

# Light Pollution in Kirksville

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MARAC Conference 2018

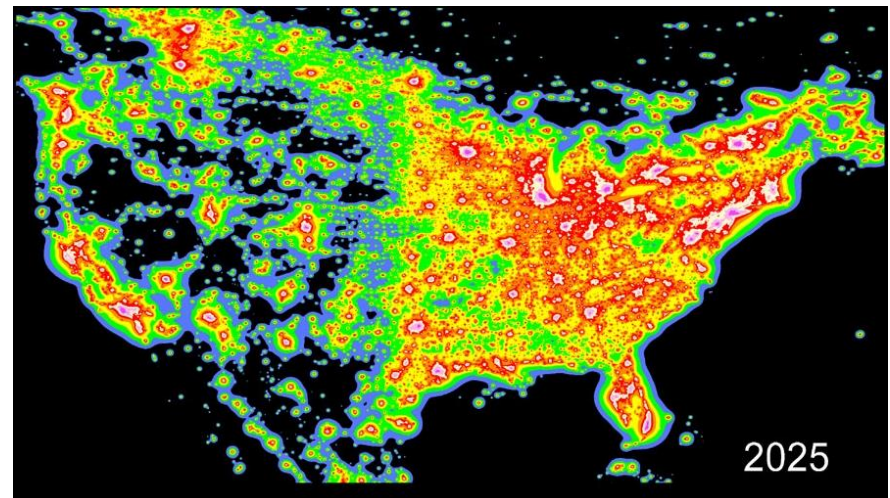
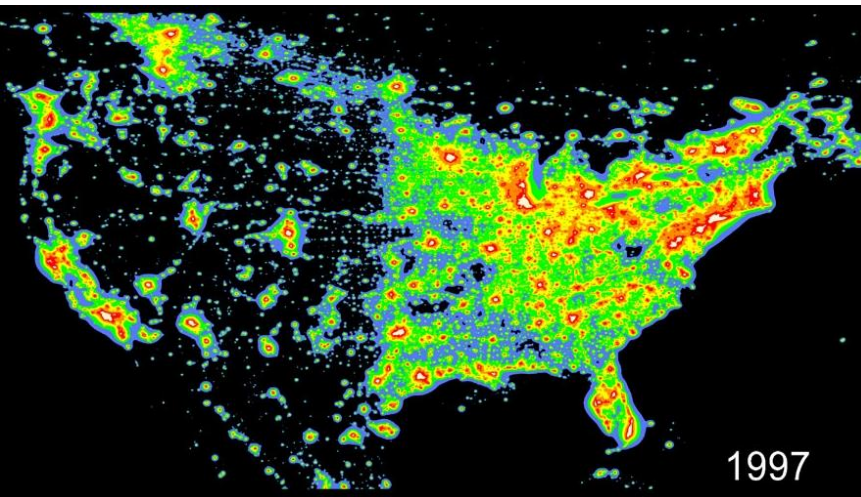
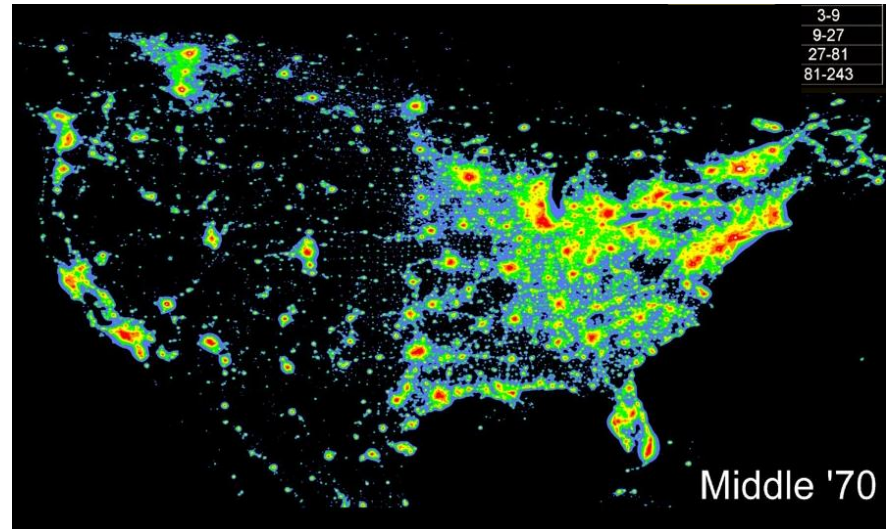
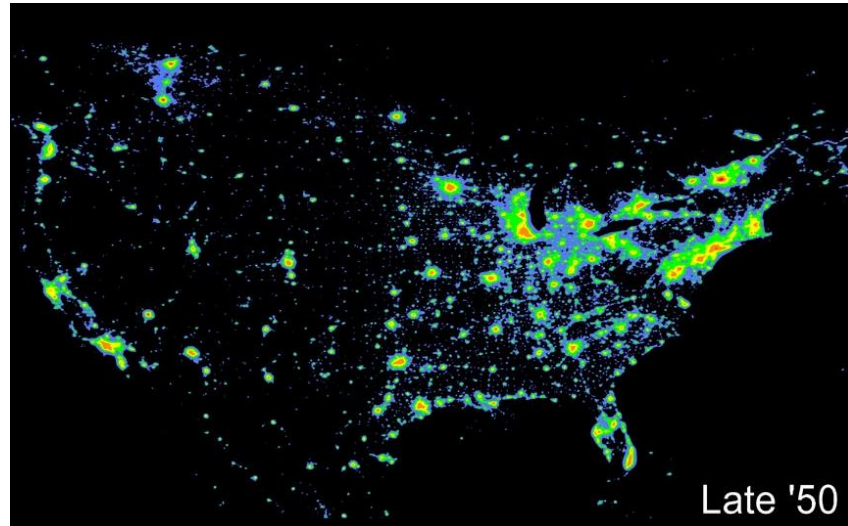
The thing's hollow. It goes on forever, and. oh my God.  
It's full of stars!

# What is Light Pollution?

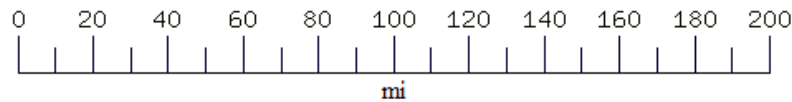
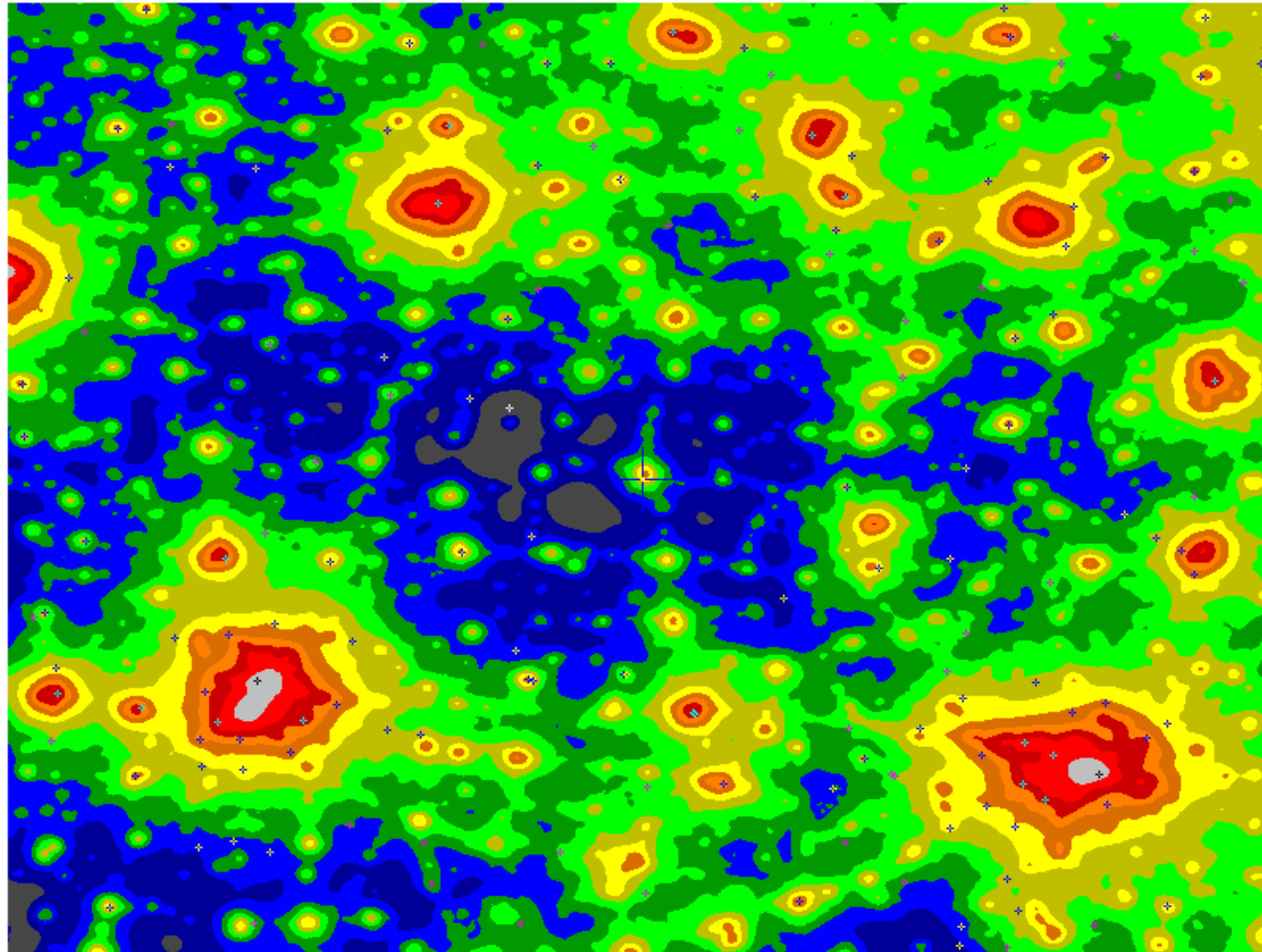
- It is **wasted light** that performs no function or task
  - Sky glow
  - Glare
- It is artificial light that goes where it's not supposed to go
  - Neighbor's window (Light **Trespass/clutter**)
  - Into the sky
- **Light Pollution** is the introduction of artificial light, either directly or indirectly, into the natural environment.



# Light Pollution



# Light Pollution Map



Color	Artificial / Natural Sky Brightness	Sky Brightness mags / sq arcsec V Band	Bortle Scale approx
Black	< 0.01	22.00 to 21.99	1
Dark Grey	0.01 to 0.06	21.99 to 21.93	2
Medium Grey	0.06 to 0.11	21.93 to 21.89	2
Dark Blue	0.11 to 0.19	21.89 to 21.81	3
Blue	0.19 to 0.33	21.81 to 21.69	3
Dark Green	0.33 to 0.58	21.69 to 21.51	4
Light Green	0.58 to 1.00	21.51 to 21.25	4
Olive Green	1.00 to 1.73	21.25 to 20.91	4.5
Yellow	1.73 to 3.00	20.91 to 20.49	4.5
Brown	3.00 to 5.20	20.49 to 20.02	5
Orange	5.20 to 9.00	20.02 to 19.50	5



# Light Pollution is a LOCAL problem with LOCAL solutions

Protecting the night sky starts with **YOU!**

- 1** Light only what you need



- 2** Use energy efficient bulbs and only as bright as you need



- 3** Shield lights and direct them down



- 4** Only use light when you need it



- 5** Choose warm white light bulbs



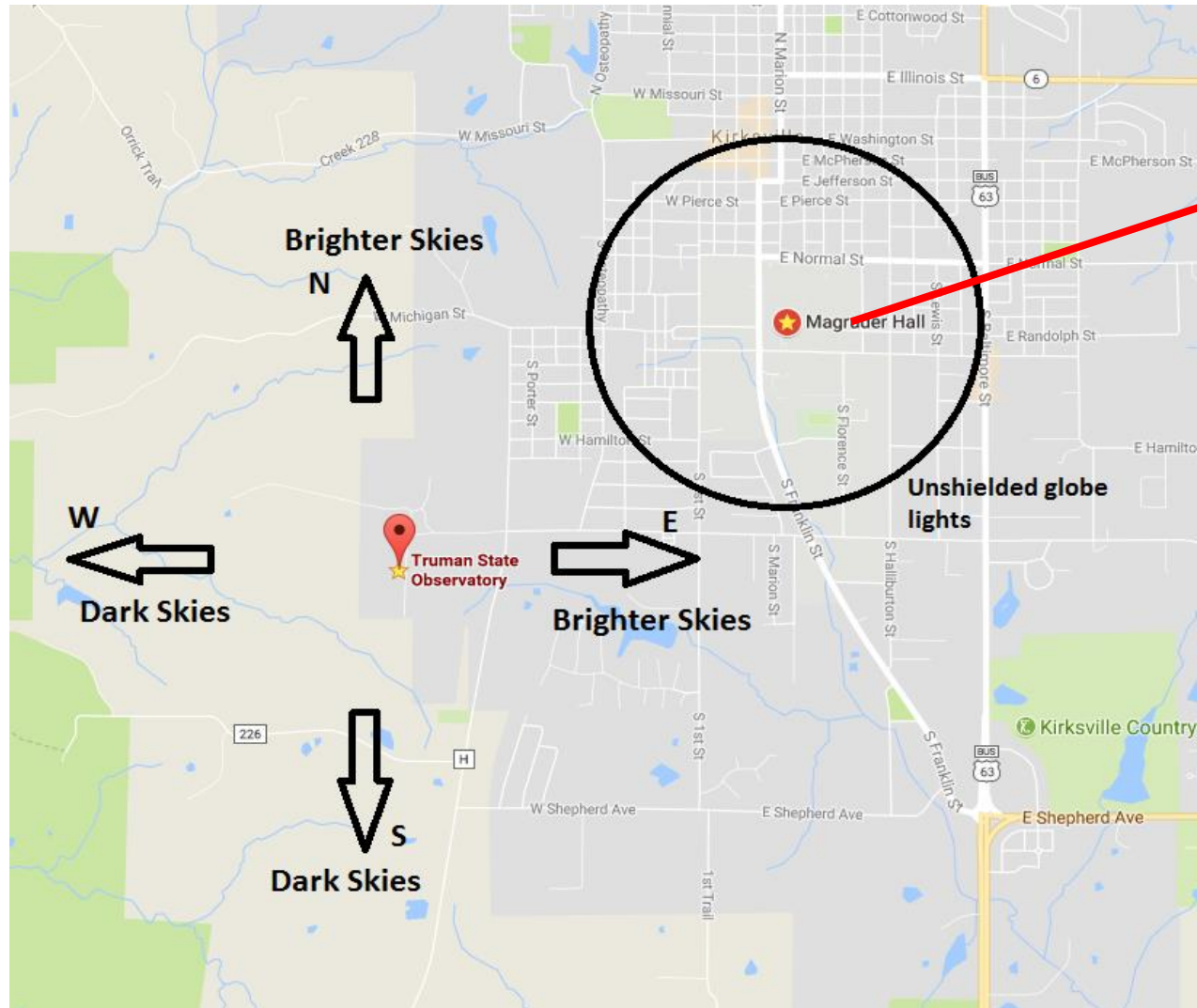
- 6** Join IDA!  
We need your help to continue the fight against light pollution.



# The Light Pollution Project

- **Research: Quantifying Light Pollution**
  - Light sensor measurements to quantify sky brightness
  - DSLR Photometry
  - DSLR Photography
- **Actions: Fixing the Problem**
  - Remedies for ‘bad’ light fixtures
  - Communicate with administrators (school, city etc)
  - Funding Sources
- **Education & Outreach**
  - ‘Losing the Dark’ Planetarium Show, IDA brochures
  - Astronomy Lab on light pollution
  - Interdisciplinary research projects & Civic Engagement

# Location: Magruder Roof & TSO



# Dark Sky Location: Anderson Mesa







Kraigstief, Mo

15 minute exposure, tracking on'

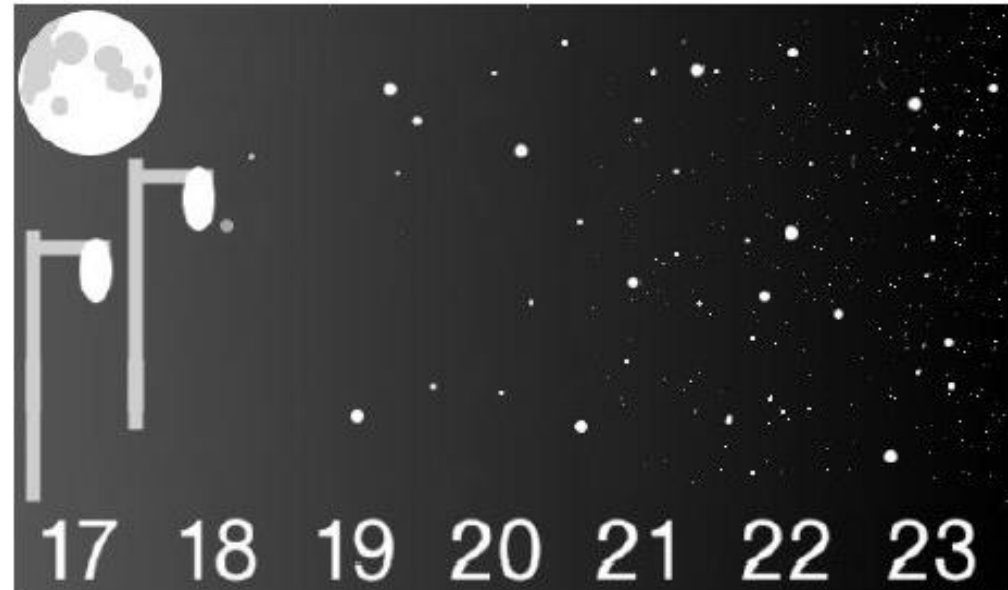


Kfragsvárf, Mo

130 minute exposure, tracking 'óff'

# Light Sensors

- SQM (84°) and SQM-L (20°)
- Readings in mag/arcsecond<sup>2</sup>
- Higher reading = darker skies



# Light Sensor: Set up

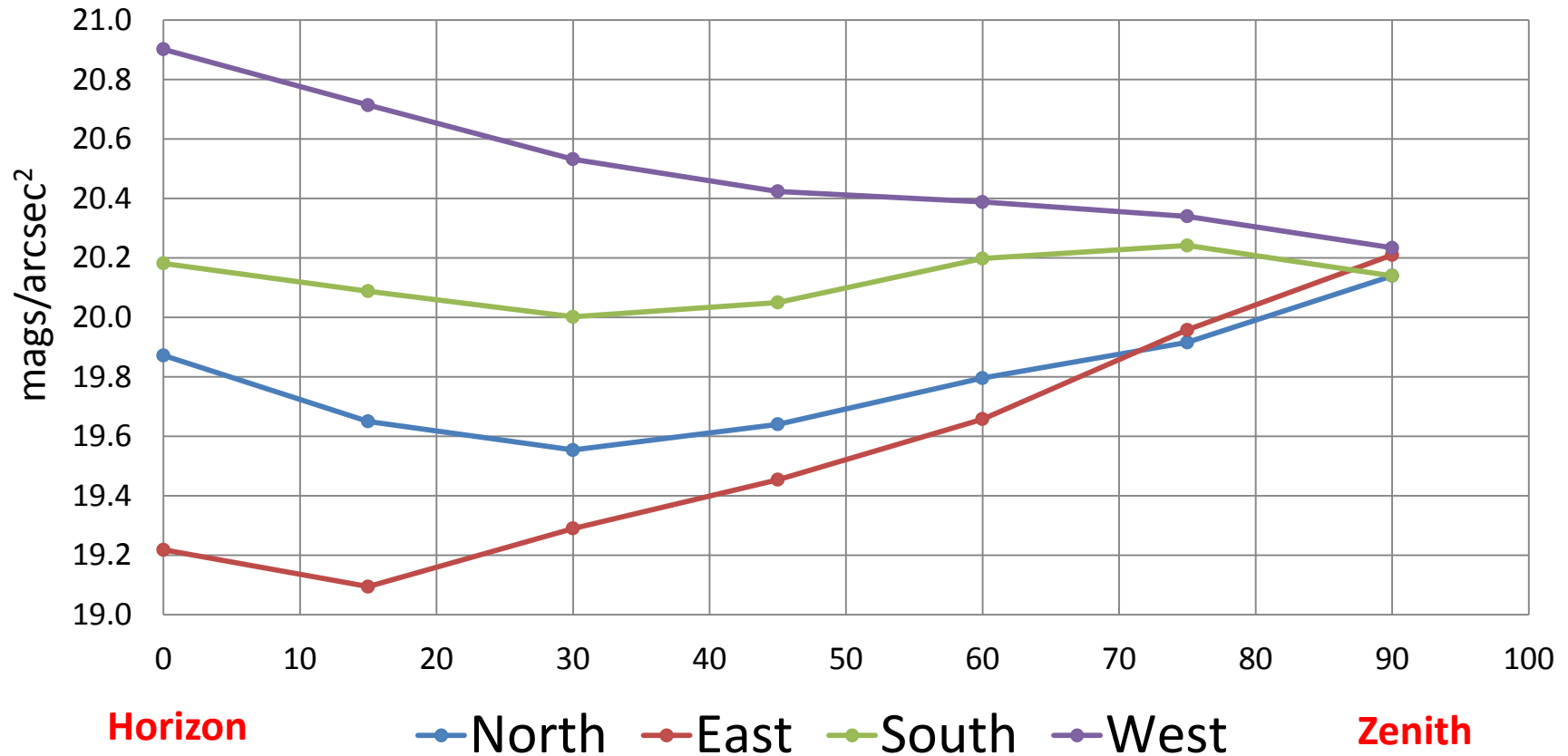


The entire set-up cost is less than \$400 (for ethernet-sensor)



# Sky Brightness with Angle

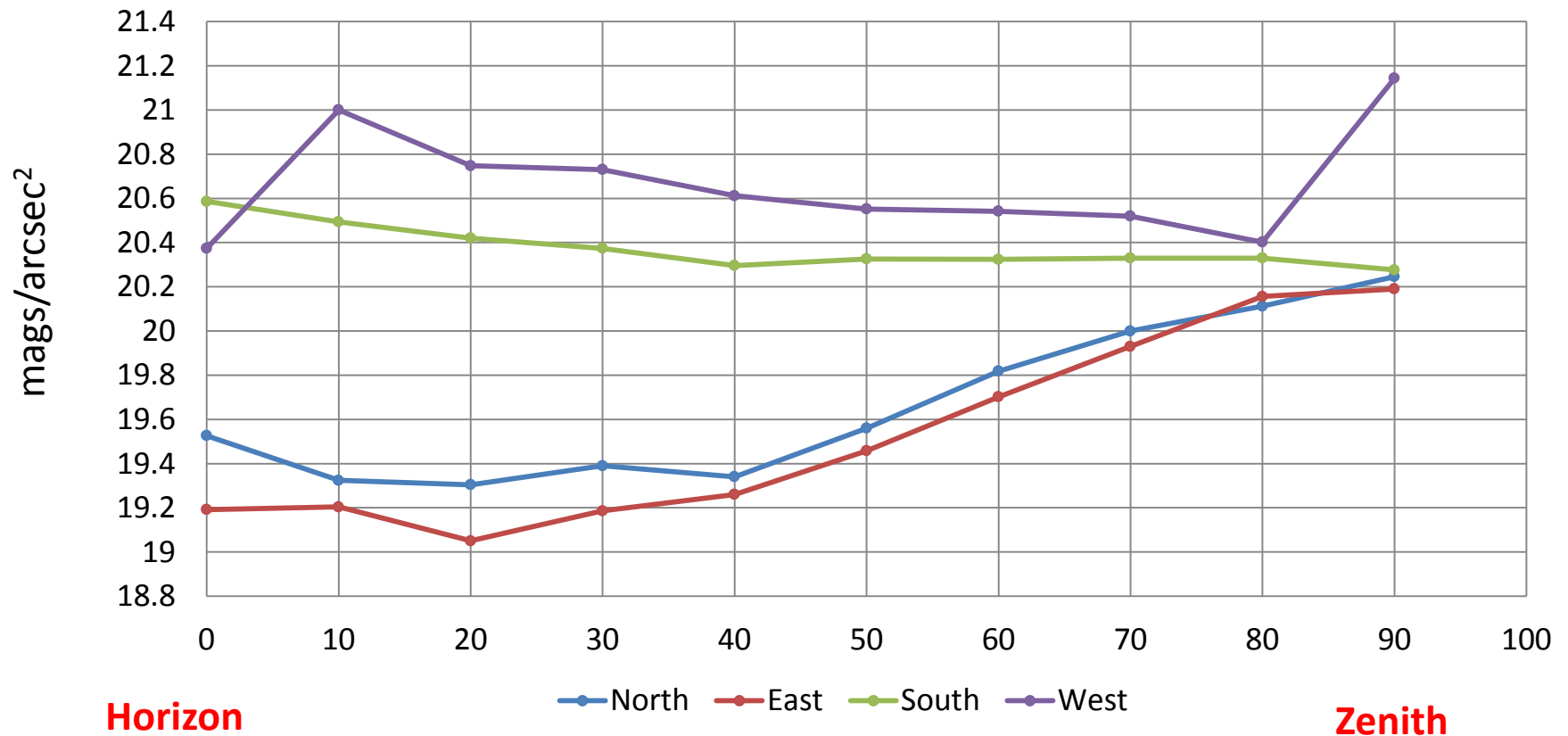
03/29/2016 - Truman State Observatory (Semi-Rural)





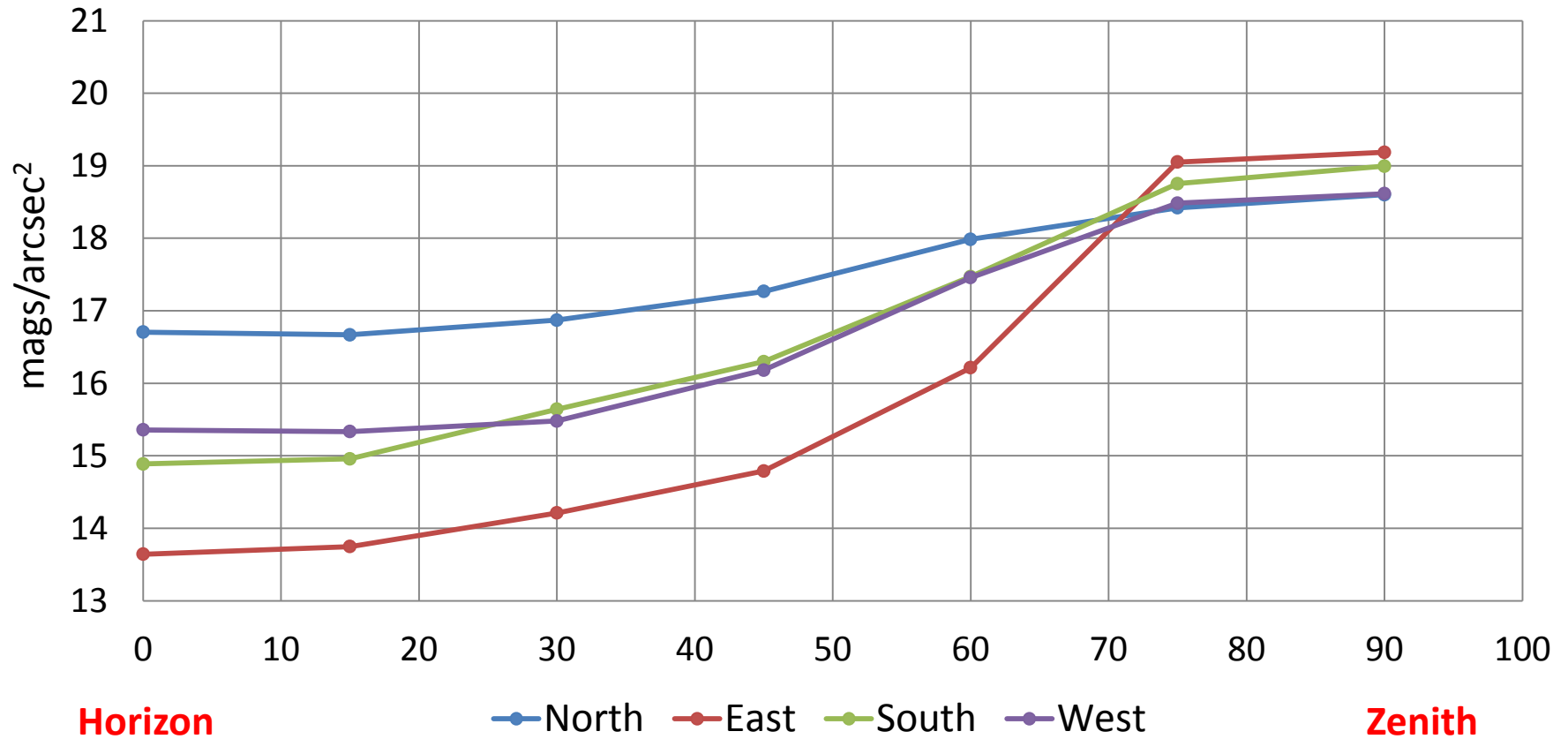
# Sky Brightness with Angle

07/20/2017 - Truman State Observatory (Semi-Rural)



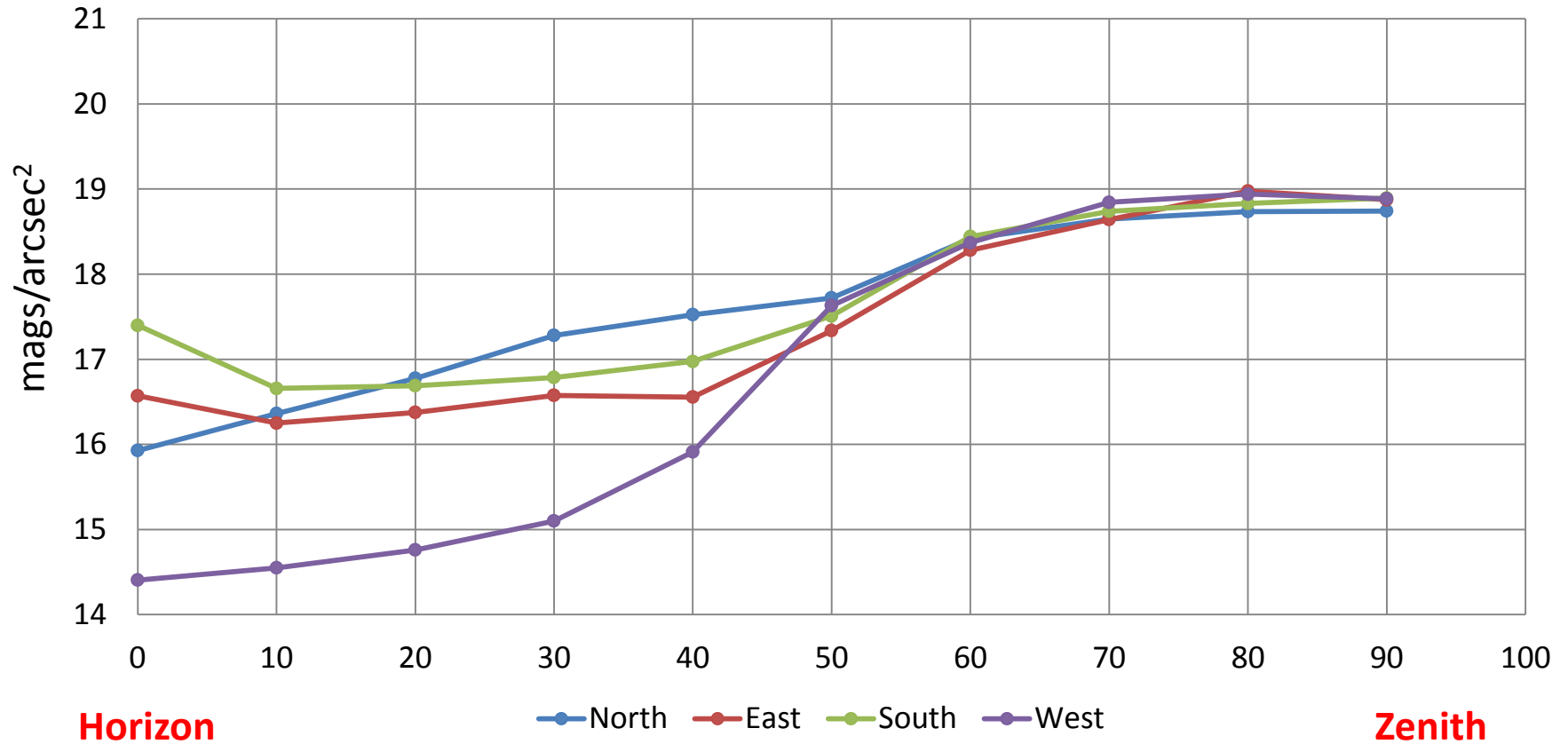
# Sky Brightness with Angle

04/02/2016 - Magruder Roof (City)



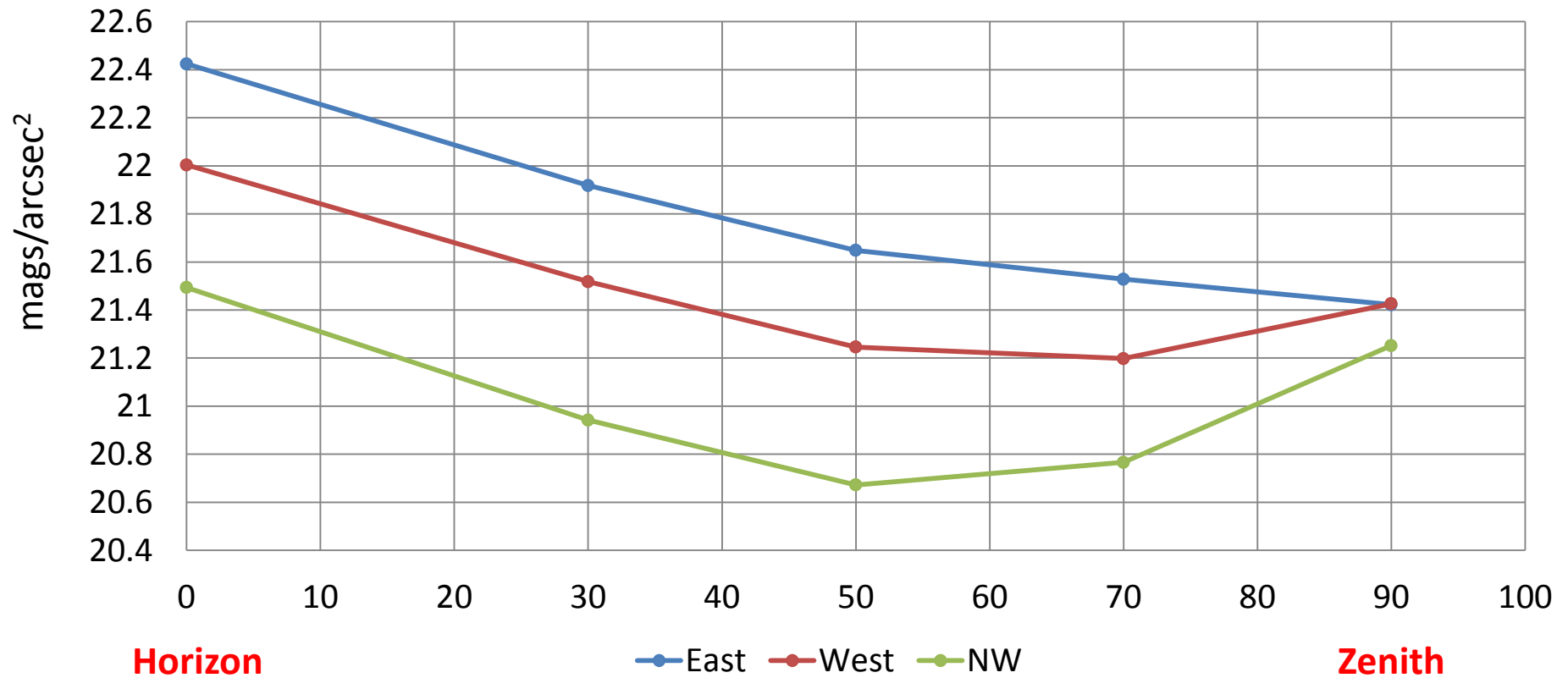
# Sky Brightness with Angle

07/23/2017 - Magruder Roof (City)



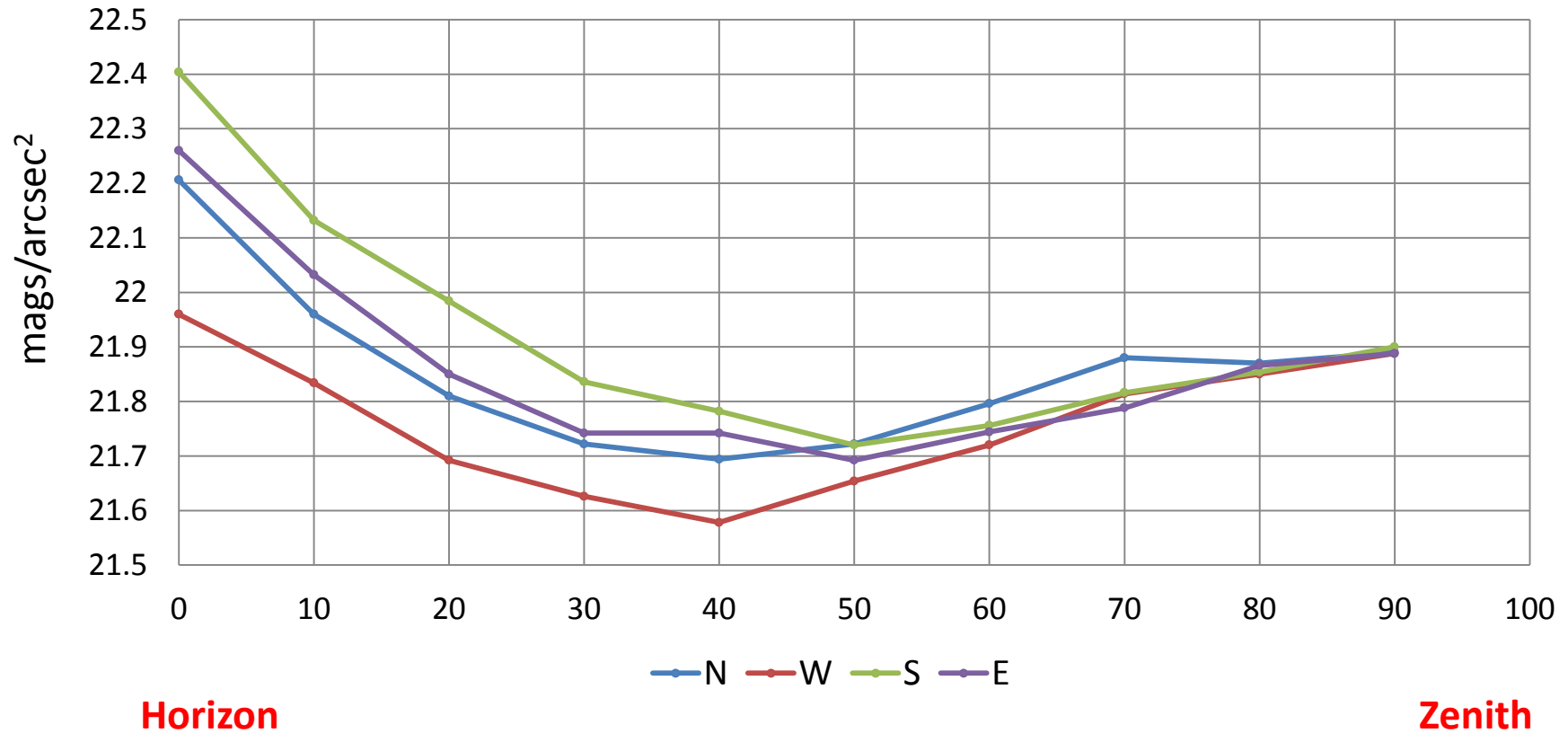
# Sky Brightness with Angle

03/10/2016 – Lowell, Observatory, Anderson Mesa  
(15 miles SE of Flagstaff)



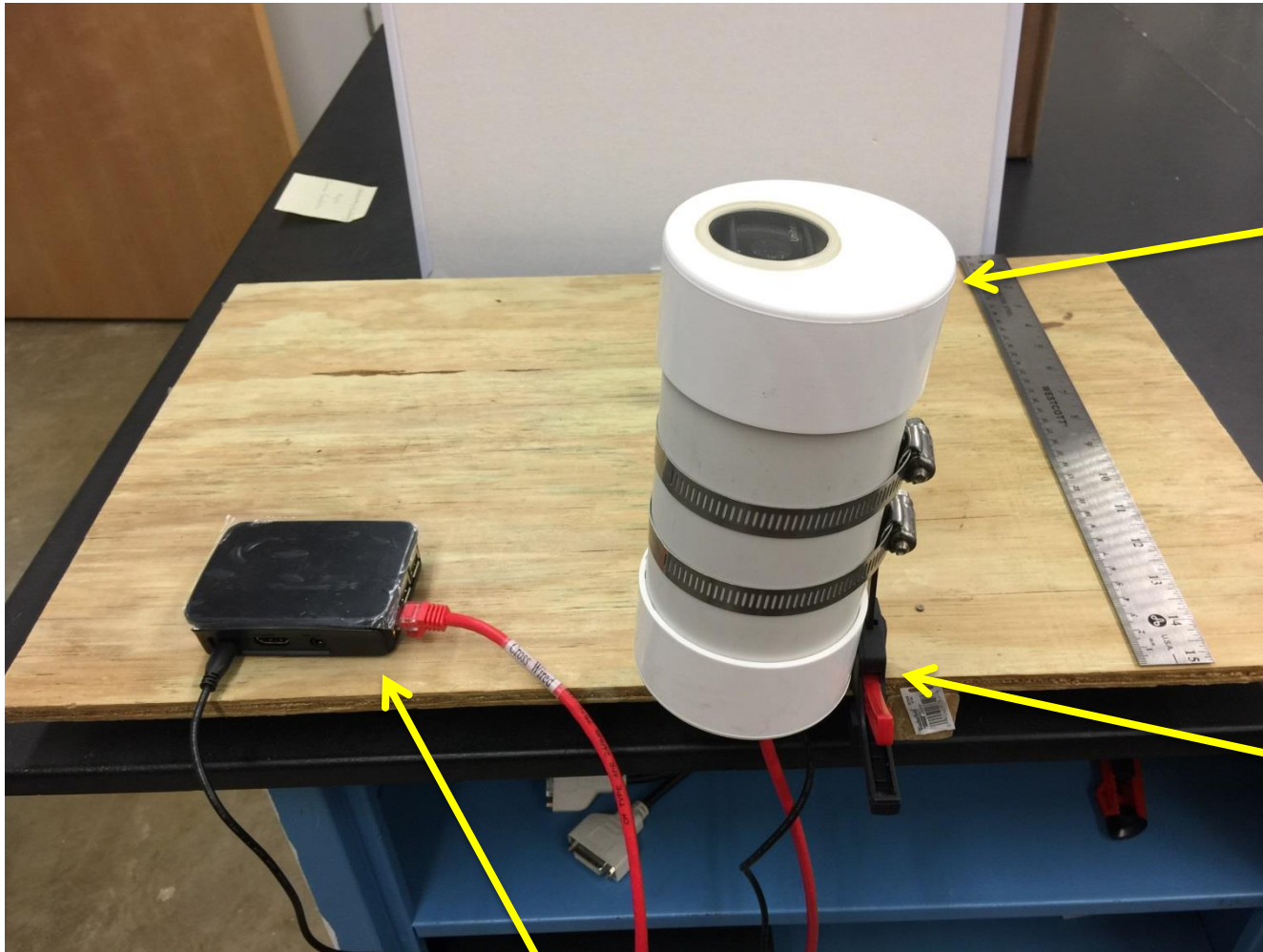
# Sky Brightness with Angle

05/24/2017 – Lowell Observatory, Anderson Mesa





# Continuous Sky Brightness Readings



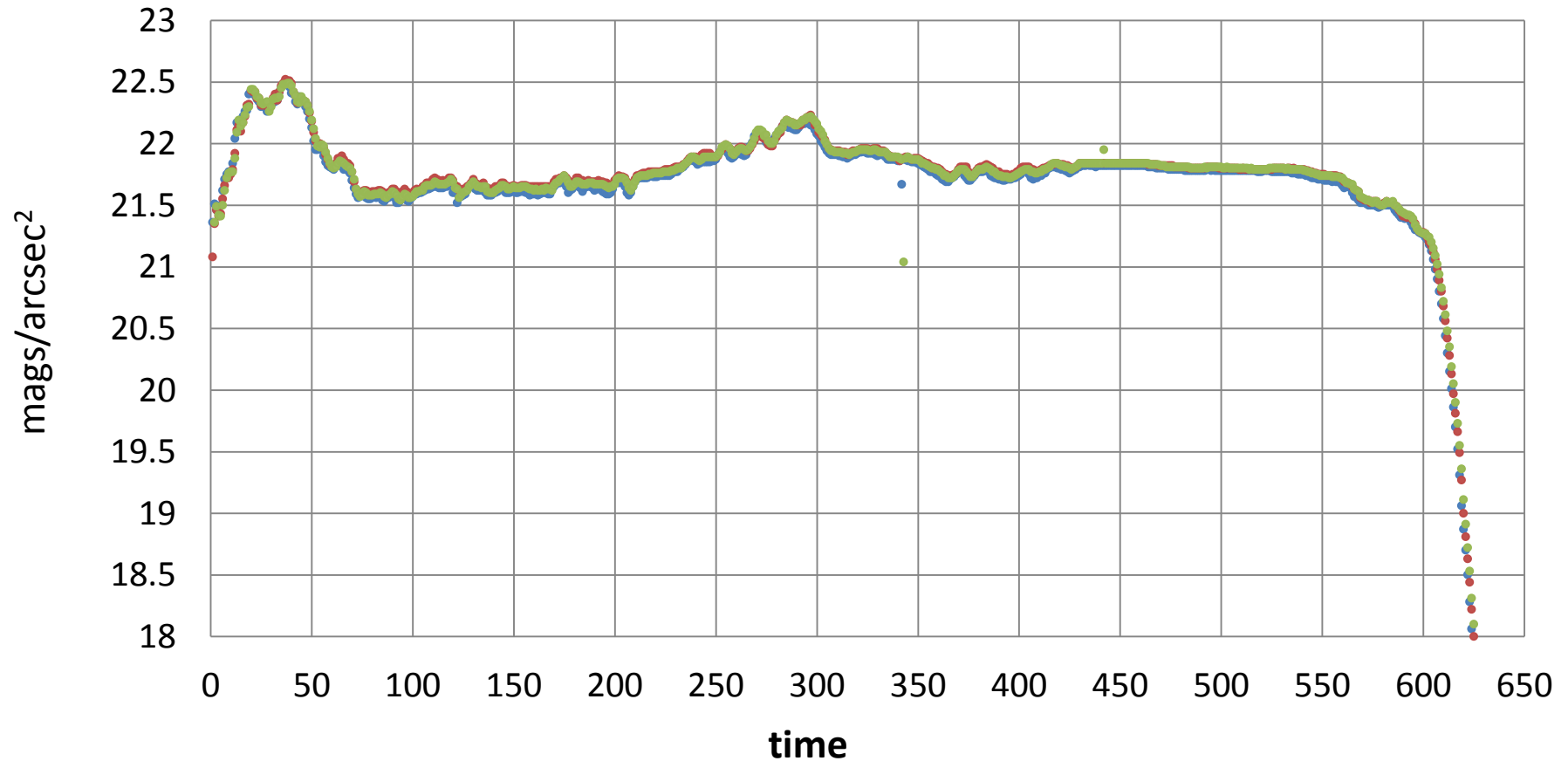
Weather-casing

Clamp

Rasp-pi

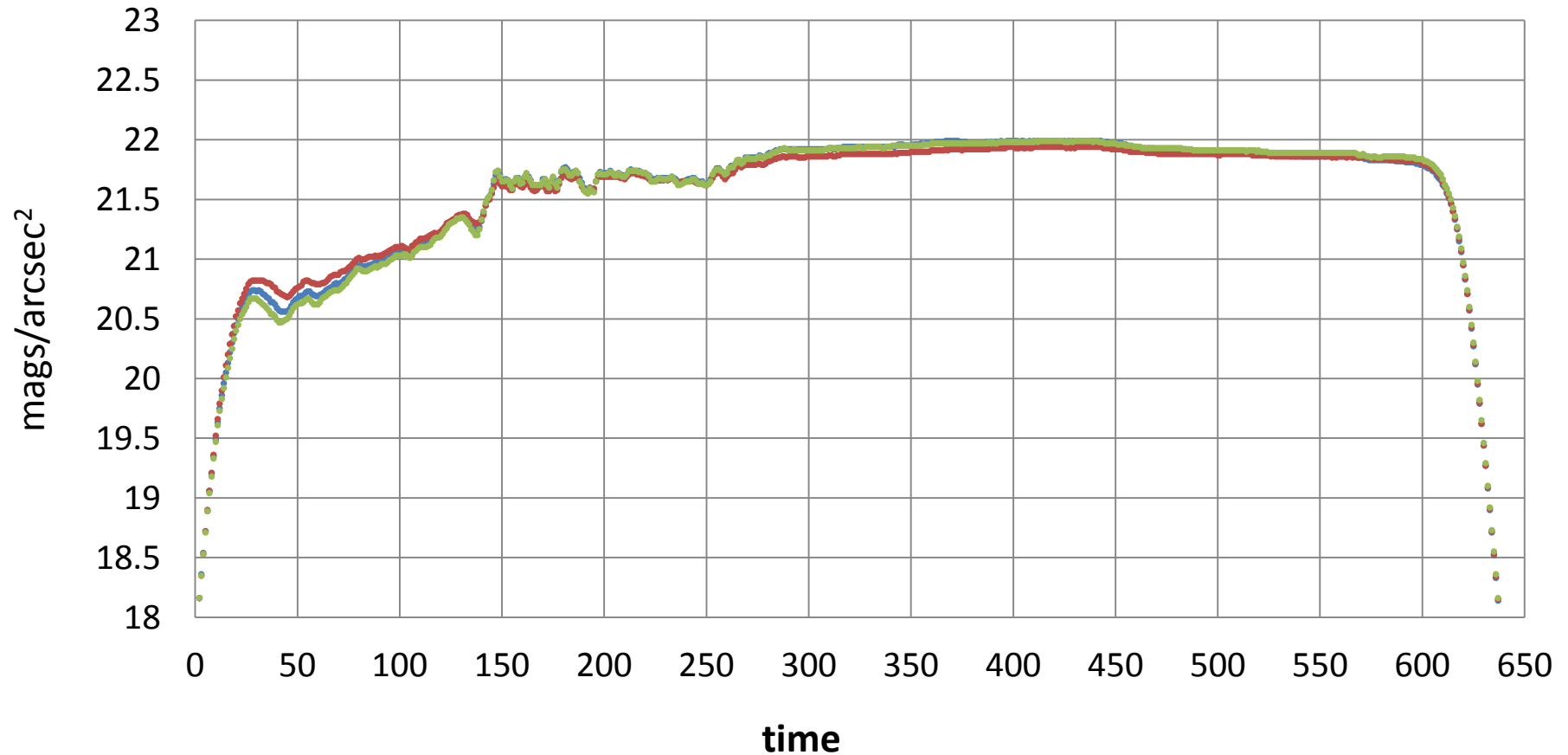
# Continuous Sky Brightness Readings

03/13/2018 -- Lowell Observatory, Anderson Mesa



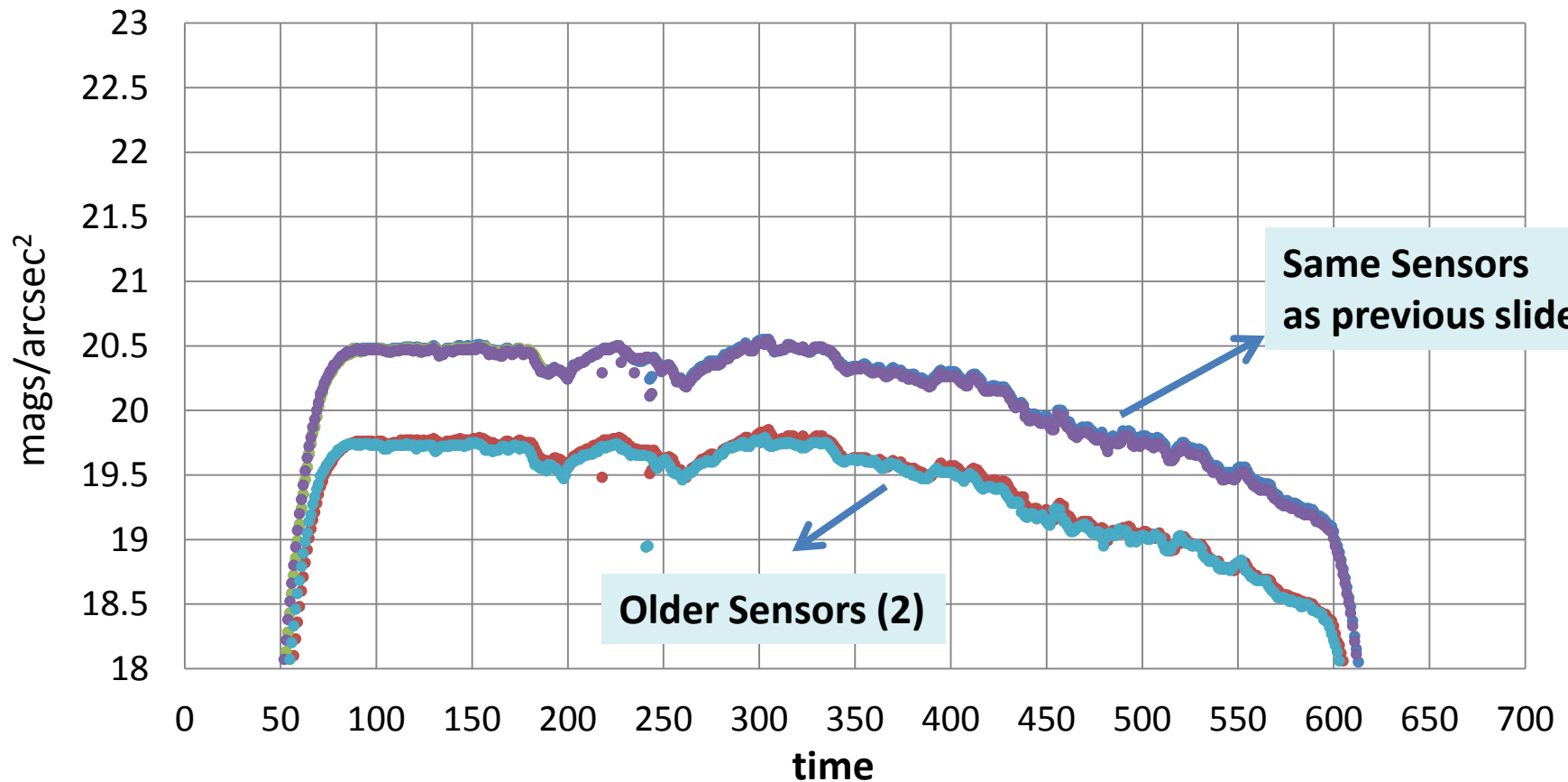
# Continuous Sky Brightness Readings

03/14/2018 -- Lowell Observatory, Anderson Mesa



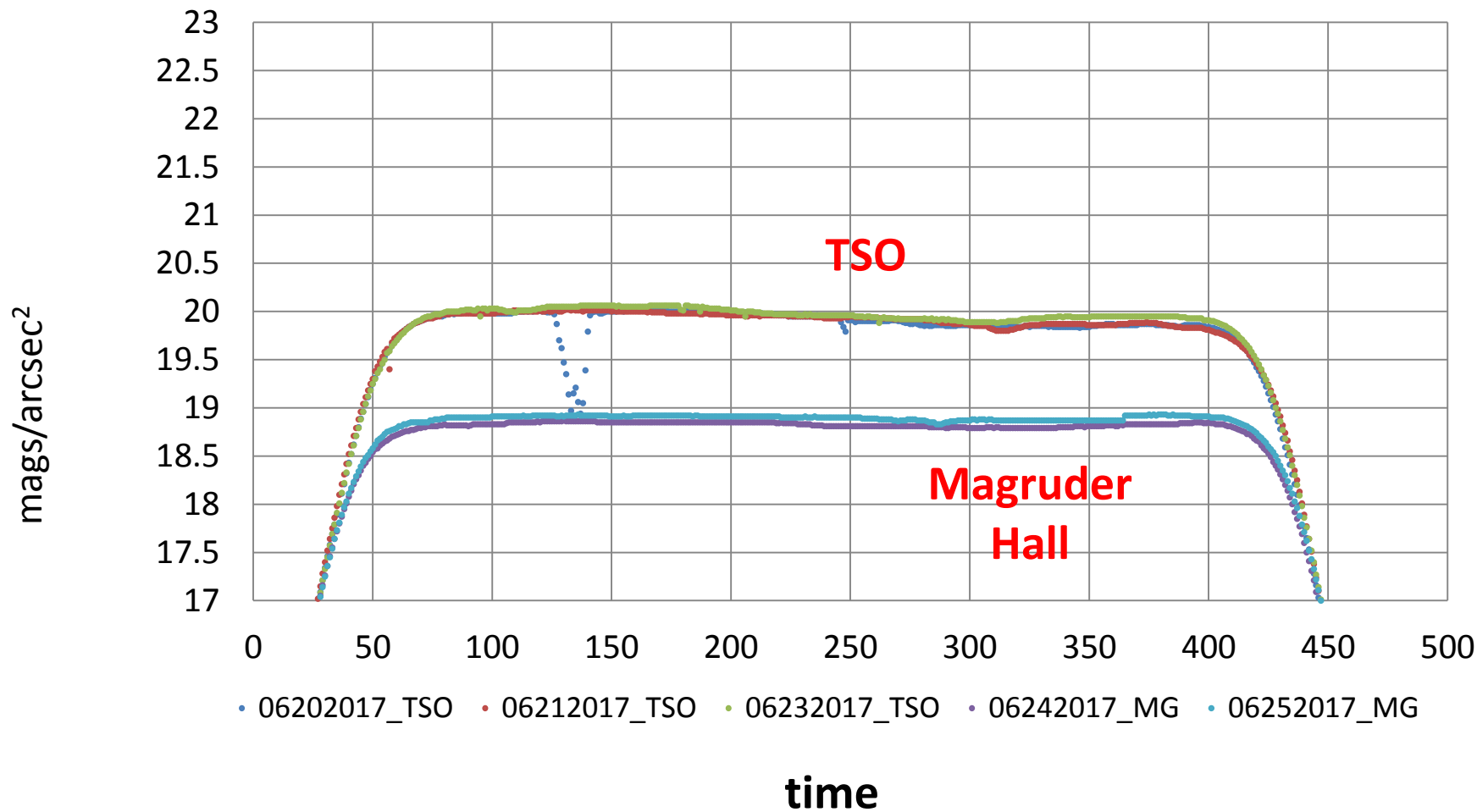
# Continuous Sky Brightness Readings

04/08/2018 – Truman Observatory, Kirksville



Not sure why there seems to be an offset – requires investigation

# Continuous Sky Brightness Readings Kirksville





# Light Pollution Mitigation

- Use low Temperature ( $T = 3000\text{ K}$ ) lights
- Retrofit 'dark sky friendly' shields on 'unfriendly' fixtures
- Contacting power companies and local administrators to ensure new fixtures are 'dark sky friendly'



# Testing Light Shields



# Testing Light Shields



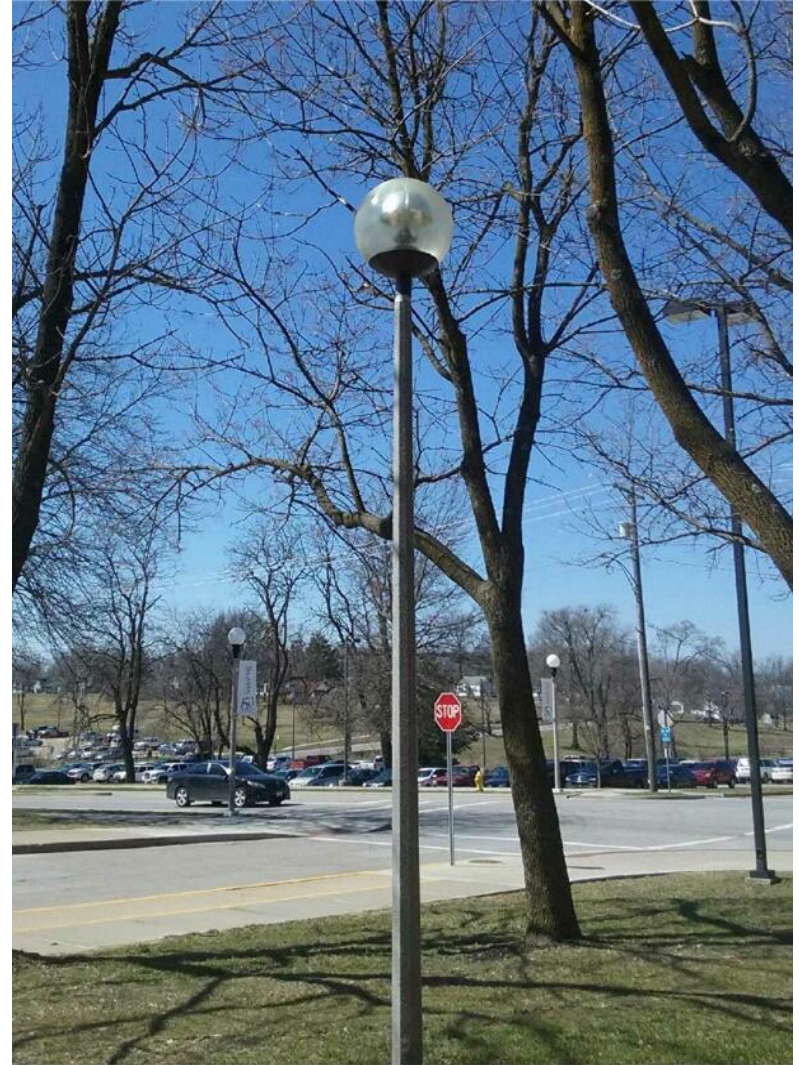
*Testing done in Del and Norma Robison  
Planetarium at Truman*

# Testing Light Shields

Setup	YODA (45 degrees above horizon)				DARTH VADER (Zenith)			
	Trial 1	Trial 2	Trial 3	Average	Trial 1	Trial 2	Trial 3	Average
complete Darkness	18.32				22.02			
no shield no globe + light	12.94	12.8	12.84	<b>12.86</b>	13.73	13.78	13.8	<b>13.77</b>
no shield with globe	13.31	13.29	13.29	<b>13.30</b>	13.98	14	14	<b>13.99</b>
shield no globe	15.92	15.42	15.58	<b>15.64</b>	16.14	16.1	16.19	<b>16.14</b>
shield and globe	15.17	14.72	14.94	<b>14.94</b>	15.94	15.93	15.98	<b>15.95</b>



# Testing Light Shields





# What can I do?

Galloway Forest Park, Scotland | Ja



- As astronomers, we have to act to stem the growing nuisance of light pollution.
  - The problem is going to get worse with the growing use of **LED lights**.
  - Be **proactive** about knowing what your school or city is planning in terms of outdoor lighting
    - Usually, administrators are receptive to our concerns, but tend to be ignorant about issues such as light pollution
    - Talking to them in time, will have positive impact with favorable outcomes
  - Urge your graduate and undergraduate **students** to bring up and pursue this issue through **student environmental groups** and **student senate**.



# Future Work

- We are looking for collaborators to set up light sensors on campuses to monitor light pollution, and testing the light sensors
- We are installing light shields and changing outdoor lighting color, and will report back what effect these actions have on the sky brightness in Kirksville

# References & Sources

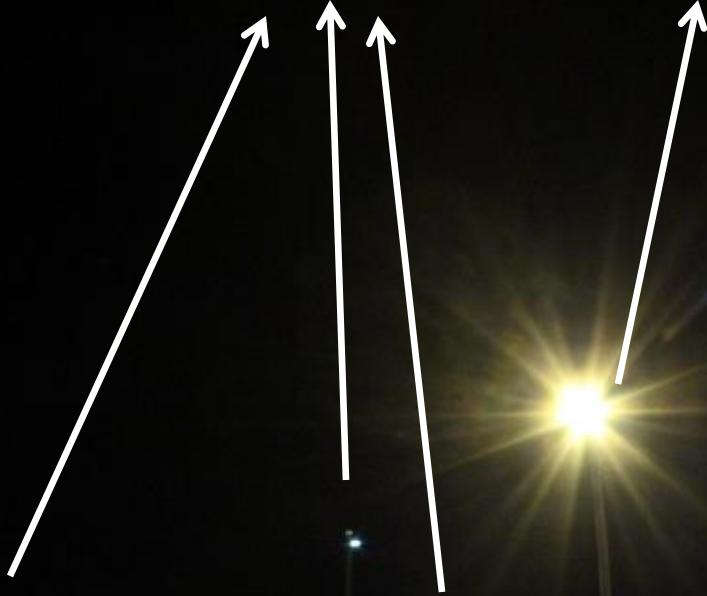
gokhale@truman.edu



- IDA website: <http://www.darksky.org/>
- Losing the dark sky movie: <http://www.darksky.org/night-sky-conservation/290>
- Light Sensor: <http://unihedron.com/projects/darksky/index.php>
- What happened to the Milky Way?  
<http://www.theatlantic.com/video/index/384755/the-night-sky/>
- Paul Bogard: 'The End of Night' (Book)  
<http://www.theatlantic.com/technology/archive/2013/07/let-there-be-night/278070/>
- Flagstaff Dark Skies: <http://www.flagstaffdarkskies.org/>
- National Parks Service:  
<http://www.nature.nps.gov/night/index.cfm>

# Extra Slides

# Good and Bad Lighting



Shaming the Admins  
Students: You pay for this!

Good



Bad



Notice the light going into the windows in the dorm rooms: Franklin Street



# Glare Bombs Galore: Franklin Street





# Glare Bombs Galore: Magruder/Violette Parking Lot

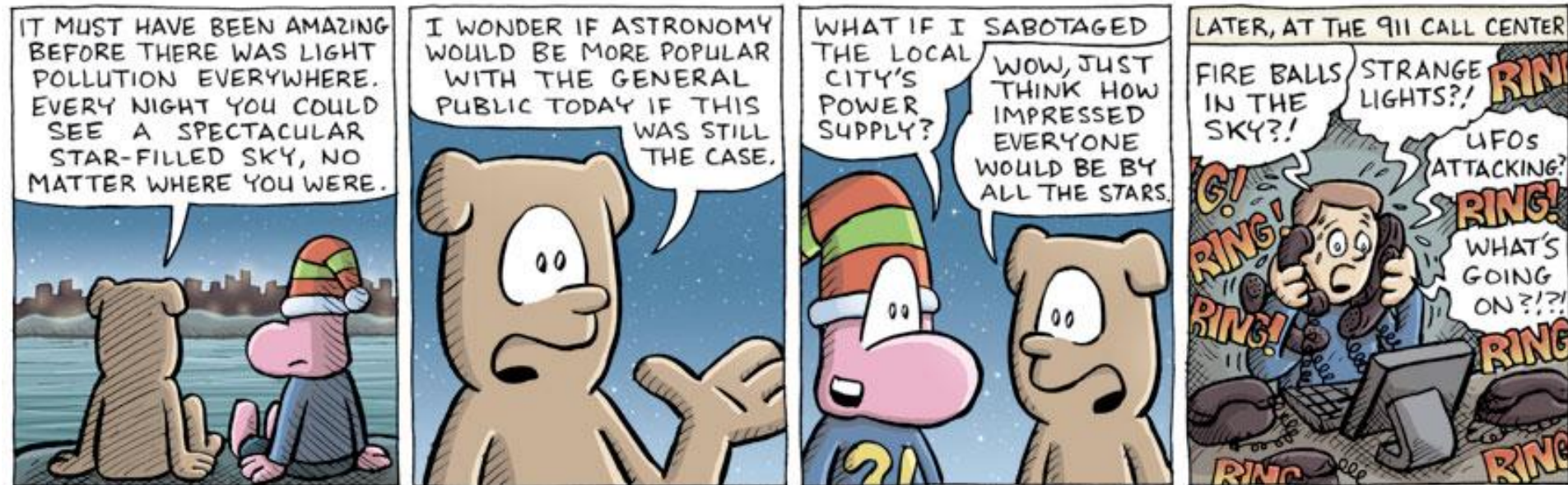


# Where we are Today



- “When a massive power outage struck southern California in the 1990s, Los Angeles residents reportedly called 911 to express alarm about strange clouds hovering overhead; they were seeing the Milky Way for the first time!” – Fraknoi

<http://www.pbs.org/seeinginthedark/astronomy-topics/light-pollution.html>



# Back of Envelope \$\$ Estimate



- A single **100 W bulb costs about \$25 to run for 12 hours a day for 365 days a year** (@\$0.12 per kW-hour).
- If approximately **30%** of light on average is ‘useless light’, **this amounts of about \$15 wasted per 100W light bulb.**
- Assuming 10,000 light fixtures (homes, apt complexes, street lights, gas stations, parking lots, offices, University etc) that are ‘on’ all night; **this amounts to \$150,000 wasted dollars per year.**
- And there is additional wastage from **excessive indoor lighting** as well.
- Add to this the environmental impact, and secondary expenses related to health.

# Back of Envelope Carbon Footprint Estimate



- 1 KW-hour corresponds to 10,768 BTU.
- $4.4 \times 10^6$  KW-hour per year is consumed by ten-thousand 50 W bulbs burning 12 hours a day.
- This corresponds to  $4.74 \times 10^{10}$  BTUs, which in turn corresponds to 2370 tons of coal, or 8170 barrels of oil.
- If 30% of this is wasted as glare or sky-glow; this corresponds to about **700 tons of coal**, or **2500 barrels of oil per year**.



# What can I do?

<http://www.darksky.org/assets/documents/PG3-residential-lighting.pdf>

**2** PG 3: Residential Lighting



George Fleenor  
The glare from an unshielded light creates deep shadows.



George Fleenor  
The glare from the light hid a possible attacker.

**Don't hesitate to ask your**

## Practical Actions:

1. **Make friends, not enemies.** Your neighbors probably don't realize the light is bothersome.
  - Always approach people in a friendly, non-threatening way.
  - Don't argue. Be tactful and understanding about their right to light their property.
  - Don't dismiss their need to feel safe.
  - Suggest alternatives to their current fixture. Ask them to move the light, shield it or add a motion sensor.
  
2. **Be informative.** Talking to your neighbor is an exciting chance to be an advocate for good lighting and share knowledge on an important issue.
  - There are many reasons to use dark sky friendly lighting. IDA sound bites can help to convey the benefits:
    - » Dark sky friendly lighting does not mean dark ground.
    - » Safety is important, but brighter does not mean safer.
    - » A starry sky is a natural resource.
  - The topics of safety, energy savings, cost, wildlife are addressed briefly in this document. Additional articles and brochures from the IDA Web site are downloadable and free for use.
    - » Print off free materials from the IDA Education tab and present this information to your neighbor.

# Light Pollution Group At Truman



- **Inventory** of outdoor lighting
  - Street Lights
  - Parking Lots and Gas Stations
  - Truman & ATSU
  - Apt Complexes & Houses
- **Contact administrators** and city of Kirksville officials to accumulate data, assess the present **protocols** regarding outdoor lighting.
- **Contact the city police and Truman police** regarding the **safety** aspects of outdoor lighting.
- **Interface with other student groups** (student health, green-initiatives etc).
- Look for **funding opportunities** to assess, plan and implement improvements to outdoor lighting fixtures across the community.

# Consequences of Light Pollution

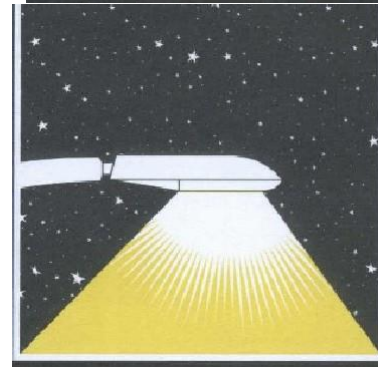
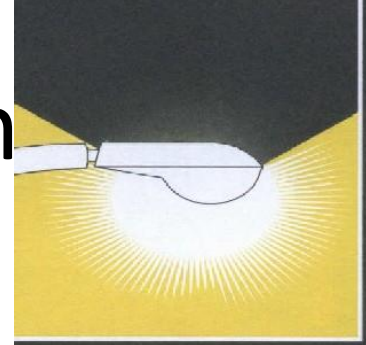
- Unshielded light sources

- **Waste energy**

- As much as 30% of outdoor lighting is beamed upward, toward the sky, rather than toward the ground.

- **Are unsafe (very counterintuitive)**

- Glare from misdirected bright lights can blind you.
    - The human eye is a remarkable instrument capable of seeing very faint objects.
    - However, if the brightness ratio between two objects is greater than 20:1; the eye cannot discern objects around the glaring light, rendering us vulnerable to an ambush.





# Non-shielded lights are unsafe

- The glaring lamp to the right of the path was installed to protect.



# Where did the student go?



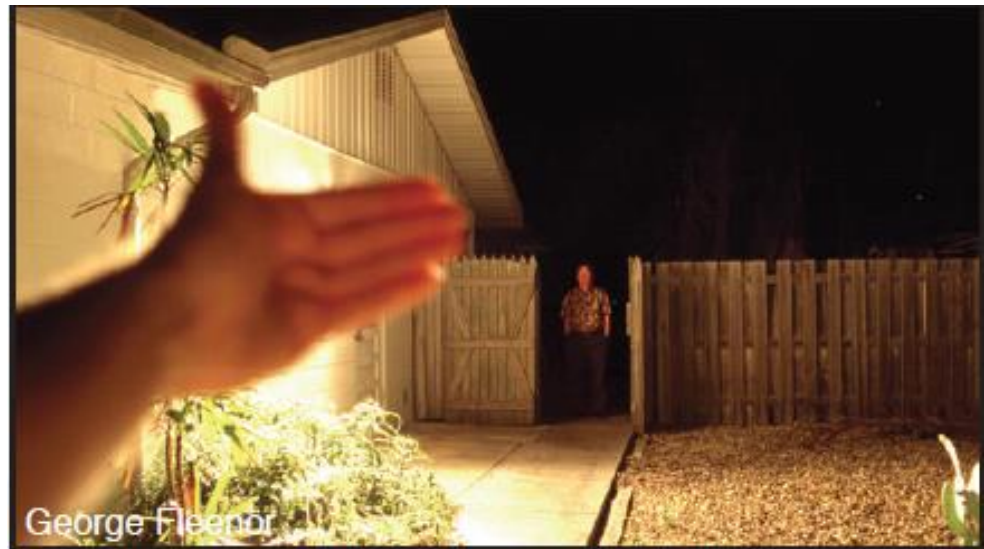
IDA in Partnership with NOAO, NSF and IYA  
Dark Skies Awareness

# Examples of Bad Lighting



George Fleenor

The glare creates deep shadows.



George Fleenor

The glare from the light hid a possible attacker.



# Examples of Bad Lighting



Martin Morgan-Taylor

Overly bright light can mask intruders.



Martin Morgan-Taylor

With the light shielded, the intruder is easily seen.

# Light Pollution

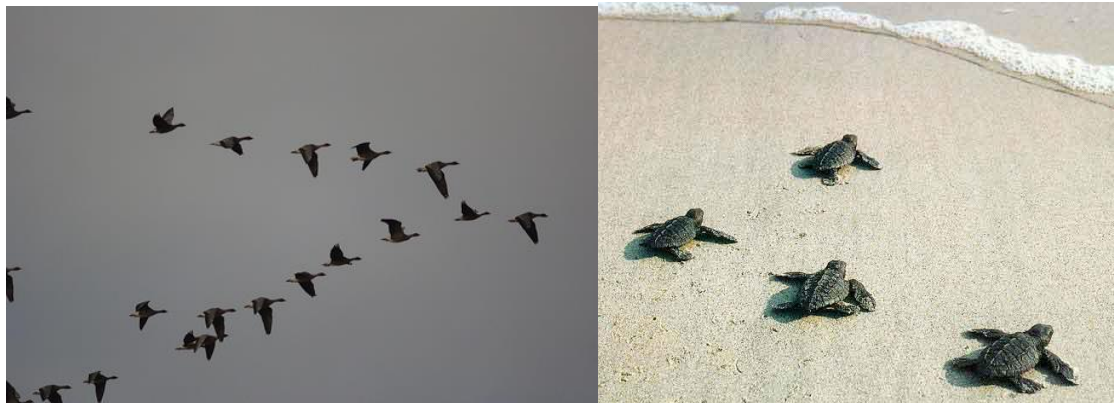


- Unshielded light sources
  - **Negatively impact animals, including humans.**
    - Disturbs *Circadian* rhythm, resulting in insomnia, depression, cancer and cardiovascular disease.
    - The ‘blue’ portion of light is especially harmful since exposure to it affects release of the hormone *Melatonin*.
    - In 2009, the AMA adopted resolutions that support reduction of light pollution and glare; and advocate for energy efficient, fully shielded outdoor lighting.

# Light Pollution



- Unshielded light sources
  - **Negatively impact animals, including humans.**
    - 100 million birds a year throughout North America die in collisions with lighted buildings and towers.
    - Artificial lights can also cause migrating birds to wander off course and never reach their natural destination.



# Light Pollution



- Unshielded light sources
  - **Negatively impact astronomy**
    - In astronomy, the role of ‘experimentation’ is largely taken by ‘observations’.
    - These observations are based on light (gamma rays, x-rays, uv, visible, IR, Radio etc) emitted by objects at immense distances from Earth.



# Light Pollution



- Unshielded light sources
  - **Negatively impact astronomy**
    - It is on the basis of studying the properties of this light that astronomers are able to piece together what the properties of the emitting object are.
    - Sky glow interferes with astronomers' ability to look the quality and quantity of light coming from these objects.
    - Sky glow decreases the ability to see fainter stars, meteor showers and nebulae; and thus affects stargazing and amateur astronomy.

# Unnecessary Indoor Light

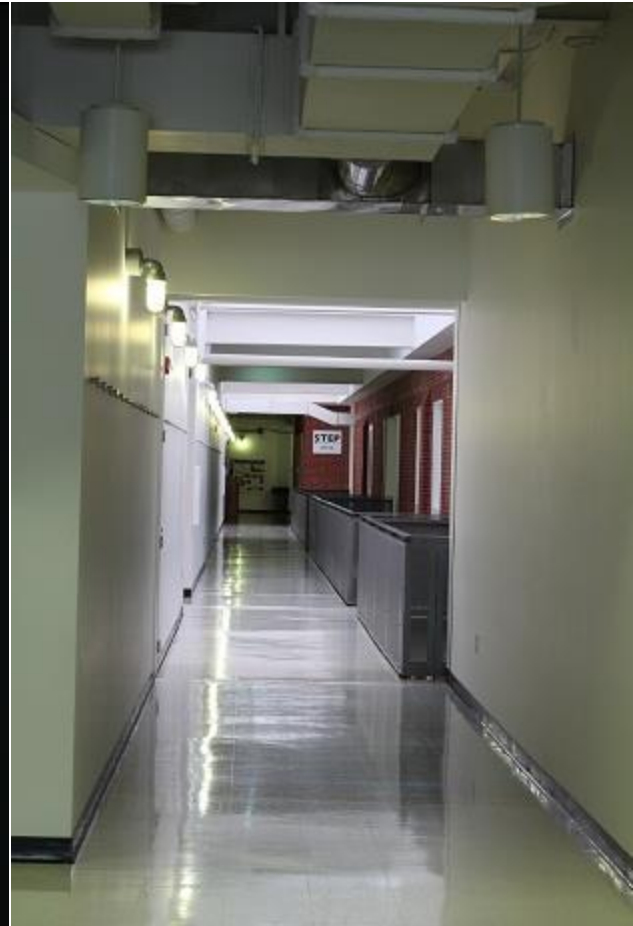


Tube-lights illuminating ceiling tucked above vents in Magruder

# The luminous beauty of the wires and pipes in Magruder

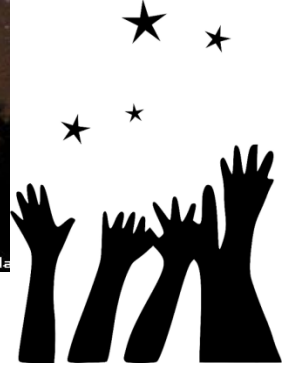


# Blazing away to glory in broad daylight



# What can I do?

Galloway Forest Park, Scotland



- Pima County, which includes Tucson, has the following ‘light ordinance’ in effect:

*The purpose of this code is to preserve the relationship of the residents of the City of Tucson, Arizona and Pima County, Arizona to their unique desert environment through **protection of access to the dark night sky**. Intended outcomes include **continuing support of astronomical activity and minimizing wasted energy**, while **not compromising the safety, security, and well being of persons engaged in outdoor night time activities**. It is the intent of this code to control the **obtrusive aspects of excessive and careless outdoor lighting** usage while preserving, protecting, and enhancing the lawful nighttime use and enjoyment of any and all property. It is recognized that developed portions of properties may be required to be unlit, covered, or have reduced lighting levels in order to allow enough lumens in the lighted areas to achieve light levels in accordance with nationally recognized recommended practices.*