VARIFORC User Manual
Chapter 2:

VARIFORC installation and first steps

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2.1 Requirements

VARIFORC runs on Wolfram Mathematica® or Wolfram PlayerPro® (www.wolfram.com). Mathematica® is a fully functional mathematical platform, while PlayerPro® is a platform for running interactive applications, such as VARIFORC, based on Wolfram technology. PlayerPro® is generally much less expensive than Mathematica® (depending on license type, see Table 2.1), and is therefore recommended for users that are not interested in other applications.

Wolfram licenses are available for Windows, Macintosh, and Linux platforms. See the Wolfram site for system requirements. All downloadable VARIFORC examples have been tested under Windows XP with 2 GB RAM, Windows 8.1 with 16 GB RAM, and Windows 10 with 32 GB RAM.

VARIFORC functions are automatically compiled in C since version 2.04 for better speed performance, provided that a C compiler is available on your machine. If such a compiler is not found, an internal Mathematica compiler is used instead, at cost of a ~25% speed reduction. Version 2.04 is up to 5× faster than previous versions, and among the fastest FORC processing software available. See Section 2.4 for detailed C compiler installation instructions if you are interested in maximum performance with extremely large datasets.

Table 2.1: Available Wolfram Mathematica® and PlayerPro® licenses (status: February 2016). Please note that the Wolfram CDF Player®, available as free download, does not support file import and export required by VARIFORC.

License	Mathematica® www.wolfram.com/mathematica/	PlayerPro® www.wolfram.com/player-pro/
Student [1]	€ 130, US$ 100	—
Home	€ 295, US$ 250	—
Standard	€ 300/year, US$ 300/year	€ 195, US$ 195

[1] Proof of student status is required for purchase.

2.2 Installation

Before installing VARIFORC, ensure yourself that you have a working copy of Wolfram Mathematica® or Wolfram PlayerPro®. Next, download the VARIFORC installation package from a provider site (e.g. http://www.conrad-observatory.at/zamg/). The installation package is a zip archive that needs to be unpacked before proceeding with the VARIFORC installation. The unpacked directory

```
.../VARIFORC_Install
```

contains a Mathematica® notebook file named `VARIFORC_Install.cdf`. Open this file, which calls a Wolfram Mathematica® or Wolfram PlayerPro® notebook containing a code beginning with:

```
InstallVARIFORC := Module[{checklist,n,sourced,fcheck,vid,installd,ov}, checklist =
```

The Wolfram Mathematica® or Wolfram PlayerPro® environment has a top menu. Locate this menu and choose

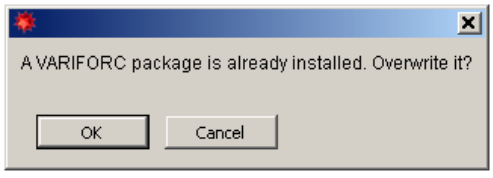
```
Evaluation → Evaluate Notebook
```

in order to run a fully automatic installation. A text similar to the following example is generated upon successful installation:

```
Source directory .....: F:\VARIFORC_Install\
Installation directory: C:\Users\...\VARIFORC
Install VARIFORC v2.04 ...
VARIFORC installation completed. You might save this notebook for your records.
```

The green message confirms that VARIFORC installation has been completed successfully. From this point on, VARIFORC is ready for use (see section 2.5). Installation problems are signaled by red messages. In this case, see section 2.9 for troubleshooting.

You can use the same procedure for upgrading or repairing an already installed VARIFORC package. In this case, you are asked by the following dialog window



to overwrite the currently installed VARIFORC package. Click `OK` to proceed or `Cancel` to interrupt the ongoing installation.

2.3 Installation troubleshooting

As explained in section 2.2, VARIFORC is automatically installed by the Mathematica® notebook file `VARIFORC_Install.nb` contained in the installation package. Installation consists in copying VARIFORC code files to a "home" directory in which user-specific Mathematica® or PlayerPro® files are stored. Installation problems are always related to the impossibility to copy the required files, either because they are missing in a damaged source directory, or because the destination directory is write-protected.

If installation files have not been found, the following message appears:

```
Source directory .....: F:\VARIFORC_Install\
Installation files missing. VARIFORC installation aborted.
```

In this case, the installation package is damaged or has been modified. Download the VARIFORC installation package again and proceed according to the instruction of section 2.2. If the destination directory of the installation files is protected against writing, the following message appears:

```
Source directory .....: F:\VARIFORC_Install\
Installation directory: C:\Users\...\VARIFORC
Unable to copy VARIFORC installation files. Check user permissions over installation
directory. VARIFORC installation aborted.
```

Writing permission problems, however, are not normally expected, because the home directory in which VARIFORC is installed, e.g.

`C:\Documents and Settings\username`	(Windows 2000, Windows XP)
`C:\Users\username`	(Windows 8)
`/home/username`	(Linux and Mac OS X)

is within the user permission domain. Check with your system administrator if this is not the case.

2.4 Optional C compiler installation

Internal compilation is used since version 2.04 to speed up data processing. A further ~25% speed gain can be obtained if a C compiler is available on your computer. The availability of a suitable compiler is checked automatically every time VARIFORC is started. For this purpose, the C compiler needs to be properly linked in the Mathematica® or PlayerPro® environment before it can be automatically used by VARIFORC.

Mathematica® or PlayerPro® accept a variety of common compilers listed under "Specific compilers" in

https://reference.wolfram.com/language/CCompilerDriver/tutorial/Overview.html

Some C compilers, such as Visual Studio, might require a manual definition update of the Mathematica® or PlayerPro® system file responsible for communication with the compiler. An example for Visual Studio 2015 is given below. Analogous solutions for other compilers can be found online. In order to check whether your C compiler is recognized by Mathematica® or PlayerPro®, open a `CalculateFORC` notebook and initialize it by evaluating the first command line (see section 2.5). The following message should appear:

```
Compile subroutines in C...
```

This message is replaced by

```
WARNING: A C compiler for faster processing is not available. Proceed with internal compilers.
```

if a C compiler is not found or not recognized. VARIFORC is still fully functional, but not as fast as with a C compiler. If your C compiler is not recognized, please check the list of tested compilers given in the above link and whether your C compiler requires a definition update. An example of definition update is given below for Visual Studio 2015.

Definition update for Visual Studio 2015

In order to make earlier versions of Mathematica® or PlayerPro® recognize the 2015 version of Visual Studio, the system file

```
C:\...\Mathematica\xx\SystemFiles\Components\CCompilerDriver\VisualStudioCompiler.m
```

where "xx" is the version number, must be modified. In case of PlayerPro® installations, the "Mathematica" directory is replaced by "Wolfram CDF Player". Once the system file has been located, make a backup copy and open the original file with a text editor. Scroll down until you find the following line:

```
$VisualStudioVersions = {"2013", "2012", "2010", "2008", "2005"}
```

and add the version year of your Visual Studio compiler, e.g. "2015" in

```
$VisualStudioVersions = {"2015", "2013", "2012", "2010", "2008", "2005"}
```

Immediately below, you find several lines of the form

```
installPath["2013"] := installPathFromEnvironment["VS120COMNTOOLS"]
```

where "VS..." is the full version specification (i.e. version 12 for Visual Studio 2013). Add a new line for the actual Visual Studio version, e.g.

```
installPath["2015"] := installPathFromEnvironment["VS140COMNTOOLS"]
```

for Visual Studio 2015 (which is version 14: version 13 does not exist). Save the system file and check whether Visual Studio 2015 is now uploaded when initializing VARIFORC.

2.5 Running VARIFORC

All VARIFORC modules are called through a Wolfram Mathematica® or Wolfram PlayerPro® interface, i.e. a so-called notebook file. Default notebook files for each VARIFORC module are provided with the installation package under

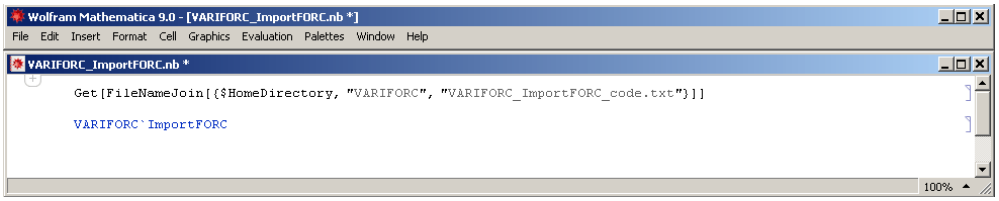
```
.../VARIFORC_Install/Functions
```

In order to use a VARIFORC module, browse the directory with the corresponding function name and open the notebook file, e.g.

```
VARIFORC_ImportFORC.cdf
```

for the `ImportFORC` module, which is used to import FORC measurements. The same directory contains also a parameter files with starting options to be used with the FORC module, and a `IMPORTANT_ReadMe.txt` file describing the starting options. For your later convenience, it is recommended to copy the notebook file and the parameter file to the directory containing the measurements being processed.

All VARIFORC module notebooks provided with the installation package look like the following example:



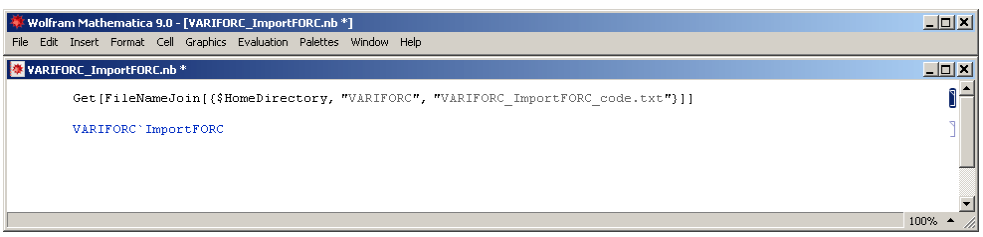
The notebooks contain two command lines. The first command line, e.g.

```
Get[FileNameJoin[{$HomeDirectory,"VARIFORC","VARIFORC_ImportFORC_code.txt"}]]
```

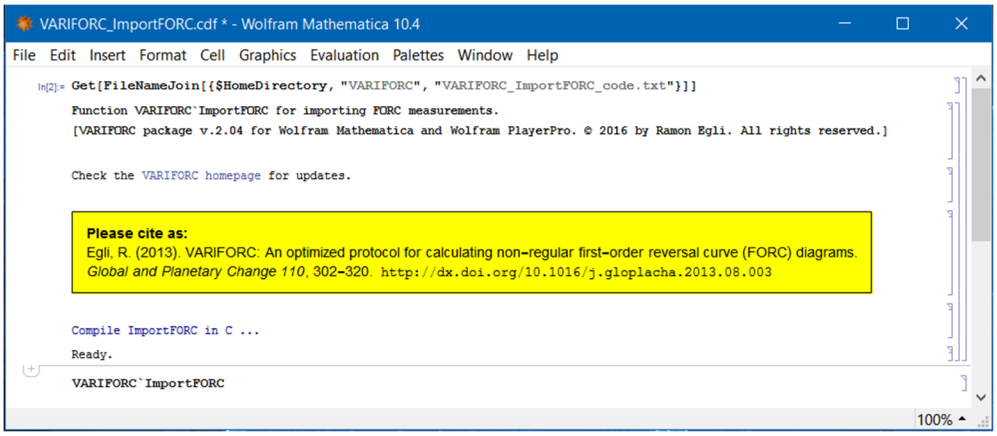
uploads the VARIFORC module into the mathematical kernel of the Wolfram Mathematica® or Wolfram PlayerPro® platform. The second command line, e.g.

```
VARIFORC`ImportFORC
```

calls the VARIFORC module for performing the desired processing step. Notebooks are always opened in an unevaluated state and you need to execute the two command lines in the sequence with which they appear in order to start processing. A command line is executed by clicking on the corresponding vertical bar to the right, which then appears in blackened form, e.g.



and then pressing the keys SHIFT and ENTER at the same time. The first command line uploads the VARIFORC module and yields the following copyright information:

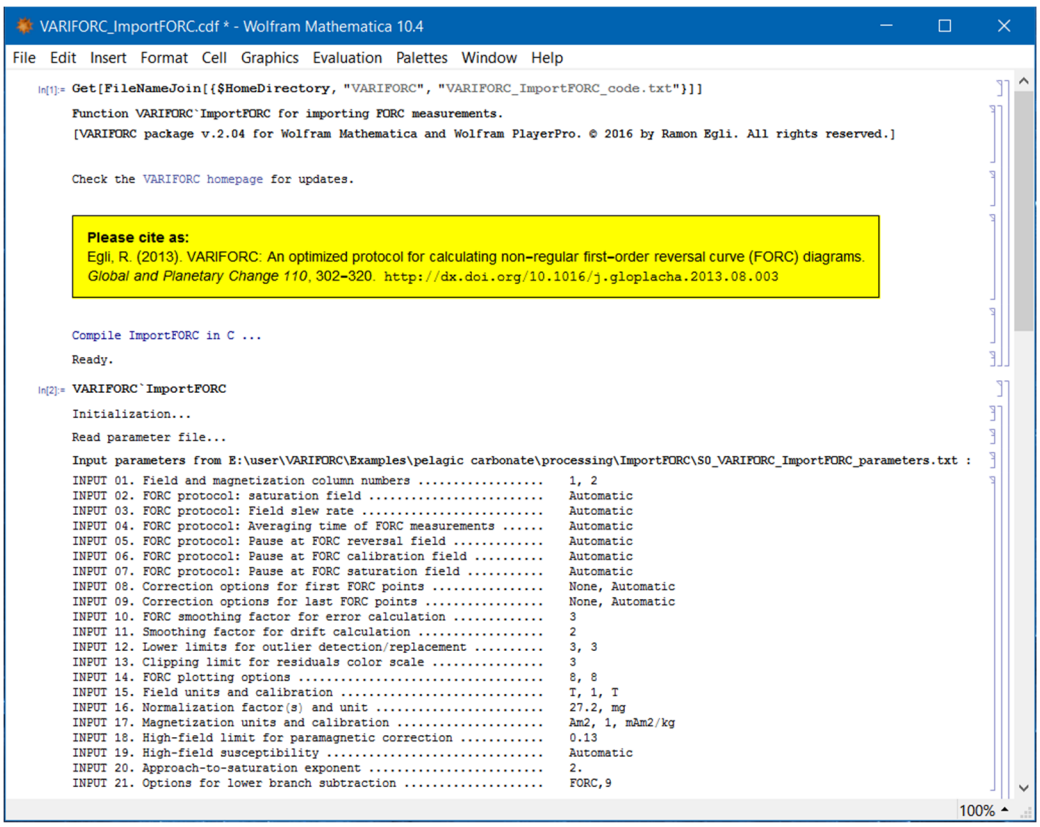


which confirms that the module is now available. The following line of the copyright information:

```
Check the VARIFORC homepage for updates
```

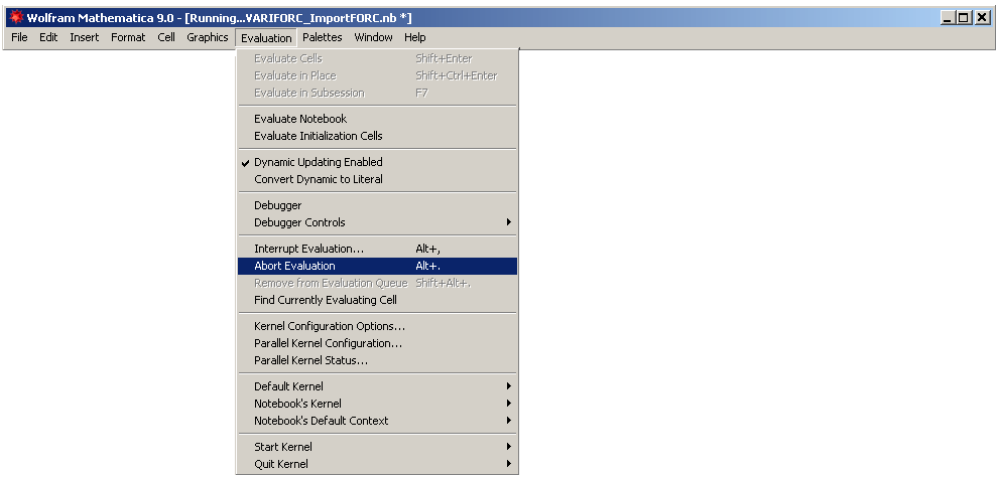
provides a direct link to the VARIFORC homepage, where you check for updates.

The second command line starts the VARIFORC module, with results (progress messages, plots, etc.) appearing below, e.g.:



Evaluation will continue automatically until completion. A running notebook is signaled by the "Running ..." state on the top menu title, i.e.:

As long as an evaluation is running, the mathematical kernel is busy. Although parallel jobs can be run on up to 4 or 8 kernels (depending on licensing), it is strongly recommended to avoid running more than one VARIFORC module at the time, because some tasks are very demanding in terms of computation time and memory usage. You can stop a running evaluation at any time with the key combination ALT and period ("."), or by choosing `Evaluation` → `Abort Evaluation` from the top menu, e.g.



Evaluated notebook files, which now contain useful processing information and plotted results, is conveniently saved for future records. Notebooks are saved with `File` → `Save` from the top menu. It is recommended to save and close notebooks after each evaluation. Closing a notebook will automatically quit the corresponding kernel, reducing memory usage. A frozen kernel (section 2.9) can be forcefully quit by choosing `Evaluation` → `Quit Kernel` from the top menu (see example above).

As a general rule, running VARIFORC modules produce progress messages in black, e.g.

```
Check FORC fields...
```

warning and non-fatal error messages in blue, e.g.

```
WARNING. Multiple entries for the averaging time have been found in the file header.
```

and important or fatal error messages in bright red, e.g.

```
No ImportFORC parameter file has been chosen. Program aborted.
```

Fatal error messages are followed by a program abort. Evaluation progress is accompanied by the production of tables and graphics summarizing specific properties of the dataset being processed. The mathematical kernel can produce its own error and warning messages, e.g.

```
FindRoot::cvmit: Failed to converge to the requested accuracy or precision within 100
                 iterations. >>
```

These messages are printed in small brown characters. VARIFORC modules have been programmed with the goal of avoiding kernel messages as far as possible. Kernel messages might be the symptom of a program bug, especially if a cascade of messages is produced. All VARIFORC modules have been extensively tested and are guaranteed to work flawlessly with all downloadable examples (section 2.6). Nevertheless, problems generated by particular combinations of data can never be completely excluded. If error message cascades are produced and progress is stopped or slowed down, you should interrupt the running evaluation and/or quit the kernel (see section 2.9 for troubleshooting).

Before running your own processing examples with VARIFORC, it is recommended that you understand the basic operating principles of VARIFORC modules (section 2.6) and collect some experience by running downloadable examples (section 2.7). A detailed description of all VARIFORC modules and their options is provided with Chapters 3-7 of this manual.

2.6 Operation principles of VARIFORC modules

All VARIFORC modules operate with the same fundamental principles (Fig. 2.1) based on the following steps:

1) Prompt the user to locate required source files (i.e. measurement files and processing parameters), and directories where output files will be stored. From this point on, subsequent processing occurs automatically with no further input requests. Time-demanding applications can therefore run in the background.

2) Read user-defined processing parameters (e.g., smoothing factors) from a previously prepared parameter file. Parameter file examples are available for download and can be easily adapted to other requirements.

3) Read/check FORC data and start processing. Progress messages, summary tables, and plots are produced during processing.

4) Export results in form of plots and data files for further processing with other VARIFORC modules.

VARIFORC modules are very simple to use and do not require any knowledge about the Wolfram platforms on which they run. The only thing that must be provided by the user – beside measurements – is a so-called parameter table, which is a two-column, unformatted text file containing a list of processing options (first column) and the corresponding values set by the user (right column). The following example shows processing options used for importing FORC measurements with the VARIFORC module `ImportFORC`:

```
Input parameters for package VARIFORC_ImportFORC; (version 1.0).

INPUT 01. Field and magnetization column numbers ..................; 1, 2
INPUT 02. FORC saturation field ...................................; Automatic
INPUT 03. Field slew rate .........................................; Automatic
INPUT 04. Averaging time of FORC measurements .....................; Automatic
INPUT 05. Pause at FORC reversal field ............................; Automatic
INPUT 06. Pause at FORC calibration field .........................; Automatic
INPUT 07. Pause at FORC saturation field ..........................; Automatic
INPUT 08. Correction options for first FORC points ................; None, Automatic
INPUT 09. Correction options for last FORC points .................; None, None
INPUT 10. FORC smoothing factor for error calculation .............; 3
INPUT 11. Smoothing factor for drift calculation ..................; 5
INPUT 12. Lower limits for outlier detection/replacement ..........; 3, 3
INPUT 13. Clipping limit for color scale of residuals .............; 3
INPUT 14. FORC plotting options ...................................; 8, 8
INPUT 15. Field units and calibration .............................; T, 1, T
INPUT 16. Normalization factor(s) and unit ........................; 27.2, mg
INPUT 17. Magnetization units and calibration .....................; Am2, 1, mAm2/kg
INPUT 18. High-field limit for paramagnetic correction ............; 0.13
INPUT 19. High-field susceptibility ...............................; Automatic
INPUT 20. Approach-to-saturation exponent .........................; 2.
INPUT 21. Number of last FORCs used for lower branch subtraction ..; 9
```

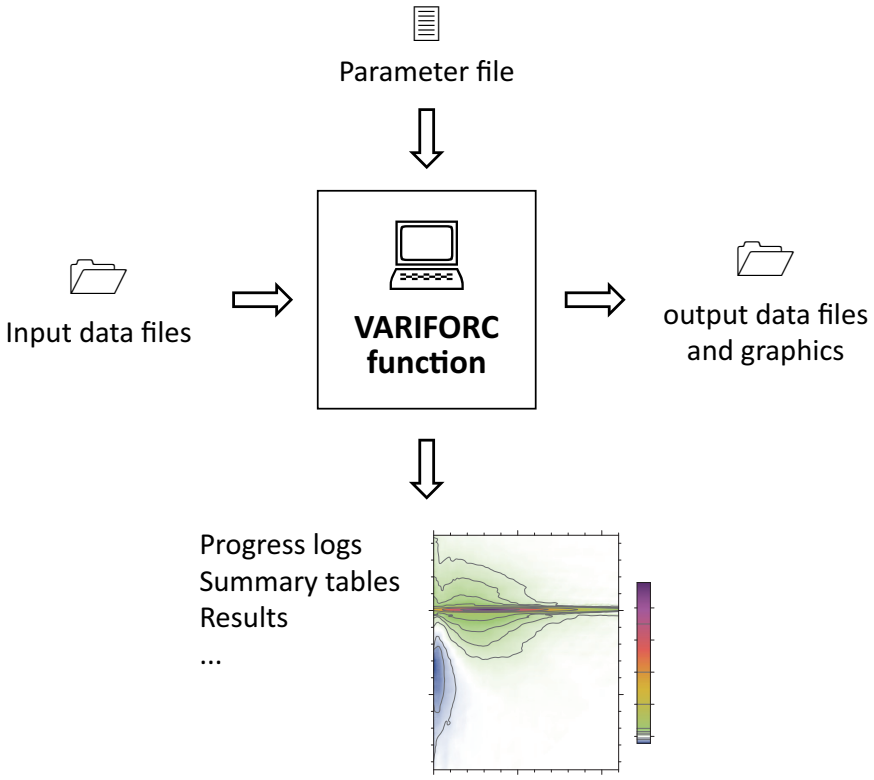


Fig. 2.1: Operation principle of VARIFORC modules. Input is provided by data files and by a parameter file containing processing options. Once all data have been acquired, VARIFORC modules proceed without other input requests until the end, when output data is generated and exported to data files and/or images. During processing, progress and warning messages are generated within the Wolfram Mathematica® or Wolfram PlayerPro® notebook, along with summary tables and graphical representation of intermediate and final results.

All processing options to be entered with the parameter table are explained in detail in Chapters 3-7 of this manual. Parameter files with default settings suitable for most applications are provided with the installation package under

```
.../VARIFORC_Install/Modules
```

These are text files named according to the corresponding VARIFORC module. For example, `Default_VARIFORC_ImportFORC_parameters.txt` is the default parameter file of the VARIFORC module `ImportFORC`, and contains universally valid options for importing FORC measurements. Default parameter files serve as basis for creating customized sets of parameters to be used with certain types of data. For this purpose, copy the default parameter files to a folder where you will store all files related to a given job, and change the processing parameters with a text editor, according to your own requirements and the instructions provided with Chapters 3-7 of this manual. For example, the notebook file `sample1_VARIFORC_ImportFORC.nb` used to import FORC measurements of "sample1" and the corresponding parameter file `sample1_VARIFORC_`

`ImportFORC_parameters.nb` are conveniently stored in the same folder along with other processing files. Parameter files provided with downloadable examples can also be used as initial template for creating your own processing options.

The default parameter files provided with the installation package support standard FORC processing options (e.g., default FORC range and constant smoothing factors) and can be used in unchanged form for uncritical tasks and preliminary processing. Special VARIFORC processing capabilities can be activated through properly chosen parameters, as explained in Chapters 3-7. The role of different processing options can be tested with the downloadable examples (see Section 2.7).

- The operation principles of VARIFORC modules differ from those of other FORC processing software. For example, FORC processing is divided into few main steps that work independently of each other. Furthermore, processing options are stored in parameter files, instead of being entered in a menu system.
- The modular structure of VARIFORC enables a better control of individual processing steps (e.g., initial quality checks, measurement corrections, FORC diagram calculation, customized plots, etc.) and speeds processing, for instance by accessing to predefined sets of processing options.

Some commonly asked questions about the VARIFORC processing philosophy are answered in the following.

Q: *Do I really need to care about FORC processing technicalities instead of using a simple, universal procedure (e.g., a constant smoothing factor of 5)?*

A: In principle, FORC diagrams are nothing else than a mixed derivative of measurements obtained with a standard protocol. Standard numerical methods, such as polynomial regression, can be used for this purpose and provide usable results in all cases where measurement noise and resolution are not an issue. Default VARIFORC parameter files provided with the installation (see above), contain standard processing options. In many cases, however, standard processing performs poorly in terms of measurement noise suppression and faithful reproduction of critical high-resolution FORC features. Measurement noise represents a problem for many weakly magnetic materials, such as thin films and geologic samples, to the point that large regions of the FORC diagram do not reach a minimum significance level. In this case, the signal-to-noise ratio can be improved by processing measurements with larger smoothing factors. However, excessive smoothing produces signal distortions, so that noise suppression capabilities of standard processing methods are rather limited and insufficient for some applications (e.g., the analysis of pelagic carbonates). Standard processing will

also fail in case of measurements characterized by first derivative discontinuities, even when measurement noise is not an issue. The processing options offered by VARIFORC provide very effective solutions to the abovementioned problems.

Q: *Why are VARIFORC processing options not fully automatized?*

A: The main reason is that a universal processing strategy does not exist. Furthermore, some options depend specifically on your requirements. For example, you might want to plot a specific region of the FORC diagram after realizing that the space covered by measurements is unnecessarily large. On the other hand, materials of a certain type can be measured with the same FORC protocol processed with the same set of VARIFORC options, enabling fully automatized processing once the processing options have been chosen the first time.

Q: *Why does VARIFORC require a Wolfram Mathematica® or Wolfram PlayerPro® platform, which is not available for free?*

A: VARIFORC uses advanced mathematical algorithms – which are implemented reliably in mathematical platforms such as Wolfram Mathematica® and MATLAB® – for performing tasks such as nonlinear regression. Less advanced versions of the same algorithms are nowadays available for other common programming languages, so that it is in principle possible to implement VARIFORC as a stand-alone application. However, this requires a significant additional programming effort. On the other hand, Wolfram PlayerPro® licenses are available at accessible prices.

Q: *Why does VARIFORC have a modular structure, instead of doing all at once as other FORC software does?*

A: Simplest FORC processing tasks can be performed in a single step. VARIFORC, on the other hand, offers a large number of completely new processing options for which a modular structure is more practical and provides a better overview. For example, it is reasonable to separate measurement import and correction tasks from FORC diagram calculation and plotting. If you want to try different FORC calculation options – as for instance variable smoothing for optimal combination of resolution and noise suppression – you do not need to repeat preliminary processing steps such as drift correction. Furthermore, FORC diagrams are themselves the starting point for additional processing. For example, you might want to plot only part of the original FORC diagram, or to add contour lines and significance limits without starting over again, especially in case of time-consuming high-resolution measurements. Certain processing steps, such as the separation of a central ridge, might become necessary only after having seen the results obtained from previous steps or from different samples. Finally, processing parameters are better organized in blocks covering specific tasks, such as import measurements, calculate the FORC diagram, combine different FORC diagrams, etc.

Q: *Why are processing options entered through parameter files, instead of interactive window-based menus?*

A: This question is best answered with the following example. The VARIFORC module `CalculateFORC` enables you to choose the field range of the output FORC diagram. This choice depends

on the characteristics of the FORC diagram, which are often not known in advance: for example, interesting or significant contributions might extend only over a small portion of the range covered by measurements. If the calculation of a FORC diagram would be possible in few tenths of a second, one could interactively choose the FORC range directly on output plots, but this is obviously not possible for calculations that might take hours. This excludes interactivity, but leaves the possibility of choosing processing options from a menu. While menu-based inputs are more 'user friendly' when processing a single sample, they become very inconvenient if several samples (e.g. from the same sediment core) need to be processed in the same manner. In this case, processing options are conveniently imported from the same parameter file (e.g. `HighRes_VARIFORC_ImportFORC_parameters.txt` for high-resolution FORC measurements). Furthermore, parameter files are helpful for keeping a consistent record of all processing options.

2.7 Downloadable VARIFORC examples and file management

As explained in section 2.6, each VARIFORC module takes a parameter file and one or more FORC data files as input, and produces one or more data files and/or images as output. Up to ~30 files are automatically produced in this manner, although the only files that need to be taken in into consideration are those containing parameter specifications and the Mathematica® notebooks where VARIFORC modules are run. A consistent file management strategy is recommended in order to keep Mathematica® notebooks and parameter files separated from data files. This strategy is best explained using VARIFORC examples available for download.

Each example (e.g. high-resolution FORC measurements of cultured magnetotactic bacteria MV-1) can be downloaded as a zip file (e.g. `VARIFORC_Vibrio-MV1_Example.zip`, which has the following folder structure upon unpacking:

```
VARIFORC_VibrioMV-1_Example
    Measurements
        MV-1.frc
    Processing
        ImportFORC
            MV-1_VARIFROC_ImportFORC.nb
            MV-1_VARIFROC_ImportFORC_parameters.txt
        CalculateFORC
            MV-1_SF3-9_W2_VARIFROC_CalculateFORC.nb
            MV-1_VARIFROC_CalculateFORC_parameters.txt
        IsolateCR
            MV-1_VARIFROC_IsolateCR.nb
            MV-1_VARIFROC_IsolateCR_parameters.txt
        PlotFORC
            MV-1_VARIFROC_PlotFORC.nb
            MV-1_VARIFROC_PlotFORC_parameters.txt
            MV-1_Background_VARIFROC_PlotFORC_parameters.txt
            MV-1_CentralRidge_VARIFROC_PlotFORC_parameters.txt
    Results
        MV-1_CorrectedMeasurements_VARIFORC.frc
        MV-1_CorrectedMeasurementDifferences_VARIFORC.frc
        MV-1_CorrectedMeasurements_Hysteresis_VARIFORC.hys
        MV-1_SF3-9_W2_FORC_VARIFORC.txt
        MV-1_SF3-9_W2_FORCStandardError_VARIFORC.txt
        MV-1_SF3-9_W2_Backfield_Linear_VARIFORC.txt
        ...
```

The `Measurements` folder contains the original single or multiple FORC measurements. The `Processing` folder typically contains a directory for every processing step and each step is associated with a Wolfram® notebook (`.nb` files) hosting the VARIFORC module used for processing, as well as the corresponding parameter file (`.txt` files). The Mathematica® notebook stores processing information, summary tables and graphical representation of results. Finally, the `Results` folder contains processing results, as for instance the corrected FORC measurements (`..._Corrected Measurements_VARIFORC.txt`), the FORC diagram matrix calculated from these measurements (`..._FORC_VARIFORC.txt`), and the corresponding standard error estimates (`..._FORCStan`

`dardError_VARIFORC.txt`), the coercivity distribution corresponding to the backfield demagnetization curve extracted from FORC measurements (`..._Back field_Linear_VARIFORC.txt`), etc. These files serve as input fur further processing: for example, the FORC diagram matrix is required by the FORC module `IsolateCR` for calculating the central ridge. Files in this folder are either tables in comma-separated column format containing FORC and coercivity distribution data, or image files in raster or vector format.

The folder structure shown in the above example is best suited for processing individual samples, each with its own parameters. If, on the other hand, entire sets of samples are processed with identical options, one might store all measurements in the `Measurements` folder, and use only one set of parameter files in the `Processing` folder.

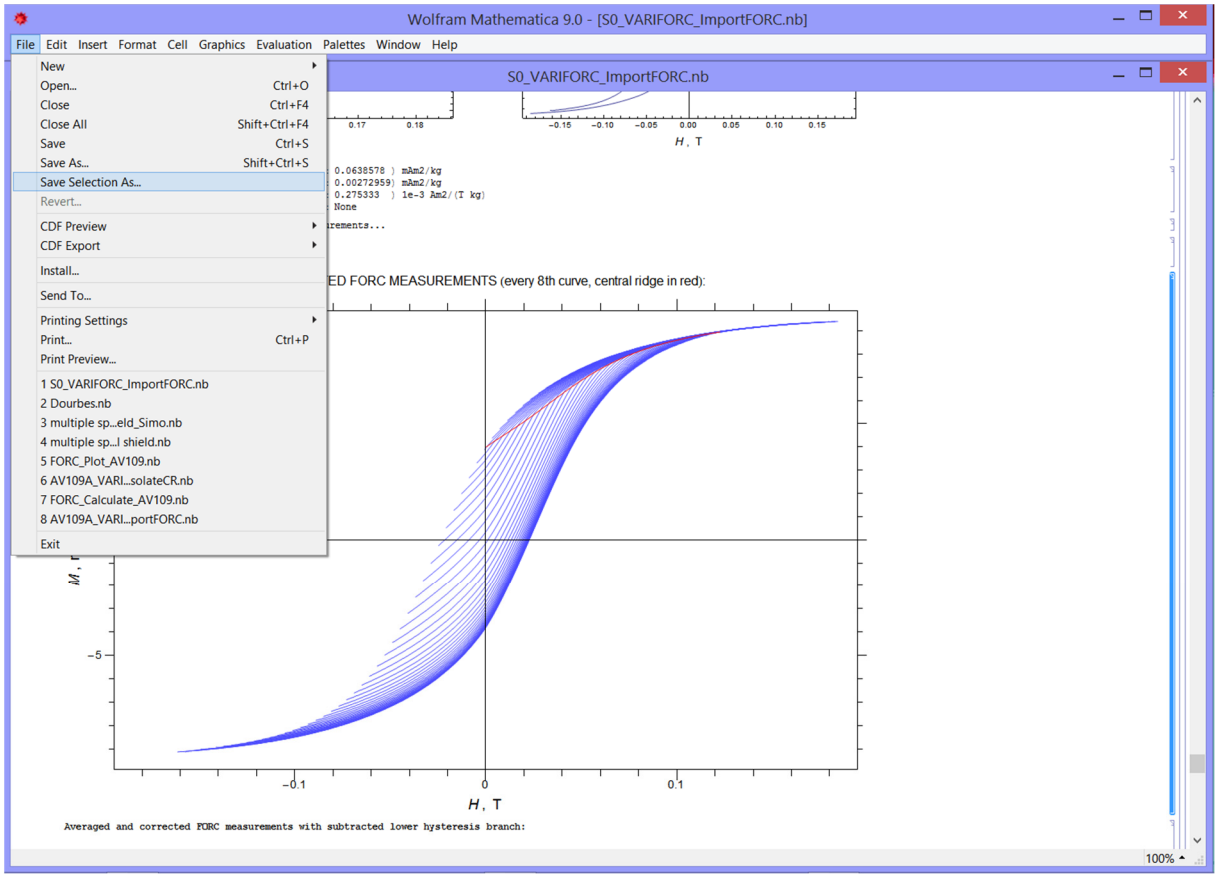
Downloadable VARIFORC examples are mostly based on high-resolution FORC measurements. Each example contains results obtained with the basic set of VARIFORC modules, i.e. `ImportFORC` for importing FORC measurements, `CalculateFORC` for calculating FORC diagrams and coercivity distribution obtained from FORC data, and `PlotFORC` for plotting FORC diagrams with advanced plotting functions not available with `CalculateFORC`. Special VARIFORC modules have been included whenever meaningful for the particular example, i.e., (1) central ridge extraction with `IsolateCR` in case of samples containing single-domain particles, and (2) linear combination of FORC data with `LinearCombineFORC` for calculating averages and differences.

VARIFORC is best learned by downloading some examples and running them with provided parameter files, as well as the same files after selectively changing selected parameters. Furthermore, parameter files from the downloadable examples can be used to process similar samples: for example, parameters used for the pelagic carbonate example provide an excellent starting point for processing high-resolution FORC measurements of other magnetofossil-bearing sediments.

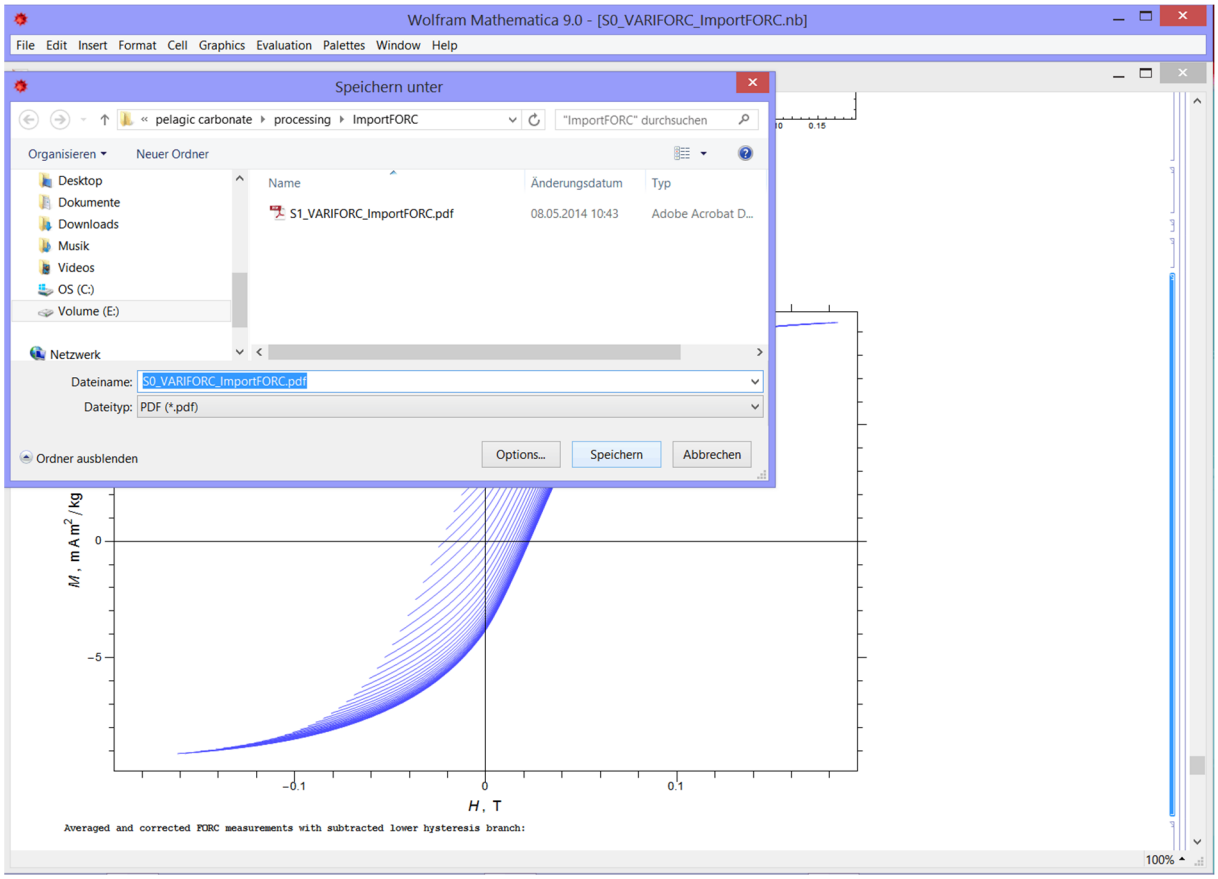
2.8 Exporting graphics

Each VARIFORC module produces several plots representing intermediate processing steps as well as final results. These plots are stored in the Mathematica® notebook, which can be saved for later record. Only FORC diagrams produced by the VARIFORC module `PlotFORC` are exported directly as image files, since they represent the final output of FORC processing. Nevertheless, it is possible to export every plot produced by VARIFORC modules, as for instance drift-corrected measurements.

In order to export a plot from a Mathematica® notebook, select it by clicking on the corresponding side bar, which becomes filled in blue (see below). Next, choose `File` → `Save Selection as ...` from the top menu, e.g.:



At this point, a file saving dialog appears (see below), and you can export the selected plot to most common vector and raster graphics formats, e.g.



for saving the selected graphics as PDF. Best results are always obtained with vector formats, e.g. PDF and EPS.

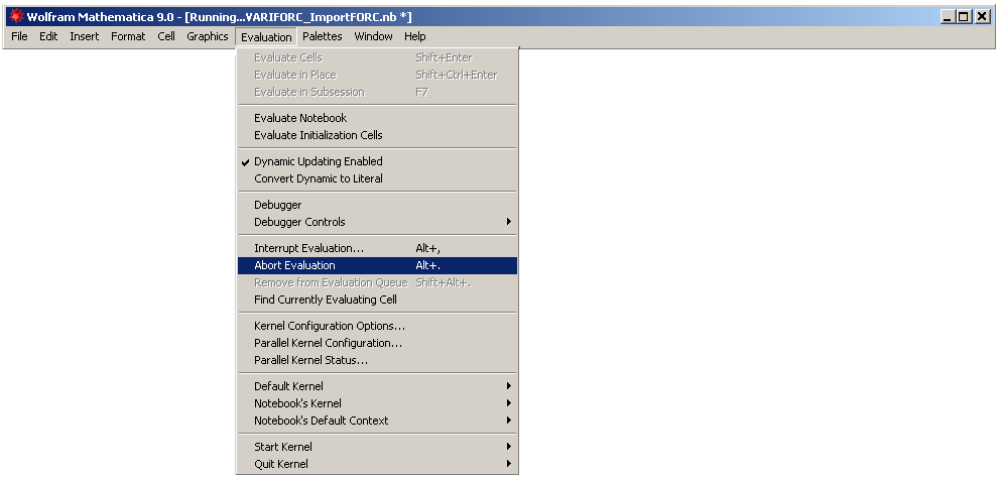
All important graphics generated by VARIFORC modules meet basic publishing quality criteria (e.g. correct labeling) and can be used for publication figures with little modifications. On the other hand, full control of the graphical output is available with FORC diagrams plotted with the VARIFORC module `PlotFORC`.

2.9 Troubleshooting

VARIFORC modules have been extensively tested with several FORC measurement examples and are guaranteed to work flawlessly with all downloadable examples. Nevertheless, possible problems cannot be completely excluded with particular combinations of data and processing options. In this case, the Mathematical kernel might produce a cascade of error messages, printed in small brown characters, with the following appearance:

```
FindRoot::cvmit: Failed to converge to the requested accuracy or precision within 100
                 iterations. >>
```

These messages differ from error messages produced directly by VARIFORC, which are printed in bright red characters. Particular care was taken to avoid kernel messages as far as possible. A cascade of kernel messages therefore signals problems that have not been handled by VARIFORC. Kernel error cascades will likely slow down evaluation, or freeze it completely. You can stop a running evaluation at any time with the key combination ALT and period (“.”), or by choosing `Evaluation` → `Abort Evaluation` from the top menu, i.e.



If evaluation continues (as seen by the notebook title “Running...”) despite the abort request, quit the kernel by choosing `Evaluation` → `Quit Kernel` from the top menu as seen above. In some cases, the kernel remains frozen and does not quit. The best solution in this case consists in killing the Wolfram Mathematica® or Wolfram PlayerPro® process through the operating system (i.e. by calling the task manager in Windows, and by the `kill` command in Linux).

If you encounter problems with a VARIFORC module, stop the evaluation and contact the author (Ramon Egli), by sending an e-mail (ramon.egli@zamg.ac.at) with the following elements:

1) Brief description of the problem, in particular, what was the last progress message before kernel error messages appeared, and if, possible, a copy of the first kernel error message.

2) Attachment with the original FORC measurement file and the parameter files used for each VARIFORC module until the problem appeared. Please do not include processing results and Wolfram Mathematica® or Wolfram PlayerPro® notebooks, because of their large size.

Eventual bugs will be fixed as soon as possible.