Fires and Emissions from Temperate and Boreal Ecosystems in North America: Past, Present, and Future

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Objectives

- Develop a historical trend of spatial and temporal distribution of fires, burned areas, and emissions of trace gases and particulate in North America's temperate and boreal ecosystems: 1985-2000

- Develop a prototype system for monitoring fires and burned areas as well as quantifying smoke emissions in North America

Major Responsibilities

- NOAA/NESDIS: Acquisition of historical 1-km AVHRR data (level 1b)
- UC/Berkeley: Processing of historical AVHRR data and implementation of the CCRS Fire/M3 system
- CCRS: Algorithm development and modification, and development of a near real-time fire monitoring system
- Forest Service/FSL: Validation of locations of active fires and burned areas, development of emissions inventory model, and project coordination

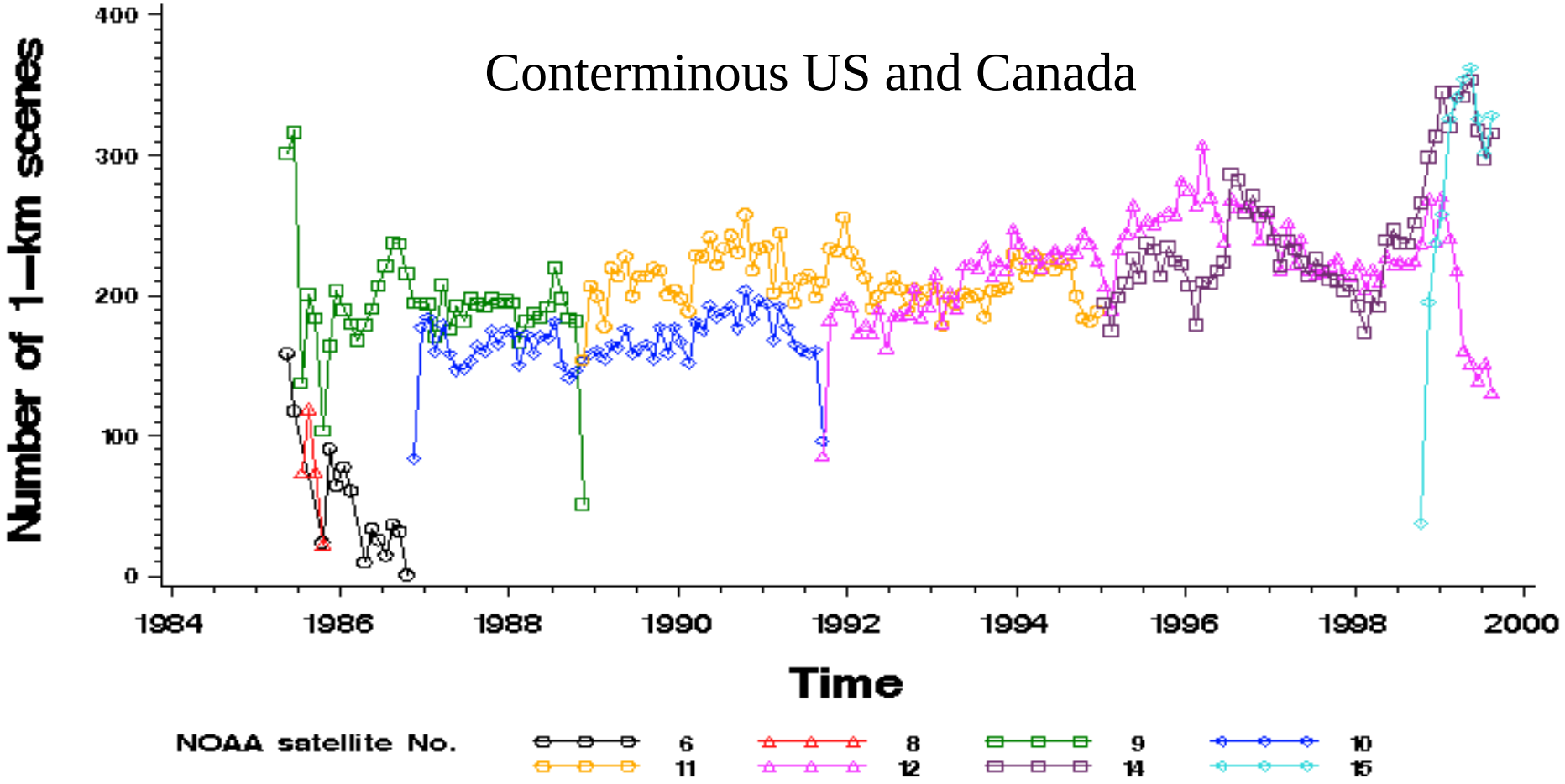
NOAA/NESDIS:

Acquisition of historical 1-km AVHRR data (level 1b)

Acquisition of 1-km AVHRR data

- Source: NOAA Satellite Active Archive (SAA)
- Datasets:
  - HRPT: direct-readout (50-60 MB/scene)
  - LHRR (LAC): recorded onboard satellite (20-30 MB/scene)
    - level-1b data files
- Only afternoon scenes for massive processing
  - morning and nighttime scenes for case studies only
- Data stored on 35GB DLT tapes (2 months/tape)

1-km Data Availability Over North America



1-km Data Availability Over North America

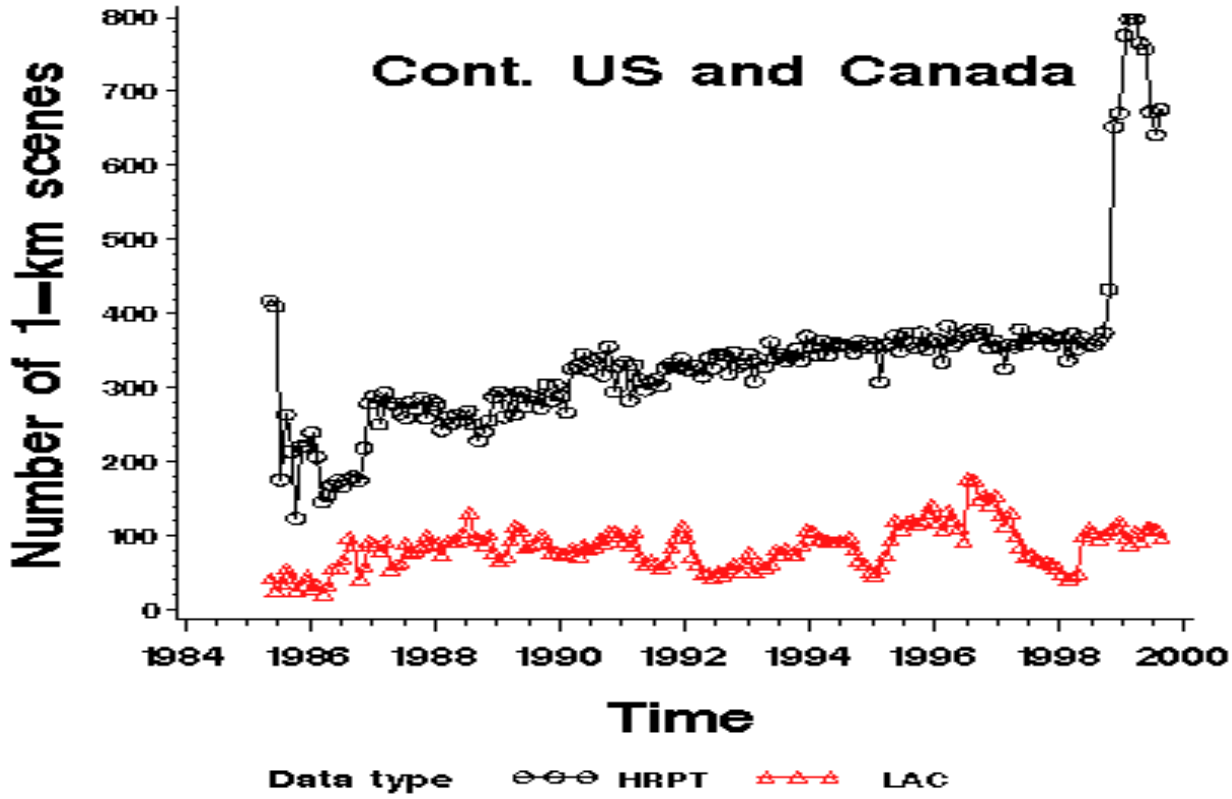
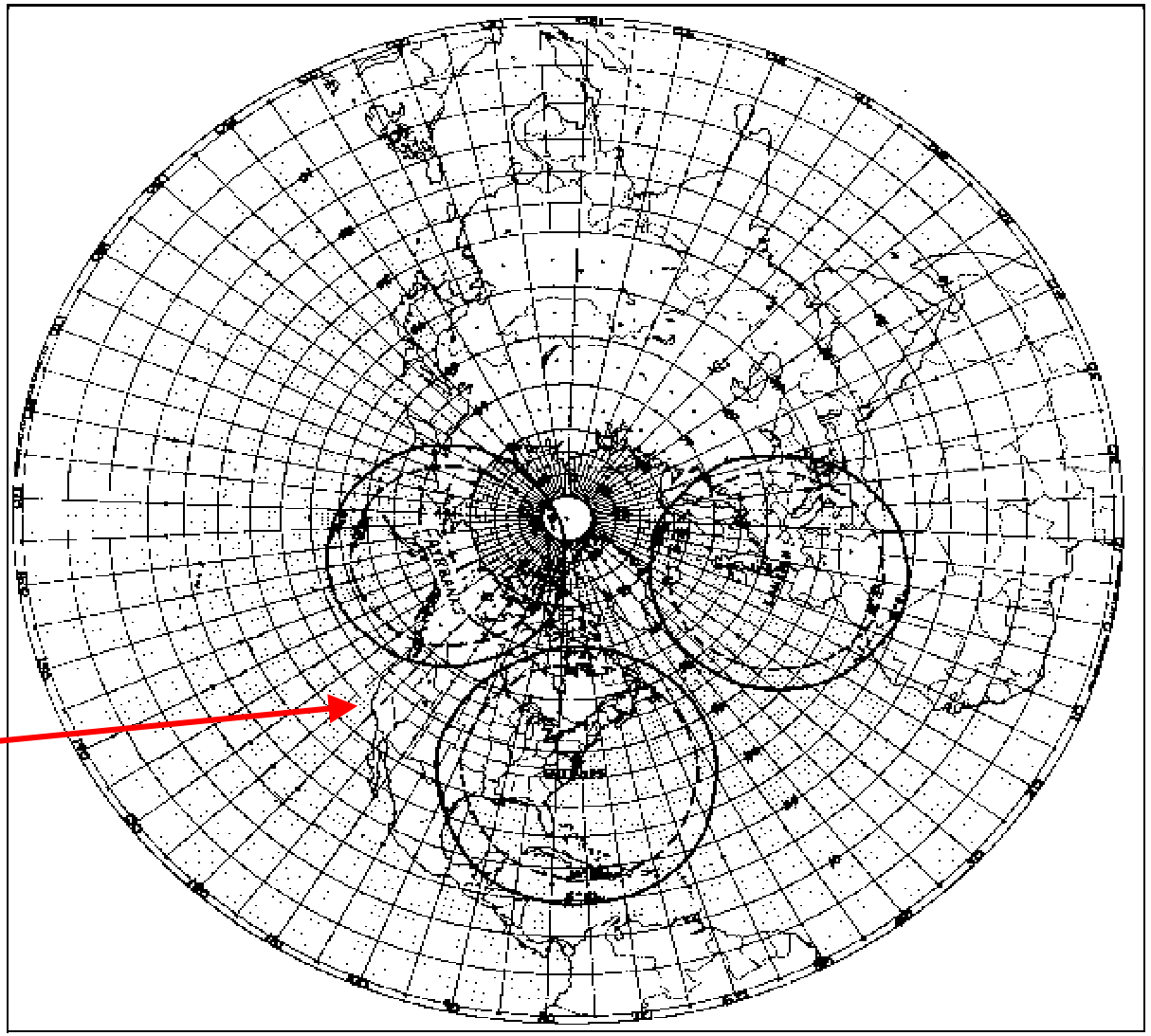


Figure 1.1-1. Overall HRPT coverage for the Northern Hemisphere.

(from NOAA Polar Orbiter Data Users' Guide)

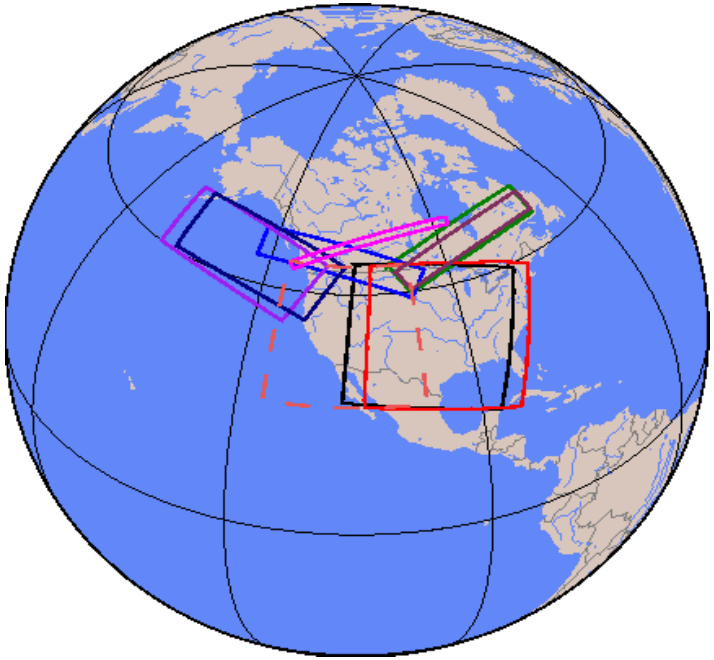


No HRPT coverage in California before August 1998

Data coverage from HRPT and LAC:

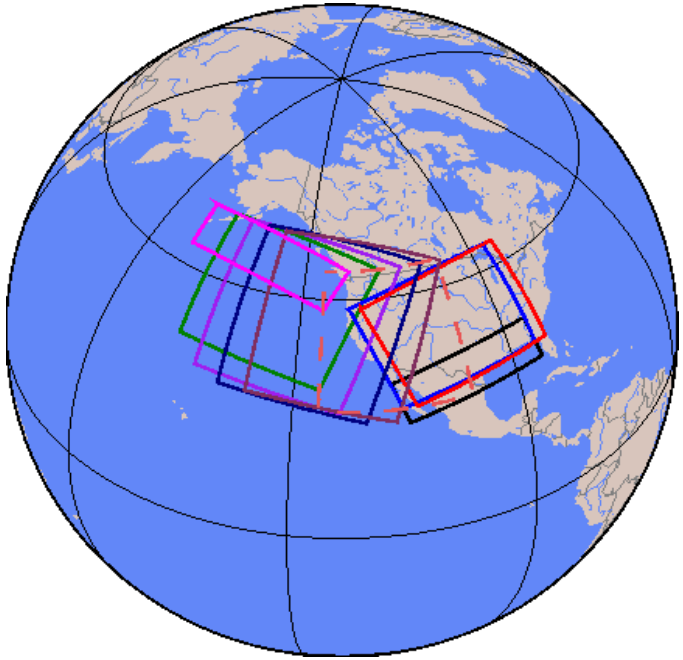
no data in the HRPT data record from California before August 1998 (Monterey)

HRPT



March 21, 1990

LAC



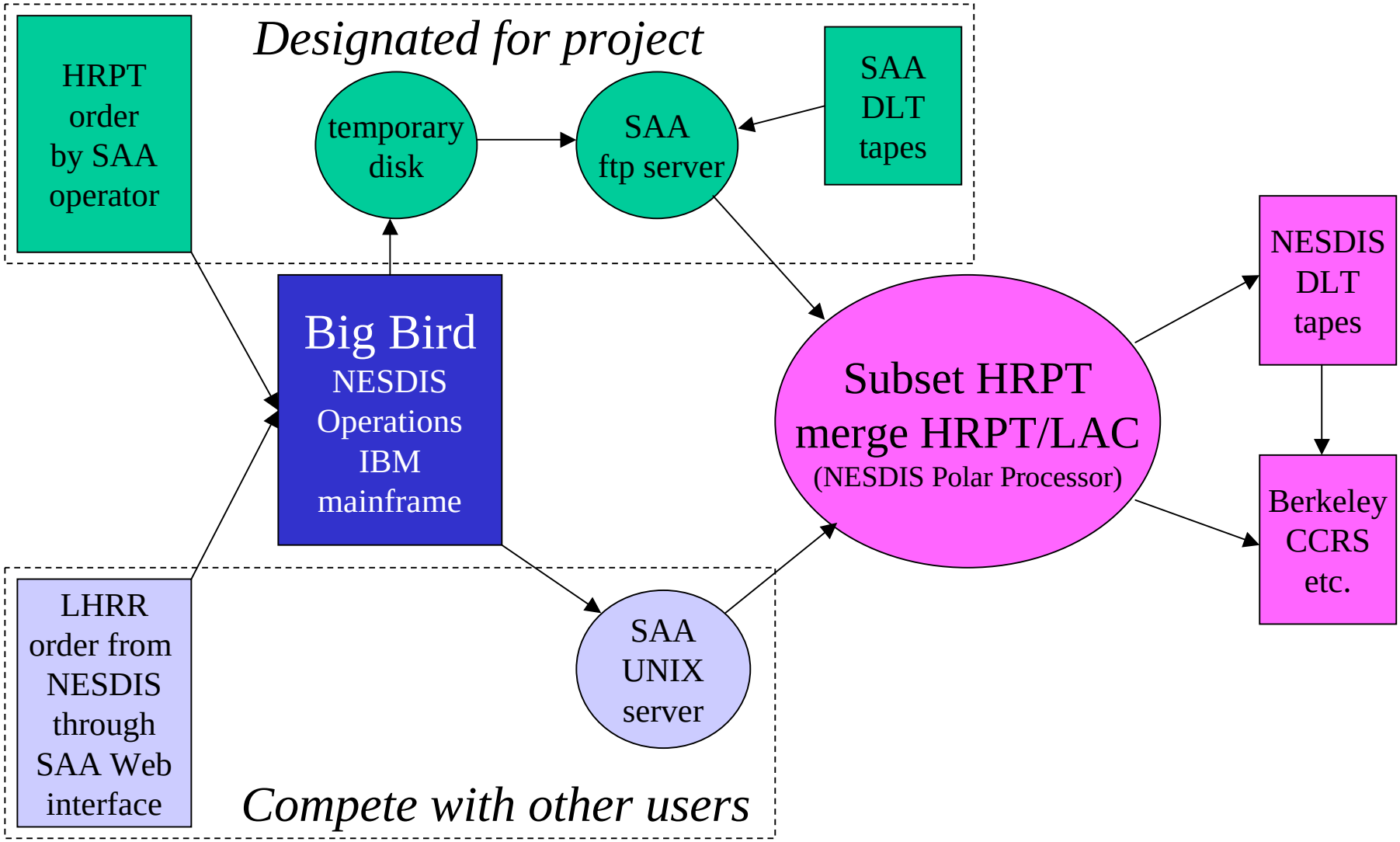
March 21-24, 1990

Current AVHRR data availability at SAA

- **1995-current: Robotic Tape Library ("Big Bird")**
- **April-December 1994: not available**
  - (+ NOAA-11 AVHRR failed in September 1994)
- **10/21/88- 3/31/94: Big Bird, DLT tapes**
- **5/1/85-10/20/88: not available**

- missing data are at NOAA National Climatic Data Center (NCDC)
  - data on 3480 tape cartridges (~3 scenes/tape)
  - negotiations under way on getting the data

Data collection



Milestones

- Currently: March 1994 - December 1999 on tapes
  - 1999 data transferred to Berkeley
- End of 2000: obtain 1993 data
  - transfer 1993, 1995-1998 data to Berkeley
- Mid-2001: obtain 1989-1992 data
  - transfer 1989-1992 data to Berkeley
- End of 2001: obtain 1985-88 and 1994 data
  - transfer 1985-88 and 1994 data to Berkeley

UC/Berkeley:

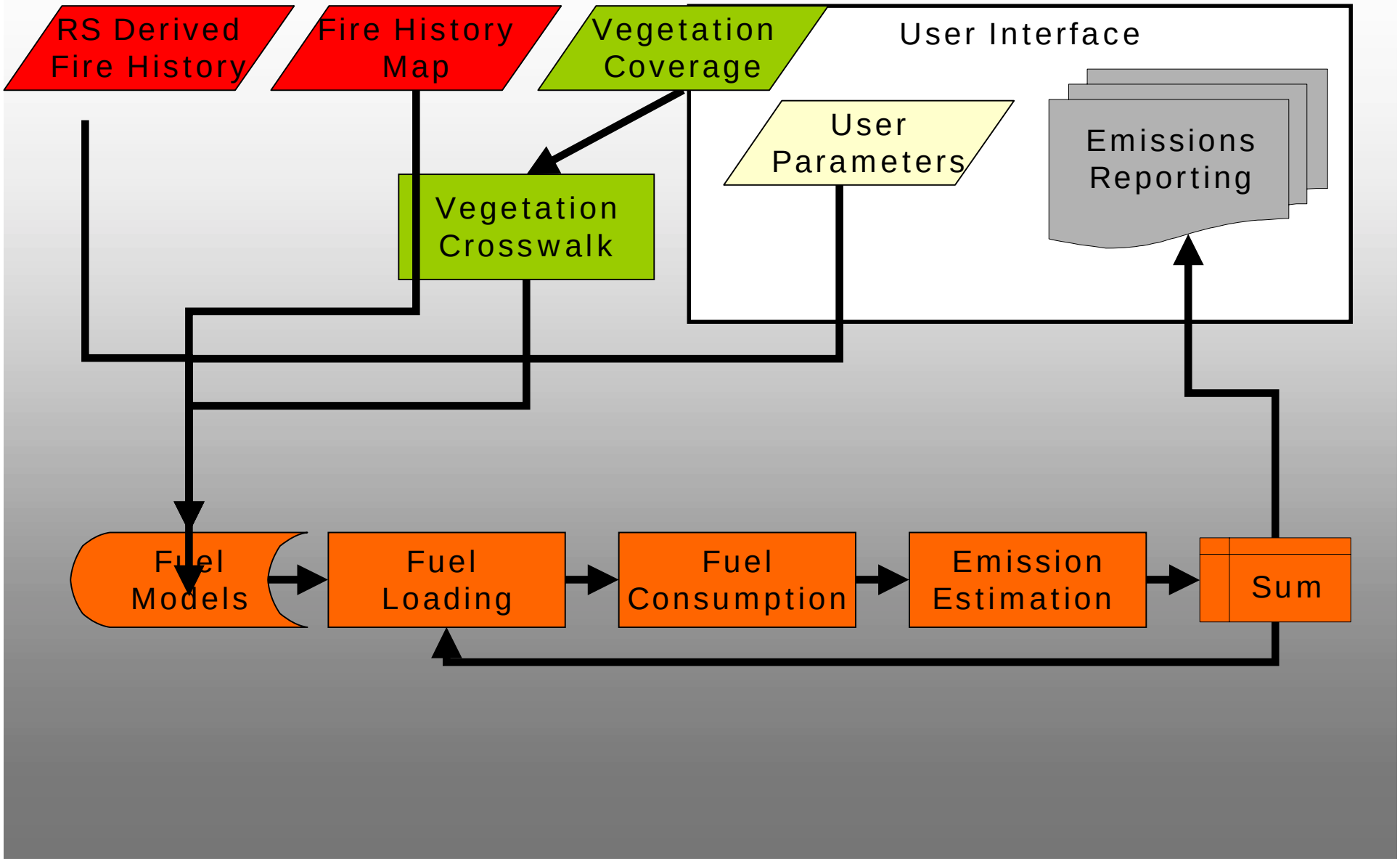
Processing of historical AVHRR data

Implementation of the CCRS Fire/M3 system

Overview

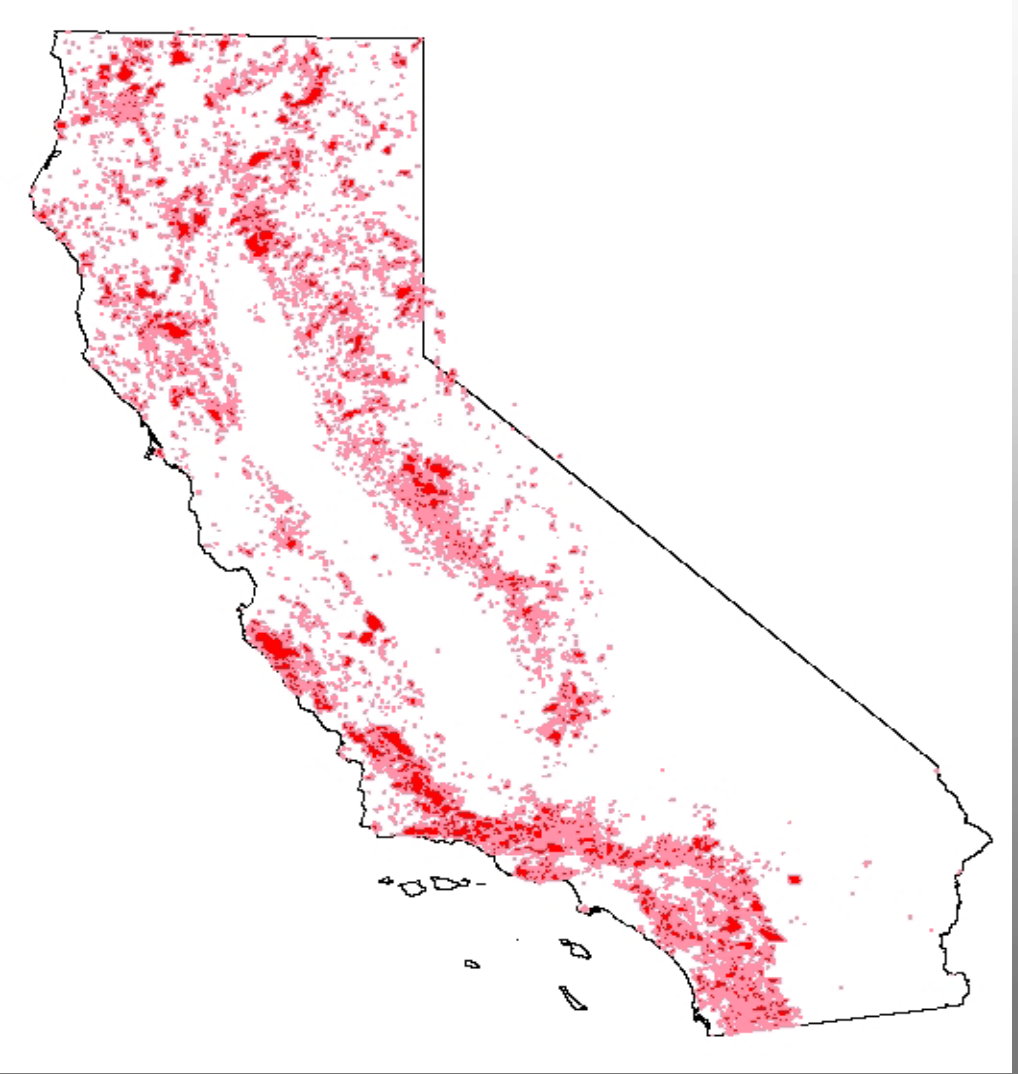
- Study objectives
- The modular approach
- Emissions Modeling in GIS
- Data collection / processing
- Multiple user interfaces
- Preliminary results
- Finale: Distribution of results

Modular System



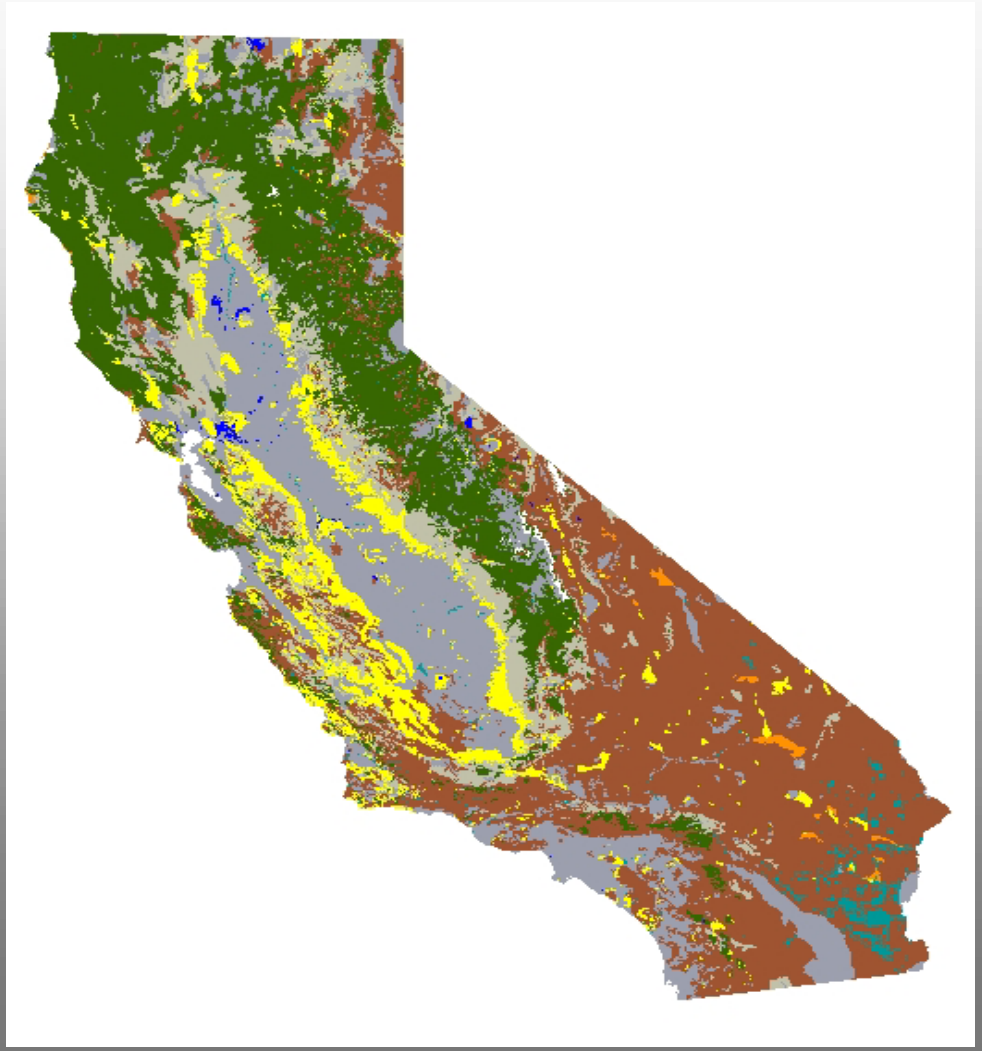
Fire History

- CDF fire polygons
- Remote sensing based fire map

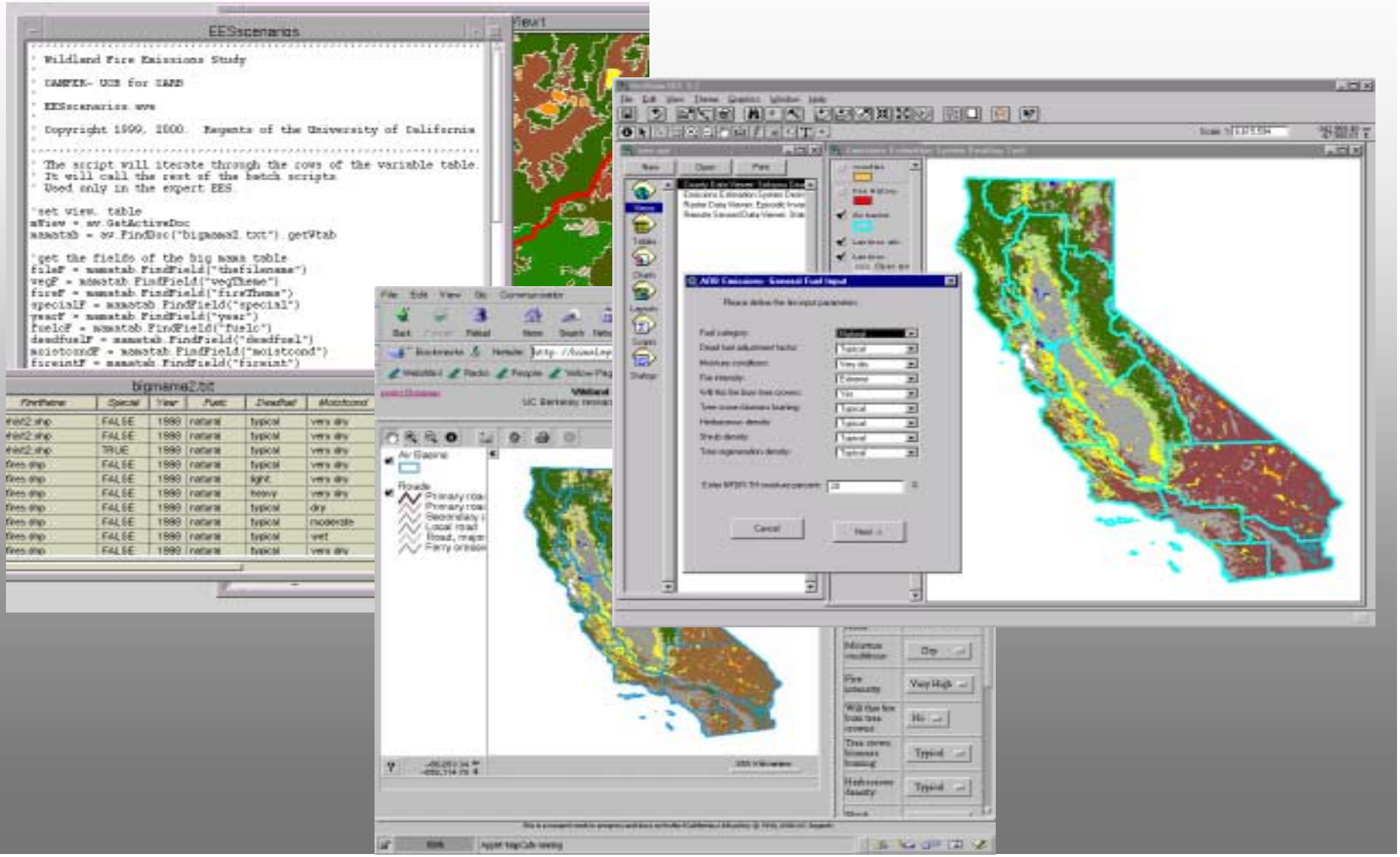


Vegetation Data

- The GAP vegetation layer
  - Statewide coverage
  - Less complex than other vegetation layers such as CALVEG
  - 1990 source data



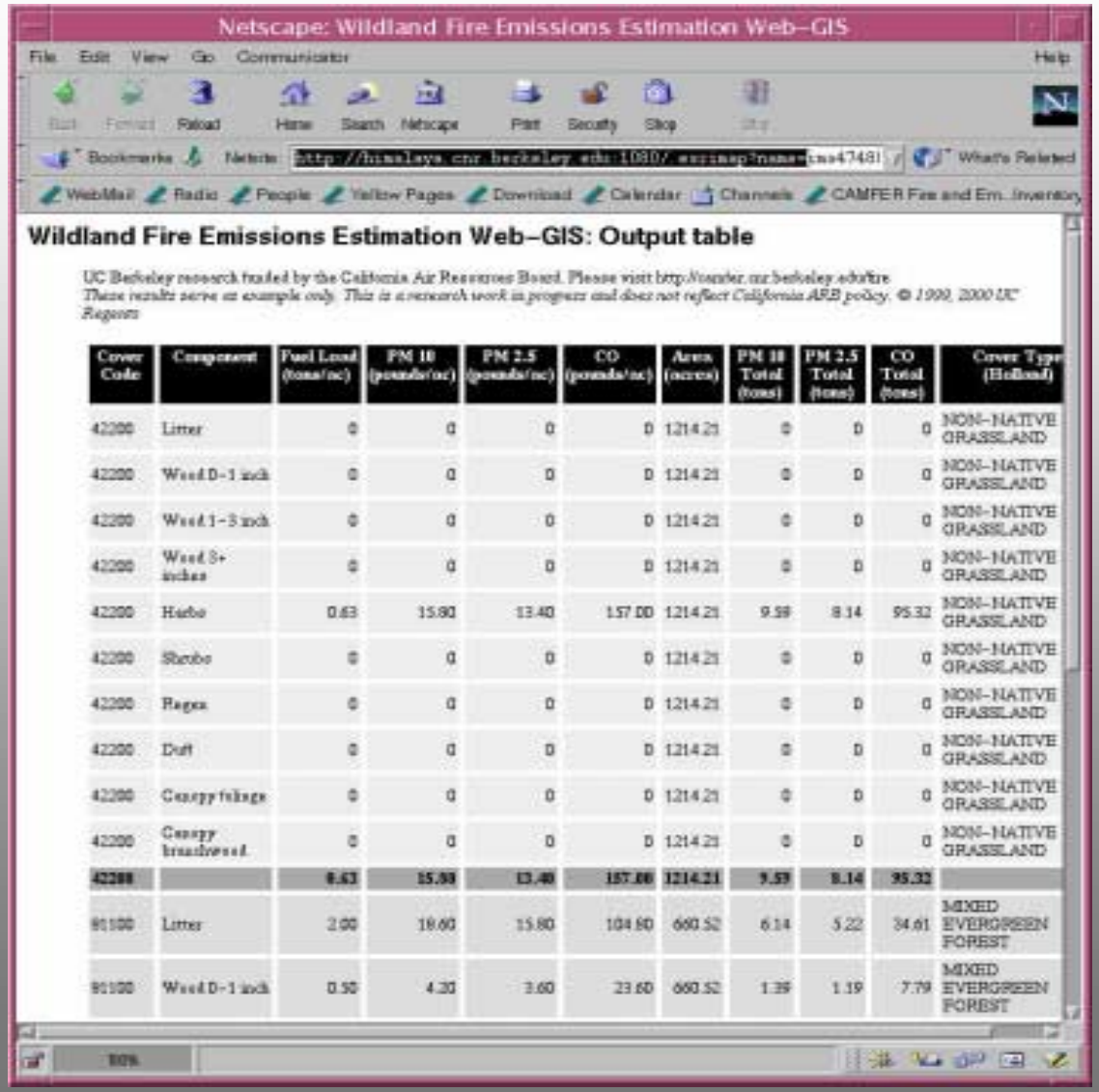
Multiple User Interfaces



Preliminary Output

- Output in the form of relational database tables
- Summarization by individual fire, fuel component, county or air basin
- Used in comparative analysis of various model configurations
- Potential for MUCH more…

Web output tables



Wildland Fire Emissions Estimation Web–GIS: Output table

UC Berkeley research funded by the California Air Resources Board. Please visit http://camfer.cnr.berkeley.edu/fire
These results serve as example only. This is a research work in progress and does not reflect California ARB policy. © 1999, 2000 UC Regents

Cover Code	Component	Fuel Load (tons/ac)	PM 10 (pounds/ac)	PM 2.5 (pounds/ac)	CO (pounds/ac)	Area (acres)	PM 10 Total (tons)	PM 2.5 Total (tons)	CO Total (tons)	Cover Type (Holland)
42200	Litter	0	0	0	0	1214.21	0	0	0	NON-NATIVE GRASSLAND
42200	Wood 0-1 inch	0	0	0	0	1214.21	0	0	0	NON-NATIVE GRASSLAND
42200	Wood 1-3 inch	0	0	0	0	1214.21	0	0	0	NON-NATIVE GRASSLAND
42200	Wood 3+ inches	0	0	0	0	1214.21	0	0	0	NON-NATIVE GRASSLAND
42200	Herbs	0.63	15.80	13.40	157.00	1214.21	9.59	8.14	95.32	NON-NATIVE GRASSLAND
42200	Shrubs	0	0	0	0	1214.21	0	0	0	NON-NATIVE GRASSLAND
42200	Ragas	0	0	0	0	1214.21	0	0	0	NON-NATIVE GRASSLAND
42200	Duff	0	0	0	0	1214.21	0	0	0	NON-NATIVE GRASSLAND
42200	Canopy foliage	0	0	0	0	1214.21	0	0	0	NON-NATIVE GRASSLAND
42200	Canopy branchwood	0	0	0	0	1214.21	0	0	0	NON-NATIVE GRASSLAND
42200		**0.63**	**15.80**	**13.40**	**157.00**	**1214.21**	**9.59**	**8.14**	**95.32**	
91100	Litter	2.00	19.60	15.80	104.60	660.52	6.14	5.22	34.61	MIXED EVERGREEN FOREST
91100	Wood 0-1 inch	0.50	4.20	3.60	23.60	660.52	1.39	1.19	7.79	MIXED EVERGREEN FOREST

dBASE output tables

defaults2.dbf

Component	Count	Sum_pm10to	Sum_cotot	Sum_pm25to
Canopy branchwood	181	159.6586	1584.9734	135.5636
Canopy foliage	181	632.1018	6275.4698	536.3978
Duff	181	3284.9549	34161.1335	2787.9309
Herbs	181	277.1631	2755.1539	235.9625
Litter	181	334.4936	1883.6882	284.6089
Regen	181	30.7011	295.9608	24.7265
Shrubs	181	1684.9955	16735.6705	1430.5304
Wood 0-1 inch	181	219.7883	1237.9966	186.8943
Wood 1-3 inch	181	183.0554	1454.2453	155.5702
Wood 3+ inches	181	5060.0499	46200.6106	4291.8235

defaults1.dbf

Fires_	Count	Ave_pm10	Ave_pm25	Ave_co	Sum
13055	40	2.1400	1.8200	21.0725	
13076	10	1.4200	1.2100	14.1300	
13077	20	3.8950	3.3100	34.6450	
13078	20	3.8950	3.3100	34.6450	
13085	10	59.6500	50.6100	574.6800	
13086	10	59.6500	50.6100	574.6800	
13087	10	59.6500	50.6100	574.6800	
13088	20	40.5050	34.3650	392.8000	
13089	10	59.6500	50.6100	574.6800	
13090	20	0.7100	0.6050	7.0650	
13091	20	0.7100	0.6050	7.0650	
13092	20	0.7900	0.6700	7.8500	
13093	10	1.4200	1.2100	14.1300	
13097	20	74.8200	63.4800	724.9750	

CCRS:

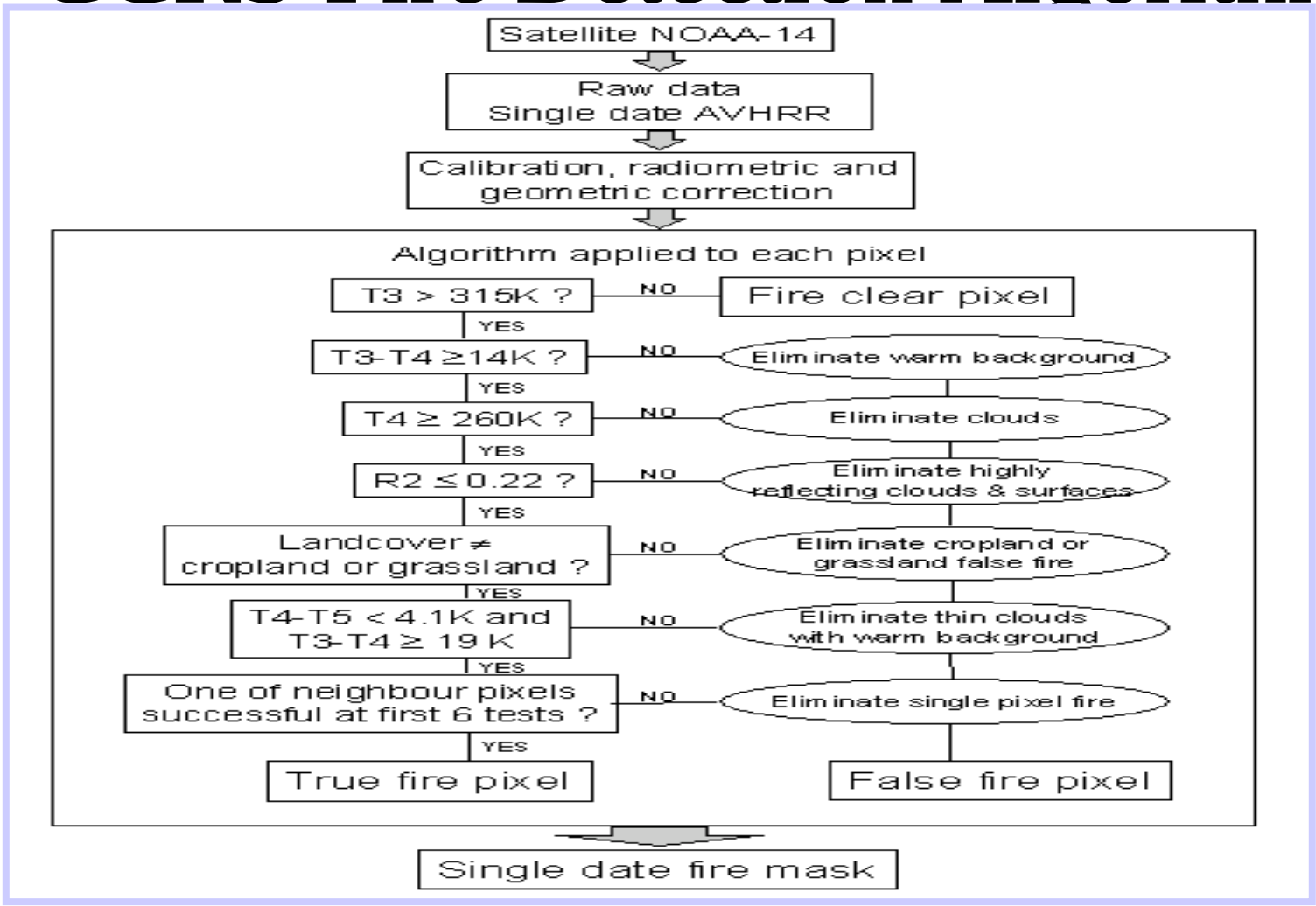
Algorithm development and modification

Development of a near real-time fire monitoring system

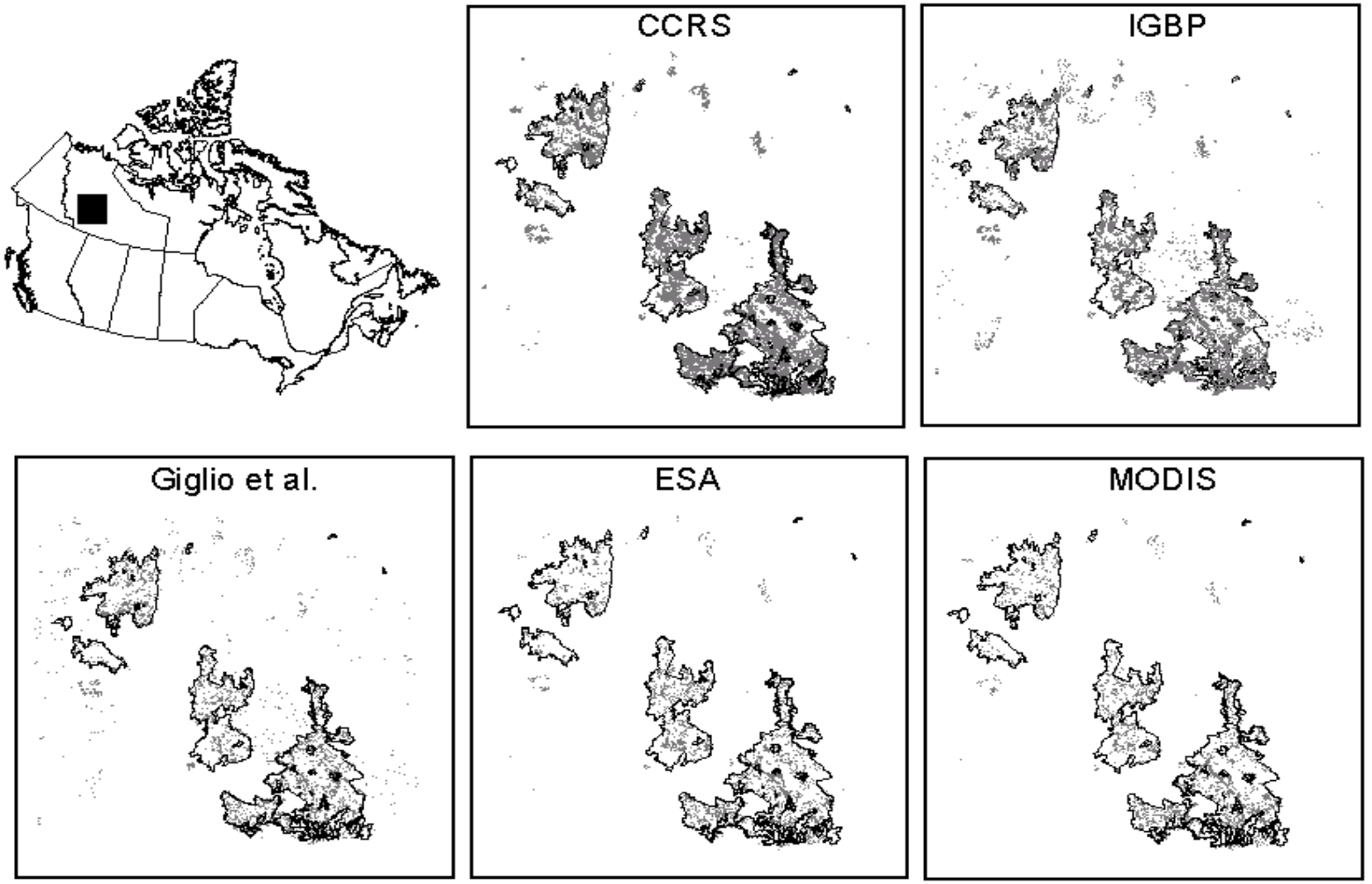
CCRS Tasks

- Algorithm development, validation and modification.
- Near rea1-time fire monitoring
- Mapping burned area in Canada
- Validation of fire products in Canada.
- Fire emission estimation in Canada

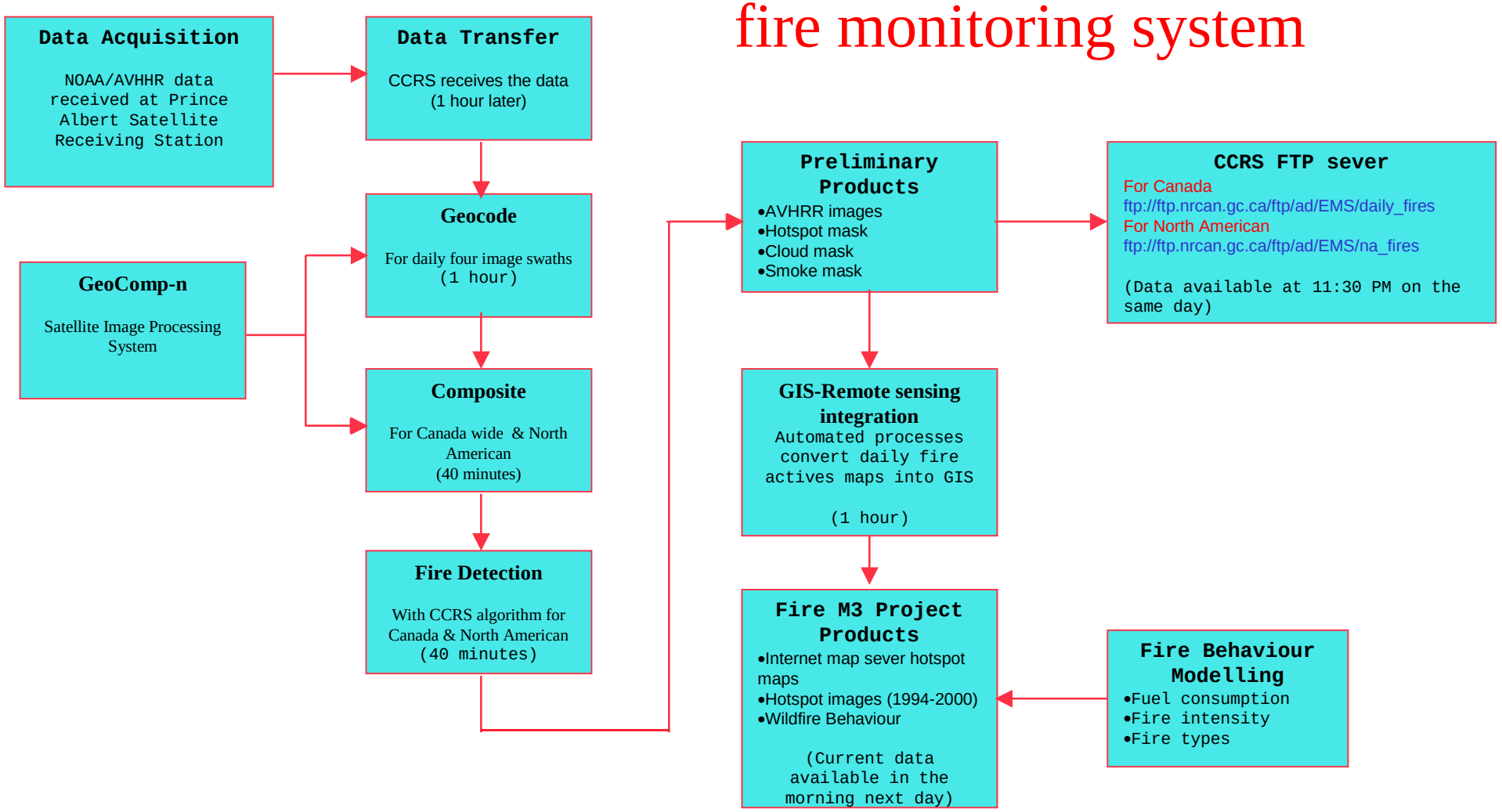
CCRS Fire Detection Algorithm



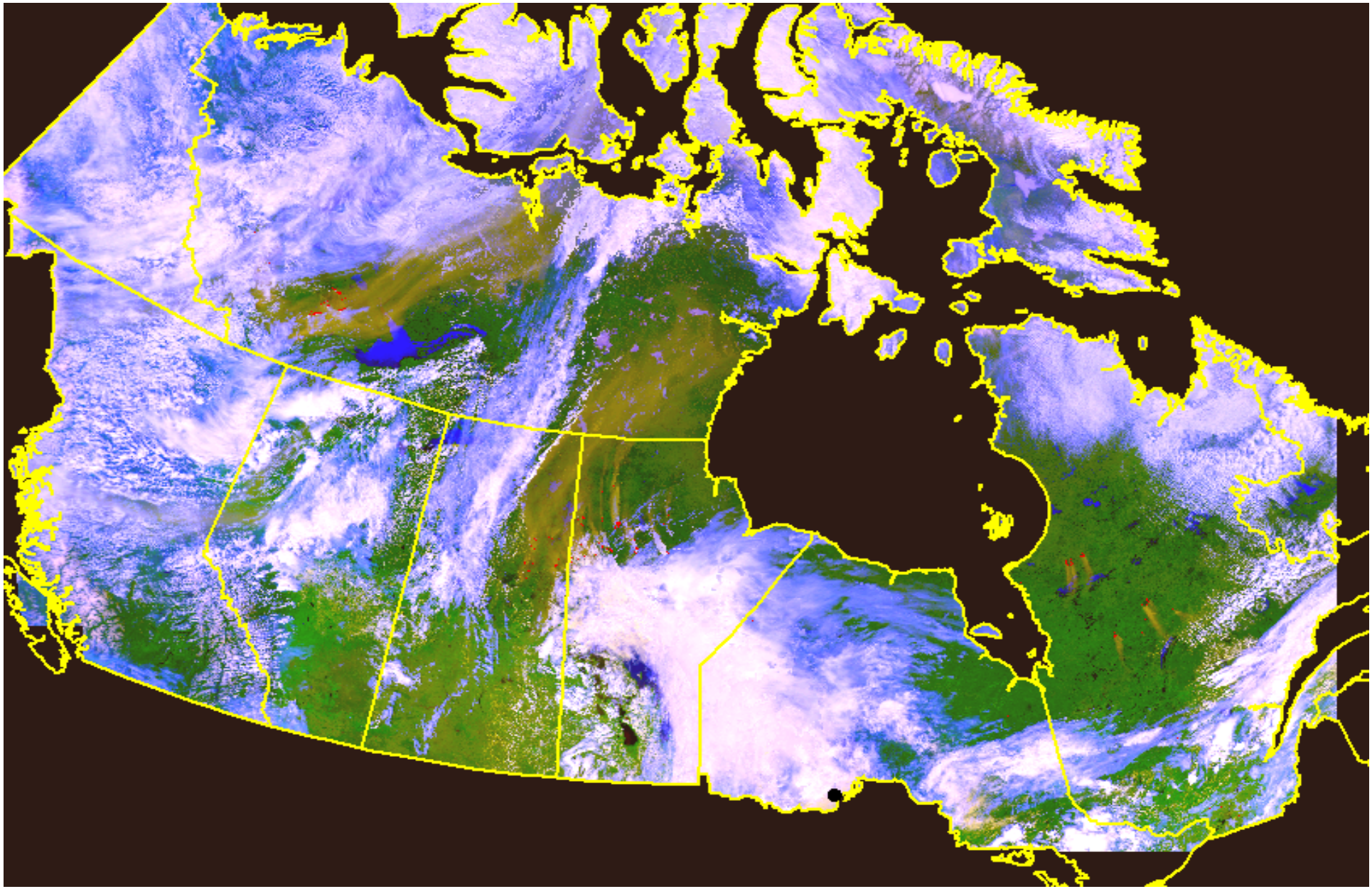
Preliminary inter-comparison of fire detection algorithms



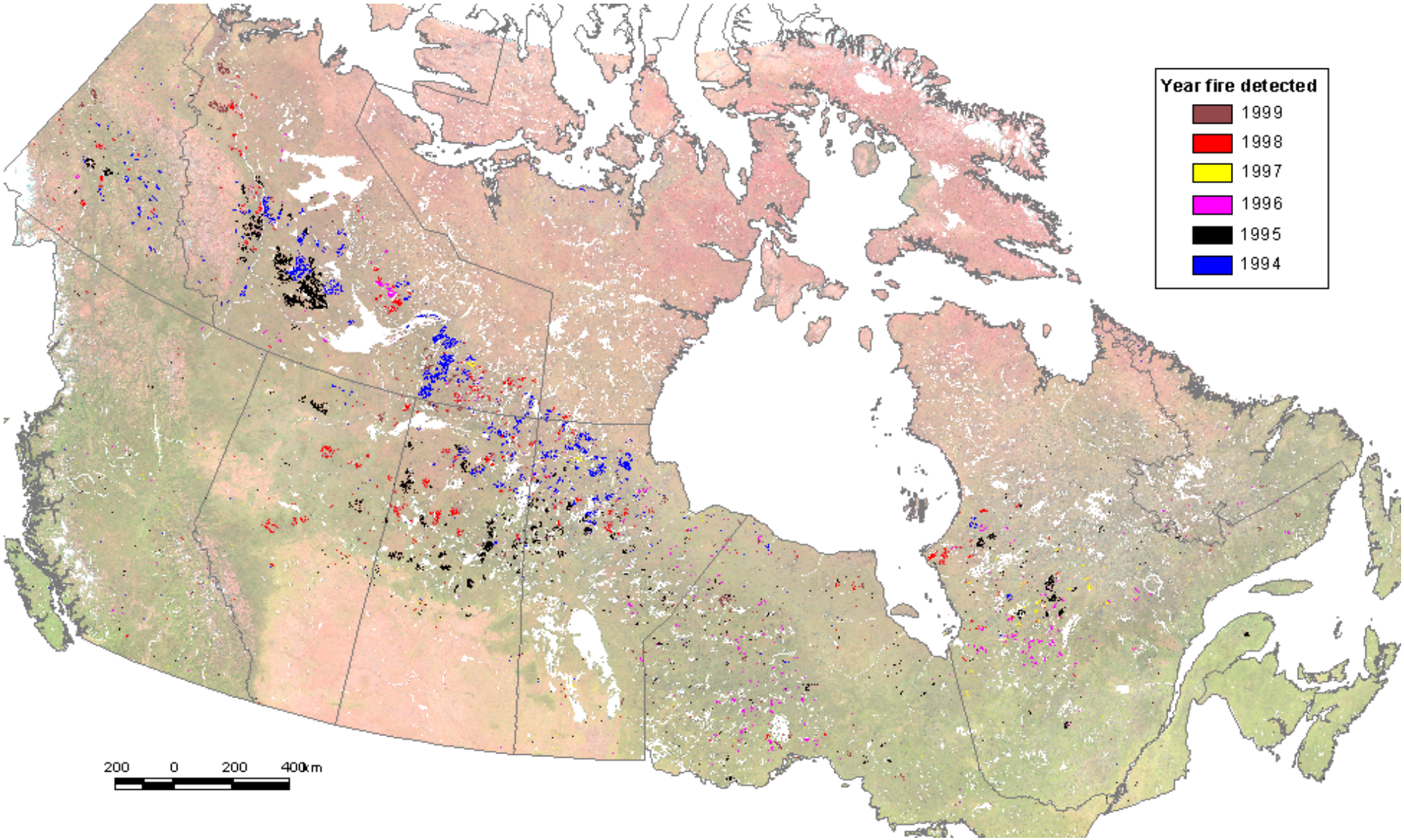
Prototype of near real-time fire monitoring system



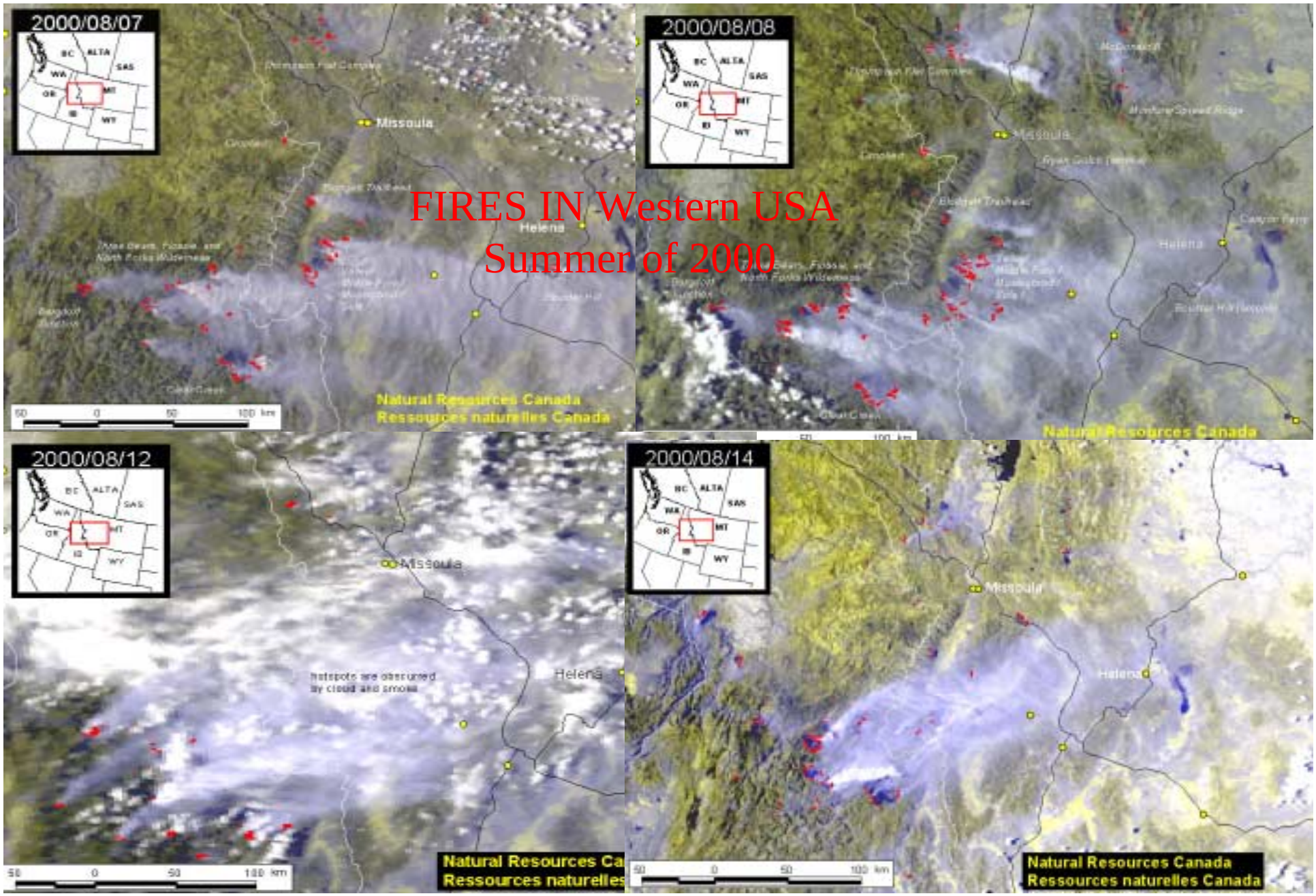
Near-real time fire and smoke detection across Canada



Fire Hot Spots Detected across Canada Using AVHRR

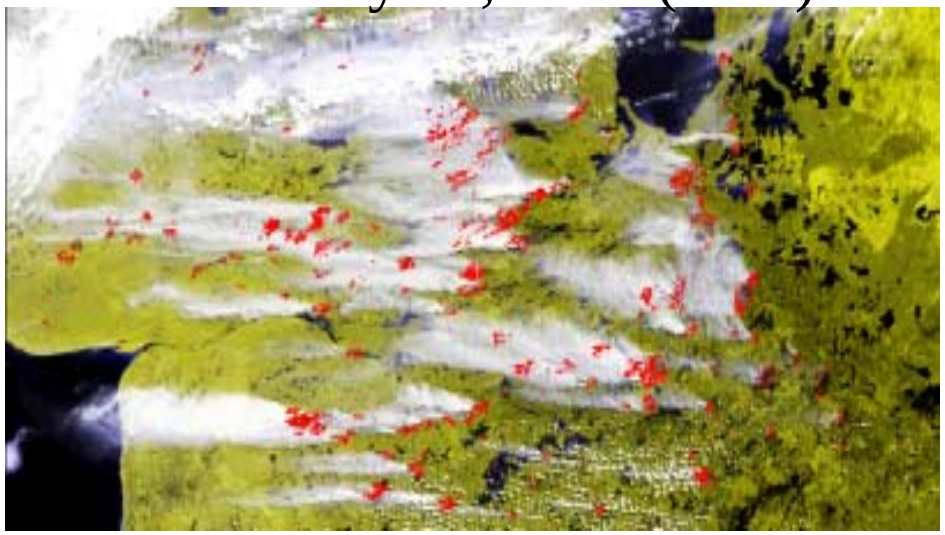


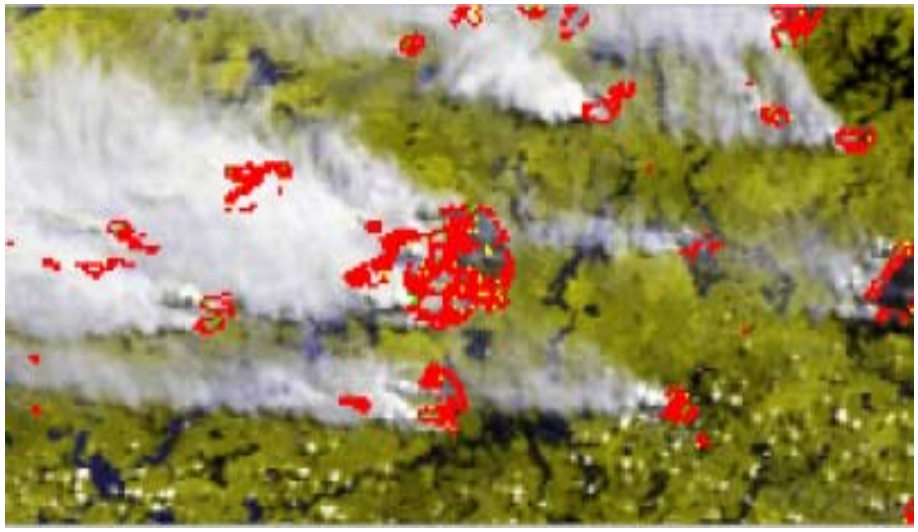
Near real-time fire monitoring across NA



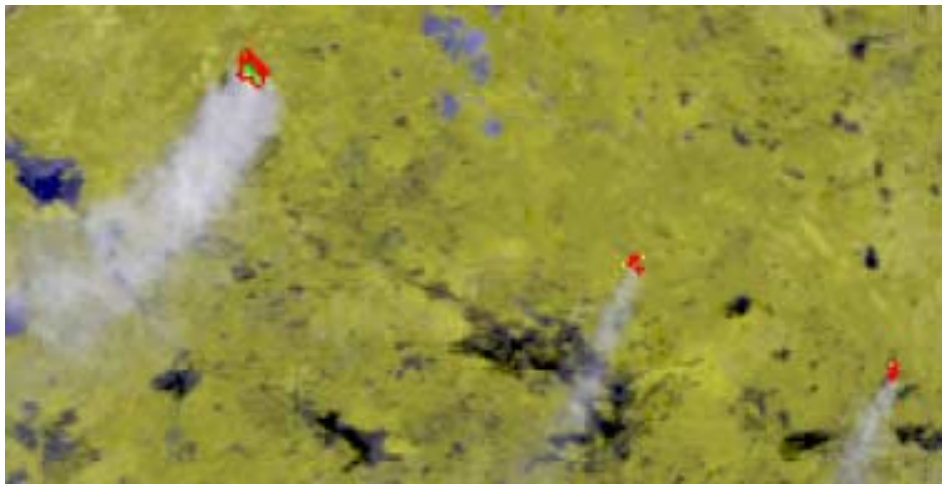
FIRES IN Western USA
Summer of 2000

July 23, 1989 (Man) NOAA-11 July 23, 1989 (Man)

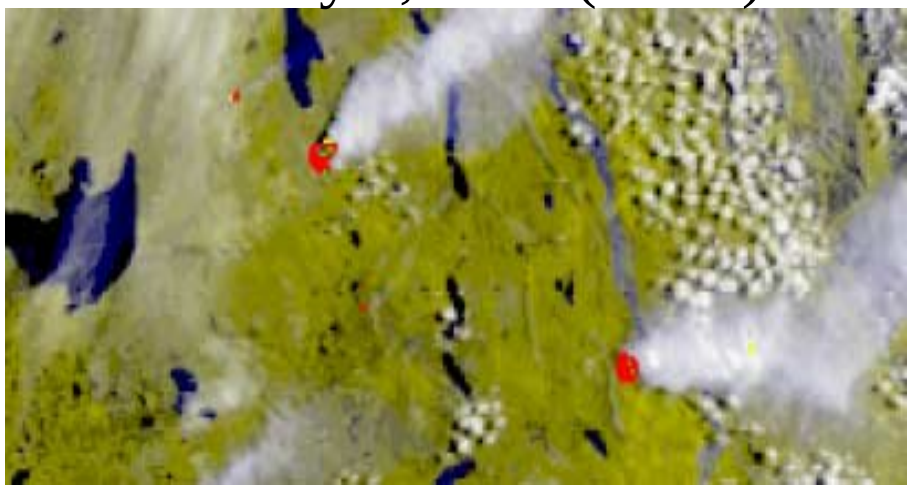




June 6, 1991 (Ont.)



July 7, 1993 (NWT)



COMMON NOAA-14 NOAA-11

Burned area mapping with hot spot Only

- Hotspot detection underestimates burned area

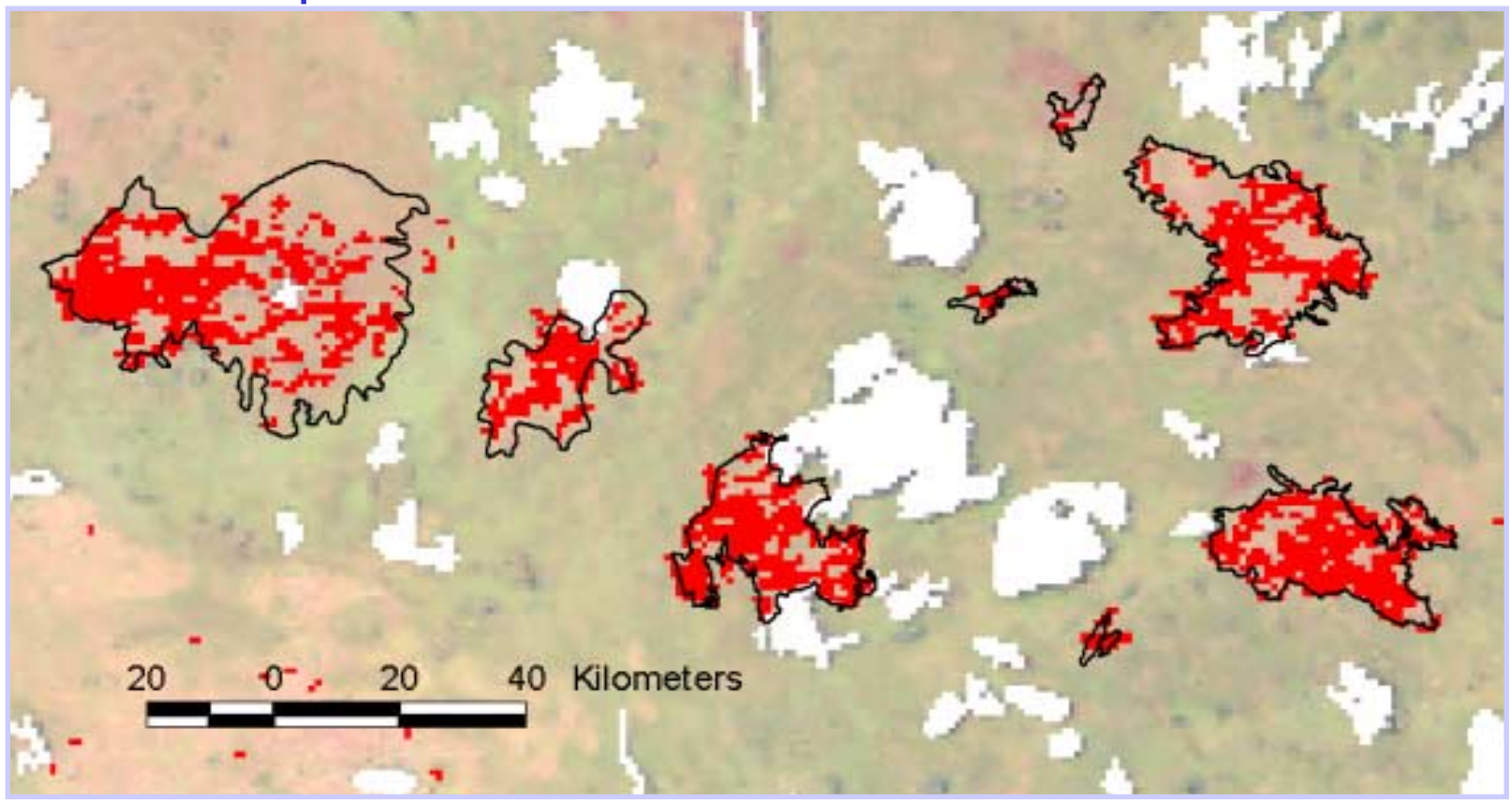
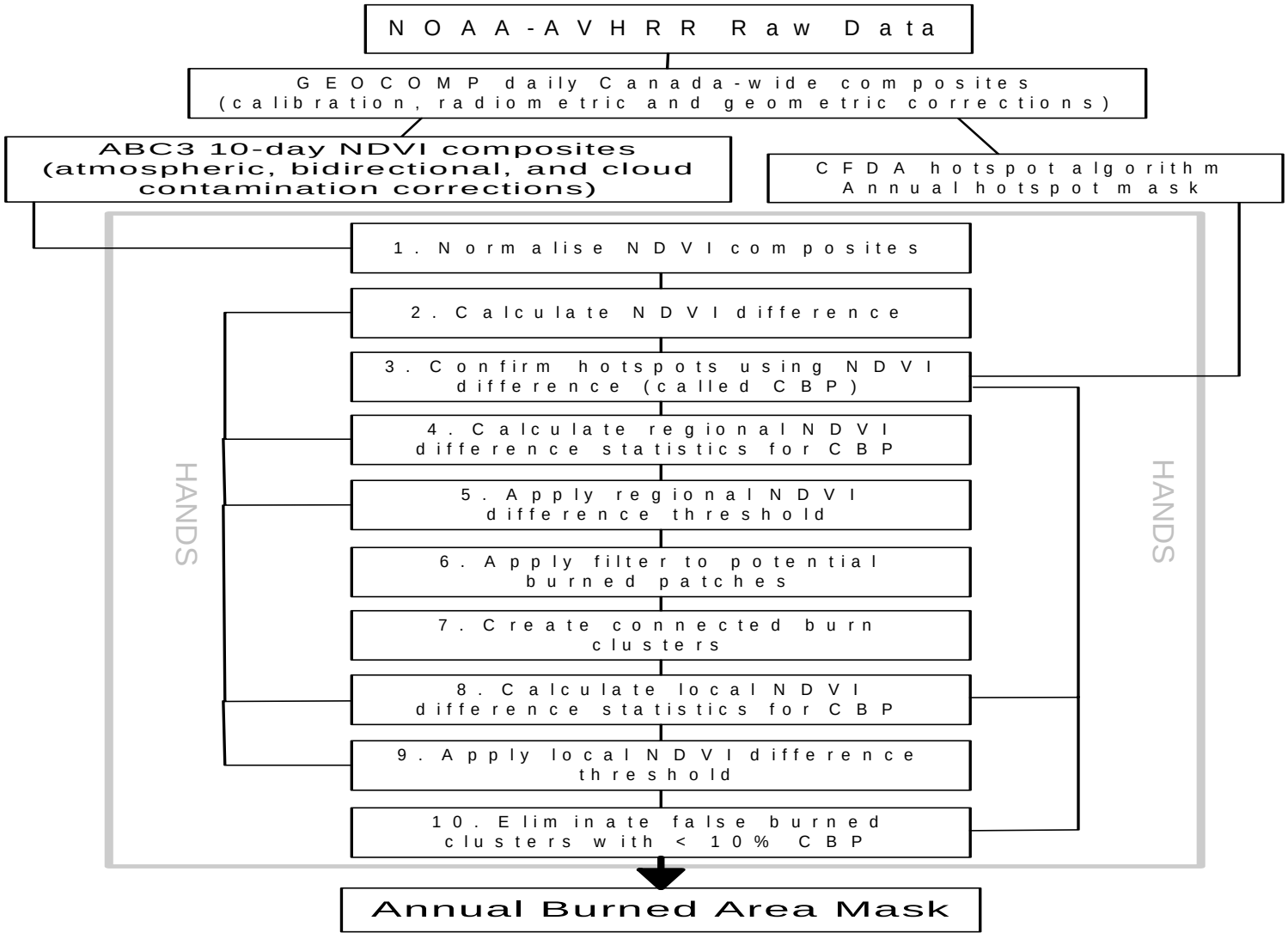


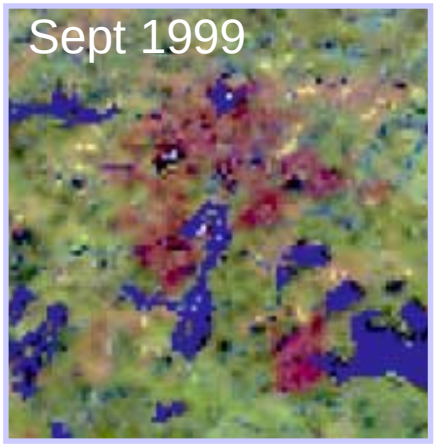
Figure 1


NOAA-AVHRR Raw Data
GEOCOMP daily Canada-wide composites (calibration, radiometric and geometric corrections)
ABC3 10-day NDVI composites (atmospheric, bidirectional, and cloud contamination corrections)
CFDA hotspot algorithm Annual hotspot mask
1. Normalise NDVI composites
2. Calculate NDVI difference
3. Confirm hotspots using NDVI difference (called CBP)
4. Calculate regional NDVI difference statistics for CBP
5. Apply regional NDVI difference threshold
6. Apply filter to potential burned patches
7. Create connected burn clusters
8. Calculate local NDVI difference statistics for CBP
9. Apply local NDVI difference threshold
10. Eliminate false burned clusters with < 10% CBP
HANDS
HANDS
Annual Burned Area Mask

Burned area mapping by combining hotspots and change detection (HANDS)

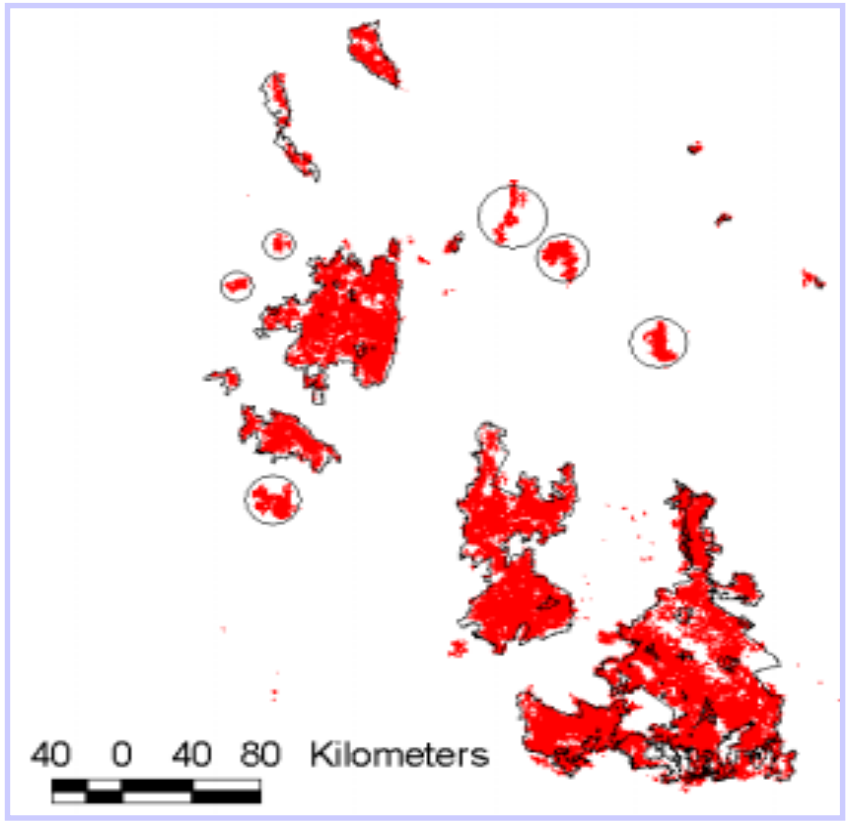
1. AVHRR hotspots

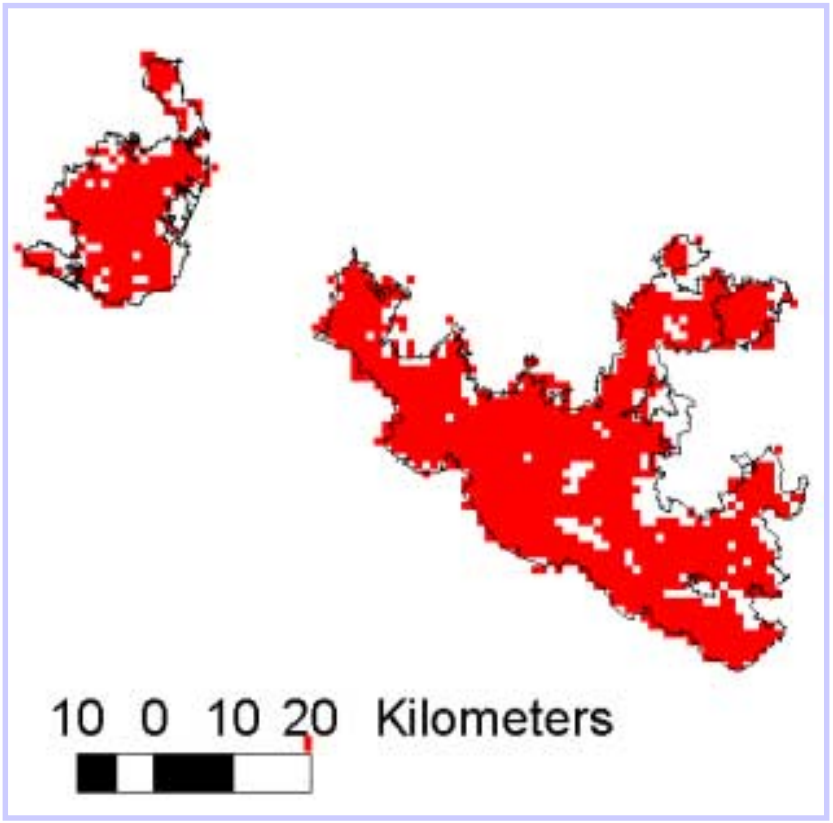
2. Multi-temporal differencing



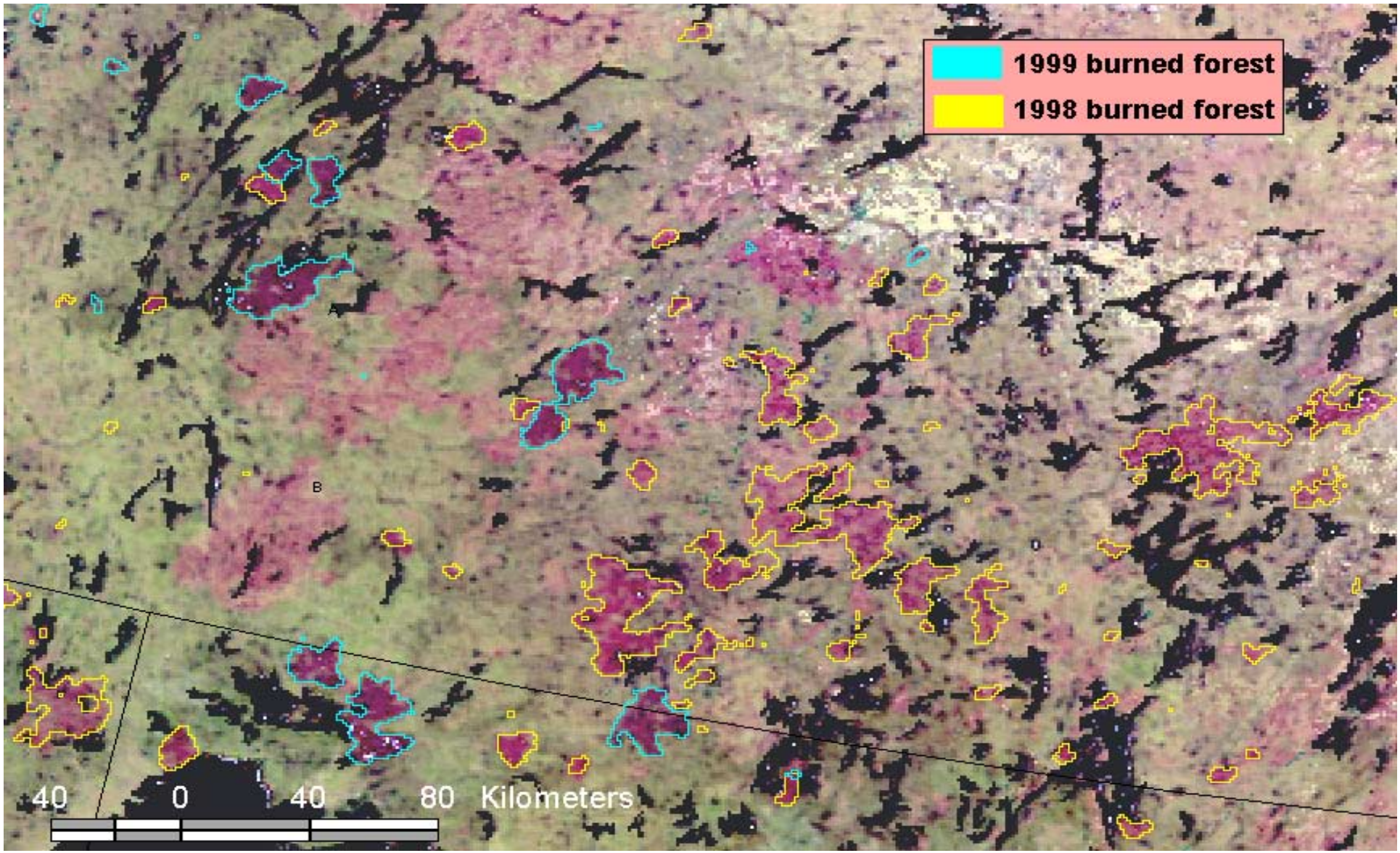
Burned Area

Validation against conventional aerial mapping of burned area



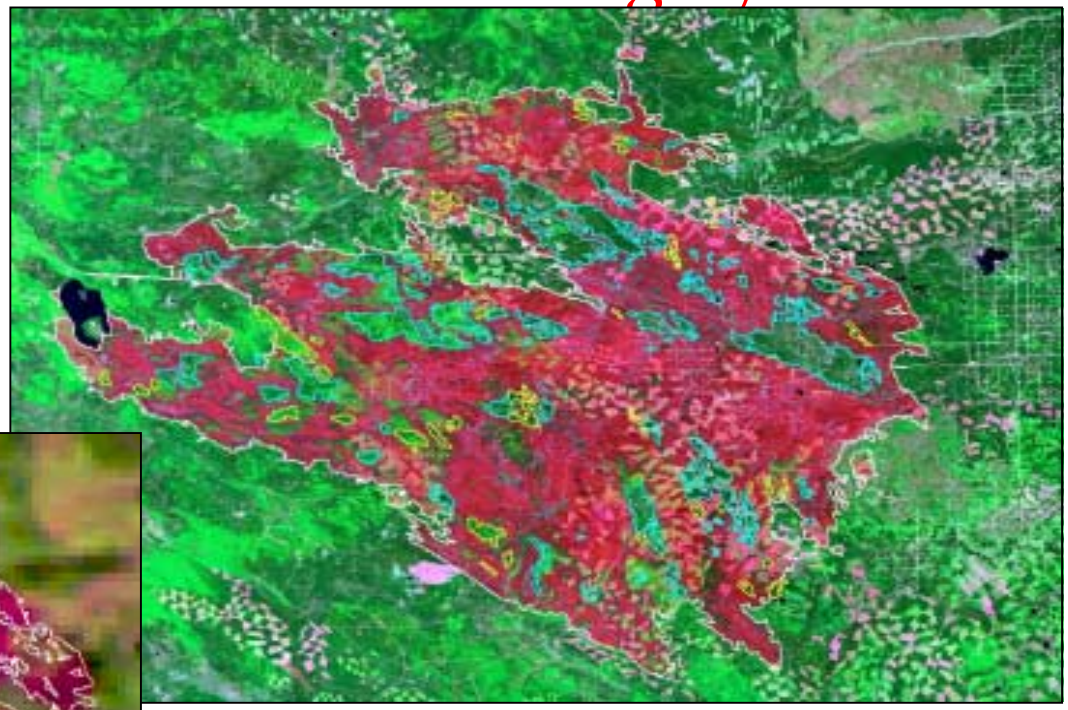


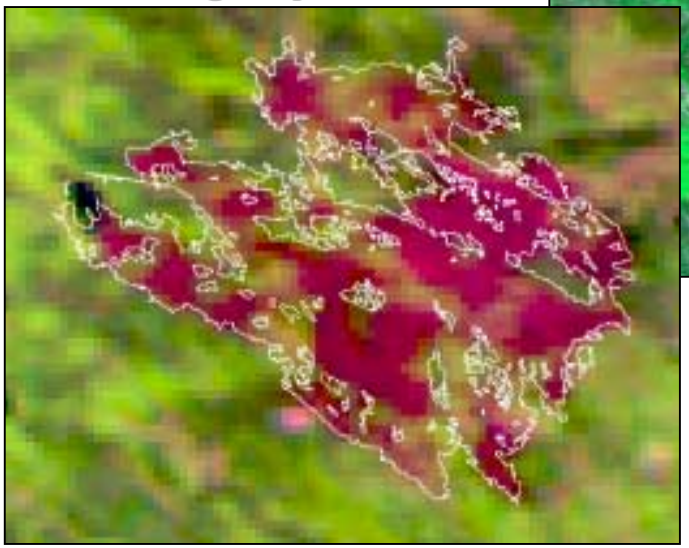
Validation against advanced sensors (currently VGT, TM, future MODIS)



Validation of burnt area mapping against VGT and Landsat TM imagery

Burned area mapping of wildland fires using SPOT VGT and Landsat 5 TM imagery





SPOT VGT mapping

Landsat 5 TM mapping for the 1998 Virginia Hills Fire in Alberta

Technical Challenges

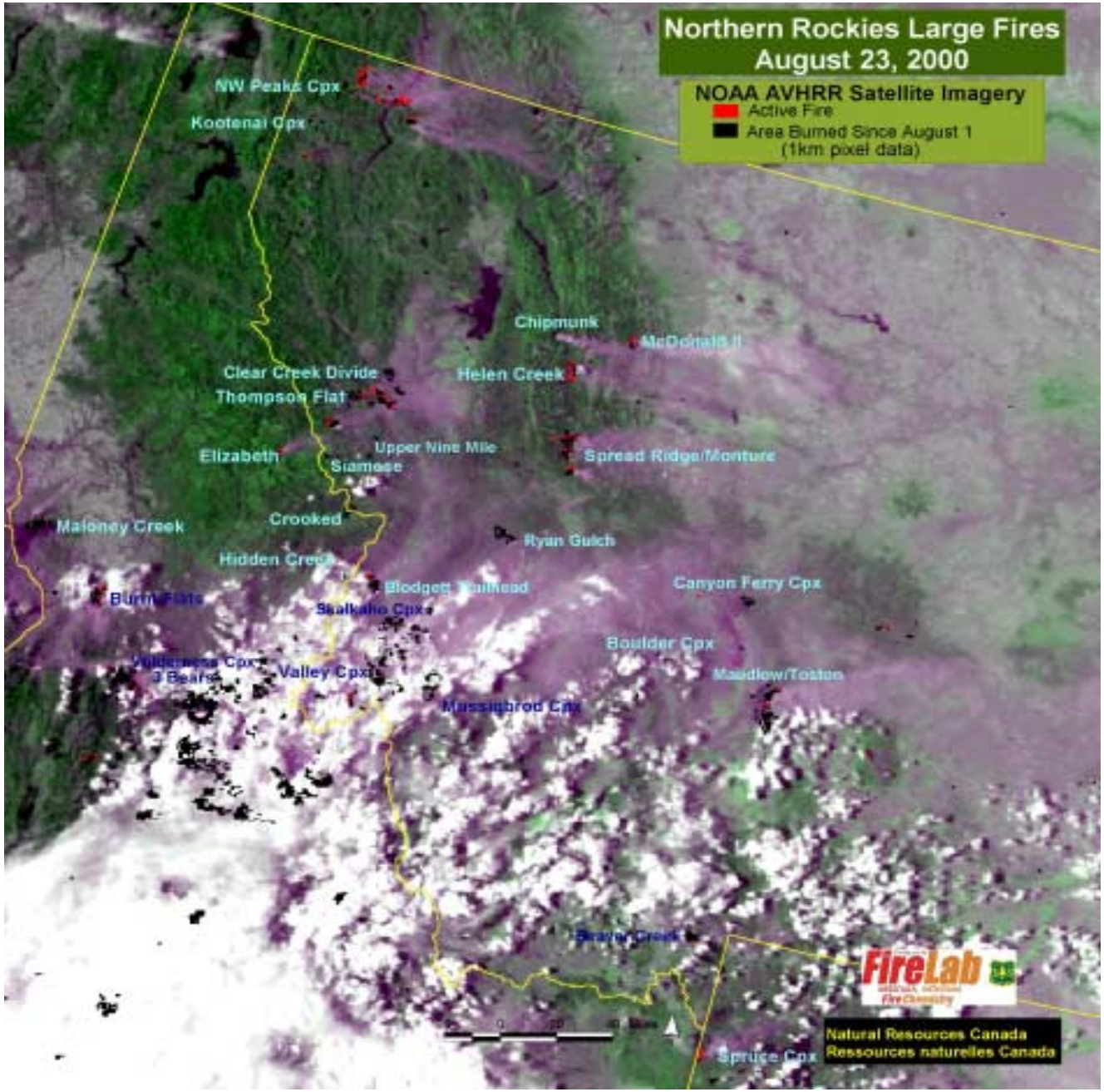
- Reduction and elimination of false fire alarms due to bright and hot scenes
- Trade-off between commission and omission errors
- Changes in sensor characteristics and observation configuration (NOAA 7, 9, 11, 14, 15)
- Variable pixel size
- Limited ground-truth information

Forest Service/FSL:

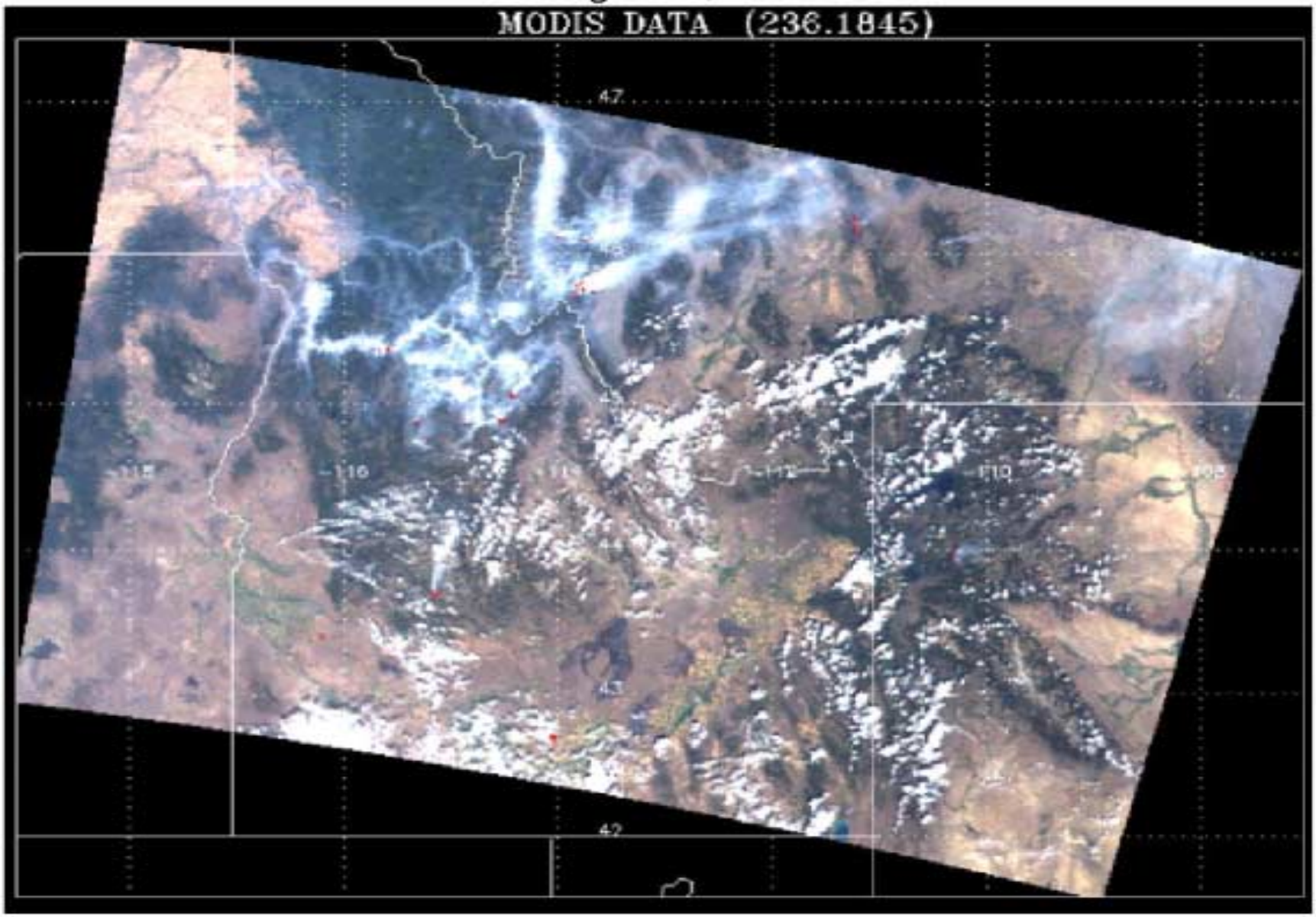
Validation of locations of active fires and burned areas

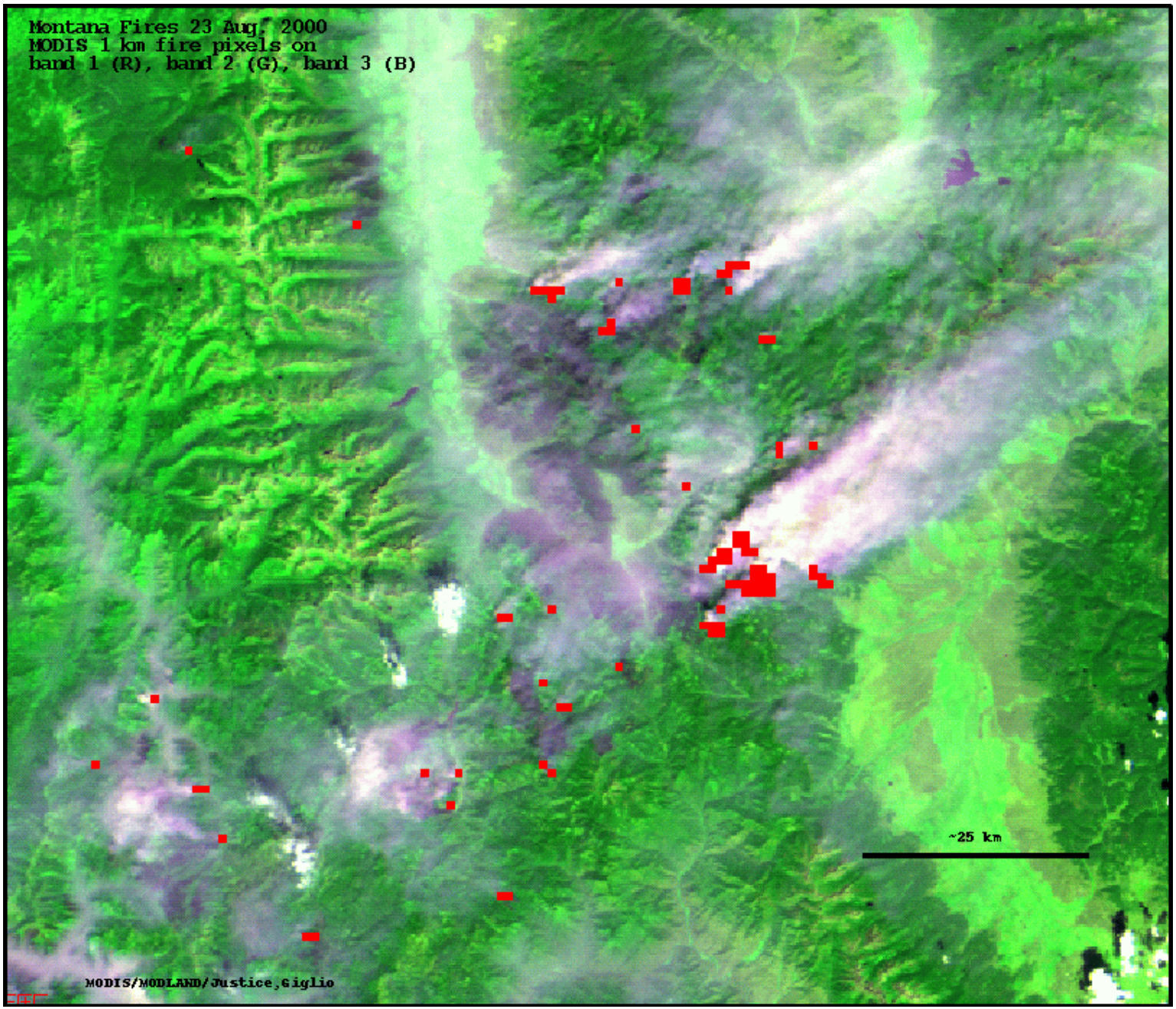
Development of emissions inventory model

Project coordination


Northern Rockies Large Fires
August 23, 2000
NOAA AVHRR Satellite Imagery
Active Fire
Area Burned Since August 1
(1km pixel data)
NW Peaks Cpx
Kootenai Cpx
Chipmunk
McDonald II
Clear Creek Divide
Thompson Flat
Helen Creek
Elizabeth
Upper Nine Mile
Siamese
Spread Ridge/Moniture
Maloney Creek
Crooked
Ryan Gulch
Hidden Creek
Blodgett Trailhead
Canyon Ferry Cpx
Burnt Flats
Scalkaho Cpx
Boulder Cpx
Meadlow/Toston
Valley Cpx
Mussigbrod Cpx
Beaver Creek
Spruce Cpx
FireLab
Natural Resources Canada
Ressources naturelles Canada

Terra (EOS AM-1) MODIS Satellite Imagery
August 23, 2000




Montana Fires 23 Aug. 2000
MODIS 1 km fire pixels on
band 1 (R), band 2 (G), band 3 (B)
~25 km
MODIS/MODLAND/Justice,Giglio

Incident Intelligence Summary (ICS-209)

Date	Time	Initial / Update / Final	Incident Number	Incident Name
		[ ] [ ] [ ]		

Incident Type	Start Date/Time	Cause	Incident Commander	IMT Type	State/Unit

County	Lat/Long or TRS	Short Location Description (in reference to nearest town)

Current Situation

Size/Area Involved	% Contained or MMA	Expected Containment Date: Time:	Line to Build (# chains)	($) Costs to Date	Declared Controlled Date: Time:

Injuries Today	Fatalities

Structure Information

Type of Structure	# Threatened	# Destroyed
Residence		
Commercial Property		
Outbuilding/Other		

Threat to Human Life/Safety
Evacuation(s) in progress _____
No evacuation(s) imminent _____
Potential future threat _____
No likely threat _____

Fuels Involved

Resources threatened (kind(s) and value/significance):

Current Weather Conditions
Wind Speed: **Temperature:**
Wind Direction: **Relative Humidity:**

Resource benefits/objectives (for prescribed/wildland fire use):

Today's observed fire behavior (leave blank for non-fire events):

Significant events today (closures, evacuations, significant progress made, etc.):

Committed Resources

Agency	CRW1	CRW2	HEL1	HEL2	HEL3	ENGS	OVHD	DOZR	WTDR	OTHER	Total Personnel
Total											

Cooperating Agencies Not Listed Above:

Prepared by:	Approved by:	Sent to: Date:	by: Time:

Outlook

Estimated Control Date: Time:	Projected Final Size	Estimated Final Cost	Tomorrow's Forecasted Weather Wind Speed: Wind Direction: Temperature: Relative Humidity:

Critical Resource Needs (kind & amount, in priority order):
1.
2.
3.

Actions planned for next operational period:

Projected incident movement/spread during next operational period (leave blank for non-fire incidents):

Major problems and concerns (control problems, social/political/economic concerns or impacts, etc.) Relate critical resource needs identified above to the Incident Action Plan:

For fire incidents, describe resistance to control in terms of:

1. Growth potential -
2. Difficulty of terrain -

How likely is it that containment/control targets will be met, given the current resources and suppression strategy?

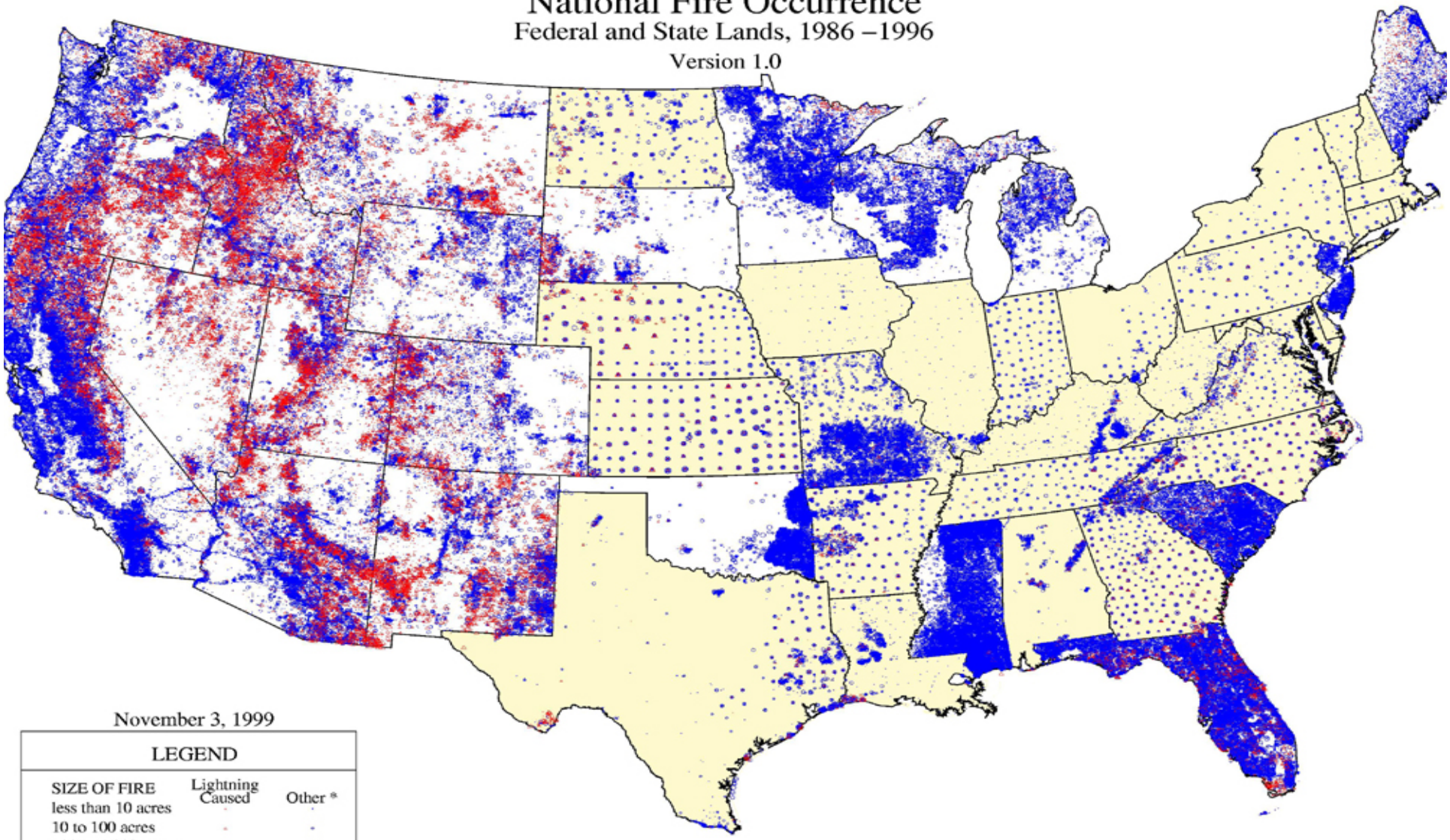
Projected Demobe Start (date and time):

Remarks:

National Fire Occurrence

Federal and State Lands, 1986 –1996

Version 1.0



November 3, 1999

LEGEND

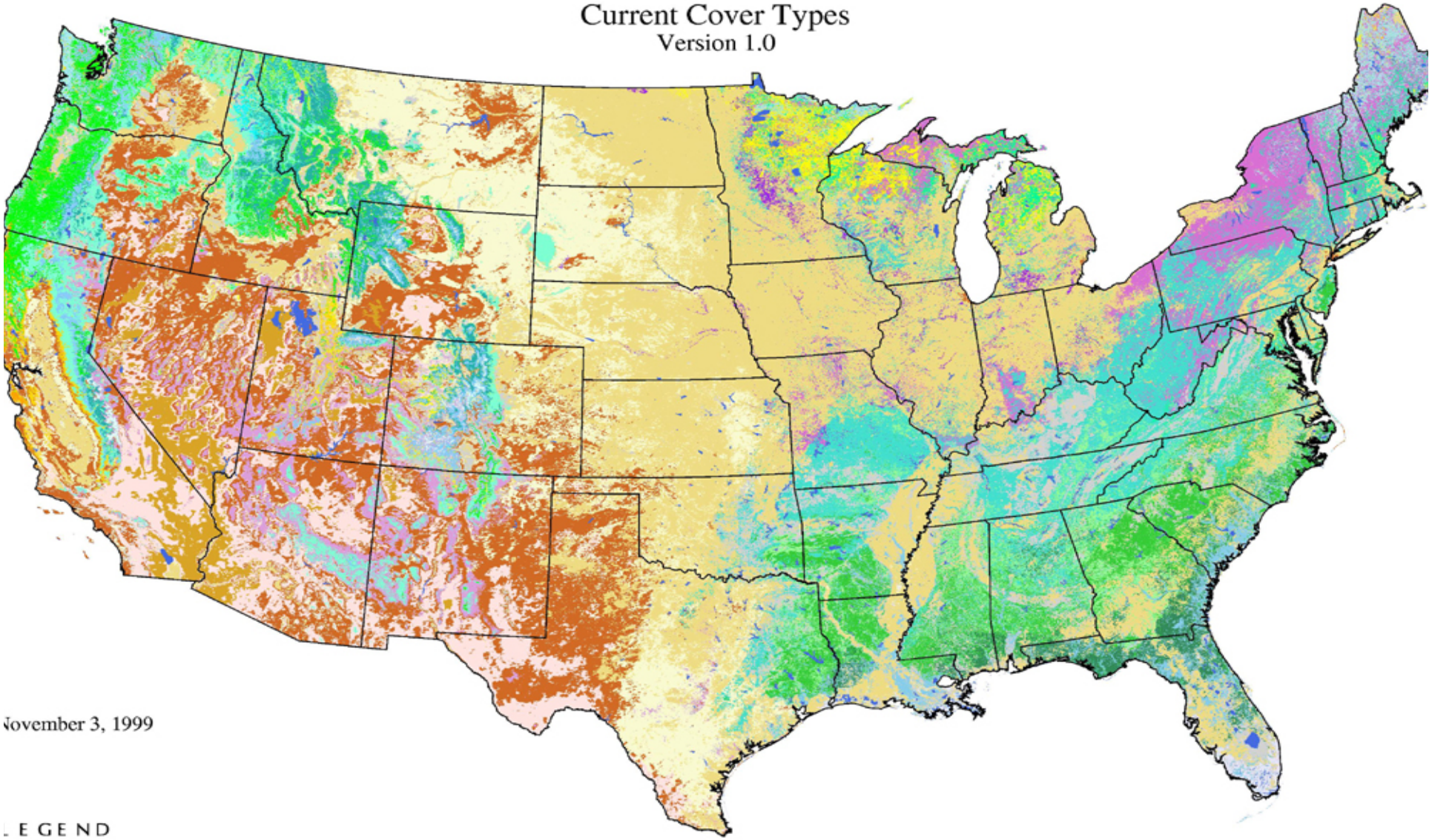
SIZE OF FIRE	Lightning Caused	Other *
less than 10 acres	·	·
10 to 100 acres	·	·
100 to 1,000 acres	△	○
1,000 to 10,000 acres	△	○
10,000 acres or more	△	○

— State Boundary

☐ States with non –federal fire locations summarized to county

* Other types of fires included: Arson, Smoking, Recreational, Children, Debris Burning, Equipment Use, Railroad, and Miscellaneous.

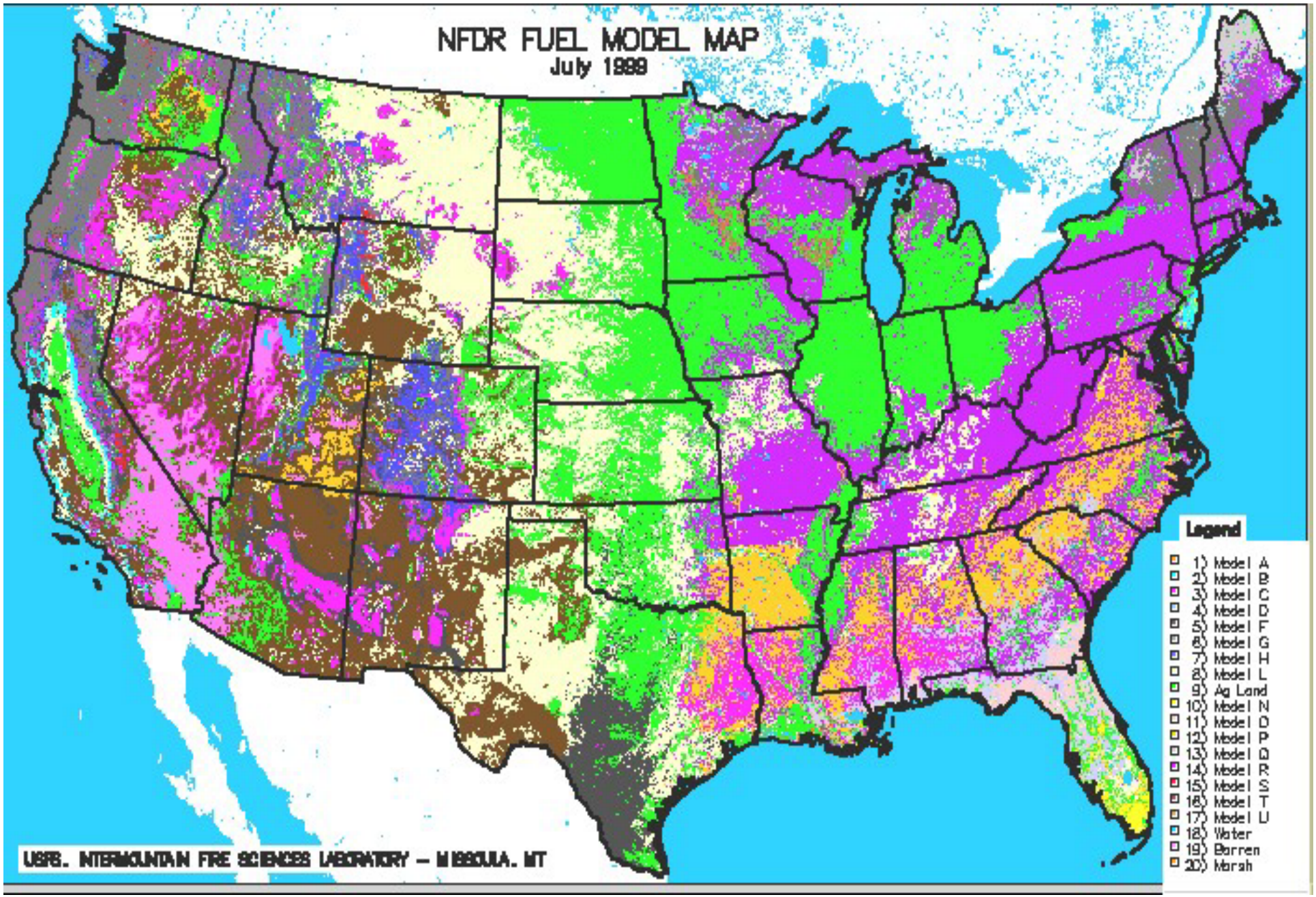
Current Cover Types
Version 1.0

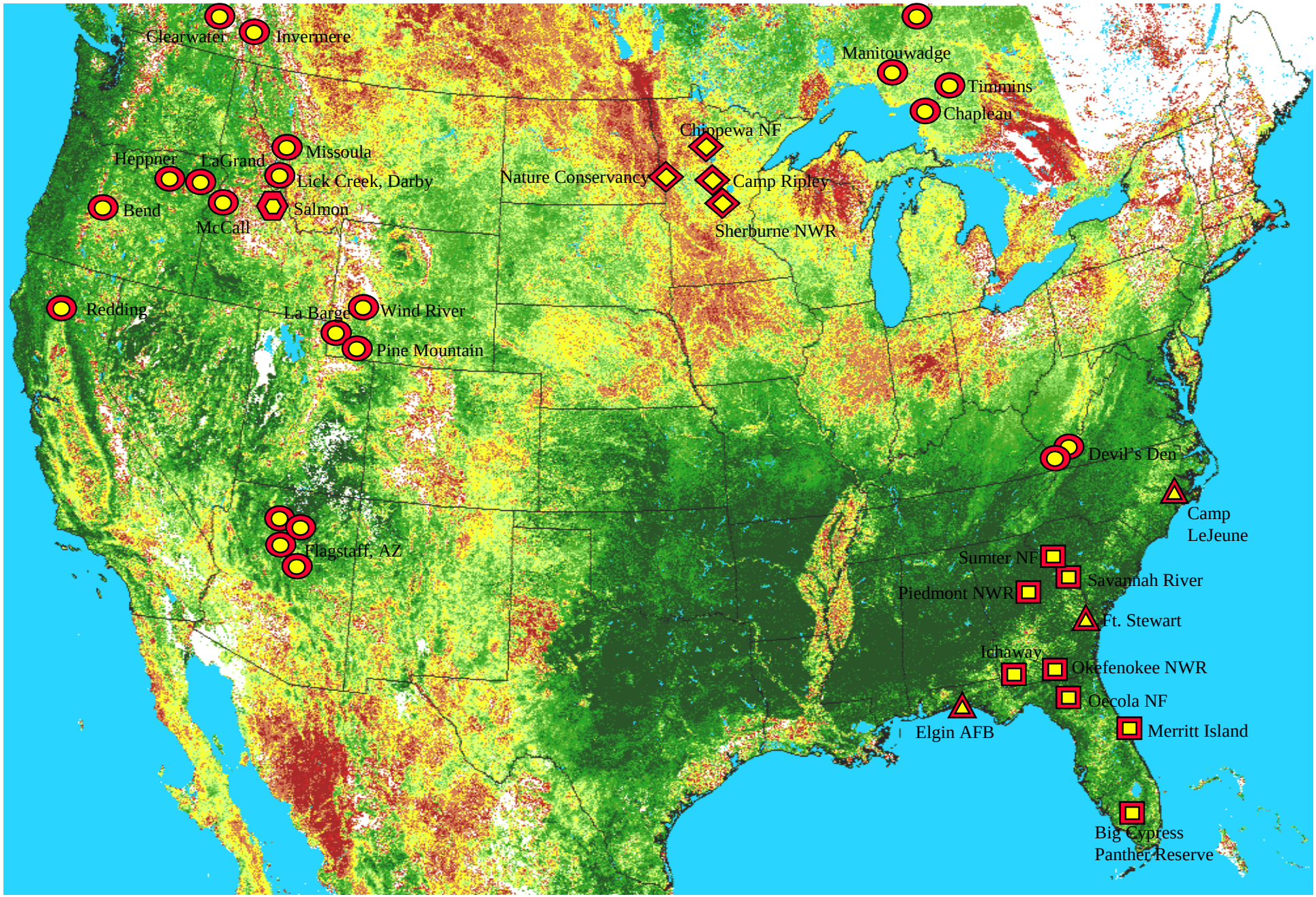


November 3, 1999

LEGEND

1: Agriculture
2: Grassland
3: Wetlands
4: Desert Shrub
5: Other Shrub
6: Oak – pine
7: Oak – hickory
8: Oak – gum – cypress
9: Elm – ash– cottonwood
10: Maple – beech – birch
11: Aspen – birch
12: Western hardwoods
13: White – red – jack pine
14: Spruce – fir (East)
15: Longleaf – slash pine
16: Loblolly – shortleaf
17: Ponderosa pine
18: Douglas – fir
19: Larch
20: Western white pine
21: Lodgepole pine
22: Hemlock – Sitka spruce
23: Fir – spruce
24: Redwood
25: Pinyon –juniper
26: Alpine Tundra
27: Barren
28: Water
30: Urban/Development/Ag


NFDR FUEL MODEL MAP
July 1999
Legend
1) Model A
2) Model B
3) Model C
4) Model D
5) Model F
6) Model G
7) Model H
8) Model L
9) Ag Land
10) Model N
11) Model O
12) Model P
13) Model Q
14) Model R
15) Model S
16) Model T
17) Model U
18) Water
19) Barren
20) Marsh
USFS. INTERMOUNTAIN FIRE SCIENCES LABORATORY – MISSOULA, MT


Clearwater
Invermere
Manitouwadge
Timmins
Chapleau
Chippewa NF
Heppner
LaGrand
Missoula
Lick Creek, Darby
Nature Conservancy
Camp Ripley
Bend
Salmon
McCall
Sherburne NWR
Redding
La Barge
Wind River
Pine Mountain
Devil's Den
Camp LeJeune
Flagstaff, AZ
Sumter NF
Savannah River
Piedmont NWR
Ft. Stewart
Ichaway
Okefenokee NWR
Oecola NF
Elgin AFB
Merritt Island
Big Cypress
Panther Reserve

Schedule for "Fires and Emissions in North America: Past, Present and Future"

	Year 1	Year 2	Year 3
Historical AVHRR data acquisition (NOAA/NESDIS)	1993 - 1999	1985 - 1992	
Historical AVHRR data processing (UC/Berkeley)	1994-1999	1989-1993	1985-1992
Fire algorithm development (CCRS and U. of Maryland)	NOAA-14 and -11	NOAA-9 and -7	
	Compare CCRS, IGBP and MODIS algorithms		
Algorithm validation (FS Fire Sciences Laboratory)	1994-1999, 2000	1989-1993, 2001	1985-1988, 2002
Emission inventory model (FS Fire Sciences Laboratory)	Select data layers	Model development	Integrate into FIRE/M3 system
Prototype fire monitoring system (All)	2000 fire season	2001 fire season	2002 fire season