

Annual Report for Period:09/2010 - 08/2011

Submitted on: 06/22/2011

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: Raynolds, Martha

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Raynolds 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 began work on this project on Aug 1, 2010 and we expect he will defend his PhD in Spring 2012.

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 continue 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 and provides expertise on Arctic plant ecology.

Michigan State University

Dr. Pat Webber has provided ground truth for vegetation changes in the High Canadian Arctic and provides arctic plant expertise.

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. D. Robinson (Rutgers University), A. Frei (Hunter College, NY), J. Cohen (AER, Boston MA), and J. Cherry (IARC UAF) have provided 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. We are analyzing the seasonality of Arctic sea ice concentrations, land surface temperatures and NDVI and how it has changed over the satellite record. We are working to include additional remote sensing data (snow and clouds) to further our understanding.

Specifically we have worked on the following activities:

- Updated our findings based on 1982-2008 from the Bhatt et al. (2010, Earth Interactions) paper with analysis for the period 1982-2010.
- 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 appeared in our Earth Interactions paper and continue to hold for the 1982-2010 period.
- Analyzed weekly climatology, variance and trends for sea ice concentration and surface temperature for the 19 Arctic regions (regions were revised in January 2011). The same analysis was conducted for biweekly NDVI. We have analyzed decadal average seasonal curves for open water, biweekly NDVI and weekly land temperatures.
- We have analyzed our parameters by bioclimate subzone (zonal divisions based on available warmth and plant type).
- We continue to hold weekly meetings for the UAF team to discuss project progress, exchange scientific ideas, and to plan future activities.
- We have conducted meetings with collaborators on this project to discuss results and plan activities at 2009 Fall AGU, 2010 State of the Arctic, and 2010 Fall AGU meetings. Telecons and emails have been used as necessary to communicate among the collaborators.
- We have worked with J. Pinzon and C.J. Tucker to identify NDVI biases so they can correct through reprocessing the biweekly NDVI needed for our seasonality analysis. We received a corrected version of the data in October 2010. This data has been corrected for errors due to clouds. The NDVI currently has relatively minor regional errors, which are being fixed. Bieniek has implemented a curve fitting method for the biweekly NDVI to provide daily NDVI values. The dates of greenup and how that has changed can be determined using these results.
- We have concluded after analysis that the snow data set from Rutgers University (D. Robinson) is not appropriate for the Arctic so have switched to the IMS snow data (after discussion with D. Robinson). The IMS data is available in daily resolution at 24 km. Unfortunately, it is only available since 1998, but quality was more critical than record length for our purposes. Graduate student Bieniek is processing this data to integrate into the NDVI, sea ice, and land temperature analysis.
- We have 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 and Spring 2011 semesters.
- We have 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 vegetation for 2009 and 2010. We have contributed to the vegetation section of the 'State of the Arctic' report in 2010 and will do so for 2011 also. We have contributed a plot of Arctic trends of NDVI, SWI and sea ice to a paper on polar amplification by Serreze et al. (2011 in Global and Planetary Change).
- We have presented results at various meetings (e.g. 2009 Fall AGU, State of the Arctic, IPY Oslo Science Conference, 2010 Fall AGU, and

2011 Polar AMS). A complete list is provided under one-time publications section of this report.

- We are working with the University of Alaska Fairbanks Museum to provide data and graphics of sea ice concentration, NDVI (over Arctic tundra), surface temperatures (over Arctic Tundra) for a visual public display to appear at the museum on a Magic Planet Display. This device is about 30 inches in diameter and will project graphics onto a sphere (from the inside) for public outreach and educational purposes. The museum project is funded by NASA and partners with the Imaginarium Discover Center at the Anchorage Museum and the Challenger Learning Center in Kenai. There is also a traveling device, so our tundra greening story will be presented throughout Alaska in outreach and educational venues.

- In January 2011, Uma Bhatt and Peter Bieniek attended a 1-day workshop in Anchorage for an NSF funded project for Dr. Ann Riordan, who is working with Calista Elders in SW Alaska. We presented several slides of our remotely sensed greening trends and listened to Elders discuss what they observe at the ground. This has helped us focus our climate data analysis on snow trends noted by the Elders.

Findings:

1) The analysis of NDVI, spring sea ice concentration, summer open water amount, and summer warmth index (SWI is the sum of the degree months above freezing) over the period 1982-2010, 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, Chutoka and Coastal West Kara Sea) and SWI (e.g. parts of central Asia between 60-120E) have decreased. The patterns in the trend are not homogeneous. Open water during summer has increased significantly everywhere in the coastal Arctic with the largest increases in Beringia and Kara-Barents Sea.
- The land warming is still 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:

- NDVI has increased most during spring over Eurasia but during peak season for North America.
- Based on preliminary greenup date analysis (curve fitting of biweekly to daily) for Northern Alaska, earlier greenup is most clearly evident in the foothills of the Brooks Range.
- 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. Many parts of Eurasian tundra have actually been cooling during the summer.
- We find that trends vary significantly by subzone and these trends vary regionally. For example, the near coastal subzone (subzone C) in the West Chukchi domain shows the largest NDVI increases whereas for the Beaufort domain the largest increases are at more southerly subzones (D and E).

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. The latest data set NDVI3g (October 2010) has been corrected for the intra-seasonal biases.

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 presented 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.

3) UAF Museum visualization of Arctic greening will serve to communicate our results to the general public. In addition to graphics, the PIs of that project have developed text in consultation with us to go with the movie. In addition, they will add video of scientists discussing their research that will be displayed with the graphics. This multi-media presentation is expected to be ready for display by the end of the year.

Journal Publications

U.S. Bhatt, D.A. Walker, M.K. Reynolds, 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). Published, doi: 10.1175/2010EI315.1

Raynolds, M.K., F. Huettmann, D.A. Walker, and D. Verbyla, "Modeling environmental controls on Arctic NDVI and effects of predicted changes in climate", Remote Sensing of Environment, p. , vol. , (2011). 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). Published,

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,

Walker, D.A.; Bhatt, U.S.; Callaghan, T.V.; J.C. Comiso; H.E. Epstein; B.C. Forbes; M. Gill; W.A. Gould; G.H.R. Henry; G.J. Jia; S.V. Kokelj; T.C. Lantz; S.F. Oberbauer; J.E. Pinzon; M.K. Raynolds; G.R. Shaver; C.J. Tucker; C.E. Tweedie, "The Arctic: Land: Vegetation", Bulletin of the American Meteorological Society, p. , vol. , (2011). Accepted,

Raynolds M. K., Walker D. A., Epstein H. E., Pinzon J. E. & Tucker C. J., "A new estimate of tundra-biome phytomass from trans-Arctic field data and AVHRR NDVI", Remote Sensing Letters, p. , vol. , (2011). Submitted,

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. Kaarlejev, 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: Second 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. Reynolds, 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. Reynolds, 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. Reynolds, 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

U.S. Bhatt, D.A. Walker, M.K. Reynolds, 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

D.A. Walker, H.E. Epstein, U.S. Bhatt, M.O. Liebman, B.C. Forbes, M.K. Reynolds, 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>

Bhatt, U.S., Walker, D.A., Reynolds, M.K., et al., "Understanding drivers of recent Arctic tundra vegetation changes.", (2010). Oral Presentation, http://www.geobotany.org/library/talks/BhattUS2010_agu_tal101217.pdf
Bibliography: Abstract GC43B-08, presented at Fall Meeting, AGU, San Francisco, CA, 13-17 December.

Bieniek, P.A., Bhatt, U.S., Walker, D.A., et al., "Alaska tundra vegetation trends and their links to the large-scale climate", (2010). Poster presentation, http://www.geobotany.org/library/posters/BieniekPA2010_agu_pos20101213.pdf
Bibliography: Abstract GC43B-0976, presented at Fall Meeting, AGU, San Francisco, CA, 13-17 December.

Reynolds, M.K., Walker, D.A., Verbyla, D., Munger, C.A., "Changes in tundra vegetation over 25 years as measured by Landsat NDVI in the Upper Kuparuk River Basin, North Slope Alaska, 1985-2009.", (2010). Oral Presentation, http://www.geobotany.org/library/posters/ReynoldsMK2010_agu_pos20101213.pdf
Bibliography: Abstract GC43B-0984, presented at Fall Meeting, AGU, San Francisco, CA, 13-17 December.

Walker, D.A., "Greening of the Arctic: Spatial and temporal (1982-2009) variation of circumpolar tundra NDVI and aboveground biomass", (2010). Oral Presentation, http://www.geobotany.org/library/talks/WalkerDA2010_agu_tal20101213.pdf
Bibliography: Abstract GC53B-01, presented at Fall Meeting, AGU, San Francisco, CA, 13-17 December.

Bhatt, U.S., Walker, D.A., Raynolds, M.K., et al., "Seasonal changes of the ice-ocean-atmosphere-terrestrial system on the Yamal.", (2011).

Poster presentation, http://www.geobotany.org/library/posters/BhattUS2011_lcluc_110328.pdf

Bibliography: LCLUC Science Team Meeting Adelphi, MD March 28-30.

Walker, D.A., "Greening of the Arctic: Climate change and circumpolar Arctic vegetation.", (2011). Oral Presentation, Published

Bibliography: Presented at: Fulbright Lecture, Cesko Budovice University Cesko Budovice, Czech Republic April 27.

Walker, D.A., "Socio-ecological effects of oil and gas development in the Arctic: Comparison of the Prudhoe Bay, Alaska and Bovanenkova, Russia regions.", (2011). Oral Presentation, Published

Bibliography: Presented at: Earth Day, 20th Celebration of the Czech Fulbright Commission American Center, Prague, Czech Republic April 21.

Walker, D.A., "Arctic vegetation along two long bioclimatic transects in North America and Russia.", (2011). Oral Presentation, Published

Bibliography: Presented at: Fulbright Lecture, Botany Dept., Masarysk University Brno, Czech Republic March 10.

Walker, D.A., Kuss, H.P., Kopecky, M., et al., "The North American and Eurasia Arctic transects: Using phytosociology and remote sensing to detect vegetation pattern and change.", (2011). Oral Presentation, http://www.geobotany.org/library/talks/WalkerDA2011_eva_tal110406.pdf

Bibliography: Presented at: European Vegetation Survey 20th Workshop Rome, Italy April 6-9.

Walker, D.A., Raynolds, M.K., Epstein, H.E., et al., "Greening of the Arctic: Spatial variation of biomass and NDVI along two Arctic transects and the Circumpolar Arctic.", (2011). Oral Presentation, http://www.geobotany.org/library/posters/WalkerDA2011_lcluc_110328.pdf

Bibliography: Presented at: LCLUC Science Team Meeting Adelphi, MD March 28-30.

Uma Bhatt, D. A. Walker, M. Raynolds, P. Bieniek, J. Comiso, J. Pinzon, and C. J. Tucker

, "Seasonality of climate parameters that characterize Arctic tundra vegetation", (2011). Oral Presentation, Published

Bibliography: Presented in: Session 5 Cryosphere and Terrestrial Processes, Wednesday 4 May 2011, Polar AMS, Boston, MA

Raynolds, M. K., "Searching for the response of northern vegetation to climate change", (2011). Oral Presentation, talk given

Bibliography: Presented to the Iceland Institute of Natural History (6 April 2011) and the University of Akureyri (28 April 2011)

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 has implications for interpretation of mechanisms of polar amplification.

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 led to a better understanding of how arctic tundra vegetation is linked to the large-scale and local climate. 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:

We have mentored a PhD student and Postdoc in doing climate research and developed their skills on how to engage in interdisciplinary research. This will better prepare them for future research opportunities.

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