Condor Array Telescope Data Products

CONDOR

Contents

1   Introduction

The Condor Array Telescope provides access to coadded sums of exposures and plans to provide access to individual exposures following an 18-month proprietary period (although this functionality is not yet implemented). This document describes how to access and interpret Condor data products.

2   Coadded Sums of Exposures

2.1   Data Access

Various coadded sums of exposures are available at:

- https://condorarraytelescope.org/data_access/.

These coadded sums of exposures may be immediately downloaded, with no requirement to register for an account or to obtain an API token. Typically, these coadded sums of exposures are the products of some scientific project carrier out by the Condor team and are described in one or more manuscripts that are published or submitted for publication.

Each release is designated by a release identifier (e.g. "2023-001"), a name (e.g. "NGC 5866 Group"), and a release version (e.g. "v0"). Each release consists of a number of images, each of which is designated by a file name, a filter, a date range, a "reach," and a file size.

The file name begins with "coadd" to indicate that the image is a coadded sum of exposures. The file name then contains either (1) a five-digit "Condor field" identifier or (2) J2000 coordinates of the field center in sexagesimal notation, truncated (rather than rounded) at six significant digits. (The "Condor fields" are a set of fields with field centers that tile the entire sky with the Condor field of view, allowing for overlap.) The file name then contains a designation of the filter. The correspondence between the filter designation and the filter name is described in Table 1 below. The file name then contains the release version. The file name ends with ".fits.gz" to indicate that the file is a gzipped file in FITS format.

Table 1: Filter Designations

Designation	Filter	Notes
L	luminance	
u	Sloan u'	
g	Sloan g'	
r	Sloan r'	
i	Sloan i'	
HeII	He II 468.6 nm	
OIII	[O III] 500.7 nm	
HeI	He I 587.5 nm	
Halpha	H-alpha 656.3 nm	
NII	[N II] 658.4 nm	
SII	[S II] 671.6 nm	
vHalpha . . .	Vir H-alpha 660 nm	H-alpha at the redshift of the Virgo Cluster
vOVI	Vir O VI 685 nm	Raman-scattered O VI at the redshift of the Virgo Cluster
SA200	diffraction grating	Resolution $R \approx 200$ diffraction grating

The "reach" is a measure of the observing resources devoted to coadded sum of exposures (or indeed of any sequence of exposures). The reach is defined as the product of the total objective

area and the exposure time devoted to a particular observation. In its current configuration, Condor consists of six telescopes, each of objective diameter 180 mm or objective area 0.0254 m^2. Hence a one-second exposure with one telescope of the array yields a reach of 0.0254 m^2 s, while a one-second exposure with the entire array (i.e. with all six telescopes of the array) yields a reach of $6 \times$ 0.0254 = 0.153 m^2 s. Because Condor is used with variety of filter configurations, with anywhere between one and six telescopes devoted to a particular filter, and because future modifications may add more telescopes to the array, the exposure time alone is not a meaningful description of the observing resources devoted to a some sequence of exposures. The reach further provides a way to compare observations obtained by different telescopes, including ordinary telescopes and array telescopes.

On the data access web page, each release is accompanied by a drop down menu that provides access to release notes and to instructions describing how to transfer the files using "wget." Each image is accompanied by a "download" button that initiates transfer of the associated file. So files can be downloaded either individually by clicking the "download" button or as a group by cutting and pasting one or more of the "wget" commands.

2.2 File Format

Each gzipped file in FITS format contains an image that consists of three planes—a "data" plane, a "sigma" plane, and a "mask" plane—and a header.

The data plane contains the drizzled, coadded image in nominal μJy units. Very rarely, some individual data pixel values pixel values are set to identically zero; these pixels contain no useful data (and should appear as masked in the mask plane described below).

The sigma plane contains the one-sigma uncertainties associated with the data plane in nominal μJy units. These uncertainties are determined by propagating photon shot noise and detector read noise through the drizzling and coaddition processes. As for the data plane, very rarely, some individual sigma pixel values are set to identically zero, and these pixels contain no useful data. It is important to note that as a consequence of the drizzling process, the uncertainties are highly correlated on spatial scales that extend over several pixels. Any analysis that makes use of the sigma plane on spatial scales extending beyond a single pixel presumably must measure and account for the data covariance.

The mask plane contains several types of pixel masks that describe various properties of the data. The mask plane is a stored as a single-byte (i.e. eight-bit) integer, where each bit is used to store a different type of these masks. Currently, two types of masks are implemented:

○ The least-significant (i.e. 2^0) bit marks rejected pixels, including pixels affected by cosmic-ray events, significant random-telegraph noise, satellite trails, and other defects and border regions containing no data. For a coadded sum of exposures involving many exposures, it is rare for such pixels to be present except in the border regions. Any analysis presumably must neglect such pixels. Here a value 1 of the 2^0 bit indicates a rejected pixel (and a value 0 indicates a non-rejected pixel).

○ The second-to-least-significant (i.e. 2^1) bit marks regions of significant object flux. Presumably regions without significant object flux correspond to "background" regions. Here a value 1 of the 2^1 bit indicates a pixel exhibiting significant object flux (and a value 0 indicates a pixel not exhibiting significant object flux).

The various types of mask are summarized in Table 2. Future modifications to the image processing may add additional types of masks to the mask plane.

Table 2: Types of Masks

Bit	Type of Mask
0	Rejected pixels
1	Regions of significant object flux

The header contains (1) world coordinate system (WCS) information and (2) an list of the file names of the constituent exposures that make up the coadded sum of exposures. The WCS information is relatively straightforward, because the drizzled images are presented on a coordinate grid that is free of geometric distortion. The file names of the constituent exposures provide a way to determine details of the coaddition. These file names are contained in a series of header keywords of the form "XPxxxxxx," where "XP" suggests "eXPosure" and where "xxxxxx" represents a six-digit integer (with leading zeros) starting at 000000. (So, for instance, the header keyword of the file name of the first constituent exposure is "XP000000.") An exposure file name serves as the primary key of a Condor database record that records information related to the corresponding exposure (e.g. exposure datetime, exposure length, filter, camera temperature, etc.). These Condor database records can be accessed through Condor API, which is described in *The Condor Array Telescope API*. These file names could in principle be used together with the Condor API to determine all details of the constituent exposures that make up the coadded sums of exposures.

2.3 Astrometric Calibration

The astrometric calibration of Condor images is described by Lanzetta et al. (2023). Typical systematic uncertainties associated with the astrometric calibration are ≈ 0.1 arcsec.

2.4 Field Flattening and Background Subtraction

The field flattening and background subtraction of Condor images is described by Lanzetta et al. (2023). It is important to note that field flattening and background subtraction becomes increasingly difficult near the corners and edges of individual exposures, with the consequence that the corners and edges of coadded sums of exposures can sometimes exhibit departures from flatness. The Condor team has found that the shapes of the twilight exposures used to flatten the science exposures depend on focus near the vignetted corners of the exposures. Hence the success of the field flattening and background subtraction can hinge on closely the twilight and science exposures are matched in focus. Future modifications to the image calibration may improve field flattening and background subtraction.

2.5 Photometric Calibration

The photometric calibration of Condor images is described by Lanzetta et al. (2023). This photometric calibration is used to present the data and sigma planes of the coadded sums of exposures (described above) in nominal μJy units. It is important to note that this calibration is intended to be representative only and that a more accurate photometric calibration (e.g. for analyzes requiring absolute photometric calibration) would require additional processing.

3   Individual Exposures

All individual exposures obtained by Condor will be released following an 18-month proprietary period. This functionality is not yet implemented.