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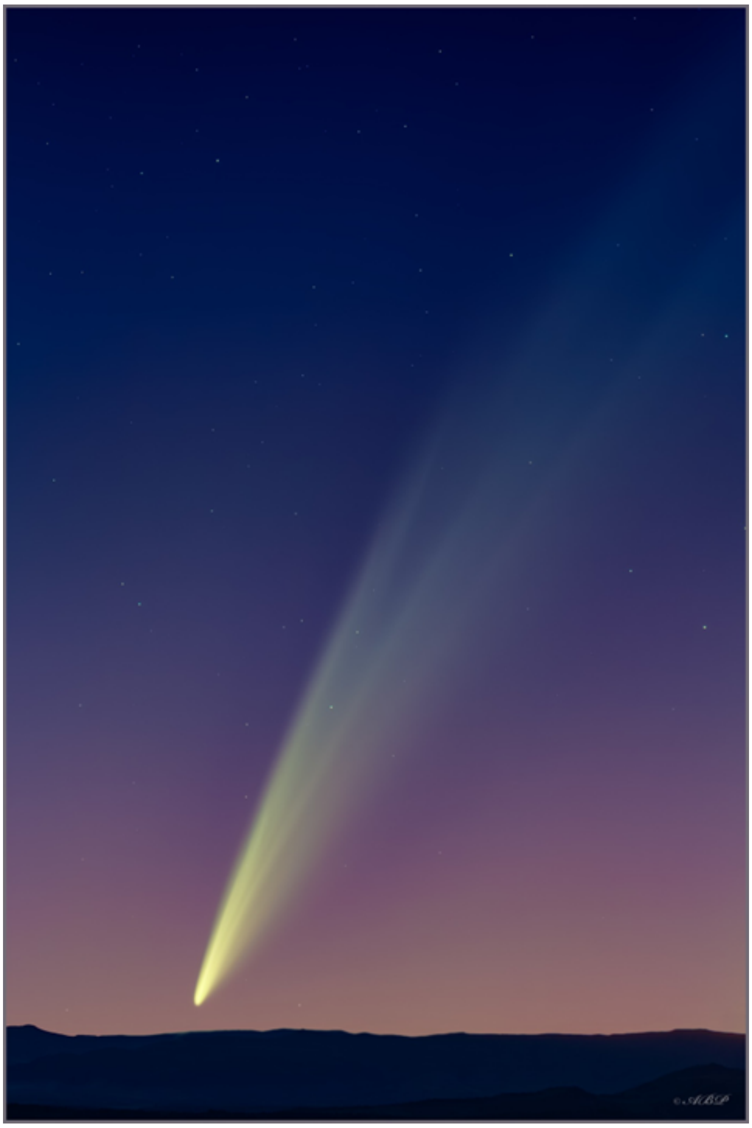

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MNASSA free download site: www.mnassa.org.za

Front Cover: This image by Angus Burns of Comet 2024/G3 (Atlas) on 19 January 2025 shows considerable striation in the tail. The date coincides with observations that the nucleus had begun to disintegrate. *See p14.*

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Vol 85 Nos 1-6 **June 2026**

Editors’ Note: Possible Closure of MNASSA

MNASSA has not appeared up till now this year as it is in urgent need of a new Editor. Willie Koorts has not been able to continue in this position but has agreed to help prepare the present issue in order to preserve continuity and publish material that has been received. However, this arrangement cannnot continue for more than one more issue. Should a new person not be found to take over, MNASSA will have to cease publication at the end of 2026.

MNASSA, preceded by JASSA, originated in an era when communication was principally by surface mail and was well supported by the professional and amateur communities. The work at South African observatories was often first published in this journal for local information, given that the main international ones took many months to appear. In more recent times, it has been a place for the publishing of worthwhile original papers, mainly written by amateur members, but refereed and later communicated to NASA-ADS so that they appear on the main astronomical search engine. In addition, we have published news of Southern African interest such as appointments and obituaries. Importantly, we are the vehicle for the Annual Reports of ASSA and its various subsections, drawing attention to the work done by the amateur community.

The duty of the editor as things stand has been to receive and check suitable material, if necessary using external referees. After any necessary corrections, the contents of a particular issue are then laid out, paginated and indexed in MSWORD format, following which a PDF is prepared and distributed, mainly via www.mnassa.org, a site hosted by SAAO. Files of individual articles are prepared and their URLs are sent to NASA-ADS for inclusion in their search engine.

It is our earnest hope that a way will be found for MNASSA to continue.

News Note: Prof. Jessica Dempsey to be next SKA Observatory Director-General

The SKA Observatory, which now has 12 member states, has announced that Prof. Jessica Dempsey will be its next Director-General, taking up the post in June 2026 for a five-year term. She will succeed Prof. Philip Diamond.

Since 2022 she has been the Director of the Netherlands Institute for Radio Astronomy (ASTRON). As the next Director-General, Prof. Dempsey will oversee the Observatory as it moves into its science verification phase, as well as the continued construction of the two arrays in Australia and South Africa. Science verification is when the community will gain access to early SKAO data, and is due to begin in the first half of 2027.

Born in Australia in 1978, Prof. Dempsey somewhat unusually studied astrophysics alongside theatre and film science at the University of New South Wales in Sydney, Australia, choosing a career in astronomy after a research internship in Antarctica.

Prof. Dempsey worked at the South Pole, in January 2000 and spent five summers there building site-testing instruments and a robotic telescope. She wintered at the South Pole station in 2005 for the Arcminute Cosmology Bolometer Array Receiver cosmic microwave background (ACBAR CMB) experiment.

After joining the staff of the James Clerk Maxwell Telescope (JCMT) in Hawaii as an instrument scientist in 2007, she became Head of Operations and later Deputy Director.

Prof. Dempsey's research interests focus on wide-field surveys of the diverse molecules in the galaxy at radio wavelengths. She was a member of the Breakthrough Prize-winning Event Horizon Telescope team, which captured an image of a black hole for the first time.

In addition to her research career, Prof. Dempsey has demonstrated a commitment to creating greater diversity, equity and opportunity at all levels of astronomy, and has spoken extensively about creating inclusive practices in the workplace. She has been the Chair of Ethics in Astronomy at Radboud University in the Netherlands since 2023.

News Note: One million satellites and mirrors in space pose grave threat to the night sky

A press release from ESO, dated July 2026, sounds the alarm about a serious development of concern to all astronomers, let alone everybody else, namely, the increasing uncontrolled pollution of the night sky by commercial satellites:

Fig: One hour of satellites over the northern Atacama Desert in Chile (October 2025) (Credit: F. Kamphues, ESO/M. Kornmesser)

A new European Southern Observatory (ESO) study has found that current proposals to launch over 1.7 million satellites into orbit, including extremely bright ones, would have “devastating consequences for astronomy.” According to the study, no more than 100 000 faint satellites, below naked eye visibility, should orbit Earth, to safeguard our ability to observe the night sky with modern telescopes. The study is the first to compute the extent to which large and bright satellite constellations — which have also raised concerns about their impacts on health and the environment — would affect astronomical observations by making the night sky brighter.

Since 2019, the number of satellites orbiting Earth has increased rapidly, to over 14 000 today [1] — dominated by SpaceX's Starlink telecommunications satellites. Satellite proposals have also escalated, both in number and in potential impact. "*Until now we have managed, but it's getting worse*," stresses Olivier Hainaut, who has been involved in developing recommendations to mitigate the impact of satellite constellations on astronomy. While companies like SpaceX have taken measures to make their satellites less bright, current satellite proposals are going “*beyond the limit*” of what astronomy can withstand, he says. Hainaut, an astronomer at ESO for over 30 years, is the author of the peer-reviewed study on the impacts of satellite constellations accepted for publication in *Astronomy & Astrophysics*.

SpaceX plans to send one million more satellites into orbit, for space-based data centres, which would significantly alter the appearance of the sky. The new study shows that, for a large fraction of each night, hundreds of satellites would be visible and, at certain times, up to several thousand, similar to the number of stars seen with the naked eye in good conditions. Other planned satellite constellations such as E-Space's Cinnamon and China’s CTC-1 and 2 would add hundreds of thousands more satellites into orbit, compounding the problem.

Reflect Orbital, a US start-up, aims to launch a constellation of very large mirror-like satellites to provide sunlight at night, with reflected beams that span at least five kilometres on Earth's surface. They intend to start with a prototype satellite in orbit this year and plan to increase their satellite population to 50 000 by 2035. These satellites would be the brightest ever in orbit, with damaging consequences for dark skies on Earth. Hainaut's calculations show that the full constellation would fill the night sky with hundreds of very brightly visible satellites. Seen from within a reflected beam, the satellite delivering sunlight would appear four times brighter than the full Moon. Even if no satellite points its beam directly at an observer, each would be as bright as the planet Venus, the ‘morning star’. From a light-polluted city, like Munich, Germany, these hundreds of satellites would be the only ‘stars’ visible in the night sky.

These proposals, combined with others considered in the study, would dramatically brighten the night sky, hindering humankind’s ability to observe faint cosmic targets, including far-away galaxies, some Earth-like planets around other stars, and even asteroids potentially dangerous to Earth.

Bright trails and brighter skies

Hainaut explains that "*satellites, illuminated by the Sun, are much brighter than distant galaxies. When a satellite crosses what we observe, it makes a bright streak on our image, zapping whatever is behind it*." To compute the impact of this and other effects of satellite constellations on astronomical observations, Hainaut simulated the positions, motion and brightness of all present and planned satellite constellations.

For the SpaceX satellite mega-constellation, he found that dozens of trails would appear in each image taken two hours into the night with ESO’s Very Large Telescope (VLT) at Paranal Observatory in Chile, representing field-of-view losses of up to 28% [2]. This assumes that the satellites would be faint enough not to be seen with the naked eye in good conditions. If they are just a little brighter, some instruments would be even more affected: for instance, a camera like that of the US National Science Foundation's Vera C. Rubin Observatory could have most of its images rendered unusable for several hours each night [3].

Hainaut's simulations assumed that no Reflect Orbital satellite would point its beam directly at or near an observatory. Even so, the trail from a single mirror-satellite could spoil an observation with a camera like that of Rubin Observatory. With the full fleet of Reflect Orbital satellites in orbit, every image from such a camera would be lost when the satellites are illuminated by the Sun.

However, it's not just the criss-crossing paths of satellites that limit what we can observe: their light can pollute the entire sky. Satellites too faint to be seen directly produce a veil of 'diffuse' light, while light from brighter satellites is 'scattered' in all directions as it passes through the atmosphere. Both contributions increase the overall brightness of the night sky. This study is the first to consider the impacts on astronomy due to the contribution of satellite constellations to background sky brightness, revealing the full extent of satellite light pollution.

Very bright constellations like Reflect Orbital would have a particularly significant effect on background sky brightness. With the full 50 000 Reflect Orbital satellites, the sky would be up to three to four times brighter overall.

Limiting satellites to safeguard the night sky

Hainaut concludes that the proposed 1.7 million new satellites would have drastic consequences for ground-based astronomy. These impacts can only be avoided by limiting the total, of both existing and future satellites, to 100 000 satellites faint enough not to be seen with the naked eye from a dark site. "*This is not a hard number, like 99 999 is good and 100 001 is bad: clearly I'd prefer 50 000*," says Hainaut. "*But 100 000 causes losses at about the level of other technical losses, such as equipment failure*." However, he adds, the satellites *must* be fainter than visual magnitude 7 [4]; should some of them be too bright — above the minimum threshold for naked-eye visibility — the total number would need to be much lower.

SpaceX and Reflect Orbital, responsible for the most extreme new proposals, have each filed with the US Federal Communications Commission (FCC) for permission to launch. This new study served as the basis for a response to the FCC on these proposals by ESO, in collaboration with the UK's Royal Astronomical Society and the International Astronomical Union.

“*The FCC received over 1800 comments regarding Reflect Orbital and nearly 1500 comments on the application by SpaceX*,” explains ESO Institutional Affairs Officer Betty Kioko, responsible for coordinating ESO’s response to the proposals. “*The ball is now in the FCC’s court, and we wait to see the determinations they make on both filings. For optical astronomy, this is an existential threat, and we hope that the regulators will share that view*.”

“*Astronomy generates huge value for humankind, including scientific, technical, economical, and educational, and helps us understand our place in the Universe*,” says ESO Director General Xavier Barcons. “*The large number of planned satellites in low-Earth orbit challenges that capacity, underscoring the need to limit future satellite launches and for astronomers, engineers, satellite operators and other stakeholders to work together to adopt strict mitigation measures*.”

"*Sending thousands of satellites has implications: economical, ecological, and astronomical*," adds Hainaut. Light pollution from very bright satellite constellations can impact the health and functioning of life on Earth, by disrupting biological clocks and ecosystems. Large constellations also have direct impacts on air quality from the numerous launches required to send and maintain thousands of satellites, as well as from the atmospheric pollution caused as they burn up on re-entry at the end of life. "*My job is astronomy, so I quantify the effects on astronomy*," explains Hainaut, "*I hope others will evaluate the other impacts in their field of expertise*."

Hainaut concludes: “*Low Earth orbit is a celestial seashore that provides immense value to modern life, from global connectivity to our clear access to the Universe. However, we must manage the footprint of mega-constellations — from the light pollution affecting astronomy to the atmospheric effects of satellite re-entry — to ensure this resource remains pristine and accessible for future generations*.”
[Edit: On Thursday 9 July, the FCC granted Reflect Orbital permission to deploy its demonstration satellite.]

Notes

[1] The number of satellites currently in orbit rises to 32 000 if dead satellites and debris are included.

[2] The instrument considered for the simulation is FORS2, the VLT workhorse, which is representative of traditional cameras on large telescopes.

[3] In cameras like the one on Rubin Observatory, with high-density, complex electronics, a satellite trail bright enough to saturate the detector causes not only a

broad streak on an astronomical image, but also a series of ghost trails that multiply the losses and can potentially contaminate an entire image.

[4] A satellite below visual magnitude 7 ensures it does not saturate the detector of cameras like that of the Rubin Observatory. It also means, coincidentally, that satellites would be too faint to be viewed to the naked eye, even under pristine dark skies.

Acknowledgment

This research was presented in a paper by Olivier Hainaut (European Southern Observatory, Germany) to appear in *Astronomy & Astrophysics*.

News Note from SKA/SKAO

The latest news from this international project in which South Africa is a major participant, can be found in their "CONTACT" magazine that is available online. https://www.skao.int/en/news-events/contact-skao-magazine

Its two main construction projects are the SKA-mid in Carnarvon, South Africa and the SKA-low in Australia.

There are currently 14 full partner countries. See www.skao.int/en/partners/skao-members. Much more information about the organisation and its structure can be found by digging into this site.

Many of the requirements at SKA-low in Wajarri County, Western Australia, parallel those at SKA-mid in Carnarvon. Recent SKA-low infrastructure includes an airstrip and a central power station. The 50 000 or so antennas are being backed by a ground plane involving 56 000 sheets of steel mesh. A Central Process in Facility will contain all the computers necessary for pre-processing the signals and has to be perfectly shielded to prevent radio-frequency interference. It contains 140 19-inch racks as well as chillers, air-conditioning and ventilation systems.

The SKA-mid at Carnarvon reports the increasingly rapid installation of the new group of 15-m diameter dishes, distributed among the 64 existing MeerKAT ones of 13.5-m diameter that have been functioning successfully for several years. Two dishes were reported to have been connected to yield "fringes", i.e. they are precise aligned. All the hardware and software had to work correctly to detect a distant radio galaxy. The addition of a third dish confirmed the consistency of the result and a fourth dish, comprising two pairs, will allow further consistency checking. There were 19 dishes on site at various stages of construction in March. The whole telescope will involve 197 dishes, including the existing MeerKAT ones. They are constructed or being constructed in China by the company CETC54. As each dish is installed its surface has to be measured to sub-mm accuracy. The project is strongly interleaved with SARAO and an important joint facility – the Engineering Operations Centre – is nearing completion near Carnarvon.

As usual, many peripheral activities have been happening – an Environmental audit, a 196-km game fence around the MeerKAT National Park, Early childhood Development Centres in Williston and other nearly towns. As many as 475 local people have been employed.

News Note: Some Recent MeerKAT Science

A team of astronomers from a large variety of institutions, called "Laduma" (Looking at the Distant Universe with the MeerKAT Array) has found the most distant megamaser yet, at a high redshift of z=1.027. Megamasers are very powerful radio emitters radiating at four wavelengths around 18 cm, characteristic of OH (hydroxyl) molecules. They are found in very strong "active galaxies".

The Laduma group were searching for OH molecular emission at high redshifts by pointing at known high-redshift galaxies and looking for emission at the expected wavelength. This particular source, H1429-0028 is a merger system of two distant (z=1.027) galaxies gravitationally-lensed by a foreground disc galaxy at z=0.218.

[z=1.207 corresponds to ~8 billion light-years.]

News Note: SKA-Low to detect High-Energy Cosmic rays

SKA Low (in Australia) can/will be used for detecting the radio signals produced by high-energy cosmic rays when they hit the earth's atmosphere, making Air Showers. The technique has already been tried out at the LOFAR telescope array whose core is in the Netherlands. The radio signals produced by an air shower are of very short duration – a few nanoseconds. Since continuous recording is impracticable, a readout is obtained from the antenna array only when a radio pulse is detected. The direction of origin of the original cosmic ray events can be pinpointed by timing the arrivals of the radio signals at the different antennas of the array. [From CONTACT, July 2026]

News Note: Inverse Compton Scattering in MeerKAT data from star-forming galaxies

Compton scattering is a familiar effect in physics in which light photons collide with electrons and lose some of their energy in the process. “Inverse Compton Scattering” is the opposite effect, when electrons collide with photons and also lose energy.

Normally, supernova activity and star formation in distant galaxies can be estimated by their radio synchrotron emission, which arises from high-energy electrons spiralling in magnetic fields. However, in very distant galaxies, the photons of the Cosmic Microwave Background are very numerous and they degrade the energy of the electrons, causing a measurable change in the radio emission. This is confirmed by a recent MeerKAT study.

News Note: Bloemfontein - New web page

The Friends of Boyden Observatory and the Naval Hill Planetarium have announced a new web page www.starsofbloem.com.

Sections and embedded links deal with the various shows on offer, educational activities, the history of the two institutions, the Boyden Observatory Museum, current research activity at the University of the Free State, and the Boyden Archives.

News Note: Africa Millimetre Telescope

The Africa Millimetre Telescope (AMT) will as a first stage be built in the Khomas Highlands of Namibia and will be moved onto the Gamsberg mountain. It will extend the baselines of the Event Horizon Telescope (EHT), which is a very long baseline interferometry (VLBI) network of mm-wave radio telescopes around the globe. Its main scientific goal is to observe supermassive black holes at their event horizon scale. The EHT is capable of achieving 20–25 micro-arcsec angular resolution*, aiming for 13 micro-arcsec.

* In single-dish mode, the AMT will further conduct monitoring observations of AGN and fast follow-ups of transient phenomena.

The AMT collaboration comprises Radboud University, University of Namibia, University of Amsterdam, Oxford University, Turku University, and UNISA. It is funded by the European Research Council, the Dutch Research Council, Radboud University, NOVA, and in-kind contributions. Prof. Heino Falcke (Radboud) is the Chairperson of the AMT board. Prof. Michael Backes, Prof. Sera Markoff, Prof. Rob Fender, Dr Talvikki Hovatta, and Prof. James Chibueze lead the teams in Windhoek, Amsterdam, Oxford, Turku, and Roodepoort, respectively.

The ESO Extremely Large Telescope - Update

Constructing of the ELT, the largest telescope ever, is continuing in Chile. “Technical First Light” is planned for 2029 and scientific observations will begin in December 2030.
Some statistics:
Mirror Diameter: 39-m
Primary mirror segments; 132 tonnes
Altitude: 3046m
Budget: Euros 1.45 billion

News Note: Cerenkov Telescope Array Observatory (CTAO)

Following the spectacular success of the HESS Cerenkov telescope in Namibia, a consortium with 12 member states has been formed to construct two new Cerenkov telescopes, one in the Canary Islands and the other in Chile, near Cerro Paranal. These arrays will be larger and more powerful than the present HESS telescope.

There will be a total of 37 “Small-sized telescopes”, each with a 4.3m diameter primary mirror and weighing 17.5 tonnes. Of Medium-sized telescopes, there will be 23, with primaries 12-m in diameter. Their height will be 27-m and their weight 89 tonnes each. Four Large-sized telescopes will be part of the northern array (but not part of the southern one, at least initially). The mirrors will be 23-m diameter, their estimated weight 100 tonnes. The “camera” portion of the large sized telescope contains 1855 photomultipliers.

Certain of the telescopes have already been constructed and tested at both sites.

In comparison to HESS, the CTAO will offer sensitivity as well as sensitivity to higher gamma-ray energies. The telescopes will also be able to slew more quickly to enable rapid response to transient events.

Obituary - Christopher Trevor Middleton (1963 – 2025)

Tim Cooper and Bruce Dickson

Chris Middleton was born on 31 July 1963. He had a life-long interest in astronomy which started at a young age, after his parents bought him a small telescope to watch the boats in the bay at Plettenberg Bay. But he also used the telescope to observe the night sky, and after he first saw the moons of Jupiter when he was fifteen, he became hooked on astronomy. Chris matriculated from Dale College Boys' High School, Qonce (former King William's Town), Eastern Cape. In 1982 he enrolled for a BSc at Wits where he studied under Ivan Kuperman and gained recognition as a top student in practical astronomy. Thereafter he did his military service in the South African Air Force gaining experience in Air Traffic Control and Radar Reporting, and during the twelve months he was stationed in Namibia, he had his telescope flown there so that he could specifically observe Halley's Comet, saying that 'observing in the desert was the best I ever had'. After completing his military service, Chris resumed his tertiary studies and completed a BSc (Honours) by distance learning at the University of Central Lancashire. He followed this with an MSc at University of Johannesburg under Dr Chris Engelbrecht, using data from the Kepler Space Telescope, submitted his thesis 'The pulsating star KIC 011175495 in a close eclipsing binary system' in November 2011, for which he received the Gold Medal from UJ as best MSc student in 2012.

Chris joined ASSA in 2002 and was an active contributor to many projects. He assisted the Johannesburg Centre by providing professional services on the 26-inch telescope, and actively supporting the annual ScopeX festival with workshops and observing sessions. He was a meticulous observer, always stressing the importance of using the correct filters and making the requisite accurate calibrations. Never shy of imparting his knowledge, he shared his equipment and methods in a paper presented at the 7th ASSA Symposium held in Bloemfontein [1]. He received an ASSA President's Award in 2006, served as Director of the Double Star Section during 2007 and thereafter as Director of the Variable Star Section from 2007 to 2013. The latter role allowed him to prepare for a thesis centred around W UMa stars (type EW, contact binary stars sharing a common envelope and displaying constant variation in brightness with no flat maximum) in the southern hemisphere, particularly those near or around the pole that cannot be observed from northern latitudes. In the process he amassed 351 695 observations [2] on fourteen mainly EW-type stars, all submitted to the AAVSO database under the observer code MXT.

Star	Type [3]	Observations by MXT
NT APS	EW	51127
V610 ARA	EW	42735
V711 CRA	EB	36782
V362 VEL	EW	36202
LT PAV	EW	34213
V839 CEN	EW/RS	33880
V653 ARA	EW	26303
ST IND	EW/KW	20771
UV GRU	EW	18199
V901 CEN	EW/RS	16525
V637 CEN	EW	12765
V448 CEN	EW/KW	7942
BS TEL	RRC	7220
HY PAV	EW/KW	7031

Chris reported many of his observations on southern W UMa stars in a series of reports in *MNASSA*. The star he observed most often was NT Apodis, with over 50 000 observations, and based on these he concluded the period was decreasing by ~125 seconds per year [4]. Another interesting variable he observed was BS Telescopii, which was initially listed as being of W UMa-type, but Chris's observations [5] confirmed the type was miss-classified as an eclipsing binary, and today the star is classified as an RR Lyrae-type variable [3].

Chris was a member of the IAU, affiliated to Divisions A (Fundamental Astronomy), C (Education, Outreach and Heritage) and G (Stars and Stellar Physics), and was a past member of Commission 26, Double and Multiple Stars up until 2015. Regarding outreach, he was ever willing to impart his knowledge. He started a company Sky Owls in 2000, involved with teaching astronomy and observing the night sky. After moving to Harkerville, he taught science to primary school learners in Plettenberg for several years.

Outside of astronomy, Chris had many different interests. In 2012 he formed a company Avian Excellence, breeding captive parrots, and obtained CITES-1 registration with Western Cape Nature Conservation for breeding endangered species. He had two African Grey's as companion birds, which he called Dogmatix and Baby Girl, both of which possessed a considerable vocabulary on account of Chris's constant talking to them. He ran Willowbrooke Gardens and was awarded several prestigious projects including the Presidency in Pretoria. Many of the trees surrounding Tim Cooper's observatory were planted by Chris, in such a way as to block out the effects of neighbouring light pollution, and these remain as a constant reminder of how Chris was always ready to help. He brought his practical skills to the construction of Bruce Dickson's telescope pier, a monster that required 25 tonnes of reinforced concrete. As a hobby he bred, worked and judged Jack Russell Terriers for a period extending over 18 years, including judging a Canadian Show in 1996. His own breeding accolades include Reserve South African Champion Bitch in the late 90s.

Of himself Chris said ‘my field of interest is an amalgamation of things astronomical and the more Earthly side of our life on this planet. My speaking engagements have been extensive in the field of “The Environment”, “Global Warming”, “Trees being Man’s Salvation” and subjects that are related generally to the landscape, the planet and our place in the Universe. I am very conversant on subjects including a multitude of facets. This from an eclectic perspective on life!’

Christopher passed away in his sleep on 23 November 2025 at his home in Harkerville, near Plettenberg Bay. Always willing to share his knowledge and passion for astronomy, he will be sorely missed.

Acknowledgement
We are greatful to Brian Kloppenborg, Executive Director of the AAVSO, for providing the summary of Chris’s observations of variable stars.

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[2] Kloppenborg, B., private communication, 15 January 2026.
[3] Types from the International Variable star Index, accessed on 18 January 2026, from https://vsx.aavso.org/index.php?view=search.top.
[4] Middleton, C. T., NT Aps, a southern sky W UMa stellar system with a decreasing period, *MNASSA* 71, pp72-76.
[5] Middleton, C. T., BS Tel, a High Amplitude δ Scuti or RRc Lyrae Star, *MNASSA* 70, pp150-155.

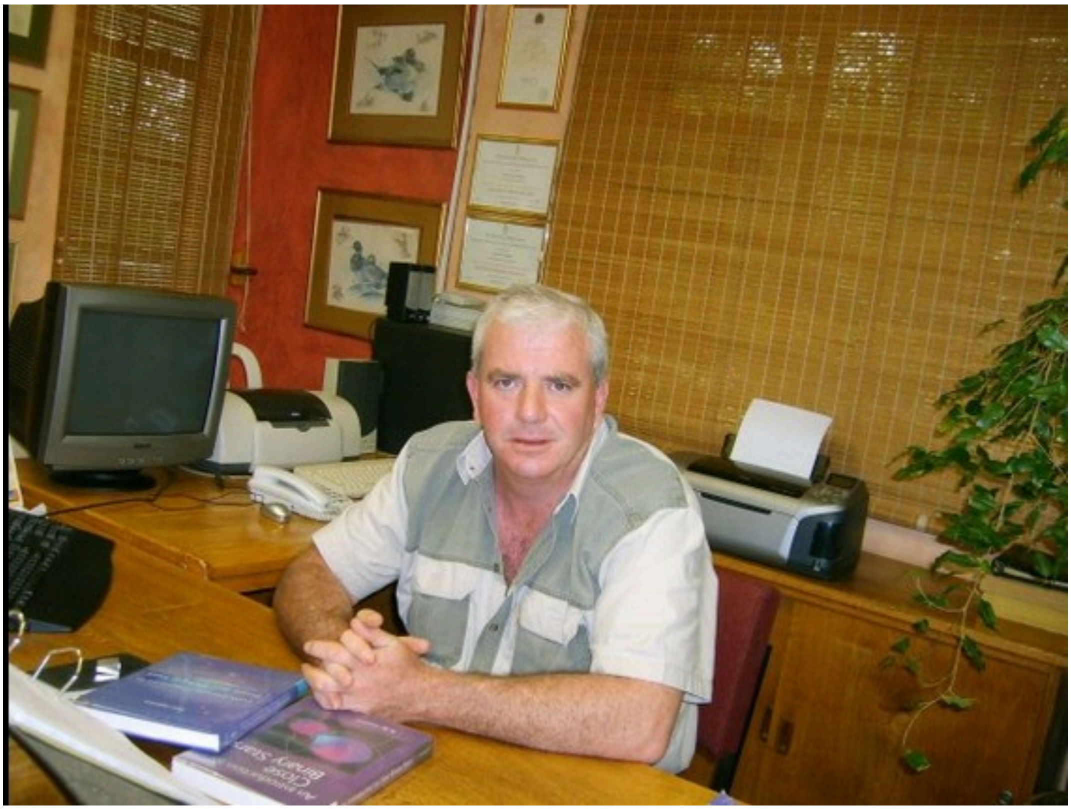

Fig 1. Christopher in his Kyalami office from where he controlled his remote telescopes. Using two 12-inch LX200s, he performed many thousands of calibrated photometric images. Image circa 2005, courtesy Bruce Dickson.

Observations and images of recent bright comets

Tim Cooper, Director, Comet, Asteroid and Meteor Section

Observations and images of comets C/2023 A3 (Tsuchinshan-ATLAS), C/2024 G3 (ATLAS) and C/2025 R2 (SWAN) are reported. All three comets reached naked eye brightness. Comet C/2023 A3 (Tsuchinshan-ATLAS) put on an excellent show in the early morning sky during September and October 2024, reaching first magnitude with a slender tail just over 16° long. Following perihelion it reappeared in the evening sky, though slightly fainter but still displaying a nice tail. C/2024 G3 (ATLAS) was not visible from southern Africa pre-perihelion but was located shortly after. It reached magnitude 0 and was visible low above the horizon in the evening sky in January 2025. The comet's nucleus disintegrated shortly after perihelion, and days later the bright coma was no longer visible, and observations were limited to the residual dust tail as it faded. Comet C/2025 R2 (SWAN) was discovered as it emerged from behind the Sun and into evening twilight during early-September 2025. The comet peaked at magnitude 5 and was visible to the naked eye from dark sky locations. The ion tail grew to around 2°, but during October diminished rapidly, leaving a large circular coma which faded to magnitude 7-8 by month's end.

Note abbreviations used are B = binoculars; D = Schmidt reflector; T = Schmidt-Cassegrain reflector; L = Newtonian reflector; R = refractor; DC = Degree of Condensation of the coma; m1 = total cometary magnitude; p.a. = position angle of the tail; LM = limiting magnitude, faintest star visible to the naked eye, Δ = Earth-comet distance in astronomical units (AU). All dates including decimals are given in UT.

Comet C/2023 A3 (Tsuchinshan-ATLAS)

The comet was first detected on 9 January 2023 from Purple Mountain Observatory, China, but no follow-up images were secured and the object was originally considered lost. The comet was detected again on 22 February 2023 using the ATLAS telescope at SAAO's Sutherland station and subsequently showed the presence of a coma. Astrometry confirmed the images from both observatories were of the same object, which was designated C/2023 A3 (Tsuchinshan-ATLAS). The orbit solution given in Green (2023) was nearly parabolic with inclination, i = 139°, i.e. the comet was long period and travelling in a retrograde orbit. Initial indications were that the comet might reach magnitude 3 near perihelion on 28 September 2024, although at small elongation from the Sun.

The comet was first observed by Magda Streicher and Tim Cooper with Magda's 40cmT on the evening of 6 May 2024, estimating the magnitude as 11.0, with a short narrow tail 4' long and slightly curved towards south. Following their observation, Tim immediately contacted Kos Coronaios, who obtained his first image on 9 May, followed up by a second on 11 May (Figure 1 left) showing the appearance of the tail, 4.8' long in p.a. 97°. By 27 June, the appearance and brightness were much the same (Figure 1 right) but the tail had grown to 8.2' in p.a. 97°. The last image of the comet in the evening sky before it was lost in the Sun's glare was by Kos Coronaios on 1 August, by which time the comet had brightened to magnitude 9, tail length 12' in p.a. 98° (Figure 2).

Fig 1. first images showing the changing appearance of the comet C/2023 A3 from 11 May (left panel) to 27 June 2024 (right panel). Object below right of the comet in the right panel is NGC 3640 (mag 11.2), and perpendicularly below the tip of the tail is the elongated image of the fainter galaxy NGC 3630 (magnitude 12.6). Images by Kos Coronaios.

Fig 2. Last image of Comet C/2023 A3 in the evening sky on 1 August 2024 before it was lost in the Sun's glare. The brightest stars are SAO 118577 (mag 6.6) near the tip of the tail and 55 Leonis (mag 5.9) below right. Image by Kos Coronaios.

By the time the comet reappeared low in the morning sky during September 2024, it had brightened to nearly magnitude 4. An image by Johan le Roux taken on 21 September shows a narrow tail 1.3° long in p.a. 250°, with the comet less than 10° above the horizon at dawn (Figure 3). On the same morning Kos Coronaios found the comet easily in 12x50 binoculars but not visible to the naked eye. On 25 September, Angus Burns said ‘I got up early this morning to see if the sky was clear enough to capture an image and was pleasantly surprised by how easy this comet was to find and photograph’. On September 25.12, Tim Cooper found the comet easily in 16x50B, despite a hazy sky after passage of a cold front, a 46% illuminated Moon, and with the comet just 8° altitude, estimating m1=3.0 after correction for extinction. Central condensation appeared stellar, coma strongly condensed, DC=9, slender tail visible to 0.75°, slightly curved towards south. Comet easily discerned with the naked eye. Observing on September 28.13, Magda Streicher found the comet visible to the naked eye under dark skies; using 10x50B, bright coma, m1 ~3.5, and tail extending to 5° despite bright twilight. Angus Burns saw the comet briefly with the naked eye on 26 September, and Kos Coronaios found it an easy naked eye object on 29 September. A visual observation by Tim Cooper on October 1.12, said comet is bright and easily visible to the naked eye, in 16x50B, m1 = 1.6 after correcting for extinction, highly condensed coma, DC=9 with slender tail, length 5°. Lafras Smit imaged the comet the same morning (Figure 4) showing an 11° tail in p.a. 255° and he commented ‘the comet is really bright now, tail and nucleus visible with the naked eye. Saw it this morning just as it was rising, what a sight!’.

Fig 3. image of Comet C/2023 A3 in the morning sky on 21 September 2024. The main tail is in p.a. 250° but dust is visible as a broad fan extending to p.a. 130°. Image by Johan le Roux.

Fig 4. By 1 October the tail had grown to 11° with the comet now a fine object in the early morning at dawn. Image by Lafras Smit.

One notable feature of the tail at this time was a dark line which split the tail into two sectors. The line is seen in an image taken by Lafras Smit on 2 October (Figure 5 left). The insert top right is by Oleg Toumilovitch taken on the same evening and apparently shows two streams of dust leaving the coma. The bottom right insert is by Angus Burns on 5 October and shows a similar appearance three days later. Angus' image on this morning (Figure 6) was the last image before the comet became too low in the early morning sky, the comet then displaying a tail 16.3° long.

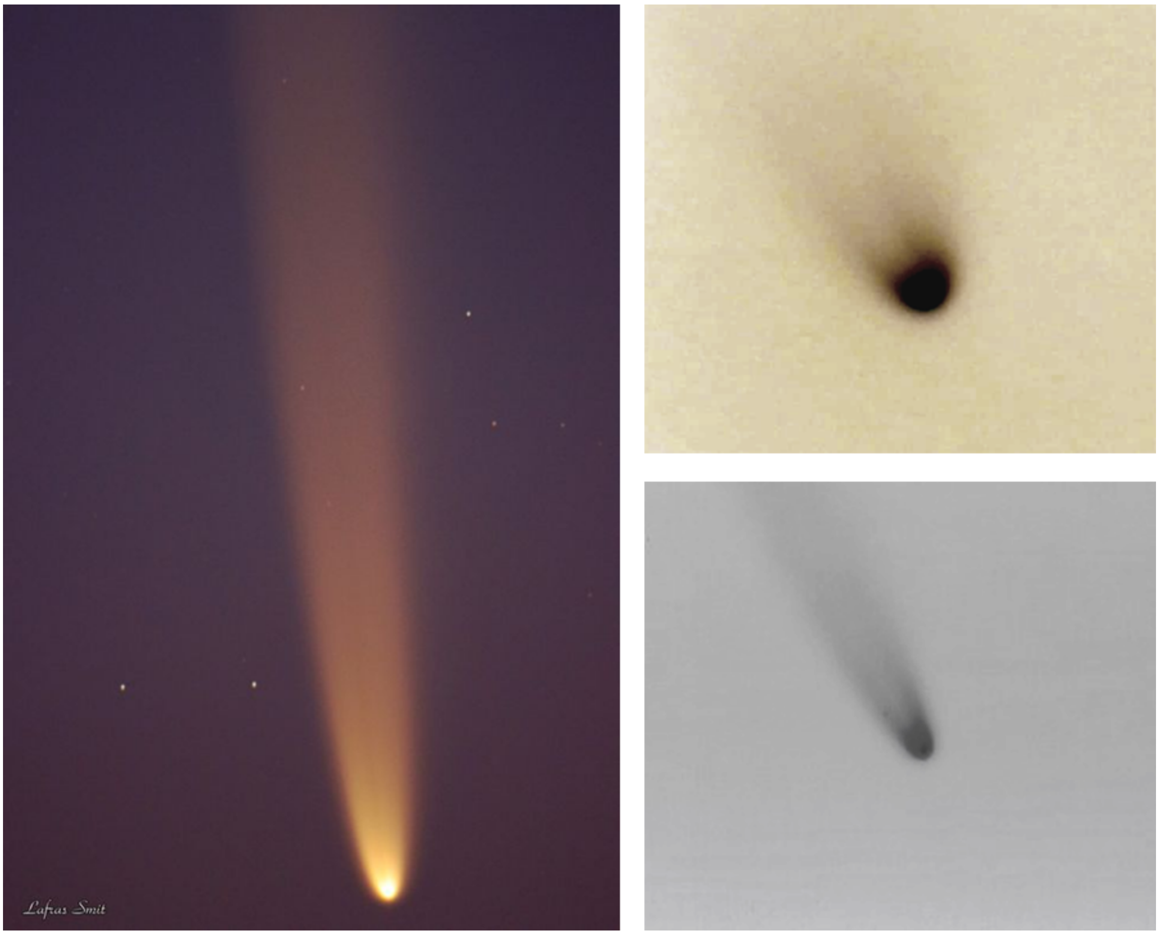

Fig 5. A narrow dark line is visible in the tail on 2 October 2024. Closer inspection shows two streams of material emanating from either side of the coma. Left hand image by Lafras Smit, negative images upper right by Oleg Toumilovitch, lower right by Angus Burns (5 October).

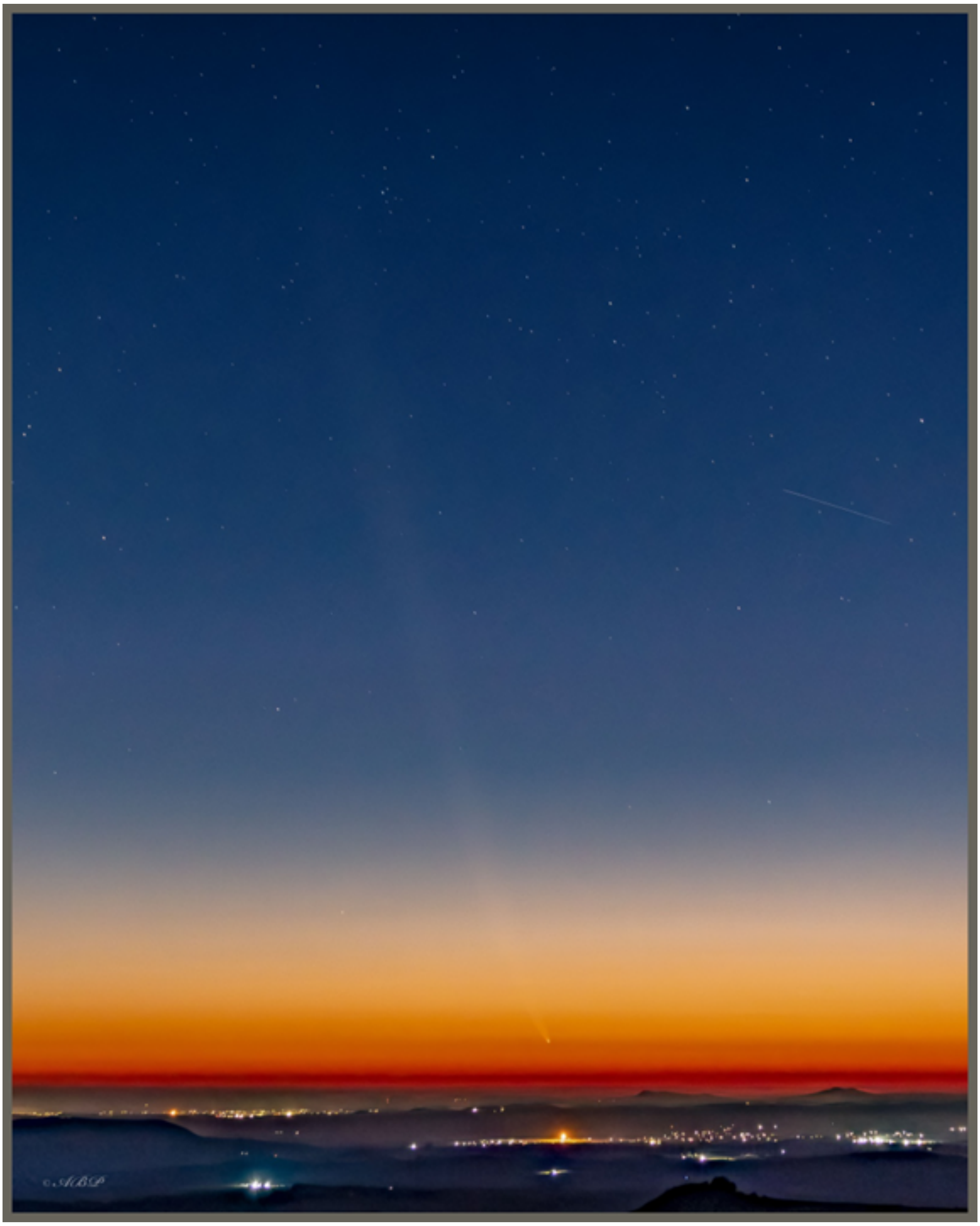

Fig 6. The tail is visible to >16° in this image taken by Angus Burns before dawn on 5 October 2024. Foreground lights are from the town of Newcastle.

Following perihelion, Comet C/2023 A3 made its closest approach to Earth on 12 October at Δ = 0.56 AU and around this time it was expected to be at its brightest. COBS data shows the comet brightened to around 0 magnitude or perhaps slightly brighter, but by the time it became high enough to observe from southern Africa, it had already begun to fade. Both Johan le Roux and Oleg Toumilovitch succeeded in imaging the comet on 15 October, Oleg's image shown in Figure 7, when the comet was just 7° above the horizon and still in bright twilight. Johan found the comet in binoculars, but not visible to the naked eye.

Fig 7. Comet C/2023 A3 reappeared in the early evening sky just after perihelion. In this image by Oleg Toumilovitch the star just above the coma is 4 Serpentis (magnitude 5.6).

In the days that followed the comet became higher each evening. Tim Cooper observed on October 16.71, the first clear evening after rain, but in a hazy sky with near-full Moon in the east and considerable bright skyglow towards the west; Comet just discernible at altitude 11°, magnitude estimated ~3.5, compact central condensation surrounded by slight nebulosity, DC=8, looks like an out of focus star; narrow tail extending 0.8° but visibility limited by bright skyglow in 16x50B. Comet not seen with naked eye. On October 18.72, Tim estimated m1 ~4.5 in 16x50B, but poor skies with considerable skyglow towards the west. The same evening, Lafras Smit imaged the comet (Figure 8) with the tail extending 14° in p.a.75° and slightly curved towards south. An anti-tail can be seen extending in p.a. 232°. The anti-tail is well seen in an image by Angus Burns the following evening (inset Figure 8).

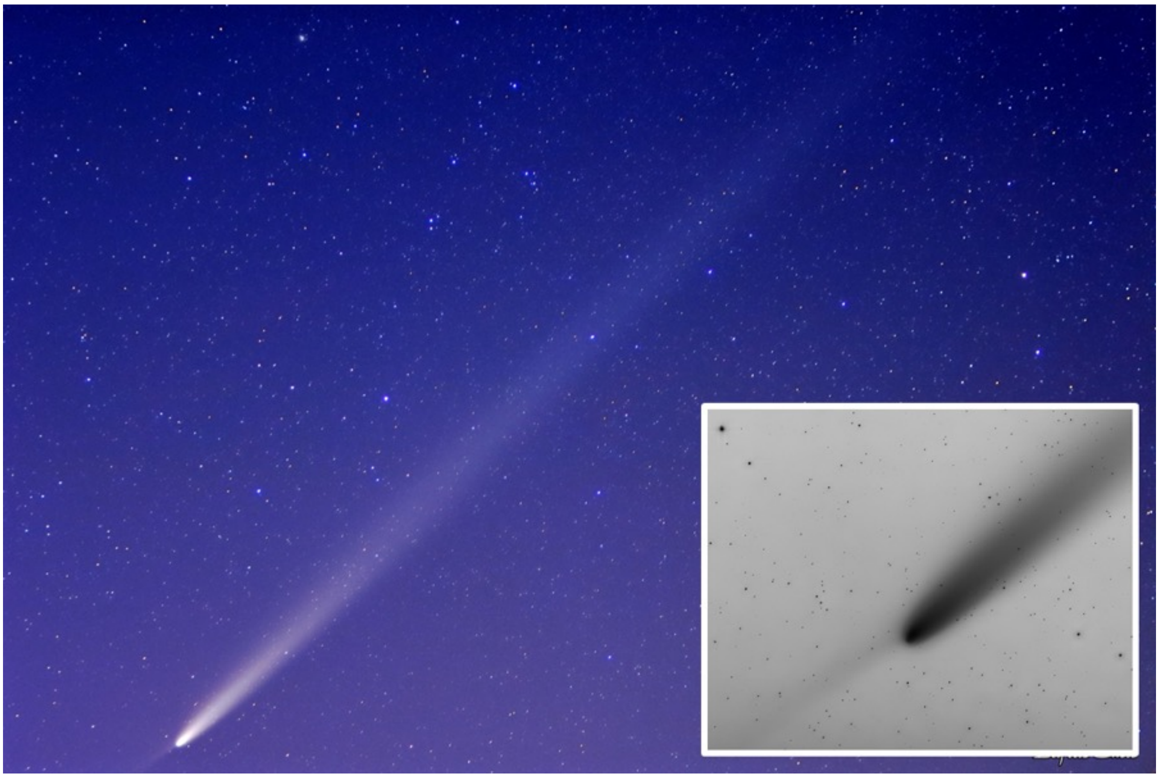

Fig 8. The comet again became a fine object in the evening sky. In this image by Lafras Smit taken on 18 October, the tail is just over 12° long in p.a. 76°, inset negative image by Angus Burns shows the anti-tail in p.a. 237° as seen the following evening.

22 October 2024 | 25 October 2024 | 29 October 2024

Fig 9. Sequence of images by Kos Coronaios shows the comet apparently fading, though note exposure conditions varied between images. At the same time the tail became shorter, the length on 22 October is 3.4° in p.a. 75° and reduces to 2.1° in the same position angle on 29 October.

During the second half of October 2024, the comet continued to fade and reached magnitude 6 near month end. Lafras Smit noted the comet was still just visible to the naked eye on 22 October. Tim Cooper made a visual observation on October 23.72, noting m1 = 5.5, bright central condensation, DC=7, looks like an out of focus star; slender tail extends 0.75° but visibility limited by bright sky in 16x50B. By 25 October Lafras could not detect the comet with the naked eye but it was still a fine object in binoculars. Kos Coronaios imaged the comet on 22, 25 and 29 October (Figure 9) showing the changing appearance of the tail and disappearance of the anti-tail. The final image of the comet was obtained on 9 November by Justin de Reuck (Figure 10), the tail a narrow parabola spanning p.a. 66° to 88°, brightest in p.a. 74° and appears split into two components in p.a. 81°, the northern component being wider and brighter than the southern component. The tail extends 1.44° but continues outside the field of view. Poor weather countrywide prevented further observations of the comet as it faded during November and December 2024.

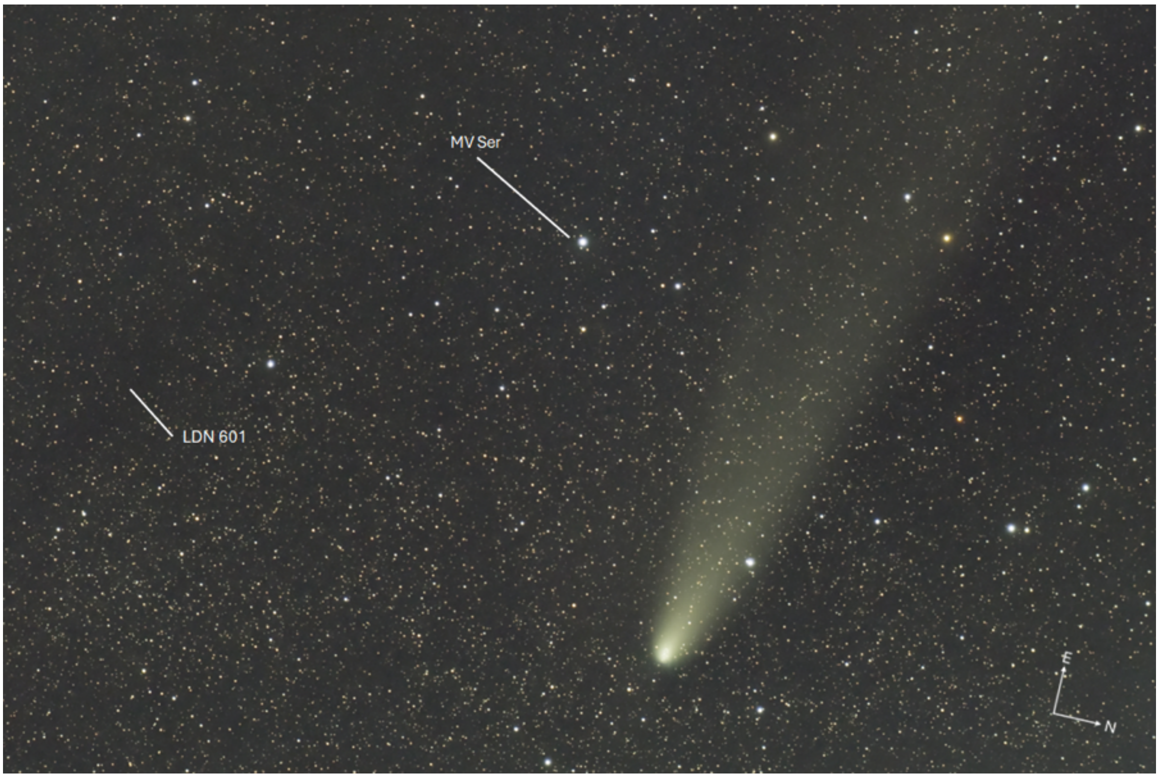

Fig 10. Last image of Comet C/2023 A3 obtained by Justin de Reuck on 9 November 2024. To the left of the comet is the dark nebula LDN 601. The brightest star to the left of the tail is variable star MV Serpentis (Type alpha CVn, magnitude 6.1 on the image date) and on the N edge of the tail and 14 arcmin from the coma is SAO 123571 (magnitude 6.6).

Comet C/2024 G3 (ATLAS)

The comet was discovered by the ATLAS telescope in Chile on 5 April 2024 and reached perihelion on 13 January 2025 at the small perihelion distance (q) = 0.093 AU. It was suggested the comet might become as bright as Venus but would be too close to the Sun to observe at that time. Given the close approach the comet makes to the Sun there were some expectations it might break up. If it survived perihelion passage it was expected to become at least a binocular object during early 2025.

Fig 11. First image of comet C/2024 G3 (ATLAS) by Oleg Toumilovitch during broad daylight and elongation only 8° from the Sun.

First image of the comet was by Oleg Toumilovitch on January 15.62, during broad daylight and with the comet located just 8° from the Sun! Oleg's remarkable image is shown in Figure 11, and COBS data indicates the comet was possibly magnitude -3 at the time. Two days later the comet had moved into the evening sky and was imaged by several ASSA members, including Oleg Toumilovitch, Lafras Smit, Willie Koorts and Johan le Roux (Figure 12), and further images were received the following evening from Clyde Foster and Kos Coronaios, who said the comet was visible to the naked eye. Tim Cooper observed visually on 18 January 2025, with the comet low in the west just after sunset and despite low clouds on the horizon found it easily in binoculars. The comet was perhaps magnitude 0 with a slender tail extending 2° in length. Once found in binoculars, the comet was discernible to the naked eye. By 19 January the comet started to rise higher in evening twilight, setting about eighty minutes after the Sun. Angus Burns imaged the comet that evening (Figure 13) showing a fan shaped tail with several striations, 3.3° long but extending outside the field of view. Tim Cooper used a trip to the Kruger Park to his advantage, and during the period 21-26 January and with dark skies observed the comet fade rapidly by around two magnitudes. At the same time the head and tail became ever less well pronounced. By the 26 January, now back home, he waited for twilight to recede as much as possible before observing the tail as a narrow wedge of faint light, slightly curved towards the north (right), but could not detect the comet with the naked eye. By 28 January the comet could no longer be detected from Bredell. King (2025) noted the comet had already begun to disintegrate as early as 18 or 19 January, as observed by Lionel Majzik of Hungary.

Fig. 12. As comet C/2024 G3 moved higher in the evening sky, it became a fine object. The image by Johan le Roux taken on 17 January is a good representation of the appearance in binoculars.

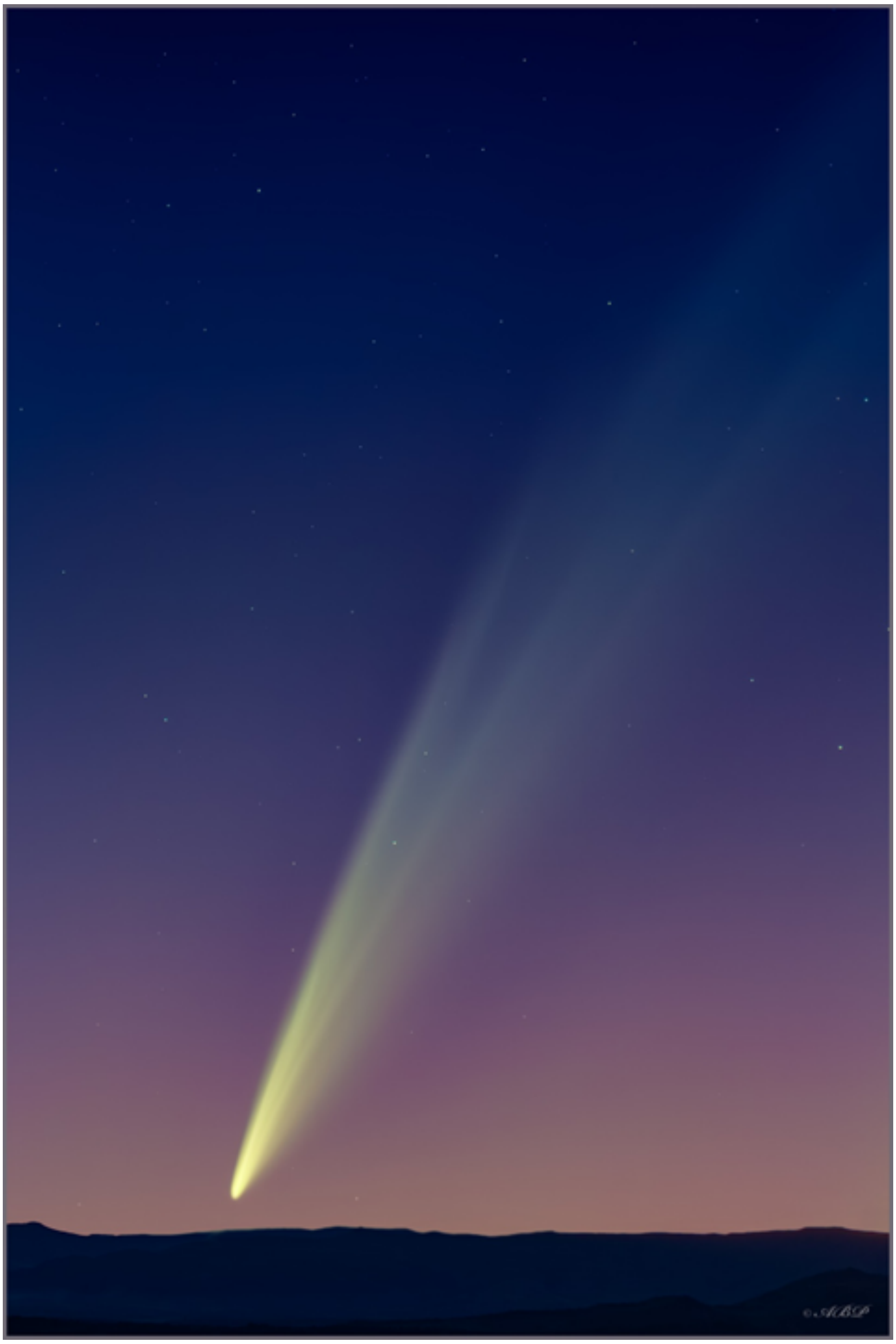

Fig 13. image by Angus Burns on 19 January shows considerable striation in the tail. The date coincides with observations that the nucleus had begun to disintegrate (see King 2025).

The change in brightness and appearance is noted in several images. Angus Burns' image on 25 January (Figure 14) shows considerable tail structure and absence of the bright head visible in his image taken six days earlier (Figure 13). The absence of the bright head is confirmed in Johan le Roux's image taken on 28 January (Figure 15), which is very similar in appearance to Tim Cooper's visual observation around that date. Johan noted the comet was no longer visible to the naked eye but was still visible in binoculars. The comet continued to fade rapidly as shown by the image taken by Oleg Toumilovitch on 30 January 2025 (Figure 16). Unfortunately, weather conditions in both the south and north of southern Africa did not permit detailed observation or imaging as it faded, though Johan le Roux managed to secure a final image on 15 February, the comet just a diffuse smudge on the sky, and a mere ghost of its appearance a month earlier.

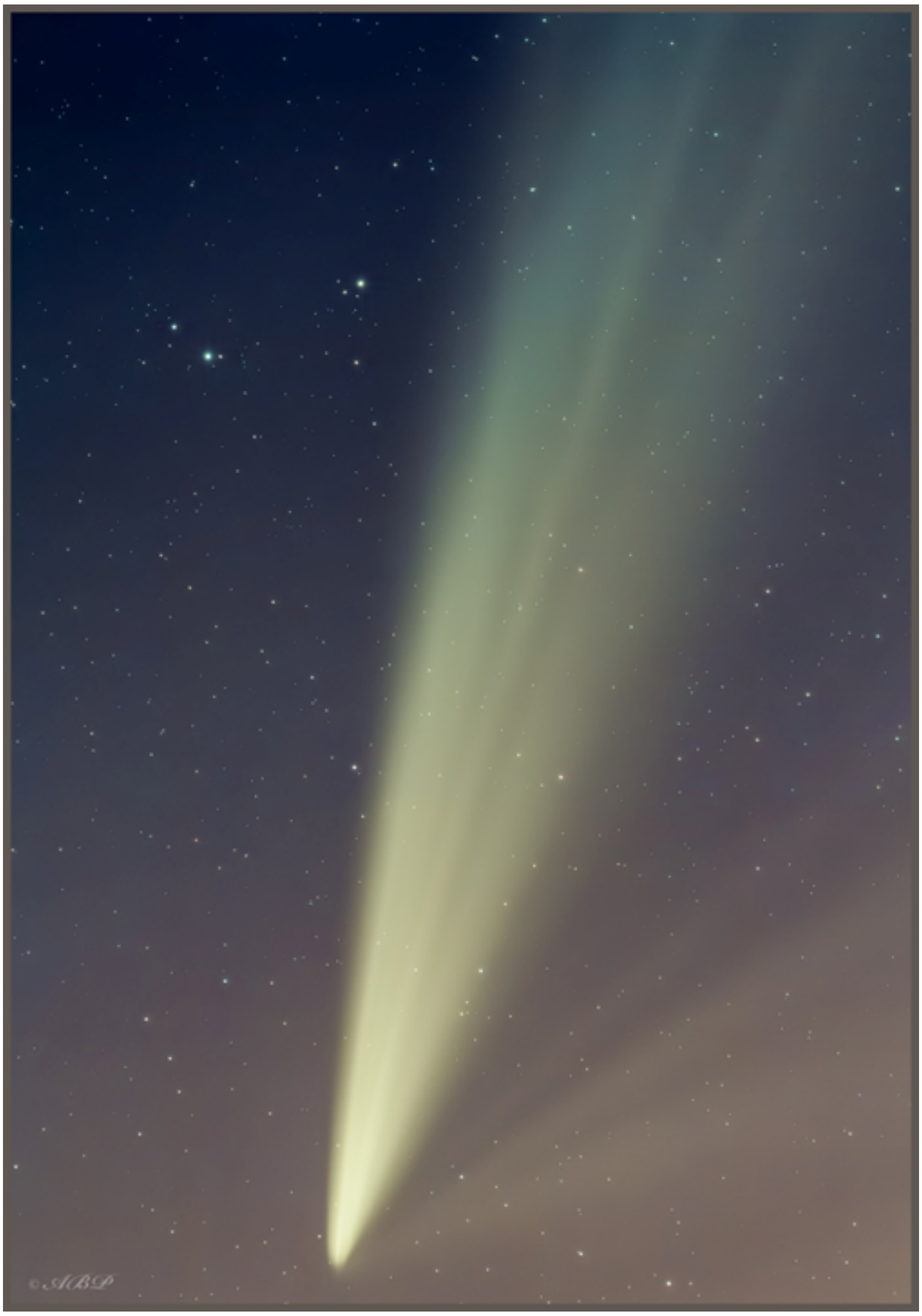

Fig 14. another image by Angus Burns showing considerable striation in the tail on 25 January, six days after the nucleus was observed to break up.

Fig 15. By 28 January the coma had disappeared and was replaced by a wedge-shaped tail 3.6° long and spanning p.a. 97° at its brightest to 76°.

Fig 16. The tail is inconspicuous in this image by Oleg Toumilovitch on 30 January, length about 1.4°.

Comet C/2025 R2 (SWAN)

This comet was a surprise discovery on 10 September 2025 after emerging from behind the Sun and passed perihelion just two days later at perihelion distance 0.50 AU. It was given the provisional designation SWAN25B, before being designated Comet C/2025 R2 (SWAN) as announced by Green (2025). The comet made a close approach to Earth on 19 October 2025, at distance 0.26 AU, when it was predicted to be a magnitude 6 object in the constellation of Scutum.

Fig 17. First image of comet C/2025 R2 by Kos Coronaios as it emerged into the evening sky as darkness fell on 14 September 2025. Brightest star at left is LP Virginis.

The comet was first detected in an image taken by Kos Coronaios on 14 September (Figure 17). The coma shows the distinct green colour from fluorescence of diatomic carbon (C_2), tail length 0.25° in p.a. 112°. On the evening of 16 September the comet was located within a degree of the bright star Spica, but Tim Cooper was unable to detect the comet using binoculars shortly after dusk with the comet 16° above the horizon. An image by Angus Burns on the same evening shows the comet located between Spica and Mars (Figure 18 left panel). In the days that followed the comet quickly became higher in the evening sky after sunset. Kos Coronaios imaged the comet again on 17 September from Van Wyksdorp in the Little Karoo, the tail extending 1.1° in p.a. 114° (Figure 19), and reaching 2° by 24 September. On 25 September Johan le Roux noted the comet was visible in binoculars though the light from the waxing Moon began to interfere but still found the comet easily on 30 September located nearby the bright double star $\alpha^{1,2}$ Librae (Zubenelgenubi – Figure 18 right panel).

Fig 18. Two images showing how the comet appeared low in the evening sky. Left panel on 16 September by Angus Burns, Spica is bottom left, Mars is top right. Right panel on 25 September by Johan le Roux, bright star above the comet is double star α 1,2 Librae (Zubenelgenubi).

Fig 19. Comet C/2025 R2 on 17 September, showing a bright greenish coma and slender tail. Image by Kos Coronaios.

During October leading up to date of closest approach on the 19th the comet maintained its brightness at magnitude 6, but the tail diminished in length. On 8 October Johan le Roux noted ‘the comet is only just visible through binoculars. Only a small part of its tail was visible tonight’, and on 12 October ‘the comet's tail is no longer as clear as it used to be’. Oleg Toumilovitch also noted on 20 October ‘comet's nucleus appears much brighter than in my previous image, but the tail has completely disappeared' (Figure 20). Tim Cooper observed the comet from Limpopo on 22 October, estimating the brightness m1 = 5.8 in 16x50B, large circular coma, diameter 12', DC=3. The comet was visible to the naked eye with averted vision. On the same evening Magda Streicher observed with her 40cmT x100, noting the coma filled the field of view of dia. 28', and with a tiny starlike bright point at the centre. Angus Burns imaged the comet on 25 October (Figure 21) showing a diffuse green coma, bright central point and a short narrow spike 0.2° long in p.a. 88°. The last image of comet C/2025 R2 was taken by Kos Coronaios on 29 October, when the comet had faded to around magnitude 7.5.

Figure 20, by 20 October the tail had disappeared, leaving a circular green coma as shown by this image by Oleg Toumilovitch.

Fig. 21. Final image of comet C/2025 R2 by Angus Burns on 25 October 2025, showing the green coma, and the tail is a narrow spike.

Key to observers and imagers

AB = Angus Burns, KwaZulu Natal; JdR = Justin de Reuck, Western Cape; JlR = Johan le Roux, Western Cape; KC = Kos Coronaios, Western Cape; LS = Lafras Smit, Free State; MS = Magda Streicher, Limpopo; OT = Oleg Toumilovitch, Western Cape; TC = Tim Cooper, Gauteng, Limpopo, Mpumalanga.

Summary of visual observations

Comet C/2023 A3 (Tsuchinshan-ATLAS):

2024 May 6.74, m1=11.0, moderately condensed, DC=4, slender pencil-like tail bulging slightly on the N edge, curved slightly towards south and ending in a sharp point, length 4', 40cmT x107 [TC].

2024 September 25.12, m1=3.0 after correction for extinction. Central condensation appears stellar, coma strongly condensed, DC=9, slender tail visible to 0.75°, slightly curved towards south, 16x50B. Comet easily discerned with the naked eye despite hazy sky and comet altitude just 8.5° [TC].

2024 September 28.13, bright coma, m1 ~3.5, and tail extends to 5° despite bright twilight, 10x50B. Comet visible to the naked eye under dark skies [MS].

2024 October 1.12, m1 = 1.6 after correcting for extinction, highly condensed coma, DC=9 with slender tail, length 5°, 16x50B. Comet is bright and easily visible to the naked eye [TC].

2024 October 16.71, first clear evening after rain, but hazy sky with near-full Moon in the east and considerable bright skyglow towards the west. Comet just discernible at altitude 11°, magnitude estimated ~3.5, compact central condensation surrounded by slight nebulosity, DC=8, looks like an out of focus star; narrow tail extending 0.8° but visibility limited by bright skyglow in 16x50B. Comet not seen with naked eye [TC].

2024 October 18.72, m1 ~4.5 in 16x50B, but poor skies with considerable skyglow towards west [TC].

2024 October 23.72, m1 = 5.5, bright central condensation looks like out of focus star, DC=7, slender tail visible for 0.75°, comet seen in bright sky [TC].

Comet C/2024 G3 (ATLAS)

2025 January 18.74, comet low in west, altitude 6.4°, easily visible, m1 = 0 after correcting for extinction, slender tail of length 2° slightly curved towards north, 16x50B [TC].

2025 January 21.73, easily visible despite bright twilight, m1 = 2.0, slender tail, length 4° and slightly curved towards north, obs. from Kruger Park, 16x50B [TC].

2025 January 22.73, very slightly fainter, m1 = 2.2, but appearance same as last night, 16x50B. Easily visible by naked eye from Kruger Park [TC]

2025 January 23.73, comet definitely fainter than last night, less well defined and just a spurious smudge in 16x50B, m1 3-4, although still visible to the naked eye from Kruger Park [TC].

2025 January 26.75, very clear conditions from Bredell, but comet low down in west towards direction of airport, appears as a wide stripe without detail in 16x50B. On January 26.76, easily visible in 16x50B as a narrow wedge, slightly curved towards north, tail visible for 1.8°, m1 ~4, not discerned naked eye [TC].

2025 January 28.76, comet not seen in 16x50B from Bredell [TC].

Comet C/2025 R2 (SWAN)

2025 September 26. 71, comet not detected near Spica just after evening twilight, 16x50B [TC].

2025 October 22.78, m1 = 5.8, coma is round and diffuse, coma dia. 12', DC = 3, no tail visible in 16x50B from dark sky location, LM = 6.5 [TC].

Image details as provided

Comet C/2023 A3 (Tsuchinshan-ATLAS):

Fig. 1, Left panel 2024 May 11, Canon EOS 5D, 200mm, 54x30 seconds at ISO 6400. [KC]. Right panel 2024 June 27, Canon EOS 5D, 200mm, 46x30 seconds at ISO 6400. [KC].

Fig. 2, 2024 Aug. 1.73, Canon EOS 60D at prime focus, 20cmL, f/8, 8x60 seconds at ISO 3200 [KC].

Fig. 3, 2024 Sep. 21.15, Canon EOS 2000D, 85mm lens at f/1.8, 50x3.2 seconds at ISO 800 [JIR].

Fig. 4, 2024 Oct. 1, Canon 90D, 40mm lens, single 13 seconds exposure at ISO 4000 [LS].

Fig. 5, Left panel 2024 Oct. 2, image through 25cmL, f/4.7 and Canon 90D, stack of 10x15 seconds exposures at ISO 3200 [LS]. Upper right panel 2024 Oct. 2.16 [OT].

Fig. 6, 2024 Oct. 5.2 Canon EOSR, 70mm f/4, single 8 seconds exposure at ISO 3200 from Mullers Pass, Newcastle [AB].

Fig. 7, 2024 Oct. 15.75 [OT].

Fig. 8, main panel 2024 Oct. 18, Canon 90D, 70mm f/2.8 lens, stack of 15x6 seconds exposures at ISO 6400 [LS]. Inset 2024 Oct. 19, Canon 60Da on RedCat 5.1cmR, f/4.9, 62x15 seconds exposures at ISO 1600, from Signal Hill, Newcastle, KZN [AB].

Fig. 9, from left to right, 2024 Oct. 22.78, Canon EOS 60D, 200mm EF lens, f/2.8, 32x60 seconds at ISO 3200; 2024 Oct. 25.78, Canon EOS 60D, 200mm EF lens, f/2.8, 24x30 seconds at ISO 3200; 2024 Oct. 29.81, Canon EOS 60D, 200mm EF lens, f/2.8, 24x60 seconds at ISO 1800 [KC].

Fig 10, 2024 Nov. 9.79, Skywatcher Evostar 72ED, 7.2cmR with 0.85 reducer, ZWO ASI 294MC Pro camera, 120 gain @ -5°C BIN 1, UV/IRCUT filter, stack of 14x120 seconds exposures between 18h32-19h16 [JdR].

Comet C/2024 G3 (ATLAS)

Fig. 11, 2025 Jan. 15.62, [OT].

Fig. 12, 2025 Jan. 17.78, Canon EOS 2000D, 85mm lens at f/4.5, stack of 30x3.2 seconds exposures at ISO 100 [JlR].

Fig. 13, 2025 Jan. 19, Canon 60Da through RedCat 5.1cmR, f/4.9, Celestron Evolution GoTo mount, 6m 50s total exposure time stacked and processed in APP/LR and CC2025. [AB].

Fig. 14, 2025 Jan. 25, Canon 60Da through RedCat 5.1cmR, f/4.9, Celestron Evolution GoTo mount, 14m 25s stacked and processed in APP/LR and CC2025 [AB].

Fig. 15, 2025 Jan. 28.79, Canon EOS 2000D, 85mm lens at f/1.8, single 48 seconds exposure at ISO 200 guided on EQ mount [JlR].

Fig. 16, 2025 Jan. 30, Jupiter-9 camera, 85mm lens, f/2, single 3.2 seconds exposure at ISO 3200 [OT].

Comet C/2025 R2 (SWAN)

Fig. 17, 2025 Sep. 14.74, Canon EOS R6m2 and 200mm EF lens, f2.8 single 2 seconds exposure at ISO 12800 unguided on tripod [KC].

Fig. 18, left panel 2025 Sep. 17.76, Canon EOS R6m2, prime focus, Sky Watcher 12cmR, 4x60 seconds at ISO 6400 [AB]. Right panel 2025 Sep. 30.75, Canon EOS 2000D, 85mm lens at f/1.8, single 61 seconds exposure at ISO 1600 guided on EQ mount [JlR].

Fig. 19, 2025 Sep. 17.76, Canon EOS R6m2, prime focus, Sky Watcher 12cmR, 4x60 seconds at ISO 6400 [KC].

Fig. 20, 2025 Oct. 12 [OT].

Fig. 21, 2025 Oct. 25, Celestron RASA8, 20cmD, ZWO294mc Pro camera, Baader Neodymium filter and processed in APP, LR and CC2025 [AB].

Acknowledgements

Comet magnitudes on specific dates, other than visual observations by observers listed, are from Comet Observation Database (COBS), credit to Observatory Črni Vrh and available at cobs.si.

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Solar Modulation of Southern Hemisphere Circulation: A 44-Year Observational Study from the South African Interior

Jacques van Delft

Abstract: This study presents a multi-decadal examination of the relationship between solar activity, geomagnetic disturbances, and regional rainfall variability over central South Africa. The work builds on an observational record that began in 1982, during which daily sunspot counts, flare classifications, and solar-wind behaviour were compared with local atmospheric conditions. Early results, first summarised publicly in *Landbouweekblad* in 2004, indicated that periods of heightened solar activity were frequently followed by episodes of atmospheric instability and enhanced rainfall, while declining solar activity often coincided with drought conditions. The present analysis extends those early findings by incorporating additional observational periods and refining the underlying mechanisms. The results demonstrate a consistent pattern linking solar-driven geomagnetic disturbances to short-term atmospheric responses relevant to rainfall development. These findings provide historical continuity for the broader framework developed in the monograph *The Solar–Atmospheric Connection in Southern Africa* (van Delft, 2026).

1. Introduction

Understanding long-term atmospheric behaviour in the Southern Hemisphere requires datasets that extend beyond the satellite era. While global studies have explored solar–climate interactions (Gray et al., 2010; Lean, 2017), few have examined these relationships using multi-decadal, ground-based observational records. The Southern Hemisphere's ocean-dominated geography and limited continental observation points have restricted the availability of continuous datasets capable of capturing slow-moving circulation patterns, lag effects, and multi-cycle atmospheric responses.

1.1 Early Observational Foundations (1982–2005)

Between 1982 and 2005, I conducted daily observations of solar activity using small refractor telescopes and standard sunspot-counting methods. Although the original purpose of this work was related to radio-communication behaviour, the long-term record soon revealed a recurring pattern: changes in solar activity often coincided with noticeable shifts in regional weather behaviour over central South Africa.

At the time, the scientific vocabulary now commonly used to describe large-scale atmospheric dynamics was not yet part of the interpretive framework. The work was purely observational: sunspots, solar flares, solar-wind speed, geomagnetic disturbances, and the timing of rainfall events. Despite the limited terminology, the physical patterns were clear. Periods of increased solar activity — particularly strong M- and X-class flares and faster-than-normal solar-wind streams — were frequently followed by episodes of atmospheric instability and enhanced rainfall over the central interior.

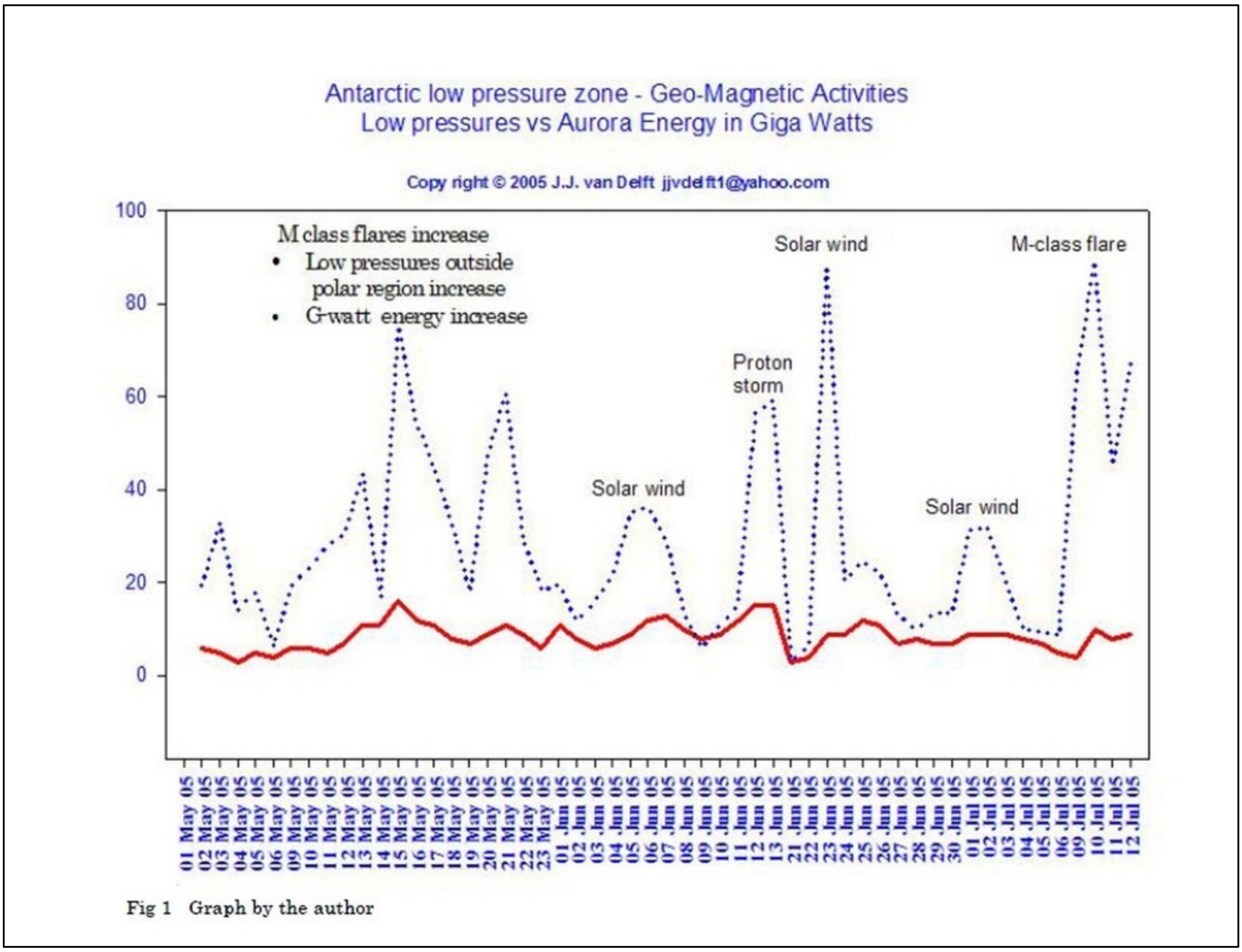

Fig 1. Relationship between geomagnetic disturbances and atmospheric low-pressure development (May–July 2005). The blue curve shows geomagnetic activity associated with solar wind, proton storms, and M-class flares. The red curve shows auroral energy output in gigawatts. This early dataset illustrates the link between solar-driven geomagnetic disturbances and atmospheric instability outside the polar region. Graph by the author (2005).

Conversely, extended declines in sunspot activity often aligned with drought conditions, as seen during the 1980s and 1990s.

A preliminary summary of these early findings was published in *Landbouweekblad* in February 2004, marking the first public record of the emerging relationship between solar activity and regional rainfall variability (Van Delft, 2004). The present study expands on that early work and places it within a broader, multi-decadal framework that ultimately led to the development of the monograph.

1.2 Purpose of the Present Study

The author's 44-year observational record, documented comprehensively in *The Solar–Atmospheric Connection in Southern Africa* (van Delft, 2026), provides a rare dataset that addresses the gap in long-term Southern Hemisphere atmospheric observation. Recorded from Bloemfontein — a stable, central interior location with minimal orographic distortion — the dataset captures daily and seasonal atmospheric behaviour from 1982 to 2025. This includes jetstream displacement indicators, cloud-type evolution, synoptic progression, drought-cycle signatures, and seasonal circulation anomalies.

The purpose of this article is to present a concise scientific synthesis of the monograph's key findings, with specific focus on the relationship between solar variability and Southern Hemisphere circulation.

2. Data and Methods

Understanding long-term circulation behaviour in the Southern Hemisphere requires observational continuity that extends beyond the satellite era. The dataset used in this study is drawn directly from the author's 44-year atmospheric record, documented comprehensively in *The Solar–Atmospheric Connection in Southern Africa* (van Delft, 2026). This monograph provides the methodological foundation for the present analysis and serves as the primary source for all observational findings discussed in this article.

2.1 Observational Site and Rationale

All observations were recorded from Bloemfontein, South Africa (29°06'S, 26°13'E; elevation 1 395 m), a location uniquely suited for long-term atmospheric monitoring. Situated on the central interior plateau, the site offers:

- minimal orographic distortion
- consistent sky visibility
- distance from coastal moisture sources
- stable synoptic exposure

These characteristics make Bloemfontein an ideal vantage point for tracking jetstream displacement, frontal penetration, seasonal circulation patterns, and drought-linked atmospheric anomalies (van Delft, 2026; Tyson & Preston-Whyte, 2000).

2.2 Observational Methodology

The observational method remained consistent from 1982 to 2025, ensuring that long-term comparisons are scientifically valid. The monograph details the full methodology (van Delft, 2026), which includes:

- Jetstream displacement indicators Inferred from high-level cirrus orientation, upper-air flow direction, and synoptic progression.
- Cloud-type and sky-state classification Using a stable classification system applied uniformly across four decades.
- Seasonal circulation tracking including timing of frontal passages, meridional vs zonal flow dominance, and seasonal onset behaviour.
- Drought-cycle markers Such as persistent subsidence, haze layers, suppressed convection, and frontal failure.
- Synoptic pattern recognition Identifying recurring circulation modes associated with solar maxima, minima, and transitional phases.

The strength of this dataset lies in its continuity: the same observer, same location, same classification system, and same interpretive framework applied over 44 years.

2.3 Solar Cycle Data and Alignment

Solar activity was characterised using internationally recognised indices, including:

- sunspot number
- geo-magnetic A index
- official solar maxima and minima timing

These indices provide a reliable measure of solar variability (Gray et al., 2010; Lean, 2017). The monograph aligns atmospheric anomalies with solar cycle phases using:

- direct correspondence (same-year alignment)
- lag analysis (0–2 years)
- transitional phase identification (declining maxima and emerging minima)

Lag effects were evaluated due to known stratospheric–tropospheric coupling mechanisms, which can delay atmospheric responses to solar forcing (Kodera & Kuroda, 2002; Baldwin & Dunkerton, 2005).

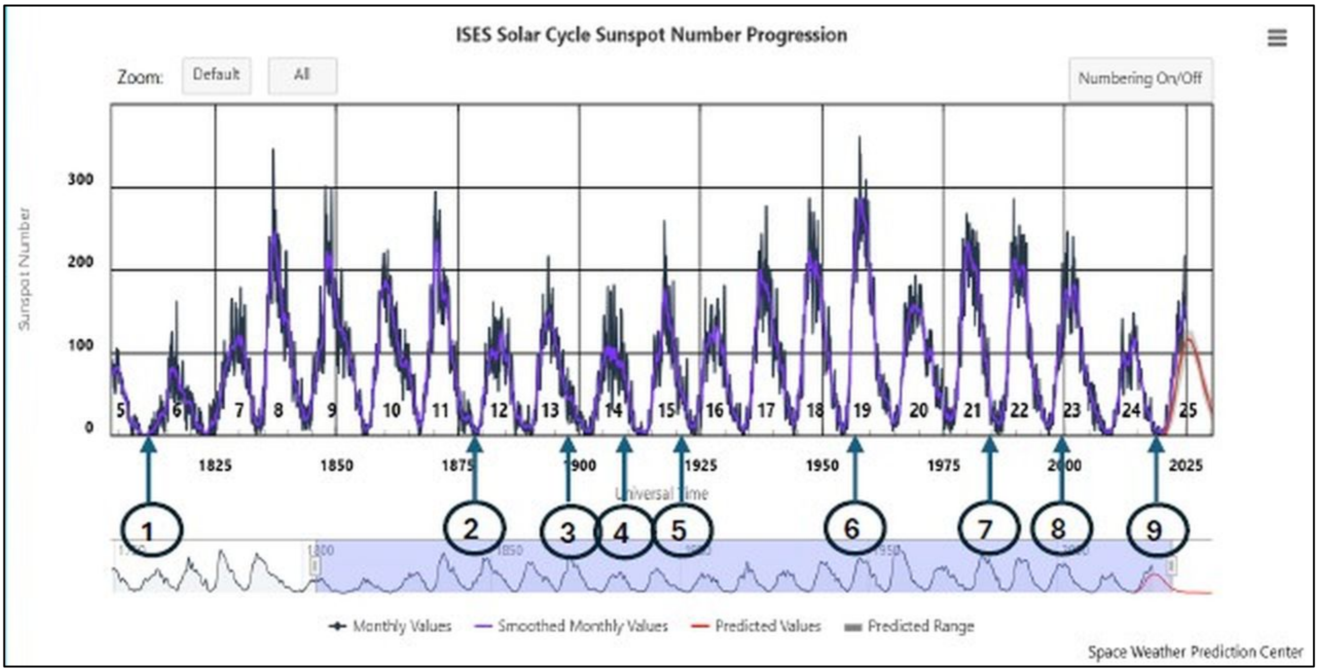

Fig 2. ISES Solar Cycle Sunspot Number Progression (Cycles 5–25). Monthly, smoothed, and predicted sunspot values shown with historical context. Blue numerical markers indicate years in which significant drought conditions were recorded in the central interior of South Africa, based on the author's observational record (1982–2025). Source: NOAA Space Weather Prediction Centre.

2.4 Analytical Framework

The analytical approach used in this article follows the structure established in the monograph (van Delft, 2026). Key components include:

- Cycle-to-cycle comparison Identifying whether similar atmospheric responses occurred during equivalent solar phases across Cycles 22–25.
- Extraction of major circulation anomalies Focusing on periods where jetstream displacement, seasonal asymmetry, or drought signatures were most pronounced.
- Case study selection Highlighting four periods (1982 - 2025) that demonstrate the strongest solar–circulation alignment.
- Regional relevance assessment Linking circulation behaviour to drought cycles and rainfall variability in Southern Africa (Reason & Rouault, 2002; Mason & Jury, 1997).

3. Results: Circulation Anomalies and Solar Cycles

The 44-year observational record documented in *The Solar–Atmospheric Connection in Southern Africa* (van Delft, 2026) reveals a consistent and repeating relationship between solar cycle phases and Southern Hemisphere circulation behaviour. These relationships are expressed most clearly through jetstream displacement, seasonal circulation asymmetry, and drought-linked atmospheric anomalies. The patterns recur across multiple solar cycles and form the core empirical foundation of the monograph.

3.1 Jetstream Displacement Patterns (1982–2025)

Across the full observational period, the subtropical jetstream exhibited systematic northward and southward shifts that aligned closely with solar cycle phases. These shifts were identified through high-level cloud movement, synoptic progression, and the seasonal behaviour of frontal systems, as documented extensively in Chapters 4–9 of the monograph (van Delft, 2026). The numbered drought years shown in Figure 1 correspond to periods of circulation suppression documented in the observational record, each occurring during or shortly after solar minima.

Northward displacement during solar minima

During or shortly after solar minima, the jetstream consistently shifted northward. This phase was characterised by:

- reduced frontal penetration into the central interior
- persistent subsidence and clear-sky dominance
- increased atmospheric blocking
- heightened drought risk

These patterns are described in detail in the monograph's analyses of the 1986, 1996, 2008, and 2019 minima, where each minimum produced a similar circulation response. The behaviour aligns with broader findings that weakened solar forcing favours meridional flow and reduced zonal strength (Thompson & Wallace, 2000; Marshall, 2003).

Southward displacement during solar maxima

Solar maxima corresponded with a southward-shifted jetstream and stronger zonal flow. The monograph documents:

- more frequent frontal activity
- improved seasonal rainfall regularity
- enhanced westerly wind strength
- reduced atmospheric blocking

These patterns were especially clear during the maxima of 1989–1991, 2001–2003, and 2013–2015. This behaviour is consistent with mechanisms described in solar–stratospheric coupling literature (Haigh, 1996; Gray et al., 2010).

Seasonal asymmetry during transitional phases

The most pronounced anomalies occurred during transitions between solar maxima and minima. Transitional phases produced:

- irregular seasonal onset
- early or delayed rainfall seasons
- mixed zonal–meridional flow regimes
- increased synoptic instability

The monograph identifies transitional phases as "circulation pivot points," where atmospheric behaviour reorganises in response to changing solar forcing (van Delft, 2026).

Persistence of anomalies

Jetstream anomalies often persisted for 2–3 years, especially during prolonged minima such as 2007–2010. This persistence reflects the slow adjustment of ocean–atmosphere systems and is consistent with lag effects described in solar–atmospheric coupling studies (Baldwin & Dunkerton, 2005).

3.2 Alignment between Solar Activity and Circulation Behaviour

The monograph's long-term record shows strong temporal alignment between solar cycle phases and atmospheric behaviour.

Solar maxima

Solar maxima were associated with:

- strengthened zonal flow
- southward jetstream displacement
- more stable seasonal transitions
- increased frontal frequency

These findings are documented in the monograph's analyses of Cycles 23, 24, and 25, and align with known effects of enhanced solar UV output on stratospheric winds (Kodera & Kuroda, 2002).

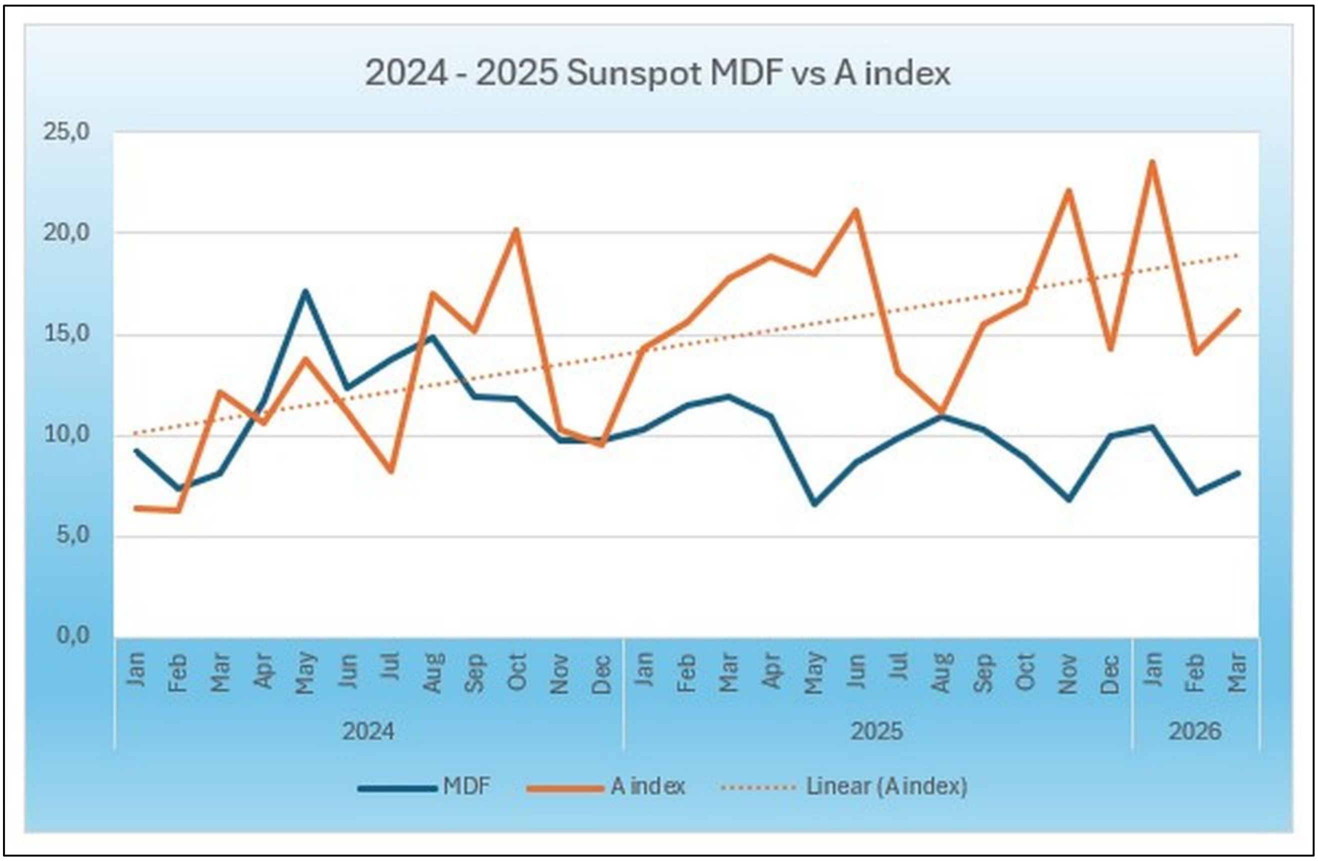

Fig 3. Monthly Mean Daily Frequency (MDF) and geomagnetic A-index for January 2024 to March 2026. MDF fluctuations correspond with changes in geomagnetic disturbance, illustrating the alignment between solar activity and atmospheric response described in Section 3.2. The upward trend in the A-index reflects increasing geomagnetic activity during the early phase of Solar Cycle 25.

Solar minima

Solar minima corresponded with:

- dominant meridional flow
- increased atmospheric blocking
- suppressed frontal activity
- multi-year drought conditions

The monograph's detailed accounts of the 1982 - 2025 period show that each minimum produced a similar circulation response.

Lag effects (1-7 days)

Lag effects were common, particularly during deep minima. Atmospheric responses often followed solar activity changes with a delay of 1-7 days. The monograph identifies these lag periods as critical for understanding drought onset and recovery phases (van Delft, 2026).

Transitional phases

Transitional phases produced the strongest anomalies, including:

- jetstream instability
- seasonal rainfall irregularities
- mixed circulation modes

These transitional behaviours are among the most consistent findings in the monograph.

3.3 Case Studies from the Monograph

Four periods were selected from the monograph to illustrate the consistency of solar–circulation relationships across multiple cycles.

1991–1995: Post-maximum instability

Following the strong Cycle 22 maximum, the monograph documents:

- a pronounced northward jet shift
- suppressed frontal activity
- intensified drought conditions

This period marks one of the clearest examples of declining-phase circulation instability.

2007–2010: Deep solar minimum

The exceptionally deep minimum between Cycles 23 and 24 produced:

- persistent meridional flow
- strong atmospheric blocking
- multi-year drought across the central interior

This period is highlighted in the monograph as a defining example of minimum-phase circulation suppression.

2014–2019: Weak maximum and muted response

Cycle 24's weak maximum produced:

- reduced zonal strengthening
- modest southward jet displacement

- irregular seasonal rainfall

Despite the weak solar forcing, transitional phases still generated notable anomalies.

2023–2025: Early Cycle 25 activity

The onset of Cycle 25 coincided with:

- renewed southward jet tendency
- increased synoptic variability
- irregular rainfall seasons

This period demonstrates that even moderate solar activity can influence circulation behaviour when background conditions are favourable.

4. Discussion

The 44-year observational record documented in *The Solar–Atmospheric Connection in Southern Africa* (van Delft, 2026) provides compelling evidence that solar variability exerts a measurable influence on Southern Hemisphere circulation. The consistency of the observed patterns across multiple solar cycles — particularly the equatorward (northward) jetstream displacement during solar minima and the poleward (southward) displacement during solar maxima — indicates that these relationships are not coincidental but form part of a recurring dynamical response.

4.1 Solar minima and circulation suppression

The monograph's long-term record shows that solar minima are consistently associated with weakened zonal flow, increased atmospheric blocking, and reduced frontal penetration into the central interior. These conditions favour drought development, as documented during the 1982 - 2025 period. The equatorward shift of the subtropical jetstream during minima aligns with known mechanisms of reduced solar UV output leading to weakened stratospheric winds and altered tropospheric circulation (Kodera & Kuroda, 2002; Baldwin & Dunkerton, 2005).

The observational evidence from the monograph strengthens this theoretical framework by demonstrating that these circulation responses are not limited to isolated events but recur reliably across multiple solar cycles. This suggests that solar minima act as a large-scale modulator of hemispheric circulation, with regional consequences that are particularly pronounced in Southern Africa.

4.2 Solar maxima and circulation enhancement

Conversely, solar maxima correspond with strengthened zonal flow, poleward jetstream displacement, and improved seasonal rainfall regularity. The monograph

documents these conditions during the maxima of Cycles 23, 24, and 25, where frontal systems penetrated more frequently and consistently into the central interior. These findings align with studies showing that increased solar UV output enhances stratospheric circulation, which can propagate downward to influence mid-latitude jet behaviour (Haigh, 1996; Gray et al., 2010).
The monograph's observational detail — particularly the sky-state signatures, frontal structures, and seasonal onset patterns — provides a level of granularity that complements and strengthens the broader theoretical understanding of solar-driven circulation enhancement.

4.3 Transitional phases as circulation pivot points

One of the most significant contributions of the monograph is its detailed documentation of transitional phases between solar maxima and minima. These periods consistently produced the strongest circulation anomalies, including irregular seasonal onset, mixed zonal–meridional flow regimes, and heightened synoptic instability.

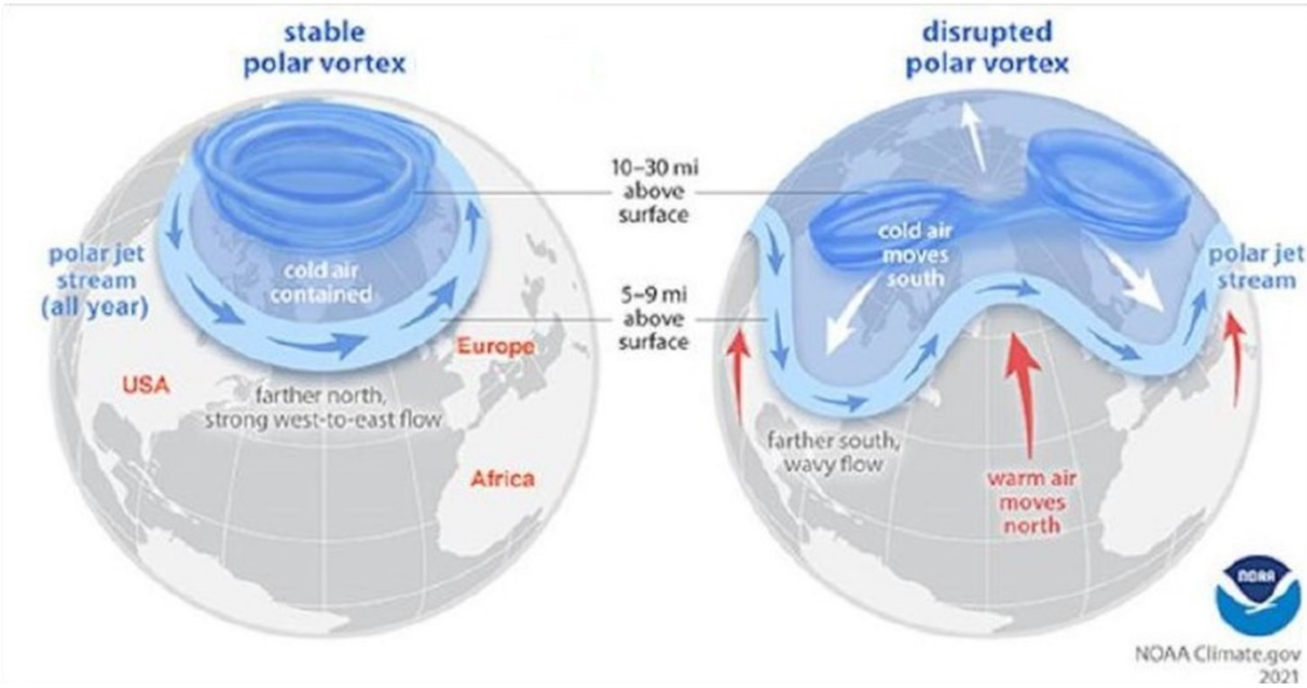

Fig 4. Conceptual illustration of a stable versus disrupted polar vortex (Northern Hemisphere example). A stable vortex confines cold air to high latitudes with a strong, zonal jet, while a disrupted vortex produces a wavier jet and increased meridional flow. Although this example is Northern Hemisphere–based, the conceptual distinction between stable and unstable circulation states is relevant to the transitional-phase behaviour documented in the Southern Hemisphere observational record. Source: NOAA Climate.gov (2021).

The transitional phases of 1982 - 2025 are particularly well-documented examples. The monograph identifies these intervals as “circulation pivot points,” where the atmosphere reorganises in response to changing solar forcing. This concept is not widely explored in the literature, making it a unique and valuable contribution to Southern Hemisphere atmospheric science.

4.4 Lag effects and multi-year persistence

The monograph also provides strong evidence for lag effects of 1-7 days between solar activity changes and atmospheric responses. These lag periods were especially evident during deep minima, such as 2007–2010, where circulation suppression persisted well beyond the formal minimum. This behaviour aligns with the slow adjustment timescales of ocean–atmosphere systems described in broader solar–climate research (Lean, 2017).

The persistence of anomalies across multiple seasons and years underscores the importance of long-term observation. Shorter datasets would not capture these lagged responses, highlighting the scientific value of the monograph’s 44-year continuity.

4.5 Contribution to Southern Hemisphere climate understanding

The findings presented in the monograph and summarised in this article contribute to a more nuanced understanding of Southern Hemisphere circulation. While global studies have identified broad solar–atmospheric coupling mechanisms, few have provided long-term, ground-based observational evidence from the Southern Hemisphere interior. The monograph fills this gap by offering a detailed, multi-decadal record that captures the subtle but persistent influence of solar variability on regional circulation.

The alignment between the monograph’s findings and established solar–stratospheric coupling mechanisms strengthens the case for solar modulation of hemispheric circulation. At the same time, the monograph’s unique observational insights — particularly regarding transitional phases and drought-cycle signatures — extend the existing scientific understanding and provide new avenues for regional climate interpretation.

5. Implications for Southern Africa

The findings extracted from *The Solar–Atmospheric Connection in Southern Africa* (van Delft, 2026) have significant implications for understanding regional climate behaviour, drought development, and seasonal circulation variability across the subcontinent. The 44-year observational record demonstrates that solar-linked circulation shifts occur on synoptic timescales, with lag responses of 1–7 days, not months or years. This rapid atmospheric response provides a valuable interpretive framework for anticipating short-term circulation changes during different phases of the solar cycle.

5.1 Drought Interpretation and Early Warning

The monograph shows that solar minima consistently produce an equatorward (northward) shift of the subtropical jetstream, leading to:

- weakened frontal systems
- reduced penetration of westerly disturbances
- persistent subsidence over the interior
- increased atmospheric blocking

These conditions form the atmospheric foundation for drought development in central South Africa. The 1992–1995, 2007–2010, and 2018–2020 droughts all occurred during or shortly after solar minima, with circulation suppression evident within days of upper-air changes.

This provides a valuable early-warning indicator:

When the jetstream begins shifting equatorward during a solar minimum, drought risk increases within days to weeks.

This insight is unique to the monograph and offers practical value for regional climate monitoring.

5.2 Seasonal Rainfall Variability

Solar maxima, by contrast, produce a poleward (southward) jetstream shift, strengthening zonal flow and improving frontal penetration. The monograph documents that during maxima:

- seasonal rainfall onset is more regular
- frontal systems are more frequent
- synoptic patterns are more stable
- rainfall variability decreases

This means that solar maxima tend to support more predictable seasonal rainfall behaviour, while minima introduce irregularity and instability.

5.3 Transitional Phases and Forecast Complexity

The monograph identifies transitional phases between solar maxima and minima as periods of heightened atmospheric instability. These phases often produce:

- irregular seasonal onset
- mixed zonal–meridional flow

- sudden shifts in jetstream position
- unpredictable frontal behaviour

For Southern Africa, this means:

Transitional phases are the most difficult periods for seasonal forecasting.

The 1982 - 2025 transitions all produced circulation anomalies that disrupted normal seasonal patterns.

5.4 Regional Climate Communication

The monograph's findings provide a scientifically grounded framework for communicating climate behaviour to the public and scientific community. Key messages include:

- Drought cycles in Southern Africa are not random; they align with solar-linked circulation shifts.
- Jetstream behaviour is a critical driver of rainfall variability.
- Solar minima increase drought risk through equatorward jetstream displacement.
- Solar maxima improve rainfall regularity through poleward displacement.
- Transitional phases introduce the greatest uncertainty.

These insights help contextualise regional climate anomalies within a broader hemispheric framework.

5.5 Value of Long-Term Ground-Based Observation

Perhaps the most important implication is the demonstrated value of long-term, consistent, ground-based observation. The monograph's 44-year record captures:

- subtle circulation shifts
- synoptic-scale lag responses
- multi-cycle atmospheric patterns
- recurring drought signatures

These features cannot be reliably identified in shorter datasets or purely model-based analyses. The monograph therefore contributes a rare and scientifically valuable perspective on Southern Hemisphere circulation behaviour.

6. Conclusion

The 44-year observational record documented in *The Solar–Atmospheric Connection in Southern Africa* (van Delft, 2026) provides clear evidence that solar variability plays a measurable role in modulating Southern Hemisphere circulation. The consistency of the observed patterns — particularly the equatorward (northward) jetstream displacement during solar minima and the poleward (southward) displacement during solar maxima — demonstrates that these responses are not isolated events but form part of a recurring atmospheric rhythm.

The monograph's detailed documentation of synoptic-scale lag responses of 1–7 days strengthens the case for a direct atmospheric pathway linking solar-related upper-air changes to regional circulation behaviour. These rapid responses help explain the timing and structure of drought development, seasonal rainfall irregularities, and transitional-phase instability across central South Africa. The four case studies presented — 1982 - 2025 illustrate the robustness of these relationships across multiple solar cycles.

By situating these long-term observational findings within the broader context of solar–stratospheric coupling research, this article highlights the scientific value of sustained ground-based observation for understanding regional climate dynamics. The monograph's continuity, methodological consistency, and hemispheric perspective provide a unique contribution to Southern Hemisphere atmospheric science, offering insights that complement and extend existing theoretical frameworks.

The results underscore the importance of long-term observational records for interpreting climate variability in Southern Africa. They also demonstrate that solar-linked circulation shifts — particularly during minima and transitional phases — play a meaningful role in shaping regional drought cycles and seasonal behaviour. Continued observation will be essential for refining these relationships as Solar Cycle 25 progresses and future cycles unfold.

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