

**Annual Report for Period:**09/2009 - 08/2010**Submitted on:** 07/02/2010**Principal Investigator:** Bhatt, Uma S.**Award ID:** 0902175**Organization:** U of Alaska Fairbanks**Submitted By:**

Bhatt, Uma - Principal Investigator

**Title:**

Collaborative Research: Seasonality of circumpolar tundra - ocean and atmosphere controls and effects on energy and carbon budgets

**Project Participants****Senior Personnel****Name:** Bhatt, Uma**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Walker, Donald**Worked for more than 160 Hours:** Yes**Contribution to Project:****Post-doc****Name:** Reynolds, Martha**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Dr. Reynolds is a plant ecologist who provided her expertise in the analysis and interpretation of NDVI and temperature data. She has had experience with remote sensing data and understands issues that arise in the Arctic in remotely sensed data.

**Graduate Student****Name:** Bieniek, Peter**Worked for more than 160 Hours:** No**Contribution to Project:**

Mr. Bieniek will officially begin on this project on Aug 1, 2010, though he has been attending our meetings since May to become more familiar with the project.

**Undergraduate Student****Technician, Programmer****Other Participant****Research Experience for Undergraduates****Organizational Partners****UNIVERSITY OF VIRGINIA**

H.E. Epstein, Dept. Env. Sci, UVA is the primary PI of this project through this collaborative proposal.

**University of Washington**

M. Steele of APL works with us on this collaborative proposal.

**NASA/GODDARD SPACE FLIGHT CENTER**

J. Comiso, J. Pinzon, and C.J. Tucker have actively worked with us in this project. Drs. Pinzon and Tucker have continued to improve the AVHRR NDVI data set for Arctic regions. Dr. Comiso provides expertise on the AVHRR sea ice concentration and surface temperature data sets. These are the longest available data sets and their length make a climate study possible.

**University of Texas at El Paso**

C. Tweedie has provided ground truth data in the High Canadian Arctic.

**Michigan State University**

Dr. Pat Webber has provided ground truth for vegetation changes in the High Canadian Arctic.

**Chinese Academy of Sciences**

Dr. G. Jia provides expertise in the interpretation of NDVI analysis.

**Other Collaborators or Contacts**

Dr. R. Gens (Alaska SAR Facility, University of Alaska) has provided remote sensing data expertise.

Drs. A. Frei (Hunter College, NY), J. Cohen (AER, Boston MA), and J. Cherry (IARC UAF) will provide snow data expertise for our project.

**Activities and Findings****Research and Education Activities:**

The major research goal of this project is to characterize the seasonal linkages between land surface greenness and a suite of land, atmosphere and ocean measures in the context of Arctic tundra vegetation. In the first year of our project we have analyzed the seasonality of Arctic sea ice concentrations, land surface temperatures and NDVI and how it has changed over the satellite record.

Specifically we have worked on the following activities:

- Fine tuned the analysis of regional trends and variability on a seasonal time scale in sea ice concentration, surface temperature and updated NDVI data. These results appear in our Earth Interactions paper.
- Analyzed weekly climatology, variance and trends for sea ice concentration and surface temperature for the 17 Arctic regions (see map in Bhatt et al. 2010 Earth Interactions). The same analysis was conducted for biweekly NDVI.
- Conducted weekly meetings for the UAF team to discuss project progress, exchange scientific ideas, and to plan future activities.
- Conducted meetings with collaborators on this project to discuss results and plan activities at 2009 Fall AGU and 2010 State of the Arctic meetings. Telecons and emails have been used as necessary to communicate among the collaborators.
- Worked with J. Pinzon and C.J. Tucker to identify NDVI biases so they can correct through reprocessing the biweekly NDVI that we will use in our seasonality analysis. We expect a newer version of the data in July 2010.
- Decided on which snow data set to use (from Rutgers University) and have begun to process this data.
- Incorporated findings from this work in the Dept. of Atmospheric Sciences climate discussion seminar (?Climate Journal Club?) for graduate students, postdocs, and faculty, during Spring 2010 semester.
- Contributed plots and text based on results from this project for the Bulletin of the American Meteorological Society ?State of the Climate? report on Arctic high latitude terrestrial component of climate.
- Presented results at various meetings (e.g. 2009 Fall AGU, State of the Arctic, and IPY Oslo Science Conference). A complete list is provided under one-time publications section of this report.

**Findings:**

1) The analysis of NDVI, sea ice concentration and summer warmth index (SWI -sum of the degree months above freezing) over the period 1982-2008, indicates that:

- SWI, sea ice concentration and time integrated NDVI (sum of biweekly NDVI values over the growing season) are significantly correlated. As sea ice decreases, SWI and TI-NDVI increase.
- SWI and NDVI have generally increased over the Arctic tundra domain, however there are several areas where NDVI (e.g. SW Alaska and Chutoka) and SWI (e.g. parts of central Asia) have decreased. The patterns in the trend are not homogeneous. Sea ice has decreased significantly everywhere in the coastal Arctic with the exception of some areas in the North Bering Sea.

- The land warming has been larger over North American than Eurasia.
- The largest magnitude increases in NDVI have occurred along the Beaufort Sea coast in Northern Alaska.

2) The analysis of the seasonality of NDVI, sea ice concentration and surface temperature indicates that:

- Largest NDVI increases are found in spring in most regions, with Beaufort displaying maximum mid-season increases.
- Sea ice declines are largest during spring and fall consistent with periods of largest variability.
- North America displays large year round warming while Eurasia displays largest warming in fall/winter.
- Variance of all parameters appears to have been largest in the 1990's.

3) The collaboration of our climate analysis group with J. Pinzon and C.J. Tucker of NASA led to the reprocessing of AVHRR NDVI data and this has permitted the first circumpolar analysis over tundra of NDVI changes in the High Arctic north of 72°N. Our seasonality analysis of NDVI, which revealed new intra-seasonal biases, has led to the current reprocessing of the AVHRR NDVI by Drs. Pinzon and Tucker.

### **Training and Development:**

This project is training a Ph.D. level graduate student and a postdoc on climate variability research and in particular is building their skills to better conduct interdisciplinary Arctic climate research. They have gained experience by interacting with faculty and researchers from the areas of plant biology, climate variability, oceanography, and remote sensing.

### **Outreach Activities:**

The following two activities will take place in the next two months but preparation for these has begun.

- 1) UAF Summer Sessions evening Monday Marvels public lecture by Bhatt on 2 August 2010 titled "Climate Variability and Change In Alaska", will include results from this project about vegetation, sea ice and temperature changes over Alaskan tundra.
- 2) Bhatt will present an invited talk titled "Seasonality shifts in circumpolar Arctic tundra vegetation, land temperatures, and coastal sea ice" on October 1, 2010 at the annual meeting of the Society for Advancement of Chicanos and Native Americans in Science in the Shifting Polar Environments Create Uncertain Futures session.

### **Journal Publications**

U.S. Bhatt, D.A. Walker, M.K. Raynolds, J.C. Comiso, H.E. Epstein, G. Jia, R. Gens, J.E. Pinzon, C.J. Tucker, C.E. Tweedie, and P.J. Webber, "Circumpolar Arctic tundra vegetation change is linked to sea-ice decline, Earth Interactions", *Earth Interactions*, p. , vol. , (2010). Accepted, doi: 10.1175/2010EI315.1

Raynolds, M.K., F. Huettmann, D.A. Walker, and D. Verbyla, "Environmental controls of the distribution of circum-Arctic vegetation", *Global Ecology and Biogeography*, p. , vol. , (2010). Submitted,

Walker, D.A, U.S. Bhatt, M.K. Raynolds, J.E. Comiso, H.E. Epstein and G.J. Jia, "Land: Vegetation, in State of the Climate in 2009", *Bulletin of the American Meteorological Society*, p. , vol. , (2010). Submitted,

Pinzon, J.E., M.K. Raynolds, E.W. Pak, U.S. Bhatt, D.A. Walker, and C.J. Tucker, "NDVI3g: a consistent long term vegetation index data set optimized for polar trend analysis", *Geoscience and Remote Sensing Letters*, p. , vol. , (2010). in preparation,

### **Books or Other One-time Publications**

U.S. Bhatt (Poster), D.A. Walker, M.K. Raynolds, H.E. Epstein, G. Jia, J.C. Comiso, J.E. Pinzon, C.J. Tucker, "Climatology and variability of the ice-ocean-atmosphere-terrestrial system on the Yamal", (2010). Poster Presentation, Not applicable  
Bibliography: LCLUC Science Team Meeting, Bethesda, MD, 20-22 April 2010

U.S. Bhatt, D.A. Walker, M.K. Raynolds, H.E. Epstein, G. Jia, J.C. Comiso, J.E. Pinzon, C.J. Tucker, "Seasonality of the atmosphere-ocean-ice-terrestrial environment of Arctic tundra", (2010). Conference Poster Presentation, Presented

Collection: State of the Arctic, Miami, FL, March 2010

Bibliography: Section 1.2. Understanding the Linkages and Feedbacks Between the Arctic System Components.

U.S. Bhatt (Talk), D.A. Walker, M.K. Raynolds, H.E. Epstein, G. Jia, J.C. Comiso, R Gens, J.E. Pinzon, C.J. Tucker, C.E. Tweedie, P.J. Webber, "Circumpolar Arctic tundra Vegetation Change is Linked to Sea-Ice Decline", (2010). Oral Presentation, Presented

Collection: State of the Arctic, 16 March 2010, Miami, FL

Bibliography: <http://soa.arcus.org/abstracts/circumpolar-arctic-tundra-vegetation-change-linked-sea-ice-decline>

U.S. Bhatt, D.A. Walker, M.K. Raynolds, H.E. Epstein, G. Jia, J.C. Comiso, J.E. Pinzon, C.J. Tucker, "Climatology and Seasonality of the ice-ocean-atmosphere-terrestrial system on the Yamal", (2010). Oral Presentation, Presented

Collection: Second Yamal Land-Cover Land-Use Change Workshop, Rovaniemi Finland 8 March 2010

Bibliography: <http://www.geobotany.uaf.edu/yamal/ptText.php?queryID=188>

H.E. Epstein (Talk), D.A. Walker, M.K. Raynolds, A.M. Kelley, G.J. Jia, C.L. Ping, G.J. Michaelson, M.O. Liebman, E. Kaarlejrvi, A.V. Khomutov, P. Kuss, N.G. Moskalenko, P. Orekhov, G. Matyshak, B.C. Forbes, and Q. Yu, "Vegetation biomass, leaf area index, and NDVI patterns and relationships along two latitudinal transects in arctic tundra", (2010). Oral Presentation, Presented

Collection: Second Yamal Land-Cover Land-Use Change Workshop, Rovaniemi, Finland, 8-10 March 2010

Bibliography: <http://www.geobotany.uaf.edu/yamal/ptText.php?queryID=166>

J. C. Comiso, "State of the Cryosphere in the Arctic", (2010). Oral Presentation, Presented

Collection: Second Yamal Land-Cover Land-Use Change Workshop, Rovaniemi, Finland, 8-10 March 2010

Bibliography: <http://www.geobotany.uaf.edu/yamal/ptText.php?queryID=164>

J.E. Pinzon and C.J. Tucker, "GIMMS 3g NDVI set and global NDVI trends", (2010). Oral Presentation, Presented

Collection: econd Yamal Land-Cover Land-Use Change Workshop, Rovaniemi, Finland, 8-10 March 2010

Bibliography: <http://www.geobotany.uaf.edu/yamal/ptText.php?queryID=168>

M.K. Raynolds, D.A. Walker, U.S. Bhatt, J.E. Pinzon, J.C. Comiso, "NDVI trends 1981-2008 in the circumpolar Arctic and Yamal", (2010). Oral Presentation, Presented

Collection: Second Yamal Land-Cover Land-Use Change Workshop, Rovaniemi, Finland, 8-10 March 2010

Bibliography: <http://www.geobotany.uaf.edu/yamal/ptText.php?queryID=184>

U.S. Bhatt, D.A. Walker, M.K. Raynolds, J.C. Comiso, H.E. Epstein, G. Jia, R. Gens, J.E. Pinzon, C.J. Tucker, C.E. Tweedie, and P.J. Webber., "Circumpolar Arctic Tundra Vegetation Change is Linked to Sea-Ice Decline", (2010). Poster Presentation, Presented

Collection: Second Yamal Land-Cover Land-Use Change Workshop, Rovaniemi, Finland, 8-10 March 2010

Bibliography: <http://www.geobotany.uaf.edu/yamal/>

U.S. Bhatt, D.A. Walker, M.K. Raynolds, M. Steele, H.E. Epstein, G. Jia, J.C. Comiso, J.E. Pinzon, C.J. Tucker, "Seasonality of the air-sea-ice-land environment of Arctic tundra in Northern Eurasia and North America", (2009). Poster Presentation, Presented

Collection: 2009 AGU Fall Meeting, Poster GC31A-0701, San Francisco, CA, Wednesday 16 December 2009

Bibliography: [www.agu.org](http://www.agu.org)

U.S. Bhatt, D.A. Walker, M.K. Raynolds, M. Steele, H.E. Epstein, G. Jia, J.C. Comiso, J.E. Pinzon, C.J. Tucker, "Seasonality of the air-sea-ice-land environment of Arctic tundra in Northern Eurasia and North America", (2009). Oral Presentation, Presented

Collection: Dept. Atmospheric Sciences Informal Seminar, Wed. 18 Nov 2009, Fairbanks, AK

Bibliography: [http://www.gi.alaska.edu/~molders/zeitplan\\_fall2009.htm](http://www.gi.alaska.edu/~molders/zeitplan_fall2009.htm)

D.A. Walker, H.E. Epstein, U.S. Bhatt, M.O. Liebman, B.C. Forbes, M.K. Raynolds, G.J. Jia, G.V. Frost, A.V. Khomutov, P. Orekhov, P.J. Webber, C.E. Tweedie, W.A. Gould, J. Mercado, C.A. Munger, H.A. Maeir, J.C. Comiso, J.E. Pinzon, J.C. Tucker, "Greening of the Arctic: A "planet to plant" analysis of vegetation change in the Arctic", (2010). Oral Presentation, Presented

Collection: IPY Oslo Science Conference, 2010 8-12 June

Bibliography: <http://ipy-osc.no/abstract/418955>

**Web/Internet Site****URL(s):**

<http://www.geobotany.uaf.edu/seasonality/index>

**Description:**

This web site outlines the project and lists presentations/publications associated with this grant.

**Other Specific Products****Contributions****Contributions within Discipline:**

One of our key findings that impacts Arctic climate understanding is that sea ice decline is linked to the nearby coastal warming in the observations.

This finding is relevant for Arctic vegetation and terrestrial research also.

**Contributions to Other Disciplines:**

I think our process of effectively conducting interdisciplinary research across various Arctic environmental disciplines has been noted by my midlatitude climate colleagues. I think that the Arctic community actually leads in interdisciplinary research because our community is small so it happens more naturally.

**Contributions to Human Resource Development:**

Mentor graduate student and Postdoc in doing climate research but particularly on how to engage in interdisciplinary research.

**Contributions to Resources for Research and Education:**

Our results have been discussed in ATM 656 Climate and Climate Change in Fall 2009, a course taught by Bhatt. This is a graduate level climate class taken by students from various disciplines (e.g. engineering, hydrology, a professional journalist, and atmospheric sciences).

**Contributions Beyond Science and Engineering:****Conference Proceedings****Special Requirements**

**Special reporting requirements:** None

**Change in Objectives or Scope:** None

**Animal, Human Subjects, Biohazards:** None

**Categories for which nothing is reported:**

Any Product

Contributions: To Any Beyond Science and Engineering

Any Conference