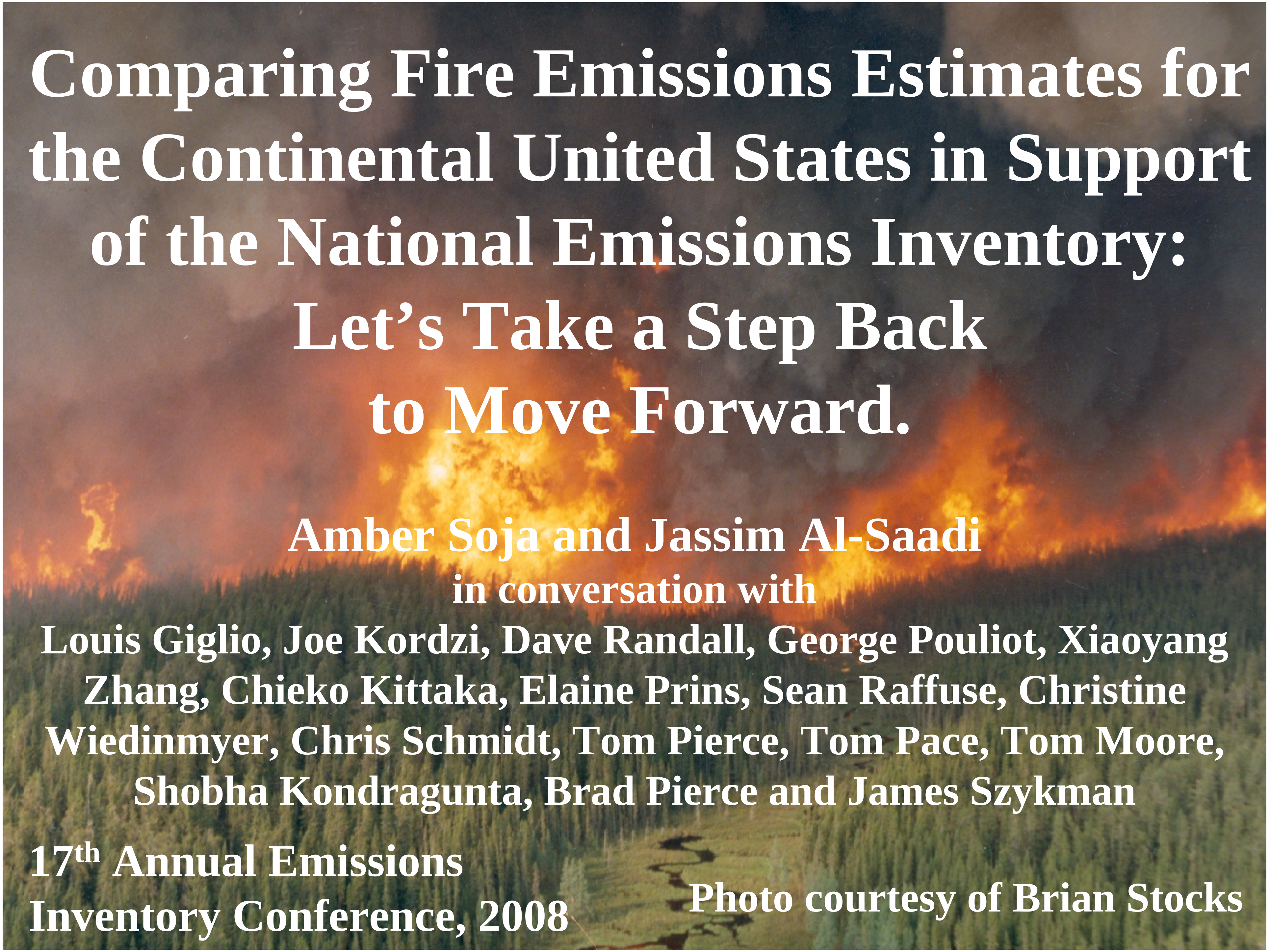
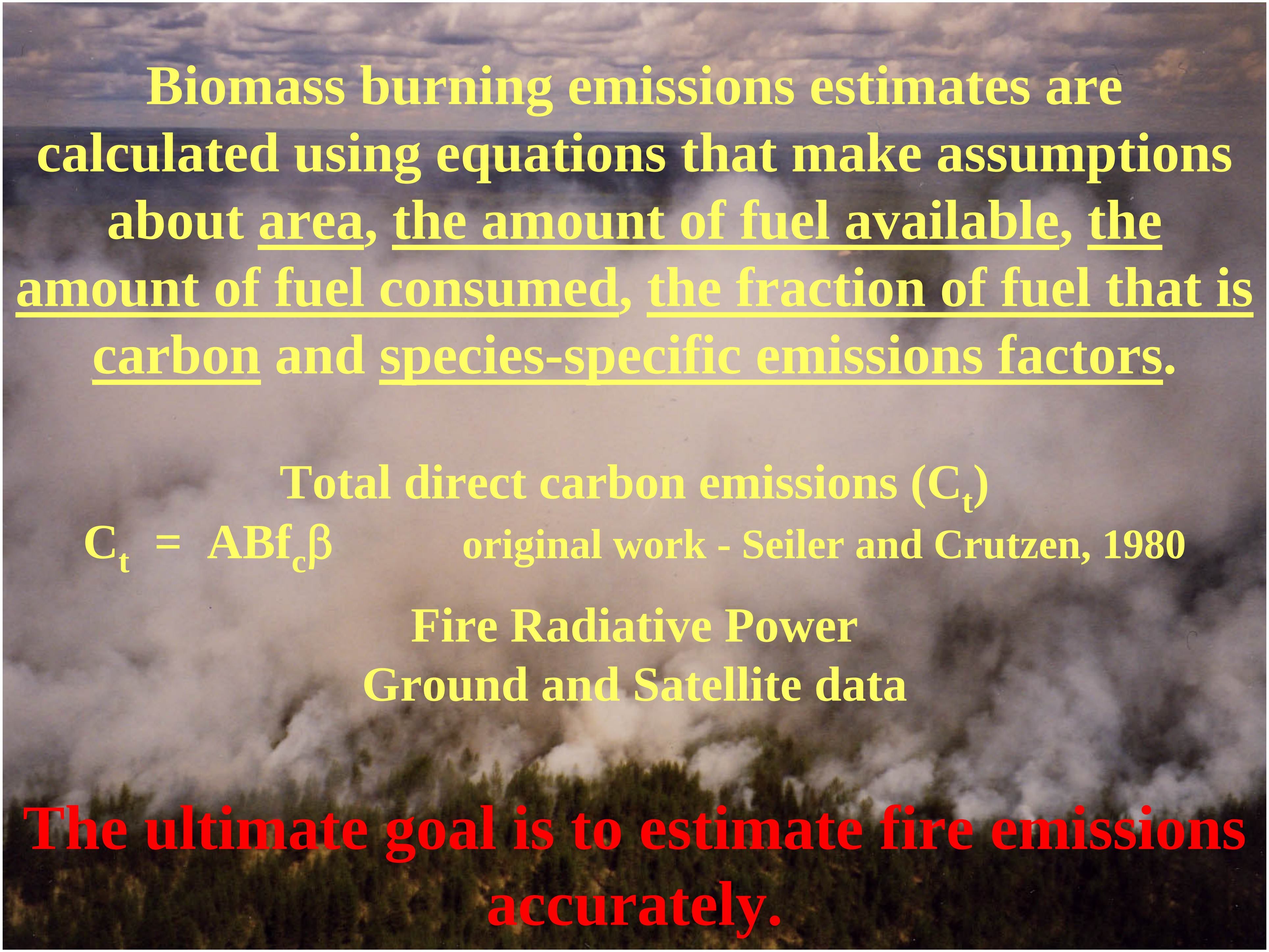
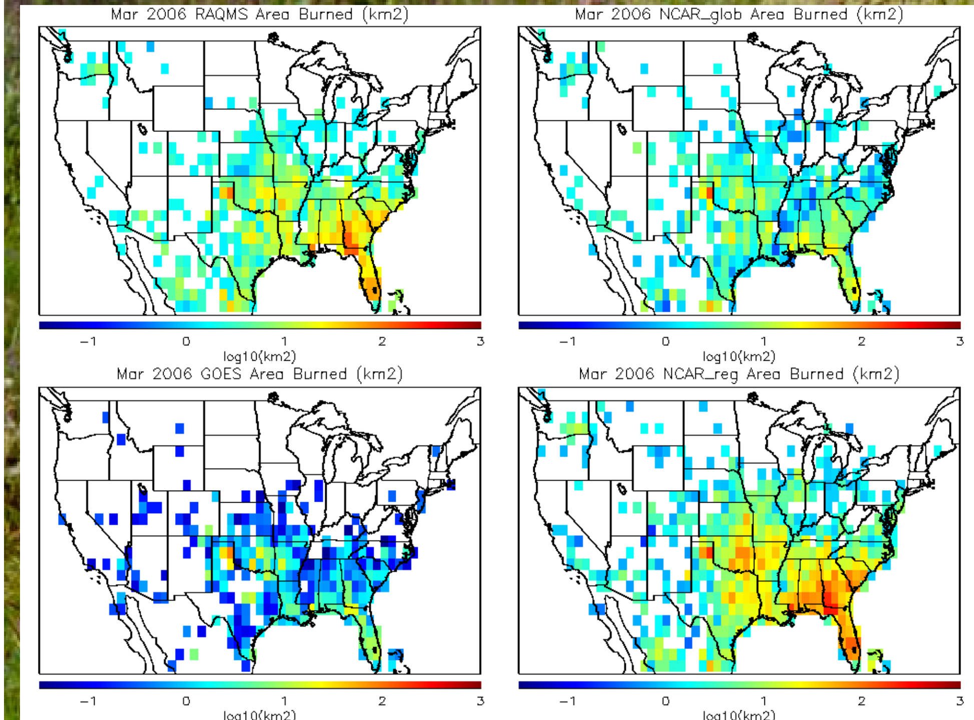

Comparing Fire Emissions Estimates for the Continental United States in Support of the National Emissions Inventory: Let's Take a Step Back to Move Forward.
Amber Soja and Jassim Al-Saadi
in conversation with
Louis Giglio, Joe Kordzi, Dave Randall, George Pouliot, Xiaoyang Zhang, Chieko Kittaka, Elaine Prins, Sean Raffuse, Christine Wiedinmyer, Chris Schmidt, Tom Pierce, Tom Pace, Tom Moore, Shobha Kondragunta, Brad Pierce and James Szykman
17th Annual Emissions Inventory Conference, 2008
Photo courtesy of Brian Stocks


Biomass burning emissions estimates are calculated using equations that make assumptions about area, the amount of fuel available, the amount of fuel consumed, the fraction of fuel that is carbon and species-specific emissions factors.
Total direct carbon emissions (C_t)
$C_t = ABf_c\beta$
original work - Seiler and Crutzen, 1980
Fire Radiative Power
Ground and Satellite data
The ultimate goal is to estimate fire emissions accurately.

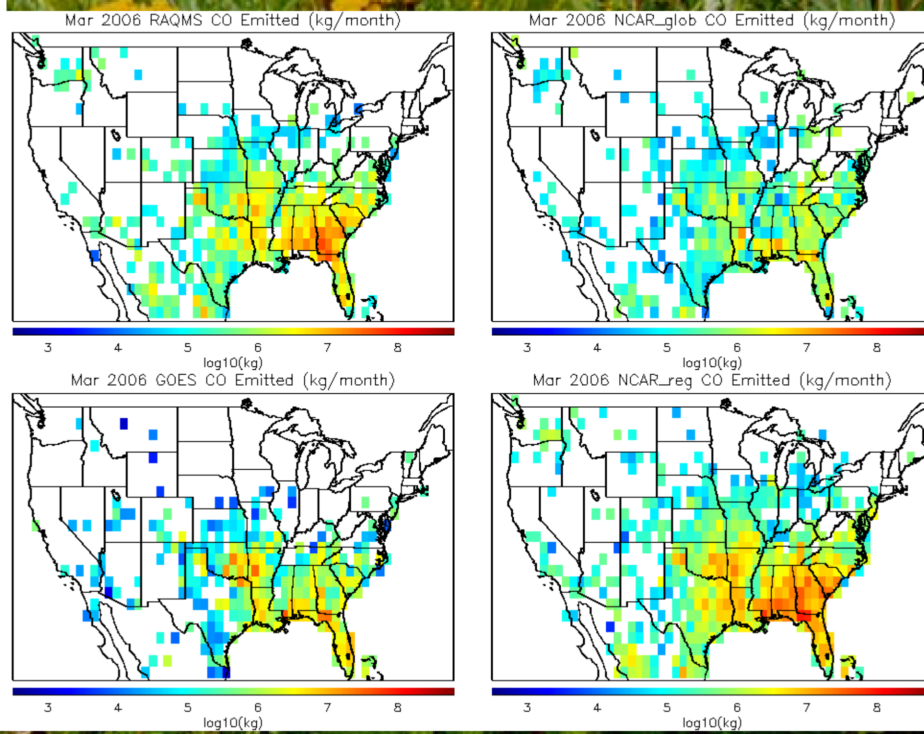
Comparison of area burned (all satellite based) and modeled CO emitted from fires

March 2006

Area Burned



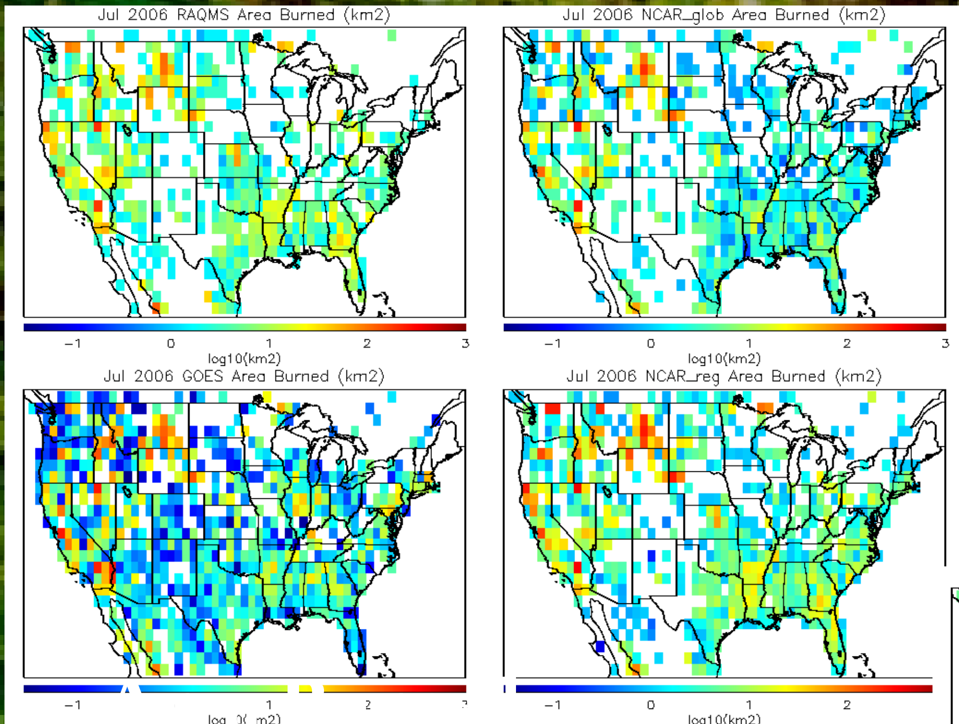
CO



Al-Saadi et al., JARS 2008

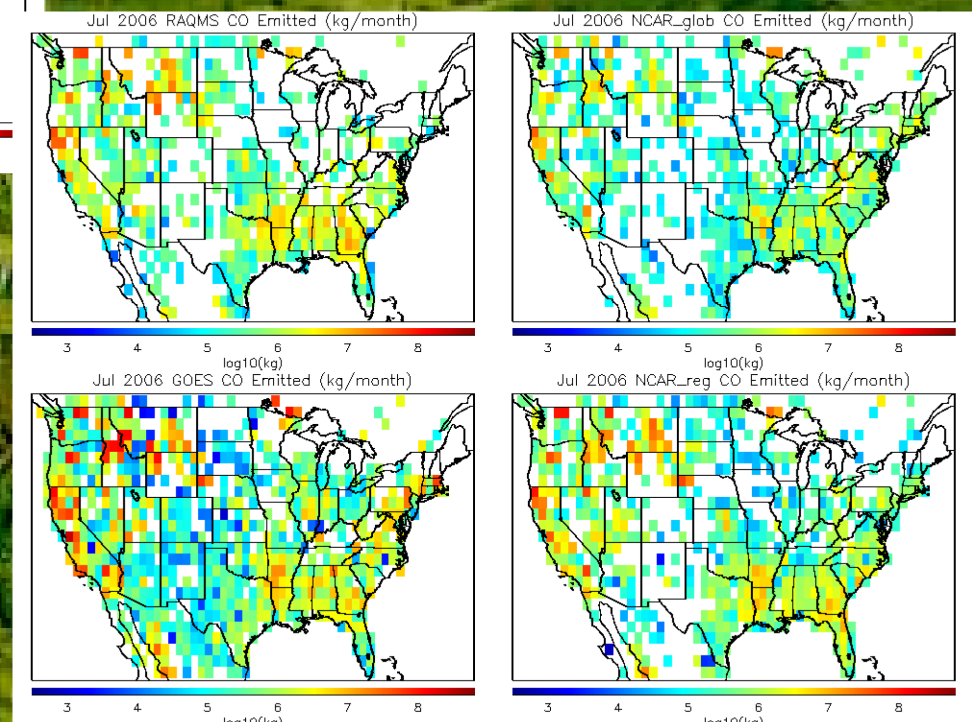
Comparison of area burned (all satellite based) and modeled CO emitted from fires

July 2006



Area Burned

CO



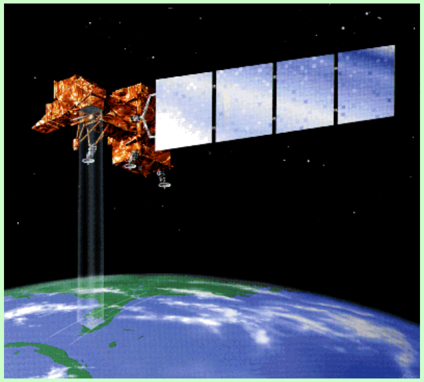
Currently Available for Estimating Area – ground data and two satellite instruments

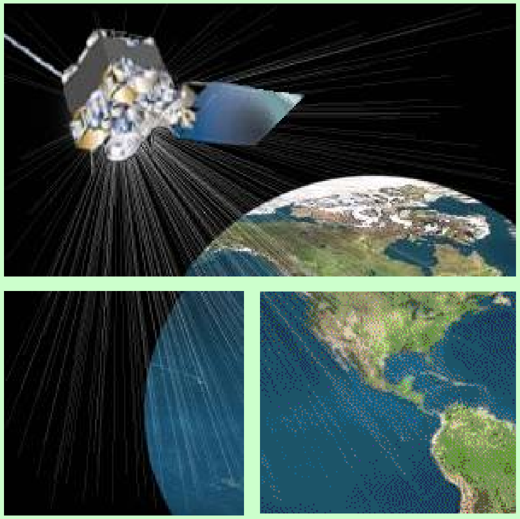
Moderate Resolution Imaging Spectroradiometer (MODIS) [fire detections, fire scars, fire radiative power, scaled area burned products] and

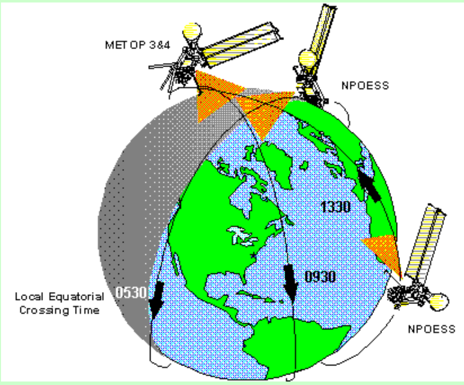
sun-synchronous orbit, twice daily (terra & aqua), spatial resolution 1 km^2

Geostationary Operational Environmental Satellite (GOES) [Automated Biomass Burning Algorithm (ABBA), scaled area burned products]

geostationary orbit, 15 minute (east & west), spatial resolution 16 km^2







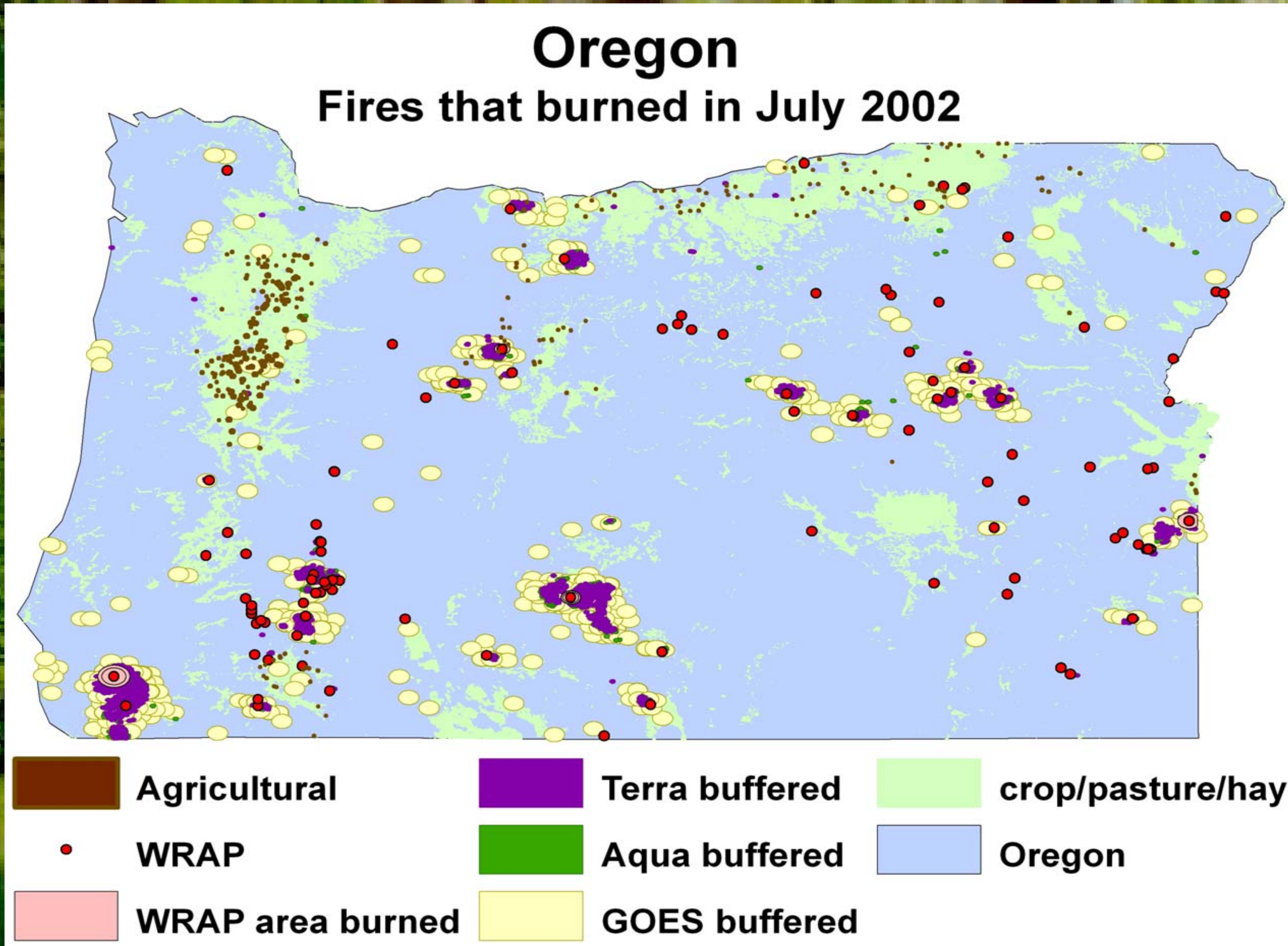
Spatial and temporal analysis of MODIS, GOES and Western Region Air Partnership (WRAP) data, 2002.

Oregon	Arizona
July	September and August

Western Region Air Partnership or WRAP Ground Fire Data

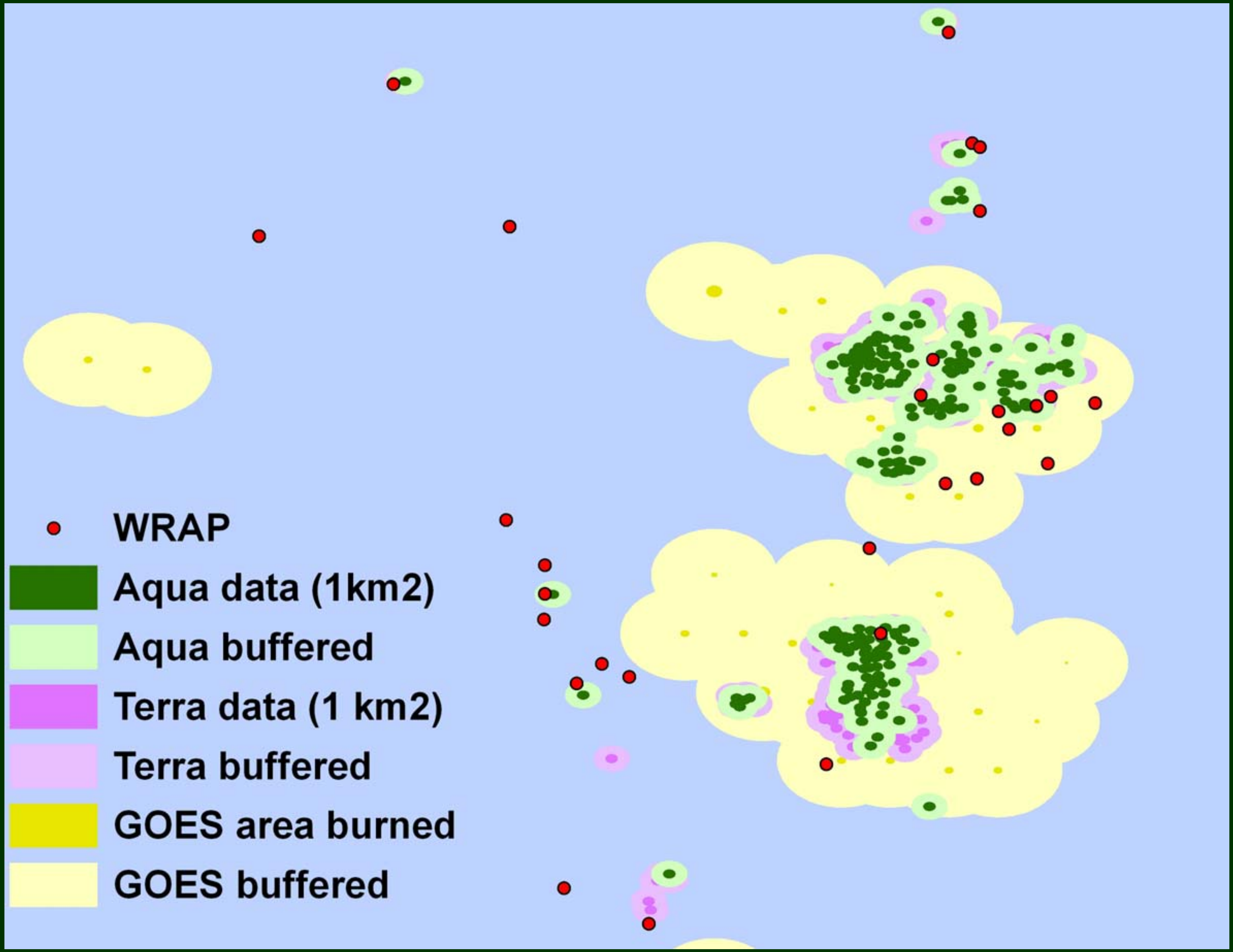
Inventories prepared for 2002 emissions inventories for wildfire, wildland fire use, prescribed burning in wildlands, non-federal rangeland fires and agricultural burning (209 reports, NIFMD/USFS, SACS/1202, DEQ reports, state and local data, etc.).

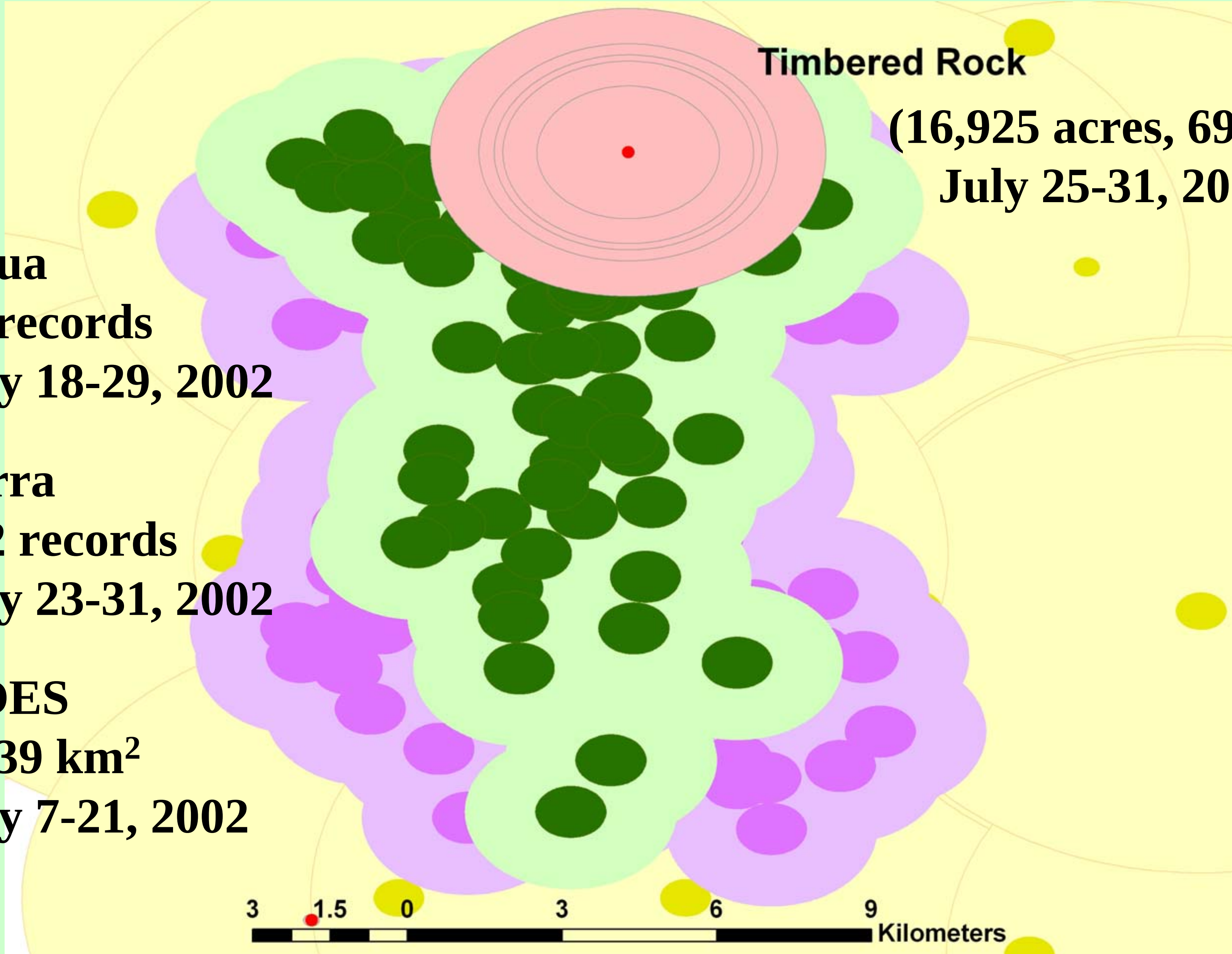
These data have been checked, geolocated and quality control reviewed by Air Sciences Inc.



Spatial coincidence in satellite- and ground-based fire data.

Zoom to data:
MODIS and GOES, area and buffered data





(16,925 acres, 69 km^2 July 25-31, 2002)

Aqua
68 records
July 18-29, 2002

Terra
132 records
July 23-31, 2002

GOES
28.39 km^2
July 7-21, 2002

Zoom – Note the size and number of fire records surrounding the WRAP fire data (red buffered with reported area in rose).

Highlights of Oregon Statistical Time and Space Analyses

Satellite perspective

95% of GOES coincides w/ WRAP (includes agric. lands);
98% of MODIS Terra coincides w/ WRAP (includes ag.);
98% of MODIS Aqua coincides w/ WRAP (includes ag.);

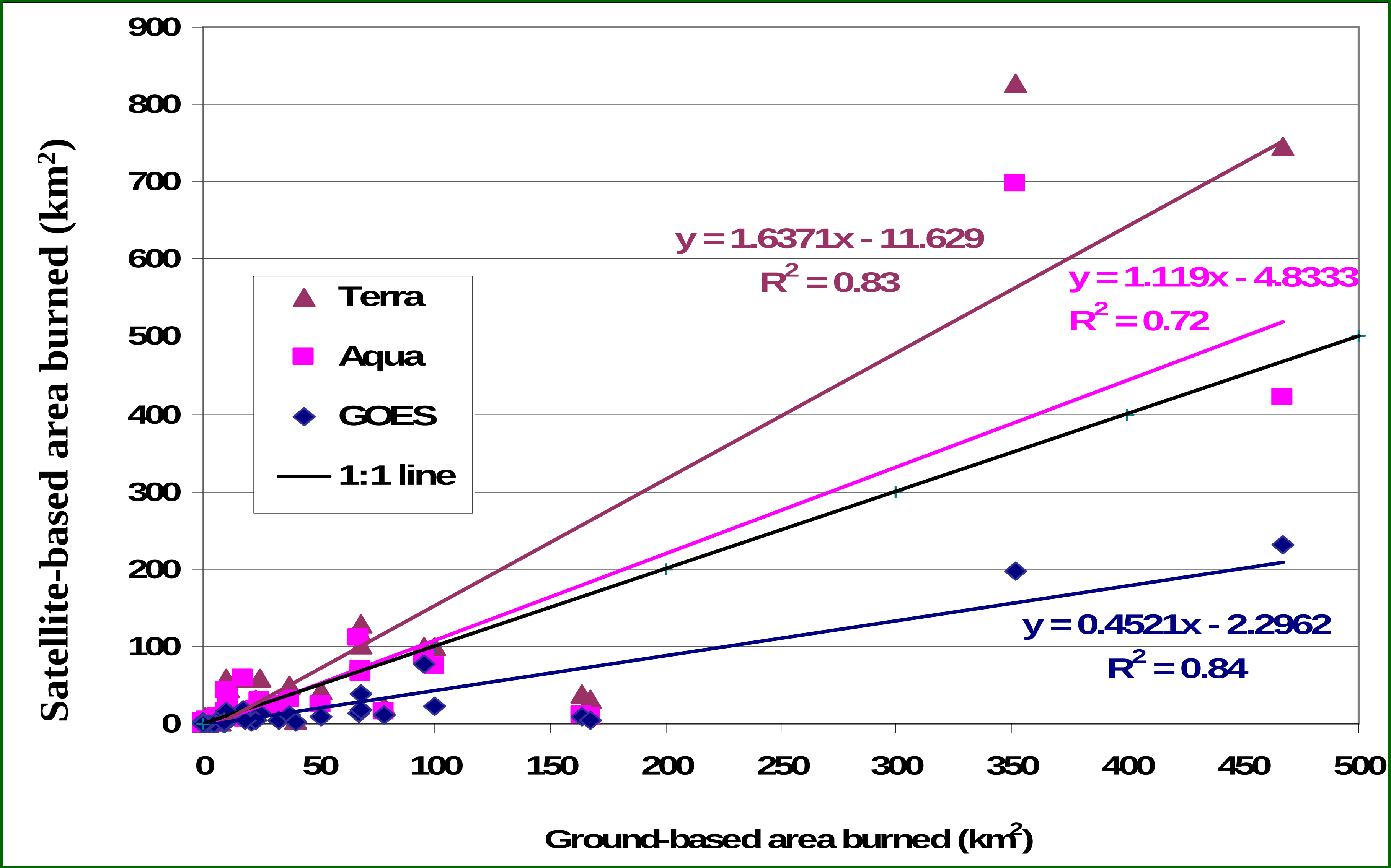
WRAP perspective

41% of WRAP data coincides with GOES
38% of WRAP data coincides with MODIS Terra
48% of WRAP data coincides with MODIS Aqua

Combined (duplication excluded),
63% of WRAP data coincides w/ satellite data;
98% of the representative WRAP area burned

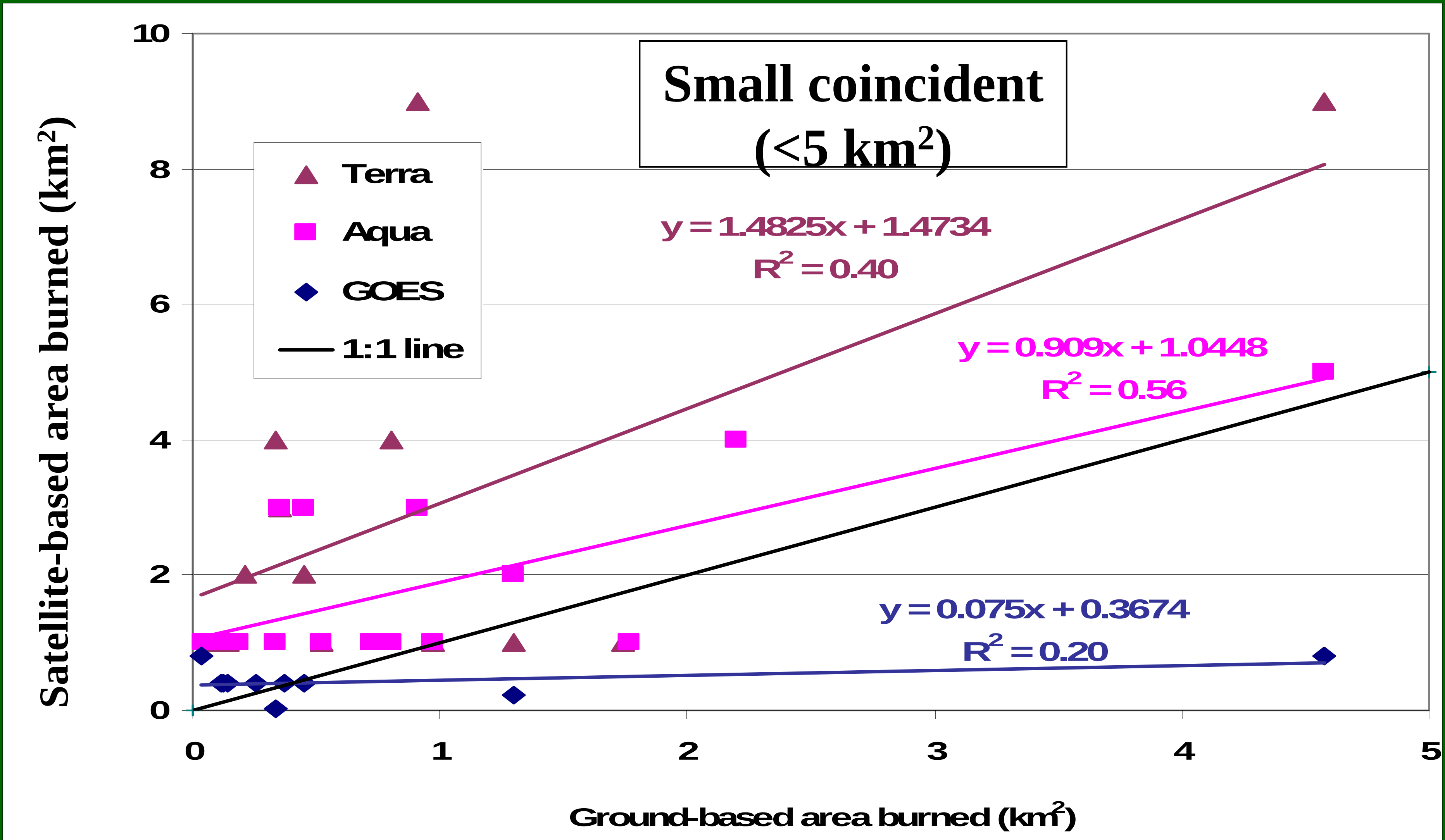
Analyzed 101 fires containing 296 records and 312 agricultural fires.

Oregon July, 2002: Coincident satellite & WRAP fire data.

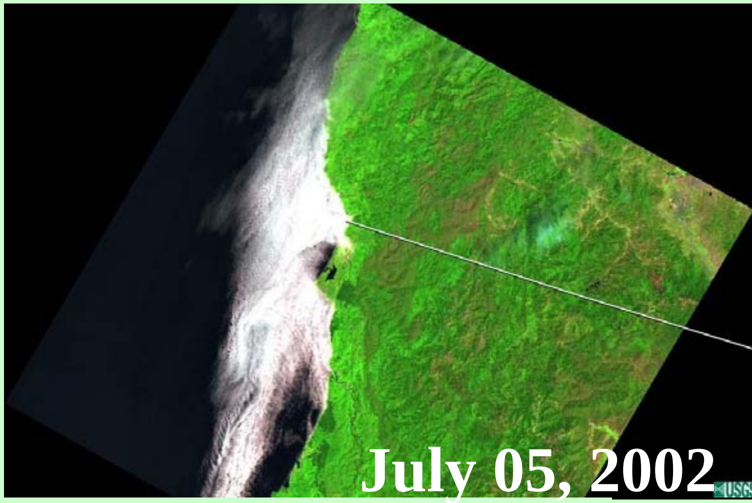


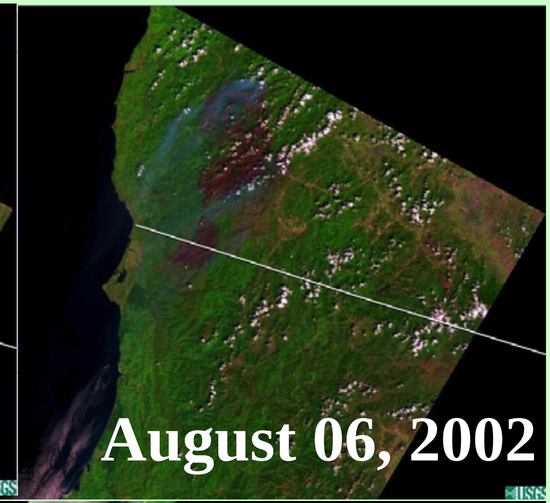
Assuming 1km^2 and/or double counting results in a substantial overestimate of area burned

Oregon July, 2002: Coincident satellite & WRAP fire data.

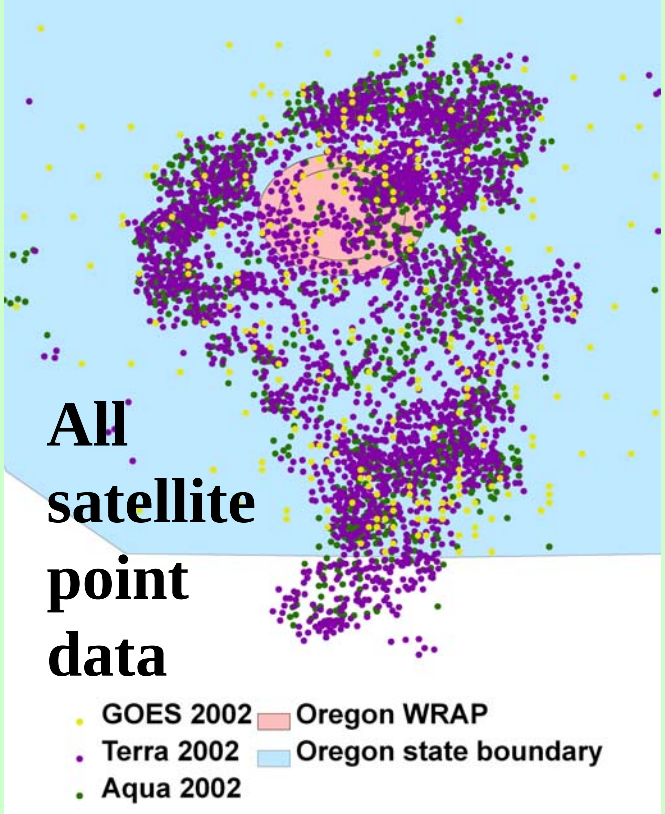


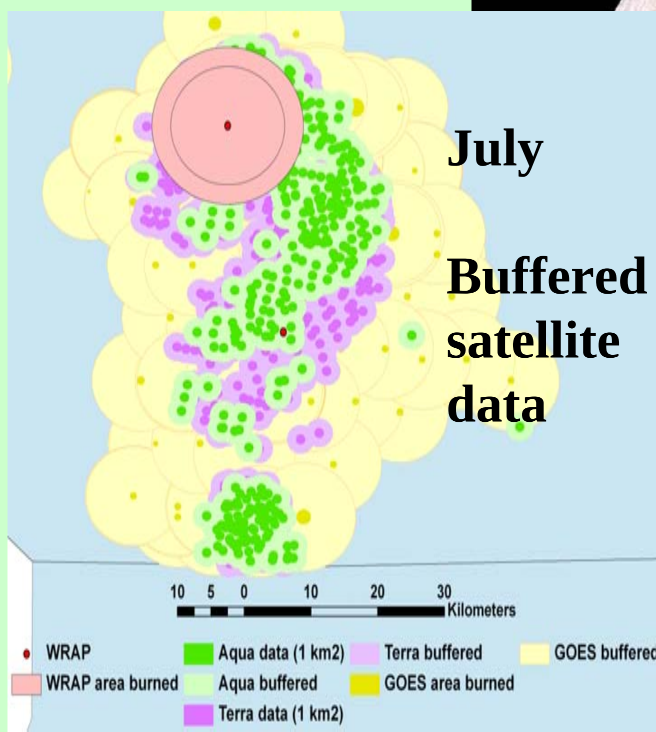
Poor relationship between satellite data and small fires.

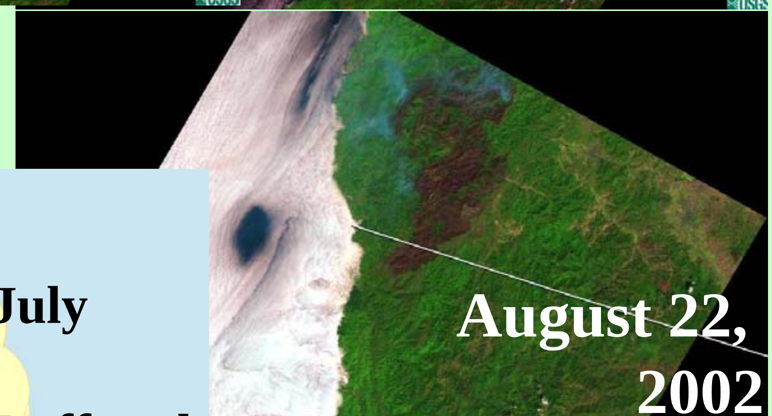


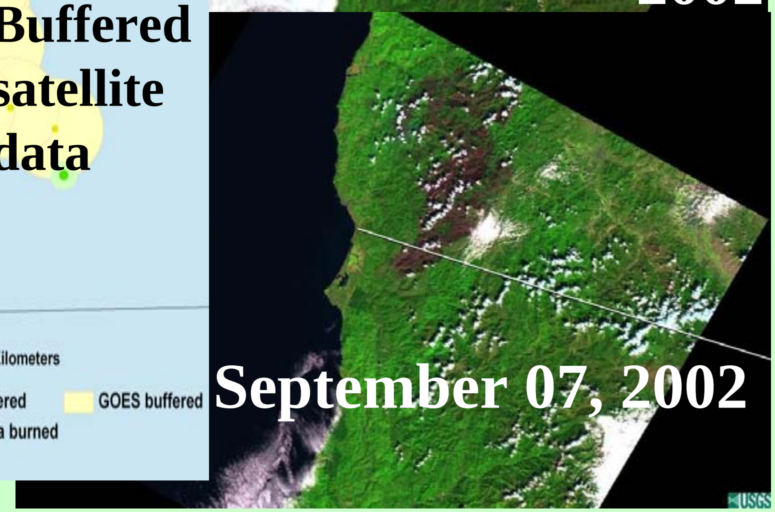


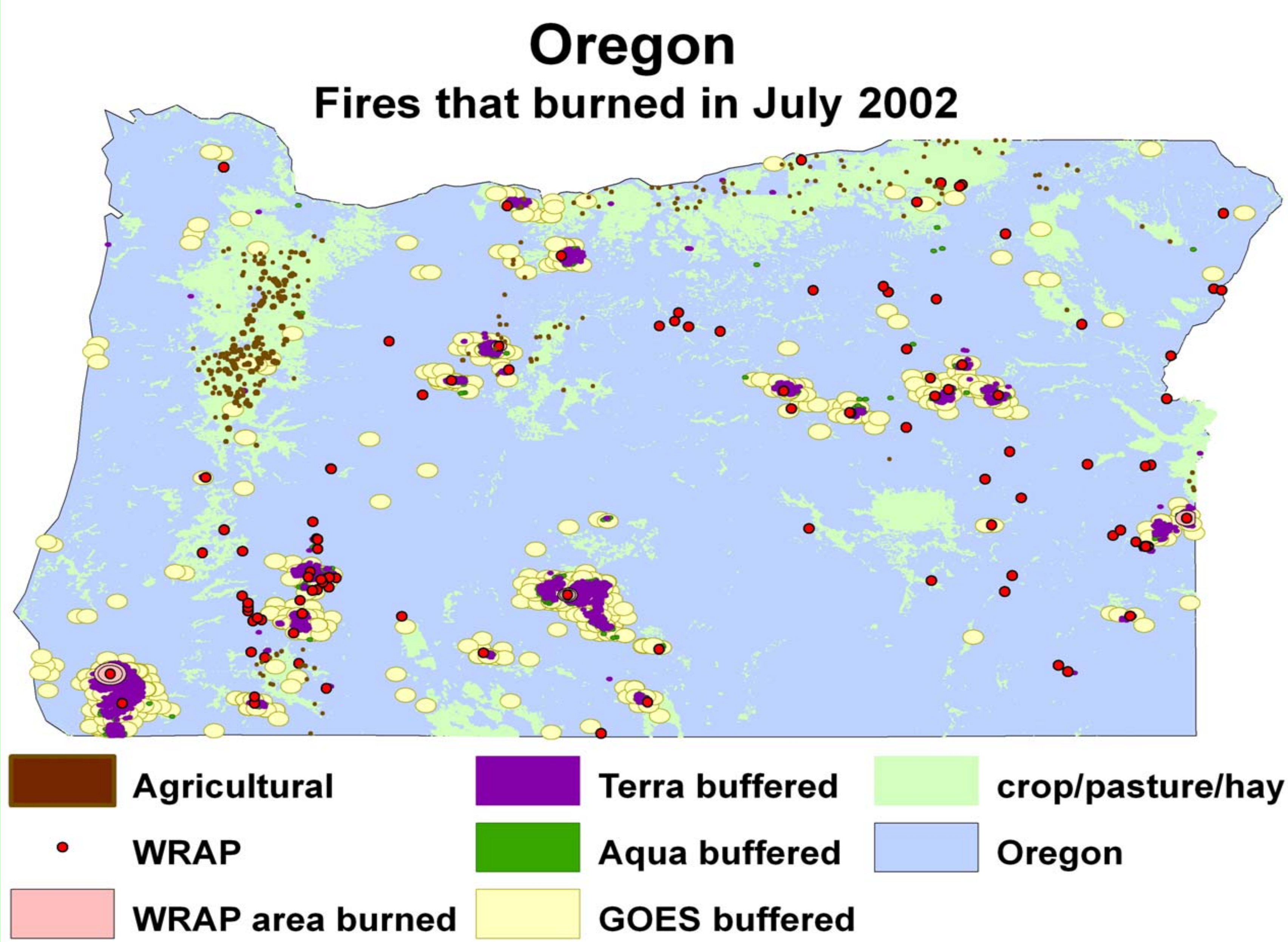
Evolution of the Biscuit fire



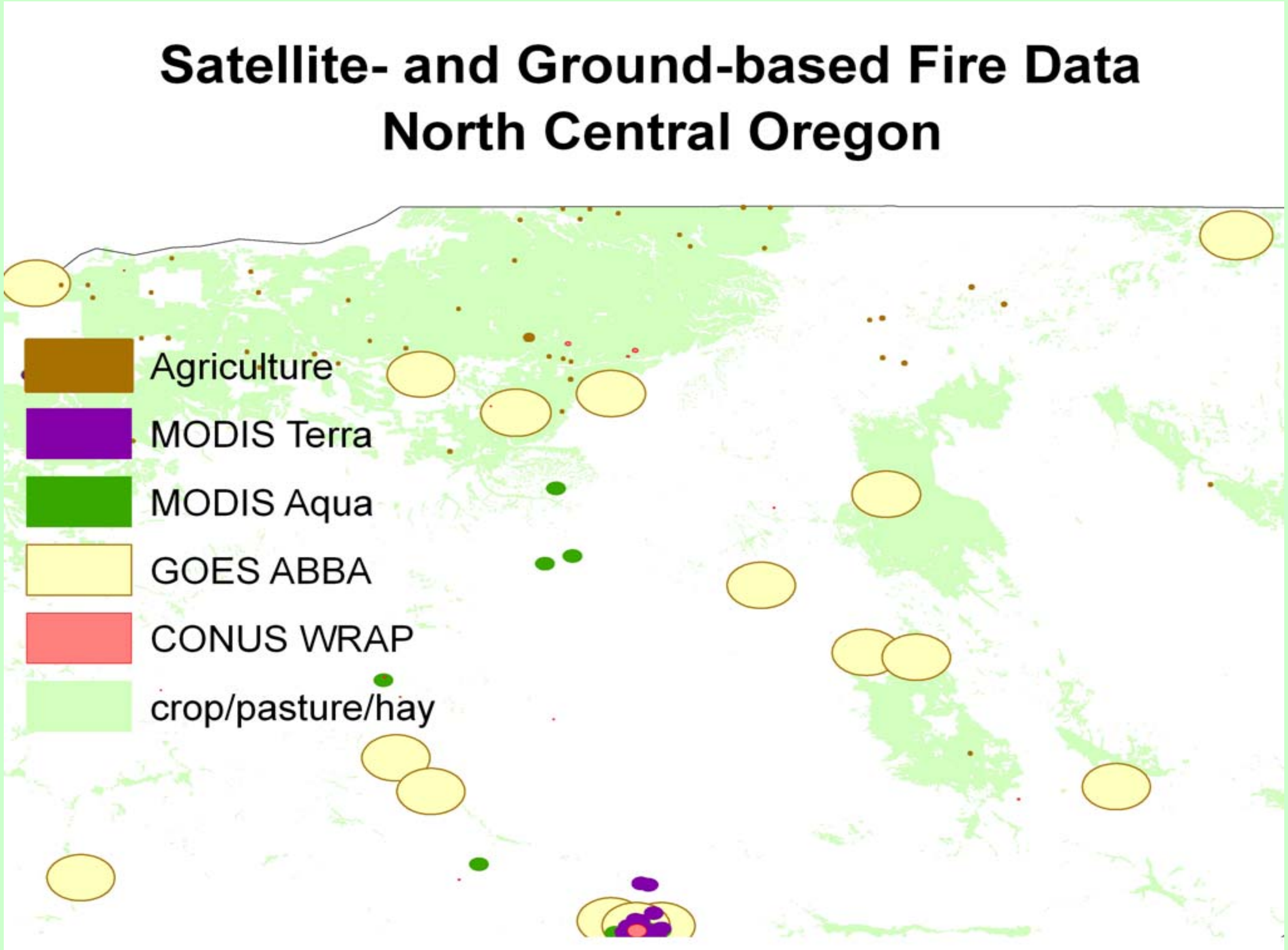






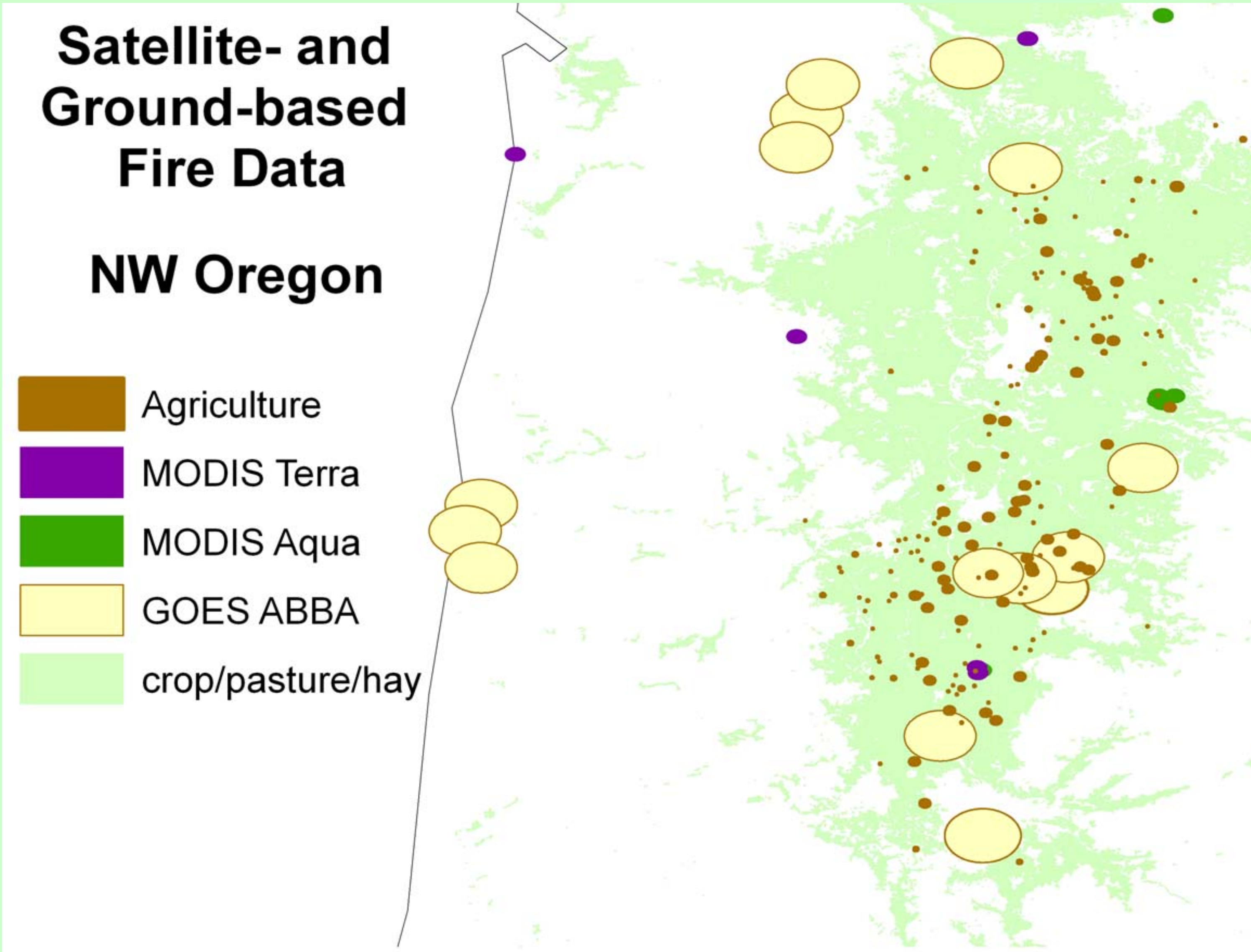


Oregon
Fires that burned in July 2002
Agricultural
WRAP
WRAP area burned
Terra buffered
Aqua buffered
GOES buffered
crop/pasture/hay
Oregon



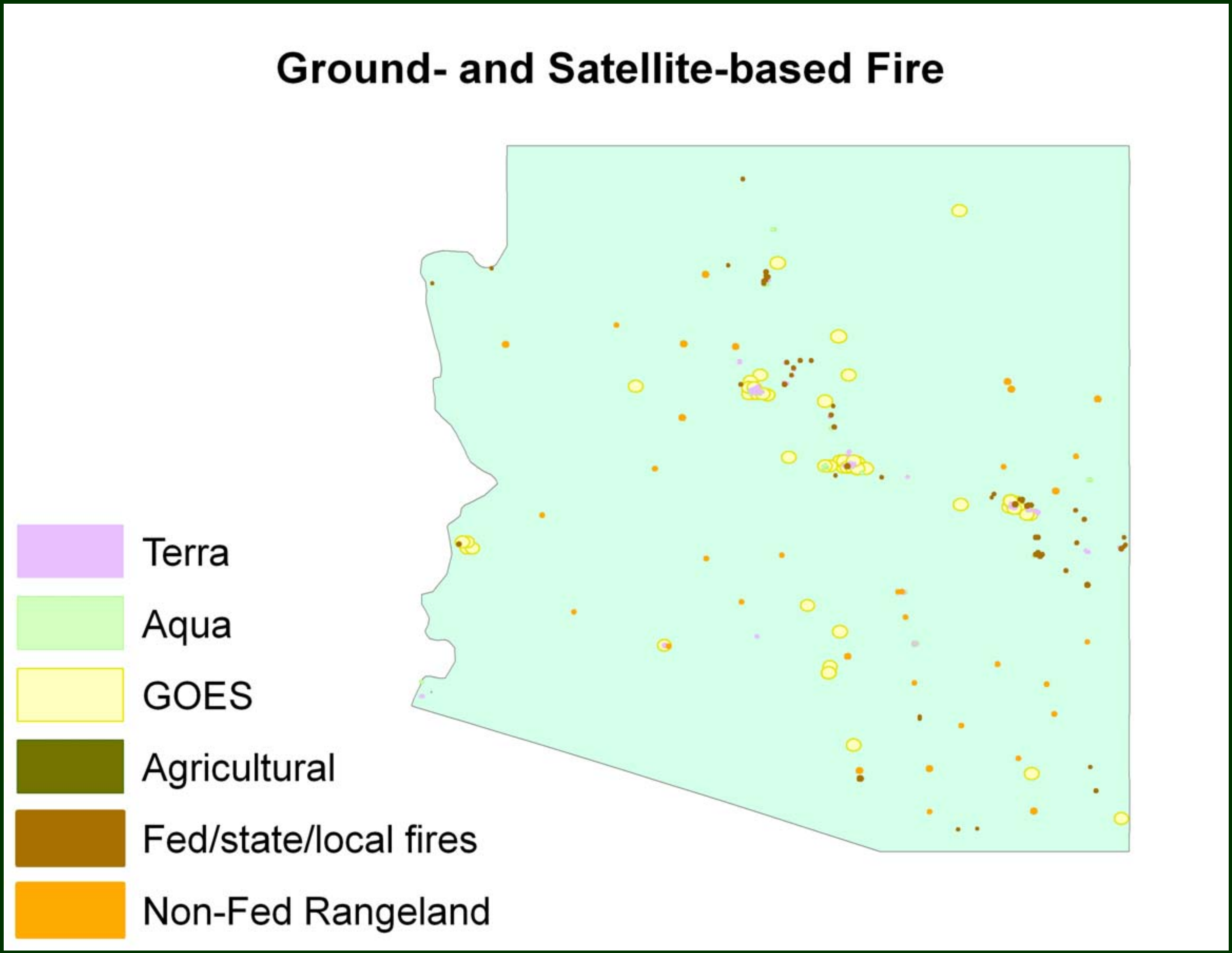
Even though Oregon did report agricultural fires, they may not have been accurately placed in space and time.

Satellite data accurately place fire in time and space.
Accurate area to area estimates are minimal – need work here.



Overall, there are 39% more GOES detections in agricultural lands than MODIS.

Spatial coincidence in satellite- and ground-based fire data.



Arizona

August and September 2002

Highlights of Arizona Statistical Time and Space Analyses

Satellite perspective

76% of GOES coincides w/ WRAP (includes agric. lands);
84% of MODIS Terra coincides w/ WRAP (includes ag.);
80% of MODIS Aqua coincides w/ WRAP (includes ag.);

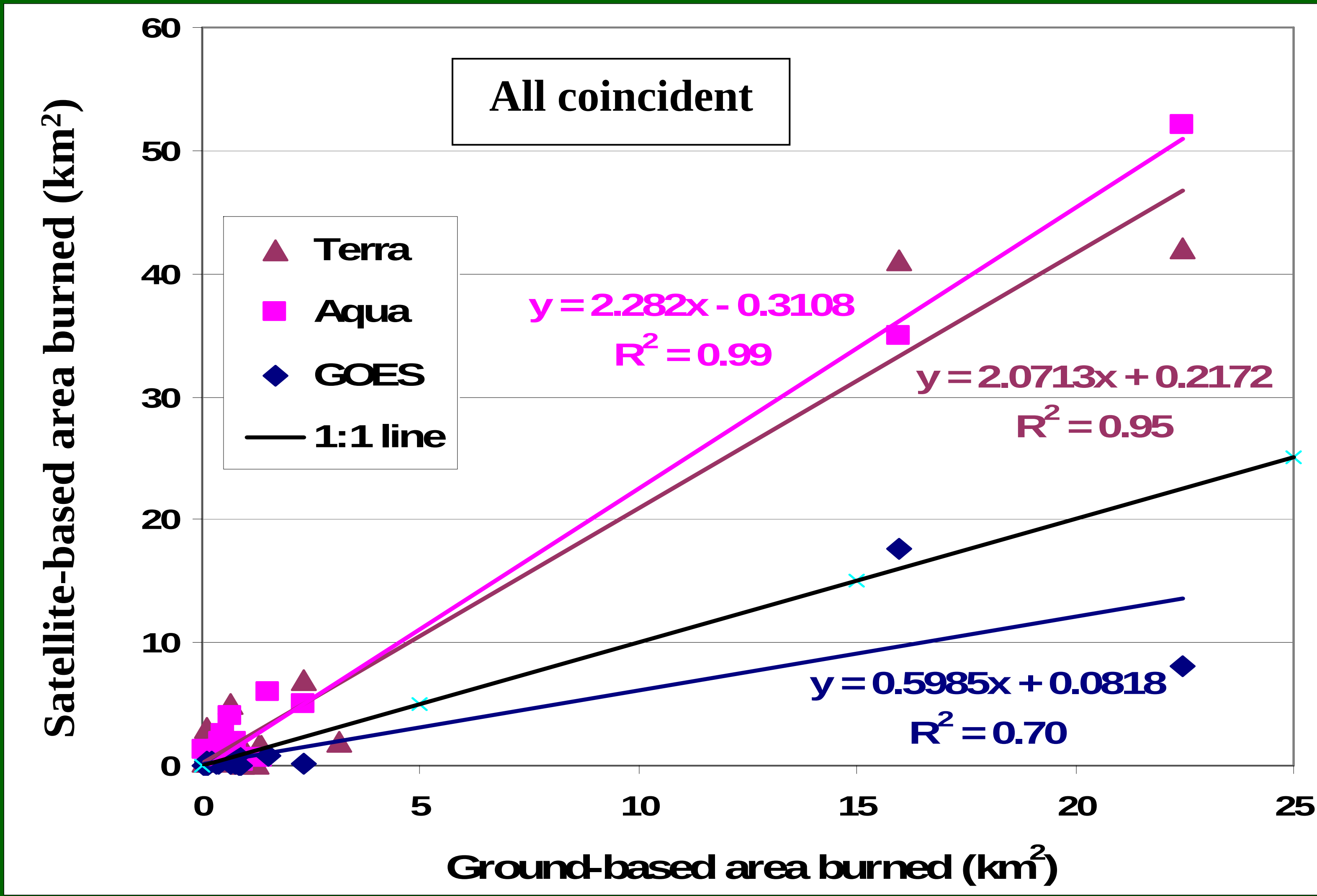
WRAP perspective

9% of WRAP data coincides with GOES
26% of WRAP data coincides with MODIS Terra
21% of WRAP data coincides with MODIS Aqua

Combined (duplication excluded),
32% of WRAP data coincides w/ satellite data;
77% of the representative WRAP area burned

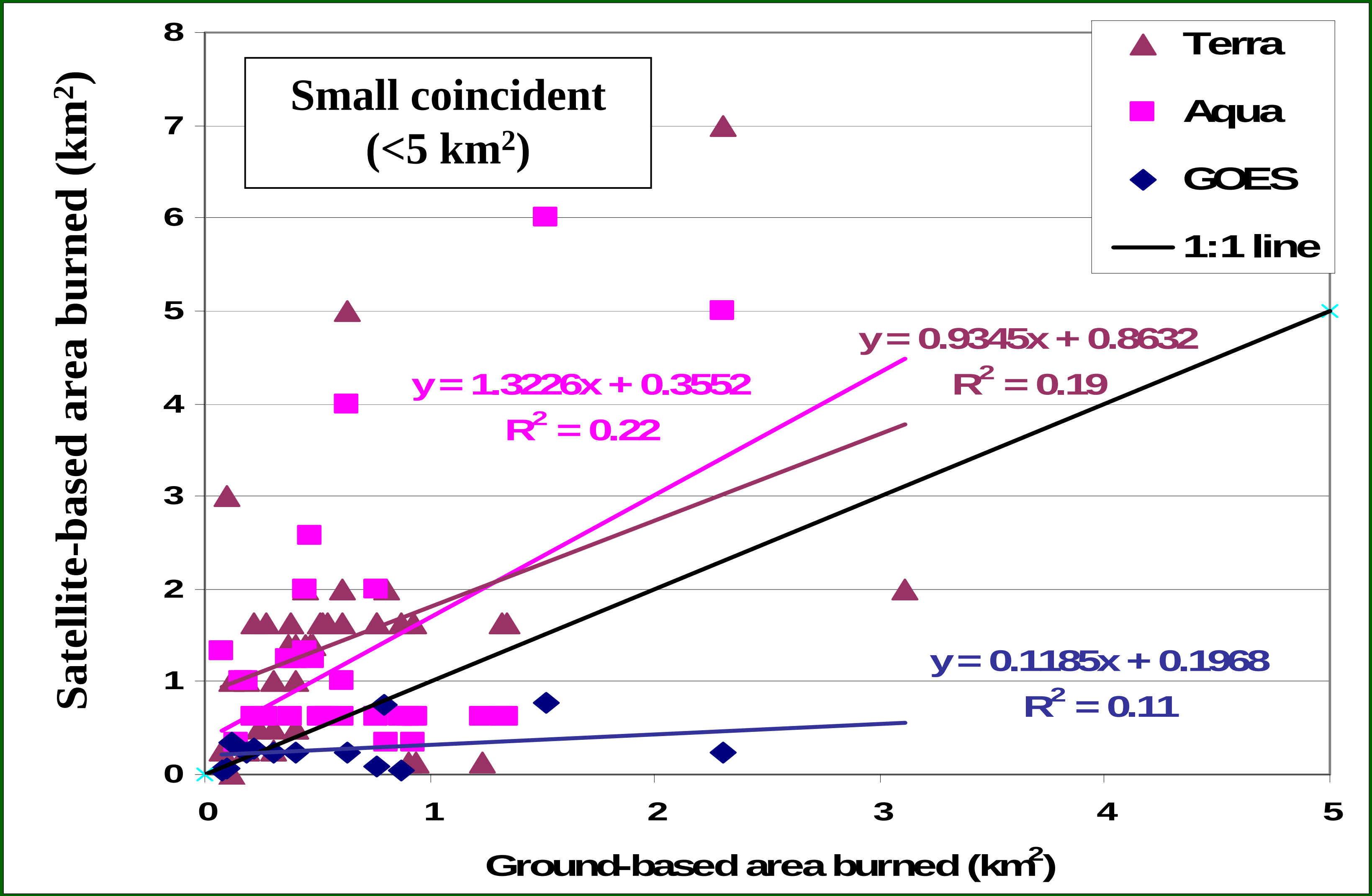
Analyzed 165 fires containing 201;
34 non-federal rangeland fires could not be analyzed.

Coincident satellite & WRAP fire data: Arizona August and September, 2002.



Assuming MODIS = 1 km^2 and/or double counting results in a substantial overestimate of area burned

Coincident satellite & WRAP fire data: Arizona August and September, 2002.



Poor relationship between satellite data and small fires.

Initial Conclusions

Inter-comparisons of area burned and emissions show a diverse range of estimates, highlighting the need for detailed evaluation, verification and validation.

In combination, satellites area able to identify fires and define most of the area burned, even in difficult to sense regions (77-98%).

Satellites accurately identify the time and spatial domain of fires in all lands (rangelands, agricultural, across state boundaries).

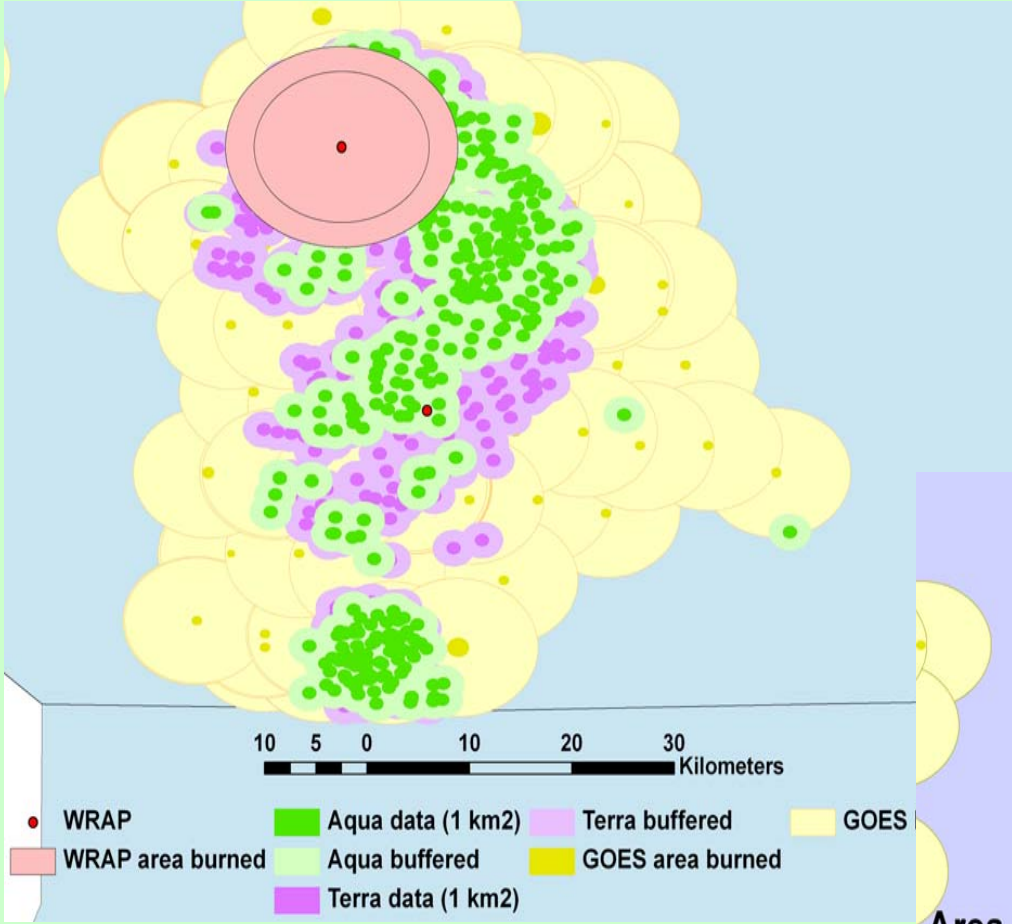
GOES data identify 33% more fires in agricultural lands than MODIS.

Not all fires are the same (agricultural, forest, rangeland, savannahs)
Mean agricultural fire size 69 acres; other 1691 acres.
One to one comparisons need to be expanded (all and small).

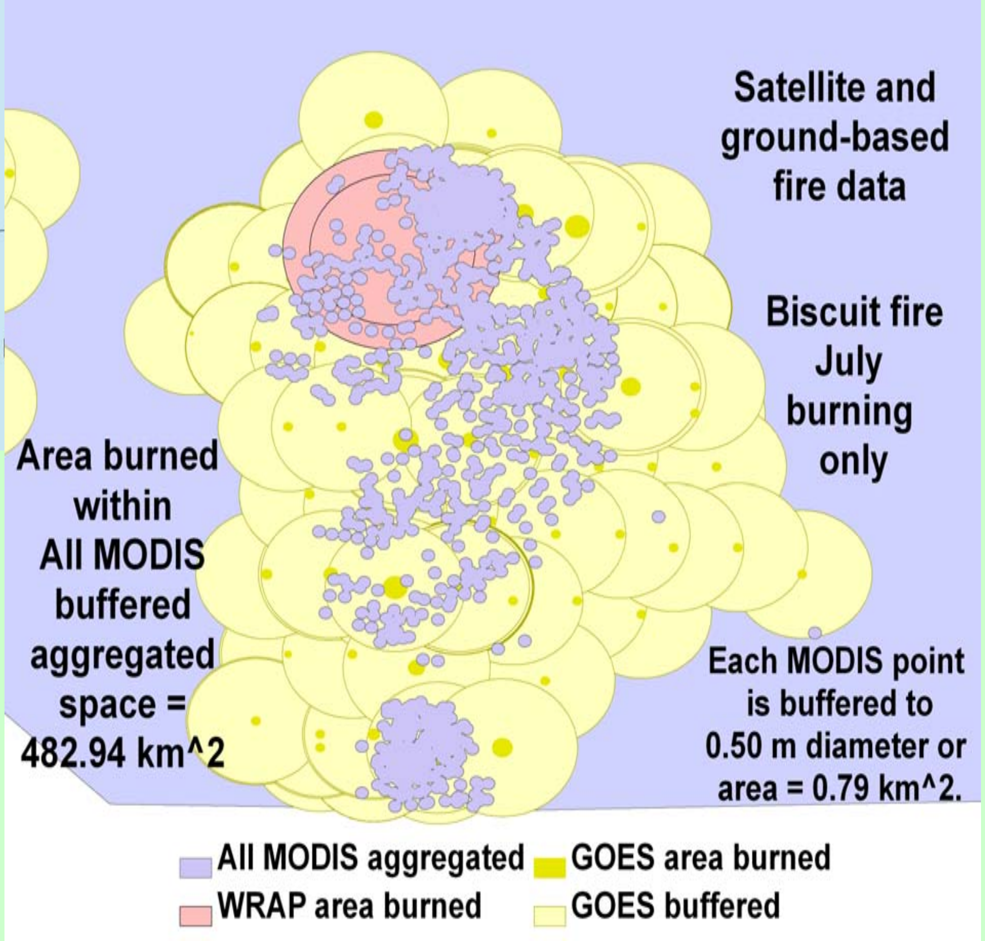
Assuming 1km^2 and/or double counting satellite data results in extreme overestimates of area burned.

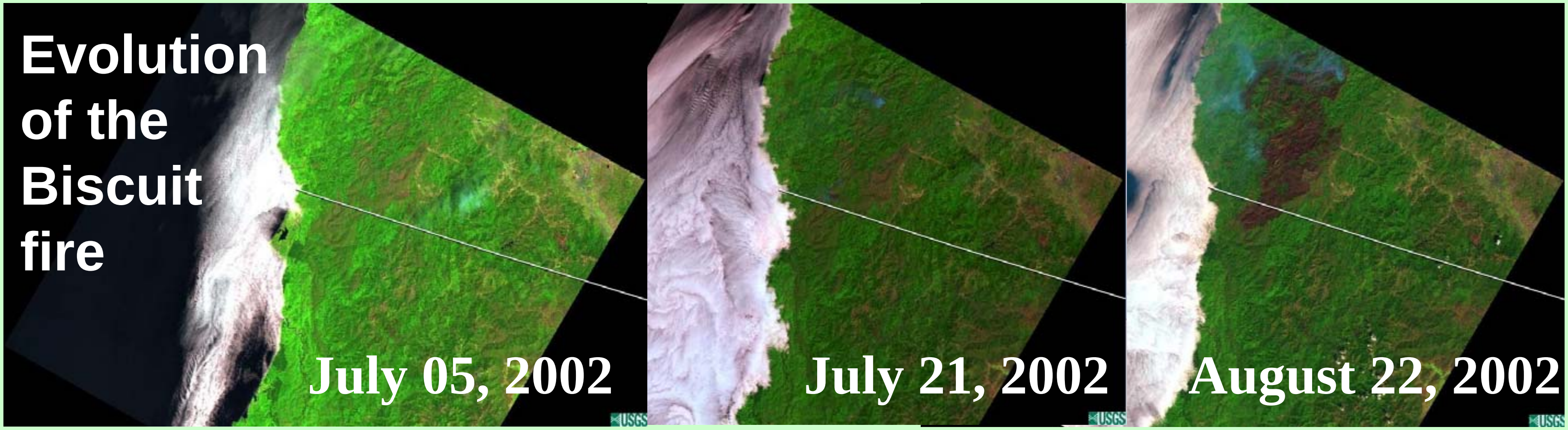
Biscuit fire

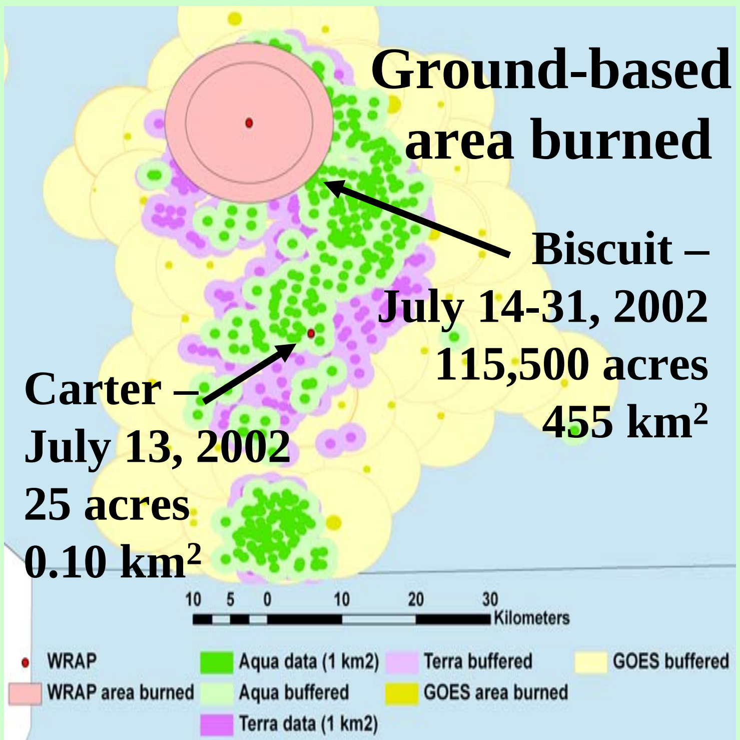
July 2002 analysis



**MODIS (Terra and Aqua) data Combined,
buffered to 0.50 radius
(1 pixel area = 0.79 km^2)
and aggregated
(overlap removed).**





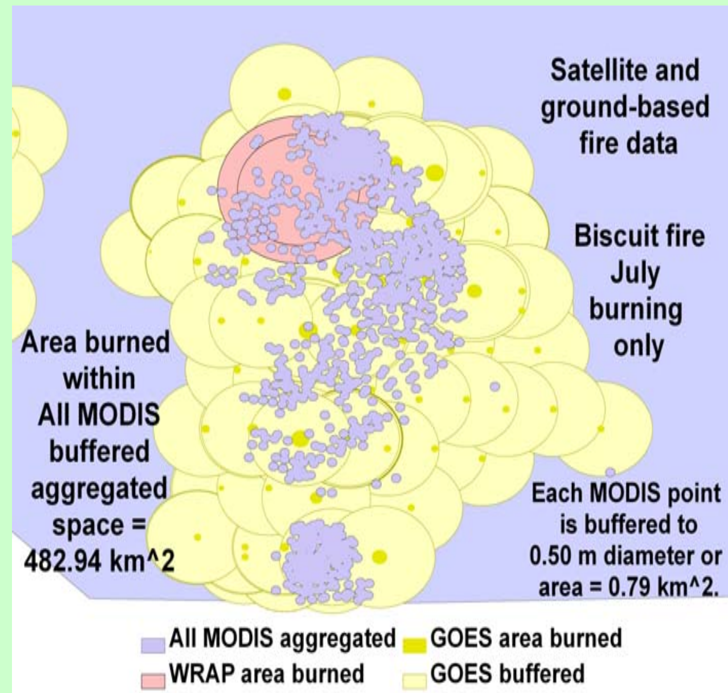


Fire detections
(1 detect = 1 km²)

Aqua
423 records
July 11-29, 2002

Terra
746 records
July 14-31, 2002
(MODIS 257% >)

GOES
231.79 km²
July 4-31, 2002 (51%)



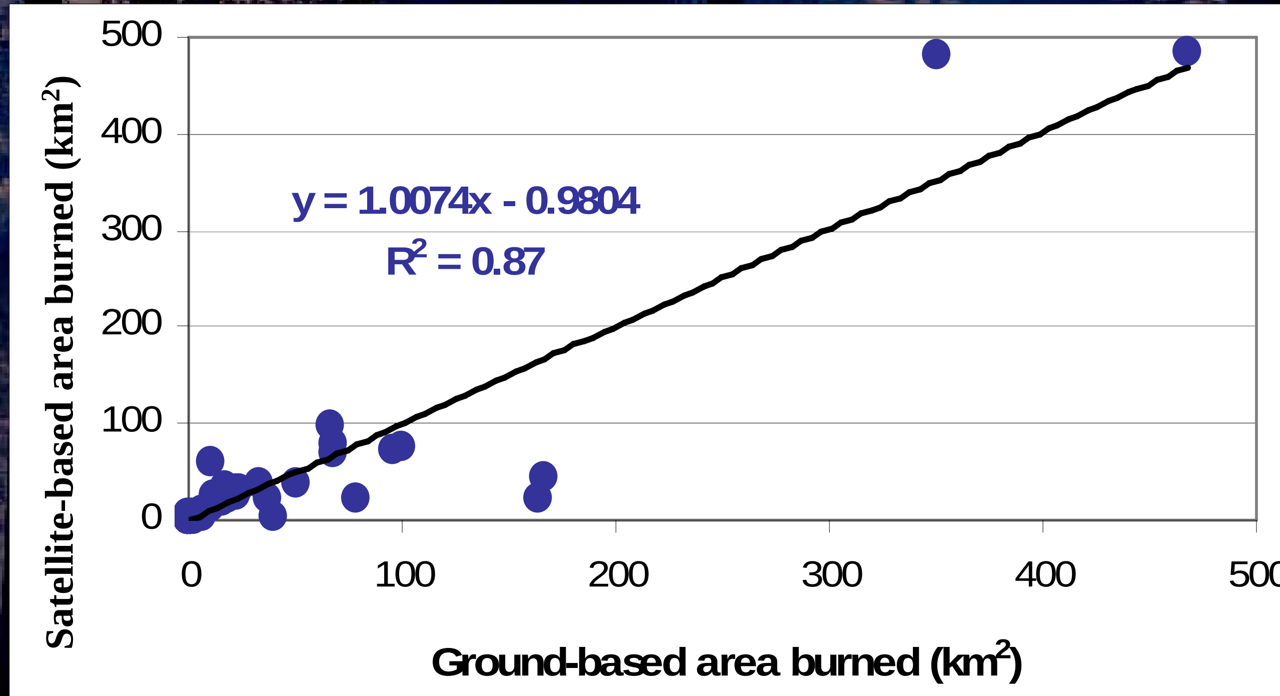
Area burned product
482.94 km² (6% >)

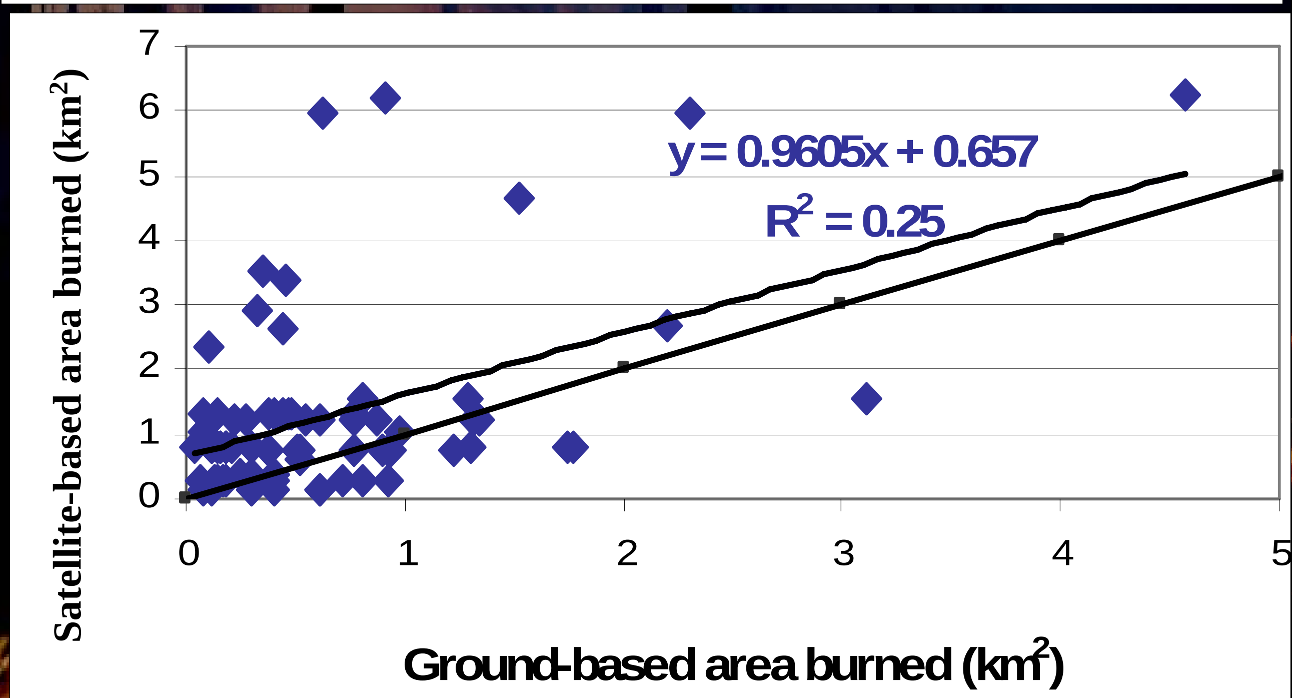
July Analysis

Total area captured with a combined product:

Arizona –
81% of all fires (wildfire, prescribed and rangeland)

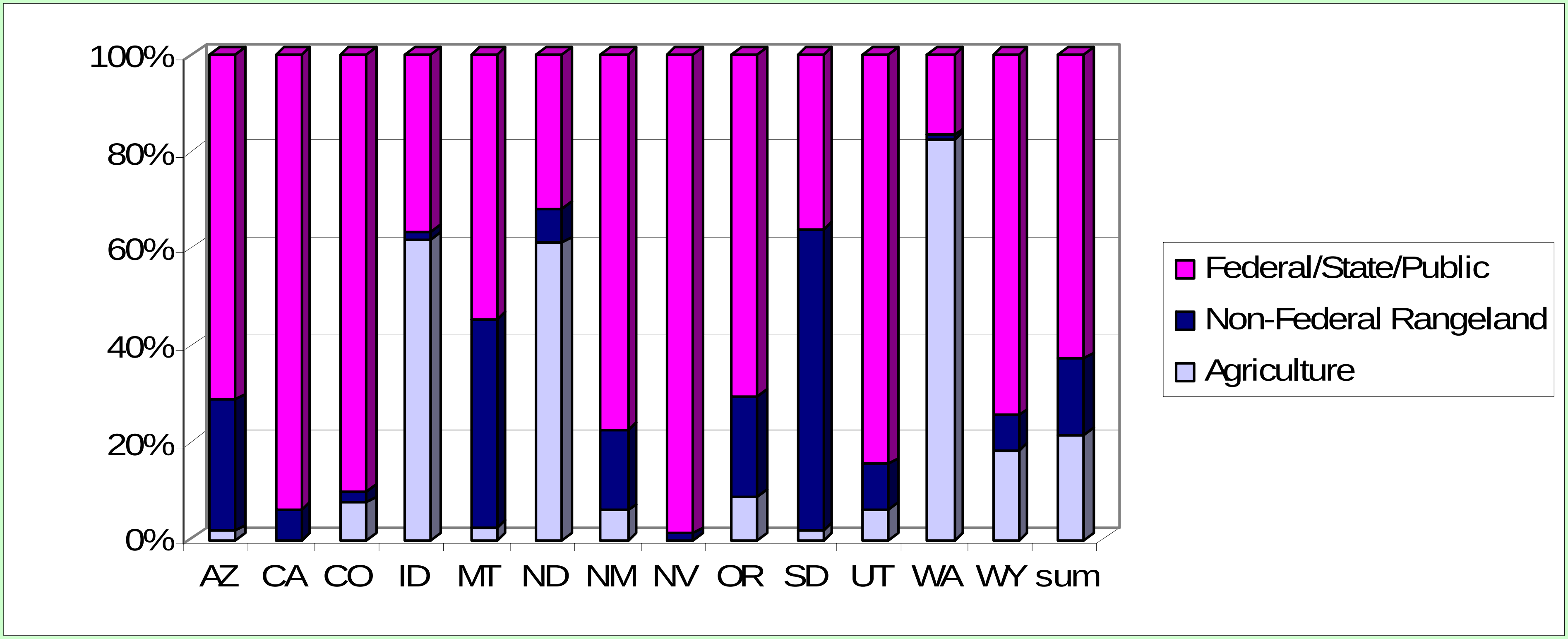
Oregon –
92% of all fires (wildfire, prescribed and agricultural)





Percent of "reported" area burned in the WRAP region, 2002

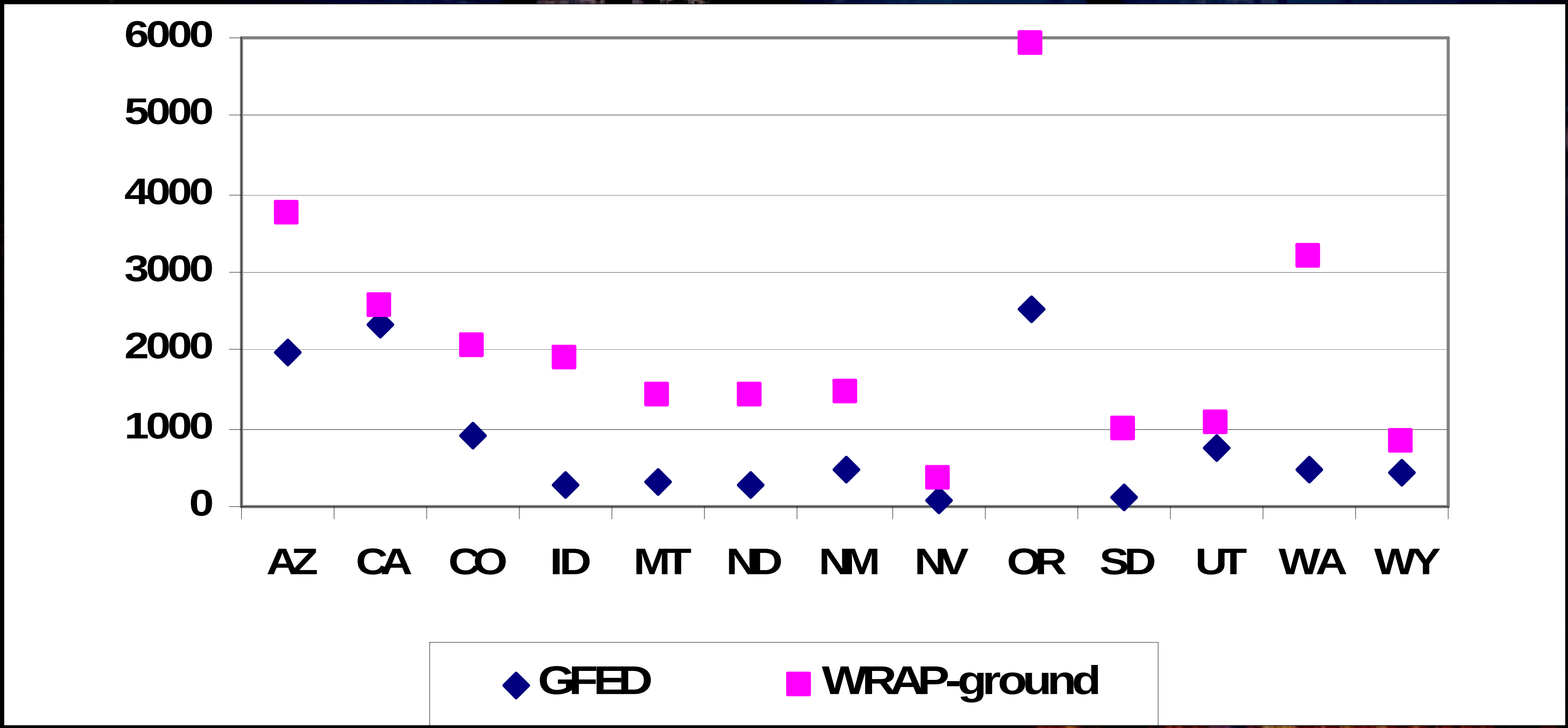
22% agricultural lands;
16% non-federal rangelands; and
63% private, state and federal lands



What do we <u>know</u>?

Comparison of Area Burned (km^2) by State: Agricultural, Non-federal Rangeland, Federal, State and Private Lands.

GFED is a MODIS-derived area burned fire scar product



Average difference 63%; Range of difference from 10% (CA) to 85% (SD). Oregon show a 56% difference.

Conclusions

Inter-comparisons of area burned and emissions show a diverse range of estimates, highlighting the need for <u>detailed</u> and <u>larger-scale</u> <u>evaluation, verification and validation</u>.

Satellites accurately identify the time and spatial domain of fires in all lands (rangelands, agricultural, across state boundaries),

but

What do we KNOW?

Suggest that we back-up, evaluate, verify and validate.

One more quick example …

Comparison of MOPITT (right) to RAQMS (left) total column CO for the North American boreal region during INTEX-A from July 1st through August 15th 2004.

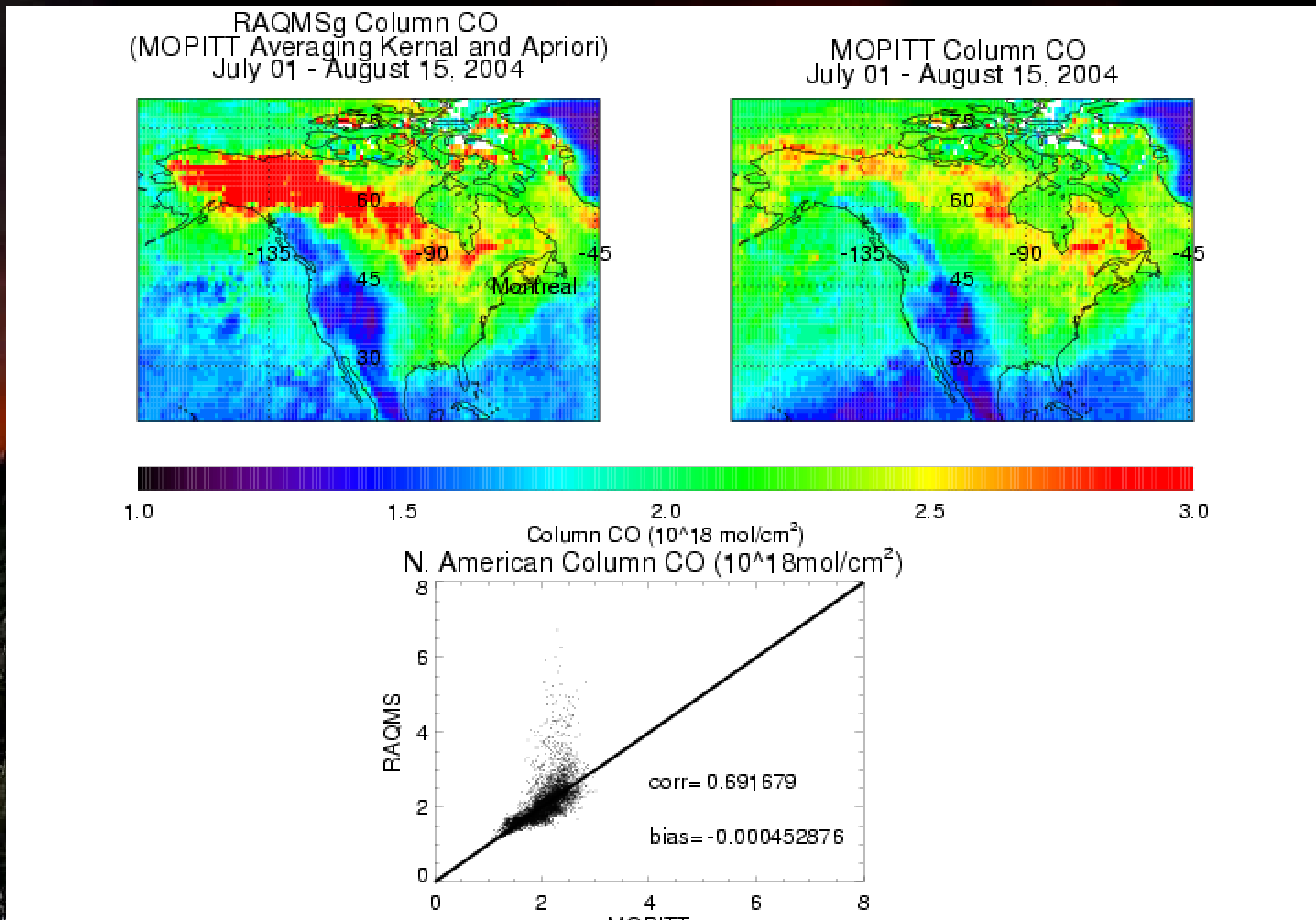
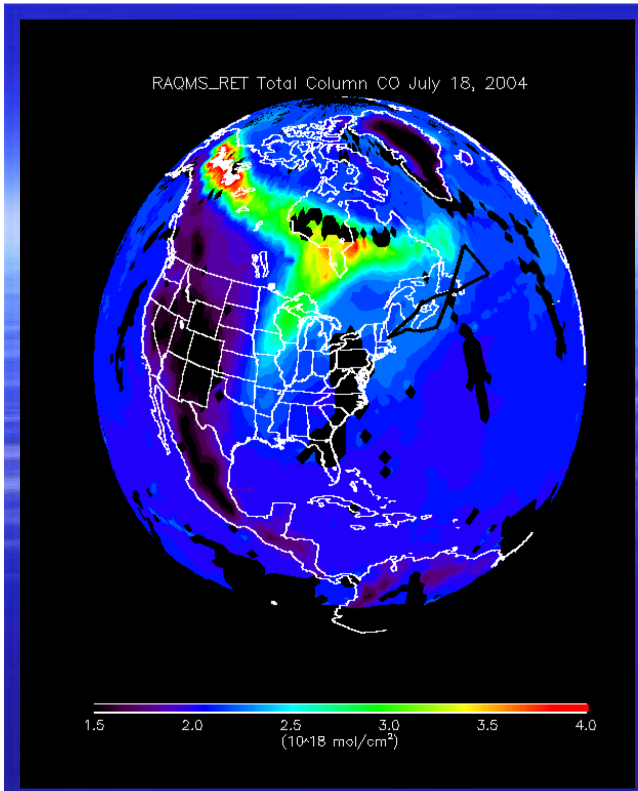


Photo courtesy of Brian Stocks

The bias is negative due to the underestimates of CO in the Pacific Ocean.

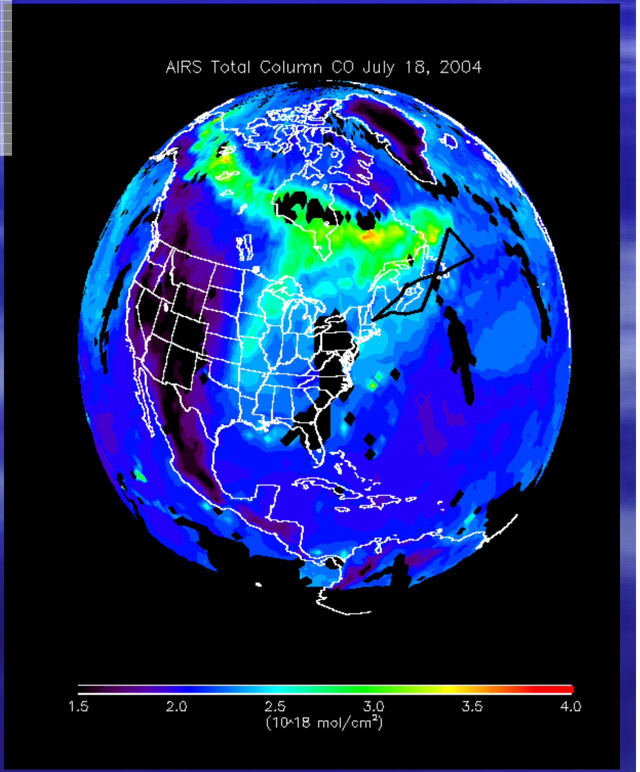


RAQMS CO column for July 18, 2004.

The RAQMS CO column is sampled at AIRS observation points and times.

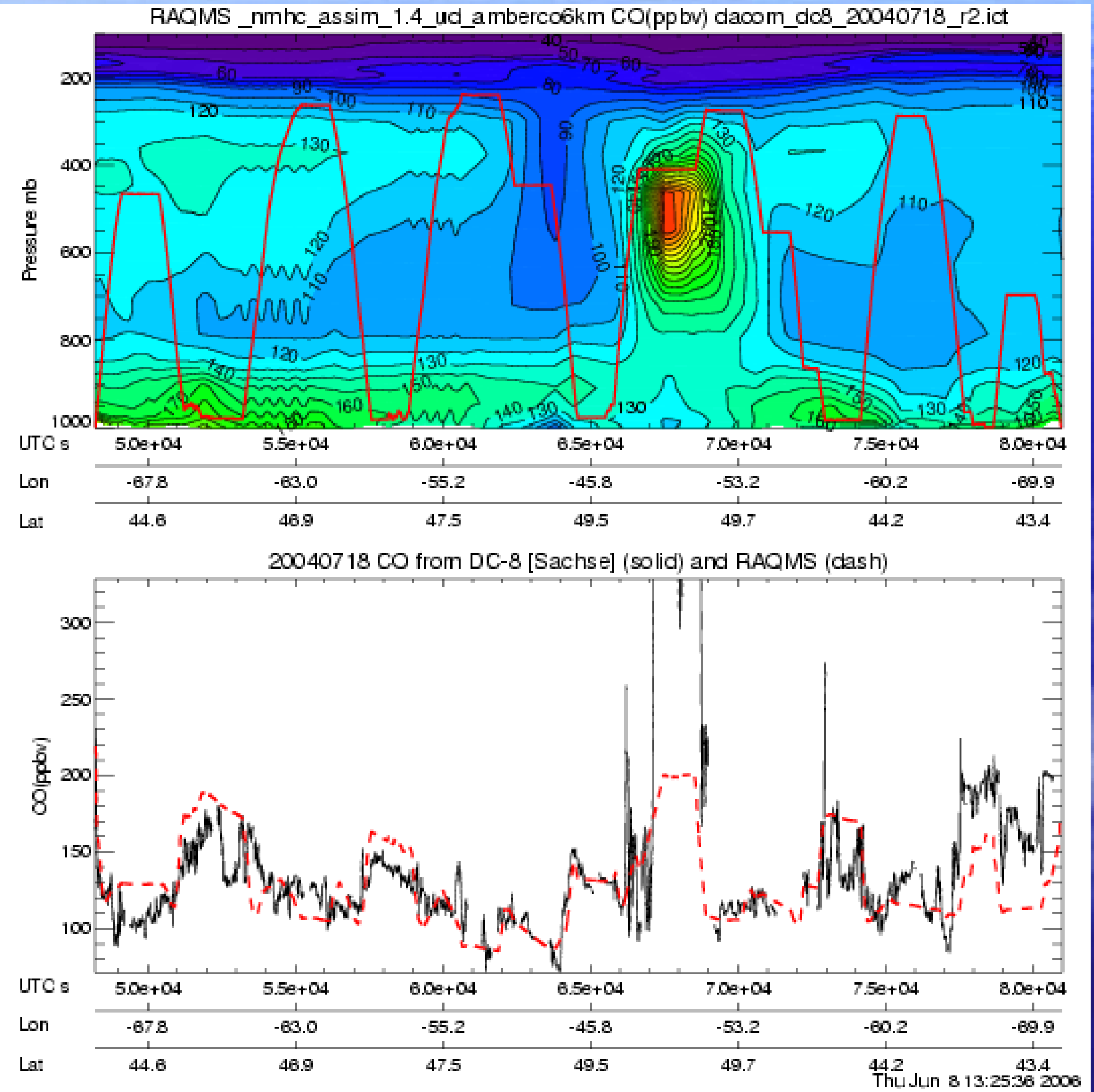
*** Note the DC-8 flight path in black.**

AIRS CO column July 18, 2004.



RAQMS column overestimates CO relative to AIRS. AIRS is advected farther to the east, closer to the flight path, and further south and southeast. Advection differences could offer a partial explanation for the column differences.

RAQMS versus in–situ CO data from the NASA DC-8 aircraft for July 18, 2004



The redline in the RAQMS curtain is the DC-8 flight track.

RAQMS and in-situ data coincide, except for the densest part of the plume.

*** RAQMS depicts the peak plume slightly lower in the atmosphere than the aircraft flight track (red center ~ 270 ppbv).**

*** RAQMS is a 1.4° x 1.4° model.**

Comparison of 147 MOZAIC ascents and descents to coincident RAQMS model simulations.

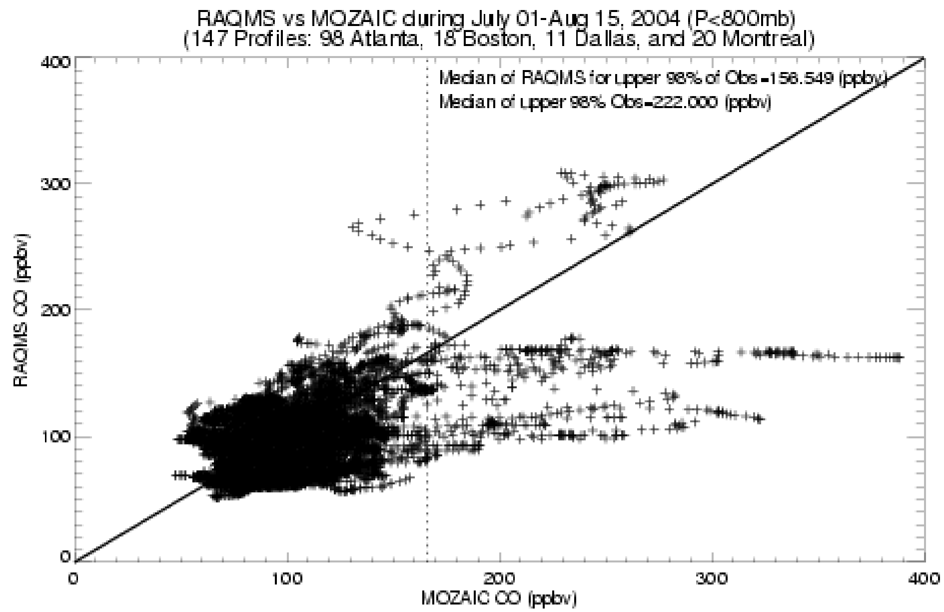
*** < 800 mb**
(to avoid urban pollution)

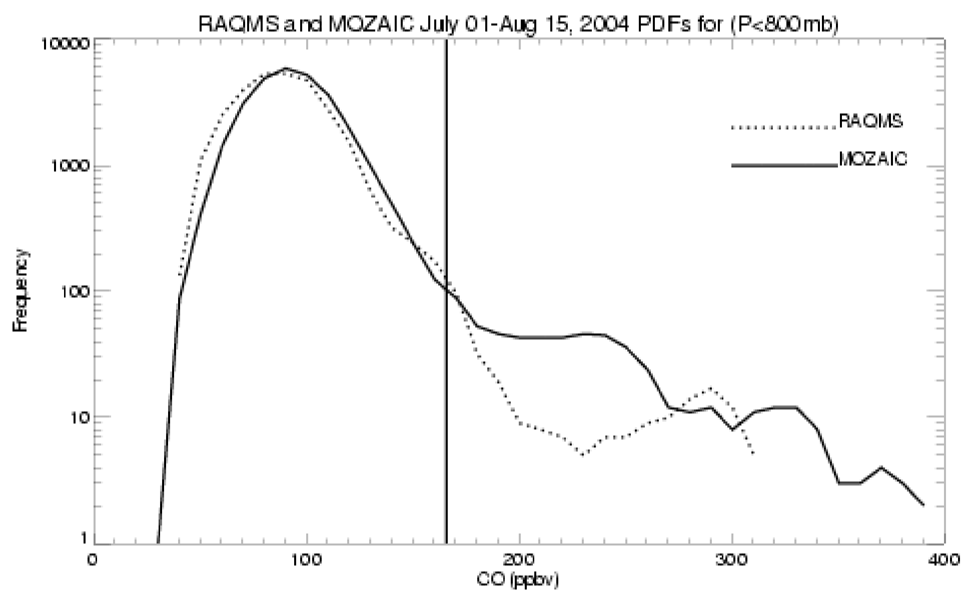
*** Vertical line, ~165 ppbv, 98th percentile of data**

*** Data points that cross this line distinguish smoke plumes**

RAQMS underestimates CO in smoke plumes in comparison to in-situ data.

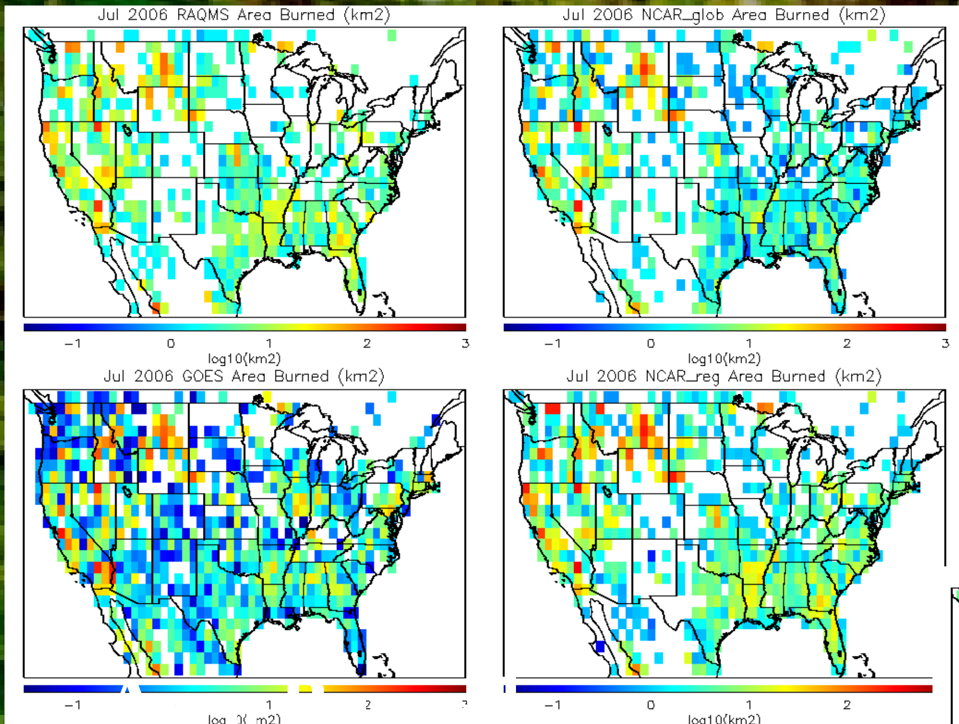
Exceptions
2 of 147 flight paths over Montreal, July 21st 2004, 12 UTC (RAQMS > 1:1 line).



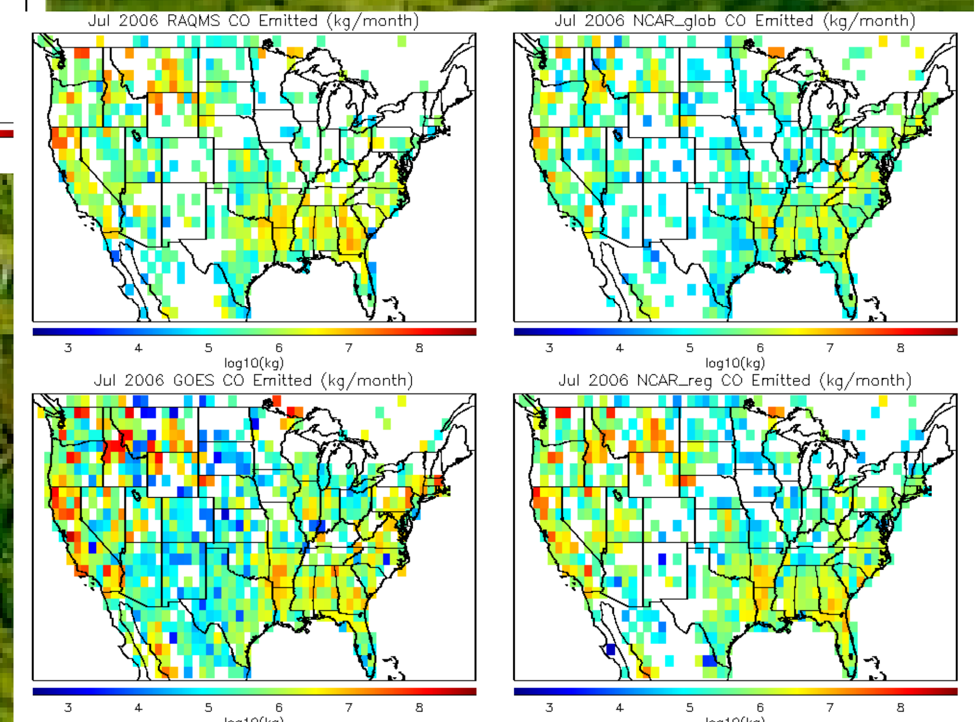


Comparison of area burned (all satellite based) and modeled CO emitted from fires

July 2006



Area Burned



CO