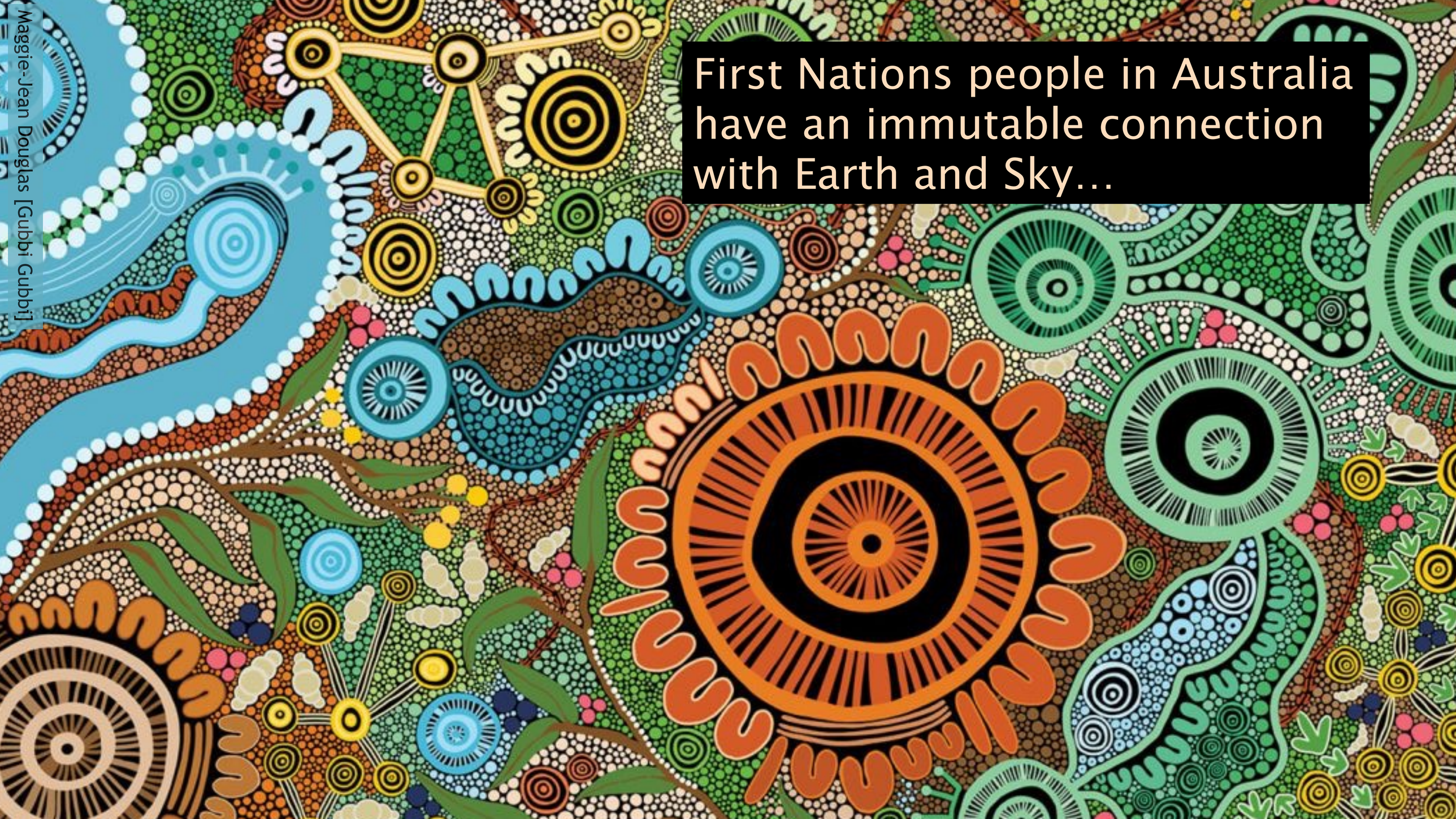
Dark and Quiet Skies

An Australian perspective

Fred Watson AM

Astronomer-at-Large
Department of Industry,
Science and Resources

Akira Fujii


First Nations people in Australia have an immutable connection with Earth and Sky…
Maggie-Jean Douglas [Gubbi Gubbi]

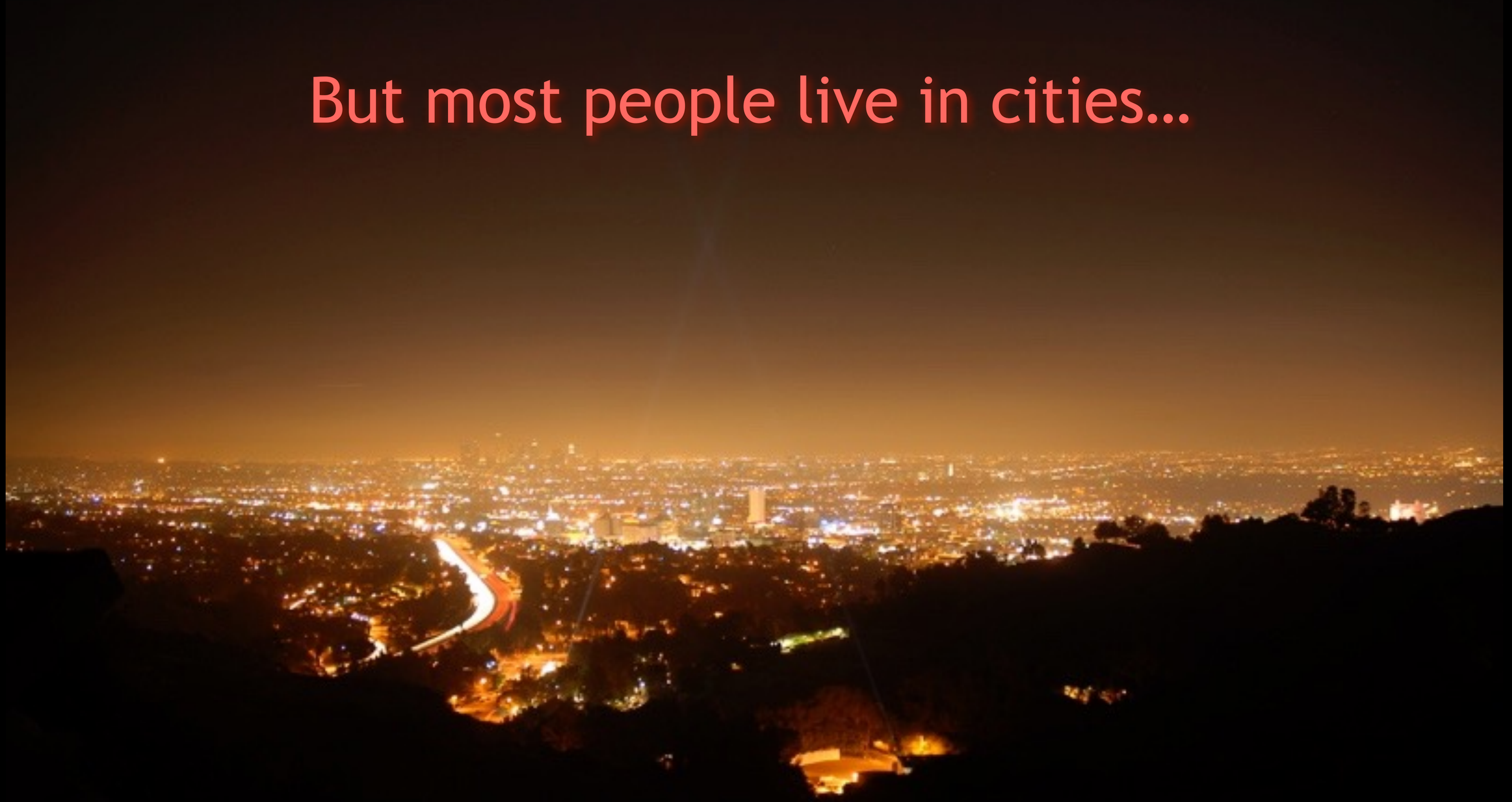
The best-known Aboriginal constellation is the Emu…

Kyle Pickett, Nyoongar People

Recognising the First Nations' Emu...

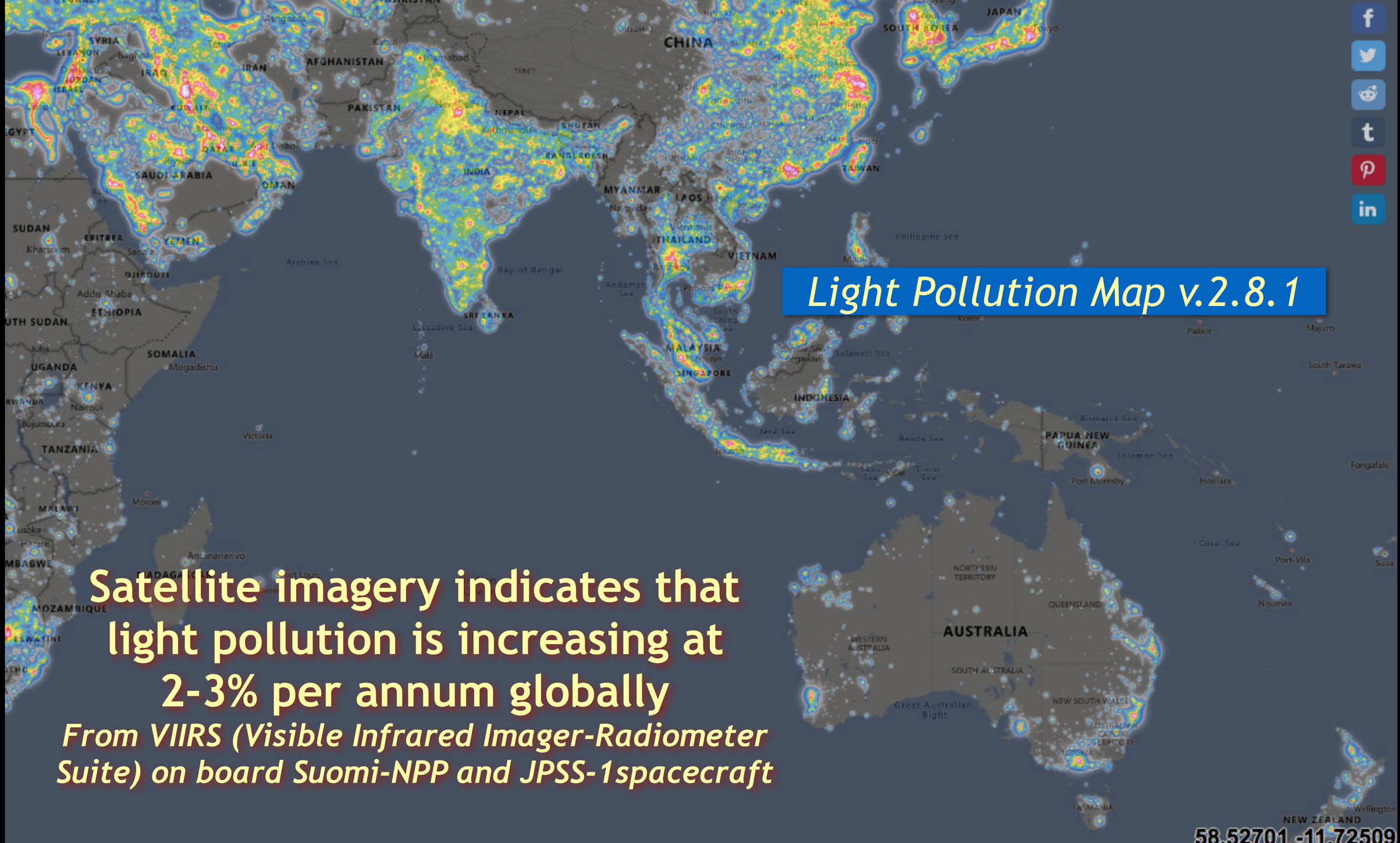
Akira Fujii

But most people live in cities…



Anon

…And no-one needs an introduction to the ills of light pollution…


Light Pollution Map v.2.8.1
Satellite imagery indicates that light pollution is increasing at 2-3% per annum globally
From VIIRS (Visible Infrared Imager-Radiometer Suite) on board Suomi-NPP and JPSS-1spacecraft
lightpollutionmap.info
58.52701 -11.72509

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Perhaps because VIIRS has little sensitivity for $\lambda < 600$nm

LIGHT POLLUTION

Citizen scientists report global rapid reductions in the visibility of stars from 2011 to 2022

Christopher C. M. Kyba,[1,2]* Yiğit Öner Altıntaş,[1]† Constance E. Walker,[3] Mark Newhouse[4]

The artificial glow of the night sky is a form of light pollution; its global change over time is not well known. Developments in lighting technology complicate any measurement because of changes in lighting practice and emission spectra. We investigated the change in global sky brightness from 2011 to 2022 using 51,351 citizen scientist observations of naked-eye stellar visibility. The number of visible stars decreased by an amount that can be explained by an increase in sky brightness of 7 to 10% per year in the human visible band. This increase is faster than emissions changes indicated by satellite observations. We ascribe this difference to spectral changes in light emission and to the average angle of light emissions.

SCIENCE 20 January 2023

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Why do astronomers need dark skies..?

Angel Lopez-Sanchez. AAO-MQ

The night sky itself is luminous, and astronomers have to measure faint objects that might be only 1% brighter than this natural sky background


Australia’s national optical astronomy observatory needs protection…
Siding Spring Observatory, NSW
Gamilaraay Country
Australian Government
Department of Industry, Science and Resources


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3.9-metre Anglo-
Australian Telescope…
Doing world-class science
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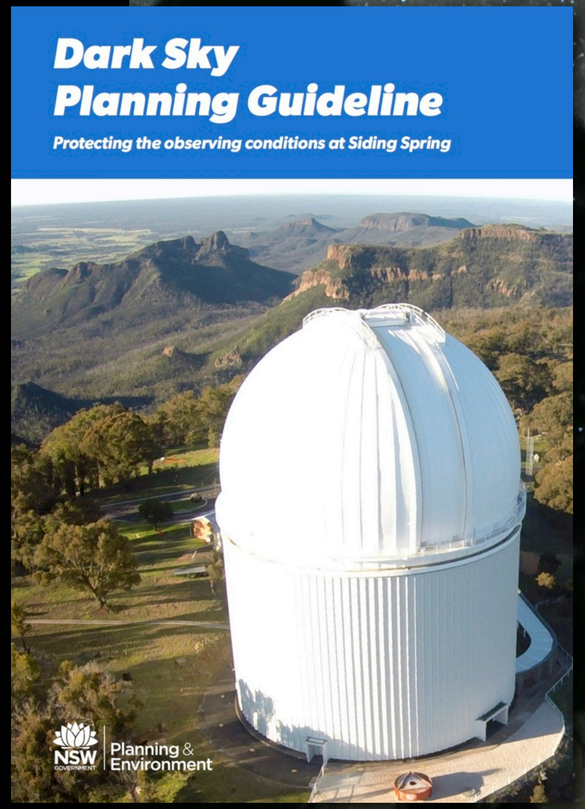
Angel Lopez-Sanchez. AAO-MQ

Dark sky legislation



NSW Dept of Planning and Environment

- *Initial legislation introduced in 1990 - hard to enforce and eventually obsolete*
- *New Planning Regulations introduced in 2016 mandate the NSW Dark Sky Planning Guideline be followed for all development within 100 km of Siding Spring Observatory.*
- *And for State Significant Developments (e.g. gas wells, coal mines) within 200 km*
- *Currently under revision*

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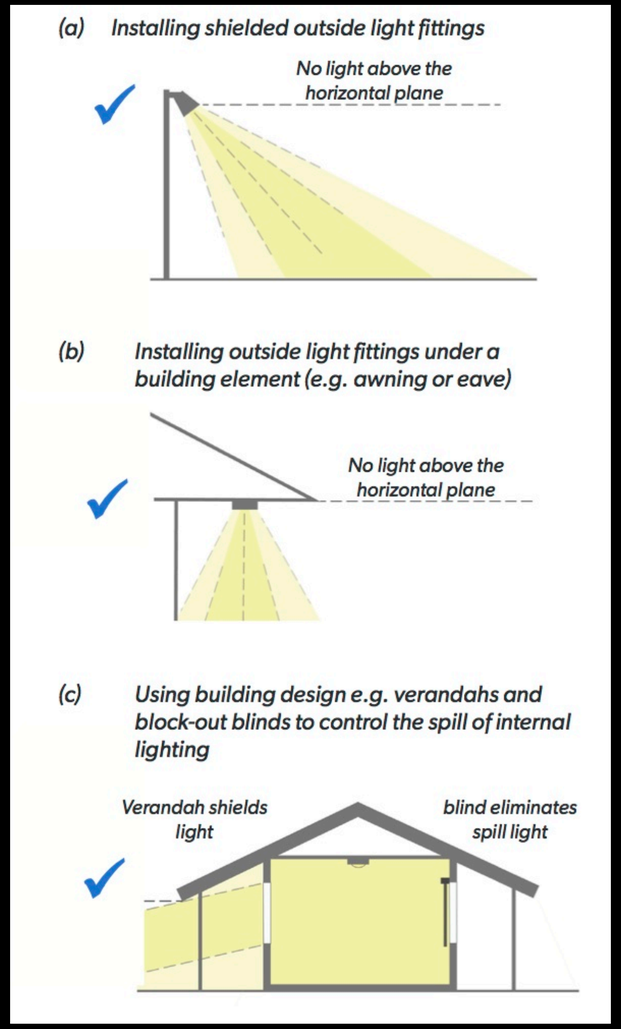
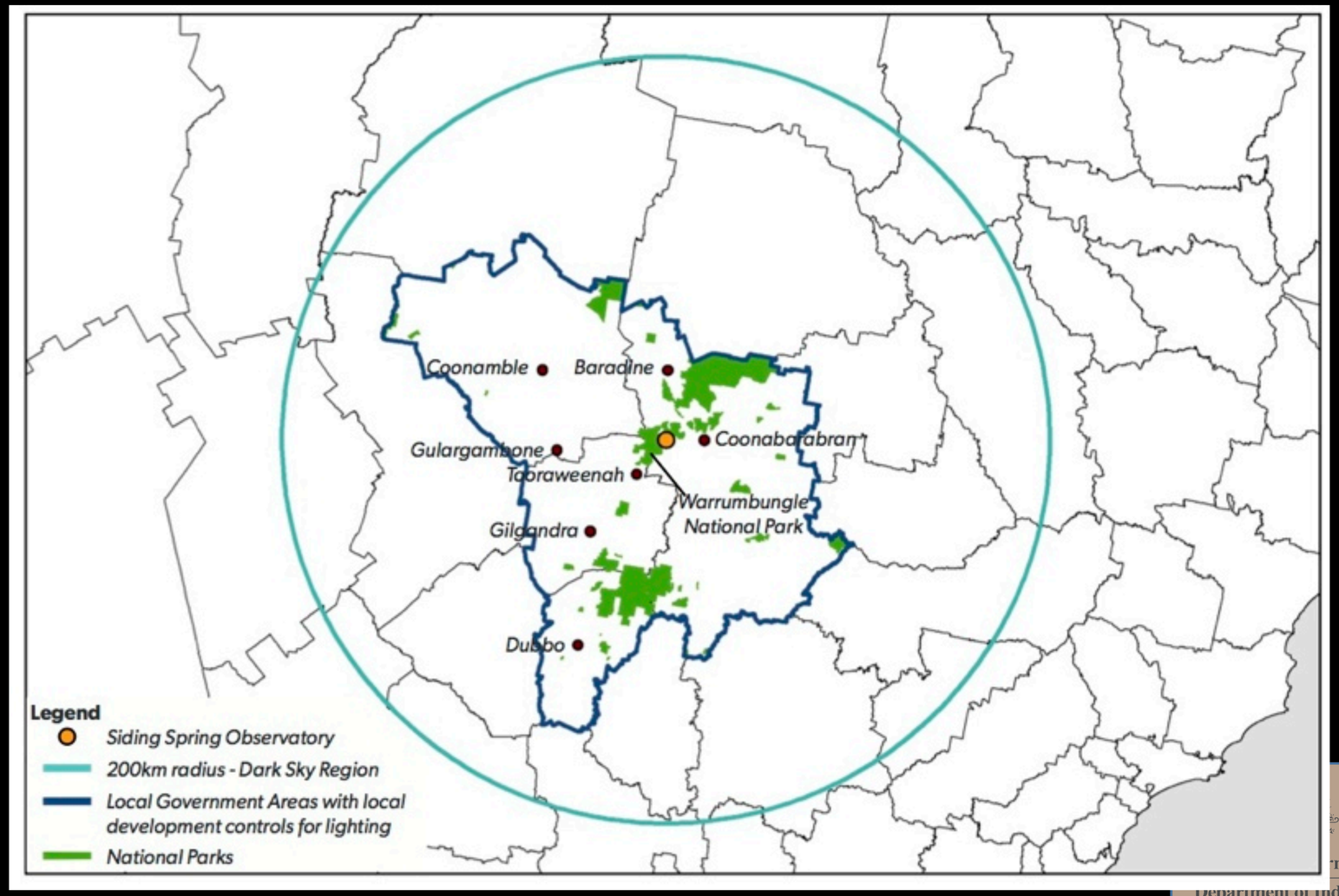
Department of Industry, Science and Resources

The Guideline presents user-friendly good lighting principles for the 400km-diameter Dark Sky Region - backed by NSW state legislation

NSW Dept of Planning and Environment





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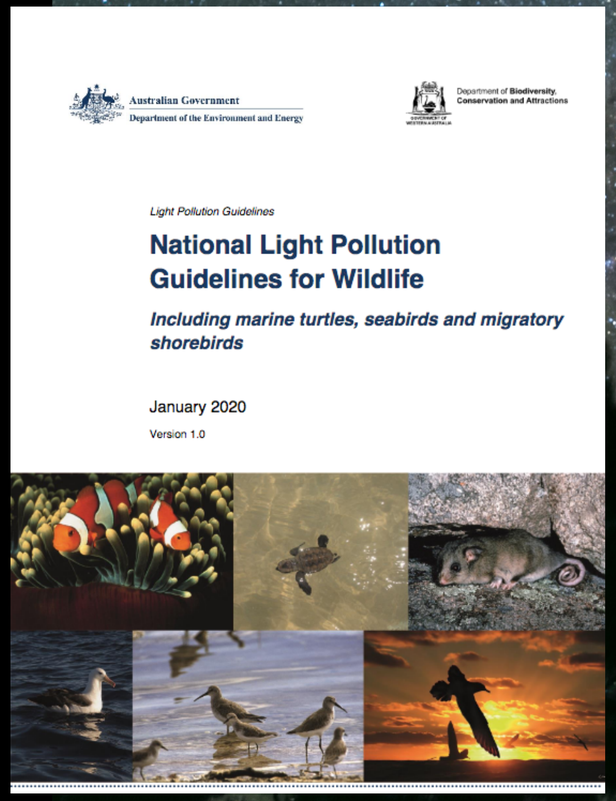
Australia-wide safeguards



DAWE (now DCCEEW)

- *National Light Pollution Guidelines for Wildlife*
- *National lighting standards: AS4282 controlling obtrusive lighting; AS/NZS1158 controlling lighting of roads and public spaces*
- *Advocacy and education by the Australasian Dark Sky Alliance*
- *Public interest in Australia's three IDA Dark Sky Places, of which the first was the Warrumbungle Dark Sky Park (2016)*
- *ASA's Designated Observatories scheme…*

Angel Lopez-Sanchez. AAO-MQ

Protecting the daytime sky

Australia's investment in radio astronomy spans the continent…

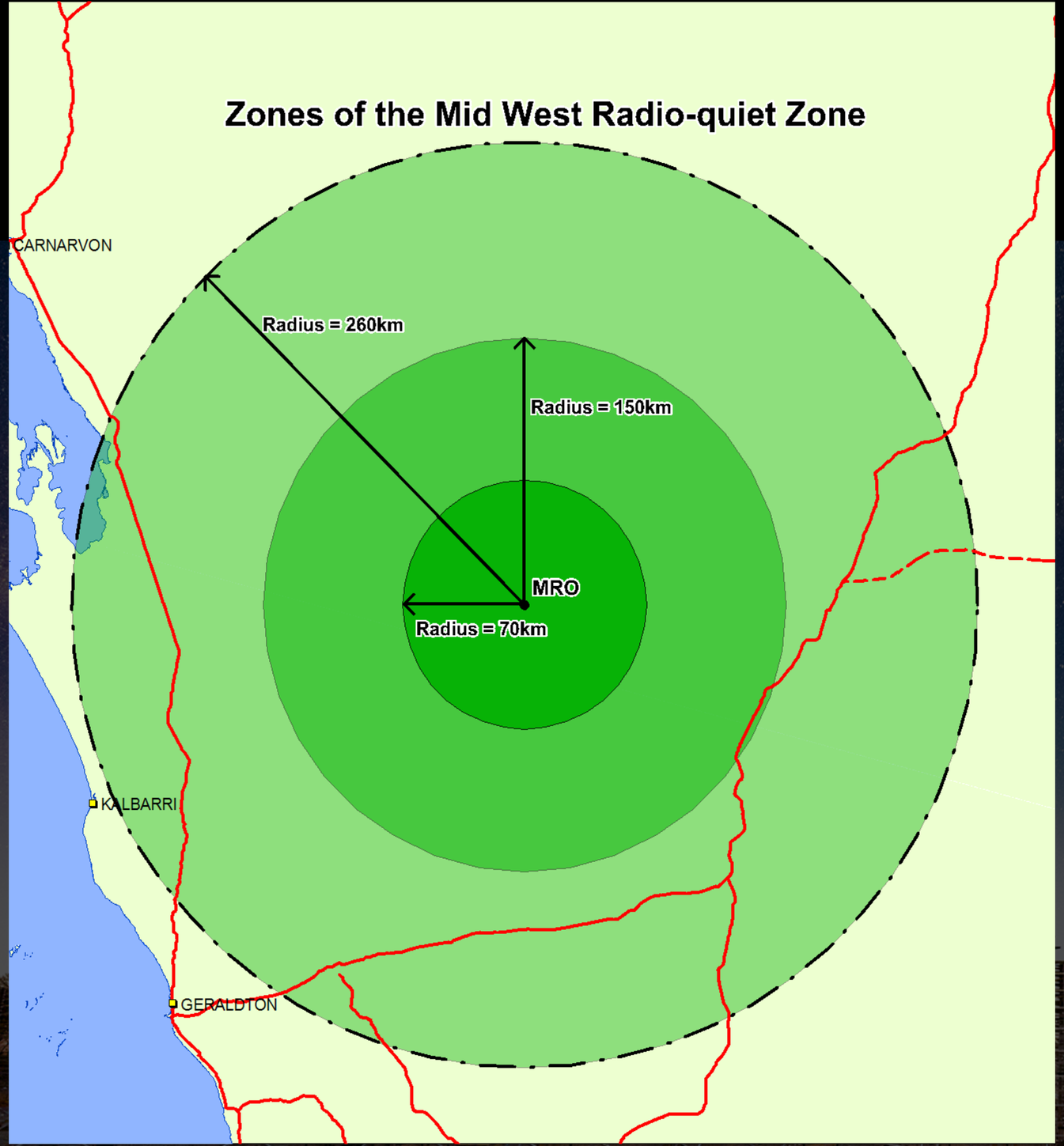
From the venerable Parkes antenna (Murriyang) in the east…

Wiradjuri Country

Operated by CSIRO, Australia's national science agency

ATNF/CSIRO


…to the CSIRO Murchison Radio-astronomy Observatory in the west
Inyarrimanha Ilgari Bundara = sharing sky and stars
Home of the future low-frequency component of the Square Kilometre Array and its existing low- and mid-frequency precursors
Offers an unprecedented level of legislated protection from radio frequency interference
Wajarri Yamatji Country
Australian Government
Department of Industry, Science and Resources
CSIRO via Carol Wilson



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- Inner Zone (0-70 km): Radio-astronomy is the primary user. Five legislative, regulatory and policy instruments (inc. Australian Communications and Media Authority (ACMA) Frequency Band Plan, class licence conditions, WA DMIRS emissions management, etc.)
- Outer Zone (70-150 km): Gov't consultation required under ACMA Radio Assignment and Licensing Instruction (RALI) MS 32
- Coordination Zones (up to 260 km depending on frequency): also specified in RALI MS 32

DISR/Carol Wilson, CSIRO

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Protection from terrestrial interference…

https://www.planning.nsw.gov.au/-/media/Files/DPE/Guidelines/dark-sky-planning-guideline-2016-06.pdf

https://www.awe.gov.au/sites/default/files/documents/national-light-pollution-guidelines-wildlife.pdf

https://www.australasiandarkskyalliance.org/

https://www.industry.gov.au/policies-and-initiatives/co-hosting-the-ska-telescope/the-australian-radio-quiet-zone-wa

Greg Priestley, David Malin Awards 2018

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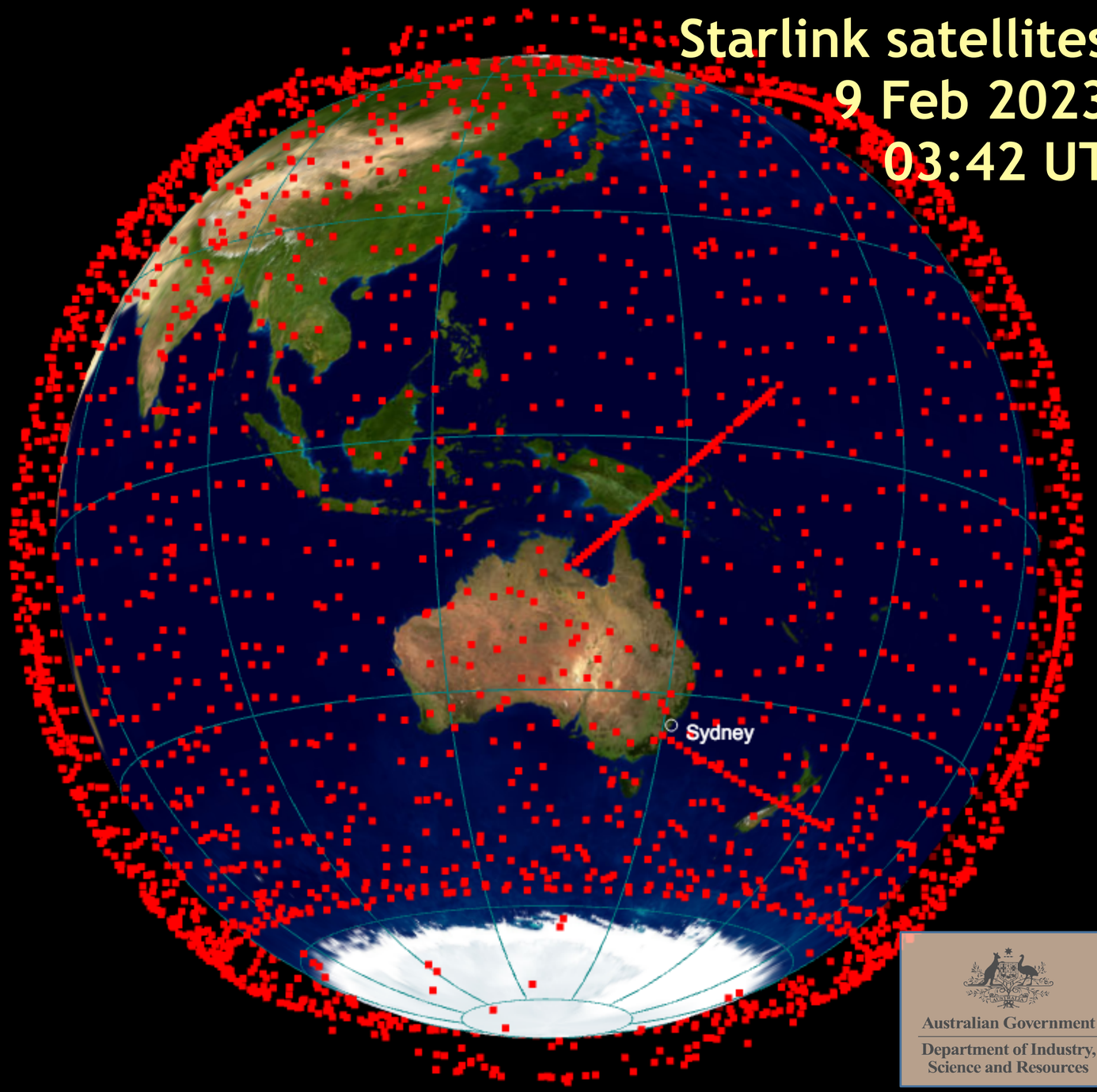
Despite all this protection from local terrestrial interference, Australian astronomy shares the global challenge of interference from satellite constellations



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Including Australia's overseas connections...

Australia-ESO Strategic Partnership 2017-2027

Giving Australian astronomers access to the world's foremost suite of southern hemisphere optical telescopes in northern Chile, operated by the European Southern Observatory

ESO

SKAO

And both sites of the future Square Kilometre Array

SKA-Mid: 197 x 13.5-m antennas
covering 350 MHz to 15.3 GHz,
Northern Cape Province, South Africa

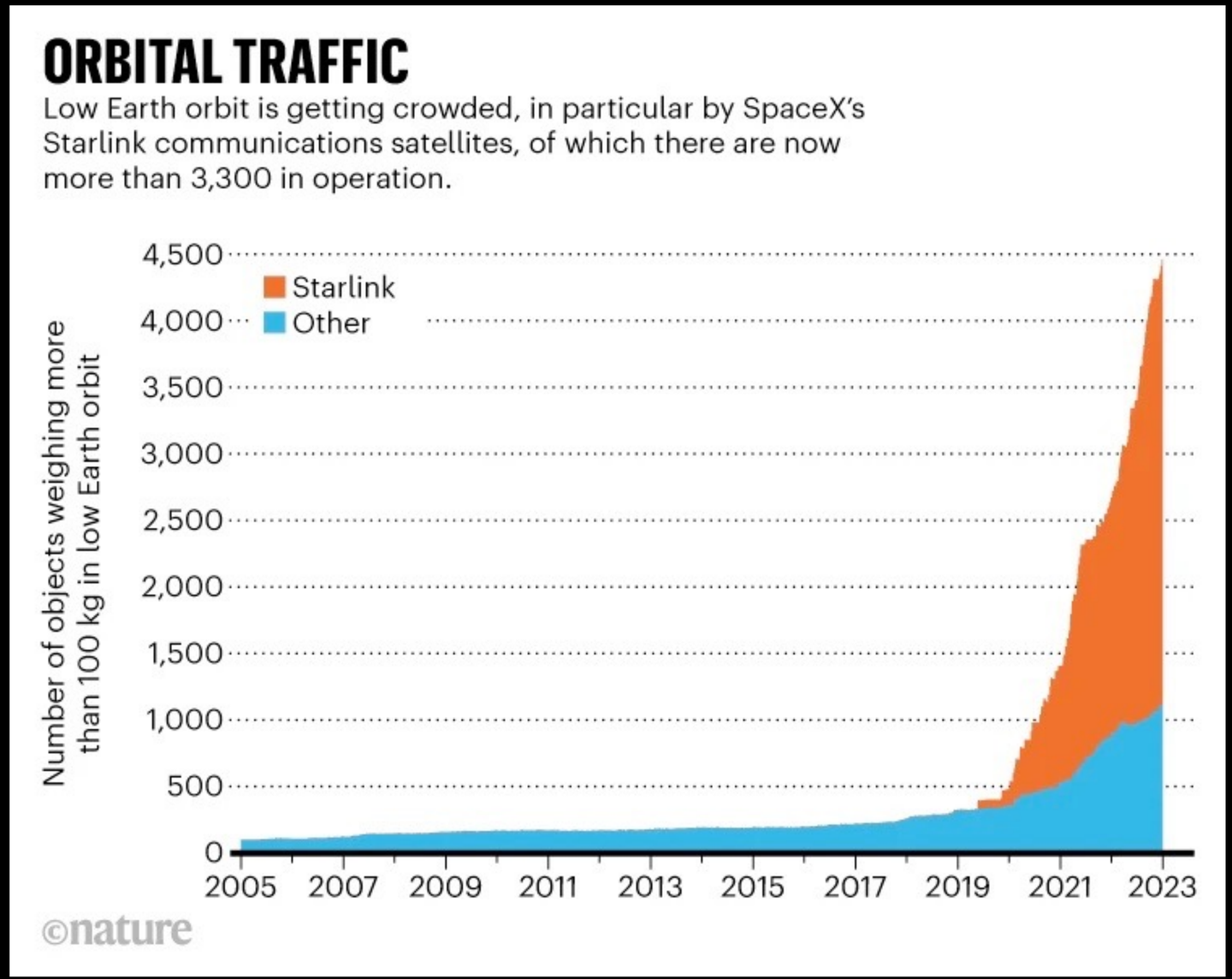
SKA-Low: 131,072 ‘Christmas tree’
dipole antennas covering 50 - 350 MHz,
Inyarrimanha Ilgarri Bundara MRO, Australia

Having started in mid-2019, Starlink (SpaceX) has 3236 of 12,000 planned satellites working (as of November 2022)

SpaceX launches at up to 106 satellites per month. ‘Gen2’ is approved to add 30,000 more.

Other players include OneWeb (428 working; 648 planned), Kuiper (Amazon) 3236 proposed, China SatNet (12,992 proposed)

21 Sep 2021, the Rwandan Government filed an application to the ITU to launch and operate two megaconstellations totalling 327,320 satellites



Jonathan McDowell via Nature

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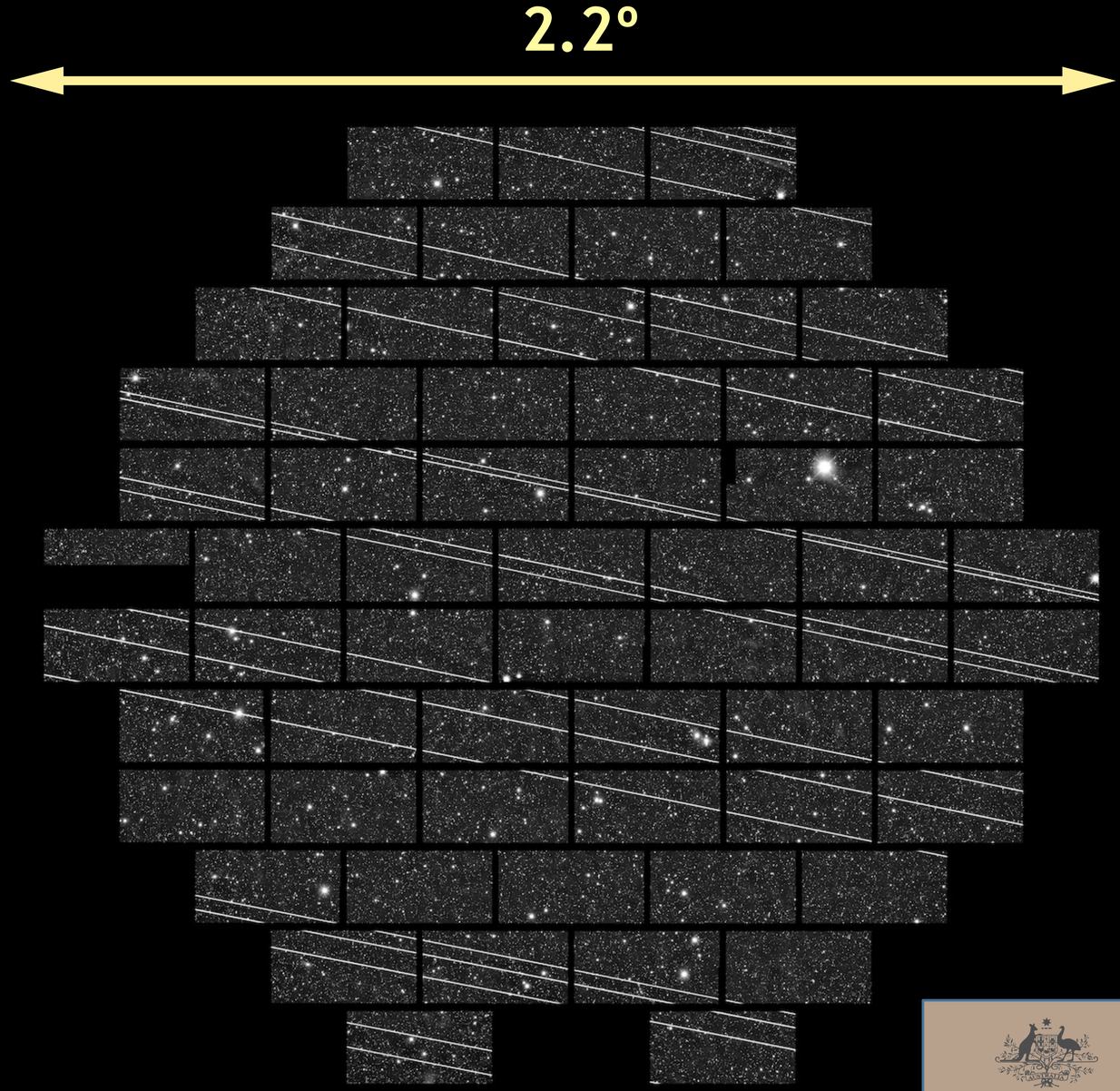
Despite mitigation strategies helping to reduce brightness below the naked-eye threshold, large LEO satellites are visible in optical telescopes during twilight

- Wide field imaging telescopes are worst-affected, both professional (e.g. Vera Rubin Obs) and amateur

- Up to 8% of images from the Hubble Telescope are affected

- NASA has highlighted the impact of SpaceX Gen2 on PHA searches

- The AAT and the main ESO telescopes are spectroscopic instruments, which experience lower levels of interference



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Radio-astronomy is at higher risk

- Interference day and night
- Direct interference from satellite beams and their sidelobes at mid frequencies
- X-Band (8-12 GHz) radar interference, which is capable of burning out a receiver
- Broad-band radiation leaking from satellite electronics
- Unregistered satellite transmissions
- Reflection from terrestrial radio signals (e.g. FM radio from Perth, Western Australia)

Australian Square Kilometre Array Pathfinder, Mark Stickells, CSIRO

What do astronomers want from the space industry?

- Reduce satellite reflectivity

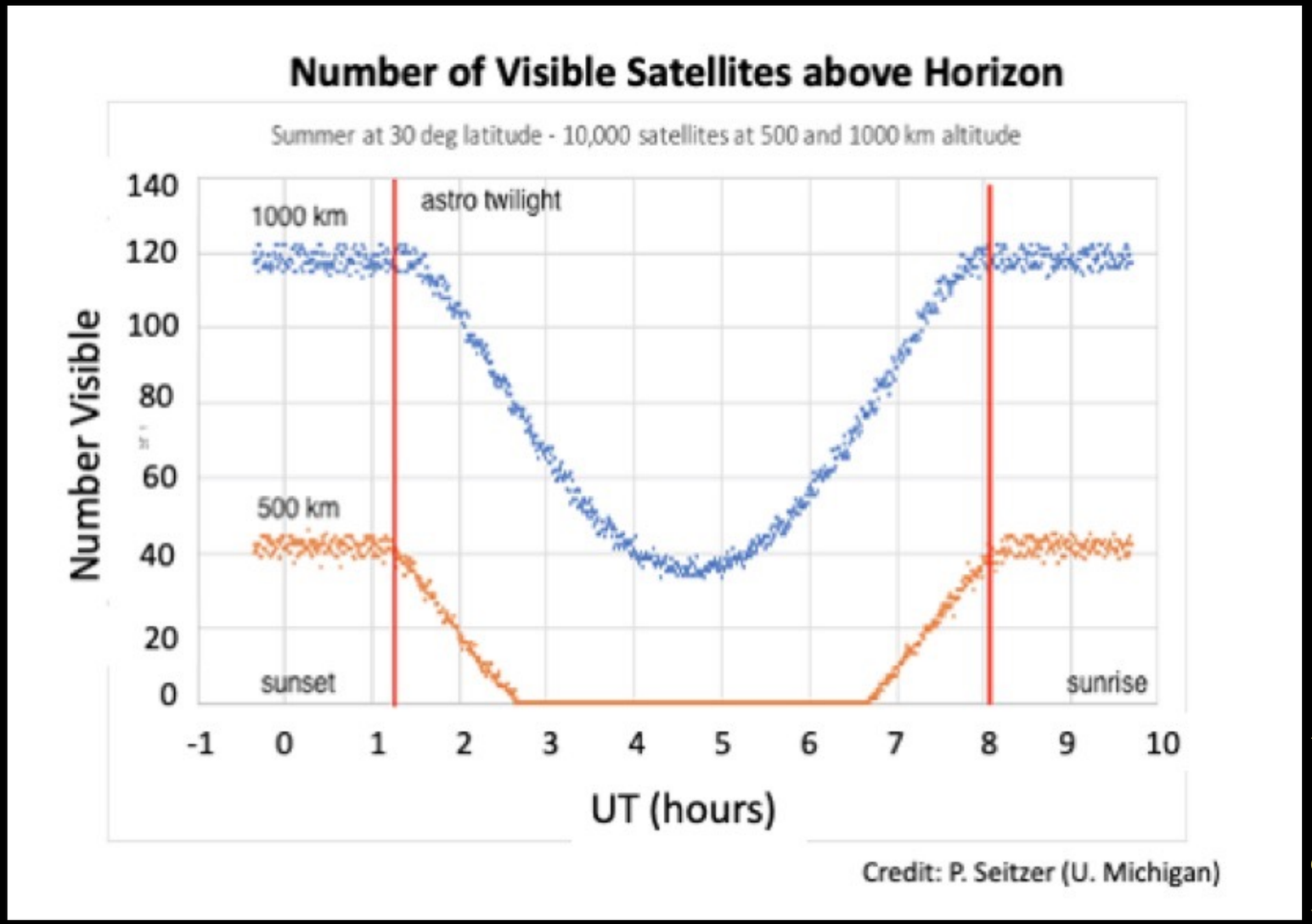
- Minimise satellite numbers and operate them below 600km (SpaceX complies from 2020)

- Avoid directly illuminating radio observatories

- Comply with ITU flux and frequency limits

- Better regulation (at present there's none relating to optical astronomy, and limited for radio)

- Provide accurate ephemerides



P. Seither (U. Michigan)

Both optical and radio astronomers are developing pre-and post-observation mitigation strategies

Australia supports efforts of the space industry and the astronomical community to build bridges between all stakeholders, continue research and disseminate resources

IAU

IAU Centre for the Protection of the Dark & Quiet Sky from Satellite Constellation Interference

Successful bid by SKAO and US NOIRLab in 2021 to jointly host the Centre, with operations starting 1 Apr 2022

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ann23004 — Announcement

NSF and SpaceX Sign Agreement to Mitigate Impact of Starlink Satellites on Ground-Based Astronomy

NSF and SpaceX continue to explore methods to further protect ground-based astronomy with new coordination agreement

10 January 2023

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Australia's position on dark and quiet skies…

Australia has both a growing civil space industry sector, and strong research capabilities in astronomy, supported by world-class infrastructure.

Australia continues to be supportive of discussions that bring together stakeholders to develop practical solutions that seek to address unintended impacts of satellite constellations on astronomy.

Thanks everyone

fred.watson@industry.gov.au *@stargazerfred*

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