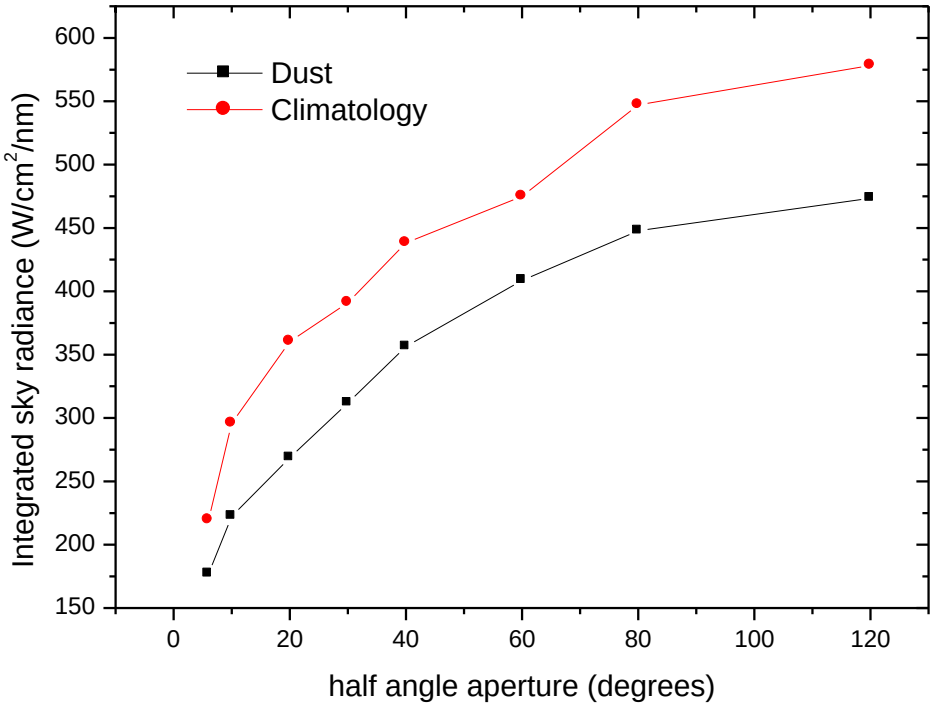
AERONET data from CIMEL sunphotometer operational at CIAO



Dust sky radiation ~ +22.1 %

Average AOD = 0.16 Dust AOD = 0.23

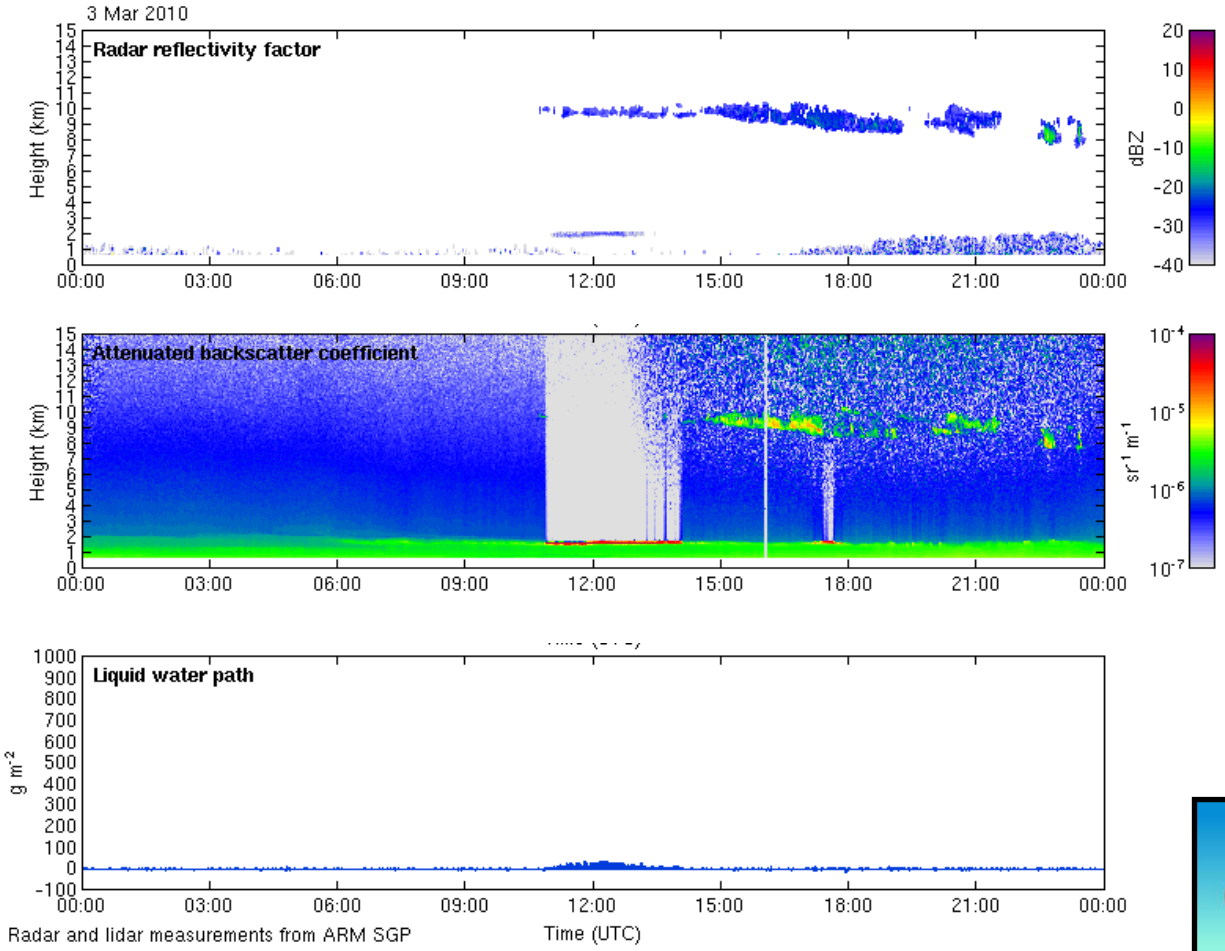
Scattered radiation



Half of the full scattered radiation is detected in ±10 degrees, 2/3 of the radiation is in ±40 degrees

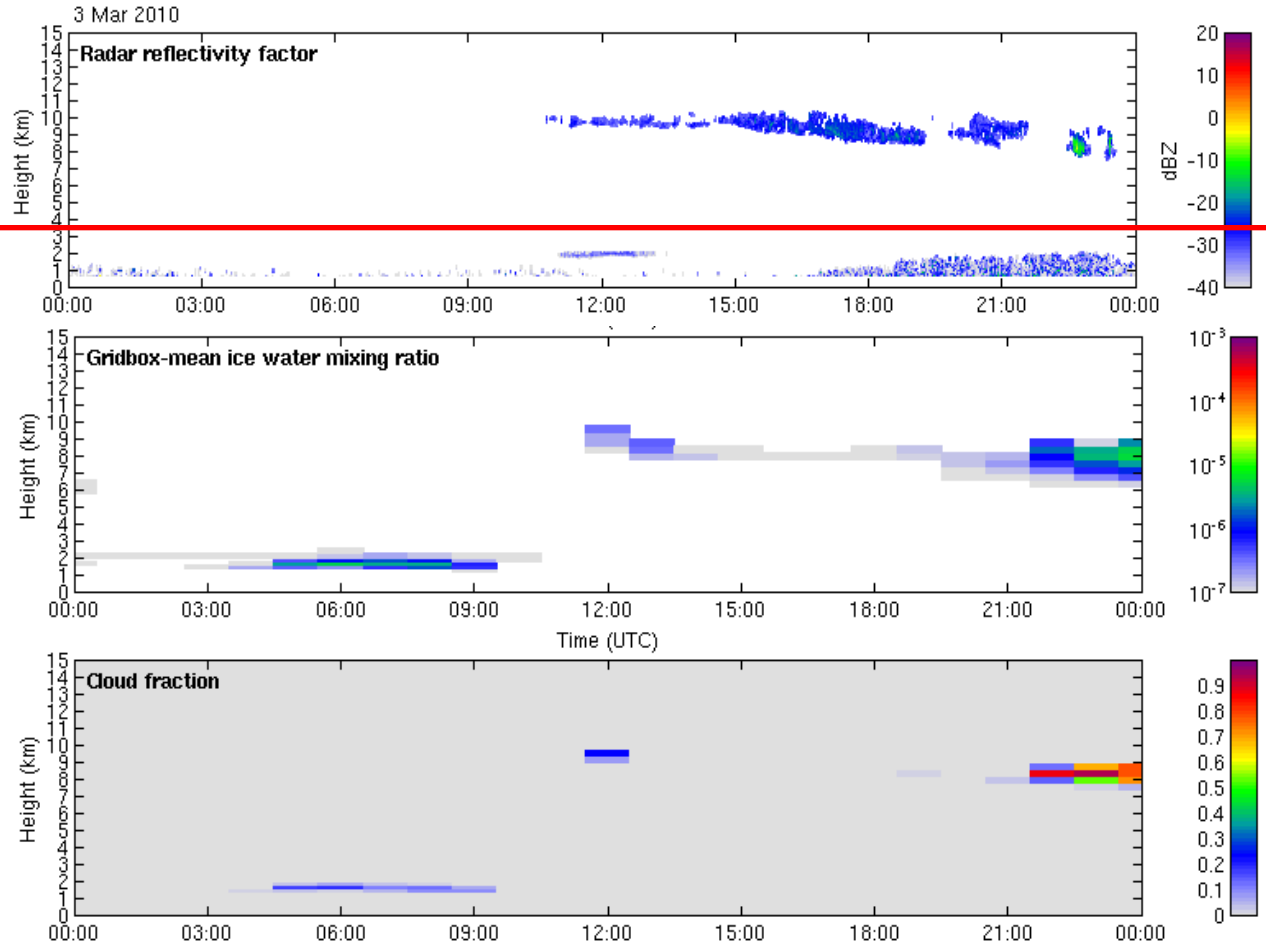
Large increase in the scattered radiation by dust between 6 and 10 degrees

Clouds



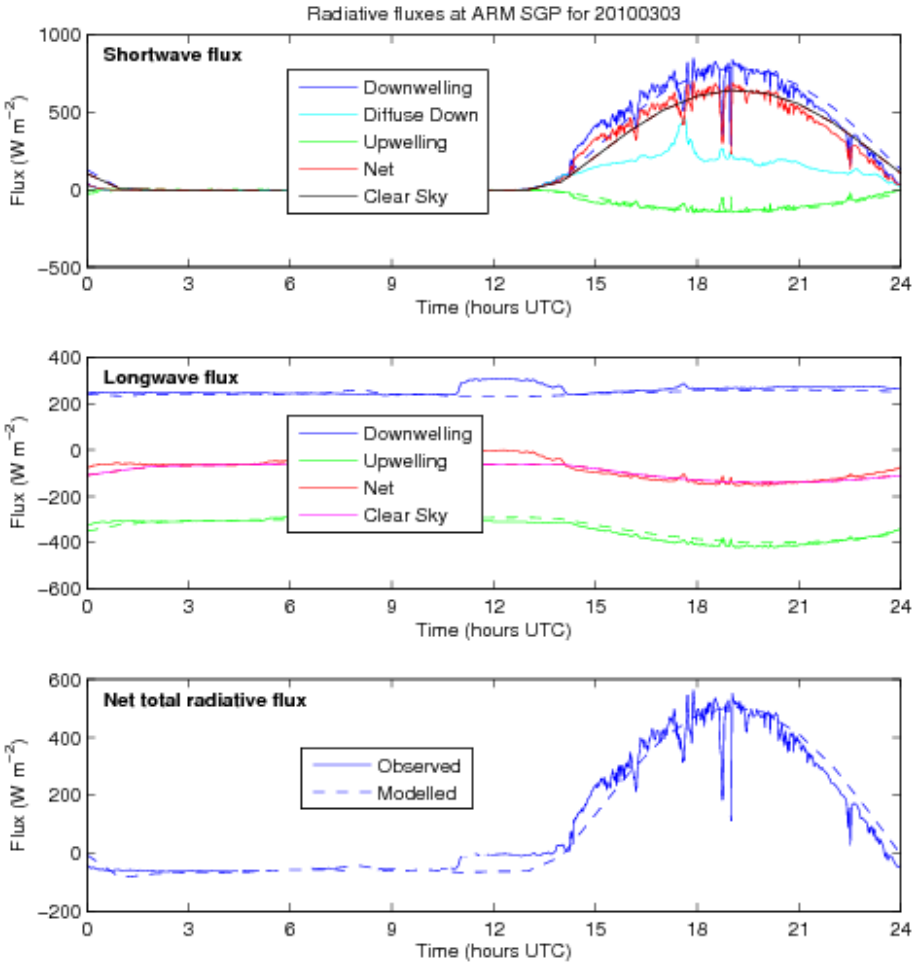
Courtesy of Dr. E. O'Connor (FMI)

Clouds
ECMWF model

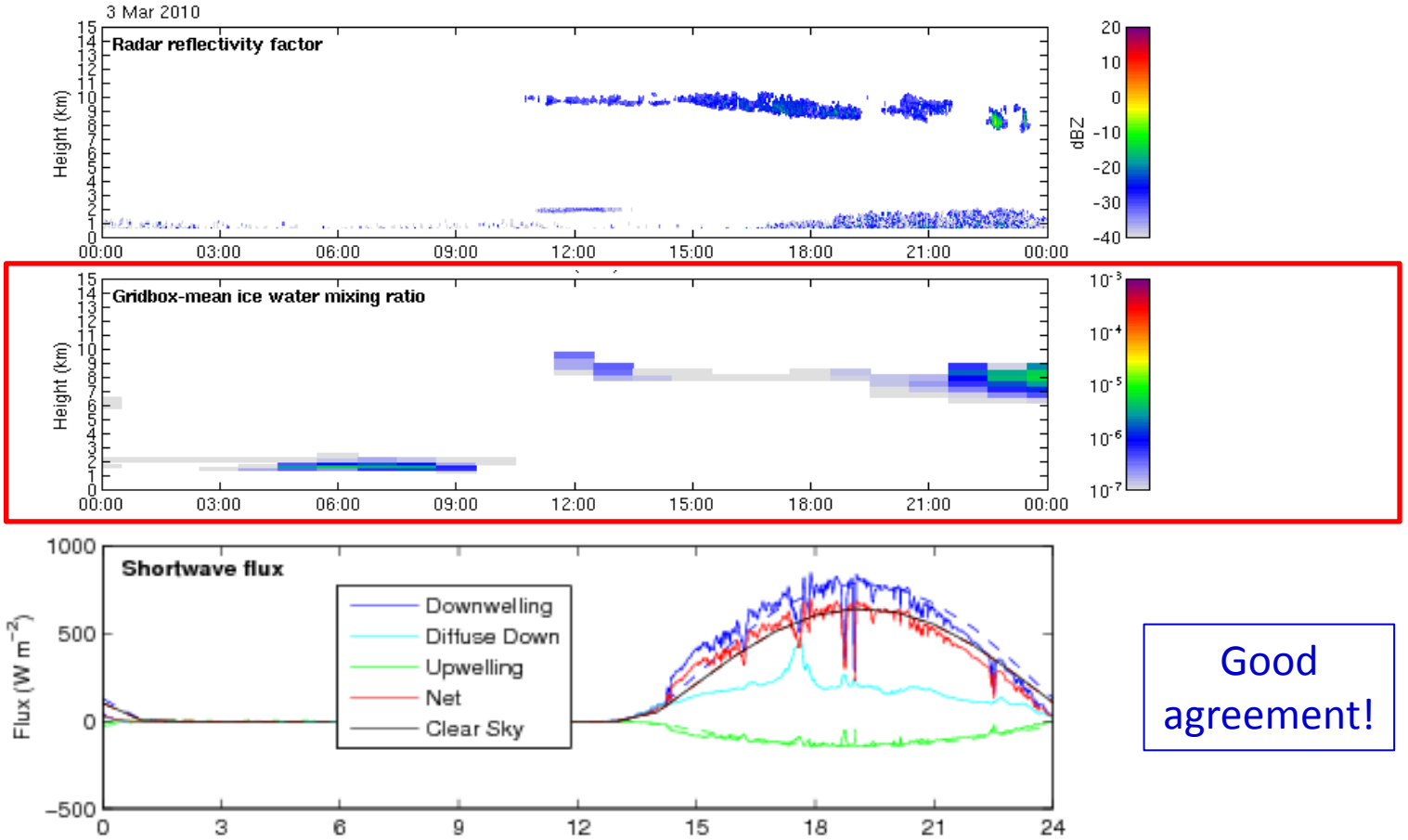


Courtesy of Dr. E. O'Connor (FMI)

Radiative fluxes



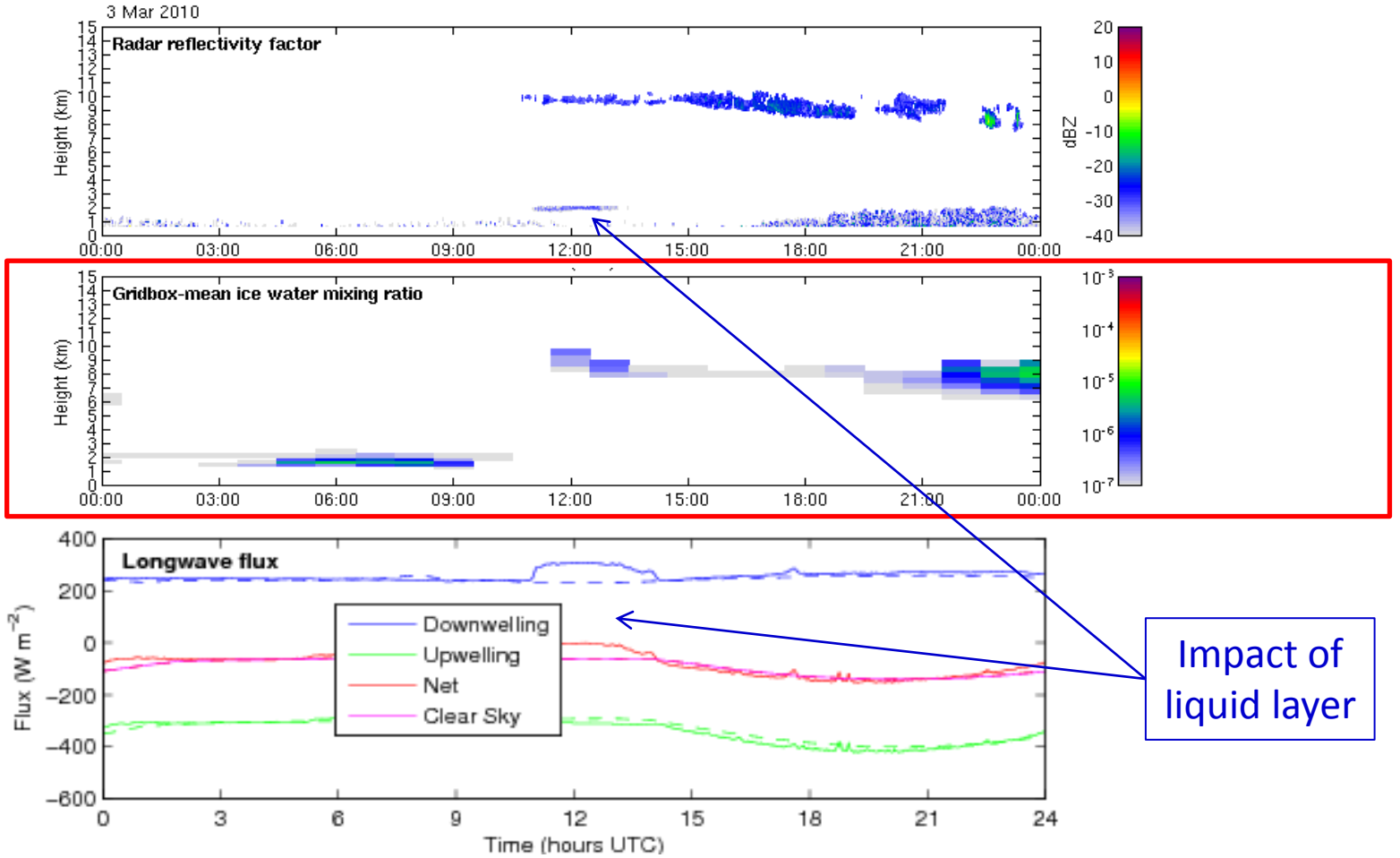
Radiative fluxes



Good agreement!

Courtesy of Dr. E. O'Connor (FMI)

Radiative fluxes



Courtesy of Dr. E. O'Connor (FMI)

.... moreover

We will also compare:

Solar radiation models

- Iqbal model C
- ASHRAE model
- Erbs et al.
- Spencer model
- Reindl et al.
- Lam and Li
- Skartveit and Olseth model
- Maxwell model
- Louche et al. model
- Vignola and McDaniels model
- Al-Riahi et al. model
- Becker et al.

Weather mesoscale models

- ECMWF
- Meteo-France
- MetOffice
- COSMO LM

Measurements

Sun photometer, lidar, radar, pyranometer, sky camera.


OSCAR

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