Optimal Passive Microwave Detection and Estimation of Precipitation over Land Surfaces and Coastlines

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Year Two Progress Report

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Grant W. Petty (PI)

Atmospheric and Oceanic Sciences
1225 W. Dayton St
University of Wisconsin-Madison
Madison, WI 53706

David Santek (Co-I)

Space Science and Engineering Center
1225 W. Dayton St
University of Wisconsin-Madison
Madison, WI 53706

Overview

This progress report outlines progress during the first year of a three-year grant.

The grant covers the following research objectives relevant to the optimal detection and estimation of precipitation over land surfaces by passive microwave radiometers:

1. Characterization of Land Surfaces: We will characterize the statistics of background variability in brightness temperatures (e.g., annual and monthly means and covariances) in a form that can be utilized to (a) validate current and future emissivity models, and (b) directly aid in optimal retrievals of radiometric signatures related to precipitation (see next objective).
2. Precipitation Retrieval Over Land: We will refine and demonstrate a new conceptual basis for optimally detecting and quantifying precipitation-related radiometric sig- natures over almost any surface type, including coastlines, deserts, and frozen ground.

Objective 1: Characterization of Land Surfaces

Global

In the first year, we completed the first phase of a cluster analysis of 6-channel passive microwave emissivities provided by C. Prigent and F. Aires. The technique involves a novel similarity test that takes into account not only the mean emissivity vector at each grid point but also its covariance. The analysis was computationally time-consuming (months of continuous computation) and involved terabytes of intermediate data.

Both the method and the results of our cluster analysis are sufficiently novel that we expect to prepare at least two journal papers on these subjects. In addition, Karen Mohr (NASA-GSFC) is preparing a co-authored paper to provide geophysical interpretations of various classes, particularly in terms of vegetation types.

Tropics and Subtropics

An immediate priority is the refinement and testing of the Goddard Profiling Algorithm (GPROF) on data from the Tropical Rainfall Measuring Mission (TRMM), which has coverage of the tropics and subtropics only. We applied the same clustering algorithm as described above to precipitation-free brightness temperatures from TRMM, leading to a small number of distinct surface classes – one ocean and six land/coast (Fig. 1). These classes are now the basis for the regionally optimized Bayesian retrieval techniques described under Objective 2.

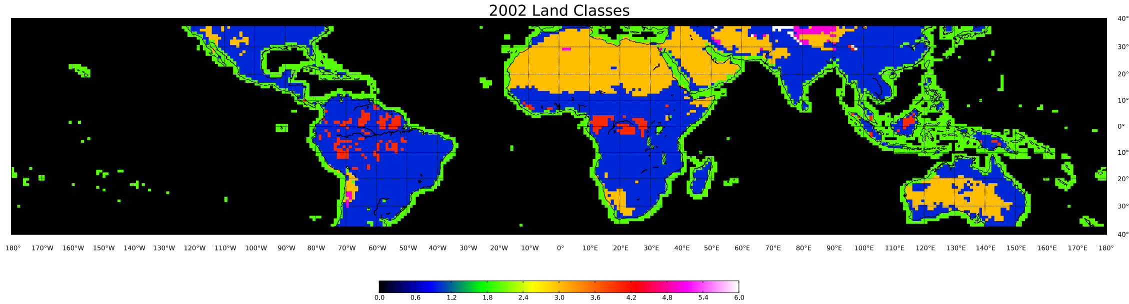

Fig. 1: Land surface class map derived from our analysis of one year's worth of multichannel brightness temperatures from TRMM.

Objective 2: Precipitation Retrieval Over Land

Dimensional reduction in Bayesian retrievals

In our proposal, we had demonstrated the use of a constrained optimal estimation technique to detect precipitation signatures against highly inhomogeneous surface types, including coastlines. We have now refined these ideas to describe an objective basis for reducing the effective dimensionality of the 9-channel observation space for TRMM to a mere three "pseudochannels" constructed from the original 9 channels and with optimal sensitivity to precipitation in the presence of temporal and spatial variability in the background brightness temperatures.

The basis for constructing these empirical pseudochannels was our own matchup of a full year's worth of 1B11 (TRMM Microwave Imager) data with 2A12 (TRMM Precipitation Radar) rain rates. We then developed a compact and efficient Bayesian algorithm scheme that appears to yield improved results over coastal and desert scenes, among others, relative to previous algorithms. Fig. 2 illustrates the results achievable using this method over the less difficult ocean areas. Fig. 3 shows the comparable results for land and coast areas.

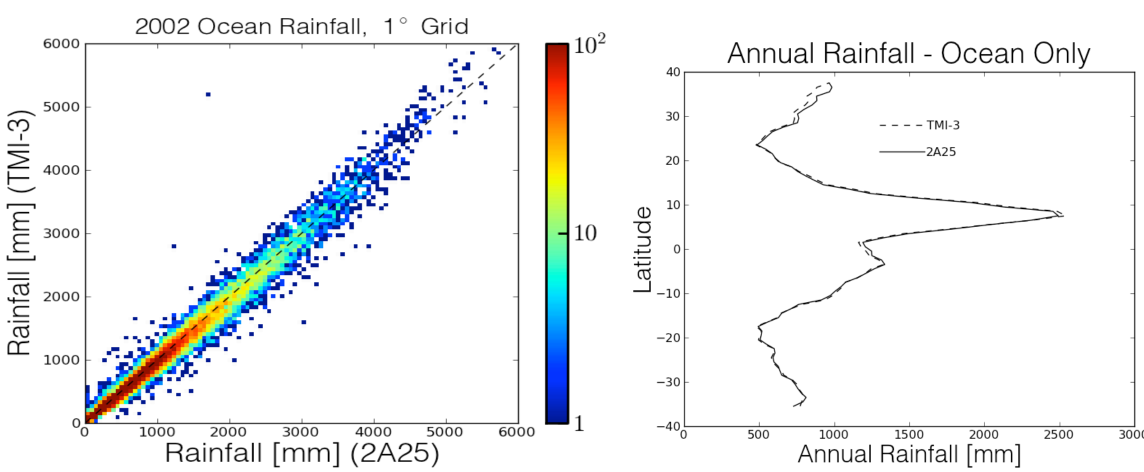

Fig. 2: Comparisons of annual rainfall totals (ocean only) derived from Bayesian TMI-3 algorithm with independent data from the Precipitation Radar (2A25) for the year 2002.

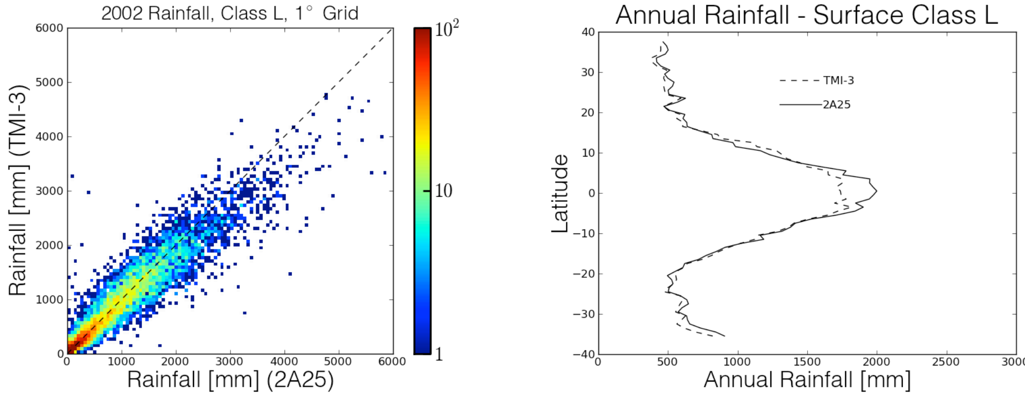

Fig. 3: Comparisons of annual rainfall totals (land and coast only) derived from Bayesian TMI-3 algorithm with independent data from the Precipitation Radar (2A25) for the year 2002.

In addition to the basic research described above, we have been tasked with incorporating our dimensional reduction scheme into the operational precipitation retrieval algorithm GPROF. This work is ongoing.

Precipitation retrieval over surface snow cover

We have hired a talented undergraduate student, Ryan Harp, as an hourly project assistant to examine the statistics of brightness temperature variations in snowpack vs. the signatures of falling precipitation. Our hope is that by using a more sophisticated analysis than has previously been undertaken, we can identify spectral differences that can be exploited to optimally separate the two signatures.

This work has now been enhanced by the availability (as of three weeks ago) of an extensive data set created by Dr. Joe Munchak matching a year's worth of SSM/IS brightness temperatures with surface snow cover analyses and ground-based radar over North America. Work on this new data set is just beginning.

New Publications

Published

Petty, G. and W. Huang, 2011: The modified gamma size distribution applied to inhomogeneous and nonspherical particles: Key relationships and conversions. *J. Atmos. Sci.*, **68**, 1460-1473

In preparation

We have achieved a number of successes in the past year in several different areas, and each one will serve as the basis for a future journal paper. Although most of the raw results are completed, short-term operational priorities (e.g., the GPROF modifications) will probably prevent us from finishing all of the papers listed below in the coming year, but certainly we hope to submit at least three of the following in short order:

Petty, G.W. , 2012: Unsupervised classification of multi-dimensional data based on both means and covariances. (manuscript in preparation, journal TBD)

Petty, G.W. , 2012: Unsupervised classification of land surface types and temporal variability based on multichannel passive microwave emissivities. (manuscript in preparation, journal TBD)

Petty, G.W., 2012: Dimensionality reduction in Bayesian estimation of precipitation from passive microwave observations. 1. Conceptual basis. (manuscript in preparation, journal TBD)

Petty, G.W., and K. Li, 2012: Dimensionality reduction in Bayesian estimation of precipitation from passive microwave observations. 2. Application to ocean precipitation retrievals from TMI. (manuscript in preparation, journal TBD)

Petty, G.W., and K. Li, 2012: Dimensionality reduction in Bayesian estimation of precipitation from passive microwave observations. 3. Application to land and coast precipitation retrievals from TMI. (manuscript in preparation, journal TBD)