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Night sky brightness at sites from satellite data

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Abstract. We present a method to evaluate the artificial night sky brightness across the entire sky at any site of the World for given atmospheric conditions and accounting for mountain screening, elevation and Earth curvature. The method is an extension of the modelling technique developed by Roy Garstang and extended by Cinzano, Falchi, Elvidge & Baugh and Cinzano, Falchi & Elvidge with the use of satellite radiance measurements at visible wavelength.

Key words. atmospheric effects – light pollution – site testing

1. Introduction

Cinzano et al. (2000) and Cinzano, Falchi & Elvidge (2001b) presented a method to map the artificial night sky brightness across large territories in a given direction of the sky by evaluating the propagation of light pollution with Garstang models (Garstang 1986, 1989a,b, 1991) and the upward light emission from high resolution radiance data from the US Air Force Defence Meteorological Satellite Program (DMSP) (Elvidge 1999; Elvidge et al. 2001). This method was extended by Cinzano, Falchi & Elvidge (2001a) to the mapping of naked eye and telescopic limiting magnitude. We further extended it to the prediction of the distribution of the night sky brightness and limiting magnitude over the entire sky at any individual site of the World, for a range of atmospheric conditions and accounting for mountain screening, elevation and Earth curvature. This open the road to a continuous monitoring of the situation of the entire sky at any site in the world in any photometrical band.

2. Method and example results

We extended the method in order to compute the night sky brightness and the limiting magnitude produced by each land area inside 200 km from the chosen site, on a grid of points in azimuth and altitude covering the entire sky of the site. Land areas are those covered by pixels of the satellite data. We obtained the upward flux from the DMSP Operational Linescan System, an oscillating scan radiometer with low-light visible and thermal infrared imaging capabilities. Special data has been acquired at a number of reduced gain set-

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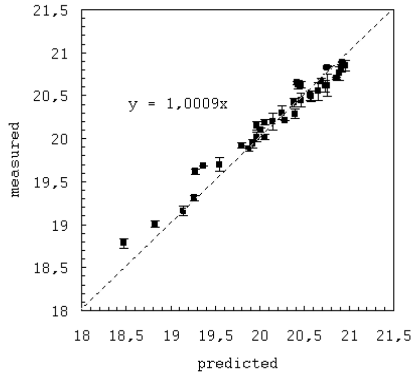

Fig. 1. Our predictions versus measurements at Serra la Nave Observatory.

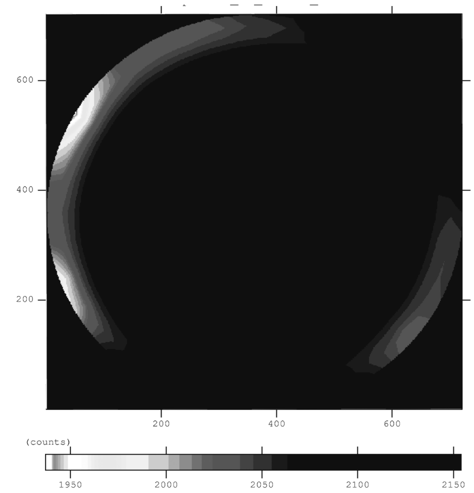

Fig. 2. A first preliminary map of the night sky brightness in V-band at Mt. Graham.

tings to avoid saturation on major urban centres and overcome dynamic range limitation. The reduction steps were described by Cinzano et al. (2000, 2001a) and Elvidge et al. (1999; see also Falchi 1998). At this stage we assumed that land areas have on average the normalized light emission function discussed by Cinzano et al. (2001a). This could be wrong near Astronomical Observatories where laws against light pollution are enforced. As Garstang (1989a) we take into account the elevation of both the source and the site. Screening by terrain elevation was accounted based on a global digital elevation model from the US Geological Survey. We also determined the observer's horizon, i.e. the altitudes above which the observer's line-of-sight is screened by terrain, and we set the total brightness to be zero below them. The natural night sky brightness was modelled as Garstang (1989a). We assumed standard clean atmosphere as Garstang (1986).

Cinzano & Elvidge (2003) presented some test simulations of umbrae on the night sky produced by mountains screening city lights. Fig. 1 shows a comparison between our preliminary predictions and the measurements taken by Catanzaro & Catalano (2000) at Serra La Nave Observatory. Fig. 2 shows a preliminary map of the night sky brightness at Mount Graham. DMSP data were obtained in the darkest nights of lunar cycles in March 1996 and January-February 1997. Upward flux calibration refers to the average lighting spectra in Cinzano et al. (2000) and to a extinction at imaging time of $\Delta m = 0.33$. Fig. 2 can be compared with the photo taken twelve years before by Officer & Welch[1].

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