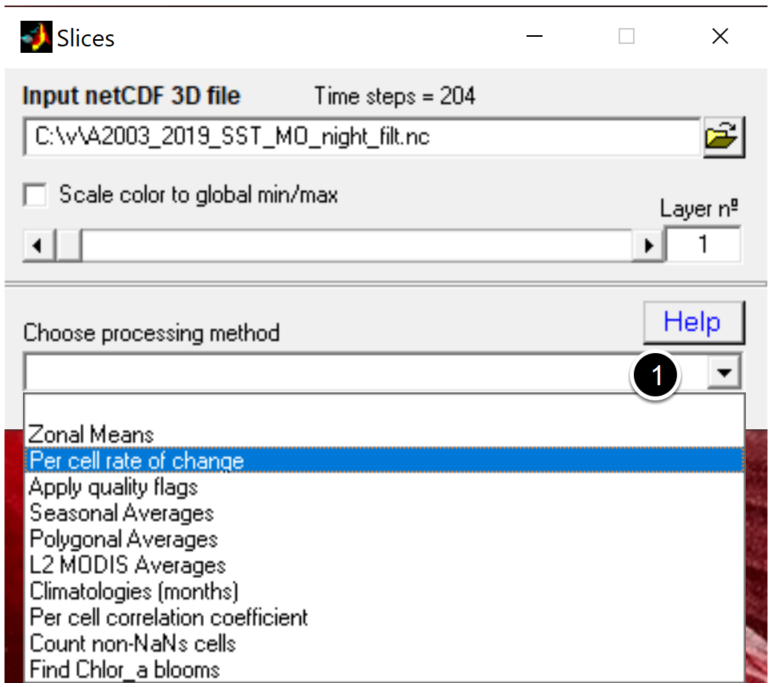
Compute the time rate of change of an stack of SST data

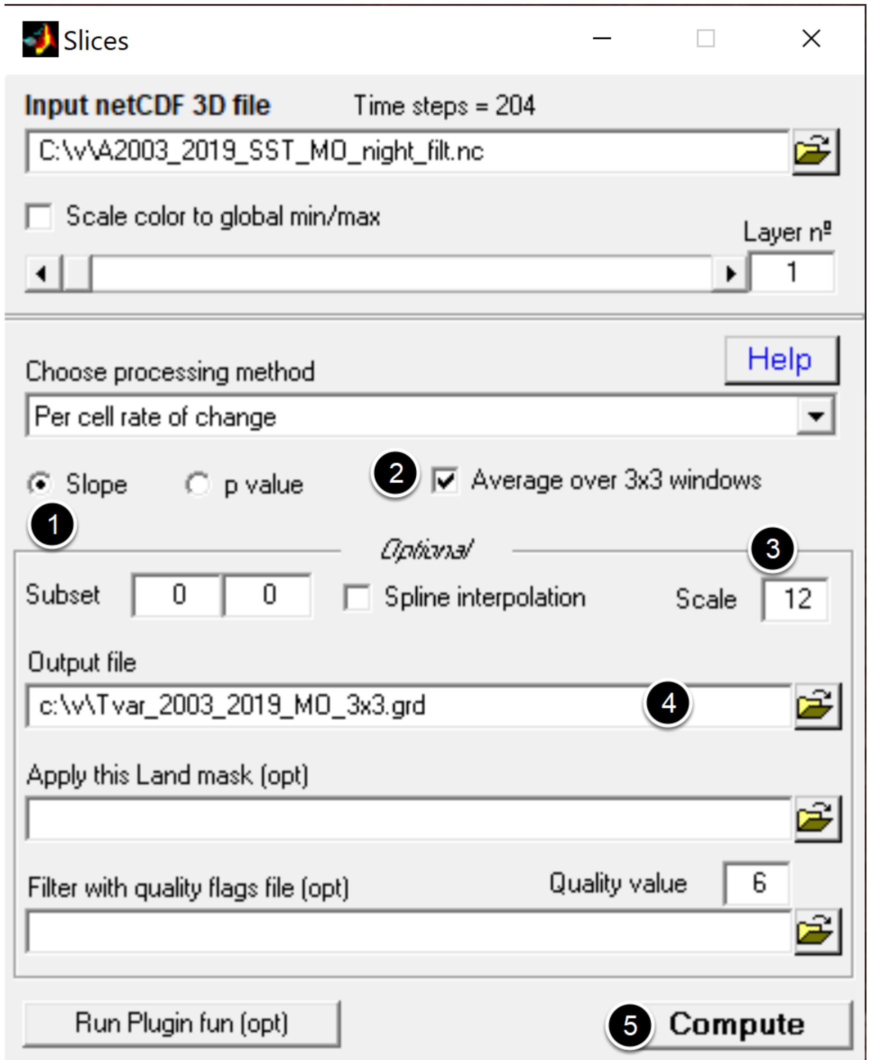
Here we are going to compute the time rate of change (i.e. the temperature variation) for all points of the region of the stack of monthly averages. We will do that using both the annual means, and directly from the monthly means. As we will see later both procedures will not give exactly the same result.

Open the stack of montly SST data



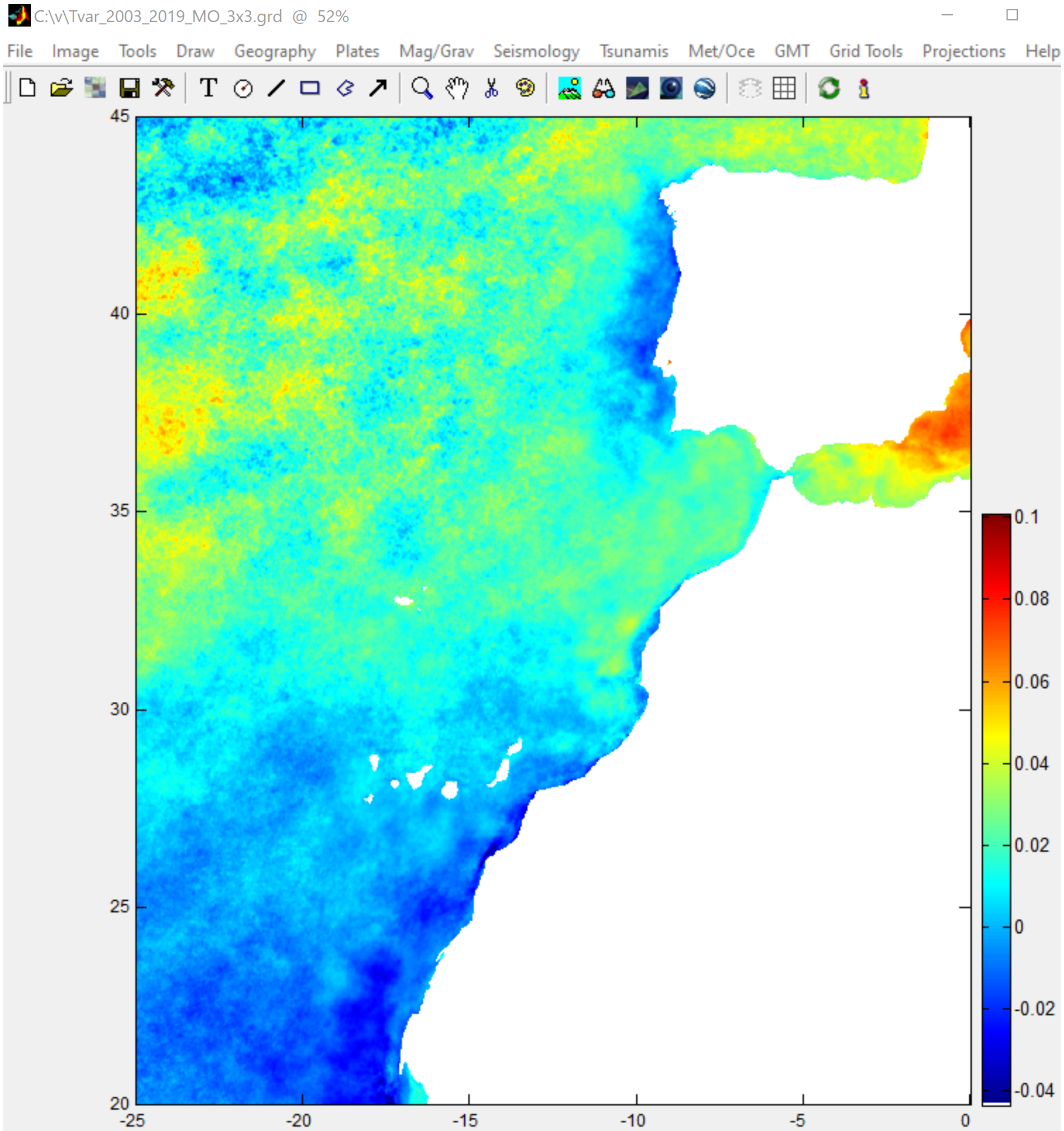
When you open the stack SST monthly file besides the display of the first layer in file, there is also a smaller window to the right that looks like the above. This window let us select the layer to display (using the slider) and to select the processing method at (1). Here we are going to use the "Per cell rate of change".

Compute the time rate on a per-month basis



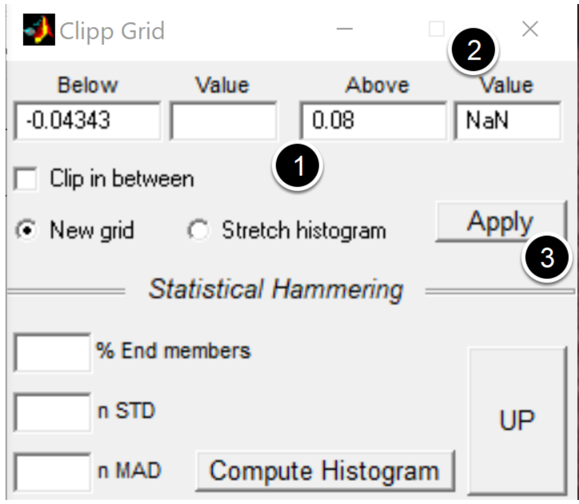
(1) This is the default value and means that we are going to compute the slope of the best fit straight line for each cell across all the 204 months. (2) The 3x3 window will calculate the slope using not only the current cell but over a neighborhood of 9 points. This will smooth out the result but mostly it will increase the statistical significance of the estimate (more about this later). (3) Because we want the final result in degrees per year and we are using months we need to multiply the final result by 12. (4) is the output file name with the time rate of change. Make sure you provide a meaningful name. If not provided, it will be asked by a separate window. At the end, hit (5) and provide a file name to save the result.

SST variation in degrees per year



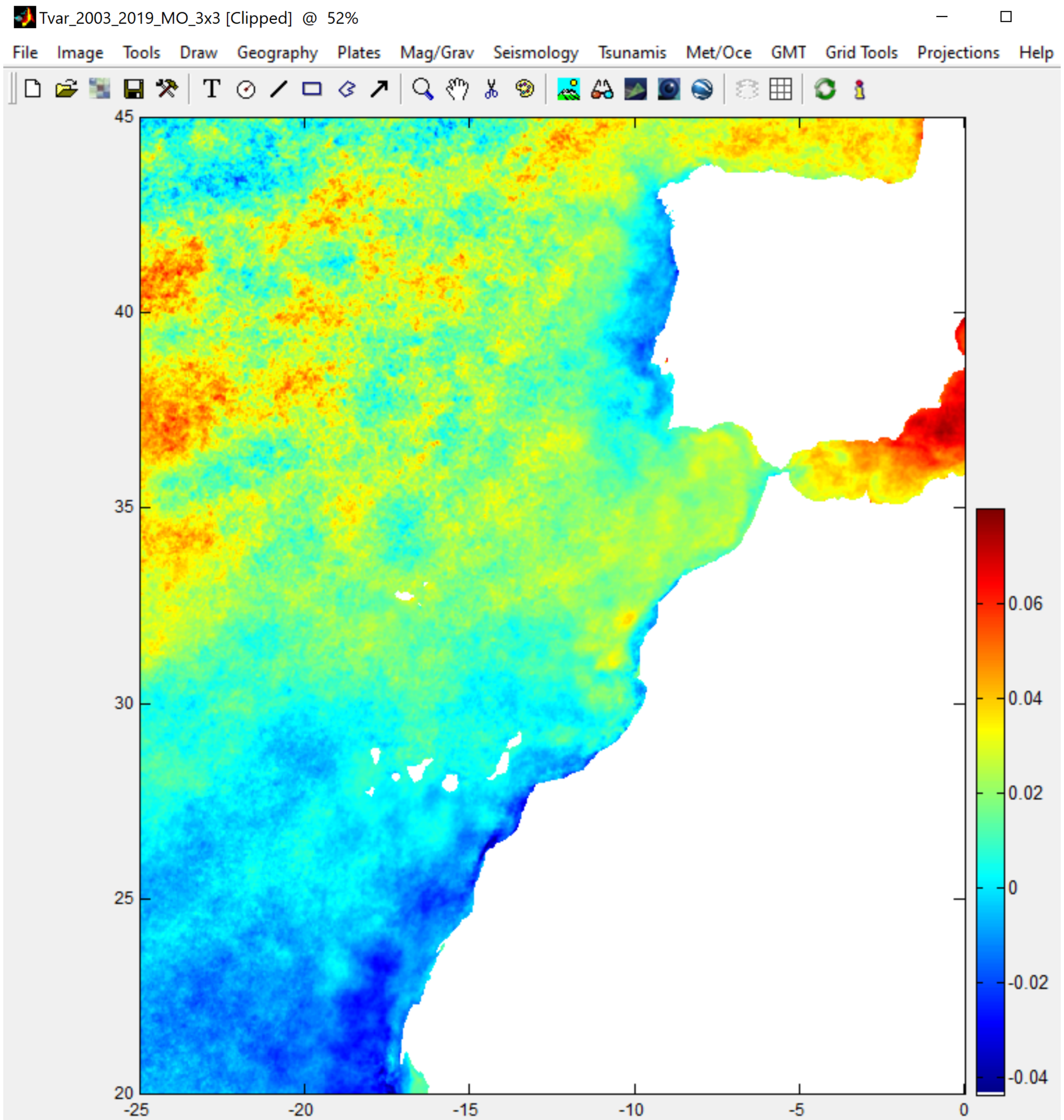
This is what we get. But at a closer look we notice that the darker reds in the colorbar are not visible in the image. This happens because outliers resulting for less good data filtering are present in reduced zones. Normally near river estuaries. To remove the outliers the easiest is if we clip the grid for extrema values. We do that with the option "*Grid Tools -> Clip Grid*"

Clip the grid to remove outliers



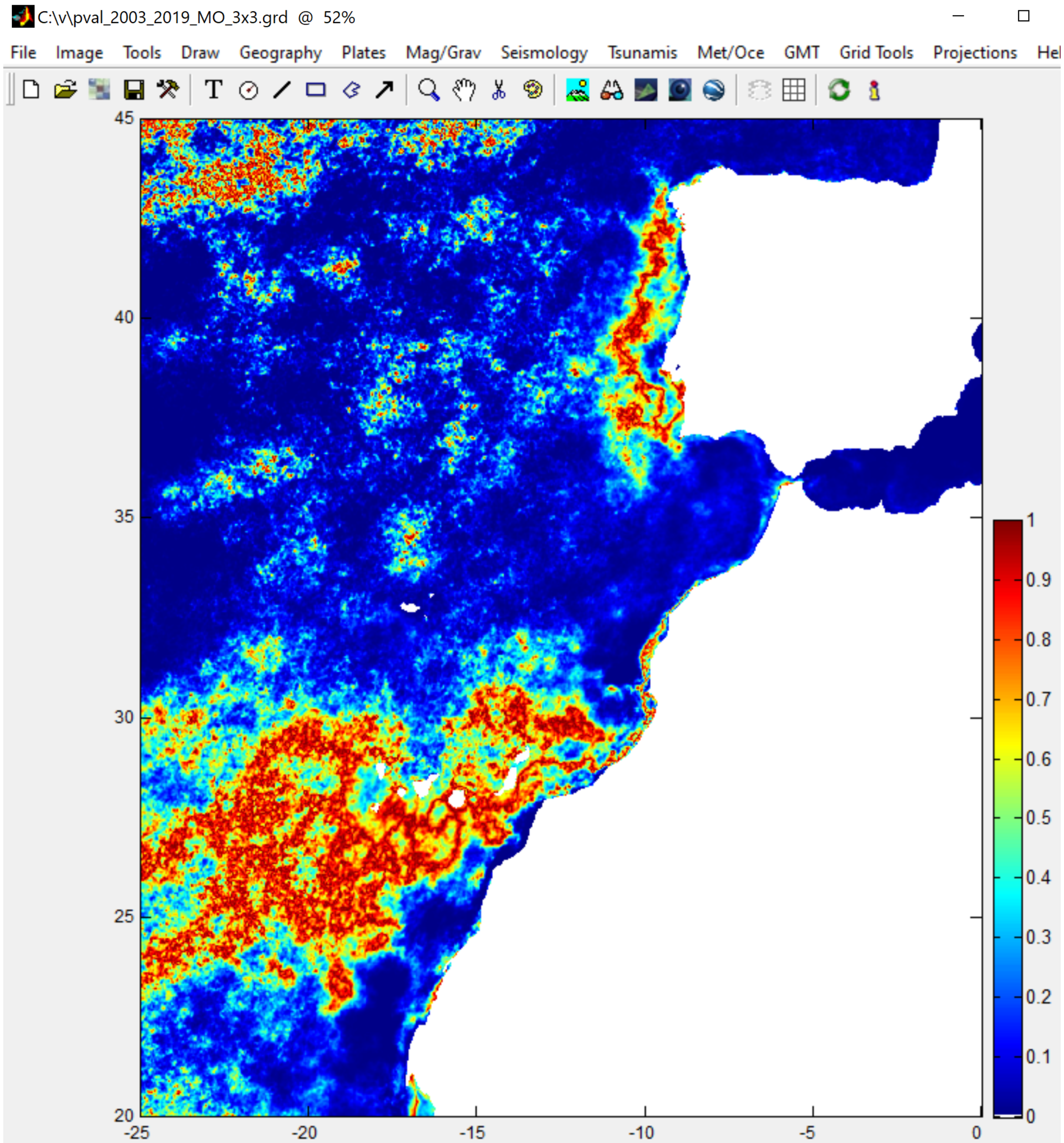
This tool let us replace all values **Above** a certain value by another value (and the same thing for **Below**). Here, after some experimenting we found that values above 0.08 degrees/year are outliers that can be safely removed. To remove values we replace them by the special NaN number. After doing the (1),(2),(3) sequence we obtain the figure below.

Outliers removed



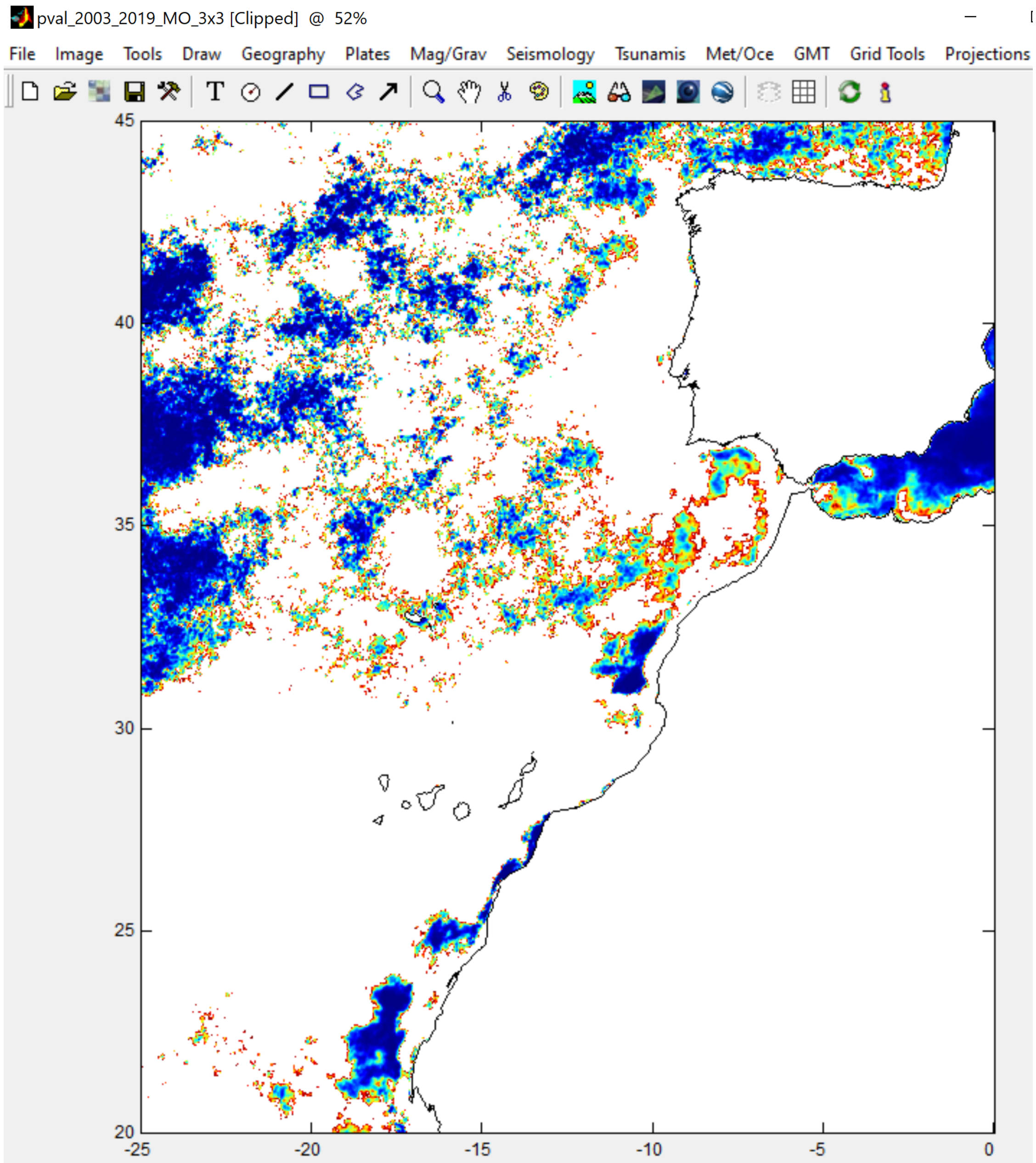
The clipped grid above now displays the full color range.

Statistical significance



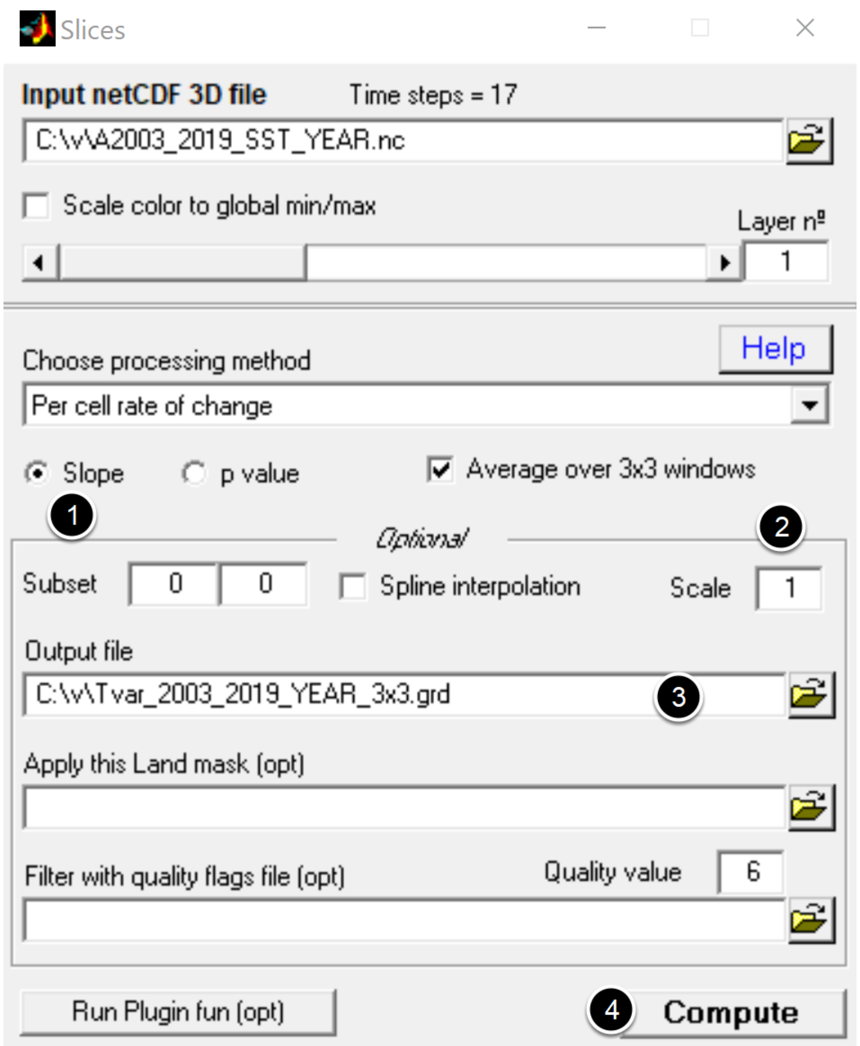
Cool, we have now an estimate on how much the STT is changing on average during the period of 2003-2019. But how trustful is that estimate? To try to answer that one way is to look at the *p-values* of the estimate. Remember that (1 - *p-value*) * 100 gives as the likelihood that the estimate was not obtained from random numbers. That is, low *p-values* ==> higher significance. The above figure displays the *p-values* obtained if in Step 2 we had selected *p value* instead of *Slope.* But since we want mainly to see where the *p-values* are low (less than 0.1 or 0.05), again the best way to visualize them is to clip the *p-values* grid.

Regions where estimates are statistically significant at 95% level



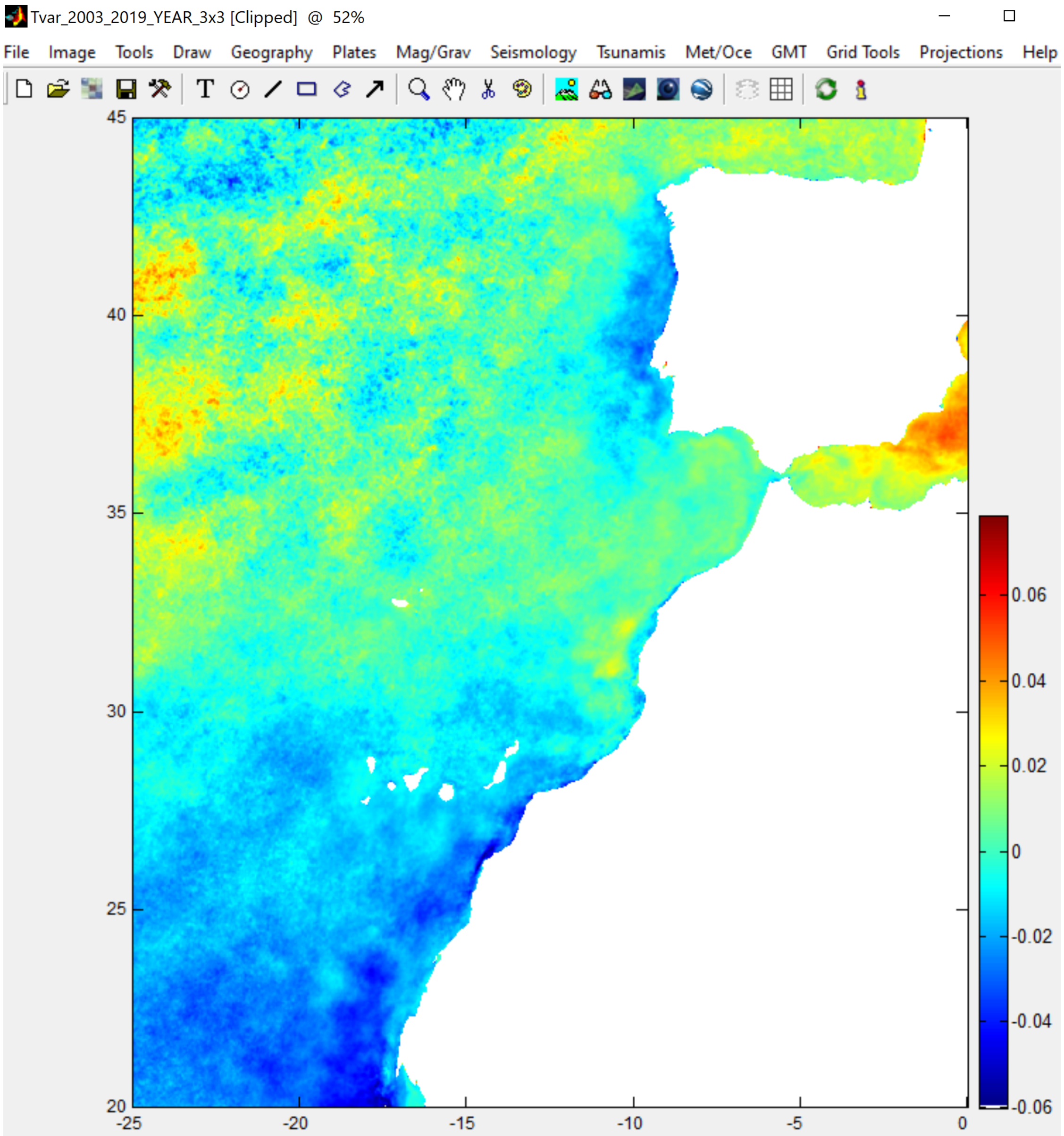
The above figure displays only the p-values that are <= 0.05. That is, where the estimates are significant at 95% level. The white areas means that there estimate were not significant. And, oops, not that much area left. Now, remember that at step 2 we selected the "*Average over 3x3 windows*". If we hadn't do that then the above image would have been almost all white. And why that? One reason is because the *p-values* determination is very much influenced by the number of points used to calculate them. The other strong reason why we have large areas of low significance is because all determination was carried out on data that still has the effect of seasons. To improve our rate of change determination we are now repeating the process but using this time the yearly averages calculated in the **Compute the time rate of change of an stack of SST data** Lesson.

Compute the temperature time rate but now on a per-year basis



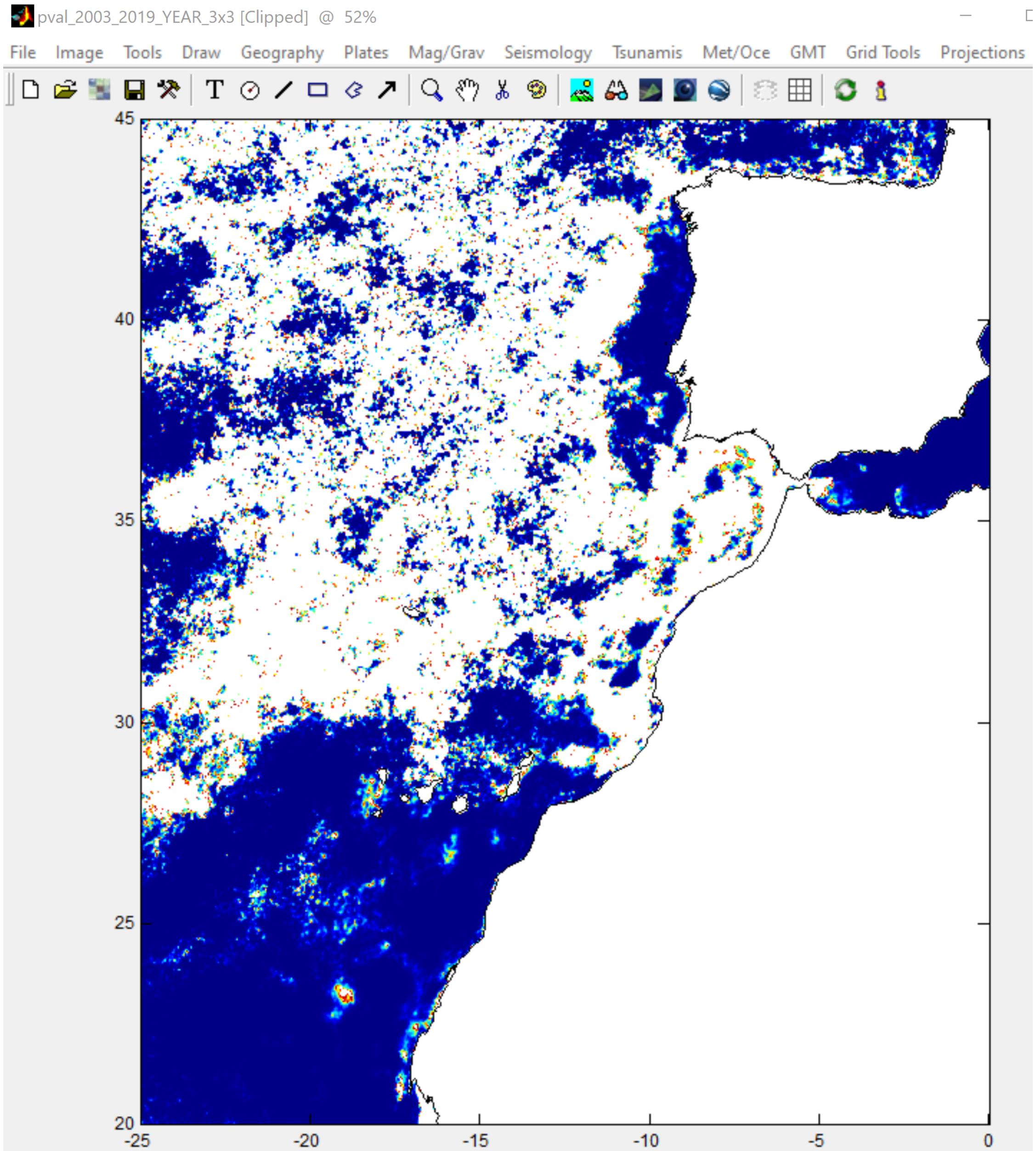
REPEAT STEP 2 ABOVE BUT MAKE SURE YOU LOADED THE ANNUAL MEANS FILE .
(1) Again, this the default choice. (2) This time we leave the Scale value at 1 because our layers now represent years. (3) Output file name. Also again, make sure you give a meaningful name. (4) Compute.

SST variation in degrees per year (second version)



And again, this what we get. ... after clipping. In order that this image be comparable to the one computed with the monthly averages the clipping was done also to remove values >= 0.08, but in fact and as we can see by the red colors in the Mediterranean Sea we could have clipped a bit lower. However, like this the two images are comparable, thouhg the lower values of the estimate by year are lower than those by month.

Regions where estimates are statistically significant at 95% level



For reference, here is the figure with the areas where the rate of changes in temperature are significant at 95% level (obtained as exemplified above).