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

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Introduction

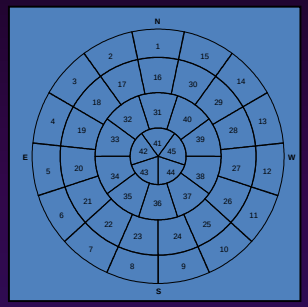
- The U.S. National Park Service Night Sky Team began collecting all-sky imaging data in 2001
- To date there are over 600 “data nights”
- High resolution false color all-sky images of both observed sky brightness and derived artificial sky glow are produced
- A suite of indicators of sky quality and 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



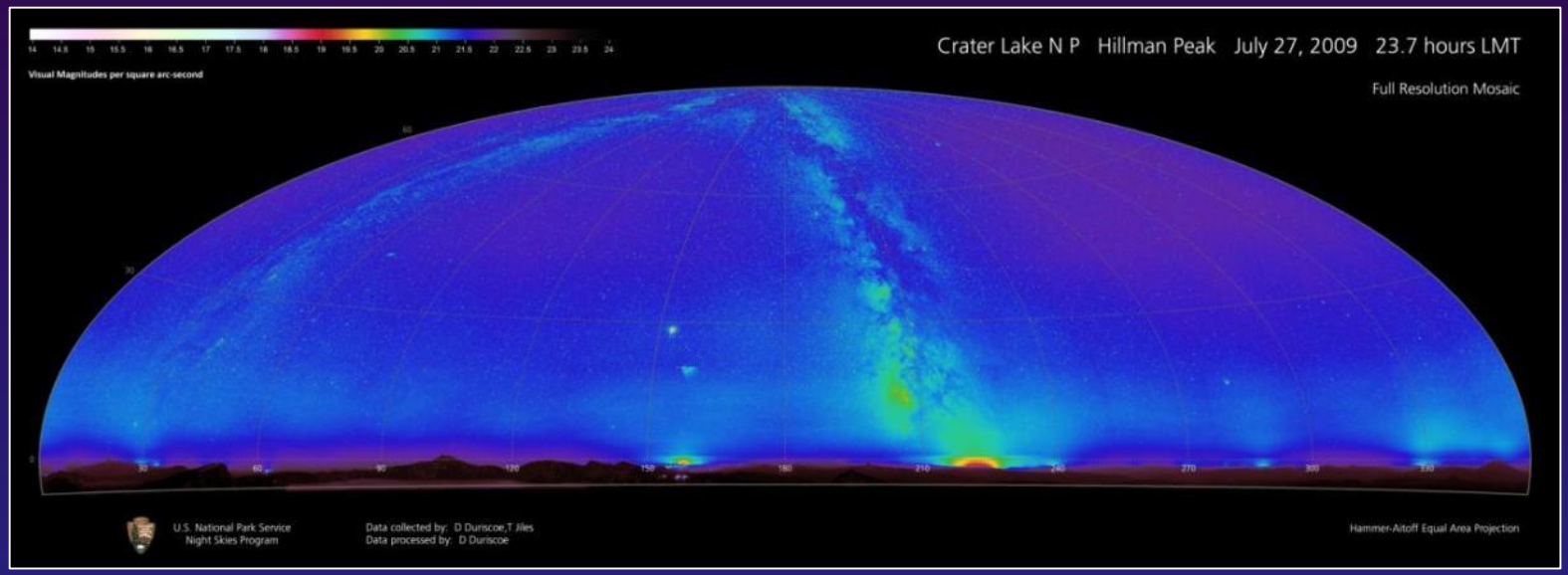
```
'subroutine to measure all sky brightness values

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 = 1.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

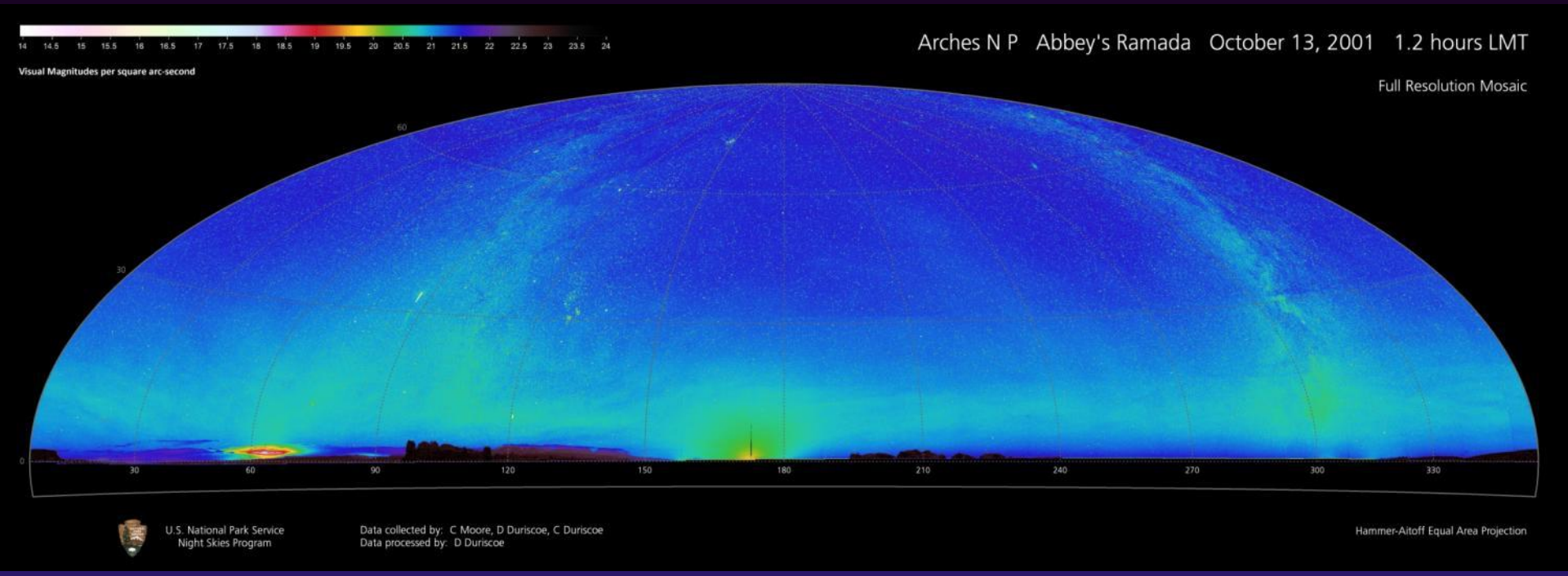
Addition of staff and cameras in 2010-2015


isle
royale
national
park
an
international
biosphere
reserve

Chad Moore leaves the NPS Night Sky team 2015

The data products

All-sky image mosaics

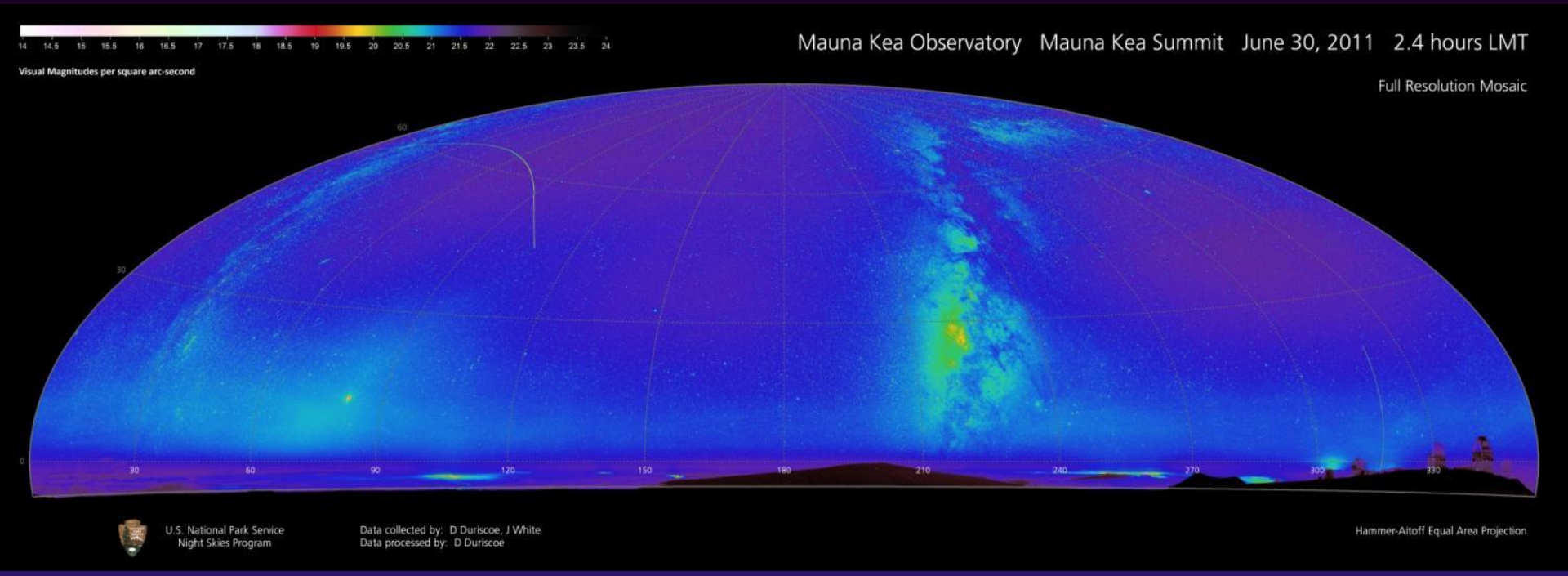


The data products

All-sky image mosaics

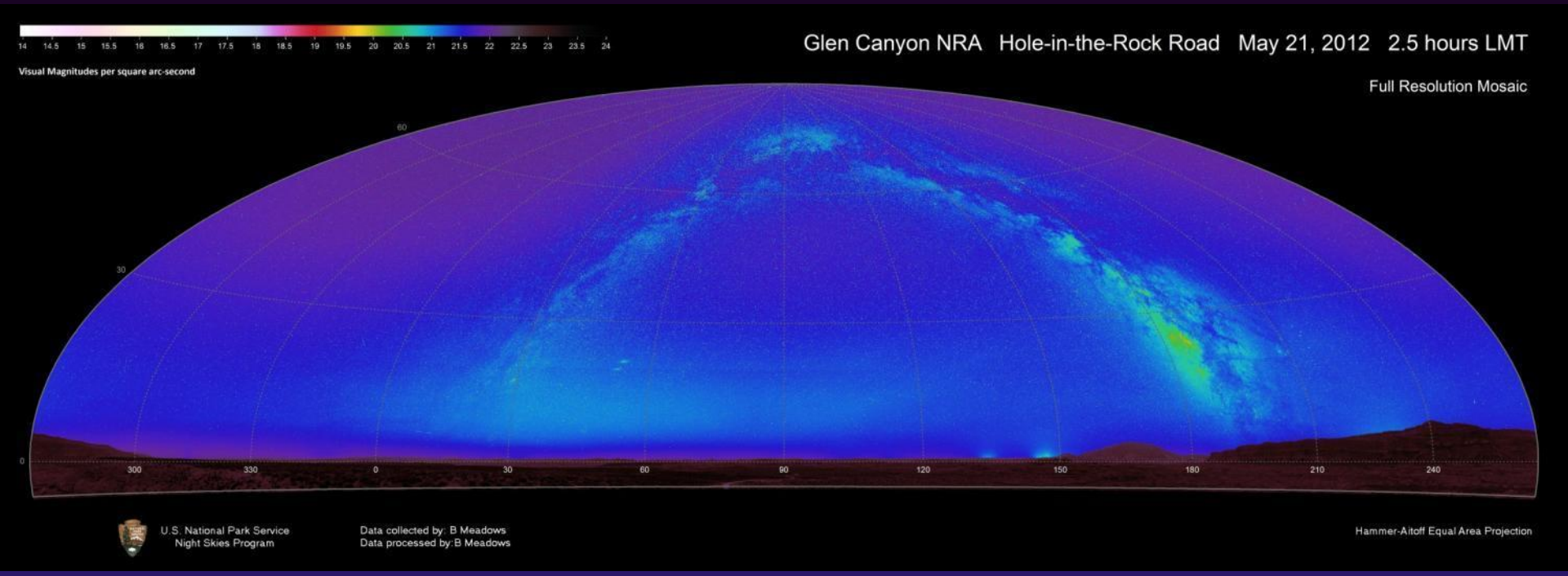
The data products

All-sky image mosaics



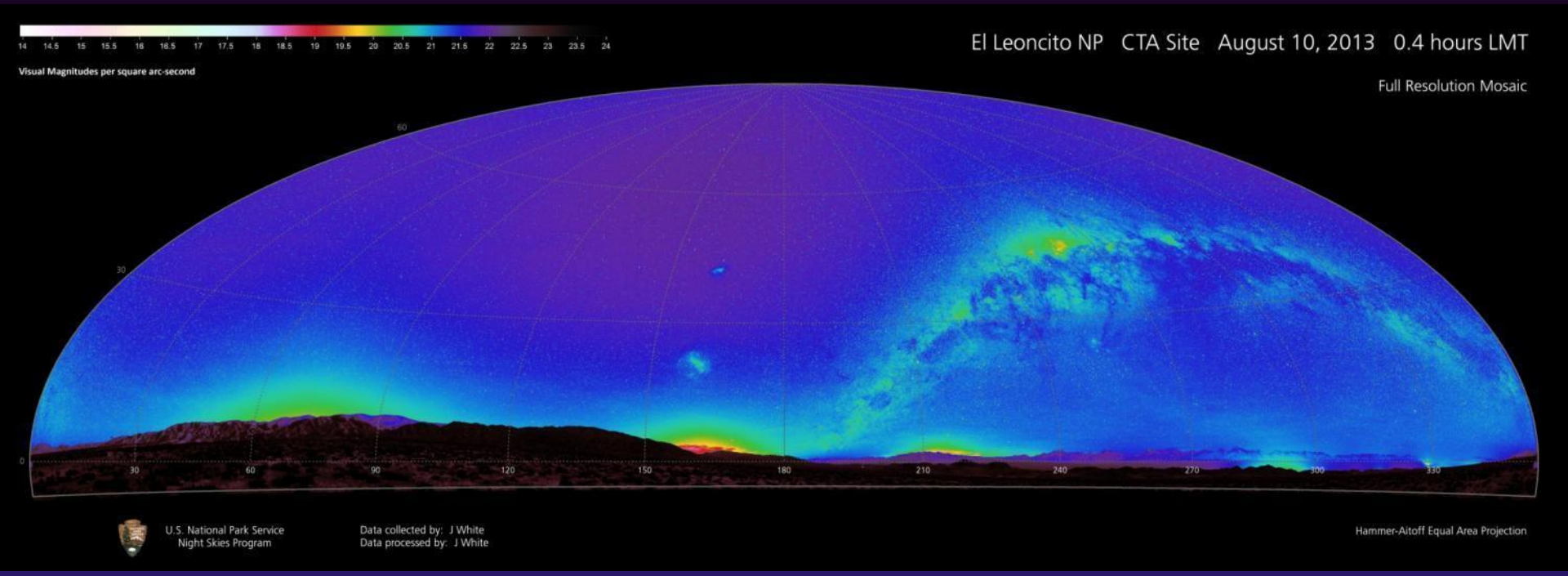
The data products

All-sky image mosaics



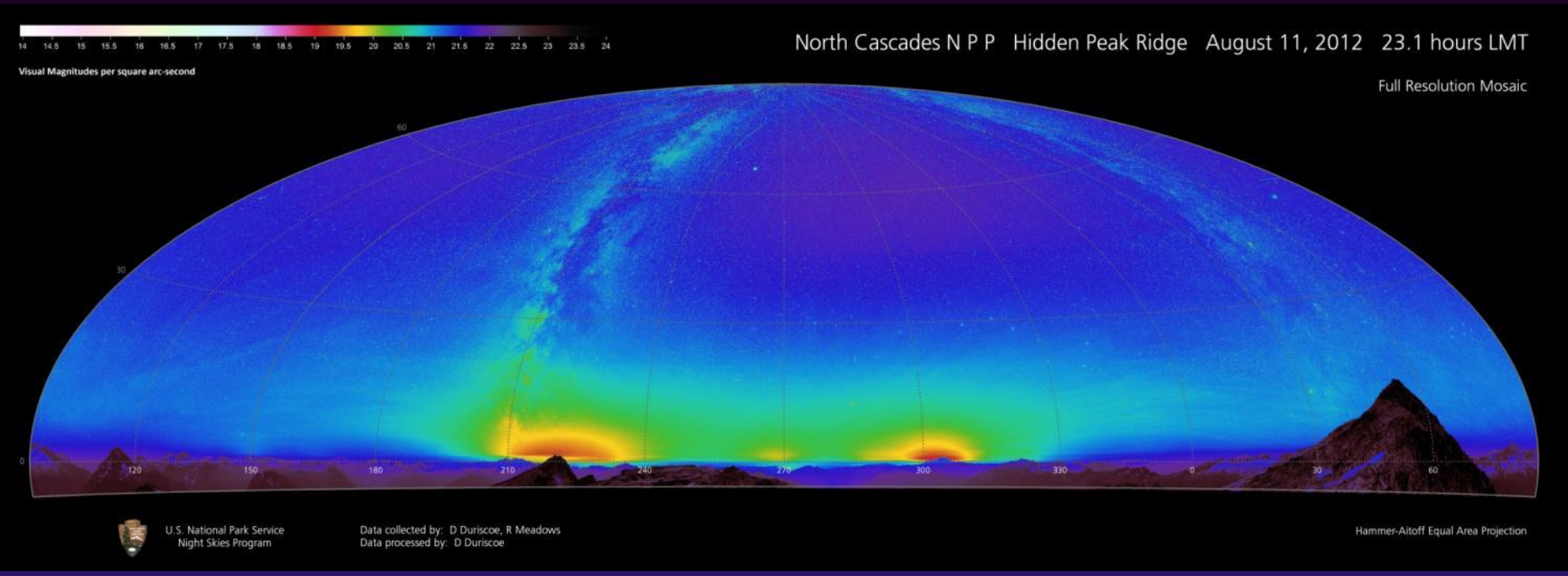
The data products

All-sky image mosaics



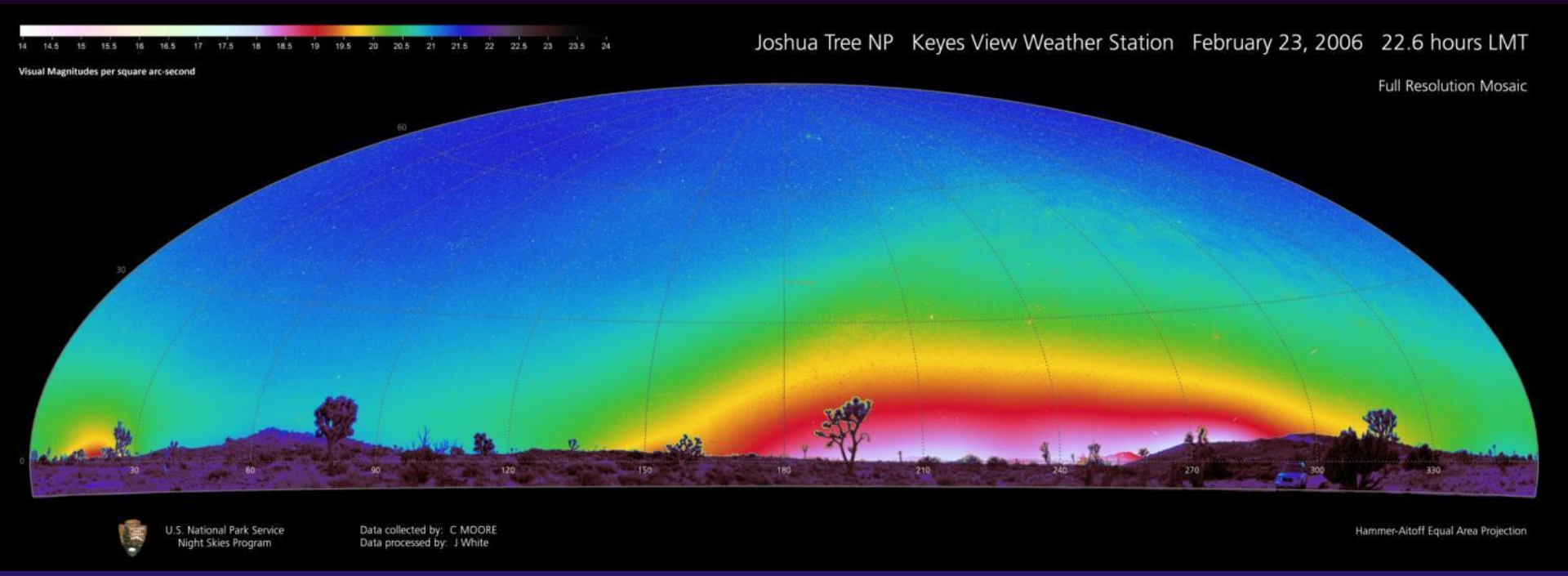
The data products

All-sky image mosaics



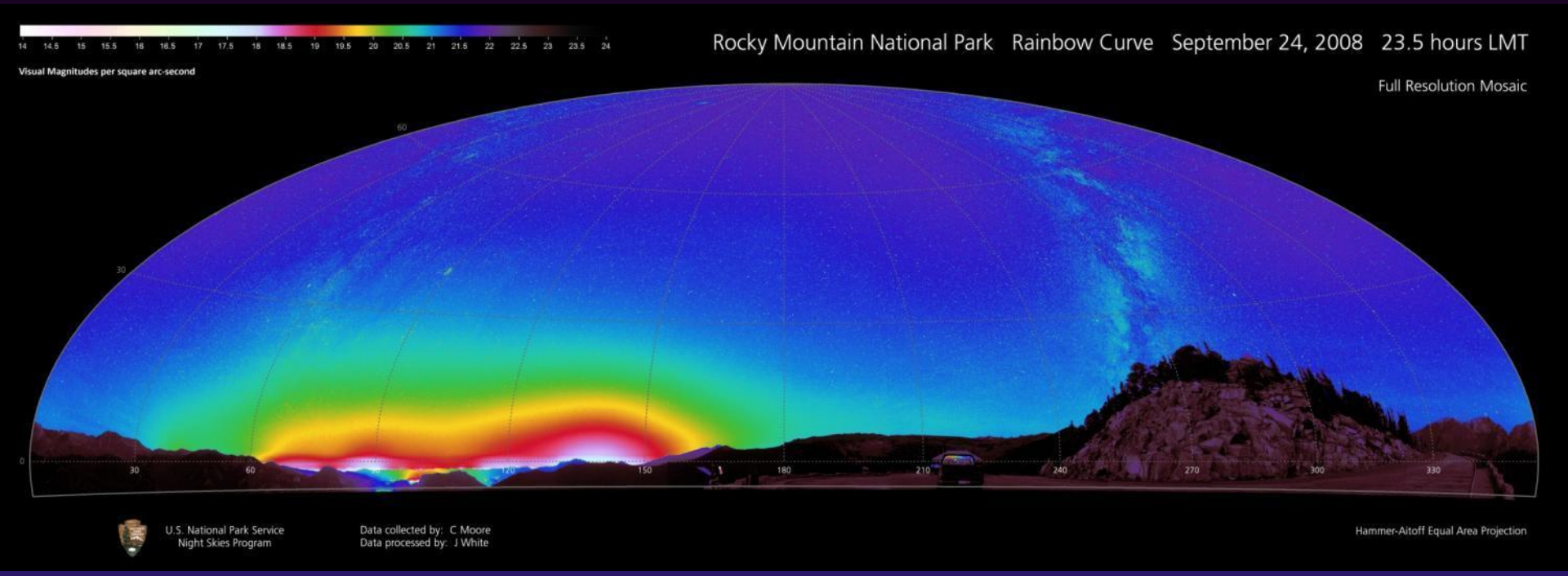
The data products

All-sky image mosaics



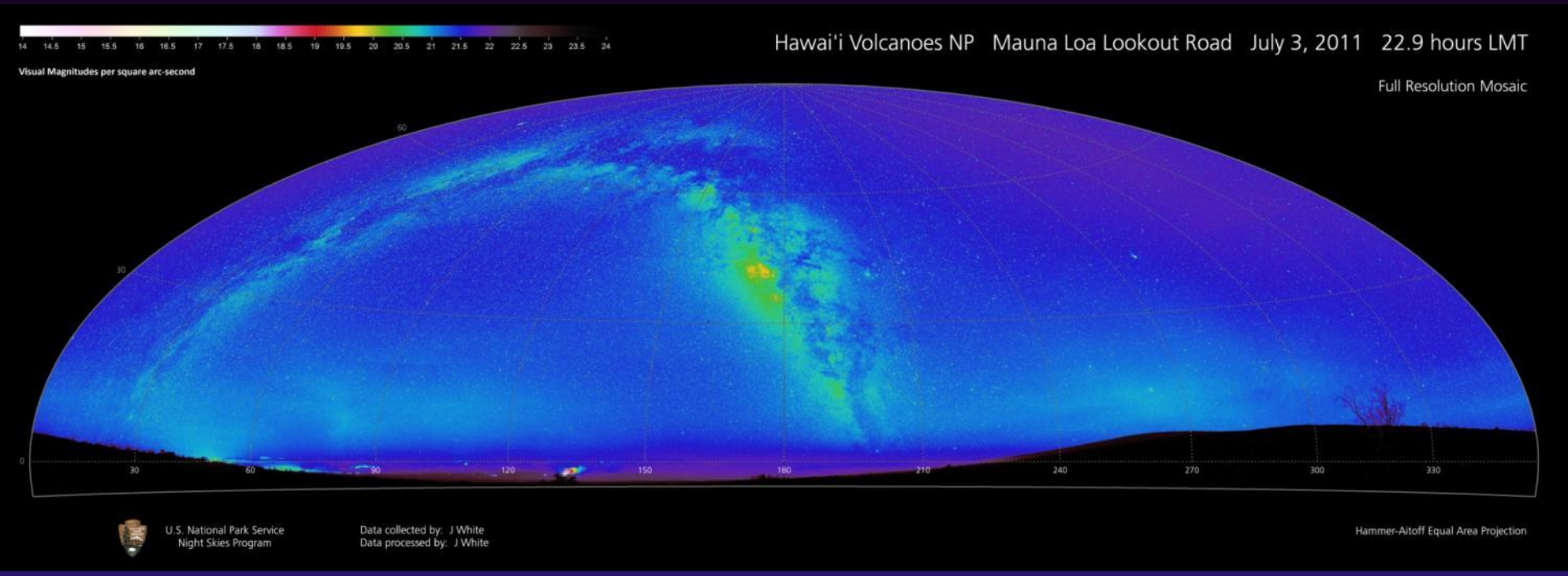
The data products

All-sky image mosaics



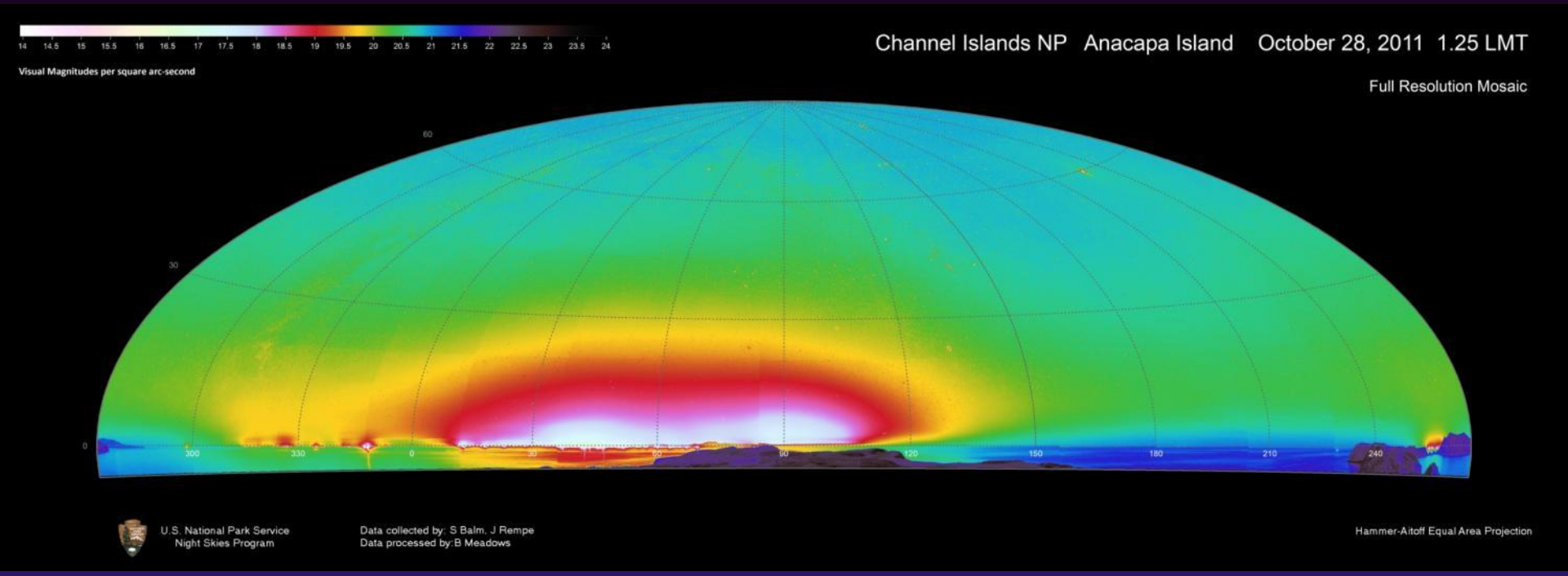
The data products

All-sky image mosaics



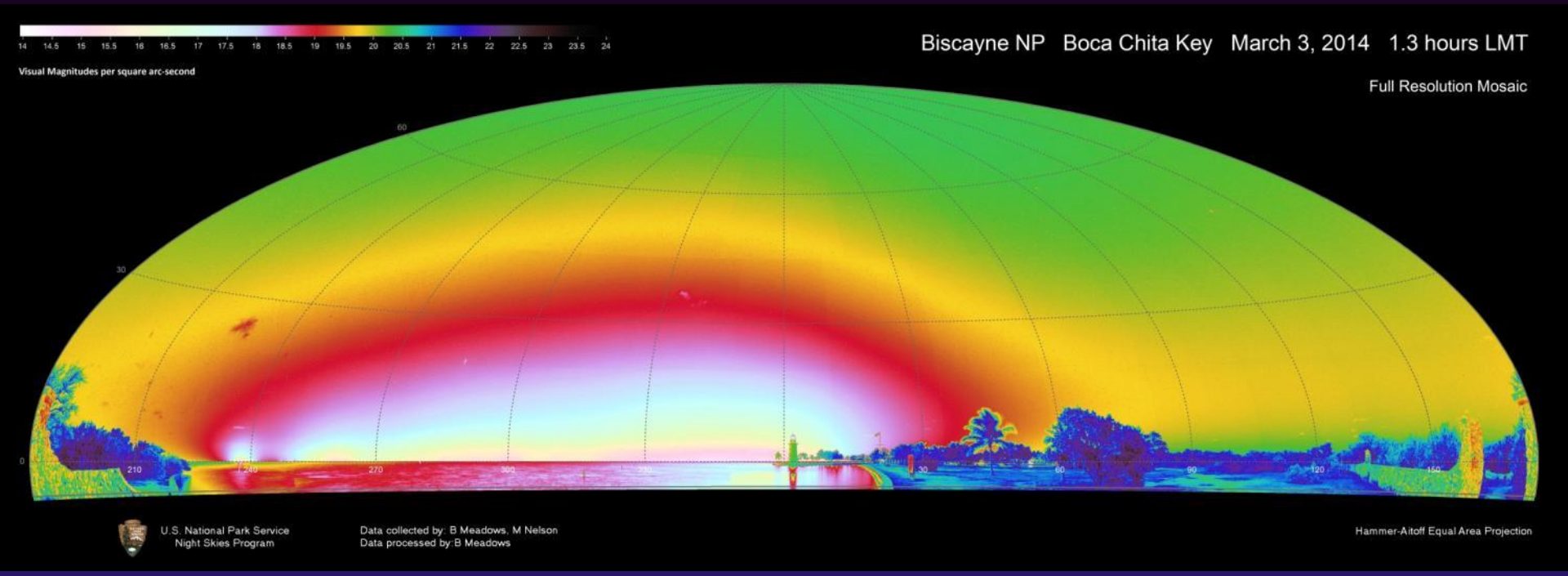
The data products

All-sky image mosaics



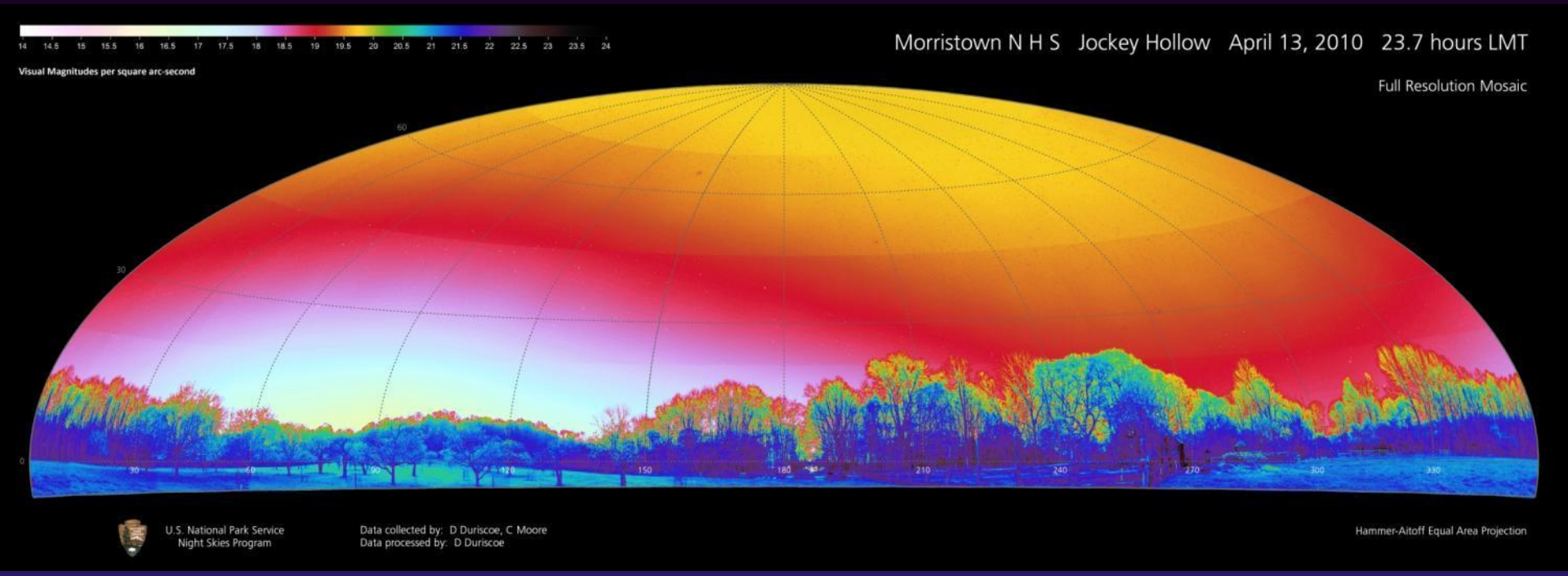
The data products

All-sky image mosaics



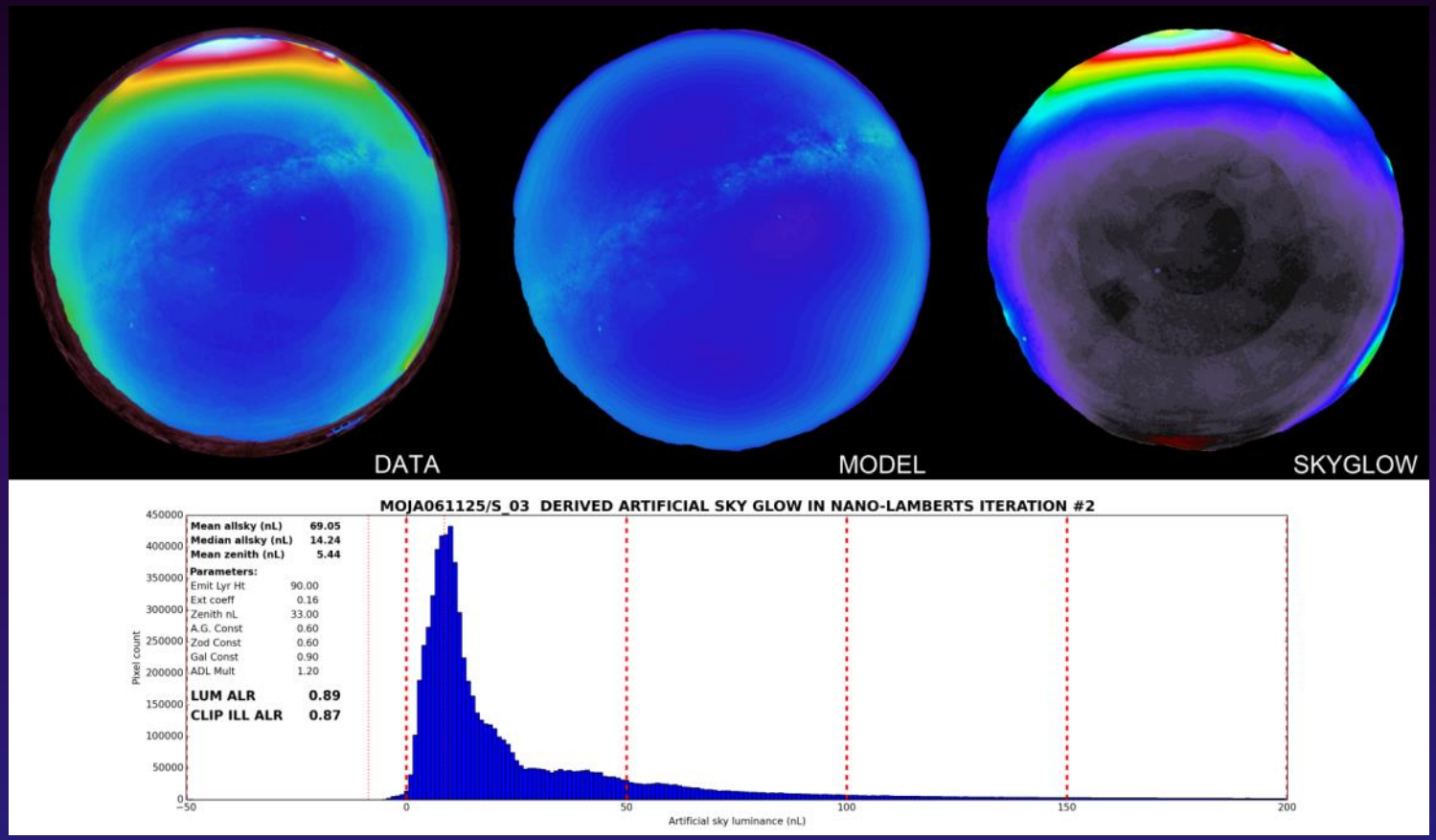
The data products

All-sky image mosaics



The data products

Natural Sky Model subtraction



The data products

Indicators derived from estimated artificial sky luminance

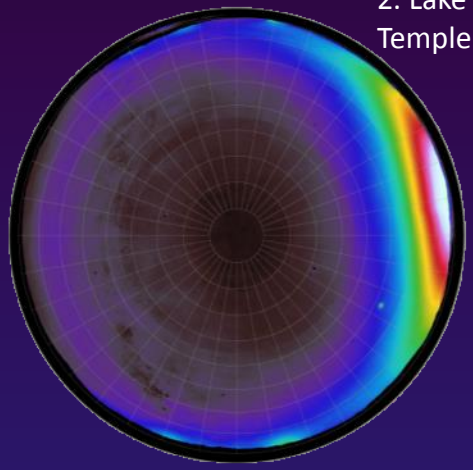
Anthropogenic sky luminance (µcd m^{-2})

zenith	average	maximum

1. Death Valley N.P.

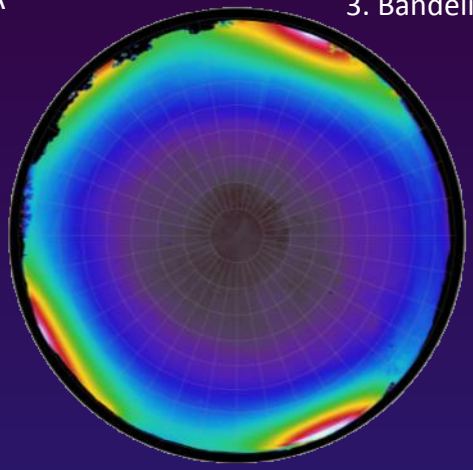
6	99	10,700

2. Lake Mead N.R.A Temple Bar



54	331	22,700

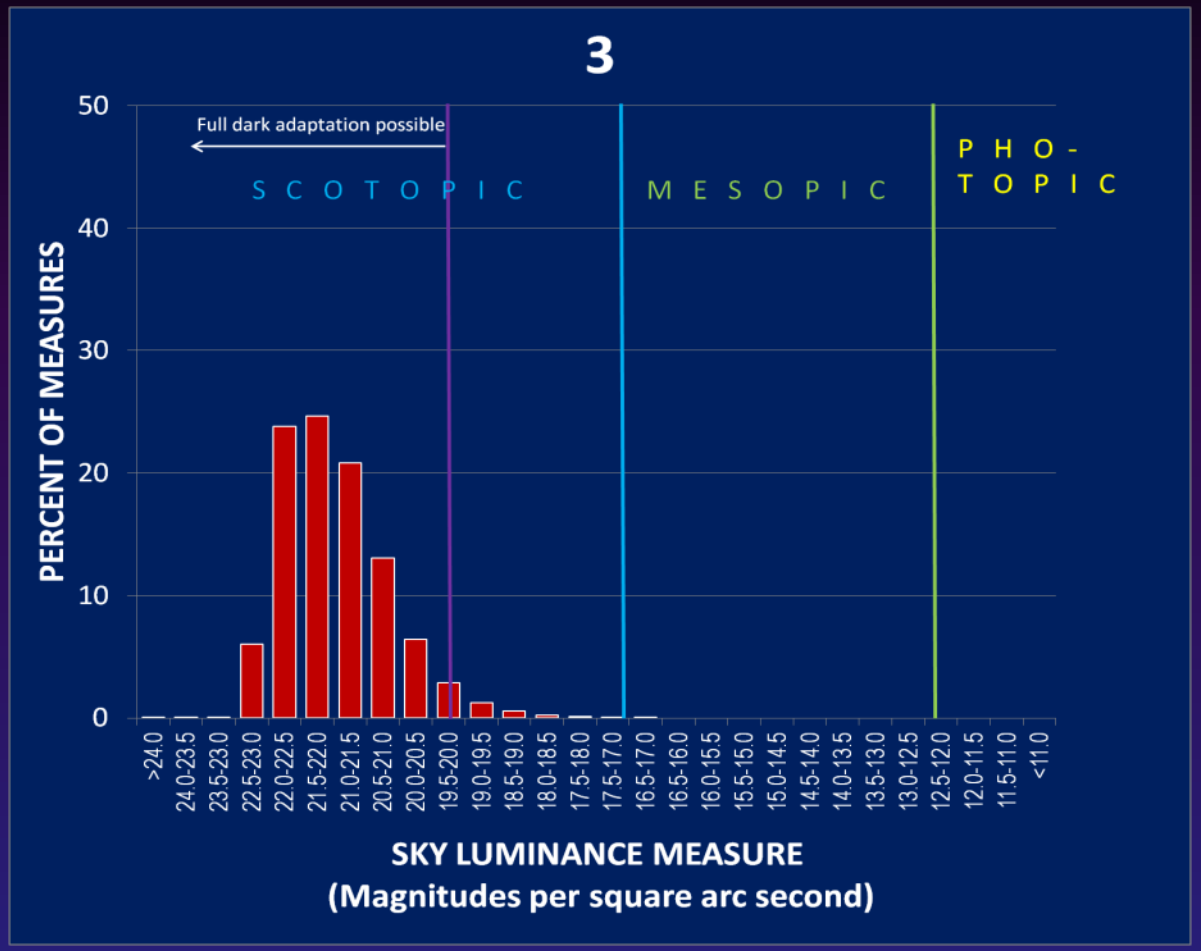
3. Bandelier N.M.

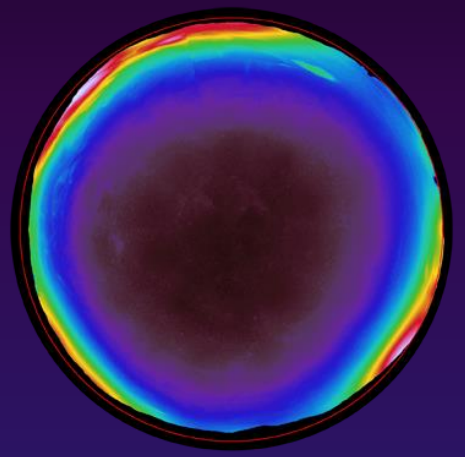


108	398	23,900

The data products

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





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/ arscec^2	µcd/ m^2	mag/ arscec^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

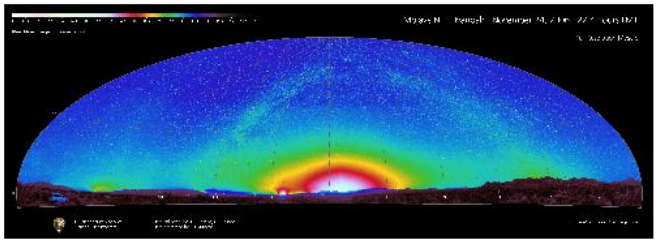
Metadata and visual observations

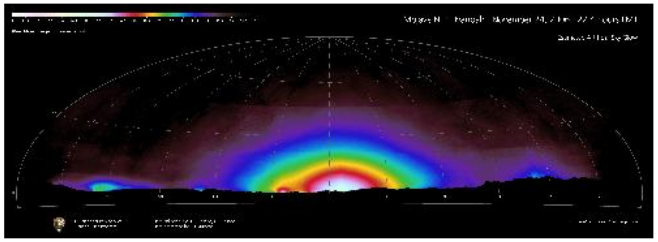
Data Set Attributes and Visual Indicators

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 casiting 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

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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%.

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The web interface

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

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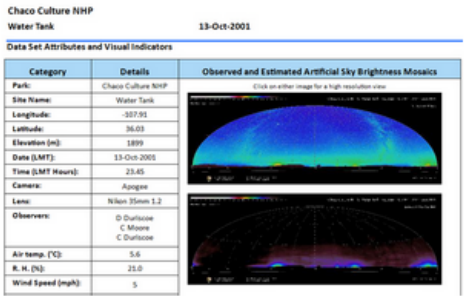
Night Sky Monitoring Report Metrics

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.


Chaco Culture NHP
Water Tank 13-Oct-2001
Data Set Attributes and Visual Indicators

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):	1899	
Date (LMT):	13-Oct-2001	
Time (LMT Hours):	23.45	
Camera:	Apogee	
Lens:	Nikon 35mm 1.2	
Observers:	D Duriscoe C Moore C Duriscoe	
Air temp. (°C):	5.6	
R. H. (%):	25.0	
Wind Speed (mph):	5	

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

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

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