AGA5802
Earth Atmosphere

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What “environmental conditions” for an observation?

- Lunar illumination (dark, grey, bright)
- Cloud coverage (photometric, thin, thick,...)
- Humidity
- Precipitable Water
- Seeing

Transparency

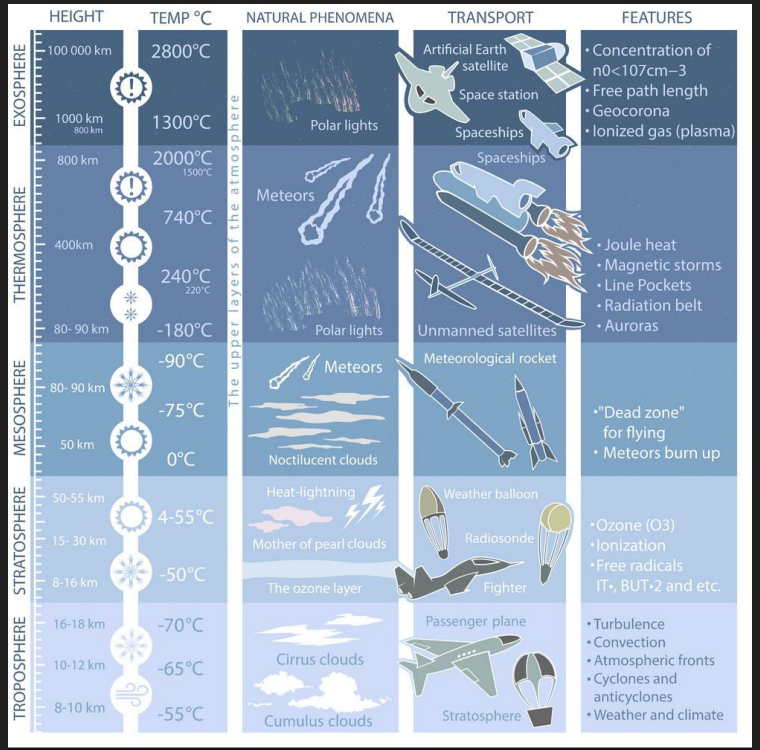
The structure of the atmosphere

Temperature change not monotonic

Density change is monotonic

For scaling:

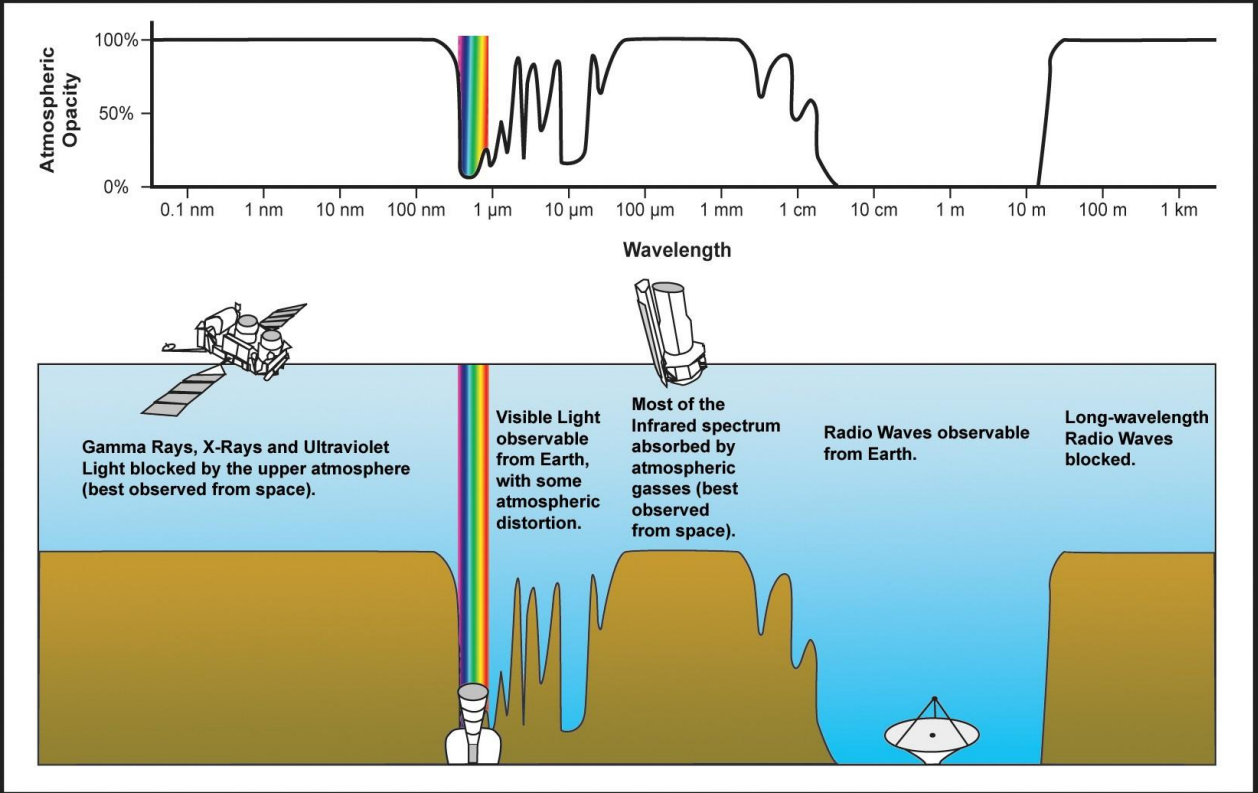
- Everest is 8,848m high
- Planes fly at ~ 10,000m
- Atmosphere “ends” at 80-100km



Not all wavelengths are affected in the same way

High energy radiation does not reach the Earth surface.

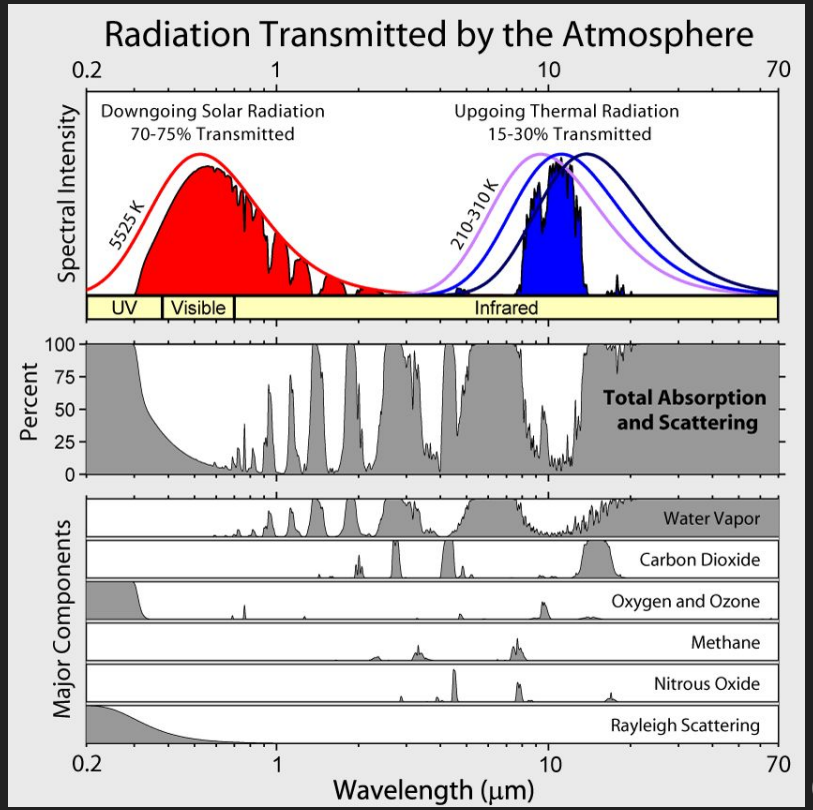
There are some “windows” in infrared and in “radio”.



Different effects are due to different sources

These effects not only are always present but they **vary**

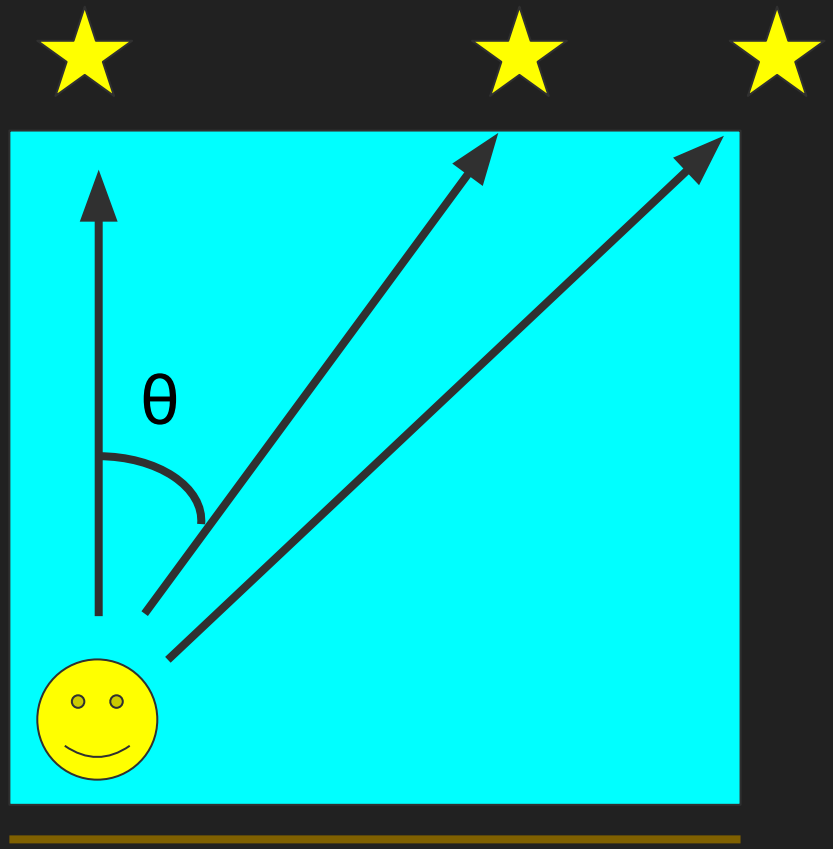
The real ability of the observer is to be able to deal with these effects.



The airmass

The further from zenith, the more atmosphere is between the observer and the star.

Airmass Z = sec θ



Bad transparency does not mean clouds

… but clouds mean bad transparency.

In practical terms

Ideally you will try to observe to minimise the amount of atmosphere

High elevation / Small zenithal distance / Small Airmass

Often measure extinction on your science images. In some cases, off of an extinction “monitor” (a dedicated telescope)

Depending on the type of science, you can observe through clouds:

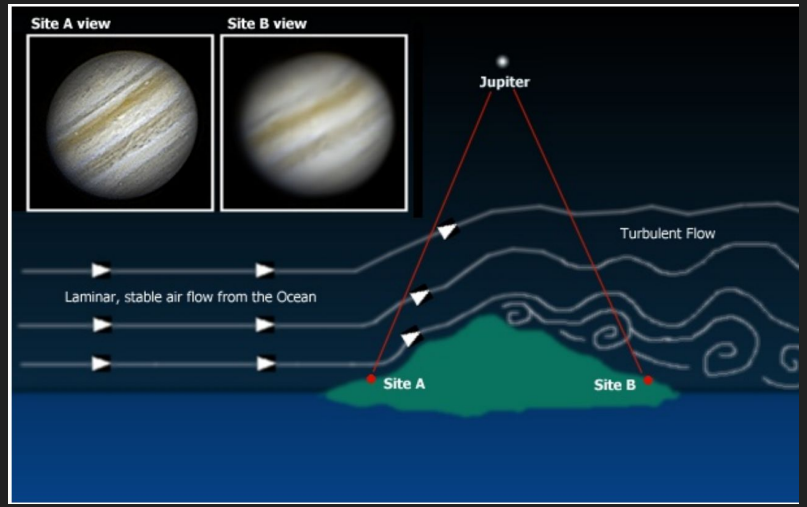
- Absolute photometry -> “photometric night”
- Differential photometry -> some cirrus is still ok
- Spectroscopy -> Even some thick cloud is ok

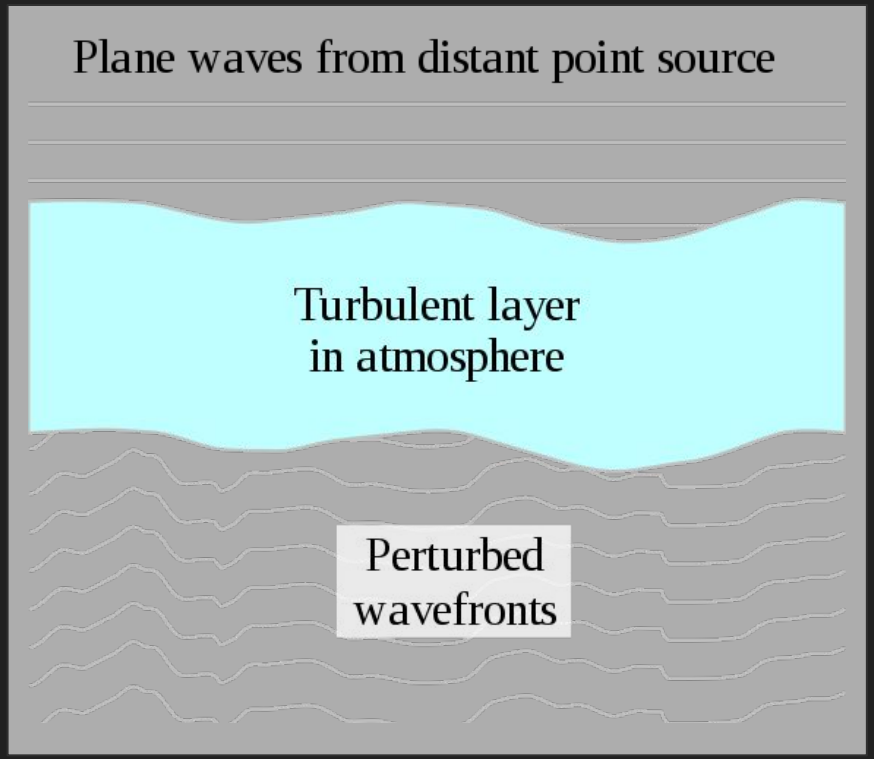
Turbulence

Laminar flux vs. non-laminar flux

Depends on

- Orography
- Wind speed / direction



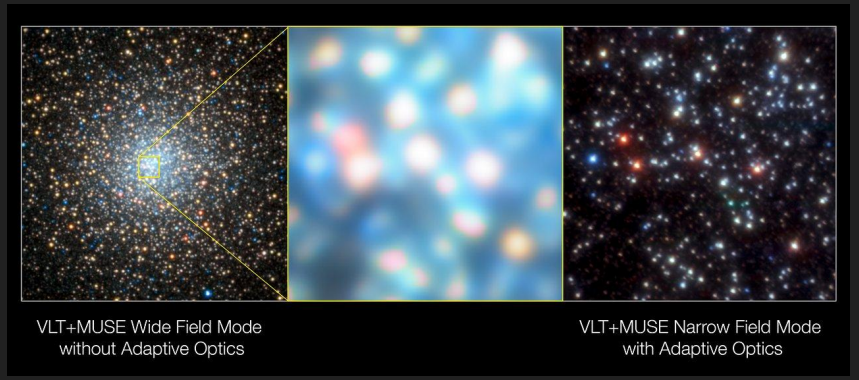


http://www.ifa.hawaii.edu/~meech/a281/handouts/seeing.pdf

Seeing and psf

The size of a point source observed through a circular aperture is the radius of the Airy disk:

$r = 1.22 \lambda / R$



This is the “diffraction limit” of our telescope

Where λ is the wavelength of your observation and R is the diameter of the telescope.

$psf_{observed}^2 = psf_{telescope}^2 + seeing^2$

In practical terms

You can’t modify the psf of your telescope

The smaller the seeing, the better.

(Yes, even with adaptive optics)

Seeing depends on site, but roughly speaking:

- < 0.8” is good / excellent
- 0.8” - 1.5” ok
- > 1.5” bad

Not all instruments “like” excellent seeing (e.g. HARPS “prefers” a 1.0” seeing)

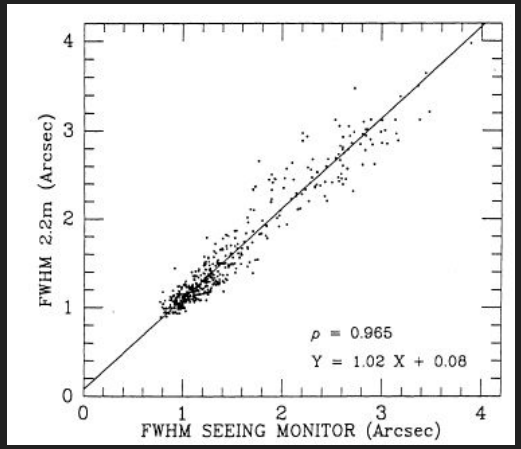
The DIMM

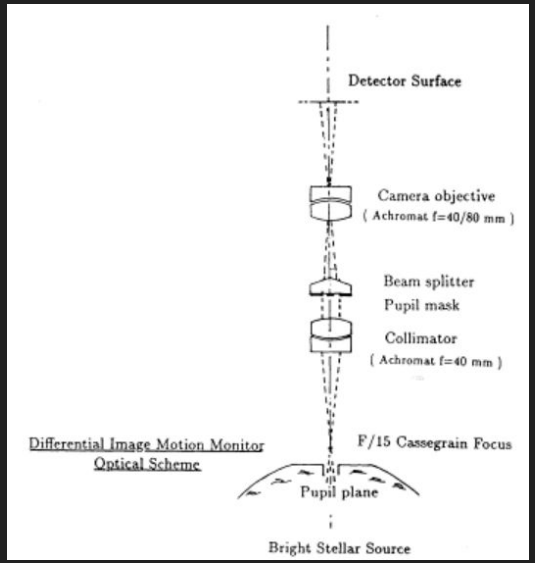
Differential Image Motion Monitor (Sarazin & Roddler 1990)

It is the most common way to measure the seeing.

It is based on the motion of two images of the same star in the focal plane. This measures the tilt of the wavefront and it correlates well with the seeing.

https://www.astro.auth.gr/~seeing-gr/seeing_gr_files/theory/node1.html





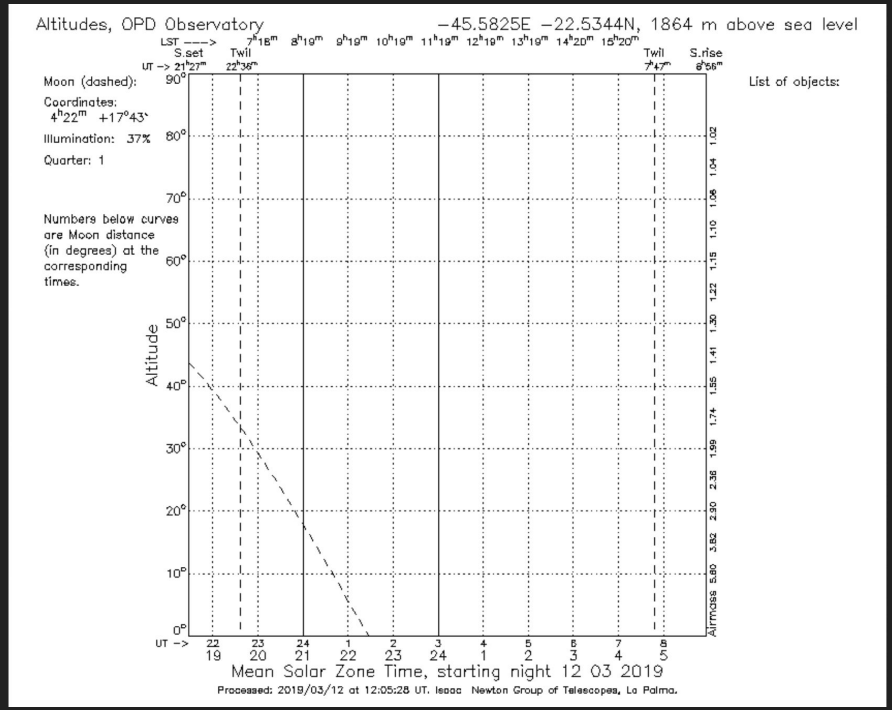
Sun and Moon

The Sun

Sunrise and Sunset are the moments when the (geometric) centre of the Sun has 0º elevation.

The astronomical night is the time when the Sun has an elevation of less than -18º

The time when the sun has -18º<*h*<0º is called “twilight”.



The Moon

Patat, F. 2004, The Messenger, 118, 11

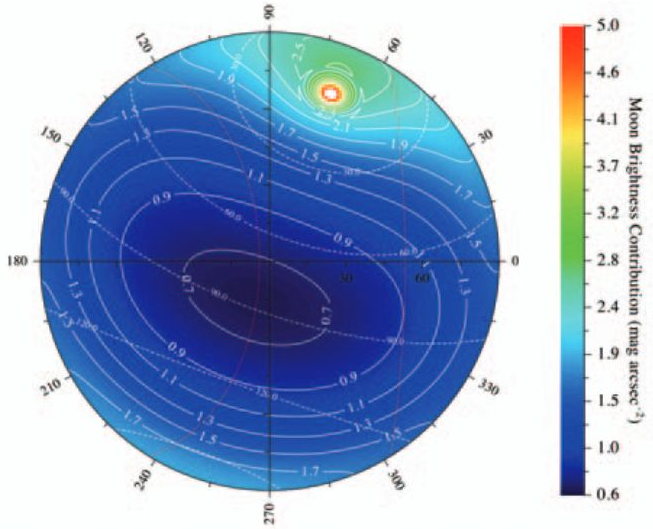


Figure 5: Example isophotal *alt-az* map for the expected moonlight contribution. The dashed white lines trace the loci at constant angular distance from the moon, while the two dotted red lines indicate the extreme apparent lunar paths during a full Saros cycle.

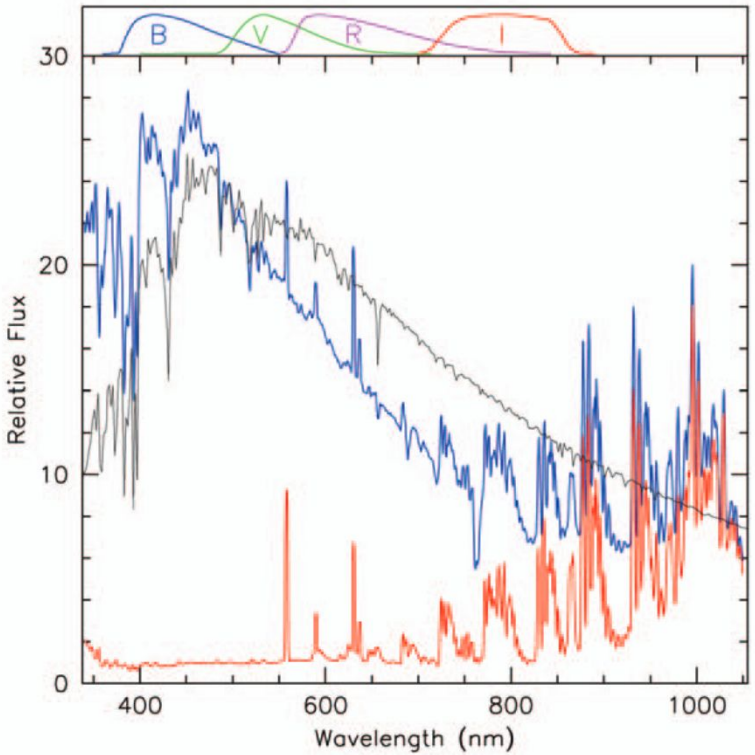


Figure 2: Comparison between the night sky spectrum during dark time (red line, Patat 2003) and bright time (blue line). The latter was obtained with FORS1 on September 1, 2004 using the low dispersion grism 150I and no order sorter filter. Due to the very blue continuum, the spectral region at wavelengths redder than 650 nm is probably contaminated by the grism second order. Both spectra have been normalized to the continuum of the first one at 500 nm. For comparison, the model spectrum of a solar-type star is also plotted (black line). For presentation, this has been normalized to the moonlit night sky spectrum at 500 nm. The upper plot shows the standard *BVRI* Johnson-Cousins passbands.

In practice

If you need low background, you wait for astronomical night and observe without Moon.

You can measure it directly on your images or you can get a “Sky Quality Meter”.

High resolution spectroscopy can observe in twilight.

Near-infrared observations are less affected by moonlight.

In the real world

The ESO Meteo Monitor

La Silla Meteo Monitor

La Silla All Sky Camera

The LNA Weather Station

Exercises

Where do I put a telescope to observe in ultraviolet (1000-3000Å)? Space, Mauna Kea or Rio de Janeiro?

How do observe a galaxy for 10 hours (in order to get enough signal)?

Can I observe Sirius with Full Moon from OPD tonight? And the Hubble Deep Field?

Can I achieve diffraction limited images with adaptive optics with an 8m class telescope from São Paulo?