Surveying Star-forming Environments with Wide-field ACIS Mosaics from the Chandra Archive

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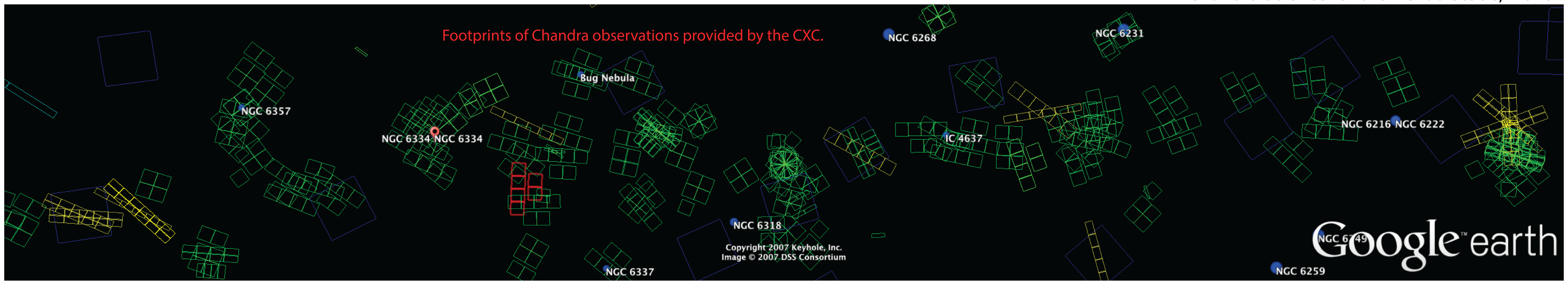
After 17 years of operations, the Chandra archive contains many groups of closely-spaced Chandra-ACIS pointings, often associated with multiple GO programs by independent PI's.

In the Galactic plane, such groupings can provide valuable wide-field "mosaic" views of multi-generational star-forming complexes, which contain collapsed objects and SNRs as well as young stars.

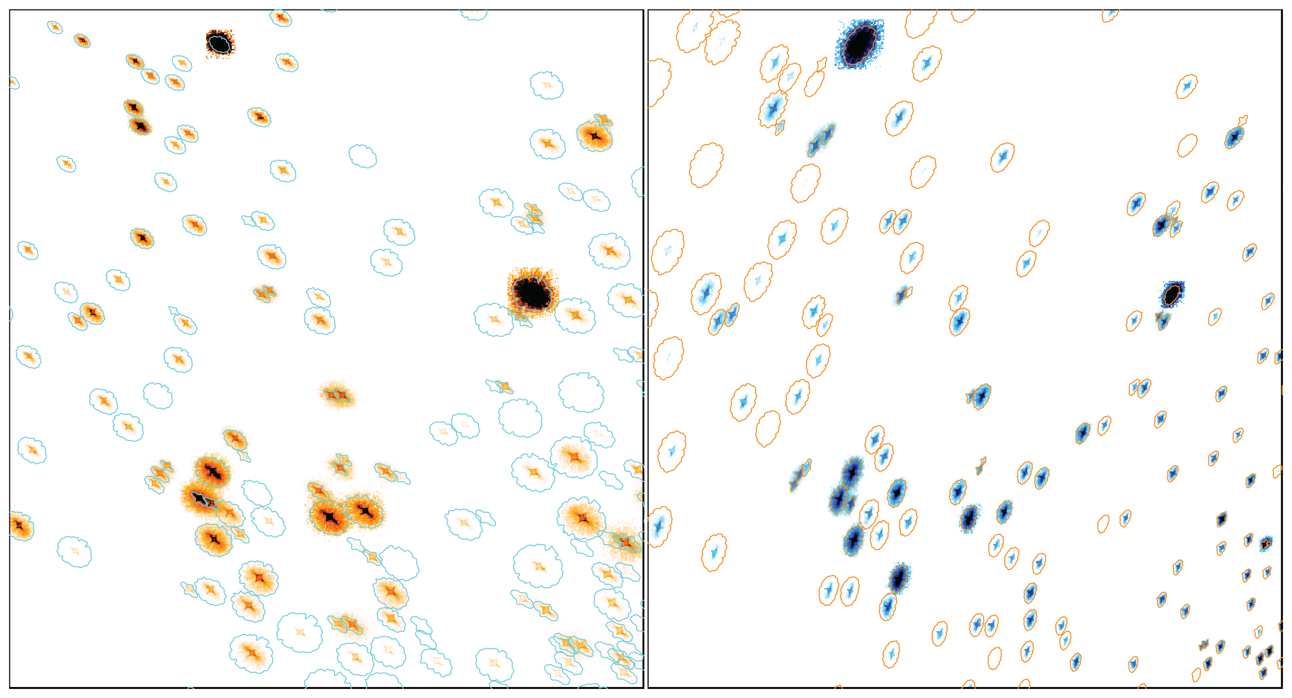


We have analyzed a few of these ACIS data groupings. Our goals are to publish high-quality point source catalogs, to identify faint diffuse X-ray structures, and to relate those structures to massive star feedback (winds and supernovae) in massive star-forming regions (e.g. Broos13, Townsley14).

CIAO and the publicly-available software package ACIS Extract are our primary tools. Our workflow begins with L1-to-L2 event processing and exposure map construction for each ObsID. Observations are shifted to improve their co-alignment and absolute astrometry.

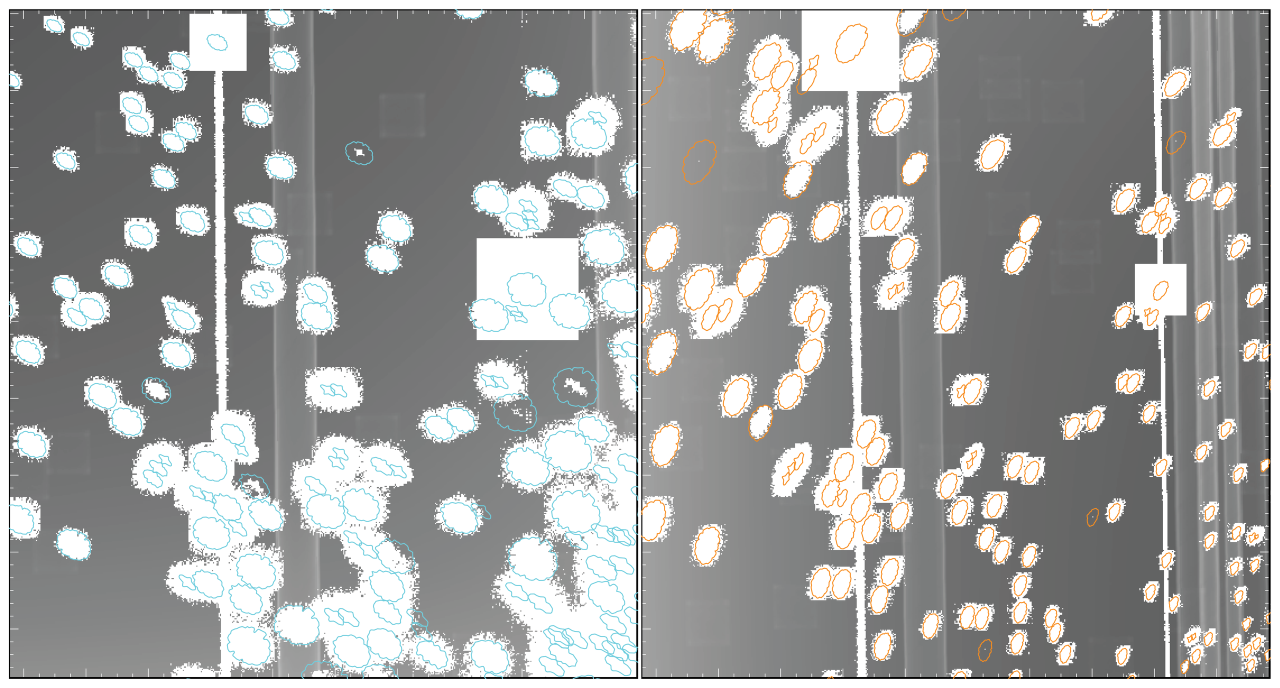
Point source detection on these data sets is difficult, because any source may be observed in multiple ObsIDs, with a wide range of angular resolutions. Our strategy is to search for sources in overlapping small images that tile the field. Each tile combines only observations within a narrow range of off-axis angle (i.e. similar angular resolution).

Point source extraction is performed by ACIS Extract. Apertures are usually 90% contours of the local PSF in each observation, but are reduced as needed to avoid overlap, as illustrated in the figure below. Source photometry is derived by combining single-ObsID extractions, discarding extractions that are excessively crowded.

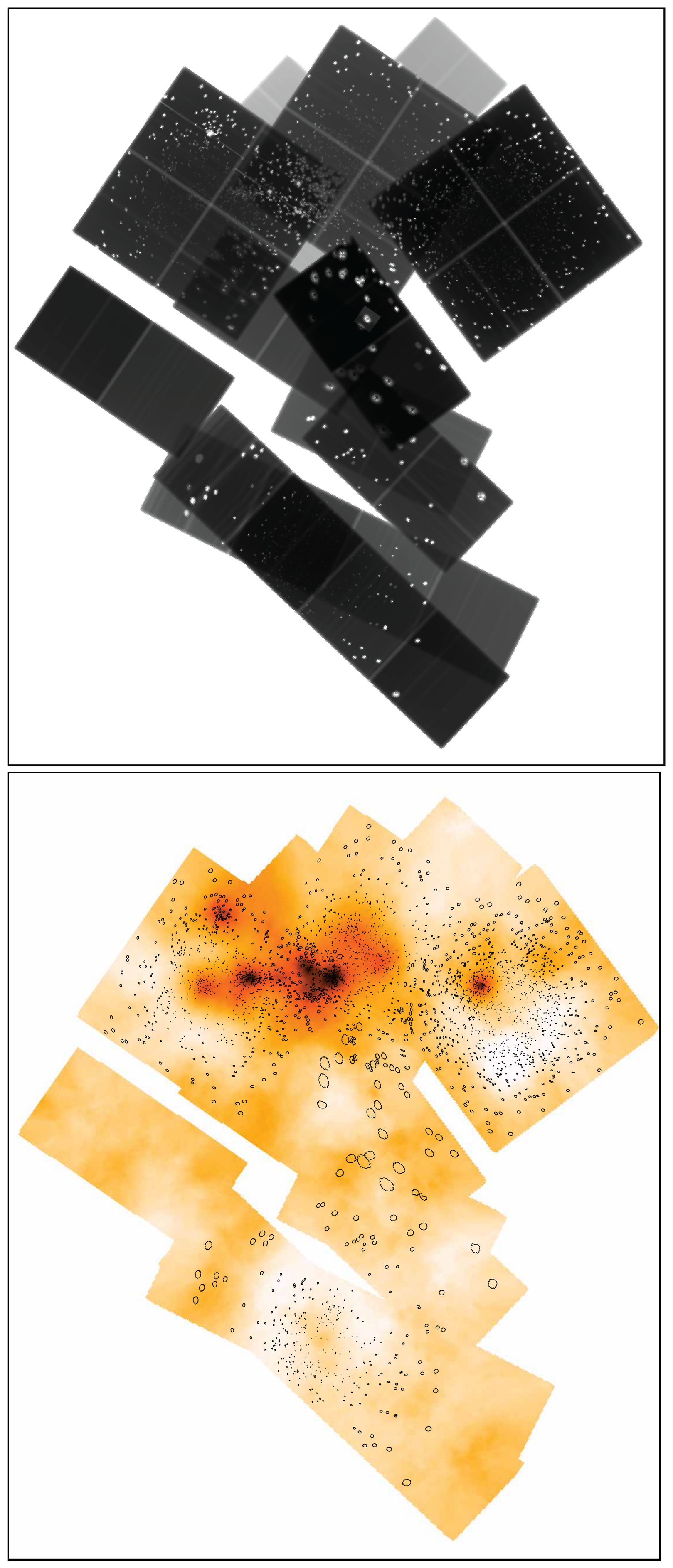


Extraction apertures in two ObsIDs for the same set of point sources. For illustration, the images shown here are models of the sources (scaled PSF images), rather than the observed events.

Point sources are removed from the data so that diffuse emission can be studied. In each ObsID three data products are masked: exposure map (below), observed event list, and a calibration product that models instrumental background (the "ACIS stowed background" data; see cxc.harvard.edu/-ciao/threads/acisbackground/).



Masked exposure maps for the scene above. The size of a mask depends on the relative surface brightness of the source model (scaled PSFs) and local background. Thin vertical masks remove bright ACIS "readout streaks". Square masks arise for bright sources because the source model (PSF image) has a finite extent.

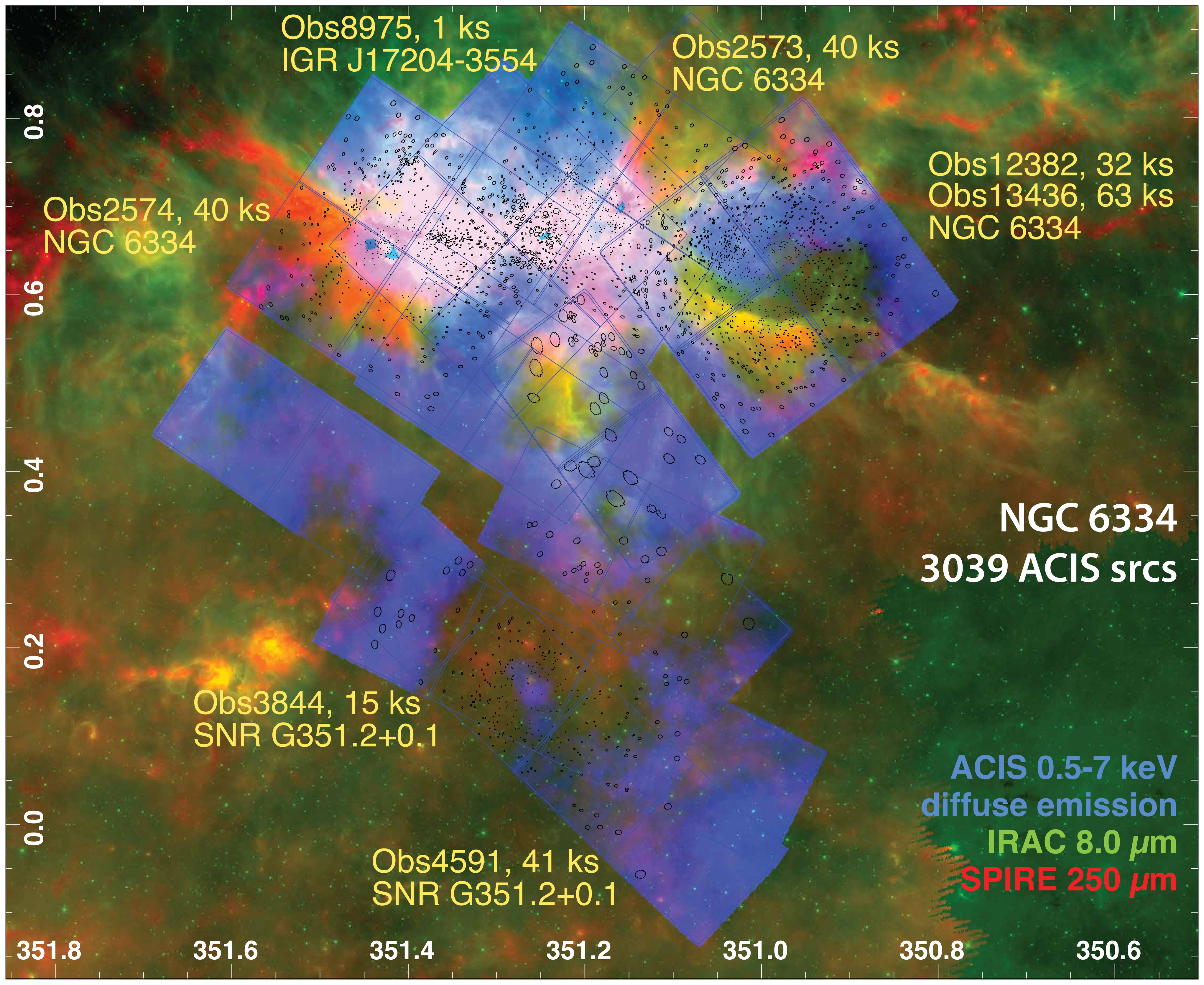


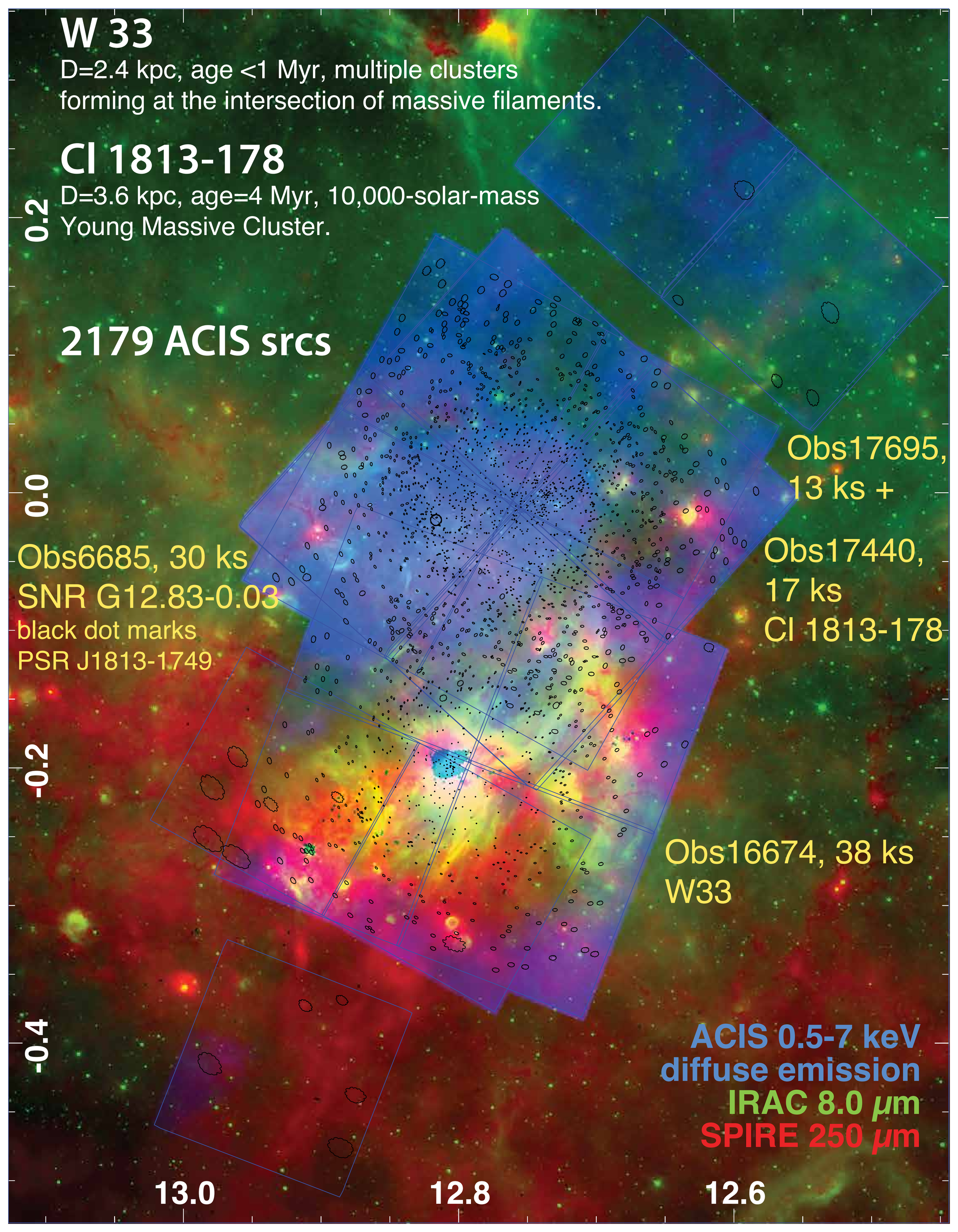
Masked exposure map (top) and full-band flux map (bottom) for ACIS-I and ACIS-S observations near the massive star-forming region NGC 6334, shown with 'inverted' color maps. Black polygons represent excised point sources; the smoothing algorithm has interpolated over masked regions.

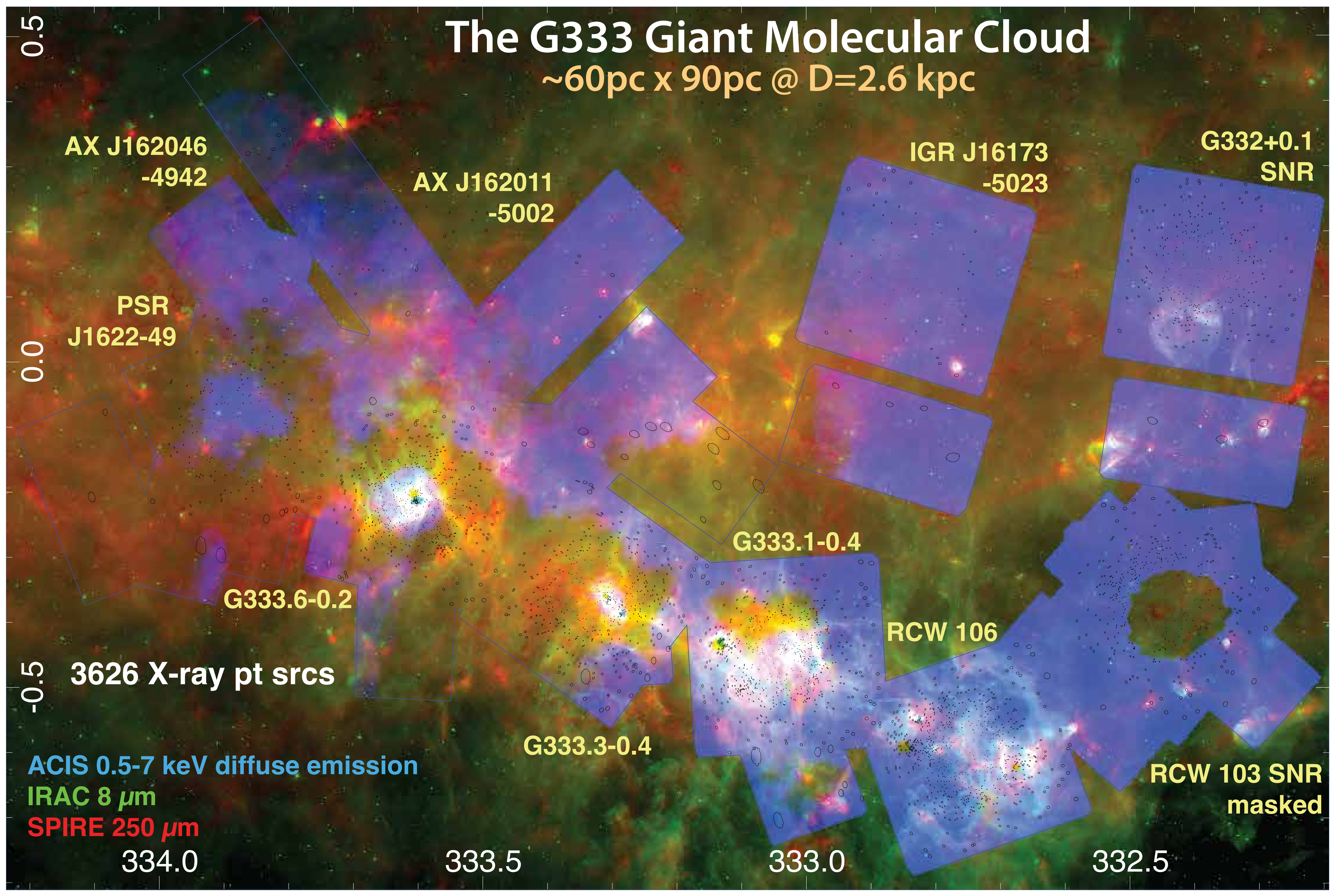
Singe-ObsID masked data products are combined to form wide-field data products (exposure map, event list, instrumental background).

Smoothed flux images are produced from the wide-field data products. Instrumental background is subtracted. The smoothing algorithm uses an adaptive kernel to deal with large exposure variations and field edges.

Spitzer and Herschel maps put the diffuse X-ray data in a broader context and aid interpretation.







Information on the ACIS Extract software package can be found at www2.astro.psu.edu/xray/docs/TARA/AE.html; Astrophysics Source Code Library, 1203.001; and Broos et al. (2010).