Responses to the Reviewers

We thank the anonymous reviewers for spending their time in a thorough review of our proposal. Below, we provide a point by point response to the reviewer's concerns. Reviewer's concerns appear in the regular font and our responses appear in the bold font.

Reviewer #1

In this project, the applicants propose to develop a novel method for improving the NAQFC PM2.5 predictions during wildfire events by assimilating the aerosol optical depth (AOD) retrievals from NOAA Geostationary Operational Environmental Satellite (GOES) measurements along with the AOD retrieval from MODIS for generating more realistic initial conditions of chemical species, and by generating more accurate long term training data for better historical analog search which eventually benefits the bias corrected PM2.5 predictions. However, the proposal is limited to the WRF-driven CMAQ (see Pages 6-7 in the proposal) rather than NMMB-driven CMAQ, the current operational NAQFC or FV3-driven CMAQ, the next updated version of NAQFC for operational implementation. The FV3GFS-driven CMAQ in offline mode will become NOAA operational AQ forecasting model in 2020.

Response: We proposed to drive CMAQ with WRF because there is no preprocessor available publicly to convert NMMB output to Meteorology-Chemistry Interface Processor (MCIP) format. We are aware that an NMMB-CMAQ processor does exist at NOAA, but we consulted with the NAQFC team (led by Pius Lee) at NOAA during our ongoing project and we were told that it is still under development and not yet ready to be shared with us. We would be happy to drive CMAQ using NMMB or FV3GFS output if past 10 years of NMMB or FV3GFS files in CMAQ-ready (i.e., MCIP) format are available at NAQFC. If NMMB/FV3GFS output are not available at NAQFC, we will be limited to drive CMAQ using WRF.

Regarding the 2nd task of the proposal, the AnEn post-processing method for bias correction has been implemented into the NAQFC in 2016 and has been replaced by the KFAN bias correction during the 2018 NAQFC operational implementation. The KFAN with current configuration still fails to capture high PM2.5 concentrations during heavy wildfire events. I don't think that the AnEn work proposed by this project will be able to solve the problem that the KFAN fails to correct underpredictions of PM2.5 by NAQFC during heavy wildfire events.

Response: The inability of the post-processing schemes to accurately correct extreme events is partly associated with the rare occurrence of these events. This problem is exacerbated with short training data sets, as it is then increasingly unlikely that forecast analogs that closely match the current forecast can be found. In the current operational system used at NCEP, the length of the training data sets is typically no more than one year, since the model is upgraded every year. In this project 10 years of model forecasts will be used, which will give us the opportunity to examine whether a training data set an order of magnitude longer than currently used has the potential to improve post-processing of extreme air quality events such as those from wildfires. Furthermore, the co-PI (Stefano Alessandrini) has developed a technique to adjust the analog predictions in case of rare events. A correction to the analog members is made when the forecast is unusual as measured in terms of its percentile relative to the climatological distribution of forecasts.

This technique has been described in a paper recently conditionally accepted for publication by Monthly Weather Review and should further mitigate the issue of the AnEn underestimating $PM_{2.5}$ peak concentrations during wildfire events.

Reviewer #2

There are a lot of strengths to the proposed project to be done under the JEDI umbrella. Chief among them developing approaches to assimilate satellite data (aerosol optical depth), improvements to CRTM (community radiative transfer model) etc. However, PI is not aware or at least did not report all the past MODIS and GOES AOD assimilation work into CMAQ that was done. A body of 10 years worth of work has already done. Approach may be new (GSI scheme) but concept is not new. AOD (both MODIS and GOES) assimilation into global models and regional models using GSI into both global and regional models in fact have been done and is being done. Some notable work has been done by Arlindo Da Silva (NASA), Ed Hyer (NRL), Sarah Lu and Jeff McQueen (NCEP), Shobha Kondragunta (NESDIS), Rohit Mathur (EPA) and Marius Pagowski, (NOAA ESRL). The PIs appear to have no knowledge of this body of work done in the last 10 years all within NOAA and a lot of it funded by the Joint Center for Satellite Data Assimilation. Although I have not taken out points for this approach not being novel or project team not acknowledging past work, this project should be selected with explicit agreement with the team that they should collaborate with satellite data folks at NESDIS.
Reply: Thanks for appreciating our approach. We are aware of all these data assimilation efforts and would like to build on the knowledge generated in the past 10 years. Unfortunately, we could not acknowledge the past work in the proposal due to space constraints. In fact, PI Kumar discussed this proposal idea with Dr. Shobha Kondragunta (NESDIS) at the AGU Fall meeting 2018 and invited her to be a co-PI on the proposal. Dr. Kondragunta said she liked the idea but she cannot be named on the proposal due to conflict of interest. However, she emphasized that she would be happy to collaborate if the proposal is funded, which we will certainly pursue. This collaboration will be very important for the success of our project. We have also collaborated with Arlindo da Silva, Pius Lee, and Youhua Tang on the development of the CMAQ-GSI system for assimilation of MODIS AOD retrievals in CMAQ, and co-authored the recently published papers on chemical data assimilation in CMAQ (Kumar et al., 2019; Tang et al., 2017) on this subject. We are very familiar with the work led by Mariusz Pagowski and colleagues on assimilation of satellite AOD retrievals using both GSI 3DVAR and optimal interpolation techniques. In summary, we have a good professional relationship with most of the leaders of chemical data assimilation in the US and fully intend to continue and pursue collaborations for the benefit of this field of work.

Issue #2) There is an over-commitment situation for both Drs. Kumar and Alessandrini....i.e., more than 100% of their time is committed in the event this proposal is funded...which is not executable without revisions. According to the submitted Current and Pending Support documents, Kumar is currently committed to 10.4 months of work and is proposing an additional 3.8 months in this proposal. 14.3 months is more than 12 months. Secondly, Alessandrini is currently committed 10.7 months and is proposing an additional 2.1 months in this proposal. 12.8 months is greater than 12 months. How do you plan to resolve these problems should this proposal be selected for funding?

Reply: We proposed that because two of our current projects, i.e., Contract #X15AH03G and Contract #EM10673 are ending on March 31, 2019. For Rajesh Kumar (PI) and Stefano Alessandrini (co-PI), we proposed 3.8 and 2.1 months, respectively, because the above mentioned projects will not be active in the period of performance for this project. However, in the meantime, we received notice that three of our pending proposals will be funded ("Crowd-Sourced Environment Sensing and Terrain Analysis using Mobile Devices", "Enhancing Decision-Making Activities in the Area of Air Quality in Delhi", and "Quantification and Attribution of Past (2005-2018) Air Quality Trends over the Contiguous United States (CONUS) via Assimilation of NASA Atmospheric Composition Observations"). As a result, we will hire a project scientist who will help with these newly funded projects and also reduce our time on the current projects so that we can focus on this project.

Issue #3) Please provide resumes and Current and Pending Support for Djalalova and Allured who are proposed to receive funding. Those documents were not submitted by PSD as required.
Reply: The CVs for both Djalalova and Allured are provided at the end of our responses and the Current and Pending Support (CPS) are provided in a separate PDF document.

Issue #4) You're proposing to need 3200 core hours and $23K worth of NOAA high performance computing. Please explain this further....why, and where do you expect to get it? NOAA has very little available HPC as warned about in the RFP. Is there a firm requirement for NOAA HPC in this project should it be funded?
Reply: We have scanned through the submitted documents to find out where we made this HPC request and were not able to find any requested HPC in our archive of the submitted documents. We originally requested HPC in our LOI, but we believe that this was removed from the final proposal. In any case, NOAA HPC is not a requirement for the project and can be omitted.

References:

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Associate Scientist, CIRES/University of Colorado, Boulder, Colorado

Education and Training

University of Colorado	Electrical Engineering and Computer Science	B.S., 1980

Appointments

2000-present: Associate Scientist, CIRES/University of Colorado, Boulder, Colorado. Joint project with NOAA/OAR/ESRL/PSD. Scientific computer support. Software engineering, data management, climate model operation, application support.

1983-1999: Consulting engineer, Boulder, Colorado. Hardware and software development for microprocessor based applications. Intermittent employment.

1980-1982: Software engineer, NBI, Boulder, Colorado.

1971-1977: Programmer and system analyst, Pittsfield Public Schools, Pittsfield, Massachusetts. Business data processing.

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Education

B.S. and M.S. in Physics, specialization in Applied Mechanics, Moscow State University, Russia, School of Mathematics and Mechanics, 1973-1980

Positions

I.Djalalova is a Senior Research Scientist in CIRES. She works in CIRES/NOAA since 2005. Previously she worked for 8 years in NOAA as a Senior Application Engineer being a contractor through the Science and Technology Corporation.

Summary of air quality research

I. Djalalova has been working on air quality forecasting research for over 14 years. She was a team member during the multi-agency air quality experiments of NEAQS (2004) and TEXAQS II (2006). She developed, organized and supported the programming tools for visual comparison of observed and modeled meteorological and chemical variables, and evaluated several biascorrected and model ensemble techniques for surface ozone and PM2.5. Most recent collaborative project with NOAA/NWS is applied to the creation and evaluation of the operational bias-correction scheme that is used operationally in NCEP for PM2.5 forecasts since January 2016 and just started to run operationally for Ozone.

Publications related to the proposed research

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Bianco, L, IV Djalalova, JM Wilczak, J Cline, S Calvert, E Konopleva-Akish, C Finley and J Freedman (2016), **A Wind Energy Ramp Tool and Metric for Measuring the Skill of Numerical Weather Prediction Models.** *Weather Forecast.*, *31* (4) 1137-1156, issn: 0882-8156, ids: DV8VX, doi: 10.1175/WAF-D-15-0144.1

Djalalova, I, J Wilczak, S McKeen, G Grell, S Peckham, M Pagowski, L DelleMonache, J McQueen, Y Tang, P Lee, J McHenry, W Gong, V Bouchet and R Mathur (2010), **Ensemble and bias-correction techniques for air quality model forecasts of surface O-3 and PM2.5 during the TEXAQS-II experiment of 2006.** *Atmos. Environ.*, *44* (4) 455-467, issn: 1352-2310, ids: 556TD, doi: 10.1016/j.atmosenv.2009.11.007

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