

# STATUS AND PLANS FOR GLOBE AT NIGHT 2006-2009

MALCOLM SMITH<sup>1,9</sup>, CONNIE WALKER<sup>2</sup>, STEPHEN POMPEA<sup>2</sup>, DOUGLAS ISBELL<sup>2</sup>, PEDRO SANHUEZA<sup>3</sup>, D. MCKENNA<sup>4</sup>, PAT SEITZER<sup>5</sup>, PETER MICHAUD<sup>6</sup>, JORGE GARCIA<sup>6</sup>, RODRIGO CARRASCO<sup>6</sup>, DAVID ORELLANA<sup>7</sup>, DAN BROCIIOUS<sup>8</sup> AND KIM PATTEN<sup>9</sup>.

<sup>1</sup>AURA/NOAO/CTIO, Chile; <sup>2</sup>Public Affairs and Educational Outreach Department, U.S.

National Optical Astronomy Observatory (NOAO); <sup>3</sup>Oficina de Protección de la Calidad del Cielo del Norte de Chile (OPCC); <sup>4</sup>Vatican Observatory, University of Arizona; <sup>5</sup>University of Michigan; <sup>6</sup>Gemini Observatory; <sup>7</sup>Centro de Apoyo a la Didáctica de la Astronomía (CADIAS);

<sup>8</sup>SAO/Whipple Observatory; <sup>9</sup>International Dark Sky Association.

Following the outstanding initial success of “GLOBE at Night” - a prototype effort to get people to go out and observe the sky, which reached more than 18,000 people in 96 countries in March 2006 ([www.noao.edu/outreach/press/pr06/pr0608.html](http://www.noao.edu/outreach/press/pr06/pr0608.html)) – we report on the second GLOBE at Night campaign held during March 8-21, 2007 and outline plans for 2008, 2009 and beyond. We have again benefited from in-kind support for the project’s Web site from the GLOBE program (Boulder, CO) and other GLOBE partners for participant data collection (see [www.globe.gov/GaN/](http://www.globe.gov/GaN/)).

In order to provide greater sensitivity in our efforts to document changes in light pollution - that will be particularly important around sensitive areas such as astronomical observatories and national parks - we have taken the “GLOBE at Night” concept a step beyond the unaided-eye constellation viewing undertaken during the 2006 version. This key new feature, introduced on a limited, pilot basis into the 2007 version of “GLOBE at Night”, is the use of Unihedron’s “Sky Quality Meters” – compact, portable, digital, sky-brightness-measurement devices that have been recommended to us by several sources. GPS receivers were used in some places to provide reliable position information as a prelude to future, detailed mapping of cities and their changing light-pollution footprints.

We have already started thinking about a subsequent GLOBE at Night 2008 effort, which would be used to extend the work of the most accomplished 2007 teams to a larger number of worldwide sites. In addition to applying and further developing best practices in using the sky quality meters pioneered at exemplary sites, we are studying ways to expand the effort, both in breadth and pedagogical value. Two possible primary expansion paths will be examined: (a) development and testing of kit-based light meters, assembled from basic hardware-store materials, such as PVC pipe, plus a special lens, sensor and electrical counter (based on the idea that the assembly and calibration of such devices has strong pedagogical value beyond simply making and recording the measurements); and (b) purchase and testing of a few remotely operable, Internet-connected, sky-brightness meters capable of highly precise, repeatable measurements, such as those currently under development by one of us (D. McKenna).

In 2009, we plan to integrate “Globe at Night” into the activities associated with the International Year of Astronomy (<http://www.astronomy2009.org/content/view/251/63/>).

## Introduction - Earlier Efforts leading up to “Globe at Night” 2006.

The massive response to the 2006 campaign is an extension of two decades of earlier public star counts. A recent article in *Sky and Telescope* summarizes some of these:

1987: NAO – Tokyo – 1<sup>st</sup> annual “Star Watch”. Supported by Japan’s Environmental Agency. >10,000 people took part in a naked-eye and photographic observation programme. Densitometer used to measure the submitted photos.

1990: IDA “Star Watch” in North America. Several hundred participants each year, who observed the Pleiades with the naked eye and with binoculars. The results are published in IDA’s Information Sheet #59. (<http://www.darksky.org>)

1995: Northern Virginia Astronomy Club. Washington Post published maps of Orion for observers to use. 1500 participants. Naked-eye observations over a two-week period in February. The “Post” published the results under the heading: “City Lights have Stolen the Night Sky”. The result was a map of the DC area to 10 brightness levels based on 700 observations taken from the downtown area - where observations down to 3.5 magnitude were recorded - out to about 50 km away, where observations in the range 4.7-5.5 magnitude were reported.

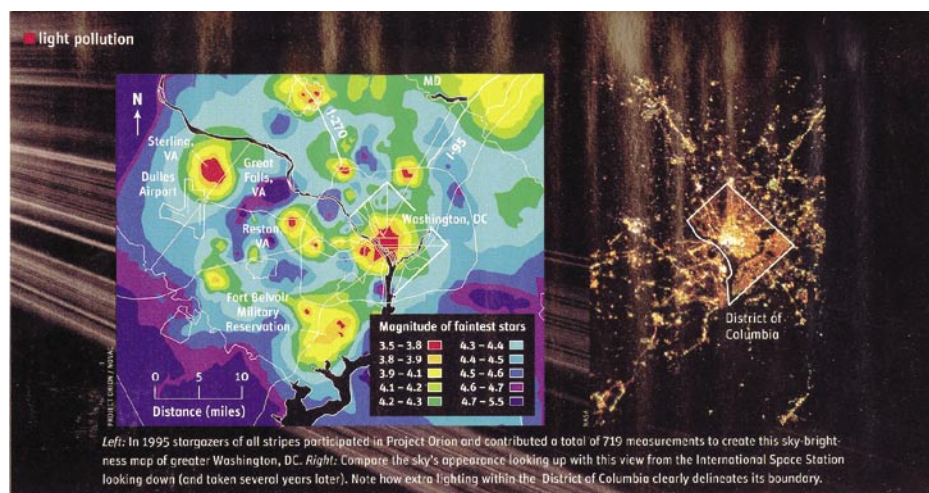


Figure 1. Courtesy “*Sky and Telescope*” – April 2007

2001: National Star Count - part of the 2001 Austrian National Science Week. They used the web and TV. Impact – reached over 2 million people over a two-week period, 500,000 of whom were estimated to have interest in science and technology. A talk later in this session, by Günter Wuchterl - from the Thüringer Landessternwarte and a member of the original Pikall et al. team - will cover this important ongoing programme in much more detail (see also <http://www.sternhell.at/>). This effort, like “Globe at Night” is also being specifically incorporated into the activities of the International Year of Astronomy, 2009 (<http://www.astronomy2009.org/content/view/251/63/>).

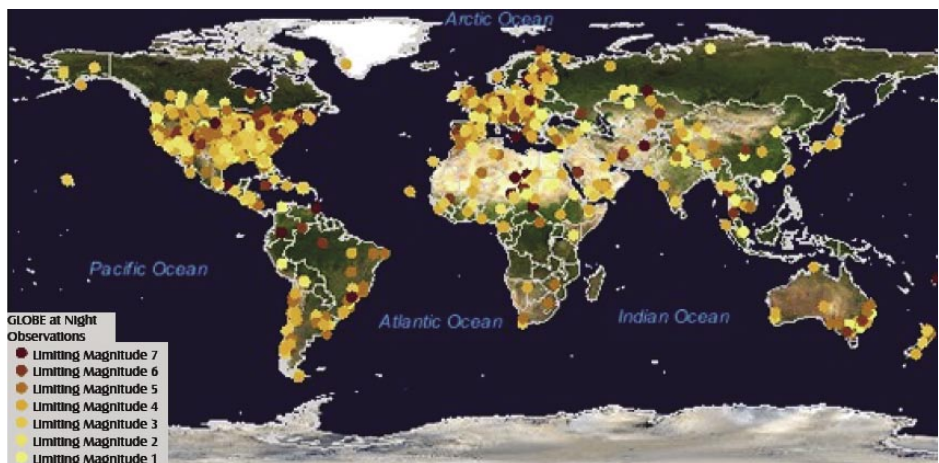
## Building on the earlier experience of Public Star Counts – “Globe at Night 2006”.

The earlier programs such as those mentioned above as examples, have not stopped the spread of light pollution. It turns out that even programs that have not carefully recorded the age or visual acuity of individual observers have produced median data that is sufficient to document that skies are still brightening rapidly in areas where comparisons between different years observations have been made. Key lessons learned for the launch of “Globe at Night” in 2006 were:

- (a) Past efforts have been too limited and infrequent to really make a difference.
- (b) The problem – and interest in it - is world wide, so we should try to reach out to a world-wide audience.
- (c) Use of the web greatly facilitates such massive outreach and facilitates the data recording process.
- (d) We need eventually to include a quantitative element to obtain the best results.
- (e) Useful results can nevertheless be obtained from large samples, even if the quality of some individual observations is low.
- (f) Star maps for different magnitude limits help inexperienced members of the public to take part more effectively.
- (g) Working with the media can greatly enhance the impact of the project and alert the public to the disappearing starlight.
- (h) A long-term approach like the Austrian programme (<http://www.sternhell.at/> - currently recording >2,500 observations in just one country) is necessary in order to obtain data on changes over a useful time base.

## “Globe at Night” – 2006.

As mentioned in the abstract, more than 18,000 people in 96 countries took part in a project that was run on a shoestring budget. Dennis Ward (UCAR) has provided an analysis (<http://www.globe.gov/GAN>) of their observations (see *Figure 2*) which were also reported in the April 2007 edition of “Sky and Telescope”.



*Figure 2.* Results from “Globe at Night, 2006” - 4,951 observations by >18,000 participants in 96 countries. All continents participated except Antarctica (from which Orion was not visible at night in late March)

Perhaps less understood is the important message underlying the histogram prepared by Dr. Ward and shown in Figure 3 (and explained in the figure caption). Humans have radically changed the night-time environment in much less than 200 years – without any understanding until recently of the underlying damage we have been accumulating (see e.g. Feder, 2005; Harder, 2006a,b; Pekkanen, 2007). Our message of the last two decades is another version of the environmental alert now being raised over global warming. We have been more fortunate in that our message – so far – involves only win-win situations (at least where corruption associated with the award of large lighting contracts to international companies does not occur). This may change with the arrival of affordable LED lighting technology (see section 8 below).

The vast majority of observations for “Globe at Night, 2006” were made in popu-

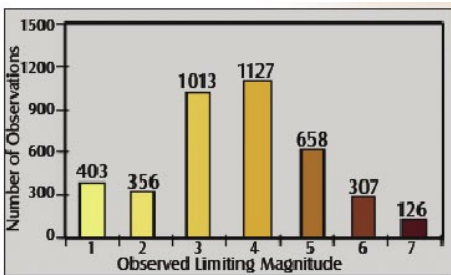


Figure 3. Number of Observations for each Limiting Magnitude

lated, light-contaminated regions of the Earth. Comparing their satellite-based “First World Atlas of the Artificial Night-Sky Brightness” (2001) (<http://arxiv.org/abs/astro-ph/0108052>) with the U.S. Department of Energy (DOE) population density database, Cinzano et al. (2001) report that “About two-thirds of the World population and 99% of the population in the 48 US contiguous states and EU live in areas where the night sky brightness

is above the threshold set by the International Astronomical Union for polluted status. Assuming average eye functionality, about one fifth of the World population, more than two thirds of the US population and more than one half of the EU population have already lost naked-eye visibility of the Milky Way.” The effects on wildlife are just beginning to be realized and acted upon (see, e.g. Harder, 2006b). Do we yet understand the potential human-health consequences of their last comment “...about one tenth of the World population, more than 40% of the US population and one sixth of the EU population no longer view the heavens with the eye adapted to night vision because of the artificial sky brightness”? The articles by Harder (2006a) and Pekkanen (2007) make for sobering reflection. All this needs to be communicated across the information spectrum - from policy makers and government officials to youngsters who ought to inherit this planet with its spectacular natural skies from us. “Globe at Night – 2009” can be a primary contribution by “The International Year of Astronomy” to humanity’s well-being.

Some have asked about the value of observations made without even providing data on the age or visual acuity of the naked-eye observers involved. By using median values from samples as large as those obtained by “Globe at Night”, useful guides can be obtained, as shown for Washington DC in Figure 1 and for the US mainland in Figure 4. Figure 1 shows the extra lighting within the District of Columbia as compared with surrounding regions. Figure 4 shows clearly the greater lighting density on the Eastern side of the United States. Such maps are worth a great deal when one remembers that the US throws over US\$1,000,000,000 of energy uselessly upwards into the sky each

year – and that over half that energy is generated from coal with its well-known pollution and CO<sub>2</sub>-emission consequences.

We can fairly claim that “Globe at Night – 2006” has been a success. Now, how do we ensure that its impact produces results beyond a one-off educational splash?

Ground-based data show that at overall sky brightness viewed from the ground matches the satellite measurements of upward light to a remarkable degree. This is to be expected from models of light-pollution based on population-density. Astronomers in sparsely populated areas, however, need measurements that depend less on available observers – hence an attempt to introduce a variety of cross-calibrated monitoring schemes. For example, mines with strong ambient lighting can expand with alarming speed near many famous observatories and potential future observatory sites.

#### “Globe at Night” – 8-21 March, 2007

The results of this years’ campaign will unfortunately not be published until the end of April and after the deadline for conference manuscripts. The group at “GLOBE” and UCAR have kindly provided, on the GLOBE web pages, some of the preliminary data - but emphasise the need for caution as the data may be revised before final publication (only a month after the final data were reported). As of early April, it has been estimated that over 9,000 observations have been reported this time, more than twice the number sent in from the 2006 campaign. Some filtering of the data will be necessary (there will always be the school kid who thinks the name of the game is to say that he/she has seen more stars than anyone else, claiming limiting magnitude 7 in the centre of Paris or New York...) but this has to be done with care – remember, for example, that Sydney switched off its city lights (*Figure 5*) for an hour on 31<sup>st</sup> March (only 10 days outside the Globe-at-Night 2007 window) to call attention to global warming!

We are here in La Palma. How much impact did Globe at Night have in Spain and on the islands? Frankly, not very much. This meeting will help us understand why and what we have to do about it. We still do not have a truly world-wide collaboration going yet. Several countries regard “Globe at Night” as a US effort. Indeed, “Globe” has restricted participation in 2007 to countries that have “Globe” schools. This policy is probably the main reason for the drop in the number of participating countries – 96 in 2006 (when data from all countries was accepted) vs 66 in 2007. Canada, Britain, Austria and others have their own similar programs at different times of the year and involving different constellations. We should discuss here how to ensure that support-

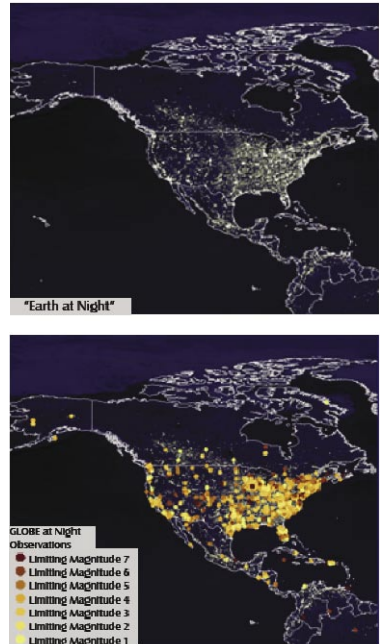


Figure 4. Comparison of “Earth at Night” in North America with Globe at Night. (C. Mayhew & R. Simmon (NASA/GSFC), NOAA/NGDC, DMPSP Digital Archive)

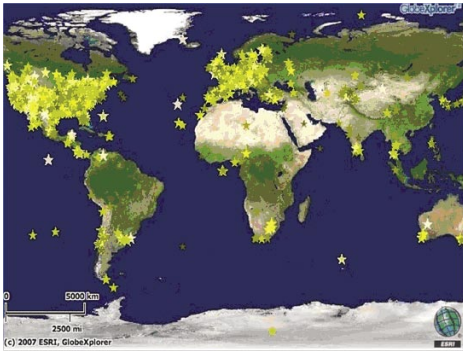


Figure 5. A glance at preliminary results from unaided-eye observations taken for “Globe at Night, 2007” - twice as many observations as in 2006 – but from only two-thirds as many countries. Final data will be released at the end of April 2007.

in addition, in Chile, Gemini and the Chilean Office for the Protection of the Quality of the Sky over Northern Chile (OPCC) bought several more meters that have been used for preliminary site measurements and device inter-comparisons at professional observatories and compared with other measurement methods and with readings taken with the same SQMs nearer to sources of light pollution that could eventually threaten the skies over these observatories.

These devices have a very wide field of view on the sky. This has advantages and disadvantages, so we are examining whether the meters should be modified in the future to allow better urban light pollution measurements. The wide field of view means that extra care currently needs to be taken to exclude off-axis urban light sources – such as streetlights.

We have found that teachers and students quickly learned to use these SQM devices reasonably reliably. In Chile we have taken care to use several (numbered) meters at each site and then to rotate meters between sites – as we explore their potential for this program.

At each site where the SQMs have been delivered, a local coordinator promoted dark-sky education using the educational kits, and trained a number of teachers and amateur astronomers on using the meter. From each area, an array of night sky measurements covering the community was obtained: a culminating activity was held in each area bringing GLOBE at Night participants together from their area to examine the local and national measurements as well as to discuss light pollution issues in more detail. In future years we will encourage student photography of good and bad lighting fixtures. This year’s campaign using the SQMs was designed to test one model for using the meters and teaching kits in a variety of mostly urban settings, using volunteer site coordinators. It was intended to test the efficacy of a light pollution education and measurement campaign conducted by volunteer educational coordinators with limited resources.

In order to increase the educational effectiveness in classrooms of our teaching kits and teaching materials, NOAO will create a document that shows the linkages between

ing this diversity becomes an advantage in gaining coordinated, truly world-wide coverage.

### Digital Meters in “Globe at Night”

Over 140 hand-held Unihedron “Sky Quality Meters” were used in the 2007 campaign. One of us (Connie Walker) organized the distribution of 135 of these. They were provided - as a result of a grant from the U.S. National Science Foundation – to educators, students, amateur astronomers, science museum staff and IDA members in 21 U.S. states, and 5 other countries including Chile (where NOAO has a major observatory). In

the light- pollution education kits and GLOBE at Night activities, to the state science standards of each U.S. state in which NOAO has a partner, and to the (U.S.) national science standards (NRC) and national technology education standards. NOAO has found that its efforts to link its materials and supplemental curricula to these sets of standards for elementary, middle, and high school levels greatly increases the usability of these materials by teachers within the USA and promotes the acceptance of the use of these supplemental instructional materials by school principals and science supervisors.

### **“Globe at Night” – 2008.**

The effort in 2008 will support ongoing student-teacher teams and build a more formal network of GLOBE at Night sites and coordinators. In addition to developing and refining best practices in using the SQMs, pairs of web-based, highly-stable meters - being developed in Tucson, Arizona by one of us (Dan McKenna) - will be installed at several major observatories. A description of these meters was published in the Commission 50 proceedings in Prague ([http://www.ctio.noao.edu/light\\_pollution/iau50/manchester.html](http://www.ctio.noao.edu/light_pollution/iau50/manchester.html)). Less expensive, possibly home-built meters may also be developed, for the pedagogical value of such activity.

### **“Globe at Night” in the “International Year of Astronomy – 2009**

We are working via various Commissions of Division XII of the International Astronomical Union and with the organizers of the IYA (co-author Isbell is the US point of contact) to incorporate “Globe at Night” activities into 2009 – possibly at several different times of the year and possibly naming the activities to reflect programs in countries such as Austria, Canada and the UK – whatever works to get the best coverage and impact. We expect by that time to have the web-based, continuous Sky Brightness Monitoring System in place at and near most major observatories - and to have a solid core of experienced and enthusiastic users of the SQMs in place and active. Our efforts in 2009 will provide a baseline for forward comparison and a reference for comparison with the satellite-based “Second World Atlas of the Artificial Night-Sky Brightness” which we hope will be published by that time and permit a thorough comparison of world-wide changes in humanity’s view of the stars over the last decade. Perhaps we can co-ordinate with cities like Sydney to stage safe demonstrations of the night sky such as that shown in *Figure 5*.

### **2010 and beyond?**

We can hope that the media publicity associated with the “Globe at Night” effort for the “International Year of Astronomy” in 2009 - and our consequent ability to make linear extrapolations of where we are headed in protection of the starlit sky - will trigger action in many parts of the planet. Nevertheless a new challenge will become more obvious at about that time. Light Emitting Diodes (LED’s) are likely to become widespread in highway and publicity lighting as the production costs make LED-based luminaires more affordable. Exterior lighting experiments are already in place in Quebec and other places. The positive public reaction to the plentiful white light has been matched by the enthusiasm for the low associated energy costs required to produce the sensation of

adequate illumination (using the photopic/scotopic wide-wavelength eye sensitivity to save wattage with respect to the astronomers' preferred narrow-band sodium). This will be the first time that astronomers have to face up to whether to try to lobby for external illumination near observatories that is less energy-efficient than other affordable, commercially-available alternatives. A more detailed examination (with modelling) is necessary of how LED-based city and roadway lighting compares to high-and low-pressure sodium in their effects on sensitive astronomical observations.

Another promising avenue is to take advantage of the building (and lighting) industries' desire to have buildings certified as environmentally "green". For example, the LEED® green building concept (which covers lighting) needs to be extended at the building level to recognized design efforts to minimize unnecessary light trespass and skyglow.

We are in for some exciting times over the next two decades! Telescopes like the LSST are counting on our success. So are plants, animals and probably many humans...

## References

1. CINZANO, P., FALCHI, F., ELVIDGE C., 2001, *The first world atlas of the artificial night sky brightness*. Monthly Notices of the Royal Astronomical Society, v. 328, p. 689.
2. PIKALL et al. 2002. *Light Pollution – The Global View*. Ed. Hugo E. Schwarz. Kluwer Academic Publishers, p. 287.
3. FEDER, T., 2005, *Physics Today*, June 2005, p. 24.
4. HARDER, B., 2006a, *Science News*, 169, p. 8.
5. HARDER, B., 2006b, *Science News*, 169, p. 170.
6. PEKKANEN, J. 2007, *The Washingtonian*, January, p131.