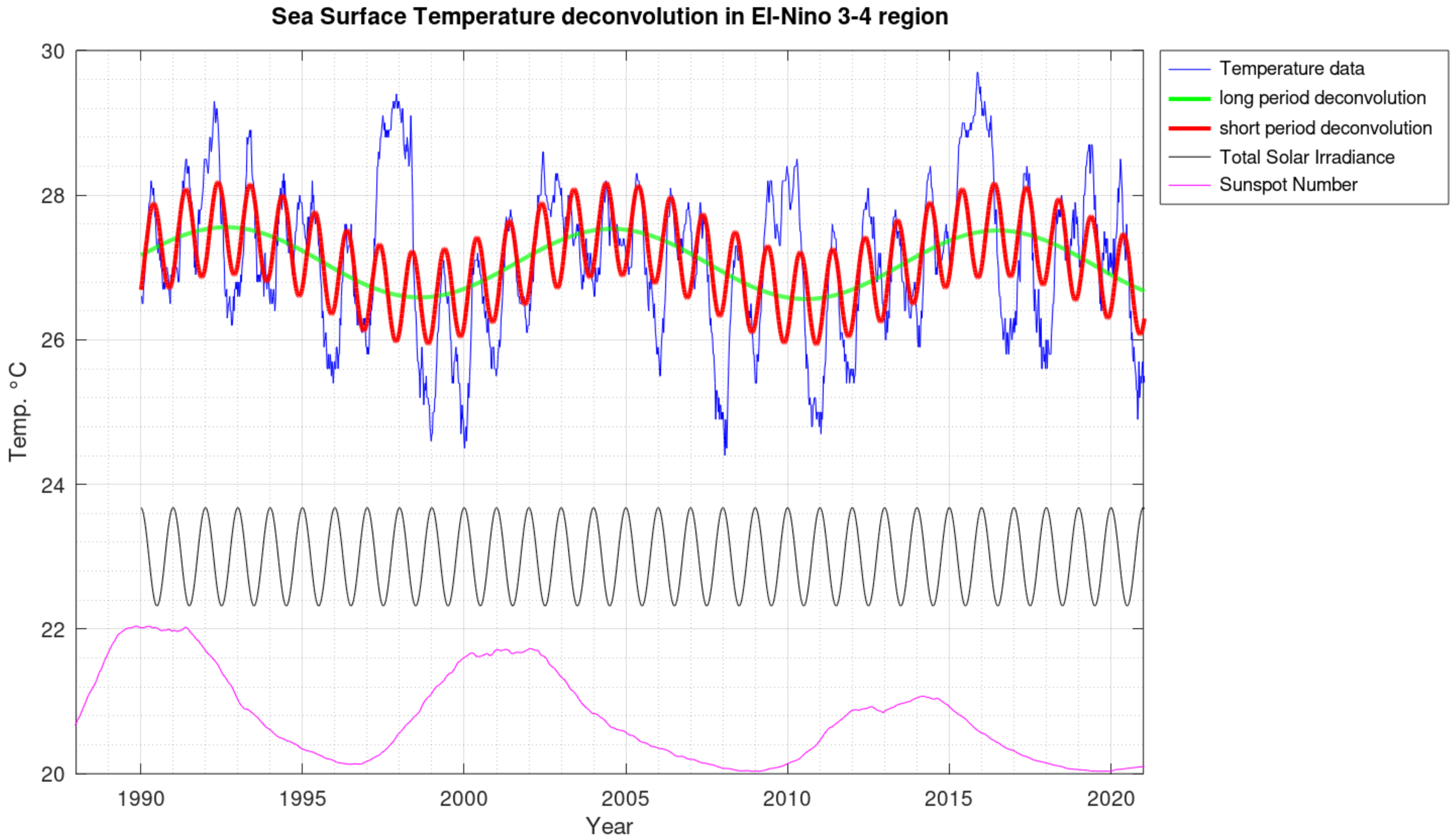

National Oceanic and Atmospheric Administration mantains records for global and regional surface temperature. Weekly records of sea surface temperature can to be obtained from the web-address listed in the script ('urlwrite' function). One of the most interesting area is the so-called El-Nino 3-4 region, which stretches around the equator in the pacific ocean, 5N-5S in latitude and 150W-90W in longitude. This area is located in the tropical eastern Pacific Ocean (figure 2) and presents an irregular periodic variation in winds and sea surface temperatures, measured usually by the ENSO index (El Niño–Southern Oscillation).

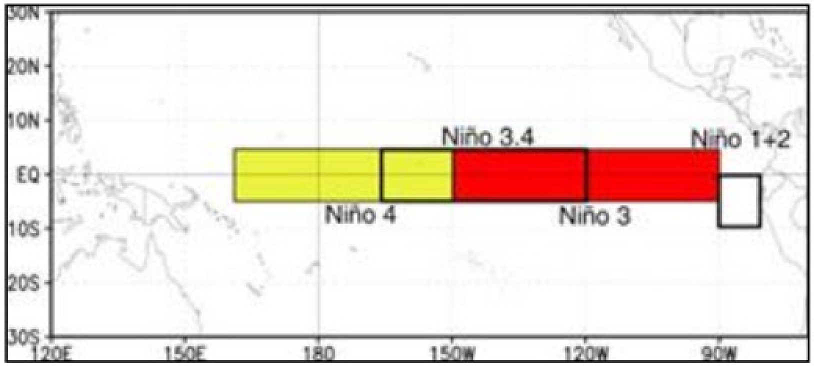

Fig.2 Geographic location of the four El Niño areas.

These variations affect the climate of much of the tropics and subtropics. The warming phase of the sea temperature is known as El Niño and the cooling phase as La Niña. Differently from the most Authors, here we examine not the ENSO index but a more direct parameter, the temperarure of the sea surface.
Data are obtained by the web site ponted out in the script in form of a weekly database from januar 1990. These data are deconvoluted firstly with a large period sinewave(from 550 to 650 weeks) , then the sinewave is detracted and the residuals are again deconvoluted with a sinewave but with a smaller period (from 50 to 60 weeks). The two periods converged to the values of

period 1 = 622.49 weeks = 11.93 years   (1 year = 365.24 days)

period 2 = 52.186 weeks = 1.000 years   (1 year = 365.24 days)

It is evident that the two periodicity are in close agreement with the solar spot cycle and the TSI (Total Tolar Irradiance), the last varying along with the sun-earth distance in the elliptic earth orbit, with an exact period of 1 year. The solar spot number is in close relationship with solar activity and hence the TSI.
The yearly variation of TSI is to be related to the earth-sun distance along the orbit. We use an approximate formula for this,

$$Q=S_0\ [1+0.034\cdot\cos(2\pi\cdot\frac{n}{365.25})] \qquad S_0=1367\,W/m^2 \quad n=number\ of\ days$$

where Q is the TSI along the year. This formula takes advantage from the perihelion (closest approach to the sun) being in the first 2-4 days of january, approximated to 0.
The sunspot number is downloaded from the web site of SILSO, Sunspot Index and Longterm Solar Observations / Royal Observatory of belgium, Brussels, according to the usual procedure of ‘urlwrite’ function in Octave.
The calculated delay results about 4 months for the short cycle and 3 years for the long one. The heat capacity of the surface layer of the ocean waters could possibly explain a 4 moths delay. The longest delay of 3 years could be explained by the longer chain of events, from the increased solar spots to solar activity and finally to ocean’s warming.
The whole script follows :

```
clear;clc;format short;format compact;
```

```
global Ud yd xd n;
% differently from Matlab, Octave functions are defined at the very beginning of the program !
function ydRes = best(p) % ------ minimizer
  global Ud yd xd n;
  Ud(:,3) = sin(2*pi/p*n);   % sin
  Ud(:,4) = cos(2*pi/p*n);   % cos
  G = inv(Ud.' * Ud);
  xd(:,1) = G*Ud.'*yd;
  ydR = yd - Ud*xd(:,1); % residuals
  ydRes = sum(abs(ydR)); % sum of residuals
endfunction              % ------ end of minimizer
%----------------------------------------------------------
% Climate Prediction Center, National Weather Service, NOAA-USA
% f = urlwrite('https://www.cpc.ncep.noaa.gov/data/indices/wksst8110.for','el_nino_2.txt')
% the above line to be activated once
S = fileread('el_nino_2.txt');
a1 = index(S,'03JAN1990');
M = S((a1-1):end);
M = strrep(M,'JAN',' 0 '); % January is == 0
M = strrep(M,'FEB',' 1 ');
M = strrep(M,'MAR',' 2 ');
M = strrep(M,'APR',' 3 ');
M = strrep(M,'MAY',' 4 ');
M = strrep(M,'JUN',' 5 ');
M = strrep(M,'JUL',' 6 ');
M = strrep(M,'AUG',' 7 ');
M = strrep(M,'SEP',' 8 ');
M = strrep(M,'OCT',' 9 ');
M = strrep(M,'NOV',' 10 ');
M = strrep(M,'DEC',' 11 '); % December is == 11
M = strrep(M,'-',' -');
X = str2num(M);
xYear = X(:,1)./365 + X(:,2)./12 + X(:,3); % date in decimal year
yd = X(':',8);  %  El Nino 3 + 4 real ocean temp. 5N-5S 150W-90W
nTot = length(yd);
disp ([X(1,1),X(1,2)+1,X(1,3)]);           % start day month year
disp ([X(nTot,1),X(nTot,2)+1,X(nTot,3)]); % end day month year
Ud = zeros(nTot,4);
Ud(1:nTot,1) = 1;                        % constant plateau
Ud(1:nTot,2) = linspace(-1,1,nTot);    % linear trend (orthogonal)
n = linspace(1,nTot,nTot);
xd = zeros(4,1);
pMin = fminbnd(@best,550,650); % 1st call to the minimizer
```

```
x2 = best(pMin);pMin         % once found , pMin is given again to the best() function
y3 = Ud*xd(:,1);              % y3 is the first SINEWAVE
y4 = yd;
yd = yd - y3;
pMin1 = fminbnd(@best,50,60); % 2nd call to the minimizer
x2 = best(pMin1);pMin1
y5 = Ud*xd(:,1) + y3;        % y5 is the second SINEWAVE
plot (xYear,y4,'b',xYear,y3,'g','LineWidth',2,xYear,y5,'r','LineWidth',2);grid on;
grid minor on;axis([1988,2021,20,30]);hold on;
%----------------------------------------------------------
% Total Solar Irradiance. An Estimate from ithaca web-site
% https://www.itacanet.org/the-sun-as-a-source-of-energy/part-2-solar-energy-reaching-the-earths-surface/#2.1.-The-
Solar-Constant
TSI = 3 + 20*(1 + 0.034*cos(2*pi*xYear));
plot (xYear,TSI,'k');hold on
%----------------------------------------------------------
% SILSO Sunspot Index and Longterm Solar Observations / Royal Observatory of belgium, Brussels
%f = urlwrite('http://sidc.oma.be/silso/DATA/SN_m_tot_V2.0.txt','silso.txt')
S = fileread('silso.txt'); % silso.txt is the downloaded text-file.
M = strrep(S,' *','');
X = str2num(M);
xYearS = X(':',3);ySpot = X(:,4)./100 + 20;
yS = movmean(ySpot,20);
plot (xYearS,yS,'m'); title ('Sea Surface Temperature deconvolution in El-Nino 3-4 region');
xlabel('Year');ylabel('Temp. °C');
legend ('Temperature data','long period deconvolution','short period deconvolution','Total Solar Irradiance',...
'Sunspot Number','Location','bestoutside')
hold off
```