Datasheet for Hueholt et al. "Assessing Outcomes in Stratospheric Aerosol Injection Scenarios Shortly After Deployment" [1]

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1. Purpose

A. For what purpose was the dataset created?

Motivation: Describe the reason for the creation of the dataset (e.g., to provide insight on a knowledge gap, or to carry out some specific task).

The dataset [2] corresponding to this datasheet was created to explore the climate response to two scenarios of stratospheric aerosol injection (SAI) climate intervention, with a focus on policy-relevant timescales after deployment. This dataset supports the goals of the U.S. National Academies of Sciences report [3] to "advance knowledge relevant to decision making" and "develop policy-relevant knowledge" about potential risks and benefits of SAI, particularly the "global- and regional-scale impacts," and the "distribution of impacts across different parts of the world." It is a subset of the pre-existing Geoengineering Large ENSemble (GLENS [4]), Assessing Responses and Impacts of Solar climate intervention on the Earth system with Stratospheric Aerosol Injection (ARISE-SAI-1.5 [5]), and CESM2(WACCM6) Historical [6] simulations including additional derived variables.

B. Who created the dataset (e.g., which individual or research group), on behalf of which entity (e.g., institution or company), and under what funding (e.g., grantor[s] and grant number[s])?

Motivation: Provide clarity about the authorship and funding source of the dataset.

The dataset [2] was created by Daniel M. Hueholt [Contact: daniel.hueholt@colostate.edu] as part of M.S. thesis work at Colorado State University advised by Prof. Elizabeth A. Barnes and Prof. James W. Hurrell. Funding was provided by the LAD Climate Fund, the Defense Advanced Research Projects Agency (DARPA, Grant HR00112290071), and National Science Foundation Graduate Research Fellowship Program (Grant 006784). The views, opinions, and/or findings expressed are those of the authors and should not be interpreted as representing the official views or policies of the Department of Defense or the U.S. government.

The full GLENS and ARISE-SAI-1.5 datasets were created by Tilmes et al. [4] with DARPA funding and Richter et al. [5] with funding through the SilverLining Safe Climate Research Initiative. CESM2(WACCM6) Historical [6] was produced by the National Science Foundation National Center for Atmospheric Research (NSF NCAR). GLENS, ARISE-SAI-1.5, and the CESM2(WACCM6) Historical were produced and maintained at NSF NCAR, a major facility sponsored by the National Science Foundation under Cooperative Agreement no. 1852977. The CESM project is supported primarily by NSF.

C. Was the author of the datasheet involved in creating the dataset? If not, please describe their relation to the dataset.

Motivation: Document the authorship of the datasheet, which may be different than the creator of the dataset.

The writer of this datasheet (DMH) was the creator of [2]. The GLENS and ARISE-SAI-1.5 modeling experiments were conducted by Tilmes et al. [4] and Richter et al. [5], and CESM2(WACCM6) Historical by Danabasoglu et al. [6].

D. What tasks has the dataset been used for? Please provide a description and/or citation(s); if there is a repository that archives uses of the dataset, provide a link.

Motivation: Document use cases of the dataset.

This specific dataset has been used for [1]. This datasheet does not archive uses of the the greater GLENS, ARISE-SAI-1.5, and CESM2(WACCM6) Historical datasets.

E. Any other comments?

Motivation: Space for any other relevant information about the creation of the dataset.

2. Structure and Processing

This section concerns technical aspects of the dataset. If documented elsewhere, provide a brief description and stable link (permanent reference, e.g., a DOI) in the relevant question(s).

A. What type(s) of data is/are contained in this dataset? (e.g., model output, observational data, reanalysis, etc.)

Motivation: Basic information about data classification. This dataset contains output from ensemble simulations with the Community Earth System Model (CESM) with Whole Atmosphere Community Climate Model (WACCM). GLENS uses CESM1(WACCM5) while ARISE-SAI-1.5 and CESM2(WACCM6) Historical use CESM2(WACCM6). Both GLENS and ARISE-SAI-1.5 contain parallel simulations: one following a climate change trajectory, and one where SAI is also deployed. GLENS and ARISE-SAI-1.5 both inject sulfur dioxide at multiple latitudes and use a proportional-integral feedback-control algorithm to maintain three climate targets: global mean temperature, the pole-to-pole temperature gradient, and the pole-to-equator temperature gradient. For a more complete summary of both experiments, see [1]. For details of GLENS and ARISE-SAI-1.5 see [4] and [5], respectively.

B. What is the data? (e.g., file format, dimensionality, variables, metadata, spatiotemporal coverage). Is there important metadata in the data filenames? If so, document this here.

Motivation: Provide format and characteristics of the data. All data files are in netCDF format. Files from each experiment are identified with the following tokens.

- **GLENS no-SAI (RCP8.5)** `control_*`
- **GLENS SAI** `feedback_*`
- **ARISE-SAI-1.5 no-SAI (SSP2-4.5)** `BWSSP245cmip6_*`
- **ARISE-SAI-1.5 SAI** `SSP245-TSMLT-GAUSS_*`
- **CESM2(WACCM6) Historical** `BWHIST_*`

The basic structure of each filename consists of the following pieces. Note these are near the 256-character maximum length imposed by many file systems.

- **id** Identifies the experiment, described above
- **rlz** The ensemble member
- **var** The variable name
- **YYYYMM1** The starting year and month
- **YYYYMMn** The ending year and month
  - The YYYYMM are chained together from each individual file when they are merged as part of processing
  - An identifier RG may also be present, indicating the data has been regridded from an ocean grid to lat-lon coordinates using `wrap_ocean_script`
- **ext** Some extra information about time contents of file (e.g., annual implies annual, sept implies September)

A filename is given by:
`id_rlz_var_YYYYMM1[...]_YYYYMMn_ext.nc`

The variables included and their basic properties are provided in the following list. Spatiotemporal coverage is described for the period 2010-2069 as this is the relevant range in [1].

- **Temperature [TREFHT]** 2m temperature from atmospheric model. Annual mean calculated from monthly data using cdo `yearmonmean`.
  - **Dimensions** time (variable) x lat (192) x lon (288)
  - **Units** Kelvin
  - **Spatiotemporal coverage through 2069**
    - **GLENS no-SAI (RCP8.5)** 21 members 2010-2030 with 4 extending through 2069, global
    - **GLENS SAI** 21 members 2020-2069, global
    - **ARISE-SAI-1.5 no-SAI (SSP2-4.5)** 10 members 2015-2069, global
    - **ARISE-SAI-1.5 SAI** 10 members 2035-2069, global
    - **CESM2(WACCM6) Historical** 3 members 2010-2014
- **Tropical nights [clxTR]** Annual tropical nights calculated from daily minimum 2m temperature using the Pyclimdex package [7].
  - **Dimensions** time (variable) x lat (192) x lon (288)
  - **Units** days/yr
  - **Spatiotemporal coverage through 2069**
    - **GLENS no-SAI (RCP8.5)** 20 members 2010-2030 with 3 extending through 2069, global
    - **GLENS SAI** 21 members 2020-2069, global
    - **ARISE-SAI-1.5 no-SAI (SSP2-4.5)** 5 members 2015-2069, global
    - **ARISE-SAI-1.5 SAI** 10 members 2035-2069, global
    - **CESM2(WACCM6) Historical** No data
- **Sea surface temperature [TEMP]** Annual sea surface temperature calculated by taking potential temperature from the top level of the ocean model. Annual mean calculated from monthly data using cdo `yearmonmean`. This data has been regridded from ocean grid to lat/lon grid using the Python implementation in `wrap_ocean_script`.
  - **Dimensions** time (variable) x lat (192) x lon (288)
  - **Units** degrees Celsius
  - **Spatiotemporal coverage through 2069**
    - **GLENS no-SAI (RCP8.5)** 21 members 2010-2030 with 4 extending through 2069, global
    - **GLENS SAI** 21 members 2020-2069, global
    - **ARISE-SAI-1.5 no-SAI (SSP2-4.5)** 10 members 2015-2069, global
    - **ARISE-SAI-1.5 SAI** 10 members 2035-2069, global

    * **CESM2(WACCM6) Historical** 3 members 2010-2014

- **Number of days with marine heatwaves [binary_mhw_pres]** Number of days with marine heatwaves at the point -30.628N, 112.5E. A binary timeseries of marine heatwave presence/absence is first calculated from daily sea surface temperature data using `marineHeatWaves` [8], implemented in accompanying Python code `fun_derive_data`. A 5-year left-aligned rolling sum of days is then applied to this data to smooth interannual variability.
  - **Dimensions** time (variable)
  - **Units** Days/yr
  - **Spatiotemporal coverage through 2069**
    * **GLENS no-SAI (RCP8.5)** 4 members 2010-2069, at point -30.628N, 112.5E
    * **GLENS SAI** 21 members 2020-2069, at point -30.628N, 112.5E
    * **ARISE-SAI-1.5 no-SAI (SSP2-4.5)** 10 members 2015-2069, at point -30.628N, 112.5E
    * **ARISE-SAI-1.5 SAI** 10 members 2035-2069, at point -30.628N, 112.5E
    * **CESM2(WACCM6) Historical** 3 members 2010-2014
    * Note the 3 Historical members and first 3 **ARISE-SAI-1.5 no-SAI (SSP2-4.5)** members have been merged into single files to simplify code
- **Sea ice extent [ICEEXTENT]** Sea ice extent calculated by summing grid cell area with ice fraction greater than 0.15 in the atmospheric model. February and September data are selected from monthly data using cdo `selmon`.
  - **Dimensions** time (variable) x lat (192) x lon (288)
  - **Units** km^2
  - **Spatiotemporal coverage through 2069**
    * **GLENS no-SAI (RCP8.5)** 21 members Feb+Sept 2010-2030 with 4 extending through 2069, global
    * **GLENS SAI** 21 members Feb+Sept 2020-2069, global
    * **ARISE-SAI-1.5 no-SAI (SSP2-4.5)** 10 members Feb+Sept 2015-2069, global
    * **ARISE-SAI-1.5 SAI** 10 members Feb+Sept 2035-2069, global
    * **CESM2(WACCM6) Historical** 3 members Feb+Sept 2010-2014, global
- **Precipitation [PRECT]** Precipitation calculated by summing the convective and stratiform precipitation in GLENS, or taking the total precipitation variable available by default in ARISE-SAI-1.5 and CESM2(WACCM6) Historical. Annual mean data is calculated from monthly output using cdo `yearmonmean`. Monsoon average precipitation is Jun-Sept mean where months selected from monthly output then averaged, corresponding to the Northern Hemisphere monsoon season.
  - **Dimensions** time (variable) x lat (192) x lon (288)
  - **Units** m/s (precipitation rate)
  - **Spatiotemporal coverage through 2069**
    * **GLENS no-SAI (RCP8.5)** 21 members 2010-2030 with 4 extending through 2069, global
    * **GLENS SAI** 21 members 2020-2069, global
    * **ARISE-SAI-1.5 no-SAI (SSP2-4.5)** 10 members 2015-2069, global
    * **ARISE-SAI-1.5 SAI** 10 members 2035-2069, global
    * **CESM2(WACCM6) Historical** 3 members 2010-2014, global
- **Simple intensity index [sdii]** Simple intensity index calculated from daily precipitation using `Pyclimdex` [7].
  - **Dimensions** time (variable) x lat (192) x lon (288)
  - **Units** mm/day
  - **Spatiotemporal coverage through 2069**
    * **GLENS no-SAI (RCP8.5)** 20 members 2010-2030 with 3 extending through 2069, global
    * **GLENS SAI** 21 members 2020-2069, global
    * **ARISE-SAI-1.5 no-SAI (SSP2-4.5)** 10 members 2015-2069, global
    * **ARISE-SAI-1.5 SAI** 10 members 2035-2069, global
    * **CESM2(WACCM6) Historical** 3 members 2010-2014, global

C. Is this dataset derived from a preexisting dataset? (e.g., variable[s] drawn from a modeling experiment). If so, please describe the process or link to the relevant paper.

Motivation: Describe whether a dataset is drawn or derived from a preexisting dataset.

This data is derived from a subset of the GLENS [4], ARISE-SAI-1.5 [5], and CESM2(WACCM6) Historical [6] modeling experiments. The subset presented here was selected to focus on the impacts of SAI on familiar climate variables on policy-relevant timescales after deployment. See [1] for more discussion of the specific variables and times of interest.

D. What processing, if any, has been applied to this data? Is any code used to process the data available? If so, please provide a stable link or other access point.

Motivation: Minimal description of the process to obtain the data described by this datasheet from its unprocessed form.

The processing for each variable is described in the answer to Question 2B. All code is available in the Python package included with the dataset [1]. Further updates may continue on GitHub at github.com/dmhuehol/SAI-ESM.

E. Is any unprocessed data available? If so, please provide a stable link.

Motivation: Clarify the location of unprocessed data to facilitate reproducibility or unforeseen future uses, if possible.

Data from GLENS, ARISE-SAI-1.5, and CESM2(WACCM6) Historical are found at the following archives.

- **GLENS:** doi.org/10.5065/D6JH3JXX
- **ARISE-SAI-1.5:** NSF NCAR Climate Data Gateway doi.org/10.5065/9kcn-9y79 (all SAI, 5 no-SAI members) and doi.org/10.26024/0cs0-ev98 (remaining 5 no-SAI members); or Amazon Web Services registry.opendata.aws/ncar-cesm2-arise/
- **CESM2(WACCM6) Historical:** in CMIP6 format from doi.org/10.22033/ESGF/CMIP6.11298. The raw version of CESM2(WACCM6) Historical directly used in this study is located on the NSF NCAR GLADE file space

F. Is any relevant information known to be missing from the dataset? If so, please provide an explanation.

Motivation: Document data missing or lost from the dataset.

See Question 2B for a description of data available for each variable. Not every ensemble member generated the same data for the same timespan due to limitations of computing availability. (This is not truly "missing" data, but should be noted when assessing the available data described here.)

Note that there may be missing data elsewhere in the GLENS, ARISE-SAI-1.5, or CESM2(WACCM6) Historical datasets. The answer here corresponds to the subset included in [2].

G. Are there known sources of noise, redundancies, or errors in the dataset? If so, please provide a description.

Motivation: Provide information about relevant known technical issues that affect all or portions of the dataset.

Daily minimum temperature data is only available for five members of the ARISE-SAI-1.5 no-SAI runs. In the other five, this data was unintentionally overwritten with daily mean temperature data. Thus, annual tropical nights can only be calculated for five ARISE-SAI no-SAI members.

Note that errors may exist elsewhere in the GLENS, ARISE-SAI-1.5, or CESM2(WACCM6) Historical datasets. The datasheet only provides information corresponding to [2].

H. Is the dataset self-contained? If external resources are involved, please describe them and any associated restrictions.

Motivation: Explicitly track external dependencies that may otherwise go unacknowledged.

This data [2] is self-contained in its ability to reproduce results from [1]. The Pyclimdex [7] and marineHeatWaves [8] Python packages used to derive data as described in Question 2B are not maintained by the author. The full GLENS, ARISE-SAI-1.5, and CESM2(WACCM6) Historical datasets are archived as described in Question 2D.

I. Any other comments?

Motivation: Space for any other relevant information about the structure and processing of the dataset.

3. Distribution and Maintenance

A. Is the dataset available to others? If not, why? If so, how will it be distributed (e.g., FTP, Earth System Grid, personal communication)? Is there a stable link?

Motivation: Document availability and access to the dataset.

[2] is archived at the Open Science Foundation doi.org/10.17605/OSF.IO/5A2ZF. GLENS, ARISE-SAI-1.5, and CESM2(WACCM6) Historical are archived at the locations described in Question 2E.

B. Who is/are the point(s) of contact for this dataset?

Motivation: Provide information about who is responsible for responding to inquiries about the dataset.

The point of contact for [2] is Daniel M. Hueholt [Contact: daniel.hueholt@colostate.edu].

As of the time of last revision to the datasheet (March 2024), the current points of contact for GLENS were provided at cesm.ucar.edu/community-projects/glens and ARISE-SAI at cesm.ucar.edu/community-projects/arise-sai. Note these links are NOT stable and may break without warning. The point of contact for CESM2(WACCM6) Historical is unclear.

C. Will the dataset be updated in the future (e.g., to add new data)? If so, will older versions continue to be available?

Motivation: Clarify whether this version of the data is final.

This data accompanies [1] and updates are not anticipated.

D. What license or other terms of use apply to the dataset? Please link to any relevant licensing terms or terms of use (if in the public domain, simply state this).

Motivation: Provide information about what future uses of the data are permitted.

This dataset is a work in the public domain. The code repository accompanying this dataset is hosted under the GNU General Public License 3.0 (included as LICENSE.txt).

E. Is there a document that describes an important error in this dataset (e.g., an erratum)? If so, please provide a link or other access point.

Motivation: Document any corrections to the dataset.

No erratum currently exists. Any future corrections will be recorded here in the datasheet.

F. Who is hosting the datasheet? Will the datasheet be updated in the future?

Motivation: Document stable access to the datasheet.

This datasheet is stably hosted on the Open Science Foundation in the same archive as the data (doi.org/10.17605/OSF.IO/5A2ZF). The point of contact is Daniel M. Hueholt [Contact: daniel.hueholt@colostate.edu]. Changes to the datasheet are recorded in the changelog of the OSF repository. Since this datasheet serves as a "demo" for the Datasheets for Earth Science Datasets project (github.com/dmhuehol/Datasheets-for-Earth-Science-Datasets), it receives regular updates to match current format standards.

G. Any other comments?

Motivation: Space for any other relevant information about data distribution and maintenance.

4. Data-dependent questions

Responses in this section will depend on the type(s) of data within the dataset. Questions that do not apply can be left blank.

A. How was the data generated or collected (e.g., model runs, reanalysis processes, observational measurements)? Please provide relevant citation(s); if none exist, describe why.

Motivation: Establish fundamental information about the methods used to generate or collect data in the dataset.

This dataset is a subset of the greater GLENS, ARISE-SAI-1.5, and CESM2(WACCM6) Historical simulations in CESM1(WACCM5) and CESM2(WACCM6). Processing to obtain this data [2] from the original datasets is described in Section 2.

B. Has the data been assessed against some baseline(s) (e.g., an observational product or physical laws)? If so, describe how, and provide any relevant citations.

Motivation: Document evaluation of the data within the scope of this datasheet.

CESM(WACCM) evaluates well against stratospheric observations in the mean state and under volcanic aerosol loading [9], [10], i.e. it is adequate for the purpose of simulating the climate response to SAI. The performance of CESM1(WACCM5) and CESM2(WACCM6) has been evaluated in depth for many products in the citations provided in Question 4F.

C. Has uncertainty quantification been carried out for this dataset? If so, describe how and provide citation(s).

Motivation: Provide information about known uncertainties.

Uncertainty quantification within CESM is discussed in [11] for CESM1 and [6] for CESM2.

D. Did the method of generation or collection of the data change within the scope of the dataset?

Motivation: Describe important changes to instruments or methodology within the dataset.

None known.

E. Are there any unexplained but relevant numerical values ("magic numbers") that go into the data generation, collection, or processing? (e.g., calibration constants, hyperparameters)

Motivation: Define unique numerical values that exist within or impact this data, but may not be documented elsewhere.

The following "magic numbers" appear in the accompanying Python code. They are documented with in-line comments and compiled here for completeness.

- Standard date fill values 7,15,12,0,0,0 (month, day, hour, minute, second, microsecond) or 1,1,0,0 (month, day, hour, minute, second) where arbitrary times must be inserted
- A 5-year left-aligned rolling sum of days applied to the marine heatwaves data to smooth interannual variability
- The exact latitude size of cells in the model is 0.94240838°
- Robustness thresholds of 15 SAI members outside of 11 no-SAI members for GLENS and 7 SAI members outside of 6 no-SAI members in ARISE-SAI. For a description of robustness, see [1].

F. Was a model used to generate data in this dataset? If so, please describe the configuration and any modifications.

Motivation: Record the exact model setup used to create data. The model was not altered as part of the project at hand. No original model runs were completed in [1]. GLENS used CESM1(WACCM5) [11], [9]. ARISE-SAI-1.5 and CESM2(WACCM6) Historical utilized CESM2(WACCM6) [6], [12].

G. Is this dataset an ensemble? If so, how many members are there? Are there any differences between members? Describe the perturbation of the members, and any relevant sampling limitations (e.g., ocean states).

Motivation: Describe the sampling, construction, and any important limitations of the ensemble.

GLENS, ARISE-SAI-1.5, and CESM2(WACCM6) Historical are single-model initial condition ensembles. GLENS does not disperse ocean internal variability (see Question 4J). See Question 2B for coverage for each variable.

- **GLENS:** 21 ensemble members. GLENS originally contained 20 members [4]; the 21st member was added later.
- **ARISE-SAI-1.5:** 10 ensemble members. The no-SAI simulations were run in two sets: five members are SSP2-4.5 simulations completed for CMIP6, while five more were run later to augment ARISE-SAI-1.5 sample size.
- **CESM2(WACCM6) Historical**: 3 ensemble members

H. Are there relevant categories, groupings, or labels within the data? If so, how are these determined?

Motivation: Document group definitions within the data.

None beyond separation of parallel SAI/no-SAI simulations.

I. Can users contribute to this dataset (e.g., citizen science or human labeling)? If so, please describe the process including evaluation or verification.

Motivation: Describe if the data includes user contributions.

Users cannot contribute directly to this dataset.

J. Are there specific tasks for which the dataset should not be used? If so, please provide a description.

Motivation: Address relevant gaps or inadequacies of the data for specific use cases.

- GLENS was run without interactive tropospheric trace gas chemistry or ocean biogeochemistry. Thus, GLENS data cannot be used to explore these processes.
- The ocean state in all GLENS members is branched off of the first member of the CESM Large Ensemble in which the Atlantic Meridional Overturning Circulation is strengthening. Until the memory of the initial conditions dissipates, GLENS does not disperse ocean internal variability.

[2] is a subset of the GLENS, ARISE-SAI-1.5, and CESM2(WACCM6) Historical datasets intended for reproducibility of [1]. For original new research, future users are encouraged to build off of the full GLENS, ARISE-SAI-1.5, or CESM2(WACCM6) Historical datasets.

K. What are the direct or downstream impacts on humans from this dataset? The non-comprehensive checklist below is intended to prompt the author to think of common impacts from data. Please check all that apply, and include a brief text description with stable links to any references. Additionally, please document potential impacts relevant to the scope of the dataset that are not included on the checklist.

Motivation: Reflect on potential impacts (direct or downstream) of the dataset.

Direct

✓ Does this dataset support reproducibility of a specific scientific finding or figure?
☐ Were there notable CO_2 emissions in creating this dataset? (e.g., from large machine learning models)
☐ Were there notable land use impacts from equipment? (e.g., in situ instruments during a field experiment)
☐ Was this dataset created through co-production of research? (e.g., for fieldwork in vulnerable communities)
☐ Does this dataset include identifying information? (e.g., community-level data, social information)

Downstream

☐ Is this dataset intended for development of a research tool? (e.g., model improvement, sensor design)
☐ Does this dataset support further use for novel research? (e.g., unrelated scientific studies)
✓ Would analysis of this dataset be policy relevant? (e.g., climate, environmental, public health issues)
☐ Would this dataset be considered actionable science? (e.g., completed with use by a specific stakeholder in mind)
☐ Could this dataset inspire behavioral changes? (e.g., change agricultural practices, city planning)
☐ Could this dataset affect operational forecasting? (e.g., improve models, forecasting, predictability)

This dataset supports reproducibility of [1], and is intended to explore questions and support discussion related to the global and regional climate responses to stratospheric aerosol injection climate intervention, consistent with the goals of [3]. We explicitly distinguish these goals from research on deployment technologies, which are discouraged at present due to ethical and governance concerns [3].

A large body of literature discusses the ethics of climate intervention. The author suggests e.g. [3], [13], [14], [15], [16] as a sample for readers interested in engaging with some of the different perspectives on this topic.

GLENS and ARISE-SAI-1.5 differed in aspects of their experimental design. We summarize these differences and their implications in [1]; [17] specifically untangles these issues. In brief, differences include the model version, greenhouse gas forcing scenario, temperature target, SAI deployment year, method of causing ensemble spread, and injection height of the sulfur dioxide. GLENS and ARISE-SAI-1.5 provide high-fidelity depictions of two scenarios of SAI intervention, but the results are specific to these scenarios and should not be assumed to be true of any general SAI scenario.

L. What biases were present in the construction or use of the dataset? The checklist below provides a non-comprehensive list of common examples in Earth science. Please check all that apply, and include a brief text description with stable links to any references. Additionally, please document any biases within the scope of the dataset that are not included in the checklist.

Motivation: Reflect on potential biases present in the dataset.

- ✓ Geographic bias (e.g., restricted or weighted to specific regions)
- ✓ Model bias (e.g., error relative to evaluation product)
- ☐ Sensor bias (e.g., calibration)
- ☐ Temporal bias (e.g., diurnal cycle, restrictions on detection)
- ☐ Seasonal bias (e.g., seasonal cycle)
- ☐ Bias towards extreme or standard conditions (e.g., catchment error, failure to represent extremes)
- ☐ Unbalanced sampling (e.g., unequal classes)
- ☐ Adversarial impacts on data (e.g., fraudulent samples in crowdsourced data)
- ☐ Label bias (e.g., subjective labeling)
- ✓ Threshold sensitivity (e.g., for an extreme index)
- ☐ Regime dependence (e.g., convective structure, mode of variability)
- ☐ Selection bias (e.g., case studies, survivorship effects, loss of historical data over time)

Marine heatwaves were calculated for a single grid point off the coast of Western Australia (30.63°S, 112.5°E), which frequently experiences marine heatwaves with substantial negative impacts to local ecology (e.g. [18], [19]). All other data in this dataset has global coverage.

CESM1(WACCM5) and CESM2(WACCM6) contains important biases and errors relative to the real world. See [11], [6], [17] for comprehensive documentation of model performance.

In general, all Earth system model output is most reliable and verifiable where observational datasets are easily available to test, evaluate, and constrain the model. Appropriate long-term observational datasets are sparse over much of the world, particularly in the Global South. It is important to evaluate model performance before making specific quantitative claims in these areas.

The Climdex extremes [20] and marine heatwave definitions [21] include thresholds in duration and intensity of events.

M. Any other comments? Are there any other citations necessary to document some important aspect of the data? If so, provide the citation(s) and describe their purpose.

Motivation: Space for any other relevant information.

References

[1] Daniel M. Hueholt, Elizabeth A. Barnes, James W. Hurrell, Jadwiga H. Richter, and Lantao Sun. Assessing Outcomes in Stratospheric Aerosol Injection Scenarios Shortly After Deployment. *Earth's Future*, 11(5):e2023EF003488, 2023. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1029/2023EF003488.

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