VMWare 虚拟机安装 Ubuntu：

可参见网址： https://www.linuxidc.com/Linux/2020-03/162547.htm
可以按照网址步骤进行安装

下载软件：

1. Download FFTW
   (e.g. fftw-3.3.9.tar)

   http://www.fftw.org/download.html

2. Download Linux's Intel parallel softwares
   (e.g. l_HPCKit_p_2021.3.0.3230_offline.sh, l_BaseKit_p_2021.3.0.3219_offline.sh)

   https://software.intel.com/content/www/us/en/develop/tools/oneapi/components/onemkl.html

2. Download DENISE codes
   (e.g. DENISE-Black-Edition-master.zip)

   https://github.com/daniel-koehn/DENISE-Black-Edition

3. Download DENISE models
   (e.g. DENISE-Black-Edition-master.zip)

   https://github.com/daniel-koehn/DENISE-Benchmar

安装软件：

1). FFTW

Extract files:

```
$ tar -xvf fftw-3.3.9.tar.gz
$ cd fftw-3.3.9/
```

Use the installation directory by using flag ' --prefix=/usr/local/fftw ' like that

```
$ sudo    ./configure --prefix=/usr/local/fftw
$ sudo    make

$ sudo make install

$ sudo vi ~/.bashrc ( Add three lines as below)
    export FFTW_PATH=/usr/local/fftw/bin:$FFTW_PATH
    export FFTW_INC=/usr/local/fftw/include:$FFTW_INC
    export FFTW_LIB=/usr/local/fftw/lib:$FFTW_LIB
$ source ~/.bashrc
```

2). see: Ubuntu18.04 安装 intel 编译器的教程_20210913.pdf

3). DENISE codes

Go to the directory you want to put the codes, and upzip the zip file:

$ unzip DENISE-Black-Edition-master.zip

In the "DENISE-Black-Edition-master/libcseife" directory simply use the shell script:

$ make

Links to the include and lib directory of FFTW in the Makefile in "DENISE-Black-Edition-master/src" directory, e.g.

SFLAGS=-L./../libcseife -L$//usr/local/fftw/lib

IFLAGS=-I./../libcseife -I$//usr/local/fftw/include

To compile the main program DENISE in DENISE-Black-Edition-master/src simply type:

$ make denise

4). DENISE models

Just unzip the DENISE-Black-Edition-master.zip:

$ unzip DENISE-Black-Edition-master.zip

Copy the model files you wanted to the corresponding directories of DENISE codes

正演部分：

(1) 首先打开“par”文件夹里的“DENISE_marm_OBC”文本，将“DENISE Mode”改为 0，进行正演模拟，修改“MFILE=start/marmousi_II_marine”，使用设置的初始数据进行正演，如下图所示：

```
 7 # ------------------ DENISE Mode --------------------------------
 8 # Operation mode:
 9 (forward_modelling_only=0;FWI=1;RTM=2)_(MODE) =0
```

```
54 #--------------------- Model ---------------------------------------
55 read_model_parameters_from_MFILE(yes=1)(READMOD) = 1
56 MFILE = start/marmousi_II_marine
57 write_model_files_(yes=1)_(WRITEMOD) = 1
58 #
```

(2) 然后在“par”终端里输入“mpirun -np 4 ../bin/denise DENISE_marm_OBC.inp FWI_workflow_marmousi.inp”进行正演运行，共运行 100 次，在“su”中得到 200 组数据；

(3) 接着在“par”中的“su”文件中新建文件夹，命名为“MARMOUSI_ricker”，将正演得到的文件移动到里面去用作反演的观测数据。

反演部分：

(1) 首先打开“par”文件夹里的“DENISE_marm_OBC”文本，将“DENISE Mode”改为 1，进行全波形反演模拟，修改“MFILE=start/marmousi_II_start_1D”，使用正演得到的观测数据进行反演，如下图所示：

```
 7 # ------------------ DENISE Mode ---------------------------------
 8 # Operation mode:
 9 (forward_modelling_only=0;FWI=1;RTM=2)_(MODE) =1
10 #

54 #--------------------- Model ---------------------------------------
55 read_model_parameters_from_MFILE(yes=1)(READMOD) = 1
56 MFILE = start/marmousi_II_start_1D
57 write_model_files_(yes=1)_(WRITEMOD) = 1
58 #
```

(2) 然后修改迭代次数，修改为 10 次；

```
128 #-------------------------------------------------------------
129 # DENISE_elastic specific parameters
130 number_of_TDFWI_iterations_(ITERMAX) = 10
131 output_of_jacobian_(JACOBIAN) = jacobian/jacobian_Test
132 seismograms_of_measured_data_(DATA_DIR) = su/MARMOUSI_ricker/DENISE_MARMOUSI
```

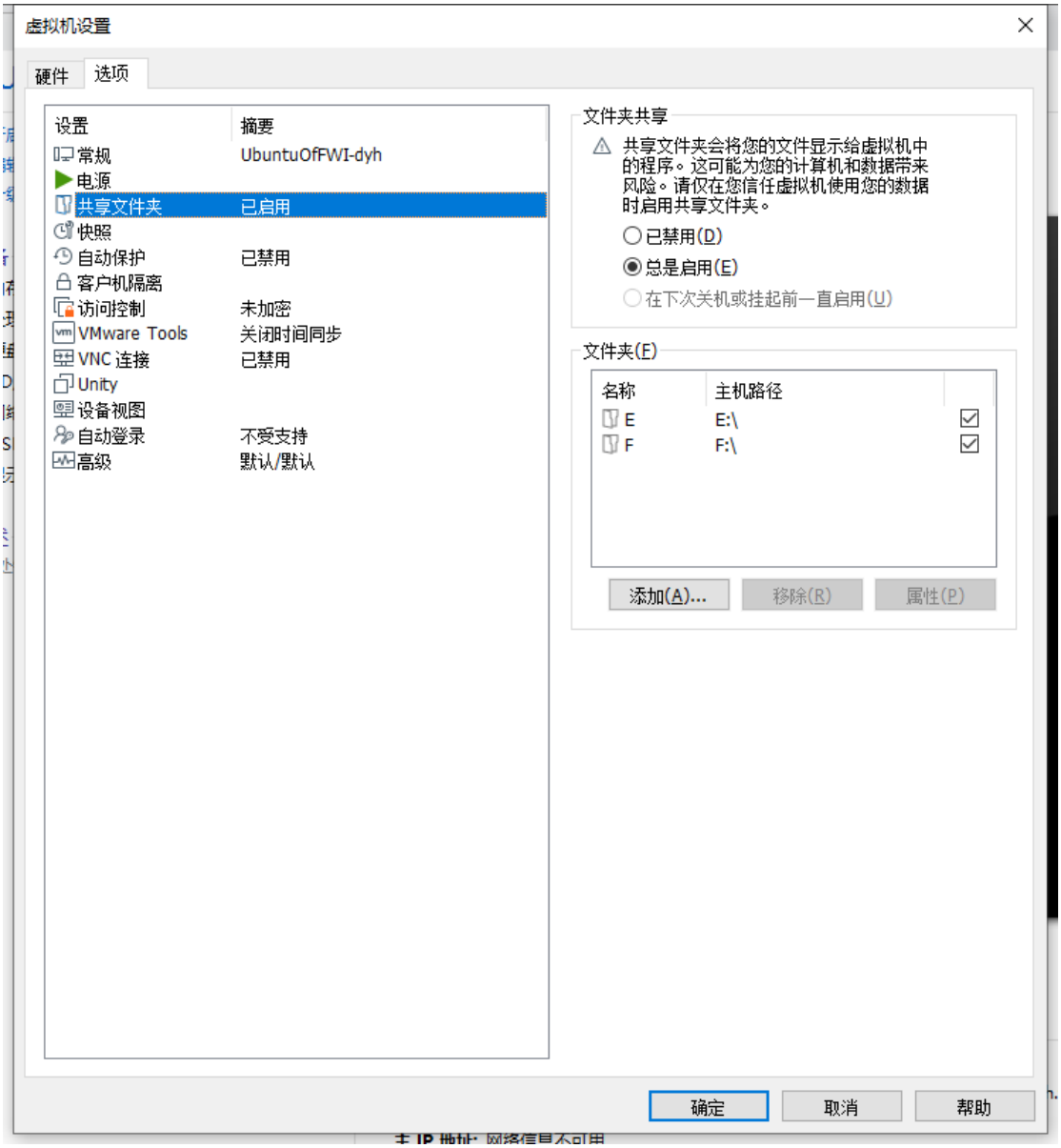
(3) 修改输出文件类型，将“samplingrate_(in_timesteps!)_(NDT) =1”修改为“samplingrate_(in_timesteps!)_(NDT) =3”，输出为“bin”文件类型（二进制文件）。

```
111 #-------------------  Seismograms  -------------------------------
112 samplingrate_(in_timesteps!)_(NDT) = 3
113 data-format_(SU(1);ASCII(2);BINARY(3)) = 3
114 # output files for seismograms
115 # particle velocities (if SEISMO=1 or SEISMO=4)
116 filename_for_Vx_(SEIS_FILE_VX) = su/DENISE_MARMOUSI_x.su
117 filename_for_Vy_(SEIS_FILE_VY) = su/DENISE_MARMOUSI_y.su
118 # curl and div of wavefield (if SEISMO=3 or SEISMO=4)
119 filename_for_curl_(SEIS_FILE_CURL) = su/2layer_rot.su
120 filename_for_div_(SEIS_FILE_DIV) = su/2layer_div.su
121 # pressure field (hydrophones) (if SEISMO=2 or SEISMO=4)
122 filename_for_pressure_(SEIS_FILE_P) = su/DENISE_MARMOUSI_p.su
```

(4) 然后在“par”终端里输入“mpirun -np 4 ../bin/denise DENISE_marm_OBC.inp FWI_workflow_marmousi.inp”进行反演运行，共运行 4*10*100 次，在“model”中得到反演数据。

绘制图形：

将虚拟机里实验得到的文件进行共享到电脑文件夹里，共享设置如下所示：



随后将得到的二进制文件使用 Matlab 软件进行绘制得出相应的图形。