Ninnion: The Observer's Operation Manual

CTMO

v 22 Feb 2020

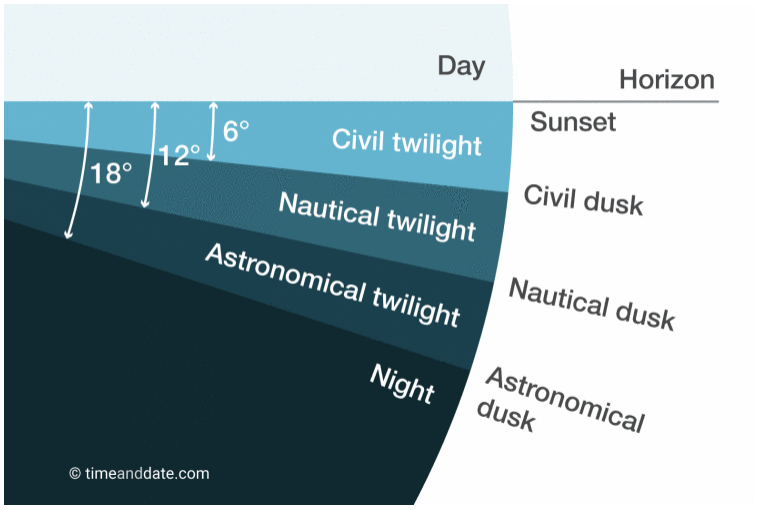
Contents

1 Planning an Observation

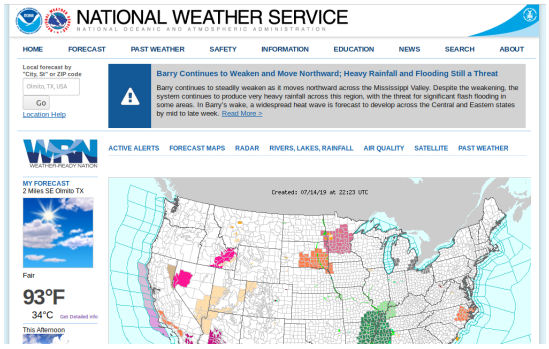
Planning an observation requires a few critical steps that should be completed before arriving at the observatory. Entering the observatory with an observation strategy and understanding of the sky conditions is crucial for completing a scientific observation.

1.1 Check the weather and sky conditions

1. Check sunset. It's 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.

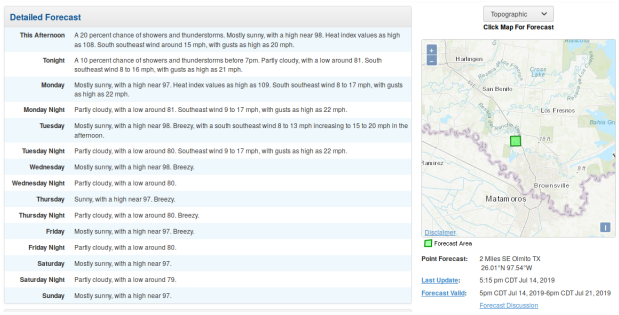


2. Check forecast. Visit the National Weather Service.

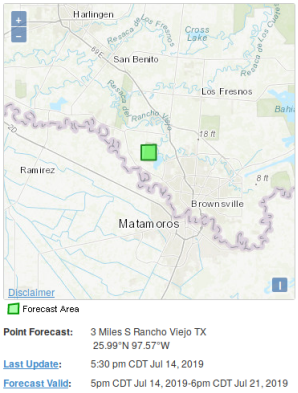


   (a) At the top left, search and select the location `Olmito, TX, USA`. This action will take you to a new page with the forecast for Olmito.

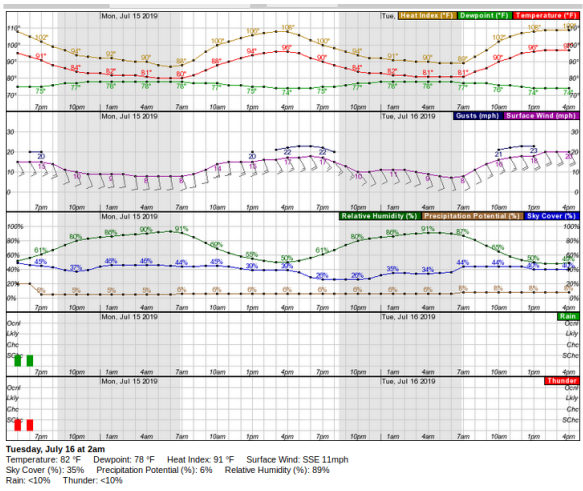
   (b) Scroll down the new page to the section titled `Detailed Forecast`.



(c) To the right of this you will see a map. Find the approximate location of Resaca de la Palma State Park and click it on the map. The page will reload. You should see the green square highlighting the region you just clicked.



(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. 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's 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 Stellarium or any optical image database online like SIMBAD, you should find a visual estimation of what your telescope will be pointing
4. Determine suitable reference stars. Make sure they aren't variable stars and that their color indices are similar to your target object.

1.3 Plan your observing strategy

1. What's 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 move with significant proper motion or only with sidereal motion?
2. If you're planning to observe multiple objects, like a selection of galaxies, then you want to observe the galaxies 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're planning to observe a single target over time, then you'll need to plan the exposure time and cadence of your image sequence. This answer will depend on the nature of your target.
   (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. Message the team that the dome has been opened.
4. Turn on all circuit breakers 1-12. Breakers 2, 7, and 11 should always remain ON.
5. Turn on the UPS battery backup. This is the slim, tall box on the table to the immediate left of the breaker box. Turn 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.
6. Turn on the AC unit on the wall.
7. Turn on Atlas. Grub should automatically boot Windows. Turn on the monitor.

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. Connect the BLACK motor cable to the BLACK (-) terminal on the battery.
5. Connect the RED motor cable to the RED (+) terminal on the battery.
6. Press and hold `OPEN` 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.

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 turn on.
2. Click the `Temperature` tab on the right in PWI3. Record the ambient temperature given by the display.

2.6 Prepare Camera

1. Open MaxIm DL.
2. Connect to camera. Under `View`, open the `Camera Control Window`. Select `Setup` and then `Connect` to enable computer connection to the camera.
3. Cool 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 thermoelectic 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 operation.
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 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.
4. Select `Commands` and then click `Home mount`. The telescope will slew and locate its reference encoders.
5. Once the telescope has stopped moving, you are ready to observe!

3 Observing

3.1 Slewing the 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 Taking a test exposure

1. In MaxIm DL, under the `Expose` tab, select a "Single" exposure (under the `Start` button on the right).
2. Select the filter under the `Filter Wheel` drop-down list.
3. Enter an exposure time under `Seconds`.
4. Subframes should be disabled, unless you're doing an observation that specifically needs them.
5. 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.
6. 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.
7. Additionally, in the `Options` menu, make sure that dark frames are not being automatically subtracted.
8. 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!

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 1 for assistance.

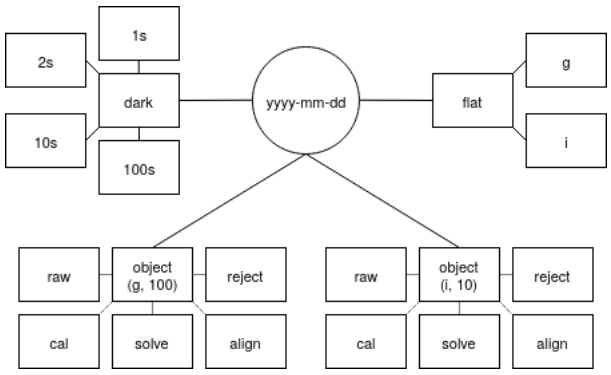


Figure 1: The directory structure for CTMO data. The object file names should be a single, unbroken string of the object's name. The (g, 100) and (i, 10) are the filters and exposure time used for that particular object (you don't need to include this in the file name).

3.4 Set up autosave routine

Note that if you're picking multiple targets, you can either set up multiple autosaves or 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. In `Autosave Filename` you will label your directory by the following convention:
   (a) Light: `yyyymmdd_<target_name>_filter`
   (b) Flat: `yyyymmdd_<target_name>_flat_filter`
   (c) Dark: `yyyymmdd_<target_name>_dark_exposure`
   (d) Bias: `yyyymmdd_<binning>_bias`
4. Make sure `Slot 1` is selected. Frame `Type` will be `Light`. Set your `Filter`, `Exposure`, `Binning`, and the number of exposures or `Repeat`.
5. 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.
6. Finally, in the `Autosave Setup` window, select `Apply` followed by `OK` to close the window.
7. In the `Camera Control` window, select `Start` to begin taking data.

3.5 Set up data log entry

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 conditions throughout night

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 (like sudden adverse weather conditions).
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

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.
6. 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.
7. Keep the lights off and take a series of 25 bias frames

4 Shutting Down

4.1 Disconnect from telescope

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. Turn off the mount.

4.2 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.

4.3 Cover the 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.

4.4 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.

4.5 Close shutter window

1. Press and hold `CLOSE` on the shutter controller. Close until the white rubber lip of the shutter window is coincident with the very top of the shutter door.
2. Remove the RED motor cable from the RED (+) terminal on the battery.
3. Remove the BLACK motor cable from the BLACK (-) terminal on the battery.
4. Place the charger on the wall.
5. Connect the charger to the battery. First connect the BLACK lead to the BLACK (-) terminal on the battery. Then connect the RED lead to the RED (-) terminal on the battery.

4.6 Power Down and Exit

1. Turn off the AC unit.
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, 7, and 11 should always remain ON.
4. Turn off the lights.
5. Exit dome and replace padlocks on the hatch.
6. Message the team that the dome has been closed.