

ESO Phase 3 Data Release Description

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Abstract

This is the release of reduced IFU data cubes from KMOS¹, the K-band Multi Object Spectrograph. The instrument is located at the VLT UT1 telescope and has 24 image slicer Integral Field Units (IFUs) that can be placed independently in the patrol field of 7.2 arcmin diameter. Each IFU has 14 slices with 14 spatial pixels along each slice and a field-of-view of 2.8x2.8 arcsec which gives a spatial resolution of 0.2 arcseconds. The light from the IFUs is dispersed by three identical cryogenic spectrographs. Five different gratings can be used which are centred at the I+Z, Y+J, H, H+K, and K infrared atmospheric bands thus allowing observations between 0.8 and 2.5 μm . Spectral resolving power depends on the grating and is between 2000 and 4200.

This release is an open stream release. It is complete from start of operations on 1st October 2013 until present. Data content is not fixed but grows with time as new data are being acquired and processed (approximately with monthly cadence and with a delay of one to two months).

Data have been reduced using the KMOS pipeline version 2.7.3 or higher. Data reduction is executed first for each IFU containing an object. It includes sky subtraction, flat fielding, wavelength calibration, flux calibration, and cube reconstruction. Telluric absorption features in the individual cube spectra are corrected. For this, an atmospheric model is fit to the closest-in-time standard star measurement using the molecfit² software. This model is scaled with the airmass difference between science observation and standard star measurement and applied to the extracted spectra. Flux calibration is applied using the zero-point measurement from the same standard star, without assessment of the photometric conditions. Note that all standard stars serve both as telluric and as photometric standards.

Release Content

The KMOS release is a stream release. The content of the release grows with time as new data are being acquired and processed. The data are tagged "KMOS" in the ESO archive user interface³. The release contains data from all five instrumental set-ups. First data have been published in June 2020. This initial release consisted of observations from October 2013 (i.e. start of operations) until end of 2019.

Data Selection

Data selection is based on the following rules:

- instrument = KMOS
- observing technique (FITS key DPR . TECH) = IFU
- category (DPR . CATG) = SCIENCE
- type (DPR . TYPE) = OBJECT,SKY.

¹ <http://www.eso.org/sci/facilities/paranal/instruments/kmos.html>

² <http://www.eso.org/sci/software/pipelines/skytools/>

³ http://archive.eso.org/wdb/wdb/adp/phase3_spectral/form

Processing of the KMOS science data has a success rate of nearly 100%, only very few input raw files are rejected. No selection is made on the basis of the observing mode (visitor or service). Data with 'test programme IDs' starting with '60' or '060' are not processed.

Settings. Data from all five spectral bands (IZ, YJ, H, HK, and K) are processed.

Data sets and input files. The processing scheme for KMOS data is template-based: all science files from a single template execution as defined by the TPL.START keyword are processed together. This is in many but not all cases identical to single OB (Observation Block) execution. A template consists of one or (typically) several exposures. In each exposure, a user-defined number of IFUs can point to object or sky positions. It is possible that any given exposure has only IFUs on objects, on sky, or a mixture between object and sky IFUs. The actual number of exposures on object and sky positions depends on the observing strategy and the used template type. Table 1 gives an overview of the KMOS science templates.

Table 1. KMOS science templates

Template type	Template ID	Description
stare	spec_obs_stare	The telescope always points (stares) to the same position. The sky background can be obtained by dedicated sky IFUs in each exposure. Optionally, a dedicated sky exposure where all IFUs are on blank sky can be added.
nod to sky	spec_obs_nodtosky	The sky background is obtained by moving (nodding) the telescope between two previously defined positions. Each IFU switches between its scientific target and a corresponding own sky background position.
free dither	spec_obs_freedither	A hybrid mode between stare and nod-to-sky can be obtained with this template. The frequency of sky positions can be chosen freely.
mosaic	spec_obs_mapping8 or spec_obs_mapping24	The individual IFUs are arranged so that with successive telescope pointings a contiguous rectangular area can be covered. Either all 24 IFUs or a subset of 8 can be used. Separate exposures on blank sky are possible.

Products. The number of products depends on the number of distinct science objects that are present in the input data set. For each object, the individual exposures are background subtracted and then combined into a single data cube. In case of the mosaic observing mode, however, there is only one final data cube for the complete rectangular area that is covered by the observation.

Release Notes

Pipeline Description

A detailed description of the KMOS pipeline can be found in the pipeline user manual which is available from the ESO pipeline web pages⁴. The initially released data set was processed with version 2.7.3 of the pipeline. The actual version used for processing can be found in the header of any data cube in the keyword "PROCSOFT".

The QC web pages⁵ contain further information about KMOS data, their reduction and the pipeline recipes for *calibration data*. Monitoring of KMOS performance and quality parameters is provided under the Health Check monitor⁶.

Data Reduction and Calibration

Reduction steps. Reduction of science data uses a cascaded recipe scheme. Table 2 gives an overview of the applied recipes.

Table 2. KMOS science pipeline recipes

Step	Recipe	Description
1	kmos_sci_red	Cube re-construction including flat fielding, wavelength calibration, sky subtraction, illumination correction, and flux calibration.
2	kmos_molecfit_calctrans	Calculates the atmospheric transmission according to the input atmospheric model (from a standard star observation) and the airmass of the science observation.
3	kmos_molecfit_correct	Divides the re-constructed science cubes from step 1 by the atmospheric transmission from step 2.
4	kmos_combine	Combines the corrected data cubes from step 3 and produces one output data cube per target.

Basic data reduction is executed within the recipe `kmos_sci_red`. The measured counts are extracted for each IFU, data are flat fielded, wavelength calibrated, sky subtracted (see below), illumination corrected, and flux calibrated, and then re-constructed into data cubes per IFU and per exposure.

The input typically consists of $N > 1$ raw science frames, each containing data from the 24 KMOS IFUs. Each IFU can be on object or on blank sky; the assignment of object or sky for each IFU can be different from one input frame to the other. The object-sky pattern has been configured for each OB by the PI. Three cases can be distinguished:

1. Separate sky exposures exist for a given IFU. Then the recipe uses such an exposure to subtract the sky and the sky background is taken from the same IFU as the science object. This is the most common observing pattern, but it may be subject to variations in the sky background from one exposure to the other. If there is more than one sky exposure available for a given IFU then the closest-in-time to the science is chosen by the pipeline.
2. Separate sky exposures do not exist for a given IFU but some IFUs are placed on blank sky in the same exposure. Then the recipe cannot perform an automatic sky subtraction. In this case, sky IFUs are also reduced and re-constructed. They are associated as ancillary products to the object data cubes. Users may then subtract the sky by themselves.
3. Neither separate sky exposures nor dedicated sky IFUs exist. Then re-constructed data cubes without sky subtraction are delivered.

⁴ Under the KMOS link at <http://www.eso.org/sci/software/pipelines/>

⁵ http://www.eso.org/observing/dfo/quality/KMOS/pipeline/pipe_gen.html

⁶ <http://www.eso.org/HC>, select KMOS

Whether or not sky subtraction was applied can be checked with the Boolean header keyword “SKY_SUB” which is T(true) in the case sky subtraction was performed and F(false) otherwise. This is also encoded in the score bit #7 (see below).

In the second step of the reduction cascade (recipe `kmos_molecfits_calctrans`), the atmospheric transmission is calculated from an input atmospheric model and the airmass of the science. The input atmospheric model comes from an observation of a standard star.

In step 3, the re-constructed data cubes are then divided by the atmospheric transmission. This is executed separately for each IFU and each exposure by the recipe `kmos_molecfits_correct`. This step is skipped if sky subtraction was not performed because it would introduce artificial features into the spectra. The atmospheric transmission from step 2 is, however, always delivered as ancillary product so that it can be used for comparison or can be applied separately. Each IFU has its own correction.

Finally, in step 4, the individual exposures are combined into data cubes per science target (recipe `kmos_combine`). For identifying separate targets, the header keywords “OBS_ARM<n> NAME” are used (with <n> = 1, ..., 24).

Depending on the configuration of the OB, a target can be observed with one or several IFUs. All exposures of the same target, independently of the IFU, are combined into a single data cube.

Master calibrations used for data reduction. Table 3 lists the required master calibrations that are used for the reduction of science data. Please see the pipeline user manual for further details.

Table 3. Master calibrations used for data reduction

Type (PRO CATG)	Description
MASTER_FLAT	Master flat, one file with separate flats for (usually) six rotator angle positions, created from three exposures per rotator angle
XCAL YCAL	Contain the positions of the IFU slitlets on the detector, calculated from flat-field frames
LCAL	Wavelength solution
ILLUM_CORR	Illumination correction, contains the relative efficiency of the slices for each IFU. For this release, the illumination correction is calculated from lamp flat-field exposures
TELLURIC_GEN	Response curve and instrument zero point
ATMOS_PARM BEST_FIT_PARM	Atmospheric model and fit parameters of the model

All master calibrations used in this release have been processed with pipeline version `kmos-2.6.5` or higher which is, with respect to calibration processing, identical to `kmos-2.7.3` (that has been used for science processing).

Flux calibration. The science data in this release are flux calibrated. Observations of standard stars for KMOS usually consist of three exposures on the star (and an additional exposure in order to determine the sky background). During each of these exposures, the star is centred on a different IFU, one for each of the three separate spectrographs. Exposures on all 24 IFUs are usually not performed. This pattern is chosen in order to save observing time during the night. However, each of the eight IFUs that feed one spectrograph varies slightly in efficiency. In order to account for these variations in relative efficiency, master response curves for each IFU have been determined. These are static input to the standard star recipes and are scaled by the actual zero point that is calculated from the standard star observation. It has to be noted that this approach is applied independently from the atmospheric conditions during the night and it is therefore not guaranteed that both the science target and the standard star were observed under the same photometric conditions.

Telluric correction. Traditionally, telluric correction is achieved by dividing the spectrum of the science target by the normalized spectrum of a telluric standard star. For this release, a different

approach has been chosen⁷. The spectrum from the standard star is fit with a model of the Earth's atmosphere. This model is then scaled with the difference in airmass between the science and the standard star observation and applied to the science spectra in the data cubes.

The model fit is executed in several dedicated wavelength regions which have been defined for each of the five spectral bands to include all relevant telluric features. The following molecules are taken into account: H₂O, O₂, CO, CO₂, and CH₄. Their actual presence depends on the spectral band. The pipeline user manual contains in Sect. 7.1.7 a detailed list of wavelength regions and the molecules that are fit for each spectral band.

The atmospheric model requires an actual profile of the atmosphere consisting of temperature and humidity vs. height. These profiles are based on the Global Data Assimilation System (GDAS⁸) and are available specifically for the Paranal site with a time resolution of three hours. The profile relevant for the standard star measurement is downloaded by the pipeline automatically; the successful download can be checked with the quality flag #5 (see section about data quality).

Standard stars are regularly observed during Service Mode nights and are usually, but not always, also taken during Visitor Mode. The KMOS calibration plan schedules standards to be taken within two hours time and 0.2 airmass difference from the science observation. For this release, the closest-in-time standard has always been associated to the science observation, even if the standard is outside the two-hour rule or, in extreme cases, not from the same night. As a measure for the quality of this association, the precipitable water vapour (PWV) from the standard star observation can be compared to the measurement from a radiometer on Paranal. The latter values are stored in the raw file headers of KMOS observations (keywords "HIERARCH ESO TEL AMBI IWV START" and "HIERARCH ESO TEL AMBI IWV END") since 15 September 2016. Figure 1 shows a comparison of both PWV values for data from 15 September 2016 until 31 December 2018.

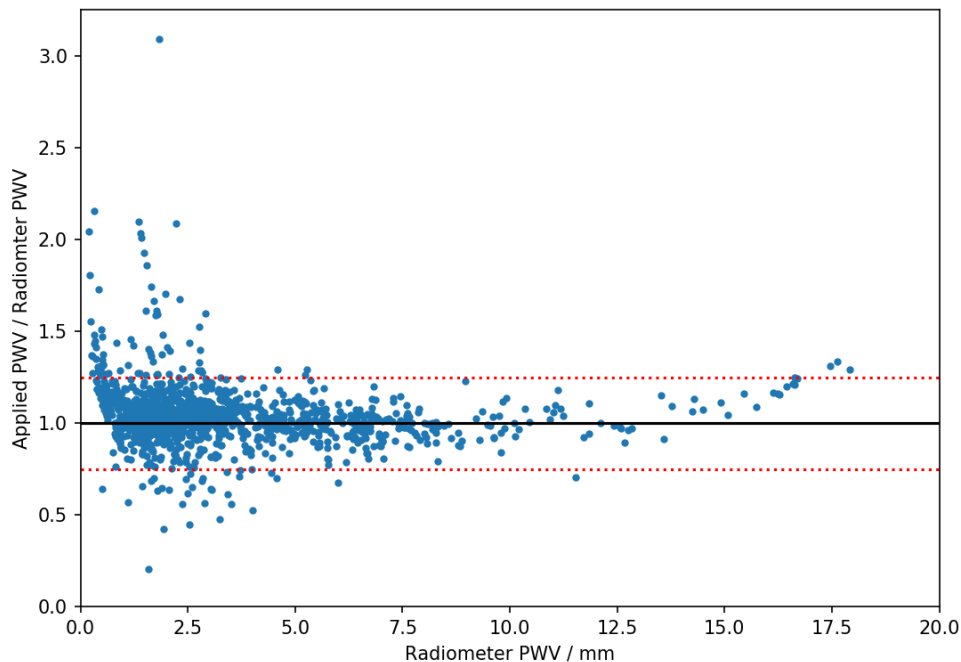


Figure 1. Normalised PWV: applied PWV from standard star divided by PWV from radiometer, plotted against radiometer PWV. The red dotted lines mark the region where the applied PWV is within +/- 25% of the radiometer value. These thresholds are used for quality flag #2 (see below).

⁷ Based on the molecfit software: <http://www.eso.org/sci/software/pipelines/skytools/>

⁸ <https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-data-assimilation-system-gdas>

Since KMOS science observations often have rather low signal-to-noise ratio, it is in general not possible to fit the atmospheric model directly to the science data which could otherwise in principle eliminate any uncertainties with respect to airmass and time difference between science and standard. It is, however, planned to directly use the recorded PWV from the time of the science observation in a future release. The water column densities would then be scaled with the actual value.

Please note that telluric correction cannot be applied if data are not sky subtracted (see above).

Products

The primary KMOS science data product has two 3D extensions in image format:

- a 3D data cube with two spatial dimensions and one wavelength axis, it is always flux-calibrated; telluric features have been removed if sky subtraction was applied, otherwise it is neither sky-subtracted nor corrected for telluric features;
- a 3D data cube of same size with the error.

The following additional files are associated to the primary product:

- 1) a 2D white-light image (field of view) from the collapsed data cube;
- 2) a 2D image giving the number of exposures per spatial pixel (spaxel) in the primary product (exposure map);
- 3) a file with two 3D extensions (same format as the primary product) where the telluric correction has not been applied; this file is not available if sky subtraction and therefore telluric correction are not applied since it would essential duplicate the primary product;
- 4) in case sky subtraction was not executed, one or more files with two 3D extensions (same format as the primary product) are associated that contain the re-constructed sky IFUs (if IFUs have been put on blank sky in the same exposures as the object IFUs);
- 5) a file with 48 extensions (1D) containing the telluric correction for each of the 24 IFUs (plus empty error extensions), dividing 3) by the proper extension in 5) gives the primary product 1);
- 6) a PNG plot file that visualizes the primary product and provides QC information.

This set of products is created for each individual target in the input raw science files.

The primary products contain some header keywords with information related to the OB and the QC process. They are listed in Table 4.

Table 4. FITS keywords added to the primary product

Parameter	Values	Meaning
<i>OB related information:</i>		
SM_VM	SM or VM	Data taken in Service Mode or Visitor Mode; VM data are less constrained in terms of OB properties; they have no user constraints defined and therefore no OB grades.
OB_GRADE	A/B/C/D; X	Immediate grade given by night astronomer, considering ambient conditions checked against user constraints (VM data are formally graded X meaning 'unknown').
OB_COMM<n>	Free text	Any optional comments added by the night astronomer, together with the approximate UT hh:mm (truncated after 200 characters).
<i>QC related information:</i>		
QCFLAG	e.g. 0000001	QC flag composed of 7 bits, see Table 5.
QC_COMM<n>	Free text	Comments about quality issues

Data Quality

Master calibrations. All used master calibrations have been quality-reviewed and certified at the time of acquisition, as part of the closed Quality Control (QC) loop with the Observatory which also includes trending. As part of the certification process for calibration data there is a scoring process to bring non-compliant behaviour of the calibrations to the attention of the QC scientist. All these cases have been handled as part of the certification procedure. Hence there is reasonable evidence that the master calibrations catch all instrument properties, as relevant for the reduction, correctly and completely.

Review and certification of science products. KMOS data cubes are reviewed and certified by a process that involves both automatic scoring and random human-supervised certification. The automatic QC systems scores parameters like

- the quality of telluric standard star measurement (see below);
- whether or not the telluric observation consisted of at least one exposure for each of the three spectrographs;
- whether the telluric observation comes from an observatory-prepared OB (which provides a reliable magnitude for the standard);
- whether a close-in-time atmospheric profile was used for modelling the atmosphere.

The measured values are compared to reference values and scored. A non-zero score flags a potential issue. Any non-zero score is reviewed. Upon review, QC comments can be entered. They are intended to be informative, but they don't claim completeness. The QC comments are propagated to the data cube headers (in the keywords `QC_COMM<n>`).

QC flag. While the QC scheme is an internal process, there is also a scheme to propagate quality information to the user. The header key "`QCFLAG`" in the KMOS products contains a quality flag that is composed of seven bits (see Table 5). For each bit, the value 0 means "OK, no concern".

Flag #1 is set when the time difference to the applied master flat-field is larger than one day. The flag is also applicable for wavelength calibrations since both are measured together. Normally, flat-field and wavelength calibrations are taken in the morning after the science observations for all set-ups of the night. There are exceptional cases when this was not possible. Due to small flexures and shifts in the instrument, the application of calibrations outside the normal time range could be a potential issue for data reduction. The issue might manifest in bad signal extraction at the edges of the IFU field-of-view (FOV), shifts of the target position within the FOV, or small shifts in the wavelength solution.

Flags #2 to #5 are related to the standard star. The quality of the telluric correction is indicated with flag #2 which is set if the correction quality is probably worse than the typical quality. The criterion for setting it depends on the availability of the PWV measurement from the Paranal radiometer. For KMOS observations after 15 September 2016, the PWV value at the time of the observation is stored in the raw file headers. The PWV measurement from the applied standard star can then be compared to it. For 95% of all cases, PWV from the standard is within +/- 25% of the radiometer value at the time of the science observations. If it is outside this range then flag #2 is set, indicating a possible issue with the telluric correction.

For science observations before 15 September 2016, or in the few cases when the radiometer PWV is not available, the fulfilment of the calibration plan is evaluated instead. Then, flag #2 is set if the standard was measured more than two hours apart from the science.

If the associated standard star was not observed with all three KMOS spectrographs then flag #3 is set. In such a case, differences in transmission between the spectrographs may not be measured accurately.

Flag #4 refers to the OB that was used to observe the standard. It is set when the OB was not an observatory-provided OB but was prepared by the observer in VM nights. Since the magnitude of the standard is entered in the OB and then used during data reduction, it cannot be guaranteed that

the correct magnitude of the standard is used in the latter case. Flux calibration may, therefore, be uncertain.

Table 5. QC flags⁹.

Bit	Content (if “yes”, value is 0, otherwise 1)	Motivation
#1 – Δt to flat-field	Time difference to master flat and wavelength calibration less than one day?	If not then this means a potential issue with flat-fielding, signal extraction, and wavelength calibration.
#2 – quality of telluric correction	Does the chosen telluric standard provide the typical quality?	If not then the telluric correction might be less accurate than usual.
#3 – telluric on all detectors	Was the telluric standard measured at least once for each of the three spectrographs?	If not then differences in transmission between the spectrographs are not correctly accounted for.
#4 – telluric OB from observatory	Was the OB for observing the standard prepared by the observatory?	The standard star magnitude that is used is entered by the user while preparing the OB. Only if the OB was prepared by the observatory, the accuracy of the magnitude (and therefore the flux calibration of the science) can be guaranteed.
#5 – actual atmospheric profile	Was the actual atmospheric profile used as input for the atmosphere model from the same night as the telluric?	In exceptional cases, not the profile from the same night but an average profile was used which may lead to inaccurate modeling of the atmosphere.
#6 – non-linear pixels	Number of pixels having more than 40000 ADU (i.e. non-linear pixels) in first raw file in normal range?	High numbers of non-linear pixels indicate saturated frames.
#7 – sky subtraction	Is a separate sky exposure available?	If not then sky subtraction is not performed and telluric correction is not applied.

During processing of the telluric standard, a close-in-time atmospheric profile¹⁰ is downloaded and used for modelling the atmosphere. This procedure is very stable but in case the download of a profile from the same night was not possible, flag #5 is set.

Flag #6 monitors the number of pixels in the first input raw file that are above 40000 ADU. At this level, the KMOS detectors become non-linear. The threshold for setting this flag is at 3000 pixels.

Finally, flag #7 refers to the sky subtraction. In many observations, a separate sky exposure is available for the IFU of the science target. Then sky subtraction is automatically applied. Otherwise, no sky subtraction and no telluric correction is executed. Both can be done separately by the user with the delivered sky and telluric-correction products.

QC plots and previews. For each science target, a preview plot is available as quick look. It is delivered as ancillary file together with the main product. An example is shown in Figure 2.

The top panel shows an averaged spectrum of the data cube (in blue) which is corrected for telluric absorption. For comparison, also the uncorrected spectrum (in red) is plotted. The panel below has the applied telluric spectrum (in cyan) and a static OH spectrum. The latter can be important in order to identify residual sky lines that might remain after sky subtraction. The averaged signal-to-noise ratio is shown in the third spectral panel.

⁹ The up-to-date list can be found at http://www.eso.org/observing/dfq/quality/PHOENIX/KMOS/score_bits.txt

¹⁰ GDAS profiles, see <http://www.eso.org/sci/software/pipelines/skytools/molecfits/gdas>

The lower left image is the re-combined FOV from the collapsed data cube. Next to it, the exposure mask gives the number of actual exposure for each spatial pixel. For producing the averaged spectra in the top panel, only those spectra have been chosen which have the highest number of exposures (five in this example). A histogram of the full data cube is shown at the lower right.

At bottom, a set of QC parameters applicable to the product are printed:

- the total exposure time of the stack, from header keyword “TEXPTIME”;
- the number of exposures on the target (keyword “NCOMBINE”);
- the limiting ABMAG (“ABMAGLIM”);
- the resolving power (“SPECRES”);
- lambda start and end of the spectra in nm (“WAVELMIN” and “WAVELMAX”);
- the time difference between science and telluric in days (delta t telluric);
- the airmass difference between science and telluric (delta airmass);
- the time difference between science and the master flat (delta t FF calib);
- the PWV (precipitable water vapour) as measured with the telluric standard star;
- the PWV from the header of the science raw frame as measured by the radiometer on Paranal, available since 15 September 2016;
- the fit RMS of the telluric lines (from the atmosphere model calculated using the standard), values are typically below 0.04;
- the score bits;
- the application of sky subtraction (“yes” or “no”);
- and the actual IFU that was used for this target.

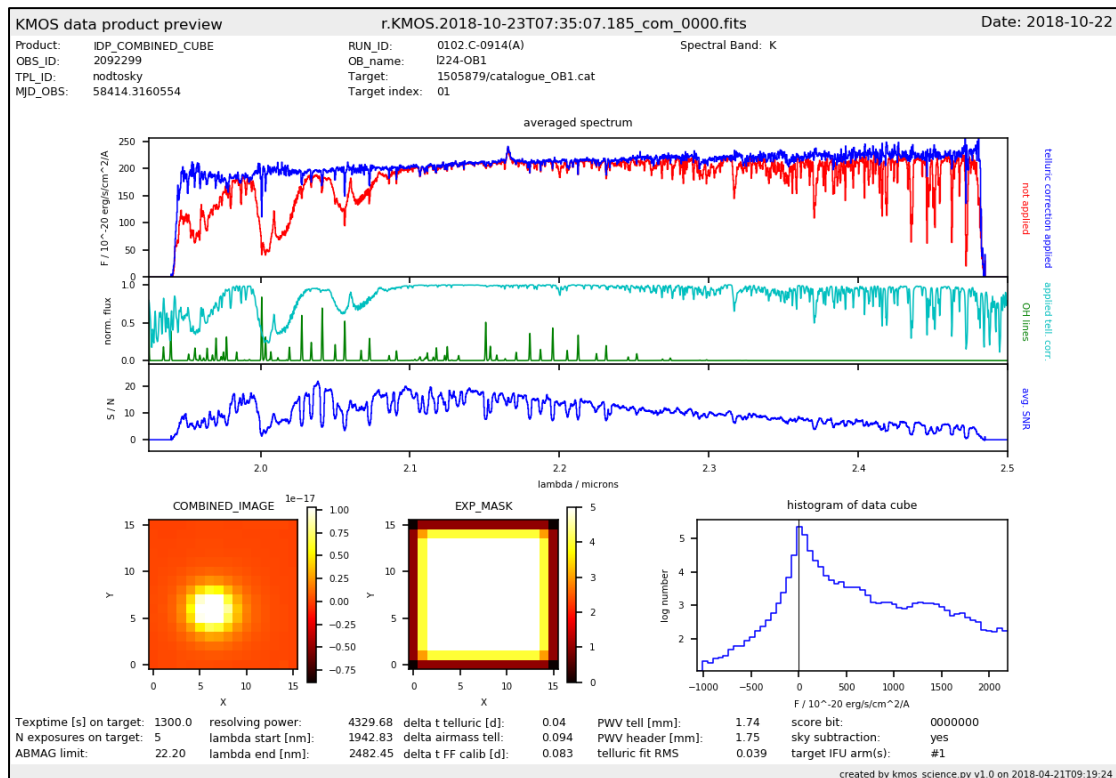


Figure 2. Preview plot associated to an IFU data cube. See text for explanation

Process quality control. The quality of the data is monitored with quality control (QC) parameters which are stored in a database. They are publicly accessible through a browser¹¹ and a plotter¹² interface. A subset of these parameters is evaluated for the QC flag (see above).

¹¹ http://archive.eso.org/qc1/qc1.cgi?action=qc1_browse_table&table=kmos_science_idp

¹² http://archive.eso.org/qc1/qc1.cgi?action=qc1_plot_table&table=kmos_science_idp

Error propagation. Error propagation is not implemented in the combination of the final data cubes. The errors given in the second extension of the products are calculated statistically. If there are at least three exposures for a given target, then the standard deviation of the input spectra is used. If there are less than three exposures, then errors are calculated for each spaxel as a running RMS along wavelengths over the data cube. The latter method provides, however, only an estimate of the true noise level.

Known Features and Issues

Over or under corrected sky background. The most common observing strategy for KMOS uses separate exposures for determining the sky background. Good sky subtraction is then obtained if sky conditions are stable between object and sky exposures. For observations with individual exposure times of 300 seconds or more, this is frequently not fulfilled. The sky background may then be over or under subtracted and the application of the telluric correction can introduce artificial features. Users may refer to the uncorrected data cubes for comparison.

Residual OH lines. Positive or negative residuals from the OH lines may be present if the sky is variable between object and sky exposures (see above).

Observations without separate sky exposures. Sky subtraction is only performed for any given object IFU if a separate exposure with the same IFU exists on blank sky. Reconstructed data cubes are nevertheless delivered for all targets. They are, however, not corrected for telluric features. If some IFUs from within the template have been placed on blank sky, then these IFUs are also reconstructed and are also delivered as ancillary products. User may wish to subtract the sky by using these products.

ABMAGLIM. The limiting AB magnitude calculated by the pipeline is systematically about two magnitudes too low. Its value is, however, still given in the products headers since it might be useful for statistical comparisons.

Flux calibration in HK. For data products created with pipeline versions 4.0.2 and earlier, flux and associated error have been under-estimated by a factor of about 1.6 in HK. This issue is solved in later pipeline releases. The pipeline version can be checked with the PROCESOFT header keyword in the data products.

Data Format

File Types

The data set for each science target consists of one primary product file, at least three ancillary fits files, and one preview plot. The number of these data sets per observation depends on the number of allocated IFUs and is typically a bit less than 24. Table 6 gives an overview of the fits files.

Table 6. Primary and ancillary fits products

ORIGFILE begins with	Product category HIERARCH ESO PRO CATG and PRODCATG	Format	Primary or ancillary?	Description
KM_SCBC	IDP_COMBINED_CUBE SCIENCE.CUBE.IFS	3D	Primary	Combined data cube
KM_SCBC	IDP_COMBINED_CUBE ANCILLARY.CUBE.IFS.SKY	3D	Ancillary	Sky data cube ¹³
KM_SIMC	COMBINED_IMAGE ANCILLARY.IMAGE.WHITELIGHT	Image	Ancillary	Collapsed white-light image of FOV
KM_SXPM	EXP_MASK ANCILLARY.PIXELCOUNTMAP	Image	Ancillary	Number of exposures per spatial pixel
KM_SCBU	COMBINED_CUBE ANCILLARY.CUBE.IFS. NO_TELLCORR	3D	Ancillary	Combined data cube without telluric correction ¹⁴
KM_STCO	TELLURIC_CORR ANCILLARY.TELLCORR	1D	Ancillary	Applicable telluric correction ¹⁵

The ORIGFILE product names follow a naming convention which is

KM_<TYPE>_<OBS_ID>_<DP_ID>_N<NN>_<OBJSKY>_<BAND>.fits

for <TYPE> = SCBC,

KM_<TYPE>_<OBS_ID>_<DP_ID>_N<NN>_<BAND>.fits

for <TYPE> = SIMC, SXPM, or SCBU, and

KM_<TYPE>_<OBS_ID>_<DP_ID>_<BAND>.fits

for <TYPE> = STCO. See Table 7 for details. An example ORIGFILE name would be

KM_SCBC_1884697_2018-01-28T06:29:03.724_N03_H.fits

for a 3D data cube from OB 1884697, observation started at 06:29:03.724 UT on 28 January 2018 and used the H band. The target has the index '03'; this is simply a running number to distinguish the different targets in the observation. The archive user may wish to read the ORIGFILE header key and to rename the archive-delivered fits files accordingly.

In addition to the fits products, also the preview plots are delivered as ancillary files. They come in the PNG image format and follow the naming convention

r.KMOS.<DP_ID>_com_<NNNN>.png

where <DP_ID> is the time stamp of the first exposure and <NNNN> is a running number with leading zeros (e.g. '0000', '0001', ...).

¹³ Only present if sky subtraction was not performed *but* dedicated sky IFUs exist (see text)

¹⁴ Only present if sky subtraction and therefore also telluric correction was performed (see text)

¹⁵ One file per observation, containing the corrections for the 24 IFUs in separate extensions

Table 7. ORIGFILE naming convention

Component	Description
KM	KMOS product
<TYPE>	Product type see Table 6 for complete list
<OBS_ID>	OB ID of the observation (header key <code>HIERACH ESO OBS ID</code>)
<DP_ID>	Time stamp in UT of the first exposure of the stack in the format <code><YEAR>-<MONTH>-<DAY>T<HOUR>:<MINUTE>:<SECOND>.<MILLISECOND></code>
<NN>	Target index, a running number with leading zero (e.g. '01', '02', ...)
<OBJSKY>	'OBJ' for <code>SCIENCE.CUBE.IFS</code> or 'SKY' for <code>ANCILLARY.CUBE.IFS.SKY</code>
<BAND>	Spectral band of the observation, one of 'IZ', 'YJ', 'H', 'HK', or 'K'.

File structure and size

The primary KMOS product is a fits file with two 3D image extensions:

- a 3D data cube with two spatial dimensions and one wavelength axis, flux-calibrated and with telluric features removed (`EXTNAME` key is '`<TARGET>.DATA`'),
- a 3D data cube of same size with the error (`EXTNAME` key is '`<TARGET>.NOISE`').

A data cube for a single target has a size of typically 4 MB. This gives about 192 MB for a complete data set from one template execution (24 IFUs and 2 data cubes, i.e. with and without telluric correction).

Acknowledgement Text

All users are kindly reminded to notify Mrs. Grothkopf (`esodata@eso.org`) upon acceptance or publication of a paper based on ESO data, including bibliographic references (title, authors, journal, volume, year, and page numbers) and the program ID(s) of the data used in the paper.

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