HST Science Products

Rachel Osten
Mission Scientist, HST Mission Office
STUC meeting
May 13, 2016
“The Hubble mission continues to operate well, in no small part due to the proactive nature of STScI’s instrument and observatory monitoring and maintenance.” (STUC report)
HST Science Products

- Instrument Science Reports (ISRs)
- Reference files
- Observing tools
- Space Telescope Analysis Newsletters (STANs)
- New science capabilities
- Monitoring
- High level science products
HST Science Products

- new science capabilities
- observing tools
- reference files
- monitoring
- high level science products
- Instrument Science Reports (ISRs)
- Space Telescope Analysis Newsletters (STANs)
The Cycle 23 Calibration Program Provides the Monitoring and Instrument Calibration Needed to Enable Science with HST

<table>
<thead>
<tr>
<th></th>
<th>External Orbits</th>
<th>Internal Orbits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS</td>
<td>33</td>
<td>936</td>
</tr>
<tr>
<td>COS</td>
<td>38</td>
<td>317</td>
</tr>
<tr>
<td>STIS</td>
<td>31</td>
<td>1388</td>
</tr>
<tr>
<td>WFC3</td>
<td>98</td>
<td>1619</td>
</tr>
<tr>
<td><strong>Total orbits</strong></td>
<td><strong>200</strong></td>
<td><strong>4260</strong></td>
</tr>
</tbody>
</table>
Science Products

Hubble Space Telescope
May 2016 STAN

In this Newsletter we provide information about updates to the COS/FUV TDSTAB and DISPTAB reference files:

Contents:

- Updated COS/FUV Time Dependent Sensitivity Reference File (TDSTAB) Released

- Updated COS/FUV Wavelength Dispersion Solution Reference File (DISPTAB) Released

where the large scatter seen in the dark rate contributed to the large dark rate adopted. The scatter has now decreased substantially, leading to dark rates that are < a factor of 2 lower than the value...
<table>
<thead>
<tr>
<th>Date</th>
<th>File</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-05-02</td>
<td>hst_0444.pmap</td>
<td>archived</td>
<td>New STIS CCD bias and dark reference files for STIS data.</td>
</tr>
<tr>
<td>2016-04-25</td>
<td>hst_0441.pmap</td>
<td>archived</td>
<td>New flash reference files for ACS full frame data.</td>
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<tr>
<td>2016-04-19</td>
<td>hst_0439.pmap</td>
<td>archived</td>
<td>These files are used in the dark current subtraction.</td>
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<tr>
<td>2016-04-15</td>
<td>hst_0438.pmap</td>
<td>archived</td>
<td>New standard and cte-corrected darks.</td>
</tr>
<tr>
<td>2016-04-06</td>
<td>hst_0436.pmap</td>
<td>archived</td>
<td>The V2 and V3 reference positions were changed.</td>
</tr>
<tr>
<td>2016-04-01</td>
<td>hst_0435.pmap</td>
<td>archived</td>
<td>New reference files for ACS WFC data taken after the V2 and V3 changes.</td>
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<tr>
<td>2016-03-25</td>
<td>hst_0434.pmap</td>
<td>archived</td>
<td>New WCPTAB with updated XC range.</td>
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<tr>
<td>2016-03-17</td>
<td>hst_0433.pmap</td>
<td>archived</td>
<td>ACS WFC FLUSHFILEs with SHUTRPOS set to ACS WFC subarray biases.</td>
</tr>
<tr>
<td>2016-03-17</td>
<td>hst_0432.pmap</td>
<td>archived</td>
<td>New ACS WFC subarray biases.</td>
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<tr>
<td>2016-03-13</td>
<td>hst_0431.pmap</td>
<td>archived</td>
<td>New reference files for ACS WFC data taken after the V2 and V3 changes.</td>
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<tr>
<td>2016-03-08</td>
<td>hst_0430.pmap</td>
<td>archived</td>
<td>These files are used in the dark current subtraction.</td>
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<tr>
<td>2016-02-29</td>
<td>hst_0429.pmap</td>
<td>archived</td>
<td>New ACS DRK, BIA, DKC after Dec. 16 2015.</td>
</tr>
<tr>
<td>2016-02-23</td>
<td>hst_0428.pmap</td>
<td>archived</td>
<td>Merging of the WFC3 branch context, along with the new ACS WFC3 drift.</td>
</tr>
<tr>
<td>2016-02-11</td>
<td>hst_0424.pmap</td>
<td>archived</td>
<td>New ACS WFC1-1K subarray bias for data taken in 2016-02-11.</td>
</tr>
<tr>
<td>2016-02-10</td>
<td>hst_0423.pmap</td>
<td>archived</td>
<td>Delivery of new STIS CCD bias and dark reference files.</td>
</tr>
<tr>
<td>2016-01-07</td>
<td>hst_0380.pmap</td>
<td>archived</td>
<td>New ACS WFC bias, dark, and cte-corrected darks.</td>
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<tr>
<td>2015-12-22</td>
<td>hst_0379.pmap</td>
<td>archived</td>
<td>These post-flashed dark current files continue the new ACS WFC3 drift.</td>
</tr>
<tr>
<td>2015-12-01</td>
<td>hst_0378.pmap</td>
<td>archived</td>
<td>Redelivery of unchanged COS SPOTTAB rmap with new ACS WFC3 drift.</td>
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<tr>
<td>2015-11-24</td>
<td>hst_0377.pmap</td>
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<td>These post-flashed dark current files continue the new ACS WFC3 drift.</td>
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<td>2015-11-19</td>
<td>hst_0375.pmap</td>
<td>archived</td>
<td>New ACS bias, darks and cte corrected dark reference files.</td>
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<tr>
<td>2015-11-18</td>
<td>hst_0374.pmap</td>
<td>archived</td>
<td>New BIASFILE rmap which includes the new aspect.</td>
</tr>
<tr>
<td>2015-11-18</td>
<td>hst_0373.pmap</td>
<td>archived</td>
<td>New STIS CCD biases and darks.</td>
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<tr>
<td>2015-11-16</td>
<td>hst_0372.pmap</td>
<td>archived</td>
<td>Reactivating previous BPIXTAB. Current file has new gainsag holes.</td>
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<tr>
<td>2015-11-12</td>
<td>hst_0371.pmap</td>
<td>archived</td>
<td>Delivery of the new COS FUV GSAGTAB.</td>
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<td>2015-11-10</td>
<td>hst_0368.pmap</td>
<td>archived</td>
<td>Reference file installation following 2015.2b installation.</td>
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<tr>
<td>2015-11-03</td>
<td>hst_0366.pmap</td>
<td>archived</td>
<td>These post-flashed dark current files continue the new ACS WFC3 drift.</td>
</tr>
</tbody>
</table>
Instrument Science Report ACS 2016-02

SBC Internal Lamp P-flat Monitoring

R.J. Avila, M. Chiaberge, R. Bohlin

March 25, 2016

January 0, 2010
16 November 2013
Basic Instrument Calibration is a Priority

- **COS**: λ calibration, FUV/LP4, C23 & C24 calibrations
- **STIS**: automated monitoring, lamp monitoring, echelle blaze function, TDS, C23 & C24 calibrations
- **ACS**: WFC CTE, WFC geometric distortion, SBC sensitivity/flatfields, PSF modelling
- **WFC3**: UVIS bias, darks; IR dark, linearity monitors, C24 calibration, grism IR λ, flux calibration, photometric repeatability, focus monitoring

FTEs in instrument teams devoted to basic calibration (yellow), user support & documentation (blue), higher level products (purple), other (management, institute service)
Priorities for higher level products are set by:

✓ free energy available after basic calibration, user support, documentation is covered
✓ concerns of user community for improvements to basic calibration, tools, monitoring
✓ resources required to implement higher level products
✓ enhancements to the legacy value of Hubble datasets
✓ discussions with the user community

High Level Science Products (HLSPs) are produced as the result of Large and Treasury Programs and are deliverables to MAST
HST Spectral Legacy Project

recommendation of working group formed after “Enhancing the Legacy of HST Spectroscopy” Workshop Nov. 15-16, 2012

The working group identified the following tasks as priorities for the next couple of years (from higher to lower priority)

- Make combined 1D spectral products available and create the pipeline to do it
- Visualization tools for spectra
- Search tool to select sources based on their classification
- Tool for feature identification and measurement (develop equivalent of source extractor for spectra)

STUC Oct. 2013 K. Sembach presentation

STUC was briefed in Oct. 2013, Oct. 2014, Nov. 2015
resource level: ~1.5 FTE per year
HST Spectral Legacy Project

Enhances spectroscopic science return of Hubble archives

- Many science cases require all/most data on a given target
- HST Spectral Legacy project available March 7, 2016: spectroscopic equivalent of mosaics for images
  - combines all COS/FUV data on 1394 targets, 13121 exposures, 1722 coadded 1D spectra, 18 science-ready target samples, one-click downloads
  - Will expand to COS/NUV, STIS, legacy spectrographs
Three Reasons to Build the Catalog

1. Time-variable phenomena – The HSC supports time-variable studies over a >20 year baseline.

2. Mosaics – Accurate spatial offsets between observations are needed to build the HSC. These can then be used to make mosaics.

3. Very large datasets – Replicating what is available in the HSC in seconds would take most researchers weeks, months, or years to produce.
Hubble Source Catalog

STUC first briefed in April 2012
resource level: ~1.5 FTE effort per year

- Enables science from catalog of hundreds of millions of sources viewed by HST over its lifetime
  - Mean photometric accuracy <0.1 mag; <0.02 mag for many sources
  - Relative astrometric residuals < 10 mas
  - Absolute astrometric offset <0.2"
- Version 2 release August 2016 includes new ACS data, version 3 (spring/summer 2017) new WFPC2 data, totaling 100 million sources
- Extensive cross matching with PanSTARRS & GAIA improves absolute astrometry to <0.01” with GAIA (currently <0.2” relative to PanSTARRS and 2MASS)
- Supports time-variable studies over a >20 year baseline → Hubble Catalog of Variables
- Accurate spatial offsets between observations needed to build the HSC, can then be used to make mosaics
- Puts very large datasets in the hands of a wider community; increases the legacy value of the archival holdings
The Value of Combining Data

- Archive combines data: exposures within a visit
- High level science products for large/treasury programs typically deliver combined data and catalogs at the program level
- Clear advantages to providing uniform combination of data at the highest level, utilizing latest advances in calibration and processing, for science-ready data products
- This is the philosophy used by the HST Spectral Legacy Project, also useful for imaging
The Value of Combining Data

- High Level Science Products are downloaded ~10x more than HST(/HLA) relative to their data volume holdings on disk

- The current largest HLSPs constitute < 10% of the total science exposures to date in wide-field imaging (ACS/WFC, WFC3/IR, WFC3/UVIS); the remaining 90% are generally smaller programs, often obtained by teams too small (or too long ago) to deliver as HLSPs: still value

Anton Koekemoer slide
The Value of Combining Data: Supermosaics

genesis of idea from A. Koekemoer’s Nov. 2015 STUC presentation

• Utilizes experience from Frontier Field processing in combining observations from current wide-field imagers
• Incorporates additional improvements in off-line processing such as:
  ★ Mitigating persistence and time-variable sky in WFC3/IR data
  ★ Improving low-level dark current residuals in ACS using self-cal
  ★ Applying low-level sky background improvements that go beyond current reference file accuracy
• Images would be registered to same pixel grid and absolute astrometric reference frame on the sky
• Creates full-depth multi-filter mosaics, and associated ancillary products, on all fields that have been imaged by Hubble

resource estimate: 0.6 FTE
The Value of Combining Data: Supermosaics

<table>
<thead>
<tr>
<th>Instr.</th>
<th><strong>WFC3/UVIS</strong></th>
<th></th>
<th><strong>ACS</strong></th>
<th></th>
<th><strong>WFC3/IR</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter</td>
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<td>435 475 555 606 625 775 814 850</td>
<td>105 110 125 140 160 164</td>
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<td>Exp/ks</td>
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<td>114 2 5 74 2 6 230 22</td>
<td>141 2 94 58 172 6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Anton Koekemoer slide
Hubble Frontier Fields

STUC first informed about Ultra Deep Fields Observing Initiative in April 2012
Hubble Frontier Fields

Hubble Deep Field Initiative (HDFI)

James Bullock (UC-Irvine) [Chair]
Mark Dickinson (NOAO)
Steven Finkelstein (UT Austin)
Adriano Fontana (INAF, Rome)
Ann Hornschemeier Cardiff (GSFC)
Jennifer Lotz (STScI)
Priya Natarajan (Yale)
Alexandra Pope (U. Mass)
Brant Robertson (Arizona)
Brian Siana (UC-Riverside)
Jason Tumlinson (STScI)
Michael Wood-Vasey (Pittsburgh)

The Committee was charged by the STScI Director to:

- Solicit input from the astronomical community in defining the science goals and recommendations.
- Define the science case and a set of science goals for a new set of ultra-deep imaging fields with sensitivity depths comparable to those of the HUDF and HUDF-09 infrared follow-up. Provide an assessment of the urgency of pursuing this science.
- Assess the prospects for near-field science that can be achieved with these deep-field observations.
- Recommend the number of fields, location, filters, and depths that should be obtained to meet the science goals.

STUC Nov. 2012 K. Sembach presentation
Hubble Frontier Fields

HDFI: Background and Process

- STScI solicited community input (pro/con) on the idea of devoting time to a new deep field initiative ("Deep Fields Beyond the HUDF")
  - Responses were due August 31, 2012

- Committee reviewed and discussed 32 white papers submitted by the community

- Considered a broad set of topics
  - Deep blank fields
  - Fields lensed by foreground clusters
  - Grism observations
  - Deep fields in parallel with COS spectroscopy
  - Synergy with JWST and other observatories, E/PO, implementation strategies, etc...

The committee presented a unanimous recommendation to the Director.
Hubble Frontier Fields

HDFI: Proposed Next Steps

**Implementation**
- Convene “HDFI Implementation Team”
- Final selection of clusters based on science priorities from panel and practical considerations
- Define the actual observing program, coordinate with other observatories (Spitzer in particular), create observing specification, and build long range scheduling plan

**Community Engagement**
- Announce initiative to the community if Matt approves
- Establish website for regular updates and reference
- Issue guidance on program so GOs can propose to supplement or analyze these data in C21.
- Engage lensing experts to support the broader community with high-quality, user-friendly lensing maps, and support their maintenance.
- Upcoming lensing workshop at STScI (April 2013).
Hubble Frontier Fields

A Model for Community Science Planning and Implementation

HDFI Science Working Group
- review white papers;
  collect community input
- set science goals, strategy
- set obs. requirements
  (number of targets, depth, ..)
- science advisory group

Astronomy Community
- write white papers
- informal input to target selection, obs. plan
- related HST GO/archival/theory programs
- funded + unfunded lensing models
- ancillary programs (ALMA, Chandra, VLT, ..)
- review committees (STUC, TAC, mid-term)
- analyze public data with public models; do science!

STScI Implementation Team
- observational planning (target choice, detailed design, scheduling)
- data pipeline + calibration (multiple versions/releases; improved calibration)
- lensing model funding + coordination
- data & model releases
- cross-observatory coordination (Spitzer; Gemini)
- ancillary data clearinghouse
- communication with community (blog, email list, public talks, formal reviews)
Broader impacts for the community

- astrodrizzle/drizpac testing by HFF data pipeline team
- improved ACS bias striping algorithms
- developed ACS “self-calibration” of CTE effects in dark
- testing of WFC3/IR “blob” mask, sky flats
- WFC3/IR variable sky ramp fitting algorithm
- testing WFC3/IR bright sky avoidance observing strategy
- better scheduling buffers for severe WFC3/IR persistence events
- first set of theoretical models in MAST directly linked to HST data
- improved ACS astrometry solution
- new ACS sky flats; improved approach to ACS darks

+ experience benefits wider cross section of archive (e.g. supermosaic initiative)

2 FTEs spread across 8-9 people