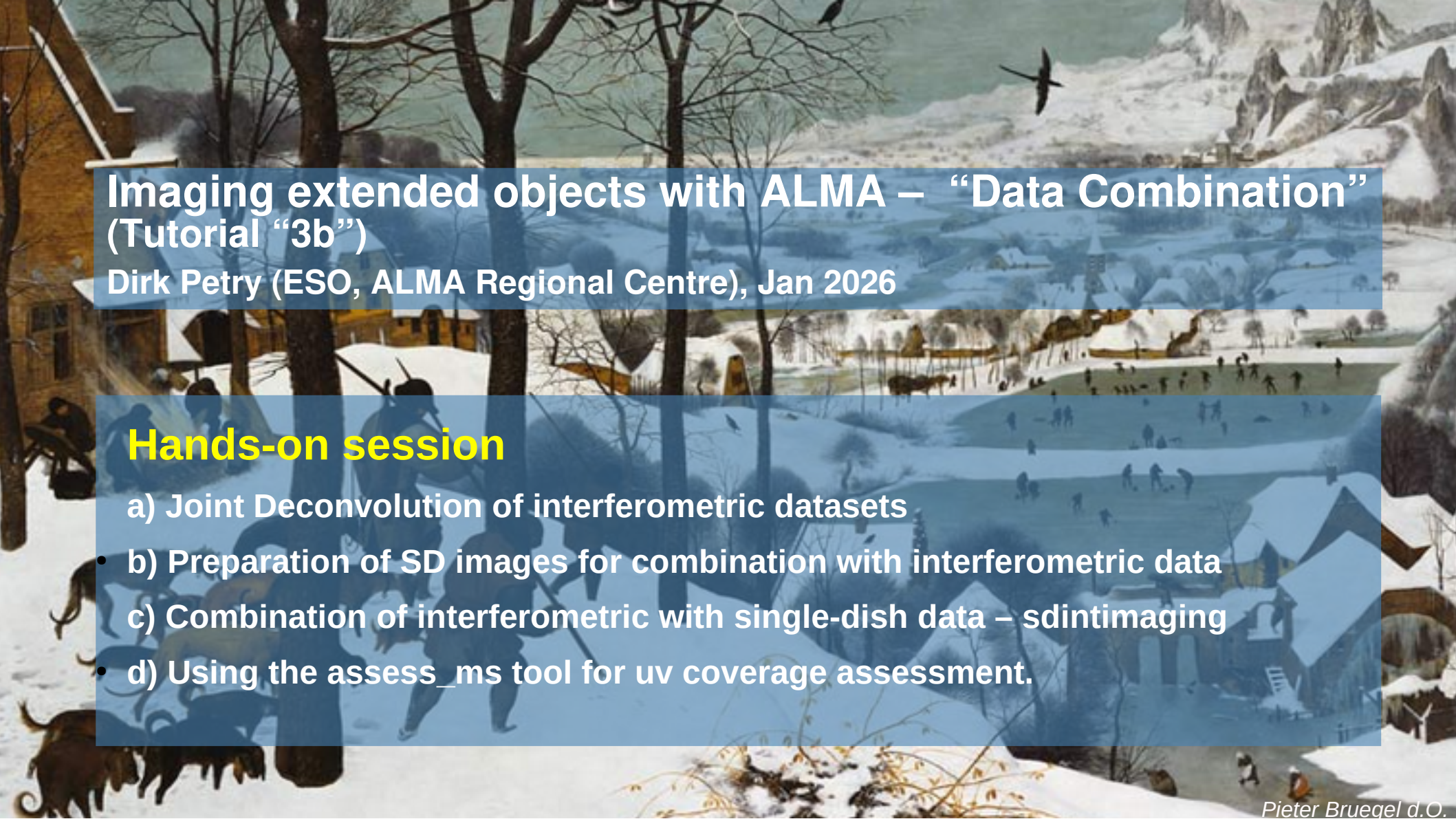


Imaging extended objects with ALMA – "Data Combination" (Tutorial "3b")

Dirk Petry (ESO, ALMA Regional Centre), Jan 2026

Hands-on session

a) Joint Deconvolution of interferometric datasets

- b) Preparation of SD images for combination with interferometric data

c) Combination of interferometric with single-dish data – sdintimaging

- d) Using the assess_ms tool for uv coverage assessment.

Pieter Bruegel d.O.

TUTORIAL 3B - DATA COMBINATION

All sessions in room BW0.32, Total time: 4.5 h

11:00 - 12:30 h:
- Intro lecture: Imaging extended objects with ALMA
- Q&A

Slides: Leiden-DataCombinationIntro-dpetry-Jan2026.pdf

13:30 h - 15:00 h::
- Setup for hands-on tutorial
- Joint deconvolution of TM and 7M MOUSs
- Start of Combination of interferometric and SD data

Slides: Leiden-DataCombinationHandsOn-dpetry-Jan2026.pdf

Leiden-DataCombination-sdintimaging-Jan2026.pdf
(lecture during long exec times of sdintimaging/tclean)

Script: leiden-tutorial3b.py
(up to launching second sdintimaging)

15:30 h - 17:00 h:
- Combination of interferometric and SD data (continued)
- uv coverage assessment

Slides: Leiden-DataCombination-assess_ms3-Jan2026.pdf

Scripts: leiden-tutorial3b.py
(final steps: image analysis with imview, sdgain tests)

leiden-tutorial3b-supplement.sh
(assess_ms)

ALMA – geared towards data combination

ALMA delivers Groups of MOUSs which still need combination.
Possible combinations are (ordered by angular resolution):

TM1	**+**	***TM2***					
TM1	**+**	***TM2***	**+**	***7M***			
TM1	**+**	***TM2***	**+**	***7M***	**+**	***TP***	
		TM1	**+**	***7M***			
		TM1	**+**	***7M***	**+**	***TP***	
				7M	**+**	***TP***	

If ALMA TP not available, use SD data from other observatories!

Two basic combination methods needed:

1) **Combination of interferometric data from different arrays**
   Visibilities + Visibilities

2) **Combination of interferometric data with single-dish data**
   Visibilities + Image
   or Visibilities + Visibililties + Image (if there is more than one INT dataset)

Data Combination Hands-On Session

Possible MOUS combinations in ALMA GOUSs:

TM1	***+***	***TM2***					
TM1	***+***	***TM2***	***+***	***7M***			
TM1	***+***	***TM2***	***+***	***7M***	***+***	***TP***	
		TM1	***+***	***7M***			
		TM1	***+***	***7M***	***+***	***TP***	
				7M	***+***	***TP***	

We use as example for both hands-on sessions a GOUS of the most general case:

TM1 + TM2 + 7M + TP

2017.1.01355.L (ALMA Cycle 5), GOUS uid___A001_X1296_X1a2 consisting of

MOUS	***SB Name***
uid___A001_X1296_X1a3	***G333.60_a_03_TM1***
uid___A001_X1296_X1a5	***G333.60_a_03_TM2***
uid___A001_X1296_X1a7	***G333.60_a_03_7M***
uid___A001_X1296_X1a9	***G333.60_a_03_TP***

Data Combination Hands-On Session: Joint Deconvolution

Joint deconvolution is needed in all ALMA GOUS types except 7M+TP:

TM1	***+***	***TM2***				
TM1	***+***	***TM2***	***+***	***7M***		
TM1	***+***	***TM2***	***+***	***7M***	***+***	***TP***
		TM1	***+***	***7M***		
		TM1	***+***	***7M***	***+***	***TP***

Data Combination Hands-On Session: Joint Deconvolution

Joint deconvolution is needed in all ALMA GOUS types except 7M+TP:

TM1	**+**	***TM2***				
TM1	**+**	***TM2***	**+**	***7M***		
TM1	**+**	***TM2***	**+**	***7M***	**+**	***TP***
		TM1	**+**	***7M***		
		TM1	**+**	***7M***	**+**	***TP***
				7M	+	*TP*

*If no TP data is involved, we speak of **pure joint deconvolution** and can use **task "tclean" with gridder "mosaic".***

In our example we just omit the TP data and jointly deconvolve TM1+TM2+7M

MOUS	***SB Name***
uid___A001_X1296_X1a3	***G333.60_a_03_TM1***
uid___A001_X1296_X1a5	***G333.60_a_03_TM2***
uid___A001_X1296_X1a7	***G333.60_a_03_7M***

Data Combination Hands-On Session

If you wanted to start our example from scratch,
you would need to obtain the following calibrated MSs:

uid___A002_Xc8ed16_X5c3d.ms.split.cal.tgz (TM1)

uid___A002_Xcd07af_X41d5.ms.split.cal.tgz (TM2)

uid___A002_Xc6ff69_X41e4.ms.split.cal.tgz (7M)
uid___A002_Xc7a409_X342e.ms.split.cal.tgz (7M)
uid___A002_Xc74b5b_X458a.ms.split.cal.tgz (7M)
uid___A002_Xc74b5b_X4102.ms.split.cal.tgz (7M)
uid___A002_Xc790bf_X4ea0.ms.split.cal.tgz (7M)

Data Combination Hands-On Session

Our example: the N_2H^+ (v=0, J=1-0) line at 93.173397 GHz, in a galactic star forming region

To make the problem tractable in the short time of this tutorial,
we only look at a small spectral region around the line.

The line is at -47 km/s. We image 30 channels from -50 km/s to -45 km/s.

The following analysis steps *have already been performed* for you on the 12M and 7M data:

- determination of the continuum channels
- uvcontsub
- split out the SPW and field of interest
- concat of the split-out MSs into one MS containing all relevant 12M and 7M data

Next step (our first step): Joint Deconvolution of the concatenated MS

Data Combination Hands-On Session: Joint Deconvolution

Joint Deconvolution of the concatenated MS

Three purposes:

1) demonstrate the joint deconvolution

2) obtain and *verify* the deconvolution (tclean) parameters for the later run of sdintimaging (shares most parameters with tclean)

3) obtain a dirty image to measure RMS and have a template image for the imregrid of the SD image

Data Combination Hands-On Session

All necessary commands for the datacombination session are collected in the file

```
/almastorage/allegro/data/projects/ztuim1kb/data_products/tutorial3b-data_combination/
   leiden-tutorial3b.py
```

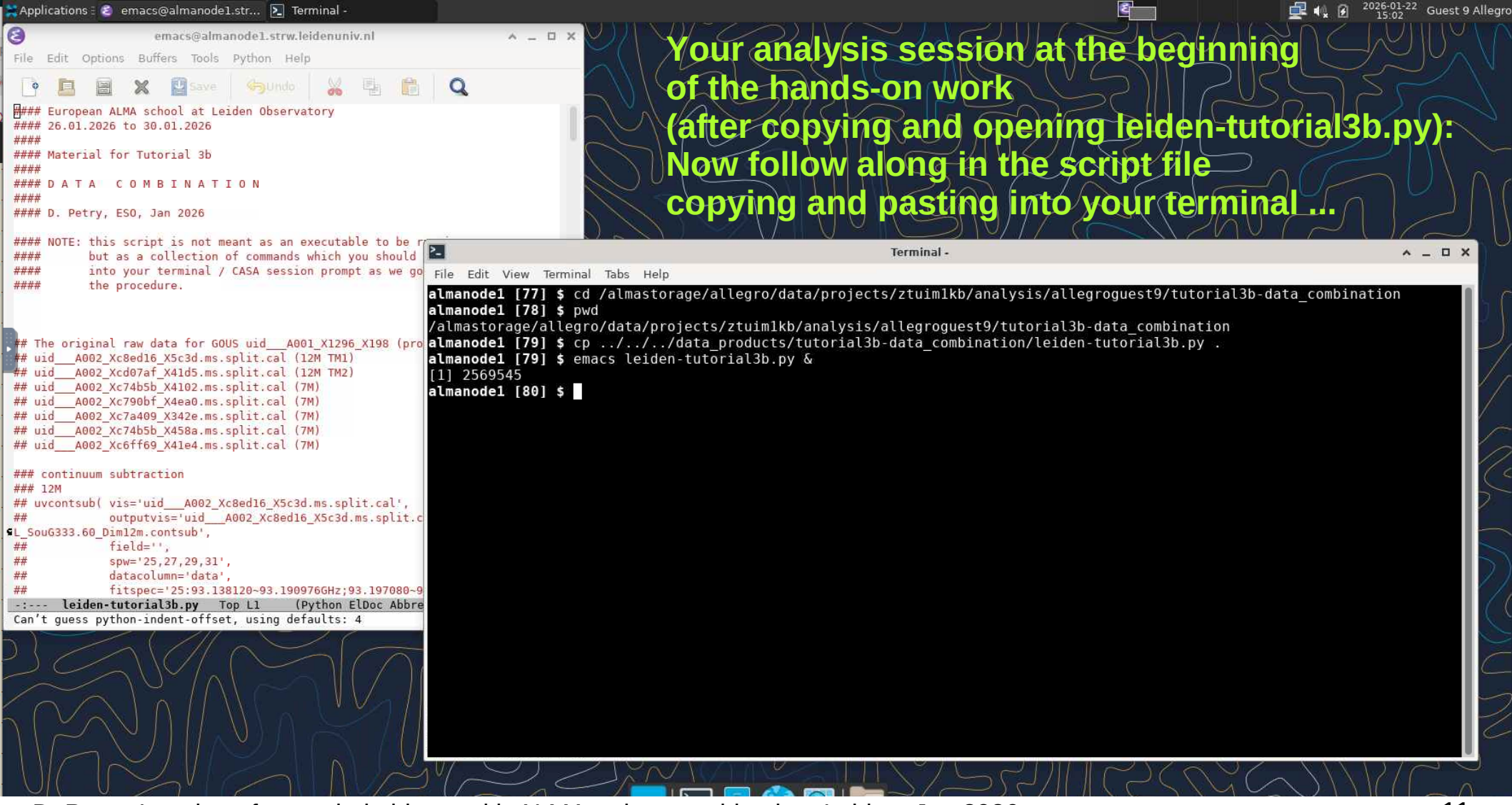
Copy this file into your working directory:

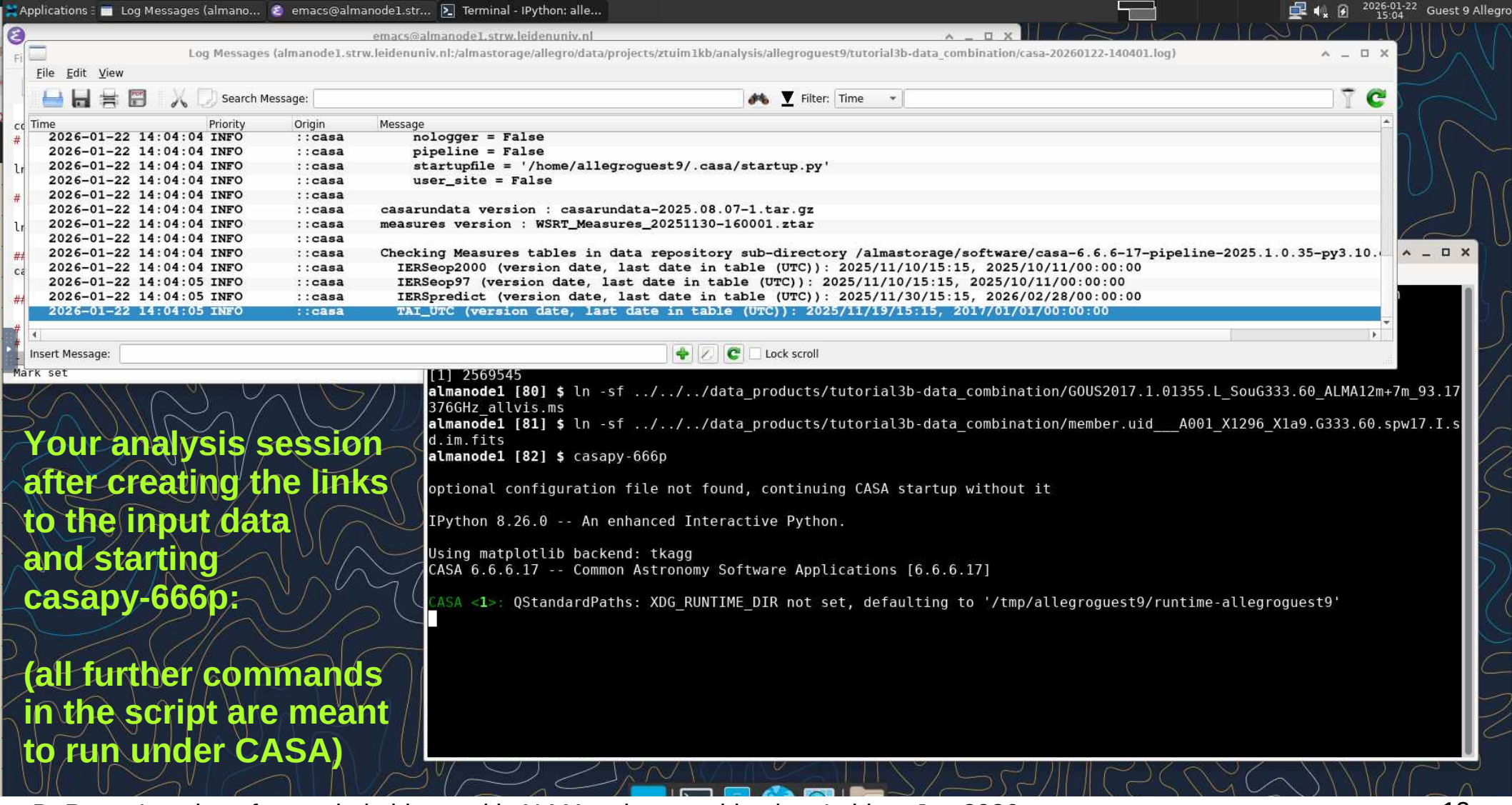
```
cd /almastorage/allegro/data/projects/ztuim1kb/analysis/$USER/tutorial3b-data_combination

cp ../../../data_products/tutorial3b-data_combination/leiden-tutorial3b.py .
```

and open it in an editor (e.g. emacs).

(Beginning of the hands-on part)

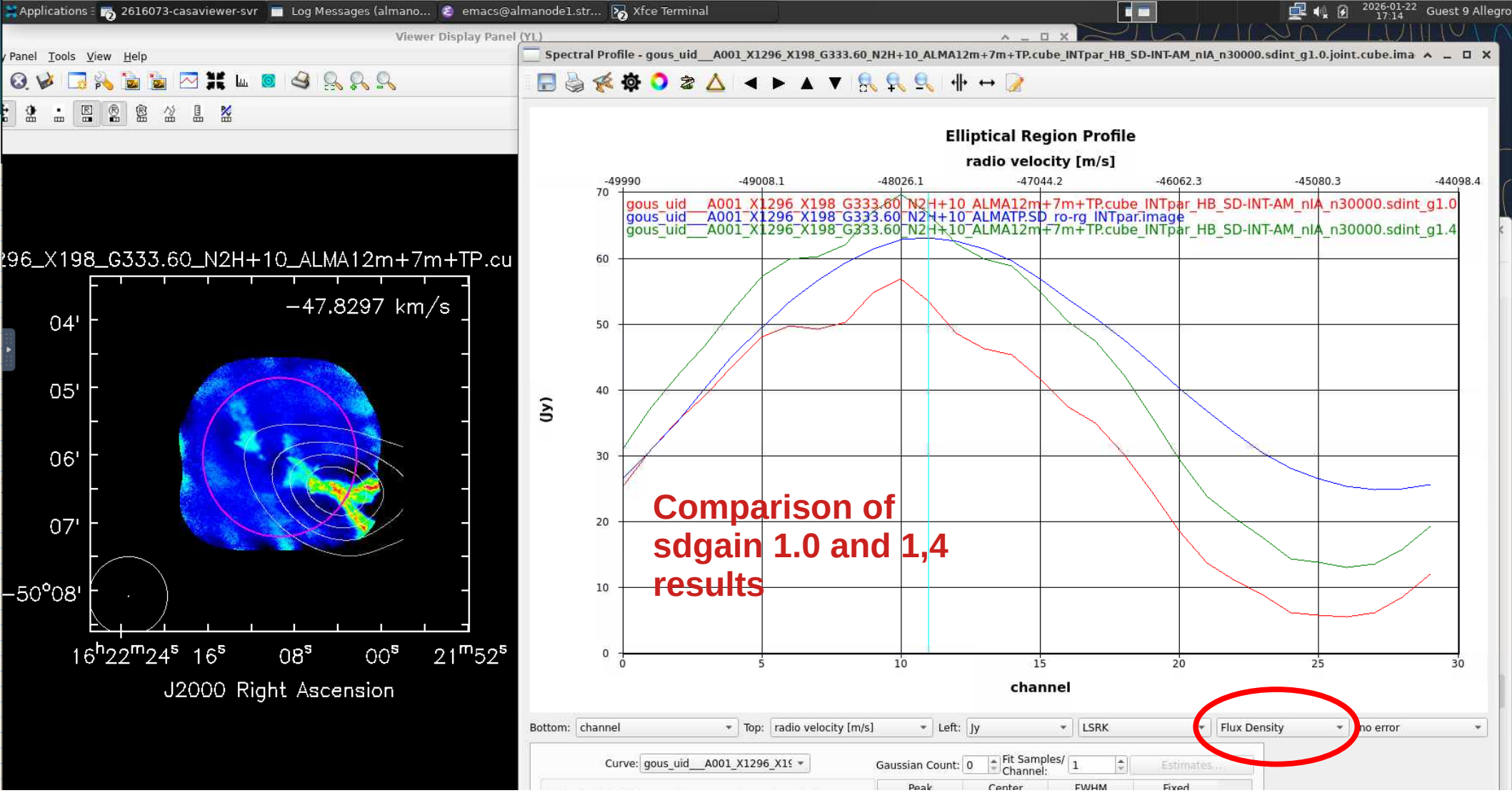
(During waiting periods, we will learn more about sdintimaging and uv coverage assessment.)


Applications
emacs@almanode1.str...
Terminal -
2026-01-22
15:02
Guest 9 Allegro
emacs@almanode1.strw.leidenuniv.nl
File Edit Options Buffers Tools Python Help
Save Undo
European ALMA school at Leiden Observatory
26.01.2026 to 30.01.2026
####
Material for Tutorial 3b
####
D A T A C O M B I N A T I O N
####
D. Petry, ESO, Jan 2026
NOTE: this script is not meant as an executable to be r
but as a collection of commands which you should
into your terminal / CASA session prompt as we go
the procedure.
The original raw data for GOUS uid___A001_X1296_X198 (pro
uid___A002_Xc8ed16_X5c3d.ms.split.cal (12M TM1)
uid___A002_Xcd07af_X41d5.ms.split.cal (12M TM2)
uid___A002_Xc74b5b_X4102.ms.split.cal (7M)
uid___A002_Xc790bf_X4ea0.ms.split.cal (7M)
uid___A002_Xc7a409_X342e.ms.split.cal (7M)
uid___A002_Xc74b5b_X458a.ms.split.cal (7M)
uid___A002_Xc6ff69_X41e4.ms.split.cal (7M)
continuum subtraction
12M
uvcontsub(vis='uid___A002_Xc8ed16_X5c3d.ms.split.cal',
outputvis='uid___A002_Xc8ed16_X5c3d.ms.split.c
L_SouG333.60_Dim12m.contsub',
field='',
spw='25,27,29,31',
datacolumn='data',
fitspec='25:93.138120~93.190976GHz;93.197080~9
-:--- leiden-tutorial3b.py Top L1 (Python ElDoc Abbre
Can't guess python-indent-offset, using defaults: 4
Your analysis session at the beginning
of the hands-on work
(after copying and opening leiden-tutorial3b.py):
Now follow along in the script file
copying and pasting into your terminal ...
Terminal -
File Edit View Terminal Tabs Help
almanode1 [77] $ cd /almastorage/allegro/data/projects/ztuim1kb/analysis/allegroguest9/tutorial3b-data_combination
almanode1 [78] $ pwd
/almastorage/allegro/data/projects/ztuim1kb/analysis/allegroguest9/tutorial3b-data_combination
almanode1 [79] $ cp ../../../data_products/tutorial3b-data_combination/leiden-tutorial3b.py .
almanode1 [79] $ emacs leiden-tutorial3b.py &
[1] 2569545
almanode1 [80] $



Your analysis session after creating the links to the input data and starting casapy-666p:

(all further commands in the script are meant to run under CASA)


Applications
2616073-casaviewer-svr
Log Messages (almano...
emacs@almanode1.str...
Xfce Terminal
Viewer Display Panel (YL)
Panel Tools View Help
296_X198_G333.60_N2H+10_ALMA12m+7m+TP.cu
−47.8297 km/s
04'
05'
06'
07'
−50°08'
16h22m24s 16s 08s 00s 21m52s
J2000 Right Ascension
Spectral Profile - gous_uid___A001_X1296_X198_G333.60_N2H+10_ALMA12m+7m+TP.cube_INTpar_HB_SD-INT-AM_nIA_n30000.sdint_g1.0.joint.cube.ima
Elliptical Region Profile
radio velocity [m/s]
-49990
-49008.1
-48026.1
-47044.2
-46062.3
-45080.3
-44098.4
gous_uid___A001_X1296_X198_G333.60_N2H+10_ALMA12m+7m+TP.cube_INTpar_HB_SD-INT-AM_nIA_n30000.sdint_g1.0
gous_uid___A001_X1296_X198_G333.60_N2H+10_ALMATP.SD_ro-rg_INTpar.image
gous_uid___A001_X1296_X198_G333.60_N2H+10_ALMA12m+7m+TP.cube_INTpar_HB_SD-INT-AM_nIA_n30000.sdint_g1.4
(Jy)
channel
Comparison of sdgain 1.0 and 1,4 results
Bottom: channel
Top: radio velocity [m/s]
Left: Jy
LSRK
Flux Density
no error
Curve: gous_uid___A001_X1296_X1
Gaussian Count: 0
Fit Samples/ Channel: 1
Estimates...
Peak
Center
FWHM
Fixed
2026-01-22 17:14
Guest 9 Allegro