Assessing Short-term AVHRR-NDVI Change Using Decision Rules Approach

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ABSTRACT

A knowledge-based approach to detection of short-term changes in land cover and/or land use based on analyses of daily AVHRR/NDVI data (supported by ancillary data) is tested. "Short-term" means that events occur from one day to the next day or over a period of a few days. Land cover/land use changes are used to augment estimates of land cover derivative products (e.g., fVEG, LAI) for input into numerical weather prediction models. Data are analyzed within the ERDAS Imagine Expert Classifier. The decision logic assumes that certain types of changes (e.g., wheat harvest) are expected to be observed in certain landscapes (e.g., northern Oklahoma) at certain times of the year (e.g., late June). Catastrophic or unusual events and clouds will not follow the expected pattern. The knowledge-based approach is used to assess the probable character and significance of NDVI change by testing various hypotheses and determining the probability of correct characterization based on assessment of ancillary data. These ancillary data will include geographic location, site characteristics (e.g., elevation, slope), time of observation, weather data, antecedent conditions (e.g., drought). Hypotheses will be tagged with levels of confidence based on accumulation of evidence. The procedure is tested retrospectively (i.e., predictions of change are confirmed or refuted based on observations of actual change).

A) DATA ACQUISITION AND PREPROCESSING

- Image acquisition: Advanced Very High Resolution Radiometer (AVHRR) data are downloaded from the NOAA Comprehensive Large Array-data Stewardship System (CLASS) server. Afternoon passes of the NOAA-17 satellite received by stations located in Missouri and Virginia can now be archived at CALMIT in about 90 minutes.
- The AVHRR level 1b format contains raw, unprocessed data at full resolution, time-referenced, and annotated with ancillary information including data quality indicators, calibration coefficients and georeferencing parameters.
- Using the calibration coefficients, radiometric corrections are applied in order to convert the raw pixel values to percent albedo in Bands 1 and 2 using a simple linear regression relationship between the measured AVHRR signal and the albedo of the reference targets. (NOAA KML User's Guide, http://www2.ncdc.noaa.gov/docs/klm/html/c7/sec7-1.htm).

Figure 1. NDVI from the first pass raw image

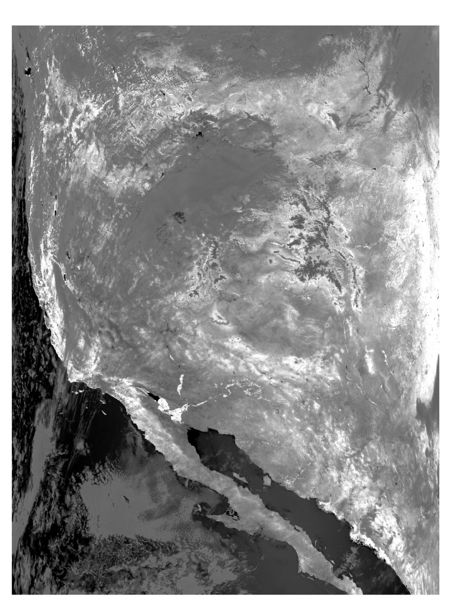


Figure 2. NDVI from the second pass raw image

B) NDVI CALCULATION AND GEOREFERENCE

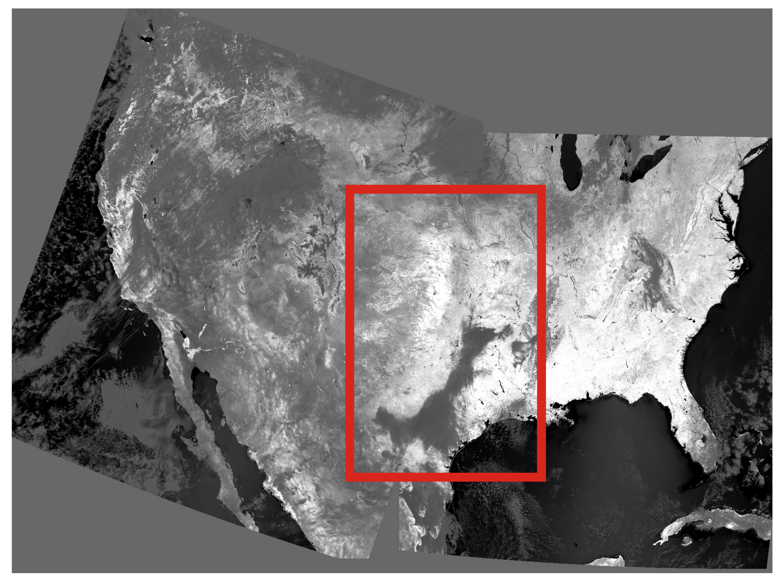


Figure 3. Rectified mosaic from two consecutive satellite passes

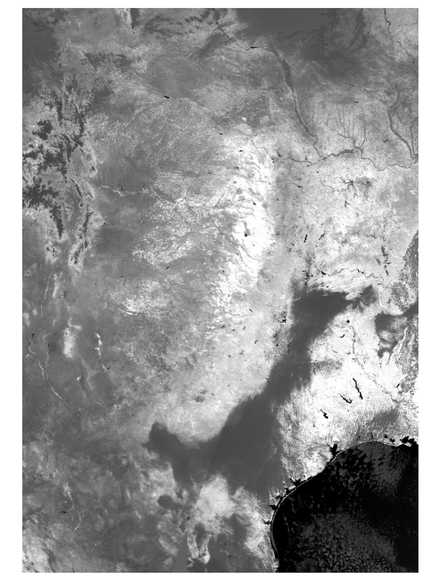


Figure 4. Subset from a rectified NDVI (one day image)

- The NDVI is calculated from the imported .l1b HRPT data. Each image is geometrically corrected using a Lambert Azimuthal projection and subset to the region of interest.
- If more than one pass is needed to cover the region of interest (see early pass Figure 2 and late pass Figure 3), then both images are mosaicked and then subseted.

C) CLOUD MASKING

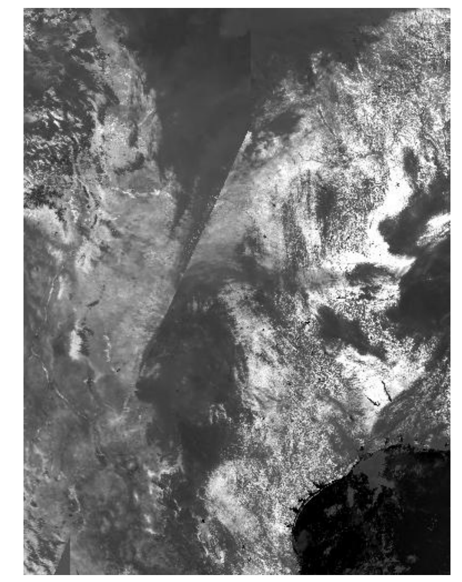


Figure 5. NDVI Day 1

Figure 6. Cloud Mask Day 1

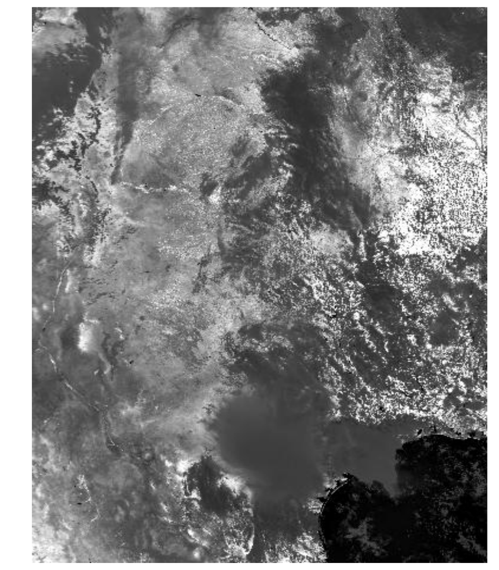


Figure 7. NDVI Day 2

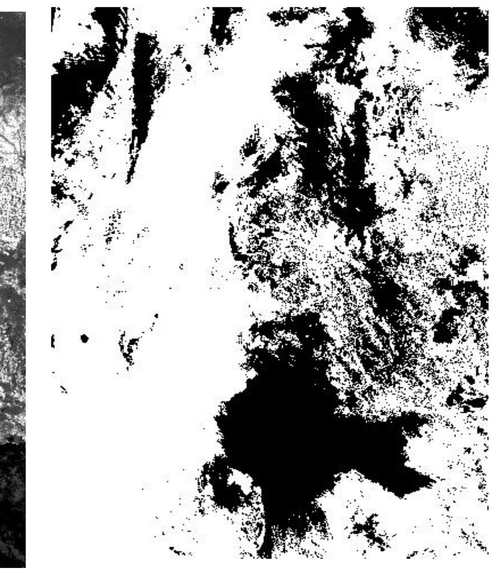
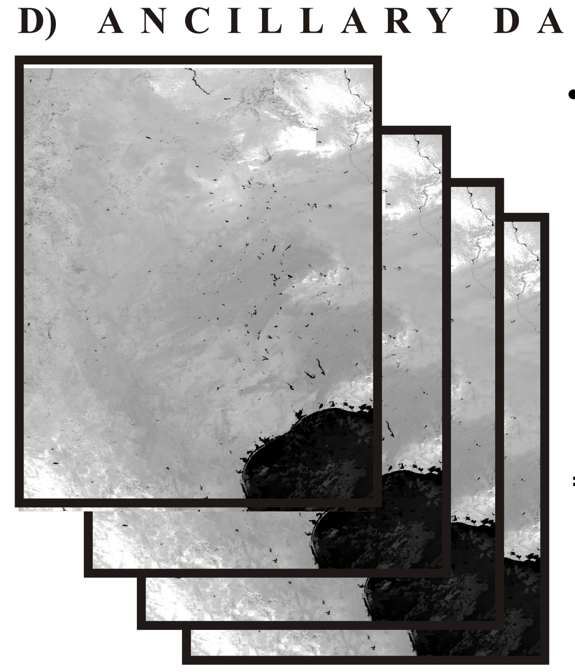


Figure 8. Cloud Mask Day 2

- A cloud masking algorithm using AVHRR bands 2, 3 and 4 (NIR, mid IR and thermal IR, respectively) is applied. The decision logic is as follows: if band 4 is negative or band 2 exceeds a reflectance threshold and band 3 band 4 exceeds 15 degrees, then a pixel is assumed to be cloudy. The reflectance threshold is defined by checking cloud values. Since the algorithm uses temperature and reflectance threshold values, calibration of the AVHRR data is needed. The output of this operation is a masked image with a value of 0 for probable clouds and a value of 1 elsewhere.
- The cloud masking processing is a first step to evaluate daily changes by knowing the percentage of the area that is covered by clouds each day and the location of the clouds on those days

D) ANCILLARY DATA



- The twenty-six biweekly periods were separated into individual files, each file corresponding to one biweekly period, and then stacked by biweekly period in order to calculate the statistics (normals or baseline values). This resulted in twenty-six files (biweekly periods) with four layers (years sampled).

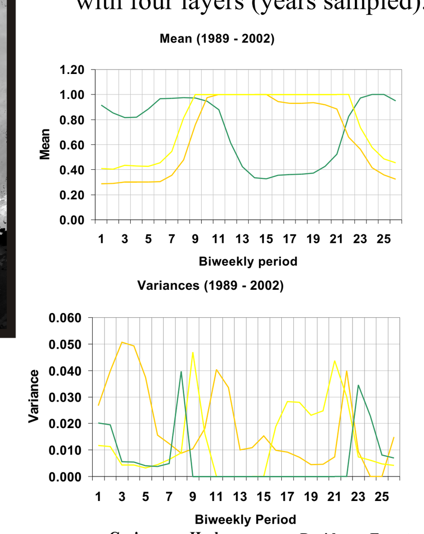


Figure 9. NDVI mean and variances values by biweekly period (1989-2002)

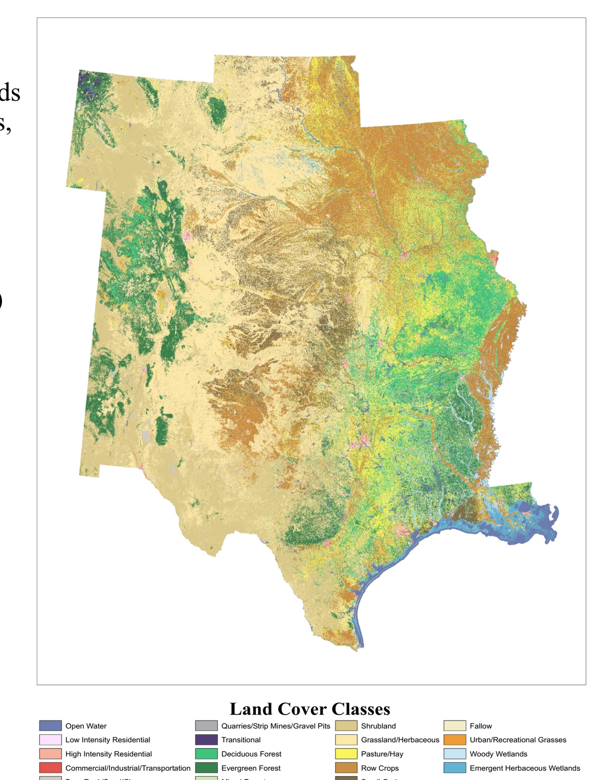


Figure 10. Land Cover Data

- The NLCD is a 30-meter resolution Landsat-derived land cover product developed by EROS Data Center under the Multi-Resolution Land Characteristics (MRLC) Consortium (http://www.mrlc.gov/index.asp). The NLCD data were downloaded state by state, re-projected, mosaicked, resampled to a 1-km pixel and subset to the area of interest.

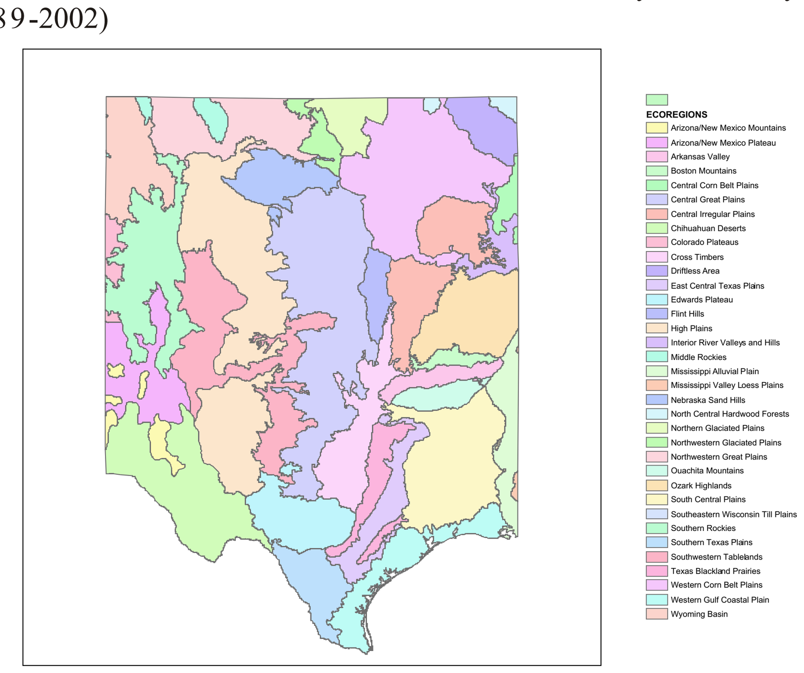


Figure 11. Ecoregions

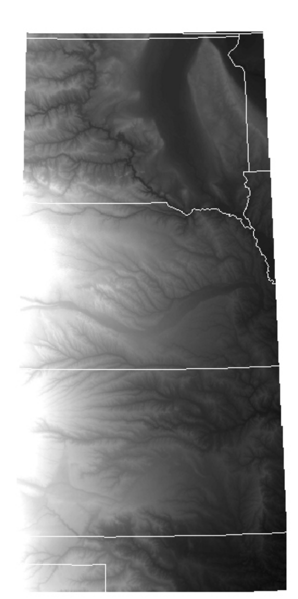
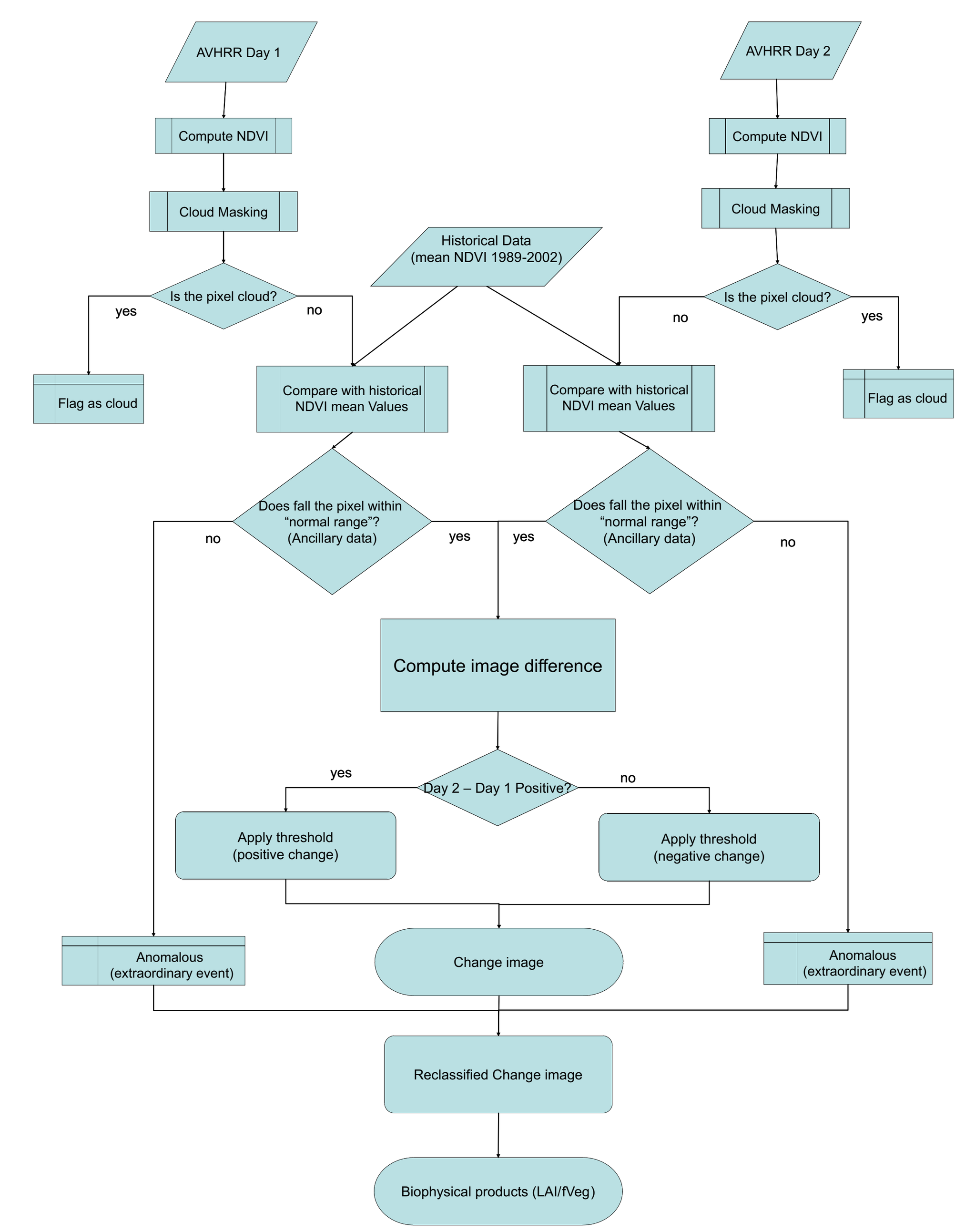


Figure 12. Digital Elevation Model

- Ancillary data will be used to define if a NDVI value change is normal to occur according to conditions such as location (ecoregion, altitude, land cover/land use) or historical record (1989-2002 NDVI data).

E) FLOW CHART



- The flow chart shows an example of decision rules to be translated into an inference engine for automatic processing.

F) THE EXPERT SYSTEM

- ERDAS Imagine's Expert Classifier is being tested. It has two main components: the knowledge engineer and the knowledge classifier
- Using the knowledge engineer, the decision rules are build using a graphical interface. The decision tree requires adding the hypothesis to be tested, under which conditions and with which confidence limits. The decision tree supports multiple inputs including raster data, scalars, or Imagine's internal models.

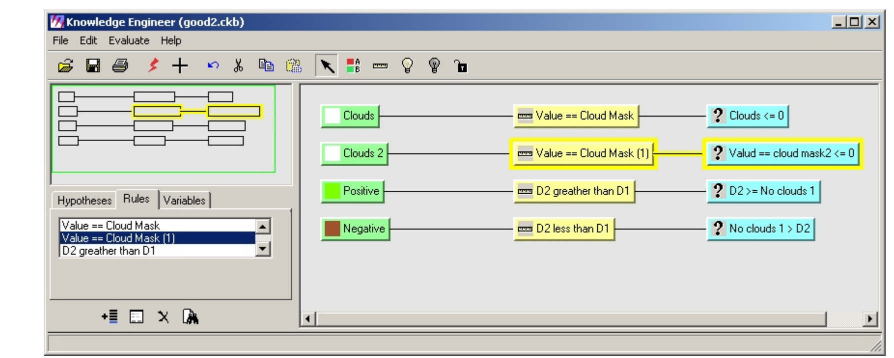


Figure 13. Imagine's Knowledge engineer interface

- Once the decision tree is formulated, the knowledge classifier classifies the images according to the rules established. Any specific output class (within the decision tree) or all classes can be selected. Figure 14 shows the result of a simple case examining two images (from figures 5 and 7). The objective is to find clouds and DN changes e.g. Positive when DN values of image 2 are greater than DN values of image 1 and negative when values of image 2 are less than those in image 1.

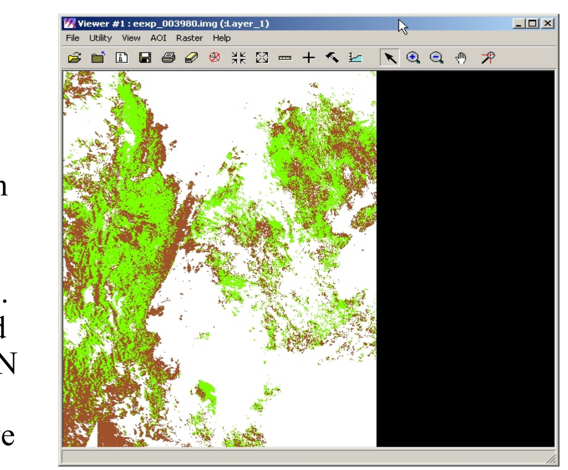


Figure 14. Imagine's Knowledge Classifier output

CONCLUSIONS AND FUTURE WORK

- Preliminary results show the advantage of incorporate ancillary data and human knowledge into a set of decision rules and analyzed by and inference engine for short term change detection between daily AVHRR imagery. There are several tools available for implementing decision rules.
- Future analysis will include testing more complex decision trees involving threshold values and ancillary data to define the degree of change between the compared images. By means of this process, one can define when a change is assumed to be part of the normal change in vegetation condition and when this change (positive or negative) is anomalous.
- Once short term changes are known, the final goal is to provide NDVI landcover derivative products (LAI and fVEG) for input into numerical weather prediction models, emphasizing areas where changes are abrupt and flagging the possible cause of the change.

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