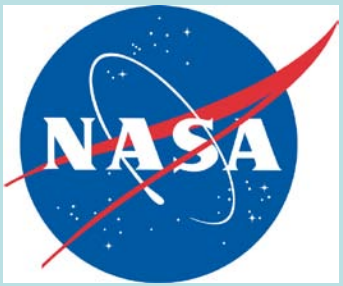
Fires in (Northern) Eurasia

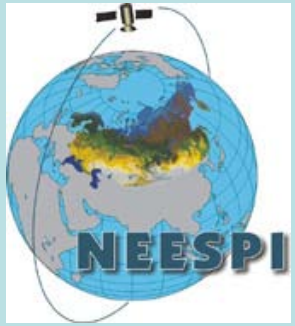
Ivan Csiszar (UMd)
Tatiana Loboda (UMd)

with contribution from

Evgeny Loupian (Moscow)
Dmitry Ershov (Moscow)
Anatoly Sukhinin (Krasnoyarsk)
Sergey Tashchilin (Irkutsk)
Vladimir Belov (Tomsk)

and others





PROJECTS

- Intercalibration of fire products from AVHRR and MODIS in Northern Eurasia
  - NASA NIP, 3 years, 3rd year starting
  - historical fire record and data continuity
    - products from additional sensors can be included (ATSR, SPOT/VGT) – “from missions to measurements”
- Biomass burning observations in Northern Eurasia
  - NASA LCLUC, 2 years, 2nd year starting
  - current and future observations
  - research and networking – “collaborative links”

RELEVANCE TO NEESPI SCIENCE PLAN

- Chapter 2: Scientific questions and motivation
  - 2.3: Goals and deliverables: “An integrated observational knowledge data base for environmental studies in Northern Eurasia that includes validated remote sensing products”
- Chapter 4: Remote Sensing
  - 4.1: Remote Sensing of Terrestrial Ecosystems
    - 4.1.4 Forest and rangeland management
- Chapter 6: Data and Information Technology
- Chapter 8: Research Strategy
  - 8.3: Five suggested research directions
    - 8.3.B: Monitoring

GOFC/GOLD-Fire Rationale

- Multiple sources of fire information exist
- Spatial and temporal coverage of datasets varies
- Conflicting data are reported
- Information is often complementary
- Little information on data quality
- Ground – and air-based data from operational management agencies are often inadequate for research
- Skepticism in management community about satellite-based products
- Interdependence between stakeholders not fully recognized and utilized

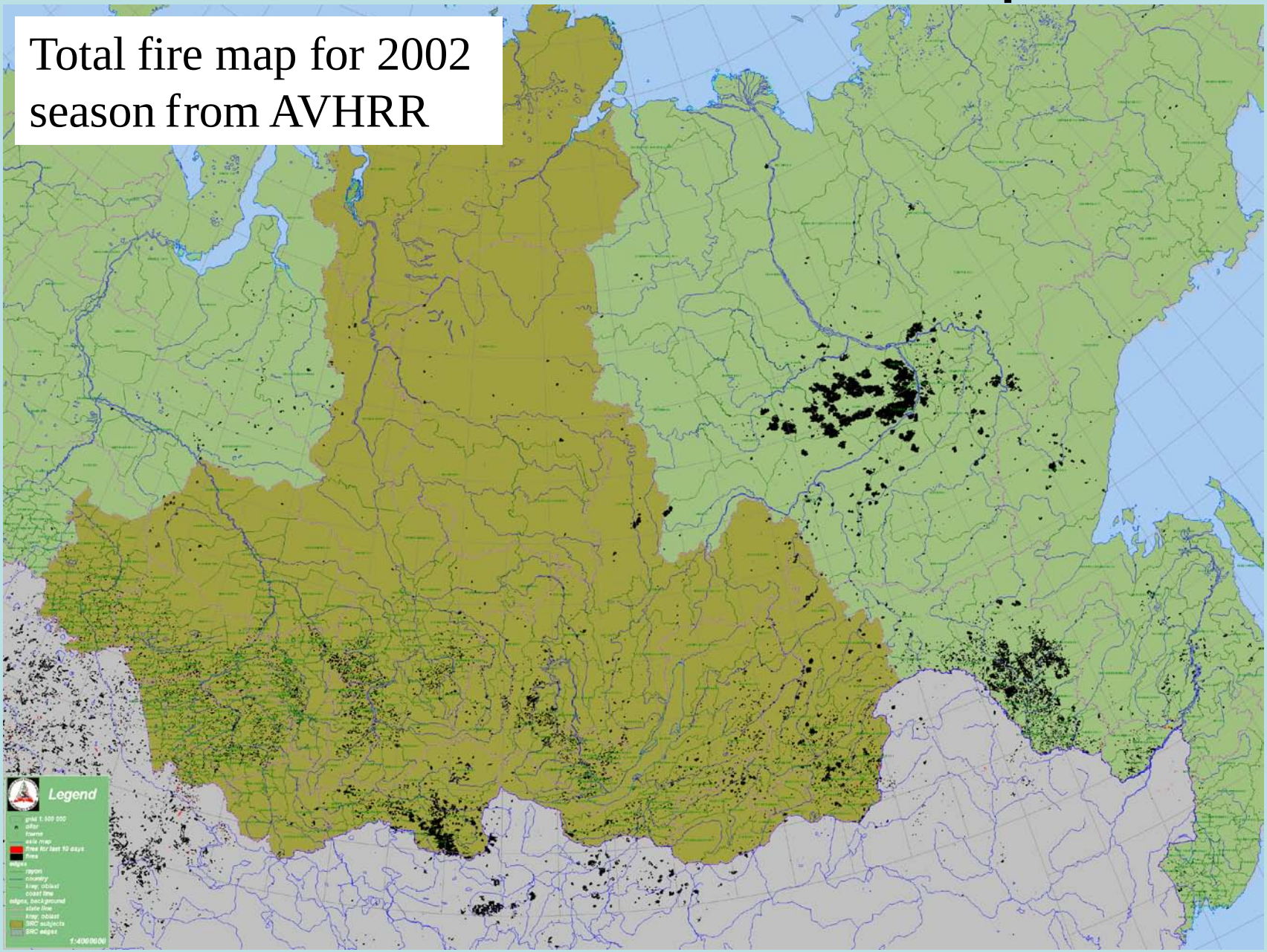
Satellite-based fire observations in Northern Eurasia

- Historically, AVHRR-based active fire detection
- Burned area maps
  - aggregated AVHRR fire pixels
  - selective explicit burn scar mapping
- Use of MODIS emerging
- SPOT VGT burned area mapping (GBA2000 and ongoing efforts)
- ATSR-based global datasets

Major AVHRR-based fire datasets

Dataset	Active fire	Burn scar	Temporal extent	Spatial extent
Sukachev Forest Institute (Krasnoyarsk)	+	selected scars	1996-present	Eastern Russia
Institute of Solar and Terrestrial Physics (Irkutsk)	+		1997-present	Eastern Russia
Space Research Institute (Moscow)	+		1995-present	Entire Russia
Center for Forest Ecology and Productivity (Moscow)		+	2002-present	Eastern Siberia
Insitute of Atmospheric Optics (Tomsk)	+		1998-present	Central Russia
University of Tokyo		+	1984-1999	Russian Far East

Satellite-based burned area product

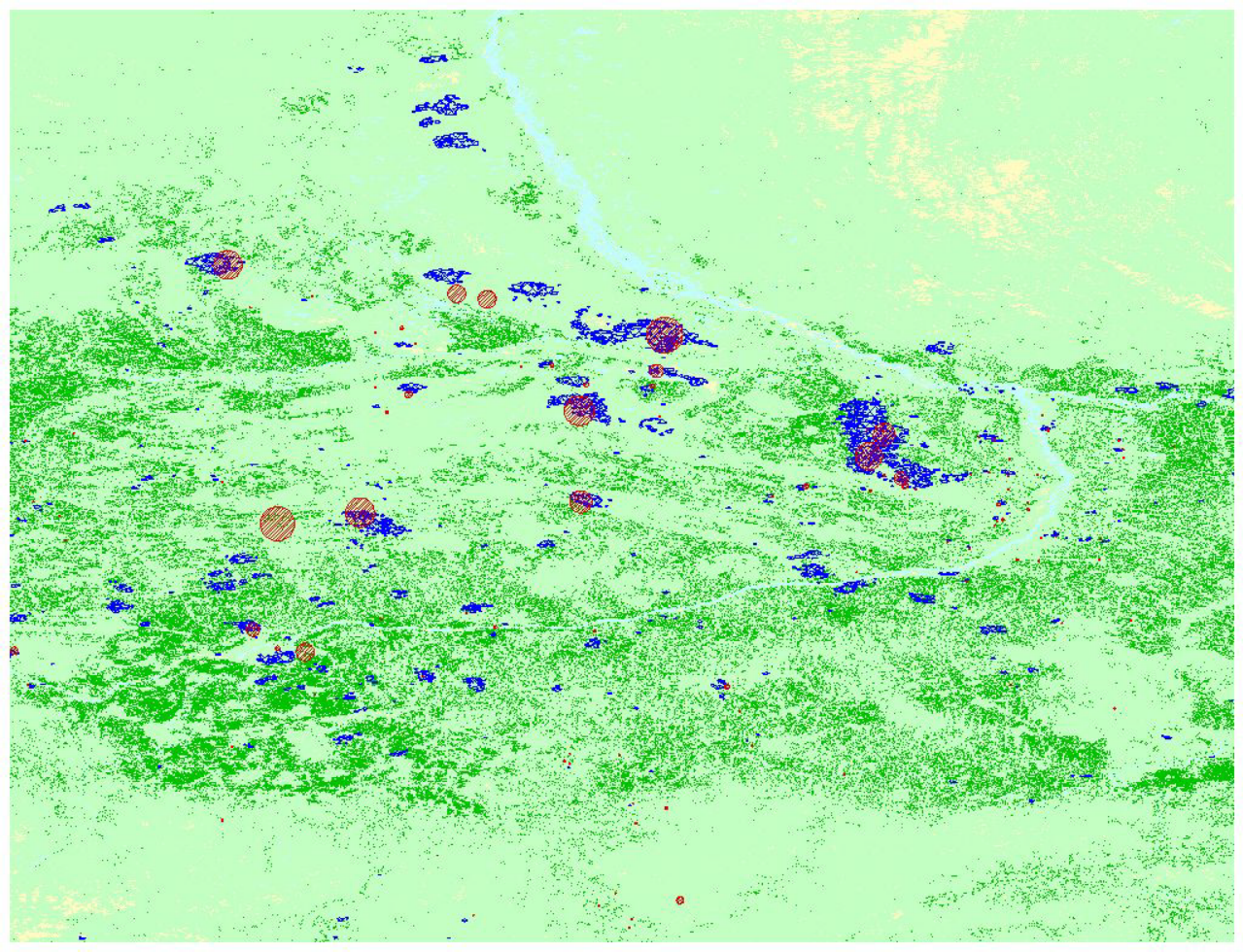


A. Sukhinin, Sukachev Forest Institute, Krasnoyarsk

In-situ fire data from operational management agencies

- **Leshozes**
  - Most detailed information
  - Reasonably accurate perimeter maps
  - Mostly (only) on paper
- **Regional Avialesookhrana airbases**
  - Daily information
  - Digital or digitized data on burned areas, number of fires
- **National Avialesookhrana database**
  - End of season
  - Least detailed
- *Historical in-situ data record goes back to at least 50 years*

Avialesookhrana vs. AVHRR

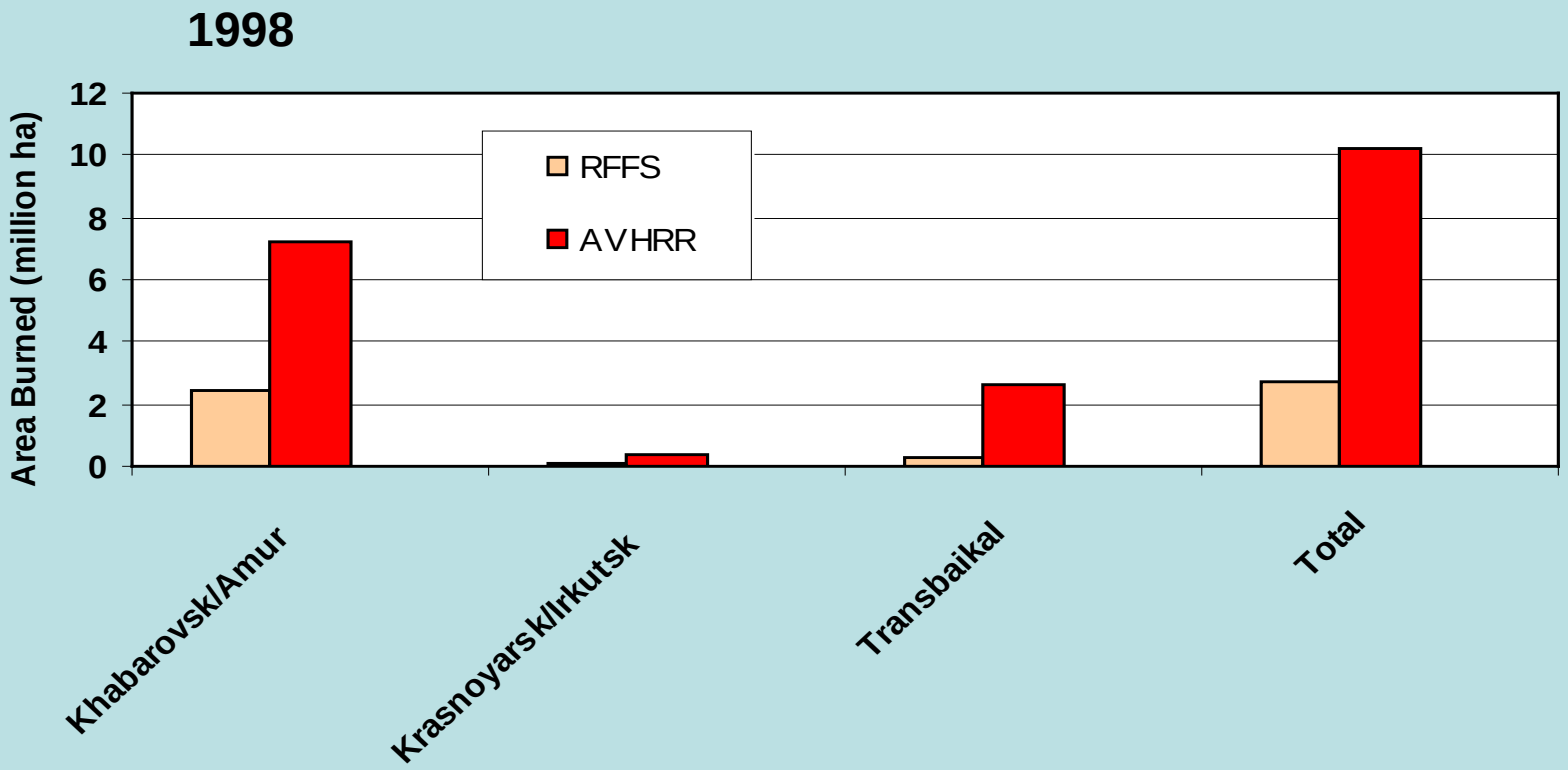


Burned area maps from Avialesookhrana (red circles) and Sukachev Forest Institute (blue clusters) for the 2001 burning season. Only data over Avialesookhrana protected area are shown.

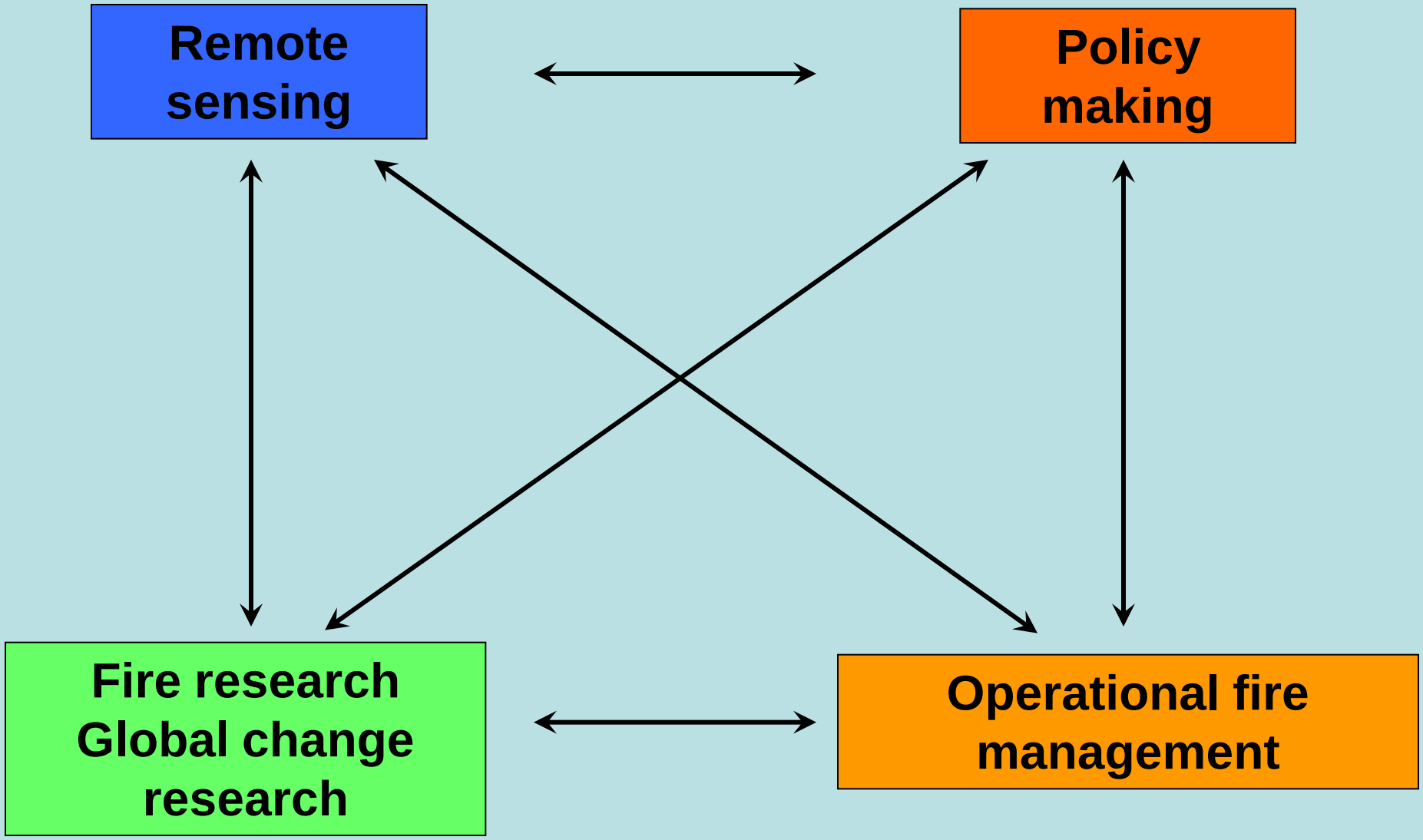
Comparison of Burned Area Estimates

Year	Agency Reports based on Ground and Aerial Observations			Satellite Derived Data (NOAA AVHRR) Based on Fire Counts and Derived Area Burned		
	Number of Fires Reported	Total Area Burned (ha)	Forest Area Burned (ha)	Number of Fire Events investigated	Total Area Burned (ha)	Forest Area Burned (ha)
2002	35,000	1,834,000	1,200,000	10,355	11,766,795	n.a.
2003	28,000	2,654,000	2,074,000	16,112	17,406,900	14, 474, 656

Comparison of wildland fire data for the Russian Federation: Agency reports vs. satellite-generated data.



Interaction between communities



Fire as a climate data record: requirements for long-term monitoring

- Spatial characteristics
  - coverage
    - gaps, overlaps, topography effects
  - homogeneity
    - potential dependence of product quality/detection capability on view angle
      - need for algorithm corrections/adjustments
    - potential inter-satellite discontinuities due to differences in sensing system specifications
      - need for algorithm/product inter-calibration

Fire as a climate data record: requirements for long-term monitoring

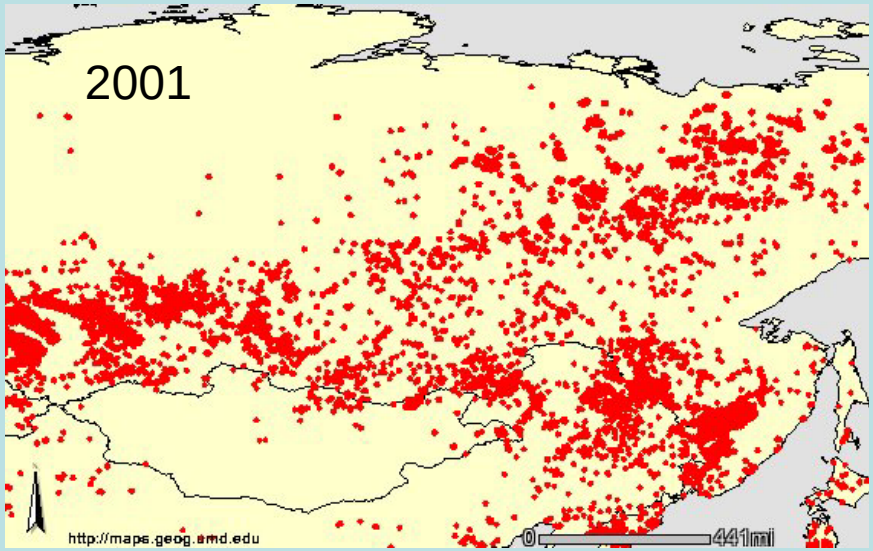
- Temporal characteristics
  - homogeneity
    - potential effects from algorithm changes
    - potential effects from sensor changes
  - continuity
    - long-term time series
    - systems need to be operated by agencies with mandate for long-term operational climate record production – most often operational agencies - operational R&D
    - continuous product validation based on agreed-upon protocols

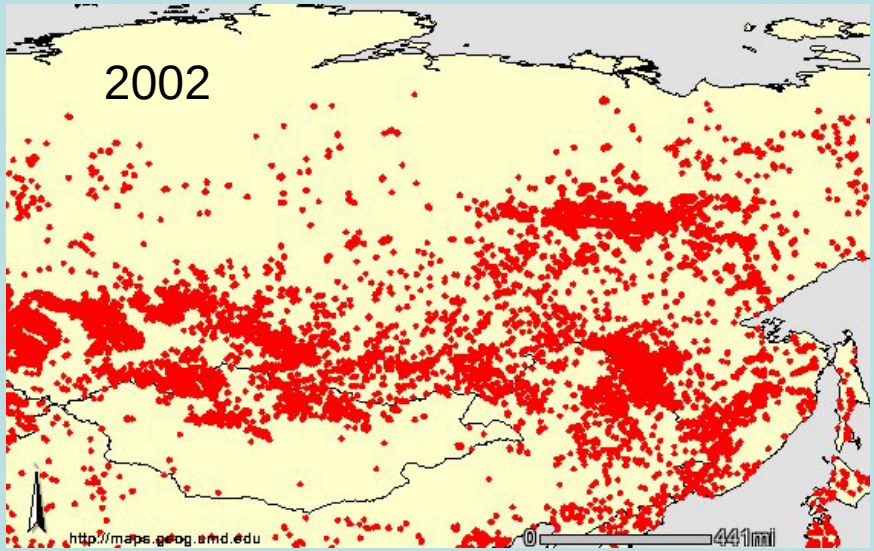
Product validation

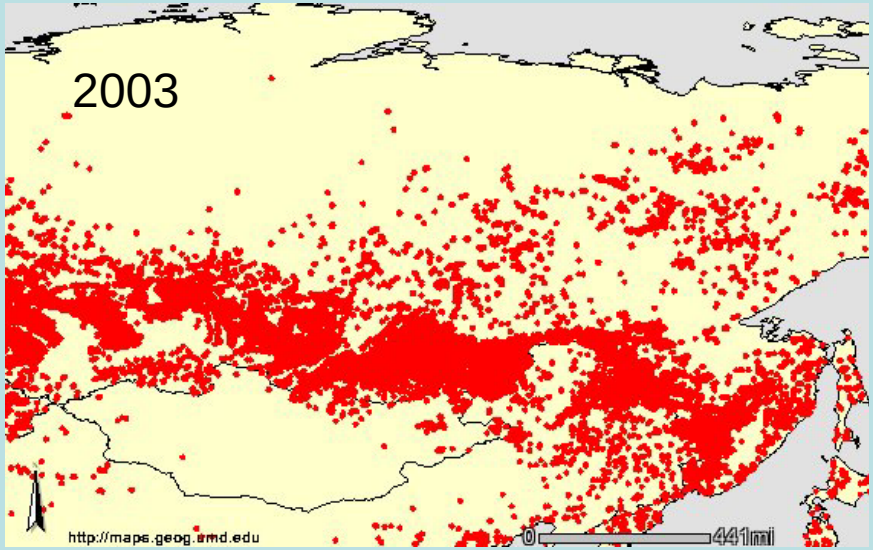
- “yes/no” binary active fire products: detection limits / probabilities
- fires in Northern Eurasia are episodic
  - long-term *a-priori* planning difficult
  - short-term response possible
- coincident high resolution imagery is the only practically feasible option
- metrics need to be meaningful for users

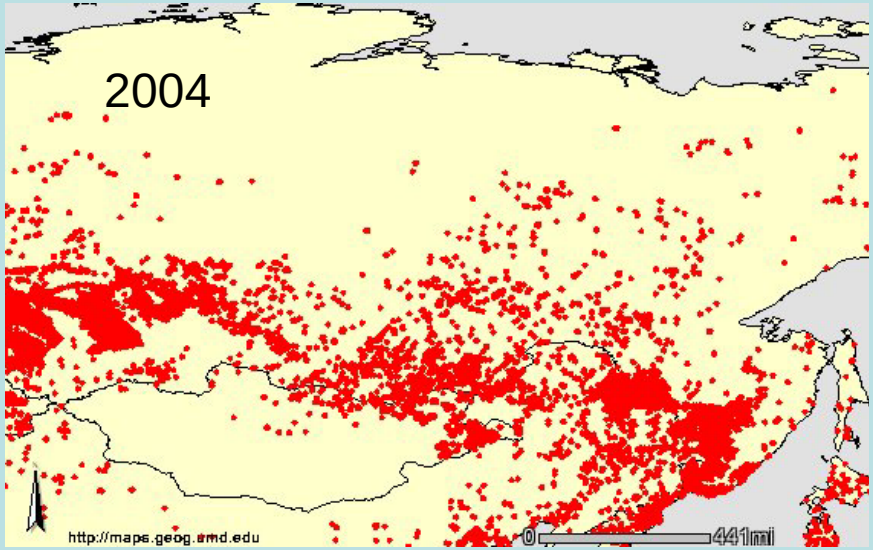
MODIS active fires

maps.geog.umd.edu



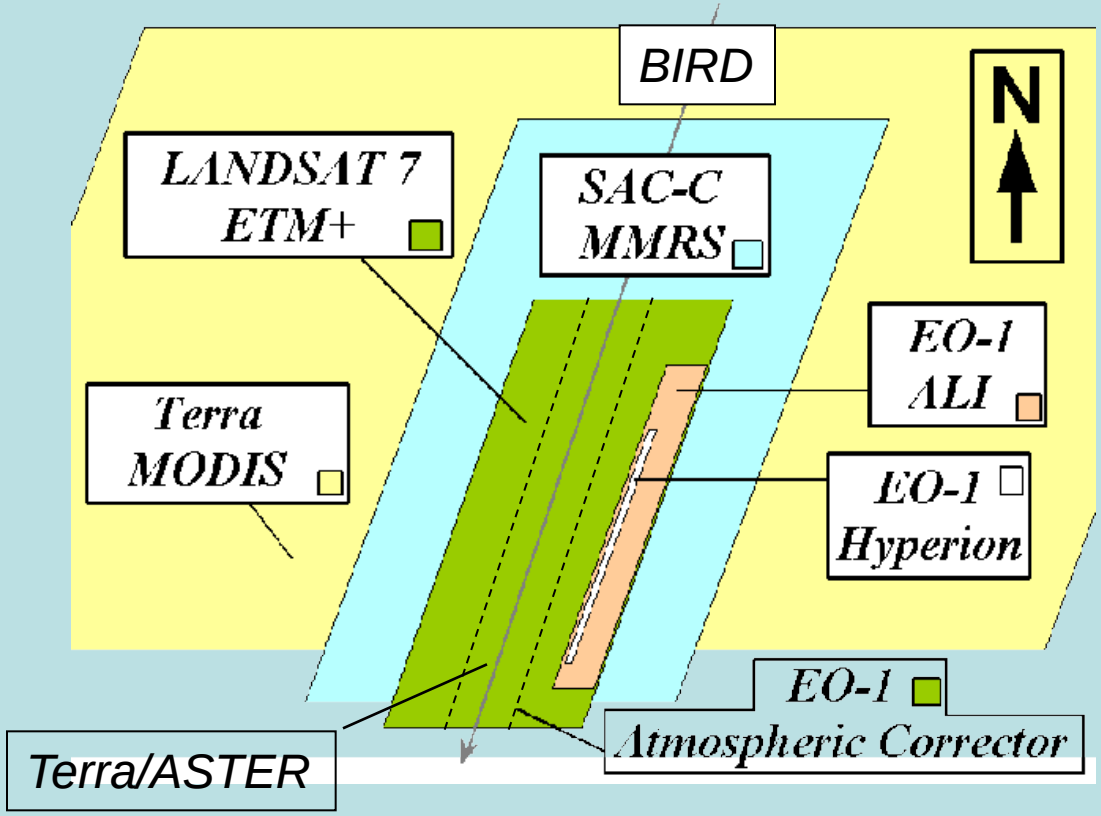






Active fire validation using coincident high resolution observations

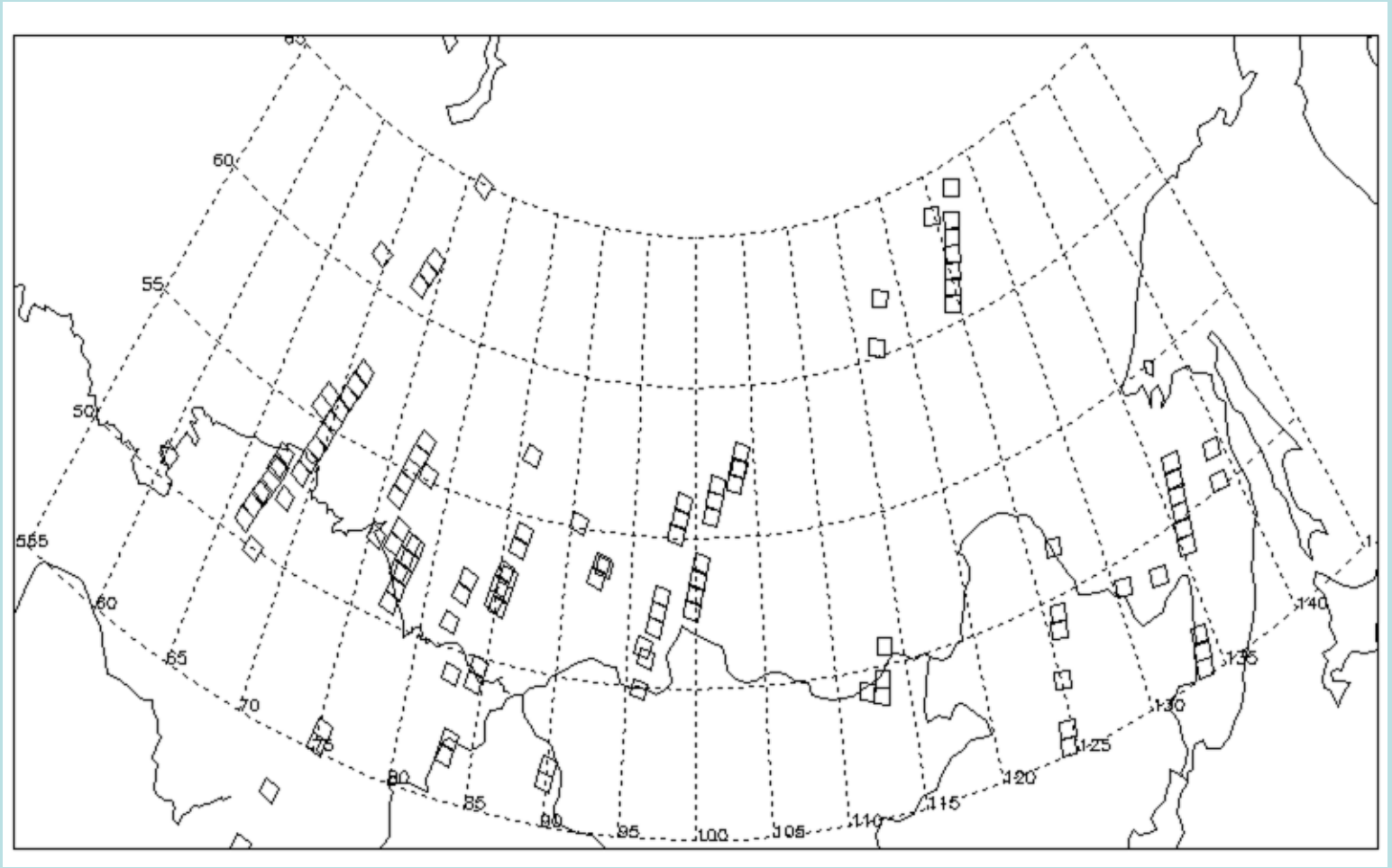
AM satellite constellation: the real “A-train”?



collocated high resolution observations are used for product evaluation

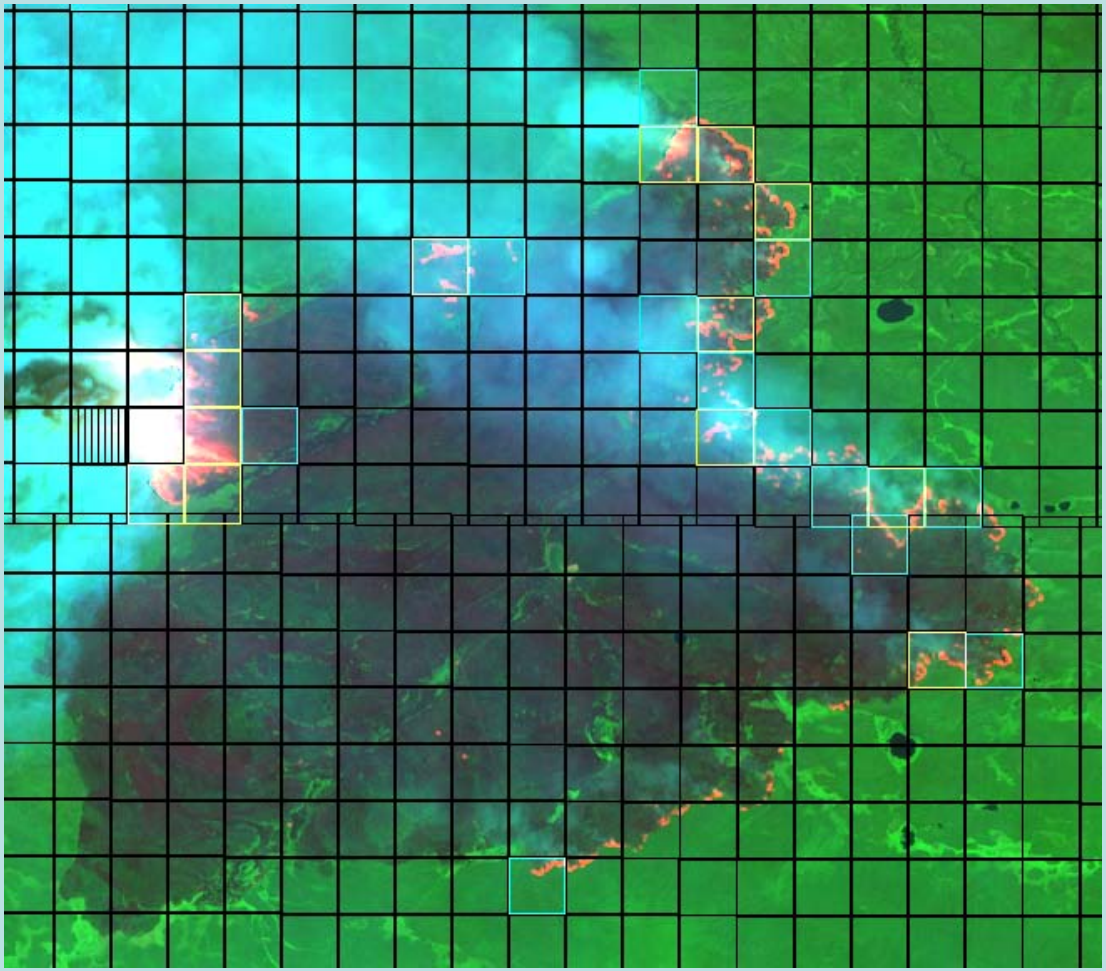
Passengers are getting off: BIRD is drifting away from Terra

Active fire validation: MODIS and ASTER



Spatial distribution of the 133 ASTER scenes from 2001-2003

Comparison with coincident high-resolution satellite observations



ASTER (30m) + 1km MODIS grid:
MODIS detections in color

MODIS v4 detection:

Yellow gridcells:
“fire”, high confidence

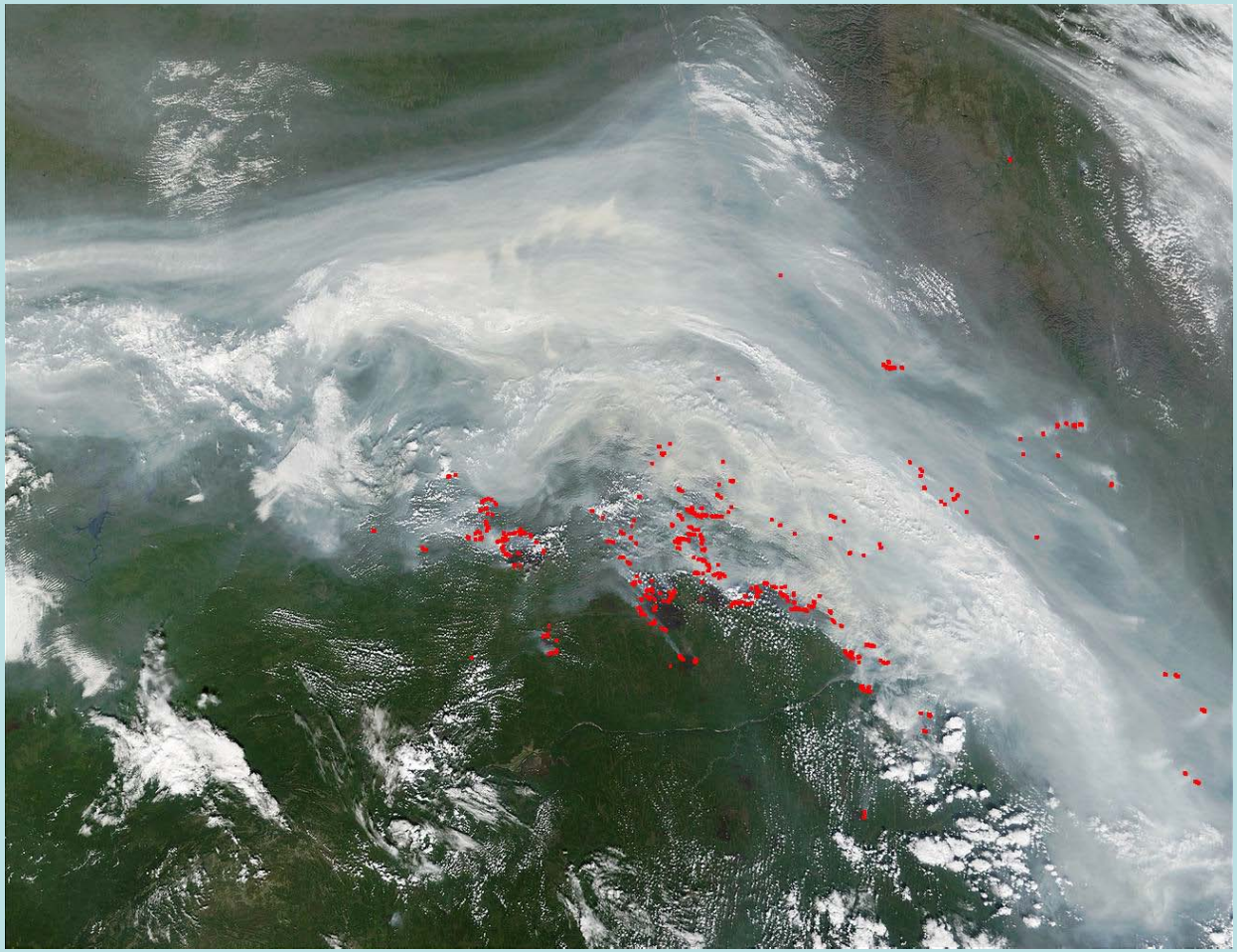
Blue gridcells:
“fire” nominal confidence

Gridcell with vertical shading:
“cloud”

Black gridcells:
“clear land”

July 23 2002 03:18 UTC
62.57N 125.72E (Siberia)

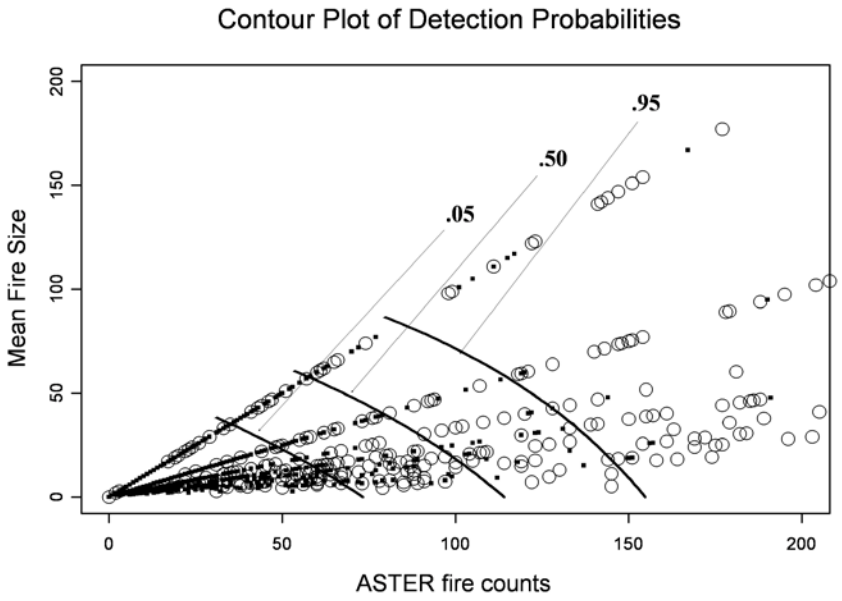
MODIS active fires



Aug 22 2002, near Yakutsk, Russia

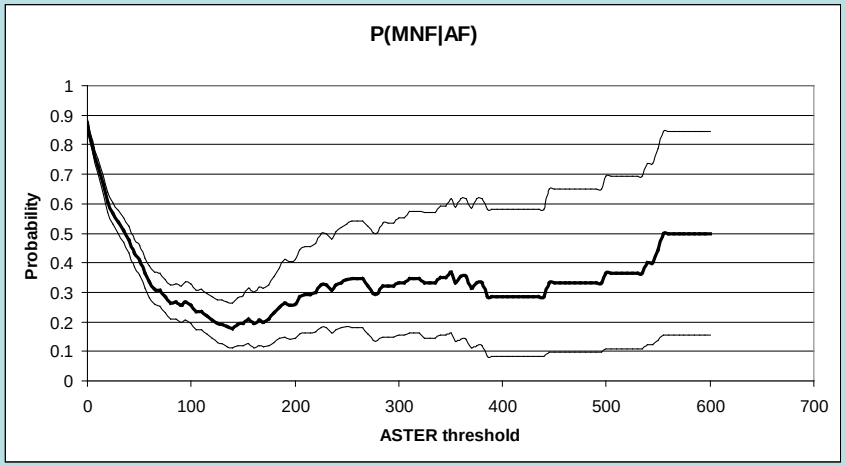
http://rapidfire.sci.gsfc.nasa.gov/gallery/?2002234-0822/Russia.A2002234.0330.1km.jpg

Comparison with coincident high-resolution satellite observations



: MODIS “fire”; :MODIS “no fire”

Probabilities of detection as a function of ASTER fire pixels within MODIS pixel

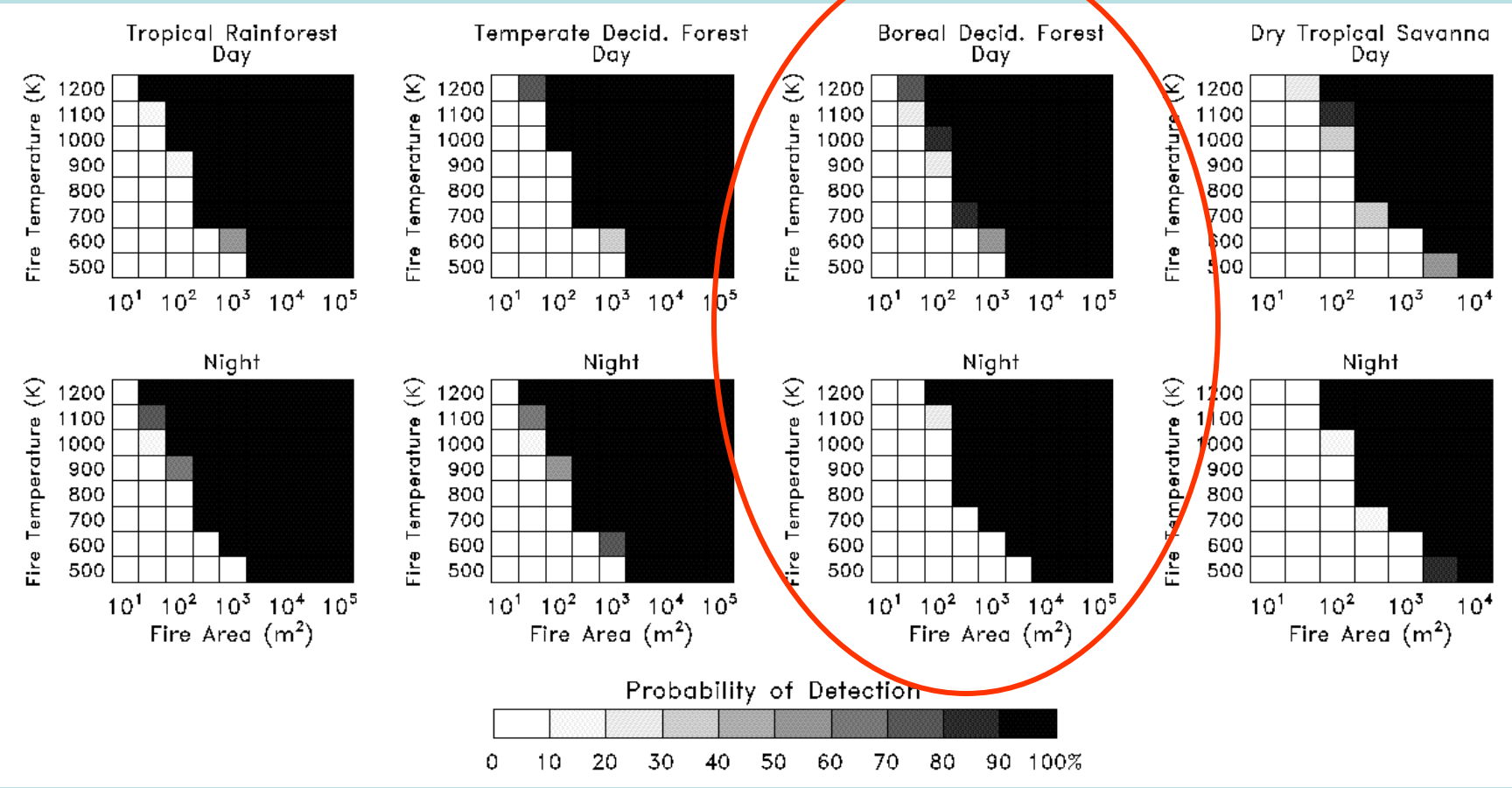


Pixel-based accuracy assessment curve with 95% exact confidence intervals: omission error rate

NPOESS/VIIRS/LANDSAT active fire validation!

significant contribution by Jeff Morisette, Louis Giglio; LBA and EOS projects

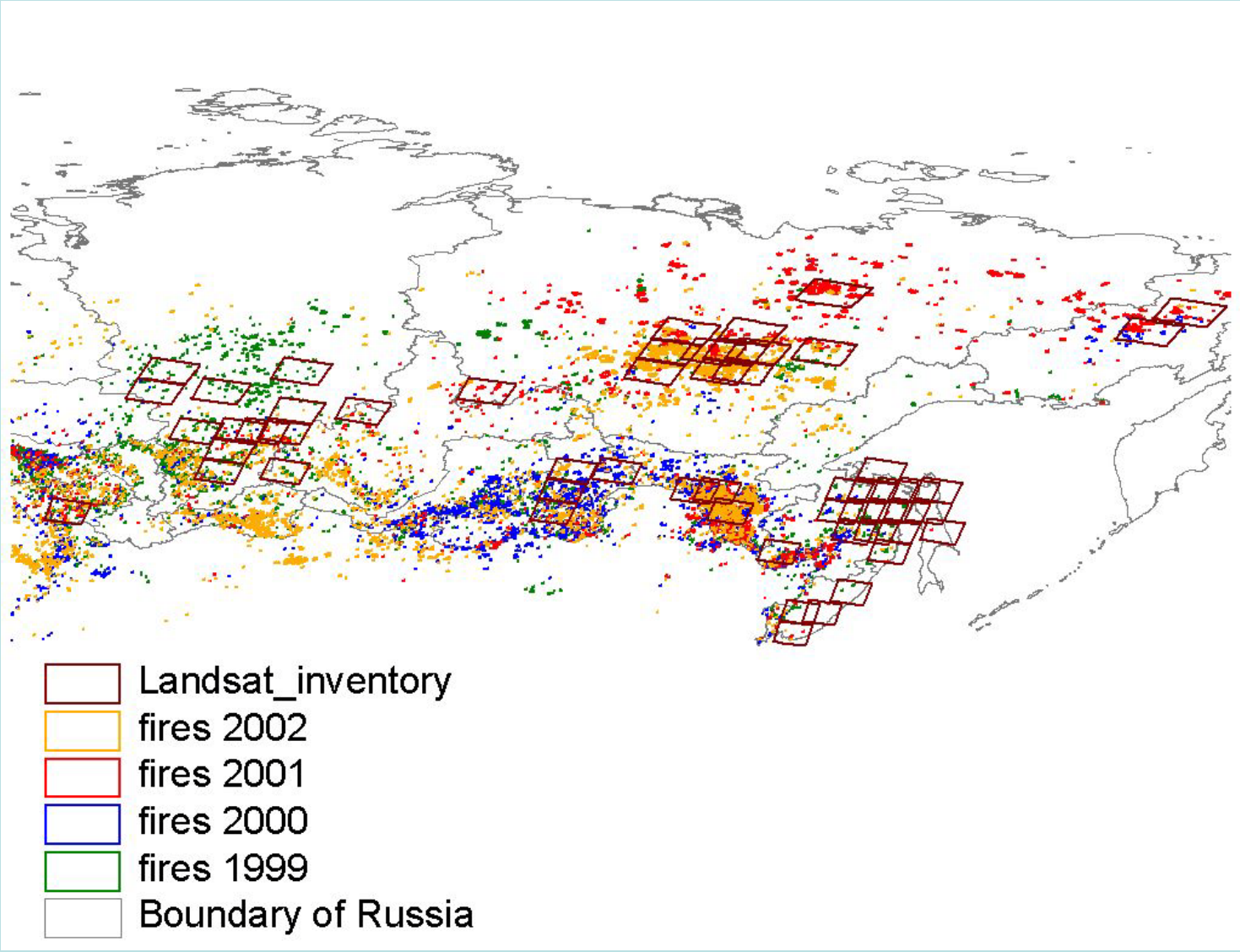
Theoretical active fire detection envelopes: MODIS, nadir view



MODIS active fire product; from radiative transfer simulation

L. Giglio

Burned area validation: Landsat/ETM+

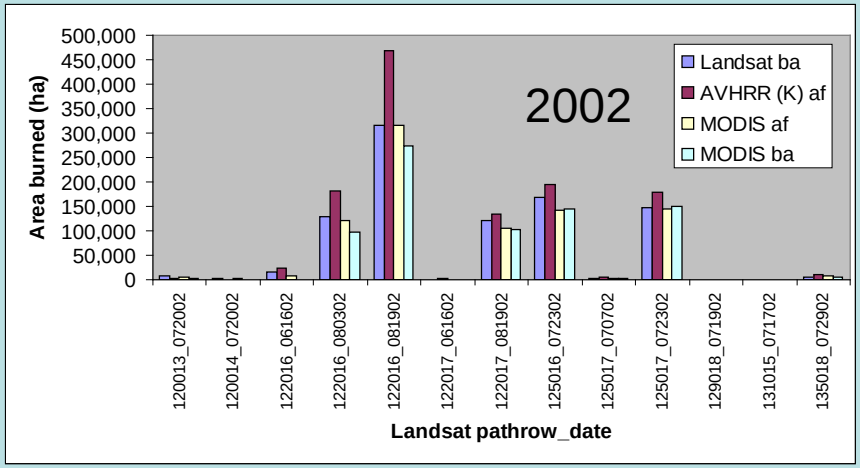


- coverage
- clouds
- smoke

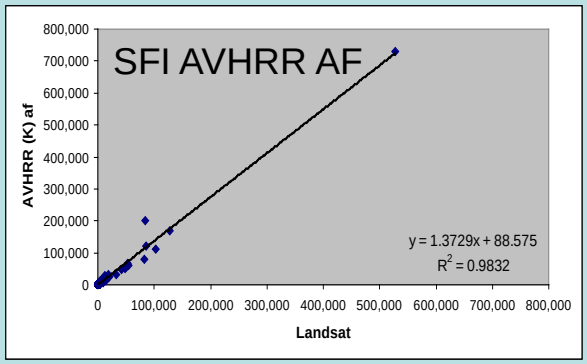
->

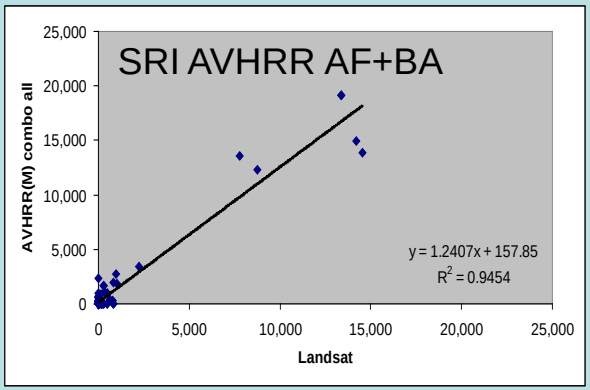
difficulty to implement two-scene burned area validation protocol

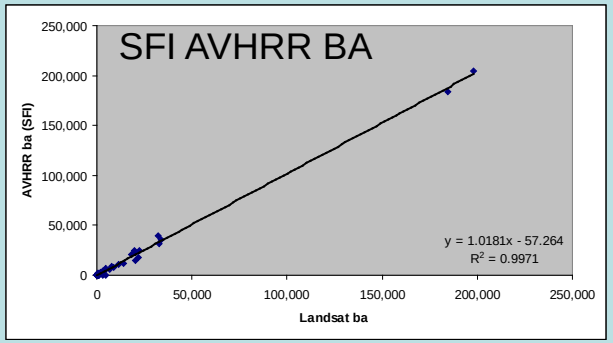
Inventory burned area validation

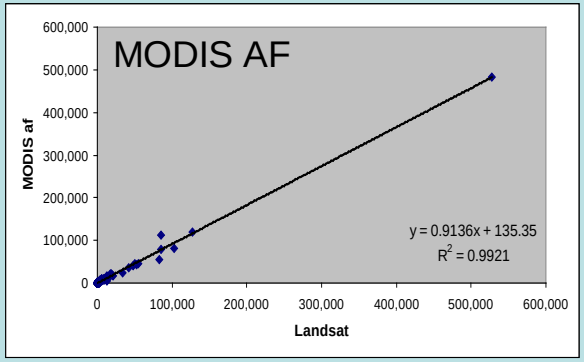


AF: Active Fires BA: Burned Areas



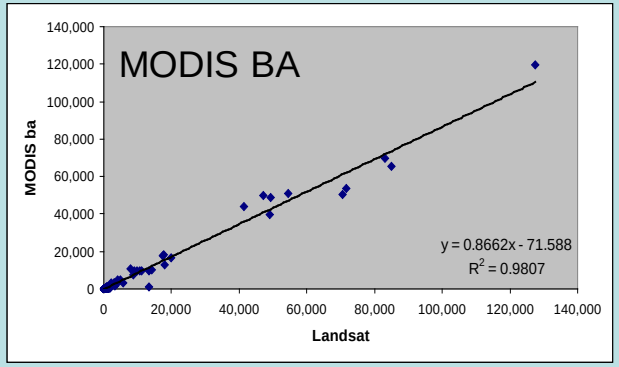






SFI: Sukachev Forest Institute
SRI: Space Research Institute

MODIS BA: experimental algorithm (courtesy L. Giglio)



(calibration regression) ←

indications that these are somewhat variable

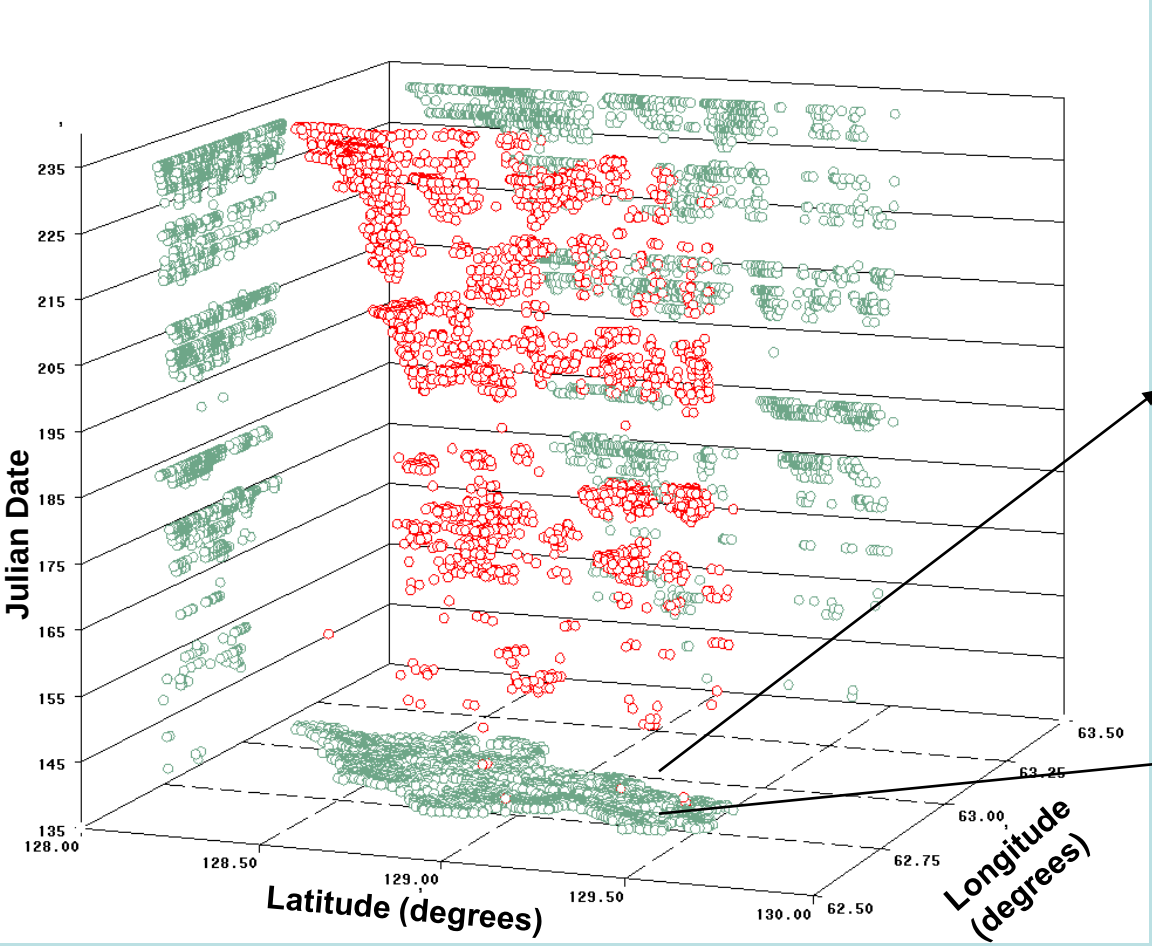
(explicit mapping)

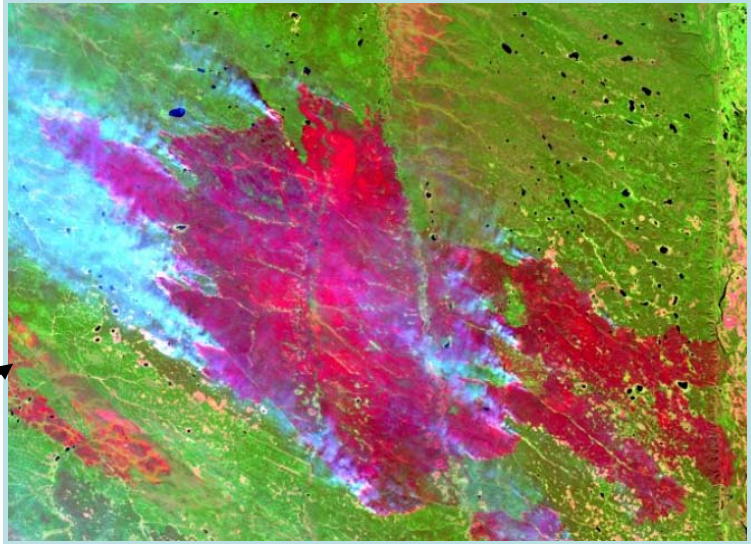
Geospatial burned area validation

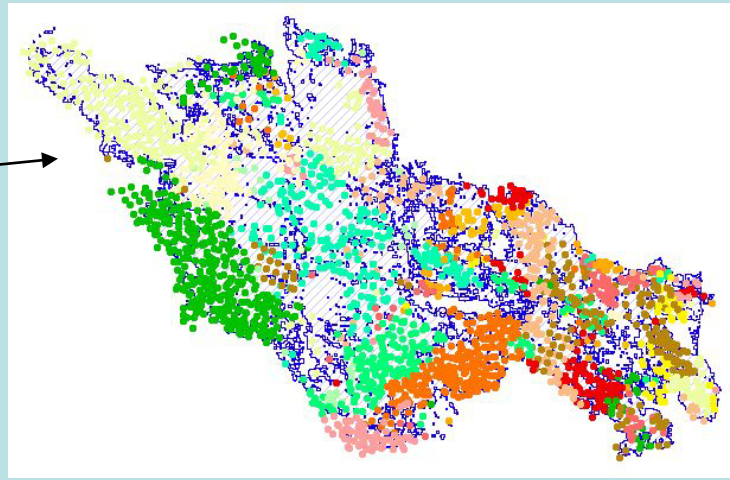
Product	Commission	Omission	Producer Accuracy	User Accuracy	Overall Accuracy	Kappa
AVHRR (Krasnoyarsk) AF	61.62	45.38	54.62	38.38	98.58	0.43
AVHRR (Moscow) AF NOAA 12	67.33	80.43	19.57	32.67	97.85	0.22
AVHRR (Moscow) BA NOAA 12	56.76	76.45	23.55	43.24	97.94	0.26
AVHRR (Moscow) Combo NOAA 12	59.17	57.86	42.14	40.83	97.84	0.38
AVHRR (Moscow) AF NOAA 14	63.85	79.48	20.52	36.15	74.43	0.26
AVHRR (Moscow) BA NOAA 14	47.14	59.04	40.96	52.86	99.60	0.46
AVHRR (Moscow) Combo NOAA 14	49.02	46.25	53.75	50.98	99.59	0.52
AVHRR (Moscow) Combo AF	54.27	54.80	45.20	45.73	99.55	0.45
AVHRR (Moscow) Combo BA	51.45	56.73	43.27	48.55	99.58	0.45
AVHRR (Moscow) Combo All	55.94	36.06	63.94	44.06	99.52	0.52
MODIS AF	49.77	53.47	46.53	50.23	98.86	0.46
MODIS BA	27.09	49.40	50.60	72.91	99.34	0.56

contribution by S. Trigg, J. Hewson and N. French

Fire spread reconstruction





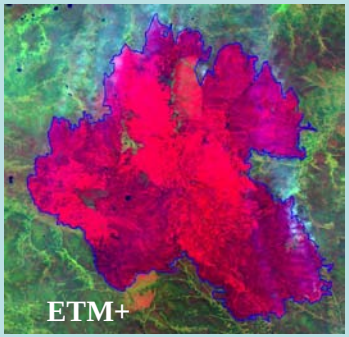


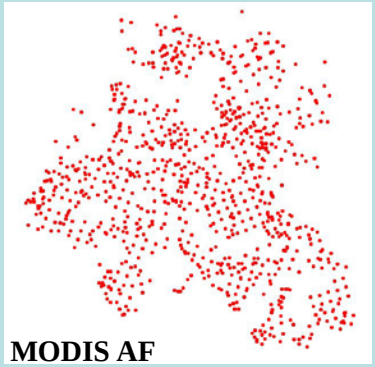
- Fire detections
- Projections of fire detections on the respective axes

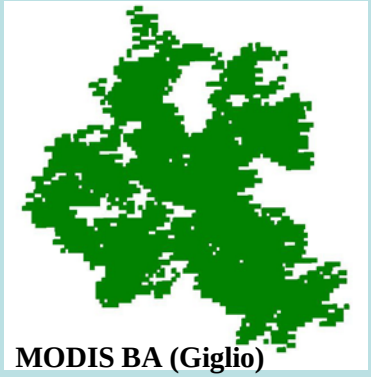
Uses of fire spread rate

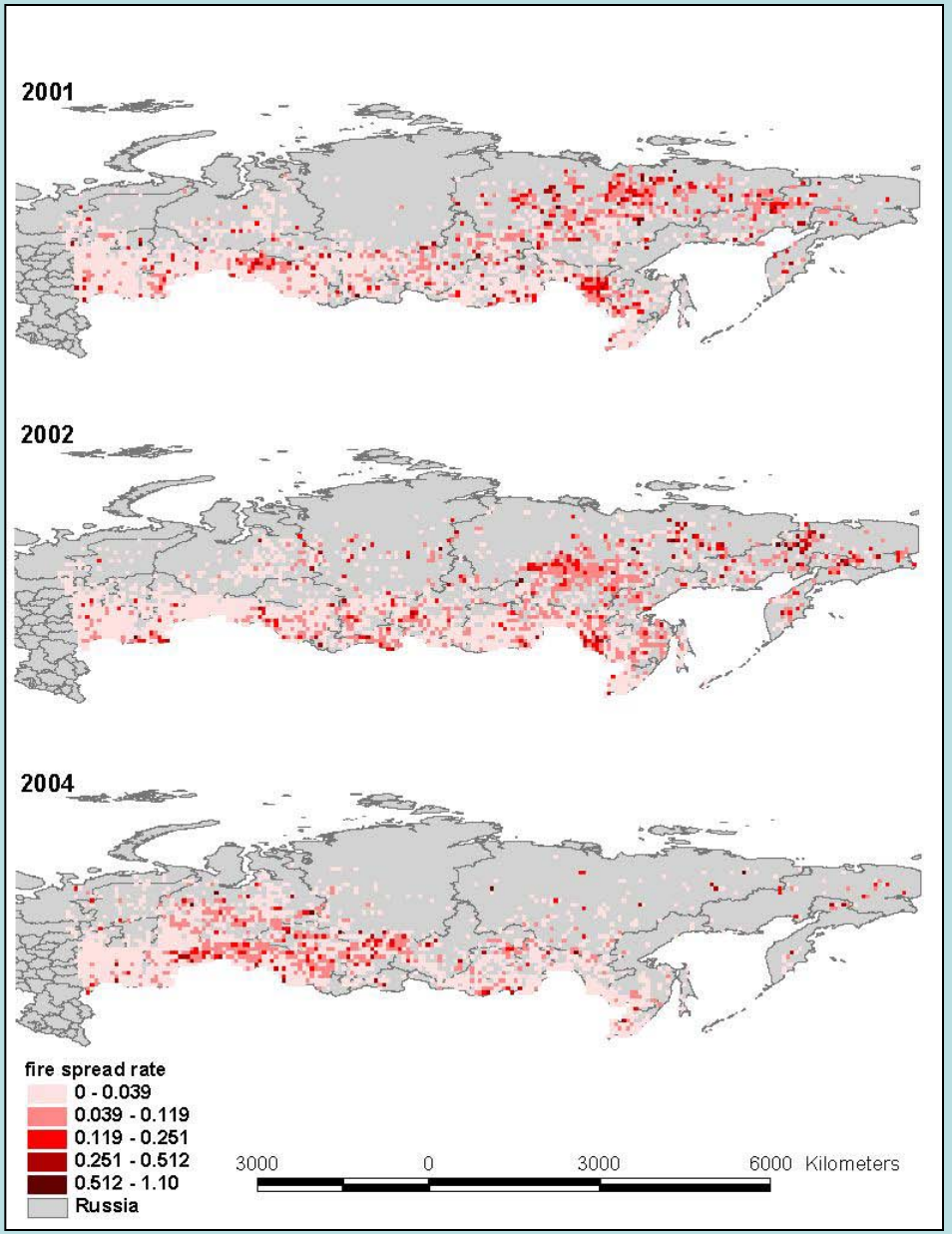
- characterization of spatial and temporal fire dynamics

- understanding burned area mapping errors from active fires







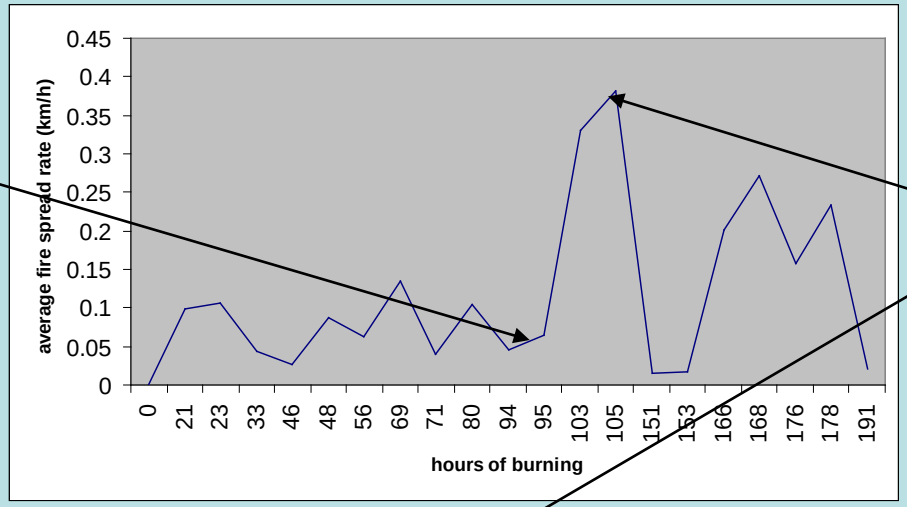


Fire spread rate (km/hr)

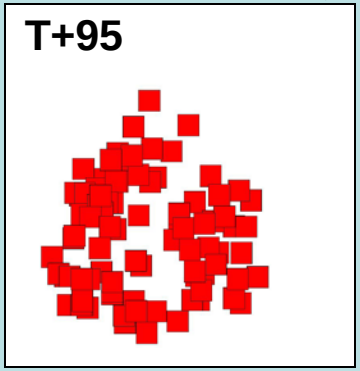
Understanding mapping errors: fire spread

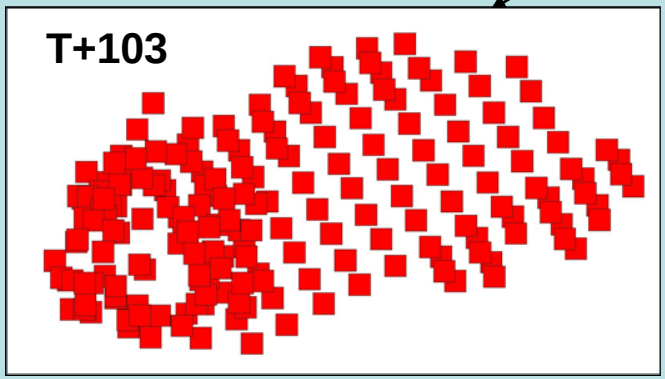
low spread rate

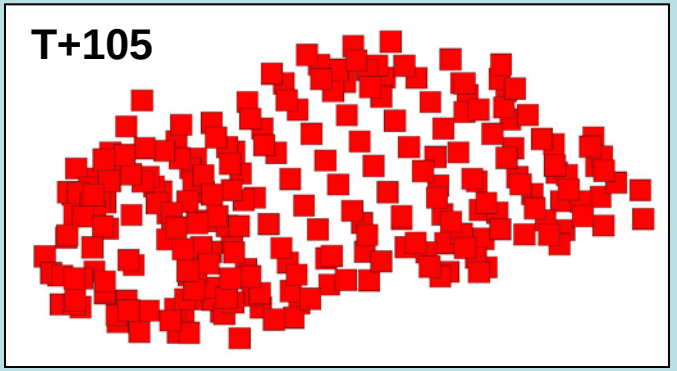
high spread rate



July 20, 2002





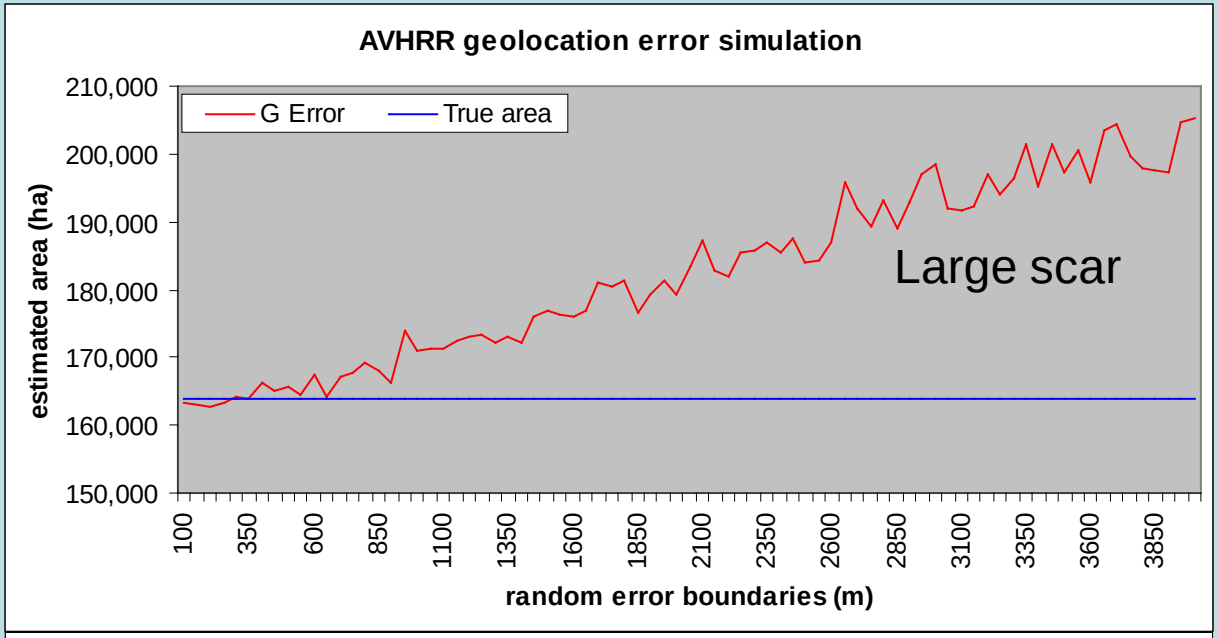


1km^2 squares around MODIS active fire detection locations

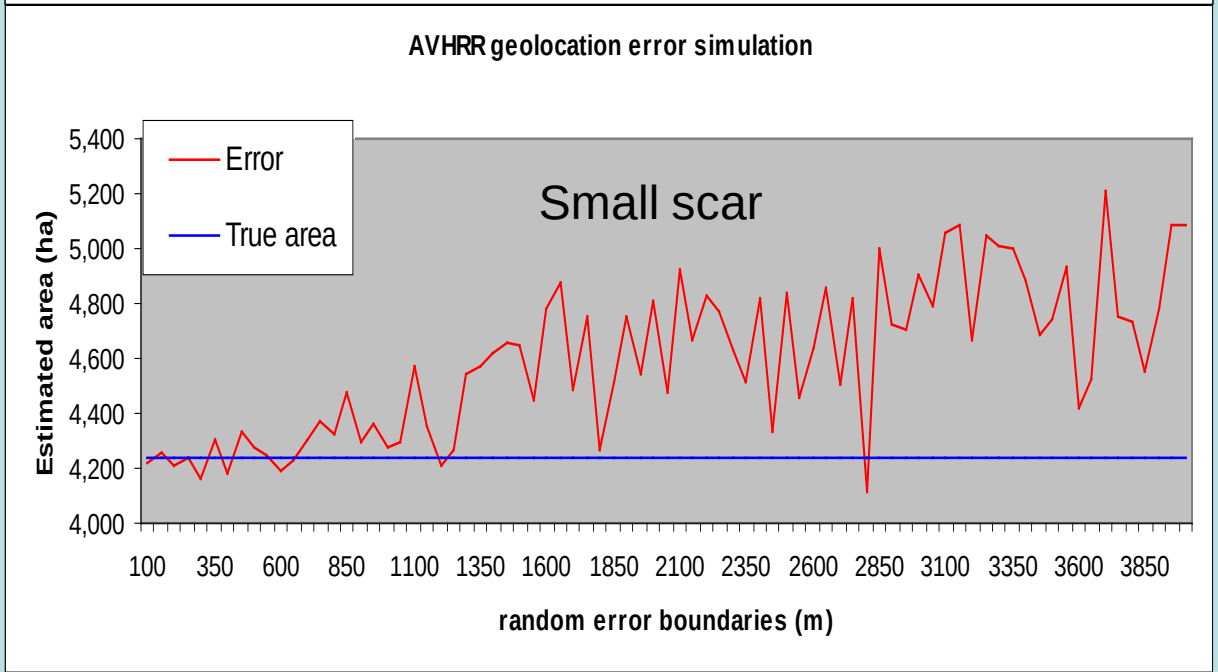
The effect of AVHRR geolocation errors

MODIS

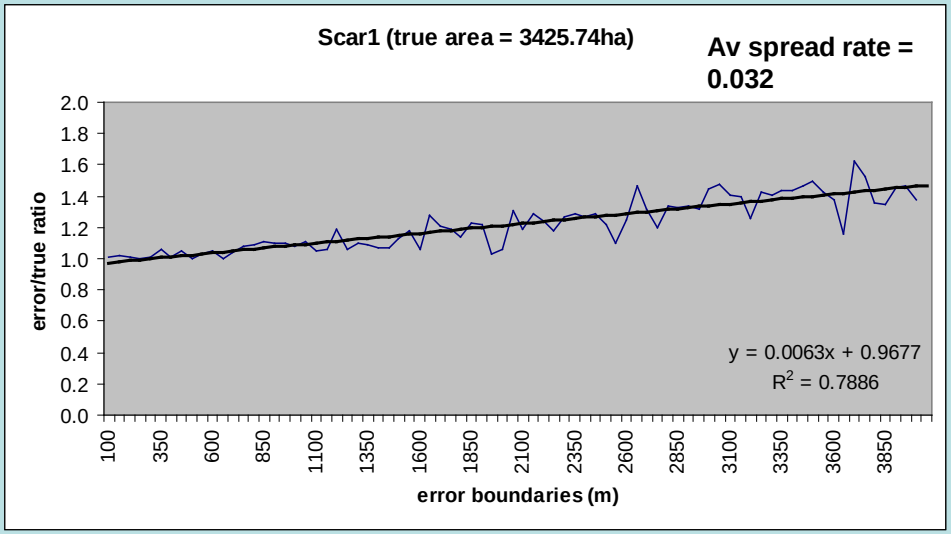
Monte Carlo simulation of AVHRR geolocation errors

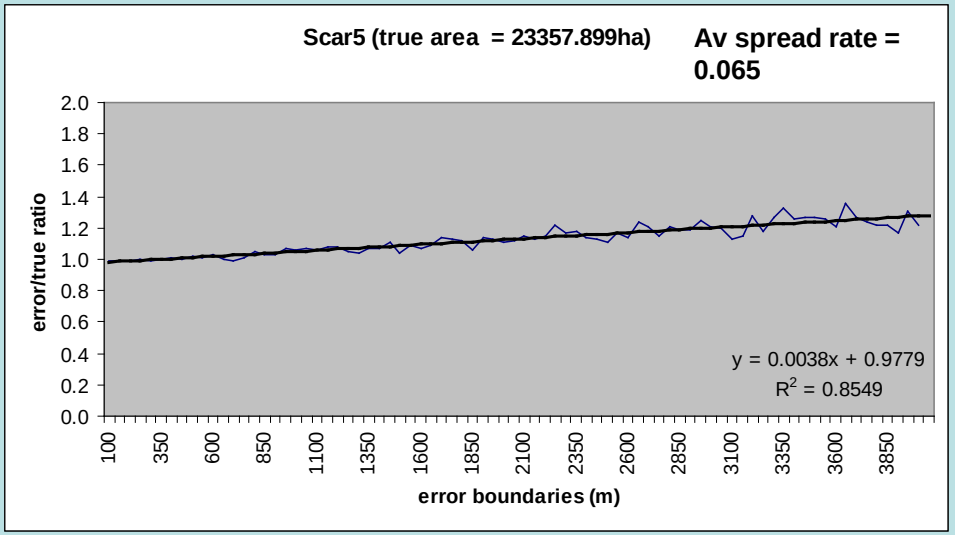


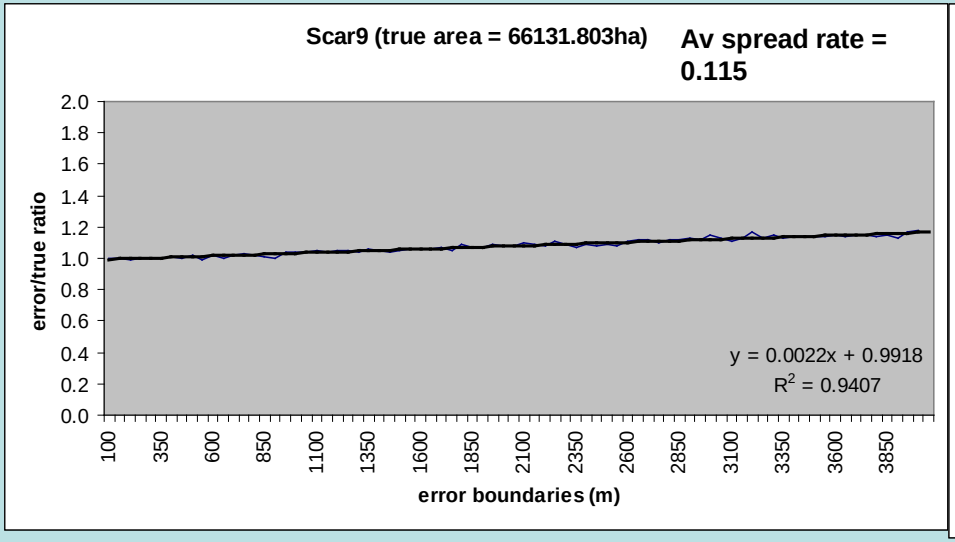
Growth of total burned area estimate as a function of geolocation error

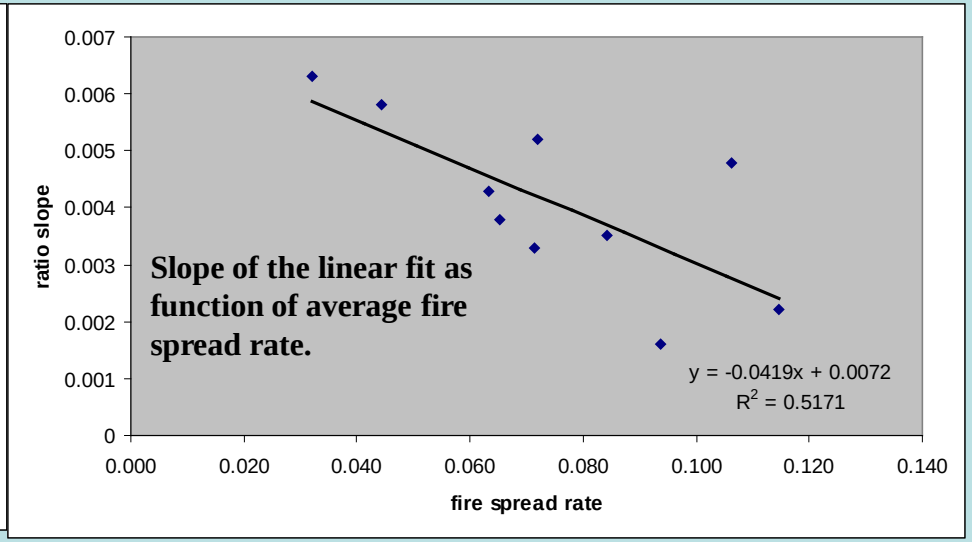


Geolocation error and spread rate





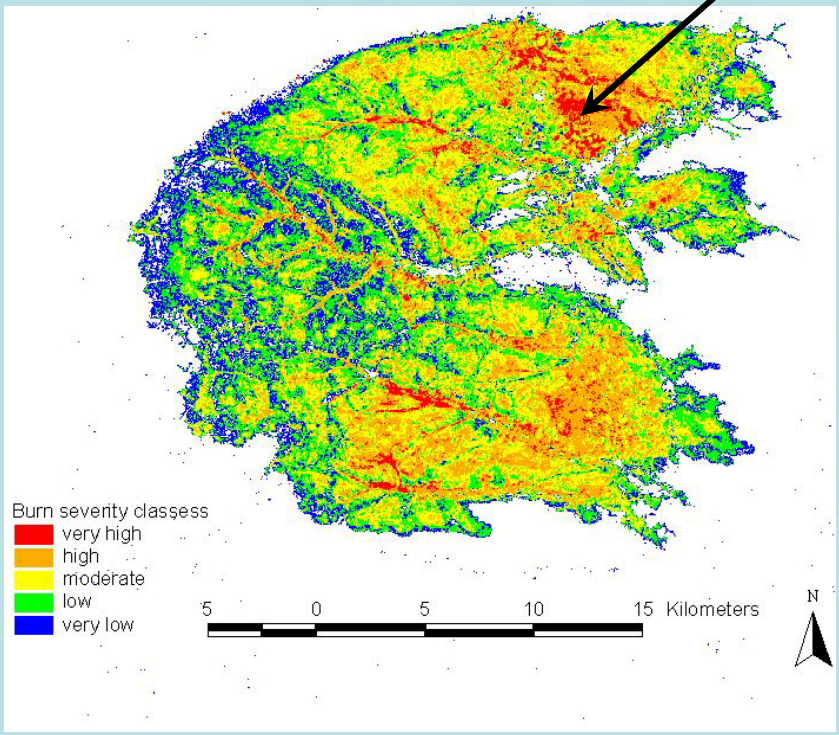


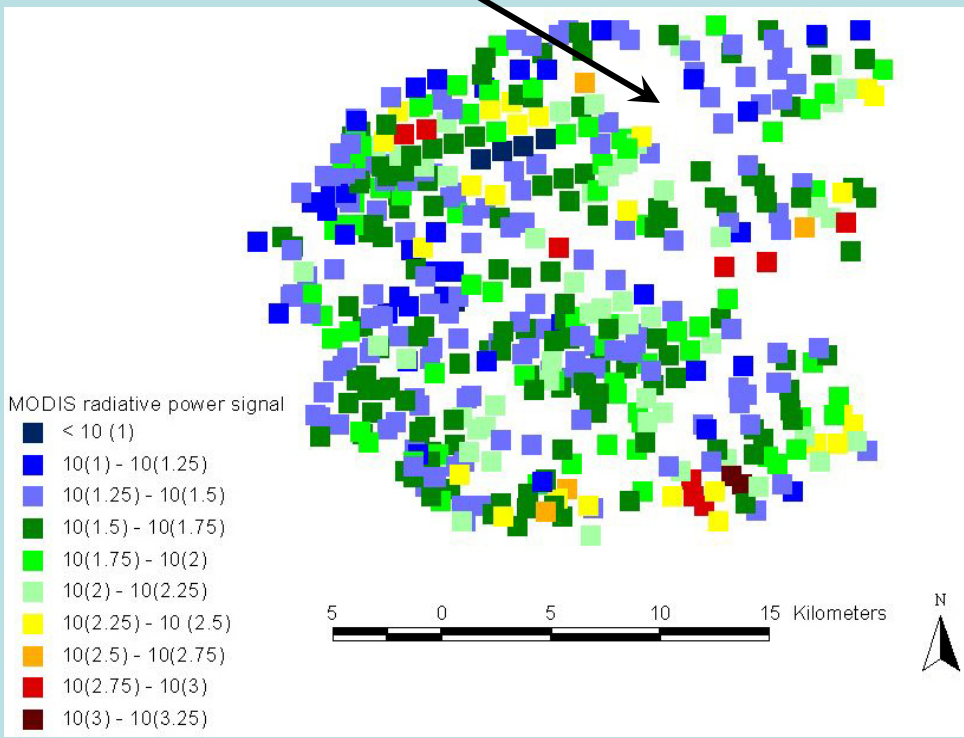


Relative area estimates

Burn severity and burning intensity

What happened here?

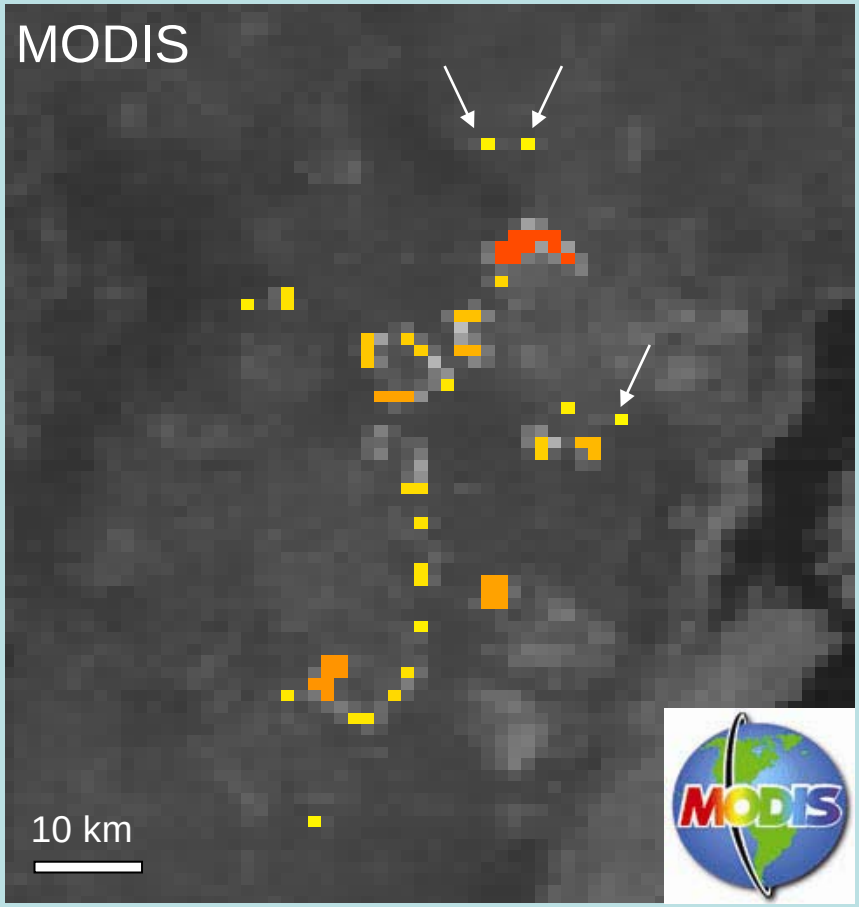


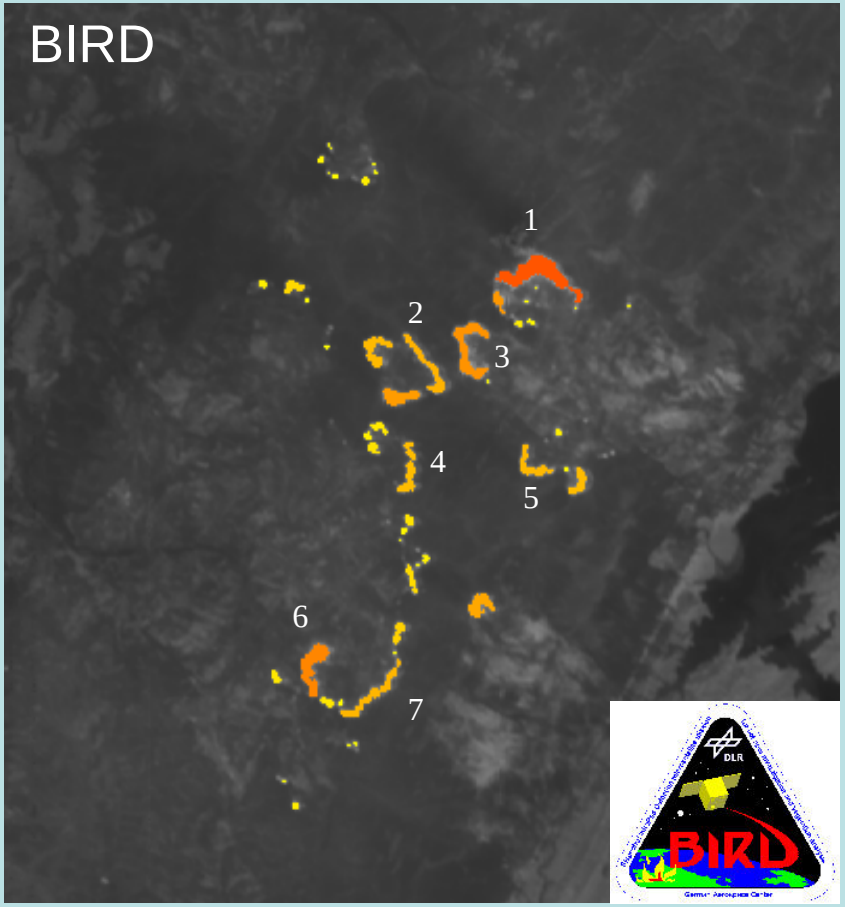


ETM+ burn severity index 2002 WRS-2 125/017 MODIS Fire Radiative Power

(also see McRae et al poster)

Zoomed fragments of forest fire images at Baikal, obtained by MODIS and BIRD on 16 July 2003





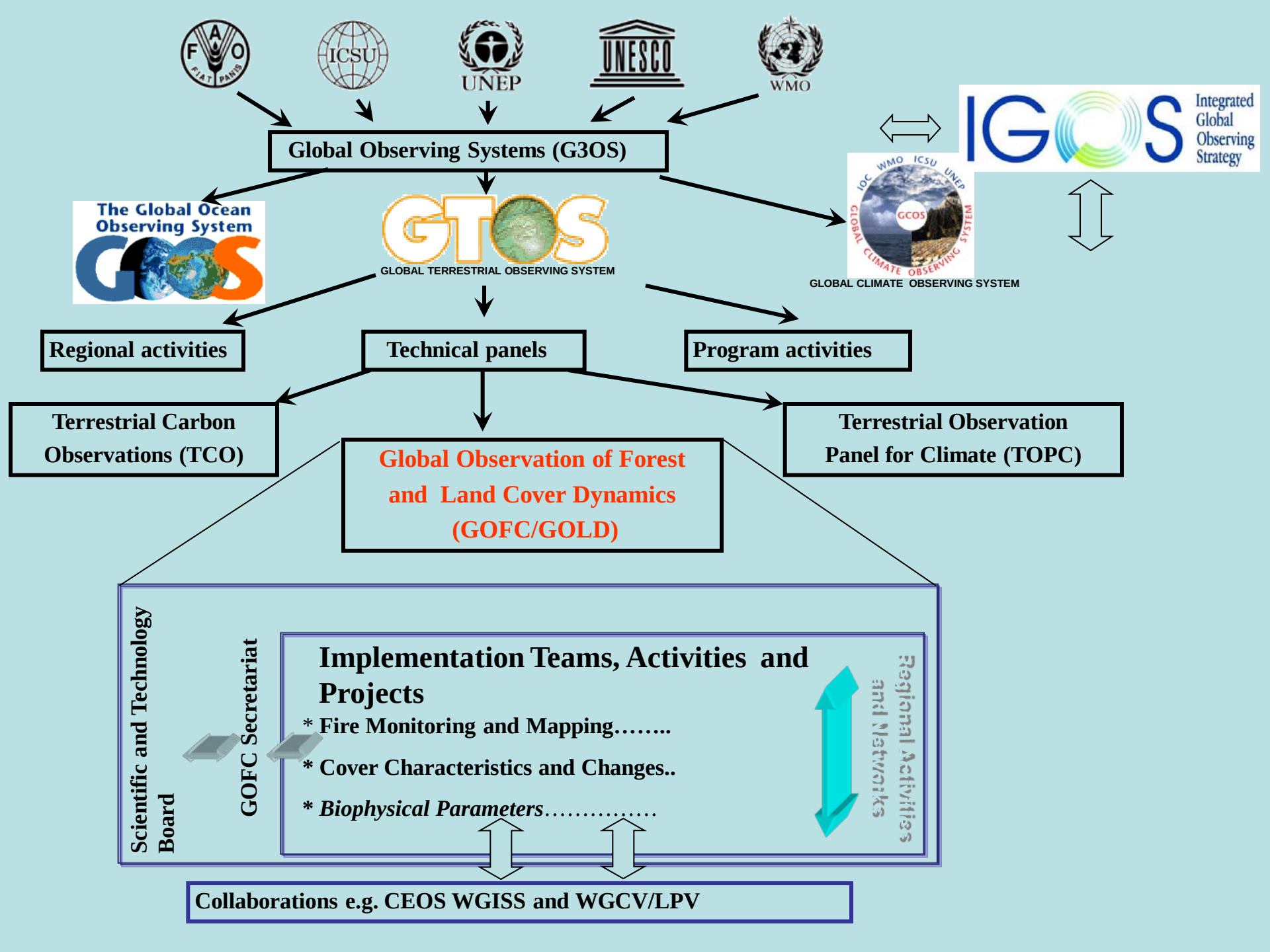
1 100 10000 MW

Projection on the MIR band

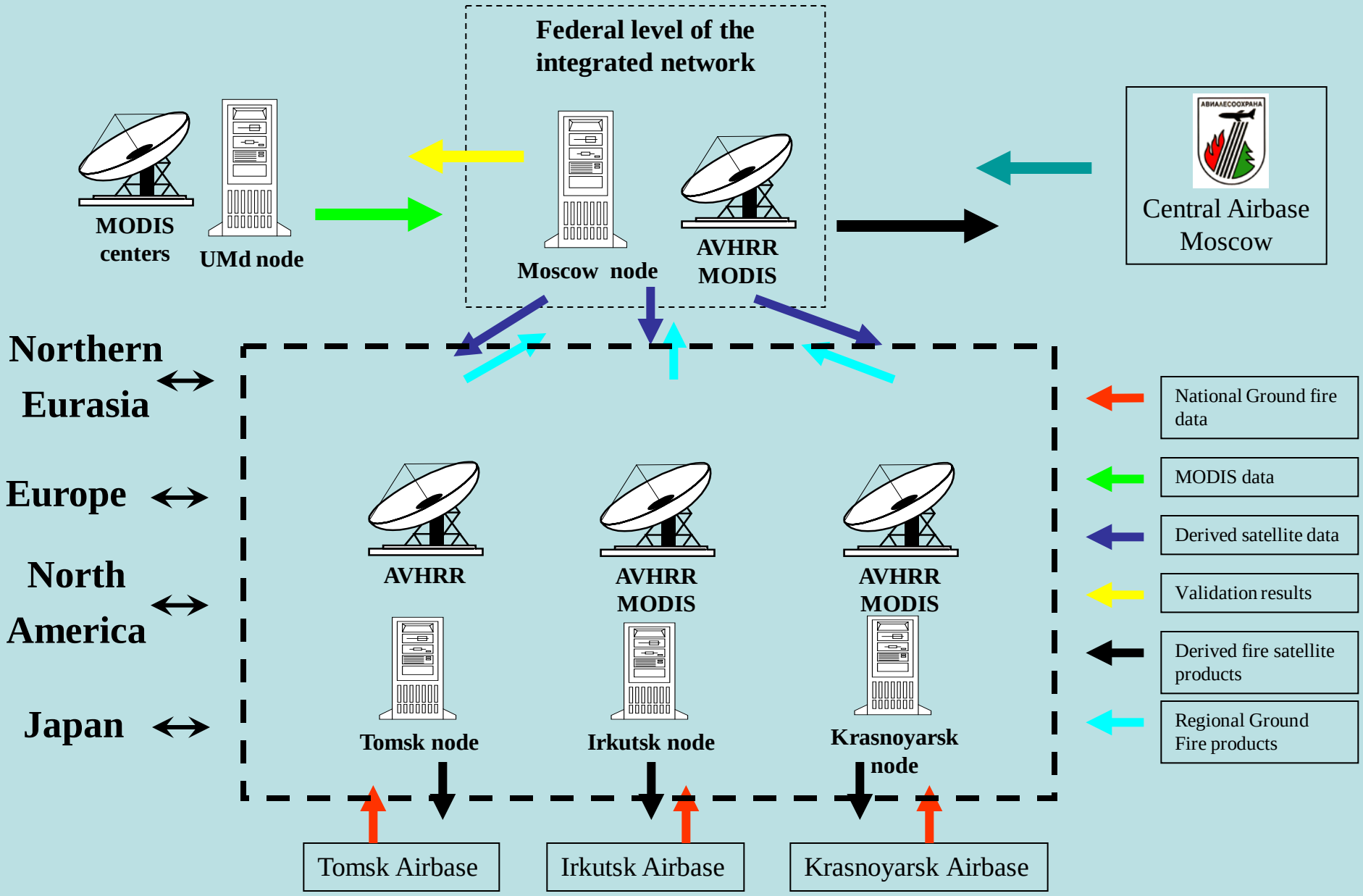
B. Zhukov (DLR, SRI) , D. Oertel (DLR), E. Lorenz (DLR), Ya. Ziman (SRI), I. Csiszar (UMd)

Northern Eurasian Regional Fire Network

- Part of GOFC/GOLD - NERIN
- Partnership between
  - Providers of satellite-based fire data by Russian and international partners
  - Operational providers of in-situ fire data
  - Users of fire data


Global Observing Systems (G3OS)
The Global Ocean Observing System
GTOS
GLOBAL TERRESTRIAL OBSERVING SYSTEM
GCOS
GLOBAL CLIMATE OBSERVING SYSTEM
IGOS
Integrated Global Observing Strategy
Regional activities
Technical panels
Program activities
Terrestrial Carbon Observations (TCO)
Terrestrial Observation Panel for Climate (TOPC)
Global Observation of Forest and Land Cover Dynamics (GOFC/GOLD)
Scientific and Technology Board
GOFC Secretariat
Implementation Teams, Activities and Projects
* Fire Monitoring and Mapping……..
* Cover Characteristics and Changes..
* Biophysical Parameters……
Regional Activities and Networks
Collaborations e.g. CEOS WGISS and WGCV/LPV

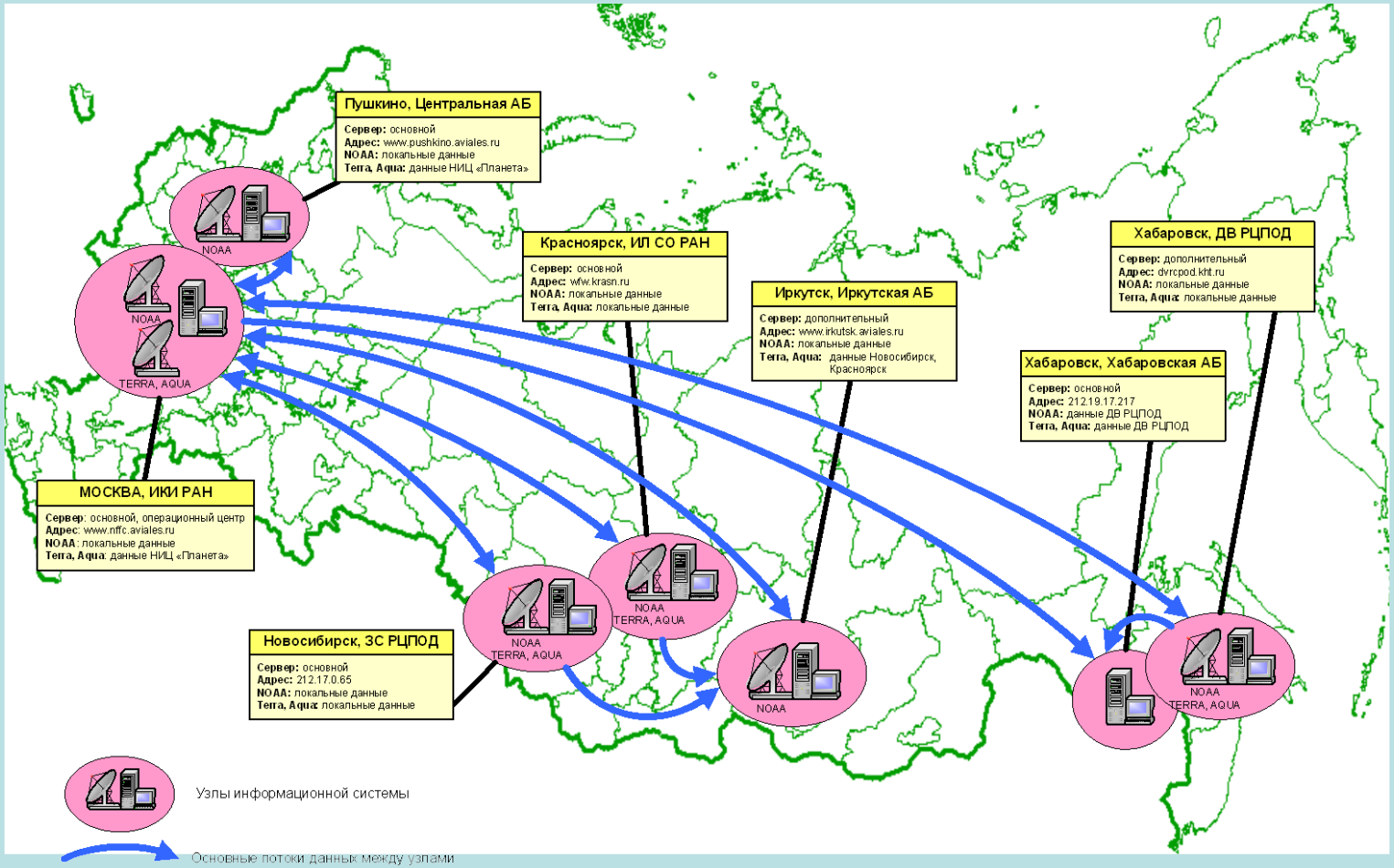
Northern Eurasian Fire Network structure



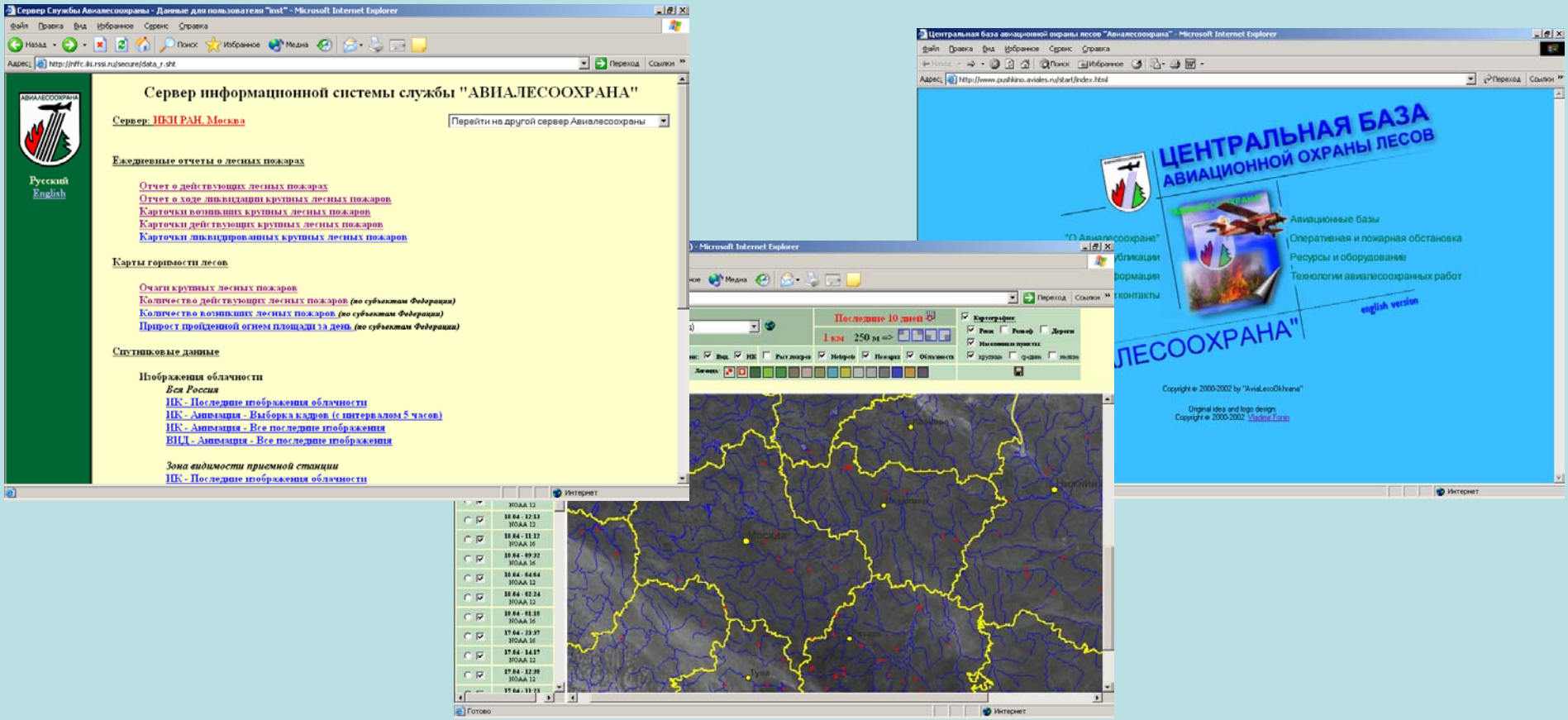
Primary network participants

- Space Research Institute (Moscow)
  - data integration, operational monitoring
- Center for Forest Ecology and Productivity (Moscow)
  - fire and disturbance mapping
- Institute for Atmospheric Optics (Tomsk)
  - radiative transfer, atmospheric correction
- Sukachev Forest Institute (Krasnoyarsk)
  - fire mapping, new sensors and technologies
- Institute for Solar and Terrestrial Physics (Irkutsk)
  - validation, high resolution sensors

Current national operational network in Russia

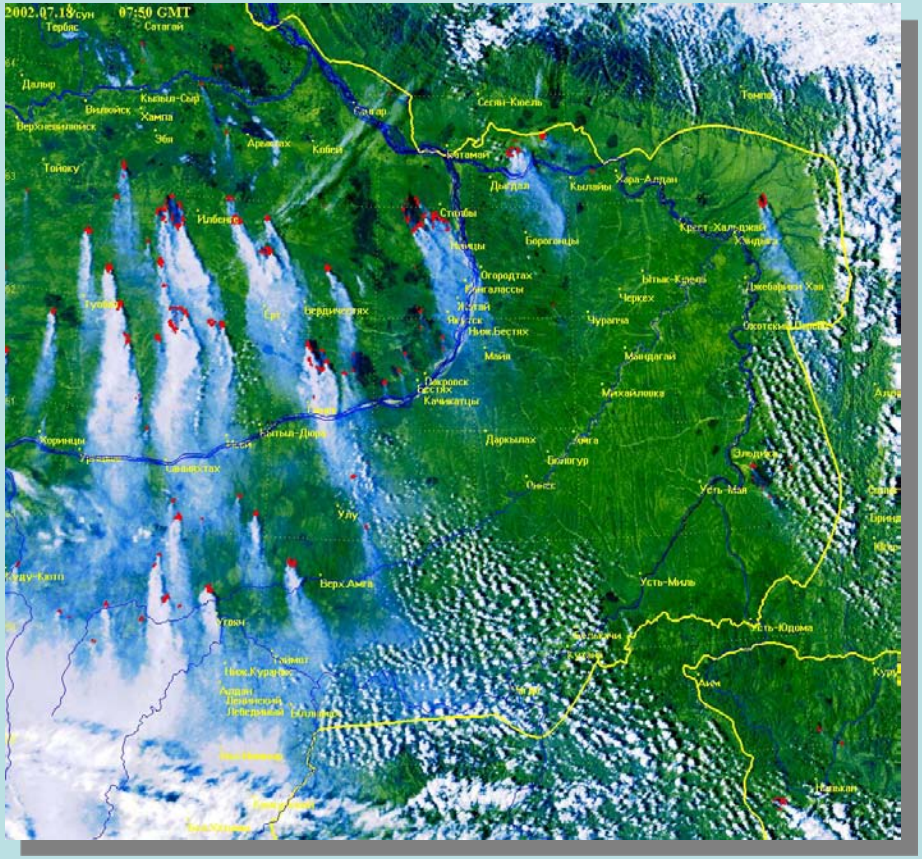


Operational web-based distribution system

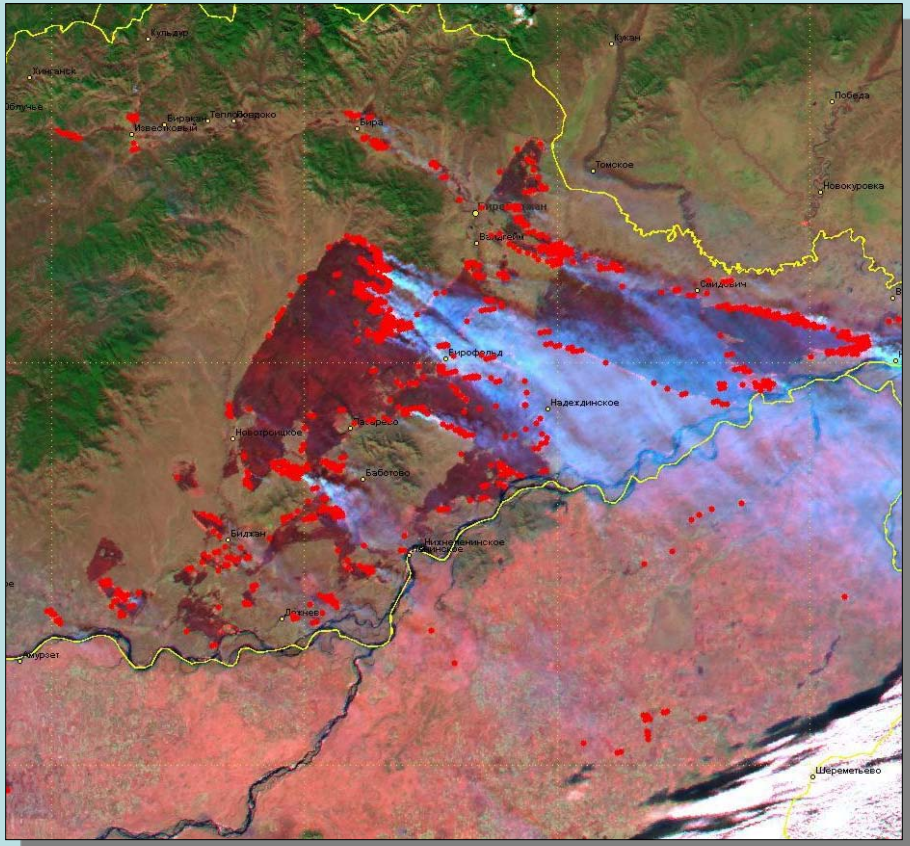


http://www.nffc.aviales.ru

Example imagery



7/18/2002 (AVHRR)

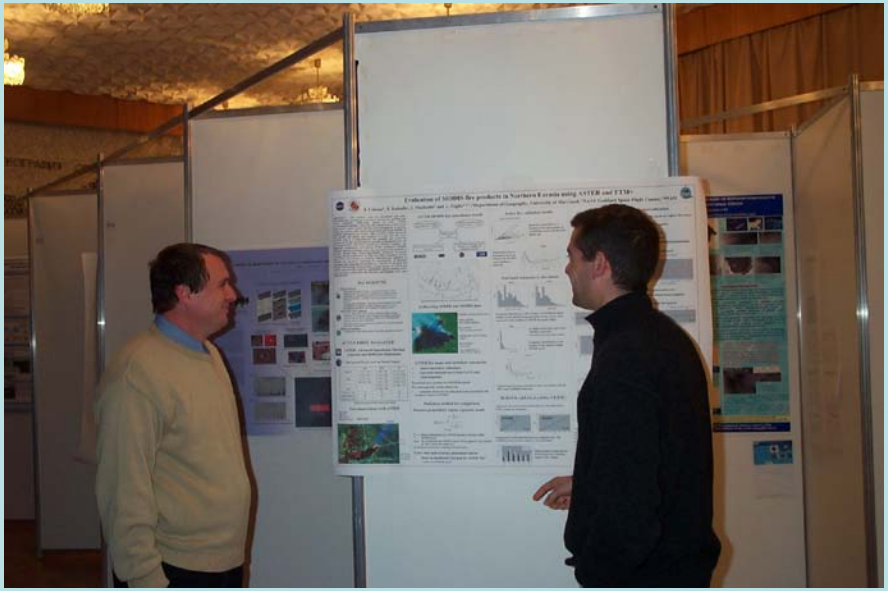


10.15.2004 (MODIS)

Current network status and results

- Organizational
  - E. Loupian and A. Sukhinin on the GOFC/GOLD Fire Implementation Team (data systems and new sensors)
  - network status is mature – regional champions taking over initiative
  - several products registered in NERIN metadata base
  - GOFC/GOLD-Fire Regional workshop: second day of Russian Remote Sensing Symposium (November 16-18 2004)
  - **Russia ratified the Kyoto protocol**
    - satellite-based fire products gaining official status
    - formal national satellite-based fire monitoring network in Russia
      - opportunity, but also a challenge
  - further countries in Northern Eurasia being involved
  - umbrella research agreement between SRI and UMd
- Collaborative
  - joint multi-product database developed at SRI and accessible to network participants (including UMd)
  - ongoing data and software exchange between UMd and SRI
  - ongoing data exchange between network participants in Russia
  - joint peer-reviewed publications on network status (published) and product validation (in preparation)

GOFC/GOLD Regional Fire Workshop
Moscow, 17 November 2004



Future network priorities

- Facilitate involvement of additional stakeholders in Russia and in neighboring countries
- Harmonize activities with NERIN and its land cover component
- Strengthen product validation based on consensus protocols
- Secure further funding
  - national agencies within Russia and neighboring countries
  - agencies in Europe, North America, Japan etc.
  - international programs: GOFC/GOLD, NEESPI etc.
- Further develop data system

Research plans for year 2005

- Refine and complete multi-year AVHRR dataset
  - at least back to 1996
- Validate forthcoming MODIS standard operational burned area product (Roy *et al.*)
- Validate locally developed / tuned active fire and burned area products
- Land cover type / vegetation continuous fields
- Evaluate science quality of network output
- Analyze burn severity and fire intensity
- Finish papers on
  - fire spread rate retrieval
  - multi-product burned are validation
  - fire characterization

Publications

Loupian E.A., A.A Mazurov, E.V. Flitman, D.V. Ershov, G.N. Korovin, V.P. Novik, N.A. Abushenko, D.A. Altyntsev, V.V. Koshelev, S.A. Tashchilin, A.V. Tatarnikov, I. Csiszar, A.I. Sukhinin, E.I. Ponomarev, S.V. Afonin, V.V. Belov, G.G. Matvienko and T. Loboda, Satellite monitoring of forest fires in Russia at federal and regional levels. **Mitigation and Adaptation Strategies for Global Change,** in press.

Sukhinin, A.I., N.H.F. French, E.S. Kasischke, J.H. Hewson, A.J. Soja, I. Csiszar, E.J. Hyer, T. Loboda, S.G. Conard, V.I. Romasko, E.A. Pavlichenko, S.I. Miskiv, and O.A. Slinkina, 2004: Satellite-based mapping of fires in Eastern Russia: new products for fire Management and carbon cycle studies. **Remote Sensing of Environment,** 93, 546-564.

Csiszar, I., T. Loboda and J. G. Goldammer, 2004: Contribution of GOFC/GOLD-Fire to fire monitoring in the Russian Federation. **New Approaches to Forest Protection and Fire Management at an Ecosystem Level.** World Bank and Alex Publishing, Moscow., 138-146. (in Russian, original English version forthcoming).

Goldammer, J.G., A. Sukhinin and I. Csiszar, The Current Fire Situation in the Russian Federation: Implications for Enhancing International and Regional Cooperation in the UN Framework and the Global Programs on Fire Monitoring and Assessment. **New Approaches to Forest Protection and Fire Management at an Ecosystem Level.** World Bank and Alex Publishing, Moscow., 26-65 (in Russian, original English version forthcoming).

Csiszar, I., J. Morisette and L. Giglio, Validation of active fire detection from moderate resolution satellite sensors: the MODIS example. In review.