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The Earth's radiation budget on a daily 1x1 degree resolution from the ESRB project

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The Earth's Surface Radiation Budget (SRB) is the key quantity that determines global climate and climate change from increased greenhouse gases. Measurements of the radiation budget at the top-of-the-atmosphere (TOA) are routinely made by satellites (e.g., the Earth Radiation Budget Experiment (ERBE)). However, the SRB needs to be computed indirectly from TOA measurements using radiation transfer models. To this end the World Climate Research Programme (WCRP) has supported projects like the Global Energy and Water Cycle Experiment (GEWEX) SRB which aims to quantify the global surface radiation budget at high resolution. ESRB is a European contribution to this project.

Specific objectives of the project were: 1. Use the new GEWEX ISCCP DX-based 1 degree resolution cloud climatologies produced by NASA Langley with FORTH's radiation transfer models to generate the daily global SRB at 1 degree resolution and compare it with the new GEWEX 1 degree resolution SRB. 2. Validate the model with a high resolution SRB for sites, where ground stations (BSRN and GEBA) measure SRB, supplemented by existing METEOSAT cloud climatologies and NOAA/AVHRR surface-properties data. 3. Upscale the GEWEX and the Model 1-degree TOARB to 2.5 degree resolution and validate these against the ERBE 2.5 degree TOARB.

Well-tested deterministic radiation transfer models were used for the shortwave (SW) and longwave (LW) fluxes using the GEWEX climatologies. The SW model apportions appropriately the incoming solar flux to the UV-visible and near-IR spectral bands. The solar radiative transfer in the Earth-atmosphere system is treated separately in each spectral band and accounts for multiple scattering. The sky at each cell is divided into clear and cloudy fractions, and hence direct and diffuse components are considered. The aerosol direct effect has been taken into consideration in the SW model. The LW model divides the thermal spectrum into twenty-eight intervals and treats each one separately. The cloudy and clear fractions of each cell are examined here too, individually. The total fraction of the cloudy sky is taken to comprise three non-overlapping low, mid and high-level cloud components. The cloud data which are required as input are: cloud cover fractions for low, middle, and high-level clouds, cloud-top pressures, temperatures, and optical depths. Other inputs include atmospheric profiles of temperature and humidity, aerosol data, surface albedo, etc.

The model behaviour has been tested through sensitivity analysis with respect to the climatological inputs. Temporal anomalies have been derived, showing the radiation response to major events, such as the El Niño, La Niña, the Pinatubo eruption, etc. Our modelled outgoing SW radiation at TOA decreases at a rate of 1.9 $\pm$ 0.3 Wm^{-2}/decade in the Tropics over the period 1984–2000, compared with the ERBE observed decrease of 2.5 $\pm$ 0.4 Wm^{-2}/decade. During the same period, the outgoing tropical LW radiation from our model shows an increase of 1.9 $\pm$ 0.2 Wm^{-2}/decade, while the ERBE observational data indicate an increase of 2.8 Wm^{-2}/decade. The main reason for both SW and LW TOA radiation trends is the decreasing cloud amount.

Among the publicly available deliverables of ESRB (EC funded 2001-2004, http://esrb.iesl.forth.gr) are estimates of the global SRB and TOARB on a monthly, 2.5 degree resolution for the period 1984-2000 and on a daily, 1 degree resolution for the period 1984-1995. Validation at the surface is achieved through comparison with ground-based measurements (GEBA and BSRN), and at TOA against satellite data (ERBE).