

# Secrets of Moon Photography



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**Hill Country Photo Club**  
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# Why listen to me?

- 400 nights imaging the moon in the last 5 years
- 2000 hours processing images
- Award winning **full disk** moon images

## Who Else to Listen to

- **Robert Reeves, Thierry Legault, Christopher Go, Damian Peach, Jerry Lodriguss**
- **Lonely Spec Tutorials**
- **Starizona Telescope Basics**
- **Warren Keller's IP4AP**



# My Shtick

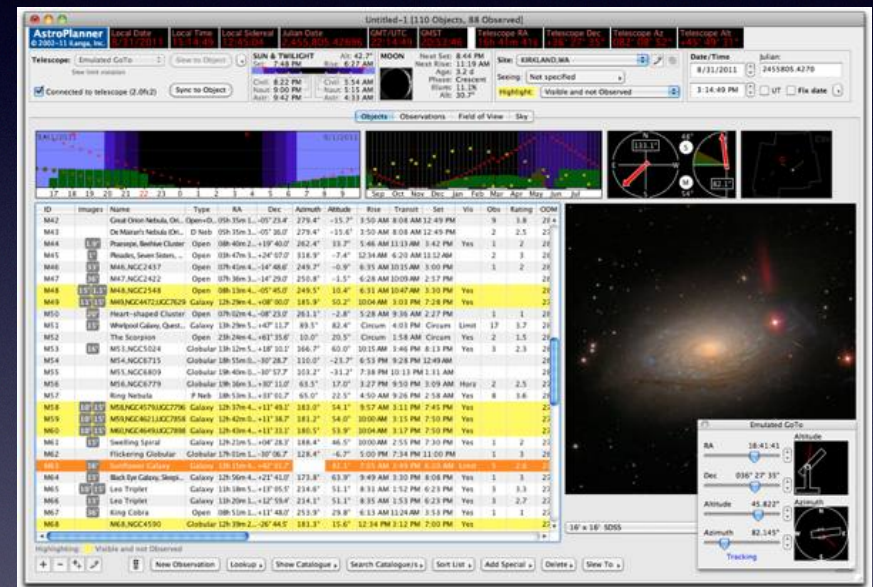
- **Astronomers like big equipment**
  - Resolution scales linearly with aperture
  - Light reach scales with aperture squared
- **I like small stuff & astronomy**
  - Microelectronics background
  - Hubble Rx with post-processing + Bob Vanderbei Questar Images  
-> push the limits of astrophotography with small equipment
  - Square law of portable telescope use - **use decreases with square of aperture**
- I'm excited **seeing the universe move**  
crater shadows, conjunctions, eclipses, transits, occultations
- **Outreach** public education, volunteer JPL NASA Solar System Ambassador
- **Creative Commons** license for all content



# Plan

## Full disk lunar photography + a bit more

- Astrophotography Basics
- Challenges
- Telling a story
- Tools Capturing Data
- Stacking
- Post Processing
- Telling stories with NASA Data



# Basics - summary

- **Manual Good - Auto Very Bad**  
auto exposure, auto focus, & image stabilization don't work
- **Mount Stability for Long Exposures and Focal Lengths**  
reduce vibration by rigid mount, reduced wight & vibration like mirror slap and mechanical shutter
- **FOV - very wide or very narrow,**  
not much use for normal focal length lenses
- **Shoot RAW**

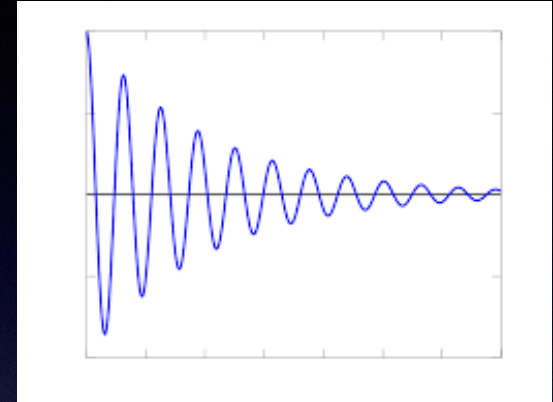
## Start with the camera you have

- **DSLRs are great**
- **Consider mirrorless for dedicated astro body**  
light (easy on the mount) and can use any manual lens



# Mount Basics

- **2 second tap test**
- **Static Tripod Mount**
  - **Earth's motion limits exposure times**  
not a problem for the moon or if using a wide FOV
  - **Rule of 500** avoids blurring due to earth's rotation  
**max exposure = 500 / Focal Length** (full frame equivalent)
- **Star Tracking Motorized Mount**
  - **Simple - polar aligned, single axis Clock Drive**
  - **Complex - two motorized axes, auto guided**



# Challenges

- **Mount - Vibration, Tracking, & Alignment**
- **Very Low Light**
- **Very High Dynamic Range**
  - **25 stops: Moon to dimmest visual star**
  - **20 stops: Eye**
  - **14 stops: Camera**
  - **10 stops: Screen**
  - **8 stops: Print (  $\sim 0.02\%$  of what the eye sees)**
  - **Solutions: HDR stacking and exposure curve stretching**



# Telling a story about the moon

**Target: the Moon +**

- **Foreground Elements**
- **Conjunctions, Occultations**
- **Framing/Point of View**
  - **Fixed Tripod for wide FOV**
    - **Earth / horizon**
    - **also good for nightscape/milky way images**
  - **Motorized Tracking Mount for narrow FOV close-ups, tracking speeds include**
    - **Moon**
    - **Sun**
    - **Stars (Sidereal) can stand in for brief periods for lunar or solar speeds**



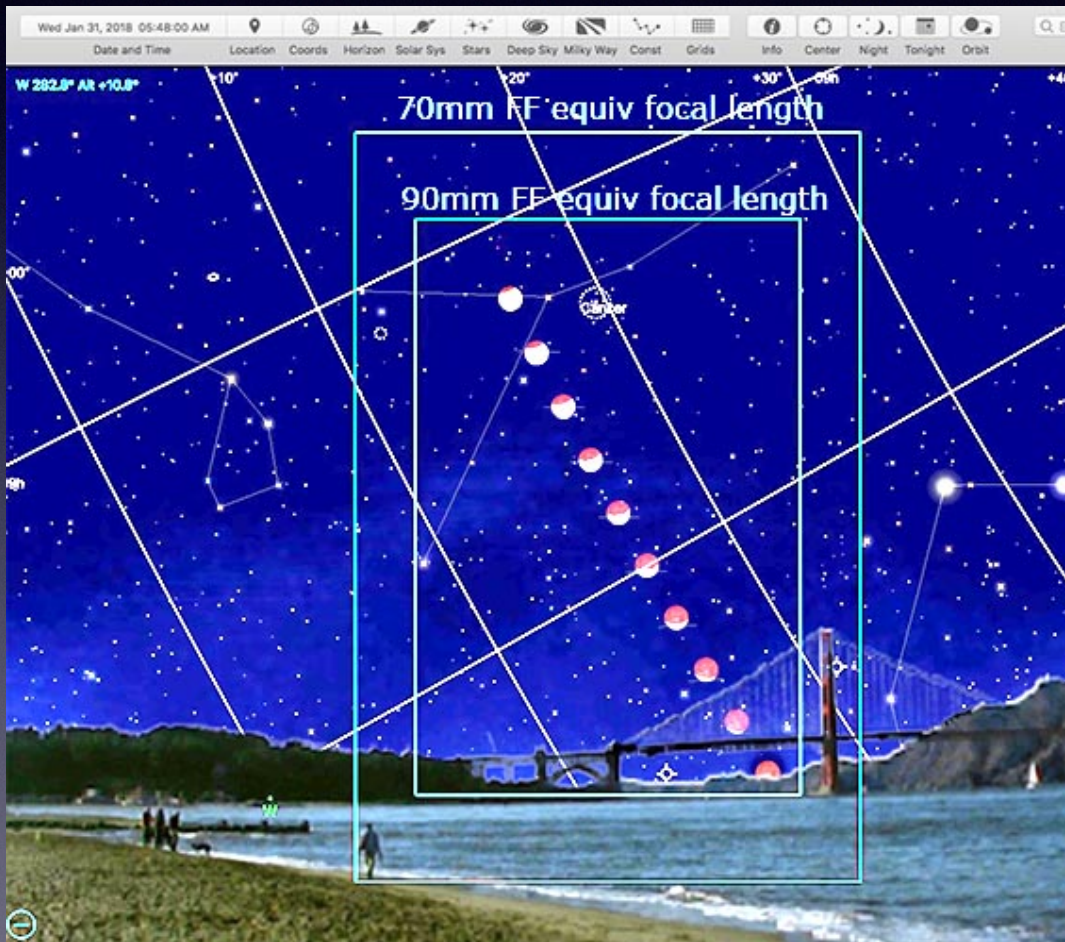


# Fixed Mount - Lunar Eclipse, Earth reference frame

Incorporate landscape elements

Planning: Photographers Ephemeris or PhotoPills

For multiple targets or wide FOV use a planetarium program.



# Tracking the Moon - Lunar Eclipse

**372.19° in 24hrs**  
**360° in 23:13**



# Tracking the Sun - Lunar Eclipse

**360° in 24 hrs**

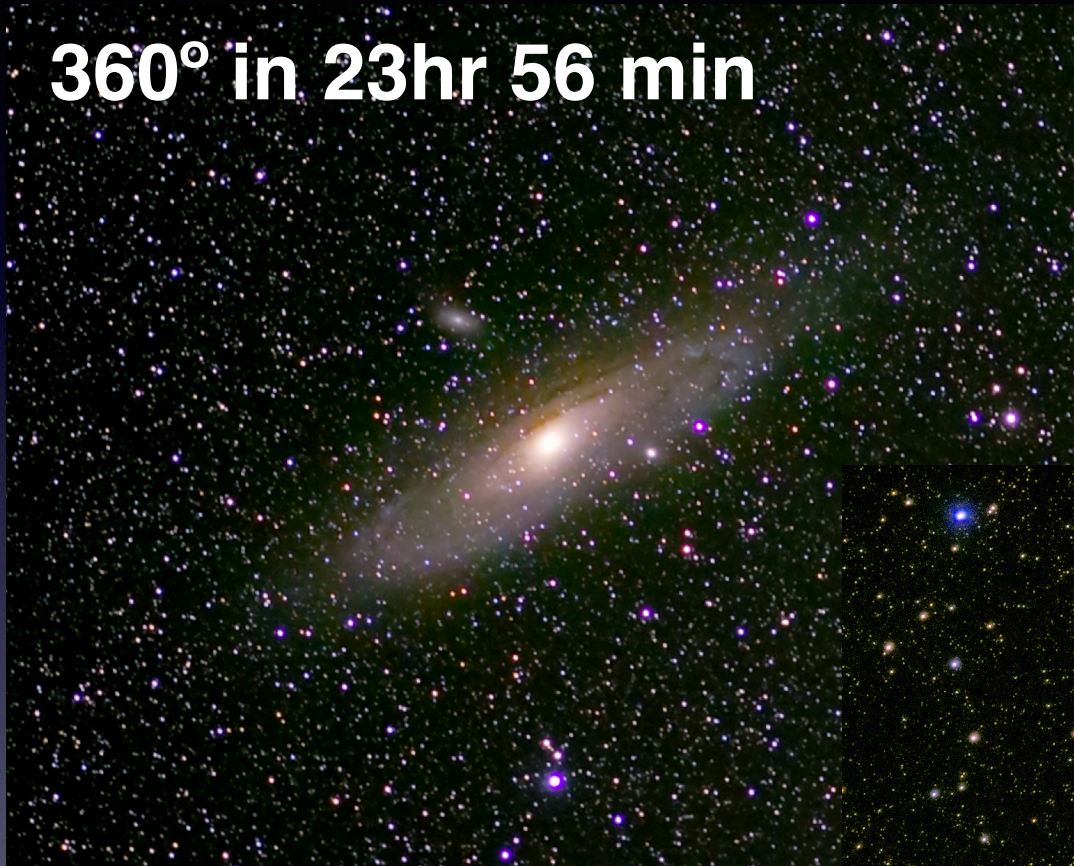


Earth's shadow is fixed in the frame



# Tracking the Stars - Move Beyond the Moon

**360° in 23hr 56 min**



You can image deep space objects with only a DSLR and tracking mount - no telescope required

Andromeda Galaxy and Omega Centauri  
\$35 135mm vintage Vivitar prime lens

Mounts with only a sidereal speed are still helpful for lunar photography, but require occasional recentering



# Tools for my Moon Images

Sony mirrorless crop sensor

Camera Lenses 12-420 mm



Telescope 1300-5000 mm



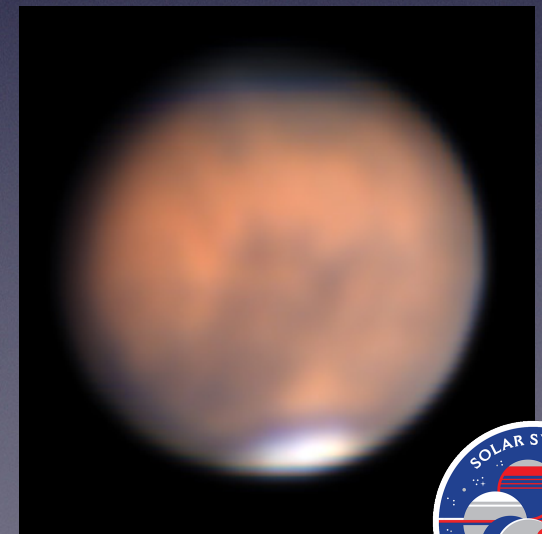
Coat Pocket Kit - Sony RX100 24-70 mm zoom



# Stacking

Compositing multiple exposures of the same scene.  
Reasons we stack include:

- **Lucky Image - selective stacking**
- **Noise Reduction**
- **Increased Dynamic Range - avoid saturation**
- **Compress Dynamic Range - HDR stacking**
- **Depth of Field stacking**
- **Increase Resolution - dithered under sampling**
- **Post Processing Resolution Enhancement**
- **Reject sensor dust**



# Example: Stacking to reduce noise and increase resolution

It is difficult to stack full disk images because of air turbulence. It can be done successfully with stackers that warp each frame for best alignment (Nebulosity, AutoStakkert 3)



# Example: Stacking to increase Resolution and Depth of Field & Reduce Noise





# Example: HDR Stacking

Earthshine in 2 exposures day-lapse

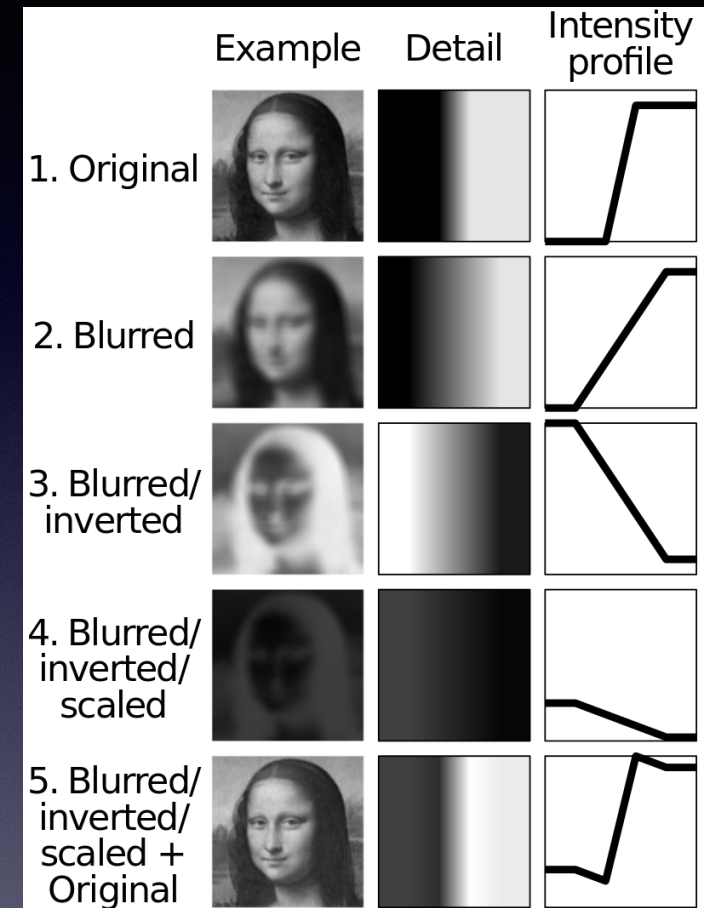


Eclipse with 9 exposure HDR



# Post processing

- Exposure Adjustment
  - Usual suspects:  
Gamma, White Balance, Saturation
- **Resolution Enhancement**
  - requires clean low noise image
  - point spread function **deconvolution**  
**or wavelets** not unsharp mask



Unsharp Mask, Credit Wikipedia PD



# Post Processing: Masking



- Avoid over sharpening near terminator and onion skin at limb
- Undersize and feather disk mask, avoid terminator
- Use tools that give you full control of the mask, not just adjustment brush



# Telling stories with NASA Data

Add a space based point of view to your images.

Sources I like:

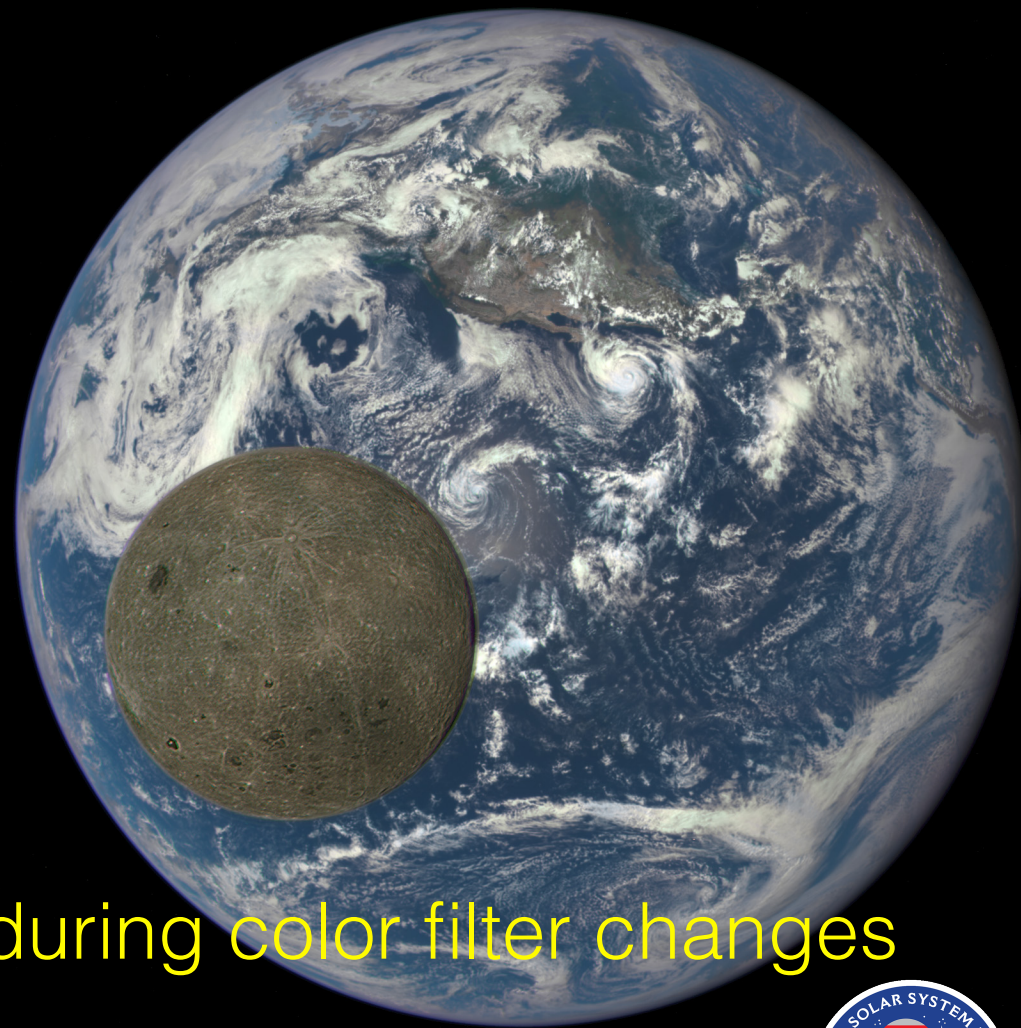
- **Lunar Reconnaissance Orbiter Camera (LROC)**  
<http://lroc.sese.asu.edu>
- **Deep Space Climate Observatory (DSCOVR EPIC)**  
<https://epic.gsfc.nasa.gov>
- **New Horizons Pluto and Ultima Thule**  
<http://pluto.jhuapl.edu/Galleries/Featured-Images/>
- **Juno Jupiter Images**  
[https://www.nasa.gov/mission\\_pages/juno/images/index.html](https://www.nasa.gov/mission_pages/juno/images/index.html)



# EXAMPLE: DSCOVER EPIC Moon photobomb

Why does this look fake?

And this processed one real?

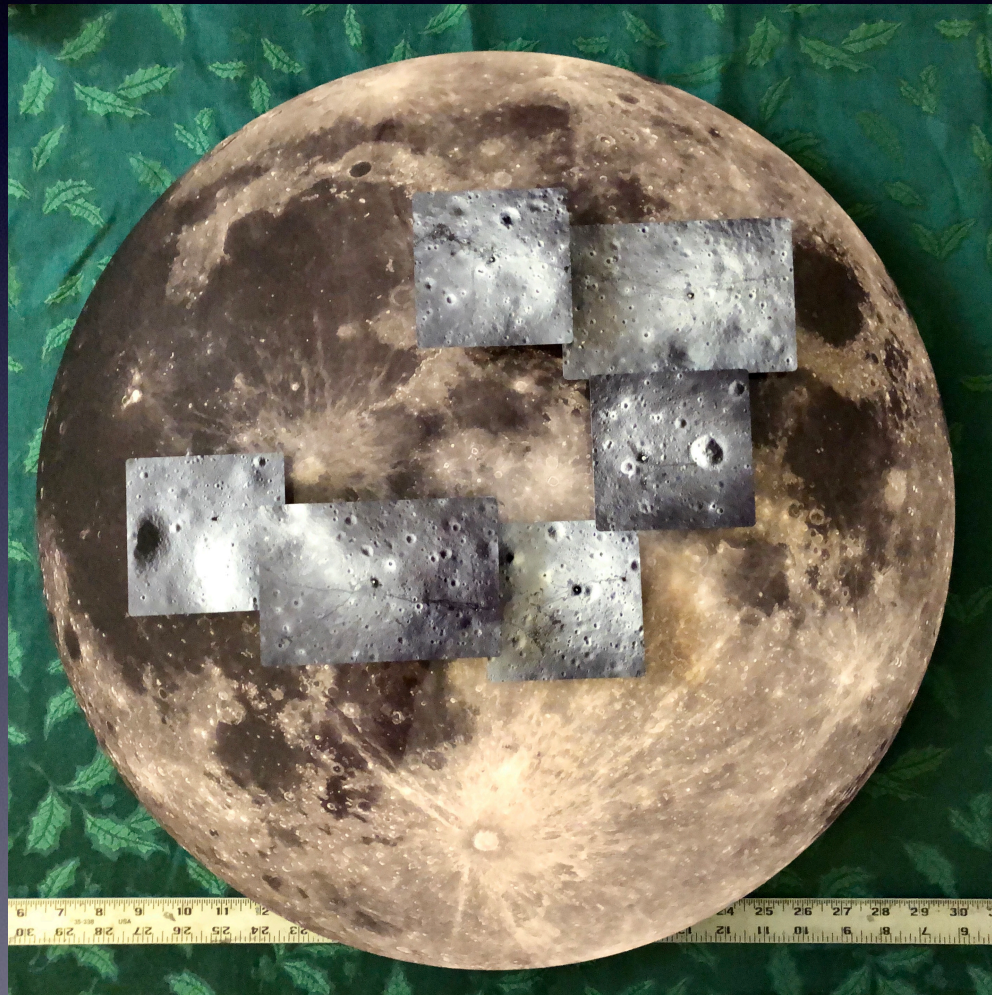


Hint - the moon is moving during color filter changes



# Example: Apollo 50th anniversary

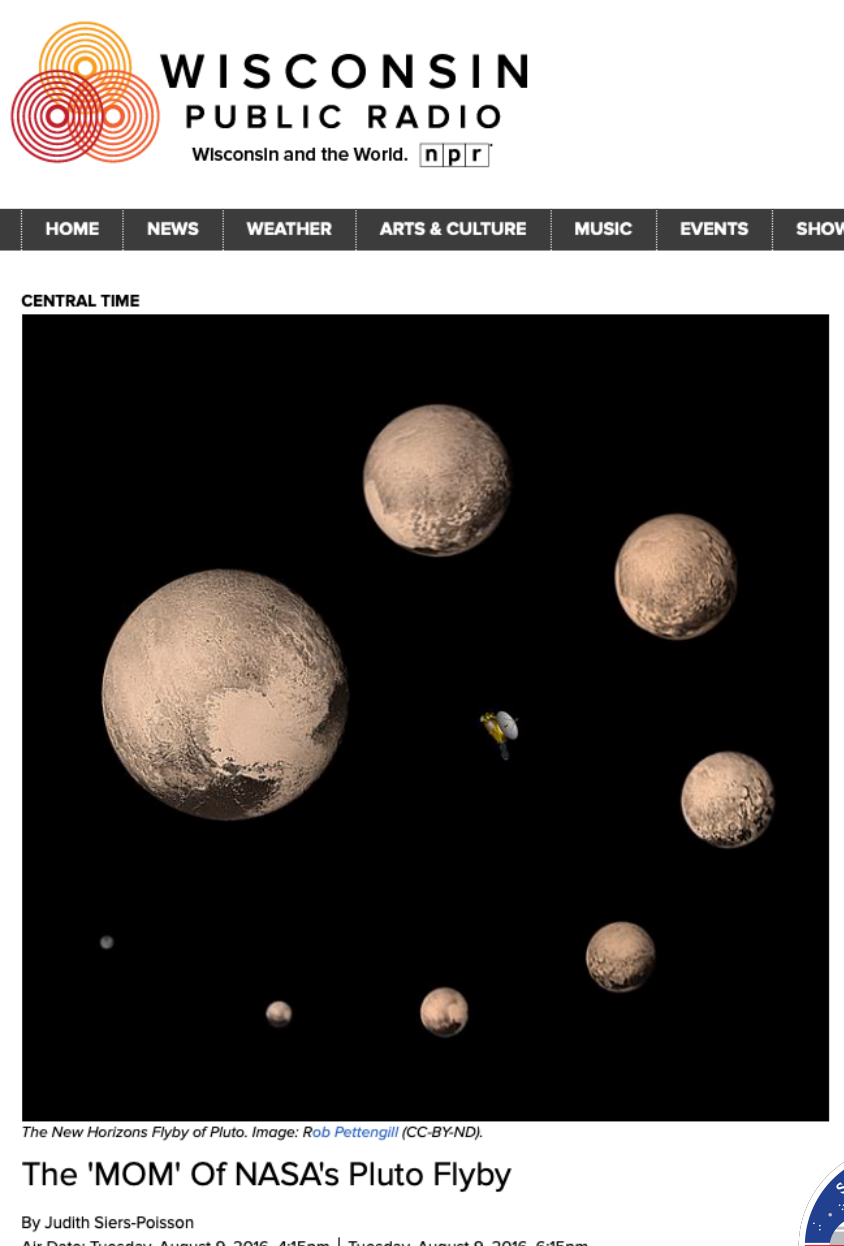
3D photo collage with LRO Apollo landing site close ups  
in context for Austin High Astronomy Classes



# Example: New Horizons - Pluto

Move beyond the reach of your own camera with images from NASA Solar System probes...

Stacking NASA image data to increase resolution and tell a story



The screenshot shows the Wisconsin Public Radio website. At the top is the logo for Wisconsin Public Radio, featuring three overlapping circles in orange and red, with the text "WISCONSIN PUBLIC RADIO" and "Wisconsin and the World. npr". Below the logo is a navigation bar with links for HOME, NEWS, WEATHER, ARTS & CULTURE, MUSIC, EVENTS, and SHOW. The main content area is titled "CENTRAL TIME" and features a large image of Pluto and its moons, with the New Horizons spacecraft visible in the distance. Below the image is the caption: "The New Horizons Flyby of Pluto. Image: Rob Pettengill (CC-BY-ND)." The article title is "The 'MOM' Of NASA's Pluto Flyby" by Judith Siers-Polsson, with an air date of Tuesday, August 9, 2016, 4:15pm.



# Resources



[BadAstroPhotos.com](http://BadAstroPhotos.com) web site all content CC BY-NC-SA

- **A visual tour of a dozen ways to shoot the Moon**  
<http://BadAstroPhotos.com/lunarPhotography.html>
- **Day-lapse Images of Earthshine on the Crescent Moon**  
<http://BadAstroPhotos.com/daylapse.html>
- **Getting started in astrophotography?**  
<http://BadAstroPhotos.com/gettingStarted.html>
- **DSO Astrophotography without a Telescope**  
<http://BadAstroPhotos.com/withoutTelescope.html>
- **Print and Display Astrophotography**  
<http://BadAstroPhotos.com/howtoPrint.html>

