Doing your own data reduction – pipelines at ESO

Wolfram Freudling

http://www.eso.org/sci/software/pipelines
What is Data Reduction and why should I worry about it?

- Processing of raw data to scientifically useful Products.
- ESO is doing it for you!
- Archive contains science products.

Why worry about it:
- Reduce data (instruments, observing mode, time frame) without science data products in archive.
- Understand your data and the impact of processing on results.
- Reprocess data using different strategy / parameters.
- Post-process archive products.
ESO Data Reduction System

Reduction algorithms “Recipes”
input: FITS files + parameters
Output: FITS files

Instrument Consortia, Pipeline Systems Group, Science Data Products Group

Workflow Instructions
To run the workflow on the demo data:
- Turn on “Enable Enable Demo Data” in “Demo Data” from the top menu before starting the workflow.
- Press the “Run” button or ctrl-r to start the workflow.

To run on different data:
- Click on ROOT_DATA_DIR under the top menu.
- All directories can be searched for data.
- Press the “Run” button or ctrl-r to start the workflow.
- Set recipe parameters
- Organize output for subsequent recipes

Organize data so that they can be fed to a recipe
Plot and inspect the results
Set recipe parameters

Setup Directories
Global Parameters

Step 1: Data Organisation and Selection
Step 2: Creation of Calibration
Step 3: Calibration
Step 4: Spectrum Extraction
Step 5: Output Organisation
**Catalogue Selection**

Select catalogues (on local machine or for CDS search). Input values must be within the allowed ranges; at least one photometric and one astrometric valid catalogue must be provided (either from local machine or for CDS search). If these criteria are not fulfilled, the workflow will stop. No check is done beforehand.

- **INSTRUMENT**: 1
- **PHOTOMETRY**: 6
- **ASTROMETRY**: 6

**Working Directories:**
- **RAW_DATA_DIR**: \$HOME/astrodata/raw/hawki
- **PRODUCTS_DIR**: \$HOME/astrodata/processed/hawki
- **CALIB_DIR**: \$HOME/astrodata/calibration/hawki
- **LOG_DIR**: \$HOME/astrodata/log/hawki
- **PRODUCTS_DIR**: \$HOME/astrodata/processed/hawki
- **DATA_DIR**: \$HOME/astrodata/data/hawki
- **BOOKKEEPING_DIR**: \$HOME/astrodata/bookkeeping/hawki

**Data Organisation and Selection**

**Step 1:** Data Organisation and Selection

- **Input Current Dataset**
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**Step 2:** Creation of Master Calibration Files

- **Master Dark**
- **Master Flat**
- **Readgain Table**
- **Calibrator Selection**
- **Calibrator Selection**

**Step 3:** Standard Star and Science Images Reduction

- **Science Processed Files**
- **Processed Standard Star**

**Step 4:** Output Organisation

- **Product Explorer**
- **Product Explorer**
- **Product Explorer**
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- **Product Explorer**

**Catalogue Selection**

Select catalogues for local machine and/or for CDS search. Input values must be within the allowed ranges; at least one photometric and one astrometric valid catalogue must be provided (either from local machine or for CDS search). If these criteria are not fulfilled, the workflow will stop. No check is done beforehand.

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**Step 4:** Output Organisation

- **Product Explorer**
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- **Product Explorer**
FORS Workflow For Imaging Data (v. 5.1.4)

Workflow Instructions

To run this workflow on the demo data:
- Turn on highlighting. Choose "Tools" -> "Animate at Runtime" from top menu and set it to "3".
- Press the 'Run' button OR cntrl-r to start the workflow.

To run on a different data set:
- Click on RAW_DATA_DIR and set as appropriate.
- All subdirectories of RAW_DATA_DIR will be searched for data.
- If desired, change END_PRODUCTS_DIR.
- IMPORTANT: END_PRODUCTS_DIR should not be a subdirectory of the RAW_DATA_DIR, otherwise it will be searched for raw data.
- Press the 'Run' button OR cntrl-r to start the workflow.

The general concepts of Reflex are described in Astron. Astrophys., 559, A96. Please credit this paper in publications on research that used Reflex.

Workflow tutorial and Fors pipeline manual can be found here: http://www.eso.org/scl/software/pipelines/reflex_workflows

Setup Directories

Input:
- ROOT_DATA_DIR: $HOME/reflex_data/
- RAW_DATA_DIR: $PATH/local/share/espipes/s/dataset/fo3/
  Only change CALIB_DATA_DIR if you do not want to use the calibration data delivered with the pipeline.
- CALIB_DATA_DIR: $PATH/local/share/espipes/dataset/cal/fo3-
  Output:
- END_PRODUCTS_DIR, SROOT_DATA_DIR, reflex_end_products

Working Directories:
- BOOKKEEPING_DIR, SROOT_DATA_DIR/reflex_bookkeeping/fo3-
- LOGS_DIR: SROOT_DATA_DIR/reflex_lego/fo3-
- TMP_PRODUCTS_DIR: SROOT_DATA_DIR/reflex_tmp_products/fo3-
- BOOKKEEPING_DIR: $HOME/BOOKKEEPING_DIR/bookkeeping.db

Global Parameters

- RecipeFailureMode: Ask
- RestoreDir: false
- FITS, VIEWER: vs
- GlobalPlotInteractivity: true
- SelectDatasetMethod: Interactive
- ProductExplorerMode: Triggred

Global parameter for the behaviour when a recipe fails, 'Ask' means that each time a recipe fails, the choice to continue or stop will be presented. 'Continue' means that the workflow will ignore errors and continue. 'Stop' means the workflow will stop.

Change "RestoreDir" to 'true' to erase BOOKKEEPING_DIR, TMP_PRODUCTS_DIR, and LOGS_DIR each time the workflow is run (Lazy Mode will not work anymore)

Program to use for the inspection of input/output products. Use full path name if it is not in the standard path.

Set to "false" to disable interactive GUIs for the whole workflow. Each interactive actor can specify its own setting, which overwrites the choice given here.

Specify how datasets for processing are selected ("All", "New" = never tried before, "Reduced" = successfully run before, "Failed" = unsuccessfully run before), or set to "Interactive" for interactive selection.

Specify when you want to see the ProductExplorer GUI.
"Triggered" = show it after all data sets have been reduced.
"Enabled" = show it after each dataset.
"Disabled" = never show it.

Step 1: Data Organisation and Selection

Step 2: Creation of Master Calibration Files

Step 3: Science Reduction

Step 4: Output Organisation
FORS Workflow For Imaging Data (v. 5.1.4)

Workflow Instructions

To run this workflow on the demo data:
- Turn on highlighting. Choose "Tools" -> "Animate at Runtime" from top menu and set it to "1".
- Press the "Run" button OR ctrl-R to start the workflow.

To run on a different data set:
- Click on RAW_DATA_DIR and set as appropriate. All subdirectories of RAW_DATA_DIR will be searched for data.
- If desired, change END_PRODUCTS_DIR.

IMPORTANT: END_PRODUCTS_DIR should not be a subdirectory of the RAW_DATA_DIR, otherwise it will be searched for raw data!
- Press the "Run" button OR ctrl-R to start the workflow.

Setup Directories

Input:
- ROOT_DATA_DIR: SHARE/reflex_data/
- RAW_DATA_DIR: /opt/local/share/series/forps/dataloader/fors/
- Only change CALIB_DATA_DIR if you do NOT want to use the calibration data delivered with the pipeline.
- CALIB_DATA_DIR: /opt/local/share/series/forps/dataloader/fors-5.1.4/

Output:
- END_PRODUCTS_DIR: SHARE/reflex_end_products

Working Directories:
- BOOKKEEPING_DIR: SHARE/reflex_bookkeeping/fors-im
- LOGS_DIR: SHARE/reflex_bookkeeping/fors-im
- TMP_PRODUCTS_DIR: SHARE/reflex_bookkeeping/fors-im
- BOOKKEEPING_DB: SHARE/reflex_bookkeeping.db

Global Parameters

- Recipe Failure Mode: Ask
- EraseDir: false
- FITS_VIEWER: ?
- Global Plot Interactivity: true
- SelectDatasetMethod: Interactive
- ProductExplorerMode: Triggered

Global parameter for the behaviour when a recipe fails. "Ask" means that each time a recipe fails, the choice to continue or stop was presented. "Continue" means that the workflow will ignore errors and continue. "Stop" means the workflow will stop.

Change "EraseDir" to true to erase BOOKKEEPING_DIR, TMP_PRODUCTS_DIR and LOGS_DIR each time the workflow is run (Lazy Mode will not work anymore)

Program to use for the inspection of input/output products. Use full path name if it is not in the standard path.

Set to false to disable interactive GUIs for the whole workflow. Each interactive actor can specify its own setting, which overrides the choice given here.

Specify how datasets for processing are selected ("All", "New" = never tried before, "Reduced" = successfully run before, "Failed" = unsuccessfully run before, or set to "Interactive" for interactive selection.

Specify when you want to see the ProductExplorer GUI. "Triggered" = show it after all data sets have been reduced. "Enabled" = show it after each dataset. "Disabled" = never show it
Data Organisation

Step 1: Data Organisation and Selection

Step 2: Creation of Master Calibration Files

Step 3: Wavelength and Response Calibration

Step 4: Spectrum Extraction

Step 5: Output Organisation
OCA Rules

classifying, organizing and associating astronomical data based on their meta-data (FITS keywords).

Processing steps imply Data organization

Data organisation defined in “OCA rules”: text file

Three types of rules:

- Classification („This is a Raw Dark“)
- Organization („These Raw Darks are processed together“)
- Association („select Biases based on properties of Raw Darks“)

DO produces DataSets: set of science files that are processed together, plus all additional files that are needed for processing

Each file in DataSet has a category (e.g. “raw bias”) and a purpose action1/action2/... (e.g. „MasterBias/MasterDark“)
Data Organisation

- **Category**: science file
- **Purpose**: associated calibration files

Workflow Instructions:
- DataOrganizer
- datasets out

Workflow Steps:
1. Data Organisation and Selection
2. Creation of Master Calibration Files
3. Wavelength and Response Calibration
4. Spectrum Extraction
5. Output Organisation
FORS Workflow For Imaging Data (v. 5.1.4)

Workflow Instructions

To run this workflow on the demo data:
- Turn on highlighting. Choose "Tools" -> "Animate at Runtime" from top menu and set it to "T".
- Press the "Run" button OR ctrl-R to start the workflow.

To run on a different data set:
- Click on RAW_DATA_DIR and set as appropriate.
- All subdirectories of RAW_DATA_DIR will be searched for data.
- If desired, change END_PRODUCTS_DIR.
- IMPORTANT: END_PRODUCTS_DIR should not be a subdirectory of the RAW_DATA_DIR, otherwise it will be searched for raw data!
- Press the "Run" button OR ctrl-R to start the workflow.

The general concepts of Reflex are described in:
Astron. Astrophys., 559, A26. Please credit this paper in publications on research that used Reflex.

Workflow tutorial and Fors pipeline manual can be found here:
http://www.eso.org/sci/software/pipelines/reflex_workflows

Setup Directories

Input:
- ROOT_DATA_DIR: $HOME/reflex_data/
- RAW_DATA_DIR: /opt/localshare/esopes/pipelines/data/bbma/fors/
  Only change CALIB_DATA_DIR if you do NOT want to use the calibration data delivered with the pipeline.
- CALIB_DATA_DIR: /opt/local/share/esopes/pipelines/data/bbma/fors-5.1.4/

Output:
- END_PRODUCTS_DIR: $ROOT_DATA_DIR/reflex_end_products

Working Directories:
- BOOKKEEPING_DIR: $ROOT_DATA_DIR/reflex_bookkeeping/fors-ima
- LOGS_DIR: $ROOT_DATA_DIR/reflex_logs/fors-ima
- TMP_PRODUCTS_DIR: $ROOT_DATA_DIR/reflex_tmp_products/fors-ima
- BOOKKEEPING_DB: $BOOKKEEPING_DIR/bookmmp.db

Global Parameters

- RecipeFailureMode: Ask
- EraseDirs: false
- FITS_VIEWER: n
- GlobalInProgressActivity: true
- SelectDatasetMethod: Interactive
- ProductExplorerMode: Triggred

Global parameter for the behaviour when a recipe fails.
'Ask' means that each time a recipe fails, the choice to continue or stop will be presented. 'Continue' means that the workflow will ignore errors and continue. 'Stop' means the workflow will stop.
Change "EraseDirs" to 'true' to erase BOOKKEEPING_DIR, TMP_PRODUCTS_DIR, and LOGS_DIR each time the workflow is run (Lazy Mode will not work anymore).
Program to use for the inspection of input/output products.
Use full path name if it is not in the standard path.
Set to 'false' to disable interactive GUIs for the whole workflow. Each interactive actor can specify its own setting, which overwrites the choice given here.
Specify how datasets for processing are selected.
"CAll" = never tried before, "Reduced" = successfully run before, "Failed" = unsuccessfully run before, or set to "Interactive" for interactive selection.
Specify when you want to see the ProductExplorer GUI.
"Triggred" = show it after all datasets have been reduced.
"Enabled" = show it after each dataset.
"Disabled" = never show it.

Step 1: Data Organisation and Selection

Step 2: Creation of Master Calibration Files

Step 3: Science Reduction

Step 4: Output Organisation
FITS Router

sorting by category

• routing by category is explicit: specify what recipe needs

• each recipe needs well defined input (e.g. category raw biases) and creates well defined output (e.g. category Masterbias).

• connections determine work„flow“.
FORS Workflow For Imaging Data (v. 5.1.4)

Workflow Instructions

To run this workflow on the demo data:
- Turn on highlighting. Choose "Tools" -> "Animate at Runtime" from top menu and set it to "1".
- Press the "Run" button OR ctrl-R to start the workflow.

To run on a different data set:
- Click on RAW_DATA_DIR and set as appropriate.
- All subdirectories of RAW_DATA_DIR will be searched for data.
- If desired, change END_PRODUCTS_DIR. IMPORTANT: END_PRODUCTS_DIR should not be a subdirectory of the RAW_DATA_DIR, otherwise it will be searched for raw data!
- Press the "Run" button OR ctrl-R to start the workflow.

The general concepts of Reflex are described in Astron. Astrophys., 559, A97. Please credit this paper in publications on research that used Reflex.

Workflow tutorial and for pipeline manual can be found here: http://www.eso.org/sci/software/pipelines/reflex_workflows

Setup Directories

Input:
- ROOT_DATA_DIR: SHOME/reflex_data/
- RAW_DATA_DIR: /opt/local/share/esopipes/dataset/fors/
- Only change CALIB_DATA_DIR if you do NOT want to use the calibration data delivered with the pipeline.
- CALIB_DATA_DIR: /opt/local/share/esopipes/dataset/cal/5.1.4/

Output:
- END_PRODUCTS_DIR: $ROOT_DATA_DIR/reflex_end_products

Working Directories:
- BOOKKEEPING_DIR: $ROOT_DATA_DIR/reflex_bookkeeping/fors-ima
- LOCS_DIR: $ROOT_DATA_DIR/reflex好奇/fors-ima
- TMP_PRODUCTS_DIR: $ROOT_DATA_DIR/reflex_tmp_products/fors-ima
- BOOKKEEPING_DIR: $BOOKKEEPING_DIR/bookkeeping.db

Global Parameters

- RecipeFailureMode: Ask
- EraseDirs: false
- FITS_VIEWER: tv
- Global/Interactivity: true
- SelectDataSetMethod: Interactive
- ProductExplorerMode: Triggered

Global parameter for the behaviour when a recipe fails. 'Ask' means that each time a recipe fails, the choice to continue or stop will be presented. 'Continue' means that the workflow will ignore errors and continue. 'Stop' means the workflow will stop.

Change "EraseDirs" to "true" to erase BOOKKEEPING_DIR, TMP_PRODUCTS_DIR and LOCS_DIR each time the workflow is run (Lazy Mode will not work anymore)

Program to use for the inspection of input/output products. Use full path name if it is not in the standard path.

Set to "false" to disable interactive GUIs for the whole workflow. Each interactive actor can specify its own setting, which overrides the choice given here.

Specify how datasets for processing are selected ("All", "New" = never tried before, "Reduced" = successfully run before, "Failed" = unsuccessfully run before), or set to "Interactive" for interactive selection.

Specify when you want to see the ProductExplorer GUI. "Triggered" = show it after all data sets have been reduced. "Enabled" = show it after each dataset. "Disabled" = never show it
SofSplitter: Sorting by Purpose

- Sorting by Purpose is implicit.
- Purpose defined in OCA rules.
- Assumes that each recipe has at least one unique file category.
FORS Workflow For Imaging Data (v. 5.1.4)

Workflow Instructions

To run this workflow on the demo data:
- Turn on highlighting. Choose "Tools" -> "Animate at Runtime" from top menu and set it to "1".
- Press the "Run" button OR ctrl+R to start the workflow.

To run on a different data set:
- Click on RAW_DATA DIR and set as appropriate. All subdirectories of RAW_DATA_DIR will be searched for data.
- If desired, change END_PRODUCTS_DIR. IMPORTANT: END_PRODUCTS_DIR should not be a subdirectory of the RAW_DATA_DIR, otherwise it will be searched for raw data.
- Press the "Run" button OR ctrl+R to start the workflow.

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Setup Directories:

- ROOT_DATA_DIR: $HOME/reflex_data/
- RAW_DATA_DIR: /opt/local/share/rospipes/datasetdemo/fors/
- GLOBAL_PARAMETERS_DIR: /opt/local/share/rospipes/datasetdemo/fors-
- CAUB_DATA_DIR: /opt/local/share/rospipes/datasetdemo/fors-
- END_PRODUCTS_DIR: $ROOT_DATA_DIR/reflex_end_products

Working Directories:

- BOOKKEEPING_DIR: $ROOT_DATA_DIR/reflex_bookkeeping/forima
- TMP_DIRS: $ROOT_DATA_DIR/reflex_timp/forima
- TMP_TEMP_DIRS: $ROOT_DATA_DIR/reflex_timp/forima
- TOOLING_DIRS: $ROOT_DATA_DIR/reflex_tooling/forima

Global Parameters

- RecipeFailureMode: Ask
- EraseDirs: false
- HTS_VIEWER: false
- GlobalPlotInteractivity: true
- SelectDatasetMethod: Interactive
- ProductExplorerMode: Triggers

Global parameter for the behaviour when a recipe fails.
- Ask" means that each time a recipe fails, the choice to continue or stop will be presented. "Continue" means that the workflow will ignore errors and continue. "Stop" means the workflow will stop.
- Change "EraseDirs" to "true" to erase
- BOOKKEEPING_DIR, TMP_DIRS, DIR and LOC_00_DIR each time the workflow is run (Lazy Mode will not work anymore)
- Program to use for the inspection of input/output products. Use full path name if it is not in the standard path.

Set to "false" to disable interactive GUIs for the whole workflow. Each interactive action can specify its own setting, which overwrites the choice given here.

Specify how datasets for processing are selected
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Specify when you want to see the ProductExplorer GUI
- "Triggered" = show it after all data sets have been reduced.
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- "Disabled" = never show it
Exploring results

- Inspect final results
- Compare and keep track of different reduction runs
- Explore Provenance
- Plot (and replot) final and intermediate products
Iteratively Improving Results

- Lazy mode: Don't redo unnecessary steps
- Lazy mode for recipes.
  - It works by comparing the input of the current execution with all the previous recipe executions:
    - All files must be the same
    - All files must have the same checksum
    - All files must have the same date
    - All recipe parameters must be the same
  - If a recipe at the beginning of the workflow is set to Not-Lazy mode, the input of the next recipes will be new and lazy mode will not be triggered.
- Lazy mode for DataOrganizer.
  - It avoids the organization of all the data in subsequent workflow runs.
  - It works similar to lazy mode for recipes
Summary
Data Reduction with
ESO Reflex

• Use the same recipes that are used at the telescope, for Quality Control and for the Production of Data Products in archive.

• Document dependencies.

• Organize data.

• Runs sequence of recipes with single click.

• Monitor progress.

• Do bookkeeping.

• Plot results.

• Allow pre-defined interaction.

• Allow insertion of user procedures in any language.