

Astronomy in Chile



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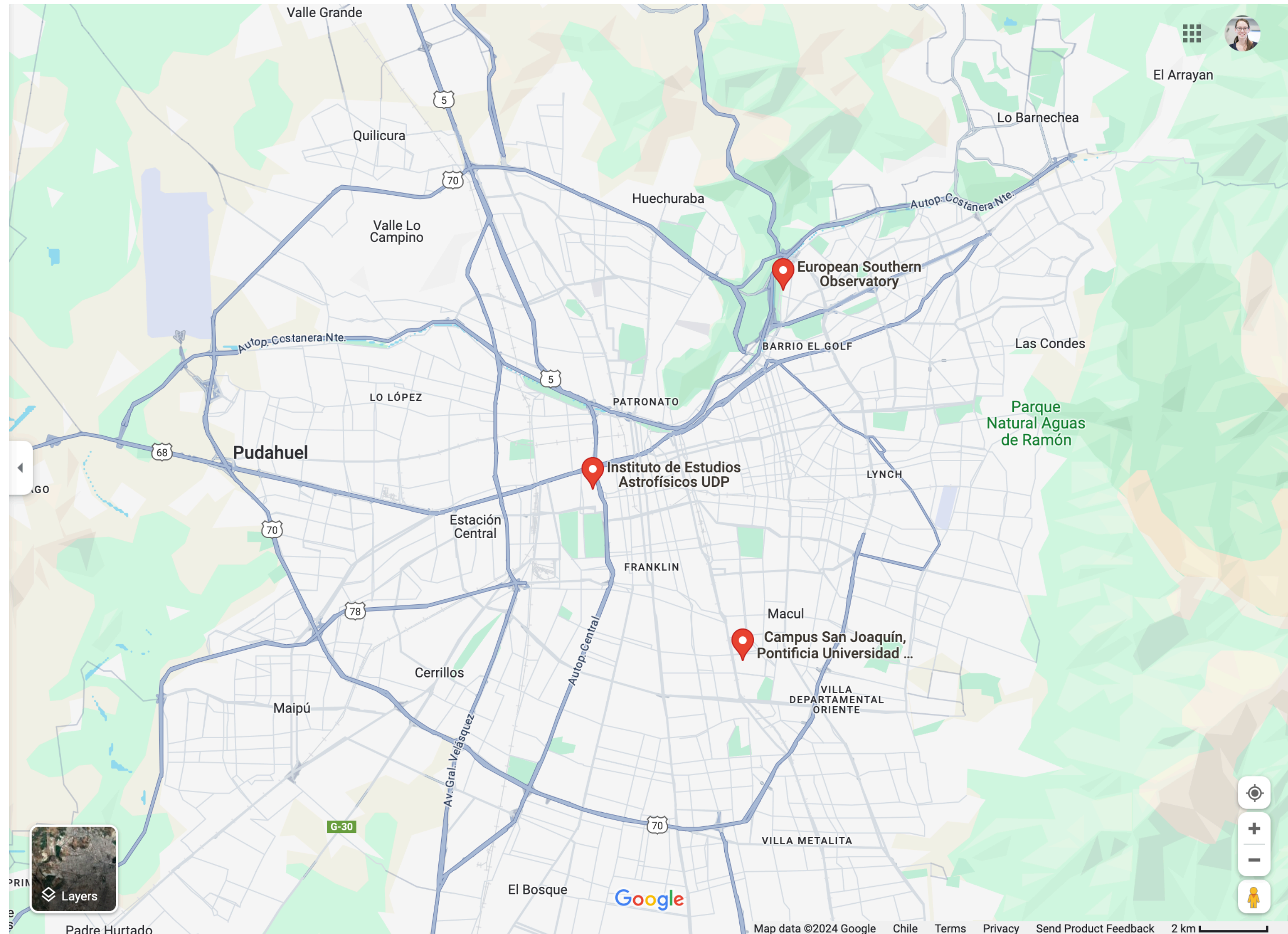
Astronomy in Chile \neq ESO

- I came to Chile in 2014 for (what I thought would be) 3 years.
- 10 years later I have:
 - Worked in 3 astronomy departments
 - Observed, in person, at 3 observatories
 - Worked in operations at 2 observatories
 - Settled here with my family



Astronomy in Chile \neq ESO

- Chile offers many opportunities to pursue a career in astronomy



Warning:
this talk is a not-so-subtle attempt to convince you to consider pursuing a career in astronomy in Chile

Plan

- The astronomy community in Chile
 - Observatories in Chile
 - What makes a good site for an Observatory
 - Astronomy departments in Chile
 - Telescopes and data access for chilean astronomers
- Job opportunities in astronomy in Chile

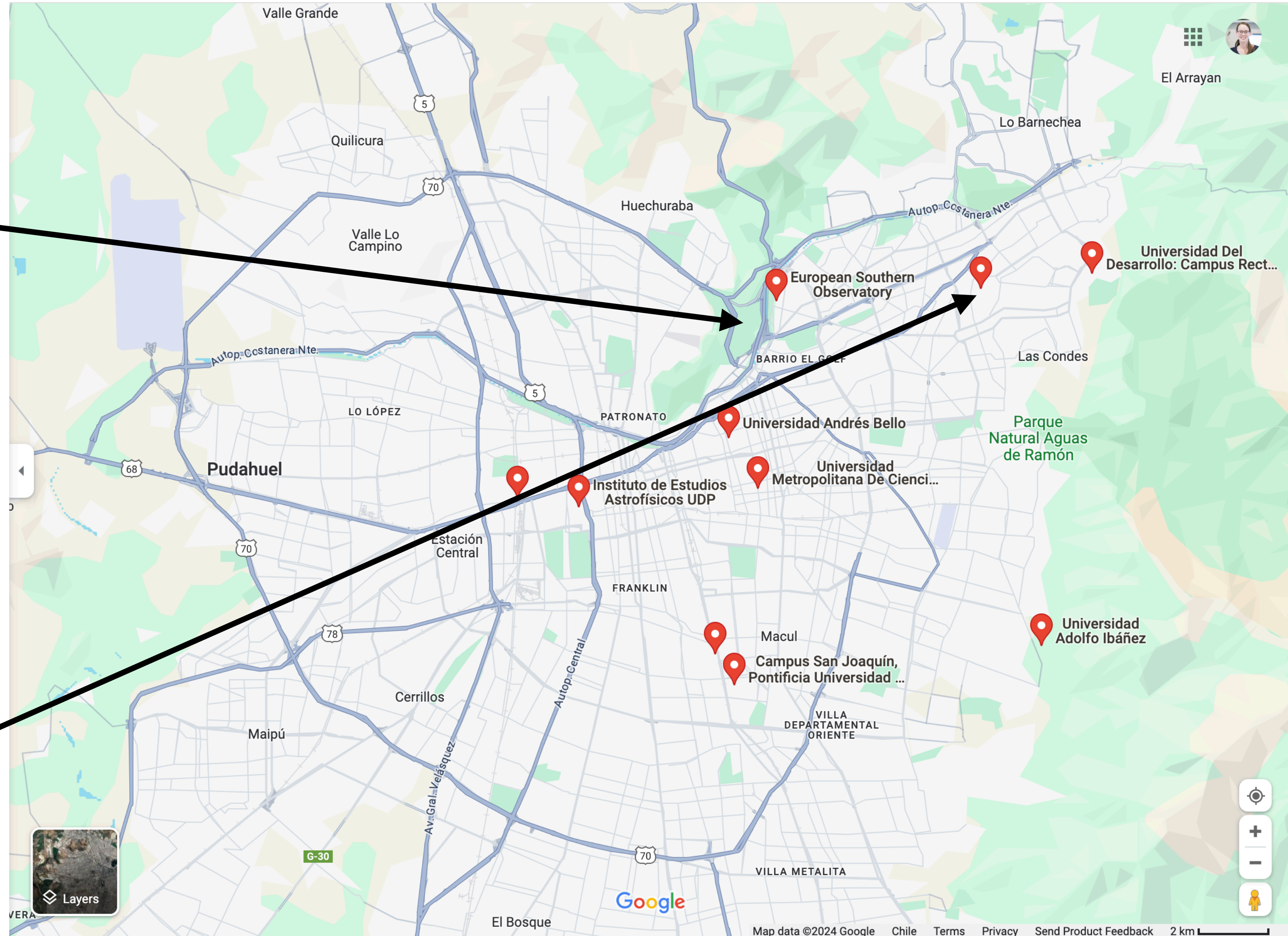
The Astronomical community in Chile

Observatories

Foster Observatory



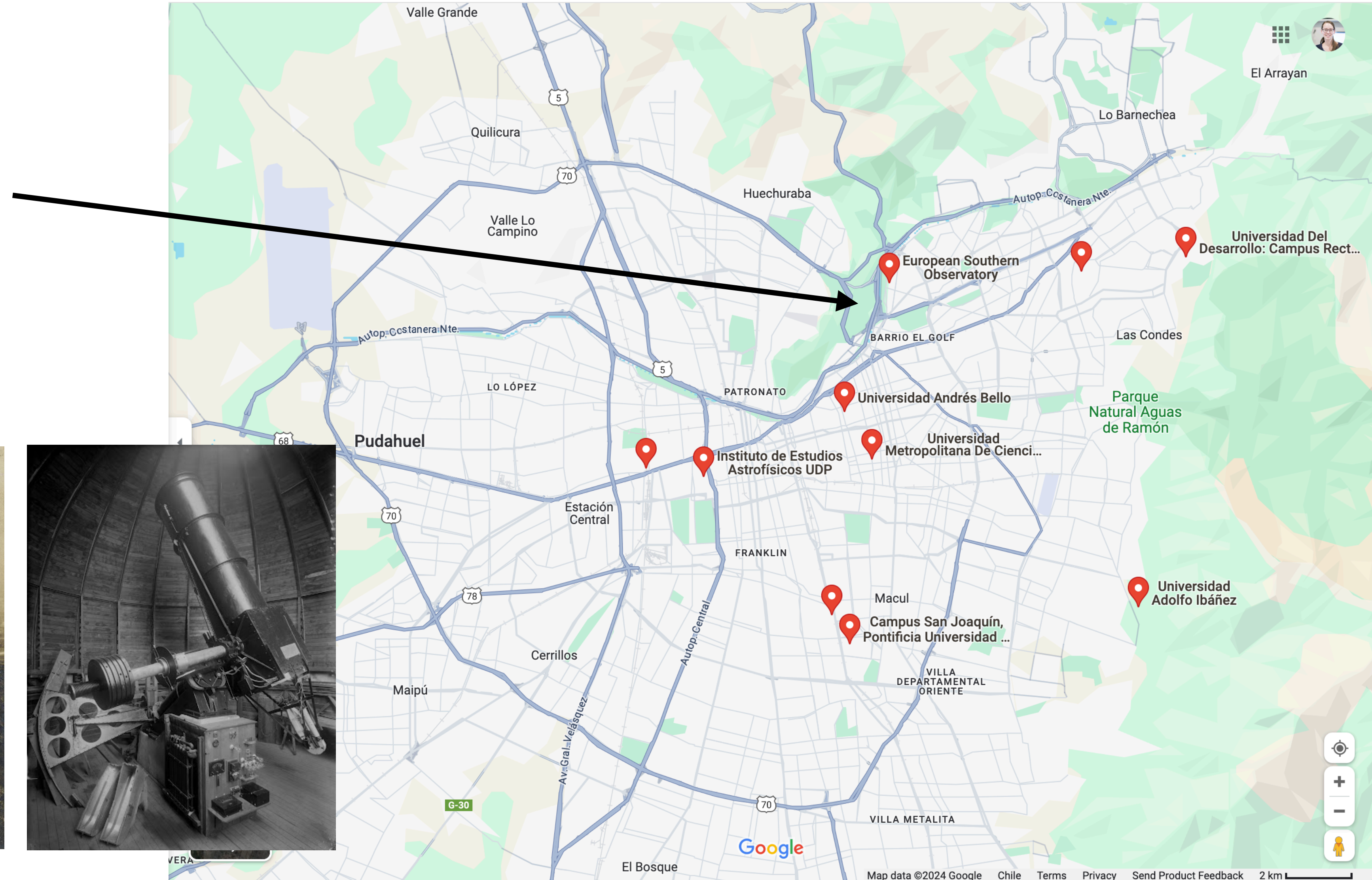
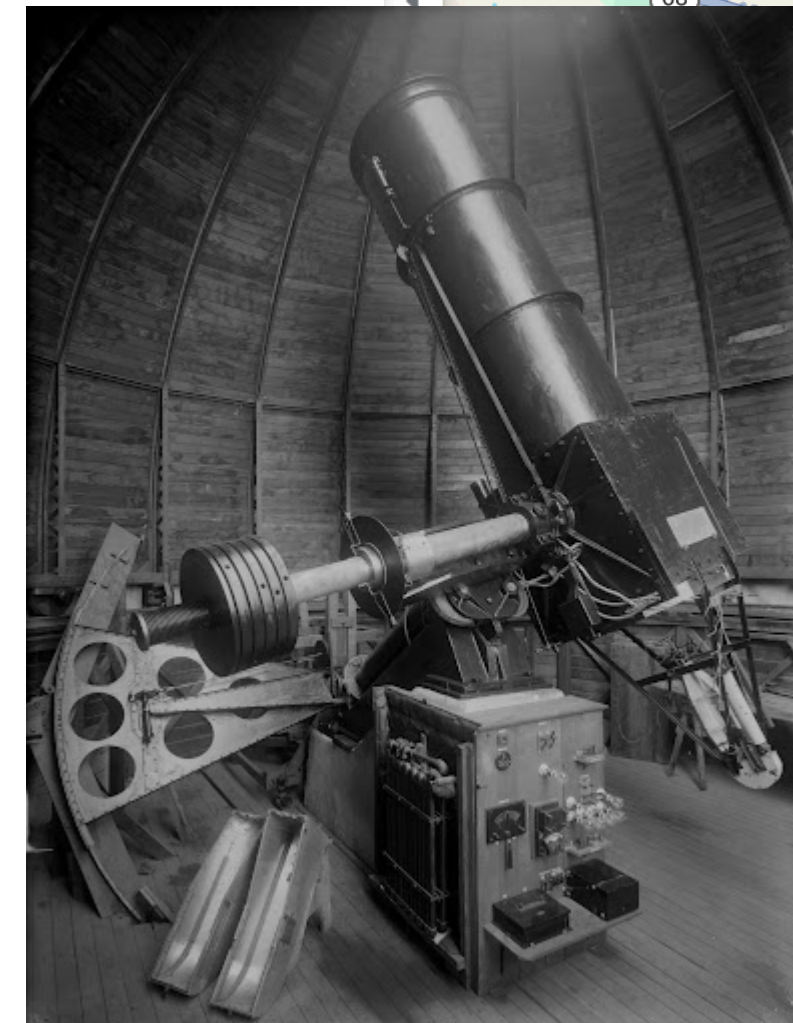
Observatorio Cerro Calan



The Astronomical community in Chile

Observatories

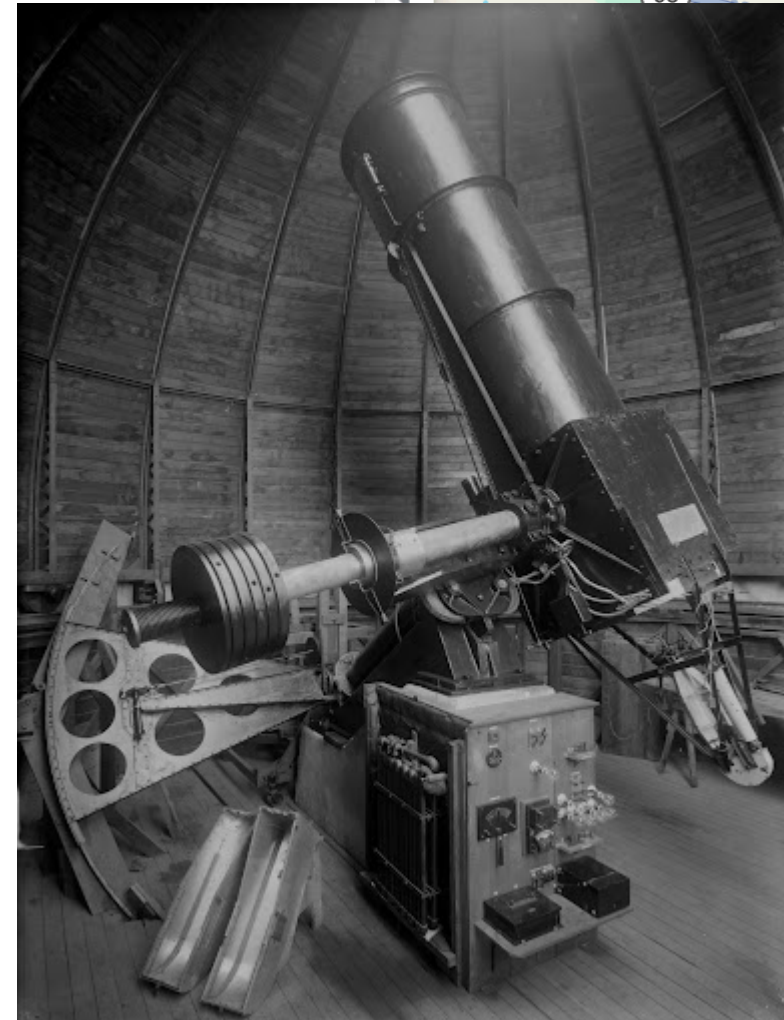
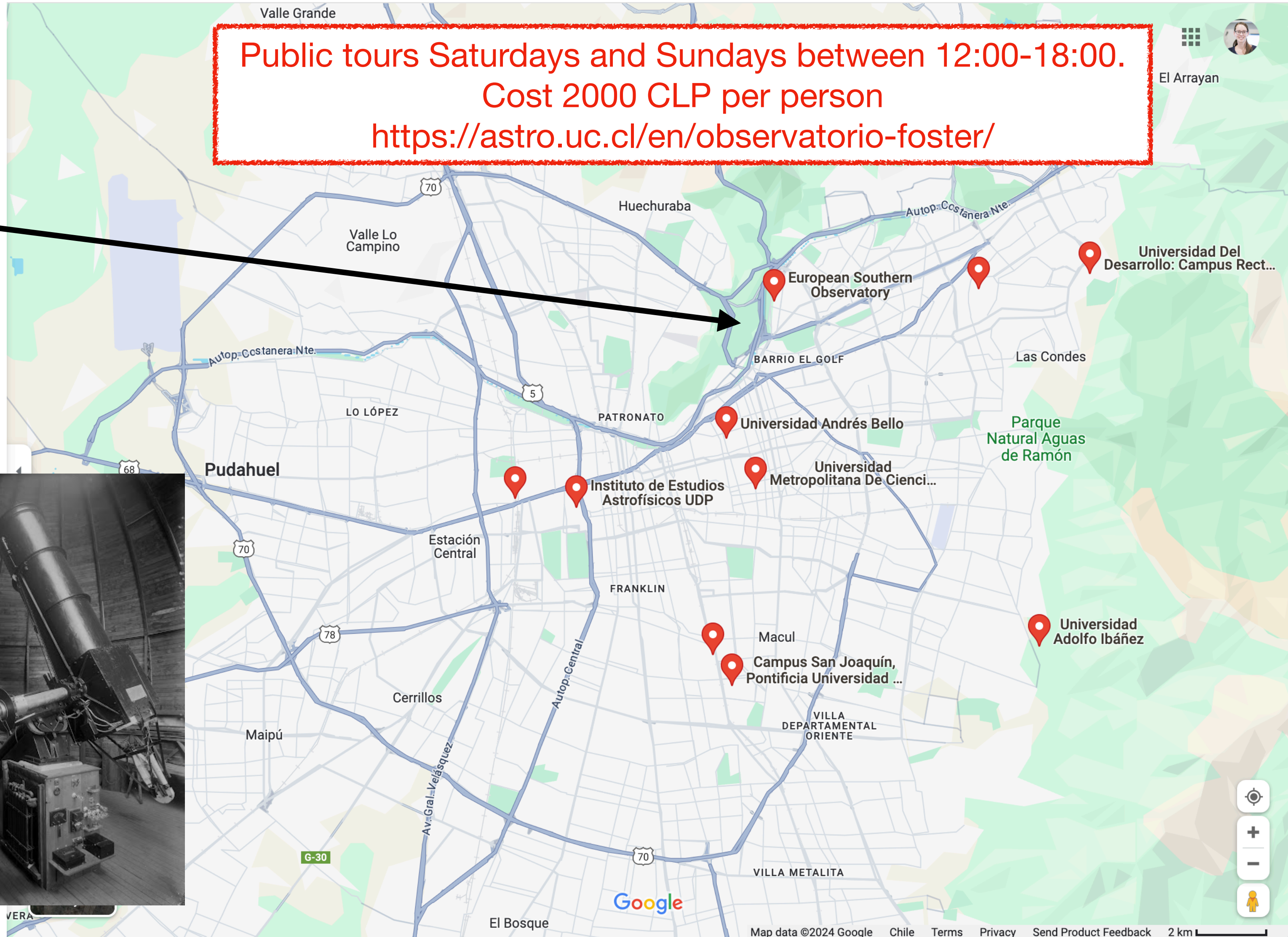
Foster Observatory



The Astronomical community in Chile

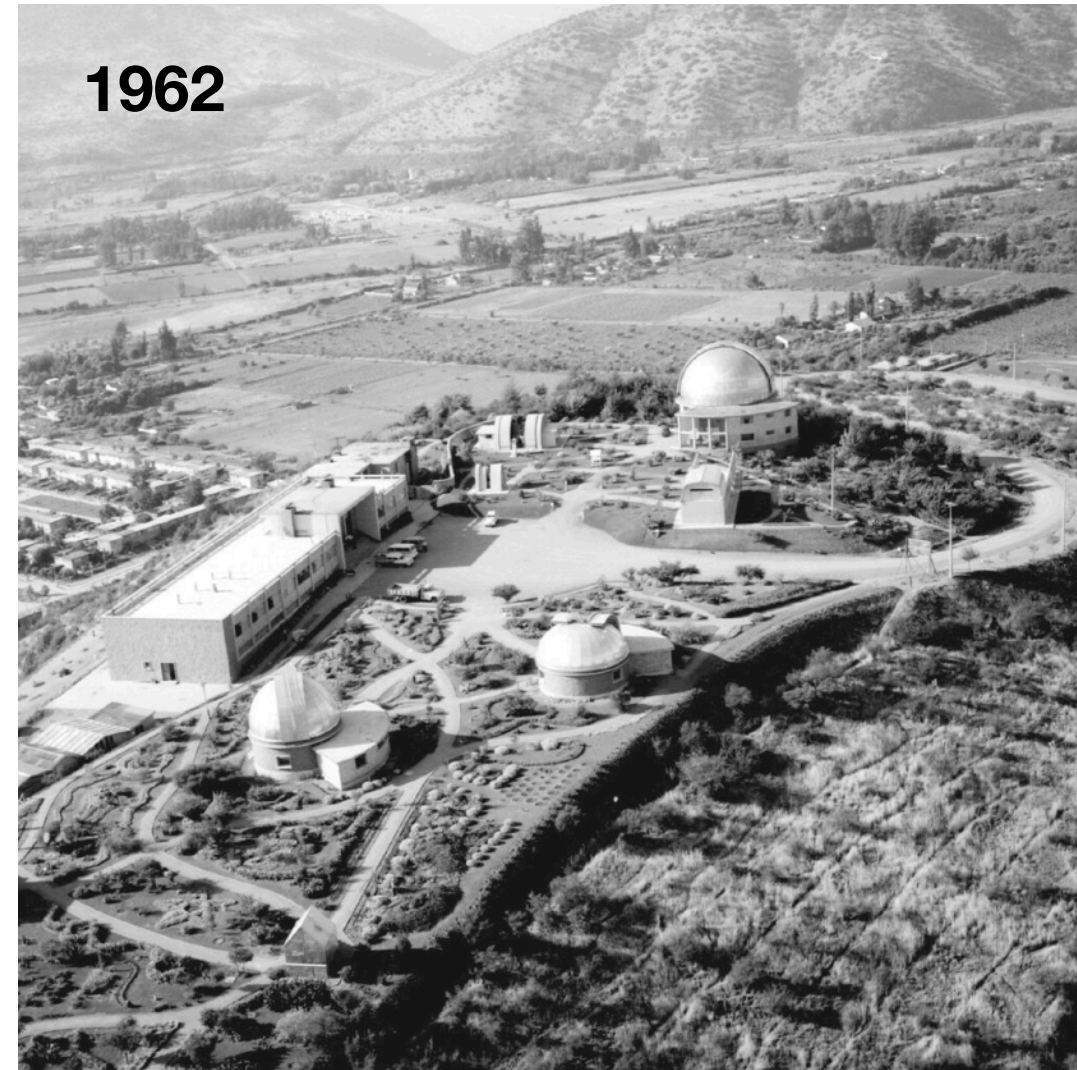
Observatories

Foster Observatory

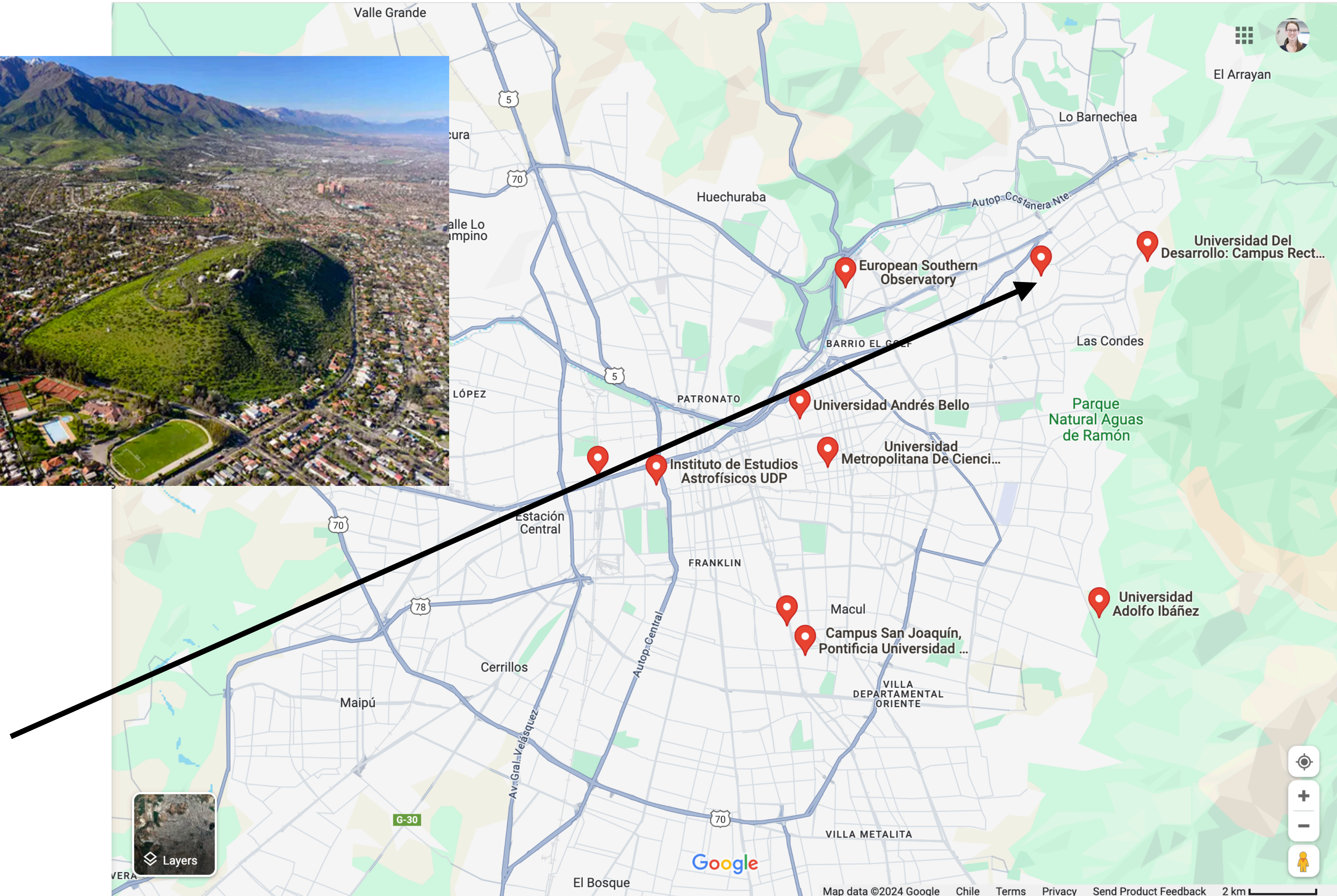


The Astronomical community in Chile

Observatories

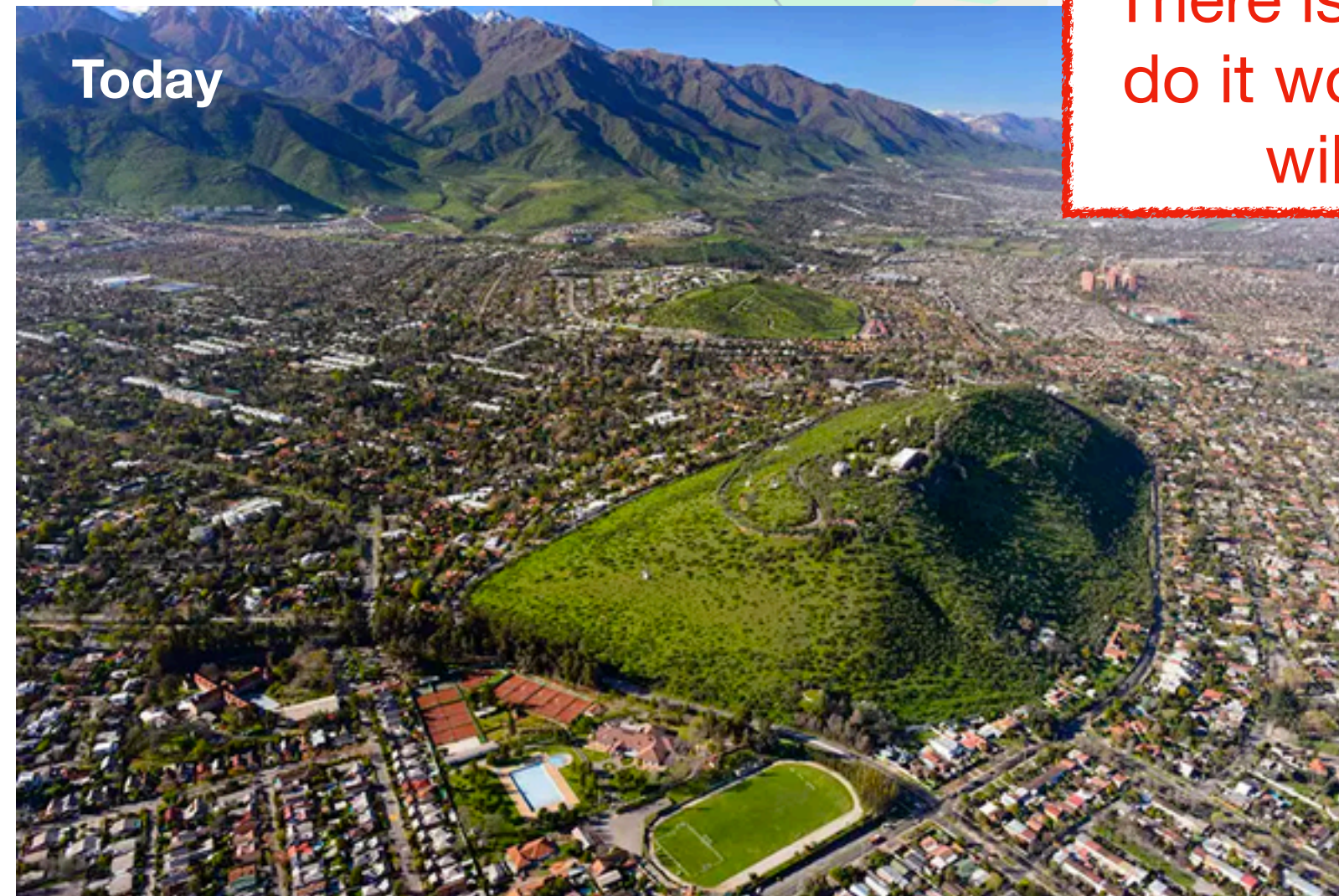
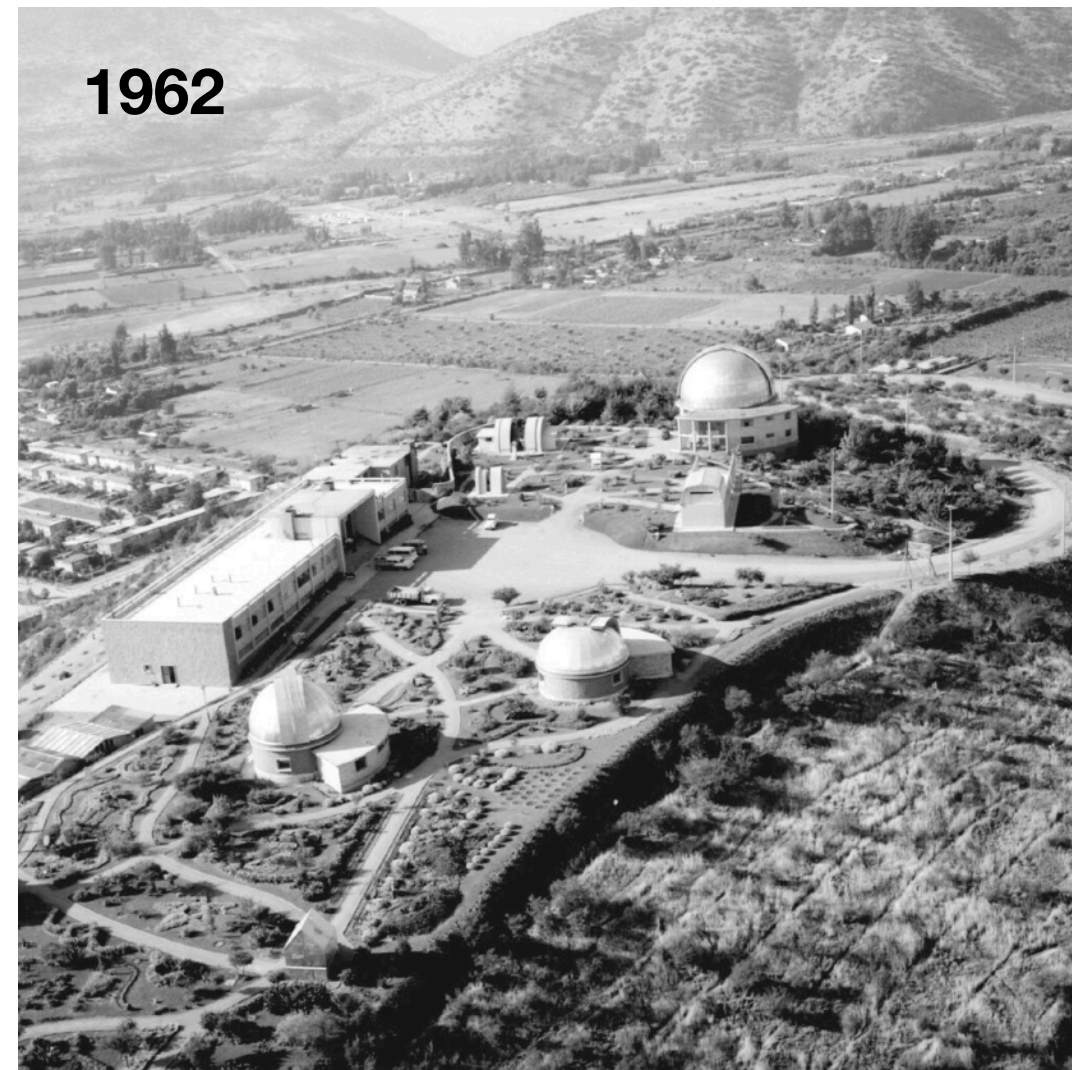


Observatorio Cerro Calan



The Astronomical community in Chile

Observatories



There is a really nice walk around Cerro Calan. Best time to do it would be before sunset when it's a bit cooler and you will see the Andes turn pink. Note: closes at 8pm

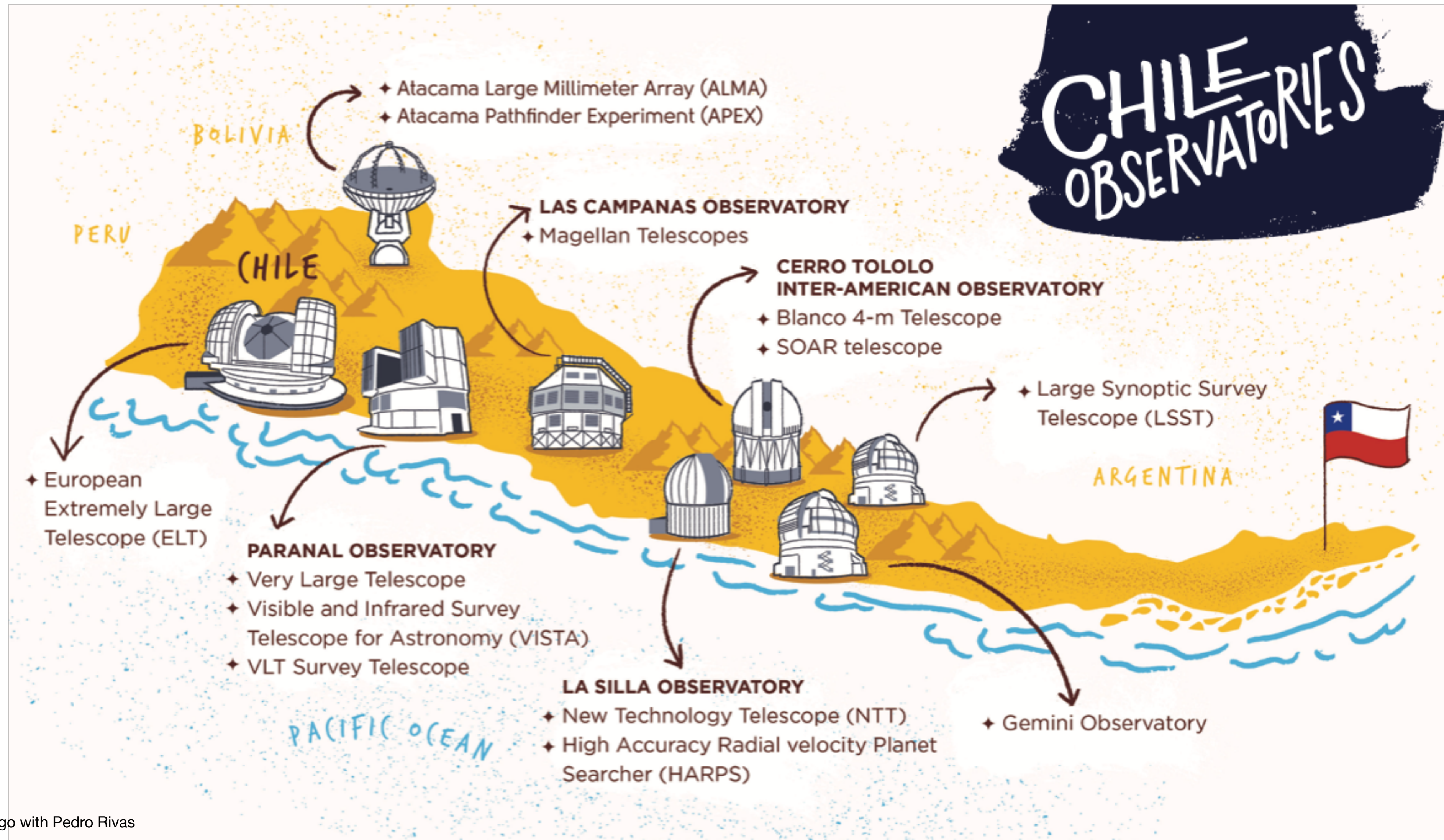


Observatorio Cerro Calan



The Astronomical community in Chile

Observatories



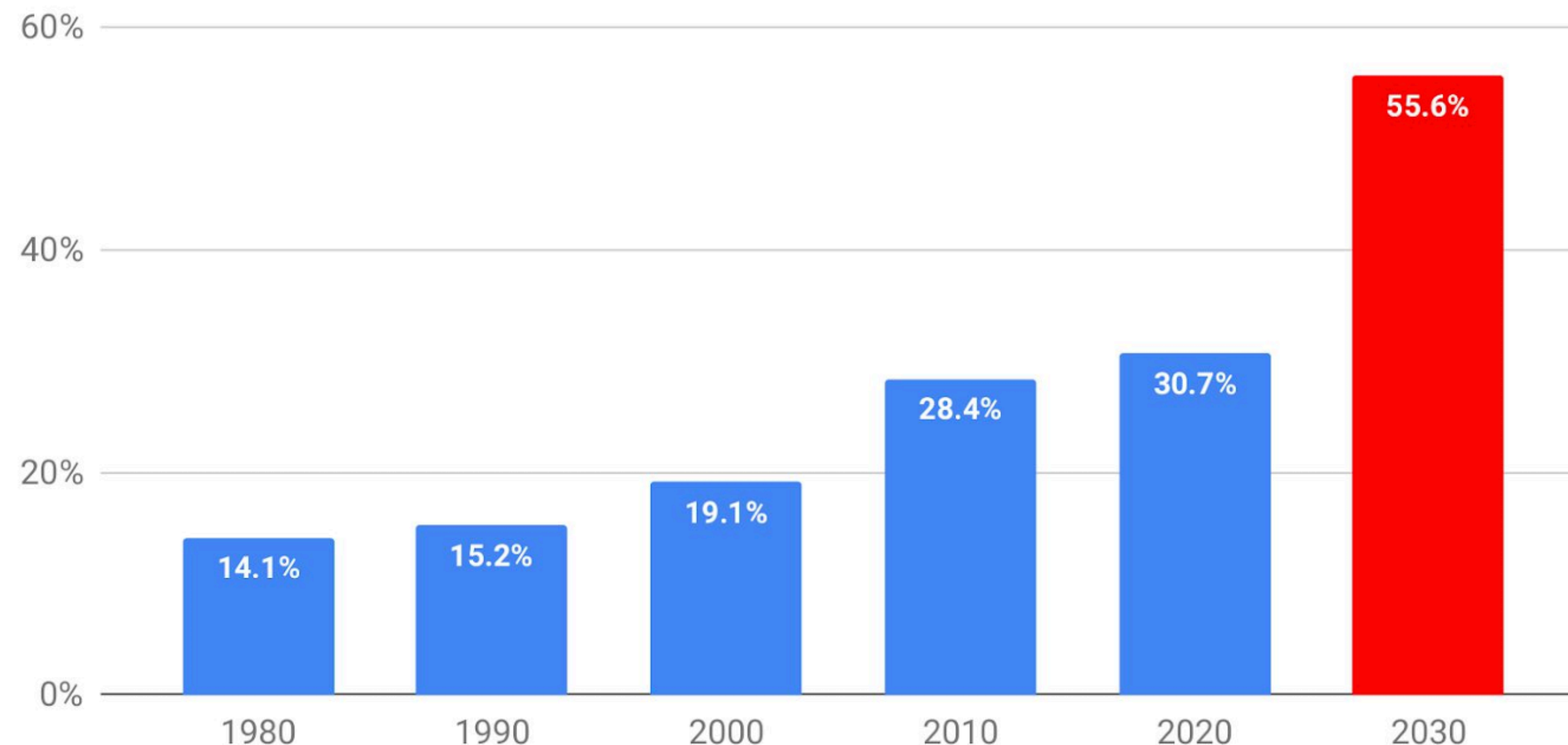
The Astronomical community in Chile

Observatories

- It is estimated that Chile will host more than 50% of the global astronomical infrastructure by 2030 *

Capacidad astronómica instalada en Chile al final de una década

Cálculo de Eduardo Unda-Sanzana (CITEVA, U. de Antofagasta)



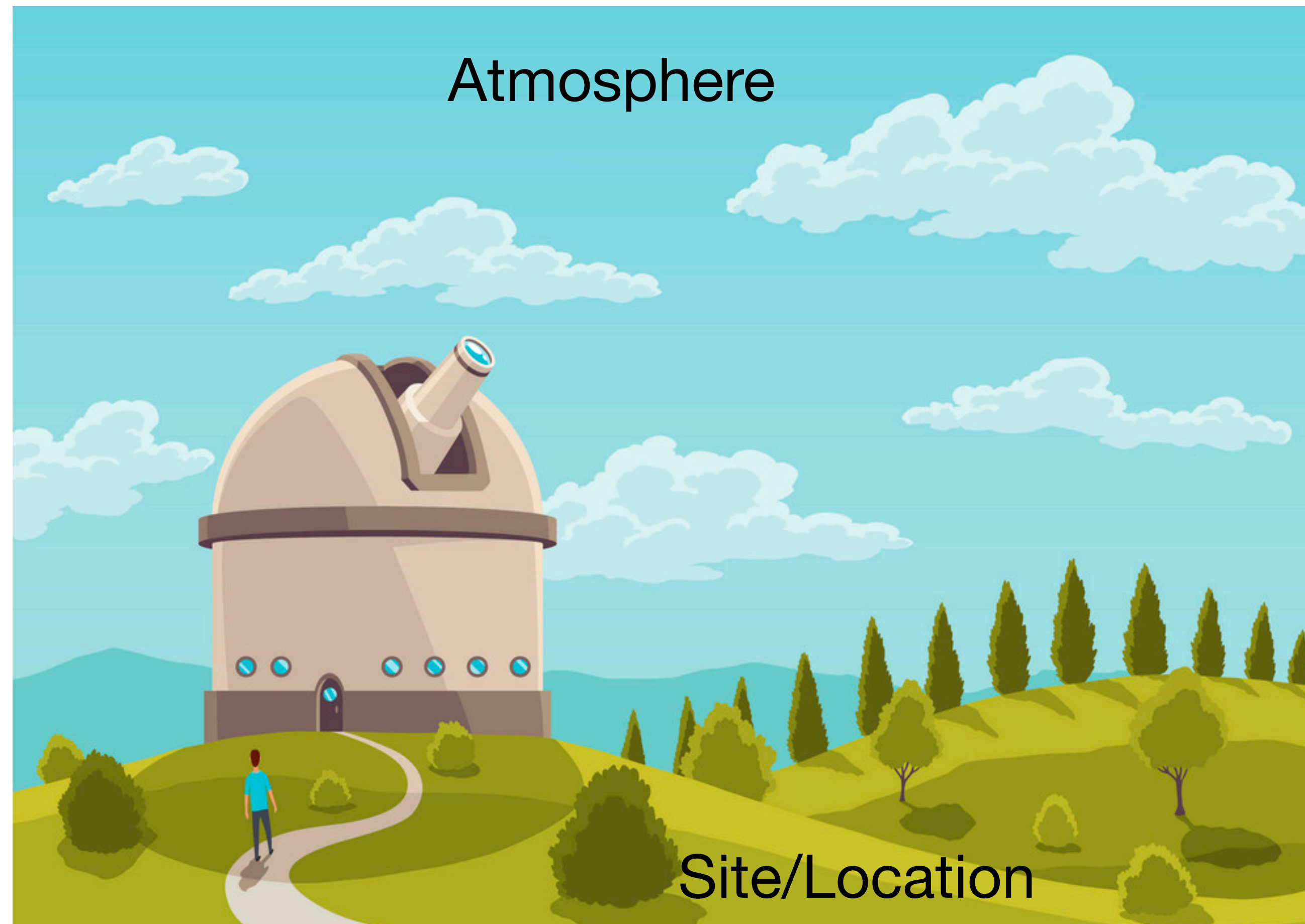
- Considerando sólo $D \geq 2$ m: 55.6%
- Considerando sólo $D \geq 4$ m: 59.3%
- Considerando sólo $D \geq 6$ m: 60.2%
- Considerando sólo $D \geq 8$ m: 61.1%
- Considerando sólo $D \geq 10$ m: 64.4%

* <https://sochias.cl/wp-content/uploads/2020/05/2020-05-14-Sobre-la-capacidad-astron%C3%B3mica-instalada-en-Chile.pdf>

The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

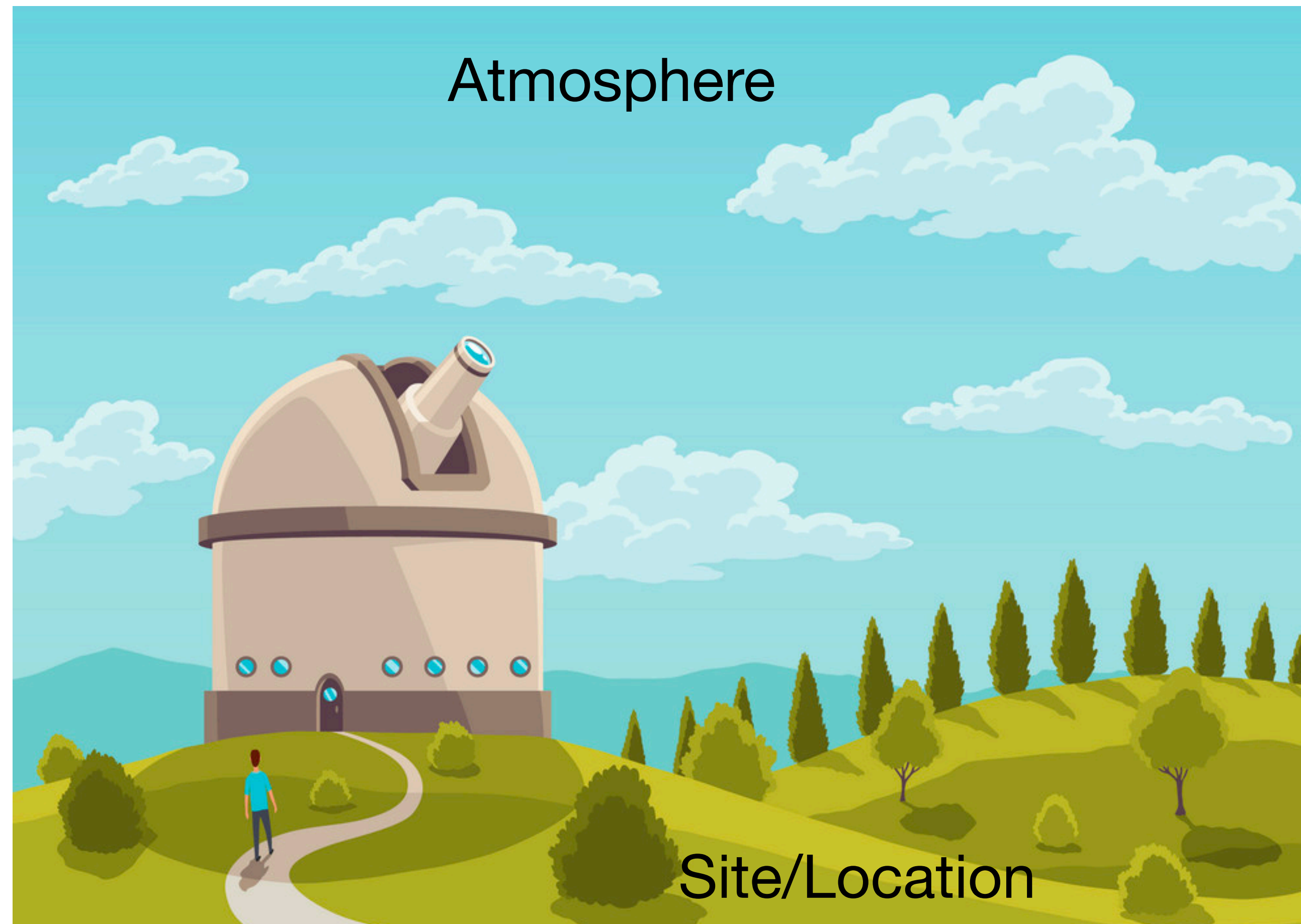
First we must consider what makes a good observatory.



The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

First we must consider what makes a good observatory.



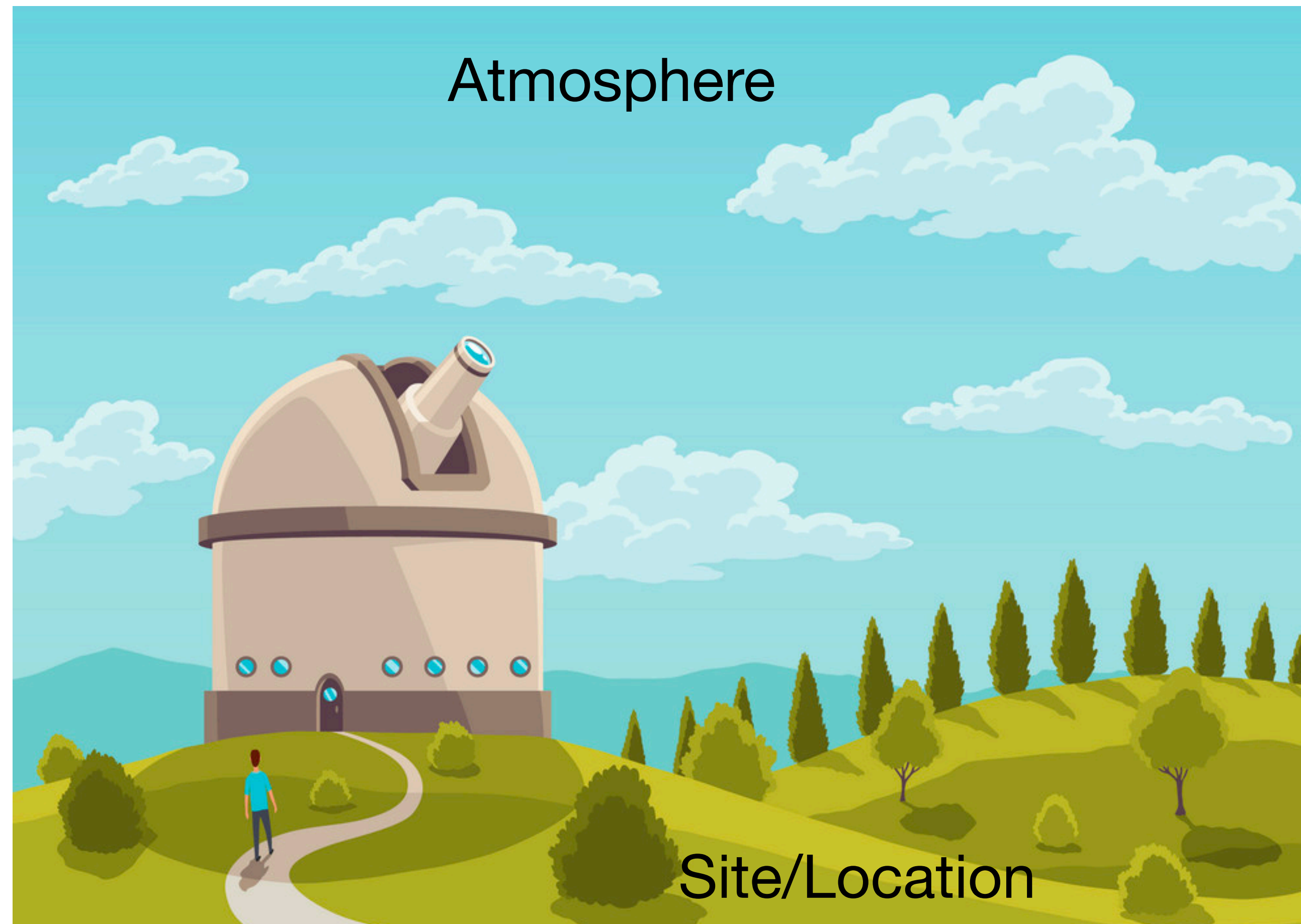
- Sky background
- Atmospheric Extinction
- Transparency variations
- Seeing

- Latitude
- Cloud cover
- Light pollution
- Seeing
- Height above sea level
- Other factors

The Astronomical community in Chile

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The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

Sky background

- The atmosphere contains dust particles and molecules
- Dust particles scatter light from the moon and the surface of the Earth (street lights etc), making the sky glow
- As a result, the sky background flux is not negligible, which is particularly an issue for faint targets



The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

Atmospheric Extinction

- Dust and molecules in the atmosphere scatter and absorb the light from astronomical objects, making them appear dimmer.
- The amount of dimming depends on the angle of the object above the horizon and the local conditions in the atmosphere at the time of observation.
- It should be noted that this effect is different to interstellar extinction

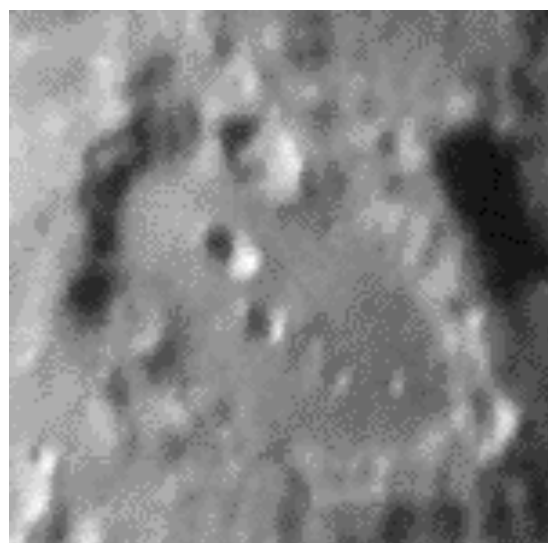


The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

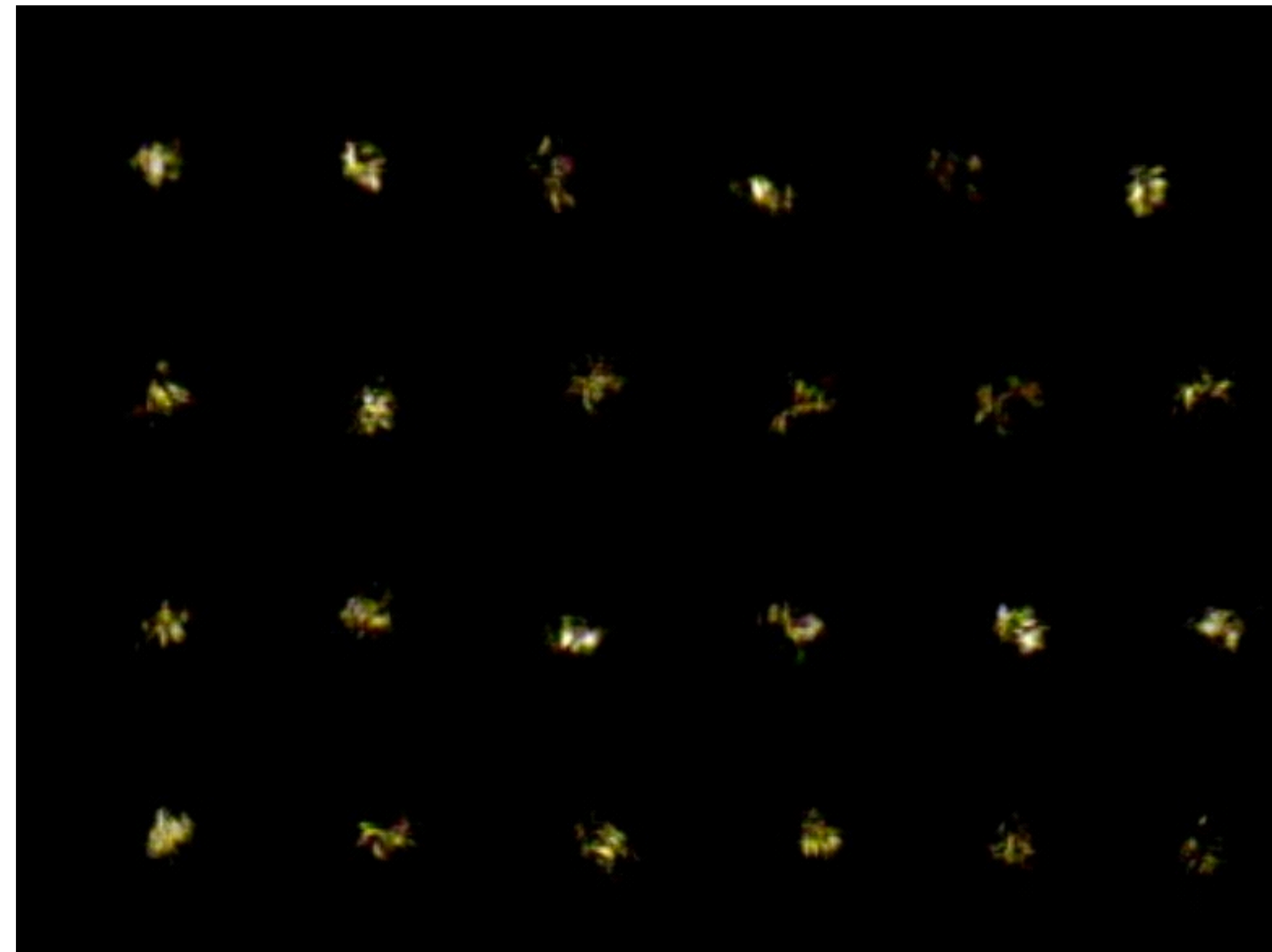
Seeing

- Completely unrelated to the above effects, turbulence in the atmosphere degrades the resolution of the image recorded by a telescope.
- The turbulence also causes a variation in the brightness of an image recorded by a telescope, a phenomenon known as scintillation (or, less formally, twinkling)



Left: An amateur astronomer's movie of the lunar crater Clavius taken in bad seeing conditions.

Right: Images of a star obtained on a large amateur telescope using a webcam with 0.01 s exposures. Each image is separated in time by about 1 second.



The Astronomical community

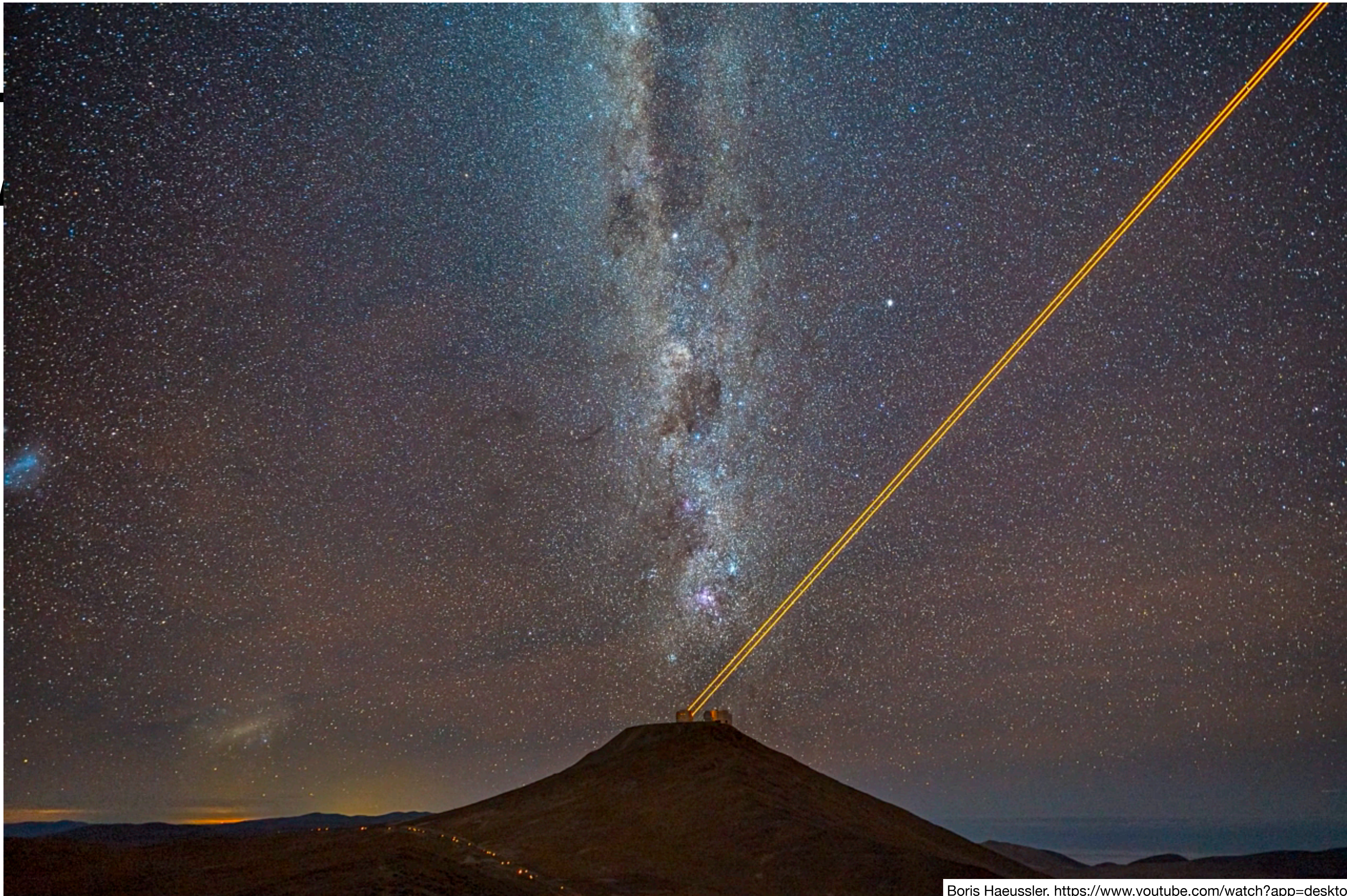
Why is Chile such an important place for astronomy?

Transparency Variations

- clouds can absorb and scatter the light from astronomical objects.
- The amount of absorption tends to be much more variable than that due to extinction, as the clouds are blown across the field of view of the telescope by the wind.
- Thin clouds can lead to partial attenuation of the object, while thicker clouds can completely obscure it



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The Astronomical community in Chile

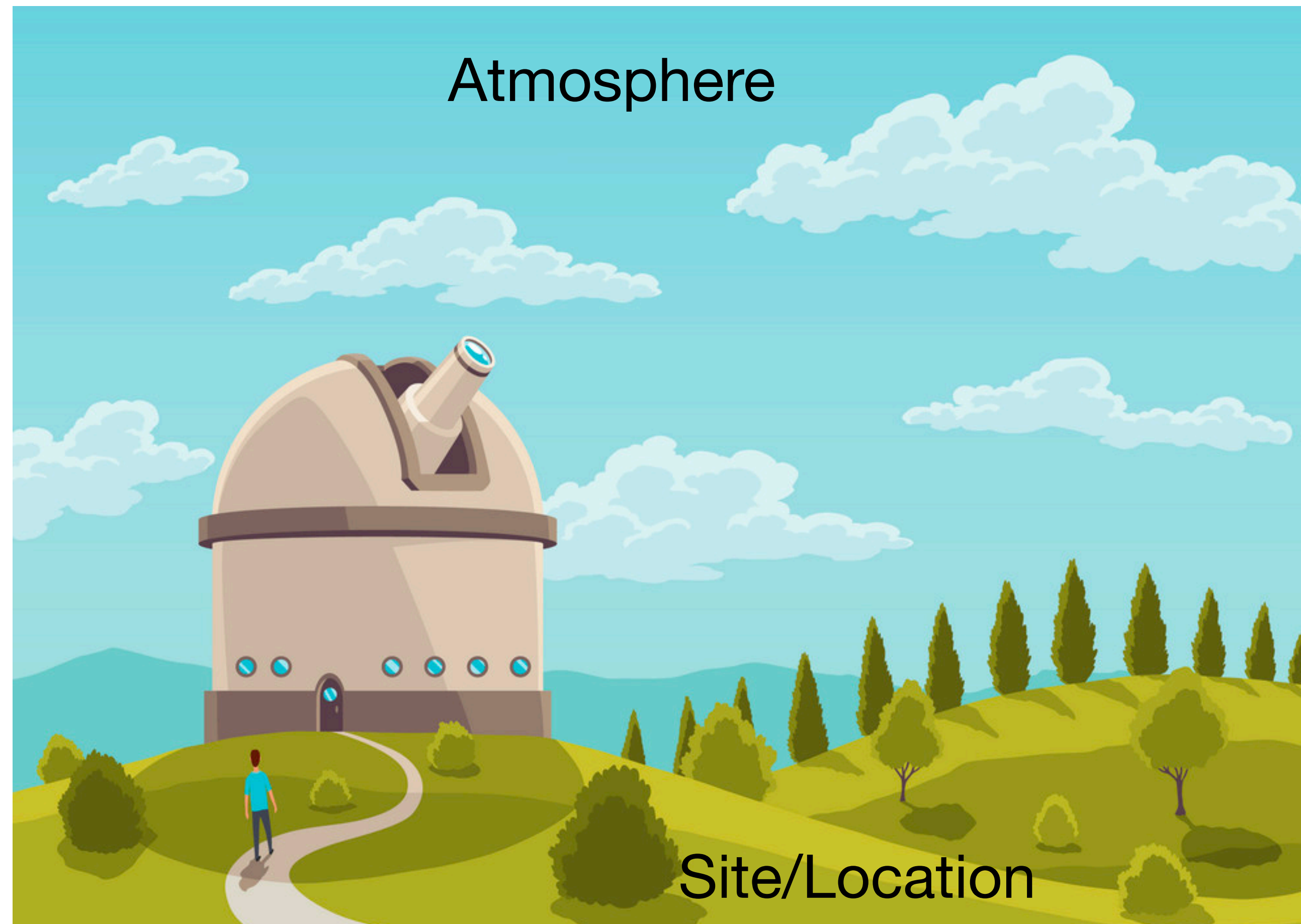
Why is Chile such an important place for Astronomy?

- It is very important not to confuse seeing and transparency. The two effects are largely unrelated
 - in poorer seeing, the image of a star will be more blurred, but its brightness will remain approximately constant
 - in poor transparency, the light from a star will be dimmed but its blurring will be largely unaffected

The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

First we must consider what makes a good observatory.



- Sky background
- Atmospheric Extinction
- Transparency variations
- Seeing

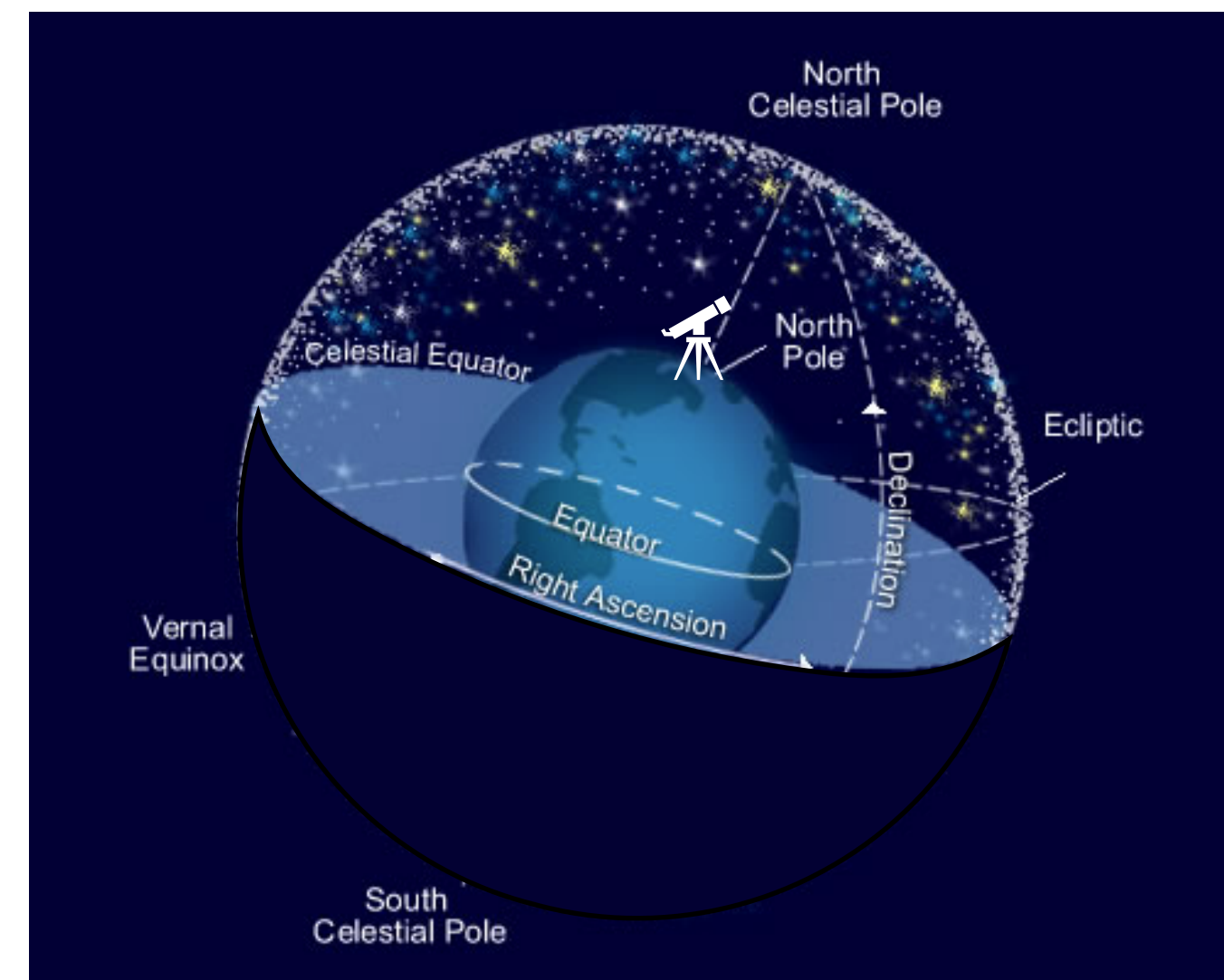
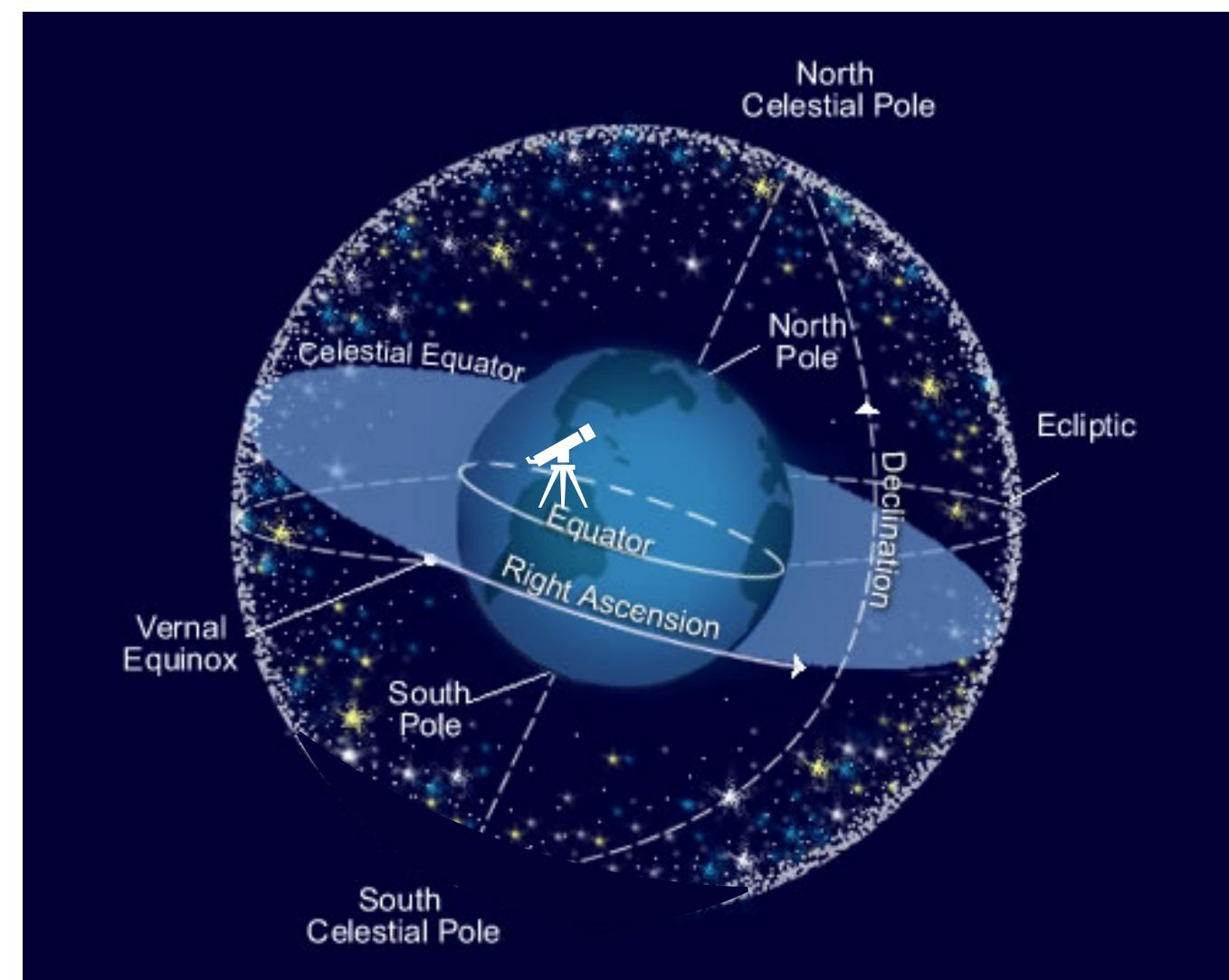
- Latitude
- Cloud cover
- Light pollution
- Seeing
- Height above sea level
- Other factors

The Astronomical community in Chile

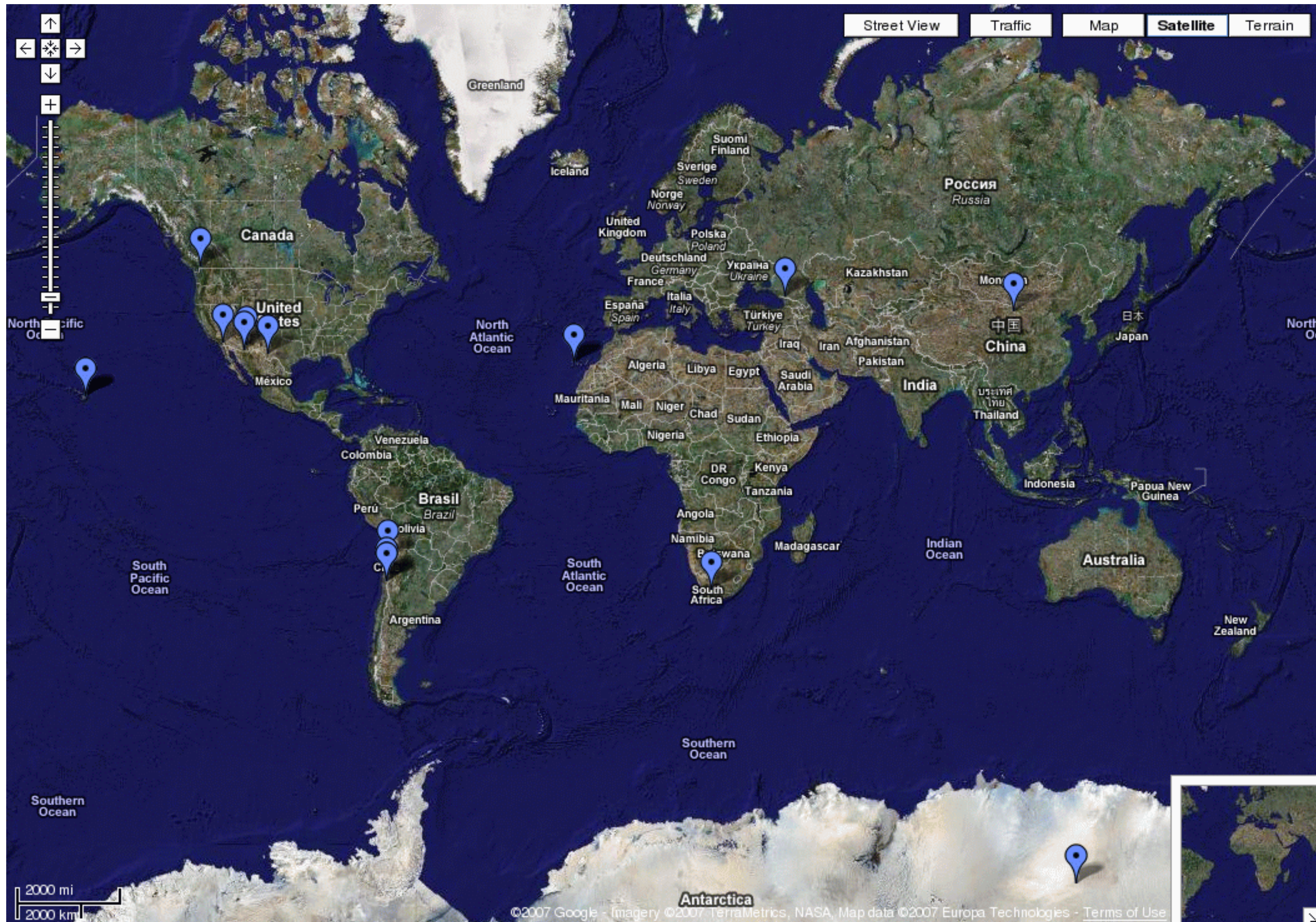
Why is Chile such an important place for Astronomy?

Latitude

- Do you want to observe the Northern or Southern hemispheres?
- North- has been studied for longer, more examples of all types of astronomical objects are known
- South- better view of the Milky Way and Magellanic Clouds
- Placing a telescope near the equator gives you access to both hemispheres
- Placing a telescope near the poles gives you longer winter nights- great for monitoring long-term stellar variability



Locations of the 23 largest telescopes (mirrors between 4-10.4m)



The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

Cloud Cover

- Radio telescopes can peer through clouds, but optical telescopes cannot.
- To maximise the use of the telescope, you want to select a site with minimal cloud coverage
- Desert regions, such as the Arctic, Antarctica, Australia, parts of Africa and the western coast of the Americas provide some of the best cloud conditions in this respect

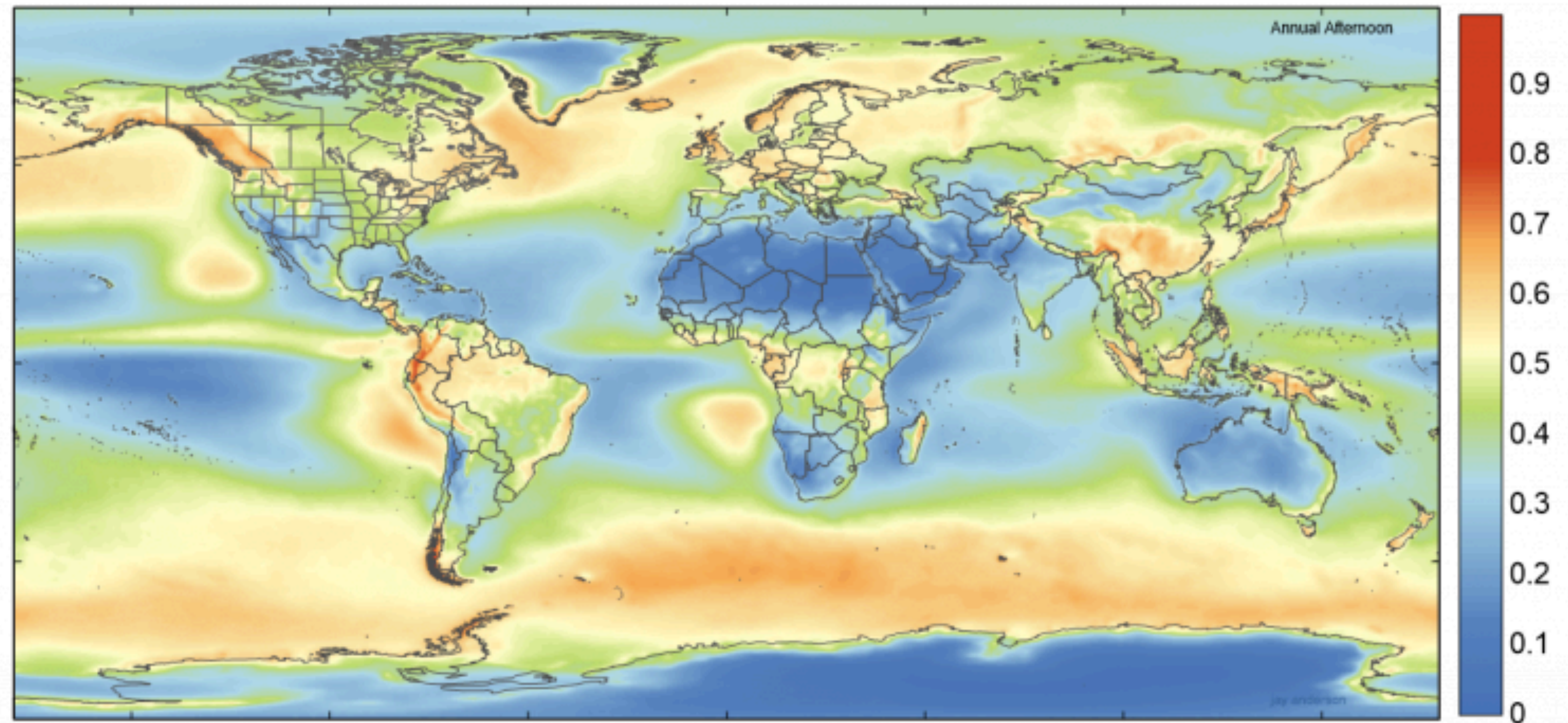


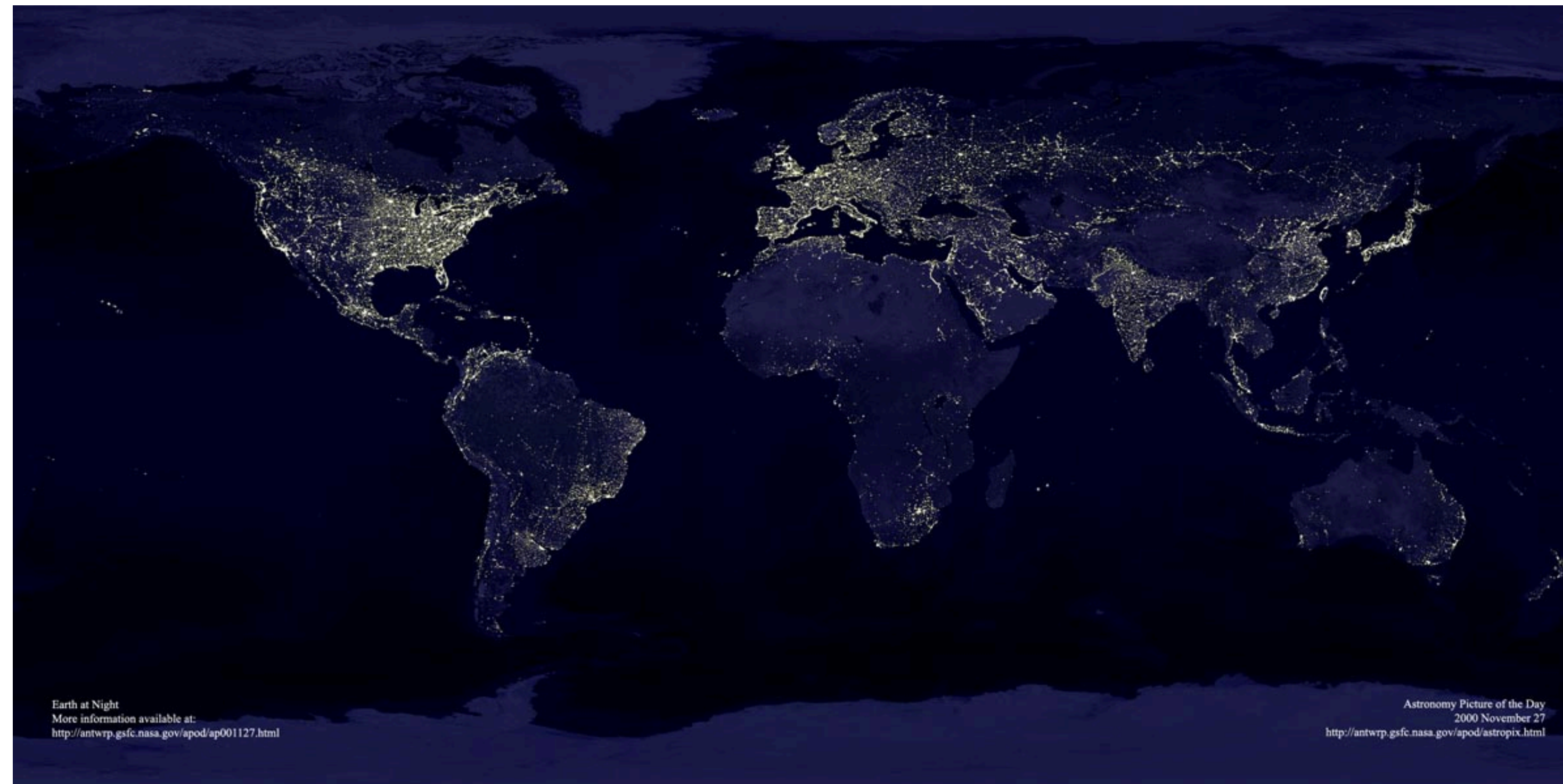
Image credit: Nasa

The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

Light pollution

- In order to observe the faintest objects, we need to minimise the light pollution from terrestrial sources (street lights etc)
- Ideally, we should locate telescopes far away from large towns and cities



The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

Seeing

- Poor seeing is a result of turbulence in the atmosphere
- Solution- find a site with less turbulent atmosphere above it!
- The atmosphere over the sea tends to be much less turbulent than the atmosphere over land, as the sea exhibits an essentially smooth, constant-temperature surface compared to the land.
- Some of the best astronomical sites are therefore located on small islands in the middle of oceans, such as Hawaii and the Canaries, as these small land masses cause little additional turbulence.
- For the same reason, coastal regions that receive winds predominantly from the direction of the ocean, such as the western coasts of the Americas and Africa, also exhibit excellent seeing.

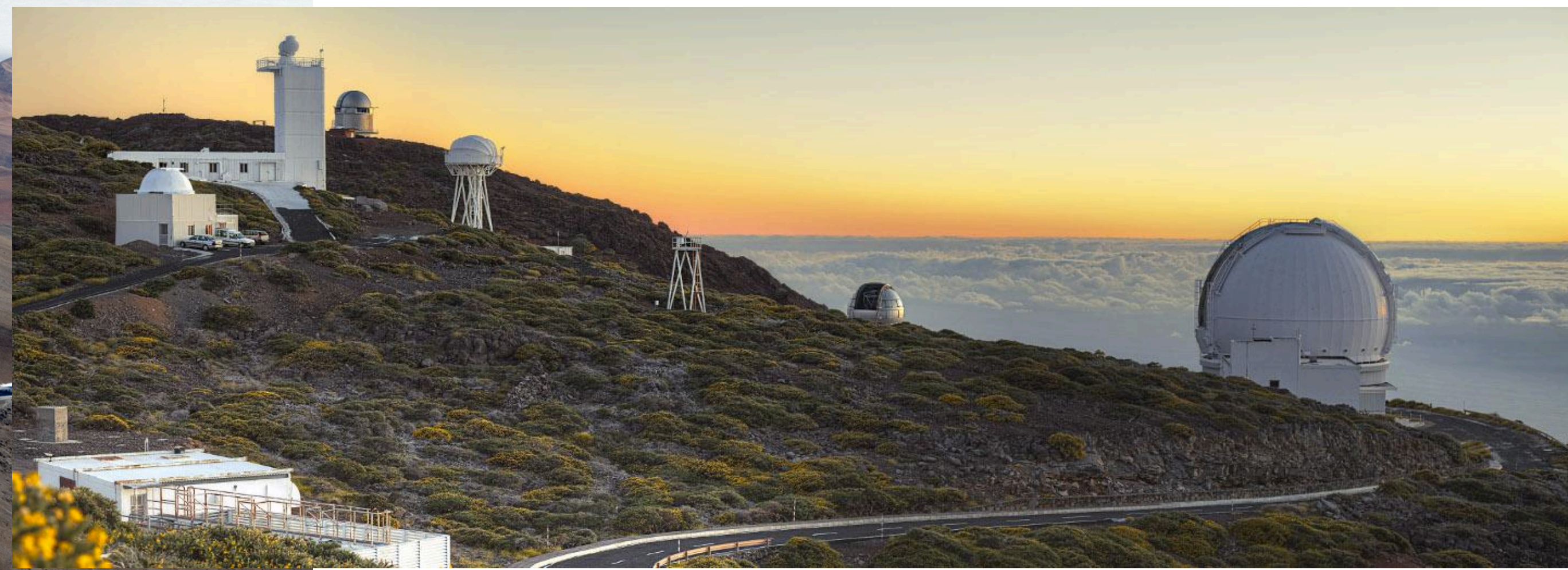
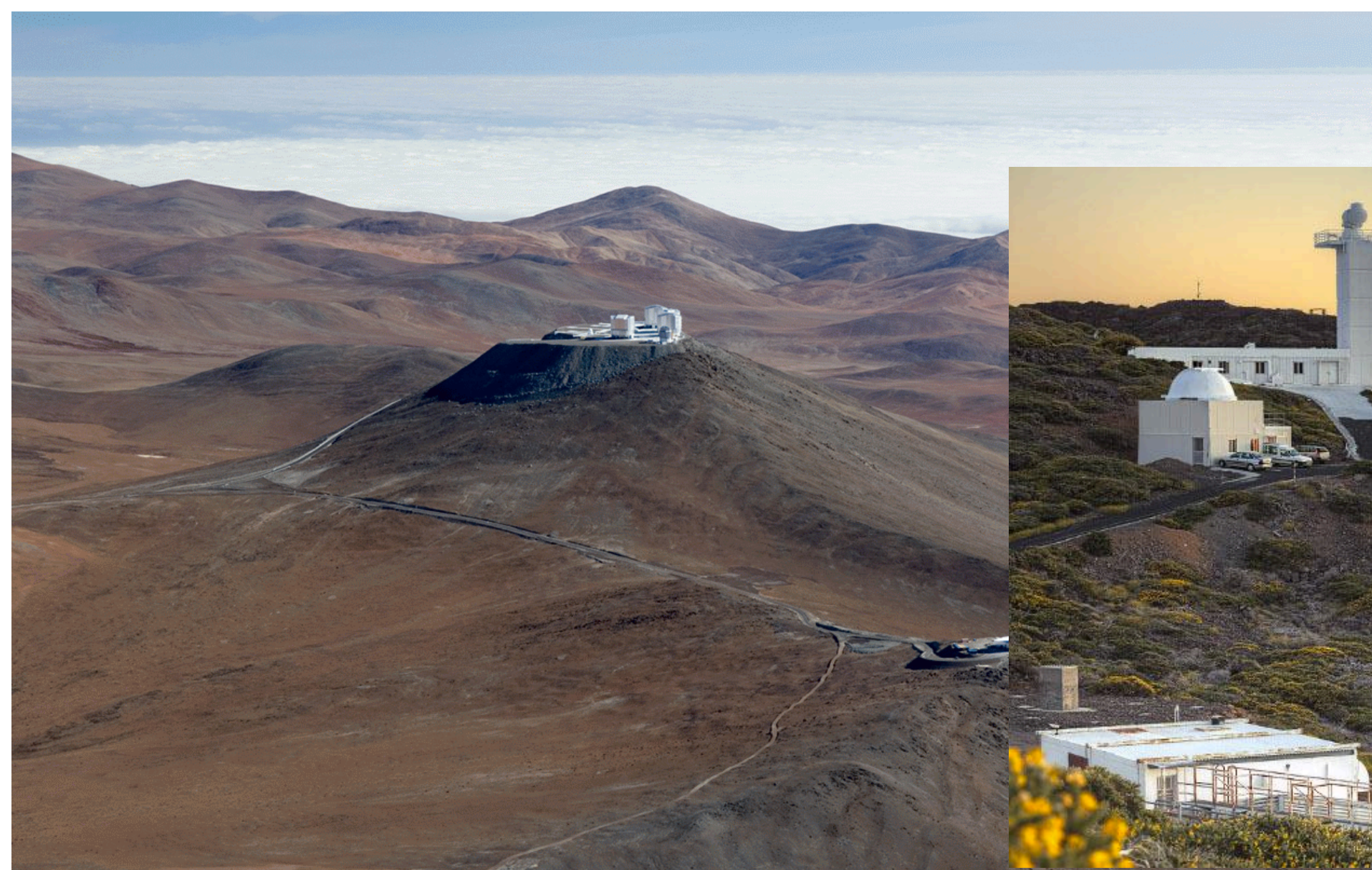


The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

Height Above Sea Level

- Another way to improve the seeing is to look through a thinner atmosphere
- As a result, many of the best observatories are located above 2000m
- High-altitude telescopes are also often above the local inversion layer in the atmosphere, meaning that local cloud formation occurs below the telescope, significantly increasing the number of usable nights at the observatory compared to a telescope sited below the inversion level.



The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

Other Factors to Consider

- **seismic activity** - telescopes built in seismically-active areas must be designed to survive strong earthquakes, which increases the complexity and cost of the facility.
- **auroral activity** - polar telescopes may be affected by light pollution from aurorae.
- **rainfall** - this is linked to cloud cover and humidity. Clearly, it is desirable to build telescopes in areas with low precipitation, as domes must be kept closed in the rain to prevent damage to the telescope.
- **wind speed** - strong winds can shake a telescope, blurring the images it produces. It is possible to design telescopes and domes in such a way that they are protected from wind shake and wind-blown debris (e.g. dust), but there are limits to how well these work when winds become very strong.
- **dust/aerosols** - widespread dust/aerosols in the atmosphere, such as produced by sandstorms in desert regions, or industrial pollution, causes additional extinction and hence attenuation of star-light. For example, due to their proximity to the Sahara, the Canary Islands are particularly susceptible to this.
- **temperature** - the sky glows in the infrared, significantly increasing the background noise in infrared images of astronomical sources. At cold sites, such as in Antarctica, this thermal emission from the sky is reduced, significantly improving the sensitivity of infrared observations.
- **accessibility** - sites must be accessible in order to build and operate telescopes there. Very remote telescopes without road access, for example, are extremely costly.

The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

Chile can offer observatories all or nearly all of these factors, making it a special place for Astronomy.

1849: first astronomical observatory built in Chile

1852: National Astronomical Observatory was born

1902: Foster Observatory built

Second half of 20th Century: Observatories built at La Silla, Cerro Tololo, Las Campanas and later Cerro Paranal, Cerro Pachon and Chajnantor



The Astronomical community in Chile

Why is Chile such an important place for Astronomy?

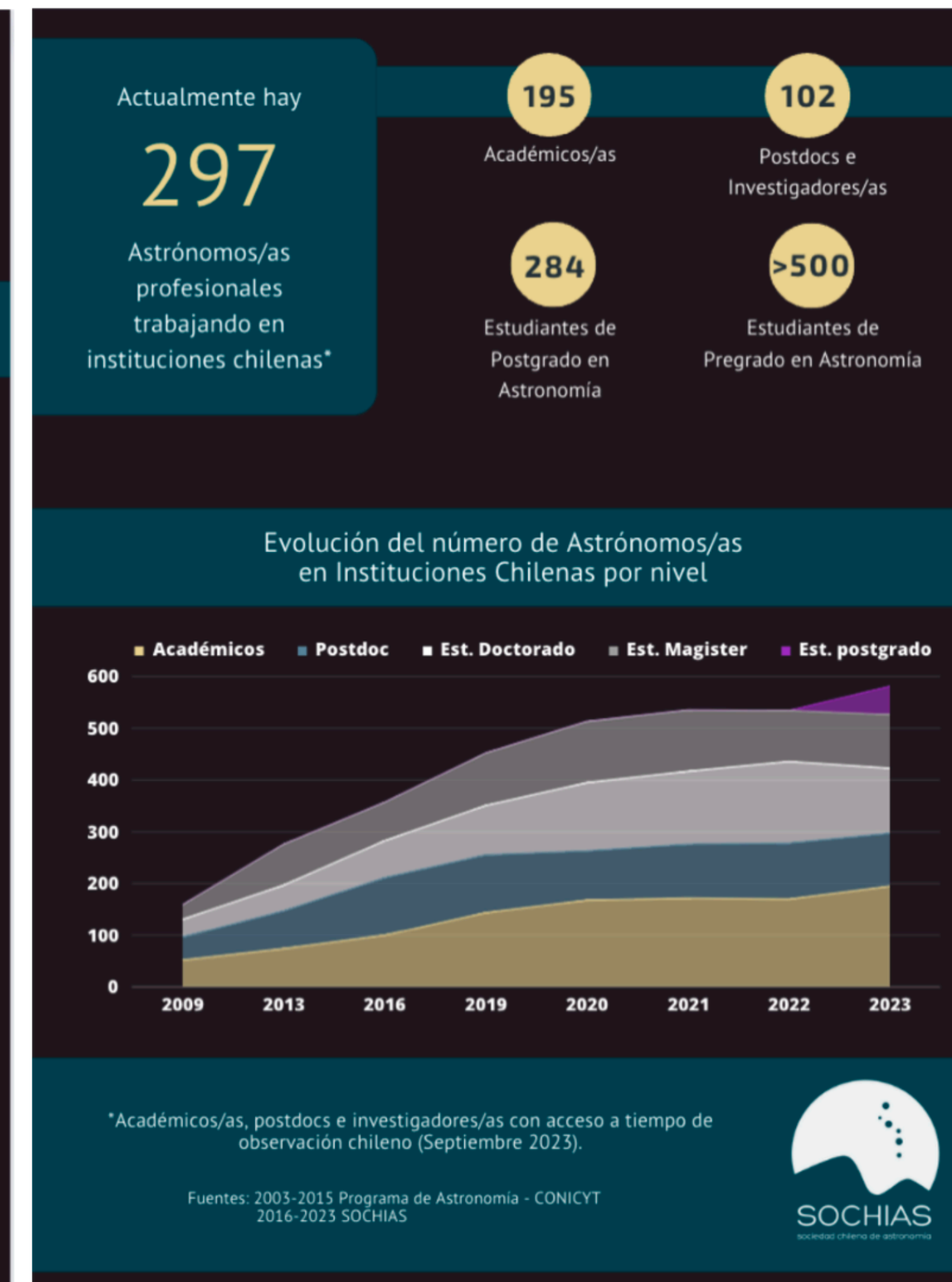
And with the Observatories came the astronomers!

- Chile now has a large and dynamic astronomical community, many of whom are international

Right: Results from the most recent census of astronomers in Chile

Source: SOCHIAS

<https://sochias.cl/astronomia-en-chile/censos-de-astronomos/>



The Astronomical community in Chile

Chilean Telescope and Data Access

“The international observatories operating in Chile have access to the best skies and observational conditions in the world, and make a percentage of their observation time, or equivalent in the case of survey telescopes, available to astronomers who work in Chilean institutions”

- Generally each observatory offers 10% of the telescope time to Chilean astronomers
- SOCHIAS maintains the “Lista Blanca” with the names of all astronomers in Chile who are eligible to access Chilean time

The Astronomical community in Chile

Chilean Telescope and Data Access

SDSS-V

- 3 surveys being carried out
- Chile now hosts all three surveys at Las Campanas Observatory
- In return, the whole Chilean community are eligible to be members of SDSS-V



The Astronomical community in Chile

Chilean Telescope and Data Access

SDSS-V LVM

- Thanks to my experience at ESO I am the Survey Operations Scientist for the LVM
- I am responsible for overseeing:
 - Science commissioning
 - Daily operations
 - Survey progress
 - Nightly observations
 - Maintenance, calibrations etc



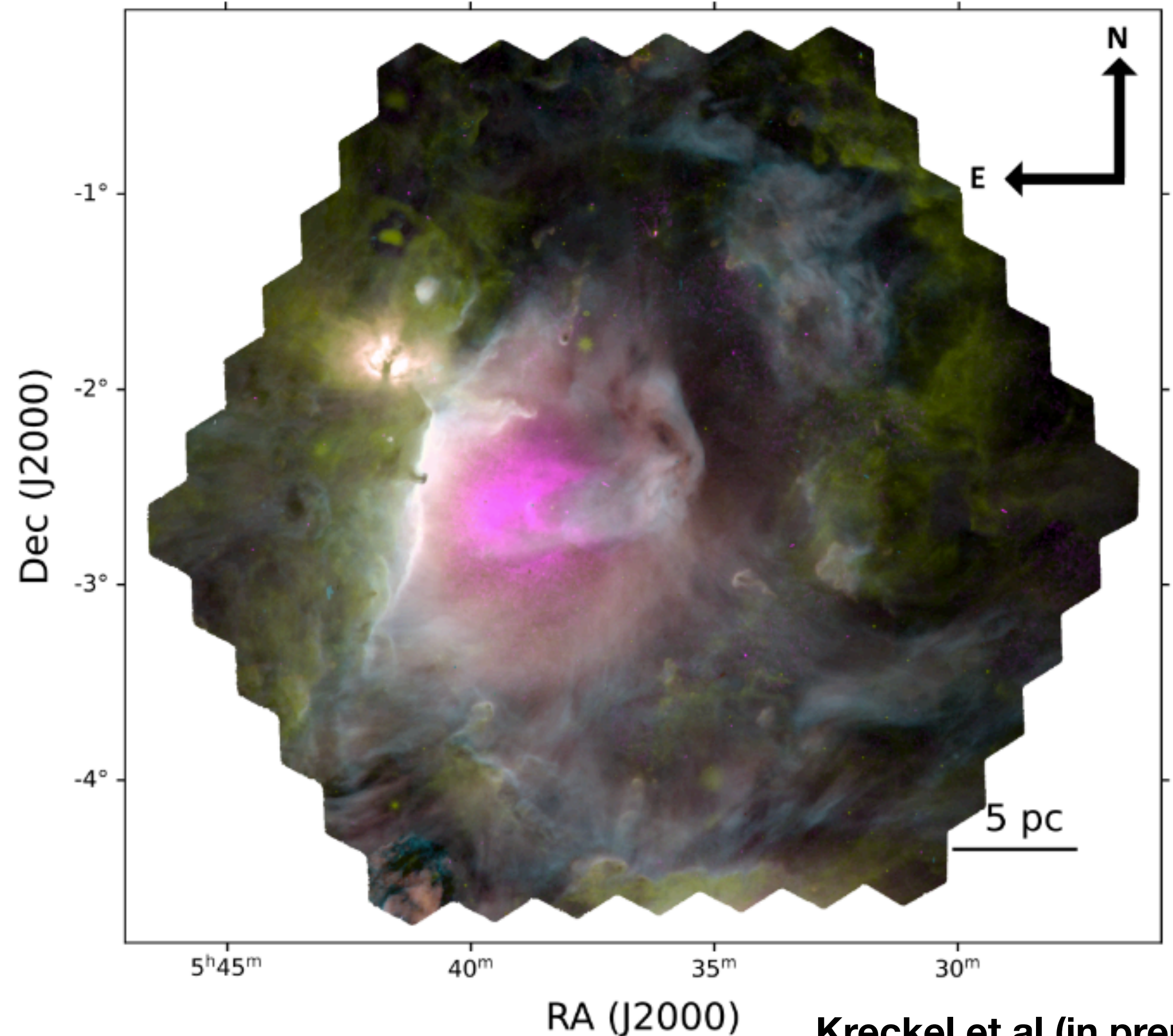
The Astronomical community in Chile

Chilean Telescope and Data Access

Orion Nebula

- First 108 tiles observed over 17 nights
- Radius $\sim 2^\circ$, final radius will be $\sim 6.5^\circ$

Colors show different emission lines (H α : orange, [Sii]6717+6731: light blue, [O iii]5007: magenta), trace the ionization structure of the nebula, and carve a bubble into surrounding dense gas (WISE 12 μ m: yellow). The ionized gas emission traces wispy, filamentary structures and dusty eroding clouds and clumps.



Job Opportunities in Astronomy in Chile

Warning:

this talk is a not-so-subtle attempt to convince you to consider pursuing a career in astronomy in Chile

Thanks to the Observatories and the growth of the astronomy community in Chile, there are many opportunities for careers in astronomy... and not just in academia.

Job Opportunities in Astronomy in Chile

Postdocs at Observatories

- ESO Fellowship
 - 3 years in Chile then 1 year either in Chile (ESO or another Chilean university) or an ESO member state
 - Time spent 50-50 on research and observatory duties
 - Great opportunity to develop instrumentation and technical knowledge
- ALMA Fellowship
 - Similar to the ESO fellowship, but with just 3 years in Chile

Job Opportunities in Astronomy in Chile

Postdocs in universities

- FONDECYT Fellowships announced each year ~April
- Many other postdocs opportunities through other funding sources:
 - ESO Comité Mixto
 - ANID-Gemini
 - ANID ALMA
 - CATA
 - Nucleo Milenios
 - MAS
- Keep an eye on the job register, or reach out to a collaborator or potential supervisor if you are interested in working with them

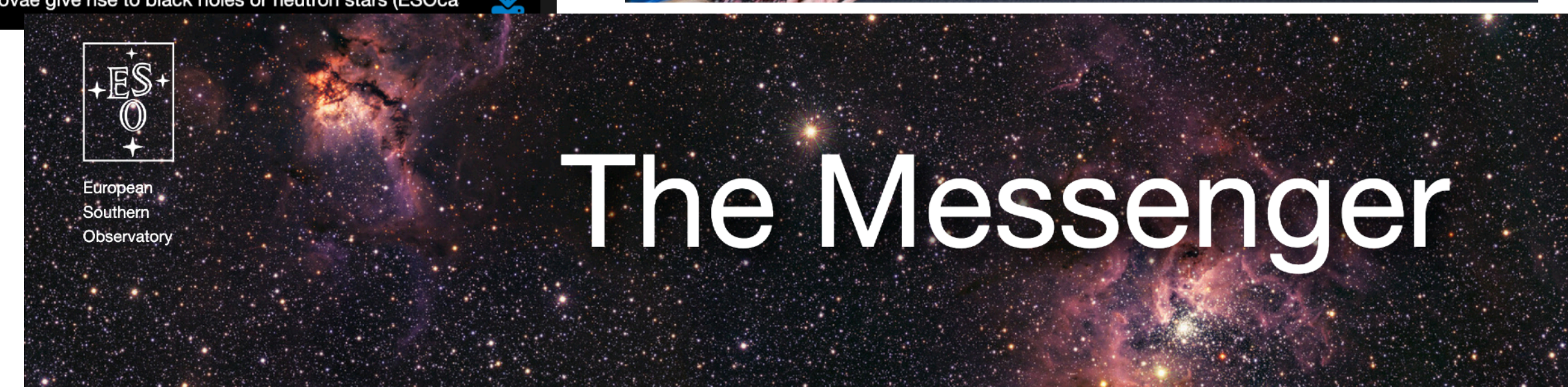
Job Opportunities in Astronomy in Chile

Outreach

- EPOD- ESO Public Outreach Department
-



A screenshot of the ESO website. At the top, there's a navigation bar with flags and menu items: ABOUT, IMAGES, VIDEOS, NEWS (highlighted), ESOSHOP, and TELESCOPES & INSTRUMENTS. Below this is a 'Press Releases' section with a sub-header 'Subscribe to receive news from ESO in your language!'. Two news items are visible: 'eso2401 - Press Release: Missing link found: supernovae give rise to black holes or neutron stars' dated 10 January 2024, and 'eso2320 - Press Release: New 1.5-billion-pixel ESO image shows Running Chicken Nebula in unprecedented detail' dated 21 December 2023. To the right is a 'Videos' section with a grid of video thumbnails. One thumbnail shows a woman with the text 'WHAT'S WRONG WITH OUR SKY?' and 'CHASING STARLIGHT'. Another shows a blue nebula with the text 'Origin of black holes PROVEN' and 'NEWS'. A third shows a star with the text 'Come to the Dark Side, we have stars | Chasing Starlight 8'. The ESO logo and 'European Southern Observatory' text are visible in the top left of the screenshot.



Job Opportunities in Astronomy in Chile

Outreach

- Outreach officers in many departments



“Ahora cuando escucho sobre las estrellas puedo imaginarlas”

Astronomía Inclusiva

Entrevista con Elizabeth Caballería, coordinadora Biblioteca Central para Ciegos en Chile.

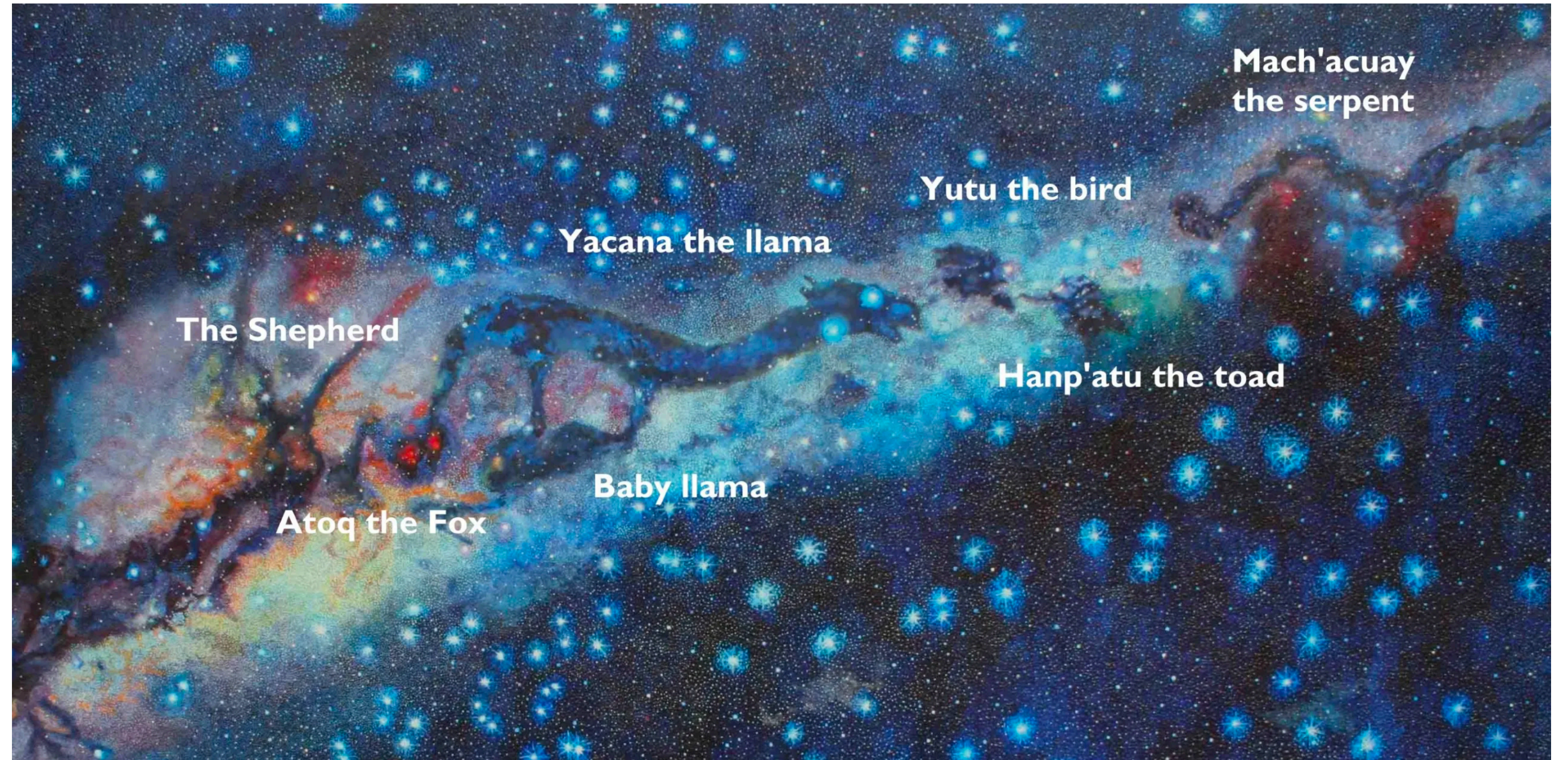
Escrito por Pamela Paredes



Job Opportunities in Astronomy in Chile

Outreach

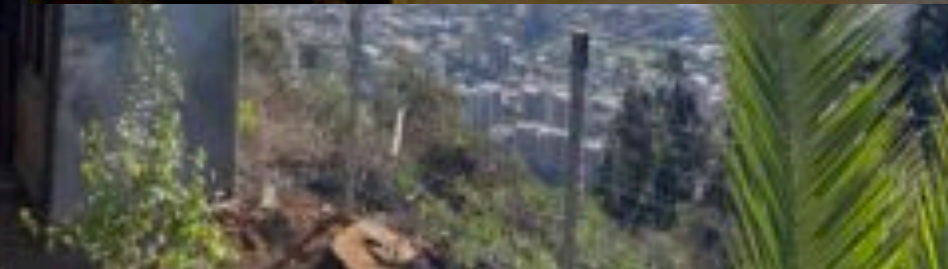
- Outreach officers in many departments



Job Opportunities in Astronomy in Chile

Outreach

- Many small observatories that run public tours all over the country



Job Opportunities in Astronomy in Chile

Outreach

- Many small observatories that run public tours all over the country



Job Opportunities in Astronomy in Chile

Observatory positions

- Observatories have various positions that astronomers can apply for
 - Support astronomer
 - With/without science time
 - Based at observatory HQ or a university when not on mountain
 - Telescope operator
 - Observing specialist (e.g. LSST)
 - Verification systems engineer (e.g. LSST)
 - Instrumentation
 - Science Archive Content Manager (e.g. ALMA)
- And many more...

Job Opportunities in Astronomy in Chile

ESO studentship

- Studentship to come to Chile and work with one of the staff astronomers or fellows
- 6 months - 2 years
- Two annual application deadlines: April 30th and October 30th
- <https://www.eso.org/sci/activities/fellowships-and-studentships/FeSt-overview/ESOstudentship.html>



Job Opportunities in Astronomy ~~in Chile~~

ING studentship

- *Based in La Palma, not Chile*
- 1 year supporting the Isaac Newton Telescope in La Palma as part of your Masters or Phd
- <https://www.ing.iac.es/astronomy/science/studentship.html>



Summary

Astronomy in Chile ≠ ESO

- In the last 170 years Chile has become one of the most important countries in the world for astronomy
- Chile now has a large and very active astronomy community, and not just in research/academia
- We host some of the best telescopes in the world, and that has brought us many opportunities within astronomy that are difficult in other places

Summary

Astronomy in Chile ≠ ESO

- In the last 170 years Chile has become one of the most important countries in the world for astronomy
 - Chile now has a large and very active astronomy community, and not just in research/academia
 - We host some of the best telescopes in the world, and that has brought us many opportunities within astronomy that are difficult in other places
-
- (Consider applying for jobs in astronomy in Chile)