**R1- Summary**

In the context of the five review elements, please  
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.  
  
This is an ambitious proposal to try to make use of the breadth of data collected at CZOs and make inroads into understanding processes occurring at multiple sites. I was most impressed by the pairing of data/computational scientists with EAR researchers with expertise in the natural processes at the various study areas. That pairing portends meaningful scientific advances with knowledgeable application of big data approaches.  
  
The research has two approaches, ground up and top down, or, as better stated for this application, an iterative “pattern to process” and “process to pattern” approach. They will investigate how CZ structure controls water, carbon, nutrients, and response to overlapping disturbances in the context of multi-dimensional resilience. The proposal includes a number of examples of avenues for scientific study and testable hypotheses. This is a starting point and addressing those questions ensures scientific contributions. However, I was struck that the hypotheses were given as ‘example hypotheses’ suggesting that they are open to follow the best research avenues as the research progresses.  
  
  
In the context of the five review elements, please  
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.  
  
The propose to run two outreach programs beyond the scientific community. The week-long CREST program will reach 7-12th grade educators. A week-long A DCODE camp will be for undergraduate students. I like that four of the PIs will be present at both camps, which speaks to the commitment to outreach. The outreach weeks also provide the opportunity for informal communication regarding research ideas among the PIs as an auxiliary benefit.  
  
They state they will actively train other researchers by offering workshops and a webinar series in collaboration with the Research Coordination Network (RCN), although details on these plans are not enumerated. However, they have budgeted for an education and outreach coordinator (50% time) to facilitate these activities. There are also funds for a consultant on leadership and diversity and funds for HBCU faculty to participate in DCODE camp.  
  
There is also a strong commitment to engage scientists not currently in the CZO network through proactive recruitment and support.  
  
Several of the PIs are early career scientists.  
  
  
Please evaluate the strengths and  
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if  
applicable  
  
-     Thematic Clusters: infrastructure and methods address key environmental variables that govern CZ processes – yes  
-     Effective management structure to coordinate the operations and research agenda of the network and support the use of the facilities by other research teams – yes. excellent  
-     Education and outreach efforts that enhance the growth of CZ science and include demographic groups that are historically underrepresented in the sciences – yes  
-     Effective data management and dissemination – yes  
  
  
Summary Statement  
  
The proposal seems in the best spirit of the CZ program and is an attempt to make use of the breadth and depth of available (and still being collected) data streams from CZOs, LTERs and NEON. I found the proposed research and plan compelling and, if funded, I hope the PIs are successful in their ambitious efforts.  
  
There is risk associated with the scientific objectives. The outreach efforts seem bullet proof as they tie into already existing outreach programs and are designed to be well supported by an outreach coordinator and a consultant on leadership and diversity.

**R-2 Summary**

In the context of the five review elements, please  
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.  
  
This project focuses on resilience and recovery of CZ systems to disturbances. The major hypothesis is that Critical Zone structure regulates ecosystem resilience and resistance to climate and land-cover disturbance. PIs at the University of Vermont (5), University of Kansas (1), Brigham Young University (1), University of Nevada (1) and the Desert Research Institute in Las Vegas, NV (1), would use sites in the northeast and southwest US to “extract patterns, seek emergent phenomena and identify key drivers of resilience” through sophisticated modeling and big-data approaches.  
  
  
  
In the context of the five review elements, please  
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.  
  
This is a very well-written proposal with strong plans for both research and broader impacts. While ambitious, the team has the necessary expertise and a strong record of past achievements. The scale of this project makes it particularly appropriate for the networking aspects of this particular call for proposals. The other networks and hub, along with the larger CZ community would undoubtedly benefit from this team’s modelling expertise and results. Their focus on multiple scales, big data, and use of advanced statistical and modeling techniques has the capacity to be truly transformative.  
  
The education and outreach plan beginning with middle school is well conceived and their assessment plan should ensure results. Building on CREST is appropriate, given that they have some prior experience with it and plan to build upon it rather than simply maintain it. It is refreshing to see that Diversity in undergraduate education camp. My only concern is that it may be difficult to recruit URM students in the summer when they may need to work. This is not a criticism of their program. I simply hope that the PI and NSF can find a way to provide some sort of subsidy for participating URM students who need financial support. Perhaps something could be added on throughout the school year to provide support?  
  
RE education, I hope that the PIs will make a conscious effort to teach team skills to all students, postdocs and early career faculty. Excellent books have been published on team skills, and even NSF includes such training for many if not all of its program office. This is particularly important for a project such as this one which includes participants at far-flung institutions and high diversity among its participants. This should be easy to implement through reading lists, seminars, workshops, and perhaps even campus courses and scientific society offerings. Perhaps this could be something the RCN could organize?  
  
Please evaluate the strengths and  
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if  
applicable  
  
Engagement Plan is strong. The modeling expertise from this project should be of interest to the broader CZ community. I expect the webinars and other training this team might offer will be well attended by students as well as new and established researchers within and beyond this project.  
  
Data Management appears solid.  
  
Project Management appears strong, particularly given the results of prior support. Although the leadership system for data science and CZ science appears strong, I would have appreciated a more detailed timeline and some discussion of steps to be taken to ensure each group is given the necessary data from the other groups in a timely manner. I would also have liked to see a plan for leadership training for all faculty, postdocs and graduate students. I would have appreciated more information on Lee's bsckground since his role is critical and I am not in his field. Has he had recent experience working with a project of this size and the necessary expertise?  
  
I am concerned about holding the annual all-hands meeting in conjunction with a National meeting such as AGU. There are far too many distractions and concurrent events. I strongly advise against this. The meeting should either be held at one of the participating institutions or one of the research sites. Special days should ideally be set aside just for students and postdocs so that they can exchange information and develop a strong peer and near-network. I strongly support their proposal for working agreements to be developed in year one. Team training would be an excellent addition to this.  
  
Summary Statement  
  
This is a strong project led by an experienced team that also includes early career researchers and a commitment to diversity. I have made some suggestions which might be helpful, but these do not detract from my overall strong support for all aspects of this project.

**R-3 Summary**

In the context of the five review elements, please  
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.  
  
Strengths  
The goals of the project are interesting. The PIs will compile ecohydrological data, perform statistical analysis, refine hypotheses and perform in-depth process investigation, going from pattern to process and process to pattern. This iterative approach will inform hypothesis development and model testing. The aim to connect the CZ community and beyond with a database is important for CZ science. The modeling choices (e.g. RHESSys and RNN-LSTM) of the PIs seem appropriate for the project and utilizing machine learning is a good choice.  
The workplan appears to be reasonable and the choice of research areas is appropriate. The focus on the sparse and dense fuels may have real significance for the community.  
  
Weaknesses  
Is the goal to develop a new database? This really isn’t what is needed here. The PIs claim that this will be transformative by integrating statistics and process-based approaches. While this is laudable, it is not clear how well this will work. Building databases is complicated. In most cyberinfrastructure projects, databases are just the beginning and need to be part of a larger framework. The hypothesis that the CZ structure controls linkages among multiple responses to disturbance and regulates ecosystem resilience is not that compelling and seems intuitive. Doesn’t a database or data structure like this exist? The information in Section 5.4 describing the database does not seem sufficient.  
  
  
In the context of the five review elements, please  
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.  
  
Strengths  
This proposal has a comprehensive educational plan will reach hundreds of students in Vermont via the CREST program. The DCODE program seems like it would be an effective means by which to train and engage underrepresented groups.  
  
Weaknesses—It seems that they should have developed a stronger program for graduate and post doc training.  
  
  
Please evaluate the strengths and  
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if  
applicable  
  
This section seems a little underdeveloped and lacking detail. It should have had more information about how this would be done.  
  
Summary Statement  
  
This project has some interesting aspect to it regarding CZ data science, but it is not clear how the PIs will develop their database and how they will link to existing data projects related to the CZOs. The Broader Impacts could be improved in terms of graduate and post doctoral training.

R4-**Summary**

In the context of the five review elements, please  
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.  
  
Strength:  
  
This is a timely research on very important topic. The overarching research question is promising. How critical zone structure controls linkages among multiple responses to disturbance and thereby regulates ecosystem resilience and resistance to climate and land cover disturbance? Answering to this question will transform understanding of the CZ processes and functioning under changing environments, and provide outstanding decision-making tools for land management. The proposed research is novel and original. Interdisciplinary assessment of ecosystem states under a range of disturbance regimes across a gradient of CZ configurations is critically required, and have not been thoroughly touched before.  
  
The team will use a data-driven approach that combines bottom-up and top-down methods. By using state of art statistical and machine learning algorithms, sophisticated modeling platform, and field measurements at some sites, their syntheses of processes are highly transferable to other regions. The team are well-qualified to conduct the proposed interdisciplinary research. The PI and co-PIs worked on diverse fields of critical zone science as well as application of data mining in environmental science.  
There are adequate resources and infrastructure available to the team to carry out the proposed research. The team will also use a previously developed sophisticated interdisciplinary modeling platform as well as advanced data science algorithms previously used in their research. Their infrastructure and methods will address most environmental variables that govern CZ processes.  
  
Weakness:  
  
The plan for carrying out the proposed research is good but not excellent. Specifically, the rational and scientific support behind some of their hypotheses are not clear. The application of advanced data mining algorithms is promising. However, it is not very clear why and how they are going to use some of the data mining algorithms.  
  
  
In the context of the five review elements, please  
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.  
  
Strength:  
  
The team proposed sound and clear engagement plan as well as education and outreach plans. The proposed research has high potential to benefit critical zone science research, society and decision making in long-term. The team also proposed sound plan for for developing collaborative research as well as for knowledge dissemination. They also proposed strong plan for education and outreach efforts that include demographic groups that are historically underrepresented in the science. They will create outstanding dataset and also facilitate the use of data by researchers both within the CZC and the broader community. The team has proposed sound and effective management plan to coordinate the operations and research agenda of the network and support the use of data by other research teams.  
  
Weakness:  
I have no concern  
  
  
Please evaluate the strengths and  
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if  
applicable  
  
  
  
Summary Statement  
  
This is a timely research on very important topic. Interdisciplinary assessment of ecosystem states under a range of disturbance regimes across a gradient of CZ configurations is critically required, and have not been thoroughly touched before. I rate the proposal as "very good".