3rd SALGEE Workshop 2013
MSG LAND SURFACE APPLICATIONS: DROUGHT AND FIRE EMISSIONS
Ericeira, Hotel Vila Galé, 20 a 21 March 2013

Robust Satellite Techniques for Fire detection (RST-FIRES): basic concepts and Total Validation

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Fire detection for what ?

Before MSG

"*For Europe, priority was assigned to the development of a* ***fire risk assessment*** *application, while for Africa monitoring of the climatic, atmospheric, and ecological impacts of* ***biomass burning*** *was considered the more important issue….*"
(**Pereira and Govaerts, 2001**)

After MSG

"*Detection and systematic monitoring of active fires over the African continent is essential for an accurate assessment of the overall fire activity.... Active fire detection over Europe is essential for early fire warning and for fire prevention****, namely in what respects to a proper calibration of risk of fire indices***"…(**Eumetsat LSA SAF, 2009**)

"Over Africa ... climatic, atmospheric and ecological processes ...thus, detection and monitoring of burning activity, using MSG imagery at the maximum temporal resolution, is the key *to characterize vegetation fires at the higher frequency cycles, e.g. daily or even weekly"……"Fire detection and monitoring over Mediterranean Europe…is* ***also*** *relevant for civil protection and forest protection activities"…(****Amraoui, 2010****)*

Pereira, J.M.C., and Y. Govaerts (2001): Potential Fire Applications from MSG/SEVIRI Observations. Programme Development Department. Technical Memorandum n.7
EUMETSAT LSA SAF (2009). Algorithm theoretical basis document for fire detection and monitoring product (LSA-29). Ref n. SAF/LAND/IM/ATBD_FD&M/02, issue: 0.2, date: 20/10/2009.
Amraoui M. (2010) . Detection and monitoring of active fires in Africa and Europe using MSG SEVIRI imagery. PhD thesys.

RST-FIRES operational implementation in Italian Regions (Sicily 2008, MSG-SEVIRI)

S. Giuseppe Jato, 10 september 2008, pyromaniacs catched

Open issues:

- sensitivity and/or reliability
- exportability (geographical, seasonal, sensors…)
- operational implementation
  (ancillary data and model input required, automation...)

Single image – fixed threshold fire detection algorithms

- **Fixed threshold on single band**

  (Muirhead and Cracknell 1985; Malingreau and Tucker 1988; Setzer and Pereira 1991b, 1992; etc.)

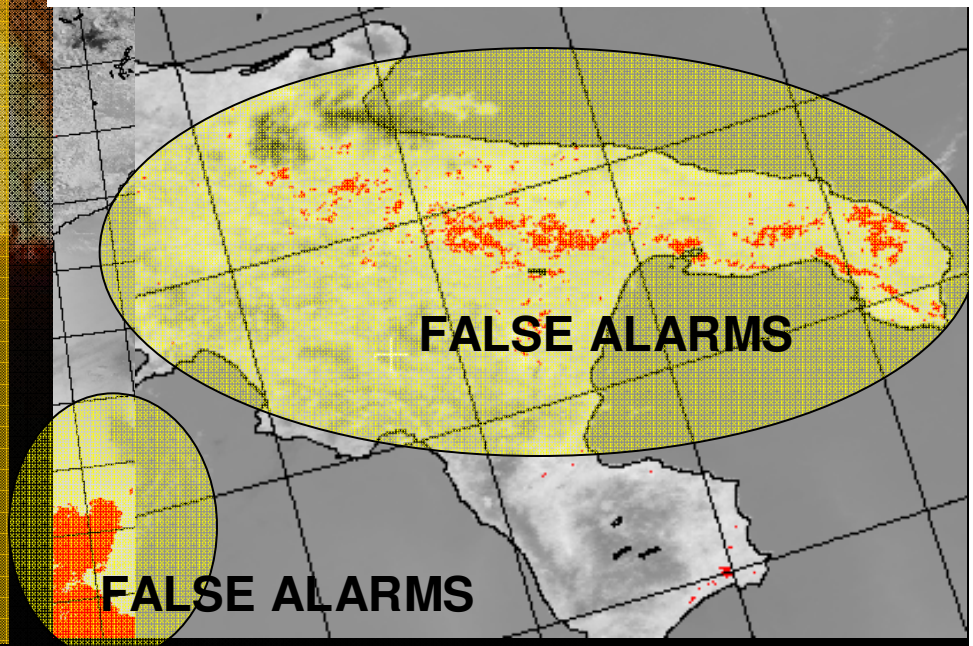
- **Fixed threshold on band combinations**

  (Kaufman et al., 1990; Arino et al., 1993; Kennedy et al., 1993;; Li et al., 2000; etc.)

NOAA-AVHRR

(Kaufman et al. 1990)

South Italy - SUMMER

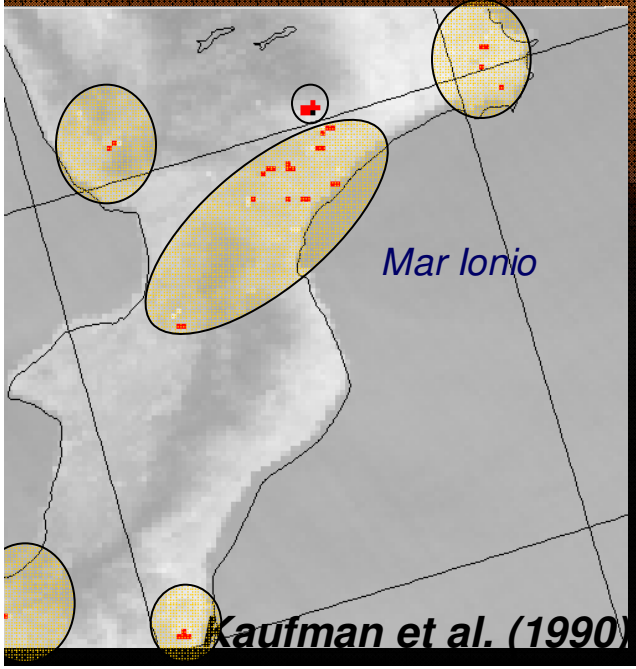


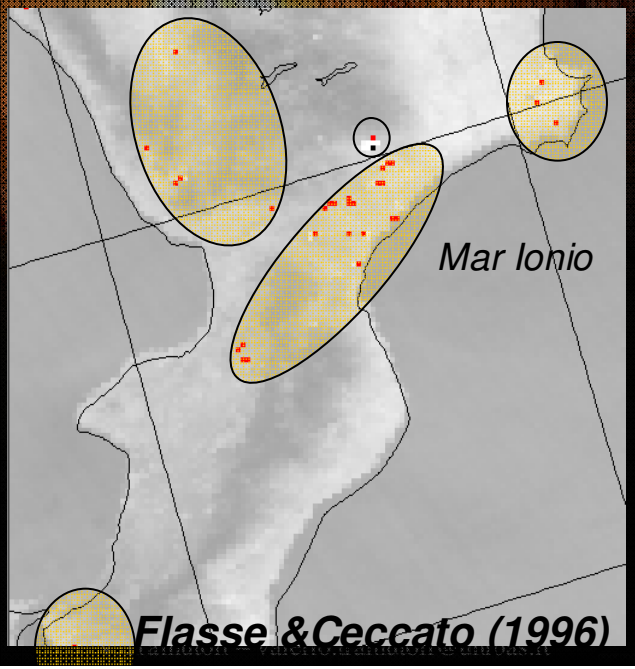
Single image – fixed threshold algorithms

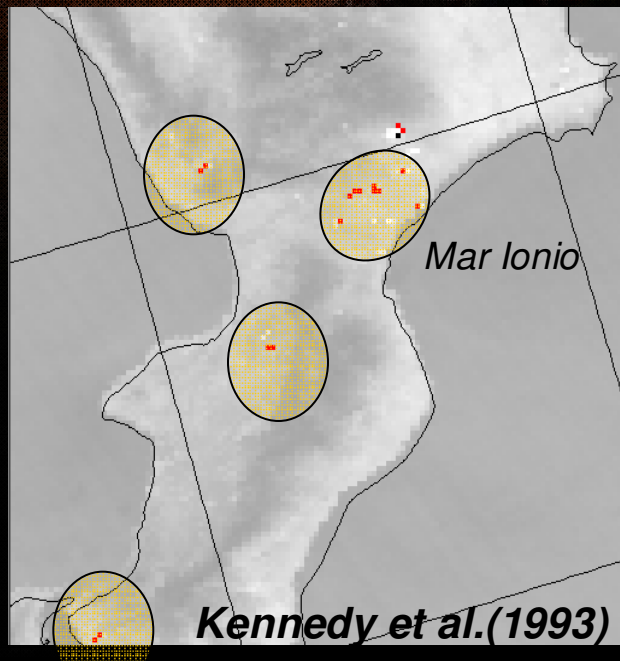
- **Fixed threshold – multi-band** *(Kaufman et al., 1990; Arino et al., 1993; Kennedy et al., 1993; Li et al., 2000; etc.)*
- **Contextual** *(Justice et al., 1996; Flasse e Ceccato, 1996, Lee et al., 2000, Elvidge et al., 1997, Giglio et al., 1999; etc.)*

AVHRR – 5 July 2000 15:00 GMT

FALSE ALLARMS **ACTUAL FIRES** **DETECTED**





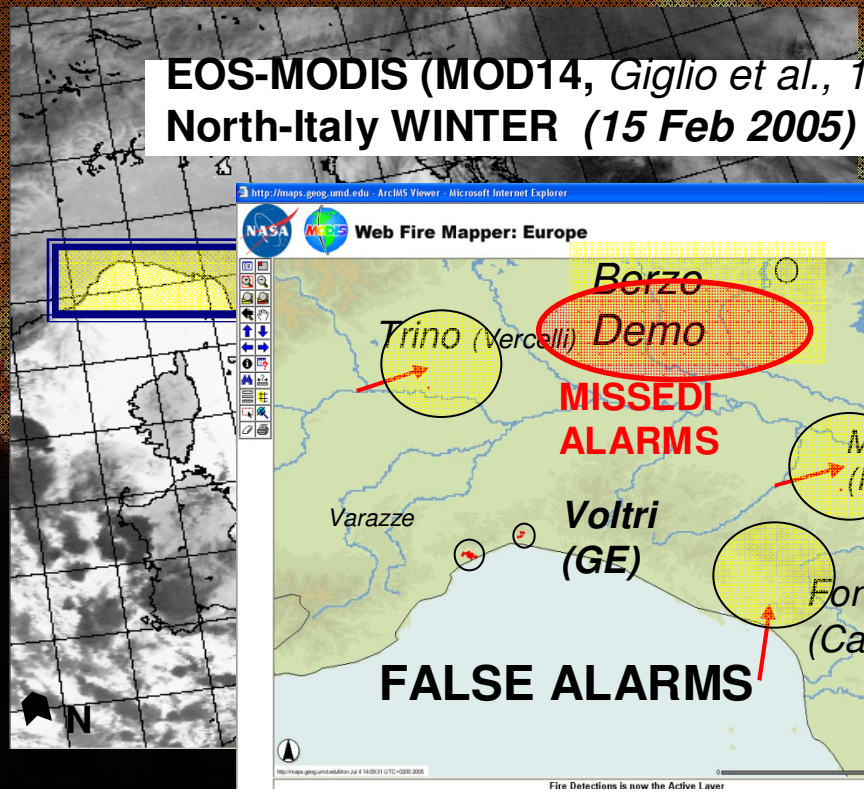


Other algorithms for polar satellites

- **Contextual**

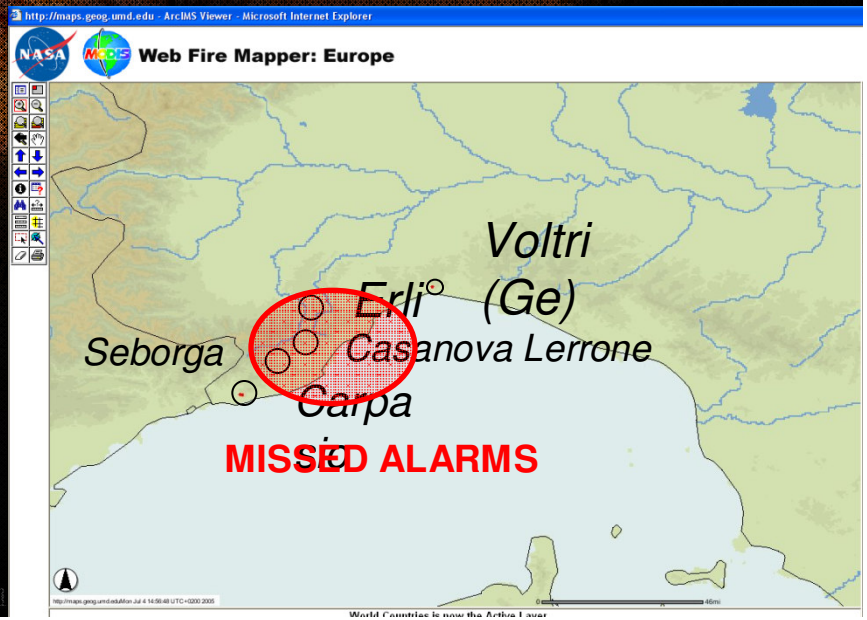
  (Justice et al., 1996; Flasse e Ceccato, 1996, Lee et al., 2000, Elvidge et al., 1997, Giglio et al., 1999; etc.)

- **Multitemporal** *(Pozo et al., 1997, Cuomo et al., 2001; Lasaponara et al., 2003)*

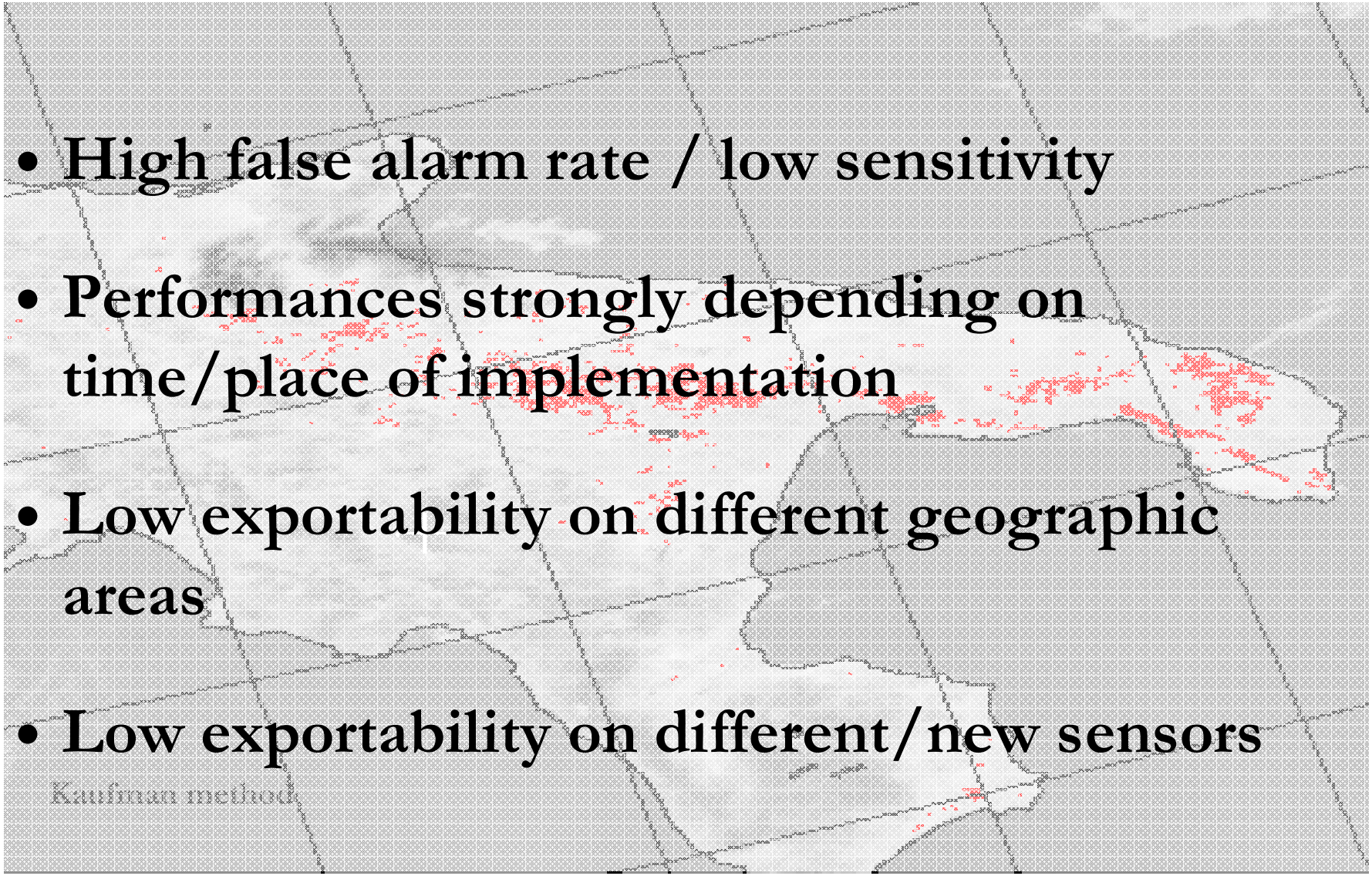


EOS-MODIS (MOD14, *Giglio et al., 1999*)
North-Italy WINTER ***(15 Feb 2005)***

EOS-MODIS (MOD14, *Giglio et al., 1999*)
North-Italy WINTER ***(17 Feb 2005)***

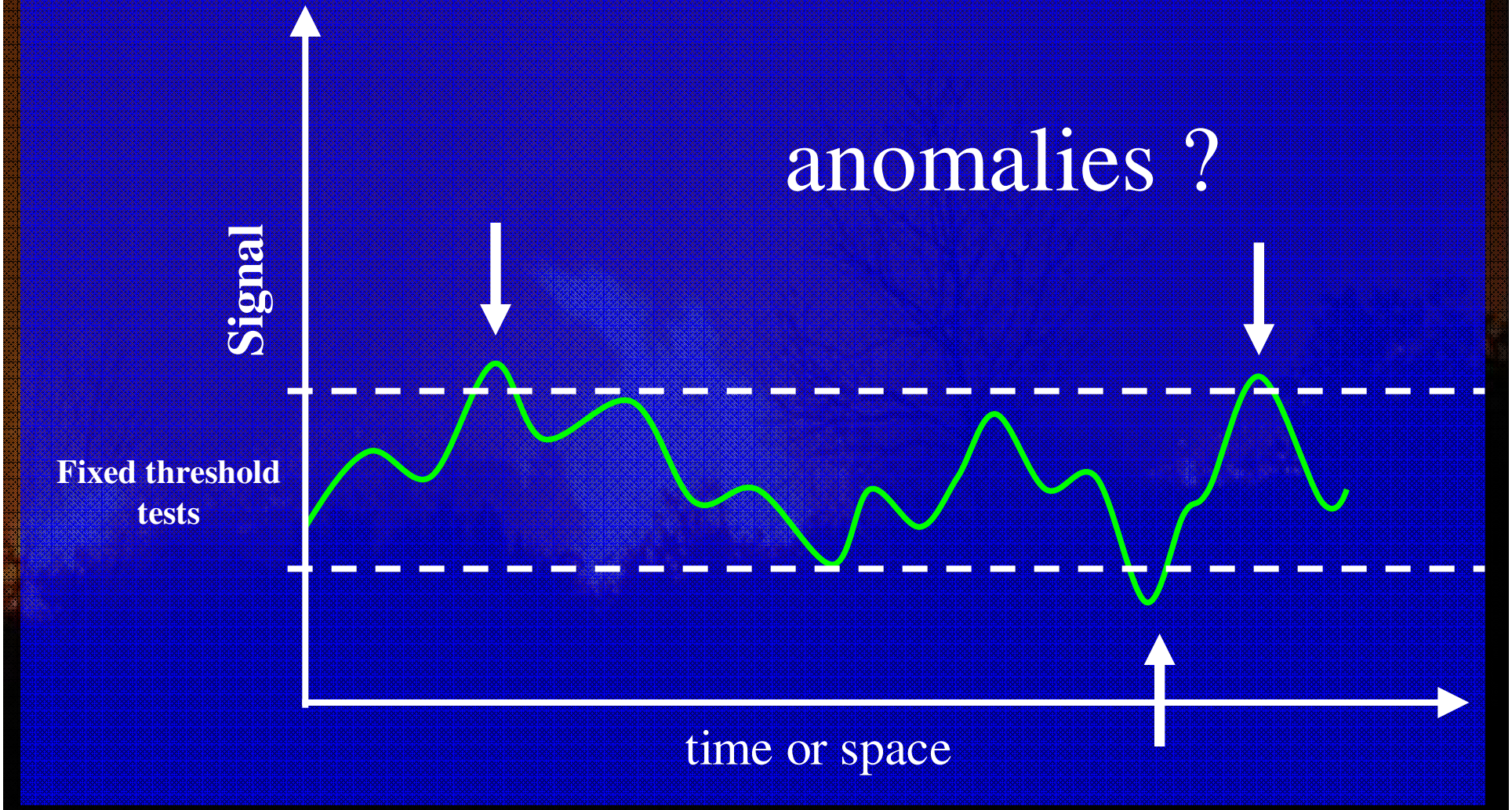


Single image – fixed threshold methods: main issues



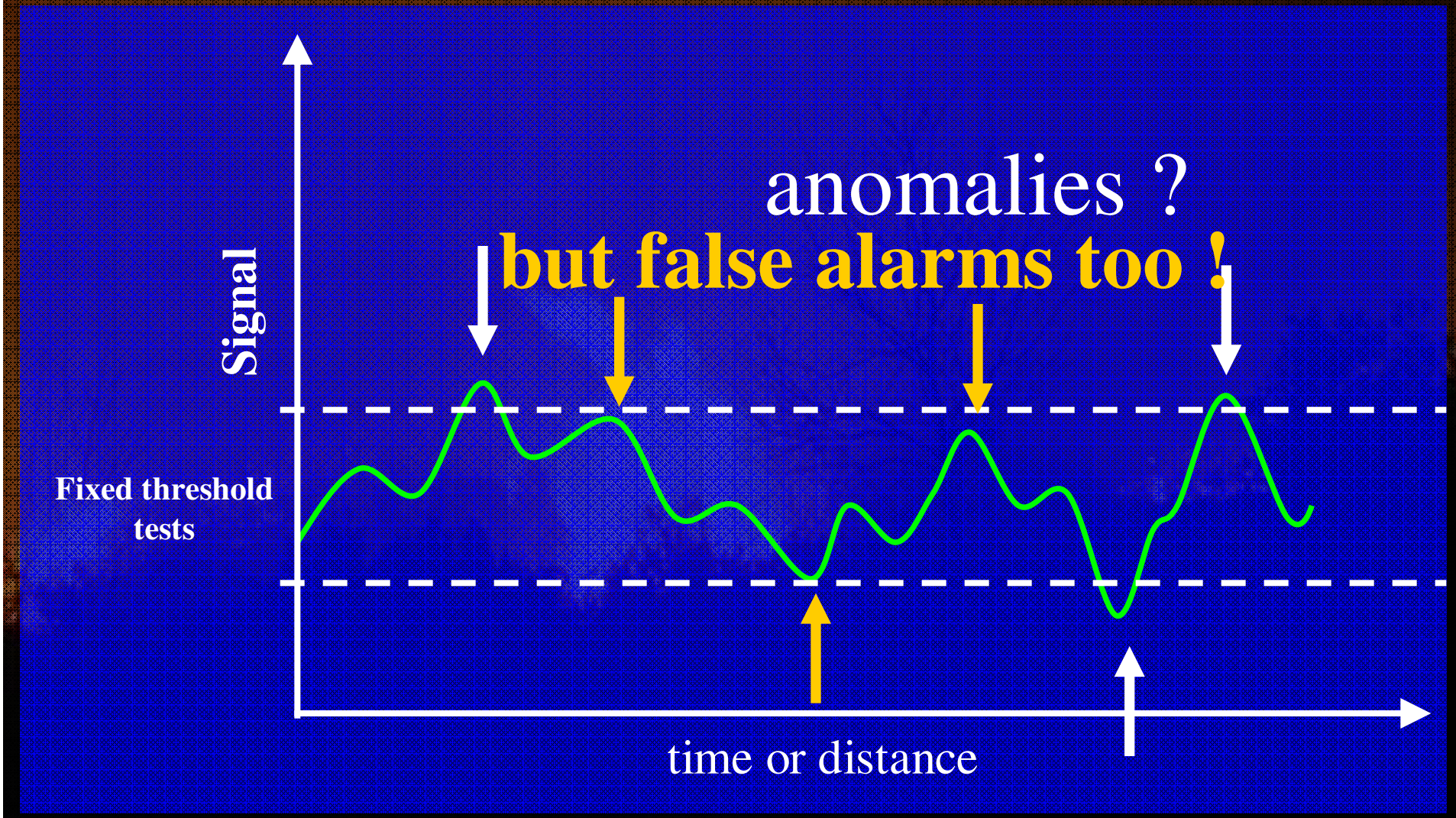
- High false alarm rate / low sensitivity
- Performances strongly depending on time/place of implementation
- Low exportability on different geographic areas
- Low exportability on different/new sensors

Tradictional single image, fixed thresholds, approaches



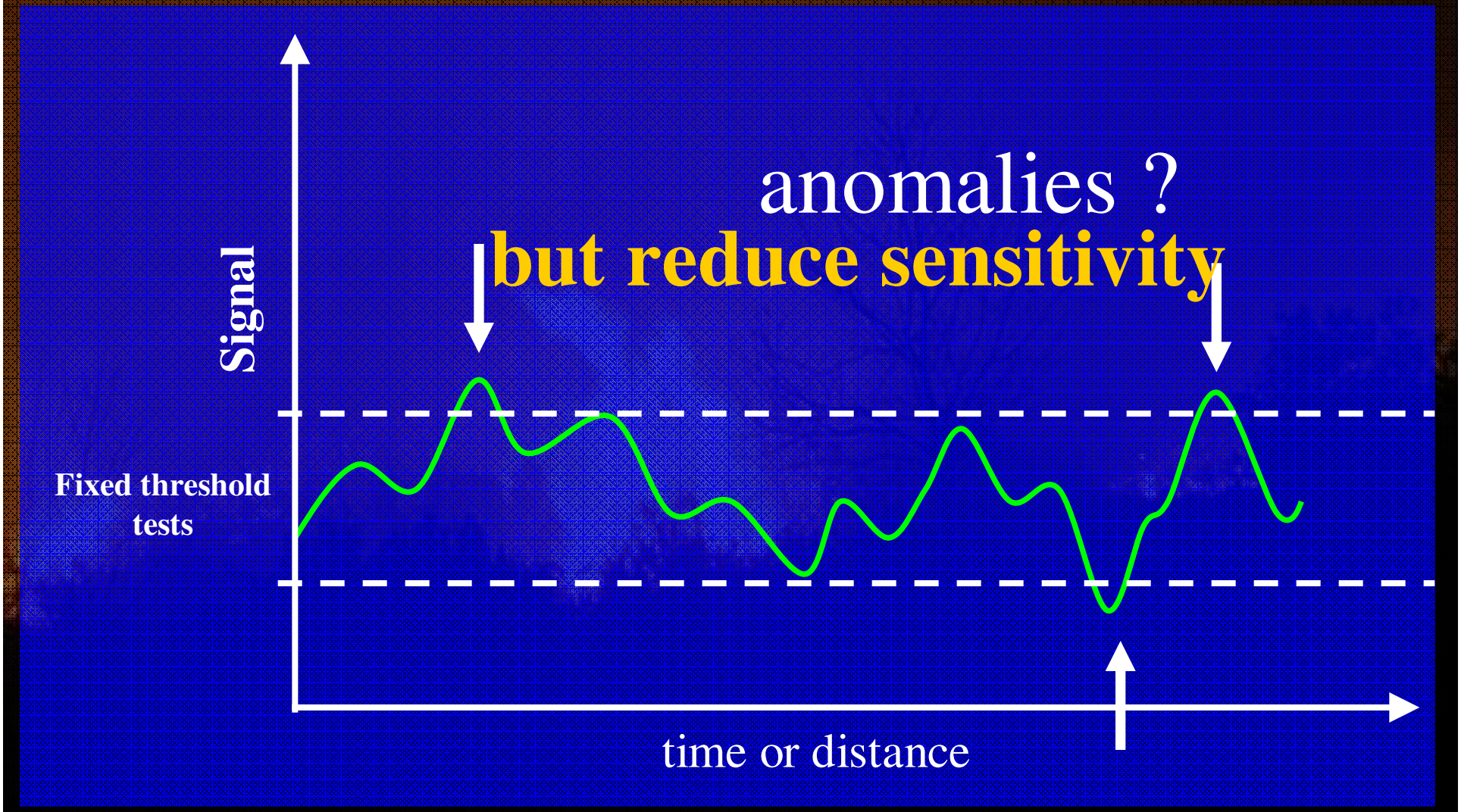
Tradictional single image, fixed thresholds, approaches

lower thresholds increase sensitivity…

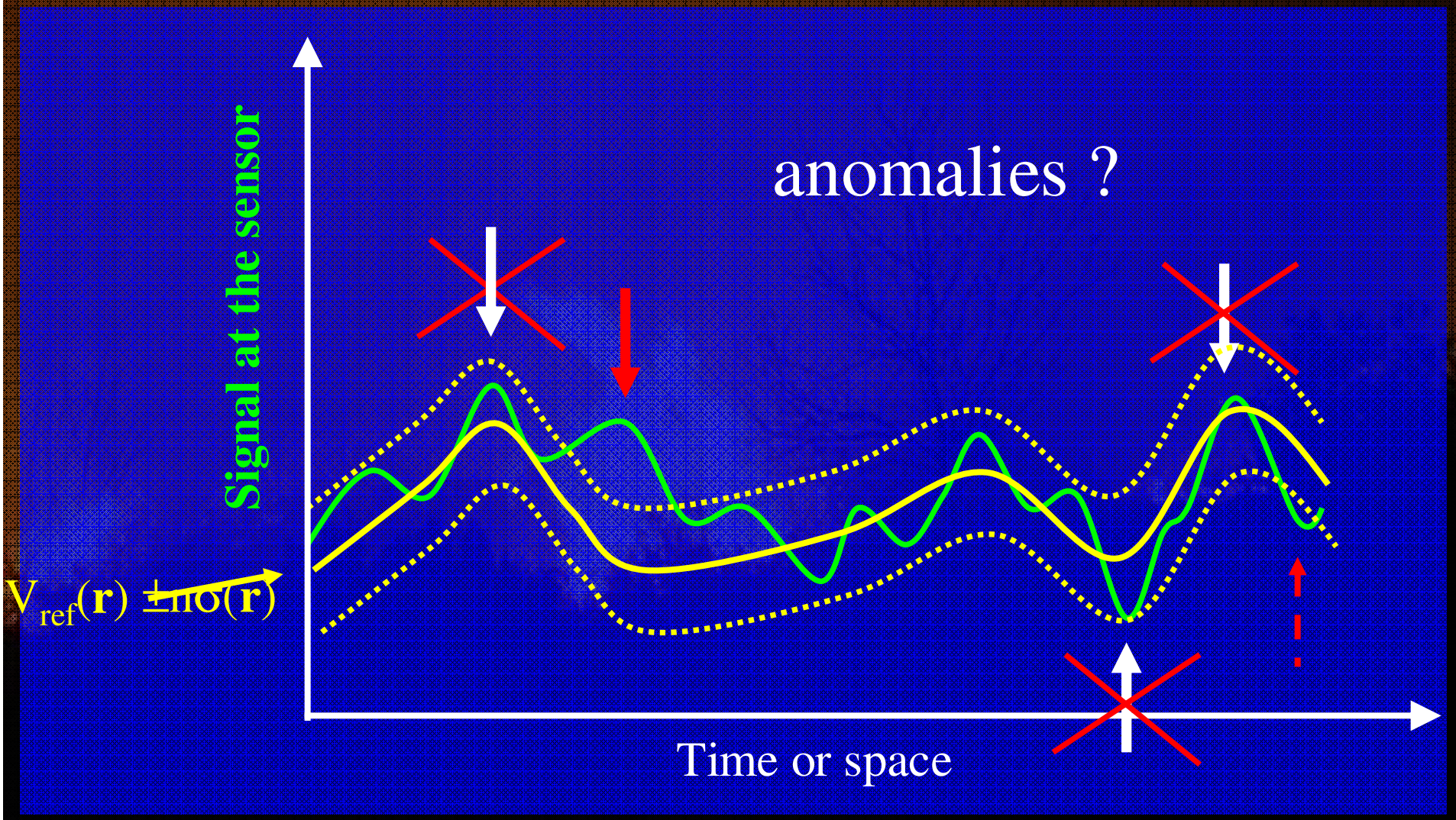


Tradictional single image, fixed thresholds, approaches

higher thresholds increase robustness…



What "anomaly" means ?

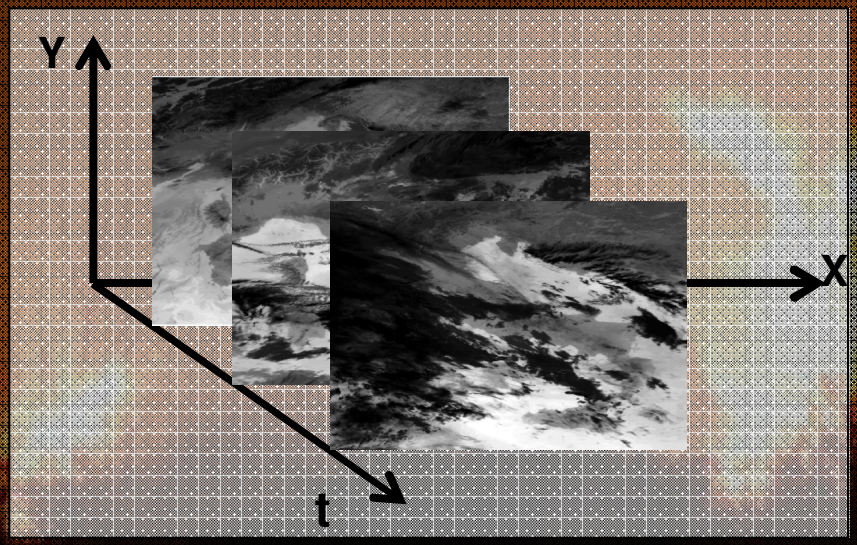


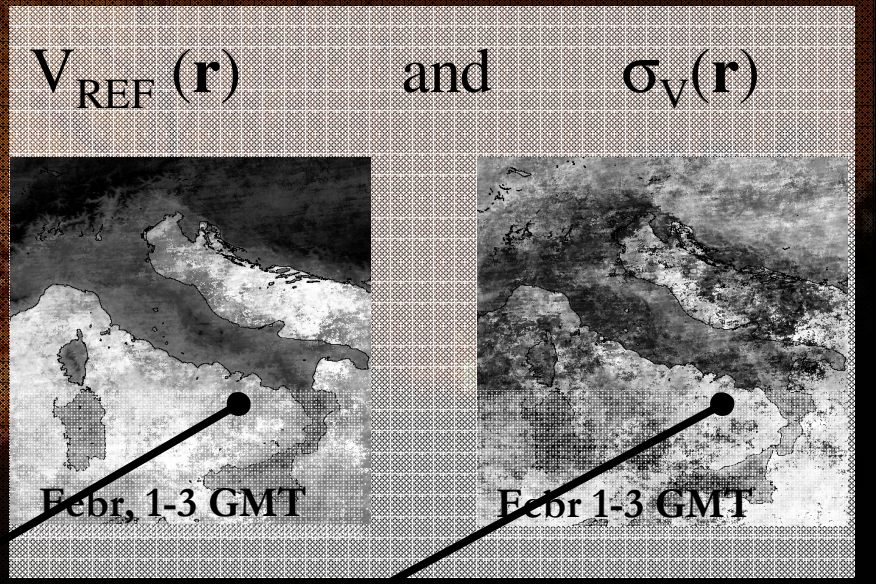
a different approach:

RST (Robust Satellite Techniques)

(formerly **RAT**: **R**obust **A**VHRR **T**echniques, *V.Tramutoli, 1998, 2005,2007*)

- **Computing the unperturbed reference fields for V(r,t) on a multi-temporal long-term HOMOGENEOUS (same time of the day, months of the year, etc.) historical satellite records**





- **Change detection at the time *t* by:**

$$\otimes_V(x,y,t) = \frac{V(x,y,t) - V_{REF}(x,y)}{\sigma_V(x,y)}$$

A.L.I.C.E.

*(**A**bsolutely **L**local **I**ndex of **C**hange of the **E**nvironment)*

15 years of RST Applications

Using several satellite/packages

- NOAA (AVHRR, AMSU)
- EOS (MODIS, AMSRE)
- METEOSAT, MSG (SEVIRI and GERB), MTSAT, GOES

from Visible to the IR and Microwave spectral range

Recently successfully applied also to ground observations (e.g., Nunnari et al., 2008)

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15 years of RST Applications

For two main classes of environmental processes:

short scale changes

- Volcanic eruptions (*e.g. Remote Sens. of Env.*, 2004a, 2004b, 2007, 2011)
- Forest fires detection (e.g *Int. J. of Rem. Sens*, 2001, *ICFFR, 2010*)
- Oil spill and water monitoring (*NHESS*, 2011, *Int. J. Rem. Sens.*, 2011, *AGU Books*, 2011)
- Cloud-detection (e.g. *Atmosph. Research.*, 2004)
- Radio interference monitoring (*IGARSS 2010, IEEE-TGRS 2012*)
- Energy production and transport systems monitoring (*IGARSS 2010, IEEE-TGRS 2012*)
- Rapid alert for security purposes (*Multitemp 2007., Springer Verlag Book*, 2009)

medium, long scale, changes

- Dust storms, air quality and pollution monitoring (*IRS, 2001, Multitemp* 2009, *IGARSS, 2009)*
- Soil Wetness and monitoring (e.g., *Rem. Sens. Env., 2005*, 2010a, 2010b, *Phys. Chem. Earth*,. 2006)
- Flood monitoring and mapping (*Int. J. Rem.Sens.., 2010, Multitemp* 2009)
- Earthquakes precursors (*Phy. Chem.Earth, 2004, Rem.Sens.Env.,2005, Tectonoph., 2007, NHESS , 2009 °-b, 2010)*

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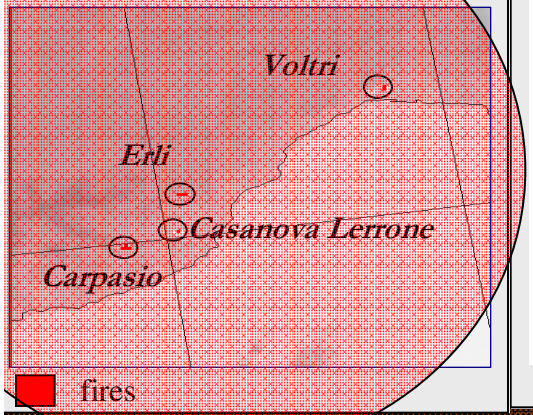
15 years of RST Applications

Forest fires

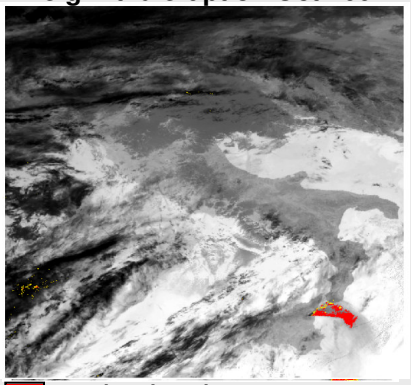
e.g. Fires in Italy, February 2005



fires

Volcanic Eruptions

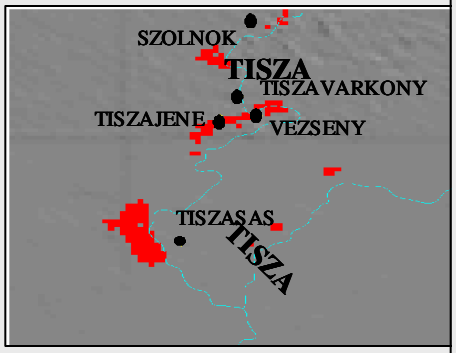
e.g. Etna eruption Oct 2002



Ash Clouds

Floods

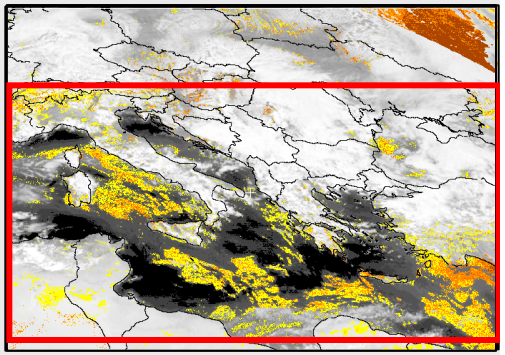
e.g. Ungary flood, April 2002



Flooded areas

Dust storms

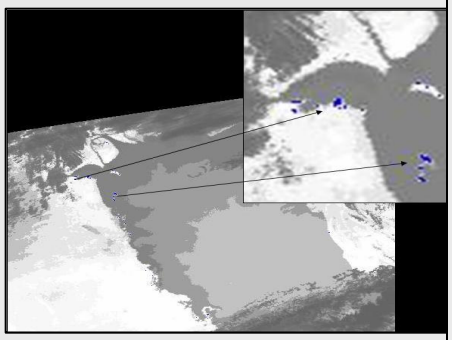
e.g.Libia 13 May 2004



Dust clouds

Oil spills

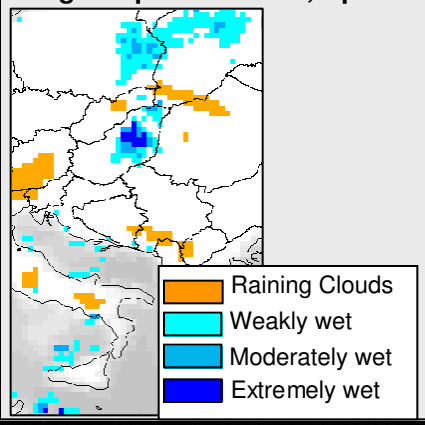
e.g. Oil spill in the Persic Gulf, January 1991



Oil spill

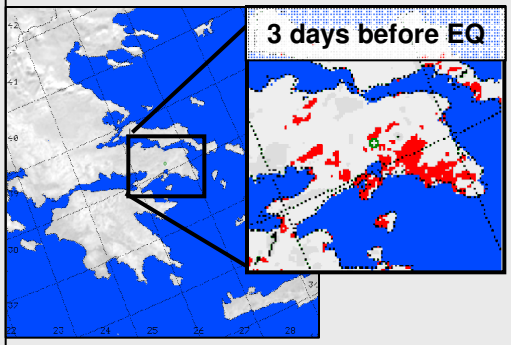
Soil wetness

e.g. Carpathian Basin, April 2000



Earthquakes

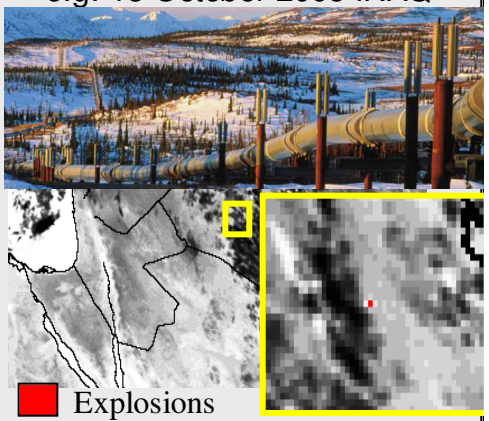
e.g. 7 September 1999 Athens Earthquake



Thermal anomalies

Infrastructures

e.g. 18 October 2005 IRAQ



Explosions

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RST-FIRES Approach

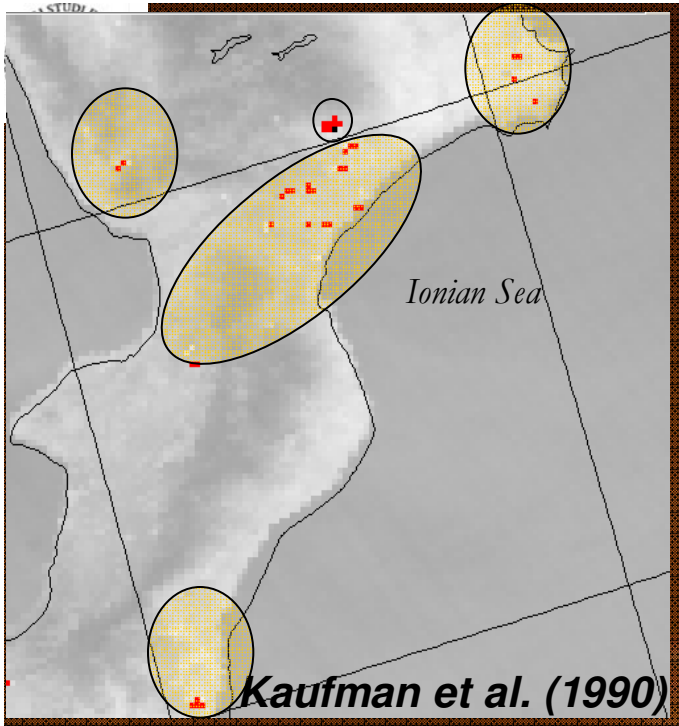
$$\otimes_V (x,y,t) = \frac{[V(x,y,t) - \mu_V(x,y)]}{\sigma_V(x,y)}$$

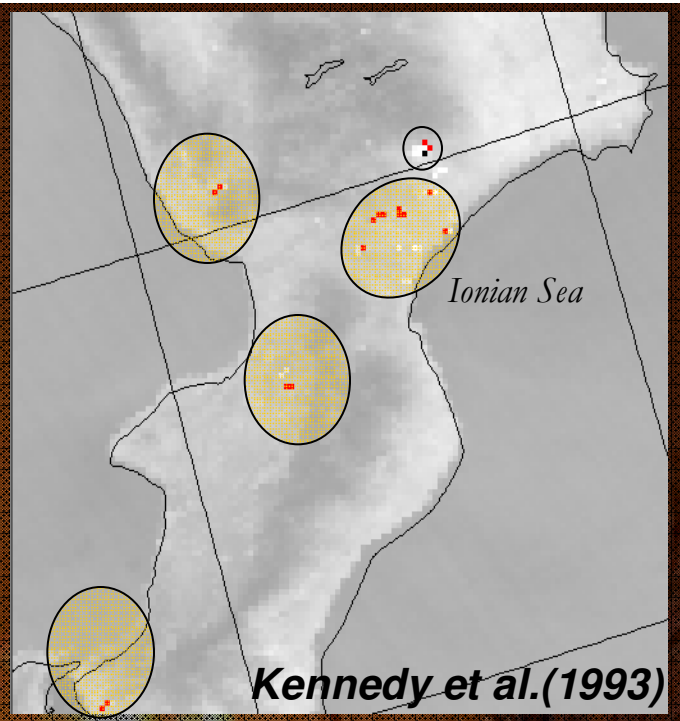
Generic RST ALICE index

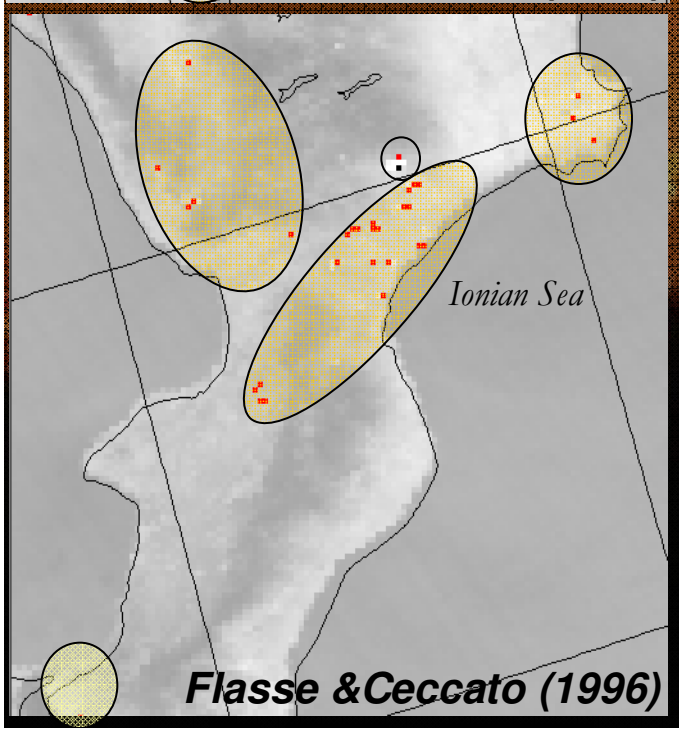
$$\otimes_{MIR} (x,y,t) = \frac{[T_{MIR}(x,y,t) - \mu_{MIR}(x,y)]}{\sigma_{MIR}(x,y)}$$

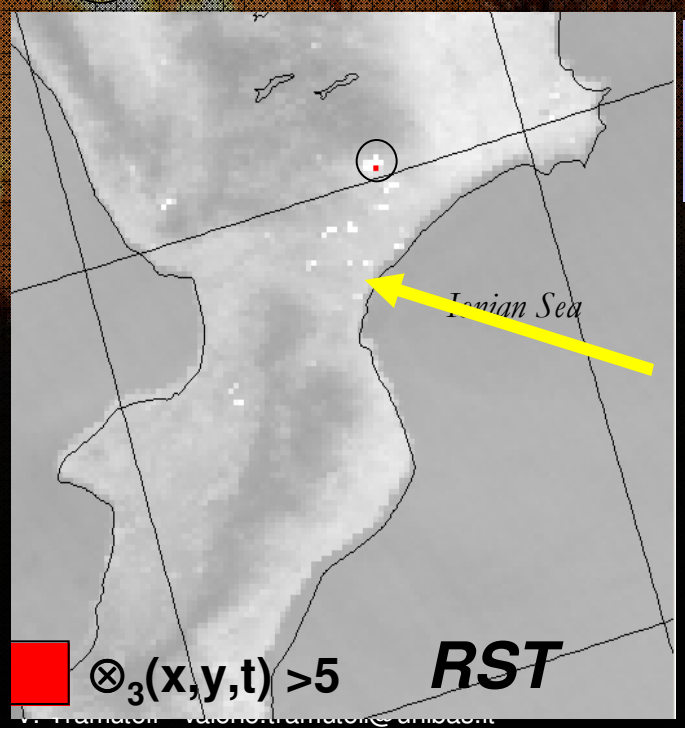
For Polar satellites (MODIS, AVHRR, etc.)

RST reliability









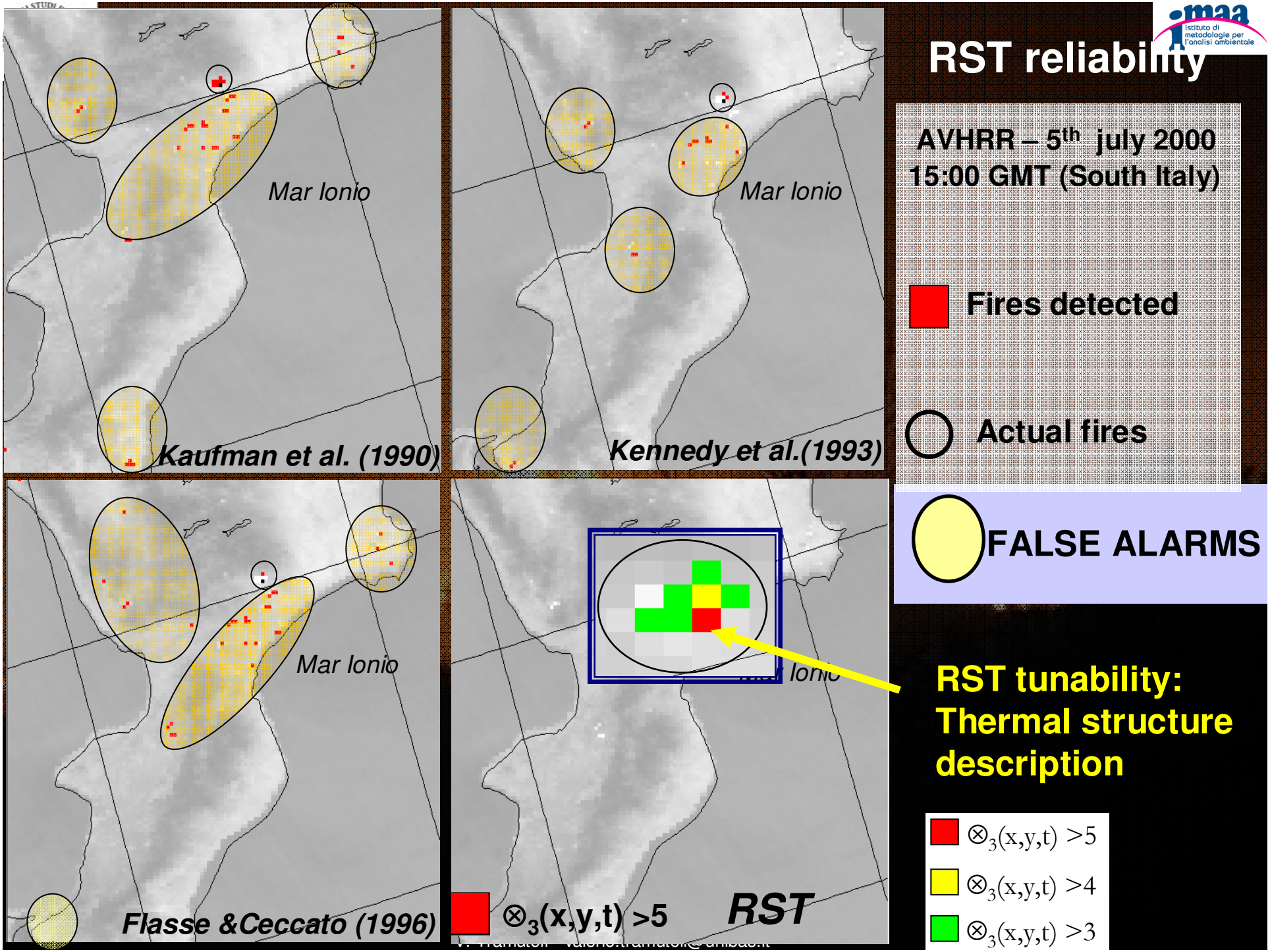
AVHRR – 5th july 2000
15:00 GMT (South Italy)

Fires detected

Actual fires

FALSE ALARMS

NO FALSE ALARMS

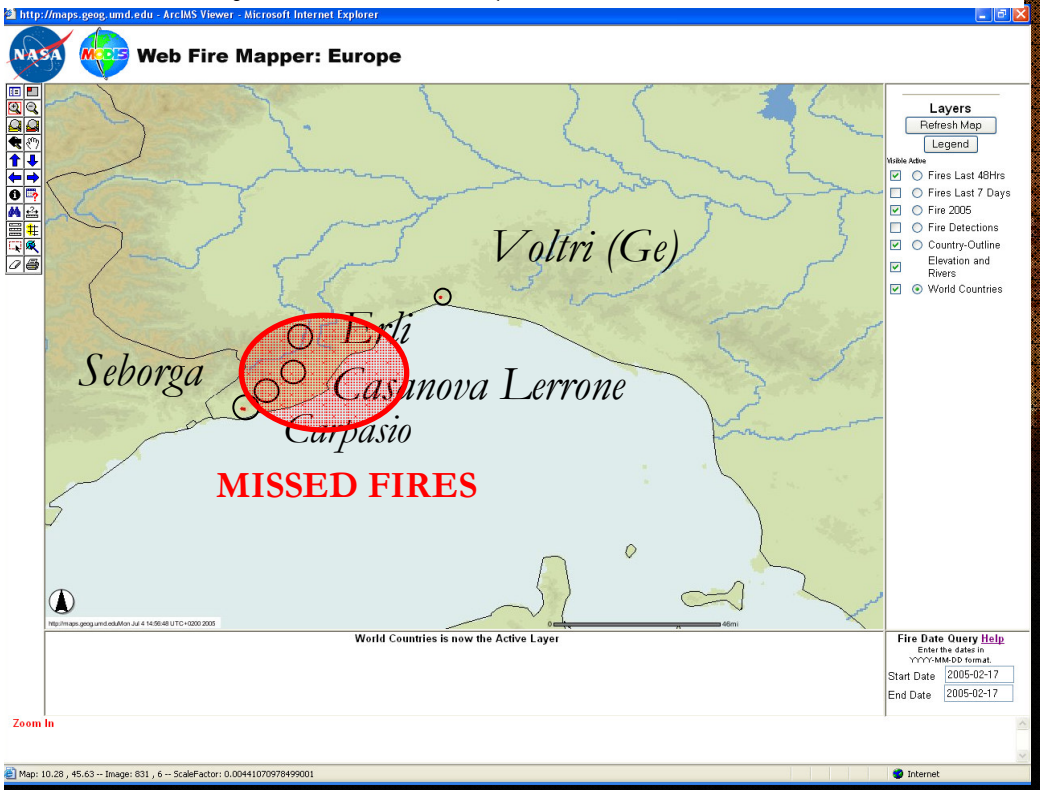

RST reliability
AVHRR – 5th july 2000
15:00 GMT (South Italy)
Fires detected
Actual fires
FALSE ALARMS
Mar Ionio
Kaufman et al. (1990)
Kennedy et al.(1993)
Flasse &Ceccato (1996)
⊗3(x,y,t) >5
RST
RST tunability:
Thermal structure
description
⊗3(x,y,t) >5
⊗3(x,y,t) >4
⊗3(x,y,t) >3

Fire Detection by MODIS

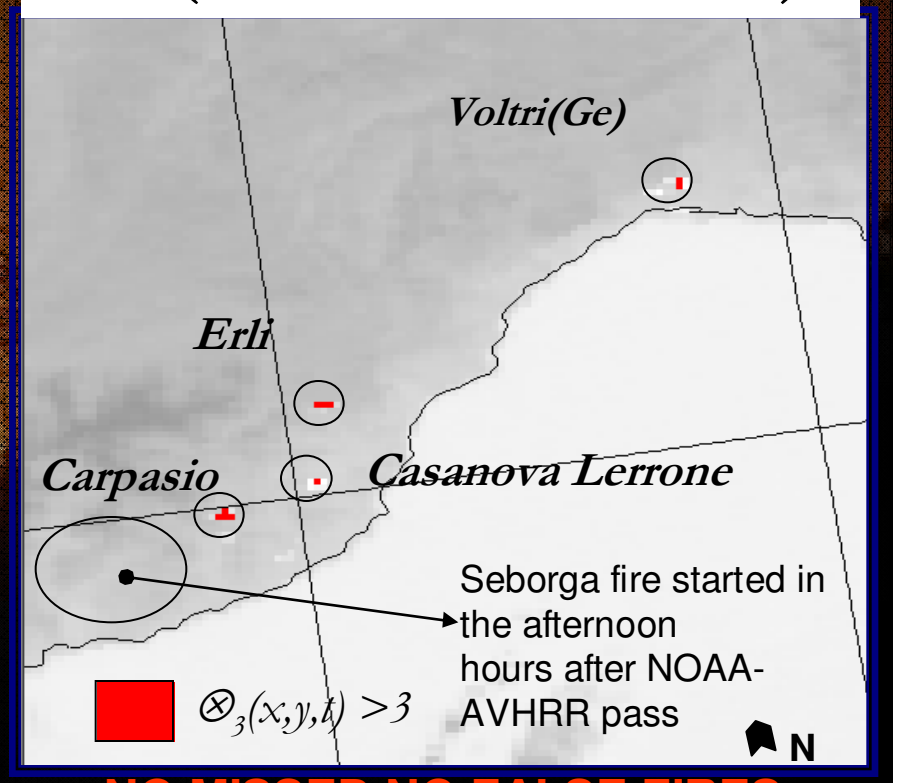
$$\otimes_{MIR}(x,y,t) \equiv \frac{T_{MIR}(x,y,t) - \mu_{MIR}(x,y)}{\sigma_{MIR}(x,y)}$$

EOS-MODIS (MOD14-algorithm)

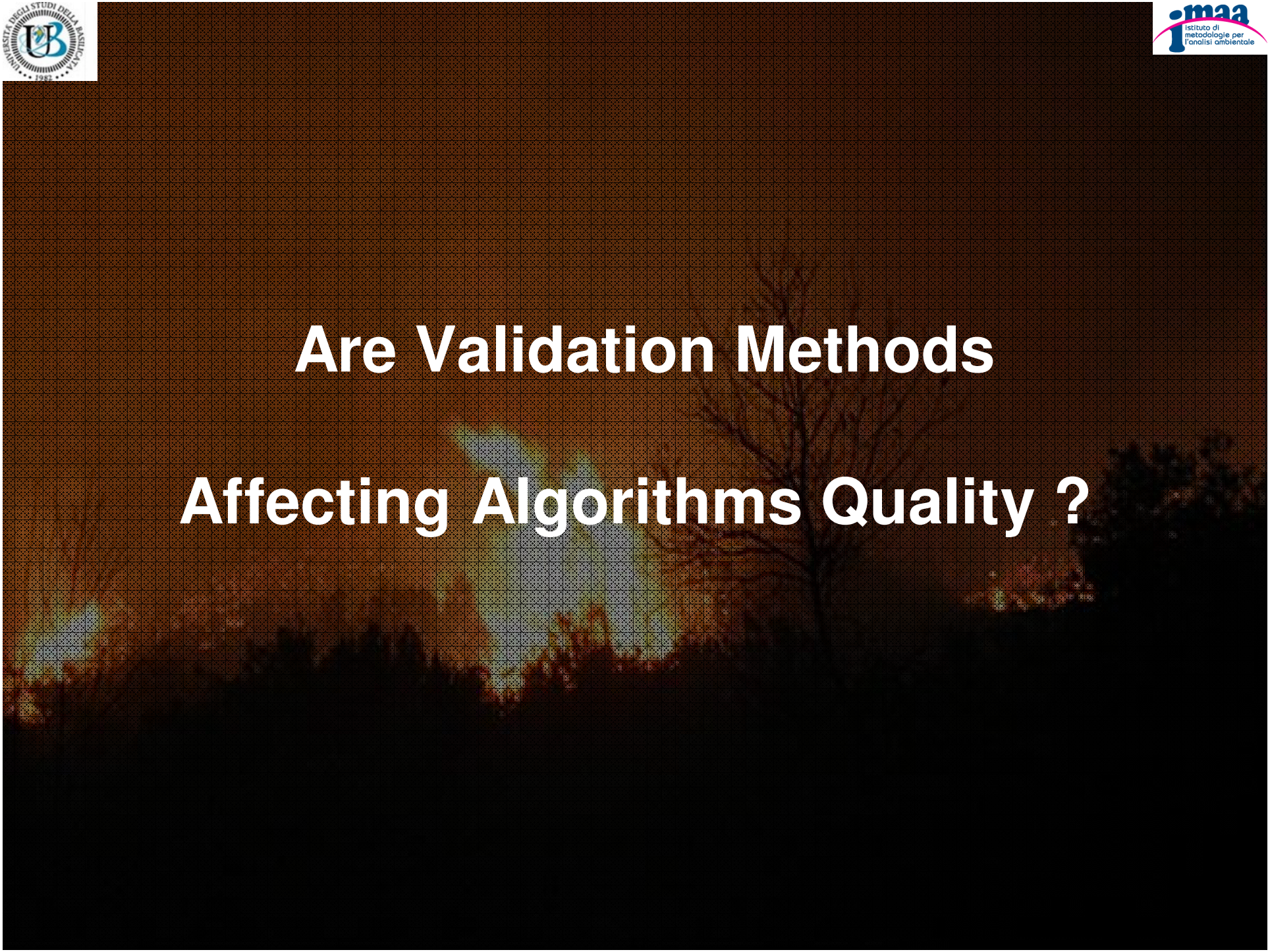
North-Italy WINTER (***17 Feb 2005 24 h***)



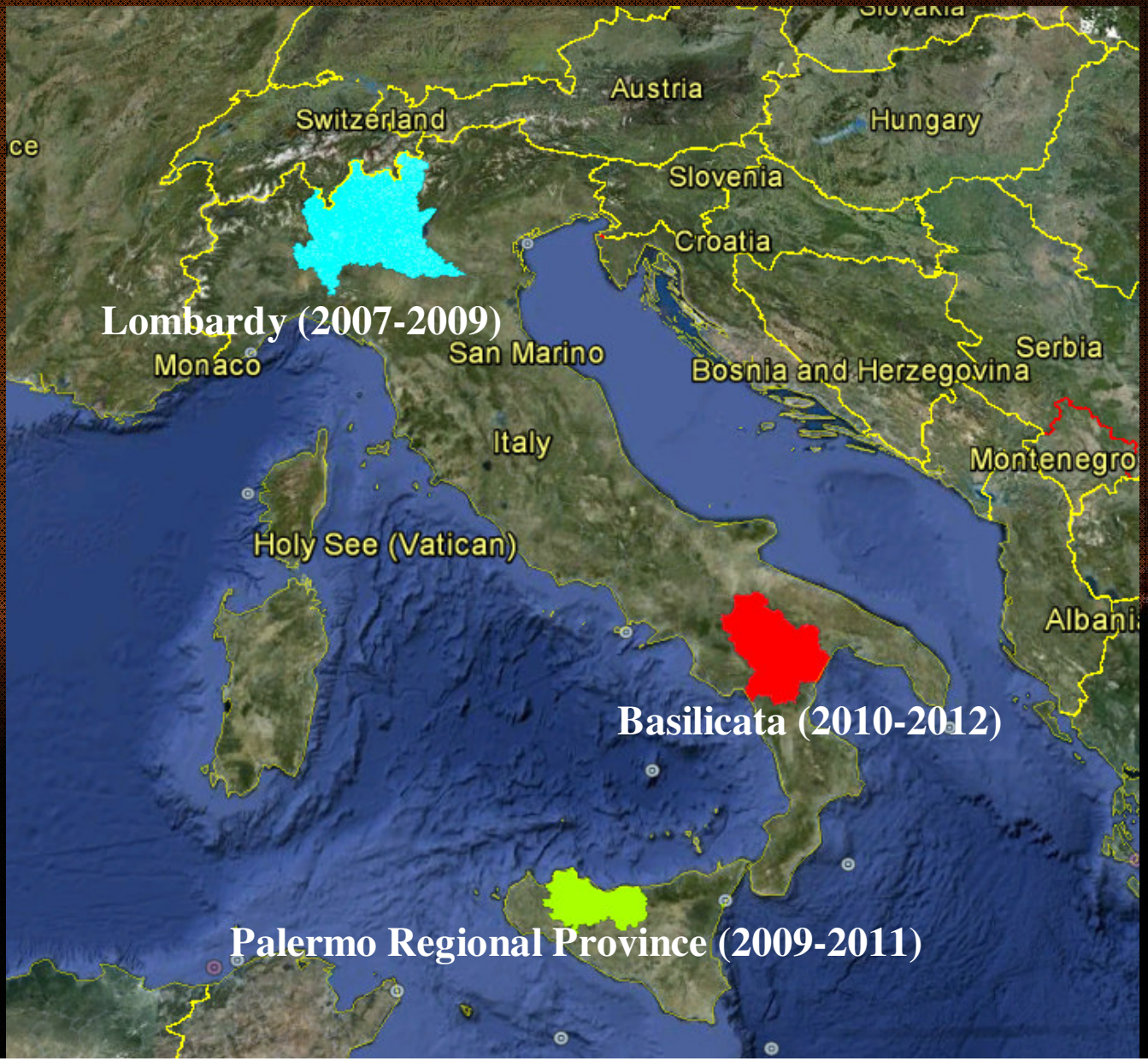
RST (AVHRR at 1:00 GMT)



NO MISSED NO FALSE FIRES


Are Validation Methods
Affecting Algorithms Quality ?

The Total Validation Experiments In Italy (2007-2012)



Traditional "a posteriori" Validation Approach

A posteriori Validation	**official databases** of occurred fires, compiled by local agencies

affected by filling mistakes

- time of occurrence
- duration of an event (start and end time)
- the exact localization
- may be also incomplete about "all" the occurred events

- **fires that spread in remote and uninhabited area**
- **events just temporarily noted but then deleted when no significant fire develops**
- **very small fires - the agencies do not act on them (*according to legal requirements*)**

biased towards large events, not so punctual and reliable, erroneously flagging all thermal anomalies, detected in correspondence of unregistered events, as false alarms !

MOST FREQUENTLY USED VALIDATION METHODS

Visual inspection (MIR images)

- Only fires with a large contrast between fire-affected pixel and surrounding pixels may be visually identified (no small/starting fires).

Information registered in official databases

- Results depend on minimum size registered events (sometimes variable during the time, e.g. from 0.1 ha in 1980–1990 to 0.001 ha in 1992–2005 for the Portugal rural database), completeness and correctness of registers, fire type (forest, burning stubbles, etc), etc.

Sensor-to-sensor comparison (MODIS, BIRD, ASTER, ETM+, ...)

- depends on strategies for taking into account for differences of satellite data in terms of spatial and temporal resolution (sometimes also spectral characteristics). Even complicated strategies should be found (e.g. Calle et al., 2008; EUMETSAT LSA SAF, 2009) or, at least, different comparison scales should be considered (e.g. like in Roberts and Wooster, 2008).
- comparison with polar satellites implies restriction due to their limited number of passages per day than geostationary.

Validation campaigns

- Use of aircraft validation campaigns/experiments was one of recommendations of GOFC-GOLD 2006

Calle, A., F. González-Alonso, S. Merino De Miguel (2008). International Journal of Remote Sensing, vol. 29 (12), pp. 3407 - 3415. ISSN 0143-1161.

EUMETSAT LSA SAF (2009). Algorithm theoretical basis document for fire detection and monitoring product (LSA-29). Ref n. SAF/LAND/IM/ATBD_FD&M/02, issue: 0.2, date: 20/10/2009.

Pereira, M. G., B. D. Malamud, R. M. Trigo, P. I. Alves (2011). The history and characteristics of the 1980–2005 Portuguese rural fire database. Nat. Hazards Earth Syst. Sci., vol. 11, pp. 3343–3358

Roberts, G. J. and M. J. Wooster (2008). Fire Detection and Fire Characterization Over Africa Using Meteosat SEVIRI. IEEE TRANSACTION on Geoscience and Remote Sensing, Vol. 46 (4), pp. 1200-1218.

Total Validation Approach (TVA)

TVA
Total Validation Approach

systematic ground or aerial check of the origin of the RST fires submitted to validation

working together with local agencies and decision makers

- made in a pre-operative scenario
- statistics based only on the analysis of thermal anomalies submitted to direct inspection

TVA allows us to recognize several thermal anomalies (associated to small fires, to variations of thermal emission in industrial plants, etc.) are not false alarms even if they are not associated to officially documented forest fires

Lombardy TVA

Capannone industriale in area residenziale

Pozze d'acqua

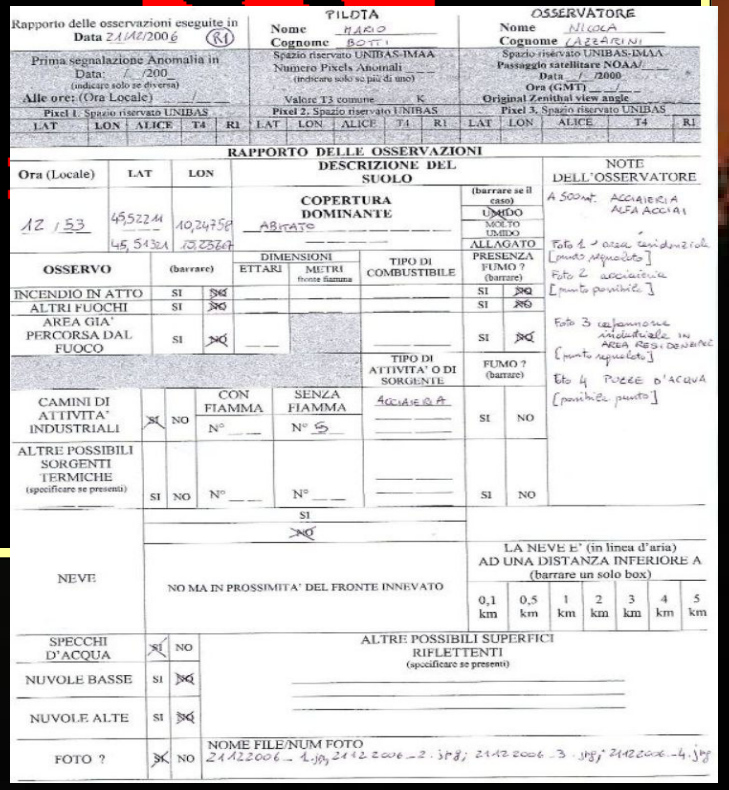
Area residenziale

Centro del pixel

Possibile sorgente

Acciaieria

Cluster 1 (Brescia)



PILOTA
Nome MARIO
Cognome BOSTI

OSSERVATORE
Nome NICOLA
Cognome LAZZARINI

Rapporto delle osservazioni eseguite in Data 21/12/2006

RAPPORTO DELLE OSSERVAZIONI

Ora (Locale)	LAT	LON	DESCRIZIONE DEL SUOLO	NOTE DELL'OSSERVATORE
12 / 53	45,52211 / 45,51321	10,24758 / 10,23367	COPERTURA DOMINANTE: ABITATO (barrare se il caso) UMIDO / SECCO / UMIDO / ALLAGATO	A 500mt. ACCIAIERIA ALFA ACCIAI

OSSERVO	(barrare)		DIMENSIONI ETTARI	DIMENSIONI METRI (fronte fiamma)	TIPO DI COMBUSTIBILE	PRESENZA FUMO ? (barrare)	
INCENDIO IN ATTO	SI	NO				SI	NO
ALTRI FUOCHI	SI	NO				SI	NO
AREA GIA' PERCORSA DAL FUOCO	SI	NO				SI	NO

			CON FIAMMA	SENZA FIAMMA	TIPO DI ATTIVITA' O DI SORGENTE	FUMO ? (barrare)	
CAMINI DI ATTIVITA' INDUSTRIALI	SI	NO	N°	N° 5	ACCIAIERIA	SI	NO
ALTRE POSSIBILI SORGENTI TERMICHE (specificare se presenti)	SI	NO	N°	N°		SI	NO

Foto 1 / area residenziale [punto segnalato]
Foto 2 acciaieria [punto possibile]
Foto 3 capannone industriale in AREA RESIDENZIALE [punto segnalato]
Foto 4 POZZE D'ACQUA [possibile punto]

NEVE	SI		LA NEVE E' (in linea d'aria) AD UNA DISTANZA INFERIORE A (barrare un solo box): 0,1 km / 0,5 km / 1 km / 2 km / 3 km / 4 km / 5 km
	NO	NO MA IN PROSSIMITA' DEL FRONTE INNEVATO	
SPECCHI D'ACQUA	SI	NO	ALTRE POSSIBILI SUPERFICI RIFLETTENTI (specificare se presenti)
NUVOLE BASSE	SI	NO	
NUVOLE ALTE	SI	NO	
FOTO ?	SI	NO	NOME FILE/NUM FOTO 21122006_1.jpg; 21122006_2.jpg; 21122006_3.jpg; 21122006_4.jpg

AVVISA

Lombardy TVA

Exclusion map for industrial (thermally variable) hot spots

Cluster 1: Brescia, 45.5061N 10.2558E

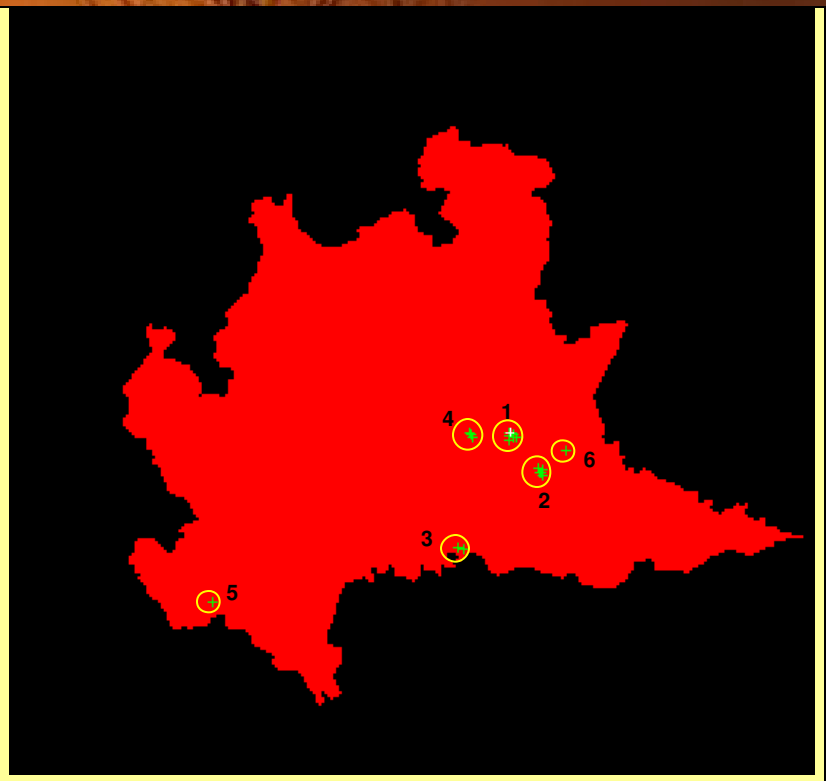
Cluster 2: Calvisano, 45.3744N 10.3472E

Cluster 3: Spinadesco, 45.1488N 9.9472E

Cluster 4: Travagliato, 45.5511N 10.0761E

Cluster 5: Ferrera Erbognone, 45.1025N 8.8363E

Cluster 6: Lonato, 45.4231N 10.4689E



AVVISA

Traditional "a posteriori" Validation Approach

One example from Lombardy Region (February 2005)

Validation Font Forestry Service + Ground Check	Forest fires occurred and actually observable	Detected Fires		Other Anomalies Reported	
				Related to other thermal sources	Not related (False Positives)
RST-FIRES (AVHRR)	19 (8 < 1 ha)	6	32%	51	0
MOD14-FIRE MAPPER (MODIS)	37 (22 < 1 ha)	0	0%	5	4
WORLD FIRE ATLAS (AATSR)	8 (6 < 1 ha)	0	0%	0	0

Lombardy TVA: first lessons learnt

Many kinds of ***actual hot sources*** are able to produce thermal anomalies, otherwise calssified simly as false alarms by traditional *a-posteriori* validation like:

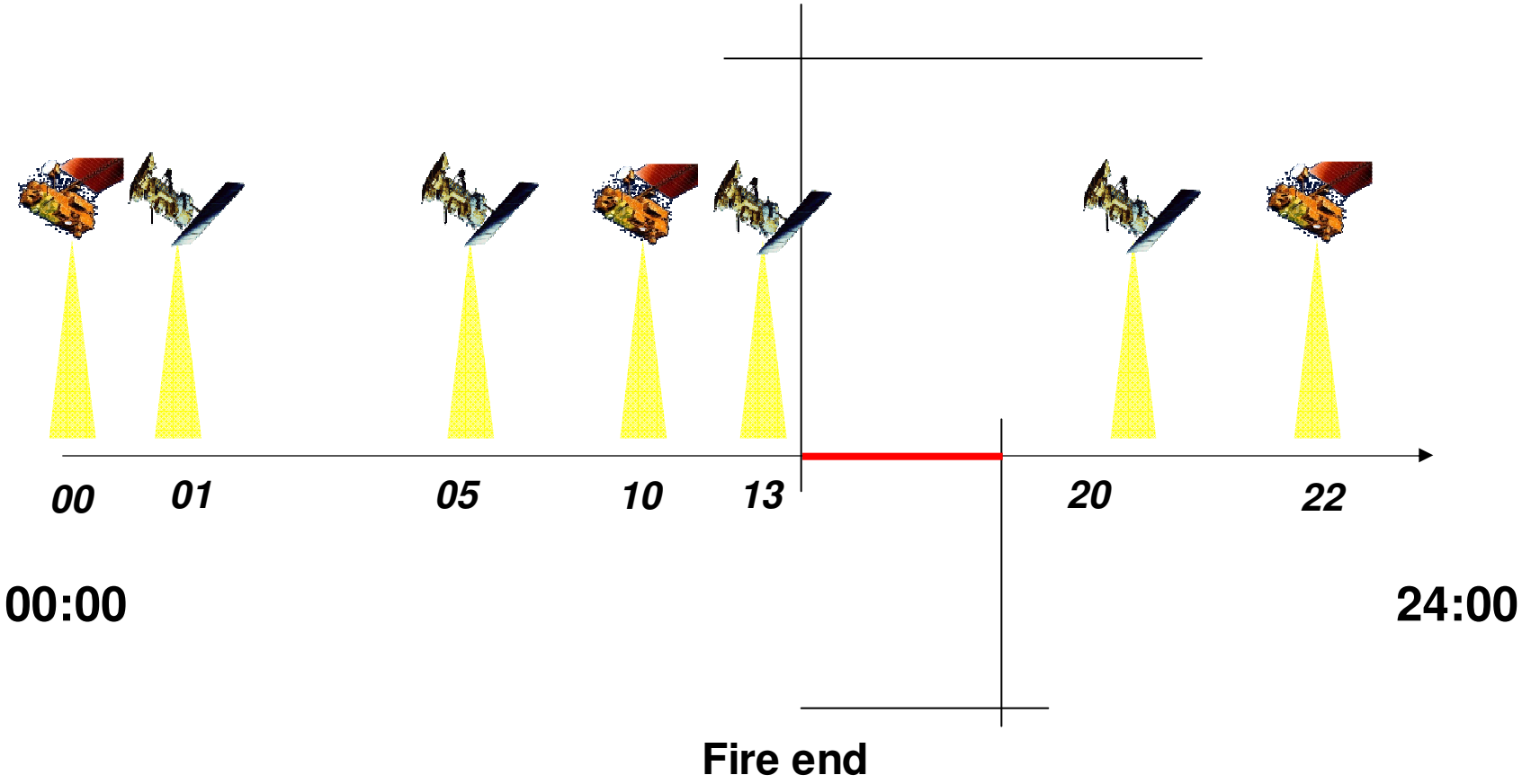
1. ***Small fires*** ***(burnt area less than 0.2 ha)***
2. ***Unsighted or late-sighted fires*** ***(due to their remote position respect to ground traditional monitoring systems)***
3. ***Cleaning fires*** ***(like burning stubbles, burning reeds, etc.)***
4. ***Anthropic accidents*** ***(like explosions, industrial accidents, etc.)***
5. ***Industrial plants***

Moving from polar to geostationary satellite:
Higher repetition rate

Curtatone (Mantova) – 13 February 2005

Es.: NOAA-AVHRR

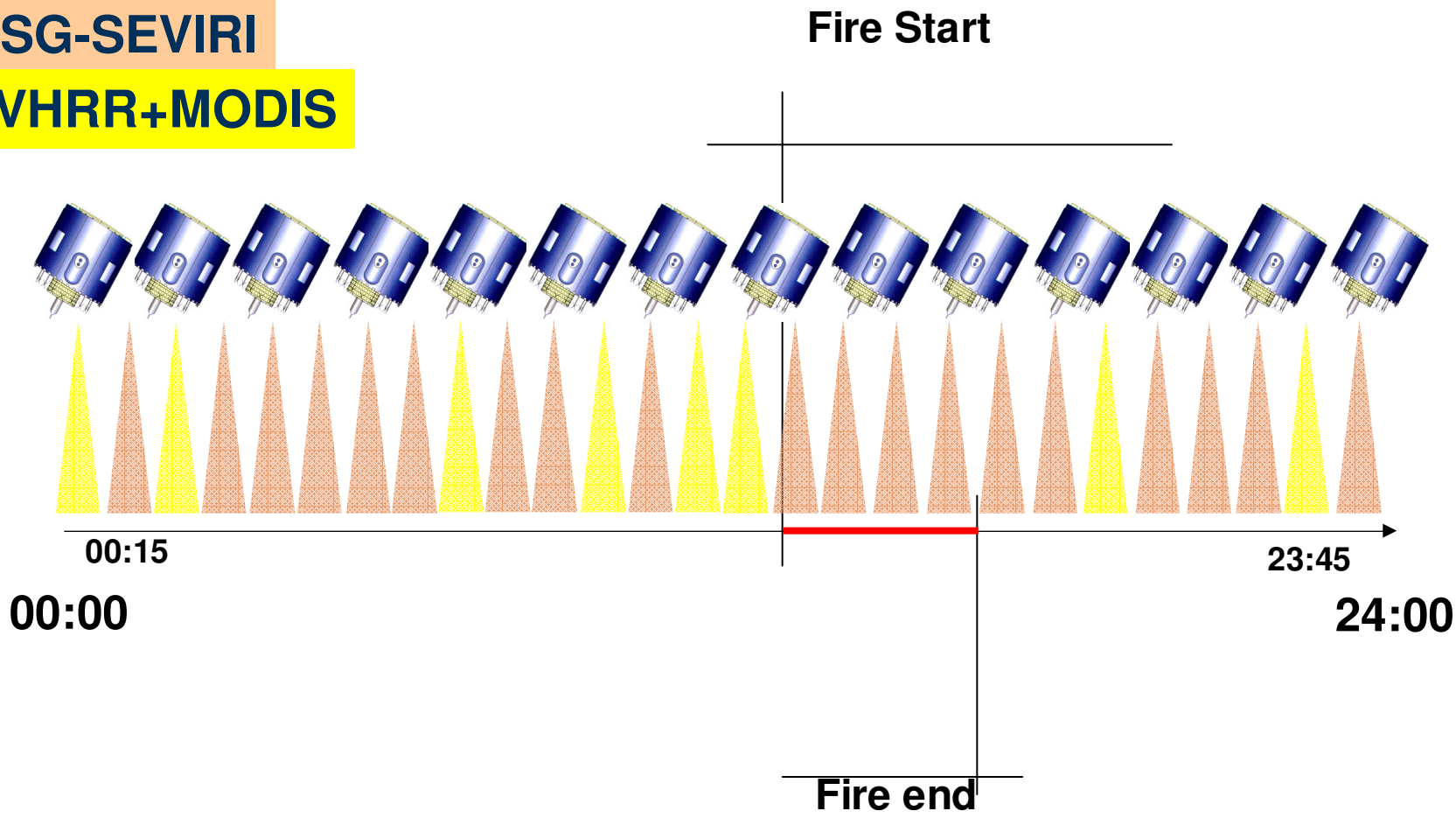
Es.: NOAA-AVHRR + EOS-MODIS



Higher repetition rate
moving from polar to geostationary satellite

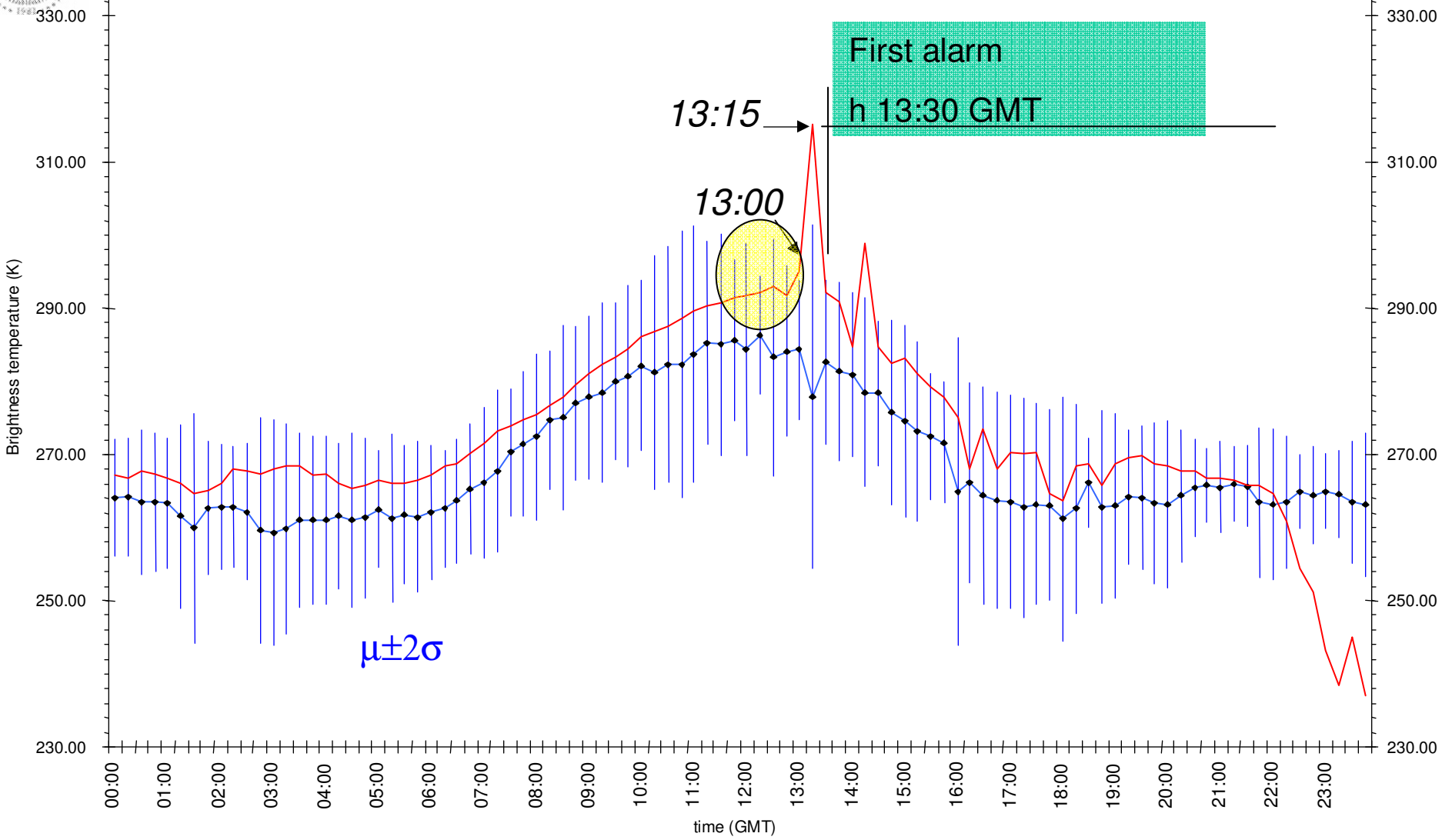
MSG-SEVIRI

AVHRR+MODIS



96 observations per day !

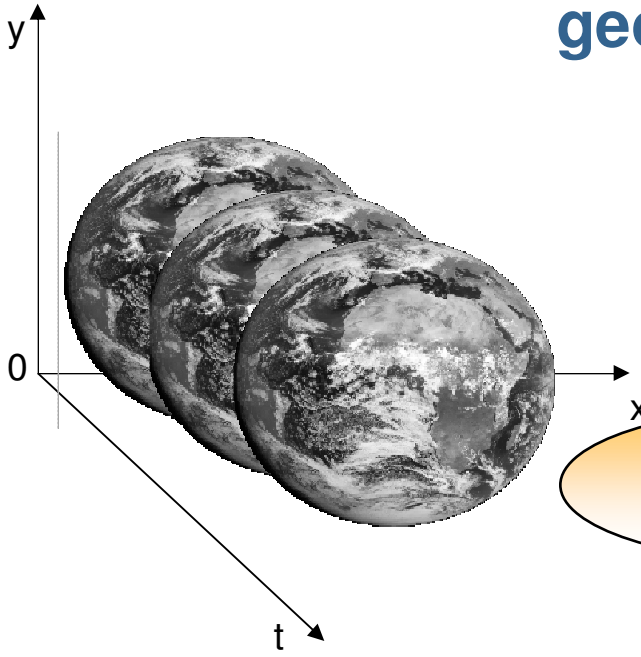
Curtatone (Mantova) – 13 Febbraio 2005



Temperatura di brillanza del pixel interessato dall'incendio

Media temporale e deviazione standard slot per slot per lo stesso pixel

Improving RST sensitivity by reducing observational noise: moving from polar to geostationary satellite



$$\otimes_V(\mathbf{r},t) \equiv \frac{[V(\mathbf{r},t) - V_{REF}(\mathbf{r})]}{\sigma_V(\mathbf{r})}$$

Natural and precise imagery co-location

Costant view-angles

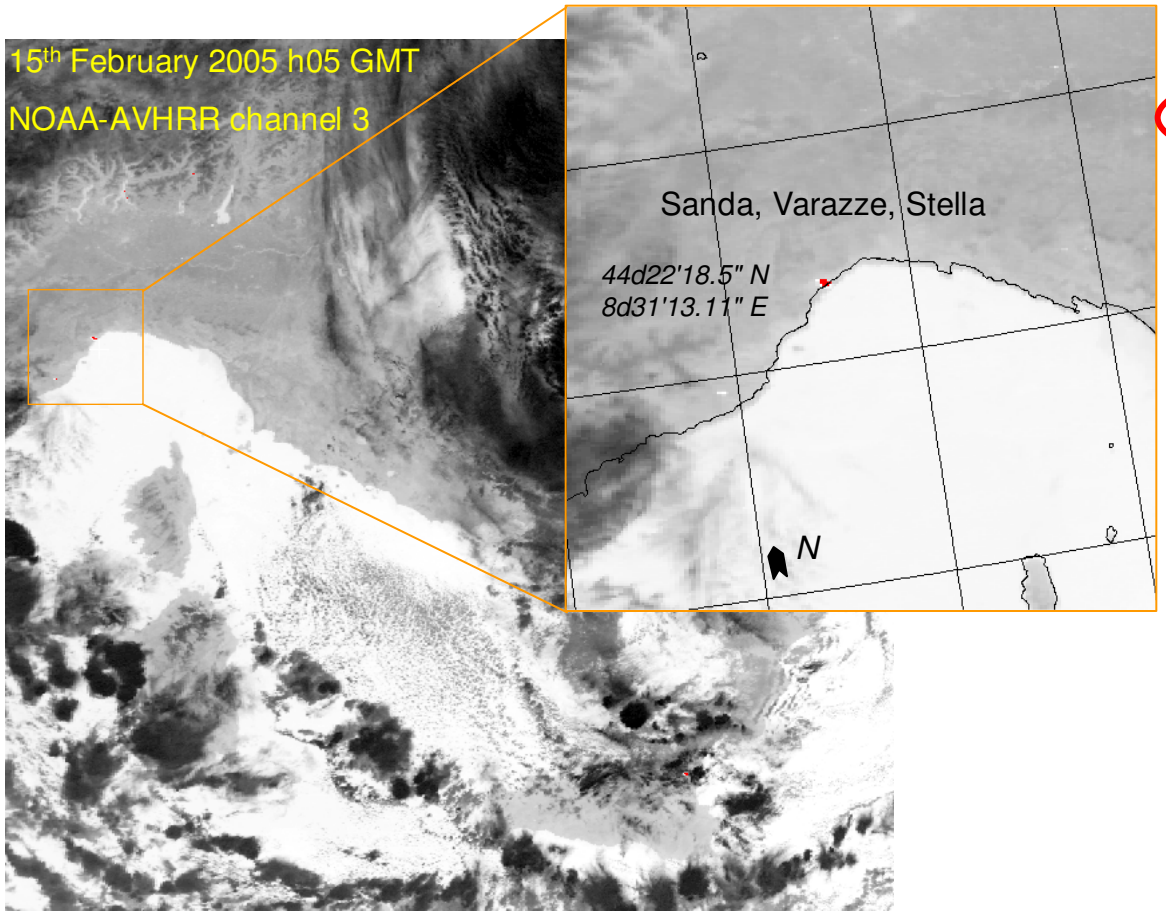
Constant obs. time

NOISE reduction

higher ALICE sensitivity

Improving RST-FIRES sensitivity moving from polar to geostationary satellites

Polar (NOAA-AVHRR)

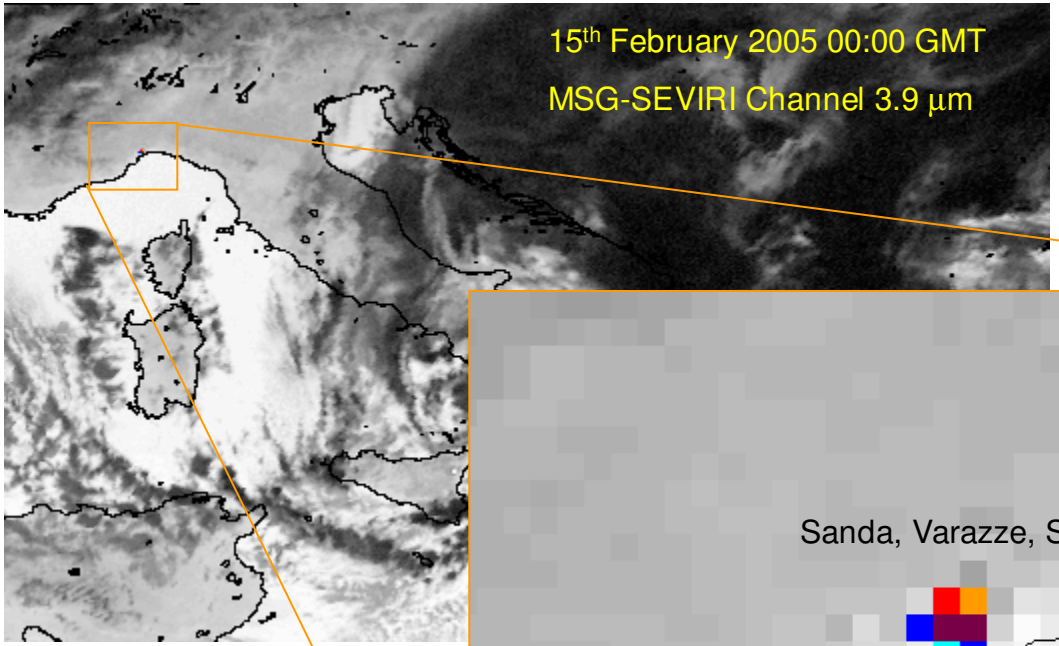


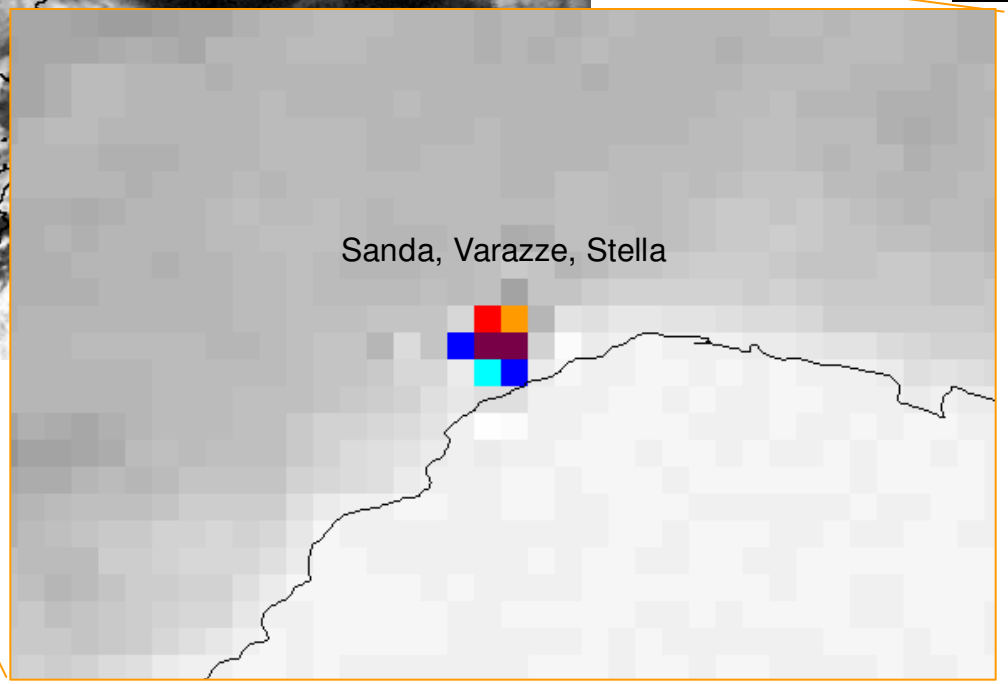
$\otimes_{ch3}(x,y,t)>2$

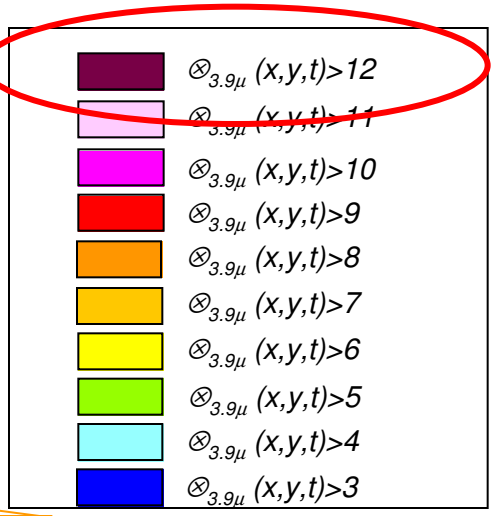
Detection of forest fires in the Ligurian Region during February 2005

Improving RST-FIRES sensitivity moving from polar to geostationary satellites

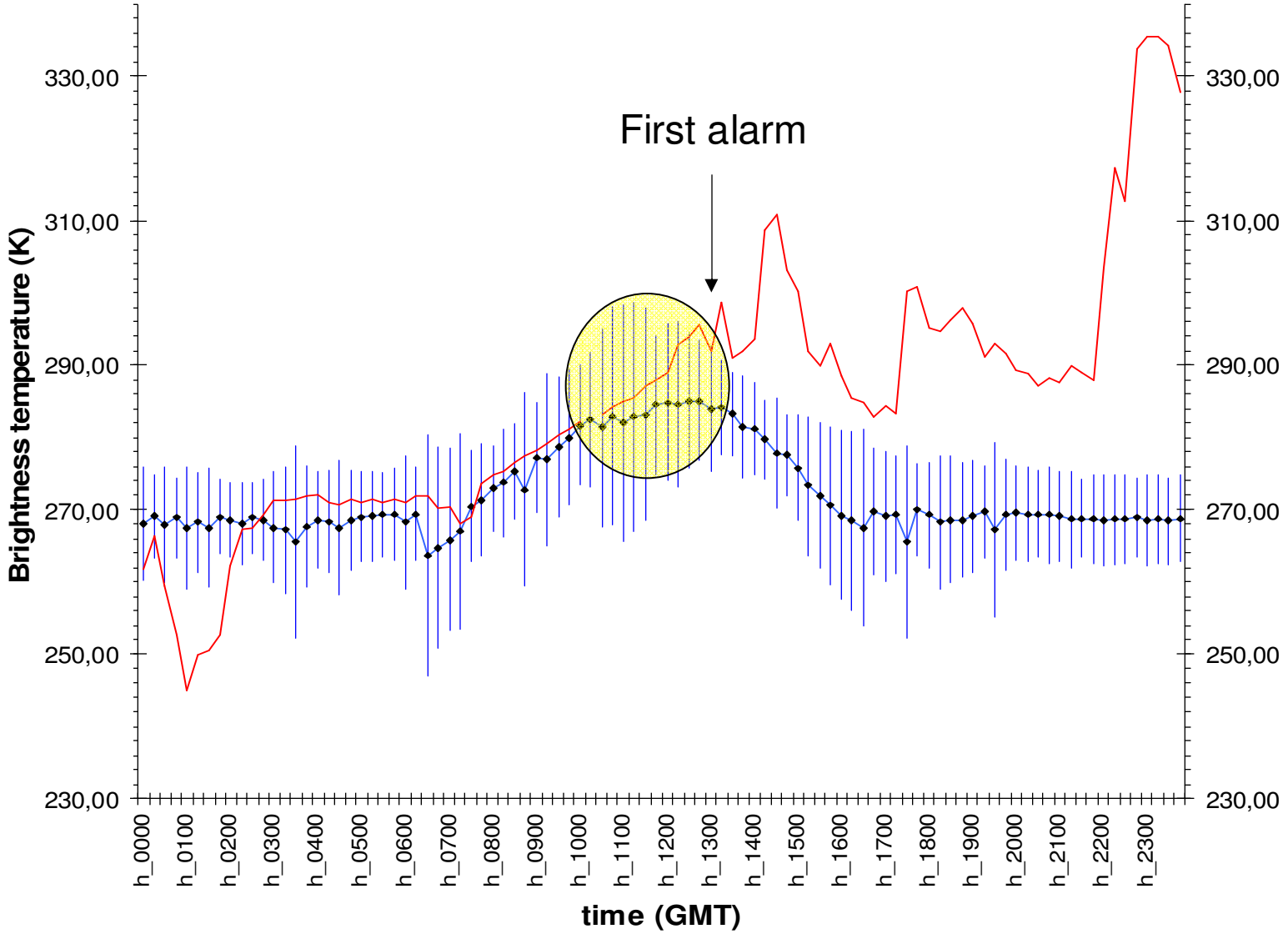
Geostationary (MSG-SEVIRI)







Varazze (14 February 2005)

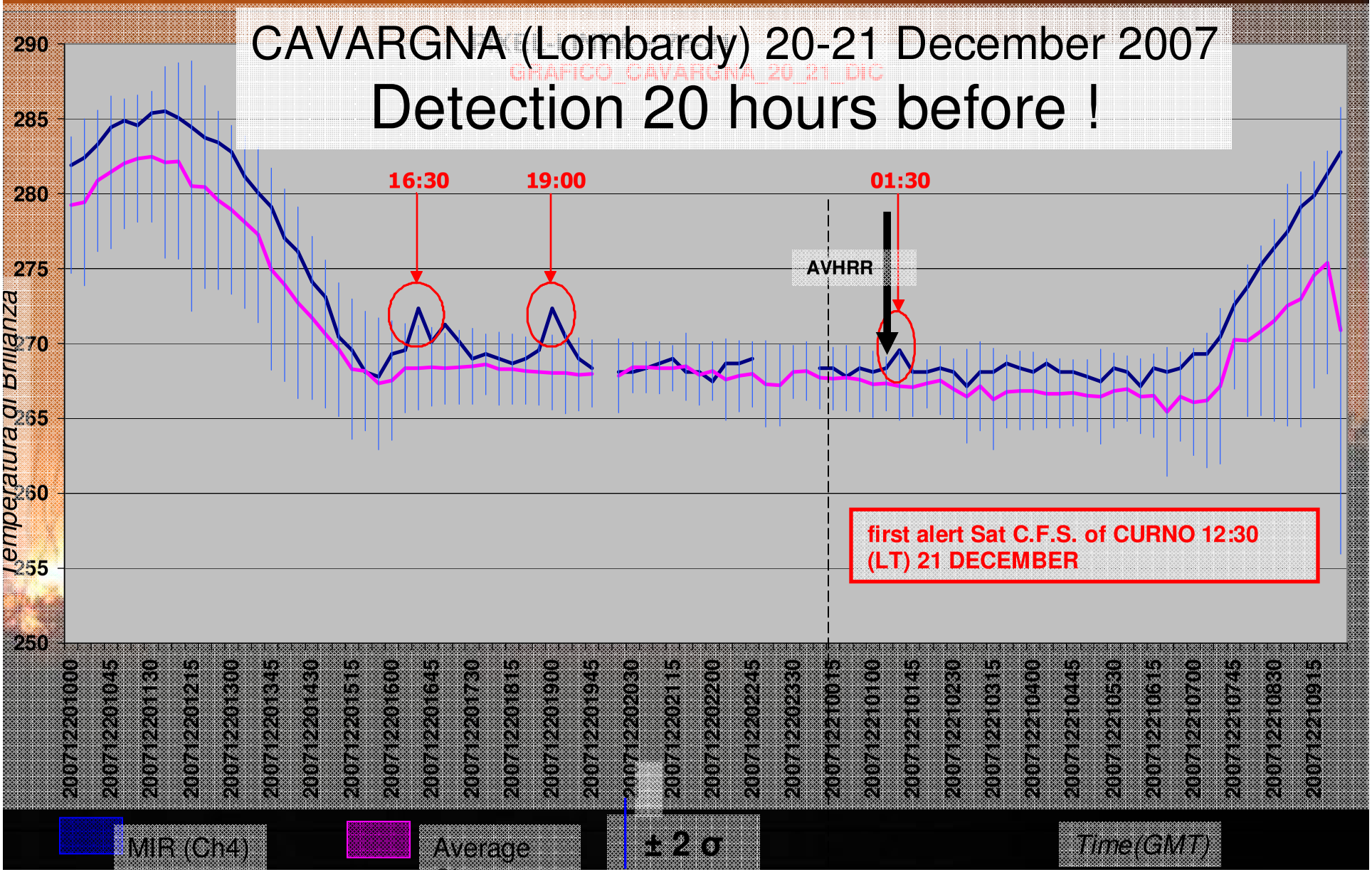


Lombardy TVA (SEVIRI preliminar)

Sensitivity Analysis (March 2008)

March 2008 (SEVIRI)	Forest fires occurred and actually observable	Detected Fires	%
FIR	7	0	0
SFIDE (Laneve et al., 2006)	16	0	0
RST-FIRES	28	14	50

Lombardy TVA



RST-FIRES Approach

$$\otimes_V (x,y,t) = \frac{[V(x,y,t) - \mu_V(x,y)]}{\sigma_V(x,y)}$$

Generic RST ALICE index

$$\otimes_{MIR} (x,y,t) = \frac{[T_{MIR}(x,y,t) - \mu_{MIR}(x,y)]}{\sigma_{MIR}(x,y)}$$

For Polar satellites (MODIS, AVHRR, etc.)

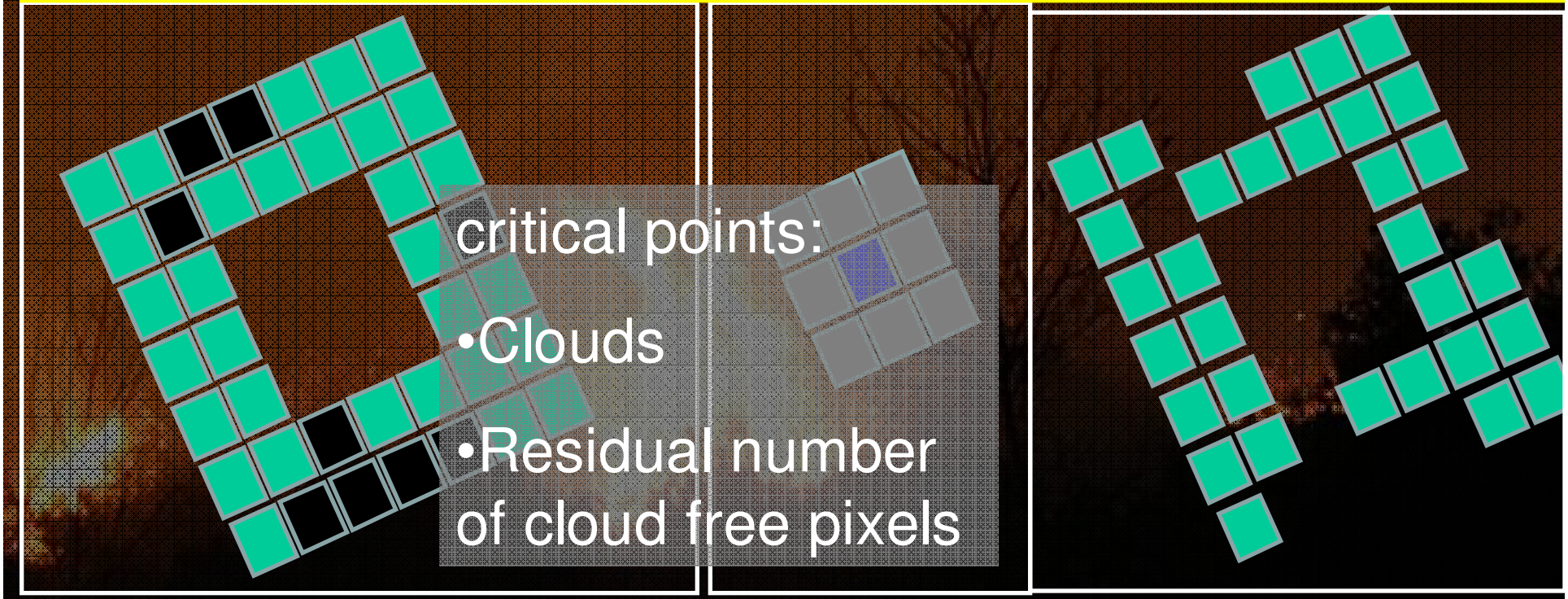
$$\otimes_{\Delta tMIR}(x,y,t-t_0) \equiv \frac{\Delta T_{\Delta tMIR}(x,y,t-t_0) - \mu_{\Delta tMIR}(x,y)}{\sigma_{\Delta tMIR}(x,y)}$$

for Geostationary Satellites (MSG, MTSAT, GOES)

$$\otimes_{\Delta sMIR} (x,y,t) \equiv \frac{\Delta T_{\Delta sMIR}(x,y,t) - \mu_{\Delta sMIR}(x,y)}{\sigma_{\Delta sMIR}(x,y)}$$

"SPATIAL" COMPONENT OF RST-FIRES

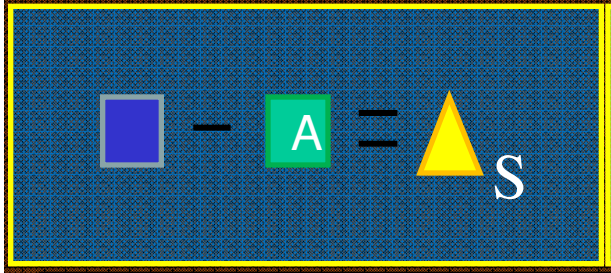
CONTEXTUAL-LIKE ALGORITHM COMPUTING DEVIATION OF THE BT FROM A SPATIAL AVERAGE OF SURROUNDING PIXELS (7X7 BOX)



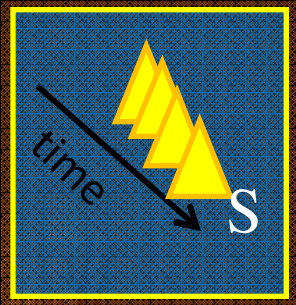
IN COMPUTING BT DEVIATION, NEAREST NEIGHBORS AND CLOUDY PIXELS WERE EXLUDED AND REMOVED BEFORE SPATIAL AVERAGE COMPUTATION

V. Tramutoli - valerio.tramutoli@unibas.it

"SPATIAL" COMPONENT OF RST



DEVIATION BETWEEN BT OF THE CENTRAL PIXELS AND THE SPATIAL AVERAGE OF (CLEAR) SURROUNDING PIXELS



MULTI-TEMPORAL ANALYSIS TO DERIVE "REFERENCE FIELDS" (TEMPORAL MEAN AND STANDARD DEVIATION) OF SUCH A DEVIATION FOR EACH IMAGE PIXEL

$\mu_{\Delta sMIR}$

$\sigma_{\Delta sMIR}$

$$\otimes_{\Delta S} = \frac{\Delta S - \mu_{\Delta sMIR}}{\sigma_{\Delta sMIR}}$$

V. Tramutoli - valerio.tramutoli@unibas.it

The Total Validation Experiments on SEVIRI in Sicily and Basilicata (2009-2012)

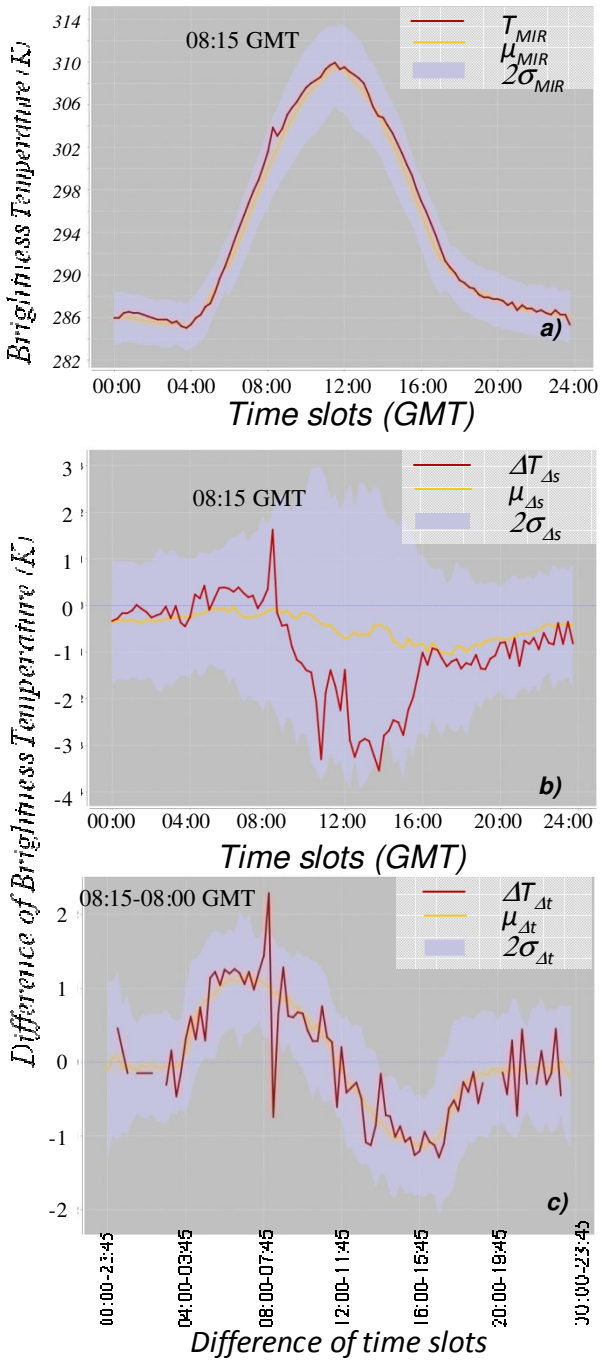
V. Tramutoli - valerio.tramutoli@unibas.it

RST-FIRES RELIABILITY
Analysis performed only on controlled alerts

VALIDATION CAMPAIGN	NUMBER OF DAYS	CONFIRMED		NOT CONFIRMED								OTHER*		TOTAL CONTROLED
				TOTAL		by ground check		by ground and aerial check		by aerial check				
Palermo 2009	39	298	82,1%	65	17,9%	65	17,9%	N.A.		N.A.		0	0,0%	363
Basilicata 2009	62	93	94,9%	3	3,1%	3	3,1%	0	0,0%	0	0,0%	2	2,0%	98
Basilicata 2010	41	87	84,5%	9	8,7%	5	4,9%	1	1,0%	3	2,9%	7	6,8%	103
Palermo 2010	38	119	77,3%	26	16,9%	24	15,6%	0	0,0%	2	1,3%	9	5,8%	154
Palermo 2011	86	159	69,1%	69	30,0%	69	30,0%	0	0,0%	0	0,0%	2	0,9%	230
TOTAL	**266**	**756**	**79,8%**	**172**	**18,1%**	166	**17,5%**	1	**0,1%**	5	**0,5%**	**20**	**2,1%**	**948**

* thermal anomalies generated by other sources like variations of thermal emission in industrial plants, newly installed photovoltaic panels, inland water bodies,…, all sources which may be eliminated (once and for all) by means of an exclusion map.

RELIABILITY: DOUBTS ABOUT SOME GROUND CHECKS



Basilicata campaign 2010

Thermal anomaly automatically detected by RST-FIRES over MSG-SEVIRI image of 26 August 2010 at 08:15 GMT (lat: 40.72348 N; long: 15.91864 E).

Ground check declared a false alarm. A later aerial check confirmed the presence of a burnt area.

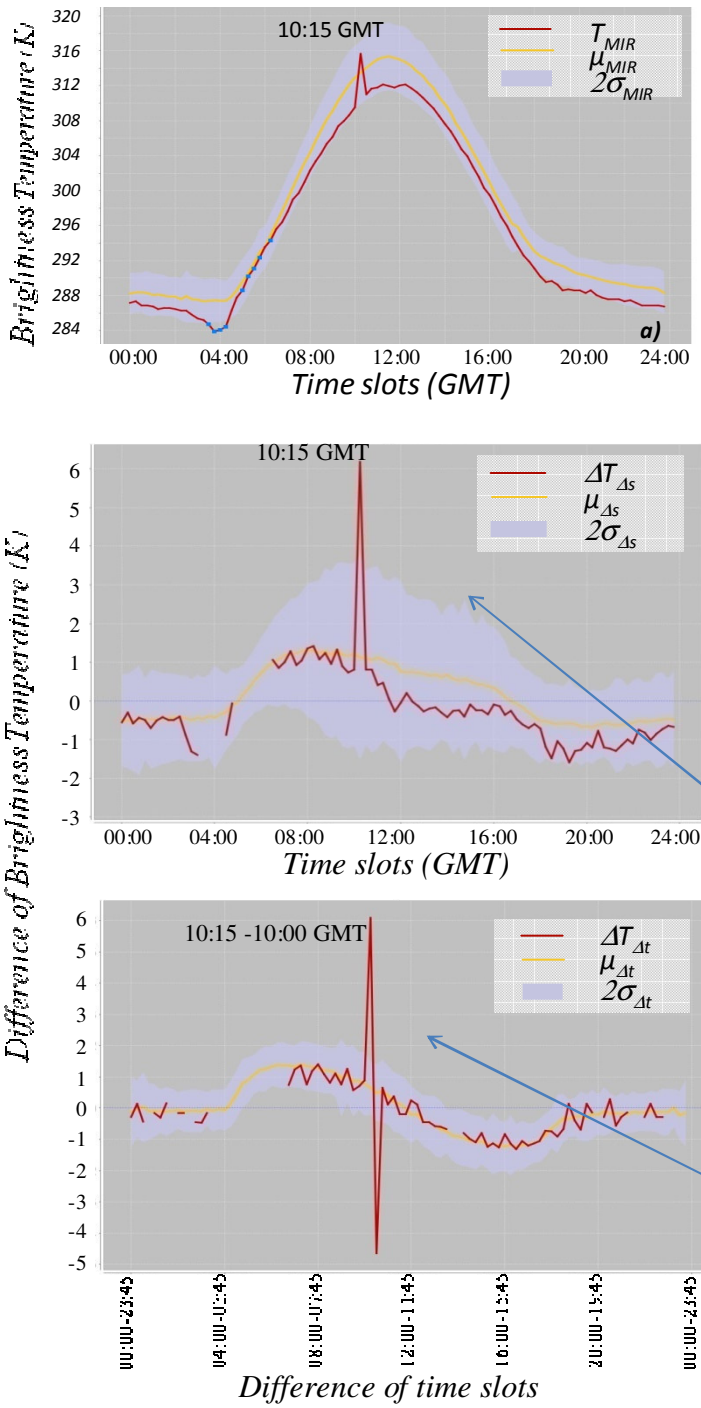
Photo from Dedalo, 15.41 GMT

RST-FIRES RELIABILITY
Analysis performed only on controlled alerts

VALIDATION CAMPAIGN	NUMBER OF DAYS	CONFIRMED		NOT CONFIRMED								OTHER*		TOTAL CONTROLED
				TOTAL		by ground check		by ground and aerial check		by aerial check				
Palermo 2009	39	298	82,1%	65	17,9%	65	17,9%	N.A.		N.A.		0	0,0%	363
Basilicata 2009	62	93	94,9%	3	3,1%	3	3,1%	0	0,0%	0	0,0%	2	2,0%	98
Basilicata 2010	41	87	84,5%	9	8,7%	5	4,9%	1	1,0%	3	2,9%	7	6,8%	103
Palermo 2010	38	119	77,3%	26	16,9%	24	15,6%	0	0,0%	2	1,3%	9	5,8%	154
Palermo 2011	86	159	69,1%	69	30,0%	69	30,0%	0	0,0%	0	0,0%	2	0,9%	230
TOTAL	**266**	**756**	**79,8%**	**172**	**18,1%**	166	**17,5%**	1	**0,1%**	5	**0,5%**	**20**	**2,1%**	**948**

* thermal anomalies generated by other sources like variations of thermal emission in industrial plants, newly installed photovoltaic panels, inland water bodies,…, all sources which may be eliminated (once and for all) by means of an exclusion map.

RELIABILITY: DOUBTS ABOUT SOME GROUND CHECKS



Palermo Regional Province campaign 2011

Thermal anomaly automatically detected by RST-FIRES over MSG-SEVIRI image of 5 August 2011 at 10:15 GMT (lat: 37.84408 N; long: 12.9586 E).

CFS and voluntaries from watch towers did not confirm any event.

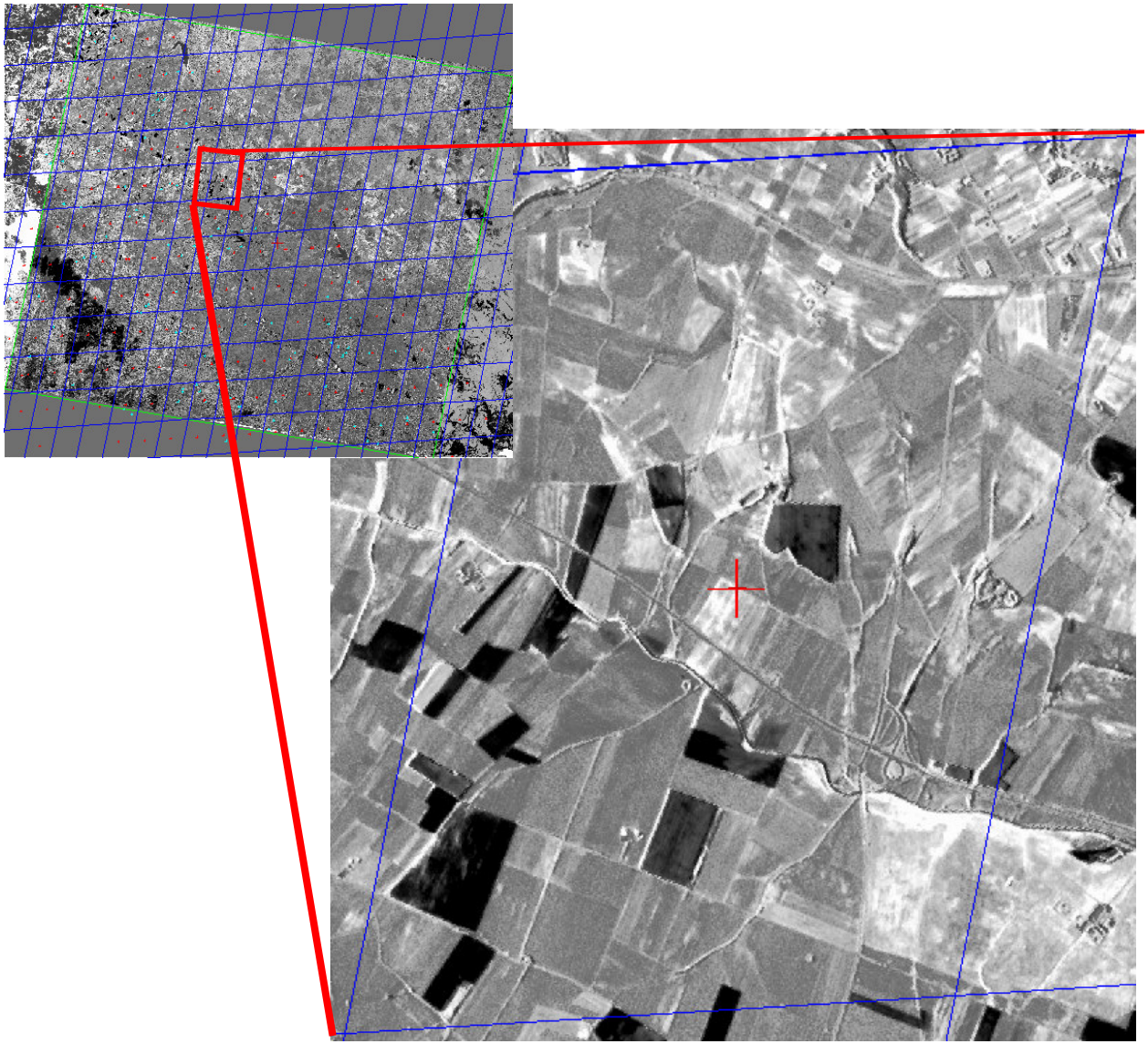
At 10:15 GMT, signal excess ($\Delta T_{\Delta s} - \mu_{\Delta s}$) is **3.82** times greater its normal variability $\sigma_{\Delta s}$

Between 10:00 and 10:15 GMT, signal excess ($\Delta T_{\Delta t} - \mu_{\Delta t}$) is **12.87** times greater its normal variability $\sigma_{\Delta t}$

RELIABILITY: DOUBTS ABOUT SOME GROUND CHECKS

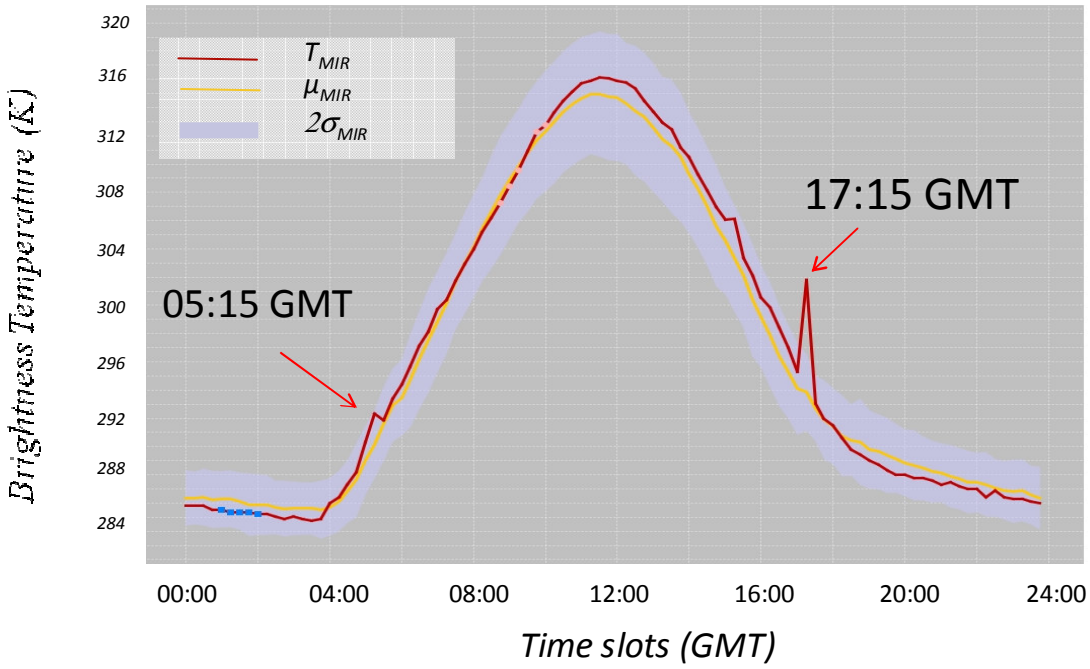
In the bulletin of SOUP, in the area of the SEVIRI pixel – centered at 40.937 N , 16.057 E, during the period between 2 August 2012 and 15 September 2012, not all events were reported. In the same area and period, we have indeed a number of RST-FIRES/SEVIRI anomalies not confirmed. In particular, we have 15 anomalies of low intensity (Possible fires and Possible Principles), and 4 anomalies of high intensity, two on 9 August (Fire at 05:15 GMT and Principle at 17:15 GMT) and two on 23 August (Principle at 11:45 GMT and 14:00 GMT).

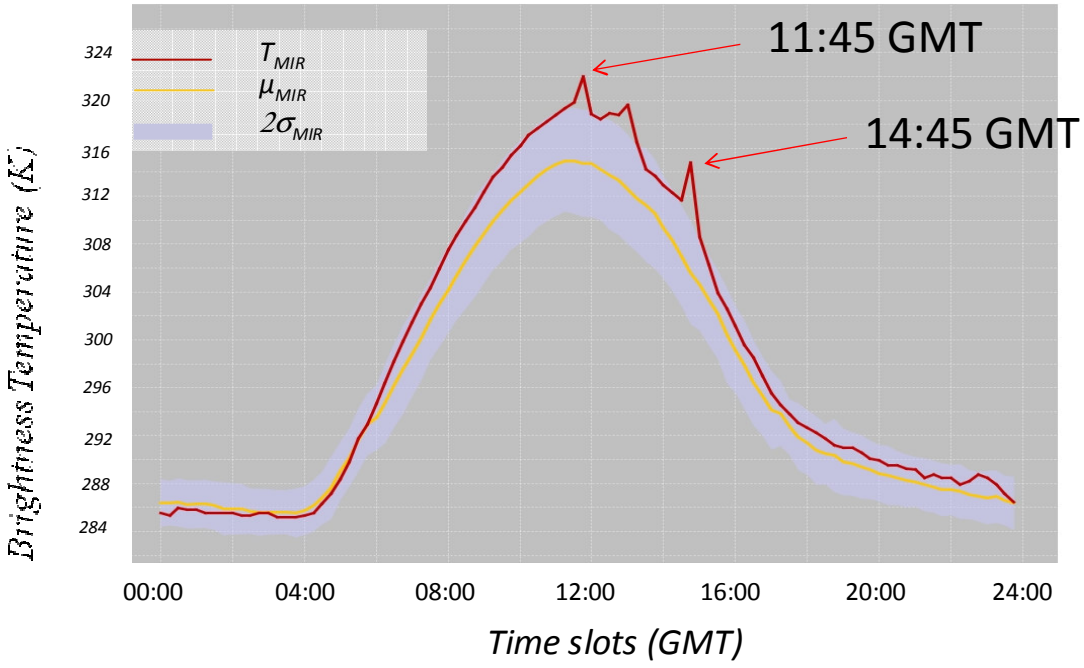
Date	Time (GMT)	Thermal anomaly
02/08/12	14.30	
09/08/12	4.00	
	5.00	
	5.15	
	15.15	
	17.15	
10/08/12	4.00	
14/08/12	6.15	
19/08/12	21.00	
21/08/12	6.45	
23/08/12	**11.45**	
	14.45	
	13.00	
	22.45	
25/08/12	23.30	
27/08/12	15.30	
05/09/12	2.00	
11/09/12	10.00	
12/09/12	12.15	



RELIABILITY: DOUBTS ABOUT SOME GROUND CHECKS

Date	Time (GMT)	Thermal anomaly
02/08/12	14.30	
09/08/12	4.00	
	5.00	
	5.15	
	15.15	
	17.15	
10/08/12	4.00	
14/08/12	6.15	
19/08/12	21.00	
21/08/12	6.45	
23/08/12	11.45	
	14.45	
	13.00	
	22.45	
25/08/12	23.30	
27/08/12	15.30	
05/09/12	2.00	
11/09/12	10.00	
12/09/12	12.15	





RST-FIRES SENSITIVITY

(during the whole campaigns duration)

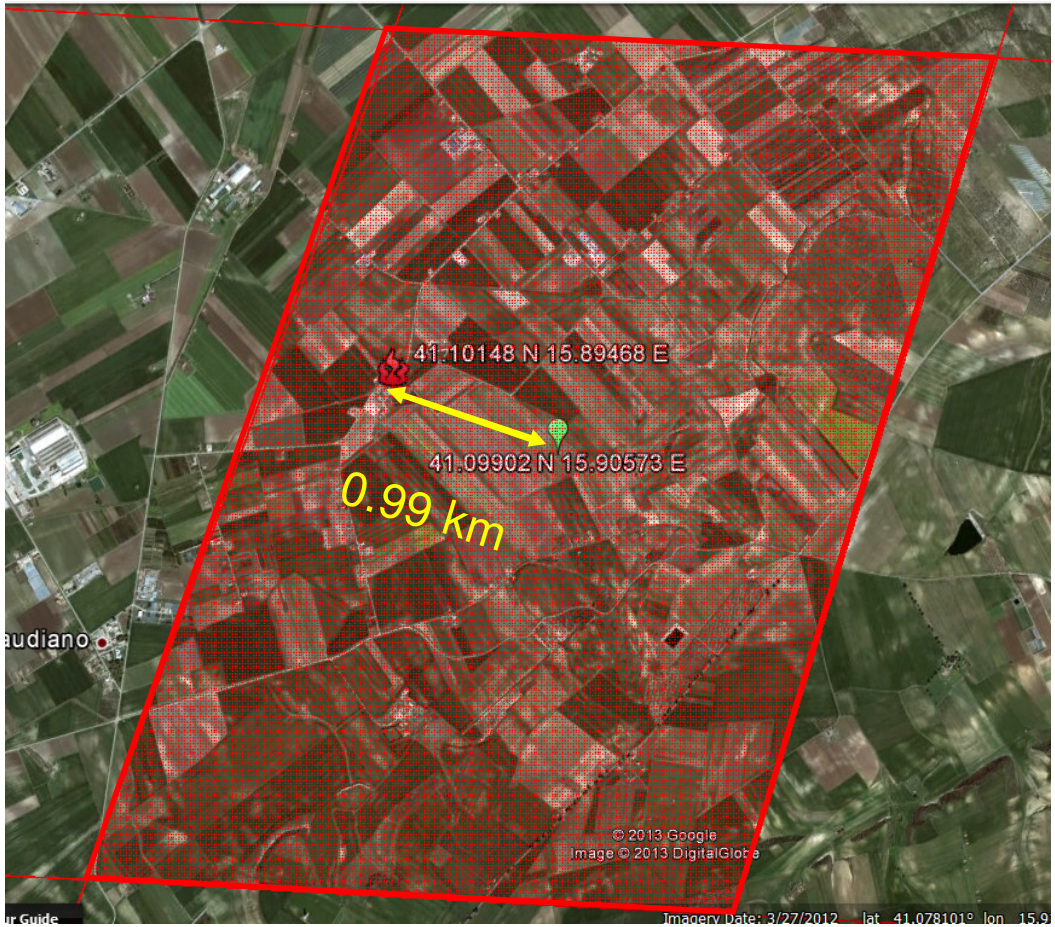
VALIDATION CAMPAIGN	NUMBER OF DAYS	TOT DOCUM. EVENTS	OBSERVABLE*	IDENTIFIABLE**	IDENTIFIED		NOT IDENTIFIED			
							low segnal		Other causes***	
Palermo 2009	39	482	349	271	248	91,5%	23	8,5%	0	0,0%
Basilicata 2010	38	610	323	182	133	73,1%	49	26,9%	0	0,0%
Palermo 2010	41	187	149	146	144	98,6%	2	1,4%	0	0,0%
Palermo 2011	86	223	188	176	159	90,3%	17	9,7%	0	0,0%
Basilicata 2012	51	882	555	454	187	41.2%	224	49.3%	43	9.5%
TOTAL	**255**	**2384**	**1564**	**1229**	**871**	**70,9%**	**315**	**25,6%**	**43**	**3,5%**

* OBSERVABLE = DOCUMENTED EVENTS – events where pixel is declared CLOUDY – NO DATA – recorded events with UNCERTAIN LOCALIZATION

** IDENTIFIABLE = OBSERVABLE EVENTS – events showing NO SEVIRI MIR SIGNAL

*** Other causes mainly due to cloud detection (e.g. pixel number within the box NxN is low)

EVENTS PRODUCING NO APPARENT SIGNAL VARIATIONS



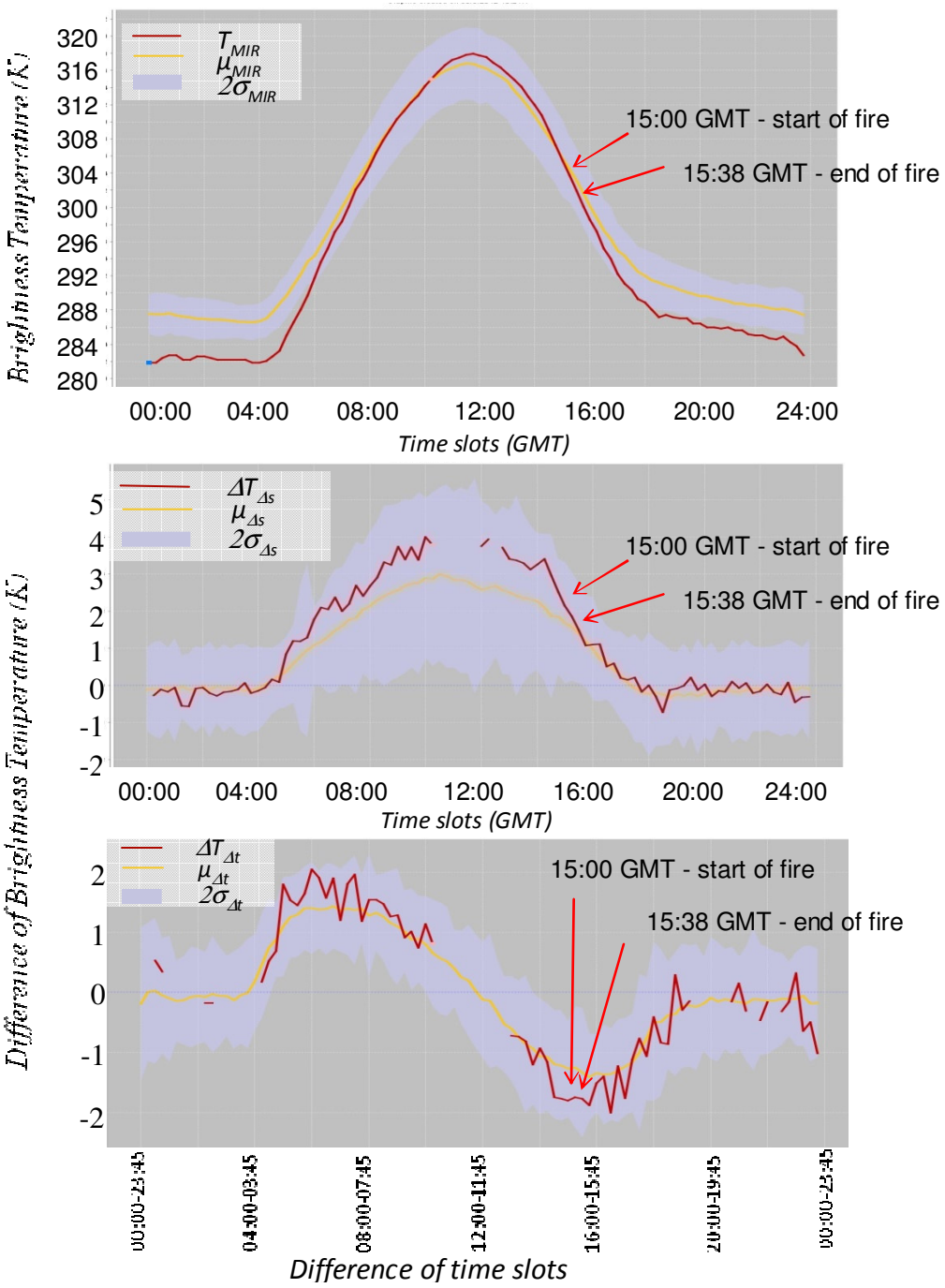
Basilicata campaign 2012

SEVIRI pixel where event occurred

SEVIRI pixel center

Event (29-08-2012, started at 15:00 GMT and ended at 15:38 GMT)

EVENTS PRODUCING NO APPARENT SIGNAL VARIATIONS



Basilicata campaign 2012

Event occurred on 29 August 2012; according to Basilicata Civil Protection database it started at 15:00 GMT and ended at 15:38 GMT.

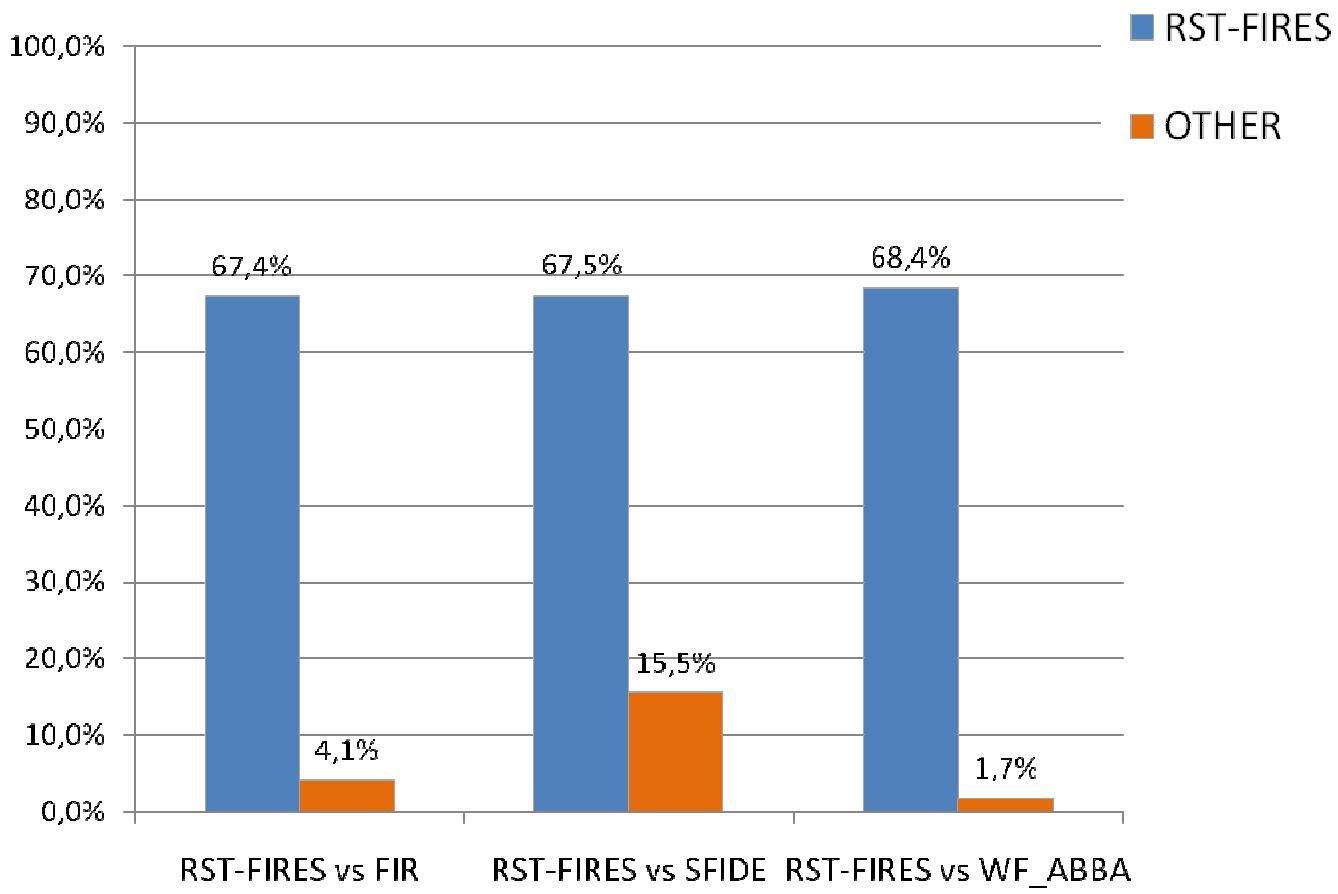
No thermal anomaly was detected.

SENSITIVITY: RST-FIRES vs FIR, SFIDE, WF_ABBA

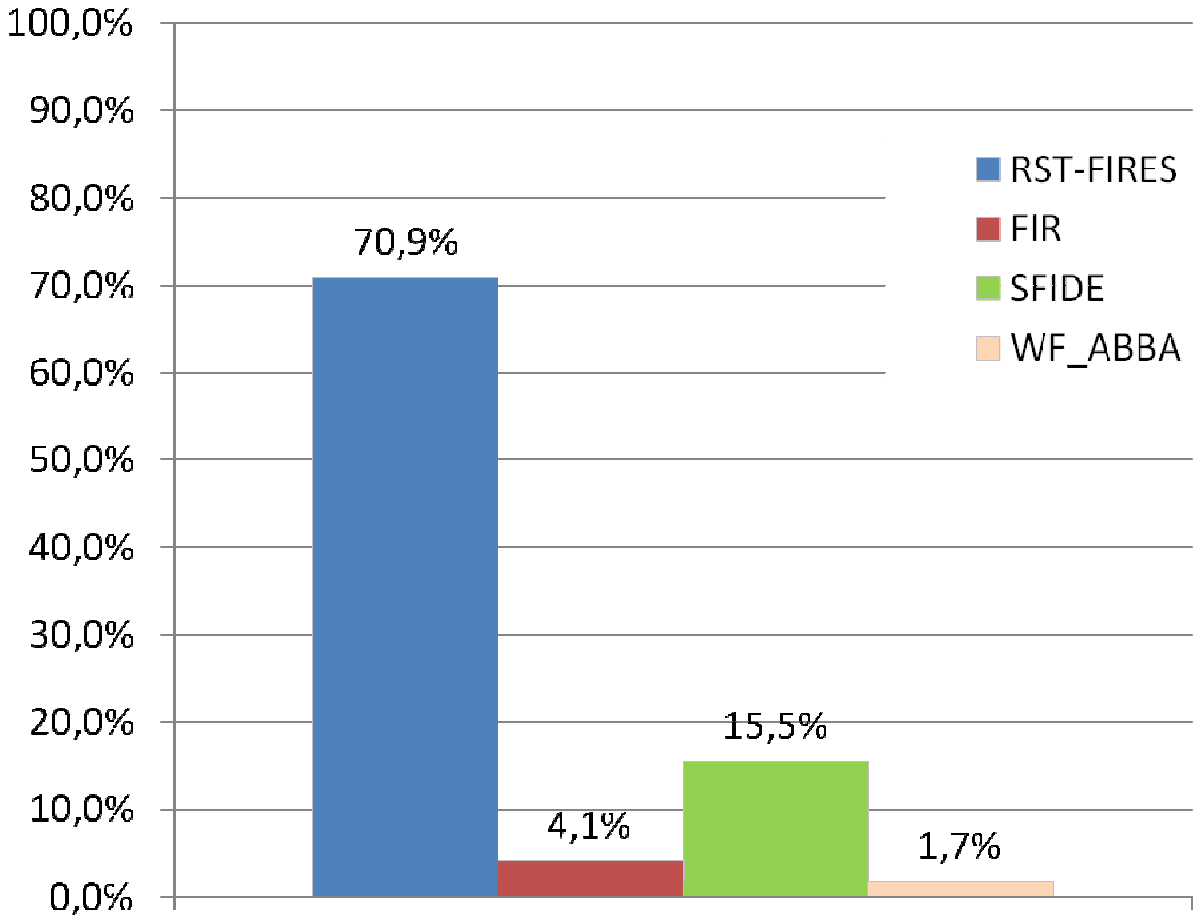
(over limitated periods according to the availability of other SEVIRI-based products at UNIBAS)

VALIDATION CAMPAIGN	NUMBER OF DAYS (period)	TOT DOC. EVENTS	OBSERV ABLE.	IDENTIFIED.	IDENTIFIED							
					RST		FIR		SFIDE		WFABBA	
Basilicata 2010	38 (26 Jul-8 Aug and 23 Aug-15 Sept)	610	323	182	133	**73,1%**	6	**3,3%**	42	**23,1%**	N.A.	
	23 (24 Aug -15 Sept)	385	207	164	71	**43,3%**	N.A.		N.A.		1	**0,6%**
Palermo 2010	42 (20 Aug – 30 Sept)	187	149	146	144	**98,6%**	9	**6,2%**	33	**22,6%**	N.A.	
	38 (24 Aug – 30 Sept)	171	140	137	135	**98,5%**	N.A.		N.A.		4	**2,9%**
Palermo 2011	71 (27 Jul- 5 Sep and 14 Sept-13 Oct)	211	211	211	149	**70,6%**	N.A.		37	**17,5%**	N.A.	
	76 (27 Jul -22 Sept and 26 Sept-13 Oct)	212	212	212	149	**70,3%**	13	**6,1%**	N.A.		N.A.	
Basilicata 2012	18 (10 -27 Aug)	414	282	242	101	**41,7%**	4	**1,4%**	9	**3,7%**	N.A.	
Overall	RST-FIRES vs FIR			782	**527**	**67.4%**	**32**	**4,1%**				
	RST-FIRES vs SFIDE			781	**527**	**67.5%**			**121**	**15,5%**		
	RST-FIRES vs WF_ABBA			301	**206**	**68.4%**					**5**	**1,7%**

SENSITIVITY: RST-FIRES vs FIR, SFIDE, WF_ABBA
(overall over common periods)



SENSITIVITY: RST-FIRES vs FIR, SFIDE, WF_ABBA (overall all periods)




Other fires

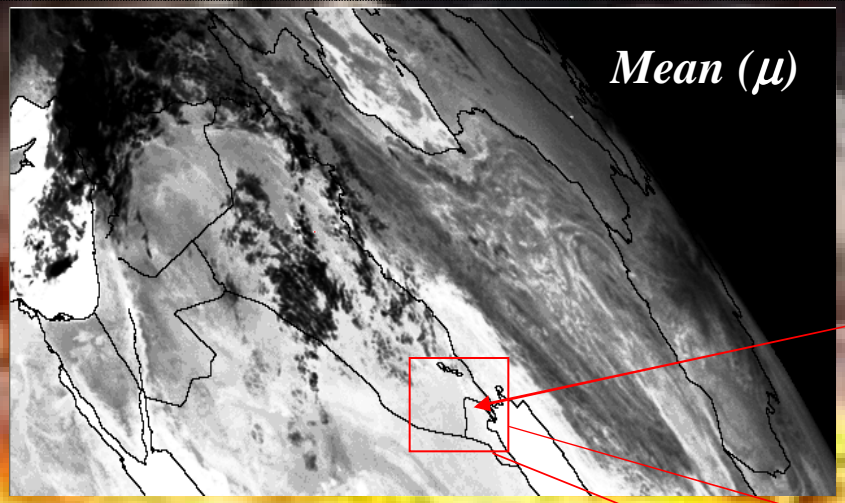
RST application to accidents/sabotages to pipelines in Iraq

More than 300 sabotage since the Iraq war started

Oil Pipeline Explosion al-Barjisiya, Iraq 8-26-04

GMOSS Global Monitoring for Security and Stability

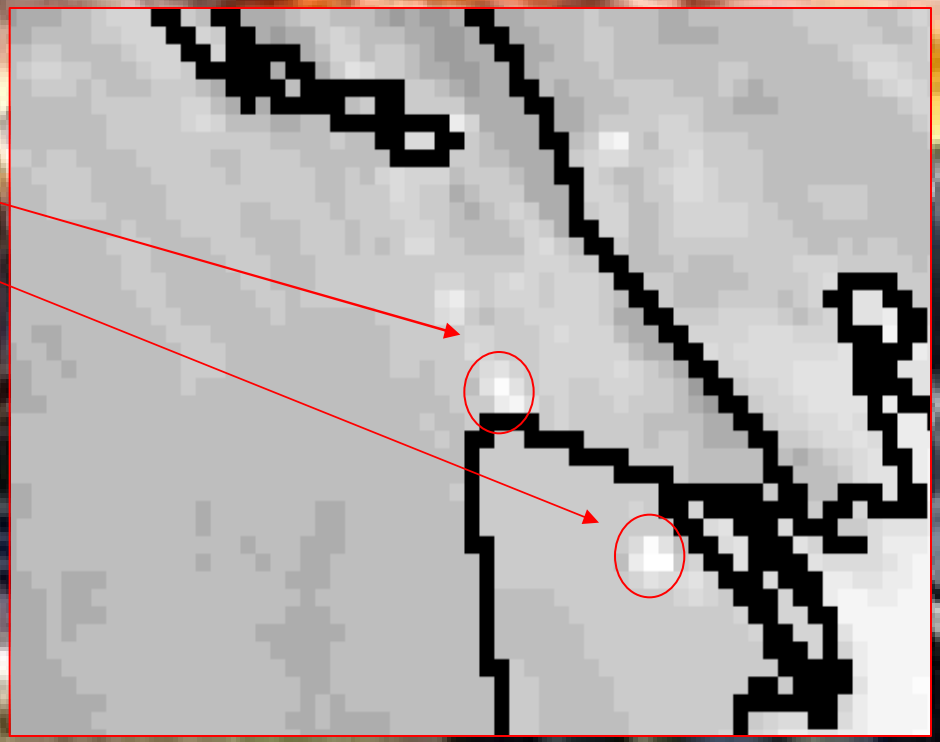
RST application to accidents/sabotages to pipelines in Iraq



Reference fields

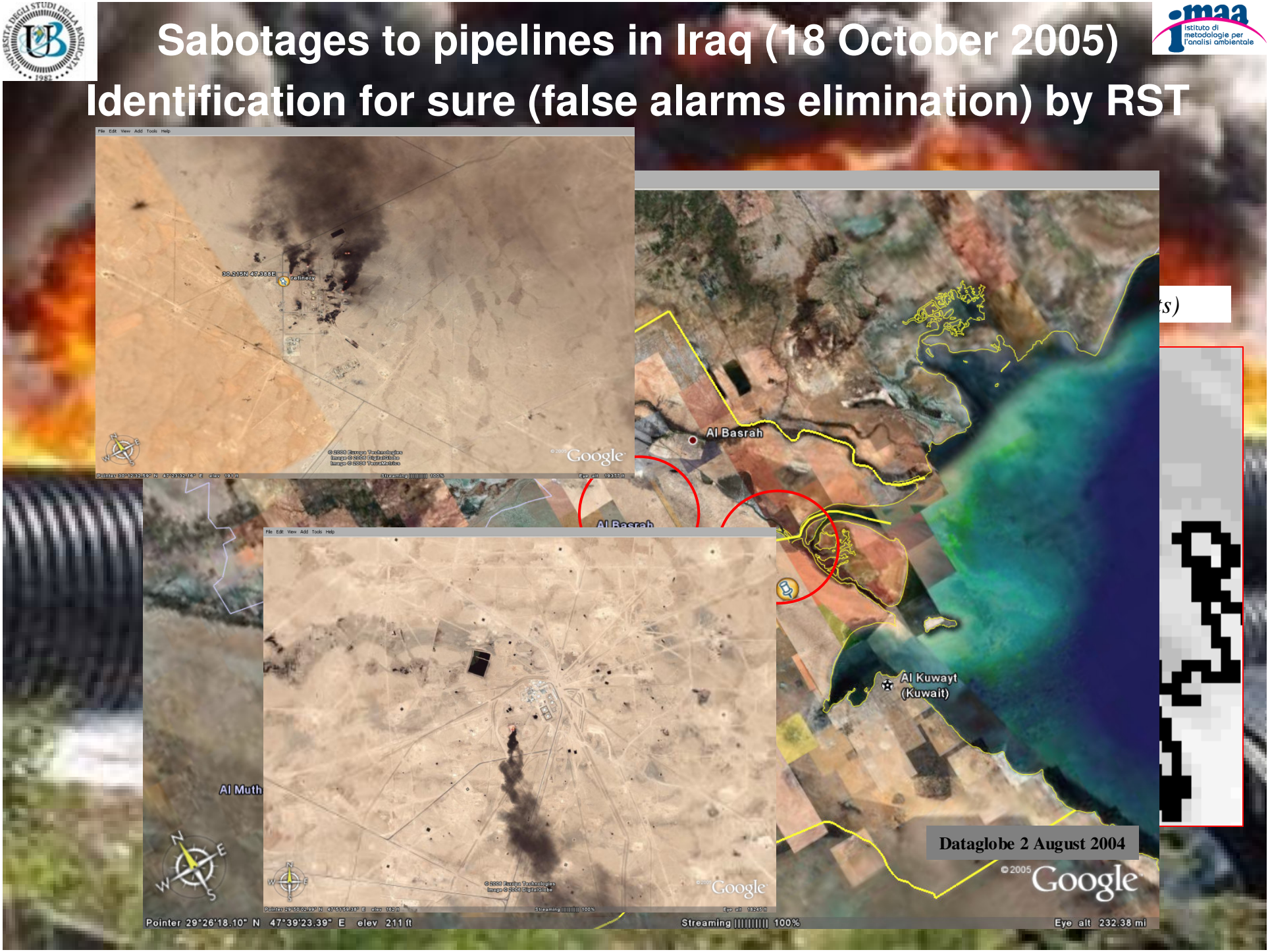
Month: October
Time-slot: 23:00 GMT
SEVIRI Channel: 3.9 μm

Permanent heat sources (e.g. refineries or power plants)

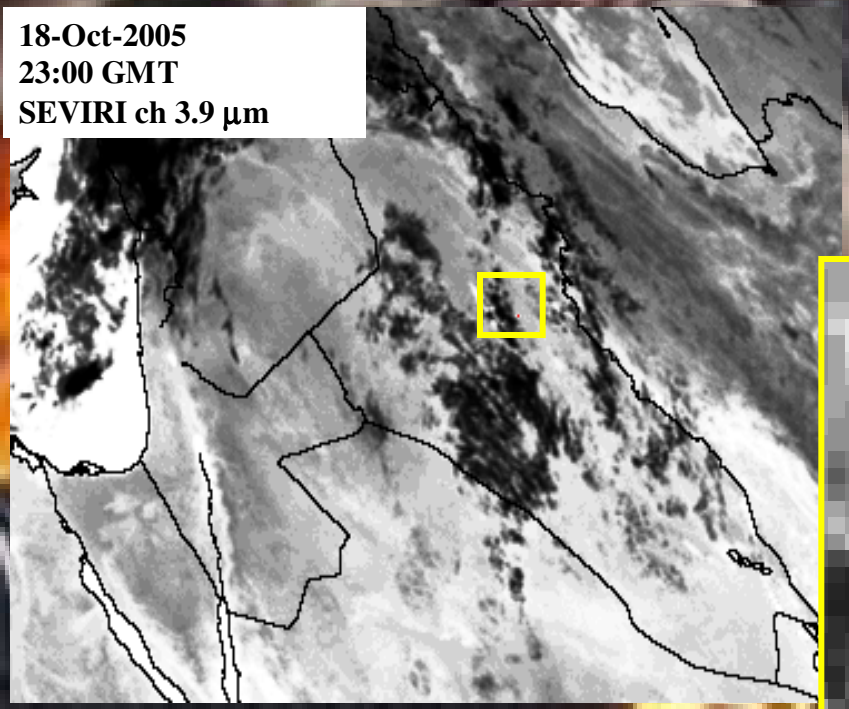


Brightness temperature (Tb)

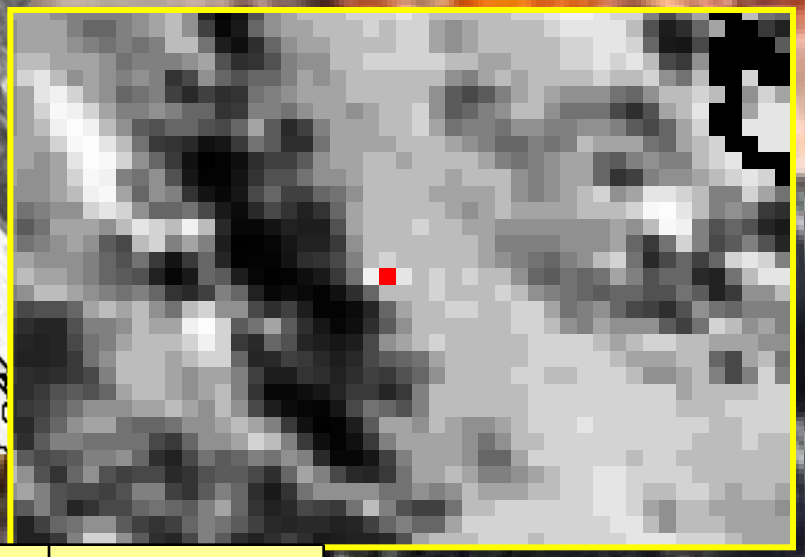
Sabotages to pipelines in Iraq (18 October 2005)
Identification for sure (false alarms elimination) by RST



RST for Pipelines monitoring



October 18th 2005 pipeline blast due to a sabotage in Iraq



ALICE >1.5

Hot spot	Tb (K)	µ (K)	σ (K)	ALICE (Tb – µ)/σ
Pipeline attack (detected) (Lat 33.972 Long 43.91)	285.66	281.58	2.60	**1.56**
Refinery (Lat 30.215N Long 47.388)	291.31	290.80	1.36	0.37

RST for Pipelines monitoring

Correcting official reports

19 October 2005 "…attack on an oil pipeline at Al-Ishaqi village south of Samarra…" by the web site http://www.iags.org/ iraqpipelinewatch.htm).

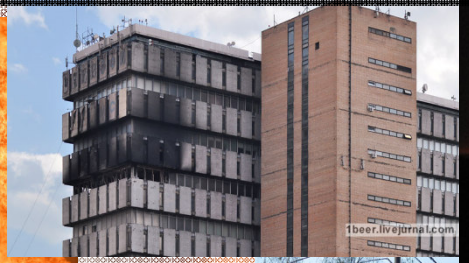
A first analysis highlighted that the accident actually **took place on 18 October** 19:30 GMT **(and not on 19 as reported by news!),** even if the oil fire continued burning until the day after.

Daily brightness temperature from SEVIRI images during 18 October 2005 in correspondence of the area affected by the pipeline blast: a strong unexpected increase of temperature is evident at 19:30 GMT.

GMOSS Global Monitoring for Security and Stability

The case of Moscow explosion (9 May 2009)

http://englishrussia.com/index.php/2009/05/11/moscow-blast-2/



http://news.bbc.co.uk/2/hi/europe/8042278.stm

On 9 May 2009 at 20:20 GMT (*i.e.* 10 May 2009, 00:20 Moscow time), a gas pipeline explosion took place in Moscow, sending flames 100m (300ft) high into the air and setting fire to a nearby building.

http://www.kavkazcenter.com/eng/content/2009/05/10/10689.shtml

According to Russian mass-media, the explosion caused damages to Physicochemical Scientific Research Institute of Lev Yakovlevich Karpov which is, according to official data:

1. A strategic factory,
2. An organisation, running dangerous production (involving radiaoctive material) and facilities
3. A factory of defense-industrial complex.

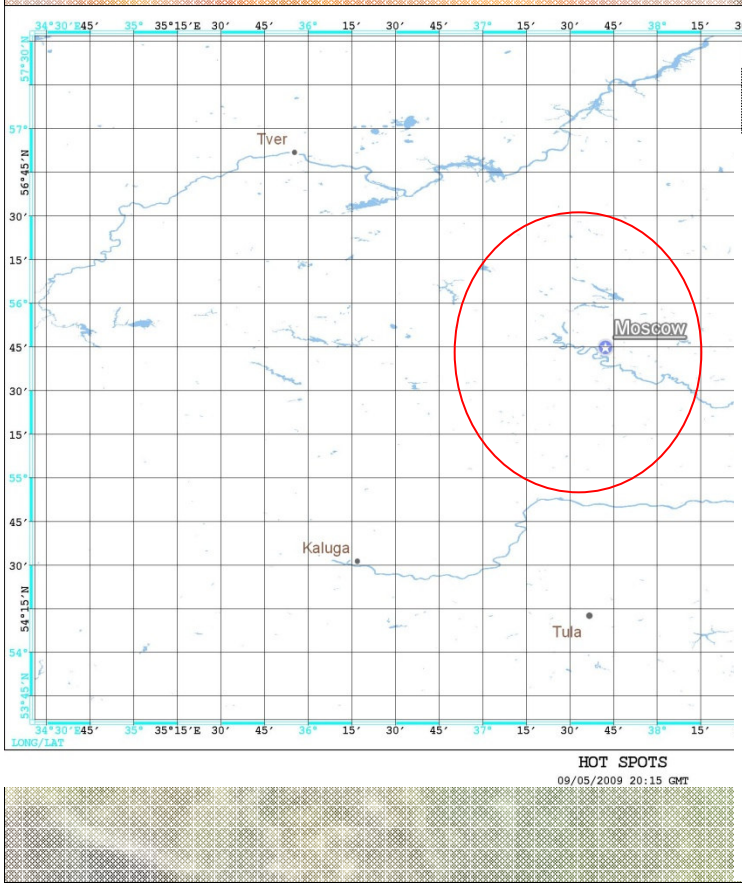
According to unofficial data, the Institute works in the field of secret production of the chemical weapons, and, probably, also the nuclear.

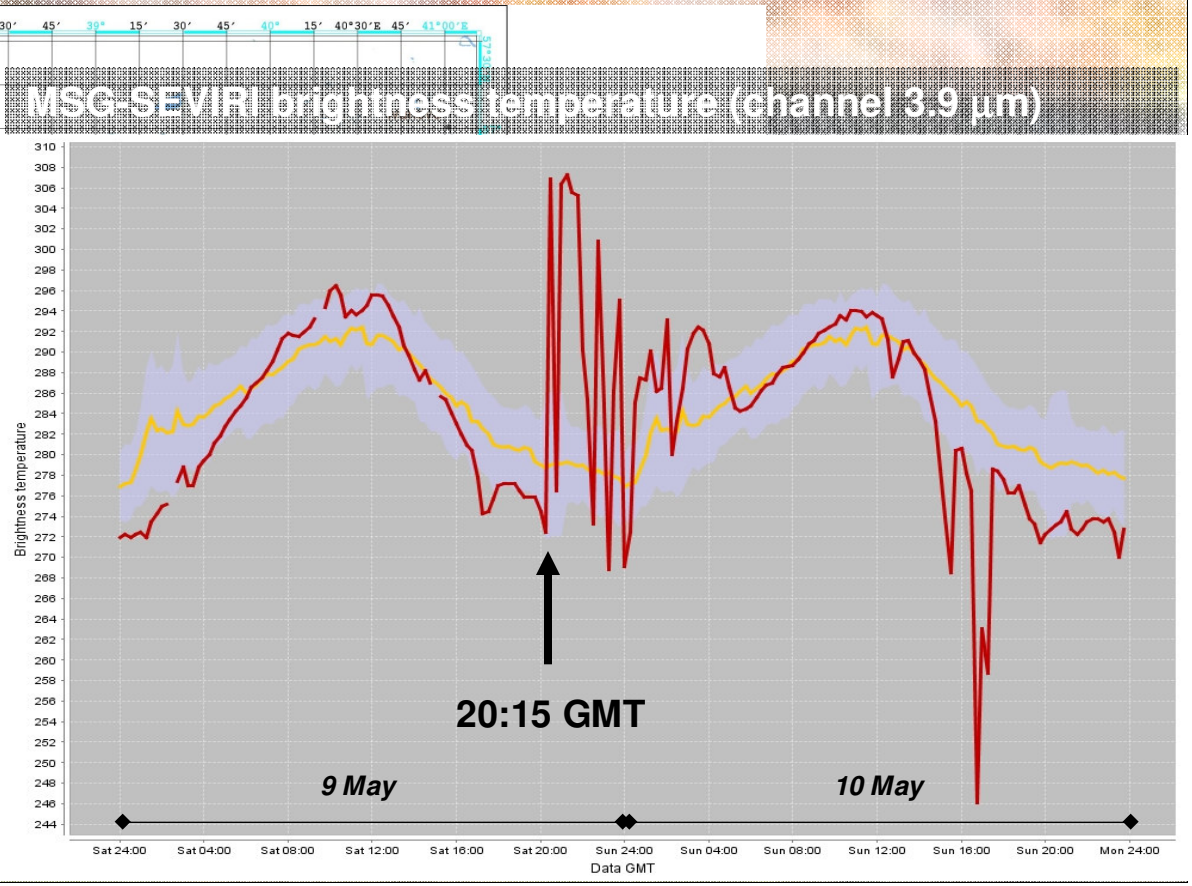
The case of Moscow explosion (9 May 2009): RST-based detection system

Before explosion (*map based on SEVIRI acquisition of 9th May 2009 at **20:15 GMT**):*

*at **20:15***

no RST-based thermal anomaly is detected in the Moscow area



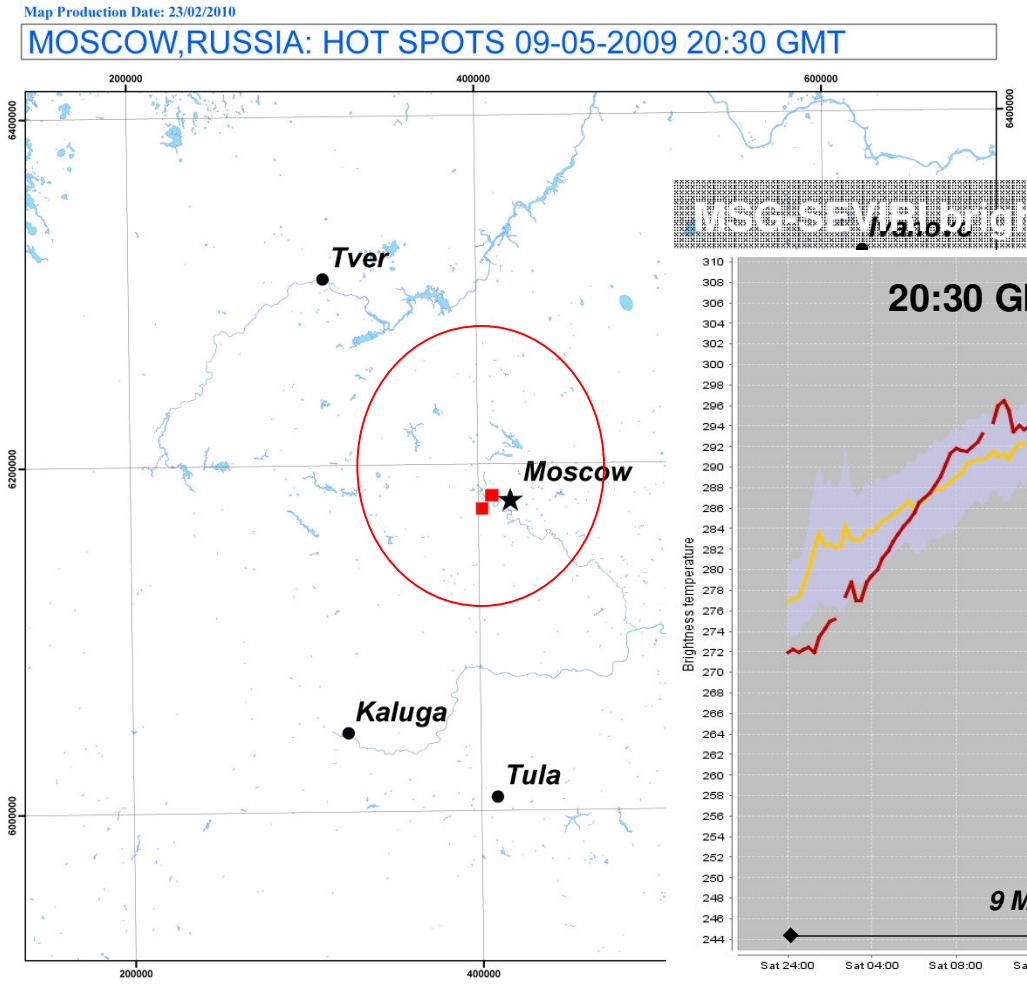


The case of Moscow explosion (9 May 2009): RST-based detection system

After the explosion

at 20:30 GMT

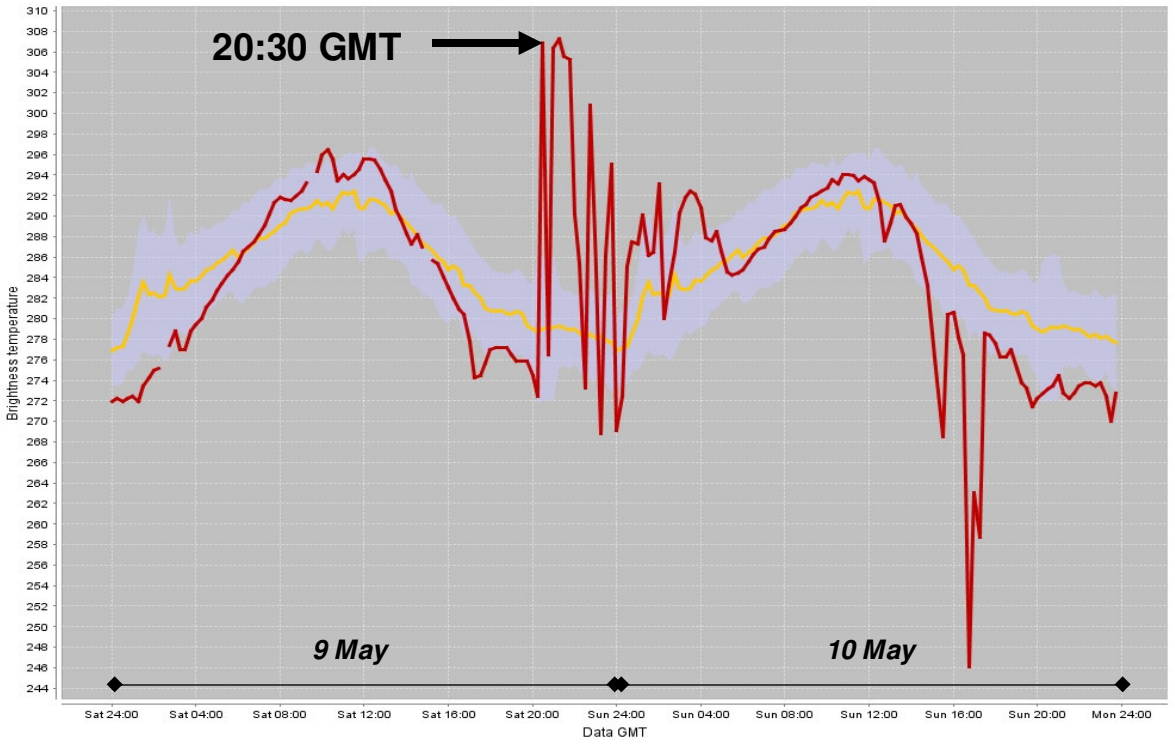
two strong RST-based thermal anomalies are detected in the SW Moscow



CTA-CAE-01-MOSCOW-04 cta

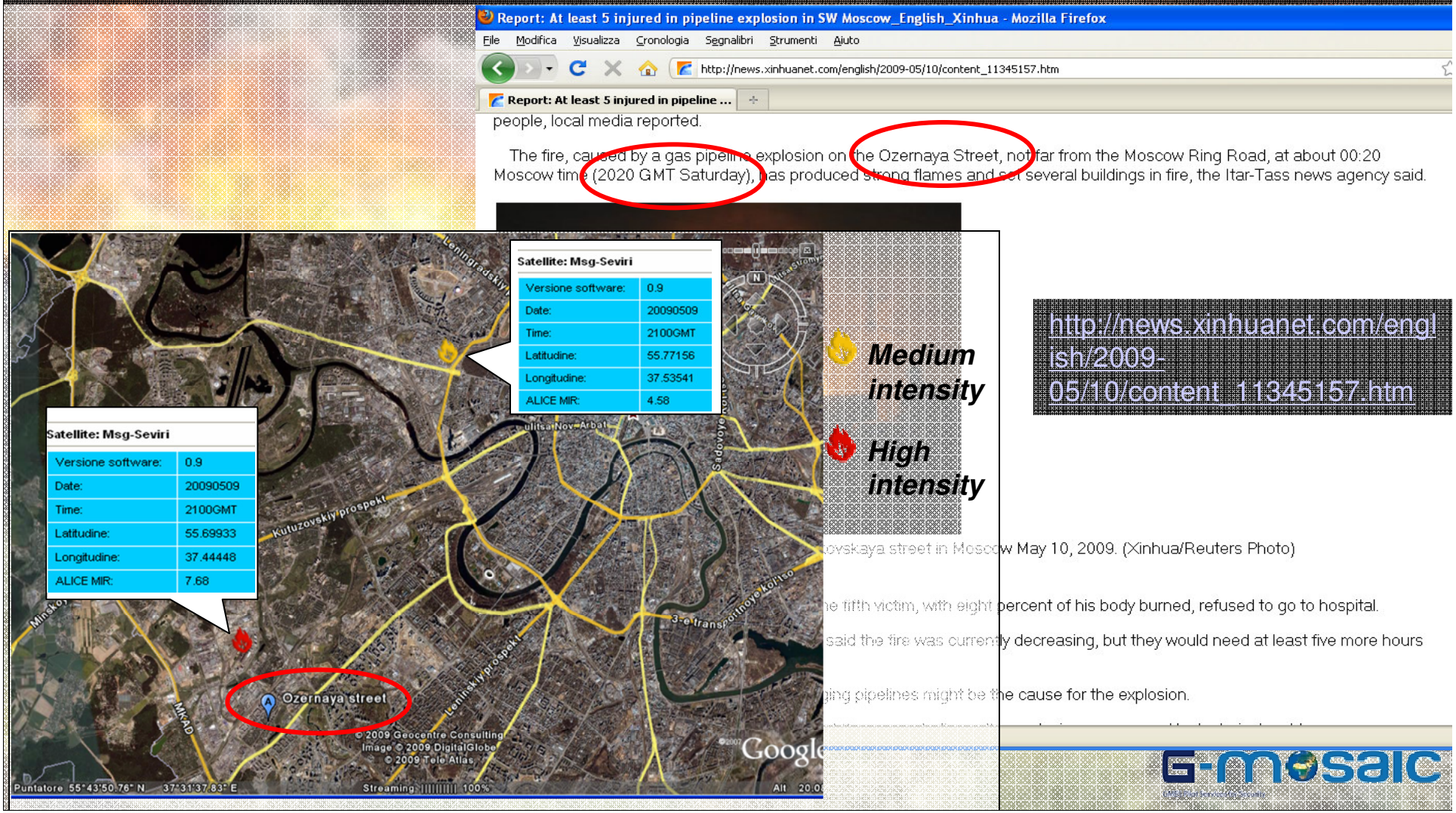
GMOSAIC GMES

MSG SEVIRI brightness temperature (channel 3.9 μm)



The case of Moscow explosion (9 May 2009): RST-based detection system

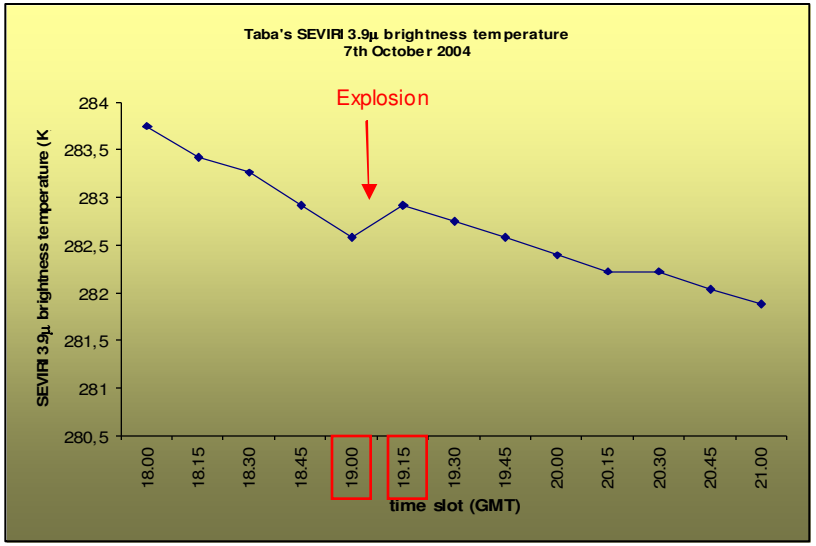
The RST-based detection (between 20:15 GMT and 20:30 GMT) of thermal anomalies related to the Moscow explosion is in perfect agreement with news

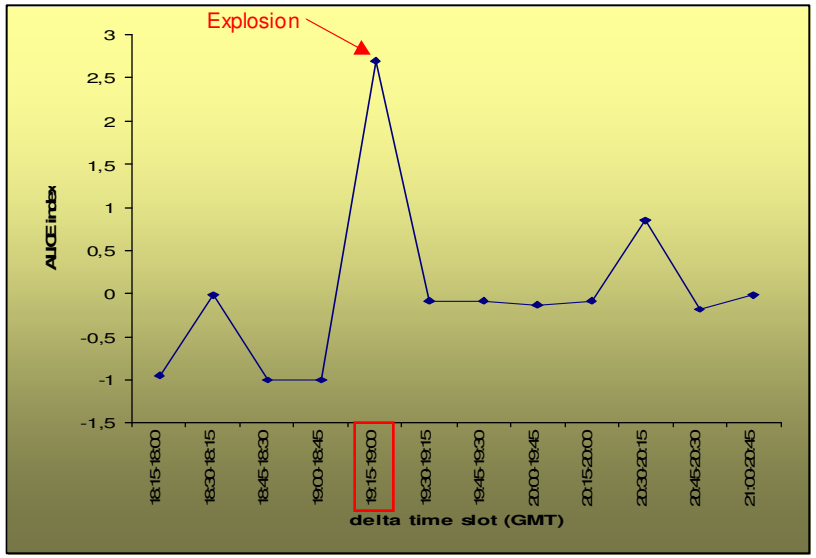


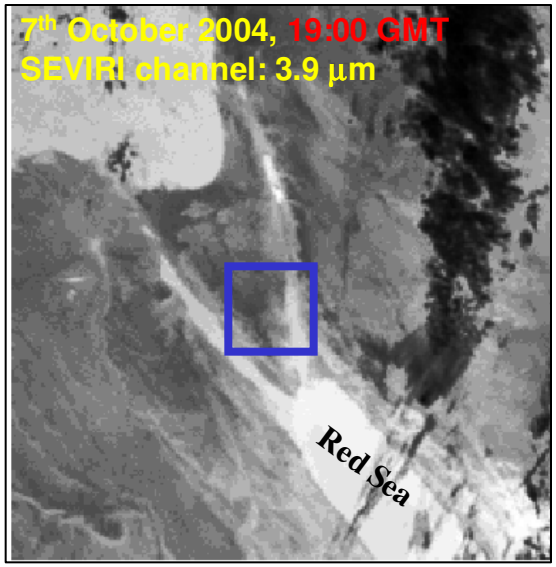
Other security issues

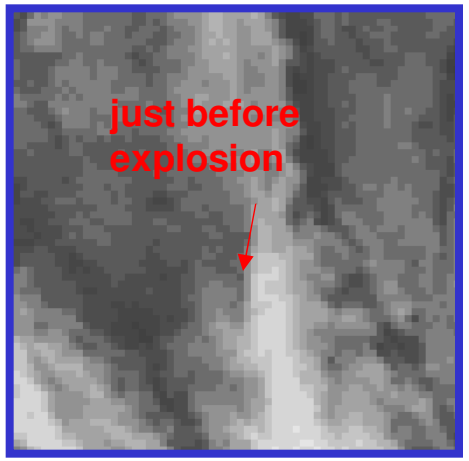
Explosion at the Hotel Hilton

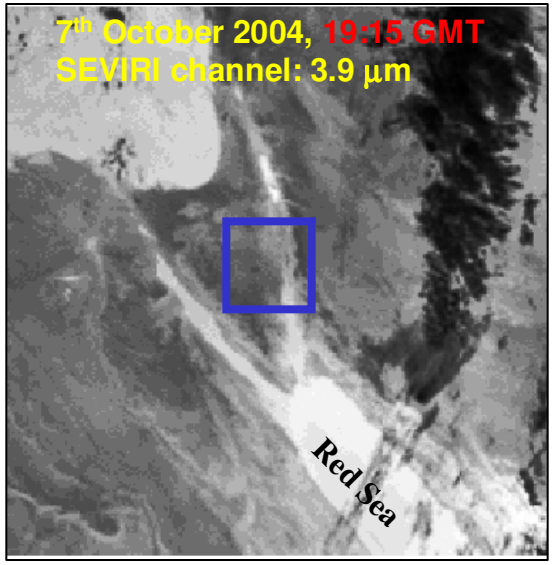
(Taba, Egypt, 7 October 2004)

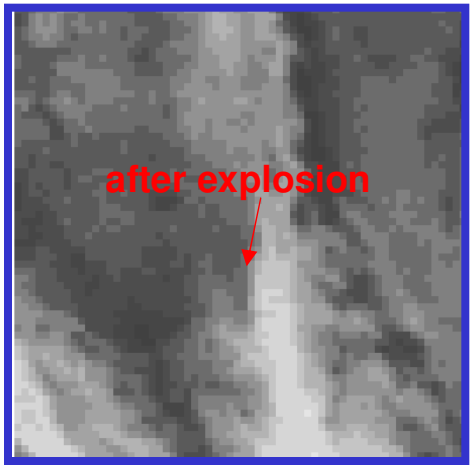








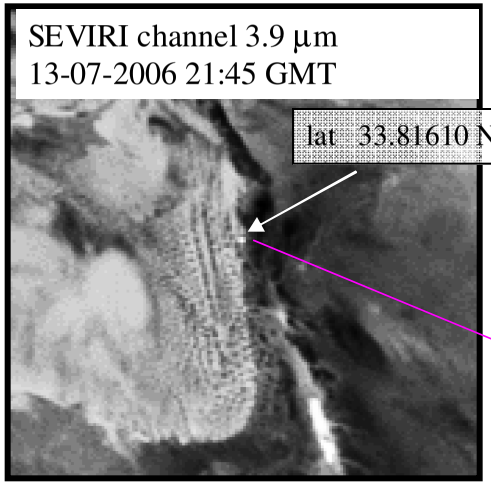


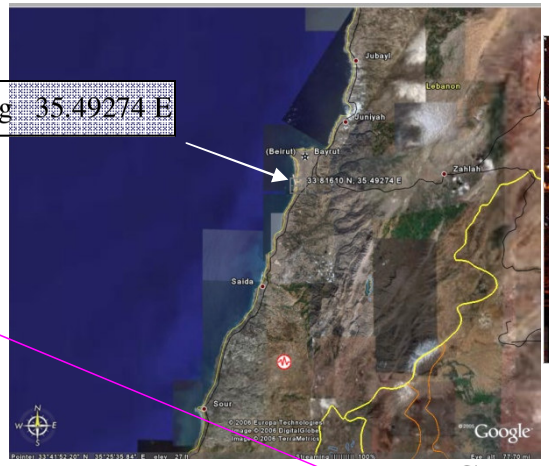


Valerio Tramutoli

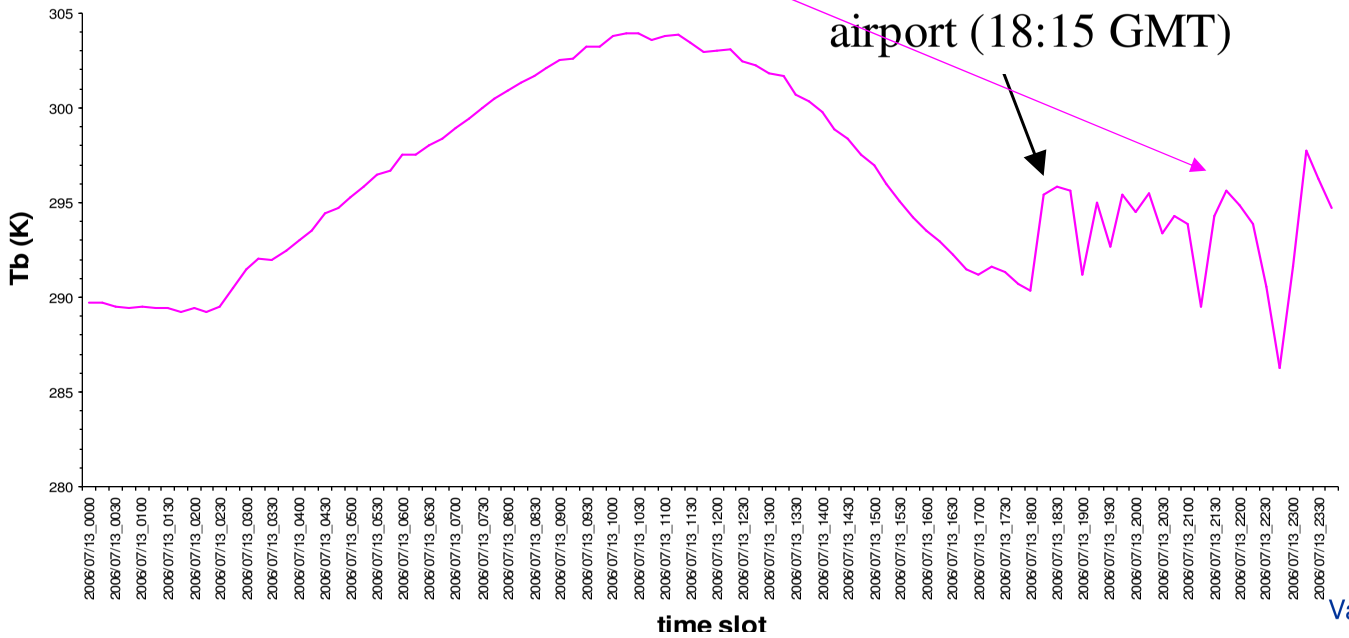
Attack to the Lebanon International Airport

Beirut 13-14 Luglio 2006





SEVIRI detection of attacks to Beirut airport (18:15 GMT)



RST for Monitoring Industrial Accident

flame burst at the Oil Center of Viggiano Italy (20/11/2008) (MSG-SEVIRI)

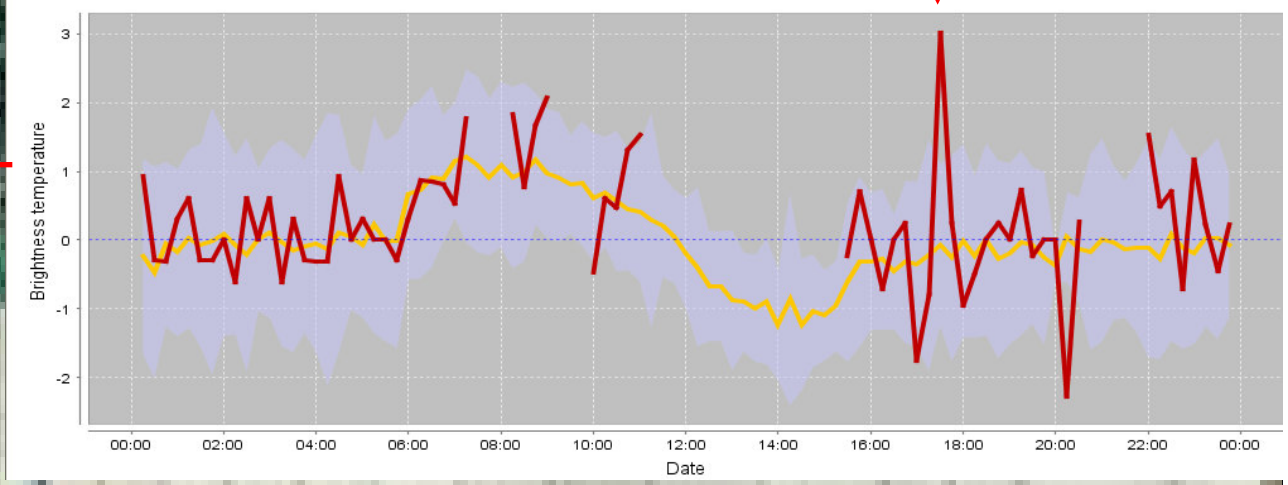
Da: La Nuova del Sud, 27/11/2008


LA NUOVA del Sud

previsto dello scorso giovedì che ha causato la fuoriuscita da uno degli impianti del Centro Oli di una fiamma di circa 30 metri che ha creato spavento i cittadini. Per fortuna quella dello scorso giovedì non era una situazione di allarme (alle 20,30 circa si sono attivati i sistemi di sicurezza al Centro olio di Viggiano in seguito ad un'erronea segnalazione dei sistemi automatici di protezione. L'episodio- ha detto l'Eni- è legato al sistema di controllo preventivo), ma nonostante

Correcting official reports

RST Anomaly identified at 17:15 GMT (i.e. 2 hours before than reported !



MSG-SEVIRI data, 20 Novembre 2008

CONCLUSIONS

- RST-FIRES allows to obtain un-precedent high reliability and sensitivity for timely detection (even very small) fires in different fire regimes
- SEVIRI seems then under exploited not only for fire detection but also for a wider range of possible applications requiring timeliness, rapid detection and short response times
- Some pre-processing aspects (e.g. re-sampling) and products (e.g. cloud masks) may impact on algorithm performances and might be re-discussed or revised
- Total Validation Approach required in order to avoid to wrongly address quality assessment of fire detection algorithms