Temperature Compensation User's Guide

August 21, 2002
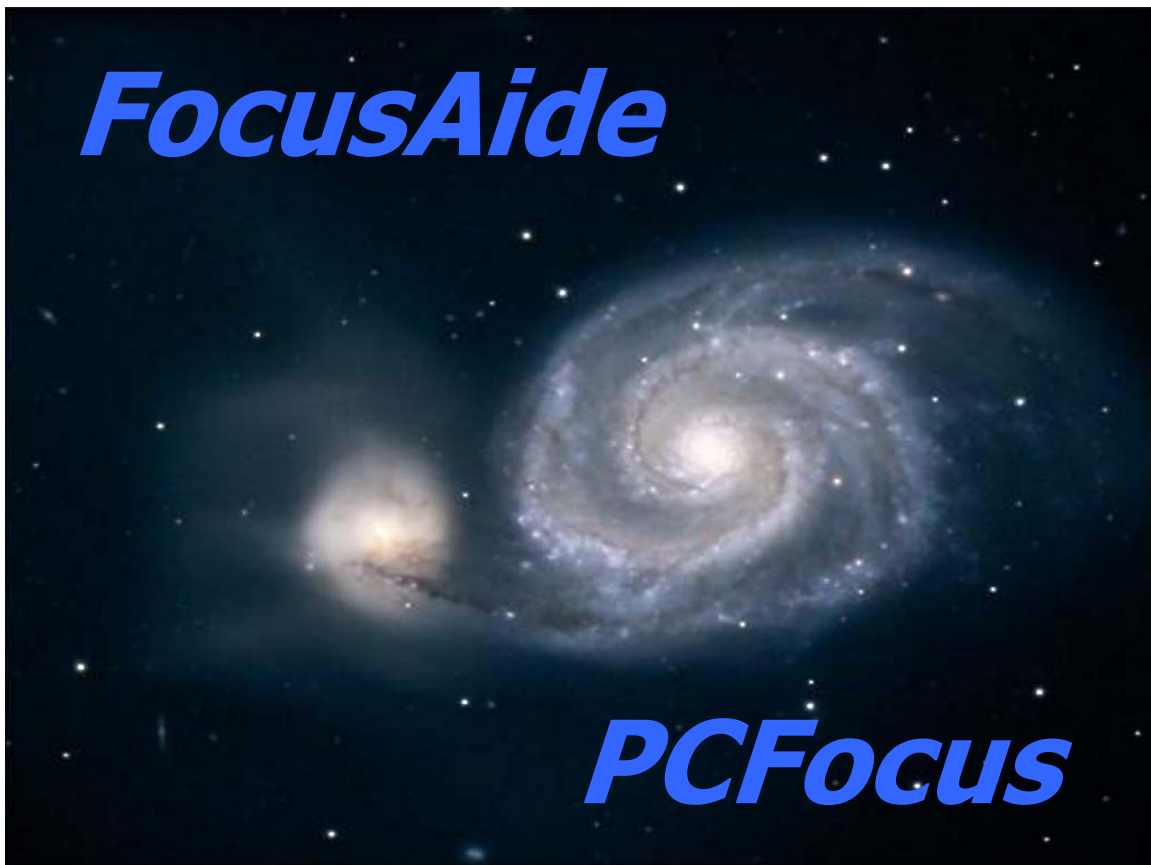
Aquest, Inc.
Boca Raton, FL

FocusAide

PCFocus

Introduction

Thank you for purchasing the temperature compensation version of PCFocus and FocusAide.

With this additional hardware and software you will have full temperature compensation capability with your JMI or Meade focuser. (Note: Optec and RoboFocus equipped focusers have their own temperature compensation and FocusAide is not used to operate the temperature compensation features of these focusers.)

The concept is quite simple. Focus of your imaging system can change rather significantly as ambient temperature changes. Since the PCFocus unit gives your focuser a serial interface and allows computer control of focus, the FocusAide software can set the focuser position at any time it is running. With the temperature compensation upgrade to PCFocus, FocusAide can now obtain temperature information and take action to adjust your focus to compensate for any temperature changes. It will do this in addition to all of the other focusing functions it now performs.

To use the temperature compensation function you must first provide FocusAide information about how much the focus changes as the temperature changes. FocusAide has tools to help you do this. Once this is done you can simply define how often you wish FocusAide to adjust your focus as the temperature is changing. You can either ask it to do a single correction at any time or set an update interval (e.g. every 5 minutes) and FocusAide will do it automatically.

Software Installation

The software is designed to run under Windows 95, 98, Me, 2000, and XP. The CD provided is the full PCFocus/FocusAide installation. If you already have FocusAide installed on your computer you need only update the **focusaide.exe** file found in the Backup folder on the CD. Simply copy the CD version of the **focusaide.exe** file into your FocusAide installation folder overwriting the file that is there. Any settings and registration that have been applied will not be affected by this installation.

If you are installing FocusAide for the first time, you may use any installation CD that is version 1.4 or higher and follow the installation directions in the FocusAide User's Guide.

Note: The hardware does not need to be connected to install the software.

1. If you are just updating the **focusaide.exe,** you should run FocusAide once after the update and in the Settings section click the **Save Settings** button. This will update your configuration with the default temperature compensation settings. See the Settings section of the guide for information on how to make changes to the temperature compensation parameters.

Note: there is software (firmware) in the PCFocus unit that is already installed. It is "permanent" in that it is stored in Read Only Memory but can be updated from your computer through the serial cable if necessary.

Hardware Setup

With the exception of the optional external temperature sensor there is no setup required beyond the basic setup described in the FocusAide/PCFocus User's Guide. All temperature compensation activity takes place over the same cables as auto-focus and other functions currently performed by the system.

The optional external sensor is used in cases where the PCFocus unit is in a place where the temperature is not representative of the temperature affecting the optical elements of the system. An example would be a "warm room" in an observatory.

An internal temperature sensor housed within the PCFocus unit comes standard and for many applications is satisfactory to measure temperature changes. There is a small hole in the end panel of the PCFocus unit (next to the connector marked "TC") which allows outside air access to the internal sensor. You should assure that nothing is disrupting the temperature measured by the internal sensor (e.g. the exhaust fan of your laptop blowing into the hole or something blocking the hole altogether). There is a setting in FocusAide to adjust for a constant temperature difference from inside the PCFocus box to outside and this will be discussed later.

To use the external temperature sensor simply turn off the power to the PCFocus unit, plug the external sensor connector into the connector marked "TC" and turn the power of the PCFocus unit back on. The internal sensor is automatically switched off and temperature readings will now be of the external sensor. The sensor can be located anywhere you wish including right on your telescope's OTA. The external sensor cable is 20 feet long but can be extended to any length up to 200 feet by using standard 2.5mm stereo audio cabling, preferably shielded. While the temperature sensor used is a digital integrated circuit, running the cable through electrically noisy environments may cause erratic temperature readings. Keep the cable clear of fluorescent sources, dew heater controllers, switching power supplies, etc.

The FocusAide Temperature Control Screen

All temperature compensation is controlled by the FocusAide software (the PCFocus utility program has no temperature compensation support). Except for some settings in the Settings section all control and operation is from the **Temp Control** tab. The selection of this tab presents the following screen:

You will see that the Temp Control tab is divided into 5 major sections:
- Focus Position and Status
- Compensation Activity
- Temperature
- Control
- Calibration

We'll discuss each section individually.

Focus Position and Status
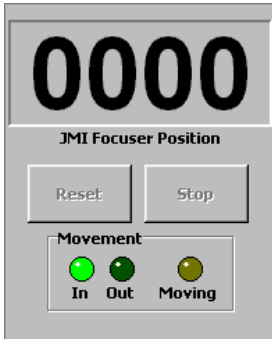
You should recognize this as the same status panel as presented on the Manual and Auto Focus tabs. The current focuser position is shown along with movement and direction indicators. The **Reset** and **Stop** buttons operate as usual on this page but are disabled if Automatic Compensation is in progress. Turning off automatic compensation will not stop any focuser movement in progress. Use the **Stop** button on this panel to do so if desired.

Compensation Activity
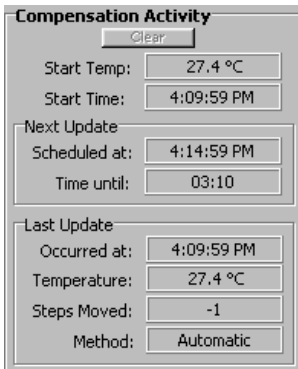
This panel is where FocusAide keeps you advised of actions it has taken or are queued to happen with regards to temperature compensation. The time and temperature when automatic compensation was initiated are shown at the top and are set whenever the **Automatic Compensation** switch is "turned on". The "Next Update" section shows what's coming: the time at which the next temperature compensation will occur and how much time remains to that point. Finally, the "Last Update" section shows what happened at the last update including how far the focuser was moved (this could be zero) and also if it was during FocusAide automatic operation or the result of a manual correction resulting from clicking the **Compensate Now** button.

The small Clear button will delete all information in this panel except while the **Automatic Compensation** switch in on.
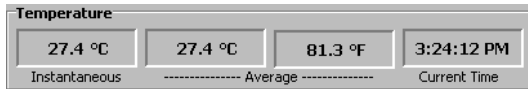
Temperature


FocusAide measures temperature frequently (shown as the instantaneous temperature) but uses the average temperature to compensate the focus setting. Both the Celsius and Fahrenheit values of average temperature are given along with current time as known to your computer. The average values are the running average of the last 10 temperature readings.

You can bring the average value to the latest instantaneous value by double-clicking on the either the Celsius or Fahrenheit average values.

Control
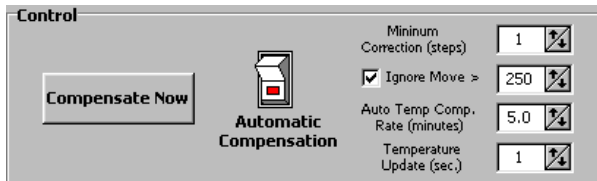
The control section is where you will operate the temperature compensation function once you have calibrated your system. The settings area on the right side of the panel control parameters for doing compensation and will typically be set once and left. There are settings corresponding to these on the Focuser Control settings tab to set what values appear on the Control panel above when FocusAide starts up. (See the Settings section below)

The parameter settings are:
- Minimum Correction (steps) - If the calculated number of focus steps required for a particular temperature change is less than this number no movement of the focuser will occur. Use this to "smooth" out movements for very small temperature changes.
- Ignore Move > - If the checkbox is checked, any calculated movement value greater than the number in the box will be suppressed and no focuser movement will occur. This is a safety feature in the event some problem occurred that resulted in an abnormally large focuser movement.
- Auto Temp Comp. Rate (minutes) - This value sets how often temperature compensation is performed, in minutes, when the **Automatic Compensation** switch is on. It is adjustable in 30-second intervals. If temperature is changing rapidly you will want to set the value lower so as to have compensations occurring more frequently.
- Temperature Update (sec.) - Sets how often, in seconds, FocusAide requests a temperature measurement from the PCFocus unit. This parameter can be set to as fast as it will go (once per second) unless the PCFocus box (not the pass-thru device) is doing other things on the same serial port (e.g. guiding), in which case, the other activity will have priority and this parameter should be adjusted to a higher value.

The other two controls on this panel are used to actually control the compensation activity as defined by the foregoing parameters. Click **Compensate Now** to request that FocusAide immediately calculate and perform any required focuser correction. This button can be clicked even if automatic compensation is underway. If no correction is required none will be taken. Turning on the **Automatic Compensation** switch allows FocusAide to take full and automatic control of compensation at the interval you set. Note that when automatic compensation is underway the FocusAide icon in the Windows Task Bar shows the current average temperature.

Calibration
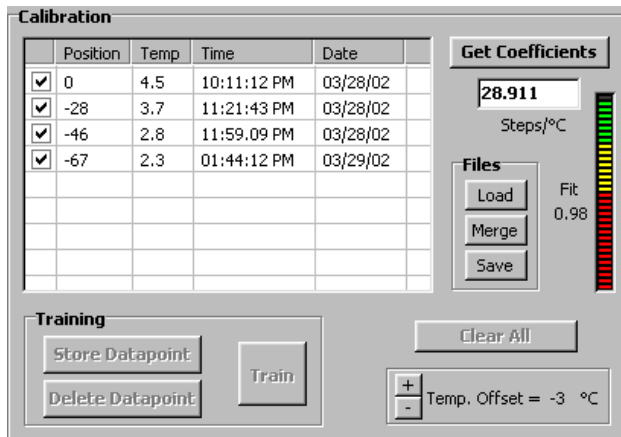
We will delve into how to do the actual calibration in the "Training the System" section below. For now, we will only describe the panel and provide an overview of the tools available.

For FocusAide to compensate focus position for temperature changes it must know how much to move the focuser for every degree change in temperature. The number shown in the Steps/$°$C box is this value or "coefficient". If you know this number you may type it into the box directly. Chances are you don't know this number for each optical configuration you may operate your system at so you will use the tools provided in this panel to obtain ("train"), store, or retrieve required calibration information.

The table shown in the above example represents data taken over the course of several hours and includes the precise focus required for each temperature taken during the period. The checkmarks allow you to include or not any particular data point. Clicking the **Get Coefficients** button does a Least Squares Fit of the temperature and focuser position data to determine the slope of the line (shown in the Steps/$°$C box). The data is normalized prior to the Least Squares Fit to minimize the y-intercept value and support merging of data files. The "Fit" value and meter show how well the data actually follows a straight line. The closer to 1.00 the number is or the higher the meter is in the green the better. If your data show a "red" fit there is likely one or more bad data points throwing things off. In this case you must determine the cause of the problem and eliminate the bad data or restart the training process.

The data in the table, including the state of the checkmarks, can be stored or retrieved by using the **Save** and **Load** buttons in the **Files** box. Data from multiple training sessions can be merged if desired using the **Merge** button. The **Clear All** button will clear the table but once cleared the data is lost if not saved before clearing.

The "Training the System" section will describe the training and calibration process in more detail but in general it is done with these rather simple steps:

1. Focus the system (using auto-focus, typically, and for the most accuracy)
2. Click the **Train** button to start the training process
3. Click the **Store Data point** button
4. After a temperature change, refocus the system
5. Click the **Store Data Point** button
6. Repeat steps 4 and 5 until at least 4 data points are entered and the "Fit" meter is in the green. (You may uncheck any data points that seem suspicious or use the **Delete Data Point** button and click the **Get Coefficients** button to see how good your fit is at any time)
7. Save the data by using the **Save** button

Note: The first data point in any set of data <u>must be checked</u> since the first reading is used as a baseline and the rest are normalized to it. This is especially true for merging data. If the first point in the set of data is bad you must delete it.

The remaining section on the calibration panel is the Temperature Offset. This setting is persistently stored in the PCFocus unit hardware which adds the value to every temperature reading it makes. This is used to adjust for any fixed offset in temperature from the actual ambient temperature to that being measured by the internal sensor inside the PCFocus unit or a fixed difference between the external sensor and the optical elements that are changing focus. It must be set the same during actual temperature compensation operation as it was set during training since it corresponds to a specific coefficient. It is best to either set the offset to zero or determine what it should be by calibrating with another thermometer of known accuracy positioned to monitor temperature in the location you wish to control. Let the system and extra thermometer come to thermal stabilization before adjusting the **Temperature Offset**. Note that the offset value is not critical since all calculations done by FocusAide are with the temperature data normalized.

Settings

The **Focuser Control** tab in the Status/Settings section allows for setting temperature compensation parameters to be set when FocusAide begins execution.

This portion of the **Focuser Control** tab looks like the panel below. This panel is only visible if JMI or other focusers which can be temperature compensated by PCFocus and FocusAide are selected:
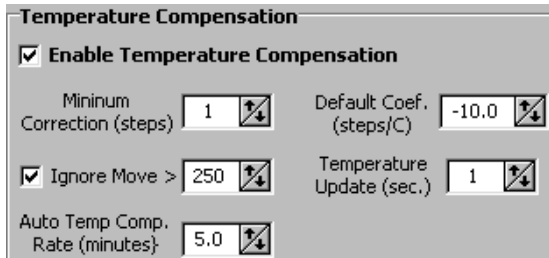
You should recognize most of the parameters as being the same as those on the **Control** panel on the **Temp Contro**l tab. The settings here allow you to set those values you wish to be inserted into the **Control** panel when FocusAide is started. There are two additional controls on this panel.

The Enable Temperature Compensation checkbox is self-explanatory and turns off all temperature compensation functions and hides the **Temp Control** tab.

The Default Coefficient provides the ability to have a coefficient inserted automatically as FocusAide starts so you don't have to load in a calibration data file have FocusAide calculate a coefficient for you.

Clicking the **Update Parameters** button will change settings for the current session of FocusAide. To save the settings to the configuration file for use on the next invocation of FocusAide click the **Save Settings** button.

Note: The pass-thru feature is still functional in a temperature compensated PCFocus unit. However, you should keep in mind that it is not possible for two Windows programs to open the same COM port at the same time. This means that pass-thru functions must be suspended while FocusAide is performing temperature compensation since it needs the COM port to do so.

Training the System

Training the system means having FocusAide learn the number of steps to move the focuser for each degree change in temperature. This is done for each optical configuration used. It may be possible to use the same coefficient for multiple configurations but you will need to determine that through training or other means.

To train the system for a specific optical configuration you will focus and refocus for various temperatures and ask FocusAide to store the information for you and calculate the best fit of the data to a straight line. It is best to use the auto-focusing capability of FocusAide during the training process so as to get the fastest and most accurate focus point. To train the system, follow these steps:

1. Perform an auto-focus as a starting point. FocusAide resets the focus position to zero prior to performing the auto-focus run. At the completion, the focus position defines how far FocusAide had to move the focuser from the starting position to achieve optimum focus.
2. Click the **Train** button to commence the training process
3. Click the **Store Data Point** button to record the temperature and initial focus position.
4. After a period of time where the temperature has changed by at least 1-2 degrees Celsius, run another auto-focus.   Note that prior to commencing the run, FocusAide again resets the focuser position to zero so that at the completion of the auto-focus run the position represents the difference in focus position.
5. Click the **Store Data Point** button to record the temperature and the new focus position.
6. Repeat steps 4 and 5 to gather at least 4 (preferably more) data points.
7. After recording at least 4 points you should click the **Get Coefficients** button to assess how good the fit of the data acquired thus far is. You may find that one or more of the data points are suspect and causing a poor fit. You can uncheck that data point and recalculate the coefficient. If it improves leave the data point unchecked but always have at least 4 data points.
8. When you have a number of data points and the fit is in the green portion of the meter you have completed the training run. Click the **Train** button to end the training process and save the data to a file by clicking the Save button.

There are some things you should know about this process:

- Do the complete training session at one time so as to have a continuous map of position vs temperature with everything else constant.
- The larger the temperature change and the more data points taken the better the calibration will be. While a smaller temperature change and less points will work, typically a 5-10°C change and 8-10 points will produce a very good calibration model.
- Two data points will always exactly define a straight line and result in a fit of unity even if the data poorly represents the actual performance of the optical system to

temperature changes. Four <u>checked</u> data points is the minimum you should have.

- If you feel you have a good coefficient and will continue to use your system in the same configuration you can make note of the resulting coefficient and enter it into the settings section and have FocusAide insert this value for you on subsequent invocations of the software.
- When you click the **Get Coefficients** button FocusAide assumes that the first value is the starting point and sets the focuser position to zero for calculation purposes and temperature normalizes all subsequent data points accordingly.
- If you merge a file of additional data it should be data that was taken with the same optical and mechanical configuration or you will "pollute" the data and get a poor coefficient.
- The first point of the merged data is assumed to have been the starting point and all of the data following in the merge file is normalize accordingly. Because of this there will be, for coefficient calculation purposes, two data points with zero focuser position and zero temperature and all other data points normalized to the 0,0 point. Do not attempt to merge a file with less than three data points.
- Data is stored to a comma delimited text file. An example file looks like this:

```
; Training Data - LX200, f/10
; 03/29/02 01:50:23 AM
; Temp. Offset = +1°C
;
1,0,4.5,10:11:12 PM,03/28/02
1,-28,3.7,11:21:43 PM,03/28/02
1,-46,2.8,11:59.09 PM,03/28/02
1,-67,2.3,01:44:12 AM,03/29/02
```

You may create or edit the files as you wish. Lines beginning with a semi-colon are ignored and can be freely inserted anywhere in the file. Each line is comprised of information separated by commas and from left to right is the state of the checkmark (1 = checked, 0 = unchecked), focuser position, average temperature in °C, time, and date.

Warning for SBIG Users:

SBIG Parallel Port cameras operating under Win95 and Win98 disable hardware interrupts during readout of any data from the camera. When interrupts are disable many functions in the computer stop. During this time Windows cannot keep system time or service the serial port, and many other functions are suspended until interrupts are again enabled.   FocusAide relies on Windows for serial port communication with the PCFocus unit controlling a focuser. Occasionally, erratic control of the focuser motor occurs since serial communications are stopped while the SBIG driver takes over the computer for download.

When FocusAide is in control of the SBIG camera, the multi-tasking operation interlocks focuser movement and camera downloads so the disabling of interrupts is not a problem. For temperature compensation where another program is controlling the camera for exposures and/or guiding, FocusAide cannot maintain control of the serial port when the other program is downloading from the camera. The result is an occasional positioning error of the focuser if interrupts are disabled after FocusAide has turned on the focuser motor. At that point, the motor is running and FocusAide cannot turn it off since the SBIG driver has disabled all interrupts and the serial port is no longer operational.

It is not possible to <u>eliminate</u> the problem unless the operating system is upgraded to Win2000 or WinXP. Under these operating systems the SBIG driver cannot turn off interrupts and there is no problem. Various CCD control application programs are instituting changes to notify FocusAide of a pending download operation. This will allow FocusAide to pause the motor until the download is complete. Focuser positioning accuracy will be restored when these changes are implemented. AstroArt has implemented these changes and an updated SBIG plug-in for AstroArt is available. Check with your CCD Control program developer and/or the Aquest website for news on these changes and how to obtain updates to your software.

You can <u>minimize</u> this problem by doing the following:

1) Set the Nudge Time and Close Nudge Time as short as possible and the Nudge Delay Time as long as possible and still have reasonable speed in positioning the focuser.
2) If auto-guiding, set the guide interval as long as possible
3) For auto-save exposure sequences, set the auto-temperature compensate interval in FocusAide such that it only occurs during exposure time and not download time. You may need to adjust the delay between exposures in your CCD control program to achieve this.
4) In manual multiple exposure sessions (i.e. not unattended, auto-save sequences) use the "Compensate Now" button during an exposure or, better, between exposures with guiding temporarily suspended (the latter will totally eliminate any risk of a focuser positioning error).

(Note: FocusAide forces all moves while automatic temperature compensation is enabled to be "nudge moves" so as to minimize this problem. It does this when it

detects the operating system to be Win95 or Win98 and an SBIG parallel port camera is involved.)

In general, the above problem only affects SBIG cameras using the parallel port under Win95 and Win 98. No other camera or operating system has the problem.

Software Updates and Support

Updates to the FocusAide software and the PCFocus unit firmware are available at no charge to registered FocusAide users at:
http://www.aquest-inc.com/downloads.htm

In the event a firmware update is made available, you will need to download a free utility program to install the new firmware to your PCFocus unit via the serial port of your computer.

Announcements of updates, new features, and general support and discussion can be found at:
http://www.aquest-inc.com/news.htm and
http://groups.yahoo.com/group/PCFocus-FocusAide

Enjoy your new focusing tools!