

Summer Institute in Earth Sciences 2010

**Satellite Based Method for Estimating Impervious Land Cover in the
Chesapeake Bay Watershed**

Gilman R. Ouellette

The Pennsylvania State University, University Park, Pennsylvania

Department of Geography

In conjunction with:

Sarah Smith

Eastern Michigan University, Ypsilanti, Michigan

Department of Geography and Geology

Mentor: Dr. Eric Brown de Colstoun

Goddard Earth Sciences and Technology Center

University of Maryland Baltimore County

Abstract

Understanding the geospatial characteristics of our urbanizing world is becoming increasingly important. The urbanizing of any given place usually leads to an increase of impervious land cover, which can have a number of adverse effects on hydrologic, ecologic and environmental systems. Monitoring and understanding impervious cover is increasingly important in areas of high environmental value. Such an area exists within the Chesapeake Bay watershed. In order to facilitate further research and understanding of urban impervious land cover in the Chesapeake Bay watershed, we created a spatially explicit method of estimating impervious land cover in the Chesapeake Bay watershed using multiple satellite based remote sensing platforms. The resulting data product is an impervious/ non-impervious land cover classification, which denotes percent impervious cover per pixel. This method was designed to be simple to employ and inexpensive, it allows spatially broad and temporally fine monitoring of impervious cover in the Chesapeake Bay watershed.

Introduction

The spatial properties of urban development play an important role in the natural environment. In a world that is becoming increasingly developed, we must likewise increase our understanding human-environment interactions. One such interaction is the increase in impermeable surfaces in the landscape, resulting from urban development.

Impermeable surfaces are characterized by their highly reduced and often complete prevention of the infiltration of water into subsurface media. Increases in impervious land cover are contributing to adverse hydrologic and environmental conditions, and can put ecosystems and the people who rely on them in jeopardy. Due to the anthropogenic nature of urban impervious cover, the effects of increases in such land cover are directly attributable to human activities. Extensive study has already linked impervious cover with adverse environmental effects. These effects include impacting the urban climate by altering sensible and latent heat fluctuation, as well as affecting surface runoff and the quality of water resources (Yang 2003).

Objectives

With the impacts of impervious cover becoming more and more evident, we sought to develop a method of quantifying the impervious cover in the Chesapeake Bay watershed, in a manner that is relatively inexpensive, easy to replicate and is able to be produced on an annual or semi-annual basis. In order to accomplish this, we relied on multi-scale satellite based data, spatial and statistical analysis software and field validation to produce impervious land cover estimations which could be applied to the entire watershed.

The data product that results from our method is a 30x30m resolution classification. Unlike most common classification methods, our final product denotes the area of impervious cover as well as what percentage of each 30mx30m is actually impervious. Often, classifications will designate a pixel as impervious as long as impervious cover is dominant in that pixel. This type of classification is far more error prone, as a pixel with 51% impervious would be entirely denoted as impervious with no regard to other cover types that could be present. Our method allows for annual creation of

percentage based impervious land cover data, resulting in more accurate quantification of impervious cover at a 30mx30m scale. The resulting percentage data has the added benefit of being more amenable to input into contemporary hydrologic and ecologic models.

Study Area

Our data production method was specifically focused on the Chesapeake Bay watershed. The watershed spans six states (NY, PA, DE, WV, MD, VA), and covers an area of 64,299 square miles. The Bay (fig.1) itself is 200miles long and 4,479 square miles in area.



Data

Multi-sensor remote sensed data were the basis for this estimation method. Landsat 5 TM data is used as the base data. The Landsat scale (30m x 30m pixels) is the target resolution for our final data product. Quickbird data was used to produce per-pixel data for the training data set. Ancillary data

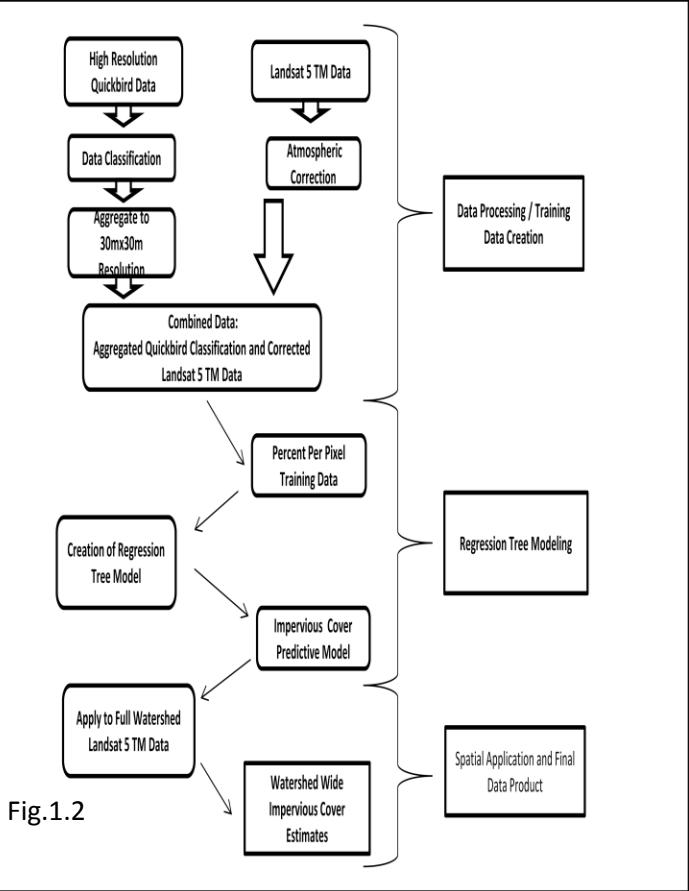
obtained from Google Earth was used during the classification process.

Methods

Overview

To create a percent per pixel impervious cover data product, we first developed a logical model to illustrate the order and flow of our method (fig.1.2). The first step within the method is the procurement and creation of training data. Training data is created from high resolution Quickbird data. A random sample of 2,000 by 2,000 pixel training areas is selected to best represent the spatial and spectral qualities of the Chesapeake Bay Watershed. The training area's are classified via the unsupervised classification (ISODATA) algorithm in ENVI IDL and then manually verified and corrected if need be. The classified training data is then statistically aggregated to a 30mx30m resolution, via the pixel aggregate algorithm.

The next step was to combine the training data with the base Landsat 5 TM data. To accomplish this we created a predictive model using a modified regression tree. The training data were layer stacked with their corresponding subsets of the atmospherically corrected Landsat 5 TM data, and then statistically regressed via a modified regression tree to produce the predictive model. The predictive model can then be applied to the entirety of the atmospherically corrected Landsat 5 TM data, producing a spatially explicit estimation of the percent impervious land cover per Landsat 5 TM pixel in the Chesapeake Bay Watershed.



Data Processing

The Landsat 5 TM data (fig.2.1) was corrected for atmospheric interference using LEDAPS atmospheric correction software. The atmospheric correction algorithm in LEDAPS improves estimation accuracy by adjusting for inconsistencies in atmospheric composition between the sensor and the earth's surface.

The Quickbird data (fig.2.2) had to be rectified to spatially match the Landsat 5 TM data. Both data sets were projected in different coordinate systems, and the resulting discrepancy can cause alignment issues when layer stacking the data. In order to maintain the spatial contiguity of the data sets, we rectified the Quickbird data to the Landsat 5 TM data via an image to image algorithm utilizing pixel control points.

In order to use the Quickbird multispectral data at the highest possible spatial resolution, we applied the Graham-Schmit pan-sharpening algorithm to the Quickbird data, effectively warping the slightly lower resolution multispectral bands to the .62m resolution panchromatic band.

Training Data

To create the training data, high resolution (.62m x .62m pixels) Quickbird imagery of the Bay watershed was classified, aggregated, and then layer stacked with Landsat 5 TM data. 20 subset regions within this area were selected at random. Each subset was 2,000 x 2,000 pixels in area. We then classified the subsets using the unsupervised Iterative Self-Organizing Data Analysis Technique (ISODATA {modified K-means}) classification algorithm in ENVI. We set the algorithm parameters to demarcate 20 classes and iterate 15 times. All other algorithm parameters were left at their default values. We combined the resulting 20 classes into two classes, Impervious {1} and pervious {0}, based on the spectral signature of each class as well as comparison with ancillary data. We then aggregated this classification data to the resolution of our Landsat 5 TM base data using the pixel aggregate algorithm that comes standard in ENVI IDL.

Classification

The classification (fig.2.3) process began using the ISODATA unsupervised classification algorithm in ENVI IDL. The ISODATA algorithm is a modified k-means clustering process. The algorithm parameters were set to produce 20 unique classes and iterate the algorithm 15 times. The results of the unsupervised classification were reviewed and combined into two classes, impervious and non-impervious. The impervious class was then designated as (1) and the non-impervious class was designated as (0), creating a binary classification.

Aggregation

The binary classified Quickbird data needed to be aggregated to be used with Landsat 5 TM data. Rather than simply averaging the classes and applying average values to larger pixels, a pixel aggregate algorithm was applied. The data was converted to a floating point format, and then the pixel aggregate algorithm was applied. The result was a continuous value for each new 30x30 meter aggregated pixel (fig.2.4). The aggregated values indicate the percent of impervious values covered by the new larger pixels, rather than an averaged integer value.

Data Combination

In order to use the percent per pixel data, it had to be combined with the Landsat 5 TM data. In order to maintain spatial contiguity in the data, the aggregated per pixel data was layer stacked in ENVI IDL. The resulting data was a file with six Landsat 5 TM bands (the thermal band was excluded due to its inconsistent spatial resolution) and one band of the percent per pixel aggregated data (fig.2.5).

nonlinear relationship between predictive and target variables (Yang 2003).

The predictive model (Appendix: 1) we produced with Cubist assigns linear equations to instances in the data which correspond to a statistically unique instance within the data (a rule). This model serves to relate the percent per pixel impervious values to the spectral values within the Landsat 5 TM data. This allows the model to be applied to the Chesapeake Bay Watershed.



Fig.2.1



Fig.2.2

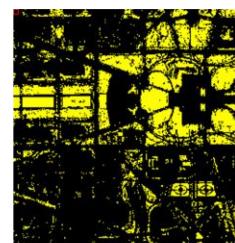


Fig.2.3



Fig.2.4

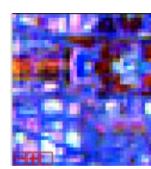


Fig.2.5

Modeling

Modified Regression Tree

In order to estimate the impervious land cover throughout the Chesapeake Bay watershed, the relationship between the percent per pixel aggregated Quickbird data and the reflectance values from the Landsat 5 TM data had to be established. In order to quantify and model the relationships between these values, the training data was input into Cubist software in order to create a modified regression tree model of the relationships between these values. The regression tree algorithm produces rule-based models for prediction of continuous variables and can account for a

Spatial Application

Spatial Application

The final model obtained from the modified regression tree algorithm will then be applied to the entire Chesapeake Bay Watershed. The entire watershed consists of 18 Landsat TM images. The model is incorporated into ENVI IDL and entered as an unsupervised classification and is applied to the Landsat 5 TM data. The final classified Landsat 5 TM data present the spatially explicit estimate of the percentage of impervious cover.

Error and Results

Error

Estimating physical properties based on satellite remote sensed data exhibits several sources of error. A major source of error lies within data rectification. Two images that are not properly rectified are very difficult to use concurrently in any type of analysis. Using spatial data that is in the same projection saves time and effort and potentially reduces error. In cases where necessary data cannot be obtained in the same projection, it must be rectified. Rectification allows for the removal of errors caused by spatially miss-registered data.

Another source of error lies in the pansharpening process. Pansharpening the Quickbird training sites occasionally resulted in artifacts in the data. These artifacts manifest as misinterpretations in the spectral data, producing spectral values that are not present in the initial multispectral data.

Error was also observed in the Landsat 5 TM imagery. This error manifested as noise along the fringe of the images which resulted in misclassifications. This error was mitigated by cropping the data to remove the erroneous data in the fringes of the imagery. The Landsat 5 TM scenes overlap enough that cropping the fringe data is possible without compromising data contiguity.

Imagery analyses are inherently subjective. One analyst may classify features differently than another analyst. This is a potential

Results

The average error ranges experienced by our model ranged from 5% to 12% and the correlation coefficient ranged from .75 to .94, indicating a strong positive correlation between actual and predicted values. Relative error remained below one in all tests run (relative error greater than one would indicate deficiencies in the accuracy of the model).

When the model was applied to a subset of Landsat 5 TM imagery in the Chesapeake Bay Watershed, the results were very promising. The correlation coefficient of the initial run was .97. Cross-validation tests of this iteration of our model showed the correlation coefficient drop to as low as .93. These findings indicate that our model is statistically sound, as the actual values and predicted values agree at least 90% of the time.

While the model appears statistically sound, further testing with further training and test data must be undertaken to fully assess the usefulness of our preliminary model.

CONCLUSIONS

We were able to develop a method of mapping impervious surfaces as continuous variables (percent per pixel), using fine and broad scale data. Our results also indicate that accurately estimating land cover conditions is possible via low cost and rapid methods utilizing remote sensed data. Though our model proved to be relatively useful and accurate, more research and development is still necessary. Extensive field validation is necessary, along with rigorous statistical validation. Further information on the accuracy of this will allow for a more conclusive determination of the usefulness of this method.

If the method and model prove accurate and useful, the final process could provide valuable estimations

for analyzing impervious cover in the Chesapeake Bay Watershed on an annual basis. Some potential applications of the model produced estimations could include comparative studies of impervious cover to: watershed hydrology, elevation, and ecosystem dynamics. This method could also be applied to other land cover types such as vegetation and tree canopy cover, animal migration, and various types of human development at a temporal scale that has yet to be seen for the Chesapeake Bay Watershed.

REFERENCES

- Brown de Colstoun, E. C., M. H. Story, C. Thompson, K. Comisso, T. G. Smith, and J. R. Irons. 2003. National park vegetation mapping using multi-temporal Landsat 7 data and a decision tree classifier. *Remote Sensing of Environment* 85:316–327.
- CBP. 2008. Chesapeake 2008. Available at <http://www.chesapeakebay.net> Accessed July 2010.
- Hall, Forrest “Remote Sensing of the Land Surface Carbon, Water and Energy Cycles: What do we know? What’s missing? Where are we headed?” Goddard Space Flight Center, Exploring Earth Seminar Series. Greenbelt, MD. 26th July, 2010
- Hansen, M., R. Dubayah, and R. DeFries. 1996. Classification trees: an alternative traditional land cover classifiers. *International Journal of Remote Sensing* 17:1075–1081.
- Huang, C et al. (2001) At-Satellite Reflectance: A first order normalization of Landsat 7 ETM+ images. Retrieved from: <http://landcover.usgs.gov/pdf/huang2.pdf>
- Huang, C., and Townshend, J.R.G. 2003. A stepwise regression tree for nonlinear approximation: applications to estimating subpixel land cover. *International Journal of Remote Sensing*, Vol. 24, No. 1, pp. 75–90.
- Jantz, P., S. Goetz, and C. Jantz. 2005. Urbanization and the loss of resource lands in the Chesapeake Bay watershed. *Environmental Management*. 36(6):808-825
- Jensen, John R. (2005) *Introductory Digital Image Processing: A remote sensing perspective*. Upper Saddle River, NJ: Pearson Prentice Hall
- Ji, M.H., and Jensen, J.R. 1999. Effectiveness of subpixel analysis in detecting and quantifying urban imperviousness from Landsat thematic mapper imagery. *Geocarto International*, Vol. 14, No. 4, pp. 31–39.
- Masek, J.G., et al. (2006a), A landsat surface reflectance dataset for North America, 1990–2000, *IEEE Geosci. Rem. Sens. Let.*, 3:68–72.
- Masek, J.G., et al. (2008), North American forest disturbance mapped from a decadal Landsat record, *Remote Sensing of Environment*, 112:2914–2926.
- Yang, L., C. Huang, C.G. Homer, B.K. Wylie, and M.J. Coan. (2003b). An approach for mapping large-area impervious surfaces; synergistic use of Landsat-7 ETM+ and high spatial resolution imagery. *Canadian Journal of Remote Sensing* 29:230-240.

Appendix

- 1) Preliminary percent per pixel predictive model.
 - a. Developed in Cubist
 - b. Based on 6 training sites
 - c. Band 1,2,3,4,5,7 : correspond to those bands in Landsat 5 TM reflectance data
 - d. Agg. Band: Aggregated percent per pixel impervious cover data {predicted value for ppp impervious cover}

```

Cubist [Release 2.07]  Wed Aug  4 11:31:59 2010
Options:
  Cross-validate (10 folds)
  Use 90% of data for training
  Permit extrapolation of <=5%
  Maximum of 200 rules

Read 7612 cases (7 attributes) from
Cubist(6sites).data

[ Fold 1 ]

Model:

  Rule 1: [1800 cases, mean 0.01908, range 0 to
0.4977, est err 0.01915]
    if
      Band1 <= 78
      Band2 > 1
      Band2 <= 61
      Band5 <= 65
    then
      Band Agg = 0.0002

  Rule 2: [1888 cases, mean 0.02990, range 0 to
1, est err 0.02558]
    if
      Band2 > 1
      Band2 <= 61
      Band5 <= 65
    then
      Band Agg = -3.1142 + 0.04 Band1

  Rule 3: [1501 cases, mean 0.09970, range 0 to
0.8826, est err 0.09674]
    if
      Band1 <= 75
      Band2 > 1
      Band2 <= 61
      Band5 > 65
    then
      Band Agg = 0.0218

  Rule 4: [755 cases, mean 0.18337, range 0 to
0.9296, est err 0.12196]
    if
      Band1 > 75
      Band3 <= 43
      Band4 > 56
    then
      Band Agg = -0.0292 - 0.02 Band5 + 0.04
      Band3 + 0.021 Band7 - 0.03 Band2
          + 0.01 Band4

  Rule 5: [1038 cases, mean 0.31936, range 0 to
1, est err 0.18239]
    if
      Band1 > 75
      Band2 > 1
      Band2 <= 61
      Band3 > 43
      Band4 > 56
    then
      Band Agg = -0.505 + 0.02 Band2 - 0.009
      Band5 + 0.01 Band1

      Rule 6: [140 cases, mean 0.44969, range 0 to 1,
est err 0.18698]
        if
          Band2 > 1
          Band2 <= 61
          Band4 <= 56
          Band5 > 65
        then
          Band Agg = -1.1299 + 0.03 Band1 + 0.02
          Band7 - 0.019 Band4 - 0.012 Band5

      Rule 7: [102 cases, mean 4.24510, range 0 to
16, est err 0.43856]
        if
          Band2 <= 1
          Band7 <= 15
        then
          Band Agg = -0 + 0.503 Band5 + 0.075 Band4
          - 0.09 Band2 + 0.045 Band7

      Rule 8: [442 cases, mean 5.76431, range 0 to
124, est err 0.51199]
        if
          Band1 > 38
          Band4 > 24
          Band5 <= 38
          Band7 <= 88
        then
          Band Agg = 2.26067 - 13.16 Band2 + 2.675
          Band5 - 1.064 Band4
              + 0.494 Band7 + 0.27 Band1 -
          0.27 Band3

      Rule 9: [209 cases, mean 11.95694, range 0 to
37, est err 1.43121]
        if
          Band1 <= 38
          Band7 <= 30
        then
          Band Agg = -11.874 + 0.568 Band4 + 0.535
          Band7 + 0.45 Band1

      Rule 10: [112 cases, mean 23.12500, range 10 to
69, est err 3.50987]
        if
          Band2 <= 1
          Band4 <= 24
          Band7 > 15
        then
          Band Agg = -8.508 + 0.84 Band1 + 0.469
          Band5 + 0.427 Band7 - 0.51 Band2
              - 0.055 Band4

      Rule 11: [153 cases, mean 26.20003, range 0 to
76, est err 1.69860]
        if
          Band1 > 22
          Band3 <= 59
          Band4 > 24
          Band5 <= 22

```

```

    then
      Band Agg = 4.59959 - 15.71 Band2 + 2.24
      Band5 + 0.163 Band7 + 0.04 Band4

  Rule 12: [27 cases, mean 42.14815, range 12 to
91, est err 7.86422]

  if
    Band1 <= 10
    Band2 <= 1
    Band4 > 24
    Band7 <= 88
  then
    Band Agg = -18.245 - 2.49 Band1 + 1.413
    Band4 + 0.482 Band7
      + 0.216 Band5

  Rule 13: [53 cases, mean 44.41509, range 19 to
75, est err 5.43609]

  if
    Band1 > 10
    Band1 <= 19
    Band7 > 30
    Band7 <= 88
  then
    Band Agg = -23.256 + 25.46 Band2 + 1.56
    Band1 + 0.461 Band5
      + 0.454 Band7 + 0.195 Band4

  Rule 14: [75 cases, mean 45.45427, range 0.6076
to 117, est err 4.06609]

  if
    Band1 > 0.1183
    Band2 > 61
    Band7 <= 151
  then
    Band Agg = -14.05201 + 0.451 Band7 + 0.75
    Band3 - 0.46 Band1
      - 0.168 Band5

  Rule 15: [42 cases, mean 47.83333, range 33 to
61, est err 1.73483]

  if
    Band1 <= 0.1183
    Band2 > 61
  then
    Band Agg = -12.73144 + 0.461 Band4 +
0.359 Band7 - 0.08 Band1
      + 0.11 Band3 - 0.036 Band5

  Rule 16: [43 cases, mean 56.86047, range 34 to
80, est err 4.96527]

  if
    Band1 > 19
    Band1 <= 38
    Band3 <= 62
    Band7 > 30
    Band7 <= 88
  then
    Band Agg = 13.174 - 3.82 Band2 + 1.272
    Band5 - 0.683 Band4 + 0.58 Band1
      + 0.463 Band7 - 0.22 Band3

  Rule 17: [41 cases, mean 61.95122, range 45 to
118, est err 5.58898]

  if
    Band1 <= 15
    Band2 <= 1
    Band7 > 88
  then
    Band Agg = 38.784 - 0.49 Band1 + 0.219
    Band7 - 0.15 Band2 + 0.022 Band5

  Rule 18: [605 cases, mean 64.21983, range 46 to
85, est err 2.46322]

  if
    Band1 > 15
    Band1 <= 22
    Band5 <= 22
    Band7 > 88
  then
    Band Agg = -12.02 - 10.13 Band2 + 1.449
    Band5 + 0.737 Band4 + 0.7 Band1
      + 0.136 Band7

  Rule 19: [45 cases, mean 67.40000, range 57 to
93, est err 5.78857]

  if
    Band1 > 22
    Band3 > 59
    Band5 <= 22
    Band7 > 88
  then
    Band Agg = 18.43713 - 17.04 Band2 + 1.69
    Band5 + 0.369 Band7
      + 0.32 Band1 - 0.42 Band3 -
0.199 Band4

  Rule 20: [32 cases, mean 71.65625, range 53 to
118, est err 8.06073]

  if
    Band1 <= 20
    Band2 <= 1
    Band5 > 22
    Band7 > 88
  then
    Band Agg = 130.253 + 3.158 Band5 - 2.27
    Band3 - 1.79 Band2 - 0.132 Band4
      + 0.087 Band7

  Rule 21: [84 cases, mean 75.78571, range 44 to
103, est err 6.32600]

  if
    Band1 > 19
    Band1 <= 38
    Band2 <= 0.398
    Band3 > 62
    Band7 > 30
    Band7 <= 88
  then
    Band Agg = 18.395 + 2.023 Band5 - 1.925
    Band4 + 0.51 Band7 + 0.15 Band1
      + 0.14 Band3

  Rule 22: [46 cases, mean 76.91304, range 58 to
137, est err 7.11917]

  if
    Band1 > 30
    Band1 <= 44
    Band5 > 22
    Band7 > 88
  then
    Band Agg = -18.59302 - 54.88 Band2 +
1.403 Band5 + 1.179 Band4
      + 1.02 Band1 + 0.309 Band7 -
0.48 Band3

  Rule 23: [23 cases, mean 77.82609, range 52 to
110, est err 7.18011]

  if
    Band1 > 19
    Band1 <= 38
    Band2 > 0.398
    Band3 > 62
    Band7 <= 88
  then
    Band Agg = -7.30662 + 0.783 Band7 + 0.371
    Band5 + 0.339 Band4
      - 0.32 Band2 + 0.08 Band1

  Rule 24: [59 cases, mean 79.22034, range 60 to
111, est err 6.60137]

  if
    Band1 > 20
    Band1 <= 30
    Band5 > 22
    Band7 > 88
  then
    Band Agg = -15.893 + 3.3 Band5 - 2.014
    Band4 + 1.74 Band1 - 1.95 Band2
      + 0.877 Band7 - 0.95 Band3

  Rule 25: [37 cases, mean 98.10811, range 47 to
143, est err 13.83798]

  if
    Band1 > 38
    Band2 <= 1
    Band5 > 38
    Band7 <= 88
  then
    Band Agg = 31.15476 - 4.508 Band4 + 3.541
    Band5 + 0.584 Band7

```

```

+ 0.47 Band3 - 0.14 Band2 +
0.07 Band1

Rule 26: [25 cases, mean 107.92000, range 65 to
122, est err 3.54627]
if
  Band7 > 151
then
  Band Agg = -32.33949 + 0.508 Band4 + 0.5
Band7 - 0.02 Band1
  - 0.011 Band5 + 0.02 Band3

Rule 27: [22 cases, mean 131.09091, range 93 to
182, est err 10.98064]
if
  Band1 > 44
  Band2 <= 1
  Band5 > 22
  Band7 > 88
then
  Band Agg = 49.31078 - 45.66 Band2 + 1.922
Band5 - 0.635 Band4
  + 0.187 Band7 + 0.17 Band1 -
  0.02 Band3

Evaluation on hold-out data (761 cases):
Mean |error| 1.00380

[ Fold 2 ]

Model:
Rule 1: [3557 cases, mean 0.06456, range 0 to
0.98, est err 0.06457]
if
  Band1 <= 78
  Band2 > 1
  Band2 <= 61
then
  Band Agg = 0.0004

Rule 2: [1475 cases, mean 0.10091, range 0 to
0.8826, est err 0.09803]
if
  Band1 <= 75
  Band2 > 1
  Band2 <= 61
  Band5 > 65
then
  Band Agg = 0.0233

Rule 3: [3388 cases, mean 0.19937, range 0 to
1, est err 0.14094]
if
  Band2 > 1
  Band2 <= 61
  Band5 > 65
then
  Band Agg = -0.811 - 0.015 Band5 + 0.017
Band7 + 0.02 Band1

Rule 4: [93 cases, mean 0.25374, range 0 to 1,
est err 0.16977]
if
  Band1 > 78
  Band2 > 1
  Band5 <= 65
then
  Band Agg = -3.1202 + 0.04 Band1

Rule 5: [103 cases, mean 3.98058, range 0 to
16, est err 0.38921]
if
  Band2 <= 1
  Band7 <= 15
then
  Band Agg = -0 + 0.81 Band4 - 0.458 Band7
- 0.22 Band2 + 0.048 Band5

Rule 6: [436 cases, mean 5.55637, range 0 to
124, est err 0.45580]
if
  Band1 > 38
  Band4 > 24
  Band5 <= 38
  Band7 <= 87
then
  Band Agg = 2.159 - 16.31 Band2 + 2.615
Band5 - 0.782 Band4 + 0.477 Band7
  + 0.24 Band1 - 0.29 Band3

Rule 7: [133 cases, mean 10.40602, range 0 to
29, est err 1.21102]
if
  Band1 <= 11
  Band2 <= 1
  Band4 <= 24
then
  Band Agg = -7.14 + 0.452 Band4 + 0.55
Band1 + 0.293 Band7 - 0.18 Band2
  + 0.041 Band5

Rule 8: [20 cases, mean 12.38165, range 0.5627
to 48, est err 3.92009]
if
  Band2 > 61
  Band7 <= 88
then
  Band Agg = -4.75105 + 0.231 Band7 + 0.225
Band4 - 0.25 Band1
  + 0.25 Band2 - 0.16 Band3 -
  0.022 Band5

Rule 9: [45 cases, mean 22.40000, range 12 to
33, est err 2.13744]
if
  Band2 <= 1
  Band4 > 24
  Band7 <= 32
then
  Band Agg = -15.786 + 0.719 Band7 + 0.45
Band1 + 0.23 Band3

Rule 10: [23 cases, mean 32.17391, range 14 to
62, est err 5.88980]
if
  Band1 > 11
  Band2 <= 1
  Band4 <= 24
  Band5 > 18
then
  Band Agg = 1.986 - 1.7 Band2 + 0.61 Band1
+ 0.384 Band5 + 0.449 Band7
  - 0.188 Band4 - 0.03 Band3

Rule 11: [24 cases, mean 37.37500, range 12 to
88, est err 7.72803]
if
  Band1 <= 10
  Band2 <= 1
  Band4 > 24
  Band7 <= 87
then
  Band Agg = 88.994 + 4.537 Band5 - 2.815
Band4 - 1.68 Band1 - 1.62 Band3
  + 0.578 Band7 - 0.02 Band2

Rule 12: [92 cases, mean 47.84783, range 15 to
117, est err 2.66274]
if
  Band1 <= 0.6364
  Band2 > 61
  Band7 <= 159
then
  Band Agg = -12.32138 + 5.22 Band1 + 0.4
Band4 + 0.36 Band7 + 0.19 Band3
  - 0.049 Band5

Rule 13: [64 cases, mean 50.89063, range 13 to
69, est err 3.24434]
if
  Band1 > 11
  Band5 <= 18
  Band7 > 15
then
  Band Agg = -137.171 + 4.634 Band5 + 0.74
Band1 + 1.01 Band3
  + 0.413 Band7 - 0.24 Band2 -
  0.027 Band4

```

Rule 14: [42 cases, mean 50.92857, range 29 to 69, est err 4.83605]

```
if
  Band1 > 10
  Band1 <= 24
  Band4 > 24
  Band4 <= 28
  Band7 > 32
  Band7 <= 87
then
  Band Agg = 49.2 + 1.29 Band1 - 0.75 Band3
+ 0.316 Band7 + 0.1 Band5
- 0.068 Band4
```

Rule 15: [22 cases, mean 51.68182, range 41 to 117, est err 6.73921]

```
if
  Band2 > 61
  Band5 > 120
  Band7 > 88
then
  Band Agg = 15.49732 + 0.376 Band7 - 0.274
Band5 + 0.5 Band3 - 0.13 Band1
+ 0.055 Band4
```

Rule 16: [47 cases, mean 62.87234, range 45 to 118, est err 6.80624]

```
if
  Band1 <= 15
  Band2 <= 1
  Band7 > 87
then
  Band Agg = 36.547 - 0.57 Band1 + 0.237
Band7 - 0.4 Band2 + 0.07 Band5
```

Rule 17: [646 cases, mean 64.21672, range 46 to 77, est err 2.46866]

```
if
  Band1 > 15
  Band1 <= 23
  Band5 <= 22
  Band7 > 87
then
  Band Agg = -13.597 - 11.12 Band2 + 1.445
Band5 + 0.661 Band4
+ 0.82 Band1 + 0.15 Band7
```

Rule 18: [55 cases, mean 65.96364, range 50 to 89, est err 5.10767]

```
if
  Band1 > 23
  Band1 <= 30
  Band5 <= 22
  Band7 > 87
then
  Band Agg = -37.716 - 13.22 Band2 + 3.758
Band5 + 0.28 Band7
```

Rule 19: [27 cases, mean 66.00000, range 56 to 93, est err 4.97904]

```
if
  Band1 > 30
  Band5 <= 22
  Band7 > 87
then
  Band Agg = -77.74252 + 2.633 Band5 - 1.2
Band2 + 0.75 Band1
+ 0.585 Band7 + 0.012 Band4
```

Rule 20: [20 cases, mean 67.35000, range 47 to 94, est err 2.39616]

```
if
  Band1 > 0.6364
  Band2 > 61
  Band5 <= 120
  Band7 > 88
  Band7 <= 159
then
  Band Agg = -24.63568 + 27.44 Band1 +
0.518 Band7 - 0.291 Band5
+ 0.38 Band3 + 0.1 Band2
```

Rule 21: [30 cases, mean 68.63333, range 33 to 90, est err 6.83862]

```
if
  Band1 > 10
  Band1 <= 24
  Band4 > 28
  Band7 > 32
  Band7 <= 87
then
  Band Agg = -32.39 + 1.2 Band1 + 0.672
Band7 + 0.468 Band5 + 0.41 Band4
- 0.07 Band3
```

Rule 22: [52 cases, mean 73.82692, range 53 to 118, est err 7.09079]

```
if
  Band1 <= 22
  Band2 <= 1
  Band5 > 22
  Band7 > 87
then
  Band Agg = 115.836 + 2.685 Band5 - 1.88
Band3 - 1.36 Band2 - 0.113 Band4
+ 0.111 Band7 - 0.02 Band1
```

Rule 23: [88 cases, mean 74.40909, range 33 to 110, est err 6.59999]

```
if
  Band1 > 24
  Band1 <= 38
  Band4 > 24
  Band7 <= 87
then
  Band Agg = 19.02124 + 1.973 Band5 - 1.258
Band4 - 1.8 Band2
+ 0.571 Band7 + 0.3 Band1 -
0.28 Band3
```

Rule 24: [34 cases, mean 75.02941, range 63 to 95, est err 4.77434]

```
if
  Band1 > 22
  Band1 <= 43
  Band2 > 0.2454
  Band5 > 22
  Band7 > 87
then
  Band Agg = 53.07191 - 2.96 Band2 + 1.114
Band5 - 0.38 Band1
+ 0.105 Band7 - 0.1 Band3 -
0.013 Band4
```

Rule 25: [47 cases, mean 79.00000, range 58 to 107, est err 8.53374]

```
if
  Band1 > 22
  Band1 <= 43
  Band2 <= 0.2454
  Band5 > 22
  Band7 > 87
then
  Band Agg = 48.38573 - 13.54 Band2 + 3.299
Band5 - 1.046 Band4
- 1.43 Band3 + 0.652 Band7 +
0.21 Band1
```

Rule 26: [37 cases, mean 98.56757, range 47 to 143, est err 13.84415]

```
if
  Band1 > 38
  Band2 <= 1
  Band5 > 38
  Band7 <= 87
then
  Band Agg = 30.87 - 3.689 Band4 + 3.027
Band5 - 3.48 Band2 + 0.527 Band7
+ 0.41 Band3 + 0.08 Band1
```

Rule 27: [22 cases, mean 112.77273, range 100 to 122, est err 2.26436]

```
if
  Band7 > 159
then
  Band Agg = 23.539 + 0.525 Band7 - 0.394
Band5 + 0.341 Band4
```

Rule 28: [29 cases, mean 125.24138, range 66 to 182, est err 10.87017]

```

if
  Band1 > 43
  Band2 <= 1
  Band5 > 22
  Band7 > 87
then
  Band Agg = 47.19072 - 48.66 Band2 + 2.148
Band5 - 0.922 Band4
      + 0.214 Band7 + 0.18 Band1
Evaluation on hold-out data (761 cases):
Mean |error| 1.14175

[ Fold 3 ]
Model:
Rule 1: [1785 cases, mean 0.01927, range 0 to
0.4646, est err 0.01933]
if
  Band1 <= 78
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = 0.0004
Rule 2: [1880 cases, mean 0.03066, range 0 to
1, est err 0.02572]
if
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = -2.6147 + 0.03 Band1 + 0.015
Band7
Rule 3: [1479 cases, mean 0.10099, range 0 to
0.8742, est err 0.09779]
if
  Band1 <= 75
  Band2 > 1
  Band2 <= 61
  Band5 > 65
then
  Band Agg = 0.0246
Rule 4: [2280 cases, mean 0.12738, range 0 to
0.9296, est err 0.10951]
if
  Band2 <= 61
  Band3 <= 43
  Band5 > 65
then
  Band Agg = -0.3834 - 0.019 Band5 + 0.04
Band3 + 0.02 Band7 - 0.02 Band2
      + 0.009 Band4
Rule 5: [1108 cases, mean 0.34598, range 0 to
1, est err 0.20533]
if
  Band1 > 75
  Band2 > 1
  Band2 <= 61
  Band3 > 43
  Band5 > 65
then
  Band Agg = 0.0381 - 0.012 Band5 + 0.012
Band7 + 0.02 Band2
Rule 6: [106 cases, mean 4.11321, range 0 to
16, est err 0.39467]
if
  Band2 <= 1
  Band7 <= 15
then
  Band Agg = -0 + 0.361 Band5 + 0.199 Band7
+ 0.08 Band4 - 0.07 Band2
Rule 7: [444 cases, mean 5.58533, range 0 to
114, est err 0.42055]
if
  Band1 > 38
  Band4 > 24
  Band5 <= 38
  Band7 <= 87
then
  Band Agg = 32.04467 - 11.64 Band2 + 2.711
Band5 - 0.466 Band4
      - 0.83 Band3 + 0.432 Band7 +
0.11 Band1
Rule 8: [117 cases, mean 22.89744, range 10 to
69, est err 3.44036]
if
  Band2 <= 1
  Band4 <= 24
  Band7 > 15
then
  Band Agg = -1.574 + 0.8 Band1 - 0.88
Band2 + 0.444 Band7 + 0.196 Band5
      - 0.086 Band4 - 0.02 Band3
Rule 9: [37 cases, mean 25.35135, range 16 to
43, est err 2.40722]
if
  Band1 > 10
  Band2 <= 0.0016
  Band4 > 24
  Band7 <= 53
then
  Band Agg = -5.096 + 0.7 Band1 + 0.551
Band7 + 0.206 Band4 - 0.013 Band5
Rule 10: [28 cases, mean 32.92857, range 12 to
70, est err 6.30797]
if
  Band1 <= 10
  Band4 > 24
  Band7 <= 87
then
  Band Agg = 4.532 - 1.61 Band1 + 0.893
Band5 + 0.435 Band7 - 0.49 Band2
      - 0.062 Band4 - 0.03 Band3
Rule 11: [120 cases, mean 46.09240, range
0.5627 to 117, est err 2.98072]
if
  Band2 > 61
  Band7 <= 149
then
  Band Agg = -9.65746 - 0.51 Band1 + 0.362
Band7 + 0.275 Band4
      + 0.49 Band3 - 0.106 Band5 -
0.03 Band2
Rule 12: [44 cases, mean 56.93182, range 15 to
91, est err 5.80058]
if
  Band1 <= 28
  Band2 > 0.0016
  Band2 <= 1
  Band3 <= 76
  Band4 > 24
  Band7 <= 87
then
  Band Agg = -32.702 + 1.47 Band5 + 1.03
Band1 + 0.581 Band7 - 0.321 Band4
Rule 13: [49 cases, mean 58.55102, range 34 to
90, est err 6.07950]
if
  Band1 > 10
  Band1 <= 38
  Band2 <= 0.0016
  Band7 > 53
  Band7 <= 87
then
  Band Agg = -24.434 + 0.99 Band1 + 0.71
Band3 + 0.146 Band7 + 0.126 Band4
      + 0.097 Band5
Rule 14: [35 cases, mean 59.85714, range 45 to
69, est err 2.93713]
if
  Band1 <= 15
  Band5 <= 21
  Band7 > 87
then

```

```

Band Agg = 39.492 - 0.58 Band1 - 0.46
Band2 + 0.208 Band7 + 0.072 Band5

Rule 15: [595 cases, mean 63.87899, range 46 to
75, est err 2.40098]
if
  Band1 > 15
  Band1 <= 22
  Band5 <= 21
  Band7 > 87
then
  Band Agg = -7.647 - 10.9 Band2 + 1.273
  Band5 + 0.625 Band4 + 0.72 Band1
    + 0.152 Band7

Rule 16: [28 cases, mean 65.64286, range 50 to
85, est err 5.63408]
if
  Band1 > 22
  Band5 <= 21
  Band7 > 87
  Band7 <= 96
then
  Band Agg = -188.3753 + 4.42 Band5 + 1.877
  Band7 - 1.27 Band2
    - 0.32 Band1

Rule 17: [58 cases, mean 65.72414, range 55 to
85, est err 3.94579]
if
  Band1 > 22
  Band5 <= 21
  Band7 > 96
then
  Band Agg = -37.27004 - 10.45 Band2 +
  3.459 Band5 + 0.303 Band7
    + 0.073 Band4 + 0.03 Band1

Rule 18: [46 cases, mean 70.17391, range 58 to
95, est err 3.51914]
if
  Band1 > 29
  Band2 > 0.2234
  Band4 <= 37
  Band7 > 87
then
  Band Agg = -39.10978 - 29.7 Band2 + 0.968
  Band4 + 0.753 Band5
    + 0.72 Band1 + 0.43 Band3 +
  0.154 Band7

Rule 19: [32 cases, mean 71.00000, range 53 to
118, est err 7.90368]
if
  Band1 <= 19
  Band2 <= 1
  Band5 > 21
  Band7 > 87
then
  Band Agg = 99.621 + 5.203 Band5 - 3.649
  Band4 - 1.26 Band1 - 1.76 Band3
    + 0.765 Band7 - 0.33 Band2

Rule 20: [48 cases, mean 75.87500, range 47 to
110, est err 7.51652]
if
  Band1 > 28
  Band1 <= 38
  Band2 > 0.0016
  Band4 > 24
  Band7 <= 87
then
  Band Agg = 7.22569 + 1.592 Band5 - 1.074
  Band4 - 1.38 Band2
    + 0.567 Band7 + 0.38 Band1 -
  0.06 Band3

Rule 21: [98 cases, mean 76.07143, range 58 to
111, est err 6.99828]
if
  Band1 > 19
  Band1 <= 29
  Band5 > 21
  Band7 > 87
then
  Band Agg = 3.7711 - 14.71 Band2 + 3.106
  Band5 + 1.7 Band1 - 1.215 Band4
    + 0.645 Band7 - 1.17 Band3

Rule 22: [20 cases, mean 78.95000, range 56 to
94, est err 5.42516]
if
  Band1 <= 28
  Band2 > 0.0016
  Band3 > 76
  Band7 <= 87
then
  Band Agg = -166.6095 + 28.38 Band2 +
  1.095 Band5 + 1.245 Band7
    + 1.17 Band1 + 0.82 Band3

Rule 23: [20 cases, mean 94.20000, range 58 to
134, est err 12.71839]
if
  Band1 > 29
  Band2 <= 0.2234
  Band4 <= 37
  Band5 > 21
  Band7 > 87
then
  Band Agg = -49.30009 - 20.21 Band2 +
  3.141 Band5 + 0.85 Band1
    + 0.219 Band7

Rule 24: [41 cases, mean 98.26830, range 47 to
143, est err 12.98609]
if
  Band1 > 38
  Band2 <= 1
  Band5 > 38
  Band7 <= 87
then
  Band Agg = 28.31374 - 7.67 Band2 - 3.582
  Band4 + 2.92 Band5
    + 0.526 Band7 + 0.5 Band3 +
  0.05 Band1

Rule 25: [23 cases, mean 107.73913, range 65 to
122, est err 3.82287]
if
  Band7 > 149
then
  Band Agg = -1.234 + 0.844 Band7 - 0.691
  Band5 + 0.25 Band2 + 0.04 Band1

Rule 26: [20 cases, mean 132.64999, range 85 to
182, est err 10.37713]
if
  Band1 > 29
  Band2 <= 1
  Band4 > 37
  Band7 > 87
then
  Band Agg = -0.39828 - 42.31 Band2 + 2.648
  Band5 - 1.334 Band4
    + 0.544 Band7 + 0.66 Band1 -
  0.27 Band3

Evaluation on hold-out data (761 cases):
Mean |error| 1.03068

[ Fold 4 ]
Model:

Rule 1: [3567 cases, mean 0.06448, range 0 to
0.98, est err 0.06454]
if
  Band1 <= 78
  Band2 > 1
  Band2 <= 61
then
  Band Agg = 0.0002

Rule 2: [1473 cases, mean 0.10289, range 0 to
0.8826, est err 0.09922]
if
  Band1 <= 75
  Band2 > 1

```

```

Band2 <= 61
Band5 > 65
then
  Band Agg = 0.0274

Rule 3: [5279 cases, mean 0.13686, range 0 to
1, est err 0.11188]
if
  Band2 > 1
  Band2 <= 61
then
  Band Agg = -2.236 + 0.03 Band1 + 0.012
Band7 - 0.007 Band5

Rule 4: [3374 cases, mean 0.19680, range 0 to
1, est err 0.14861]
if
  Band2 > 1
  Band2 <= 61
  Band5 > 65
then
  Band Agg = 0.074 - 0.015 Band5 + 0.017
Band7 + 0.01 Band1

Rule 5: [674 cases, mean 3.69026, range 0 to
124, est err 0.28610]
if
  Band1 > 38
  Band5 <= 38
  Band7 <= 87
then
  Band Agg = -83.971 - 19.67 Band2 + 2.658
Band5 + 0.98 Band1
           + 0.786 Band7 - 0.301 Band4 -
0.1 Band3

Rule 6: [106 cases, mean 3.84906, range 0 to
16, est err 0.41406]
if
  Band2 <= 1
  Band7 <= 15
then
  Band Agg = 0 + 0.357 Band5 + 0.21 Band7 -
0.21 Band2 + 0.091 Band4

Rule 7: [281 cases, mean 4.17964, range 0 to
69, est err 0.44937]
if
  Band1 > 15
  Band4 <= 24
then
  Band Agg = -26.858 - 13.51 Band2 + 1.678
Band4 + 0.53 Band1
           + 0.354 Band7 + 0.052 Band5

Rule 8: [20 cases, mean 11.33165, range 0.5627
to 48, est err 3.22496]
if
  Band2 > 61
  Band7 <= 88
then
  Band Agg = -7.56 - 0.37 Band1 + 0.258
Band7 + 0.31 Band3 + 0.132 Band4
           - 0.092 Band5 + 0.17 Band2

Rule 9: [84 cases, mean 18.02381, range 10 to
39, est err 2.68511]
if
  Band1 <= 15
  Band2 <= 1
  Band4 <= 24
  Band7 > 15
then
  Band Agg = 0.191 + 0.69 Band1 + 0.353
Band7 - 0.39 Band2 + 0.139 Band5
           - 0.033 Band4

Rule 10: [35 cases, mean 22.91429, range 16 to
35, est err 1.60429]
if
  Band1 > 10
  Band1 <= 38
  Band4 > 24
  Band7 <= 35
then
  Band Agg = -8.735 + 0.737 Band7 + 0.411
Band5 + 0.57 Band1 - 0.58 Band2
           - 0.068 Band4 - 0.03 Band3

Rule 11: [28 cases, mean 37.78571, range 12 to
88, est err 7.06407]
if
  Band1 <= 10
  Band2 <= 1
  Band4 > 24
  Band7 <= 87
then
  Band Agg = 30.157 + 3.3 Band5 - 3.454
Band4 - 1.69 Band1 + 0.651 Band7
           - 0.3 Band2 - 0.02 Band3

Rule 12: [101 cases, mean 50.30693, range 15 to
117, est err 2.73884]
if
  Band1 <= 0.8058
  Band2 > 61
then
  Band Agg = -14.55774 + 3.36 Band1 + 0.325
Band7 + 0.321 Band4
           + 0.35 Band3 - 0.016 Band5

Rule 13: [27 cases, mean 51.03704, range 29 to
75, est err 6.78236]
if
  Band1 > 10
  Band1 <= 19
  Band4 > 24
  Band7 > 35
  Band7 <= 87
then
  Band Agg = -25.238 + 1.52 Band1 + 0.744
Band5 + 0.498 Band7
           - 0.034 Band4

Rule 14: [23 cases, mean 52.13044, range 41 to
117, est err 6.63367]
if
  Band2 > 61
  Band5 > 120
  Band7 > 88
then
  Band Agg = 13.64924 + 0.463 Band7 - 0.301
Band5 - 0.23 Band1
           + 0.31 Band3 + 0.103 Band4

Rule 15: [46 cases, mean 61.95652, range 47 to
102, est err 4.45576]
if
  Band1 <= 15
  Band2 <= 1
  Band7 > 87
then
  Band Agg = 14.002 + 1.082 Band5 - 0.46
Band1 + 0.26 Band7 - 0.07 Band2

Rule 16: [34 cases, mean 62.76471, range 27 to
77, est err 3.66277]
if
  Band1 > 15
  Band1 <= 23
  Band2 > 0.0001
  Band3 > 59
  Band4 > 24
  Band5 <= 22
then
  Band Agg = -57.03861 + 2.582 Band5 - 3.94
Band2 + 1.14 Band1
           + 0.569 Band7 - 0.126 Band4 -
0.16 Band3

Rule 17: [94 cases, mean 63.45745, range 50 to
78, est err 3.42140]
if
  Band2 > 0.0001
  Band3 <= 59
  Band5 <= 22
  Band7 > 87
then
  Band Agg = -14.268 + 2.366 Band5 + 0.984
Band4 + 0.042 Band7

```

Rule 18: [543 cases, mean 64.35359, range 54 to 85, est err 2.24828]

```
if
  Band1 > 15
  Band1 <= 23
  Band2 <= 0.0001
  Band5 <= 22
  Band7 > 87
then
  Band Agg = -9.832 + 1.246 Band5 + 0.771
  Band4 + 0.85 Band1 - 1.14 Band2
  + 0.119 Band7
```

Rule 19: [57 cases, mean 64.71930, range 50 to 85, est err 4.50931]

```
if
  Band1 > 23
  Band1 <= 30
  Band5 <= 22
  Band7 > 87
then
  Band Agg = -21.93322 - 12.47 Band2 + 3.13
  Band5 + 0.302 Band7
  - 0.083 Band4 + 0.07 Band1 -
  0.09 Band3
```

Rule 20: [29 cases, mean 66.62069, range 56 to 93, est err 5.77201]

```
if
  Band1 > 30
  Band5 <= 22
  Band7 > 87
then
  Band Agg = -45.61167 + 2.265 Band5 - 3.35
  Band2 + 0.69 Band1
  + 0.391 Band7 + 0.029 Band4 -
  0.05 Band3
```

Rule 21: [24 cases, mean 70.58334, range 54 to 102, est err 7.70196]

```
if
  Band1 <= 19
  Band2 <= 1
  Band5 > 22
  Band7 > 87
then
  Band Agg = 41.134 + 0.497 Band5 + 0.096
  Band7 - 0.05 Band1 + 0.06 Band3
  + 0.023 Band4
```

Rule 22: [120 cases, mean 71.11667, range 34 to 110, est err 6.40716]

```
if
  Band1 > 19
  Band1 <= 38
  Band7 > 35
  Band7 <= 87
then
  Band Agg = 10.043 + 1.653 Band5 - 1.18
  Band4 + 0.514 Band7 + 0.3 Band1
```

Rule 23: [31 cases, mean 74.74194, range 60 to 103, est err 5.58479]

```
if
  Band1 > 19
  Band1 <= 30
  Band5 > 22
  Band7 > 87
  Band7 <= 95
then
  Band Agg = 55.74411 + 2.618 Band5 - 1.94
  Band2 - 1.47 Band3 + 0.68 Band1
  + 0.32 Band7 - 0.173 Band4
```

Rule 24: [46 cases, mean 78.97826, range 59 to 121, est err 7.14634]

```
if
  Band1 > 30
  Band5 > 22
  Band5 <= 34
  Band7 > 87
then
  Band Agg = -34.18037 - 56.56 Band2 +
  2.083 Band5 + 1.417 Band4
  + 0.51 Band1 + 0.072 Band7
```

Rule 25: [50 cases, mean 81.18000, range 60 to 111, est err 6.75843]

```
if
  Band1 > 19
  Band1 <= 30
  Band5 > 22
  Band7 > 95
then
  Band Agg = 31.09633 + 2.394 Band5 + 1.84
  Band1 - 2.38 Band2 - 1.29 Band3
  + 0.301 Band7 - 0.15 Band4
```

Rule 26: [32 cases, mean 94.00000, range 49 to 122, est err 1.91963]

```
if
  Band1 > 0.8058
  Band2 > 61
  Band5 <= 120
  Band7 > 88
then
  Band Agg = 3.756 + 0.595 Band7 - 0.313
  Band5 + 0.201 Band4 + 0.09 Band2
```

Rule 27: [38 cases, mean 96.71053, range 47 to 143, est err 11.53235]

```
if
  Band1 > 38
  Band2 <= 1
  Band5 > 38
  Band7 <= 87
then
  Band Agg = 40.80466 - 6.71 Band2 + 2.925
  Band5 - 2.655 Band4
  + 0.374 Band7 + 0.11 Band1 -
  0.03 Band3
```

Rule 28: [24 cases, mean 127.95834, range 77 to 182, est err 12.41758]

```
if
  Band1 > 30
  Band2 <= 1
  Band5 > 34
  Band7 > 87
then
  Band Agg = 8.262 - 51.21 Band2 + 1.254
  Band5 + 0.512 Band4 + 0.334 Band7
  + 0.35 Band1
```

Evaluation on hold-out data (761 cases):

Mean |error| 1.18914

[Fold 5]

Model:

Rule 1: [1896 cases, mean 0.03133, range 0 to 1, est err 0.02599]

```
if
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = -2.7208 + 0.03 Band1 + 0.02
  Band7
```

Rule 2: [1277 cases, mean 0.04628, range 0 to 0.9296, est err 0.04655]

```
if
  Band1 <= 87
  Band2 > 1
  Band2 <= 61
  Band4 <= 66
then
  Band Agg = -1.6037 + 0.02 Band1
```

Rule 3: [3542 cases, mean 0.06456, range 0 to 0.98, est err 0.06462]

```
if
  Band1 <= 78
  Band2 > 1
  Band2 <= 61
then
  Band Agg = 0.0002
```

```

Rule 4: [1462 cases, mean 0.10226, range 0 to
0.8826, est err 0.09915]
if
  Band1 <= 75
  Band2 > 1
  Band2 <= 61
  Band5 > 65
then
  Band Agg = 0.0258

Rule 5: [1285 cases, mean 0.23447, range 0 to
1, est err 0.17326]
if
  Band1 > 75
  Band2 > 1
  Band2 <= 61
  Band4 > 66
  Band5 > 65
then
  Band Agg = 0.912 + 0.02 Band7 - 0.016
Band5

Rule 6: [66 cases, mean 0.24242, range 0 to 16,
est err 0.00003]
if
  Band2 <= 1
  Band7 <= 12
then
  Band Agg = 0 + 0.762 Band4

Rule 7: [844 cases, mean 0.39656, range 0 to 1,
est err 0.20960]
if
  Band1 > 87
  Band2 > 1
  Band2 <= 61
  Band5 > 65
then
  Band Agg = -0.726 - 0.018 Band4 + 0.02
Band1 - 0.011 Band7 + 0.02 Band3

Rule 8: [450 cases, mean 5.26777, range 0 to
124, est err 0.44238]
if
  Band1 > 38
  Band4 > 24
  Band5 <= 38
  Band7 <= 87
then
  Band Agg = 10.03875 - 12.52 Band2 + 2.965
Band5 - 1.701 Band4
          + 0.536 Band7 + 0.25 Band1 -
  0.24 Band3

Rule 9: [74 cases, mean 12.48649, range 8 to
19, est err 1.03344]
if
  Band2 <= 1
  Band7 > 12
  Band7 <= 18
then
  Band Agg = -3.18 + 0.653 Band5 + 0.33
Band1 + 0.39 Band2 + 0.153 Band7
          - 0.108 Band4 + 0.02 Band3

Rule 10: [21 cases, mean 13.22061, range 0.5627
to 48, est err 3.65260]
if
  Band2 > 61
  Band7 <= 88
then
  Band Agg = -4.35949 + 0.242 Band4 + 0.228
Band7 - 0.24 Band1
          + 0.26 Band2 - 0.21 Band3 -
  0.021 Band5

Rule 11: [100 cases, mean 15.73000, range 0 to
41, est err 1.69468]
if
  Band1 > 10
  Band1 <= 38
  Band7 <= 34
then
  Band Agg = -7.739 + 0.966 Band7 + 0.35
Band1 + 0.083 Band5 + 0.02 Band3

Rule 12: [79 cases, mean 27.88608, range 10 to
69, est err 4.18303]
if
  Band2 <= 1
  Band4 <= 24
  Band7 > 18
then
  Band Agg = -2.517 + 0.87 Band1 + 0.428
Band7 - 0.65 Band2 + 0.138 Band5
          - 0.071 Band4

Rule 13: [26 cases, mean 38.07692, range 12 to
88, est err 7.60299]
if
  Band1 <= 10
  Band2 <= 1
  Band4 > 24
  Band7 <= 87
then
  Band Agg = 27.36212 + 2.92 Band5 - 2.9
Band4 - 1.87 Band1 + 0.611 Band7
          - 0.42 Band2 - 0.02 Band3

Rule 14: [36 cases, mean 42.69444, range 19 to
75, est err 6.68625]
if
  Band1 > 10
  Band1 <= 18
  Band7 > 34
  Band7 <= 87
then
  Band Agg = 6.791 + 1.091 Band4 + 0.803
Band5 + 1.08 Band1 - 0.64 Band3
          + 0.245 Band7

Rule 15: [25 cases, mean 51.00000, range 41 to
117, est err 6.24306]
if
  Band2 > 61
  Band5 > 120
  Band7 > 88
then
  Band Agg = -6.284 + 0.407 Band7 + 0.47
Band3 + 0.206 Band4 - 0.165 Band5

Rule 16: [70 cases, mean 53.00000, range 33 to
116, est err 2.03749]
if
  Band1 <= 0.8398
  Band2 > 61
  Band5 <= 120
  Band7 > 88
then
  Band Agg = -13.38849 + 3.82 Band1 + 0.453
Band4 + 0.371 Band7
          + 0.08 Band3 - 0.029 Band5

Rule 17: [33 cases, mean 54.57576, range 12 to
73, est err 4.86851]
if
  Band1 <= 23
  Band2 > 0.027
  Band5 > 19
  Band5 <= 21
then
  Band Agg = -80.4069 + 5.015 Band5 + 0.391
Band7 - 0.44 Band2
          + 0.24 Band1 - 0.052 Band4 -
  0.02 Band3

Rule 18: [59 cases, mean 59.76271, range 34 to
83, est err 5.60875]
if
  Band1 > 18
  Band1 <= 38
  Band5 <= 28
  Band7 > 34
  Band7 <= 87
then
  Band Agg = 10.33877 + 0.878 Band5 - 1.62
Band2 - 0.701 Band4
          + 0.474 Band7 + 0.4 Band1 +
  0.05 Band3

```

```

Rule 19: [36 cases, mean 60.41667, range 45 to
73, est err 3.04161]

if
  Band1 <= 15
  Band5 <= 21
  Band7 > 87
then
  Band Agg = 37.968 - 0.53 Band1 + 0.228
Band7 - 0.39 Band2 + 0.064 Band5

Rule 20: [66 cases, mean 61.68182, range 44 to
73, est err 3.51957]

if
  Band1 > 15
  Band1 <= 23
  Band2 <= 0.027
  Band5 > 19
  Band5 <= 21
  Band7 <= 97
then
  Band Agg = -38.576 + 0.94 Band1 + 0.432
Band7 + 0.72 Band3

Rule 21: [346 cases, mean 63.27746, range 54 to
73, est err 2.19743]

if
  Band1 > 15
  Band1 <= 23
  Band5 <= 19
  Band7 > 87
then
  Band Agg = -5.6 - 9.27 Band2 + 1.178
Band5 + 0.67 Band4 + 0.72 Band1
  + 0.139 Band7

Rule 22: [42 cases, mean 64.42857, range 55 to
78, est err 3.36782]

if
  Band1 > 23
  Band5 <= 21
  Band7 > 96
then
  Band Agg = -5.329 - 7.04 Band2 + 2.768
Band5 + 0.28 Band1 + 0.153 Band7
  - 0.17 Band3 + 0.08 Band4

Rule 23: [23 cases, mean 65.52174, range 50 to
85, est err 6.03143]

if
  Band1 > 23
  Band5 <= 21
  Band7 > 87
  Band7 <= 96
then
  Band Agg = -214.384 + 4.375 Band5 + 2.064
Band7 - 0.01 Band1

Rule 24: [204 cases, mean 65.72549, range 56 to
77, est err 2.54213]

if
  Band1 > 15
  Band1 <= 23
  Band2 <= 0.027
  Band5 > 19
  Band5 <= 21
  Band7 > 97
then
  Band Agg = -28.755 + 2.24 Band5 + 0.74
Band4 + 0.88 Band1 + 0.107 Band7
  - 0.04 Band2

Rule 25: [45 cases, mean 69.13333, range 57 to
95, est err 3.81699]

if
  Band2 > 0.2799
  Band2 <= 1
  Band4 <= 37
  Band7 > 87
then
  Band Agg = -32.15956 - 14.4 Band2 + 2.162
Band5 + 0.649 Band7
  - 0.548 Band4 + 0.14 Band1

Rule 26: [28 cases, mean 72.03571, range 53 to
118, est err 9.57293]

if
  Band1 <= 19
  Band2 <= 1
  Band5 > 21
  Band7 > 87
then
  Band Agg = 101.79 + 4.951 Band5 - 3.005
Band4 - 1.31 Band1 - 1.89 Band3
  + 0.712 Band7

Rule 27: [41 cases, mean 72.60976, range 60 to
90, est err 4.97179]

if
  Band1 > 19
  Band1 <= 22
  Band5 > 21
  Band7 > 87
then
  Band Agg = 57.42021 - 4.58 Band2 + 2.029
Band4 - 1.1 Band3 + 0.384 Band5
  + 0.129 Band7 + 0.06 Band1

Rule 28: [32 cases, mean 73.03125, range 58 to
98, est err 7.30232]

if
  Band1 > 22
  Band2 > 0.0246
  Band2 <= 0.2799
  Band3 <= 65
  Band5 > 21
  Band7 > 87
then
  Band Agg = 192.20871 + 4.425 Band5 - 8.14
Band2 - 3.85 Band3
  - 0.627 Band4 + 0.52 Band1 +
  0.165 Band7

Rule 29: [40 cases, mean 76.15000, range 52 to
97, est err 7.83761]

if
  Band1 > 18
  Band1 <= 38
  Band5 > 28
  Band7 <= 80
then
  Band Agg = 42.28749 - 15.14 Band2 - 2.424
Band4 + 1.936 Band5
  + 0.61 Band1 + 0.44 Band3 +
  0.065 Band7

Rule 30: [23 cases, mean 82.21739, range 68 to
112, est err 6.60774]

if
  Band1 > 22
  Band2 <= 0.0246
  Band3 <= 65
  Band5 > 21
  Band7 > 87
then
  Band Agg = 20.80207 + 202.99 Band2 +
  3.759 Band5 - 1.134 Band4
  + 0.398 Band7 - 0.74 Band3 +
  0.31 Band1

Rule 31: [33 cases, mean 82.42424, range 73 to
110, est err 5.62236]

if
  Band1 > 18
  Band1 <= 38
  Band5 > 28
  Band7 > 80
  Band7 <= 87
then
  Band Agg = 53.96143 + 1.676 Band5 - 0.688
Band4 - 0.53 Band3
  + 0.272 Band7 + 0.26 Band1 -
  0.25 Band2

Rule 32: [30 cases, mean 95.90000, range 49 to
122, est err 1.96467]

if
  Band1 > 0.8398
  Band2 > 61
  Band7 > 88
then
  Band Agg = -2.1 + 0.596 Band7 - 0.28
Band5 + 0.24 Band3 + 0.09 Band2

```

```

+ 0.032 Band4

Rule 33: [38 cases, mean 96.00000, range 47 to
142, est err 11.78129]
if
  Band1 > 38
  Band2 <= 1
  Band3 > 38
  Band7 <= 87
then
  Band Agg = 44.57675 - 20.61 Band2 - 3.412
Band4 + 2.572 Band5
+ 0.74 Band3 + 0.283 Band7

Rule 34: [21 cases, mean 99.80952, range 68 to
134, est err 9.48294]
if
  Band1 > 22
  Band2 <= 0.2799
  Band3 > 65
  Band4 <= 37
  Band7 > 87
then
  Band Agg = 17.65966 - 71.16 Band2 + 2.133
Band5 + 0.87 Band1
- 0.18 Band3 + 0.095 Band7

Rule 35: [24 cases, mean 125.95834, range 78 to
182, est err 13.85157]
if
  Band1 > 22
  Band2 <= 1
  Band4 > 37
  Band7 > 87
then
  Band Agg = -32.315 - 38.42 Band2 + 1.365
Band5 + 0.72 Band7 + 0.61 Band1
- 0.031 Band4 - 0.05 Band3

Evaluation on hold-out data (761 cases):
Mean |error| 1.06859

[ Fold 6 ]
Model:

Rule 1: [1804 cases, mean 0.01808, range 0 to
0.4977, est err 0.01814]
if
  Band1 <= 78
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = 0.0001

Rule 2: [1394 cases, mean 0.09655, range 0 to
0.8826, est err 0.09447]
if
  Band1 <= 74
  Band2 > 1
  Band2 <= 61
  Band5 > 65
then
  Band Agg = 0.0198

Rule 3: [863 cases, mean 0.17606, range 0 to
0.8848, est err 0.12697]
if
  Band1 > 74
  Band3 <= 43
  Band5 > 65
then
  Band Agg = -0.1063 + 0.04 Band3 - 0.017
Band5 + 0.018 Band7 - 0.03 Band2
+ 0.009 Band4

Rule 4: [71 cases, mean 0.22535, range 0 to 16,
est err 0.00003]
if
  Band2 <= 1
  Band7 <= 12
then
  Band Agg = -0 + 0.762 Band4

Rule 5: [92 cases, mean 0.26347, range 0 to 1,
est err 0.19612]
if
  Band1 > 78
  Band2 > 1
  Band5 <= 65
then
  Band Agg = -2.1862 + 0.027 Band7 + 0.02
Band1 - 0.013 Band5 + 0.02 Band3

Rule 6: [1129 cases, mean 0.34596, range 0 to
1, est err 0.20169]
if
  Band1 > 74
  Band2 > 1
  Band3 > 43
  Band5 > 65
then
  Band Agg = 0.057 - 0.011 Band5 + 0.01
Band7 + 0.01 Band1

Rule 7: [444 cases, mean 5.14662, range 0 to
124, est err 0.41854]
if
  Band1 > 38
  Band4 > 24
  Band5 <= 38
  Band7 <= 87
then
  Band Agg = -60.976 - 15.84 Band2 + 2.852
Band5 + 0.63 Band1 + 0.48 Band7
- 0.204 Band4

Rule 8: [72 cases, mean 12.69444, range 8 to
21, est err 1.21480]
if
  Band2 <= 1
  Band7 > 12
  Band7 <= 18
then
  Band Agg = -5.235 + 0.43 Band5 + 0.467
Band7 + 0.32 Band1

Rule 9: [20 cases, mean 16.38828, range 0.5627
to 52, est err 3.74885]
if
  Band2 > 61
  Band7 <= 90
then
  Band Agg = -4.323 + 0.417 Band4 - 0.46
Band1 + 0.301 Band7 - 0.037 Band5
+ 0.08 Band3 + 0.04 Band2

Rule 10: [56 cases, mean 20.16072, range 10 to
39, est err 3.24990]
if
  Band1 <= 15
  Band2 <= 1
  Band4 <= 24
  Band7 > 18
then
  Band Agg = -1.644 + 0.94 Band1 + 0.37
Band7 - 0.57 Band2 + 0.117 Band5
- 0.059 Band4

Rule 11: [43 cases, mean 22.16279, range 12 to
33, est err 2.39616]
if
  Band2 <= 1
  Band4 > 24
  Band7 <= 32
then
  Band Agg = -32.732 + 0.8 Band1 - 0.496
Band5 + 0.8 Band3 + 0.087 Band7

Rule 12: [22 cases, mean 39.31818, range 15 to
88, est err 7.93330]
if
  Band1 <= 9
  Band2 <= 1
  Band4 > 24
  Band7 <= 87
then

```

```

Band Agg = -7.74352 - 2.58 Band1 + 1.18
Band4 + 0.438 Band7 + 0.21 Band5
- 0.21 Band2
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 13: [27 cases, mean 40.70370, range 19 to
69, est err 4.89979]
if
    Band1 > 15
    Band4 <= 24
    Band7 > 18
then
    Band Agg = -28.35 + 2.642 Band5 + 0.397
Band7 - 0.4 Band2 + 0.08 Band1
- 0.042 Band4
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 14: [28 cases, mean 46.32143, range 29 to
75, est err 6.93049]
if
    Band1 > 9
    Band1 <= 18
    Band4 > 24
    Band7 > 32
    Band7 <= 87
then
    Band Agg = 102.90826 + 15.22 Band2 +
4.723 Band5 - 2.78 Band4
- 2.3 Band3 + 1.35 Band1 +
0.552 Band7
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 15: [82 cases, mean 51.50000, range 33 to
94, est err 2.10417]
if
    Band2 > 61
    Band5 > 89
    Band7 > 90
    Band7 <= 160
then
    Band Agg = -2.26213 + 2.43 Band1 + 0.372
Band4 + 0.35 Band7
- 0.097 Band5 + 0.14 Band3
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 16: [20 cases, mean 59.55000, range 39 to
94, est err 2.19046]
if
    Band2 > 61
    Band5 <= 89
    Band7 > 90
then
    Band Agg = -29.1552 + 7.14 Band1 + 0.84
Band3 + 0.382 Band7
- 0.024 Band5 + 0.03 Band2
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 17: [36 cases, mean 59.55556, range 45 to
73, est err 3.03307]
if
    Band1 <= 15
    Band5 <= 21
    Band7 > 87
then
    Band Agg = 35.153 - 0.53 Band1 + 0.243
Band7 - 0.34 Band2 + 0.069 Band5
+ 0.014 Band4
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 18: [40 cases, mean 61.42500, range 34 to
90, est err 6.77454]
if
    Band1 > 18
    Band1 <= 38
    Band2 <= 0.004
    Band7 > 32
    Band7 <= 87
then
    Band Agg = -7.338 - 6.11 Band2 + 1.428
Band5 - 0.816 Band4 + 0.467 Band7
+ 0.35 Band1 + 0.22 Band3
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 19: [80 cases, mean 63.11250, range 54 to
73, est err 3.24677]
if
    Band1 <= 22
    Band2 > 0.0001
    Band5 <= 21
    Band7 > 87
then
    Band Agg = -4.85054 - 5.97 Band2 + 2.464
Band5 + 0.301 Band7
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 20: [28 cases, mean 64.14286, range 55 to
85, est err 4.26782]
if
    Band1 > 22
    Band2 > 0.0016
    Band5 <= 21
    Band7 > 96
then
    Band Agg = -81.003 + 3.878 Band5 + 0.633
Band7 + 0.02 Band3 - 0.01 Band1
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 21: [527 cases, mean 64.16319, range 46 to
77, est err 2.30028]
if
    Band1 > 15
    Band1 <= 22
    Band2 <= 0.0001
    Band5 <= 21
    Band7 > 87
then
    Band Agg = -9.409 + 1.319 Band5 + 0.84
Band1 + 0.667 Band4 - 0.63 Band2
+ 0.129 Band7
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 22: [27 cases, mean 66.48148, range 50 to
85, est err 6.06086]
if
    Band1 > 22
    Band5 <= 21
    Band7 > 87
    Band7 <= 96
then
    Band Agg = -139.43 + 3.908 Band5 + 1.492
Band7 - 1.4 Band2 - 0.36 Band1
- 0.03 Band3
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 23: [56 cases, mean 68.66071, range 27 to
103, est err 6.76088]
if
    Band1 > 18
    Band1 <= 38
    Band2 > 0.004
    Band3 <= 74
    Band4 > 24
    Band7 <= 87
then
    Band Agg = 17.80897 - 5.62 Band2 + 2.23
Band5 - 0.779 Band4
+ 0.535 Band7 - 0.56 Band3 +
0.35 Band1
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 24: [31 cases, mean 71.61290, range 53 to
118, est err 8.49634]
if
    Band1 <= 19
    Band2 <= 1
    Band5 > 21
    Band7 > 87
then
    Band Agg = 103.07624 + 5.193 Band5 -
3.076 Band4 - 2.04 Band3
- 1.23 Band1 + 0.75 Band7 -
0.07 Band2
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 25: [53 cases, mean 73.00000, range 58 to
134, est err 6.93722]
if
    Band1 > 30
    Band1 <= 43
    Band5 > 21
    Band7 > 87
then
    Band Agg = 30.08825 - 33.47 Band2 + 3.11
Band5 - 1.632 Band4
+ 0.59 Band1 + 0.456 Band7 -
0.69 Band3
+ 0.22 Band1 - 0.136 Band4 -
0.21 Band3

Rule 26: [97 cases, mean 75.74227, range 58 to
111, est err 6.49787]
if
    Band1 > 19
    Band1 <= 30
    Band5 > 21

```

```

    Band7 > 87
then
    Band Agg = 8.81662 - 8.38 Band2 + 2.585
Band5 + 1.31 Band1 - 1.27 Band3
        + 0.638 Band7 - 0.416 Band4

    Rule 27: [60 cases, mean 77.36667, range 59 to
144, est err 5.17679]

if
    Band1 > 22
    Band2 <= 0.0016
    Band7 > 87
then
    Band Agg = -8.323 + 2.889 Band5 - 4.84
Band2 + 0.221 Band4 + 0.105 Band7
        + 0.09 Band1

    Rule 28: [58 cases, mean 79.53448, range 62 to
97, est err 5.46899]

if
    Band1 > 18
    Band1 <= 38
    Band3 > 74
then
    Band Agg = 18.20022 - 7.95 Band2 + 0.885
Band5 - 0.459 Band4
        + 0.365 Band7 + 0.19 Band1 +
0.13 Band3

    Rule 29: [39 cases, mean 98.23077, range 47 to
143, est err 13.55791]

if
    Band1 > 38
    Band2 <= 1
    Band5 > 38
    Band7 <= 87
then
    Band Agg = 31.5294 - 3.691 Band4 + 2.959
Band5 - 4.32 Band2
        + 0.497 Band7 + 0.47 Band3 +
0.07 Band1

    Rule 30: [32 cases, mean 112.29957, range
0.0071 to 182, est err 9.02678]

if
    Band1 > 43
    Band5 > 21
    Band7 > 87
then
    Band Agg = 49.2636 - 45.61 Band2 + 2.081
Band5 - 0.821 Band4
        + 0.169 Band7 + 0.17 Band1

    Rule 31: [20 cases, mean 113.40000, range 100
to 122, est err 2.40652]

if
    Band7 > 160
then
    Band Agg = 16.622 + 0.45 Band7 - 0.182
Band5 + 0.177 Band4 - 0.16 Band1
        + 0.19 Band3

Evaluation on hold-out data (761 cases):
Mean |error| 1.05796

[ Fold 7 ]

Model:
Rule 1: [2557 cases, mean 0.03850, range 0 to
0.7428, est err 0.03842]
if
    Band1 <= 70
    Band2 > 1
    Band2 <= 63
then
    Band Agg = 0.0019

Rule 2: [262 cases, mean 0.05323, range 0 to
0.7256, est err 0.06523]
if
    Band1 > 70
    Band2 > 1
    Band5 <= 57
then
    Band Agg = -0.8534 + 0.011 Band7 + 0.01
Band1

    Rule 3: [1596 cases, mean 0.17083, range 0 to
0.98, est err 0.15328]
if
    Band1 > 70
    Band1 <= 87
    Band2 > 1
    Band5 > 57
then
    Band Agg = -0.1147 + 0.029 Band7 - 0.024
Band5 + 0.03 Band3

    Rule 4: [1059 cases, mean 0.20255, range 0 to
0.98, est err 0.16147]
if
    Band1 > 70
    Band1 <= 87
    Band2 > 1
    Band4 > 71
then
    Band Agg = 0.5329 + 0.017 Band7 - 0.011
Band5

    Rule 5: [871 cases, mean 0.40609, range 0 to 1,
est err 0.20013]
if
    Band1 > 87
    Band2 > 1
    Band2 <= 63
    Band5 > 57
then
    Band Agg = -0.2186 + 0.02 Band1 - 0.011
Band5

    Rule 6: [101 cases, mean 4.04950, range 0 to
16, est err 0.40835]
if
    Band2 <= 1
    Band7 <= 15
then
    Band Agg = -0 + 0.484 Band5 - 0.17 Band2
+ 0.08 Band4 + 0.055 Band7

    Rule 7: [439 cases, mean 7.09690, range 0 to
124, est err 0.56032]
if
    Band1 > 36
    Band4 > 24
    Band5 <= 38
    Band7 <= 87
then
    Band Agg = -3.54592 - 12.73 Band2 + 3.351
Band5 - 1.242 Band4
        + 0.73 Band1 + 0.539 Band7 -
0.75 Band3

    Rule 8: [95 cases, mean 16.68421, range 0 to
41, est err 1.79716]
if
    Band1 > 10
    Band1 <= 36
    Band7 <= 35
then
    Band Agg = -14.858 + 0.792 Band7 + 0.46
Band1 + 0.19 Band3

    Rule 9: [84 cases, mean 17.89286, range 10 to
39, est err 2.56970]
if
    Band1 <= 15
    Band2 <= 1
    Band4 <= 24
    Band7 > 15
then
    Band Agg = 1.268 + 5.15 Band2 + 0.72
Band1 + 0.36 Band7 + 0.036 Band5
        - 0.018 Band4

    Rule 10: [31 cases, mean 37.00000, range 0 to
69, est err 5.41803]
if
    Band1 > 15

```

```

    Band4 <= 24
    Band7 > 15
  then
    Band Agg = 9.07776 - 2.58 Band2 + 0.505
Band5 + 0.448 Band7 + 0.44 Band1
      - 0.256 Band4 - 0.04 Band3

  Rule 11: [27 cases, mean 38.48148, range 12 to
88, est err 7.37736]

  if
    Band1 <= 10
    Band2 <= 1
    Band4 > 24
    Band7 <= 87
  then
    Band Agg = 29.81 + 3.301 Band5 - 3.453
Band4 - 1.69 Band1 + 0.65 Band7
      - 0.31 Band2 - 0.02 Band3

  Rule 12: [112 cases, mean 47.05944, range
0.5627 to 117, est err 3.08637]

  if
    Band2 > 63
    Band7 <= 151
  then
    Band Agg = -8.49622 + 0.418 Band7 - 0.48
Band1 + 0.51 Band3
      + 0.216 Band4 - 0.156 Band5 -
0.04 Band2

  Rule 13: [29 cases, mean 58.37931, range 43 to
81, est err 5.54886]

  if
    Band1 > 18
    Band1 <= 36
    Band4 > 24
    Band4 <= 27
    Band7 > 35
    Band7 <= 87
  then
    Band Agg = -4.658 + 0.9 Band1 + 0.498
Band5 + 0.485 Band7 - 0.151 Band4

  Rule 14: [167 cases, mean 59.73653, range 29 to
77, est err 3.12731]

  if
    Band1 > 10
    Band1 <= 18
    Band4 > 24
    Band7 > 35
  then
    Band Agg = 3.507 + 1.053 Band5 + 1.2
Band1 + 0.962 Band4 - 0.78 Band3
      + 0.344 Band7

  Rule 15: [38 cases, mean 59.84211, range 45 to
73, est err 2.98289]

  if
    Band1 <= 15
    Band5 <= 21
    Band7 > 87
  then
    Band Agg = 35.208 - 0.54 Band1 + 0.25
Band7 - 0.37 Band2 + 0.068 Band5

  Rule 16: [53 cases, mean 60.60378, range 44 to
70, est err 3.59309]

  if
    Band1 > 15
    Band1 <= 22
    Band2 <= 0
    Band5 > 19
    Band5 <= 21
    Band7 <= 97
  then
    Band Agg = -27.968 + 0.549 Band7 + 0.66
Band3 - 0.46 Band2 + 0.091 Band5
      - 0.046 Band4 + 0.02 Band1

  Rule 17: [52 cases, mean 60.78846, range 54 to
69, est err 2.51812]

  if
    Band1 > 15
    Band1 <= 22
    Band5 <= 19
    Band7 > 87
  then
    Band Agg = -11.867 - 6.69 Band2 + 2.639
Band5 + 0.588 Band4 + 0.26 Band1
      + 0.13 Band7 - 0.16 Band3

  Rule 18: [21 cases, mean 61.42857, range 54 to
69, est err 3.38289]

  if
    Band1 <= 22
    Band2 > 0
    Band5 > 19
    Band5 <= 21
    Band7 > 87
    Band7 <= 97
  then
    Band Agg = 77.62878 + 7.582 Band5 + 12.14
Band2 - 2.94 Band3
      - 0.12 Band4 + 0.06 Band1 +
0.045 Band7

  Rule 19: [245 cases, mean 62.02449, range 16 to
71, est err 2.64510]

  if
    Band1 > 15
    Band1 <= 22
    Band2 <= 0.005
    Band3 > 57
    Band3 <= 59
    Band5 <= 20
    Band7 <= 118
  then
    Band Agg = -60.222 + 1.19 Band5 + 0.694
Band4 + 0.67 Band1 + 0.91 Band3
      + 0.15 Band7 - 0.18 Band2

  Rule 20: [26 cases, mean 62.38462, range 56 to
70, est err 2.95898]

  if
    Band1 <= 22
    Band2 > 0.005
    Band5 <= 20
    Band7 > 97
  then
    Band Agg = 9.25991 - 4.47 Band2 + 0.47
Band5 + 0.335 Band7 + 0.15 Band1
      + 0.119 Band4 + 0.06 Band3

  Rule 21: [60 cases, mean 63.93333, range 56 to
74, est err 2.37631]

  if
    Band3 <= 57
    Band5 <= 20
    Band7 > 97
  then
    Band Agg = -3.639 - 6.46 Band2 + 1.615
Band5 + 0.486 Band4 + 0.56 Band1
      + 0.133 Band7 - 0.02 Band3

  Rule 22: [92 cases, mean 64.58696, range 58 to
74, est err 2.55400]

  if
    Band1 > 15
    Band1 <= 22
    Band2 <= 0.005
    Band3 > 59
    Band5 <= 20
    Band7 > 97
    Band7 <= 118
  then
    Band Agg = 10.851 + 1.29 Band1 + 0.419
Band4 + 0.161 Band7

  Rule 23: [62 cases, mean 65.90323, range 55 to
85, est err 3.90696]

  if
    Band1 > 22
    Band5 <= 21
    Band7 > 95
  then
    Band Agg = -47.546 - 9.49 Band2 + 4.409
Band5 + 0.244 Band7
      + 0.009 Band4

  Rule 24: [25 cases, mean 65.92000, range 50 to
85, est err 6.19578]

```

```

if      Band1 > 22
      Band5 <= 21
      Band7 > 87
      Band7 <= 95
    then
      Band Agg = -193.73383 + 4.565 Band5 +
1.827 Band7 - 2.61 Band2
          + 0.02 Band1 - 0.03 Band3
    Rule 25: [94 cases, mean 65.98936, range 61 to
77, est err 1.70166]

if      Band1 > 15
      Band1 <= 22
      Band7 > 118
    then
      Band Agg = -2.525 - 2.66 Band2 + 1.058
Band5 + 0.53 Band1 + 0.274 Band7
          + 0.141 Band4
    Rule 26: [50 cases, mean 67.90000, range 58 to
77, est err 2.91700]

if      Band1 <= 22
      Band5 > 20
      Band5 <= 21
      Band7 > 97
    then
      Band Agg = -39.027 + 1.259 Band4 - 1.36
Band2 + 0.528 Band5 + 0.62 Band1
          + 0.66 Band3 + 0.096 Band7
    Rule 27: [22 cases, mean 68.31818, range 56 to
91, est err 6.28460]

if      Band1 > 10
      Band1 <= 36
      Band3 <= 65
      Band4 > 27
      Band7 <= 87
    then
      Band Agg = -82.372 + 3.546 Band4 + 0.917
Band5 + 0.254 Band7
          - 0.32 Band2 + 0.12 Band1 -
0.02 Band3
    Rule 28: [58 cases, mean 69.70689, range 56 to
107, est err 5.72838]

if      Band1 > 27
      Band1 <= 42
      Band2 > 0.074
      Band7 > 87
    then
      Band Agg = 23.08074 - 22.84 Band2 + 2.217
Band5 - 1.189 Band4
          + 0.38 Band1 + 0.223 Band7 -
0.04 Band3
    Rule 29: [27 cases, mean 71.37037, range 53 to
118, est err 8.00614]

if      Band1 <= 19
      Band2 <= 1
      Band5 > 21
      Band7 > 87
    then
      Band Agg = 65.473 + 5.415 Band5 - 3.352
Band4 - 1.41 Band1 + 0.938 Band7
          - 1.69 Band3
    Rule 30: [25 cases, mean 71.48000, range 62 to
90, est err 3.18671]

if      Band1 > 19
      Band1 <= 22
      Band5 > 21
      Band7 > 87
      Band7 <= 102
    then
      Band Agg = 52.38997 + 2.057 Band4 - 1.06
Band3 + 0.401 Band5
          + 0.15 Band1 + 0.111 Band7 -
0.06 Band2
    Rule 31: [40 cases, mean 72.55000, range 44 to
103, est err 6.69469]

if      Band1 > 18
      Band1 <= 36
      Band3 > 65
      Band4 <= 36
      Band7 <= 87
    then
      Band Agg = -9.428 + 1.877 Band5 - 0.416
Band4 + 0.388 Band7 + 0.09 Band1
          + 0.07 Band3
    Rule 32: [39 cases, mean 76.30769, range 58 to
103, est err 6.96049]

if      Band1 > 22
      Band1 <= 27
      Band5 > 21
      Band7 > 87
      Band7 <= 102
    then
      Band Agg = -42.40812 + 4.245 Band5 - 4.37
Band4 - 4.14 Band2
          + 1.21 Band7 + 1.28 Band1 -
0.11 Band3
    Rule 33: [22 cases, mean 78.27273, range 63 to
104, est err 7.46802]

if      Band1 > 19
      Band1 <= 27
      Band5 > 21
      Band7 > 102
    then
      Band Agg = 32.138 - 5.28 Band2 + 2.425
Band5 - 0.864 Band4 + 1.01 Band1
          - 0.91 Band3 + 0.432 Band7
    Rule 34: [30 cases, mean 80.93333, range 62 to
94, est err 5.47543]

if      Band1 > 18
      Band1 <= 36
      Band4 > 36
      Band7 <= 87
    then
      Band Agg = -12.334 + 1.575 Band5 - 0.518
Band4 + 0.496 Band7
          + 0.15 Band1 + 0.08 Band3
    Rule 35: [41 cases, mean 97.09756, range 47 to
143, est err 11.44167]

if      Band1 > 36
      Band2 <= 1
      Band5 > 38
      Band7 <= 87
    then
      Band Agg = 45.66138 - 10.32 Band2 + 2.285
Band5 - 2.08 Band4
          + 0.319 Band7 + 0.13 Band1 +
0.03 Band3
    Rule 36: [22 cases, mean 106.90909, range 65 to
122, est err 3.81452]

if      Band7 > 151
    then
      Band Agg = -35.2655 + 0.515 Band4 + 0.511
Band7 - 0.02 Band1
          - 0.011 Band5 + 0.02 Band3
    Rule 37: [25 cases, mean 109.28000, range 60 to
144, est err 8.18241]

if      Band1 > 27
      Band2 <= 0.074
      Band5 > 21
      Band7 > 87
    then
      Band Agg = -27.884 - 306.75 Band2 + 2.327
Band5 + 0.737 Band7
          - 0.336 Band4 + 0.08 Band1

```

```

Rule 38: [23 cases, mean 110.26087, range 65 to
182, est err 9.99974]

if
  Band1 > 42
  Band2 > 0.074
  Band2 <= 1
  Band7 > 87
then
  Band Agg = 59.73439 - 49.42 Band2 + 3.28
Band5 - 2.613 Band4
  + 0.31 Band1 + 0.241 Band7

Evaluation on hold-out data (761 cases):
Mean |error|  0.96896

[ Fold 8 ]

Model:

Rule 1: [1811 cases, mean 0.01929, range 0 to
0.4977, est err 0.01936]

if
  Band1 <= 78
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = 0.0004

Rule 2: [1903 cases, mean 0.03065, range 0 to
1, est err 0.02555]

if
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = -2.4657 + 0.03 Band1 + 0.022
Band7 - 0.007 Band5

Rule 3: [1499 cases, mean 0.10042, range 0 to
0.8826, est err 0.09753]

if
  Band1 <= 75
  Band2 > 1
  Band2 <= 61
  Band5 > 65
then
  Band Agg = 0.0223

Rule 4: [640 cases, mean 0.14359, range 0 to
0.9296, est err 0.12093]

if
  Band2 <= 61
  Band3 <= 43
  Band4 <= 78
  Band5 > 65
then
  Band Agg = -1.1373 + 0.033 Band7 - 0.027
Band5 + 0.04 Band3
  + 0.012 Band4

Rule 5: [253 cases, mean 0.24109, range 0 to
0.8322, est err 0.12819]

if
  Band1 > 75
  Band3 <= 43
  Band4 > 78
then
  Band Agg = 0.9137 - 0.013 Band5 + 0.014
Band7 - 0.02 Band2 + 0.02 Band3

Rule 6: [1090 cases, mean 0.35555, range 0 to
1, est err 0.19715]

if
  Band1 > 75
  Band2 > 1
  Band2 <= 61
  Band3 > 43
then
  Band Agg = 0.188 - 0.013 Band5 + 0.012
Band7 + 0.01 Band1

Rule 7: [734 cases, mean 2.76638, range 0 to
124, est err 0.17873]

if
  Band1 > 41
  Band5 <= 41
  Band7 <= 87
then
  Band Agg = -66.91299 - 14.63 Band2 +
2.551 Band5 + 2 Band4 + 1.15 Band1
  - 1.54 Band3 + 0.805 Band7

Rule 8: [286 cases, mean 4.10044, range 0 to
69, est err 0.54860]

if
  Band1 > 15
  Band4 <= 24
then
  Band Agg = -18.35374 - 2.6 Band2 + 1.077
Band4 + 0.487 Band5
  + 0.422 Band7 + 0.34 Band1 -
0.04 Band3

Rule 9: [106 cases, mean 4.30189, range 0 to
16, est err 0.49087]

if
  Band2 <= 1
  Band7 <= 15
then
  Band Agg = 0 + 0.362 Band5 + 0.147 Band4
+ 0.04 Band7 + 0.03 Band3

Rule 10: [219 cases, mean 12.24658, range 0 to
39, est err 1.55379]

if
  Band1 <= 41
  Band2 <= 1
  Band7 <= 32
then
  Band Agg = -14.464 + 0.652 Band7 + 0.51
Band1 + 0.22 Band3

Rule 11: [21 cases, mean 13.23212, range 0.5627
to 48, est err 3.57309]

if
  Band2 > 61
  Band7 <= 88
then
  Band Agg = -4.80461 + 0.24 Band7 - 0.26
Band1 + 0.195 Band4 + 0.24 Band2
  - 0.11 Band3 - 0.029 Band5

Rule 12: [85 cases, mean 18.10588, range 10 to
39, est err 2.73966]

if
  Band1 <= 15
  Band4 <= 24
  Band7 > 15
then
  Band Agg = 1.126 + 0.72 Band1 + 0.361
Band7 - 0.16 Band2 + 0.035 Band5
  - 0.026 Band4

Rule 13: [26 cases, mean 38.19231, range 12 to
88, est err 6.87913]

if
  Band1 <= 10
  Band2 <= 1
  Band4 > 24
  Band7 <= 87
then
  Band Agg = -13.674 - 2.54 Band1 + 1.404
Band4 + 0.418 Band7
  + 0.176 Band5

Rule 14: [26 cases, mean 48.57692, range 29 to
75, est err 7.59709]

if
  Band1 > 10
  Band1 <= 18
  Band4 > 24
  Band7 > 32
  Band7 <= 87
then
  Band Agg = -20.495 + 17.91 Band2 + 1.32
Band1 + 0.577 Band5
  + 0.429 Band7 + 0.135 Band4 +
0.02 Band3

```

Rule 15: [80 cases, mean 49.77500, range 15 to 116, est err 2.28877]

 if
 Band1 <= 0.8058
 Band2 > 61
 Band5 <= 122
 then
 Band Agg = -10.158 + 0.476 Band4 + 0.332
 Band7 + 0.17 Band3
 - 0.049 Band5

Rule 16: [21 cases, mean 51.28571, range 41 to 117, est err 7.17860]

 if
 Band2 > 61
 Band5 > 122
 Band7 > 88
 then
 Band Agg = 14.81962 + 0.346 Band7 - 0.278
 Band5 + 0.45 Band3
 - 0.14 Band1 + 0.09 Band2 +
 0.044 Band4

Rule 17: [36 cases, mean 57.22222, range 34 to 84, est err 4.87218]

 if
 Band1 > 18
 Band1 <= 41
 Band4 <= 27
 Band7 > 32
 Band7 <= 87
 then
 Band Agg = -2.988 + 0.97 Band1 - 1.37
 Band2 + 0.479 Band7 + 0.313 Band5
 - 0.207 Band4 + 0.05 Band3

Rule 18: [39 cases, mean 60.05128, range 45 to 73, est err 2.86100]

 if
 Band1 <= 15
 Band5 <= 27
 Band7 > 87
 then
 Band Agg = 12 + 1.24 Band5 - 0.62 Band1 +
 0.26 Band7 - 0.02 Band2

Rule 19: [524 cases, mean 63.61450, range 54 to 73, est err 2.32720]

 if
 Band1 > 15
 Band1 <= 22
 Band5 <= 20
 Band7 > 87
 then
 Band Agg = -2.36775 - 12.57 Band2 + 0.952
 Band5 + 0.677 Band4
 + 0.73 Band1 + 0.145 Band7

Rule 20: [96 cases, mean 65.02084, range 54 to 95, est err 4.82629]

 if
 Band1 <= 30
 Band2 > 0.0295
 Band5 <= 27
 Band7 > 87
 then
 Band Agg = -3.33456 + 4.317 Band5 - 2.616
 Band4 - 3.41 Band2
 + 0.578 Band7 - 0.17 Band3 +
 0.06 Band1

Rule 21: [39 cases, mean 65.79487, range 44 to 88, est err 5.66096]

 if
 Band1 > 10
 Band4 > 27
 Band5 <= 28
 Band7 > 32
 Band7 <= 87
 then
 Band Agg = 16.80194 - 0.9 Band2 + 0.501
 Band7 + 0.322 Band5
 - 0.073 Band4 + 0.08 Band1

Rule 22: [68 cases, mean 66.42647, range 46 to 81, est err 3.43716]

 if
 Band1 > 15
 Band1 <= 22
 Band5 > 20
 Band5 <= 27
 Band7 > 87
 Band7 <= 105
 then
 Band Agg = 5.926 - 9.88 Band2 + 1.949
 Band5 - 0.405 Band4 + 0.405 Band7
 + 0.44 Band1 - 0.31 Band3

Rule 23: [59 cases, mean 67.15254, range 56 to 93, est err 5.29278]

 if
 Band1 > 30
 Band5 <= 27
 Band7 > 87
 then
 Band Agg = 16.61428 - 16.32 Band2 + 1.742
 Band5 + 0.59 Band1
 - 0.154 Band4 - 0.25 Band3 +
 0.118 Band7

Rule 24: [132 cases, mean 68.63636, range 46 to 90, est err 3.76410]

 if
 Band1 > 15
 Band1 <= 22
 Band5 > 20
 Band7 > 87
 then
 Band Agg = 10.292 + 0.745 Band5 + 0.75
 Band1 + 0.246 Band7

Rule 25: [62 cases, mean 70.87096, range 60 to 92, est err 4.31992]

 if
 Band1 > 22
 Band1 <= 30
 Band2 <= 0.0295
 Band5 <= 27
 Band7 > 87
 then
 Band Agg = 7.20293 + 3.355 Band5 - 1.96
 Band2 - 0.146 Band4 - 0.1 Band3
 + 0.031 Band7

Rule 26: [27 cases, mean 75.33334, range 53 to 118, est err 8.23978]

 if
 Band1 <= 22
 Band2 <= 1
 Band5 > 27
 Band7 > 87
 then
 Band Agg = 97.8 + 3.48 Band5 - 2.57 Band2
 - 1.61 Band3 - 0.89 Band1
 - 0.375 Band4 + 0.075 Band7

Rule 27: [25 cases, mean 75.80000, range 52 to 103, est err 8.20942]

 if
 Band1 > 18
 Band1 <= 41
 Band3 <= 72
 Band5 > 28
 Band7 <= 87
 then
 Band Agg = 21.63092 - 10.15 Band2 + 2.547
 Band5 - 1.223 Band4
 + 0.464 Band7 + 0.57 Band1 -
 0.56 Band3

Rule 28: [51 cases, mean 81.19608, range 62 to 110, est err 6.05295]

 if
 Band1 > 18
 Band1 <= 41
 Band3 > 72
 Band7 <= 87
 then
 Band Agg = 31.06632 - 13.31 Band2 + 0.818
 Band5 - 0.376 Band4

```

+ 0.43 Band1 + 0.205 Band7 +
0.09 Band3

Rule 29: [37 cases, mean 82.41002, range 0.0071
to 166, est err 8.13720]
if
  Band1 > 22
  Band5 > 27
  Band7 > 87
  Band7 <= 100
then
  Band Agg = -142.6181 - 49 Band2 + 1.986
Band7 + 1.571 Band5
  + 0.992 Band4 + 0.58 Band1 -
0.64 Band3

Rule 30: [34 cases, mean 91.52941, range 49 to
122, est err 2.29419]
if
  Band1 > 0.8058
  Band2 > 61
  Band7 > 88
then
  Band Agg = 5.43 + 0.579 Band7 - 0.365
Band5 + 0.48 Band3

Rule 31: [34 cases, mean 97.70588, range 68 to
143, est err 11.60151]
if
  Band1 > 41
  Band2 <= 1
  Band5 > 41
  Band7 <= 87
then
  Band Agg = 52.936 - 4.037 Band4 + 3.346
Band5 + 0.322 Band7 + 0.26 Band3
  + 0.09 Band1

Rule 32: [27 cases, mean 124.33334, range 85 to
182, est err 7.98777]
if
  Band1 > 22
  Band2 <= 1
  Band5 > 27
  Band7 > 100
then
  Band Agg = -29.99508 - 92.01 Band2 +
1.105 Band5 + 1.62 Band3
  - 0.113 Band4 + 0.037 Band7 +
0.03 Band1

Evaluation on hold-out data (761 cases):
Mean |error| 1.14124

[ Fold 9 ]
Model:
Rule 1: [1789 cases, mean 0.02020, range 0 to
0.4977, est err 0.02026]
if
  Band1 <= 78
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = 0.0004

Rule 2: [1873 cases, mean 0.03056, range 0 to
1, est err 0.02620]
if
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = -1.6005 + 0.028 Band7 + 0.02
Band1 - 0.011 Band5

Rule 3: [1469 cases, mean 0.10139, range 0 to
0.8826, est err 0.09826]
if
  Band1 <= 75
  Band2 > 1
  Band2 <= 61

Band5 > 65
then
  Band Agg = 0.0234

Rule 4: [499 cases, mean 0.15466, range 0 to
0.9296, est err 0.11893]
if
  Band1 > 75
  Band3 <= 39
  Band5 > 65
then
  Band Agg = 0.2557 - 0.04 Band2 + 0.04
Band3 - 0.016 Band5 + 0.016 Band7
  + 0.009 Band4

Rule 5: [1433 cases, mean 0.31224, range 0 to
1, est err 0.19013]
if
  Band1 > 75
  Band2 > 1
  Band2 <= 61
  Band3 > 39
  Band5 > 65
then
  Band Agg = 0.104 - 0.015 Band5 + 0.017
Band7 + 0.02 Band2

Rule 6: [628 cases, mean 0.34571, range 0 to 1,
est err 0.22930]
if
  Band1 > 75
  Band2 > 1
  Band4 <= 66
  Band5 > 65
then
  Band Agg = -0.8061 + 0.02 Band1 - 0.008
Band5

Rule 7: [106 cases, mean 4.37736, range 0 to
16, est err 0.48809]
if
  Band2 <= 1
  Band7 <= 15
then
  Band Agg = 0 + 0.353 Band5 + 0.276 Band7
- 0.21 Band2 + 0.069 Band4

Rule 8: [440 cases, mean 5.87690, range 0 to
124, est err 0.49404]
if
  Band1 > 38
  Band4 > 24
  Band5 <= 38
  Band7 <= 87
then
  Band Agg = -18.68854 - 13.31 Band2 +
3.182 Band5 + 0.78 Band1
  + 0.476 Band7 - 0.88 Band3 -
0.255 Band4

Rule 9: [51 cases, mean 16.31373, range 11 to
24, est err 1.82022]
if
  Band1 <= 13
  Band3 > 57
  Band4 <= 24
  Band7 > 15
then
  Band Agg = -11.524 + 4.39 Band2 + 0.78
Band1 + 0.272 Band7 + 0.23 Band3
  + 0.014 Band5

Rule 10: [36 cases, mean 23.33333, range 16 to
35, est err 2.10031]
if
  Band1 > 10
  Band1 <= 18
  Band4 > 24
  Band7 <= 51
then
  Band Agg = -12.24 + 0.558 Band4 + 0.6
Band1 + 0.353 Band7 + 0.09 Band5

Rule 11: [40 cases, mean 25.77500, range 10 to
69, est err 3.77189]

```

```

if      Band2 <= 1
      Band3 <= 57
      Band4 <= 24
      Band7 > 15
    then
      Band Agg = -1.581 + 0.771 Band5 - 1.44
      Band2 + 0.456 Band7 - 0.313 Band4
      + 0.38 Band1 - 0.06 Band3
    Rule 12: [35 cases, mean 34.34286, range 13 to
69, est err 5.96107]

if      Band1 > 13
      Band2 <= 1
      Band4 <= 24
      Band7 > 15
    then
      Band Agg = 3.88693 - 1.33 Band2 + 0.58
      Band1 + 0.447 Band7 + 0.336 Band5
      - 0.153 Band4 - 0.03 Band3
    Rule 13: [23 cases, mean 36.17391, range 12 to
88, est err 8.98068]

if      Band1 <= 10
      Band2 <= 1
      Band4 > 24
      Band7 <= 87
    then
      Band Agg = -13.279 - 2.21 Band1 + 1.212
      Band4 + 0.441 Band7
      + 0.235 Band5
    Rule 14: [75 cases, mean 41.33333, range 0 to
91, est err 4.05889]

if      Band1 > 18
      Band1 <= 38
      Band2 <= 0.4198
      Band3 <= 64
      Band7 <= 87
    then
      Band Agg = -24.50118 + 1.815 Band5 - 1.36
      Band2 + 0.7 Band1 + 0.52 Band7
      - 0.187 Band4 - 0.09 Band3
    Rule 15: [93 cases, mean 49.03226, range 15 to
117, est err 2.92579]

if      Band1 <= 0.6099
      Band2 > 61
    then
      Band Agg = -10.14765 + 5.06 Band1 + 0.395
      Band4 + 0.35 Band7
      + 0.17 Band3 - 0.049 Band5
    Rule 16: [23 cases, mean 50.17391, range 33 to
75, est err 6.24420]

if      Band1 > 10
      Band1 <= 18
      Band4 > 24
      Band7 > 51
      Band7 <= 87
    then
      Band Agg = 12.664 + 1.374 Band5 + 0.72
      Band1 + 0.384 Band7 - 0.63 Band2
      - 0.48 Band3 - 0.086 Band4
    Rule 17: [35 cases, mean 59.91429, range 45 to
73, est err 2.99800]

if      Band1 <= 15
      Band5 <= 21
      Band7 > 87
    then
      Band Agg = 36.371 - 0.55 Band1 + 0.24
      Band7 - 0.36 Band2 + 0.071 Band5
    Rule 18: [619 cases, mean 64.15509, range 46 to
77, est err 2.48738]

if      Band1 > 15
      Band1 <= 23
      Band5 <= 21
      Band7 > 87
    then
      Band Agg = -10.658 - 12.21 Band2 + 1.476
      Band5 + 0.82 Band1
      + 0.512 Band4 + 0.154 Band7
    Rule 19: [58 cases, mean 64.85574, range 0.5627
to 122, est err 4.43610]

if      Band1 > 0.6099
      Band2 > 61
    then
      Band Agg = -10.1214 + 0.677 Band7 - 0.421
      Band5 + 0.24 Band2
      + 0.123 Band4 - 0.1 Band1
    Rule 20: [24 cases, mean 65.16666, range 50 to
85, est err 6.14922]

if      Band1 > 23
      Band5 <= 21
      Band7 > 87
      Band7 <= 96
    then
      Band Agg = -196.24079 + 4.561 Band5 +
      1.916 Band7 - 1.24 Band2
      - 0.23 Band1 + 0.022 Band4 -
      0.03 Band3
    Rule 21: [42 cases, mean 65.57143, range 55 to
85, est err 4.35953]

if      Band1 > 23
      Band5 <= 21
      Band7 > 96
    then
      Band Agg = -64.81737 + 4.502 Band5 - 2.27
      Band2 + 0.369 Band7
      + 0.06 Band1 + 0.034 Band4 -
      0.02 Band3
    Rule 22: [39 cases, mean 67.51282, range 23 to
103, est err 6.21736]

if      Band1 > 18
      Band1 <= 38
      Band2 <= 0.4198
      Band3 > 64
      Band4 <= 35
      Band7 <= 87
    then
      Band Agg = -73.405 + 1.413 Band5 + 0.559
      Band7 + 0.89 Band3
      - 0.131 Band4 + 0.02 Band1
    Rule 23: [32 cases, mean 71.00000, range 53 to
118, est err 7.76876]

if      Band1 <= 19
      Band2 <= 1
      Band5 > 21
      Band7 > 87
    then
      Band Agg = 49.354 + 4.82 Band5 - 5.246
      Band4 - 1.6 Band2 - 1.01 Band1
      + 0.753 Band7 - 0.13 Band3
    Rule 24: [48 cases, mean 72.79166, range 58 to
95, est err 5.80438]

if      Band1 > 19
      Band1 <= 30
      Band5 > 21
      Band5 <= 28
      Band7 > 87
      Band7 <= 102
    then
      Band Agg = -37.27683 - 14.11 Band2 +
      4.857 Band5 - 2.038 Band4
      + 1.35 Band1 + 1.059 Band7 -
      1.3 Band3
    Rule 25: [54 cases, mean 73.46296, range 58 to
134, est err 7.57240]

if      Band1 > 30

```

```

Band1 <= 43
Band5 > 21
Band7 > 87
then
  Band Agg = 29.85076 - 40.83 Band2 + 3.024
Band5 - 1.914 Band4
      + 0.92 Band1 + 0.272 Band7 -
0.4 Band3

Rule 26: [20 cases, mean 74.55000, range 52 to
110, est err 8.76130]

if
  Band1 > 18
  Band1 <= 38
  Band2 > 0.4198
  Band4 > 24
  Band7 <= 87
then
  Band Agg = 0.69745 - 3.76 Band2 + 1.739
Band5 - 0.776 Band4
      + 0.644 Band7 + 0.36 Band1 -
0.18 Band3

Rule 27: [41 cases, mean 75.48781, range 58 to
111, est err 6.51712]

if
  Band1 <= 30
  Band2 <= 1
  Band5 > 21
  Band7 > 102
then
  Band Agg = 16.78476 + 2.74 Band1 - 2.44
Band2 + 0.514 Band5
      - 0.171 Band4 - 0.22 Band3 +
0.078 Band7

Rule 28: [22 cases, mean 80.45454, range 63 to
107, est err 7.96035]

if
  Band1 > 19
  Band1 <= 30
  Band5 > 28
  Band7 > 87
  Band7 <= 102
then
  Band Agg = -49.808 + 3.822 Band5 - 1.701
Band4 + 1.43 Band1
      + 1.149 Band7 - 1.15 Band3

Rule 29: [46 cases, mean 81.10870, range 69 to
103, est err 5.38034]

if
  Band1 > 18
  Band1 <= 38
  Band2 <= 0.4198
  Band4 > 35
then
  Band Agg = -4.846 + 1.445 Band5 - 0.893
Band4 + 0.514 Band7 + 0.34 Band1
      + 0.15 Band3

Rule 30: [35 cases, mean 97.77143, range 47 to
143, est err 11.36409]

if
  Band1 > 38
  Band2 <= 1
  Band5 > 38
  Band7 <= 87
then
  Band Agg = 28.37 + 2.767 Band5 - 3.129
Band4 + 0.531 Band7 + 0.29 Band3
      + 0.05 Band1

Rule 31: [29 cases, mean 123.75862, range 66 to
166, est err 10.11605]

if
  Band1 > 43
  Band2 <= 1
  Band5 > 21
  Band7 > 87
then
  Band Agg = 55.86784 - 51.51 Band2 + 1.888
Band5 - 0.512 Band4
      + 0.119 Band7 + 0.12 Band1

Evaluation on hold-out data (762 cases):

```

Mean |error| 0.87907

[Fold 10]

Model:

Rule 1: [1810 cases, mean 0.01908, range 0 to 0.4977, est err 0.01913]

```

if
  Band1 <= 78
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = 0.0004

```

Rule 2: [1904 cases, mean 0.03108, range 0 to 1, est err 0.02519]

```

if
  Band2 > 1
  Band2 <= 61
  Band5 <= 65
then
  Band Agg = -2.6208 + 0.03 Band1 + 0.015
Band7

```

Rule 3: [1275 cases, mean 0.04591, range 0 to 0.9296, est err 0.04485]

```

if
  Band1 <= 87
  Band2 > 1
  Band2 <= 61
  Band4 <= 66
then
  Band Agg = -0.786 + 0.01 Band1

```

Rule 4: [1408 cases, mean 0.09651, range 0 to 0.8826, est err 0.09415]

```

if
  Band1 <= 74
  Band2 > 1
  Band2 <= 61
  Band5 > 65
then
  Band Agg = 0.0209

```

Rule 5: [87 cases, mean 0.12270, range 0 to 0.5684, est err 0.09979]

```

if
  Band1 > 74
  Band3 <= 39
  Band4 > 95
then
  Band Agg = 0.0799

```

Rule 6: [879 cases, mean 0.14760, range 0 to 0.9296, est err 0.12992]

```

if
  Band2 <= 61
  Band3 <= 39
  Band4 <= 95
  Band5 > 65
then
  Band Agg = 0.0553 + 0.025 Band7 - 0.02
Band5 - 0.04 Band2 + 0.04 Band3
      + 0.012 Band4

```

Rule 7: [222 cases, mean 0.17553, range 0 to 1, est err 0.11567]

```

if
  Band1 > 74
  Band2 > 1
  Band2 <= 61
  Band7 > 69
then
  Band Agg = -0.5216 + 0.05 Band2 + 0.018
Band7 - 0.013 Band5 - 0.02 Band3

```

Rule 8: [719 cases, mean 0.29452, range 0 to 1, est err 0.18417]

```

if
  Band1 > 74
  Band3 > 39
  Band4 > 66

```

```

        Band7 <= 69
    then
        Band Agg = 0.959 + 0.018 Band7 - 0.015
Band5

    Rule 9: [321 cases, mean 0.54877, range 0 to 1,
est err 0.24948]

    if
        Band1 > 87
        Band4 <= 66
        Band5 > 65
        Band7 <= 69
    then
        Band Agg = -0.0166 + 0.03 Band1 - 0.022
Band4 - 0.018 Band7

    Rule 10: [102 cases, mean 3.93137, range 0 to
16, est err 0.49879]

    if
        Band2 <= 1
        Band7 <= 15
    then
        Band Agg = 0 + 0.621 Band5 + 0.28 Band2 +
0.043 Band7 - 0.028 Band4
        + 0.01 Band1

    Rule 11: [446 cases, mean 5.60467, range 0 to
124, est err 0.35542]

    if
        Band1 > 38
        Band4 > 24
        Band5 <= 38
        Band7 <= 87
    then
        Band Agg = -1.52 - 21.48 Band2 + 2.647
Band5 + 1.65 Band1 - 0.9 Band3
        - 0.176 Band4 + 0.046 Band7

    Rule 12: [212 cases, mean 11.95755, range 0 to
37, est err 1.63223]

    if
        Band1 <= 38
        Band2 <= 1
        Band7 <= 30
    then
        Band Agg = -19.134 + 0.54 Band1 + 0.43
Band3 + 0.105 Band7 + 0.064 Band5
        + 0.013 Band4

    Rule 13: [20 cases, mean 14.38667, range 0.5627
to 52, est err 3.35556]

    if
        Band2 > 61
        Band7 <= 90
    then
        Band Agg = -5.62378 + 0.295 Band7 - 0.32
Band1 + 0.26 Band3
        - 0.096 Band5 + 0.18 Band2 +
0.036 Band4

    Rule 14: [113 cases, mean 23.65487, range 10 to
69, est err 3.39516]

    if
        Band2 <= 1
        Band4 <= 24
        Band7 > 15
    then
        Band Agg = -1.566 + 0.84 Band1 - 1.07
Band2 + 0.432 Band7 + 0.202 Band5
        - 0.1 Band4 - 0.02 Band3

    Rule 15: [25 cases, mean 40.12000, range 18 to
88, est err 7.71170]

    if
        Band1 <= 10
        Band2 <= 1
        Band4 > 24
        Band7 <= 87
    then
        Band Agg = -4.4212 - 2.21 Band1 + 0.931
Band4 + 0.441 Band7
        + 0.256 Band5 - 0.14 Band2

    Rule 16: [45 cases, mean 42.75555, range 19 to
75, est err 5.08417]

```

```

        if
            Band1 > 10
            Band1 <= 19
            Band7 > 30
            Band7 <= 87
        then
            Band Agg = -23.286 + 31.43 Band2 + 2.08
Band1 + 1.271 Band4
            + 0.361 Band7 + 0.237 Band5 -
0.45 Band3

    Rule 17: [76 cases, mean 50.94737, range 19 to
116, est err 2.18498]

    if
        Band1 <= 0.7775
        Band2 > 61
        Band5 <= 119
    then
        Band Agg = -15.11622 + 2.52 Band1 + 0.344
Band7 + 0.53 Band3
            + 0.243 Band4 - 0.037 Band5 -
0.04 Band2

    Rule 18: [23 cases, mean 51.78261, range 41 to
117, est err 6.40580]

    if
        Band2 > 61
        Band5 > 119
        Band7 > 90
    then
        Band Agg = 0.305 + 0.382 Band7 + 0.44
Band3 - 0.183 Band5 + 0.184 Band4

    Rule 19: [30 cases, mean 53.83333, range 23 to
67, est err 4.58943]

    if
        Band1 > 19
        Band1 <= 38
        Band4 > 24
        Band5 <= 28
        Band7 <= 80
    then
        Band Agg = 33.185 + 2.308 Band4 + 1.535
Band5 - 1.69 Band3 + 0.46 Band7

    Rule 20: [40 cases, mean 59.75000, range 45 to
73, est err 2.93609]

    if
        Band1 <= 15
        Band5 <= 21
        Band7 > 87
    then
        Band Agg = 36.71 - 0.55 Band1 + 0.238
Band7 - 0.34 Band2 + 0.066 Band5

    Rule 21: [36 cases, mean 63.50000, range 54 to
77, est err 4.43706]

    if
        Band1 <= 23
        Band2 > 0.06
        Band5 <= 21
        Band7 > 87
    then
        Band Agg = 20.83471 - 9.42 Band2 + 3.106
Band5 - 0.93 Band3
            + 0.335 Band7 + 0.35 Band1 -
0.17 Band4

    Rule 22: [22 cases, mean 63.90909, range 50 to
85, est err 5.89703]

    if
        Band1 > 23
        Band5 <= 21
        Band7 > 87
        Band7 <= 96
    then
        Band Agg = -202.17354 + 4.535 Band5 +
1.879 Band7 - 0.23 Band2
            + 0.016 Band4

    Rule 23: [57 cases, mean 63.94737, range 54 to
86, est err 4.18343]

    if
        Band1 <= 43
        Band2 > 0.2142
        Band2 <= 1

```

```

Band4 <= 30
Band7 > 87
then
  Band Agg = 14.52916 - 8.32 Band2 + 2.367
Band5 - 0.842 Band4
      + 0.449 Band7 - 0.52 Band3 +
0.3 Band1

Rule 24: [579 cases, mean 64.07944, range 46 to
77, est err 2.37008]

if
  Band1 > 15
  Band1 <= 23
  Band2 <= 0.06
  Band5 <= 21
  Band7 > 87
then
  Band Agg = -12.31098 + 1.395 Band5 + 0.69
Band4 + 0.84 Band1
      + 0.136 Band7 - 0.17 Band2

Rule 25: [44 cases, mean 65.50000, range 55 to
85, est err 4.19730]

if
  Band1 > 23
  Band5 <= 21
  Band7 > 96
then
  Band Agg = -48.328 + 3.869 Band5 - 3.64
Band2 + 0.298 Band7
      + 0.148 Band4 + 0.07 Band1

Rule 26: [37 cases, mean 68.54054, range 55 to
88, est err 7.16354]

if
  Band1 > 19
  Band5 <= 28
  Band7 > 80
  Band7 <= 87
then
  Band Agg = -0.027 + 1.051 Band5 - 0.569
Band4 + 0.537 Band7 + 0.3 Band1
      + 0.05 Band3

Rule 27: [30 cases, mean 71.20000, range 53 to
118, est err 7.99695]

if
  Band1 <= 19
  Band2 <= 1
  Band5 > 21
  Band7 > 87
then
  Band Agg = 96.724 + 5.655 Band5 - 4.1
Band4 - 1.72 Band3 - 1.1 Band1
      + 0.768 Band7 - 0.14 Band2

Rule 28: [53 cases, mean 73.16982, range 58 to
90, est err 5.44594]

if
  Band1 > 19
  Band1 <= 23
  Band5 > 21
  Band7 > 87
then
  Band Agg = 71.47283 + 1.586 Band5 - 1.67
Band2 + 0.85 Band4 - 1.4 Band3
      + 0.232 Band7 + 0.03 Band1

Rule 29: [60 cases, mean 75.11667, range 43 to
100, est err 7.61469]

if
  Band1 > 23
  Band2 <= 0.2142
  Band4 <= 30
  Band5 > 21
then
  Band Agg = 62.37604 - 23.43 Band2 + 4.161
Band5 - 2.369 Band4
      - 1.27 Band3 + 0.581 Band7 +
0.25 Band1

Rule 30: [43 cases, mean 77.20930, range 52 to
103, est err 6.23848]

if
  Band1 > 19
  Band1 <= 38
  Band3 <= 79
  Band5 > 28
  Band7 <= 87
then
  Band Agg = 30.13355 - 7.36 Band2 + 2.581
Band5 - 1.275 Band4 + 0.5 Band7
      - 0.66 Band3 + 0.42 Band1

Rule 31: [22 cases, mean 82.77273, range 67 to
110, est err 9.77725]

if
  Band1 <= 38
  Band3 > 79
  Band7 <= 87
then
  Band Agg = 89.14768 - 2.953 Band4 + 2.245
Band5 + 0.206 Band7
      - 0.08 Band2 + 0.05 Band3 -
0.03 Band1

Rule 32: [41 cases, mean 83.68293, range 67 to
134, est err 8.54398]

if
  Band1 > 23
  Band1 <= 43
  Band4 > 30
  Band7 > 87
then
  Band Agg = 32.96097 - 30.07 Band2 + 3.532
Band5 - 3.725 Band4
      + 0.916 Band7 - 0.28 Band3 +
0.13 Band1

Rule 33: [30 cases, mean 92.20000, range 49 to
122, est err 1.89523]

if
  Band1 > 0.7775
  Band2 > 61
  Band5 <= 119
  Band7 > 90
then
  Band Agg = -1.857 + 0.617 Band7 - 0.31
Band5 + 0.24 Band3 + 0.11 Band2

Rule 34: [39 cases, mean 99.02564, range 47 to
143, est err 11.86320]

if
  Band1 > 38
  Band2 <= 1
  Band5 > 38
  Band7 <= 87
then
  Band Agg = 33.086 - 16.25 Band2 - 5.022
Band4 + 3.461 Band5
      + 0.517 Band7 + 0.93 Band3 +
0.07 Band1

Rule 35: [29 cases, mean 123.55173, range 66 to
182, est err 11.18024]

if
  Band1 > 43
  Band2 <= 1
  Band5 > 21
  Band7 > 87
then
  Band Agg = 47.22772 - 48.33 Band2 + 2.154
Band5 - 0.959 Band4
      + 0.206 Band7 + 0.22 Band1

Evaluation on hold-out data (762 cases):

Mean |error| 1.01873

Summary:
Average |error| 1.04996
Relative |error| 0.05
Correlation coefficient 0.99

Time: 3.5 secs

```