

# Using Satellite-based Products to Enhance Existing Area Burned Data

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## **Purpose:**

**Improve biomass burning emissions estimates by enhancing estimates of area burned.**

## **Initial Assessment**

**(1) Combined two satellite products**

**(2) Compare to ground data  
Florida**

**May 1, 2002 through August 30, 2002**

# Motivation

## Biomass burning:

- ❖ Major contributor of particulate matter and other pollutants.
- ❖ Poorly defined.
- ❖ Impedes the ability of regions to achieve National Ambient Air Quality Standards for PM 2.5 and ozone.
- ❖ No standard biomass burning products exist for the United States.

Satellite imagery offers the opportunity to remotely sense fire across governmental and private boundaries.



Fireweed  
1 year after burn

# Biomass burning emissions estimates

**Step One** Total direct carbon emissions ( $C_t$ )

$$C_t = ABf_c\beta$$

(Seiler and Crutzen 1980)

**A** is area;

**B** is biomass density;

$f_c$  is carbon fraction of the biomass;

$\beta$  is the fraction of biomass consumed

**Step Two** Emissions factors or ratios  
to estimate species specific emissions

# Two satellite products

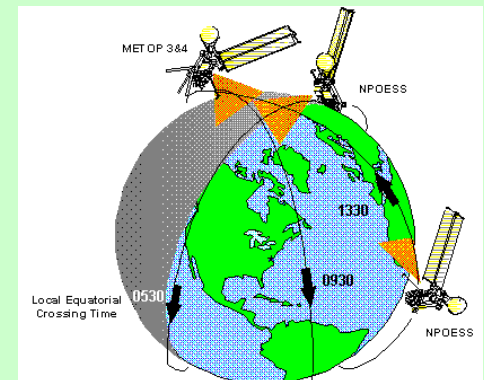
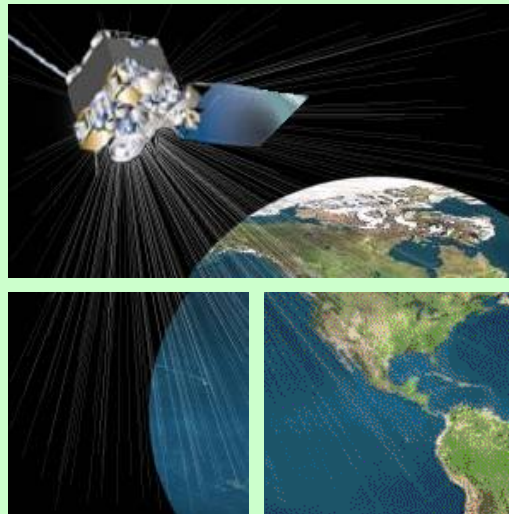
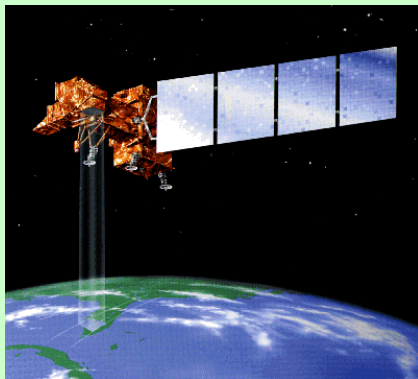
- (1) Moderate Resolution Imaging Spectroradiometer (MODIS)  
and
- (2 ) Geostationary Operational Environmental Satellite (GOES)  
Automated Biomass Burning Algorithm (ABBA)

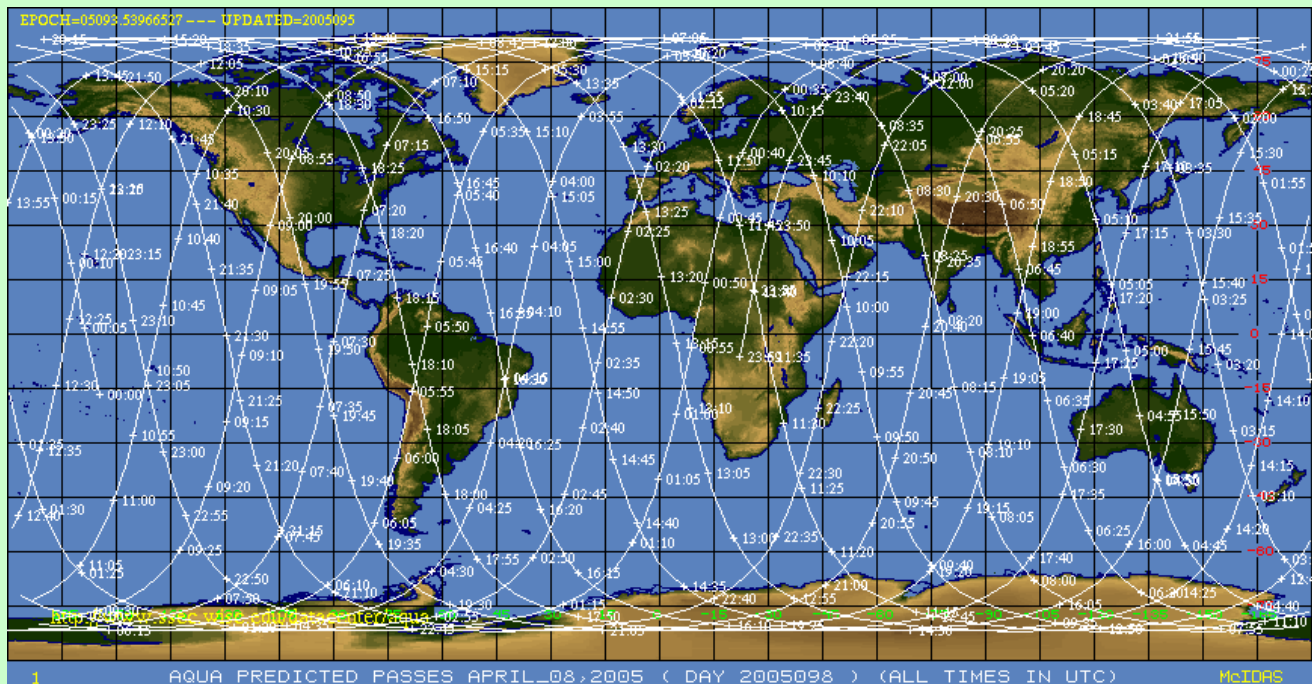
## MODIS

sun-synchronous orbit  
twice daily (terra & aqua)  
spatial resolution 1 km<sup>2</sup>

## GOES

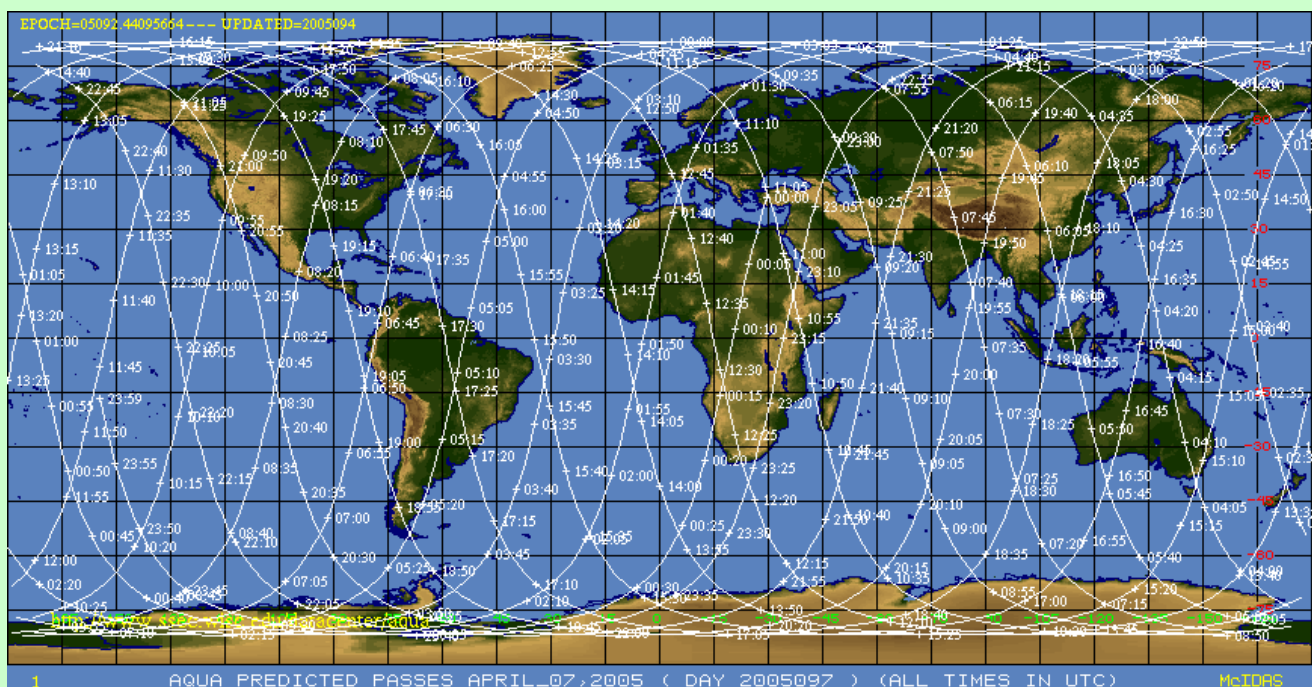
geostationary orbit  
15 minute (east & west)  
spatial resolution 16 km<sup>2</sup>





# MODIS Aqua

## Predicted Sequential Orbit



# Active Fire Detected by AVHRR channel 3 ( $3.7\text{ }\mu\text{m}$ )

## Considerations

**Clouds prohibit detection.**

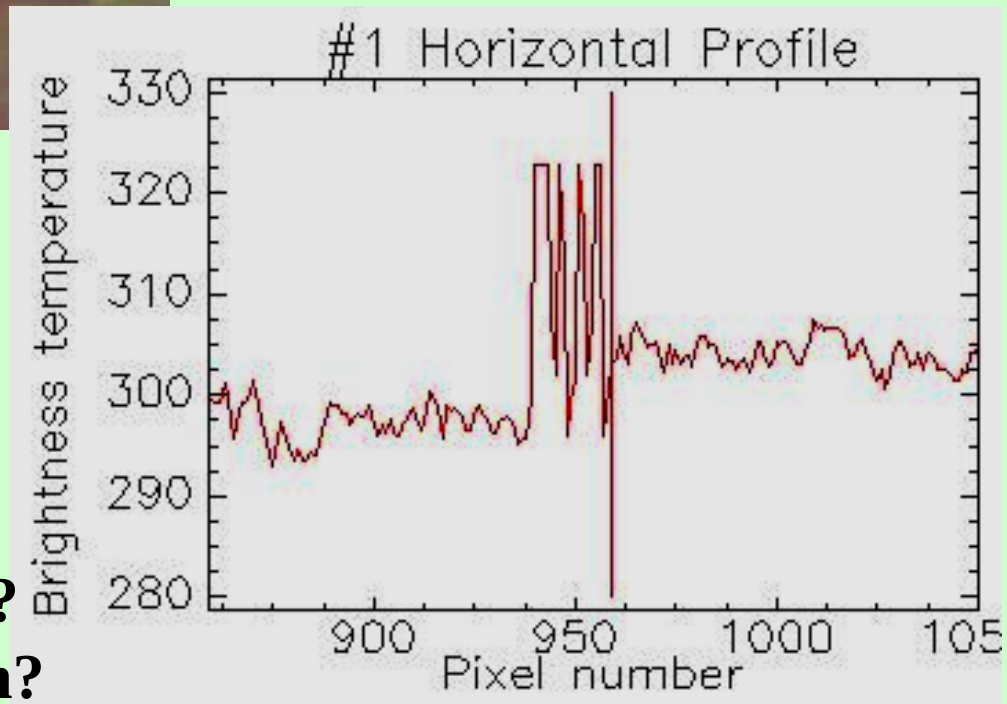
**Fire size?**

**Fire intensity?**

**Viewing angle of satellite?**

**Instrument spatial resolution?**

**Instrument temporal resolution?**



## GOES data processing

- ❖ Downloaded data from the historic ABBA data website: Fire Locating and Modeling of Burning Emissions (FLAMBE)
- ❖ Integrated ½ hour data from GOES east & west into daily files
- ❖ Combined data from GOES east and GOES west
- ❖ Delete low probability fire data (flag 5)
- ❖ Average the area of processed data (flag 0) and assign the average area to flags 1 – 4.\*\*\*\*\*
- ❖ Generate a cumulative ArcGIS shape file. Polygons are defined by area. \*\*\*\*\*

\*\*\*\*\* Area computed for the process data (flag 0) represents the instantaneous fire area burning \*\*\*\*\*



**Fireweed**

# **MODIS data processing**

**MODIS Terra and Aqua data are  
downloaded from the  
Rapid Response Fire team**

**Combine Aqua and Terra data**

**Exclude data that are  $< 20\%$  confident**

**Convert the point data to  
ArcGIS shape files**

**These are point data, no area**



# Florida ground-based fire data

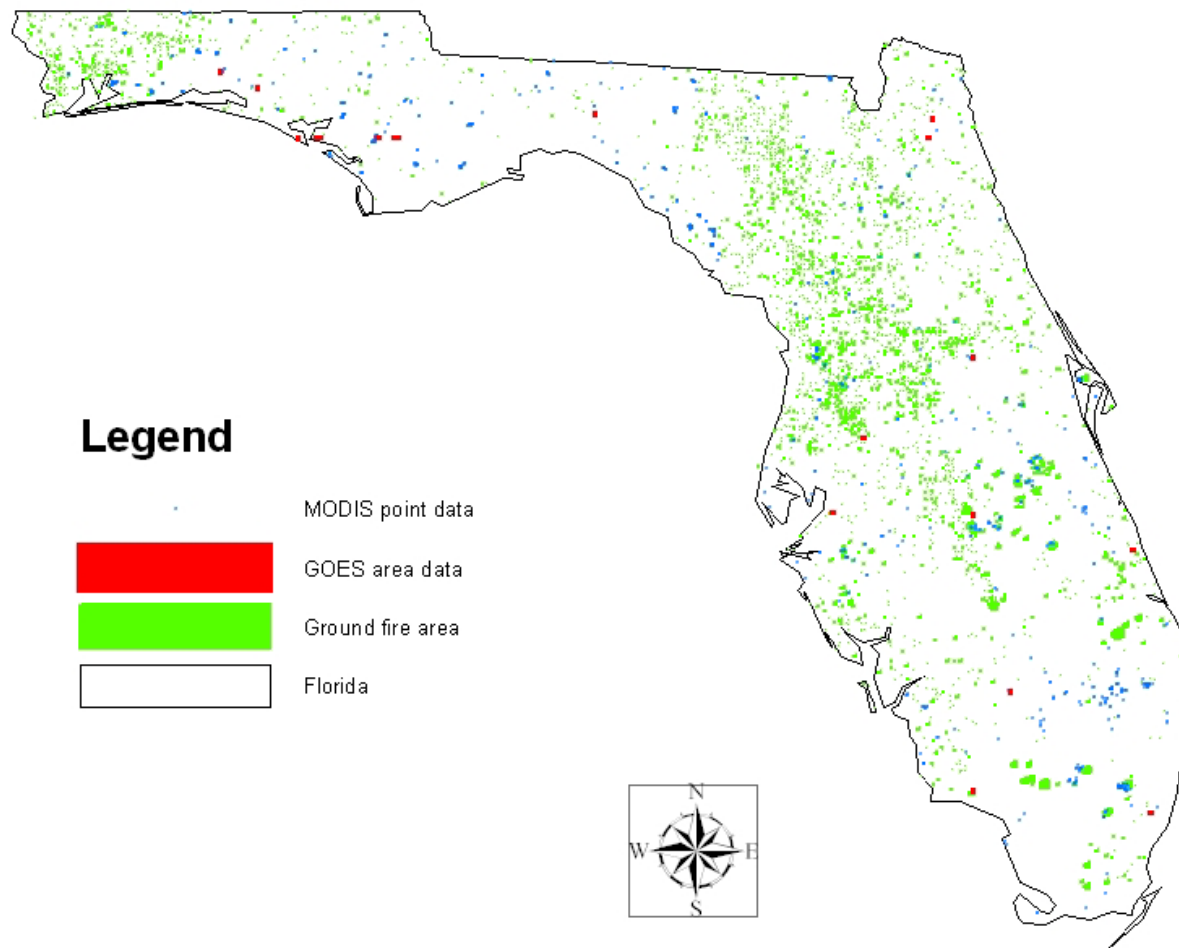
Wildfire database – contained wildfires and prescribed burns that are reported on state and privately held lands (1077 records after data exclusion).

Open burns – contains reported agricultural, land clearing and silvicultural fires (3265 records after data exclusion).

## Treatment

- ❖ Data records that exclude location (latitude, longitude) and area are eliminated.
- ❖ Data are converted to ArcGIS shape files, where area defines the polygon size.

*P. Siberica* under a  
*P. Sylvestris* canopy



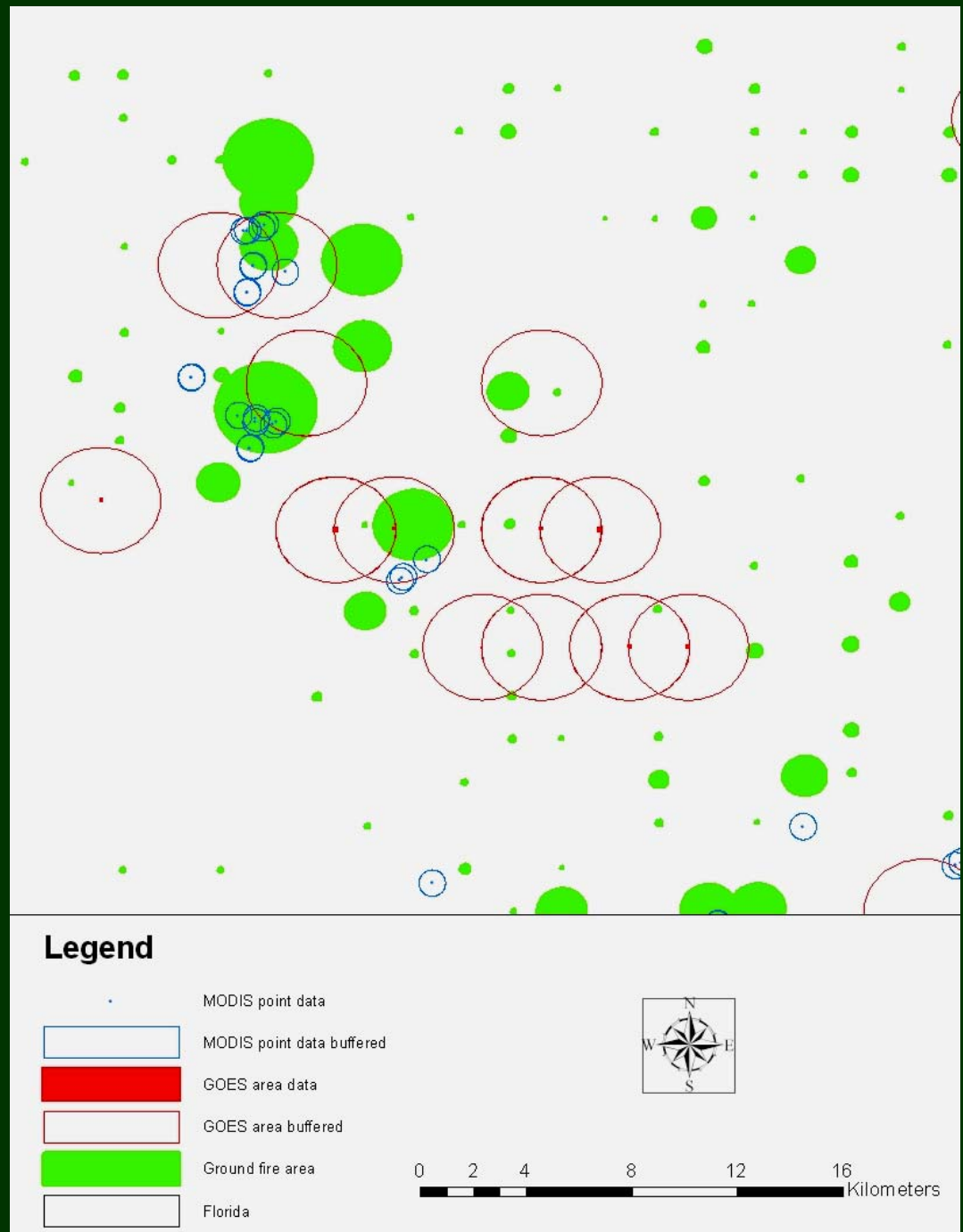
**Spatial coincidence of satellite-based and ground-based fire data.**

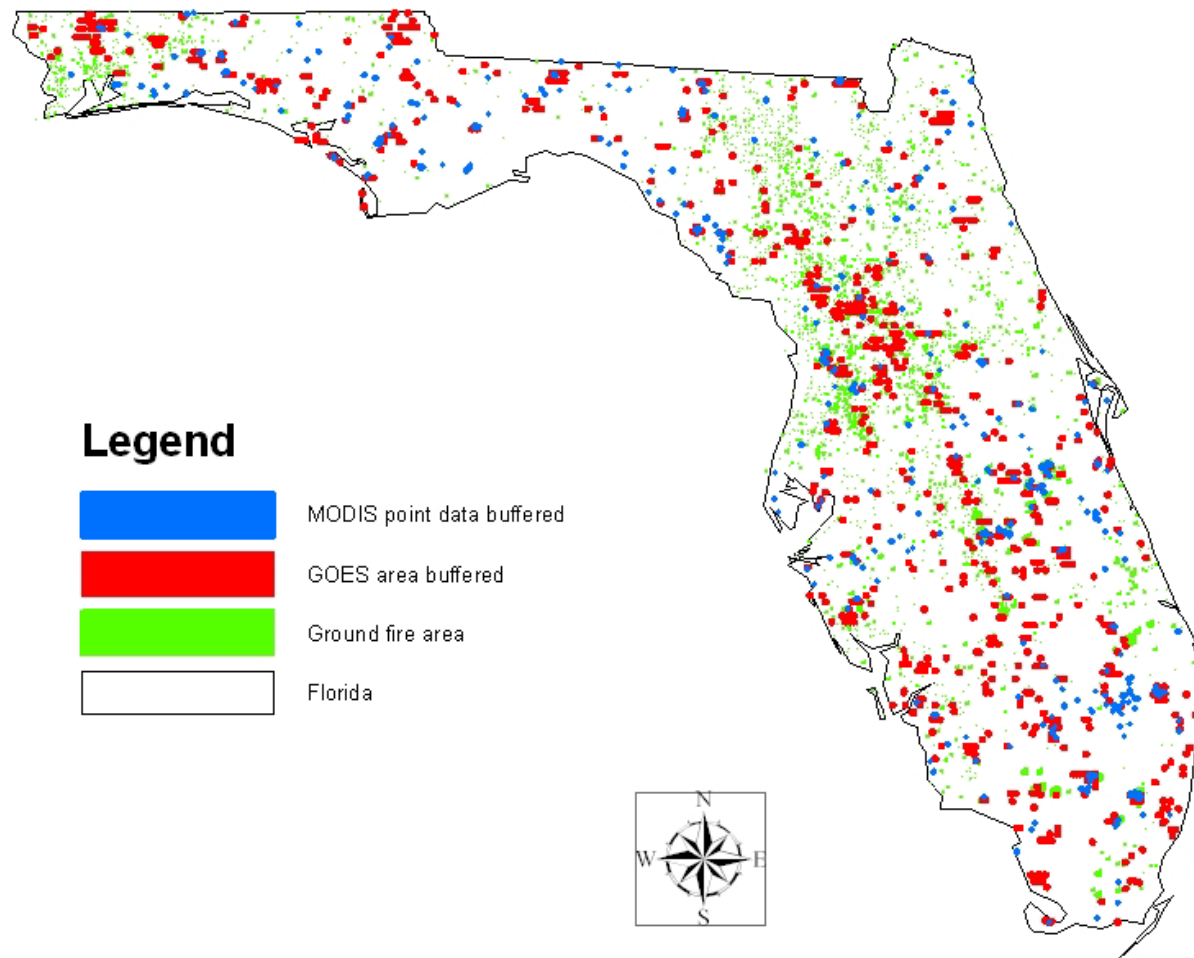
❖ **9% (74) of the MODIS points lie on the ground area burned data.**

❖ **5% (80) of the GOES fire records intersect the ground data.**

## Zoom to data

**MODIS and GOES  
data are buffered to  
1 km<sup>2</sup> and 16 km<sup>2</sup>,  
respectively.**





**Spatial  
coincidence of  
buffered  
satellite data  
and ground  
data.**

**GOES data are  
buffered to  
16 km<sup>2</sup>.**

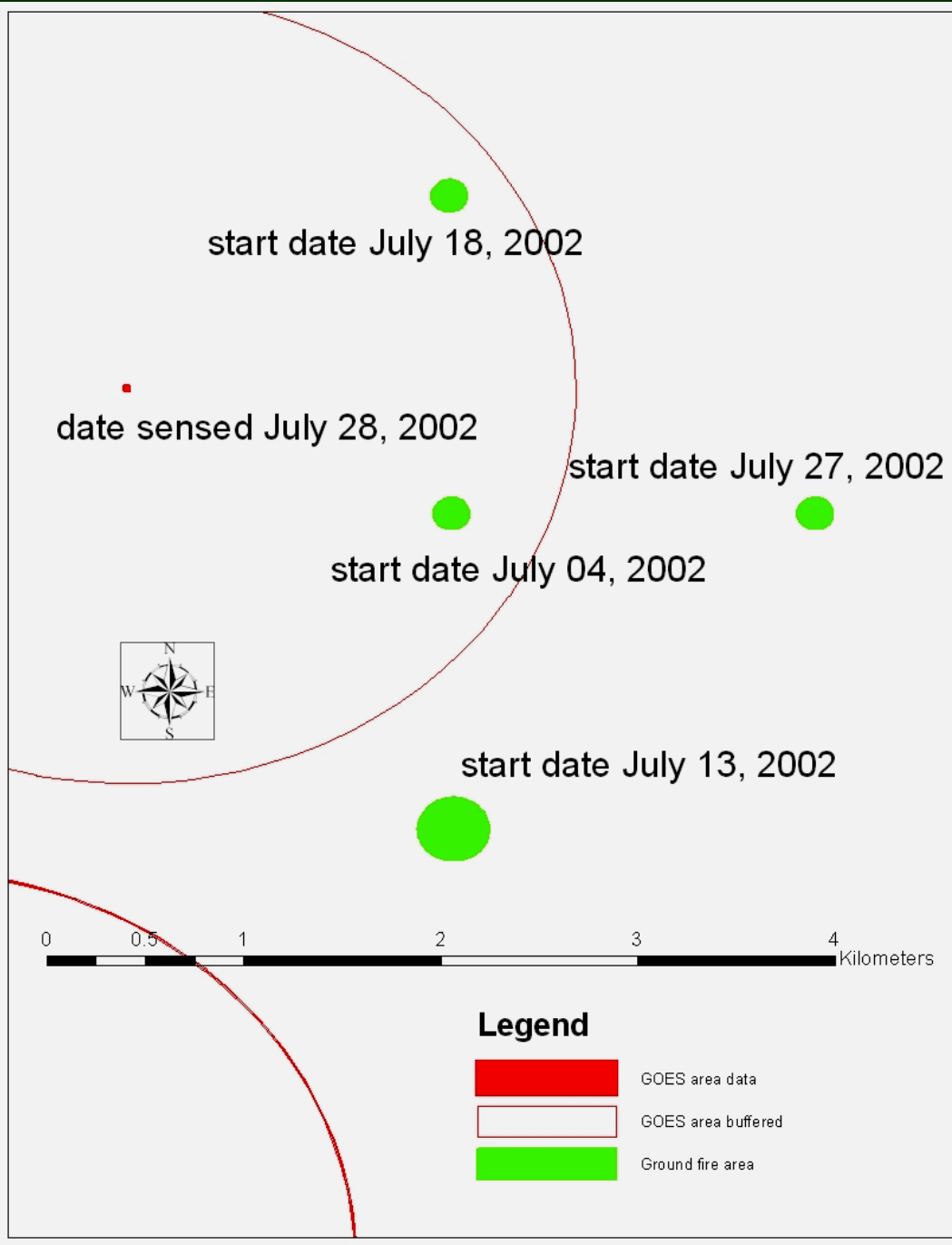
**MODIS data are  
buffered to  
1 km<sup>2</sup>.**

# Comparison of Florida fire data from May 1 through August 30, 2002

| <b>Data source</b>              | <b>Number<br/>of<br/>records</b> | <b>Number of<br/>intersecting<br/>records<br/>(satellite to<br/>ground)</b> | <b>Reported<br/>acres burned<br/>(range)</b> | <b>Ground fire<br/>area covered<br/>after<br/>buffering<br/>(acres)</b> |
|---------------------------------|----------------------------------|-----------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------------|
| <b>GOES ABBA</b>                | <b>1596</b>                      | <b>80</b>                                                                   | <b>66,491<br/>(0.23 – 187)</b>               | <b>100,960</b>                                                          |
| <b>MODIS</b>                    | <b>811</b>                       | <b>74</b>                                                                   | <b>none<br/>reported</b>                     | <b>8,637</b>                                                            |
| <b>Florida ground<br/>fires</b> | <b>4342</b>                      |                                                                             | <b>201,380<br/>(0.1 – 9000)</b>              |                                                                         |

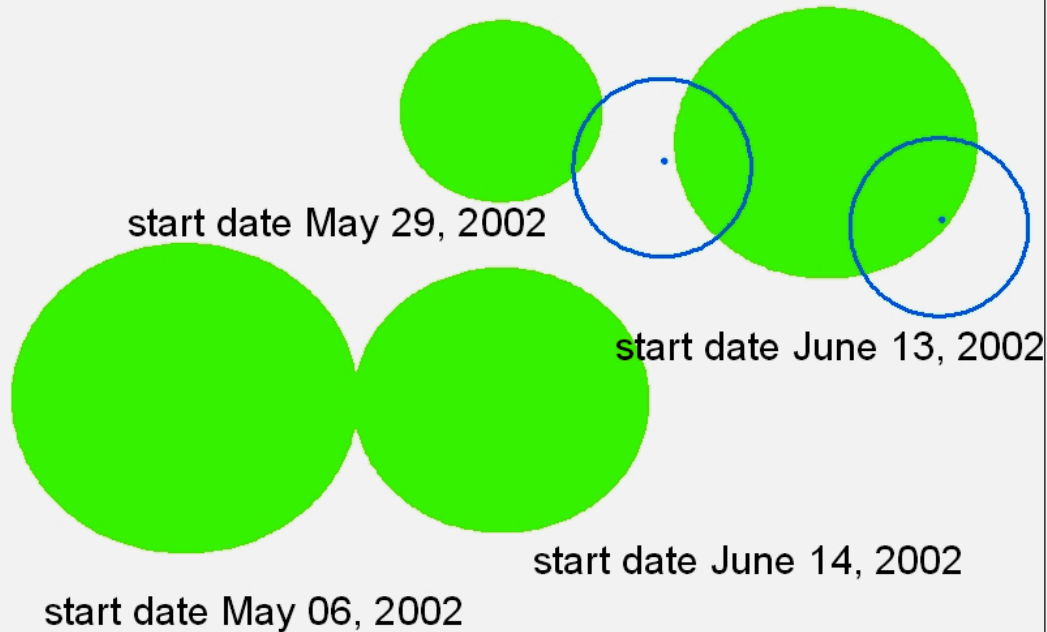
GOES buffered to 16 km<sup>2</sup> and MODIS buffered to 1 km<sup>2</sup>.

## Zoom to data



**\* Note the proximity of the GOES July 28<sup>th</sup> detection and the July 27<sup>th</sup> fire start date.**

date both MODIS points sensed  
June 14, 2002



0 0.5 1 2 3 4 Kilometers



### Legend

- MODIS point data
-  MODIS point data buffered
-  Ground fire area

**\* Note the proximity of the MODIS June 14<sup>th</sup> detection and the June 14<sup>th</sup> fire start date.**

## Legend



MODIS point data buffered



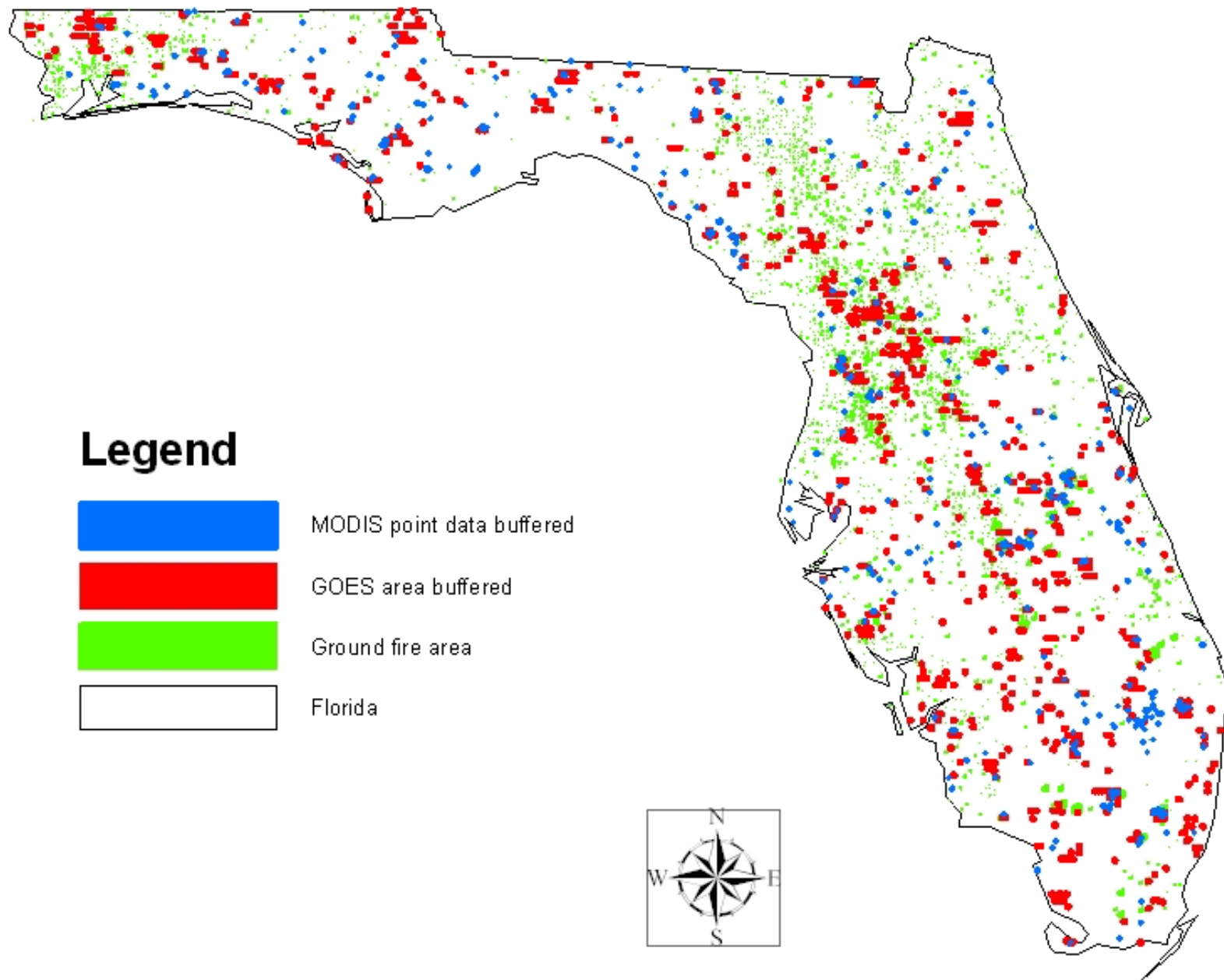
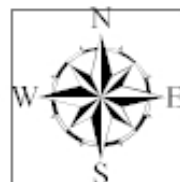
GOES area buffered

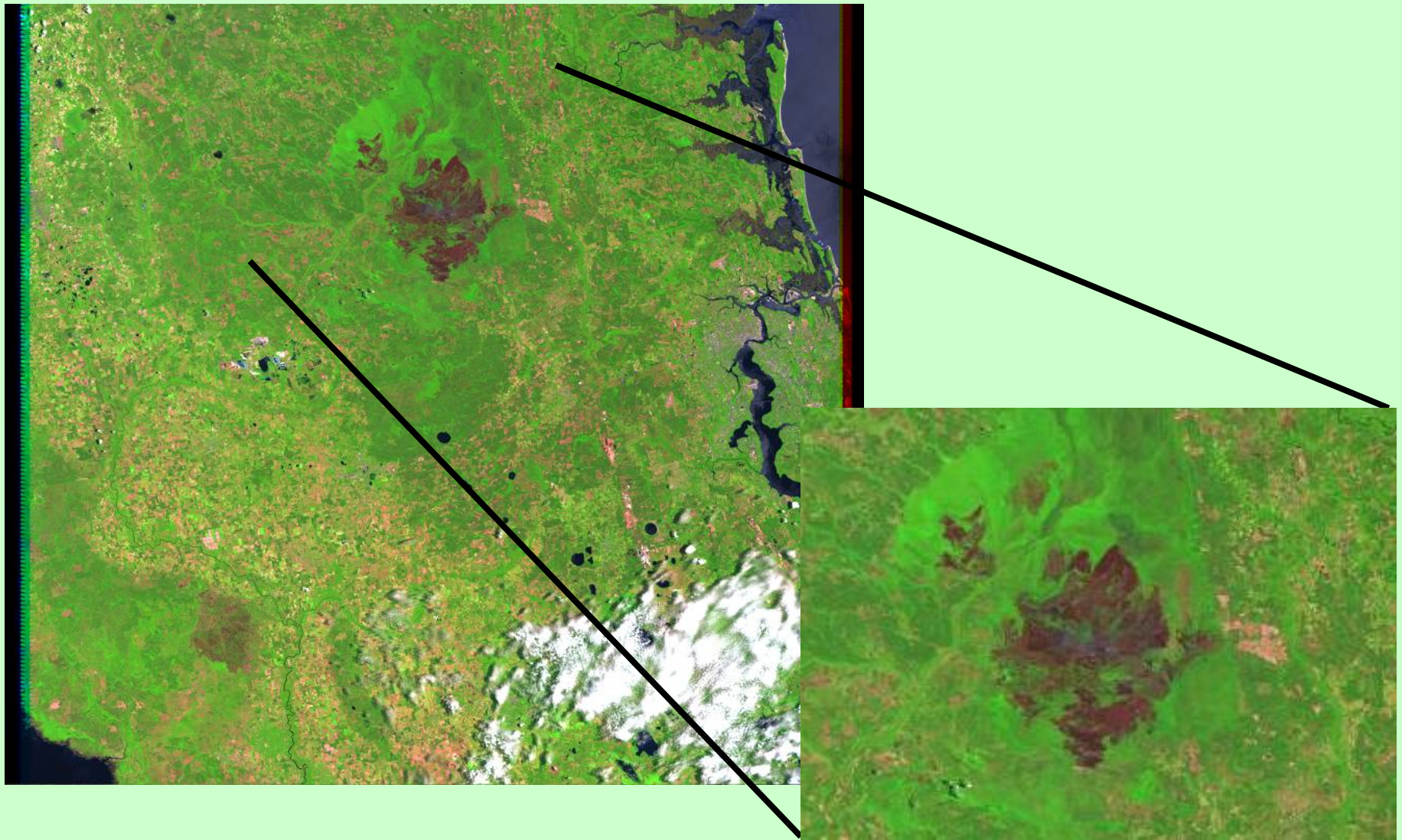


Ground fire area



Florida





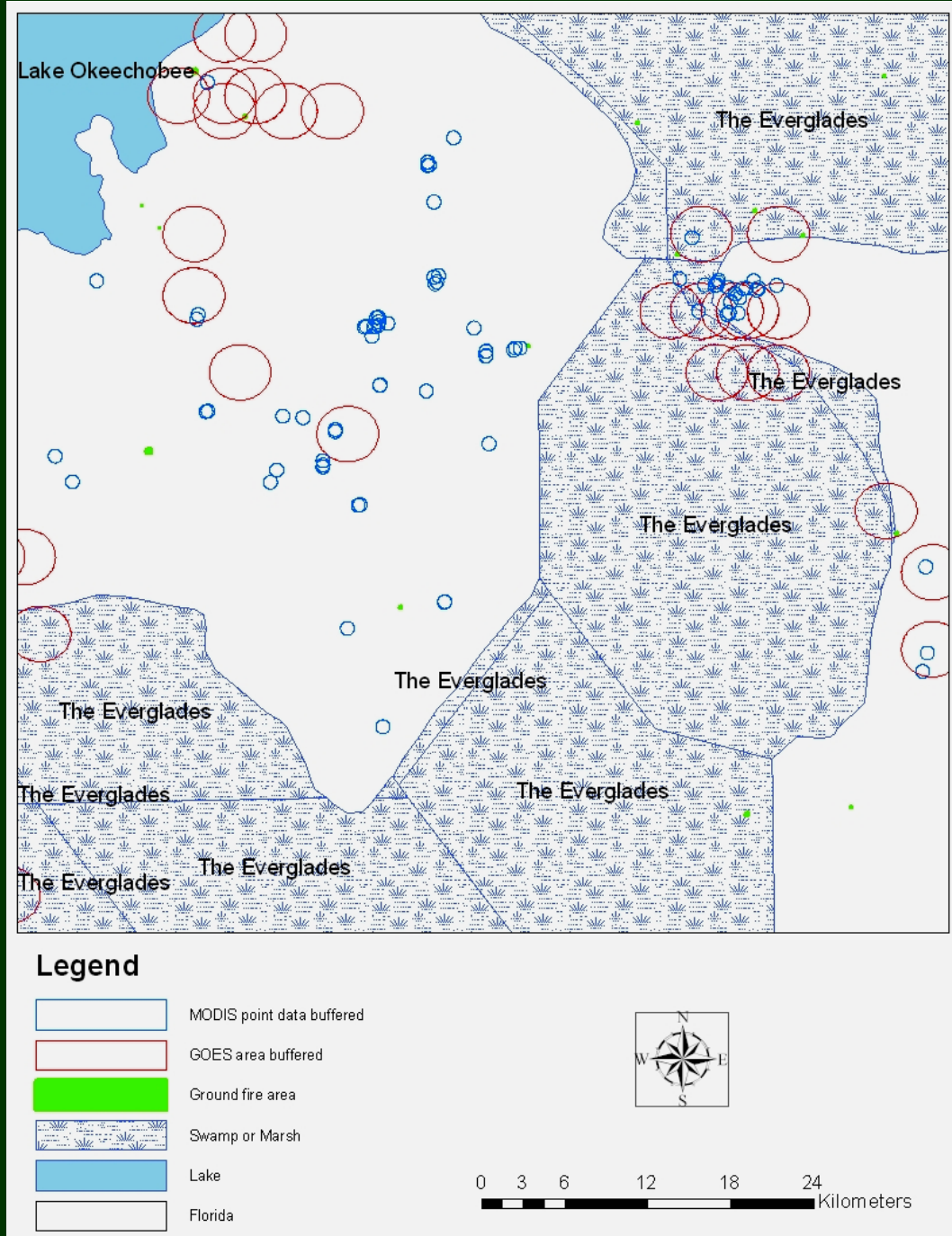
**Enhanced Thematic Mapper (ETM) imagery**

**Quick Look**

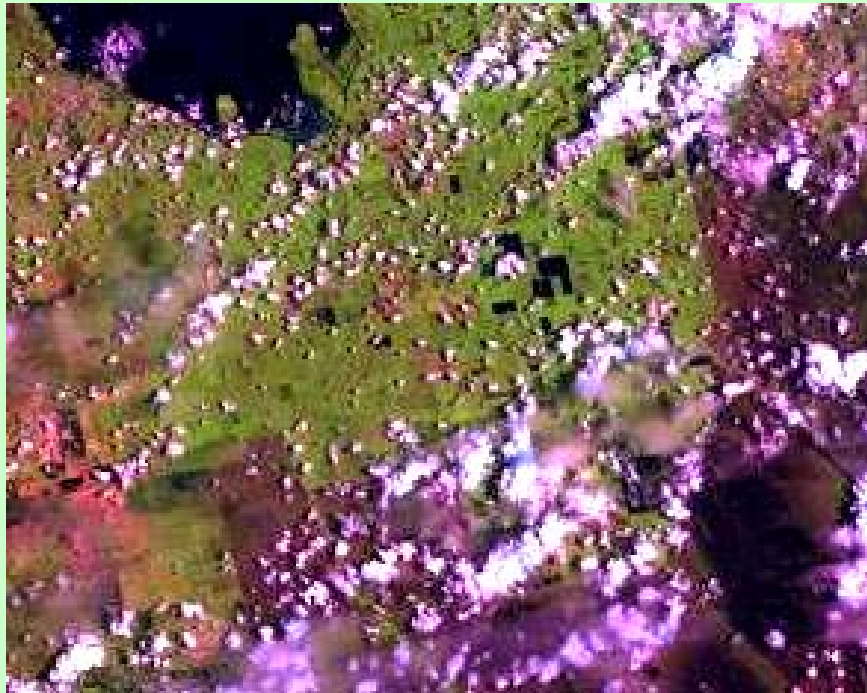
**ETM data are high resolution (30 meters)**

# Zoom to Everglades

**Note the numerous  
GOES and MODIS  
active-fire detections  
and the lack of  
reported ground fire  
data.**



**Time series**  
**Enlarged ETM quick looks**  
**Near the Everglades**



**July 20, 2002**

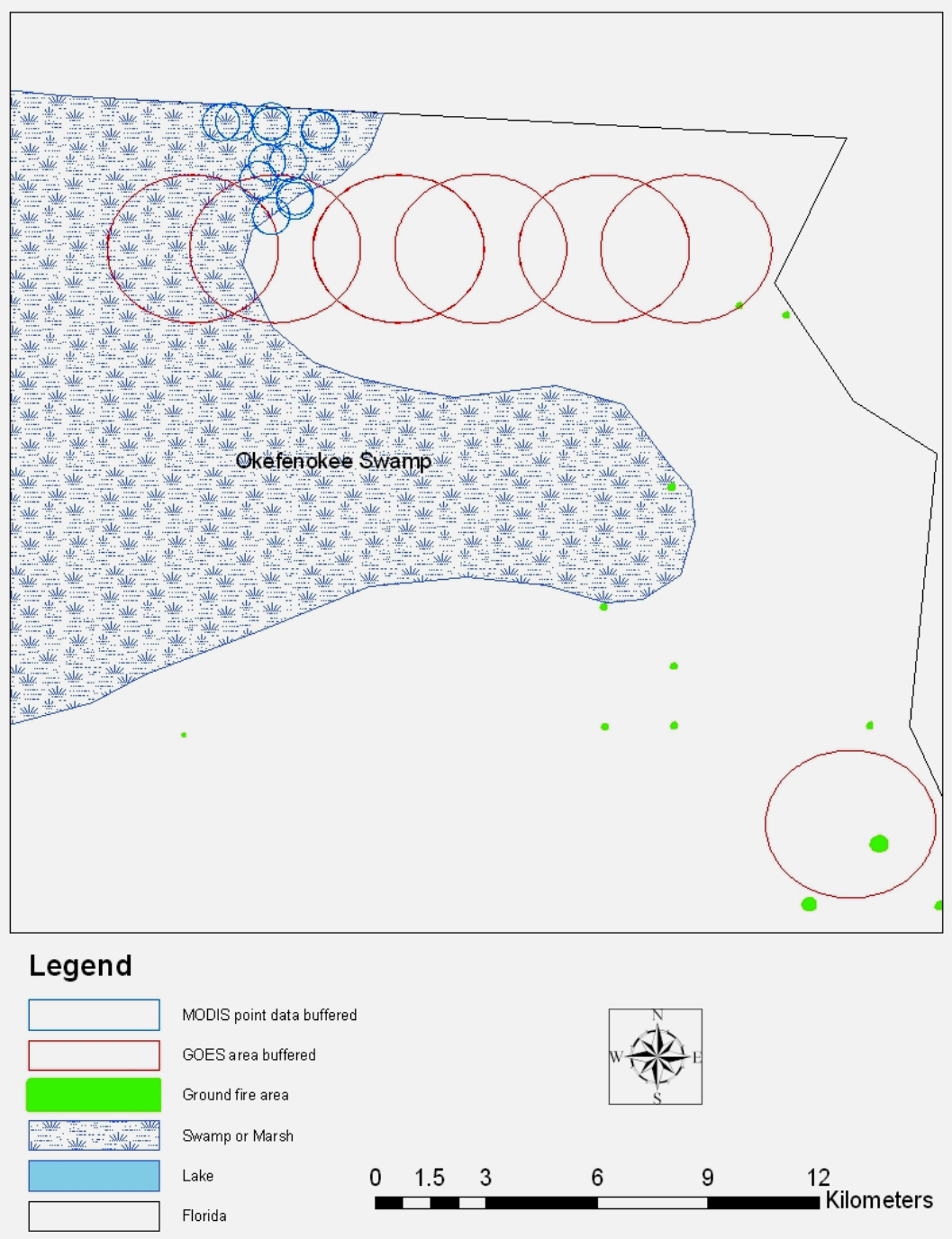


**August 5, 2002**

**These scars coincide, spatially and temporally,  
with MODIS active-fire detections**

# Zoom to Okeefenokee

Satellite data may be most useful in detecting and defining unreported regions of burning



# **Time series**

## **Enlarged ETM quick looks**

### **Near Okefenokee Swamp**



**May 15, 2002**



**May 31, 2002**



**June 16, 2002**

**Typically large fires account for the greatest amount of area burned and emissions.**

**In Canada, the largest 2-3% of the fires account for 97-98% of the area burned (Stocks, 1991).**

**Alaskan fire records show that since 1950, 96% of area burned is by large (> 2000 ha) fires (AFS, 1992).**

**In the Florida 2002 open burns database, the largest 5% of the fire events account for 77% of the area burned.**

**In the Florida 2002 wildfire database, the largest 1% of the fire events account for 75% of the area burned.**

Photo courtesy of  
Brian Stocks

## Conclusions

**GOES instantaneous fire area accounts for over 33% of the area burned reported in ground-based record.**

**After accounting for the spatial resolution of the instruments, (1) 14% of the ground records are coincident with the satellite data; and (2) satellite data coincides with 54% of the ground area burned.**

**The largest 1-5% of the fire events account for most of the area burned (75-98%), and satellite data do a good job of accounting for large fire events.**

**Satellite data detect fires across boundaries in regions where fires are not reported, and these data could greatly enhance existing area burned data and emissions estimate.**

## **Future Research**

**Through the NASA Applications program, funding is available to support the EPA in its missions to improve emissions estimates from biomass burning by using existing satellite data.**

**We need ground data to define, compare, verify and validate area burned as quantified by satellite imagery for a variety of ecosystem types.**

**We would like to make the data products available to the EPA, the RPOs and the larger emissions community.**

**Let's begin discussions by defining what is possible for 2002 and then the potential for the future.**

# Acknowledgements

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