

Vesturdalsá river temperature 22 years

Objectives

The main objective of this case was to develop a method in PatternFinder to evaluate annual and seasonal river temperature changes.

The research is based on 22 years of temperature data from the river Vesturdalsá in Iceland. Vesturdalsá is located in the northeast of Iceland and enters the fjord of Vopnafjörður (estuary at: 65°44'N and 14°54'W). The catchment area is 190 km² and has an average flow of 5.0 m³s⁻¹.

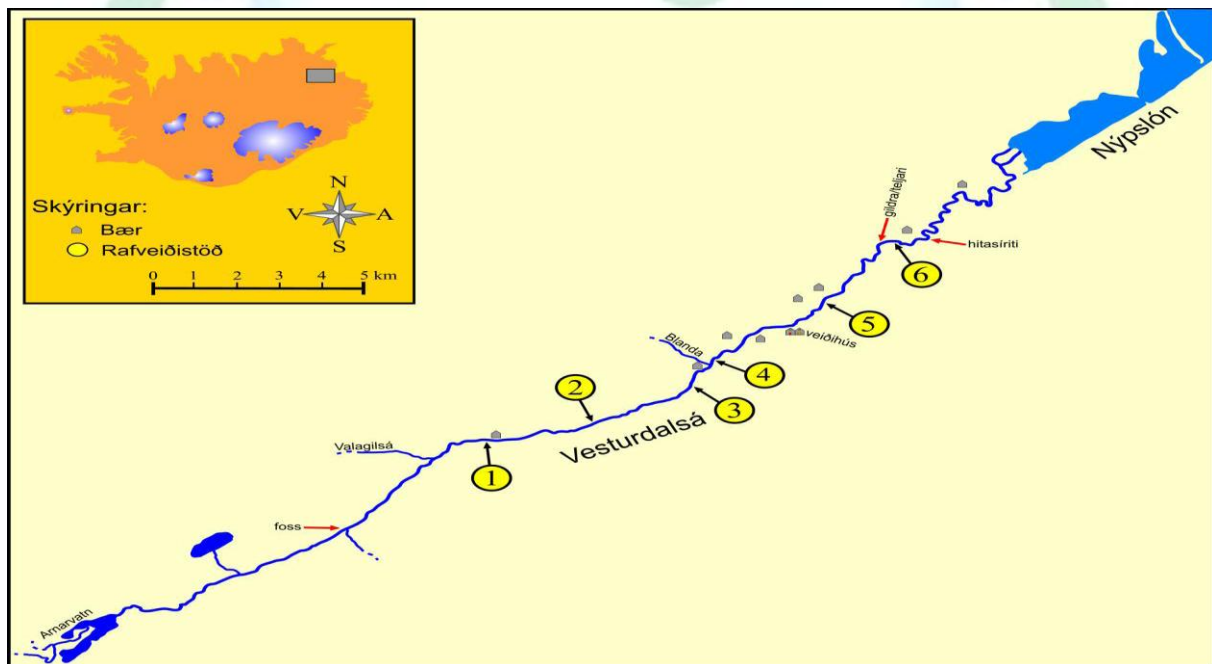


Figure 1. Vesturdalsá river location.

It is classified as wetland heaths stream which originate in moraine heaths with lake and wetland systems. Vesturdalsá has been an index river in studies on salmon for the northeast part of Iceland. The temperature meter was located approximately 8.0 km upstream from the estuary.

Method

1. We start by importing the temperature data and creating a project for river measurements. The temperature data is appraised graphically, via histogram and daily graphical intensity.
2. The data is statistically evaluated by looking at periods, years and months. One of the statistical parameters is energy that can yield yearly and monthly day-degrees.
3. Another way of looking at how the higher temperatures stretch over the years is by using event analysis. By setting a temperature threshold and calculating the relative time temperatures that exceed this limit, the distribution of the temperature can be seen.
4. As the data is not continuous in the first 10 years, a seasonal day-degree value is calculated as an annual value, giving an alternative to the year-day-degree values. Seasonal period is defined as 28.6-13.8, thereby all the years are represented.
5. Overlaying the temperature data annually gives a great view of the yearly changes. Monthly overlaying reveals the monthly average temperature changes over a year, and daily overlaying gives the daily average temperature oscillation.
6. Measurements on Salmon and Arctic charr have been carried out in Vesturdalsá river since 1979. A new project is created by importing annual population, length and weight numbers for Salmon smolt. By extracting data from [1989-2009], a new file is created that can be added to our Vesturdalsá river temperature project.
- R. Finally a summary of the main statistical results. We compare seasonal day-degree values to Salmon weight data, visually and through correlation analysis.

1 Creating a single file project (SFP)

As the data was collected from various recorders over the 22 years, the import option was used to create the SFP.

Import File to New SFP Project

Import options

File to import: E:\PF-Cases\Veidimál-Vesturdalsá\Hiti Vesturd 1989-2010.txt

Name of new SFP project: VD

Project Path: C:\PatternFinder 1.0M1\Projects\SFP\VD\VD.SFP

Column setup

Number of data columns: 1

☐ Last column included as data point comments

☒ Measurement numbers included as first column

☐ Fixed sampling rate (specified in import file)

☒ Date and time as first column (2nd if meas. numbers)

☐ Start time: 7. 3 .2011 00:00:00

Interval: 1 Seconds

Select decimal point

☒ Comma (,)

☐ Dot (.)

Column separation

☒ Tab ☐ Semicolon

☐ Space ☐ Comma

Date format

☒ dd mm yy

☐ mm dd yy

Date separation

☒ Dot (.)

☐ Slash (/)

☐ Dash (-)

Time separation

☒ Colon (:)

☐ Dot (.)

Date and time column definition

☐ Joined date and time

☒ Seperate date and time

OK Cancel

Figure 1.1 Import options

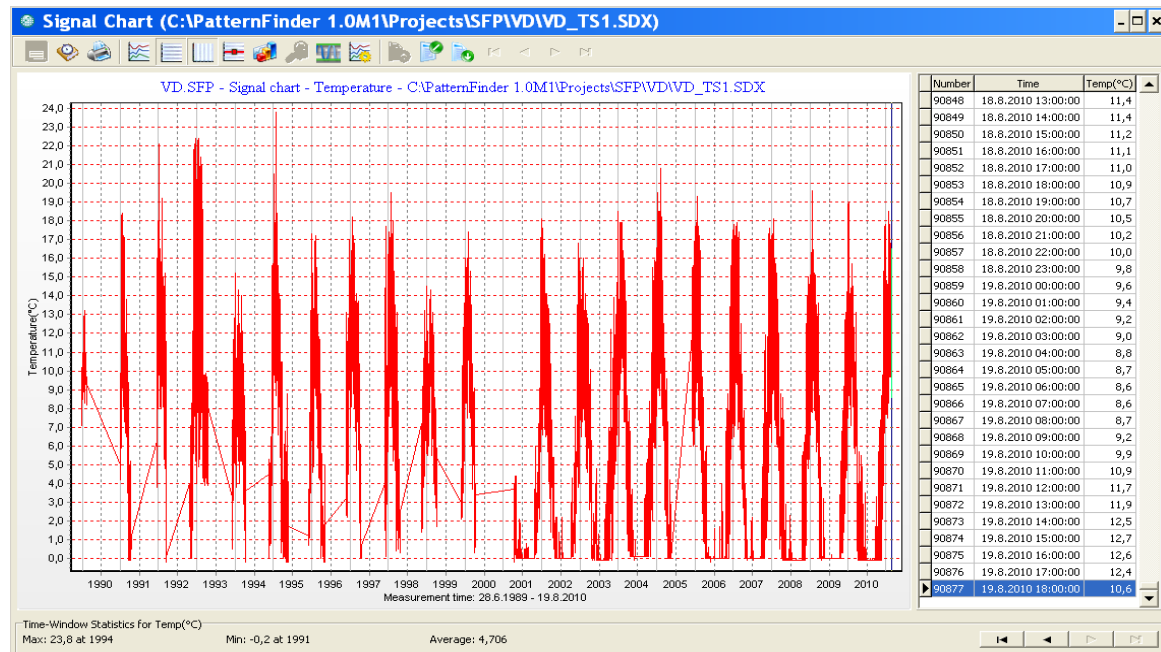


Figure 1.2. Temperature values over 22 years.

The temperature file is given an alias name, "T".

The measurements are not continuous, most evident is the lack of measurements in the year 2000.

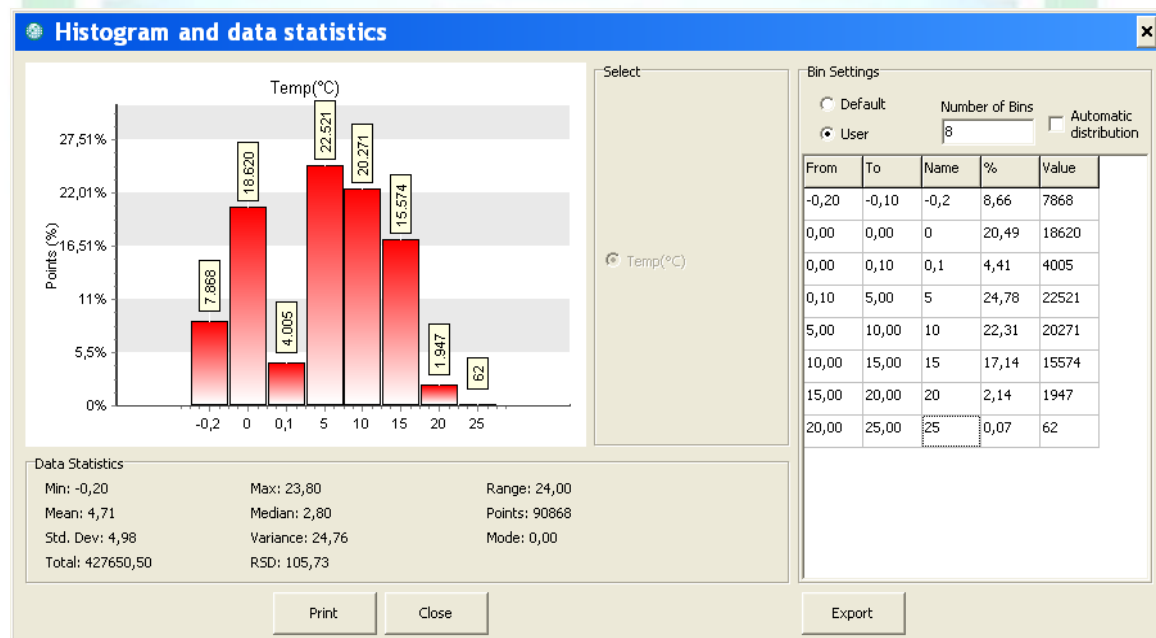


Figure 1.3. Histogram for all the data in figure 1.2

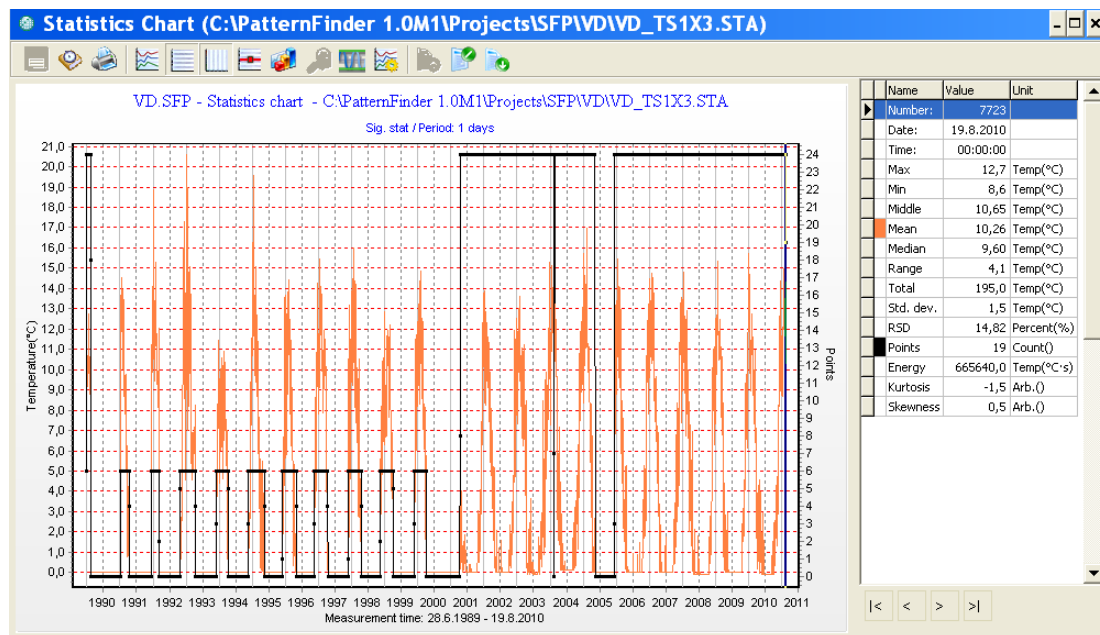


Figure 1.4. 1 day period, number of measurements and mean temp.

As can be seen in figure 1.4, from the year 1989 to 2001 measurements are performed every 4 hours mainly from May to October. In 2001 to 2010 measurements are continuous and performed every hour with a gap in 2005, where there are no measurements the first 5 months.

Case study

2 Signal Periodic Statistics

2.1 Period definition

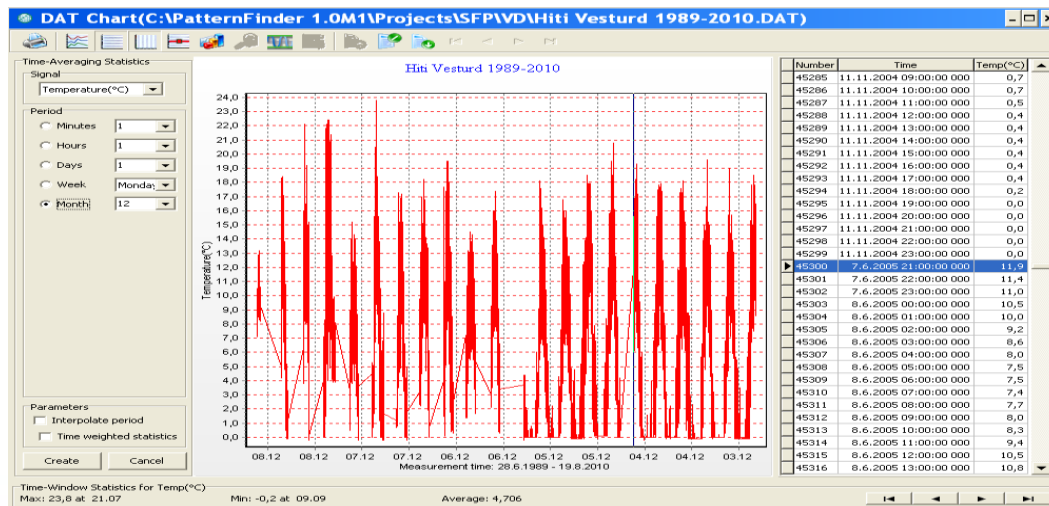


Figure 2.1 Defining a Signal Period Statistics operation as a year (12months)

2.2 Year Period

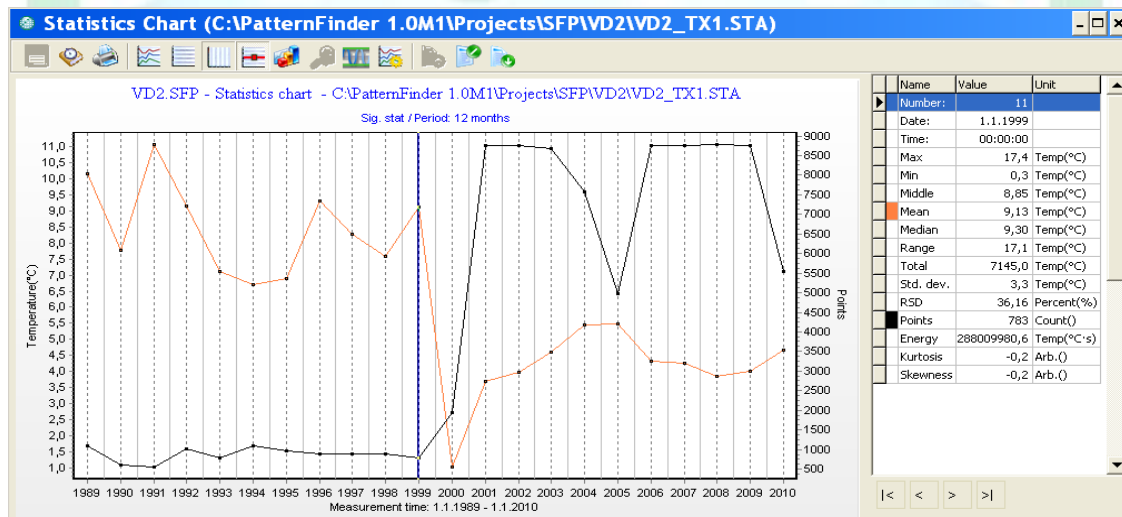


Figure 2.2 Yearly statistics, Mean and number of points

The statistics chart in figure 2.2 is saved as T_xy.

The number of measurements is around 1000 per year from 1989 to 1999. The year 2000 is an anomaly as there are very few measurements. In the year 2001 to 2010 the number of measurements per year is about 8000, except in 2005 where the measurements are about 5000. The mean values are obviously much lower in the years following 1999 because of all the near to zero measurements in the years 2001-2010.

2.2.1 Energy

Extract **Energy** from T_XY.

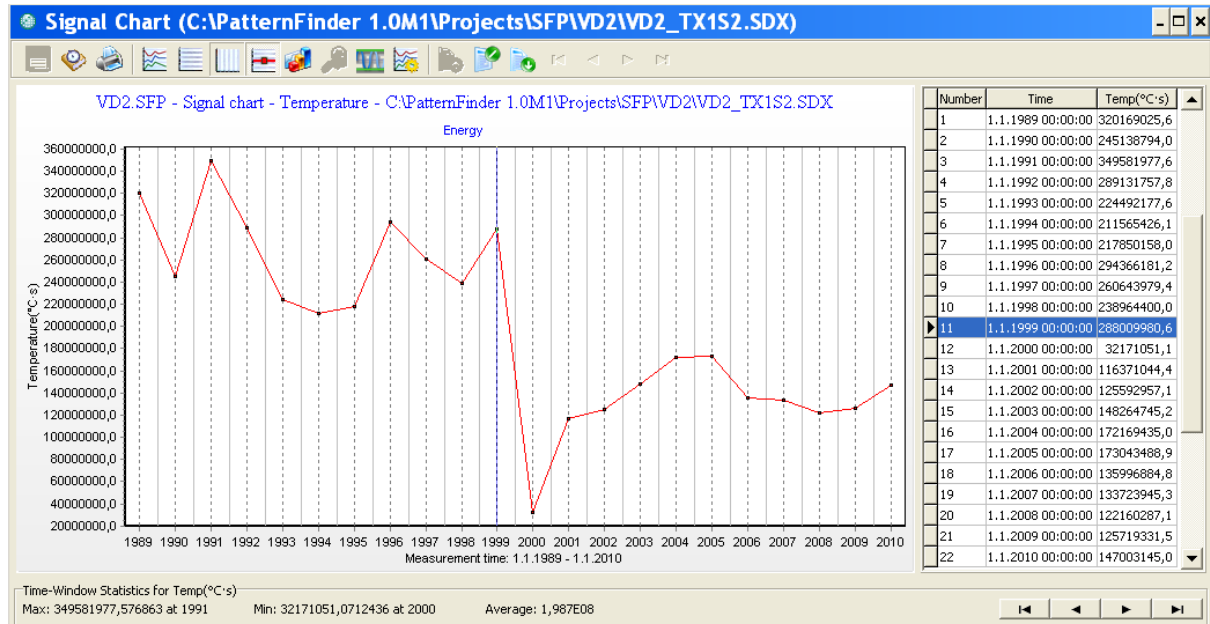


Figure 2.3 Yearly energy

The signal chart in figure 2.3 is saved as Yenergy.

This is the energy per year in degree Celsius seconds (°Cs)

2.2.2 Day-Degrees

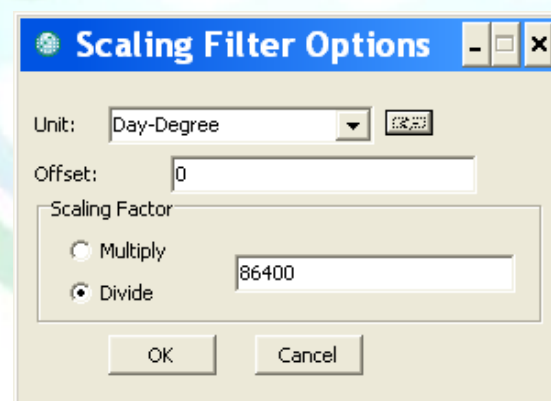


Figure 2.4 Scaling

By using the filter option **Scale**, you can divide the energy with the number of seconds in one day. The result is day-degrees. At the same time this new unit can be defined.

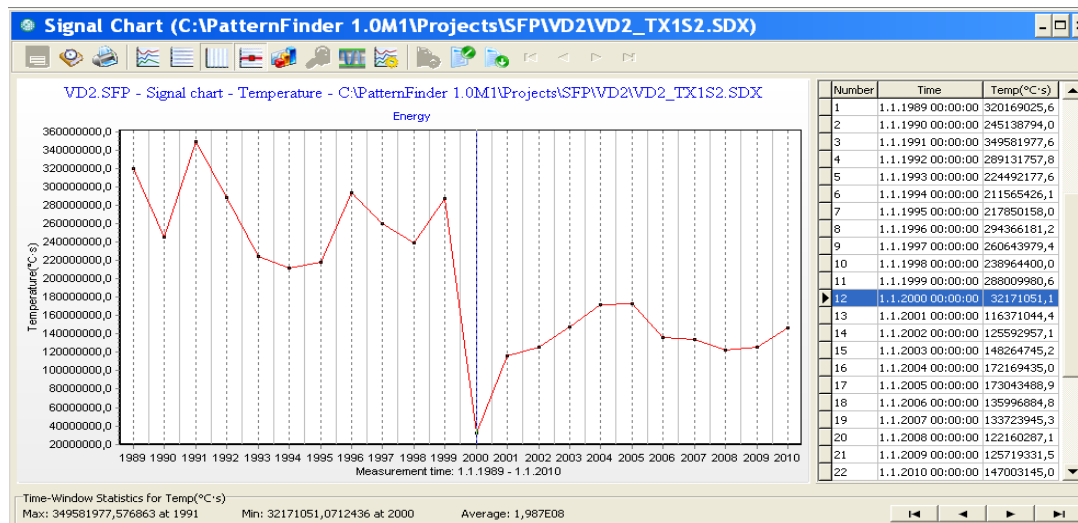


Figure 2.5 Yearly Day-Degree

The year day-degree seems to mimic the year mean degree graph and the number of measurements and the period does play a role. The years before 2000 had only a few measurement months, and there were no measurements in 2000. Thus looking at the data as is, only the years between 2001 and 2010, with a year-round measurement coverage, can give a realistic picture of year-day degree.

There are other options, one is to remove all the zero values and near to zero values. Another approach, which we prefer, is to look at seasonal values that can reflect annual fluctuations. We'll take a closer look at that later.

2.3 Monthly Period

For more detailed results we can look at changes per month.

By using the same procedure as with the year period we get the **Monthly** statistics for the T data.

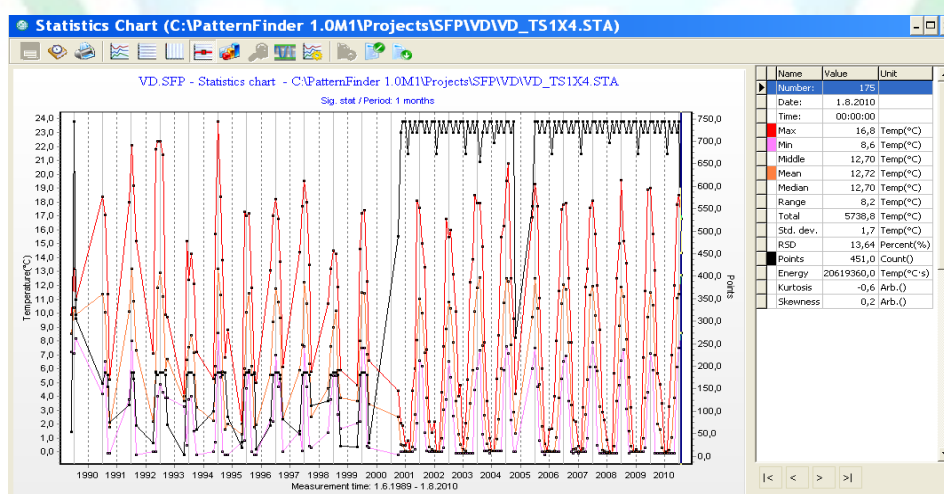


Figure 2.6 Monthly statistics, Max, Mean, Min and number of points

There are 175 points in the chart, thus there are 80 months with no measurements.

Case study

By using the same procedure as in chapter 2.2.2 we get the Day-Degrees per month.

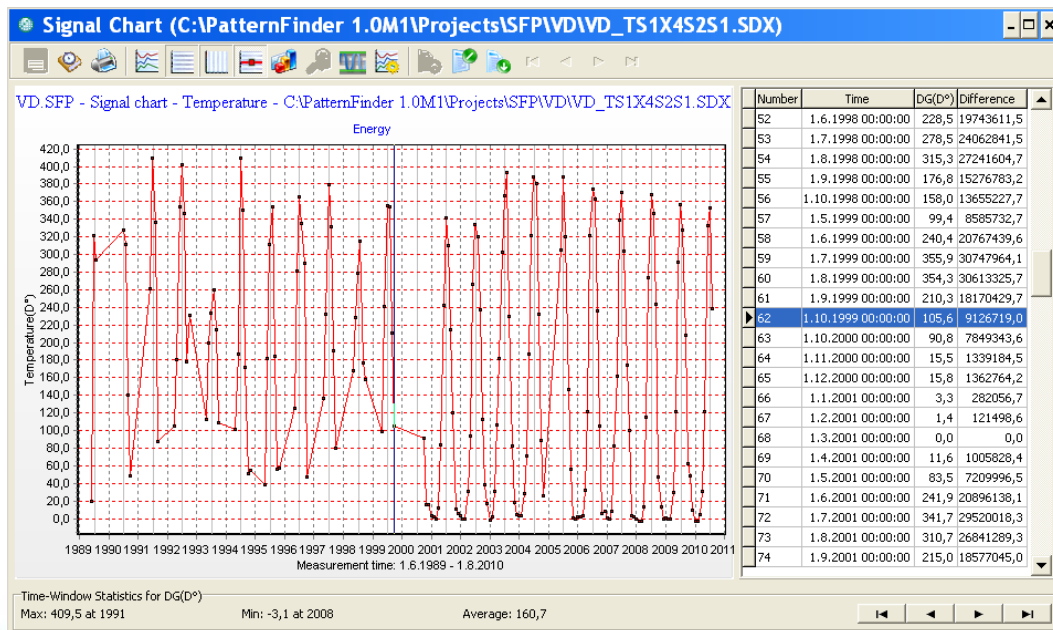


Figure 2.7 Monthly Day-degree

We look at average temperature values, combining the monthly and yearly mean for the years 1989 - 2010:

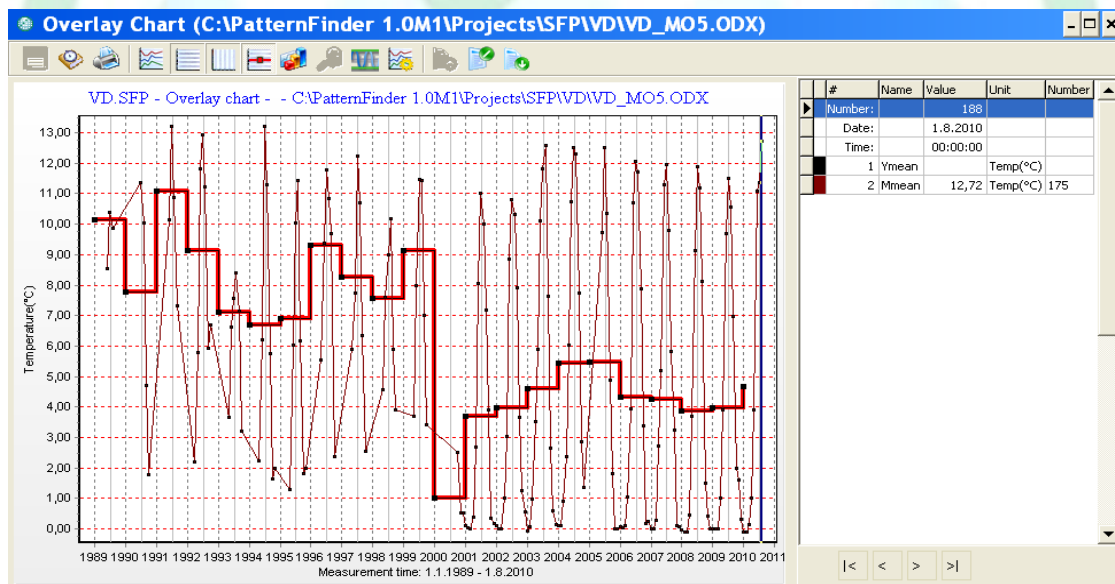


Figure 2.8 Yearly and Monthly averages

3 Event analysis

3.1 Event definition

As a comparison to the Day-degree values, we can analyze the time the temperature is above a certain limit. We use the T file and set our limit to 5°C.

Create Event Graph

1. Select series for event chart

☒ Temp(°C)

2. Select parameter type

☐ Behavioral

☒ Ambient

☐ Manual

3. Set event conditions (behavioral only)

Define minimum event duration

- Minimal number of points: 2

Define minimum event amplitude

☐ Percentage of range (0-100%): 5

☒ Absolute value (°C): 2

4. Define amplitude levels

Number of levels: 2

☐ Automatic definition

L1: from -0,2 to 5,0

L2: from 5 to 25

L3: from to

L4: from to

L5: from to

<< >>

Status: OK

OK Cancel

Figure 3.1 Ambient/Limit event definition

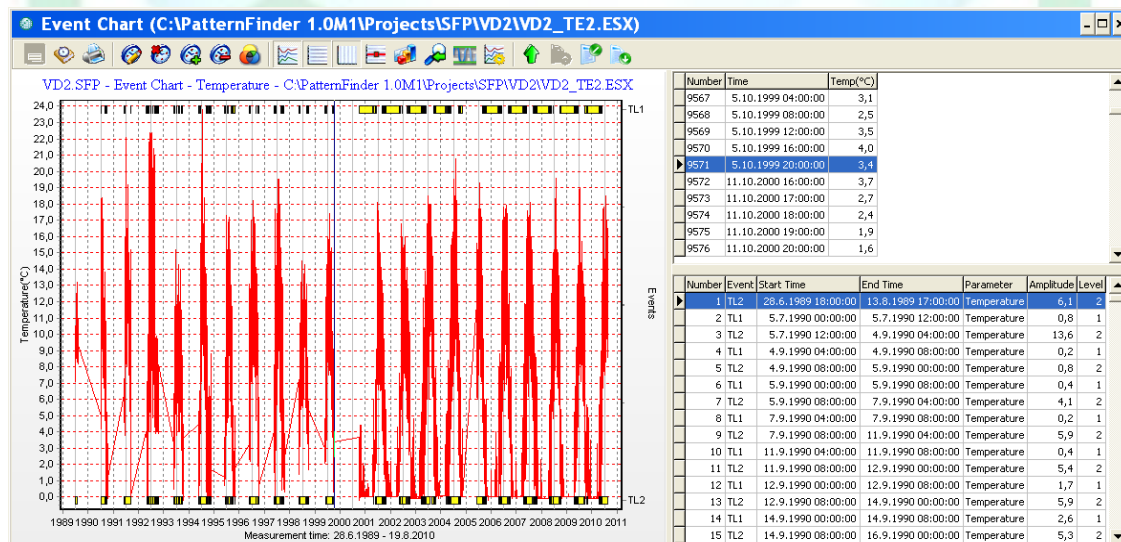


Figure 3.2 Event analysis results. TL2 holds the higher limit ($\geq 5^{\circ}\text{C}$)

The results of the event analysis can be seen in figure 3.2.

3.2 Periodic statistical event analysis

3.2.1 Monthly statistical event analysis

We define the periodic event as a month and look at the event duration.

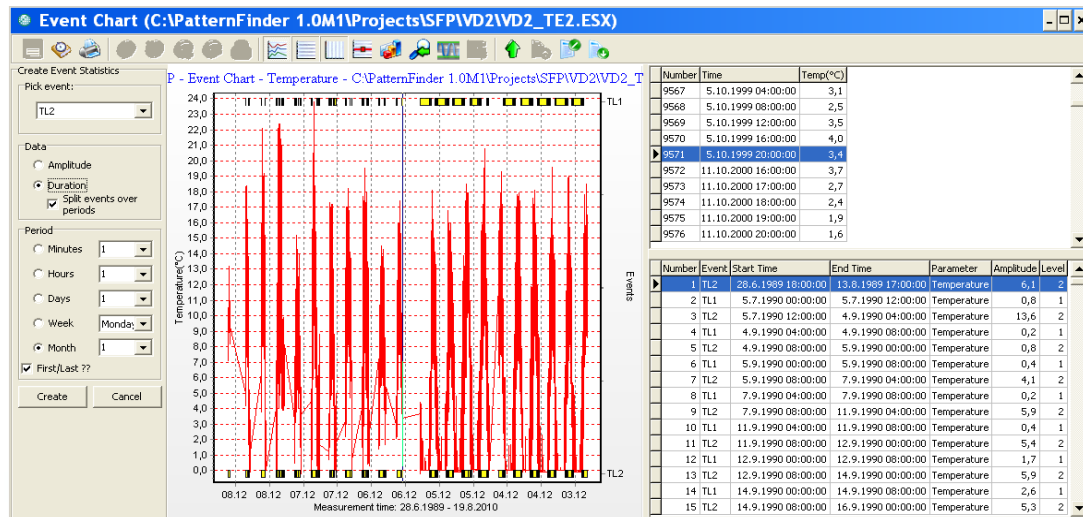


Figure 3.3 Periodic statistical event analysis definitions

Part of the results of the event statistical analysis can be seen in figure 3.4. Occurrences and total time parameters are active.

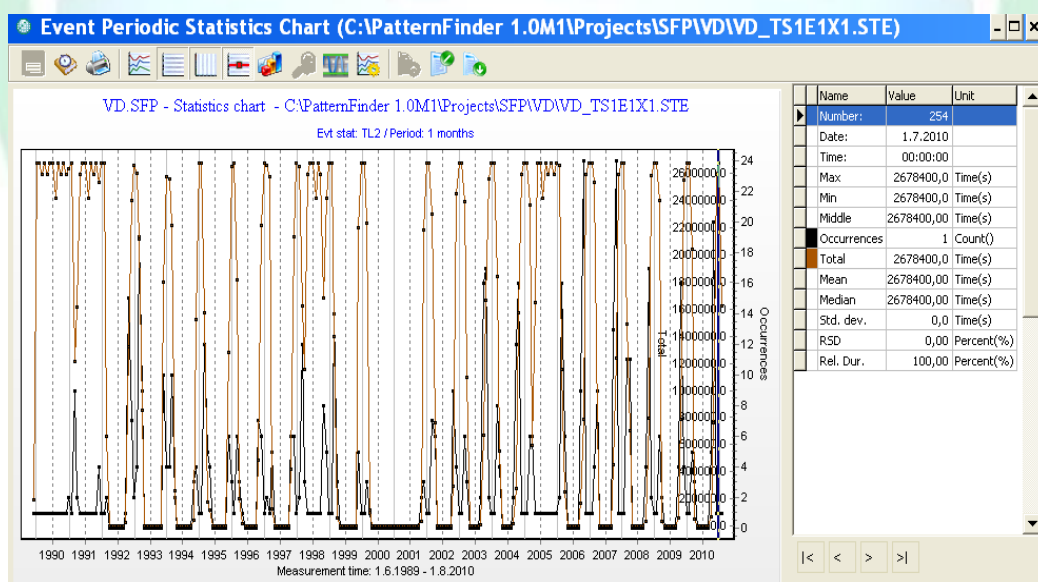


Figure 3.4 Monthly statistical event analysis. Occurrences and total event time per month.

The Rel. Dur. parameter represents relative event time per month. The value is shown in percentages.

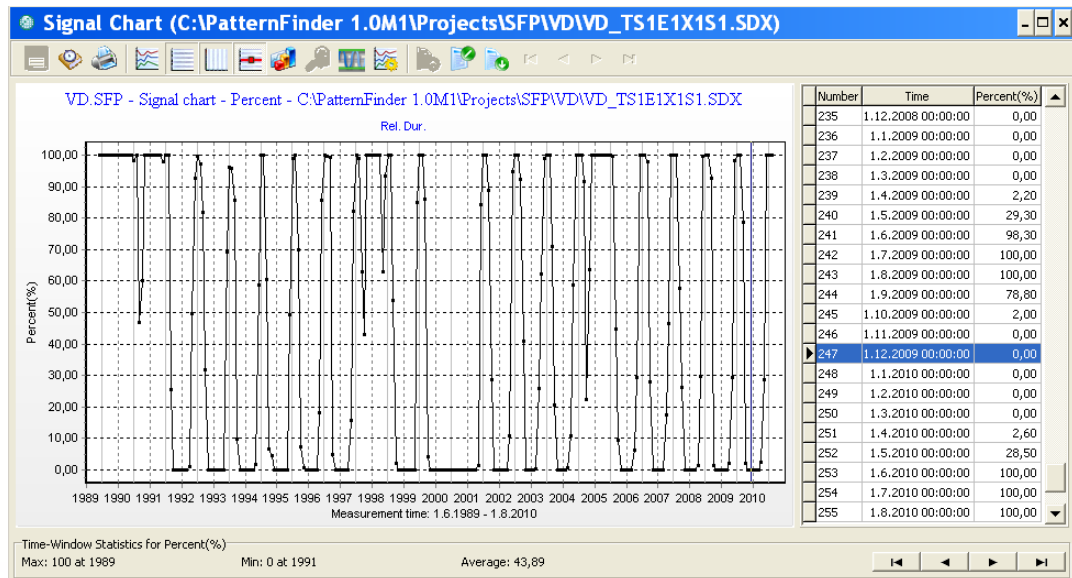


Figure 3.5 Monthly relative event duration.

3.2.2 Yearly statistical event analysis

We compute the yearly event duration in the same manner.

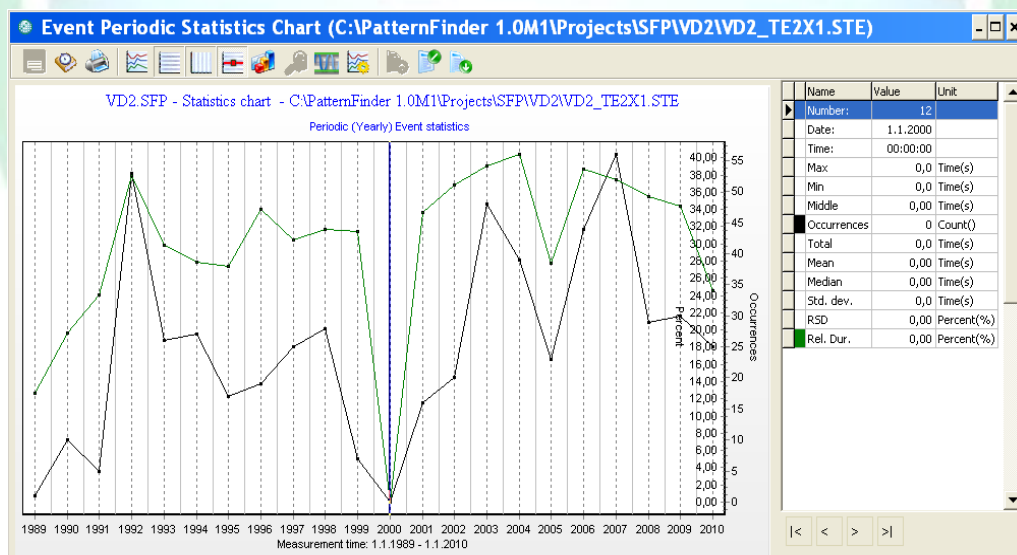


Figure 3.6 Periodic (Yearly) event analysis, showing occurrences and relative duration.

The green line represents the relative duration per year. As can be seen the year 2000 has no values as there are no measurements and in 2005 only half the year is represented. We will therefore extract the relative duration and interpolate these two years, i.e. 2000 and 2005, to reveal a more realistic trend.

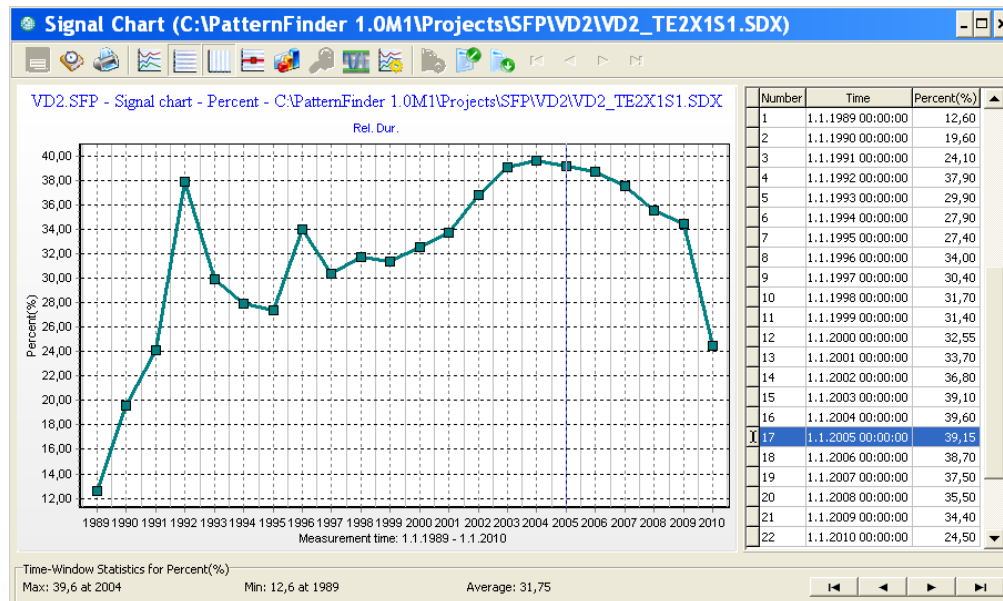


Figure 3.7 Yearly relative duration.

We emphasize that this case study is not a scientific paper and we change the values in 2000 and 2005 knowing that this is not a scientific procedure. This case study is meant to show the possibilities in PatternFinder and we leave the scientific deductions to the scientists.

4 Seasonal periodic analysis

As the data is not continuous in the first 10 years, a seasonal day-degree value is calculated as an annual value, giving an alternative to the year-day-degree values calculation method.

We select the original data and define the period to be 28th of June to 13th of August, thereby all the years are represented.

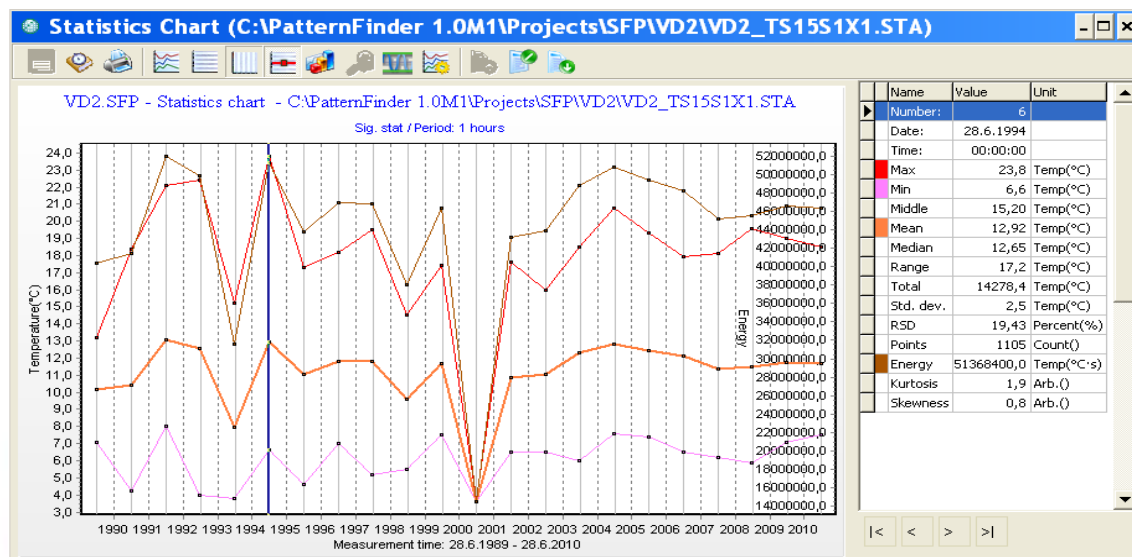


Figure 4.1 Seasonal periodic analysis results. Energy is brown, Max is red, mean is orange and min is purple.

There is a similarity between the year period statistics and the seasonal ones, but mean values are more persistent and the energy looks better. We observe now the drop in max, mean and energy values in 1993 and also in 1998, although not as much. In figure 1.2 we see that these two years are obviously lower, so this is normal

We extract the energy value, convert it to seasonal day degrees and interpolate the year 2000.

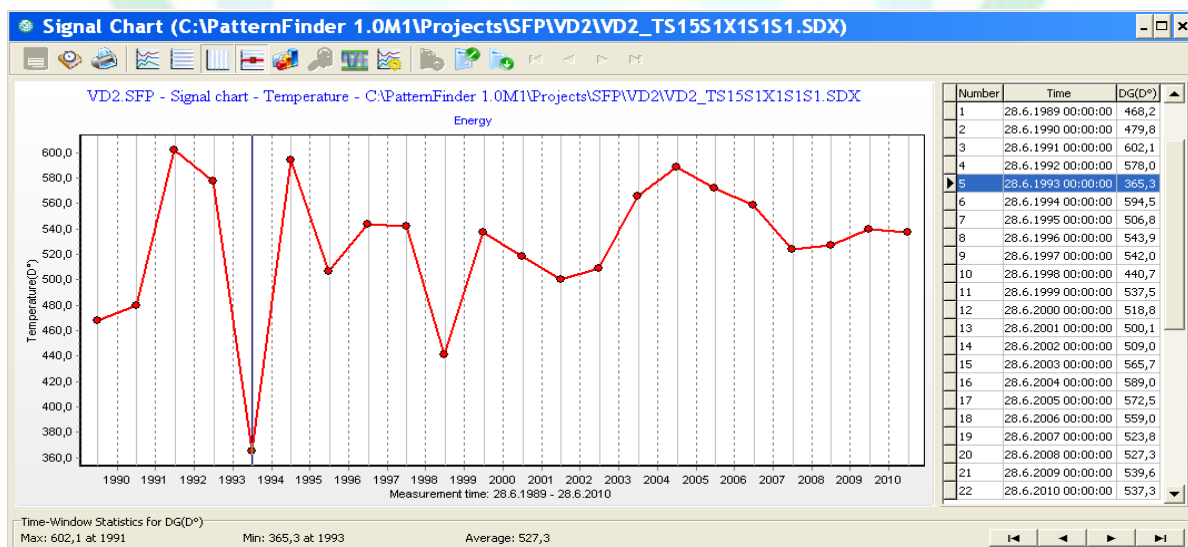


Figure 4.2 Seasonal day-degrees.

5 Overlaying data

5.1 Annual overlay

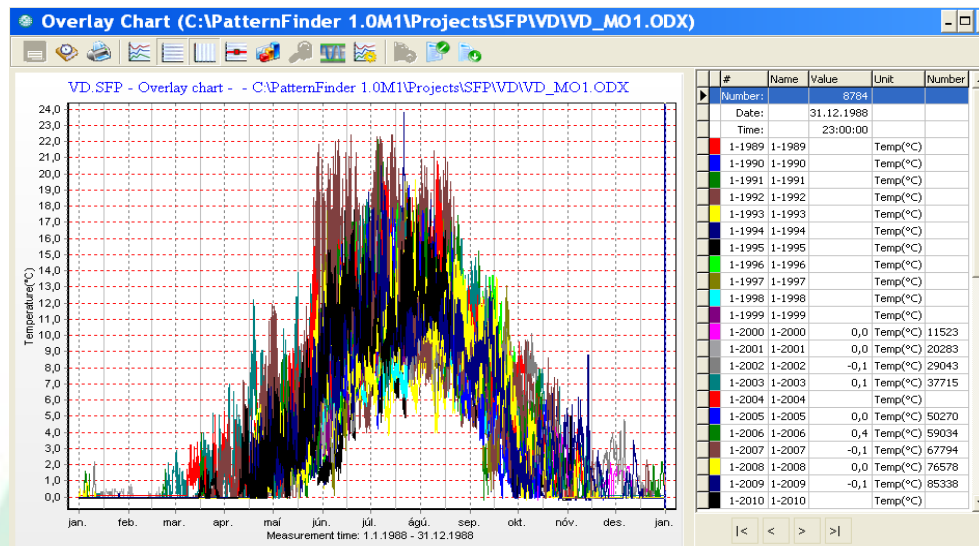


Figure 5.1 Annual overlay of the original data (chart T)

All data is overlaid to the year 1989.

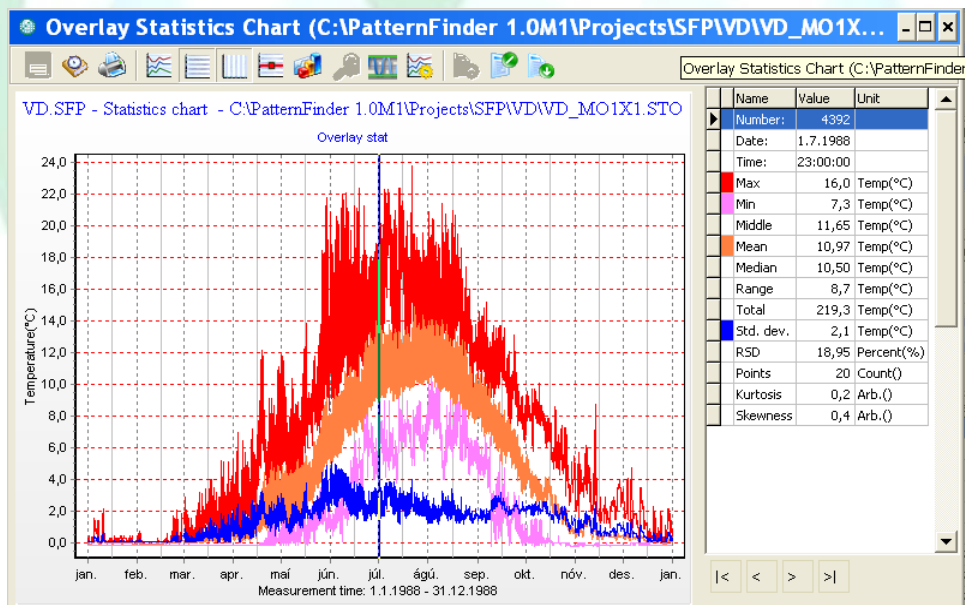


Figure 5.2 Annual overlay statistics. Max, mean, min and SD.

5.2 Overlay of monthly data

We use the monthly day degree data, see figure 2.7.

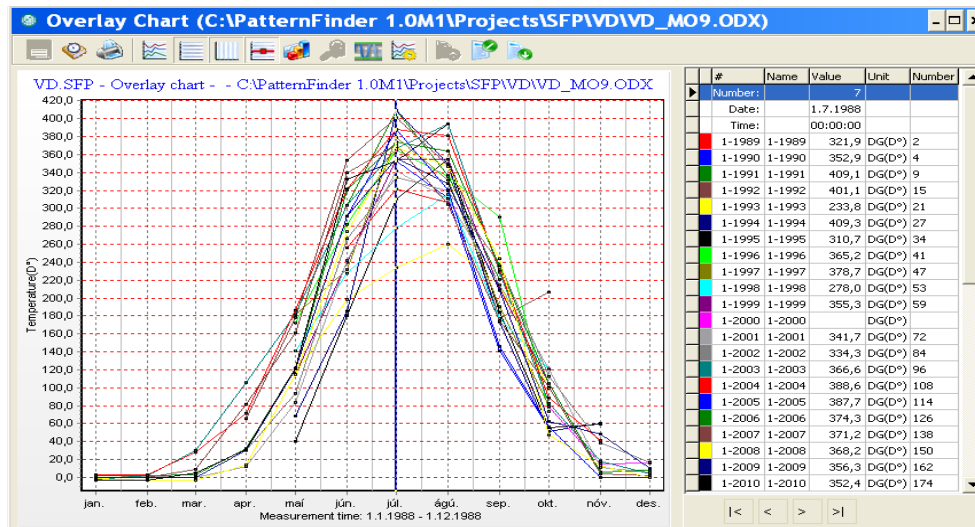


Figure 5.3 Annual overlay of Monthly-“Over 5° threshold relative duration”

By performing an overlay statistics analysis we get the average value for the monthly day degree.

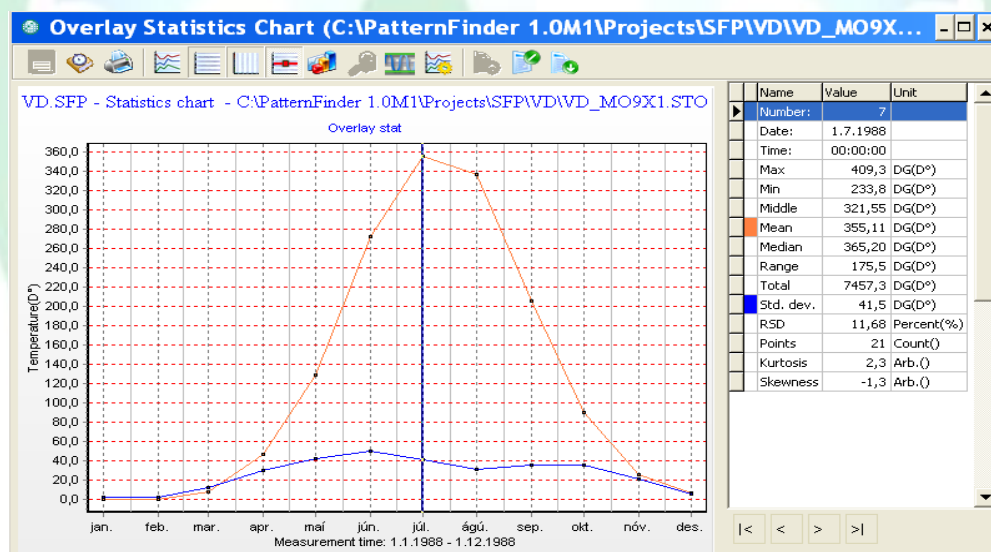


Figure.5.4 Annual overlay statistics of Monthly-Day Degree. Showing average and SD

5.3 Daily overlay

By looking at the temperature data it can be seen that half the year is near 0°C, for example, in the year 2008.

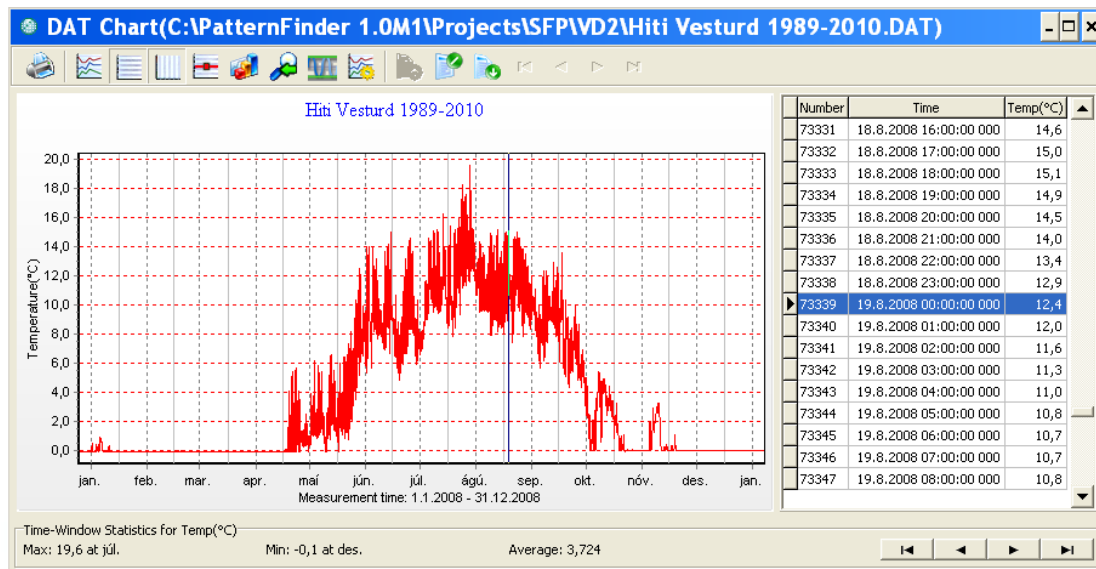


Figure 5.5 year 2008

In order to get a fair average of daily temperature changes, we concentrate on the interval from May 23 to September 27. We also interpolate all measurements to 1hour.

All the data is then overlaid to cover a singular day.

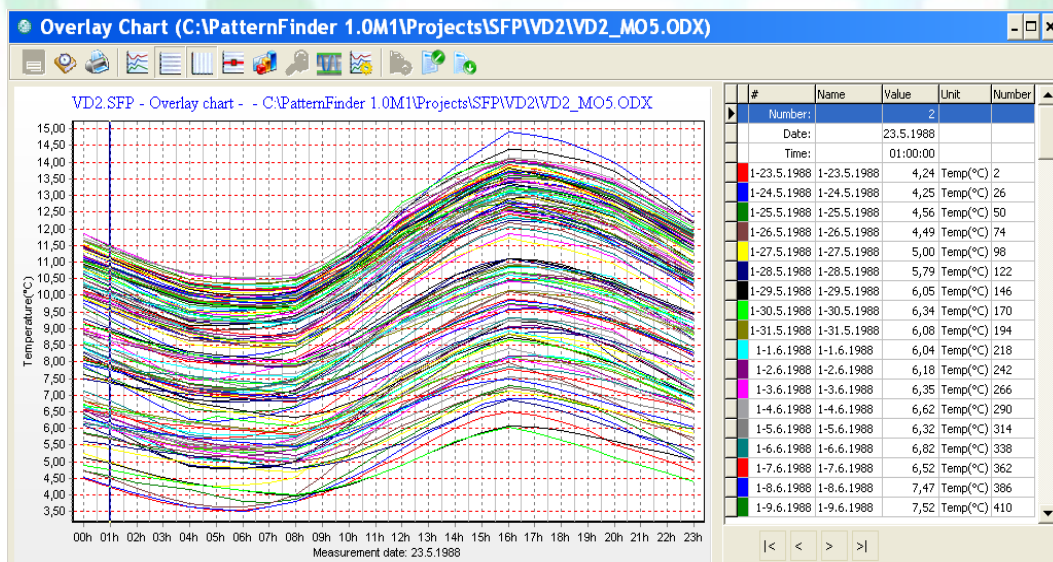


Figure 5.6 Daily overlay of the all the years in the interval 23 May-27 Sept.

Case study

The overlay statistics reveal the average daily temperature changes from May to September over a 22 year period.

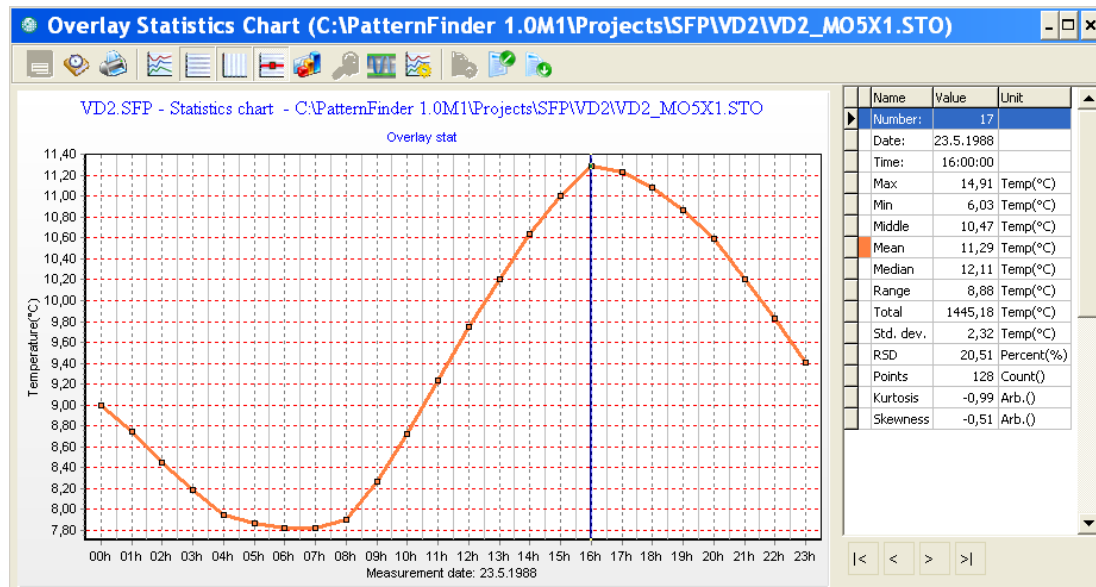


Figure 5.7 Statistical results of daily overlay

5 Importing Salmon smolt annual data

Measurements on Salmon and Arctic charr have been carried out in Vesturdalsá river since 1979. A summary of these measurements can be found in “Vesturdalsá 2009. Gönguseiði, endurheimtur, talningar og seiðabúskapur” by Þórólfur Antonsson and Ingi Rúnar Jónsson employed by Institute of Freshwater Fisheries in Iceland.

We create a new project named PLW by importing average annual population(number per 100m²), length(cm) and weight(g) data for two year old Salmon smolt.

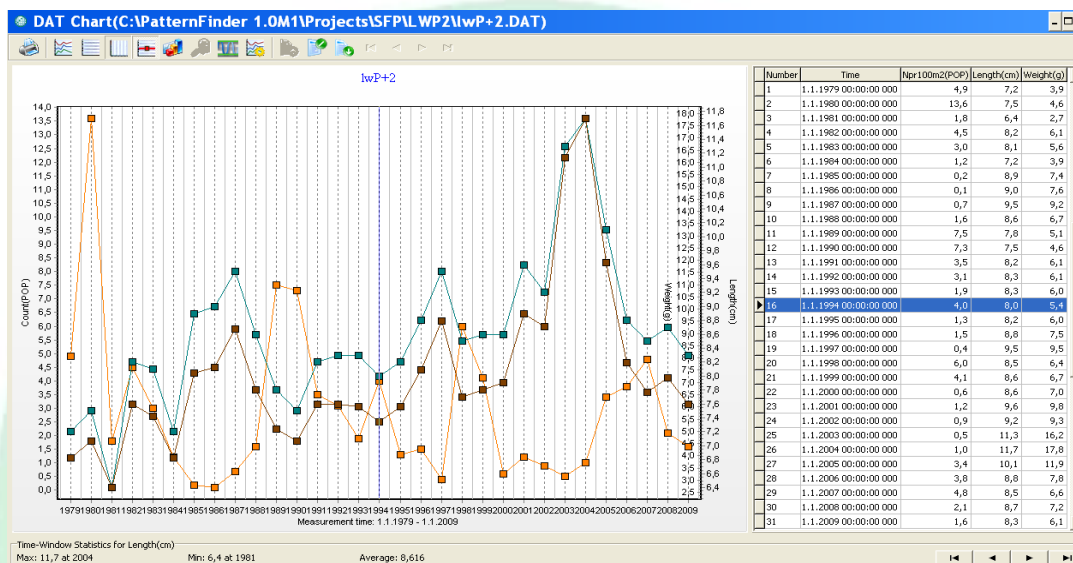


Figure 5.1 Annual average 2 year old Salmon smolt population, length and weight, 1979-2009.

We can see that the weight (brown) and the length (green) go hand in hand, but the population is somewhat different.

We extract both the Length(cm) and the Weight(g) signals from DAT file, cutting out the years 1989-2009.

Case study

We now return to our Vesturdalsá river temperature project. By using the **Add Files to Project** button



we incorporate the Length and Weight signals from the PLW project.

For comparison purposes a index signal that incorporates both the length and weight values would be ideal. Not a scientifically proven comparison method, but one we like to “experiment” with here.

By selecting one of the signals we can use the multiply option in the **Signal Operation** menu to multiply these two signals together.

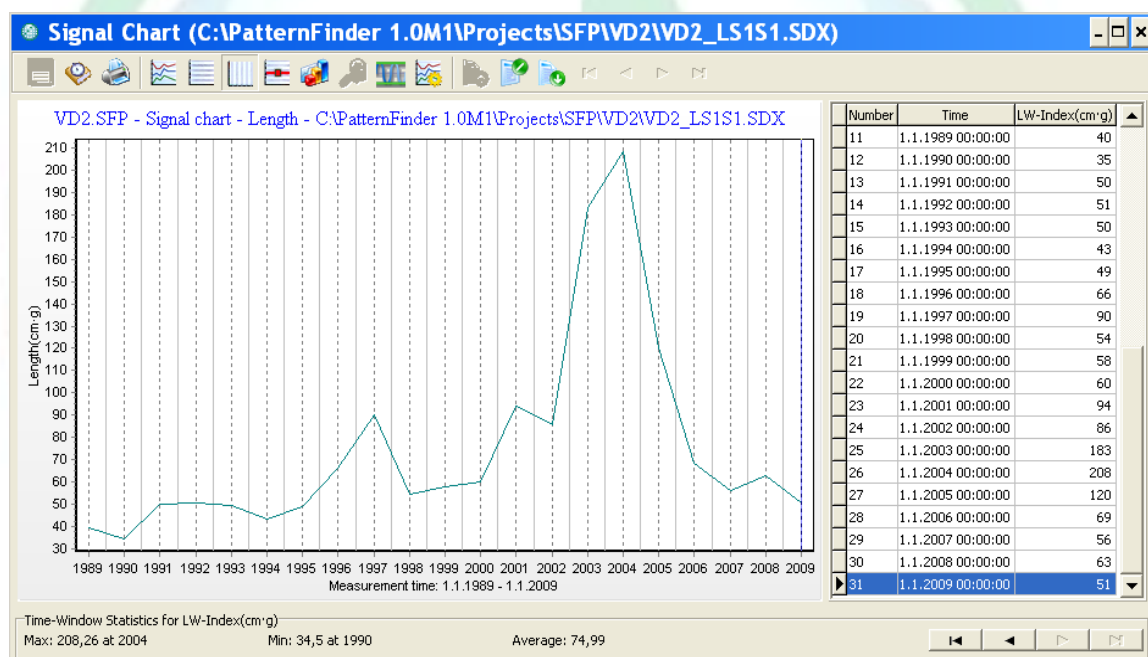
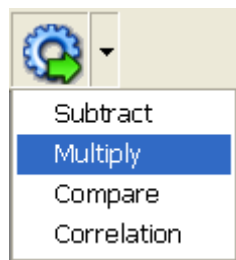


Figure 5.2 Annual average 2 year Salmon smolt Length-weight index (cm.g), 1989-2009.

The resulting Length-Weight Index (cm g) value signal can be viewed in figure 5.2.

Results:

R.1 Seasonal statistics results

Summarizing statistical results.

First we take a better look at the statistical seasonal yearly temperature values, correcting the 2000 (no measurements) year.

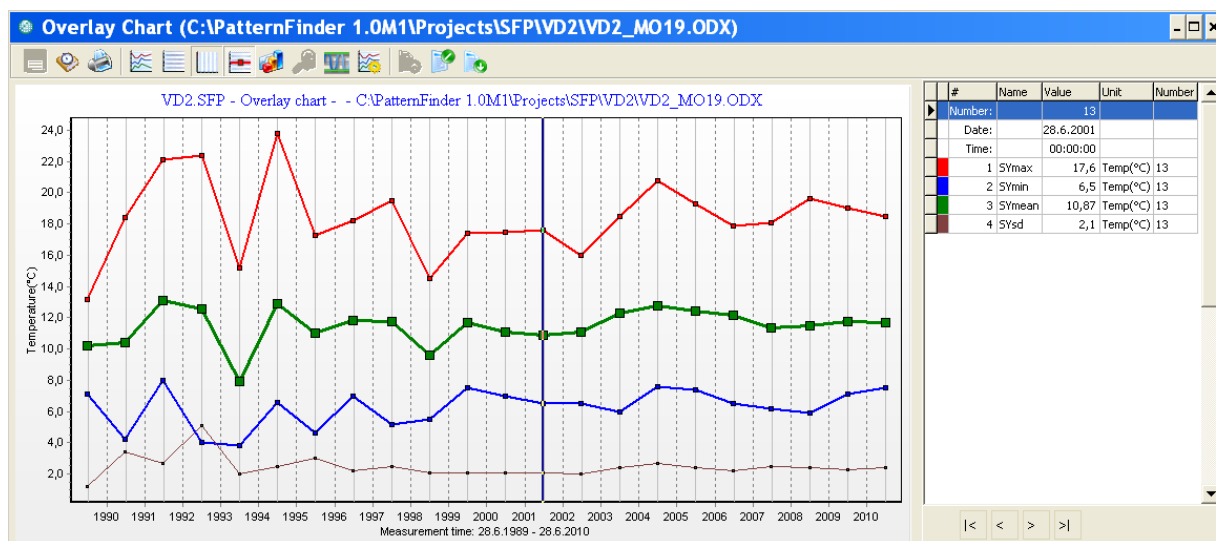


Figure R.1 Statistical seasonal values, max(red), mean(green), min(blue) and SD(brown)

Average values are fairly stable throughout the years. The years 1993 and 1998 stand out.

Histogram of mean values reveals the mean of the mean to be 11,45°C, and the histogram in figure R.2 shows the standard deviation to be 90% around 2°C.

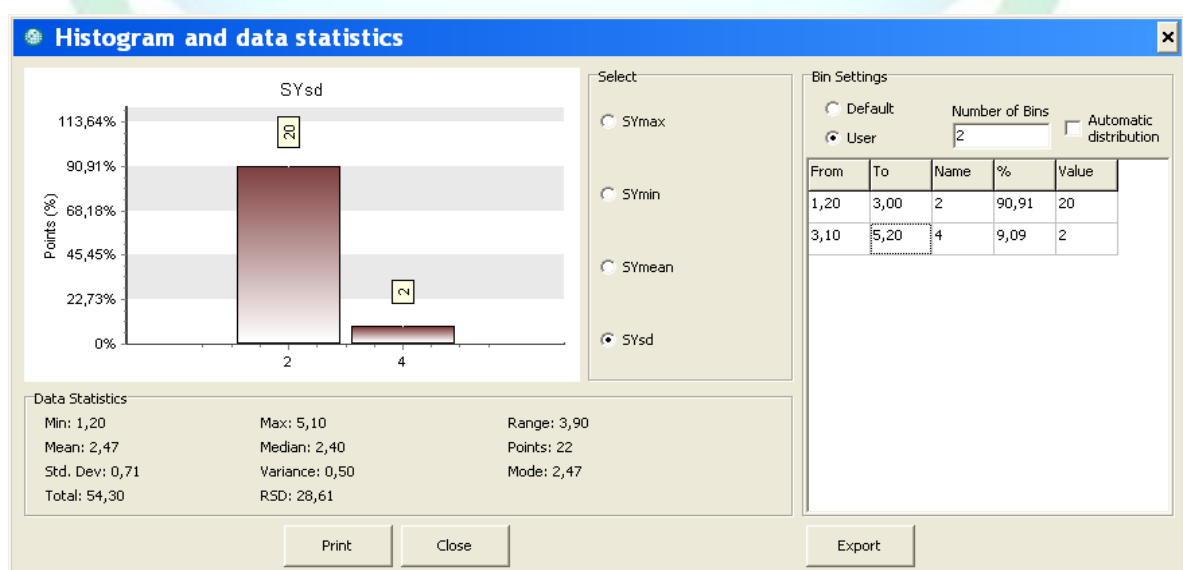


Figure R.2 Histogram of standard deviation.

R.2 Average monthly comparison

We take a look at average monthly day-degrees and average monthly 5°C duration.

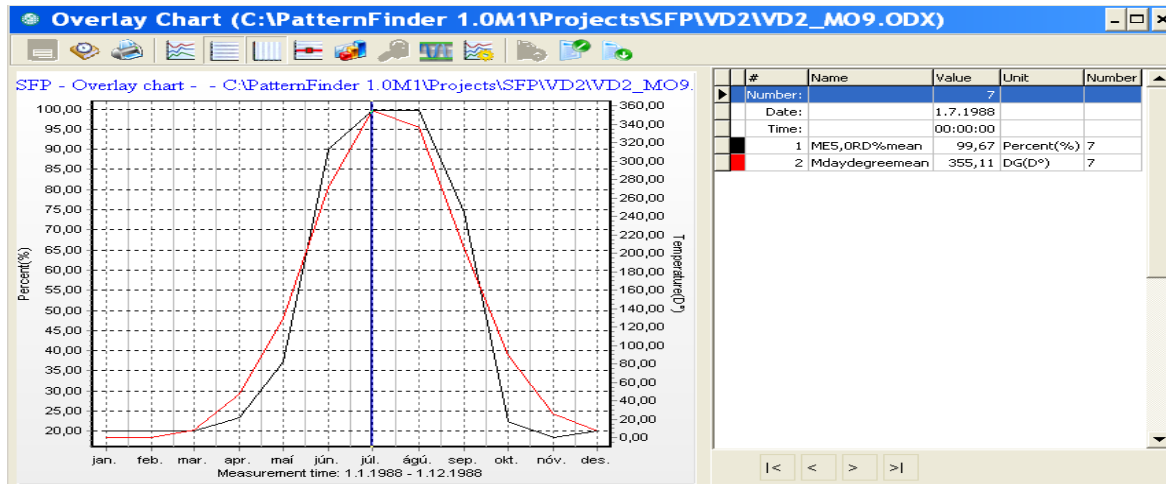


Figure R.3 Comparison of average Monthly day-degree and average Monthly -“ Over 5° threshold relative duration”

There is a relatively good coherence between the two averaging values, compared to the yearly data. Probably the 2001-2010 years play a dominant part.

R.3 Annual river temperature vs. Salmon smolt data

Now we compare the Seasonal yearly day-degree (D°) and the event based over 5°C yearly relative duration (%) to the *Salmon smolt Length-Weight index (cm g) data*.

The day-degrees indicate the energy in the river.

The 5°C duration relates to the stretching of the warm summer periods over the years.

The LW-index value is an indication of Salmon smolt growth.

R3.1 Visual inspection

The seasonal values are all dated 28.06 and the relative duration values as well as the LW-index values are dated 01.01. To clarify visual comparison, we use a time shifted start option so all points start on 01.01.

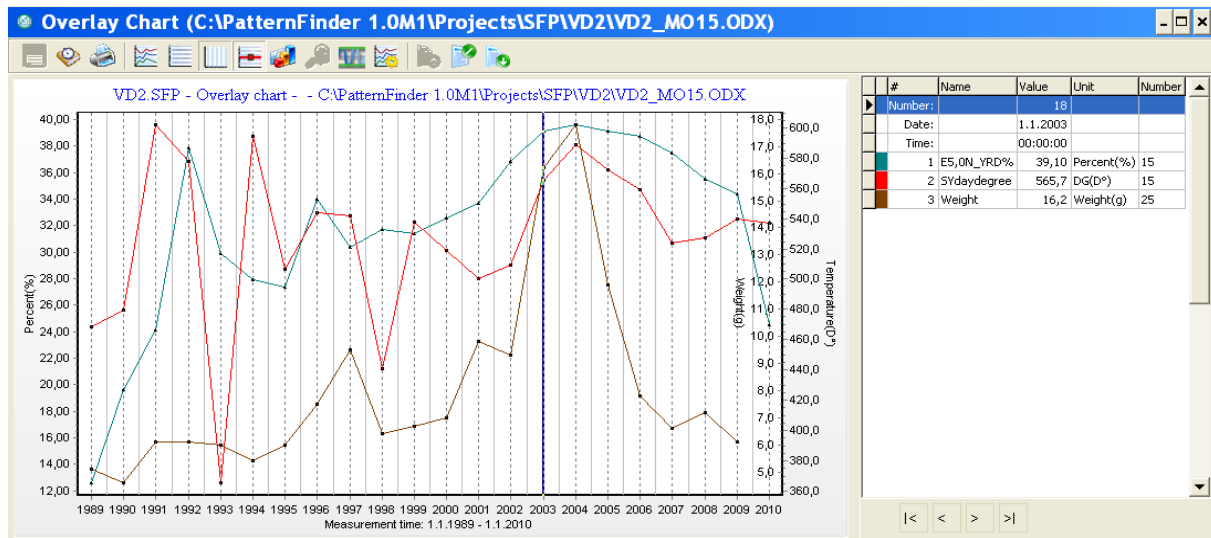


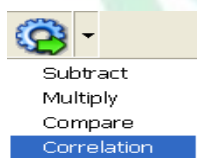
Figure R.4 Comparison between Seasonal Yearly day-degree (Red), 5°C yearly duration (green) and LW-index (brown)

There is some similarity between the day-degree and the 5° relative duration, especially after 2000. However, as expected, they don't go hand-in-hand, especially seasonal day-degrees in the year 1993 and 1998 stand out.

Comparing the LW-index against the duration and day-degree parameters, one must lean towards the 5°C duration parameter.

R3.2 Correlation analysis.

By using the **Correlation** option in the **Signal Operation** menu two signals can be compared periodically. In this case we select the whole signal (a single period).



The main correlation result parameters are:

- Pearson's-r: Linear correlation
- Sperman's-r: Correlation not restricted to linearity

Correlation comparison reveals the following:

	Covar	Pearson's r	Spearman's r
1) LW-Index vs. Seasonal-day-degrees	55	0,36	0,34
2) 5°C relative duration vs. Seasonal-day-degrees	113	0,45	0,42
3) LW-Index vs. 5°C relative duration	164	0,58	0,76

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The highest correlation, although not good, was number 3) LW-Index vs. 5°C relative duration.

Cross correlation was also computed and the best result there was also for 3), where a shift of one year gave Covar = 149, Pearson's-r = 0,62 and Sperman's-r = 0,76 (as before)

Results for number 3) correlation analysis can be seen in figure R5.

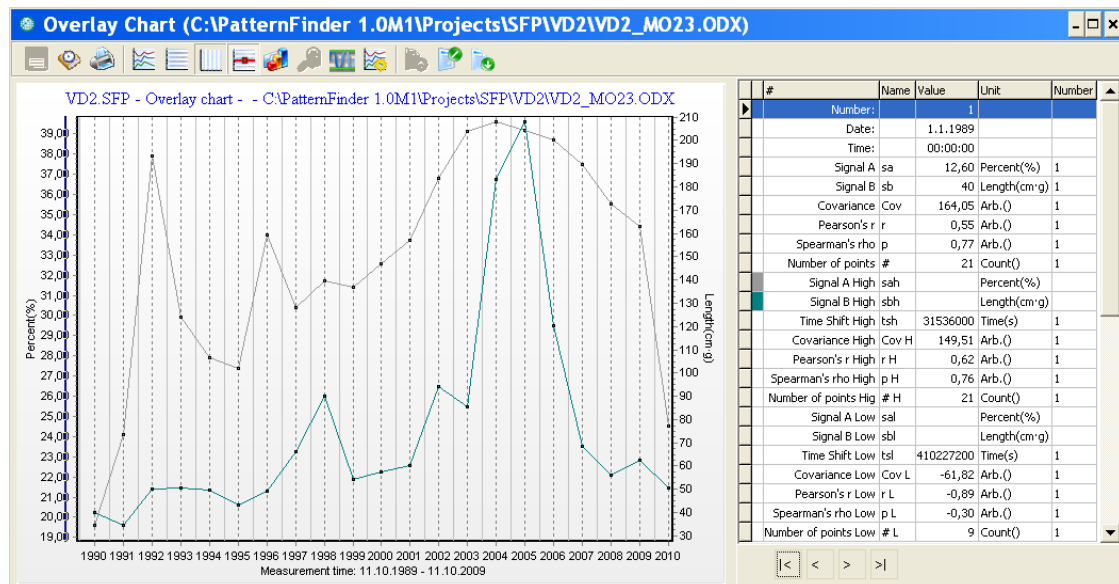


Figure R.5 Correlation between. 5°C relative duration and LW-Index.

Figure R.5 shows the LW-index signal shifted one year which was the highest cross correlation.

References:

Þórólfur Antonsson og Sigurður Guðjónsson 2002. Variability in Timing and Characteristics of Atlantic Salmon Smolt in Icelandic Rivers. Transactions of American Fisheries Society 131:643-655.

Ingi Rúnar Jónsson and Þórólfur Antonsson 2005. Emigration of age-1 Arctic charr, *Salvelinus alpinus*, into a brackish lagoon. Environmental Biology of Fishes 74:195-200.

Thorolfur Antonsson, Thorkell Heidarsson and Sigurdur S. Snorrason 2010. Smolt Emigration and Survival to Adulthood in Two Icelandic Stocks of Atlantic Salmon. Transactions of the American Fisheries Society 139 (6): 1688-1698.

Þórólfur Antonsson og Ingi Rúnar Jónsson 2010. Vesturdalsá 2009. Gönguseiði, endurheimtur, talningar og seiðabúskapur. VMST/10018. 26 bls. http://www.veidimal.is/files/Skra_0040982.pdf

