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Preview of Award 1419445 - Annual Project Report

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Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1419445
Project Title:	EaSM-3: Land Use Change and Land Atmosphere Feedback Processes as Regulators of Regional Climate Change
PD/PI Name:	Paul A Dirmeyer, Principal Investigator
Recipient Organization:	George Mason University
Project/Grant Period:	08/01/2014 - 07/31/2020
Reporting Period:	08/01/2018 - 07/31/2019
Submitting Official (if other than PD\PI):	N/A
Submission Date:	N/A
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	N/A

Accomplishments

*** What are the major goals of the project?**

Goals for the project are:

1. Examine the coupled feedback processes between land and atmosphere in CESM. This includes the relationships

between soil moisture and surface fluxes, and the connection between surface fluxes and the development of the atmospheric boundary layer, clouds and precipitation, and the role of the biogeophysical elements of CLM in these processes.

2. Develop and refine metrics for (a) quantifying land-atmosphere coupling in models and observations for purposes of model validation and the quantification of important climate processes over land; (b) land use changes in the context of their effects on, and response to, climate variations and change.
3. Investigate the evolution of coupled land-atmosphere climate processes in CESM under the dual axes of a changing climate and regional land use change.

These are to be executed in the following tasks:

- Task 1: Develop analysis tools for offline and coupled models
- a: Land-atmosphere interaction diagnostics
- b: Metrics for assessment of modeled terrestrial response to land use
- Task 2: Assess land-atmosphere coupling under varying land uses in CAM-CLM
- a: Land-atmosphere coupling assessment across CAM-CLM configurations
- b: Analysis of offline CLM simulation across a variety of land covers and land uses
- c: Analysis of land-atmosphere coupling across range of land cover / land use
- Task 3: Decadal-timescale evolution of land-atmosphere feedbacks due to dual axes of climate and land use change
- a: Assess changes in land-atmosphere feedback due to climate change and land use change separately
- b: Land-atmosphere feedbacks and impact on extremes under scenarios with both climate change and land use change

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities:

Specific Objectives:

- Under task 3a: We have provided a protocol for “fair” comparisons between the observations and model simulations in terms of the impacts of deforestation on hot extremes that disambiguates the effect of replacing “space for time”, i.e., substituting current land use changes between two locations in current climate as a proxy for large-scale land use change and its effects in the future (Chen and Dirmeyer 2019b).
- Under task 3b: We have evaluated the relative importance of land use forcing to temperature extremes compared with other anthropogenic forcings using CESM Last Millennium Ensemble (LME) and CMIP5 output (Chen and Dirmeyer 2018). We have estimated the local impacts of global irrigation on temperature extremes based on satellite observations and CESM simulations (Chen and Dirmeyer 2019a). We also have noted and carefully evaluated in observations and climate models, including but not limited to CESM, the differing impacts of land use change on surface versus near-surface air temperature (Chen and Dirmeyer 2019c).

Significant Results:

- Under task 3a: to reconcile the disagreement between the observed and simulated temperature response to deforestation, we separate the local and non-local impacts from the CESM deforestation simulations. CESM can well capture the observed local warming (on summer daily maximum temperature) of deforestation, however, which can be overwhelmed by the simulated non-local effects mainly due to the changes in atmospheric background. Our work provides a protocol for “fair” comparisons between the observations and model simulations, which is particularly useful for the model evaluation and comparison in the Land Use Model Intercomparison Project (LUMIP).
- Under task 3b: The comparison among the single-forcing and full-forcing experiments suggests that land use forcing plays an important role in temperature

extremes, especially for the hot extremes and diurnal temperature range. Even though there is not a good agreement concerning the temperature response to the land use forcing among the CMIP5 models, the relative contribution of historical land use to temperature extremes in full-forcing experiments is still very robust. Disagreement among studies reporting various temperature responses to land use change have been reconciled by noting that careful accounting of surface temperature changes, such as those observable by satellite and reported as skin temperature or surface temperature in model output, depicts different change characteristics than near surface air temperature reported by meteorological stations and flux tower sites, typically reported as “2m air temperature” in climate models. Changes in surface roughness with deforestation are the major factor contributing to discrepancies in surface versus near surface air temperature, disrupting the pathway of sensible heat flux and the ability of deforested surfaces to dissipate absorbed radiation. Researchers and the media need to be very careful to note which temperature variable they are considering when reporting deforestation effects on climate.

Key outcomes or Other achievements: See publications below.

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

This project supported postdoctroal fellow Dr. Liang Chen (Texas A&M Ph.D. May 2015) through December 2018.

This project is supporting PhD student Hsin Hsu (National Taiwan U. M.S. June 2016).

These young scientists receive training and professional development commensurate with their participation and roles within the project.

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

Results have been presented at the CESM Annual meeting in Boulder, the 2018 AGU Fall meeting in Washington, D.C. the AMS Annual Meeting in Phoenix, in January 2019, as well as via publications, seminars and other workshop presentations as listed below.

*** What do you plan to do during the next reporting period to accomplish the goals?**

A no-cost extension has been granted to complete the proposed work. The post-doc L. Chen who has been supported on the project left GMU to take a permanent post at U. Illinois at the beginning of 2019. There remain two papers in the pipeline that still need revising and publishing.

There is also an opportunity to pick up another GMU post-doc who can contribute to the final task in the proposed work (Task 3b: Land-atmosphere feedbacks and impact on extremes under scenarios with both climate change and land use change). Erfani Ehsan, who works with Dr. Natalie Burls, was supported on a different NSF grant where his support is ending (NSF #1756658). He has done research and developed climate sensitivity methodologies that can directly contribute to, and help complete, that final element of the proposed work.

Products

Books

Book Chapters

Inventions

Journals or Juried Conference Papers
Chen, L. and P. A. Dirmeyer (2019). Global observed and modeled impacts of irrigation on surface temperature. *Int. J. Climatology*. 39 2587. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/joc.5973

Chen, L. and P. A. Dirmeyer (2019). The Relative Importance among Anthropogenic Forcings of Land Use/Land Cover Change in Affecting Temperature Extremes. *Climate Dynamics*. 52 2269. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s00382-018-4250-z

Chen, L., and P. A. Dirmeyer (2019). Differing responses of the diurnal cycle of land surface and air temperatures to deforestation.. *J. Climate*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Chen, L., and P. A. Dirmeyer (2019). Reconciling the Disagreement between Observed and Simulated Temperature Responses to Deforestation. *Nature Communications*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Licenses

Other Conference Presentations / Papers
Chen, L., and P. A. Dirmeyer (2018). *Reconciling the disagreement between observed and simulated temperature responses to deforestation*. American Geophysical Union Fall Meeting. Washington, DC, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Chen, L., and P. A. Dirmeyer (2019). *Response in diurnal cycle of land surface and air temperature to deforestation (invited).*. American Meteorological Society 32nd Conference on Climate Variability and Change. Phoenix, AZ, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Other Publications

Patents

Technologies or Techniques

Thesis/Dissertations

Websites

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Dirmeyer, Paul	PD/PI	1
Chen, Liang	Postdoctoral (scholar, fellow or other postdoctoral position)	5
Hsu, Hsin	Graduate Student (research assistant)	7

Full details of individuals who have worked on the project:

Paul A Dirmeyer
Email: pdirmeye@gmu.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: PI, leadership and management of project, mentoring of student and postdoc, analysis of model output, authoring and coauthoring of publications, giving conference and workshop presentations on results of project research.

Funding Support: N/A

International Collaboration: No
International Travel: No

Liang Chen
Email: lchen15@gmu.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 5

Contribution to the Project: Primary modeler and data analyst for this project, lead author on several papers, co-author, presenter of results at conferences and workshops.

Funding Support: N/A

International Collaboration: No
International Travel: No

Hsin Hsu
Email: hhsu@gmu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 7

Contribution to the Project: Developing information theoretical approach to assess the interrelation between multiple factors driving land surface fluxes and other climate responses, which can be applied to CESM or observational data (reanalyses; for validation).

Funding Support: N/A

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
NCAR	Academic Institution	Boulder, CO

Full details of organizations that have been involved as partners:

NCAR

Organization Type: Academic Institution
Organization Location: Boulder, CO

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Part of this Collaborative Research project - grant support provided by USDA; David Lawrence is NCAR PI, Rich Neale is NCAR co-PI.

What other collaborators or contacts have been involved?

Relevant past collaborations listed here previously have ended prior to the start of this reporting period.

Impacts

What is the impact on the development of the principal discipline(s) of the project?

Basic land-atmosphere metrics development is being shared with the broader scientific community through the World Climate Research Programme (WCRP) Global Energy and Water Exchanges (GEWEX) Global Land-Atmosphere System Study (GLASS), of which the PI was a cofounder, and which is concerned with modeling and understanding the coupled land climate system. The primary means of distribution has been via the web site: http://tiny.cc/l-a-metrics

Our testing of CLM and CAM in various configurations is also contributing the NCAR CESM model development and has been informing the production of CLM5, released as part of CESM2.

The Land Surface, Snow and Soil Moisture Model Intercomparison Project (LS3MIP); a CMIP6-endorsed project is also be a beneficiary of this work.

Land use change-climate metrics development will be shared with the broader scientific community through the Land Use Model Intercomparison Project (LUMIP); a CMIP6-endorsed project of which co-PI Lawrence of NCAR is co-chair.

What is the impact on other disciplines?
Nothing to report.

What is the impact on the development of human resources?

The PI is a Professor in the department of Atmospheric, Oceanic and Earth Sciences (AOES) which is home of the Ph.D. program in Climate Dynamics. In Fall 2018 a new Ph.D. student is being supported on this project (Hsu); this project is helping him develop skills necessary for independent research.

The postdoc on this project (Chen) has developed independent research skills and expand professional contacts and experience. This has led to his recent hire to a prestigeous joint position with the University of Illinois and the Illinois State Water Survey wherein he will apply his research and organizational skills, as well as have opportunity to participate in teaching and mentoring.

What is the impact on physical resources that form infrastructure?
Nothing to report.

What is the impact on institutional resources that form infrastructure?
Nothing to report.

What is the impact on information resources that form infrastructure?

A university computing proposal was submitted to NCAR/CISL in March 2015 for 4.2M core supercomputing hours to conduct the necessary CESM simulations and analysis of the model output under this project. 3.5M core hours were granted, along with 50TB of project space and 200TB of HPSS storage. Additionally, 200K CPU hours have been granted on Cheyenne to aid transition of the modeling work to the new platform before the end of 2017. With the transition of work to Cheyenne, unused resources were converted to 2M core hours on the new platform. This resource has been used for the CESM model simulations, including version 2 as of June 2018.

A significant portion of this project involves new simulations with the CESM-CLM model framework. Due to the exploratory and investigative nature of the proposed model work, we do not anticipate that there will be a large demand from the broader scientific community for model data generated during the course of this project. Consequently, we have not budgeted any costs into this proposal for data dissemination. Naturally, if there are specific requests for data that arise through interactions with current or future collaborators who are external to this project, we will be happy to share the data with them. The data volume is not expected to be large by today's standards so we will be able to transfer this data via normal data transfer methods (e.g., through anonymous ftp site or the Earth System Grid). Results from the model integrations will be reported through conferences and in the peer reviewed literature. Storage costs for any data that needs to be archived for the lifetime of this project have been folded into the Yellowstone request for computing allocations to support the work outlined in this proposal.

What is the impact on technology transfer?
Nothing to report.

What is the impact on society beyond science and technology?
Nothing to report.

Changes/Problems

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them

Delays in release of CESM2 and the timelines for LUMIP and LS3MIP set back execution of some model simulations. The last year was a period of no-cost extension due to these delays and the loss of the PhD student previously supported. As described above, a new PhD student is now supported on this grant and is beginning fruitful research.

The departure of post-doc Liang Chen, who has been wonderfully productive, publishing 6 papers as lead author with another 2 papers currently in revision, has warranted our request for a second 12-month no-cost extension. We anticipate bringing on board a new post-doc to this project, Erfani Ehsan, who works with Dr. Natalie Burls and was supported on a different NSF grant wherein support is ending (NSF #1756658). He has done research that can directly contribute to, and help complete, the final elements of the proposed work. We anticipate him coming on board the project in the next couple of months and contributing approximately 6-7 months effort.

These changes will not ultimately affect the overall project goals.

Changes that have a significant impact on expenditures

The personnel changes above, particularly the departure of the post-doc at the end of December, have caused expenditures to be below those anticipated. The changes above should exhaust allocated funds by summer 2020.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.

Special Requirements

Responses to any special reporting requirements specified in the award terms and conditions, as well as any award specific reporting requirements.
Nothing to report.