

L'ORÉAL AND SOLAR ULTRAVIOLET RADIATION

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ABSTRACT

The L'Oréal group includes 17 global brands, some of which propose lines of high-grade sunscreens. Research on the biological and chemical effects of ultraviolet (UV) radiation on the skin and hair is of paramount importance to assess the efficacy of cosmetic UV filters. UV irradiances and daily doses are provided by the Tropospheric Emission Monitoring Internet Service, which is managed by the National Dutch Meteorological Institute. The data and the quality of service have been assessed. Comparisons with available data, even if limited, showed excellent agreement. A few requirements remain to be addressed, particularly data on UV-A radiation. They will be implemented within the existing user-friendly interface. All these data will be used to improve the customization of sunscreens to consumers' needs while answering health authorities' demands.

1 THE L'ORÉAL GROUP AND ITS RESEARCH

The [L'Oréal group](#) is the global leader in the cosmetics industry. Cosmetic products include hair care, dyes, shampoos, skin care, sunscreens, make-up and drugs (dermatology). The group's major global brands come from Europe, the United States of America and Asia, enabling L'Oréal to provide consumers worldwide with a portfolio of brands of diverse cultural origins that satisfy all tastes, whatever the demand. Each culture has its personal care and presentation rituals, its make-up secrets, its vision of beauty... L'Oréal draws on this diversity to provide the best response to consumers' expectations everywhere. In addition, while beauty is a world traditionally associated with women, L'Oréal's care lines are increasingly devoted to the specific needs of men (Vichy, Biotherm, Lancôme, L'Oréal Paris...), and adapted to the desires and needs of each age group.

L'Oréal group has a research and development department for cosmetics and dermatological research with about 2,900 scientists and support staff. A network of research and evaluation centers has been established, which includes 14 research centers and 10 evaluation centers worldwide. The role of the evaluation centers is to observe the personal care habits of the women and men in their respective country and to check that a product is attuned to the culture, climate and environ-

ment of the market where it is to be launched, and comply with the needs of the different skin or hair types. Part of the research consists of studying the effects of the sun's radiation and air pollution on skin and hair. For example, research has been done on the harmful effects of urban pollution on the health, skin and hair of the people in Mexico City.

2 MOTIVATION FOR PARTICIPATING IN THE PROJECT (BACKGROUND)

[Hair](#) and [skin](#) occupy a special place on the surface of the human body, in direct contact with the environment. This explains the diversity of their properties according to places where people live, and their alterations in terms of: structure, function, appearance. This diversity and these alterations (cosmetic and pathologic) are partly linked to climate and pollution. Albeit atmospheric pollution has significant effects on skin and hair, this paper will deal only with solar ultraviolet (UV) radiation.

The solar spectrum includes several wavebands, including UV (280-400 nm), visible and infrared light. UV radiation from the Sun is largely absorbed by ozone in the stratosphere, notably at the shortest wavelengths. A small part of the UV-B (280-320 nm) and most of the UV-A (320-400 nm) radiation, however, reach the Earth's surface. The amount of harmful UV radiation that will reach the Earth's surface is directly related to the thickness of the UV absorbing ozone layer (which is located between 10-40 km altitude). Thinning of the atmospheric ozone layer due to ozone depletion and changes in the meteorology in the stratosphere leads to elevated levels of UV-B at ground level (1-7). A decrease in ozone of 1%, for example, will lead to an estimated 2% increase in UV-B.

Although the UV portion represents less than 7% of total solar irradiance between 280 and 2500 nm received on the earth's surface (8), the UV photons are the most biologically effective ones. This radiation can be harmful to vegetation growth and human health, in particular UV-B radiation. Sunburn, for example, is largely due to UV-B rays, though UV-A rays significantly contribute too. Exposure to UV radiation can have severe consequences on both the skin and hair. Consequences on skin include erythema (also called sunburn), ageing (9-

11), wrinkles (12), dryness, immunodeficiency (13-16), allergies, pigmentation (also called tanning) (17-20)... but also skin cancers (21-27); consequences on hair include protein and lipid oxidation, and alterations of the cosmetic aspect (appearance), structure, function, and properties (fragility) (28-30).

3 INFORMATION NEEDS AND REQUIREMENTS

Therefore, it is important that the UV radiation at ground level be monitored. The exposure conditions need to be characterized. The amount of energy the skin is exposed to, can be quantified. Irradiance (unit: $W \cdot m^{-2}$) is the right parameter to be used; it measures a power (energy per second) divided by the exposed area. The energetic dose (unit: $J \cdot m^{-2}$) is the product of the irradiance by the duration of exposure. Since effects depend highly on wavelength, spectral irradiance is of interest (unit: $W \cdot m^{-2} \cdot nm^{-1}$). In addition, summed irradiances and doses, over UVB and UVA wavebands, provide useful information, partly because numerous laboratory studies involved lamps that emit energy at these wavelengths.

The erythemal UV index is derived from the erythemal irradiance, which is an integration of the UV irradiance between 280 and 400 nm, weighted by the CIE erythema spectral action function. The CIE action spectrum is a model for the susceptibility of the Caucasian skin to sunburn (erythema). It was proposed by McKinlay & Diffey (31) and adopted as a standard by the [Commission Internationale de l'Éclairage](#) (International Commission on Illumination) (32). The erythemal UV index is given for local solar noon, when the Sun is highest in the sky. The erythemal UV index is generally simply referred to as UV index, but to distinguish it from similar quantities based on other action spectra, the adjective "erythemal" is added throughout the document.

The daily erythemal UV dose is an integration of the erythemal UV index from sunrise to sunset, taking attenuation of the UV (by clouds, pollutants...) into account. The daily erythemal UV dose is therefore the total amount of UV radiation that may cause sunburn when received by the human skin during the day.

Furthermore, useful information can be extracted from the UV irradiances and doses: climatologies, global and local maxima and averages, time series at different locations and forecasts.

3.1 Limitations of existing information

Yet, data on UV radiation are already available, in published literature (33) or through networks (34-36).

However, there are too few (or geographically missing) collecting sites worldwide; the availability of data over time is limited; data come from instruments that are different and that are calibrated using different methods and materials, therefore instrumental intercomparisons are mandatory; and hardly no data on UVA radiation are available.

For this purpose, the UV Radiation Monitoring Service of the Tropospheric Emission Monitoring Internet Service (TEMIS) provides UV index and UV dose, which are derived from total ozone column data as measured by [GOME](#): Global Ozone Monitoring Experiment onboard the [ERS-2](#) (European Remote Sensing) satellite and [SCIAMACHY: SCanning Imaging Absorption spectroMeter for Atmospheric CartographY](#) onboard ESA's [ENVISAT \(ENVironmental SATellite\)](#). TEMIS is a project within [Data User Programme](#) (DUP) of the [European Space Agency](#) (ESA). The products and service received are developed below.

3.2 Requirements

The requirements are summarized in a document written by the TEMIS workgroup and are accessible at http://www.temis.nl/internal/impphase/URD_v2.5.doc.

The UV irradiances and doses should be calculated at sea level, for any region in the world, with additional focus on selected populated areas. The spatial resolution is fixed to 1 by 1 latitude/longitude degree, because the proposed variable spatial grid (100 kms if population density is lower than 100 inhabitants / km², 10 kms otherwise) is not achievable yet. The time span for climatologies is as wide as possible, i.e. data since 1995 and afterwards are considered. Means of data for every ten days or less, depending on the variation in time of the product (a significant variation is 20 %), are of interest. When spectral data are considered, the spectral step should be 1 nm. The agreement with results from other models should be better than 5%.

The interface is required to be user-friendly, that is why results should be given in the form of data files and images. Interactive maps would be a must. Thus, the preferred delivery method is web pages.

Special access to data is also required by L'Oréal, to get a leading advantage over its competitors.

4 INVOLVEMENT IN THE PROJECT

The implementation of the TEMIS service results from direct interactions with parties interested in the tropospheric satellite data products –here, namely L'Oréal and the Dutch Meteorological Institute ([KNMI](#)). The final choice of data sets that are delivered through

TEMIS depends on the requests and requirements from L'Oréal.

Thanks to an open collaboration, the involvement was effective. The follow-up was periodically made, by e-mail and by attending progress meetings. L'Oréal gave numerous feed-backs, proposing improvements and additional reference documents (e.g., a UV model that is accessible on-line; a link to a site to get latitude and longitude coordinates of any place).

5 PRODUCTS AND SERVICES RECEIVED

Advanced retrieval techniques, chemistry transport modeling and data assimilation techniques are used to derive high-quality tropospheric products based on the measurements of SCIAMACHY and GOME.

The images and data files are available via the TEMIS website at <http://www.temis.nl/uvradiation/>. The service report delivered is described here: http://www.temis.nl/internal/impphase/SR_UV.doc.

Two products have been delivered. The first product is the UV erythemal index, for clear-sky conditions, for the world and Europe. Today and 4-days forecast are based on SCIAMACHY data. Climatologies of the UV erythemal index are based on GOME data, including monthly averages and yearly extrema. The second product is daily erythemal UV doses. Data for 2004 are based on SCIAMACHY measures, and climatologies (1995-2003) come from GOME data. Last, an on-line help is also provided. Although it is not a product, it is mentioned as a valuable service.

6 ASSESSMENT OF THE PRODUCTS AND SERVICES

The results, the ease of use of the products, and the assistance quality have been qualitatively assessed.

6.1 Comparisons with other models

UV irradiances and doses can be calculated using numerous numerical models, most of them based on Radiative Transfer equations (33,37-41). The models have been intercompared (42-46), and their validation includes comparisons with ground measures (47-51). The Diffey model is far too imprecise ($\pm 40\%$). The equations in the Green *et al.* model need corrections and therefore cannot be used. The results published by Sabziparvar *et al.*, though they are given with a spatial resolution of 5 by 5 degree, are of value. Since for data from Lubin *et al.* the time periods are different and the spectral step is 5 nm, which is too wide to warrant accurate calculations when spectra are biologically weighted, the results cannot be directly assessed. However, climatologies would worth being developed from them, cal-

culating the mean over several years. Results from the model made available by Engelsen may be accurate, but only local comparisons can be done. The cloudiness parameter and the total ozone column have to be entered. The ozone values are calculated from TOMS satellite instruments measures, which may not be as reliable as those calculated from GOME or SCIAMACHY measures.

One can note that any other data are available with a lower spatial resolution. Therefore, comparisons could be made only for given locations; and most of the time these comparisons were uneasy to perform, due to different formats and/or numerous inputs to be entered manually. Some other published data are of value, e.g. to set a maximum spectral irradiance at the ground level (52,53). They can be used to assess a tiny part of the results from TEMIS.

In addition, TEMIS results were believed to be given after exhaustive quality controls, and cross-checks with other existing models were implicitly made by the KNMI. At last, as UV radiation models are far from the core of the activity of L'Oréal research, very little time has been devoted to this task. All the tests performed showed good agreement, but the differences between the results from TEMIS and those from other models have not been calculated.

6.2 Ease of use

The ease of use of the delivered products and care of specifications has also been monitored. The products are really easy-to-use and displayed with user-friendly formats.

6.3 Assistance quality

Some questions have been raised, outside a systematic assessment of the assistance quality. Yet, we have noticed that the answers were always obtained within a few days, and were very relevant and completely addressing the question with additional matter of thought when applicable.

7 EXPECTATIONS FOR THE REMAINDER OF THE PROJECT

L'Oréal has some requirements that were not written in the users' specifications document. The corresponding complementary products include interactive maps, UV-index and UV doses results after May 2003 (i.e. based on SCIAMACHY): Yearly averages and extrema, monthly averages and climatologies, both globally and for areas of interest. Data on UVA radiation are still waited. Time series at specific locations should be delivered soon. The remaining question is the date of

delivery, which is expected to be before the end of the project. At last, a higher spatial resolution: 10 x 10 km, and an extended spectral range for the spectral irradiance (280-1100 nm) have been indicated in L'Oréal's requirements but are not expected for the remainder of the project. Nevertheless, information about whether these improvements can be achieved is expected as soon as possible.

8 PLANS FOR THE USE OF THE SERVICES

The TEMIS services on UV radiation monitoring are used in two main applications. The first benefit for L'Oréal's research is the improvement of the relevance of indoor tests. Actual UV spectra can be better mimicked in solar simulators, by adjusting the filtering systems. The UV doses that are delivered can be fine-tuned, for example using knowledge of realistic daily doses at given places and dates. This fine-tuning is applied to internal tests, studies made by sub-contractors laboratories, and studies made within scientific collaboration programs. This geographically- and time-fitted calculations aim to provide cosmetic products customised to consumer needs, worldwide.

The second benefit for L'Oréal is to help the scientific communication on UV radiation. Photo-education is part of the communication package of sunscreens. A simple argument is based on a four-step demonstration. First, healthy, unexposed skin is taken as a reference. Second, the UV doses that can be received are calculated thanks to data from TEMIS. Third, studies made indoor and/or outdoor assess the skin biological damage when exposed to such doses, together with reduction of biological damage when sunscreens are applied onto the skin. Fourth, the benefits of applying the right products become evident. This scientific communication ultimately aims at convincing people about the benefits of a lifetime UV photoprotection. A possible way includes providing of Internet services to consumers. Such services rely on high-technology work, which will help L'Oréal to take a lead over its competitors.

9 CONCLUSION

The collaboration displayed here leads to a state-of-the-work that is fitted to industrial needs and can address the consumers' daily expectations on health, beauty and related science. This project is a unique opportunity to make a user-friendly database, which helps to think global to better act local.

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