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Advanced WWT Topics

This document holds many advanced tutorials and guides for users already familiar with WWT. It is organized loosely by either the intended target audience or common method, for example, "For Explorers" refer to any casual user of WWT, and "Adding Data" refers to how to add different data to WWT to all audiences.

Earth to Solar System Fast Forward Time and Back

This tour segment shows how to zoom out from the Earth and see a face-on view of the Solar System with planetary orbits. Then time is run forward with a time indicator and at an end time we zoom back to another location on the Earth. This segment can be used to show the passage of time probably with a timescale of one or more years.

1. Make sure that you are in 3D Solar System mode. Also, since later on we want to illustrate the passage of time using the motion of the planets – and especially the Earth – make sure that in the Layer Manager, under Earth that “Planetary Obits” is checked.
2. First start by setting the start time. Open view tab and enter the date and time in the Observing Time.
3. Finding a location on the Earth where you want to start from and end at. In this example, I am starting at a hospital in Mountain View California. Note that depending on the time you selected above the location may be in darkness; if so you will have to change time such that it is in light.
4. Set this as the beginning location of Slide 1.
5. Zoom out using the mouse. When you are close to the ground, you probably want to limit the changes in camera to zooms and not any rotations or else the ground will move wildly when you are zooming out. In this example, I will just do a zoom out to a view of the Earth with no translation or rotation.
6. Set this view as end location of Slide 1.
7. Make a new slide – Slide 2.
8. Adjust the final orientation of the Solar System such that the Earth is directly above the Sun. I use a tool called A Ruler for Windows to put a visual guide on the screen that I can use to make sure the alignment is correct as well as maintain scales. For reference I often take a screen shot of the view with the Solar System centered on the Earth before the next step. Use the ruler to measure the distance between the Earth and the Sun. You can click in the tick-mark area of the ruler and it will put a mark and numeric label at that location.
9. Set this as the end location of Slide 2.
10. Add new slide (Slide 3).
11. Select (double-click) the Sun from the context menu on the bottom of the page. This will zoom into a close-up view of the Sun. Pull back out and get a face-on view of the Solar System. Align it such that the Earth is directly above the Sun and that the distance between the Earth and the Sun is what it was in the Earth-centered view.
12. Set this as the end position of Slide 3.
13. Add new slide (Slide 4).
14. Add a text object and from the “Insert Field” menu – the right most menu item of the Text Editor window – select “Date.” Save the object and move it to a blank location on

the screen.

15. Click on the View tab and advance time to the desired date. This makes sense if it shows the motions of the planets, so this should be more like years than days.
16. Set this as the end position of Slide 4.

Sunrise-Sunset from Location

1. Go into Earth Mode (not Solar System).
2. Search for Earth-based location, suggest “Yosemite Valley.”
3. Right-click on Earth in Layer Manager and select “Add Reference Frame.”
4. Enter name for reference frame, enter “Yosemite Valley.”
5. Take defaults but change altitude of 1,000 meters.
6. Go into 3D Solar System mode.
7. Target Earth by double-clicking in it in the Context Menu at the bottom.
8. Under Earth, right click on “Yosemite Valley” and “Track this Reference Frame.”
9. If the altitude is not correct – maybe you want to be higher to hover and look down or lower to see the view from the ground – right-click on new “Yosemite Valley” reference frame and select Properties. In the Position Tab you can make changes to the altitude, which are reflected in the view when you click “Done.”
10. Change Observing Time under view to show daylight changes. Turn to face east and get the time to go past sunrise to see the stars go away and blue sky come out.
11. Note that this requires atmospheric effects and lighting are enabled.
    i. Atmospherics: In the Layer Manager under “Sun/Earth/Overlays” that “Clouds & Atmosphere” is checked.
    ii. Lighting: In the Layer Manager under “Sky/3d Solar System” that “Lighting and Shadows” is checked.

Great Circle to Show Route

In visual storytelling, sometimes you want to show a time-varying path from one point on a globe to another—think of the flight paths in the movies, *Raiders of the Lost Ark* or *The Amazing Race*. WorldWide Telescope makes this easy to do. In this documentation, we will add an expanding great circle from Chicago to Hawaii.

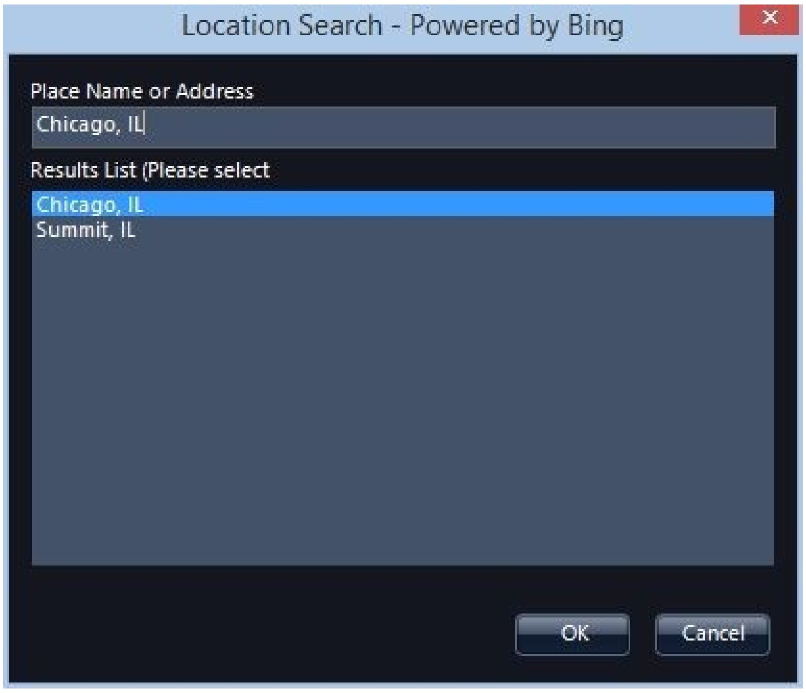
First, download the tour, Chicago-Hawaii Great Circle Route.

1. Download Chicago-Hawaii Great Circle Route.wtt
2. Open WorldWide Telescope
3. Click **Explore** and select **Open**, and then **Tour**
4. Navigate to the **Chicago-Hawaii Great Circle Route.wtt** file on your computer and click **Open** (Note that double-clicking this Tour directly from the file system will autoplay the Tour)

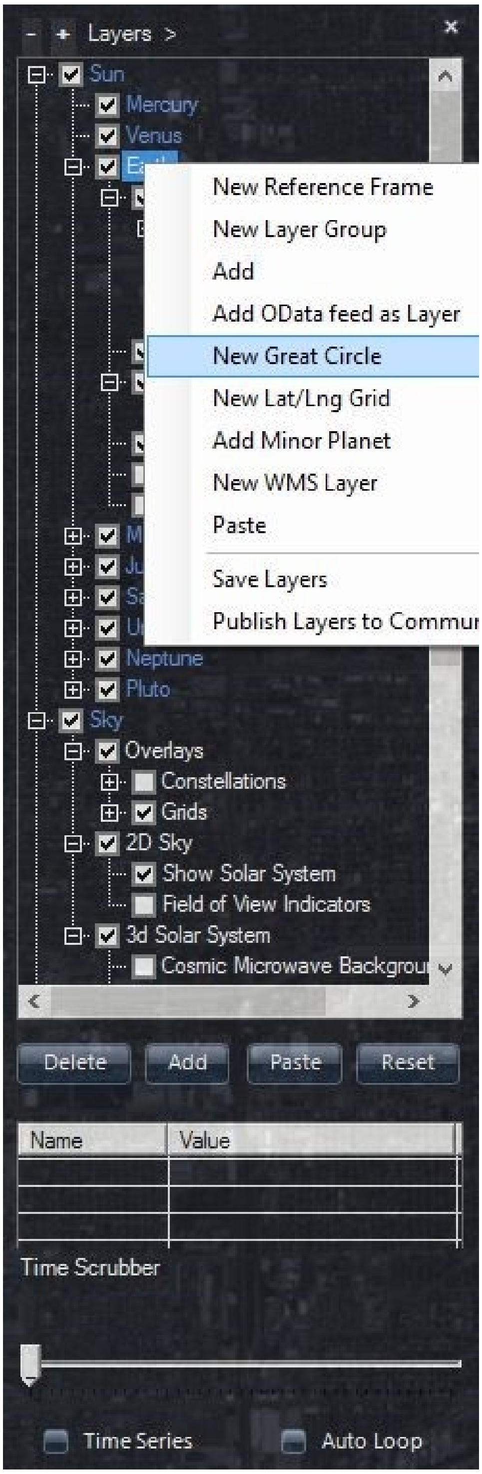
This opens the example tour. You should now see the **Chicago-Hawaii Great Circle Route** tour the top menu bar of WWT. Play this tour to get an visual example of how this functionality works.

To create a Great Circle Route:

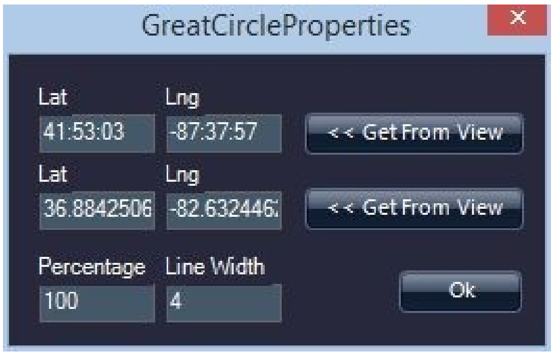
1. Go into **Earth** mode.
2. In the **Search/Find Earth Based Location…** enter **Chicago, IL**. This will orient the view to center and zoom in on Chicago.



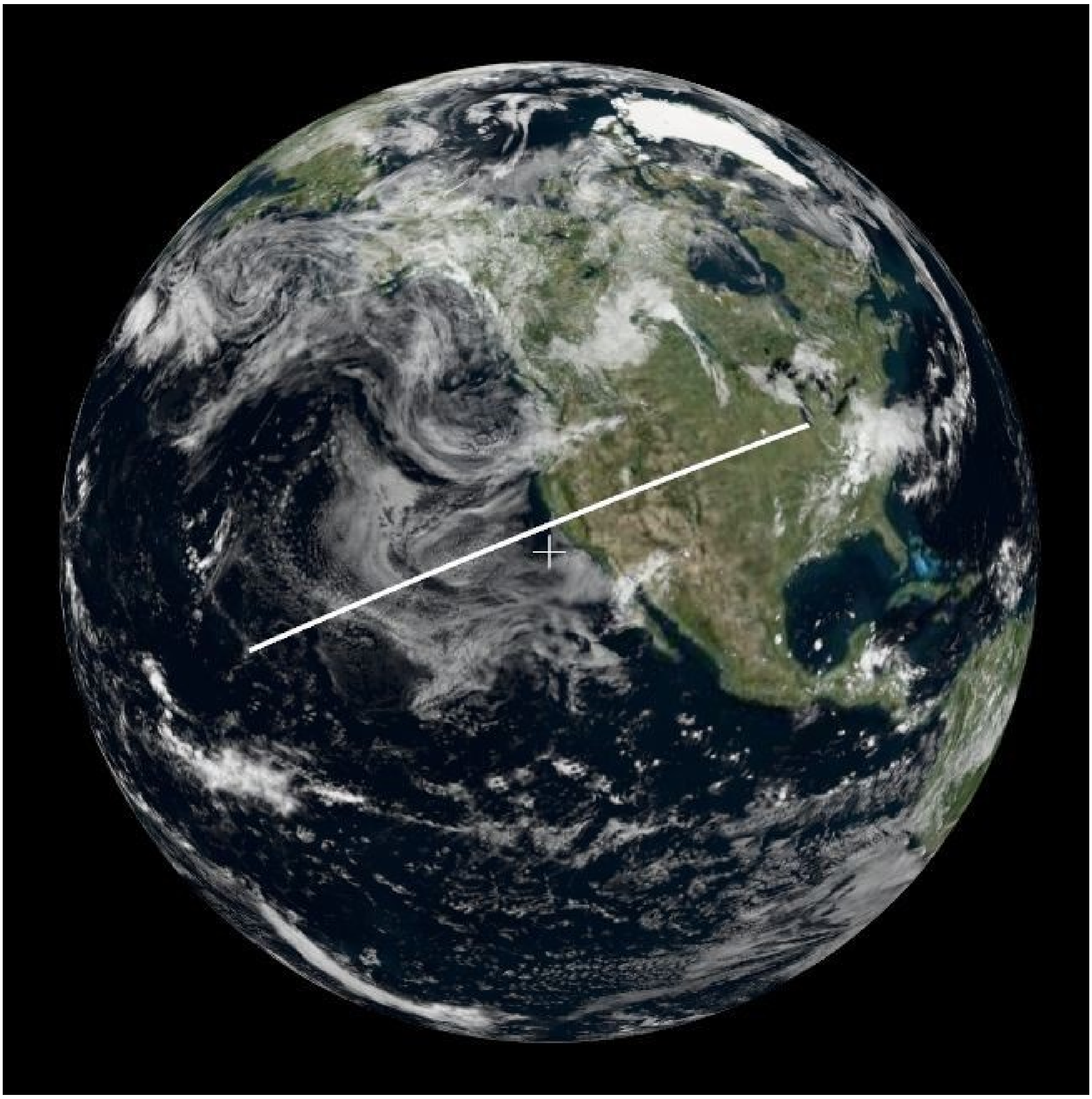
3. Open the **Layer Manager**, right-click **Sun/Earth**, and select **New Great Circle Route**.



4. The top Lat/Lng coordinates are the start of the route and the bottom coordinates are the end position. Since you are already centered on Chicago, which is our starting location, click top **<< Get From View** button, and then click **Ok**.



5. This will create an object entitled **Great Circle Route**. Right-click it and select **Rename** and give it a more descriptive title: **Chicago-Hawaii Great Circle**.
6. Next, set the end location. Open **Search/Find Earth Based Location…** and enter **Mauna Kea, HI**. This will center your view on the big island of Hawaii and zoom into the top of the large volcano, Mauna Kea, where some of the world's most powerful telescopes are located.
7. Right-click **Chicago-Hawaii Great Circle** and select properties. To enter Hawaii as the end position, click **<< Get From View** next to the lower Lat/Lng position.
8. Zoom out to see the entire Great Circle.



To make a slide that starts in Chicago rotates the Earth as the circle extends in time, make a new tour

1. Click **Explore/ > New > Slide-Based Tour…** Give it a title, **Chicago-Hawaii Great Circle Route**.

A tour can display the great circle route in either Solar System mode viewing Earth or in the Earth mode. For this example, we will be in **Solar System mode** viewing Earth.

1. Center your view on Chicago and then in the slide editor panel at the top, click **Add New Slide**.
2. Right-click the **Chicago-Hawaii Great Circle** object under **Sun/Earth** in the **Layer Manager**, and select **properties**. Change the **Percentage** field to **2**. The view should still be centered on Chicago.
3. Right-click the slide and then select **Set Start Camera Position**.
4. Move the view to Hawaii. Perhaps you might zoom in slightly.

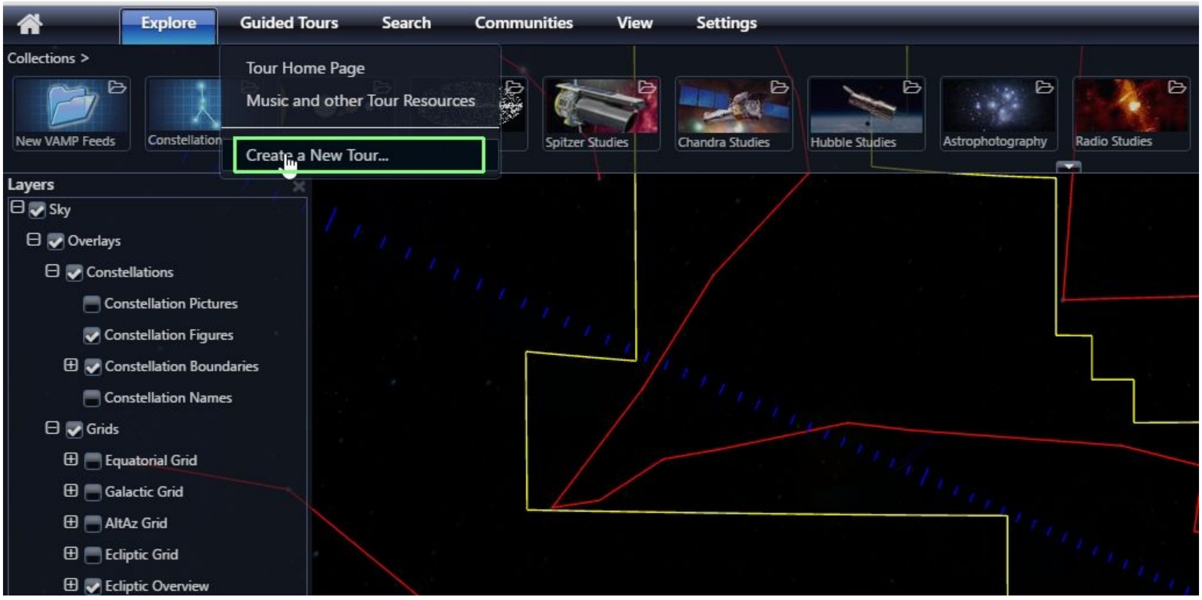
5. Edit the properties of the **Chicago-Hawaii Great Circle** object again. Change the **Percentage** field to **100**. The view should still be centered on Chicago.
6. Right-click the slide and then select **Set End Camera Position**.
7. Press the Play button, which should start the view in Chicago and then rotate the Earth from Chicago to Hawaii. The path extends with the rotation.

Web-based Tour Authoring

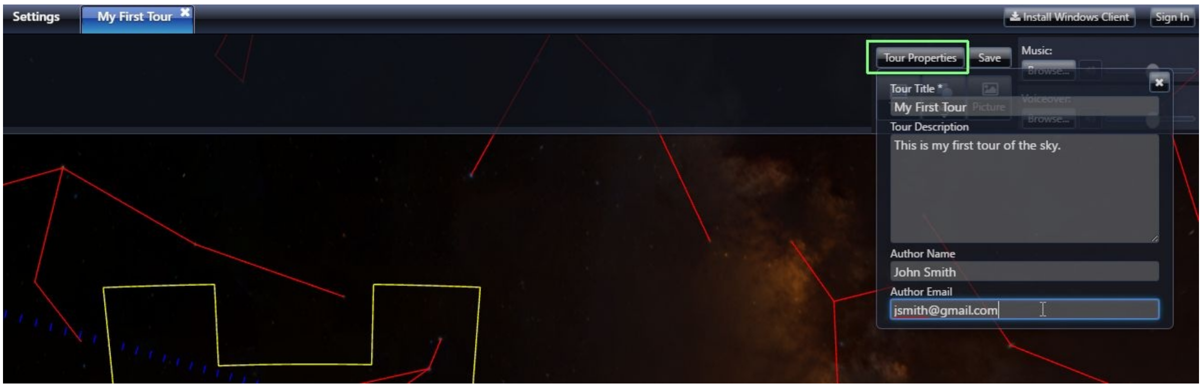
While you are exploring the universe you can create tours that capture your exploration and share them easily with your friends. This can all be done easily in the new and improved web client. The new web client is built upon WebGL which enables desktop-like performance and graphics functionality from within a web browser. Web-based tours use Slides, which are similar to those in PowerPoint. Tours authored in the Web Client can be played back on any device that support WebGL, including smart phones, tablets and PCs with any operating system. The tours can also be loaded into the Windows Desktop client used in planetariums or other complex visualization facilities.

Creating your first tour

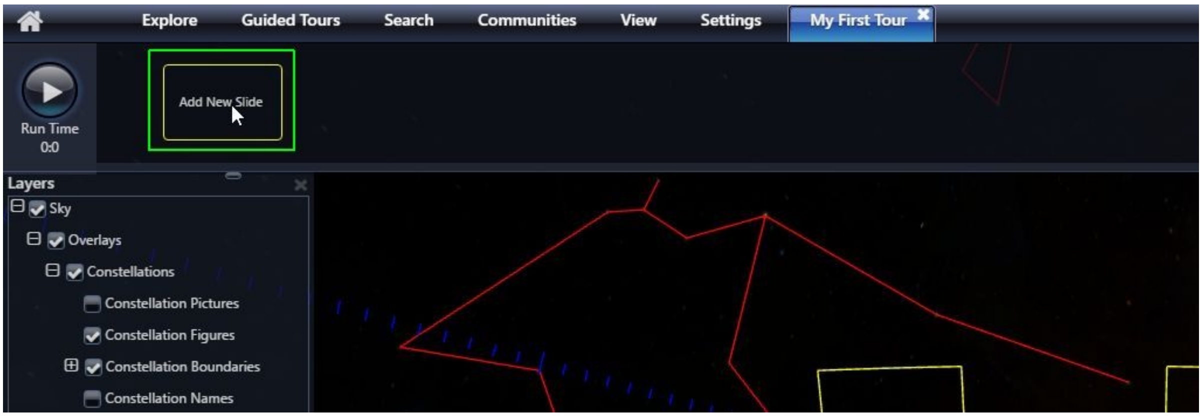
1. To start open the web client on the WorldWide Telescope Site http://www.worldwidetelescope.org/webclient/). Although you can play the tour you create on the web on small mobile devices you probably want a desktop or laptop with a mouse (with left, right buttons and scroll wheel) or modern track pad (with similar gestures).
2. Throughout this tutorial, we will have you change initial views which require you to navigate the view.
   i. The left-mouse click and drag – moves the camera's view of the sky.
   ii. Control-left-mouse click and drag – rotates the view around the center point.
   iii. **When editing at tour**, the right-mouse click on an object brings up a context menu where you can select items like "Properties". **When not editing**, the right click brings up a finder scope where you can find more information about an object.
   iv. Scroll wheel zooms in-and-out.
3. Now, let's actually build the tour. Under the "Guided Tours" tab at the top, select "Create New Tour". This will create a tab entitled "New Tour" to the right of "Setting" tab.



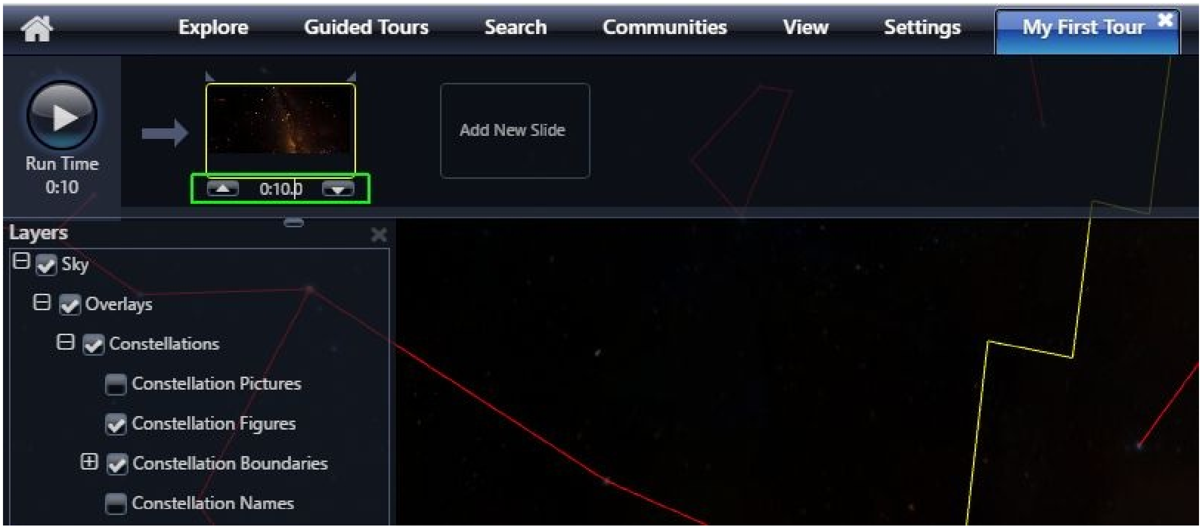
4. Let's now bring up a Tour Properties box. You must provide a Tour Title, but all other fields are optional. The Tour Title also changes the title of the tour in the menu bar at the top. Here you can see the tile in both palaces is "My First Tour".



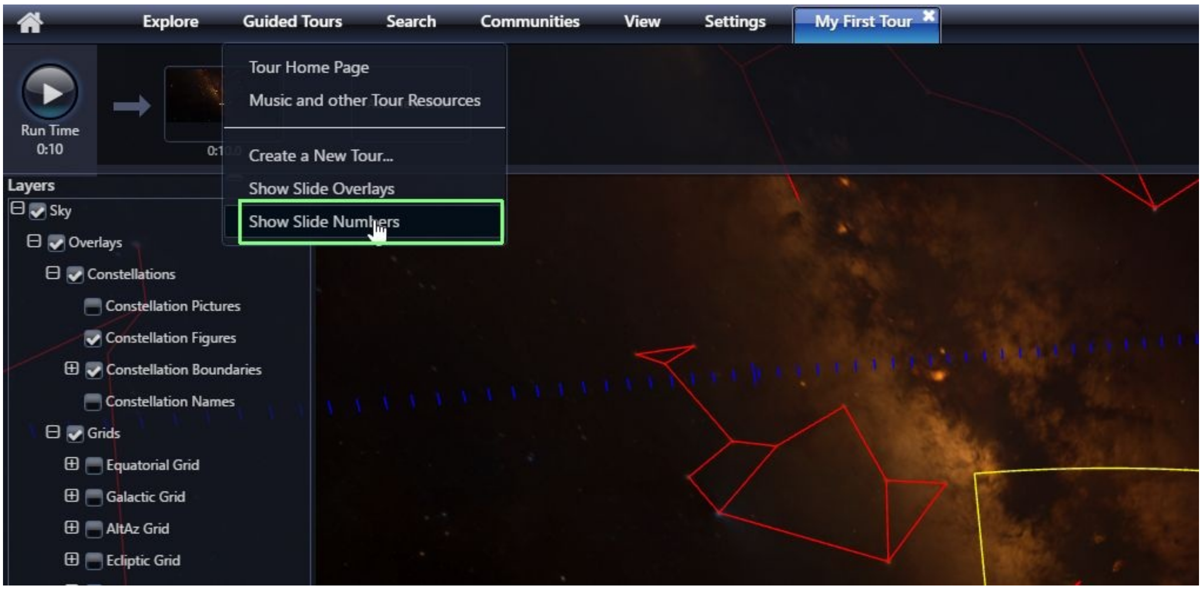
5. Let's setup the initial view for the Tour. For this tour we will be creating a tour of the Sky. It is the default but make sure that Sky is selected in the **Look At** menu in the lower left. Move the screen around until you have a view of the sky you like and then click "Add New Slide" button in the slide bar at the top.



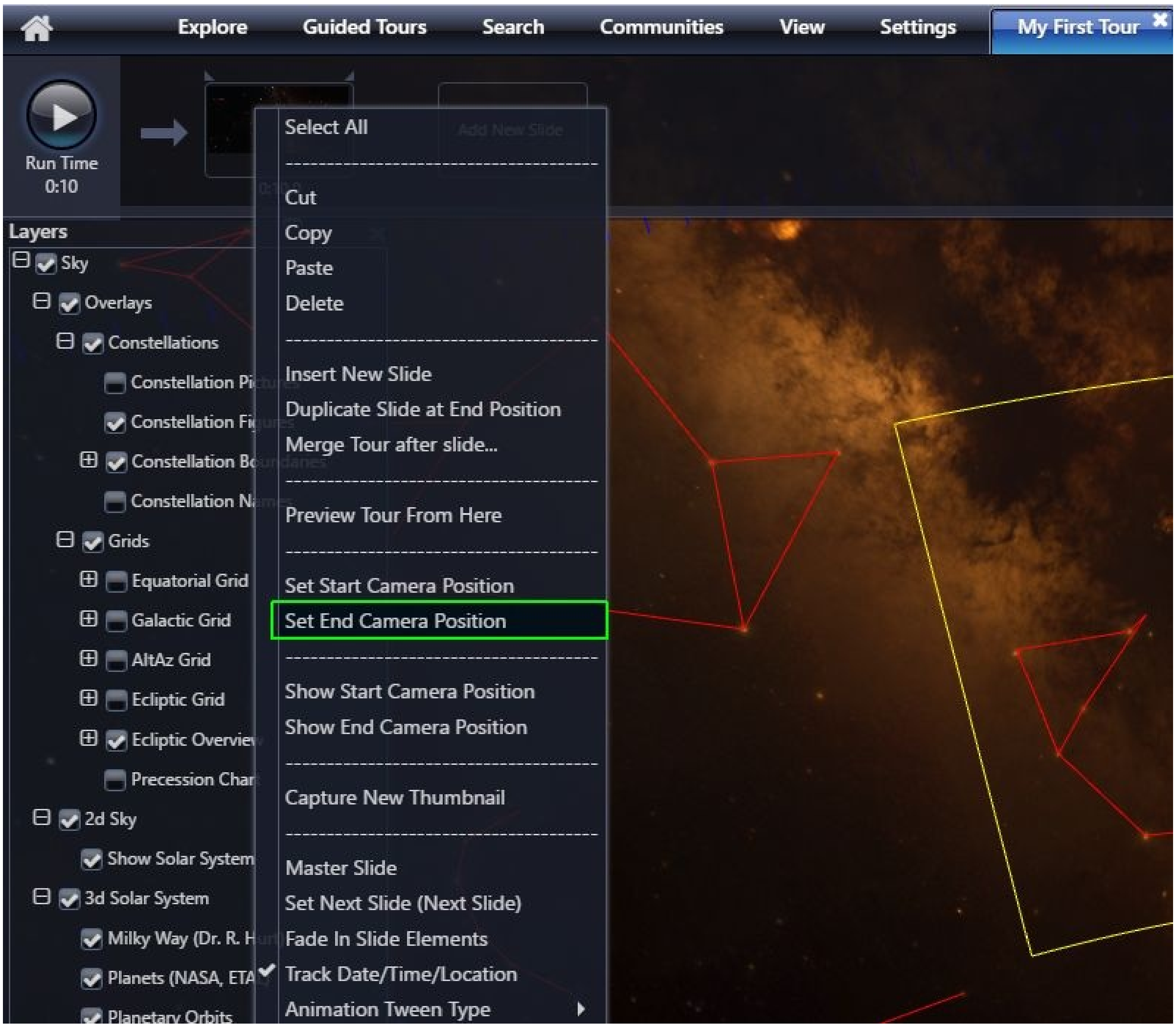
6. This will create your fist slide and capture a thumbnail image for it from the current view. It will also setup a default duration for the slide, which is 10 seconds. You can adjust this by clicking in the time field and directly typing the time or using the little up and down arrows on either side of the time.



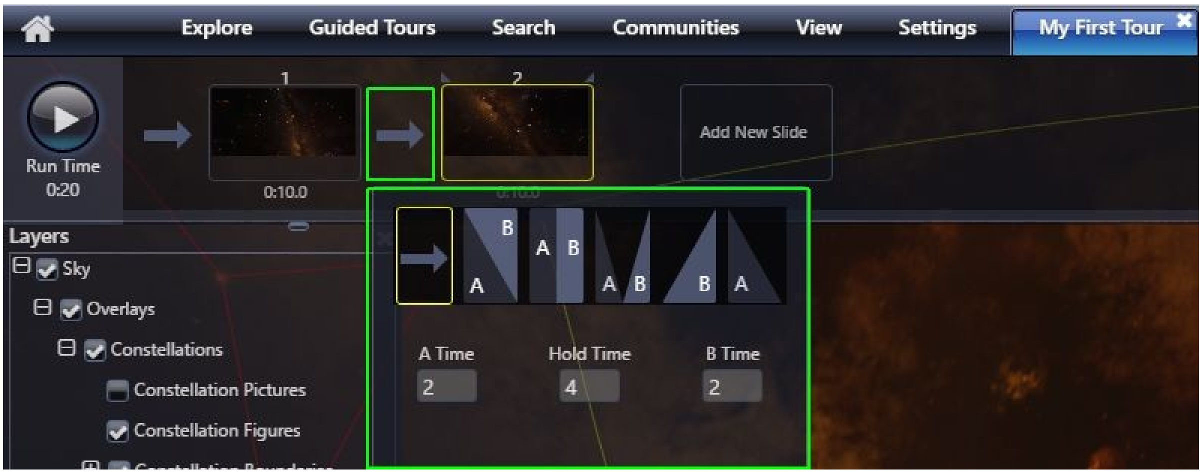
7. It is useful to show slide numbers to keep track of where you are. Do to that under "Guided Tours" tab select "Show Slide Numbers. This will put a numeric slide number at the top of each slide.



8. You now have a slide with an initial view. You now should set an ending viewpoint for the slide. When you play the tour the viewpoint will smoothly change between the beginning and ending camera positions. To set the end slide position, change the view, using the mouse controls explained in item 2 above. Then right-click on the slide and select "Set End Camera Position." Note, there is a yellow ear on the top left of the slide when you are looking at the start position and on the right hand part of the slide when looking at the end camera position.

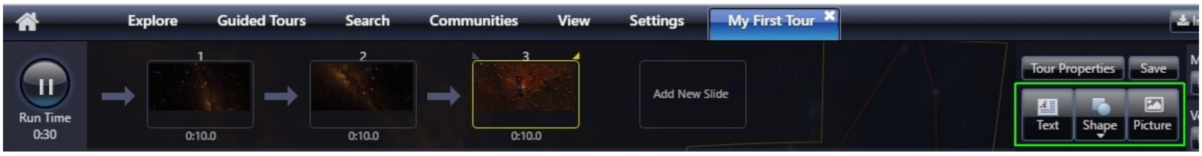


9. Now you have a 10-second tour consisting of one slide. Go ahead and press the Play button to see how it works.
10. When the tour is finished playing, click “Add New Slide” again. This will add a second slide using the end camera position as the starting position for the new slide. If a sequence of slides is intended to show contiguous motion, you should make sure that the end camera position of one slide is the same as the beginning camera position of the next one.
11. You can continue these steps to create a sequence of slides.
12. Between every two slides there are various transition options, shown below. Note that some transitions take time which is taken out of the start time for the second slide (Slide B). Note that the transitions can be thought of as being added on top of camera motion defined by the slides.



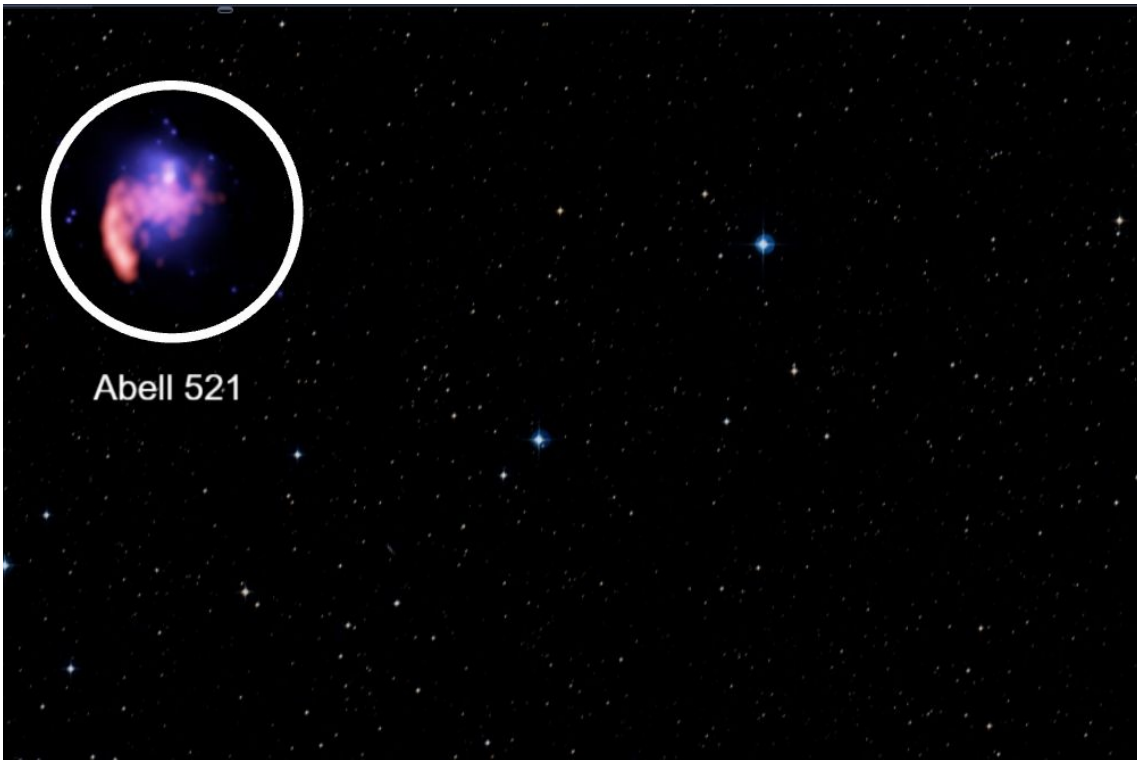
i. The default arrow means that the slide moves from the end of one slide to the next without pause. This is used for contiguous motion.
ii. The A\B transition is a cross-fade between two viewpoints.
iii. The A|B transition is a hard cut between two viewpoints.
iv. The A\/B transition is one that fades through black between two viewpoints.
v. The /B transition is a hard cut from A to black and then fades in B
vi. The A\ transition fades out to black and then does a hard cut to B.

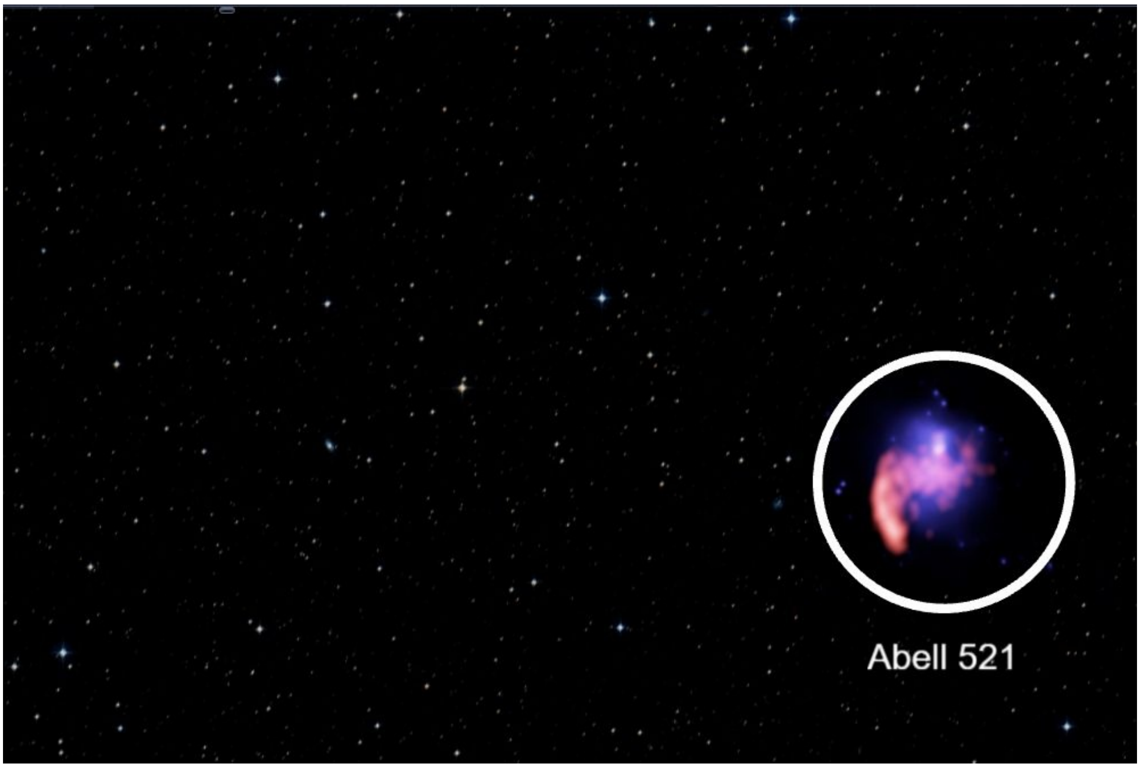
13. At the upper right-hand side is an interface that allows you to add overlay elements to slides: Text, Shapes and Pictures.



i. Clicking "Text" shows a text dialog box where you can enter text, select font and font-size, foreground color, background color, style (bold, italics, underline), text and background colors.
ii. You can add built-in shapes, such as circle, rectangle etc.
iii. Finally, you can add pictures. Clicking this opens a dialog box where you can browse for local images to add.
iv. By default, all objects that are added stay in the same place on the screen throughout the slide. However, once added, you can right-click on an object and click "Animate." This enables you to specify how the object should look at the beginning and also the end of the slide. Once an object is animated, you can right click on the slide and "Show Start Camera Position" and then change the location, size etc. of the object and the right-click and "Set Start Camera Position." You can do this again for the end positions changing the end characteristics of animated objects. You can also turn off animation. It will default to whatever slide position is showing (Start or End). For instance, the example below shows the galaxy cluster Abell 521. A ring and text label have been added to identify the object, which is at the upper left at the Slide Start position. The camera was moved such that the object was in the lower right at the Slide End. The text and ring overlay objects

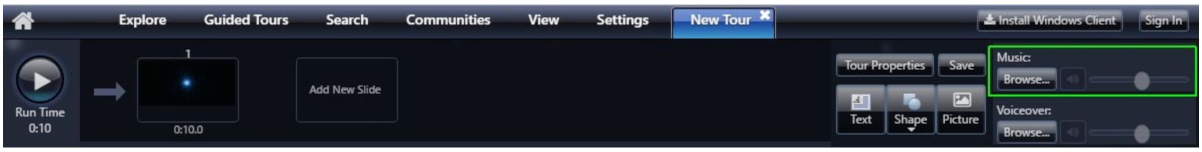
were animated (right-click, select “Animate”). They were positioned over the object at the slide start and moved to where the object was at the slide end. Below are screenshots of the slide start and end. When you play the slide the object and text move smoothly from start to end.



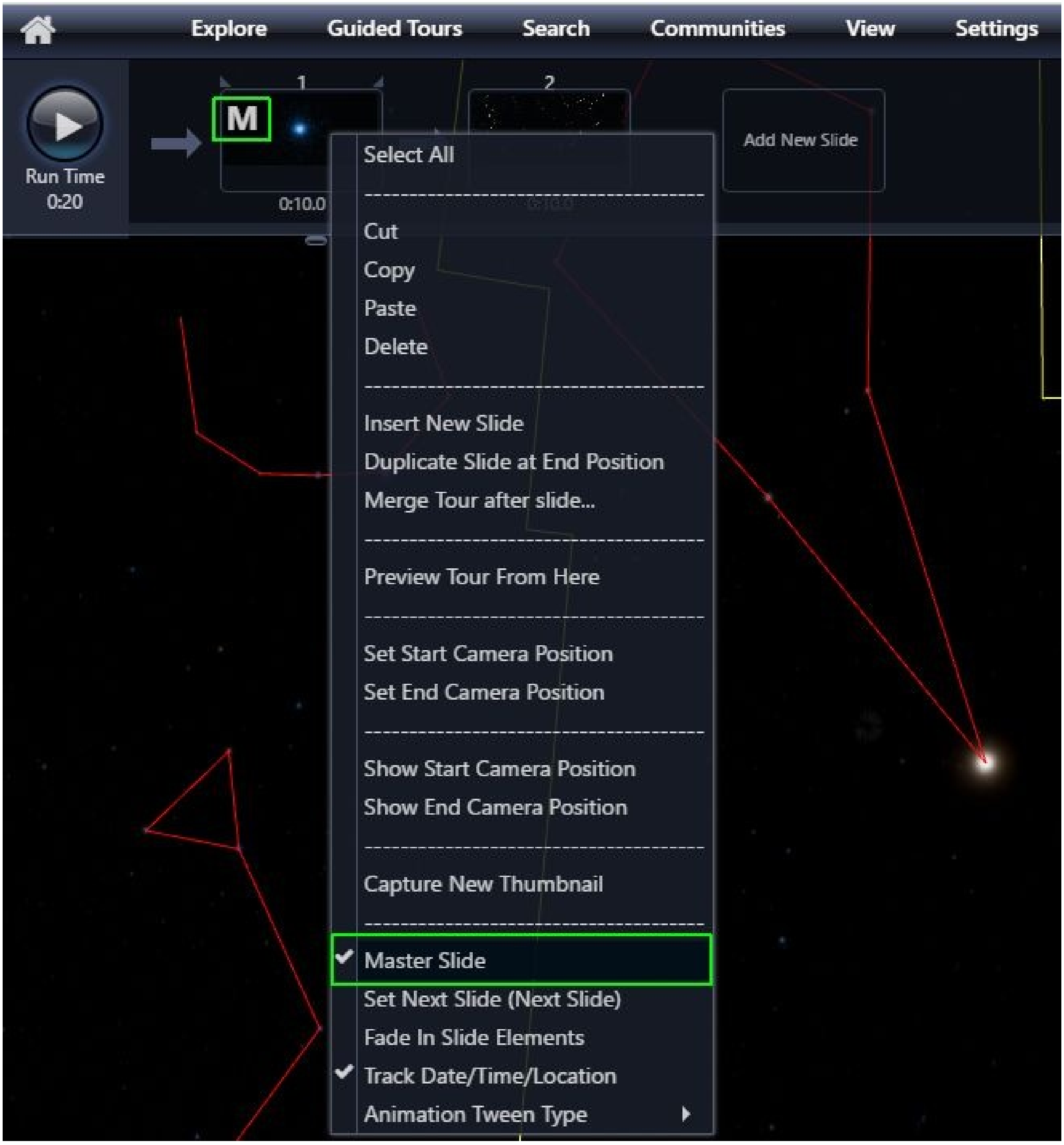


14. If you have a long tour it is time-consuming to watch the entire tour to see the effect of a change near the end. You can right-click in any slide and select “Preview Tour From Here” and the tour will play from that location.
15. You can add an audio soundtrack (Music and/or Voiceover). The files must be MP3. The

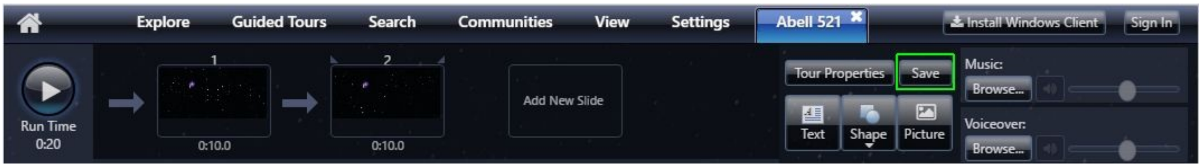
volume of each audio file is controlled by a slider and are mixed together during playback. Each slide can have its own audio tracks. This is helpful when you change the timing of a slide you don’t have to re-record the entire narration. Audio will end at the end of the slide unless slide is a master slide (see below)



16. There is special type of slide called a Master Slide. You make a slide a Master slide by right-clicking and selecting “Master Slide.” Overlay elements (Text, Shapes and Pictures) remain on all subsequent slides until another Maser Slide is encountered. This also affects audio. Audio on a master slide continues to play through subsequent slides. Per-slide audio can be added on slides after the master slide and both audio tracks will be mixed. Objects on a master slide (Text, Shape, Picture and Audio) remain until the tour ends or encounters another Master Slide.



17. You can reorder the slides by clicking a slide and moving it to a new location in the slide set. You can select multiple slides by holding down Control while clicking on slides; selected slides will be outlines in yellow.
18. When you are want to save the tour, you can click the Save button in the upper right. Currently, saving the file saves a local .wtt file in your Downloads folder.



Advanced Tour Authoring

Since the Windows Desktop Client was created first, there is extensive documentation on the use of that client. The web client has been created to be very similar to the Windows Desktop Client, much of that information is relevant for the web client. Also, the web client is under active development and is increasingly similar and closer in functionality to the Desktop Client. Below are links to documentation created for the Desktop Client that are relevant to the Web Client.

- Dealing with Audio
- Editing Audio
- Making Video Abstracts with WWT
- Adding Astronomical Image Data – Currently only Loading of Remotely-served AVM-tagged Images is supported (no local images or FITS files)
- Processing All-Sky Images

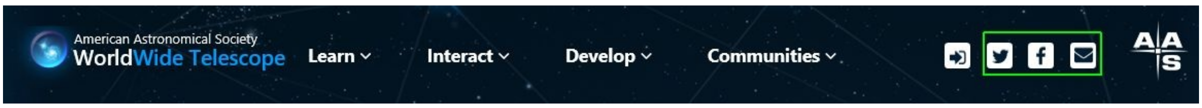
How is Web-based Authoring Different from Authoring with the Windows Desktop Client?

For those familiar with the Windows Desktop Client, it is instructive to show how the Web Client differs from the Desktop one.

i. No Timeline-based tours that have Keyframes.
ii. Audio Files must be MP3.
iii. 3D models are not currently supported.
iv. Web Client cannot be used in a dome or cluster installation.
v. Web Client cannot now render to video (but it may be coming in 2017).
vi. No VR capability.

Keeping in Touch about Web Client Development

The Web Client is under active development in 2016-17 and functionality (both feature parity with Windows Desktop client as well as new features) is being added. This new capability will show up when you use the Web Client in the future without you having to do anything. We will try to keep this documentation current but when you use the Web Client in the future you will notice subtle changes as features are added. We will announce big additions in news items. We also recommend that you connect with the WWT project with Twitter, Facebook and Email links using the WWT home page.



Authoring for Virtual Reality

When making tours for Virtual Reality (VR), it helps to come up with certain rules about how the user interacts with the virtual environment and then stick to them. This helps to make tours that don't provide visual information that is in conflict with other sensory input such as head orientation, which is provided by your inner ear. This disparity between what you feel in the physical environment (like turning your head) and what you see in the virtual environment can create symptoms similar to motion sickness.

One of the amazing things about VR is that users have a natural sense of interaction by moving their heads that requires no training. For instance the Impacts Tour has been shown to kids in Kindergarten, to seniors and all folks in between – all of them interacted with the experience without any specific instruction – with the exception that people do need to be reminded to look in some direction other than forward.

In WWT there are two different types of VR experiences. One experience is a more formal **Virtual Reality** experience. The other type we call **Divine Visualization**.

Creating Virtual Reality Experiences

Virtual Reality Experiences are constrained by rules; when these rules are followed, they support the presence of the user in the virtual environment and natural appreciation of scale and distance. Below are rules that we follow when making VR tours.

1. Throughout a scene keep the same camera view. Don't zoom your camera as you navigate a scene. That would be equivalent to scaling you to be bigger and smaller as you explore an environment. When you zoom the camera you change the stereo separation which confuses the sense of scale brain interprets through motion.
2. In the tour only control the XYZ translations. The user will naturally control rotation by moving their head, which is then coordinated with the physical input that the inner ear gives the brain.
3. Think about the user as a participant in the scene and actually decide *what is the representation of the user is in the virtual environment* – the user's avatar. Even if the avatar is not visually displayed it will have specific capability (e.g., size, stereo separation of eyes, speed etc.). For instance, if the user is an astronaut with a jet pack that responds to a thruster then the translations should be of that speed.
4. Be very careful about giving the user too much control. People thing they want to have as much control as possible, but if they don't interact well with the environment, they can leave the system completely or be looking the wrong direction. Worse they can induce virtual reality sickness by quickly moving their view with the joystick in a way that is in conflict with their head's motion. Training can help mitigate these effects but takes

time and a carefully planned training experience.

In VR you can keep the zoom level constant and move the camera through a scene by reference frame for the camera and move that.

Creating Divine Visualization Experiences

Divine Visualization is a category of experiences where the producer breaks the rules of VR in order to tell a story or explore data. In this view, the user is not limited by rules of interaction of an avatar with a virtual environment, as is the case for creating strict VR experiences above. One simple example is moving the view of the Solar System from edge-on to face on. Here the divine viewpoint, which is not constrained by the laws of physics, is understood by the user as viewing and potentially manipulating the Solar System as a model or scientific visualization. As a producer, you may feel this is necessary to communicate some things this way. The user will probably not feel as though they are moving wildly in the Solar System but will likely interpret this as playing with a 3D model in a classroom.

When you decide to break the rules, you can do anything you want. However, you should be aware of dissonance between visual and inner-ear-provided orientations and try to minimize them.

1. Keep objects in front of the user while you are moving or changing them (e.g. rapid, non-linear advances in time). This will reinforce the feeling that the user is manipulating an object.
2. Don’t introduce motions that would require the user to turn their head very much. This will reduce the amount of dissonance.
3. Be very careful in creating interactive VR experiences where the user can use an Xbox controller to fly around a scene. Even experienced VR producers can get sick doing this. If you are designing an unconstrained interactive, we recommend some training phase of the interactive where they are taught how to move their view slowly, especially in rotation.

The Story

It is very important to start with the story. Tours naturally lend themselves to fairly strict VR experiences and many WWT stories involve moving the user through space and telling them what the objects are that they are seeing. This is the basic structure of the Impacts tour. In the Impacts tour, we were in this VR experience mode until the last two slides where we switched to Divine Visualization where we showed the Solar System in an unrealistic way.

Tilting the view of the Solar System and even visualizing asteroids and orbit lines break the illusion of what someone would actually see. In Impacts we transition from one form to another, but don't go back and forth in the Tour.

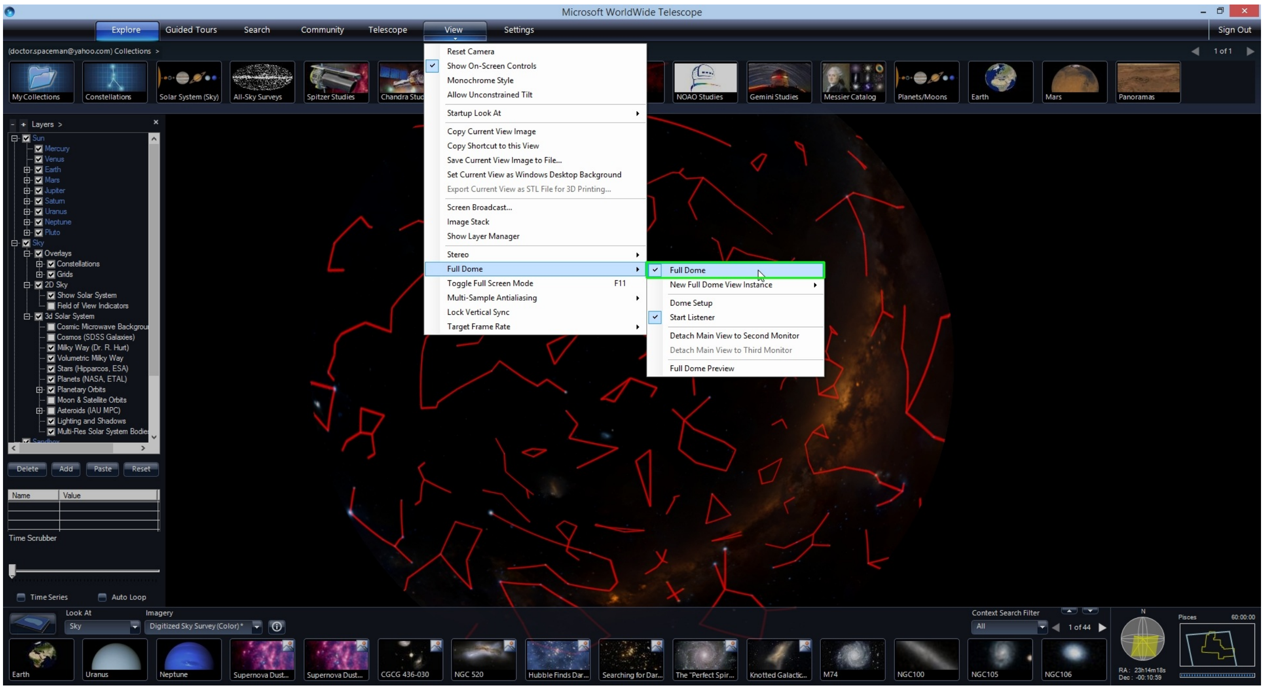
We created Impacts to test out the production features of WWT as well as learn about VR production. You can follow your own production experiences but certainly give adequate time for testing and refinement. Our experience is that when you are in VR during production, you get your VR-legs and will be able to handle more extreme motions and dissonance. That is why it is important to have people who are not familiar with VR to test out your experience. Carefully consider their input of how they interpret the experience and any susceptibility they have to motion sickness.

Authoring for the Dome

WorldWide Telescope 5.0 has specific functionality to enable dome authoring and playback. Technically, tours created on/for a flat display, such as a laptop, will work on the dome. However, differences in the projection and the field of view create challenges to creating content on a flat screen and having it look good in a dome. This guide will go over some function in WWT that help move between these two views.

The main window view can be changed to preview a full dome view. To go into a dome view, under the View tab, select "Full Dome/Full Dome."

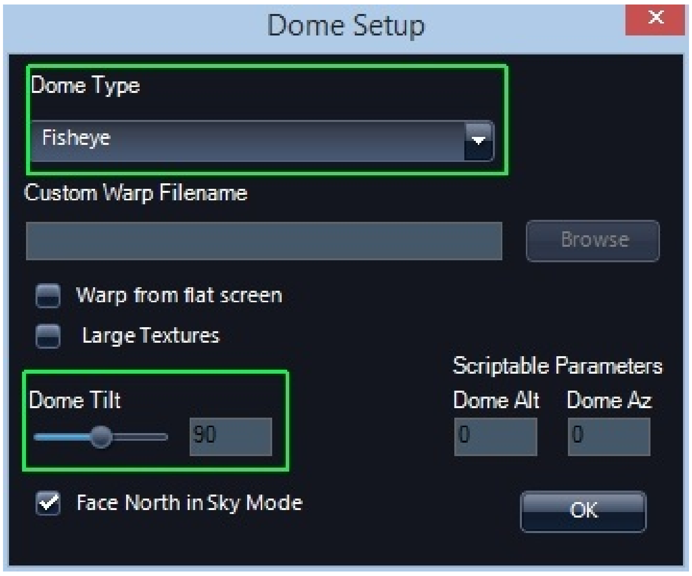
Note: The default full dome view has a wide hemispherical view of 180 degrees. In the flat projection the default view is about 60 x 34 degrees. Where this sub-region of the full dome view is located on the dome is controlled by the dome tilt. At 90 degree dome tilt, this view will be at the Zenith and at 0 degree dome tilt it will be near the bottom of the full dome image in the front.



Authoring on Single-Projector Systems

For systems with a single fish-eye or mirror-dome projector attached to a separate video output on the Master Server - which is probably the only computer, under the View tab, you can select “Full Dome/Detach Main View to Second [or Third] Monitor.” This will allow full-dome authoring playback on the same system. Menu and interface windows stay on the first monitor and the second or third monitor outputs drives the single full-dome projector. In this case, text positions are placed in the dome view and seen in the same way it will be viewed in a show, which facilitates the placement of their placement, as well as the pacing of motion, etc..

To setup the dome parameters, select **View/Full Dome/Dome Setup**, which opens a setup window.



Under Dome Type, you can select “FishEye,” “Mirrordome 16:9” or “Mirrordome 4:3.” You can also set the Dome Tilt. Multiple projector, or non-standard projections can be implemented by solving for projector geometries using “Settings/Advanced/Multi-Channel Calibration.” Details of this are given in a separate document.

If you have a single Projector Server which is different from the Master, the dome setup is the same but you will need to setup a simple 2-computer cluster, which is described in the WWT Multi-Channel Setup document.

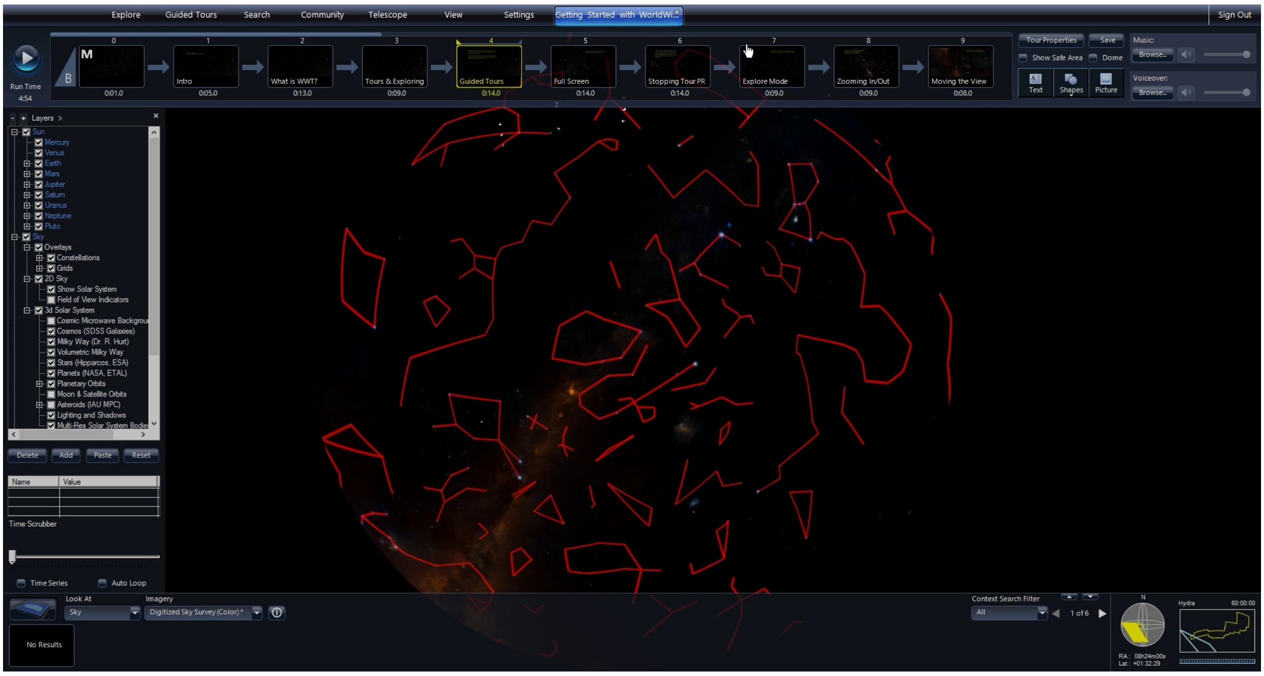
Authoring on Flat Displays for Presentation on Dome

For the remainder of this document, I will assume you are authoring on a flat screen and will be playing back on another full-dome system, which could potentially be multi-channel. WWT has specific tools to facilitate this.

In the full-dome view the size and location of overlay objects like text, shapes and images makes it hard to see them when the hemisphere is projected back onto a flat screen as a full dome preview. Usually in the flat screen you just click on overlay objects in the main view. However, it is sometimes hard to see the overlaid objects in full dome preview on a flat screen. Note, that even if you can see the objects it is hard to actually select one to move, edit, etc..

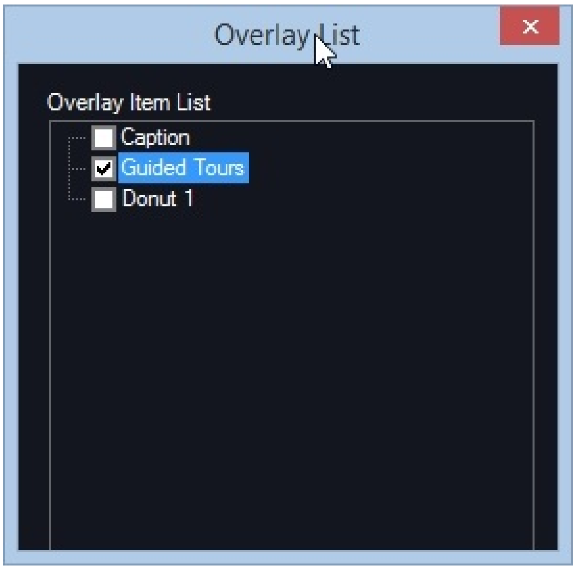
Full Dome Mode

On a desktop you can view the full dome view in the main window by selecting **View/Full Dome/Full Dome**. This will change the main view into a hemisphere projected onto a flat display with black area around it.



Overlay List

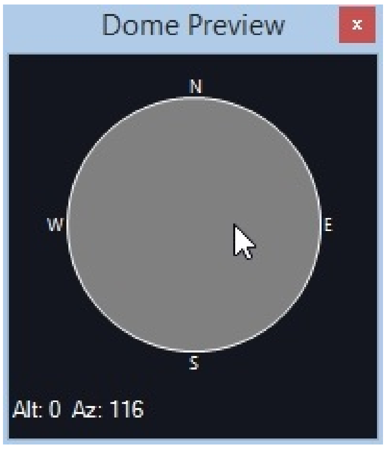
To interact with overlay objects (Text, Shapes & Pictures) in dome mode it is easier to use the Overlay List window, which is accessed under **Guided Tours/Show Overlay List**. The overlay objects have names that default to file names for imported pictures or the first line of text for text object. Shapes are named by their name followed by a number (e.g., “Donut 1”). You can always rename any overlay object by right-clicking and opening the Properties dialog.



Right-clicking on any of the images brings up a menu. Most options are the same is if you right clicked on the object in the main view. You also have an “Edit” option which is the same as double-clicking the overlay object in the main view. The Overlay List can make objects accessible when they are hard to click on in dome mode or off-screen or hidden under menu tabs.

Dome Preview

You can view a flat projection of a part of the full dome view using the Dome Preview. Since this is a flat projection you must make sure you are *not in full dome mode*. Make sure that **View/Full Dome/Full Dome** is unchecked. At this point you are viewing a virtual camera view of the full dome view. You can move the camera to see in detail what is being shown on any part of the dome with the Dome Preview window, which is shown by selecting **View/Full Dome/Full Dome Preview.**



As you click your mouse and move it in the grey circle in the Dome Preview the main window will show a smaller tangent view of the full dome view. The preview is centered on the Alt/Az positions shown in the lower left hand corner of the Dome Preview window which changes are you click and move your mouse.

Rendering to Video

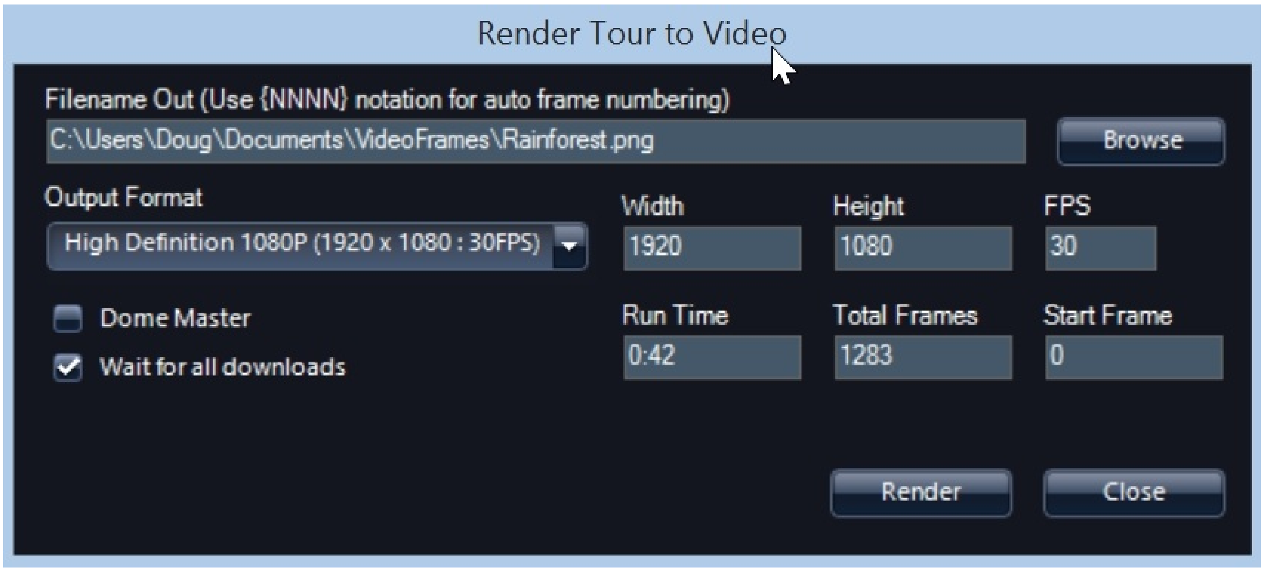
You can use WWT to create still frames, which can be encoded into a video. Note, that WWT writes out a sequence of frames and does not do the encoding to video. You will have to use another solution to create the video and include any audio. Some suggestions are given below. Rendering out of WWT might be desired in the following situations:

- You have a planetarium with its own video playback system.
- You want to combine WWT images and videos with other content. For instance, this could be done to use WWT to render out a star field at a certain time and then composite a horizon or other elements in front of it. Or you might want to render some scenes in WWT and other ones in another package and then splice them together.

- You want to distribute a video to YouTube or create a video for a presentation in PowerPoint.

Simple Case

In the case of a flat screen, things are pretty straight forward. Once a tour your want to render out is loaded, select Guided Tours/Render to Video. This will open the Render Tour to Video dialog box.



By default the frames are written to “VideoFrames” folder under your “Documents.” In the dialog box, you just need to specify a filename. WWT will create a sequence of frames based on that name. If you give the name “C:\Users\Doug\Documents\VideoFrames\Rainforest.png” in the dialog box, WWT will write a sequence of images named Rainforest_0000.png, Rainforest_0001.png, etc. You should also leave the output extension as PNG. Don’t change it to anything else or give the name without an extension. WWT only writes PNG files.

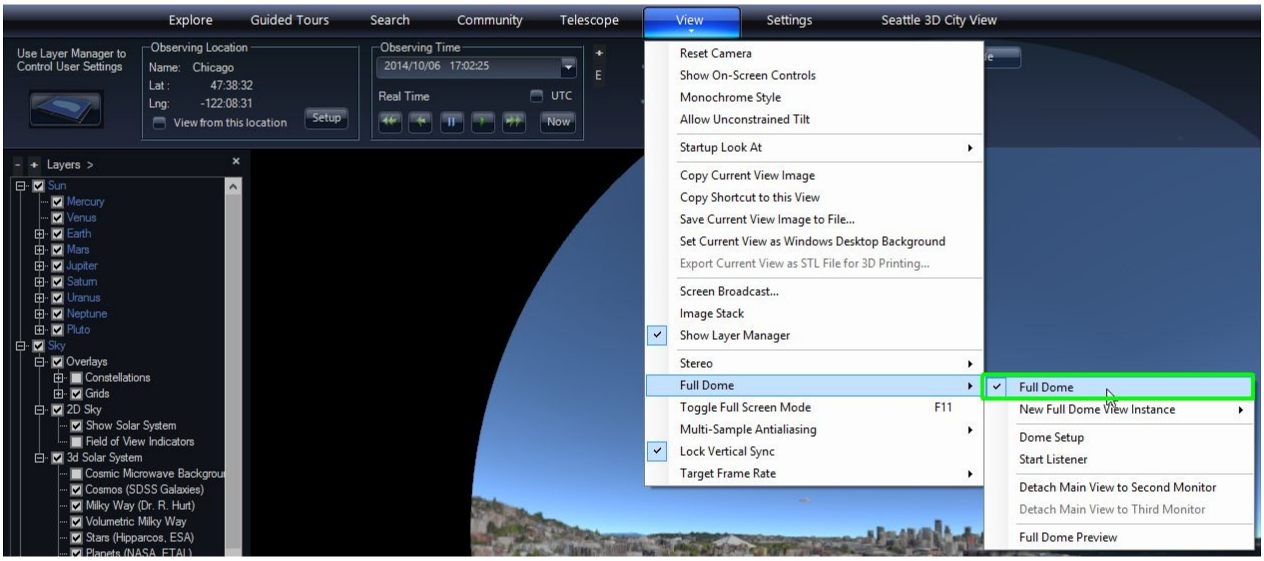
Also, currently for flat (i.e., non-dome) output format is set to the same resolution as the display, so if you are on a 1080x1920 display that will be the output size of the PNG images. For flat screens, don’t change these numbers and WWT only renders out 30 frames per second (FPS).

The **Run Time** and **Total Frames** are reported from the Tour. You can adjust the **Start Frame** number to begin rendering frames to some point into the Tour. This can be useful when you want to render frames in sections or make a change to a part of the tour and render those frames out. Note, there is no way to specify the end frame here, so you will have to watch the progress dialog that reports how much has been rendered and then click **Cancel** when you want to stop it.

When rendering, we recommend checking the box **Wait for all downloads**, which will force WWT to wait to load any data, tiled images, 3D terrain, 3D cities needed to render each frame. Unless you just want to make a quick small pre-visualization, the additional amount of time to wait for all data to download is a small price to pay for better rendered output.

Dome

To render frames for dome output you have to do the following:



1. Make sure you are in Dome view. Select this under **View/Full Dome/Full Dome.**
2. Open the **Render Tour to Video** dialog box.
3. Check the **Dome Master** check box.
4. Check the **Wait for all downloads** check box.
5. In the **Output Format** pull-down, select one of the Dome Master formats: 1k, 2k, 3k, 4k, or 8k.
6. Click Render to write the files.

Note that for large 4k or 8k images, writing each frame may take several seconds.

Making Video from Rendered Frames

Once you have your frames rendered you can make the output into a video. This functionality is not built into WorldWide Telescope, but here are some options of how to proceed.

First make sure the frames look ok and that the frame numbers are contiguous. Be careful if you render parts and try to put them together. If you do that we recommend that you render each part to its own folder and then copy the frames you want into a final folder.

If you want to add audio, you can use the voiceover and music audio files from the tour. Note, that you can include a sequence of audio files associated with each slide, but it may be easier if you combine those files outside the video encoding program and bring in just one audio file for voiceover and one for music.

QuickTime Pro ($29.99 from Apple) is a relatively inexpensive way to encode the sequence of PNG files into a video.

1. Open the PNG images by selecting **File/Open Image Sequence…** Browse to the name of the *first file* of the sequence. This will open the sequence in its own window.
2. In that new window, select **File/Export**, which will bring up a dialog box.
3. Set the output video file name and options in this box and then click **Save**.

Adobe Premiere is a more powerful way to encode video.

1. Open the PNG images by selecting File/Import and then browsing to the name of the first file of the sequence. Check the **Image Sequence** box above the file name and click Open.
2. In a similar way you can import your audio tracks as well.
3. You will see your image sequence and audio if you imported that in the media browser in the lower left panel. Drag the image sequence and audio files into the timeline in the lower right.
4. To output the video, select **File/Export/Media…**. You can change any of the export controls in the dialog box and when you are happy click the **Export** button.

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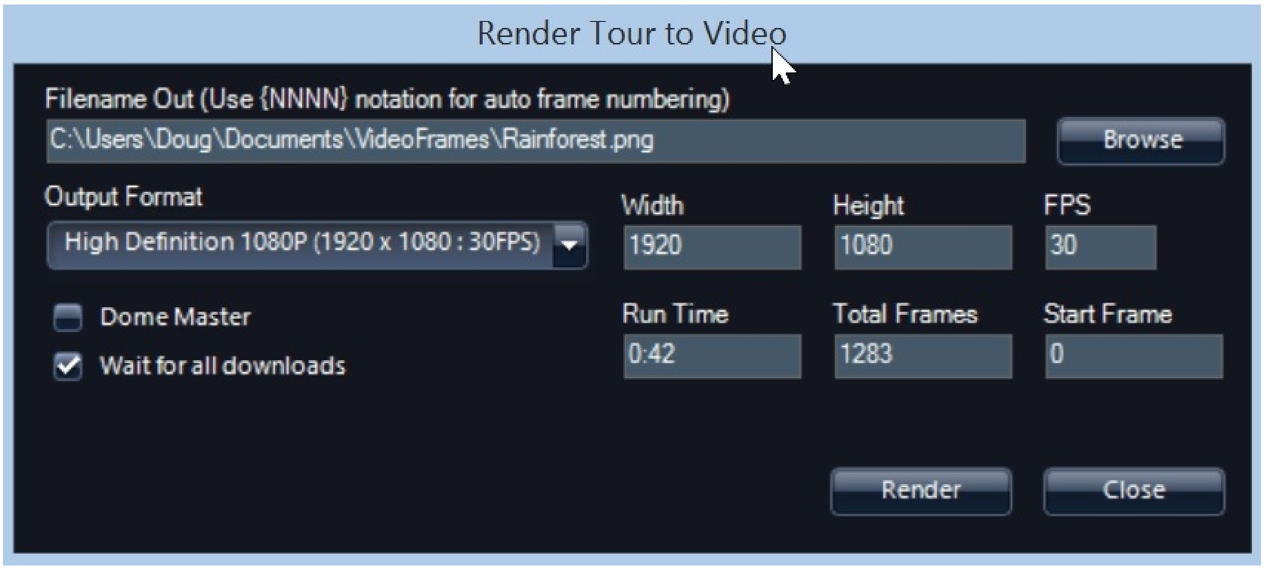

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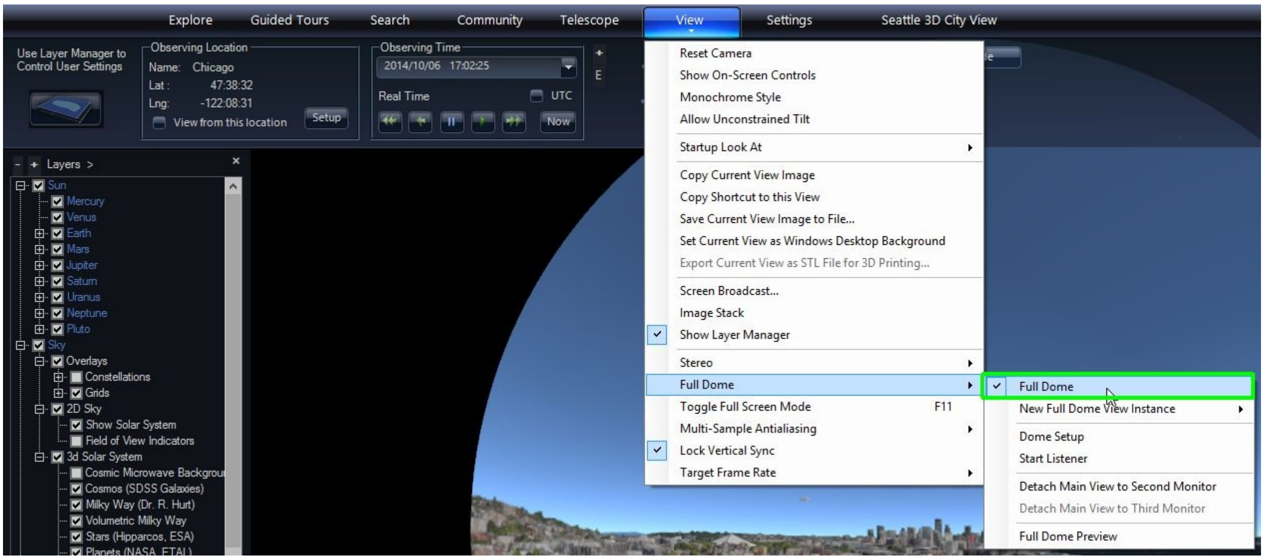

1. Make sure you are in Dome view. Select this under **View/Full Dome/Full Dome.**
2. Open the **Render Tour to Video** dialog box.
3. Check the **Dome Master** check box.
4. Check the **Wait for all downloads** check box.
5. In the **Output Format** pull-down, select one of the Dome Master formats: 1k, 2k, 3k, 4k, or 8k.
6. Click Render to write the files.

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1. Open the PNG images by selecting **File/Open Image Sequence…** Browse to the name of the *first file* of the sequence. This will open the sequence in its own window.
2. In that new window, select **File/Export**, which will bring up a dialog box.
3. Set the output video file name and options in this box and then click **Save**.

Adobe Premiere is a more powerful way to encode video.

1. Open the PNG images by selecting File/Import and then browsing to the name of the first file of the sequence. Check the **Image Sequence** box above the file name and click Open.
2. In a similar way you can import your audio tracks as well.
3. You will see your image sequence and audio if you imported that in the media browser in the lower left panel. Drag the image sequence and audio files into the timeline in the lower right.
4. To output the video, select **File/Export/Media…**. You can change any of the export controls in the dialog box and when you are happy click the **Export** button.

Using the Timeline Editor

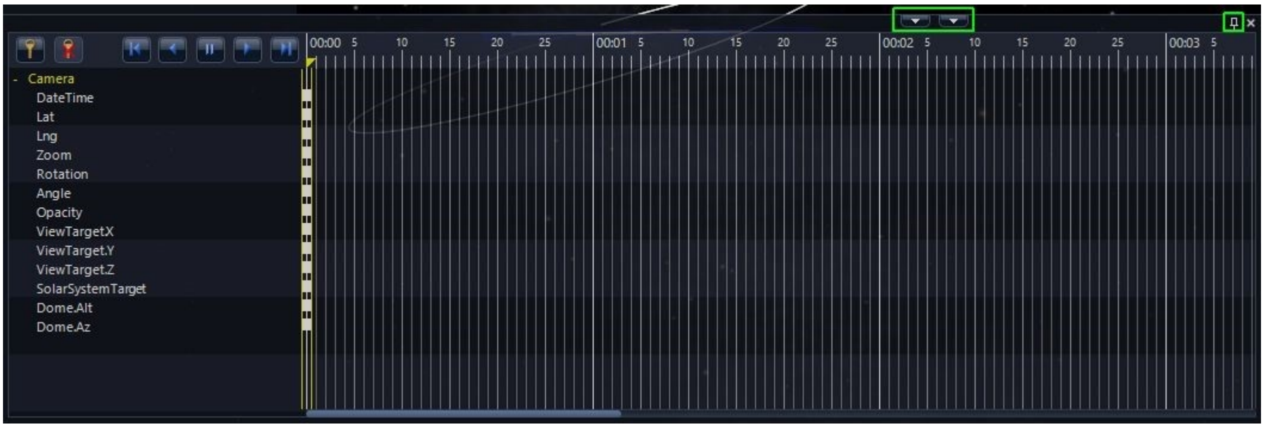
Slide-based tours have only a start and end position and WWT smoothly moves between them. However, you may need finer control to change views, location and appearance of objects in a more flexible fashion. To do this, you can edit the timeline control for each slide of a tour.

Important: Tours containing timelines can only be played back on WWT 5.0 or later.

Create a tour using the Timeline Editor

To create a tour using timelines, do the following:

1. Create a new tour - **Guided Tours** and then click **Create a New Tour...**
2. Set **Look At** mode and the orient initial view for the Tour.
3. Create an initial slide by clicking **Add New Slide**.
4. Right-click on this slide and select **Create Timeline**. This will display a timeline window at the bottom of screen. The buttons outlined allow you to adjust the size of the window as well as unpin it from the main window.



The WWT timeline

The timeline editor shows objects and settings on the left. Initially, there will be a single element on the left called **Camera**. The + symbol to the left will open a list of attributes you can control. There are transport controls which take you to the beginning or end of the timeline as well as playing forward or backward. The time is shown across the top of the remainder of the frame. Time is shown in MM:SS along with frame numbers – 30 frames per second. Objects can be controlled down to one frame = 1/30 of a second. While over the timeline you can use the scroll wheel on your mouse to change the scale of the timeline and to scroll the view of the timeline left and right. You can grab the yellow triangle which adjusts the current time. This is useful to get from one point to another and to see motion in the main window.

Note: The one aspect of the view that cannot currently be controlled by the timeline is the Look At mode. This must be set once for the entire slide.

Example:

For this example I will Look At SolarSystem. A one-slide tour showing this example is available here

Adding objects: You can right click and select **Add to Timeline** on most of the objects in the Layer Control Manager on the left hand side of the screen. For some planetarium productions, the constellations might need to be turned on at some point and then fade out. You can add separately control Constellation Pictures, Figures, Boundaries and Names. In this example, I will add constellation figures and planetary orbits, both with labels.

1. In the **Layer Manager**, under **Sky > Overlays > Constellations**, make sure that the **Constellation Figures** is checked and then right-click and select **Add to Timeline**. This will create an object called **ConstellationFigures** in the timeline.
2. Also in the **Layer Manager**, under **Sky > 3d Solar System**, make sure that the **Planetary Orbits** is checked and then right-click and select **Add to Timeline**. This will create an object called **SolarSystemOrbits** in the timeline.

You can also add overlay objects such as Text, Shapes or Pictures. For this example, I'll create two Text Objects called **Our Solar System** and **The Sky** and put them at the same location. Then I will right-click and select **Add to Timeline**.

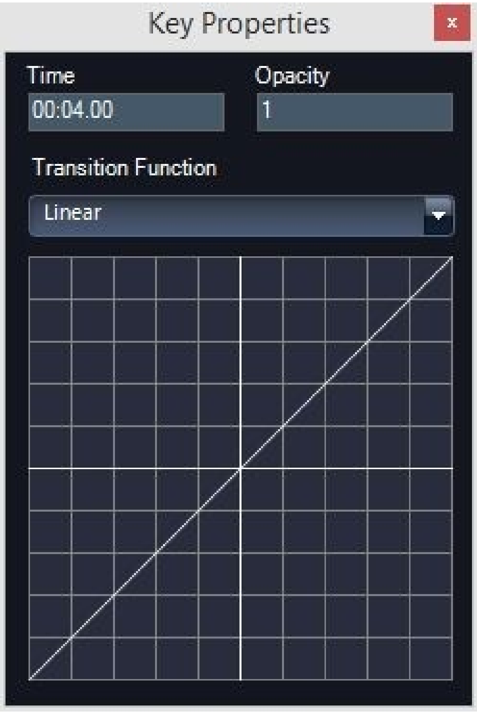
Hint: Sometimes you can't see the overlay objects because then are stacked up, underneath a menu or difficult to find in Full Dome mode. In the **Guided Tours** menu select **Show Overlay List**. A list of text, shape and image overlays is shown. You can right click on overlay objects and change the ordering, color etc. If you are going to add something to the timeline with color, you should change the color in this right-click menu rather than the text entry box. You can change the name in the Overlay List by right clicking and selecting Properties. When using the timeline editor do not select Animation, which is a slide-based way of doing a similar as timeline editing.Sometimes you can't see the overlay objects because then are stacked up, underneath a menu or difficult to find in Full Dome mode. In the Guided Tours menu select Show Overlay List. A list of text, shape and image overlays is shown. You can right click on overlay objects and change the ordering, color etc. If you are going to add something to the timeline with color, you should change the color in this right-click menu rather than the text entry box. You can change the name in the Overlay List by right clicking and selecting **Properties**. When using the timeline editor do not select **Animation**, which is a slide-based way of doing a similar as timeline editing.

Keyframes: Each object or setting in the timeline can change display attributes at specific times and WWT will smoothly move between them. These are called Keyframes and are represented in the timeline editor as small rectangles. Above the list, there is button to create (key) and delete (key with x over it) keyframes. Initially, there is a keyframe at the beginning of the timeline for every object that has been added to it.

In this example, start with a view of the sky with constellations, fade out the constellations and fade in planet orbits and end with a view of the Solar System. You can easily move keyframes in time, so start by considering the sequence and refine the timing later.

Start by expanding the timeline editor clicking the up arrow. First adjust the constellation figures to fade out from second 3 to second 5.

1. Click the "+" symbols to the left of **ConstellationFigures**.
2. Click on **Opacity** under **ConstellationFigures**.
3. Move the time to **00:03**.
4. Click the **Add Key** button (looks like a key above the list).
5. Move the time to 00:05.
6. Make sure **Opacity** is still highlighted and click the **Add Key** button.
7. Click the first key you made at **3** seconds. An editor box will show up. If a single key is selected then the label of the key will be shown above the field on the upper right. If key object is not expanded a keyframe will control all attributes. Note, the time field is also shown but you cannot change the time.



Key Properties pop-up window

1. Make sure the **Opacity** is set to 1.
2. Edit the **Opacity** keyframe at time **00:05**, and set it **0**. Then close the window by clicking the X in the upper right.
3. Do the same for the **Opacity** keyframe at time **00:00**.
4. Edit the **Opacity** keyframe at time **00:05**, and check that it is **1**.
5. Do the same (steps 1–12) for the **Color.Alpha** attribute under the object entitled **The Sky**.
6. Run the time scrubber back and fort hand you should see that at time **00:03-00:05** the constellations and text **The Sky** will fade out
7. For the **SolarSystemOrbits** create keyframes at **00:03 and 00:05** the **Opacity** attributes to **0** at time 00:00 and time 00:03 and to **1 at 00:05**.
8. Repeat this for **Color.Alpha** for the text object **Our Solar System**.

Now when you play the tour (either with the play button in the timeline editor or the big play button to the left of the single slide of the tour), the tour plays, showing the sky rotating with constellation figures and text label **The Sky** shown. Then at **00:03-00:05** these elements fade out and the planetary orbits fade in with a text label **Our Solar System.**

Transition Functions: Keyframe editor can also allow you to select **Transition Functions**. These affect the way attribute changes between one keyframe and another. The transition of input and output values is shown graphically. You can select from the following choices.

- **Linear** – Numbers are linear changes between values
- **Exponential** – Changes are change faster at the begging and slow down at the end – similar to EaseIn below.
- **EaseIn** – Changes are change rapidly at the begging and slowly at the end.

- **EaseOut** – Changes are change slower at the begging and rapidly up at the end.
- **EaseInOut** – Changes slowly at beginning, changes rapidly in the middle and slowly at the end.
- **Instant** – Keeps starting value until the very end where it changes instantly to a new value.
- **Custom** – Allows you to change the curve interactively. Grab the yellow square handle on each end of the curve which manipulates the beginning and ending shape of the transition curve.

It is good to choose a keyframe such as camera motion and try out all the transition functions to get a sense of what they can do.

Manipulating Keyframes in Timeline Editor

Besides changing the properties of keyframes, single or multiple keyframes can be selected for deletion, copying or pasting. Selected keys are shown as yellow. There are three ways of selecting keyframes:

- **Control-A** – selects all keys in timeline.
- **Control-click** – holding down the control key and clicking multiple keys adds them to a group.
- **Drag rectangle** – dragging a rectangle around the keys of interested groups those keys.

Note: you cannot move the keyframes at time = **00:00** from that time, even if they are selected as part of a group.

In this example, I will move the keys from **03:00 to 04:00** to make a shorter transition. To do this,

1. Show timeline editor and move it to show time **03:00 to 04:00**.
2. Drag a rectangle over the keys at **03:00**. They should all turn from white to yellow.
3. Move the selected group of keys to the right and place them at **04:00**.

Adding Fade-In and Out for Slide

If you are comfortable with the timeline editor, it is better to use it to control slide **Fade-In** and **Out**. Controlling the **Fade-In** can be very helpful to hide data loading especially.

1. Move the time slider in the timeline to the left. Find the **Fade to black** in the layer manager. Make sure the **Fade Dome Only** is *not* set. Check the **Fade to black box**.
2. Right-click on **Fade to black** and select **Add to Timeline**.
3. Move the time slide to **01:00**. Uncheck the **Fade to black** box. Right-click on **Fade to black** and select **Add keyframe**.
4. Move the time slider to **09:00**. Right-click on **Fade to black** and select **Add keyframe**.

5. Move the time slider to **10:00**. Check the **Fade to black** box. Right-click on **Fade to black** and select **Add keyframe**.

Now when you play the slide in the timeline editor or tour player, it will fade in and out. Note that scrubbing by manually moving the time doesn’t trigger the fade to black.

Note: If you change the duration of a slide with an existing timeline, it will ask you if you want to trim/extend or scale the timeline. If you trim, be careful because you won’t have an end position for the slide. When trimming and the camera or other properties are changing, you probably want to move the time slider to just before the trim point. Then make key frames for the changing parameters. Then when you trim the timeline it retains keyframes of an end position for interpolating between values.

Dealing with Audio

WorldWide Telescope can play back a separate stereo voice-over and music tracks to tell a narrative story and provide a music soundscape for a tour. Before starting to create audio you should decide which of two general strategies you want to follow. The first is to produce an entire audio file for the entire tour and the other is to create separate audio files that are tied to each slide. The advantage of creating a single audio file is that you can globally adjust the level for audio on all slides, and work on global timing. However, for narration you will have to acquire a long sequence in one go, or use an audio editor to cut out sections, replace flubs etc. Also, if audio is recorded as one long track and you change the timing of the visuals you have to re-record or re-edit the narration track.

For these reasons, the recommended way to do audio is to place the musical bed as a single soundtrack and to include narration audio on a per-slide basic. This how-to will show how to do this.

1. Get at least a draft of your tour done visually. Word drive the visuals and visuals drive the audio. The visuals will provide an estimate of the tour length.
2. Find an audio file that has the sound and length that fit your tour. More ambient music is more appropriate to loop and thus allows a shorter file to be used as a bed for a longer tour.
3. Make a short first slide. I often make the tour and then duplicate the first slide and make the first of the duplicates a very short – 0.5 to 1.0 second – slide. Make this slide a Master and don't have any – or a very small amount of – motion and don't have any text or images. The reason we make a short Master is to separate audio that spans multiple slides from text and images that will be on only a slide or two. If you put these elements onto a Master slide they will persist until the next master slide.
4. Add the audio to the slide buy clicking on Browse under Music in the upper right hand of the WWT window. Browse to the music file. You can enter a Fade In and Fade Out times for the music and setting it to automatically repeat or not. Adjust the slider to be 1/2 to 2/3 the way to maximum. Since this is a Master slide, the music will play over all slides until the tour hits a music track on another Master slide.
5. You can add music tracks on a per-slide basis which will be mixed into the musical bed of the master slide. This might be useful if you wanted to coordinate a sound effect coordinated with a visual on one slide.
6. Assuming you have a script, which may or may not be displayed as text on each slide, you know what words to say for each slide. Record a voiceover file (e.g., MP3) for each slide. It is worthwhile to label the slides with text and use the automatic slide numbering (check Guided Tours/Show Slide Numbers) for the slides and use a similar naming for the narration audio files. When recording try to use a quiet room without hard surfaces

(i.e., carpet, drapes and objects in the room are good and fans air conditioners etc. are bad). It is useful to normalize the voiceovers in their uncompressed form before compressing to MP3. Tips on getting great audio are in another how-to (Editing Audio). You want to make sure that the slide is at least as long as the narration audio. Add the audio by clicking Browse for Voiceover which is just below the Music selector.

7. You can preview the tour from that slide and adjust the level of the narration relative to the music. When in doubt it is more important to be able to hear the voiceover than the music.

Editing Audio

In the Dealing with Audio how-to, we show how to get audio tracks into WWT. This guide will give some tips on how to create and edit the audio that you want to include in your tour. WWT can play a variety of audio files. Playback quality it limited to the quality of the input audio file so start with the highest quality. If you are getting an existing file or if you are creating your own try to get a lossless format, like WAV, or a high-bitrate one, like 320 kbps MP3.

I will illustrate how to edit audio using an open source windows program called Audacity (http://audacity.sourceforge.net/), however most audio editing software can probably do the same things.

I edit software for the following purposes: trimming, normalization, background noise removal and format conversion. I would do all editing in WAV and then convert to MP3 at the last step. Also, I would use draft audio until you have finalized the visual timing and then do audio editing and conversion.

Trimming

When you get music of narration files often the timing of the files needs to be adjusted. When you know the timing of the tour you are trying to match and the audio file you may need to cut some off of the audio file. Cutting the length for the file can make is smaller and you can also add custom fades (in and out) at this point.

Figure out the time you want to trim to and if you want to add a fade in or fade out. For this example I will put a 2 second fade out at the end of a musical audio file. Since the music builds gradually, I will not change the beginning of that with a fade-in.

1. Open Audacity and load input audio file. Identify the length you want the audio piece to be.
2. Use mouse to select 2 seconds from the end.
3. Click “Effect” in the top menu and select “Fade Out.” This will create a linear fade out that you can see graph in Audacity.
4. Select from the beginning to the end of the ending fade.
5. Click “File” in menu and “Export Selection.”
6. Choose WAV -- assuming you will save this uncompressed WAV file as an archive and convert to MP3 in another step (see below).

Normalization

Audio is inherently analog and capturing a digital copy requires you to sample it into a range of digital values. Digitized signals have specific steps between each level. In order to have the best sounding signal it should be normalized such that the maximum signal is at the highest value of the digital signal. This has the effect of making the signal as loud as it can be without clipping. Then you can reduce the volume with the slider in WWT.

1. Open Audacity and load input audio file. Identify the length you want the audio piece to be.
2. Use mouse to select the entire file (or the part you want to export and use).
3. Click “Effect” in the top menu and select “Normalize.” This will bring up a dialog box. I check all boxes and set the maximum amplitude to 0.0 dB. This will scan the file and determine the scaling to amplify the signal to the maximum values.
4. Select from entire file of a selection.
5. Click “File” in menu and “Export Selection.”
6. Choose WAV -- assuming you will save this uncompressed WAV file as an archive and convert to MP3 in another step (see below).

Background Noise Removal

1. Open Audacity and load input audio file.
2. Put cursor in file window and select a part of the audio file where there is noise. You may want to expand the range to see this clearly.
3. Click “Effect” in the top menu and select “Noise Removal…” This will bring up a dialog box. Click “Get Profile.”
4. Then select the entire audio file (or the part you want to save out).
5. Click “Effect” in the top menu and select “Noise Removal…” This will bring up a dialog box. I leave the default values and then make sure “Remove” is selected and click the “OK” button.
6. Click “File” in menu and “Export Selection.”
7. Choose WAV -- assuming you will save this uncompressed WAV file as an archive and convert to MP3 in another step (see below).

Format Conversion

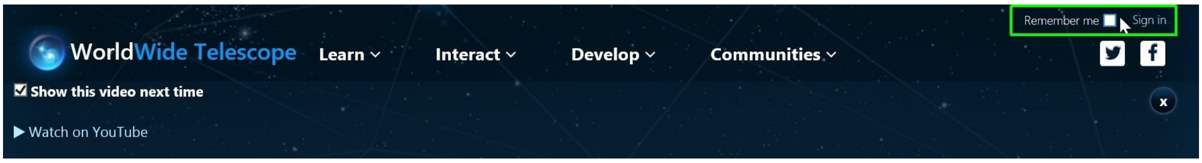
If you are getting music files, WAV files are great for quality, but can be large. Note, that tours encapsulate assets like audio and images so be aware that file sizes could be large if you include uncompressed audio like WAV. I suggest working with WAV files and keeping copies of those around for editing, but before putting the files into WWT, converting it to compressed MP3. Audacity can read in almost any format file and you can select the same file for export to another format.

1. Open Audacity and load input audio file.
2. Put cursor in file window and Control-A (select all).
3. Under “File” click “Export Selection.”
4. In the dialog box that comes up, select “MP 3 Files” as output format.
5. Click the “Options” button which opens a box to select MP3 output encoding options. I use Variable Bit Rate, Quality level 5, 110-150 kbps. You can also use Constant Bit Rate with 128 kbps or higher.
6. Load the file into WWT and play it back to make sure it sounds ok. If you are in a very quiet room with good acoustics and speakers you might hear MP3 compression and want to use a higher bit rate. Note that variable bit rate MP3 use file space a bit more efficiently and plays fine in WWT.

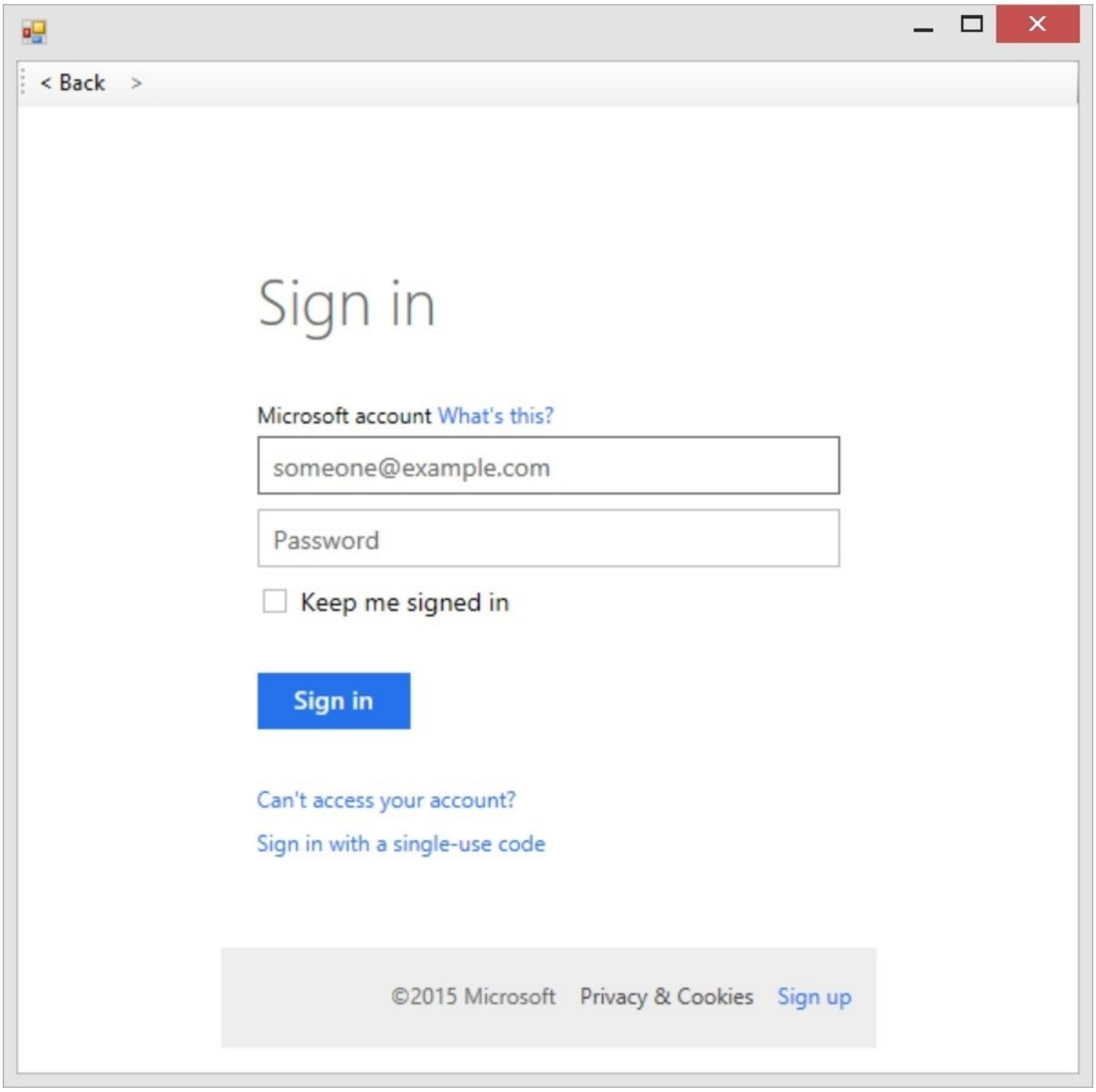
Using Communities

Content in WorldWide Telescope can be organized, curated and shared using the Communities feature. Communities replaces the Layerscape functionality. To get started with Communities, you first have to create an account.

1. Open http://www.worldwidetelescope.org
2. In the upper right click on “Sign-In”.



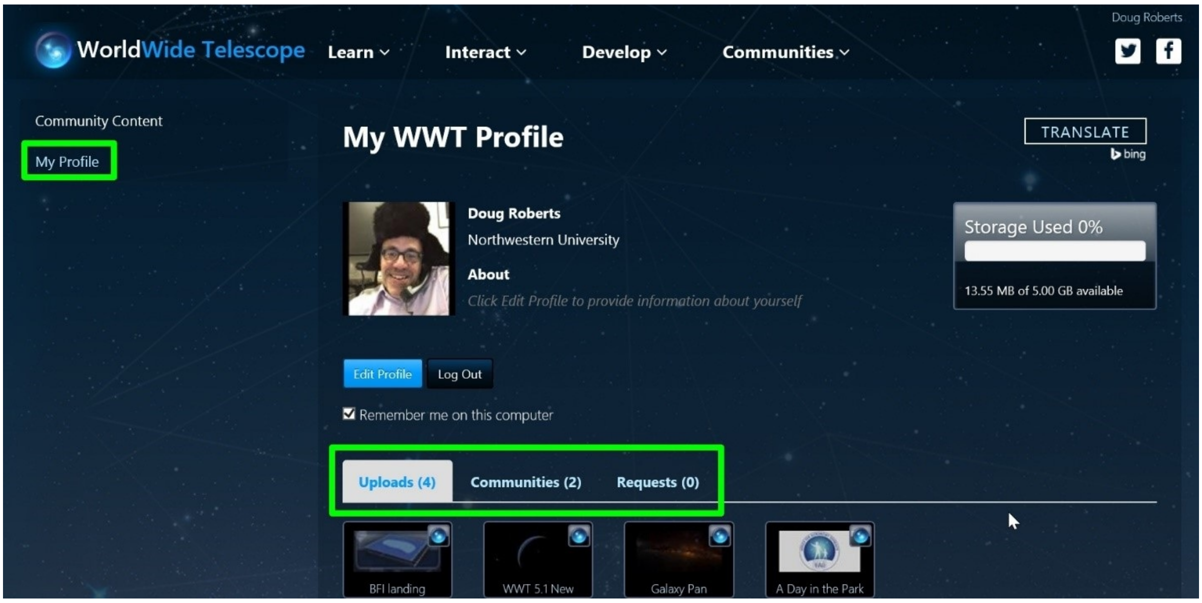
3. If this is the first time you logged in you will see a dialog box where you can create a new or login to an existing account.



4. Once you have logged into your account, you will see “My Profile” in the left navigation.

Clicking on this will take you to a page showing your profile and the communities and content you have uploaded to WorldWide Telescope.

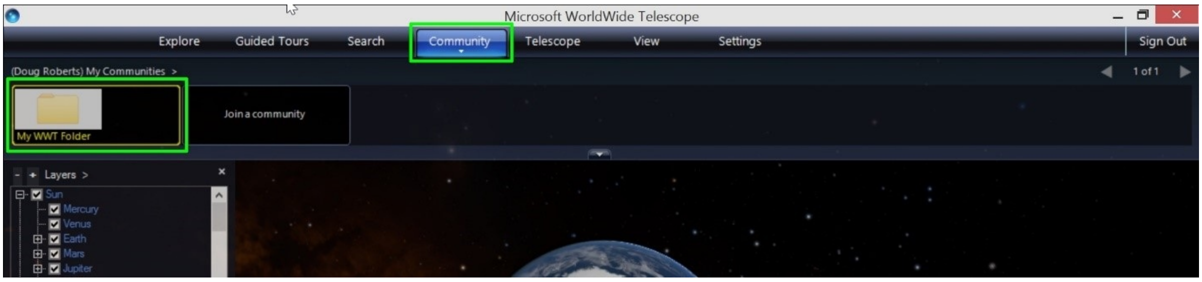
5. You will a tab for uploaded items, such as tours. Another tab shows all of the communities you have created. The last tab shows requests submitted to you as the owner of your communities. Here you can approve requests to join a community.



6. You can create new communities, sub-communities and upload files to communities from the “My Profile”. When you upload a tour, the Tour Properties are used to populate the descriptive fields on the website. You can provide a thumbnail (wide aspect ratio of 2:1) as well.

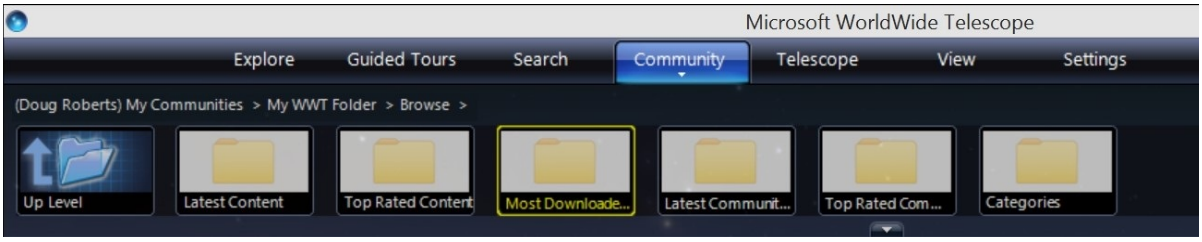
Similarly, you can access communities from within the Desktop Client.

7. Once you have signed in (upper right) you can click on the Community tab to show the same community structure as the web site.



8. Clicking on “My Communities” and then “My WWT Folder” and then you can drill down to see your tours organized by community.

9. You can also Browse all tours you have access to, which includes your communities (the ones you own and the ones you are a member of) as well as the stock tours available in WWT.

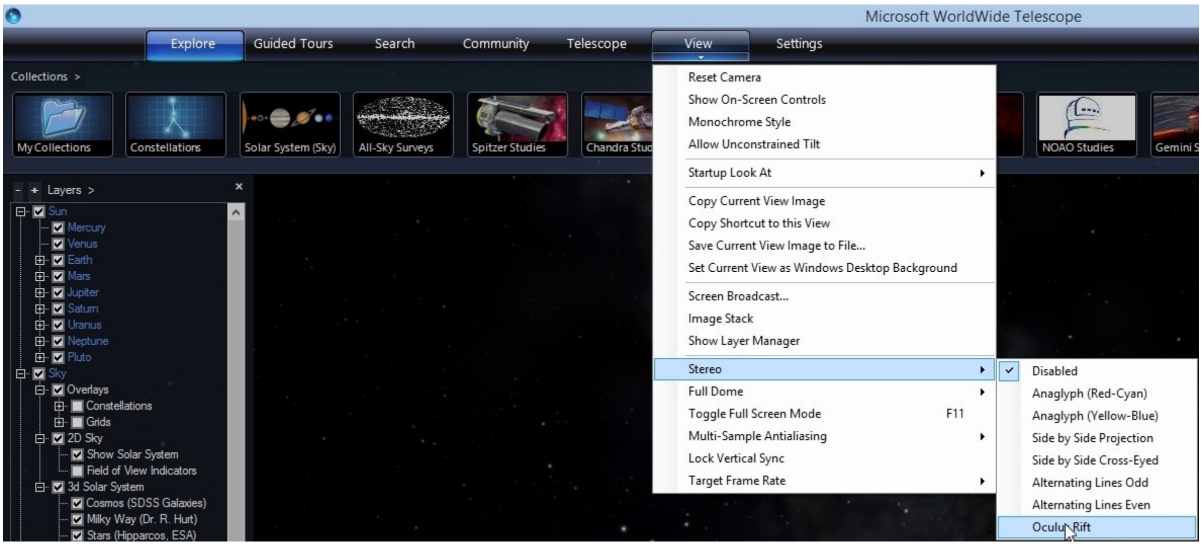


10. Note that all administration of your community content is done through the Community section of the worldwidetelescope.org website.

Using Oculus with WWT

WorldWide Telescope (WWT) works with Oculus Rift virtual reality headset as a special stereo mode. Note, currently WWT supports Oculus Rift Development Kit 1, (Oculus Rift DK1). You can use this mode by following these steps.

1. Make sure you are running WorldWide Telescope 5.0 or later, which is available here: http://www.worldwidetelescope.org/Download/.
2. Connect the Oculus to the computer.
3. Turn the Oculus on. The Oculus will appear as a secondary monitor. If you look through the Oculus without WWT running you should see a desktop similar to what you see if you connected a secondary monitor.
4. Note, you should try to put the Oculus over your eyeglasses.
5. Start WWT.
6. Enable Oculus Rift mode. Open the menu under View and select Stereo/Oculus Rift. See screenshot below.



7. The scene should be visible in the Oculus. Note the menu items are still on the primary display and the main window in the primary will go blank when outputting to Oculus.
8. You can interact with WWT while wearing the headset. Since you can't see the keyboard and menus, it is easier to use an Xbox or MIDI controller. However, be careful doing fast rotations with the controller, since if the motion is not coordinated with your head rotations, you can induce motion sickness.
9. You can also download and play a tour on asteroid impacts which was created by the WWT team specifically for virtual reality. This tour, called Impacts, and additional information is available here http://www.worldwidetelescope.org/Planetariums/Impacts
10. You can create a virtual or physical button (see http://worldwidetelescope.org/Learn/SettingUp#controllersandbuttons) to reset the Oculus Rift view. The function ResetRiftView is under Navigation/Action. This can be

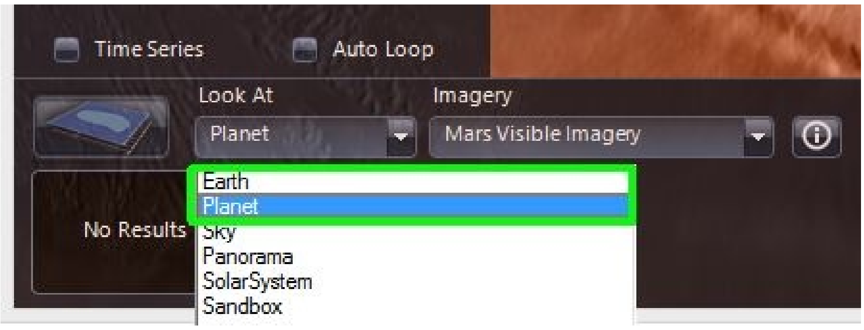
useful to set the initial orientation of the virtual environment relative the physical orientation of the Rift.

3D Printing from WorldWide Telescope

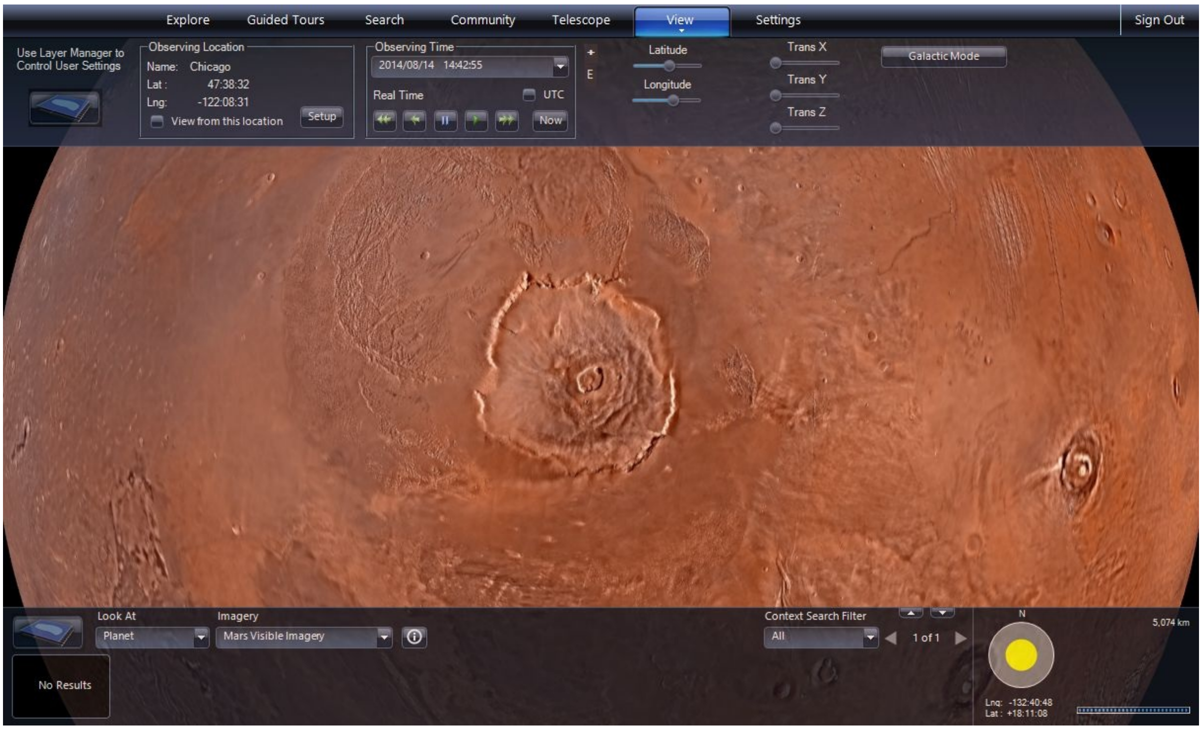
You can print 3D terrains from Solar System bodies from WorldWide Telescope. This could be done to create a 3d model of mountains, canyons or other terrain. Currently 3D surface data is available for the Earth, the Moon and Mars. You can select a region and then use WWT to create a file for printing in the Standard Tessellation Language (STL) format.

Steps

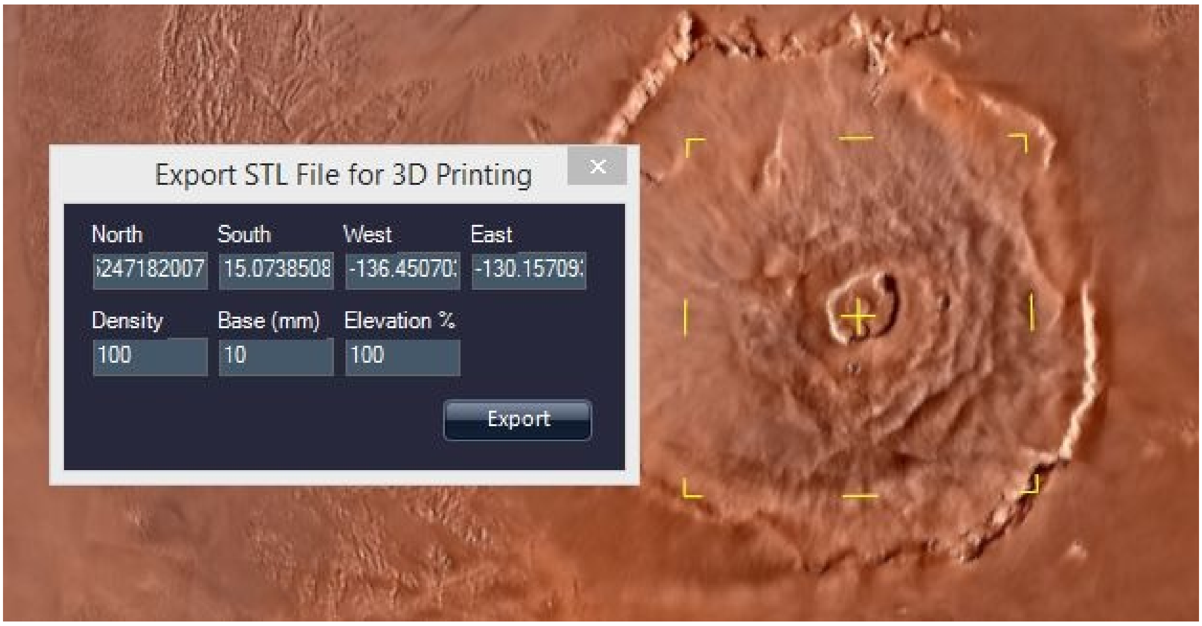
1. Startup WorldWide Telescope.



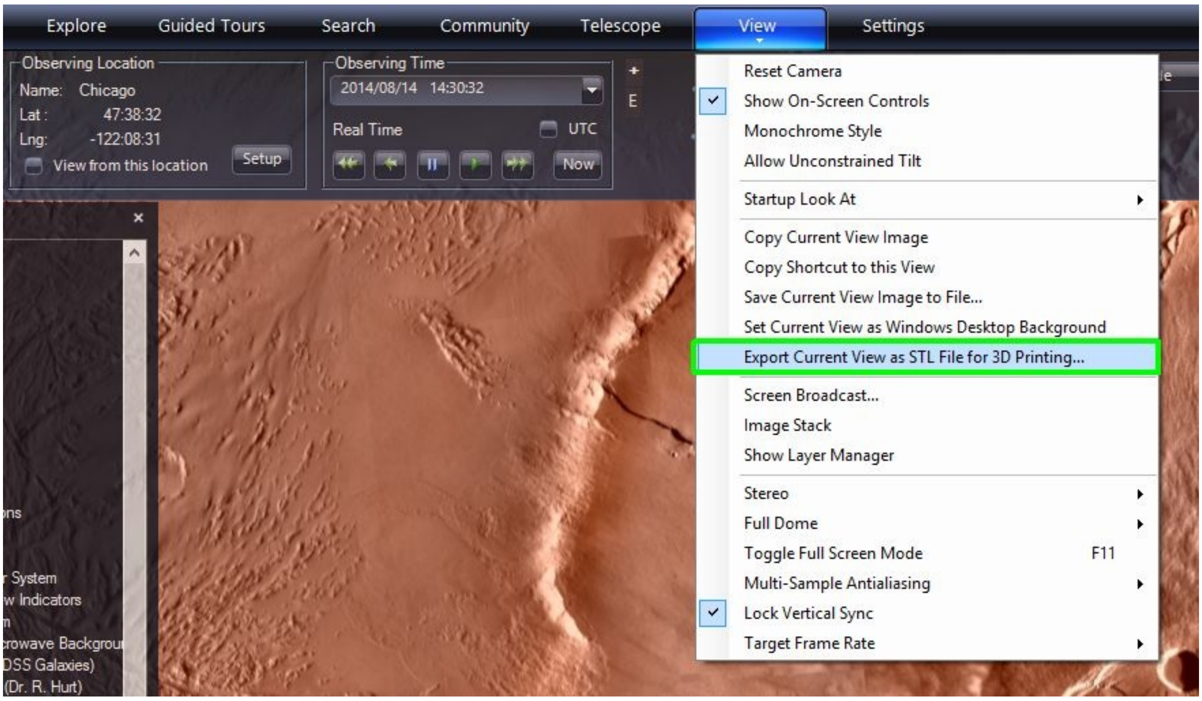
2. Set the **Look At** mode to the **Earth** or the **Planet** of your choice. For this example, we will use Mars. Select **Look At** to be **Planet** and then in the selection to the right select **Mars Visible Imagery**.



3. Move the view to show the region you want to print. In this example we will make a model of Olympus Mons, which is the largest mountain on any planet of our Solar System – almost three times as tall as Mount Everest's height above sea level.



4. To print the terrain that is in view, choose **Export Current View as STL File for 3D Printing…**
5. This will show a default region selection in yellow and bring up a dialog box where you can adjust exactly what is printed.



6. First you should make sure to define the region of the surface terrain you want to print. You can grab and adjust one of the yellow region handles in the main view or enter the latitude and longitude coordinates in decimal degrees in the box.
7. Next you can select the **Density** of model. Higher densities show more detail but the file sizes will be larger.
8. You can then specify the thickness of the base of the 3D printed model by changing the value of **Base (mm)**.
9. By default the elevation is at 100%. All the planets in our Solar System are large and

massive; and relative to the size of the planets even the highest mountains don't deviate from the planet's spherical shape. So you might want to exaggerate the vertical scale of the terrain by making the **Elevation %** to be greater than 100%.

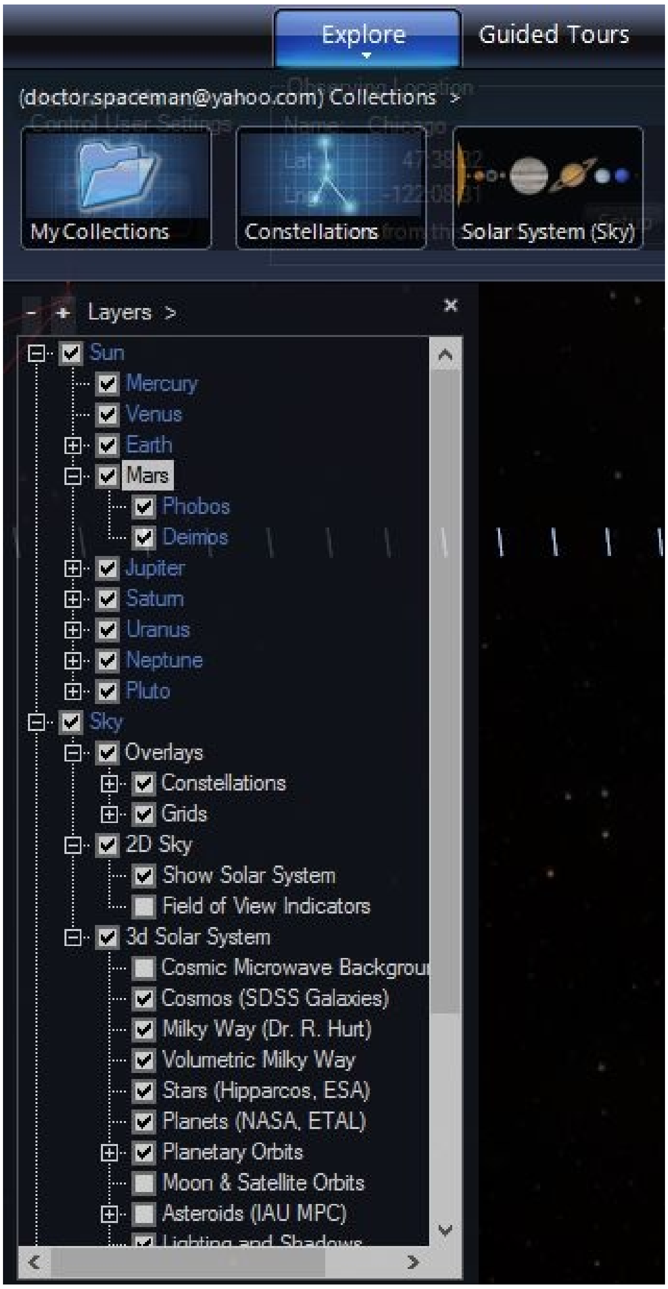
10. Press the **Export** button which will open a box where you can specify the location and name of the output STL file.
11. You can then print out the STL file on your attached 3D printer using a program, such as "3D Builder" or "MakerBot Desktop".

Creating a Traverse Trail Layer

Tutorial contributed by A. David Weigel, Christenberry Planetarium, Samford University.

Layers

WorldWide Telescope can show many layers and types of data. A layer is an object or a dataset that can be placed into your viewing window. There are many types of layers you can create, such as importing 3D objects, or displaying aurora evolution over time overlaid on the high latitudes of the Earth. This tutorial will demonstrate how to create a layer that displays the traverse trail of the Curiosity rover on Mars within Gale Crater towards Aeolis Mons (Mt Sharp). The Layer Manager is located in the lower left of the screen and can be toggled on/off.

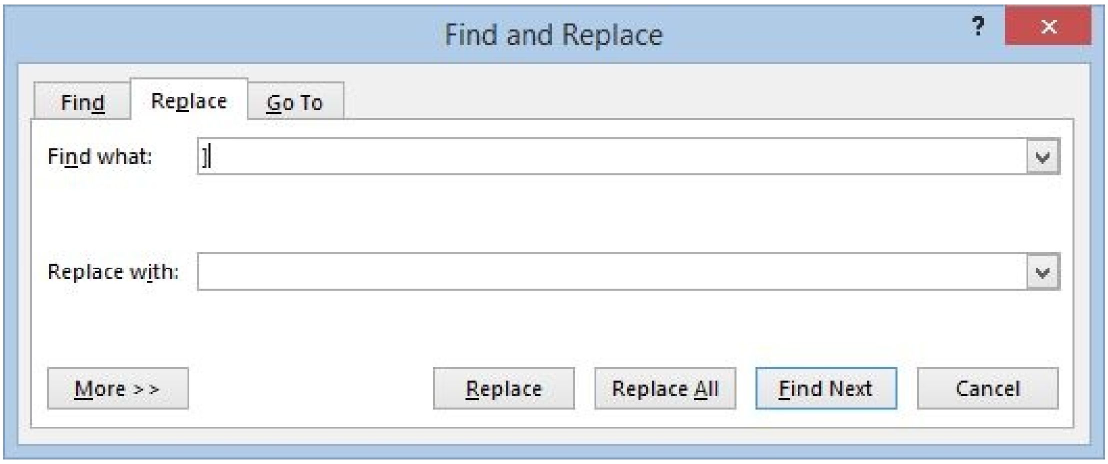


Within the Layer Manager, you can check boxes on and off to show the different visualizations that are built into WWT. Expanding the **Earth** menu will show six children layers, including **Overlays**, the **Moon** and the **ISS**. Likewise for **Mars**, the only options are **Phobos and Deimos**.

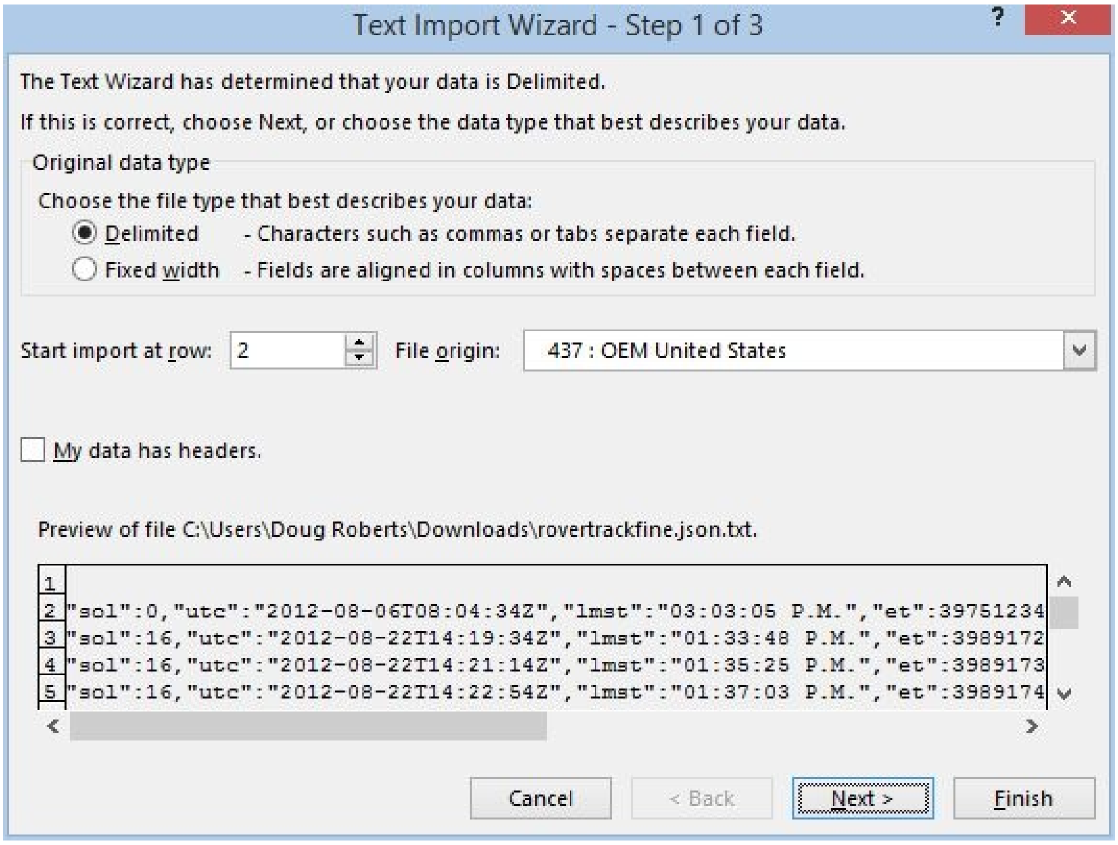
1. To create our own layer for Mars, we first need to ensure that the Layerscape Excel Add-In is installed for your computer, which can be found here: http://www.layerscape.org/Home/ExcelAddInWelcome.

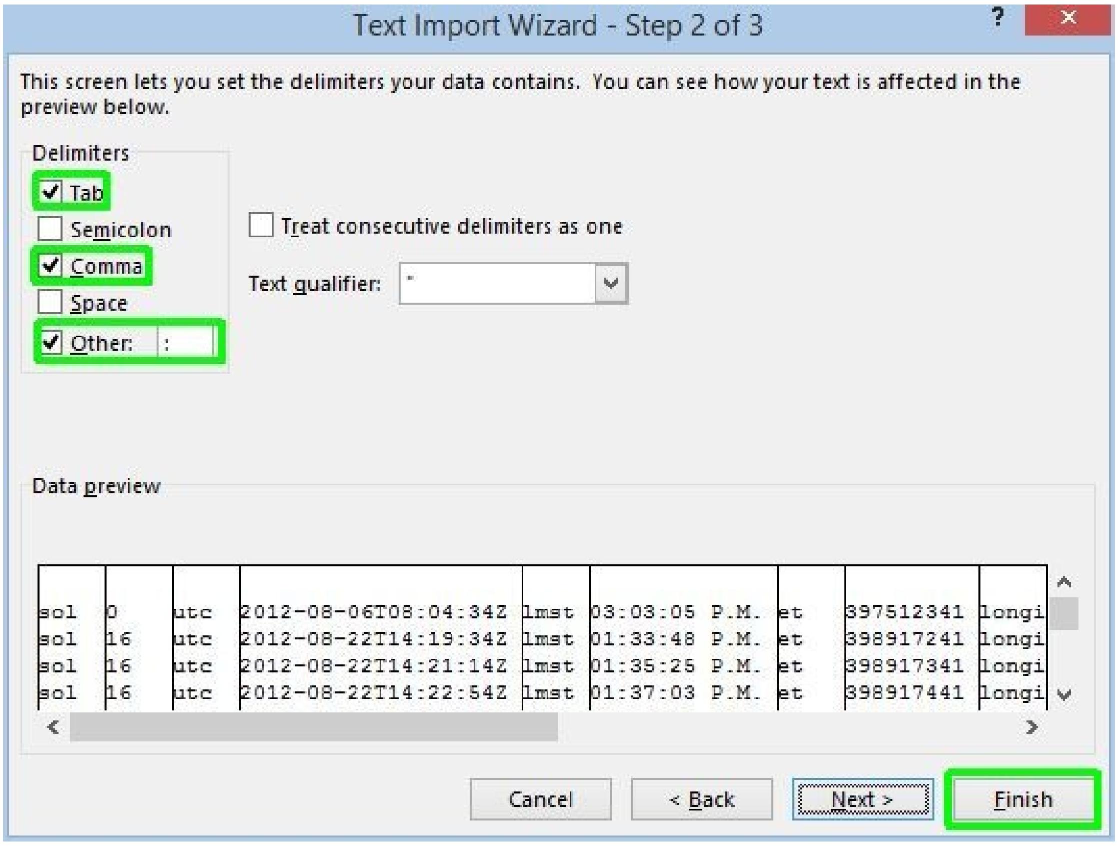
Curiosity traverse coordinates courtesy of Joe Knapp (curiosityrover.com) can be found here: http://curiosityrover.com/rovertrackfine.json.

1. Right-click and **Save As** to save the file rovertrackfine.json. Open the file with Microsoft Word and use **Replace** (Ctrl-H) to replace the following characters enclosed in the double quotes (but don't type in the quotes) from the JSON file with nothing: "[" "]" "{" "}," "}" . Save As a plain text file and ignore all prompts that formatting will be lost in doing so.



1. Open **Microsoft Excel** and click **DATA/From Text**. Import the plain text file just saved from Word. In the Text Import Wizard, choose **Delimited** (default choice) and start import at row 2 if there is an empty row at the beginning of the data. In step 2, check the delimiter boxes for **Comma** and **Other** and in the Other box, type in a colon (:). Step 3 can be skipped and click Finish.

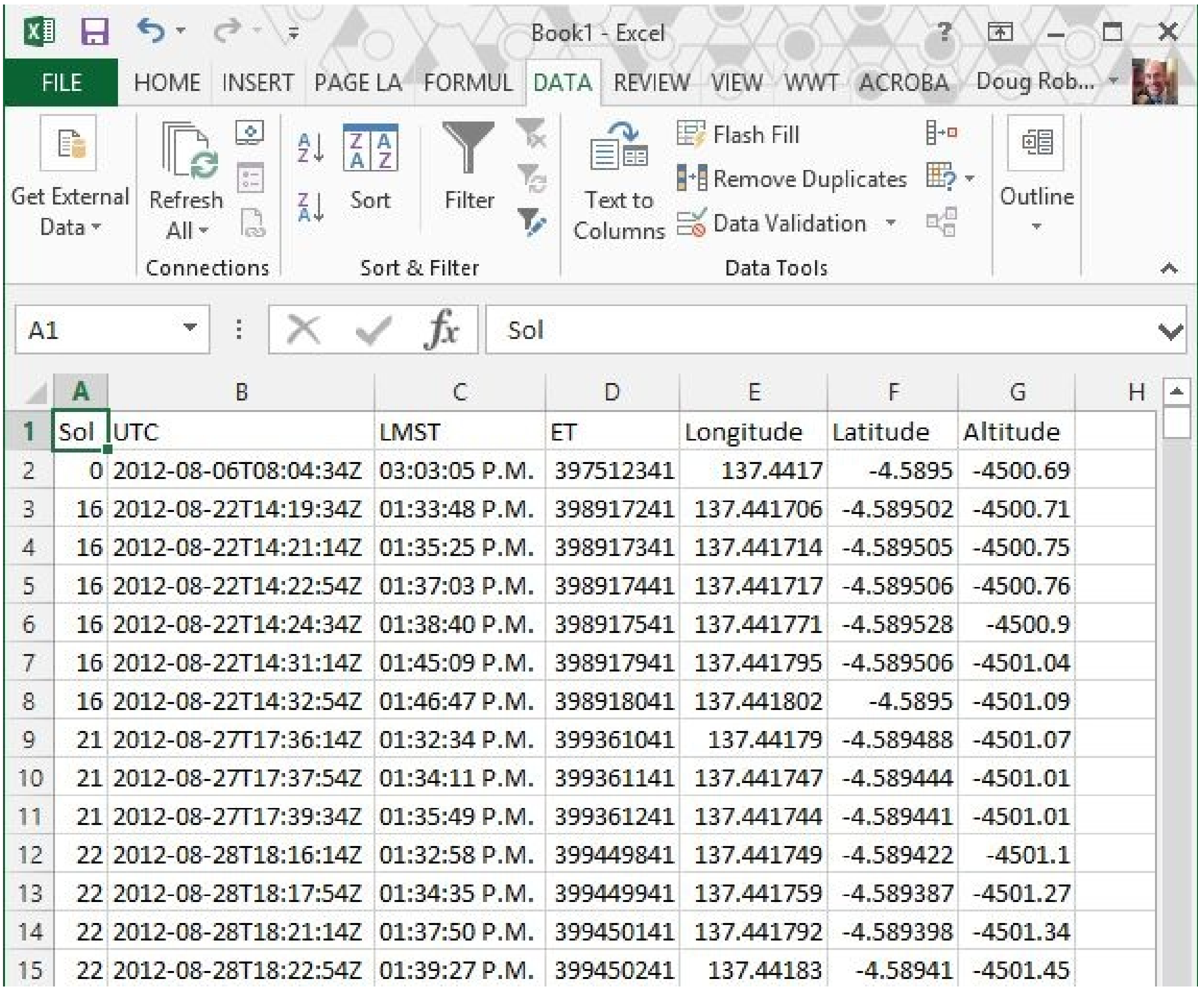




Once imported, add a row at the beginning of the spreadsheet and label the columns with the appropriate labels (column B will be labeled Sol, and etc.). After labeling, delete the columns that only consist of labels (every other column).

1. Be sure to Save As and Excel Workbook and it should look something like this.

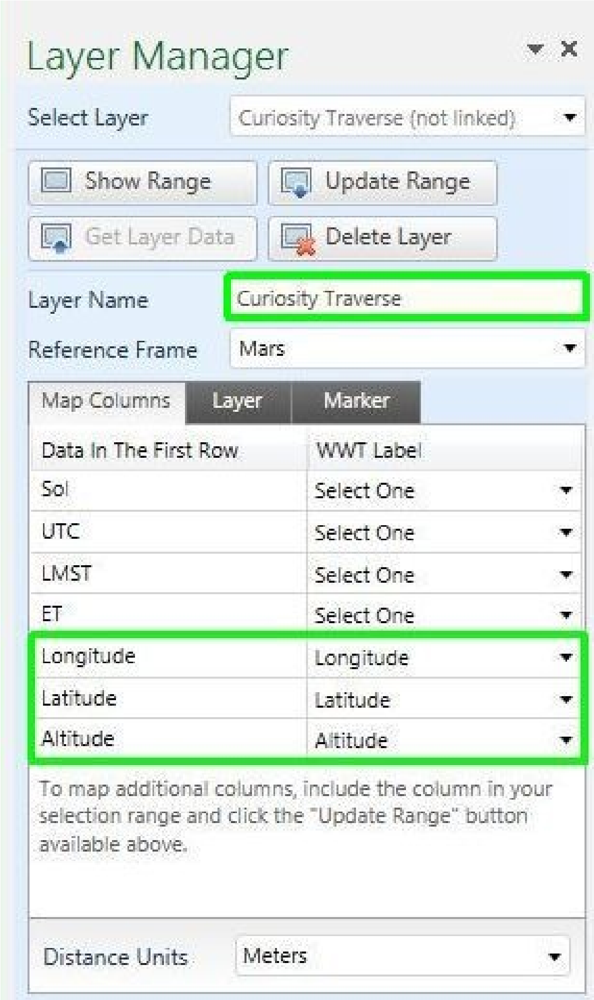
Note: The Excel spreadsheet used in this tutorial is available here as a reference: Curiosity Traverse.xlsx.



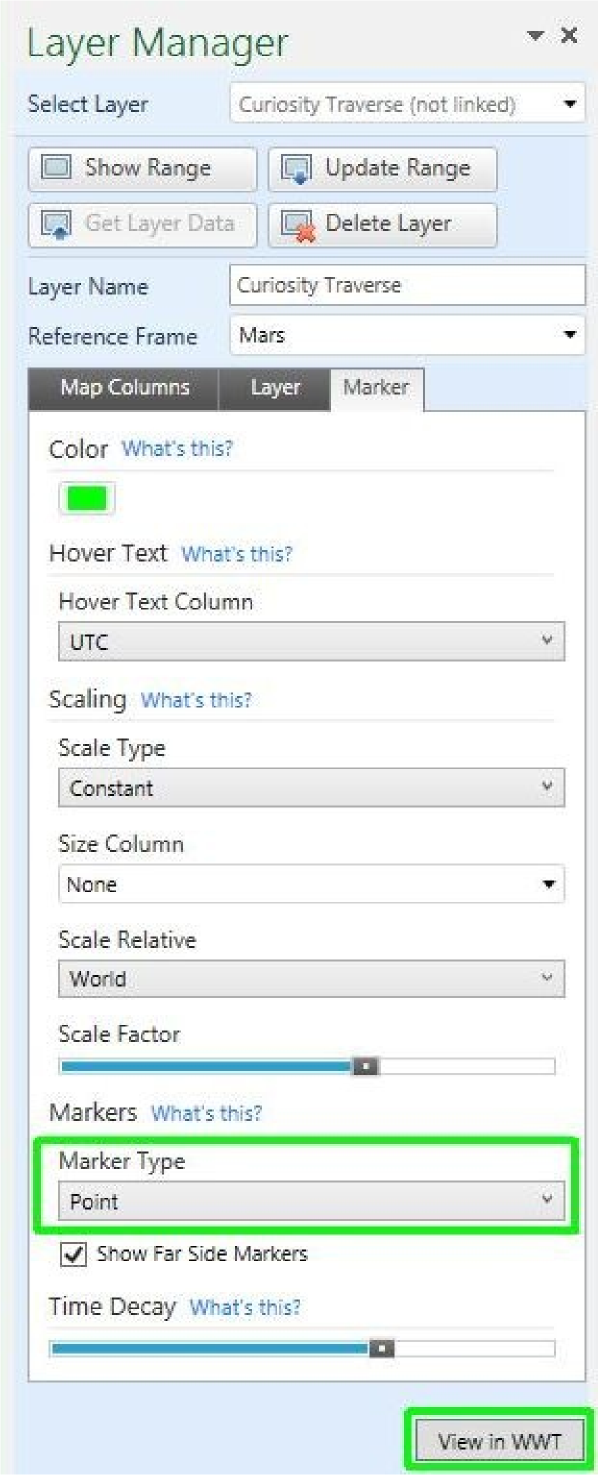
Sol	UTC	LMST	ET	Longitude	Latitude	Altitude
0	2012-08-06T08:04:34Z	03:03:05 P.M.	397512341	137.4417	-4.5895	-4500.69
16	2012-08-22T14:19:34Z	01:33:48 P.M.	398917241	137.441706	-4.589502	-4500.71
16	2012-08-22T14:21:14Z	01:35:25 P.M.	398917341	137.441714	-4.589505	-4500.75
16	2012-08-22T14:22:54Z	01:37:03 P.M.	398917441	137.441717	-4.589506	-4500.76
16	2012-08-22T14:24:34Z	01:38:40 P.M.	398917541	137.441771	-4.589528	-4500.9
16	2012-08-22T14:31:14Z	01:45:09 P.M.	398917941	137.441795	-4.589506	-4501.04
16	2012-08-22T14:32:54Z	01:46:47 P.M.	398918041	137.441802	-4.5895	-4501.09
21	2012-08-27T17:36:14Z	01:32:34 P.M.	399361041	137.44179	-4.589488	-4501.07
21	2012-08-27T17:37:54Z	01:34:11 P.M.	399361141	137.441747	-4.589444	-4501.01
21	2012-08-27T17:39:34Z	01:35:49 P.M.	399361241	137.441744	-4.589441	-4501.01
22	2012-08-28T18:16:14Z	01:32:58 P.M.	399449841	137.441749	-4.589422	-4501.1
22	2012-08-28T18:17:54Z	01:34:35 P.M.	399449941	137.441759	-4.589387	-4501.27
22	2012-08-28T18:21:14Z	01:37:50 P.M.	399450141	137.441792	-4.589398	-4501.34
22	2012-08-28T18:22:54Z	01:39:27 P.M.	399450241	137.44183	-4.58941	-4501.45

- **Sol** is the number of Martian day since landing (0).
- **LMST** is Local Mean Solar Time.
- **ET** is ephemeral time, or seconds elapsed since 1/1/2000, so subtracting ET at landing (Sol 0) from another data point gives elapsed mission time in seconds.
- **Longitude and Latitude** are from a reference point that is defined with WWT. **Altitude** is the elevation of the rover with respect to datum, essentially sea level for Mars.

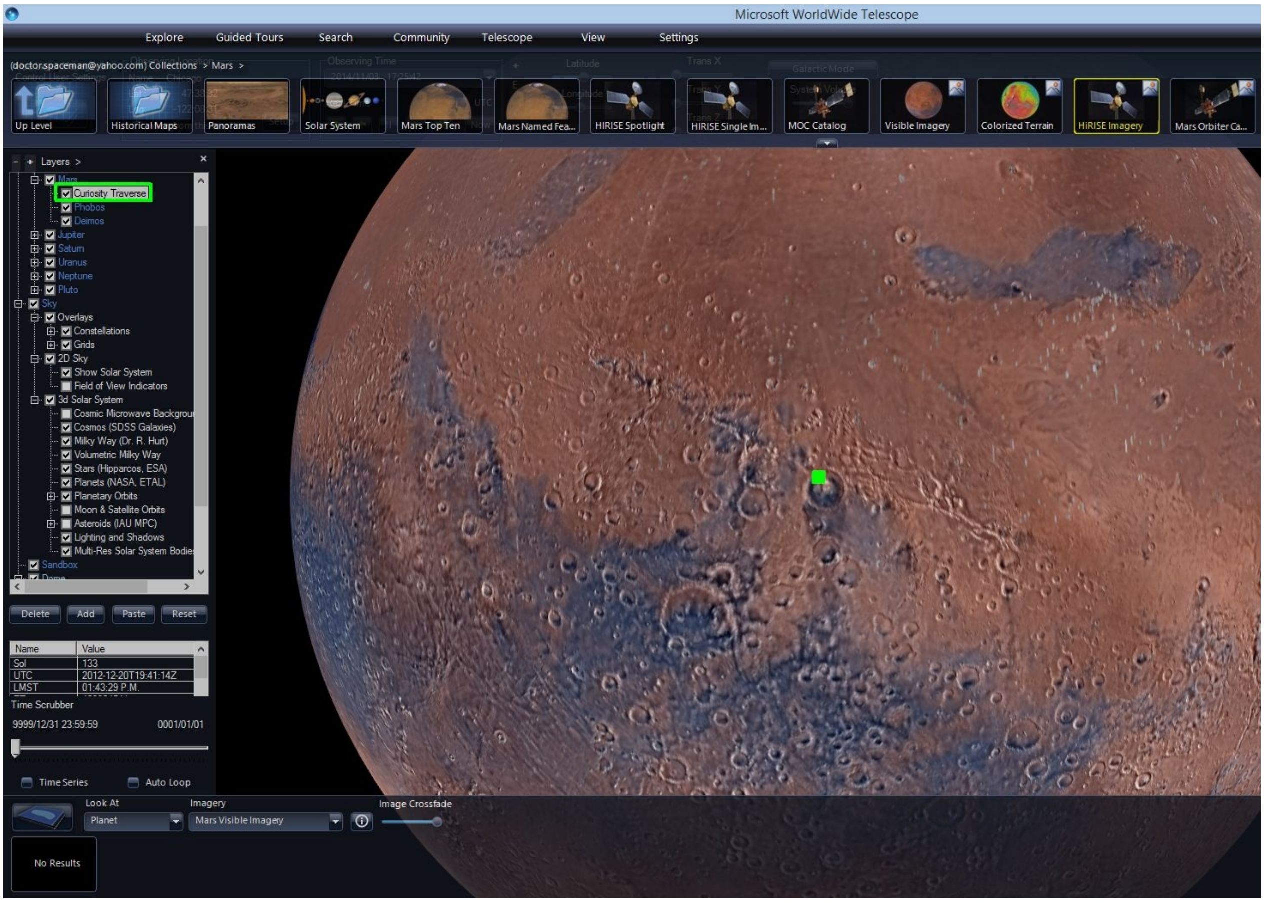
- Now, open **WorldWide Telescope**, go back to Excel and click on the **WWT** heading. Control-A selects all data and then click **Visualize Selection**. We are only interested in the **Longitude, Latitude and Altitude** which are automatically mapped to their respective columns in the table.



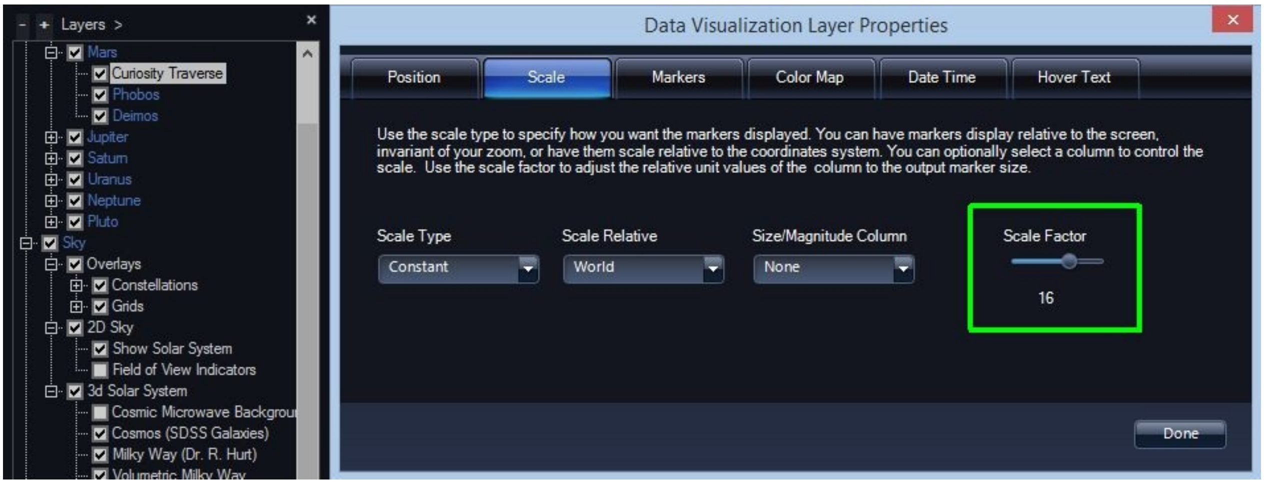
1. Change the **Layer Name** to **Curiosity Traverse**.
2. Change the **Reference Frame** to **Mars** (from Earth). Make sure the WWT Label matches the highlighted data and that the distance is in meters.
3. Under the **Marker** tab change the color to lime green (shows up very well on Mars and is my favorite color). **Hover Text** should be none, **Scale Type** Constant, and **Scale Factor** can start at 1 or larger (it will be easy to find if its bigger and you don't know where Gale Crater is located off the top of your head). Eventually we will want to change the Scale Factor to the smallest scale but we can do this through the layer property editor in WWT. **Marker Type** should be Point.
4. Finally click **View in WWT**.



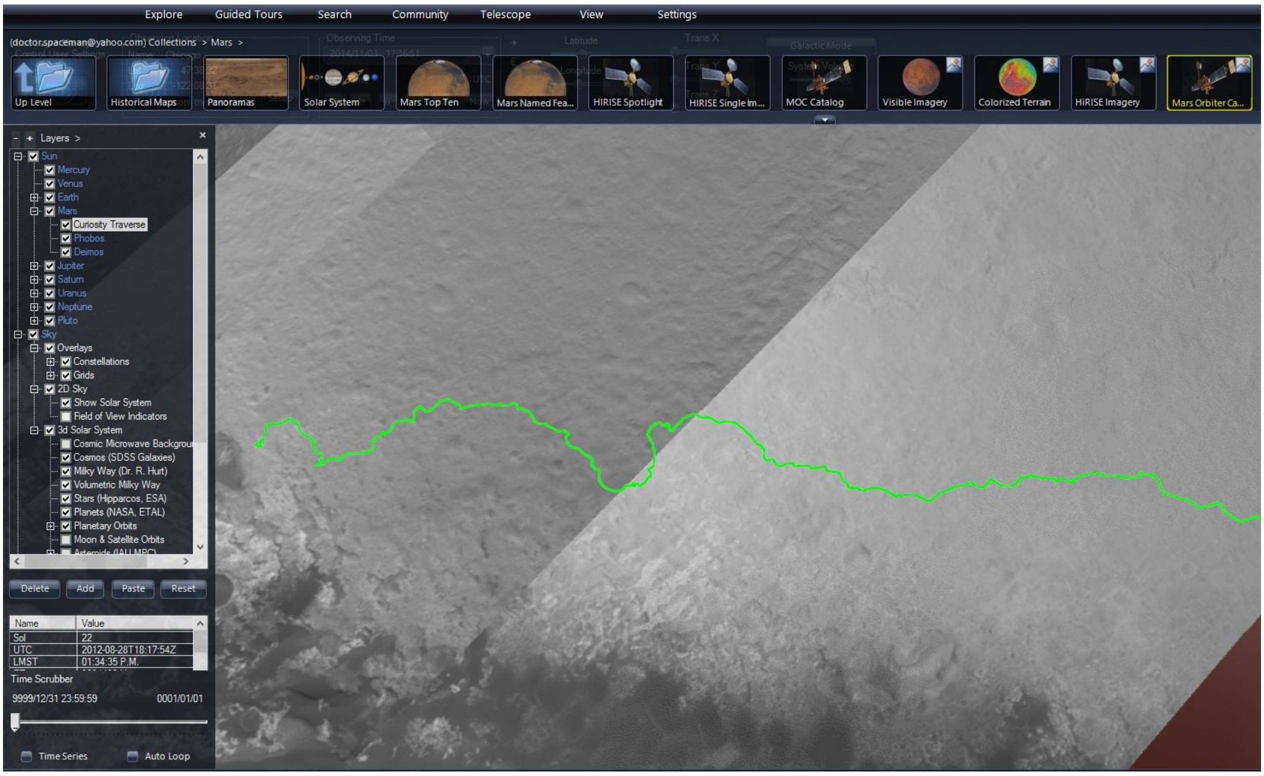
In WWT you should see the **Curiosity Traverse** layer as a child of Mars (if not, check to make sure it isn't under Earth, in which case you need to adjust the reference frame in Excel). Make sure the layer is turned on and find Gale Crater, you will see a large green marker.



1. You can now turn down the scale all the way by right clicking the **Curiosity Traverse** layer and selecting **Properties**. Under the **Scale** tab, slide the **Scale Factor** to a number like 0.003 or lower.



1. Now from the **Explore/Collections/Mars** at the top of WWT, right click **Mars Orbiter Camera Imagery** and select **Add as New Layer** (be sure that it becomes a child of Mars). Right-click the layer and click **Background Image Set**. Now the rover traverse map in overlaid on a higher resolution set of images of Gale Crater.



Note: a copy of the traverse trail used for this tutorial in a layer (.wttl) file is available here as a reference: Curiosity Traverse.wwtl.

Adding Astronomical Image Data

Astronomical Images, defined as those with overlay sky coordinates can be loaded directly into WorldWide Telescope (WWT) in several ways.

Loading Local AVM-tagged Images

Astronomical Visual Metadata (AVM) is a way to storing information about the original astronomical image in the header of a standard image file, such as TIFF and JPEG. This standard uses existing header infrastructure and populates it with astronomy-specific metadata. The relevant metadata to WWT is:

- Image Name
- URL
- Credits
- Caption
- World Coordinate System (WCS) coordinate information

The idea behind AVM is to allow visualizers to manipulate colors, add annotations etc. and maintain the description of that manipulation – e.g., original data location, color representation – so that subsequent people know how it was created and how to interpret it. For WWT, coordinates allow the image to be placed at the correct location on the sky.

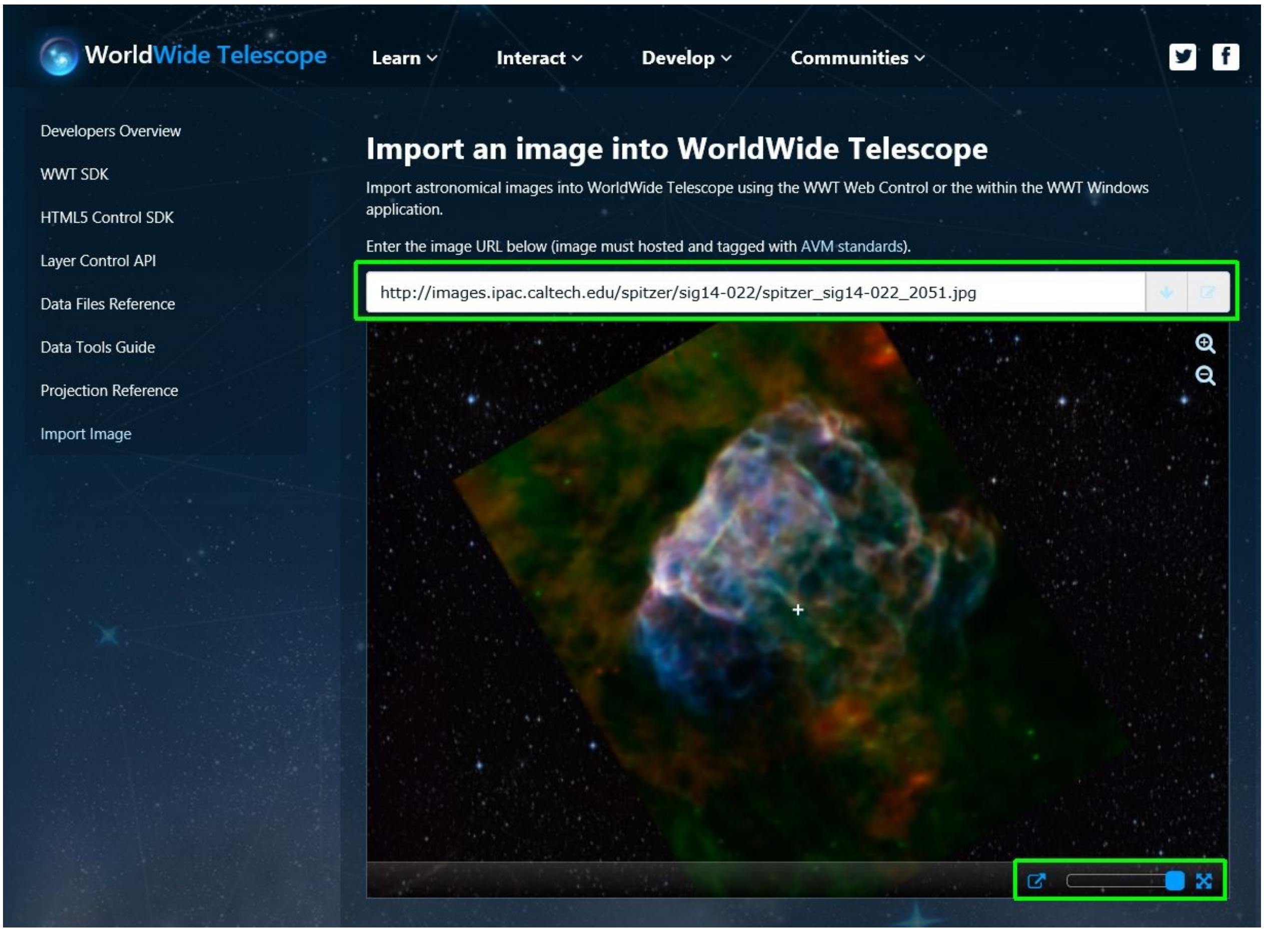
You can download AVM-tagged data from a variety of data sources. If your favorite source of image data provider doesn't currently include AVM tags, you can direct them to the AVM resources below. If you want to get a test image, you can browse for one in the Astropix website, which aggregates AVM-tagged images - http://astropix.ipac.caltech.edu/. Once you have it, you can add the data to WWT by:

1. Make sure you are in Sky Mode.
2. Under the Explore Tab, click on Open/Astronomical Image…
3. Browse to the appropriate file.
4. WWT will load the data into WWT and add it to a default collection called "Open Collections," shown in the upper left-hand part of WWT. You can right click and add it to a collection of your choice for image organization after you have loaded it.
5. You can right-click on the image in the collection and select "Properties" to see the image, coordinates, image name, caption, URL. These values are all pulled from the AVM tags when the file is read.
6. You can adjust the cross-fader to change the opacity of this overlaid image on top of the current background.
7. You can also adjust the Image Alignment by pressing CTRL+E to open the Image Alignment instructions.

Loading Remotely-served AVM-tagged Images

In a similar fashion, you can point your browser to an AVM-tagged image on the Internet and it will show the image in your browser in a similar overlay using web controls, with a link to view the image in WWT. Clicking this send this image to the WWT desktop client and allows display control and exploration, similar to interaction with local AVM-tagged Images, above. You can try this out for yourself.

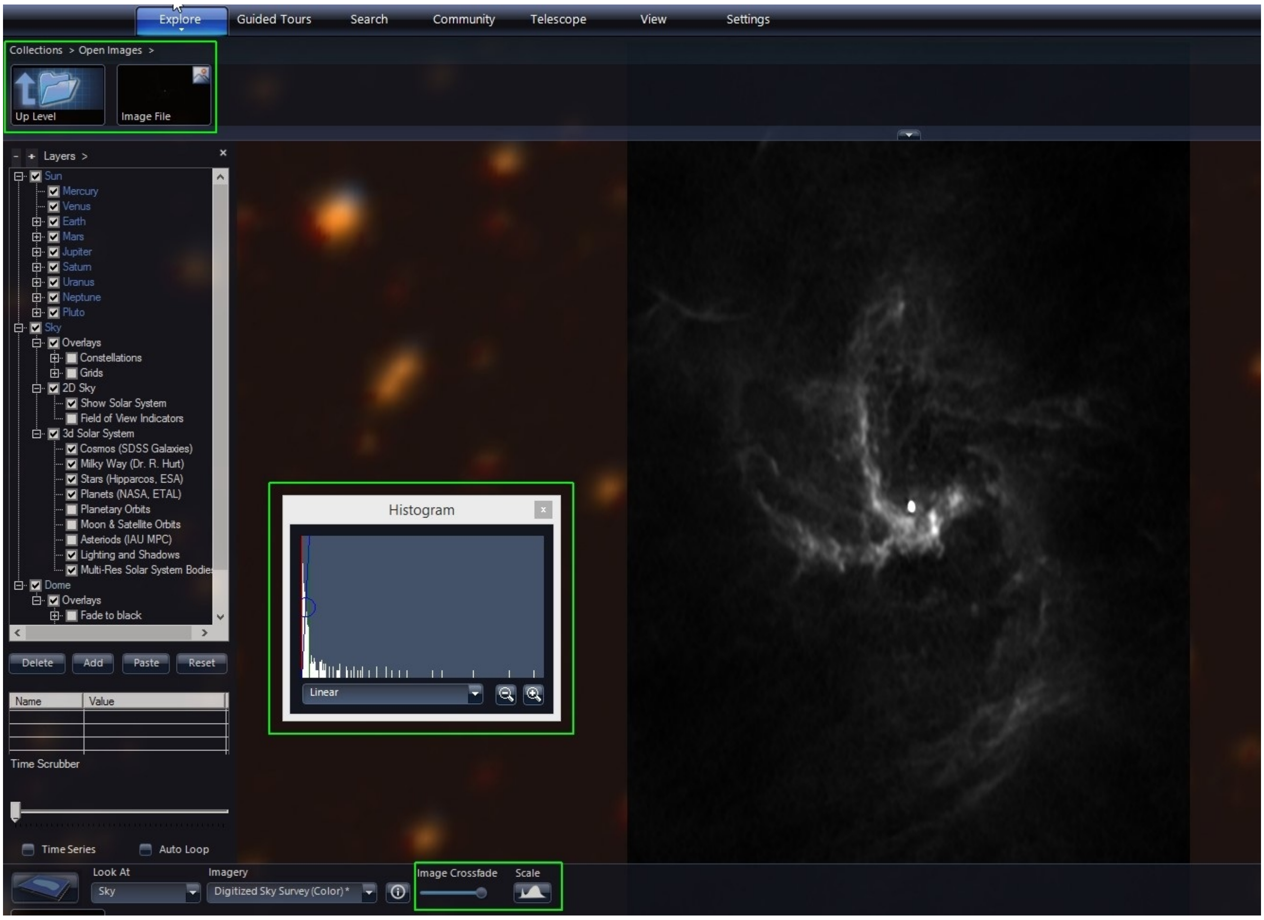
1. Open the following URL in your browser - http://www.worldwidetelescope.org/Developers/ImportImage - or click on “Develop />Import Image in this documentation”.
2. Paste the URL to this composite X-ray and Infrared image of Puppis A, which has already been AVM-tagged into the Image URL input field on the web-page. You can also put the URL of the AVM-tagged image after the URL to the image import page, separated by “#”, as: http://www.worldwidetelescope.org/Developers/ImportImage#http://images.ipac.caltech.edu/spitzer/sig14-022/spitzer_sig14-022_2051.jpg
3. This will open the image the webpage with control over image cross-fade and full-screen in the lower right. You can also click the button to the left of the cross-fader which opens the image in the WWT desktop client.



Loading FITS Files

1. Make sure you are in Sky Mode.
2. Under the Explore Tab, click on Open/Astronomical Image…
3. Browse to the appropriate FITS data file. This can be pulled from the Internet or from an attached telescope or a local file.
4. WWT will load the FITS file into WWT and add it to a default collection called “Open Collections,” shown in the upper left-hand part of WWT. You can right click and add it to a collection of your choice for image organization after you have loaded it.
5. Note that FITS files contain pixels, which are mapped to physical coordinates, and data values. To view the image data values must be mapped to colors. The default color map is a linear greyscale one where the lowest value is mapped to black and the highest to white, with linear steps in between. You can interactively adjust this mapping by clicking on the Scale button, which opens the Histogram dialog box.
6. In the Histogram dialog you can select the mapping function between Linear, Log, Power, Square Root and Histogram Equalization.
7. You can change the minimum and maximum data ranges by moving the red and green vertical lines, respectively. If you move the green line to the left of the red line, this inverts the mapping and low values will be show white and high values black.
8. Grabbing the blue circle in the middle will allow you to keep the mapping function width of the function and move it through the histogram left and right.

9. You can adjust the cross-fader to change the opacity of this overlaid image on top of the current background.

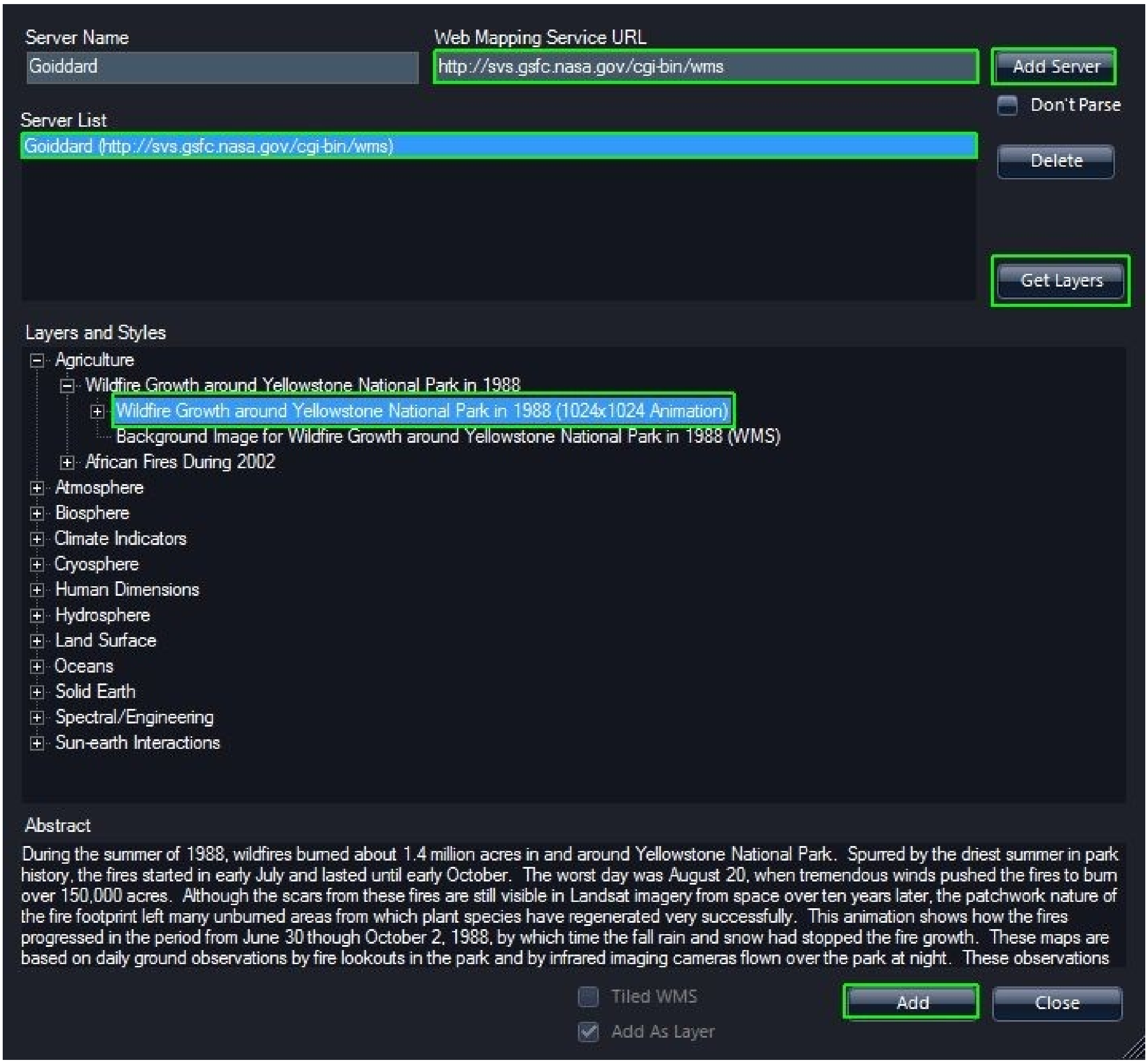


AVM Resources:

- VAMP - http://www.virtualastronomy.org/avm_metadata.php
- Astropix Home Page - http://astropix.ipac.caltech.edu
- Astropix Image Browser - http://astropix.ipac.caltech.edu/browse

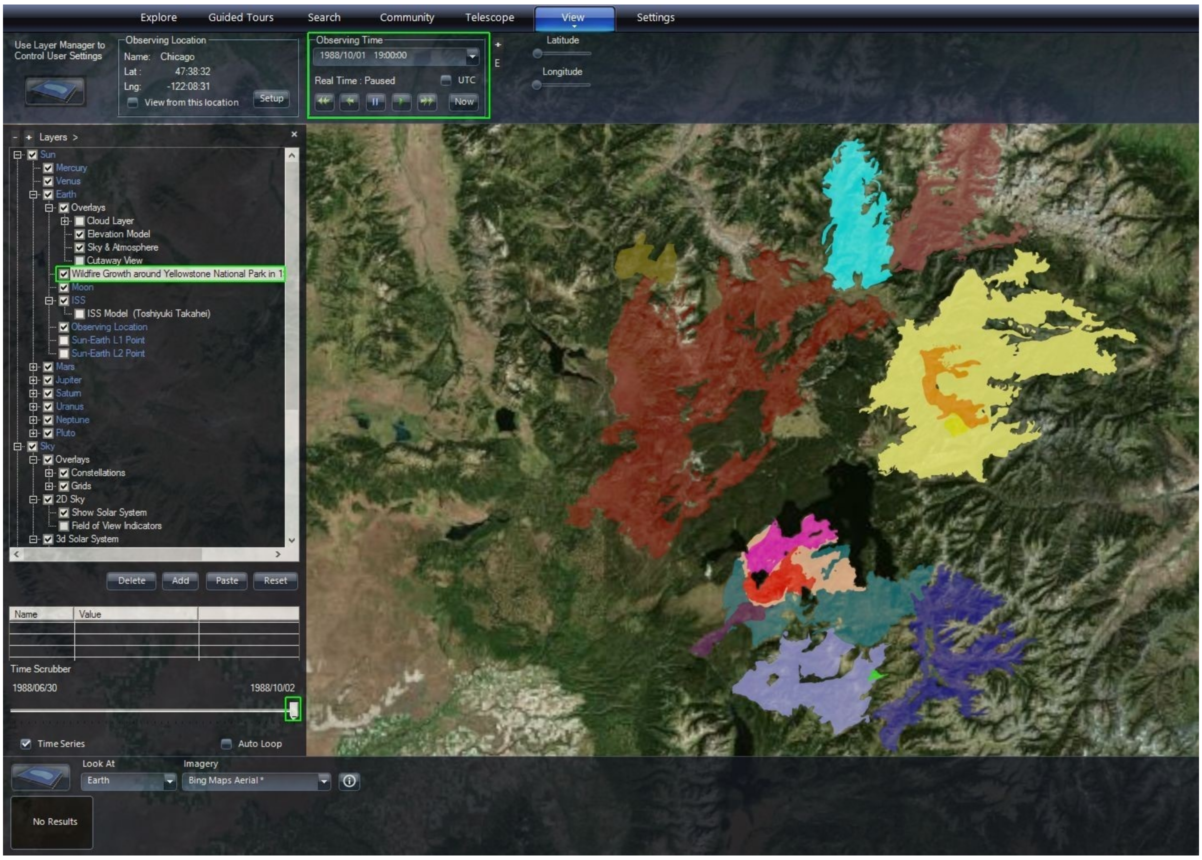
Adding WMS Data

WWT can read Web Mapping Service (WMS) data from various data services. WMS data are served by various sources, and often show time-varying map overlays which can be displayed on the Earth or planets. In the example below, we will add a time-sequence of WMS maps showing wild fires in Yellowstone, but a similar process would be used to add other mapping data for other planets.



1. In the Layer Manager, under the Sun, right-click on the Earth and select "New WMS Layer" to bring up the WMS wizard.
2. In this example, we will use the default server at NASA Goddard Space Flight Center, which is identified by the Web Mapping Service URL field “ http://svs.gsfc.nasa.gov/cgi-bin/wms.” You could also enter a URL from the list below or construct your own list to choose from. Set the “Server Name” to something like “Goddard” and click the "Add Server" button to add this to your Server List.

3. Click on “Goddard (http://svs.gsfc.nasa.gov/cgi-bin/wms), and then click the “Get Layers Button” receive a list of available layers.
4. Data providers categorize WMS data; for this example, expand – by pressing the “+” to the left of “Agriculture,” and then further expand the “Wildlife Growth around Yellowstone National Park in 1988” to show “Wildlife Growth around Yellowstone National Park in 1988 (1024x1024 Animation).”



5. Then press the “Add” button in the lower right. Close the dialog box by clicking “Close” to the right of “Add” button. Now in the Layer Manager under Sun/Earth, there is a layer entitled “Wildlife Growth around Yellowstone National Park in 1988 (1024x1024 Animation).”

6. Since these data represent a time sequence as you scrub through time in the SolarSystem mode, the lighting and Earth rotation will change as well and you will not view the same location on the Earth as time changes. To be able to scrub through time, you should Look At: Earth.
7. Make sure the checkbox next to “Wildlife Growth around Yellowstone National Park in 1988 (1024x1024 Animation)” under Sun/Earth in the Layer Manager is checked.
8. Find Yellowstone National Park on the Earth.
9. Move the Time Scrubber, which is shown below the Layer Manager. You will see a sequence of different maps. Note, the colors are chosen by the WMS data provider and you should go to the data source to find out what the color represent. Note, that as you move the Time Scrubber, Observing Time in the View tab also shows the detailed

time/date.

Here are some WMS sources to experiment with:

1. NASA GSFC – http://svs.gsfc.nasa.gov/cgi-bin/wms
2. MBARI – http://odss.mbari.org/thredds/wms/ucsc/sst
3. GIBS – http://map1.vis.earthdata.nasa.gov/twms-geo/twms.cgi
4. NEOWMS NASA SCI – http://neowms.sci.gsfc.nasa.gov/wms/wms
5. JPL NewMoon – http://onmoon.jpl.nasa.gov/wms.cgi
6. NASA OnMoon – http://onmoon.lmmp.nasa.gov/wms.cgi
7. NASA On Mars – http://OnMars.jpl.nasa.gov/wms.cgi
8. NASA WorldWind - http://data.worldwind.arc.nasa.gov/wms
9. Moon Modeling – http://onmoon.lmmp.nasa.gov/sites_a/wms.cgi
10. Moon Modeling 1 – http://onmoon.lmmp.nasa.gov/sites/wms.cgi
11. NASA OnEarth WMS – http://onearth.jpl.nasa.gov/wms.cgi
12. NASA Earth Observatory – http://neowms.sci.gsfc.nasa.gov/wms/wms

Adding Satellite and Minor Planet Orbits

WorldWide Telescope (WWT) allows for a variety of bodies in the Solar System to be represented by orbital lines with and by 3D representations (planets or spacecraft models).

- Planets
- Moons
- Asteroids
- Satellites from Two-Line Elements (TLE)*
- Minor Planets from Minor Planet Center (MPC)*
- User-defined trajectories and orbits*

- indicates orbital information that can be added by the user.

In all these cases the motion is rendered with proper motion for the desired rate of the passage of time showing orbital motions. Below are instructions showing how to input user defined data and data from data sources outside WWT.

Satellites from Two-Line Element set (TLE)

Satellites orbits are often represented in a compressed format called a two-line element set (TLE). Below is an example TLE.

```
ATLAS CENTAUR 2
1 00694U 63047A   16133.33455413  .00000915  00000-0  10743-3 0
9994
2 00694 30.3557  209.6188 0589210 154.7583 208.3053
14.01718748626428
```

Line 0 is the name of the object. Lines 1 & 2 contain the orbital information. Information on this format is here: https://en.wikipedia.org/wiki/Two-line_element_set

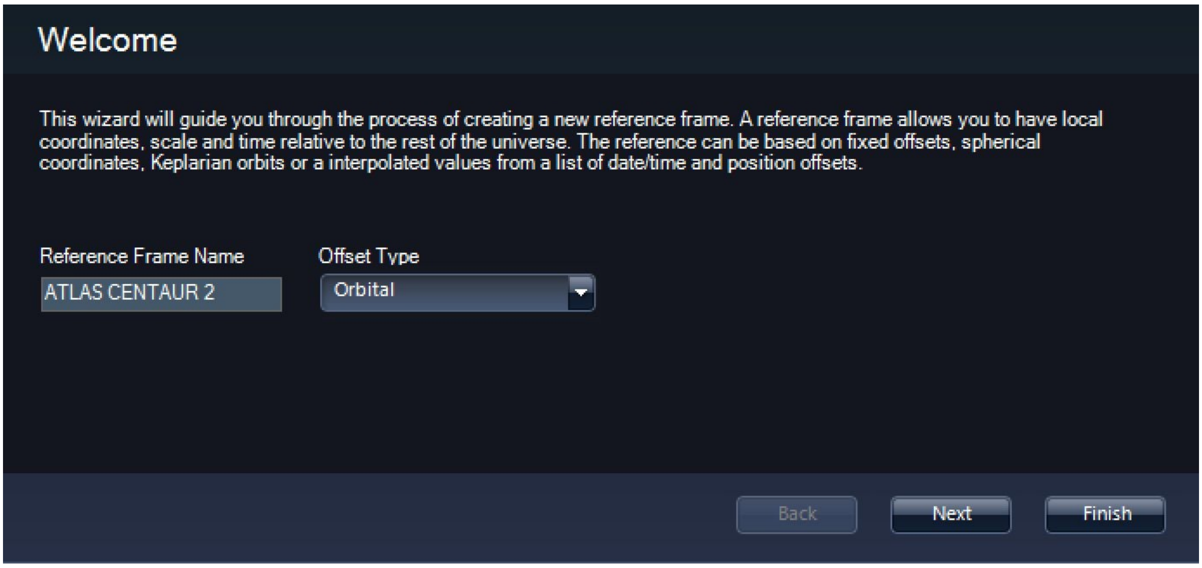
These are available from various sources including:

- Heavens Above - http://heavens-above.com/
- Celestrack - http://celestrak.com/

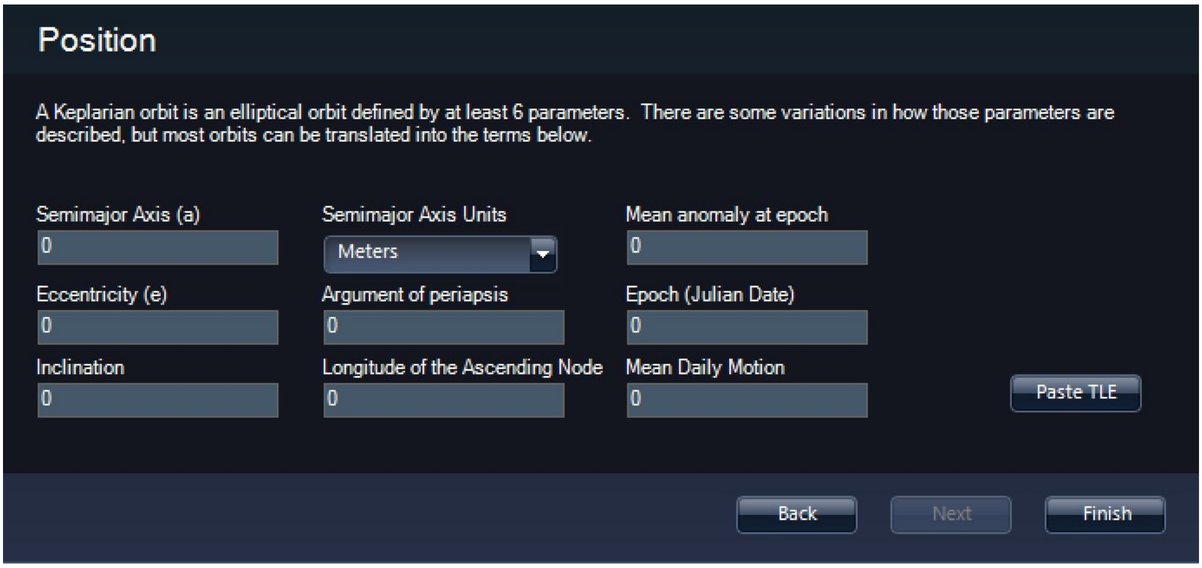
Below are steps needed to take orbital information from these sites and import them into WWT.

Single TLE as a reference frame

1. Start WWT Desktop Client
2. Open a web browser and find a web-site that provides TLEs (e.g., http://celestrak.com/NORAD/elements/visual.txt) and highlight a single line. This can include the Line 0 (name) or not, but must include a single Line 1 & 2.
3. In WWT layer manager (list on the left-hand side of the main window), under Sun, make sure the planets are visible (may need to expand with the "+" symbol). Then right-click on "Earth" and select "New Reference Frame".



4. In the "Welcome" menu, give the new frame a name (e.g., "ATLAS CENTAUR 2"). And under "Offset Type", select "Orbital". Click Next.
5. In the "General Options" menu, you can probably take the defaults of a reference frame as a sphere of 1km diameter and not rotational motion. If needed these can easily be changed later. Click Next.



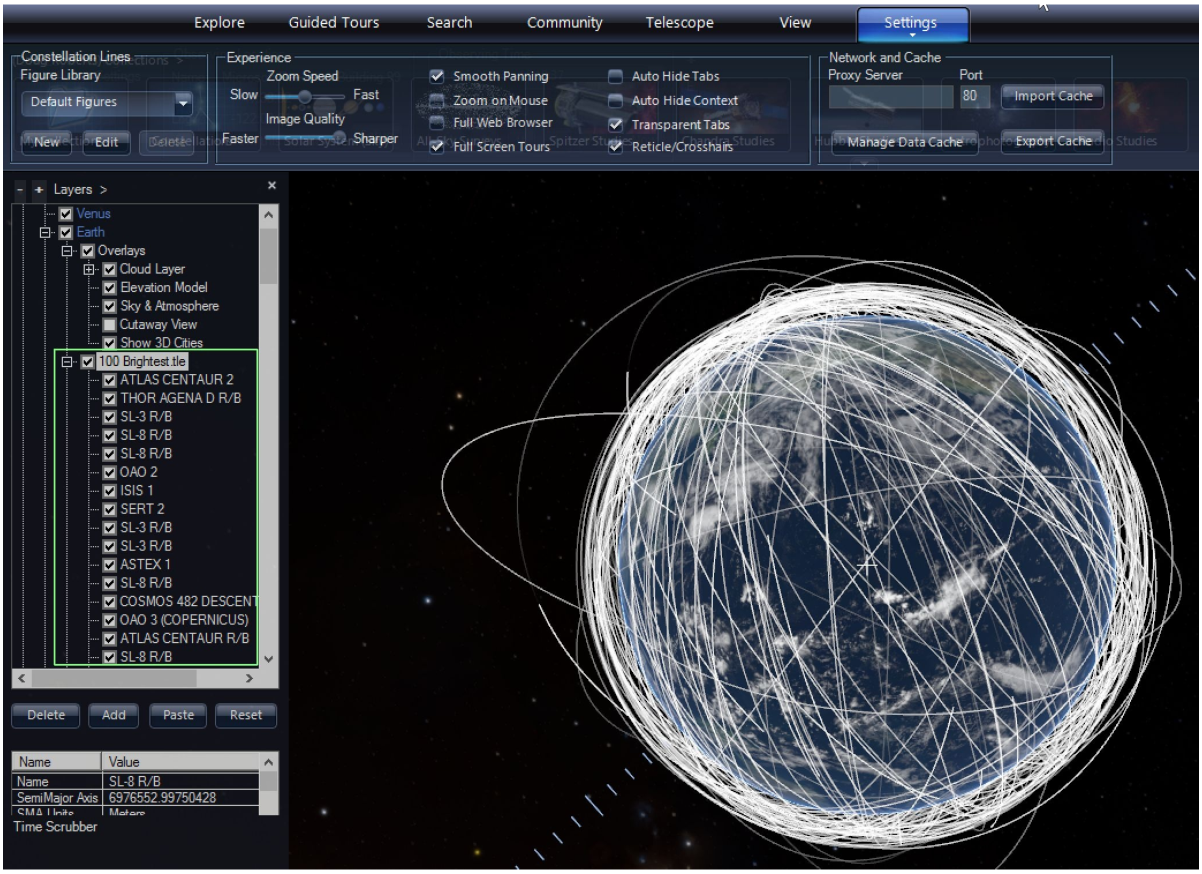
6. Make sure the text is properly highlighted (see step 2). Then in the "Position" menu click "Paste TLE".
7. This creates a reference frame that orbits the Earth in the proper orbit. To visualize it you will want to put a 3D model of the object. Right-click on the name of the new

reference frame and select “Add”. Then navigate to the location of the 3D model (in OBJ or 3DS format). This will attach the model at the location of the reference frame. This way you can show spacecraft in the proper location and it will move properly as you advance time. More information is available here:
http://worldwidetelescope.org/Learn/Authoring#wwt3dmodels

8. If you want to find or see the model you can right-click on the reference frame and select “Track this frame”.

Single TLE as one or more orbits

1. Start WWT Desktop Client
2. Open a web browser and find a web-site that provides TLEs (e.g., http://celestrak.com/NORAD/elements/visual.txt) and highlight many lines of text. Open Notepad (or similar plain text editor) and paste the contents into the file. See this file as an example).
3. In WWT layer manager (list on the left-hand side of the main window), under Sun, make sure the planets are visible (may need to expand with the “+” symbol). Then right-click on “Earth” and select “Add”.
4. Navigate to and select the desired TLE file.
5. It will be shown “100 tle” in the under the “Earth” object.
6. You can right-click on the TLE file name and select “Expand” to show all member objects with TLEs in the file. You can uncheck any object you don’t want shown.



7. Note, the TLE file (filtered by the named object selection) can be added to the timeline for keyframe
8. You can advance time on the time slider to show the satellites in motion.

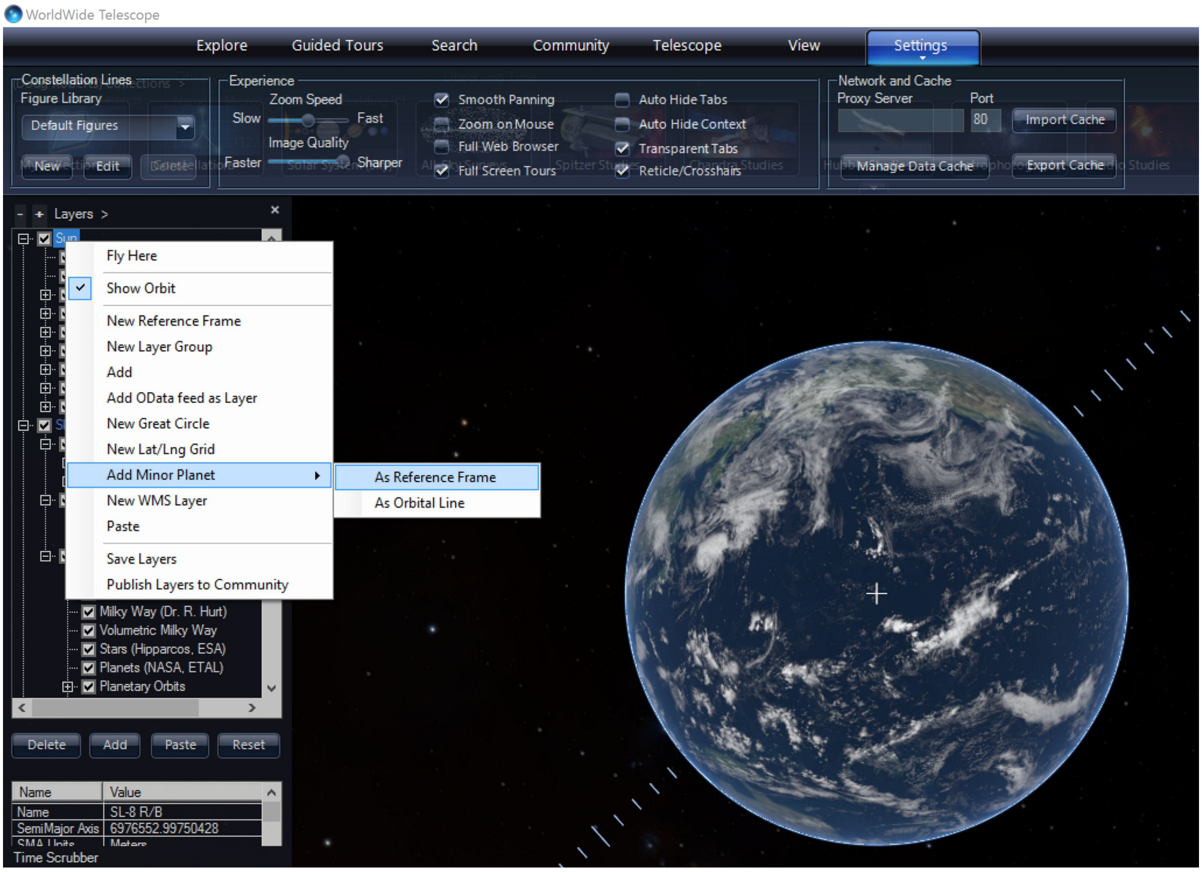
Minor Planets from Minor Planet Center (MPC)

Like TLEs, you can add minor planets as either a reference frame or an obit line.

- **Minor Planets as reference frames** can be used if you want to bring in a 3D model of the object or represent it as a coordinate grid. Orbit lines are also shown when viewed at a distance. Showing orbit lines for reference frames also requires that in the layer manager under “3d Solar System” that “Moon & Satellite Orbits” is checked. However, if you want to add a minor planet as reference frame to the timeline, you cannot control the fading in and out of the associated orbit lines.
- **Minor Planets as orbit lines** do not show a dot at the location of the body. The orbit line is brightest at the location of the object and fades as it gets more distant so you can see its location at a distance for large scale motion. These can be added to the timeline editor and can be controlled for opacity (fade-in and out).

Minor Planets as reference frames

1. Start WWT Desktop Client
2. In WWT layer manager (list on the left-hand side of the main window), under Sun, make sure the planets are visible (may need to expand with the “+” symbol). Then right-click on “Earth” and select “Add”.



3. Select “As Reference Frame”.
4. Then in the dialog box enter the exact name of the minor planet. More information on names is available here: http://www.minorplanetcenter.net/iau/mpc.html
5. This will create a reference frame with the name of the object. It is shown as a dot as well as an orbit line (assuming “Moon & Satellite Orbits” is checked in the “3d Solar System” in the layer manager). You can include a 3D model of the object as well (download Vesta.wwtl).

Minor Planets as orbit lines

1. Start WWT Desktop Client
2. In WWT layer manager (list on the left-hand side of the main window), under Sun, make sure the planets are visible (may need to expand with the “+” symbol). Then right-click on “Earth” and select “Add”.
3. Select “As Orbit Line”.
4. Then in the dialog box enter the exact name of the minor planet. More information on names is available here: http://www.minorplanetcenter.net/iau/mpc.html
5. This will create an orbit line with the name of the object. It is shown as an orbit line (no dot at the position). Unlike a reference frame, you *cannot* include any 3D model of the object.

User-defined trajectories and orbits

You can add a reference frame to WWT. All reference frames need to be attached to another frame. This concept of nested reference frames is what allows WWT to represent data at scales from inches to parsecs.

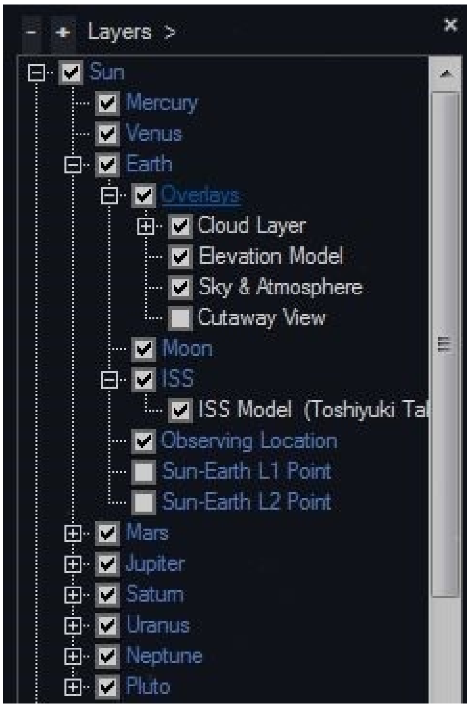
1. Start WWT Desktop Client
2. In WWT layer manager (list on the left-hand side of the main window), select the object you wish to nest the user-supplied reference frame to. For instance, if you want to place a 3D object on the surface of the Earth, right-click on “Earth” and select “New Reference Frame”.
3. In the “Welcome” menu, give the new frame a name (e.g., “My Reference Frame”).
4. Choices for “Offset Type”
    i. **Fixed Spherical**. This puts a reference frame at a specific latitude and longitude and altitude on the parent body. This is used for instance to put a 3D model of an observatory on the surface of the Earth.
    ii. **Orbital**. This allows you to enter orbital information describing the motion of an object such as a satellite, see section above: single TLE as a reference frame. You either need to provide orbital elements separately (e.g., semimajor axis, eccentricity etc.) or you can paste in a two-line element set (see above)
    iii. **Trajectory**. You can add trajectories for spacecraft relative to a reference frame. The trajectories are a list of X, Y, Z locations as a function of time.
    iv. **Synodic**
5. This creates a reference frame that orbits the parent body in the proper orbit. To visualize it you will want to put a 3D model of the object. Right-click on the name of the new reference frame and select “Add”. Then navigate to the location of the 3D model (in OBJ or 3DS format). This will attach the model at the location of the reference frame. This way you can show spacecraft in the proper location and it will move properly as you advance time. More information is available here: http://worldwidetelescope.org/Learn/Authoring#wwt3dmodels
6. If you want to find or see the model you can right-click on the reference frame and select “Track this frame”.

3D Models in WorldWide Telescope

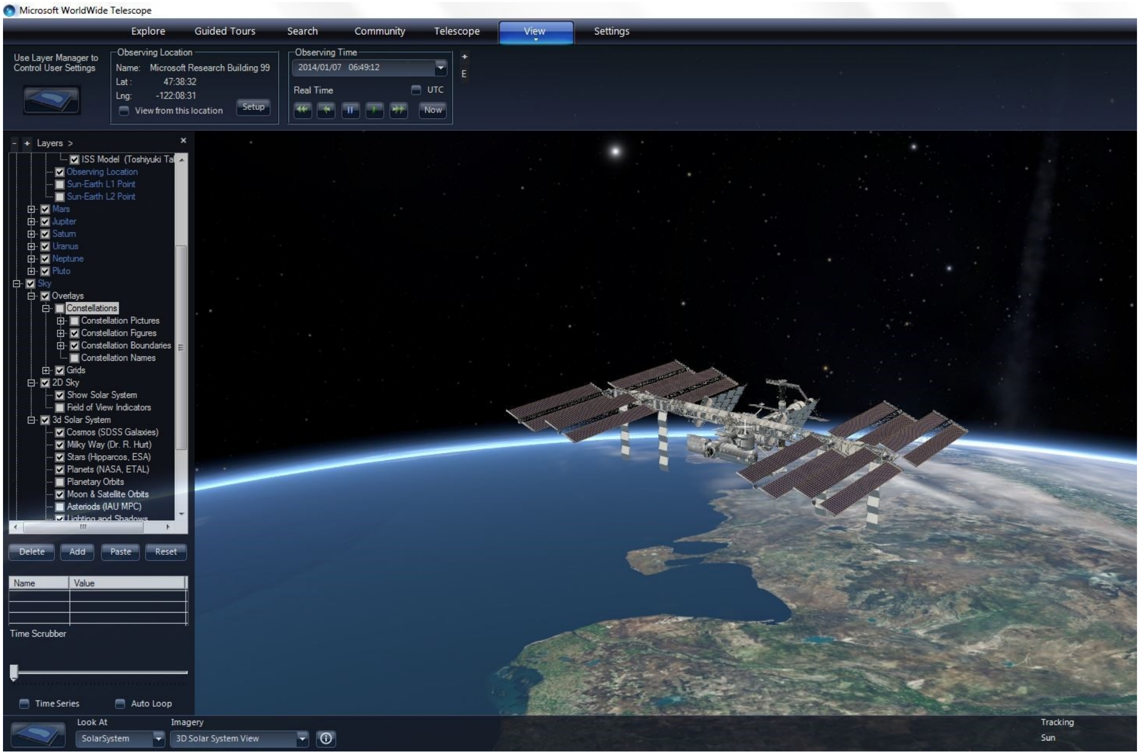
International Space Station

With the latest release of WorldWide Telescope, version 5, the International Space Station (ISS) is included in WorldWide Telescope!

- Open up the Layer Manager (click View, Show Layer Manager)
- Open Earth node, then ISS node and click on ISS Model
  - The first time you do this, WWT will silently download the model so it may take a little while to show up depending on your internet connection.



- Right click on the ISS Reference Frame (not the ISS Model) and click Track this Frame
  - If the ISS model has completed downloading, you should see the model in orbit around Earth (pan around a little if you don't see it right away).



- Try turning on Observing Time (View button) and you'll see the space station orbiting in its actual orbit around Earth!

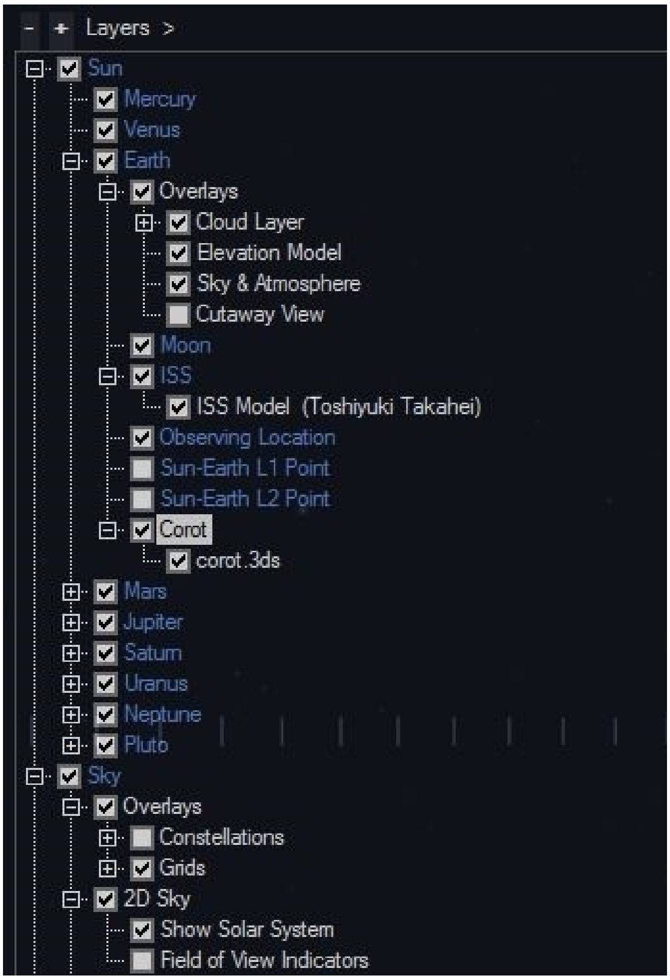
(ISS Model Credit: Toshiyuki Takahei)

3D Models

Several 3D Models have been made available on the WorldWide Telescope website. These 3D Models are embedded in WWT Layer files; where possible, the models have placed in realistic locations in relevant positions and orientations; accurate orbits have been created for relevant models.

To load and view a 3D Model:

- Navigate to http://www.worldwidetelescope.org/Download/TourAssets.
- Select the 3D Model you'd like to view (for example, Corot)
- Click on the Corot link which will download the Corot Model in a WWT Layer
- Open the Corot Layer File (either by double clicking on the file or clicking Explore – Open – Layer)
  - The 3D Model will be loaded in the Reference Frame in which it was saved

- 

- If the Layer Manager is not already open, ensure it is opened (View – Show Layer Manager)
- Navigate through the Layer Manager to see the Reference Frame (for Corot: Earth – Corot)
- Right click on Corot Reference Frame and click Track this Frame
    - WWT will jump to the Corot 3D Model

Try turning on Observing Time (View button) and you'll see Corot orbiting in its actual orbit around Earth!

You can also add your own 3D Models (OBJ and 3DS formats) into WWT using the Layer Manager.

Loading Data Using pyWWT

Contributed by Mark SubbaRao, Adler Planetarium and John Zuhone, MIT.

John Zuhone wrote a very nice python package – pyWWT – that allows data import directly into WorldWide Telescope. Mark SubbaRao used this package to load and visualize extragalactic data into WWT and has written up an IPython notebook to illustrate the process.

This document will go through the install from nuts to bolts to reproduce this visualization to learn more about using the pyWWT package and WWT. In this example we assume you are using pyWWT on the same Windows machine where you are running WorldWide Telescope. You can also run the python package on a different machine running Linux or MacOS and connect to WWT on the remote Windows machine over the network.

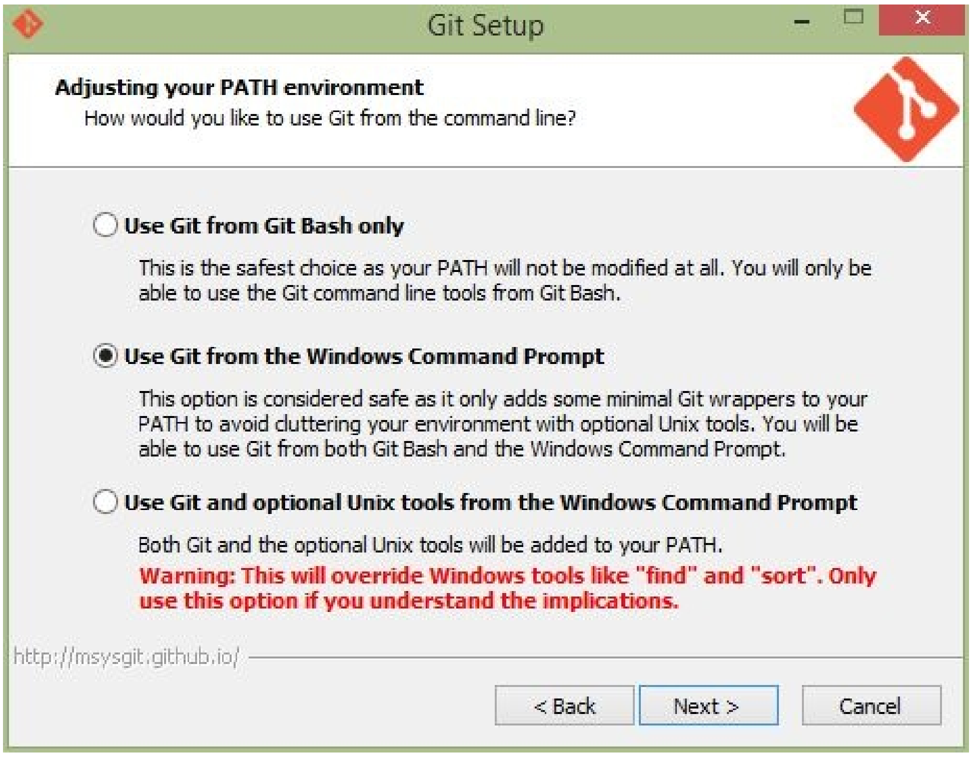
There is good documentation on installation and usage of pyWWT on the project website - http://www.jzuhone.com/pywwt/index.html. Below we take through one specific path, which will be useful if you are new to Python.

Step 1 - Installing Python (Anaconda)

1. First download the Anaconda Python distribution https://store.continuum.io/cshop/anaconda/. You don't have to use this distribution, but instructions on adding the packages that pyWWT depends on will be specific to Anaconda. Note, you will have to provide an email to get to the download page. When you install the distribution, it is easier to install it for "Just Me", rather than for "All Users."

   Anaconda Python this includes most of the packages that are needed by pyWWT. If you are using another Python distribution, you will have to make sure the following are installed:

   - NumPy
   - Matplotlib
   - AstroPy
   - Beautiful Soup 4
   - Requests
   - Dateutil
2. The only extra package you need to install is astroquery. First download and git - http://git-scm.com/download/win. Run the installer and take the defaults until the page on "Adjusting your PATH environment." On that page, select "Use Git from the Window Command Prompt."

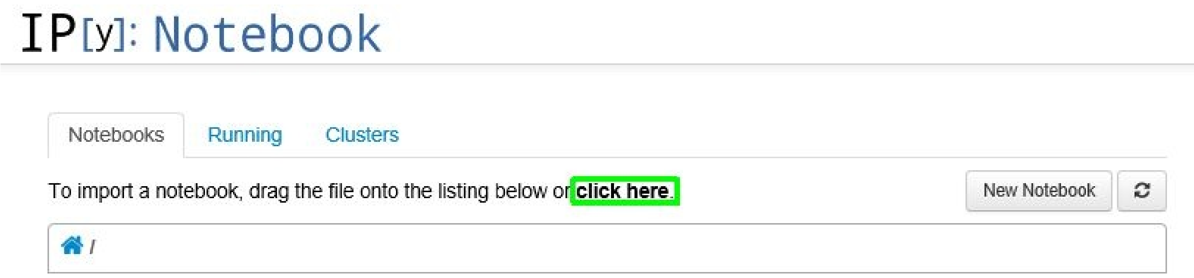


3. Now open the "Anaconda Command Prompt," accessible through Windows Start Menu. Note, if you installed Anaconda for All Users, you have to run the command prompt as administrator.
4. Install astroquery package: `> pip install git+http://github.com/astropy/astroquery.git#egg=astroquery`
5. While the Anaconda Command Prompt is open, install pyWWT: `> pip install pywwt`

Running IPython Notebook

Mark SubbaRao created an IPython Notebook to import and visualize extragalactic datasets.

1. First download the Notebook here.
2. If it is not open already startup the "Anaconda Command Prompt."
3. Open up the Notebook viewer in a web browser: `>ipython notebook`
4. Import the downloaded Notebook by either dragging the "Visualizing Extragalactic Data in WWT.ipynb" file to the IPython Notebook viewer or clicking " **click here**" at the top and navigate to the file.



5. After importing it click the blue "Upload" button.
6. Click on the Notebook title. This should open up the Notebook in a separate tab. The

Notebook is made up of a series of cells, which can have various types of information, including code. The current cell is indicated.

7. Click the “Run Cell” button, which will move past the first text cell to the first part of code “In[1]”

8. When you get to the “In[2], which Acquires Data from GAMA database a status bar at the bottom of the cell will show the progress of downloading the database (2.6MB). Wait for the file to finish downloading and then run the next cell.
9. Before connecting to WWT using LCAPI, startup WorldWide Telescope. In this example, we are running on the same machine. If this is not the case, you can start it on the remote machine and then give the IP address of the WWT machine in In[4].
10. When you execute In[5], you will see a new “GAMA Galaxies” layer appear in the Layer Manager.
11. You can view this in SolarSystem mode and fly out to see the new dataset as well as the SDSS Galaxies shipped with WWT. Note, in the Layer Manger SDSS galaxies are called “Cosmos (SDSS Galaxies)”.
12. You can also switch to Sky mode and then right-click on the “GAMA Galaxies” layer and bring up the properties dialog box. In the Scale tab, use the slider to set Scale Factor to 16. In the Markers tab, select the “Marker Type” to be “Circle.” Then when you view the patch of sky where the GAMA galaxies are found and zoom in you will see the positions marked as circles.
13. You can edit the code to create other data columns in the Notebook and rerun to make a new data layer and play with adjusting the interactive visualization.

Processing Panoramas

Panoramas are wide field of view images taken with either wide-angle fish-eye lenses or stitched together from individual images take of a wide field of view scene.

This tutorial will walk through how to process these data so that they can be TOAST projected into a multi-resolution format that can be hosted in the Cloud.

If you have a collection of images.

Many high resolution panoramas, especially ones obtained by remote space craft, are taken as a collection of individual images. In the case where you have a collection the first step is to stitch them together to create a single panorama image that can be processed for WWT (see below).

There are several programs that

1. PTAssembler - http://www.tawbaware.com/ptasmblr.htm
2. Auto Stitch - http://matthewalunbrown.com/autostitch/autostitch.html
3. GigaPan (hardware mount + software) - http://www.gigapan.com/
4. Image Composite Editor - http://research.microsoft.com/en-us/um/redmond/projects/ice/

This tutorial uses Image Composite Editor (ICE).

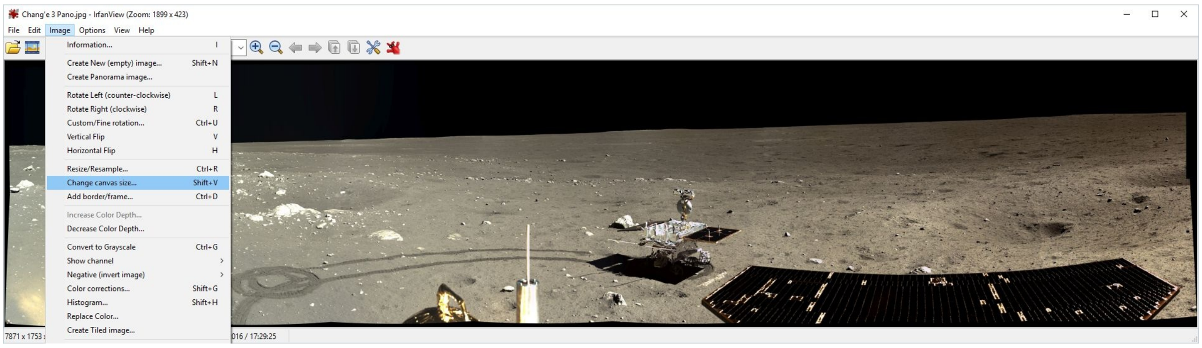
Collect the images that cover as much of your field of view as possible. They do not need to be in any specific order or have any naming convention.

1. Startup ICE.
2. Click "New Panorama From Images".
3. Navigate to the folder with the images. Assuming the folder had only the images to be stitched together, click Control-A to select all the images and then click "Open".
4. Under "Camera Motion" in the upper right, make sure "Auto-detect" is clicked.
5. At the upper menu, click "Stitch".
6. When it is finished it will show the images stitched together and projected. Leave the projection as "Cylindrical".
7. In the upper menu, click "Crop". You should probably not apply any crops.
8. In the upper menu, click "Export". In the upper right don't change any of the parameters, and click "Export to disk…"

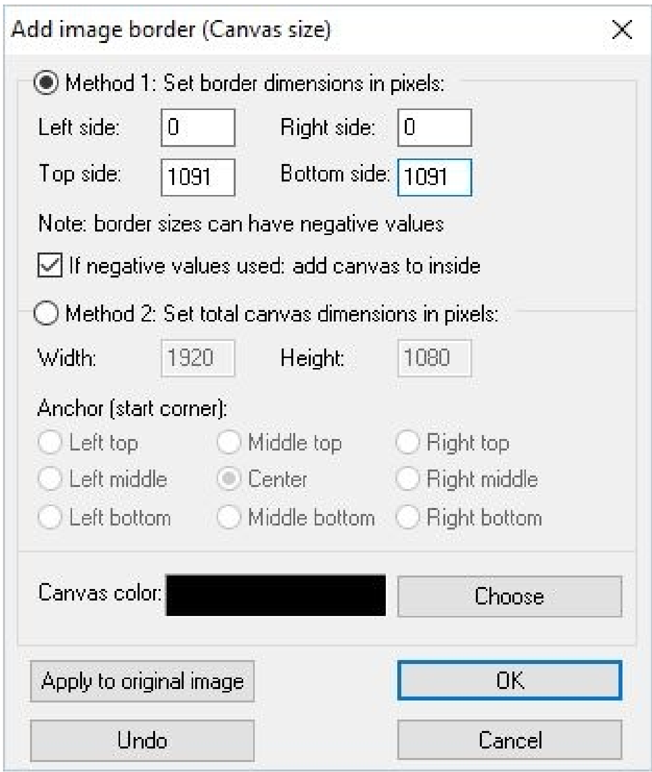
If you have a panoramic image already.

Many cameras can obtain panoramic images directly. Examples are Ricoh Theta - https://theta360.com/en/ and Kodak Pixpro - http://kodakpixpro.com/Americas/cameras/actioncamera/sp360.php cameras. Even smart phones can capture panoramic images with software such as Microsoft's Photosynth - https://photosynth.net/ of the built-in camera app on iOS. This could be useful in capturing panoramic views of observatories or observational locations. Of course another important type of data are panoramic views of surfaces of other bodies of the Solar System. However the panoramic image was obtained, this image is the input to the next step, which is to use the SphereToaster tool.

1. Open the panorama and make sure that it is of the correct size. The input panorama file should be in equi-rectangular (aka cylindrical equidistant) projection. In this projection the panorama should be twice as wide as it is tall and should cover the entire 360 field of view. If the image is projected correctly but isn't the entire size, I recommend that you pad the image with black space. In this example, we will use a free Windows program called Irfanview (http://www.irfanview.com/). You can open the image and the image dimensions are shown in the lower left corner. In this example, the image is 7872 x 1752 pixels.

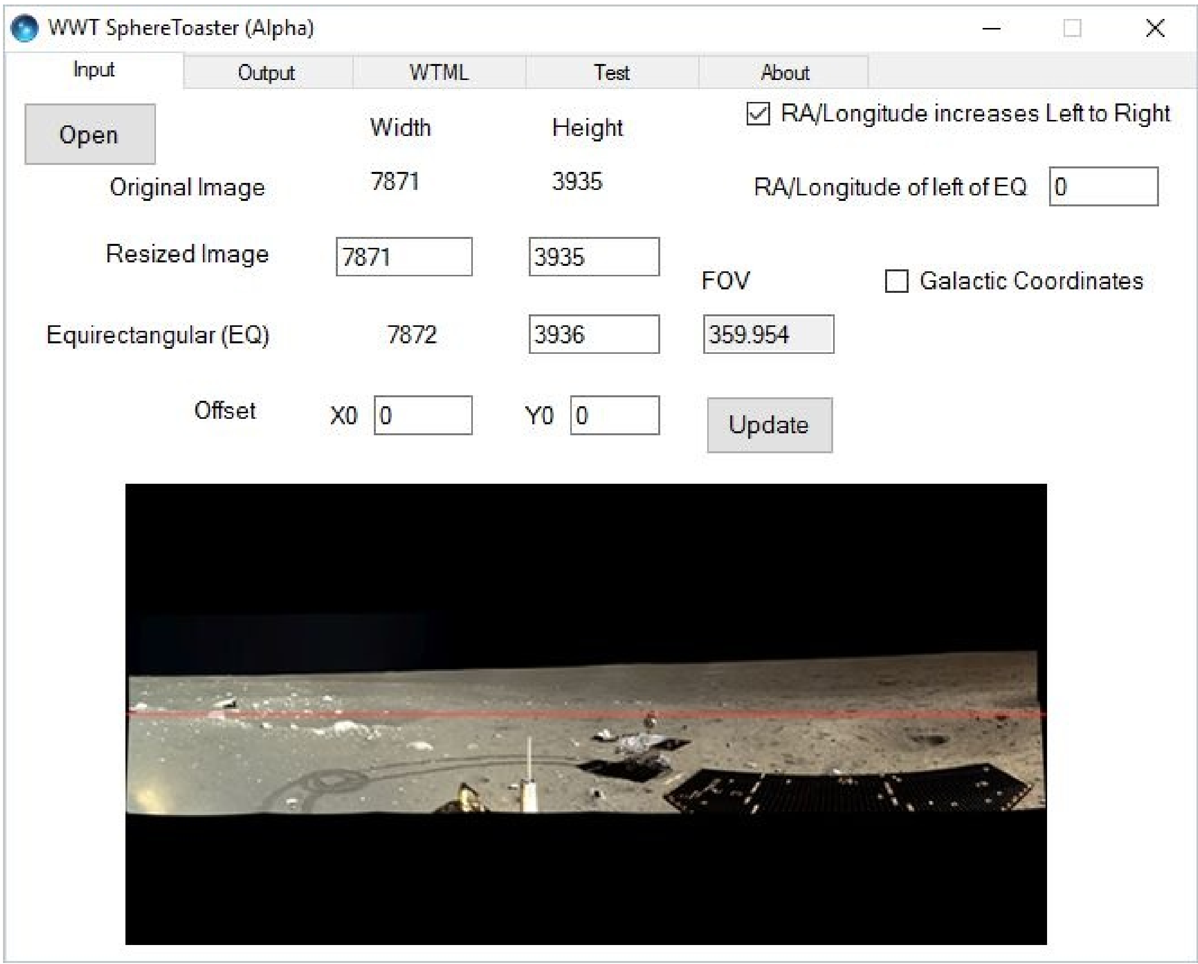


2. If you need to pad the image to be 2:1 then in Irfanview, under the Image menu, select "Change canvas size". In this example, the width of the image is 360 degrees but it covers the middle part and does not go to the top and bottom. Given that the width is 7872 the final height should be half that or 3936 pixels. Since the image is actually 1752 pixels high we have to pad 3936-1752=2184 pixels. This padding needs to be split equally to be added to the top and bottom; that is, 1092 to top and bottom and 0 to left

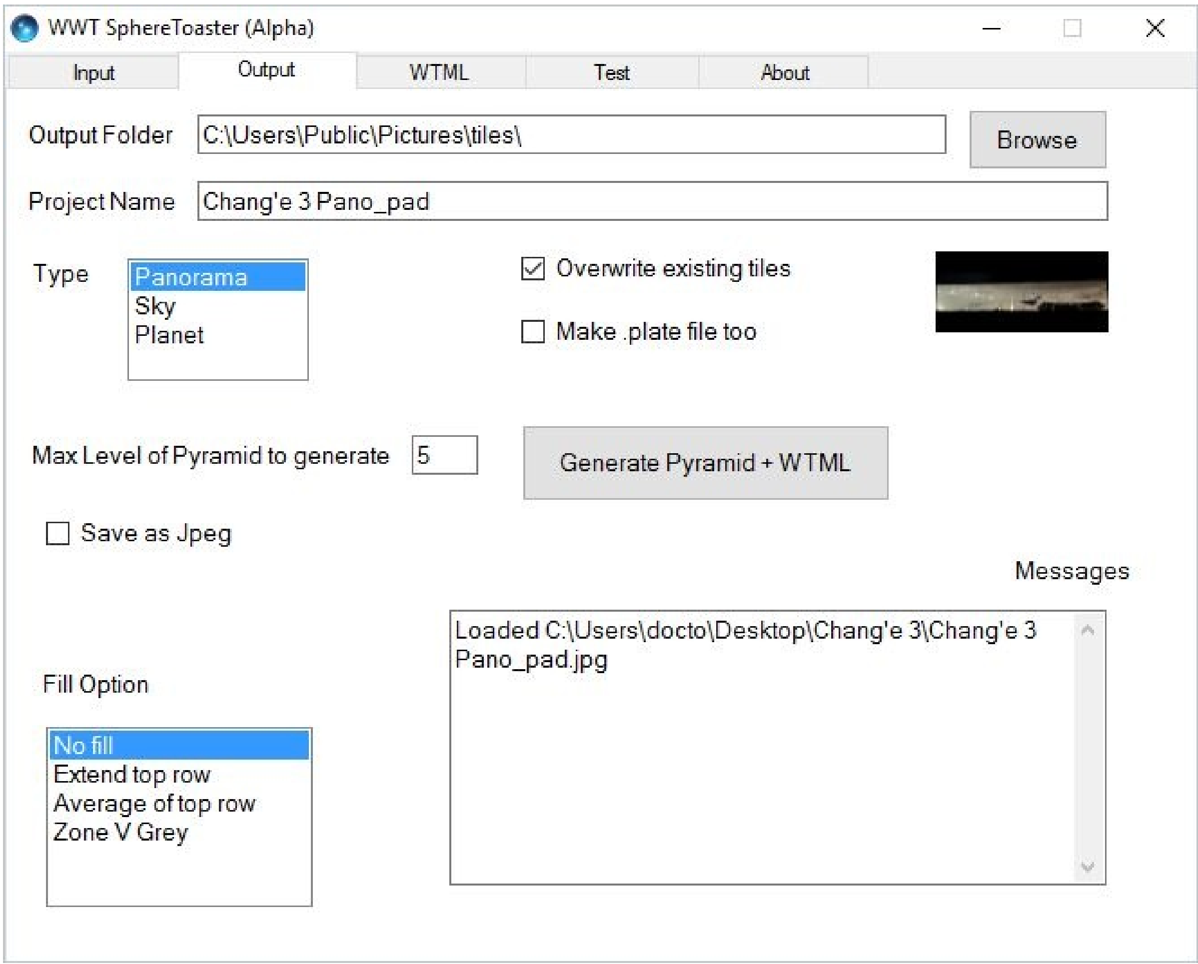


and right.

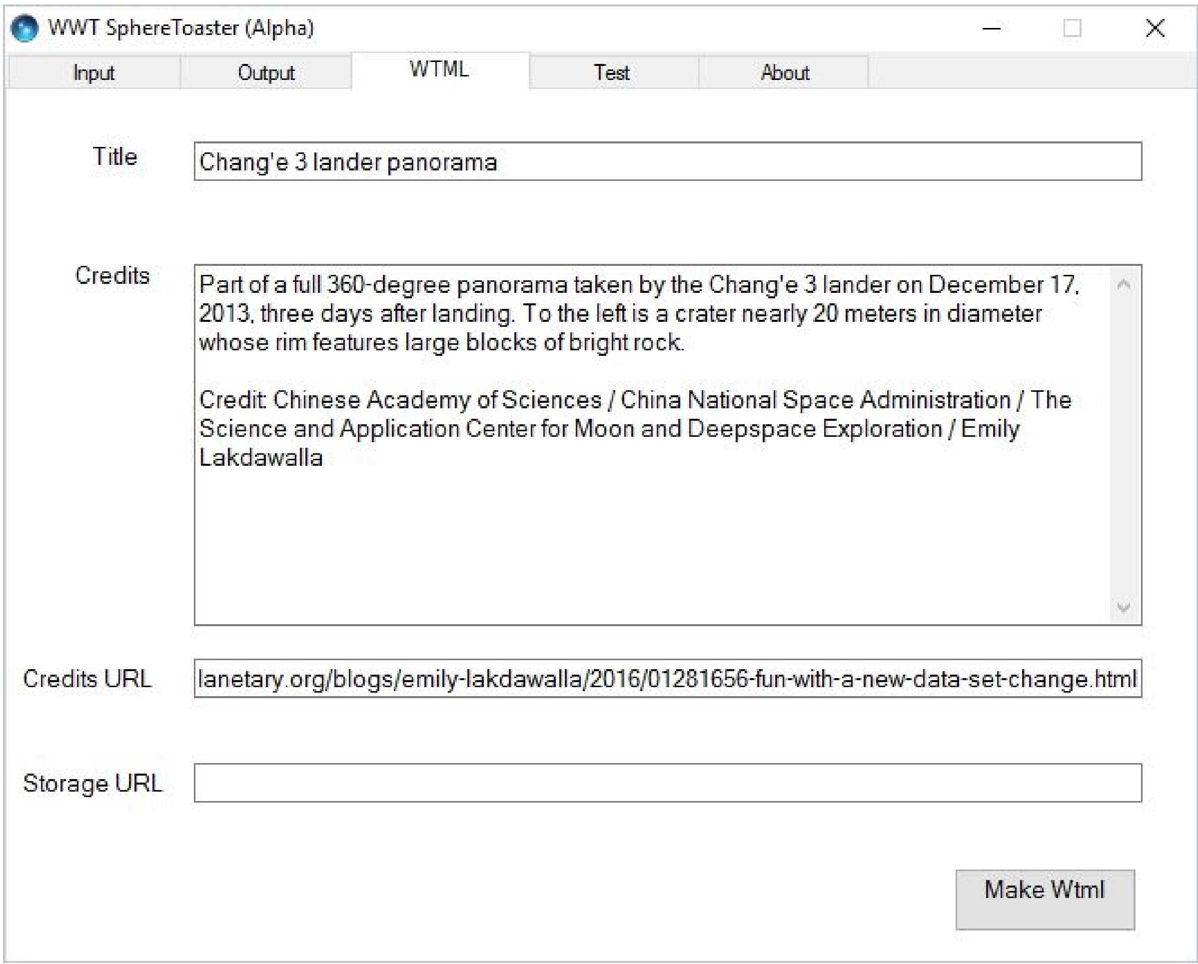
3. Then save the image and it should now have the dimensions 7872 x 2936.
4. Download the WWT SDK, available here: On the Tools page: http://www.worldwidetelescope.org/Download/Tools click on "SDK with data pipeline and original ADK tools" which should link to: http://wwtweb.blob.core.windows.net/drops/WWTSDK.msi.
5. Install the SDK. It will install a folder: C:\Program Files (x86)\Microsoft Research\WorldWide Telescope SDK. Go into that folder and then into "Sphere Toaster" and then execute the program: "SphereToaster.exe".
6. In SphereToaster start with the "Input" tab. Click "Open" and navigate to the padded image in equi-rectangular projection. Assuming you did your padding correctly, you should not have to change anything.



7. Under the Output tab, select a folder where the processed files will be created. Note, that the total size of the processed data can be much more than the original, especially if the input image is compressed with much black, so make sure the output drive has sufficient space. The default Project Name is taken from the input file name, which you can change. This is the name of the output WTML file.
8. Under Type, choose "Panorama". In order to preserve transparency, keep the output format as PNG and do not select JPEG.
9. Since you have padded the image in the previous step, under "Fill Option" select "No fill".



10. Under the WTML tab, you can give the descriptive information for the image. Under Title, you should give a descriptive (and short) title that will show up in WWT. Under Credits, you can put the caption information, including the credit to the person or organization who owns the copyright of the image. You can specify the URL (Credits URL) which points to web page that described the image or data. Assuming you are going to make this panorama available on-line you can specify the URL to the web server that will serve the panorama data (Storage URL). Note this can be changed easily if you don't set this now or change the location of the server later.



11. When you are finished entering this metadata, go back to the Output tab and click on: "Generate Pyramid + WTML". This will take a while. For this example (7,872 x 3,936) it took about 40 minutes on a reasonably fast PC. Note, that while it is working the GUI doesn't get updated and the window banner will show "WWT SphereToaster (Alpha) (Not Responding." It is actually running so don't close the window. It will report some progress in the Messages window in the lower right of the Output tab. When you first load the image it will report that it found the input image ("Loaded C:\Users\docto\Downloads\Chang'e 3.jpg" in this example). You can check on it with the task manager or by looking at the properties of the output folder; the total output size should be increasing as the process runs and generates more files. When it is finished SphereToaster will report the number of tiles created and time to process the data.
12. When this is complete, the process will create the following:
    - Folder full of tiles, e.g., "Chang'e 3"
    - WTML file to use locally, "Chang'e 3LOCAL.wtml". This is only used for local testing and cannot be shared outside the machine you are working on.
    - WTML file to use when the data are on a web server, "Chang'e 3.wtml". Once the data are processed and moved to the specified server, sharing this file will provide access to it.
    - Thumbnail; the name is a lower case version of the title with spaces replaced with underscores (e.g.,, "chang'e_3.jpg")

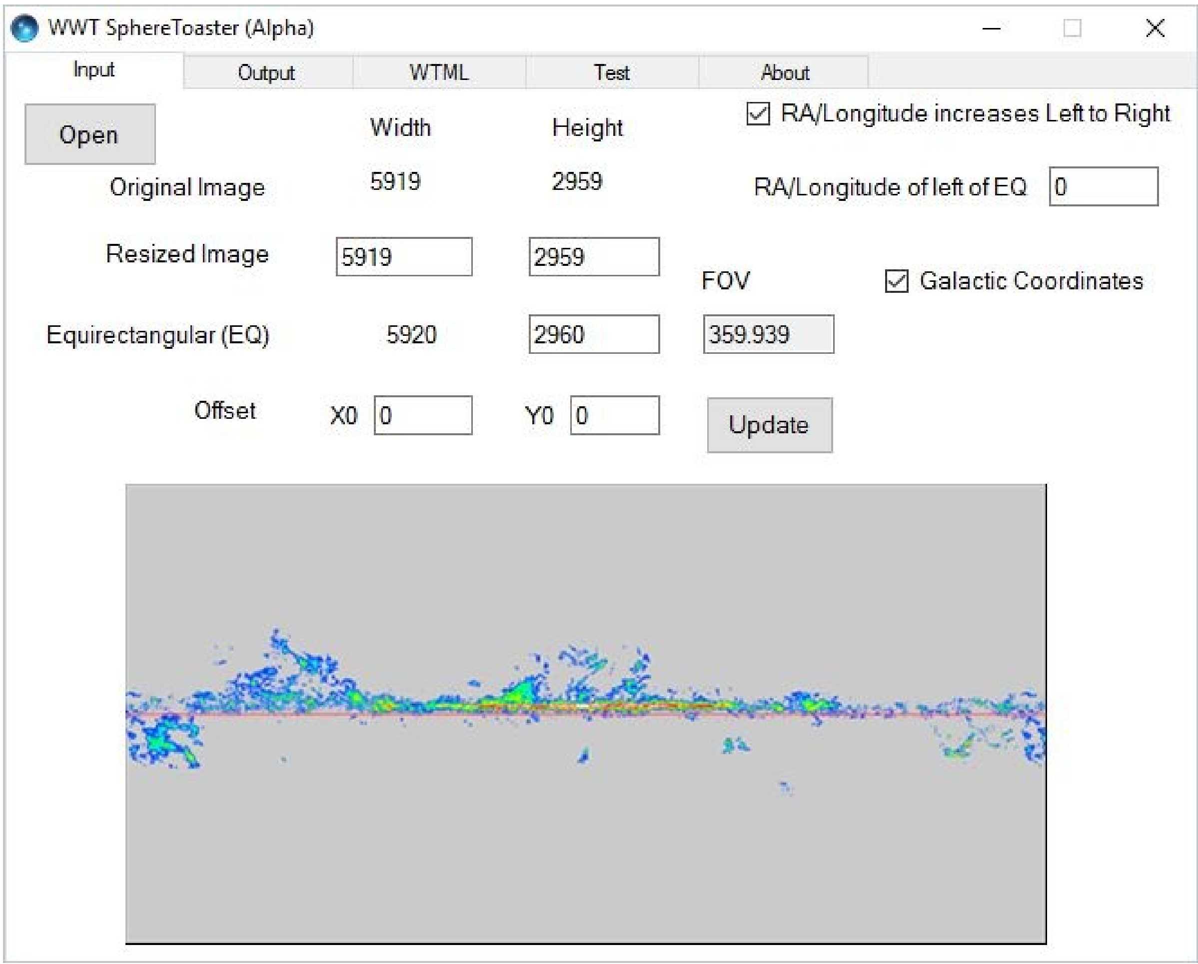
13. You can view the generated panorama by starting WorldWide Telescope and then double-clicking on the local version of the WTML file. In this example it is "Chang'e 3LOCAL.wtml". Note, that this points to the specific location on disk where you specified the output, so if you move that folder you have to edit this local WTML file.
14. The other version of the WTML file (Chang'e 3.wtml) is setup to point to a data on a web server. In the WTML file, you should review the location of (Url="[Storage Url]/Chang'e 3 Pano/{1}/{3}/{3}_{2}.jpg", “Storage URL” was specified in the WTML tab). After the image pyramid is created, you can move it to the web server and then use the “Chang’e 3.wtml” to access the data over the web. If you move the data to a different web server, you need to change the server address in the Url tag in the WTML file.

You can find additional information on how to use SphereToaster tool in the SDK (as well as the other tools) here:
http://www.worldwidetelescope.org/docs/WorldWideTelescopeDataToolsGuide.html#WWTSphereToaster

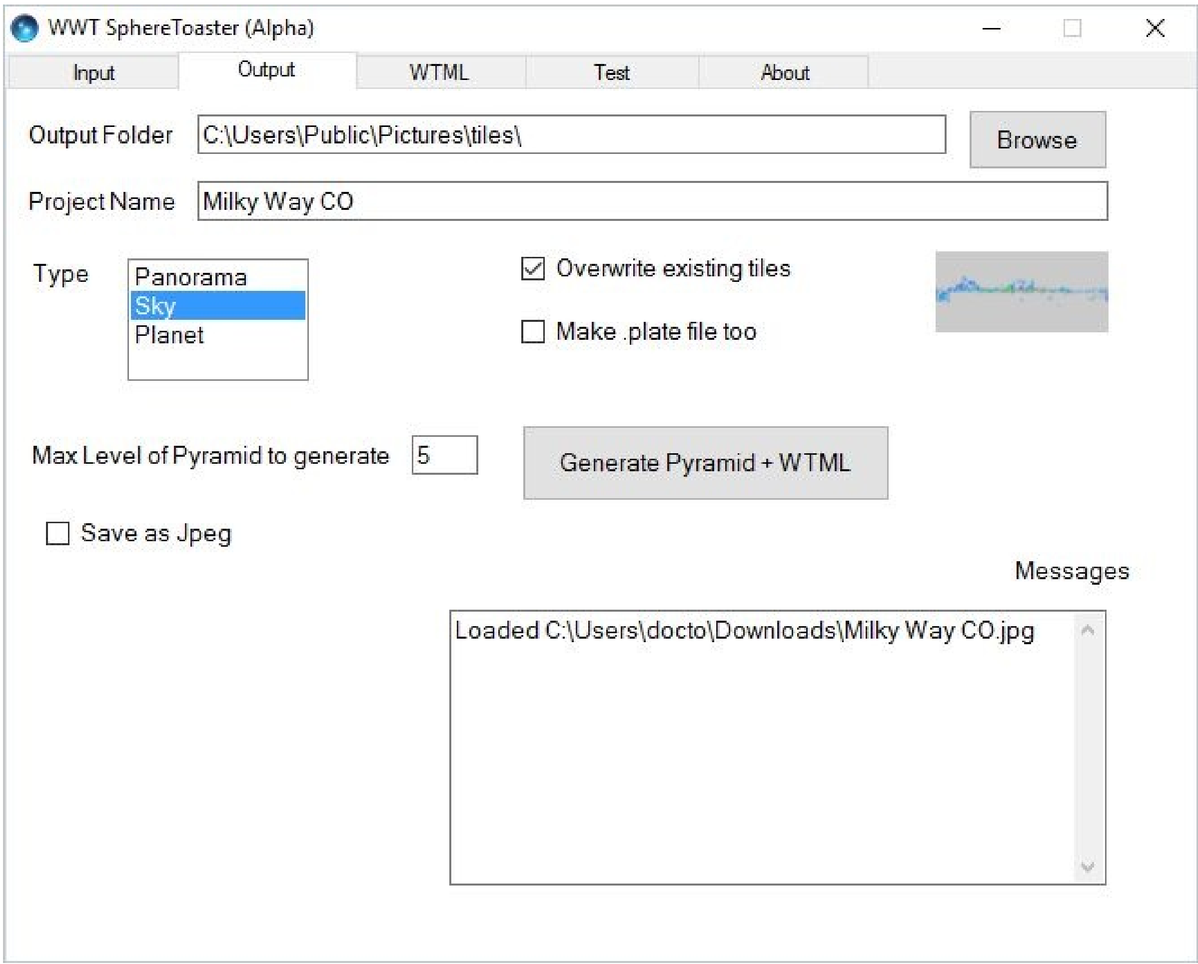
Processing All-Sky Images

All-sky images are acquired by a variety of surveys and are usually created by combining together individual images into a full-sky mosaic. The process described below assumes that you are starting with an all-sky image and will walk through how to process these data so that they can be TOAST projected into a multi-resolution format that can be hosted in the Cloud.

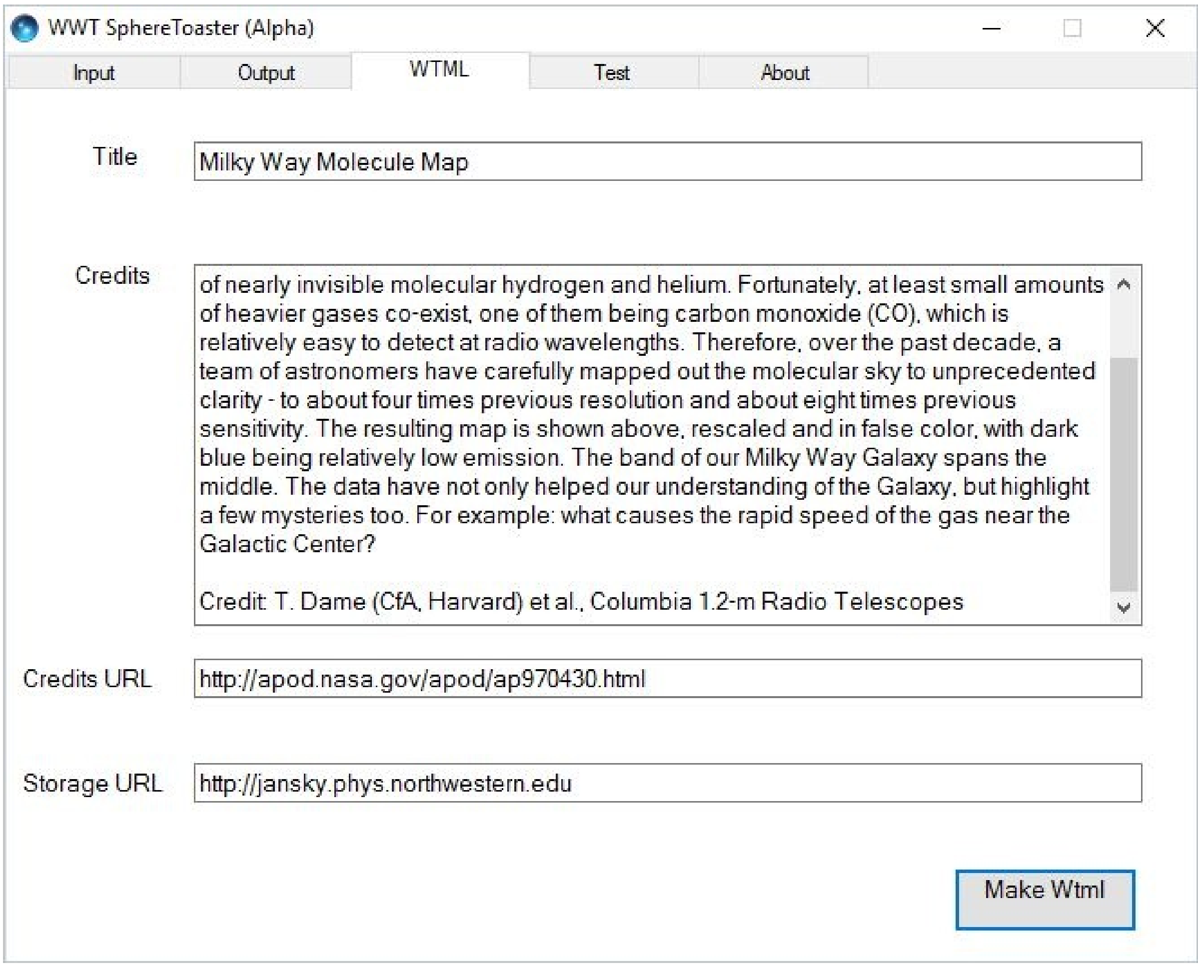
1. Download the WWT SDK, available here: On the Tools page: http://www.worldwidetelescope.org/Download/Tools click on "SDK with data pipeline and original ADK tools" which should link to: http://wwtweb.blob.core.windows.net/drops/WWTSDK.msi.
2. Install the SDK. It will install a folder: C:\Program Files (x86)\Microsoft Research\WorldWide Telescope SDK. Go into that folder and then into "Sphere Toaster" and then execute the program: "SphereToaster.exe".
3. In SphereToaster start with the "Input" tab. Click "Open" and navigate to the padded image in equi-rectangular projection. Assuming you have a full 360 all-sky image, you should not have to change any of the numbers.
4. Many all-sky surveys, such as this example, are in Galactic coordinates; check the “Galactic Coordinates” checkbox if that is the case.



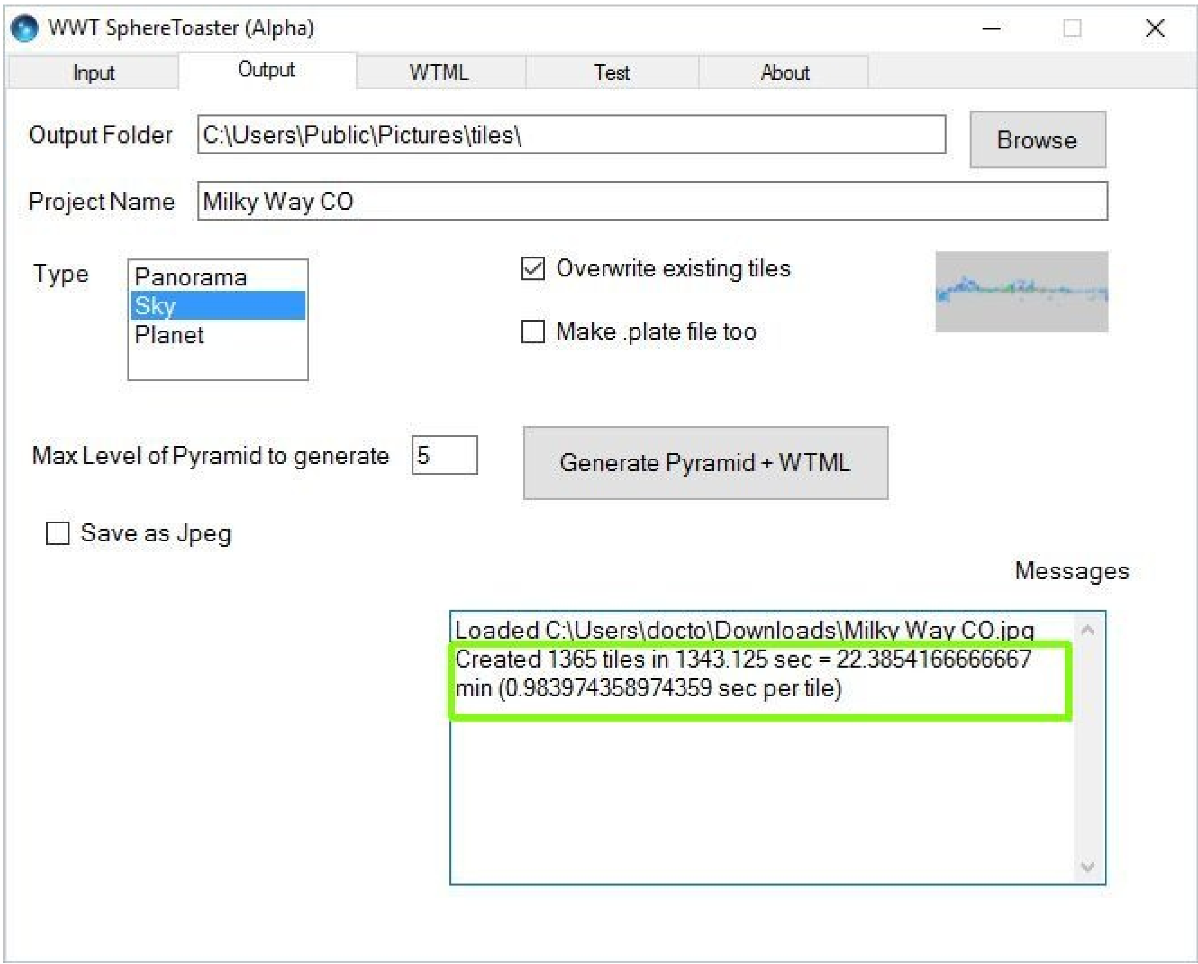
5. Under the Output tab, select a folder where the processed files will be created. Note, that the total size of the processed data can be much more than the original, especially if the input image is compressed with much black, so make sure the output drive has sufficient space.
6. Under Type, choose "Sky". In order to preserve transparency, keep the output format as PNG and do not select JPEG.



7. Under the WTML tab, you can give the descriptive information for the image. Under Title, you should give a descriptive (and short) title that will show up in WWT. Under Credits, you can put the caption information, including the credit to the person or organization who owns the copyright of the image. You can specify the URL (Credits URL) which points to web page that described the image or data. Assuming you are going to make this all-sky image available on-line you can specify the URL to the web server that will serve the all-sky data (Storage URL). Note this can be changed easily if you don't set this now or change the location of the server later.



8. When you are finished entering this metadata, go back to the Output tab and click on: "Generate Pyramid + WTML". This will take a while. For this example (roughly 6,000 x 3,000) it took about 22 minutes on a reasonably fast PC. Note, that while it is working the GUI doesn't get updated and the window banner will show "WWT SphereToaster (Alpha) (Not Responding." It is actually running so don’t close the window. It will report some progress in the Messages window in the lower right of the Output tab. When you first load the image it will report that it found the input image (“Loaded C:\Users\docto\Downloads\Milky Way CO.jpg” in this example). You can check on it with the task manager or by looking at the properties of the output folder; the total output size should be increasing as the process runs and generates more files. When it is finished SphereToaster will report the number of tiles created and time to process the data (“Created 1365 tiles in 1343.125 sec = 22.3854166666667 min (0.983974358974359 sec per tile)” in this example), see below.



9. When this is complete, the process will create the following
   - Folder full of tiles, g., "Milky Way CO"
   - WTML file to use locally, "Milky Way COLOCAL.wtml". This is only used for local testing and cannot be shared outside the machine you are working on.
   - WTML file to use when the data are on a web server, "Milky Way CO.wtml". Once the data are processed and moved to the specified server, sharing this file will provide access to it.
   - Thumbnail; the name is a lower case version of the title with spaces replaced with underscores (e.g.,, "milky_way_co.jpg")
10. You can view the generated all-sky image by starting WorldWide Telescope and then double-clicking on the local version of the WTML file. In this example it is "Milky Way COLOCAL.wtml". Note, that this points to the specific location on disk where you specified the output, so if you move that folder you have to edit this local WTML file.
11. The other version of the WTML file without appended "LOCAL" (in this example, "Milky Way CO.wtml") is setup to point to a data on a web server. In the WTML file, you should review the location of (Url="[Storage URL]/Milky Way CO/{1}/{3}/{3}_{2}.jpg", "Storage URL" was specified in the WTML tab). After the image pyramid is created, you can move it to the web server and then use the "Milky Way CO.wtml" to access the data over the web. If you move the data to a different web server, you need to change the server address in the Url tag in the WTML file.

You can find additional information on how to use SphereToaster tool in the SDK (as well as the other tools) here:

http://www.worldwidetelescope.org/Developers/DataToolsGuide#WWTSphereToaster

Making Video Abstracts with WWT

Pre-flight Question:

Can one or more images be used as a primary way to communicate the main science result?

If the answer is no, it will be difficult to make a video abstract completely with WWT. It will take more time and WWT could be used for parts, but final abstract would have most of the visuals created outside of WWT and edited together.

If yes, keep reading.

Overview

Total Time about 6 - 14 hr

1. Prepare data: 0 - 4 hr
2. Make story board: 0.5 hr
3. Write draft script: 1 hr
4. Record draft narration: 0.5 hr
5. Create draft tour: 1 - 3 hr
6. Create draft video [OPTIONAL]: 0.5 hr
7. Sharing and feedback: 1.0 hr
8. Record final narration: 0.5 -1.5 hr
9. Refine tour: 1 - 2 hr
10. Create final video [OPTIONAL]: 0.5 hr

Appendix A: Limitation of the web-based tour player

Appendix B: Using Communities

1 Prepare data

Estimated Time: 0-4 hr

Tools: FITS Liberator (http://www.spacetelescope.org/projects/fits_liberator/), Adobe Photoshop, Adobe Illustrator

Some abstracts can be presented with the data in WWT, adding only text and image overlays. Other, more complex tours will want to represent the original new data presented in the paper. In these cases, significant time might have to be taken to import FITS or other data formats into WWT.

Below is one representative workflow used to get the data into WWT necessary for a video abstract. This workflow assumes that the data that will be added to WWT in order to present the abstract are in the form of FITS files. More detailed instructions on loading images are available here: http://www.worldwidetelescope.org/Learn/Exploring#AstroImageData.

1. Use FITS Liberator (http://www.spacetelescope.org/projects/fits_liberator/) to make TIFF from original FITS file.
   i. Had to select "No Flip" (which controls vertical flips)
   ii. The image was still flipped horizontally, so…
   iii. Loaded output TIFF into Photoshop and did a horizontal flip and resaved
2. Test by loading large TIFF into WWT
3. When final TIFFs are made, post TIF on website e.g., http://jansky.phys.northwestern.edu/wwt/Sgr_A_West-Ka.tif. Note that since the TIF file was derived from a very large image, the output TIF file is also large – 450 MB.
4. Import the image into WWT (i.e., process TIFF to create a multiresolution version of the data in TOAST format), http://worldwidetelescope.org/interact/embed
5. Return collection (WTML file) which has reference to new tiled images that can now be used in a tour.

In the example, this was done for two images. One was the astronomical VLA image “Sgr_A_West-Ka” and the second was a line plot. For the plot, the coordinates were copied from an image at the same scale. The plot was exported from Illustrator as a PNG with transparency everywhere except where the lines of the plot were to be drawn.

You can also add other types of data:

- Pointed images (i.e., FITS, see above): http://www.worldwidetelescope.org/Learn/Exploring#AstroImageData
- Web Map Service (mostly for layer data on the surface of the Earth) http://www.worldwidetelescope.org/Learn/Exploring#AddingWMSData
- Catalogs and tabular information: http://www.worldwidetelescope.org/Learn/Exploring#UsingVOTables
- Panoramic images (e.g., panorama of observatory): http://www.worldwidetelescope.org/Learn/Exploring#processingpanoramas
- All-sky images (e.g., any all-sky map not already in WWT): http://www.worldwidetelescope.org/Learn/Exploring#processingallskyimages

2 Make story board

Estimated Time: 0.5 hr

The story board is a sequence of draft visuals representing what will be on screen. It can be in the form of descriptions of what is to be shown or a list of figures (from WWT as well as those in the paper). In the case of the example Proplyd paper, it was a list of figures, selecting those from the paper that directly supporting the words of the written abstract (script of the tour).

3 Write draft script

Estimated Time: 1 hr

Drafting a script in either bullet or written form is the first step in the process. The simplest way to do this is to read the written abstract with modest revisions for acronyms, jargon and detailed numerical data. In an example, reading the text of the abstract verbatim took about 2:15. It is probably easier to start by using a template for script and story board. A template is available here: **Tour Template.docx** and an example script is available here: **Video Abstract - Proplyd - v1.1.docx.**

4 Record draft narration

Estimated Time: 0.5 hr

Tools: Audacity (http://audacity.sourceforge.net)

Record draft narration for timing. Don't worry about flubs or mistakes as long as they don't change the time appreciably. It is suggested to use Audacity (http://audacity.sourceforge.net), which is a free tool available on Mac OS, Linux or Windows to record and edit audio. However, feel free to use any program that can create a high-quality MP3 file. There are on-line tutorials on how to create audio:

- http://www.worldwidetelescope.org/Learn/Authoring#dealingwithaudio
- http://www.worldwidetelescope.org/Learn/Authoring#editingaudio

5 Create draft tour

Estimated Time: 1-3 hr

Tools: WorldWide Telescope (http://www.worldwidetelescope.org)

Create a draft tour showing visuals timed to draft narration. Work is on-going to enable creation of tours in the web client, but for now, you must use the Microsoft Windows Desktop client (http://www.worldwidetelescope.org) to author your tour. Note that there are two type of tours. The simplest is a “slide-based tour” which is composed of a sequence of slides, each with a begin and end position. The visualizations are interpolated between the beginning and end of each slide. Slide-based tours can be played back in the web tour player or the Windows Desktop client.

There is a more advanced type of tour called a keyframe-based (or timeline). Keyframe-based tours provide fine-grained control over the tour with the ability to specify any parameter at any time (down to 1/30 of a second). Timeline based tours can provide more cinematic tours but cannot be played back in the web tour player and can only be shared on-line in the form of videos. Since much of the power of WWT-based video abstracts comes from comparing data supporting the journal article with other data, you should create your tour as a slide-based tour. After this is created for your paper, you can convert a slide-based tour into a timeline one in order to make a more polished video but the tour directly related to your paper would be the slide-based, web-playable version.

There is more information on creating slide-based tours here: http://www.worldwidetelescope.org/Learn/Authoring#slidebasedtours

When you are finished with the tour, make sure to save your tours with good naming and versioning information to help organize your files as you refine in the later steps.

6 Create draft video (optional)

Estimated Time: 0.5 hr

Tools: Adobe Premiere, Apple QuickTime or FFmpeg (http://ffmpeg.org/)

You have to use the Windows Desktop client to render the tour to a sequence of image frames (PNG). Instructions on that are available here:

- http://www.worldwidetelescope.org/Learn/Authoring#rendertovideo

Once you have the frames, you need to use a program to take that and the audio narration and encode them as a video. This is straightforward to do with a modern video encoder, such as Adobe Premiere. It is also possible to use the cheap Apple QuickTime program to do this. This process may take a while to complete, but user interaction time is modest. When complete, you will likely want to post your video YouTube or similar video sharing service to share with your colleagues for feedback.

7 Sharing & Feedback

Estimated Time: 1.0 hr

Share your tour with colleagues (e.g., co-authors on paper) to get feedback. Sharing the tour can be done in one of a few ways:

1. If they have a Windows PC with WWT installed, you can share the tour file itself, which should be small unless you have many high-resolution images included.
2. You can also share the YouTube video link if you did the optional step of making a video from the tour (see Section 6 above). This of course can be viewed on most desktop and mobile devices.
3. You can also create a community (http://worldwidetelescope.org/Learn/Authoring#usingcommunities – also included as Appendix B below). From here you can share a link directly or you can have your colleagues join the community.

Organize the responses and make clear choices about what you will change to address them. This is likely to be in form that you assumed the viewer would know something and need to add descriptive text on screen or in narration for those that don't. This will likely require changes to the script as well as tour (timing and adding text labels, data etc.).

8 Record final narration

Estimated Time: 0.5 – 1.5 hr

Refine script and record new audio based on feedback. You will use the same tools as you did to record the draft narration. However, you will want to get a high a quality recording as possible (good microphone, quiet room, a fresh voice). You may want to embellish the narration with a music or ambient sound bed. If you do add music, make sure that is low in volume, compared to the narration.

9 Refine tour

Tools: WorldWide Telescope (http://www.worldwidetelescope.org)

Estimated Time: 1 - 2 hr

Refine tour base on feedback. Use the final audio for final timings. Slide lengths may need be changed to accommodate changes in narration timing. Also

10 Create final video (optional)

Tools: Audacity (http://audacity.sourceforge.net)

Estimated Time: 0.5 hr

Using the same work flow as you did to create the draft video, create the final one. The steps are essentially the same.

Appendix A: Limitation of the web-based tour player

Some tours can be played back in a web-based Tour player. You can put your tour on some website (e.g., http://jansky.phys.northwestern.edu/Video_Abtract-Proplyd.wtt) and then point embed the code to play the tour in the web-based Tour player here:

- http://worldwidetelescope.org/interact/embed

You can try to play the tour by embedding this code into a web-site and viewing the page.

Below is a non-exhaustive list of issues about Tours in the web player:

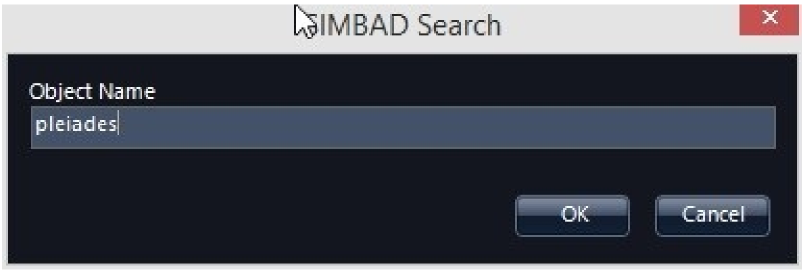
- Audio must be one audio file for complete tour (can't be separate ones per slide and can't be separate music and narration)
- Audio must be in MP3 format.
- Only sky mode is allowed.
- Can't use layered data.
- Can't use timeline.

Using Virtual Observatory (VO) Tables

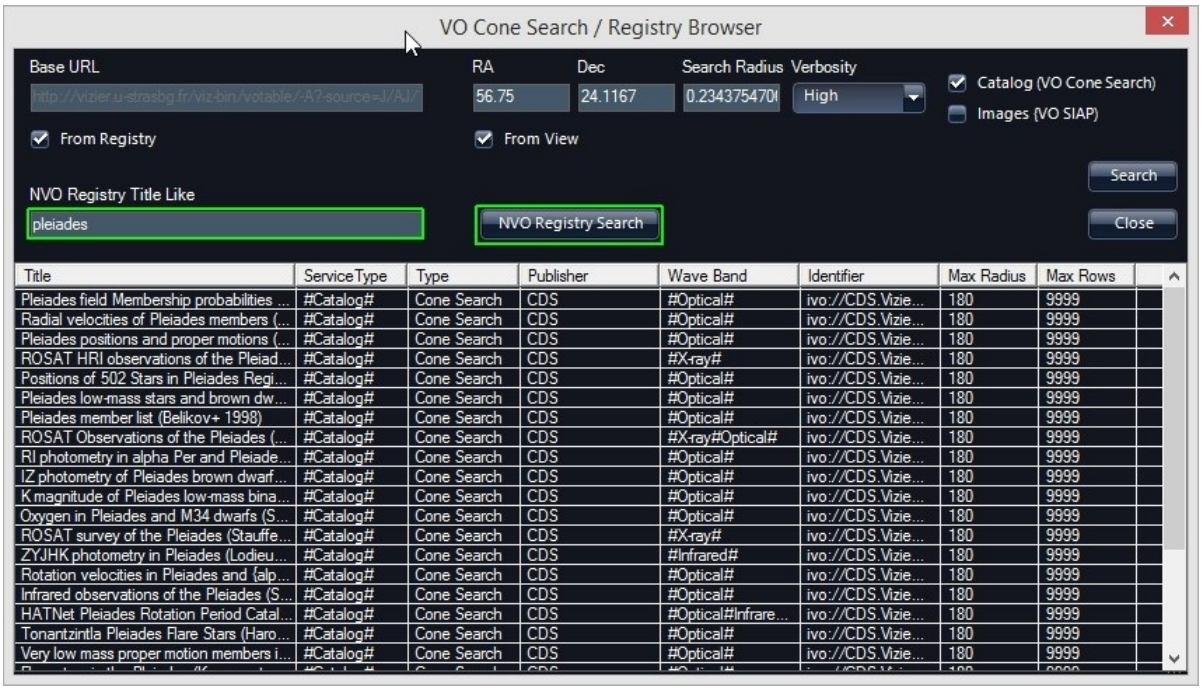
VO Tables are a standard exchange format of catalog data and queries to registries allow you to find, plot and interact with a wide variety of catalogs that have VO table interfaces.

First orient the view to a location, for this example the Pleiades open cluster.

1. Make sure you are in Sky mode.
2. Under the Search Tab, select "SIMBAD Search…"
3. Enter "pleiades" in the search box. This will orient your view to the Pleiades cluster and zoom in.

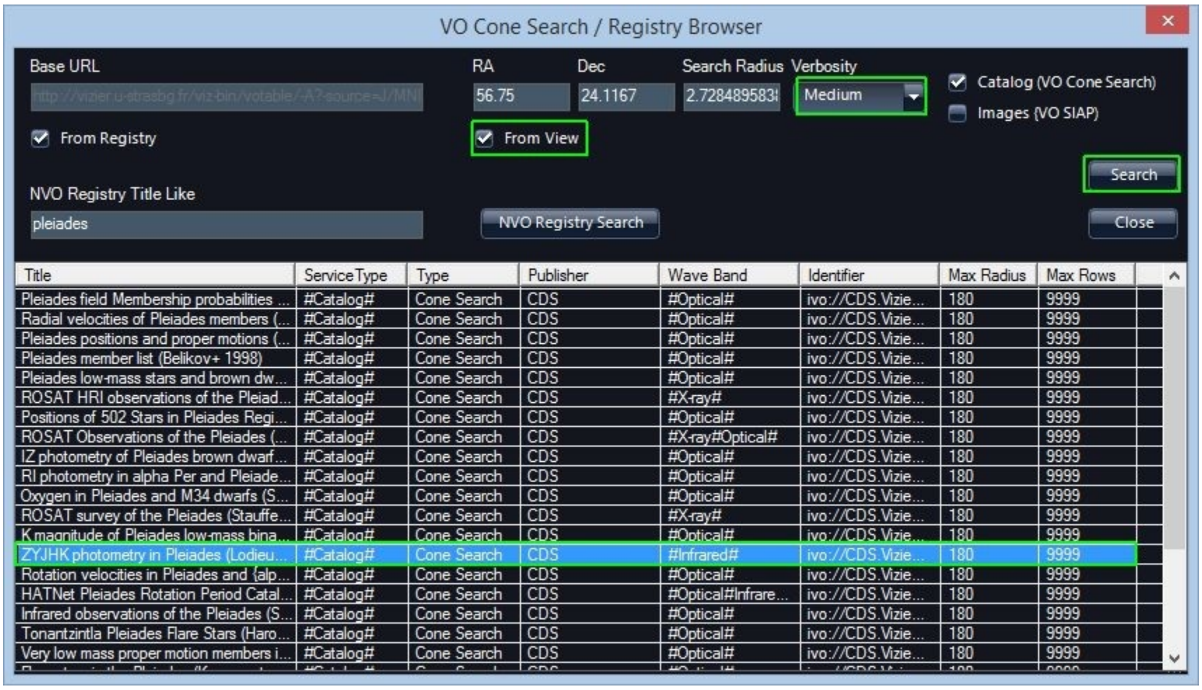


4. Next under the Search Tab, open the "VO Cone Search/Registry Lookup…"
5. In the field "NVO Registry Title Like" enter "Pleiades." And Click "NVO Registry Search" button.

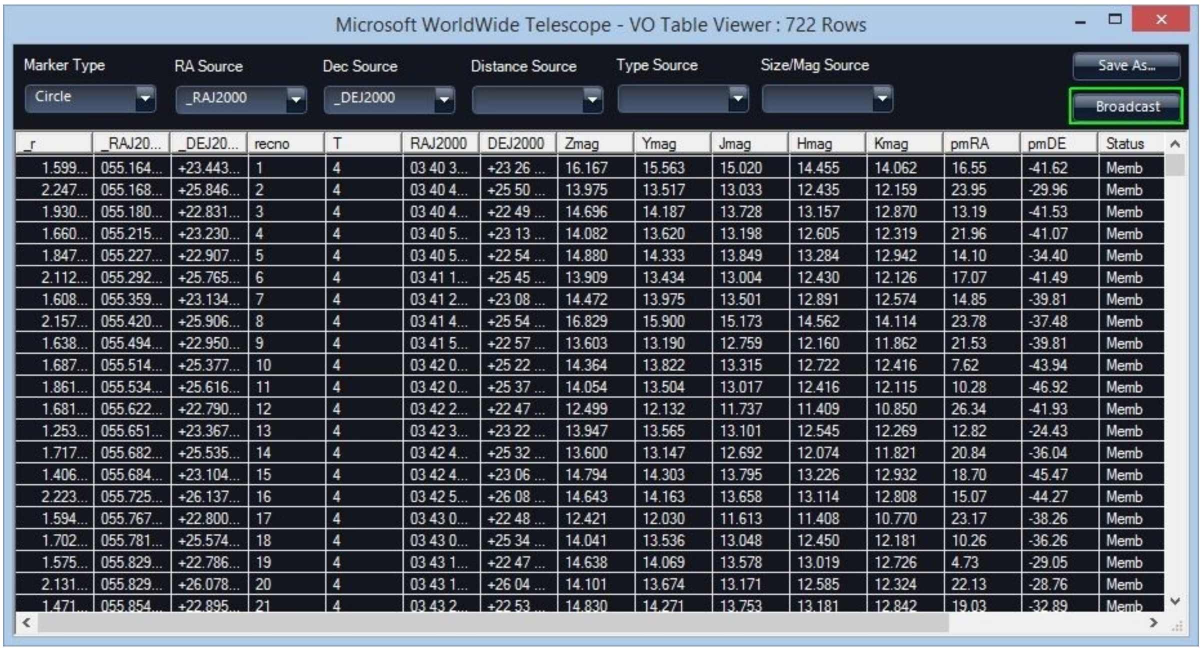


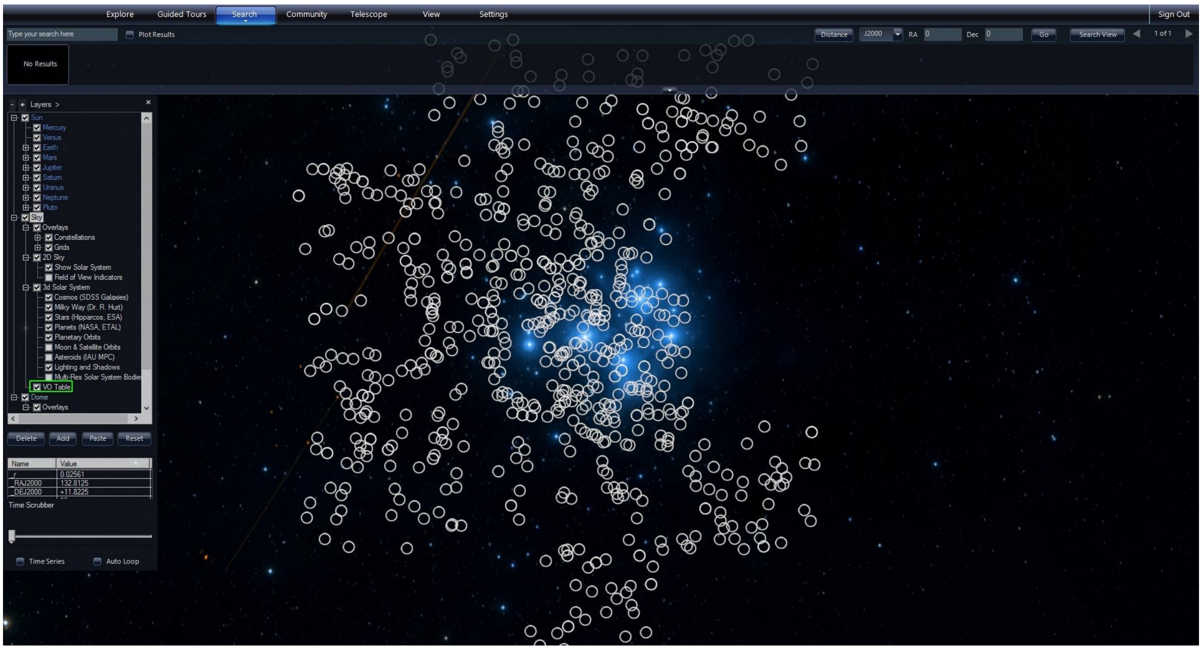
6. This will populate the bottom of the table with a list of registries (registered catalogs in this case).
7. Click on a row to search that catalog. This will load values into "Base URL." For this example select "ZYJHK photometry in Pleiades…" Since you are looking at the location of the Pleiades, you can click the checkbox next to "from View." Set the Verbosity pull-down to "Medium" in order to return photometric measurements at all observed bands, rather than the default positions if the default "Low" is used. Then click "Search" on the

right.

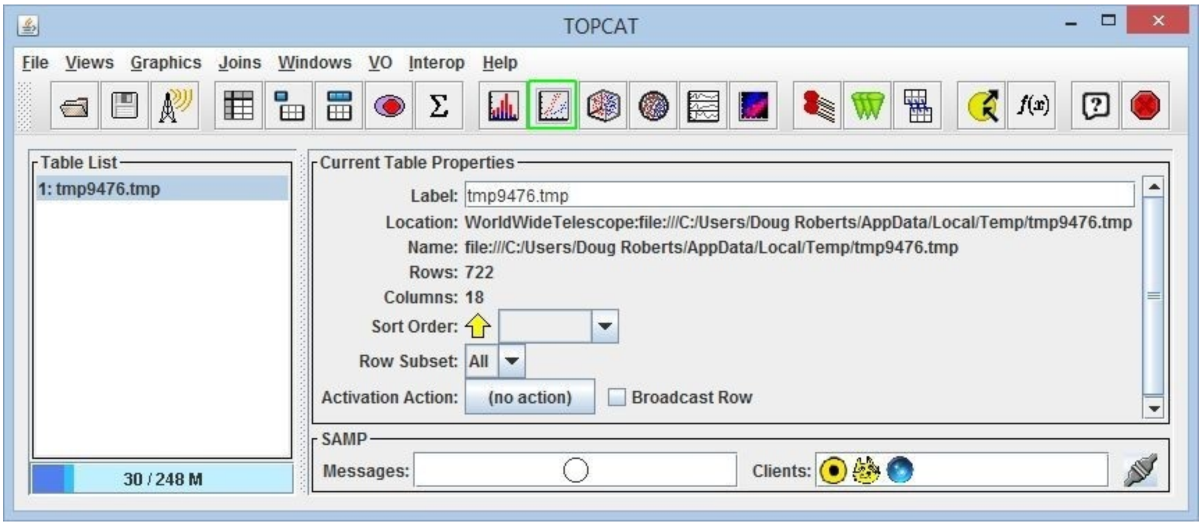


8. This will plot the catalog entries of the returned table on the background sky image. The default is to plot circles at each location. Also, this table is added as a layer (default name is “VO Table”) under the “Sky” of the Layer Manager on the left. If you close this table, you can always right-click on the “VO Table” in the layer manager and select “VO Table Viewer.”

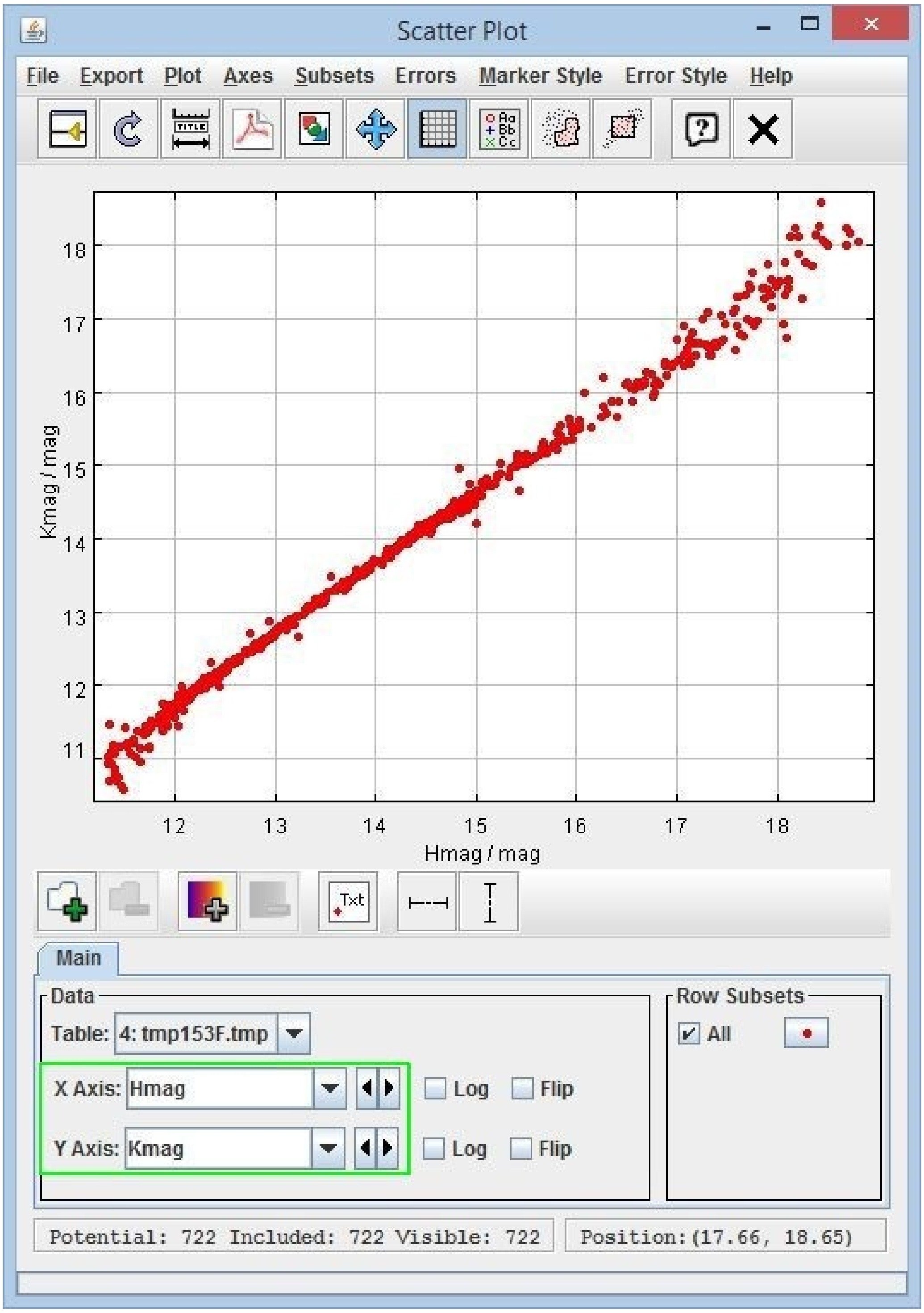




9. Clicking on an entry of the returned table will center the display on the location of the catalog entry and show a label.
10.
    i. You can right-click on the VO Table layer in the layer manager and select **Copy** and then you can paste the table into an Excel spreadsheet.
11. To do plotting, you can use TOPCAT, which is a free Java program available here: http://www.star.bris.ac.uk/~mbt/topcat/. First download *and run* TOPCAT – by double-clicking on the topcat-full.jar file.
12. Then in the VO Table Viewer click the “Broadcast” button. This uses the SAMP messaging protocol to send the retrieved VO Table to TOPCAT for plotting.
13. In TOPCAT, you can then select setup a scatter plot, but clicking the icon at the top menu.



14. This brings up a scatter plot window. You can map columns to axes in the plotting



window.

15. You can also save the current table out of TOPCAT as Comma Separated Variable (CSV) format for input into Excel.

WWT Kiosk

Overview

WorldWide Telescope can be launched in a Kiosk mode, which is designed for unfacilitated use in museums or other informal learning environments. There are two general ways this can be done. One is to show a narrative presentation in the form of a tour. The other mode is to allow free exploration.

Unless you go to great lengths to harden your kiosk computer by installing software to intercept certain windows keyboard commands, you should not have a publically-accessible keyboard connected. A connected keyboard gives the user the ability to Control-Alt-Delete to get task manager, which could break out of WWT and give access to the computer. For administration purposes, museum staff will want to be able to connect a keyboard or remote desktop to the computer to do this.

Kiosk Tour

1. Create the tour in WWT. Save it to a file at a folder on your PC.
2. On the last slide of your tour Right-click and choose “Set Next Slide.” This will bring up a dialog box click the first slide of the tour. Clicking the slide will also check the box “Link to Slide (Selected below).” Click Ok.
3. Create a shortcut.
    i. Right-click at the location you want the shortcut to live and select “New/Shortcut”
    ii. This will open a dialog box to type the location of the item. You can browse to the WWT install or if it is a standard installation, you can enter "C:\Program Files (x86)\Microsoft Research\Microsoft WorldWide Telescope\WWTExplorer.exe". Don’t forget that the entire path should be enclosed in double quotes.
    iii. Following the location for WWTExplorer.exe (which is the WWT application), you should put the location of the Kiosk Tour you created in the first step. In this example, the tour (named “Kiosk Tour.wtt”) is on the desktop for the user named Exhibit and the full path to the tour "C:\Users\Exhibit\Desktop\Kiosk Tour.wtt”.
    iv. Following the path to the tour, put the flag that puts the application into the kiosk mode “-kiosk”.
    v. For the above example, the entire entry for the location of the item would be: "C:\Program Files (x86)\Microsoft Research\Microsoft WorldWide Telescope\WWTExplorer.exe" "C:\Users\Exhibit\Desktop\Kiosk Tour.wtt” -kiosk. When you are finished you might want to change the name of the shortcut to something relating to the tour, such as “Run Cool WWT Kiosk Tour,” otherwise it will default to the name “WWTExplorer.exe”.

vi. You can always change this by right-clicking on the shortcut and selecting "Properties". In the dialog box that comes up you can edit the Target field.

Interactive Kiosk Tour

In all cases you should consider what interaction you want with the public to have with WWT. Possibilities are:

- Mouse/trackball
- Xbox controller
- Touch screen

Auto-start the Tour on Startup

1. Setup auto-login for user running WWT.
2. Setup shortcut to be executed on login
3. Links to tools for timed startup and shutdown.

Multi-Channel Setup

This guide is intended to provide a simple path for planetarium setups. It assumes that you aren't very familiar with WorldWide Telescope (WWT) in domes and steps you through setting it up, loading and playing a tour designed for domes. This guide is meant to be a starting place and is not exhaustive.

Digital planetarium systems are either single computer, which can drive a single projector or cluster of computers which is needed to drive multiple projectors. WWT can be used in both situations. Most steps are common but we describe the two scenarios separately.

Note: There is no special dome version of WWT.

Single Computer Quick Start

This is the simplest setup and has a single computer with two video outputs. One output acts as the console and the other drives the projector that drives the some through a fisheye lens or spherical mirror.

1. Get the hardware ready.
   i. Make sure the computer is setup with the primary display connected to a desktop monitor and the secondary display connected to the projector powering the dome.
   ii. Also, make sure the audio output of the computer is connected to a dome audio system.
   iii. Connect the computer to the network.
2. Install the latest build of WWT - http://worldwidetelescope.org/Download/.
3. Startup WWT.
4. Setup Dome. **View/Full Dome/Dome Setup**. Under Dome Type, you can select "FishEye," "Mirrordome 16:9" or "Mirrordome 4:3." You can also set the Dome Tilt.
5. Send dome view to projector by selecting **View/Full Dome/Detatch Main View to Second Monitor**. You should see the view in dome format through your connected projector.
6. Download the full dome version of the Impacts tour - http://cdn.worldwidetelescope.org/Content/Planetariums/Impacts%20-%20FULL%20DOME%20v2.1.wtt.
7. Load and play the tour. Run the tour through once to cache the data. Subsequent viewing should not show data loading.
8. If performance is choppy take a look at the Setting Up/Tweaking Performance document.

Cluster Quick Start

WWT can be setup on multiple computers with a single **master** and 1 or more **projection servers**. You can build your own system from scratch or install WWT alongside an existing planetarium system.

1. Get the hardware ready.
   i. Make sure the master computer is setup connected to a desktop monitor and all projection servers (one per projector) are connected to their projectors and that all servers and projectors are powered on.
   ii. Also, make sure the audio output of the master computer is connected to a dome audio system.
   iii. Connect all computers to the network.
2. Setup the cluster environment. Usually people make a network share that all projection servers can access and put the installer there and then use VNC to login to each computer and do the initial install. Or you can login to each projector server and download from a USB drive or the Internet.
3. Follow the Multi-Channel Setup Guide
4. Download the full dome version of the Impacts tour - http://cdn.worldwidetelescope.org/Content/Planetariums/Impacts%20-%20FULL%20DOME%20v2.1.wtt
5. Load the Impacts tour on the Master.
6. Send the Tour to the projection servers – **Guided Tours/Send Tour to Projection Servers**. Make sure that **Guided Tours/Automatic Tour Sync with Projects Servers** is checked. This will ensure that any changes to the tour on the master are sent immediately to the projection severs.
7. Load and play the tour. Run the tour through once to cache the data. Subsequent viewing should not show data loading
8. If performance is choppy take a look at the Setting Up/Tweaking Performance document.

Making Your Own Dome Shows

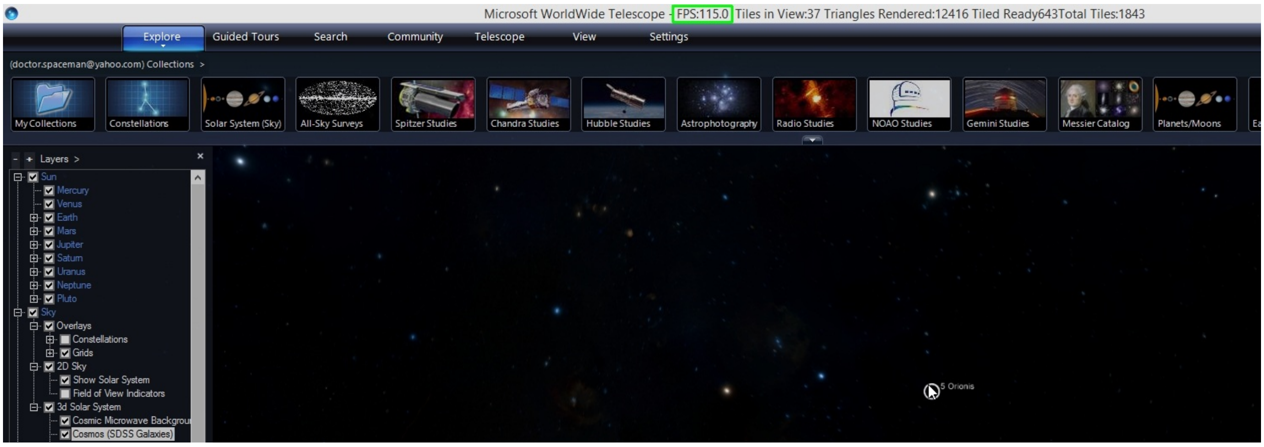
You can play any Tour on the dome. Some objects may not be placed in the desired location and timing may require adjustment. Of course you can also create tours from scratch designed specifically for the dome. Details of authoring for the dome are available here.

Tweaking Performance

Evaluating Performance

WorldWide Telescope can show many layers and types of data, but various things can affect visual performance, both interactivity and during playback. A rule of thumb is that a modern PC with a dedicated graphics card will likely perform fine for most installations. But older machines or modern ones that have integrated graphics might not be adequate for the most accurate rendering. The most immediate way to evaluate performance is to show the frame rate. This can be done by selecting: **Settings/Advanced/Show Performance Data**.

When this is selected, WorldWide Telescope displays the frames per second (FPS) along with other information about loaded data in the title bar of the main WWT window.



For cluster and dome installations, WWT can also report this frame rate for all projector servers in a GUI on the master. To show this GUI, select **Settings/Advanced/Projector Server List**. This GUI shows the status of each projector server. This example has a single projection server (Pluto) and shows whether the computer is on the network (Online), if WWT is running (Ready), the IP for the projection server (192.168.0.110) and the frame rate for that projector (20.5 FPS).

The frame rate could be capped by the WWT itself – see below – otherwise WWT tries to draw as a new frame as fast as it can and the effective frame rate is shown in the window. Frame rates of less than 30 will introduce noticeable stuttering and numbers of less than 15 FPS will be very distracting. Note that for simple scenes and fast hardware the FPS could be a large number – hundreds – much larger in fact than the ability of a projector or monitor to display it.

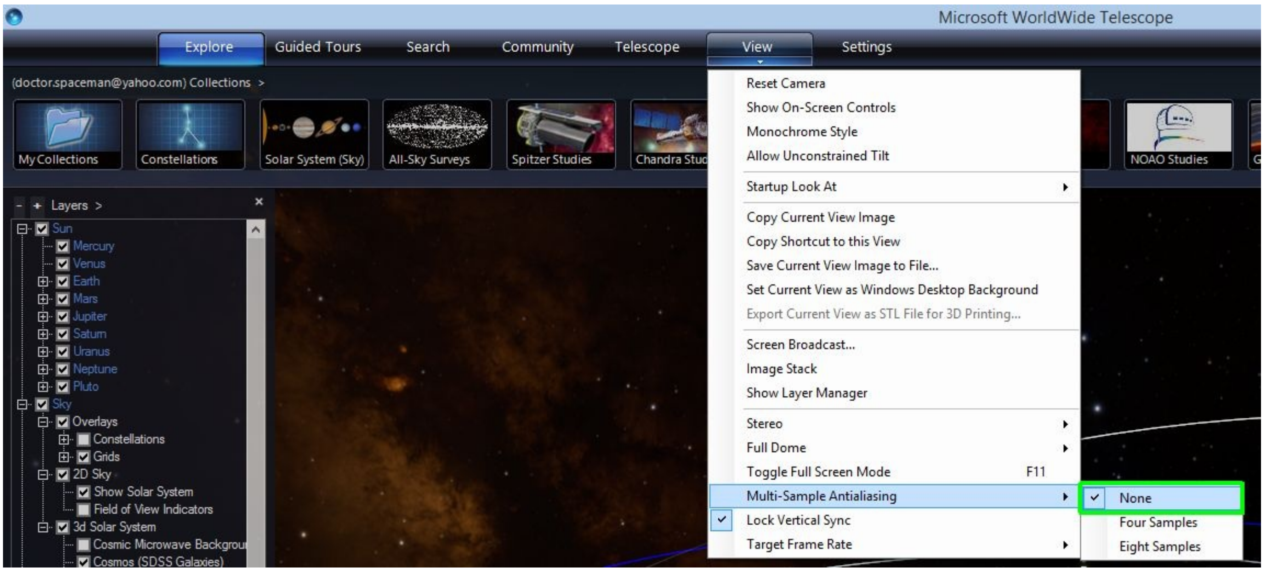
Optimizing Performance

All visualization programs trade off visual fidelity with rendering time. When you are using WWT to run a live program usually you want to trade off fidelity with rendering time. In fast moving scenes where it may be hard to keep up visually without having very low frame rates, the human perception of fidelity is limited. So usually, you want to do what you can to keep FPS to 30 or above and compromise on rendering quality if necessary.

For interactive and playback uses, you can change the following settings to try to improve the performance.

Anti-aliasing

Antialiasing is a graphics technique to redraw lines and edges with to avoid showing them as jagged lines made up of individual pixels. Modern graphics cards can usually handle this easily. However, most integrated graphics can't do this and thus those calculations are done by the CPU not the GPU, resulting in very poor performance. The first step in improving performance is turning off anti-aliasing. Open the menu **View/Multi-Sample Antialiasing** and select **None**. Note, changing this value will require a restart of WWT to take effect. When you have restarted play the tour again and look at the FPS and see if that has improved the frame rate adequately.



Content

The frame rate depends on the scene as well as the performance of the graphics hardware. Within the constraints of the graphics hardware the only other thing you can change is the content. The most difficult content to render is 3D content: terrains of planetary surfaces, 3D models, or 3D cities. Content affects performance in two stages. The first stage is data loading. Running the tour through will load the data onto your local disk cache. This is the first step, but final performance depends on how quickly you can get the data into the computer's GPU. When you play the tour if the data is being drawn as you move through a scene then you want to make sure that data loading is done before the audience sees it. The easiest way to do this is add the have the first 1-2 seconds of the scene rendered while the display is faded to black. Then fade up from black and most of the data will have been loaded for the scene.

1. In the lower part of the layer manager, right-click on **Dome/Overlays/Fade to black** and select **Add to Timeline**. Unless the Tour will only be shown in a dome environment, make sure the **Fade Dome Only** under **Fade to black** is *not* checked.
2. In the Timeline editor make a key for **FadeToBlack** at start time 00:00 and set the Opacity, which is the only sub-property, to 1, which means it is faded to black. If the

timeline editor is not shown, you can expose it be selecting **Show Timeline Editor** under the **Guided Tours** tab.

3. Then move the time slider to 2 seconds into the slide and make another **FadeToBlack** key and set it to 1 as well.
4. Make a third **FadeToBlack** key 1 second following the second key (at 3 seconds) and set that value to 0.
5. Play the slide and it should be black for the first 2 seconds, and hopefully that is enough time to load the necessary data. Then between 2 and 3 seconds the scene should fade in from black.
6.
    i. Adjust the time locations of the keys to keep it black for long enough to hide the data loading if the suggested times are not sufficient.

Target Frame Rate

WWT attempts to render frames as fast as the GPU can make them. This results in the GPU being pushed hard and will cause it to consume more power and heat up. If the GPU overheats, it can scale back its performance or shut down completely. In real-world environments, the projectors and monitors only operate at a certain refresh rate and rendering more frames per second isn't necessary. You can set the limit on the frame rate in the menu View/Target Frame Rate. In most cases you want to choose 60 or 30 FPS.

Rendering to Video

Interactive performance requires WWT to render the scene every frame, every 1/30 of a second. For playback that doesn't require interactivity – for instance in a planetarium system – one way to deal with performance issues it to render the tour to a video for playback. That way, WWT can take as much time as it needs to render a frame including fetching the data, putting the scene together and finally rendering. To do this, load the desired tour. Then under the open the **Render Tour to Video** dialog box under **Guided Tours/Render to Video**. Then make sure the "Wait for all downloads" is checked before rendering. More details on rendering to video are available here.

Creating WorldWide Telescope Caches

Overview

WorldWide Telescope (WWT) is a great tool with access to Petabytes of image data from the cloud, but in some educational contexts the internet may not be available but it is desirable to use WWT as a tool on a stand-alone basis. WorldWide Telescope already can operate off-line when the internet is available, and browse any data previously viewed by that user on that machine. In a new installation, there is no cache history for a user to rely on and the experience is not acceptable.

To solve this issue we have created a tool that will allow for the creation of curated cache content that would be installed from a DVD or thumb drive along with the WWT client to allow a disconnected or poorly connected machine to run most of WWT features without ever having to connect to the internet.

Tools

WWT already has existing tools for basic cache management. With the Eclipse release WWT adds several new tools to help curate the cache contents. This is a combined list of both the new and old tools.

- Cache measurement/purge utility in the Settings tab
- Cache Management Menu from Right click menu item in explore/context tabs.
  - Cache Image Tile Pyramid
  - Show Cache Space Used
  - Remove from Image Cache
- Playing a tour caches all data it views.
- Playing tours with “Play all” option will play and repeat tours in a collection
- Browsing collections will add images you view to the cache.
- Play collection as slideshow will go from image to image and cache data as it goes.
- Editing the cache directory manually thru Windows explorer.
  - C:\Users{user name here}\AppData\Local\Microsoft\WorldWideTelescope
- Setting up WMS servers, and caching data they use.
- Running WWT in Solar System mode with Multi-Resolution planets will load in base maps need for that mode.
- Save the Cache in Settings…Advanced..Save Cache as Cabinet File…
- Load the Cache in Settings…Advances…Restore Cache from Cabinet File…

Process

1. Ensure your WWT instance has a fresh, clean cache.
2. Use the cache tools to load data you thing is important .
3. Measure the cache size as you go budgeting for the data sets you need.
4. Use the UI or manual cache management in Explorer to trim excess if needed.
5. Save The Cache file to a cabinet file.
6. Move the cabinet file to a fresh non-internet connected machine.
7. Install a fresh WWT install.
8. Restore the Cabinet file.
9. Verity operation and note any missing data.
10. Repeat the above steps as necessary until the cache meets the educational requirements.

Deployment

In the final Eclipse release the setup will detect the presence of a cache cabinet file and offer to install it automatically. This file should be named “WwtFileCache.cabinet” and be placed next to the WWTSetup.5.x.x.msi file. After installation WWT will use this cache transparently as if it actually visited all the data already.

Video is not visible, most likely your browser does not support HTML5 video

Advanced Audio Playback

WorldWide Telescope (WWT) can playback an SMPTE timing track to provide timing control of off-board audio or other SMPTE-controller effects. SMPTE provides a flexible, easy-to-implement control solution; this flexibility makes it possible to setup things in various ways. This document will provide a description of two potential scenarios, but more can be created if these don't map to your facility.

Simple Audio Using Embedded Audio File in WWT Tour

The easiest way to setup a system is for the Master Server to output audio, via analog or digital audio output. The mono or stereo audio tracks are created for narration and music on per-slide or Master-slide basis in the tour – see LINK: Authoring/Dealing with Audio and LINK: Authoring/Editing Audio. Then direct connections between the Master Server and hardware sound system (amplifiers and speakers) takes care of the audio. This is a simple case with few pieces, but is limited by the number of audio channels and potentially the quality of the underlying audio files.

Note: For all WWT cluster implementations, Tours that are distributed to Projector Servers have the audio stripped out, to reduce file size and speed updating.

Multi-Channel Dome with SMPTE-controlled Audio Server

At some planetaria, such as the Grainger Sky Theater at the Adler Planetarium, they have a configuration with three types of servers: Master, Projector and Audio.

The Master Server controls any number or Projection Servers over the network via WWT and WWT Remote. These controls include:

- Power control of Projection Servers from Master.
- Updating Tour and Data from Master to Projection Servers.
- Synchronization of playback on multiple Projection Servers.

For audio, audio tracks (mono, stereo or multi-channel) are loaded onto a dedicated Audio Server. On the WWT Master Server the normal audio track is replaced with a SMPTE timing track. This is usually done with a short-duration slide at the beginning of the tour that is a master and has the SMPTE track as MP3 or WAV format. The analog audio output of the Master Server is connected to an input port on the Audio Server. Once the appropriate audio track(s) are loaded on the Audio Server and the Audio Server is setup to be controlled by input SMPTE timing from Master (via analog audio connections), the audio and video are synchronized via the Master Server.

Note: Currently, the timing of WWT cannot be controlled by an external SMPTE source, such as a stand-alone SMPTE generator or Audio Server.

Controllers & Virtual Buttons

MIDI (Musical Instrument Digital Interface) is a protocol for connecting commodity controllers, such as MIDI keyboards, control panels, foot pedals or any other MIDI capable USB device. WWT provides a setup panel for users to map keys, buttons, knobs, sliders and foot pedals to nearly all of WWT functionality. Similarly, WWT allows custom mapping to an Xbox game controller. This functionality can be used in classroom presentations, planetarium control boards, in museum settings, and for data exploration with temporal and other controls.

Skills Required: You need to be able to understand how to connect your MIDI device to your computer, and use the WWT device configuration panel to map your Xbox controller or MIDI device to WWT functions. Note, more custom MIDI devices may require coding or hardware assembly, but off-the-shelf MIDI controllers are plug and play with WWT.

Currently, WorldWide Telescope (WWT) can be controlled by a variety of controllers. Custom mapping can be done for MIDI and Xbox controllers, connected by USB to the computer running WWT as well as configurable virtual buttons.

MIDI Controller

Any MIDI controller can be used to control WorldWide Telescope. You can re-use mapping of WWT functions created by someone else. You can also create your own or edit a previously-created mapping. Start by selecting “Settings/Controller Setup...” This brings up a dialog window where you can select a file containing the mapping functions. For the Numark DJ2Go you can download a standard mapping file.

You can save and load different files with different mappings.

Highlighting a device in the list of MIDI devices on the left and clicking “Properties” below will bring up the Controller Properties window that presents the status of the controller and location to the image file used for mapping. Note, that this image can be specified as a URL, such as

@Model.ImgDir/learn/numark_djtogo.jpg

or it can point to a local file, such as

\Documents\MIDI\numarkdj2go.png.

To remove an existing binding, select it in the list and click the “-” button. A box will come up to ask you to confirm the removal of the control.

To remove an existing binding, select it in the list and click the “-” button. A box will come up to ask you to confirm the removal of the control.

To add a new binding, click the “+” button. This will bring up a box saying that WorldWide Telescope is listening to the controller waiting for you to manipulate a control that has not been previously mapped. When such a control is moved, it will ask for the control type; select one of:

- **KeyPress** — detects that a key has been pressed and does some action.
- **KeyUpDown** — this sets up two actions, one when the key goes from Down to Up and the other from Up to Down. These can be defined separately.
- **Slider** — linear slider from one value to another
- **Knob** — rotating know from one value to another
- **Jog** — jog dial that can be move spun repeatedly, often used in advancing time

Once you have selected the control type it will be added to the list of control bindings with the Control Name the same is the ID number. You can then define what you want to happen when you manipulate the control. When you select a control binding the properties are shown below the list and you can change or set the following properties:

- **Binding Target Type pull-down** — Categories of actions that can be sent to WWT.
- **Bind Type pull-down** — Ways to bind the controller to WWT.
- **Property pull-down** — Specific properties controlled.
- **Repeat checkbox** — If this is checked, holding down will continuously send the same command. This makes sense for actions like zooming.

A full list of potential bindings is available in an Excel spreadsheet here.

The labels for the functions can be placed on the position of the corresponding knob on the image for the controller. In the case of the default map this has already been done. Click the function in the list and hold and drag onto the image. Release your mouse when the label is at the desired location. Note that when the “Monitor” box is checked and the key is pressed on the controller the label changes from white to yellow.

Xbox Controller

WWT can be controlled by a PC version of an Xbox Controller. This is an excellent interface to use in a planetarium or presentation environment because the controller is portable and the buttons can be distinguished in the dark.

WWT comes with a standard binding of functions. This default is for the left/right triggers to zoom out/in. The right bumper steps through objects in the context menu (at the bottom of WWT screen). The left thumbstick pan and scroll and the right thumbstick rotates the view. The Back key steps backwards and the Start key steps forwards through LookAt modes (Sky, Earth, SolarSystem etc.). The ABXY keys are defined in the table below.

Look At Earth	Look At Sky	Look At Solar System	
A	Equatorial Grid	Asteroids	
B	Constellation Boundaries	Milky Way Model	
X	Clouds	Ecliptic Overview	Planetary Orbits
Y	Clouds	Constellation Figures	3D Stars

Default mappings appropriate for print or reference is available here.

In order to define your own settings select “Settings/Xbox Controller Setup...” This brings up a dialog window where you can select a file containing the mapping functions. Check the “Use Custom Mappings” box and you can see the default mapping and change any of them. You can control the properties in the same way as the MIDI controller, described above. Checking the “Use Mode Dependent Mappings” allows a different mapping to be used depending on the mode.

A full list of potential bindings is available in an Excel spreadsheet here.

You can save, load and share custom mappings files (extension .wwtxm) from this dialog box.

Virtual Buttons

Clicking the View button will show the View controls at the top of the WWT window. The blank area to the right of the control – identified by the green box in the image below – is a place where you can define and place custom virtual buttons. These buttons can have the same bindings as the MIDI and Xbox controllers.

Clicking the “+” key brings up a binding dialog box. You can give the button a “Name,” select “Button Type,” “Binding Target Type,” “Bind Type,” and “Property,” just like the MIDI controller, described above.

In the example above I have defined a Longitude and Latitude slider. Clicking the “E” enters an editing mode for the buttons. When in edit mode, you can rearrange the buttons. Right clicking on a button will allow you to toggle the button editing mode, change the binding properties or delete a virtual button.