9.2 Appendix B – Processing steps

In the following pages, figures of the different processing stages are shown with detail such as specific settings.

9.2.1 Data input and header assignment

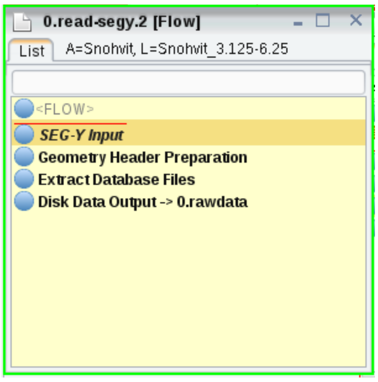

Figure 1 – Configuration in ProMAX for the "upload the SEG-Y file" flow, and load the database.

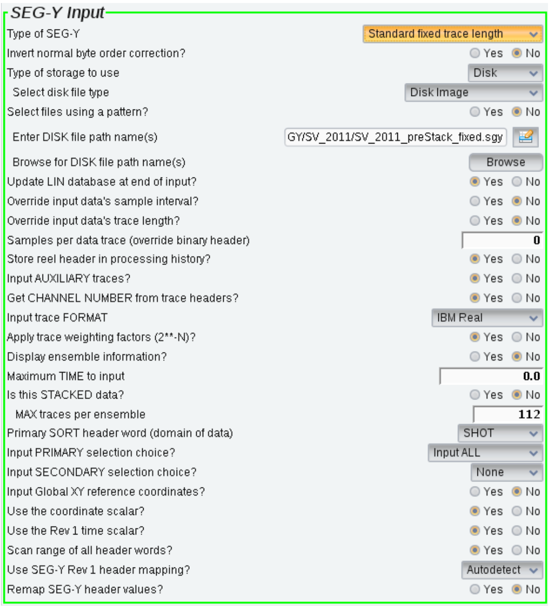

Figure 2 – SEG-Y input settings.

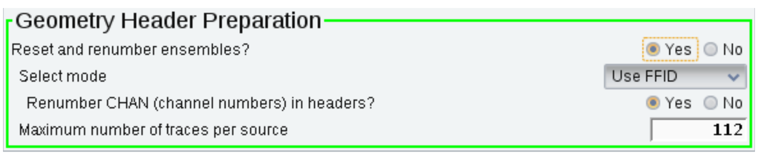

Figure 3 – Geometry header Preparation.

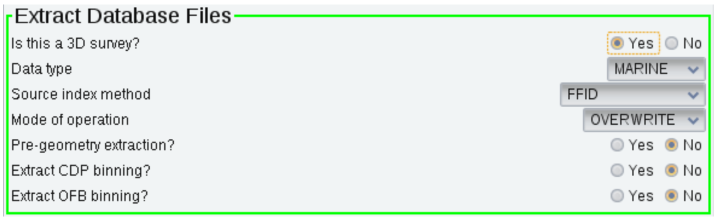

Figure 4 –Extraxt Data base Files; which updates the database.

9.2.2 Geometry assignment and Binning

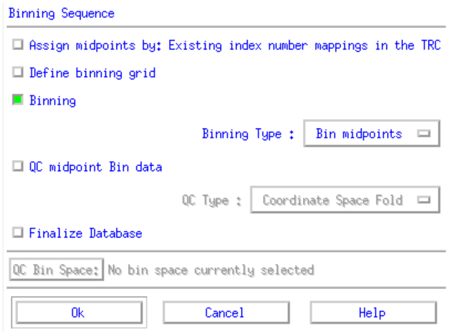

Figure 5 – Binning sequence settings part of geometry spreadsheet.

Figure 6 – Definition of bin size and numbers of dx and dy cells. This example show grid bin x equal to 6.25 and for y 3.125 m.

Mark Block	Rec X*	Rec Y*	Rec Depth	Offset*	Azimuth*	Channel*	CHN_LTBL*	SIN*	SIN_LTBL*	SRF*	SRF_LTBL*	CDP*	CDP_LTBL*	ILN*	ILN_LTBL*	XLN*	XLN_LTBL*	OFB*	OFB_LTBL*	FB Pick
1	713636.7	7960036.5	0.0	128.0	201.0	1	1	1	1				781767		128355		1473512		4856	
2	713638.1	7960034.0	0.0	129.8	200.0	2	113	1	2				785234		129697		1473519		4863	
3	713639.4	7960031.0	0.0	132.2	199.0	3	225	1	3				781763		129699		1473520		4864	
4	713640.8	7960028.5	0.0	134.1	198.1	4	337	1	4				781764		129700		1473526		4870	
5	713642.2	7960025.5	0.0	136.6	197.2	5	449	1	5				778408		129701		1473527		4871	
6	713647.9	7960031.0	0.0	129.7	195.5	6	561	1	6				781761		129702		1473534		4872	
7	713649.2	7960028.5	0.0	131.8	194.6	7	673	1	7				781762		129703		1473535		4879	
8	713650.6	7960025.5	0.0	134.3	193.7	8	785	1	8				778406		130929		1473542		4880	
9	713652.0	7960022.5	0.0	136.9	192.9	9	897	1	9				778407		130930		1473543		4881	
10	713643.6	7960022.5	0.0	139.0	196.2	10	1009	1	10				778404		130931		1473552		4893	
11	713645.0	7960020.0	0.0	141.1	195.4	11	1121	1	11				778405		130932		1477077		4894	
12	713646.3	7960017.0	0.0	143.6	194.6	12	1233	1	12				774936		130933		1477079		5168	
13	713653.4	7960020.0	0.0	139.1	192.1	13	1345	1	13				778402		130935		1477084		5174	
14	713654.8	7960017.0	0.0	141.7	191.3	14	1457	1	14				778403		132497		1477085		5175	
15	713656.1	7960014.5	0.0	143.9	190.6	15	1569	1	15				778401		132498		1477090		5176	
16	713657.5	7960011.5	0.0	146.6	189.8	16	1681	1	16				771463		132499		1477091		5179	
17	713659.4	7960026.5	0.0	131.5	190.1	17	1793	1	17				464465		132500		1477097		5180	
18	713660.8	7960023.5	0.0	134.3	189.3	18	1905	1	18				461668		397271		1477129		5181	
19	713662.2	7960020.5	0.0	137.0	188.5	19	2017	1	19				461669		397272		1477130		5182	
20	713663.5	7960018.0	0.0	139.3	187.8	20	2129	1	20				458424		399169		1477141		5183	
21	713664.9	7960015.0	0.0	142.1	187.1	21	2241	1	21				461666		399170		1477143		5184	
22	713666.3	7960012.5	0.0	144.4	186.4	22	2353	1	22				461667		399171		1477144		5186	
23	713667.7	7960009.5	0.0	147.2	185.8	23	2465	1	23				458422		399172		1477156		5187	
24	713669.1	7960006.5	0.0	150.1	185.1	24	2577	1	24				458423		399173		1477157		5188	
25	713671.3	7960022.5	0.0	134.0	184.8	25	2689	1	25				461665		399174		1477158		5189	
26	713672.7	7960019.5	0.0	136.9	184.1	26	2801	1	26				458420		399175		1480421		5190	
27	713674.1	7960017.0	0.0	139.3	183.4	27	2913	1	27				458421		399176		1480422		5191	
28	713683.6	7960020.0	0.0	136.0	179.5	28	3025	1	28				456184		401297		1480426		5192	
29	713684.9	7960017.0	0.0	139.0	179.0	29	3137	1	29				458418		401298		1480427		5193	
30	713686.3	7960014.5	0.0	141.6	178.5	30	3249	1	30				458419		401299		1480505		5194	
31	713675.5	7960014.0	0.0	142.2	182.8	31	3361	1	31				456182		401300		1480506		5195	

Figure 7 – TRC ordered parameter file spreadsheet for the Snøhvit data.

Mark Block	Source	Line	Station	X	Y	H20 Depth	Src Depth	FFID	Strmr Azmth	Time	Date	Shot Fold*	Static
1	1			713682.5	7960156.0	0.0	0.0	1				112	0.0
2	2			713686.4	7960146.5	0.0	0.0	2				112	0.0
3	3			713688.6	7960221.5	0.0	0.0	3				112	0.0
4	4			713690.4	7960136.5	0.0	0.0	4				112	0.0
5	5			713693.1	7960211.5	0.0	0.0	5				112	0.0
6	6			713694.6	7960126.5	0.0	0.0	6				112	0.0
7	7			713697.4	7960202.0	0.0	0.0	7				112	0.0
8	8			713698.9	7960117.0	0.0	0.0	8				112	0.0
9	9			713702.4	7960190.5	0.0	0.0	9				112	0.0
10	10			713703.5	7960107.5	0.0	0.0	10				112	0.0
11	11			713705.8	7960183.0	0.0	0.0	11				112	0.0
12	12			713708.1	7960097.5	0.0	0.0	12				112	0.0
13	13			713710.5	7960172.0	0.0	0.0	13				112	0.0
14	14			713712.7	7960087.0	0.0	0.0	14				112	0.0
15	15			713713.6	7960164.5	0.0	0.0	15				112	0.0
16	16			713716.3	7960078.5	0.0	0.0	16				112	0.0
17	17			713717.5	7960155.5	0.0	0.0	17				112	0.0
18	18			713720.7	7960068.0	0.0	0.0	18				112	0.0
19	19			713721.5	7960146.5	0.0	0.0	19				112	0.0
20	20			713725.0	7960057.0	0.0	0.0	20				112	0.0
21	21			713725.4	7960137.0	0.0	0.0	21				112	0.0
22	22			713729.2	7960046.5	0.0	0.0	22				112	0.0
23	23			713729.3	7960127.5	0.0	0.0	23				112	0.0
24	24			713730.7	7959900.0	0.0	0.0	24				112	0.0
25	25			713733.7	7960036.5	0.0	0.0	25				112	0.0
26	26			713734.4	7960116.0	0.0	0.0	26				112	0.0
27	27			713734.5	7959892.5	0.0	0.0	27				112	0.0
28	28			713736.8	7960110.5	0.0	0.0	28				112	0.0
29	29			713738.1	7959885.0	0.0	0.0	29				112	0.0
30	30			713738.2	7960026.5	0.0	0.0	30				112	0.0
31	31			713740.9	7960101.0	0.0	0.0	31				112	0.0

Figure 8 – SIN ordered parameter file spreadsheet for the Snøhvit data.

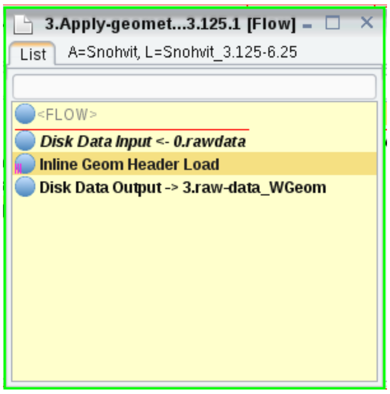

Figure 9 –Apply geometry flow, containing disk data input, inline geom header load, and disk data output.

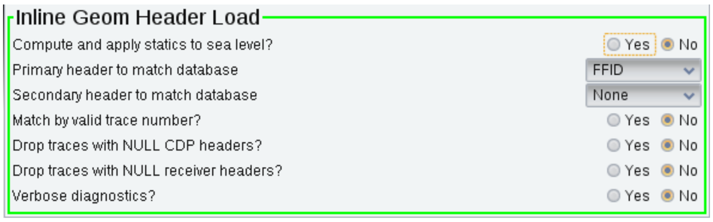

Figure 10 – Inline geom header load.

9.2.3 Resampling

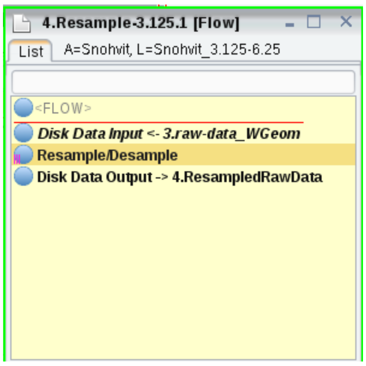

Figure 11 – Configuration of the resampling flow.

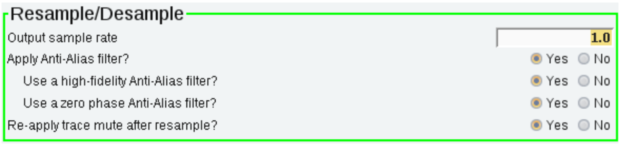

Figure 12 – Resample/desample settings.

9.2.4 Initial Stack

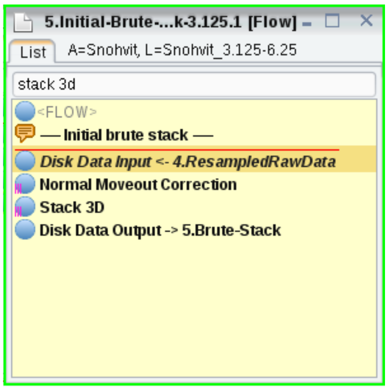

Figure 13 – Initial stack flow configuration.

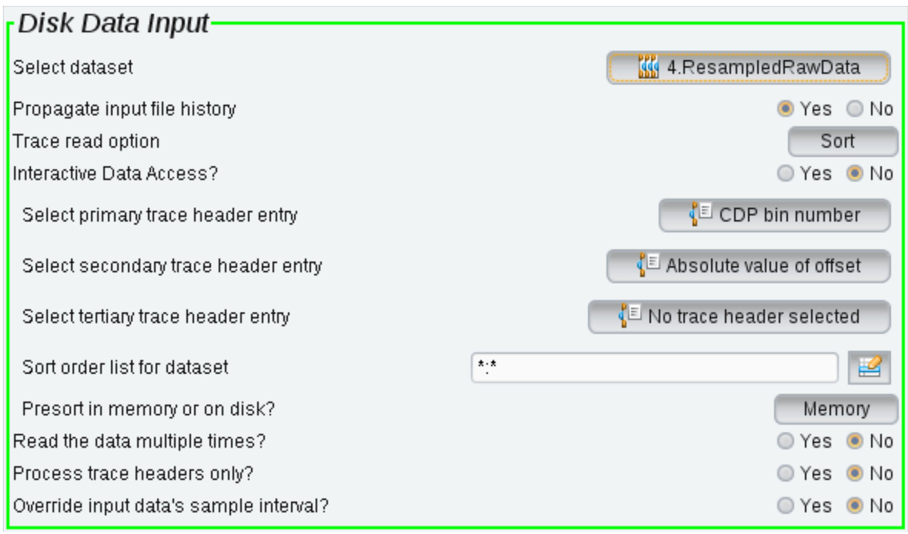

Figure 14 – Disk data input setup, sorted on CDP bin number and absolute value of offset.

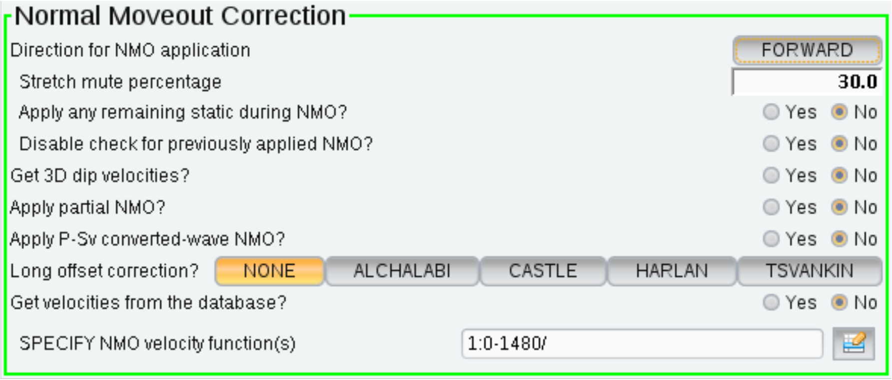

Figure 15 – Setup for the normal moveout correction with specified NMO function.

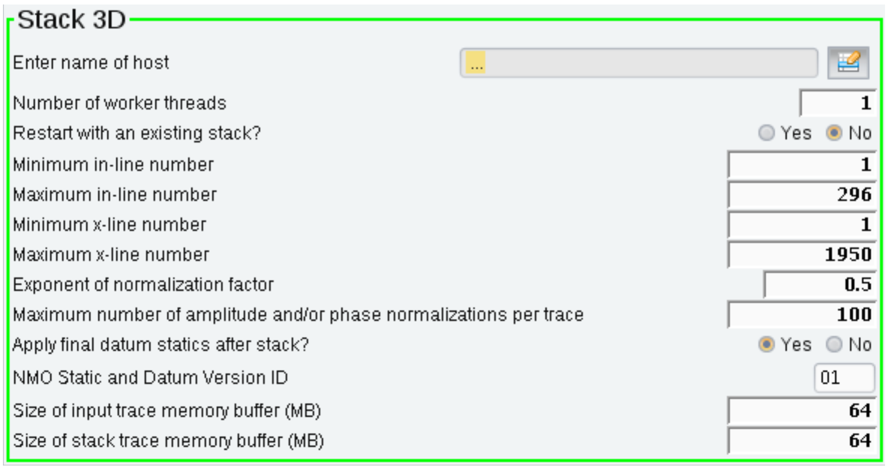

Figure 16 – Stack 3D setup.

9.2.5 F-XY Deconvolution

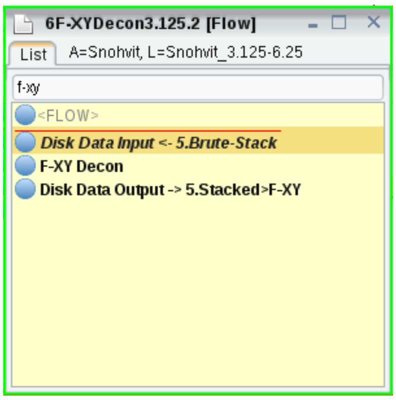

Figure 17 – F-XY deconvolution flow configuration.

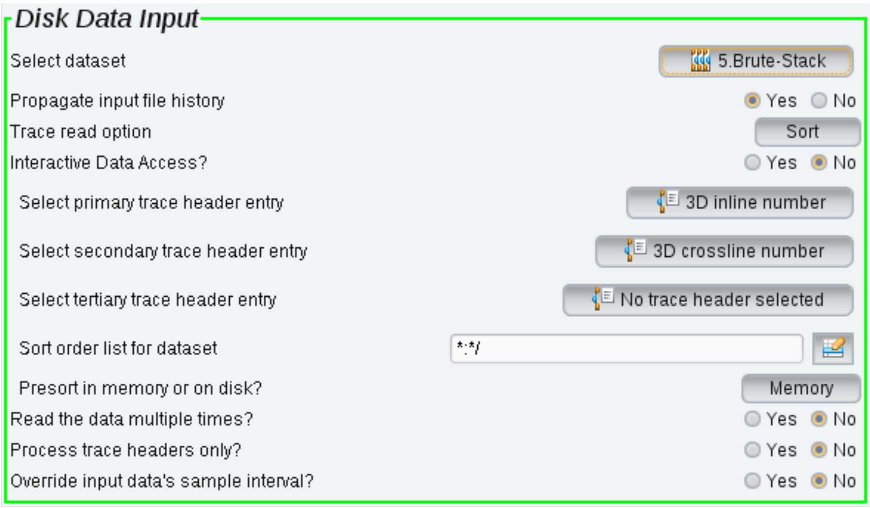

Figure 18 – Disk data input setup.

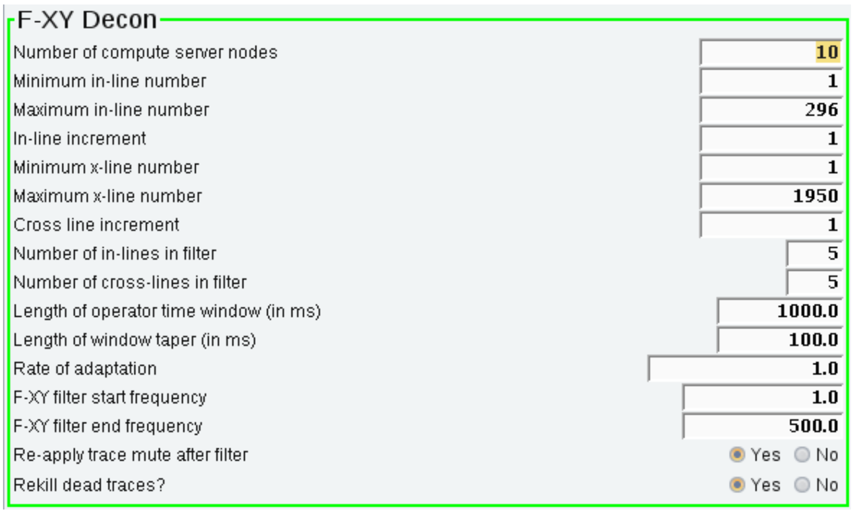

Figure 19 – F-XY Deconvolution configuration.

9.2.6 Missing data interpolation (script used in Madagascar)

from rsf.proj import +ACo-

segyfile+AD0AIg-SnohvitF-XY3.125-6.25.sgy+ACI-

+ACM-Read SEGY

Flow('data tfile bfile hfile', segyfile, 'sfsegyread tape+AD0AJAB7-SOURCES+AFs-0+AF0AfQ- tfile+AD0AJAB7-TARGETS+AFs-1+AF0AfQ- bfile+AD0AJAB7-TARGETS+AFs-2+AF0AfQ- hfile+AD0AJAB7-TARGETS+AFs-3+AF0AfQ- +AHw- sfput n2+AD0-2000 n3+AD0-296 d2+AD0-3.125 d3+AD0-6.25 o2+AD0-0 o3+AD0-0 +AHw- sfwindow min1+AD0-0.3 out+AD0-stdout',stdin+AD0-0)

Flow('mask', 'data', 'sfmath output+AD0AIg-in/(in 16)+ACI- +AHw- sfdd type+AD0-int out+AD0-stdout')

Flow('qdip','data mask',

'dip rect1+AD0-5 rect2+AD0-5 rect3+AD0-5 order+AD0-3 mask+AD0AJAB7-SOURCES+AFs-1+AF0AfQ-')

Flow('pmiss','data mask qdip',

'''

planemis3 mask+AD0AJAB7-SOURCES+AFs-1+AF0AfQ- dip+AD0AJAB7-SOURCES+AFs-2+AF0AfQ-

order+AD0-3 niter+AD0-20 verb+AD0-y

''')

Flow('data-final', 'pmiss', 'pad beg1+AD0-300 out+AD0-stdout')

+ACM-Write SEGY with final data

newsegyfile+AD0AIg-SnohvitF-XY3.125-6-25MDI.sgy+ACI-

Flow(newsegyfile, 'data-final tfile bfile hfile', 'sfsegywrite tape+AD0AJAB7-TARGETS+AFs-0+AF0AfQ- tfile+AD0AJAB7-SOURCES+AFs-1+AF0AfQ- bfile+AD0AJAB7-SOURCES+AFs-2+AF0AfQ- hfile+AD0AJAB7-SOURCES+AFs-3+AF0AfQ-',stdout+AD0-0)

End()

9.2.7 Trace Mute

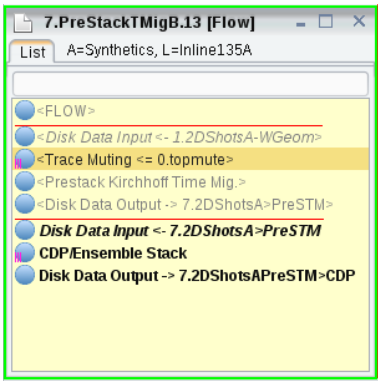

Figure 20 – Trace mute flow (performed with prestack time migration)

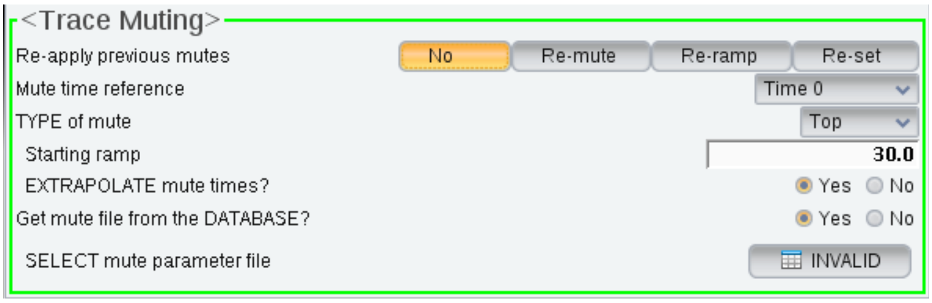

Figure 21 – Trace muting setup.

9.2.8 Velocity Manipulation

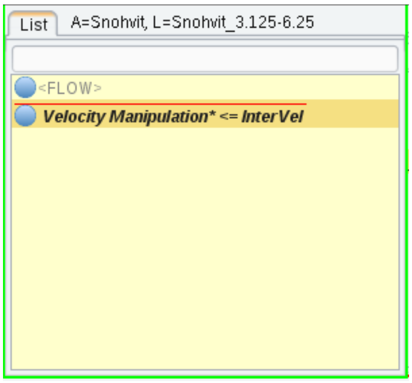

Figure 22 – Velocity manipulation flow

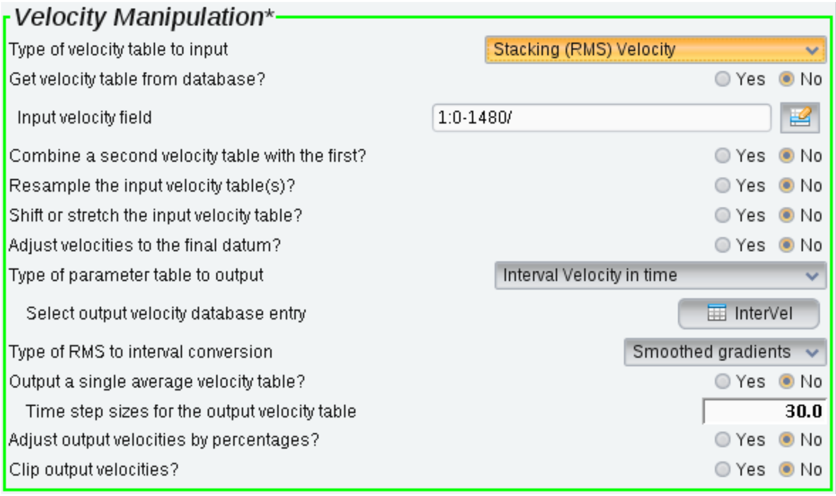

Figure 23 – Velocity manipulation setup.

9.2.9 Stolt Migration

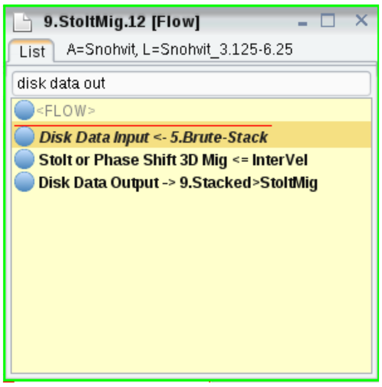

Figure 24 – Stolt migration flow configuration.

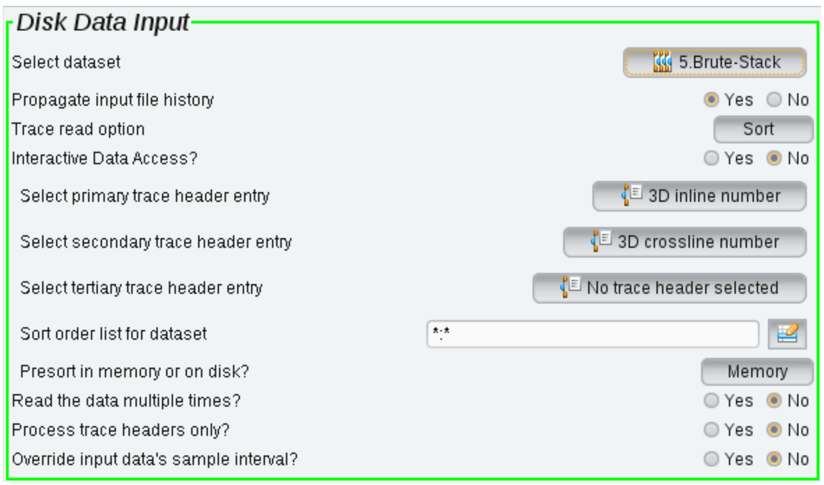

Figure 25 – Disk data input setup.

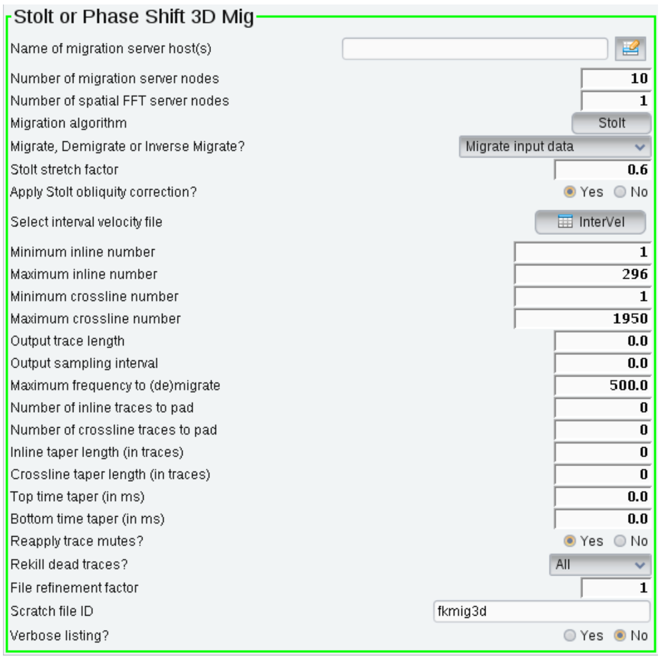

Figure 26 – Stolt migration setup.

9.2.10 Prestack time migration (script used in Madagascar)

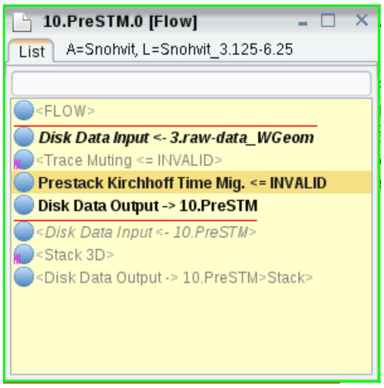

Figure 27 – Prestack time migration flow

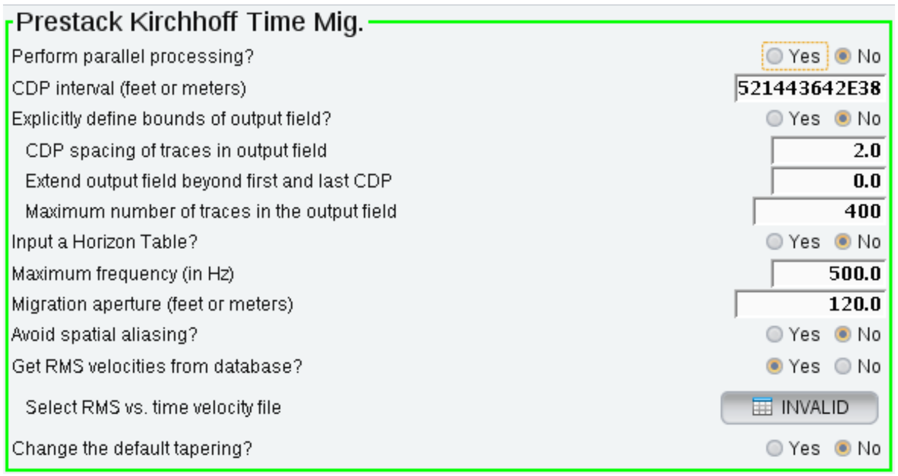

Figure 28 – Prestack Kirchhoff time migration setup.

Prestack time migration of Vestnesa Ridge (script used in Madagascar):

sfderiv < ../Datasets/shotsB_wind.rsf | sfderiv out=stdout > shots_deriv.rsf
sfpstm3d < shots_deriv.rsf hdr=mig3dhdr.rsf antialias='flat' n2=2561 d2=3.125 apert2=135 apert3=10 o2=0 o3=0 n3=1 d3=6.25 vel=1480.0 n1=2401 t_start=1.6 t_end=2.4 out=stdout > pstm_test.rsf

Prestack time migration of Snøhvit using MPI (script used in Madagascar):

sfspike n1=1500 d1=1e-3 o1=0 n2=596 d2=6.25 o2=0 d3=6.25 o3=0 n3=2394 mag=1480 out=stdout > vp_rms.rsf
mpirun -np 12 sfmpipstm3d data=data-deriv.rsf hdr=hdrmig3.rsf antialias='flat' apert2=100 apert3=135 velfile=vp_rms.rsf t_start=0.3 t_end=1.40 out=stdout mig=pstm.rsf

9.2.11 Make 2D synthetic seismic data (script used in Madagascar)

from rsf.proj import +ACo-

+ACM- Get 2D inline from synthetic model

Flow('vp', '../modelA.rsf', 'sfwindow n3+AD0-1 f3+AD0-135 +AHw- sfmodint2d d1f+AD0-1.5 d2f+AD0-1.5 method+AD0-1 +AHw- put o3+AD0-0 out+AD0-stdout')

Flow('rho', 'vp', 'sfmath output+AD0-1000 out+AD0-stdout')

+ACM- Make 2D geometry

Flow('tfile-2d', None, 'sfmakehdr3d nsx+AD0-321 dsx+AD0-25.0 ngx+AD0-6 dgx+AD0-6.25 gx0+AD0-103 scalco+AD0--100 nt+AD0-3001 dt+AD0-1e-3 out+AD0-stdout')

Flow('hdrmig shotmap', 'tfile-2d', 'sfheadersplit headin+AD0AJAB7-SOURCES+AFs-0+AF0AfQ-headout+AD0AJAB7-TARGETS+AFs-0+AF0AfQ- map+AD0AJAB7-TARGETS+AFs-1+AF0AfQ-verb+AD0-1 out+AD0-stdout', stdin+AD0-0, stdout+AD0-0)

+ACM- Make a wavelet

+ACM-Flow('wavelet', None, 'sfwavelet dt+AD0-2.0e-4 t0+AD0-0.1 f0+AD0-10 f1+AD0-20 f2+AD0-175 f3+AD0-250 tend+AD0-3.1 turkey+AD0-1 out+AD0-stdout')

Flow('wavelet', None, 'sfwavelet dt+AD0-2.0e-4 t0+AD0-0.1 f0+AD0-175 tend+AD0-3.1 order+AD0-1 turkey+AD0-0 +AHw- sfbandpass fhi+AD0-200 out+AD0-stdout')

+ACM- Run modelling

Flow('status+AF8-mod.txt', None, '''

sfmpicmod

Prec+AD0AIg-shotsA.rsf+ACI-

vp+AD0AIg-vp.rsf+ACI-

rho+AD0AIg-rho.rsf+ACI-

sx+AD0AIg-sx.rsf+ACI-

gx+AD0AIg-gx.rsf+ACI-

source+AD0-+ACI-wavelet.rsf+ACI-

shotmap+AD0AIg-shotmap.rsf+ACI-

hdr+AD0AIg-hdrmig.rsf+ACI-

localpath+AD0AIg-./Local+ACI-

modprog+AD0AIg-sfacufdm2d+ACI-

temppath+AD0AIg-./Temp+ACI-

workpath+AD0AIg-.+ACI-

datapath+AD0AIg-./Data+ACI-

dim+AD0-2

apert2+AD0-270.

zrec+AD0-3

zsource+AD0-1

free+AF8-surface+AD0-0

verb+AD0-1

Lpml+AD0-10

wemva+AD0-0

records+AD0-1

snapdt+AD0-0.001

recdt+AD0-0.001

''' , np+AD0-12, stdin+AD0-0)

2D modelling in Stallo:

```
#SBATCH --job-name=Vnesa2D
#SBATCH --account=nn9434k

# 80 MPI tasks in total
# Stallo has 16 or 20 cores/node and therefore we take
# a number that is divisible by both
#SBATCH --ntasks=80

# run for five minutes
#            d-hh:mm:ss
#SBATCH --time=1-00:00:00

# short partition should do it
#SBATCH --partition normal

# 500MB memory per core
# this is a hard limit
#SBATCH --mem-per-cpu=500MB

# turn on all mail notification
#SBATCH --mail-type=ALL

# you may not place bash commands before the last SBATCH directive


# Getting current working directory path
WORKDIR=`pwd`
echo $WORKDIR

# define and create a unique scratch directory
```

```
SCRATCH_DIRECTORY=/global/work/${USER}/example/${SLURM_JOBID}
mkdir -p ${SCRATCH_DIRECTORY}
cd ${SCRATCH_DIRECTORY}
mkdir Local
mkdir Temp

# we copy everything we need to the scratch directory
# ${SLURM_SUBMIT_DIR} points to the path where this script was submitted from
cp ${SLURM_SUBMIT_DIR}/vp.rsf ${SCRATCH_DIRECTORY}
cp ${SLURM_SUBMIT_DIR}/rho.rsf ${SCRATCH_DIRECTORY}
cp ${SLURM_SUBMIT_DIR}/hdrmig.rsf ${SCRATCH_DIRECTORY}
cp ${SLURM_SUBMIT_DIR}/shotmap.rsf ${SCRATCH_DIRECTORY}

# Make a wavelet
$RSFROOT/bin/sfwavelet dt=2.0e-4 t0=0.1 f0=175 tend=3.1 order=1 turkey=0 | sfbandpass fhi=200
out=stdout > wavelet.rsf

mpirun $RSFROOT/bin/sfmpicmod \
        Prec="shots.rsf"        \
        vp="vp.rsf"        \
        rho="rho.rsf"        \
        sx="sx.rsf"        \
        gx="gx.rsf"        \
        source="wavelet.rsf"        \
        shotmap="shotmap.rsf"        \
        hdr="hdrmig.rsf"        \
        modprog="sfacufdm2d"        \
            localpath="${SCRATCH_DIRECTORY}/Local"                                \
            temppath="${SCRATCH_DIRECTORY}/Temp"                                \
            workpath="${SCRATCH_DIRECTORY}"                                \
            datapath="${SCRATCH_DIRECTORY}"                              \
            dim=2        \
        apert2=270.        \
        zrec=3        \
        zsource=1        \
        free_surface=0        \
        verb=1        \
        Lpml=10        \
        wemva=0        \
        records=1        \
        snapdt=0.001        \
        recdt=0.001

# after the job is done we copy our output back to $SLURM_SUBMIT_DIR
mkdir -p ${SLURM_SUBMIT_DIR}/results/${SLURM_JOBID}
cp ${SCRATCH_DIRECTORY}/*.txt ${SLURM_SUBMIT_DIR}/results/${SLURM_JOBID}
cp ${SCRATCH_DIRECTORY}/shots.rsf ${SLURM_SUBMIT_DIR}/results/${SLURM_JOBID}

# we step out of the scratch directory and remove it
cd ${SLURM_SUBMIT_DIR}
rm -rf ${SCRATCH_DIRECTORY}

# happy end
exit 0
```

9.2.12 Reverse time migration (script used in Stallo)

```
#SBATCH --job-name=Vnesa2D
#SBATCH --account=nn9434k

# 80 MPI tasks in total
# Stallo has 16 or 20 cores/node and therefore we take
# a number that is divisible by both
#SBATCH --ntasks=80

# run for five minutes
#           d-hh:mm:ss
#SBATCH --time=1-00:00:00

# short partition should do it
#SBATCH --partition normal

#SBATCH --mem-per-cpu=2000MB

# turn on all mail notification
#SBATCH --mail-type=ALL

# you may not place bash commands before the last SBATCH directive


# Getting current working directory path
WORKDIR=`pwd`
echo $WORKDIR

# define and create a unique scratch directory
SCRATCH_DIRECTORY=/global/work/${USER}/example/${SLURM_JOBID}
mkdir -p ${SCRATCH_DIRECTORY}
cd ${SCRATCH_DIRECTORY}
mkdir Local
mkdir Temp

# we copy everything we need to the scratch directory
# ${SLURM_SUBMIT_DIR} points to the path where this script was submitted from
cp ${SLURM_SUBMIT_DIR}/vp_water.rsf ${SCRATCH_DIRECTORY}
cp ${SLURM_SUBMIT_DIR}/rho.rsf ${SCRATCH_DIRECTORY}
cp ${SLURM_SUBMIT_DIR}/hdrmig.rsf ${SCRATCH_DIRECTORY}
cp ${SLURM_SUBMIT_DIR}/shotmap.rsf ${SCRATCH_DIRECTORY}
cp ${SLURM_SUBMIT_DIR}/datamig.rsf ${SCRATCH_DIRECTORY}

# Make a wavelet
$RSFROOT/bin/sfwavelet dt=2.0e-4 t0=0.1 f0=175 tend=2.4 order=1 turkey=0 | sfbandpass fhi=200
out=stdout > wavelet.rsf

mpirun $RSFROOT/bin/sfmpicrtm \
	Prec="datamig.rsf"	\
	vp="vp_water.rsf"	\
	rho="rho.rsf"	\
	sx="sx.rsf"	\
	gx="gx.rsf"	\
	fw_P="fw.rsf"	\
	bw_P="bw.rsf"	\
	source="wavelet.rsf"	\
	shotmap="shotmap.rsf"	\
	hdr="hdrmig.rsf"	\
	image="migimage.rsf"	\
```

```
        migprog="sfacufwm2d"        \
        migprog="sfacurtm2d"        \
            localpath="${SCRATCH_DIRECTORY}/Local"                  \
            temppath="${SCRATCH_DIRECTORY}/Temp"                    \
            workpath="${SCRATCH_DIRECTORY}"                         \
            datapath="${SCRATCH_DIRECTORY}"                         \
            dim=2        \
        apert2=270.        \
        zrec=3        \
        zsource=1        \
        free_surface=0        \
        verb=1        \
        Lpml=10        \
        wemva=0        \
        records=1        \
        snapdt=0.001        \
        recdt=0.001


# Stacking images
mpirun $RSFROOT/bin/sfmpistackcip2d \
verb=0 \
clean=1 \
getpos=0 \
listfile=stacklist.txt \
max_x=8196.875 \
min_x=200.0 \
stack=pimage.rsf \
out=stdout

# after the job is done we copy our output back to $SLURM_SUBMIT_DIR
mkdir -p ${SLURM_SUBMIT_DIR}/results/${SLURM_JOBID}
cp ${SCRATCH_DIRECTORY}/*.txt ${SLURM_SUBMIT_DIR}/results/${SLURM_JOBID}
cp ${SCRATCH_DIRECTORY}/pimage.rsf ${SLURM_SUBMIT_DIR}/results/${SLURM_JOBID}

# we step out of the scratch directory and remove it
cd ${SLURM_SUBMIT_DIR}
cp job.sh ${SLURM_SUBMIT_DIR}/results/${SLURM_JOBID}
rm -rf ${SCRATCH_DIRECTORY}

# happy end
exit 0
```

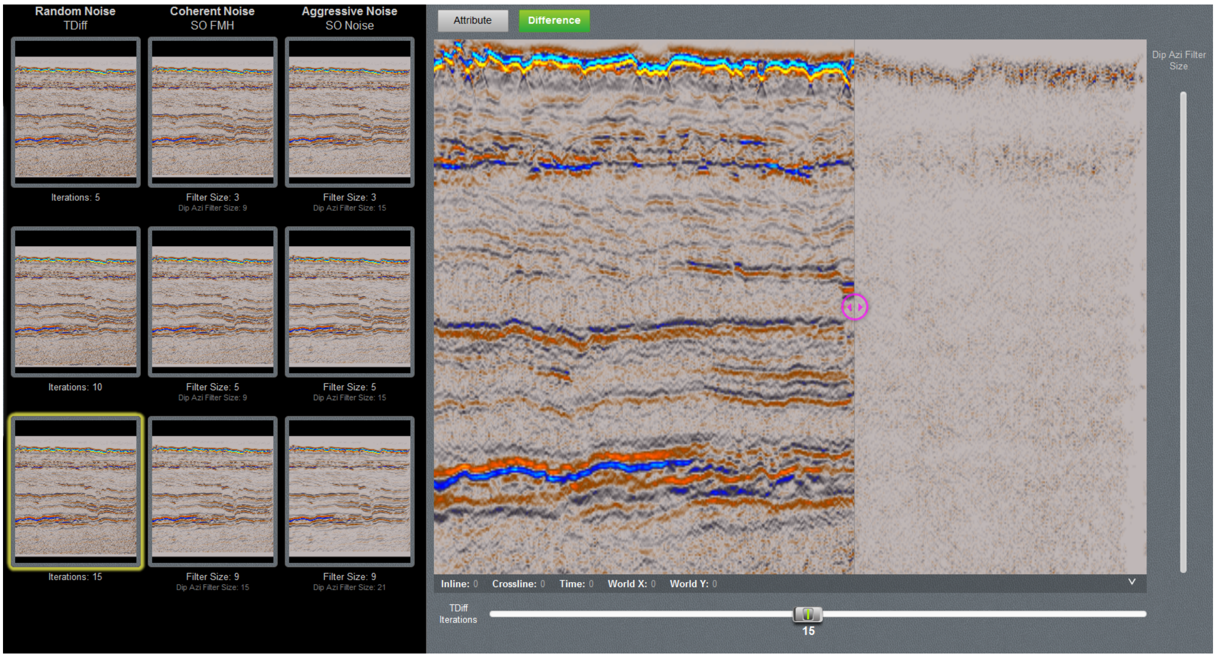

Figure 29 – Noise expression interface, TDiff and SO noise filters applied.

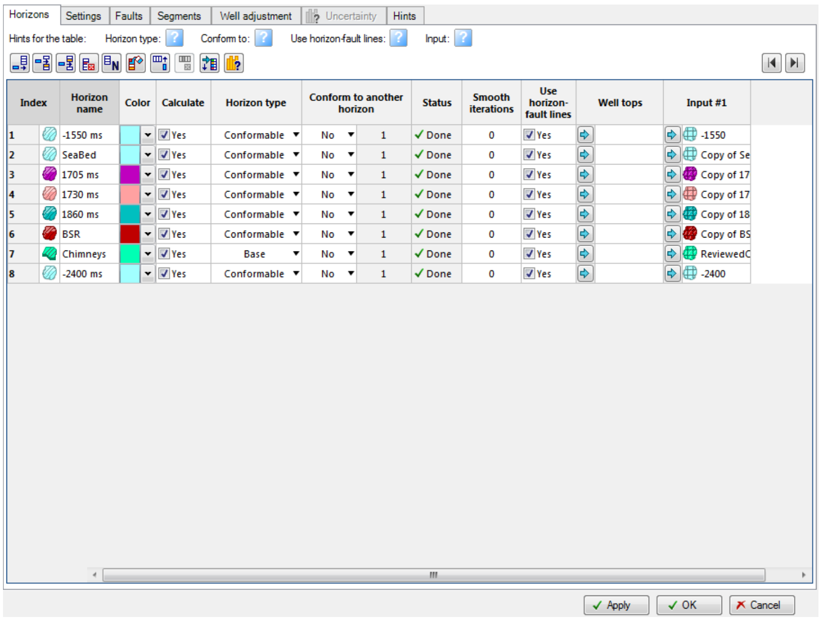

Figure 30 – Make horizons to make zone model.

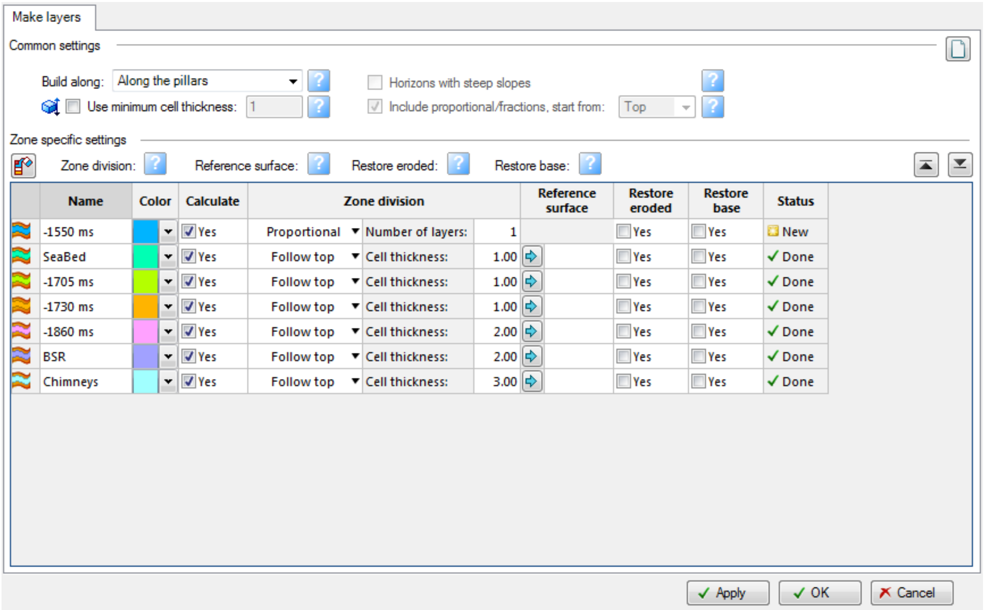

Figure 31 – Layering do construct layers.

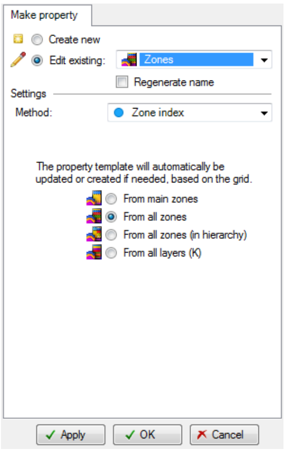

Figure 32 - Geometrical modelling

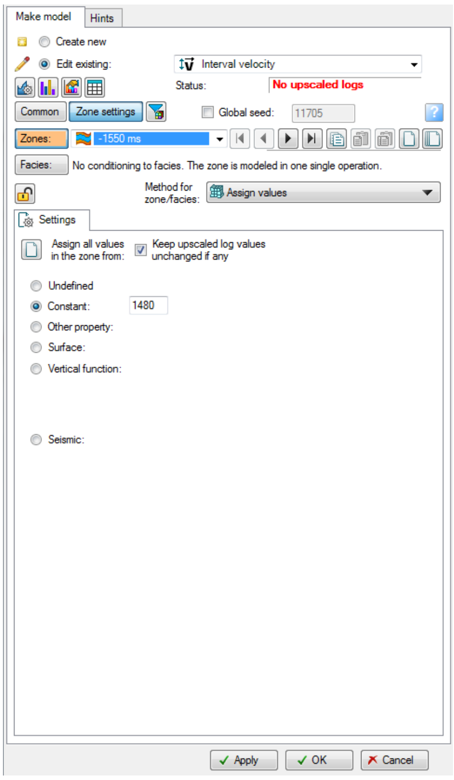

Figure 33 – Petrophysical modelling with specific parameters to define interval velocity between -1550 and Seabed

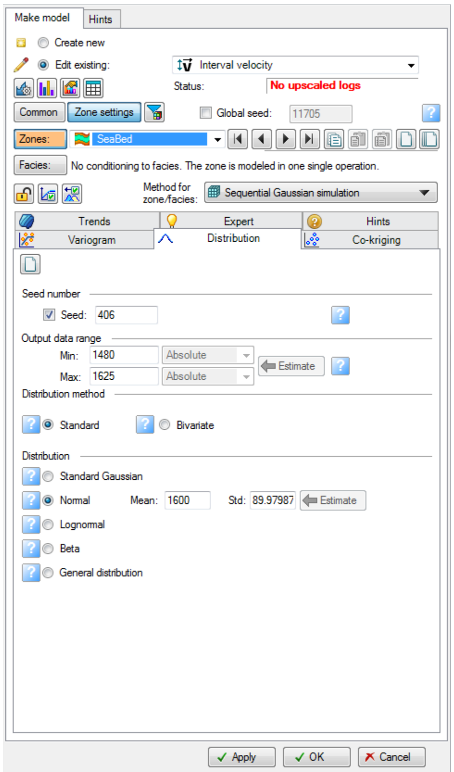

Figure 34 - Petrophysical modelling with specific parameters to define interval velocity between seabed and -1705

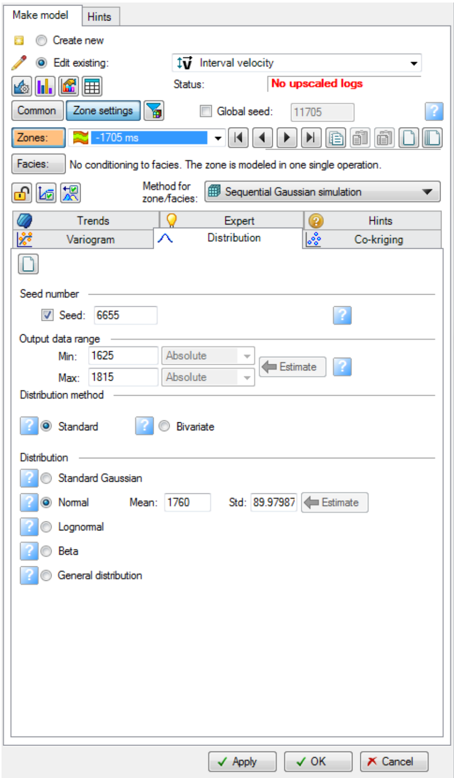

Figure 35 - Petrophysical modelling with specific parameters to define interval velocity between -1705 and -1730

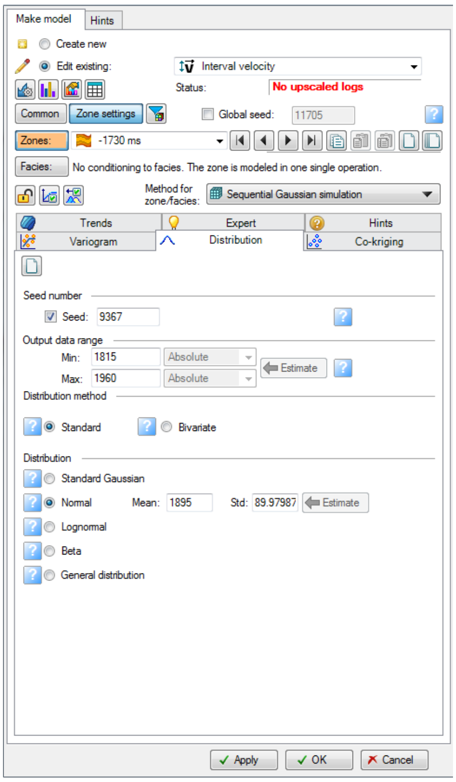

Figure 36 - Petrophysical modelling with specific parameters to define interval velocity between -1730 and -1860.

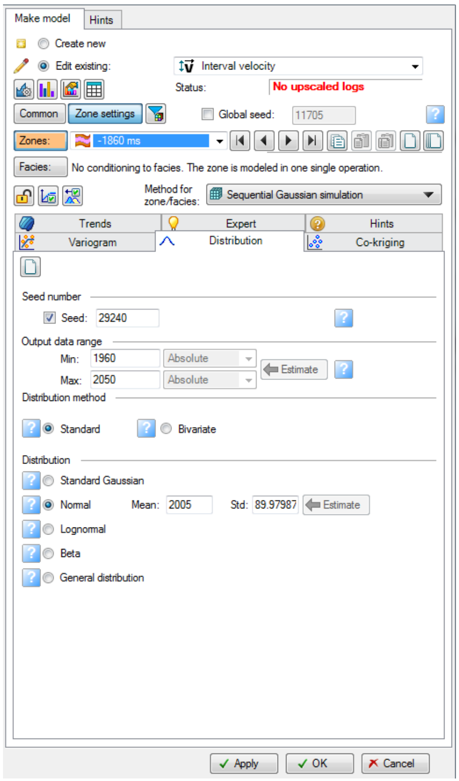

Figure 37 - Petrophysical modelling with specific parameters to define interval velocity between -1860 and BSR

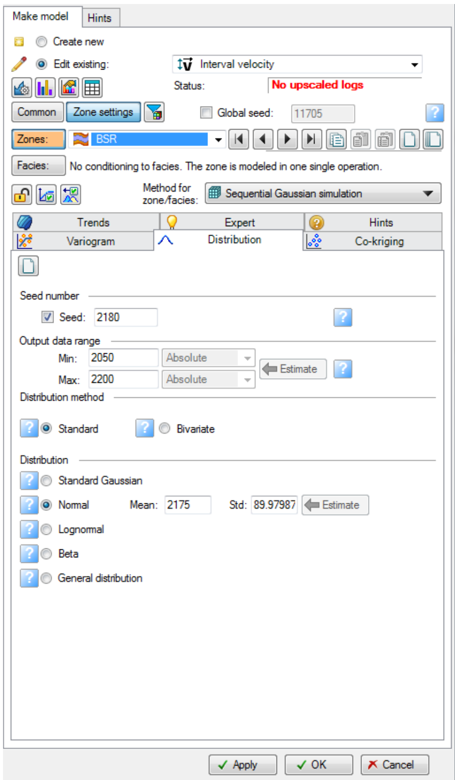

Figure 38 - Petrophysical modelling with specific parameters to define interval velocity between BSR and Chimneys.

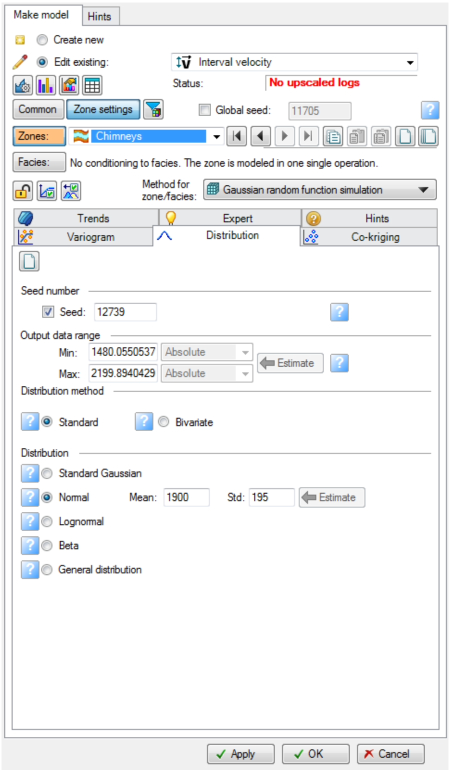

Figure 39 - Petrophysical modelling with specific parameters to define interval velocity between chimneys and -2400.

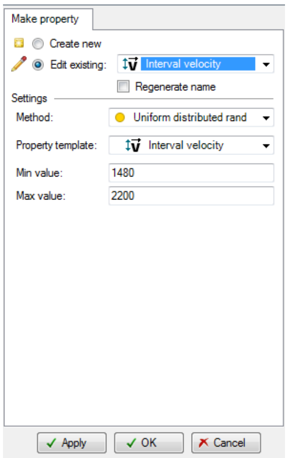

Figure 40 – Geometrical modelling to construct 3D velocity model