

# Exercises using sea level altimetry data

Sea level height reflects ocean dynamics, such as eddies, upwelling, El Nino, etc. Sea level height away from coasts can be measured by satellite altimeters. The single track altimeter data are often merged and gridded and presented as a raster image that can be analyzed and visualized with WIM/WAM. Altimetry measurements are not obscured by clouds that make them especially valuable in cloudy regions where the usefulness of visible and infrared imagery is limited. The task of this exercise is to use a series of global altimetry files, select your area of interest and remap to your area of interest. Finally, we will make image loops that show the dynamics of eddies. An example of what you need to accomplish is included in a PowerPoint presentation file *3\_sea\_level\_anomaly.pdf* in the *Course\3* folder of the WIM DVD and is also available on the web at [http://www.wimsoft.com/Course/3/3\\_sea\\_level\\_anomaly.pdf](http://www.wimsoft.com/Course/3/3_sea_level_anomaly.pdf) and the movie loop is also at [http://spg.ucsd.edu/Satellite\\_Projects/Sea\\_Level\\_Anomalies\\_in\\_Eastern\\_Central\\_Pacific/Sea\\_level\\_anomalies\\_in\\_eastern\\_central\\_pacific.htm](http://spg.ucsd.edu/Satellite_Projects/Sea_Level_Anomalies_in_Eastern_Central_Pacific/Sea_level_anomalies_in_eastern_central_pacific.htm). This particular example shows sea level height anomalies in the Eastern Central Pacific that is a very dynamic region and well suited for this kind of analysis.

Here is what you need to do:

Get the mapped sea level anomaly (MSLA) data either the altimetry folder of the WIM/WAM DVD or download the data yourself from the French AVISO ftp. Currently the AVISO site requires registration. To get a personal account on the ftp server, you have to fill out the registration form at:

<http://www.aviso.oceanobs.com/en/data/registration-form/index.html>

You can download the data from the authenticated ftp server at

`/global/delayed-time/grids/msla/all-sat-merged/h`

You should download files with names like

`dt_global_allsat_msla_h_20140101_20140829.nc.gz`.



These are daily maps of Mean Sea Level Anomaly (MSLA) merged from multiple instruments (TOPEX/POSEIDON, Jason and ERS-1/2) and created by SSALTO/DUACS and distributed by AVISO. The data series starts on January 1, 1993 and currently ends in 2014. These are the so-called “delayed-time” or updated datasets. Similar near-real-time files for the current year are in a folder like `/global/near-real-time/grids/msla/all-sat-merged`.

After downloading the data files, uncompress them, e.g. with `gzip -d *.gz`.

The files are net-CDF files that you can read and view with WIM/WAM as netCDF (\*.nc) files. However, it is better to convert them to HDF4 and save a lot of space with a command like:

## Exercises using sea level altimetry data

wam\_convert\_avisosla \*.nc

Select your area of interest and create your target projection map. For example, create your area map with *File-New* and setting the latitude and longitude range. Alternatively, you can open any 9-km or 4-km standard global equal angle image (e.g. SeaWiFS or MODISA) and cut out your area of interest (select a rectangle with the mouse left button down and then do *Cut* (the  icon on toolbar). Now create coastlines for this cut image with *Geo-Get Map Overlay – coast\_full.b – Background Value = 0, Foreground Value = 1*. Stretch the colors *Start* and *End* value down, so that you can see the coastlines. Now fill the land with pixel value 255 (to make it white) with *Edit – Draw – Fill Paint* with *Outline = 255* and *Fill = 255*. As “paint” can easily spill outside of the broken coastlines, you may have to experiment with this and use the *Undo* icon  on the Toolbar to return to the previous step. You can fill some holes in the coastlines manually with the Paintbrush tool. Save your target map as HDF. Alternatively, if you know the Lat-Lon range of your area of interest, you can also create your target map with the *File-New* menu in WIM. In that case you can select the *Latitude-Longitude* range and the pixel size. An example is shown below. Note that land is white (pixel value 255), coastlines have pixel value 1 and ocean is black (pixel value 0). You can overlay other features, such as grids, grid labels, stations, color scales, etc. You also need to consider where the date label will be written. The best place for the label would be over land. Write down the X and Y coordinates where you want the date label to start.

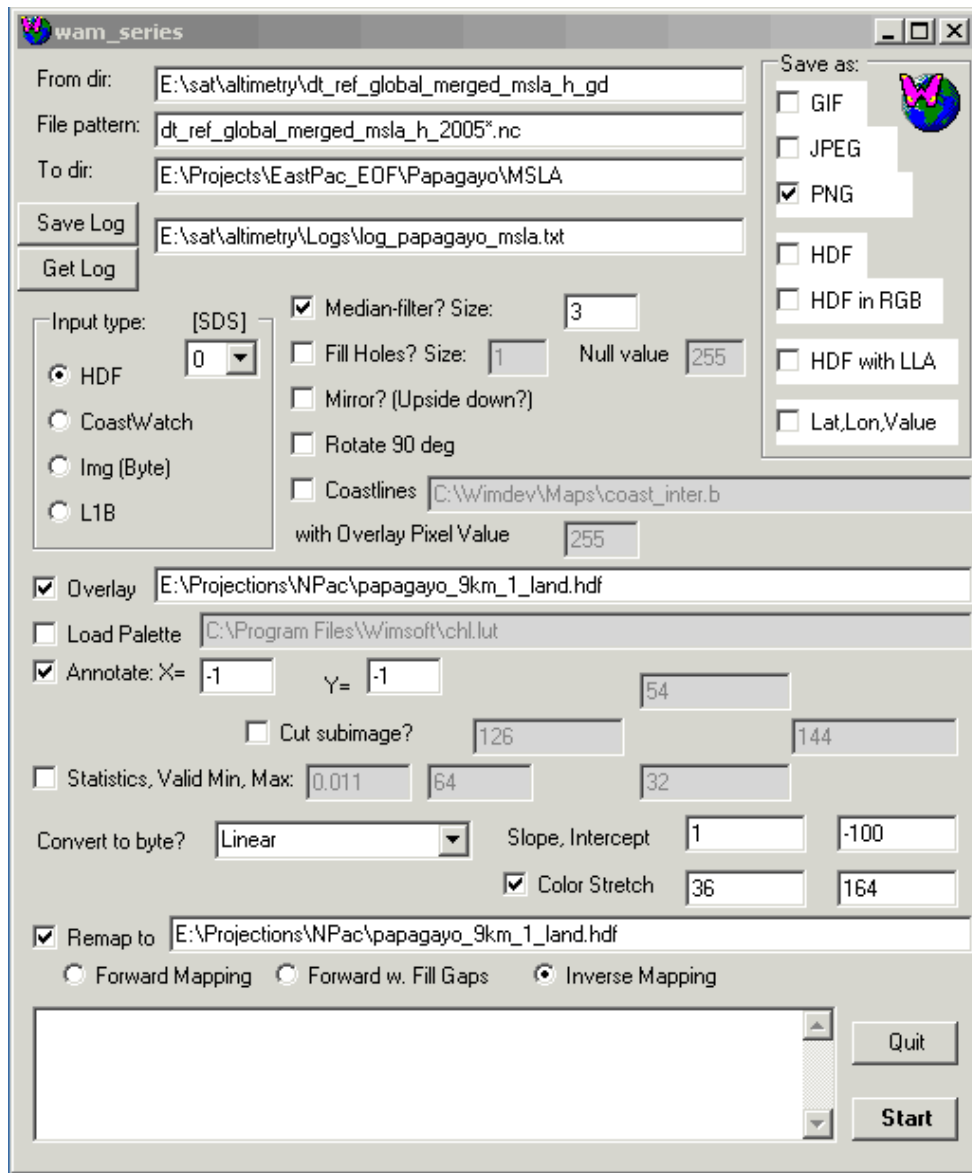


Now you are ready to remap the global images to your projection and overlay at the same time the land with coastlines file that you just made. The overlay is just needed to make the images look better. You remap, overlay, annotate with the label with *wam\_series*. Open *wam\_series* and fill the text boxes. An example screenshot of *wam\_series* is given below. You will probably need to replace the “*From dir:*” with the location of your files, “*File pattern:*” with a pattern matching your files, “*To dir:*” with the directory where you want the output, the “*Overlay*” and “*Remap to*” with your overlay file name. Try to understand the meaning of the many options. *WAM.pdf* has detailed information on *wam\_series*.

## Exercises using sea level altimetry data

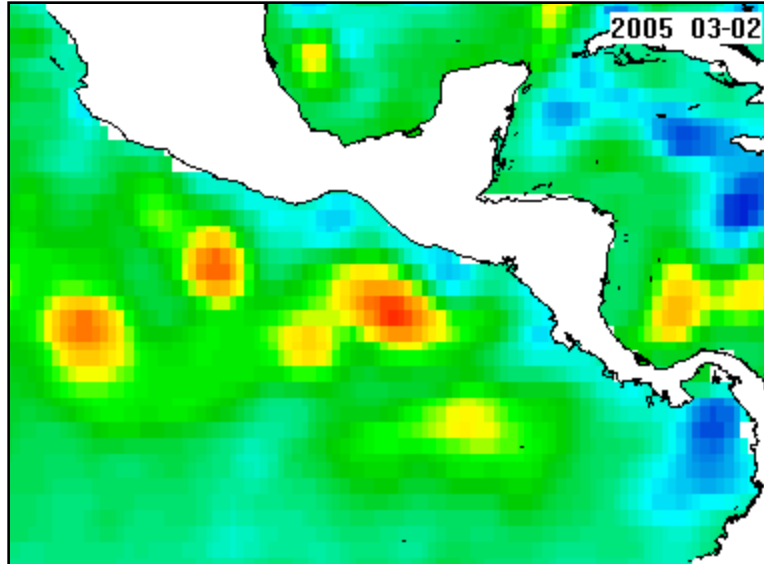
I will explain some of the operations done with *wam\_series*. We save PNG as we are going to use them in creating an animated GIF but as a test you can also save HDF. We apply *Median* filter to make the images look smoother. The “*Overlay*” and the “*Remap to*” text boxes refer to the same HDF image (shown above) that serves both as the target projection and as the overlay image. Annotate location is by default in the upper right corner (that’s why they are -1 and -1). You can replace them with the X and Y coordinates where you want the label to start. Please note that the Float32 pixels are converted to a Byte with Linear scaling with *Slope* = 1 and *Intercept* = -100. Byte images save space and are better to visualize. The negative intercept is needed as sea level anomalies are both positive and negative. With this scaling pixel value 100 means anomaly of 0, therefore I set the color stretch from *Start*=36 to *End*=164 as they are symmetric relative to 100 (both are 64 pixels away from 100). As a result, negative anomalies are shown as blue and positive as yellow or red (using my default palette *chl1\_white\_end.lut*). If you want to use another palette, select the “Load Palette” check box and specify the palette file next to it.

## Exercises using sea level altimetry data



- A sample PNG image is shown below.

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You can now make an animated GIF of the series of images that you just created, using, for example, *Babarosa Gif Animator* (you can find it in the *Tools* folder of the WIM DVD). My results are shown in [http://spg.ucsd.edu/Satellite Projects/Sea Level Anomalies in Eastern Central Pacific/Sea level anomalies in eastern central pacific.htm](http://spg.ucsd.edu/Satellite%20Projects/Sea%20Level%20Anomalies%20in%20Eastern%20Central%20Pacific/Sea%20level%20anomalies%20in%20eastern%20central%20pacific.htm).