PS6_王雅滢

陈鹏翰、龚国庆、蒋莲洁向我解释了此次作业，跟他们学习了很多，非常感谢他们。

1. Matrix multiplication

1.1 Write a program Main.f90 to read fortran_demo1/M.dat as the matrix M, and fortran_demo1/N.dat as the matrix N.

Main.f90：

```
Program Main

implicit none

integer                                        ::x1, x2, mc, mr, nc, nr, i, j
real(8),dimension(:,:),allocatable             :: M, N

x1=50
x2=51
mc=3
mr=4
nc=4
nr=3

open(unit=x1,file='M.dat',status='old')
open(unit=x2,file='N.dat',status='old')

allocate(M(mr,mc))
allocate(N(nr,nc))

do i=1,mr
   read(x1,*) M(i,:)
enddo

do i=1,nr
   read(x2,*) N(i,:)
enddo

do i=1,mr
   write(*,*) 'Line',i,':',M(i,:)
enddo

do i=1,nr
   write(*,*) 'Line',i,':',N(i,:)
enddo
```

```
deallocate(M)
deallocate(N)

End Program Main
```

输出:

```
[ese-wangyy@login02 fortran_demo1]$ gfortran Main.f90 -o Main.x
[ese-wangyy@login02 fortran_demo1]$ ./Main.x
 Line           1 :   19.480000000000000        15.789999999999999        19.280000000000001

 Line           2 :   19.280000000000001        12.920000000000000        15.859999999999999

 Line           3 :   15.859999999999999        11.289999999999999        14.039999999999999

 Line           4 :   11.930000000000000        18.600000000000001        18.230000000000000

 Line           1 :   7.7199999999999998        4.1100000000000003        1.4399999999999999
       4.7999999999999998
 Line           2 :   5.5499999999999998        4.7999999999999998        4.0400000000000000
      0.58999999999999997
 Line           3 :  0.58999999999999997        8.5800000000000001        2.2599999999999998
       7.7199999999999998
```

1.2 Write a subroutine Matrix_multip.f90 to do matrix multiplication.
subroutine Matrix_multip(M,N,MN)

脚本：

```
subroutine Matrix_multip(M,N,MN)

implicit none

real(8),dimension(4,3),intent(in)    :: M
real(8),dimension(4,3),intent(in)    :: N
real(8),dimension(4,4),intent(out) :: MN
integer                                         :: i,j,k
real(8)                                         :: t

do i=1,4
   do j=1,4
      t=0
      do k=1,3
         t=t+M(i,k)*N(k,j)
      enddo
      MN(i,j)=t
   enddo
enddo

End subroutine Matrix_multip
```

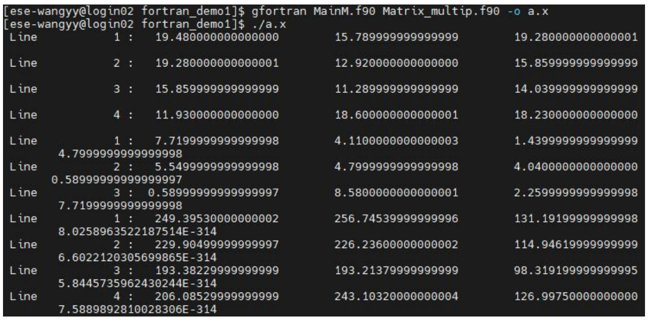
1.3 Call the subroutine Matrix_multip() from Main.f90 to compute M*N; write the output to a new file MN.dat, values are in formats of f9.2.

脚本：

```
Program MainM

implicit none

integer                                    :: x1, x2, mc, mr, nc, nr, i, j
real(8), dimension(:,:),allocatable        :: M, N
real(8), dimension(4,4)                    :: MN

x1=50
x2=51
mc=3
mr=4
nc=4
nr=3

open(unit=x1,file='M.dat',status='old')
open(unit=x2,file='N.dat',status='old')

allocate(M(mr,mc))
allocate(N(nr,nc))

do i=1,mr
   read(x1,*) M(i,:)
enddo

do i=1,nr
   read(x2,*) N(i,:)
enddo

close(x1)
close(x2)

do i=1,mr
   write(*,*) "Line ",i,":",M(i,:)
enddo

do i=1,nr
   write(*,*) "Line ",i,":",N(i,:)
enddo

call Matrix_multip(M,N,MN)
```

```
do i=1,4
   write(*,*) "Line ",i,":",MN(i,:)
enddo

open(unit=u1,file='new1.dat',status='replace')

do i=1,4
   write(u1,'(f9.2)') MN(i,:)
enddo

close(x1)

deallocate(M)
deallocate(N)

End Program MainM
```

输出：



```
[ese-wangyy@login02 fortran_demo1]$ gfortran MainM.f90 Matrix_multip.f90 -o a.x
[ese-wangyy@login02 fortran_demo1]$ ./a.x
 Line           1 :   19.480000000000000        15.789999999999999        19.280000000000001

 Line           2 :   19.280000000000001        12.920000000000000        15.859999999999999

 Line           3 :   15.859999999999999        11.289999999999999        14.039999999999999

 Line           4 :   11.930000000000000        18.600000000000001        18.230000000000000

 Line           1 :   7.7199999999999998        4.1100000000000003        1.4399999999999999
   4.7999999999999998
 Line           2 :   5.5499999999999998        4.7999999999999998        4.0400000000000000
  0.58999999999999997
 Line           3 :  0.58999999999999997        8.5800000000000001        2.2599999999999998
   7.7199999999999998
 Line           1 :   249.39530000000002        256.74539999999996        131.19199999999998
   8.0258963522187514E-314
 Line           2 :   229.90499999999997        226.23600000000002        114.94619999999999
   6.6022120305699865E-314
 Line           3 :   193.38229999999999        193.21379999999999        98.319199999999995
   5.8445735962430244E-314
 Line           4 :   206.08529999999999        243.10320000000004        126.99750000000000
   7.5889892810028306E-314
```

2. Calculate the Solar Elevation Angle

The solar elevation angle (SEA) is the angle between the imaginary horizontal plane on which you are standing and the sun in the sky. SEA is very important in deciding the inclination of solar panels, in both photovoltaics (PV) and thermal. The value of the SEA depends on the location on the Earth and the local date and time.

Please read this Solar Elevation Angle – Calculating Altitude of Sun and links therein for how to calculate SEA.

2.1 Write a module Declination_angle that calculates the declination angle on a given date. [Hint: using the "Better formula" from Solar Declination Angle & How to Calculate it]

创建：vi Declination_angle.f90

脚本：

```
module Declination_angle

implicit none
! 考虑一个月 30 天。

real, parameter :: pi=3.1415926536

contains

    subroutine cal_angle(m,d,da)

    implicit none

    integer,intent(in) :: m, d
    real(8),intent(out) :: da
    integer ::doy

    doy=(m-1)*30+d

da=asin(sin(-23.44/180*pi)*cos(((360/365.24)*(doy+10)+360/pi*0.0167*sin(360/365.24*(doy-2)))/180*pi))
    da=da/pi*180

    End subroutine cal_angle

End module Declination_angle
```

经过测试，可以运行：

```
[ese-wangyy@login02 fortran_demo1]$ gfortran Main.f90 Declination_angle.f90 -o a.x
[ese-wangyy@login02 fortran_demo1]$ ./a.x
 Line           1 :   19.480000000000000        15.789999999999999        19.280000000000001

 Line           2 :   19.280000000000001        12.920000000000000        15.859999999999999

 Line           3 :   15.859999999999999        11.289999999999999        14.039999999999999

 Line           4 :   11.930000000000000        18.600000000000001        18.230000000000000

 Line           1 :   7.7199999999999998        4.1100000000000003        1.4399999999999999
        4.7999999999999998
 Line           2 :   5.5499999999999998        4.7999999999999998        4.0400000000000000
       0.58999999999999997
 Line           3 :  0.58999999999999997        8.5800000000000001        2.2599999999999998
        7.7199999999999998
```

2.2 Write a module Solar_hour_angle that calculates the solar hour angle in a given location for a given date and time.

[Hint: using the formulas from Solar Hour Angle & How to Calculate it]
创建：vi Solar_hour_angle
脚本：

```
module Solar_angle_hour

implicit none

real, parameter :: pi=3.1415926536

contains

   subroutine cal_sla(lon,m,d,t,sah)
   implicit none

   integer,intent(in) :: m,d
   real(8),intent(in) :: lon, t
   real(8),intent(out) :: sah
   integer :: doy
   real(8) :: offset, eot, gam

   doy=(m-1)*30+d
   gam=2*pi/365*(doy-1+(t-12)/24)

eot=229.18*(0.000075+0.001868*cos(gam)-0.032077*sin(gam)-0.014615*cos(2*gam)-0.040849
*sin(2*gam))
   offset=eot+MOD(lon,15.0)
   sah=15*(t-12)+offset/60

   End subroutine cal_sla
```

经过测试，可以运行。

```
[ese-wangyy@login02 fortran_demo1]$ vi Test2.f90
[ese-wangyy@login02 fortran_demo1]$ gfortran Solar_hour_angle.f90 Test2.f90 -o b.x
[ese-wangyy@login02 fortran_demo1]$ ./b.x
   52.513306131446733
```

2.3 Write a main program (Solar_elevation_angle.f90) that uses module Declination_angle and Solar_hour_angle to calculate and print the SEA in a given location for a given date and time.

创建： vi Solar_elevation_angle.f90

脚本：

```
Program Solar_elevation_angle

use Declination_angle
use Solar_angle_hour

implicit none

real, parameter    :: pii=3.1415926536
real(8)            :: lat,lon,t,sah,da
integer            :: m,d
real(8)            :: aes

lat=32.22
lon=1.0
t=10.0
m=3
d=3

call cal_angle(m,d,da)
call cal_sla(lon,m,d,t,sah)

aes=asin(sin(lat/180*pii)*sin(da/180*pii)+cos(lat/180*pii)*cos(da/180*pii)*cos(sah/180*pii))

aes=aes/pii*180.0
write(*,*) aes

End program Solar_elevation_angle
```

输出：

```
[ese-wangyy@login02 fortran_demo1]$ gfortran Solar_elevation_angle.f90 Declination_angle.f90 Solar_hour_angle.f90 -o c.x
[ese-wangyy@login02 fortran_demo1]$ ./c.x
   41.045703954998608
```

2.4 Create a library (libsea.a) that contains Declination_angle.o and Solar_hour_angle.o. Compile Solar_elevation_angle.f90 using libsea.a. Print the SEA for Shenzhen (22.542883N, 114.062996E) at 10:32 (Beijing time; UTC+8) on 2021-12-31.

创建 libsea.a：

```
[ese-wangyy@login02 fortran_demo1]$ gfortran -c Declination_angle.f90
[ese-wangyy@login02 fortran_demo1]$ gfortran -c Solar_hour_angle.f90
[ese-wangyy@login02 fortran_demo1]$ ar rcvf libsea.a Declination_angle.o Solar_hour_angle.o
a - Declination_angle.o
a - Solar_hour_angle.o
```

深圳的 SEA 脚本：

```
Program SZ_SEA

use Declination_angle
use Solar_angle_hour

implicit    none

real, parameter :: pii=3.1415926536
real(8) :: lat,lon,t,sah,da
integer :: m,d
real(8) :: aes

lat=22.542883
lon=114.062996
t=10.0+32/60
m=12
d=31

call cal_angle(m,d,da)
call cal_sla(lon,m,d,t,sah)

aes=asin(sin(lat/180*pii)*sin(da/180*pii)+cos(lat/180*pii)*cos(da/180*pii)*cos(sah/180*pii))
aes=aes/pii*180.0

write(*,*) aes

End program SZ_SEA
```

输出：

```
[ese-wangyy@login02 fortran_demo1]$ gfortran SZ_SEA.f90 -o d.x -L. -lsea
[ese-wangyy@login02 fortran_demo1]$ ./d.x
   35.790305803209272
```