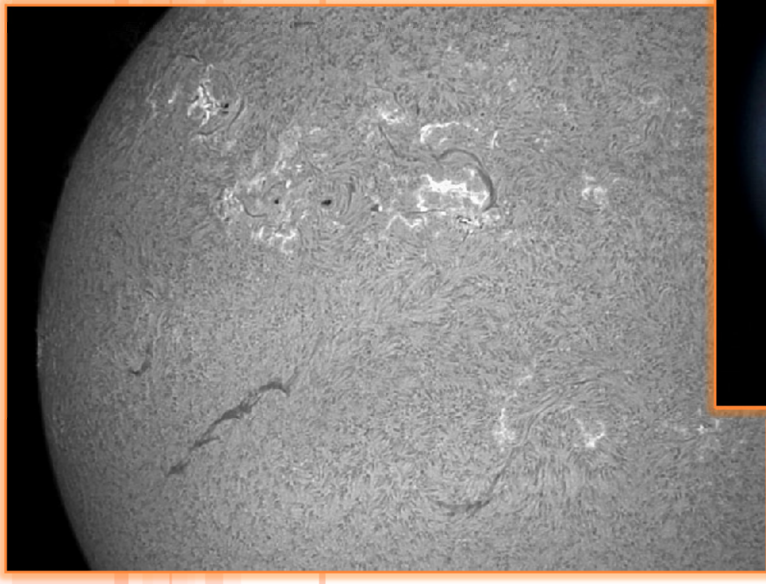
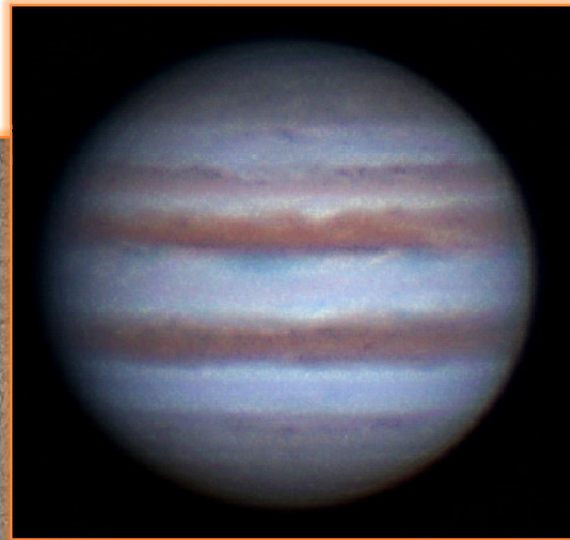
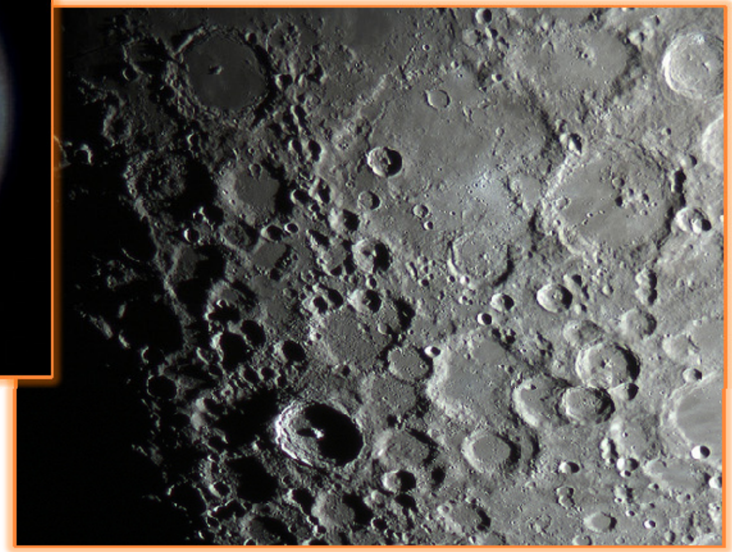




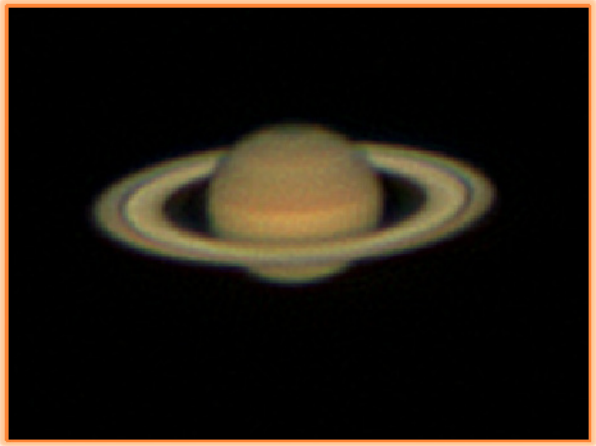
Solar System Imaging For Dummies

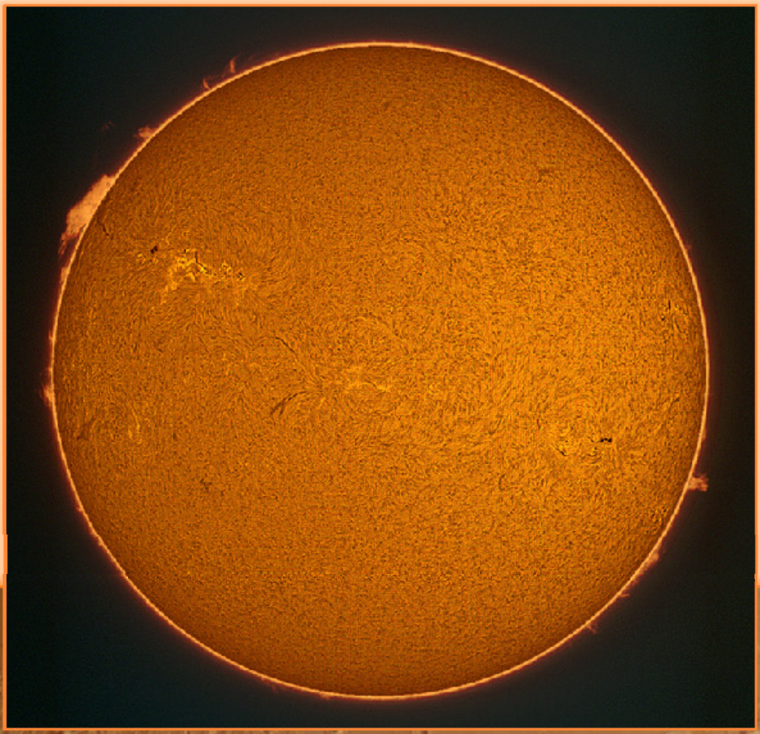
By: Jim Thompson

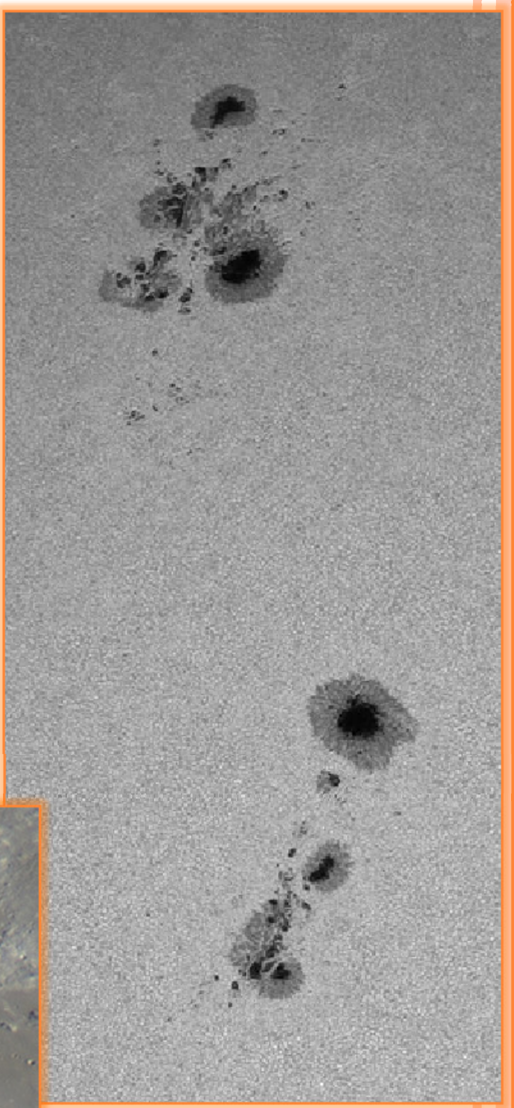
OAWS #10 – Feb. 20th, 2015

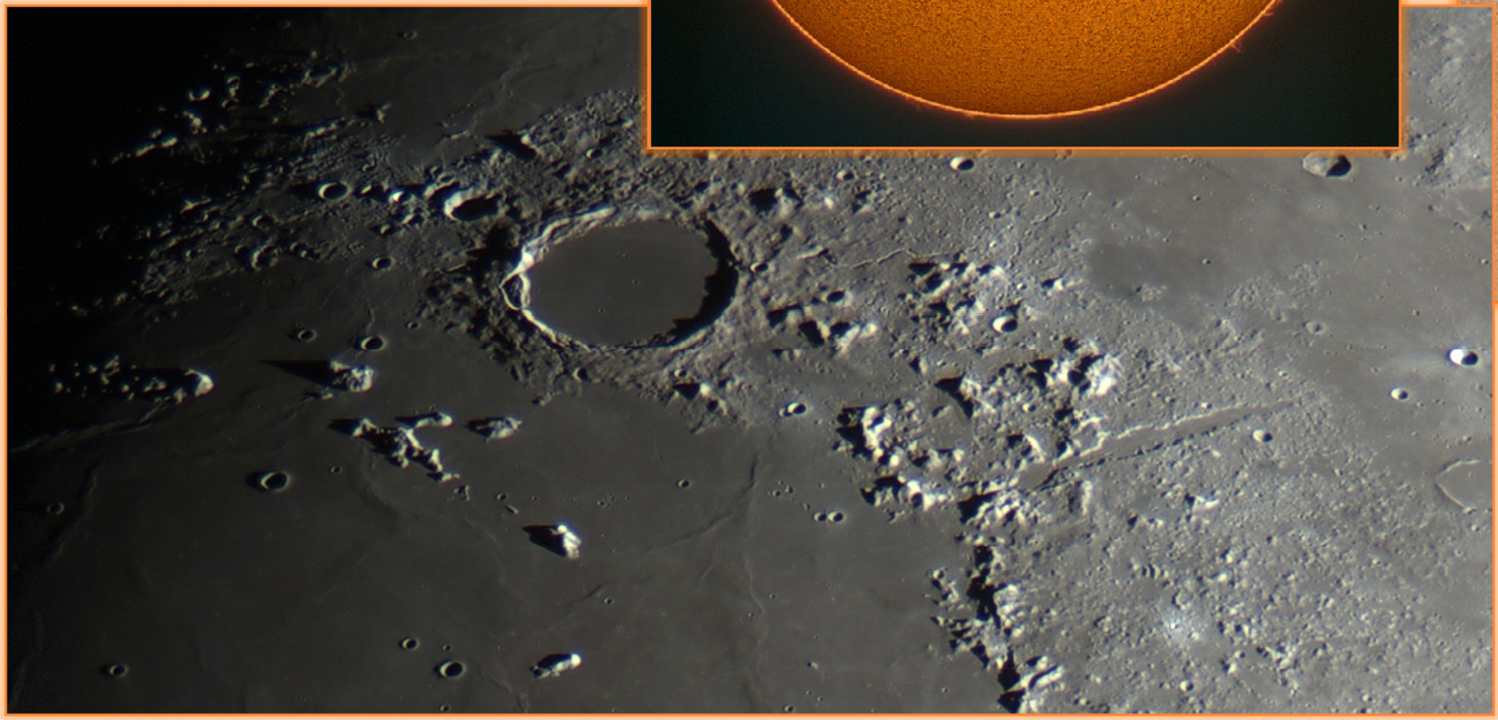
In The Beginning…

AND MORE RECENTLY…









Introduction

- Solar System Imaging is equal parts challenging & rewarding.
- My first lunar images were taken on Aug. 26th, 2010.
- Since then I continue to hone my techniques & equipment.
- This presentation passes on what I have learned in the past 4 ½ years.

Overview

- What is Solar System Imaging?
  - Objectives
  - Challenges
- Introduction to "Lucky Imaging"
- Equipment Requirements
  - Telescope & mount
  - Camera
- Computing Requirements
- Techniques, Tips & Tricks (T3)
  - Capture
  - Align & Stack
  - Wavelets & other post processing

What is Solar System Imaging?

- Capturing pictures of objects in our own solar system:
  - Sun
  - Moon
  - Planets
  - (not Comets or Asteroids) – use different techniques
- Objects are relatively bright
  (exposures ~ 1/10th to 1/10,000th sec)
- Image magnification typically very high
  (focal lengths ~ 600 to 8000mm or more)
- Target changes appearance with time
  (can discern: surface detail, rotation, orbital motion)

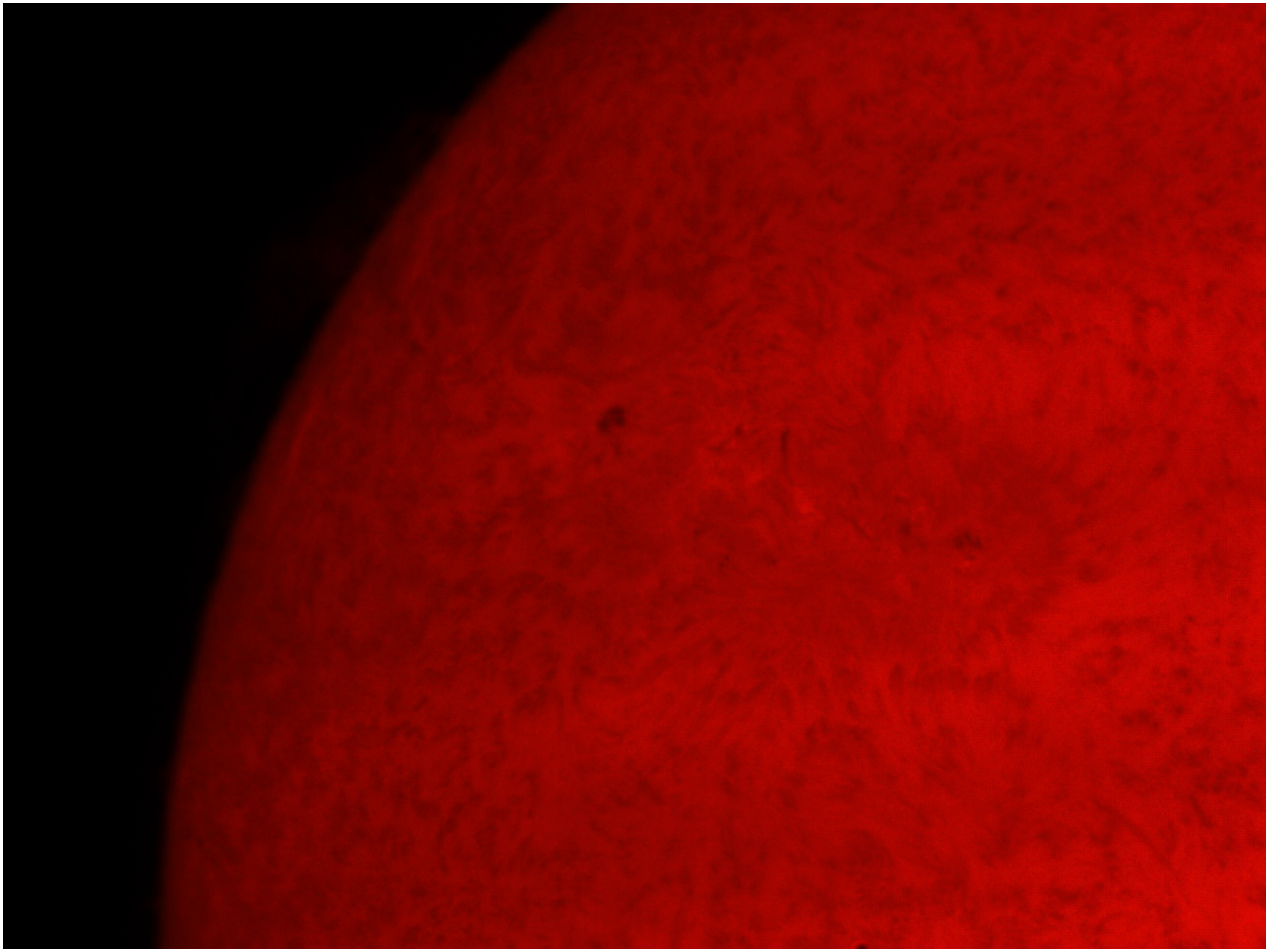
Imaging Challenges

- Earth's atmosphere:
  - **Cloud Cover**: clouds can fully or partially obscure target
  - **Transparency**: water vapour/ice, dust & aerosols all affect sharpness of contrast and clarity of fine surface detail
  - **Seeing**: random turbulent refraction of light by our constantly moving atmosphere, blurs detail & softens focus
  - **Dispersion**: different colours refract differently in atmosphere, causes blue-red halos & loss of focus at high magnification

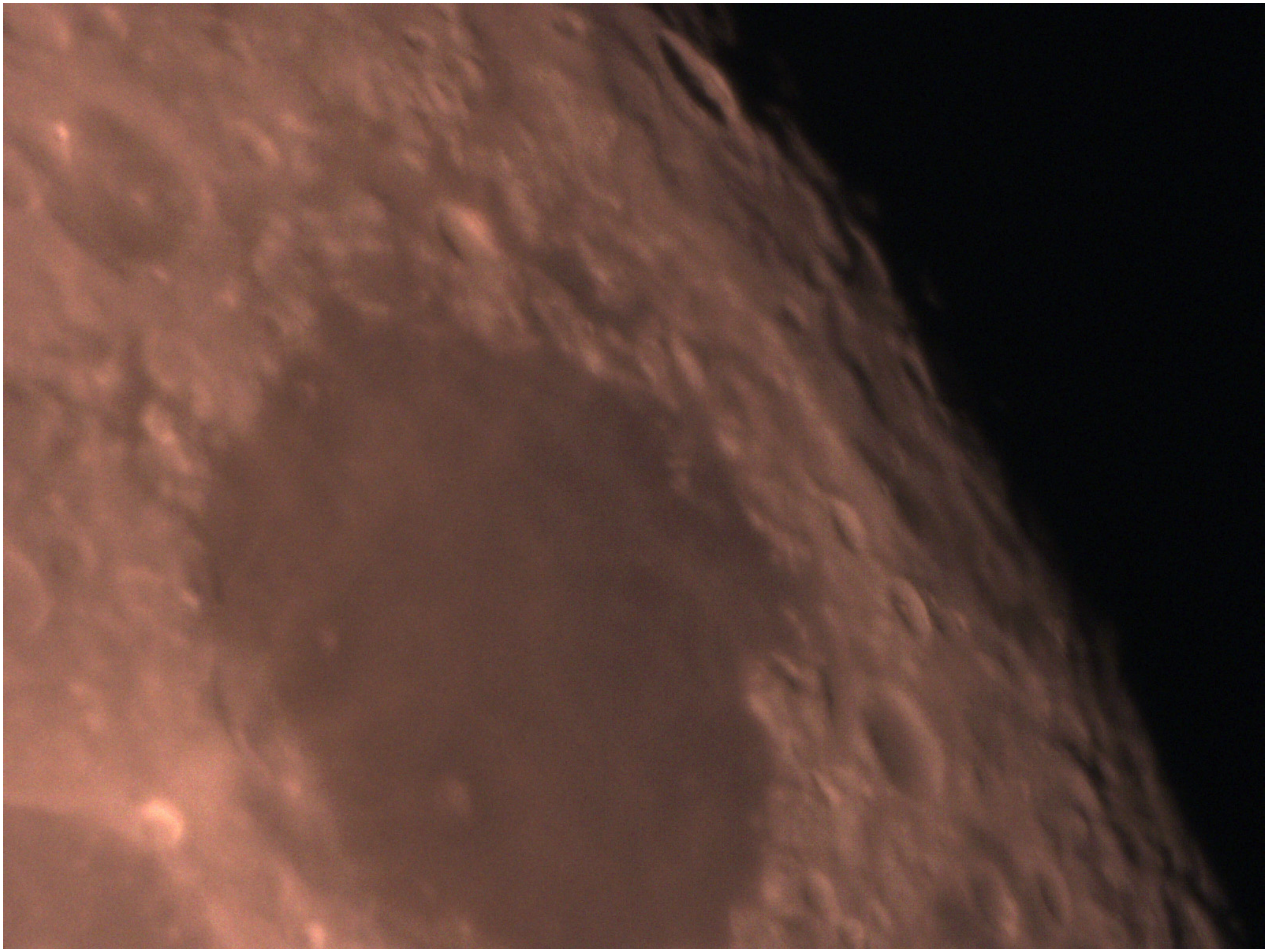
IMAGING CHALLENGES, CONT'D

- Earth's atmosphere, cont'd:
  - All these effects worsen the lower in altitude the target is…looking through more atmosphere
- Time:
  - Target is changing appearance in a short period of time
  - Longer exposures blur detail due to Seeing
  - Camera & scope limit exposure time & frame rate

Example: Sun



Example: Moon



Example: Planet

Imaging Challenges, cont'd

- In above examples, high magnification + atmospheric effects make only parts of view clear at any one time
- Visually effect is lessened by eye-brain time averaging ability
- For imaging need way to pick best part of images out and combine them into single sharp image

Lucky Imaging

Steps To Lucky Imaging

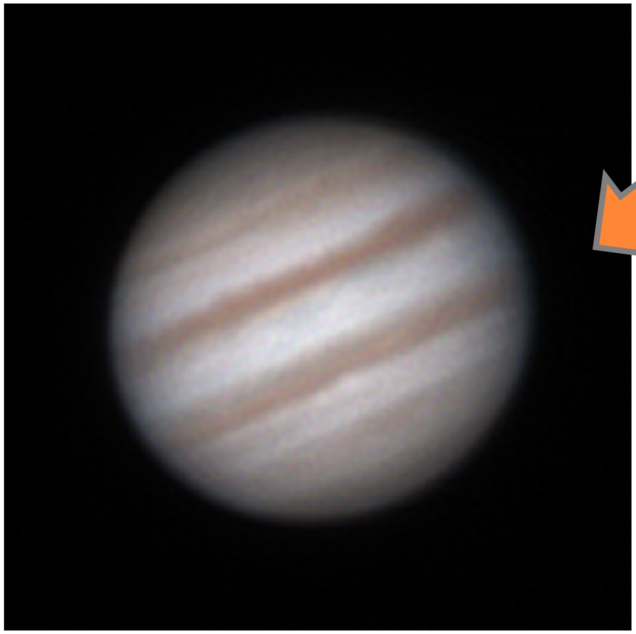
1. Capture many images of your target, 100's to 1000's of frames
2. Pick the best frame from those captured to be a reference frame
3. Compare all other frames to the reference frame, noting relative quality and changes to alignment of features
4. Reject all poor quality frames, and align & stack the rest into one averaged image

LUCKY IMAGING WORKS!

Single
frame

Align &
stack 250
of 3000

Wavelets
& tone
adjust



Equipment: Telescope & Mount

- Telescope type flexible, but choose focal length to get desired magnification
  - Barlow/telextender highly recommended
  - 1000 to 2000mm f.l. good place to start
- Good focuser w/fine focus highly desirable
- RA tracking necessary
  - Equatorial mount best but Alt-Az okay

Equipment: Telescope & Mount, cont'd

- Scopes I Use:
  - Solar – white light, 98mm refractor (f.l. 618mm); Hα, 66mm refractor (f.l. 388mm) $
  - Lunar – 98mm refractor; 10" RC (f.l. 2000mm)
  - Planets – 10" RC
  - 2x and 4x Barlow/telextenders

- Mount I Use:
  - German Equatorial – Orion Atlas EQ/G

EQUIPMENT: CAMERA

- Any camera that will digitally record video or an image sequence will work
- Wide variety of options to fit any budget
  - $5 webcam to $10,000 AP CCD
- Best results come from high sensitivity + fast frame rate
- Monochrome vs. colour
  - Mono more sensitive & better resolution
  - Colour much easier to get colour image

EQUIPMENT: CAMERA, CONT'D

Webcam

- $5-30
- easy to use
- low sensitivity

Security Camera

- $30-400
- good sensitivity
- low resolution

Astro-Video Camera

- $90-2000
- good sensitivity
- low resolution

Planetary Camera

- $200-1500
- good sensitivity
- fast refresh rate

DSLR

- $500-3000
- multi-purpose
- good sensitivity

Astrophotography CCD

- $1000-10,000+
- good sensitivity
- some slow refresh rate

Equipment: Computer & Software

- Need a reasonably powerful computer – capturing and manipulating video
  - Multi-processor
  - >4Gb RAM
  - Large HD (1 TB or more)
  - OS not super important, but more software available for Window OS
  - Camera type will impact computer requirement – low demand (webcam) vs. high demand (AP CCD)
- Video capture software – whatever you like to use, many free packages available (VirtualDub, AMCap, FireCapture, SharpCap)

Equipment: Computer & Software, cont'd

- Alignment & stacking software
  - Registax 6.1 (align, stack, post processing)
  - AutoStakkert!2 (align & stack only)

- Image editing software – whatever you like to use
  - Crop & rotate
  - Adjust white/black point, gamma (ie. tone mapping, curves, etc.)
  - Adjust saturation & hue
  - Unsharp mask & other effects
  - Composites, mosaics, etc.

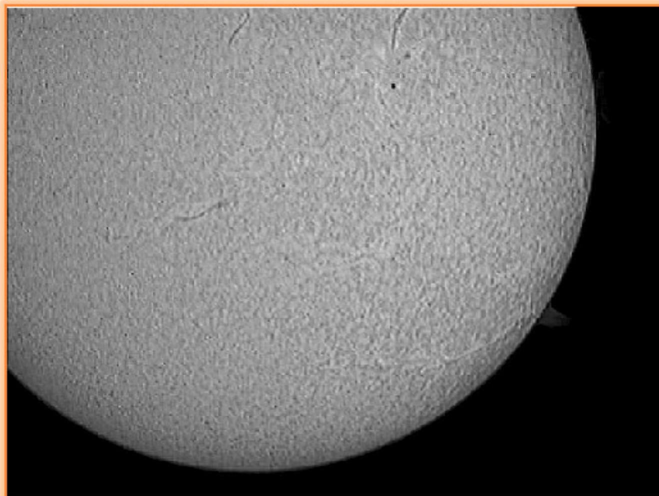
T3: CAPTURE

- Focus:
  - Let your scope cool down to ambient temp at least 30min before, 1 hour if you can
  - Take your sweet time focusing – very important!
  - Seeing can make focusing a challenge
- Filters:
  - Can help sharpen your focus & improve contrast
    - UV/IR Cut – generally recommended for any solar system imaging in absence of any other filters
    - Moon & Skyglow – improves colour and contrast on planets
    - Red, Hα or IR Pass – seeing less pronounced at long wavelengths, sharpens focus and better detail
    - Solar Continuum – for white light solar, improves contrast and focus

T3: Capture, cont'd

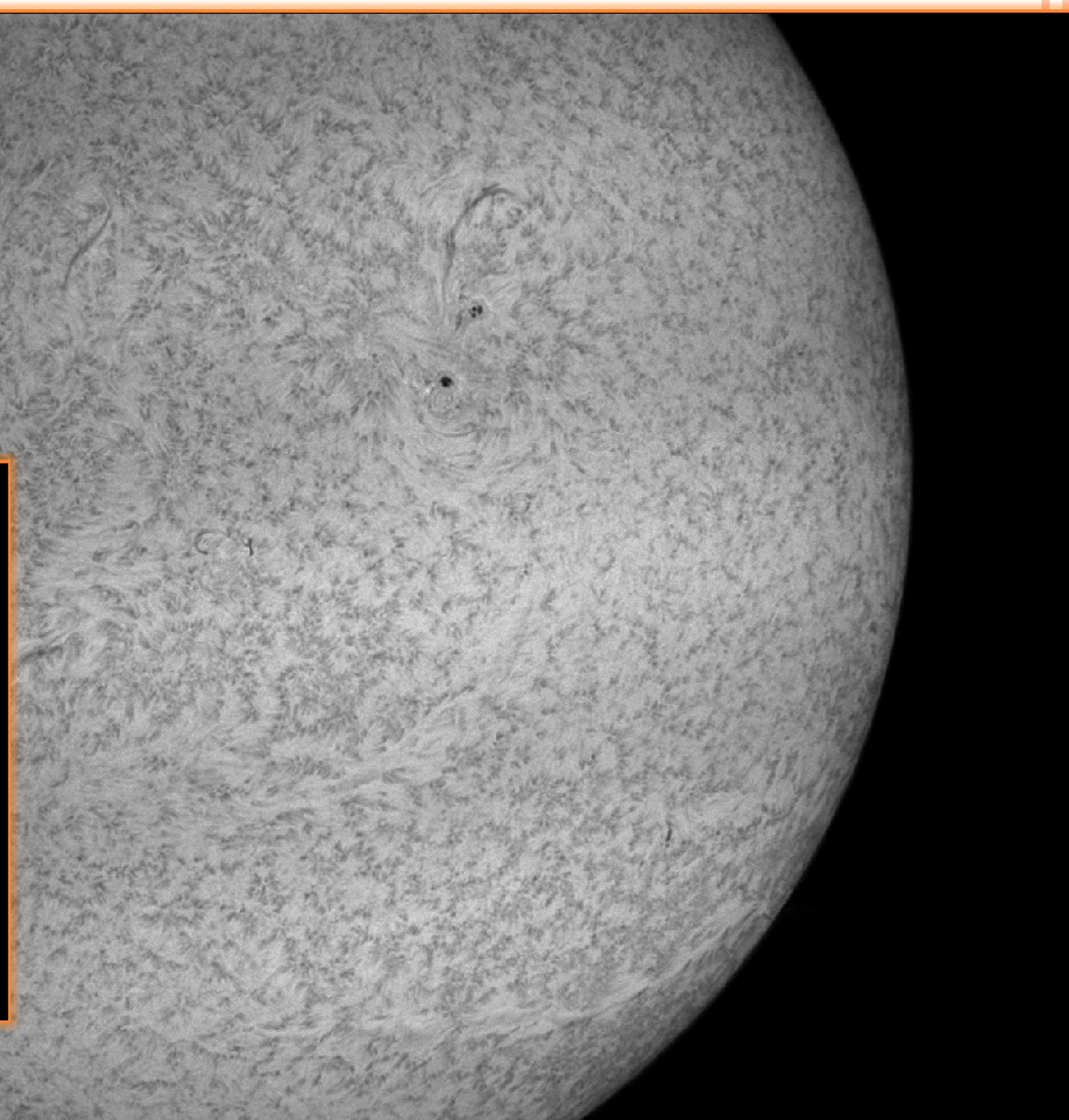
- Dispersion Reduction:
  - Problem at high magnification (>4000mm f.l.)
  - Narrow band pass filter avoids problem
  - Gadgets available to reduce effect (wedge prism) but pricey
  - I am yet to try ADC or narrowband filter!
- Newton's Rings:
  - Optical effect common with Hα solar imaging
  - Alternating light/dark bands – image plane & camera sensor plane not parallel
  - Gadgets available to reduce effect but pricey
- Barlows/Telextenders:
  - Worth having & using – higher spatial resolution
  - Use limited by seeing conditions

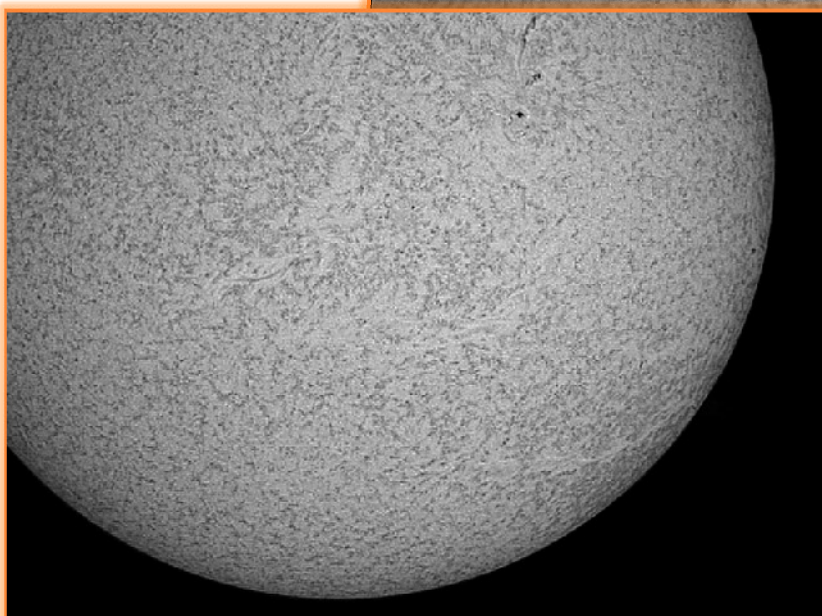
Effect of Resolution



0.25” sensor, 0.3MB, no Barlow

0.56” sensor, 1.8MB, 2x Barlow





0.56” sensor, 1.8MB, no Barlow (cropped)

T3: Capture, cont'd

- Exposure:
  - Balance exposure time with gain to get a view that is not too noisy but quick per frame
  - Aiming to get ~1000 to 2000 frames in <60sec
  - Adjust image a little on flat side, ie. no clipping/saturation at black or white end of histogram
  - Get white balance close before capture
  - Use a live histogram if you have one
- Video File:
  - Record to uncompressed AVI
  - Alternatively can save as series of images
  - Be prepared for lots of data!

T3: Align & Stack

- My experience based on using Registax

1. Load AVI or image sequence
2. Go to roughly the middle of data
3. Manually search for best looking frame
4. Select alignment points using this reference frame
5. Align frames – resulting tails indicates overall quality of frame alignment
6. Select which & how many frames to keep
7. Stack the frames you're keeping
8. Save your stacked image

T3: Align & Stack

- Picking good reference frame has big impact on results – take a few minutes
- AutoStakkert!2 can select reference frame for you automatically
- I place alignment points using AUTO feature, then manually add more to key image features
- For objects with poor contrast, fewer alignment points manually placed may work better
- Numerous alignment features in Registax & AutoStakkert I have not explored yet!
- Aim for a stack of >100 frames (I try to use 250) to give you good control of noise – affects capture size

T3: Wavelets & Post Processing

- Wavelets = layered approach to sharpening the image
- No rules, totally up to user & what they think looks nice
- Over aggressive use of wavelets will result in noisy image & artifacts
- I like:
  - Linear – Gaussian – Linked for most targets when seeing is good, and when stack size is large (noise low)
  - Dyadic – Gaussian - Un-Linked for targets at very high magnification and/or when seeing is poor, and when stack size is small (noise high)
  - Rarely use more than 2 levels of Wavelets

T3: Wavelets & Post Processing

- Some post processing can be done in Registax (white balance, red-blue alignment, histogram adjust)
- Again no rules, totally up to user & what they think looks nice
- A final pass through image editing software can be useful to make images really POP
- Noise reduction software useful, esp. if pushing Wavelets for more detail
  - try "Neat Image" software, works very well!

Demonstration

- Budget camera…

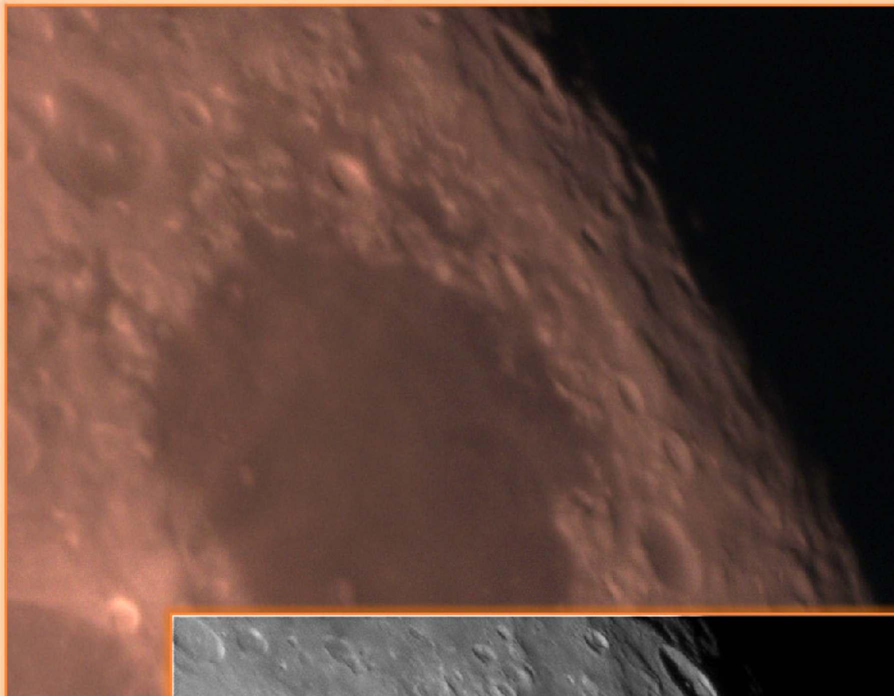
DEMONSTRATION: SUN

Single frame

Align & stack 250 of 2000

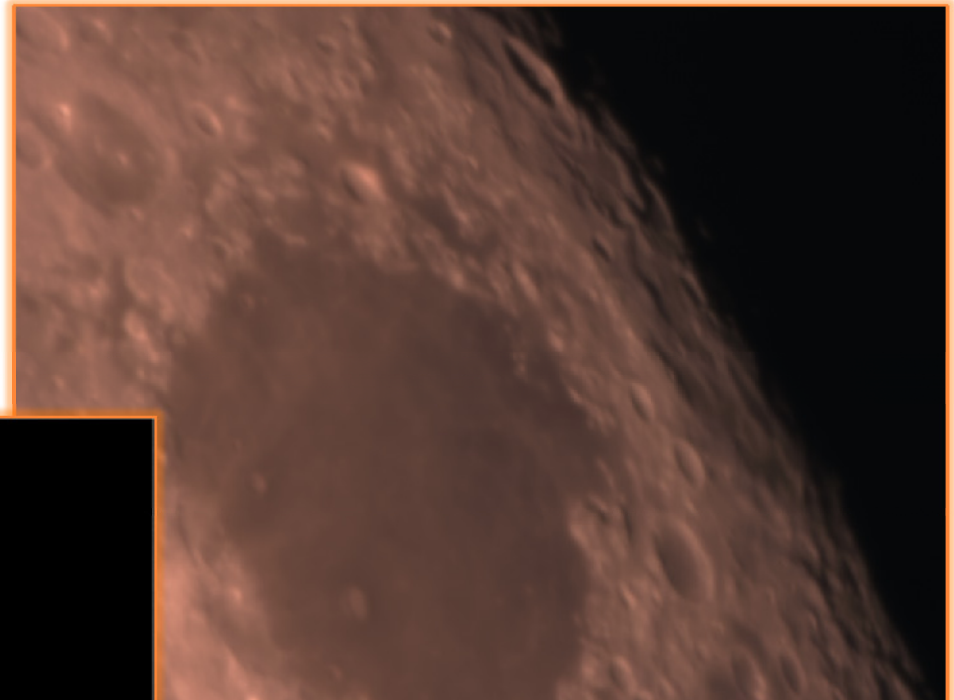
Wavelets & tone adjust

Demonstration: Moon



Single frame

Align & stack
250 of 2000



Wavelets &
tone adjust

Conclusions

- Much enjoyment can be found in Solar System Imaging
- Investment of time & money can be small and still be successful
- There is a large community of people available to answer questions & give advice
- Have fun!