

CURRICULUM VITAE

MARK A. FRIEDL

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RESEARCH AND TEACHING INTERESTS

- Remote sensing, emphasizing biophysical modeling and classification theory
- 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 EXPERIENCE

- Chair, 2010 to 2012: Department of Earth Sciences, Boston University.
- Co-Director, 2009 to present: Boston University Terrestrial Biogeosciences Program.
- Chair, 2003 to 2009: Department of Geography & Environment, Boston University.
- Professor, 2007 to present: Department of Geography & Environment, Boston University.
- Visiting Scientist, 2005/2006: Complex Systems Research Center, University of New Hampshire.
- 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: Center for Remote Sensing and Environmental Optics, 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

PROFESSIONAL ACTIVITIES

- Advisory committee, *AAAS Scientific Responsibility, Human Rights & Law Program Initiative in Geospatial Technologies and Human Rights*, 2012-2014.
- Co-Chair: *Land Process Validation Working Group Sub-Committee on Land Cover Validation*; *Committee on Earth Observation Satellites*, 2009-2011.
- Associate Editor, *Journal of Geophysical Research, Biogeosciences*, 2008-present.
- Assigning Editor, *Ecological Applications*, 2007- 2009.
- Editorial Board, *Ecological Applications*, 2004 – 2009.
- Chair, *Oak Ridge National Lab Distributed Active Archive Center User Working Group* (2006 - 2009); member, 2004 - 2009.

- NASA Science Teams: *Moderate Resolution Imaging Spectroradiometer Science Team* (2004 - present); *Land Measurement Science Team* (2005 -present); *NPOESS Preparatory Project Science Team* (2007-present).

AWARDS

- *Charles Bullard Fellowship in Forest Research*, 2012/2013, Harvard University
- Natural Sciences and Engineering Research Council of Canada Postgraduate Scholarship
- University of California Regents Fellowship
- 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

GRADUATE STUDENT ADVISEES

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

Adam Sibley (MA 2010), Douglas Bolton (MA, 2011)

CURRENT PROJECTS

1. *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, United States Geological Survey.
2. *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, National Aeronautics and Space Administration.
3. *Science and Management Support for NPP VIIRS Surface Type Environmental Data Record*, Mark **Friedl** Principal Investigator. National Oceanographic and Atmospheric Administration.
4. *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, National Aeronautics and Space Administration
5. *Towards and Land Cover Climate Data Record from VIIRS*, Mark **Friedl**, Principal Investigator, Curtis Woodcock, Co-Investigator; National Aeronautics and Space Administration
6. *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. National Science Foundation.
7. *Crops, Climate, Canals, and the Cryosphere in Asia – Changing Water Resources Around the Earth’s Third Pole*, Mark **Friedl**, BU Principal Investigator; Steve Folking, Project Principal Investigator; Richard Lammers, Dominik Wisser, Karen Fisher-Vanden, Ian Sue-Wing, Co-Investigators, National Science Foundation.
8. *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, National Aeronautics and Space Administration.
9. *Functional Data Modeling of Climate-Ecosystem Dynamics*, Surajit Ray, Principal Investigator, Mark **Friedl**, Co-Principal Investigator, National Science foundation.
10. *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. National Science Foundation.

11. *Vegetation phenology and enhanced vegetation index products from multiple long term satellite data records*, Kamel Didan, Principal Investigator, Mark **Friedl**, BU-Principal Investigator, National Aeronautics and Space Administration.

PUBLICATIONS

Journal Papers

1. 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.
2. 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
3. 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
4. Sonnentag, O., Hufkens, K., Teshera-Sterne, Young, A.M., **Friedl**, M.A., Braswell, B.H., Milliman, T., O'Keefe, J., and A.D. Richardson, 2012, Digital repeat photography for phenological research in forest ecosystems, *Agricultural and Forest Meteorology*, 152, pp. 159-177.
5. Avitabile, V., Baccini, A., **Friedl**, M.A. and C. Schmullius, 2012. Capabilities and limitations of Landsat and land cover data for aboveground biomass estimation in Uganda, *Remote Sensing of Environment*, 117(15), pp. 366-380.
6. Hufkens, K, **Friedl**, M.A. Sonnetag, O., Braswell, B.H., Millman, T. and A.D. Richardson, 2012. Linking near-surface and satellite remote sensing measurements of deciduous broadleaf forest phenology, *Remote Sensing of Environment*, 117(15), pp. 366-380.
7. Olofsson, P., Stehman, S.V., Woodcock, C.E., **Friedl**, M.A. Sulla-Menashe, D., Sibley, A.M., Newell, J.D. and M. Herold 2012. A global land cover validation data set, I: Fundamental Design principles, in press, *International Journal of Remote Sensing*.
8. Stehman, S.V., Olofsson, P., Woodcock, C.E., M. Herold , and M.A. **Friedl**, 2012. A global land cover validation data set, II: Augmenting a stratified sampling design to estimate accuracy by region and land-cover class, in press, *International Journal of Remote Sensing*, 33(22), pp. 6975-6993.
9. Pflugmacher, D., Krankina, O.N., Cohen, W.B., **Friedl**, M.A., Sulla-Menashe, D., Kennedy, R.E, Nelson, P. Loboda, T.V., Kuemmerle, T., Dyukarev, E., Elsakov, V., Kharuk, V.I. 2011. Comparison and Assessment of Coarse Resolution Land Cover Maps for Northern Eurasia. *Remote Sensing of Environment*, 115, pp. 3539-3553.
10. van der Molen, M.K., A.J. Dolman, P. Ciais, T. Eglin, N. Gobron, B.E. Law, P. MMeir, W. Peters, O.L. Phillips, M. Reichstein, T. Chen, S.C. Dekker, M. Doubbková, M.A. **Friedl**, M. Jung, B.J.J.M. van den Hurk, R.A.M. de Jeu, B. Kruijt, T. Ohta, K.T. Rebel, S. Plummer, S.I. Seneviratne, S. Sitch, A.J. Teuling, G.R. van der Werf and G. Wang.

2011. Drought and ecosystem carbon cycling, *Agricultural and Forest Meteorology*, 151(7), pp. 765-773.
11. Sulla-Menashe, D., **Friedl**, M.A., Krnakina, O.N., Baccini, A., Woodcock, C.E., Sibley, A., Sun, G., Kharuk, V., and V. Elsakov 2011. Hierarchical mapping of northern Eurasia land Cover using MODIS Data, *Remote Sensing of Environment*, 115, pp. 392-403.
 12. Richardson, A.D., Black, T.A., Ciais, P., Delbart, N., **Friedl**, M.A., Gobron, N., Hollinger, D.Y., Kutsch, W.L., Longdoz, B., Luyssaert, S., Migliavaca, M., Montagnani, L., Munger, J.W., Moors, E., Piao, S., Rebmann, C., Reichstein, M., Saigusa, N., Tomelleri, E., Vargas, R., and A. Varlagin 2010. Influence of spring and autumn phenological transitions on forest ecosystem productivity. *Philosophical Transactions of the Royal Society B*. 365 (1115), pp. 3227-3246; doi:10.1098/rstb.2010.0102.
 13. Zhang, X, Goldberg, M., Tarpley, D., **Friedl**, M.A., Morisette, J., Kogan, F. and Y. Yu 2010. Drought-induced vegetation stress in southwestern North America, *Environmental Research Letters*, 5, 024008, 11 pp.
 14. Schneider, A., **Friedl**, M.A. and D. Potere 2010. Mapping urban areas using MODIS 500-m data: New methods and data sets based on ‘urban ecoregions.’ *Remote Sensing of Environment*, 114, pp. 1733-1746
 15. Ganguly, S., **Friedl**, M.A., Tan, B., Zhang, X. and M. Verma 2010. Land surface phenology from MODIS: Characterization of the Collection 5 global land cover dynamics product. *Remote Sensing of Environment*, 114, pp. 1805-1816.
 16. **Friedl**, M.A., Sulla-Menashe, D., Tan, B., Schneider, A., Ramankutty, N., Sibley, A. and X. Huang 2010. MODIS collection 5 global land cover: Algorithm Refinements and characterization of datasets. *Remote Sensing of Environment*, 114, pp. 168-182.
 17. Schneider, A, **Friedl**, M.A. and D. Potere 2009. A new map of global urban extent from MODIS satellite data. *Environmental Research Letters*, 4, DOI: 10.1088/1748-9326/4/4/044003.
 18. Zhang, X.Y., **Friedl**, M.A. and C.B. Schaaf 2009. Sensitivity of vegetation phenology detection to the temporal resolution of satellite data, *International Journal of Remote Sensing*, 30(8), pp. 2061-2074.
 19. Krankina, O.N., Pflugmacher D., **Friedl**, M. Cohen, W.B., Nelson, P. and A. Baccinni 2008. Meeting the challenge of mapping peatlands with remotely sensed data. *Biogeosciences*, 5(6), pp. 1809-1820.
 20. Ordoyne, C. and M.A. **Friedl** 2008. Using MODIS data to characterize seasonal inundation patterns in the Florida Everglades, *Remote Sensing of Environment*, 112(11), pp 4107-4119.
 21. Santanello, J.A. **Friedl**, M.A. and M.B. Ek 2007. Convective planetary boundary layer interactions with the land surface at diurnal time scales: Diagnostics and Feedbacks. *Journal of Hydrometeorology*, Vol 8, pp 1082-1097. DOI: 10.1175/JHM614.1
 22. Baccini, A., **Friedl**, M.A., Woodcock, C.E. and Z. Zhu. 2007. Scaling field data to calibrate and validate moderate spatial resolution remote sensing models, *Photogrammetric Engineering and Remote Sensing* 73(8), pp. 945-954.

23. Myneni, R.B., Yang, W., Nemani, R.R., Huete, A.R., Dickinson, R.e., Knyazikhin, Didan, K., Fu, R., Negron Juarez,, R.I., Saatchi, S.S., Hashimoto, H. Ichii, K., Shabanov, N.V., Tan, B., Ratana, P., Privette, J.L., Morisette, J.T., Vermote, E.F., Roy, D.P., Wolfe, R.E., **Friedl**, M.A., Running, S.W., Votava, P., El-Saleous, N., Devadiga, S., Su, Y. and V.V. Salomonson 2007. Large seasonal swings in leaf area of Amazon rainforests, *Proceedings of the National Academy of Sciences*, 104 (12), pp. 4820-4823.
24. Zhang X., **Friedl** M.A., and C.B. Schaaf 2006. Global vegetation phenology from Moderate Resolution Imaging Spectroradiometer (MODIS): Evaluation of global patterns and comparison with in situ measurements, *Journal of Geophysical Research*, Vol. 111, G04017, doi: 10.1029/2006JG00217.
25. Zhang X., **Friedl** M.A., Schaaf C.B., and A.H. Strahler 2005. Monitoring the response of vegetation phenology to precipitation in Africa by coupling MODIS and TRMM instruments, *Journal of Geophysical Research*, Vol. 110 No. D12: Art. No. D12103 JUN 17 2005
26. Lotsch A., **Friedl** M.A., Anderson B.T. and C.J. Tucker 2005. Response of terrestrial ecosystems to recent Northern Hemispheric drought, *Geophysical Research Letters*, 32 (6): Art. No. L06705 MAR 19 2005
27. Santanello, J.A., Jr., M.A. **Friedl** and W. P. Kustas 2005. An empirical investigation of convective planetary layer evolution and its relationship with the land surface, *Journal of Applied Meteorology*, vol. 44, pp. 917-932.
28. Zhang, X., M.A. **Friedl**, C.B. Schaaf, A.H. Strahler and A. Schneider, 2004. The footprint of urban climates on vegetation phenology. *Geophysical Research Letters*, Vol. 31, L12209, doi:10.1029/2004GL020137.
29. Baccini, A, M.A. **Friedl**, C.E. Woodcock and R. Warbington 2004. Forest biomass estimation over regional scales using multisource data, *Geophysical Research Letters*, Vol. 31, L10501, doi:10.1029/2004GL019782.
30. Tian, Y., R. Dickinson, L. Zhou, K.W. Oleson, S. Levis, R. Myneni, M.A. **Friedl**, C. Schaaf, and M. Carrol. 2004. Land boundary conditions from MODIS data and consequences for the albedo of a climate model, *Geophysical Research Letters*, 31 (5): Art. No. L05504.
31. Zhang, X., M.A. **Friedl**, C.B. Schaaf and A.H. Strahler 2004. Climate Controls on vegetation phenological patterns in northern mid- and high latitudes inferred from MODIS data, *Global Change Biology*, Vol 10, pp. 1133-1145.
32. Tian, Y., Dickinson, R., Zhou, L., Zeng, X., Dia, Y., Myneni, R., Knyazikhin, Y., Zhang, X., **Friedl**, M.A., Yu, H., Wanru, W. and M. Shaikh 2004. Comparison of seasonal and spatial variations of LAI/FPAR from MODIS and the common land model, *Journal of Geophysical Research, Atmospheres*, Vol. 109, No. D1, D01103, doi 10.1029/2003JD003777.
33. Lotsch, A, M.A. **Friedl**, and J. Pinzon, 2003. Spatio-Temporal Deconvolution of NDVI Image sequences using independent component analysis, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 41. No. 12, pp. 2938-2942.

34. Schneider, A., **Friedl**, M.A., McIver, D.K. and C.E. Woodcock 2003. Mapping urban areas by fusing multiple sources of coarse resolution remotely sensed data, *Photogrammetric Engineering and Remote Sensing*, Vol 69, no. 12, pp 1377-1386.
35. Lotsch, A., **Friedl**, M.A., Anderson, B.T. and C.J. Tucker 2003. Coupled vegetation-precipitation variability observed from satellite and climate records, *Geophysical Research Letters*, 30(14), 1774, doi: 10.1029/2003GL017506
36. Yang, R. and M.A. **Friedl** 2003. Modeling the effects of 3-D vegetation structure on surface radiation and energy balance in boreal forests, in press, *Journal of Geophysical Research, Atmospheres*, 108 (D16), 8615, doi: 10.1029/2002JD003109.
37. Lotsch, A., Y. Tian, M.A. **Friedl** and R.B. Myneni 2003. Land cover mapping in support of LAI/FPAR retrievals from EOS MODIS and MISR. Classification methods and sensitivities to errors, *International Journal of Remote Sensing*, 24(10):1997-2016.
38. Santanello, J.A. and M.A. **Friedl** 2003. Diurnal covariation in soil heat flux and net radiation, *Journal of Applied Meteorology*, 42: 851-862.
39. Yang, R.Q. and M.A. **Friedl** 2003. Determination of roughness lengths for heat and momentum over Boreal forests, *Boundary Layer Meteorology*, Vol. 107(3), pp. 581-603.
40. Zhang, X. **Friedl**, M.A., Schaaf, C.B., Strahler, A.H., Hodges, J.C.F, and F. Gao 2003: Monitoring vegetation phenology using MODIS, *Remote Sensing of Environment*, Vol. 84, pp. 471-575.
41. **Friedl**, M.A., D. K. McIver, J. C. F. Hodges, X. Y. Zhang, D. Muchoney, A. H. Strahler, C. E. Woodcock, S. Gopal, A. Schneider, A. Cooper, A. Baccini, F. Gao, C. Schaaf 2002: Global land cover mapping from MODIS: algorithms and early results, *Remote Sensing of Environment*, Vol. 83 (1-2), pp. 287-302.
42. Myneni, R.B., S. Hoffman, Y. Knyazikhin, J. L. Privette, J. Glassy, Y. Tian, Y. Wang, X. Song, Y. Zhang, G. R. Smith, A. Lotsch, M. **Friedl**, J. T. Morisette, P. Votava, R. R. Nemani and S. W. Running 2002: Global products of vegetation leaf area and fraction absorbed PAR from year one of MODIS data, *Remote Sensing of Environment*, Vol. 83 (1-2), pp. 214-231.
43. Su, L.H., Li, X.W. **Friedl**, M.A., Strahler, A.H. and X.F. Gu 2002. A kernel driven model of effective directional emissivity for non-isothermal surfaces, *Progress in Natural Science*, Vol 12 (8), pp. 603-607.
44. McIver, D.K. and M.A. **Friedl** 2002. Using prior probabilities in decision-tree classification of remotely sensed data, *Remote Sensing of Environment*, Vol. 81, pp. 253-261.
45. **Friedl**, M.A. 2002: Forward and inverse modeling of surface energy balance using land surface temperature measurements, *Remote Sensing of Environment*, Vol. 79, pp. 344-354.
46. McIver, D.K. and M.A. **Friedl** 2001. Estimating pixel-scale land cover classification confidence using non-parametric machine learning methods, *IEEE Transactions on Geoscience and Remote Sensing*. Vol 39(9), pp. 1959-1968.

47. Yang, R., **Friedl**, M.A., and W. Ni 2001. Parameterization of shortwave radiation fluxes for non-uniform vegetation canopies in land surface models, *Journal of Geophysical Research – Atmospheres*, Vol. 106, No. D13, pp. 14,275-14,286.
48. Yan, G.J., M.A. **Friedl**, X.Li, J. Wang, C. Zhu, and A.H. Strahler 2001: Modeling thermal directional effects for wide-band thermal infrared measurements, *IEEE Transactions on Geoscience and Remote Sensing*. Vol 39(5), pp. 1095-1099.
49. **Friedl**, M.A., D. Muchoney, D.K. McIver, A.H. Strahler, and J.C.F. Hodges 2000: Characterization of North American land cover from AVHRR Data, *Geophysical Research Letters*, vol. 27, no. 7, pp. 977-980.
50. **Friedl**, M.A., C. Woodcock, S. Gopal, D. Muchoney, A.H.Strahler, and C. Barker-Schaaf 2000. A note on procedures used for accuracy assessment in land cover maps derived from AVHRR data, *International Journal of Remote Sensing*, vol. 21, pp.1073-1077.
51. Liu QH, Gu XF, Li XW, Jacob F, Hanocq JF, **Friedl** M, Strahler AH, Yu T, Tian GL 2000. Study on thermal infrared emission directionality over crop canopies with TIR camera imagery. *Science in China Series E-Technological Sciences* 43: 95-103 Suppl. S.
52. Muchoney, D., Borak, J, Chi, H., **Friedl**, M.A., Hodges, J. Morrow, N. and A.H. Strahler 2000: Application of the MODIS global supervised classification model to vegetation and land cover mapping of Central America, *International Journal of Remote Sensing*, Vol 21, no 6 & 7, pp. 1115-1138.
53. Li, X., Strahler, A.H. and M.A. **Friedl** 1999: A conceptual model for effective directional emissivity from nonisothermal surfaces, *IEEE Transactions on Geoscience and Remote Sensing*, vol. 37(5), pp. 2508-2517.
54. Brodley, C.E. and M.A. **Friedl** 1999: Identifying mislabeled training data, *Journal of Artificial Intelligence Research*, vol. 11, pp. 131-167.
55. **Friedl**, M.A., Brodley, C.E. and A.H. Strahler 1999: Maximizing land cover classification accuracies at continental to global scales, *IEEE Transactions on Geoscience and Remote Sensing*, vol. 37, pp. 969-977.
56. Morrow, N. and M.A. **Friedl** 1998: Modeling biophysical controls on land surface temperature and reflectance in grasslands, *Agricultural and Forest Meteorology*, vol. 92, pp. 147-161.
57. **Friedl**, M.A. and C.E. Brodley 1997: Decision tree classification of land cover from remotely sensed data, *Remote Sensing of Environment*, vol. 61, pp. 399-409.
58. Brodley, C. and M.A. **Friedl** 1996: Identifying and eliminating mislabeled training instances, *Proceedings, Thirteenth National Conference on Artificial Intelligence*, Portland Oregon, August, 1996, AAAI Press, pp. 799-805.
59. **Friedl**, M.A. 1996: Relationships among remotely sensed data, surface energy balance, and area-averaged fluxes over partially vegetated land surfaces, *Journal of Applied Meteorology*, vol. 35, No. 11, pp. 2091-2103.
60. **Friedl**, M.A. 1995: Modeling land surface fluxes using a sparse canopy model and radiometric surface temperature measurements, *Journal of Geophysical Research*, vol. 100, No D12, pp. 25,435-25,446.

61. **Friedl**, M.A., Davis, F.W., Michaelsen, J. and M.A. Moritz 1995: Scaling and uncertainty in the relationship between the NDVI and land surface biophysical variables: An analysis using a scene simulation model and data from FIFE, *Remote Sensing of Environment*, vol. 54, pp. 233-246.
62. Michaelsen, J.C., D.S. Schimel, **Friedl**, M.A., Davis, F.W. and R.C. Dubayah 1994: Regression tree analysis of satellite and terrain data to guide vegetation sampling surveys, *Journal of Vegetation Science*, vol. 5, pp. 673-686.
63. **Friedl**, M.A. and F.W. Davis 1994: Sources of variation in radiometric surface temperature over a tallgrass prairie, *Remote Sensing of Environment*, vol. 48, pp. 1-17.
64. **Friedl**, M.A., Michaelsen, J., Davis, F.W., Walker, H. and D.S. Schimel 1994: Estimating grassland biomass and leaf area index using ground and satellite data, *International Journal Remote Sensing*, vol., 15, no. 7, pp. 1401-1420.
65. McGwire, K., **Friedl**, M. and J.E. Estes 1993: Spatial structure, sampling design, and scale in remotely sensed imagery of a California savanna woodland, *International Journal of Remote Sensing*, vol. 14, no. 11, 2137-2164.
66. Davis, F.W., Schimel, D.S., **Friedl**, M.A., Michaelsen, J.C., Kittel, T.G.F., Dubayah, R. and J. Dozier 1992: Correspondence of biophysical data with digital topographic and landuse maps over the FIFE site, *Journal of Geophysical Research.*, vol. 97, no. D17, pp. 19,009-19,021.
67. **Friedl**, M.A., McGwire, K.C. and J.L. Star 1989: MAPWD: An interactive mapping tool for accessing geo-referenced data sets, *Computers and Geoscience*, vol. 15, no. 8 pp. 1203-1219.
68. **Friedl**, M.A., Estes, J.E. and J.L. Star 1988: Advanced information-extraction tools in remote sensing for Earth science applications: AI and GIS, *AI Applications in Natural Resource Management*, vol. 2, nos. 2 and 3, pp. 17-31.

Refereed Book Chapters

1. **Friedl**, M.A., Zhang, X and A.H. Strahler, 2011. Characterizing global land cover type and seasonal land cover dynamics at moderate spatial resolution with MODIS data, Chapter 32 in *Land Remote Sensing and Global Environmental Change: NASA's Earth Observing System and the Science of ASTER and MODIS*. B. Ramachandran, C.O. Justice and M.J Abrams (Eds), Springer, New York, pp.725-746.
2. **Friedl**, M.A., 1997: Examining the effects of sensor resolution and sub-pixel heterogeneity on spectral vegetation indices: Implications for biophysical modeling, Chapter 6 in, *Scaling in Remote Sensing and GIS*, D.A. Quattrochi and M.F. Goodchild (Eds), Lewis Publishers, New York, pp. 113-139.
3. **Friedl**, M.A., KcGwire, K. and D.K. McIver 2001: An overview of uncertainty in optical remotely sensed data for ecological applications, Chapter 13 in *Spatial Uncertainty in Ecology, Implications for Remote Sensing and GIS Applications*, Hunsaker, C., Goodchild, M., **Friedl**, M.A. and T. Case (Eds), Springer-Verlag, New York, pp. 284-307.

4. Zhang, Xiaoyang, Mark A. **Friedl**, Bin Tan, Mitchell D. Goldberg and Yunyue Yu (2012). Long-Term Detection of Global Vegetation Phenology from Satellite Instruments, Phenology and Climate Change, Dr. Xiaoyang Zhang (Ed.), ISBN: 978-953-51-0336-3, InTech, Available from: <http://www.intechopen.com/books/phenology-and-climate-change/long-term-detection-of-global-vegetation-phenology-from-satellite-instruments>

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. 2012. Understanding the Response of Ecosystem Phenology to Climate Change: Recent Anomalous Spring Climate and Phenology in the Northeastern United States, *Phenology 2012*, September 10, 2012, Milwaukee, WI
2. Melass, E., **Friedl**, M.A. and Z. Zhu 2012. Extracting interannual observations of Temperate Deciduous Broadleaf Forest Phenology Using Landsat, *Phenology 2012*, September 12, 2012, Milwaukee, WI.
3. **Friedl**, M.A. 2012. Observing and Modeling Phenology Across Multiple Scales, Invited seminar, *Harvard University Herbarium Seminar Series*, September 5, 2012.
4. **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. *American Meteorological Society First Conference on Atmospheric Biogeosciences*, May 30, 2012, Boston, MA.
5. Toomey, M., A. D. Richardson, O. Sonnentag, K. Hufkens, M. **Friedl**, S. Frolking, and T. Milliman 2012. Determining phenological controls on ecosystem productivity among multiple biomes using digital cameras and eddy covariance data. *American Meteorological Society First Conference on Atmospheric Biogeosciences*, May 30, 2012, Boston, MA.
6. Klosterman, S., K. Hufkens, M. A. **Friedl**, I. Lavine, T. Milliman, O. Sonnentag, S. Frolking, and A. D. Richardson 2012. Comparison of phenology dates in deciduous forests from near-surface and remote sensing. *American Meteorological Society First Conference on Atmospheric Biogeosciences*, May 30, 2012, Boston, MA.
7. Templer, P. N. G. Phillips, M. **Friedl**, and A. B. Reinmann 2012. Effects of changes in the winter snowpack on water and carbon fluxes in a temperate hardwood forest. *American Meteorological Society First Conference on Atmospheric Biogeosciences*, May 30, 2012, Boston, MA.
8. 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. *American Meteorological Society First Conference on Atmospheric Biogeosciences*, May 30, 2012, Boston, MA.

9. **Friedl**, M.A. 2012. Seeing the Forest for the Trees - Observing and Modeling Phenology Across Multiple Scales, Invited seminar, *Interdisciplinary Climate Change Seminar Series, University of Idaho*, April 23, 2012.
10. **Friedl**, M.A. 2012. Seeing the Forest for the Trees - Observing and Modeling Phenology Across Multiple Scales, Invited seminar, *Harvard Forest Seminar Series*, April 27, 2012.
11. Richardson, A.D., M.A. **Friedl**, S. Frolking, R. Pless 2011. PhenoCam: A continental-scale observatory for monitoring the phenology of terrestrial vegetation (Invited). *Fall Meeting of the American Geophysical Union*. December 5, 2011. San Francisco, CA.
12. Hufkens, K., O. Sonnentag, T.F. Keenan, A.D. Richardson, E.K. Melaas, A. Bailey, J. O'Keefe, M.A. **Friedl**, 2011. Community impacts of mid-May frost event during an anomalously warm spring. Oral paper presentation. *Fall Meeting of the American Geophysical Union*. December 6, 2011. San Francisco, CA.
13. **Friedl**, M.A., K. Hufkens, A.D. Richardson, E.K. Melaas, O. Sonnentag, A. Bailey, J. O'Keefe 2011. Anomalous Spring Warmth in 2010: A Precursor of Future Changes to Ecosystem Phenology and Function in the Northeastern United States. Oral paper presentation. *Fall Meeting of the American Geophysical Union*. December 9, 2011. San Francisco, CA.
14. **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
15. **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
16. **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.
17. **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.
18. **Friedl**, M.A., Hufkens, K. and A.D. Richardson. Multiscale analysis of phenology data sets - implications for remote sensing methods. *Invited paper, Annual Meeting of the International Association of Landscape Ecology*, April 8, 2010, Athens, Georgia.
19. **Friedl**, M.A. 2009. Recent Progress Estimating Phenology From MODIS: Comparison of Collection 5 Results With Ground Data and Other Sensors. *Invited paper, Fall Meeting of the American Geophysical Union*. December 17, 2009. San Francisco, CA.
20. 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.

21. **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.
22. **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 Southampton, U.K.*, July 1, 2009.
23. **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.
24. **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.
25. **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.
26. **Friedl, M.A.** Remote Sensing of Land Surface Phenology from Moderate Resolution Remote Sensing, *Department of Geography, Clark University, Worcester, MA*. Nov. 29, 2007.
27. **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.
28. **Friedl, M.A.**, Moderate Resolution Remote Sensing of Phenology, *Coordinating a Northeast Phenology Network*, Durham, NH, Nov., 8-9, 2007.
29. **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.
30. **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*.
31. **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.
32. **Friedl, M.A.** Remote Sensing of Global Vegetation Phenology: Biospheric Data Sets for Studies of Global Change. *Department of Atmospheric Sciences, Dalhousie University, Halifax, Nova Scotia*. March 17, 2006.
33. **Friedl, M.A.** Global Vegetation Phenology from Remote Sensing: Seasonal Dynamics and Interannual Variability from MODIS. *NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ*, February 16, 2006.
34. **Friedl, M.A.** and X.Y. Zhang 2005, Monitoring Global Vegetation Phenology From MODIS: Spatio-Temporal Correspondence Between Climate and Vegetation Activity at

Regional to Global Scales. *Fall Meeting of the American Geophysical Union*, San Francisco, CA., Dec. 8, 2005

35. **Friedl**, M.A., X. Zhang, J.C.F Hodges and A.H. Strahler. MODIS Global Land Cover and Global Vegetation Phenology. MODIS Vegetation Workshop II. *School of Forestry, University of Montana*, Missoula, MT, August 18, 2004.
36. **Friedl**, M.A. Remote Sensing of Global Land Cover and Vegetation Phenology: Methods and Data Sets in Support of Global change Research. *Department of Geography, University of Waterloo*, March 27, 2004.
37. **Friedl**, M.A. Global Land Cover and Vegetation Phenology From MODIS: Land Surface Data Sets in Support of Global change Research. *Center for Sustainability and the Global Environment, University of Wisconsin*, Madison, WI., March 21, 2004.
38. **Friedl** M.A., Zhang, X. and C. Van Dellen 2004. Using Multitemporal Remote Sensing to Map Global Land Cover and Vegetation Dynamics. Spring Meeting of the American Geophysical Union, Montreal, Quebec. May 18, 2004.
39. Baccini, A., M.A. **Friedl**, C.E. Woodcock and R. Warbington 2003. Estimating Forest Biomass over Large Areas Using Remote Sensing, Topographic, and Climate Data. *Department of Evolutionary and Organismal Biology, Harvard University*, May 14, 2003.
40. **Friedl**, M.A. 2003. Using Supervised and Unsupervised Methods in Remote Sensing, Examples, Perspectives, and Opportunities. *Department of Mathematics and Statistics, Boston University*, March 20, 2003.
41. **Friedl**, M.A., X. Zhang and E. Tsvetsinskaya 2003. Observing and Deriving Land Cover Properties and Dynamics for use in Weather and Climate Models. *Annual Meeting of the American Meteorological Society*, Long Beach California. February 8, 2003.
42. **Friedl**, M.A. McIver, D and C.E. Brodley 2002. Integration of Domain Knowledge in the Form of ancillary Map Data into Supervised Classification of Remotely Sensed data. *International Geoscience and Remote Sensing Symposium (IGARSS)*, Toronto, Ontario, July 21, 2002.
43. **Friedl**, MA. and C.E. Brodley 2002. Supervised Learning From Large, High Dimensional Remote Sensing Data Sets, paper presented at *Interface 2002*, April 18, 2002, Montreal, Quebec.
44. **Friedl**, M.A. Mapping Global Land Cover From MODIS: New Data Sets for Global Land Surface Parameterization. Spring Meeting of the American Geophysical Union, Boston, MA. May 30, 2001.
45. Lotsch, A., **Friedl**, M.A. and B.T. Anderson 2002. Mining global Geophysical Space-Time Data Sets Using Linear and Non-Linear Techniques. *Computing, Information and Communications Technology Branch, NASA Ames Research Center*, Dec. 9, 2002.
46. **Friedl**, M.A. and Brodley, C.E. 1999: Mining Satellite Images for Land Cover Classification. *NASA workshop on Issues in the Application of Data Mining to Scientific Data*, Huntsville AL, October 13, 1999.

47. **Friedl, M.A.** 1999: Modeling Fluxes of Heat and Moisture Between Land Surfaces and the Atmosphere: In-situ Measurements and Remote Sensing Observations, *Department of Geography and Cooperative Institute for Research in the Environmental Sciences*, University of Colorado, Boulder, CO, April 23, 1999.
48. **Friedl, M.A.** 1999: Forward and Inverse Modeling of Land Surface Energy Balance. *Center for Climate and Global Change Research, McGill University*, Montreal, Quebec, April 7, 1999.
49. **Friedl, M.A.** 1999: Remote Sensing-based Modeling of Heat and Moisture Fluxes Between Land Surfaces and the Atmosphere. *Department of Geography, University of Toronto*, January 22, 1999.
50. **Friedl, M.A.** 1998: Land Cover Prototyping Activities for MODIS. *USGS EROS Data Center*, Sioux Falls, South Dakota, July 24, 1998.
51. **Friedl, M.A.** 1998: Remote Sensing, Land Surface Processes, and Earth System Science. *Department of Geography, University of Utah*, January 30, 1998.
52. **Friedl, M.A.** 1997: An Overview of Uncertainty in Remotely Sensed Data. *National Center for Ecological Analysis and Synthesis Workshop on Uncertainty in Ecological Data*, Sept. 29, 1997, Santa Barbara, CA.
53. **Friedl, M.A.** and C.E. Brodley 1996: Using Homogeneous and Heterogeneous Classification Trees to Map Land Cover from Remotely Sensed Data. *Symposium on Artificial Intelligence Research in Environmental Science (AIRIES'96)*, August 28, 1996 Boston, MA.
54. **Friedl, M.A.** 1994: Modeling Surface Energy Balance Using Remotely Sensed Data: Experiences From FIFE. *Department of Civil and Environmental Engineering, Massachusetts Institute of Technology*, Cambridge, MA, Nov. 18, 1994.
55. **Friedl, M.A.** 1994: First Principles Scene Simulation Modeling of Remotely Sensed Imagery. *NASA Kennedy Space Center*, Cape Canaveral, Florida, March 18, 1994.