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The attached proposal is being submitted to you for your consideration by a NOAA Cooperative Institute. Should you recommend funding for this proposal, we request that the funding be transferred through our current NOAA cooperative agreement # NA20OAR4320472. The NOAA contact (described below) for this cooperative agreement should be contacted immediately if this proposal is accepted for funding.

Title of Proposal:	Processed-Oriented Diagnostics of Aerosol-Cloud Interactions in CMP6 Models
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7. Are any permits required to conduct this project? ☐Yes ☒No
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Process-Oriented Diagnostics of Aerosol-Cloud Interactions in CMIP6 Models

A proposal to the NOAA Climate Program Office:

Modeling, Analysis, Predictions, and Projections (MAPP) Program FY 2021

Process-Oriented Diagnostics for NOAA Climate Model Improvement and Applications
(Type 1 Proposal)

November 30, 2020

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Year 1 - $176,675, Year 2 - $171,788, Year 3 - $177,090

For the Period:

1 June 2021 to 31 May 2024

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Processed-Oriented Diagnostics of Aerosol-Cloud Interactions in CMP6 Models

1. Abstract

Aerosols represent a key source of uncertainty in global climate models. Through the absorption and scattering of shortwave radiation, aerosols reduce the incoming solar radiation at the surface and thus offset part of the warming resulting from increases in anthropogenic greenhouse gases. In addition to this direct radiative effect, certain types of aerosols are known to act as cloud condensation nuclei, altering the cloud albedo and lifetime. Differences in modeling the effective radiative forcing from aerosol-cloud interactions (ERFaci) are a substantial source of uncertainty in predicting climate change.

Aerosol-climate interactions (ACI) play an important role in climate projections despite the limited ability of models to represent aerosol and cloud processes accurately. Indeed, climate models can disagree on both the sign and magnitude of the radiative effects from aerosol-cloud interactions. This disagreement reflects, in part, the absence of a consistent methodology to quantify their effects in models. Indeed, even the direct radiative effects of aerosols are rarely calculated explicitly. The lack of a coherent framework to quantify the radiative impact of aerosol-cloud interactions limits our ability to compare its importance across different models, or even between different versions of the same model. This is compounded by the lack of regionally-resolved observations of ACI on a global scale, that account for the presence of co-varying meteorological conditions on ACI. Thus, despite their fundamental role in determining both historical and future climate change, the magnitude of ACI remains poorly constrained in models.

This proposal aims to fill this gap by developing a set of diagnostics for evaluating aerosol-cloud interactions in models that can be derived from existing CMIP6 simulations, or from standard model performed by labs runs during the model development cycle, and can be applied to both historical and future emission scenarios. The model diagnostics will be compared to observationally-constrained estimates of ERFaci for low (warm) marine clouds which are the dominant source of uncertainty of ACI in models. These estimates use satellite measurements to provide observational constraints on the cloud susceptibility to aerosols within a framework that accounts for the role of varying environmental factors in modulating the strength of aerosol–cloud interactions.

Through these diagnostics, we aim to both quantify and better constrain the representation of aerosol-cloud processes in CMIP6 models. This will directly support the MAPP program goal to "*advance understanding of biases generally affecting CMIP6-era and next-generation models and to identify targeted model improvements that can improve model fidelity.*"

This research is a component of the Cooperative Institute for Marine and Atmospheric Science (CIMAS), a NOAA Joint Institute with the University of Miami. The research conducted under this proposal relates to CIMAS Theme 2: "Ocean and Climate Observation, Analysis and Prediction" and directly contributes to NOAA's Strategic Goal of "Climate: An informed society anticipating and responding to climate and its impacts". In particular, this research addresses the NOAA climate activity: "Improved scientific understanding of the changing climate system and its impacts."

2. Results from Prior Research

The PI was previously funded under the NOAA Model Diagnostics Task Force to develop Process Oriented Diagnostics (PODs) to quantify the instantaneous radiative forcing and radiative feedback in models. The instantaneous radiative forcing measures the perturbation in energy that initiates all externally-forced climate change. It has long been known that significant biases exist in model calculations of radiative forcing under identical emission scenarios **(Soden et al. 2018)**. These biases remain largely undocumented since radiative forcing is rarely calculated or archived, despite its fundamental role in determining the forced response to anthropogenic emissions.

The POD we developed fills this diagnostic gap by providing software to compute a set of metrics that derive the instantaneous radiative forcing (IRF) from standard model output. The Python-based software was developed to become part of the standard MDTF toolkit and also provides a common framework for feedback diagnostics to be developed within the Climate Sensitivity Task Force.

The PI has published several papers illustrating the utility of this POD to better understand radiative forcing and radiative feedbacks in CMIP6 models. **Kramer et al. (2020a)** used these tools to document the inter-model spread in instantaneous radiative forcing across multiple climate drivers. Using a multi-model ensemble of climate model simulations under various idealized forcing experiments we showed that differences in instantaneous radiative forcing (IRF), not rapid adjustments, are the dominant contributor to inter-model spread in effective radiative forcing (ERF). For greenhouse gases, instantaneous radiative forcing is relatively well constrained by radiative transfer theory, and thus provides a tractable solution to reducing the inter-model spread in effective radiative forcing and, consequently, future climate change projections.

Kramer et al. (2020b) used the POD kernels to obtain the first direct observational evidence for increasing global radiative forcing. The initial radiative imbalance to the climate system caused by increasing greenhouse gases is a fundamental metric that has not been directly observed globally; all previous estimates have come from models. This is largely because current space-based instruments cannot distinguish the instantaneous radiative forcing from the climate's radiative response. Kramer et al. (2020b) applied radiative kernels to satellite observations to separate these components and demonstrated that the all-sky instantaneous radiative forcing has increased 0.53 +/- 0.11 W/m^2 from 2003 through 2018 and accounts for the positive trends in the total TOA radiative imbalance. This has been caused by a combination of rising well-mixed greenhouse gases and recent reductions in aerosol emissions. These results highlight the distinct fingerprints of anthropogenic activity in observations of Earth's changing energy budget.

Wang et al. (2020) used the POD kernels to examine the relationship between cloud feedback, effective climate sensitivity, and aerosol-cloud interactions in CMIP6 models. The CMIP6 generation of climate models yield estimates of effective climate sensitivity (ECS) that are much higher than past generations due to stronger amplification from cloud feedbacks. If plausible, these models require substantially larger greenhouse gas reductions to meet the warming targets. Wang et al. (2020) show that models with more positive cloud feedback also have a stronger cooling effect from aerosol-cloud interactions. These two effects offset each other during the historical period when both aerosols and greenhouse gases increase, allowing either strong or weak cloud feedback models to reproduce the observed global-mean temperature change. Since anthropogenic aerosols primarily occurred in the Northern Hemisphere, strong aerosol-cloud interaction models produce a distinct hemispheric asymmetry in the pattern of warming. We show that the observed interhemispheric warming asymmetry during the mid to late 20th century is more consistent with low ECS (weak aerosol indirect effect) models.

He et al. (2020) used the POD kernels to develop observation-based emergent constraints to evaluate the intermodel spread in water vapor (WV), lapse rate (LR), and cloud feedbacks. The observed interannual variation provides a useful constraint on global-mean long-term cloud feedback, with corroboration from a physically plausible empirical relationship between interannual and long-term cloud feedbacks, explained by consistent behavior of low cloud changes. However, internal variability does not serve to constrain the long-term LR+WV feedback spread, which we find is mostly associated with the local response of relative humidity in the tropics. Model differences in hemispheric warming asymmetries due to ocean heat uptake also contribute to this spread.

Zhang et al. (2019) used the POD kernels to diagnose radiative feedbacks induced by the Madden-Julian oscillation (MJO). Over the Indo-Pacific warm pool, positive cloud and water vapor feedbacks were shown to be coincident with the convective envelope of the MJO during its active phases. Cloud changes induce the largest radiative perturbations associated with the MJO. We also found that for individual MJO events, cloud feedback and precipitation are highly correlated. Stronger radiative heating due clouds helps the MJO survive the barrier effect of the Maritime Continent, leading to further eastward propagation. These results offer process-oriented metrics that could help to improve model simulations and predictions of the MJO in the future.

All data produced from this research is publicly available upon request to the authors and/or available from publicly accessible data archives.

Publications:

Kramer, R.J. and co-authors, 2020a: Inter-model spread in instantaneous radiative forcing across multiple climate drivers, *Nature Geosci*., submitted.

Kramer, R.J., H. He, B.J. Soden, L. Oreopolus, G. Myhre, P. Forster, C.J. Smith, 2020b: Observational evidence of increasing radiative forcing, *Geophys. Res. Lett*. submitted.

He, H. R.J. Kramer, B.J. Soden, 2020: Constraining the intermodel spread in cloud and water vapor feedback, *J. Climate*, in preparation.

Soden, B. J., Collins, W. D., & Feldman, D. R., 2018: Reducing uncertainties in climate models. *Science*, **361**(6400), 326-327. doi:10.1126/science.aau1864

Wang, C., B.J. Soden, W. Yang, G.A. Vecchi, 2020: Compensation between cloud feedback and aerosol-cloud interactions, *Geophys. Res. Lett*. submitted.

Zhang, B., R.J. Kramer, B.J. Soden, 2019: Radiative feedbacks associated with the Madden-Julian Oscillation, *J. Climate*, **32** (20), 7055-7065.

3. Statement of Work

3.1 Background

a) Motivation: Uncertainty in Aerosol-Cloud Interactions

Anthropogenic aerosols and their interactions with clouds play a pivotal role in regulating the Earth's radiation balance and represent a dominant source of uncertainty in regulating global and regional climate change. Aerosols influence the radiation budget both directly, by scattering and absorbing solar radiation, and indirectly by serving as cloud condensation nuclei which, in turn, alters cloud optical properties and cloud lifetime. Increasing aerosol concentrations can enhance the concentration of cloud droplet numbers and, for a given cloud liquid water path, decreases the effective radius of the cloud droplets resulting in high cloud albedos – the "Twomey effect" (e.g., Twomey, 1977). This form of aerosol-cloud interactions (ACIs) is now widely referred to as the Radiative Forcing due to ACI (RFaci). In addition, the aerosol-induced reduction in effective radius can also impact the macrophysical properties of clouds by reducing precipitation rate, thus enhancing the cloud liquid water path, cloud lifetime and cloud fraction (e.g., Albrecht 1989; Pincus and Baker 1994; Brenguier et al. 2000; Fiedler et al., 2019). This form of ACI is now widely referred to as the cloud adjustment (CA) due to aerosols. The sum of the RFaci and CA constitute the effective radiative forcing from ACI (ERFaci).

Models suggest that aerosol alter both the distribution of liquid water within the cloud as well as vertical motion within the cloud, both of which are capable of modifying the cloud's duration, coverage, and precipitation (Dagan et al., 2016). By delaying the collision and coalescence of cloud droplets aerosols can increase cloud lifetime. On the other hand, evaporation–entrainment may decrease cloud lifetime (Small et al., 2009). Indeed, observations suggest that marine clouds can increase or decrease depending on the background state of the cloud and aerosol fields (Chen et al., 2015) as well as state-dependent interactions with the environment (Gryspeerdt et al., 2019). Similarly, changes in entrainment or precipitation due to ACI can, in turn, alter the environment.

Given the complexity and scale of these interactions, significant uncertainty exists in their representation in global climate models (Myhre et al., 2013; Smith et al., 2020; Zelinka et al., 2014). Indeed, the spread among model-calculated ERFaci constitutes the largest known source of uncertainty in historical forcing estimates of radiative forcing (Myhre et al. 2013). This reflects both the lack of understanding of these processes as well as the lack of metrics for quantifying their impact in models. As shown below, the lack of quantifiable metrics of ACI and observational constraints directly contributes to most of the intermodel spread in climate sensitivity (Sherwood et al. 2020; Wang et al. 2020).

Part of the complexity of ACI stems from the recognition that they are not separable from each other or from their environment. Indeed, the impact of changes in particle size or liquid water content, both influence and are influenced by their environment. The interactions between clouds, aerosols and their environment can lead to a range of cloud responses to aerosol loading that differ depending on the local conditions of the environment in which they occur (Douglas and L'Ecuyer, 2019). Thus, observational constraints on ACI must distinguish the individual components of ACI (RFaci and CA) as well as their individual dependence on the environment.

In this proposal, we intend to address these gaps in understanding by: (i) developing a set of metrics of ERFaci that can be derived from existing CMIP6 simulations (or from standard model performed by labs runs during the model development cycle), (ii) comparing these metrics of low (warm) marine clouds to recently-developed observations of ERFaci that are account for the influences of local environment, (iii) decomposing the spread in model simulated ERFaci into contributions from both RFaci and CA; and (iv) using the observations of ERFaci to constrain CMIP6 projections.

b) Uncertainty in Aerosol-Cloud Interactions in CMIP6

Uncertainties in quantifying the effective radiative forcing due to aerosol–cloud interactions (ERFaci) is directly related to uncertainties in model predictions of cloud feedback and climate sensitivity. As the climate warms from increasing greenhouse gases (GHGs), it is not yet clear whether changes in cloud properties will further amplify or dampen the GHG induced warming. Uncertainties in predicting this radiative feedback from clouds are the largest cause of spread in model predictions of future global warming (Boucher et al., 2013; Ceppi et al., 2017; Zelinka et al., 2020).

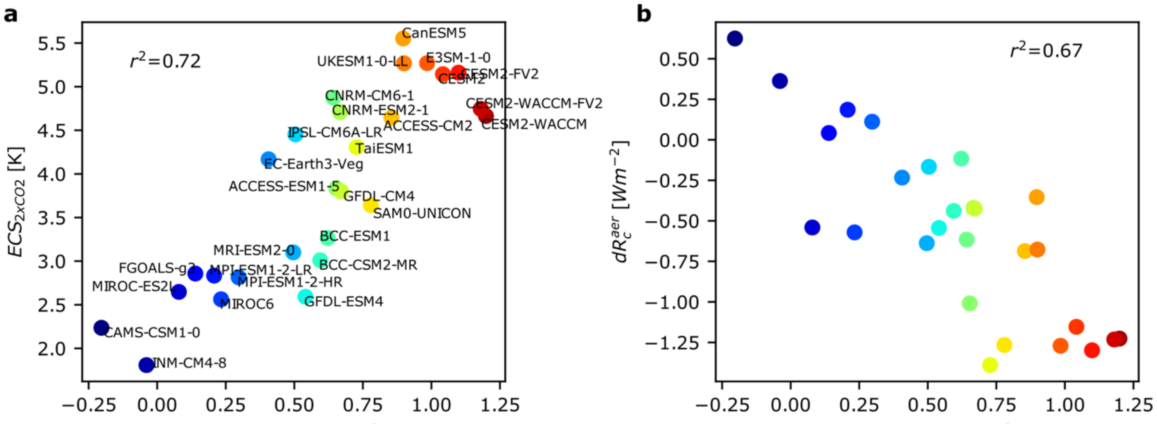

Figure 1. *Cloud feedbacks, effective climate sensitivity (ECS), and aerosol-mediated cloud radiative responses (ΔR_c^{aer}) in the CMIP6 models. a) Scatter plot of ECS and cloud feedback parameter. b) Inter-model relationship between cloud feedback and aerosol-mediated cloud radiative responses. The cloud feedback and ECS are computed from the response to 4xCO2 forcing and the aerosol-mediated cloud radiative response is calculated from the historical experiments (1950-2000 mean). Each dot represents a single model. The colors from red to blue indicate high cloud feedback models to low cloud feedback models. From Wang et al. (2020).*

Current estimates of cloud feedback range from effectively neutral to substantially positive in response to GHG forcing (Chung & Soden, 2015; Vial et al., 2013; Zelinka et al., 2013, 2016). The latest climate models form the Sixth Phase of the Coupled Model Intercomparison Project (CMIP6) has been introduced a number of models with significantly higher effective climate sensitivity (ECS) compared to previous generations (Zelinka et al., 2020). This higher ECS has been shown to result primarily from a more positive cloud feedback in models. The ECS ranges from 1.8-5.6 K in the CMIP6 models, with seven of them having an ECS greater than 4.7 K, the upper bound of ECS in CMIP5 (Flato et al., 2014). If plausible, these models require substantially larger greenhouse gas reductions to meet the warming targets.

A preliminary study of the aerosol cloud interactions in CMIP6 show that models with more positive cloud feedback also have a stronger cooling effect from aerosol-cloud interactions (Wang et al. 2020). Figure 1 compares the global mean values of cloud feedback and ECS from the abrupt4xCO2 simulations (Fig. 1a) and cloud feedback versus the corresponding value ERFaci from the historical simultions (Fig 1b). There is a strong relationship between cloud feedback and ECS: models with more positive cloud feedback show higher ECS (Figure 1a, r^2=0.69) (Meehl et al., 2020; Zelinka et al., 2020). However, there exists a strong compensation between the cloud feedback from CO2-induced surface warming and the aerosol-mediated cloud response (ERFaci). This anti-correlation is clearly shown in Figure. 1b, which compares the global-mean cloud feedback for each model from the abrupt-4xCO2 simulations with the corresponding ERFaci from the historical simulations. Models with a more positive cloud feedback tend to have a larger negative aerosol-mediated response (r^2=0.60).

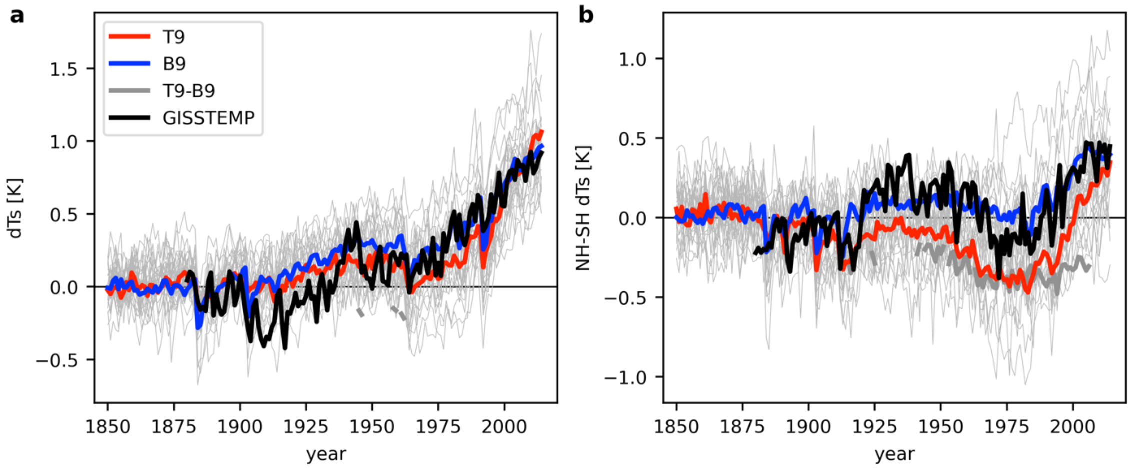

Figure 2: *Modeled and observed response of global-mean and inter-hemispheric difference in surface temperature. Annual time-series of a) the global mean surface temperature anomaly, and b) the interhemispheric temperature anomaly difference (NH-SH). The black line is from the GISS surface temperature observations. Each thin grey line represents a single ensemble from one model. The red and blue lines indicate the*

model ensemble mean of the T9 (largest ERFaci) and B9 (smallest ERFaci) models, respectively. From Wang et al. (2020).

In terms of their effect on global mean temperature, these two effects offset each other during the historical period when both aerosols and greenhouse gases increase, allowing either strong or weak cloud feedback models to reproduce the observed global-mean temperature change. For example, Figure 2a compares the observed global mean temperature anomaly (black line) with that simulated from the historical experiment for all CMIP6 models (thin gray lines) as well as the average of the models with the largest ERFaci (T9) and smallest ERFaci (B9). Both models with low and high ECS are able to reproduce the observed changes in global-mean temperature. However, since anthropogenic aerosols primarily occurred in the Northern Hemisphere, strong aerosol-cloud interaction models produce a distinct hemispheric asymmetry in the spatial distribution of warming. In particular, the observed interhemispheric warming asymmetry during the mid to late 20th century is more consistent with low ECS (small ERFaci) models (Figure 2b). This highlights the importance of ACI in governing both the ECS and well as the hemispheric asymmetry in warming. Both of these directly impact the projected changes in climate extremes with significant societal consequences.

c) Relevance of Aerosol-Cloud Interactions to Climate Extremes

As illustrated above, ACIs represent a key uncertainty in climate sensitivity and handicap our ability to constrain climate sensitivity over the historical period. Both low and high ECS models are capable of reproducing the observed change in global mean temperature. This has direct consequences for changes in regional extremes, since for any given model, the amplification of the frequency or severity of changes in extreme events scales roughly in proportion to the change in global mean temperature. Thus, reducing the uncertainty in ERFaci and ECS, would also likely lead to a reduction in the uncertainty in model projections of the changes in extremes (e.g., floods, droughts, heat waves, etc.)

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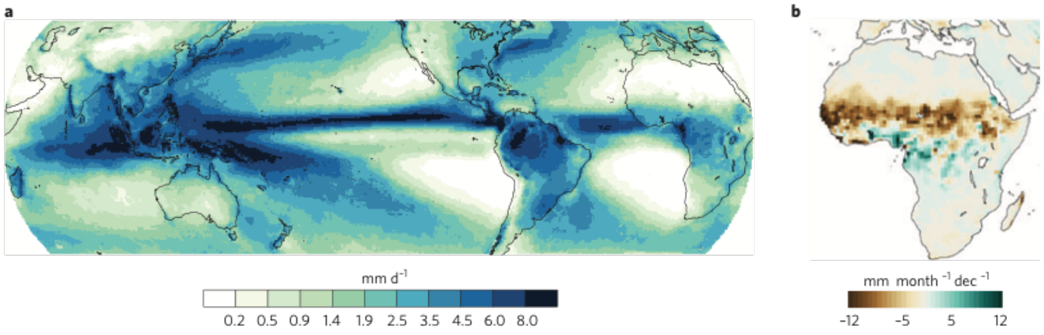

Figure 3: Left: *The observed distribution of precipitation from TRMM for 1998-2005 highlighting the large spatial contrast in rainfall over the tropics* **Right**: *The observed decadal trend in Sahel wet-season rainfall from 1950-2000. From Bony et al. (2015).*

The hemispheric asymmetry in warming (Fig 1b) also induces large-scale shifts in the atmospheric circulation that have a significant impact on regional changes in rainfall [e.g., Zhang and Delworth, 2006; Ming and Ramaswamy 2011; Hwang et al., 2013; Allen et al., 2015; Wang, 2015; Salzman 2016]. Consider the observed spatial distribution of rainfall over the tropics and sub-tropics illustrated in Figure 3 (left). This region encompasses many of the world's wettest and driest climates. Indeed, the large contrast in precipitation between the wet tropics and the dry subtropics largely determines the climate of the tropical zones and dictates much of the built infrastructure in these regions. Small changes in this pattern dominates the regional signal of projected rainfall changes and has enormous societal and ecological impacts. A southward shift of the tropical rain belt (Figure 1, right) has been observed throughout the latter half of the twentieth century with profound consequences, including severe droughts throughout much of the Sahel and Amazon. These changes have been attributed, at least in part, to changes in anthropogenic aerosols (Zhang and Delworth, 2006; Held et al. 2005; Neelin et al. 2006; Hwang et al., 2013; Allen et al., 2015; Chung and Soden 2017).

d) Relationship to Existing MDTF Activities

Despite its fundamental importance in determining historical forcing and climate sensitivity, and large uncertainty in its representation in climate models, there does not currently exist a consistent framework to quantify and evaluate aerosol-cloud interactions in climate models. Moreover, there exists no prior project with the MDTF (team 1 or team 2) to develop diagnostics for aerosol-cloud interactions. While the Climate Sensitivity Task Force has funded several projects to investigate cloud feedback and potentially develop diagnostics, none of these projects address aerosol-cloud interactions either. This proposal aims to fill this gap by developing a consistent set of diagnostics that can be computed from standard coupled GCM integrations and are directly comparable to observations within a processed-oriented framework that accounts for their dependence on the local state of the environment. In doing so, this proposal will help to both better constrain estimates of ECS and the associated impacts of changes in climate extremes in future model generations.

e) Research Objectives and Relevant to MAPP Goals

Aerosol-climate interactions play fundamental role in climate projections and represent a critical source of uncertainty in model projections of future climate change. Indeed, current climate models disagree on both the sign and magnitude of the radiative effects from aerosol-cloud interactions. This disagreement reflects, in part, our limited ability to quantify their effects in models in a manner that is comparable to observations.

This proposal seeks to provide a common framework to quantify aerosol-cloud interactions in climate models, to compare the model estimates to observations, and ultimately better constrain their representation in models. By developing and applying process-oriented metrics that enable users to quantify and constrain intermodel differences in aerosol-cloud interactions, this proposal will yield a better understand the physical mechanisms that drive the intermodal spread in model projections of historical and future climate projections. By combining these model-based metrics with historical observations, this proposal will directly serve the MAPP goal of of developing and applying process-oriented metrics to "*advance understanding of biases generally* *affecting CMIP6-era and next-generation models and to identify targeted model improvements that can improve model fidelity.*"

3.2. Developing Process-Oriented Diagnostics of Aerosol Cloud Interactions

The model diagnostics of ERFaci that will be developed in this proposal use "*radiative kernels*" to decompose the TOA flux anomalies into contributions from aerosols, clouds and other feedback variables. The sections below provides a brief description of radiative kernels and the computation of the ERFaci metrics. For additional details on the radiative kernel methodology, the reviewer is referred to Soden et al. (2008).

a) Radiative Kernels

Originally developed by Soden and Held (2006) to facilitate the analysis of radiative feedbacks, "radiative kernels" describe the differential response of radiative fluxes to incremental changes in the radiative state variables (e.g., temperature, water vapor, clouds, etc.). The use of radiative kernels enables one to decompose radiative flux changes into two parts: one that depends on radiative transfer and the unperturbed climate state, and a second that arises from the climate response of the state variables. By cleanly separating the radiative changes in this manner, the relative importance of different responses in the state variables can be quantified. Such decomposition facilitates an understanding of the causes and implications of differences among models, or between models and observations.

To calculate the ERFaci, monthly model output from standard coupled model integrations (e.g., historical, piControl, and 1pctCO2) are used to decompose the TOA flux anomalies into contributions from aerosols, clouds and aerosol-cloud interactions. Diagnostics of ERFaci can be computed for future climate scenarios in the same manner.

The radiative decomposition begins by isolating the temperature-dependent radiative feedbacks, defined in terms of the changes in global mean surface temperature and net radiative flux at the top of the atmosphere (*R*). Feedbacks may arise from changes in water vapor (*W*), clouds (*C*), surface albedo (α) and temperature (*T*). One can define radiative perturbations for each variable; let $\Delta \overline{T}_s = \Delta \overline{R} / \overline{\lambda}$, where $\lambda = \lambda_T + \lambda_C + \lambda_w + \lambda_\alpha$.and the overbar indicates global averaging.

Following Soden et al. (2008), the radiative perturbations for each feedback variable can be further decomposed using the radiative kernel technique in which the radiative perturbations are separated into two parts. The first, termed the *radiative kernel*, depends only on the radiative transfer and base climate state. We define the radiative kernel for a particular feedback variable *x* as: $K^x = \frac{\partial R}{\partial x}$. The extraction of the kernel *K*, which depends only on radiative transfer within the control climate, explicitly or implicitly underlies most discussions of water vapor, cloud and temperature feedback. The second term represents the *climatic perturbation* of that particular variable; $\frac{dx}{d\bar{T}_s} = \frac{x^B - x^A}{\bar{T}_s^B - \bar{T}_s^A}$ where A and B represent two climate states. The product of the radiative kernel and the climate perturbation yield the radiative perturbation for that variable, $\lambda_X = \frac{\partial R}{\partial x}\frac{dx}{d\bar{T}_s} = K^x \frac{dx}{d\bar{T}_s}$. Both K^x and x are functions of latitude, longitude, altitude and *monthly*-resolved season.

b) Calculation of Aerosol-Cloud Interaction Diagnostics from CMIP6

For small climate changes, the net radiative flux imbalance at the top of the atmosphere for clear-sky conditions (ΔR^0) can be decomposed into radiative flux perturbations associated with changes in climate variables in the troposphere and stratosphere, and the direct radiative forcing from a forcing agent at the top of the atmosphere (G^0) as follows:

$$\begin{aligned}\Delta R^0 &= \Delta R_T^0 + \Delta R_{WV}^0 + \Delta R_a^0 + G^0 \\ &= K_T^0 \Delta T + K_{WV}^0 \Delta WV + K_a^0 \Delta a + G^0\end{aligned}$$

The radiative flux perturbations due to changes in climate variables for clear-sky conditions are computed here by multiplying the changes of temperature, water vapor, and surface albedo with the corresponding radiative kernel (K^0) (e.g., Soden et al. 2008). Such decomposition allows one to determine the direct clear-sky radiative forcing from the imposed forcing agent (G^0). In other words,

$$G^0 = \Delta R^0 - (K_T^0 \Delta T + K_{WV}^0 \Delta WV + K_a^0 \Delta a)$$

The total-sky radiative flux imbalance at the top of the atmosphere is similarly decomposed after including the terms related to cloud changes

$$\Delta R = \Delta R_T + \Delta R_{WV} + \Delta R_a + \Delta R_C + G$$

where the radiative perturbations due to clouds (ΔR_C) are computed using the changes in cloud radiative effect (ΔCRE) after accounting for the cloud masking effects on other variables (see Soden et al., 2008).

$$\Delta R_C = \Delta CRE + (K_T^0 - K_T)\Delta T + (K_{WV}^0 - K_{WV})\Delta WV + (K_a^0 - K_a)\Delta a + (G^0 - G).$$

Following Soden and Chung (2017), one can then decompose the total cloud radiative response (ΔR_C) in the historical experiment into two parts: the part due to global-mean surface temperature change and the part due to aerosol-cloud interactions (ERFaci). The aerosol-mediated cloud response includes both the aerosol indirect effect and non-local changes in clouds that result from aerosol-induced changes in the large-scale circulation (Soden and Chung, 2017). The first part can be estimated by multiplying the global-mean temperature anomaly and the normalized cloud radiative response parameter α obtained from the corresponding 1pctCO2 experiment for each model. Therefore, the aerosol-mediated cloud radiative response (ERFaci) can be expressed as:

$$\text{ERFaci} = \Delta R_C - \alpha_{1pctCO2} \cdot \Delta \overline{T_s}$$

As shown by Soden and Chung (2017) and Wang et al. (2020), this approach successfully reproduces the estimates of ERFaci calculated using single forcing (*i.e.*, aerosol-only) experiments with fixed SSTs to suppress the surface temperature driven cloud feedbacks. These estimates are also consistent with the aerosol-cloud interaction cooling effect estimated by the approximate partial radiative perturbation method (Smith et al. 2020).

One of the advantages of this approach is that it provides a consistent framework for estimating ERFaci in both historical and future emission scenarios. This proposal will provide estimates of ERFaci for each model under both historical and a select set of future emission scenarios. This will enable us to assess whether models with strong ERFaci under historical emissions (where anthropogenic aerosols increase) have similarly large ERFaci in future emission scenarios (where anthropogenic aerosols decrease).

Because the dominant source of ACI arise from low (warm) marine stratus and stratocumulus clouds, and because observations of ACI are most robust for these cloud types, we will further decompose the ERFaci into different vertical cloud types following Soden and Vecchi (2011). While the diagnostics to quantify ERFaci in models will be performed for all cloud types, as described below, the focus for the observational evaluation will be on low cloud cover, which are the dominant contributor of ACI to ERFaci (Christensen et al., 2016). Marine low clouds have been the primary focus of ACI research due to their ubiquitous nature, proximity to anthropogenic sources, and susceptibility to changes in aerosol loading.

c) Observations of Aerosol-Cloud Interactions

Satellite data have been widely used to analyze aerosol-cloud correlations, such as relationships between aerosol optical depth and droplet effective radii or liquid water path. However, one of the challenges in estimating the cloud radiative response to aerosols is to account for the influences of the local meteorology on these relationships. Recently, Douglas and L'Ecuyer (2019, 2020) used observations of warm clouds from the NASA A-Train constellation of satellites along with reanalysis fields to estimate the ERFaci in low marine clouds using observed radiative fluxes, cloud fraction, and aerosol optical depth. Observations of low (warm) marine clouds and aerosols from the Cloud Profiling Radar (CPR) and Moderate Resolution Imaging Spectroradiometer (MODIS) aboard CloudSat and Aqua, respectively, are utilized to estimate the effects of aerosol–cloud interactions on the radiative properties of clouds. Radiative fluxes are computed using the CloudSat 2B-FLXHR-LIDAR product.

The methodology uses the coincident cloud and aerosol information to derive susceptibility factors (λ) for both RFaci:

$$\lambda_{\mathrm{RFaci}} = \partial \mathrm{SW}_{\mathrm{Cloudy}} / \partial \ln(\mathrm{AI})$$

and CA:

$$\lambda_{\mathrm{CA}} =. \partial \mathrm{CF} / \partial \ln(\mathrm{AI})$$

where SW_{Cloudy} is the cloudy sky shortwave flux at the top of the atmosphere, CF is the cloud fraction, and AI is the aerosol index, defined as the product of the aerosol optical depth and the Angstrom exponent and is more closely associated with changes in cloud condensation nuclei than aerosol optical depth.

The data are then aggregated according to atmospheric state to account for the influences of liquid water path (LWP), relative humidity (RH) and boundary layer stability (EIS) regimes when computing the susceptibility factors, thus allowing λ_{RFaci} and λ_{CA} to vary as a function of these environmental factors. Each susceptibility (λ) is evaluated in distinct EIS, RH, and LWP regimes regionally. The susceptibility is then computed by integrating over each of these variable bins,

$$\lambda = \sum_{l=1}^{N_{reg}} \sum_{k=1}^{N_{LWP}} \sum_{j=1}^{N_{RH}} \sum_{i=1}^{N_{EIS}} \lambda_{i,j,k,l} W_{i,j,k,l}$$

where the weighting function, W_{ijkl} accounts for the size of the region, mean cloud fraction CF and mean cloudy sky shortwave flux SW_{Cloudy}. The ERFaci is then computed as ERFaci = $(\lambda_{\mathrm{CA}} + \lambda_{\mathrm{RFaci}}) \times \Delta\ln(\mathrm{AI})$

For historical estimates of ERFaci, Δln(AI) is obtained from model simulations of the change in aerosol index between pre-industrial and present day simulations using the SPRINTARS chemistry transport model (Takemura et al., 2000). However, one can also use the observational estimates of the susceptibility factors (λ_{RFaci} and λ_{CA}) with CMIP6 model simulations of Δln(AI) to better understand how intermodel differences in cloud susceptibility and aerosol loading contribute to spread in ERFaci.

A strength of this method is that it provides a near-global data set of observationally-constrained estimates of ERFaci. The methodology accounts for the regionally specific environmental conditions and liquid water path and is directly comparable to the low cloud ERFaci diagnostic obtained from the CMIP6 models. Although it is restricted to low (warm), marine clouds, these cloud types are the dominant contributor to the ERFaci and the primary source of uncertainty in models.

3.3. Science Plan

a) Comparison of Observed and CMIP6 simulated ERFaci

Because aerosol-cloud interactions are difficult to quantify from model simulations, ERFaci is not explicitly computed and is not part of the standard DECK output for **CMIP6**. In the absence of any dedicated single-forcing experiments to specifically isolate aerosol-cloud interactions from other forcing agents, the radiative kernel method outlined above currently provides the only method to estimate ERFaci using standard CMIP output and emission scenarios. The first part of our proposed work will be to develop the software to compute ERFaci from standard model simulations (e.g., piCNTRL, historical and 1%CO2) and apply them to the CMIP6 archive. This effort will be combined with a corresponding set of analyses of the ERFaci from future emission scenarios, which have a reduction in anthropogenic aerosols to provide a consistent framework to compare the importance of aerosol-cloud interactions in both historical and future emission scenarios.

The historical simulations of ERFaci (3.2b) will also be compared to the observational estimates (3.2c). The emphasis will be on both the global mean values and their spatial distribution, particularly the hemispheric asymmetry in ERFaci. Preliminary comparison of the observed global-mean estimate from Douglas and L'Ecuyer (2020) of -0.32 ± 0.16 W/m^2 with those presented in Wang et al. (2020) (Figure 1b), suggest that less than one-third of the CMIP6 models have a value of ERFaci over the historical period that is within the observational uncertainty. Note, however, that the results in Figure 1b are for all cloud types, rather than just low (warm) marine clouds. The analysis proposed here will more carefully compare the observed and CMIP6-simulated values by separating the ERFaci from the models according to cloud type following Soden and Vecchi (2011) (See section 3.2b).

We will also examine the spatial distribution of ERFaci, paying particular attention to the hemispheric asymmetry. As shown in Figure 2b, observations of the hemispheric asymmetry in the historical warming are more consistent with CMIP6 models that have a small global-mean ERFaci. It will be important to compare this result with observationally-constrained estimates of ERFaci from satellite measurements.

b) Observationally-constrained estimates of ERFaci from CMIP6 models

The magnitude of ERFaci over the historical period depends primarily on two factors: the amount of aerosol loading between the pre-industrial and present day, $\Delta\ln(AI)$, and the susceptibility of cloud albedo and cloud lifetime to that aerosol loading, λ_{RFaci} and λ_{CA}.

The second part of this proposal will isolate the contributions of these two factors to the intermodel spread, and model-observational differences in ERFaci. This will be accomplished by first normalizing the observed ERFaci by the SPRINTARS simulated aerosol loading for the historical period to define an ERFaci sensitivity

$$\lambda_{ERFaci} = ERFaci / \Delta\ln(AI)$$

Then we will compute an observationally-constrained estimate of ERFaci for each

CMIP6 model by multiplying λ_{RFaci} by that model's simulated change in aerosol loading $\Delta\ln(AI_{\mathrm{CMIP6}})$

$$ERFaci_{\mathrm{CMIP6}} = \lambda_{\mathrm{ERFaci}} \times \Delta\ln(AI_{\mathrm{CMIP6}})$$

Figure 4 shows the distribution $\lambda_{\mathrm{ERFaci}}$ from Douglas and L'Ecuyer (2020). Note the strong spatial variability in the sensitivity with the largest negative sensitivities found over colder ocean waters of the southern oceans and upwelling regions associated with marine stratocumulus clouds and stable, low marine boundary layers.

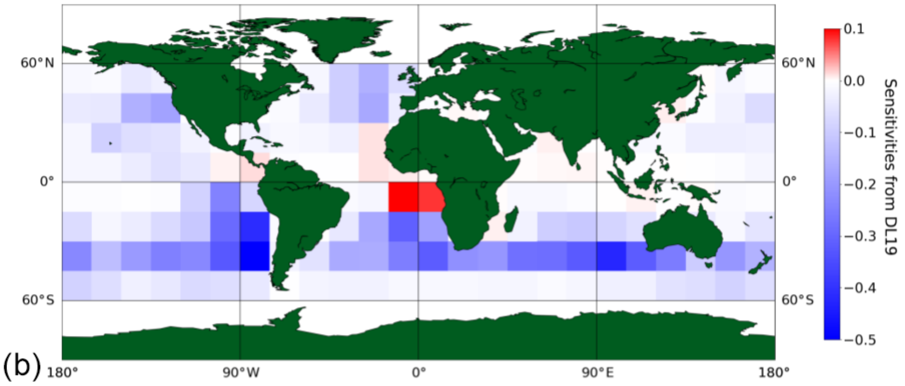

Figure 4: *Map of the annual mean distribution of* $\lambda_{\mathrm{ERFaci}}$ *from Douglas and L'Ecuyer (2020). This data will be used in conjunction with model simulated values of aerosol loading from CMIP6 to produce estimates of observationally-constrained ERFaci for both historical and future emission scenarios.*

By comparing these observationally-constrained estimates of ERFaci with the actual ERFaci simulated from CMIP6 models, we will be able to isolate and quantify the contributions of differences in cloud susceptibility and differences in aerosol loading to the intermodel spread in ERFaci for both historical and future emission scenarios. This analysis will also reveal the extent to which biases in the model simulations of cloud susceptibility are responsible for differences in the historical ERFaci between observations and models.

c) Decomposition and environmental dependences of ERFaci

The last portion of this project will decompose the model values of $\lambda_{\mathrm{ERFaci}}$ into contributions from λ_{RFaci} and λ_{CA} and evaluate these as a function of the environmental conditions: EIS, RH, and LWP. The decomposition and environmental dependences will be assessed using the same procedure and regime boundaries used for the observations, but applying them to model output at daily time resolution. The method of Soden and Chung (2017) described in section 3.2b will be used to compute from $\lambda_{\mathrm{ERFaci}}$. We will follow the methodology of Douglas and L'Ecuyer (2020) to .decompose these into contributions from λ_{RFaci} and λ_{CA}.

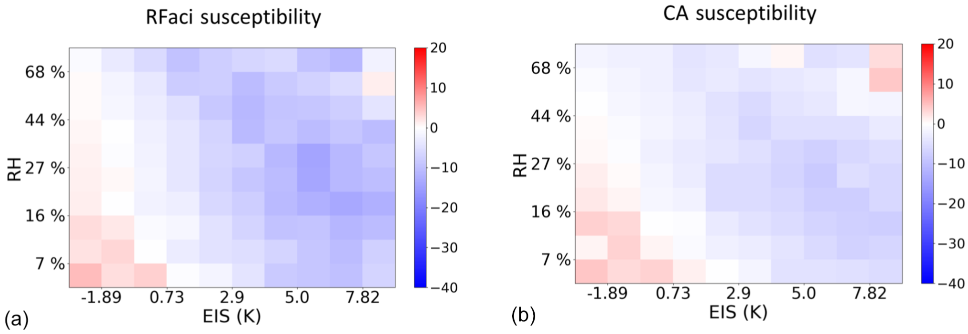

Figure 5: *Illustration of the observed dependence of* λRFaci and λCA *as a function of the environmental regimes. From Douglas and L'Ecuyer (2020).*

Figure 5 illustrates a decomposition of the observed estimates of cloud susceptibility λRFaci and λCA as a function of EIS and RH from Douglas and L'Ecuyer (2020). The results highlight a strong dependence on both RH and EIS, with more stable regimes exhibiting a stronger susceptibility of clouds to aerosol loading. Diagnostics such as this will be invaluable to understanding the causes of differences between models as well as helping to elucidate the cause of systematic biases compared to observations, and provide developers with observationally-based constraints for improving the representation of ACI in models, thus ultimately reducing uncertainty in climate projections.

3.4 Task Schedule and Deliverables

Task Schedule

Task	Year 1	Year 2	Year 3
Archive required variables from CMIP6 simulations for selected scenarios (PIcntrl, historical, 1%CO2, and future emission scenarios)	X		
Compute the effective radiative forcing from aerosol-cloud interactions for both historical and future emission scenarios from each model	X		
Decompose CMIP6 ERFaci into contributions from low, middle and high clouds types	X	X	
Compare observed and CMIP6 estimates of ERFaci.		X	
Use observed values of cloud susceptibility to compute observationally-constrained estimates ERFaci from CMIP6 models. Compare observationally constrained ERFaci from the historical period to observed ERFaci		X	X
Decompose ERFaci from CMIP6 models into contributions from RFaci and CA.		X	X
Evaluate the dependence of RFaci and CA on environmental factors in CMIP6 models.			X
Present results at scientific conferences	X	X	X
Submit papers to peer-reviewed journals	X	X	X

4. Data Sharing Plan

This project will produce the following data sets: 1) A set of 2-D gridded data sets of the ERFaci for each model, under both historical and future emission scenarios from CMIP6 with decadal time resolution; 2) A decomposition of the ERFaci for low, middle and high clouds for each CMIP6 model; 3) Estimates of the observationally-constrained ERFaci for each CMIP6 model; 4) Decompositions of the cloud susceptibility (λ_{RFaci} and λ_{CA}) as a function of environmental regimes for each CMIP6 model; 5) A Python based software package will also be made publicly available that will allow users to compute the ERFaci using standard CMIP model output. The gridded data sets will be created and organized separately for each model and emission scenario. To save the constructed data sets for all interested researchers, the data sets will be stored in the data archiving system at the University of Miami. We have the capabilities to make the data available via anonymous ftp or other web-based access. In addition, the data sets and code will be submitted to the NOAA MDTF website along with metadata records, in which detailed information on the data sets produced in this project is described.

5. Statement of Diversity, Inclusion, and Broader Impacts

If supported, this project will help identify the primary mechanisms that determine the aerosol-cloud interactions in models, and identify the key physical processes that require observational validation to improve model projections. Enhanced understanding of the processes that determine aerosol-cloud interactions will help model developers refine the relevant physical processes represented in models. By increasing the reliability of long term projections of climate change, this project will help decision makers plan adequate adaptation and mitigation strategies. This project will also support the education and training of one graduate student. More information on Diversity and Inclusion at the U. Miami can be found here: https://diversity.rsmas.miami.edu/ and https://www.hr.miami.edu/working-at-the-u/diversity-and-inclusion/index.html.

The work proposed here will be conducted within an inclusive environment, in which there is a full participation by, and equitable valuation of the contributions from, all members of the team, regardless of race, gender, or religious beliefs. All efforts will be made to identify and encourage participation from underrepresented groups in the activities outlined in this project, including the selection of the graduate student and any involvement by "volunteer" undergraduate interns.

The PI is involved in a number of outreach activities that support the education and awareness of the broader public. As one example, the PI is a member of the Leadership Circle of the Climate Leadership Engagement Opportunities (CLEO) Institute (www.cleoinstitute.org). Based in Miami, the goal of CLEO is to educate local leaders and the general public so that they are better able to make informed decisions about climate resilience. By bringing climate scientists together with elected, business, and community leaders, and the public through both formal and informal outreach activities, it serves to bridge the divide between science and society. By improving our understanding of key processes that regulate the changes in climate and their impact on weather extremes, this research can facilitate CLEO's mission to educate community leaders and the local citizenry on the local impacts of climate change.

This project will also support the training of one graduate student. One of the PIs former graduate students, Dr. Angela Colbert, is now Director of Science Communications at the Frost Museum of Science in Miami (www.frostscience.org). The PI maintains regular contact with Dr. Colbert, who strives to foster improved communication of scientific research to the general public. By increasing our understanding of the processes that regulate long-term changes in climate, the research supported by this project can contribute to the museum's mission and increase the public awareness of the local consequences of climate changes.

6. Detailed Budget

Personnel:	**Role:**	**YEAR 1**			**YEAR 2**			**YEAR 3**			**BUDGET**
Principal Investigators:		**Months**	**%**	**Amount**	**Months**	**%**	**Amount**	**Months**	**%**	**Amount**	**TOTALS**
Brian Soden	PI	1.5	13%	34,530	1.5	13%	35,566	1.5	13%	36,633	106,729
Graduate Students:											
TBA	Graduate Student	12.0	100%	31,221	12.00	100%	32,158	12.00	100%	33,123	96,502
TOTAL SALARIES				**65,751**			**67,724**			**69,756**	**203,231**
Fringe Benefits:											
Faculty Fringe Benefits				8,115			8,358			8,609	25,082
TOTAL SALARIES & CFB				**73,866**			**76,082**			**78,365**	**228,313**
Travel:											
Domestic				4,000			4,000			4,000	12,000
Foreign				3,000			3,000			3,000	9,000
Other Direct Costs:											
Grad Student health insurance				4,026			4,227			4,438	12,691
Publication Costs				5,000			5,000			5,000	15,000
MODIFIED TOTAL DIRECT COSTS (MTDC)				**89,892**			**92,309**			**94,803**	**277,004**
Other Direct Costs - F&A Excluded (Non-MTDC)											
Grad student tuition				27,342			28,709			30,145	86,196
Large data storage disk array				6,000			-			-	6,000
Workstation				4,000			-			-	4,000
TOTAL DIRECT COSTS (TDC)				**127,234**			**121,018**			**124,948**	**373,200**
FACILITIES & ADMINSTRATIVE COST (F&A) of MTD			55.0%	**49,441**			**50,770**			**52,142**	**152,353**
TOTAL PROJECT COSTS				**176,675**			**171,788**			**177,090**	**525,553**

7. Budget Justification

The personnel for this project include one PI (BJS) and one gradaute students (TBD).

Dr. Brian Soden -PI - Will provide the overall scientific guidance and management of the project and has significant expertise on the use of satellite observations to better understand radiative forcing and feedbacks in climate models and their use in understanding changes in climate. The level of technical expertise required for the successful completion of the proposed observational and modeling tasks is the primary justification for the time commitment of the PI (1.5 months).

TBA – Graduate Student - PhD level graduate student will be supported under this project and will assist in the analysis of the observations and GCM experiments as part of their PhD dissertation. The PI (Soden) will be the chair of the student’s academic committee.

Fringe Benefits:

Fringe benefit rates by UM fiscal year (ending 31 May) are:

Faculty - 23.5 % FY21

Travel:

Costs are estimated for two domestic trips per year, 5 days each, between Miami and the national science meeting (e.g., AGU or AMS) for the PI and the graduate student.

Airfare:	$500 per person
Hotel:	$200 per day per person
Per Diem:	$50 per day per person
Parking/taxi/misc.:	$250 per person
Total for two trips:	$4,000

Costs are estimated for one international trip per year, for 5 days, between Miami and western europe (e.g. Paris) for the PI to present the results at an international conference (e.g. IUGG).

Airfare:	$1,000 per person
Hotel:	$200 per day per person
Per Diem:	$100 per day per person
Parking/taxi/misc.:	$250 per person
Registration:	$250 per person
Total for one trip:	$3,000

Equipment:

The data analysis will be carried out at RSMAS and we therefore request a computer workstation to support the computational requirements of this research. We also request funds to purchase a RAID data storage system for archiving the climate model output and satellite data sets to be developed under this project.

Workstation:	$4,000
Data archive disk system:	$6,000

Other direct Cost:

Publication charges: Funds totaling $15,000 are requested for Publication across the project.

Graduate Student Tuition - Funds totaling across $86,196 are requested for graduate student tuition (F&A excluded) across the project.

Graduate Health Insurance - Funds totaling $12,691 are requested for graduate student health insurance across the project.

Facility and Administrative Costs (F&A):

The F&A cost type is Predetermined. F&A costs are requested at the federally negotiated rate of 55.0% of the Modified Total Direct Costs (MTDC) (excludes equipment, graduate student tuition, and subcontract amounts over $25,000). This rate is based on the agreement dated 07/26/2019 by DHHS, Darryl W. Mayes (301) 492-4855.

8. UM Indirect Cost Rate Agreement

COLLEGES AND UNIVERSITIES RATE AGREEMENT

EIN: 15-90624458

ORGANIZATION:
University of Miami
Office of the Controller
P.O. Box 248106
Coral Gables, FL 33124-1422

DATE:09/10/2020

FILING REF.: The preceding agreement was dated 07/26/2019

The rates approved in this agreement are for use on grants, contracts and other agreements with the Federal Government, subject to the conditions in Section III.

SECTION I: INDIRECT COST RATES

RATE TYPES: FIXED FINAL PROV. (PROVISIONAL) PRED. (PREDETERMINED)

	EFFECTIVE PERIOD				
TYPE	**FROM**	**TO**	**RATE(%)**	**LOCATION**	**APPLICABLE TO**
PRED.	06/01/2021	05/31/2025	53.50	On-Campus	Org Rsch Medical
PRED.	06/01/2021	05/31/2025	50.50	On-Campus	Org Rsch Main
PRED.	06/01/2021	05/31/2025	55.00	On-Campus	Org Rsch Marine
PRED.	06/01/2021	05/31/2025	50.00	On-Campus	Instruction
PRED.	06/01/2021	05/31/2025	36.00	On-Campus	Other Sponsored Activities
PRED.	06/01/2021	05/31/2025	26.00	Off-Campus	All Programs
PROV.	06/01/2025	Until Amended			Use same rates and conditions as those cited for fiscal year ending May 31, 2025.

*BASE

Modified total direct costs, consisting of all direct salaries and wages, applicable fringe benefits, materials and supplies, services, travel and up to the first $25,000 of each subaward (regardless of the period of performance of the subawards under the award). Modified total direct costs shall exclude equipment, capital expenditures, charges for patient care, rental costs, tuition remission, scholarships and fellowships, participant support costs and the portion of each subaward in excess of $25,000. Other items may only be excluded when necessary to avoid a serious inequity in the distribution of indirect costs, and with the approval of the cognizant agency for indirect costs.

SECTION I: FRINGE BENEFIT RATES**

TYPE	FROM	TO	RATE(%)	LOCATION	APPLICABLE TO
FIXED	6/1/2020	5/31/2021	23.50	All	Regular Faculty (A)
FIXED	6/1/2020	5/31/2021	13.40	All	Clinical Faculty (B)
FIXED	6/1/2020	5/31/2021	33.30	All	Other Staff (A)
FIXED	6/1/2020	5/31/2021	10.00	All	Part-Time Staff (C)
PROV.	6/1/2021	Until amended			Use same rates and conditions as those cited for fiscal year ending May 31, 2021.

** DESCRIPTION OF FRINGE BENEFITS RATE BASE:

Salaries and wages.

SECTION II: SPECIAL REMARKS

TREATMENT OF FRINGE BENEFITS:

The fringe benefits are charged using the rate(s) listed in the Fringe Benefits Section of this Agreement. The fringe benefits included in the rate(s) are listed below.

TREATMENT OF PAID ABSENCES

Vacation, holiday, sick leave pay and other paid absences are included in salaries and wages and are claimed on grants, contracts and other agreements as part of the normal cost for salaries and wages. Separate claims are not made for the cost of these paid absences.

OFF-CAMPUS DEFINITION: For all activities performed in facilities not owned by the institution and to which rent is directly allocated to the project(s) the off-campus rate will apply. Grants or contracts will not be subject to more than one F&A cost rate. If more than 50% of a project is performed off-campus, the off-campus rate will apply to the entire project.

Equipment means an article of nonexpendable tangible personal property having a useful life of more than one year, and an acquisition cost of $2,500 or more per unit.

(A) Fringe Benefits include: FICA, Retirement, Life Insurance, Unemployment Compensation, Health Insurance, Workers' Compensation, Tuition Remission, Fringe Benefits Office and Professional Disability.

(B) Fringe Benefits include: FICA, Retirement, Life Insurance, Health Insurance, Workers' Compensation, Tuition Remission, Fringe Benefits Office and Professional Disability.

(C) Fringe Benefits include: FICA, Retirement, Unemployment, Workers' Compensation and Fringe Benefits Office.

Per 2 CFR 200.414(g) - A rate extension has been applied to the Indirect Cost Rate section only.

Next indirect cost rate proposal based on the fiscal year ending May 31, 2024 is due in our office by November 30, 2024.

Next fringe benefit rate proposal based on the fiscal year ending May 31, 2020 is due in our office by November 30, 2020.

SECTION III: GENERAL

A. LIMITATIONS:

The rates in this Agreement are subject to any statutory or administrative limitations and apply to a given grant, contract or other agreement only to the extent that funds are available. Acceptance of the rates is subject to the following conditions: (1) Only costs incurred by the organization were included in its facilities and administrative cost pools as finally accepted: such costs are legal obligations of the organization and are allowable under the governing cost principles; (2) The same costs that have been treated as facilities and administrative costs are not claimed as direct costs; (3) Similar types of costs have been accorded consistent accounting treatment; and (4) The information provided by the organization which was used to establish the rates is not later found to be materially incomplete or inaccurate by the Federal Government. In such situations the rate(s) would be subject to renegotiation at the discretion of the Federal Government.

B. ACCOUNTING CHANGES:

This Agreement is based on the accounting system purported by the organization to be in effect during the Agreement period. Changes to the method of accounting for costs which affect the amount of reimbursement resulting from the use of this Agreement require prior approval of the authorized representative of the cognizant agency. Such changes include, but are not limited to, changes in the charging of a particular type of cost from facilities and administrative to direct. Failure to obtain approval may result in cost disallowances.

C. FIXED RATES:

If a fixed rate is in this Agreement, it is based on an estimate of the costs for the period covered by the rate. When the actual costs for this period are determined, an adjustment will be made to a rate of a future year(s) to compensate for the difference between the costs used to establish the fixed rate and actual costs.

D. USE BY OTHER FEDERAL AGENCIES:

The rates in this Agreement were approved in accordance with the authority in Title 2 of the Code of Federal Regulations, Part 200 (2 CFR 200), and should be applied to grants, contracts and other agreements covered by 2 CFR 200, subject to any limitations in A above. The organization may provide copies of the Agreement to other Federal Agencies to give them early notification of the Agreement.

E. OTHER:

If any Federal contract, grant or other agreement is reimbursing facilities and administrative costs by a means other than the approved rate(s) in this Agreement, the organization should (1) credit such costs to the affected programs, and (2) apply the approved rate(s) to the appropriate base to identify the proper amount of facilities and administrative costs allocable to these programs.

BY THE INSTITUTION:

University of Miami

(INSTITUTION)

(SIGNATURE)

Barbara A Cole Digitally signed by Barbara A Cole
Date: 2020.09.11 16:08:18 -04'00'

(NAME)

ASSOCIATE VICE PRESIDENT
OFFICE OF RESEARCH ADMINISTRATION
UNIVERSITY OF MIAMI

(TITLE)

(DATE)

ON BEHALF OF THE FEDERAL GOVERNMENT:

DEPARTMENT OF HEALTH AND HUMAN SERVICES

(AGENCY)

Darryl W. Mayes -S
Digitally signed by Darryl W. Mayes -S
DN: c=US, o=U.S. Government, ou=HHS, ou=PSC, ou=People, 0.9.2342.19200300.100.1.1=2000131669, cn=Darryl W. Mayes -S
Date: 2020.09.11 14:26:04 -04'00'

(SIGNATURE)

Darryl W. Mayes

(NAME)

Deputy Director, Cost Allocation Services

(TITLE)

9/10/2020

(DATE) 7076

HHS REPRESENTATIVE: Steven Zuraf

Telephone: (301) 492-4855

8. Curriculum Vitae

Brian J. Soden

Professor of Atmospheric Science
University of Miami, Rosenstiel School of Marine and Atmospheric Science
4600 Rickenbacker Causeway, Miami, Florida 33149-1031
Phone: (305) 421-4202; Fax: (305) 421-4696; email: *b.soden@miami.edu*

Professional Preparation:

June 1993	Ph. D. Geophysical Sciences, University of Chicago Honorary Fellow, UW/Space Science and Engineering Center
March 1990	M.S. Geophysical Sciences, University of Chicago
May 1988	B.S. Geological Sciences/Applied Math, University of Miami Jay F.W. Pearson Scholarship (1984-1988), Magna Cum Laude

Appointments:

6/08 -	Professor, Rosenstiel School for Marine and Atmospheric Science University of Miami, FL.
8/04 – 5/08	Assoc. Professor, Rosenstiel School for Marine & Atmos. Science University of Miami, FL.
6/94 – 7/04	Physical Scientist, Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration, Princeton, NJ.
6/94 - 7/04	Lecturer with Rank of Associate Professor, Atmospheric and Oceanic Sciences Program, Princeton University.
7/93 - 5/94	Visiting Scientist, Atmospheric and Oceanic Sciences Program, Princeton University.

Relevant Publications (5):

Chung, E-S, and B.J. Soden, 2017: Hemispheric climate shifts driven by anthropogenic aerosol-cloud interactions, *Nature Geoscience,* **10**, 566-571.

Soden, B.J., W.D. Collins, and D.R. Feldman, 2018: Reducing uncertainties in climate models, *Science*, **361**, 326-327.

Soden, B.J., and E-S. Chung, 2017: The large-scale dynamical response of clouds to aerosol forcing, *J. Climate*, **30**, 8783-8794.

Soden, B.J., and I.M. Held, 2006: An assessment of climate feedbacks in coupled ocean-atmosphere models. *J. Climate*, **19**, 3354-3360.

Soden, B.J**.,** and G.A. Vecchi, 2011: The vertical distribution of cloud feedback in coupled ocean-atmosphere models, *Geophys. Res. Lett.,* **38,** L 12704, doi: 10.1029/2011GL047632.

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Other Publications (over 100 publications; over 20,000 citations; H-Index 56):

Allan, R.P. and B.J. Soden, 2008: Atmospheric warming and the amplification of precipitation extremes, *Science*, **321**, 1481-1484.

Chung, E-S., B.J. Soden, B.J. Sohn, and L. Shi, 2014: Upper-tropospheric moistening in response to anthropogenic warming, *Proc. Natl. Acad. Sci.*, doi:10.1073/pnas.1409659111

Held, I.M. and B.J. Soden, 2000: Water vapor feedback and global warming, *Ann. Rev. Energy Env.,* 25, 441-475, DOI: 10.1146/annurev.energy.25.1.441.

Soden, B.J., R.T. Wetherald, G.L. Stenchikov, and A. Robock, 2002: Global cooling following the eruption of Mt. Pinatubo: A test of climate feedback by water vapor. *Science*, **296**, 727-730.

Soden, B.J., D.L. Jackson, V. Ramaswamy, M.D. Schwarzkopf, and X. Huang, 2005: The radiative signature of upper tropospheric moistening, *Science,* **310**, 841-844

Synergistic Activities (5):

Lead Author, Intergovernmental Panel on Climate Change, AR5 (2011-13).
Lead Author, Intergovernmental Panel on Climate Change, AR4 (2005-07).
Chairman, AMS Committee on Atmospheric Radiation (1998-2000).
Editor, Journal of Climate (2010-2016).
Chief Editor, Curent Climate Change Reports (2014-).

Professional Awards (5):

Fellow, American Meteorological Society (2012).
NSC David S. Johnson Award (2001).
AMS Henry G. Houghton Award (2001).
NASA Langely H.E. Reid Award (2002).
NOAA Outstanding Scientific Paper Award (2000, 2002, 2003, 2007).

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10. Current and Pending Support

Current and Pending Support

Investigator: **Brian Soden**

CURRENT SUPPORT:

Project / Proposal Title: Investigating the Fast and Slow Response of the Hydrological Cycle
Role: PI
Sources of Support: NSF-AGS175366
Contact information: Ming Cai (703) 292-8527; m.cai@nsf.gov
Proposal Time Period: 04/01/2018 – 03/31/2021
Location of Project: UM/RSMAS, Miami, FL
Total Amount Requested: $539,210
Person-Month per Year Committed to the Project: 2 mos./yr. (academic/summer)

Project / Proposal Title: Investigating Radiative Feedbacks During the EOS Era
Role: PI
Sources of Support: NASA-80NSSC18K1032
Contact information: David Considine (202) 358-2277; david.b.considine@nasa.gov
Proposal Time Period: 06/05/2018 – 06/04/2021
Location of Project: UM/RSMAS, Miami, FL
Total Amount Requested: $515,465
Person-Month per Year Committed to the Project 1.0 mo./yr. (academic/summer)

Project / Proposal Title: Development of Water Vapor Data Sets for Long-Term Climate Monitoring
Role: PI
Sources of Support: NOAA-NA18OAR4310421
Contact Information: James Todd (301) 734-1258; james.todd@noaa.gov
Proposal Time Period: 09/01/2018 – 08/31/2020
Location of Project: UM/RSMAS, Miami, FL
Total Amount Requested: $294,488
Person-Month per Year Committed to the Project: 1.0 mo./yr. (academic/summer)

Project / Proposal Title: Understanding the Role of Radiative Forcing and Cloud-Circulation Feedback on Spatial Rainfall Shifts in CMIP6
Role: PI
Sources of Support: NOAA-NA18OAR4310269
Contact Information: Kathleen Palermo (301) 734-1052; kathleen.palermo@noaa.gov
Proposal Time Period: 08/01/2018 – 07/31/2021
Location of Project: UM/RSMAS, Miami, FL
Total Amount Requested: $502,355
Person-Month per Year Committed to the Project: 1.5 mos./yr. (academic/summer)

Project / Proposal Title: Investigating Linkages Between Ocean Salinity, the Hydrological Cycle, and Climate Sensitivity
Role: PI
Sources of Support: NASA-80NSSC20K0879
Contact Information: Nayda Vinogradova; (202) 358-0976; nayda@nasa.gov
Proposal Time Period: 06/01/2020 – 05/31/2023
Location of Project: UM/RSMAS, Miami, FL
Total Amount Requested: $609,431
Person-Month per Year Committed to the Project: 1.0 mos./yr. (academic/summer)

Project / Proposal Title: Investigating Tropical Cyclone Impacts on Ocean Salinity Stratification and its Feedback on Tropical Cyclone Intensification
Role: PI
Sources of Support: Princeton University (SUB0000299) (Prime NASA-80NSSC18K1435)
Contact Information: Princeton-Teresa D'Artagnan; (609) 258-3111; tupsher@princeton.edu
Proposal Time Period: 07/26/2018 – 07/25/2021
Location of Project: UM/RSMAS, Miami, FL
Total Amount Requested: $93,752
Person-Month per Year Committed to the Project: 0.5 mos./yr. (academic/summer)

Project / Proposal Title: Investigating Cloud-Circulation Feedbacks in Earth System Models
Role: PI
Sources of Support: DOE-SC0021333
Contact Information: Renu R. Joseph; (301) 903-9237; joseph.renu@science.doe.gov
Proposal Time Period: 09/14/2020 – 09/15/2023
Location of Project: UM/RSMAS, Miami, FL
Total Amount Requested: $784,997
Person-Month per Year Committed to the Project 1.5 mos./yr. (academic/summer)

PENDING SUPPORT:
Project / Proposal Title: Investigating SST Pattern Controls on Cloud-Circulation Feedbacks in CMIP6 Coupled Models
Role: PI
Sources of Support: Princeton University (Prime NOAA)
Contact Information: Melissa Williams; (609) 258-6325; mellissa@princeton.edu
Proposal Time Period: 06/01/2020 – 05/31/2023
Location of Project: UM/RSMAS, Miami, FL
Total Amount Requested: $78,394
Person-Month per Year Committed to the Project: 0.50/yr.1; 0.70/yr.2; 0.64/yr.0.30 (Academic/Summer)

Application for Federal Assistance SF-424

* 1. Type of Submission:
☐ Preapplication
☒ Application
☐ Changed/Corrected Application

* 2. Type of Application:
☒ New
☐ Continuation
☐ Revision

* If Revision, select appropriate letter(s):

* Other (Specify):

* 3. Date Received: 11/30/2020

4. Applicant Identifier:

5a. Federal Entity Identifier:

5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:

7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name: University of Miami

* b. Employer/Taxpayer Identification Number (EIN/TIN): 59-0624458

* c. Organizational DUNS: 152764007

d. Address:

* Street1: 4600 Rickenbacker Causeway
Street2:
* City: Miami
County/Parish:
* State: FL: Florida
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 331491031

e. Organizational Unit:

Department Name:

Division Name:

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:
* First Name: Yanira
Middle Name:
* Last Name: Blanco
Suffix:

Title: Manager, Sponsored Programs

Organizational Affiliation:
University of Miami

* Telephone Number: (305) 421-4183
Fax Number: (305) 421-4183

* Email: yblanco1@miami.edu

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

O: Private Institution of Higher Education

Type of Applicant 2: Select Applicant Type:

Type of Applicant 3: Select Applicant Type:

* Other (specify):

*** 10. Name of Federal Agency:**

Department of Commerce

11. Catalog of Federal Domestic Assistance Number:

11.431

CFDA Title:

Climate and Atmospheric Research

*** 12. Funding Opportunity Number:**

NOAA-OAR-CPO-2021-2006389

* Title:

Climate Program Office FY2021

13. Competition Identification Number:

2864458

Title:

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Process-Oriented Diagnostics of Aerosol-Cloud Interactions in CMIP6 Models

Attach supporting documents as specified in agency instructions.

Add Attachments | Delete Attachments | View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant: FL-027
* b. Program/Project: FL-027

Attach an additional list of Program/Project Congressional Districts if needed.

Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 06/01/2021
* b. End Date: 05/31/2024

18. Estimated Funding ($):

* a. Federal	525,553.00
* b. Applicant	0.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	525,553.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

☐ a. This application was made available to the State under the Executive Order 12372 Process for review on .

☐ b. Program is subject to E.O. 12372 but has not been selected by the State for review.

☒ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

☐ Yes ☒ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☒ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix:
* First Name: Brandon
Middle Name:
* Last Name: Strickland
Suffix:

* Title: Executive Director, ORA

* Telephone Number: (305) 284-3952
Fax Number:

* Email: bstrickland@miami.edu

* Signature of Authorized Representative: Brandon.Strickland
* Date Signed: 11/30/2020

BUDGET INFORMATION - Non-Construction Programs

OMB Number: 4040-0006
Expiration Date: 02/28/2022

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. NOAA-OAR-CPO-2021-2006389	11.431	$	$	$ 525,553.00	$	$ 525,553.00
2. NOAA-OAR-CPO-2021-2006389						0.00
3. NOAA-OAR-CPO-2021-2006389						0.00
4.						
5. **Totals**		$	$	$ 525,553.00	$	$ 525,553.00

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SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total (5)
	(1) NOAA-OAR-CPO-2021-2006389	(2) NOAA-OAR-CPO-2021-2006389	(3) NOAA-OAR-CPO-2021-2006389	(4)	
a. Personnel	$ 65,751.00	$ 67,724.00	$ 69,756.00	$	$ 203,231.00
b. Fringe Benefits	8,115.00	8,358.00	8,609.00		25,082.00
c. Travel	7,000.00	9,227.00	7,000.00		23,227.00
d. Equipment	10,000.00				10,000.00
e. Supplies					
f. Contractual					
g. Construction					
h. Other	36,368.00	37,936.00	39,583.00		113,887.00
i. Total Direct Charges (sum of 6a-6h)	127,234.00	123,245.00	124,948.00		$ 375,427.00
j. Indirect Charges	49,441.00	50,770.00	52,142.00		$ 152,353.00
k. TOTALS (sum of 6i and 6j)	$ 176,675.00	$ 174,015.00	$ 177,090.00	$	$ 527,780.00
7. Program Income	$ 0.00	$ 0.00	$ 0.00	$	$ 0.00

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SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e)TOTALS
8. NOAA-OAR-CPO-2021-2006389	$	$	$	$
9. NOAA-OAR-CPO-2021-2006389				
10. NOAA-OAR-CPO-2021-2006389				
11.				
12. TOTAL (sum of lines 8-11)	$	$	$	$

SECTION D - FORECASTED CASH NEEDS

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	$ 176,675.00	$ 44,168.75	$ 44,168.75	$ 44,168.75	$ 44,168.75
14. Non-Federal	$ 0.00	0.00	0.00	0.00	0.00
15. TOTAL (sum of lines 13 and 14)	$ 176,675.00	$ 44,168.75	$ 44,168.75	$ 44,168.75	$ 44,168.75

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

(a) Grant Program	FUTURE FUNDING PERIODS (YEARS)			
	(b)First	(c) Second	(d) Third	(e) Fourth
16. NOAA-OAR-CPO-2021-2006389	$ 171,788.00	$ 177,090.00	$	$
17. NOAA-OAR-CPO-2021-2006389				
18. NOAA-OAR-CPO-2021-2006389				
19.				
20. TOTAL (sum of lines 16 - 19)	$ 171,788.00	$ 177,090.00	$	$

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges: TDC = $373,200

22. Indirect Charges: F&A @ 55% is based on MTDC of $277,004 = $152,353

23. Remarks:

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OMB Number: 4040-0007
Expiration Date: 02/28/2022

ASSURANCES - NON-CONSTRUCTION PROGRAMS

Public reporting burden for this collection of information is estimated to average 15 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (0348-0040), Washington, DC 20503.

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.

NOTE: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.

2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.

3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.

4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.

5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).

6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C.§§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee- 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and, (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.

7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.

8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

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Prescribed by OMB Circular A-102

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-333), regarding labor standards for federally-assisted construction subagreements.

10. Will comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is $10,000 or more.

11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) Implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).

12. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.

13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593(identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq.).

14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.

15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. §§2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.

16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.

17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."

18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.

19. Will comply with the requirements of Section 106(g) of the Trafficking Victims Protection Act (TVPA) of 2000, as amended (22 U.S.C. 7104) which prohibits grant award recipients or a sub-recipient from (1) Engaging in severe forms of trafficking in persons during the period of time that the award is in effect (2) Procuring a commercial sex act during the period of time that the award is in effect or (3) Using forced labor in the performance of the award or subawards under the award.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL Brandon.Strickland	TITLE Executive Director, ORA
APPLICANT ORGANIZATION University of Miami	DATE SUBMITTED 11/30/2020

Standard Form 424B (Rev. 7-97) Back

FORM **CD-511**
(REV 1-05)

U.S. DEPARTMENT OF COMMERCE

CERTIFICATION REGARDING LOBBYING

Applicants should also review the instructions for certification included in the regulations before completing this form. Signature on this form provides for compliance with certification requirements under 15 CFR Part 28, 'New Restrictions on Lobbying.' The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of Commerce determines to award the covered transaction, grant, or cooperative agreement.

LOBBYING

As required by Section 1352, Title 31 of the U.S. Code, and implemented at 15 CFR Part 28, for persons entering into a grant, cooperative agreement or contract over $100,000 or a loan or loan guarantee over $150,000 as defined at 15 CFR Part 28, Sections 28.105 and 28.110, the applicant certifies that to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, 'Disclosure Form to Report Lobbying.' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure occurring on or before October 23, 1996, and of not less than $11,000 and not more than $110,000 for each such failure occurring after October 23, 1996.

Statement for Loan Guarantees and Loan Insurance

The undersigned states, to the best of his or her knowledge and belief, that:

In any funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this commitment providing for the United States to insure or guarantee a loan, the undersigned shall complete and submit Standard Form-LLL, 'Disclosure Form to Report Lobbying,' in accordance with its instructions.

Submission of this statement is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required statement shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure occurring on or before October 23, 1996, and of not less than $11,000 and not more than $110,000 for each such failure occurring after October 23, 1996.

As the duly authorized representative of the applicant, I hereby certify that the applicant will comply with the above applicable certification.

* NAME OF APPLICANT: University of Miami

* AWARD NUMBER: N/A

* PROJECT NAME: N/A

Prefix:

* First Name: Brandon

Middle Name:

* Last Name: Strickland

Suffix:

* Title: Executive Director, ORA

* SIGNATURE: Brandon.Strickland

* DATE: 11/30/2020