Albedo Project

# EXPERIMENTATION OF TECHNOLOGIES FOR GLOBAL WARMING REDUCTION AND CERTIFICATION OF ARTIFICIAL SURFACES BY SATELLITE DIFFERENTIAL SPECTROPHOTOMETRY

## Research project

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### Introduction

In the last 100 years (1906-2005) a 0.56 – 0.92 °C (best estimate: 0.74 °C) Earth's surface's temperature increase has occured: polar and continental glaciers melting, ocean level increase (1.8 mm/year in the period of 1961 to 2003), frequency and intensity high rate of extreme weather phenomena (hurricanes, floods, drought, etc) are a direct consquence of this occurance.

In agreement with IV Report of IPCC (Intergovernmental Panel on Climate Change) the observed recent global warming is caused, with a probability of around 90%, by anthropic activities which introduce greenhouse gases (mainly $CO_2$) in the atmosphere due to fossil fuel burning processes.

Today the 1997 Kyoto Protocol is the only significant instrument to control $CO_2$ emissions. It requires the 38 signatory states to reduce their emissions to 5% below 1990 levels during the 2008-2012 commitment period.

Recent studies show that global warming reduction would be very low (3-10% in a century) even if all involved countries fulfilled the Kyoto's goals. Moreover many nations, including the United States (responsible for 36.1% of the total $CO_2$ emissions) have refused to ratify the agreement and no precautionary measures have been taken for developing countries (that contribute to half of the world's total greenhouse gas emissions). Thus, the Protocol is clearly not adequate to effectively control global warming.

On the other hand the same greenhouse gas emission control policies adopted by industrialized countries, could have negative consequences in developing countries in terms of growth.

The rapid and continuous increase in concentration of greenhouse gases and the lack of policies and technical instruments to oppose the phenomenon made it necessary to find environmentally friendly, technically simple and cheap solutions to be applied in countries with limited economic resources to control the global average temperature increase.

An effective solution to reduce global warming and compensate the effect produced by the emission of greenhouse gases into the atmosphere could be to artificially modify the Earth's surface reflectance increasing the Solar energy reflected to space and reducing the amount of energy that contributes to the Earth's warming.

Two different methodologies have been patented and adjusted for this purpose (Italian patent 2006 A 0086 and patent PG 2007 A 0009)

This research project will conduct studies for the theoretical and experimental assessment of the above methodologies and the adjustment of different technologies to quantify, under variable operating conditions, the effectiveness of white reflecting surfaces. A certification procedure will be introduced as well.

Synergy among different partners is crucial for the development of the project’s activities: high level scientific competence is required in thermodynamics, environmental modeling, meteorology, certification procedures, remote sensing, environmental and economic assessment.

## 1. Proposed technology

The proposed solution to compensate for the increase in Earth's temperature is the development of surfaces with an higher reflection coefficient than the earth's surface’s one for the solar spectrum wavelengths (wavelengths range: 0,2 - 4 μm) and with an higher emissivity in the infrared zone (wavelengths range:4 - 25 μm).

The proposed solution contributes towards the reduction of the absorbed energy thus increasing Earth's surface reflectance and at the same time increasing Earth's emissivity factor in the infrared zone for the global cooling.

Two patents have been registered. The following methodologies, materials and technologies have been identified:

- method of calculation to evaluate the relation between the extent of the installed horizontal reflecting surface and the associated global earth’s temperature decrease;
- numeric value of the needed extent of the installed horizontal reflecting surface to compensate one ton of $CO_2$ equivalent in relation with the effect on global earth’s temperature. This value will depend on the latitude of the installation site;
- relation between the installed horizontal reflecting surface and emission trading;
- technical solutions, components and materials for the construction of the reflecting surfaces.

The reflecting surfaces can be laid both on land and on sea; both artificial and natural surfaces can be used (roofs of houses, sport facilities and industrial plants, roads, pedestrian areas, city squares, car parking lots, gardens, parks, etc).

Alternatively the growing of trees, shrubs or flowers with appropriate colour characteristics and high average reflection coefficients can be utilized.

Floating or semi-floating islands could be laid on ocean surfaces.

In land applications the reflective surface can be obtained by laying paints, films, plates or any type of coating with a high reflection coefficient and a high infrared emissivity.

The use of titanium dioxide paints and films is particularly interesting for the construction of the reflecting surfaces. This chemical compound has a great sunlight reflection (its high refractive index is second only to diamond) and it’s an excellent catalyst that can degrade through oxidation several volatile organic compounds in polluted air (its use is suggested by Italian legislation, see D.M. 1 april 2004).

Paints made with titanium dioxide pigment could constitute a solution to make surfaces with high reflection coefficients and good cleaning and depolluting properties.

Other cheaper materials, such calcium carbonate powder, grain patterns for flower beds or gardens, lime hydrate, could be used for many applications.

Vertical or arbitrarily oriented surfaces can give their contribution (lower than horizontal orientated surface) adopting a treatment to realized a lambertian highly reflecting surfaces.

A lambertian surface is a perfectly diffusing surface; the intensity of the light emanating in a given direction from any small surface component is proportional to the cosine of the angle of the normal to the surface. The mentioned materials have this feature and therefore they are particularly suitable for the treatment of arbitrarily oriented surfaces.

The effectiveness of laid reflective materials is closely related to latitude and meteorological and morphological characteristics of the installation area and the original value of the reflectance of the spot where these materials are placed.

Effectiveness of reflecting materials is higher if they are used to coat surfaces with a natural high absorptivity (low albedo) due to a major reduction of absorbed solar radiation. Solutions which modify sea surfaces albedo would be particularly effective.

Territories in Southern Italy and in the equatorial belt (intertropical zones), dry and low cloudiness areas, seas, oceans and in general all low albedo surfaces, are favourite locations to implement the proposed solution.

Interesting economical opportunities could arise for all the poor and developing countries in such areas. If the global warming reduction effectiveness of reflecting surfaces was internationally acknowledged, these countries could join the Emission Trading system instituted by european directive 2003/87/CE. A certification procedure could be established; under the "BIANCO RIFLETTENTE" (meaning "White Reflecting") project, the effectiveness of reflecting surfaces could be monitored in time using high definition satellite differential spectrophotometry; a coefficient of depreciation could be evaluated. Therefore, even small sized surfaces could economically benefit from this project. Collaborations with certifying organizations like UNFCC are envisaged to validate both methodology and certification procedures.

A grid of trusted surfaces (10 $m^2$ each), both horizontally and vertically arranged, will guarantee the requested accuracy in the measure of albedo through satellite differential spectrophotometry: their albedo will be precisely measured on ground by integration sphere spectrophotometers. Trusted surfaces can lead to a very accurate technology for the satellite differential spectrophotometry, based both on direct measurement of the reflected radiation and the differences between values of albedo.

As an example, a 2 $m^2$ **"Bianco Riflettente"** horizontal surface placed in Quagadougou (Burkina Faso, site with a high level of sunshine), can compensate for the global warming produced by one ton of $CO_2$ emitted in the atmosphere. Following the goal, decided during the recent G8 in Germany, of reducing the global warming to a maximum of 2 °C before 2050, the proposed reflecting surface in Burkina Faso should be kept in full efficiency for 40 years. This period is long enough to illustrate the example (it could be reduced to 20 or 30 years if international agreements allow).

In 2008 penalty for failing Kyoto's goals will rise to 100 euros per ton of $CO_2$; today, after a period of market fluctuations, the cost of the emission unit is rising and it will likely reach 80 Euro/ton in the next future. Thus, every single squared meter of "Bianco Riflettente" surface, albedo-certified, installed in Quagadougou could be worth, under the emission trading system, a minimum of 1 euro for 40 years. Some countries could see their annual family average income doubling or tripling by building and maintaining for 40 years 1000 or 2000 $m^2$ of "Bianco Riflettente" surfaces. Every year the certification authority, through satellite measures, would guarantee the effectiveness of accomplished maintenance on the reflecting surfaces, evaluating the energy reflected and determining the annual amount to be paid. In order to install reflecting surfaces, operations could be achieved by simple technologies like kits for painting large surfaces, hand pumps to spray whitewash on the roofs, etc.

This example shows how to create new scenarios in the international relations between the North and the South of the world, allowing for income increase even in those poor countries where drought and desertification force the population to emigrate. Due to the easiness of technology involved, chances to increase income in poor countries have a double effect: a social and humanitarian value and a potential restraint to illegal immigration towards developed countries.

Finally, even in developed coutries, the use of white reflecting everyday items (tents, umbrellas, garments, etc.) could accomplish global warming reduction without additional costs. For example a white reflecting station wagon car, with an albedo-certified (reflection coeff. 0.9) surface of 9 $m^2$, could compensate for 1-1.4 tons of $CO_2$ introduced in the atmosphere, equivalent to the vehicle's emission for 10000 km (for instance Golf SW $CO_2$ emission is 137 g/km). A white reflecting umbrella with an albedo-certified (reflection coeff. 0.9) surface of 90 $cm^2$, could compensate for about 100-150 kg of $CO_2$ introduced in the atmosphere.

## 2. Partners

Partecipation to the project from partners with different technical and scientific expertise is expected: they share the same objectives of promoting innovative systems for the protection of the environment and they have personnel with the skills requested to develop the project.

**CMCC (O.U. 1):** the "Centro Euro-Mediterraneo per i Cambiamenti Climatici" (Euro-Mediterranean Centre for Climate Change) is a Ltd Company (CMCC S.c.a.r.l.) with its registered office and administration in Lecce and local units in Bologna, Venice, Capua and Sassari. The society doesn't pursue profitable ends and aims to realize and manage the Centre, its promotion, and research coordination and different scientific and applied activities in the field of climate change study. These activities are developed exclusively for the Centre's work objectives, and favour collaboration among Universities, national and international research bodies, territorial bodies and the industrial sector. Technical coordination and management tasks of the project have been assigned to CMCC, due to its proved experience in the development of models (both world-wide and regional), simulations, middleware and application software in the field of climate dynamics.

CMCC has a major expertise due to its collaboration with Ansaldo Energia and the american certification authority EPA with regard to the project of gasification plants for RDF (Refuse Derived Fuels) and their environmental issues, which are strictly related to weather modelling.

Collaboration with EPA will allow to verify the potential of certification activities for white reflecting surfaces in the USA; an alternative partecipation to the Kyoto's goal could be envisaged for USA through the installation of white reflecting certified surfaces instead of reducing direct emissions of greenhouse gases.

**CIRIAF (O.U. 2)**: the "Centro Interuniversitario di Ricerca sull'Inquinamento da Agenti Fisici" (Interuniversity Research Centre on Pollution from Physical Agents) is a research center of multidisciplinary excellence constituted by more than 100 academic staff in 17 italian universities: Università di Perugia, Università di Roma "La Sapienza", Università di Roma Tre, Politecnico di Bari, Università di Genova, Università di Pavia, Università di Firenze, Università di Pisa, Istituto

Universitario di Architettura di Firenze, Università dell'Aquila, Polo Scientifico Didattico di Terni, Università di Chieti, Università di Messina, Università di Napoli, Università di Palermo, Università di Reggio Calabria and Università di Urbino. Scientific tasks n. 2, 3 and 4 (see later) are assigned to CIRIAF on account of its proved experience in the management of projects in the field of solar energy, energetics and environmental technologies, in particular in the thermodynamics of Earth system and in laboratory experimentations.

**CRC – University of Perugia (O.U. 3)**: the "Centro di Ricerca sul Clima e Cambiamenti Climatici" (Research Center on Climate), recently established, has its offices at the CRB (Research Center on Biomass) of the University of Perugia and it is a member of CMCC.

CRC gives support for the bibliographic research and for the definition of theoretical models to evaluate the relation between albedo and earth average temperature, as defined on Task 1.

**External collaborations**

A collaboration is expected with Pipe§net company, which holds the rights of the patents that include: methodology to estimate the average global temperature in function of the Earth's surface's albedo; technological solutions to modify the albedo in order to control global temperature.

UNFCCC (United Nations Framework Convention on Climate Change) will be involved to get the credentials to standardize the proposed methodologies.

Collaboration for the experimental testing activity may be expected with the Global Engineering S.r.l. company, international leader in the research, production and selling of photocatalysis systems made of titanium dioxide.

Professor Greg Blonder will also partecipate to the project (see letter of intentions annexed): he will contribute to the exploitation of scientific results coming from the research and to their dissemination, thanks to his contacts with government agencies, high-tech industries and american universities. Thus, organization of meetings and conferences will be assigned to professor Blonder and to his company, the Genuine Ideas LLC, with the collaboration of universities like Princeton, Columbia, MIT and architectural schools like Harvard's and Pratt's. Professor Blonder, thanks to his deep knowledge of concerned issues (testified by publications on international scientific and economical journals like "Business Week"), will contribute directly to the research and in particular to the analysis of the social-economical consequences of proposed solutions.

The project includes the partecipation of CAPS (Center for Analysis and Prediction of Storms, see letter of intentions annexed) at the University of Oklahoma, as the developer of the award-winning Advanced Regional Prediction System (ARPS). CAPS may share its knowledge in high resolution modeling of weather phenomena as well as in processing data gathered by radar and satellite systems. For this purpose, the project will use the resources of Telespazio (Finmeccanica group) and possibly of ESA for the acquisition of images from satellites.

Partecipation to the project from unit CMCC will allow possible collaborations with EPA, whom CMCC has already cooperated with, on the occasion of the modelling of environmental impact of RDF gasification plants. EPA is an american certification authority which could contribute, together with UNFCC, to the acknowledgment of white reflecting surfaces as an official mean to fight climate change, introducing an equivalence with emission trading.

## 3. Research tasks

The project consists of the following research tasks:

Task 1: investigation and theoretical verification of the methodology proposed in the patents

*Operational Unit involved: CIRIAF (O.U. 2)*

*Description of Task 1*

Activities include investigation of the proposed relation between albedo of the Earth's surface (land, seas, oceans) and average Earth's temperature.

A deep analysis will be carried out on the time response of temperature to the modification of albedo; this study will allow to determine the exact exposure time of reflecting surface to guarantee a specific effect on Earth's temperature. Much importance relies on the gathering and elaboration of the bibliography for the historical series of the major climatic parameters in particular the relation between natural changes in albedo and temperature changes. Examples of possible studies are the effect on temperature changing caused by glaciers reduction, desertification of Middle-East and areas close to Sahara, deforestation of Amazonia, spreading of buildings in the territory, reduction of salinity in the northern Atlantic Ocean.

A more accurate relation is expected between the extent of installed reflecting surfaces and the compensated $CO_2$ quantity; such relation will be expressed in terms of both absolute $CO_{2eq}$ introduced in the atmosphere and of the value of $CO_{2eq}$ present in the atmosphere; only half of the carbon dioxide naturally or artificially introduced in the environment, infact, contributes to the increase of $CO_2$ concentration, whereas the remaining part is absorbed by the system Earth through many complex phenomena like adsorption in the oceans and photosynthesis process.

Through such relation, contribution to the $CO_2$ emission compensation will be evaluated both for vehicles equipped with an albedo-certified white reflecting surface and for personal items to be exposed to the sun like tents, umbrellas, clothing, etc.

The results provided by the model proposed in the patent will be compared with a numerical model obtained from the scientific literature and possibly adjusted to the project’s goal.

CIRIAF (O.U. 2) will fulfill to all the requested obligations towards the patent exploitation and will manage all the contacts towards patent rights holders. Costs from such activities, a 10 % of the whole project, are charged to CIRIAF.

Task 2: development of previsional models to study the interaction between albedo and climatic characteristics

*Operational Unit involved: CMCC (O.U. 1)*

*Description of Research Task 2*

Under this research task a model will be developed to study the interaction between albedo of natural/artificial surfaces and the climate/geographical features of the installation site; in particular:

- geographical position of the installation site chosen for the reflecting surfaces;
- sunshine feature in the installation site chosen for the reflecting surfaces;
- climate data, in particular with reference to sunshine and average cloud cover in the installation site chosen for the reflecting surfaces;
- complex phenomena of thermal exchange which could cause positive or negative feedbacks.

Results out of this study will allow to locate the most suitable areas to install the white reflecting surfaces and to purposefully define a map of italian territory.

A global index will be introduced to characterize territory with reference to the natural albedo, the weather and the geographical features of each area.

Effectiveness of reflecting surfaces is notably higher in areas where a major sunshine level is combined with low cloud cover and low albedo; for this reason, both sea surfaces (albedo 0.02÷0.06) and areas in subtropical or equatorial zones, are particularly suitable to have reflecting surfaces installed.

Task 3: experimental verification of proposed methodology

*Operational Unit involved: CIRIAF (O.U. 2)*

*Description of research Task 3*

Under this research task, data from theoretical model of patents will be experimentally validated. Verification will accomplished through three different experimental devices.

First phase of experimental validation includes the installation, in three suitable sites chosen both for their sunshine and size, of reflecting surfaces as large as 10000 $m^2$ at least. Such sites could be located in northern Italy (Milano), southern Italy (Napoli) and in the center (Perugia), in order to evaluate the effect of latitude on the reflecting surfaces' performance. A specific methodology of installation, validation and measure will be developed in order to evaluate the effect of reflecting surfaces on the temperature: local temperature sensors, satellite remote sensing using radiometers and image processing of satellite photographs (Fig. 1), as foreseen in research Task 3.

In order to enhance the accuracy of spectrophotometric measurement from satellites a station of **trusted surfaces** will be built: the albedo of two surfaces, one horizontal and one vertical of about 10 $m^2$ each, will be precisely measured *in situ* with an integration sphere spectrophotometer. Purpose of such station is to verify advantages of differential satellite spectrophotometry and possibly define potential grids of trusted surfaces both locally and world-wide.

Second phase of experimentation includes the building of a first device made by a lab-scale prototype (physical model) to reproduce the system Sun/Universe/Earth allowing to evaluate changes in Earth's surface's temperature as average reflection coefficient changes. Fig. 2 and 3 show a sketch of a possible prototype.

The second device will be made by two greenhouses with base surfaces having a variable albedo and the same orientation. Fig. 4 shows a drawing of the two possible greenhouses. Greenhouses will be equipped with sensors to measure internal temperature, temperature of the bases and of the transparent surface exposed to solar radiation. Relation between the albedo and the internal temperature in the greenhouses will be determined by comparing sensor readings inside both installations in function of albedo changing.

Results from the three experiments will be compared with the model proposed in the patent in order to evaluate possible differences and define a methodology to tune the model through the introduction of control parameters. In order to comply with the results granted by the model proposed using the IV Report of IPCC, the measure of the reflecting surface effect will be both expressed in terms of reduction in the atmospheric concentration of $CO_{2eq}$, and converted in radiating forcing.

CIRIAF (O.U. 2), with the collaboration of experienced companies like Global Engineering, will take care of the first phase of experimental validation, installing in three specifically chosen italian sites three reflecting surfaces with an extent of at least 10000 $m^2$. Costs for this activity have been estimated and assigned to CIRIAF in order to perform its research Task (see Costs Table).

Task 4: certification of methodology to determine albedo of white reflecting surfaces: differential satellite spectrophotometry

*Operational Unit involved: CRC (O.U. 3)*

*Description of research Task 4*

Under this task a methodology will be defined to certify the photometric properties of reflecting surfaces. In particular the methodology will determine:

- photometric variables which characterize reflection and emission properties of surfaces (reflection coefficient in the solar spctrum, directional specific emission, etc.);
- requirements of the devices to measure such photometric variables (operational wavelength interval, thermal-oxidation degree, ageing due to sun exposure, specular and diffuse reflectivity, etc.);
- in presence of weather-caused decay, the minimum threshold of photometric properties under which a restore of the original conditions of surfaces is necessary;
- procedure of building the surfaces in function of their structural features and of the installation site typology;
- frequency of measurements to verify photometric properties in function of physical-chemical characteristics of surfaces, in function of installation procedures and climate features of the installation site (rainfall frequency, average wind velocity, maximum and minimum value of temperature, etc.).

Research activities include the development and certification of a design method to estimate albedo of arbitrarily oriented reflecting surfaces, based on theoretical evaluation of solar radiation energy data as reported in standards like UNI 8477, UNI 10349, ISO 9845, etc. In particular such methodology will allow to determine the effectiveness of an arbitrarily oriented surface in terms of the equivalent horizontal surface, in function of changes in latitude and in the orographic/urbanistic scenario surrounding. The reflected portion of solar radiation depends upon the angle of incidence of the radiation, but also upon the latitude of installation site (solar radiation intensity decreases with latitude) and the typology of terrain surrounding the site (presence of natural obstacles like hills or mountains and artificial ones like buildings, etc.).

Finally, a methodology is expected to measure/verify the albedo of reflecting surfaces through the processing of remote sensing data collected with the technique of differential satellite photometry. For this purpose a software will be developed to estimate the solar radiation reflected by the Earth's surface and to automatically calculate the albedo. A validation methodology is expected to set up measurement technique through differential measuring of albedo using trusted surfaces (see Task 2). A comparison between experimental data from Task 2 and results from such measurement methodology will allow to determine possible errors in the relation between the $CO_{2eq}$ reduction and the extent of reflecting surface.

Task 5: credential for the methodology to determine the albedo of arbitrarily oriented surfaces

*Operational Unit involved: CIRIAF (O.U. 2)*

*Description of research Task 5*

In order to get credentials for the methodology to determine the relation between the extent of horizontal reflecting surface and the corresponding temperature decrease and to determine the albedo of arbitrarily_oriented surfaces, a collaboration is envisaged with certifying autorithies like UNFCCC (United Nations Framework Convention on Climate Change) who is the international agency in charge of giving credentials to private and public companies as Designated Operational Entity (DOE).

CIRIAF (O.U. 2) will take care of managing contacts with such autorithies and it will undertake any cost due to credential negotiations. All costs from this activity will be charged to CIRIAF.

Task 6: life cycle analysis of the different solutions to build the reflecting surfaces as proposed in the patents

*Operational Units involved : CIRIAF (O.U. 2), CRC (O.U. 3)*

*Description of research Task 6*

Under this phase, a study will be carried out to determine the costs, the energy loads and the potential impact along the whole life cycle (Life Cycle Assessment), associated to the six application solutions for the reduction of global warming as proposed in patent PG 2007 A 0009.

The study, besides the technical-economical evaluation, will show the $CO_{2eq}$ released during the processes to produce and/or implement the different proposed solutions as well as during the operational, maintenance and dismiss phases of them. Particular attention will be devoted to the calculation of $CO_{2eq}$ released during the production of raw materials necessary for the reflecting surfaces. The most suitable material to build the reflecting surfaces will be infact chosen not only out of its photometric features but also out of its cost and the $CO_{2eq}$ generated during its production, maintenance and dismissal.

The effect of proposed systems on local climate and on vegetal and animal organisms living at the installation site,  will be studied as well; so will be all the possible external costs which the local population could bear because of climate changes, health issues, damages to structures produced by such systems.

Task 7: social, economical and political consequences of the proposed solutions

*Operational Unit involved: CMCC (O.U. 1)*

*Description of research Task 7*

In this phase the social, economical and political consequences of the proposed solutions will be taken into account. As previously noted, the effectiveness of the solutions as depicted in the patents is presumably higher for installation sites located in intertropical zones and generally at lower latitudes. If such effectiveness, in terms of global warming reduction, was internationally acknowledged and assessed through a mechanism similar to the emission trading one, the installation of reflecting surfaces could represent a valuable source of development for many countries geographically located in those areas. Chances of income could come from:

- direct profit generated from emission trading by the sell of credits earned becasue of $CO_{2eq}$ avoided proportional to the reflecting surface installed;
- indirect profit generated from the production, management and maintenance of the reflecting surfaces on behalf of those industrialized countries which, for different reasons (geographically unsuitable, lack of available free and low valuable land), have no advantage in installing reflecting devices in their own territory.

Task 8: dissemination and scientific exploitation of results of the research

*Operational Units involved: CMCC (O.U. 1), CIRIAF (O.U. 2)*

*Description of research Task 8*

This task include the dissemination and scientific exploitation of results of the project through the organization and the partecipation to conferences, workshops and meetings both at national and international level, particularly in the USA due to the preexistent collaboration between CMCC and EPA; extended partecipation to other american partners will be pursued and papers will be published in scientific journals as well.

Dissemination will be preferably carried out in those countries where pollutant emission is a major issue like for instance all the industrialized countries which are responsible of the highest emissions of greenhouse gases (USA, Germany, France, etc.) and the developing nations with obsolete power plants (China, India, etc.).

Thanks to the above mentioned collaboration between CMCC and EPA, the possibility to extend the white reflecting surface certification procedure to the USA will be taken into account. An alternative participation to the Kyoto’s goal could be envisaged for the USA through the installation of white reflecting certified surfaces instead of reducing direct emissions of greenhouse gases.

**4. Duration of the project**

Duration of project is 18 months.

**5. Coordination and management**

General coordinator of the project is dott. Antonio Navarra

Technical-scientific coordinator is prof. ing. Franco Cotana

**6. References**

F. Rossi, F. Cotana, M. Amantini, “ Prototipo di un dispositivo per il Controllo dell’Albedo terrestre finalizzato a contenimento del riscaldamento globale”. Atti del 7° congresso nazionale CIRIAF. Perugia 30-31 marzo 2007, pp. 77-82.

F. Cotana “Award - Prize - Commitment for sustainable development”. IAEE, Firenze 12 giugno 2007.

Web site: www.biancoriflettente.it

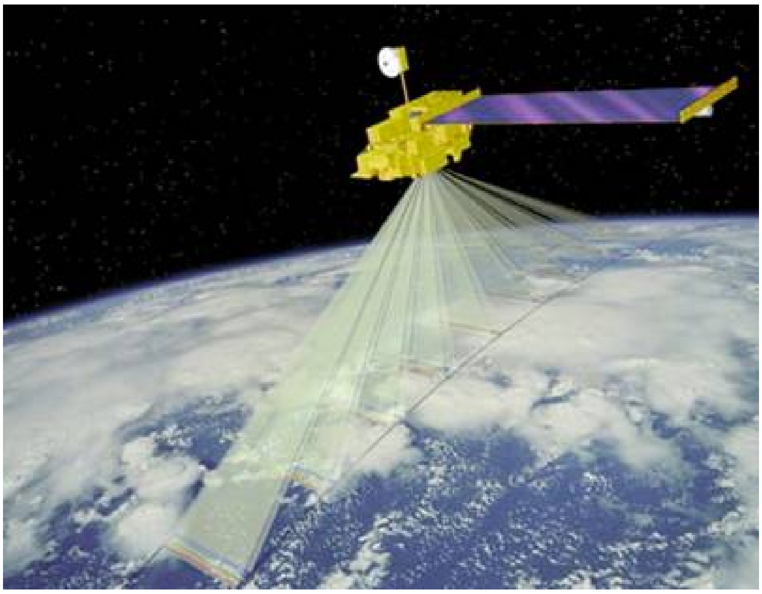

Figure 1: *measurement of Earth’s surface’s albedo through image processing of satellite photographs.*

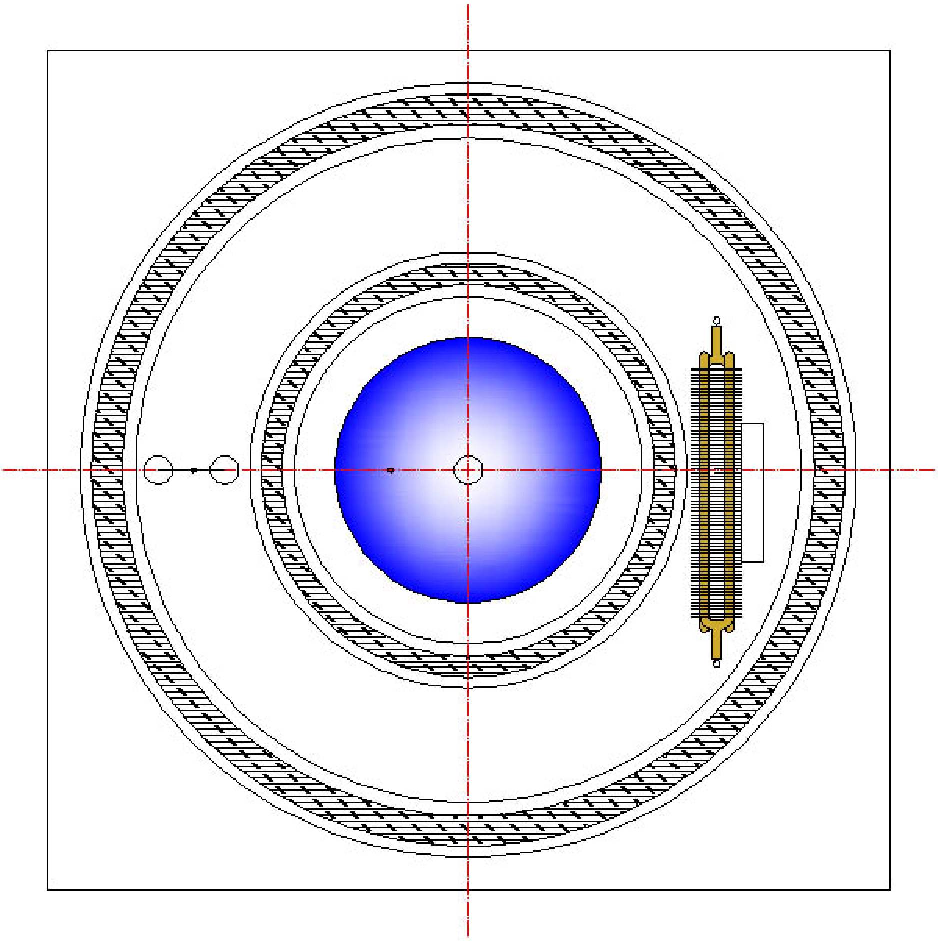

Figure 2: *sketch of possible prototype for the modelling of the Sun/Universe/Earth system. Upper view.*

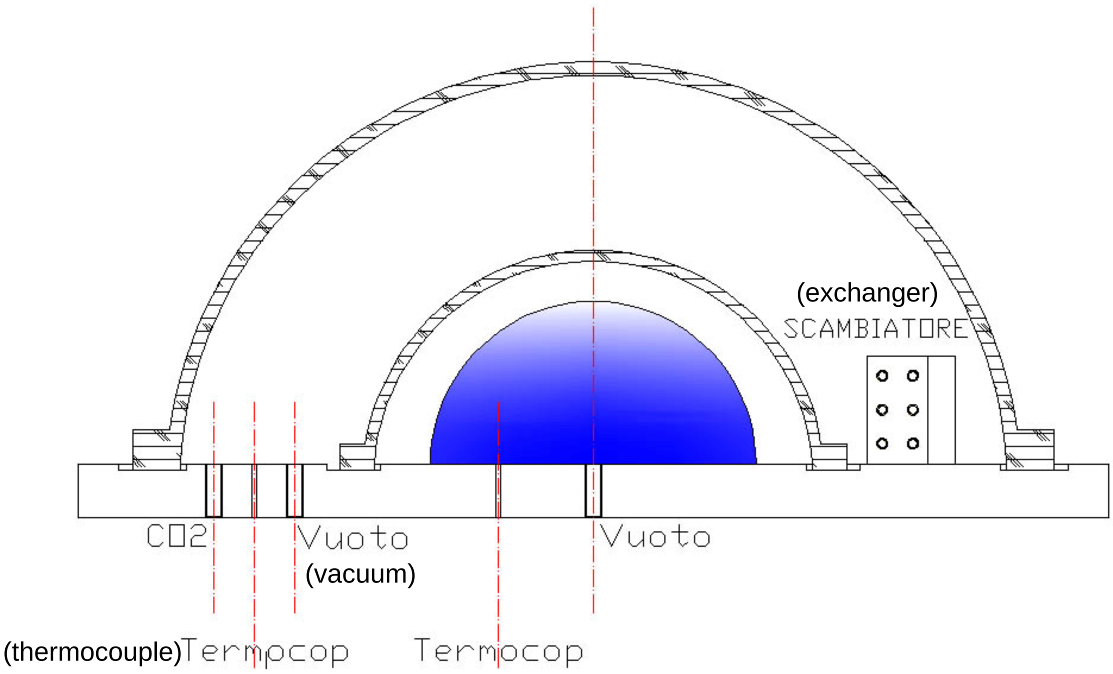

Figure 3: *sketch of possible prototype for the modelling of the Sun/Universe/Earth system. Lateral view*

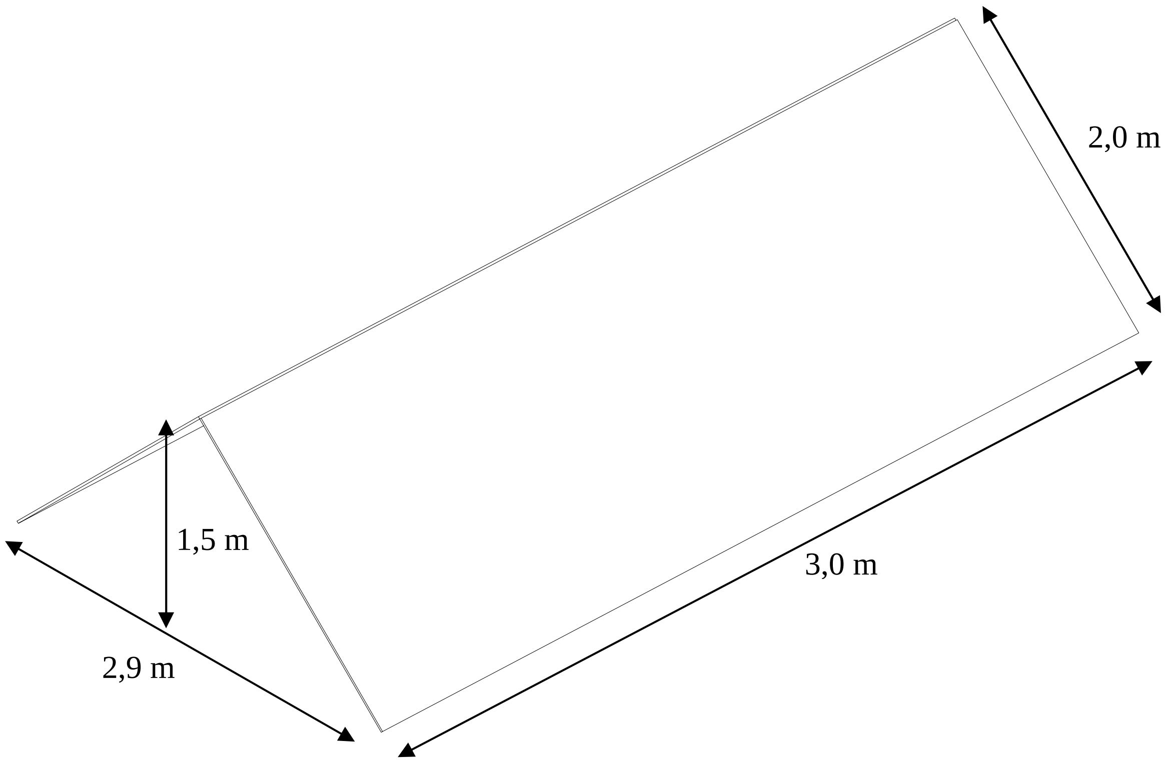


Figure 4: *sketch of possible project for a greenhouse using surfaces with variable albedo.*