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Spatial Relationships between Biomass Burning and Land Use / Land Cover Dynamics in Sub-Saharan Africa

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Abstract

Biomass burning (BB) is an extensive and persistent phenomenon across the world, and is a result of either natural (via lightning strikes) or anthropogenic processes, depending on the location. In Northern Sub-Saharan Africa (NSSA), where access to affordable modern farming equipment is extremely limited, agricultural practices dominate and BB is completely anthropogenic for all practical purposes, resulting in NSSA consistently contributing 15-20% of the total global annual emission of particulate matter from fires, according to estimates from version 1.0 of the Fire Energetics and Emissions Research BB emissions inventory (FEERv1.0, http://feer.gsfc.nasa.gov/data/emissions/). The FEERv1.0 algorithm uses a land cover type (LCT) product at either 0.5° or 0.1° resolutions for the conversion of total particulate matter estimates to various other smoke constituents. Due to the fact that fires are closely associated with land cover types, it became apparent that a fire-prone land cover type product at those spatial resolutions were needed, resulting in the FEERv1 BB-LCT product (http://feer.gsfc.nasa.gov/data/landcover/). In version 2 of the product, it was found that 8% of all grid cells with partial or full land cover in the original 0.5° LCT product is reclassified when considering BB practices. In NSSA, we see that the differences fall mainly along the borders between major regions of different LCT. Roughly speaking, fires along the cropland/savanna and savanna/forest borders in NSSA are mostly from from savanna burning. An in-depth analysis of the spatial extent and variability of fires and land cover in NSSA reveals that within the last one-and-a-half decades, the maximum fire activity occurred in the 2006/07 fire season and has been decreasing ever since. Interestingly, despite this decrease in fire activity, we observe a continuing increase in land cover conversion to cropland over the same time period at a rate of 0.3%/yr, which is equal to ≈37,500 km²/yr, or about 9 million new farms each year (assuming a farm size of one acre.)

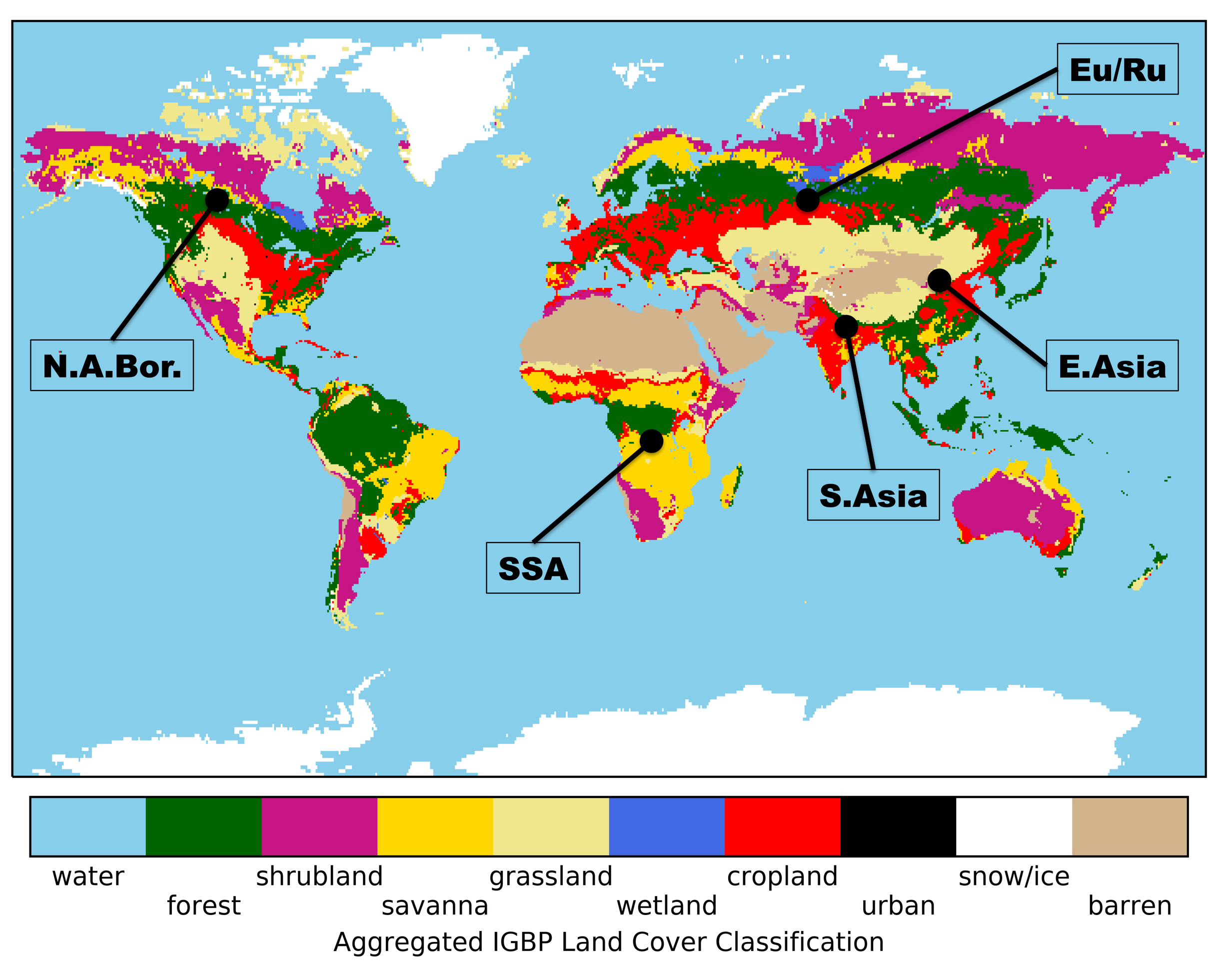

Figure 1: This MCD12C1 Climatology product at 3arcmin resolution was created using the IGBP land cover classification and assessment indices (aggregated into the above 10 classifications) from the yearly MCD12C1 MODIS product, using the years 2001-2012.

References

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Land Cover & Land Use Dynamics wrt Biomass Burning

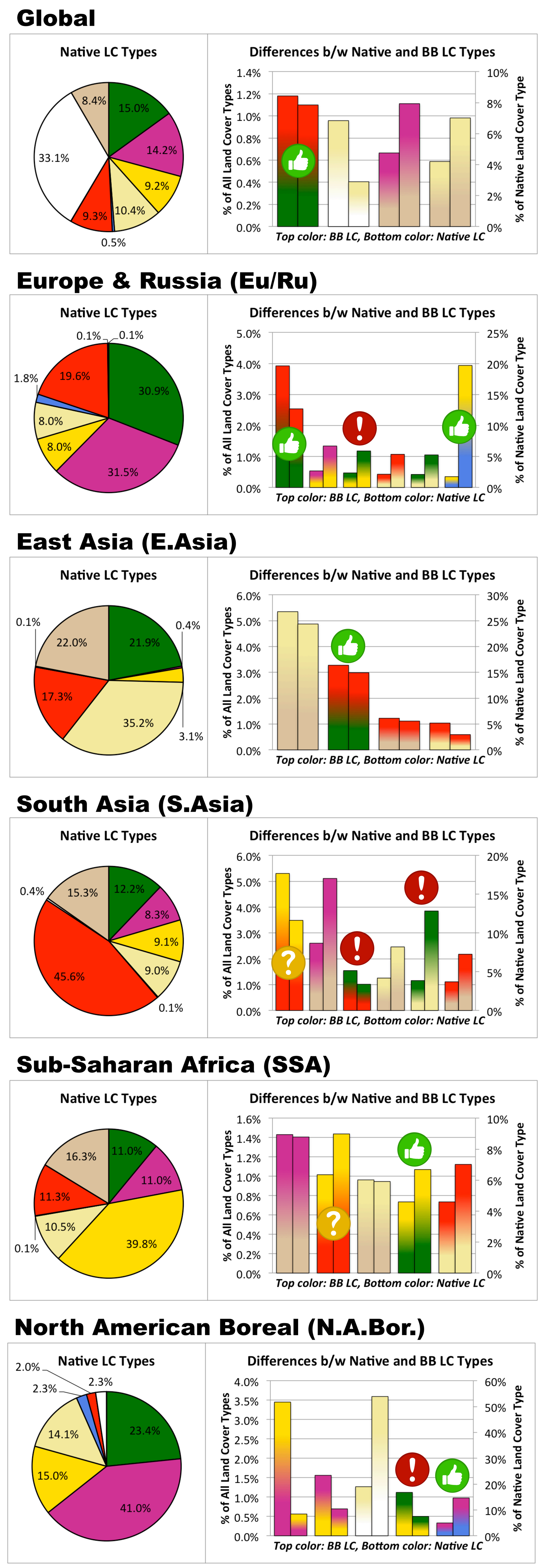

Figure 3: These analyses of land cover type and biomass burning (BB) for the globe and for five regions of interest show distinct differences between the FEER BB-LCT v2 and MCD12C1 Climatological products. The major differences are shown in the right-hand graphs, and on the left are breakdowns of the native land cover (LC) types. Of particular concern are the burning tendencies of sensitive land types like forest and wetland.

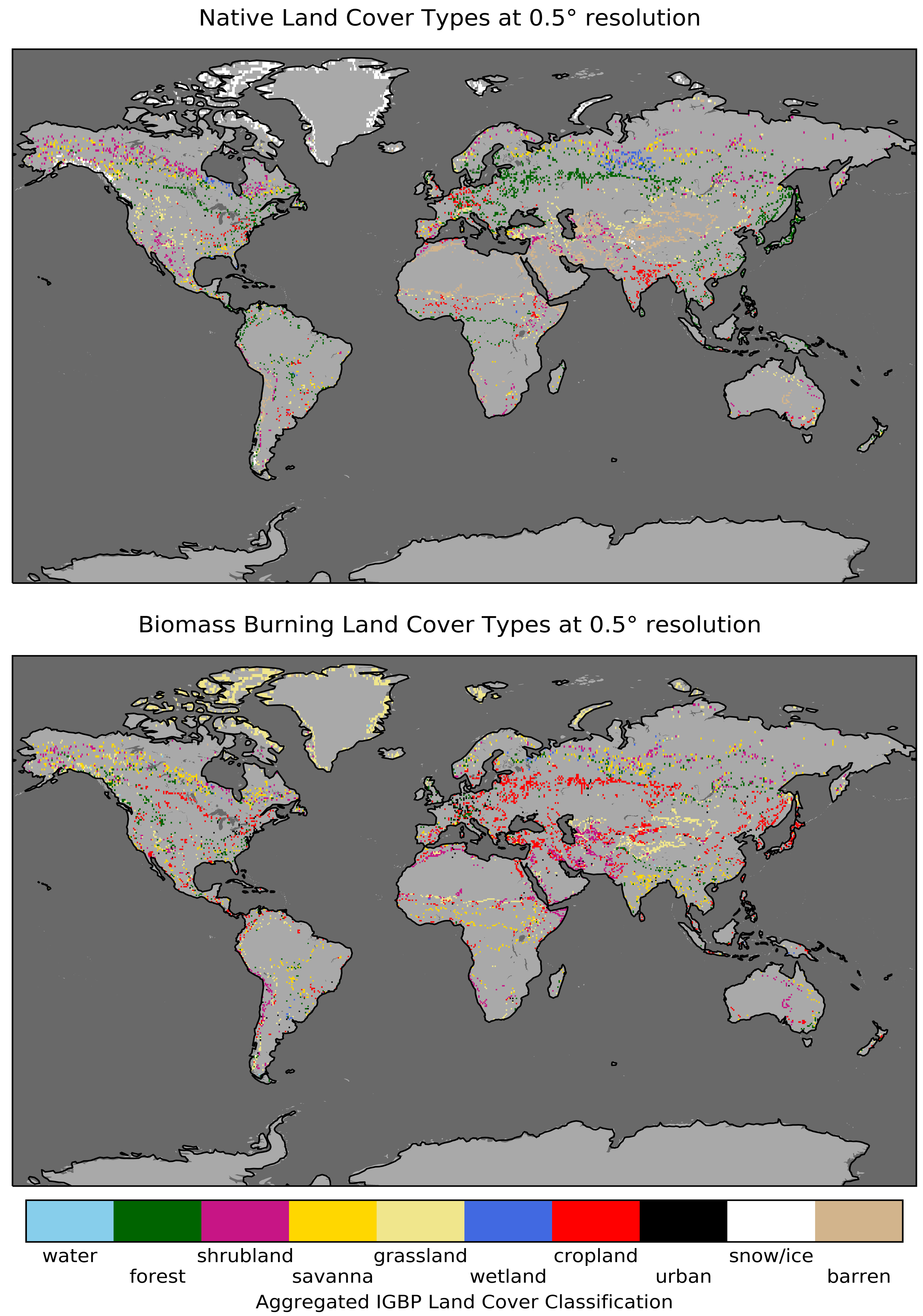

Figure 2: The MODIS fire product (MOD14/MYD14) was combined with the MCD12C1 Climatological product in Fig. 1 to create the FEER BB-LCT v2 product at 1°, 0.5° and 0.1° resolutions for each year between 2003-2012. The differences between this product and a downscaled MCD12C1 Climatological product are highlighted above for 0.5° resolution (disregarding water pixels to eliminate coastal effects), resulting in a difference of 8% between the two classifications over land areas (10% for the 1° product, 3% for the 0.1° product). Five regions with distinct differences are analyzed further in Fig. 3. The FEER BB-LCT v1 precursor product was used to determine proper emission factor ratios between species for the FEERv1.0 Emissions product available at http://feer.gsfc.nasa.gov/data/emissions/. The next iteration of this emissions product (FEERv1.1) will use the improved FEER BB-LCT v2.

Cropland and Savanna Burning in Sub-Saharan Africa

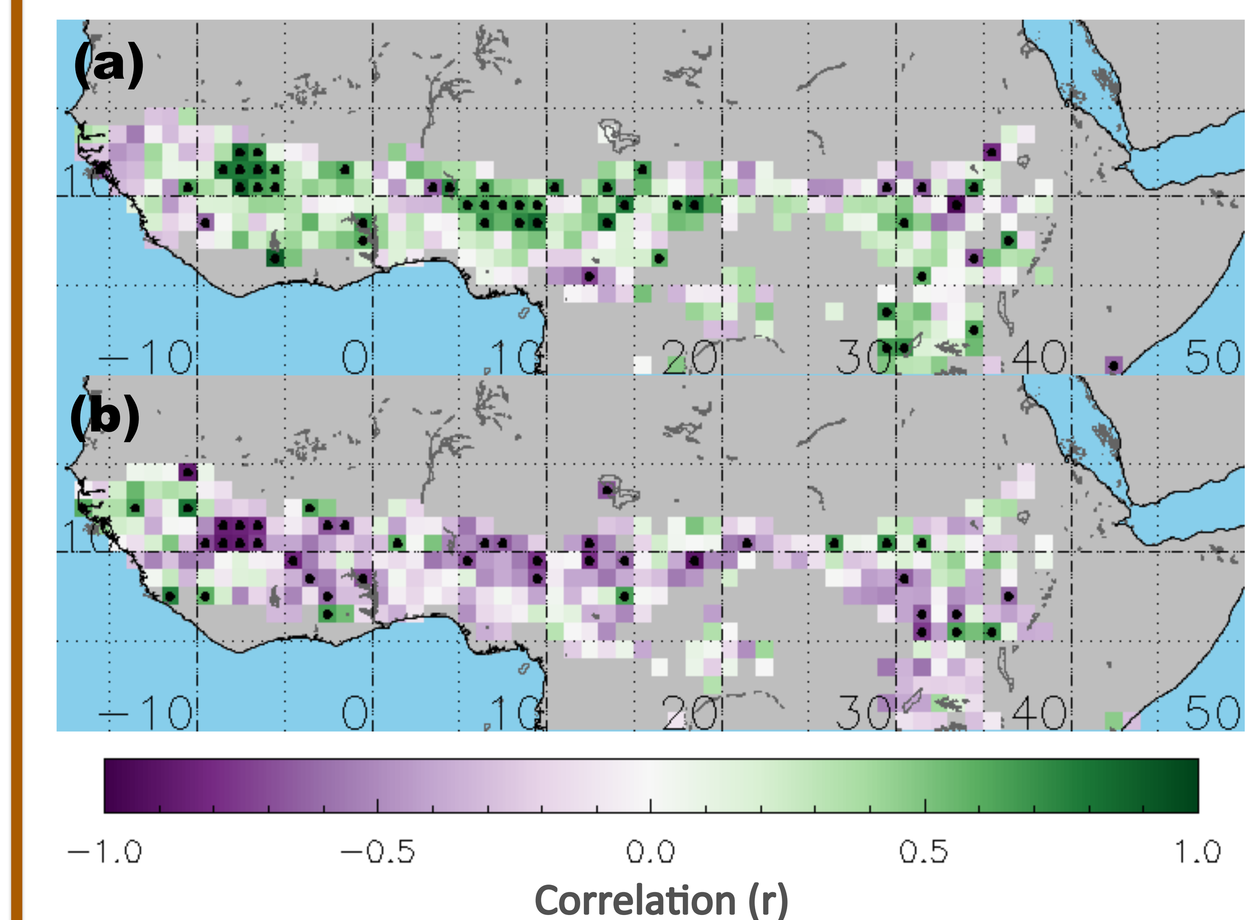

Figure 4: The correlation between the number of detected MODIS 1km fires and (a) cropland-to-savanna and (b) savanna-to-cropland conversions at 1° resolution show distinct biases in Northern Sub-Saharan Africa (NSSA). Statistically significant grid cells are signified with a dot. The results suggest that fires in NSSA tend strongly to produce savanna from cropland areas and to prevent savanna conversion to cropland. However, it is well known that cropland burning is a regular practice in NSSA as a precursor for cultivation. While cropland area has been increasing during this time at a rate of 0.3%/yr, fire detection rates have been decreasing for this region. There are, however, stipulations in using the MODIS 1km resolution fire data to measure small cropland fires (see Fig. 5).

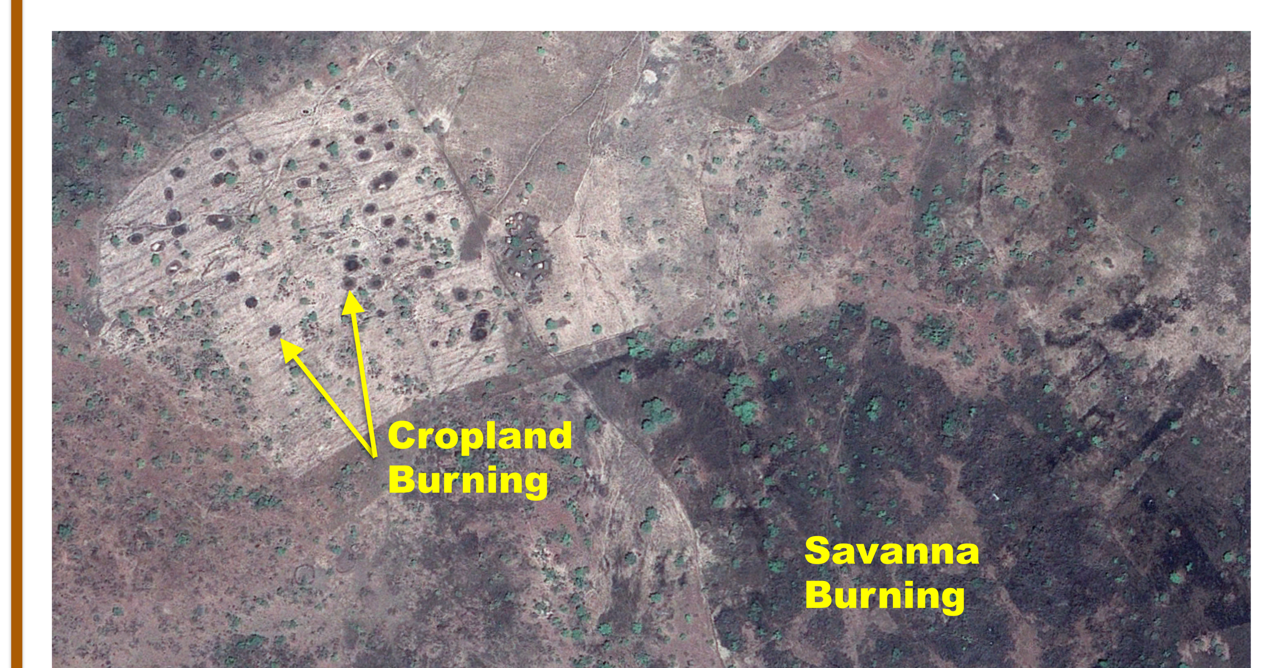

Figure 5: This image shows two types of burning around one village in Africa – savanna fires spread at will whereas for cropland burning, the residue is collected into piles, left to dry, and then ignited as bonfires at the beginning of the dry season. The effects on fire detection could be significant, and could introduce uncertainty in cropland and savanna burning comparisons. For instance, if cropland fire detection rates are lower than for savanna fires, the coincident increase in cropland and decrease in fires in NSSA becomes more of an issue in detection capabilities, and results like Fig. 4 must be taken with a grain of salt. Therefore, follow-up research must include a comparison between fire-detection products at different high-to-medium resolutions. *[Map data: Google, DigitalGlobe]*