Demo: Access Distributed NASA Earth Science Data from OPeNDAP Services from your Python Workspace

Analyze the difference of radiation between January and July

Step 1. Load python modules: pydap, basemap, numpy, and matplotlib

In [1]:
```
%matplotlib inline
from pydap.client import open_url
from mpl_toolkits.basemap import Basemap
import numpy as np
import matplotlib.pyplot as plt
```

Step 2. Define spatial extent of your interest (North America)

In [2]:
```
# BBOX for CONUS
west = -124.848974
south = 24.396308
east = -66.885444
north = 49.384358

# BBOX for North America
#west = -170.0
#south = 20.0
#east = -50.0
#north = 80.0
```

Step 3. Connect to a climatology data set on the ORNL DAAC OPeNDAP server and list its variables

In [3]:
```
dataset = open_url("http://thredds.daac.ornl.gov/thredds/dodsC/ornldaac/542/climate61
dataset.keys()
```

Out[3]:
```
['RAD', 'lat', 'climatology_bounds', 'lat_bnds', 'lon_bnds', 'time', 'lon']
```

Step 4. Check attributes of variable 'RAD'

In [4]:
```
dataset.RAD.attributes
```

Out[4]:
```
{'_ChunkSizes': [6, 180, 360],
 '_FillValue': -9999,
 'cell_methods': 'time: mean within months time: mean over years',
 'long_name': 'Radiation',
 'units': 'w/m2',
 'valid_range': [0, 1000]}
```

Step 5. Check dimensions of variable 'RAD'

In [5]:
```
dataset.RAD.array.dimensions
```
Out[5]:
```
('time', 'lat', 'lon')
```

Step 6. Check size of variable 'RAD'

In [6]:
```
dataset.RAD.array.shape
```
Out[6]:
```
(12, 360, 720)
```

Step 7. Find out indices for the spatial extent of your interest

Step 7.1. Retrieve latitudes

In [7]:
```
lats = dataset.lat[:]
lats
```

Out[7]:
```
array([-89.75, -89.25, -88.75, -88.25, -87.75, -87.25, -86.75, -86.25,
       -85.75, -85.25, -84.75, -84.25, -83.75, -83.25, -82.75, -82.25,
       -81.75, -81.25, -80.75, -80.25, -79.75, -79.25, -78.75, -78.25,
       -77.75, -77.25, -76.75, -76.25, -75.75, -75.25, -74.75, -74.25,
       -73.75, -73.25, -72.75, -72.25, -71.75, -71.25, -70.75, -70.25,
       -69.75, -69.25, -68.75, -68.25, -67.75, -67.25, -66.75, -66.25,
       -65.75, -65.25, -64.75, -64.25, -63.75, -63.25, -62.75, -62.25,
       -61.75, -61.25, -60.75, -60.25, -59.75, -59.25, -58.75, -58.25,
       -57.75, -57.25, -56.75, -56.25, -55.75, -55.25, -54.75, -54.25,
       -53.75, -53.25, -52.75, -52.25, -51.75, -51.25, -50.75, -50.25,
       -49.75, -49.25, -48.75, -48.25, -47.75, -47.25, -46.75, -46.25,
       -45.75, -45.25, -44.75, -44.25, -43.75, -43.25, -42.75, -42.25,
       -41.75, -41.25, -40.75, -40.25, -39.75, -39.25, -38.75, -38.25,
       -37.75, -37.25, -36.75, -36.25, -35.75, -35.25, -34.75, -34.25,
       -33.75, -33.25, -32.75, -32.25, -31.75, -31.25, -30.75, -30.25,
       -29.75, -29.25, -28.75, -28.25, -27.75, -27.25, -26.75, -26.25,
       -25.75, -25.25, -24.75, -24.25, -23.75, -23.25, -22.75, -22.25,
       -21.75, -21.25, -20.75, -20.25, -19.75, -19.25, -18.75, -18.25,
       -17.75, -17.25, -16.75, -16.25, -15.75, -15.25, -14.75, -14.25,
       -13.75, -13.25, -12.75, -12.25, -11.75, -11.25, -10.75, -10.25,
        -9.75,  -9.25,  -8.75,  -8.25,  -7.75,  -7.25,  -6.75,  -6.25,
        -5.75,  -5.25,  -4.75,  -4.25,  -3.75,  -3.25,  -2.75,  -2.25,
        -1.75,  -1.25,  -0.75,  -0.25,   0.25,   0.75,   1.25,   1.75,
         2.25,   2.75,   3.25,   3.75,   4.25,   4.75,   5.25,   5.75,
         6.25,   6.75,   7.25,   7.75,   8.25,   8.75,   9.25,   9.75,
        10.25,  10.75,  11.25,  11.75,  12.25,  12.75,  13.25,  13.75,
        14.25,  14.75,  15.25,  15.75,  16.25,  16.75,  17.25,  17.75,
        18.25,  18.75,  19.25,  19.75,  20.25,  20.75,  21.25,  21.75,
        22.25,  22.75,  23.25,  23.75,  24.25,  24.75,  25.25,  25.75,
        26.25,  26.75,  27.25,  27.75,  28.25,  28.75,  29.25,  29.75,
        30.25,  30.75,  31.25,  31.75,  32.25,  32.75,  33.25,  33.75,
        34.25,  34.75,  35.25,  35.75,  36.25,  36.75,  37.25,  37.75,
        38.25,  38.75,  39.25,  39.75,  40.25,  40.75,  41.25,  41.75,
        42.25,  42.75,  43.25,  43.75,  44.25,  44.75,  45.25,  45.75,
        46.25,  46.75,  47.25,  47.75,  48.25,  48.75,  49.25,  49.75,
        50.25,  50.75,  51.25,  51.75,  52.25,  52.75,  53.25,  53.75,
        54.25,  54.75,  55.25,  55.75,  56.25,  56.75,  57.25,  57.75,
        58.25,  58.75,  59.25,  59.75,  60.25,  60.75,  61.25,  61.75,
        62.25,  62.75,  63.25,  63.75,  64.25,  64.75,  65.25,  65.75,
        66.25,  66.75,  67.25,  67.75,  68.25,  68.75,  69.25,  69.75,
        70.25,  70.75,  71.25,  71.75,  72.25,  72.75,  73.25,  73.75,
        74.25,  74.75,  75.25,  75.75,  76.25,  76.75,  77.25,  77.75,
        78.25,  78.75,  79.25,  79.75,  80.25,  80.75,  81.25,  81.75,
        82.25,  82.75,  83.25,  83.75,  84.25,  84.75,  85.25,  85.75,
        86.25,  86.75,  87.25,  87.75,  88.25,  88.75,  89.25,  89.75])
```

Step 7.2. Retrieve longitudes

In [8]:
```
lons = dataset.lon[:]
lons
```

Out[8]:
```
array([-179.75, -179.25, -178.75, -178.25, -177.75, -177.25, -176.75,
       -176.25, -175.75, -175.25, -174.75, -174.25, -173.75, -173.25,
       -172.75, -172.25, -171.75, -171.25, -170.75, -170.25, -169.75,
       -169.25, -168.75, -168.25, -167.75, -167.25, -166.75, -166.25,
       -165.75, -165.25, -164.75, -164.25, -163.75, -163.25, -162.75,
       -162.25, -161.75, -161.25, -160.75, -160.25, -159.75, -159.25,
       -158.75, -158.25, -157.75, -157.25, -156.75, -156.25, -155.75,
       -155.25, -154.75, -154.25, -153.75, -153.25, -152.75, -152.25,
       -151.75, -151.25, -150.75, -150.25, -149.75, -149.25, -148.75,
       -148.25, -147.75, -147.25, -146.75, -146.25, -145.75, -145.25,
       -144.75, -144.25, -143.75, -143.25, -142.75, -142.25, -141.75,
       -141.25, -140.75, -140.25, -139.75, -139.25, -138.75, -138.25,
       -137.75, -137.25, -136.75, -136.25, -135.75, -135.25, -134.75,
       -134.25, -133.75, -133.25, -132.75, -132.25, -131.75, -131.25,
       -130.75, -130.25, -129.75, -129.25, -128.75, -128.25, -127.75,
       -127.25, -126.75, -126.25, -125.75, -125.25, -124.75, -124.25,
       -123.75, -123.25, -122.75, -122.25, -121.75, -121.25, -120.75,
       -120.25, -119.75, -119.25, -118.75, -118.25, -117.75, -117.25,
       -116.75, -116.25, -115.75, -115.25, -114.75, -114.25, -113.75,
       -113.25, -112.75, -112.25, -111.75, -111.25, -110.75, -110.25,
       -109.75, -109.25, -108.75, -108.25, -107.75, -107.25, -106.75,
       -106.25, -105.75, -105.25, -104.75, -104.25, -103.75, -103.25,
       -102.75, -102.25, -101.75, -101.25, -100.75, -100.25,  -99.75,
        -99.25,  -98.75,  -98.25,  -97.75,  -97.25,  -96.75,  -96.25,
        -95.75,  -95.25,  -94.75,  -94.25,  -93.75,  -93.25,  -92.75,
        -92.25,  -91.75,  -91.25,  -90.75,  -90.25,  -89.75,  -89.25,
        -88.75,  -88.25,  -87.75,  -87.25,  -86.75,  -86.25,  -85.75,
        -85.25,  -84.75,  -84.25,  -83.75,  -83.25,  -82.75,  -82.25,
        -81.75,  -81.25,  -80.75,  -80.25,  -79.75,  -79.25,  -78.75,
        -78.25,  -77.75,  -77.25,  -76.75,  -76.25,  -75.75,  -75.25,
        -74.75,  -74.25,  -73.75,  -73.25,  -72.75,  -72.25,  -71.75,
        -71.25,  -70.75,  -70.25,  -69.75,  -69.25,  -68.75,  -68.25,
        -67.75,  -67.25,  -66.75,  -66.25,  -65.75,  -65.25,  -64.75,
        -64.25,  -63.75,  -63.25,  -62.75,  -62.25,  -61.75,  -61.25,
        -60.75,  -60.25,  -59.75,  -59.25,  -58.75,  -58.25,  -57.75,
        -57.25,  -56.75,  -56.25,  -55.75,  -55.25,  -54.75,  -54.25,
        -53.75,  -53.25,  -52.75,  -52.25,  -51.75,  -51.25,  -50.75,
        -50.25,  -49.75,  -49.25,  -48.75,  -48.25,  -47.75,  -47.25,
        -46.75,  -46.25,  -45.75,  -45.25,  -44.75,  -44.25,  -43.75,
        -43.25,  -42.75,  -42.25,  -41.75,  -41.25,  -40.75,  -40.25,
        -39.75,  -39.25,  -38.75,  -38.25,  -37.75,  -37.25,  -36.75,
        -36.25,  -35.75,  -35.25,  -34.75,  -34.25,  -33.75,  -33.25,
        -32.75,  -32.25,  -31.75,  -31.25,  -30.75,  -30.25,  -29.75,
        -29.25,  -28.75,  -28.25,  -27.75,  -27.25,  -26.75,  -26.25,
        -25.75,  -25.25,  -24.75,  -24.25,  -23.75,  -23.25,  -22.75,
        -22.25,  -21.75,  -21.25,  -20.75,  -20.25,  -19.75,  -19.25,
        -18.75,  -18.25,  -17.75,  -17.25,  -16.75,  -16.25,  -15.75,
        -15.25,  -14.75,  -14.25,  -13.75,  -13.25,  -12.75,  -12.25,
        -11.75,  -11.25,  -10.75,  -10.25,   -9.75,   -9.25,   -8.75,
         -8.25,   -7.75,   -7.25,   -6.75,   -6.25,   -5.75,   -5.25,
         -4.75,   -4.25,   -3.75,   -3.25,   -2.75,   -2.25,   -1.75,
         -1.25,   -0.75,   -0.25,    0.25,    0.75,    1.25,    1.75,
          2.25,    2.75,    3.25,    3.75,    4.25,    4.75,    5.25,
          5.75,    6.25,    6.75,    7.25,    7.75,    8.25,    8.75,
          9.25,    9.75,   10.25,   10.75,   11.25,   11.75,   12.25,
         12.75,   13.25,   13.75,   14.25,   14.75,   15.25,   15.75,
         16.25,   16.75,   17.25,   17.75,   18.25,   18.75,   19.25,
         19.75,   20.25,   20.75,   21.25,   21.75,   22.25,   22.75,
         23.25,   23.75,   24.25,   24.75,   25.25,   25.75,   26.25,
         26.75,   27.25,   27.75,   28.25,   28.75,   29.25,   29.75,
         30.25,   30.75,   31.25,   31.75,   32.25,   32.75,   33.25,
         33.75,   34.25,   34.75,   35.25,   35.75,   36.25,   36.75
```

Step 7.3. Calculate indices

In [9]:
```
idx_west = np.argmin(np.abs(lons - west))
idx_south = np.argmin(np.abs(lats - south))
idx_east = np.argmin(np.abs(lons - east))
idx_north = np.argmin(np.abs(lats - north))
print [idx_west, idx_south, idx_east, idx_north]
```

```
[110, 228, 226, 278]
```

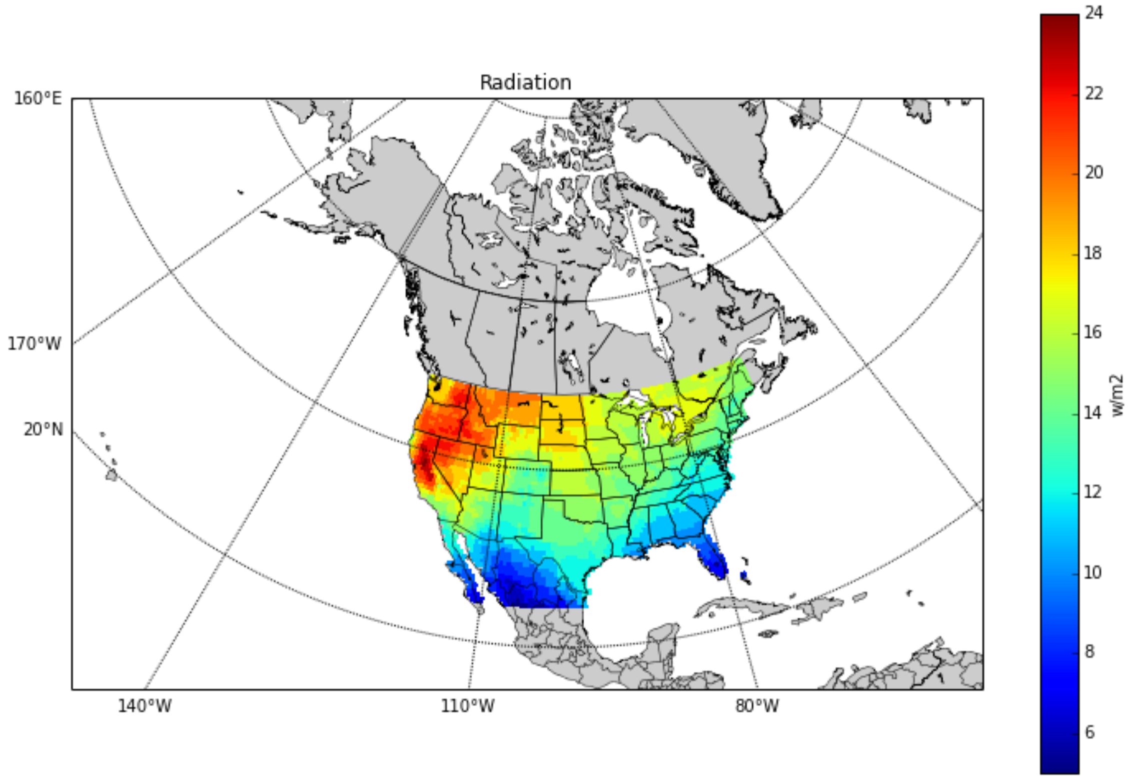
Step 8. Retrieve subsets of the radiation data in January and July for North America. Calculate the radiation difference between July and January

In [10]:
```
rad_na_jan = dataset.RAD[0,idx_south:idx_north,idx_west:idx_east]
lats_subset = rad_na_jan.lat[:]
lons_subset = rad_na_jan.lon[:]
rad_na_jan = np.ma.masked_where(rad_na_jan.RAD==dataset.RAD._FillValue, rad_na_jan.RA
rad_na_jul = dataset.RAD[6,idx_south:idx_north,idx_west:idx_east]
rad_na_jul = np.ma.masked_where(rad_na_jul.RAD==dataset.RAD._FillValue, rad_na_jul.RA

rad_na_diff=rad_na_jul-rad_na_jan
```

Step 9. Plot the radiation difference on a map

In [11]:
```
fig = plt.figure(figsize=(12,8))
ax = fig.add_axes([0.1, 0.1, 0.8, 0.8])
m = Basemap(llcrnrlon=-145.5,\
                    llcrnrlat=1.,\
                    urcrnrlon=-2.566,\
                    urcrnrlat=46.352,\
                    rsphere=(6378137.00,6356752.3142),\
                    resolution='l',\
                    area_thresh=1000.,\
                    projection='lcc',\
                    lat_1=50.,
                    lon_0=-100.,
                    ax=ax)
X, Y = m(*np.meshgrid(lons_subset, lats_subset))
Z = np.mean(rad_na_diff, axis=0)
colors = m.pcolor(X, Y, Z)
cb = plt.colorbar(colors)
cb.set_label(dataset.RAD.units)
m.drawlsmask()
m.drawcoastlines(linewidth=0.5)
m.drawcountries()
m.drawstates()
parallels = np.arange(0.,80,20.)
m.drawparallels(parallels,labels=[1,0,0,1])
meridians = np.arange(10.,360.,30.)
m.drawmeridians(meridians,labels=[1,0,0,1])
ax.set_title(dataset.RAD.long_name)
plt.show()
```



In [ ]: