CURRICULUM VITAE

MARK A. FRIEDL

Department of Earth and Environment, Boston University
675 Commonwealth Avenue, Boston, Massachusetts 02215
Tel: (617) 353-5745; Fax: (617) 353-8399; E-mail: friedl@bu.edu

RESEARCH AND TEACHING INTERESTS

- Remote sensing, emphasizing ecosystem monitoring and land cover mapping
- Land surface climatology, emphasizing land surface energy and radiation balance
- Data analysis and modeling, emphasizing applied problems in physical geography

EDUCATION

- Ph.D. Department of Geography: University of California, Santa Barbara, 1993
- M.A. Department of Geography: University of California, Santa Barbara, 1988
- B.Sc. (with Honors*)* in Physical Geography: McGill University, 1986

PROFESSIONAL APPOINTMENTS AND EXPERIENCE

- Chair, 2010 to 2012: Department of Earth Sciences, Boston University.
- Chair, 2003 to 2009: Department of Geography & Environment, Boston University.
- Co-Director, 2009 to present: Boston University Terrestrial Biogeosciences Program.
- Professor, 2007 to present: Department of Earth & Environment, Boston University.
- Associate Professor, 2000 to 2007: Department of Geography, Boston University
- Assistant Professor, 1993 to 2000: Department of Geography, Boston University
- Graduate Student Researcher, 1986-92: University of California, Santa Barbara
- Lecturer, 1989: Department of Geography, University of California, Santa Barbara
- Programmer, 1986: McGill University Advanced Cartography Laboratory
- Field Research Assistant, 1984: McGill University Sub-arctic Research Station, Schefferville, Quebec

VISITING APPOINTMENTS AND FELLOWSHIPS

- Charles Bullard Fellowship in Forest Research, 2012/2013: Harvard University.
- Erasmus Mundus Visiting Scholar, 2009: University of Southhampton, United Kingdom; ITC Faculty of Geoinformation Science and Earth Observation, Enscede, Netherlands; Lund University, Sweden.
- Visiting Scientist, 2005/2006: Complex Systems Research Center, University of New Hampshire.
- Natural Sciences and Engineering Research Council of Canada Postgraduate Scholarship
- University of California Regents Fellowship

PROFESSIONAL ACTIVITIES

- Science Teams*: Moderate Resolution Imaging Spectroradiometer Science Team* (NASA, 2004 - present); *Land Measurement Science Team* (NASA, 2005 -present); *NPOESS Preparatory Project Science Team* (NASA, 2007-present); Suomi VIIRS Land Calibration and Validation Science Team (NOAA, 2009-present); *Landsat 8 Science Team* (USGS, 2013-present).
- Associate Editor, 2013-2014; Editorial Board, 2015-, *Remote Sensing of Environment*.
- Associate Editor, *Journal of Geophysical Research, Biogeosciences*, 2008-2011.
- Assigning Editor, *Ecological Applications*, 2007- 2009.
- Editorial Board, *Ecological Applications*, 2004 – 2009.
- Co-Chair: *Land Process Validation Working Group Sub-Committee on Land Cover*, Validation; *Committee on Earth Observation Satellites*, 2009-2011.
- Chair, *Oak Ridge National Lab Distributed Active Archive Center User Working Group* (2006 - 2009); member, 2004 - 2009.
- Member, *National Ecological Observatory Network (NEON) Plant Productivity Technical Working Group*.
- Advisory committee member, *AAAS Scientific Responsibility, Human Rights & Law Program Initiative in Geospatial Technologies and Human Rights*, 2012-2014.

AWARDS

- Leica Geosystems *Second Place Award for Best Scientific Paper in Remote Sensing* American Society for Photogrammetry and Remote Sensing, 2004
- John I Davidson President's *Second Place Award for Practical Papers*, American Society for Photogrammetry and Remote Sensing, 2008
- Leica Geosystems *First Place Award for Best Scientific Paper in Remote Sensing*, American Society for Photogrammetry and Remote Sensing, 2008

MEMBERSHIPS

- American Geophysical Union

TEACHING EXPERIENCE

University of California at Santa Barbara:

Introduction to Air Photo Interpretation and Remote Sensing

Boston University:

Natural Environments: The Physical Landscape
Natural Environments: The Atmosphere
Global Dynamics of the Earth's Atmosphere and Surface
Micrometeorology: Energy and Mass Transfer at the Earth's Surface
Environmental Modeling and Analysis Using GIS
Seminar in Physical Climatology: Land Surface-Atmosphere Interactions
Seminar in Ecological Climatology
Multivariate Analysis: Applied Data Analysis for Environmental Science

GRADUATE STUDENT ADVISEES

(i) Graduated

Paul S. Fisher, M.A., 1995; Thesis Title: *The Utility of Derivative Spectroscopy and Linear Modeling Techniques for the Identification of Canopy Spectral Endmembers*.

Nathan Morrow, M.A., 1998; Thesis Title: *Biophysical Controls on Surface Reflectance and Surface Temperature at a Tallgrass Prairie Site*.

Alexander Lotsch, M.A., 1999; *Biome-Level Classification of Land Cover at Continental Scales Using Decision Trees.*

Douglas McIver, Ph.D. 2001*; Machine Learning Tools for Large Scale Land Cover Mapping from Multitemporal Satellite Data*.

Rongqian Yang, Ph.D. 2002; *Parameterization of Spatial Heterogeneity in Vegetation for Studies of Land Surface-Atmosphere Interaction.*

Su-Yin Tan, M.A.2003: *Modeling Spatial Patterns of Vegetation Activity and Climatological Parameters in the U.S. Great Plains.*

Alexander Lotsch, Ph..D. 2004. *Spatio-Temporal Dynamics of Global Precipitation and Terrestrial Vegetation Inferred from Satellite and Climate Records*.

Alessandro Baccini, Ph.D. 2005. *Linking Plot Scale Data to Multi-Resolution Remote Sensing for Forest Structure Mapping*.

Joe Santenello, Ph.D. 2005. *Estimation of Land Surface Energy Balance and Surface Properties using Remotely Sensed Observations*.

Callan Ordoyne, M.A. 2005. *Characterizing Everglades Hydrology: Wetland Flooding Delineation Using Remotely Sensed Data.*

William Boykin-Morris, 2007. *The MODIS Crop Type Dataset (MODCTD): Global Scale Classification of Agriculture Using Data from the Moderate Resolution Imaging Spectroradiometer (MODIS).*

Manish Verma, Ph.D. 2012. *Observing and Modeling Dynamics in Terrestrial Gross Primary Productivity and Phenology from Remote Sensing: An Assessment Using In-Situ Measurements.*

Jessica Meghan Salmon, Ph.D. 2012. *Using Satellite Remote Sensing and hydrologic Modeling to Improve Understanding of Crop Management and Agricultural Water Use at Regional to Global Scales.*

Xiaomam Huang, Ph.D. 2014. *Mapping Regional Land Cover and Land Use Change Using MODIS Time Series*

Eli Melaas, Ph.D. 2014. *Using Eddy Covariance, Remote Sensing, and In-situ Observations to Improve Models of Springtime Phenology in Temperate Deciduous Forests*

Adam Sibley (MA 2010), Douglas Bolton (MA, 2011), Parker Abercrombie (M.A., 2014), Mary Farina (M.A., 2014)

(ii) In progress

Damien Sulla-Menashe (Ph.D.) – expected graduation, Dec 2014
Jon Wang (Ph.D.) – expected graduation, May 2019
Radost Stamirova (Ph.D.) – expected graduation, May 2020.

BOSTON UNIVERSITY ADMINISTRATIVE RESPONSIBILITIES

- Undergraduate Advisor, Environmental Sciences: 1993-present.
- Undergraduate Advisor, Center for Energy & Environmental Science: 1993-2002
- Director of Graduate Studies, Department of Geography: 1994-1996.
- Chair, GIS and Remote Sensing Search Committee, Department of Geography: 1995
- Climatology Search Committee, Department of Geography: 1995
- Chair, Climatology Search Committee, Department of Geography: 1998
- Biogeography Search Committee, Department of Geography: 1998
- Director of Undergraduate Programs, Boston University Center for Energy and Environmental Studies: Sept. 1999-2002
- Associate Chair, Department of Geography, Boston University. 2001-2003
- Chair, Department of Geography & Environment, Boston University, 2003-2009
- Co-Director – 2009 to present: Boston University Terrestrial Biogeosciences Program.
- Chair, Department of Earth Sciences, Boston University, 2010-present
- Board of Directors, Bahaa Hariri Institute for Computational Science and Engineering at Boston University, 2010-present
- Chair, Organizing Committee, Boston University Earth Systems Forum, 2010-2011.
- Member, Boston University Research Computing Governance Committee; 2011-present
- Member, Search Committee for Director of the Pardee Center for Longer Range Future (2011/2012)
- Chair, Member, Ecological Modeling and Remote Sensing search committees, Department of Geography and Environment, 2011/2012.
- Associate Chair, Department of Earth and Environment, 2013-2015

SPONSORED RESEARCH

Current

1. *Development and Validation of a Global Land Surface Phenology Product from NPP VIIRS for EOS-MODIS Continuity,* Xiaoyang Zhang, Principal Investigator, Mark **Friedl** and Geoffrey Henebry, Co-Investigators, Boston University budget $243,077, for period 11/14/14-11/13/17, National Aeronautics and Space Administration.

2. *Incorporating a New Urban Dataset from SeaWinds into a Multi-Sensor Analysis of Global Daytime and Nighttime Urban Heat Islands*, Steve Frolking, Principal Investigator, Mark **Friedl**, Annemarie Schneider and Jingfeng Xiao, Co-Investigators, Boston University budget $86,759 for period 8/1/14-7/31/17, National Aeronautics and Space Administration.

3. *Final Maintenance and Refinement of the MODIS Land Cover Product,* Mark **Friedl**, Principal Investigator**,** Damien Sulla-Menashe and Joshua Gray, Co-Investigators, $230,306 for period 7/1/14/-6/30/16, National Aeronautics and Space Administration
4. *Quantifying Carbon Signatures Across Urban-to-Rural Gradients: Advancing the Capacity for Monitoring, Reporting, and Verification Through Observations, Models, and Remote Sensing,* Lucy Hutyra, Principal Investigator; Mark **Friedl**, Thomas Nehrkorn, Steve Raciti, Pamela Templer, Steven Wofsy, and Curtis Woodcock, Co-Investigators. $795,495 for period 8/1/14-7/31/17. National Oceanic and Atmospheric Administration.
5. *Using Three Decades of Landsat Data to Characterize Changes and Vulnerability of Temperate and Boreal Forest Phenology to Climate Change,* Mark **Friedl**, Principal Investigator, Curtis Woodcock, and Eli Melaas, Co-Investigators, $680,444 for period 1/16/14-1/15/17, National Aeronautics and Space Administration
6. *Better Use of the Landsat Temporal Domain Monitoring Land Cover Type, Condition and Change*, Curtis Woodcock, Principal Investigator, Mark **Friedl** and Pontus Olofsson, Co-investigators, $1,017,798 for period 9/1/12-8/31/17, United States Geological Survey.
7. *4-D Modeling of the Regional Carbon Cycle in and Around Urban Environments: An Interdisciplinary Study to Advance Observational and Modeling Foundations,* Mark **Friedl**, Principal Investigator, Curtis Woodcock, Lucy Hutyra, Kelly Chance and Steve Wofsy, Co-Investigators, $1,282,141 for period 7/1/12-6/30/15, National Aeronautics and Space Administration.
8. *Continental-scale monitoring, modeling and forecasting of phenological responses to climate change;* Mark **Friedl**, BU Principal Investigator; Andrew Richardson Project principal investigator; Steve Folking, Robert Pless, Co-Investigators. Boston University Budget $268,034 for period 5/1/11-4/30/16. National Science Foundation.
9. *Crops, Climate, Canals, and the Cryosphere in Asia – Changing Water Resources Around the Earth's Third Pole,* Mark **Friedl**, BU Principal Investigator; Steve Frolking, Project Principal Investigator; Richard Lammers, Dominik Wisser, Karen Fisher-Vanden, Ian Sue-Wing, Co-Investigators, Boston University budget $224,014 for the period 10/1/10 - 9/30/14. National Science Foundation.

Completed

1. *Using MODIS to Monitor Dynamics in Land Cover and Phenology at Seasonal to Decadal Time Scales*, Mark **Friedl**, Principal Investigator, Curtis Woodcock, Robert Wolfe, and Bin Tan, Co-Investigators, $588,725 for period 1/1/11-6/30/14, National Aeronautics and Space Administration
2. *Towards and Land Cover Climate Data Record from VIIRS*, Mark **Friedl**, Principal Investigator, Curtis Woodcock, Co-Investigator; $628,995 for period 5/1/11-4/30/14, National Aeronautics and Space Administration
3. *Development and Validation Support for the Surface Type EDR from Suomi NPP VIIRS,* Mark **Friedl**, Principal Investigator, $80,694 for period 9/6/13-5/31/14, National Oceanic and Atmospheric Administration.

4. *Science and Management Support for NPP VIIRS Surface Type Environmental Data Record*, Mark **Friedl** Principal Investigator. $130,893 for period 09/01/11/-03/31/13. National Oceanographic and Atmospheric Administration.

5. *Data-model fusion and forecasting 21st-Century environmental change in northeastern North America*, Aaron Ellison, Principal Investigator, Andrew Richardson, Mark **Friedl** and Nsalambi Nkongolo, Co-Investigators, $420,000 for period 12/1/10-11/30/13. National Aeronautics and Space Administration.

6. *Effects of winter climate Change on growing season sap flow and carbon exchange in the northern hardwood forest*; Pamela Templer Principal Investigator; Nathan Phillips and Mark **Friedl**, Co-investigators**;** $131,391 for period 9/1/09-8/31/012, Northeastern States Research Cooperative.

7. *Functional Data Modeling of Climate-Ecosystem Dynamics,* Surajit Ray, Principal Investigator, Mark **Friedl**, Co-Principal Investigator, $350,000 for period 09/01/09-8/31/12. National Science foundation.

8. *Vegetation phenology and enhanced vegetation index products from multiple long term satellite data records,* Kamel Didan, Principal Investigator, Mark **Friedl**, BU-Principal Investigator, Boston University Budget $316,332 for period 08/01/08-07/31/13. National Aeronautics and Space Administration.

9. *Metabolism of Boston: Developing an integrated research strategy for long-term analysis of the Boston Region*. Nathan Phillips and Lucy Hutyra Co-principal Investigators; Mark **Friedl**, Robert Kaufmann and Suchi Gopal, Co-investigators. $300,000 for period 9/1/09/-8/31/12. National Science Foundation.

10. *Future Trend of Irrigation Water Demand Using Integrated Remote Sensing and Physical Models,* Mark **Friedl**, Principal Investigator (NASA ESS Fellowship for Jessica Salmon). $90,000 for period from 9/1/09-8/31/12. National Aeronautics and Space Administration.

11. *Establishing a Satellite Product Validation Framework Based on SPEC;* Crystal Schaaf, Principal Investigator; Mark **Friedl**, Co-investigator. $145,000 for period 05/01/09-6/30/10. National Oceanic and Atmospheric Administration.

12. *The history of agricultural irrigation expansion: Developing useful datasets of geography and water use from remote sensing and hydrologic modeling*, Mark **Friedl**, Principal Investigator, $287,709 for period 10/01/07-02-09/31/10. National Aeronautics and Space Administration.

13. *Remote Sensing Data Sets to Support Pan-Tropical Forest Mapping, Nadine Laporte, Principal Investigator;* Mark **Friedl** BU-Principal Investigator, Boston University Budget $99,881 for period 04/01/09-03/31/11. Google-Moore Foundation.

14. *MODIS Algorithm Refinement and Earth Science Data Record Development for Global Land Cover and Land Cover Dynamics*, Mark **Friedl**, Principal Investigator, Alan Strahler, Bin Tan and Crystal Schaaf, Co-Investigators. $911,716 for period from 12/25/07-12/26/10. National Aeronautics and Space Administration.

15. *Monitoring and validating the distribution and change in land cover across northern Eurasia*, Olga Krankina PI, Mark **Friedl** (and seven others) co-investigator. Boston

University budget $163,542 (Friedl, BU PI) for period from 1/1/06-12/31/08. National Aeronautics and Space Administration.

16. *Real time estimation and assimilation of remotely sensed surface properties for numerical weather prediction models***,** Mark **Friedl**, Principal Investigator, Bruce Anderson, Xiaoyang Zhang and Feng Gao, Co-Investigators. $200,000 for period 8/1/04-7/31/07. National Oceanic and Atmospheric Administration.

17. *Global land cover and land cover dynamics from MODIS: Algorithm refinement in support of global change research*, Mark **Friedl**, Principal Investigator, Alan Strahler and Xiaoyang Zhang Co-Investigators. $672,237 for period from 1/1/04-12/31/07. National Aeronautics and Space Administration.

18. *Using EOS data to characterize impacts of land use/cover change on surface hydrological processes in climate models*, Robert Dickinson Principal Investigator, Mark **Friedl** (and 17 others) co-investigator. Boston University budget $300,000 (approx). National Aeronautics and Space Administration: Interdisciplinary Science Team.

19. *Assessment of aerosol, and albedo and surface type environmental data records (EDRs) from VIIRS,* Crystal Schaaf, Principal Investigator, Mark **Friedl**, Feng Gao, Shunlin Liang and and Alan Strahler Co-Investigators, $470,996 for period from 9/1/03-8/31/06. National Aeronautics and Space Administration

20. *Vegetation Control of Ecohydrological Processes*, Nathan Phillips, Principal Investigator, Mark **Friedl** and Guido Salvucci, Co-investigators*,* $ 338,412 for period 01/01/03-12/31/06. Hydrologic Sciences Program, National Science Foundation.

21. *Developing Next-Generation Tools for Remote Sensing in Support of LANDFIRE,* Mark **Friedl**, Principal Investigator, Curtis Woodcock and Alessandro Baccini, Co-Investigators, $164,693 for period 7/15/02-7/14/05. United States Geological Survey.

22. *Retrieval of time-varying land cover and vegetation properties from MODIS in support of the NCEP-WRF land surface model,* Mark **Friedl**, Principal Investigator, Bruce Anderson, Xiaoyang Zhang and Feng Gao, Co-Investigators. $100,000 for period 8/1/03-7/31/04. National Oceanic and Atmospheric Administration.

23. *Estimation of Land Surface Energy Balance and Surface Properties using Remotely Sensed Observations*, Mark **Friedl** Principal Investigator . $74,000 for period from 9/1/01-*8/31/04;* National Aeronautics and Space Administration; NASA Earth System Science Fellowship Program

24. *The Effects of Agricultural Expansion on regional Hydrology in Southeastern Turkey*, Guido Salvucci, Principal Investigator, Curtis Woodcock, Mark **Friedl**, Bruce Anderson, and Mutlu Ozdogan, Co-Investigators; $541,982 for period 9/1/01-8/31/04 . National Aeronautics and Space Administration: Land Use Land cover Change Program.

25. *Machine Learning and Data Mining for Intelligent Data Understanding of High Dimensional Earth Science Data,* Carla Brodley and Mark **Friedl**, Co-Principal Investigators, $586,177 for period 5/30/01- 7/31/04, National Aeronautics and Space Administration: Intelligent Systems Program.

26. *Improving the Representation of Land in Climate Models by Application of EOS Observations,* R.E. Dickinson, Principal Investigator, G.B. Bonan, R.S DeFries, M.A. **Friedl**, S.N. Goward, M. Jin, Y. Knyazikhin, R.B. Myneni, C.B. Schaaf, K.J. Schaudt, A.H. Strahler, Z-L. Yang, and X. Zeng, Co-Investigators. $1,800,000 (approx) for period 1/1/01/-12/31/04. National Aeronautics and Space Administration: Interdisciplinary Science Team.

27. *Investigation of Aerodynamic and Radiometric land Surface Temperatures:* Mark **Friedl**, Principal Investigator; $65,906, for period 6/1/99-5/31/02. National Aeronautics and Space Administration: Land Surface Hydrology Program (in collaboration with Rich Crago (University of Illinois) and Bill Kustas (USDA)).

28. *Modeling Fluxes of Radiation and Heat Over Heterogeneous Land Surfaces: Parameterization of Spatial Heterogeneity in Vegetation for Studies of Land Surface-Atmosphere Interaction*. Mark **Friedl**, Principal Investigator; $170,000 for period 09/01/98-/08/31/01. NASA- /NSF-/DOE/USDA/NOAA: Joint Program On Terrestrial Ecology and Global Change (TECO*)*.

29. *A Simple Model for Land Surface Parameterization and Modeling*. Mark **Friedl**, Principal Investigator; $80,693 for period 1/6/98-31/5/01. National Science Foundation: Hydrologic Sciences.

30. *Geometric-Optical Modeling of Directional Thermal Radiance for Improvement of Land Surface Temperature Retrievals from MODIS, ASTER and Landsat-7 Instruments*. Xiaowen Li, Principal Investigator, M.A. **Friedl** and A.H. Strahler, Co-Investigators, $300,236 for period 05/01/98-04/30/01. National Aeronautics and Space Administration: Terrestrial Ecology Program.

31. *Machine Learning to Improve Land Cover Classifications from Multisensor and Multitemporal Data*. Mark **Friedl**, Principal Investigator; $84,433 for period 05/01/98-04/30/01. National Aeronautics and Space Administration: Terrestrial Ecology Program (In collaboration with Ruth DeFries (UMD) and Carla Brodley (Purdue)).

32. *Direct Estimation of the Form and Scale-dependence of Soil Moisture Control on Land Surface Water Balance*, Guido Salvucci, Principal Investigator, Mark **Friedl**, Co-Investigator; $50,000, for period 6/1/99-5/31/00. National Aeronautics and Space Administration: Land Surface Hydrology Program.

33. *Algorithm Development for NPOESS*. Crystal Schaaf, Principal Investigator; M. **Friedl**, J. Key, A. Strahler and C. Woodcock Co-Principal Investigators. $606,450 for period 9/22/97- 1/30/00; subcontract from Atmospheric and Environment Research, Inc., Cambridge, MA.

34. *Quantification of Uncertainty in Spatial Data for Ecological Applications*. C. Hunsaker, Principal Investigator; C. Ehlschlaeger, T. Case, M. **Friedl**, M. Goodchild, and P. Stine, Co-Investigators; $127,450 for period 01/06/96-31/05/99; National Science Foundation (through the National Center for Ecological Analysis and Synthesis*)*.

35. *Center for Excellence in Remote Sensing at Boston University*. Curtis Woodcock, Principal Investigator; F. El-Baz, C. Cleveland, M. **Friedl**, S. Gopal, R. Kaufmann, J. Key, D. Dye, R. Myneni, G. Salvucci, and A. Strahler, Co-Investigators. $444,310 for period 01/01/97-12/31/98. National Aeronautics and Space Administration.

36. *Scale Dependence In Area Averaged Fluxes Over the FIFE Site*: F.W. Davis, Principal Investigator; M.A. **Friedl**, J. Michaelsen and D.S. Schimel, Co-Investigators; $170,000 for period 06/92-06/94; National Aeronautics and Space Administration.

PUBLICATIONS

Journal Papers

1. Salmon, J.M. M.A. Friedl, S. Frolking, D. Wisser and E. M. Douglas, 2015. Global rain-fed, irrigated, and paddy croplands: A new high resolution map derived from remote sensing, crop inventories, and climate data. *International Journal of Applied Earth Observation and Geoinformation*, 38, pp. 321-334; doi:10.1016/j.jag.2015.01.014.
2. Michael Toomey, Mark A. Friedl, Steve Frolking, Koen Hufkens, Stephen Klosterman, Oliver Sonnentag, Dennis D. Baldocchi, Carl J. Bernacchi, Gil Bohrer, Edward Brzostek, Sean P. Burns, Carole Coursolle, David Y. Hollinger, Hank A. Margolis, Harry McCaughey, Russell K. Monson, J. William Munger, Stephen Pallardy, Richard P. Phillips, Margaret Torn, Sonia Wharton, Marcelo Zeri, Andrew D. Richardson, 2015. Greenness indices from digital cameras predict the timing and seasonal dynamics of canopy-scale photosynthesis, *Ecological Applications,* 25(1), pp.99-115.
3. Keenan, T.F., B. Darby, E. Felts, O. Sonnentag, M. Friedl, K. Hufkens, J. O'Keefe, S. Klosterman, J.W. Munger, M. Toomey, A.D. Richardson, 2014. Tracking forest phenology and seasonal physiology using digital repeat photography: a critical assessment, *Ecological Applications,* 24, pp.1478–1489, DOI: 10.1890/13-0652.1
4. Gray, J.M, S. Frolking, E.A. Kort, D.K. Ray, C.J. Kucharik, N. Ramankutty, & M.A. Friedl 2014, Direct human influence on atmospheric CO_2 seasonality from increased cropland productivity, *Nature*, 515, pp 398-401, doi:10.1038/nature13957
5. Glanz, H., L. Carvalho, D. Sulla-Menashe and M.A. Friedl, 2014. A parametric model for classifying land cover and evaluating training data based on mulit-temporal remote sensing data, *ISPRS Journal of Photogrammetry and Remote Sensing*, 97, pp. 219-228; doi: 0.1016/j.isprsjprs.2014.09.004
6. Gray, J.M, M.A. Friedl, S. Frolking, N. Ramankutty, A.Nelson and M. Gumma, 2014. Mapping Asian Cropping Intensity with MODIS. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing,* 7(8), pp. 3373-3379. DOI:10.1109/JSTARS.2014.2344630
7. Sulla-Menashe, D., R. Kennedy, Z. Yang, J. Braaten, O.N. Krankina and **M.A. Friedl** 2014, Detecting forest disturbance in the Pacific Northwest from MODIS time series using temporal segmentation, *Remote Sensing of Environment*, 151, pp 114-123, DOI: 10.1016/j.rse.2013.07.042.
8. Martellozzo, F, N. Ramankutty, R.J. Hall, D.T. Price, B. Purdy and M.A. Friedl, 2014. Urbanization and the loss of prime farmland: a case study in the Calgary-Edmonton corridor of Alberta, *Regional Environmental Change*, DOI 10.1007/s10113-014-0658-0
9. Klosterman, S.T., K. Hufkens, J.M. Gray, E. Melaas, O. Sonnetag, I. Lavine, L. Mitchell, R. Norman, M.A. Friedl, and A.D. Richardson, 2014. Evaluating remote sensing of

deciduous forest phenology at multiple spatial scales using PhenoCam imagery, *Biogeosciences*, 11, 4305-4320. Doi: 10.5194/bg-11-4305-2014.

10. Friedl, M.A., J.M. Gray, E.K. Melaas, A.D. Richardson, K. Hufkens, T.F. Keenan, A. Bailey and J. O'Keefe. 2014. A tale of two springs: using recent climate anomalies to characterize the sensitivity of temperate forest phenology to climate change. *Environmental Research. Letters.* **9** 054006 doi:10.1088/1748-9326/9/5/054006

11. Verma,M., M. A. Friedl, A. D. Richardson, G. Kiely, A. Cescatti, B. E. Law, G. Wohlfahrt, B. Gielen, O. Roupsard, E. J. Moors, P. Toscano, F. P. Vaccari, D. Gianelle, G. Bohrer, A. Varlagin, N. Buchmann, E. van Gorsel, L. Montagnani, and P. Propastin, 2014. Remote sensing of annual terrestrial gross primary productivity from MODIS: an assessment using the FLUXNET La Thuile data set, *Biogeosciences*, 11, 2185-2200.

12. Li, L.; Friedl, M.A.; Xin, Q.; Gray, J.; Pan, Y.; Frolking, S, 2014**.** Mapping Crop Cycles in China Using MODIS-EVI Time Series. *Remote Sensing*, *6*, 2473-2493.

13. Huang, X and M.A. Friedl, 2014. Distance metric-based forest cover change detection using MODIS time series, *International Journal of Applied Remote Sensing and Geoinformation*, 29:78-92

14. Keenan, T.F., J. Gray, M.A. Friedl, M. Toomey, G. Bohrer, D. Y. Hollinger, J.W. Munger, J.O'Keefe, H.P. Schmid, I. Sue Wing, B. Yang and A.D. Richardson, 2014. Net carbon uptake has increased through warming-induced changes in temperate forest phenology, *Nature Climate Change*, doi:10.1038/nclimate2253

15. Cai, S. Liu, D. Sulla-Menashe, D and M.A. Friedl 2014. Enhancing MODIS land cover product with a spatial-temporal modeling algorithm. *Remote Sensing of Environment*, 147, pp. 243-255.

16. Justice, C.O., M.O, Roman, I. Csiszar, E.F. Vermote, R.E. Wolfe, S.J. Hook, M. **Friedl**, Z.S. Wang, C.B. Schaaf, T. Miura, M. Tschudi, G. Riggs, D.K. Hall, A. Lyapustin,S. Sadashiva, C. Davidson, E.J. Masuoka, 2013 Land and cryosphere products from Suomi NPP VIIRS: Overview and Status, *Journal of Geophysical Research-Atmospheres*, 118(17), pp. 9753-9765, DOI: 10.1002/jgrd.50771.

17. Frolking, S., T. Milliman, K. Seto and M.A. **Friedl** 2013. A global fingerprint of macro-scale changes in urban structure from 1999-2009, *Environmental Research Letters,* (8) 2013, 10 pp.

18. Bolton, D.K. and M.A. **Friedl** 2013. Forecasting crop yield using remotely sensed vegetation indices and crop phenology metrics, *Agricultural and Forest Meteorology*, 173, 74-84.

19. Melaas, E.K., M.A. **Friedl** and Z. Zhe 2013. Detecting interannual variation in deciduous broadleaf forest phenology using Landsat TM/ETN+ data, *Remote Sensing of Environment*, 132, 176-185.

20. Melaas, E.K., A.D. Richardson, M.A. **Friedl,** D. Dragoni, C.M. Gough, M. Herbst, L. Montagnani, and E. Moors 2013. Using FLUXNET data to improve models of springtime vegetation activity onset in forest ecosystems, *Agricultural and Forest Meteorology*, 171-172, 46-56.

21. Chong, L., S. Ray, G. Hooker and M.A. **Friedl** 2012. Functional factor analysis for periodic remote sensing data, *The Annals of Applied Statistics*, 6(2), pp 610-624, DOI: 10.1214/11-AOAS518.

22. Hufkens, K., M.A. **Friedl**, T.F. Keenan, O. Sonnentag, A. Bailey, J. O'Keefe and A. D. Richardson 2012. Ecological impacts of a widespread frost event following early spring leaf-out, *Global Change Biology*, 18 (7), pp. 2365-2367, DOI: 10.1111/j.1365-2486.2012.02712.x

23. Baccini, A., Goetz, S.J., Walker, W.S. Laporte, N.T., Sun, M., Sulla-Menashe, D., Hackler, J., Beck, P.S.A., Dubayah, R., **Friedl**, M.A., Samanta, S. and R.A. Houghton 2012. Estimated carbon dioxide emissions from tropical deforestation improved by carbon density maps, *Nature Climate Change*, 2, 182-185 doi:10.1038/nclimate1354

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Edited Books

1. Hunsaker, C., Goodchild, M., **Friedl**, M.A. and T. Case (Eds) 2001: *Spatial Uncertainty in Ecology, Implications for Remote Sensing and GIS Applications*, Springer-Verlag, New York. July 1, 2009.

Invited Seminars and Presentations at International Meetings & Workshops

1. **Friedl**, M.A., E. Melaas, D. Sulla-Menashe and J. Gray (2014). Using Time Series of Landsat Data to Improve Understanding of Short- and Long-Term Changes to Vegetation Phenology in Response to Climate Change (invited), *Fall Meeting of the American Geophysical Union*, Dec 5-9, 2014, San Francisco, CA.
2. **Friedl,** MA. Characterizing the Sensitivity of Temperate Forest Growing Season Dynamics to Climate Change*, Earth Observation Data for Climate Science,* NASA Earth

Exchange (NEX) Virtual Workshop and Challenge, *NASA Ames Research Center*, April 21, 2014.

3. **Friedl,** MA. Characterizing the Sensitivity of Temperate Forest Growing Season Dynamics to Climate Change*, Arthur Robinson Lecture,* The Ohio State University, Columbus Ohio, April 4, 2014.
4. **Friedl**, M.A. Using Time Series of Landsat, MODIS, and Ground Measurements to Characterize and Quantify the Sensitivity of Temperate Forest Phenology to Climate Change. Invited oral presentation, *Fall Meeting of the American Geophysical Union*, Dec 13, 2013, San Francisco, CA.
5. **Friedl**, M.A. *Using In-Situ and Satellite Data to Characterize the Sensitivity of New England Forest Phenology to Climate Change*. Invited seminar presentation, Biogeosciences Seminar Series, Boston University, Nov. 13, 2013.
6. **Friedl,** M.A. *Three Decades of Variation in Northeastern Temperate Forest Phenology from In-Situ and Remotely Sensed Observations*. Invited seminar presentation, Earth Systems Research Center, University of New Hampshire, Nov. 8 2013.
7. **Friedl**, M.A. *Characterizing the Sensitivity of Temperate Forest Growing Season Dynamics to Climate Change*. Invited seminar presentation, Global Environmental and Climate Change Center, McGill University, Oct. 15, 2013.
8. **Friedl**, M.A, E. K. Melaas, J. Gray, A. D. Richardson, J. O'Keefe, and A. Bailey 2013. Using Remote Sensing to Characterize and Model Forest Phenology in New England, *24th Annual Harvard Forest Ecology Symposium*, March 20, 2013, Petersham, MA.
9. **Friedl**, M.A., A.D. Richardson, R. Pless, S. Frolking, T.E. Milliman, S. Klosterman, M.P. Toomey, and J.M. Gray. Phenocam: A continental observatory in support of monitoring, modeling, and forecasting Phnological responses to climate change. Invited oral presentation, *Fall Meeting of the American Geophysical Union*, Dec 3-7, 2012, San Francisco, CA.
10. **Friedl**, M.A. 2012. Understanding the Response of Ecosystem Phenology to Climate Change: Recent Anomalous Spring Climate and Phenology in the Northeastern United States, oral presentation, *Phenology 2012*, September 10, 2012, Milwaukee, WI
11. **Friedl**, M.A. 2012. Observing and Modeling Phenology Across Multiple Scales, Invited seminar, *Harvard University Herbarium Seminar Series*, September 5, 2012.
12. **Friedl**, M.A, K. Hufkens, E. K. Melaas, A. D. Richardson, J. O'Keefe, and A. Bailey 2012. Response of Ecosystem Phenology to Anomalous Spring Warmth in the Northeastern United States in 2010. Oral presentation, *American Meteorological Society First Conference on Atmospheric Biogeosciences,* May 30, 2012, Boston, MA.
13. Schneider, A., **Friedl**, M.A. and D. Potere 2009. A new map of global urban extent from MODIS 500m data. *Invited paper, Fall Meeting of the American Geophysical Union*. December 16, 2009. San Francisco, CA.
14. **Friedl**, M.A. 2009. Seasonal Patterns in Phenology, Microclimate, and Remotely Sensed Vegetation Properties in northeastern Forests, Seminar in Terrestrial Biogeosciences, *Boston University*, September 23, 2009.

15. **Friedl**, M.A. Land Surface Phenology from Moderate Resolution Remote Sensing: Biospheric Datasets for Studies of Global Ecology. *Invited seminar, Department of Geography, University of Southamption*, U.K., July 1, 2009.

16. **Friedl**, M.A. Global Land Cover and Land Surface Phenology from Moderate Resolution Remote Sensing. *Invited seminar, International Institute for Geoinformation Science and Earth Observation*, Enschede, Netherlands, July 15, 2009.

17. **Friedl, M.A**. Data Mining and Knowledge Discovery of Land Cover and Terrestrial Ecosystem Processes from Global Remote Sensing Data, *Conference on Intelligent Data Understanding*, NASA Headquarters, Washington, D.C., Sept. 8-9, 2008.

18. **Friedl**, M.A. Global Land Use Mapping from MODIS, Global Land Use Workshop, *Institute of Social Ecology*, Klagenfurt University, Vienna, Austria, May 22-23, 2008.

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20. **Friedl**, M.A., An Overview of the Current Status and Collection 5 MODIS Land Cover and Land Cover Dynamics Products, *Global Observations of Forest Cover and Land Dynamics Implementation Team Meeting*, October 25, 2007. Boston, MA.

21. **Friedl**, M.A., Moderate Resolution Remote Sensing of Phenology, *Coordinating a Northeast Phenology* Network, Durham, NH, Nov., 8-9, 2007.

22. **Friedl**, M.A., Algorithm Refinements in the Collection 5 MODIS Land Cover and Land Cover Dynamics Products, *MODIS Land Products User Workshop*, January 24, 2007.College Park, MD.

23. **Friedl**, M.A. Remote Sensing of Global Land Cover and Phenology: Biospheric Data Sets for Studies of Global Change. *Department of Biology, Boston University, November 11, 2006.*

24. **Friedl**, M.A. Monitoring and Mapping Wetlands from MODIS, Workshop on the Role of Earth Observation for Understanding Ecosystem Function of Northern Hemisphere Wetlands, *Global Environmental and Climate Change Centre, McGill University*, Montreal, Quebec. May 5, 2006.

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1. Milliman, T., Richardson, A., Klosterman, S, Gray, J., Hufkens, K., Aubrecht, D., Chen, M. and M. **Friedl** (2014), Standardizing PhenoCam Image Processing and Data Products, *Fall Meeting of the American Geophysical Union*, Dec 5-9, 2014, San Francisco, CA.
2. Keenan, T. Richardson, A., Gray, J. **Friedl**, M., Toomey, M., Bohrer, G., Hollinger, D., Munger, J., Schmid, H.P., Sue Wing, I. and B. Yang (2014). Net Carbon Uptake Has Increased through Warming-Induced Changes in Temperate Forest Phenology (invited), *Fall Meeting of the American Geophysical Union*, Dec 5-9, 2014, San Francisco, CA.
3. Melaas, K., **Friedl**, M.A. and Richardson, A. (2014). *Tree species composition influences dependence of climate forcing on spring phenology across temperate deciduous broadleaf forests in Eastern United States, Fall Meeting of the American Geophysical Union*, Dec 5-9, 2014, San Francisco, CA.
4. Sulla-Menashe, D., **Friedl**, M and C. Woodcock (2014), On the Use of Landsat Data to Detect Long-Term NDVI Trends in Canadian Boreal Forest, *Fall Meeting of the American Geophysical Union*, Dec 5-9, 2014, San Francisco, CA.

5. Gray, J., Frolking, S., Kort, K., Ray, D., Kucharik, C., Ramankutty, N. and M. **Friedl** (2014). A direct human influence on atmospheric CO2 seasonality from increased cropland productivity, *Fall Meeting of the American Geophysical Union*, Dec 5-9, 2014, San Francisco, CA.

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8. Steve M. Raciti; Lucy Hutyra; Brittain M. Briber; Allison L. Dunn; Mark A. Friedl; Curtis Woodcock; Zhe Zhu; Pontus Olofsson, Quantifying ecosystem carbon losses and gains following development in New England: A combined field, modeling, and remote sensing approach, poster presentation, *Fall Meeting of the American Geophysical Union*, Dec 9-13, 2013, San Francisco, CA.

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12. Xiaoyang Zhang; Mark A. Friedl; Yunyue Yu, Interannual Variations in Global Vegetation Phenology Derived from a Long Term AVHRR and MODIS Data Record, poster poster presentation, *Fall Meeting of the American Geophysical Union*, Dec 9-13, 2013, San Francisco, CA.

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17. Melaas, E.M., Mark Friedl and Zhe Zhe, Detecting Interannual Variation in Deciduous Broadleaf Forests Phenology Using Landsat TM/ETM+ Data, *MultiTemp 2013*, June 25, 2013, Banff, Alberta
18. Melaas, E.K., **Friedl,** M.A. and Z. Zhe. Monitoring interannual variation in deciduous forest phenology using Landsat, poster presentation, *Fall Meeting of the American Geophysical Union*, Dec 3-7, 2012, San Francisco, CA.
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20. Toomey, M.P., **Friedl**, M.A., Hufkens, K., Sonnentag, O., Milliman, T.E., Frolking S., and A.D. Richardson, Monitoring of phenological control on ecosystem fluxes using digital cameras and eddy covariance data, oral presentation, *Fall Meeting of the American Geophysical Union*, Dec 3-7, 2012, San Francisco, CA.
21. Frolking, S., Milliman, T.E., **Friedl**, M.A., Hagen, S.C. and B.H. Braswell. Global analysis of the growth of large cities, 1999-2009, as seen with the Seawinds Scatterometer and DMSP/OLS nighttime lights, poster presentation, *Fall Meeting of the American Geophysical Union*, Dec 3-7, 2012, San Francisco, CA.
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23. Sulla-Menashe, D.S., Oloffson, P., Woodcock, C.E., Holden, Metcalfe, M., Stehman, S.V., Herold, M., C. Giri and M.A. **Friedl**, Development of an independent global land cover dataset, oral presentation, *Fall Meeting of the American Geophysical Union*, Dec 3-7, 2012, San Francisco, CA.
24. Huang, X, **Friedl,** M.A. and D. Sulla-Menashe, Distance metric-based forest cover change detection using MODIS time series, oral presentation, *Fall Meeting of the American Geophysical Union*, Dec 3-7, 2012, San Francisco, CA.
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29. Melaas, E.K.,A. D. Richardson and M. A. **Friedl** 2012. Using FLUXNET Data to Improve Models of Springtime Vegetation Activity Onset in Forest Ecosystems. Oral presentation, *American Meteorological Society First Conference on Atmospheric Biogeosciences,* May 30, 2012, Boston, MA.

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35. **Friedl**, M.A. *Mapping Global Land Cover, Land Cover Dynamics, and Land Use Using Moderate Resolution Remote Sensing Data*, invited seminar, College of Resources, Science and Technology, Beijing Normal University, Beijing, China, January 13, 2011

36. **Friedl**, M.A. *Lessons Learned From Mapping Global Land Cover at Moderate Spatial Resolution From MODIS*, invited presentation, International Workshop on Global Land Cover Mapping, Tsinghua University, Beijing, China, January 11, 2011

37. **Friedl**, M.A. Global land cover, land use, and land cover change from remote sensing: Data sets, limits to knowledge, and current challenges. Global Land Project Open Science Meeting, Oct 17-19, 2010, Phoenix, Az.

38. **Friedl**, M.A., Richardson, A., Hufkens, K., Braswell, B., Migliavacca, M., Milliman, T., and S. Frolking. *Regional-to-Continental Scale Monitoring of Phenology Using Remote Sensing with a Network of Digital Cameras: Progress and Results from PhenoCam.* Invited paper, Annual Meeting of the Ecological Society of America, Aug 3, 2010, Pittsburgh, PA.

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45. L.A. Vierling**,** D.D. Baldocchi**,** N.C. Coops**,** J. Eitel**,** M.A. **Friedl,** J.A. Gamon**,** S.R. Garrity**,** T. Hilker**,** K.F. Huemmrich**,** A.D. Richardson**,** C. Schaaf**,** O. Sonnentag**,** C.E. Tweedie 2011. Beyond Greenness: Towards a Continuous Phenology of Vegetation. *Fall Meeting of the American Geophysical Union*. December 8, 2011. San Francisco, CA.

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47. Sonnentag, O., K. Hufkens**,** T.F. Keenan**,** M.A. **Friedl,** A.D. Richardson, 2011. New insights on the link between phenology and productivity of temperate and boreal broadleaf deciduous forests across the globe 2011. *Fall Meeting of the American Geophysical Union*. December 8, 2011. San Francisco, CA.

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Using Temporal Segmentation 2011. *Fall Meeting of the American Geophysical Union*. December 9, 2011. San Francisco, CA.

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51. Hufkens, K., Richardson, A.D., Migliavacca, M., Frolking, S.E. Braswell, B.H., Millman, T. and M.A. **Friedl**, 2010. Comparing near-earth and satellite remote sensing based phenophase estimates: an analysis using multiple webcams and MODIS (*Invited*), Abstract B52C-03 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.
52. Sulla-Menashe, D.J., Olofsson, P., Stehman, S.V., Woodcock, C.E., Herold, M., Newell, J., Sibley, A.M. and **Friedl**, M.A. 2010, Abstract B41C-0313, presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.
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Massachusetts. *Poster presentation, Fall Meeting of the American Geophysical Union*. December 17, 2009. San Francisco, CA.

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