# Ninnion: The Observer's Operation Manual

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# Contents

# 1 Planning an Observation

Planning an observation requires a few critical steps that should be completed before arriving at the observatory. Entering the observatory with an observation strategy and understanding of the sky conditions is crucial for completing a scientific observation.

## 1.1 Check the weather and sky conditions

1. Check sunset. It is advised that you choose the beginning of your critical scientific data run to be no earlier than astronomical twilight. Astronomical twilight occurs when the Sun is 18 degrees below the local horizon. In Brownsville, during the summer, astronomical twilight occurs roughly 1.5 hours after sunset. You can certainly observe before this time, during civil or nautical twilight, but extinction by sunlight will be much more significant. See Figure 1.

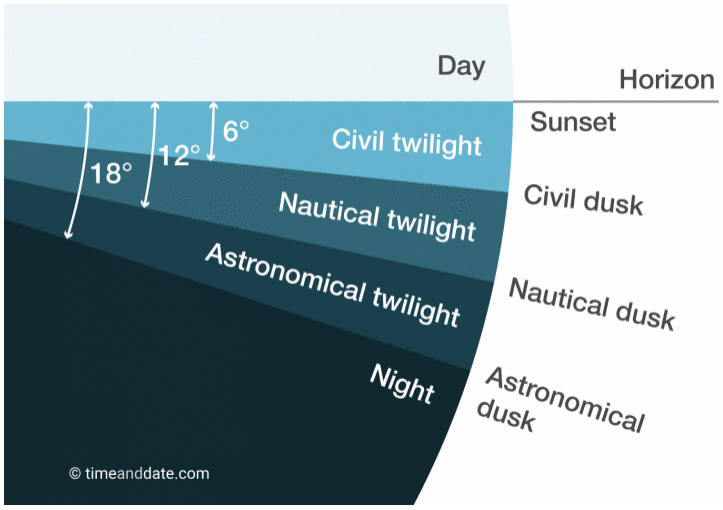



Figure 1: The definition of dusk (or twilight) depending on the altitude of the Sun below the local horizon.

2. Check forecast. Visit the National Weather Service. See Figure 2.

   (a) At the top left, search and select the location `Olmito, TX, USA`. This action will take you to a new page with the forecast for Olmito.

   (b) Scroll down the new page to the section titled `Detailed Forecast`. See Figure 3.

   (c) To the right of this you will see a map. There will be a green square on the map already, but ignore it for now. Find the approximate location of the observatory and click it on the map. Wait for the page to reload. You should see the green square highlighting the region you just clicked. See Figure 4.

   (d) Immediately below this, click the graph titled `Hourly Weather Forecast`. This action takes you to a new page with the forecast in graphical form of the location you clicked. See Figure 5.

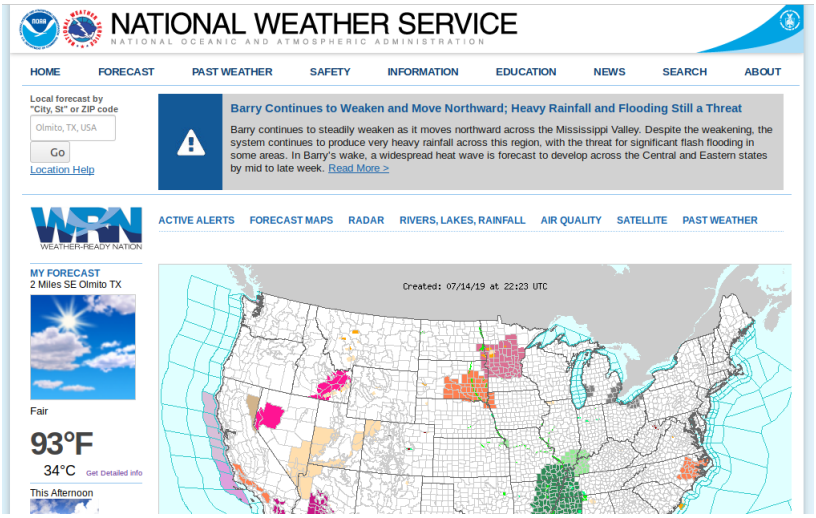



Figure 2: The home page of the National Weather Service.

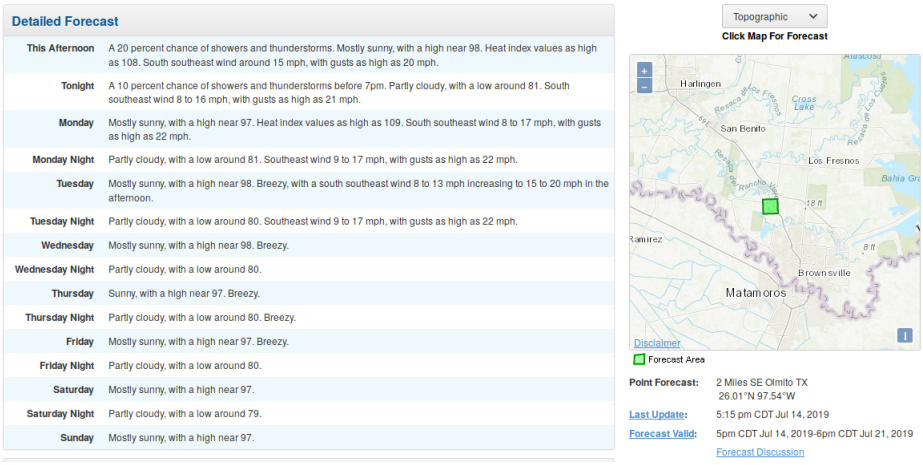



Figure 3: The detailed forecast of the default location selected for Olmito, TX.

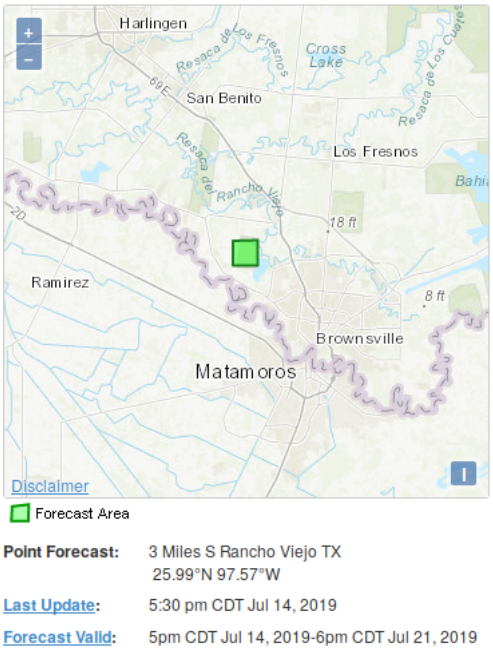



Figure 4: The green square after the page reloads, indicating the correct position has been selected.

This page is extremely useful and it is recommended to bookmark this page for future reference. You will want to monitor the changing conditions throughout the day before your observation. Typically, 50% or greater cloud coverage is a sign that an observation is a no-go.

3. Check the Moon. Using Stellarium, check to see the phase and position of the Moon during the course of the night. Moonlight significantly interferes with photometric precision. You'll want to make sure your targets are far enough away from the Moon so as not to affect your exposures.

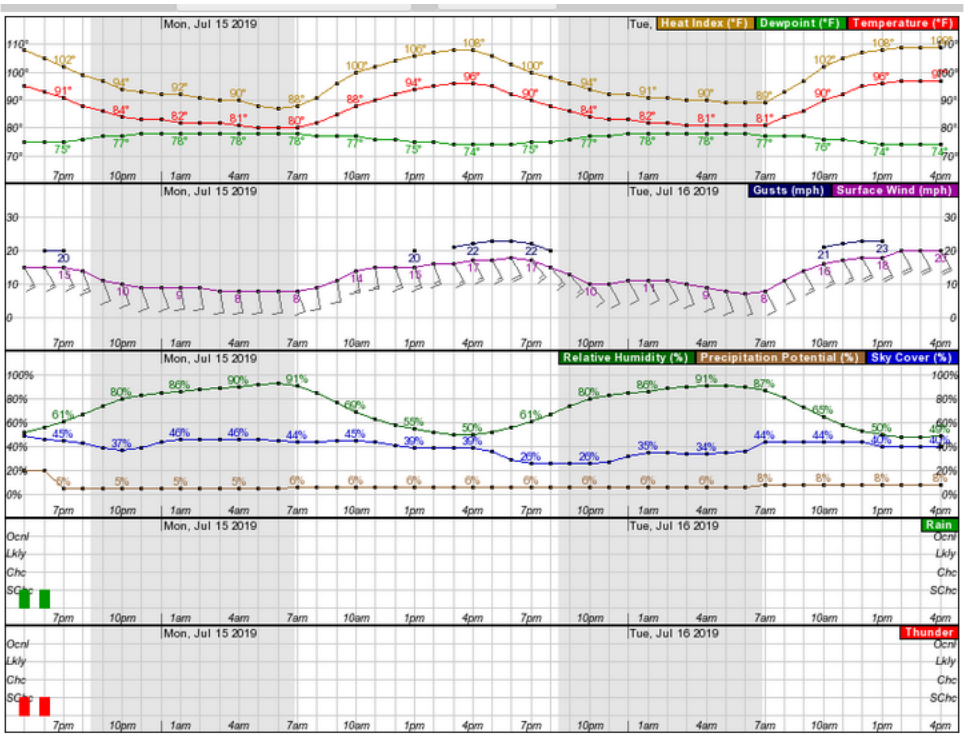
## 1.2 Identify your target

1. What are the coordinates of your object? Object coordinates are typically expressed in right ascension (`hh:mm:ss.ssss`) and declination (±`dd:mm:ss.ssss`) in the J2000 epoch.

2. Check the altitude range over your expected observation time. For accurate photometry, you want to make sure your object is above 30 degrees in altitude. It is useful to visualize the path of the object in the sky ahead of time, using planetarium software like Stellarium.

3. Obtain a reference field for your night. Using software such as Stellarium, or any optical image database online like SIMBAD or the STScI Digitized Sky Survey. Finding archival images of your target fields will also help you check the pointing of the telescope.

4. Determine suitable reference stars. Make sure they are not variable stars and that their color indices are similar to your target object.




**Tuesday, July 16 at 2am**
Temperature: 82 °F Dewpoint: 78 °F Heat Index: 91 °F Surface Wind: SSE 11mph
Sky Cover (%): 35% Precipitation Potential (%): 6% Relative Humidity (%): 89%
Rain: <10% Thunder: <10%

Figure 5: The graphical forecast at the location of the observatory.

## 1.3 Plan your observing strategy

1. What is your strategy?
   (a) Do you have a list of targets that you want to observe throughout the night?
   (b) Are you tracking a single object?
   (c) Does the object have significant proper motion?
2. If you plan to observe multiple objects, like a selection of galaxies, then you want to observe the targets that are scheduled to set first. That way you can observe the most amount of galaxies on your list at a suitable air mass.
3. If you plan to observe a single target over time, then you will need to decide on the exposure time and cadence of your image sequence. This answer will depend on the nature of your target and the response of the optical system.
   (a) Asteroids move with proper motion and can have a wide range of velocities.
   (b) Exoplanet transits can be quite faint and are at a fixed point in time.
   (c) Variable stars have a wide variety of periods and magnitude changes.
   (d) Filters, a significant Moon, and low altitude are examples of factors that reduce the signal-to-noise ratio (SNR) and change the color of your target.

# 2 Starting Up

## 2.1 Entry and power up

1. Remove padlocks from the hatch. Bring padlocks inside.
2. Turn on the lights. Use the switch on the right side entering the dome.
3. Bring the padlocks and your personal belongings into the control room. Remember that the control room door should always be shut.
4. Message the team on the "CTMO Leaders" WhatsApp group that the dome has been opened.
5. Turn on all circuit breakers 1-12. Breakers numbered 2, 5, 7, and 11 should always remain on.
6. Turn on the UPS battery backup. This is the slim, tall box on the table to the immediate left of the breaker box. Turn it on using the center power button. After a beep and some warming up, the information screen should indicate the battery is running on the power line rather than on the battery.
7. In the control room, turn on the AC unit.
8. Turn on Atlas. First, you need to toggle the power switch on the back of the computer. GRUB should automatically boot Windows.

## 2.2 Open shutter window

1. Unplug the battery charger from the wall outlet.
2. Remove the charger from the battery. First remove the red leads from the red (+) terminal on the battery. Then remove the black lead from the black (-) terminal on the battery.
3. Remove the charger from the wall and place it safely on the floor.
4. Take the shutter controller with the plastic cover. Press the green power button on the controller. Press and hold `UP` on the shutter controller. Open until the white rubber lip of the shutter window is coincident with the blue metal bar near zenith.

## 2.3 Open shutter door

1. Undo the rope and let down the shutter door. It is normal for the rope to stretch diagonally across the shutter door opening.

## 2.4 Prepare telescope

1. Slide the light shroud up toward the front of the optical tube assembly (OTA).
2. Remove the cloth cover from the secondary mirror.

3. Remove the plastic shower cap.
4. Remove the round plastic lid from the primary aperture.
5. Slide the light shroud back down to completely enclose the OTA.
6. Turn on the mount.
7. Make sure all cables attached to the telescope and accessories are loose and that there is enough free cable to allow for the telescope's full range of motion.

## 2.5 Connect to EFA kit

1. Open PWI3. Verify the computer established connection to the electronic focus assembly (EFA). The EFA should connect automatically to the computer and begin cooling the OTA and primary mirror. You should hear the fans in the mount turn on.
2. Click the `Temperature` tab on the right in PWI3. Record the ambient temperature given by the display.

## 2.6 Connect to camera

1. Open MaxIm DL.
2. Connect to the camera. Under `View`, open the `Camera Control Window`. Select `Setup` and then `Connect` to enable computer connection to the camera.
3. Cool the camera. Click `Cooler` and enter the set point. It is advisable to limit the initial set point to no more than 40 degrees C relative to the ambient temperature to avoid over-straining the thermoelectric coolers. (For example, if the ambient temperature is 30 degrees C, then the set point should be about -10 degrees C.)
4. Under `Connect` select `On` to begin cooling the camera. The cooler power should not exceed 80% during stable operation (although the power might exceed this during the cooling phase).
5. Once the camera temperature stabilizes, take 10 bias frames on `Continuous` (these don't need to be saved). Taking a quick set of bias frames will clear any residual charge stored from previous exposures on the CCD.

## 2.7 Connect to filter wheel

1. Open FLIFilter. Click `Home`.
2. The filter wheel will initially be at position "unknown" and will end up at slot 0 "unfiltered". You can select filters by clicking each of their corresponding buttons once homing is finished.
3. If you click `CW` or `CCW`, you will have to re-home the filter wheel before selecting another one.

## 2.8 Connect to mount

1. Open PWI4. Click `Connect` at the top left of the window.
2. Click `Enable RA` and `Enable Dec` under `Connect`.
3. Make sure the area around the telescope is completely clear. Select `Commands` and then click `Home Mount`. The telescope will slew and locate its reference encoders.
4. Once the telescope has stopped moving, you are ready to observe!

# 3 Observing

## 3.1 Slew telescope

1. In PWI4, under the `Goto` tab, enter the right ascension and declination of your intended object. Make sure the format is either sexagesimal (`hh:mm:ss.ssss` and ±`dd:mm:ss.ssss`) or decimal (`dd.dddd` and ±`dd.dddd`).

## 3.2 Take test exposure

1. In MaxIm DL, under the `Expose` tab, select a "Single" exposure (under the `Start` button on the right).
2. Enter an exposure time under `Seconds`.
3. Subframes should be disabled, unless you're doing an observation that specifically needs them.
4. Select the binning under the `X Binning` drop-down list. Binning should match the nightly atmospheric seeing, as well as chosen for balancing the SNR and resolution of your particular object. Higher binning means higher SNR per pixel, but at a loss of pixel resolution on the overall image.
5. If your image is out of focus, go to the `AF CONFIG` tab in PWI3. Take an image count (`Steps`) of 10 and set the exposure length (under `Seconds`) and binning (under `X Binning`) you will be using for your target. Under the tab `AF CONFIG`, click `START AF`, which will focus your images. Wait until all 10 images are done being processed.
6. Additionally, in the `Options` menu, make sure that dark frames are not being automatically subtracted.
7. Finally, once your telescope is settled on a target and your exposure parameters are set, click the `Start` button at the top right of the camera control window. The idle bar will begin to fill as the exposure commences. A picture should automatically render in MaxIm DL once the exposure is complete. First light!
8. If you used ASCOM (see Appendix A), to test the ASCOM connection, to go `View`, select `FITS Header Window`, and check for `EXPTIME`, `FOCUSPOS`, `OBJCTRA`, and `OBJCTDEC` to make sure it is reading the correct information you are using with your observation.

## 3.3 Set up directory structure

1. Under `C:\Documents\Observations` create a directory with the evening date in the format `yyyy-mm-dd`.
2. Under the newly-made directory, create a directory called `dark`, a directory called `flat`, and a directory for each of your targets by name (e.g. for target exoplanet system HAT-P-7 the directory would be something like `hatp7`). See Figure 6.

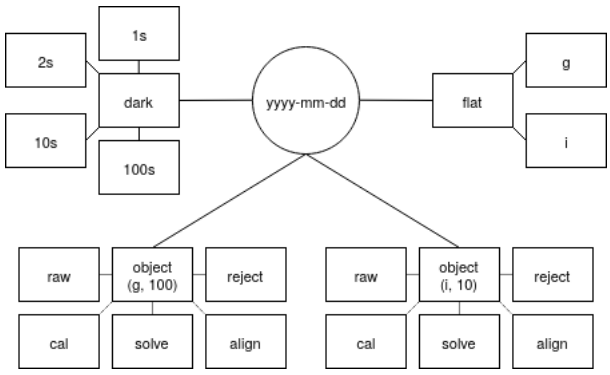



Figure 6: The directory structure for CTMO data. The object file names should be a single, unbroken string of the object's name. The (g, 100) and (i, 10) are the filters and exposure time used for that particular object (you don't need to include this in the file name).

### 3.4 Set up autosave routine

Note that if you choose multiple targets, you can either i) set up multiple autosave routines, or ii) use the `Single` exposure option to manually expose each target.

1. In MaxIm DL, in the `Camera Control` window, under the `Expose` tab, click the `Autosave` button. A new window should appear called `Autosave Setup`.
2. In the `Autosave Setup` window, set `Autosave Filename` to the name of your target.
3. Make sure `Slot 1` is selected. Frame `Type` will be `Light`. Set your `Exposure`, `Binning`, and the number of exposures or `Repeat`.
4. Select `Options` and `Set Image Save Path...`. Under `Documents`, `Observations`, create a new directory with the current date (in `yyyy-mm-dd` format). Then, under this new directory, create a new subdirectory with the name of your target. Click `OK` to close this window.
5. Finally, in the `Autosave Setup` window, select `Apply` followed by `OK` to close the window.
6. In the `Camera Control` window, select `Start` to begin taking data.

### 3.5 Set up data log

1. In a web browser, navigate to the CTMO Data Log.
2. Create a new entry and follow previous examples for the proper entry format and syntax.

### 3.6 Monitor observing conditions

1. Weather and sky coverage should be a priority, since this directly affects the data stream and could pose risks to the telescope and dome.

2. Make sure the dome shutter window remains in line with the telescope pointing. At the time of writing, the dome rotation has not been integrated into the telescope motion.

3. Make sure the data is being saved in the correct directory and recorded in the data log.

## 3.7 Take calibration frames

### 3.7.1 Flat frames

1. Make sure the area around the telescope is completely clear.

2. In PWI4, select `Commands` and then click `Home Mount`. The telescope will slew and locate its reference encoders.

3. In PWI4, under the `Goto` tab, enter the right altitude and azimuth of the flatfield screen. Use an azimuth of 352 degrees and an altitude of 12 degrees. You will then need to slew the dome to center the flatfield screen in the telescope FOV.

4. Connect the dimmer switch plug and press the dimmer switch knob to click it on. Next, turn the dimmer switch to produce some light and take a test exposure. This process will be iterative until the appropriate level is reached. The average pixel value across the frame should be roughly 50% the saturation limit of the camera. For a 16-bit camera like the ProLine 16803, the saturation limit is 65535 counts.

5. Take a series of at least 15 flats per filter used that night.

### 3.7.2 Dark frames

1. Turn off lights and take a series of 15 dark frames. For each integration time used in an observation (including those of your flats), a series of 15 darks per integration time will be needed.

### 3.7.3 Bias frames

1. Keep the lights off and take a series of 25 bias frames.

# 4 Shutting Down

## 4.1 Disconnect from mount

1. Make sure the area around the telescope is completely clear.
2. In PWI4, select `Commands` and then click `Home Mount`. The telescope will slew and locate its reference encoders.
3. In PWI3, select `Disconnect` at the top right of the window to turn off the OTA fans.
4. Close PWI3 and PWI4.
5. If you used ASCOM (see Appendix A), disconnect `Telescope`, `Dome`, and `Focuser`. Close ASCOM.
6. Turn off the mount.

## 4.2 Disconnect from filter wheel

1. Close FLIFilter.

## 4.3 Disconnect from camera

1. In MaxIm DL, in the `Camera Control Window`, select `Setup` and then `Warm Up` to begin warming up the camera.
2. Wait until the cooler power has dropped to close to 0% and the temperature of the chip is close to the ambient temperature. This might take a while, therefore you may continue with shutting down the rest of the observatory (up to, but not including, turning off the UPS battery backup) and then come back to this point.
3. Select `Off` under `Setup` to turn off the camera cooler.
4. Select `Disconnect` and then close MaxIm DL.
5. Shut down the computer (allow for updates before shutting off power). Turn off the monitors.

## 4.4 Cover telescope

1. Slide the light shroud up toward the front of the OTA.
2. Replace the round plastic lid onto the primary aperture.
3. Replace the plastic shower cap and use clips to fasten it.
4. Replace the cloth cover onto the secondary mirror.
5. Slide the light shroud back down to completely enclose the OTA.

## 4.5 Close shutter door

1. Pull the door back up to its original position.
2. Wrap the rope completely around the handle, making sure the door remains flush against the dome (even with a decent push). Tie the rope into a knot to keep it secure.

## 4.6 Close shutter window

1. Press and hold `CLOSE` on the shutter controller (the one with a plastic cover). Close the shutter until the shutter door automatically stops.
2. Place the charger on the wall. Connect the charger to the battery.
3. First connect the BLACK lead to the BLACK (-) terminal on the battery. Then connect the RED lead to the RED (-) terminal on the battery.

## 4.7 Power Down and Exit

1. Turn off the AC unit in the control room.
2. Turn off the UPS battery backup. Press and hold the center power button until you hear it beep.
3. Turn off circuits breakers. Breakers 2, 5, 7, and 11 should always remain ON.
4. Turn off the lights, both inside and outside the control room, and shut the control room door.
5. Exit the dome and replace the padlocks on the hatch.
6. Message the team that the dome has been closed.

# A Set up ASCOM

1. Open ASCOM Device Hub. Click `Device Setup` and click `Tools`.
2. Click `Telescope Setup`, click `Choose`, select `Plane Wave Interface`, click `OK`.
3. Click `Dome Setup`, click `Choose`, select `Dome Simulator NET`, click `OK`.
4. Click `Focuser Setup`, click `Choose`, select `PlaneWave Focuser PWI3`, click `OK`.
5. Connect `Telescope` to `Device HUB`.
6. Connect `HUB` to `Device HUB`.
7. Connect `Focuser` to `Device HUB`.
8. Open MaxIm DL Pro 5. At the top click `View` and then go to `Observatory Control Window`.
9. Under `Telescope`, click `Options`, click `Choose`, select `Device Hub Telescope`, click `OK`.
10. Next, under `Dome`, click `Options`, click `Choose`, select `Device Hub Dome`, click `OK`.
11. Next, go to `Focuser 1`, click `Choose`, select `Device Hub Focuser`, then click `OK`.
12. At the very bottom, click `Option` and `Connect All`.
13. You can compare the right ascension and declination of the telescope pointing given by MaxIM to that given by PWI4.
14. Next, you will click on `Dome`, go to `Options`, click `Slewing Parameters`.
15. Here we can compare the focuser position given by MaxIM DL to that given by PWI3. Focusing corrections can be made by reading the MaxIm position and moving the focus status position in PWI3.
16. Go to Section 3.2, Step 8 to test if ASCOM is running.