CyberWay Annual Report Form

The following table is a copy of the annual report form on <http://www.research.gov>. Please fill in the form and return it together with supplement documents (if any) to Dr. Ziheng Sun ([zsun@gmu.edu](mailto:zsun@gmu.edu)). Dr. Sun will organize and combine them into one report for Professor Di’s review before the final submission.

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**Accomplishments - What was done? What was learned?**

If there is nothing significant to report during this reporting period, please check "Nothing to Report" if applicable.

\* Required fields

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* **\* What are the major goals of the project?** Characters Remaining: **8000**

This project will build a production system of systems integrating EarthCube building blocks, particularly BCube, CyberConnector, CHORDS, and GeoWS, to advance geosciences research through improved interoperability and integration across diverse polar science and atmospheric science research, methods, and resources. Named CyberWay, the system is built through connecting Earth observations, polar science outcomes, and climate model outcomes via the EarthCube architecture. The system itself will also become an element of the EarthCube infrastructure.

In CyberWay, infrastructures and technologies from two building blocks – Bcube and CyberConnector – will be adapted to operate together to achieve the discovery of observations and data as well as the registration and publication of model outcome metadata in a standard catalogue system.

In CyberWay, the connection to real-time data in CHORDS will be established to provide the capabilities to access the real-time sensor data. A unified data access mechanism is enabled with open standards like OGC WCS, WFS, WMS, or OPeNDAP protocols.

The data pre-processing, integration, and assimilation services (PIAS) of CyberConnector provide several types of pre-processing steps that need to be run to prepare data for inter-comparison or validation, including re-formatting, units homogenization, re-projection, scaling and assimilation/interpolation. CyberWay will reuse the conventional tools scientists usually use and wrap and link them to automate the data preprocessing workflow. PIAS has a model construction service for experts to construct geospatial processing models.

CyberWay is designed to enable enhanced dissemination of model outputs by integrating the capabilities of CyberConnector and BCube in product dissemination. ISO 19115-1, ISO 19115-2, and ISO 19157 are the standards to be supported in encoding the metadata, data quality, and provenance of model outputs. The standard access interface OGC web services will be supported to allow easy access using standard-compliant software. The outputs will be viewed in browsers without specific requirements at the users’ end.

Showcase the value of CyberWay in facilitating the collaboration and fostering knowledge discovery by a use case in a climate teleconnection experiment via taking multiple data sources as inputs and integrating various models.

* **\* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**  more information about what was accomplished under these goals
  + Major Activities: Characters Remaining: **8000**
* Developed and updated the technical framework of CyberWay prototype according to requirements surveyed among the member scientists. The COVALI framework includes three major items: 1) data searcher: cataloging the data from Thredds Data Server and some other standards (REST, OAI-PMH, CSW and OpenSearch); 2) data processing functionality: wrapping and providing general tools from interpolation, regridding, reformatting, and reprojection; 3) data renderer: rendering and displaying data on web-based maps simply and responsively. (GMU CSISS/OMS Tech/GMU COLA/OSU)
* Opened accounts for CSISS to access the huge volume of data on COLA server and UCAR server. (GMU CSISS)
* Opened accounts for OSU to upload sample datasets to CyberWay server. (GMU CSISS)
* Retrieved the data from COLA and OSU and studied their internal data structures to understand their commons and differences. Read papers published by COLA and OSU to get an overview impression on the teleconnection models and reanalysis products. (GMU CSISS)
* Developed an initial version of COVALI for the inter-comparison and validation of atmospheric models based on the EarthCube building block CyberConnector. (GMU CSISS)
* Developed an initial version of Geoweaver, derived from the model construction software of CyberConnector, for the linking and automation of feeding Earth observation into geoscience models and disseminating model outputs. (GMU CSISS)
* Attended the EarthCube all hands meeting to learn from colleagues’ work and communicate with collaborators like Mike Daniels (CHORDS PI) and Mohan (GeoWS Co-I). (GMU CSISS/GMU COLA)
* Participated in monthly Cyberway meetings. Meeting minutes are posted online (<https://github.com/CSISS/CyberWay/tree/master/docs>). (OSU/GMU CSISS/GMU COLA/OMS Tech)
* Demonstrated the COLA teleconnection models and experiments on California drought. Showcase the world-renowned software – GrADS and wgrib, which are widely used by atmospheric scientists. Explained the entire workflow and research routine of a climate scientist. (GMU COLA)
* Learned the teleconnection models might use a long list of data sources which may be considered as model inputs or observation for validation, such as Model NMME North America MultiModel Ensemble, Global Modeling and Assimilation Office dataset, CPC Global Unified Cauge-based Analysis of Daily Precipitation, and Extended reconstructed Sea Surface Temperature (ERSST). BCube’s crawler and broker could help find and retrieve the datasets. (GMU COLA/GMU CSISS/OMS Tech)
* Discussed the availability of existing catalog services in COLA to remotely querying and downloading data. Make it clear that the data is too big to move around. It will be very slow if using the conventional data indexing and processing schema. (GMU COLA)
* Introduced the ASR dataset (No. DS363.1) to the entire team,including how to access and download from the NCAR RDA server. The product is in netCDF-4 HDF-5 CF-1.4 format. The RDA server provides a series of web services like TDS (Thredds Data Service), FTP, Globus, and CSW. Introduced the historical products are archived on tapes and there is a system to automatically mount and load the data. (OSU)
* Provided intellectual input and technical suggestions on the development of CyberWay. Suggested that the project should be flexible as the polar researchers are mostly using different spatial reference systems than the web mecator. The maps should support rotation so that scientists can examine the data from their comfortable angle. It is better to enable the modification of the data units or scale so scientists can compare data in the consistent grid or unit. 3D data and software is rare in atmospheric domain at present. Need more thinking on data uploading file maximum limit and how to handle the situation for distributed processing. Take a deep look at the currently popular software and analyze their advantage and how they are so successful in driving scientists to engage and enlarge its user community. Learn from them and create a practical solution for not only the teleconnection use case, but also other models in Earth science. (OSU/COLA/OMS Tech)
* More detailed suggestions on developing COVALI:
  + Enable checking the value of a place by clicking on it
  + Enable checking the variable description stored in GRIB
  + Show legend for both maps
  + Enable contour line style rendering
  + Ability to show map underneath (boundaries)
  + Animated data in time
  + Calculate difference map
  + Spatial analysis by point, bounding box or polygon
  + Showing the altitude, longitude, and label boxes which are useful but not critical. (GMU COLA)
* High resolution ASRv2, 15-km (2000-2016) has been produced and been delivered to NCAR RDA server. (OSU)
* Provide sample ASR data and short document to GMU CSISS. (OSU)
* Configuration of the Service Status Checker for integration into the CyberWay architecture, as well as write documentation for its use. (OMS Tech)
* Research into the reuse of the BCube Broker and its configuration for integration into the CyberWay architecture. (OMS Tech)
* Instantiation and building of the Web Crawler in order to test it and integrate it into the CyberWay architecture.(OMS Tech)

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* + Specific Objectives: Characters Remaining: **8000**

**GMU CSISS objective:**

* Integration of global and regional climate model outcomes for teleconnection studies across multiple disciplines
* Inter-comparison and validation across models
* Streamlined process for models
* Enhanced dissemination

**OSU objective:**

* Produce and provide ASR data access (through NCAR CISL) for CyberWay.
* Provide ASR data support to CyberWay.
* Provide intellectual input for EarthCube Cyberway project.
* Advise the development of CyberWay system of systems from user perspective
* Test the developed CyberWay prototype and provide scientist opinions
* Participate in an integrated teleconnection analysis between COLA products and OSU products to enable new scientific discovery, e.g., the connection of Arctic changes to mid-latitude and tropical climate dynamics.

**OMS Tech objective:**

* Successfully integrate the EartCube BCube components into the CyberWay architecture, allow them to be reusable, and to provide appropriate documentation as to how they are used. The components to be provided by OMS Tech include:
  + Broker (provided by CNR to BCube)
  + Web Crawler (provided by NSIDC)
  + Service Status Checker (provided by FGDC to BCube)
* Publish the endpoints, custom client code, and documentation for use of the Service Status Checker.
* Publish the endpoints, custom client code (based on API), and documentation for use of the Broker.
* Publish the endpoints, custom client code, and documentation for use of the crawler.

**GMU COLA objective:**

* Provide access to COLA products.
* Introduce the research routine workflow from scientist perspective.
* Provide support on both GrADS software and data sources.
* Provide scientist opinions to the development of CyberWay prototype
* Try and evaluate CyberWay in teleconnection studies
* Examine data from both observations and seasonal forecasts to better understand the relationship between polar region climate and California rainfall/drought.

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* + Significant results: Characters Remaining: **8000**

Southern California seasonal rainfall is heavily influenced by unpredicted atmospheric variability. Provides an explanation for why the expected enhanced rainfall during the 2015/16 El Niño event did not materialize.

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* + Key outcomes or Other achievements: Characters Remaining: **8000**

The initial version of COVALI and Geoweaver has been implemented and the source code has been published on GitHub (<http://github/CSISS/cc>).

The metadata harvester and searcher of Thredds Data server has been implemented and the source code has been published on GitHub (<https://github.com/CSISS/cc-thredds-pycsw>).

ASRv2, 15-km (2000-2016) data is available at NCAR CISL RDA server <http://rda.ucar.edu/datasets/ds631.1>

The Service Status Checker has been tested and custom client code is being written, along with user documentation.

The Crawler is being instantiated and configured for testing.

An open source EarthCube broker has been identified as an option for the CybereWay project.

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* **\* What opportunities for training and professional development has the project provided?**

more information about opportunities for training and professional developmentmore information about opportunities for training and professional developmentNothing to report

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* **\* How have the results been disseminated to communities of interest?**

Nothing to report



Attended ESIP winter meeting, AAG, EarthCube All hands meeting to present our work to the communities via posters and sessions.

* State-of-the-art Trends in Big Data Cyberinfrastructure, Social Media and Spatialtemporal Analysis, AAG 2018 Session.
* Building a highspeed CyberWay to Geospatial Cyberinfrastructure, AAG 2018 talk
* Substantial exercises of Cyberconnector on atmospheric science datasets and models, EarthCube All hands poster

Publication in peer-reviewed journals, communication with forecasters and users of climate data via professional conferences and telecons.

ASR data has been generated a wide variety of interests in Arctic research communities. The citations could reflect that:

Akperov et al., 2018: Cyclone activity in the Arctic from an ensemble of regional climate models (Arctic CORDEX). J. Geophys. Res.: Atmospheres, 123, 2537-2554, https://doi.org/10.1002/2017/JD027703.

Bromwich, D., A. Wilson, L. Bai, Z. Liu, M. Barlage, C. Shih, S. Maldonado, K. Hines, S.-H. Wang, J. Woollen, B. Kuo, H. Lin, T. Wee, M. Serreze, and J. Walsh, 2018: The Arctic System Reanalysis Version 2. Bull. Amer. Meteor. Soc., 99, 805-828, doi: 10.1175/BAMS-D-16-0215.1.

Kohnemann, S. H. E., G. Heinemann, D. H. Bromwich, and O. Gutjahr, 2017: Extreme warming in the Kara Sea and Barents Sea during the winter period 2000-2016. J. Climate., 30, 8913-8927, doi: 10.1175/JCLI-D-16-0693.

Kolstad, E. W., 2017: Higher ocean wind speeds during marine cold air outbreaks. Q. J. R. Meteorol. Soc., 143, 2084-2092, doi: 10.1002/qj.23068.

Smirnova, J., and P. Golubkin, 2017: Comparing polar lows in atmospheric reanalyses: Arctic System Reanalysis versus ERA-Interim. Mon. Wea. Rev., 145, 2375-2383, doi: 10.1175/MWR-D-16-0333.1.

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* **\* What do you plan to do during the next reporting period to accomplish the goals?**
* Nothing to report

Finish the development of COVALI and Geoweaver.

Establish the connection among CyberConnector, BCube, CHORDS and GeoWS. Make these resources available at one place for scientists to take advantage of.

Implement the teleconnection experiment on COVALI and Geoweaver to showcase its benefits over the conventional methods.

Finish the ongoing analysis of rainfall and its remote association (teleconnections) with slowly varying components of the climate system. In particular, the droughts in the western United States and southern Africa.

Complete ASR 2017 run, and deliver it to NCAR CISL RDA server.

An integrated teleconnection analysis on COLA products and OSU products will be performed, to examine the connection of Arctic changes to mid-latitude and tropical climate dynamics.

Assist the GMU CSISS team in the successful integration of all components and documentation.

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**Supporting Files**

You may upload pdf files with images, tables, charts, or other graphics in support of this section. You may upload up to 4 pdf files with a maximum file size of 5 MB each.

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 **Please select a file.**

 Description (required if uploading a file). Please provide a description of the content contained in the attached file.

**Products**

**(Ziheng to all: please list your products here in any way you want. I will sort out them later. )**

**Submit New Product(s)**

Select the type of product you want to add to your report or upload multiple products using BibTex file.

Select Product:

Book

Book Chapters

Invention

Journal or Juried Conference Paper

License

Other Conference Presentation / Paper

Other Product

Other Publications

Patent

Technologies and Techniques

Thesis / Dissertation

Website

**Journal or Juried Conference Paper**

**Sun, Z., etc. 2018: Building a highspeed CyberWay to Geospatial Cyberinfrastructure, AAG, New Orleans, LA.** [**https://aag.secure-abstracts.com/AAG%20Annual%20Meeting%202018/abstracts-gallery/12702**](https://aag.secure-abstracts.com/AAG%20Annual%20Meeting%202018/abstracts-gallery/12702)

**Sun, Z., Di, L., Fang, H., 2018: Using long short-term memory recurrent neural network in land cover classification on Landsat and Cropland data layer time series, International Journal of Remote Sensing, in press.**

**Bromwich, D., A. Wilson, L. Bai, Z. Liu, M. Barlage, C. Shih, S. Maldonado, K. Hines, S.-H. Wang, J. Woollen, B. Kuo, H. Lin, T. Wee, M. Serreze, and J. Walsh, 2018: The Arctic System Reanalysis Version 2. Bull. Amer. Meteor. Soc., 99, 805-828, doi: 10.1175/BAMS-D-16-0215.1.**

**Bromwich et al., 2018: Arctic System Reanalysis provides high-resolution accuracy for Arctic studies. SCAR/IASC Open Science Conference, June 19-23, 2018, Davos, Switzerland.**

**Bromwich et al., 2017: Improving the representation of the Greater Arctic with ASRv2. 5th International Conference on Reanalysis (ICR5), November 13-17, 2017, Rome, Italy.**

**Bromwich et al., 2017: The Arctic System Reanalysis. MOSAiC Implementation Workshop, November 13-16, 2017, St. Petersburg, Russia.**

**Other Product**

**Data:**

**NCAR CISL RDA server, ASR data** [**https://rda.ucar.edu/datasets/ds631.1/**](https://rda.ucar.edu/datasets/ds631.1/)

**Websites:**

**CyberWay portal:** [**http://cube.csiss.gmu.edu/CyberWay**](http://cube.csiss.gmu.edu/CyberWay)

**CyberConnector Portal:** [**http://cube.csiss.gmu.edu/CyberConnector**](http://cube.csiss.gmu.edu/CyberConnector)

**OSU Polar Meteorology Goup, ASR web:** [**http://polarmet.osu.edu/ASR/**](http://polarmet.osu.edu/ASR/)

**NCAR CISL RDA, ASR web:** [**https://rda.ucar.edu/datasets/ds631.1/**](https://rda.ucar.edu/datasets/ds631.1/)

**NCAR Climate Data Guide, ASR web:**

[**https://climatedataguide.ucar.edu/climate-data/arctic-system-reanalysis-asr**](https://climatedataguide.ucar.edu/climate-data/arctic-system-reanalysis-asr)

Source Code:

<https://github.com/CSISS/CyberWay>

<https://github.com/CSISS/cc/>

<https://github.com/CSISS/cc-thredds-pycsw>

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--OR--

Nothing to report

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**Supporting Files**

You may also upload PDF files with images, tables, charts, or other graphics in support of this section. You may also upload up to 4 PDF files with a maximum file size of 5 MB each.

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 **Please select a file.**

 Description (required if uploading a file). Please provide a description of the content contained in the attached file.



### **Participants & Other Collaborating Organizations - Who has been involved?**

For NSF purposes, for separately submitted and awarded collaborative proposals, the PI should report progress on his/her institution's portion of the collaborative effort only.

In each of the subsections below, note which collaborators or contacts are involved in data contribution and/or management.

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* \* Required fields
* **\* What individuals have worked on the project?**

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| [**Name**](https://reporting.research.gov/rppr-web/rppr?d-7822565-p=1&d-7822565-o=2&d-7822565-s=0&execution=e1s6) | [**Most Senior Project Role**](https://reporting.research.gov/rppr-web/rppr?d-7822565-p=1&d-7822565-o=2&d-7822565-s=1&execution=e1s6) | [**Nearest Person Month Worked**](https://reporting.research.gov/rppr-web/rppr?d-7822565-p=1&d-7822565-o=2&d-7822565-s=2&execution=e1s6) | [**Status**](https://reporting.research.gov/rppr-web/rppr?d-7822565-p=1&d-7822565-o=2&d-7822565-s=3&execution=e1s6) | [**Previous Participant**](https://reporting.research.gov/rppr-web/rppr?d-7822565-p=1&d-7822565-o=2&d-7822565-s=4&execution=e1s6) | **Actions** |
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 **\* What other organizations have been involved as partners?** Nothing to report

**NCAR CISL**

 No organizations entered.

 **\* What other collaborators or contacts have been involved?** more information about other collaborators or contacts

**NCAR CISL, Data Support Section: Chi-Fan Shih**

List any other people or organizations involved in the project that were not separately reported as participants or partner organizations.

Nothing to report

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**Impact - What is the impact of the project? How has it contributed?**

INSTRUCTIONS - This component will be used to describe ways in which the work, findings, and specific products of the project have had an impact during this reporting period.

For NSF purposes, include, where appropriate, discussion of data resources and the acquisition of data skills. Include the emergence of new career paths, such as data scientists, or new disciplines.

If there is nothing significant to report during this reporting period, please check "Nothing to Report" if applicable.

more information about other collaborators or contacts

Top of Form

\* Required fields

* **\* What is the impact on the development of the principal discipline(s) of the project?** more information about the impact of the development of the principal discipline

Describe how findings, results, techniques that were developed or extended, or other products from the project made an impact or are likely to make an impact on the base of knowledge, theory, and research and/or pedagogical methods in the principal disciplinary field(s) of the project.

Nothing to report

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* **\* What is the impact on other disciplines?**

Describe how the findings, results, or techniques that were developed or improved, or other products from the project made an impact or are likely to make an impact on other disciplines. The open geospatial standards and specifications on cataloguing, provenance, and publication exposes outcomes of science models to a more extensive world. The information becomes not only discoverable and accessible but also traceable. The quality of the information is explicitly accessible to other researchers and decision makers. The re-use of the model output can be assured with metadata and quality of information.

Nothing to report

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* **\* What is the impact on the development of human resources?**more information about the impact on the development of human resources

Describe how the project made an impact or is likely to make an impact on human resource development in science, engineering, and technology.

Nothing to report

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* **\* What is the impact on physical resources that form infrastructure?**

Describe ways, if any, in which the project made an impact, or is likely to make an impact, on physical resources that form infrastructure, Including physical resources such as facilities, laboratories, or instruments.

Nothing to report

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* **\* What is the impact on institutional resources that form infrastructure?**more information about the impact on institutional resources that form infrastructure

Describe ways, if any, in which the project made an impact, or is likely to make an impact, on institutional resources that form infrastructure,

Nothing to report

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| CyberWay will reduce the institutional resources spent on managing the infrastructure facilities. Once installed, the scientists could directly use the web services to do their experiments via web browsers without bothering managers and coordinators. |
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* **\* What is the impact on information resources that form infrastructure?**more information about the impact on information resources that form infrastructure

Describe ways, if any, in which the project made an impact, or is likely to make an impact, on information resources that form infrastructure,

Nothing to report

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| CyberWay makes it easier to share and publish information resources by installing the system, especially the huge amount of data residing on servers for a long time and gradually being forgot. CyberWay facilitates the inter-comparison and validation of the model products from different organizations. It opens up the archived datasets which used to be only accessible by their owners. |
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* **\* What is the impact on technology transfer?** more information about the impact on technology transfer

Describe ways in which the project made an impact, or is likely to make an impact, on commercial technology or public use.

Nothing to report

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* **\* What is the impact on society beyond science and technology?** more information about the impact on society beyond science and technology

Describe how results from the project made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world.

Nothing to report

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**Changes/ Problems**

**INSTRUCTIONS -**

The PI is reminded that the grantee is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction. See agency specific instructions for submission of these requests.

If not previously reported in writing to the agency through other mechanisms, provide the following additional information or state, "Nothing to Report", if applicable:

\* Required fields

**Notifications and Request**

For more information on Grantee Notifications to and Requests for approval from the National Science Foundation, please visit the Notifications and Requests section in FastLane or refer to Exhibit VII-1 of the Proposal & Award Policies & Procedures Guide (PAPPG).

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* **\* Changes in approach and reasons for change** more information about changes in approach and reasons for change

Nothing to report

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* **\* Actual or Anticipated problems or delays and actions or plans to resolve them** more information about actual or anticipated problems or delays and actions or plans to resolve them

Nothing to report

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* **\* Changes that have significant impact on expenditures** more information about changes that have significant impact on expenditures

Nothing to report

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* **\* Significant changes in use or care of human subjects** more information about significant changes in use or care of human subjects

Nothing to report

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* **\* Significant changes in use or care of vertebrate animals** more information about significant changes in use or care of vertebrate animals

Nothing to report

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* **\* Significant changes in use or care of biohazards** more information about significant changes in use or care of biohazards

Nothing to report

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