Seasonal and Interannual Distribution of Global Agricultural Fires Using MODIS

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Introduction and Aim

Burning in the fields is a common agricultural practice used during the harvesting, post harvesting or pre-planting periods. The most cultivated crop globally is cereals (*FAO*, 2002), which require fire application for their management. There is a notable paucity of quantitative data regarding agricultural fires in the scientific literature. Estimates of agricultural burning have so far relied on national statistics and simple, generalized assumptions about burned crop residues as a fraction of the available agricultural waste (Andreae, 1991; Hao and Liu, 1994; Yevich and Logan, 2003). A consistent, reliable, large-scale characterization of the spatial and temporal distribution of agricultural burning is required to assess its atmospheric impacts and to support fire management of natural resources. The present study provides the first global assessment of agricultural fire activity and aims at identifying regional seasonal and interannual patterns in agricultural burning from 2001 to 2003 using MODIS Terra data.

Methods

The 1 km multiyear (January 2001-December 2003) MODIS Terra active fire data record used for the analysis was generated with the latest and improved MODIS version 4 active fire detection algorithm (Giglio *et al*., 2003). Corrections were applied to the data prior to the analysis to account for inconsistent data coverage, swath overlap in the mid and high latitudes during adjacent passes, and morning and night fire detections in the same pixel.

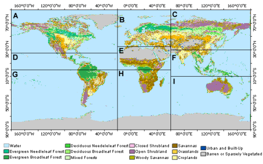


Figure 1. Map of the MODIS 1km Land Cover Types dataset (Friedl et al., 2002) used to derive fire distribution over various land cover and location of the regional windows used in this study.

Results

A. Global Distribution

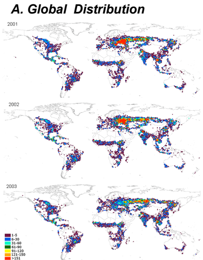
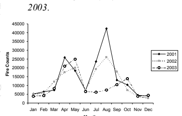


Figure 2. Left: Spatial distribution of global agricultural fires from 2001 to 2003.
Bottom: Monthly time series of MODIS Terra agricultural fire detections globally from 2001 to 2003.



Agricultural fires accounted for 8-11% of the annual global fire activity during the 3 years.

B. Regional Distribution

1. North America (Region A)

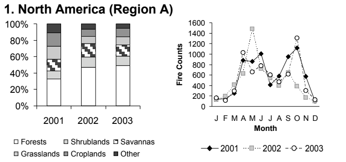


Figure 3. Left: Distribution of fire occurrence in Region A within various land covers from 2001 to 2003.
Right: Monthly time series of MODIS Terra agricultural fire detections in Region A from 2001 to 2003.

Agricultural burning contributed 9-16% of all fires over the various land covers in region A. There were two distinct peaks in agricultural burning, the first during March-April and the second during September-October. In 2001 and 2002 the timing and magnitude of the agricultural fires were similar, and the spring and fall fire activities were comparable. In 2003 more spring burning took place relative to the fall.

2. Europe and European Russia (Region B)

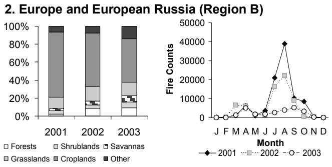


Figure 4. Left: Distribution of fire occurrence in Region B within various land covers from 2001 to 2003.
Right: Monthly time series of MODIS Terra agricultural fire detections in Region B from 2001 to 2003.

Cropland burning accounted for a remarkable 48-73% of all fires in the various land cover types. The majority of crop burning in region B occurred in the cropland-dominated areas of Eastern Europe and southern European Russia (Fig 2). Fire activity in this region was the determinant for the August peak observed globally (Fig 2). The significantly lower fire activity in August 2003 compared with the previous years (10 times lower than in August 2001) can be mainly attributed to inclement weather which resulted in a reduction of planted area and unusually high winterkill of grains in European Russia (*USDA/FAS*, 2003a).

3. Asiatic Russia, Central and Northeast Asia (Region C)

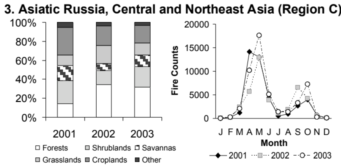


Figure 5. Left: Distribution of fire occurrence in Region C within various land covers from 2001 to 2003.
Right: Monthly time series of MODIS Terra agricultural fire detections in Region C from 2001 to 2003.

Agricultural burning accounted for 18-29% of all fires detected within the various land covers. The spring (April-March) agricultural fire maximum was mainly due to burning in central and southeast Russia, followed by burning in northern and southern Kazakhstan and the Russian-China border (Fig 2). The smaller fall (September-October) fire peak resulted from agricultural burning mainly in the Russian-China border. The entire Russian Federation accounted for 31%-36% of the global agricultural fires during the 3 years.

4. Central America and the Caribbean (Region D)

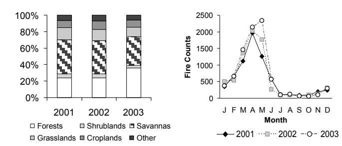


Figure 6. Left: Distribution of fire occurrence in Region D within various land covers from 2001 to 2003.
Right: Monthly time series of MODIS Terra agricultural fire detections in Region D from 2001 to 2003.

Agricultural burning accounted for ~9% of all fires detected over the various land covers during the three years. The main period for agricultural burning occurred from March to May, during harvesting in the maize belt throughout C. America. The seasonal distribution and magnitude of agricultural fires were fairly similar among the 3 years.

5. Northern Africa (Region E)

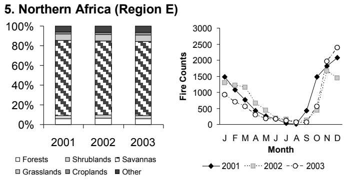


Figure 7. Left: Distribution of fire occurrence in Region E within various land covers from 2001 to 2003.
Right: Monthly time series of MODIS Terra agricultural fire detections in Region E from 2001 to 2003.

Agricultural fires made a small contribution (~2%). Agricultural burning heightened from November through February, which is also generally the main period for savanna burning in this region (see Csiszar *et al*., poster). No significant interannual variations in the amount and seasonality of agricultural fire activity were found.

6. Southeast Asia and India (Region F)

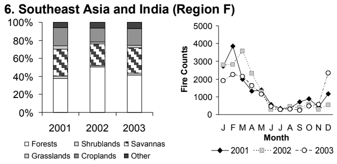


Figure 8. Left: Distribution of fire occurrence in Region F within various land covers from 2001 to 2003.
Right: Monthly time series of MODIS Terra agricultural fire detections in Region F from 2001 to 2003.

Agricultural burning was also substantial in this region contributing 16-20% of the total fire counts. The agricultural fire activity was concentrated in the months of December through April. In 2002 the peak fire activity lagged a month behind the 2001 February peak, whereas the 2003 peak fire activity occurred two months earlier compared with 2001. These temporal variations are likely related to different lengths in the growing seasons.

7. South America (Region G)

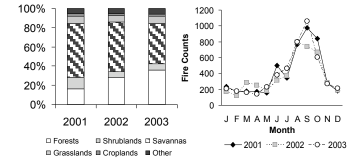


Figure 9. Left: Distribution of fire occurrence in Region G within various land covers from 2001 to 2003.
Right: Monthly time series of MODIS Terra agricultural fire detections in Region G from 2001 to 2003.

In South America cropland burning accounted for a small 2% of all fires in various land cover types. The majority of agricultural fires occurred in the late dry season (July-October). In South America, maize and soybean cultivation dominate in the northern parts of the continent as well as in southeastern Brazil, whereas wheat cultivation dominates in the southern portions in Argentina and Chile (Leff *et al*., 2004). The magnitude and seasonality of agricultural burning in South America was fairly similar among the 3 years.

8. Southern Africa (Region H)

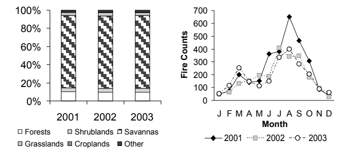


Figure 10. Left: Distribution of fire occurrence in Region H within various land covers from 2001 to 2003.
Right: Monthly time series of MODIS Terra agricultural fire detections in Region H from 2001 to 2003.

In southern Africa agricultural fires contributed only 1% of all fires during the 3-year period. The majority of agricultural fires occurred in the late dry season. The drop in the 2002 and 2003 late dry season fire activity was possibly related to drought conditions that affected several countries in southern Africa and likely also to low crop prices (*USDA/FAS*, 2002a; 2002b; 2003b; 2003c)

9. Australia and New Zealand (Region I)

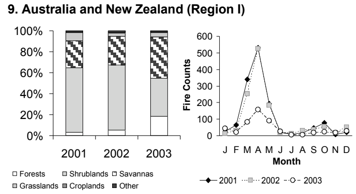


Figure 11. Left: Distribution of fire occurrence in Region I within various land covers from 2001 to 2003.
Right: Monthly time series of MODIS Terra agricultural fire detections in Region I from 2001 to 2003.

Agricultural burning (~1%) in Australia occurred mostly during March to April in the wheat producing regions of southwestern Western Australia and the eastern parts of the wheat belt that stretches from southern South Australia to central Queensland. An El Niño drought resulted in significant decrease in the 2002/2003 wheat production (*USDA/FAS*, 2003d) and this was also reflected in the 2003 fire activity.

Conclusions

Our assessment from 3 years of MODIS Terra fire data from 2001 to 2003 indicates that fire is regularly used in agricultural practices around the world. This study succeeds in providing a consistent spatially and temporally explicit characterization of global agricultural fires, despite the inherent inaccuracies of the underlying remotely sensed datasets. Distinct differences in the seasonality of agricultural fire activity were observed among regions, related to processing and harvesting of different crops. Year to year changes in agricultural fire activity were substantial in Eastern Europe and European Russia and had a significant influence on the global scale agricultural fire occurrences. The comparison of our results with multi-year agricultural reports provided by the USDA for several regions and countries reveals a generally consistency between interannual fire trends and reported agricultural production. Further work is evidently required for assessing sub-pixel agricultural burned area, diurnal variations in agricultural burning and for estimation of greenhouse gas emissions from different crop type burns.

Acknowledgements

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