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

Kevin Gallo, NOAA/NESDIS/Office of Research & Applications
Tim Owen, NOAA/NCDC
Brad Reed, SAIC/EROS Data Center
SATELLITE-DERIVED LAND USE AND SEASONAL GREEN VEGETATION COVER OF THE CONTERMINOUS USA FOR USE IN NUMERICAL WEATHER MODELS

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### Historical Aspects of Data Used in Numerical Models

#### Key factors: data/instruments, science of data assimilation, computer and communications capacity

<table>
<thead>
<tr>
<th>Year</th>
<th>Data Type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>Insitu data</td>
<td>Limited use of derived sounding data in models</td>
</tr>
<tr>
<td>1990</td>
<td>Satellite radiances</td>
<td>~85 % of data in models</td>
</tr>
<tr>
<td>2000</td>
<td>Satellite radiances</td>
<td>~97% of data</td>
</tr>
<tr>
<td>2002</td>
<td>Satellite radiances</td>
<td>~97% of data</td>
</tr>
</tbody>
</table>

- **1960**
  - Insitu data

- **1990**
  - Limited use of derived sounding data in models
  - All LEO
  - 250K obs/day
  - Atmosphere

- **2000**
  - Nearly all LEO
  - 1 million obs/day
  - Surface/ocean atmosphere

- **2002**
  - Predominantly LEO; some GEO
  - 95 million obs/day
  - Surface/ocean atmosphere
Alternate Title/Initial Question: Should land cover classes and associated information be aggregated for use in Numerical Weather Models?
Introduction
Land Use/Land Cover
Season changes in Land Cover
Introduction

What is land surface contribution to energy budget/weather?
Indianapolis
ASTER
image acquired
16 June
2001
Simulated color-IR of Indianapolis airport (from ASTER data).
Current coupled land-atmosphere models require information about the type of land surface, and the seasonal changes associated with the land surface.
Green Vegetation Fraction (F_{green})

\textbf{F}_{green} \textit{is defined as the fraction of horizontal area associated with the photosynthetically active green vegetation that occupies a model grid cell.}
Operational Vegetation Type Database at NCEP (currently 1 vegetation type per 15 km grid cell)
June Green Vegetation Fraction
(also 1 value per 15 km grid cell)
Annual Time Series of Green Vegetation Fraction

- Oklahoma (Wheat)
- Iowa (Corn/Soybeans)
Does the number of LULC classes and Fgreen signatures/signals vary greatly enough within a 20 km grid cell to warrant >1 class per grid cell?
Underlying OBJECTIVE

Develop improved high-resolution data sets that represent the seasonal characteristics of global land surfaces.
Land Surface Variables

METHODOLOGY

Study Area:
Conterminous USA+

Source Data:
1 km AVHRR products (historical availability); visible & near-IR reflectance, vegetation index, & …
METHODOLOGY cont.

Source Data:
1 km-based IGBP land cover classes from AVHRR used to derive the most dominant land cover classes in each model grid cell (initially 20 km).
Land Use/Land Cover
METHODOLOGY cont.

Source Data:
1 km-based IGBP land cover classes from AVHRR used to derive the most dominant land cover classes in each model grid cell (initially 20 km).
1 km pixels within 20 x 20 km grid cells

METHODOLOGY

near Miles City, MT
Grassland 69.0%
Cropland 31.0

Chicago, IL
Urban 93.2%
Open Shrub 5.5
Grassland 1.2

CIGBP Land Cover Classes

- Mixed Forest
- Evergreen Broadleaf Forest
- Deciduous Needleleaf Forest
- Closed Shrubland
- Open Shrubland
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands/Natural Vegetation Mosaic
- Urban or Built-Up
- Snow and Ice
- Barren or Sparsely Vegetated
- No Land Classes/Water Bodies
Land Use/Land Cover

1 km grid cells

Chicago, IL

Urban 93.2%
Open Shrub 5.5
Grassland 1.2

20 km grid cells

Most dominant classes
CHICAGO, IL

20 km grid cells

FIRST

SECOND

THIRD

IGBP COVER CLASSES (REVISED) PREDOMINANT, 20 km GRID CELL

Mixed Forest
Open Shrubland
Woody Savannas

Grasslands
Croplands/Natural Vegetation
Urban or Built-Up
No Land Classes/Water Bodies
Land Use/Land Cover

PRODUCTS

The three most dominant land cover types (IGBP) per 20-km model grid cell have been identified for conterminous USA. Additionally....
PRODUCTS cont.

- % area per 20 km grid cell associated with each of 3 most dominant land cover types, and
- % area per 20 km grid cell defined as water.

Land Use/Land Cover

Most Dominant Land Cover Type

<table>
<thead>
<tr>
<th>Water</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Area</td>
<td>% Area</td>
<td>% Area</td>
</tr>
</tbody>
</table>

Map of North America showing land use/land cover distribution.
# CONUS+ LULC Comparison

(Most dominant land cover type)

<table>
<thead>
<tr>
<th>LULC</th>
<th>% area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>36.3</td>
</tr>
<tr>
<td>Cropland</td>
<td>26.8</td>
</tr>
<tr>
<td>Open Shrubs</td>
<td>16.3</td>
</tr>
<tr>
<td>Grasslands</td>
<td>14.4</td>
</tr>
<tr>
<td>W. Savanna</td>
<td>4.1</td>
</tr>
<tr>
<td>Urban</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Percent area associated with three most dominant cover types.

- 45% of area represented by 2 classes
- 15% represented by 1 class
Are three classes per grid cell sufficient to represent grid cell LULC?

1 km pixels within 20 x 20 km grid cells

near Miles City, MT

Chicago, IL

20 km
More than 90% of the 20 km land grid cells have > 98% of their land area identified by 3 or less CIGBP classes.
Seasonal changes in Land Cover
**Green Vegetation Fraction (Fgreen)**

**Fgreen** is defined as the fraction of horizontal area associated with the photosynthetically active green vegetation that occupies a model grid cell.
Fraction Green Vegetation (F\text{green})

F\text{green} vs NDVI

F\text{green} (Gallo et al., 2001) = (ndvi-.09)/(.69-.09)
Fgreen validation
fgreen vs. ndvi: corn-soyb

3 July 2001

n = 38
r^2 = 0.60
b1 = 1.94
Temporally refined 1 km NDVI data

- Processed (Swets et al., 1999) to remove NDVI signal perturbations.
- Conterminous USA+ region,
PRODUCTS

Version 1.0 of monthly fractional green vegetation has been produced for the 3 most predominant land cover types per 20-km grid cell based on 5 year climatology of NDVI & Fgreen.
Are three classes per grid cell needed to represent grid cell Fgreen?

CHICAGO, IL

FIRST
SECOND
THIRD

IGBP COVER CLASSES (REVISED)  PREDOMINANT, 20 km GRID CELL

- Mixed Forest
- Open Shrubland
- Woody Savannas

- Grasslands
- Croplands/Natural Vegetation
- Urban or Built-Up
- No Land Classes/Water Bodies
Fractional Green Vegetation: 5-year mean
forest class dominant: 36.1N 94.9W

significant difference
\geq 0.10 fgreen
Fractional Green Vegetation: 5-year mean
cropland class dominant: 36.3N 90.7W

Fractional Green Vegetation: 5-year mean

cropland class dominant: 36.3N 90.7W

significant difference
≥ 0.10 fgreen
58% of grid cells had 1 or more months with significant differences (>10%) in fgreen.
Percent of grid cells in CONUS+ with significant differences in monthly values of $F_{green}$.

<table>
<thead>
<tr>
<th># of Months</th>
<th>% of grid cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>42%</td>
</tr>
<tr>
<td>$\geq 1$</td>
<td>58</td>
</tr>
<tr>
<td>$\geq 2$</td>
<td>53</td>
</tr>
<tr>
<td>$\geq 6$</td>
<td>29</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>
Standard Deviation of $F_{green}$
Relatively large standard deviation in Fgreen within NW Iowa and S. Minnesota (left) a result of heavy rains during 1993 as observed with SSM/I soil wetness index (right).
Summary

The results indicated that three land cover classes were warranted per 20 km grid cell to adequately characterize the land cover and seasonal changes in the land cover (fgreen) within the grid cell.
Future

Develop methodology for real-time NDVI-fgreen currently under development.
Future
Assess MODIS derived Land Cover and NDVI.
Extra slides
Annual Time Series of Green Fraction Over Oklahoma Wheat Country

- Early Spring intense green up.
- Rapid senescence.
- Harvesting and return of land to near bare soil by early Summer.
- Planting in Fall.

![Graph showing green fraction over time]
Green-up and peak $F_{\text{green}}$ of corn occurs less rapidly than for wheat.

Corn harvested much later in the warm season than wheat.
Land Use/Land Cover

1 km grid cells

Chicago, IL

Urban 93.2%
Open Shrub 5.5
Grassland 1.2

20 km grid cells

CHICAGO, IL

IGBP COVER CLASSES (REVISED)
PREDOMINANT, 20 km GRID CELL

Mixed Forest
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