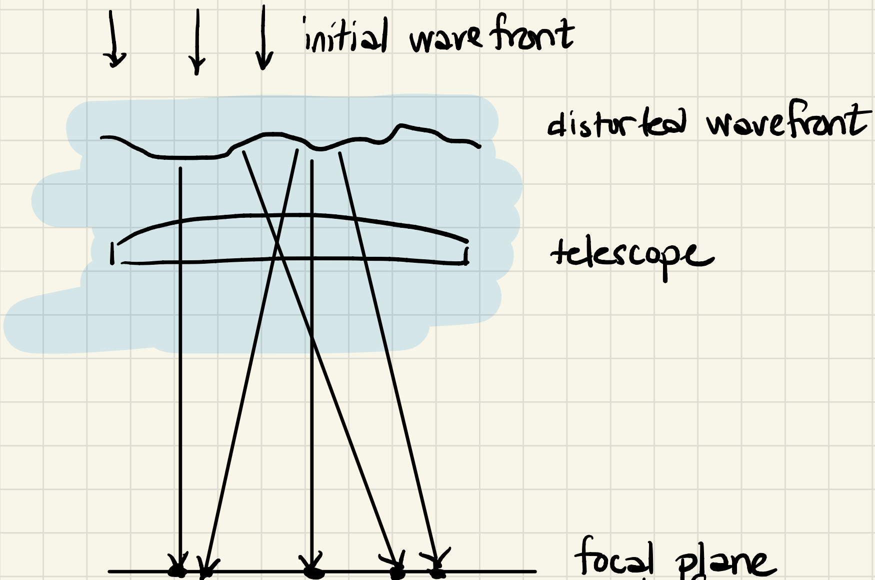
Earth's Atmosphere

Atmospheric Blur (Chromey Ch. 6.5)

"Seeing" is caused by turbulence in the atmosphere. Temperature gradients and bubbles will create cells with different indices of refraction. The wavefront from a source which arrived as a plane will be distorted by the time it reaches the telescope.



In a short exposure this causes speckles to form in the image. This speckle pattern reforms quickly, so in longer exposures it blurs into the seeing disk.

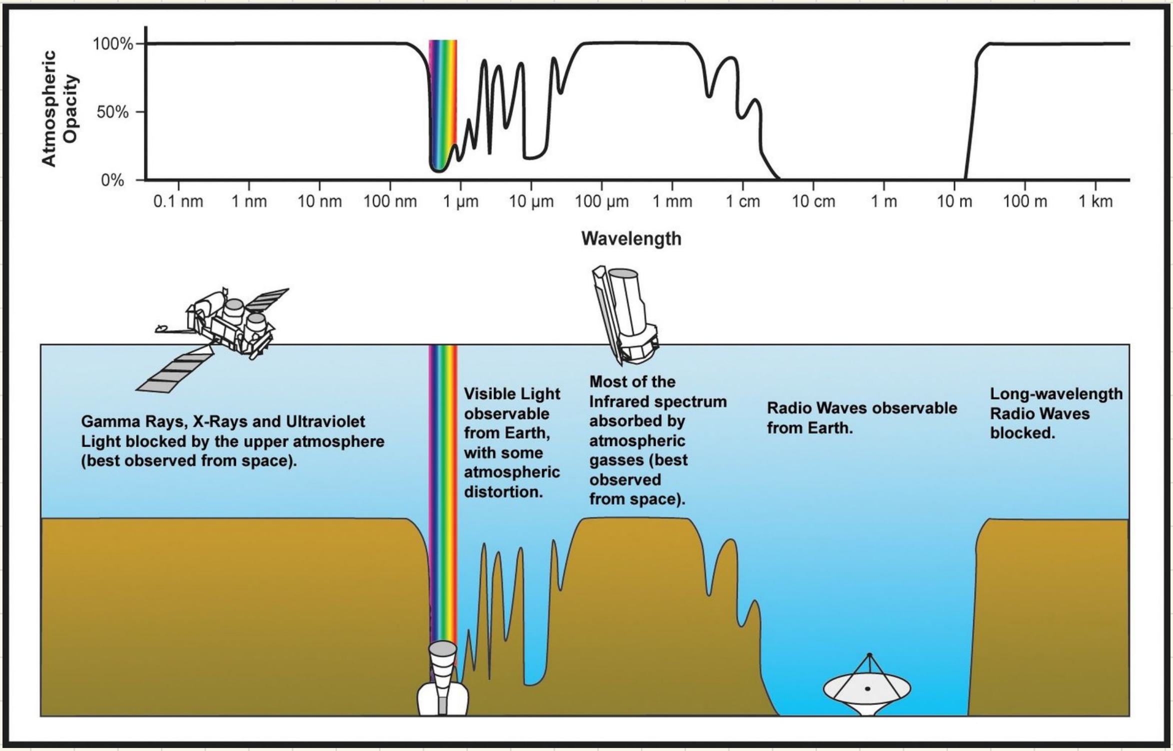
Observations will be seeing limited if the segment of wavefront that can be treated as a wave is bigger than the telescope diameter;

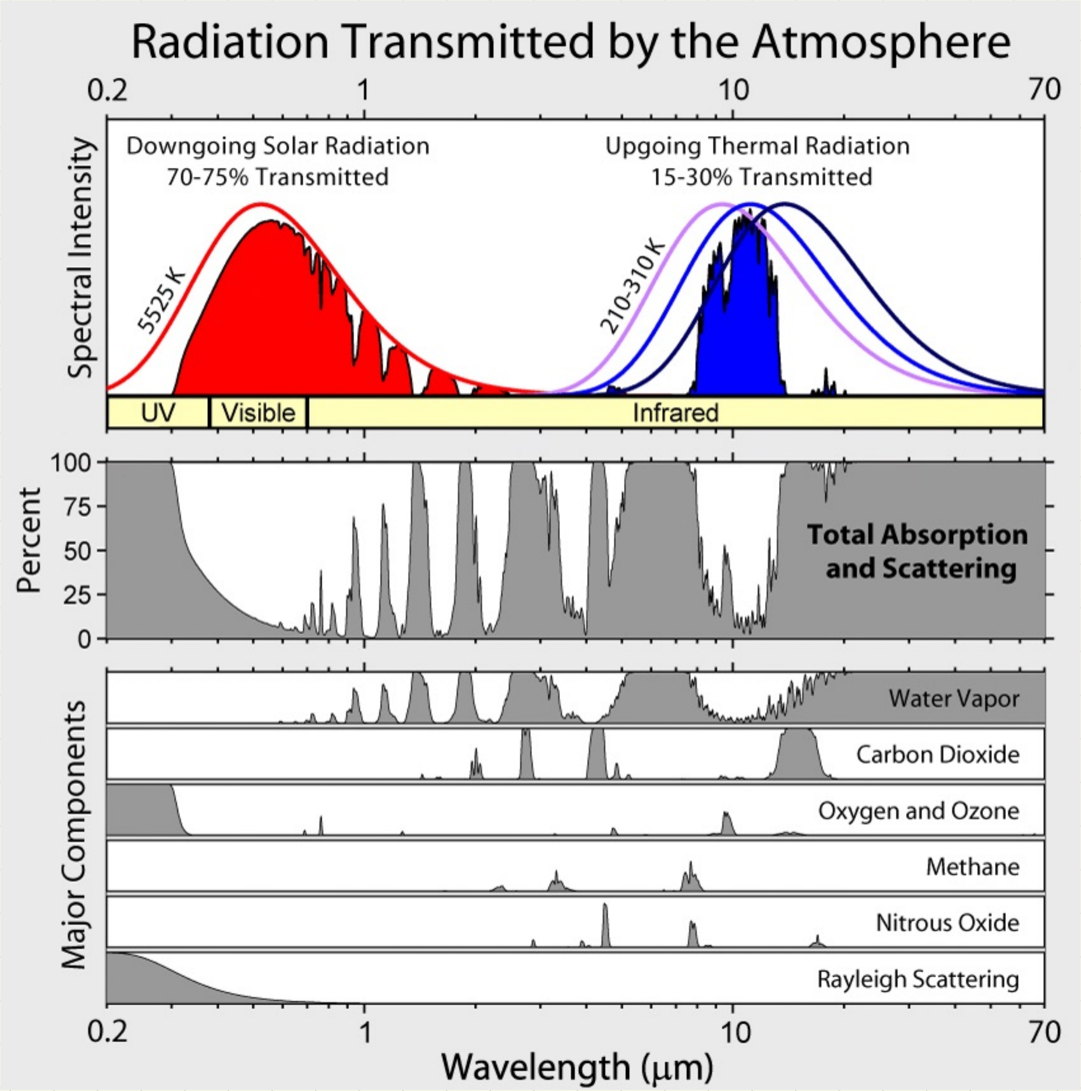
$$\Theta \text{ (seeing, in arcsec)} \approx 0.2 \frac{\lambda [\mu m]}{r_{0\lambda} [m]}$$

$r_{0\lambda}$ → Fried parameter, length that can be treated as plane

Usually, though, you don't know $r_{0\lambda}$, so you can't calculate seeing. More often, you'll observe it in your data. Typical values are ~1". Values like 0.25"–0.75" are good, whereas >2" is possible (and bad).

Extinction / Absorption





Radiation Transmitted by the Atmosphere
0.2
1
10
70
Spectral Intensity
Downgoing Solar Radiation
70-75% Transmitted
Upgoing Thermal Radiation
15-30% Transmitted
5525 K
210-310 K
UV
Visible
Infrared
Percent
100
75
50
25
0
Total Absorption
and Scattering
Major Components
Water Vapor
Carbon Dioxide
Oxygen and Ozone
Methane
Nitrous Oxide
Rayleigh Scattering
Wavelength (μm)

Main contributions to continuum extinction in optical:

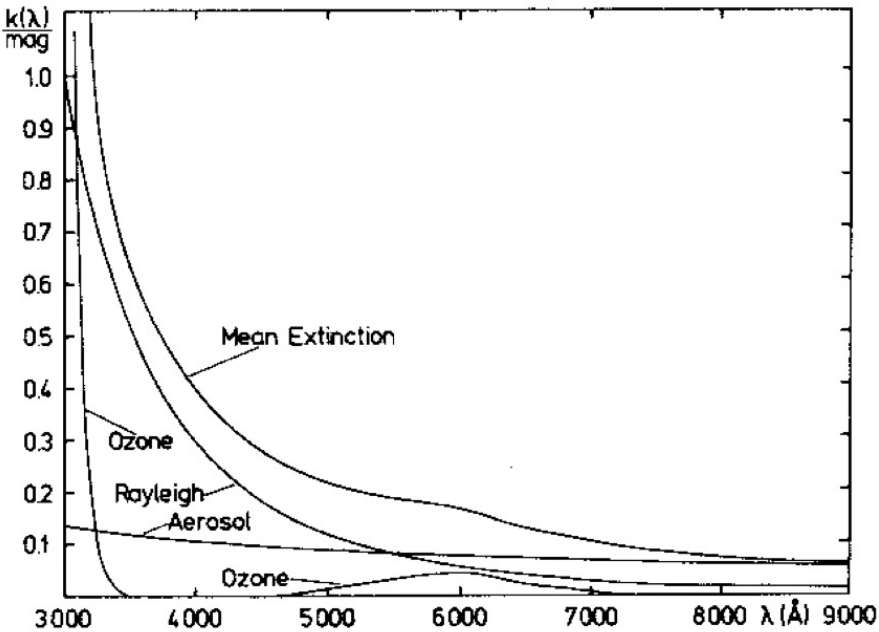


Fig. 1. Mean vertical extinction at Flagstaff, Arizona, in May-June 1976. The assumed ozone and Rayleigh contributions are shown separately

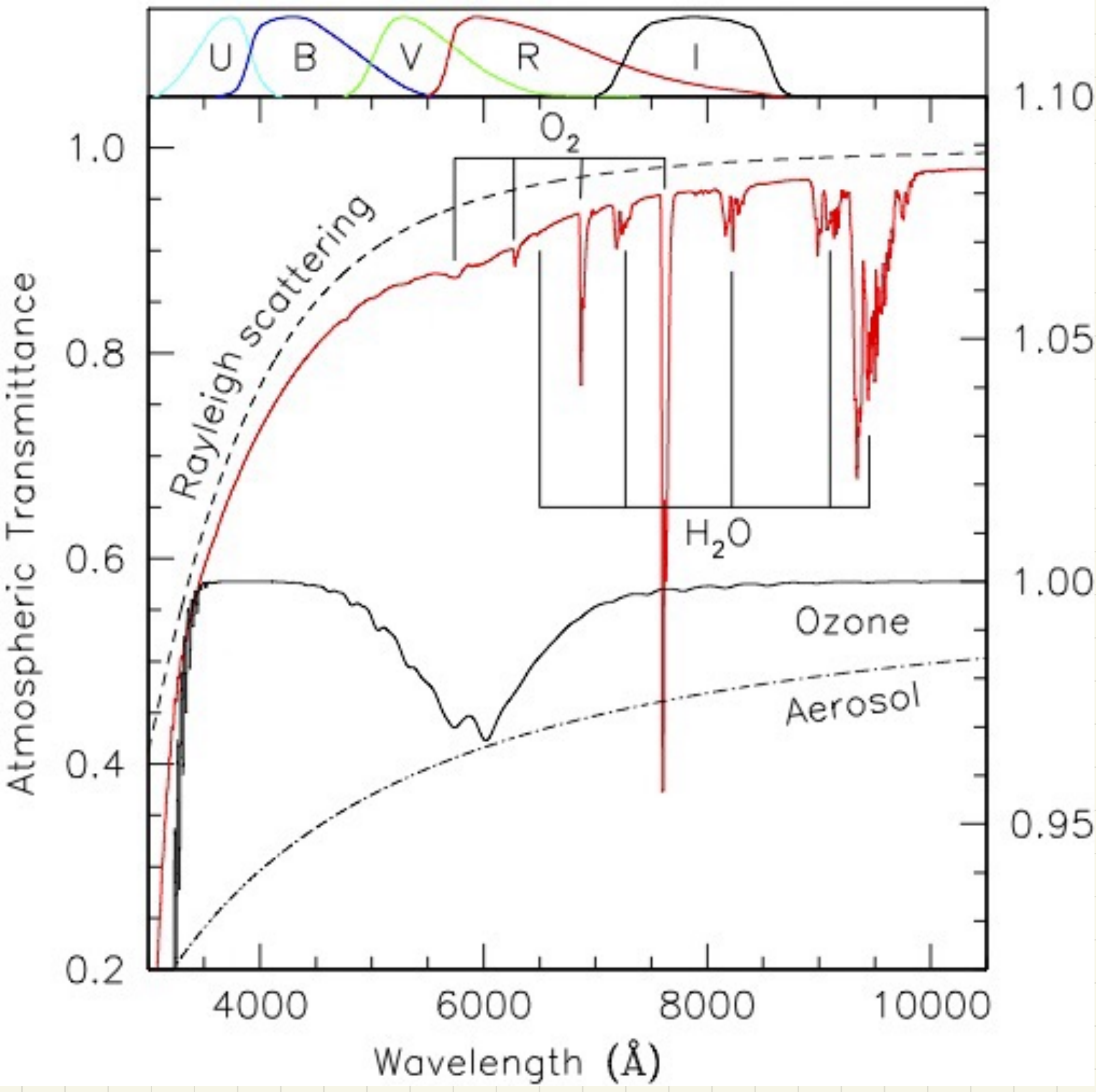
Rayleigh – particles with sizes smaller than λ scatter light. Amount of scattering depends on λ^{-4}, so shorter wavelengths are preferentially scattered – this is why the sky looks blue.

Ozone (O_3) – effective at short wavelengths, especially the UV (this is why the ozone layer is so important).

Some typical extinction coefficients:

B = 0.4 mag/airmass, V = 0.2 mag/airmass, I = 0.1 mag/airmass

- depends on location, season, fires, volcanoes ...



U
B
V
R
I
O_2
H_2O
Rayleigh scattering
Ozone
Aerosol
Atmospheric Transmittance
Wavelength (Å)
1.0
0.8
0.6
0.4
0.2
1.10
1.05
1.00
0.95
4000
6000
8000
10000

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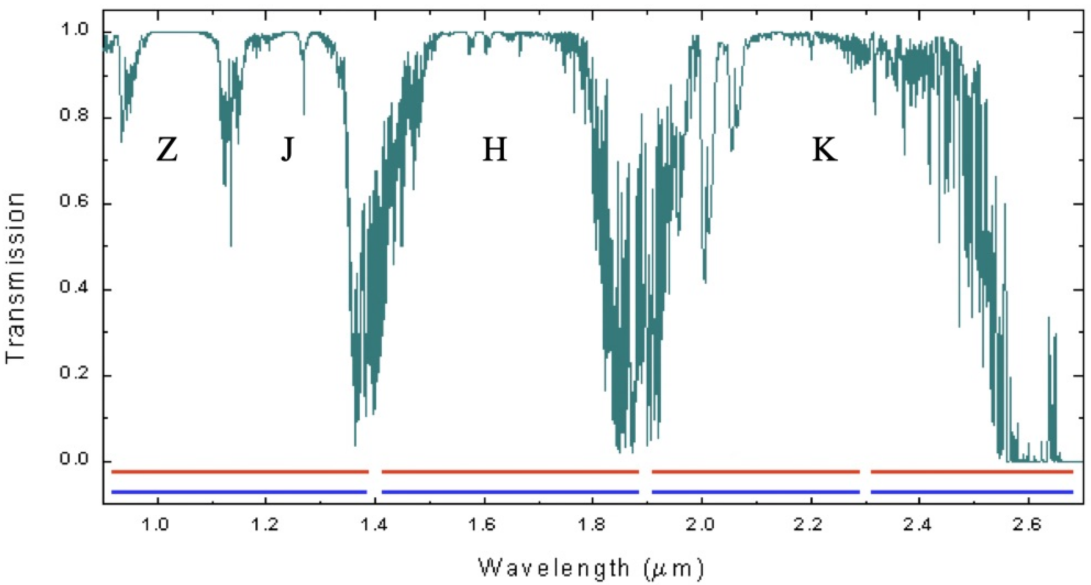
Infrared sky transmission (based on Lord 1992 AIRTRAN)



IR observations are often done from space to avoid the IR extinction.

Approximate IR transmission bands:

Z ~ 1.1 μm
J ~ 1.1–1.4 μm
H ~ 1.4–1.8 μm
K ~ 2.0–2.5 μm
L ~ 3.0 μm
M ~ 4.1 μm

Emission:

The night sky also emits a background light from e.g.:

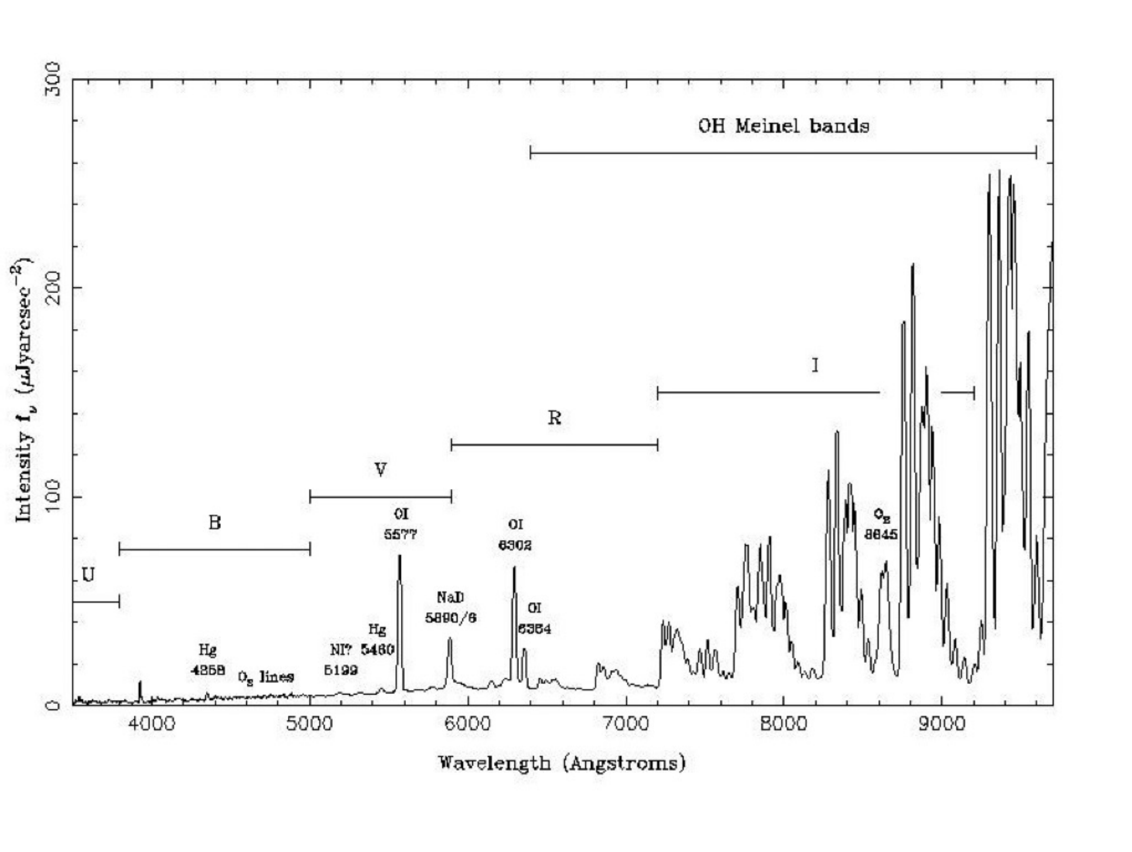
Natural

Airglow (O, Na, OH Meinel, continuum)
Zodiacal light (sunlight scattered by dust)
Starlight
Extragalactic light (e.g. CMB)

Human:

Light pollution
(Na, Hg, Ti)

Optical / IR sky brightness:



Optical sky brightness:

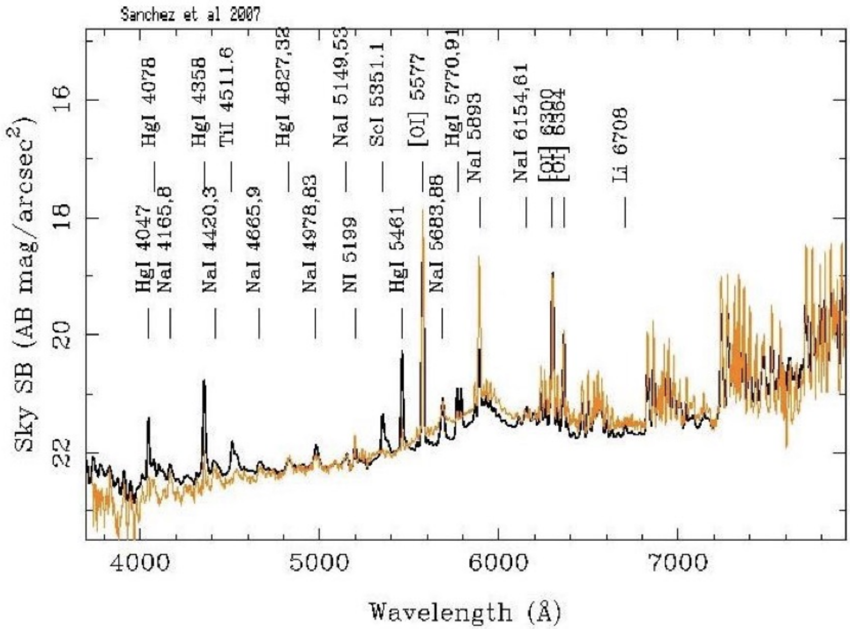


FIG. 1.— Night-sky spectrum at the Calar Alto Observatory in the optical wavelength range (3700-7950Å), obtained after averaging 10 spectra of 6 moonless nights pointing near the zenit (Black solid-line). The intensity has been scaled to that of the darkest moonless night in the V-band. Several emission lines are indentified in the spectrum. The most relevant ones have been labeled with its corresponding name and wavelength. In addition, the broad-emission band of NaI centred at ~5900Å, and the water vapor Meinel bands are clearly identified in the spectrum. For comparison purposes we included the night sky spectrum at the Kitt Peak observatory derived by Massey & Foltz (2000), obtained from their webpage: *http://www.lowell.edu/users/massey/nightsky.html* (Orange dotted-line). It is appreciated how strong are the pollution lines at Calar Alto, in comparison with that observatory.

Sky brightness depends on eg location, especially lunar phase

Sky brightness in mag/arcsec^2:

lunar age (days)	U	B	V	R	I
0	22.0	22.7	21.8	20.9	19.9
3	21.5	22.4	21.7	20.8	19.9
7	19.9	21.6	21.4	20.6	19.7
10	18.5	20.7	20.7	20.3	19.5
14	17.0	19.5	20.0	19.9	19.2