CMS FCT-22_DB (Findclouds Trinity) - Cloud Analysis Software
Database Setup - FCT22 Setup - Table Structures
Release 241q08

Table of Content

1 Introduction

Please download the latest software (ASI-Manager, FCT-22, tools), release notes, and user manual from CMS-CRM (https://service.schreder-cms.com/crm/) using your all-in-one username/password.

1.1 Improvements and Features

FCT-22_DB (FindClouds Trinity) cloud analysis software is based on our well-known FCT-19. Cloud analysis algorithms, most GUI settings, and functions remain as known, but with significant internal improvements in stability, especially in multi-camera and short shooting-interval real-time analysis.

FCT-22 now stores all evaluation data in an SQL database ("DB"). The database allows user-developed software (e.g. "Nowcasting Software") direct, real-time access via user-created SQL queries. *Working with a DB requires knowledge of SQL (Structured Query Language)!*

For simple tasks and maintenance (deleting data or corrupt tables), the DB can also be accessed via a "Database Client" (Azure Data Studio, HeidiSQL, DBeaver, ...).

If necessary, the results can still be stored in TXT-, CSV- and JPG files for backward compatibility.

Currently, FCT-22 supports "PostgreSQL" and "MariaDB" (or "MySQL").

1.2 This add-on manual

This add-on manual is provided as an addition to the FCT22 user manual. It includes ...

- a step-by-step guide on how to set up a database server and create a database for the FCT-22

- a description of the DB schema (table structure, relevant columns, and constraints)

- the new and modified software functions and GUI settings, compared to the FCT-19

We strongly recommend installing the "SQL Database Server" on a dedicated (server) PC or a professional NAS (Network Attached Storage) with a failsafe RAID file system (RAID-5/6).

For stable, multi-imager real-time operation, FCT-22 should be installed on a dedicated and powerful WIN-10 PC (32 GB RAM, min. 8 Cores, min. 4 GHz). When using the "real-time mode" with a shooting interval of 15 seconds, analysing more than 5 ASI imagers in parallel may cause instabilities. If that happens, the processing load must be distributed between two independent PC's.

> **Note:** Setting up a database server requires knowledge about databases, SQL syntax and computer networks. Wrong or incomplete configurations might cause problems and can pose security risks, especially if the DB is exposed to a public network like the internet. This guide provides an overview over the steps necessary to setup a database server on a typical desktop computer, only.
>
> **Please consult with your IT department, if you plan on using a database server over your companies' network!**

2 SQL Database - Setup

2.1 PostgreSQL

2.1.1 Install Database Server

At first download the PostgreSQL installer from https://www.enterprisedb.com/downloads/postgres-postgresql-downloads. Choose any version ≥ 12 and the platform "Windows x86-64" (32-bit Windows is not supported).

Once the download is finished, run the installer:

1. **Setup – PostgreSQL:** Click "Next".

2. **Installation Directory:** Choose the directory where PostgreSQL should be installed. The rest of this guide will assume that you choose the default directory `C:\Program Files\PostgreSQL\XX` where `XX` is the version number.

3. **Select Components:** Select at least "PostgreSQL Server", "pgAdmin X" and "Command Line Tools". The component "Stack Builder" is not used in this guide and is therefore optional.

4. **Data Directory:** Next, you must choose the directory in which PostgreSQL will store its data. You can choose a custom directory or keep the default directory.

   > **Note:** You will need this directory when performing backups, so you should choose an easily accessible location.

5. **Password:** Choose a password for the PostgreSQL superuser. Remember or write down the password. **Make sure to use a secure password!**

6. **Port:** The installer will then ask you to choose a port. Use the default port "5432" unless this port is already in use on your computer.

7. **Advanced Options:** Choose "[Default locale]" as locale.

8. **Pre-Installation Summary:** Click "Next".

9. **Ready to Install:** Click "Next".

10. **Installing:** Wait for the installation to finish.

11. **Completing the PostgreSQL Setup Wizard:** Click "Finish" to exit the installer.
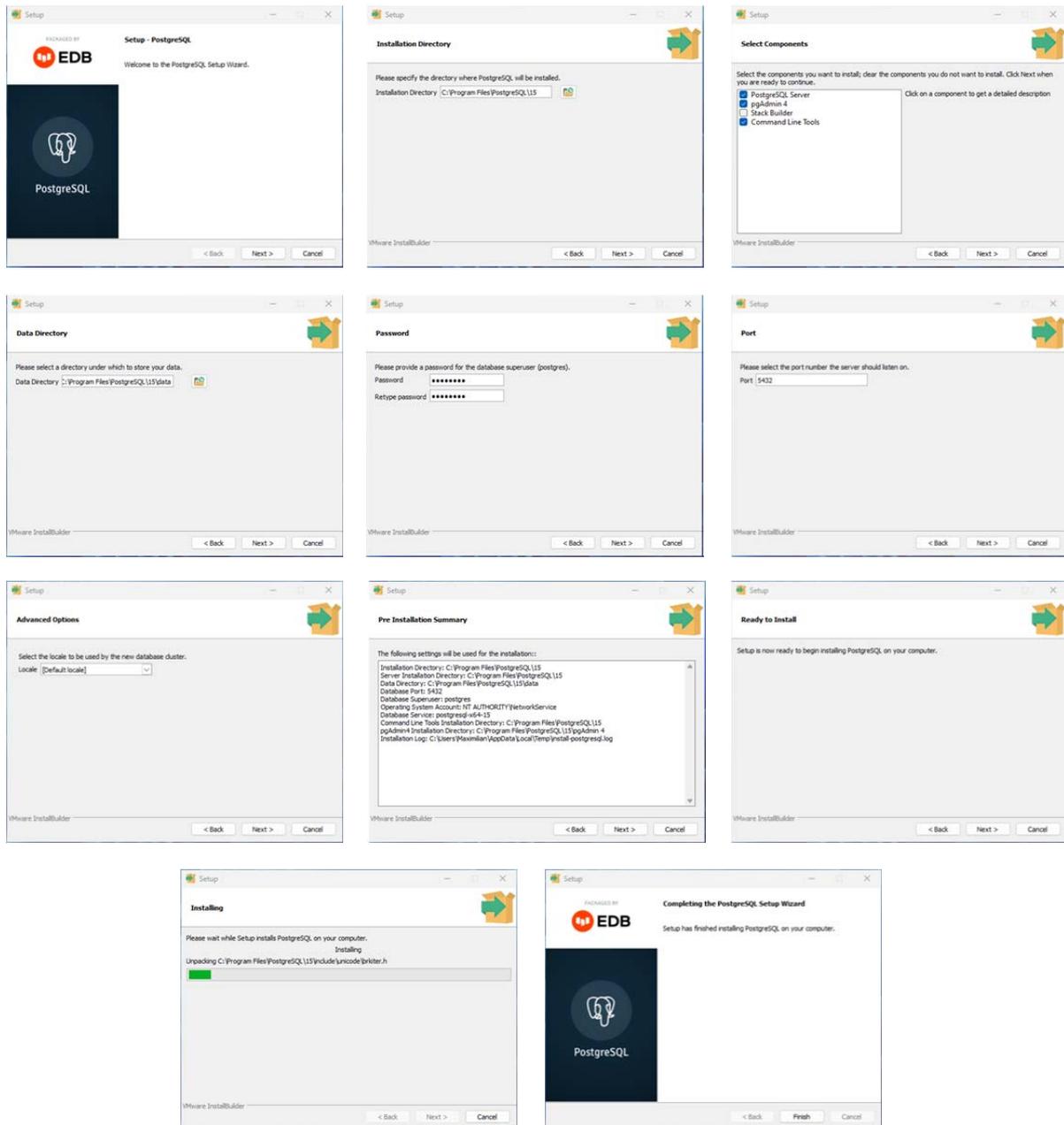
Figure 1: PostgreSQL installation procedure.

The PostgreSQL server is now installed and running in the background as a service. The server starts automatically whenever you start your computer and login. There is no need to start it manually.

2.1.2 Create a User and a Database for FCT-22

Now that the PostgreSQL server is installed, we can create a database for FCT-22. We are going to use pgAdmin – a management tool for PostgreSQL – since it is already part of the PostgreSQL installation.

Open pgAdmin from the Windows start menu, "All Apps" → "PostgreSQL XX" → "pgAdmin X". Upon the first start, you will be asked to set a master password for pgAdmin. Choose and enter a password and remember it or write it down. You will need it whenever you start pgAdmin.
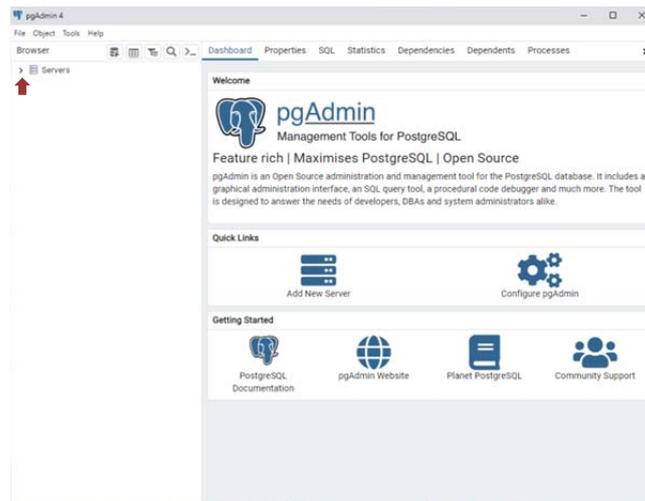
Figure 2: pgAdmin start screen.

Next, expand the entry "Servers" in the left sidebar by clicking on the ">" symbol (see Figure 2). A popup window will appear asking for the PostgreSQL password. Enter the PostgreSQL superuser password that you chose during the installation of PostgreSQL (see 2.1.1, step 5) and click "Ok". You should now see a new entry "PostgreSQL XX" right below "Servers" with three sub-entries "Databases", "Login/Group Roles" and "Tablespaces".

2.1.2.1 Create a User

First, we will create a PostgreSQL user with limited permissions. That way FCT-22 doesn't get access to the entire PostgreSQL server and can instead only access its own database:

1. In the left sidebar, right-click on the entry "Login/Group Roles" and choose "Create" → "Login/Group Role…".

2. In the tab "General", enter the name `fct_user` into the field "Name".

3. In the tab "Definition", enter a password for the FCT-22 user and remember it or write it down. **For security reasons, this password should <u>not</u> be the same as the PostgreSQL Superuser password (2.1.1, step 5)!**

4. In the tab "Privileges" activate the privilege "Can login?".

5. Create the new user by clicking on the button "Save" in the bottom-right corner.
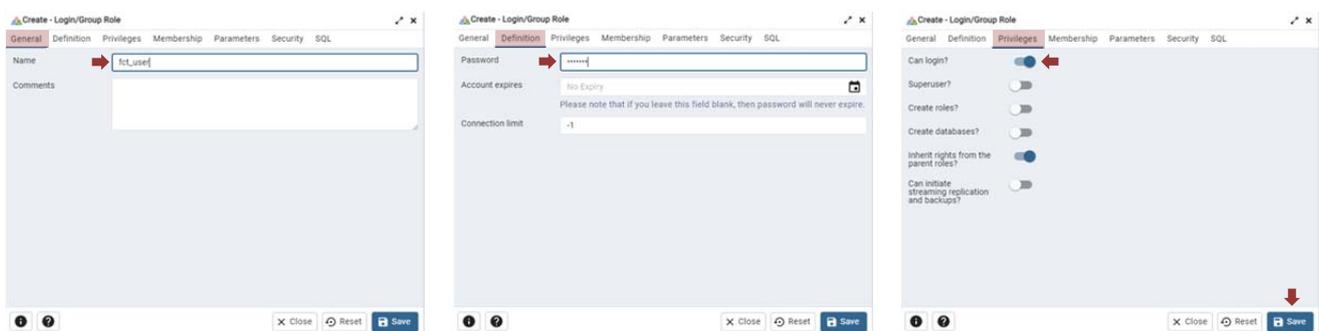
Figure 3: Creating a new user in pgAdmin.

2.1.2.2   Create a Database

Next, we can create the actual database:

1. In the left sidebar, right-click on the entry "Databases" and choose "Create" →
    "Database…".

2. In the tab "General", enter the name `fct_22` into the field "Database". As "Owner" select
    the user "fct_user" from the dropdown menu.

3. Create the database by clicking on the button "Save" in the bottom-right corner.
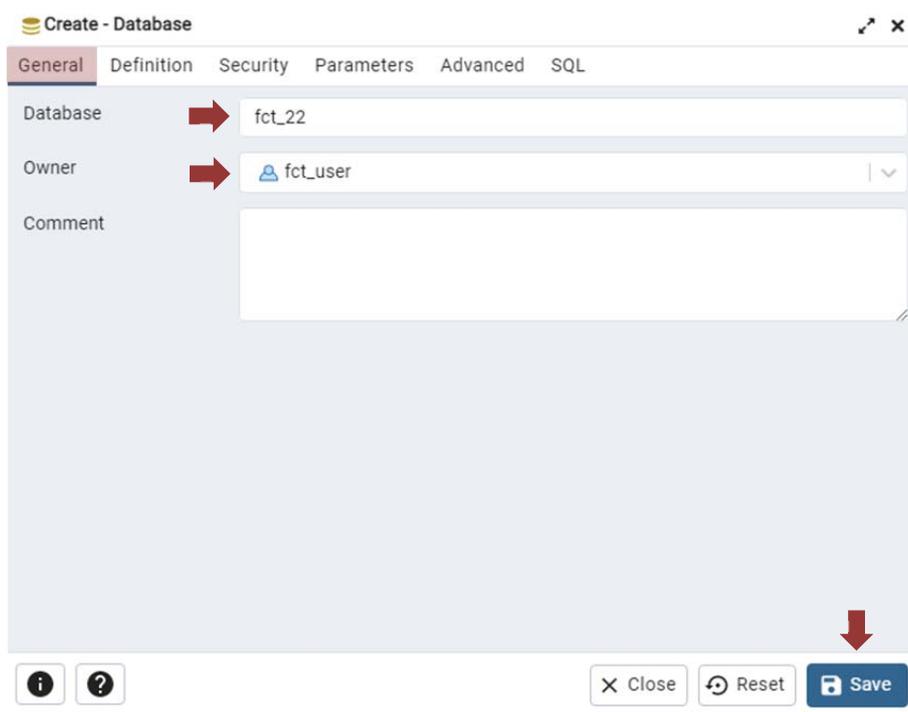
Figure 4: Creating a new database in pgAdmin.

We have now successfully created a new database and user for FCT-22. Use the following
credentials to login to your database from FCT-22software:

DBMS:	"PostgreSQL"
Server Address:	`127.0.0.1`
Server Port:	`5432`
Database:	`fct_22`
Username:	`fct_user`
Password:	*Password chosen in 2.1.2.1, step 3*

2.1.3   Enable Local Network Access to Database

Note (NOT RECOMMENDED): In a professional environment a SQL-server is installed on a
dedicated "server PC" or runs on a professional NAS (Network Attached Storage). If – for short
time test purpose – you intend to use FCT-22 on the same machine that also runs the PostgreSQL
server, you can skip this section.

Currently the PostgreSQL server is only reachable from the computer that runs it. If you want to access the database from another computer, you must configure the server accordingly. This guide describes how to expose the database server to all computers within the local network.

We do not describe how to expose the PostgreSQL server to the internet, nor do we recommend doing so, unless you know exactly what you are doing.

In the Windows Explorer, navigate to the PostgreSQL data directory (chosen in 2.1.1 step 4). Within this directory you should be able to find the two files `postgresql.conf` and `pg_hba.conf`.

First, open the file `postgresql.conf` by right-clicking on it and selecting "Open with" → "Notepad". Make sure that there is a line `listen_addresses = '*'`. If you can find that line, no changes are necessary. If this line has some other value on the right side, like `listen_addresses = 'localhost'`, make sure to change it to `listen_addresses = '*'`. After saving any potential changes, close the editor.

Next, open the file `pg_hba.conf` by right-clicking on it and selecting "Open with" → "Notepad". At the end of the file, add a new line

`host     all     all     `*ip-address*/*subnet-suffix*   `scram-sha-256`

where *ip-address* is an address from your local network and *subnet-suffix* is the subnet of your local network in suffix notation. This notation is known as CIDR notation (e.g. 192.168.0.0/24). Finally save the file and close the editor.

How can I find an IP address and the subnet of my local network?

To expose the database server to our local network, we must tell it which IP addresses belong to the network. All those IP addresses will then be allowed to communicate with the PostgreSQL server.

Finding out the correct information might not be trivial since computers can be connected to multiple local networks. Ideally consult with your IT department or system administrator to find the right settings.

In the majority of cases however, you should be able to find the required information by following these steps:

1. Open the terminal from the start menu "All apps" → "Terminal".
2. Enter the command `ipconfig` and press the "Enter"-key.
3. In the output you can find the IP address and the subnet mask (see Figure 5).
4. Since we need the subnet mask in CIDR notation, we must convert it using Table 1.

Figure 5: Terminal with ipconfig output

Table 1: Conversion between subnet mask and CIDR notation

Subnet Mask	CIDR	Subnet Mask	CIDR
255.0.0.0	/8	255.255.248	/21
255.128.0.0	/9	255.255.252	/22
255.192.0.0	/10	255.255.254	/23
255.224.0.0	/11	255.255.255.0	/24
255.240.0.0	/12	255.255.255.128	/25
255.248.0.0	/13	255.255.255.192	/26
255.252.0.0	/14	255.255.255.224	/27
255.254.0.0	/15	255.255.255.240	/28
255.255.0.0	/16	255.255.255.248	/29
255.255.128.0	/17	255.255.255.252	/30
255.255.192.0	/18	255.255.255.254	/31
255.255.224.0	/19	255.255.255.255	/32
255.255.240.0	/20		

To load the new configuration, you must restart the PostgreSQL server:

1. Open the Services app from the start menu "All apps" → "Administrative Tools" → "Services".
2. Select the PostgreSQL service from the list on the right side (see Figure 6).
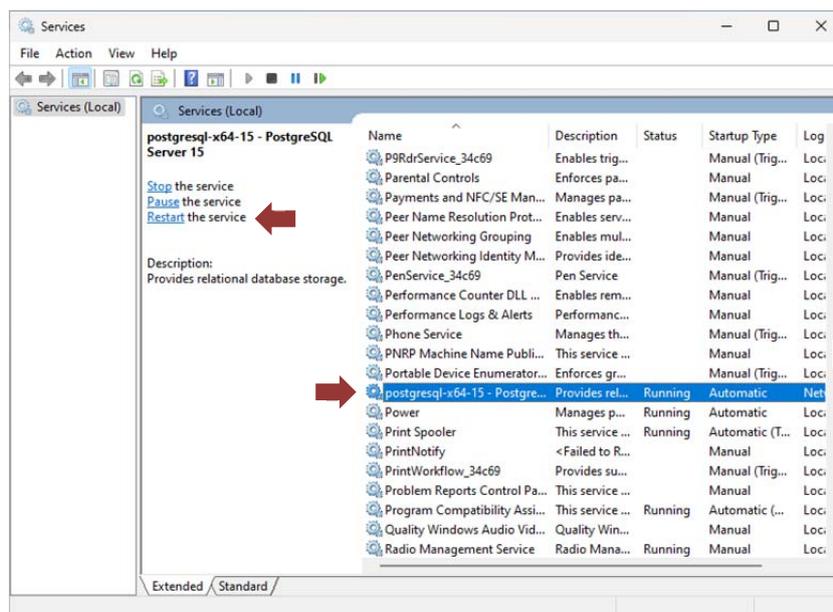3. Click "Restart the service" on the left side of the list (see Figure 6).

Figure 6: Services app with the PostgreSQL service selected

Once the PostgreSQL service has started again, it should be reachable from all computers within the local network (i.e. the network specified in `pg_hba.conf`).

2.2 MariaDB

2.2.1 Install Database Server

At first download the MariaDB Server installer from https://mariadb.org/download/. Choose any version ≥ 9, operating system "Windows", architecture "x86_64" (32-bit Windows is not supported) and the package type "MSI Package".

Once the download finished, run the installer:

1. **Welcome to the MariaDB Setup Wizard:** Click "Next".

2. **End-User License Agreement:** Accept the license agreement and click "Next".

3. **Custom Setup:** Choose which components should be installed as well as the location that MariaDB should be installed into.

   a. For this guide, make sure to install at least the features "Database instance", "Client Programs" and "HeidiSQL". All other features are optional.

   b. Stick with the default installation location `C:\Program Files\MariaDB XX.X\` unless you want to install MariaDB somewhere else.

4. **User settings:** On this page, you will have to choose a password for the MariaDB root user and choose a data directory.

   a. Make sure that the "Modify password for database user 'root'" checkbox is selected and enter a password for the root user. Remember the password or write it down. **Make sure to use a secure password!**

   b. Make sure that the "Enable access from remote machines for 'root' user" is **<u>not</u>** selected.

   c. Choose a data directory where MariaDB can store its data. You can choose a custom location or keep the default location.

   > **Note:** You will need this directory when performing backups, so you should choose an easily accessible location.

5. **Database settings:** Leave all settings on their defaults. You can change the port, if port 3306 is already used by another application on your computer. Click "Next".

6. **Ready to install MariaDB:** Click "Install" to install MariaDB.

The MariaDB server is now installed and running in the background. The server starts automatically whenever you start your computer and log in. There is no need to start it manually.
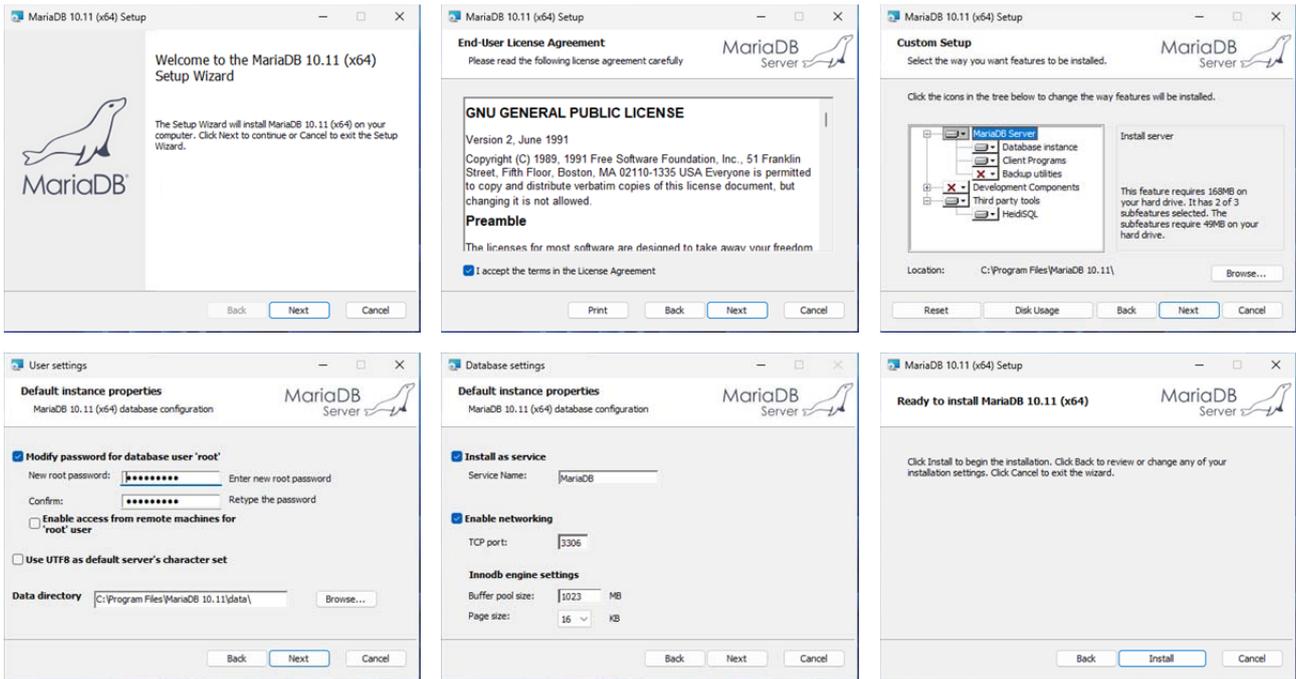
Figure 7: MariaDB installation procedure

2.2.2 Create a User and a Database for FCT-22

Now that the MariaDB server is installed, we can create a database for FCT-22. We are going to use HeidiSQL – a tool for managing SQL servers – since it is already part of the MariaDB installation.

Open HeidiSQL from the Windows start menu, "All Apps" → "MariaDB XX.X (x64)" → "HeidiSQL". Click on "New" in the bottom-left corner, enter a name for the connection and then set the following fields in the tab "Settings" on the right side (see Figure 8):

Network type: "MariaDB or MySQL (TCP/IP)"
Library: "libmariadb.dll"
Hostname / IP: `127.0.0.1`
User: `root`
Password: *Password chosen in 2.2.1, step 4.a*
Port: `3306` *(or the port chosen in 2.2.1, step 5)*
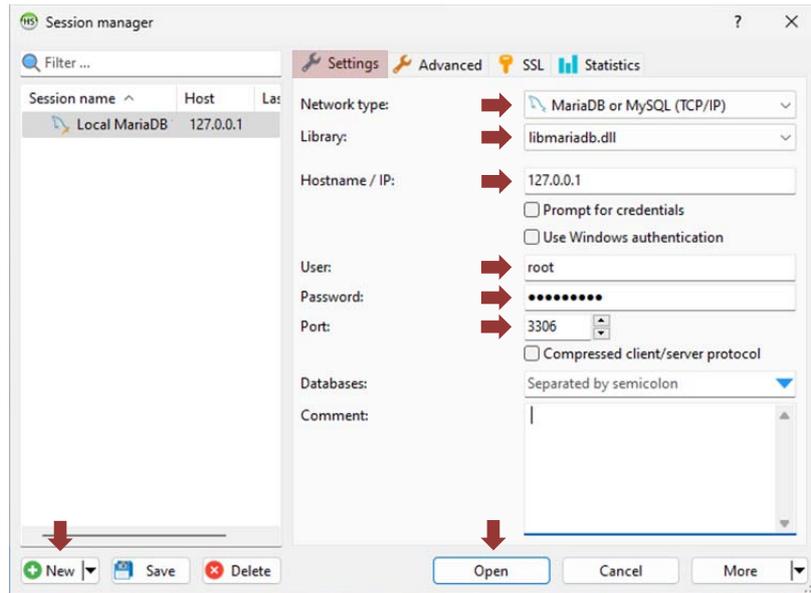
Figure 8: HeidiSQL Session Manager Settings

Click on the button "Save" and then "Open" to connect HeidiSQL to the MariaDB database server.

Note: If HeidiSQL shows the error "Library libmariadb.dll could not be loaded." when trying to connect, change the field "Library" to "libmysql.dll" and try again.

2.2.2.1 Create a Database

We can now create a database for FCT-22:

1. Right-click on the top-level entry in the left sidebar (in Figure 8 called "Local MariaDB") and choose "Create new" → "Database".

2. Once a new window "Create database…" pops up, enter `fct_22` into the field "Name" and click on "Ok".
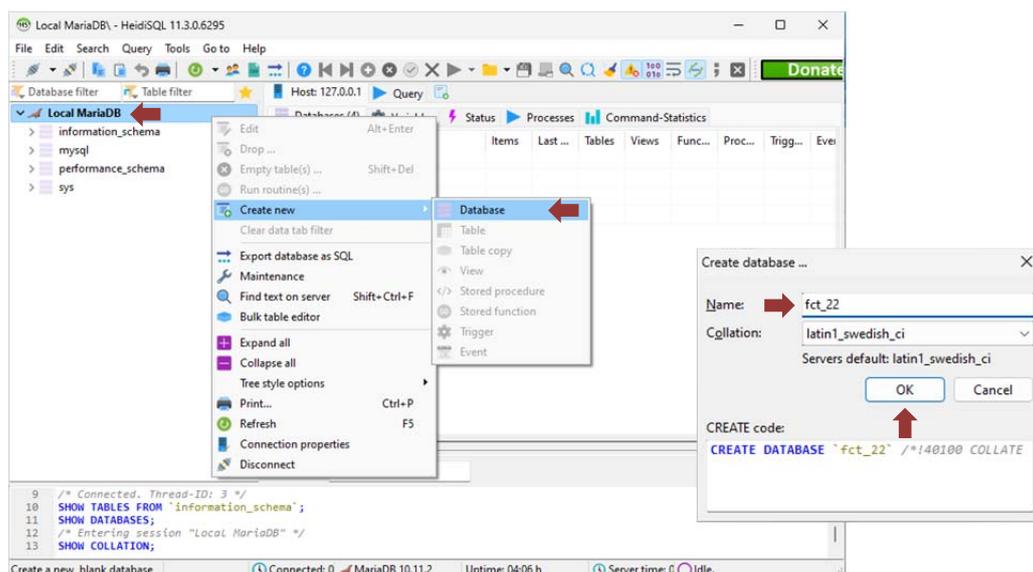
Figure 9: Creating a database in HeidiSQL

2.2.2.2   Create a User

Next, we will create a MariaDB user with limited permissions. That way FCT-22 doesn't get access to the entire MariaDB server and can instead only access its own database:

1. Open the user manager from the top menu bar: "Tools" → "User manager".

2. Click on the button "Add" in the top left corner.

3. In the tab "Credentials" enter `fct_user` as "User name" and a password for the new user in the fields "Password" and "Repeat password". Remember the password or write it down. **For security reasons, this password should not be the same as the root user password (2.2.1, step 4.a)!**

4. Click on the button "Add object" right below the "Credentials" tab.

5. In the window that opens, select the entry "fct_22" and click on "Ok".

6. Activate the checkbox right next to the entry "Database: fct_22".

7. Click on "Save" and then "Close".
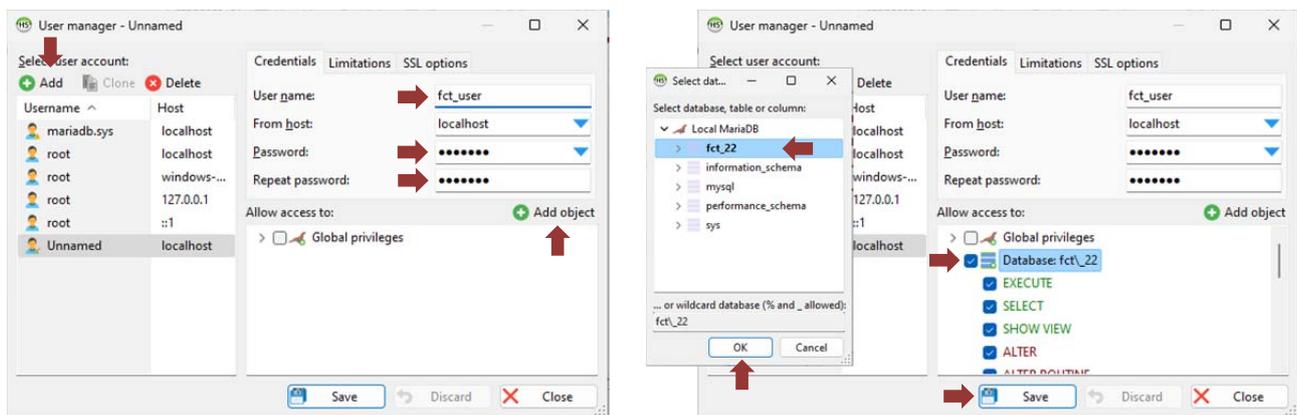
Figure 10: Creating a user in HeidiSQL

We have now successfully created a new database and user for FCT-22. Use the following credentials to login to your database from FCT-22:

DBMS:	"MariaDB or MySQL"
Server Address:	127.0.0.1
Server Port:	3306 *(or the port chosen in 2.2.1, step 5)*
Database:	fct_22
Username:	fct_user
Password:	*Password chosen in 2.2.2.2, step 3*

2.2.3 Enable Local Network Access to Database

Note (NOT RECOMMENDED): In a professional environment a SQL-server is installed on a dedicated "server PC" or runs on a professional NAS (Network Attached Storage). If – for short time test purpose – you intend to use FCT-22 on the same machine that also runs the PostgreSQL server, you can skip this section.

Currently, the MariaDB server is only reachable from the computer that runs it. If you want to access the database from another computer, you must configure the server accordingly. This guide describes how to expose the FCT-22 database to all computers within the local network.

We do not describe how to expose the database to the internet, nor do we recommend doing so, unless you know exactly what you are doing.

First, we must make sure that the MariaDB server can be reached from hosts other than the local host. To do that we need to check the defaults file `my.ini`. This file is located within the MariaDB data directory i.e., the directory chosen in 2.2.1, step 4.c. Navigate to that directory and open the file my.ini by right-clicking on it and selecting "Open with" → "Notepad".

Next, check whether one of the following two lines can be found in the file:

```
skip-networking
bind-address = [ip-address]
```

If one or both of those lines is/are in the defaults file, deactivate them by putting a `#` in front of them:

```
#skip-networking
#bind-address = [ip-address]
```

Save any changes and close the editor. If you changed the file, you need to restart the MariaDB service to load the new configuration. If no changes were made, you can skip that part:

1. Open the Services app from the start menu "All apps" → "Administrative Tools" → "Services".
2. Select the MariaDB service from the list on the right side (see Figure 11).
3. Click on "Restart the service" on the left side of the list (see Figure 11).
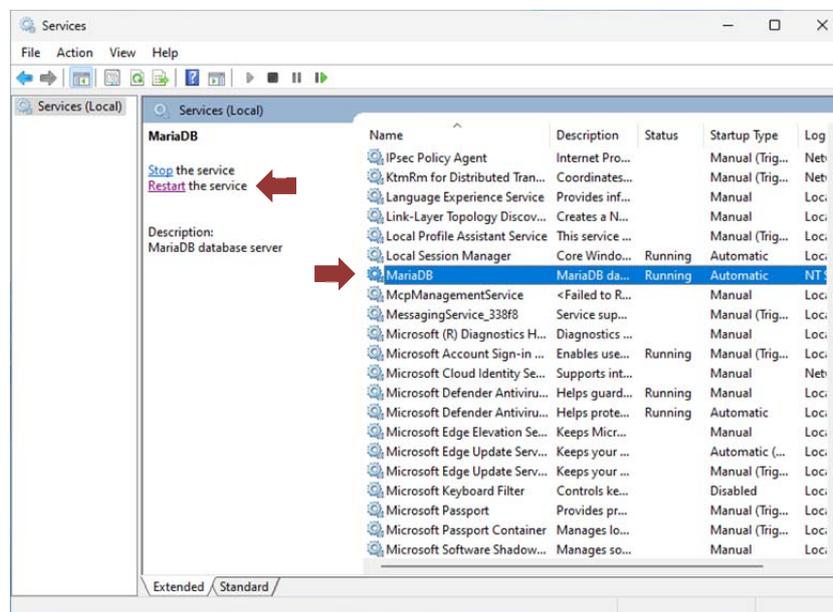
Figure 11: Services app with the MariaDB service selected

Additionally, the FCT-22 user needs permission to log in from other computers within the local network:

1. Open HeidiSQL from the Windows start menu, "All Apps" → "MariaDB XX.X (x64)" → "HeidiSQL".
2. All necessary server information and login credentials should already be filled in from 2.2.2. If not fill in the information as described in 2.2.2.
3. Click on "Open" (see Figure 8).
4. Open the user manager from the top menu bar: "Tools" → "User manager".
5. Select the "fct_user" in the left sidebar (see Figure 12).
6. In the tab "Credentials" on the right side, change the field "From host" from "localhost" to "192.168.%" by selecting "Local network: 192.168.%" from the dropdown menu.
7. Click "Save" and "Close".
8. Exit HeidiSQL.
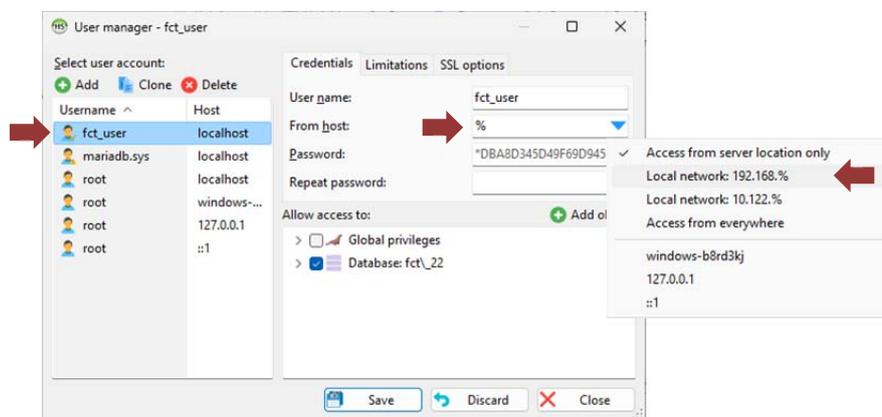
Figure 12: Grant local network access permission to "fct_user"

The MariaDB server will now allow logins from all computers with an IP address starting with *192.168,* i.e. *192.168.[...].[...].* This is a subnet commonly used for local networks however, your local network might use another subnet! In that case, change the field "From host" in step X from "192.168.%" to the correct Subnet/Prefix. For example, if your local network uses IP addresses in the range 10.5.0.0 to 10.5.255.255, then allow access "From host" "10.5.%".

How can I find the correct subnet of my local network?

Finding out the correct information might not be trivial since computers can be connected to multiple local networks. Ideally consult with your IT department or system administrator to find the right settings.

In the majority of cases however, you should be able to find the required information by following these steps:

1. Open the terminal from the start menu "All apps" → "Terminal".
2. Enter the command `ipconfig` and press the "Enter"-key.
3. In the output you can find the IP address of your computer and the subnet mask (see Figure 5).

From this IP address and the subnet mask, we can derive the correct setting for MariaDB. If the IP address of our computer is shown to be 10.5.20.3, the correct setting depending on the subnet is given in Table 2.

Table 2: Correct "From host" setting for IP address 10.5.20.3 and different subnets

Subnet	MariaDB "From host" setting
255.0.0.0	10.%
255.255.0.0	10.5.%
255.255.255.0	10.5.20.%

3 Database Backup

If the database created in this guide will be used with FCT-22 to store evaluation results, we want to make sure that the data is safe even if something goes wrong. A disk failure, software bug, or similar event could destroy the database or make the data inconsistent and therefore unusable in which case all the results would be lost.

To avoid that, regular backups should be performed. There are multiple different ways to back up databases, and you might want to investigate different approaches for you chosen database server to find the best fit for your requirements.

This guide will describe a very simple backup strategy. One way to backup all settings and data of the database server, is to back up the entire data directory. To do so, you will have to stop the database server, copy the data directory, and finally start the database server again. Backing up the data directory with the database server still running could lead to corrupted backups and is therefore not recommended.

3.1 Manual Backups

3.1.1 Stopping the Database Server

Before copying the data directory, we must stop the database server:

1. Open the Services app from the start menu "All apps" → "Administrative Tools" → "Services".
2. Depending on which database system you use, select either the PostgreSQL or the MariaDB service from the list on the right side.
3. Click on "Stop the service" on the left side of the list.
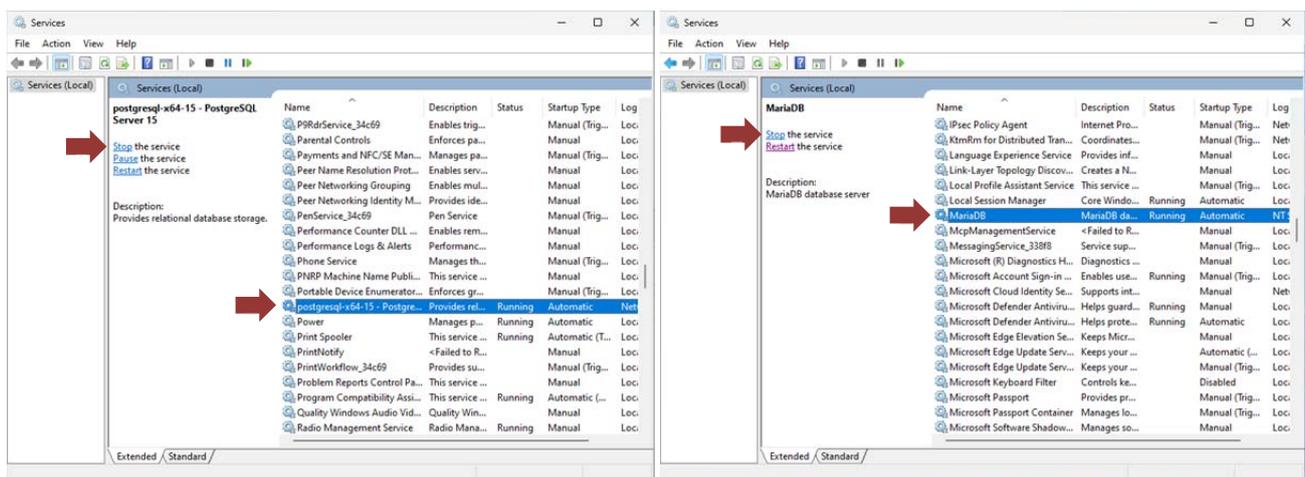
Figure 13: Stopping the PostgreSQL/MariaDB service

The database server is now stopped.

3.1.2 Copying the Data Directory

With the database server stopped, we can now create a backup by copying the data directory to a safe location (e.g., network drive, USB-Stick, cloud storage, etc.).

You chose the location of the data directory in 2.1.1 step 4 (PostgreSQL) or 2.2.1 step 4.c (MariaDB). Navigate to that location in the Windows Explorer. You can now either copy the entire data folder to a safe location, or to save space compress the entire data folder into a ZIP archive (right-click on folder and select "Compress to ZIP file") and move ZIP archive to a safe location.

> **Note:** Do <u>not</u> *move* but *copy* the data folder to a safe location i.e., the original data folder must remain at its current location. Otherwise, the database and all settings will be gone next time you start the database server.

3.1.3 Starting the Database Server

Once you have copied the data directory, you can start the database server again (similar to Figure 13):

1. Open Services app via start menu "All apps" → "Administrative Tools" → "Services".
2. Depending on which database system you use, select either the PostgreSQL or the MariaDB service from the list on the right side.
3. Click on "Start the service" on the left side of the list.

The database server is now running again, and you can continue using it. You should perform this backup routine regularly and always keep multiple backups to prevent data loss.

3.2 Automatic Backups

Backup procedures described in 3.1 can also be automated using a batch script that can then be executed automatically executed in regular intervals. **This requires additional knowledge and is only recommended for experienced users.** The below outlines what an automatic backup script might look like and how it can be scheduled for automatic execution at a predefined time.

3.2.1 Backup Script

The backup steps – stopping the database server, copying the data directory, and restarting the database server – could be automated in a batch script like ...

```
@echo off

:: Stop the database service
net stop <database-service-name>

:: Create timestamp for backup directory
:: Source: https://stackoverflow.com/a/23476347
for /f "tokens=2 delims==" %%a in ('wmic OS Get localdatetime /value') do set
"dt=%%a"
set "YY=%dt:~2,2%" & set "YYYY=%dt:~0,4%" & set "MM=%dt:~4,2%" & set
"DD=%dt:~6,2%"
set "HH=%dt:~8,2%" & set "Min=%dt:~10,2%" & set "Sec=%dt:~12,2%"
set "fullstamp=%YYYY%-%MM%-%DD%_%HH%-%Min%-%Sec%"

:: Copy the data directory to a safe location
xcopy /s/e "<data-directory-path>" "<safe-location-path>\%fullstamp%\"

:: Start the database service
net start <database-service-name>
```

where `<data-directory-path>` is the path to the data directory (2.1.1 step 4 for PostgreSQL or 2.2.1 step 4.c for MariaDB) and `<safe-location-path>` is the path to the location where the backup should be stored.

The `<database-service-name>` is the name of the database service which you can find in the Services app "All apps" → "Administrative Tools" → "Services" by looking for the PostgreSQL/MariaDB service, right-clicking on it and selecting "Properties". There you will find the "Service name" under the tab "General".

This script will stop the database server and then copy the entire data directory to a subdirectory in `<safe-location-path>` where the name of the subdirectory is the current timestamp. Finally, it restarts the database server.

Save the script in a file with the ending .bat using the Windows "Notepad" app or some other code editor. You can check whether it is working correctly, by double clicking on the script which will execute it.

3.2.2 Scheduling the Backup Script

For now, we must manually run the backup script to create a backup. Using the Windows "Task Scheduler" we can automate this task and run the script every day at a certain time without any user interaction.

To do that, open the Terminal from the start menu "All apps" → "Terminal". Then run the following command to create a scheduled task, replacing `<backup-script>` with the path to your backup script:

```
schtasks.exe /create /tn "Database Backup" /sc daily /st 00:03 /tr <backup-script>
```

This will create a new task called "Database Backup" that runs the backup script daily at 3am, thus creating regular backups of the database.

Note: As mentioned above, the backup script creates a new folder for each backup with the current timestamp as name. That way you can easily see the date and time at which the backups have been created. The backup script however does not delete old backups. Old backups must therefore be removed manually. Always keep at least a few old backups in case that data loss occurred unnoticed.

4 FCT-22 Installation and Configuration

4.1 Prepare Directory Structure

(1) Create a new folder (e.g. `.../config`) to store the FCT-22 configuration files. In a multi-user environment, we recommend a folder on a file server (file share).

(2) Create two folders (e.g. `.../results/files` and `.../results/images`) for the FCT analysis output files, one for text files and one for the processed images. In a multi-user environment, we recommend a folder on a file server (file share).

The directory structure below is a recommendation ONLY, based on our experience. However, we strongly recommend separating the ASI raw images from the FCT-22 configuration and evaluation files/images.

The directory structure must be set up BEFORE the initial setup of the FCT software.

4.1.1 Recommended Setup with network share

The figure below depicts the recommended setup. A file server stores the ASI images, FCT configuration, and FCT evaluation results on a physical drive. The ASI image directory *asi16_data* is shared via an FTP server running on the file server, allowing the ASI to upload its images to the directory. Additionally, the entire structure i.e. the root directory *share* is shared with the client PC running the FCT via a Windows file share. This setup allows the client PC to get the ASI images as soon as they become available and facilitates sharing them between multiple clients in a multiuser setup.

Note, that this setup is recommended for most users but is not the only possible setup. An alternative setup without a file share is described in the next section.
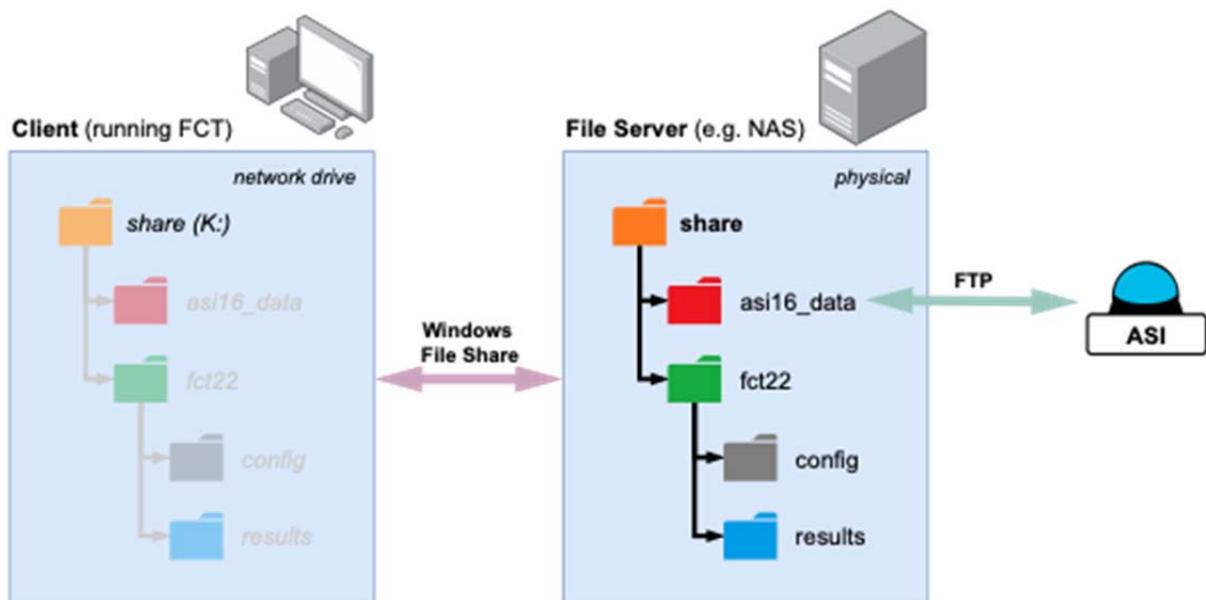
Orange	File share root directory. This directory is physically located on the file server (e.g. a continuously running PC or NAS) and shared with the client PC running the FCT via a file-sharing service like Windows file share.
Red	ASI-16 image directory. The ASI uploads its images directly into this directory. This can be achieved by setting up an FTP server on the file server that shares the directory. Since the directory is also located within the file share root directory, it will be shared over the Windows file share allowing the client to access new images as soon as they arrive.
Green	FCT directory containing the configuration (`config`) and the evaluation results (`results`). These directories must be created manually, before setting up the FCT.
Grey	FCT configuration directory, to be selected when setting up the FCT. Camera subfolders (*asi_16115*, ...) will be created automatically by the FCT during the initial setup.
Blue	FCT evaluation result directory used for data files and processed images generated by the FCT. This directory must contain two subfolders, one for evaluation images and one for the evaluation data files. The FCT will create camera subfolders (*asi_16115*, ...) automatically to sort the evaluation artifacts by camera.

To recreate the setup illustrated above, create a new directory *share* on the file server and add the subfolders *asi16_data* and *fct22* with the folders *config* and *results* as shown above. Also, create two subfolder *images* and *files* in the newly created *results* directory.

Next, set up an FTP server that shares the *asi16_data* directory. Add the FTP server's URL and login credentials to the ASI's "Imager" → "Storage" → "Data Storage" configuration page under "Server Settings" (red). Also fill in the folder name (green), which will depend on the directory that the FTP server shares. If the FTP server shares the *asi16_data* directory as in the example setup, fill in "/".
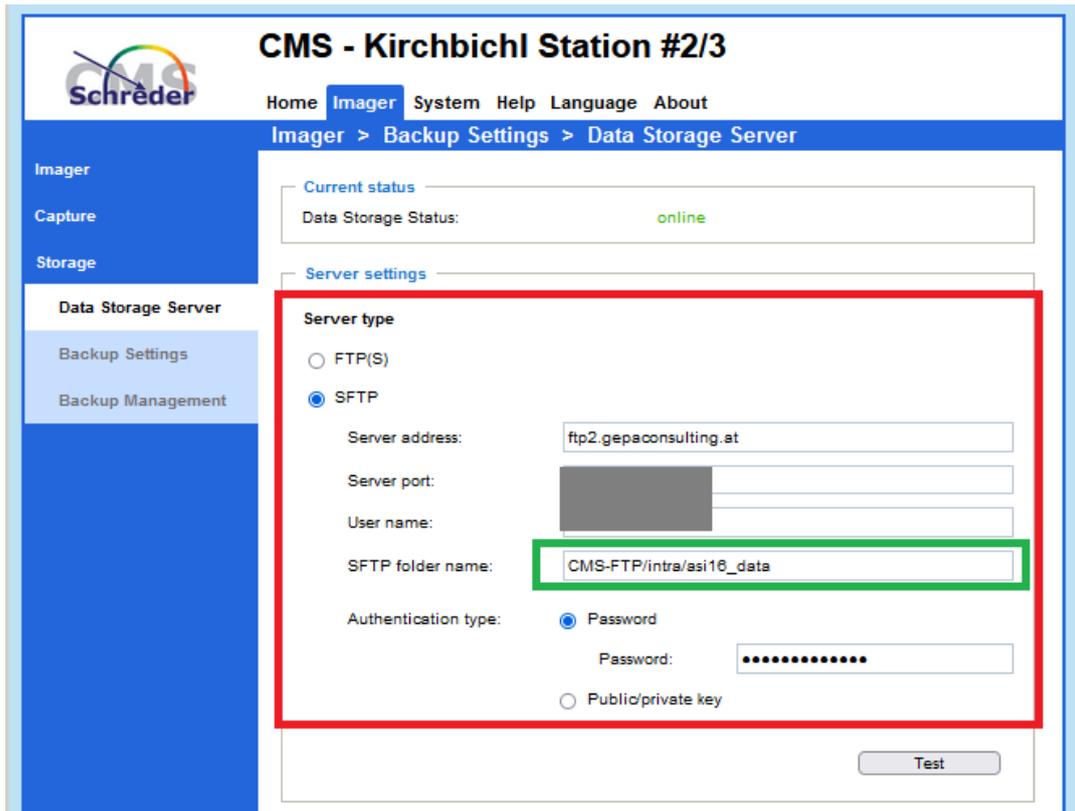
At this point, new images from the ASI are uploaded to the *asi16_data* directory on the file server. To complete the example setup, share the *share* directory on the file server using a Windows file share. On the client, add this file share as a network drive.

If those steps are performed correctly, the client should show a new (network) drive containing the folder structure from above, like the screenshot below.
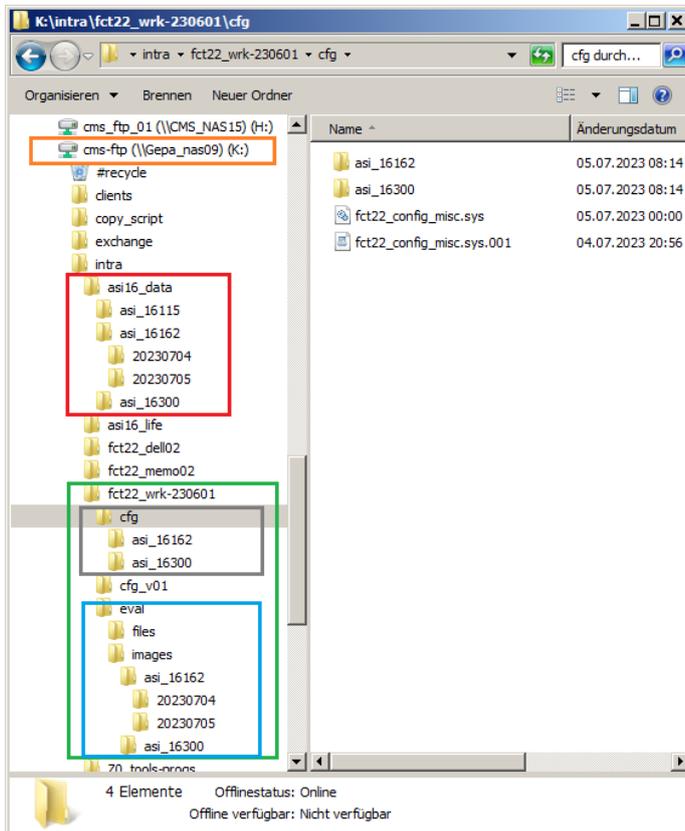
4.1.2 Recommended setup with local FTP synchronization

Some users might be unable to set up a network share on the same directory as the FTP server. In this case, it is possible to use a local directory for the ASI images instead and synchronize it with the FTP server using the open-source FTP client *WinSCP*. With this setup, the ASI images can be stored on any FTP server eliminating the need for a dedicated server running an FTP and file share service.
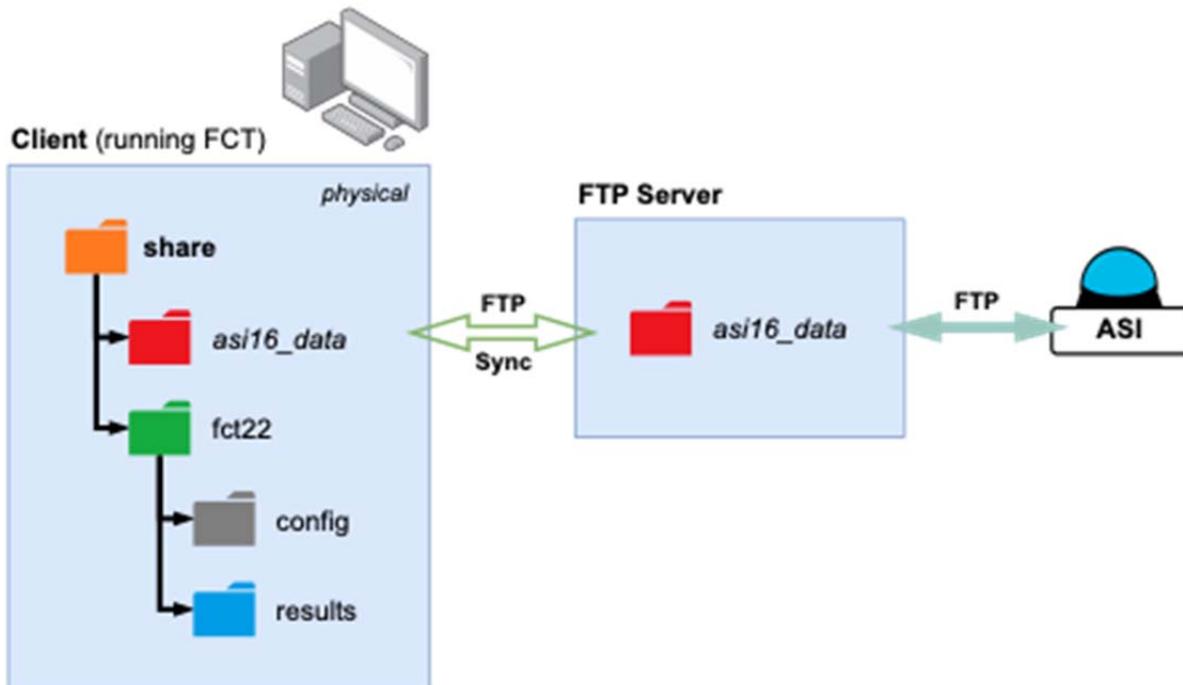
To use this setup, first create the directory structure (*share*, *asi16_data*, *fct_22*, etc.) somewhere on the local drive of the client running the FCT. Next, you must set up a continuous synchronization of the local *asi16_data* directory with the *asi16_data* directory on the FTP server. This will ensure that the images uploaded by the camera to the FTP server also appear on the local drive.

Download and install the WinSCP client from https://winscp.net/. To set up the automatic synchronization, open the Windows *Task Scheduler* and click "Create Task..." in the right sidebar. In the dialog that opens, choose a descriptive name for the task. Then, change to the "Trigger" tab and click "New...". Set the trigger type to "Daily" and set the "Start" time to *00:00:00*. Activate the "Advanced settings" → "Repeat every" option and set the repetition interval to *1 minute*. Click "OK" to add the new trigger. This trigger will execute the task once every minute. For some use cases, that might be sufficient but – especially for the live evaluation of new images – a shorter update interval is preferable. To reduce the update interval to 30 seconds, add another trigger by clicking on "New..." again and follow the steps above again with one difference: instead of setting the "Start" time to *00:00:00* like before, set it to *00:00:30*.

After creating the triggers, go to the "Actions" tab and add a new action by clicking "New...". Use the "Browse..." button to select the WinSCP executable. Finally, add the following arguments

```
/command "open sftp://user:password@ftp-url.com:port/" "synchronize both
-transfer=binary  C:\path\to\local\asi16_data /ftp/path/to/asi16_data"
"exit"
```

replacing the FTP **username**, **password**, **URL**, and **port** as well as the paths to the **local** and **FTP** *asi16_data* directory. Afterward, click "OK" twice to add the new action and task. The task should now be active and synchronize the local and the FTP *asi16_data* directory every 30 seconds.

4.2 Setup and configure ASI-16 All-Sky-Imager

Please read and follow the instructions in the latest "Release Notes" and in the "ASI-16 User Manual". Setting up the ASI-16 requires you to configure multiple settings in the CMS CRM portal, especially...

- Operation site name and site address (descriptive text).
- GPS data (latitude, longitude, elevation) and the local time zone of the operation site.
- Network data storage server (FTP/SFTP) configuration (see 4.1.1).
- Shooting Template, compatible with the desired FCT analysis functions.

Afterward, perform the following steps to get the ASI up and running.

(1) Check all data in the CRM again and press "Update".
(2) In your office (!) connect the ASI to your LAN, and power it on.
(3) Read the "Release Notes", follow the instructions, start the "ASI-Manager", and run a "FULL RESET".
(4) Open the ASI web interface in your web browser and double-check all settings. Also, check the FTP connectivity.
(5) In your FTP server data directory (e.g. `.../asi16_data`) look for the imager's directory and check whether images have been/are being uploaded correctly.

4.3 FCT-22 Software – Download and Installation

Open https://service.schreder-cms.com/crm in your browser and log in with your username and password. Navigate to "Downloads" and scroll down until you find the download link for the "FCT-22 Findclouds_Trinity" software. Click on the Download button on the right-hand side.

After downloading and unpacking, run the "FCT-22_Installer.exe" binary to install the FCT on your system.

- Read and agree to the EULA (End User License Agreement).
- Define the installation directory for the program files.
  Recommendation: Keep "Program Files", as set by default.
- Define the "Configuration Folder" where the FCT-22 will store its configuration files. In the example configuration presented in 4.1.1 you would choose the `K:/fct22/config/` directory on the network drive.
- Start installation and complete FCT-22 setup.
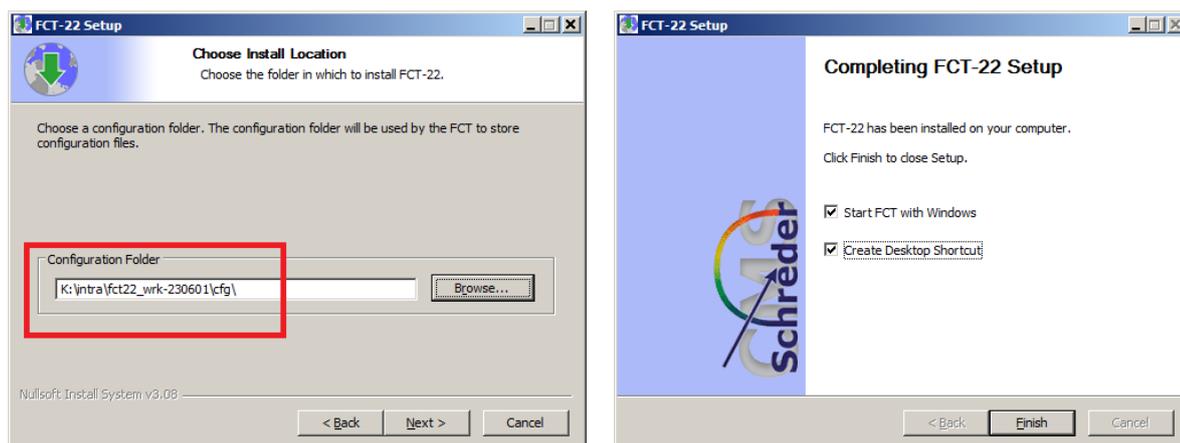
4.4 FCT-22 Software – Initial Setup and Configuration

For the initial setup, start the FCT-22 software. If asked, choose the configuration folder where the FCT will store its configuration (only if not already set during installation).

Next, enter the database server information in the "Database Configuration" window. For further information on how to set up a database server see section 2.

Click *Save and Test*. The FCT should now update the database. After the update is complete, the main window should open. Now perform the configuration steps described in the following sections. As a rule, after making any configuration change, close the FCT, restart it, and check if everything works.

4.4.1 Step 1: "Camera and Directory Definition"

- Click *Add*, and select a raw image data root directory (./asi_data/asi_16123).
- Select the root directory for "Evaluation files" (./fct22_wrk-230601/eval/files).
- Select the root directory for "Evaluation images" (./fct22_wrk-230601/eval/images).
- Click on *Ok* to store settings for this specific imager.
- Repeat the above procedure for all imagers.

4.4.2 Step 2: "Configuration Cameras"
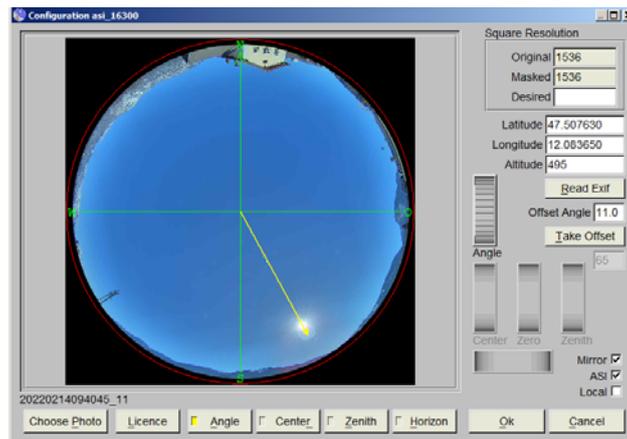
Look for an image from a day with few to no clouds around noon where the sun is clearly visible. Copy this image to the imager's root data directory, i.e. the parent directory of the date folders. This makes it easier to find the images as they are necessary for the camera configuration.

Follow the instructions in the FCT-22 user manual. Adjust the "Angle" and set the "Horizon". We recommend NOT changing other numeric parameters unless required.

After configuring each imager, close and restart FCT, and check if the new imager shows up in the main window.

4.4.3 System Configuration:
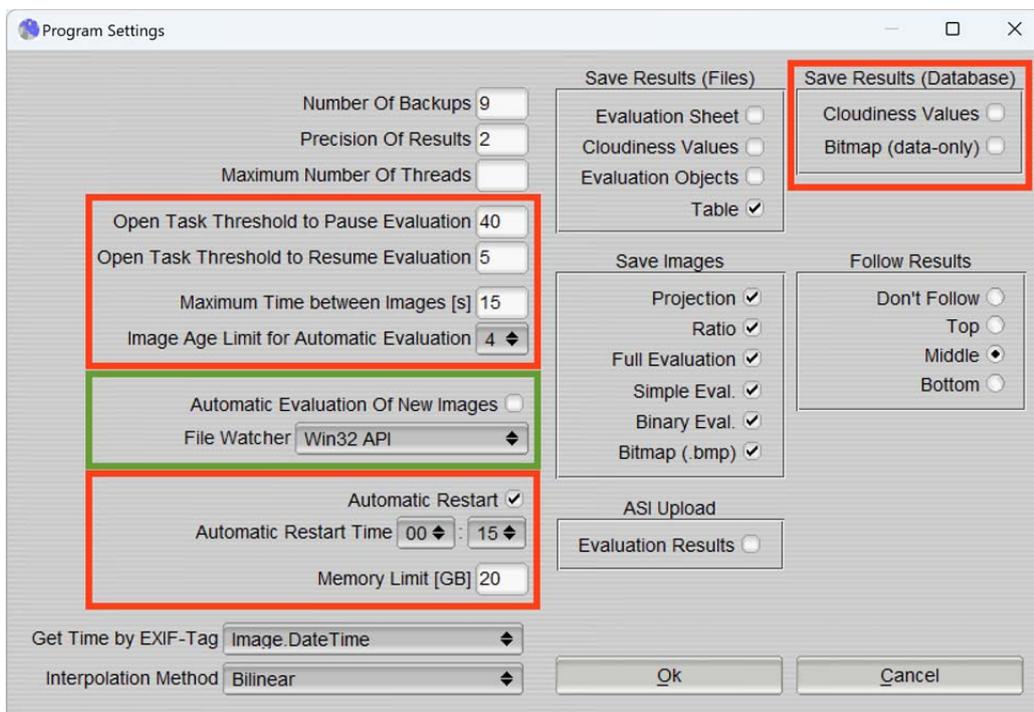
Green box: Check *Automatic Evaluation Of New Images* for continuous real-time evaluation of new images.

Save Results (Files) and *Save Images*: Select which results should be stored in TXT/CSV files and images. Use *Save Results (Database)* to store cloudiness values or the bitmap in the database. The other results are stored in the database by default.

Other parameters: Do not change without need.

4.4.4 Pair Definition (only if two imagers are mounted as "CBH-Pair"):

Only applicable if two close imagers should be used as a pair for cloud height estimation. Follow the instructions in the FCT-22 user manual.

4.4.5 Configuration Cloud Motion:

Set the *Maximum Time Between Motion Images [s]* to 20 seconds. In the ASI-16 Web GUI, set the shooting interval to 15 seconds.

This parameter is critical for the Automatic Evaluation in general, not just for CMV!
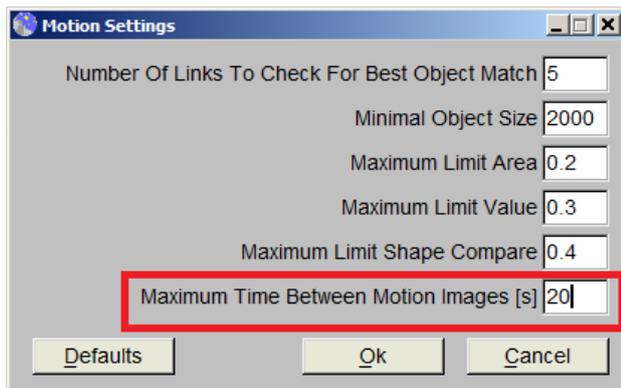
4.5 FCT-22 Software – ASI Web Interface Live Data

The ASI can display the most recent evaluation results from an ongoing automatic evaluation on the web interface's main page (red).
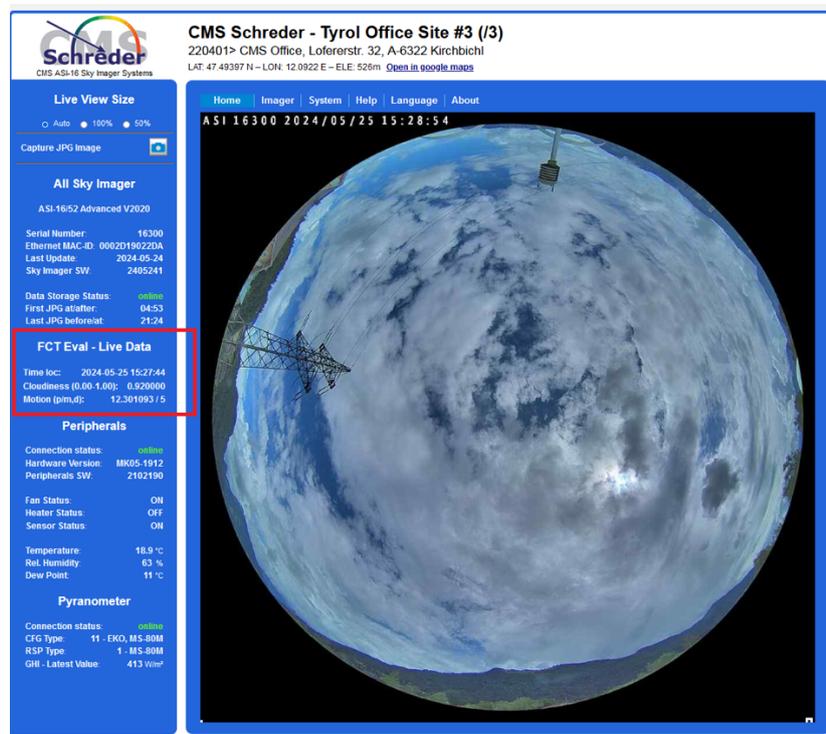
If this feature is activated, the FCT will save a small text file in the ASI's image directory which contains the most recent evaluation results for this ASI. Thus, this function only works if the ASI can access this file i.e. if the communication between the image directory accessible by the FCT and the ASI works in both directions. Using the recommended setup described in 4.1.1 ensures this.

To set up the live data, first activate the upload of the "Evaluation Results" (red) in the FCT-22 "Program Settings".
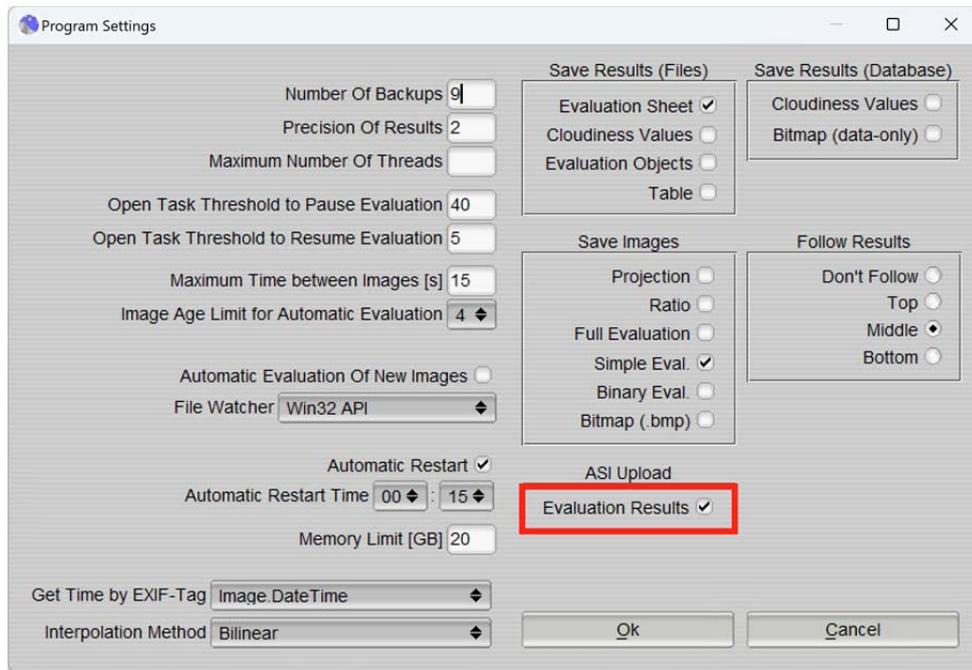
Next, open the ASI web interface and navigate to "System" → "Maintenance" → "FCT Eval - Live Data". Here you can choose how often the evaluation results are checked/updated ("Interval"), how long they should be retained if no new results are published ("Keep for min.") and which time zone should be used when displaying the date and time ("Time zone").
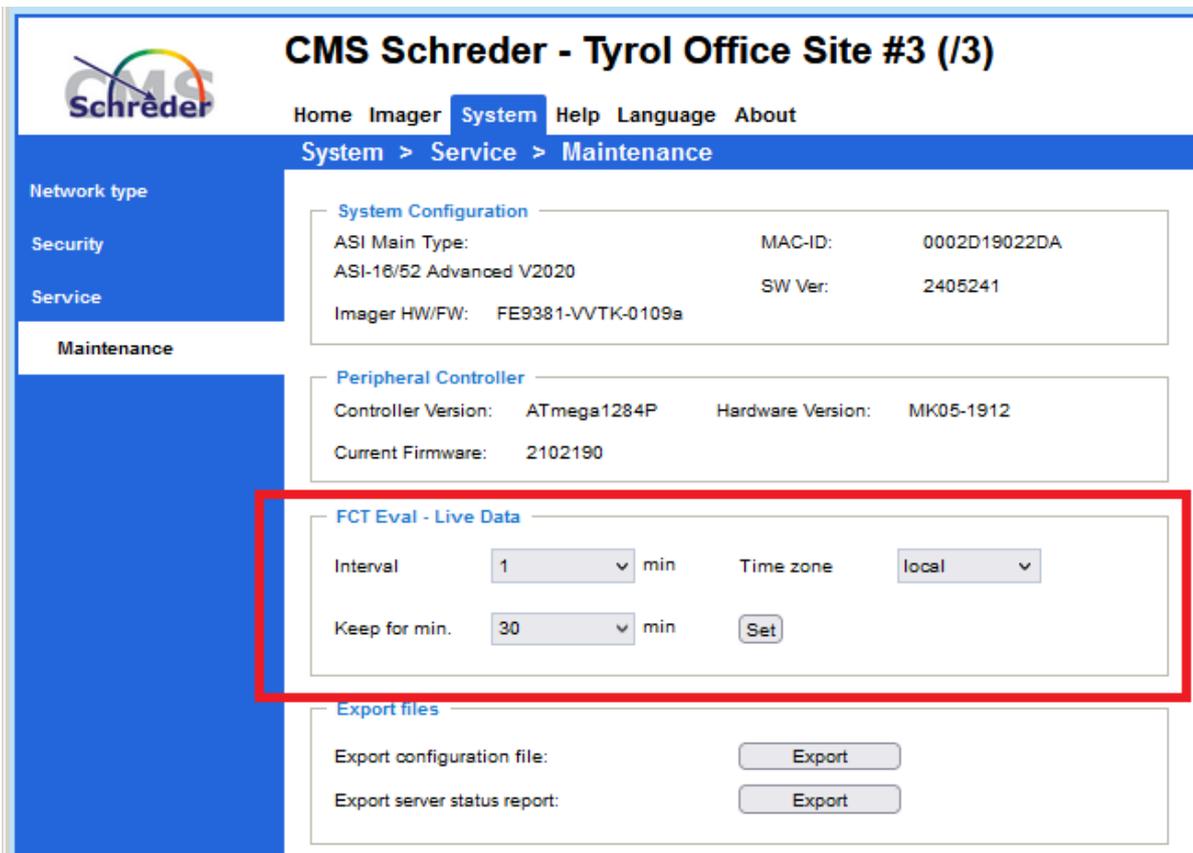
5 Attachments

5.1 Sample Network Configuration

Describes typical components (Router, ASI-16, Fileserver, DB-Server, PC workstation), LAN connectivity, and network protocol dataflow in a larger "reference" environment.

5.2 FCT-22 DB Table Chart

Database tables, keys, and relations. - Necessary to define nested joins in SQL scripts.

5.3 FCT-22 DB Tables and Columns

A detailed description of the tables and all their columns. Necessary to create SQL scripts.

HTTP/s (Monitoring, Config, ASI-Manager SW Updates

ASI-16
using S/FTP
and HTTP/S

ASI-16
using S/FTP
and HTTP/S

Monitoring PC
& Service PC
(ASI-16, others)

S/FTP (ASI Data: Raw JPG Images, Periph. Data)

"FS (FileShare"): A network drive on a fileserver,
with associated Drive-Letter on on the PC's. - One
FileShare shall be the data storage folder for
customer's S/FTP server, holding ASI raw images.
Another FileShare shall hold processed images.

DB: SQL Database, for next generation of FCT SW.
In the future, FCT will store numeric data in a DB.
Initally FCT will work with "postgres" databases.

LAN ROUTER

FS (jpg): Raw sky images
FS (csv): Sensor Data files

FS / DB: FCT Numeric Cloud Evalution Data
FS / DB: FCT Processed False Color Images

FS (csv, txt) / DB: Numeric Eval. Data
FS (bmp) / DB : False Color Images

Customer's Post Processing Data

CMS FCT-19 / FCT-22
Cloud Analysis SW
for Pre-Processing
(HW not by CMS)

NAS (Server-PC)
S/FTP Server, SQL DBServer,
Fileserver, Timeserver, ...
(HW/SW/NET not by CMS)

Customer / Third Party
Post Processing SW
(Not by CMS)

Satellite

Temporarily:
Laptop, Tablet,
using ASI-Manager,
fileshare, browser.

Optional:
WIFI Hotspot for
more easy access

MODEM
LDE + SIM Card
Satellite Uplink
MW Radio Relay
(WiFi Modem)
(PowerLine)

GPRS, LDE, ...

Internet Cloud

MW Radio Link

HTTP (Web Browser for Config), FileShare (for Data).

HTTP (Web Browser for Life Check), ASI-Manager.

LOCAL ROUTER
DHCP and HW FW
Set fixed IPs here!
Port forwarding
(Local NTP server)

Small UPS
> 100 VAh

Company Main Building
Local Building / Substation

S/FTP (ASI data)

NAS RAID-1 Storage
2x4TB - FileShare
S/FTP Server
Fileserver, ..., ...

ASI-16 Imager
using (S/)FTP
and HTTP(/S)

Highly recommended:
Local NTP Time Server
GPS or LW radio clock

Maybe only:
Some local PC
(web browser)

Red line connections: Minimum requirements; Black dashed line connections: Optional, temporarily;

Operative example: LAN/NAS/PC/ASI setup at GEPA CONSULTING (Gerhard Papst) site in Styria/Austria, >500km distance to CMS Schreder office site.

asi_16008
...151.78
Gepa Site

asi_16162
...151.72
Gepa Site

LDE/4G
"Mobile Intern

asi_16115
CMS Schreder Site
Distance: >500 km
Connection to ASI:
CMS-DDNS/VPN

LDE/4G
"Mobile Internet"

asi_16300
CMS Schreder Site
Distance: >500 km
Connection to ASI:
CMS-DDNS/VPN

LDE/4G Modem
Via public mobile
internet provider.
30 mbit up/down

Primary NAS 09
---.---.151.231
S/FTP Server
SQL Server (DB)
Fileserver (FS)
Multimedia Server
12 TB Raid-5 (5 HDD)

Backup NAS 15
---.---.151.235
Backup for NAS09
4 TB Raid-1

DB Server PC
---.---.151.233
PostgreSQL DB
CMS FCT-22
0,5 TB SSD
1 TB Raid-1

ADSL - Landline Internet

ADSL Landline Modem

MAIN ROUTER
---.---.151.212
DHCP, Firewall,
VPN, ...

DAVIS Vantage Pro2
---.---.151.83
Weather Station
TRH, BP, Rain, Wind,
GHI, GHI UV, ...

Application PC
---.---.151.185
CMS FCT-22
0,5 TB SSD

Office PC #1
---.---.151.181
Office Software
Web Browser
Remote Desktop
ASI-Manager
Postgres Admin
HeidiSQL App
...

Office PC #2
---.---.151.182
Office Software
Web Browser
Remote Desktop
ASI-Manager
Postgres Admin
HeidiSQL App
...

Office PC #3
---.---.151.183
Office Software
Web Browser
Remote Desktop
ASI-Manager
Postgres Admin
HeidiSQL App
...

Lenovo Laptop
---.---.151.114
Office Software
Web Browser
Remote Desktop
ASI-Manager
Postgres Admin
HeidiSQL App
...

WiFi Hotspot
---.---.151.217

Not shown: Scanner/Printer (.215), PLC (.191), 8P Switch (.217); 16P PoE Switch (.219); 8P Switch (.124): APC UPS; two small NAS, multimedia devices, ...

CMS FCT-22_DB - "Findclouds Trinity"
Cloud Analysis Software with SQL Database Interface

SQL Database - Primary Tables, Keys and Relations

client

PK	client_id: int
	description: varchar(30)

evacfg

PK	evacfg_id: int
	client_id: int
	description: varchar(30)

errors

PK	error_id: int
	cam_id: int
	image_id: int
	error: varchar(2056)

migrations

PK	name: varchar(100)
	migrated: datetime

cameras

PK	cam_id: int
	name: varchar(12)

date_list

PK	date_id: int
	cam_id: int
Text	date: varchar(12)

image_list

PK	image_id: int
	cam_id: int
	filename: varchar(255)

eval_numeric

PK	eval_id: int
	cam_id: int
	image_id: int
	evacfg_id: int
	client_id: int
	angular_area: double

cloud_dens

PK	cdens_id: int
	eval_id: int
	value: double

TABLE_NAME	COLUMN_NAME	COLUMN_TYPE	KEY	DESCRIPTION (also see FCT-22 user manual, suppl.)
cameras	cam_id	int(10) unsigned	PRI	primary key
cameras	name	varchar(12)		ASI imager name (ASI serial number); e.g. "asi_16234"
cameras	timstmp	datetime		dataset timestamp
date_list	date_id	int(10) unsigned	PRI	primary key
date_list	cam_id	int(10) unsigned	MUL	reference key
date_list	date	varchar(12)		image date folder; e.g. "20230317"
date_list	timstmp	datetime		dataset timestamp
date_list	image_files	int(10) unsigned		number of images at that date folder
image_list	image_id	int(10) unsigned	PRI	primary key
image_list	cam_id	int(10) unsigned	MUL	reference key
image_list	filename	varchar(255)		image filename (date-time), e.g. "20230317110615_11.jpg"
image_list	timstmp	datetime		dataset timestamp
eval_numeric	eval_id	int(10) unsigned	PRI	primary key
eval_numeric	image_id	int(10) unsigned	MUL	reference key
eval_numeric	cam_id	int(10) unsigned	MUL	reference key
eval_numeric	evacfg_id	int(10) unsigned	MUL	reference key
eval_numeric	client_id	int(10) unsigned	MUL	reference key
eval_numeric	angular_area	double		see FCT-19/22 user manual
eval_numeric	angular_distance	double		see FCT-19/22 user manual
eval_numeric	cloudiness	double		see FCT-19/22 user manual
eval_numeric	humidity	int(11)		see FCT-19/22 user manual
eval_numeric	irradiance	int(11)		see FCT-19/22 user manual
eval_numeric	temperature	double		see FCT-19/22 user manual
eval_numeric	direction	double		see FCT-19/22 user manual
eval_numeric	motion_diameter	int(11)		see FCT-19/22 user manual
eval_numeric	motion_seconds	int(11)		see FCT-19/22 user manual
eval_numeric	motion_x	double		see FCT-19/22 user manual
eval_numeric	motion_y	double		see FCT-19/22 user manual
eval_numeric	sun_azimuth	double		see FCT-19/22 user manual
eval_numeric	sun_elevation	double		see FCT-19/22 user manual
eval_numeric	sun_inside	int(11)		see FCT-19/22 user manual
eval_numeric	sunflag	int(11)		see FCT-19/22 user manual
eval_numeric	velocity	varchar(50)		see FCT-19/22 user manual
eval_numeric	zenith_angle	double		see FCT-19/22 user manual
eval_numeric	heights	varchar(50)		see FCT-19/22 user manual
eval_numeric	fctsw_ver	varchar(18)		see FCT-19/22 user manual
eval_numeric	sun_pos_x	int(11)		see FCT-19/22 user manual
eval_numeric	sun_pos_y	int(11)		see FCT-19/22 user manual
eval_numeric	bitmap	blob		False color image, bitmap 256x256 px; see manual;
eval_numeric	motion_x_norm	double		Motion vector X, px/min, normalized to bitmap 256x256;
eval_numeric	motion_y_norm	double		Motion vector Y, px/min, normalized to bitmap 256x256;
eval_numeric	timstmp	datetime		dataset timestamp
cloud_dens	cdens_id	int(10) unsigned	PRI	primary key
cloud_dens	eval_id	int(10) unsigned	MUL	reference key
cloud_dens	value	double		see FCT-19/22 user manual
cloud_dens	area	double		see FCT-19/22 user manual
cloud_dens	timstmp	datetime		dataset timestamp
errors	error_id	int(10) unsigned	PRI	primary key
errors	cam_id	int(10) unsigned	MUL	reference key
errors	image_id	int(10) unsigned	MUL	reference key
errors	error	varchar(2056)		Error code and description, see FCT-22 user manual
errors	timstmp	datetime		dataset timestamp
client	client_id	int(10) unsigned	PRI	primary key
client	description	varchar(30)		Name/description of user/departement
client	comment	text		Further explanation/comment
client	timstmp	datetime		dataset timestamp

| TABLE_NAME	COLUMN_NAME	COLUMN_TYPE	KEY	DESCRIPTION (also see FCT-22 user manual, suppl.)
evacfg	evacfg_id	int(10) unsigned	PRI	primary key
evacfg	client_id	int(10) unsigned	MUL	reference key
evacfg	description	varchar(30)		Name/description of evaluation project/setting
evacfg	comment	text		Further explanation/comment
evacfg	timstmp	datetime		dataset timestamp
migrations	version	bigint(20) unsigned		Version of fct-22 database table structure
migrations	name	varchar(100)		Content of fct-22 database table structure
migrations	migrated	datetime		dataset timestamp

5.4 Cloud Density Bitmap File (.bmp, DB):

The cloud density bitmap contains the calculated cloud density values. When activated in the FCT Program Settings, it will be stored as...
(a) a standard 4BPP indexed bitmap file (.bmp), and/or
(b) a binary blob in the "eval-numeric" table in the database.

The bitmap uses indices to represent the different cloud densities (five categories), clear sky, invalid areas, and the sunmask. A color table is added as well, such that the BMP image file can be easily looked at in a standard image viewer. Third-party applications (e.g. "Nowcasting Software") can easily load the segmentation results by reading the indices directly from the bitmap pixel array.

File Type:	BMP-File (.bmp);
Size:	256 x 256 pixel;
Bits-per-Pixel:	4;
File size:	~ 33 KB
DB data type:	BLOB
Size:	256 x 256 half-bytes; 32768 bytes
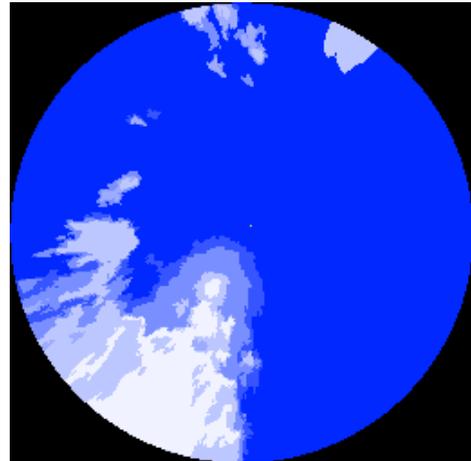
Pixel array:
The pixel array is stored *TOP-DOWN*, meaning that the first half-byte of the array represents the pixel on the top left corner. This is why the height is set to a negative value.
See "https://en.wikipedia.org/wiki/BMP_file_format#Pixel_array_(bitmap_data) for further information about the BMP file format.

5.4.1 Pixel Index Interpretation

Index	Hex	Interpretation	Color
0	0	Clear Sky	■ RGB(0, 40,255)
1	1	Cloud 1 (*sparse*)	■ RGB(54, 85,255)
2	2	Cloud 2	■ RGB(122,143,255)
3	3	Cloud 3	■ RGB(156,171,255)
4	4	Cloud 4	■ RGB(189,199,255)
5	5	Cloud 5 (*dense*)	□ RGB(255,255,255)
6	6	*Reserved*	-
7	7	*Reserved*	-
8	8	*Reserved*	-
9	9	*Reserved*	-
10	A	*Reserved*	-
11	B	*Reserved*	-
12	C	*Reserved*	-
13	D	Sunmask	■ RGB(255,255, 0)
14	E	Sun Center	■ RGB(255, 0, 0)
15	F	Empty Area	■ RGB(0, 0, 0)

"Sun Center":
A single pixel (value 15), indicating the center point of the sun disk.

"Sunmask":
A circular area around the sun center, where reliable cloud density data is unavailable.
Such areas likely should be ignored by customers' software.

"Empty Area":
Not part of the original fisheye image or masked by the horizon mask. Such areas likely should be
ignored by customers' software.

EULA – (V03)
<u>SOFTWARE END USER LICENSE AGREEMENT</u>

<u>CMS Ing. Dr. Schreder GmbH. - Lofererstrasse 32, A-6322 Kirchbichl - AUSTRIA</u>

THIS IS A LIMITED LICENSE-TO-USE, NOT A SALE.

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