Preprocessing

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1 Preprocessing

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1.0.1 Download Data

Downloading data from box is tricky, here's the URL for the data download.

Data are created by Park Williams, from various sources. Download from Box

Fire data are created by Caroline Juang and Park Williams, from the Monitoring Trends in Burn Severity (MTBS) product and government agency databases. Use the `burnarea_combined.nc` file. Download from Box

1.0.2 Workspace Setup

Import variables

Just for technical use * EPA ecoregion `epa_l2` * western US region `mask_US`

Variable to predict * forest burned area `burnarea`

Static * fractional forest area `forest` * elevation `elev`

Land cover change * Distance to wildland-urban interface `wui_distance_new` * Months since gridcell burned `return_months` * Years since gridcell burned `return_years`

Climate (and z-variables which represent `observed - 1984-2019 average`) * daily maximum temperature `Tmax` `Tmax_z` * vapor-pressure deficit `vpd` `vpd_z` * relative humidity `rh` `rh_z` * precipitation `prec` `prec_z` * wind `wind`

Initial investigations * create mask for the western US land * Monthly and yearly fire return frequency (to get `return_months` and `return_years`)

[1]:
```
# import
import numpy as np
import xarray as xr
import pandas as pd
import rioxarray as rio
import matplotlib.pyplot as plt
```

[2]:
```
# importing data string
directory = 'C:\\Users\\carol\\Documents\\Research Data 2020\\12km\\'
```

1.0.3 Ecoregions

- 10.1 Cold deserts
- 7.1 Marine west coast forest
- 11.1 Mediterranean California
- 9.4 South Central Semiarid Prairies
- 9.2 Temperate Prairies (not included)
- 13.1 Upper Gila Mountains
- 10.2 Warm Deserts
- 9.3 West-Central Semiarid Prairies
- 6.2 Western Cordillera
- 12.1 Western Sierra Madre Piedmont

[3]:
```
## open the ecoregion data
ecoregion_data = xr.open_dataset(directory +␣
↪'landcover\\Ecoregions_EPA\\epa_level2.nc')
# drop the bad ecoregion
ecoregion_data = ecoregion_data.sel(province=[0,1,2,3,5,6,7,8,9], drop=True)

ecoregion_legend = ecoregion_data.ecoregion
print(ecoregion_legend.legend)
epa_l2 = ecoregion_data.epa_level2
ecoregion_data = None
```

```
1: COLD DESERTS, 2: MARINE WEST COAST FOREST, 3: MEDITERRANEAN CALIFORNIA, 4:
SOUTH CENTRAL SEMIARID PRAIRIES, 5: TEMPERATE PRAIRIES, 6: UPPER GILA MOUNTAINS,
7: WARM DESERTS, 8: WEST-CENTRAL SEMIARID PRAIRIES, 9: WESTERN CORDILLERA, 10:
WESTERN SIERRA MADRE PIEDMONT
```

[4]:
```
# setup forested area burned

firsttime = "1984-01-15"
finaltime = "2019-12-15"

# forest fractional area (Ruefenacht et al., 2018)
forest_type_data = xr.open_dataset(directory +␣
↪'landcover\\US_ForestType_Ruefenacht\\forest_type_frac.nc')

# fire burned area (Williams and Juang)
burnarea_data = xr.open_dataset(directory + 'wildfire\\burnarea_combined.nc',␣
↪engine='netcdf4')
time_str = burnarea_data.time
X = burnarea_data.X
Y = burnarea_data.Y
```

```
burnarea_data = burnarea_data.rio.set_spatial_dims(x_dim='X', y_dim='Y',␣
↪inplace=True)
burn = burnarea_data.burnarea

# get forest burned area (forest fraction x burned area)

# storage
forest = np.zeros((len(Y), len(X)), np.single)
# add up the forest percentages for each forest type
forest = forest_type_data.sum(dim='ftype').forest_type_frac
burnarea = burn*forest.values # result

# constrain time to 2019 (last year of fully-known data)
burnarea = burnarea.loc[firsttime:finaltime]
```

[5]:
```
# import and setup other data

# CLIMATE

ea = xr.open_dataset(directory + 'climate\\primary\\ea.nc')
es = xr.open_dataset(directory + 'climate\\primary\\es.nc')
vpd = es.es.loc[firsttime:finaltime] - ea.ea.loc[firsttime:finaltime]

rh = xr.open_dataset(directory + 'climate\\primary\\rh.nc')
rh = rh.rh.loc[firsttime:finaltime]

tmax = xr.open_dataset(directory + 'climate\\primary\\tmax.nc')
tmax = tmax.tmax.loc[firsttime:finaltime]

prec = xr.open_dataset(directory + 'climate\\primary\\prec.nc')
prec = prec.prec.loc[firsttime:finaltime]

wind = xr.open_dataset(directory + 'climate\\primary\\wind.nc')
wind = wind.wind.loc[firsttime:finaltime]

# LAND COVER

elevstd = xr.open_dataset(directory + 'topography\\elevstd.nc')
elevstd = elevstd.elevstd

wui_distance = xr.open_dataset(directory + 'population\\silvis\\wui_distance.
↪nc')
wui_distance = wui_distance.wui_distance
```

[6]:
```
time = burnarea.time
province = epa_l2.province
```

```
for thisregion in province:
    # vpd
    tmpavg = (vpd*epa_l2[thisregion]).sum(dim=['Y','X','time']) /␣
 ↪(epa_l2[thisregion].sum()*len(time))
    vpd_z = vpd*epa_l2[thisregion] - tmpavg

    # rh
    tmpavg = (rh*epa_l2[thisregion]).sum(dim=['Y','X','time']) /␣
 ↪(epa_l2[thisregion].sum()*len(time))
    rh_z = rh*epa_l2[thisregion] - tmpavg

    # tmax
    tmpavg = (tmax*epa_l2[thisregion]).sum(dim=['Y','X','time']) /␣
 ↪(epa_l2[thisregion].sum()*len(time))
    tmax_z = tmax*epa_l2[thisregion] - tmpavg

    # prec
    tmpavg = (prec*epa_l2[thisregion]).sum(dim=['Y','X','time']) /␣
 ↪(epa_l2[thisregion].sum()*len(time))
    prec_z = tmax*epa_l2[thisregion] - tmpavg
```

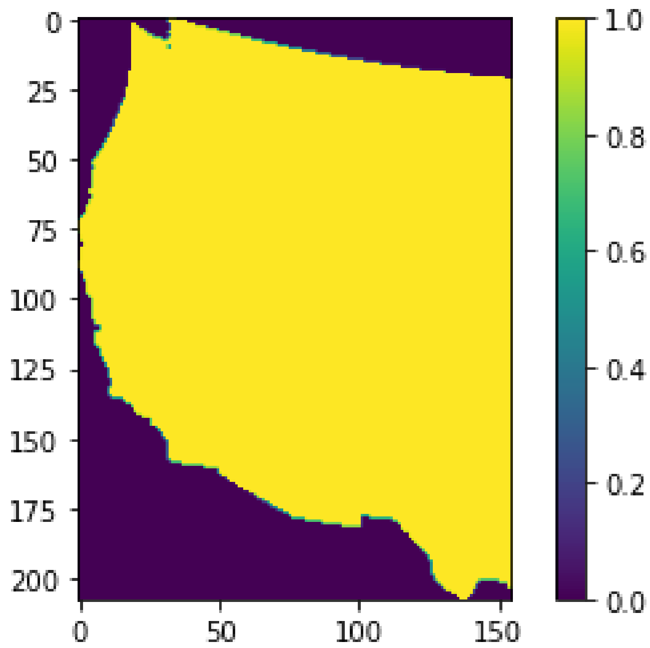
[7]:
```
# convert wui distance into variable for all years

# get time and set up
firstyear = pd.DatetimeIndex(burnarea.time.values).year.min()
finalyear = pd.DatetimeIndex(burnarea.time.values).year.max()
years = np.arange(firstyear, finalyear+1, 1)

wui_distance_new = wui_distance.interp(year=years) # interpolate to fill in␣
 ↪years
```

2 Initial investigations

Some interesting ways to look at fire return rate

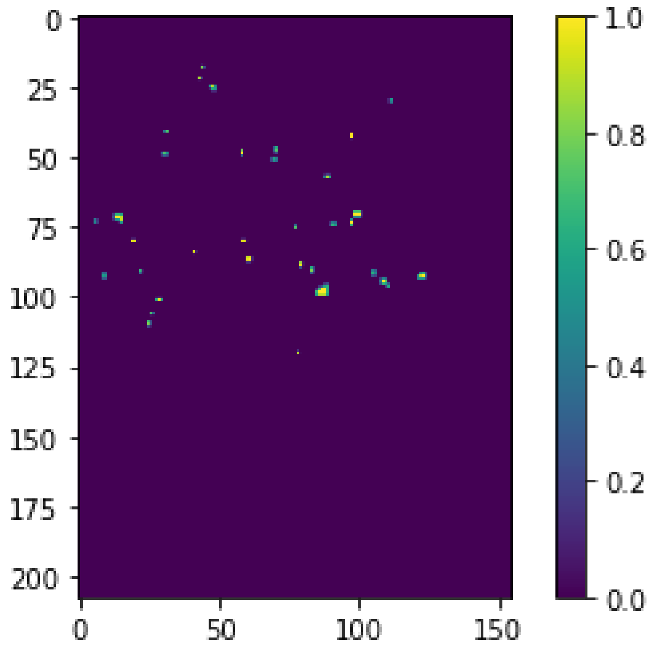
[8]:
```
# storage
time = burnarea.time
X = burnarea_data.X
Y = burnarea_data.Y

# get the NaN values in a mask
maskUS = ~np.isnan(burnarea.isel(time=0))
fig, ax = plt.subplots()
this = ax.imshow(maskUS)
fig.colorbar(this)
```

[8]:
```
<matplotlib.colorbar.Colorbar at 0x20aa6895be0>
```



[9]:
```
burnyes_month = (burnarea>0).astype(int)

fig, ax = plt.subplots()
this = ax.imshow(burnyes_month.sel(time="2018-09-15"))
fig.colorbar(this)
```

[9]: <matplotlib.colorbar.Colorbar at 0x20aac3c62e0>



[10]:
```
burnyes_month.where((burnyes_month!=1) & (burnyes_month!=0)).count()
```

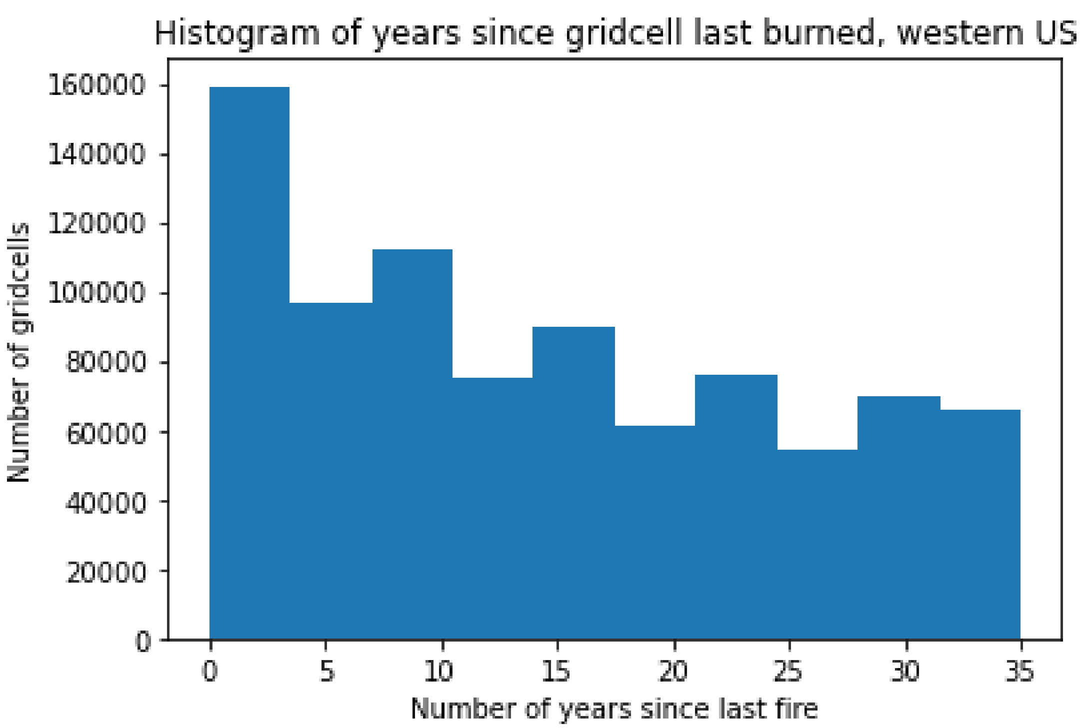
[10]:
```
<xarray.DataArray 'burnarea' ()>
array(0)
```

[11]:
```
# burnno_yr captures conditionally whether a gridcell burned.
# 1 = gricell did not burn
# 0 = gricell burned
burnno_yr = burnarea.resample(indexer={'time':'Y'}).sum(skipna=True)
burnno_yr = (burnno_yr==0).astype(int)

# extract dimension info
time = burnno_yr.time
X = burnno_yr.X
Y = burnno_yr.Y

# initialize storage
return_years = np.zeros((len(time), len(Y), len(X))) # empty storage for years␣
 ↪since the last fire

# iterate
index = 1
for year in burnno_yr.time[index:]:
    tmp_thisyr = burnno_yr.isel(time=index) # 2d DataArray
    tmp_prevyr = return_years[index-1] # last year's burn info
```

```
    tmp_return = tmp_thisyr + tmp_prevyr # add new year
    tmp_return = tmp_return.where(tmp_thisyr>0, other=0) # if a fire burned,␣
↪reset the counter with 0
    return_years[index] = tmp_return # store this memory
    index+=1

# transform return_years into a xarray DataArray
return_years = xr.DataArray(data=return_years,
                            dims=['time','Y','X'],
                            coords=dict(X=X, Y=Y, time=time),
                            attrs=dict(
                                description='Time since gridcell last burned',
                                units='years'
                            ))
return_years = return_years.where(maskUS) # put NaN outside western US border
```

[12]:
```
fig, ax = plt.subplots()
ax.hist(np.ndarray.flatten(return_years.values))
ax.set_title('Histogram of years since gridcell last burned, western US')
ax.set_xlabel('Number of years since last fire')
ax.set_ylabel('Number of gridcells')
```

[12]:
```
Text(0, 0.5, 'Number of gridcells')
```



[13]:

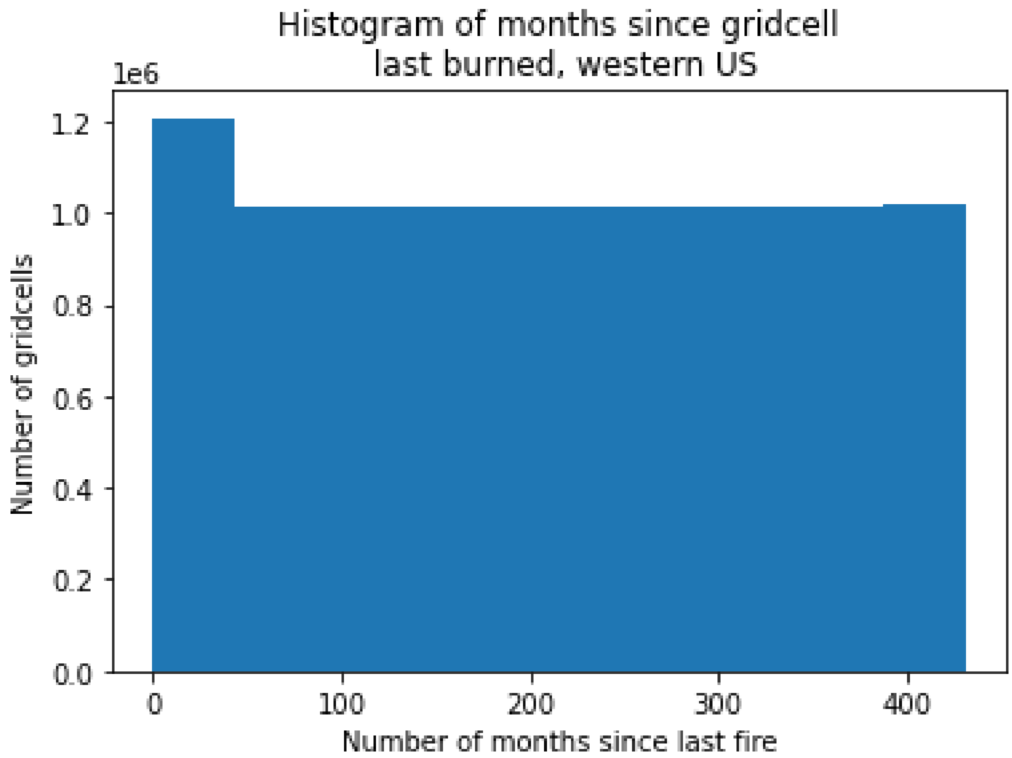
```
# burnno_mo captures conditionally how many months since the last time the␣
↪gridcell burned.
# 1 = gricell did not burn
# 0 = gricell burned
burnno_mo = (burnarea==0).astype(int)

# extract dimension info
time = burnno_mo.time
X = burnno_mo.X
Y = burnno_mo.Y

# initialize storage
return_months = np.zeros((len(time), len(Y), len(X))) # empty storage for years␣
↪since the last fire

# iterate
index = 1
for year in burnno_mo.time[index:]:
    tmp_thismo = burnno_mo.isel(time=index) # 2d DataArray
    tmp_prevmo = return_months[index-1] # last year's burn info
    tmp_return = tmp_thismo + tmp_prevmo # add new year
    tmp_return = tmp_return.where(tmp_thisyr>0, other=0) # if a fire burned,␣
↪reset the counter with 0
    return_months[index] = tmp_return # store this memory
    index+=1

# transform into a xarray DataArray
return_months = xr.DataArray(data=return_months,
                             dims=['time','Y','X'],
                             coords=dict(X=X, Y=Y, time=time),
                             attrs=dict(
                                 description='Time since gridcell last burned',
                                 units='months'
                             ))
return_months = return_months.where(maskUS) # put NaN outside western US border
```

[14]:

```
fig, ax = plt.subplots()
ax.hist(np.ndarray.flatten(return_months.values))
ax.set_title('Histogram of months since gridcell\n last burned, western US')
ax.set_xlabel('Number of months since last fire')
ax.set_ylabel('Number of gridcells')
```

[14]:

```
Text(0, 0.5, 'Number of gridcells')
```



[18]:
```
# export all data as new netCDF files

epa_l2.to_netcdf('data\\epa_l2.nc') # static
maskUS.to_netcdf('data\\maskUS.nc')
forest.to_netcdf('data\\forest.nc')
elevstd.to_netcdf('data\\elevstd.nc')

vpd.to_netcdf('data\\vpd.nc') # climate
rh.to_netcdf('data\\rh.nc')
tmax.to_netcdf('data\\tmax.nc')
prec.to_netcdf('data\\prec.nc')
wind.to_netcdf('data\\wind.nc')
vpd_z.to_netcdf('data\\vpd_z.nc')
rh_z.to_netcdf('data\\rh_z.nc')
tmax_z.to_netcdf('data\\tmax_z.nc')
prec_z.to_netcdf('data\\prec_z.nc')

burnarea.to_netcdf('data\\burnarea.nc') # y variable to predict
wui_distance_new.to_netcdf('data\\wui_distance_new.nc') # land change
return_years.to_netcdf('data\\return_years.nc')
return_months.to_netcdf('data\\return_months.nc')
```

```
[ ]:
```