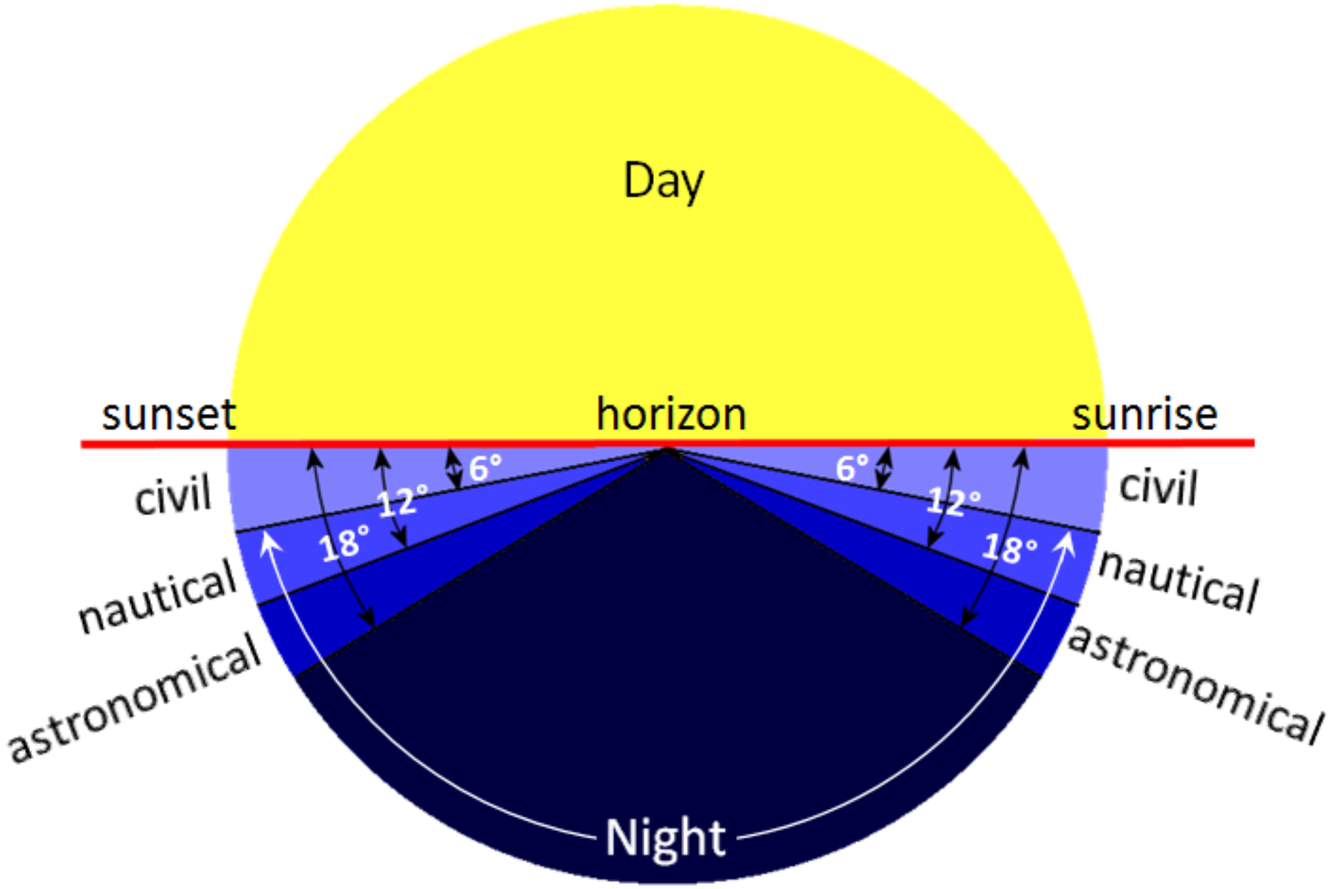
Error sources in Photometric Measurements

Scattered sunlight



Solar events	Local time
Sunset	Thu, 30 Oct 2025 at 18:23:53
End of civil twilight	Thu, 30 Oct 2025 at 18:40:14
End of nautical twilight	Thu, 30 Oct 2025 at 19:09:17
End of astronomical twilight	Thu, 30 Oct 2025 at 19:38:02
Start of astronomical twilight	Fri, 31 Oct 2025 at 05:56:28
Start of nautical twilight	Fri, 31 Oct 2025 at 06:25:15
Start of civil twilight	Fri, 31 Oct 2025 at 06:54:20
Sunrise	Fri, 31 Oct 2025 at 07:10:42
Length of night (sunset-sunrise)	12:47
Length of astronomical night	10:18

Civil, nautical, astronomical twilights are arbitrarily defined “official” types of twilights.

Moonlight

Dark time -- time when moon is less than 1/4 full (within about 3-4 days of New Moon).

Bright time -- when the moon is more than half full (i.e., time within about a week of Full Moon).

At bright time of the month usually schedule either: (1) work on bright objects, particularly spectroscopy, or (2) infrared observations, which are not as affected by the moonlight compared to optical.

Grey time — the rest of the month, time near First or Third Quarter Moon

Moon	
Rises	Thu, 30 Oct 2025 at 14:32:29
Sets	Fri, 31 Oct 2025 at 02:05:11
Altitude at midnight	20.0°
Illuminated fraction	0.66
Days past full	24
Next full moon	Wed, 5 Nov 2025 at 13:20:25

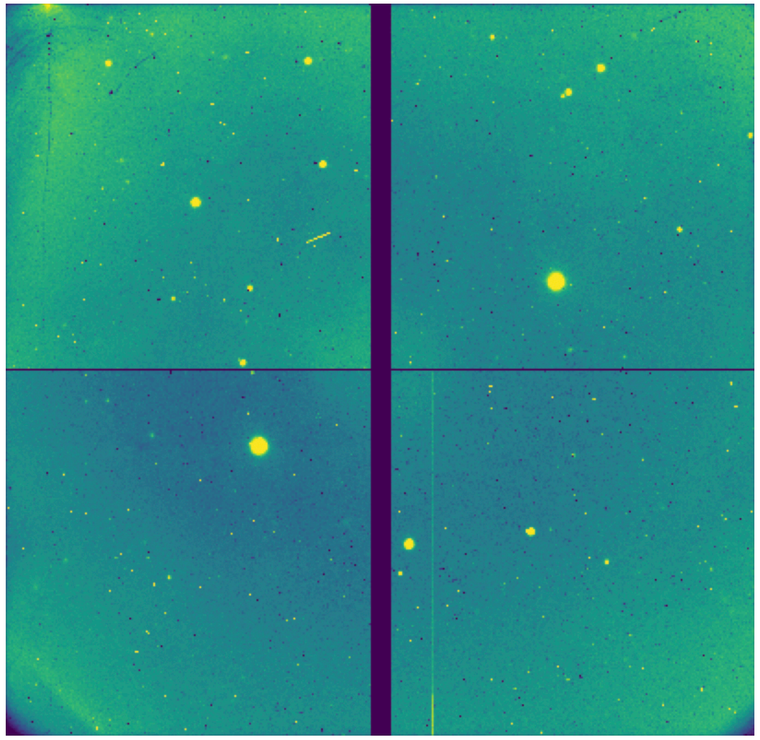
Sky background as a function of wavelength

Table 1.5. Typical brightness of the night sky for each photometric band at a high-altitude site, in magnitude per arcsecond square

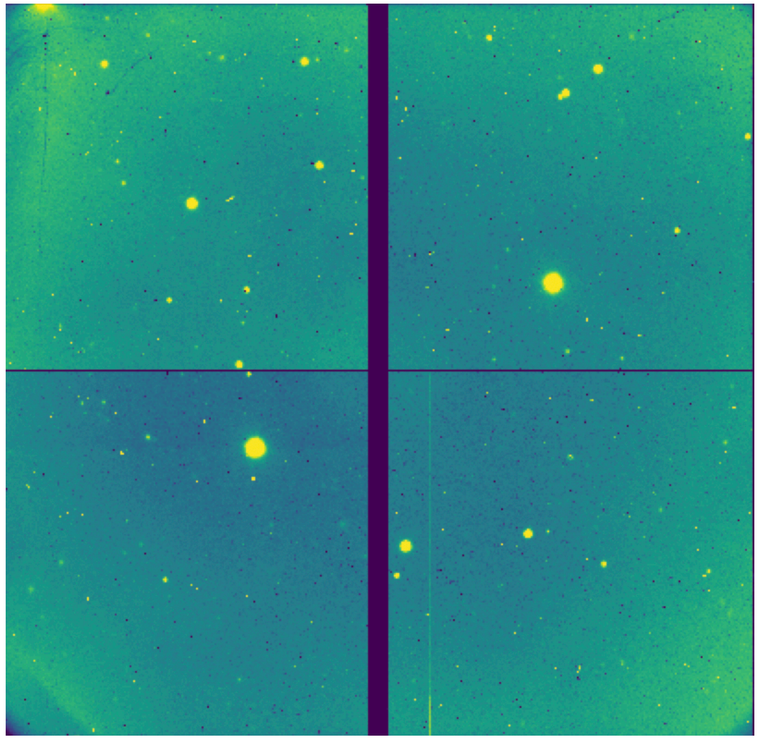
Days from New Moon	U	B	V	R	I	J	H	K	L	M
0	21.3	22.1	21.3	20.4	19.1	15.7	14.0	12.0	3.4	0.5
7	19.2	20.9	20.7	19.9	18.9	15.7	14.0	12.0	3.4	0.5
14	15.0	17.5	18.0	17.9	18.3	15.7	14.0	12.0	3.4	0.5

Emission from the Earth Atmospheres

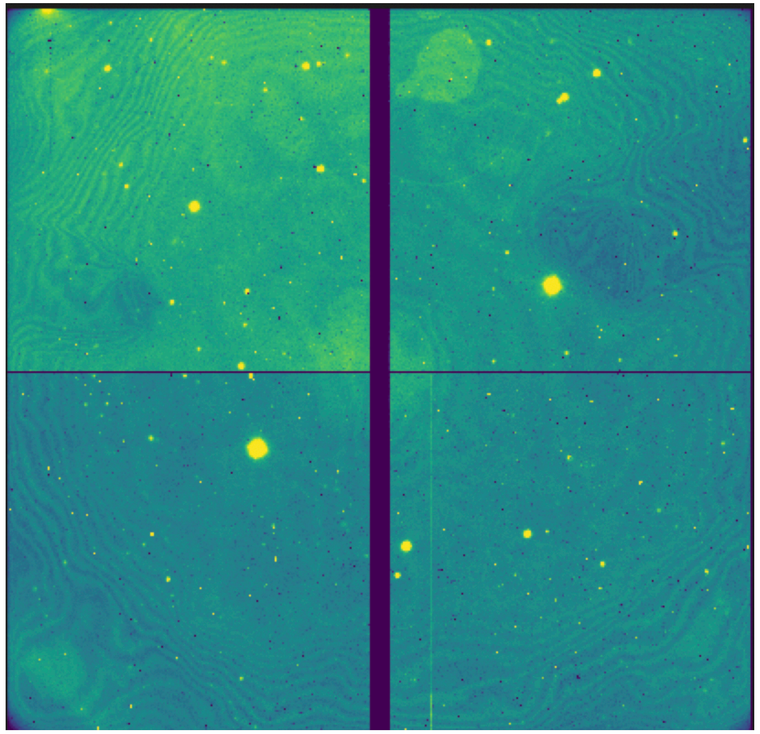
V band



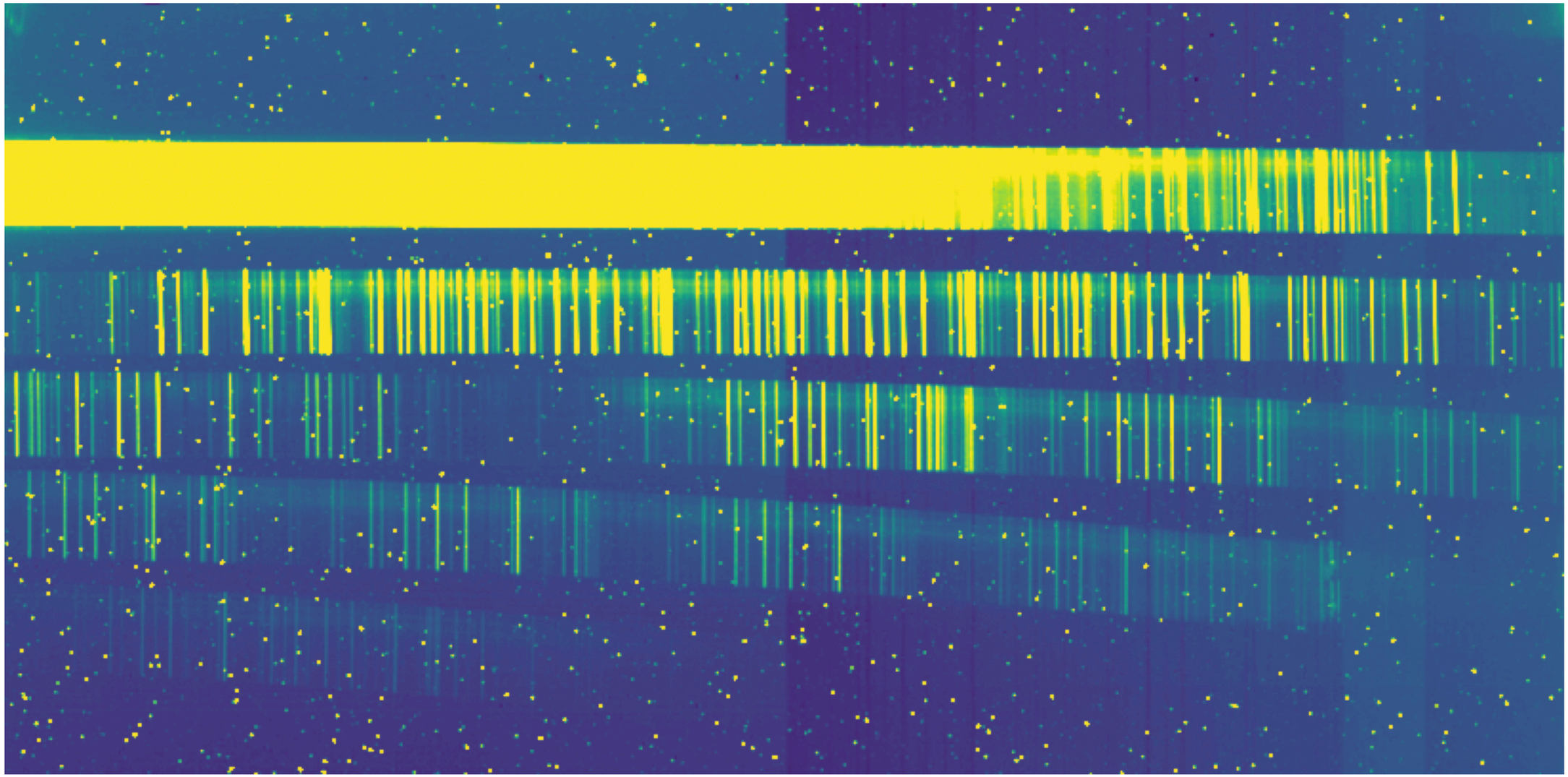
R band



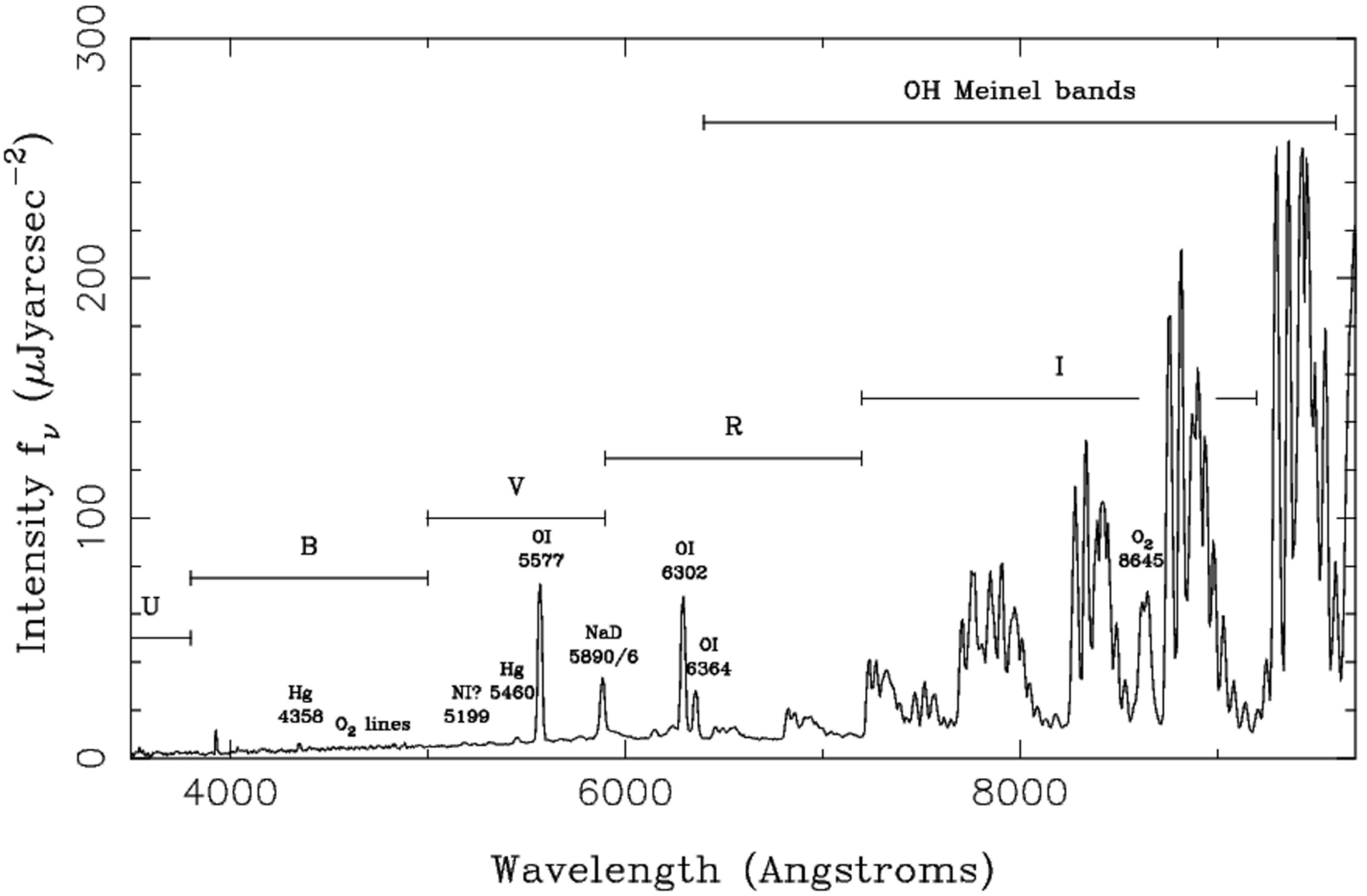
I band



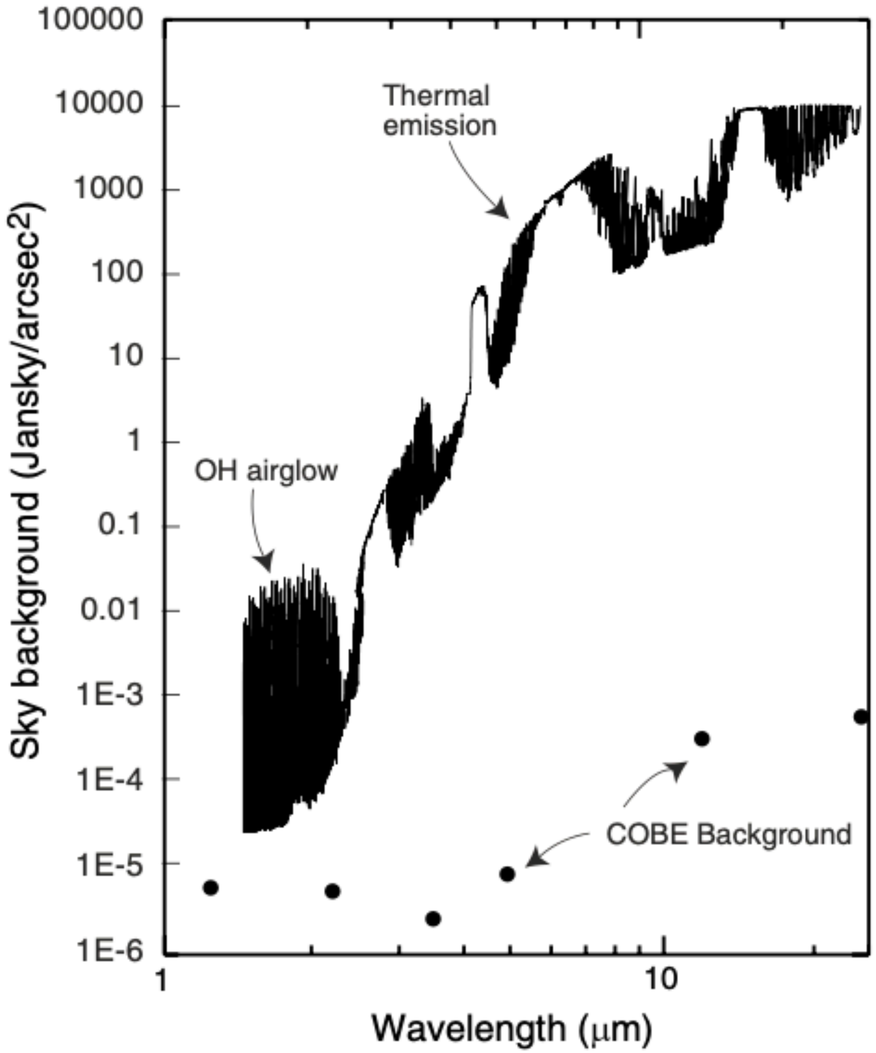
Emission from the Earth Atmospheres

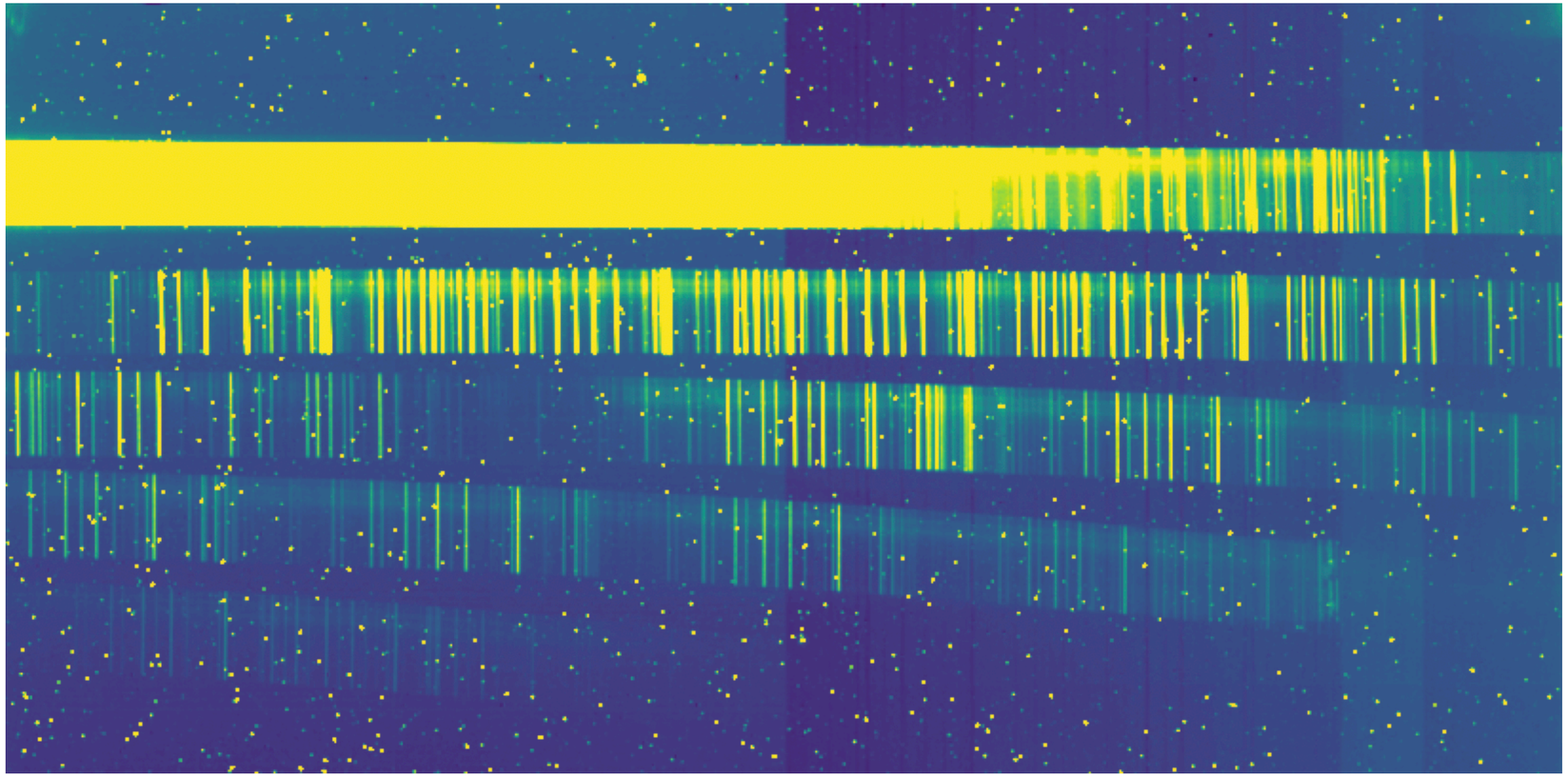


Emission from the Earth Atmospheres



Emission from the Earth Atmospheres





Atmospheric extinction — Bouguer's Law of Attenuation

- Photometry of multiple sources obtained from the ground will in general be measured along different paths through the atmosphere.

- By convention, the measurements are all corrected to the equivalent values as if they had been made directly overhead, through one “air mass.”

- Airmass: sec(z) for plane parallel atmosphere. At higher zenith angle, correction for the Earth’s curvature might be needed.

  air mass $= \sec z - 0.0018167\,(\sec z - 1) - 0.002875\,(\sec z - 1)^2 - 0.0008083\,(\sec z - 1)^3$

Atmospheric extinction — Bouguer's Law of Attenuation

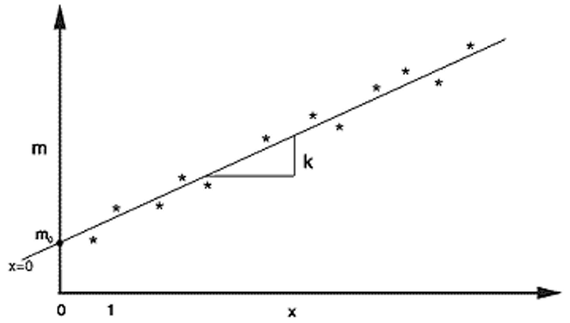
- Earth's atmospheric extinction:

$$\frac{dI_\lambda}{ds} = -\kappa_\lambda I_\lambda$$

where I_λ is the intensity, κ_λ the absorption coefficient, and s the path length.

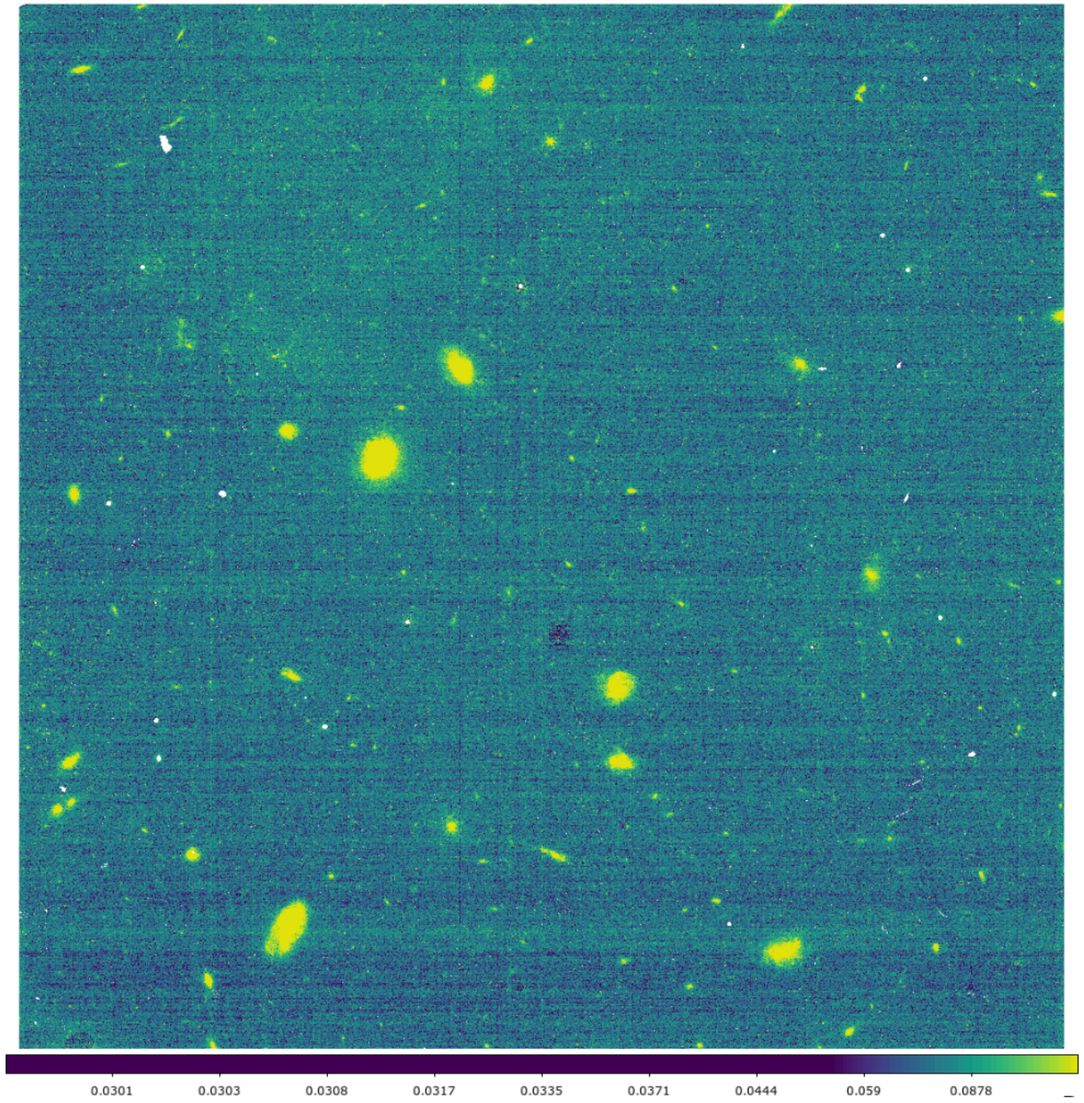
- Then

$$m_\lambda(am) - m_\lambda(am = 1) = \frac{2.5\,\kappa_\lambda\,(am - 1)}{\ln(10)}$$



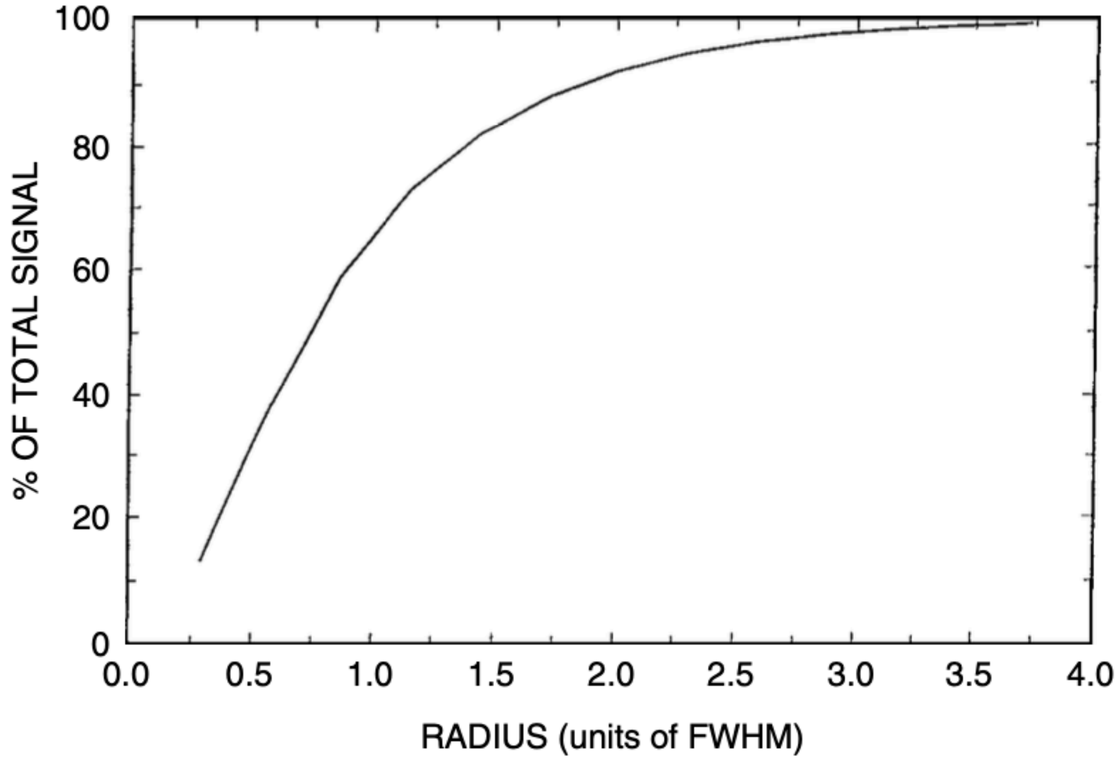
- The linear relationship between loss of brightness in magnitudes and airmass is known as Bouguer's Law.

Instrument related systematics



Aperture correction

Growth curve: Fraction of light as a function of the aperture radius



To obtain the growth curve, one needs an accurate PSF model or an isolated bright star.