UNIVERSITY OF CAMBRIDGE

CENTER-TBI

ICM+ Users' Meeting

Processing large volumes of data with ICM+

CENTER-TBI case study

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Brain Physics Lab

Research question

1) What is the Dose of ICP>22 behaviour in TBI patients in CENTER-TBI HR cohort in the first 3 days from the date of injury ?

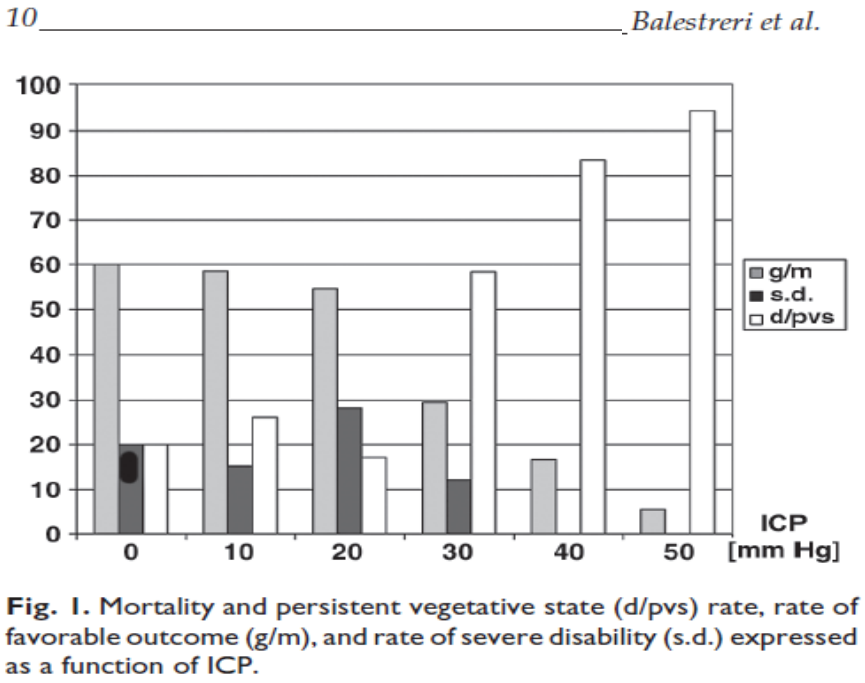
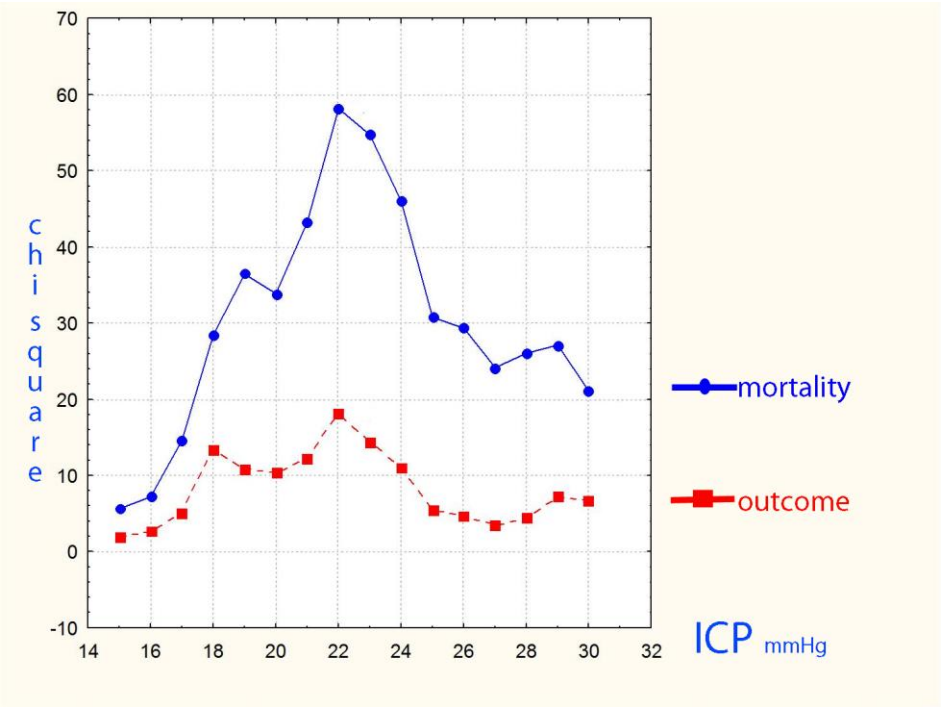


Fig. 1. Mortality and persistent vegetative state (d/pvs) rate, rate of favorable outcome (g/m), and rate of severe disability (s.d.) expressed as a function of ICP.

Critical Thresholds for Cerebrovascular Reactivity After Traumatic Brain Injury

E. Sorrentino · J. Diedler · M. Kasprowicz · K. P. Budohoski · C. Haubrich · P. Smielewski · J. G. Outtrim · A. Manktelow · P. J. Hutchinson · J. D. Pickard · D. K. Menon · M. Czosnyka

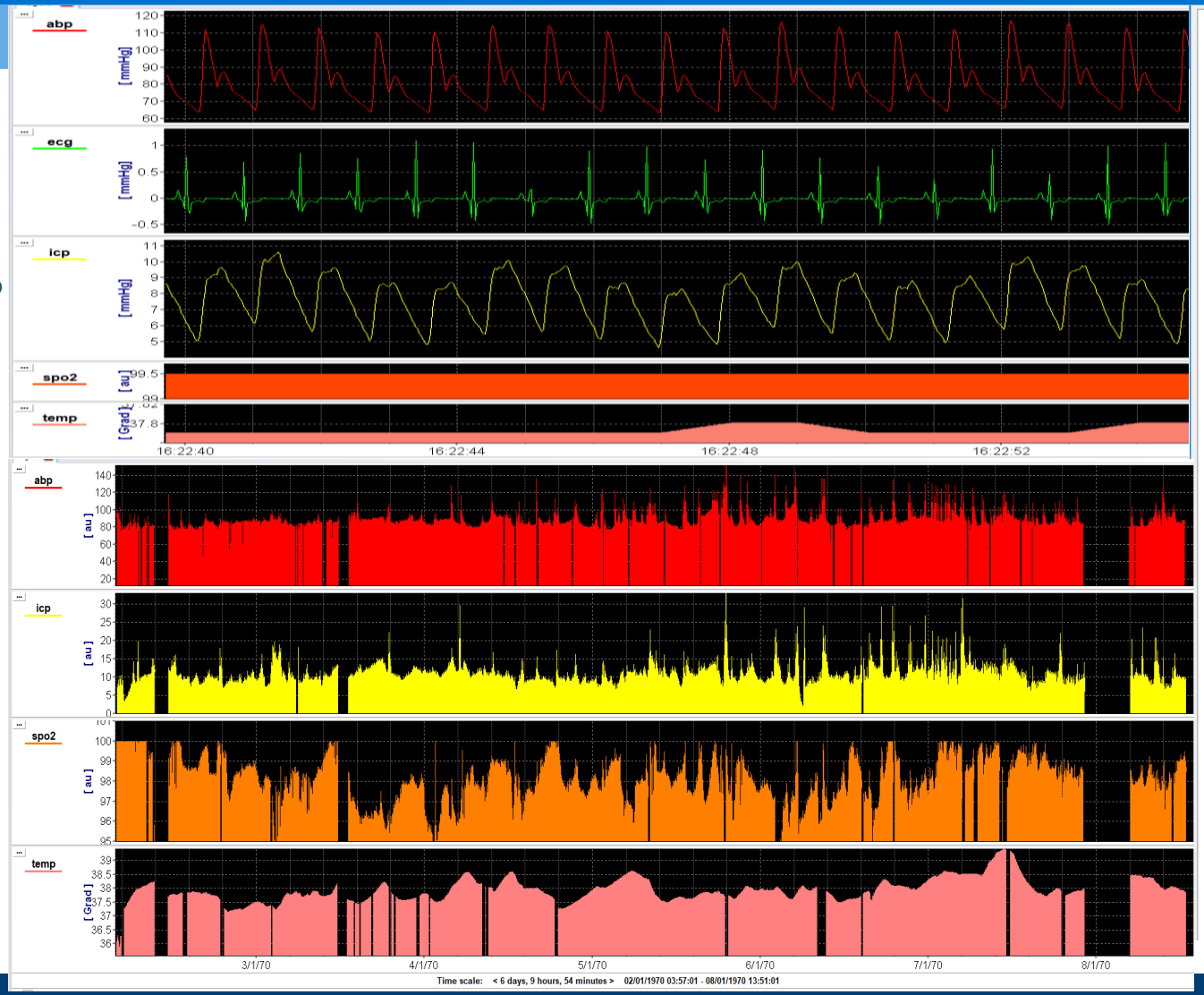


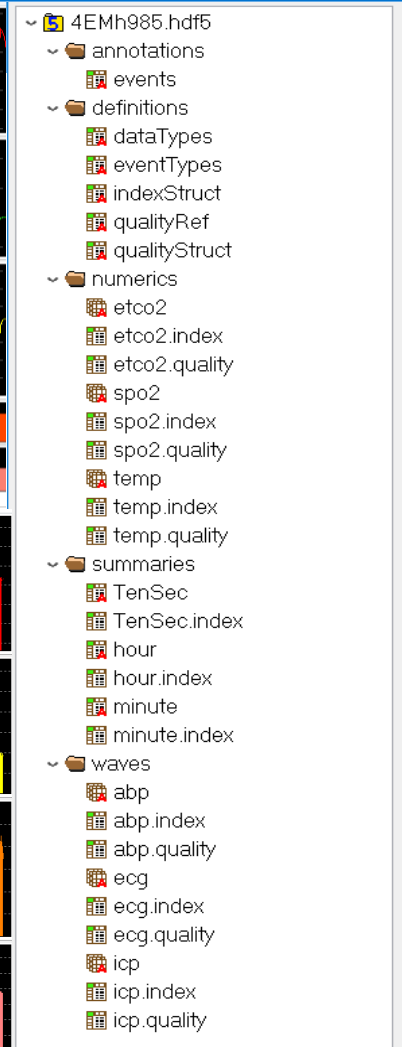
Data browsing

The data used for this demonstration is from the CENTER-TBI HR-ICU:

- Data from 21 centres
- 230 Recordings with parenchymal ICP
- Data recorded at multiple sampling frequencies
- Saved in HDF5 files
- More than 1600 days of recording
- Data is somewhat clean but with some outstanding artefacts

Answering this question will require the use of ICM+ advanced tools!





Summary of the steps of data analysis

1. Pre-processing - Manual Data Cleaning
2. Pre-processing - Automatic data cleaning + Downsampling
3. Pre-processing - re-slicing with time relative to the date of injury
4. Analysis – Create an analysis profile and apply it to your dataset
5. Analysis – Calculate one value of dose of ICP per patient
6. Analysis – Post-ICM+ statistical analysis

Step 1: Pre-processing - Manual Data Cleaning

4EMh985 - Notepad

File Edit Format View Help

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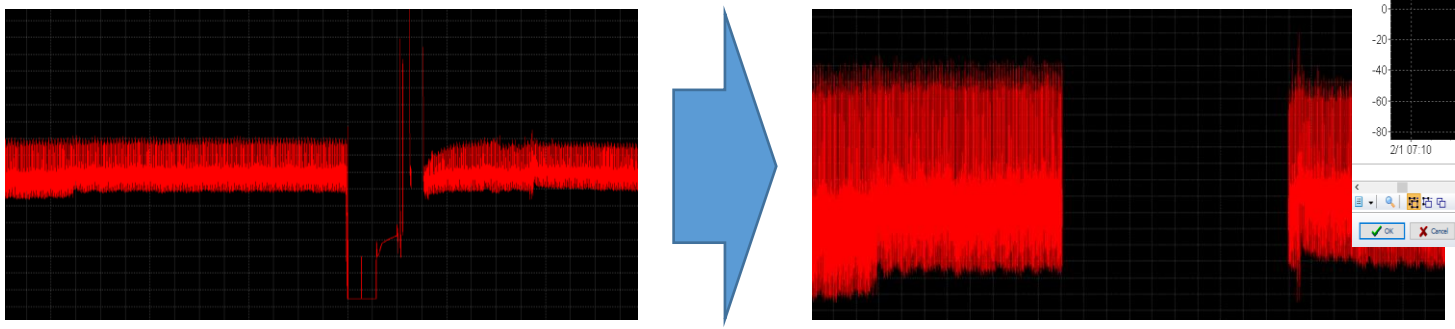
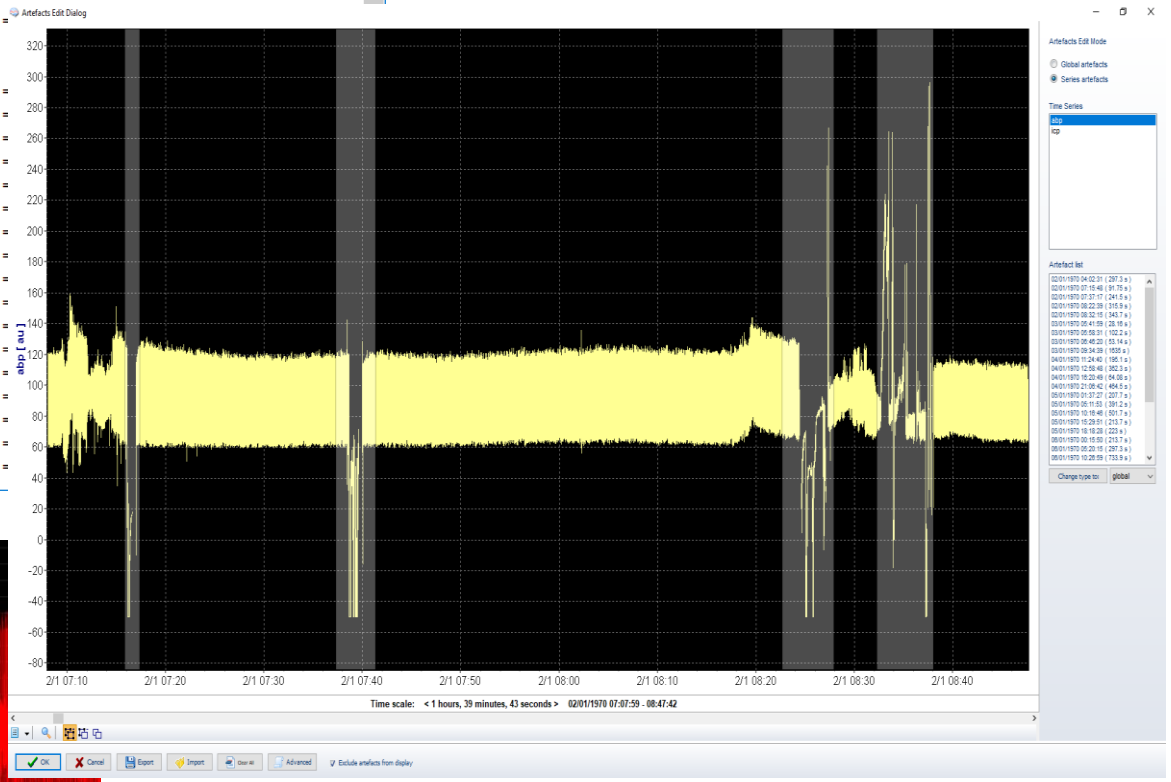




Step 2: Pre-processing - Automatic data cleaning + Downsampling

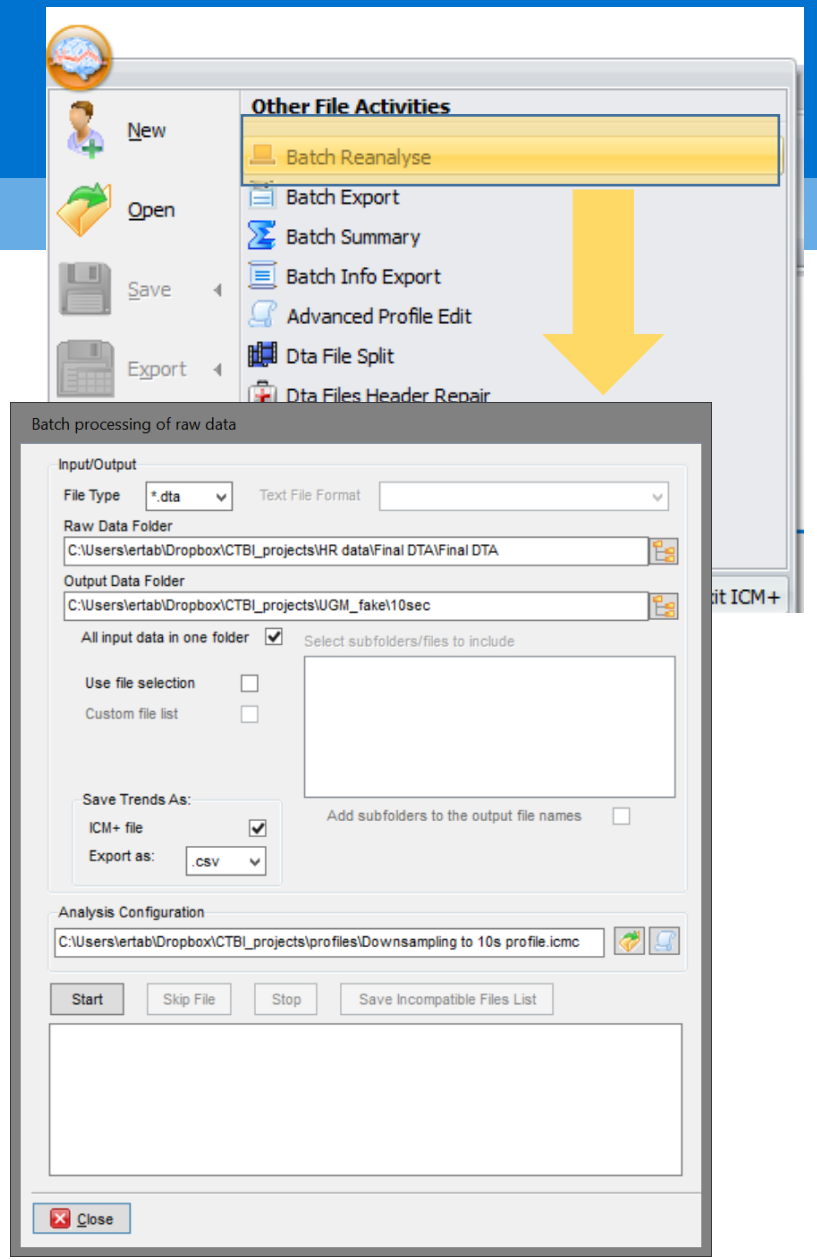
- To clean the data further we can apply some automatic artefact detection algorithms

- In order to make the data more 'workable' we need to downsample
  - As most of the calculations we usually do are based on 10 second averages of data, this is a good downsample target

If we use the Batch reanalysis tool we can then apply the profile to all the dataset in one run!!

To apply these transformations to the data systematically we will have to build an ICM+ profile.

The Original dataset of 127GB of data is transformed, in this way, in a much more manageable ~1Gb CSV data



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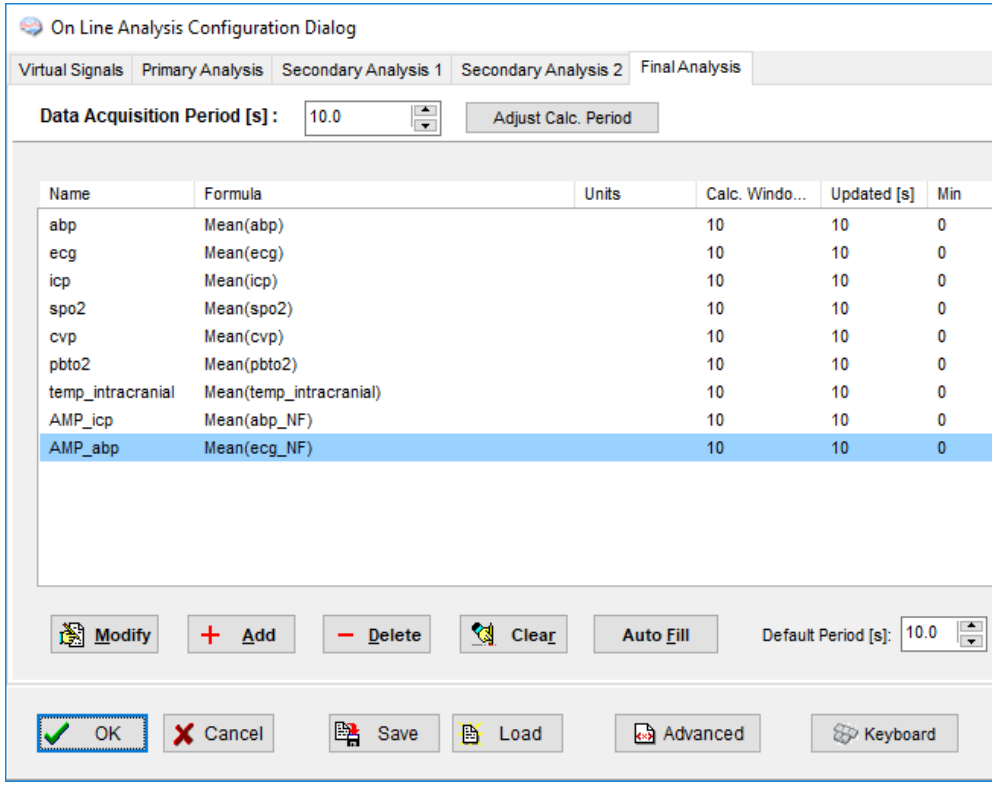
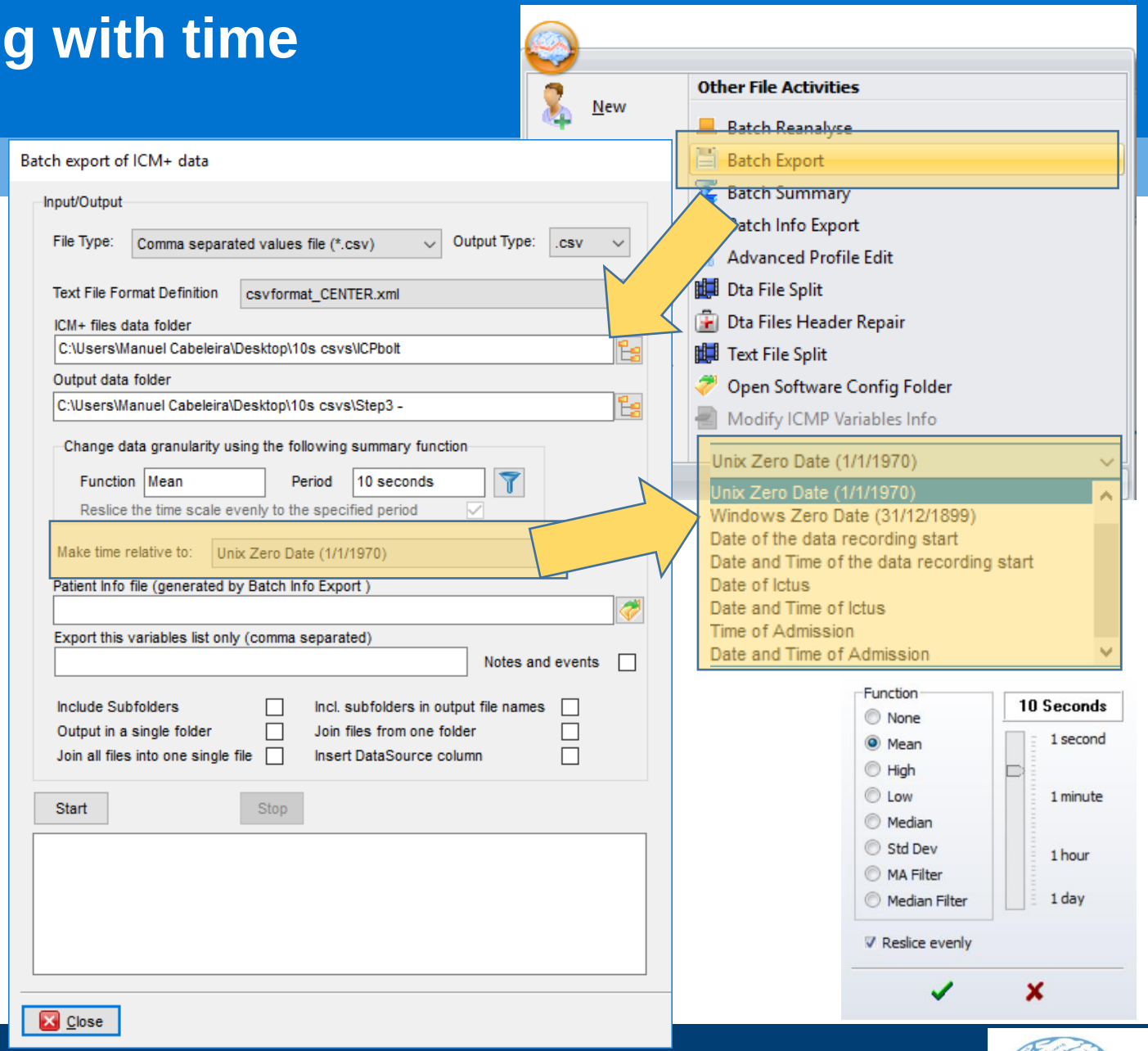


Step 3: Pre-processing - re-slicing with time relative to the date of injury

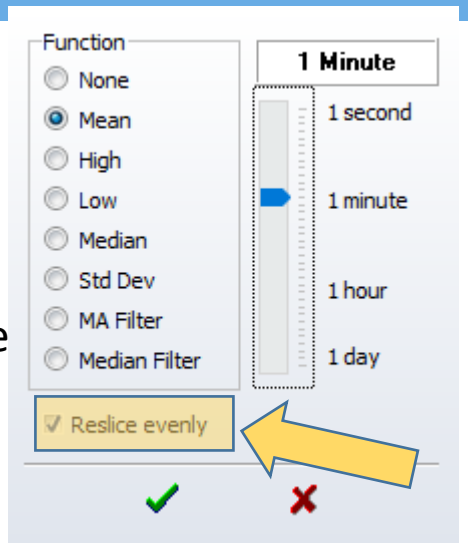
- In here we will use the batch export to convert time axis of the data to number of days post injury using the 'Make time relative' box
- We will also Re-slice the data time points evenly in order to make the times compatible
- In this dataset moment of injury = 01/01/1970 00:00, so we just need to subtract this date to the absolute time and we have the # of days post injury
- Clicking start will generate new CSVs with the new time scale and a dataset ready to be used in any further analysis

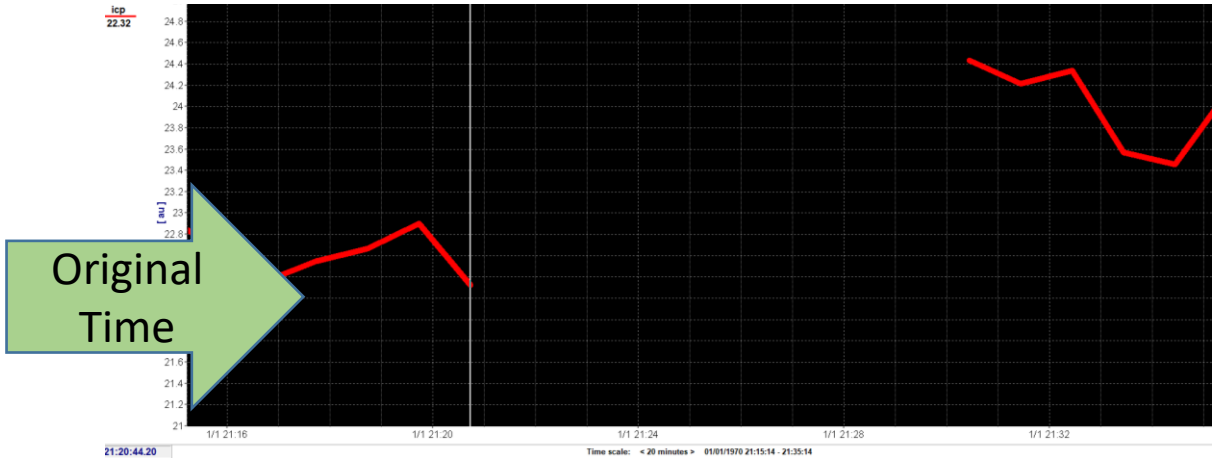


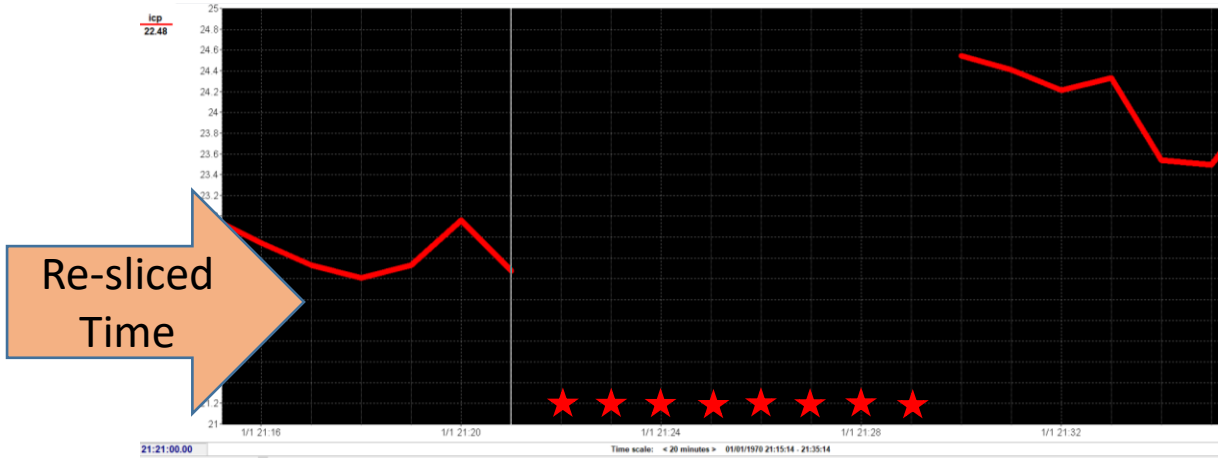
Time Re-slicing

Aligns the data in time

- Recalculates mean values according to fixed time anchors
- Makes time points compatible within the same file and in between files



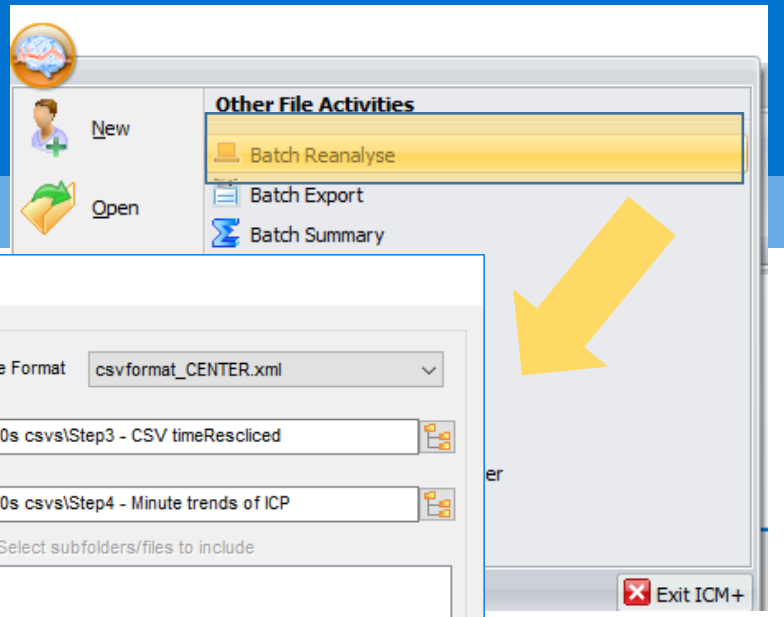




DateTime	icp
01/01/1970 21:18:44	22.67
01/01/1970 21:19:44	22.9
01/01/1970 21:20:44	22.32
01/01/1970 21:30:27	24.43
01/01/1970 21:31:27	24.22
01/01/1970 21:32:27	24.34

DateTime	icp
01/01/1970 21:19:00	22.53
01/01/1970 21:20:00	22.96
01/01/1970 21:21:00	22.48
01/01/1970 21:22:00	NAN
...	NAN
01/01/1970 21:29:00	NAN
01/01/1970 21:30:00	24.55
01/01/1970 21:31:00	24.41
01/01/1970 21:32:00	24.22

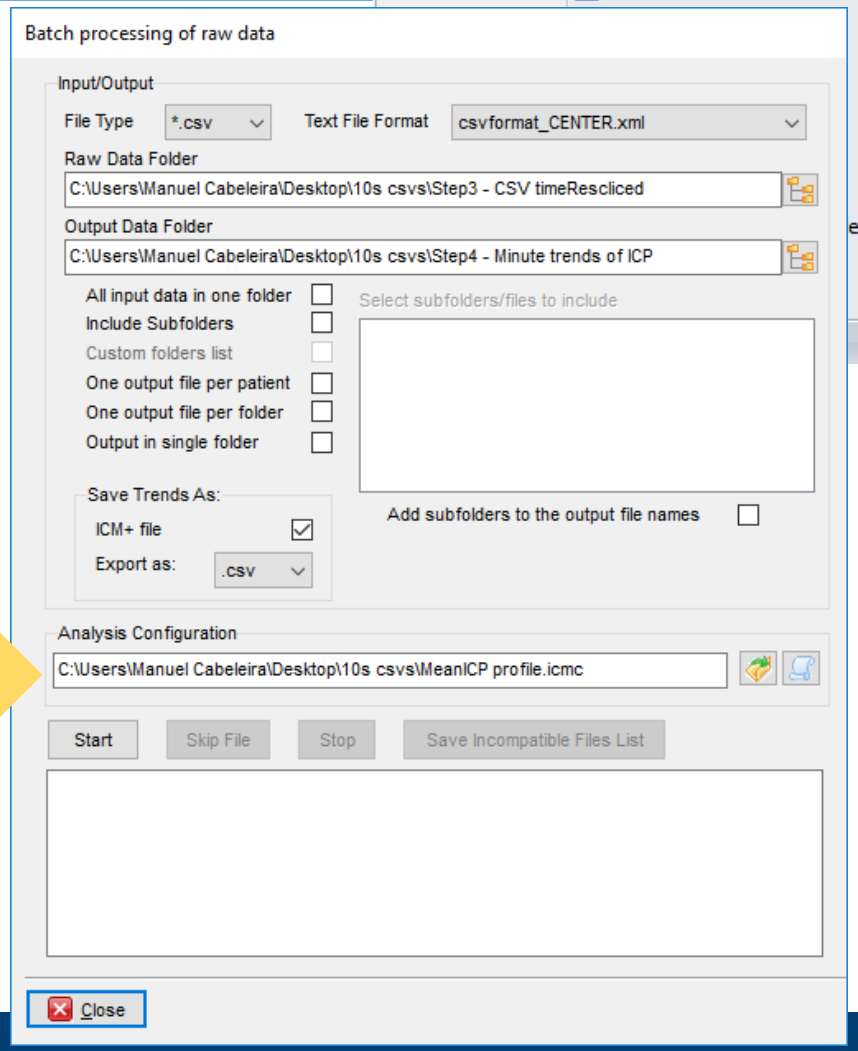
Step 4: Analysis – Create an analysis profile and apply it to your dataset



- Up to this moment all steps were fairly generic and are usually replicated in most types of analysis you will need (as long as these do not require higher frequency components, like pulse)

- From this moment on, the method of analysis will depend on your research question

- The usual SOP here is to:
  - Build a profile
  - Apply it to some of the data in a patient by patient basis
  - Readjust the profile as needed
  - Apply to all database with the batch analysis tool, once the profile is ready



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- The usual SOP here is to:
  - Build a profile
  - Apply it to some of the data in a patient by patient basis
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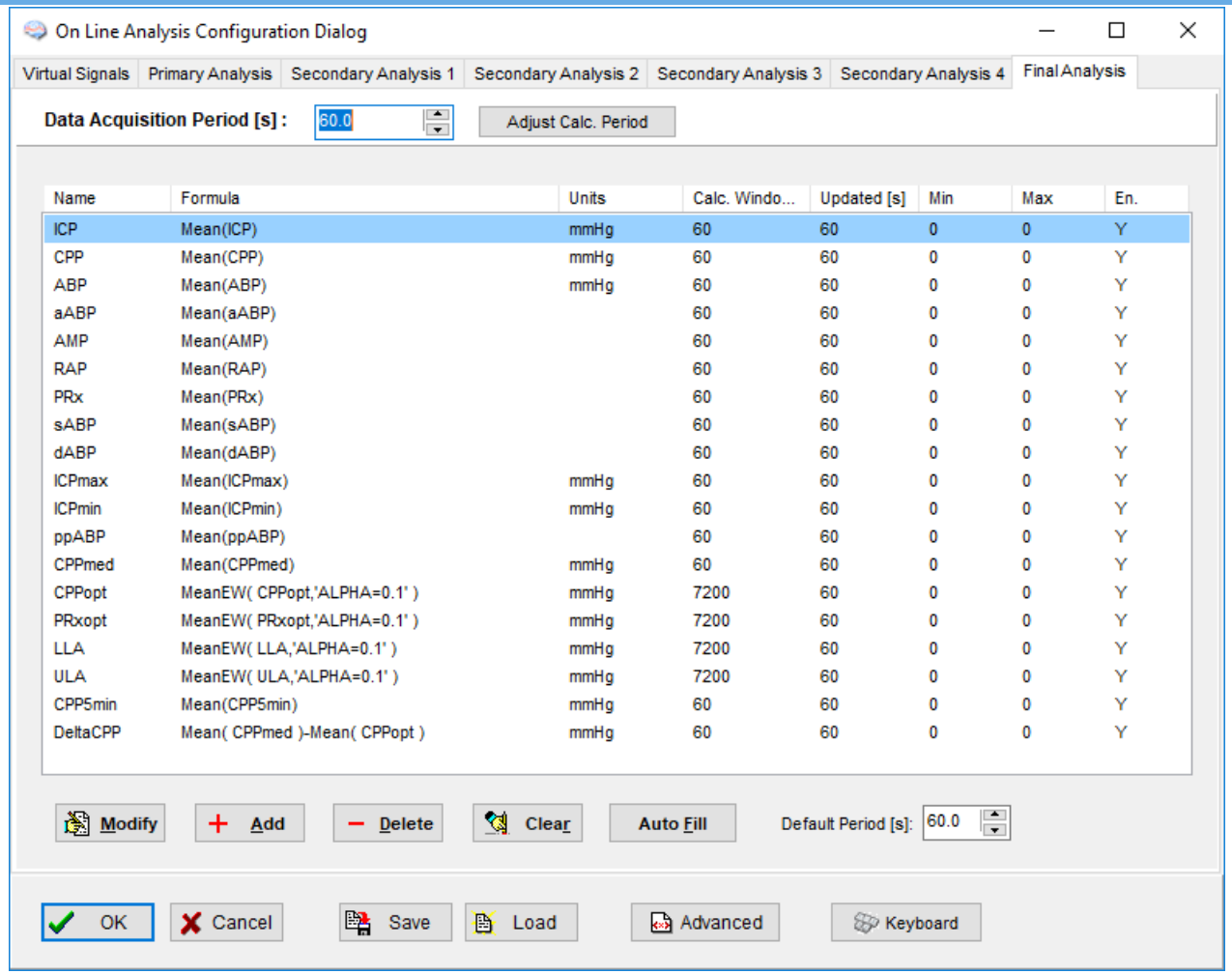
- For this demonstration the profile calculates 1 minute trends of ICP only



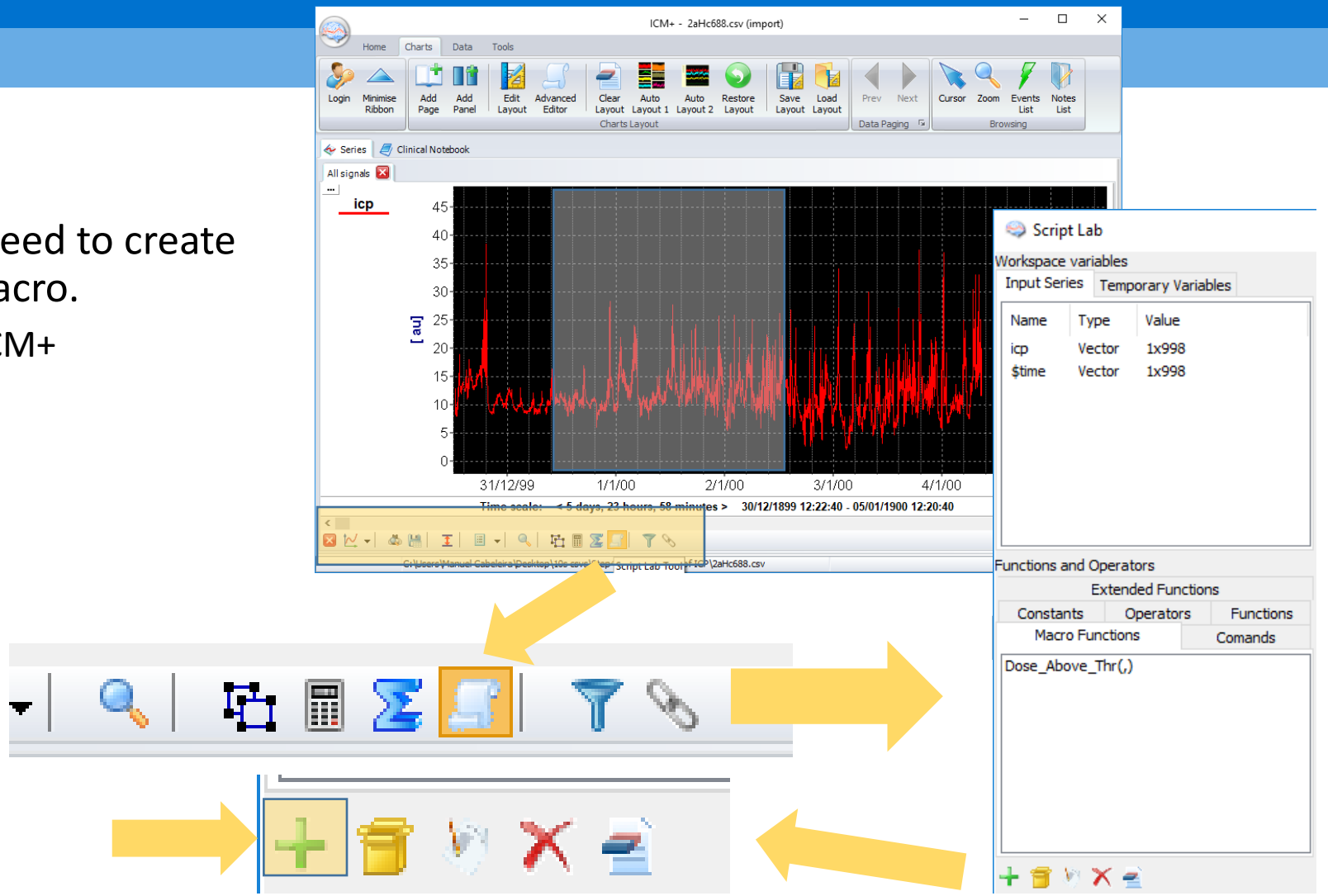
Create a Macro function using script lab tool

- To calculate the dose of ICP we will need to create a custom function and save it as a macro.
  - This is done in ScriptLab tool on ICM+

This function is :

- $Bool = \begin{matrix} 0\ if\ ICP < threshold \\ 1\ if\ ICP > threshold \end{matrix}$

- $dose = \frac{\sum(ICP - Threshold) * Bool}{SamplingFreq(ICP) * 3600}$



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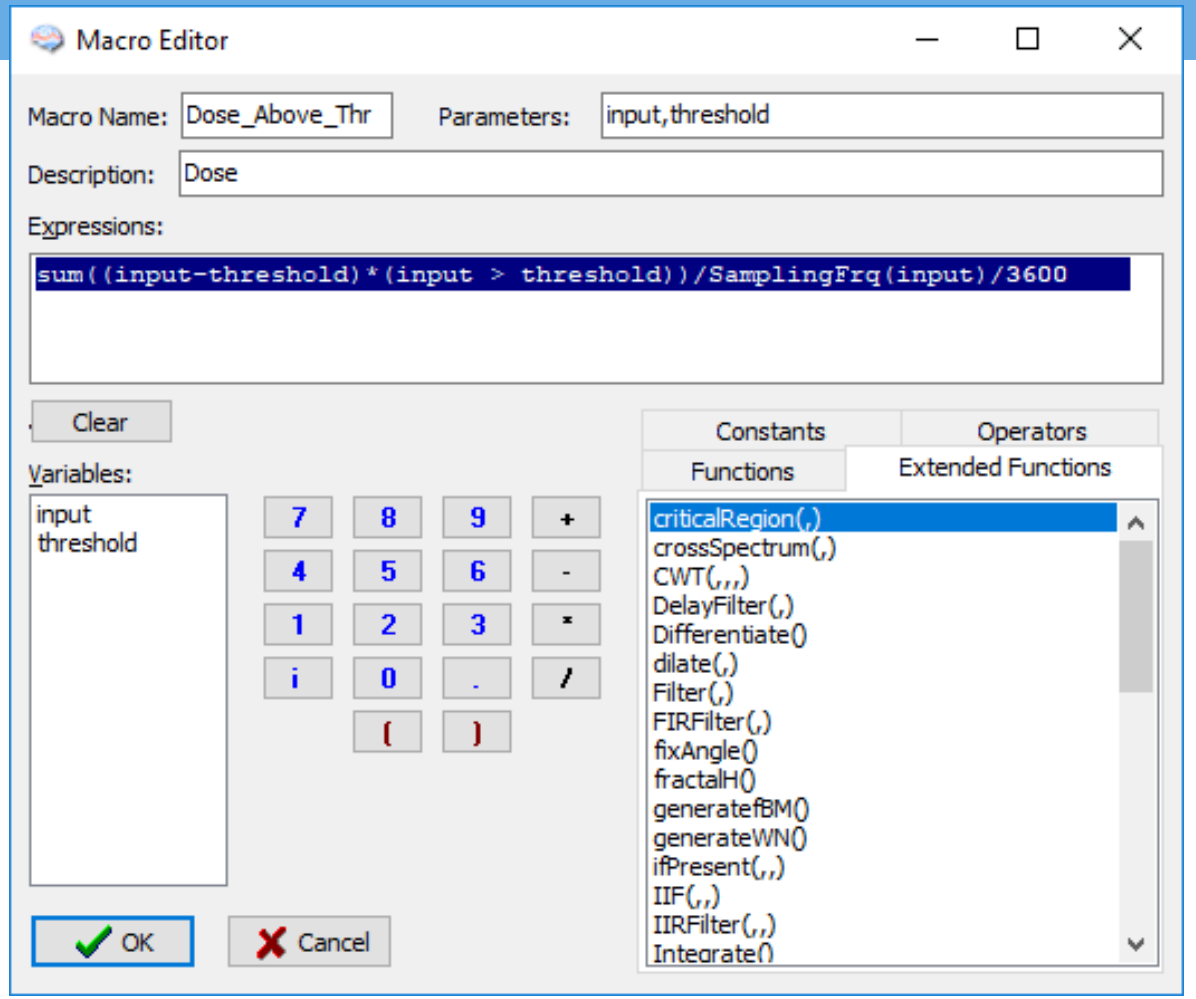
- $Bool = \begin{matrix} 0\ if\ ICP < threshold \\ 1\ if\ ICP > threshold \end{matrix}$
- $dose = \frac{\sum(ICP - Threshold) * Bool}{SamplingFreq(ICP) * 3600}$

<u>In ICM+ this would look as</u> :

sum((input-threshold)*(input > threshold))/SamplingFrq(input)/3600



Step 5: Analysis – Calculate one value of dose of ICP per patient

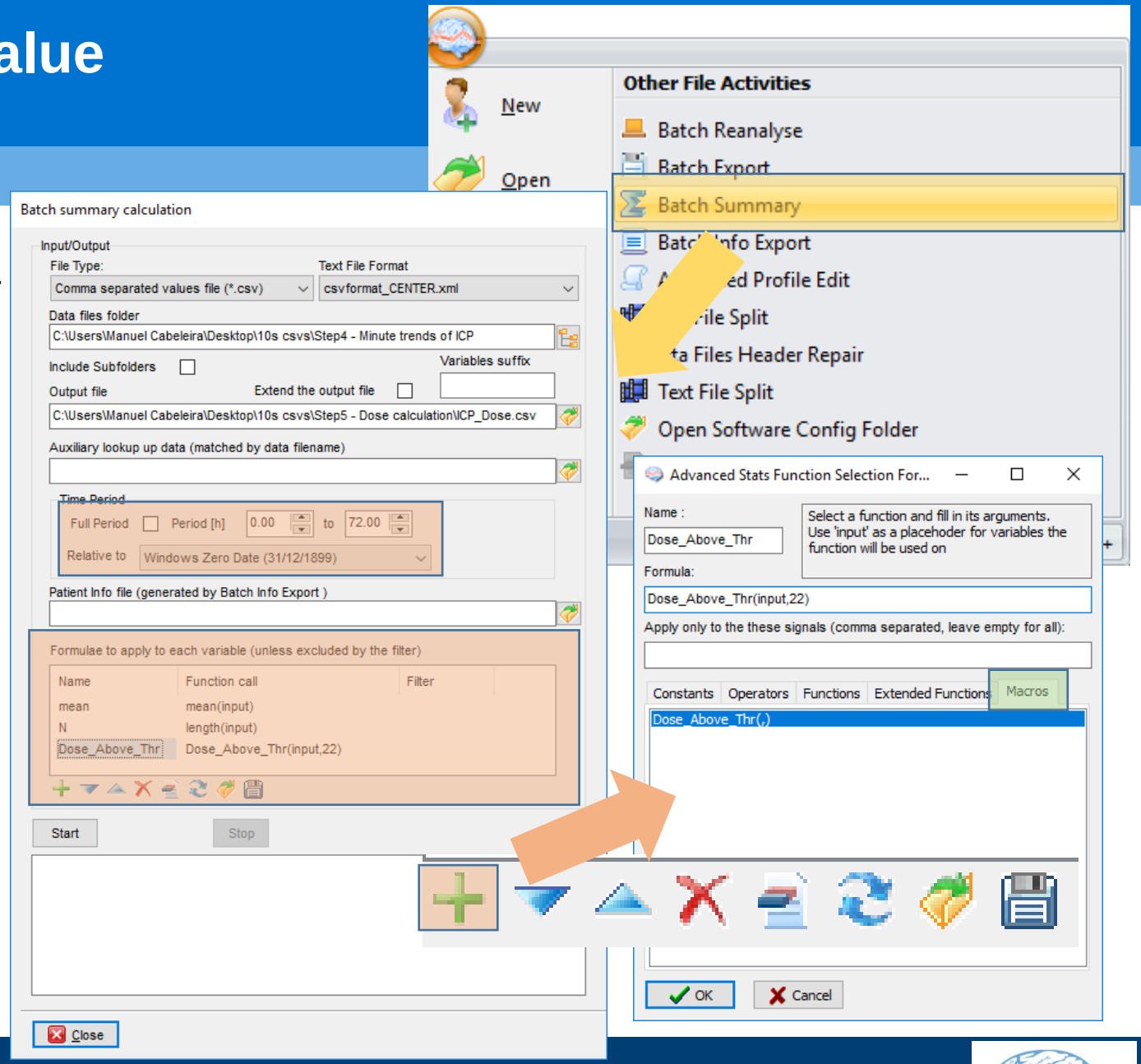
Batch Summary tool allows the user to calculate one number/recording according to the required criteria.

In the case of our research question the criteria are:

- Time period = 3 days (72 hours)
- Calculate the dose of ICP as defined before

Clicking Start generates a file containing:

- Name of the recording
- Mean value
- Number of occurrences
- Dose of ICP



Step 5: Analysis – Calculate one value of dose of ICP per patient

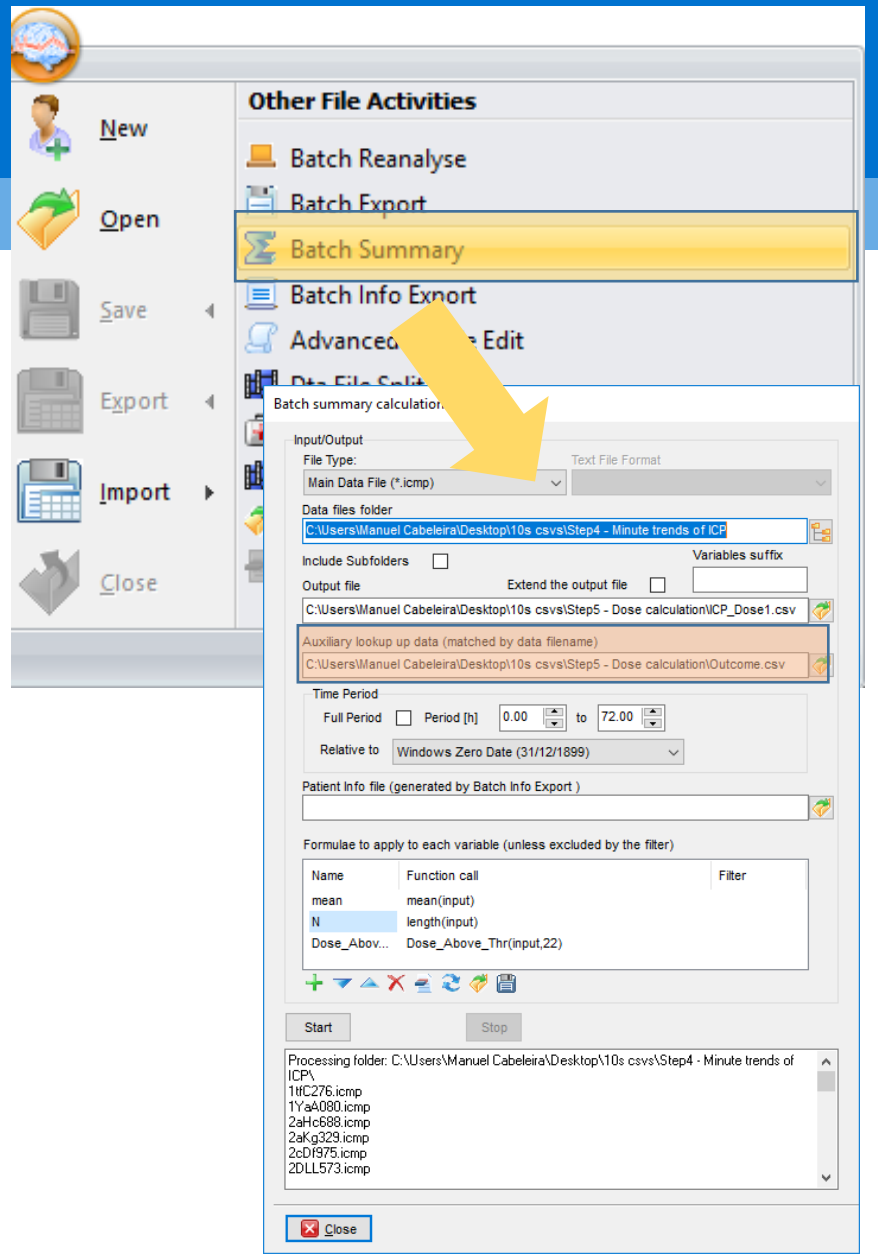
Here you can also imbue the data with extra information by loading a comma separated text file

In this file, the patient identifiers need to be the same as in the dataset

For this demonstration we have added GOS information to the resulting file

DataSource	GOS
1tfC276	1
1YaA080	3
2aHc688	5
2aKg329	2
2cDf975	3
2DLL573	1
2eCT283	4
2EeT899	3
2GGu783	2
2KDX695	4
2LvU583	3

	A	B	C	D	E
1	DataSource	GOS	ICP_mean	ICP_N	ICP_Dose_Above_Thr
2	1tfC276	1	15.99	2375	0.0498
3	1YaA080	3	24.26	2279	160.5
4	2aHc688	5	12.01	3578	2.575
5	2aKg329	2	13.45	2040	0.1515
6	2cDf975	3	7.245	2228	0
7	2DLL573	1	16.23	3888	31.66
8	2eCT283	4	8.375	1955	1.128
9	2EeT899	3	55.9	3238	1748
10	2GGu783	2	8.372	3488	4.109
11	2KDX695	4	12.22	2185	0.5888
12	2LvU583	3	10.58	3408	0.0437



Step 6: Analysis – Post-ICM+ statistical analysis

The CSV file can now be easily imported and used for statistical analysis in any other statistical tool or handed directly to your local statistician

	A	B	C	D	E
1	DataSource	GOS	ICP_mean	ICP_N	ICP_Dose_Above_Thr
2	1tfC276	1	15.99	2375	0.0498
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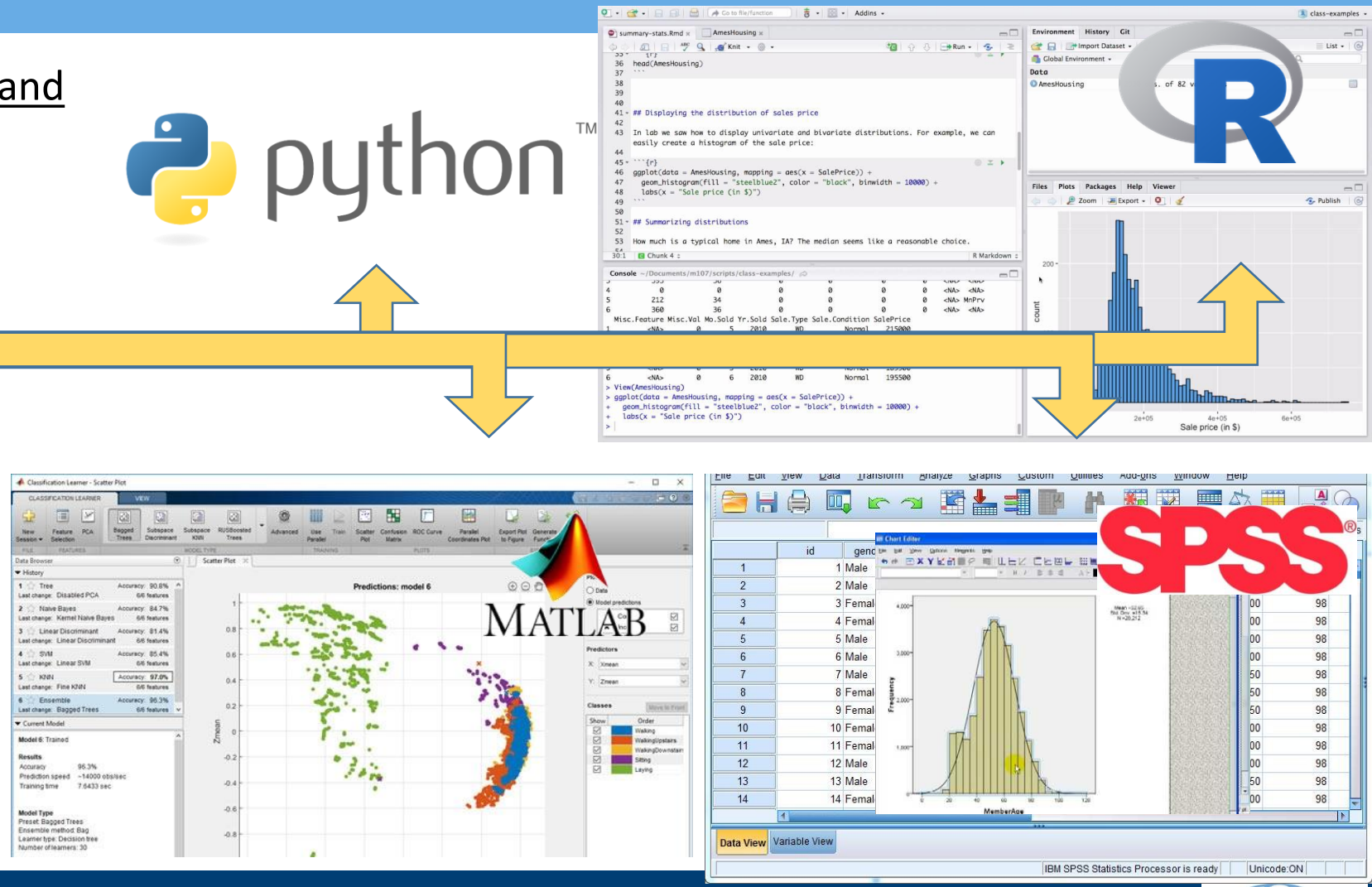
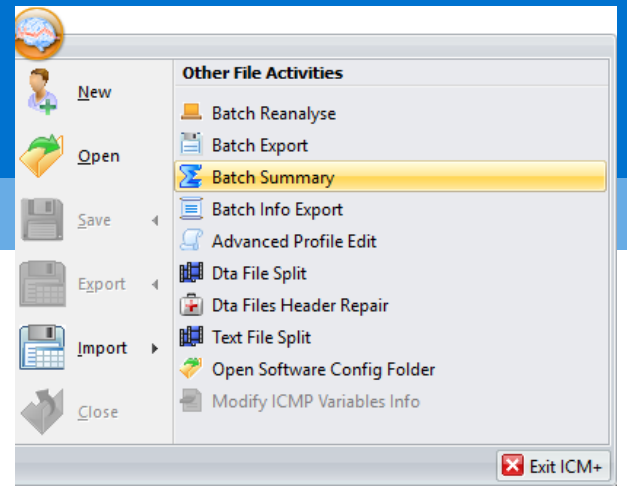
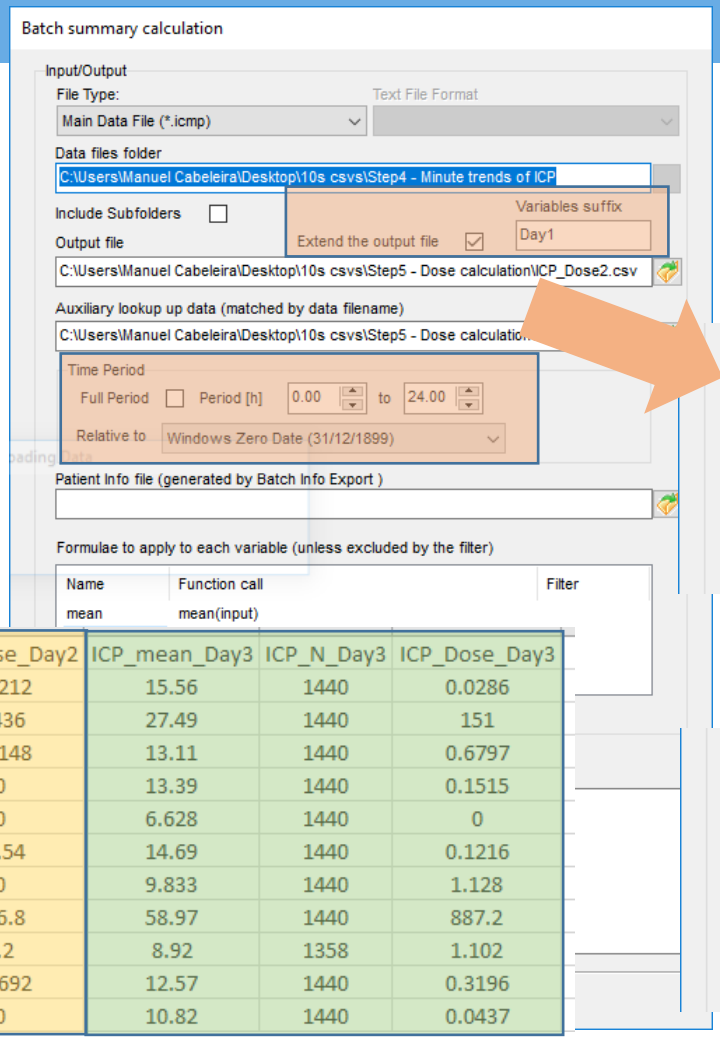


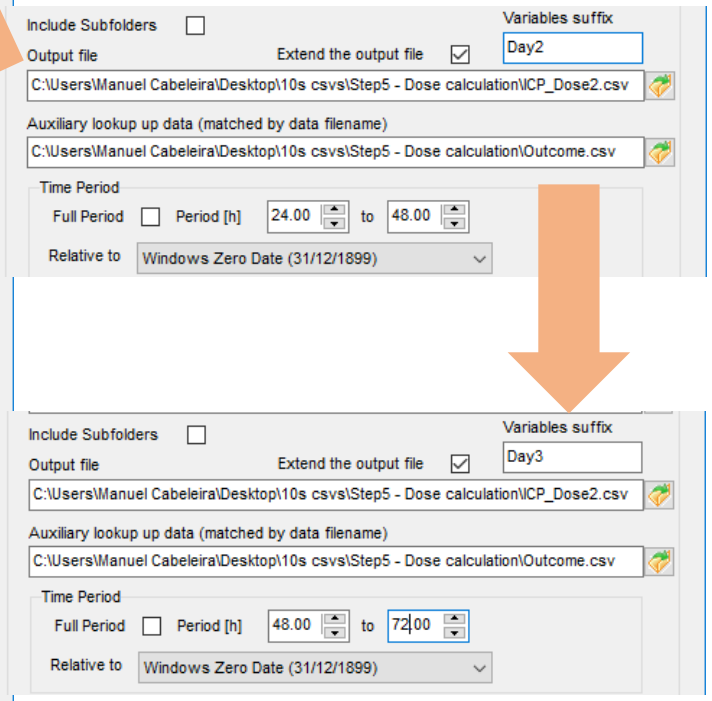
Another research question – ICP daily dose time profile

In here we proceed the same as we did for the previous case but here, we will have to run a Batch Summary for every day.

If you tick the 'Extend the output file' ICM+ will add every new run of the summary calculations to the same file







	DataSource	GOS	ICP_mean_Day1	ICP_N_Day1	ICP_Dose_Day1	ICP_mean_Day2	ICP_N_Day2	ICP_Dose_Day2	ICP_mean_Day3	ICP_N_Day3	ICP_Dose_Day3
2	1tfC276	1	0	0	0	16.72	935	0.0212	15.56	1440	0.0286
3	1YaA080	3	0	0	0	18.71	839	9.436	27.49	1440	151
4	2aHc688	5	12.8	698	1.481	10.49	1440	0.4148	13.11	1440	0.6797
5	2aKg329	2	0	0	0	13.58	600	0	13.39	1440	0.1515
6	2cDf975	3	0	0	0	8.372	788	0	6.628	1440	0
7	2DLL573	1	14.46	1008	0	18.99	1440	31.54	14.69	1440	0.1216
8	2eCT283	4	0	0	0	4.382	515	0	9.833	1440	1.128
9	2EeT899	3	36.58	358	54.47	55.62	1440	806.8	58.97	1440	887.2
10	2GGu783	2	8.54	690	0.8074	7.971	1440	2.2	8.92	1358	1.102
11	2KDX695	4	0	0	0	11.57	745	0.2692	12.57	1440	0.3196
12	2LvU583	3	12.27	528	0	9.575	1440	0	10.82	1440	0.0437

Thank you for listening!

Now you can concentrate mostly on having ideas and write papers as ICM+ will do the analysis for you =D