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% CISC 330
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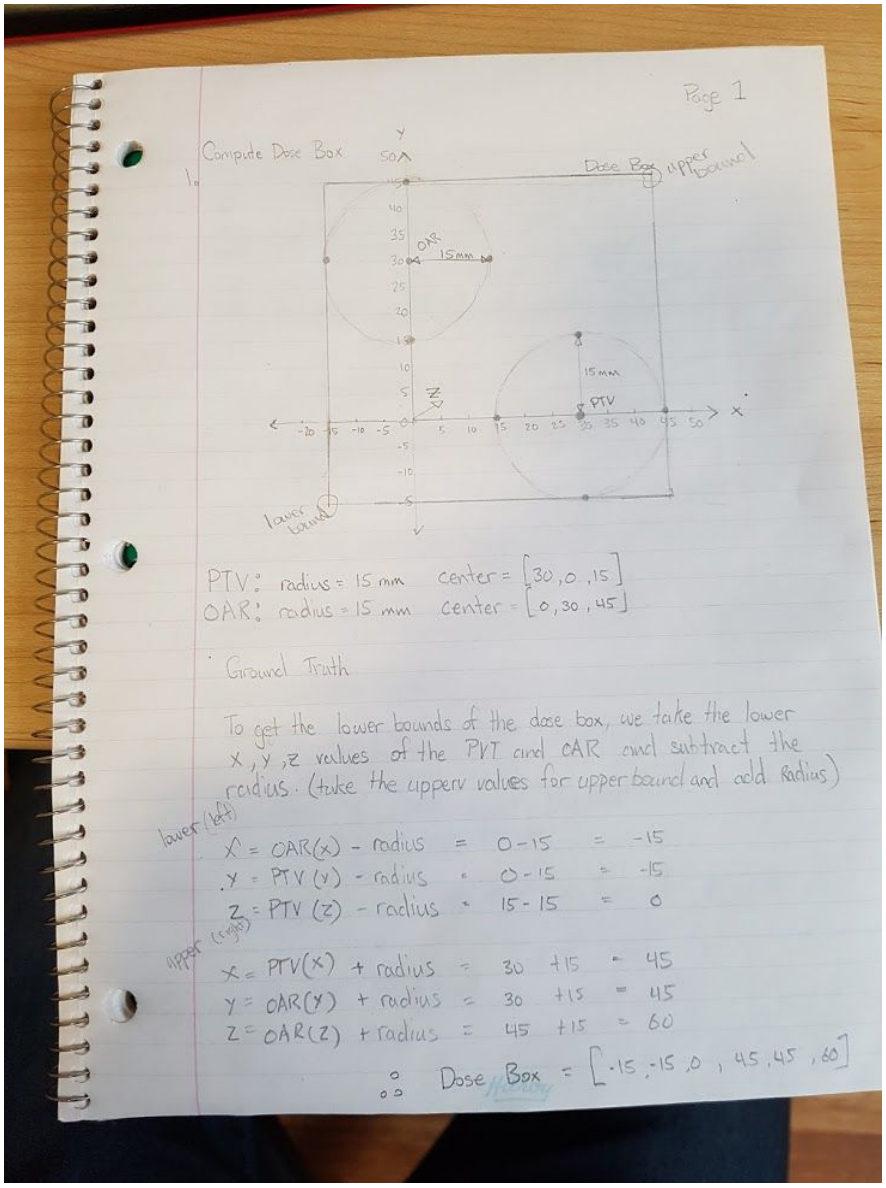
% Assignment 4: Gamma Knife Radiosurgery

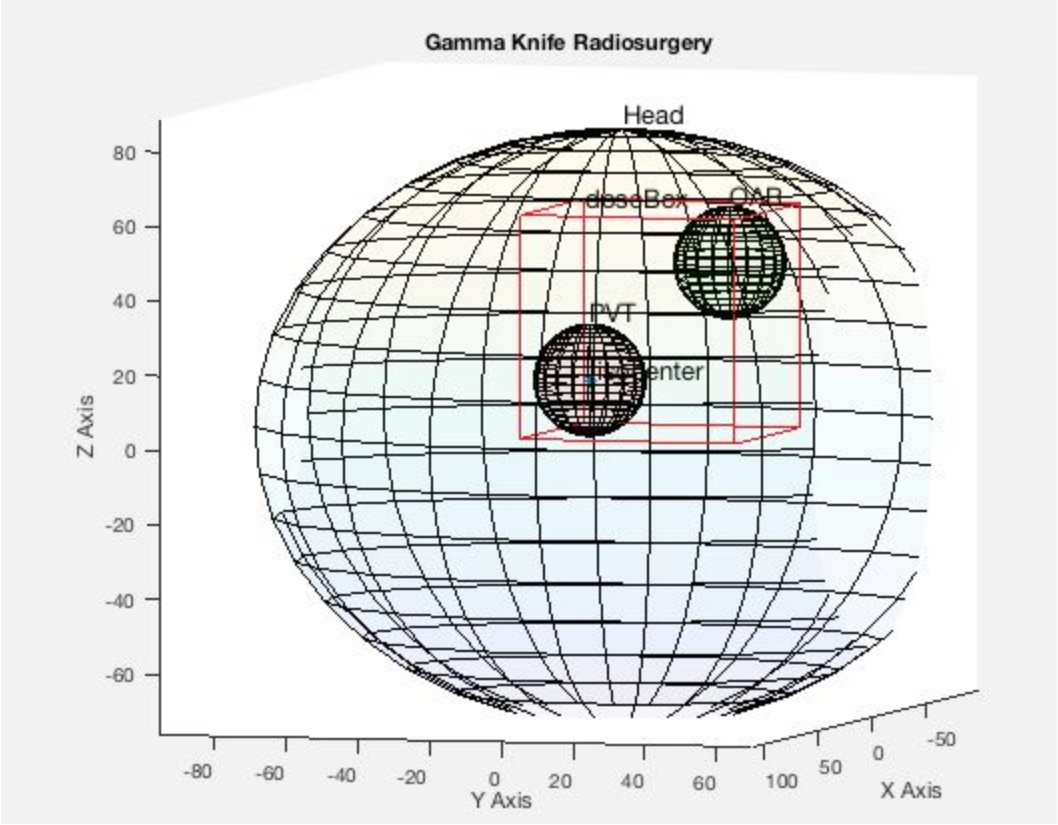
1. Compute Dose Box

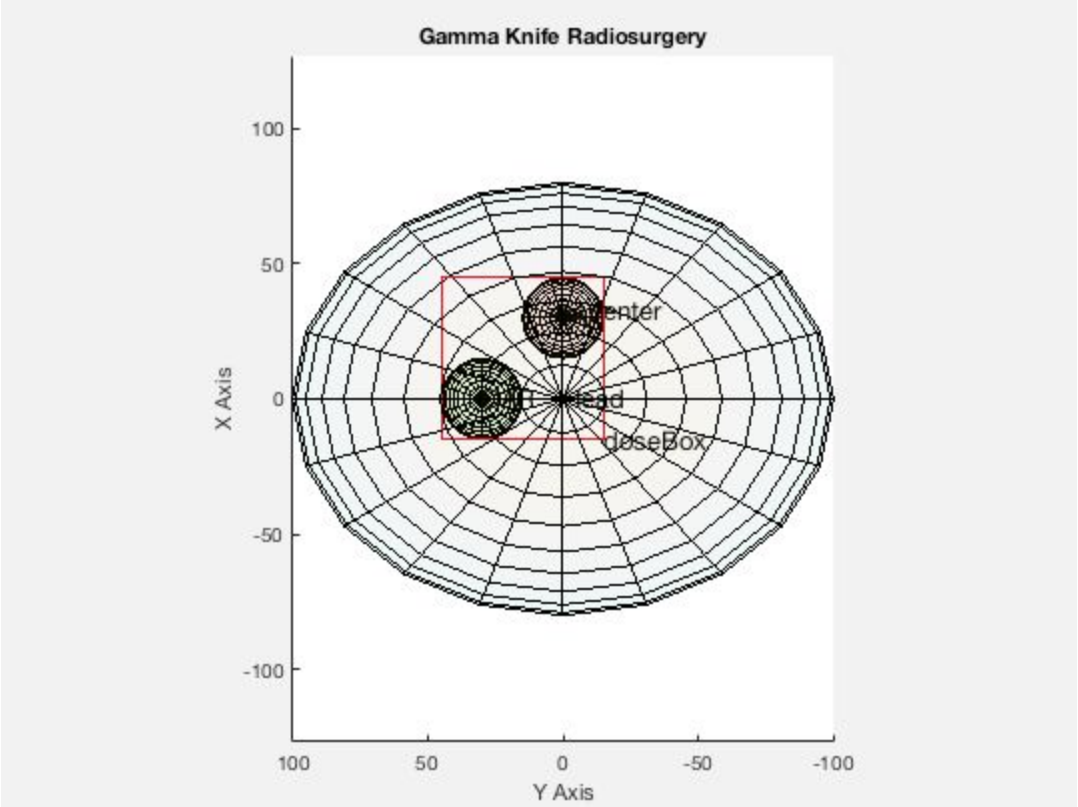
The dose box is the smallest box possible with holds both the PTV and OAR. The functions takes the PTV and the OAR, and returns the smallest dose box defined with the lower left and upper right.

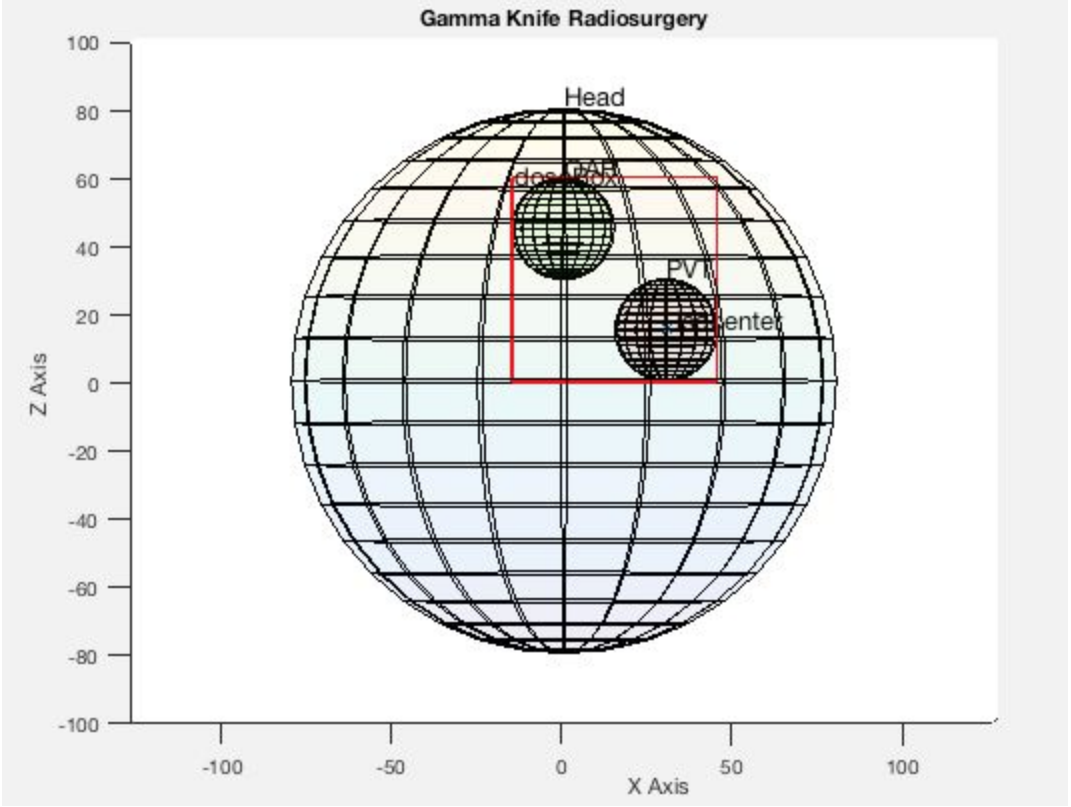


2. Draw 3D Scene

The 3D scene is a visual of the Gamma-Knife radiosurgery. The ellipsoid is the head of the patient, whole the PVT is the red sphere and the OAR is the green sphere. The dose box from question 1 is in red.




Gamma Knife Radiosurgery
X Axis
Y Axis
100
50
0
-50
-100
enter
ead
doseBox


Gamma Knife Radiosurgery
Z Axis
X Axis
100
80
60
40
20
0
-20
-40
-60
-80
-100
Head
PVI
enter

3. Compute Linear Function

Taking two 2D points and an x value, the y value is determined. We can use the two points to create a line, and calculate the slope (m) using the point slope formula. This will alow us to solve for the y value.

```
>> Compute_Linear_Function_Test
    1.0000

    2.0000

    3.0000

    4.0000

    5.0000

    6.0000
```

P1 = [1,1] P2 = [5,5] x = {1,2,3,4,6}

The two points y = x, so the slope (m) = 1. This means that any x input, should be the output/

4. Compute Radial Distance

Taking a point on a line, the direction vector and a point in space, the distance is found by finding the direction vector from the point on the line and the point in space. We find the shortest distance by taking the cross product of the two direction vectors, and the norm to find the scalar distance.

```
>> Compute_Radial_Distance_Test
Test 1

distance =

     1

Test 2

distance2 =

     1
```

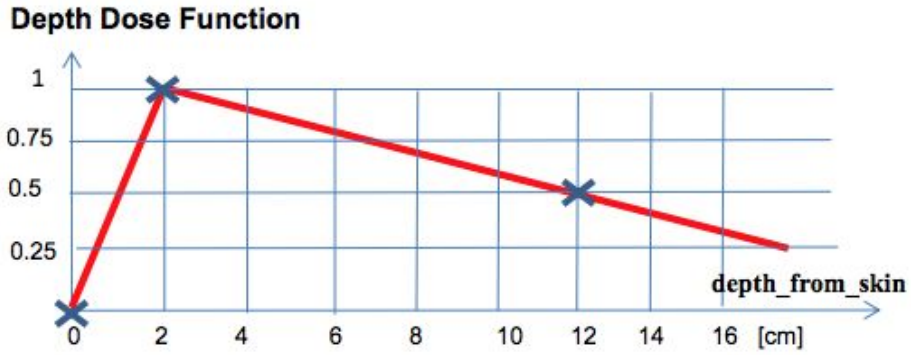
Test 1, The line is vertical, so it should be the difference in x-values

Test 2, The point and line create a right triangle

5.Compute Depth Dose

Using the graph given in the assignment, we can see that at 20mm, the dose is full, while at 120mm the dose is half. Between 0 and d0 we can use question 3, and similarly for d0 and beyond.

Depth dose, 20mm = 1, 120mm = 0.5

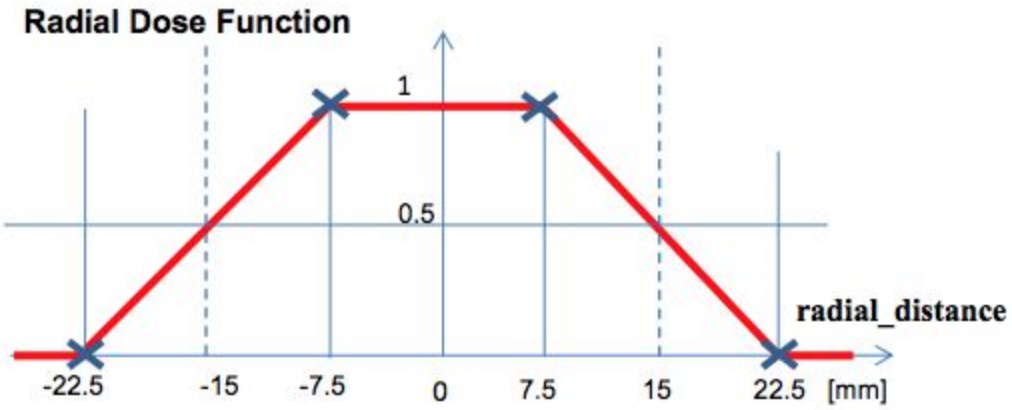


0	0
1.0000	0.0500
2.0000	1.0900
3.0000	1.0850
4.0000	1.0800
5.0000	1.0750
6.0000	1.0700
7.0000	1.0650
8.0000	1.0600
9.0000	1.0550
10.0000	1.0500
11.0000	1.0450
12.0000	1.0400
.	.
.	.
.	.
110.0000	0.5500
111.0000	0.5450
112.0000	0.5400
113.0000	0.5350
114.0000	0.5300
115.0000	0.5250
116.0000	0.5200
117.0000	0.5150
118.0000	0.5100
119.0000	0.5050
120.0000	0.5000

6. Compute Radial Dose

Similarly to question 5, using the graph given in the question, we can break up the graph into 3 segment and use question 3 at each segment.

Depth dose, -22.5mm = 0, -7.5 = 1 , 22.5mm = 0, 7.5 = 1




```
>> Compute_Radial_Dose_Test
  -23.0000         0
  -22.0000    0.0333
  -21.0000    0.1000
  -20.0000    0.1667
  -19.0000    0.2333
  -18.0000    0.3000
  -17.0000    0.3667
  -16.0000    0.4333
  -15.0000    0.5000
  -14.0000    0.5667
  -13.0000    0.6333
  -12.0000    0.7000
  -11.0000    0.7667
  -10.0000    0.8333
   -9.0000    0.9000
   -8.0000    0.9667
   -7.0000    1.0000
   -6.0000    1.0000
   -5.0000    1.0000
   -4.0000    1.0000
   -3.0000    1.0000
   -2.0000    1.0000
   -1.0000    1.0000
         0    1.0000
    1.0000    1.0000
    2.0000    1.0000
    3.0000    1.0000
    4.0000    1.0000
    5.0000    1.0000
    6.0000    1.0000
    7.0000    1.0000
    8.0000    0.9667
    9.0000    0.9000
   10.0000    0.8333
   11.0000    0.7667
   12.0000    0.7000
   13.0000    0.6333
   14.0000    0.5667
   15.0000    0.5000
   16.0000    0.4333
   17.0000    0.3667
   18.0000    0.3000
   19.0000    0.2333
   20.0000    0.1667
   21.0000    0.1000
   22.0000    0.0333
   23.0000         0
```

7. Compute Beam Direction Vector

With the source longitude and latitude on the gamma knife, we can determine the direction vector of the beam. Using azimuth(longitude) and elevation(latitude) we can find points on the sphere. We can use those points subtract the iso center [0,0,0] to find the direction vector.

```
>> Compute_Beam_Direction_Vector_Test
   -1.0000         0         0   -0.0000         0   -1.0000
   -0.0000   -1.0000         0   -0.0000   -0.0000   -1.0000
    1.0000   -0.0000         0    0.0000   -0.0000   -1.0000
    0.0000    1.0000         0    0.0000    0.0000   -1.0000
```

8. Compute Skin Entry Point

Using the information from question 7, we can solve for p1 = iso center - direction vector and find the intersection of the head and the line from the two points.

10/11. Compute Beam Safety/Compute Beam Safety Table

If the pencil beam intersected or came in contact with the OAR, then the value in the table would become 0 (unsafe).

```
>> Compute_Beam_Safety_Table
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     0     0     0     0     0     1     1     1
     1     0     0     0     0     0     0     1     1     1
     1     0     0     0     0     0     0     1     1     1
     1     0     0     0     0     0     0     0     1     1
     1     0     0     0     0     0     0     0     1     1
     1     0     0     0     0     0     0     1     1     1
     1     0     0     0     0     0     0     1     1     1
     1     1     0     0     0     0     0     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1     1     1
```

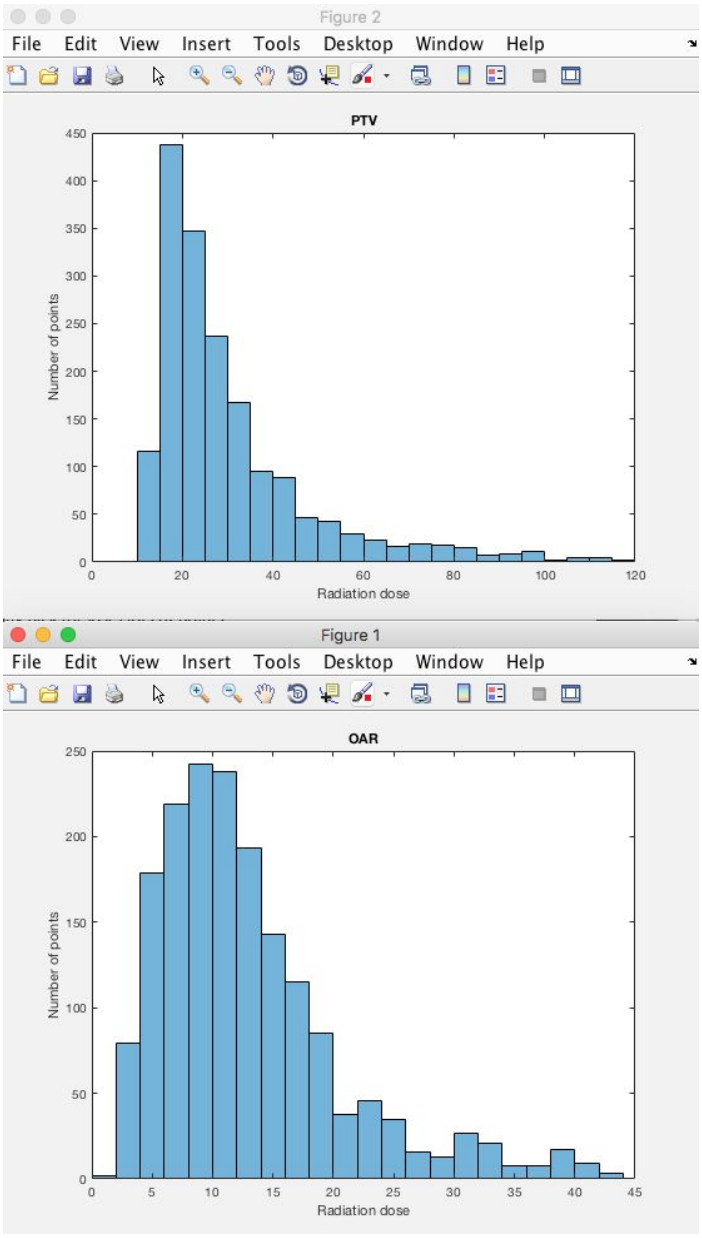
12. Compute Point Dose from Beam

These number were verified in the Depth & Radial dose tables

```
Computed radiation doses [0,0,0]
Isocenter point [0,0,0]
Longitude 0 , Latitude 0

doseTest1 =

    0.7000

Longitude 0 , Latitude 90

doseTest2 =

    0.7000

Longitude 90 , Latitude 0

doseTest3 =

    0.6000

Longitude 90 , Latitude 90

doseTest4 =

    0.7000
```

14. Compute Dose Volume Histogram

Using doseBox we can take every 2 points (voxel size of 2) and find if they are inside the OAR or PTV.We can the use question 12 on all these points to find the radiation dose for the histogram().



15/16. Compute Surface Dose/Compute Dose Surface Histogram
Creating points on a sphere, and calculating the maximum dose in the PTV and OAR.

```
>> Compute_Dose_Surface_Histogram
hottest on PTV
  219.6710

   33.7500   -2.7245   29.2658

coldest on PTV
  156.6270

   20.0180   11.0861   16.5679

hottest on OAR
    3.3817

   12.0688   21.2315   46.5679

coldest on OAR
     0

  -12.9904   30.0000   37.5000
```