Przemysław Mikołajczyk

mikolajczyk@astro.uni.wroc.pl

"Useful Python packages for astronomy"

I. Keep your configuration and FITS files in order

Spectroscopic Summer School

26 - 29 June 2018, Wrocław, Poland

0) What do you need?

→ standard Python 2.6+ environment
→ style.py & func.py (inside DAY1.tar.gz archive)
get_conf.py & get_conf.sh
→ astropy (already used by iSpec)
→ jdcal
→ urllib, urllib2, csv
→ argparse
→ gvim text editor

If one or more libraries are missing, use **pip:**
pip install package_name

1) One configuration file for all your scripts

```
mikolajczyk@winston:~/Pulpit/DAY1$ ./conf.py
[ERROR] Wrong number of arguments! (0)
Usage: conf.py <--edit/--run/--dump/--copy/--show/--set/--showall/--check/--restore> [<PREFIX>]
```

1) One configuration file for all your scripts

```
mikolajczyk@winston:~/Pulpit/DAY1$ ./conf.py
[ERROR] Wrong number of arguments! (0)
Usage: conf.py <--edit/--run/--dump/--copy/--show/--set/--showall/--check/--restore> [<PREFIX>]
```

```
mikolajczyk@winston:~/Pulpit/DAY1$ ./conf.py --check
[ERROR] No configuration file present! Run 'conf.py --set' to configure or '--restore'.
```

Useful Python packages for astronomy – part I

1) One configuration file for all your scripts

master_tmp.dat (~/Pulpit/DAY1) - GVIM

Plik Edycja Narzędzia Składnia Bufory Widoki Pomoc

```
# CURRENT CONFIGURATION
# FOR RECOMMENDED LAYOUTS FOR FILES SEE 'files_tmp.dat'

##############################
# BASIC CONFIGURATION        #
##############################

  DIR_INPUT       : /home/zibi/source/phot-ccd/OBS_INFO/     : str   : Path to the folder containing input files
  DIR_OBJECTS     : /home/DATA/OBJECTS/                      : str   : Path to directory with list of stars (.tar.gz)
  DIR_OBJPOS      : /home/zibi/source/phot-ccd/OBS_INFO/     : str   : Path to local objects database (objpos.dat)
  DAOPHOT         : daophot                                  : str   : System command to run DAOPHOT
  DAO_SIGMA       : 4                                        : float : Default sigma threshold for DAOPHOT
  ALLSTAR         : allstar                                  : str   : System command to run ALLSTAR
  PATTERN         : CALIB                                    : str   : Deafult pattern for searchnig files
  ITERS           : 3                                        : int   : Number of iterations for statistics
  OFFSET          : 2                                        : int   : Number of pixels from the edge to be ignored

##############################
#  INPUT FILES CONFIGURATION  #
##############################

  HJD_COL         : 1                                        : int   : Number of column with heliocentric julian time
  PHOT_COL        : 6                                        : int   : Number of column with profile photometry
  PHOT_ERR_COL    : 7                                        : int   : Number of column with p. phot. error
  AIRMASS_COL     : 13                                       : int   : Number of column with air mass value
  OTH_PHOT_COL    : 8 10                                     : str   : Numbers of columns with other photometry

##########################################
# OBSERVATORY VARIABLES (FROM OBS.INFO FILE)  #
##########################################

~
~
~
~
~
~
~
```

27,0-1 Wszystko

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Useful Python packages for astronomy – part I

1) One configuration file for all your scripts

mikolajczyk_winston_master.conf (~) - GVIM

Plik Edycja Narzędzia Składnia Bufory Widoki Pomoc

```
# CURRENT CONFIGURATION
# FOR RECOMMENDED LAYOUTS FOR FILES SEE 'files_tmp.dat'

##############################
# BASIC CONFIGURATION        #
##############################

  DIR_INPUT       : /home/mikolajczyk/Pulpit/DAY1/OBS_INFO/   : str   : Path to the folder containing input files
  DIR_OBJECTS     : /home/DATA/OBJECTS/                       : str   : Path to directory with list of stars (.tar.gz)
  DIR_OBJPOS      : /home/mikolajczyk/Pulpit/DAY1/OBS_INFO/   : str   : Path to local objects database (objpos.dat)
  DAOPHOT         : daophot                                   : str   : System command to run DAOPHOT
  DAO_SIGMA       : 4                                         : float : Default sigma threshold for DAOPHOT
  ALLSTAR         : allstar                                   : str   : System command to run ALLSTAR
  PATTERN         : CALIB                                     : str   : Deafult pattern for searchnig files
  ITERS           : 3                                         : int   : Number of iterations for statistics
  OFFSET          : 2                                         : int   : Number of pixels from the edge to be ignored

##############################
#  INPUT FILES CONFIGURATION  #
##############################

  HJD_COL         : 1                                         : int   : Number of column with heliocentric julian time
  PHOT_COL        : 6                                         : int   : Number of column with profile photometry
  PHOT_ERR_COL    : 7                                         : int   : Number of column with p. phot. error
  AIRMASS_COL     : 13                                        : int   : Number of column with air mass value
  OTH_PHOT_COL    : 8 10                                      : str   : Numbers of columns with other photometry

############################################
# OBSERVATORY VARIABLES (FROM OBS.INFO FILE)  #
############################################

~
~
~
~
~
~
~
~
-- WPROWADZANIE --                                                    10,59     Wszystko
```

1) One configuration file for all your scripts

```
mikolajczyk@winston:~/Pulpit/DAY1$ ./conf.py --check
[OK] Configuration file present.
```

Configuration file is always inside /home/$USER/ directory and named $USER_$HOST_master.conf.

In my case: mikolajczyk_winston_master.conf

```
mikolajczyk@winston:~/Pulpit/DAY1$ ./conf.py --show

    CURRENT CONFIGURATION in '/home/mikolajczyk/mikolajczyk_winston_master.conf'

DIR_INPUT        /home/mikolajczyk/Pulpit/DAY1/OBS_INFO/   str
DIR_OBJECTS      /home/DATA/OBJECTS/                       str
DAOPHOT          sdaophot                                  str
DAO_SIGMA        4                                         float
ALLSTAR          sallstar                                  str
PATTERN          CALIB                                     str
ITERS            3                                         int
OFFSET           2                                         int
HJD_COL          1                                         int
PHOT_COL         6                                         int
PHOT_ERR_COL     7                                         int
AIRMASS_COL      13                                        int
OTH_PHOT_COL     8 10                                      str
```

1) One configuration file for all your scripts

Parsing your existing configuration to any Python or Bash script.

Bash

source get_conf.sh

```
#!/bin/bash
# -*- coding: utf-8 -*-
#
# 'get_conf.sh'
#
# script passes existing configuration to shell scripts
# version: 2017.03.18
# author: (PM) - http://github.com/astromiki
# more: README.pdf
#
#  commentary
## test module

USR=$USER
HOST=$HOSTNAME
CONF_FILE=${HOME}"/"${USR}"_"${HOST}"_master.conf"

get_variables(){
cat $CONF_FILE | awk -F" : " '/^[^#]/ {print $1, $2}' > .t
while read p; do
    readonly $(echo $p | awk '{print $1}')=$(echo $p | awk
'{print $2}')
    done <.t
rm .t
}
```

Useful Python packages for astronomy – part I

1) One configuration file for all your scripts

Parsing your exis

Python

```
#! /usr/bin/env python
# -*- coding: utf-8 -*-
#
# 'get_conf.py'
#
# script passes existing configuration to python scripts
# version: 2017.03.18
# author: (PM) - http://github.com/astromiki
# more: README.pdf
#
#  commentary
## test module

# (!!!) YOU NEED TO PASTE CODE BELOW TO YOUR PYTHON SCRIPT (!!!)
#
# (BEGINNING OF CODE) - if you want your script to work only with a certain observatory
#                       change variable observatory to desired prefix, f.e. "BIALKOW"
#
## run configuration package
#if os.system("conf.py --run " + observatory) != 0:
#       print printf("Problem while applying configuration. Process will terminate.", "ERROR")
#       sys.exit(1)
#else:
#       try:
#               from get_conf import *
#       except ImportError, msg:
#               exit(str(msg) + "!")
#       get_variables()
# (END OF CODE)

# importing dependiencies
try:
        import os
        import sys
        import getpass
        import socket
except ImportError, msg:
        exit(str(msg) + "!")

```

2) FITS headers (**F**lexible **I**mage **T**ransfer **S**ystem)

SPACE TELESCOPE SCIENCE INSTITUTE
Operated for NASA by AURA

Definition of the Flexible Image Transport System (*FITS*)

March 29, 1999

NOST 100-2.0

NASA/Science Office of Standards and Technology
Code 633.2
NASA Goddard Space Flight Center
Greenbelt MD 20771
USA

https://archive.stsci.edu/fits/fits_standard/

NASA/Science Office of Standards & Technology

Useful Python packages for astronomy – part I

2) FITS headers (**F**lexible **I**mage **T**ransfer **S**ystem)

GIRAF.2007-09-28T07:09:19.186.fits

File Edit Font

```
SIMPLE  =                    T          / Standard FITS format (NOST-100.0)
BITPIX  =                   16          / # of bits storing pix values
NAXIS   =                    2          / # of axes in data array
NAXIS1  =                 2148          / # pixels/axis
NAXIS2  =                 4096          / # pixels/axis
EXTEND  =                    T          / Extension may be present
PCOUNT  =                    0          / Number of parameters per group
GCOUNT  =                    1          / Number of groups
BZERO   =              32768.0          / pixel=FITS*BSCALE+BZERO
BSCALE  =                  1.0          / pixel=FITS*BSCALE+BZERO
ORIGIN  = 'ESO     '                    / European Southern Observatory
DATE    = '2007-10-30T09:21:26.044'     / Date this file was written
TELESCOP= 'ESO-VLT-U2'                  / ESO Telescope Name
INSTRUME= 'GIRAFFE '                    / Instrument used
OBJECT  = 'SMC_DPVs_field'              / Target description
RA      =            12.779250          / 00:51:07.0 RA (J2000) pointing
DEC     =            -73.04159          / -73:02:29.7 DEC (J2000) pointing
EQUINOX =               2000.           / Standard FK5 (years)
RADECSYS= 'FK5     '                    / Coordinate reference frame
EXPTIME =            1350.0027          / Total integration time
MJD-OBS =       54371.29813873          / MJD start (2007-09-28T07:09:19.186)
DATE-OBS= '2007-09-28T07:09:19.186'     / Date of observation
UTC     =            25754.000          / 07:09:14.000 UTC
LST     =            10461.855          / 02:54:21.855 LST
PI-COI  = 'UNKNOWN '                    / Name of PI-COI.
OBSERVER= 'UNKNOWN '                    / Name of observer.
CTYPE1  = 'PIXEL   '                    / Pixel coordinate system
CTYPE2  = 'PIXEL   '                    / Pixel coordinate system
CRVAL1  =                  1.0          / value of ref pixel
CRVAL2  =                  1.0          / value of ref pixel
CRPIX1  =                -49.0          / Ref. pixel of center of rotation
CRPIX2  =                  1.0          / Ref. pixel of center of rotation
CDELT1  =                  1.0          / Binning factor
CDELT2  =                  1.0          / Binning factor
ORIGFILE= 'FLAMES_GIRAF_OBS271_0003.fits' / Original File Name
ARCFILE = 'GIRAF.2007-09-28T07:09:19.186.fits' / Archive File Name
UT      = '07:09:14.000'                / UT at start
ST      = '02:54:21.855'                / ST at start
AIRMASS =              1.59200          / Averaged air mass
IMAGETYP= 'OBJECT,SimCal'               / Observation type
GRAT    = 'HR      '                    / Grating name
WLEN    =                447.1          / Grating central wavelen
ORDER   =                   12          / Grating order used
HIERARCH ESO OBS DID        = 'ESO-VLT-DIC.OBS-1.11' / OBS Dictionary
```

BH_Oph-0296.fits

File Edit Font

```
SIMPLE  = T
BITPIX  = 16
NAXIS   = 2
NAXIS1  = 1250
NAXIS2  = 1152
BSCALE  = 1.00000
BZERO   = 32768.00000
OBS-DATE= '20/05/2018'
UT      = '00:40:28'
EXPOSURE= 25.000
DATA-TYP= 'OBJECT'
FILTER  = 'V'
GAIN    = 16  // Speed in microsec/pix
BIN     = 1
CCDTEMP = -50.0 C
OBJECT  = BH_Oph
OBSERVER= PM
ORIGIN  = Bialkow Observatory
END
```

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Useful Python packages for astronomy – part I

2) FITS headers (**F**lexible **I**mage

FITS standards

- 5.4.1 Mandatory Keywords
  - 5.4.1.1 Principal
    - 7.1.1.1 SIMPLE Keyword
    - 7.1.1.2 BITPIX Keyword
    - 7.1.1.3 NAXIS Keyword
    - NAXISn Keywords
    - 7.1.1.9 END Keyword
  - 5.4.1.2 Conforming Extensions
    - XTENSION Keyword
    - 7.1.1.7 PCOUNT Keyword
    - 7.1.1.8 GCOUNT Keyword
    - EXTEND Keyword
- 5.4.2 Other Reserved Keywords
  - 5.4.2.1 Keywords Describing the History or Physical Construction of the HDU
    - DATE Keyword
    - ORIGIN Keyword
    - BLOCKED Keyword
  - 5.4.2.2 Keywords Describing Observations
    - DATE-OBS Keyword
    - DATExxxx Keywords
    - TELESCOP Keyword
    - INSTRUME Keyword
    - OBSERVER Keyword
    - OBJECT Keyword
    - EQUINOX Keyword
    - EPOCH Keyword
  - 5.4.2.3 Bibliographic Keywords
    - AUTHOR Keyword
    - REFERENC Keyword
  - 5.4.2.4 Commentary Keywords
    - COMMENT Keyword
    - HISTORY Keyword
    - Keyword Field is Blank
  - 5.4.2.5 Array Keywords
    - BSCALE Keyword
    - BZERO Keyword
    - BUNIT Keyword
    - BLANK Keyword
    - CTYPEn Keywords
    - CRPIXn Keywords
    - CRVALn Keywords
    - CDELTn Keywords
    - CROTAn Keywords
    - DATAMAX Keyword
    - DATAMIN Keyword
  - 5.4.2.6 Extension Keywords
    - EXTNAME Keyword
    - EXTVER Keyword
    - EXTLEVEL Keyword
- 5.4.3 Additional Keywords
  - 5.4.3.1 Requirements
  - 5.4.3.2 Restrictions

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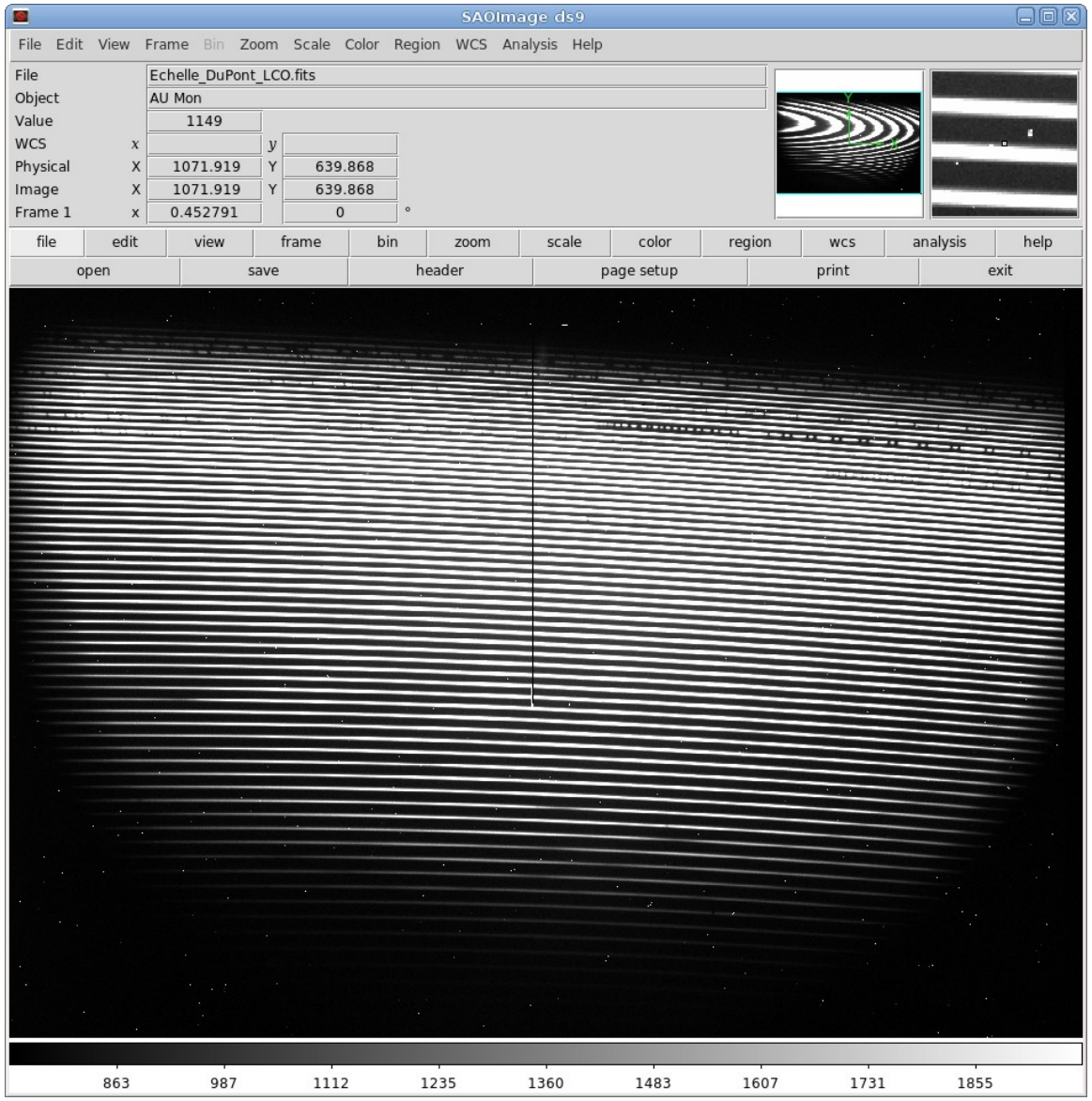
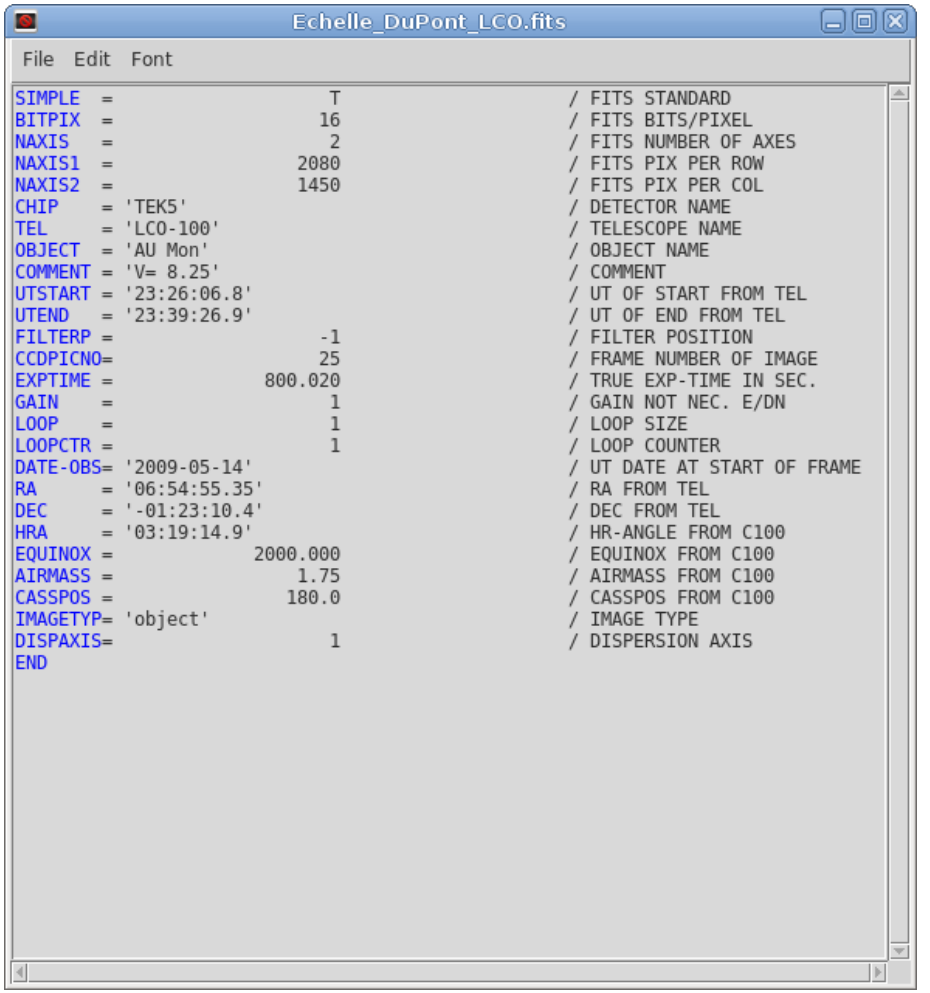
Useful Python packages for astronomy – part I

2) FITS headers





2) OBS_INFO

2)

# DESCRIPTION	KEYWORD (in FITS)	KEYWORD (standard)	FORMAT	VALUE(s)	COMMENT	CONF FLAG (True/False)
OBSERVATORY						
Observatory	-	OBSERVAT	str	PT5M_La_Palma	observatory ID	False
Observer	-	OBSERVER	str	Liam_K_Hardy	observer ID	False
Observatory longitude [deg]	-	LONGITUD	float	28.76075	deg	False
Observatory latitude [deg]	-	LATITUDE	float	-17.88144	deg	False
Observatory altitude [m]	-	ALTITUDE	float	2383	meters	False
Telescope	TELE	TELESCOP	str	Dall-Kirkham_0.5	telescope ID	False
Organization	ORIGIN	ORIGIN	str	PT5M	institution ID	False
TIME (start of exposition)						
Time system	-	TIMESYS	str	UTC	used time standard	False
Date	DATE-OBS	DATE-OBS	yyyy/mm/dd	-	date of exposure	False
Time	-	TIME-OBS	hh:mm:ss	-	time of exposure	False
Julian date	-	JD	float	-	middle of exposure	False
Exposition time	EXPOSURE	EXPTIME	float	-	seconds	False
INSTRUMENT						
Instrument name	INSTRUME	INSTRUME	str	QSI_532	camera ID	False
Detector X size [pix]	NAXIS1	NAXIS1	int	1092	pixels	True
Detector Y size [pix]	NAXIS2	NAXIS2	int	736	pixels	True
Binning	XBINNING	BIN	int	2	binning-2	False
Instr. mode, readout speed	-	READTIME	int	3000	ns/pix	False
Gain	EGAIN	GAIN	float	1.3	e/ADU	True
Read-out noise	-	RDNOISE	float	8 : 11 & 14 ADU for 2x2 & 3x3 binning respectively		True
Saturation limit	-	SATURATE	int	65535	ADU	True
Pixel scale along x-axis	-	CDELT1	float	0.000077778	deg/pix (for 1x1 bin)	True
Pixel scale along y-axis	-	CDELT2	float	0.000077778	deg/pix (for 1x1 bin)	True
Position angle	-	ORIENTAT	float	0.0	deg	False
Image type	TYPE	OBSTYPE	str	SCIENCE | OBJECT	type of data	True
Filters	FILTER	FILTER	str	B, V, R, I	passband ID	True
Pixel size along x-axis	XPIXSZ	PIXSIZE1	float	13.6	microm	False
Pixel size along y-axis	YPIXSZ	PIXSIZE2	float	13.6	microm	False
X reference pixel (center)	CRPIX1	CRPIX1	int	546	X reference pixel	True
Y reference pixel (center)	CRPIX2	CRPIX2	int	368	Y reference pixel	True
OBJECT & WCS						
Object name	OBJECT	OBJECT	str	-	object name	False
Epoch of coord. system	EQUINOX	EQUINOX	float	2000.0	year	False
Coord. system	RADECSYS	RADECSYS	str	FK5	coord. ref. system	False
Coord. type projection RA	CTYPE1	CTYPE1	str	RA---TAN	RA projection type	False
Coord. type projection DEC	CTYPE2	CTYPE2	str	DEC--TAN	DEC projection type	False
Coord. unit RA	-	CUNIT1	str	deg	RA unit	False
Coord. unit DEC	-	CUNIT2	str	deg	DEC unit	False
Right Ascension	RA2	RA	float	-	deg	False
Declination	DEC2	DEC	float	-	deg	False
Right Ascension WCS	CRVAL1	CRVAL1	float	-	deg	False
Declination WCS	CRVAL2	CRVAL2	float	-	deg	False
OTHER						
Original filename	-	FILENAME	str	-	original filename	False

FITS file extension	.fits
Time system shift (t - UTC)	0
Time accuracy [s]	100ms
Linearity range [ADU]	1:45000
Photometric system	Johnson B, Johnson V, Cousins R, Cousins I
Useful detector area	[1:2184,1:1472]
WCS included in header	Yes, usually
Image orientation	Depends on TRACKING value (1 or 3). 1= East down, North to right. 3= East up, North to left.

Useful Python packages for astronomy – part I

2) OBS_INFO

```
mikolajczyk@winston:~/Pulpit/DAY1$ ./conf.py --run PT5M
mikolajczyk@winston:~/Pulpit/DAY1$ ./conf.py --show

    CURRENT CONFIGURATION in '/home/mikolajczyk/mikolajczyk_winston_master.conf'

DIR_INPUT         /home/mikolajczyk/Pulpit/DAY1/OBS_INFO/   str
DIR_OBJECTS       /home/DATA/OBJECTS/                       str
DAOPHOT           sdaophot                                  str
DAO_SIGMA         4                                         float
ALLSTAR           sallstar                                  str
PATTERN           CALIB                                     str
ITERS             3                                         int
OFFSET            2                                         int
HJD_COL           1                                         int
PHOT_COL          6                                         int
PHOT_ERR_COL      7                                         int
AIRMASS_COL       13                                        int
OTH_PHOT_COL      8 10                                      str
OBS_NAXIS1        1092                                      int
OBS_NAXIS2        736                                       int
OBS_GAIN          1.3                                       float
OBS_RDNOISE       8                                         float
OBS_SATURATE      65535                                     int
OBS_CDELT1        0.000077778                               float
OBS_CDELT2        0.000077778                               float
OBS_OBSTYPE       SCIENCE | OBJECT                          str
OBS_FILTER        B, V, R, I                                str
OBS_CRPIX1        546                                       int
OBS_CRPIX2        368                                       int
```

Useful Python packages for astronomy – part I

2) OBS_INFO

```
mikolajczyk@winston:~/Pulpit/DAY1$ ./conf.py --run LOIANO
mikolajczyk@winston:~/Pulpit/DAY1$ ./conf.py --show

    CURRENT CONFIGURATION in '/home/mikolajczyk/mikolajczyk_winston_master.conf'

DIR_INPUT        /home/mikolajczyk/Pulpit/DAY1/OBS_INFO/   str
DIR_OBJECTS      /home/DATA/OBJECTS/                       str
DAOPHOT          sdaophot                                  str
DAO_SIGMA        4                                         float
ALLSTAR          sallstar                                  str
PATTERN          CALIB                                     str
ITERS            3                                         int
OFFSET           2                                         int
HJD_COL          1                                         int
PHOT_COL         6                                         int
PHOT_ERR_COL     7                                         int
AIRMASS_COL      13                                        int
OTH_PHOT_COL     8 10                                      str
OBS_NAXIS1       -                                         int
OBS_NAXIS2       -                                         int
OBS_GAIN         2.22                                      float
OBS_RDNOISE      1.38                                      float
OBS_SATURATE     52000                                     int
OBS_CDELT1       0.000161                                  float
OBS_CDELT2       0.000161                                  float
OBS_OBSTYPE      OBJECT                                    str
OBS_FILTER       2 7 | g-Gunn r-Gunn                       str
OBS_CRPIX1       650                                       int
OBS_CRPIX2       670                                       int
```

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Useful Python packages for astronomy – part I

3) Local database '**objpos.dat**'

Otwórz

objpos.dat
~/Pulpit/DAY1/OBS_INFO

```
 73 Gaia15ath           18 58 41  43 28 08  2000
 74 Gaia15agc           12 18 23  35 37 06  2000
 75 Gaia15agh           12 04 05  14 04 05  2000
 76 Gaia16apd           12 02 52  44 15 27  2000
 77 Gaia16abw              10 33 51  60 51 07  2000
 78 Gaia16alt           21 43 04  66 07 44  2000
 79 Gaia16aye           19 40 01  30 07 53  2000
 80 Gaia16bbi           23 59 16  22 03 01  2000
 81 Gaia16bbz           19 16 39  46 21 07  2000
 82 %Comet_ISON 06.03.2013:
 83 Comet_ISON          06 47 00  31 24 22  2000
 84 Comet_PS            00 34 32  11 07 00  2000
 85 CZ_Cam              03 58 44  69 01 00  2000
 86 DI_Cam              04 28 42  79 42 06  2000
 87 %Comet_Lovejoy 31.12.2013 4UT:
 88 Lovejoy             17 26 41  20 39 42  2000
 89 CygOB2              20 33 04  41 18 00  2000
 90 del_Ser             15 34 48  10 32 20  2000
 91 Dembowska           10 33 29  15 08 27  2000
 92 EE_Cep              22 09 23  55 45 24  2000
 93 eps_Cep             22 15 02  57 02 37  2000
 94 FG_Sge              20 11 56  20 20 06  2000
 95 FR1                  4 30  0  55  0  0  2000
 96 G93_48              21 52 26  02 23 00  2000
 97 Gaia14aaa           13 21 02  45 28 26  2000
 98 GSC0321             14 29 15   2 30 06  2000
 99 GSC2566                15 22 22  32 58 45  2000
100 GSC2977              8 19 18  41 59 00  2000
101 GSC2988              8 46 10  43 04 31  2000
102 GSC3004             10 21 35  40 31 41  2000
103 GSC3832             11 48 42  54 43 08  2000
104 GSC3863             14 41 38  56 26 17  2000
105 GSC4552             11 24 25  77 42 16  2000
106 GSC4556             12 03 17  80 33 43  2000
107 HD256413            06 24 02  19 54 32  2000
108 QSOB1215            12 17 52  30 07 00  2000
109 Saturn              13 32 14  -6 43 00  2000
110 Veil                20 45 44  31 02 11  2000
111 M71                 19 53 47  18 46 45  2000
112 NovaCep2014         20 54 24  60 17 07  2000
113 NvCyg2014           20 21 43  31 03 30  2000
114 NGC6543             17 58 34  66 38 00  2000
115 NGC7662             23 25 54  42 32 06  2000
116 NGC7640             23 22 07  40 50 43  2000
117 NGC7318             22 35 58  33 57 56  2000
118 PTF12gzk            22 12 42  00 30 43  2000
119 PSN0413+2528        04 13 38  25 28 46  2000
120 R1_Lovejoy          16 35 00  30 45 00  2013.95
121 RRCaeli             04 21 06 -48 39 07  2000
122 TY_UMi              15 17 57  83 51 34  2000
123 V454_Aur            06 22 03  34 35 50  2000
124 V455_Aur            06 28 54  52 07 33  2000
125 V572_Per            03 15 49  50 57 21  2000
126 V821_Cas            23 58 49  53 40 19  2000
127 V1125_Tau           03 38 59  00 47 48  2000
128 FK_Dra              12 30 12  63 53 21  2000
```

4) Setting FITS headers to standards

```
mikolajczyk@winston:~/Pulpit/DAY1$ cd BIALKOW_test_files/
mikolajczyk@winston:~/Pulpit/DAY1/BIALKOW_test_files$ ls *fits > in.cat
mikolajczyk@winston:~/Pulpit/DAY1/BIALKOW_test_files$ cat in.cat
BH_Oph-0296.fits
Gaia18anr-0129.fits
NGC6823-0336.fits
WZ_Oph-0151.fits
mikolajczyk@winston:~/Pulpit/DAY1/BIALKOW_test_files$ ../std_hdr.py -f in.cat -o BIALKOW --verbose
[PROCESS] Handling headers...
[WARNING] BH_Oph-0296.fits: Found no matching object name in 'objpos.dat'! Trying SESAME... [OK]
[INFO] Updated 'objpos.dat' with new object: BH_Oph
[OK] BH_Oph-0296.fits > BH_Oph-0296h.fits
[WARNING] Gaia18anr-0129.fits: Found no matching object name in 'objpos.dat'! Trying SESAME... [ERROR]  Tryi
ng Gaia Alerts Server... [OK]
[INFO] Updated 'objpos.dat' with new object: Gaia18anr
[OK] Gaia18anr-0129.fits > Gaia18anr-0129h.fits
[OK] NGC6823-0336.fits > NGC6823-0336h.fits
[WARNING] WZ_Oph-0151.fits: Found no matching object name in 'objpos.dat'! Trying SESAME... [OK]
[INFO] Updated 'objpos.dat' with new object: WZ_Oph
[OK] WZ_Oph-0151.fits > WZ_Oph-0151h.fits
[DONE]
mikolajczyk@winston:~/Pulpit/DAY1/BIALKOW_test_files$ ls *fits
BH_Oph-0296.fits   Gaia18anr-0129.fits   NGC6823-0336.fits   WZ_Oph-0151.fits
BH_Oph-0296h.fits  Gaia18anr-0129h.fits  NGC6823-0336h.fits  WZ_Oph-0151h.fits
mikolajczyk@winston:~/Pulpit/DAY1/BIALKOW_test_files$ ../std_hdr.py -f in.cat -o BIALKOW --verbose --names
[PROCESS] Handling headers...
[OK] BH_Oph-0296.fits > BIALKOW_BH_Oph_58258.02825.fits
[OK] Gaia18anr-0129.fits > BIALKOW_Gaia18anr_58257.88135.fits
[OK] NGC6823-0336.fits > BIALKOW_NGC6823_58258.06774.fits
[OK] WZ_Oph-0151.fits > BIALKOW_WZ_Oph_58257.93002.fits
[DONE]
mikolajczyk@winston:~/Pulpit/DAY1/BIALKOW_test_files$ ls *fits
BH_Oph-0296.fits                  BIALKOW_NGC6823_58258.06774.fits  NGC6823-0336.fits
BH_Oph-0296h.fits                 BIALKOW_WZ_Oph_58257.93002.fits   NGC6823-0336h.fits
BIALKOW_BH_Oph_58258.02825.fits   Gaia18anr-0129.fits               WZ_Oph-0151.fits
BIALKOW_Gaia18anr_58257.88135.fits Gaia18anr-0129h.fits             WZ_Oph-0151h.fits
mikolajczyk@winston:~/Pulpit/DAY1/BIALKOW_test_files$
```

4) Setting FITS headers to standards

BH_Oph-0296.fits

File Edit Font

```
SIMPLE  = T
BITPIX  = 16
NAXIS   = 2
NAXIS1  = 1250
NAXIS2  = 1152
BSCALE  = 1.00000
BZERO   = 32768.00000
OBS-DATE= '20/05/2018'
UT      = '00:40:28'
EXPOSURE= 25.000
DATA-TYP= 'OBJECT'
FILTER  = 'V'
GAIN    = 16  // Speed in microsec/pix
BIN     = 1
CCDTEMP = -50.0 C
OBJECT  = BH_Oph
OBSERVER= PM
ORIGIN  = Bialkow Observatory
END
```

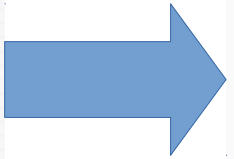
BH_Oph-0296h.fits

File Edit Font

```
SIMPLE  = T
BITPIX  = 16
NAXIS   = 2
NAXIS1  =                 1250 / pixels
NAXIS2  =                 1152 / pixels
BSCALE  = 1.00000
BZERO   = 32768.00000
OBS-DATE= '20/05/2018'
UT      = '00:40:28'
EXPOSURE= 25.000
DATA-TYP= 'OBJECT'
FILTER  = ' V      '           / passband ID
CCDTEMP = '-50.0 C '
ORIGIN  = 'Bialkow Observatory' / institution ID
OBSERVAT= 'BIALKOW '           / observatory ID
LONGITUD=           343.341944 / deg
LATITUDE=            51.474167 / deg
ALTITUDE=                150.0 / meters
TELESCOP= 'Cassegrain_0.6'     / telescope ID
TIMESYS = 'UTC     '           / used time standard
INSTRUME= 'ANDOR_CCD'          / camera ID
BIN     =                    1 / no binning
CDELT1  =            0.0001702 / deg/pix
CDELT2  =            0.0001702 / deg/pix
ORIENTAT=                  0.0 / deg
PIXSIZE1=                 22.5 / microm
PIXSIZE2=                 22.5 / microm
CRPIX1  =                  625 / X reference pixel
CRPIX2  =                  575 / Y reference pixel
EQUINOX =               2000.0 / year
RADECSYS= 'FK5     '           / coord. ref. system
CTYPE1  = 'RA---TAN'           / RA projection type
CTYPE2  = 'DEC--TAN'           / DEC projection type
CUNIT1  = 'deg     '           / RA unit
CUNIT2  = 'deg     '           / DEC unit
OBSERVER= 'PM      '           / observer ID
DATE-OBS= '2018-05-20T00:40:28.0' / date & time (beginning of exposition)
TIME-OBS= '00:40:28'           / time (beginning of exposition)
EXPTIME =                 25.0 / seconds
OBSTYPE = 'OBJECT  '           / type of data
```

4) Setting FITS headers to standards

528	ASAS192622+4915.5	19	26	22	49	15	30	2000
529	ASAS194028+4844.0	19	40	28	48	44	00	2000
530	ASAS194436+4739.2	19	44	36	47	39	12	2000
531	ASAS194528+4337.7	19	45	28	43	37	42	2000
532	ASAS194654+4504.8	19	46	54	45	04	48	2000
533	ASAS195131+4941.7	19	51	31	49	41	42	2000
534	ASAS195751+4512.7	19	57	51	45	12	42	2000
535	ASAS200116+4432.1	20	01	16	44	32	06	2000
536	ASASSN13ck	00	11	34	04	51	23	2000
537	ASASSN13dd	9	7	37	3	23	40	2000
538	M31	00	43	27	41	20	16	2000
539	FLAT	00	00	00	00	00	00	2000



528	ASAS192622+4915.5	19	26	22	49	15	30	2000
529	ASAS194028+4844.0	19	40	28	48	44	00	2000
530	ASAS194436+4739.2	19	44	36	47	39	12	2000
531	ASAS194528+4337.7	19	45	28	43	37	42	2000
532	ASAS194654+4504.8	19	46	54	45	04	48	2000
533	ASAS195131+4941.7	19	51	31	49	41	42	2000
534	ASAS195751+4512.7	19	57	51	45	12	42	2000
535	ASAS200116+4432.1	20	01	16	44	32	06	2000
536	ASASSN13ck	00	11	34	04	51	23	2000
537	ASASSN13dd	9	7	37	3	23	40	2000
538	M31	00	43	27	41	20	16	2000
539	FLAT	00	00	00	00	00	00	2000
540	BH_Oph	18	15	51	12	5	44	2000
541	Gaia18anr	6	18	3	78	22	1	2000
542	WZ_Oph	17	6	39	7	46	58	2000

4) Other useful scripts

modify_header.py

```
    modify_header.py (PM, 17.03.18)
    Program modifies / appends FITS header value of a given key.
    Usage: modify_header.py -f <file> -k <keyword> -v <value> [-l]
    Requires: Python 2.7+, PyFITS, style.py (PM), func.py (PM)
    Example: modify_header.py -f in.lst -k OBJECT -v NGC6811 -l

optional arguments:
  -h, --help            show this help message and exit
  -f FILE, --file FILE  : list of FITS files to be processed
  -k KEY, --key KEY     : desired key
  -v VAR, --value VAR   : desired value
  -l, --list            : processing list of files
```

fits_invert.py

```
    'fits_invert.py' (PM, 17.03.18)
    Program inverts X axis and Y axis in FITS data.
    Usage: fits_invert.py -f <file> [-l] [-x] [-y] [-u] [-v]
    Requires: Python 2.7+, PyFITS, style.py (PM), func.py (PM)
    Example: fits_invert.py -f King10-231-bdtfah.fits -y --update

optional arguments:
  -h, --help            show this help message and exit
  -f FILE, --file FILE  : list of FITS files to be processed
  -l, --list            : processing list of files
  -x, --x               : inverts only X axis
  -y, --y               : inverts only Y axis
  -u, --update          : processing list of files
  -v, --verbose         : enables prompt messages
```


Thank you!

Przemysław Mikołajczyk

mikolajczyk@astro.uni.wroc.pl

"Useful Python packages for astronomy"

II. FITS files & simple statistics

Spectroscopic Summer School

26 - 29 June 2018, Wrocław, Poland

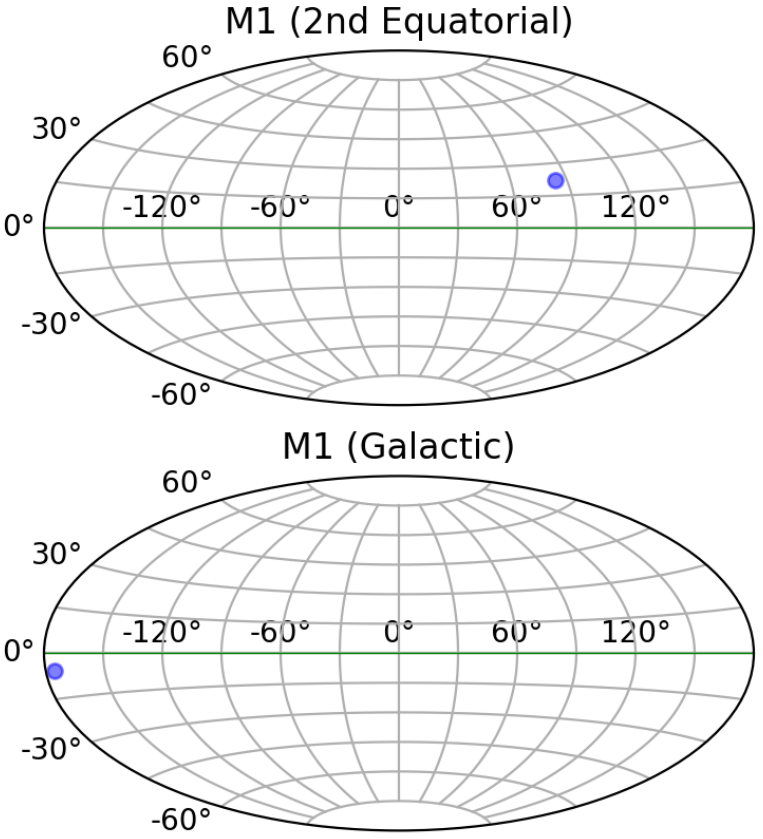
0) What do you need?

→ standard Python 2.6+ environment
→ astropy (already used by iSpec)
→ array_split
→ plotly
→ photutils

If one or more libraries are missing, use **pip:**
pip install package_name

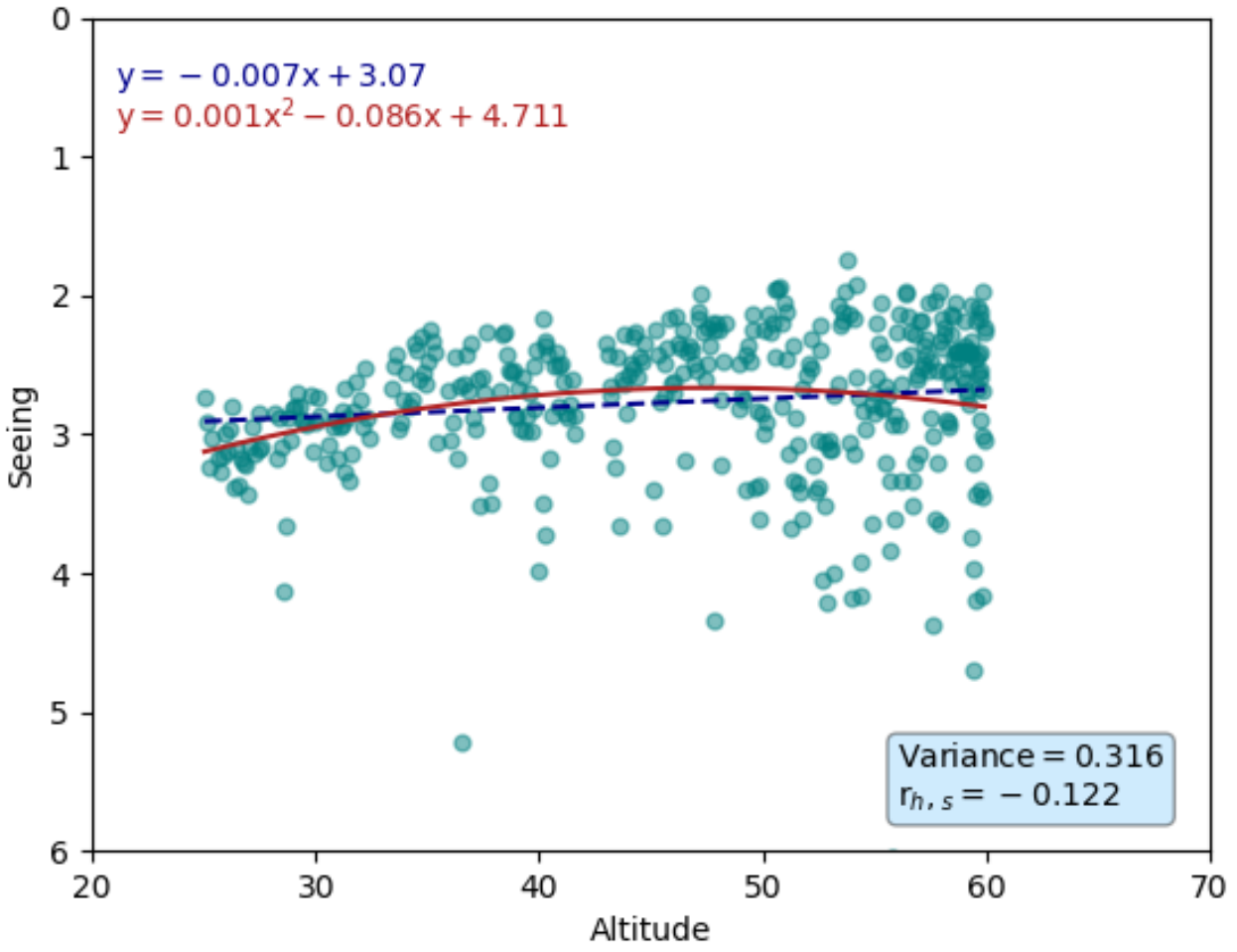
1) Where is your object located on the sky?

python show_objects.py OBJECT



2) Performing simple statistics

python work_with_stats.py WASP-14b_h_seeing.data

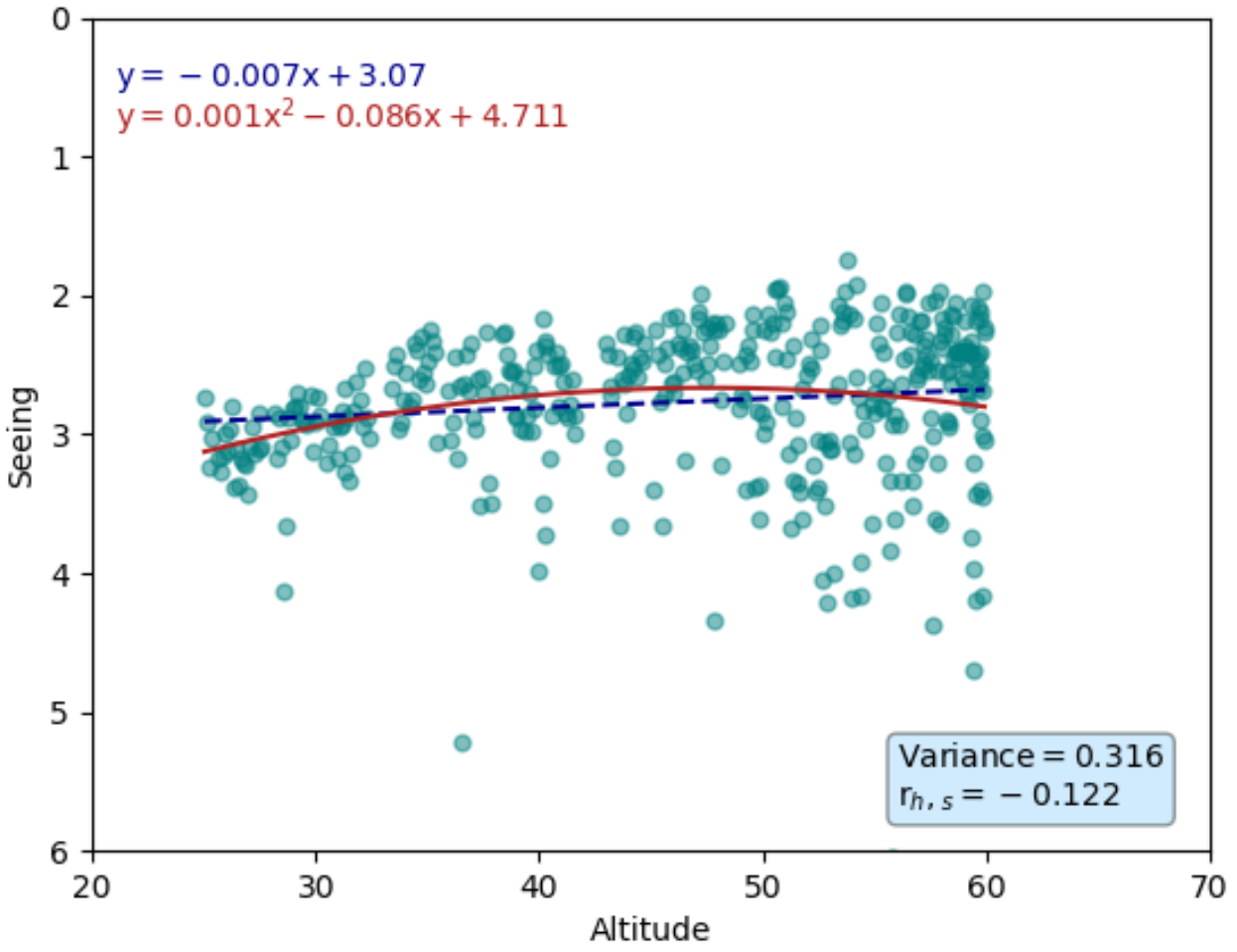


2) Performing simple statistics

```
try:
    plik = open(args.nazwa_pliku)
    dane = plik.read()
    plik.close()
except IOError:
        print '\nNie ma pliku o tej nazwie.'
try:
    horyzont, seeing = np.genfromtxt(BytesIO(dane), usecols=[0,1], dtype=float,\
    unpack=True) # zczytywanie kolumn
    nachylenie, przeciecie, wspol_korelacji, pvalue, blad_std = \
    stats.linregress(horyzont, seeing) # regresja liniowa
    wielomian = np.polyfit(horyzont, seeing, 2) # wielomian drugiego stopnia
    # wyliczenie wariancji resztowej
    suma = 0
    for i in range(len(horyzont)):
        suma = (seeing[i] - nachylenie * horyzont[i] - przeciecie)**2 + suma
    wariancja = (suma/(len(horyzont) - 2))
    # wykres
    ramka = dict(boxstyle='round', facecolor='lightskyblue', alpha=0.4)
    tekst = '$\mathrm{Variance}=%.3f$\n$\mathrm{r}_h,_s=%.3f$' % (wariancja, \
    wspol_korelacji)
    tekst2 = '$\mathrm{y}=%.3f$$\mathrm{x}+%.2f$' % (nachylenie, przeciecie)
    tekst3 = '$\mathrm{y}=%.3f$$\mathrm{x}^2%.3f$$\mathrm{x}+%.3f$'% \
    (wielomian[0], wielomian[1], wielomian[2])
    plt.plot(horyzont, seeing, 'o', markersize=5, color='teal', alpha=0.5)
    plt.axis([20, 70, 6, 0])
    plt.plot(horyzont, przeciecie + nachylenie * horyzont, '--', color='darkblue')
    plt.plot(horyzont, np.polyval(wielomian, horyzont), color='firebrick')
    plt.text(56, 5.7, tekst, color='black', fontsize=10, bbox=ramka)
    plt.text(21, 0.5, tekst2, color='darkblue', fontsize=10)
    plt.text(21, 0.8, tekst3, color='firebrick', fontsize=10)
    plt.xlabel(u'Altitude')
    plt.ylabel(u'Seeing')
    plt.savefig('seeing.png')
    plt.show()
except NameError:
    print '\nOjej...'
```

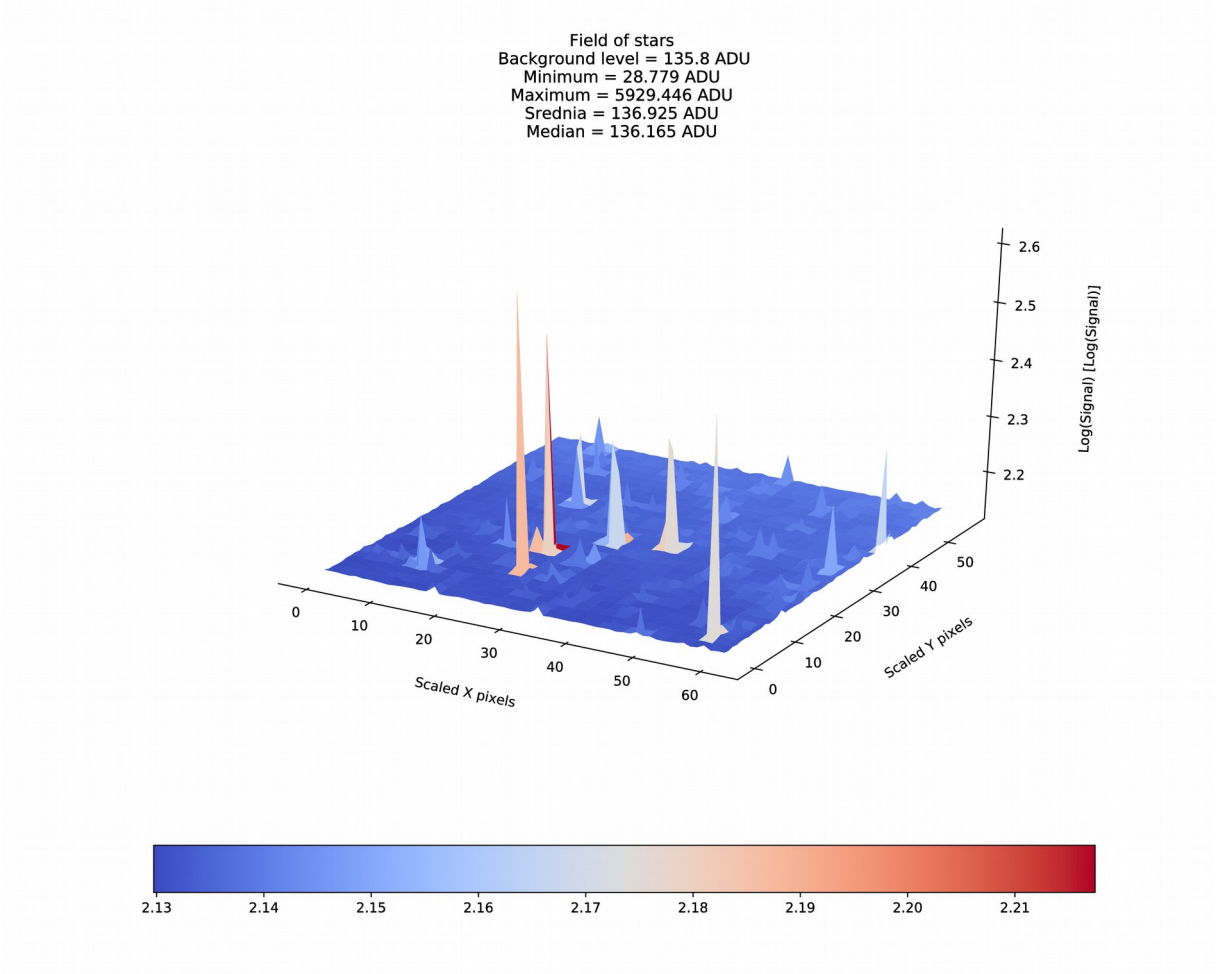
2) Performing simple statistics

python work_with_stats.py WASP-14b_h_seeing.data



3) Displaying your FITS file in a different way

python work_with_FITS.py FITS_FILE




Thank you!