

(Instructions and Distribution on Reverse)

1. CONTRACTOR: SSAI	2. CONTRACT NO.: NNG12HP06C	3. TASK/REVISION NO.: 5 Rev. 1
-------------------------------	---------------------------------------	-----------------------------------

4. JOB ORDER NO./PROJECT:	5. FLIGHT HARDWARE/SOFTWARE; CRITICAL GSA (IF, YES, OBTAIN BLOCK 16 CONCURRENCE): YES <input checked="" type="checkbox"/> NO	6. DESIGNATED FLIGHT ASSURANCE MGR.:
---------------------------	---	---

7. DESCRIPTION OF WORK TO BE PERFORMED (OBJECTIVES OR RESULTS DESIRED):

GMAO Climate Simulations, Forecasts and Analysis

8. TASK DOCUMENTATION REQUIREMENTS/DELIVERABLE ITEMS:

See Attached

9. PERFORMANCE/MILESTONE SCHEDULE:

February 1, 2015 – January 31, 2016

10. QUALITY ASSURANCE REQUIREMENTS:

11. TRAVEL, MATERIALS, ETC., KNOWN TO BE REQUIRED:

12. OTHER (FUNDING, NTE, HOURS, ETC.):

	From	By	To
Estimated Cost			
Fixed Fee			
Estimated Total Cost-Plus-Fixed Fee	\$719,525	\$11,081	\$822,876

13. TASK ORIGINATOR/MONITOR/CODE/PHONE:

Siegfried Schubert

14. BRANCH APPROVAL:

15. DIVISION CONCURRENCE:

16. CONTRACTING OFFICER'S TECHNICAL REPRESENTATIVE:

Stephen Cohn

17. CONTRACTOR SIGNATURE:

18. THIS TASK ORDER IS ISSUED PURSUANT TO THE TERMS OF THE CONTRACT.

Makara Nevils 5/12/15

CONTRACTING OFFICER'S SIGNATURE/ DATE

Makara Nevils
TYPED OR PRINTED NAME

Science Systems and Applications, Inc.
NNG12HP06C
Task Order Statement of Work

Task Order Number: CY4_05_Mod0

Task Order Title: GMAO Climate Simulations, Forecasts and Analysis

1.0 Task Monitor (TM):

Name: Siegfried Schubert
Organization: GMAO:GMAO
Email Address: Siegfried.d.Schubert@nasa.gov

2.0 Description of Work to be Performed

Changes from CY3 to CY4 are indicated in red.

This task involves a number of activities to support work on the production and analysis of subseasonal, seasonal and decadal hindcasts and forecasts, as well as long-term climate simulations. The task includes work to generate an ocean reanalysis to initialize short-term climate forecasts, to develop innovative methods for analyzing climate variability and predictability, to develop methods for improving prediction skill, with a focus on the hydrological cycle, and to undertake scientific diagnostics and produce post-processed products from the GMAO's atmospheric reanalysis.

The work is divided into the following subtasks:

Subtask A: Climate Simulation and Analysis

This subtask involves the utilization of GMAO climate model simulations, MERRA and MERRA2, and satellite and other observations to better understand the causes of short term climate extremes and long-term variations in the hydrological cycle, including the potential impact of vegetation changes and global warming.

Specific tasks are to:

- i) In collaboration with the civil servant staff, analyze GEOS-5 simulations and decadal predictions to identify relevant contributions of land feedbacks and SST on long-term drought for various regions of North America;
- ii) In collaboration with the civil servant staff, conduct and analyze long-term coupled model and AGCM experiments to better understand long-term atmosphere/ocean/land climate variability such as that associated with the PDO and AMO and their regional impacts;

- iii) In collaboration with the civil servant staff, conduct and analyze long-term AGCM experiments to better understand the nature and role of Rossby Waves in the development of short term heat waves and drought and their regional impacts;
- iv) Document the experiments and system performance as needed.

Subtask B: Improving Hydrological Forecasts

The focus of this subtask is to enhance prediction skill utilizing NASA observations, reanalyses and climate models. The work includes extensive use and validation of the MERRA and MERRA-2 reanalyses and related products for both diagnostics studies and for initializing model predictions. Both medium- and high-resolution versions of the GMAO climate model will be used to help understand and predict the hydrological cycle, and to assess the sensitivity of the predictions to the atmospheric, land and ocean initial conditions. The task involves the conduct and analysis of ensembles of coupled model predictions, as well as off-line simulations with the GMAO land model.

Specific tasks are to:

- i) In collaboration with the civil servant staff, analyze MERRA, MERRA-2, and existing AGCM and coupled model simulations with a focus on identifying and understanding the nature of subseasonal to seasonal variability in the hydrological cycle such as that associated with heat waves and floods;
- ii) Conduct medium- and high-resolution prediction experiments as specified by civil servant staff to assess the predictability of specific short-term climate extremes with a focus on heat waves and droughts, and with some emphasis on the impacts of soil moisture and vegetation state initialization;
- iii) Process forecasted precipitation and temperature fields as needed through an offline version of the GMAO land model
- iv) In collaboration with civil service staff, estimate improvements in hydrological forecasts (streamflow, soil moisture, etc.) associated with the downscaling of the forecasted fields and/or the downscaling of the initial land conditions;
- v) Perform any associated land modeling activities required by civil servant staff for GMAO drought prediction studies;
- vi) Document the experiments and system performance as needed.

Subtask C: Production of Short-term Climate Forecasts

This subtask involves support for the conduct and analysis of short-term (subseasonal to decadal) forecast experiments and predictability experiments with GMAO's coupled model, and with appropriate component models, such as the coupled atmosphere-land surface model, as specified by the civil servant staff. Specific tasks include:

- i) Participating in the team of GMAO scientists and support staff who conduct ensemble simulations and predictions to help characterize the forecast uncertainty of extratropical teleconnections, including atmosphere-land-surface only predictions forced by observed and forecast SSTs. The coupled model forecast simulations will be conducted by GSFC civil service staff. Contractor staff must be able to provide a back-up to undertake these forecasts as needed. Contractor staff will contribute to the initialization of the coupled model by providing initial conditions for the atmosphere, ocean, and land surface. Contractor staff shall prepare the subsets of data (surface temperature, precipitation, air temperature at 2 m, and other fields as specified by the TM) for delivery to the National Multi-Model Ensemble (NMME) project.
- ii) Undertaking coupled predictions on the decadal time scale in collaboration with civil service staff in the GMAO with a focus on recent major decadal shifts. Contractor staff will contribute to the initialization of the coupled model by providing consistent initial states for the ocean, atmosphere and land surface. Contractor staff will undertake predictions to help identify sources of predictability as well as the success of coupled initialization with GEOS-5. Contractor staff shall undertake quality assurance tests of the forecast fields generated to ensure that there are no errors in the generated products.
- iii) Documenting the experiments and system performance on the GMAO web site and in a NASA technical report as required by GMAO science leads. The forecast accuracy of the coupled model forecasts will be assessed by the amplitude and phase of SST anomaly measures for specified regions and by the patterns of SST, thermocline, and surface wind stress anomalies over the tropical Pacific. The forecast accuracy of the atmosphere-land forecasts will be assessed by the patterns and amplitude of upper-level wind, precipitation and surface temperature anomalies.
- iv) Retrieving the data sets necessary for validation and analysis.

Subtask D: Ocean Reanalysis

This subtask will support the GMAO ocean data assimilation activities. Particular focus is on production of an ocean reanalysis for the initialization of the ocean model for global coupled forecasts and the system development in support of priority satellite data streams identified by the TM. The contractor will also support the evaluation of the observing system, again focused on the contributions of satellite data, in the context of ocean climate diagnostics and short-term climate prediction. The contractor will also be responsible for assembling data sets for assimilation ingest and for analysis validation. In particular, the contractor will:

- (i) Retrieve, quality control and document the forcing and ingest data sets required for the ODAS. The different data types to be used include: sea surface height from altimeters, satellite-derived sea surface salinity, satellite-derived sea surface temperature, subsurface temperature

profiles from tropical moored buoy arrays (TAO/TRITON, PIRATA, RAMA), subsurface salinity profiles where available, subsurface temperature from XBT data, data from drifting sensors, and satellite-based surface winds and precipitation where available.

(ii) Implement a quality assurance capability that tests the ocean analyses for unrealistic field values.

(iii) Conduct ocean analyses of the historical data for the periods specified by the TM. These include (a) at least 1960 to present for decadal predictions, (b) from 1982 to present for seasonal prediction, and (c) for the era of satellite altimetry with a focus on assimilation of altimeter data. Restarts are to be provided at times required to initialize the GEOS-5 AOGCM seasonal predictions and GEOS-5 AOGCM decadal predictions.

(iv) Develop a set of metrics to evaluate ocean analysis quality. Performance measures for evaluation of the systems and the analyses will include difference measures from observations (including a cross-validation), impact on forecast accuracy (measured by the amplitude of sea surface temperature (SST), sea surface height (SSH) and heat content anomalies in standard regions, the Atlantic Meridional Overturning Circulation, and by patterns of SST, sea surface height, and thermocline anomalies over the tropical oceans), as well as wall clock time to produce the analysis. Undertake analyses of the climate variability in the historical reanalyses, focused on upper ocean heat and salt content, variations in the Atlantic Meridional Overturning Circulation, water mass variability in ocean regions selected by the TM, and similar metrics adopted by the ocean climate community. Evaluate the impact of specified data sets, specifically altimetry and Argo, on the quality of the ocean analyses.

(v) Conduct tests assimilating remotely sensed sea surface salinity from Aquarius. These will be evaluated by comparison with Argo data, and documented in a peer-reviewed publication.

(vi) Develop and maintain HTML-based software to document data processing and Quality Control procedures and available validation and ingest data and to display ocean analyses, diagnostics of performance (such as comparisons with validation data) and the current state of the ocean climate. Maintain and further develop, as identified by the contractor and/or TM, the ocean elements of the OBSVIEW software used as part of performance diagnostics. Maintain online access to selected analysis data sets, as specified by the TM.

(vii) Document the ODAS and system performance in NASA Technical Reports and/or peer-reviewed publications.

Subtask E: Atmospheric Reanalysis

This subtask will support the GMAO's atmospheric reanalysis activities. The contractor will be responsible for undertaking scientific QA for ongoing reanalyses, for providing support for GMAO reanalysis users, for web publication of a reanalysis atlas and for the development of specialized products and web access tools relevant to climate assessment studies. The contractor will:

(i) Support users of GMAO's atmospheric reanalyses and serve as the interface with the product distribution center, providing (a) software/algorithm documents and user guides in conformance with GMAO guidelines as appropriate and as specified by the TM, (b) online documentation of products, and (c) email support to answer user questions and requests regarding reanalysis products.

(ii) Maintain a web publication of the GMAO's atmospheric reanalysis that provides a statistical summary of the reanalysis climatology and comparisons with other available reanalyses and gridded observational data sets, as specified by the TM. Retrieve and catalog other reanalyses and data sets to be used for comparison with the GMAO reanalysis. Develop a local repository of these validation data sets.

(iii) Develop diagnostic software and scripts to monitor and diagnose the character of a long-term reanalysis during production, as specified by the TM. This includes (a) examination of the moisture budget (precipitation, moisture increments, etc); (b) advanced climate diagnostics such as those available through the Climate Data Operators (CDO) toolkit as well as new climate indicators, especially those relevant for extremes; (c) analysis of observational use and impact in the reanalysis using available tools to examine the time series of innovations and analysis departures; and (d) other diagnostics that emerge from climate assessment activities, as identified by the TM.

3.0 Special Requirements

None

4.0 Performance/Milestone Schedule

The GMAO Contract Year 4 POP is February 01, 2015 - January 31, 2016

5.0 Deliverables/Reporting Requirements

Monthly status reports will be provided to the TM.

All subtasks will provide software/algorithm documents and user guides in conformance with GMAO guidelines as appropriate.

Subtask A: Climate Simulation and Analysis

i) The status of all on-going simulations and the analysis of the results will be documented and posted on a website for discussion with the civil servant staff on a weekly basis.

ii) Model fields will be extracted from these simulations on a timely basis for visualization purposes.

iii) Figures and movies will be provided to staff members on a timely basis for presentations and publication.

iv) Contractor staff will meet with the TM on a weekly basis to review progress.

Subtask B: Improving Hydrological Forecasts

i) The status of all on-going simulations and the analysis of the results will be documented and posted on a website for discussion with the civil servant staff on a weekly basis.

ii) Model fields will be extracted from these simulations on a timely basis for visualization purposes.

iii) Figures and movies will be provided to staff members on a timely basis for presentations and publication.

iv) Contractor staff will meet with the TM on a weekly basis to review progress.

Subtask C: Production of Short-term Climate Forecasts

i) The status of all on-going simulations and the analysis of the results will be documented and posted on a website for discussion with the civil servant staff on a weekly basis.

ii) Model fields will be extracted from these simulations on a timely basis for visualization purposes.

iii) Contractor staff will ensure that the decadal predictions are served correctly through the Earth System Grid node in the NASA Center for Climate Simulation.

iv) Contractor staff will ensure that the seasonal predictions are made available to customers (e.g., CPC) on a timely basis and free of post-processing errors.

Subtask D: Ocean Reanalysis

i) The status of all on-going simulations and the analysis of the results will be documented and posted on a website for discussion with the civil servant staff on a weekly basis.

ii) Ocean data streams for assimilation and analyses are to be updated on a weekly basis from internet accessible archives, processed for quality control and for ingest into the ocean assimilation system.

iii) The observation archive will be documented on the GMAO web pages and kept current within 5 working days of new data uploads.

iv) Figures and movies will be provided as needed to staff members for presentations and publication.

v) The analyses (with metrics that are relevant to the global ocean, quantities determined in collaboration with the civil servant staff) will be posted on the GMAO web pages, presented at weekly ODAS meetings with the TM, and presented at appropriate GMAO science theme meetings, at least once per year.

vi) The routine near-real-time ocean analyses for initialization of ensembles of coupled forecasts will be conducted according to the schedule defined by the TM. Information as to experiments conducted will be updated on the GMAO web within 2 working days of the completion of the analysis.

vii) The analysis data sets will be updated into the LAS within 5 working days of the completion of the analysis.

viii) The OBSVIEW system will be documented on the GMAO web pages. Output from ocean assimilation experiments will be documented online and presented at weekly ODAS meetings with the TM.

Subtask E: Atmospheric Reanalysis

i) Issues, performance characteristics, information for users, and such information as identified by the TM shall be documented on the reanalysis web pages within 5 business days of approval by the TM.

ii) Figures and movies will be provided as needed to staff members for presentations and publication. Explanatory figure captions and details of any calculations involved will be provided as needed.

iii) Science results and reanalysis performance will be presented at appropriate GMAO science theme meetings, at least once per year.

6.0 Other Information Needed for Performance of Task

Travel Authorized: Attendance of up to 4 contractor support staff (one each) at major national meetings (e.g., AMS, AGU, Ocean Sciences) and attendance at two international meetings focused on atmospheric and/or ocean reanalysis or climate prediction during this period is authorized. Local travel for training purposes, not to exceed 5 person-days, will be authorized at the request of the TM.

7.0 Data Rights

N/A

8.0 Safety

Staff on this task will comply with federal, state, local, and center safety regulations. This will be accomplished through management emphasis, technical training, and personal responsibility.

Staff will participate in safety orientation and training in accordance with the contract Safety and Health Plan, and work within the requirements of that plan.

9.0 Risk

Contractor shall provide ongoing risk assessment and mitigation in performance of the Task Order. Priorities shall be re-evaluated as appropriate with the TM. Cost and schedule performance shall be assessed on a regular basis (no less frequently than monthly) and significant variations discussed and acted on in consultation with the TM and COTR.

10.0 Proposed Cost and Fixed Fee

In accordance with Paragraph B.5, of the contract, propose the Cost and Fixed Fee amount.