MODIS Science Team Member

Semi-Annual Report

Jan 2003 to Jul 2003

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A. FOCUS ACTIVITIES DURING THE REPORTING PERIOD

The most important activities undertaken during this reporting period are the following:

1. Land surface reflectance code development, testing and delivery
2. Validation activities.
3. AVHRR/MODIS Long term data set
4. Development of continental data set from MOD09A1 and Inter-annual Change study
5. MODIS Adaptive Processing System (MODAPS)/PI Processing

1. Land surface reflectance code development, testing and delivery

Several corrections were done to the code for generating Level 2, Level 3 land surface reflectance (MOD_PR09, PGE 11, MOD_PRO09A1/PGE 21 and MOD_PR09C/PGE75).

1.1 Level 2 surface reflectance

- Added a more robust testing of bad aerosol retrieval over salt pans.

- Added an “aerosol retrieval forbidden” mask to the aerosol retrieval process, this mask will be populated as QA/validation continues toward collection 5 re-processing.

- Corrected erroneous retrieval of aerosol over desert area by introducing a desert detection test.

- Continued to work on cloud/cloud shadow improvement, although no improved version of the PGE was delivered, mainly for collection 5 reprocessing.

- In anticipation of Collection 5 reprocessing, a complete re-designed version of PGE11 has been developed. This version considerably enhances the readability of the code (as measured by the cyclomatic complexity metrics), as well as the I/O performances. This version also enables standard tools for memory leaks checking, such as puma or dmalloc, to run more easily.

1.2 Level 3 surface reflectance

-Refined collection 4 of the composite code, correcting problems at the poles (high solar zenith angle), and in the 250m resolution.

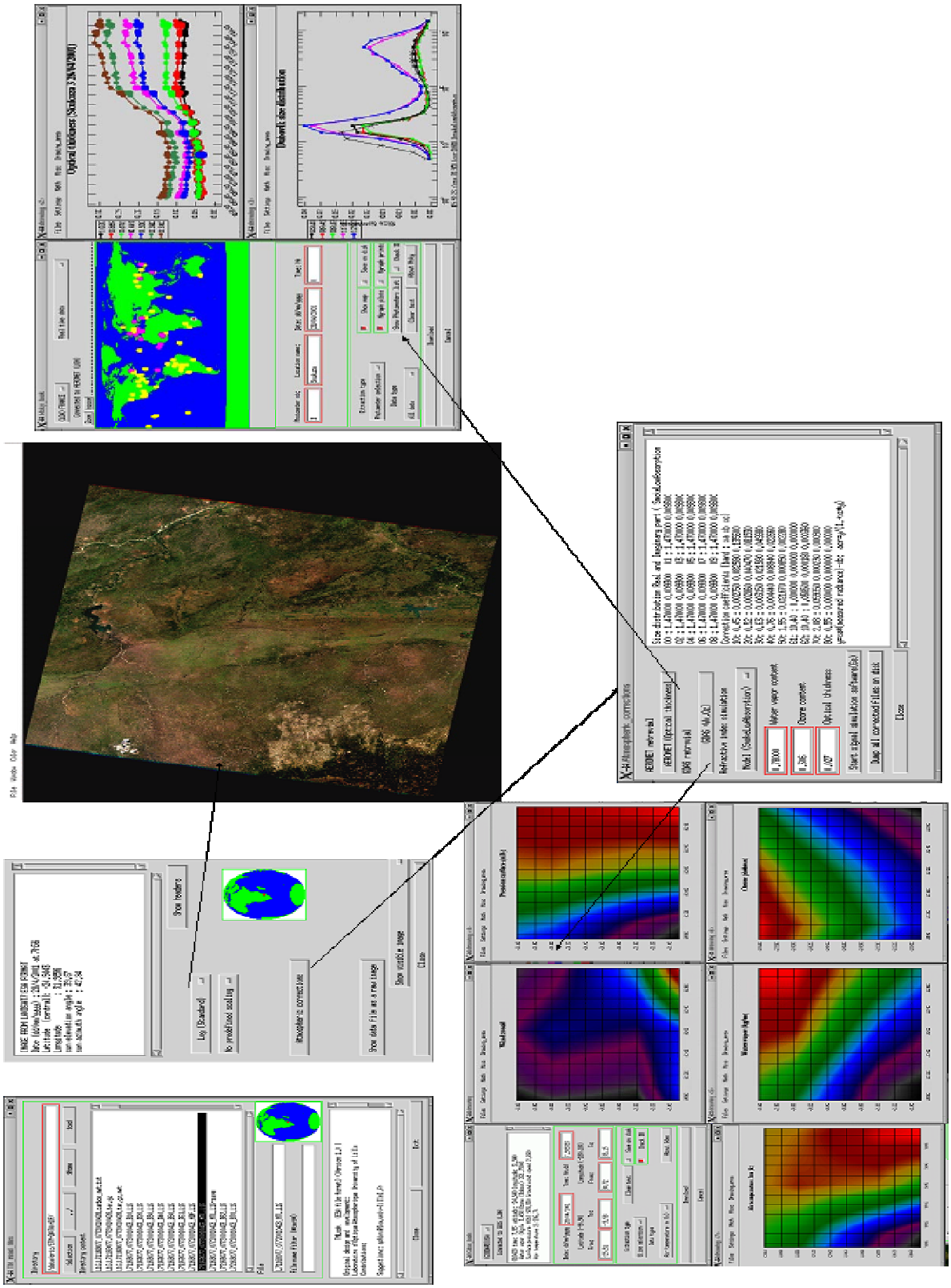
1.3 Level 3 daily surface reflectance CMG product (PGE75)

-Refined PGE75, in particular the area of metadata attributes to bring the CMG product to the point at which it could be ingested by the EDC DAAC.

2. Validation activities

A tool for automatic generation of ETM+ surface reflectance (TMLook) used for validation is under development with the University of Lille (see Figure 1). The tool combines an interface for decoding several Thematic Mapper input formats (HDF, GeotTiff and CEOS), a link to atmospheric parameters database (NCEP and AERONET), the 6S radiative transfer code, a visualization interface, and a re-projection library. This tool is also able to correct for atmospheric effects, inspect the results, and output a standard surface reflectance data set to be compared to MODIS product.

Figure 1: Screen shot of the TMLook tool used for generation of ETM+ surface reflectance data used in the MODIS reflectance validation activity,



3. AVHRR/MODIS Long term data record generation

The MODIS Terra set that has been collected globally since Feb 2000, has been calibrated to reflectance units in the solar reflective bands using a state of the art on-board calibration system. The absolute accuracy of the reflective bands is within the 2% specification and the land bands have been carefully selected to avoid major contamination by water vapor, which has been a major limitation on previous earth remote sensing missions such as AVHRR. In addition, MODIS water vapor absorption bands in the near infrared (band 18 and 19) enable very accurate retrieval of the integrated amount of water vapor which allows us to perform an adequate correction of that effect in the land bands.

We have been using the substantial time record of MODIS data to characterize a stable desert site. In a first step, we used two years of Terra data to derive the BRDF of the desert site. Then, we used this characterization to predict the reflectance observed by MODIS-Aqua during the first few months of operations. We have compared the at-launch to preflight ratio derived by the cross-calibration to the independent ratio derived by the MODIS calibration Team using the solar diffuser. In addition, we also have analyzed the complete Terra record to find possible trends in the calibration. Those results have been shared with the MODIS Characterization Support Team (MCST). Those efforts were described in details in the previous report (July 2002 to December 2002).

We have been using the same desert site to prototype some activities toward establishing a long term data set for land studies using AVHRR and MODIS data. In part, we have been using the desert site model to predict the reflectance that will be observed by AVHRR (NOAA16) in the red, near-infrared and shortwave infrared (1.6 micrometers) wavelengths, and therefore validate its certification.

The AVHRR data for the calibration site are processed and corrected for the atmosphere according to the method described in (El Saleous et al., 2002). Rayleigh, ozone and water vapor corrections are applied. For water vapor, we used the split window technique to increase the accuracy versus using the NCEP data, which have low spatial resolution. We first validate the split-window technique on MODIS aqua by comparing the temperature difference observed in MODIS band 31 and 32 to the integrated water vapor content derived from the near-infrared MODIS band (King et al., 2003). We used the period 2002219 to 2003060 because it is necessary that the calibration in the thermal infrared is very stable to ensure good retrieval of integrated water vapor content. Figure 2 shows the comparison between the integrated water vapor content derived from the MODIS near infrared absorption bands (band 18 and 19) with the temperature difference in the longwave. The very high correlation observed in figure 2 demonstrates the feasibility of using longwave brightness temperature difference to retrieve integrated water vapor content for this type of site using a linear relationship. To derive the coefficient for NOAA-16 AVHRR channel 4 and 5, we compared on figure 3, the AVHRR observations with MODIS Aqua retrieval of water vapor based on the near infrared performed within 30min of the AVHRR observations.

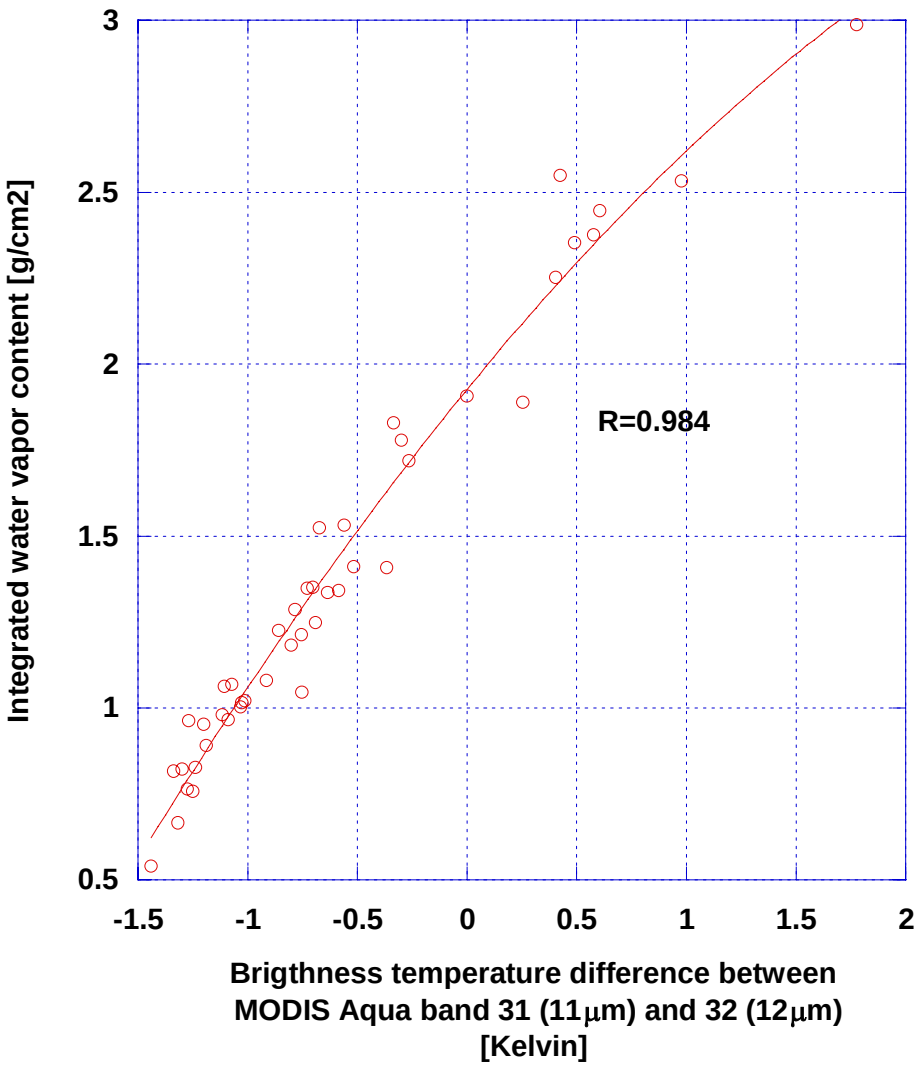


Figure 2: Integrated water vapor derived from MODIS near-infrared absorption bands (bands 18 and 19) as a function of brightness temperature difference in band 31 (11μm) and 32 (12μm) for Aqua data collected over the calibration site during the August, 2002 through February, 2003 period.

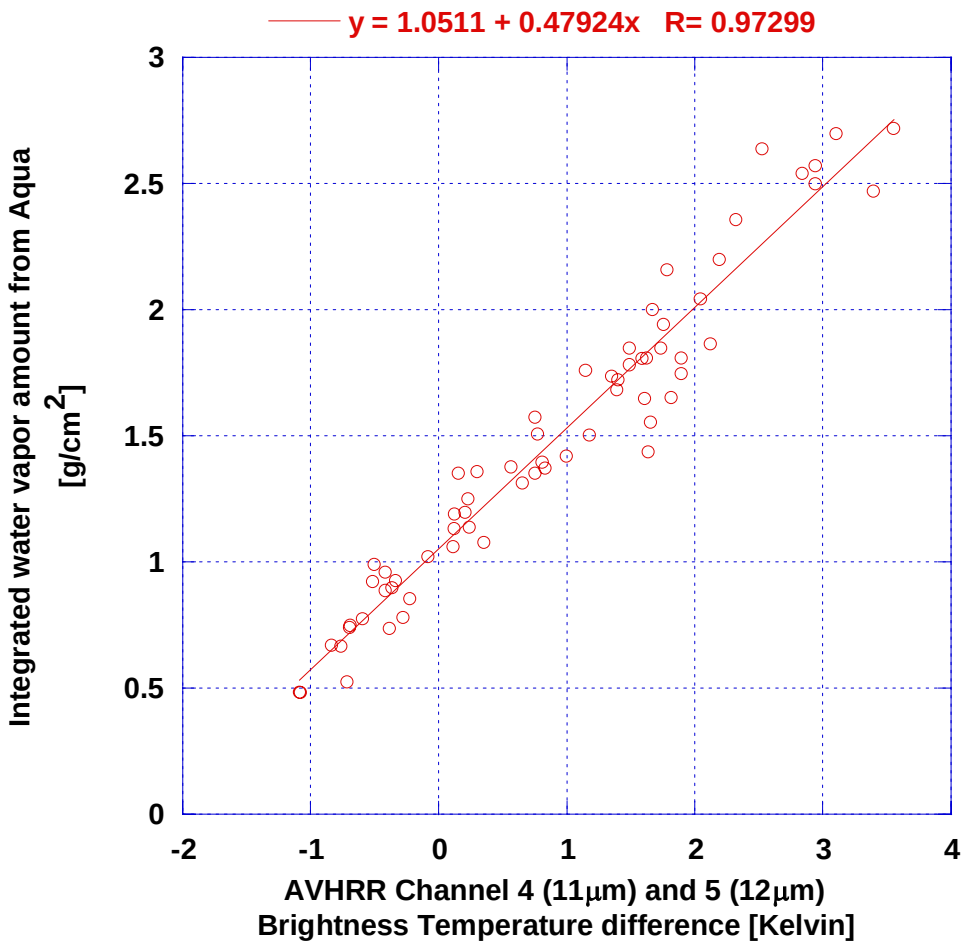


Figure 3: Integrated water vapor derived from MODIS Aqua near-infrared absorption bands (bands 18 and 19) collected 30minutes or less from the temperature difference in channel 4 (11μm) and 5 (12μm) for AVHRR data collected over the calibration site.

We compared the actual observations of NOAA16-AVHRR in channel 1, 2 and 3 corrected for rayleigh, ozone, water vapor and carbon dioxide absorption to the predicted reflectances based on the Terra characterization of the site using the spectral adjustments for AVHRR given in section 2.2. The ratio between the observed and the predicted reflectance is plotted on Figure 4 as a function of time. The figure shows that for band 1 and 3 the dispersion is very small along the general trend, channel 2 shows a little more dispersion probably due to residual water vapor effects. NOAA16 AVHRR has a bi-linear gain feature, observations over the desert site are always at low gain for channel 3, but can be acquired at high gain in channel 1 and 2. In channel 2, there is very little difference between the two gain setting. In channel 1, the difference between the two gain settings is about 1%. The results obtained for channel 1 and 2 are finally compared to independent estimate using the cloud and ocean method (Saleous and Vermote, 2003). The agreement is very good is Channel 1, in Channel 2 our estimate is about 2% lower than the ocean and clouds results which is within the error bars or both calibration approaches for channel 2.

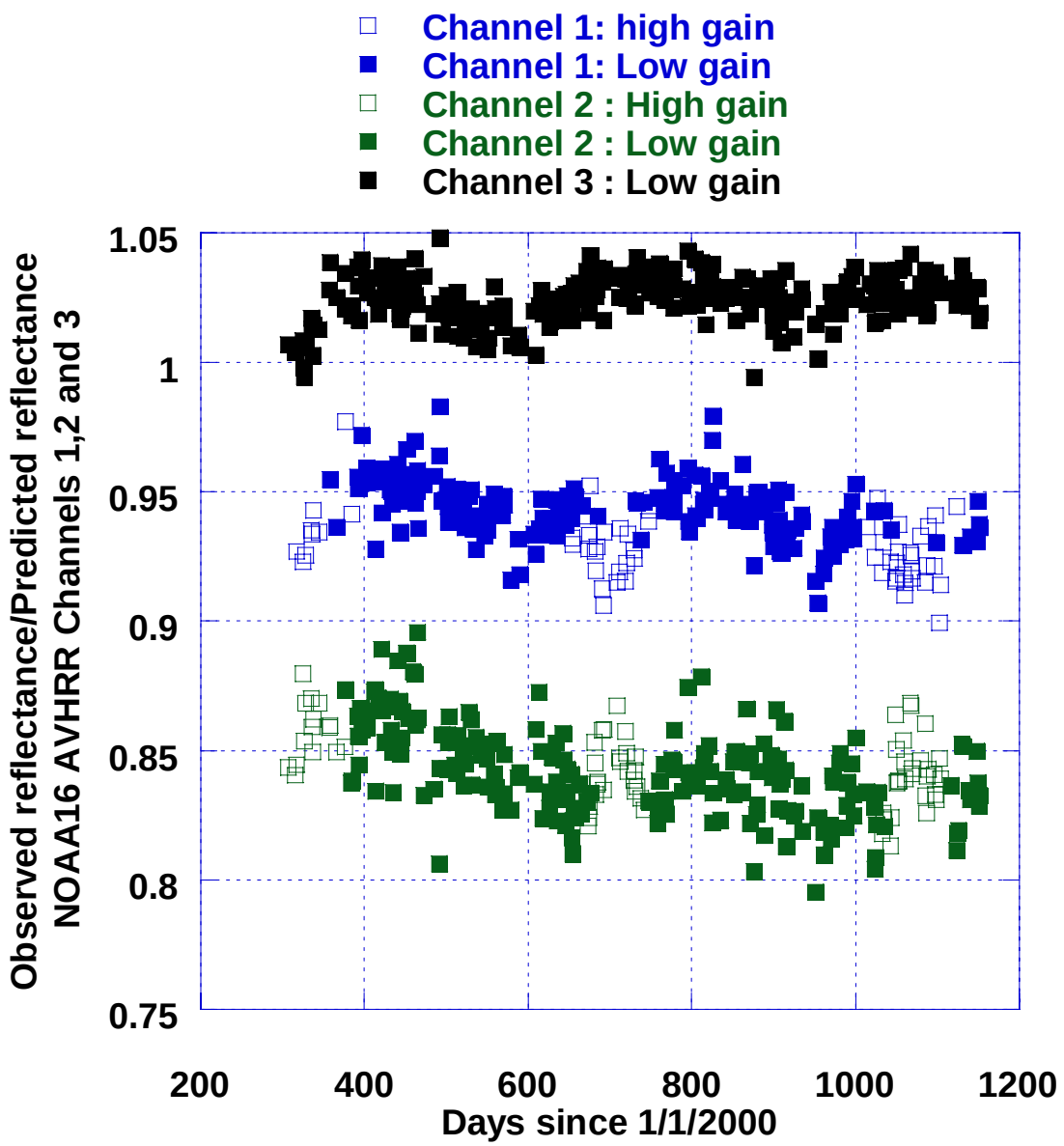


Figure 4: Variation of the ratio observed (using pre-flight calibration) to predicted reflectance for NOAA16-AVHRR during the November, 2000 to February, 2003 period.

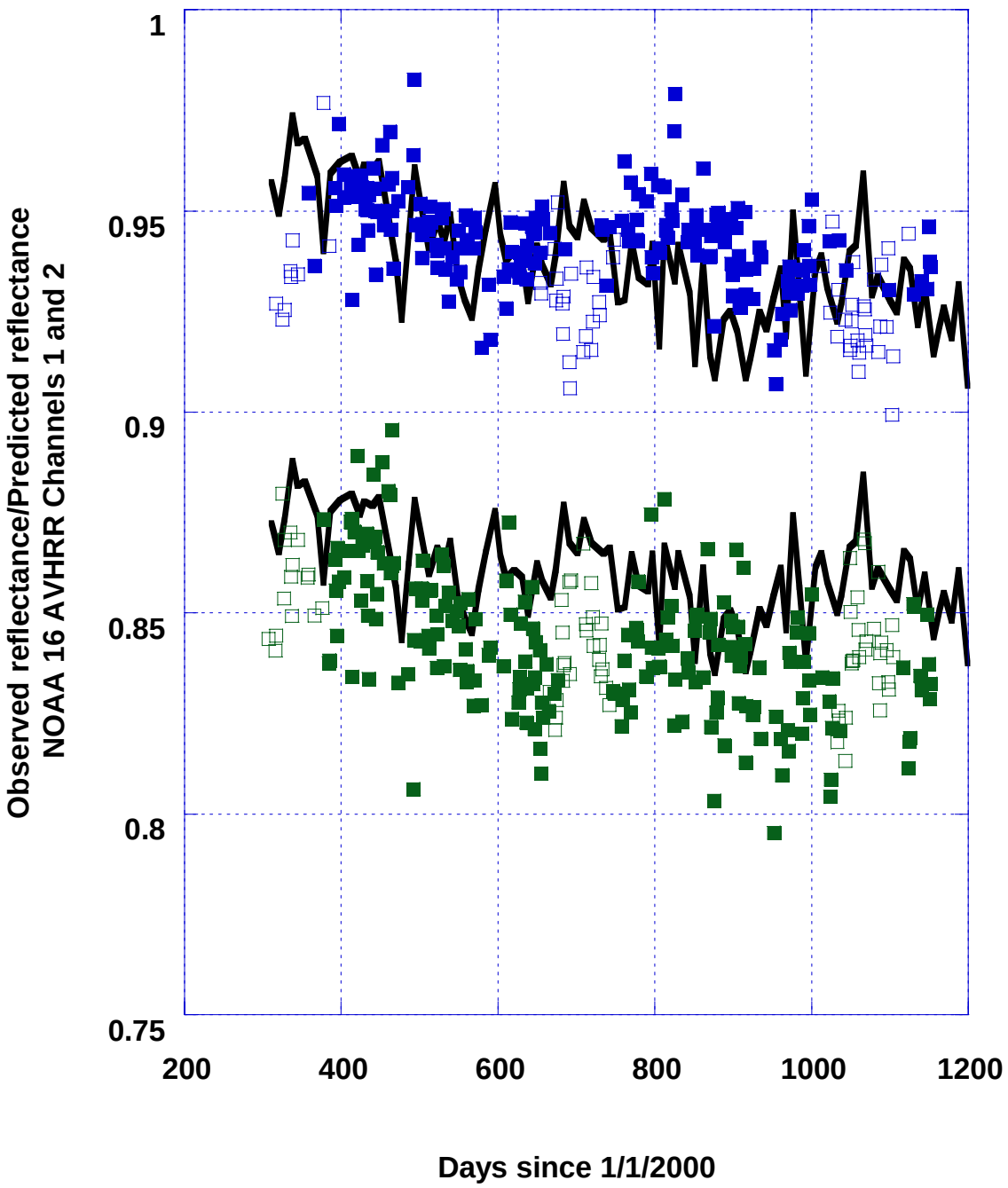


Figure 5: Same a figure 4 except only Channel 1 and 2 are reported here and the results obtained from the Ocean and cloud method are added for comparison as solid black lines.

References

El Saleous, N.Z., Vermote, E.F., Justice, C.O., Townshend, J.R.G., Tucker, C.J., Goward, S.N., 2000, Improvements in the global biospheric record from the Advanced Very High Resolution Radiometer (AVHRR), *International Journal of Remote Sensing*,21,6,1251-1277

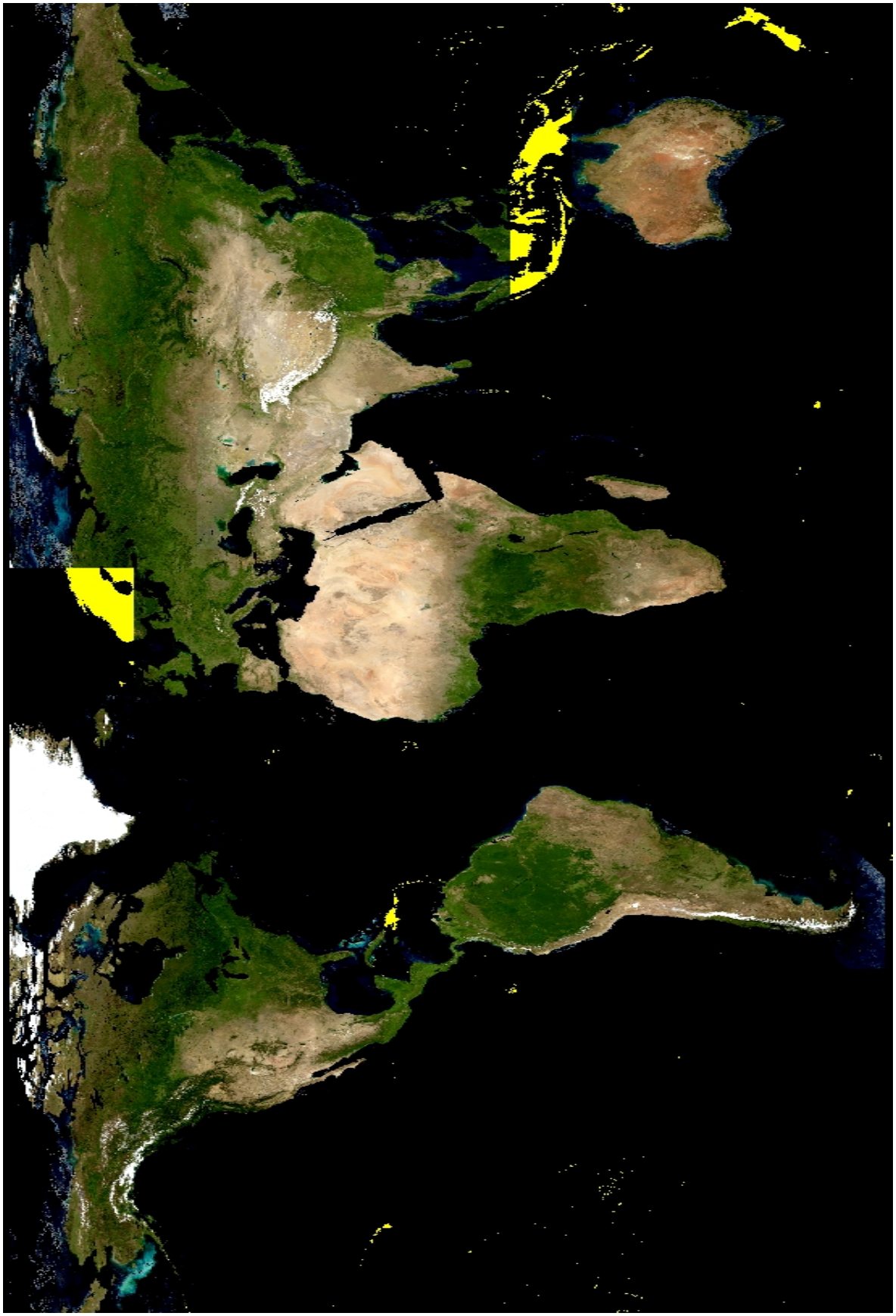
Saleous and Vermote, 2003, Derivation of the NOAA16 AVHRR channel 1 and 2 calibration using ocean and clouds, report.

4. Development of continental data set from MOD09A1 (8 days composite surface reflectance).

We have continued using the 8 days surface reflectance to assemble a continental data set that could be presented as large size RGB poster for educational purposes. These activities also enable us to further increase the Quality Assurance of the surface reflectance product by carefully inspecting higher quality data selected by compositing several 8 days period together. Those activities also drove us to implement and refine a simple correction for BRDF effect using the Ross Thick Li Sparse Model currently used for derivation of albedo or nadir adjusted data (MOD43 product suite). The data set produced at this point (at 500m), for mainly collection 4, is presented in Figure5. As it can be seen, the global data set is nearly complete, the yellow areas (mainly Caribbean, Indonesia and New Zealand) which represents only a few tiles that need to be completed. We also have made available the postscript files and images on our web site (http://www.modis-land.gsfc.nasa.gov/mod09/html/posters.htm).

We have started prototyping the generation of the 250m dataset, by using a specific case, where that resolution is providing a unique insight on the anthropogenic changes. We have selected an area in Paraguay where rapid and extensive deforestation is on-going. Figure 6a shows an overview of the area where we specifically focus on 3 different time periods (2001 dry season, 2002 wet season, 2002 dry season). The area in question is mapped using the 250m data to enhance the RGB MODIS bands in figure 6b,c,d. The areas where massive deforestation occurs are surrounded by red boxes. A conservative estimate of the number of pixels deforested (see figure 6e where the pixels are marked in Magenta) leads to 57666 pixels which corresponds to 1% of the area of figure 6e or about 290 square kilometers in only one year!!

Figure 5: Currrent status of the global 500m cloud free data.



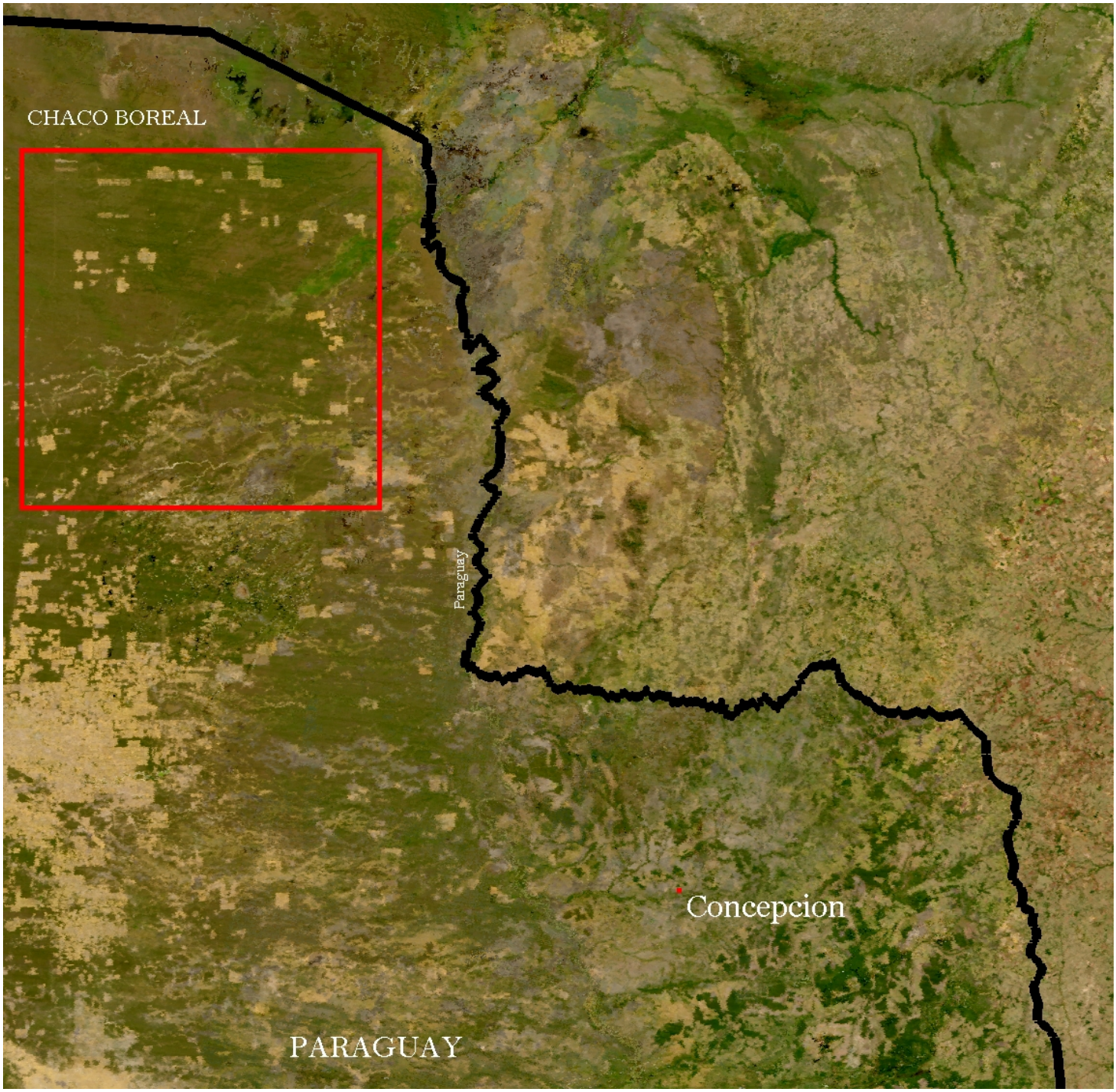


Figure 6a: Extract of the 500m continental data reflectance corresponding to the 21 August 2001 to 05 September 2001 (Dry Season). The red box dimensions are 170 x 170 km.

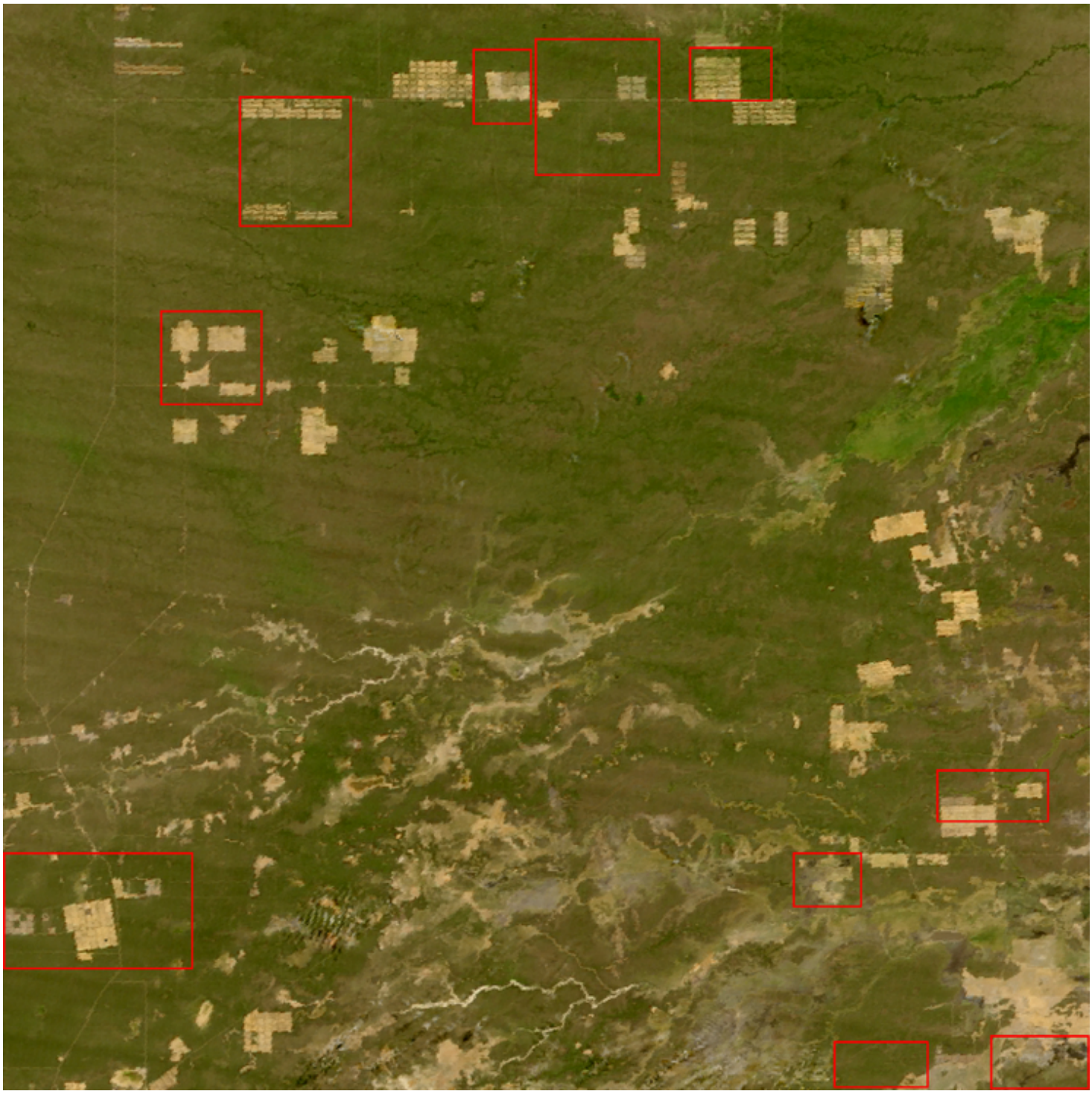


Figure 6b: Details of figure 6a (2002 Dry Season), the area outlined in red were identified as area where deforestation occurred during 2002, 250m red data are used to enhanced the 500m RGB.

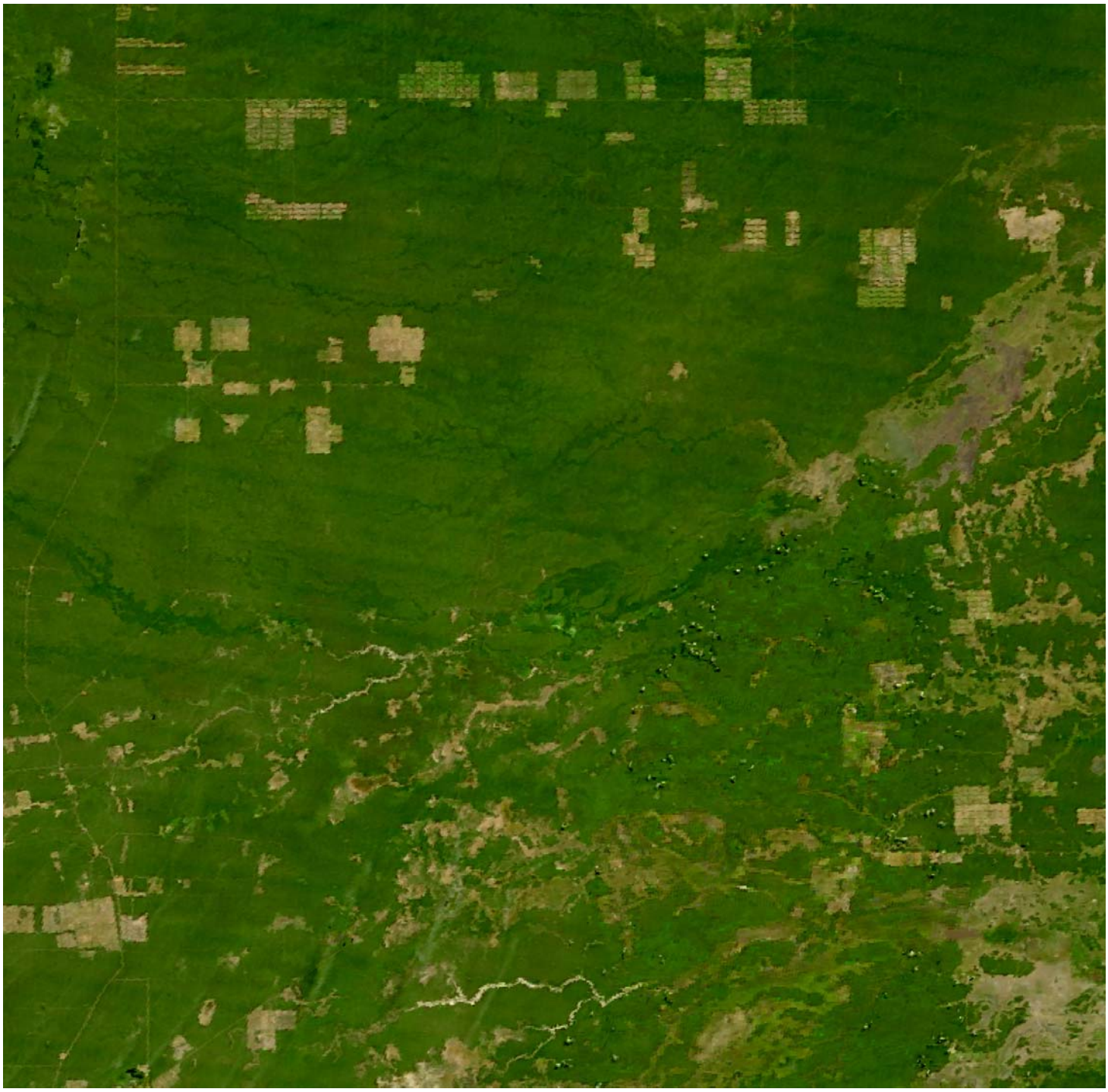


Figure 6c: Same as figure 6b but for the 2002 wet season (23 April 2002 to 16 May 2002)

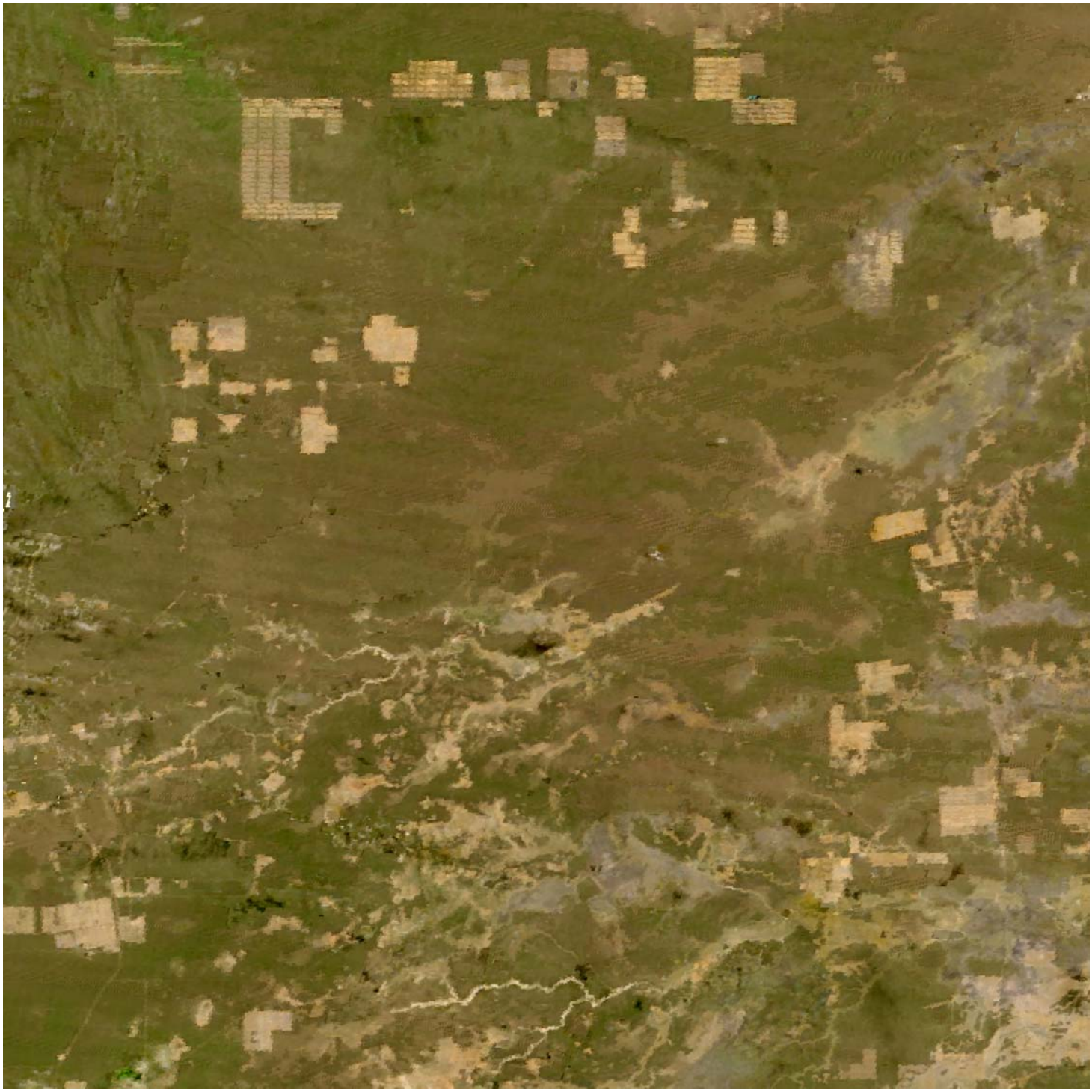


Figure 6d: Same as figure 6b but for the 2002 dry season (29 August 2002 to 21 September 2002)

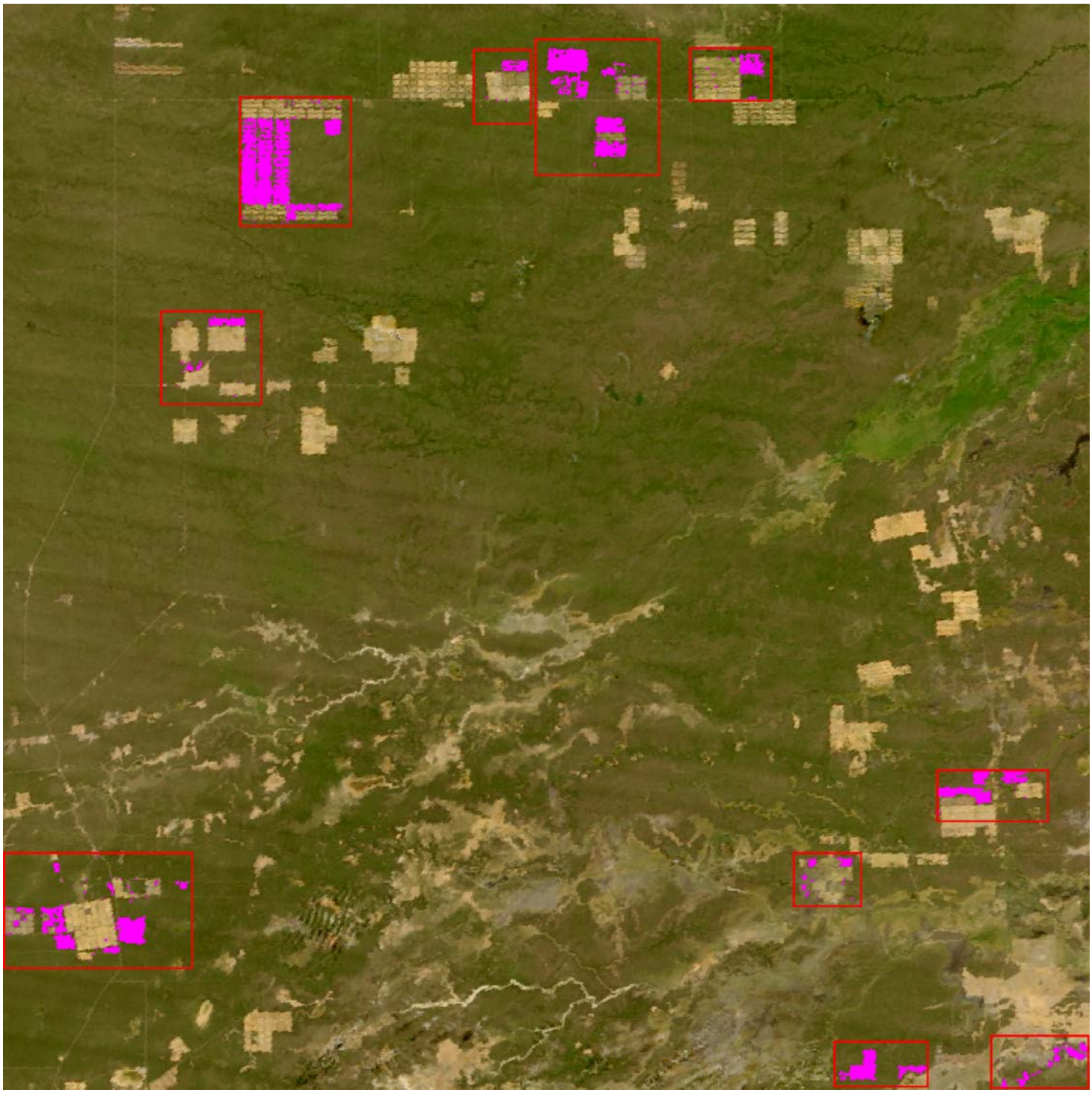


Figure 6e: Same as figure 6b but with the area identified as deforested in magenta.

5.0 MODIS Adaptive Processing System (MODAPS) / PI Processing

The Land Surface Reflectance SCF remains actively involved in the PI-led processing activity ranging from making sure that PI's needs are accurately perceived by the MODAPS development team and by management, as well as participating in the development of the processing system and various phases of testing.

The SCF participated in the weekly PI-Processing meetings where Eric Vermote represented the land group.

The SCF also participated in all of the weekly MODAPS meetings/telecons, where problems were discussed to identify solutions and where progress in the new development was tracked.

B. **MEETINGS ATTENDED**

- IGARSS 2003, July 2003 Toulouse, France.
- Weekly PI Processing Status Meetings, NASA/GSFC.
- Weekly Technical Team Meetings, NASA/GSFC.
- Bi-Weekly SDDT (Science Data Discipline Team) Meetings.
- Weekly MsWG (MCST Science Working Group) Meeting

C. **PUBLICATIONS**

Vermote E.F., "Adjacency effect on Remotely Sensed Data: Theory and Correction", contribution to the *Encyclopedia of optical engineering*, Driggers R.G. and E. Lichtenstein (Eds.), publisher Marcel Dekker, Inc., (In press)

Privette J.L. and Vermote E.F**.**, "The Impact of Atmospheric Effects on Directional Reflectance Measurements", Chapter 6 of Reflection properties of Vegetation and Soil - with a BRDF Data base, Maria von Schönermark, Bernhard Geiger, and Hans-Peter Röser (Eds)), 2002, publisher Wissenschaft & Technik Verlag (In press).

C. K. Gatebe, M. D. King, S. Platnick, G. T. Arnold, E. F. Vermote and B. Schmid, Airborne Spectral Measurements of Surface-AtmosphereAnisotropy for Several Surfaces and Ecosystem over Southern Africa, Journal of Geophysical Research, (In press)