



*Fig.1 Temperature anomaly , whole globe (reference period is 1991-2020)*

**Global monthly average temperatures** are reported on one of the most visited climate-site, the [University of Alabama](https://climate.geog.udel.edu/) at Huntsville (UAH), USA. Other authoritative web-based sources for global temperature records are RSS(Remote Sensing System) and HadCRUT.

The following graphs all use the data obtained by the National Oceanographic and Atmospheric Administration (NOAA) TIROS-N satellite, interpreted by Dr. Roy Spencer and Dr. John Christy, both at Global Hydrology and Climate Center of the same University.

Records start from december,1978 and are regularly updated. They refer to four layers of the planet's atmosphere:

1. lower troposphere
2. middle troposphere
3. tropopause
4. lower stratosphere

For each of the four regions of the atmosphere 24 regions of the globe are examined, namely :

3 = Globe	4 = Land	5 = Ocean	<i>whole globe 90S-90N</i>
6 = Globe	7 = Land	8 = Ocean	<i>northern hemisphere 0-90N</i>
9 = Globe	10 = Land	11 = Ocean	<i>southern hemisphere 90S-0</i>
12 = Globe	13 = Land	14 = Ocean	<i>tropics 20S-20N</i>
15 = Globe	16 = Land	17 = Ocean	<i>northern extention 20N-90N</i>
18 = Globe	19 = Land	20 = Ocean	<i>southern extention 20N-90N</i>
21 = Globe	22 = Land	23 = Ocean	<i>north pole 60N-90N</i>
24 = Globe	25 = Land	26 = Ocean	<i>south pole 90S-60N</i>

*(numbers refer to the columns in the matrix)*

The combination of the 4 layers with the 24 regions gives a total of  $24 \times 4 = 96$  possible graphs. Not all of them have the same Spearman rank correlations, which determines how well the relationship between two variables can be described using a monotonic function (see section about Spearman coeff.).

In fig.1 is reported the curve having the highest Spearman correlation (0.703) in magenta, accompanied by its moving average (15 points, can be varied) in blue and the parabolic trend in green. The data download procedure, data analysis and graphics are described in the following.

The curve refers to the lower troposphere monthly averaged values for the whole globe. (last update february 2021). It interesting to note that the parabolic (opening upwards) trend coming from interpolation. This result cannot be however extrapolated to future, and other types of data analysis offers a 'staircase' global trend (see section).

The cooling and warming periods are directly influenced by [the 1991 Mt. Pinatubo volcanic eruption](#) and the [El Niño](#) index, respectively, are clearly visible. Temperatures are expressed as anomalies (differences from the average in the period january 1991 – december 2020).

## How to obtain the graph

**Octave® is a free platform, downloading and running it is totally free.**

**Once it is installed, you will be able to perform all the following scripts.**

First step is to download the file, using the `urlwrite` statement in Octave. The full path of the downloaded file is returned in `f`, and the local file name will be 'uah.txt'. This is the address of the lower troposphere data, the closer one to surface.

```
f = urlwrite('http://vortex.nsstc.uah.edu/data/msu/v6.0/tlt/uahncdc_lt_6.0.txt','uah.txt')
```

Once the file is downloaded the above instruction is no more needed, unless a new version is available at UAH (normally in the first days of each month). In the following script it is transformed into a comment by the character '%'.

The following is a simple script for the data-plot according a chosen region (among the 24 shown above). In this case the selected region is nr.3, the whole globe. But before this, the file 'uah.txt' is stored in a [character string](#) with the instruction `fileread`. The data are preceded by comments, so we have to find data start and end using `index` and `rindex`. Accordingly a new character string 'M' is extracted and then transformed in a numeric [matrix 'X'](#) by the

powerful function str2num(). In the matrix **'X'** the first two columns refer to year and month so **xYear** vector contains the decimal year starting from 1978.958 (1978+11.5/12, december 1978). **yd** vector then stores the temperature anomaly data of the specified region (in this case 3, whole globe) and **ym** vector stores the moving average of **yd**, calculated with **movmean()** function with a parameter of 15 (consecutive points, can be varied by user). Finally the two mighty functions **polyfit()** and **polyval()** do the job of interpolate the points. The first function requires **x,y** vectors and a degree for the polynomial (in this case 2, but it can be varied), the second calculates the polynomial values according to abscissa **xYear** and the coefficients stored in vector **p**. The plot in fig.1 is produced by **plot, legend** and **title** functions.

```
clear;clc;format short;format compact;
% f = urlwrite('http://vortex.nsstc.uah.edu/data/msu/v6.0/tlt/uahncdc_lt_6.0.txt','uah.txt')
S = fileread('uah.txt'); % uah.txt is the local,downloaded file
a1 = index(S,'1978');
a2 = rindex(S,'Year Mo') - 2;
M = S(a1:a2);
X = str2num(M);
xYear = X(':',1) + X(':',2)./12; % date in decima year
% Average satellite of the lower troposphere refers to ...
% 3 = Globe, 4 = Land, 5 = Ocean (whole globe 90S-90N)
% 6 = Globe, 7 = Land, 8 = Ocean (northern hemisphere 0-90N)
% 9 = Globe, 10 = Land, 11 = Ocean (southern hemisphere 90S-0)
% 12 = Globe, 13 = Land, 14 = Ocean (tropics 20S-20N)
% 15 = Globe, 16 = Land, 17 = Ocean (northern extention 20N-90N)
% 18 = Globe, 19 = Land, 20 = Ocean (southern extention 20N-90N)
% 21 = Globe, 22 = Land, 23 = Ocean (north pole 60N-90N)
% 24 = Globe, 25 = Land, 26 = Ocean (south pole 90S-60N)
yd = X(':',3); % 3 = Globe .. this can be adjusted by user
p = polyfit(xYear,yd,2);y2 = polyval(p,xYear);
ym = movmean(yd,15); % 15 can be modified
plot (xYear,yd,'m',xYear,ym,'b','LineWidth',2,xYear,y2,'g','LineWidth',2);grid on;hold on;
grid minor on;axis([1978,2022,-0.7,0.8]);
xlabel('Year');ylabel('temp. anomaly °C');
title(['parabola = ',num2str(p(1)),' x^2 ',num2str(p(2)),' x +',num2str(p(3))]);
```

In Octave, like in Matlab, if a line of program terminates with a semicolon (;) then the output is suppressed. As an example, the following line displays the content of **p**, which is a vector containing the three coefficients of the polynomial interpolation (starting from the highest degree) as it does not end with a semicolon. The function **axis()** defines the range of **x,y** data to be plotted.

```
p = polyfit(xYear,ym,2) % show the coefficients of the interpolated polynomial.
```