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Reducing Global Surface Emissivity Similarity Classification by Ecosystem Matching

Karen I. Mohr[1] and Grant Petty[2]

(1) Code 612, Mesoscale Atmospheric Processes Laboratory, NASA-GSFC, Greenbelt, MD 20771 (karen.mohr-1@nasa.gov) (2) Dept. of Atmospheric and Oceanic Sciences, University of Wisconsin–Madison

1. Introduction

Accurate land surface emissivity (LSE) estimates are critical to the successful inversion of passive microwave radiometric signatures into instantaneous rainfall rates. Improving the dynamic estimation of LSE for physically-based retrievals is a key objective of NASA's Precipitation Measuring Mission whose core satellite launch is in 2013. Because land surface emissivity is a function of land surface state variables such as surface roughness and wetness, the dynamic estimation of LSE using land surface models (LSM) is linked to the specification of both fixed and dynamic parameters describing land surface characteristics.

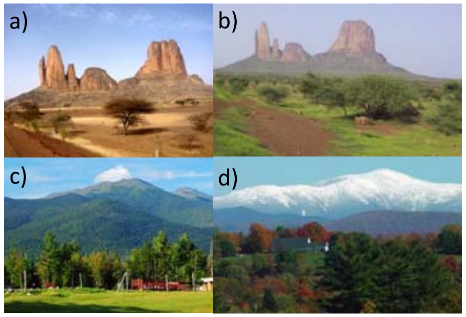


Figure 1: Seasonal changes in a) dry season and b) wet season in northern Mali and c) spring and d) fall by Mt Washington, NH. Note the surface roughness changes due to seasonal aridity in Mali and, in c vs. d, due to deciduous trees and snow in NH.

The long history of SSM/I observations has enabled Prigent, Aires, and colleagues to estimate surface emissivities from all available SSMI observations from 1993 to 2008, under clear sky conditions. Their emissivity database was subjected to a global cluster analysis of 6-channel monthly mean emissivities with covariances. The analysis resulted in 300 distinct surface classes over land and over high latitude, coastal, and continental shelf ocean regions in which seasonal variability is prominent.

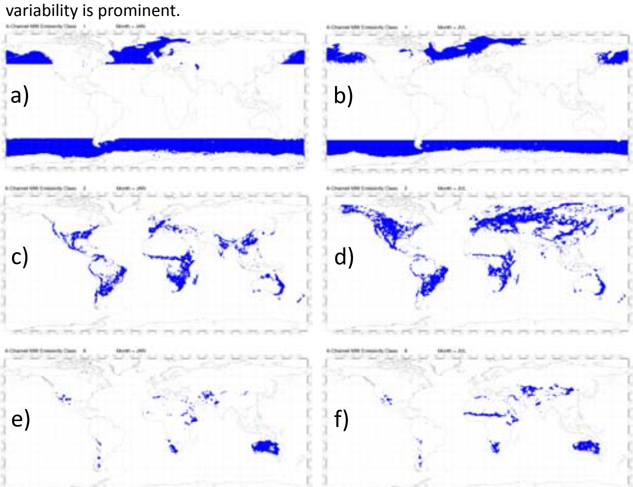


Figure 2: Cluster analysis results: class 1 a) Jan and b) Jul; class 2 c) Jan and d) Jul; and class 8 e) Jan and f) Jul. Class 1 pertains only to high latitude oceans with artificial boundaries at the 45° parallels. Although pelagic tropical/sub-tropical oceans observed by TRMM are excluded from the analysis, coastal and continental shelf regions of the oceans at all latitudes are analyzed.

2. Approach

Each class map (12 maps/year) was converted into an Arc/Info format grid at 0.188° resolution from 80°N to 80°S and then all surface emissivity cluster classes for each month were combined into one grid. Some cells were not classifiable (< 5%). These cells and the tropical/subtropical oceans between 45°N–45°S were assigned "undefined" codes. In Figure 3 are the maps for January and July.

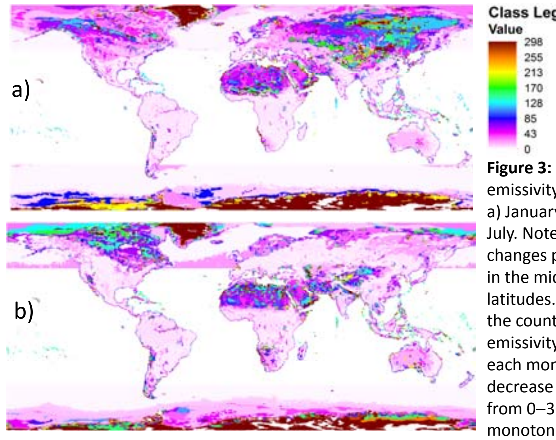
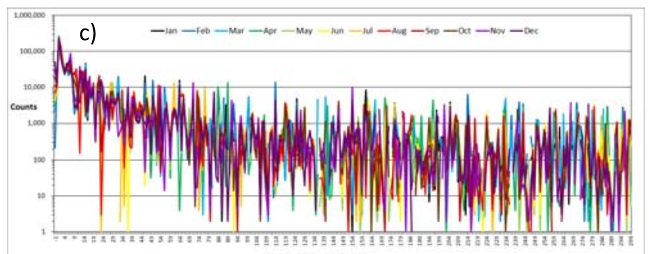


Figure 3: Surface emissivity classes for a) January and b) July. Note seasonal changes particularly in the middle to high latitudes. In c) are the counts in each emissivity class for each month. The decrease in count from 0–300 is not monotonic.



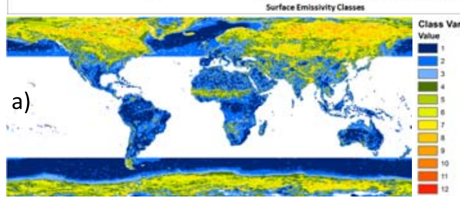
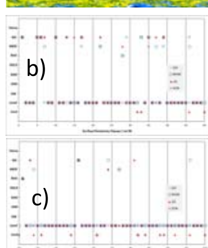


Figure 4: In a) are the number of times each gridcells is assigned a emissivity class. A grid cell of 7 (yellow) is assigned 7 different classes Jan to Dec.



In b) are emissivity classes 1–50 and c) classes 50–100, representing 80% and 10%, respectively, of the total number of gridcells analyzed. Key to b): DO deep ocean, MCO mid-continental ocean, ShO shallow (coastal) ocean, and DIW, SIW, EW = deep, shallow, ephemeral inland water. In a) note the variability in the middle to high northern latitudes, Antarctica, and the semi-arid regions of the tropics and sub-tropics. Class changes mainly take place interseasonally, but intraseasonal changes are common in regions with highly variable snow cover and sea ice [orange and red areas in a)].

3. Preliminary Results

In the GPROF ATBD Ver 1.0 (12/2010), it is proposed to reproduce a global self-similarity classification for each location/month with a goal of 15–25 classes. In this analysis, we looked to see if standard climate classifications had any value in grouping emissivity classes. Two standard classifications were tested vs. the monthly emissivity maps. These were Koeppen-Geiger (Rubel and Kottek 2010) and Bailey's Ecoregions (Bailey 1995, 1998) , tested for spatial overlap and month-to-month stability. The overlap was determined using the Arc/Info COMBINE function. This utility assesses how much a series (2–50) of grids overlaps spatially by finding the common sets of gridcell values. It is essentially a *spatially-distributed form of clustering* based on shared values.

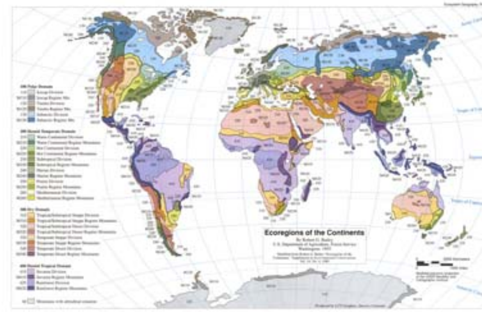


Figure 5: Bailey's Ecoregions of the Continents. Unlike Koeppen-Geiger's climate regimes, this classification includes, is based on vegetation cover in addition to climate drivers affecting seasonal temperature and humidity changes.

Bailey's Ecoregions of the First 10 Emissivity Classes

	1	2	3	4	5	6	7	8	9	10
Dec	Ocean	Savanna Div	Rainforest Div	T/St Steppe Div	Ocean	Ocean	Ocean	T/St Desert Div	Subtropical Reg Mts	Ocean
Jan	Ocean	Savanna Div	Rainforest Div	T/St Steppe Div	Ocean	Ocean	Ocean	T/St Desert Div	Subtropical Reg Mts	Ocean
Feb	Ocean	Savanna Div	Rainforest Div	T/St Steppe Div	Ocean	Ocean	Ocean	T/St Desert Div	Subtropical Reg Mts	Ocean
Mar	Ocean	Savanna Div	Rainforest Div	Savanna Div	Ocean	Ocean	Ocean	T/St Desert Div	Subtropical Reg Mts	Ocean
Apr	Ocean	Savanna Div	Rainforest Div	Savanna Div	Ocean	Ocean	Ocean	T/St Desert Div	Subarctic Div	Ocean
May	Ocean	Savanna Div	Rainforest Div	Savanna Div	Ocean	Ocean	Ocean	T/St Desert Div	Subarctic Div	Ocean
Jun	Ocean	Savanna Div	Rainforest Div	Savanna Div	Ocean	Ocean	Ocean	T/St Desert Div	Subarctic Div	Ocean
Jul	Ocean	Savanna Div	Rainforest Div	Savanna Div	Ocean	Ocean	Ocean	T/St Desert Div	Subarctic Reg Mts	Ocean
Aug	Ocean	Savanna Div	Rainforest Div	Savanna Div	Ocean	Ocean	Ocean	T/St Desert Div	Subarctic Reg Mts	Ocean
Sep	Ocean	Savanna Div	Rainforest Div	Savanna Div	Ocean	Ocean	Ocean	T/St Desert Div	Subarctic Div	Ocean
Oct	Ocean	Savanna Div	Rainforest Div	Savanna Div	Ocean	Ocean	Ocean	T/St Desert Div	Subarctic Div	Ocean
Nov	Ocean	Savanna Div	Rainforest Div	Savanna Div	Ocean	Ocean	Ocean	T/St Desert Div	Subtropical Reg Mts	Ocean

All 300	% of classes with more than 1 BER Div.	Top 20	% of classes with more than 1 BER Div.
Dec	29%	Dec	5%
Jan	31%	Jan	4%
Feb	31%	Feb	4%
Mar	28%	Mar	5%
Apr	25%	Apr	5%
May	27%	May	5%
Jun	24%	Jun	4%
Jul	23%	Jul	4%
Aug	25%	Aug	4%
Sep	27%	Sep	4%
Oct	28%	Oct	4%
Nov	32%	Nov	4%

Tables (top, middle, bottom): These tables illustrate how closely the emissivity classes, particularly the large classes (< 20) correspond to the Bailey's Ecoregions.

The TOP table shows the principal classification for the first 10 classes. Over 80% of the cells in these classes fell into the regime listed for that class each month. Note seasonal changes.

Bailey vs. SE Map	Percent of Spatial Overlap Globally
Dec	79%
Jan	77%
Feb	77%
Mar	78%
Apr	80%
May	81%
Jun	81%
Jul	80%
Aug	82%
Sep	80%
Oct	80%
Nov	79%

The middle table shows that fewer than 4-5% of the top 20 classes had more than one regime listed for the class. There is more variability for the smaller, higher numbered classes, but less than one-third fell into multiple regimes.

The bottom table shows the overlap between the Bailey's map and the monthly emissivity maps. Cell-to-cell, the SE classes tend to fall into specific Bailey's Ecoregions.

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