The challenges of the "detection and attribution of global warming"

A group presentation for the Tom Nelson podcast

by Dr. Michael Connolly, Dr. Ronan Connolly and Dr. Willie Soon

Center for Environmental Research and Earth Sciences

(www.ceres-science.com)

September 27th, 2023

Outline of this presentation

1. Michael: The **UN panel's** approach to "**the detection and attribution of global warming**"
2. Ronan: Problems in the UN's "**detection**" approach:
   - Underestimating the extent of the urban heat island problem
   - Problems with current "temperature homogenization" approach
3. Ronan: Our **rural-only** Northern Hemisphere land temperature record
4. Ronan: Other non-urbanized temperature series (**oceans**, **tree-rings**, **glaciers**)
5. Willie: Problems with the UN's "**attribution**" approach:
   - UN's "radiative forcings" underestimate the role of natural climate change
6. Willie: Trying to better answer how solar activity has changed since 1850
   - Different aspects of solar activity
   - Changes in solar activity during satellite era
   - Using solar proxies to reconstruct solar activity in the past
7. Willie: 27 different estimates of solar activity changes since 1850
8. Michael: Our **latest** detection and attribution results
9. Michael: Conclusions

The UN Intergovernmental Panel on Climate Change (IPCC)

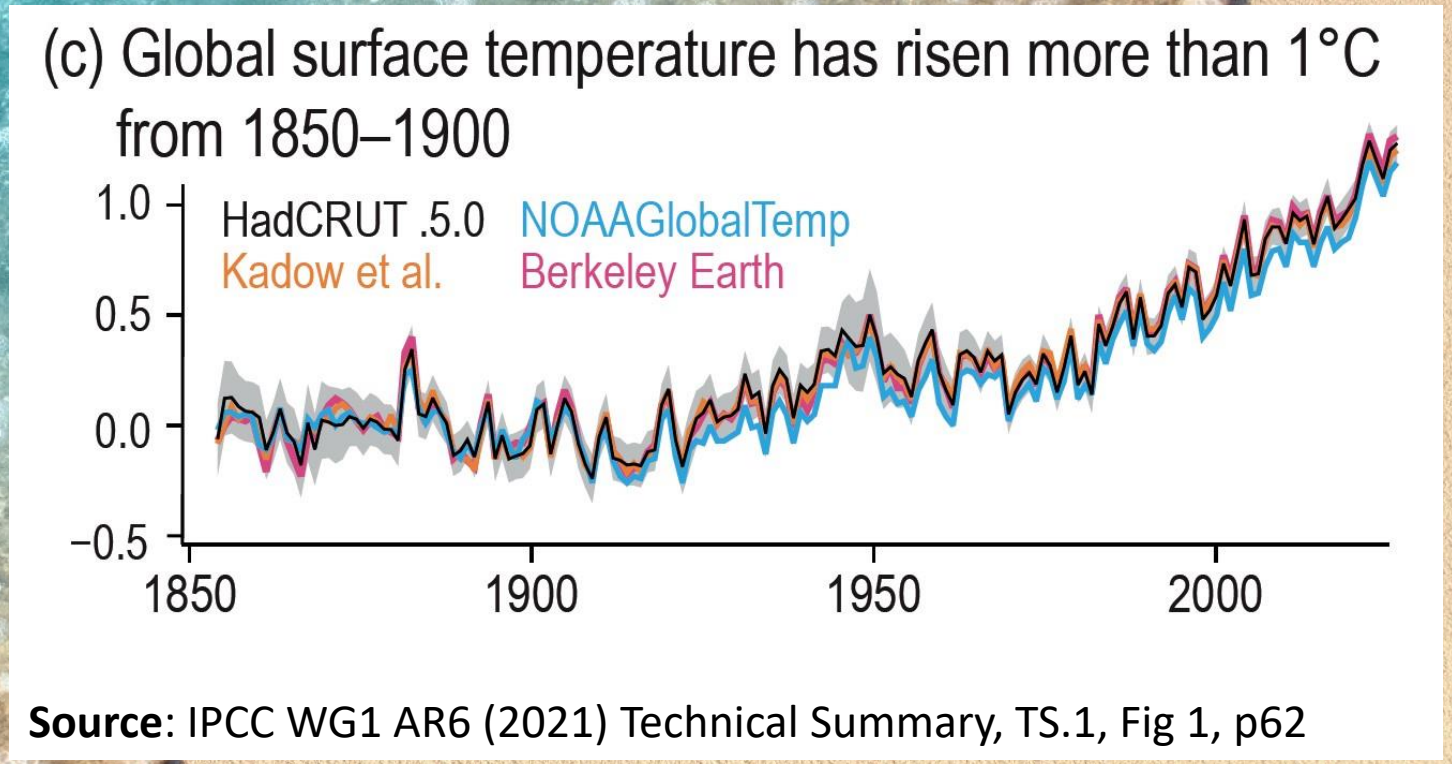
- "Created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), the objective of the IPCC is to provide governments at all levels **with scientific information that they can use to develop climate policies**." - https://www.ipcc.ch/about/

- They have so far published 6 Assessment Reports (AR for short):
  - AR1 (1990); AR2 (1995); AR3 (2001); AR4 (2007); AR5 (2013); AR6 (2021)

- **Most iconic statement**: *The observed global warming since **at least** 1950s is mostly human-caused and also unprecedented*.

- How did they reach this conclusion? And is it scientifically justified?

The IPCC's approach: Detection

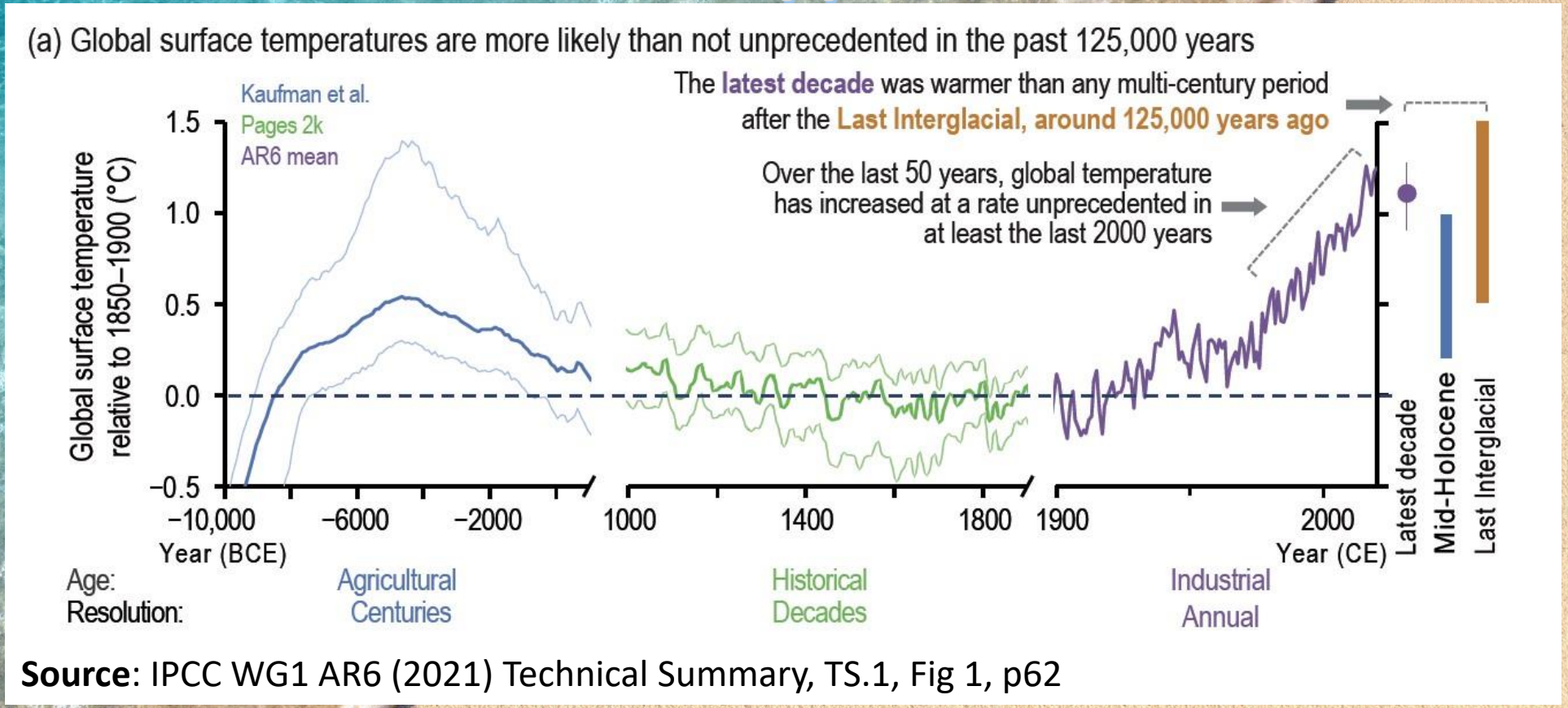


Source: IPCC WG1 AR6 (2021) Technical Summary, TS.1, Fig 1, p62

IPCC's "Detection" of global warming

- IPCC compiled several "**global surface temperature anomaly**" time series (1850-2020)
- All of them show an almost continuous "global warming" of 1°C since the 19th century

The IPCC's approach: Detection



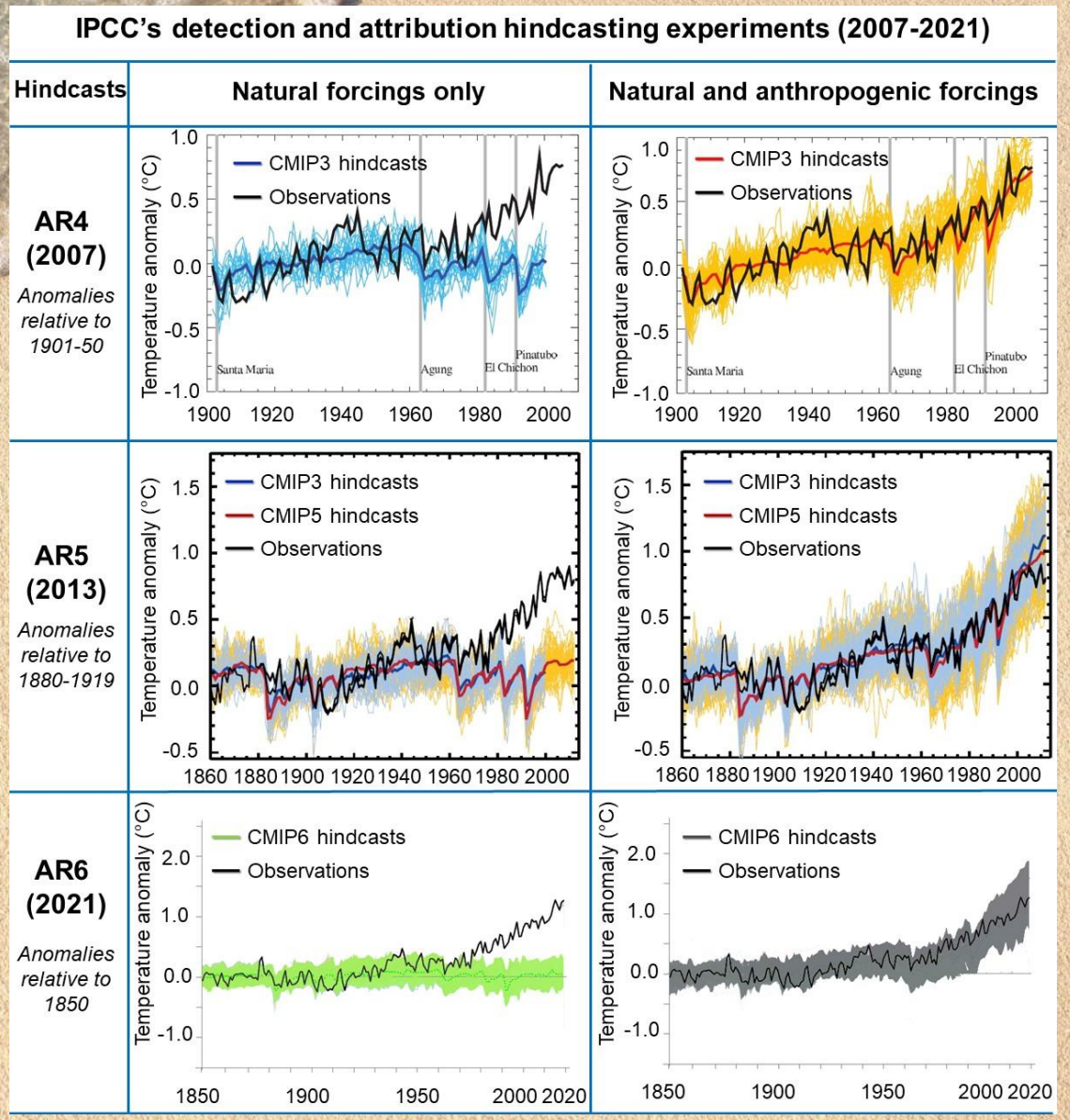
Source: IPCC WG1 AR6 (2021) Technical Summary, TS.1, Fig 1, p62

IPCC's "Detection" of global warming

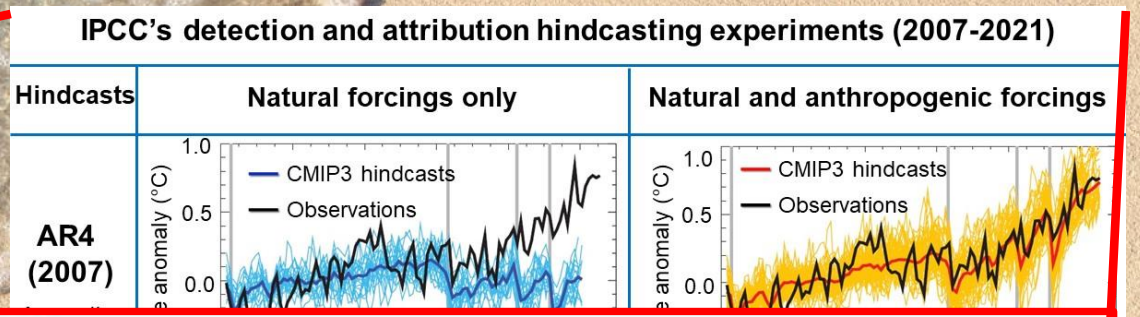
- They compared the **instrumental-based** global temperature estimates (1850-2020) with **temperature proxy-based** estimates (PAGES2k proxy dataset)
- They conclude recent warming is "unprecedented" in at least 2000 years

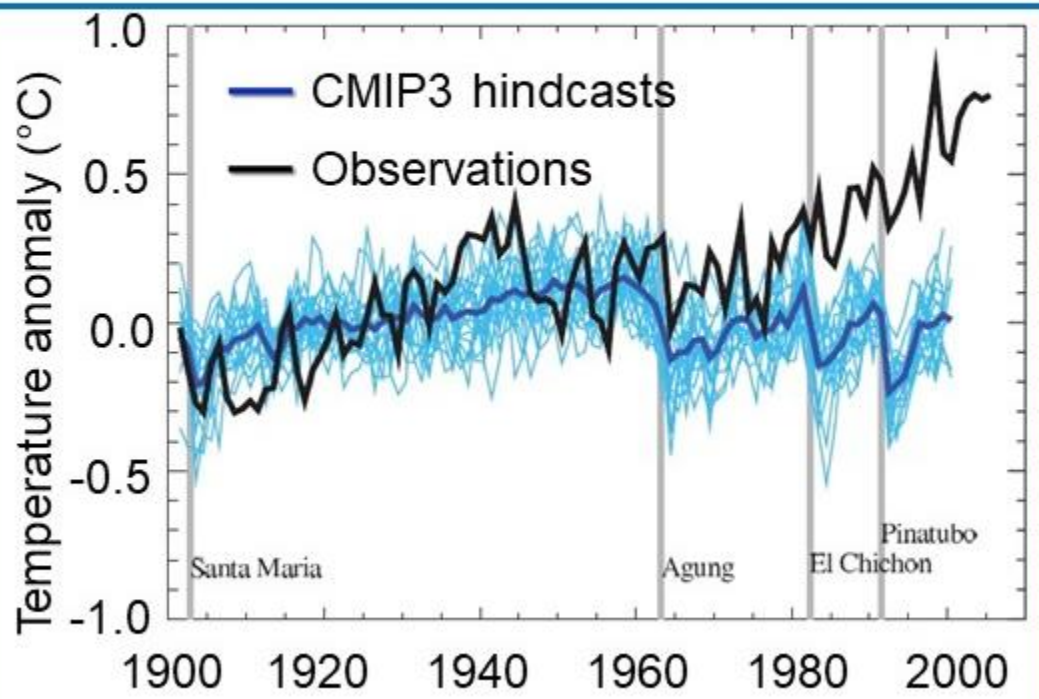
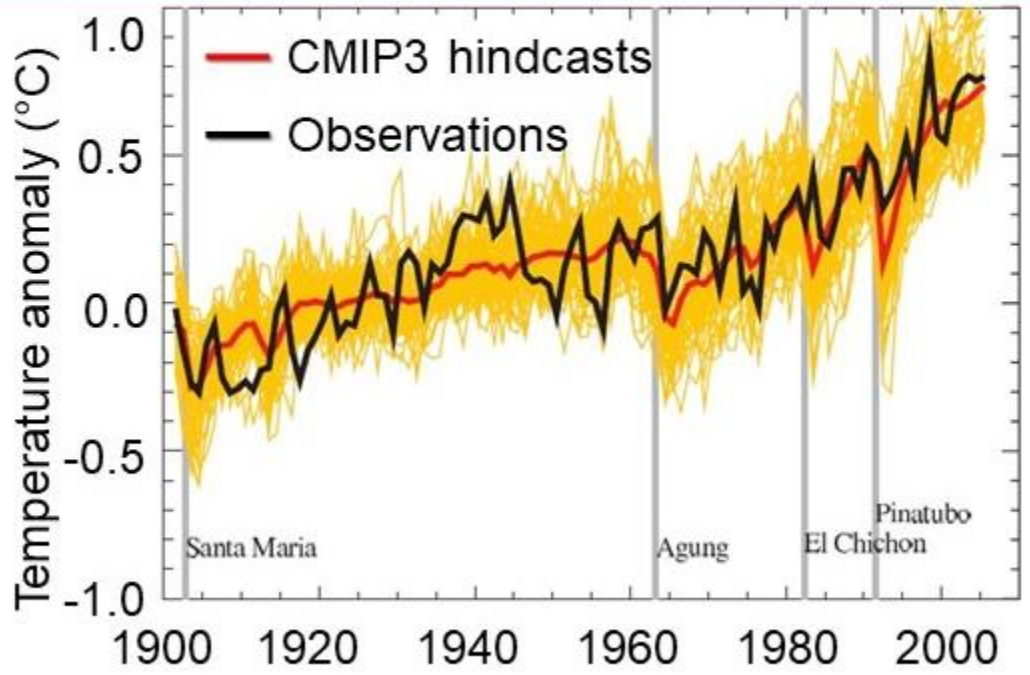
The IPCC's approach: Attribution

- The IPCC's "attribution" statements are based on comparing the "observed" temperature record to computer model "**hindcasts**".
- A computer model "hindcast" is the opposite of a "forecast" – what the model says **should** have happened in the past.
- When the hindcasts use only natural factors (sun & volcanoes), they can't explain the warming after 1950. But, when they add in anthropogenic ("human-caused") factors, they can.
- Their conclusion: "it's mostly human-caused"!



The IPCC's approach: Attribution



Hindcasts	Natural forcings only	Natural and anthropogenic forcings
AR4 (2007) *Anomalies relative to 1901-50*		

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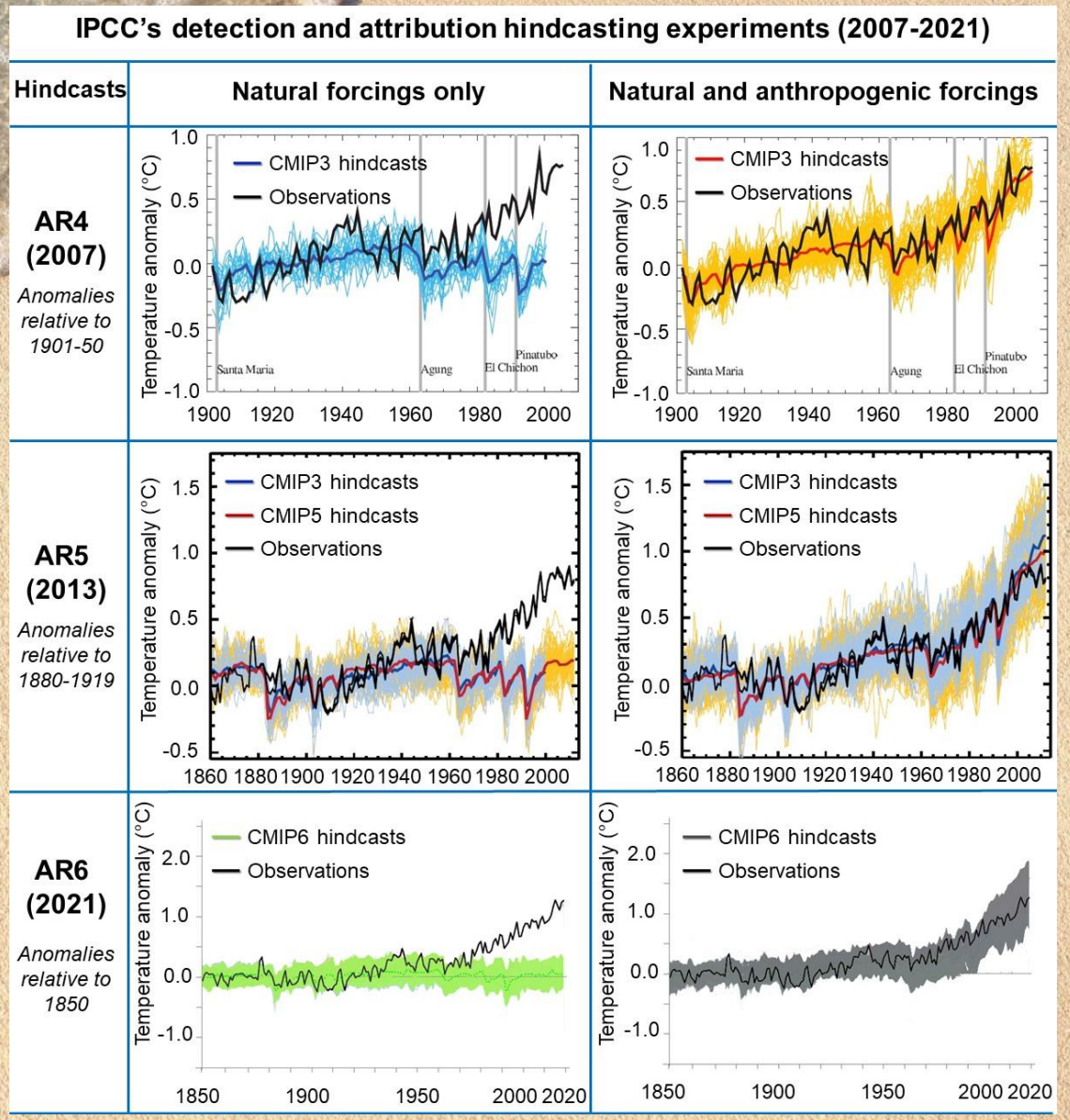


Is the IPCC's analysis scientifically justified?

- We have published a number of papers since AR5 highlighting at least two major problems with their "detection and attribution" modelling experiments:

  1. The land component of their global temperature record ("observations") is contaminated by "**urbanization bias**" due to the "**urban heat island**" (**UHI** for short) effect.

  2. Their estimates for the changes in solar activity ("**Total Solar Irradiance**" or **TSI** for short) are **only a small subset** of those used by the scientific community. And, this subset coincidentally only comprises "**low variability**" reconstructions that imply a negligible solar contribution.

Our relevant papers on the challenges of the detection and attribution of global warming

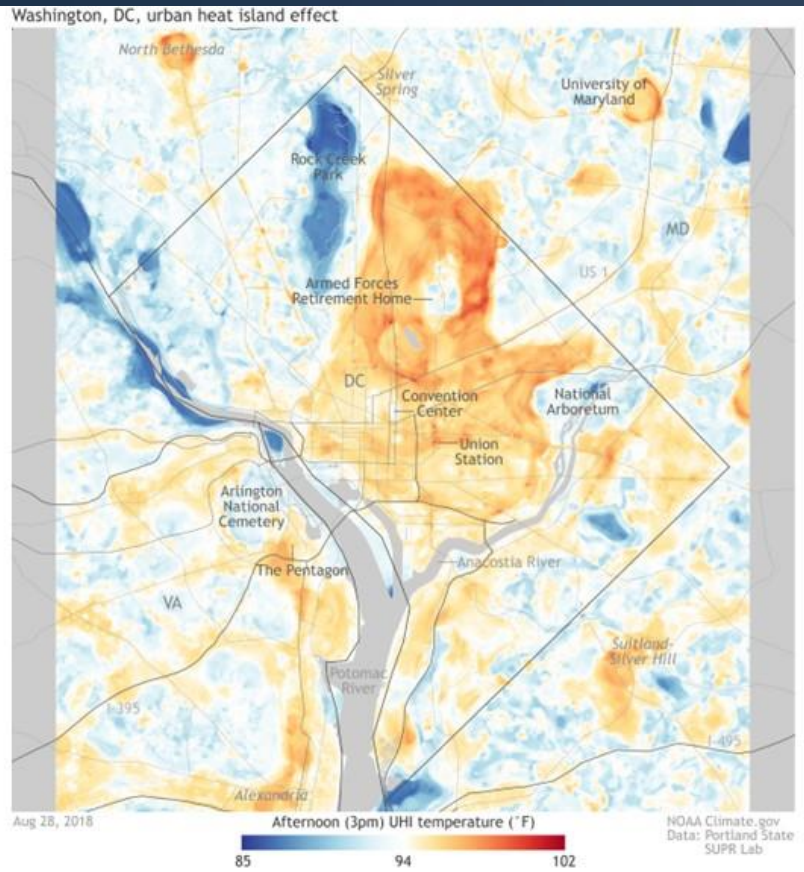
1. **S2015**: Soon, Connolly & Connolly (**2015**). *Earth-Science Reviews*, 150, 409-452. https://doi.org/10.1016/j.earscirev.2015.08.010.
2. **C2017**: Connolly, Connolly & Soon (**2017**). *Hydrological Sciences Journal*, 62, 1317-1340. https://doi.org/10.1080/02626667.2017.1324974.
3. **S2018**: Soon and 7 co-authors (**2018**). *Earth-Science Reviews*, 185, 80-101. https://doi.org/10.1016/j.earscirev.2018.05.013.
4. **S2019**: Soon and 7 co-authors (**2019**). *Earth-Science Reviews*, 189, 102950. https://doi.org/10.1016/j.earscirev.2019.102950.
5. **C2020**: Connolly and 3 co-authors (**2020**). *Energies*, 13, 1365. https://doi.org/10.3390/en13061365.
6. **C2021**: Connolly and 22 co-authors (**2021**). *Research in Astronomy and Astrophysics*, 21, 131. https://doi.org/10.1088/1674-4527/21/6/131.
7. **O'N2022**: O'Neill and 16 co-authors (**2022**). *Atmosphere*, 13(2), 285. https://doi.org/10.3390/atmos13020285.
8. **K2023**: Katata, Connolly & O'Neill (**2023**). *Journal of Applied Meteorology and Climatology*. 62(8), 1095-1114. https://doi.org/10.1175/JAMC-D-22-0122.1.
9. **C2023**: Connolly and 19 co-authors (**2023**). *Research in Astronomy and Astrophysics*. https://doi.org/10.1088/1674-4527/acf18e.
10. **S2023**: Soon and 36 co-authors (**2023**). *Climate*, 11(9), 179; https://doi.org/10.3390/cli11090179.

The IPCC's detection process

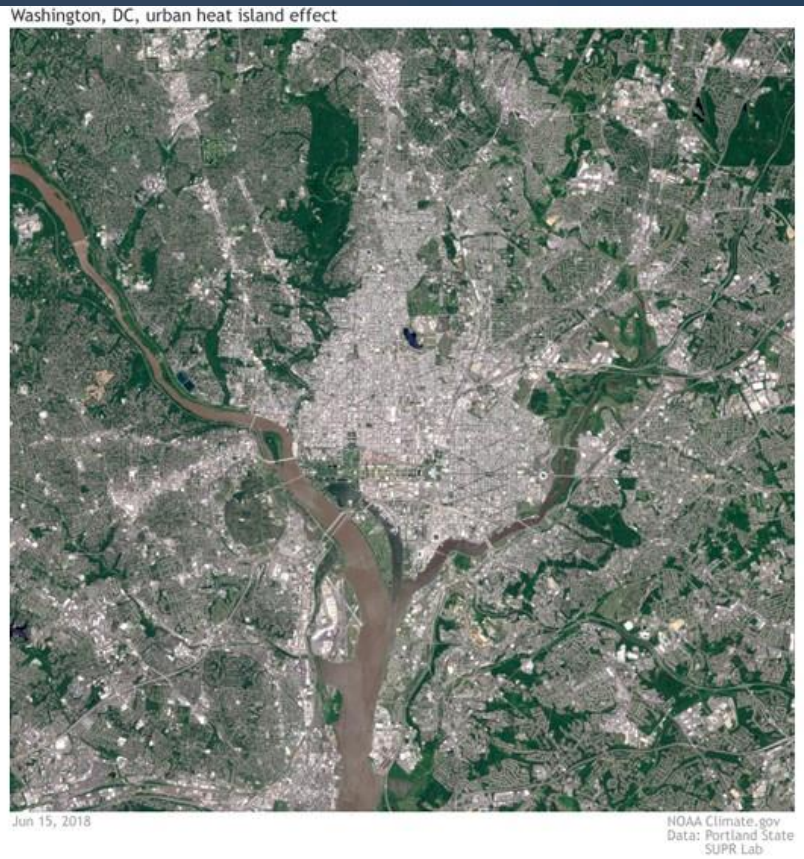
- The IPCC's global temperature estimates from 1850-present comprise two components:
  1. Land Surface Temperatures (LST) based on weather station thermometer records
  2. Sea Surface Temperatures (SST) based on ship-based samplings of ocean temperatures and more recently (since 1980s), thermometers on buoys

- The IPCC's claims that the recent warming is "unprecedented" in thousands of years are based on combining these instrumental temperature measurements with "temperature proxies", e.g., tree-ring widths, ice cores, lake sediments, glacier changes.

The Urban Heat Island (UHI) effect



Urban heat map, August 28, 2018



Satellite image, June 15, 2018

Urban areas are known to be hotter than the surrounding countryside. The maps here illustrate an example – Washington D.C., USA. The hottest areas (red) correspond to high-density urban areas. The cold areas (blue) on the heat map correspond to green parkland and waterway areas within the city.

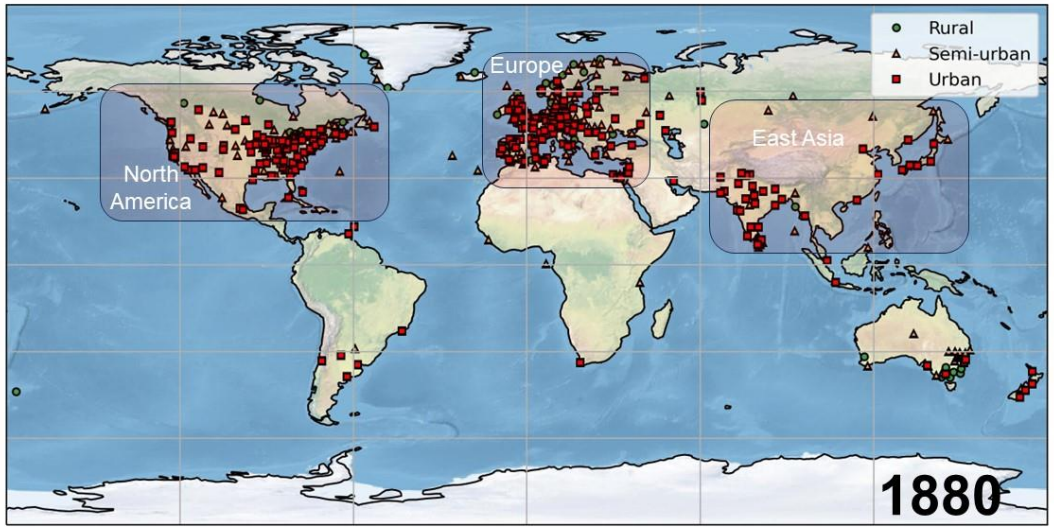
Urban climate change

- The urban heat island (UHI) has been known since 1800s
- Cities are getting bigger and UHIs are also getting bigger
- Urban areas still only make up 3-4% of the land and less than 2% of planet
- But, more than 75% of weather stations are in areas that are now urbanized
- Since 2011, more than half of the world's population live in urban areas. This means **for most people** the biggest local climate change they experience is urban warming

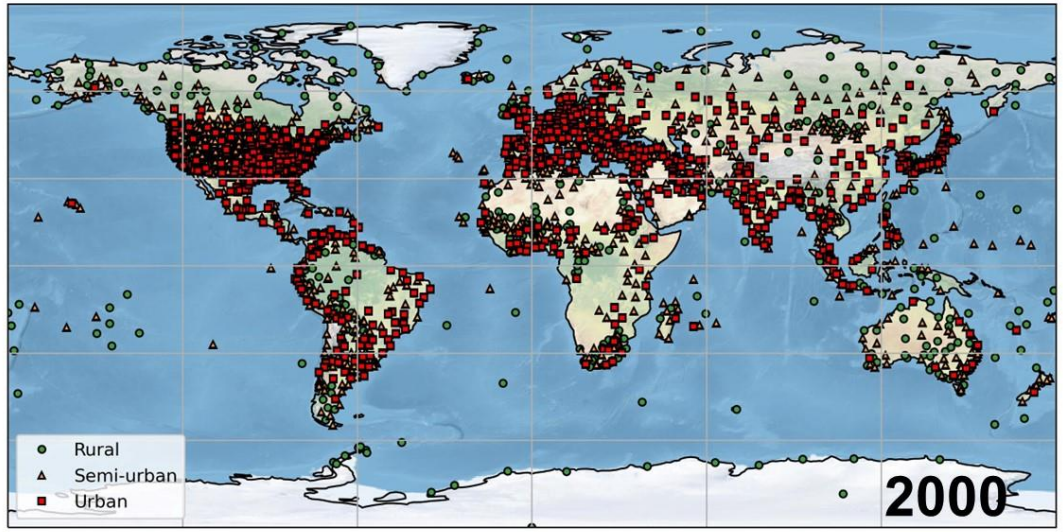
Not enough rural data globally?

- For late 19th century, most of the weather stations are in North America and Europe with some East Asian stations (mostly urbanized) – **not** "global", but "**Northern Hemisphere**"
- More than 75% of the weather stations have become urbanized
- For the longest and most complete station records that reach back to the early 20th century or earlier, it's more like 80-90% of the stations

Distribution of rural, semi-urban and urban stations available in **1880**
Global Historical Climatology Network (GHCN), version 3



Distribution of rural, semi-urban and urban stations available in **2000**
Global Historical Climatology Network (GHCN), version 3



Automatic Climate Station, Clonmacnoise (Ireland)
Visited: 2nd Aug 2021

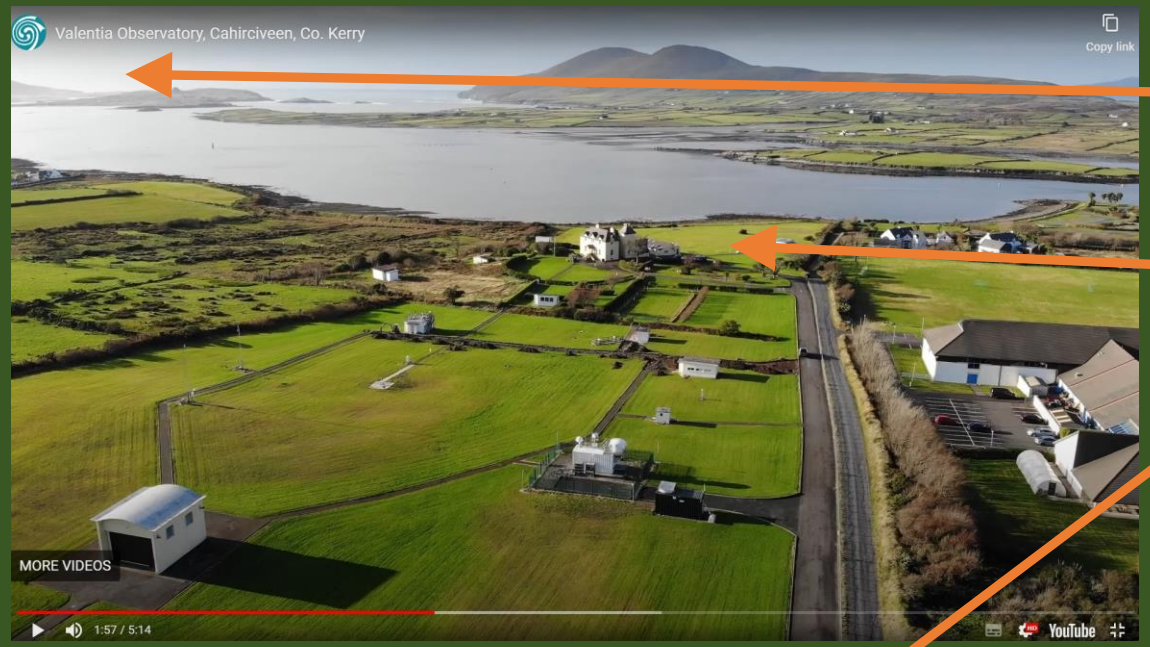
Automatic Weather Station (*GHCN v3, RA*)
Valentia Observatory (Ireland)
Visited: 14th Jan 2015

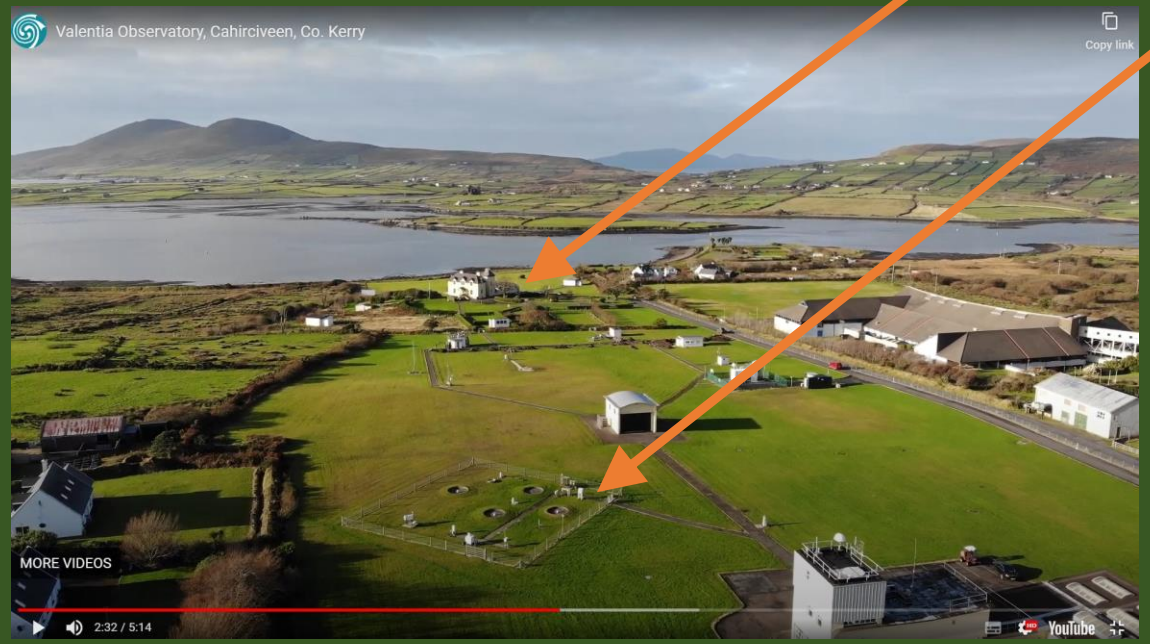
(*GHCN v3, SA*)
Tromsø (Norway)
Visited: 24th Mar 2022

Rural stations also have problems

- Even with rural stations, there can be non-climatic biases in the records, e.g.
  - Changes in instrumentation and observation practice over the years
  - Changes in local "microclimate" (nearby buildings, concrete, trees)
  - Station moves – often weather stations are moved after a few decades

A rare long, rural record: Valentia Observatory, Ireland





1867-1892: Located on Valentia Island

1892-2001: Located near ocean

2001-present: Current location.
Automatic weather station since 2012

Station history metadata (key changes)

- 1892. Station move. Valentia Island to the mainland
- 1937. Change in government. Republic of Ireland formed. But staff and observations remained the same.
- 2001. Station move 350 m inland (~20 m higher)
- 2012. Instrumentation change. Manual weather station to automatic

Correcting the raw Valentia Observatory record

Earth-Science Reviews 150 (2015) 409–452

Re-evaluating the role of solar variability on Northern Hemisphere temperature trends since the 19th century

Willie Soon [a,*], Ronan Connolly [b], Michael Connolly [b]

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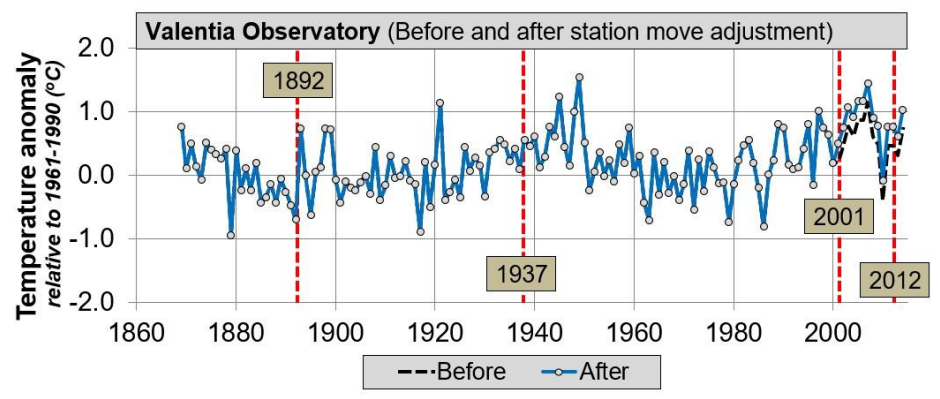
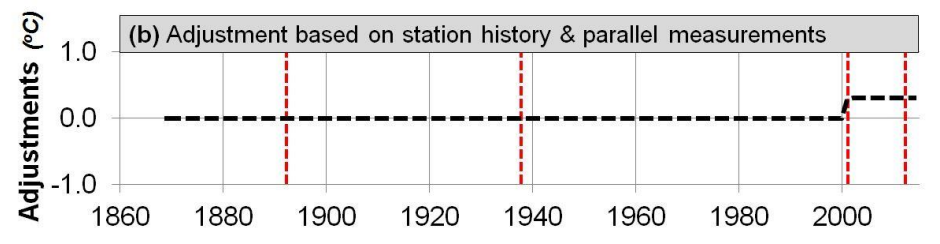
[b] Independent research scientists, Dublin, Ireland





Soon et al. 2015: Corrections for non-climatic biases

- **1892**. Station move. Valentia Island to the mainland. Possible bias, but unclear what magnitude or sign. **No adjustments applied**.
- **1937**. Change in government. Republic of Ireland formed. But staff and observations remained the same. **No adjustments necessary**
- **2001**. Station move. 350 m. Parallel measurements reveal the new location was 0.3 °C colder. **+0.3 °C adjustment applied**.
- **2012**. Instrumentation change. Parallel measurements show bias was less than 0.1 °C. **No adjustments necessary**

The standard approach: “temperature homogenization”

- Other groups **don’t** take our approach of combining known station history metadata & information to develop empirical corrections.
- Instead, they mostly rely on automated computer programs that use statistical algorithms to try and identify and remove “non-climatic biases”.
- NOAA’s Menne & Williams (2009) “PHA” is one of main ones
- Compares each station record to neighboring stations & applies adjustments – usually run without using station history metadata

Homogenization of Temperature Series via Pairwise Comparisons

MATTHEW J. MENNE AND CLAUDE N. WILLIAMS JR.
NOAA/National Climatic Data Center, Asheville, North Carolina

(Manuscript received 2 October 2007, in final form 2 September 2008)

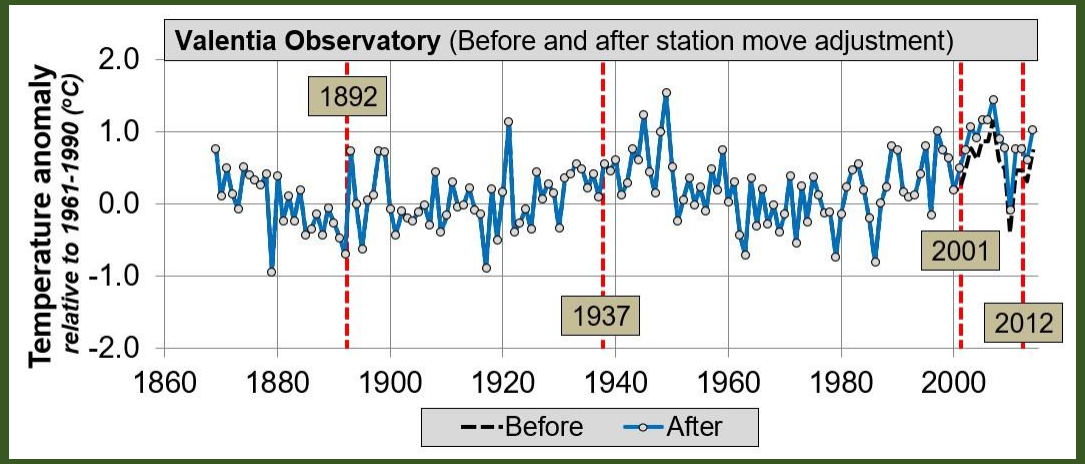
ABSTRACT

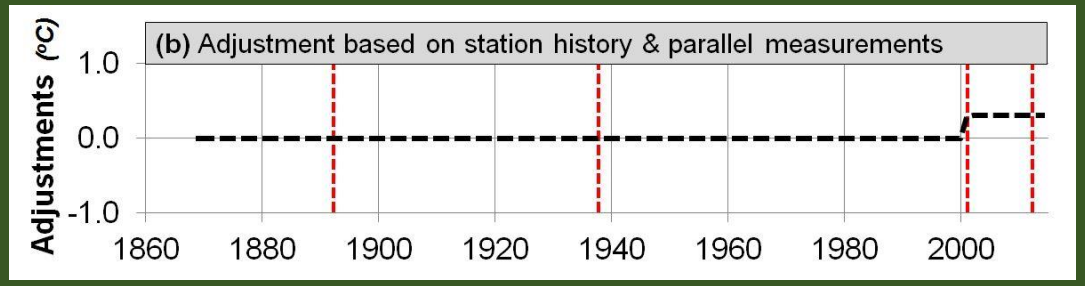
An automated homogenization algorithm based on the pairwise comparison of monthly temperature series is described. The algorithm works by forming pairwise difference series between serial monthly temperature values from a network of observing stations. Each difference series is then evaluated for undocumented shifts, and the station series responsible for such breaks is identified automatically. The algorithm also makes use of station history information, when available, to improve the identification of artificial shifts in temperature data. In addition, an evaluation is carried out to distinguish trend inhomogeneities from abrupt shifts. When the magnitude of an apparent shift attributed to a particular station can be reliably estimated, an adjustment is made for the target series. The pairwise algorithm is shown to be robust and efficient at detecting undocumented step changes under a variety of simulated scenarios with step- and trend-type inhomogeneities. Moreover, the approach is shown to yield a lower false-alarm rate for undocumented changepoint detection relative to the more common use of a reference series. Results from the algorithm are used to assess evidence for trend inhomogeneities in U.S. monthly temperature data.

How well does statistical homogenization work?

Soon et al. 2015:

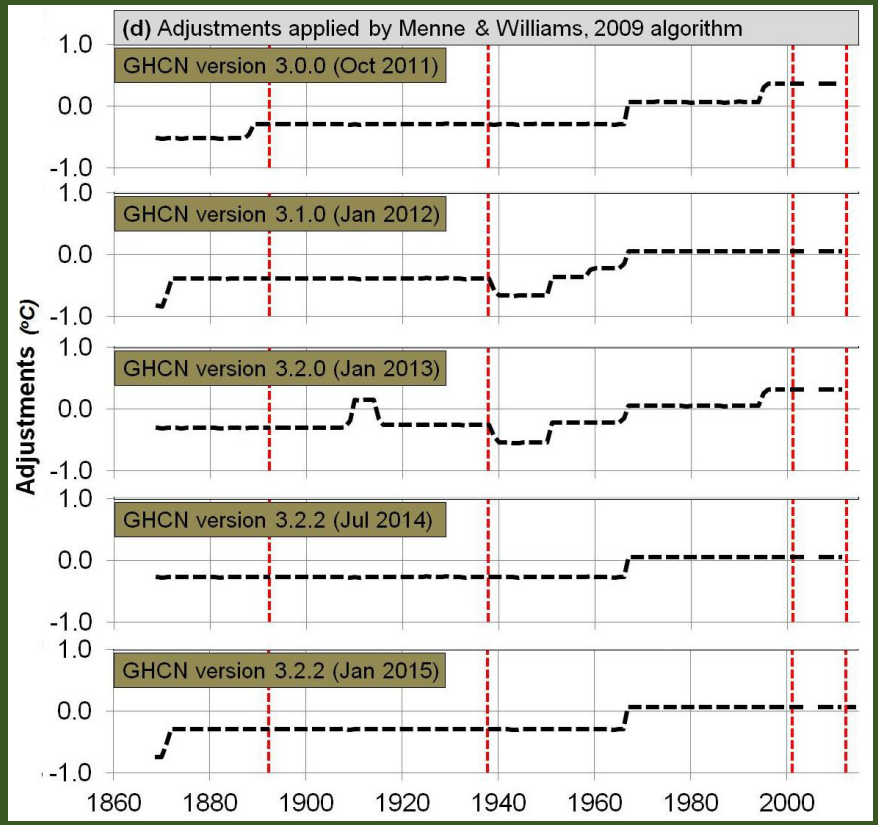
Our empirically-based corrections for non-climatic biases using station histories

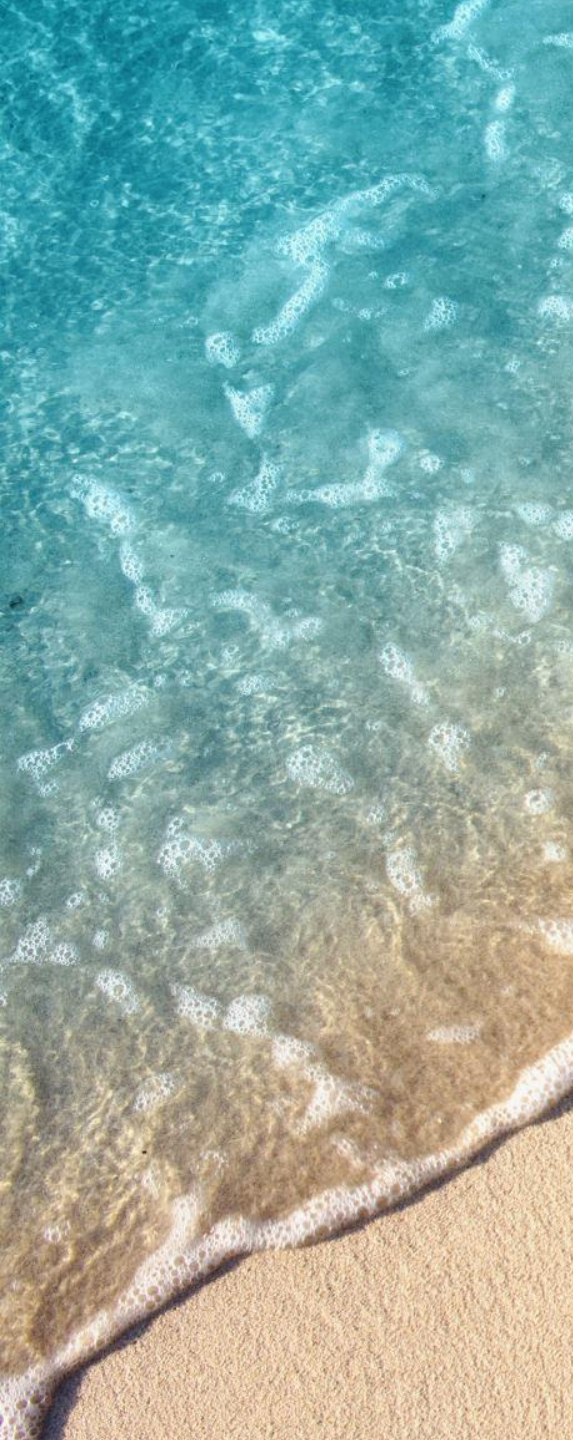




NOAA's statistical homogenization adjustments

- Every time they run the program, NOAA changes their mind!
- None of their adjustments matched with reality!





atmosphere

MDPI

Article

Evaluation of the Homogenization Adjustments Applied to European Temperature Records in the Global Historical Climatology Network Dataset

Peter O'Neill [1], Ronan Connolly [2,3,*], Michael Connolly [3], Willie Soon [2,4], Barbara Chimani [5], Marcel Crok [6], Rob de Vos [7], Hermann Harde [8], Peter Kajaba [9], Peter Nojarov [10], Rajmund Przybylak [11,12], Dubravka Rasol [13], Oleg Skrynyk [14,15], Olesya Skrynyk [14,16], Petr Štěpánek [17,18], Agnieszka Wypych [19,20] and Pavel Zahradníček [17,18]

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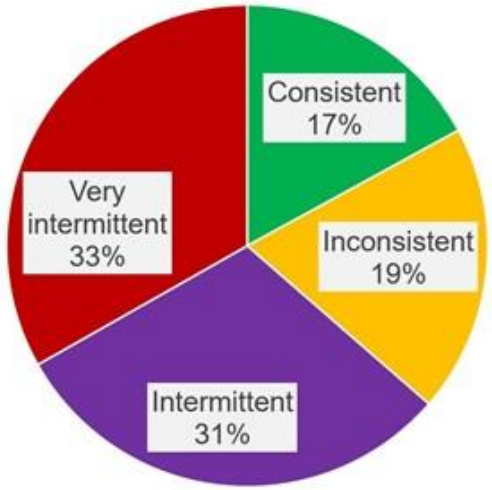
European Thermometers Project at CERES-science.com

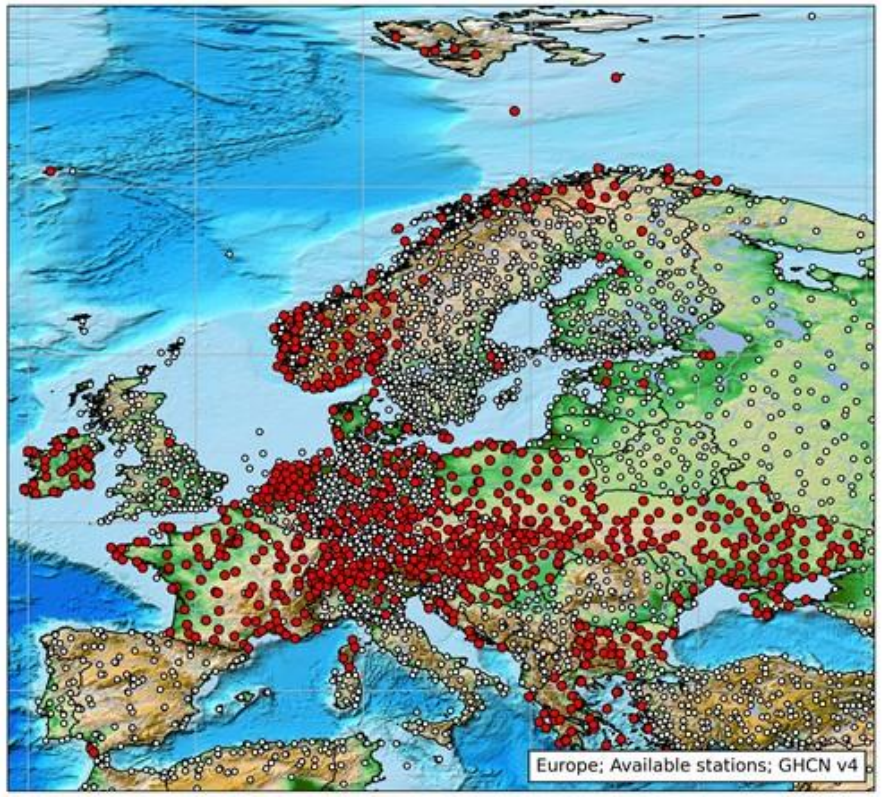
Summary of the new study on NOAA's temperature adjustments

Consistency of NOAA's adjustments for each station

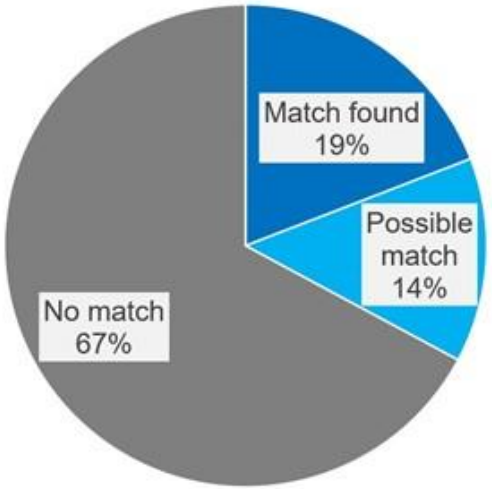


Only 17% of NOAA's adjustments are applied consistently

Details on the histories of more than 800 weather stations from 24 European countries were collected to check if the adjustments corresponded to documented changes associated with the weather station. The locations of these stations are indicated below in red.



How often do NOAA's adjustments match to known documented station events?



Less than 20% of NOAA's adjustments were clearly associated with a documented change to the weather station observations

A second problem: “urban blending”

Evidence of Urban Blending in Homogenized Temperature Records in Japan and in the United States: Implications for the Reliability of Global Land Surface Air Temperature Data

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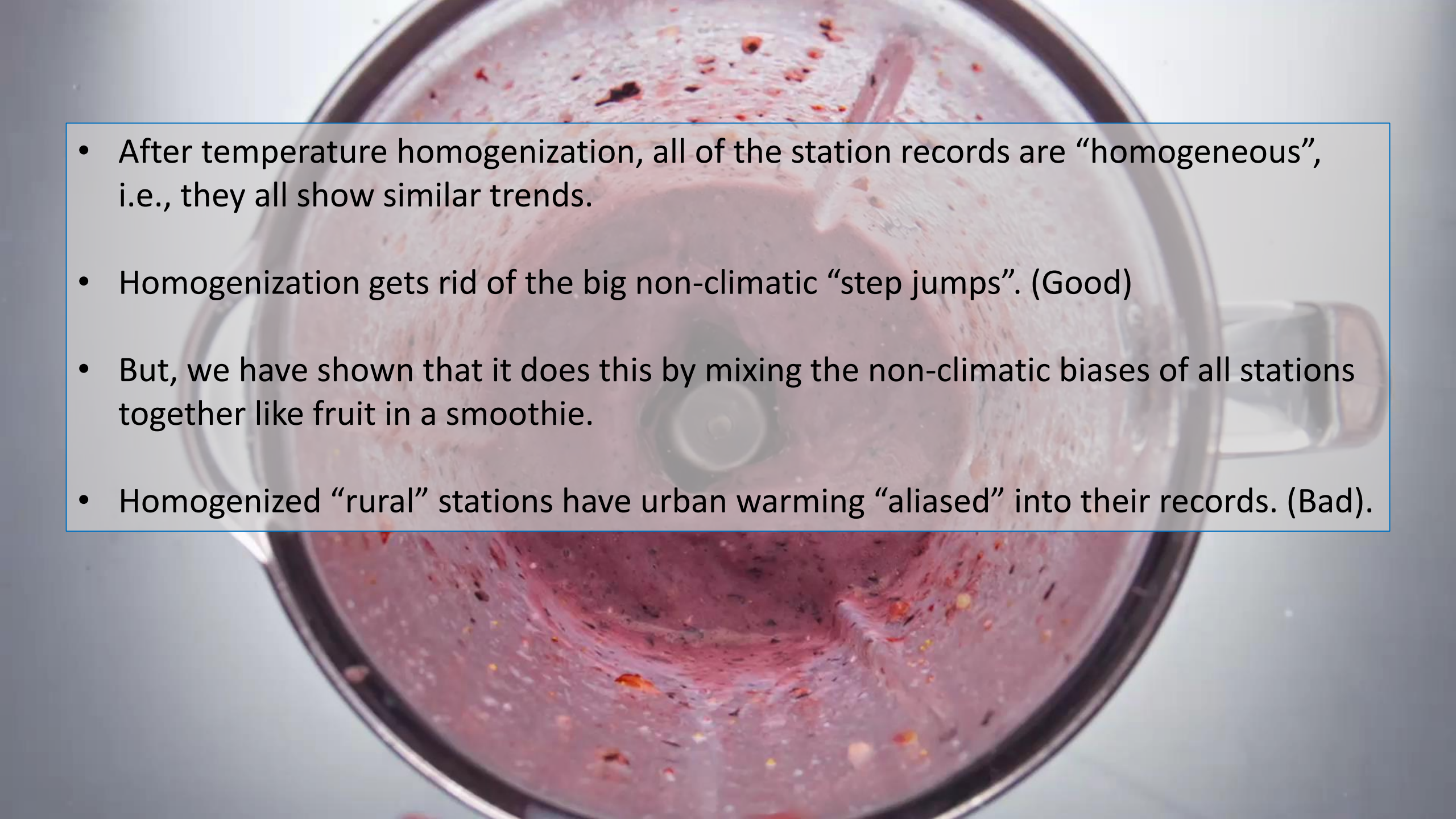
[d] *School of Mechanical and Materials Engineering, University College Dublin, Dublin, Ireland*

(Manuscript received 30 July 2022, in final form 4 June 2023, accepted 3 July 2023)

- When the standard temperature homogenization algorithms are calculating the size of a non-climatic bias, they use the differences between the temperature records of the neighbors before and after the non-climatic change

- But, if the neighbors are affected by urbanization bias, then the “homogenization adjustment” will add urban warming to rural station records!



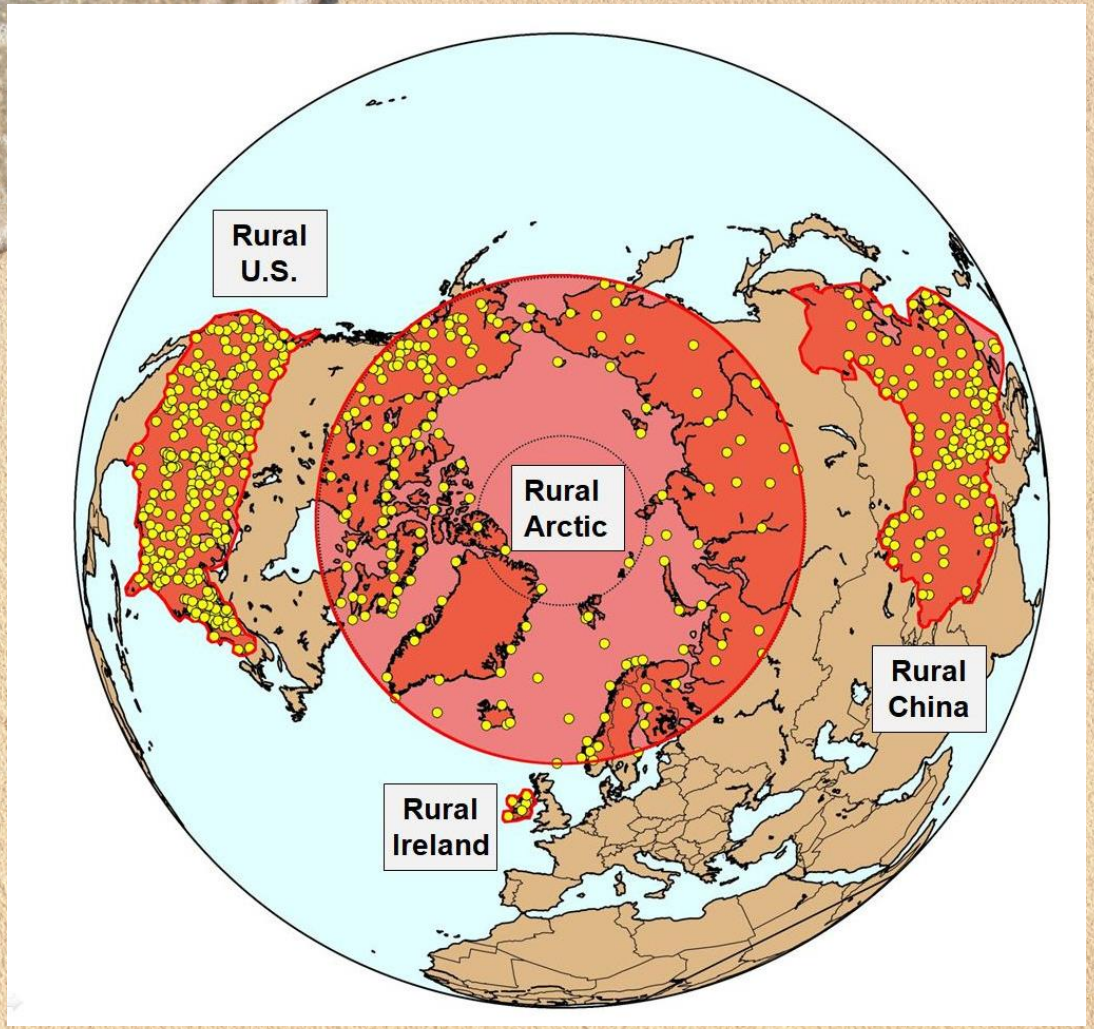
- After temperature homogenization, all of the station records are “homogeneous”, i.e., they all show similar trends.
- Homogenization gets rid of the big non-climatic “step jumps”. (Good)
- But, we have shown that it does this by mixing the non-climatic biases of all stations together like fruit in a smoothie.
- Homogenized “rural” stations have urban warming “aliased” into their records. (Bad).

Our future efforts

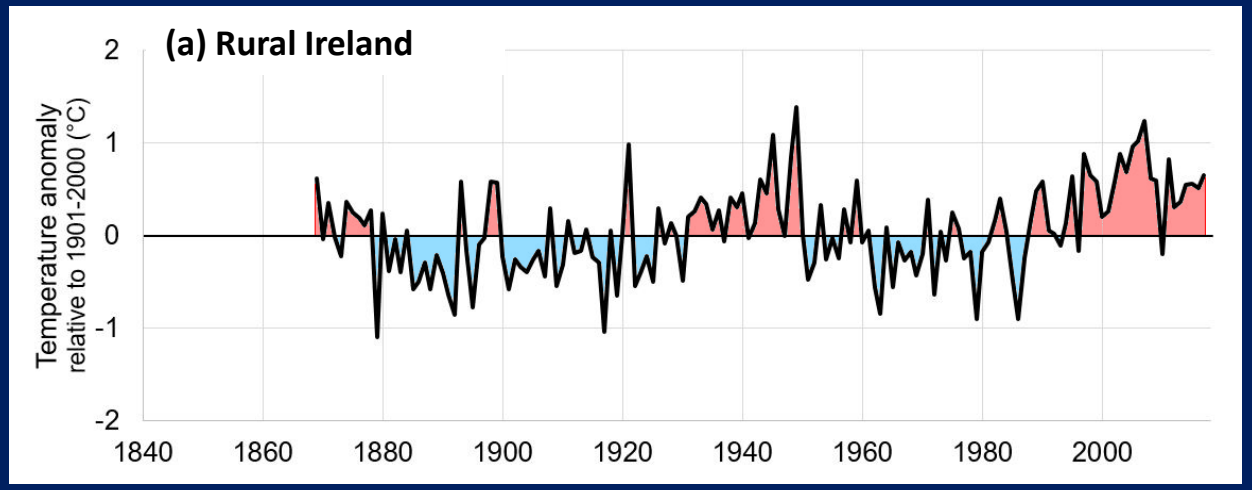
- With S2018, O'N2022 and K2023 published, we are **now** in a position to begin compiling more robust and comprehensive rural and urban temperature records.
- S2018: We developed new approaches for ranking stations from most urban to most rural – already tested on China.
- O'N2022: (a) We compiled station history metadata for 800 European stations. (b) Demonstrated that NOAA's current homogenization approach is unreliable
- K2023: (a) Expanded our urban ranking system to Japan and USA. (b) Demonstrated that all current homogenization approaches lead to "urban blending". (c) Two work-arounds proposed.
- In future, we plan on applying these new insights to NOAA's GHCN version 4 dataset

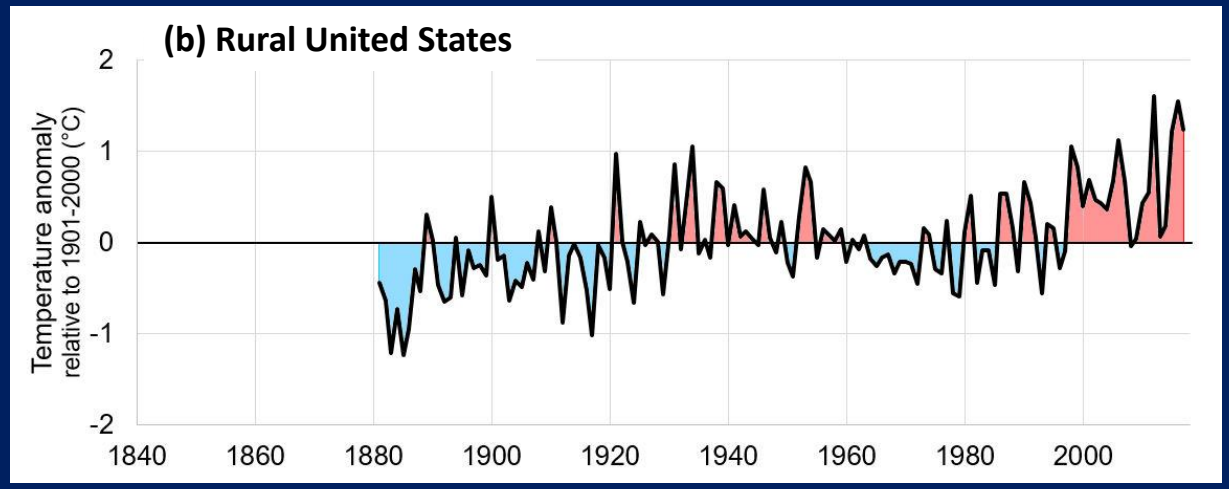
Our current rural-only Northern Hemisphere record

- In the meantime, in S2015 and C2021, we developed a rural-only temperature record using version 3 of NOAA's GHCN temperature dataset (1850-2018)
- Only uses 10-15% of the available temperature records, and confined to four geographical regions (all in N. Hemisphere)
- However, these regions account for more than 90% of the rural records that cover long enough to reach back to 19th century
- All four regions are geographically isolated from each other and cover tropics to poles



S2015 and C2021: Rural Northern Hemisphere time series – 4 regions

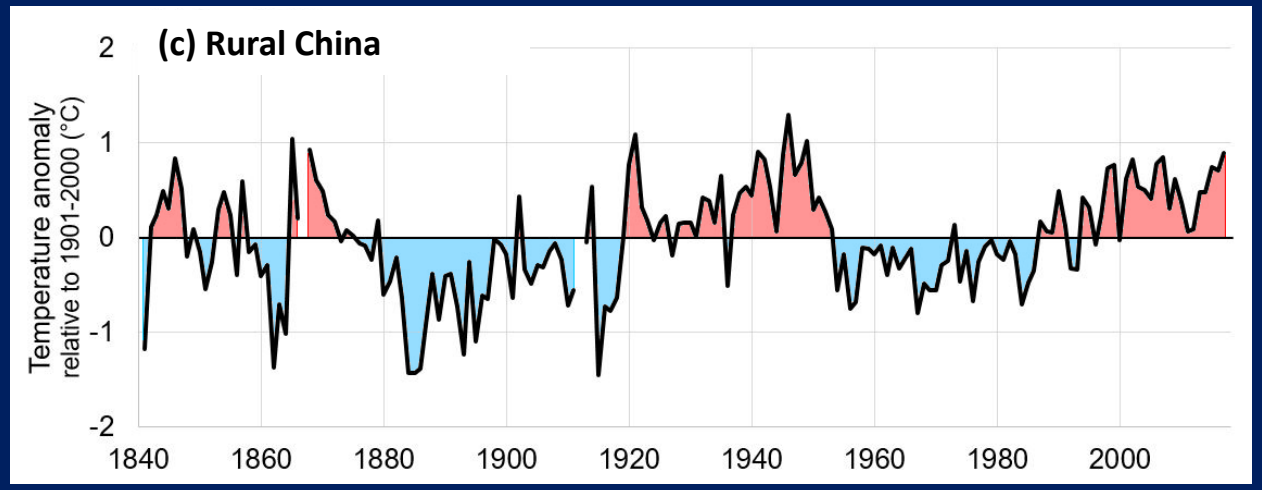


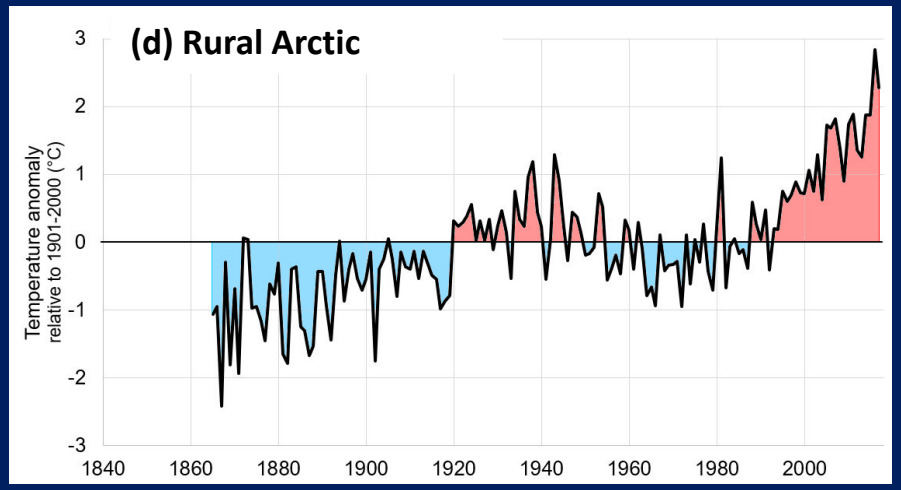


- All five rural Ireland stations after applying the corrections for Valentia Observatory
- A small geographic area. But, a lot of careful work to correct for non-climatic biases
- We called for similar work for the rest of Europe. This is ongoing work.

- US has a lot of rural data – only used fully rural stations (~25% of records)
- Used version corrected by NOAA for changes in Time of Observations
- Applied empirical correction to account for siting biases based on Watts et al.'s Surfacestations project (2011 version)

Soon et al. 2015; Connolly et al. 2021 – Rural Northern Hemisphere time series – 4 regions



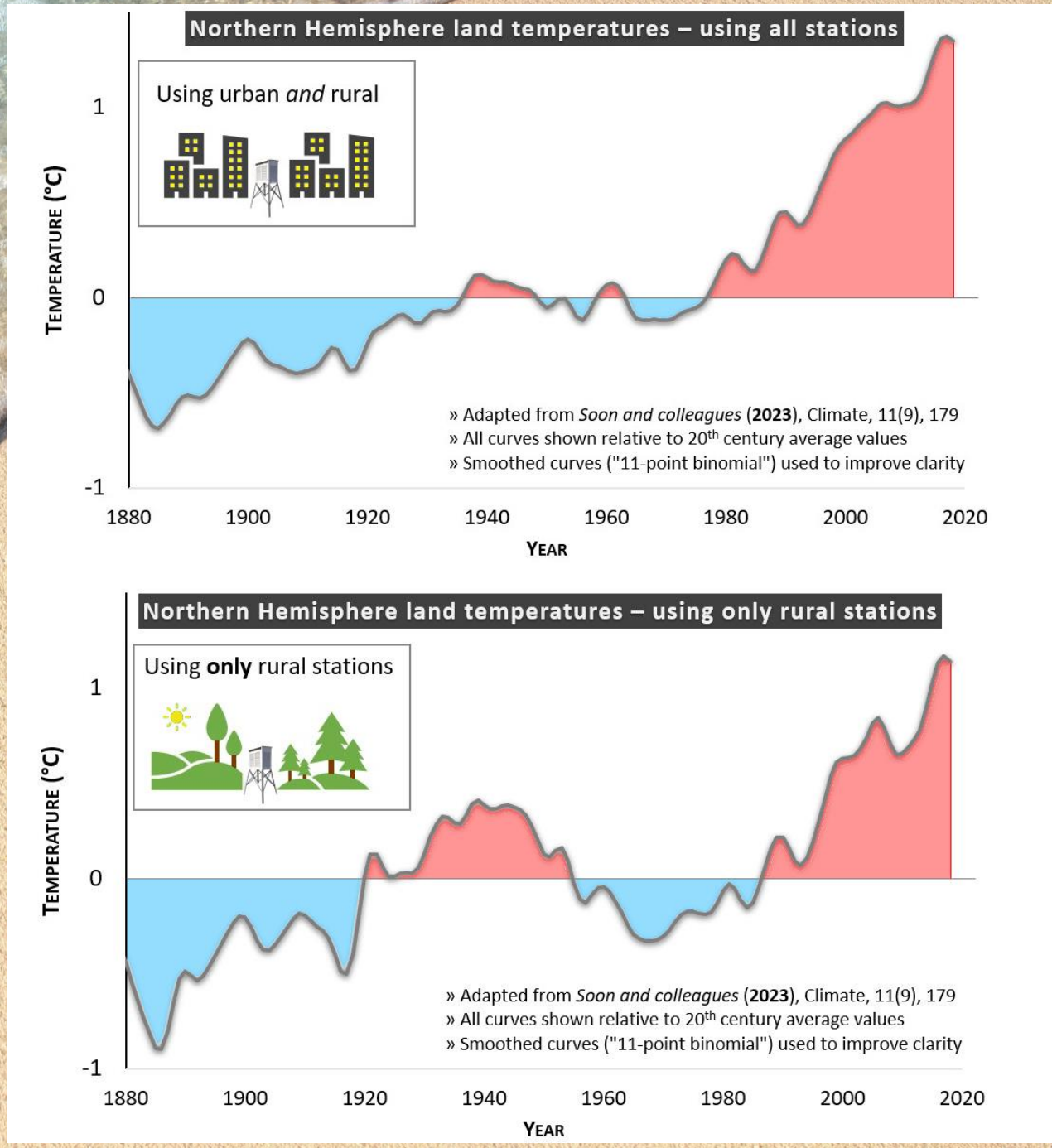


- China has some rural data for 1950-present, but very limited pre-Mao
- Whenever not enough rural data, used the longer urban records, but applied adjustments to match the rural records during overlap period

- All rural stations north of 60°N
- Probably our weakest region. Despite months of research and attempted collaboration with Arctic researchers, nobody at the time (2015-2019) seemed to have relevant station history metadata.
- So, we simply excluded any urban stations

How does our rural record compare to IPCC's?

- Our rural-only record is "noisier" because only uses 10-15% of the data of the standard "urban & rural" records
- Shows roughly same timings for warming/cooling/warming periods
- Except early warming to 1940s and cooling to 1970s is more pronounced
- Long-term warming (0.6°C per century) is **much less** than the "urban and rural" estimates (0.9°C per century)



Are there other climate change indicators?

- The weather station-based land component actually is the best data – **direct** temperature measurements taken daily from the **same physical location** (between station moves) for centuries or longer. [Direct ✓ + Fixed spot ✓ + long records ✓]

- Sea surface temperature (SST) and marine air temperature (MAT) measurements are direct measurements, but different locations and measurement methods (until fixed buoys began deployment in 1980s-1990s)
  [Direct ✓ + long records ✓, but inconsistent measurements ✗]

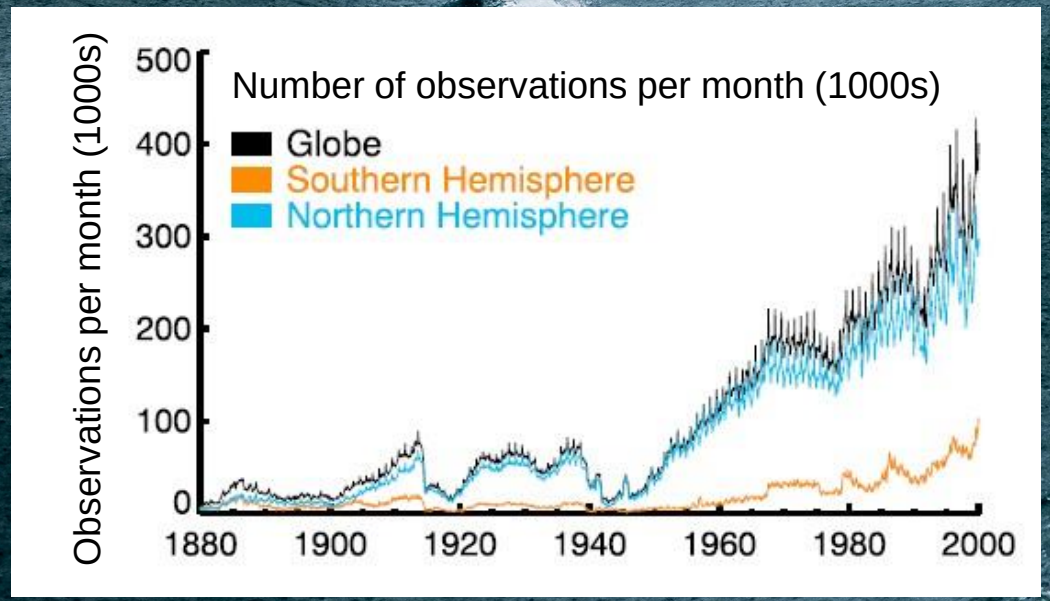
- Temperature proxies (tree-ring widths, lake sediments, etc.) are **indirect** estimates of temperatures that are also affected by other factors.
  [Fixed spot ✓ + long records ✓, but indirect ✗]

- Other climate records typically **only began** in the 1950s (e.g., weather balloons), the 1970s (e.g., satellite temperature records) or 2000s (ice sheet monitoring)

Sea surface temperature (SST) data available

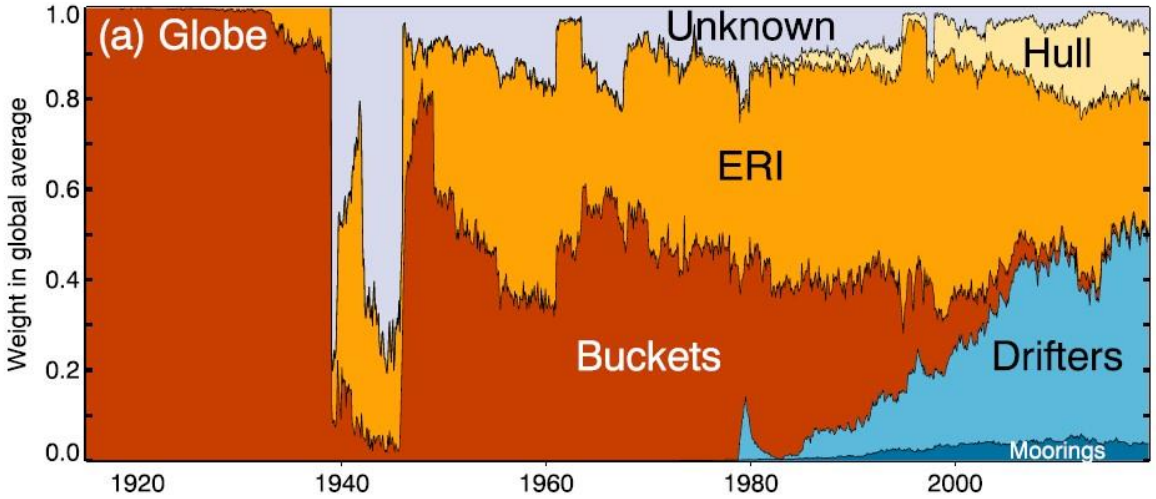
Key challenges for use for 1850–present

- SST data is very limited before 1950s
- SST data is mostly Northern Hemisphere
- Major changes in data sources over years.
- Ships: “Bucket” readings to “Engine Room Intake” (ERI) readings - each show different SST trends
- 1980s – present: mostly ships to 50% buoys

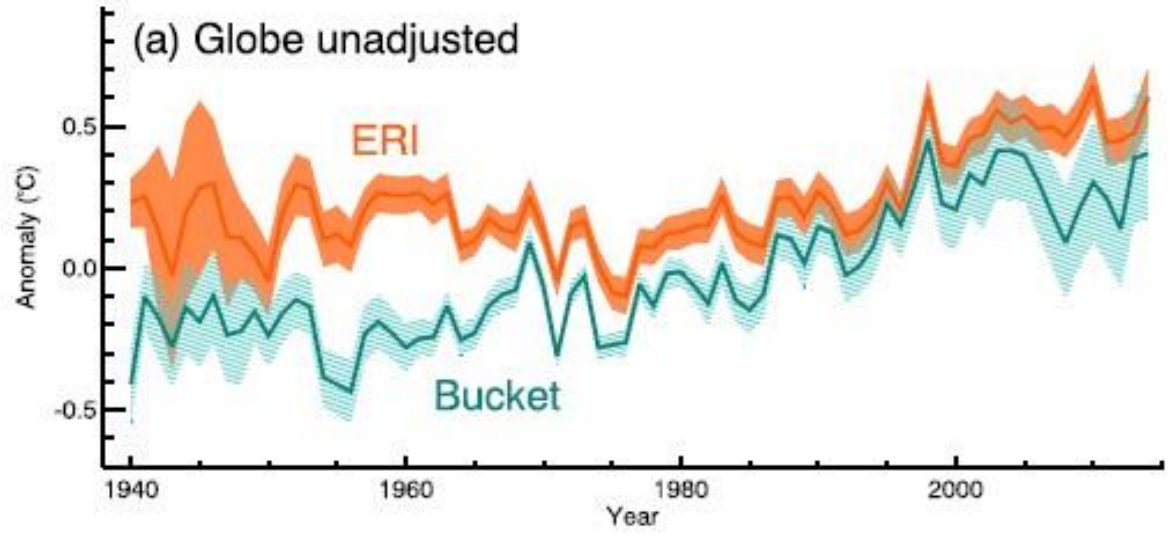


Source: Adapted from Figures 1, 2 and 10 of Kennedy, Rayner, Atkinson, & Killick (**2019**). J. Geophys. Res. Atmos., 124, 7719–7763. https://doi.org/10.1029/2018JD029867

Types of measurements for each year (1915-2014)



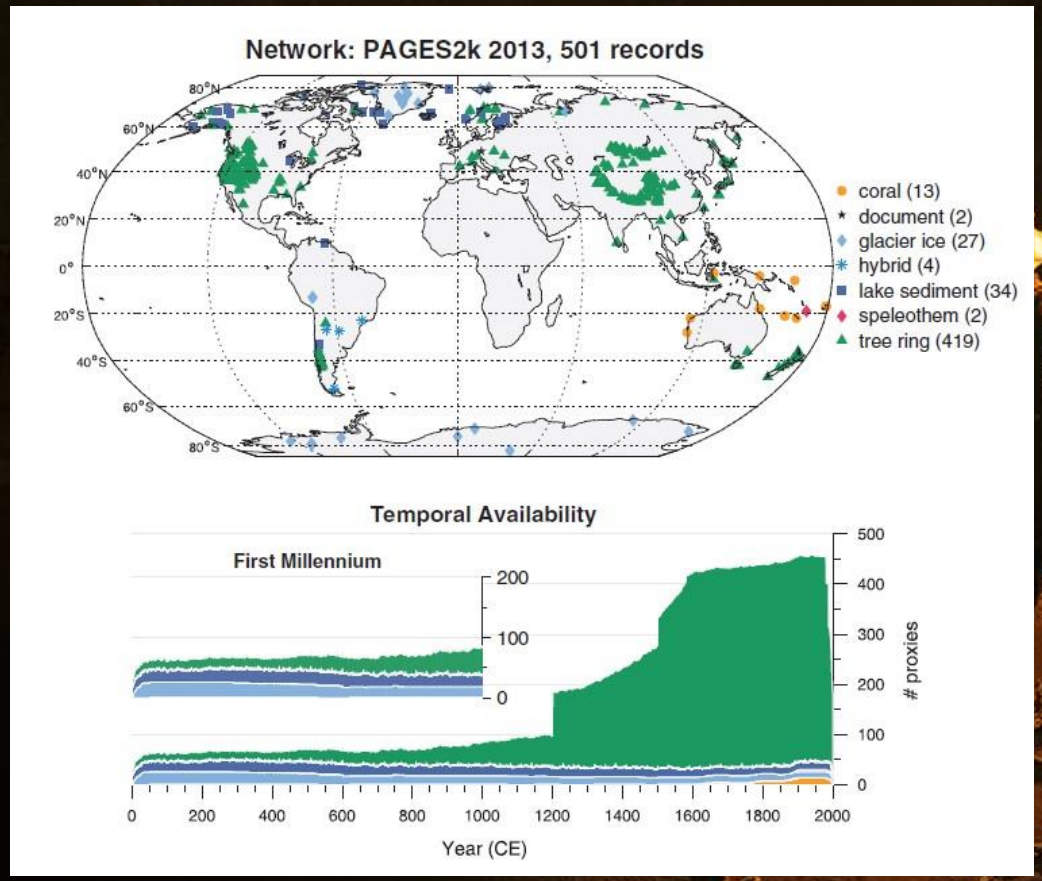
Temperatures estimated using **either** ERI **or** bucket data



Temperature proxy data available (PAGES2k dataset)

Key challenges for use for 1850–present

- Most of the available temperature proxies are Northern Hemisphere (see left figure)
- Implied temperature trends are **very different** for each type of temperature proxy (see right figure)
- Most of the proxies (84%) are of one type, i.e., tree-rings



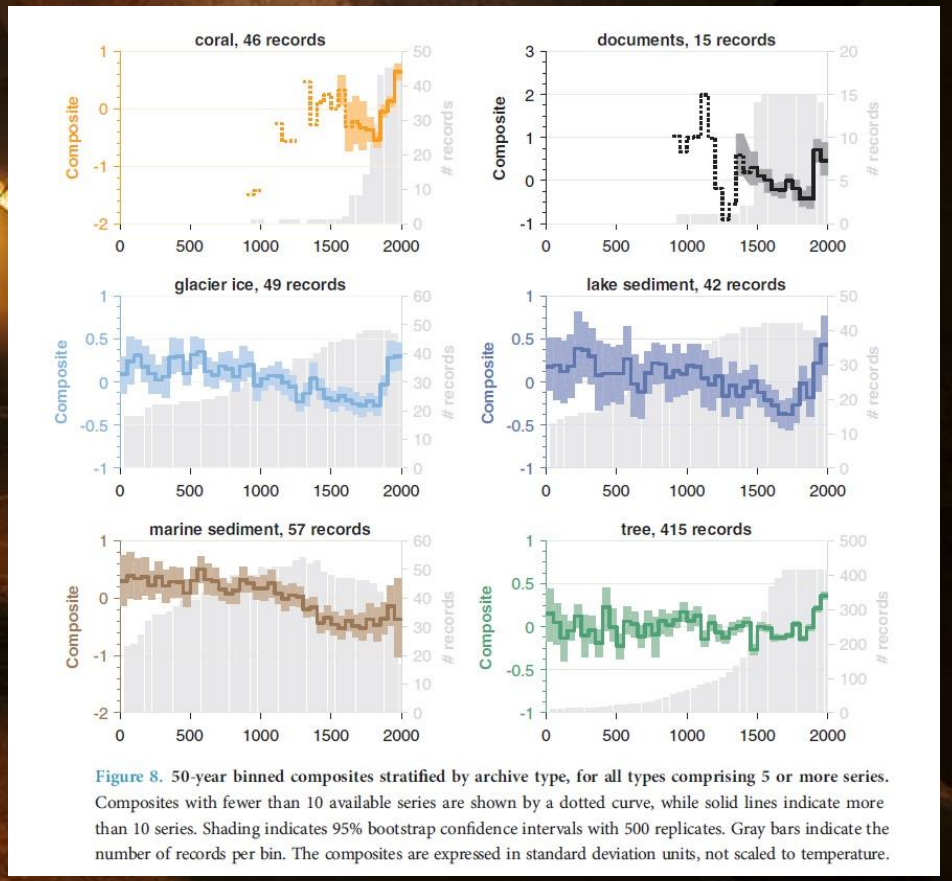
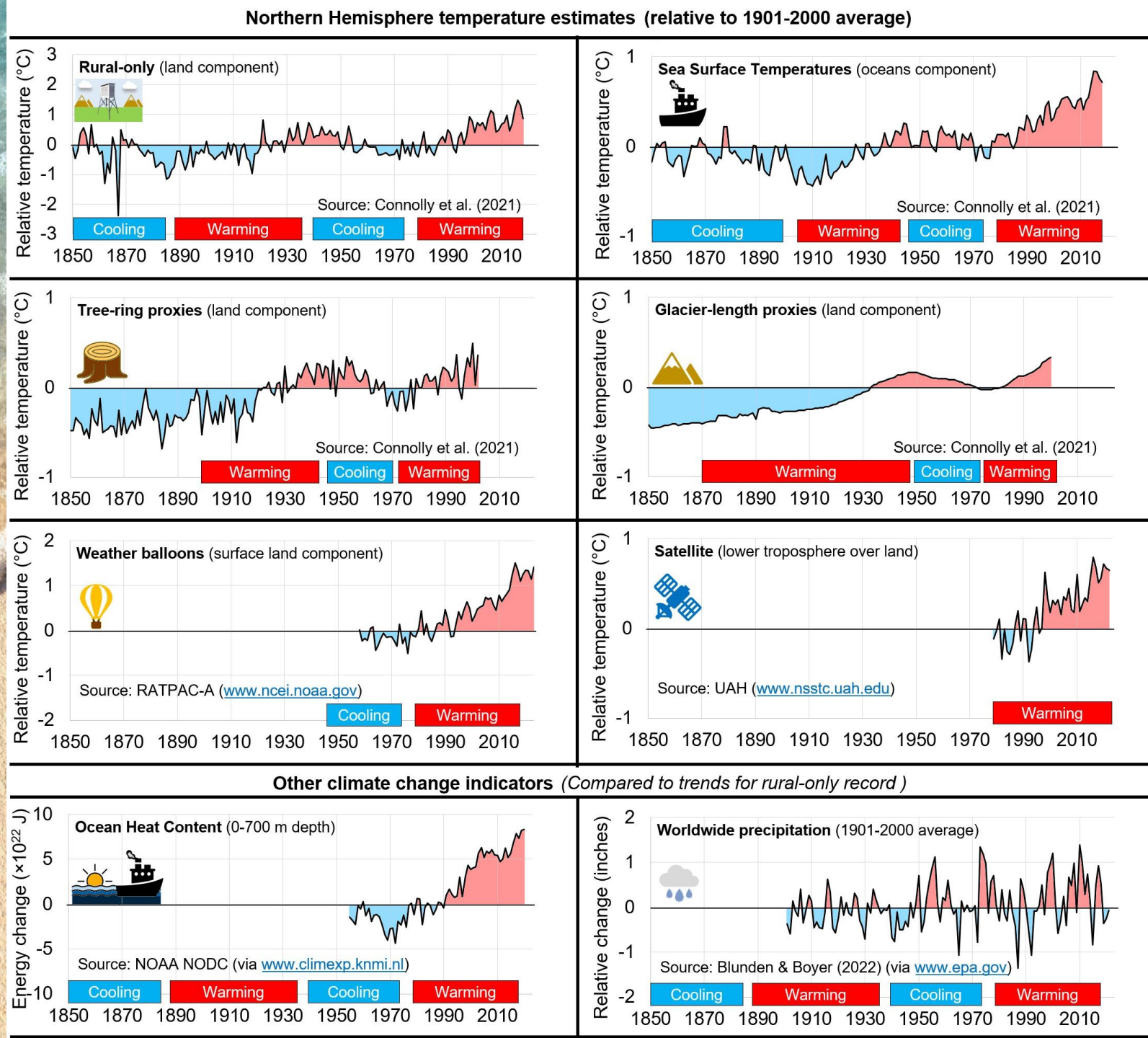


Figure 8. 50-year binned composites stratified by archive type, for all types comprising 5 or more series. Composites with fewer than 10 available series are shown by a dotted curve, while solid lines indicate more than 10 series. Shading indicates 95% bootstrap confidence intervals with 500 replicates. Gray bars indicate the number of records per bin. The composites are expressed in standard deviation units, not scaled to temperature.

Source: Adapted from Figures 2 and 8 of PAGES2k Consortium (2017). Scientific Data, 4, 170088. https://doi.org/10.1038/sdata.2017.88

How does it compare?

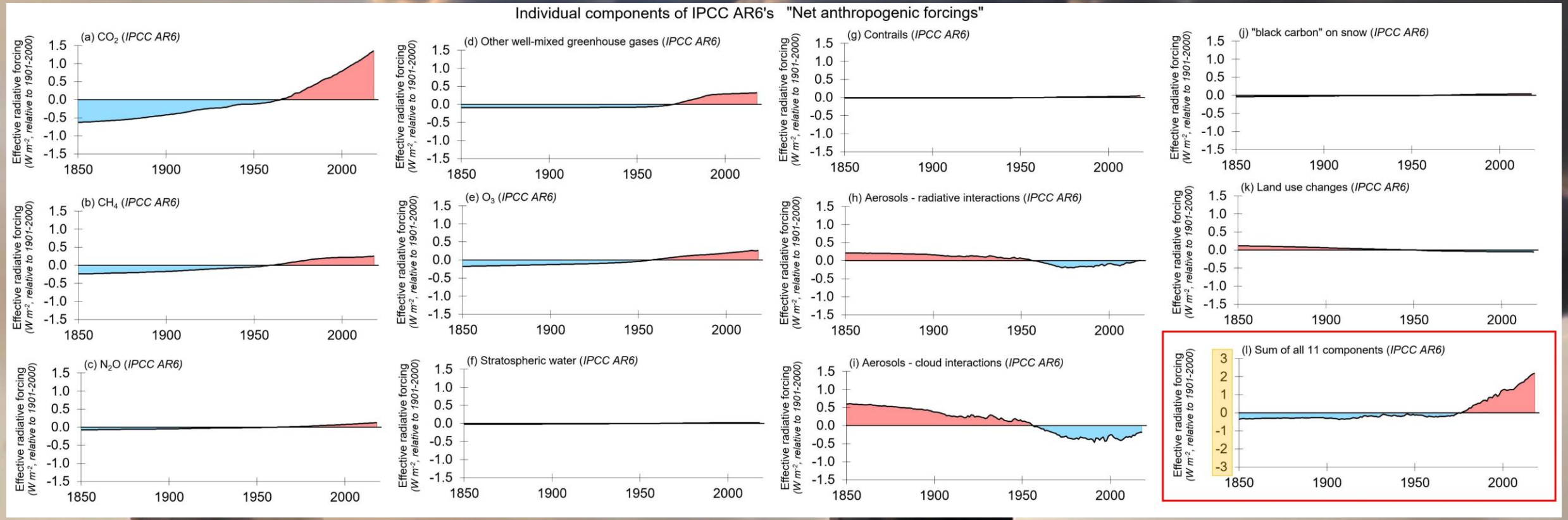
- Nonetheless, our rural-only Northern Hemisphere temperature estimates match surprisingly well to the other non-urbanized climate records
- All capture warming to 1940s, then cooling to 1970s then warming (if long enough)
- One exception: worldwide precipitation – no clear trend



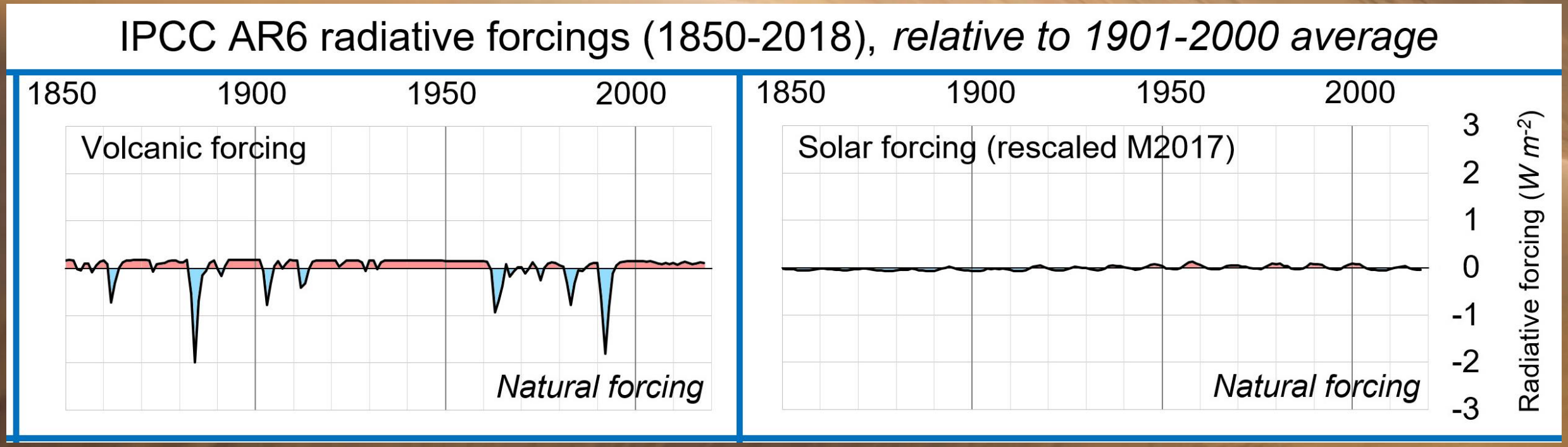
The IPCC's attribution process

- The computer model hindcasts used by the IPCC for their attribution involve plugging two types of climatic drivers:
  - natural factors and human-caused ("anthropogenic") factors
- IPCC describe drivers in terms of "radiative forcings" in Watts per m^2
- The hindcasts only consider two natural climatic drivers ("solar" and "volcanic")
- But, they consider 11 human-caused climatic drivers (mostly greenhouse gases and aerosol particles)

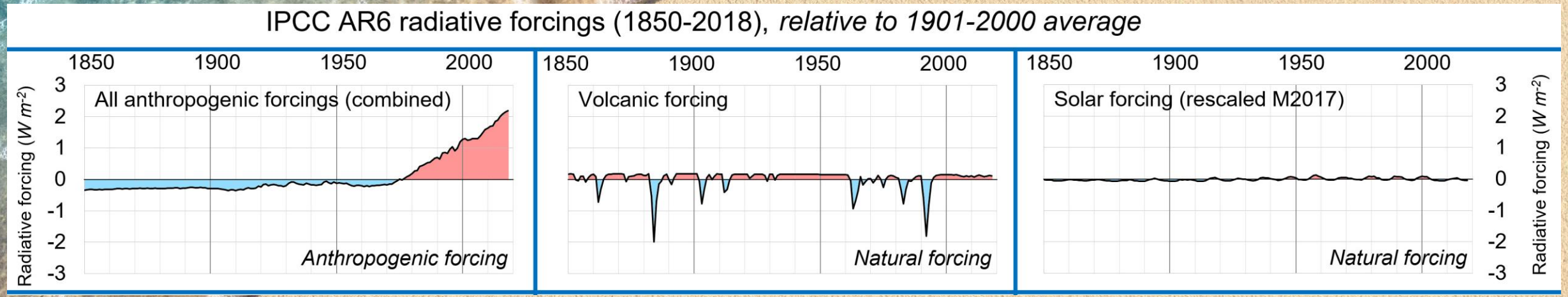
The IPCC thinks human-activities are the 11 smoking guns



They are not so interested in finding natural climate drivers



These are all the "natural and anthropogenic" forcings used for the IPCC AR6 hindcasts



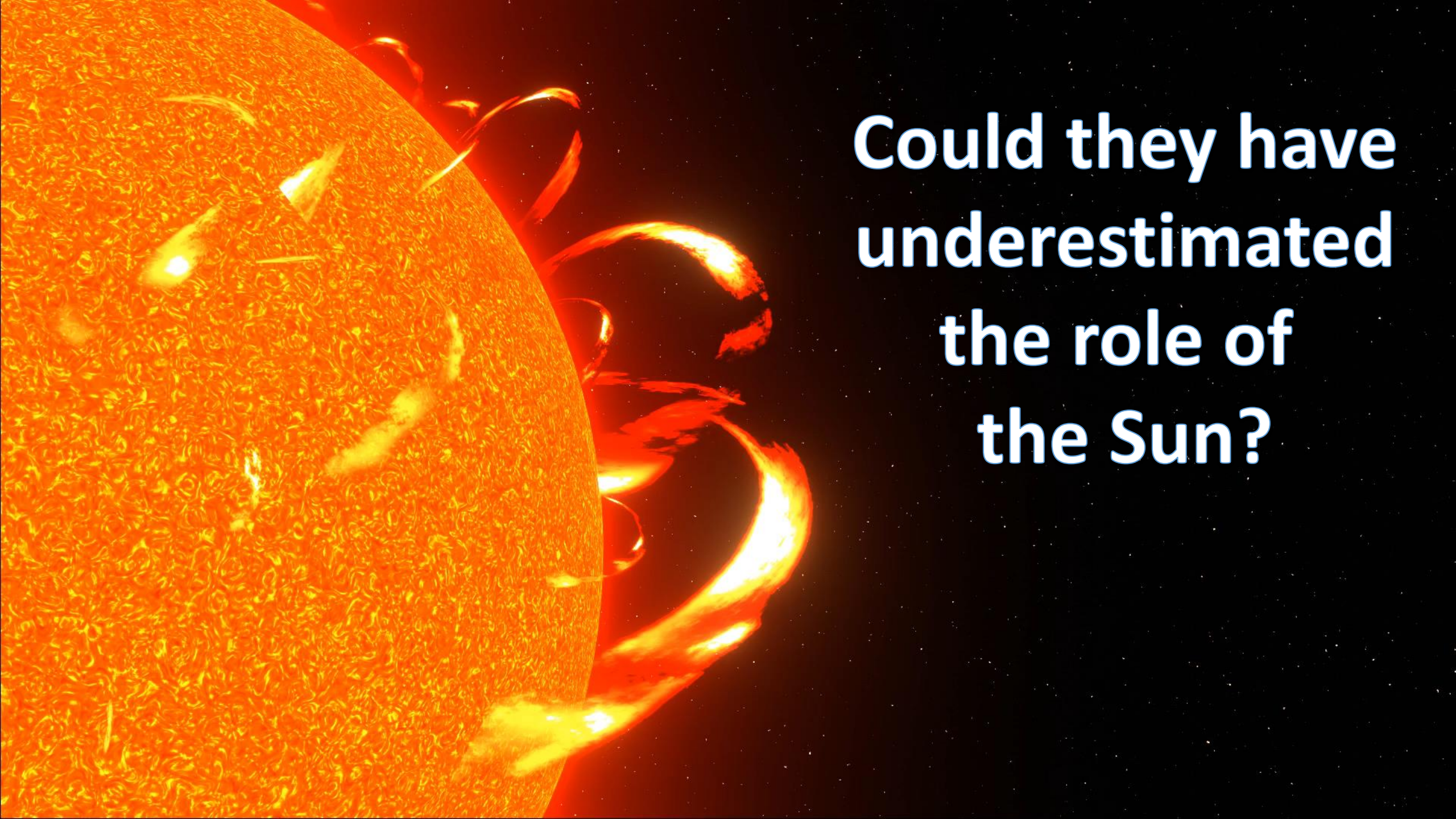
The weather-climate system is powered by solar energy

Power: 4×10^{26} W (Earth is 2 billion times weaker) 2×10^{17} W

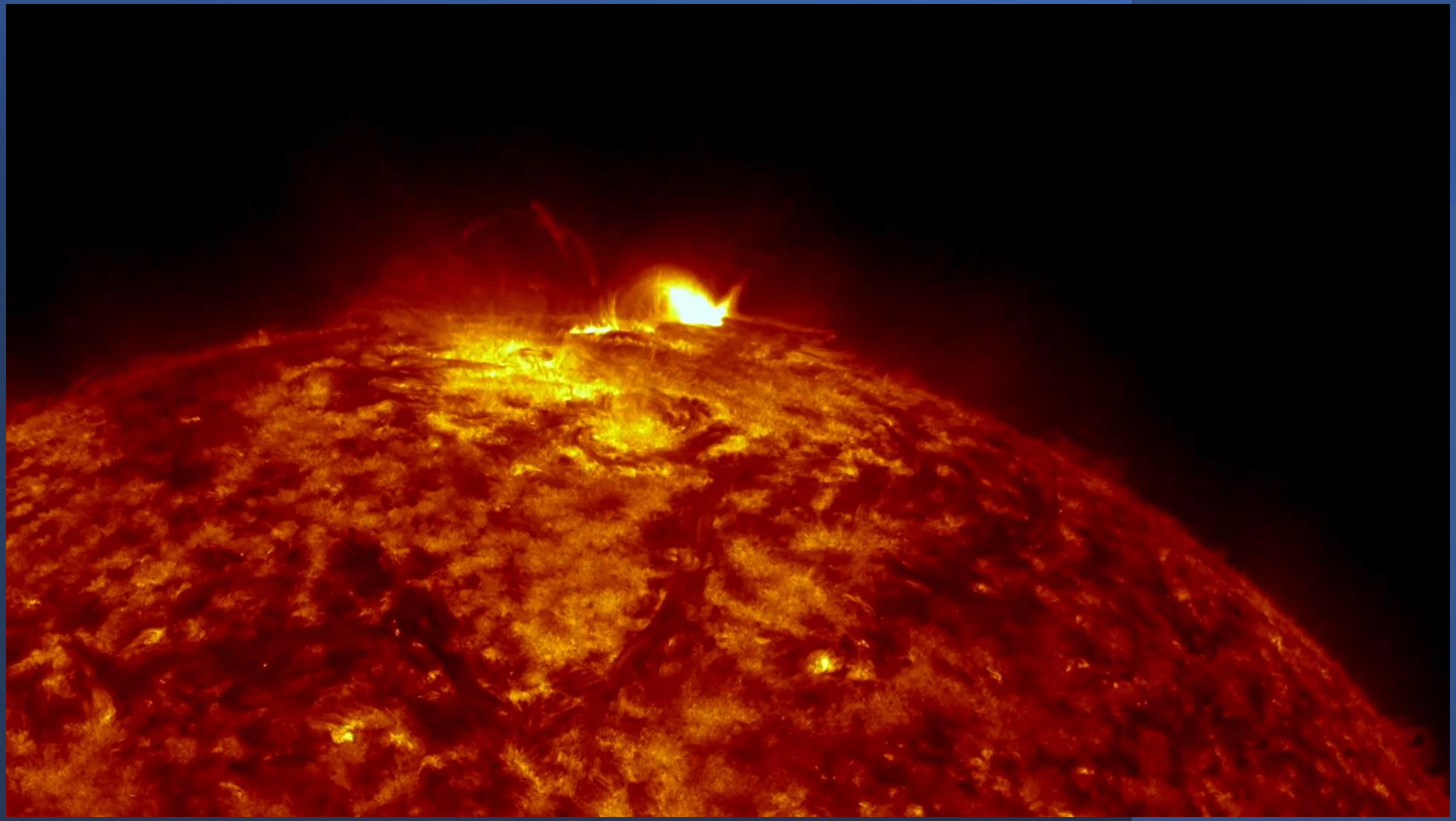
(world's most powerful laser: 5-10 x 10^{15} W; 100 petawatts pulse coming*)

Adapted from Jurg Beer 2007's presentation

*Ruxin Li, Shanghai Superintense Ultrafast Laser Facility (January 24, 2018 Science Magazine News)


Could they have
underestimated
the role of
the Sun?

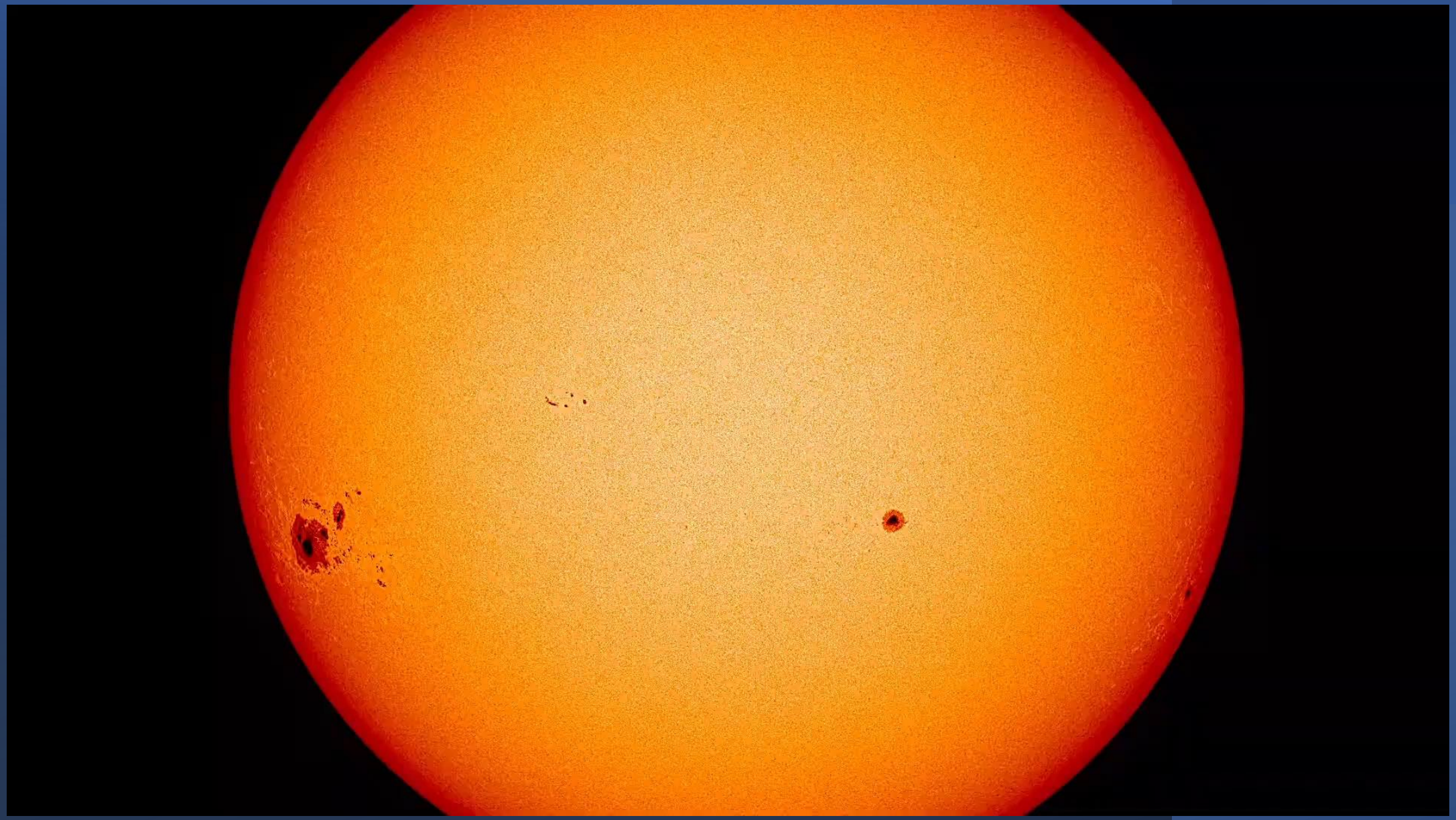
The Sun is a very dynamic source of energy



Source: NASA GSFC

"Cosmic Cycles: The Sun" (https://svs.gsfc.nasa.gov/14313)

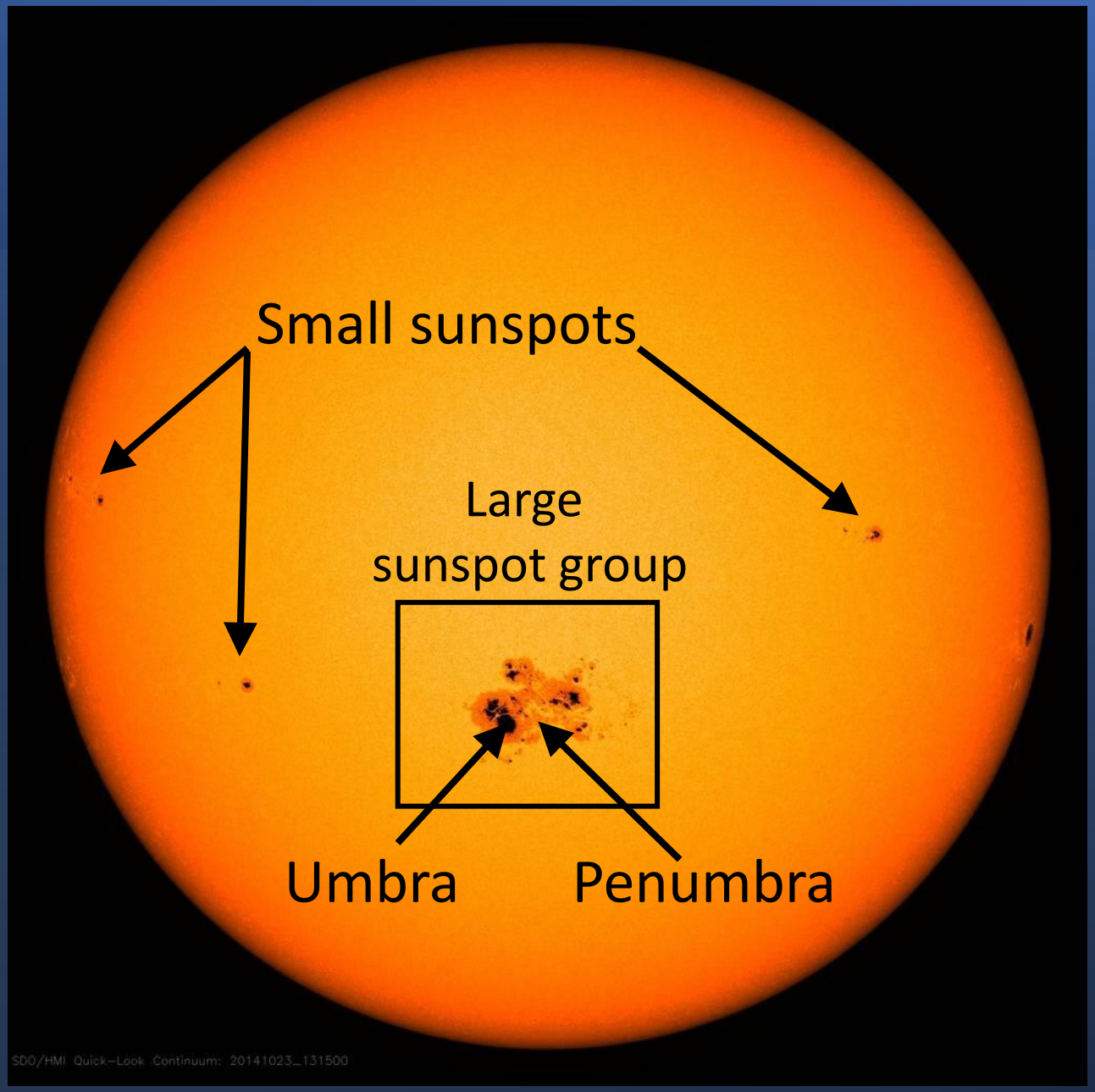
Oldest noticed feature: “sunspots”



Source: NASA GSFC

“Cosmic Cycles: The Sun” (https://svs.gsfc.nasa.gov/14313)

Some “sunspots”

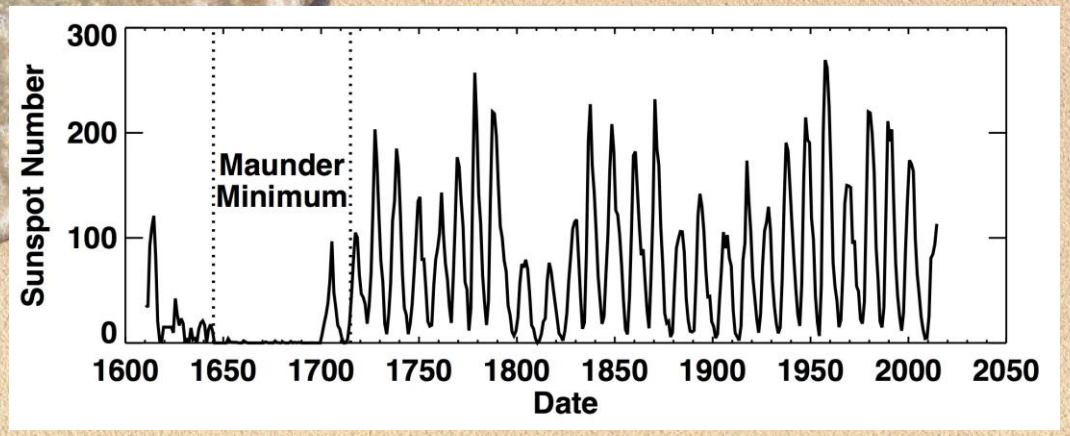


Source: NASA

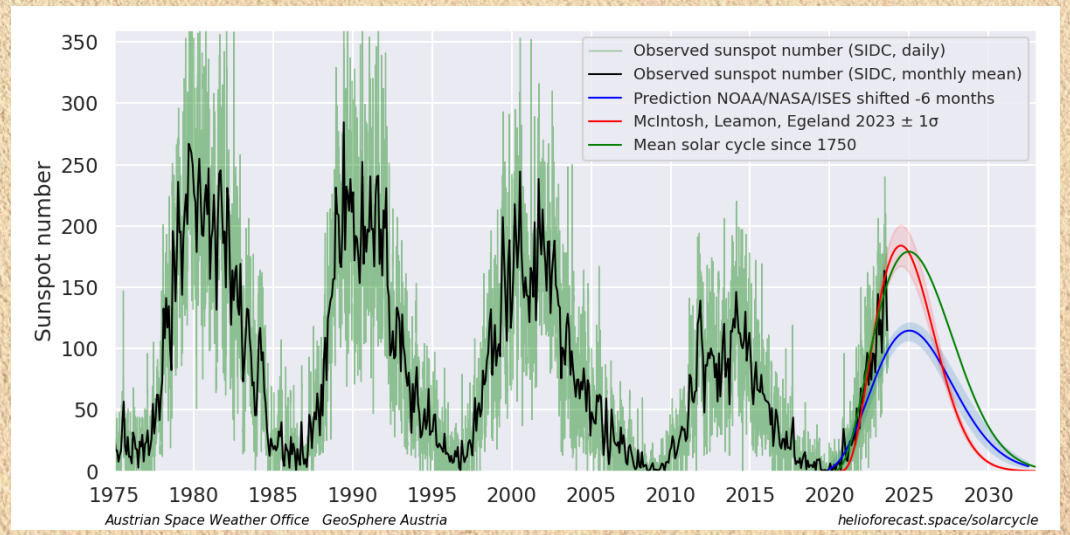
Sunspots have been recorded since Galileo

- Galileo noticed dark spots on the Sun with his early telescope in 1610 – called “sunspots”
- Number of sunspots increases to a maximum and then decreases to zero over a **roughly** 11 year cycle (“Sunspot cycle” or “solar cycle”)
- Sunspots disappeared from 1645-1715 (“Maunder Minimum”), but then reappeared
- Sunspot numbers (SSN) are clearly a measure of solar activity – but not a direct measurement of TSI – just a “solar proxy”
- There are other solar proxies, e.g., Ca(II)+H/K emission lines, penumbra/umbra ratios, etc.

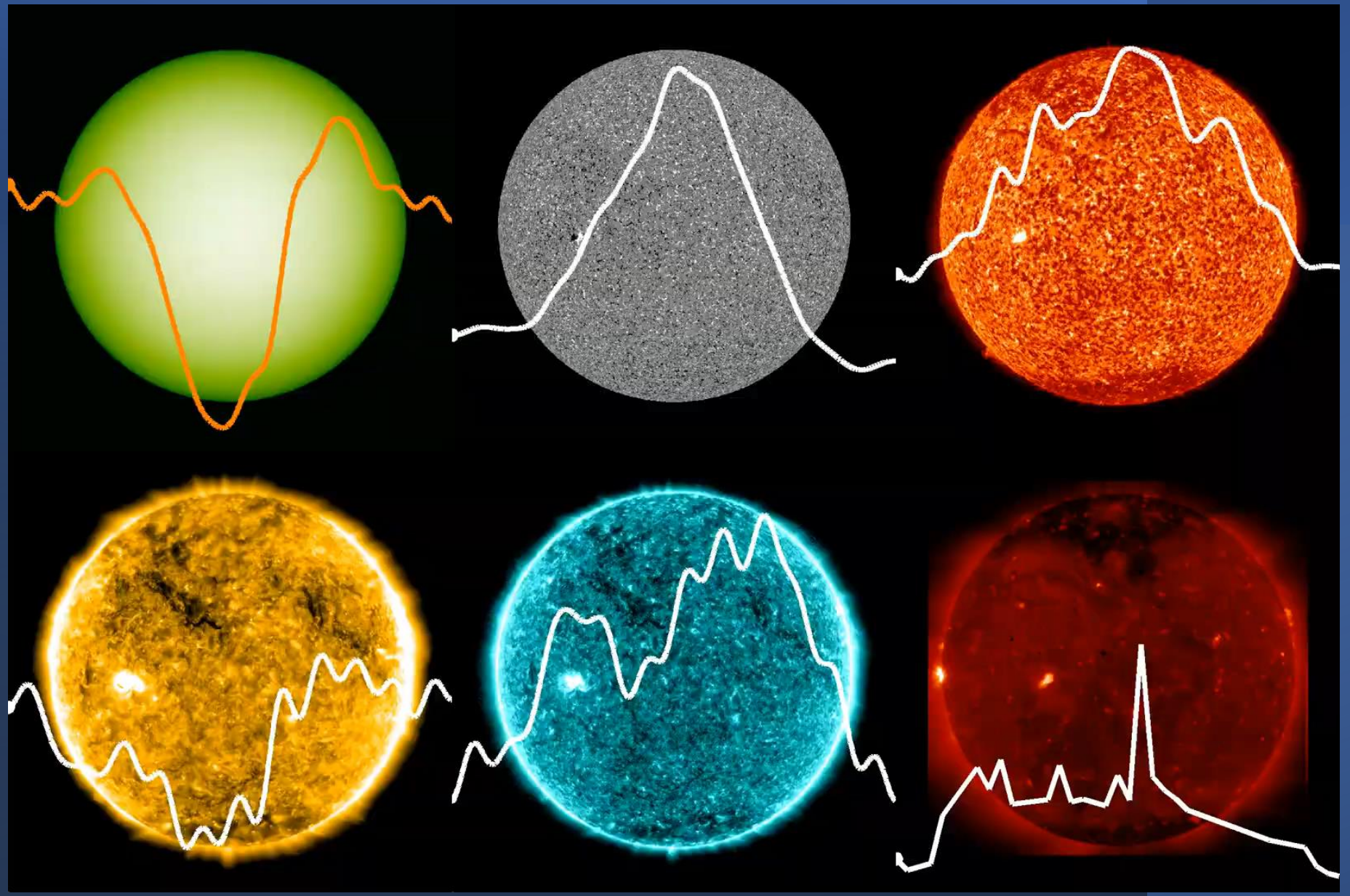
Yearly sunspots (Galileo to present)



Daily sunspots (1975 to the future!)



Different aspects of solar magnetism during solar rotation

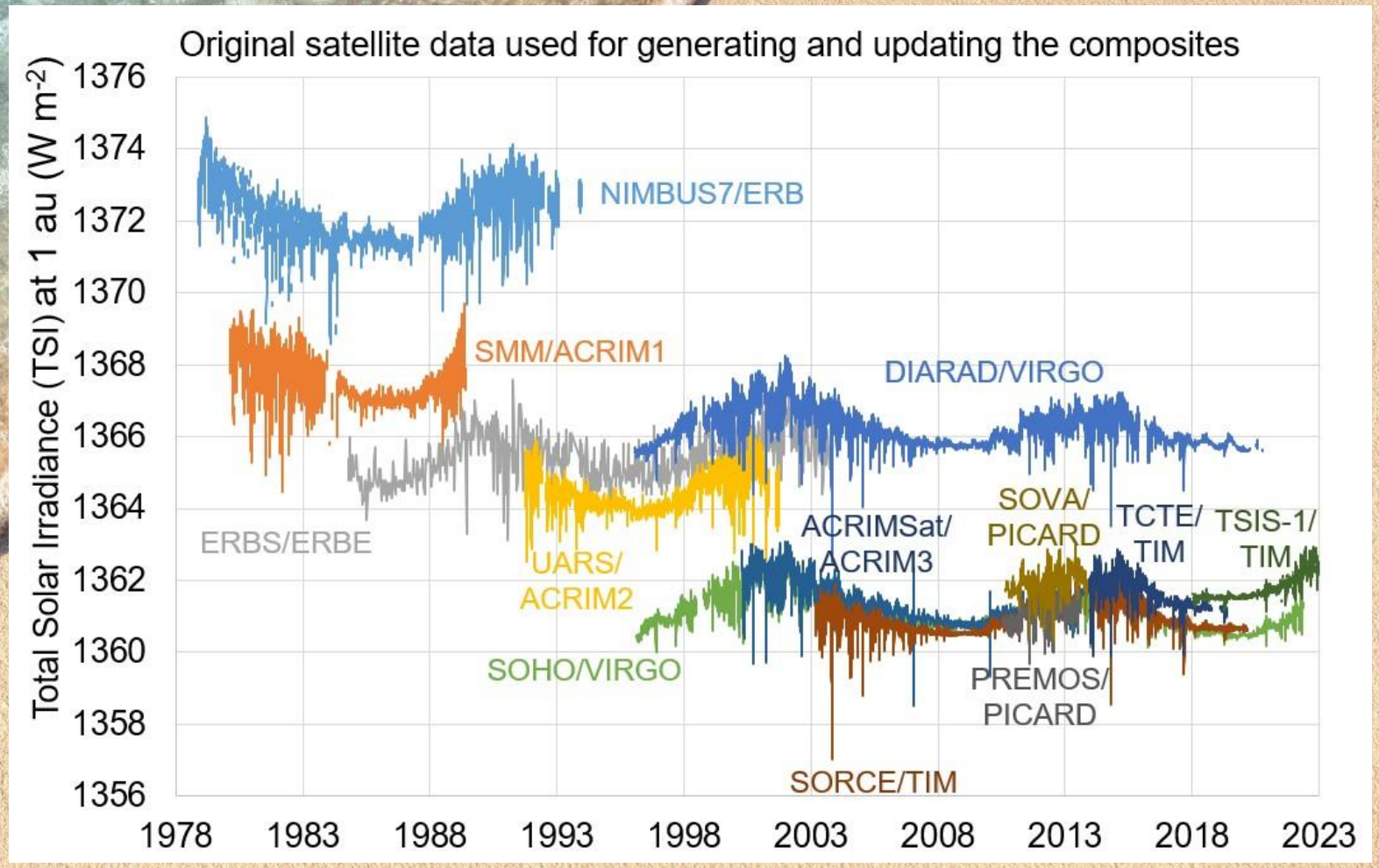


Source: NASA

https://www.nasa.gov/feature/goddard/2020/a-new-look-at-sunspots-is-helping-nasa-scientists-understand-major-flares-and-life-around/

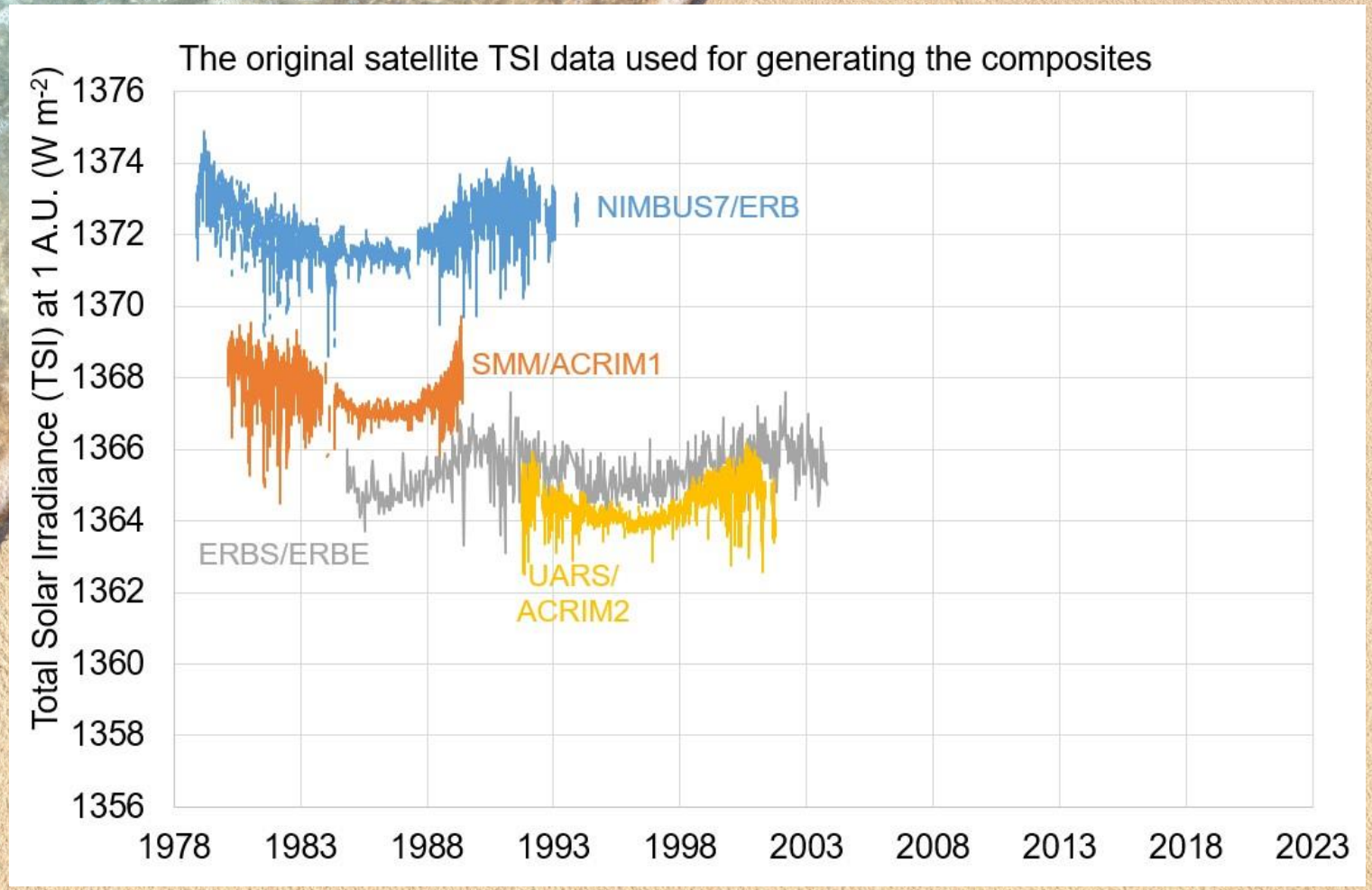
The satellite era TSI problem!

- Direct measurements of Total Solar Irradiance (TSI) above the Earth's atmosphere **only** began in 1978
- Each satellite only lasts 10-15 years. And implies a different average TSI!
- All capture the up/down roughly 11 year sunspot cycle.
- But, each shows different trends between cycles.



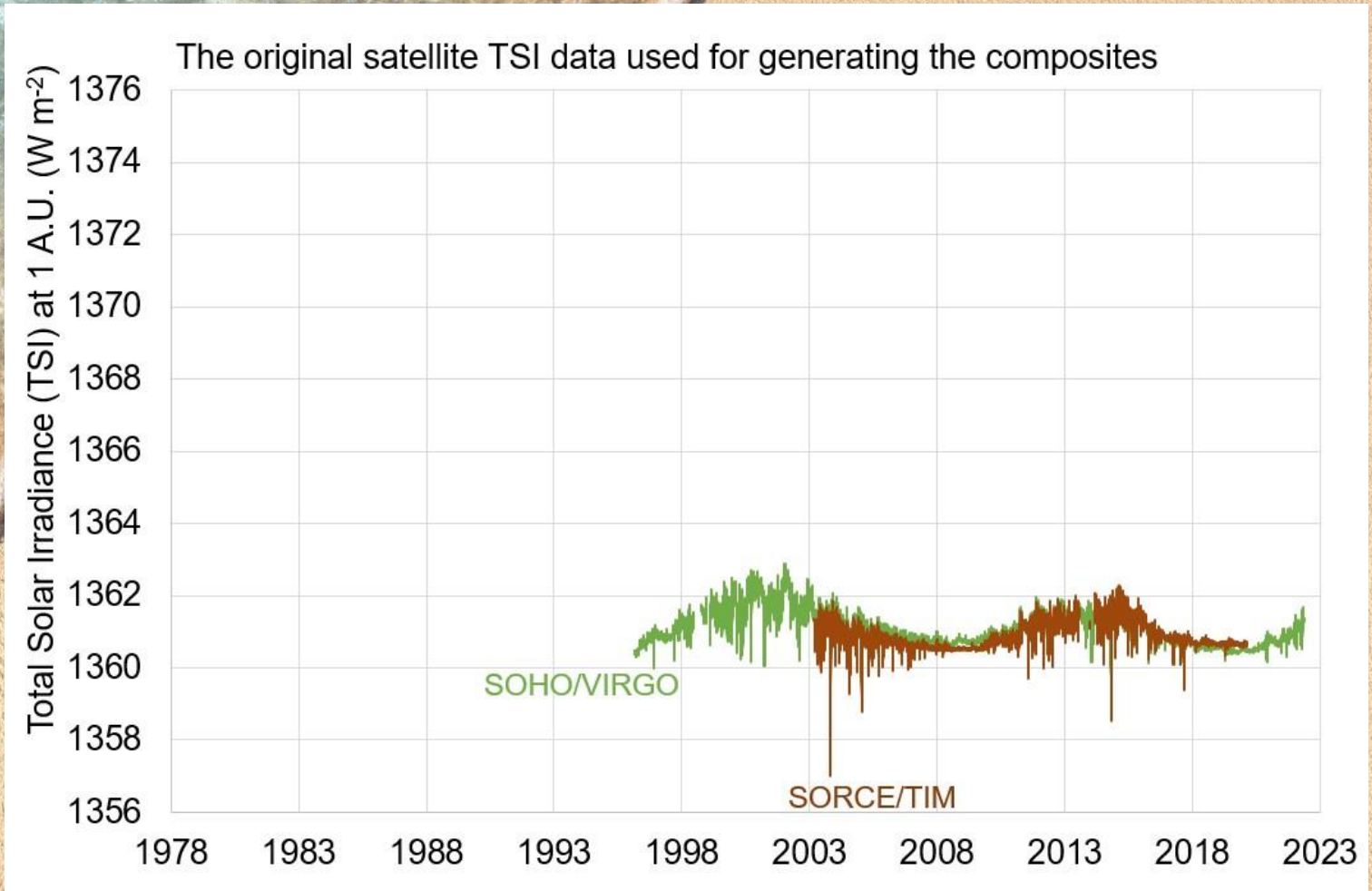
The satellite era TSI problem! – the ACRIM GAP

- ACRIM2 was supposed to be launched before ACRIM1 finished.
- USS Challenger tragedy (1986) delayed all space launches for several years
- This leaves “the ACRIM gap”
- NIMBUS7 suggests increase, but ERBS suggests decrease
- Led to two rival composites: ACRIM vs. PMOD



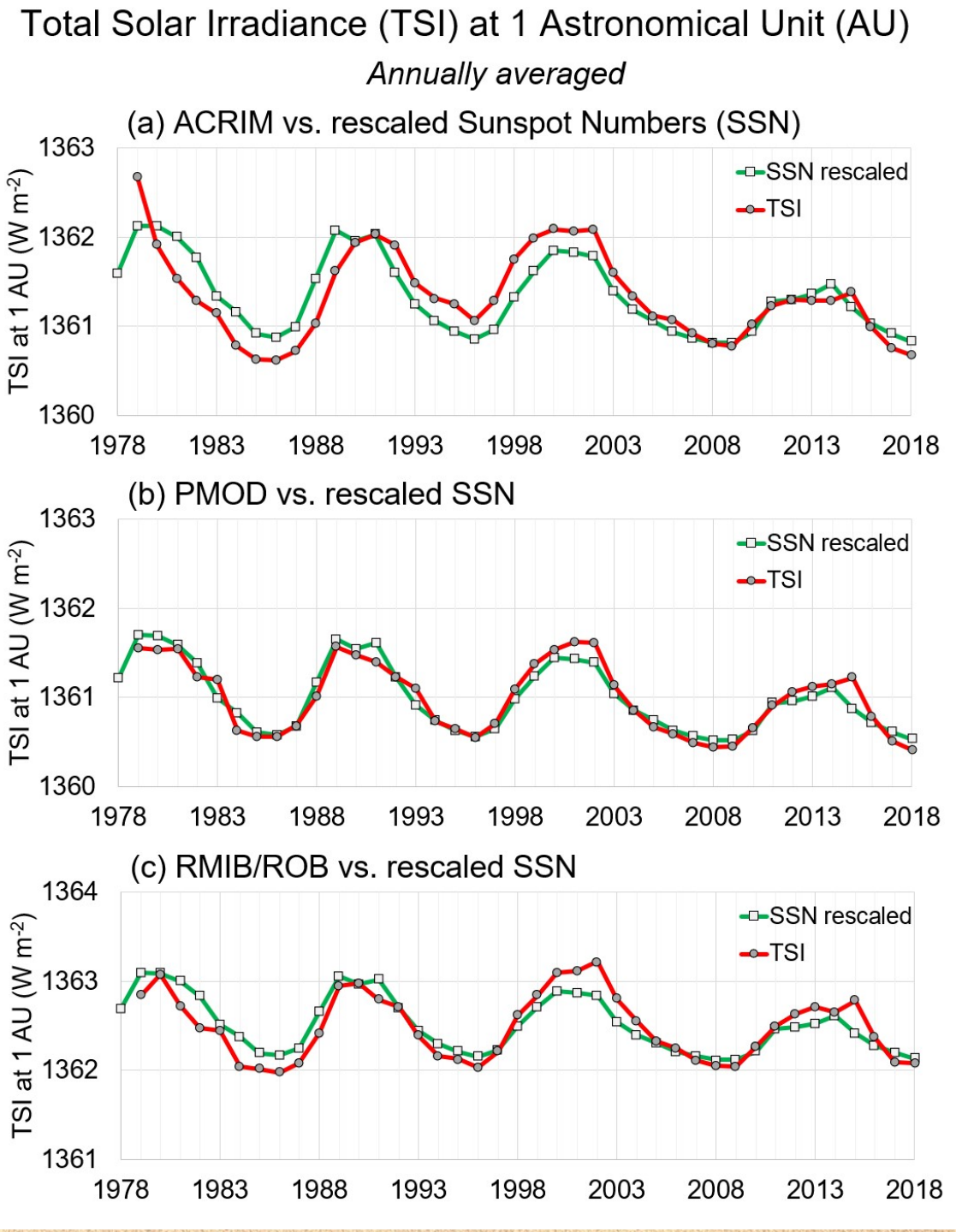
The satellite era TSI problem! – current trends

- Even when the satellite overlap, we still have problems
- E.g., SORCE and SOHO overlapped from 2003 to 2020
- But, notice, SORCE increased relative to SOHO between cycles
- Was SORCE correct? SOHO? Neither?

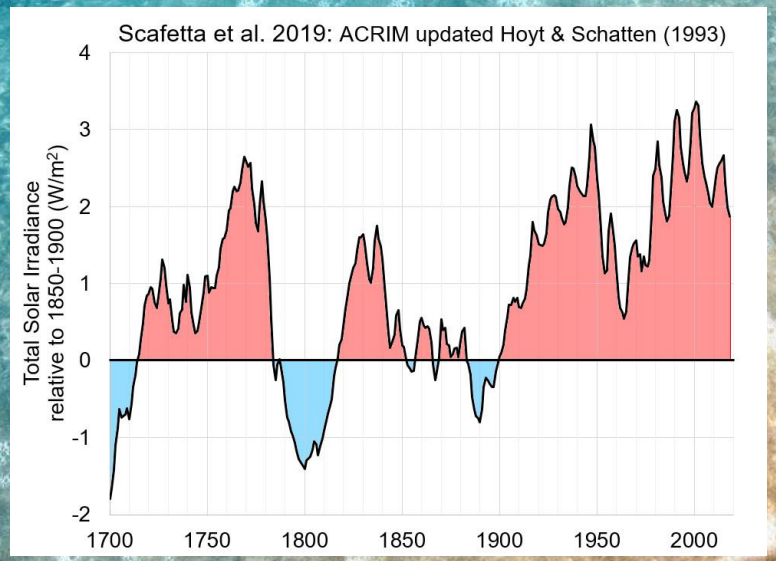


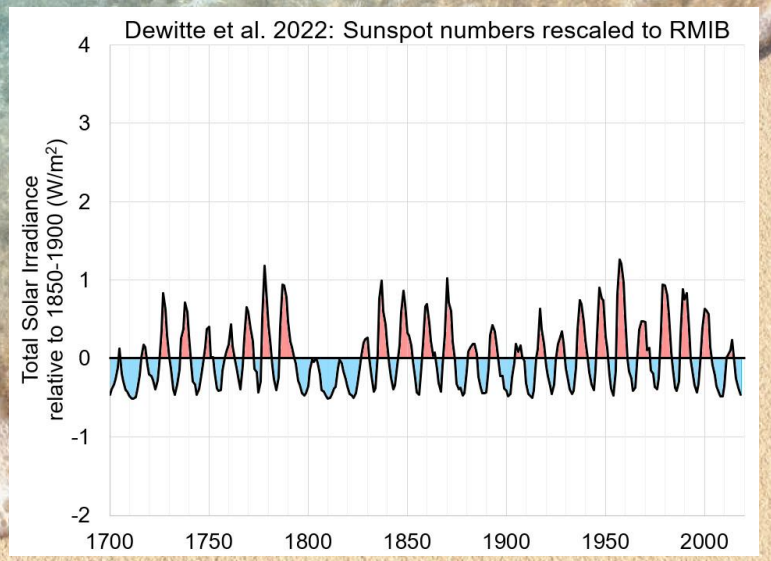
Using satellite TSI composites to calibrate solar proxies

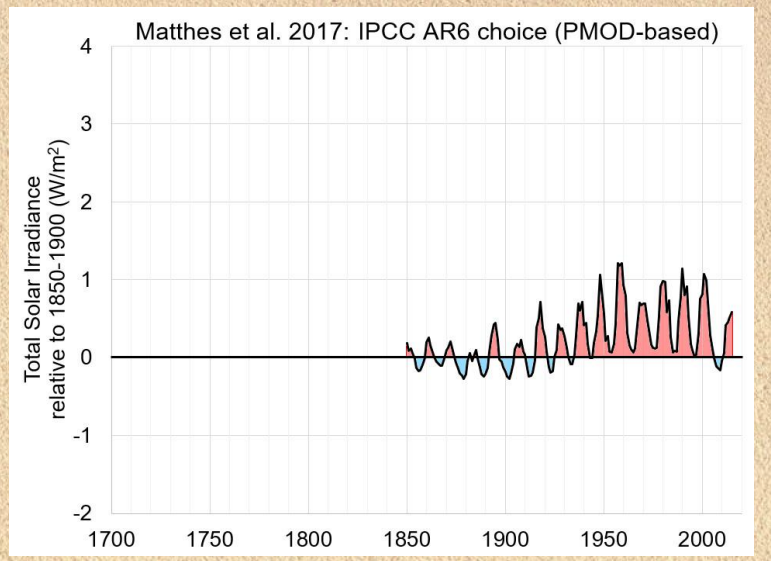
- By scaling a solar proxy to match TSI in the satellite era, you can extend the rescaled proxy TSI values for the entire solar proxy record
- But, the solar proxies do not capture all of the observed TSI variability during the satellite era – so they might be missing important trends for the pre-satellite era too
- PMOD matches almost exactly to SSN. PMOD-scaled reconstructions are simple! Just SSN and maybe 1 or 2 more proxies
- ACRIM suggests multiple different solar proxies needed – SSN is important but not enough!



Using satellite TSI composites to calibrate solar proxies: Three examples of very different TSI estimates







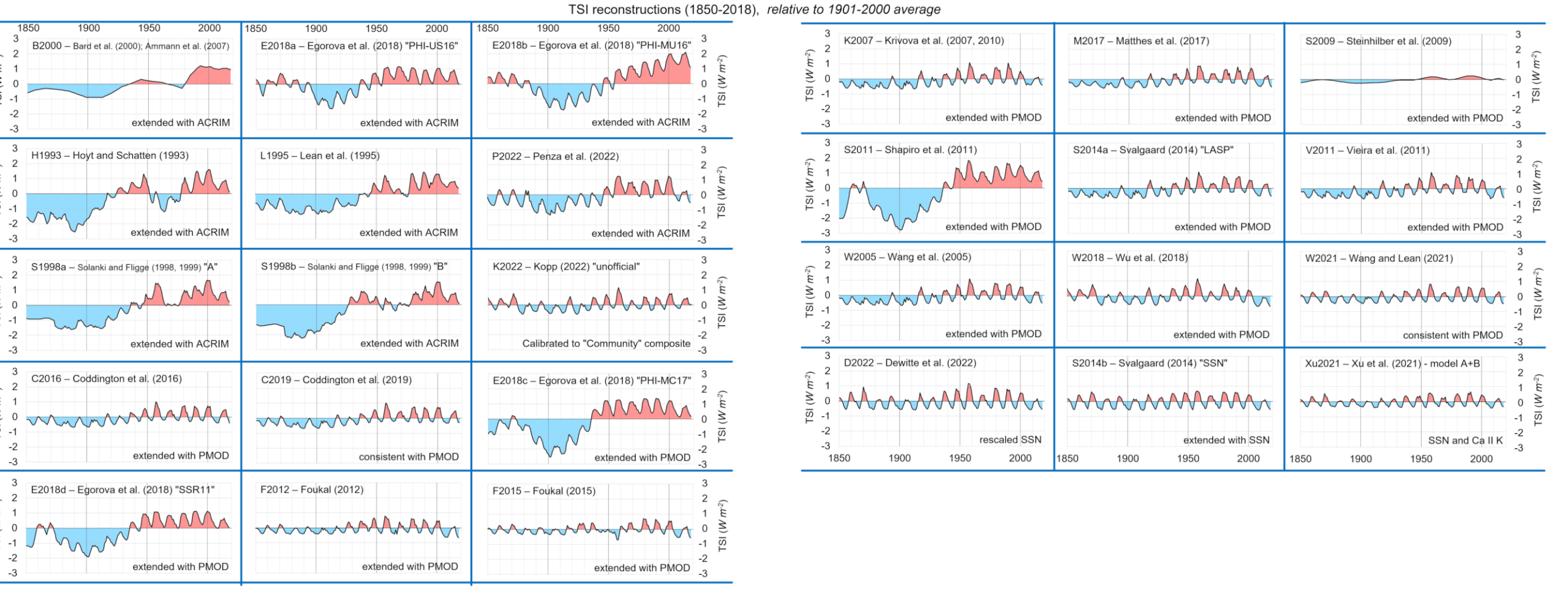
ACRIM-calibrated
5 solar proxies used

RMIB-calibrated
1 solar proxy used (SSN)

PMOD-calibrated
2-3 solar proxies used

Which of the 27 estimates is correct?

- We compiled 27 different TSI estimates and updated them all to cover period 1850-2018
- 8 ACRIM, 15 PMOD, 1 “Community” composite and 3 “SSN-based” estimates
- IPCC AR5 considered 4 of these: K2007, S2009, V2011 and W2005
- IPCC AR6 only considered 1 of them: M2017 (the average of C2016 and K2007)



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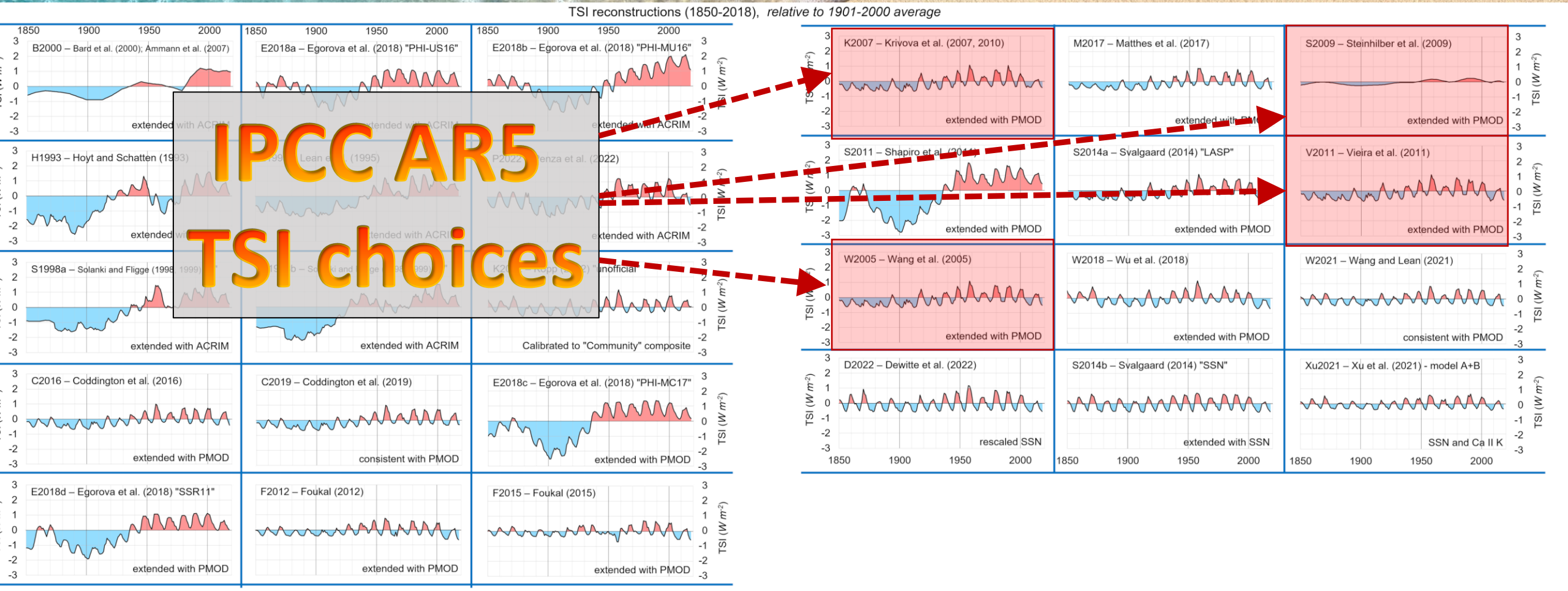

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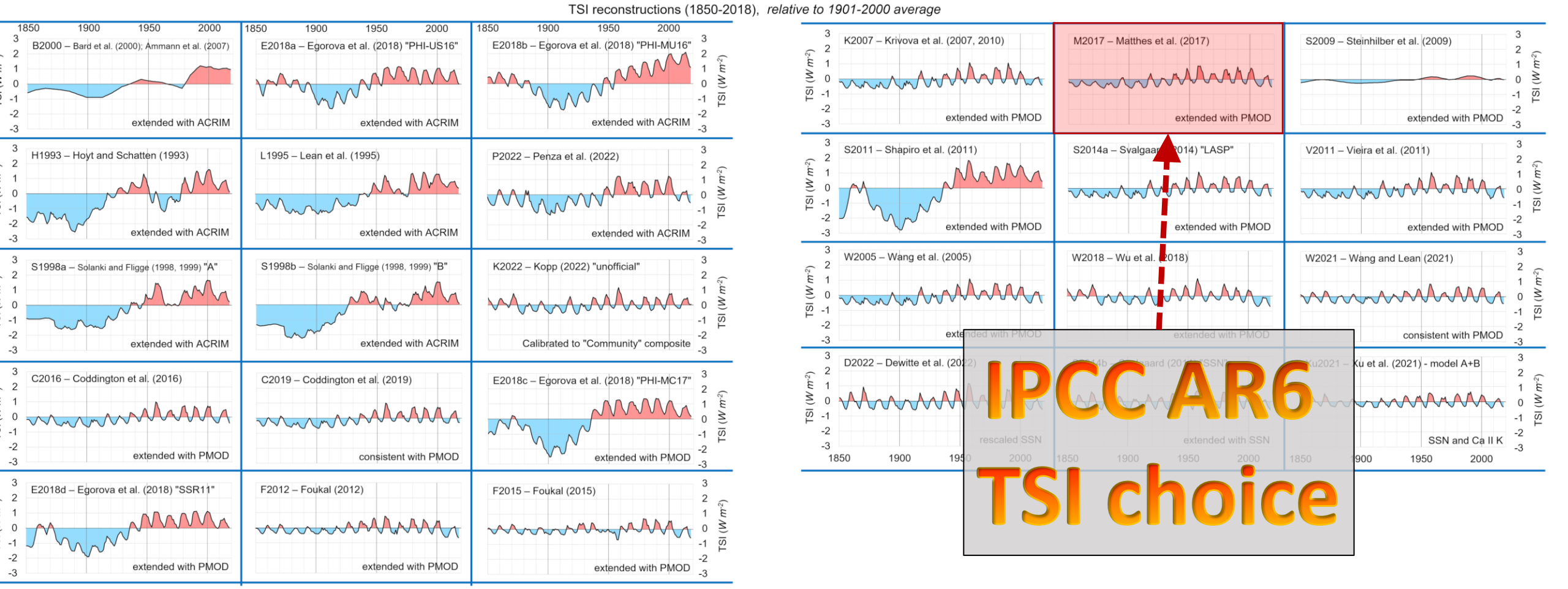

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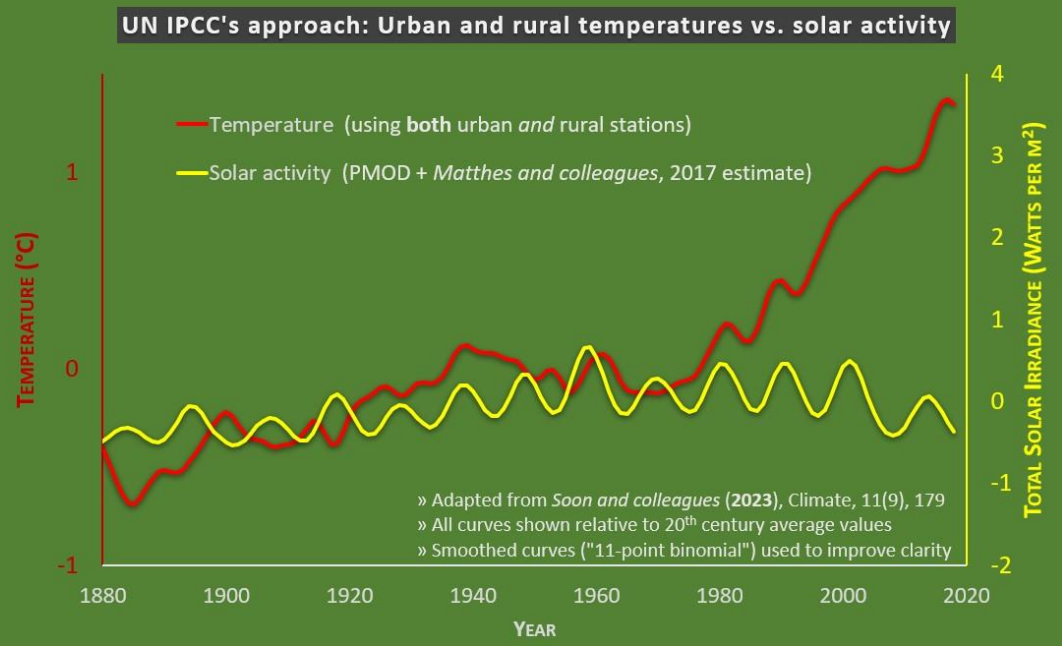
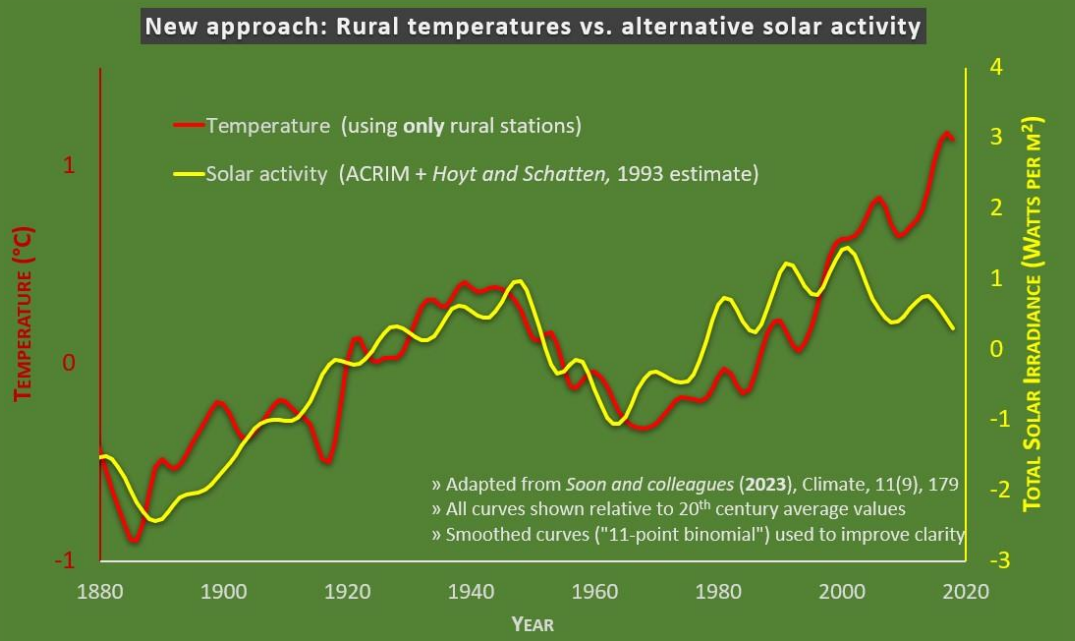
8 ACRIM-calibrated

Available now

S2023: Urban & rural vs. Rural-only and Two TSI series

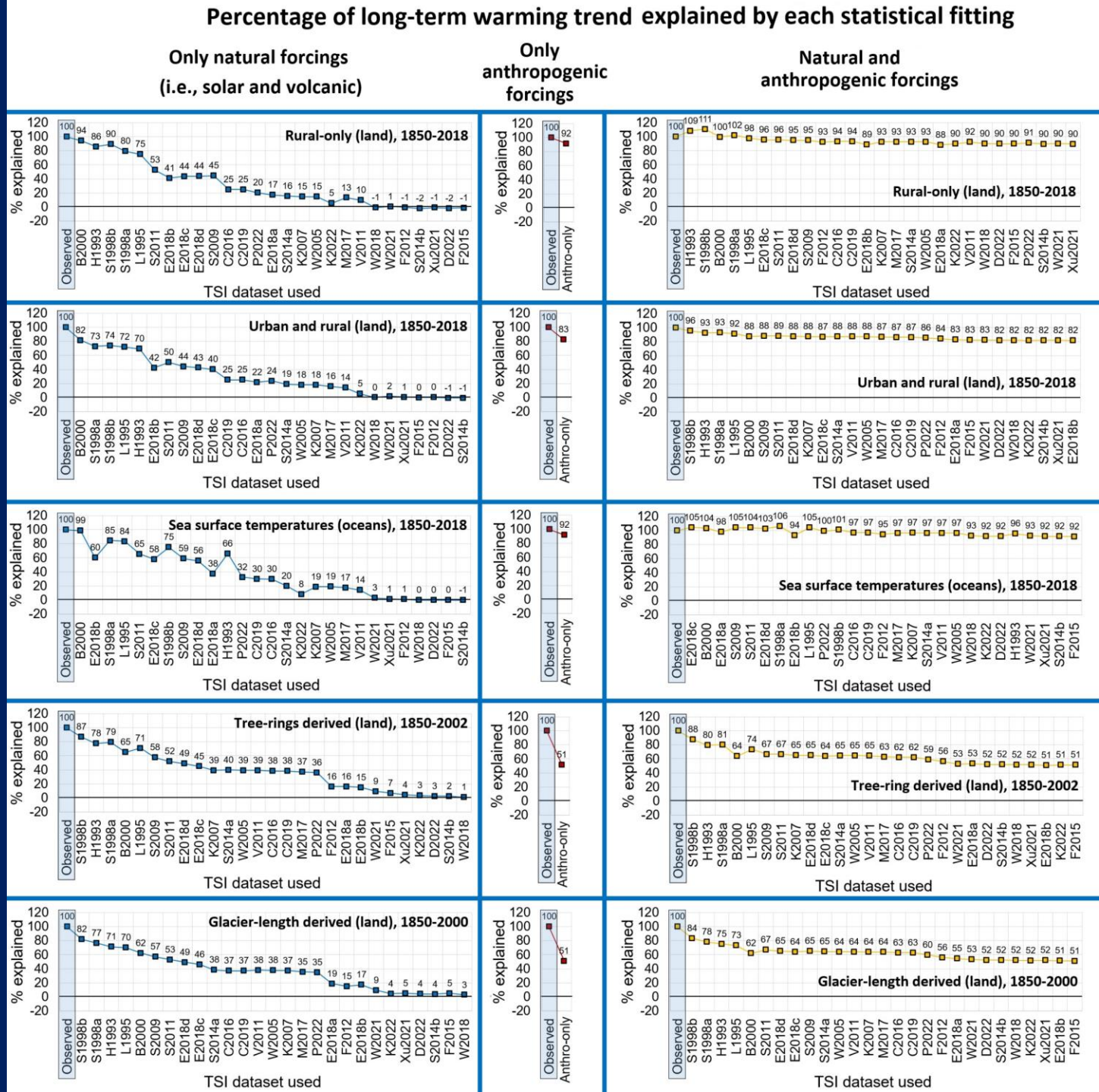




- IPCC AR6 uses both urban and rural data for calculating global temperatures
- Their chosen estimate of solar activity was that of Matthes and colleagues (2017) ("M2017).
- **IPCC**: Solar activity cannot explain any of the warming since the mid-20th century
- If we use our rural-only record, we see a more cyclical behavior and less overall warming.
- If we use one of the ACRIM-calibrated TSI estimates (H1993) it suggests that most of the rural temperature changes since the 19th century have been natural

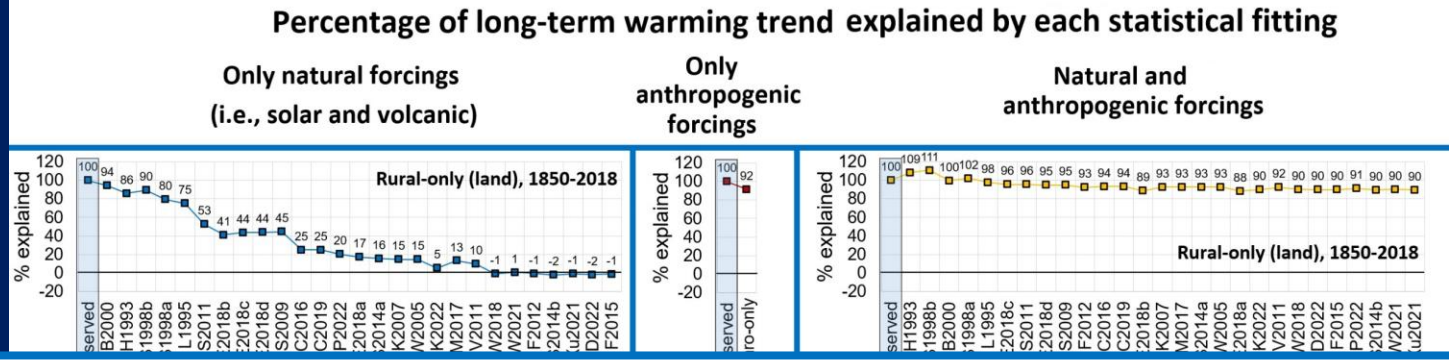
C2023: Five temperature estimates and 27 TSI series

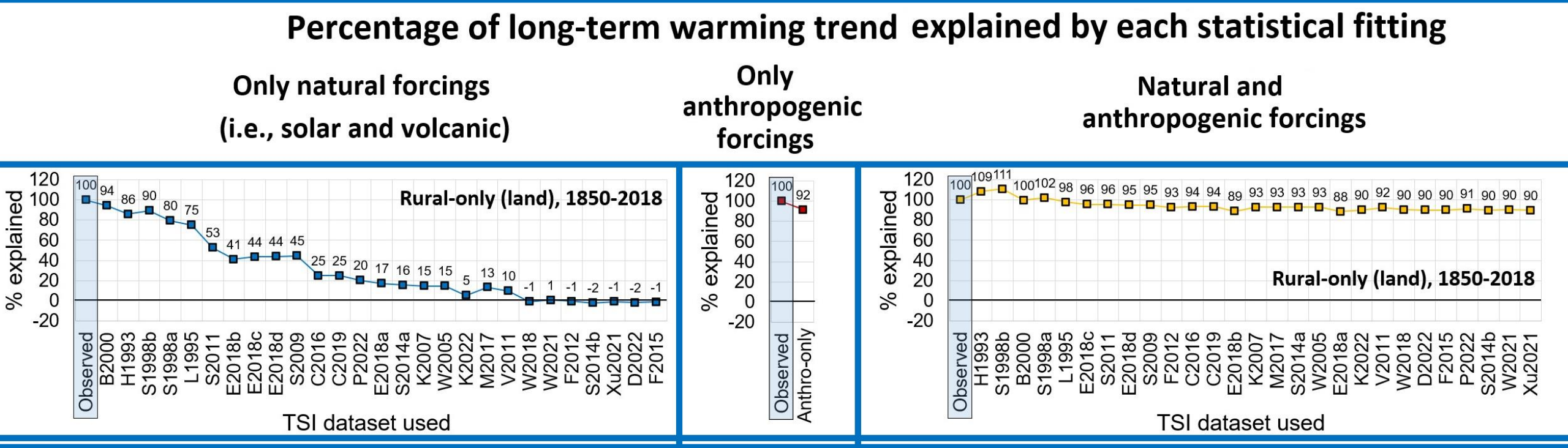
- If we use any of the PMOD-calibrated TSI records, we can only explain 15-25% of the warming in “natural-only”
- TSI estimates based on rescaled SSN are useless!
- But, 5 of the ACRIM-calibrated TSI records can explain 60-90% of the warming as “natural-only”
- If we add in “natural and anthropogenic”, the warming is “a mixture of human and natural”



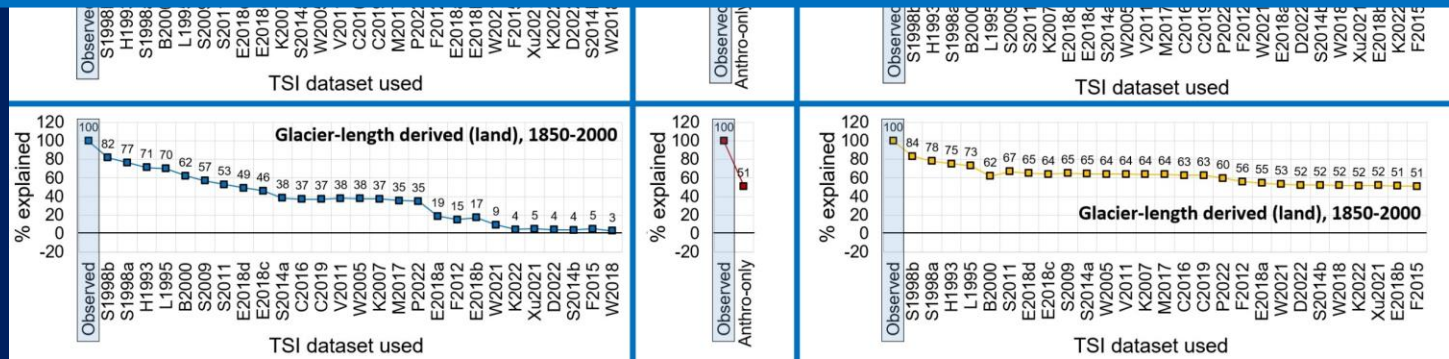
C2023: Five temperature estimates and 27 TSI series

- If we use any of the PMOD-



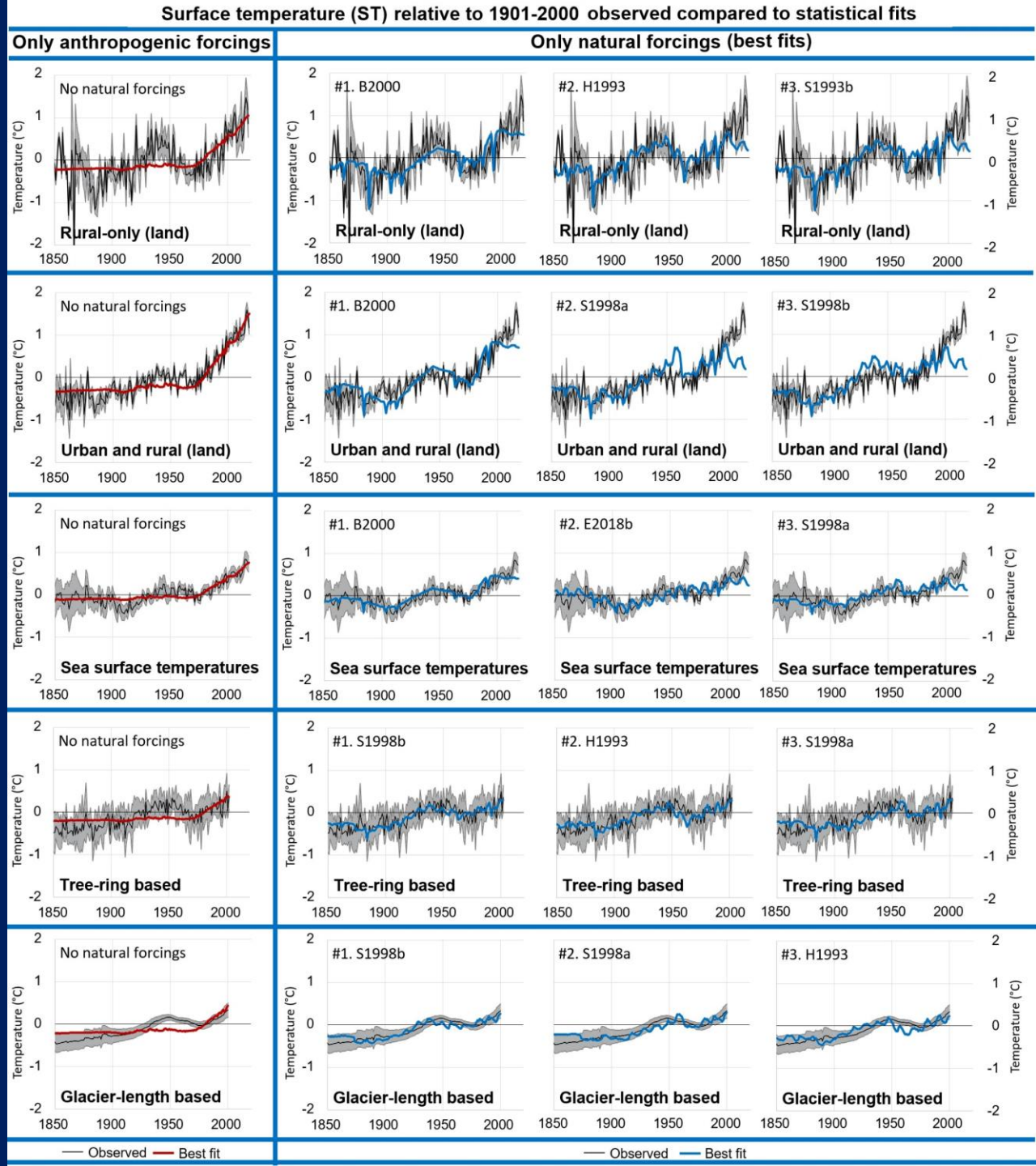


- If we add in "natural and anthropogenic", the warming is "a mixture of human and natural"



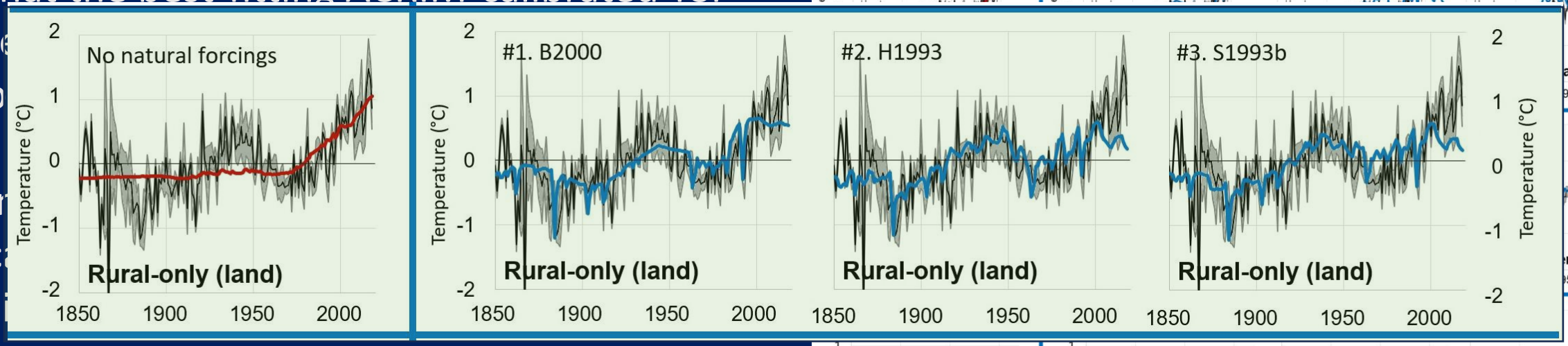
C2023: Five temperature estimates and 27 TSI series

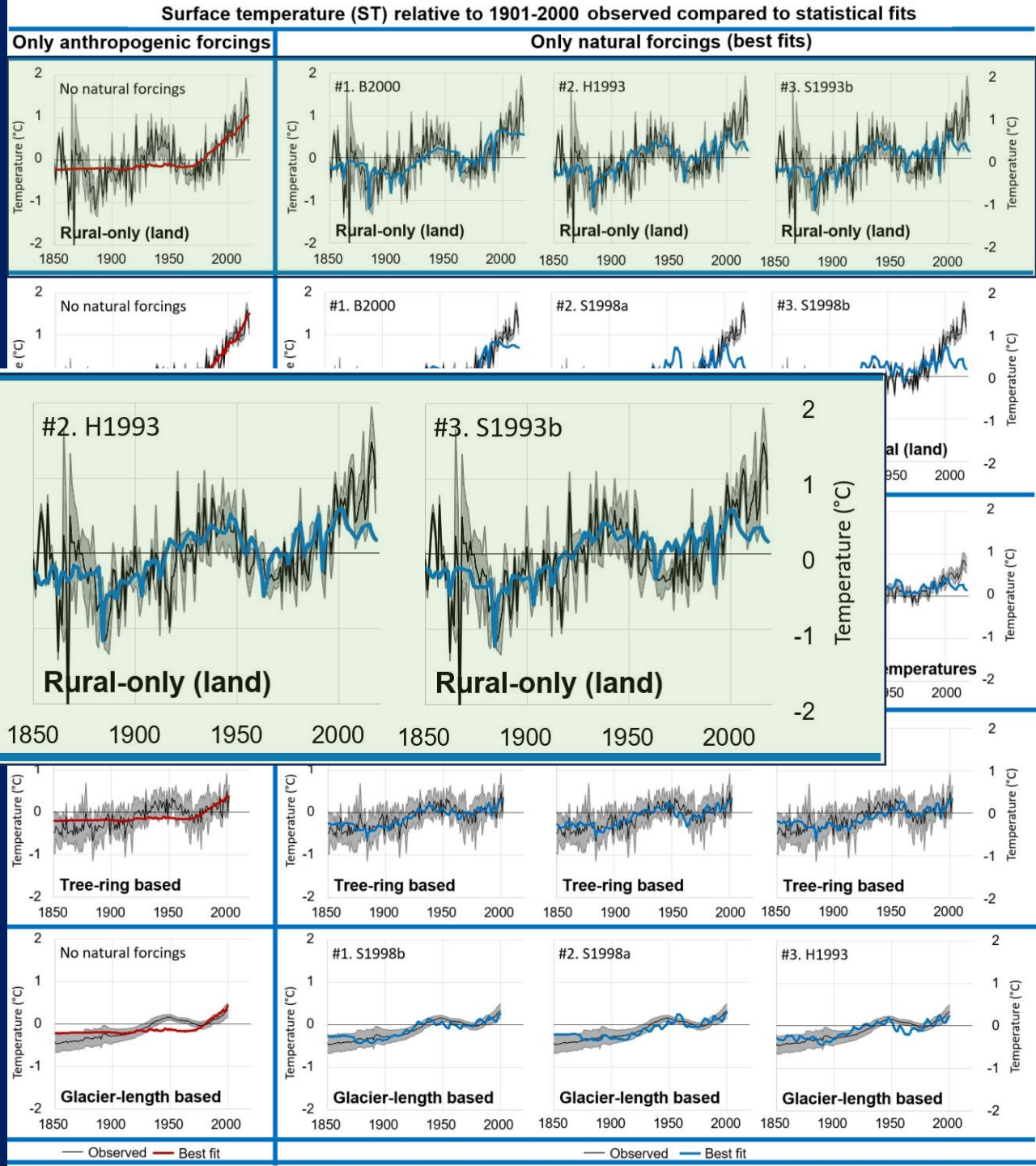
- If we look at the fits themselves, we find that the best-fitting ACRIM-calibrated TSI records capture the warming and cooling periods surprisingly well
- In contrast, the “only anthropogenic factors” can only really capture the recent warming since the 1970s
- We don’t know which of the 27 TSI is most accurate – but neither does the IPCC!!!



C2023: Five temperature estimates and 27 TSI series

- If we look at the fits themselves, we find that the best-fitting ACRIM-calibrated TSI r… p…
- In… c… si…
- We don't know which of the 27 TSI is most accurate – but neither does the IPCC!!!





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- records capture the warming and cooling periods surprisingly well

- In contrast, the “only anthropogenic factors” can only really capture the recent warming since the 1970s

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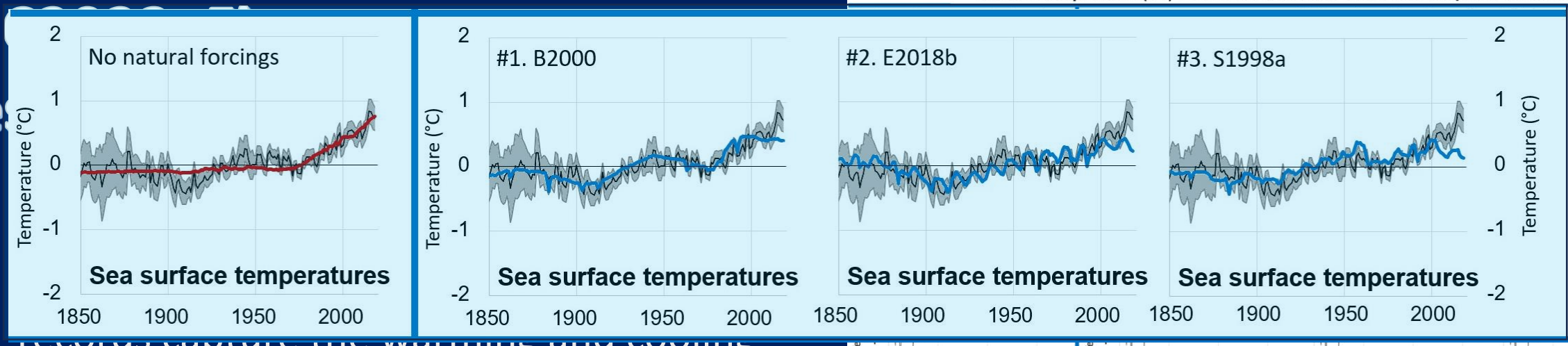

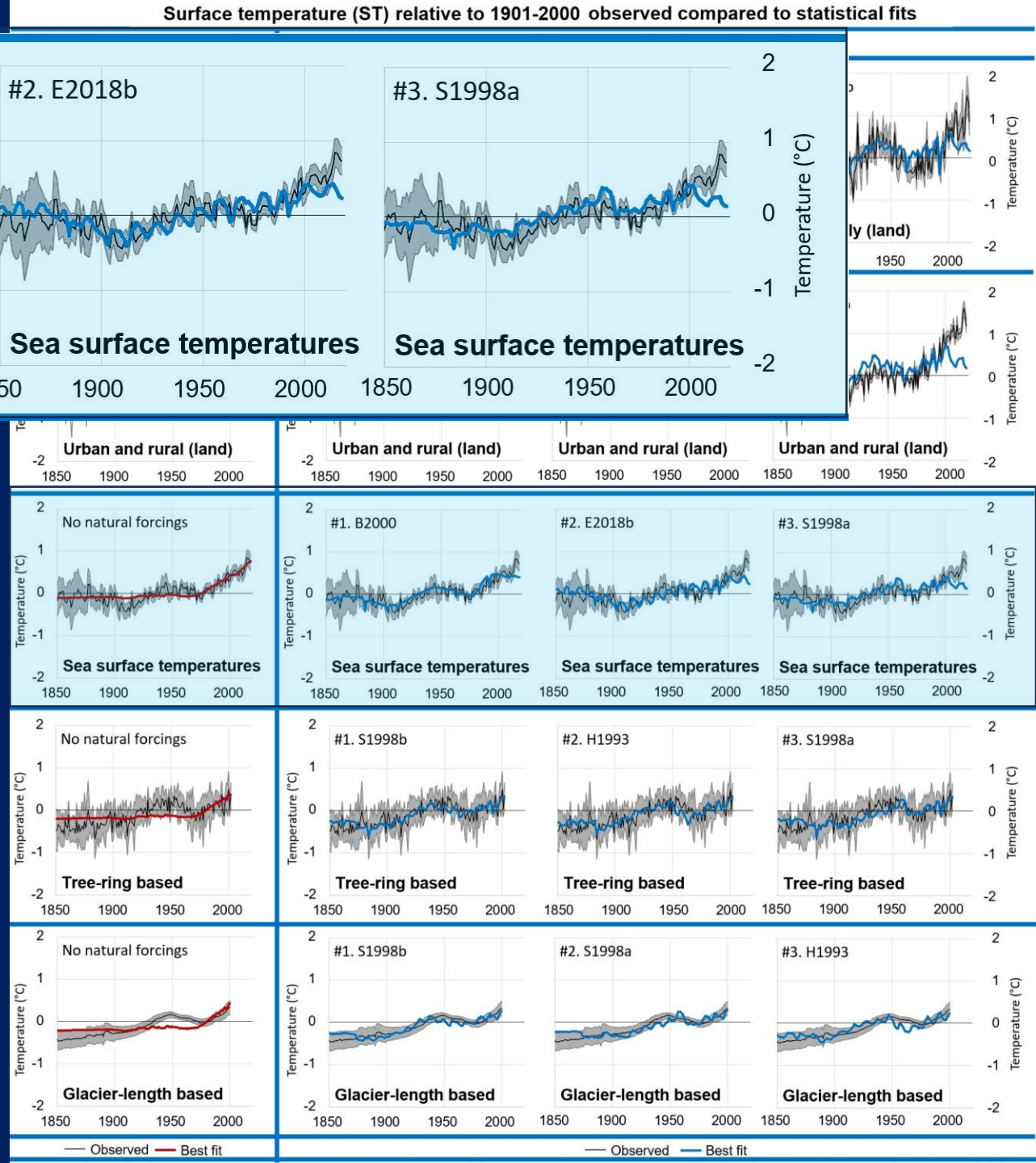

Ge… es…

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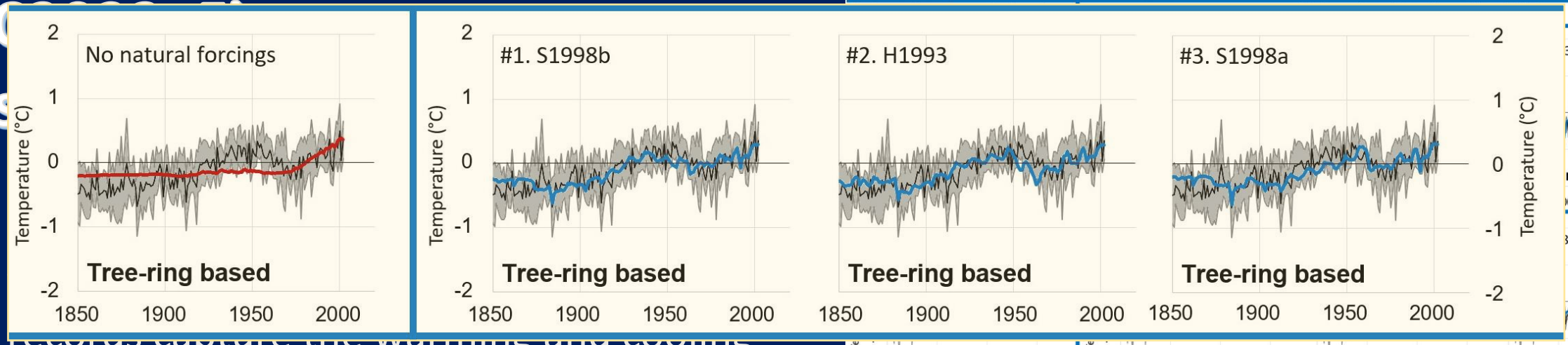

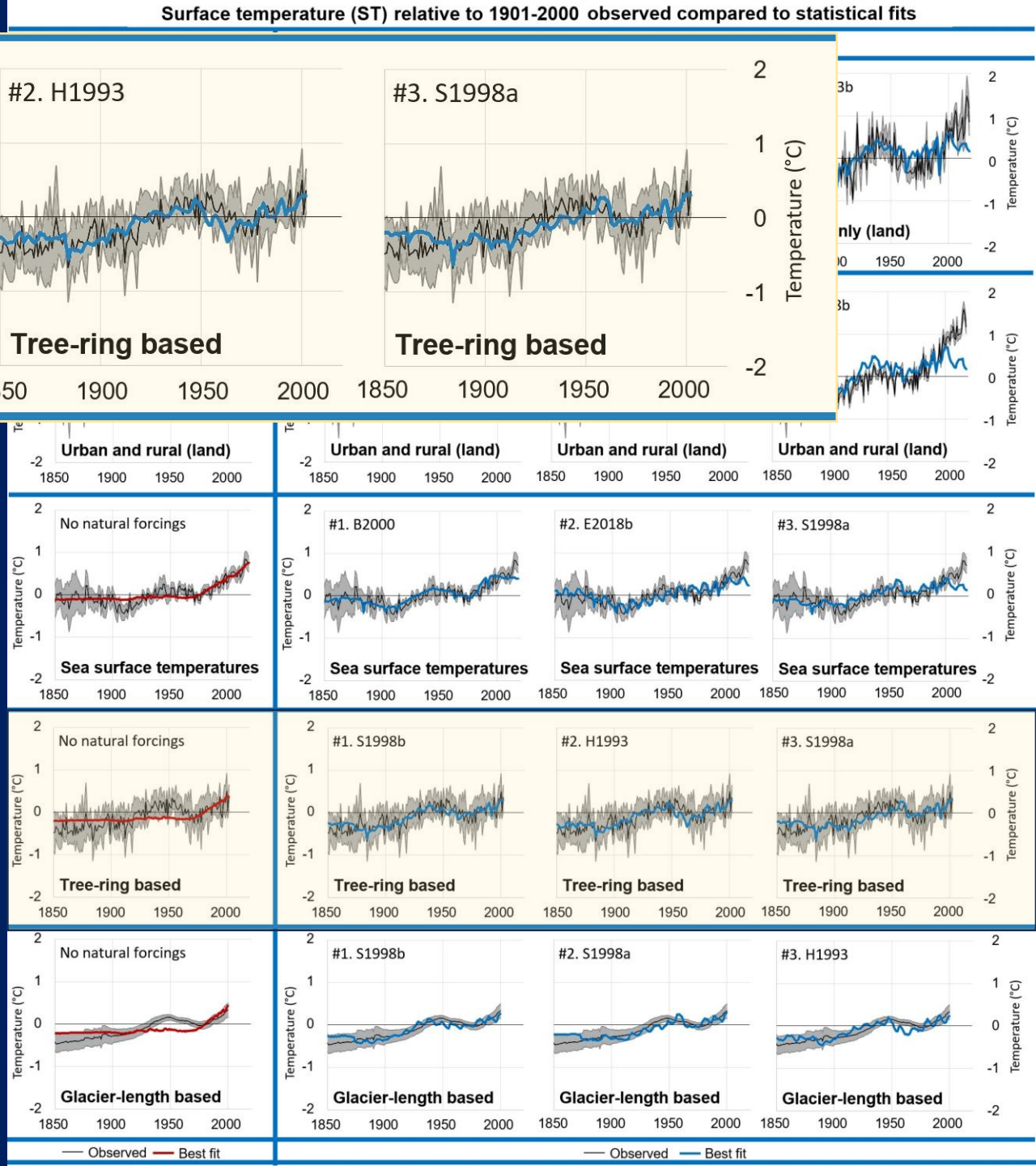

Conclusions

- The IPCC insist that urbanization bias is less than 10% of the warming and therefore doesn't need to be accounted for – They are wrong on this!

- The IPCC insist that they have already resolved the best solar activity ("TSI") records, for their latest 6th Assessment Report (2021), they only considered one estimate. But, we have found 27. They are wrong on TSI too!

- When we consider the non-urbanized temperature data, we can explain almost all the observed warming **and** cooling periods since 1850 in terms of changes in the Sun: whether looking at rural temperatures, ocean temperatures or temperature proxies (tree-rings and glaciers).

- The scientific community is not yet able to establish if the global warming since 1850 is: a) "mostly natural", b) "both natural and human-caused" or c) "mostly human-caused".

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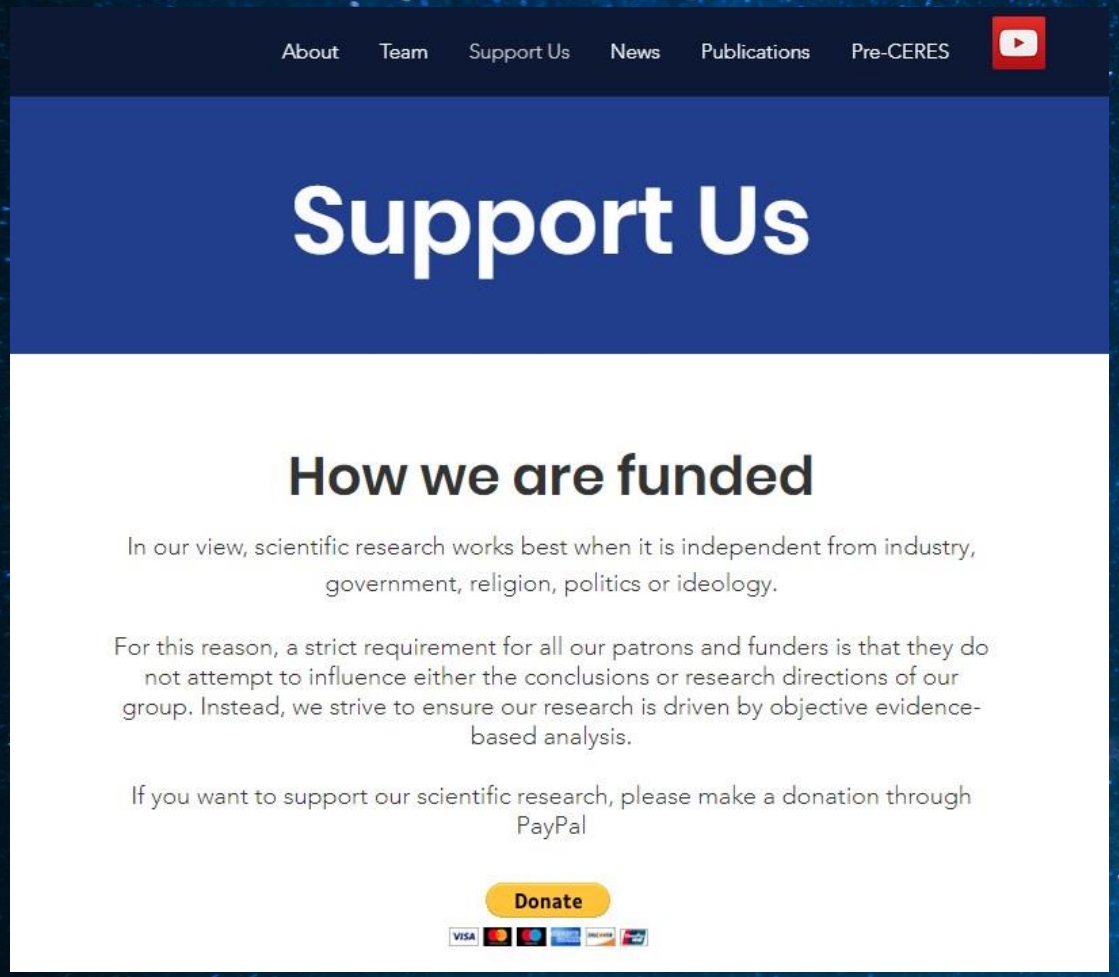

- If you think we are doing good work, you can support our efforts by making a donation at www.ceres-science.com
- **Our funding comes from donors like you that want us to actually follow science** instead of "Following The Science ™" like the IPCC
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- Or, simply spread the word about our work and our efforts!