Announcing IDRISI Taiga

Clark Labs is pleased to announce the release of the 16th version of its flagship IDRISI GIS and Image Processing System. Among the major new features of the Taiga Edition are the Earth Trends Modeler and a suite of segment-based image classification tools.

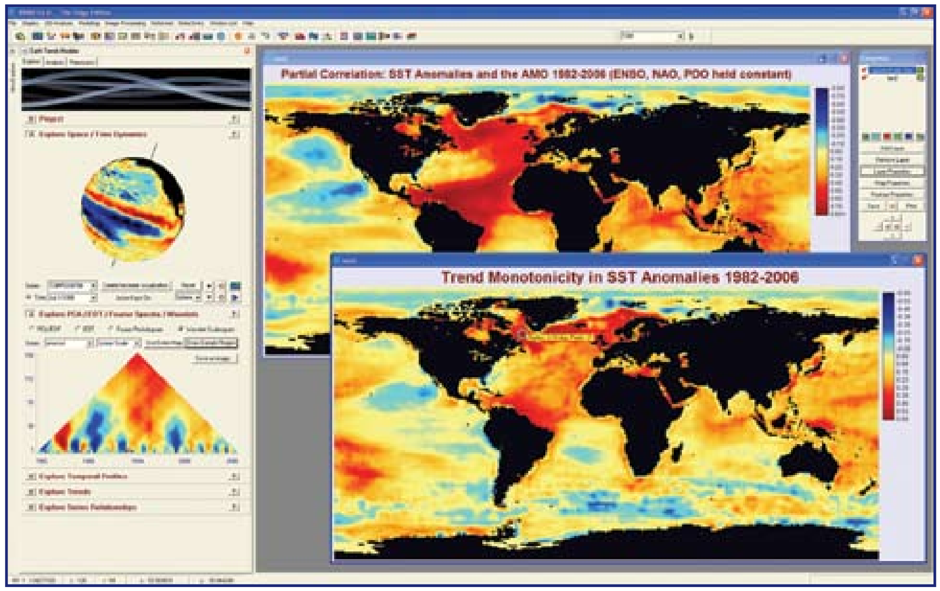


Figure 1: An analysis of trends in sea surface temperature from 1982 to 2006. The strong monotonic trend of increasing temperature in the Atlantic is seen to be related to the Atlantic Multidecadal Oscillation (AMO) as determined from a temporal regression with four major climate teleconnection indices. The triangular wavelet analysis diagram shows the nature and scale of variations in sea surface temperature in the Labrador Sea. The animated globe shows variations in ocean height which are closely related with temperature variations.

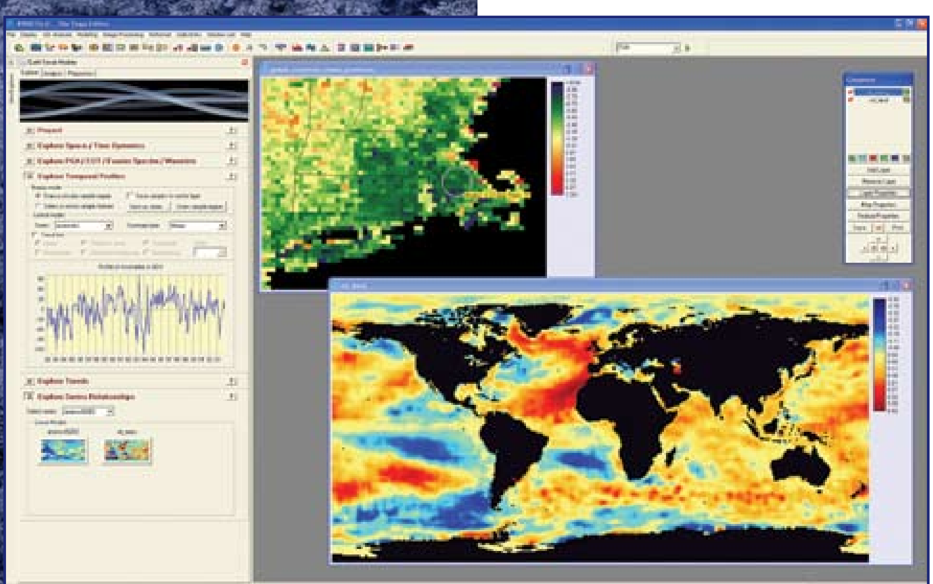


Figure 2: An example of temporal profiling (of NDVI anomalies in southeast Massachusetts) followed by subsequent analysis of its relationship with global sea surface temperatures using the linear modeling tool.

The Earth Trends Modeler

The Earth Trends Modeler (ETM) is specially designed for the analysis of image time series from earth observing systems such as the instruments on NASA's Terra and Aqua satellites or the NASA/JAXA TRMM (Tropical Rainfall Measuring Mission) satellite. It includes a coordinated suite of data mining tools for the extraction of trends and underlying determinants of variability, and will be of special importance to scientists focused on climate change and ecosystem dynamics.

The Earth Trends Modeler is a major addition to the IDRISI analytical system and has been created as a special application in the same manner as the Land Change Modeler. Developed, in part, under grants from the Gordon and Betty Moore Foundation and Google.org, ETM provides a critical set of tools for the scientific examination of Earth Observation imagery, such as that provided

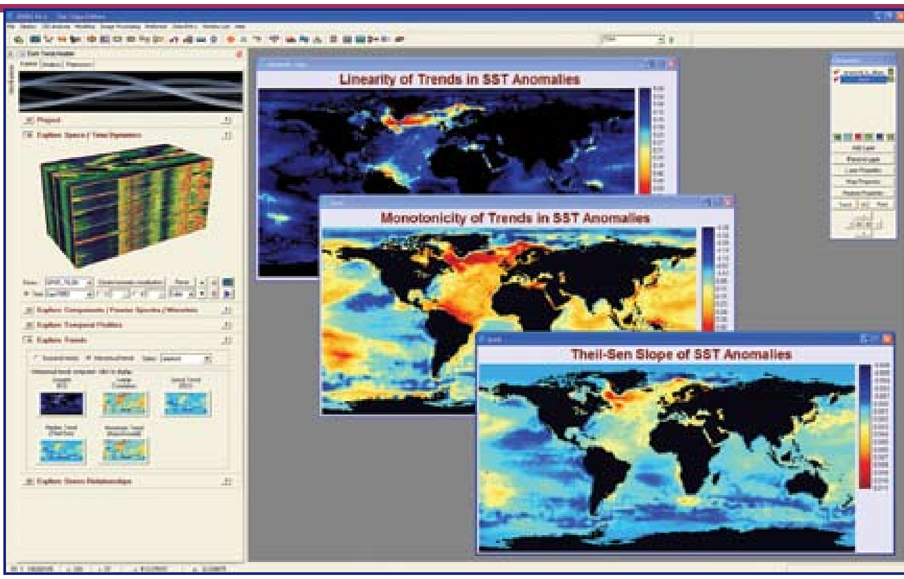


Figure 3: An illustration of several trend measures. The top image measures linearity in trends in sea surface temperature. As can be seen, the most linear trends include increases in the East and West Greenland currents and the Labrador Sea (all parts of the North Atlantic Subpolar Gyre), and the region at the mouth of the Amazon, most particularly, the Orinoco River.

through NASA's EOS program. However, the tools are also very easy to use so that they are appropriate for use both in teaching and in demonstrating the dynamics of the earth system and in monitoring trends such as land and climate change.

Earth Trends Modeler allows you to:

* View animations of series in a space-time cube format, allowing views of the series over space, time and space-time.

* Analyze variability across varying temporal scales. For example, in the illustration in Figure 1, 25 years of monthly sea surface temperatures in the Labrador Sea are analyzed. The colors in the wavelet diagram indicate cooling or warming. The X axis represents time while the Y axis represents scale (in months). On time scales greater than approximately 6 years, we only see warming in this region. However, a major cooling event is seen in 1989 with an impact that lasted a little over 6 years. Similarly in 1998-2000, we see a cooling period that took 3 years to develop and recover. This procedure utilizes an Inverse-Haar Wavelet analysis.

* Extract profiles of the values over time for either a circular region of interest or by selecting a vector feature. The profile is normally viewed as a graph but it can also be stored as a new index time series. For example, in Figure 2, a profile is extracted of monthly anomalies in vegetation condition (NDVI) over the 22 year period from 1982-2003, and then saved as a series. This series is then used as the independent variable in a regression with sea surface temperature. The result indicates that the area of the ocean whose sea surface temperature anomalies most closely co-vary with vegetation anomalies in southeast

Taiga is the name of the world's largest biome – a vast circumpolar region south of the tundra zone in the northern hemisphere. Also known as the Boreal Forest, the taiga is predominantly covered by coniferous forest, commonly with poorly drained glacial depressions that form bogs (muskeg).

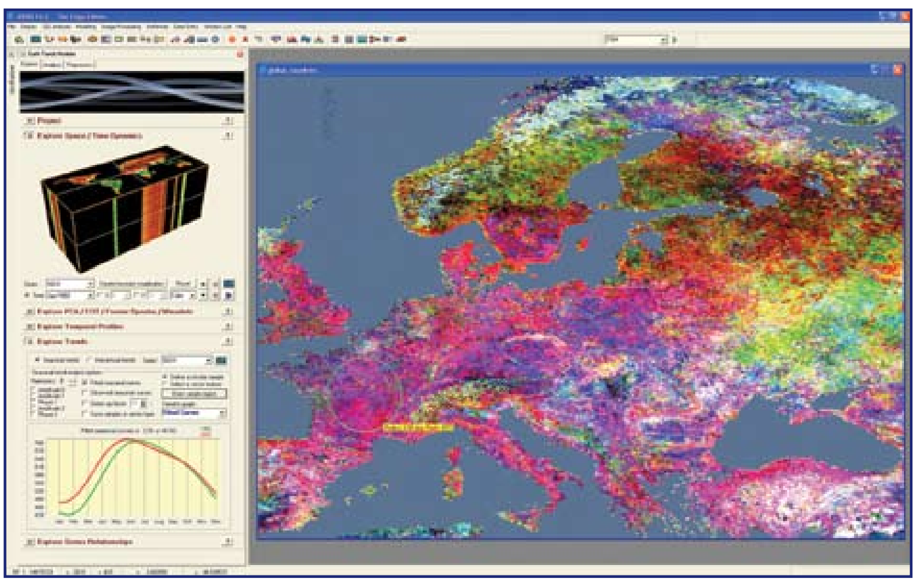
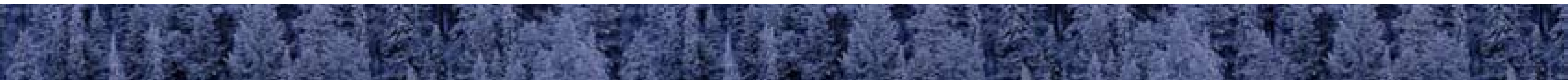


Figure 4: A Seasonal Trend Analysis of vegetation conditions in Europe for the period 1982-2003 based on an analysis of vegetation index imagery from the AVHRR instrument on the NOAA Polar Orbiter satellites (shown in the space-time visualization cube). The colors represent different types of trends in the seasonal curve of vegetation photosynthesis. The graph shows vegetation photosynthetic activity (Y-axis) for each of the 12 months (X-axis) of 1982 (in green) and 2003 (in red) for the area circled in France. As can be seen, the red color that is found over most of Europe relates to increased photosynthetic activity through the winter and spring. Note that by looking at the graph, one can see that spring is coming about a month earlier in 2003 than it was in 1982.



Massachusetts is the Canary Current off of Africa. Note that the Canary Current and the Gulf Stream are both important components of the North Atlantic Subtropical Gyre and commonly exhibit a dipole relationship in temperature.

* Analyze long-term trends with a variety of techniques for trend analysis, including measures of linearity, monotonicity, and trend rate (see Figure 3). A special trend estimation tool is also included that is robust to the effects of outliers. Known as a Theil-Sen Median Slope estimator, it is unaffected by wild values until they exceed 29% of the length of the series. Associated measures of trend non-parametric significance are also provided.

* Examine trends in seasonality, such as phenological change in plant species, with a newly developed procedure for Seasonal Trend Analysis. While vegetation phenology is an evident application, the tool can be applied to any data set that exhibits a seasonal response to environmental conditions. Figure 4 presents an illustration of this tool. The procedure combines the logic of Windowed Fourier Analysis with non-parametric trend analysis.

* Utilize Principal Components Analysis (also known as Empirical Orthogonal Function Analysis) for the decomposition of a series into its underlying constituents (Figure 5). PCA/EOF is probably the most commonly used procedure for the analysis of image time series as used in the geographic and climatological communities. Both standardized and unstandardized PCA are provided.

* Uncover characteristic patterns of variability over space-time with Empirical Orthogonal Teleconnection (EOT) analysis. EOTs are characteristic patterns over time. EOT relaxes the strict orthogonality of Principal Components Analysis (where the components are independent in both

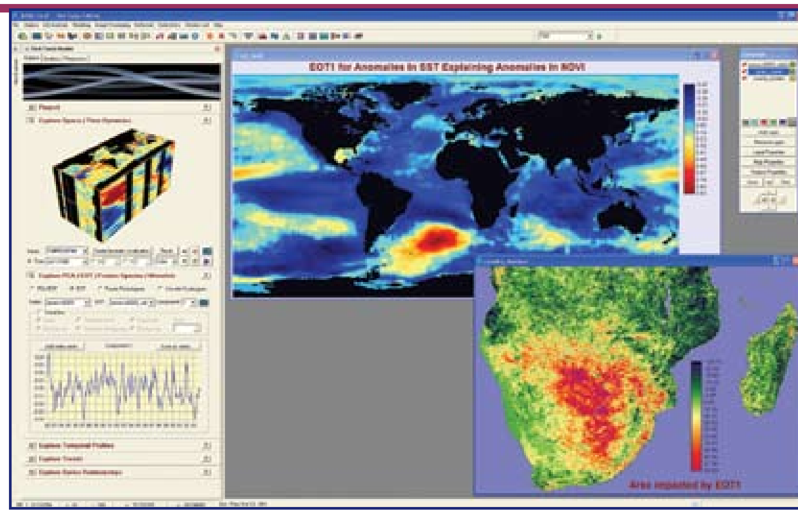


Figure 5: A Principal Components Analysis of monthly precipitation imagery from 1979-2006 reveals the impact of the El Nino / La Nina phenomenon. The loading chart at the left shows its evolution over time. The chart at the top left shows a space-time plot of precipitation anomalies over time (vertical dimension) and all longitudes (horizontal dimension) at the equator. This is also known as a Hovmoller plot.

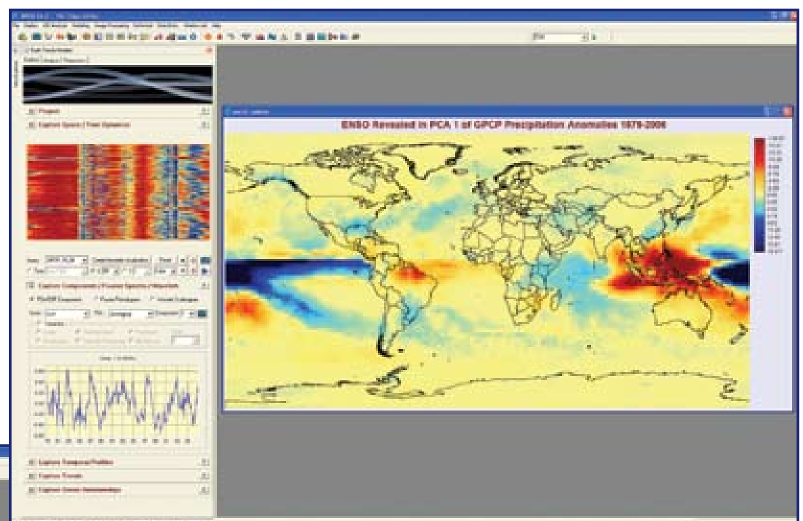


Figure 6 (above): The area in the oceans (top, yellow through red) determined to have the most significant impact on growing conditions in Southern Africa (bottom, the area in red experiencing the greatest impact). This mapping results from an analytical procedure known as Empirical Orthogonal Teleconnection analysis. Information such as this can be used in the development of Early Warning Systems.

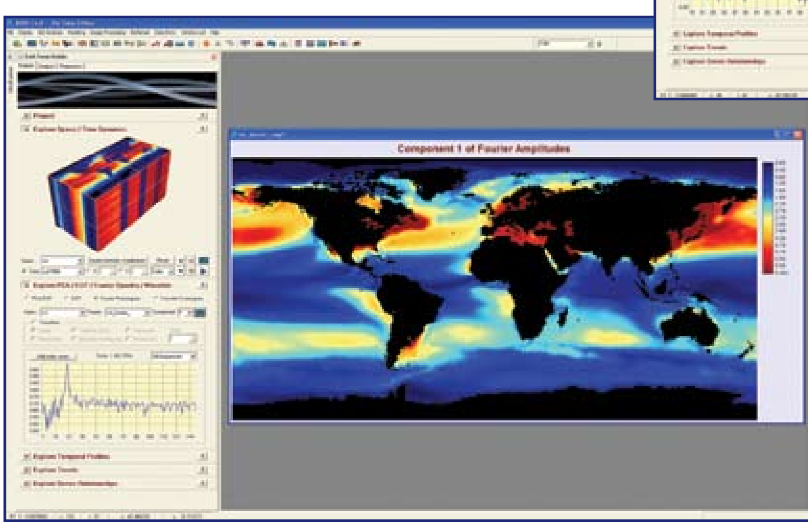


Figure 7 (left): An illustration of the output from Fourier-PCA using the frequency plot view. This one is quite simple to understand. The component is associated with locations that show a strong presence of 25 sine wave cycles over the 25 years of the series. It thus represents the degree to which an annual cycle is present.

space and time) to maintain only the condition of independence in time. The result is essentially the same as that of rotated components but is both simpler to understand and does not require subjective parameter choices. Both EOT and Cross-EOT analyses are provided. In EOT analysis, only a single series is analyzed. For example, EOT can be used to determine areas in the ocean that can best explain variability in other areas of the ocean with regards to surface temperature. In Cross-EOT analysis, two series are analyzed. For instance, the Cross-EOT procedure can be used to determine what areas of the ocean show temperature patterns that best explain variations in vegetation conditions on the land.

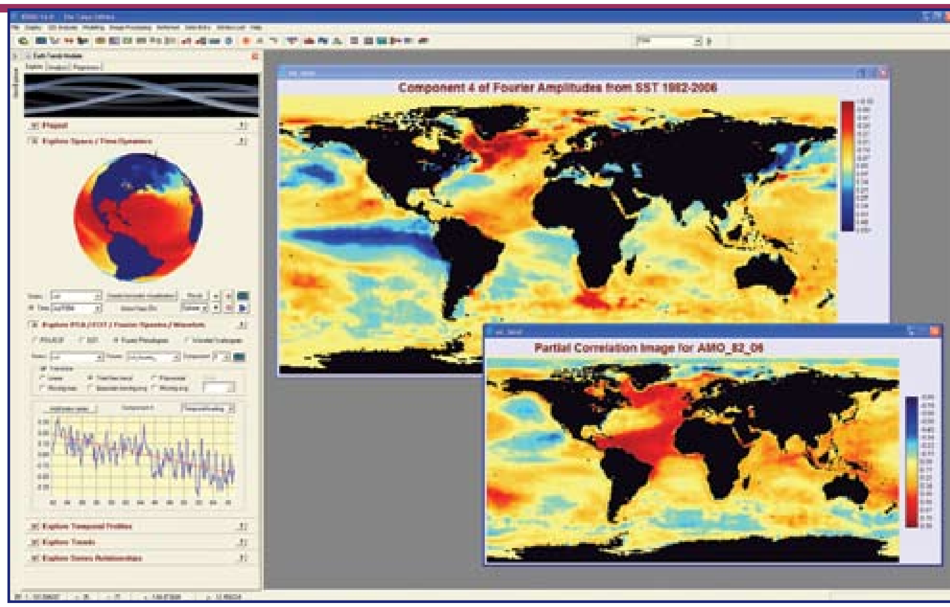


Figure 8 (above): Another illustration of Fourier-PCA. Component 4 from the same analysis as above showed a very difficult combination of frequencies to interpret. The loadings view (graph) however shows that the pattern is associated with a linear trend. The red areas in the top image thus indicate areas that are warming (a negative negative). Most of the world's oceans show this effect. The region in the central Pacific though, affected by the extraordinary variability of the ENSO cycle, shows a residual cooling effect (ENSO appeared in Components 2 and 3 of this analysis). The bottom image shows that the pattern in the Atlantic shares some similarity to that of the Atlantic Multidecadal Oscillation, but is substantially different.

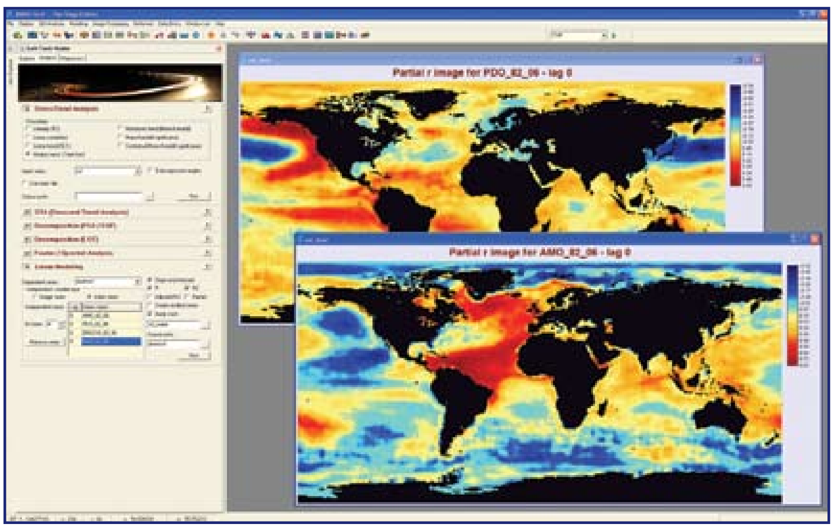


Figure 9 (left): The partial correlation images for the Pacific Decadal Oscillation (top) and the Atlantic Multidecadal Oscillation (bottom) after removing the effects of the ENSO (El Nino / Southern Oscillation) and the North Atlantic Oscillation phenomena. In this analysis, climate indices for these four teleconnections were used as independent variables while monthly anomalies in sea surface temperature were the dependent variable. Each pixel is analyzed independently.

* Explore for the presence of cycles in the series utilizing Fourier-PCA. This three-step analysis first conducts a Fourier decomposition of the series into a sequence of phase and amplitude images for a family of sine waves. The amplitudes are then analyzed for characteristic patterns of waves using principal components analysis. In the third stage, image correlation analysis relates these characteristic patterns back to time. Figures 7 and 8 show some results from this experimental technique.

* Examine relationships between series using a linear modeling (multiple regression) tool. Options are provided for a variety of outputs (R, R2, adjusted R2, slope and intercept images, partial R images and residual series). Relationships can be examined between image series and index series (such as climate teleconnection indices) or between image series and multiple independent image series (see Figure 9).

* Preprocess and edit series with a suite of utilities which allow for the interpolation of missing data (such as from cloud contamination), and the denoising and deseasoning of a series. Tools

We chose the name Taiga for the 16th release of IDRISI because it is emblematic of the risk we are now facing from climate change. Present trends exhibit a rate of temperature increase that exceeds the ability of the forest to adapt by relocation. The taiga is thus on the frontline of the impact of climate change.

are also provided for testing for serial correlation (Durbin-Watson), trend-preserving, prewhitening to remove series correlation in residuals, and significance testing in the presence of serially correlated residuals utilizing the Cochrane-Orcutt transformation.

Segmentation

IDRISI Taiga provides three new modules for classification from image segments. Segmentation is a process by which pixels are grouped that share a homogeneous spectral similarity. Across space and over all input bands, a moving window assesses this similarity and segments are defined according to a stated similarity threshold. The smaller the threshold, the more homogeneous the segments. A larger threshold will cause a more heterogeneous and generalized segmentation result.

The three modules provide a sequence for segment-based classification. SEGMENTATION creates an image of segments. SEGTRAIN interactively develops training sites and signatures. SEGCLASS classifies the imagery utilizing a majority rule algorithm.

Land Change Modeler Enhancements

IDRISI's Land Change Modeler now includes an interface to MARXAN that facilitates its use. MARXAN is a widely used conservation planning tool for reserve selection and design. Given a number of potential reserve sites (also called planning units) and the distribution of conservation features (such as biodiversity representation), MARXAN identifies a portfolio of sites which meet a particular target, such as minimal cost or compactness.

The Land Change Modeler application also now includes a validation panel, allowing the user to determine the quality of the prediction land use map in relation to a map of reality. A 3-way crosstabulation can be run between the later landcover map, the prediction map, and a map of reality in order to evaluate the result of a possible prediction

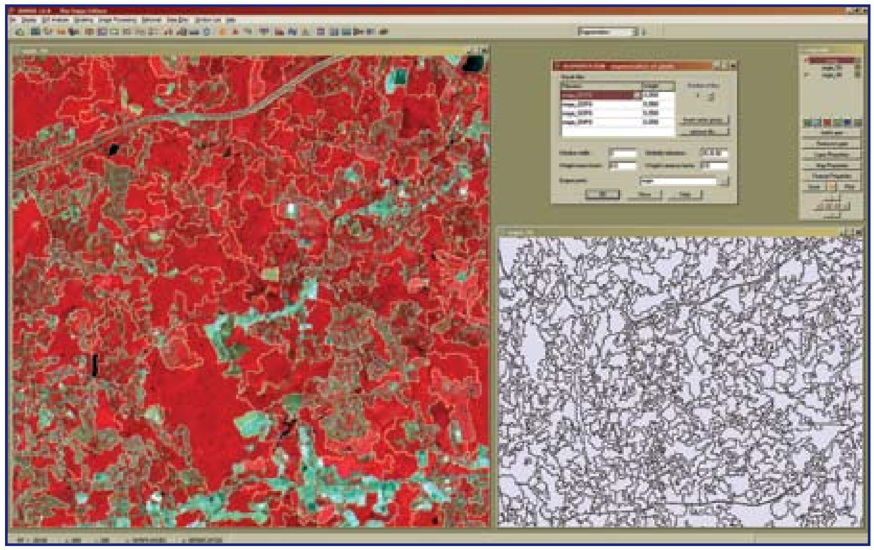


Figure 10: The SEGMENTATION module creates an image of segments that have spectral similarity across many input bands.

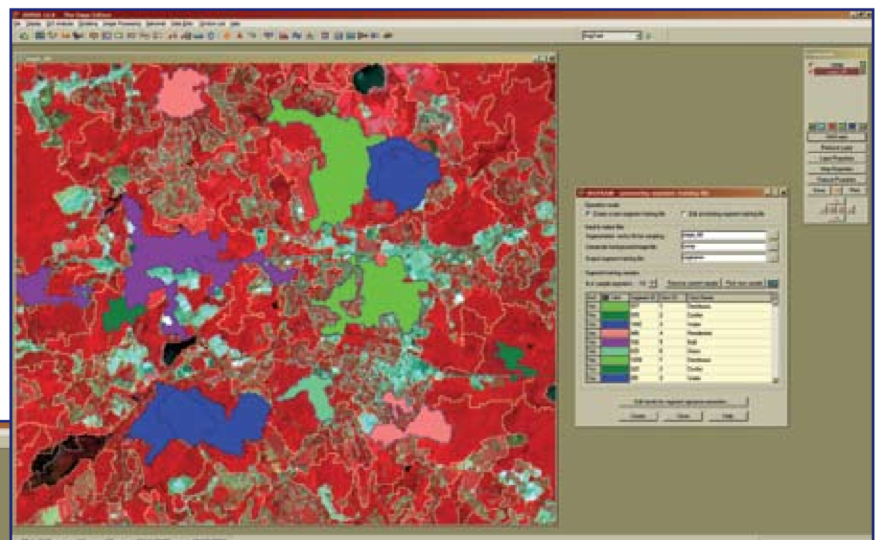


Figure 11: SEGTRAIN assigns these segments to specific land cover types for the development of training site data. The user interactively selects segments and assigns class IDs and class names.

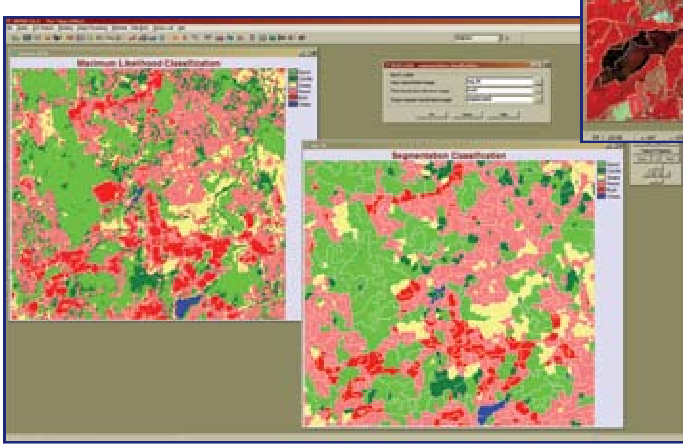


Figure 12: SEGCLASS classifies the imagery using a majority rule algorithm to assign each segment to a class, based on class majority within each segment as well as the segments of a previously classified image. SEGCLASS can improve the accuracy of a pixel-based classification and produce a smoother map-like classification result while preserving the boundaries between the segments.

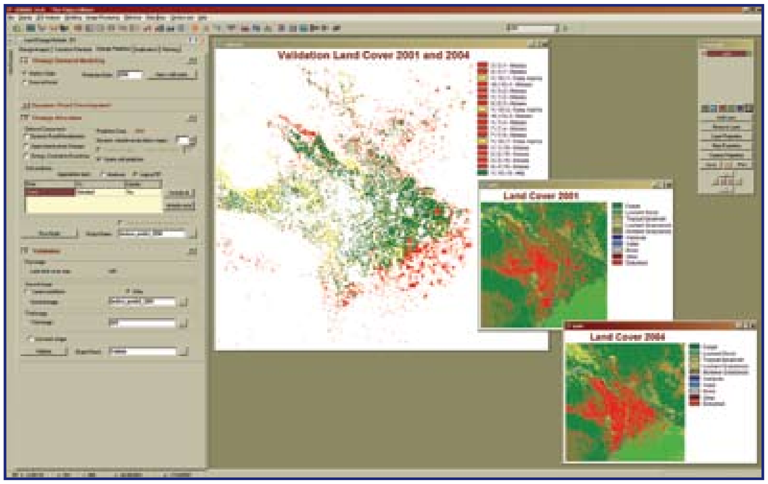


Figure 13: Validation allows you to assess the quality of your prediction model. In this example, a model was developed to predict forest cover loss to 2004 based on historical patterns. We predicted from a known state in 2001 to 2004 and validated the prediction map to a known state in 2004. The validation map shows the hits (green), misses (red), and false alarms (yellow) of our model.

outcome. Hits (model predicted change and it changed), misses (model predicted persistence and it changed) and false alarms (model predicted change and it persisted) are reported.

Additionally, options to print and manipulate the graphs generated by Land Change Modeler are now included.

Display Navigation Tools

Enhancements have been made to the pan and zoom in/zoom out functions. The stretch options on Composer have also been revised.

Other Features

IDRISI Taiga also includes an extension of the Multi-Layer Perceptron neural network classifier to support multiple regression applications, an ISODATA unsupervised classification procedure, and additional time series utilities (such as the ability to compute various statistics over time, a procedure to correlate a single pattern image with all members of a series, a completely revised PROFILE module and a utility to update the metadata for a whole series at once).

A wide range of new import procedures have been added. Many of these are designed to support the varied earth observing system image time series including NetCDF (a format very popular with the climatological community), specific imports for Global Aerosols Climatology Project and ISCCP (International Cloud Climatology Project) GPC-D2 data, import of Physical Sciences Division (PSD) climate index data, import of MODIS Quality Control flags from the Vegetation Index and Land Surface Temperature series, and a special procedure for reading Outgoing Longwave Radiation imagery.

In addition, the Taiga Edition of IDRISI now supports the creation of KML layers, both as single layers and as pyramid structures for streaming over the Internet. Finally, an interface is provided to the open source GDAL raster translation software.

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