PACS Photometer Highly Processed Data Products with Unimap: Release Notes

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1 Introduction

Standard PACS photometric maps (Level 2, Level 2.5 and Level 3 products) are generated by the Standard Product Generator (SPG), stored into the Herschel Science Archive (HSA) and returned to the community for downloading. Among those, the so called Level 2.5 maps are generated by means of the JScanam and Unimap mapmakers, by combining scan observation with the associated cross-scan one. This operation increases the quality of the final maps with respect to the Level 2 maps, as it makes use of a larger data-set and exploits the capabilities of these two sophisticated mappers, designed for recovering the sky emission collected by PACS both from point like sources as well extended emissions.

Nevertheless, there is a consistent number of observations (129 ObsIDs in Parallel Mode and 4452 ObsIDs in Scan Map mode) that don't satisfy the requirements for this combination into Level 2.5 products and they are processed by the SPG only up to Level 2. They are mostly spurious observations, where the sky areas are covered by other higher level maps (Level 2.5 or Level 3) but, in some cases, they are large maps that were acquired by using a scan strategy that prevents the generation of the standard Level 2.5 products. Among those there are the North and South Galactic Pole observations, acquired within the HATLAS observing programme, and the Magellanic Clouds, acquired within the HERITAGE observing programme.

In order to increase the quality of the PACS legacy maps, the Unimap Highly Processed Data Product (HPDP) maps are generated for large observations where the SPG was not capable to generate Level 2.5, or where spurious Level 2 observations exist, among higher level products of the same sky regions, that can be combined together to enhance the quality of the final maps.

2 Unimap HPDP maps

The purpose of the Unimap HPDPs is to use the Unimap mapmaker on ObsIDs that are processed only up to Level 2 products by SPG, and increase the overall quality of the data over the considered sky regions. Unimap is a Generalised Least Square (GLS) mapmaker with sophisticated pre-processing modules designed for the PACS photometer and for combining any number of observations acquired for a certain sky region. The input for Unimap are FRAME FITS files for every observation (ObsID), which are generated by using the standard script for SPG, also available as interactive script within the HIPE environment.

The goal of this data release is to recover, with the Unimap HPDP maps, large sky regions belonging to PACS surveys that were not processed by SPG to Level 2.5. The selected observations are all acquired in Parallel observing mode and they concern about 963 observing hours for 141 obdIDs. Taking into account the total observing time in routine phase for Parallel AORs (6229 h in 754 AORs), the observations selected for the generation of Unimap HPDPs are just the 5 % of Parallel obdIDs, but they involve a relevant fraction of observing time allocated for Parallel observations (15 %).

3 Deliverables

The Unimap HPDP maps are served by the Herschel Science Archive, but alternatively they can be downloaded as individual files for each field and wavelength at the following link: `http://archives.esac.esa.int/hsa/legacy/HPDP/PACS/PACS-P/UNIMAP/`. This repository also allows to browse through postcards separately. For each field and wavelength, one FITS file and one Unimap processing LOG file is made available, together with a postcard combining all available wavelengths. Within each FITS file, three separate extensions are combined, that contain respectively the scientific map in itself ('image'), the standard deviation or error map (called 'error', although this corresponds to the standard deviation map for products generated with Unimap version 6.3.3, and to the error map for product generated with Unimap version 6.4.2 and later – see the 'mapper' FITS header parameter to check this) and the coverage map (called 'coverage'). The following file naming convention is adopted for the delivered products:

<NAME>_UnimapHPDP_<wavelength>.<EXT>

where:

- <NAME> is the name of the field (see first column in Table 1);
- <wavelength> can be 70, 100 or 160, corresponding to the observed wavelength of the camera in μm;
- <EXT> is 'fits' for the FITS file containing the maps (i.e. IMAGE,STD/ERROR,COVE products) and 'txt' for the log file. All FITS files are gzip-compressed.

4 Unimap HPDP fields

Field name	RA	Dec	Unimap version	proposal	#ObsIDs	Speed ″/sec
NGP1	195.449	31.828	6.3.3	KPOT_seales01_2	5	60
NGP2	196.019	25.977	6.3.3(R),6.4.2(B)	KPOT_seales01_2	4	60
NGP3	203.106	32.518	6.3.3	KPOT_seales01_2	5	60
NGP4	203.441	26.704	6.3.3	KPOT_seales01_2	4	60
SGP1	339.429	-32.264	6.3.3	KPOT_seales01_2	7	60
SGP2	347.296	-32.647	6.3.3	KPOT_seales01_2	5	60
SGP3	354.856	-32.877	6.3.3	KPOT_seales01_2	4	60
SGP5	10.785	-30.788	6.3.3	KPOT_seales01_2	4	60
SGP6	18.569	-30.801	6.3.3	KPOT_seales01_2	4	60
SGP7	24.546	-30.791	6.3.3	KPOT_seales01_2	4	60
LMC	79.102	-68.539	6.5.3	KPOT_mmeixner_1	21	20
SMC	16.655	-72.879	6.5.3	KPOT_mmeixner_1	9	20
Bridge	31.237	-74.265	6.3.3	KPOT_mmeixner_1	6	20
Bootes	217.853	34.382	6.3.3	KPGT_soliver_1	9	20
L1521	65.071	27.776	6.3.3	KPGT_pandre_1	3	60
XMM	35.454	-4.424	6.3.3(R), 6.4.2(B)	KPGT_soliver_1	18	60
GAMA12	181.588	-0.562	6.3.3	KPOT_seales01_2	7	60
ELAIS S1	8.579	-43.870	6.3.3	KPGT_soliver_1	7	20

Table 1: Unimap HPDP fields. Blue and Red (160 μm) images are provided for every field, except ELAIS S1, where only the 160 μm map was generated. All fields were acquired with the 100 μm filter in the Blue camera, except L1521 which was observed with the 70 μm filter. All the Unimap HPDP maps are from observations acquired in Parallel observing mode.

4.1 North and South Galactic Pole (NGP and SGP)

The North and South Galactic Poles fields were observed within the *The Herschel Thousand Degree Survey* open time Key Program (PI S. Eales). They include 51 ObsIDs, all Level 2 processed by SPG, that can be grouped into 4 and 7 adjacent, squared tiles (for NGP and SGP, respectively), by providing the wide sky coverage shown in Figure 1. Table 2 and 3 report the ObsIDs belonging to every tile. Each tile is composed by 4 rectangular, partially overlapping observations acquired according to the scanning strategy described in Figure 2, that prevented the generation of Level 2.5 products by SPG. In some cases (SGP1, SGP2, SGP4, NGP1, NGP3), the field can be composed by more than 4 ObsIDs, because of rescheduled observations due to anomalies that affected the SPIRE instrument.

The SGP4 field is not included into this data release, because of major problems in the signal drift that could not be fixed in the processing. The NGP2 field was processed in the Blue camera with a higher Unimap release (6.4.2), because of residual drift not correctly compensated by the 6.3.3 version.

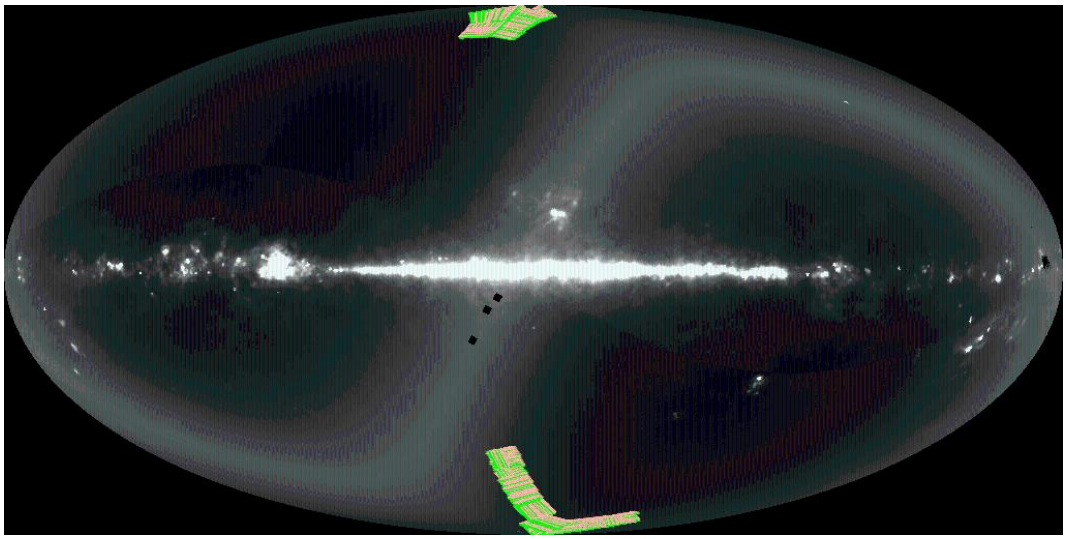

Figure 1: All sky in galactic coordinates. The NGP and SGP fields are reported with their footprints.

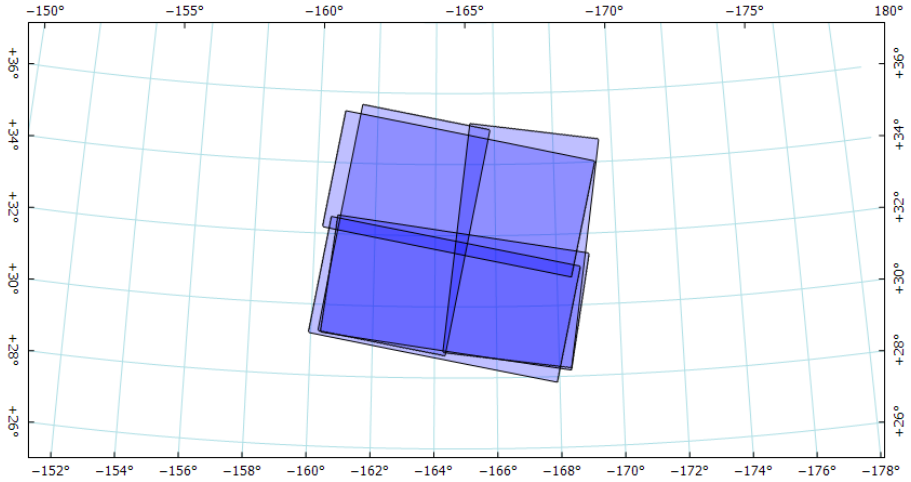

Figure 2: NGP1 footprint. The footprint represents the typical scanning strategy adopted for the N/S Galactic Pole fields. If more than 4 ObsIDs are in a field, they are a usually repeats because of contingencies with the SPIRE instrument at the time of observation.

NGP1	NGP2	NGP3	NGP4
1342222676	1342210946	1342211292	1342210947
1342210963	1342210917	1342210982	1342210918
1342222626	1342210559	1342222677	1342210568
1342210567	1342210558	1342210902	1342210932
1342210903		1342210931	

Table 2: ObsIDs belonging to the North Galactic Fields

SGP1	SGP2	SGP3	SGP5	SGP6	SGP7
1342219619	1342219643	1342219978	1342221465	1342221905	1342221922
1342231850	1342232727	1342220648	1342221464	1342222130	1342222113
1342219620	1342219811	1342219951	1342221474	1342221921	1342221904
1342231849	1342232726	1342220618	1342221475	1342222112	1342222131
1342219629	1342220534				
1342219642					
1342232059					

Table 3: ObsIDs belonging to the South Galactic Fields. SGP4 was discarded for this data release

4.2 Magellanic Clouds

The Magellanic Clouds were observed by the HERITAGE Key Program in open time (PI M. Meixner). 21 ObsIDs of the Large Magellanic Clouds were acquired in two distinct epochs by adopting the scanning strategy reported in Figure 3 (parallel, rectangular strips in orthogonal positions) that prevented the generation of Level 2.5 maps by SPG. A similar strategy was adopted for the 15 ObsIDs of the Small Magellanic Cloud (including the Bridge region, see Figure 4). In this data release, the Bridge and SMC are distributed in two separate maps, since they recover two distinct, very slightly overlapping sky regions. LMC and SMC maps were generated in a second stage of the data processing by using the Unimap release 6.5.2, that was optimised for handling the huge dataset that Unimap has to load for processing these sky regions.

LMC		SMC	SMC Bridge
epoch 1	epoch 2		
1342195668	1342202086	1342192680	1342192698
1342195669	1342202087	1342192681	1342192699
1342195683	1342202202	1342192697	1342198591
1342195684	1342202203	1342198565	1342198863
1342195707	1342202216	1342198566	1342205049
1342195708	1342202217	1342198590	1342205050
1342195712	1342202224	1342205054	
1342195713	1342202225	1342205055	
1342195728	1342202243	1342205092	
	1342202244		
	1342187189		
	1342187188		

Table 4: ObsIDs belonging to LMC and SMC regions

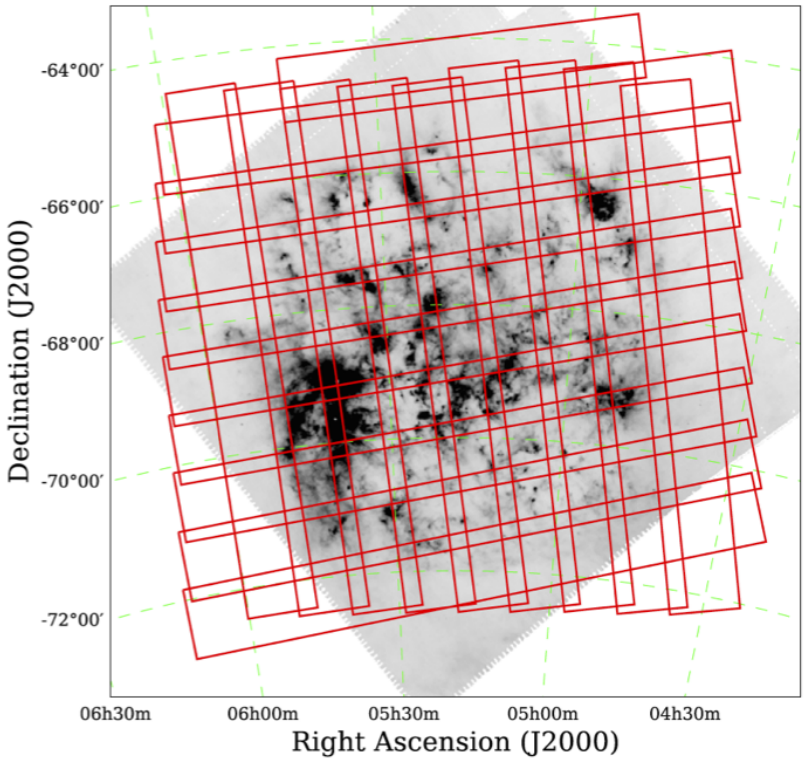

Figure 3: LMC image (MIPS 160 μm) and the overlapping scanning strategy taken from Meixner et al. 2013 (AJ 146, 62)

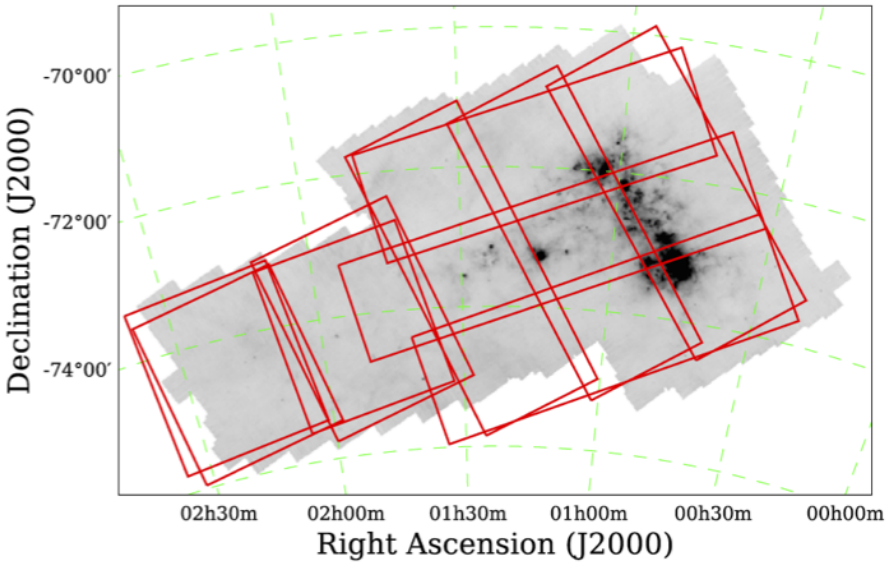

Figure 4: SMC image (MIPS 160 μm) and the overlapping scanning strategy taken from Meixner et al. 2013 (AJ 146, 62)

5 Bootes-Spitzer Field

The Bootes-Spitzer sky region was observed within the HerMES guaranteed time Key Programme (PI S. Oliver). SPG generates the Level 3 maps shown by the central, squared footprint in Figure 5. Four further observations were processed only up to Level 2 products, because they were acquired in the same fashion as for the N/SGP fields (rectangular, not fully overlapping fields shown in Figure 5). Both the 100 μm and 160 μm Unimap maps show a strong signal persistence due to saturated frames around the sky position [216.75°, 33.42°], while less prominent artefacts are visible at the edge of the central Level 3 region (especially in the red map), because of a non optimal removal of the calibration block signal drifts.

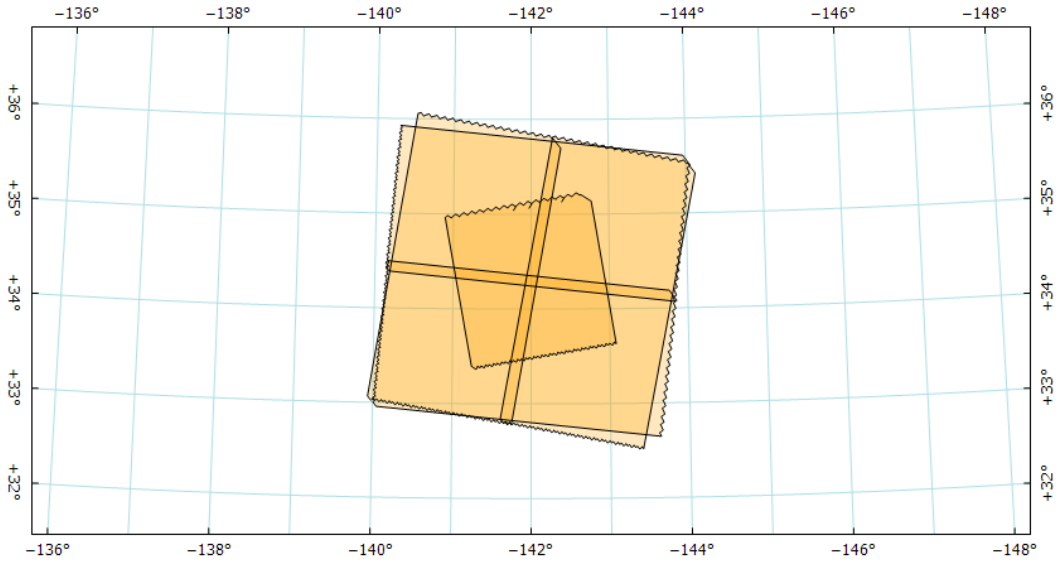

Figure 5: Bootes field footprint. The central patch represents the Level 3 map (4 ObsIDs), while the rectangular footprints of Level 2 observations (4 ObsIDs) identify the large squared area (similar to the scanning strategy of the North/South Galactic Pole fields)

Bootes	
Level 3	Level 2
1342187711	1342188650
1342187712	1342188651
1342187713	1342188681
1342188090	1342188682
	1342189108

Table 5: ObsIDs belonging to the Bootes-Spitzer field

6 L1521

The L1521 region was observed within the Gould Belt survey (PI P. André). Three ObsIDs were acquired with the scanning strategy reported in Figure 6 and processed by SPG up to Level 2 products. A further Level 2 ObsID (1342242047) was acquired in the filling region between the two squared footprints, but it was not included in the data processing because it was acquired in Scan Map mode, while all the others were acquired in Parallel observing mode. Moreover, a Level 2.5 map acquired in Scan Map mode exists (1342216549), centred on the cloud region.
Figure 7 shows, as an example, how the HPDP processing is essential for nearby star forming regions dominated by extended emission (like for the Magellanic Clouds), since the standard Level 2 maps are not capable to properly recover this sky emission.

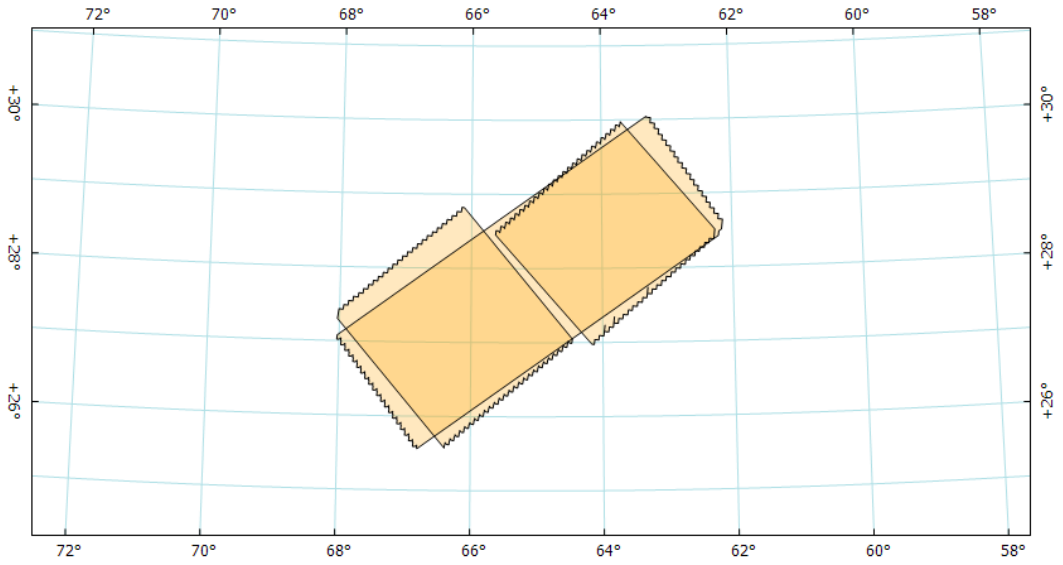

Figure 6: Footprints of the three Level 2 observations of the L1521 field

L1521
1342190616
1342202090
1342202254

Table 6: ObsIDs belonging to the L1521 field

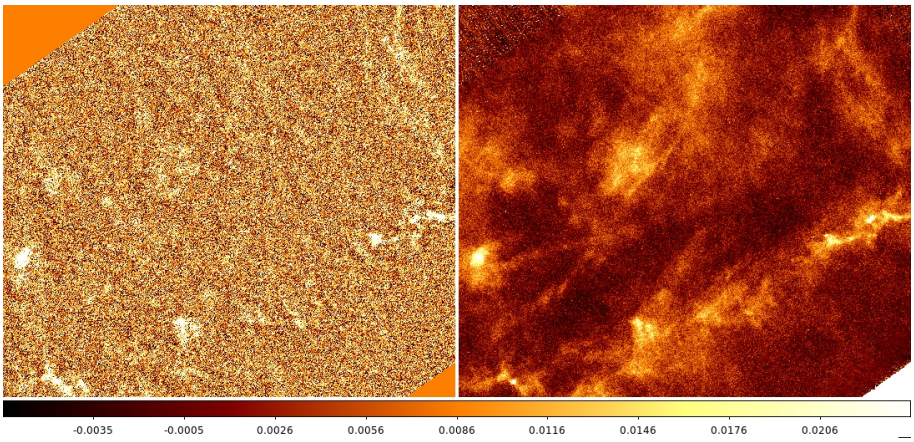

Figure 7: L1521, red camera. Left: SPG Level 2 maps (1342202254). Right: Unimap HPDP map

7 Video-XMM Field

The Video-XMM field belongs to the HerMES Key Programme in guaranteed time (PI S. Oliver). Three distinct Level 3 maps exist for this field (14 ObsIDs, yellow footprints in Figure 8) and 4 further observations are Level 2 processed by SPG (blue footprints in Figure 8). These observations (see Table 7) were processed all together for the generation of the Unimap HPDP maps. The 100 μm map was processed with the Unimap version 6.4.2, because of strong artefacts not recovered by the 6.3.3 Unimap release (see Figure 9).

Video-XMM			
Level 3 (cross)	Level 3	Level 3	Level 2
1342189003	1342223217	1342223213	1342189004
1342190313	1342223218	1342223267	1342189031
1342223214	1342223265	1342223268	1342190324
1342223215	1342223266	1342223268	1342190325
1342223216			
1342223219			

Table 7: ObsIDs belonging to the Video-XMM field

8 GAMA12

The GAMA12 field, observed within the *The Herschel Thousand Degree Survey* Key Programme (PI S. Eales), is largely reproduced by the three Level 2.5 maps generated by SPG and shown as the yellow footprints in Figure 10. Nevertheless, a further Level 2 processed patch observation (blue footprints in Figure 10) and the partial superposition of the Level 2.5 maps, motivated the combination of all ObsIDs in Unimap HPDP maps in order to increase the signal-to-noise ratio in a substantial sky region.

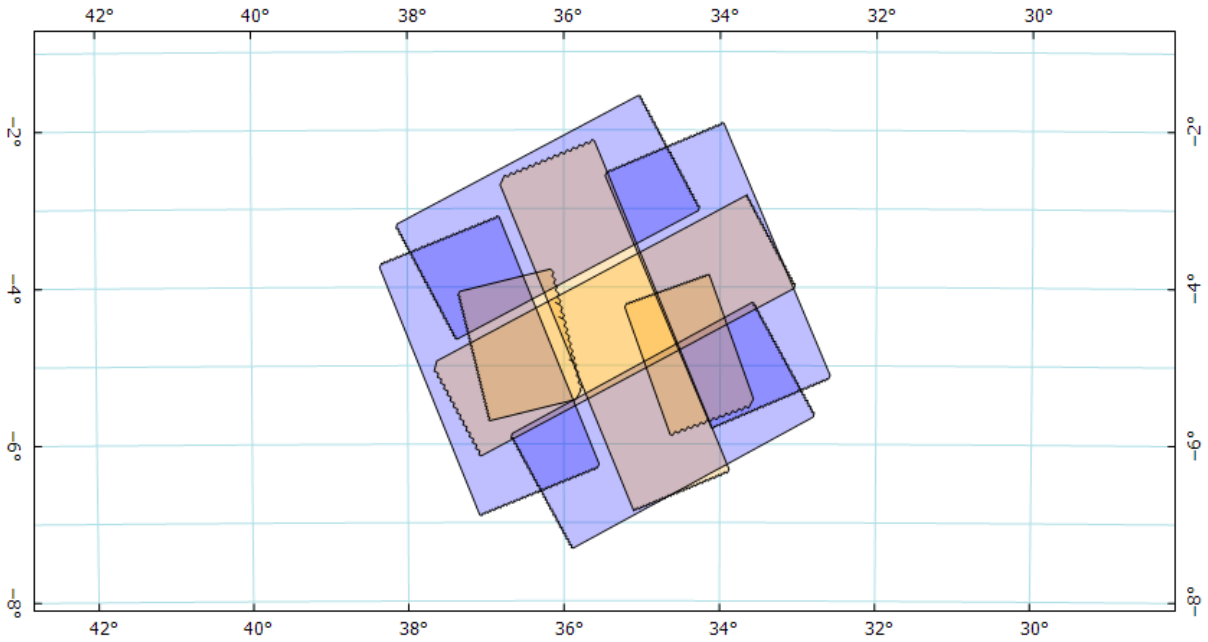

Figure 8: XMM footprints. The central cross and the two small rectangular patches (yellow footprints) represent three distinct level 3 maps. The four side rectangular blue footprints are Level 2 observations.

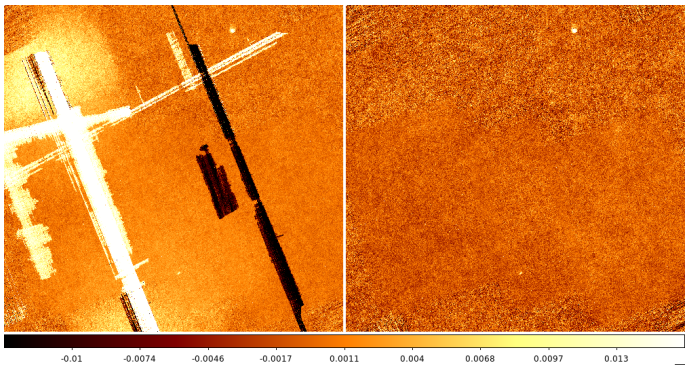

Figure 9: Video-XMM field, Blue map. Unimap 6.3.3 on the left, Unimap 6.42 on the right

GAMA12			
Level 2.5	Level 2.5	Level 2.5	Level 2
1342200121	1342211317	1342222625	1342224030
1342200122	1342211318	1342224138	

Table 8: ObsIDs belonging to the GAMA12 field

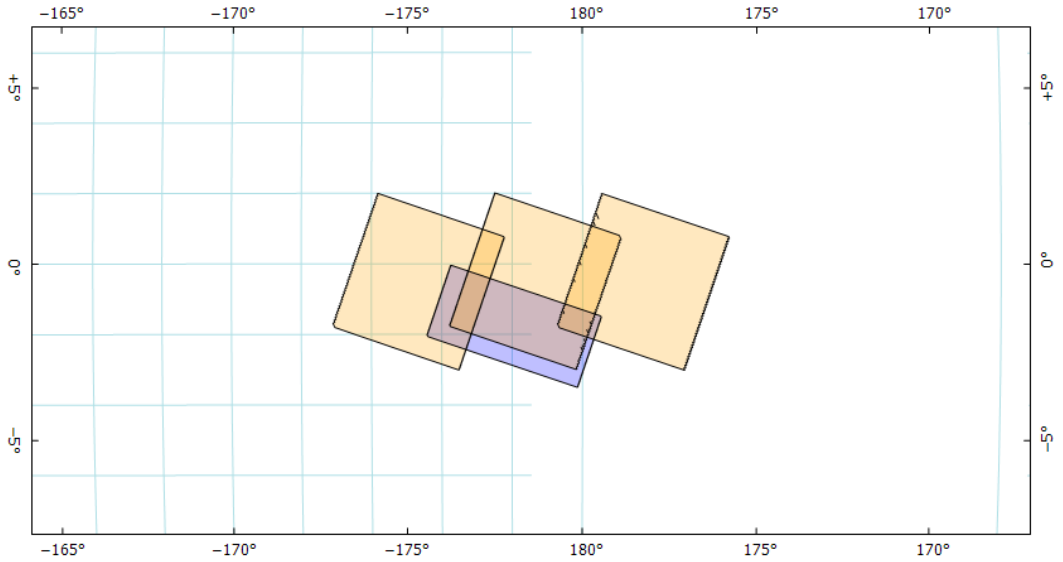

Figure 10: GAMA12 field footprint. The squared footprints are three distinct Level 2.5 maps, while the rectangular blue patch is a Level 2 observation.

ELAIS S1	
Level 3	Level 2
1342196656	1342195729
1342219621	1342195743
1342220649	1342220880
1342220833	

Table 9: ObsIDs belonging to the ELAIS S1 field

9 ELAIS S1

Level 3 processed maps exist for the ELAIS S1 cluster (HerMES Key Programme), represented by the blue footprint in Figure 11 (4 ObsIDs). In addition, the same sky region is observed in an additional Level 2 observation, while two further observations of a wider sky region (and acquired in cross-scan mode) were processed up to Level 2 by SPG because they were acquired with different filter in the Blue camera (larger rectangular region in Figure 11). These 7 ObsIDs were processed all together to generate a Unimap HPDP map only in the Red camera.

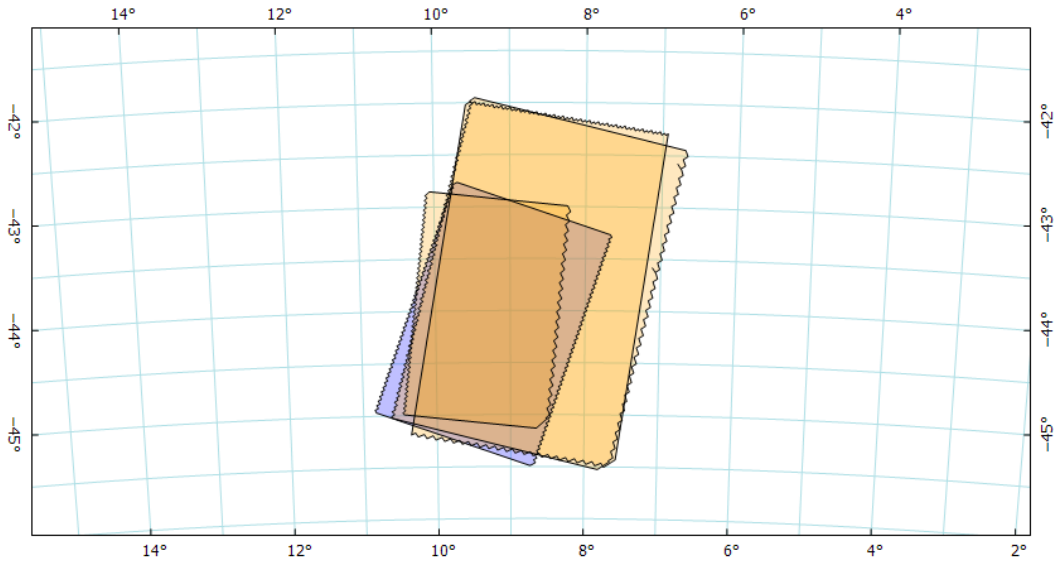

Figure 11: ELAIS S1 footprint. The blue footprint represents the standard Level 3 maps, while the yellow footprints show the three observations, Level 2 processed by SPG.