Introduction to the Data Library (DL):

Trends and De-trending

Training Module
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## Contents

1 Introduction to the Data Library (DL) - Trends and De-trending
   1.1 Introduction ................................................................. 1
   1.2 Overview ................................................................. 1
   1.3 Access ................................................................. 1
   1.4 Linear Trend and De-trending ............................................ 2
   1.5 How to interpret a trend map ............................................. 5
   1.6 De-trend Using Time Differences ....................................... 5
   1.7 De-trend Using [runningAverage] ....................................... 9
   1.8 Summary ............................................................... 9
   1.9 Quiz ................................................................. 9
   1.10 Reference(s) .......................................................... 10
1.1 Introduction

The IRI Climate Data Library is a library of datasets. By library we mean a collection of datasets, collected from various sources, designed to make them more accessible for the library’s users (Blumenthal, 2004). For this module we will be expanding on trends and de-trending. Traditional GIS platforms are now widely used by planners and decision makers in society. However, they are highly-focused on geospatial capabilities and have limited functionality for temporal analysis. Without information on the latter, meaningful inference about the causation of disease outbreaks is impossible (Jacquez 2000). Furthermore, many tools are unable to readily process the vast quantities of space-time data associated with, for example, the outputs of a global climate model. The IRI Climate Data Library overcomes the limitations imposed by GIS platforms by being based on a much more general multi-dimensional data model that includes both space and time dimensions. All datasets, including GIS features (such as points, lines, and polygons) are geo-located and temporally referenced in a uniform framework.

1.2 Overview

What will be working on?

For this manual we will be working on trend calculations [and subtraction]:

- Linear trend and De-trending
- “Differences” in time
- Subtraction of an average

1.3 Access

The IRI Data Library can be accessed with the following links:

- Worldwide: http://iridl.ldeo.columbia.edu/
- Chile: http://www.climatedatalibrary.cl/
- Venezuela: http://datoteca.ole2.org/
- Uruguay: http://dlibrary.snia.gub.uy/
- Rwanda: http://maproom.meteorwanda.gov.rw/
1.4 Linear Trend and De-trending

The calculation of the linear trend depends on the period chosen E.g.: Case of the overall mean temperature (global mean surface temperature)

Least-squares best-fit linear trend. It is a “special” case of linear regression, where x=time (look at Fig 1.2).

In this least-squares best-fit context, we can assess the statistical significance of the trend. This can be done by comparing Fig 1.3 (a), the hypothesis to test is whether $a_2$ is significantly different from zero, for example Fig 1.3 (b).

Linear trend in DL, the function to be used is: detrend-bfl (Fig 1.4).

Fig 1.5 is the NASA/GISS global land average temperature with its linearly de-trended version.
\[ y = a_1 + a_2 x \]
\[ a_2 = \frac{\sigma_{yx}}{\sigma_x^2} \]
\[ \sigma_{a_2} = \frac{1}{\sqrt{n-1}} \frac{\sigma_y}{\sigma_x} \]
\[ \sigma_{yx} = \frac{1}{n-1} \sum_{i}(x_i - \bar{x})(y_i - \bar{y}) \]

Fig. 1.2: Regression

\begin{align*}
a_2, \sigma_{a_2} & \quad \text{a)} \\
a_2 \pm 2\sigma_{a_2} = 0 & \quad \text{b)}
\end{align*}

Fig. 1.3: Regression Comparison

bfl = best fit line [quadratic fit]

Fig. 1.4: [detrend-bfl] Function

1.4. Linear Trend and De-trending
The expert mode of Fig 1.5:

```
SOURCES .NASA .GISS .GISSTEMP .Global .Ts
T 12 boxAverage
a:
  /fullname (giss global land temp) def
:a:
  [T]detrend-bfl
    /fullname (linearly detrended) def
:a
T fig: medium black line red line :fig
```

or:

```
SOURCES .NASA .GISS .GISSTEMP .Global .Ts
T 12 boxAverage
/fullname (giss global land temp) def
dup
[T]detrend-bfl
/fullname (linearly detrended) def
```

[detrend-bfl] subtracts the linear trend. But the question on how to exploit it to calculate the trend itself is what follows. In other words - where is the trend in the figure 1.4. The trend is the difference between the two series !!!

### 1.4.1 Expert Mode

```
:: SOURCES .NASA .GISS .GISSTEMP .Global .Ts
  T 12 boxAverage
dup
  [T]detrend-bfl
  sub
```
1.5 How to interpret a trend map

First we observe the trends in annual precipitation, refer to Fig. 1.6.

The we look at the observed trend in annual precipitation 1983-2014 through following expert mode and resulting in Fig 1.7:

SOURCES .MaliMeteo .ENACTS .rainfall .MON .dekdly .rfe_merged T (Jan 1983) (Dec 2014) RANGE
monthlyAverage T 12 boxAverage
    dup [T]detrend-bfl sub
    dup T last VALUE exch T first VALUE sub
prcp_anomaly
DATA -100 100 RANGE
X Y fig: colors :fig

If we look back at 1.5 the best fit line doesn’t quite capture the nature of the global mean temperature increase.

1.6 De-trend Using Time Differences

There is another simple technique to “de-trend”, a technique that does not impose a shape to the fit, rather adapts to the data. It takes differences in time, between one time step and the previous. In the DL: [T] differences
For each point, it is the coefficient $a_2$ in the regression with time (from Fig 1.3)

Fig. 1.7: Trends in Annual Precipitation in 1983 to 2005 in Mali
1.6.1 Example

Fig 1.8 shows the agricultural production and climate in Mali 1961-2009. The sum of production in: millet, sorghum, maize and rice.

Expert Mode:


item_codes (79) (83) (56) (27) VALUES [item_codes]sum

T fig: red medium line :fig

Fig. 1.8: Agricultural production in Mali 1961-2009 (http://iridl.ldeo.columbia.edu/SOURCES/.UN/.FAO/.FAOSTAT/.Mali/.Feb2012/.Production/.Crops/.production/item_codes/%2879%29%2883%29%2856%29%2827%29VALUES%5Bitem_codes%5Dsum)

We add the precipitation into the figure with expert mode:


SOURCES .WCRP .GCOS .GPCC .FDP .version5 .2p5 .prcp

1.6. De-trend Using Time Differences
The result is Fig 1.9, showing the crop production and mean precipitation in Mali between 1961-2009. There are significant “trends” in both production and precipitation, but they are not linear.

Year-to-year differences in staple production and rainfall bring out their relationship clearly. So we de-trend by using the expert mode and resulting in Fig 1.10:

```plaintext
   item_codes (79) (83) (56) (27) VALUES [item_codes]sum
   [T]differences
SOURCES .WCRP .GCOS .GPCC .FDP .version5 .2p5 .prcp
   Y 12 16 RANGE X -15 5 RANGE [X Y] average
   T (May-Oct) seasonalAverage
   [T]differences
T fig: twolines :fig
```
1.7 De-trend Using [runningAverage]

For this section we will be subtracting a dynamic average and de-trending.

The expert mode:

SOURCES .UEA .CRU .TS2p1 .monthly .prcp

X -20 40 RANGE Y 12 18 RANGE [X Y]average

T (Jan 1901) (Dec 2000) RANGE yearly-anomalies T (Jul 1901) (Sep 2000) RANGE T 3 boxAverage T 12 STEP
dup T 252 runningAverage

sub

T fig: red line :fig

1.7.1 The Results (Fig 1.11)

1.8 Summary

For this module we hope you are able to calculate Trends, De-trending, Differences in Time and Subtracting dynamic averages.

1.9 Quiz

Please answer the following questions using the IRI Data Library
Q1. What does the \texttt{[detrend-bfl]} function do?

Q2. What is the use of \texttt{[T]} differences?

\textbf{1.9.1 Quiz - Answers}

A1. \texttt{[detrend-bfl]} function, detrends with a best-fit line.

A2. \texttt{[T]} differences takes the differences in time between one time step and the previous one.

\textbf{1.10 Reference(s)}

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