

A database of night sky brightness photometry for U.S. National Parks



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Introduction

- The U.S. National Park Service Night Sky Team began collecting all-sky imaging data in 2001
- To date there are over 600 “data nights”
- High resolution false color all-sky images of both observed sky brightness and derived artificial sky glow are produced
- A suite of indicators of sky quality and the photic environment is produced and stored in a relational database
- The data is now available on a public website for about 2/3 of the data nights

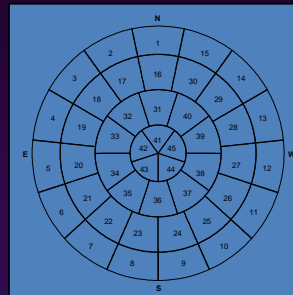
Review of data collection methods

Portable CCD camera with panoramic mount, modest beginnings in 2001



Review of data collection methods

Larger format, data collection and photometric calibration automation 2004



```
'subroutine to measure all sky brightness values
```

```
sub measure
```

```
    rings = Array(20,0,1)  
    aper = rings(0)
```

```
    Do While sheet2.cells(j,5).Value = k  
        px = sheet2.cells(j,10).value  
        py = sheet2.cells(j,11).Value  
        r = l.CalcInformation(px, py, rings)  
        sheet2.cells(j,3).Value = r(3)  
        j = j + 1  
    Loop
```

```
End Sub
```



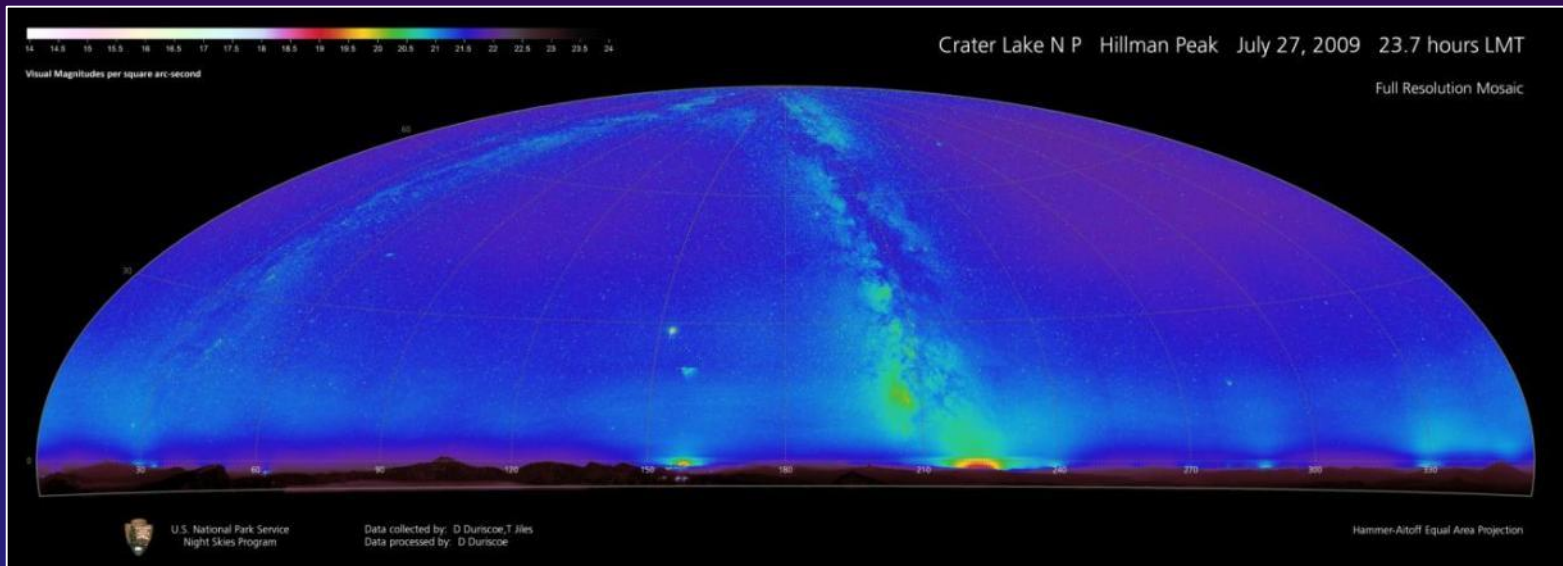
Review of data collection methods

Bryce Canyon and Death Valley Days 2004 - 2007



Review of data collection methods

Data processing automation and data collection “heydays” in 2007-2009



Review of data collection methods

Cooperators purchase their own equipment



Review of data collection methods

Addition of staff and cameras in 2010-2015



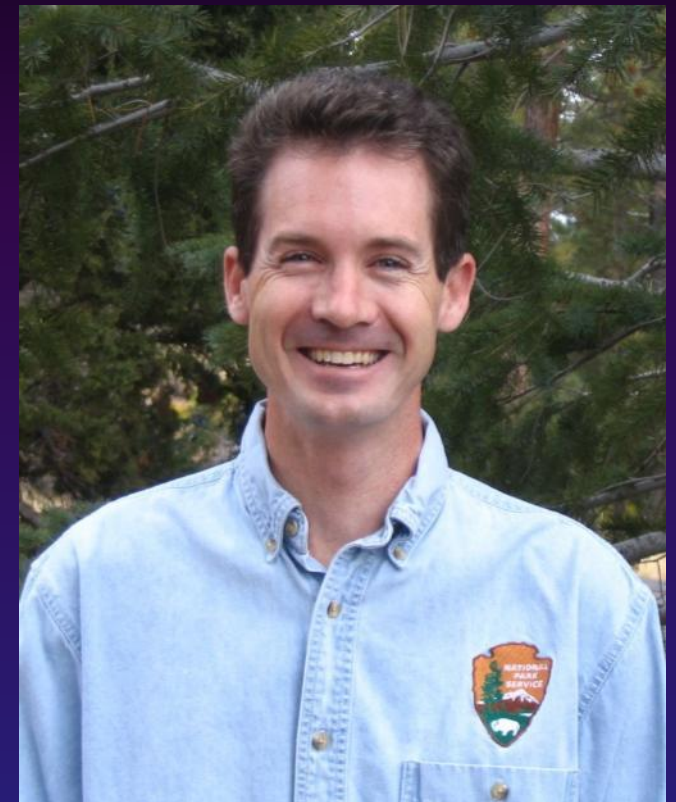








Chad Moore leaves the NPS Night Sky team 2015



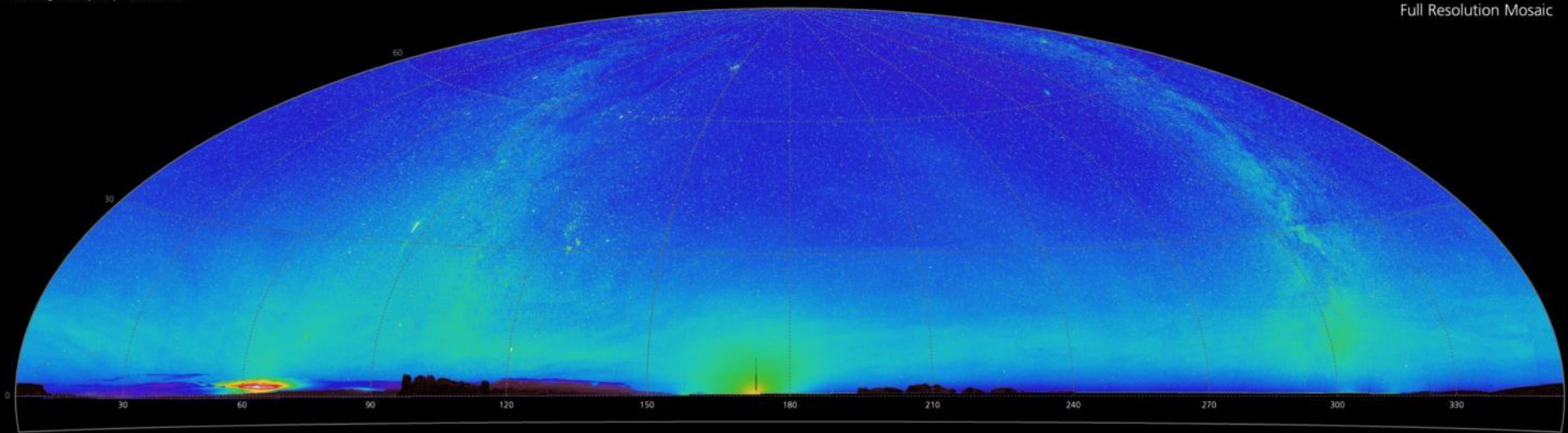
The data products

All-sky image mosaics



Arches N P Abbey's Ramada October 13, 2001 1.2 hours LMT

Full Resolution Mosaic



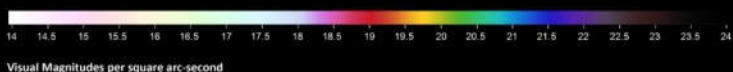
U.S. National Park Service
Night Skies Program

Data collected by: C Moore, D Duriscoe, C Duriscoe
Data processed by: D Duriscoe

Hammer-Aitoff Equal Area Projection

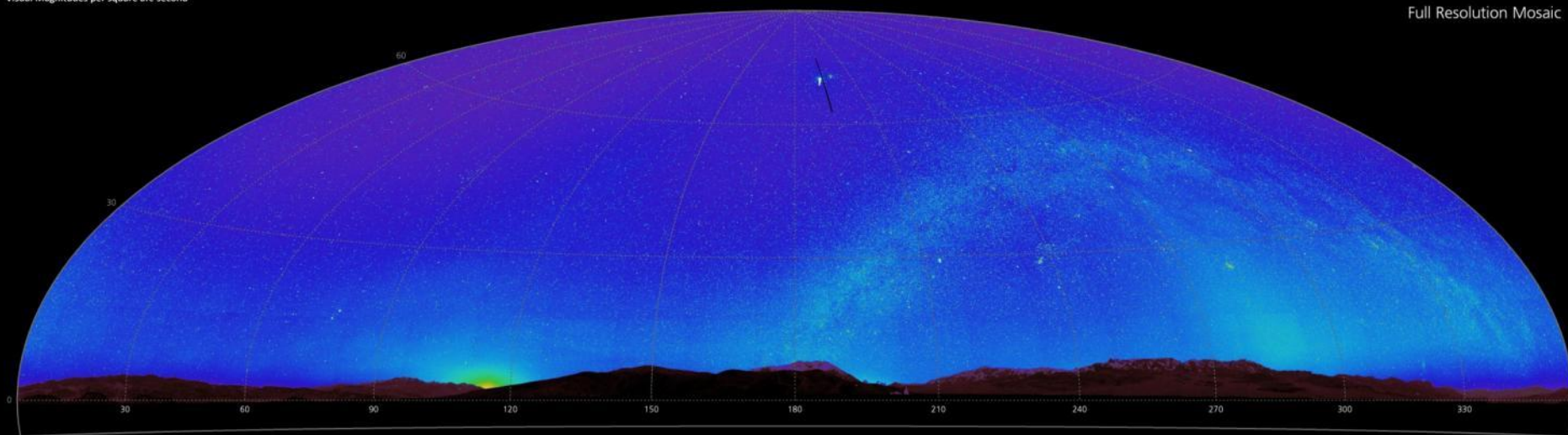
The data products

All-sky image mosaics



Death Valley N P Ubehebe Crater March 5, 2003 21.8 hours LMT

Full Resolution Mosaic



U.S. National Park Service
Night Skies Program

Data collected by: C Moore, D Duriscoe, G Poole
Data processed by: D Duriscoe

Hammer-Aitoff Equal Area Projection

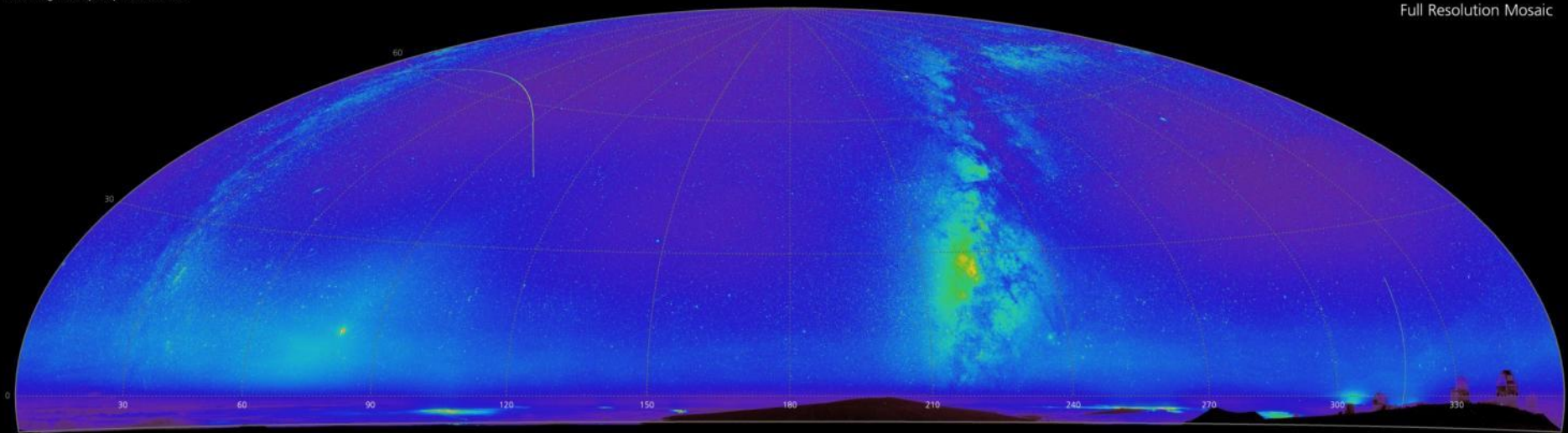
The data products

All-sky image mosaics



Mauna Kea Observatory Mauna Kea Summit June 30, 2011 2.4 hours LMT

Full Resolution Mosaic



U.S. National Park Service
Night Skies Program

Data collected by: D Duriscoe, J White
Data processed by: D Duriscoe

Hammer-Aitoff Equal Area Projection

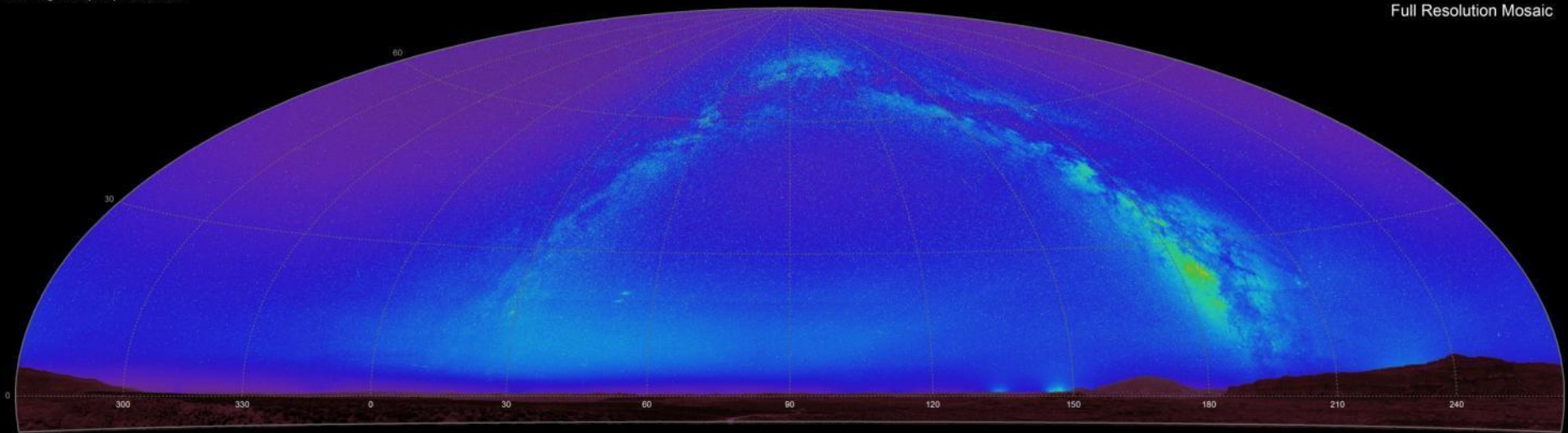
The data products

All-sky image mosaics



Glen Canyon NRA Hole-in-the-Rock Road May 21, 2012 2.5 hours LMT

Full Resolution Mosaic



U.S. National Park Service
Night Skies Program

Data collected by: B Meadows
Data processed by: B Meadows

Hammer-Aitoff Equal Area Projection

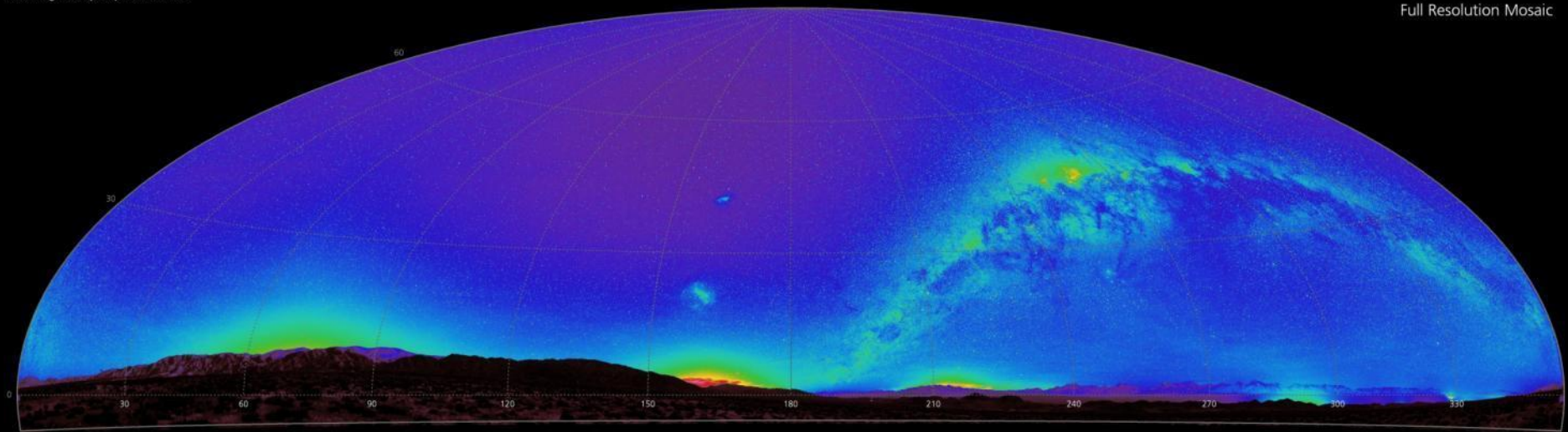
The data products

All-sky image mosaics



El Leoncito NP CTA Site August 10, 2013 0.4 hours LMT

Full Resolution Mosaic



U.S. National Park Service
Night Skies Program

Data collected by: J White
Data processed by: J White

Hammer-Aitoff Equal Area Projection

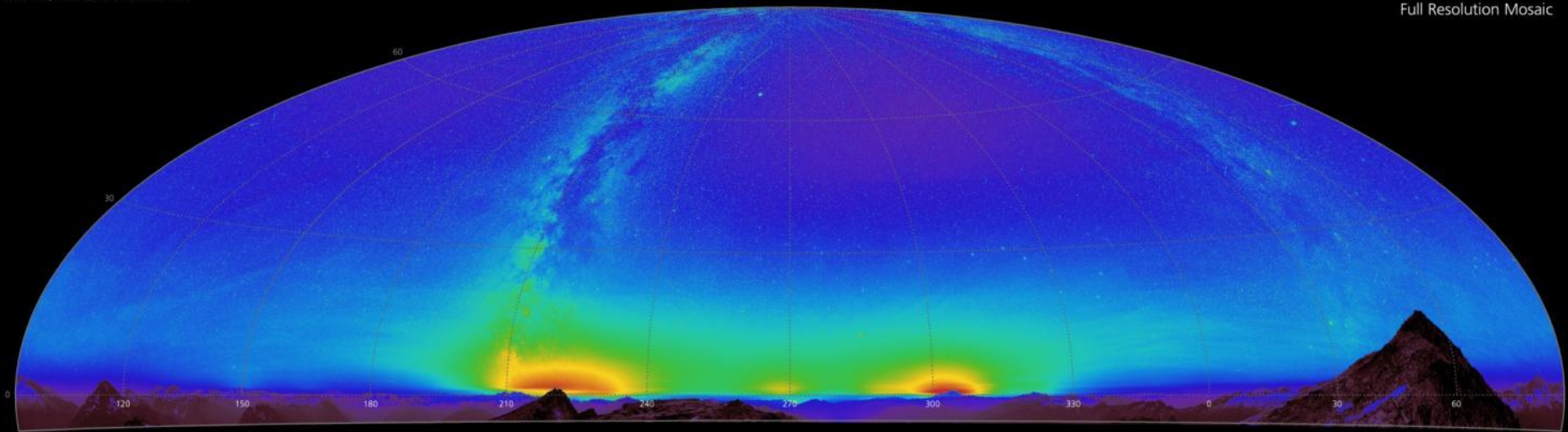
The data products

All-sky image mosaics



North Cascades N P P Hidden Peak Ridge August 11, 2012 23.1 hours LMT

Full Resolution Mosaic



U.S. National Park Service
Night Skies Program

Data collected by: D Duriscoe, R Meadows
Data processed by: D Duriscoe

Hammer-Aitoff Equal Area Projection

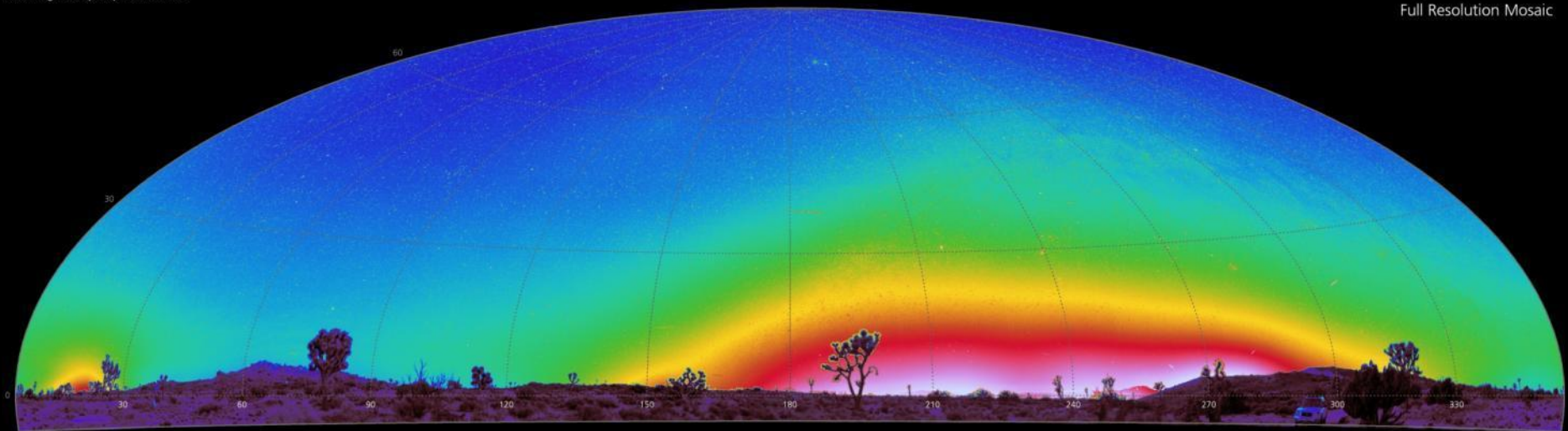
The data products

All-sky image mosaics



Joshua Tree NP Keyes View Weather Station February 23, 2006 22.6 hours LMT

Full Resolution Mosaic



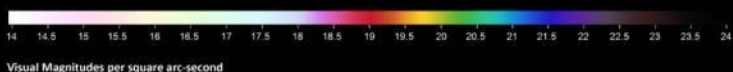
U.S. National Park Service
Night Skies Program

Data collected by: C. MOORE
Data processed by: J. WHITE

Hammer-Aitoff Equal Area Projection

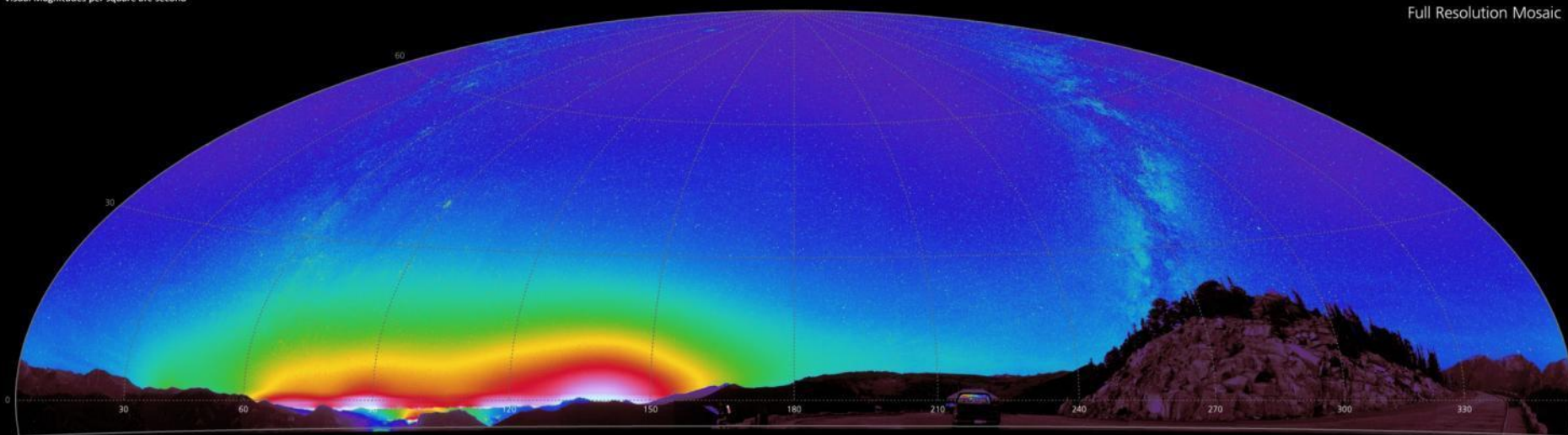
The data products

All-sky image mosaics



Rocky Mountain National Park Rainbow Curve September 24, 2008 23.5 hours LMT

Full Resolution Mosaic



U.S. National Park Service
Night Skies Program

Data collected by: C. Moore
Data processed by: J. White

Hammer-Aitoff Equal Area Projection

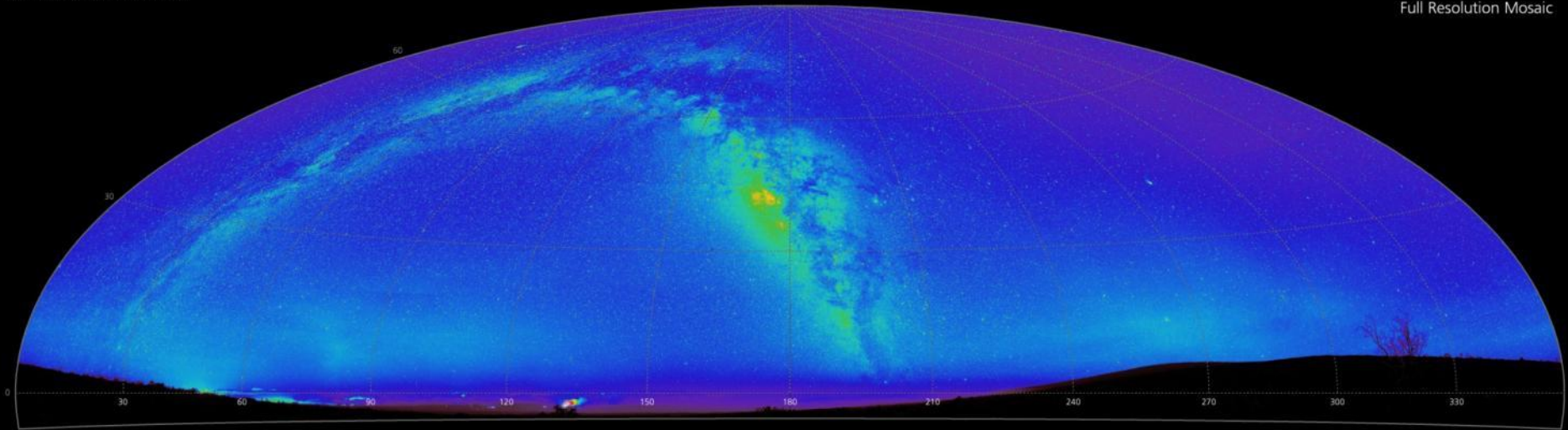
The data products

All-sky image mosaics



Hawai'i Volcanoes NP Mauna Loa Lookout Road July 3, 2011 22.9 hours LMT

Full Resolution Mosaic



U.S. National Park Service
Night Skies Program

Data collected by: J White
Data processed by: J White

Hammer-Aitoff Equal Area Projection

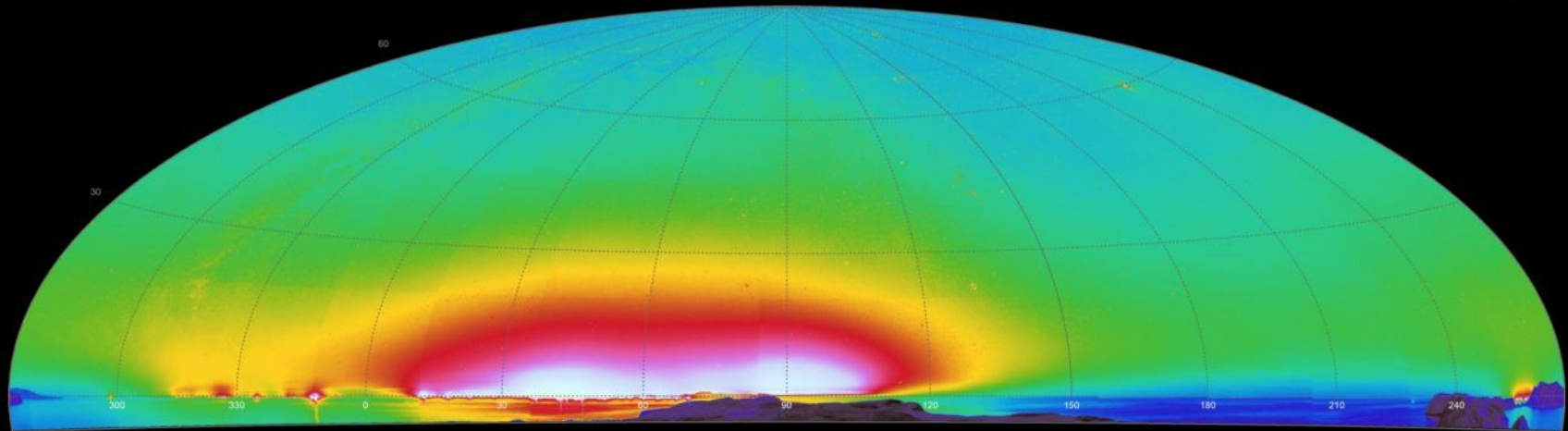
The data products

All-sky image mosaics



Channel Islands NP Anacapa Island October 28, 2011 1.25 LMT

Full Resolution Mosaic



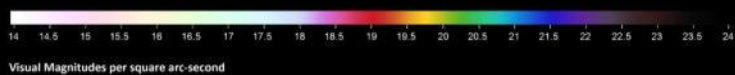
U.S. National Park Service
Night Skies Program

Data collected by: S Balm, J Rempe
Data processed by: B Meadows

Hammer-Aitoff Equal Area Projection

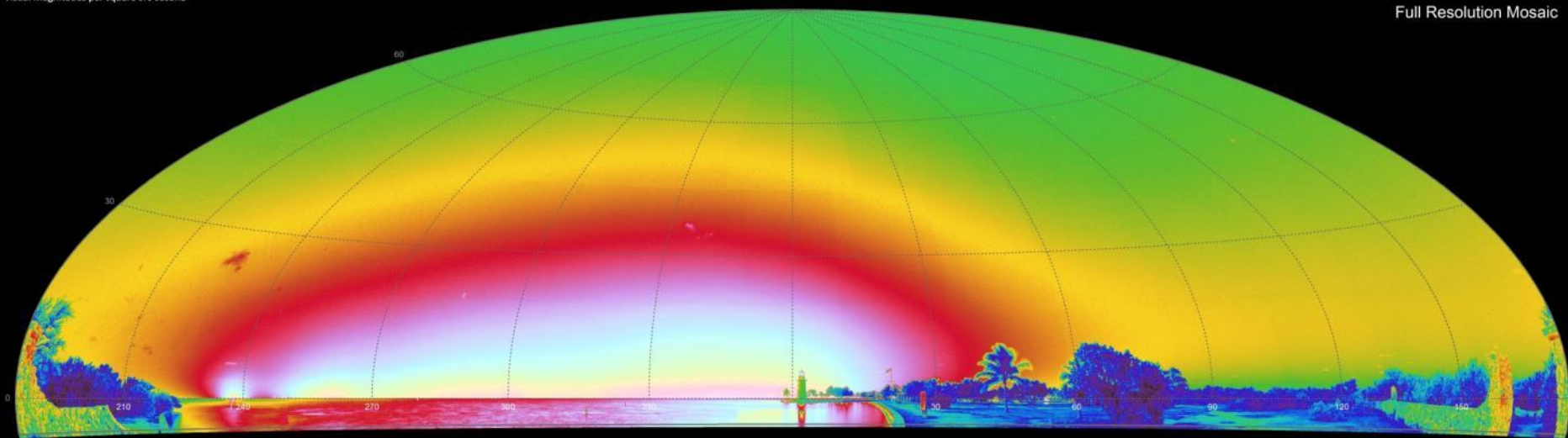
The data products

All-sky image mosaics



Biscayne NP Boca Chita Key March 3, 2014 1.3 hours LMT

Full Resolution Mosaic



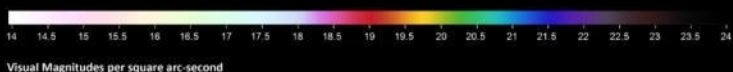
U.S. National Park Service
Night Skies Program

Data collected by: B Meadows, M Nelson
Data processed by: B Meadows

Hammer-Aitoff Equal Area Projection

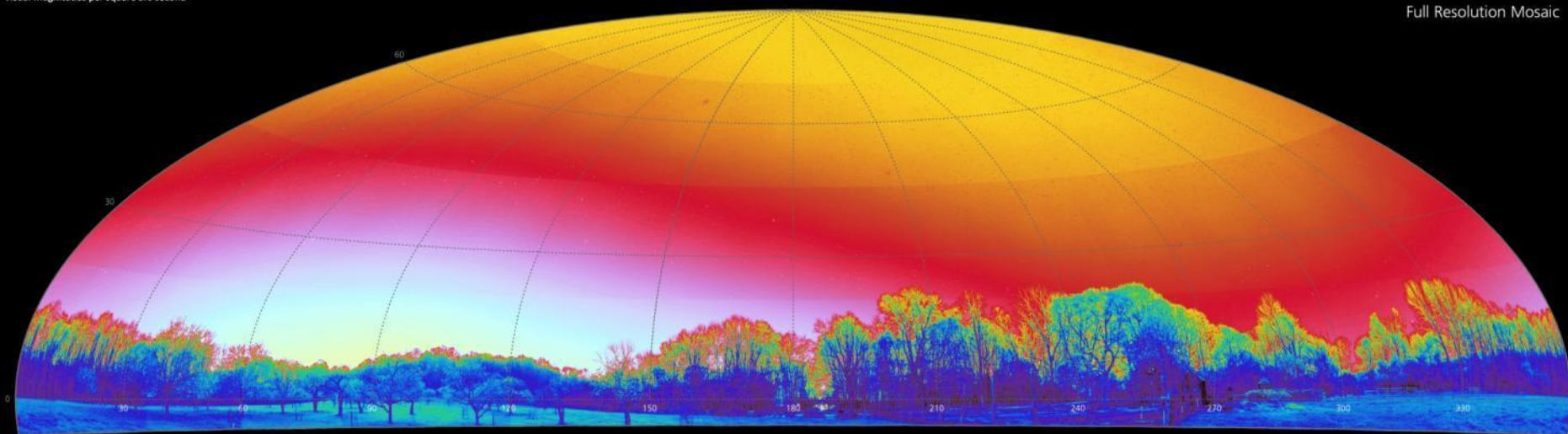
The data products

All-sky image mosaics



Morristown N H S Jockey Hollow April 13, 2010 23.7 hours LMT

Full Resolution Mosaic



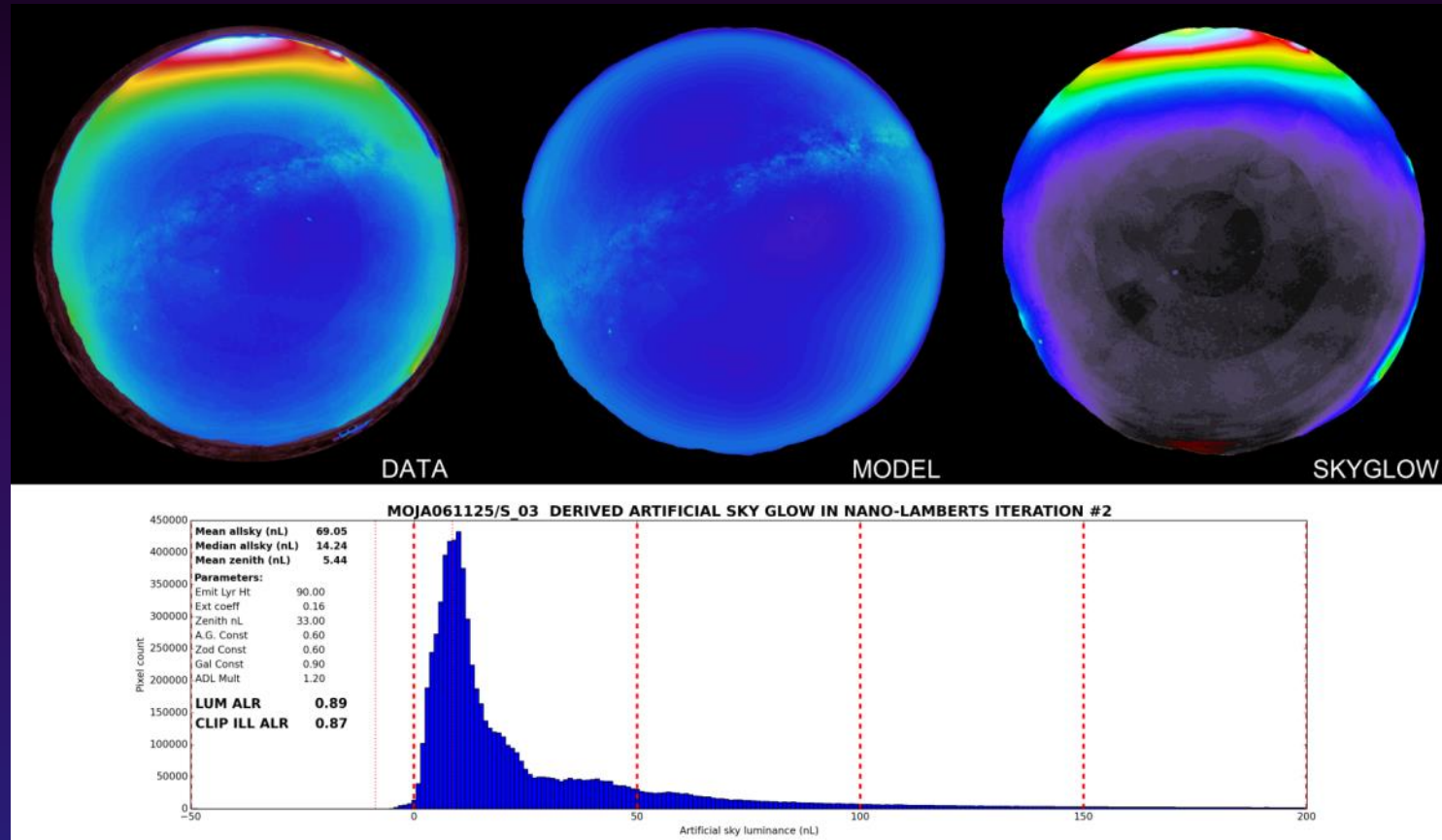
U.S. National Park Service
Night Skies Program

Data collected by: D Duriscoe, C Moore
Data processed by: D Duriscoe

Hammer-Aitoff Equal Area Projection

The data products

Natural Sky Model subtraction



The data products

Indicators derived from estimated artificial sky luminance

Anthropogenic sky luminance ($\mu\text{cd m}^{-2}$)

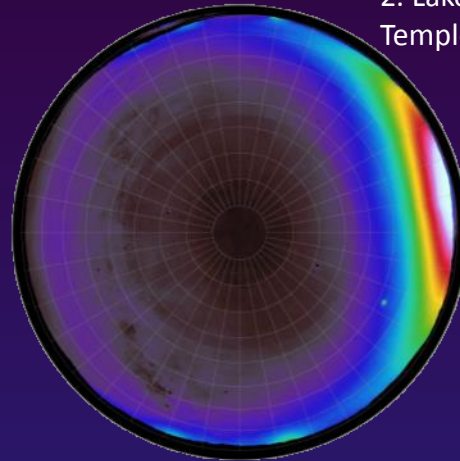
zenith average maximum

1. Death Valley N.P.



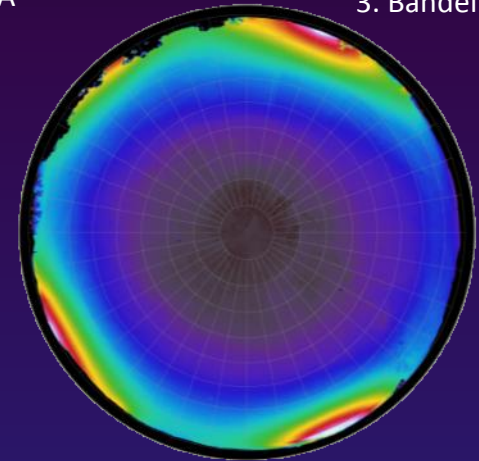
6 99 10,700

2. Lake Mead N.R.A
Temple Bar



54 331 22,700

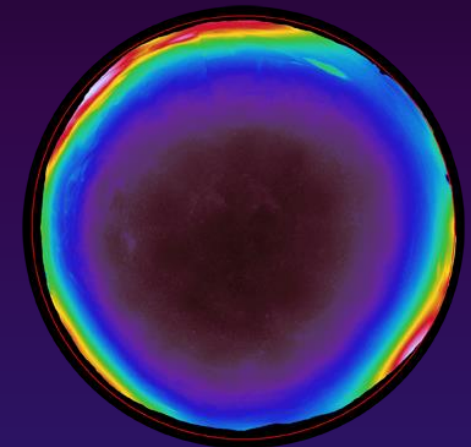
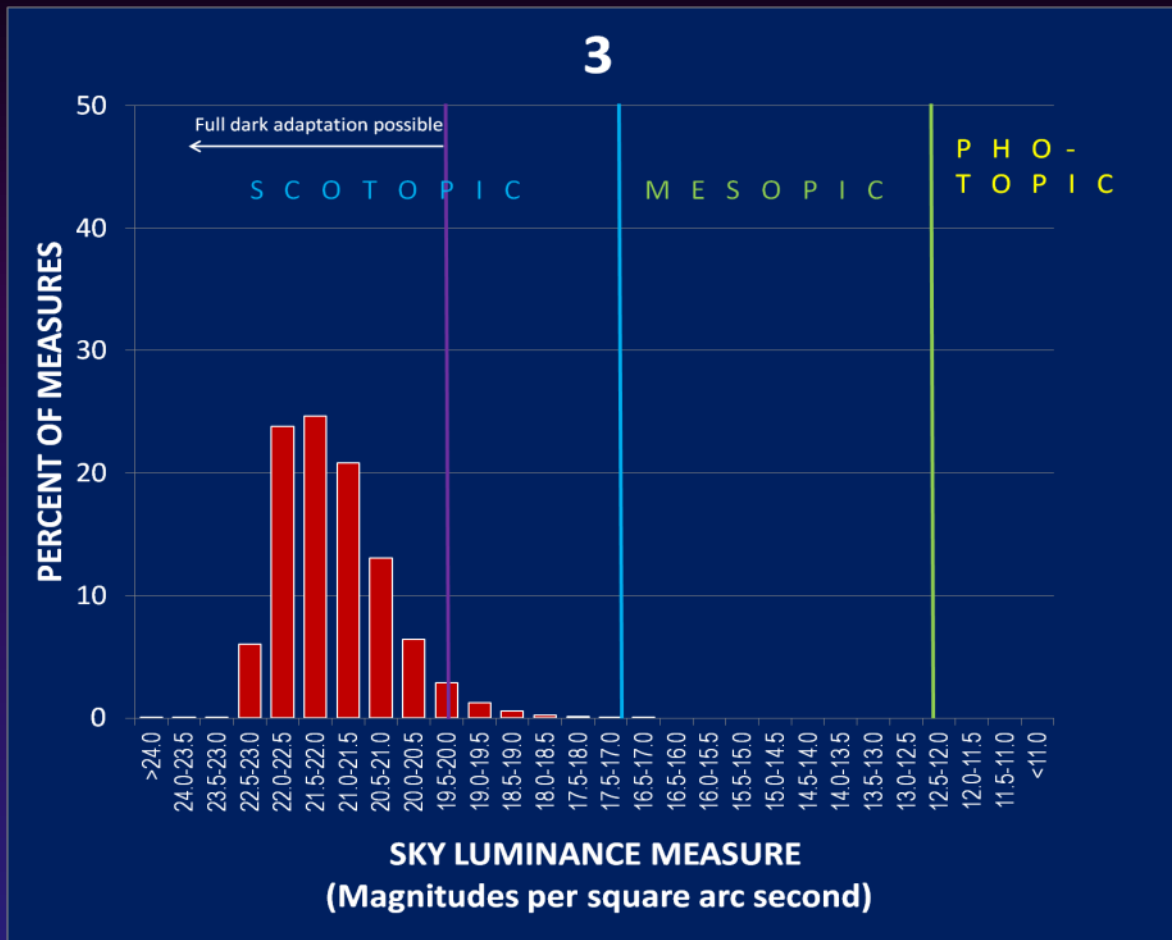
3. Bandelier N.M.



108 398 23,900

The data products

The Sky Quality Index from the all-sky artificial luminance distribution

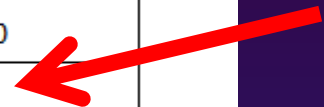


SQI = 59

The data products

The All-sky light pollution ratio (A.L.R.) from average artificial sky luminance

Photometric Indicators					
Indicator	Observed		Estimated Artificial		Light Pollution Ratio (Artificial/Natural)
Sky Luminance Measures					
	mag/ arcsec ²	μcd/ m ²	mag/ arcsec ²	μcd/ m ²	
Zenith	22.10	157	> 24.5	< 17	< 0.10
Mean all-sky	21.68	231	24.26	21	0.09
Brightest	19.58	1,570	19.77	1,322	7.73
Darkest	22.21	139	> 24.5	< 17	< 0.10
Median	21.73	218	> 25.1	< 10	< 0.03
Illuminance Measures					
	mags	milli-lux	mags	milli-lux	
Horizontal	-6.00	0.64	-2.47	0.02	0.03
Max Vertical	-5.49	0.40	-3.73	0.08	0.20



The data products

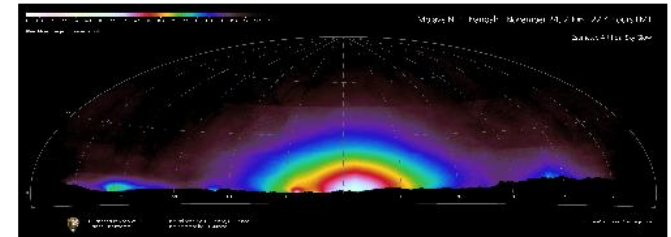
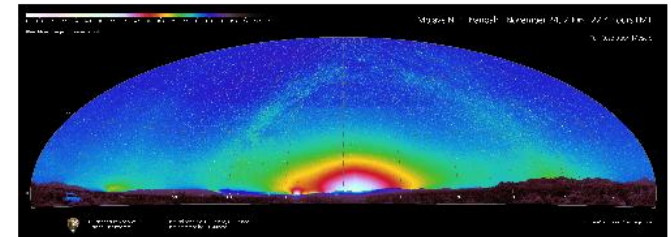
Metadata and
visual observations

Data Set Attributes and Visual Indicators

Category	Details
Park:	Mojave NP
Site Name:	Ivanpah
Longitude:	-115.27
Latitude:	35.39
Elevation (m):	995
Date (LMT):	24-Nov-2006
Time (LMT Hours):	22.42
Camera:	SBIG 1
Lens:	Nikon 1.8
Observers:	D Duriscoe C Duriscoe
Air temp. (°C):	8.3
R. H. (%):	31.0
Wind Speed (mph):	3
Extinction Coeff. (mag/airmass):	0.16
NELM:	7.1
Bortle Class:	4
Synthetic SQM:	21.37
SQI All- sky:	76.4
SQI to Z.A. 70°:	87.7
Number of stars visible:	3490

Observed and Estimated Artificial Sky Brightness Mosaics

Click on either image for a high resolution view –**THESE ARE LARGE FILES**



NARRATIVE: Very steady and transparent, perfect night for astronomy, site 4 miles northeast of Ivanpah RR xing on dirt road paralleling north side of tracks to Saddle Horn Road (siding labelled "Moore" on topo map), then 200 feet north on Saddle Horn Road. Las Vegas light dome is very bright, easily casting shadows after dark adaptation, navigating without flashlight pretty easy if facing away from the light dome. Direct glare from Primm is annoying, brighter than any planet, while the overall light dome from Primm is small on this clear night. Las Vegas dome extends to 40 degrees above the horizon, Primm to 10, Laughlin to 20, LA area a low glow to west, possibly reflecting off clouds, Searchlight also seen but faint and small. ZLM 7.1 despite light pollution (6.8 pretty easy), because of steady, clear air. M33, however, is a very difficult averted vision object and no part of the Milky Way has minute detail. 10 Pleiades seen with relative ease, 12 with difficulty, 14 with extreme care and averted vision techniques. The sky seems to have gradient of brightness all the way to the zenith. SQM 21.44 at end of 2nd set.

The web interface

Download the Google Earth kml at
<http://nature.nps.gov/night/skymap.cfm>

The screenshot shows the National Park Service website's "Night Sky Monitoring Database" page. The page has a dark green header with the National Park Service logo and navigation tabs for "Find a Park", "Discover History", "Explore Nature", "Working with Communities", "Get Involved", "Teachers", "Kids", and "About Us". The "Explore Nature" tab is selected. The main content area is titled "Night Sky Monitoring Database" and includes a breadcrumb trail: "NPS » Explore Nature » Natural Sounds & Night Skies » Night Skies". The page describes the NPS Night Skies Team's data collection efforts and provides instructions for viewing the data in Google Earth. A list of links is provided for users to explore various aspects of night skies, such as "Science of Light", "Managing Lightscapes", and "Measuring Lightscapes". A sidebar on the left contains a "Natural Sounds & Night Skies" menu with sub-links like "Natural Sounds", "Night Skies", "Science of Light", "Managing Lightscapes", "Light Pollution", "Measuring Lightscapes", "Exploring Night Skies", "Enhance Your Nighttime Experience", "Rate Your Night Sky", "Junior Ranger Night Explorer (Kids)", "Where to Stargaze", "Making a Difference", and "Useful Resources". Below the sidebar are icons for "Explore Nature Home", "About Natural Resources", "Contact Natural Resources", "Search", and "RSS". At the bottom of the page, there is a Google Earth interface showing a satellite view of the United States with a dark overlay representing the night sky data.

National Park Service
National Park Service
U.S. Department of the Interior

Find a Park Discover History Explore Nature Working with Communities Get Involved Teachers Kids About Us

NPS » Explore Nature » Natural Sounds & Night Skies » Night Skies

Natural Sounds & NIGHT SKIES

Night Sky Monitoring Database

The NPS Night Skies Team has collected data at over 317 sites in 116 park units, as well as some areas outside of national parks. To learn more about how we collect these data, visit our [Measuring Lightscapes page](#). For an interpretations of the metrics in the reports, visit the [Night Sky Monitoring Report Metrics page](#).

Night sky images and reports are available in a database via a Google Earth.

- Make sure that [Google Earth](#) is installed on your computer - this is how you'll view the data.
- Download the [Google Earth kml file](#) to view the night sky database.
- Download the [Google Earth kmz file](#) to view an overlay of upward radiance from the VIIRS DNB satellite (lower 48 United States only).

Instructions for viewing in Google Earth:

Add the NPS Night Sky data layer (kml file). There are red circle placemarks for each monitoring site.

Add the VIIRS DNB layer(kmz file) and set its transparency to about 30%.

Explore Nature Home
About Natural Resources
Contact Natural Resources
Search
RSS

The web interface

Description of the measurements at <http://nature.nps.gov/night/skydata.cfm>

National Park Service National Park Service U.S. Department of the Interior

Find a Park Discover History **Explore Nature** Working with Communities Get Involved Teachers Kids About Us

NPS » Explore Nature » Natural Sounds & Night Skies » Night Skies

NATURAL SOUNDS & NIGHT SKIES

Natural Sounds

Night Skies

- Science of Light
- Managing Lightscapes
- Light Pollution
- Measuring Lightscapes
- Exploring Night Skies
 - Enhance Your Nighttime Experience
 - Rate Your Night Sky
 - Junior Ranger Night Explorer (Kids)
 - Where to Stargaze
- Making a Difference
- Useful Resources

About Us

[Explore Nature Home](#)

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[Contact Natural Resources](#)

[Search](#)

[RSS](#)

Night Sky Monitoring Report Metrics

This page provides a quick explanation of the web reports. A brief description of each table, and each attribute reported within, is included.

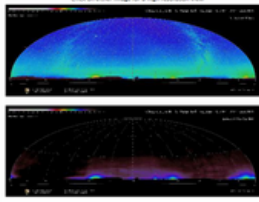
Introduction

A "Data Set" is one complete set of 45 images that cover the entire sky. Multiple data sets are often taken over the course of the night to detect changes in artificial sky glow from evening to early morning. The web report shows data from the best or most representative set only.

The report contains three main sections:

1. A table showing general attributes of the data collection event and visual indicators of sky quality
2. Panoramic images of the entire sky shown in false color revealing calibrated sky brightness with links to the high resolution images
3. Photometric indicators of sky quality and the photic environment derived from the all-sky mosaics. Photometric units of measure used include SI units of luminance (candela per square meter) and illuminance (lux), as well as astronomical units of luminance (magnitudes per square arc second) and illuminance (magnitudes) in the V, or visual, band. SI units are linear, astronomical units are inverse logarithmic, that is, smaller values indicate brighter objects, and negative values are possible.

The NPS methods are unique in that a natural sky model is built for each all-sky observation and subtracted

Category	Details	Observed and Estimated Artificial Sky Brightness Mosaics
Park:	Chaco Culture NHP	
Site Name:	Water Tank	
Longitude:	-107.91	
Latitude:	36.03	
Elevation (m):	1879	
Date (LMT):	13-Oct-2005	
Time (LMT Hours):	23:45	
Camera:	Apogee	
Lens:	Nikon 35mm 1.2	
Observers:	D Durlisse C Moore C Durlisse	
Air temp. (°C):	5.6	
R. H. (%):	23.0	
Wind Speed (mph):	5	

Chaco Culture NHP
Water Tank
13-Oct-2005

Data Set Attributes and Visual Indicators

Sample night sky monitoring report from Chaco Culture National Historic Park.

Natural Sounds and Night Skies
Natural Resource Stewardship and Science
www.nature.nps.gov



National Park Service
U.S. Department of the Interior