Final Progress Report for DOE Award # DE-SC0001898 at University of Alaska Fairbanks

Project Title: "Characterization of the dynamics of climate systems and identification of missing mechanisms impacting the long term predictive capabilities of Global Climate Models utilizing dynamical systems approaches to the analysis of observed and modeled climate"

PI: Uma S. Bhatt, Dept. of Atmospheric Sciences and Geophysical Institute

Date of Report: November 12, 2015

Period Covered: August 15, 2009 – August 14, 2015

Budget Amount: Total $495,000. (DoE $450,000.00 and UAF match $45,000.00)

Participating National Laboratory: Oak Ridge National Laboratory

Project Summary, Objective and Goals:

The *goal* of this research was to apply fractional and non-linear analysis techniques in order to develop a more complete characterization of climate change and variability for the oceanic, sea ice and atmospheric components of the Earth System. This research applied two measures of dynamical characteristics of time series, the R/S method of calculating the Hurst exponent and Renyi entropy, to observational and modeled climate data in order to evaluate how well climate models capture the long-term dynamics evident in observations. Fractional diffusion analysis was applied to ARGO ocean buoy data to quantify ocean transport. Self organized maps were applied to North Pacific sea level pressure and analyzed in ways to improve seasonal predictability for Alaska fire weather. This body of research shows that these methods can be used to evaluate climate models and shed light on climate mechanisms (i.e., understanding why something happens). With further research, these methods show promise for improving seasonal to longer time scale forecasts of climate.

Project Results:

1) *North Atlantic Ocean Variability* (MS student Legatt, Polyakov, and Bhatt)

Highlight Finding: The simulated response to atmospheric forcing in a simple box model of the North Atlantic may be viewed as a delayed response to the cumulative atmospheric forcing over an interval defined by the damping properties of the system. AMOC drives multidecadal SST changes. The box model (Legatt et al. 2012 **[1]**) suggests that SST changes induced by (stochastic) atmospheric forcing can drive Multidecadal variability in AMOC. At the same time, the model suggests that the AMOC also can excite SST variations therefore, both mechanisms can independently drive Multidecadal variability in the North Atlantic system. Understanding mechanisms of low-frequency variations in the North Atlantic can ultimately contribute to improved climate forecasts. Publication **[1]**.

2) *Network model for the sea ice-albedo feedback in the Arctic* (PhD student Mueller-Stoffels and Wackerbauer)

Highlight Finding: Arctic sea ice cover has been receding rapidly in recent years, and global climate models typically predict continued decline over the next century. It is an open question whether a possible loss of Arctic sea ice is reversible. We studied the stability of Arctic model sea ice in a conceptual, two-dimensional energy-based regular net-work model of the ice-ocean layer that considers Department of Energy's Barrow Atmospheric Radiation Measurement (ARM) longwave radiative budget data and SHEBA albedo measurements. Seasonal ice cover, perennial ice and perennial open water are asymptotic states accessible by the model. We show that the shape of albedo parameterization near the melting temperature differentiates between reversible continuous sea ice decrease under atmospheric forcing and hysteresis behavior. Fixed points induced solely by the surface energy budget are essential for understanding the interaction of surface energy with the radiative forcing and the underlying body of ice/water, particularly close to a bifurcation point. Publication **[2]**.

3) *Use of Hurst and Renyi Analysis to Detect and Characterize Pacific Decadal Oscillation Impacts on Climate Variability in Alaska* (MS student Talbot, Bhatt, Wackerbauer, Polyakov, Newman, and Sanchez)

Highlight Finding: Differences of predictability of temperature data during opposite phases of the PDO were found in many Alaska stations, both on long (five to 15 years) and short (two to 13 days) time scales. Hurst analysis was used to find differences in persistence on long time scales of five to 15 years, and Renyi analysis was used to find changes in order on short time scales of two to 13 days. These two time scales are unconnected, and represent different processes in the climate.

It was found that on long time scales, surface air temperature in interior and northwestern Alaska is random during the negative PDO, and persistent during the positive PDO. This implies that the long term variability of temperature for those regions of Alaska are statistically more predictable during the positive PDO. Sea level pressure in interior, western and southeastern Alaska are for the most part weakly anti-persistent during the negative PDO, and weakly persistent during the positive PDO. While this is an interesting dynamical change, it does not indicate a change in the long term predictability of pressure.

On short time scales it was found that while Renyi analysis of SLP did not change with the PDO, SAT in southwestern Alaska and along the northwestern coast became more ordered during the positive PDO compared to the negative PDO. The increase of order implies that the most frequent events happen even more frequently during the positive PDO, and statistical weather forecasts in those areas could be made more accurate during the positive PDO.

These methods have also proven useful at finding relationships between climate time series and synoptic mechanisms. The improved predictability of the short term temperature variability in southwestern Alaska and along the northwest coast was plausibly linked to the more preferential behavior of the Aleutian low during the positive PDO. Also the improved predictability of the long term temperature variability in interior and northwestern Alaska was plausibly linked to the increase of warm storms from south of 40˚N in the Bering Sea during the positive PDO. Both the Renyi and Hurst analysis results can be linked to circulation changes in the synoptic system.

CMIP5 climate models were evaluated in this study and showed both strengths and weaknesses when compared to observations.
Publication **[3]** & **[4]**.

4) *Using Self-Organizing Maps to Detail Synoptic Connections Between Climate Indices and Alaska Weather* (MS student Winnan, Bhatt, and Wackerbauer)
Highlight Finding: Seasonal forecasts for Alaska strongly depend on the phases of Pacific Decadal Oscillation (PDO), El Niño-Southern Oscillation (ENSO), and possibly the so-called "Pacific blob." The canonical descriptions of these climate indices are based on averages, and anomalies that are based on a long-term mean. They show the general geographical placement, and display sharper contrast between opposite phases, but this also may be misleading. Self-organizing maps (SOMs) are a way of describing multidimensional data, like daily sea level pressure (SLP) time series, by comparing actual data to multiple patterns that are representative of that data. This study used SOMs to describe the range of synoptic patterns that make up major Pacific indices in finer detail. Results suggest that the patterns common during a given phase of the PDO include subtle differences that would result in Alaska weather that is very different from what is expected from the canonical PDO description. These subtle differences would not be evident in the overall average used to produce the canonical PDO description. The paper also finds evidence that supports recent studies suggesting that the pattern responsible for the 2014 Pacific warm blob is linked to tropical SST forcing. A summer SOMs analysis identified distinct patterns characterized by low pressure in the Bering Sea or Gulf of Alaska that are present in summers with large fire seasons. These patterns are consistent with increased lightning activity, which provide ignition to start the fires given ideal fuel conditions (i.e., dry fuel). Publication **[5]**.

5) *Fractional diffusion in the ocean* (Sanchez, Newman, Polyakov, and Bhatt)
Highlight Finding: ARGO floats deep data were used to identify non-diffusive motion at the parking depth of the buoys. We constructed time by adding successive deep periods and displacements by projecting motion on a local Euclidean frame.
The findings of this analysis are as follows:

- We have applied stochastic transport techniques to assess the nature of zonal and meridional deep motion of ARGO buoys regionally in the ocean (equatorial, midlatitude etc..)
- The R/S results suggest that the dynamics are different in the zonal and meridional direction. This suggests that ocean models should treat diffusion in the east-west and north-south direction differently. This is currently not done.

Dr. Sanchez plans to recalculate the fractional diffusion with recently added ARGO buoy data and refine his results before this work will be ready for publication.

6) *Comparing GCM and observed climate variability through characterization of dynamics using nonlinear analysis techniques* (Bhatt, Newman, Wackerbauer, Polyakov, Sanchez, Talbot)

Highlight Finding: New comparison techniques are important for furthering development of predictability. GCM simulations of varying complexity were compared using R/S and Renyi entropy. The results show:

- These measures highlight differences between different simulations of climate indices. This means that a full coupled climate simulation with air-sea interaction has has different long term correlations and short term persistence than a fix sea ice simulation. These analysis focused on climate indices of the Arctic Oscillation (calculated as the first empirical orthogonal function of daily sea level pressure), North Atlantic Oscillation, and an index Arctic Oscillations (calculated by annual area average pressure difference between the Arctic and midlatitutes).
- Our measures indicate that the long term correlations are different between the AO and the index AO. This warrants more attention because EOF analysis may be unrealistically impacting the dynamics of time series.
- The indices shed light on missing physics in models, physicas that is important in the observations.

This suggests that these metrics would be useful as part of a suite of metrics to evaluate climate models. This study was conducted using the CMIP3 models and will be publishable with the addition of the CMIP5 models.

Reviewed Publications: (Students underlined)

[1] Legatt, R., I.V. Polyakov, U.S. Bhatt, X. Zhang, and R. Bekryaev, 2012: *North Atlantic Variability Driven by Atmospheric and Oceanic Stochastic Forcing in a Simple Box Model*, Tellus A, 64, 18695, http://dx.doi.org/10.3402/tellusa.v64i0.18695.

[2] M Mueller-Stoffels and R Wackerbauer, 2012: *Albedo parameterization and reversibility of sea ice decay*, Nonlinear Processes in Geophysics 19, 81-94.

[3] J K Talbot, 2011: *Use of Hurst and Renyi Analysis to Detect and Characterize Pacific Decadal Oscillation Impacts on Climate Variability in Alaska*, M.S. Thesis, Department of Atmospheric Sciences, University of Alaska Fairbanks, 57 pp. online at: http://ffden-2.phys.uaf.edu/atm/atm/graduates.html_files/Talbot_MS2011.pdf.

[4] JK Talbot, U S Bhatt, D Newman, R Wackerbauer, IV Polyakov, R Sanchez, H. Angeloff, R Thoman, PA Bieniek, 2015: *Use of Hurst and Renyi Analysis to Detect and Characterize PDO Impacts on Climate Variability in Alaska,* J. Geophys. Res. Atmospheres (to be submitted Dec 2015).

[5] R Winnan, 2015: *Using Self-Organizing Maps to Detail Synoptic Connections Between Climate Indices and Alaska Weather,* Department of Atmospheric Sciences, University of Alaska Fairbanks, 72 pp. (In final editing stage and will be available online by end of Fall 2015 Semester).

Personnel who worked on project and what support they received:

Core Scientific Team

- **Uma S. Bhatt**, Professor in Department of Atmospheric Sciences, University of Alaska (supported by this grant at 2 months/year and expert on climate variability).

- **Igor V. Polyakov**, Professor, Department of Atmospheric Sciences, UAF (supported by this grant at 1 month/year and expert on Atlantic and Arctic oceanography).
- **Renate Wackerbauer**, Professor, Department of Physics, UAF (supported by this grant at 1 month/year and expert on Renyi Analysis).
- **David E. Newman**, Professor, Department of Physics, UAF (unfunded collaborator and expert on Hurst Analysis).
- **Raul E. Sanchez III**, Fusion Energy Division, Oak Ridge National Laboratory, Oak Ridge, TN, currently Professor of Physics at Universidad Carlos III, Madrid Spain (unfunded collaborator and expert on Fractional Diffusion).

Students

- **Jeanie Talbot**, MS Fall 2011, Dept of Atmospheric Sciences, UAF, supervisor Bhatt, (Funded by this grant for MS study and 1 semester of PhD ~ 2.5 years of support of a total of 3 years including stipend and tuition). Ms. Talbot is currently the Physics Laboratory Manager at the Dept. of Physics, UAF.
- **Reynir Winnan**, MS Fall 2015, Dept. of Atmospheric Sciences, UAF, supervisor Bhatt, (Funded by this grant for 1 year of MS study including stipend and tuition). Mr. Winnan plans to work for the climate services sector (i.e., weather hazard forecasting) in the greater New York area.
- **Marc Mueller-Stoffels**, PhD 2012, Dept. of Physics, UAF, supervisor Wackerbauer (not funded by this grant). Dr. Muller-Stoffels is currently a Research Assistant Professor, Power Systems Integration Program at Institute of Northern Engineering at UAF.
- **Rebecca Legatt**, MS Fall 2010, UAF, supervisor Polyakov (not funded by this grant). Ms. Legatt (Heim) is currently the National Weather Service Alaska Program Sea Ice Leader, Anchorage Alaska.

Additional Scientists that contributed substantially to this work

- Heather Angeloff, Geophysical Institute, UAF, provided assistance and expertise concerning Alaska meteorological station data.
- Richard Thoman, Climate Science and Services Manager, NOAA/National Weather Service, Fairbanks Alaska, provided weather and climate forecasting/processes expertise.

Other support for this work:

We submitted a proposal to NOAA in October 2015 to investigate and apply SOMs for forecasting fire weather in Alaska based on the promising results of Winnan MS thesis. We are seeking grant support to build on this work and the next key scientific step is to develop methodology for applying the Hurst analysis to prediction. This will require partnering with theoreticians.

Cost Status: Please see attached original budget and final budget form on following pages.

BUDGET: ***Key the Proposal Title Here*** | **GI 08-02**

U. Bhatt

Period of Performance: ***Start*** *1-Oct-07* ***End*** *30-Sep-10*

					$ Month	YR1 - GI	Cost Share	YR1 - IARC	Cost Share	YR1 - CNSM	Cost Share	YR2 - GI	Cost Share	YR2 - IARC	Cost Share	YR2 - CNSM	Cost Share	YR3 - GI	Cost Share	YR3 - IARC	Cost Share	YR3 - CNSM	Cost Share	TOTALS
A. SALARIES - Senior																								
Months	Senior Salaries			Department																				
2/2/2/0/0	PI	F9	U. Bhatt	GI	$6,862	$ 13,724	$ 3,016					$ 14,342	$ 2,988					$ 14,987	$ 2,955					$ 52,012
1/1/1/0/0	CO-I	F9	I. Polyakov	IARC	$8,751			$ 8,751	$ 1,895					$ 9,145	$ 1,895					$ 9,556	$ 1,895			$ 33,137
0/0/0/0/0	CO-I	F9	D. Newman	GI	$8,415	$ -	$ -					$ -	$ -					$ -	$ -					$ -
2/2/2/0/0	CO-I	F9	R. Wackerbauer	CNSM	$6,645					$ 13,290	$ 2,878					$ 13,888	$ 2,878					$ 14,513	$ 2,878	$ 50,325
			(Includes 1.4% Leave Reserve)		*Total Seniors*	*13,724*	*3,016*	*8,751*	*1,895*	*13,290*	*2,878*	*14,342*	*2,988*	*9,145*	*1,895*	*13,888*	*2,878*	*14,987*	*2,955*	*9,556*	*1,895*	*14,513*	*2,878*	*135,474*
B. SALARIES - Other Personnel																								
Hours	Undergraduate Student Salaries				*Hours*																			
450/450/0/0/0	1	ST	Undergraduate Student (summer only)			4,275						4,275						-						8,550
			(Includes 0.0% Leave Reserve)		*Total Temps*	*4,275*		-		-		*4,275*		-		-		-		-		-		*8,550*
Pay Periods	:e Student Salaries					*AY07*						*AY08*						*AY09*						
19/19/19/0/0	1	GN/GT	PhD prior to advancement			16,454						18,346						18,897						53,697
7/7/7/0/0	1		PhD prior to advancement (summer only)			7,794						6,759						6,962						21,515
			(Includes 0.0% Leave Reserve)		*Total Grad Students*	*24,248*		-		-		*25,105*		-		-		*25,859*		-		-		*75,212*
					Total Salaries	*42,247*	*3,016*	*8,751*	*1,895*	*13,290*	*2,878*	*43,722*	*2,988*	*9,145*	*1,895*	*13,888*	*2,878*	*40,846*	*2,955*	*9,556*	*1,895*	*14,513*	*2,878*	*219,236*
C. STAFF BENEFITS																								
36.5%		F9	Senior Salaries*			5,009	1,101	3,194	692	4,851	1,050	5,307	1,106	3,384	701	5,139	1,065	5,635	1,111	3,593	713	5,457	1,082	50,190
8.5%		ST	U-graduate Salaries (summers only; flat rate for all y			$363						$363						$0						$726
8.5%		GT	PhD prior Student Salaries (summers only)			662						575						592						1,829
			*(*Rate increases by 1.5% ea. year)*		*Total Staff Benefits*	6,034	1,101	3,194	692	4,851	1,050	6,245	1,106	3,384	701	5,139	1,065	6,227	1,111	3,593	713	5,457	1,082	52,745
			TOTAL SALARIES & STAFF BENEFITS			**48,281**	**4,117**	**11,945**	**2,587**	**18,141**	**3,928**	**49,967**	**4,094**	**12,529**	**2,596**	**19,027**	**3,943**	**47,073**	**4,066**	**13,149**	**2,608**	**19,970**	**3,960**	**271,981**
D. EQUIPMENT																								
1/0/1/0/0	/ea		Data server computer system		$5,000 /ea	5,000						-						5,000						10,000
			TOTAL EQUIPMENT			**5,000**						**-**						**5,000**						**10,000**
E. TRAVEL																								
	Domestic																							
2/2/2/0/0	/trips		RT Fairbanks/Washington DC		$800 /trip	1,600						1,600						1,600						4,800
10/10/10/0/0	/days		Days Per Diem		$259 /day	2,590						2,590						2,590						7,770
10/10/10/0/0	/days		Days Auto Rental		$40 /day	400						400						400						1,200
3/3/2/0/0	/trips		RT Fairbanks/Denver		$800 /trip	2,400						2,400						1,600						6,400
15/15/10/0/0	/days		Days Per Diem		$176 /day	2,640						2,640						1,760						7,040
15/15/10/0/0	/days		Days Auto Rental		$40 /day	600						600						400						1,600
					Total Domestic	*10,230*						*10,230*						*8,350*						*28,810*
	Foreign																							
1/1/1/0/0	/trips		RT Fairbanks/Vienna, or equivalent TBD		$1,200 /trip	1,200						1,200						1,200						3,600
8/8/8/0/0	/days		Days Per Diem		$299 /day	2,392						2,392						2,392						7,176
8/8/8/0/0	/days		Days Auto Rental		$50 /day	400						400						400						1,200
					Total Foreign	*3,992*						*3,992*						*3,992*						*11,976*
			TOTAL TRAVEL			**14,222**						**14,222**						**12,342**						**40,786**
G.1. MATERIALS/SUPPLIES																								
1.1894/1.1854/0.6254/0/0			Project Supplies		$1,000 /ea	1,289						1,289						733						3,311
			TOTAL MATERIALS/SUPPLIES			**1,289**						**1,289**						**733**						**3,311**
G. OTHER DIRECT COSTS																								
1/1/1/0/0	/ea		Grad Student Tuition (Resident)	*Tuition***	$5,166 /yr	5,166						5,683						6,251						17,100
3/3/3/0/0	/ea		Student Health Insurance		$500 /ea	1,500						1,500						1,500						4,500
2/2/2/0/0	/ea		***Student Fees (Each semester)		$498 /ea	996						996						996						2,988
1/1/1/0/0	/ea		Publications		$2,131 /ea	2,131						2,131						2,131						6,393
			TOTAL OTHER DIRECT COSTS			**9,793**		**-**		**-**		**10,310**		**-**		**-**		**10,878**		**-**		**-**		**30,981**
			TOTAL DIRECT COSTS			**$ 78,585**	**$ 4,117**	**$ 11,945**	**$ 2,587**	**$ 18,141**	**$ 3,928**	**$ 75,788**	**$ 4,094**	**$ 12,529**	**$ 2,596**	**$ 19,027**	**$ 3,943**	**$ 76,026**	**$ 4,066**	**$ 13,149**	**$ 2,608**	**$ 19,970**	**$ 3,960**	**$ 357,059**
L. FACILITIES & ADMINISTRATIVE COSTS																								
			*F&A Exempt - Tuition***			*5,166*						*5,683*						*6,251*						*17,100*
			- Student Health Insurance			*1,500*						*1,500*						*1,500*						*4,500*
			*- Student Fees****			*996*						*996*						*996*						*2,988*
			- Equipment			*5,000*						*-*						*5,000*						*10,000*
					MTDC base =	*65,923*	*4,117*	*11,945*	*2,587*	*18,141*	*3,928*	*67,609*	*4,094*	*12,529*	*2,596*	*19,027*	*3,943*	*62,279*	*4,066*	*13,149*	*2,608*	*19,970*	*3,960*	*322,471*
			TOTAL GI F&A COSTS		***45.1%***	***29,731***	***1,857***					***30,492***	***1,846***					***28,088***	***1,834***					***93,848***
			TOTAL IARC F&A COSTS		***28.6%***			***3,416***	***740***					***3,583***	***742***					***3,761***	***746***			***12,988***
			TOTAL CNSM F&A COSTS		***45.1%***					***8,182***	***1,772***					***8,581***	***1,778***					***9,006***	***1,786***	***31,105***
			TOTAL F&A COSTS			***29,731***	***1,857***	***3,416***	***740***	***8,182***	***1,772***	***30,492***	***1,846***	***3,583***	***742***	***8,581***	***1,778***	***28,088***	***1,834***	***3,761***	***746***	***9,006***	***1,786***	***137,941***
			TOTAL BUDGETS PER DEPT.			**$ 108,316**	**$ 5,974**	**$ 15,361**	**$ 3,327**	**$ 26,323**	**$ 5,700**	**$ 106,280**	**$ 5,940**	**$ 16,112**	**$ 3,338**	**$ 27,608**	**$ 5,721**	**$ 104,114**	**$ 5,900**	**$ 16,910**	**$ 3,354**	**$ 28,976**	**$ 5,746**	**$ 495,000**
			TOTAL AGENCY YEARLY BUDGETS			**$ 150,000**						**$ 150,000**						**$ 150,000**						**$ 450,000**
			TOTAL YEARLY COST SHARE			**$ 15,001**						**$ 14,999**						**$ 15,000**						**45,000**

FEDERAL FINANCIAL REPORT

(Follow form instructions)

1. Federal Agency and Organizational Element to Which Report is Submitted	2. Federal Grant or Other Identifying Number Assigned by Federal Agency (To report multiple grants, use FFR Attachment)	Page	of
US Department of Energy	DE-SC0001898	1	1 pages

3. Recipient Organization (Name and complete address including Zip code)
University of Alaska
UAF Grants & Contracts Admin
West Ridge Research Bldg 008
PO Box 757880
Fairbanks Alaska 99775-7880

4a. DUNS Number	4b. EIN	5. Recipient Account Number or Identifying Number (To report multiple grants, use FFR Attachment)	6. Report Type	7. Basis of Accounting
615245164	92-6000147	G00005984	Quarterly Semi-Annual Annual x Final	☐ Cash X Accrual

8. Project/Grant Period From: (Month, Day, Year)	To: (Month, Day, Year)	9. Reporting Period End Date (Month, Day, Year)
August 15, 2009	August 14, 2015	August 14, 2015

10. **Transactions**	Cumulative
(Use lines a-c for single or multiple grant reporting)	
Federal Cash (To report multiple grants, also use FFR Attachment):	
a. Cash Receipts	$448,481.65
b. Cash Disbursements	$448,481.65
c. Cash on Hand (line a minus b)	$0.00
(Use lines d-o for single grant reporting)	
Federal Expenditures and Unobligated Balance:	
d. Total Federal funds authorized	$450,000.00
e. Federal share of expenditures	$448,481.65
f. Federal share of unliquidated obligations	$0.00
g. Total Federal share (sum of lines e and f)	$448,481.65
h. Unobligated balance of Federal funds (line d minus g)	$1,518.35
Recipient Share:	
i. Total recipient share required	$45,000.00
j. Recipient share of expenditures	$45,009.52
k. Remaining recipient share to be provided (line i minus j)	($9.52)
Program Income:	
l. Total Federal program income earned	$0.00
m. Program income expended in accordance with the deduction alternative	$0.00
n. Program income expended in accordance with the addition alternative	$0.00
o. Unexpended program income (line l minus line m or line n)	$0.00

11. Indirect Expense	a. Type	b. Rate	c. Period From	Period To	d. Base	e. Amount Charged	f. Federal Share
	Predetemined	45.1%	15-Aug-09	30-Jun-15	$144,024.19	$83,434.57	$83,434.57
	Predetemined	45.1%	15-Aug-09	30-Jun-15	$55,684.91	$25,113.90	$25,113.90
	Predetemined	28.6%	27-Oct-09	30-Jun-15	$37,588.45	$10,750.29	$10,750.29
				g. Totals:	$237,297.55	$119,298.76	$119,298.76

12. *Remarks: Attach any explanations deemed necessary or information required by Federal sponsoring agency in compliance with governing legislation:*

Cash on hand is negative; have requested reimbursement for $6,830.35 but have not received payment yet.

13. Certification: By signing this report, I certify that it is true, complete, and accurate to the best of my knowledge. I am aware that any false, fictitious, or fraudulent information may subject me to criminal, civil, or administrative penalities. (U.S. Code, Title 218, Section 1001)

a. Typed or Printed Name and Title of Authorized Certifying Official	c. Telephone (Area code, number and extension)
Rosemary Madnick Executive Director	(907) 474-7301
	d. Email address uaf-ogca@alaska.edu
b. Signature of Authorized Certifying Official  Digitally signed by Rosemary Madnick DN: cn=Rosemary Madnick, o=University of Alaska Fairbanks, ou=Office of Grants and Contracts Administration, email=rmadnick@alaska.edu, c=US Date: 2015.11.11 16:08:37 -09'00' Adobe Reader version: 11.0.13	e. Date Report Submitted (Month, Day, Year)
	14. Agency use only:

Standard Form 425
OMB Approval Number: 0348-0061
Expiration Date: 10/31/2011

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