J8.2 LAND USE AND SEASONAL GREEN VEGETATION COVER OF THE CONTERMINOUS USA FOR USE IN NUMERICAL WEATHER MODELS

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1. INTRODUCTION

The land cover classes developed under the coordination of the International Geosphere-Biosphere Programme Data and Information System (IGBP-DIS) have been analyzed for a study area that includes the Conterminous United States and portions of Mexico and Canada. The 1-km resolution data have been analyzed to produce a gridded data set that includes within each 20-km grid cell: 1) the three most dominant land cover classes, 2) the fractional area associated with each of the three dominant classes, and 3) the fractional area covered by water. Additionally, the monthly fraction of green vegetation cover (fgreen) associated with each of the three dominant land cover classes per grid cell was derived from a 5-year climatology of 1-km resolution NOAA-AVHRR data. The fgreen values derived in this study provide a potential improvement over the use of monthly fgreen linked to a single land cover class per model grid cell, as currently used in some numerical weather models. The fgreen variable will be described and its relationship with land cover class will be discussed.

2. MODEL REPRESENTATION OF VEGETATION

The land surface variables in the land surface model component of the coupled Eta model include vegetation (land cover) type and fractional green vegetation cover (fgreen). Fgreen is defined as the fraction of horizontal area associated with the photosynthetically active green vegetation that occupies a model grid cell. Fgreen, as used by the National Centers for Environmental Prediction (NCEP) in the land surface model component in the Eta model, is varied through the growing season while a constant value of leaf area index (LAI) is utilized. The introduction of improved satellite-derived monthly values of fgreen into the Eta model resulted in improved model forecasts of land-surface fluxes and planetary boundary layer structure (Betts et al., 1997). The current land cover class and fgreen variables used in the NCEP analyses are represented in the model as one (most dominant) land cover class per grid cell with monthly fgreen values derived as an average for the grid cell. The advantages of sub-grid cell vegetation information have been discussed by Koster and Suarez (1992) and demonstrated by Avissar and Pielke (1989) as well as others. The objectives of this study included development of land surface data sets for use in coupled land-atmosphere models that include sub-grid cell land classes and the seasonal characteristics of vegetation (fgreen) associated with each of those land classes for the Conterminous USA. A grid cell size of 20 km by 20 km was selected for this initial analysis as this is the nominal grid cell size in the current operational Eta model at NCEP.

The land cover information for this study was extracted from the IGBP-DIS 1 km land cover data set (Loveland and Belward, 1997) that was produced to make available a global data set with high spatial resolution and known accuracy. The 17 IGBP classes were condensed into 14 classes (CIGBP) by combining several of the classes. Additional information on the methodology can be found in Gallo et al. (2001).

3. FRACTION OF GREEN VEGETATION COVER

The fraction of green vegetation per grid cell (fgreen, Equation 1),

fgreen =(NDVI- NDVIo)/(NDVIi - NDVIo) (1)

as described by Gutman and Ignatov (1998), and demonstrated useful in coupled land-atmosphere models (Betts et al., 1997), requires maximum and minimum thresholds of the normalized difference vegetation index (NDVI). Selection of the maximum (NDVIi) and minimum (NDVIo) thresholds of NDVI required for computation of fgreen was based on NDVI values of the biweekly Conterminous USA 1-km AVHRR data set (Eidenshink, 1992) in combination with the CIGBP land cover classes.

An interpolated mid-month NDVI data set was prepared from the biweekly Conterminous USA data set. All biweekly data available from 1993 and 1995 through 1998 were interpolated on a daily basis and temporally processed to remove fluctuations in the NDVI signal due to cloud or other contamination (Swets, et al., 1999). The mid-month NDVI value was retained from the interpolated daily values. Data of 1994 were excluded from the analysis due to low solar elevation angles associated with the AVHRR data acquisitions during this year.

The mid-month NDVI values were averaged on a

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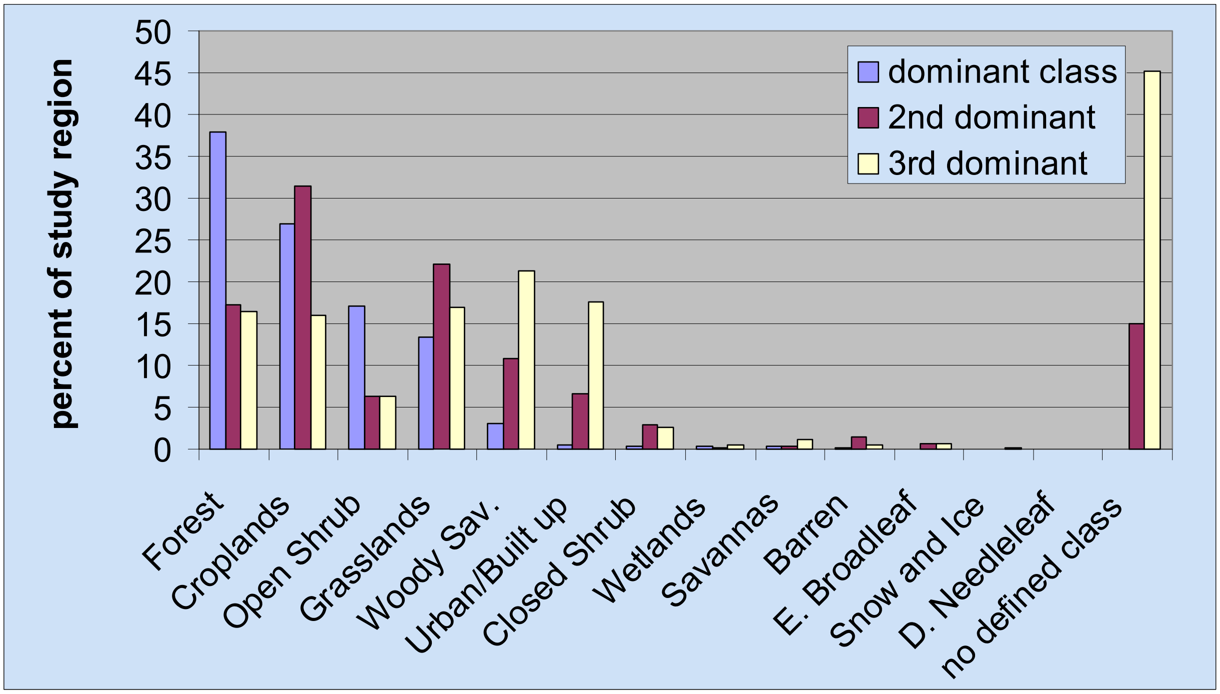

Figure 1. The percent of study region associated with the land cover classes that were the dominant, second most dominant, and third most dominant classes within the individual 20-km grid cells. The area associated with the "no defined class" category is excluded from the computation of the values for the second or third most dominant classes. The area associated with water bodies is excluded from this analysis.

monthly basis over the 5 available years of data. Monthly values of fgreen were computed (equation 1) from the 5-year monthly NDVI values with NDVIo = 0.09 and NDVIi = 0.69 (Gallo et al, 2001). When observed NDVI values were less than 0.09 fgreen was assigned a value of 0.0, and when observed values were greater than 0.69 fgreen was assigned a value of 1.0.

4. RESULTS

Two of the questions related to development of this data set were; 1) what number of classes adequately represents the land cover within the study region at the selected 20 km grid cell size, and 2) does fgreen vary sufficiently between the land cover classes within a grid cell to warrant monthly fgreen data for each land cover class within a grid cell. Water bodies were excluded from these results.

4.1 *Land Cover Classes*

The CIGBP classes and percent area within the study area associated with each class are included in Figure 1. More than 37% of the study area included forests as the most dominant class per 20-km grid cell. Cropland and Open Shrublands followed with >26 and >17% respectively. When added with the Forest class, the Cropland and Open Shrubland classes account for over 81% of the non-water area that is associated with the most predominant classes per grid cell. Croplands (31%) occupied the greatest portion of the study area of the second most dominant land cover classes, followed by Grasslands and Forests. Approximately 15% of the study region included grid cells that were solely one class per grid cell (no defined class within second most dominant class). And approximately 45% of the grid cells were solely comprised of one or two classes (no defined class within third most dominant class). Additional analysis revealed that approximately 97% of the 20-km grid cells in the study area included three or less land cover classes. These results suggest that three CIGBP classes are sufficient for representation of the most dominant land cover classes at this grid cell size.

4.2 *Fractional Green Vegetation Cover*

One of the motivating factors for development of sub-grid cell information was the recognition that within vegetation cover transition zones a single land cover class per grid cell will likely misrepresent the surface conditions within the grid cell. Six grid cells that lie on an east-west transect from Eastern

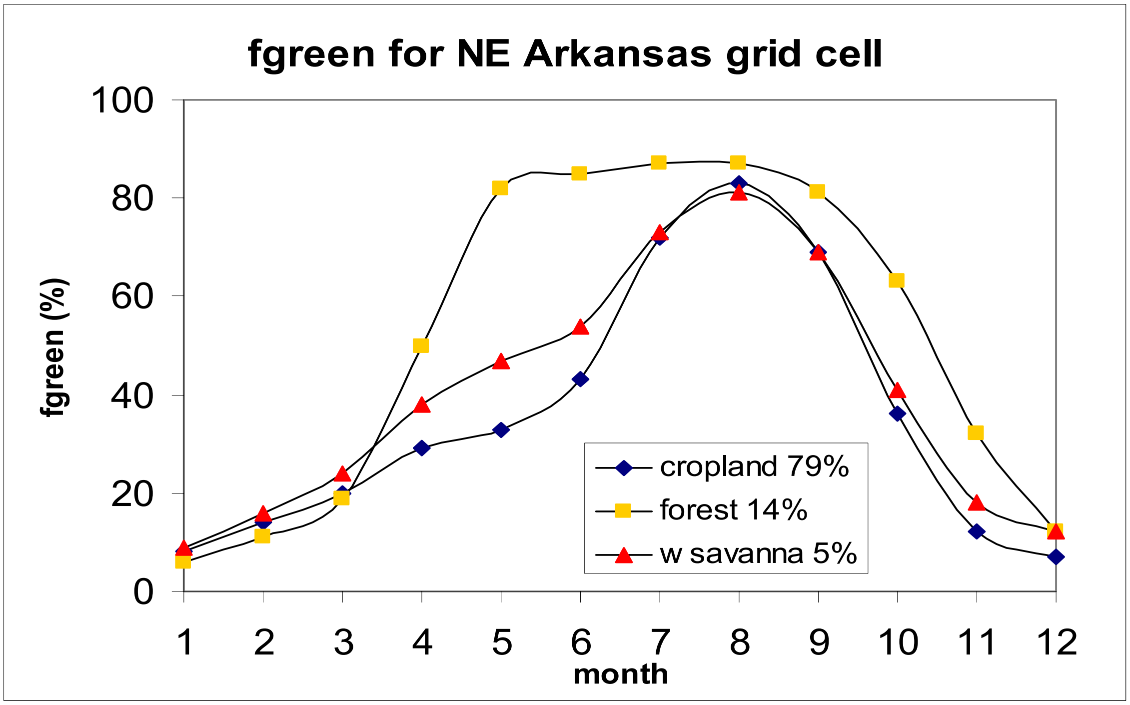

Figure 2. Five-year mean Fgreen for a cropland dominated grid cell (36.3 °N, 90.7 °W). Note that the percentage of land area of each cover type, per grid cell, is also provided in this data set.

Arkansas through Tulsa, Oklahoma, to Western Oklahoma were intensively examined. This region represents a gradient of annual precipitation from over 127 cm for the eastern grid cell to less than 70 cm for the western grid cell. The crops associated with the Croplands dominated grid cells varied from cotton and rice (east) to wheat (west) (USDA, 1994). The fgreen values were examined for the three most dominant land covers of each grid cell. Some grid cells displayed similar trends in fgreen for the three land covers, while trends within the other grid cells differed (Figure 2). Cropland dominates the land area within a grid cell in NE Arkansas, however, seasonal fgreen for the forested areas of the grid cell rises above 50% at least one month earlier than either the Wooded Savanna or Cropland classes. While the maximum value of fgreen was similar for all three classes, the forest class displayed the greatest duration of fgreen above thresholds of either 50% or 75%.

The overall impact of the use of three land cover classes and their associated monthly fgreen values was assessed for the entire study area. A significant difference in fgreen, defined as a difference greater than 0.1 (10%), between any of the land cover classes within a grid cell, was assessed for each grid cell on a monthly basis. Significant differences in fgreen were observed for over 57% of the non-water grid cells in the study area during at least one month. More than 29% of the grid cells displayed significant differences in fgreen for six or more months. Over 6% of the grid cells exhibited significant differences in fgreen during all 12 months.

5. SUMMARY

The results suggest that for the CIGBP land cover classes, at a 20 km grid cell size, three land cover classes are sufficient to represent the land cover within a grid cell. The results also suggest that differences in fgreen between the classes within a grid cell are sufficient to warrant derivation of fgreen for each of the three land cover classes within a grid cell. Future analysis will include the variability in fgreen

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