Highlights of Spanish Astrophysics VII, Proceedings of the X Scientific Meeting of the Spanish Astronomical Society held on July 9 - 13, 2012, in Valencia, Spain. J. C. Guirado, L.M. Lara, V. Quilis, and J. Gorgas (eds.)

NIXNOX project: Enjoy the dark skies of Spain

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Abstract

The NIXNOX project, sponsored by the Spanish Astronomical Society, is a Pro-Am collaboration with the aim of finding sites with dark skies. All sky data of the night sky brightness is being obtained by amateur astronomers with Sky Quality Meter (SQM) photometers. We are not looking for remote locations because the places should be easily accessible by people with children. Our goal is to motivate citizens to observe the night sky. NIXNOX will provide information to answer the question: where can I go to observe the stars with my family?

1 Introduction

Light pollution (the introduction by humans, directly or indirectly, of artificial light into the environment) is a major issue worldwide, especially in urban areas. It increases the sky glow and prevents us from observing a dark starry sky. As *"Starlight, A Common Heritage"* (promoted by the International Astronomical Union and the UNESCO), which is a international campaign in defense of the values associated with the night sky and the general right to observe the stars said: "An unpolluted night sky that allows the enjoyment and contemplation of the firmament should be considered an inalienable right of humankind equivalent to all other environmental, social, and cultural rights, due to its impact on the development of all peoples and on the conservation of biodiversity." Starlight Declaration [5].

The brightness of the night sky measured in some place is related to the amount of light emitted to the sky in an extended area around. The increase in light pollution reduces the number and quality of sites where we can access to this cultural heritage. We intend to find and characterize these privileged places to inform the citizens and to preserve them.

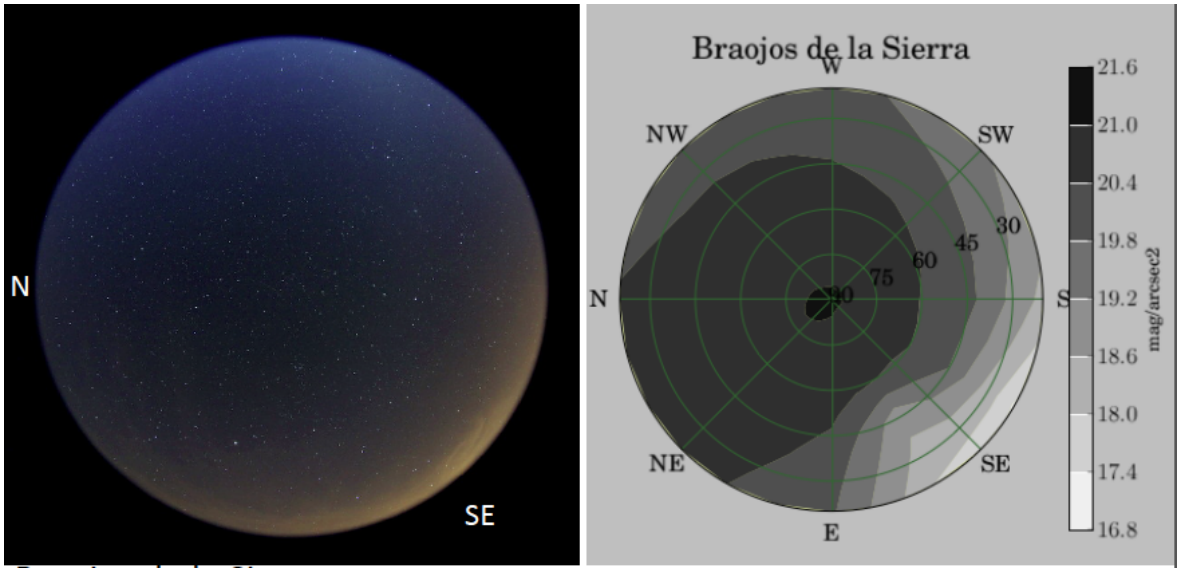

Figure 1: Comparison of the picture obtained with fish eye all sky lens on DSLR camera and the map built with SQM observations on the same place. The main sources of light pollution are located between south and east direction and are easily related to nearby villages and Madrid which is located 50 km away.

2 The NIXNOX project

This is a Pro-Am collaborative effort promoted and sponsored by the Spanish Astronomical Society (SEA) to find and characterize open air observatories. The observations and additional information are being provided by amateur astronomers. It contributes to outreach in Astronomy and it is a help to dark skies fights but it is also a scientific project. We do not intend neither to obtain the map of the light pollution in Spain nor to collide with other efforts made by dark skies associations. Our objectives are to locate sites with dark skies with easy access, to encourage local authorities to preserve them and finally to help citizens to enjoy the starry skies.

The sites are being selected by amateur astronomers associations. They are mostly the same places where they meet to observe. Amateur astronomers have the knowledge and capability to be our task force. More than 50 amateur astronomical associations of Spain (around one third of them) are enrolled in this collaboration.

The best way to map the night sky brightness is to use an all-sky camera monitor as AstMon [1]. These devices could perform all-sky astronomical photometry. A cheaper method uses a digital camera (DSLR) with fish eye lens and extract information from the RGB channels. While the overall picture of the sky brightness is ready after taking the picture, its calibration is not easy. For these reasons we select to use SQM photometers. We plan to obtain all sky images of all the NIXNOX sites in the future.

Figure 2: *Left panel:* SQM-L photometer mounted on tripod and pointing 20 degrees from zenith. *Right panel:* DSLR camera and fish eye lens providing all-sky view of the sky.

3 Night sky brightness maps

3.1 The SQM photometers

There are several initiatives to measure the night sky brightness with the help of motivated citizens. Most of them are using the Sky Quality Meter (SQM) photometer which was designed to be portable. It is pocket size, battery powered, cheap, and very user friendly. After pointing, you press the only button available and read the night sky brightness in magnitudes per square arc sec on the display after a while.

The spectral response of the SQM photometers encompasses the astronomical Johnson B and V bands trying to mimic the human eye response. Cinzano (2005) has shown that the photometer could be used as a scientific instrument. Complete information about photometry with SQM photometer should be read in his report on SQM [2]. The SQM magnitudes are between the B and V sky brightness. The transformation from SQM to Johnson V varies with the color of the night sky. The night sky spectrum depends on the type, intensity, and quantity (along with other parameters as distance and atmospheric conditions) of the pollutant luminaries used on public lighting. We are not trying to convert the maps to astronomical photometric bands.

SEA has acquired 12 units of the SQM-L photometer to be used on loan by the amateur astronomers. Since our SQM have been acquired and shipped together, we had a good opportunity to test them at the laboratory before using them in the field. Knowing their internal precision and differences in zero point, the collected values could be transformed to a common reference frame. After testing the photometers we have found differences in zero point bellow 0.1 magnitudes as stated by the manufacturer. The internal precision of the photometer is also around 0.1 mag arcsec^{-2}.

We performed additional test on the field with the help of volunteers of *Asociacón de Astrónomos Aficionados de la UCM (ASAAF-UCM)*. The differences in night sky bright-

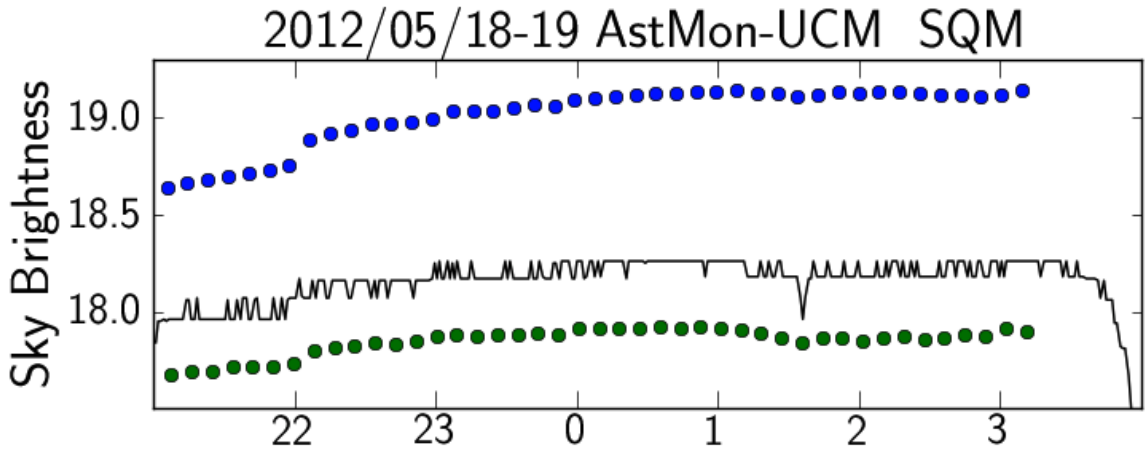

Figure 3: Comparison of the night sky brightness along one night provided by SQM and the obtained with AstMon-UCM on the B and V Johnson bands.

ness measured by different astronomers using different photometers were again bellow 0.1 mag arcsec^{-2}. Complete information on SQM cross-calibration can be read on the reports of two trainee projects made by UCM students ([3] and [4]).

3.2 NIXNOX procedure

The astronomers are provided with the SQM photometer and a complete set of instructions. The observations should be made on clear and moonless nights. Instead of measuring the night sky brightness at zenith, we decided to get values in different positions of the sky vault. With these observations we can build night sky brightness maps similar to those obtained with all-sky imaging devices.

The spatial sampling is a trade-off between resolution and the time needed to complete a map. Since SQM-L photometers have a field of view of 20 degrees (FWHM), we select to observe, besides zenith, 12 positions in azimuth at 20, 40, 60 and 80 degrees of altitude. The resulting all-sky maps (in units of magnitudes per square arc second) are similar to calibrated fish eye pictures of the sky and they inform us of the sources of light pollution. Evolution of the light pollution will be measured with repeated observations over the next years.

3.3 Validation of NixNox all-sky maps

To asses the quality of the all-sky maps of the night sky brightness obtained with SQM following the NIXNOX procedure, we have performed some tests. On the one hand, brightness maps (Johnson B and V bands) obtained with the all-sky monitor AstMon-UCM located at the astronomical observatory of the Universidad Complutense de Madrid (Observatorio UCM) and simultaneous observations with SQM-L were compared.

We have also used digital cameras with fish eye lens that provide all-sky views of the

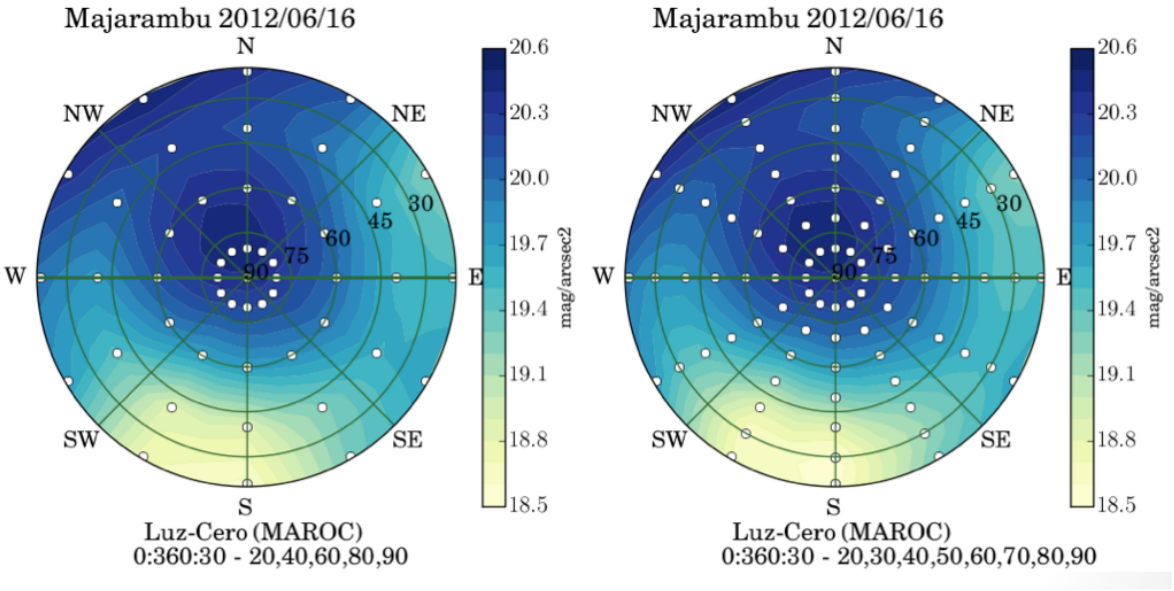

Figure 4: *Left panel:* The selected sampling for NIXNOX is marked as white dots on the map. It is a trade off between resolution and time to complete the observation. *Right panel:* However, better spatial resolution is not obtained after increasing the number of measurements.

sky as a cheaper alternative. Since the green G channel of the Bayer matrix of DSLR cameras is similar to the Johnson V band, we have detected and measure star fluxes to perform all-sky photometry. The calibrated images (with our own software [6]) show all-sky maps brightness that are comparable to the NIXNOX maps.

3.4 Additional information

More than 50 amateur astronomer associations of Spain are collaborating with SEA. They are also gathering additional information. For each site the SEA web page will also provide a brief description with panoramic pictures, lodging and meteo information, how to reach the site, etc.

The Spanish Astronomical Society will publish these information to help the citizens to choose where to go to observe the stars with their family or friends. More info about NIXNOX can be obtained at SEA web page http://www.sea-astronomia.es/.

4 Preliminary results

SEA SQM photometers are being sent to the amateur astronomical associations for a two month period of observing time. When atmospheric time prevents the astronomers to observe and take data of good quality, a extended time is provided.

We have already data for 52 maps all around Spain. The distribution is not as homoge-

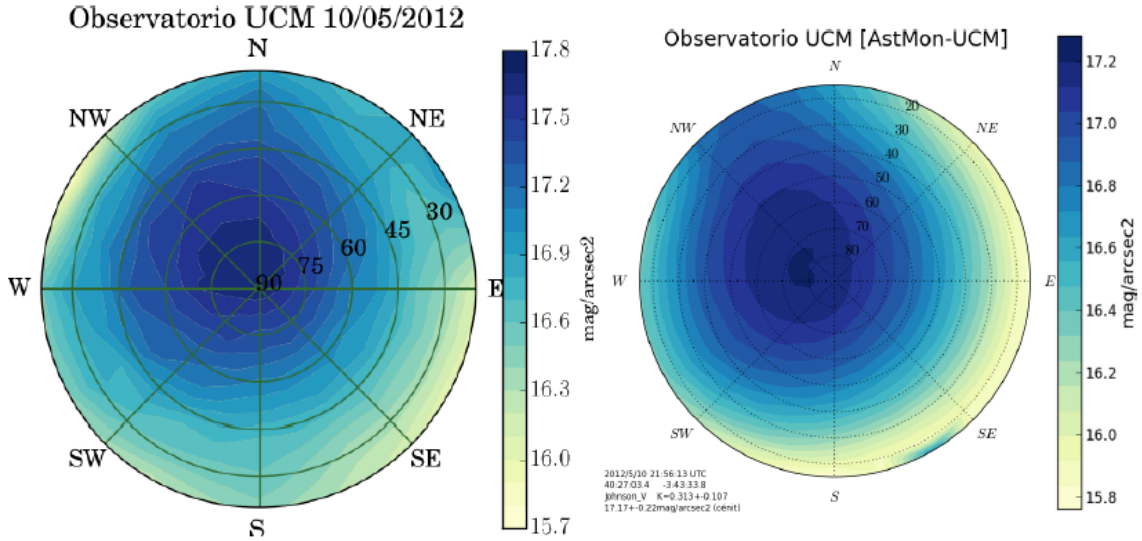

Figure 5: *Left panel:* Night sky brightness map built with the NIXNOX procedure using SQM-L. *Right panel:* allsky brightness map in Johnson V band obtained with AstMon-UCM.

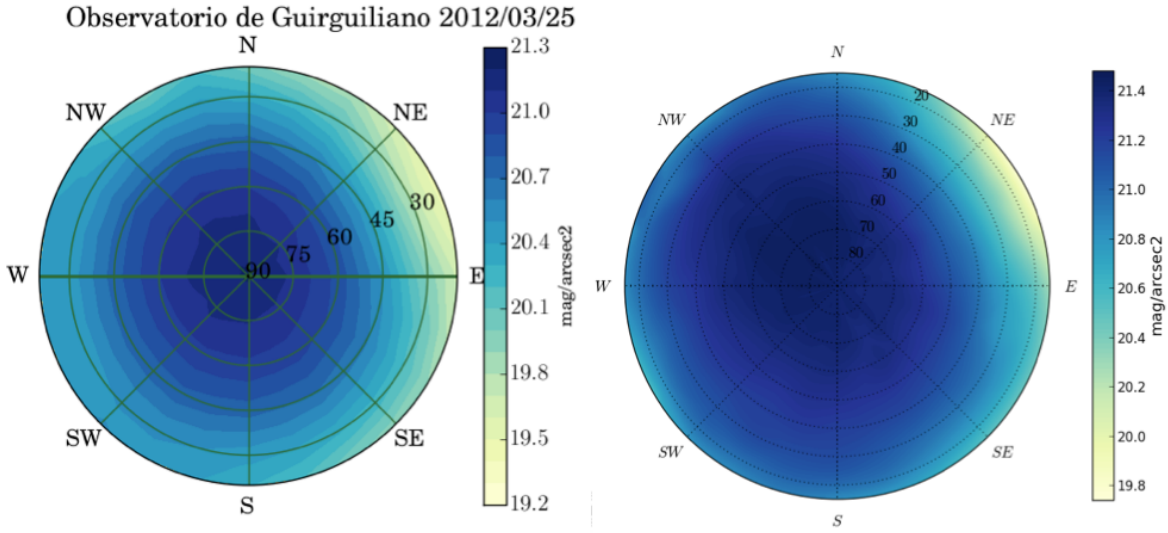

Figure 6: *Left panel:* Calibrated all sky brightness map in Johnson V band obtained from a picture taken with Nikon D700 DSLR camera and 8mm lens. *Right panel:* NIXNOX map with SQM-L data.

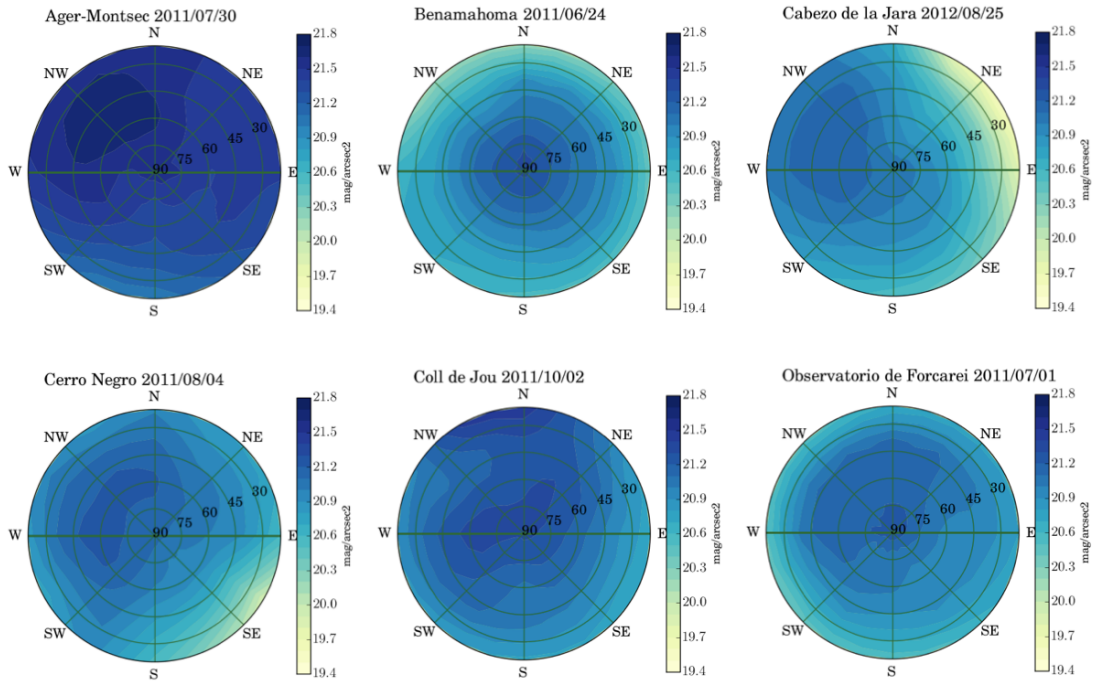

Figure 7: Examples of all sky brightness maps of the NIXNOX project.

neous as we would wish and some areas are under sampled. However we have not finished the complete rotation of photometers and some associations are waiting to get the opportunity to contribute. Our last figures show a representative sample of NIXNOX maps.

5 Conclusions

NixNox is a Pro-Am project of SEA to find and characterize open air observatories. Citizens will select one of these privileged places to enjoy its dark starry sky with their family or friends. Observations and additional information provided by amateur astronomers is used to build all-sky maps of the night sky brightness. Comparison with observations with astronomical photometric systems have shown that the maps are accurate enough. The maps are useful to detect the sources of light pollution. The evolution of the light pollution around these places will be measured with repeated observations in the next years.

Acknowledgments

The SQM photometer cross-calibration was performed at the *Laboratorio de Investigación Científica Avanzada* (LICA-UCM) of the *Moncloa Campus of International Excellence* (UCM-UPM). We acknowledge support from the Spanish Programa Nacional de Astronomía y Astrofísica under grant AYA2009-10368. Partially funded by the Spanish MICINN under the

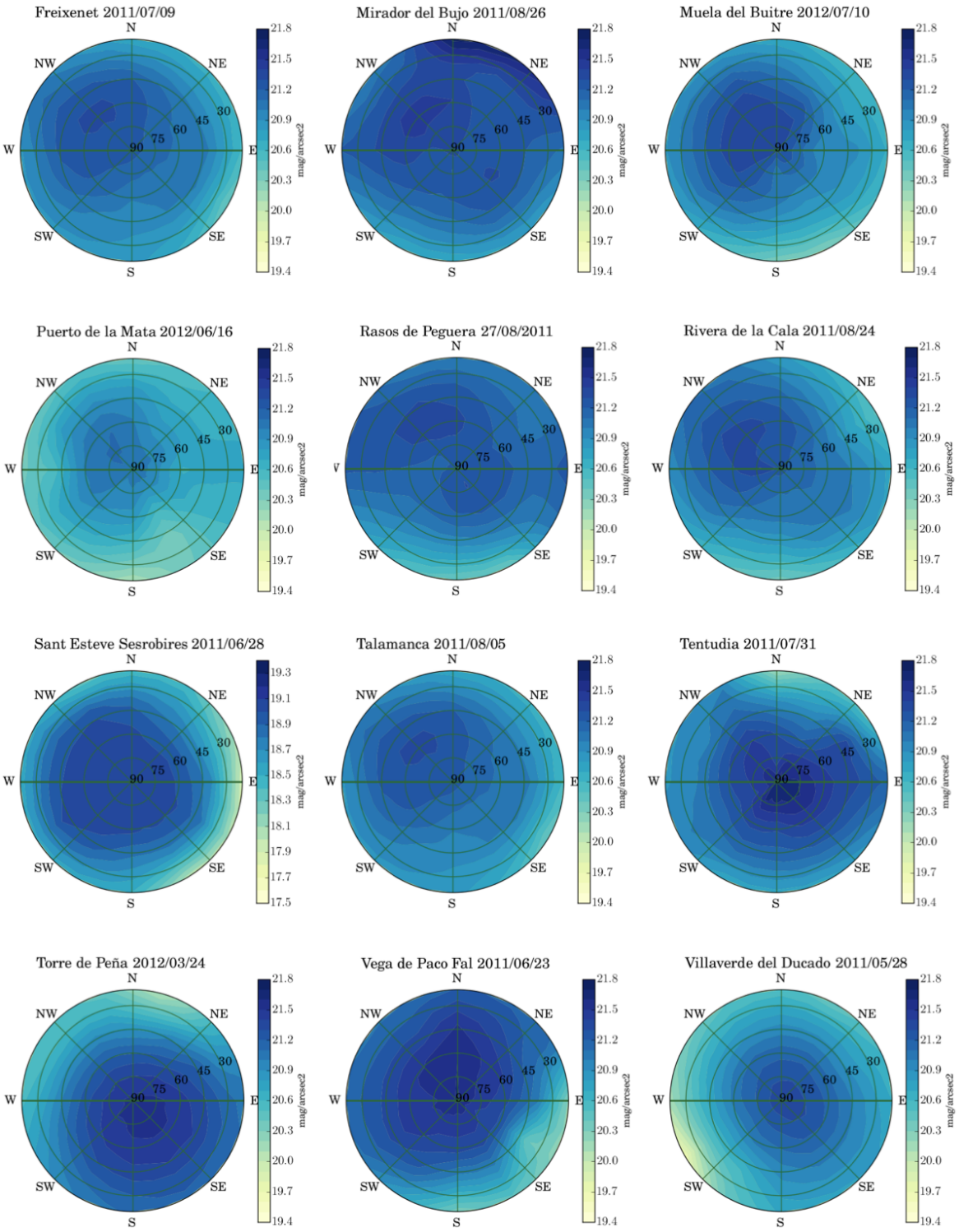

Figure 8: Examples of all sky brightness maps of the NIXNOX project (cont.)

Figure 9: Example of information gathered by Agrupación Astronómica de Sabadell for Talamanca site.

Consolider-Ingenio 2010 Program grant CSD2006-00070: *First Science with the GTC.*

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