Oscar: a portable prototype system for the study of climate variability

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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)

Duration: October 2013 – June 2015

Objectives

Integration of different ground–based remote sensing techniques controlled using technologies such as mini-PC, smartphone or tablet (locally and remotely). Suitable for monitoring networks at a regional scale, also run by environmental agencies.

Motivation
ENERGY & ATMOSPHERE

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

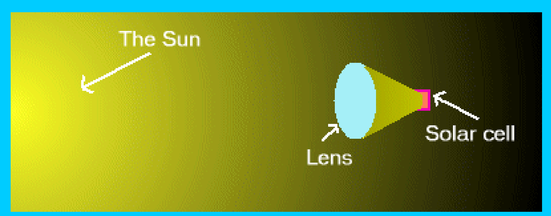
Climate change, both at global and regional scales, requires a continuous monitoring of wind and solar radiation fields.

Clouds, fog, water vapor, and the presence of large concentrations of aerosol, Saharan **dust** in particular, 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.

OSCAR project aims at providing a system able to identify 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.

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

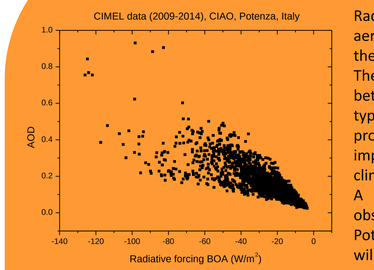


Approach

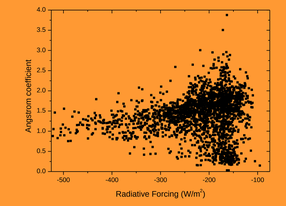
To study both the direct and diffuse component of the solar radiattion we are using:
►aerosol radiative forcing calcaulted by AERONET as a function of aerosol optical properties (dust cases have been identified using the lidar processing).
►sky radiation (almucantar and principal plane scenarios) from AERONET to study the diffused solar radiation 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 a tool for the optimization of the sun tracking in different sky conditions;
3. To provide the manufacturer of solar tools with recommendations about the possible acceptance angles that the solar installations could use and to exploit the sky radiation.

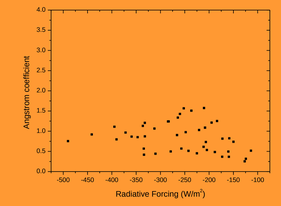
First results: aerosol



Radiative forcing depends on the aerosol optical depth (AOD) and, therefore, on the aerosol type.
The study of the relationship between aerosol AOD, aerosol type and radiative forcing provides a tool to map the impact of aerosols in different climatic regions.
A quasi bi-linear bevaviour is observed at CIAO station, in Potenza, South italy. The study will be completed by June 2015.

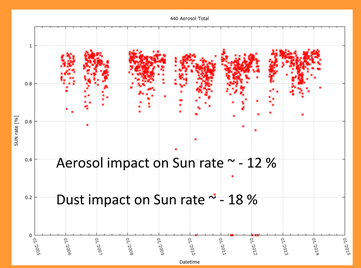


Climatology

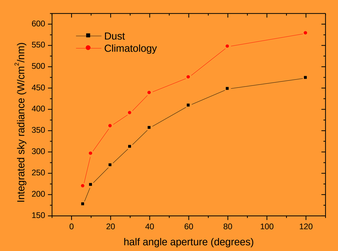


Dust cases (in the period 2009-2013)
Only those with simultaneous lidar and AERONET measurements

Angstrom coefficient (inversely proportional to the particle size) show no precise correlation with the radiative forcing BOA (Madonna et al., 2014)



Averaging forcing efficiency aerosol = -(236± 83) W/m²
Averaging forcing efficiency dust = -(255 ± 87) W/m²



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

Solar tools could exploit also this additional contribution for the energy production.

Outlook

-The characterization of the impact of aerosol on the direct and diffuse components of the solar radiation will be extended to include the classification of different aerosol types.

-The impact of the different type of **clouds** will be also assessed using the sun photometer measurements of **cloud radiance** as well as the reflectivity provided by a Doppler radar.

- Comparisons with radiative transfer models and engineering models are already ongoing.

References
Madonna, F., F. Amato, L. Mona, M. Rosoldi, G. Pappalardo: *OSCAR : A portable prototype system for the study of climate variability*, in Proceedings of DUST2014, 1st International Conference on Atmospheric Dust, 1-6 June 2014, Castellaneta, Italy.

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