P1.32

Multi-spectral precipitation estimation using Artificial Neural Networks

Ali Behrangi[1], Kuo-lin Hsu[1], Soroosh Sorooshian[1] and Robert J. Kuligowski[2]

[1] Center For Hydrometeorology and Remote Sensing (CHRS), Department of Civil and Environmental Engineering, University of California, Irvine

[2] NOAA/NESDIS Center for Satellite Applications and Research (STAR), Camp Springs, MD

Introduction

Geostationary satellite sensors have been widely applied to precipitation estimation due to their capability of providing good temporal and spatial image resolution. Although most of the current geostationary-based precipitation retrieval algorithms are using single or bi-spectral channels, experiments have shown that multi-spectral imagery can benefit precipitation estimation. With the advent of the next generation of geostationary satellites (e.g., GOES-R) more spectral channels with higher temporal and spatial resolution will be provided. Meanwhile, with the increased amount of information and different embedded properties, the retrieval algorithms are required to have the capability of processing multiple channels in a computationally efficient and effective manner. In the present work, A multi-spectral precipitation retrieval algorithm using an Artificial Neural Network (ANN) model has been developed that integrates information from multi-spectral channels to estimate precipitation rate.

Methodology

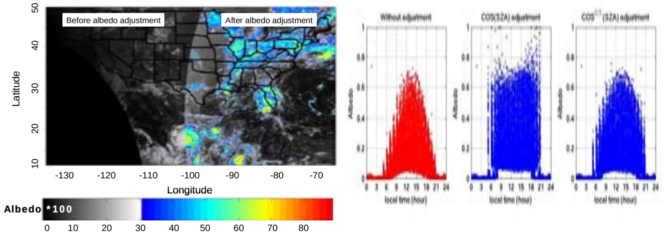
The algorithm consists of four separate stages: (1) extraction of input features from multi-spectral data (2) unsupervised classification of the input features to a number of predetermined clusters (3) supervised computation of mean precipitation rate (MPR) for each classified cluster (4) ranking and sorting the clusters based on their MPR, and (5) redistribution of observed precipitation rates to the clusters based on clusters' MPR and computing new MPR for clusters.

Attempts to use multi-spectral bands and their associated textural features for precipitation estimation highly increases the input space dimension. Principal component analysis (PCA) is applied to eliminate highly correlated input features.

The classification stage relies on the unsupervised self organizing feature map (SOFM) classifier based on Artificial Neural Networks (ANN). SOFM classifies image pixels, with their associated multidimensional input features, into a number of predetermined clusters. These clusters are organized into a two dimensional discrete map which preserves the topological order.

Albedo Adjustment

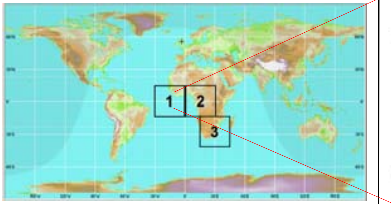
Albedo from the VIS imagery is adjusted for sun angle by dividing each value by cosine of the Solar Zenith Angle (SZA). The cosine of SZA greater than 0.5 was used in this study due to some shortcomings in the normalization during early morning and late afternoon.



Case Study

Twenty days of data (5 days for each season) from the 12-channel spinning imager (SEVIRI) onboard EUMETDSAT's MSG satellite were used in this study.

The spectral bands used are: 0.6, 0.8, 1.6, 6.2, 7.3, 8.7, 9.7, 10.8, 12.0, and 13.4 micron. In addition, half hourly precipitation rate data obtained from combined microwave data* were used for model training and testing. The results reported here are based on the training and testing over the three boxes shown here.

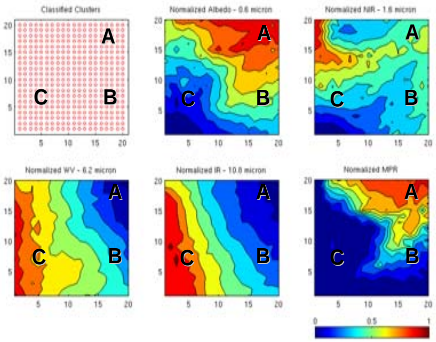


* Joyce, R. J., J. E. Janowiak, P. A. Arkin, and P. Xie, 2004: CMORPH: A Method that Produces Global Precipitation Estimates from Passive Microwave and Infrared Data at High Spatial and Temporal Resolution. Journal of Hydrometeorology, 5, 487-503

Results: Exploratory Analysis

A scenario using four spectral bands(0.6, 1.6, 6.2, and 10.8 micron) is presented to illustrate how the SOFM portion of the model detects and classifies patterns in high-dimensional input features into a number of clusters arranged in a two-dimensional space. The mean precipitation rate (MPR) for each SOFM cluster is calculated from the training dataset.

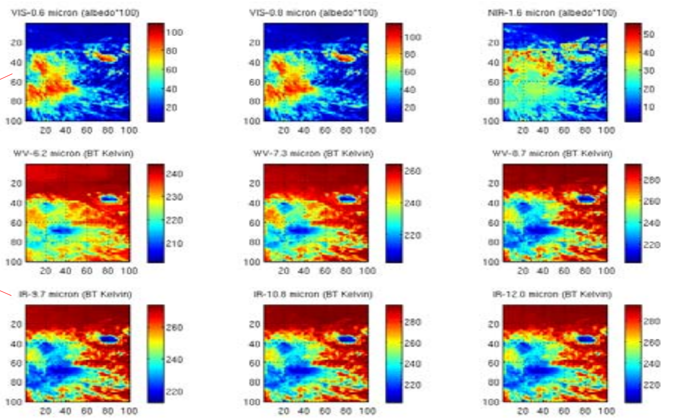
As shown, high MPR is mostly associated with low brightness-temperature (BT) and high albedo, which are signs for cold and thick clouds (see zone A of the figures). Cold-thin cirrus clouds are with BT and low albedo, which is related to lower MPR (see zone B). Also, Clear sky is associated with high BT, zero MPR, and low albedo (see zone C).



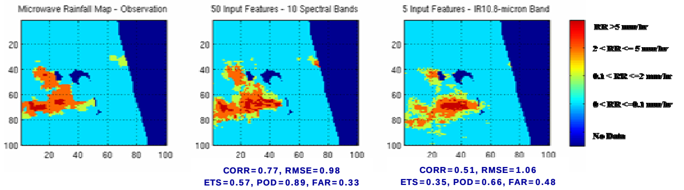
Input features

Additional information on precipitation intensities obtained from the textural information extracted within rectangle windows (3x3 and 5x5) around each pixel of each channel. The local-texture features computed in the present work are standard deviation and mean pixel value over each pixel. A combination of pixel data and textural statistics gives rise to 5 features for each channel and in the case of using all 10 channels results in 50 features that dramatically increases the computational cost. Principal Component Analysis (PCA) was used to eliminate highly correlated features and reduce the input feature dimensions.

An event on January 4, 2005 at 16:42 UTC over the Box1 was used to demonstrate the potential of the multi-spectral data and PCA technique to improve precipitation rate estimation. Results for two scenarios are reported here. In the first scenario multi-spectral data from 10 bands were used. Through using PCA technique, the 50 dimensional input features were compacted to only 8 dimensions by preserving 99% of the information. In the second scenario the common thermal channel(IR10.8) and its textural features (5 dimensions) were used as a reference for comparison.



Rain Rate (RR) Map



Overall statistics for 20 days of study

	BOX 1		BOX 2		BOX 3	
	10 Spectral Bands (50 Input features)	Single IR 10.8 (5 Input features)	10 Spectral Bands (50 Input features)	Single IR 10.8 (5 Input features)	10 Spectral Bands (50 Input features)	Single IR 10.8 (5 Input features)
CORR	0.69	0.62	0.67	0.55	0.55	0.51
RMSE	0.79	0.86	1.09	1.13	0.89	0.85
ETS	0.45	0.34	0.41	0.34	0.35	0.24
POD	0.61	0.50	0.59	0.52	0.48	0.38
FAR	0.36	0.49	0.31	0.40	0.29	0.52
BIAS	0.93	0.95	0.85	0.83	0.78	0.79

Conclusion and Future Work

An algorithm was developed to integrate multi-spectral data and their correspondent textural features for precipitation rate retrieval. The overall statistics show that incorporating the multi-spectral data is promising towards improving the performance of the model for extracting the rate and areal extent of precipitation. While infrared channels provide information about cloud top temperature, visible channels can provide added information relevant to the thickness of cloud. The present work shows ANN is a useful tool for processing the multi-dimensional input data and once trained, it can be used quickly.

Acknowledgment

Partial financial support is made available from **NASA-PMM** (grant NNG04GC74G), **NOAA/NESDIS** GOES-R Program Office (GPO) via the COES-R Algorithm Working Group (AWG), **NSF STC** for Sustainability of Semi-Arid Hydrology and Riparian Areas (**SAHRA**) (grant EAR-9876800), and **NASA NEWS** (grant NNX06AF934) programs.

UCIrvine
University of California, Irvine