replace_mss_L2

October 25, 2023

1 one must install pygmt using the instructions linked below https://www.pygmt.org/v0.3.0/install.html#installing-gmt-and-other-dependencies

[19]:
```
import xarray as xr
import matplotlib.pyplot as plt
import pygmt
import os
import pandas as pd
```

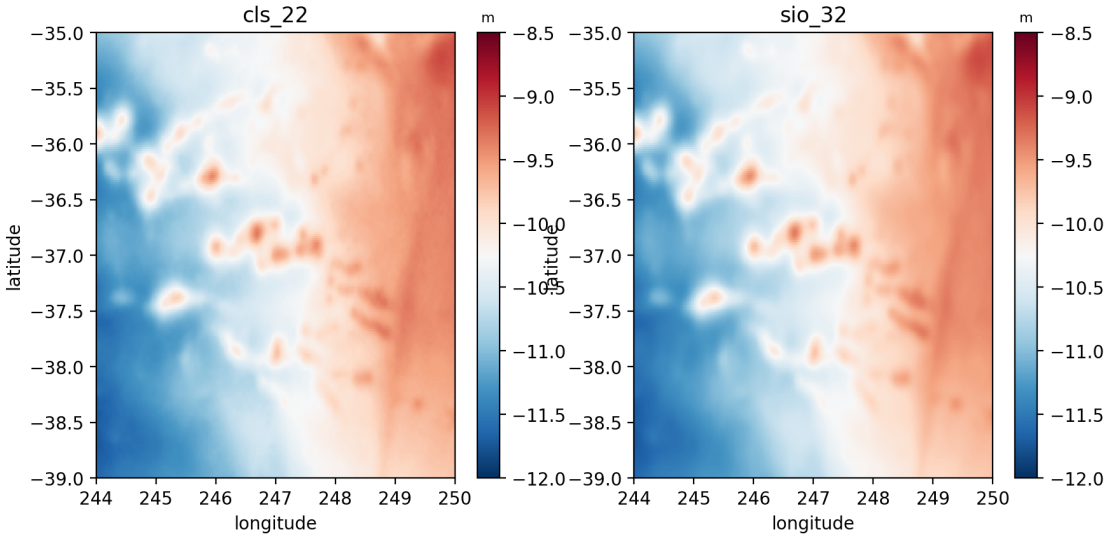
2 get the global MSS grids the first time only. also get the MDT grid if you need it.

[20]:
```
#!wget -q --no-check-certificate https://topex.ucsd.edu/pub/MSS_replace/
 ↪CNES_CLS_22_H_WGS84.nc
#!wget -q --no-check-certificate https://topex.ucsd.edu/pub/MSS_replace/
 ↪mss_sio_32.1_WGS84.nc
#!wget -q --no-check-certificate https://topex.ucsd.edu/pub/MSS_replace/
 ↪mdt_cnes_cls22_fg.nc
```

3 open the two mss grid and display an area

[21]:
```
grid_file32 = xr.open_dataset("mss_sio_32.1_WGS84.nc")
cgrid32 = grid_file32.sel(lon=slice(244,250), lat=slice(-39,-35))
grid_file22 = xr.open_dataset("CNES_CLS_22_H_WGS84.nc")
cgrid22 = grid_file22.sel(lon=slice(244,250), lat=slice(-39,-35))
plt.figure(figsize=(10, 10), dpi=200)
plt.subplot(222); plt.pcolormesh(cgrid32.lon, cgrid32.lat, cgrid32.z,␣
 ↪cmap='RdBu_r', shading='auto', vmin = -12, vmax = -8.5)
plt.xlim([244,250]); plt.ylim([-39,-35]); plt.title('sio_32'); plt.
 ↪xlabel('longitude'); plt.ylabel('latitude')
```

```
clb = plt.colorbar(); clb.ax.set_title('m',fontsize=8);
plt.subplot(221); plt.pcolormesh(cgrid22.lon, cgrid22.lat, cgrid22.z,␣
 ↪cmap='RdBu_r', shading='auto', vmin = -12, vmax = -8.5)
plt.xlim([244,250]); plt.ylim([-39,-35]); plt.title('cls_22'); plt.
 ↪xlabel('longitude'); plt.ylabel('latitude')
clb = plt.colorbar(); clb.ax.set_title('m',fontsize=8);
plt.show()
```

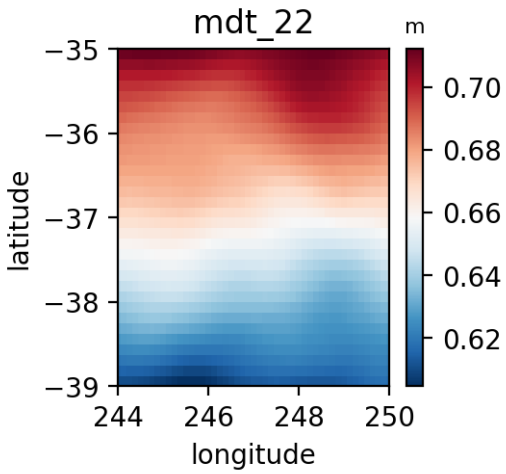


4 open the MDT grid and diaplay the area.

4.0.1 Note the MDT is not normally used because most users.

4.0.2 want just the time varying part of the dynamic topography.

[22]:
```
grid_file_mdt = xr.open_dataset("mdt_cnes_cls22_fg.nc")
cgrid_mdt = grid_file_mdt.sel(lon=slice(244,250), lat=slice(-39,-35))
plt.figure(figsize=(5, 5), dpi=200)
plt.subplot(222); plt.pcolormesh(cgrid_mdt.lon, cgrid_mdt.lat, cgrid_mdt.z,␣
 ↪cmap='RdBu_r', shading='auto')
plt.xlim([244,250]);
plt.ylim([-39,-35]);
plt.title('mdt_22'); plt.xlabel('longitude'); plt.ylabel('latitude')
clb = plt.colorbar(); clb.ax.set_title('m',fontsize=8);
plt.show()
```



5 read a netcdf file of L2 expert

[23]:
```
ds_Foundation = xr.
 ↪open_dataset("SWOT_L2_LR_SSH_Expert_547_011_20230609T190904_20230609T200011_PIB0_01.
 ↪nc")
num_lines = ds_Foundation.sizes['num_lines']
num_pixels = ds_Foundation.sizes['num_pixels']
num_lines
```

[23]: 9866

6 extract the sio_32 MSS at the locations of the SWOT data using grdtrack

[24]:
```
grid32 = "mss_sio_32.1_WGS84.nc"
data32 = {'longitude': ds_Foundation["longitude"].values.flatten(),
        'latitude': ds_Foundation["latitude"].values.flatten()}
track_points = pd.DataFrame(data32)
# Use grdtrack to sample the grid along the track
track_data32 = pygmt.grdtrack(points=track_points,␣
 ↪grid=grid32,newcolname="sio32")
```

7 extract the cls_22 MSS at the locations of the SWOT data using grdtrack

[25]:
```
grid22 = "CNES_CLS_22_H_WGS84.nc"
data22 = {'longitude': ds_Foundation["longitude"].values.flatten(),
        'latitude': ds_Foundation["latitude"].values.flatten()}
track_points = pd.DataFrame(data22)
# Use grdtrack to sample the grid along the track
track_data22 = pygmt.grdtrack(points=track_points,␣
 ↪grid=grid22,newcolname="cls22")
```

8 take the three-way differences of the models

[26]:
```
cls22_mss_hy = track_data22.cls22.to_numpy().reshape(num_lines, num_pixels) -␣
 ↪ds_Foundation.mean_sea_surface_cnescls
sio32_mss_hy = track_data32.sio32.to_numpy().reshape(num_lines, num_pixels) -␣
 ↪ds_Foundation.mean_sea_surface_cnescls
cls22_sio32 = track_data22.cls22.to_numpy().reshape(num_lines, num_pixels) -␣
 ↪track_data32.sio32.to_numpy().reshape(num_lines, num_pixels)
```

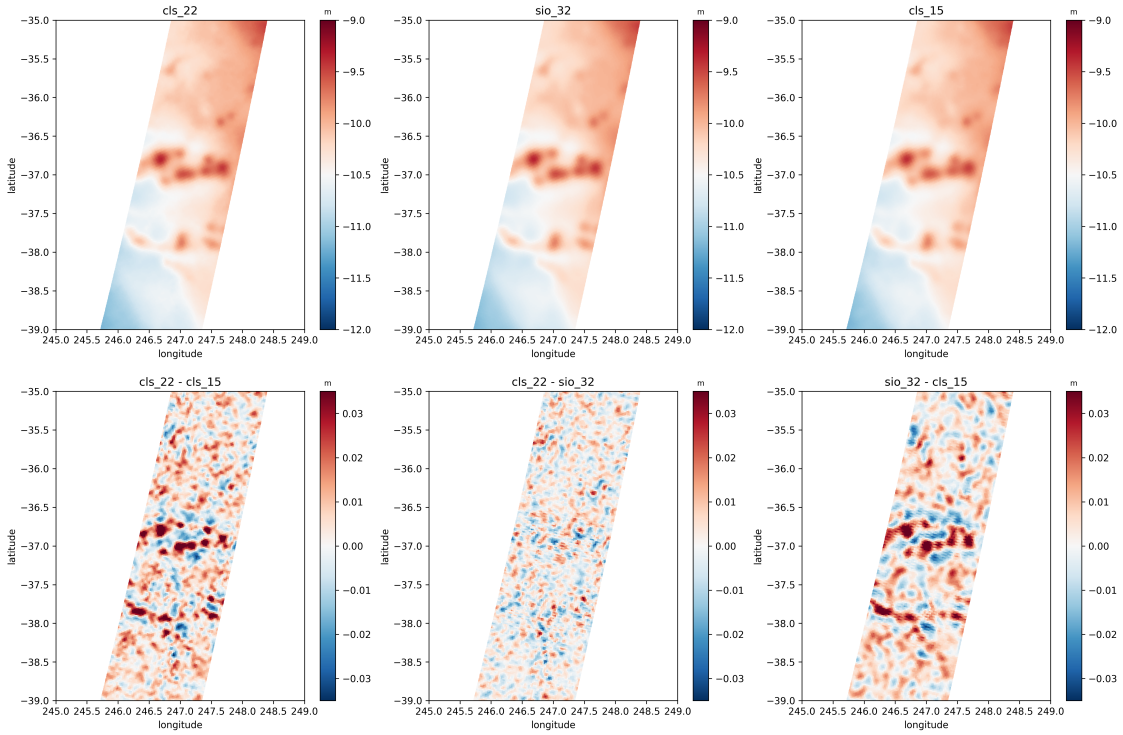
9 plot the three models and their differences

[27]:
```
plt.figure(figsize=(20,20), dpi=300)

plt.subplot(331)
plt.pcolormesh(track_data22.longitude.to_numpy().reshape(num_lines,␣
 ↪num_pixels), track_data22.latitude.to_numpy().reshape(num_lines, num_pixels),␣
 ↪track_data22.cls22.to_numpy().reshape(num_lines, num_pixels), cmap='RdBu_r',␣
 ↪vmin=-12, vmax=-9,  shading='auto')
plt.xlim([245,249]); plt.ylim([-39,-35]); plt.xlabel('longitude'); plt.
 ↪ylabel('latitude'); clb = plt.colorbar(); clb.ax.set_title('m',fontsize=8)
plt.title('cls_22')

plt.subplot(332)
plt.pcolormesh(track_data32.longitude.to_numpy().reshape(num_lines,␣
 ↪num_pixels), track_data32.latitude.to_numpy().reshape(num_lines, num_pixels),␣
 ↪track_data32.sio32.to_numpy().reshape(num_lines, num_pixels), cmap='RdBu_r',␣
 ↪vmin=-12, vmax=-9., shading='auto')
plt.xlim([245,249]); plt.ylim([-39,-35]); plt.xlabel('longitude'); plt.
 ↪ylabel('latitude'); clb = plt.colorbar(); clb.ax.set_title('m',fontsize=8)
plt.title('sio_32')
```

```
plt.subplot(333)
plt.pcolormesh(ds_Foundation.longitude, ds_Foundation.latitude, ds_Foundation.
 ↪mean_sea_surface_cnescls, cmap='RdBu_r', vmin=-12, vmax=-9, shading='auto')
plt.xlim([245,249]); plt.ylim([-39,-35]); plt.xlabel('longitude'); plt.
 ↪ylabel('latitude'); clb = plt.colorbar(); clb.ax.set_title('m',fontsize=8)
plt.title('cls_15')

plt.subplot(334)
plt.pcolormesh(ds_Foundation.longitude, ds_Foundation.latitude, cls22_mss_hy,␣
 ↪cmap='RdBu_r', shading='auto',vmin = -.035, vmax = .035)
plt.xlim([245,249]); plt.ylim([-39,-35]); plt.xlabel('longitude'); plt.
 ↪ylabel('latitude'); clb = plt.colorbar(); clb.ax.set_title('m',fontsize=8)
plt.title('cls_22 - cls_15')

plt.subplot(335)
plt.pcolormesh(ds_Foundation.longitude, ds_Foundation.latitude, cls22_sio32,␣
 ↪cmap='RdBu_r', shading='auto',vmin = -.035, vmax = .035)
plt.xlim([245,249]); plt.ylim([-39,-35]); plt.xlabel('longitude'); plt.
 ↪ylabel('latitude'); clb = plt.colorbar(); clb.ax.set_title('m',fontsize=8)
plt.title('cls_22 - sio_32')

plt.subplot(336)
plt.pcolormesh(ds_Foundation.longitude, ds_Foundation.latitude, sio32_mss_hy,␣
 ↪cmap='RdBu_r', shading='auto', vmin = -.035, vmax = .035)
plt.xlim([245,249]); plt.ylim([-39,-35]); plt.xlabel('longitude'); plt.
 ↪ylabel('latitude'); clb = plt.colorbar(); clb.ax.set_title('m',fontsize=8)
plt.title('sio_32 - cls_15')


plt.show()
```

```
/var/folders/s1/2g7wjdhn58v1v_07s05z64280006y5/T/ipykernel_47473/1177260575.py:4
: UserWarning: The input coordinates to pcolormesh are interpreted as cell
centers, but are not monotonically increasing or decreasing. This may lead to
incorrectly calculated cell edges, in which case, please supply explicit cell
edges to pcolormesh.
  plt.pcolormesh(track_data22.longitude.to_numpy().reshape(num_lines,
num_pixels), track_data22.latitude.to_numpy().reshape(num_lines, num_pixels),
track_data22.cls22.to_numpy().reshape(num_lines, num_pixels), cmap='RdBu_r',
vmin=-12, vmax=-9,  shading='auto')
/var/folders/s1/2g7wjdhn58v1v_07s05z64280006y5/T/ipykernel_47473/1177260575.py:9
: UserWarning: The input coordinates to pcolormesh are interpreted as cell
centers, but are not monotonically increasing or decreasing. This may lead to
incorrectly calculated cell edges, in which case, please supply explicit cell
edges to pcolormesh.
  plt.pcolormesh(track_data32.longitude.to_numpy().reshape(num_lines,
num_pixels), track_data32.latitude.to_numpy().reshape(num_lines, num_pixels),
```

```
track_data32.sio32.to_numpy().reshape(num_lines, num_pixels), cmap='RdBu_r',
vmin=-12, vmax=-9., shading='auto')
/var/folders/s1/2g7wjdhn58v1v_07s05z64280006y5/T/ipykernel_47473/1177260575.py:1
4: UserWarning: The input coordinates to pcolormesh are interpreted as cell
centers, but are not monotonically increasing or decreasing. This may lead to
incorrectly calculated cell edges, in which case, please supply explicit cell
edges to pcolormesh.
  plt.pcolormesh(ds_Foundation.longitude, ds_Foundation.latitude,
ds_Foundation.mean_sea_surface_cnescls, cmap='RdBu_r', vmin=-12, vmax=-9,
shading='auto')
/var/folders/s1/2g7wjdhn58v1v_07s05z64280006y5/T/ipykernel_47473/1177260575.py:1
9: UserWarning: The input coordinates to pcolormesh are interpreted as cell
centers, but are not monotonically increasing or decreasing. This may lead to
incorrectly calculated cell edges, in which case, please supply explicit cell
edges to pcolormesh.
  plt.pcolormesh(ds_Foundation.longitude, ds_Foundation.latitude, cls22_mss_hy,
cmap='RdBu_r', shading='auto',vmin = -.035, vmax = .035)
/var/folders/s1/2g7wjdhn58v1v_07s05z64280006y5/T/ipykernel_47473/1177260575.py:2
4: UserWarning: The input coordinates to pcolormesh are interpreted as cell
centers, but are not monotonically increasing or decreasing. This may lead to
incorrectly calculated cell edges, in which case, please supply explicit cell
edges to pcolormesh.
  plt.pcolormesh(ds_Foundation.longitude, ds_Foundation.latitude, cls22_sio32,
cmap='RdBu_r', shading='auto',vmin = -.035, vmax = .035)
/var/folders/s1/2g7wjdhn58v1v_07s05z64280006y5/T/ipykernel_47473/1177260575.py:2
9: UserWarning: The input coordinates to pcolormesh are interpreted as cell
centers, but are not monotonically increasing or decreasing. This may lead to
incorrectly calculated cell edges, in which case, please supply explicit cell
edges to pcolormesh.
  plt.pcolormesh(ds_Foundation.longitude, ds_Foundation.latitude, sio32_mss_hy,
cmap='RdBu_r', shading='auto', vmin = -.035, vmax = .035)
```


cls_22
sio_32
cls_15
cls_22 - cls_15
cls_22 - sio_32
sio_32 - cls_15
latitude
longitude
m