

The role of end-users in improving science products performance: satellite based early fire detection in 3 Italian Regions

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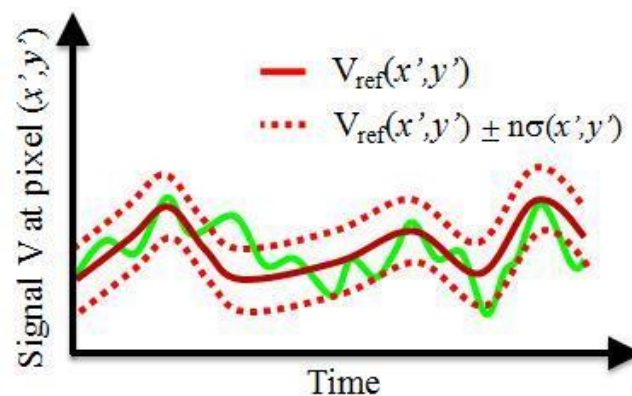
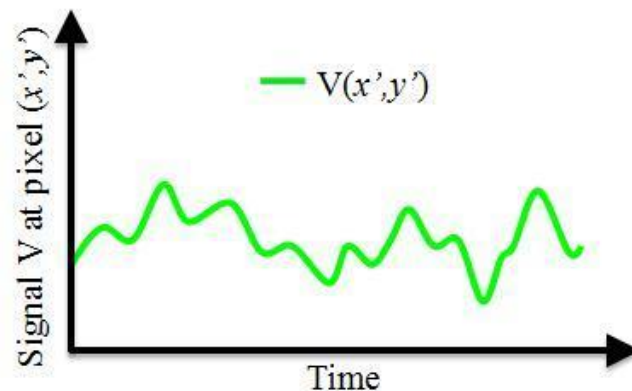
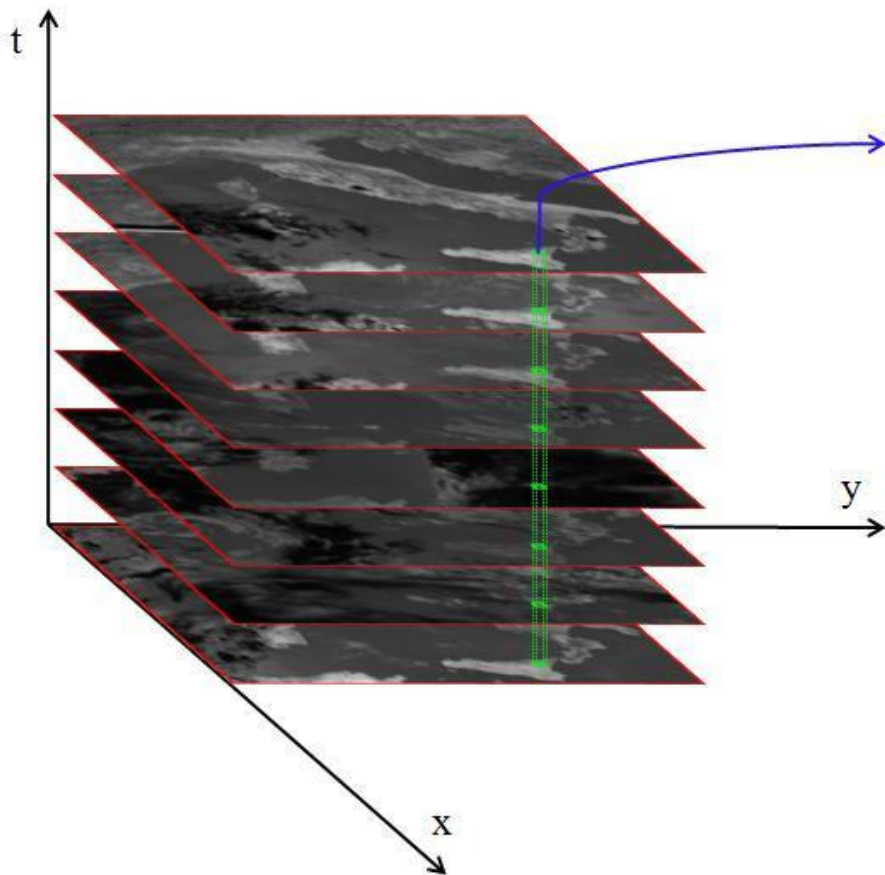
(5) Civil Protection Office, Regione Basilicata C.so Garibaldi 139, 85100 – Potenza, Italy



Rationale

- Design and development of Advanced Satellite techniques and original algorithms for **timely detection and Early Warning of forest fires.**
- RT/NRT Implementation and pre-operational testing **in strict collaboration with end-users** to assess and evaluate the actual impact of satellite technologies in fire monitoring procedures.
- **Training and Education programs** dedicated to the personnel, in order to ensure the full understanding and the better integration of satellite based products and tools within the existing fire fighting protocols.

Robust Satellite Techniques (RST)*: An original scheme of satellite data analysis in space-time domain.



Change detection scheme

It considers an anomaly as a deviation from "normal" conditions



Analysis of **relative** (rather than absolute) satellite signal variations

- Reducing "site" and "local" effects
- Improving sensitivity and reliability

* Tramutoli 1998, 2005, 2007

15 years of RST applications for natural and environmental hazards monitoring and investigation

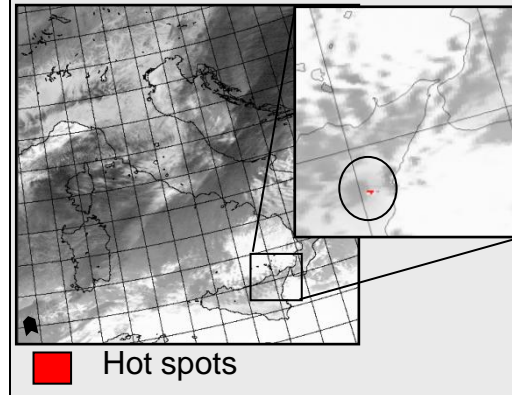
Forest fires

e.g. Fires in Italy, February 2005



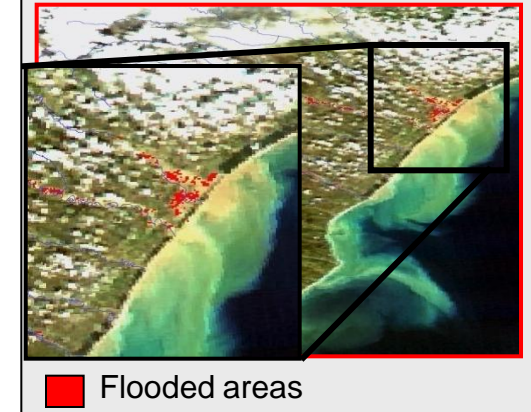
Volcanic eruptions

e.g. 2004-2005 Etna eruption (Italy)



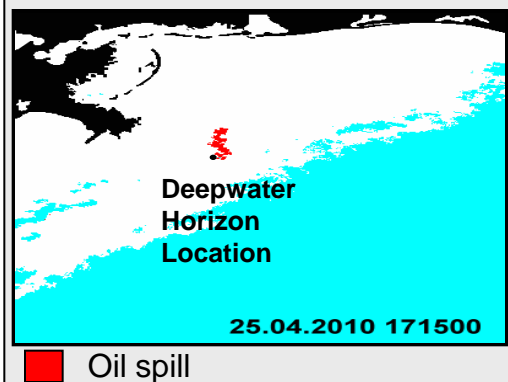
Floods

e.g. Basilicata flood, March 2011



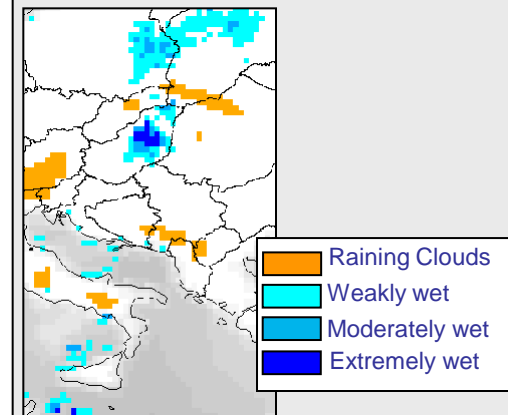
Oil spills

e.g. Oil spill in the Mexico Gulf, April 2010



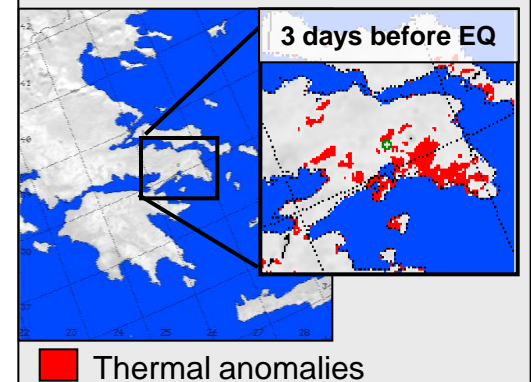
Soil moisture

e.g. Carpathian Basin, April 2000



Earthquakes

e.g. 7 September 1999 Athens Earthquake





The collaboration with end-users: LRAs co-funded initiatives in 3 Italian regions

→ **AVVISA (2007-2009)**
(Forest Fires Detection by Satellite)

→ **AVVISTA (2009-2011)**
(Fire Hotbed Detection by Satellite)

→ **AVVISA-Basilicata
(2010-2013)**
(Forest Fires Detection by Satellite)

→ **Lombardy Region** Civil Protection Office



→ **Sicily Region, Palermo Province**
Civil Protection Office



→ **Basilicata Region** Civil Protection Office



The collaboration with end-users

Real-time test campaigns

Pre-operational assessment of satellite fire detection systems through real-time test campaigns

Satellite products
(*thermal anomaly maps*) **immediately delivered** to Civil Protection operational rooms



The collaboration with end-users

Real-time test campaigns

Pre-operational assessment of satellite fire detection systems through real-time test campaigns

End-users ***promptly check*** satellite warnings activating ground and/or aerial surveys





The collaboration with end-users

Real-time test campaigns

Pre-operational assessment of satellite fire detection systems through real-time test campaigns

Timely provisions of feedbacks to tune algorithm and improve knowledge and technique performances



Rapporto delle osservazioni eseguite in		Nome		PILLOVA							
Data: 4/6/2009		Cognome Mancino		Livello							
Prima segnalazione Anomalia F. Data: ___/___/200__ (Indicare solo se diversa)		Spazio riservato UNIBAS: Numero Pixel Anomali: ___ (Indicare solo se più di uno)		Spazio riservato UNIBAS: IMAA							
				Immagine satellitare NOAA/MODIS/SEVIRI Data: ___/___/200__ Ora (GMT): ___:___:___ Original: 25000x1 view 512x512							
Alle ore: (Ora Locale) ___:___ GMT: ___:___											
Pixel 1: Spazio riservato IMAA/UNIBAS		Pixel 2: Spazio riservato IMAA/UNIBAS									
LAT	LOW	ALTE	dist/altaz	T4	P1	LAT	LOW	ALTE	dist/altaz	T4	P1
RAPPORTO DELLE OSSERVAZIONI						RICOGNITORE NUM.					
ORA (Locale)	LAT	LON	DESCRIZIONE DEL SUOLO								
12.20	N 40 48 12	E 15 59 33	COPERTURA DOMINANTE: (battere se il terreno è arido) UNICID terreni aridi-stoppe: MOLTO UMIDO ALLAGATO								
OSSERVO	UMIDITÀ	METRI	TIPO DI COMBUSTIBILE								
INCENDIO IN ATTO	SI	---	PRESENZA FUMO ?								
ALTRI FUOCHI	SI	---	NO								
PERCORSO DAL FUOCO	SI	---	NO								
			TIPO DI ATTIVITÀ O DI SORLENTE			FUMO ? (battere)					
			SENZA IMAA			NO					
			N°1			NO					
OSSIBILI SUPERFICI RIFLETTENTI (specificare se presenti)											
VEDI NOTE											
FO. ROMANOLI											
È fotografata a cavallo delle coordinate e segnalata, si deve fotografare l'Anomalia che potrebbe "sfornare" tutto un quadro inquadro e "fococoso" si											

The collaboration with end-users

Overcoming the traditional “*a posteriori*” validation approach towards a Total Validation Approach (TVA)

A posteriori
Validation
Approach

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**” 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 !

The collaboration with end-users

Overcoming the traditional “*a posteriori*” validation approach towards a Total Validation Approach (TVA)

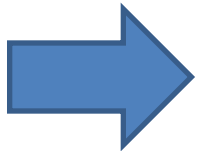
TVA
Total Validation
Approach

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

The collaboration with end-users

Overcoming the traditional “*a posteriori*” validation approach towards a Total Validation Approach (TVA)

Many kinds of *actual hot sources* are able to produce thermal anomalies, otherwise classified simply 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. *Industrial plants***

End user collaboration: fundamental

Actual validation of the RST-FIRES performances. Other validation methods (such as sensor-to-sensor comparison, official databases, visual inspection) would not be able to do the same.

Small fires: Burnt area near Montemilone (PZ), Basilicata Region, about 0.09 hectares



Unsighted or late-sighted fires: area near Cavargna (CO) Lombardia Region, in a Alpine valley



Cleaning fires: active large cleaning fire over the area of Prizzi (PA), Sicilia Region

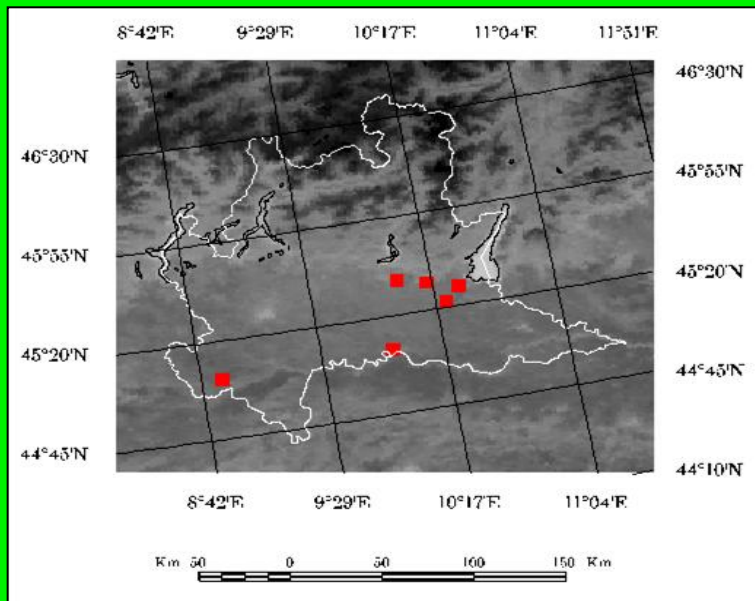


Industrial plants with thermal variations in production, near Brescia (MI), Lombardia Region



End user collaboration: fundamental

Direct observations allow to construct exclusion map only on the basis of a multi-temporal satellite data analysis

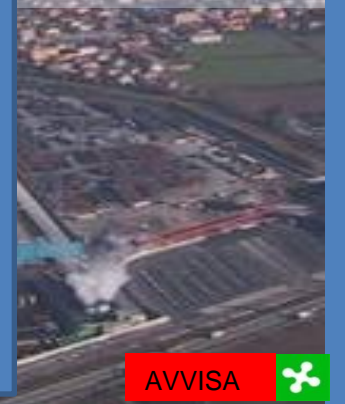


Intermittent anomalous MIR signals (green crosses) detected by RST-FIRES system during AVVISA campaign, clustered in specific areas in Lombardy region

Not related to fires occurred

Rapporto delle osservazioni eseguite in		TILDTA				OSSERVATORE			
Data 21/10/2006		Nome <u>MARO</u>				Nome <u>NICOLA</u>			
Prima segnalazione Anomalia in Data: / / 2006		Cognome <u>BOTTI</u>				Cognome <u>ARZARONI</u>			
Alle ore: (Ora Locale)		Spazio riservato UNIBAS-IMAA				Spazio riservato UNIBAS-IMAA			
Pixel 1. Spazio riservato UNIBAS		Numero Pixels Anomali (indicare solo se diversa)				Passaggio satellitare NOAA			
LAT		Valore T3 comune				Data / / 2006			
LON		Pixel 2. Spazio riservato UNIBAS				Ora (GMT)			
ALICE		Pixel 3. Spazio riservato UNIBAS				Original Zenithal view angle			
T4		LAT				LAT			
RI		LON				LON			
		ALICE				ALICE			
		T4				T4			
		RI				RI			
RAPPORTO DELLE OSSERVAZIONI									
Ora (Locale)	LAT	LON	DESCRIZIONE DEL SUOLO				NOTE DELL'OSSERVATORE		
12 / 53	45°52'24"	10°24'59"	COPERTURA DOMINANTE				A.S. ACQUA ACCIAIERIA ALFA ACCIAI		
	45°54'30"	10°25'00"	ARBITRATO				Foto 1 - area residenziale [punto segnalato]		
OSSERVO	(barrare)	ETTARI	METRI	TIPO DI COMBUSTIBILE		PRESENZA FUMO ?			
INCENDIO IN ATTO	SI	NO	fonti diverse		SI		NO		Foto 2 - acciaieria [punto segnalato]
ALTRI FUOCHI	SI	NO			SI		NO		Foto 3 - capannoni industriali in AREA RESIDENZIALE [punto segnalato]
PERCORSO DAL FUOCO	SI	NO			SI		NO		Foto 4 - PIZZERIA D'ACQUA [punto segnalato]
CAMINI DI ATTIVITA' INDUSTRIALI		CON FIAMMA	SENZA FIAMMA	TIPO DI ATTIVITA' O DI SORGENTE		FUMO ?			
X		NO	NO	ACCIAIERIA		SI		NO	
ALTRE POSSIBILI SORGENTI TERMICHE (specificare se presenti)		SI	NO			SI		NO	
		SI	NO			SI		NO	
NEVE		LA NEVE E' (in linea d'aria) AD UNA DISTANZA INFERIORE A (barrare un solo box)							
		NO MA IN PROSSIMITA' DEL FRONTE INNEVATO							
		0,1 km 0,5 km 1 km 2 km 3 km 4 km 5 km							
SPECCHI D'ACQUA		ALTRE POSSIBILI SUPERFICI RIFLETTENTI (specificare se presenti)							
X									
NUVOLE BASSE									
SI									
NUVOLE ALTE									
SI									
FOTO ?		NOME FILE/NUM FOTO							
X		21122006_1.jpg; 21122006_2.jpg; 21122006_3.jpg; 21122006_4.jpg							

al variations in Lombardia Region

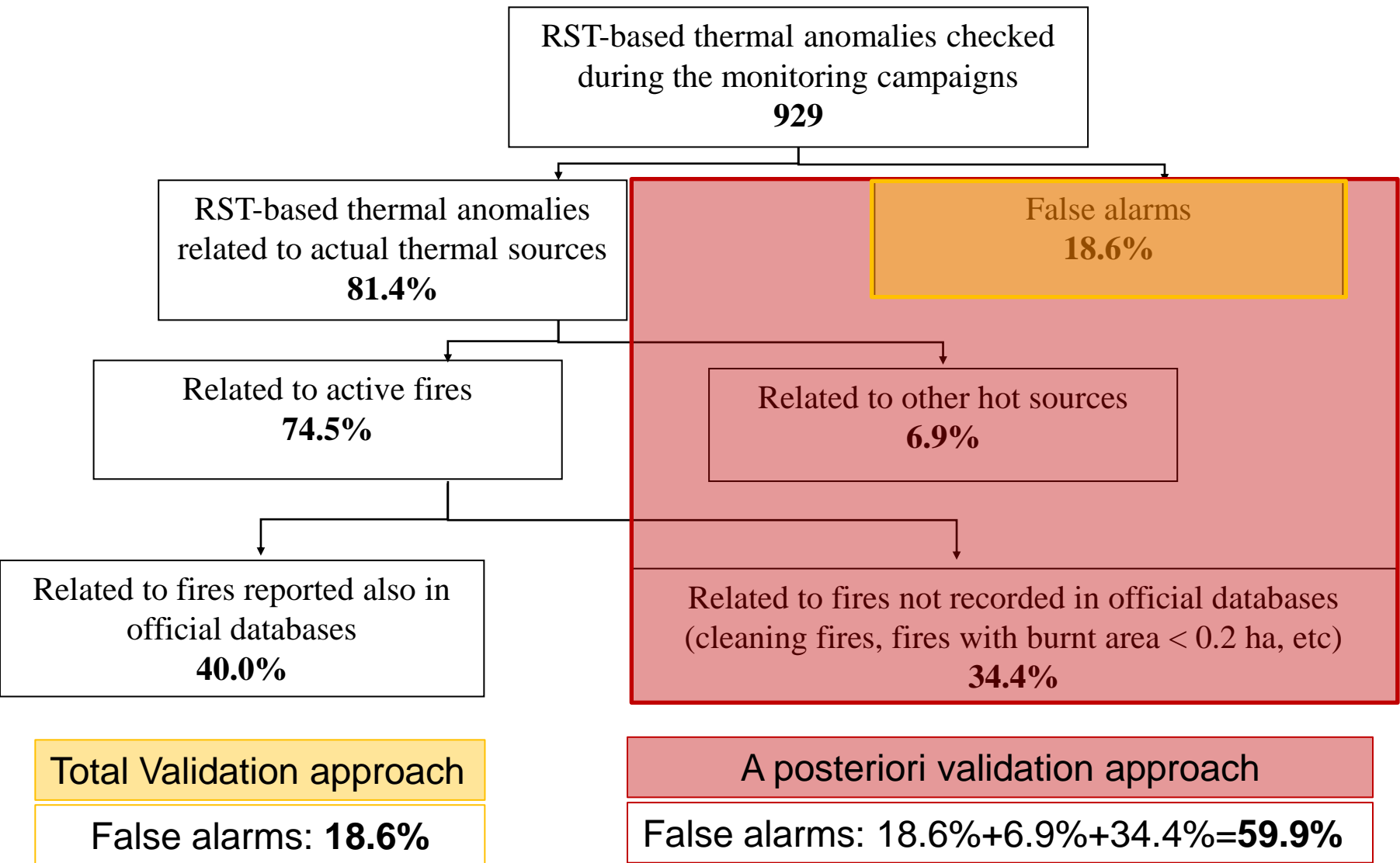


AVVISA



RST-FIRES RELIABILITY

Analysis performed on controlled alerts



RST-FIRES RELIABILITY

Analysis performed on controlled alerts

VALIDATION CAMPAIGN	NUMBER OF DAYS	TOTAL CONTROLLED ANOMALIES	CONFIRMED		NOT CONFIRMED/FALSE								OTHER*	
					TOTAL		by ground check		by ground and aerial check		by aerial check			
Palermo 2009	39	363	298	82,1%	65	17,9%	65	17,9%	N.A.		N.A.		0	0,0%
Basilicata 2009	62	98	93	94,9%	3	3,1%	3	3,1%	0	0,0%	0	0,0%	2	2,0%
Basilicata 2010	38	103	87	84,5%	9	8,7%	5	4,9%	1	1,0%	3	2,9%	7	6,8%
Palermo 2010	42	154	119	77,3%	26	16,9%	24	15,6%	0	0,0%	2	1,3%	9	5,8%
Palermo 2011	86	230	159	69,1%	69	30,0%	69	30,0%	0	0,0%	0	0,0%	2	0,9%
TOTAL	267	948	756	79,7%	172	18,1%	166	17,5%	1	0,1%	5	0,5%	20	2,1%

* 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.

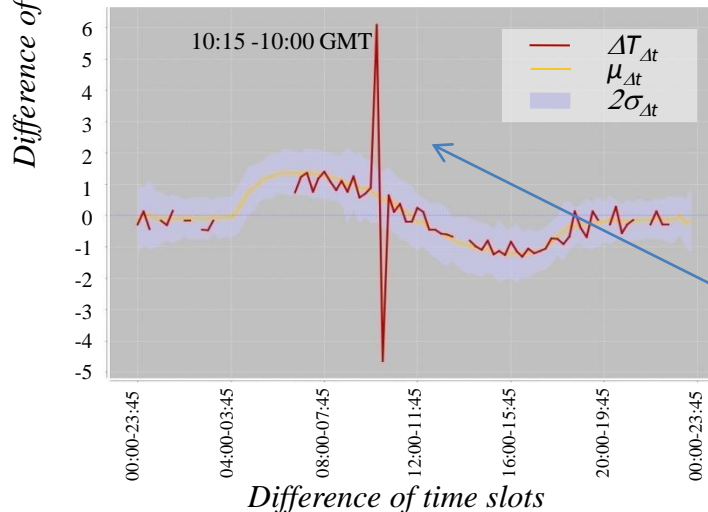
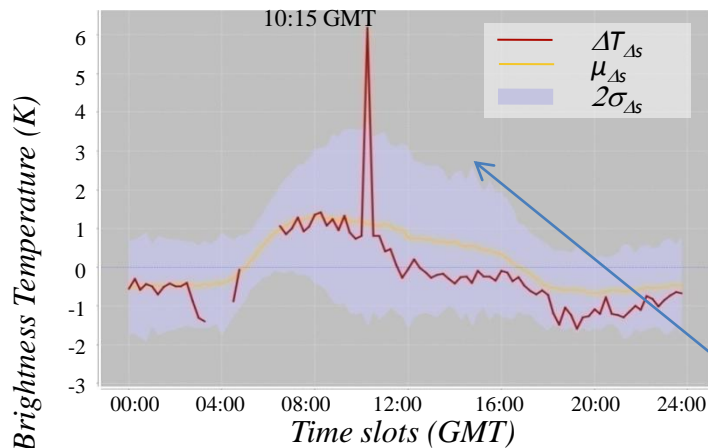
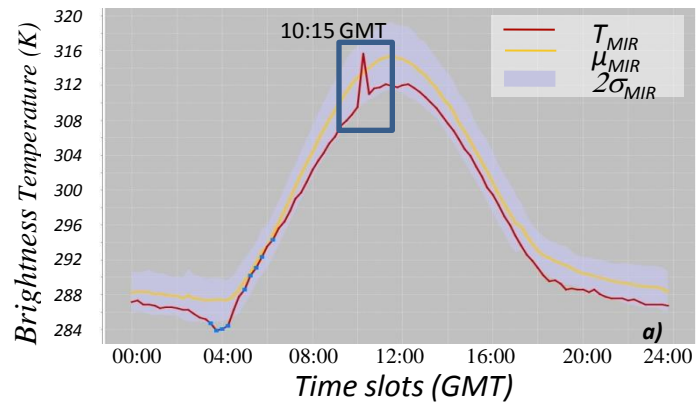
RELIABILITY: DOUBTS ABOUT SOME GROUND CHECKS



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.

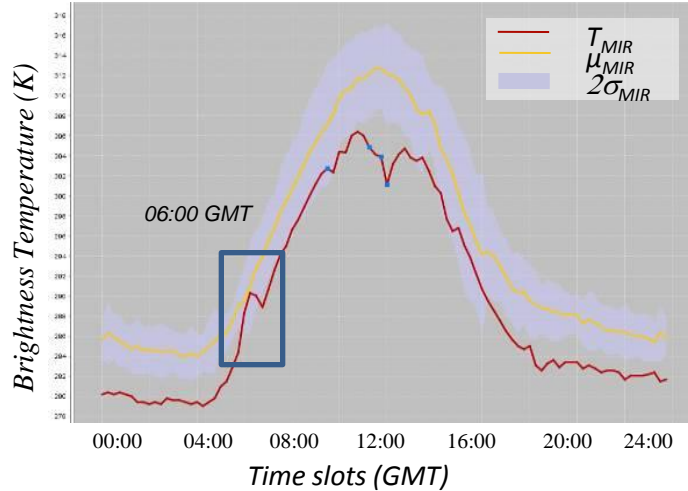
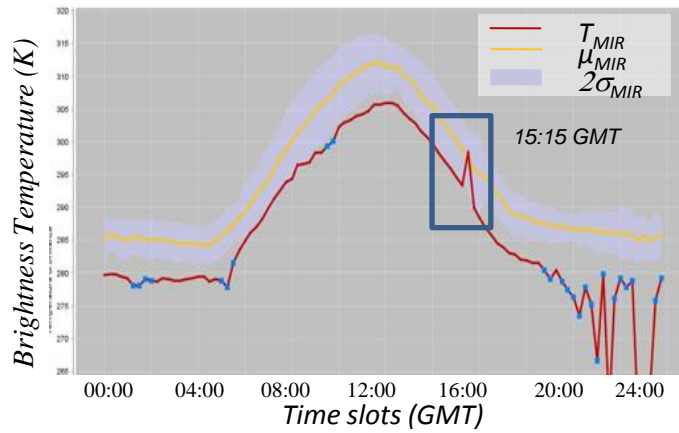
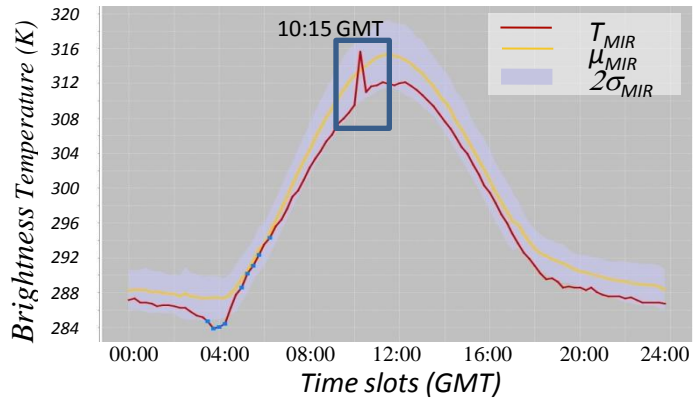


Spatial and temporal differential indexes

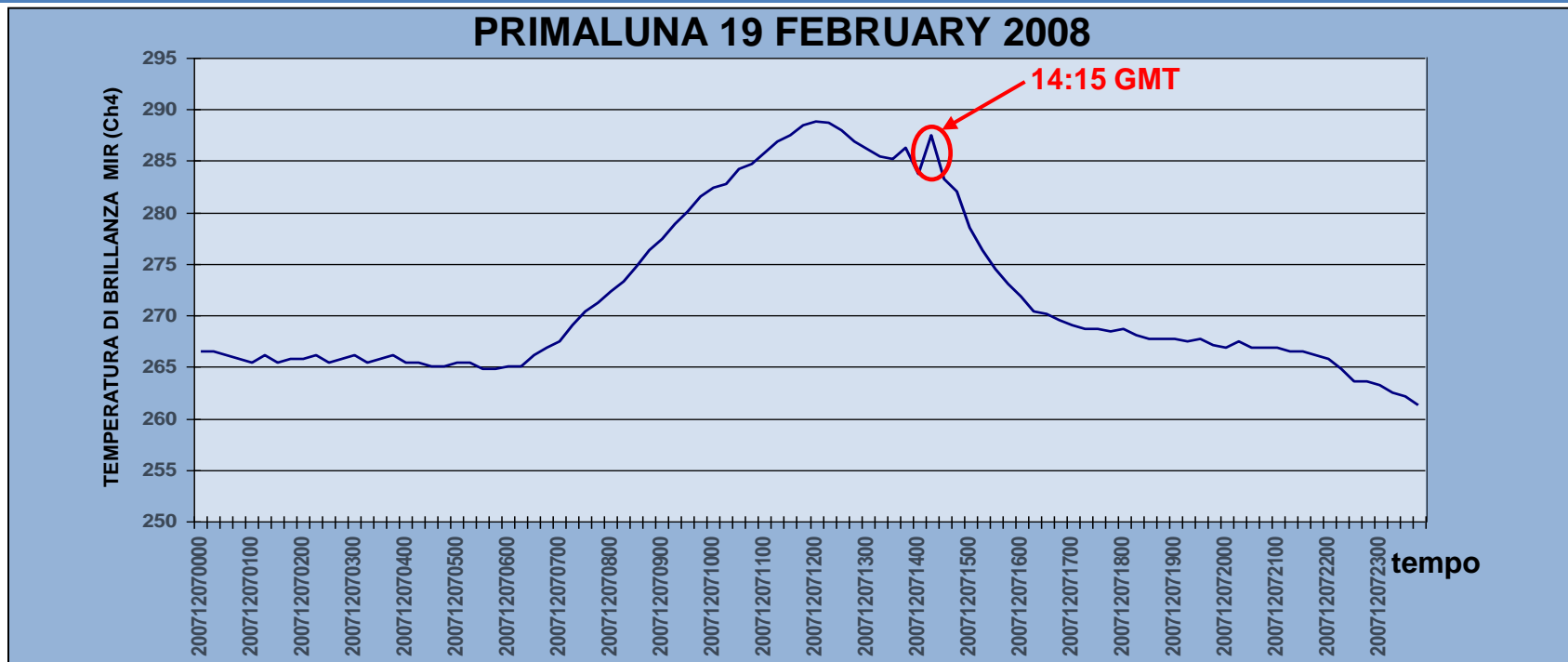
At 10:15 GMT, signal excess ($\Delta T_{\Delta s} - \mu_{\Delta s}$) is **3.82** times greater its normal variability $\sigma_{\Delta s}$

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

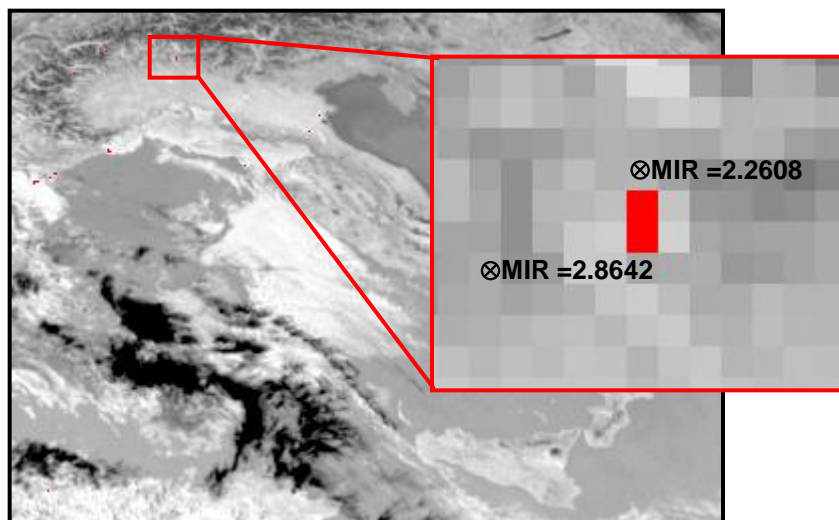
RELIABILITY: DOUBTS ABOUT SOME GROUND CHECKS



End-users success stories: early detection capability



SLOT 14:15 GMT $\otimes_{\text{MIR}}(r, t) > 2.0$

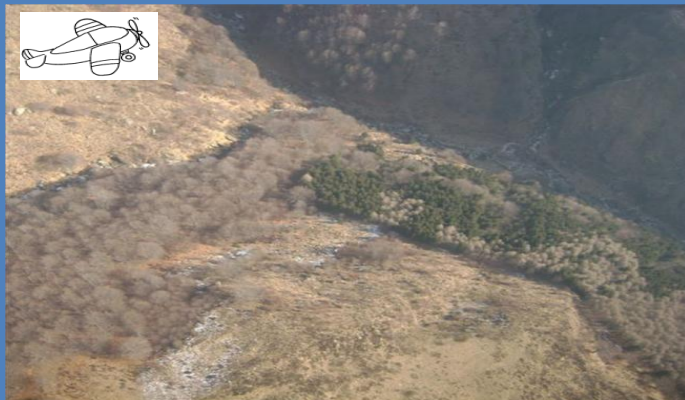
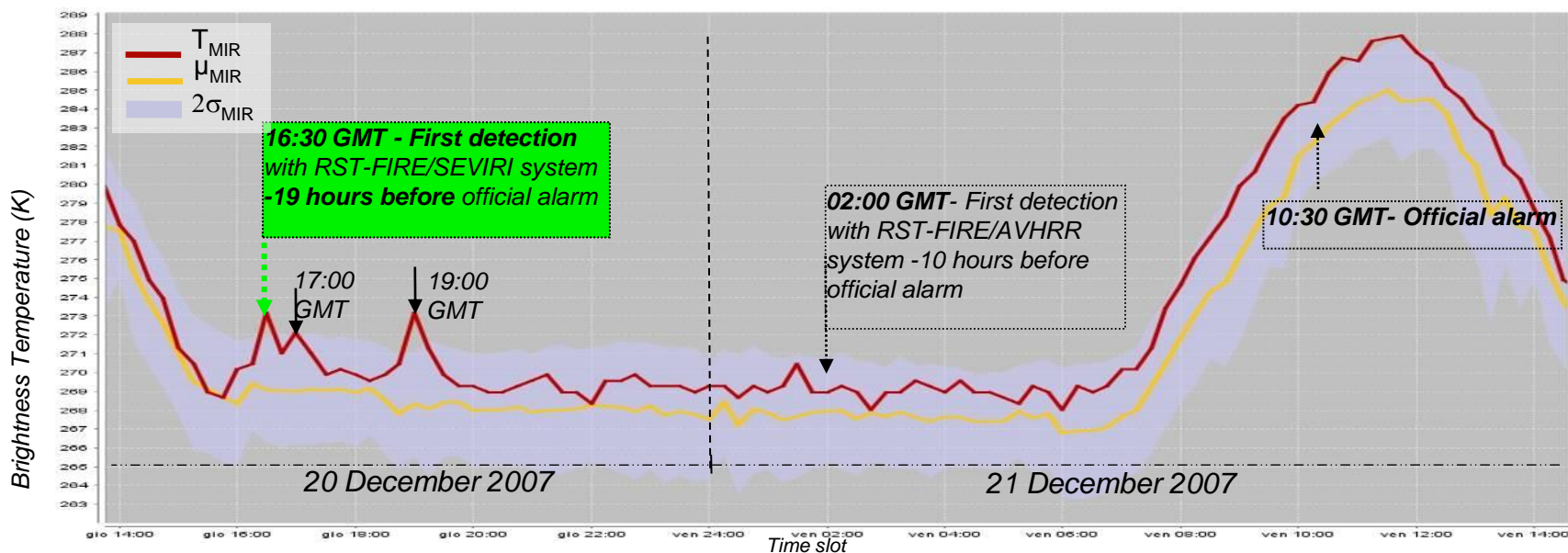


OPERATIONAL ROOM OF REGIONAL CIVIL PROTECTION OFFICE RECEIVED AN ALERT AT 15:10 GMT i.e. ABOUT 1 HOUR AFTER THE SATELLITE WARNING

End-users success stories: early detection capability

Cavargna (Co), Lombardia Region
20 - 21 DECEMBER 2007

remote position respect to ground
traditional monitoring systems



RST-FIRES/SEVIRI records a first anomalous signal on 20 December 2007 at 16:30 GMT, about 19 hours before the official alarm received by Civil Protection at 10:30 GMT the day after.

At 02:00 GMT, RST-FIRES/AVHRR is able to detect the fire, as soon as NOAA-AVHRR passed over the area, even 10 hours before the official warning.

End-users success stories: early detection capability

CAVARGNA

Rapporto delle osservazioni eseguite in Data 28/12/2007		PILOTA Nome MARIO Cognome ROTTI		OSSERVATORE Nome ALESSANDRO Cognome LABAA	
Prima segnalazione Anomalia in Data: 20/12/2007 (indicare solo se diversa) Alle ore: (Ora Locale) 17/30		Spazio riservato UNIBAS-IMAA Numero Pixels Anomali (indicare solo se più di uno)		Spazio riservato UNIBAS-IMAA Passaggio satellitare NOAA/ Data / / 2000 Ora (GMT) / /	
Pixel 1. Spazio riservato UNIBAS LAT LON ALICE T4 RI		Pixel 2. Spazio riservato UNIBAS LAT LON ALICE T4 RI		Pixel 3. Spazio riservato UNIBAS LAT LON ALICE T4 RI	
RAPPORTO DELLE OSSERVAZIONI					
Ora (Locale)	LAT	LONG	DESCRIZIONE DEL SUOLO		
10/55	46° 06' N	09° 06' E	COPERTURA DOMINANTE PASCOLO - GERBOSCIATO - RIMBOSCHIMENTO RESINOSO PRESENTE		
OSSERVO		DIMENSIONI ETTARI METRI		TIPO DI COMBUSTIBILE	
INCENDIO IN ATTO		SI NO		SI NO	
ALTRI FUOCHI		SI NO		SI NO	
AREA GIA' PERCORSO DAL FUOCO		SI NO		SI NO	
		30		PASCOLO	
				TIPO DI ATTIVITA' O DI SORGENTE	
CAMINI DI ATTIVITA' INDUSTRIALI		CON FIAMMA N°		SENZA FIAMMA N°	
ALTRE POSSIBILI SORGENTI TERMICHE (specificare se presenti)		SI NO		SI NO	
NEVE		SI NO		LA NEVE E' (in linea d'aria) AD UNA DISTANZA INFERIORE A (barrare un solo box)	
		X		0,1 km X 1 km 2 km 3 km 4 km 5 km	
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/NOME FOTO	
		X		CAVARGNA / FOTO N° 1 - n° 2	

NOTE DELL'OSSERVATORE
SU COORDINATE
46 06 554 N
09 06 574 E
INCENDIO DI PASCOLO
30 ETTARI CIRCA CON
NEVE A MOUTE
- - -
CIRCA 20 mt N
LINGUA DI GHIACCIO
IN CANALONE LUNGA
CIRCA 10 mt



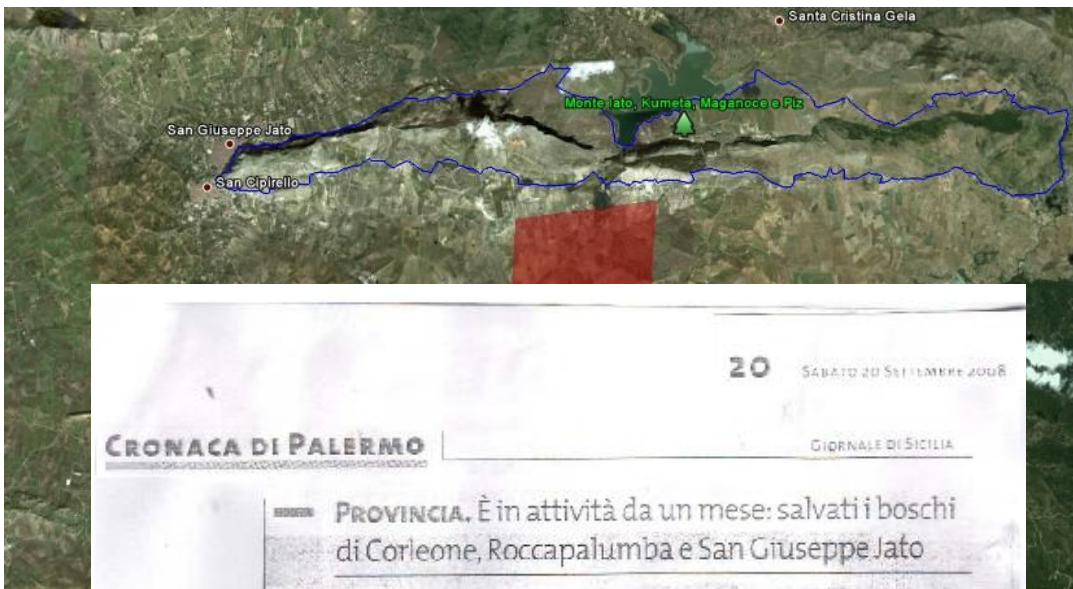
REPORT FROM AERIAL SURVEY
(5 days later)

End-users success stories: actual impact on fire fighting

Fires promptly detected and extinguished



Satellite-based rapid detection and prompt intervention of fire fighting teams prevent the near *Special Protection Zone* from being reached by flames.



S.

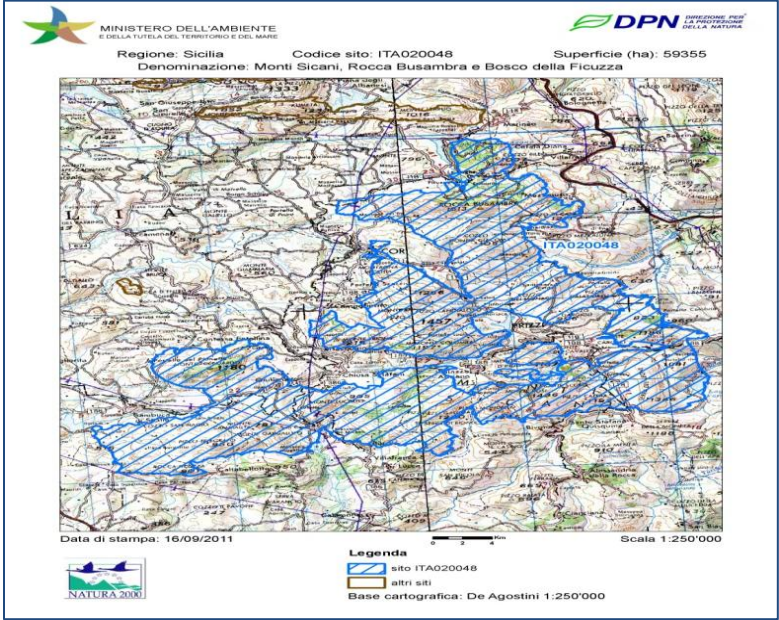
Gi. Ma.

End-users success stories: actual impact on fire fighting

Fires promptly detected and extinguished



Another similar case was the event occurred on 15 September 2009, near Marineo (PA, Sicily Region), close to the valuable area ZPS-ITA020048 “M. Sicani, Rocca Busambra and Bosco della Ficuzza”



Volontariato Ulm antincendio sulla Sicilia

Testo e foto di Sergio Bartocchetti

CACCIATORI DI FALO

A bordo di un Savannah del Club Albatros abbiamo volato per la Protezione Civile; due missioni al giorno tra Termini Imerese e Trapani. Avvistando le fiamme e fotografando i piromani in azione.

IL CRIMINALE "BECCATO" AL VOLO

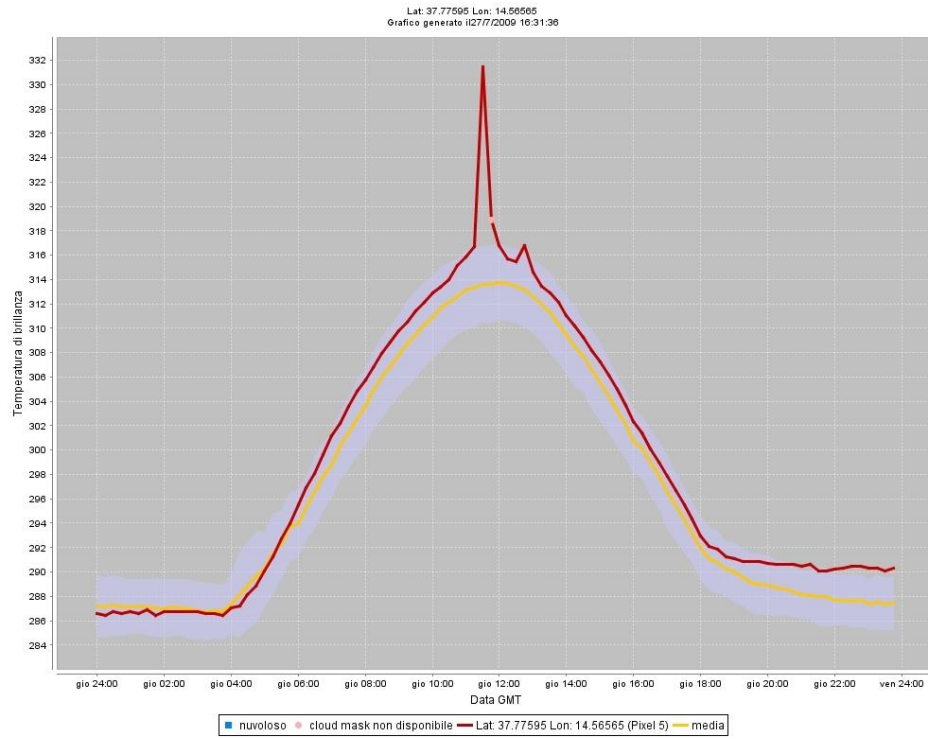
Summi e cattivi
Qui accanto, gli agenti del Corpo Forestale dello Stato in azione con un autobotte accanto, nel cerchio rosso, un piromane in azione ripreso dall'ultralivello del pilota siciliano Roberto Pascià.

58 59 VOLARE Ottobre 2009

Pyromaniac caught "in action"

Other End-users success stories

National Civil Protection Department : Support to decision on aerial resources (Canadair) usage



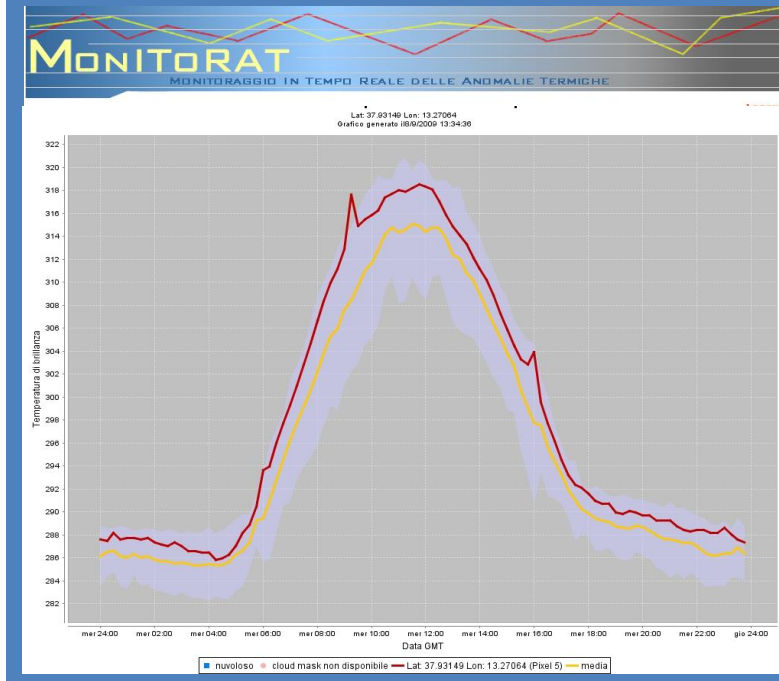
Regalbuto (Enna – Sicilia)



Pau (Oristano – Sardegna)

Friendly, ready-to-use tools and training for LRAs' personnel

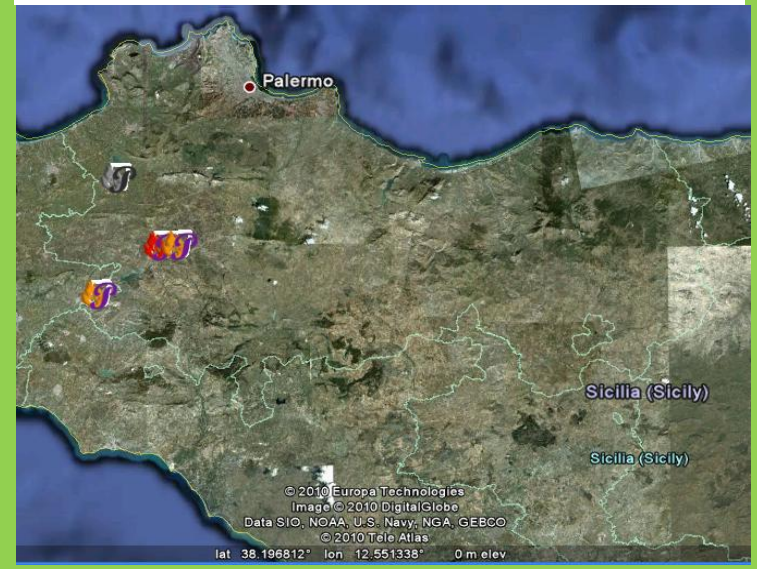
Web-based tools



Google Earth plugins

RST-based thermal anomalies

2010-08-07 15:00 GMT



Conclusions & Lessons learnt

- Positive impact of ST on fire fighting confirmed
- Product quality necessary but not sufficient
- Education of potential ST users fundamental
- Dedicated funds required to support end-users in the pre-operational testing and implementation phases