PAPER CHECK · SPACE WEATHER AND THE WEATHER

A forum report on space weather and the weather below is right to urge caution

Sixteen scientists report what a 2022 forum in Bern concluded about how weather in space and weather in the lower atmosphere affect each other [1 Abstract]. On whether space weather drives the weather and climate below, the report is cautious: direct connections to the climate of the lowest layer of the atmosphere "remain an active research topic and should not be overstated" [1 p. 28]. The evidence we checked backs that caution [3][23]. By our count of the paper's text [1], none of the 18 statements on the subject that our filter found cites a study, nor do 10 more that it missed. The report discusses one of five routes proposed in the literature (section 4), in line with its stated focus, coupling from the lower atmosphere up [1 p. 4]. S0 News linked the paper on November 15, 2026 [2].

By Fact-Checked Science · Published November 15, 2026

OUR ANALYSIS marks our own reasoning, including our pre-registered count of the paper's statements on space weather and the atmosphere below, and the verdicts are our assessment. Everything else comes from the numbered sources. For the paper [1], p. gives a page of its 33-page PDF, § a section, and Table its Table 1. The troposphere is the lowest layer of the atmosphere, where the weather happens; above it lie the stratosphere, home of the ozone layer, then the mesosphere and the thermosphere, where space weather plays out.

Right to urge caution, though none of the 18 statements our filter found on space weather's effects below cites a study

OUR ASSESSMENT

0 of 18

Our analysis: of the statements our filter found in which the paper says solar or space phenomena affect the atmosphere below the mesosphere, its weather or its climate, those that cite a study. None of 10 more that it missed does either. Its only citations on how anything above reaches the weather concern the stratosphere's pull on it [1 p. 14].

16

people on ISSI's list for the three-day forum of November 2022 that the paper reports. ISSI describes its forums as "informal and free-ranging debates" [5].

1 of 5

Our analysis: routes from space to the weather below, proposed in the literature, that the paper discusses; its stated focus is the other direction [1 p. 4]. It covers energetic particles, and names cosmic rays only in lists [1 p. 6][1 p. 27].

THE PAPER'S CLAIMS

PARTLY TRUE

"Solar and space phenomena (e.g., solar wind, cosmic rays, auroral and energetic particles) affect atmospheric chemistry and climate, notably through ozone depletion and thermospheric heating."

The paper's summary of the forum's discussions [1 p. 27]

The chemistry and the upper atmosphere, yes: particles destroy ozone high over the poles [3 p. 15], and storms heat the thermosphere, as our storms-and-weather check sets out. Effects on the climate at the surface are debated, and cosmic rays' effect on the climate is assessed as negligible [23 §7.3.4.5]. The paper's own conclusion warns against overstating links to the climate below [1 p. 28]. See section 3.

TRUE

"…NO_x has a long lifetime in the darkness of the polar night, and can be transported downward into the main ozone layer in the stratosphere."

The paper, on the chemistry of particle forcing [1 p. 7]

Observed and modelled for decades: nitric oxide made by particles lasts weeks to months in the polar night and is carried down into the stratosphere [3 p. 11]. The paper's 60–110 km leaves out solar protons and the fastest electrons, which ionize the upper stratosphere directly [3 p. 4]. See section 3.

TRUE

"Particle forcing has been shown to correlate with the local polar region surface weather patterns, but what exactly is the pathway, is not fully understood."

The paper [1 p. 7]

Such correlations are reported: polar winter temperatures differed by up to about 4.5 K between years of high and low geomagnetic activity in 1957–2006 [10 Abstract]. The special issue's own review calls the evidence strong but the record limited, and the correlations sensitive to how the data are chosen [3 p. 27][3 p. 28]. See section 3.

TRUE

"…electron fluxes are estimated by (mainly) geomagnetic index-based proxies that are used in climate modeling today."

The paper [1 p. 7]

The standard solar forcing for climate models has included particles since its CMIP6 version, with the electrons extended back in time by the geomagnetic Ap index [8 Abstract][3 p. 10]. Seasonal forecasts and many climate models still leave particles out [3 p. 32]. See section 3.

TRUE

"The evidence for such links is strongest for pathways involving the middle atmosphere, while direct causal connections from space weather to tropospheric climate remain an active research topic and should not be overstated."

The paper's conclusions [1 p. 28]

The two studies the paper cites show the stratosphere's pull on the weather [14 Abstract][15 Abstract]. The direct routes from space to the surface are contested, or assessed as negligible [4 p. 25][23 §7.3.4.5]. See section 4.

PARTLY TRUE

"NASA's Dynamic Atmosphere–Ionosphere Explorer (DAPHNE) mission, selected in 2026, will study how upper atmospheric forcing influences space weather in the mesosphere and ionosphere."

The paper [1 p. 26]

Selected, yes: NASA chose DAPHNE in June 2026 for its next phase of design. But NASA gives the mission's main goal the other way round: how changes in Earth's lower atmosphere influence the upper atmosphere, with measurements in the thermosphere [27]. See section 5.

1 · THE REPORT

A three-day forum's conclusions, published almost four years later

The paper reports the conclusions of an ISSI Forum, "Physical Links Between Weather in Space and Weather in the Lower Atmosphere", held in Bern on November 14–16, 2022 [1 p. 3][5]. It brings no new data or analysis, and it serves as the introduction to a special issue of 16 papers [1 p. 28][7].

THE FORUM

16 people

on ISSI's list: 4 convenors and 12 participants. Fifteen of them are among the paper's 16 authors [5][1 p. 33].

ONLINE

Oct. 2026

published online October 28, 2026, a year after it was received. ISSI held a follow-on workshop in January 2024 [1 p. 1][6].

GUEST EDITORS

8 of 16

authors are guest editors of the special issue the paper introduces, as it declares. The journal publishes refereed reviews [1 p. 29][7].

What a forum is

ISSI's invitation described its forums as "informal and free-ranging debates, among some fifteen to twenty-five high-level participants, on open questions of a scientific nature or on science policy matters" [5]. This one's agenda ran from keynotes and a short input from each participant to drafting a "white paper with roadmap" [5].

What the paper covers

Coupling in both directions (its section 2), the models and observations available (section 3) and recommendations (section 4), led by an international "Great ITM (or IMUA) Observatory": a shared framework for satellites, ground instruments and models of the ionosphere, thermosphere and mesosphere [1 p. 19][1 p. 25]. It has no data and no supplement, and it is licensed CC BY 4.0 [1 p. 29].

OUR ANALYSIS

Reading it for one question

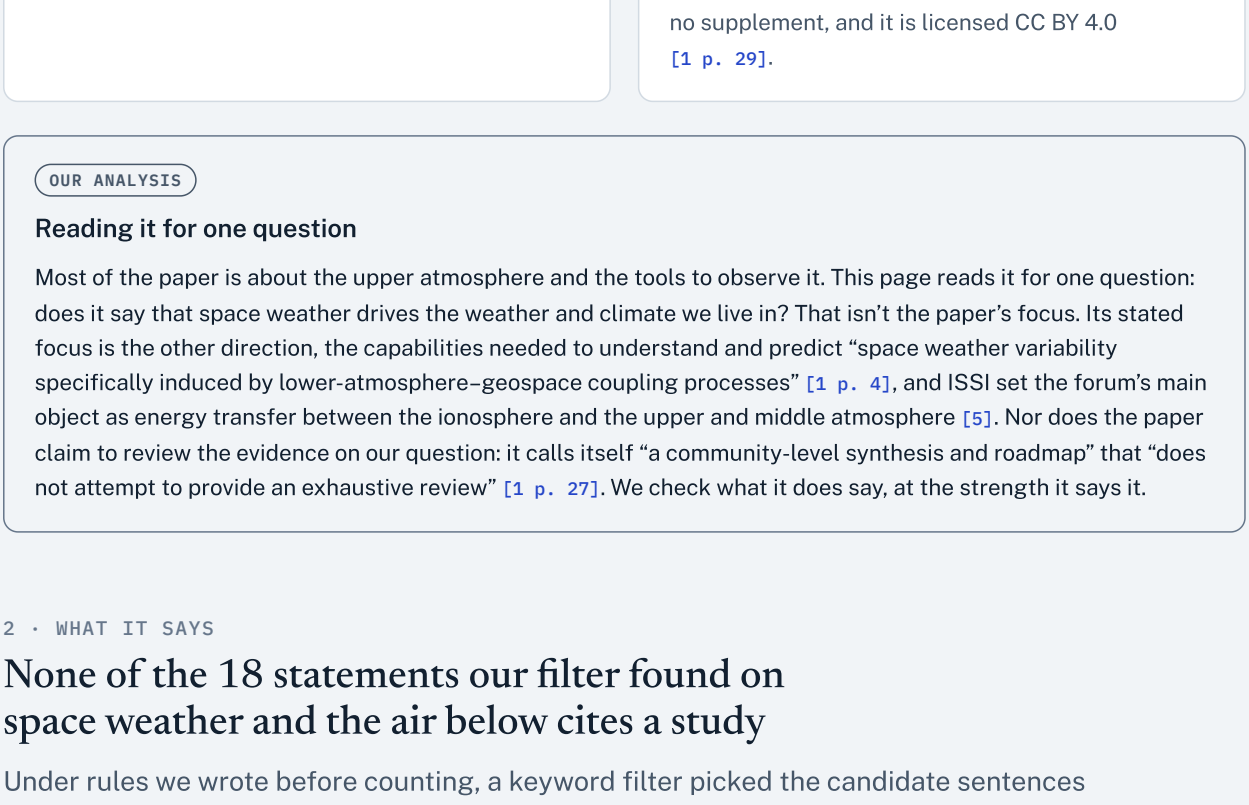
Most of the paper is about the upper atmosphere and the tools to observe it. This page reads it for one question: does it say that space weather drives the weather and climate we live in? That isn't the paper's focus. Its stated focus is the other direction, the capabilities needed to understand and predict "space weather variability specifically induced by lower-atmosphere–geospace coupling processes" [1 p. 4], and ISSI set the forum's main object as energy transfer between the ionosphere and the upper and middle atmosphere [5]. Nor does the paper claim to review the evidence on our question: it calls itself "a community-level synthesis and roadmap" that "does not attempt to provide an exhaustive review" [1 p. 27]. We check what it does say, at the strength it says it.

2 · WHAT IT SAYS

None of the 18 statements our filter found on space weather and the air below cites a study

Under rules we wrote before counting, a keyword filter picked the candidate sentences and we classed each by hand. Of the 18 in which the paper says that solar or space phenomena affect the atmosphere below the mesosphere, its weather or its climate, six are hedged or put as questions, and none cites a study; nor do 10 more on the subject that the filter missed [1].

How the paper states them OUR ANALYSIS



Our analysis of the paper's text [1]. A keyword filter written into the rules picked 51 candidate sentences, and we classed each by hand. Eleven relevant sentences the filter missed are listed apart and not counted; one of them cites two studies, on the stratosphere and the weather [1 p. 14]. One of the 18 is the caption of the paper's Fig. 4, on the chains of processes that couple the atmosphere to space, which the text extraction joins to the sentence it interrupts on p. 8; we classed it on the caption [1 p. 9]. Every call is in our files, in section 7.

In the authors' words Two of the eighteen, and one sentence the filter missed

> *"…and conversely how solar and space phenomena may affect chemistry, dynamics and climate in the lower atmosphere."*
>
> The abstract [1 p. 1]

> *"The Forum notes good progress and results demonstrating the value of studying forcing from above (impact of weather in space on the weather in the middle and lower atmosphere)."*
>
> Section 4.2 [1 p. 20]

> *"Whether circulation changes in the mesosphere or thermosphere produce similarly robust and quantitatively useful feedback on tropospheric weather remains much less well-established."*
>
> Section 3.1 [1 p. 14]

OUR ANALYSIS

What the count shows

Where the paper is careful, it is careful in line with the literature, as sections 3 and 4 show. But by our count its statements that space weather affects the air below are made without a citation. That is all the counts mean: the paper isn't unsourced. It has 66 references, cited for other statements, such as those on solar flares and the ionosphere [1 p. 6] and on metals from spacecraft re-entry [1 p. 25]. On how anything above reaches the weather, its only citations, Domeisen (2019) and Oehrlein and colleagues (2021) [1 p. 14], are about the stratosphere's influence on the weather, not about space weather, and both studies support what the paper says of them [14 Abstract][15 Abstract]. Which sentences assert, hedge or only call for research is our judgment, recorded sentence by sentence so that it can be checked.

3 · THE PARTICLE ROUTE

The chemistry is solid, the link to the surface is debated, and the standard forcing for climate models includes it

The paper's two short paragraphs on how space weather reaches the atmosphere below are about energetic particles [1 p. 6][1 p. 7]. The special issue it introduces has a detailed review of this route, by Nesse and colleagues, which the paper doesn't cite [3].

STEP 1 · ESTABLISHED

Particles ionize the air

Solar protons, and electrons from the aurora and Earth's radiation belts, ionize the polar atmosphere from the thermosphere down; the most energetic reach the upper stratosphere directly [3 p. 4].

STEP 2 · ESTABLISHED

Ozone destroyers form

The ionization makes nitrogen and hydrogen oxides, NO_x and HO_x, which destroy ozone. The review finds "strong evidence" that particles are a significant driver of ozone's variation in the mesosphere [3 p. 15].

STEP 3 · ESTABLISHED

Down into the ozone layer

In the dark polar winter, nitric oxide lasts weeks to months and is carried down into the stratosphere [3 p. 11]. Models put the ozone it destroys high over Antarctica at 2–10% near solar minimum and 10–50% near maximum, almost every winter [3 p. 16].

STEP 4 · DEBATED

On to the surface?

The review argues that through the winter polar vortex the effects can reach the surface [3 p. 1]. Correlations are reported, and how robust they are is argued over [3 p. 28].

What the paper says

"Strong ionization sources produce odd nitrogen (NO_x) and odd hydrogen (HO_x) in the mesosphere–lower thermosphere region, between about 60 and 110 km. These gases can catalytically deplete ozone." The NO_x can be "transported downward into the main ozone layer in the stratosphere", and particle forcing "has been shown to correlate with the local polar region surface weather patterns, but what exactly is the pathway, is not fully understood" [1 p. 7].

OUR ANALYSIS

Claims 2 and 3 hold, at the paper's own strength

The chemistry is as the paper says, except that its 60–110 km is too narrow: protons and the fastest electrons also make NO_x in the upper stratosphere [3 p. 4]. On the surface, the paper claims a correlation and calls the pathway unclear, which is where the evidence stands. The review goes further, presenting findings "demonstrating" that the effects "can migrate downwards into the troposphere and reach the surface" [3 p. 1], while warning that the correlations are "highly sensitive to dataset length, statistical methods, and the choice of atmospheric preconditioning" [3 p. 28].

Particles and the weather at the surface: what studies found

STUDY	FINDING
Seppälä and colleagues, 2009 Reanalysis, 1957–2006	Polar winter surface temperatures up to about 4.5 K apart in years of high and low geomagnetic activity, significant at the two-sigma level; the authors could not conclusively show a physical link, but concluded that geomagnetic activity likely plays a part in winter surface temperatures [10 Abstract]
Baumgaertner and colleagues, 2011 Chemistry–climate model	Strong geomagnetic activity leads to ozone loss, a more stable polar vortex and surface patterns like those observed [11 Abstract]
Meraner and Schmidt, 2018 Earth system model	Particle ozone loss warms the polar stratosphere and weakens the vortex a little; few significant changes in the surface climate [13 Abstract]
Maliniemi and colleagues, 2019 Reanalysis, 1948–2017	Geomagnetic activity goes with a stronger polar vortex and a pattern like the positive North Atlantic Oscillation in December–February [12 Abstract]
Nesse and colleagues, 2026 Review	**"Strong evidence" linking geomagnetic forcing to regional surface temperature and pressure, but "the observational record is limited"** [3 p. 27]

Particles in climate models

The standard solar forcing for climate models, prepared for CMIP6, was the first to recommend particle forcing [8 Abstract]. Its electrons come from satellite measurements, extended back in time with the geomagnetic Ap index as a proxy [3 p. 10], and the version proposed for CMIP7 would reconstruct them "back to 1850 by means of geomagnetic proxy data" [9 Abstract]. Comparisons found CMIP6's electron forcing too weak, and the proposed CMIP7 forcing may make two to ten times as much NO_x [9 p. 1220][9 p. 1222]. Seasonal forecast models, and many climate models that stop short of the upper atmosphere, still leave particles out [3 p. 32][3 p. 33].

OUR ANALYSIS

Claim 4 holds, and so does our earlier note

The paper's "index-based proxies that are used in climate modeling today" describes this exactly [1 p. 7]. Its "instead of longterm measurements" needs a gloss: the proxies extend a satellite record more than four solar cycles long [3 p. 11] to years it doesn't cover. The paper agrees with our video check's note on whether particles are "left out of climate models", which we rate Overstated: they are in the standard forcing, though many models still don't use it.

4 · THE ROUTES IT LEAVES OUT

Of five proposed routes from space to the weather, the paper discusses one

Researchers have proposed several ways in which changes on the Sun or in space could reach the weather. The paper, whose stated focus is coupling from the lower atmosphere up [1 p. 4], discusses the particle route and names cosmic rays only in lists [1 p. 6][1 p. 27]. Here is where each route stands, in tiers adapted from our check of a 2026 storms-and-weather study, with a last tier added for the route the IPCC assesses as negligible, and where on this site each is checked.

Well established

The atmosphere above the weather responds

Particles destroy ozone in the mesosphere and the upper stratosphere, as in section 3 [3 p. 15][3 p. 16]. Over the 11-year cycle, the Sun's changing ultraviolet light warms the upper stratosphere and adds to its ozone; "it is well established", writes a study that doubts the next step [16 p. 3]. And the stratosphere does shape the weather below: two-thirds of sudden stratospheric warmings are followed by a switch to, or a long spell of, the negative North Atlantic Oscillation [14 Abstract], though the size and pattern of the surface response vary a good deal [15 Abstract].

Checked on this site: ozone loss after four storms, of 30–80% at about 60–80 km, as our check confirms.

Supported, still debated

Patterns at the surface, over seasons to years

Particles and the polar winter weather, as in section 3 [10 Abstract][3 p. 28]. The solar cycle's ultraviolet and the North Atlantic Oscillation a few years later: a model finds the cycle can pace the oscillation's decade-long swings [17 Abstract], and reanalysis shows separate signals from sunspots and from geomagnetic activity [12 Abstract]. A 2019 study, though, finds no solar signal in the oscillation before the mid-1960s and a marginal one after, which might be chance [16 p. 2].

Checked on this site: S0 News's research note on the solar cycle and the Amundsen Sea Low, which claims a solar link to the low's pressure; our check rates that claim Overstated, as the data since 2016 haven't confirmed it.

Contested

Effects on the weather within days

The solar wind's field and polar pressure

Shifts in By, the dawn–dusk component of the solar wind's magnetic field, are said to change polar surface pressure through the global electric circuit: the Mansurov effect. One group calls the polar response well established and adds a pattern at middle latitudes [18 Abstract].

With tests suited to strongly autocorrelated data, there is "a fairly high probability of obtaining the cyclic response and associated correlation merely by chance" [19 p. 1]. A sequel finds "no significant response confirming the current Mansurov hypothesis"; a significant spring signal it does find comes about five days before the peak in By, which its authors call "not physically justified" [20 p. 1][20 p. 17]. The special issue's paper on the circuit says the results "have not yet led to any definitive conclusions" [4 p. 25].

Checked on this site: a 2026 thesis on lightning and the solar wind's sector boundaries, whose claim that By shapes pressure at middle latitudes our check rates Overstated.

Lightning and the solar wind

Lightning over Europe, and thunder days at UK stations, rose for about 40 days after fast solar-wind streams arrived [21 Abstract]. UK lightning and thunder differed by 40–60% between the two polarities of the Sun's magnetic field carried past Earth, and the authors speculate about the mechanism [22 Abstract].

Checked on this site: the same thesis, whose tests, our check finds, can't yet confirm the link it sees in US lightning.

Storms and the global electric circuit

Near the poles, a potential set up by the solar wind adds to the circuit that thunderstorms drive [4 p. 1]. In strong storms, extra ionization from solar protons and the drop in cosmic rays pull the air's conductivity in opposite directions, which "often makes it difficult to attribute certain GEC changes to specific processes" [4 p. 13]. The cloud processes that would carry such changes to the weather are "still the most uncertain element" [4 p. 17].

Checked on this site: two papers on the May 2024 storm, on four stations' electric field and lightning signals, where the rise in the field is real but Earth's shield kept solar protons out, and on seven stations' potential gradient, where the effects are patchy and unproven; and a strong storm's effects in the air near Moscow, which rest on one storm.

Also checked on this site, as claims of effects within days: a 2026 study of storms and North American weather, which our check places in this tier until it passes a matched random test, and a 2018 solar-effect index, whose match with temperature our check traces to humidity.

Not supported

Cosmic rays, clouds and the climate

Cosmic rays help new particles form in the air, but the IPCC finds it "unlikely that cosmic ray intensity affects present-day climate via nucleation", and has "high confidence that GCRs contribute a negligible ERF over the period 1750–2019": a negligible push on the climate [23 §7.3.4.5]. A 2009 model put the change in cloud seeds over a solar cycle at about a hundredth of what the reported cloud changes would need [24 Abstract].

Checked on this site: short-term cloud responses to sudden drops in cosmic rays, which our storms-and-weather check lists as contested; it rates Overstated a claim that the cosmic-ray–cloud hypothesis is falsified. This tier concerns the push on the climate that the IPCC assessed.

OUR ANALYSIS

The pattern, as we read it

The better-supported effects of space weather on the weather work over weeks to seasons, through the stratosphere, in polar winter; claims of effects within days have not held up under the stricter tests we read [19 p. 9][20 p. 17]. That is the paper's own conclusion, that "the evidence for such links is strongest for pathways involving the middle atmosphere" [1 p. 28]. It is right, though it reaches that conclusion without citing the studies on space weather's effects that support it.

5 · MISSIONS AND NUMBERS

The numbers we checked hold, but the goal of NASA's new mission is stated the wrong way round

The paper names dozens of missions, instruments and networks [1 p. 14][1 p. 16]. We checked those we could against their operators' own pages and records.

DAPHNE, as NASA describes it

On June 18, 2026, NASA chose the Dynamic Atmosphere-Ionosphere Explorer to enter Phase B, its next stage of planning and design. A confirmation review is due in 2027, and launch no earlier than 2029. "It will use identical twin satellites to study how changes in Earth's lower atmosphere influence our planet's upper atmosphere, where space weather is manifested," measuring winds, temperature and composition in the thermosphere [27].

OUR ANALYSIS

A slip in direction

The paper says that DAPHNE "will study how upper atmospheric forcing influences space weather in the mesosphere and ionosphere" [1 p. 26]. NASA's release names the ionosphere too, and counts space weather among the influences it lists, but it puts the emphasis on forcing from below, and it describes measurements in the thermosphere, not the mesosphere [27]. A little further on, the paper pairs DAPHNE with another mission concept as covering "inputs from above and below", which fits NASA's account, so this looks like a slip [1 p. 26]. We rate the claim Partly true: the 2026 selection holds; the direction of its main goal is stated the wrong way round.

10.7 CM RADIO FLUX SINCE

1946

as the paper says [1 p. 14]. It was measured near Ottawa from 1946 to 1990 and has been measured at Penticton since, three times a day, one at local noon [28].

SUPERDARN RADARS

36

in January 2018 [29 p. 1], in line with the paper's "close to 40" today [1 p. 16]

RE-ENTRY METALS

~10%

of stratospheric sulfuric-acid particles larger than 120 nm carry metals from spacecraft re-entry, as the study the paper cites reports [26 Abstract][1 p. 25]

OUR ANALYSIS

Small slips we noticed

- GOES's "SEM" is expanded as "scanning electron microscope" [1 p. 15]; on GOES it is the Space Environment Monitor [30].
- ACE's SWEPAM is named as a source of protons "up to some tens of MeV" [1 p. 15]. It measures the solar wind's plasma; ACE's EPAM and SIS measure energetic particles [31].
- The list of "eleven ISRs" operating in the last ten years [1 p. 16] leaves out incoherent-scatter radars at Irkutsk, Kharkiv, Qujing and Sanya, each with work published between 2017 and 2026 [32].
- Section 2.1 says that section 2.3 addresses the geomagnetic field's variation driven by the geodynamo, and its effects [1 p. 6]. Section 2.3 is about horizontal redistribution; the topic gets two sentences in section 2.4 [1 p. 10].
- Checking the 66 references' DOIs and titles against Crossref and DataCite, under rules we wrote first, we found three DOIs that point to another work or to none, one malformed DOI and two wrong titles. The US decadal surveys of 2013 and 2024, cited by author and year [1 p. 28], have no entry in the reference list [1 pp. 30–33][33]. The list is in our files, in section 7.
- That check didn't compare authors, except in one case found since: the 1980 paper cited as Crowley's [1 p. 31] is registered at Crossref to Barron, Sloan and Harrison [34].

None of these touches the paper's statements on space weather and the weather below. We haven't asked the authors about them.

6 · THROUGH THE CATASTROPHISM LENS

Nothing here points to sudden change

Catastrophist readings of space weather picture the Sun, or a changing magnetic field, driving abrupt change in the weather and climate. This section is our reading of what the paper, and the special issue it introduces, mean for that.

THE PARTICLE ROUTE TAKES

Weeks

to months: the nitric oxide that particles make sinks through the polar winter before it reaches the ozone layer [3 p. 11]

THE SUN SINCE 1750

$0.01\ W\ m^{-2}$

the IPCC's best estimate of the change in solar forcing since pre-industrial times, likely −0.06 to +0.08 [23 §7.3.4.4], against 2.72 $W\ m^{-2}$ from human activity over 1750–2019 [23 §7.3.5.2]

THE 11-YEAR CYCLE

$\sim 0.2\ W\ m^{-2}$

"a small radiative forcing", in the words of a study of its effect on the North Atlantic [16 p. 2]

Extremes

The paper's "strong storms" are space-weather events to collect data on for forecasting [1 p. 19]. The special issue's particle review ties particles to sudden stratospheric warmings, which "typically lead to extreme cold spells in Northern Europe and the US" [3 p. 32]. One reanalysis study found more warmings in winters of low geomagnetic activity under one phase of the tropical stratosphere's winds; a model test found no significant change in minor warmings [3 p. 23].

OUR ANALYSIS

What it means

At most, particles may tilt the odds of a winter cold spell in some years, and even that is argued over. Nothing in the paper, or in the special issue's two papers we read, describes a sudden change driven from space. The paper treats earthquakes, tsunamis and eruptions only as sources of waves that reach the ionosphere [1 p. 6], not as things space weather causes. On the magnetic field, it says the field's shape matters for coupling in the thermosphere and ionosphere [1 p. 6]; the review it cites puts the long-term change up there down mainly to rising carbon dioxide, with changes in the field acting on the ionosphere [25 Abstract]. Nothing ties a changing field to the weather. Our guide to the magnetic field gives the sizes. Over Antarctica, the slow fall in surface pressure that stations confirm is the Southern Annular Mode's shift of air to the middle latitudes, which published assessments attribute to ozone depletion and greenhouse gases, as our check of S0 News's note on polar pressure trends sets out; the note itself proposes no cause.

7 · REPEAT OUR NUMBERS

What we ran, with the rules we wrote first

The rules came first, with their hashes; the logs record what came after. Each script needs Python, and the count also needs the pdftotext program.

PY **inventory_rerun.py**

Fetches the paper's PDF and checks its hash, extracts its text with pdftotext, picks the candidate sentences by our keyword rule, checks each against our hash and applies our classification · 10 KB

CSV **inventory-classified.csv** and **inventory-missed.csv**

Our class for each of the 51 candidates, and the 11 sentences the filter missed: section, page, the sentence's hash and first words, not its text · 10 KB and 1 KB

TXT **inventory-summary.txt** and **RULES_inventory.txt**

The counts, and the rules written before the count · 4 KB and 3 KB

TXT **inventory-log.txt**

The SHA-256 of the rules, the PDF and every output, in the order they were made · 4 KB

PY **refcheck_rerun.py**

Repeats our check of the 66 references against Crossref, DataCite and the DOI handle service · 5 KB

CSV **refcheck-results.csv**, **refcheck-manual.txt**, **RULES_refcheck.txt** and **refcheck-log.txt**

Each reference's result, without the printed reference; our reading of the six flagged, and of the wrong author found since; the rules; the hashes · 9 KB, 3 KB, 1 KB and 2 KB

Run it

`python3 -I inventory_rerun.py <folder>`, with the two CSV files beside it, downloads the paper into that folder, checks it, and writes the counts and the full candidate sentences to its `out` folder. If Springer answers with a check page meant for browsers, as it did to our script on November 15, download the PDF from the paper's DOI in your browser and add `--pdf <file>`. If that copy's hash differs from ours, the script says so and goes on, since it checks each candidate sentence against our hashes.

`python3 -I refcheck_rerun.py <folder>` repeats the reference check in a few minutes.

The data and their terms

The paper: CC BY 4.0, but we host neither its PDF nor its sentences; the script fetches the one and extracts the other [1].

Reference records: Crossref's and DataCite's open metadata, which the second script fetches.

8 · LIMITS

What we couldn't check

What was said at the forum

ISSI published the forum's agenda and participant list, but no minutes [5]. We check the paper as written, not the discussions it summarizes.

A count is a classification

Whether a sentence asserts, hedges or only calls for research is our judgment. The rules came first, and every call is in our files, so it can be disputed line by line.

Abstracts and other papers

We read 13 of the studies cited here only as abstracts, as the source list marks, and several are open to read in full. The special issue has 13 other papers we didn't read [7].

Studies as the review reports them

Where this page gives what the special issue's particle review says of other studies, it relies on the review's account [3].

What the keyword filter missed

Our filter missed 11 relevant sentences, mostly on particle chemistry and on open questions. We list them apart, as the rules say, and none of them changes the picture: the one with citations is the paper's sentence on the stratosphere and the weather [1 p. 14].

Missions we didn't check

The paper names dozens of instruments and their dates [1 p. 15]. We checked those in section 5 and left the rest, none of which bears on the weather below.

What would change these verdicts

01

A surface signal that holds up. A particle effect on the surface weather that survives independent data and stricter statistics, and appears consistently in model ensembles, would move claim 1 toward True and settle the debate around claim 3.

02

Cosmic rays that matter. Evidence that cosmic rays change clouds enough to move the climate, against the IPCC's assessment [23 §7.3.4.5], would change claim 1 too.

03

A direct route that passes the tests. A link from the solar wind to the weather within days that holds up under tests suited to autocorrelated data [19 p. 1] would make claim 5's caution too strong.

Related checks

OVERSTATED Particles "left out of climate models" The Disaster Cycle, Fact-Checked

Sources

Bracketed numbers refer to this list. For the paper [1], read in full in Springer's PDF, p. gives a page of that 33-page PDF, § a section, Table its Table 1 and Abstract its abstract. For [3], [4], [19], [20] and [29], p. gives a page of the article's PDF; for [9], a page of the journal; for [16], read in its accepted manuscript, a page of that PDF; for [23], § gives a section of the IPCC chapter. Abstract marks the part of a source we rely on; a source marked "Abstract only" or "Record only" was read no further, and its wording is paraphrased here, not quoted. Numbers marked "our analysis" are ours, not the sources'. Links checked November 15, 2026.

1 Blanc, M., Taylor, M. G. G. T., Strømme, A., Floberghagen, R., Baddeley, L., Donovan, E., Doornbos, E., Grandin, M., Kauristie, K., Kepko, E. L., Milan, S., Opgenoorth, H., Partamies, N., Stockdale, T., Stolle, C., and Rast, M. (2026). Physical Links Between Weather in Space and Weather in the Lower Atmosphere. *Surveys in Geophysics*, published online October 28, 2026 (received October 23, 2025; accepted October 5, 2026); 33 pages. Peer reviewed: the journal publishes refereed reviews [7]. Eight of the authors are guest editors of the special issue the paper introduces, as it declares (p. 29). Open access, CC BY 4.0, as the paper states; its Figs. 2 and 5 carry other copyright holders' notices, and no figure of the paper is redrawn here. Read in full in Springer's PDF (SHA-256 cfb48529…415f).

2 SpaceWeatherNews (S0) (November 15, 2026). Solar Electromagnetic Earth Dance | S0 News Nov.15.2026. YouTube video, https://www.youtube.com/watch?v=gzYwpyefO5g. Linked the source; no transcript was available, so nothing it says is rated here.

3 Nesse, H., Asikainen, T., Decotte, M., Funke, B., et al. (2026). Why is Energetic Particle Precipitation Important for Climate Research and Seasonal Forecasting? *Surveys in Geophysics*, published online March 30, 2026 (received April 7, 2025; accepted February 24, 2026). Peer reviewed; in the same special issue, but not cited by [1]. CC BY-NC-ND 4.0, so it is quoted and paraphrased here, not adapted. Read in full.

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5 International Space Science Institute. Physical Links Between Weather in Space and Weather in the Lower Atmosphere, Forum, Bern, November 14–16, 2022: the forum's pages, its invitation letter of August 17, 2022, its agenda and its participant list, updated November 15, 2022. Read November 15, 2026.

6 International Space Science Institute. Physical Links Between Weather and Climate in Space and the Lower Atmosphere, Workshop, Bern, January 22–26, 2024. Read November 15, 2026.

7 Springer Nature. *Surveys in Geophysics*: Aims and scope, and the journal's page for the Special Issue: Physical links between Weather and Climate in Space and the lower Atmosphere, which lists 16 papers. Read November 15, 2026.

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20 Edvartsen, J. Ø., Maliniemi, V., Nesse, H., and Hatch, S. (2023). The Mansurov effect: Seasonal and solar wind sector structure dependence. *Journal of Space Weather and Space Climate* 13, 17. CC BY 4.0. Read in full, in a copy the site's owner downloaded because the journal's site refuses our client.

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METHOD

How this was checked

On November 15, 2026, we checked every statement, number, quotation and citation on this page against its source. We read the paper in full in Springer's PDF, and read in full two of the special issue's papers, on energetic particles [3] and on the global electric circuit [4]. Of the 30 further sources, 2 were read in full, in copies the site's owner downloaded because the journal's site refuses our client [19][20]; 5 were read in part and 13 as abstracts only; 7 are pages of ISSI, Springer, NASA, NOAA, Caltech and Space Weather Canada; and 3 are index records. DOIs were resolved through Crossref, and every quotation was checked word for word against its saved source.

The verdicts and the items tagged "Our analysis" are our own assessment, built on the cited sources. No transcript of the S0 News episode that linked the paper was available [2], so this page reviews the paper on its own and rates nothing from the episode.

We wrote the rules for our count of the paper's statements on space weather and the atmosphere below before running it, and logged the SHA-256 of the rules, the paper's PDF and every output. A hosted script repeats the count from the PDF: run on our copy, it found the same 51 candidate sentences and gave our summary byte for byte. When we tried a fresh scripted download, Springer sent a check page meant for browsers, so the script also accepts a copy downloaded in a browser. We also checked the paper's 66 references against Crossref and DataCite under rules written first; a second hosted script repeats that check, and its re-run matched the first in every row. After the page was built, a second reviewer who hadn't seen the drafting re-ran the count's script, which gave our summary byte for byte, repeated the reference check with its own code, adding one wrong author, and checked every quotation, locator and source; we applied its 1 must-fix, 11 should-fix and 17 of its 18 minor findings, and no verdict changed. We couldn't check what was said at the Forum itself, which kept no public minutes, and several sources were read only as abstracts.

This page was researched and written with Claude, an AI assistant made by Anthropic, and then re-checked against its sources in a separate verification pass.

The verdicts on this page

PARTLY TRUE	Part of the claim holds up and part doesn't.
TRUE	The evidence supports the claim.

All ten verdicts, and how we check

CORRECTIONS

Corrections and changes

If we get something wrong, we fix it and record the change below with the date. If a correction changes a verdict, the log says what the old verdict was.

Change log

Nov 15, 2026	Published on factchecked.science after a full check against the sources. Built from the paper, read in full; two of the special issue's papers, on the particle and global-circuit routes; ISSI's pages on the Forum; and our pre-registered count of the paper's statements on space weather and the atmosphere below, and our check of its reference list. The one chart is our own analysis, and no figure of the paper is redrawn.

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