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Winter College on Optics in Environmental Science

2 - 18 February 2009

Robust Satellite Techniques (RST) for Natural and Environmental Hazards Monitoring: applications

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WINTER COLLEGE ON OPTICS IN ENVIRONMENTAL SCIENCE
Trieste 2 – 13 February 2009

Robust Satellite Techniques (RST) for Natural and Environmental Hazards Monitoring: applications

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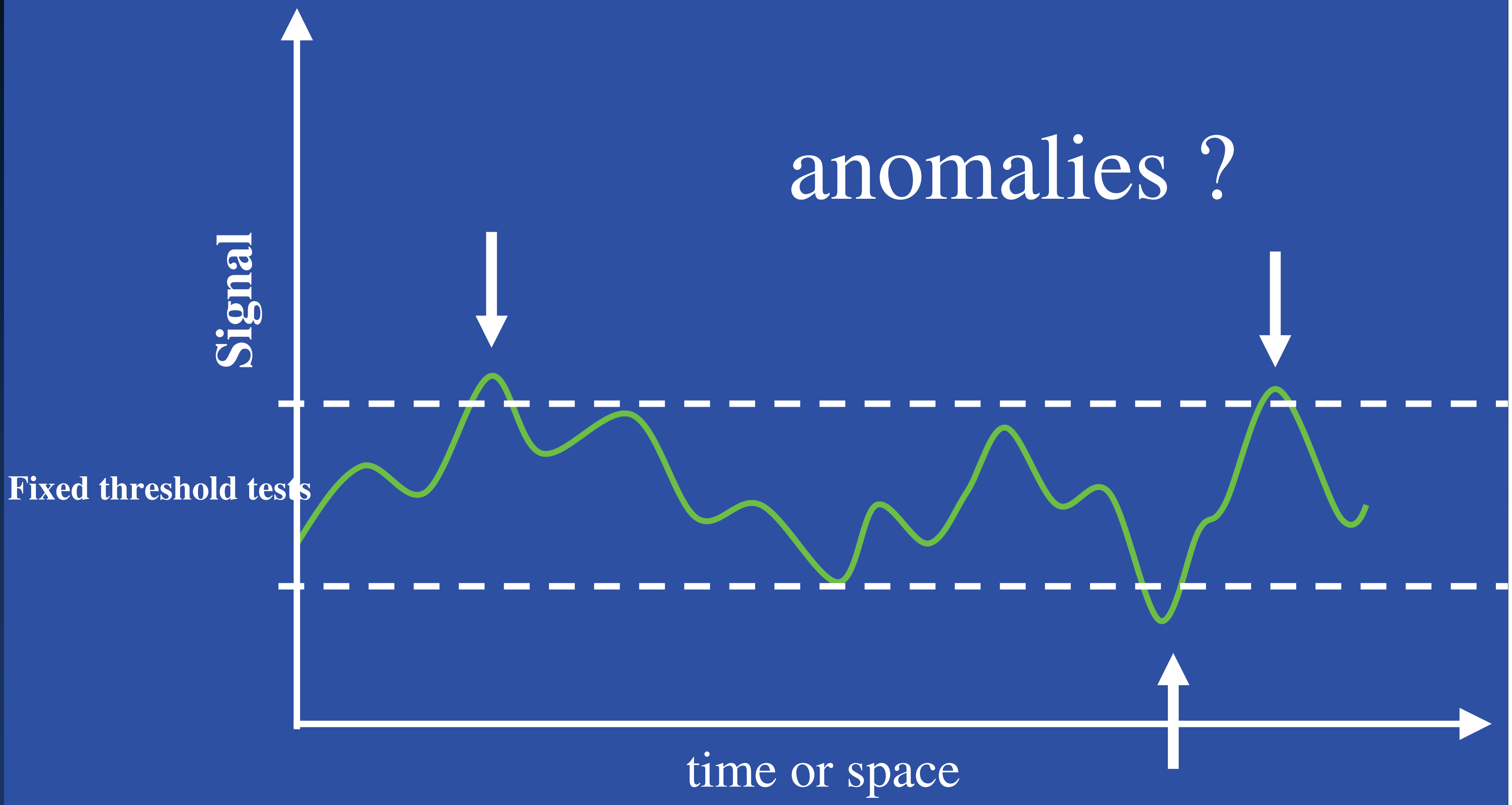
Single image – fixed threshold methods: main issues

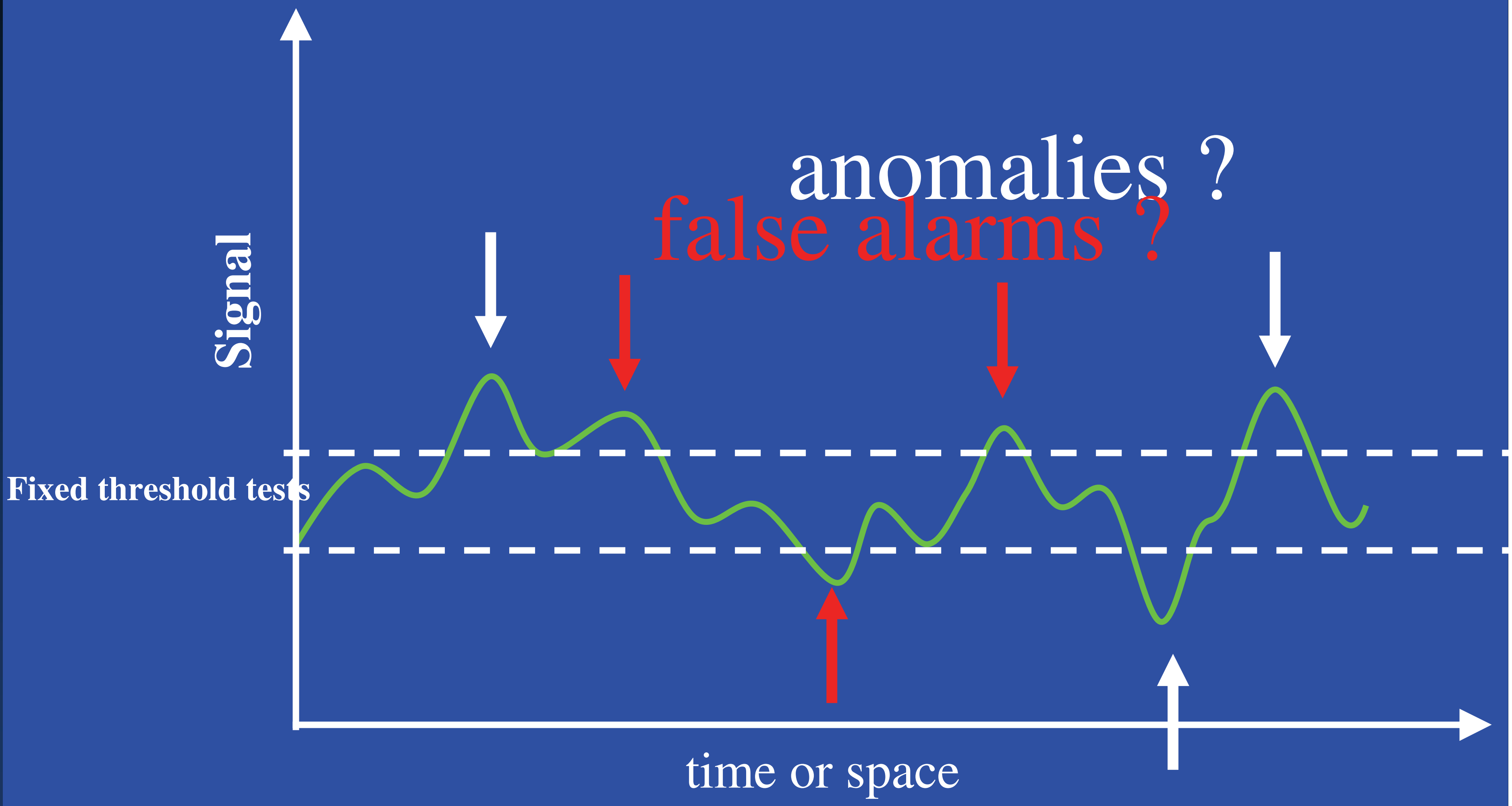
- High false alarm rate / low sensitivity
- Performances strongly depending on time/place of implementation
- Low exportability on different geographic areas
- Low exportability on different/new sensors

Kaufman method

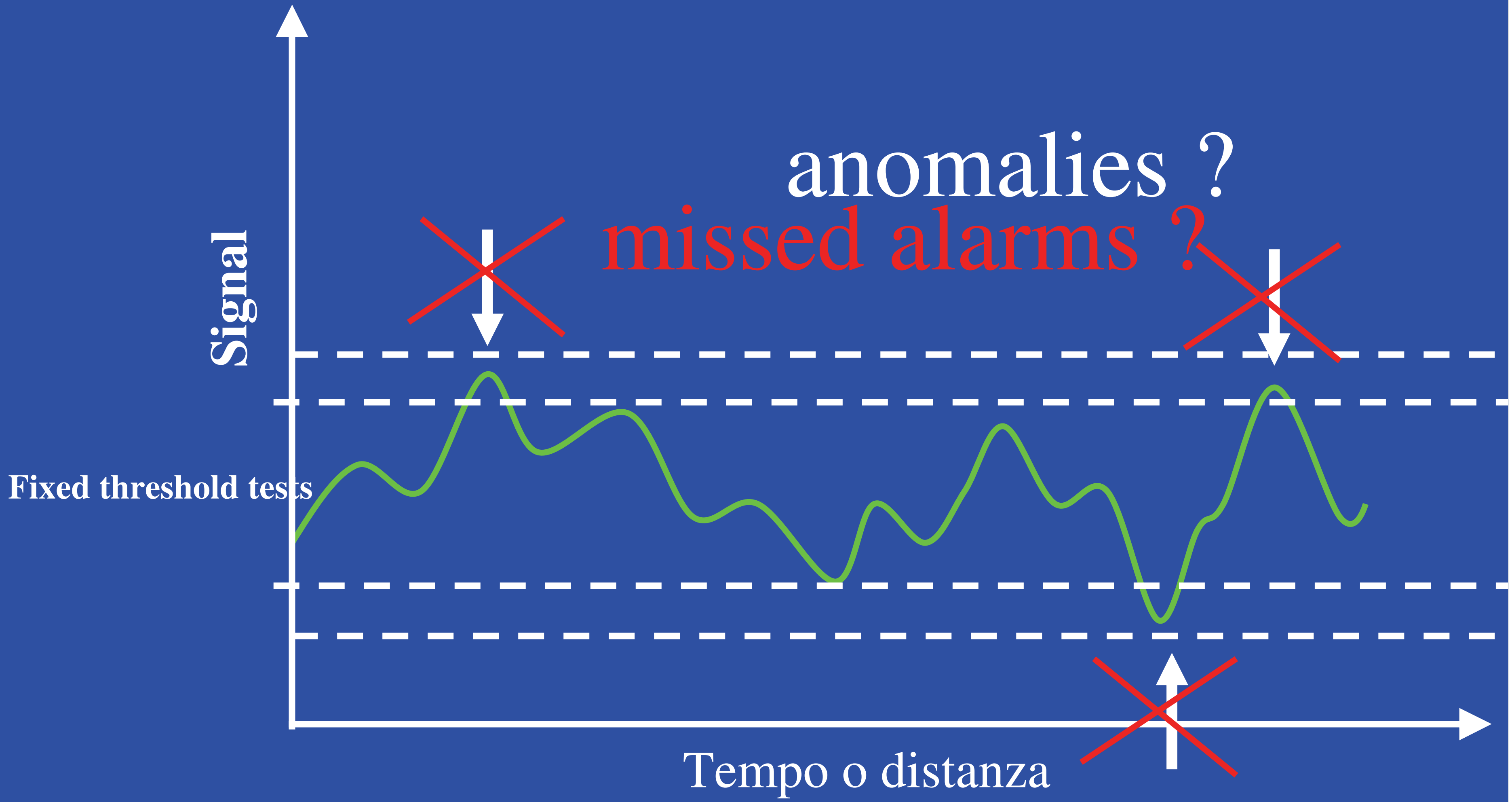
threshold approaches



to reduce thresholds to increase sensitivity….



or to increase thresholds in order to reduce false alarms ?

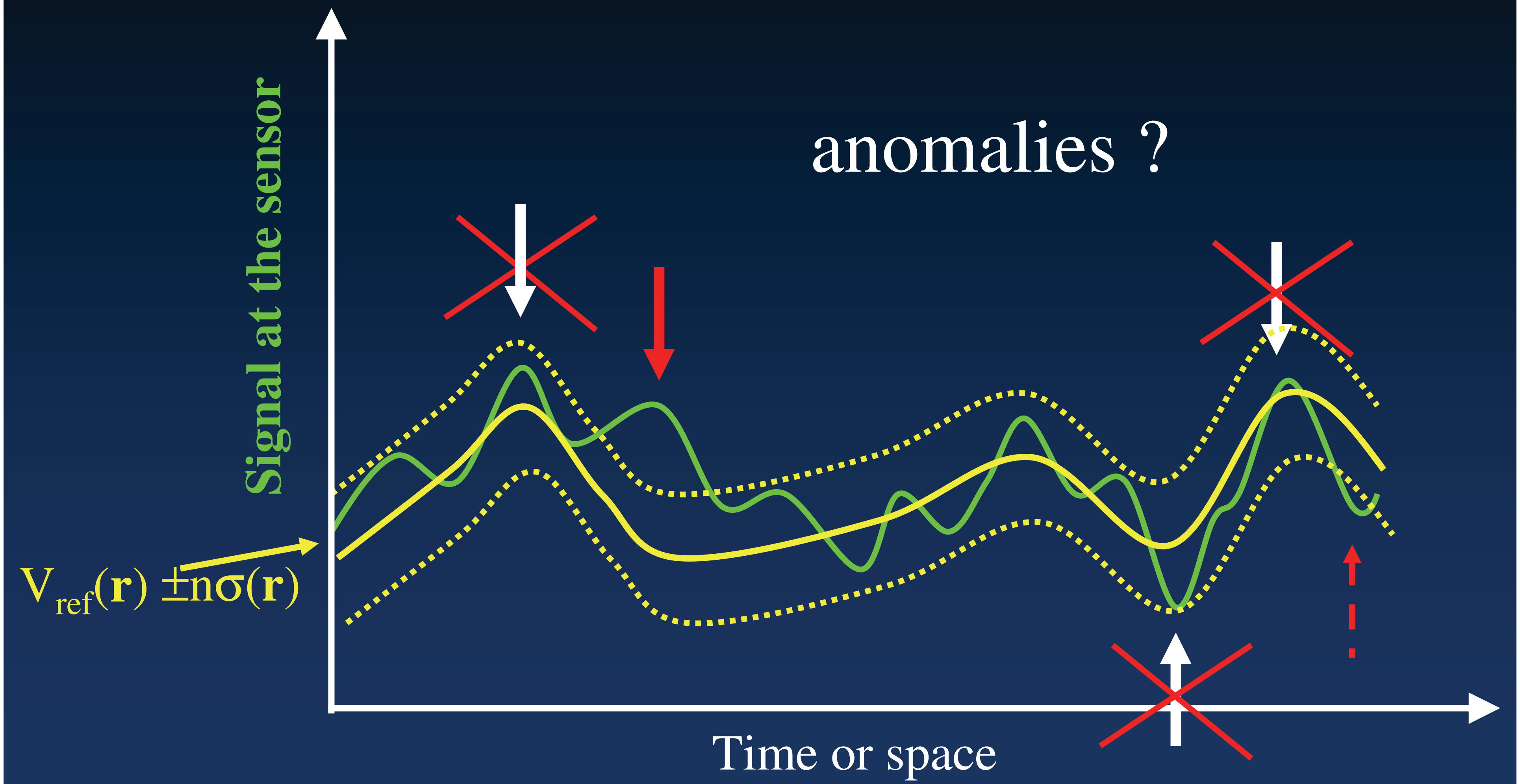


THEORETICAL ISSUES

What "anomaly" means ?

(common sense do not consider fixed thresholds)

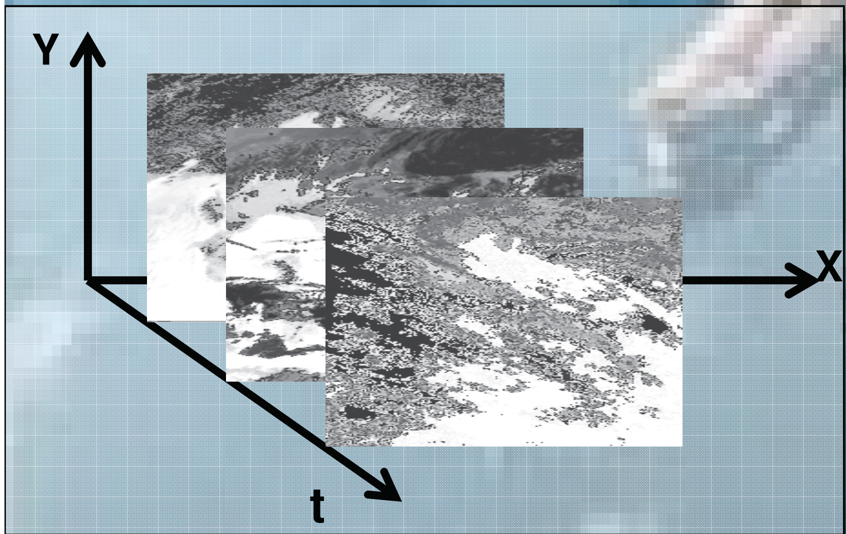
What "anomaly" means ?



A different approach: Robust Satellite Techniques (RST)

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

1. Select an **historical data-set** *V(r,t)* as homogeneous as possible: same time of the day and period of the year (*T*–domain) in order to reduce natural/observational noise



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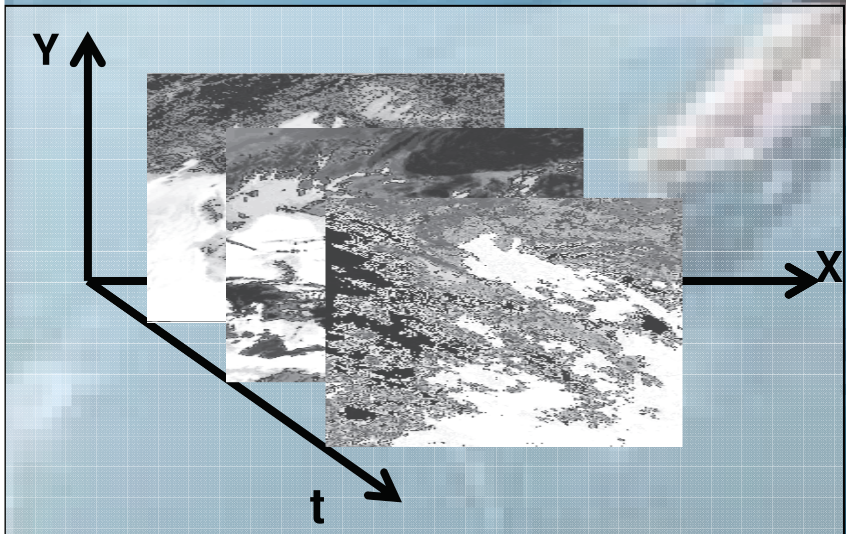
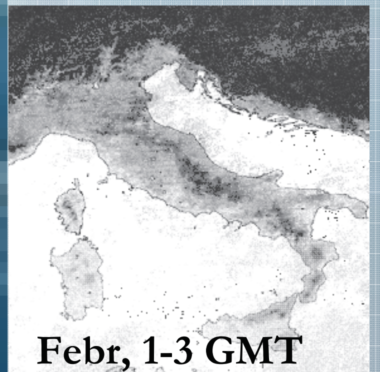
A different approach: Robust Satellite Techniques (RST)

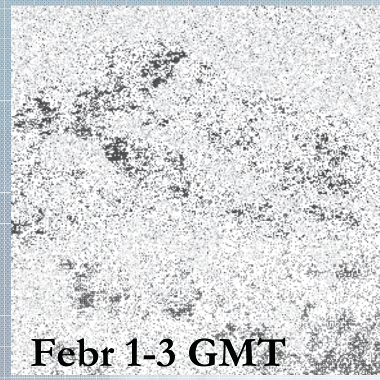
1. Select an **historical data-set** *V(r,t)* as homogeneous as possible: same time of the day and period of the year (*T*–domain) in order to reduce natural/observational noise

2. Compute the ***unperturbed*** **reference fields** for the observable $V(\mathbf{r},t)$



$V_{REF}(\mathbf{r})$ and $\sigma_V(\mathbf{r})$

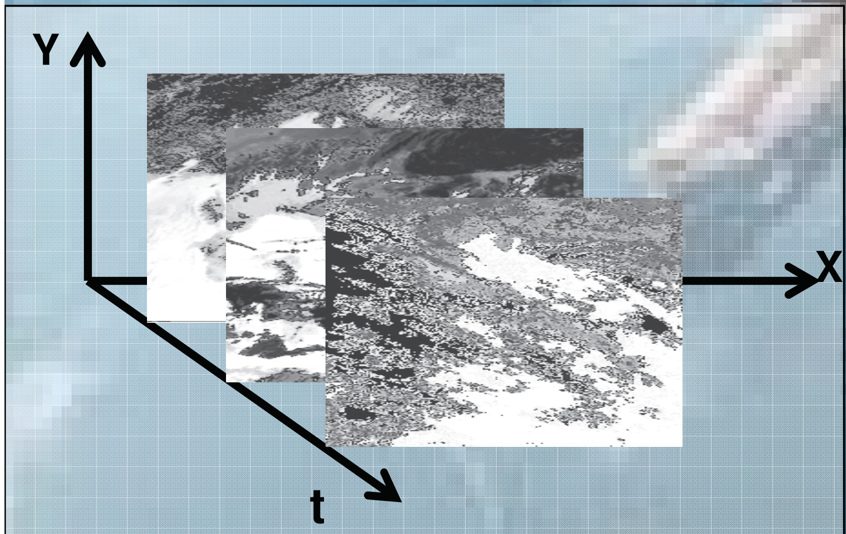




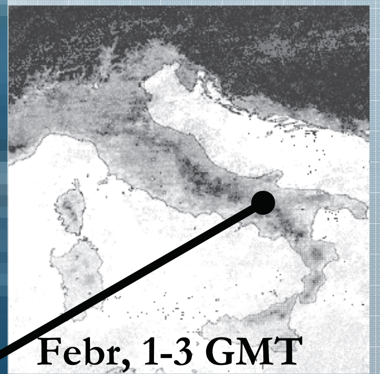
A different approach: Robust Satellite Techniques (RST)

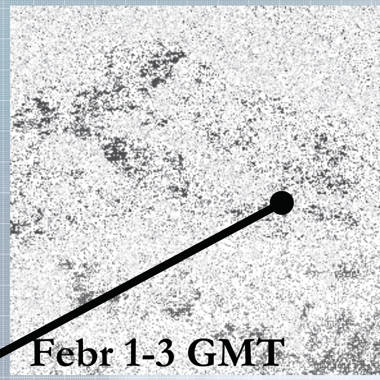
1. Select an **historical data-set** $V(\mathbf{r},t)$ as homogeneous as possible: same time of the day and period of the year (T–domain) in order to reduce natural/observational noise
2. Computing the ***unperturbed* reference fields** for the observable $V(\mathbf{r},t)$

3. Change - Detection at the time t by



$V_{REF}(\mathbf{r})$ and $\sigma_V(\mathbf{r})$





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

A.L.I.C.E.

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

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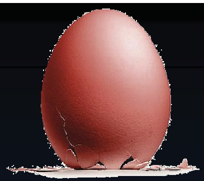


10 years of RST Applications

Using several satellite/packages

- NOAA (AVHRR, AMSU)
- METEOSAT, GMS, GOES, MSG (SEVIRI)

from Visible to the Microwave spectral range

10 years of RST Applications

For two main classes of environmental processes:

short scale changes (relatively confined in the space and/or in time) to be detected mainly for damages mitigation purposes

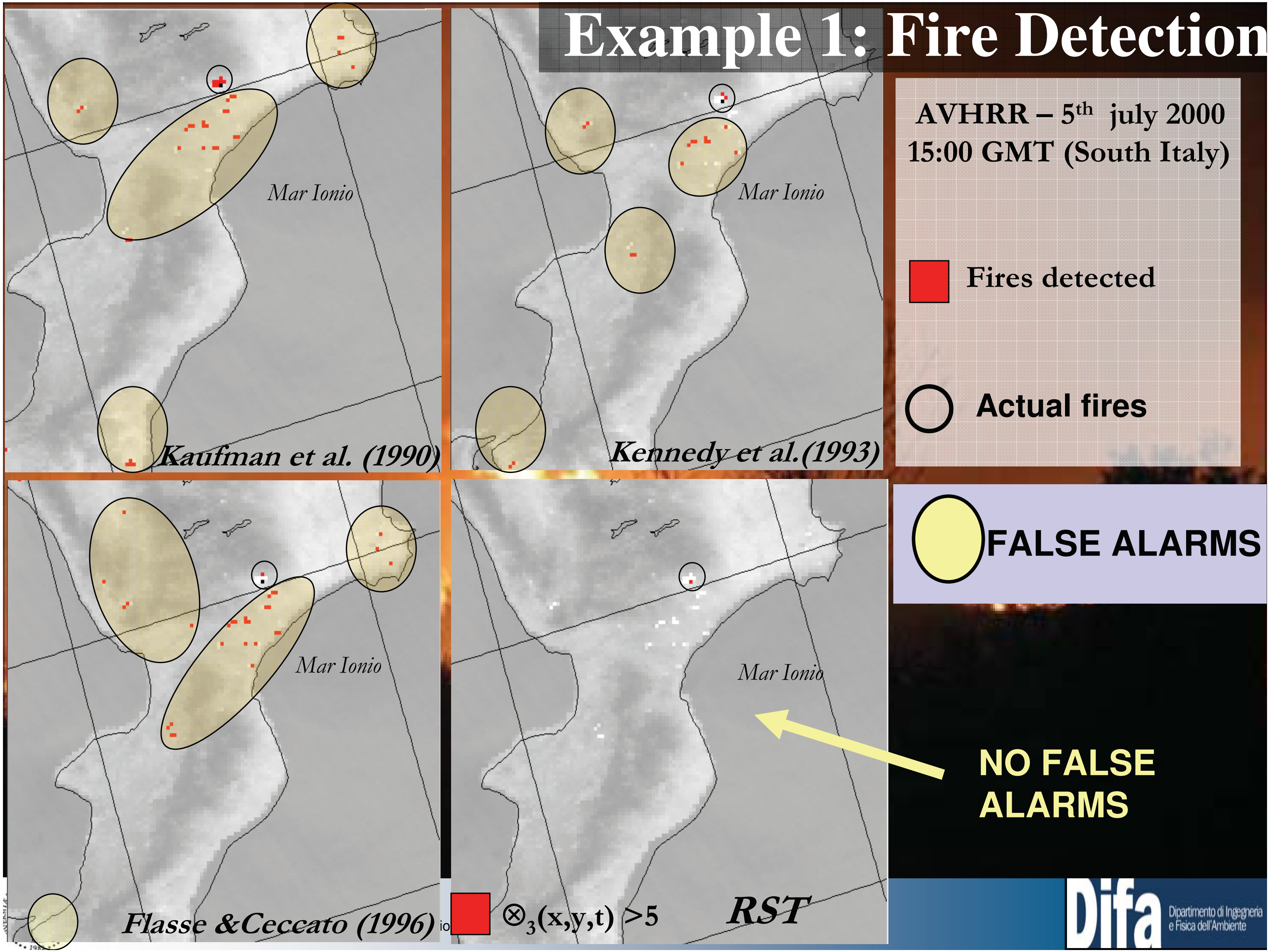
- volcanic eruptions (*Ann.of Geoph.*,2001, 2004, *Remote Sens. of Env.*, 2004a, 2004b)
- forest fires detection (*Int. J. of Rem. Sens*, 2001)
- oil spill monitoring (*IWA*, 2003, *RSE-sub. 2005*)
- cloud-detection (*Atmosph. Research.*, 2004)
- rapid alert for security purposes (GMOSS)

medium, long scale, changes (in space and/or time) to be analysed in terms of relative trends or as precursor of short scale events

- air and water quality and pollution monitoring (e.g. *IRS, 2001*)
- flood mapping and Soil Wetness Variation monitoring (*IJRS 2008, RSE 2005*)
- seismic area monitoring (*Ann. Geoph.,2001, 2004, Phy. Chem.Earth, 2004, RSE 2005, Tectonophysics, 2007)*
- desertification processes monitoring, etc……

Improving reliability saving sensitivity

Example 1
Detecting fires:


Example 1: Fire Detection
AVHRR – 5th july 2000
15:00 GMT (South Italy)
Fires detected
Actual fires
FALSE ALARMS
Mar Ionio
Kaufman et al. (1990)
Mar Ionio
Kennedy et al.(1993)
Mar Ionio
Flasse &Ceccato (1996)
Mar Ionio
⊗3(x,y,t) >5
RST
NO FALSE ALARMS
Difa
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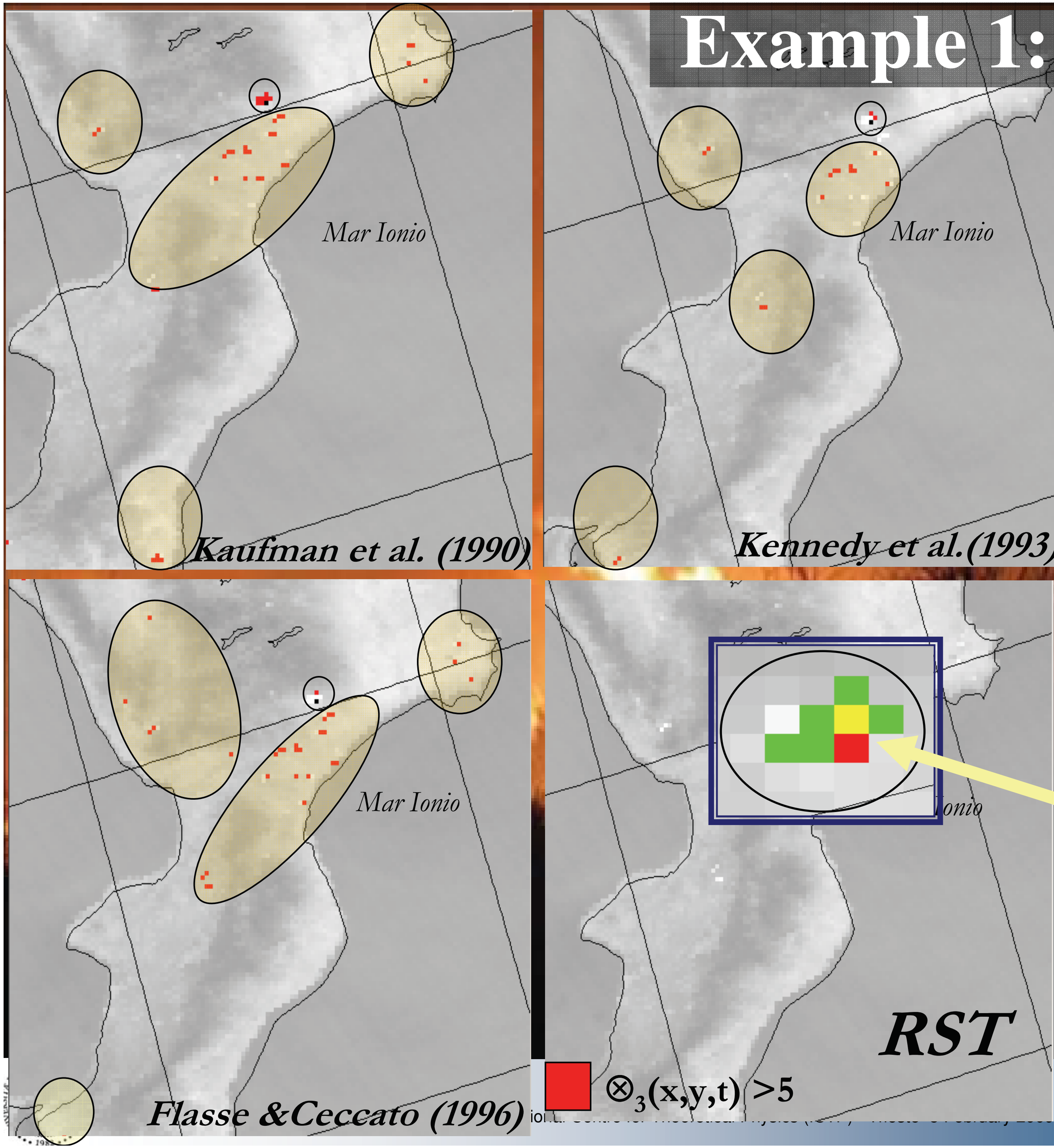
Example 1: Fire Detection

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



Fires detected

Actual fires

FALSE ALARMS

RST tunability: Thermal structure description

$\otimes_3(x,y,t) > 5$

$\otimes_3(x,y,t) > 4$

$\otimes_3(x,y,t) > 3$

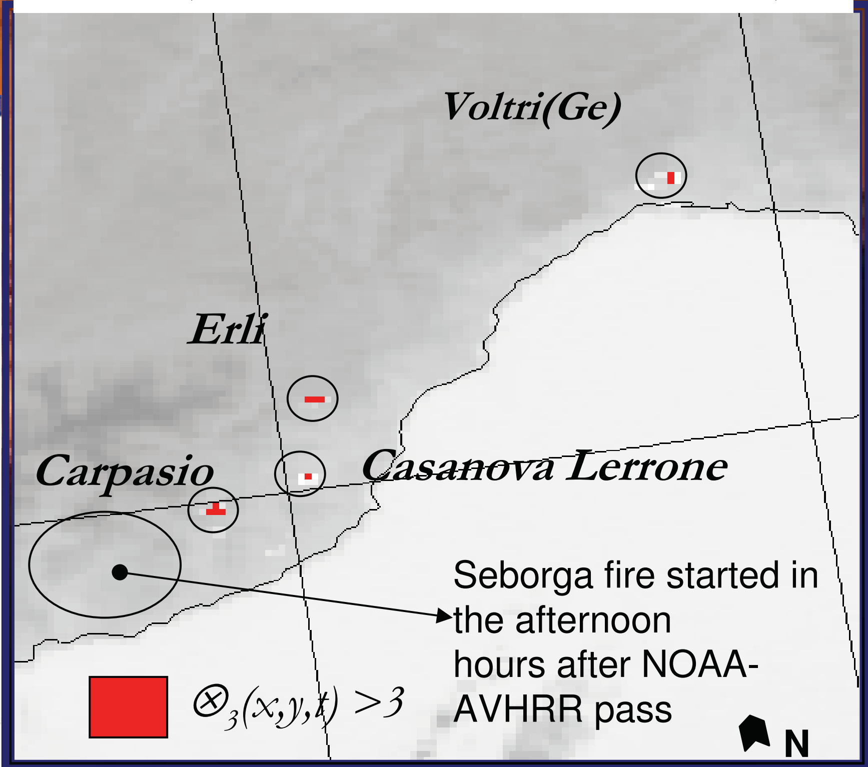
Example 1: Fire Detection

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

EOS-MODIS (MOD14-algorithm)

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

RST (AVHRR at 1:00 GMT)



NO MISSED NO FALSE FIRES

Improving reliability saving sensitivity

Example 2
Detecting oil spills

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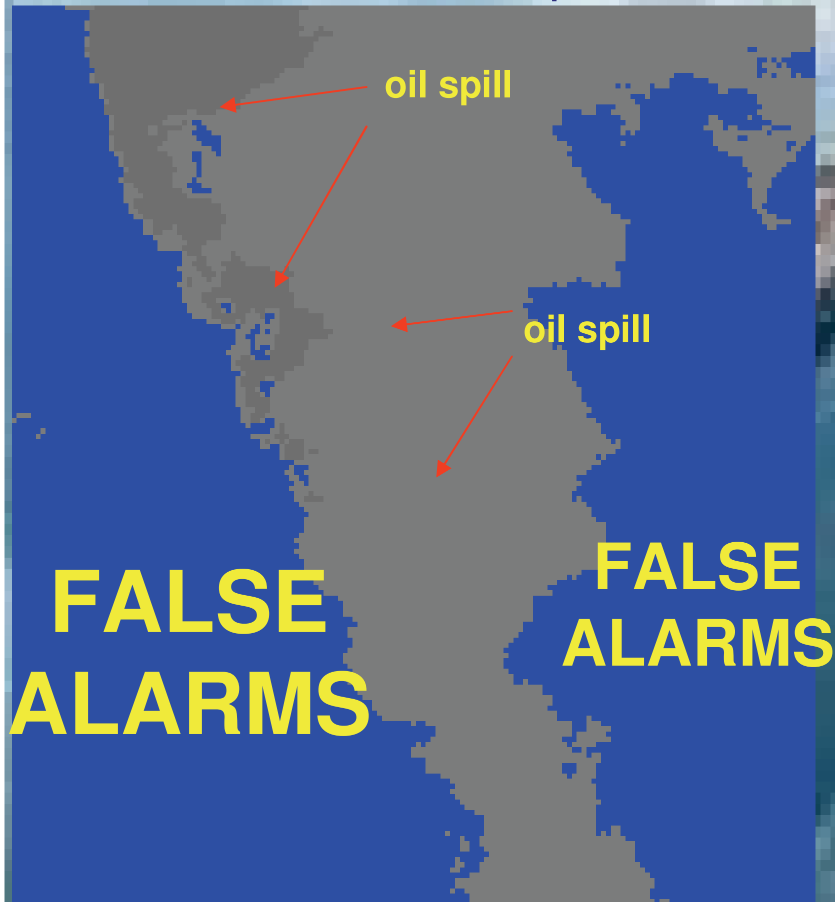
Example 2: Oil Spill Detection

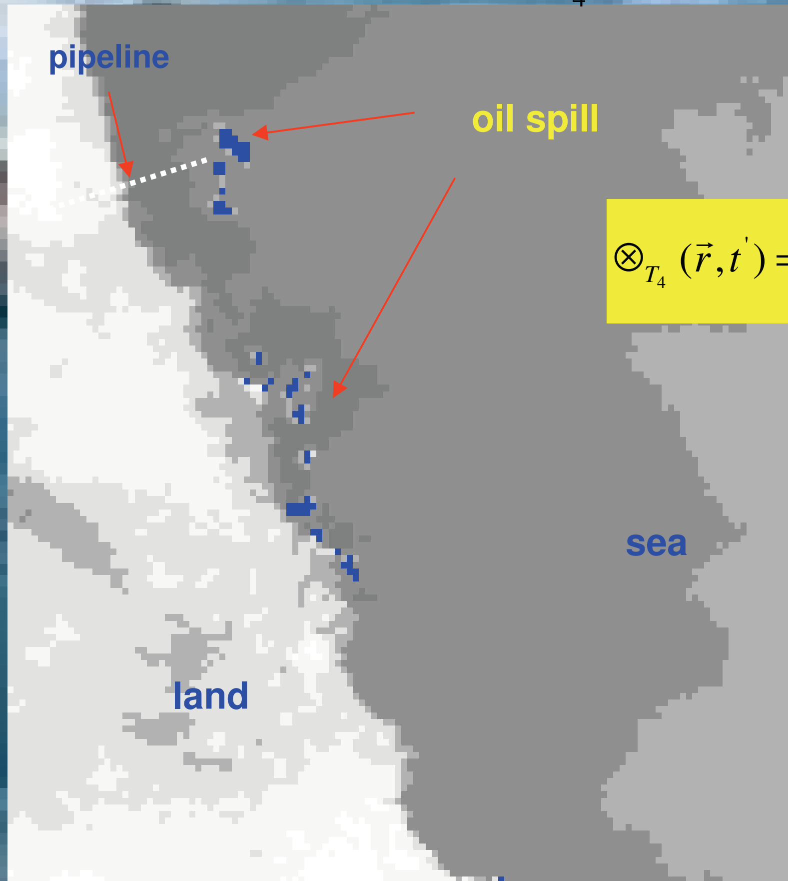
23 - 30 January 1991 (Gulf War): release of crude oil on Kuwait and Saudi Arabia coast)

Cross (1991) ■ $T_4 > 289.8$ K



1991- 01- 24
(channel 4 AVHRR - 10.38 GMT)

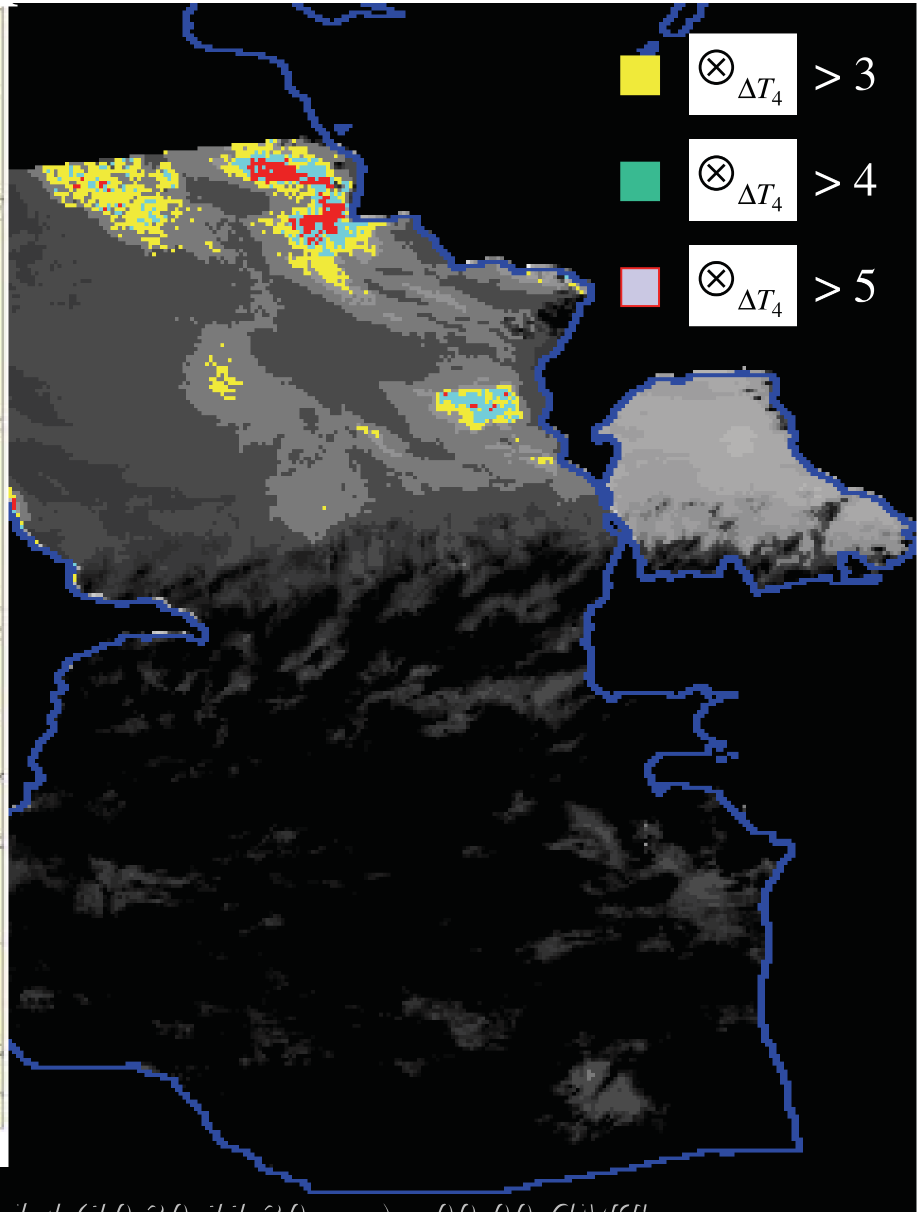
RST ■ $\otimes_{T_4} > 5$



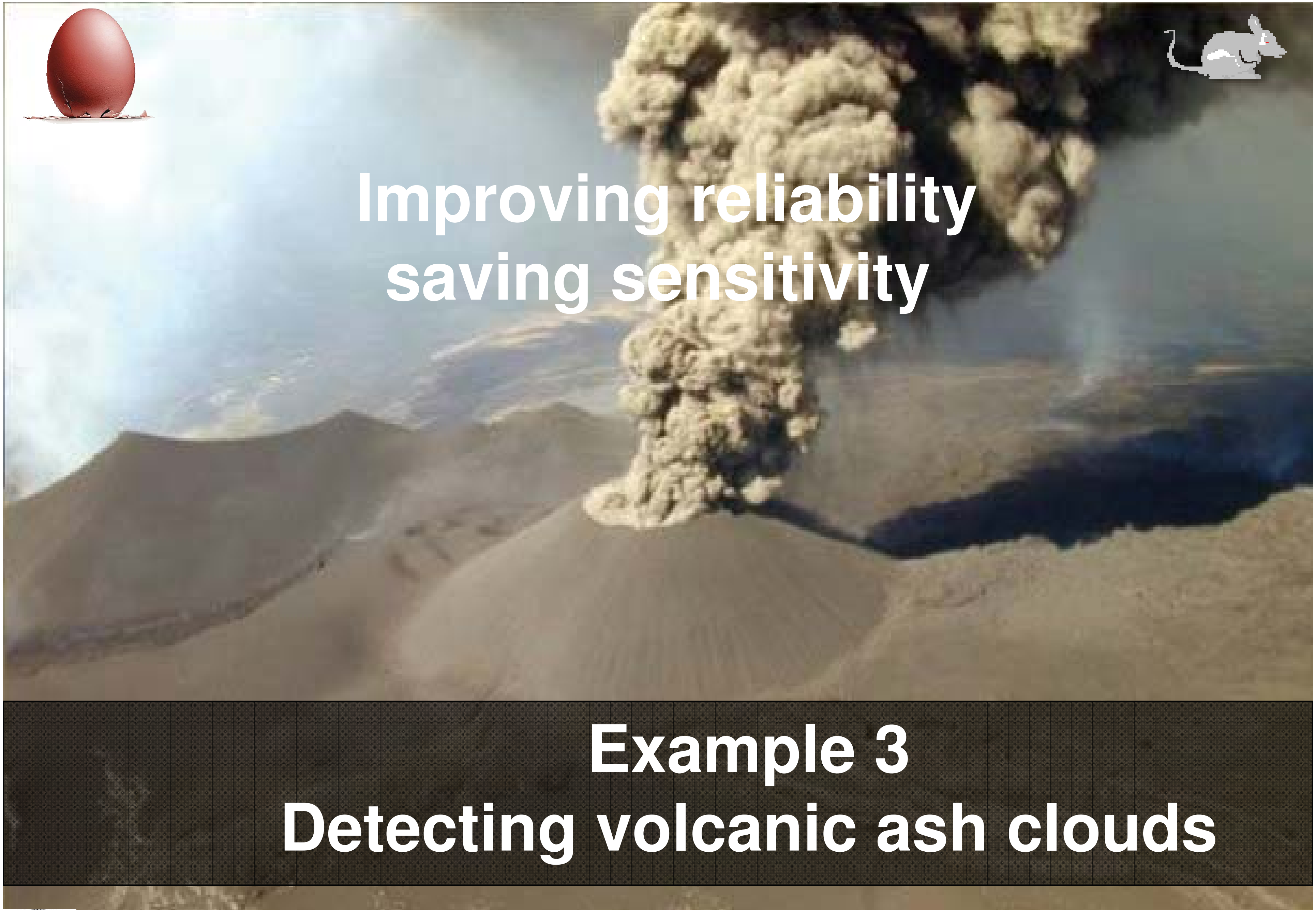
1991- 01- 24
(channel 4 AVHRR - 10.38 GMT)

$$\otimes_{T_4}(\vec{r},t') = \frac{T_4(\vec{r},t') - \mu_4(r')}{\sigma_4(\vec{r})}$$

Oil Spill and Seepage Detection on the Caspian Sea



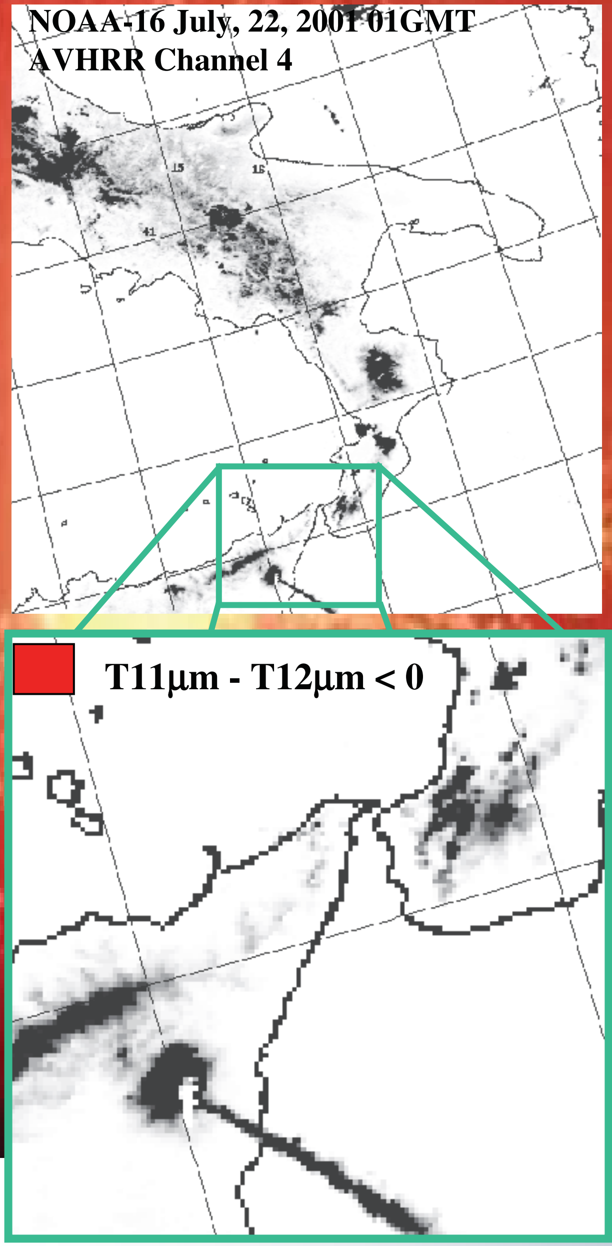
AVHRR image of the 1996-05-12, channel 4 (10.30-11.30 μm) - 09.00 GMT



Improving reliability saving sensitivity

Example 3
Detecting volcanic ash clouds

Example 2: Ash Cloud Detection Traditional methods (Prata, 1989)




July-August, 2001 Etna eruption

$$\Delta T = T_{11\mu m} - T_{12\mu m} < 0\ K$$

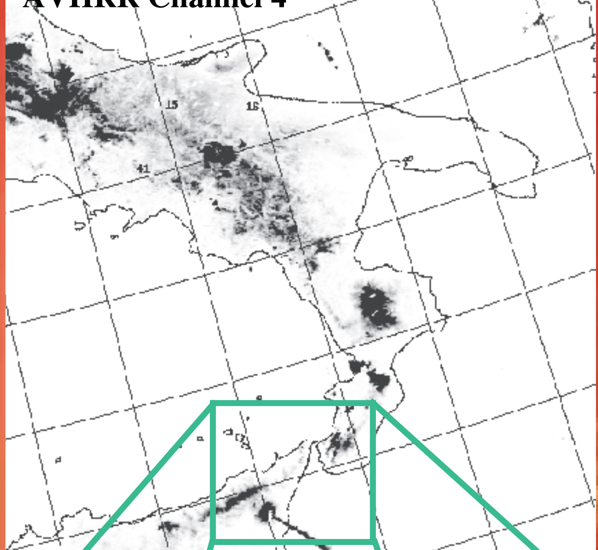
e.g. Prata, 1989

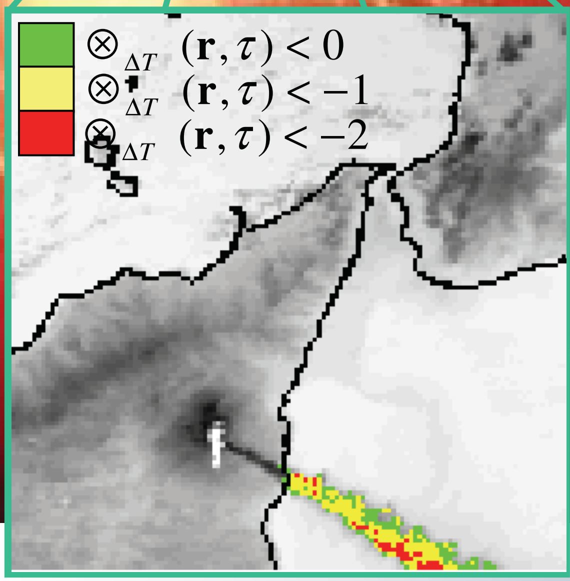
Traditional fixed threshold methods

NO DETECTION!!

Example 2: Ash Cloud Detection RST

NOAA-16 July, 22, 2001 01GMT
AVHRR Channel 4





July-August, 2001 Etna eruption

$$\otimes_{\Delta T}(\mathbf{r},t) = \frac{[\Delta T(\mathbf{r},t) - \mu_{\Delta T}(\mathbf{r})]}{\sigma_{\Delta T}(\mathbf{r})}$$

$$\Delta T(\mathbf{r},t) = T_{11\mu}(\mathbf{r},t) - T_{12\mu}(\mathbf{r},t)$$

RST

DETECTION AND TUNEABILITY!

Improving reliability saving sensitivity

Example 4
Monitoring lava flows

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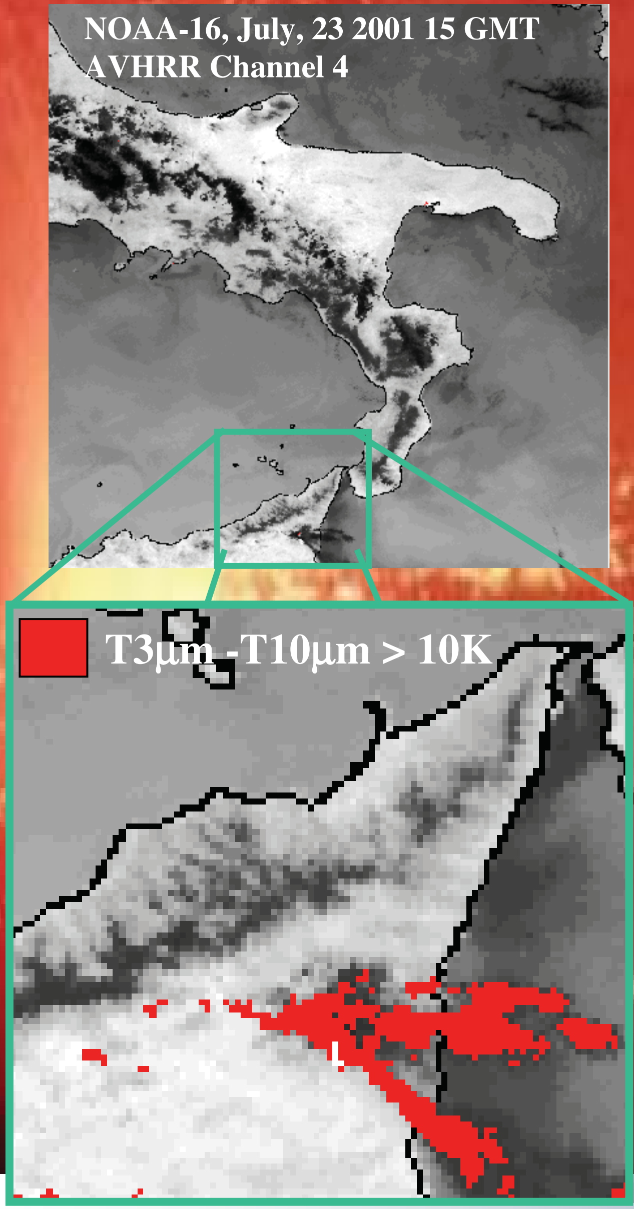
Example 4: Volcanic Lava flow Detection
Tradictional Methods (Harris et al. , 1995)



Summer

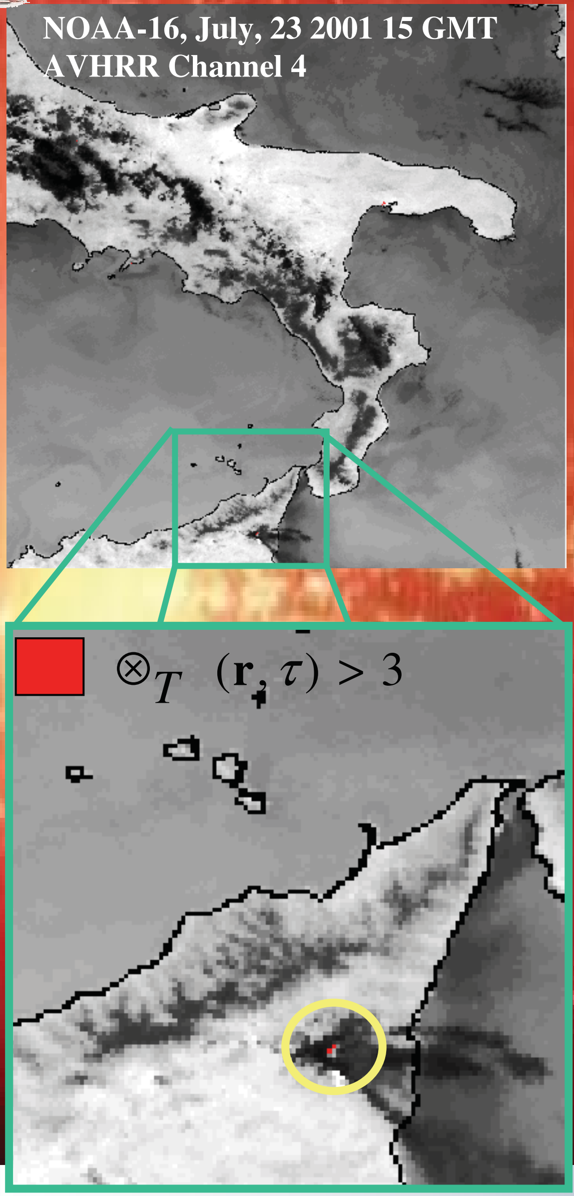
$$\Delta T = T_{3\mu m} - T_{11\mu m} > 10K$$

Harris *et al.* 1995

Tradictional fixed threshold methods

NO FALSE DETECTIONS!!

Example 4: Volcanic Lava flow Detection
RST



Summer

$$\otimes_{T_{3\mu m}}(\mathbf{r},\tau)=\frac{\left|T_{3\mu m}(\mathbf{r},\tau)-\mu_{T_{3\mu m}}(\mathbf{r})\right|}{\sigma_{T_{3\mu m}}(\mathbf{r})}$$

RST approach

NO FALSE DETECTIONS!

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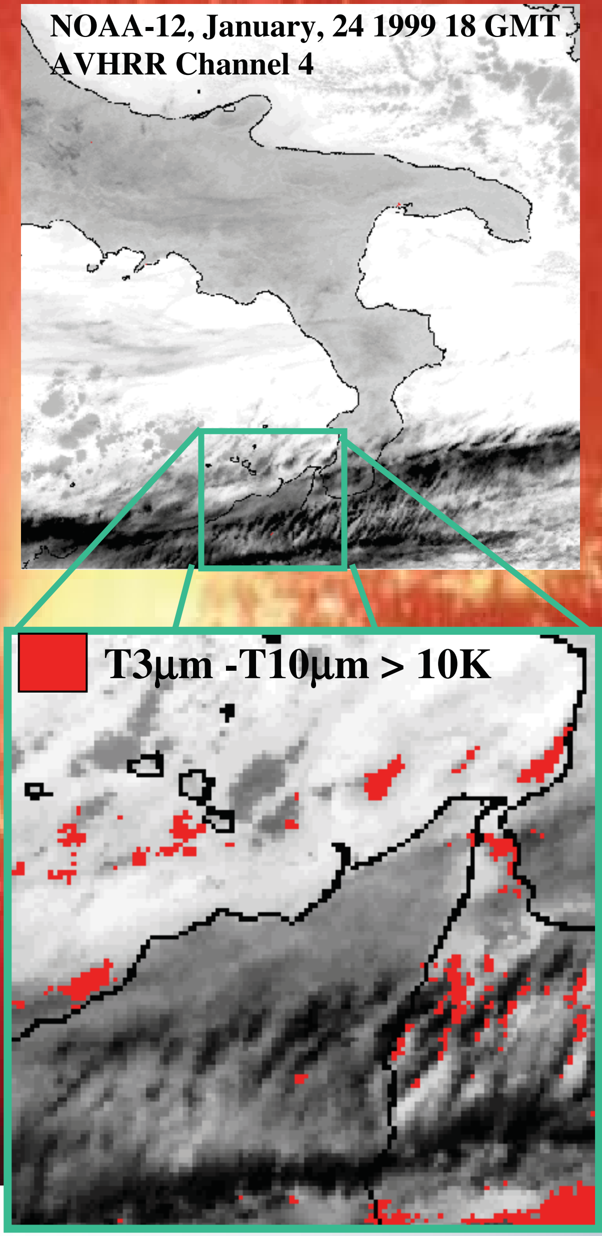
Example 4: Volcanic Lava flow Detection
Tradictional Methods (Harris et al. , 1995)



January-February, 1999 Etna eruption

Winter

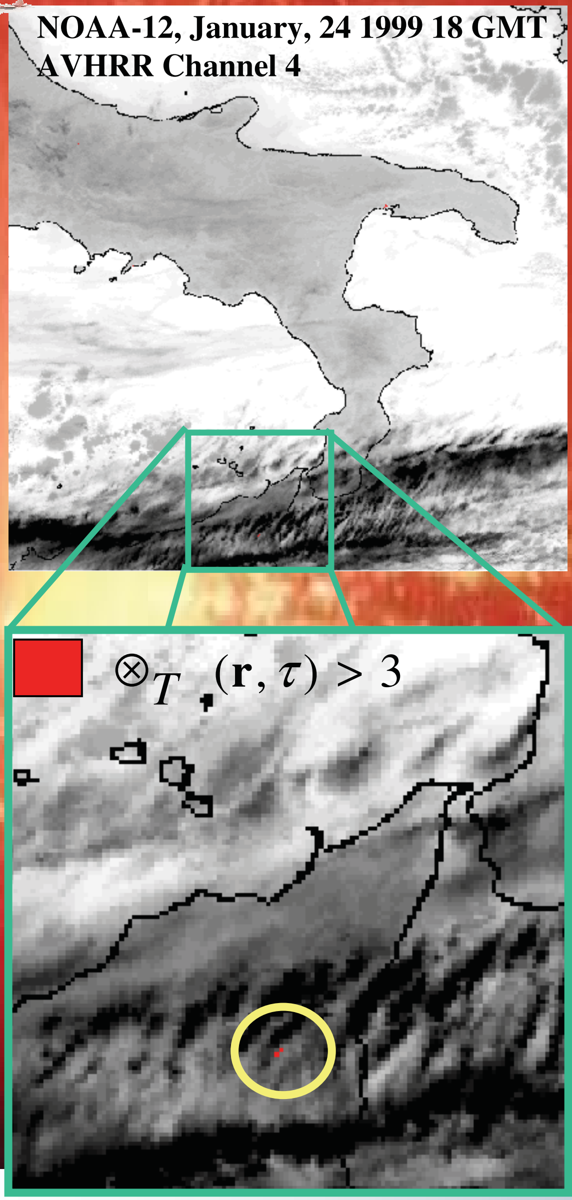
$$\Delta T = T_{3\mu m} - T_{11\mu m} > 10K$$

Harris *et al.* 1995

Traditional fixed threshold methods

→ **FALSE DETECTIONS!!**

Example 4: Volcanic Lava flow Detection RST



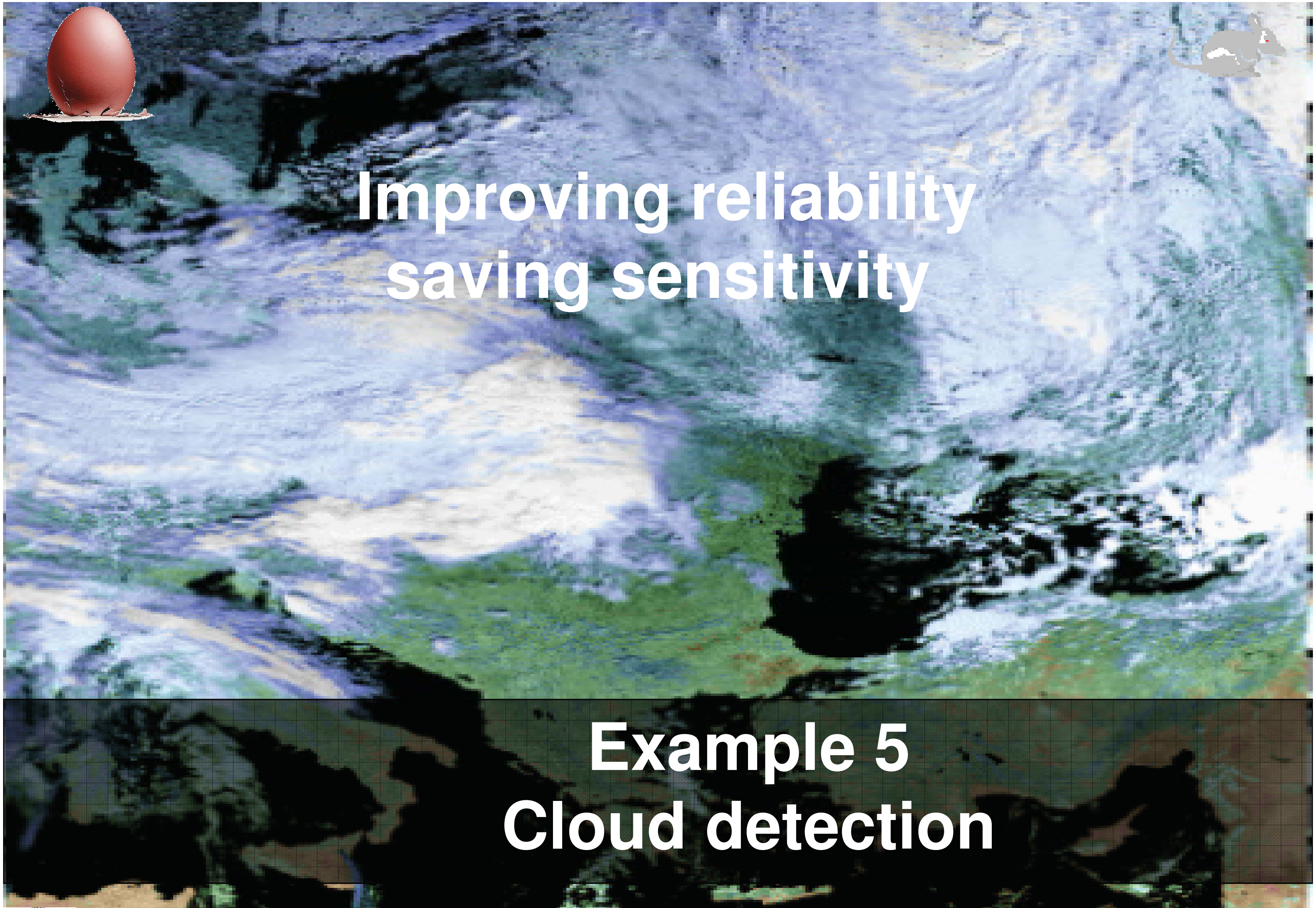

January-February, 1999 Etna eruption

$$\otimes_T(\mathbf{r},\tau) = \frac{\left[T_{3\mu m}(\mathbf{r},\tau) - \overline{T}_{3\mu m}(\mathbf{r})\right]}{\sigma_{T_{3\mu m}}(\mathbf{r})}$$

$\overline{T}_{3\mu m}(\mathbf{r})$ and $\sigma_{3\mu m}(\mathbf{r})$ are computed as before on 5 years

RST approach

→ NO FALSE DETECTIONS!!



Improving reliability saving sensitivity

Example 5
Cloud detection

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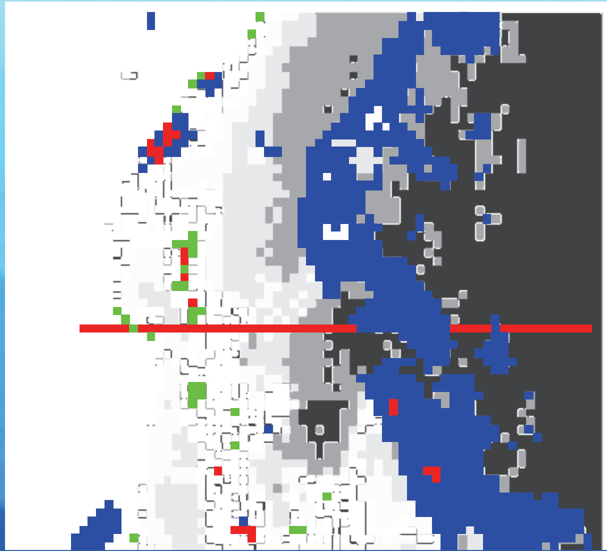
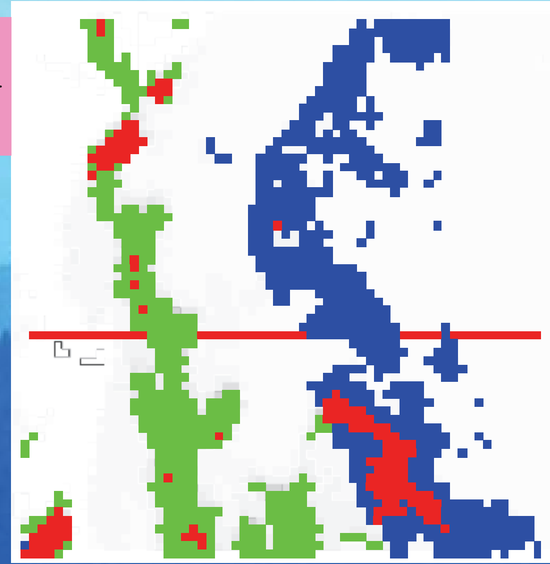
Example 5: Cloud Detection:

CMS vs RST-OCA (One Channel Cloudy-radiance-detection Algorithm)



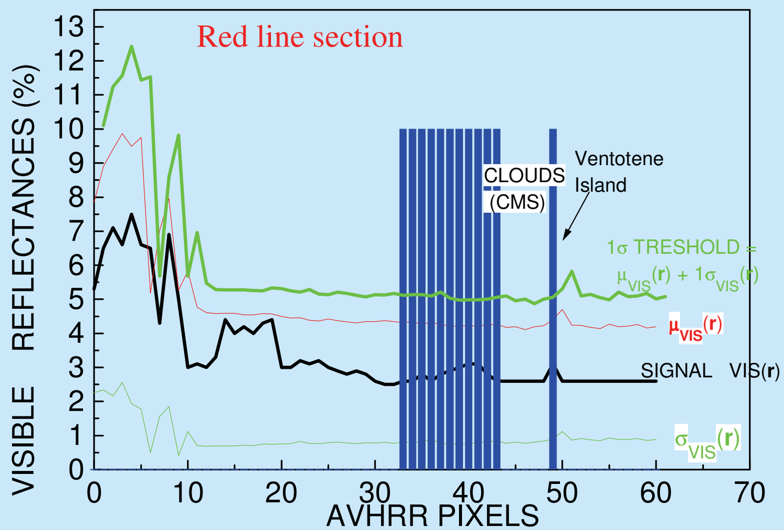
$$\otimes_{T_4}(\vec{r},t') = \frac{T_4(\vec{r},t') - \mu_4(\vec{r})}{\sigma_4(\vec{r})}$$



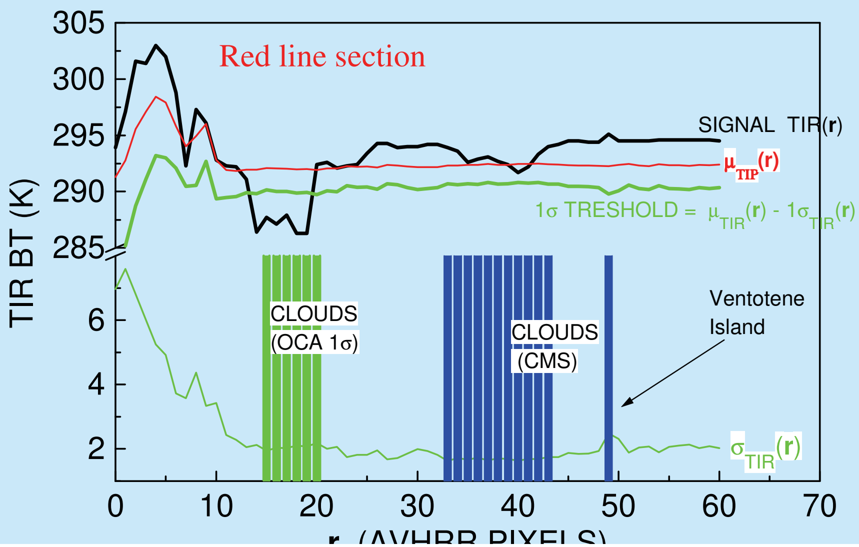
- **OCA & CMS**
- **OCA at 1σ**
- **CMS only**

$$\otimes_{R_1}(\vec{r},t') = \frac{R_1(\vec{r},t') - \mu_1(\vec{r})}{\sigma_1(\vec{r})}$$

AVHRR (ch1) VIS



AVHRR (ch4) TIR

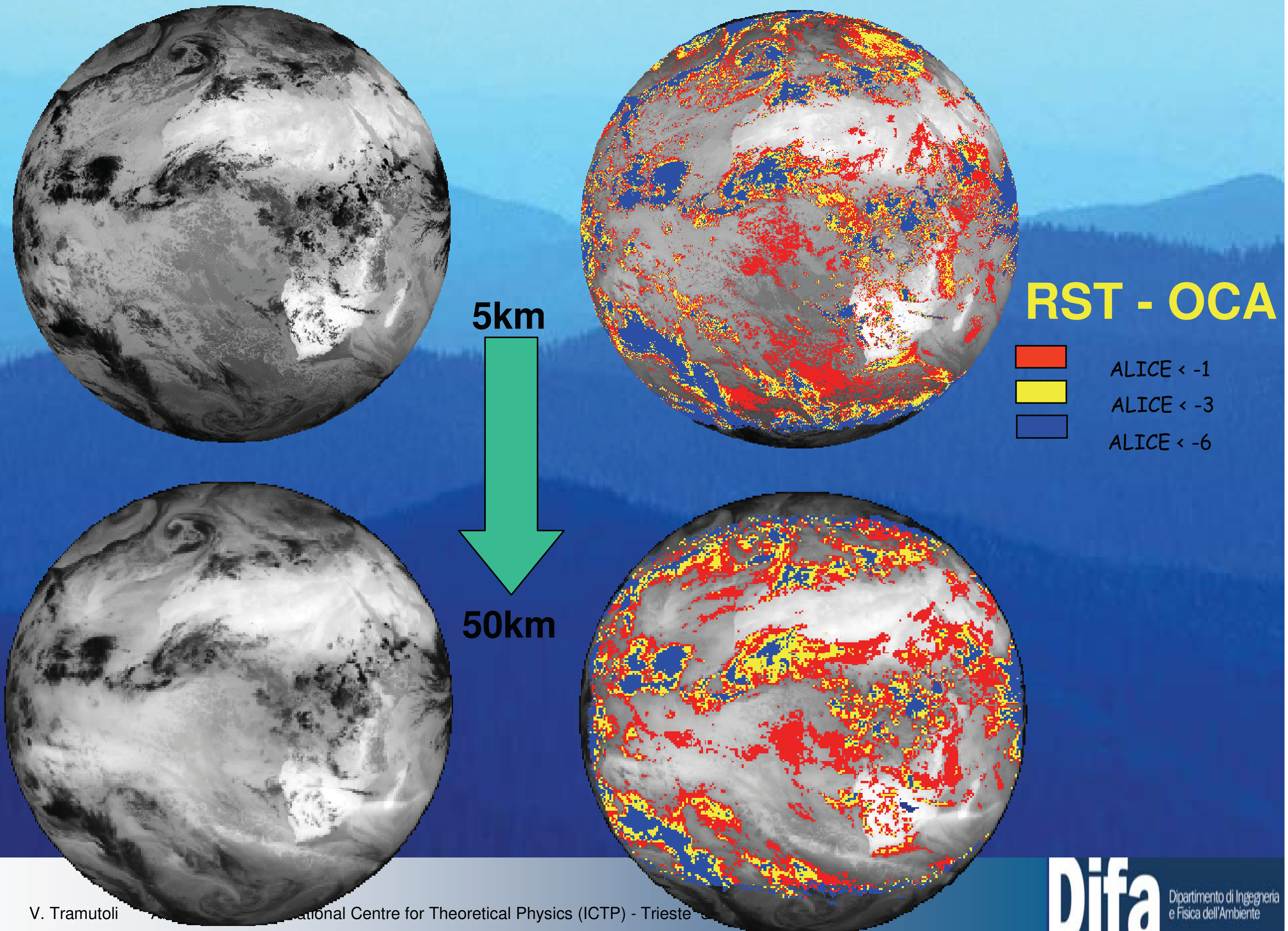


CLOUDS vs CLOUDY RADIANCES

METEOSAT vs (SYNTHETIC) GERB-MSG (*Atm. Research, 2004*)

Meteosat-7 IR
16 Ottobre 1999
(11:00 GMT)

GERB Th
16 Ottobre 1999
(11:00 GMT)



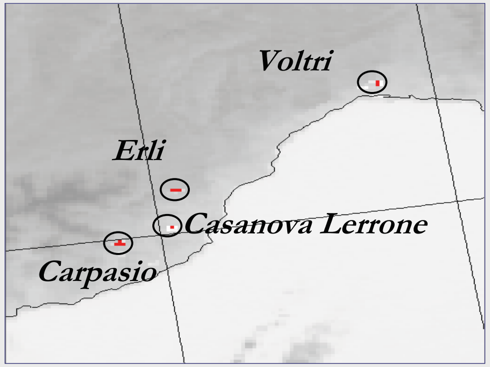
APPLICATIONS

To do more

Main RST applications using Polar satellites (NOAA-AVHRR/AMSU)

Forest fires

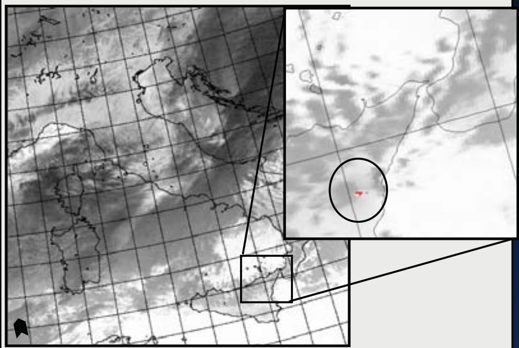
e.g. Fires in Italy, February 2005



fires

Volcanic eruptions

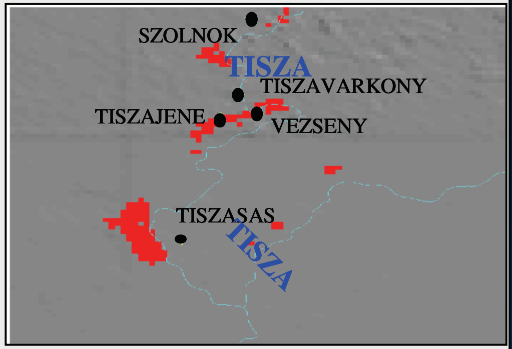
e.g. 2004-2005 Etna eruption (Italy)



Hot spot

Floods

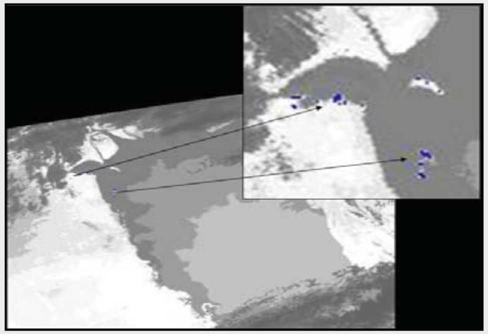
e.g. Ungary flood, April 2002



Flooded areas

Sea pollution

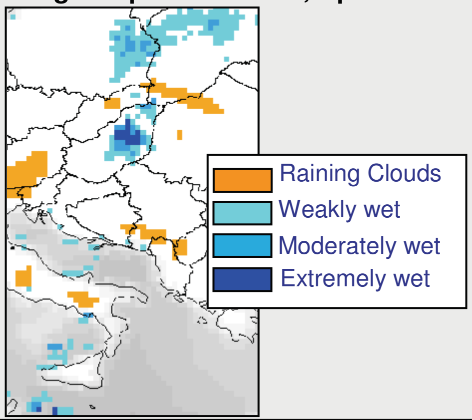
e.g. Oil spill in the Persic Gulf, January 1991



Oil spill

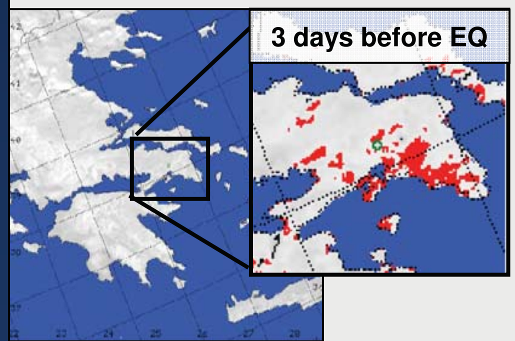
Soil wetness

e.g. Carpathian Basin, April 2000



Earthquakes

e.g. 7 September 1999 Athens Earthquake



Thermal anomalies

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Robust Satellite Techniques for Early Warning

Monitoring flooding risk by MW (NOAA-AMSU)

(Rem. Sens. Env., 2005)

Soil Wetness Index: $SWI = T_{89GHz} - T_{23G}$

Reference fields for August (4 years)

μ_{SWI}

σ_{SWI}

Soil Wetness Variation Index: SWVI = $\otimes_{SWI}(x,y,t) = \dfrac{SWI(x,y,t) - \mu_{SWI}(x,y)}{\sigma_{SWI}(x,y)}$

Reducing site (vegetation, roughness, etc.) effects

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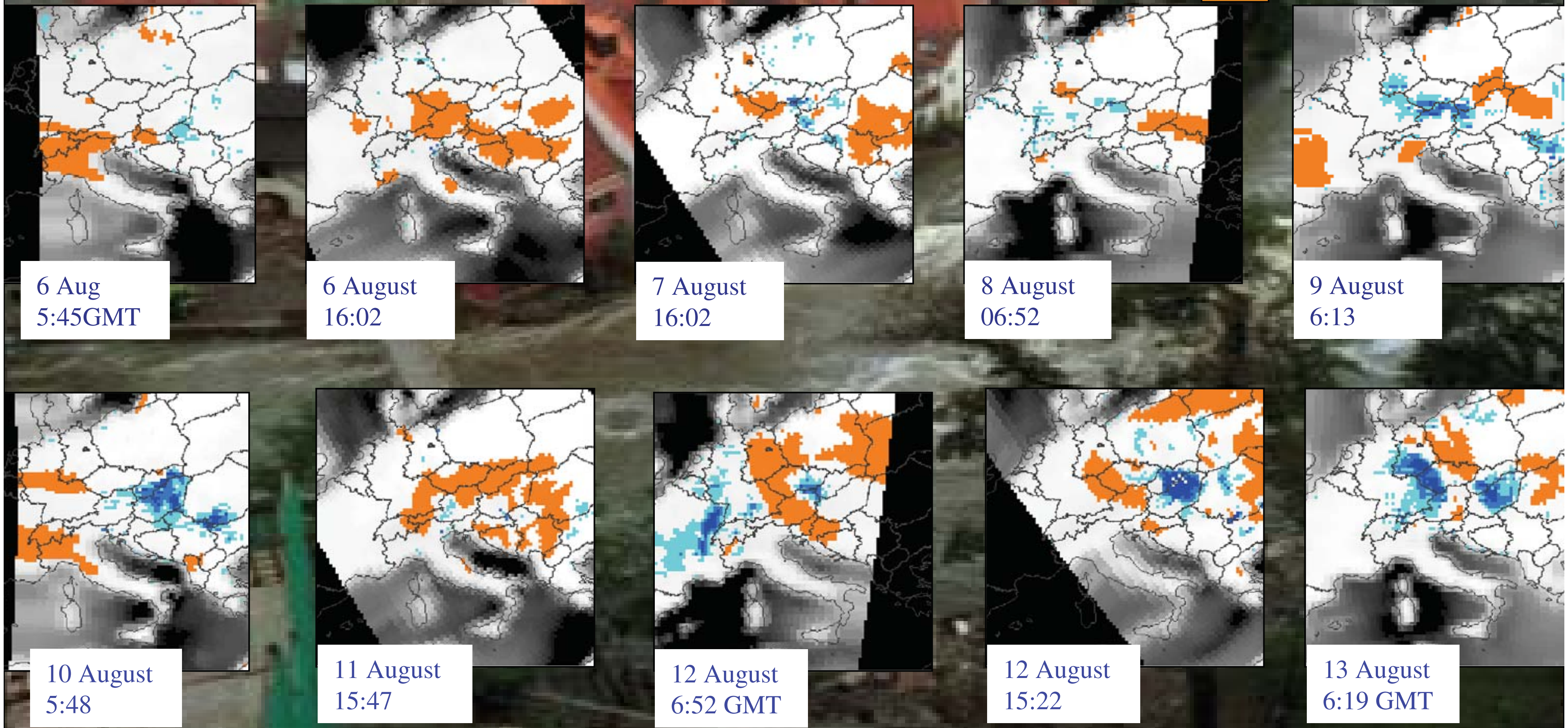
Robust Satellite Techniques for Early Warning

Monitoring flooding risk by MW (NOAA-AMSU)

August 2002
Hungary flood

$$\otimes_{SWI}(x,y,t) = \frac{SWI(x,y,t) - \mu_{SWI}(x,y)}{\sigma_{SWI}(x,y)}$$

- SWVI > 2
- SWVI > 3
- SWVI > 4
- Raining Clouds



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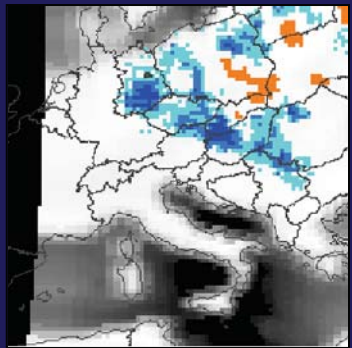
Robust Satellite Techniques for Early Warning

Monitoring flooding risk by MW (NOAA-AMSU)

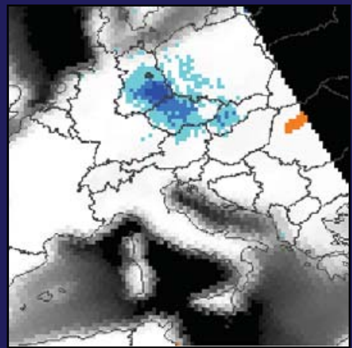
August 2002 Ungary flood

$$\otimes_{SWI}(x, y, t) = \frac{SWI(x, y, t) - \mu_{SWI}(x, y)}{\sigma_{SWI}(x, y)}$$

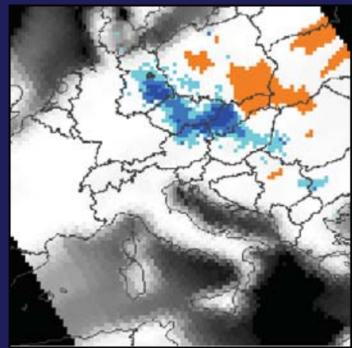
- SWVI > 2
- SWVI > 3
- SWVI > 4
- Raining Clouds



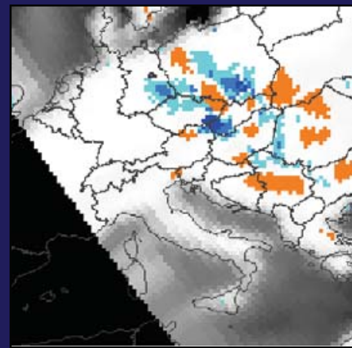
14 August 5:56



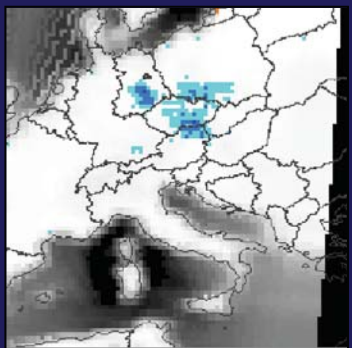
14 August 16:16



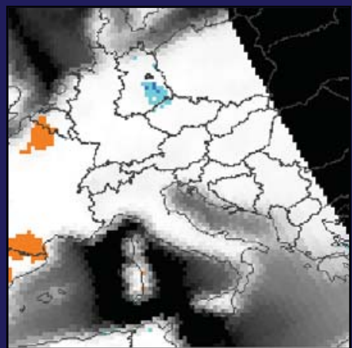
15 August 16:16



16 August 15:45



17 August 6:42



18 August 16:25

Robust Satellite Techniques for Rapid Mapping

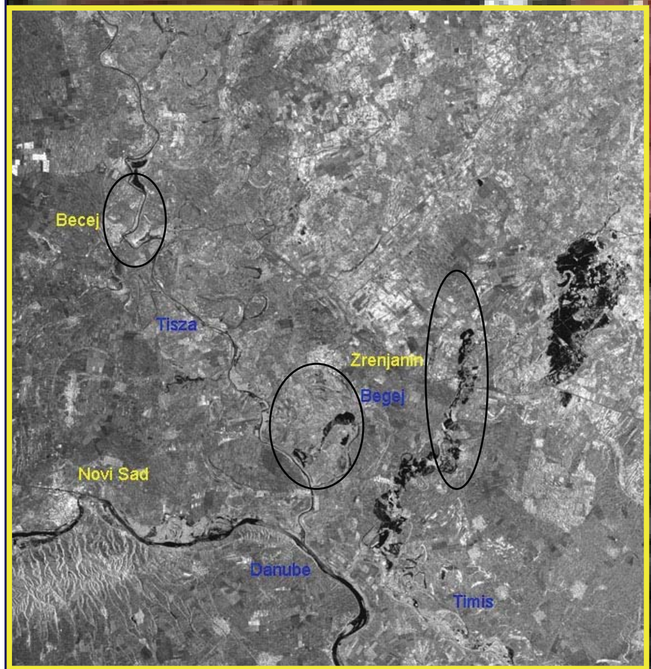
Monitoring flooded areas (NOAA-AVHRR)

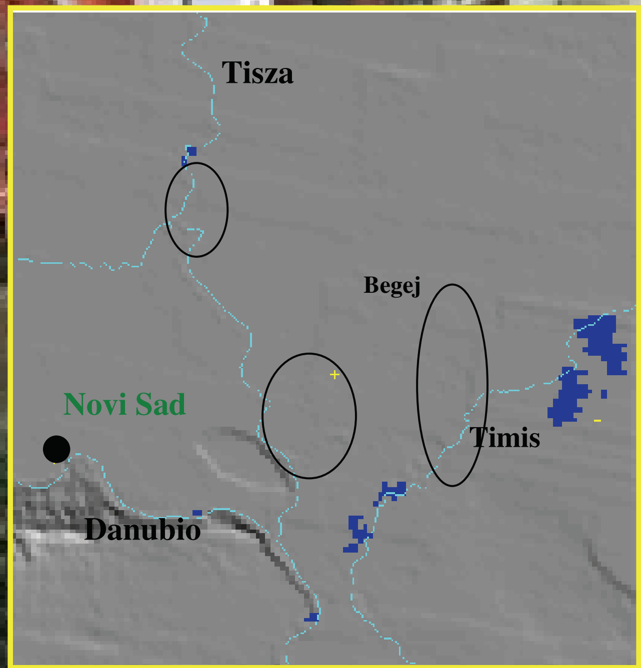
April 2000 Central Europe

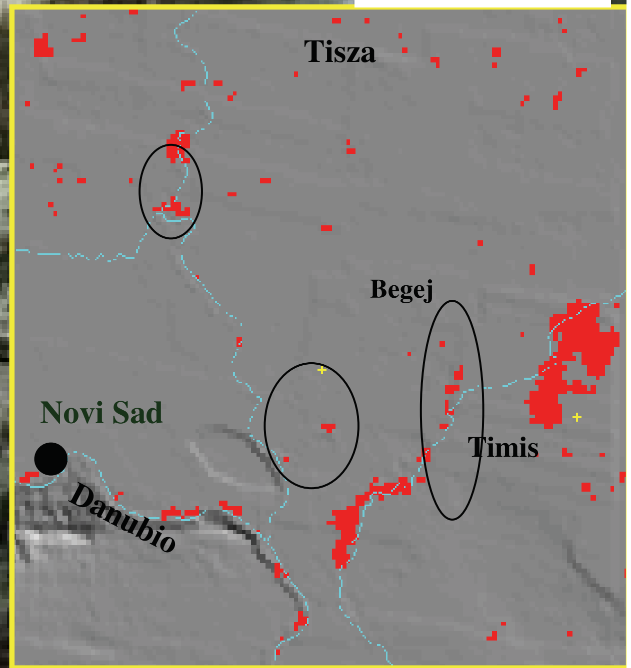
SAR Image of 13/04/00

XIAO & CHEN $\rho_2 - \rho_1 < 1$

RST $\otimes_{\rho_{2-1}} \leq -1$





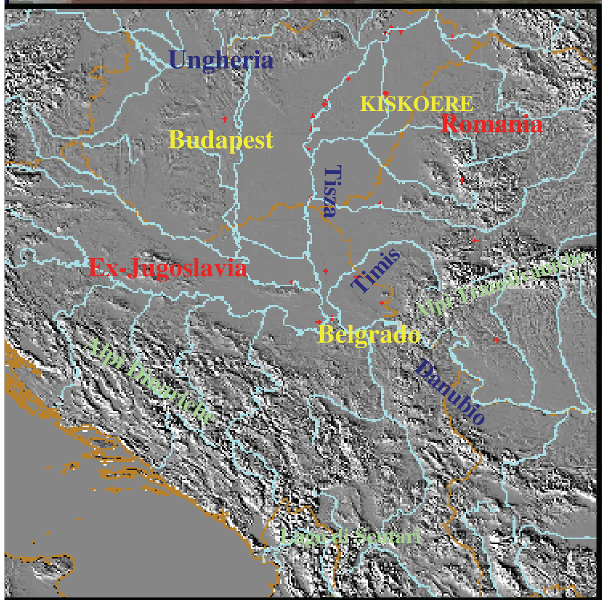


AVHRR 14/04/00 13:00

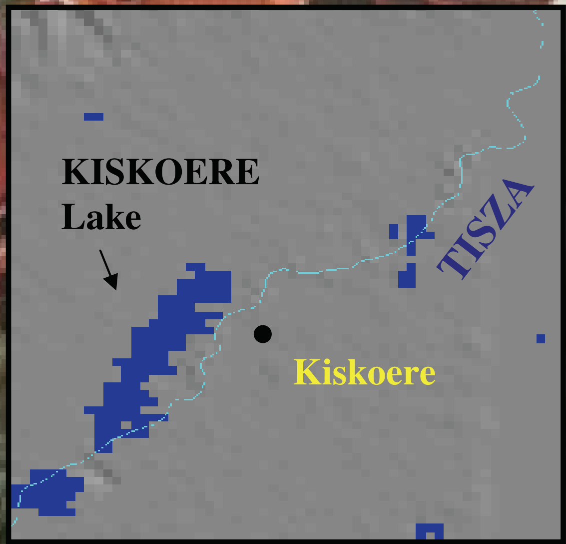
Robust Satellite Techniques for Rapid Mapping

Monitoring flooded areas (NOAA-AVHRR) (IJRS, 2008)

April 2000 Central Europe

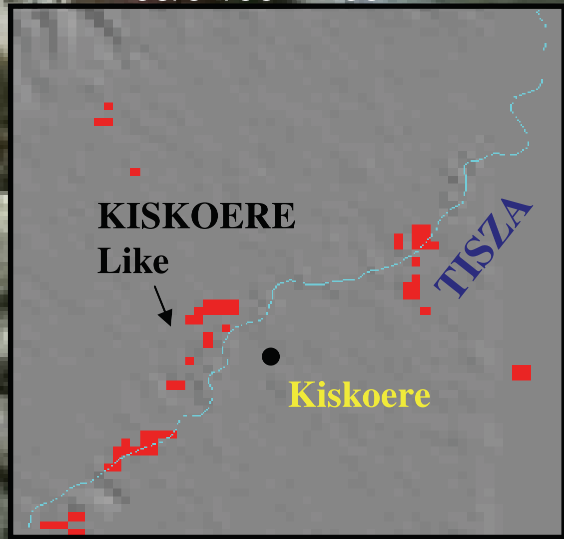


09/04/00 14:00



XIAO & CHEN, 1987

09/04/00 14:00



RST $\otimes_{2\text{-}1} \leq -1$

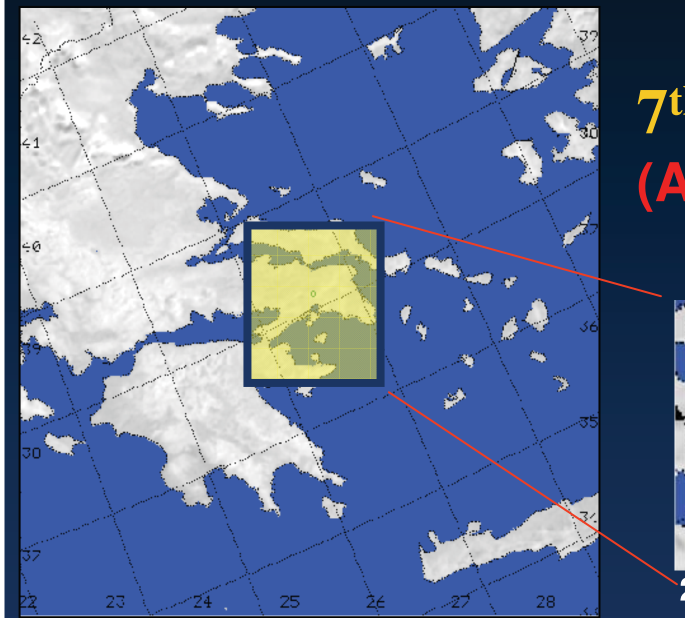
Robust Satellite Techniques for Seismic Areas Monitoring

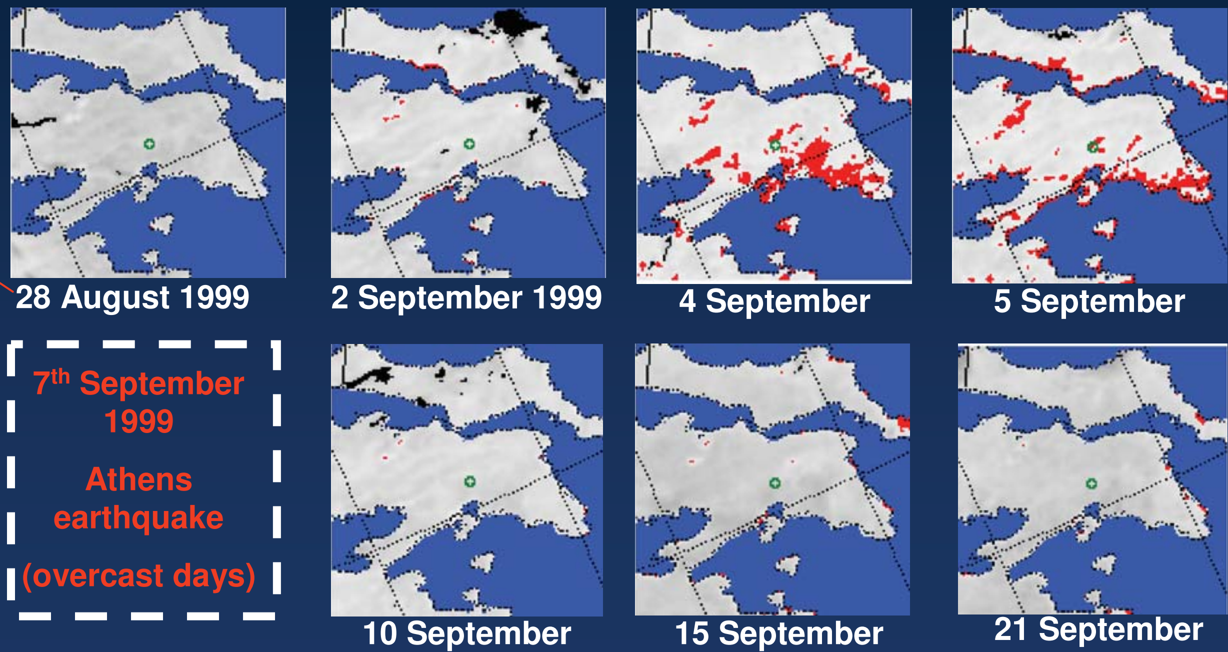
from polar data (NOAA-AVHRR)…

Thermal Infrared analysis (*Phy. Chem.Earth, 2004*)

7th September 1999 Athens EQ (Ms=5.9)

(AVHRR – ΔLST)





7th September 1999

Athens earthquake

(overcast days)

Pixels with S/N > 1.5

Epicentral area

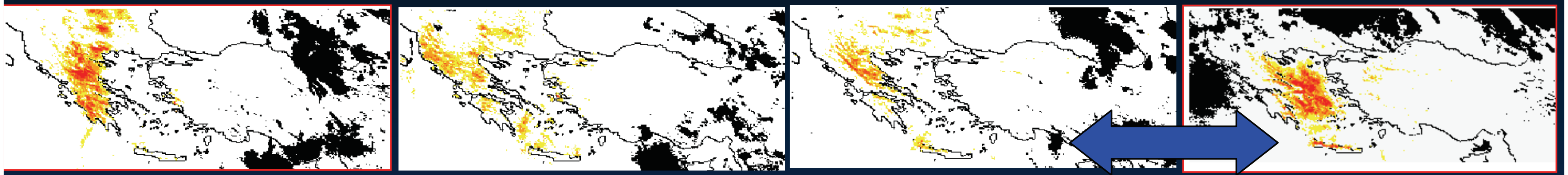
S/N>1.5

Difa Dipartimento di Ingegneria e Fisica dell'Ambiente

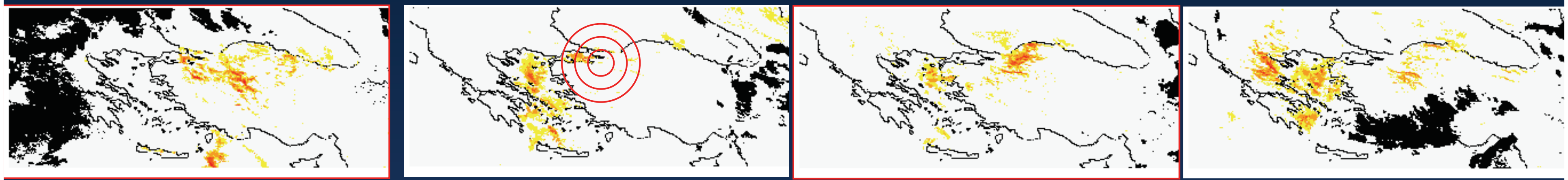
Robust Satellite Techniques for Seismic Areas Monitoring

Kocaeli-Izmit (Turkey) 17 th August 1999 (Ms=7.4)

(Remote Sensing of Environment, 2005)



9 August 1999 — 10 August 1999 — 11 August 1999 — 12 August 1999



13 August 1999 — 17 August 1999 — 18 August 1999 — 19 August 1999

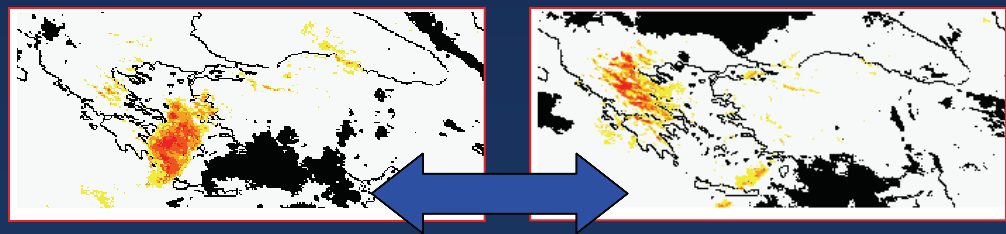
S/N> 2

S/N > 2.5

S/N > 3

S/N > 3.5

S/N>3.5



20 August 1999 — 21 August 1999

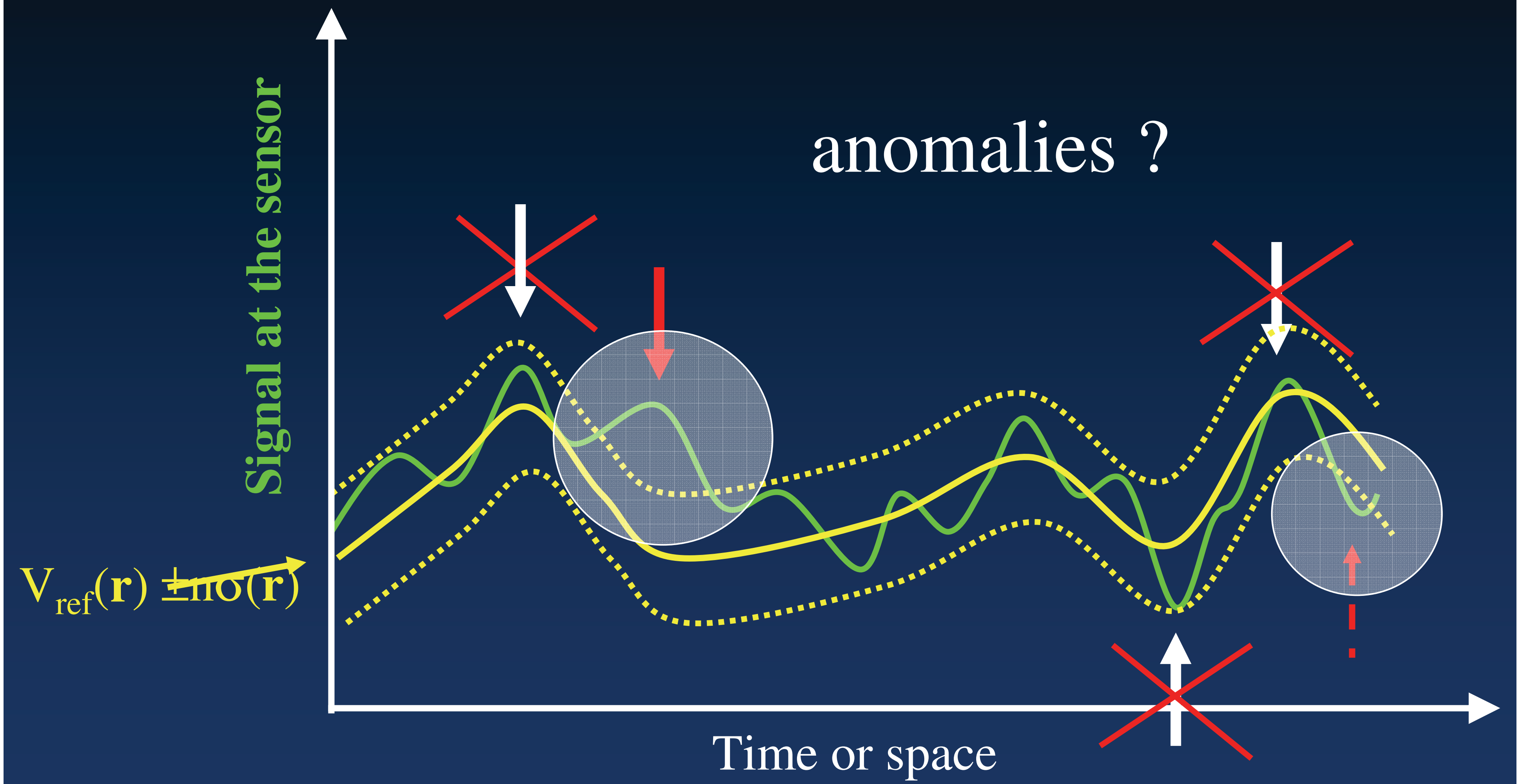
Difa Dipartimento di Ingegneria e Fisica dell'Ambiente

APPLICATIONS

to do better:

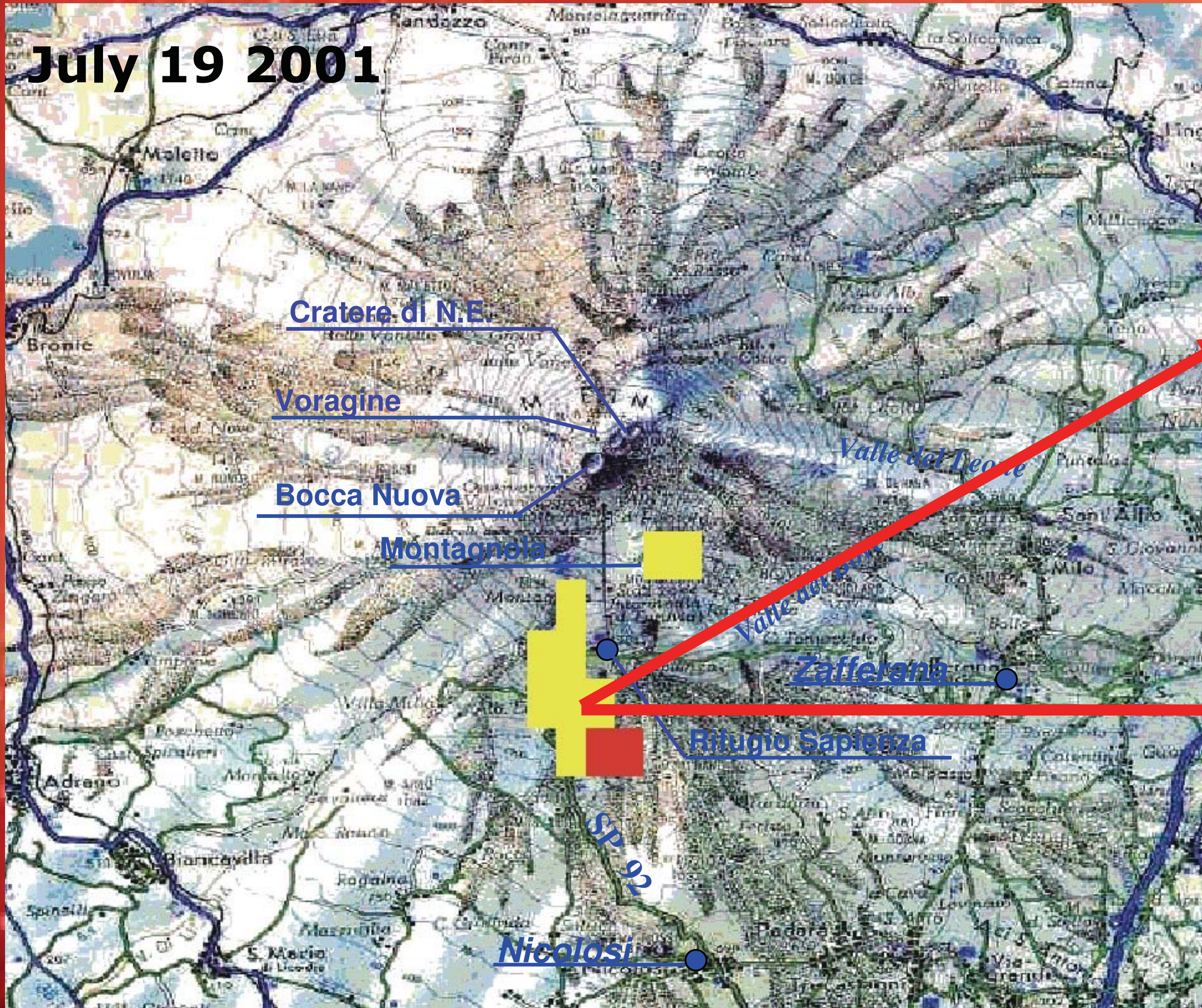
Improving sensitivity toward low intensity signals

How ?

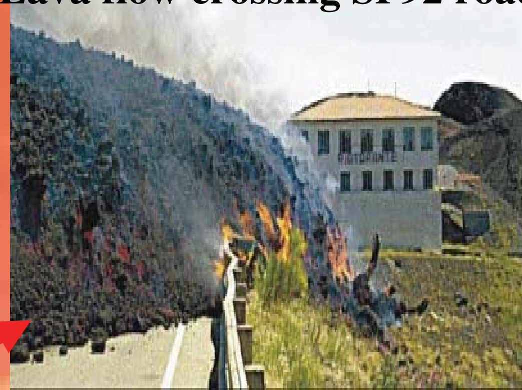


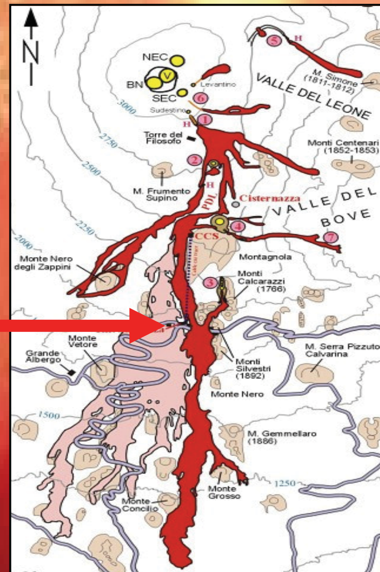
Difa Dipartimento di Ingegneria e Fisica dell'Ambiente

Lava flow Monitoring (July-August, 2001 Etna flank eruption)



Lava flow crossing SP92 road

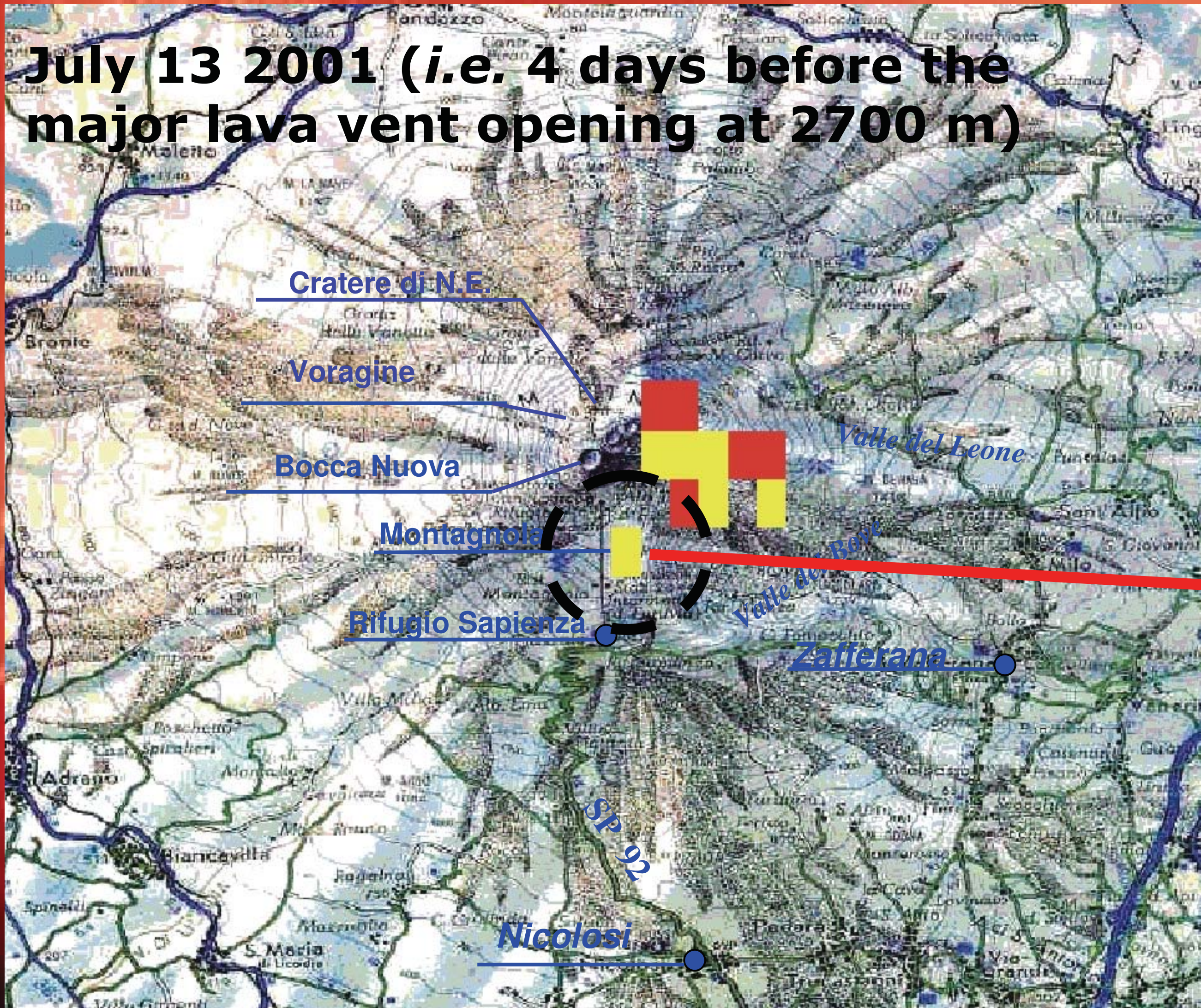




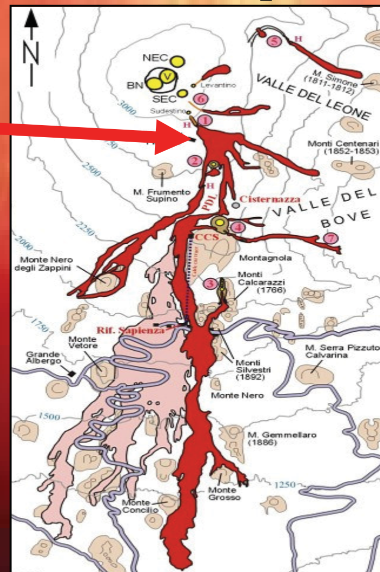
July-August 2001
lava flows reports

Alice >2 Alice >3

Pre-eruptive thermal anomalies (July-August, 2001 Etna flank eruption)



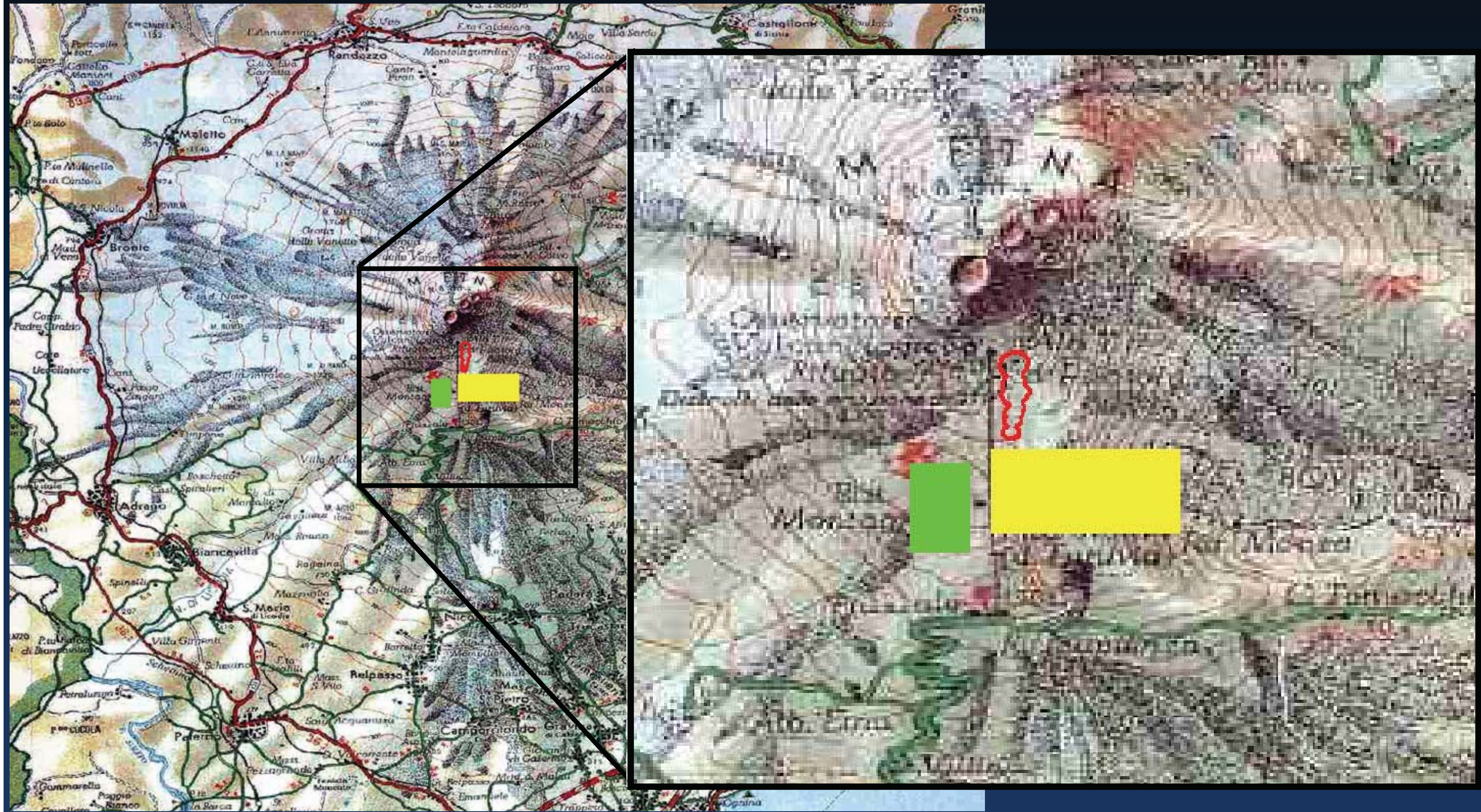
July-August 2001 lava flows reports



Alice >2 | Alice >3

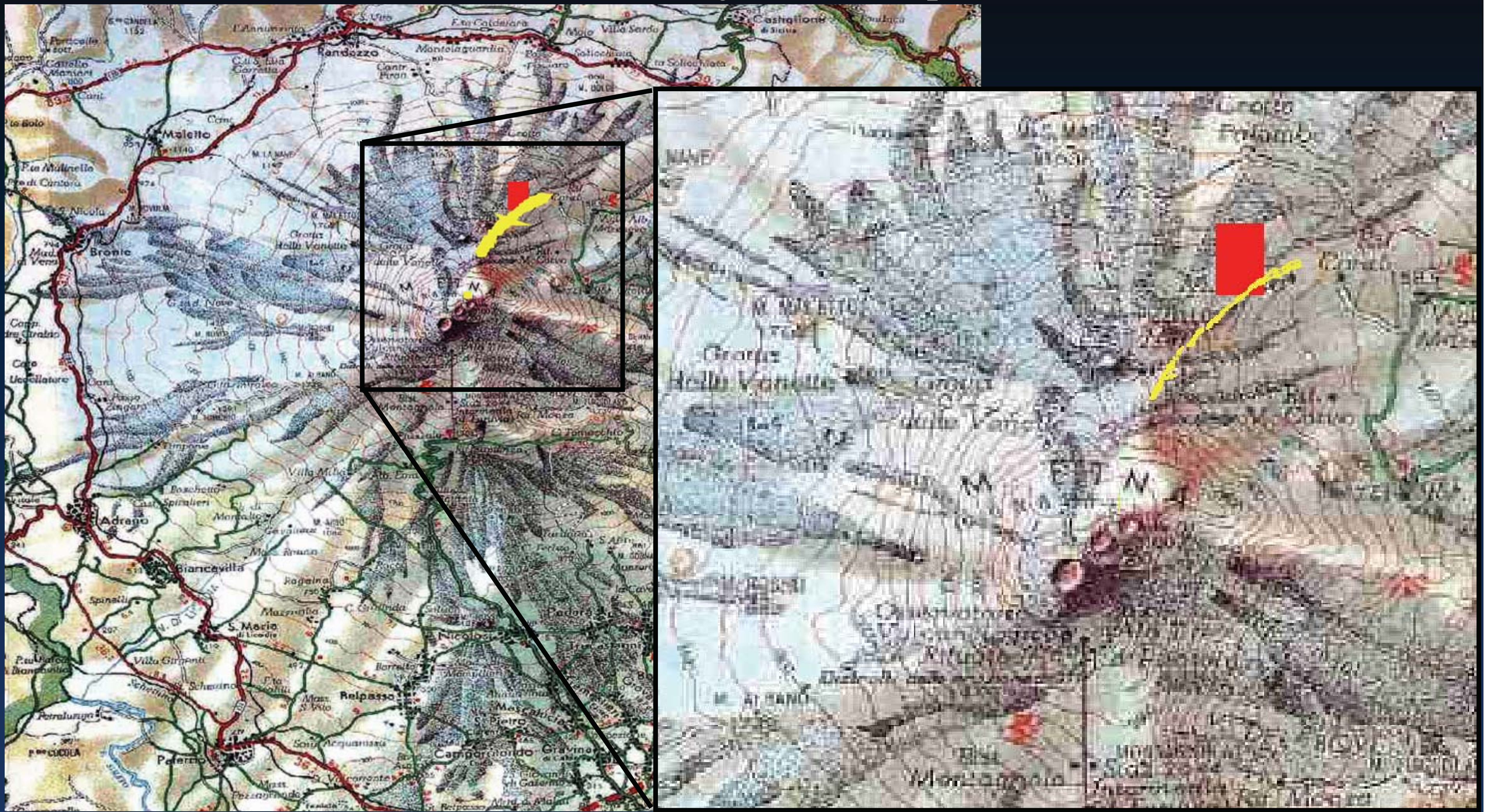
Pre-eruptive thermal anomalies (October, 2002 Etna flank eruption)

20th October 2002 (i.e. 6 days before eruption onset)



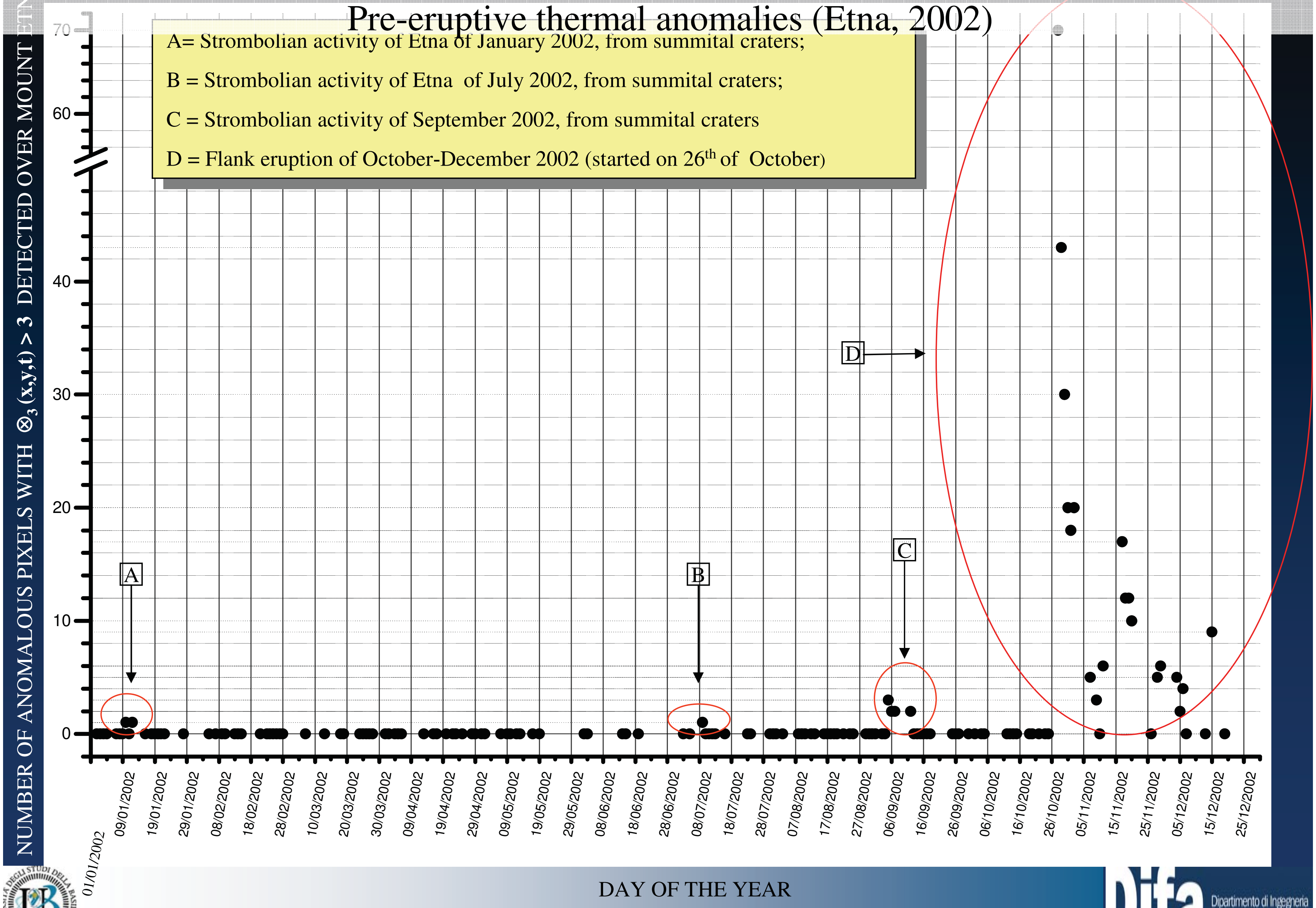
Pre-eruptive thermal anomalies (October, 2002 Etna flank eruption)

22th October 2002 (i.e 4 days before eruption onset)

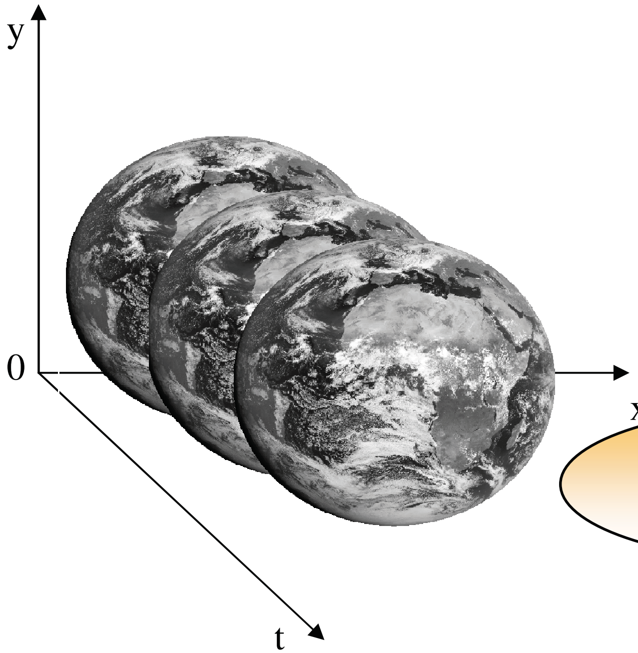


RST Robustness vs False Alarms

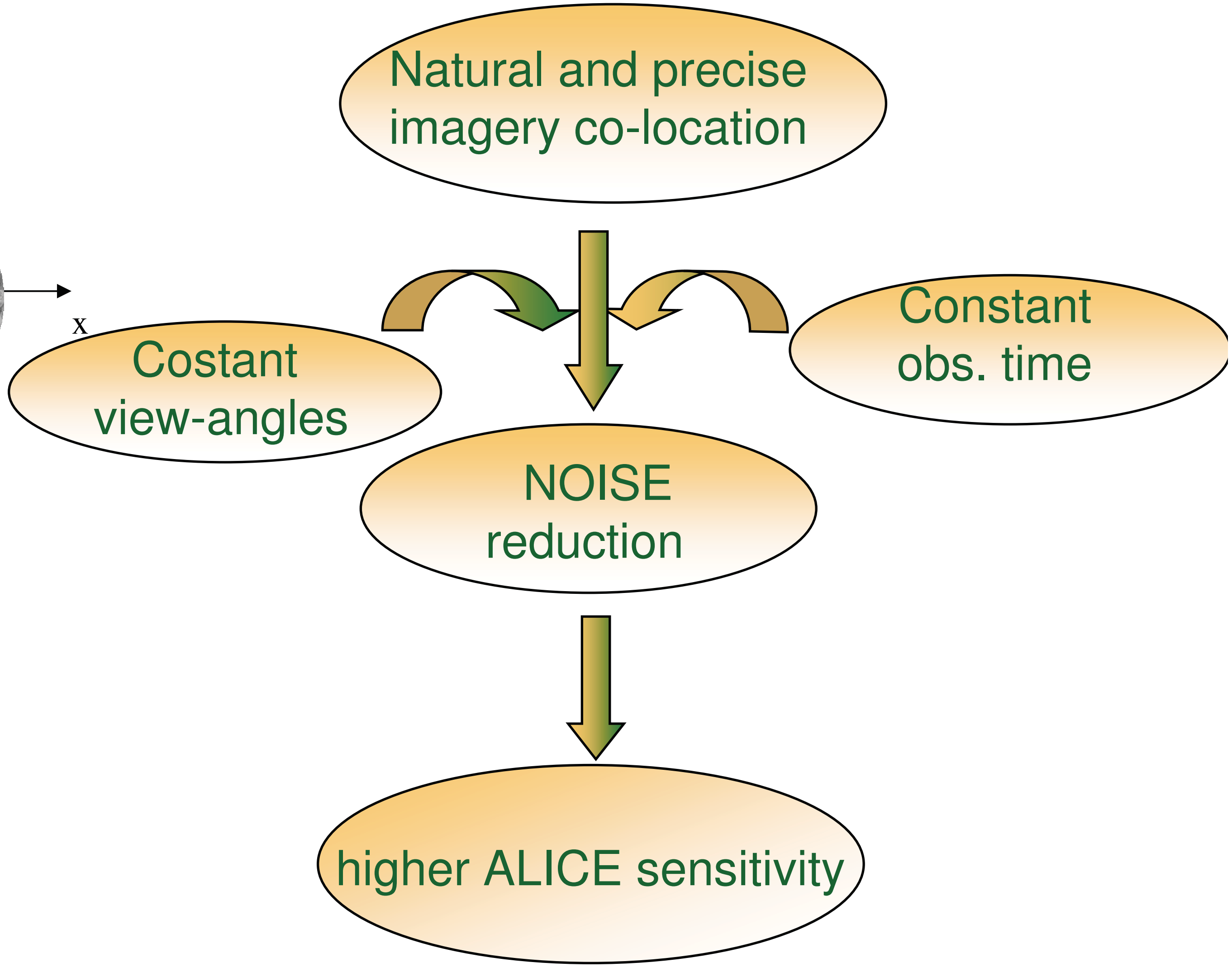
Pre-eruptive thermal anomalies (Etna, 2002)



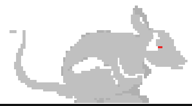
Improving RST sensitivity by reducing observational noise: moving from polar to geostationary satellite

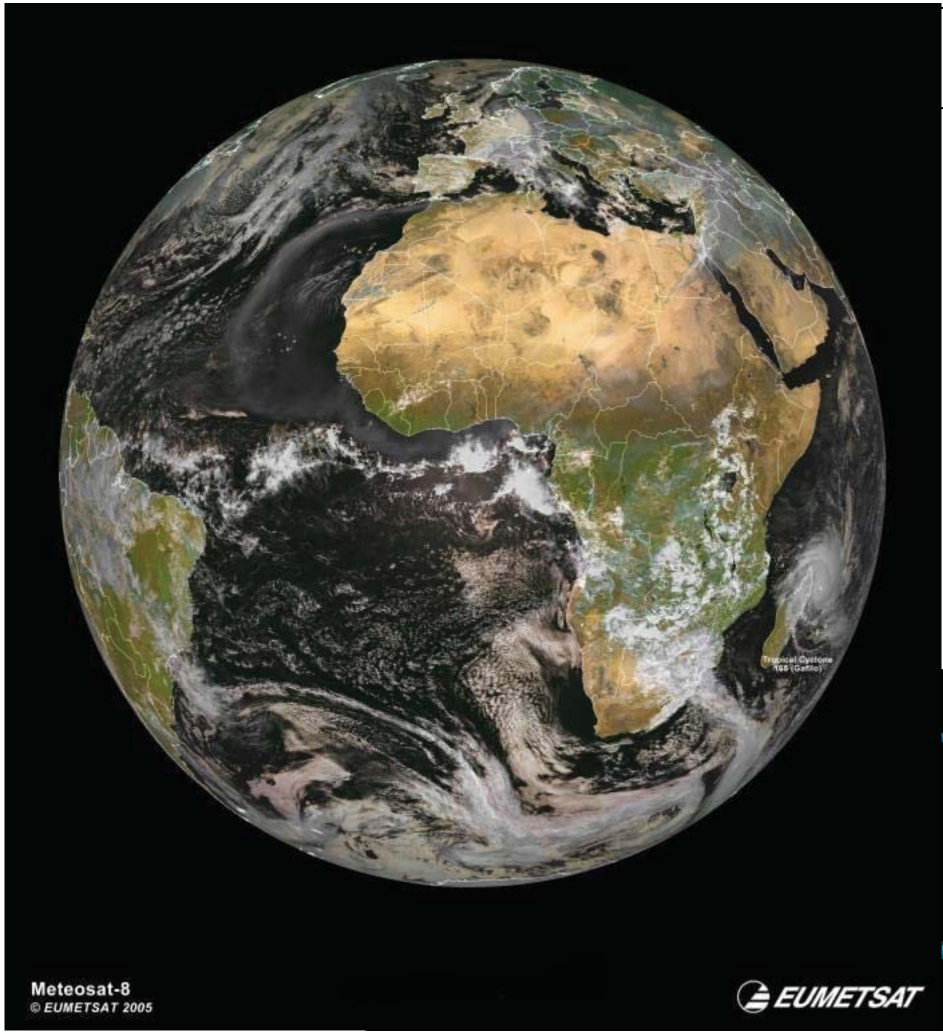


$$\otimes_V(\mathbf{r},t) \equiv \frac{[V(\mathbf{r},t)-V_{REF}(\mathbf{r})]}{\sigma_V(\mathbf{r})}$$



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





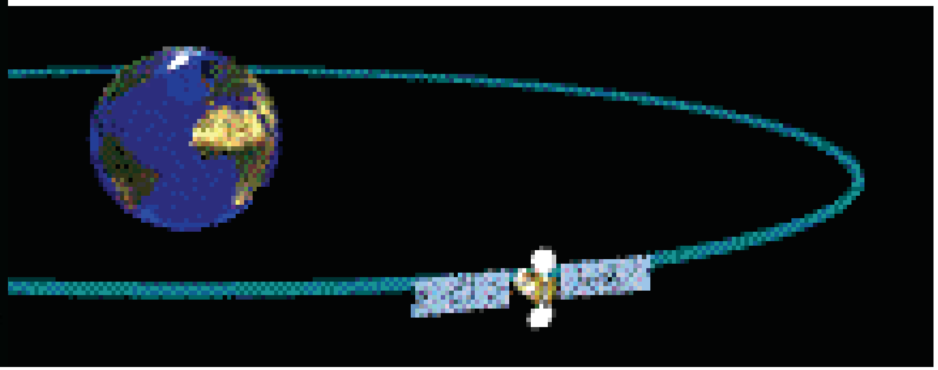
SEVIRI

(Spinning Enhanced Vis and IR Imager)

- **12 channels**
- **Temporal resolution: 15 Minutes**
- **Spatial resolution:**

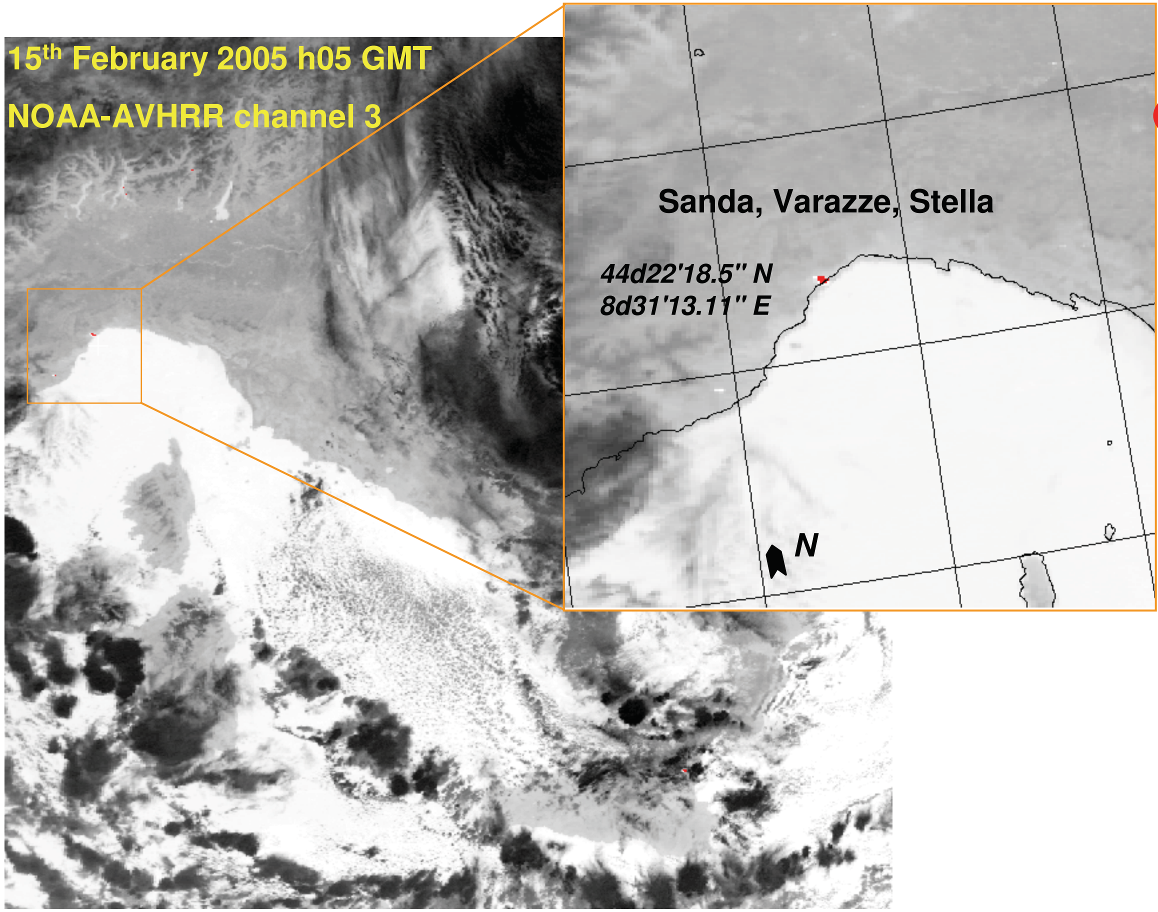
  11 channels: 3 km

  HRV: 1 km



Improving RST sensitivity moving from polar to geostationary satellites (forest fires)

Polar (NOAA-AVHRR)

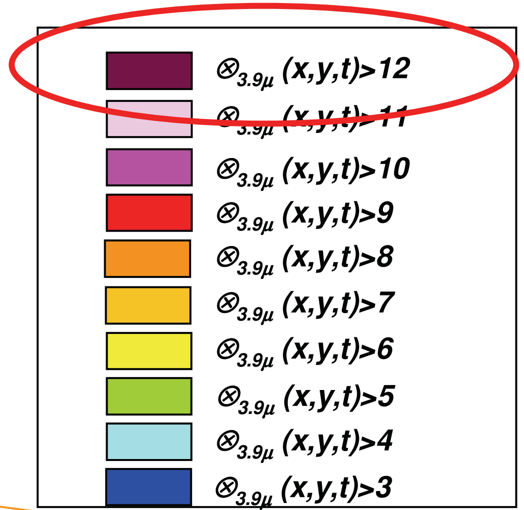


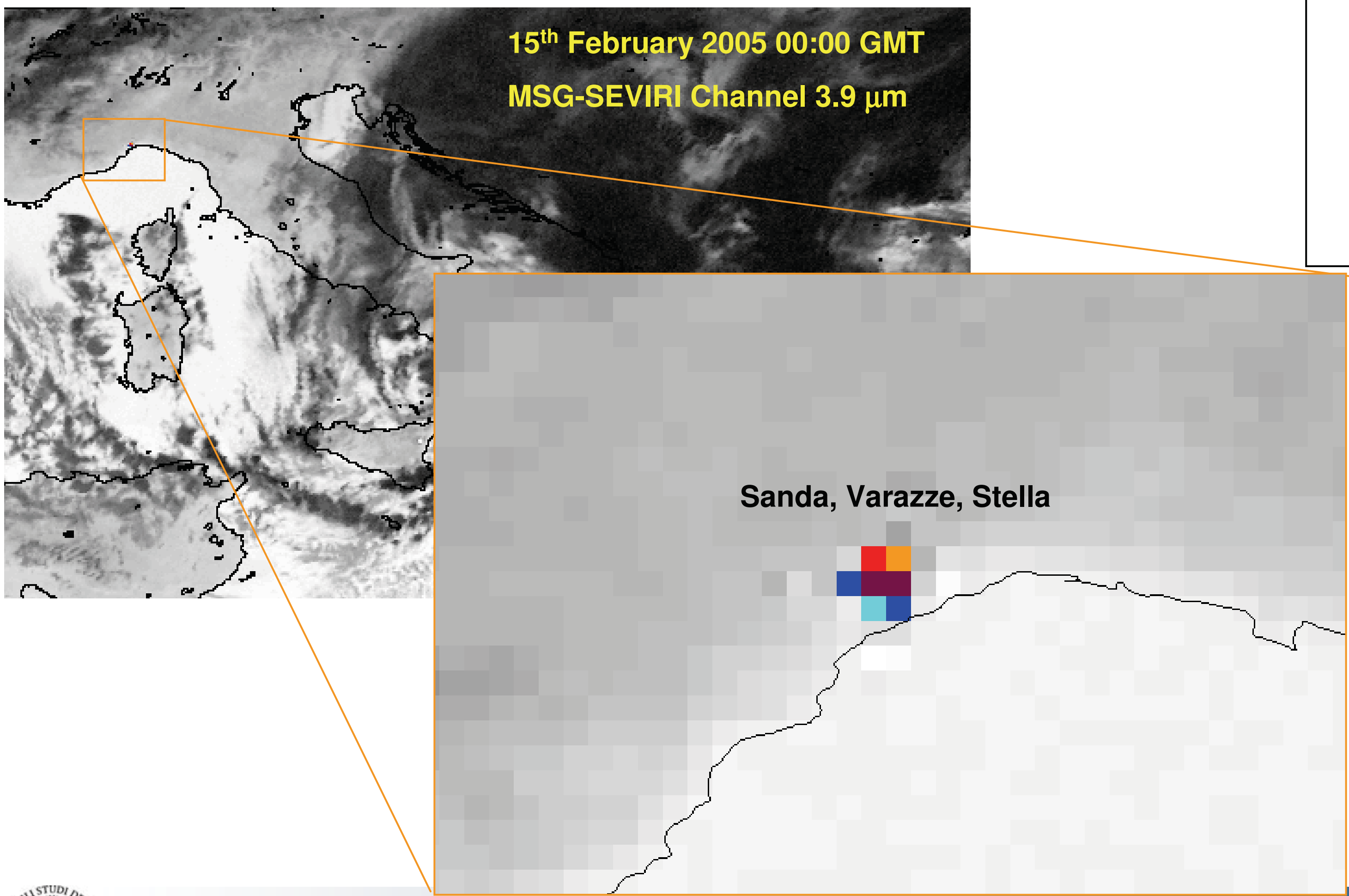
$\otimes_{ch3}(x,y,t)>2$

Detection of ***forest fires*** *in the Ligurian Region during February 2005*

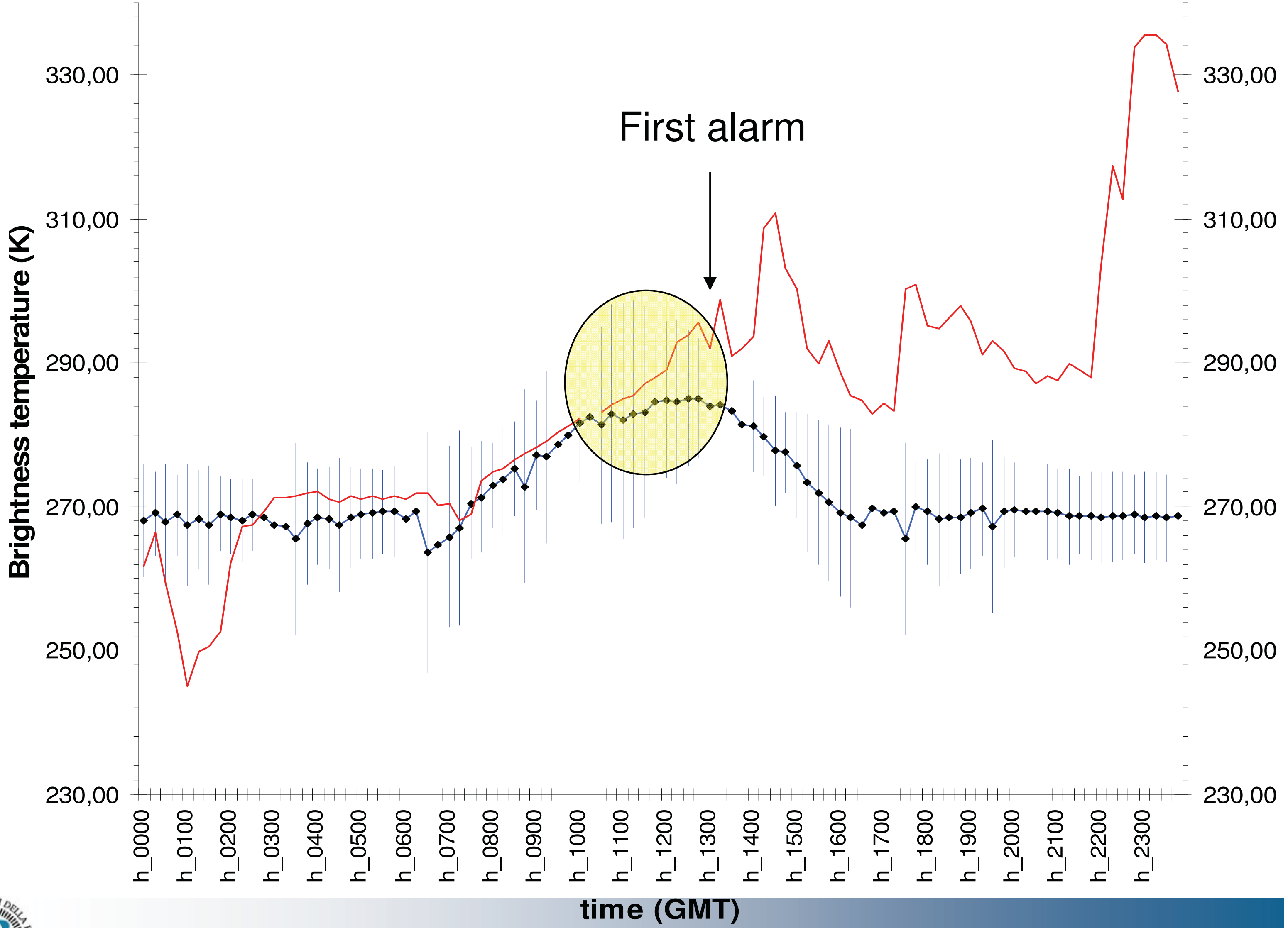
Improving RST sensitivity moving from polar to geostationary satellites (e.g. forest fires)

Geostationary (MSG-SEVIRI)



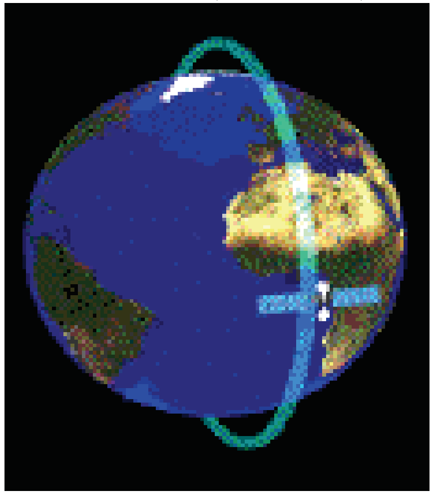


Varazze (14 February 2005)



Higher sensitivity + higher repetition rate moving from polar to geostationary satellite

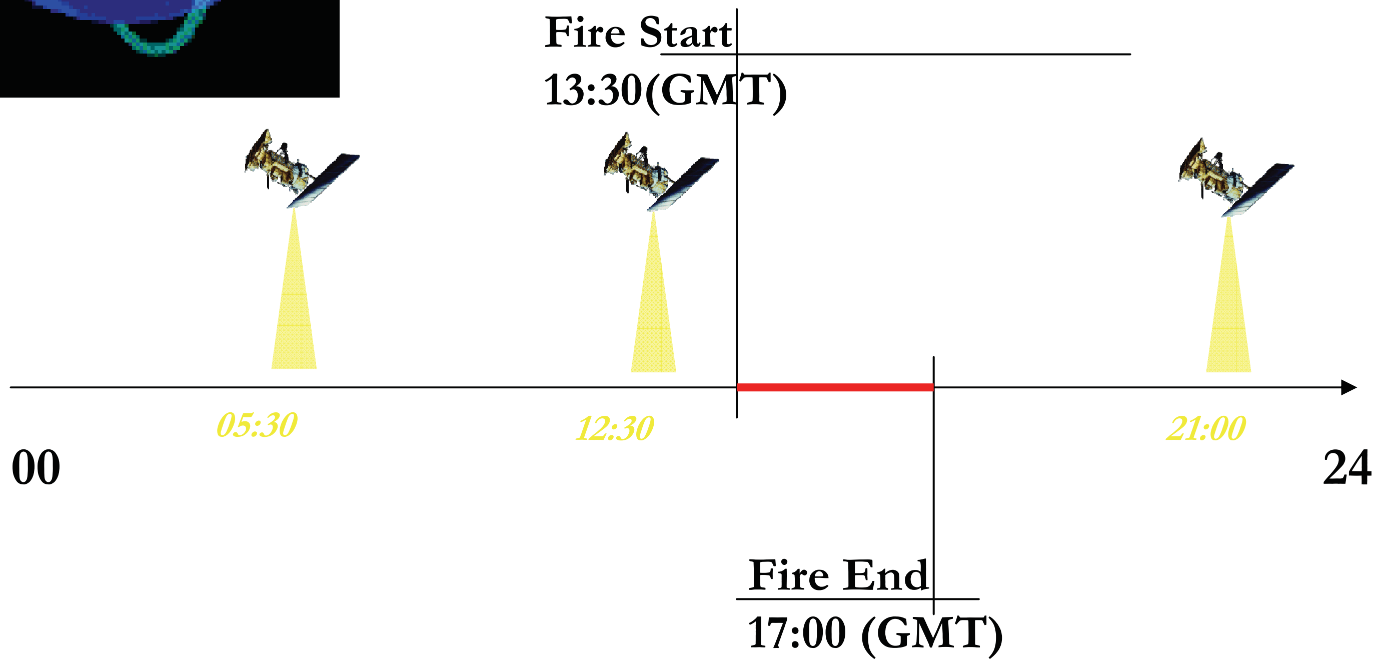
Polar Satellites, NOAA, EOS, etc



Curtatone (Mantova) – 13 February 2005

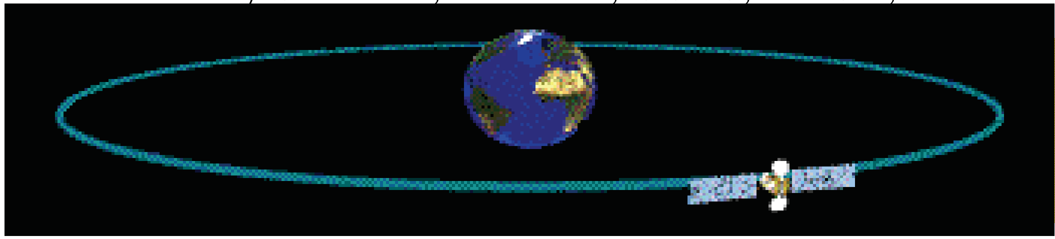
AVHRR

13 February 2005



Improving performances by continuity:
moving from polar to geostationary satellite

Geostationary Satellites, Meteosat, GOES, MetSat, etc.

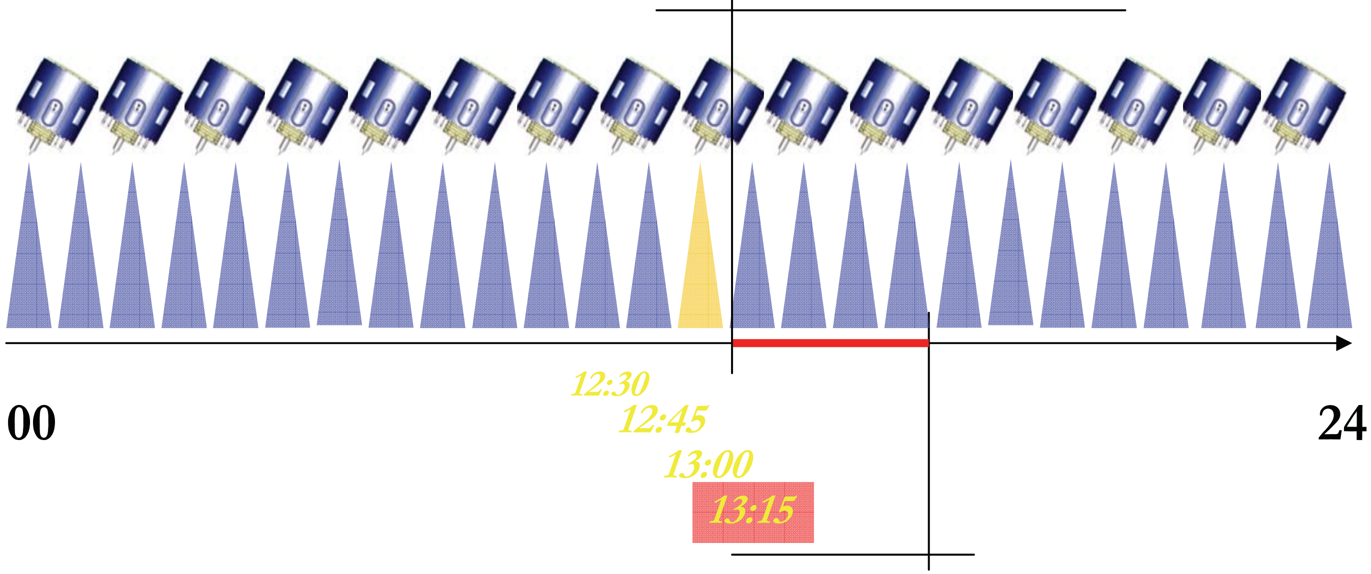


SEVIRI

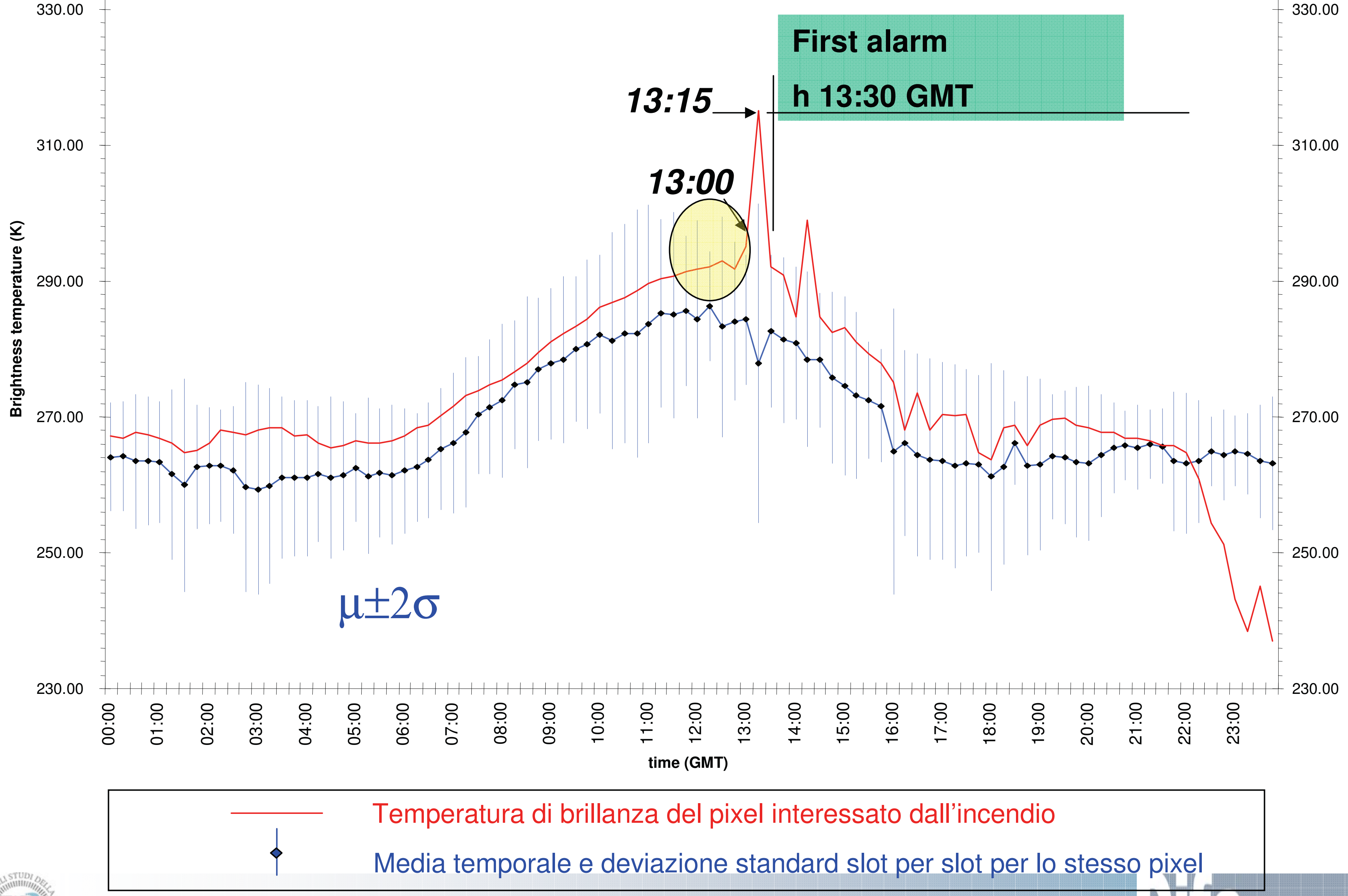
13 February 2005

Fire Start/end

13:30/17:00 (GMT)

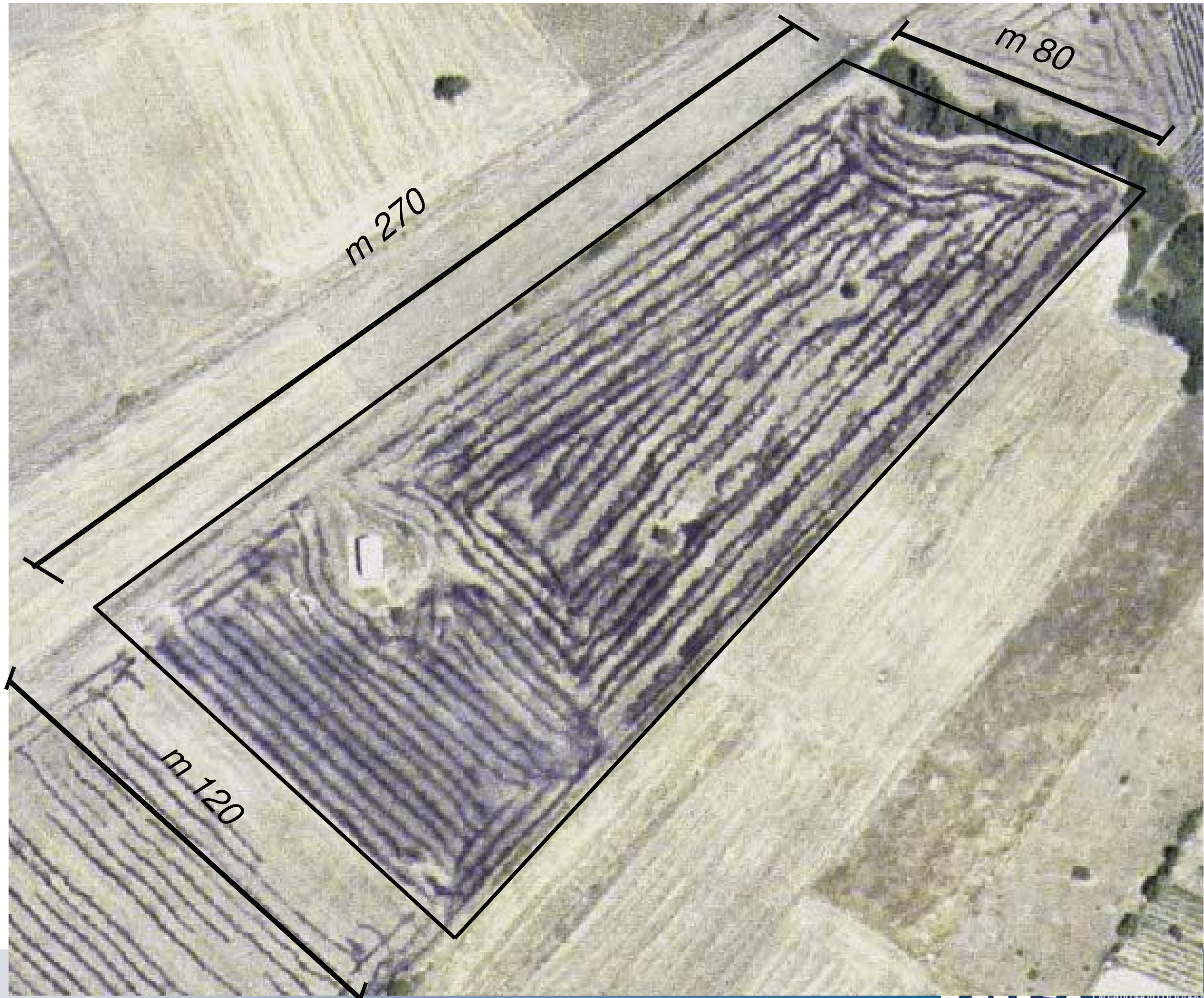


Curtatone (Mantova) – 13 Febbraio 2005



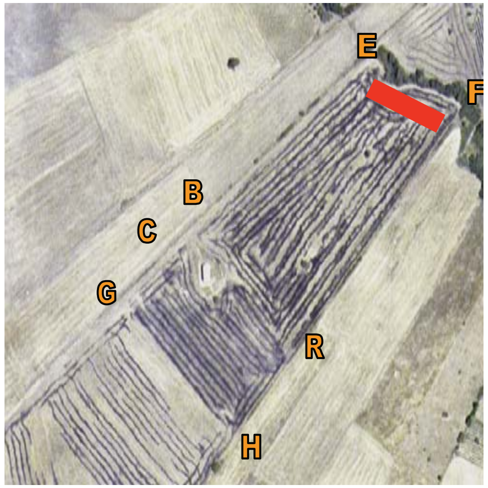
How small ?

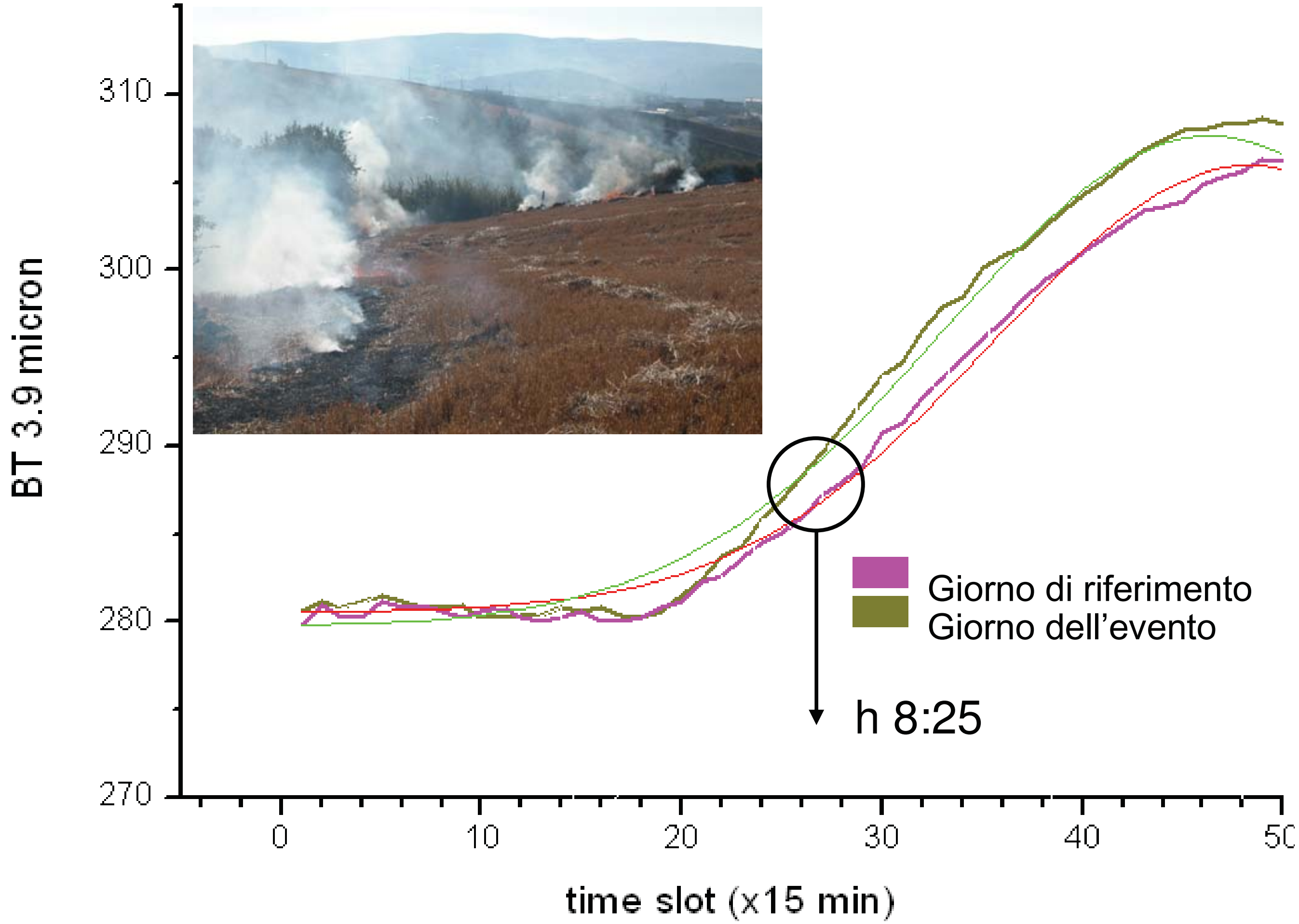
Potenza 29 August 2005 – Controled cleaning fires



How small ?

Potenza 29 August 2005 – Controled cleaning fires



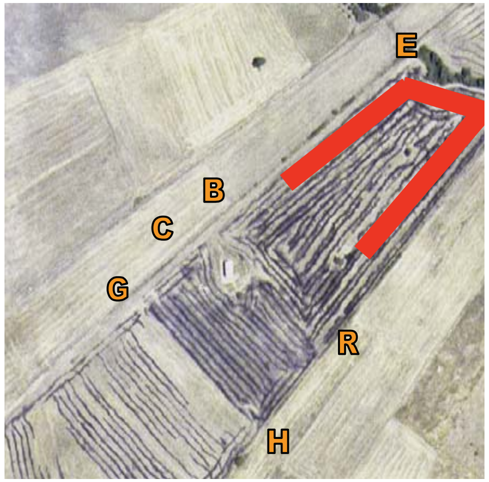


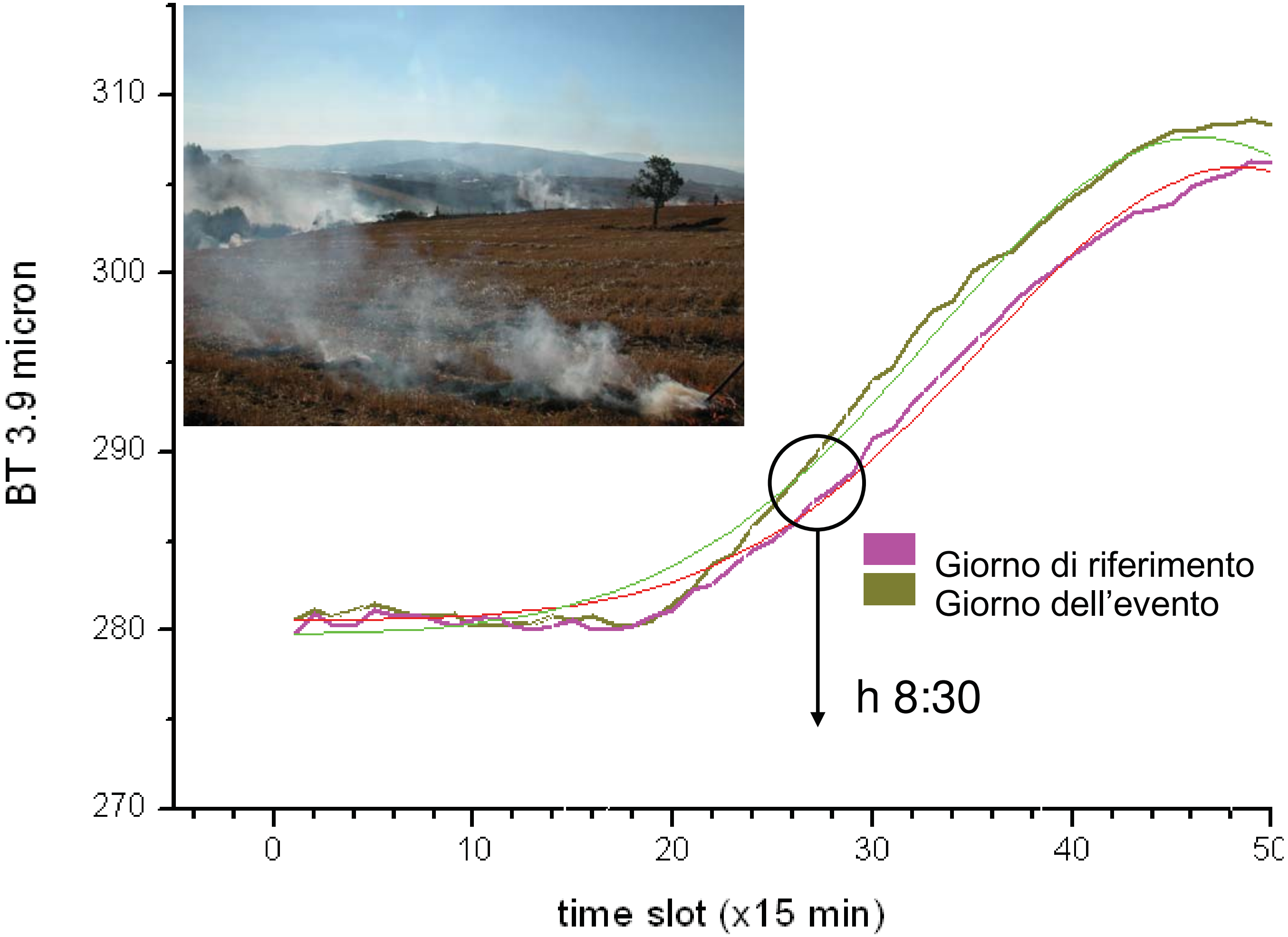
8:25

How small ?

Timely (<15min) detection of small (<30sm) fires

Potenza 29 August 2005 – Controled cleaning fires



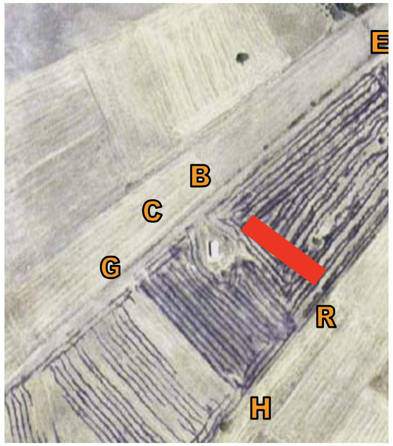


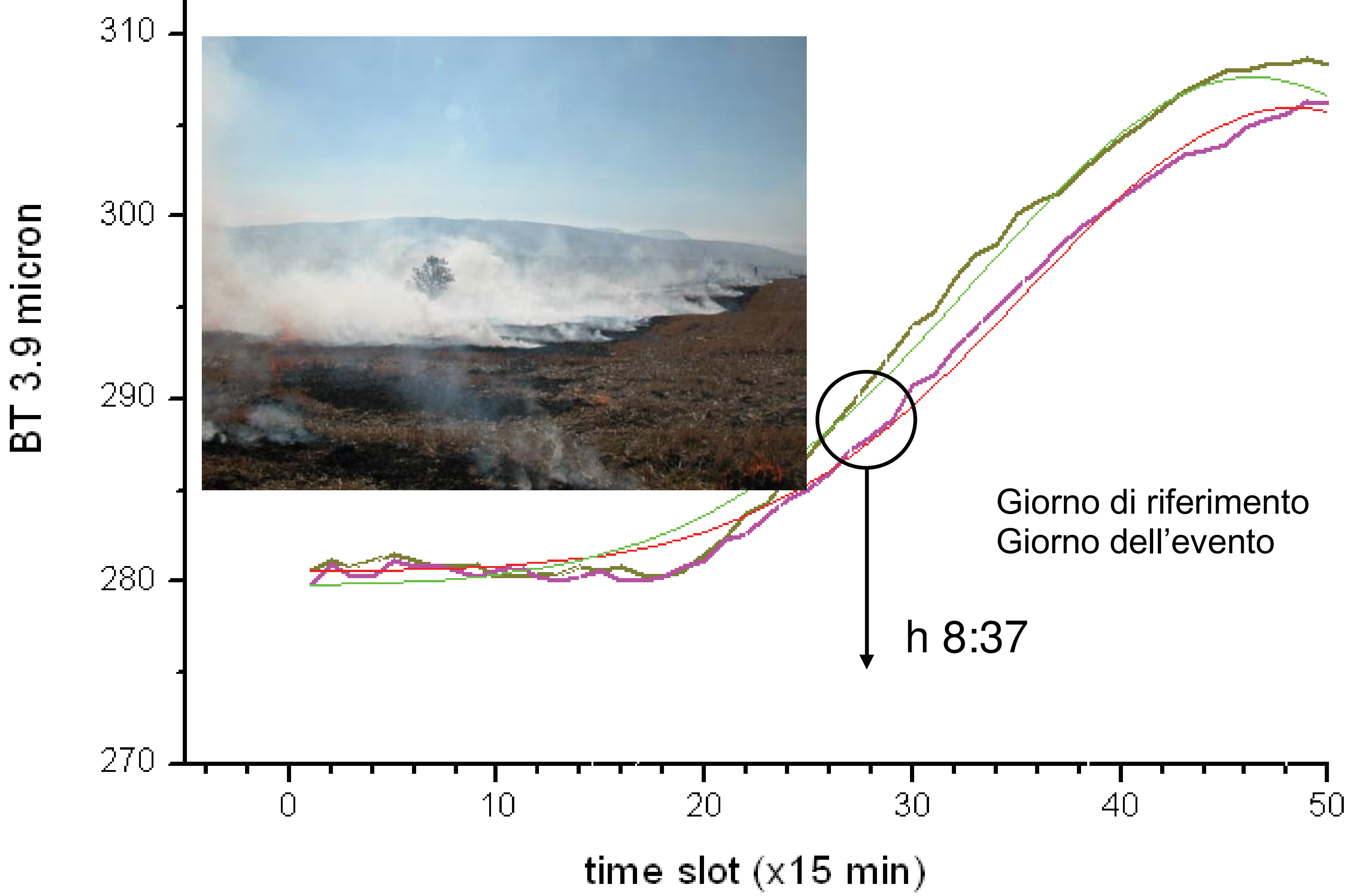
8:30

How small ?

Timely (<15min) detection of small (<30sm) fires

Potenza 29 August 2005 – Controled cleaning fires

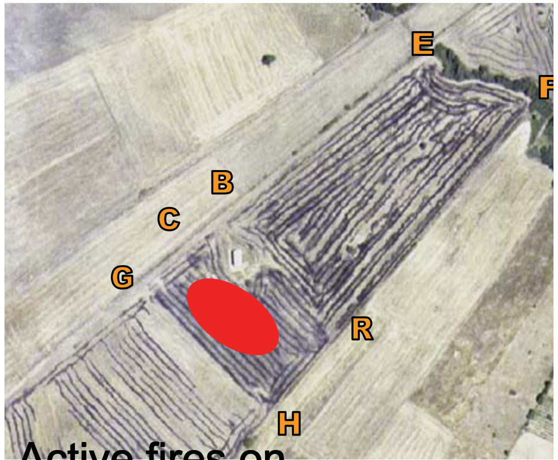




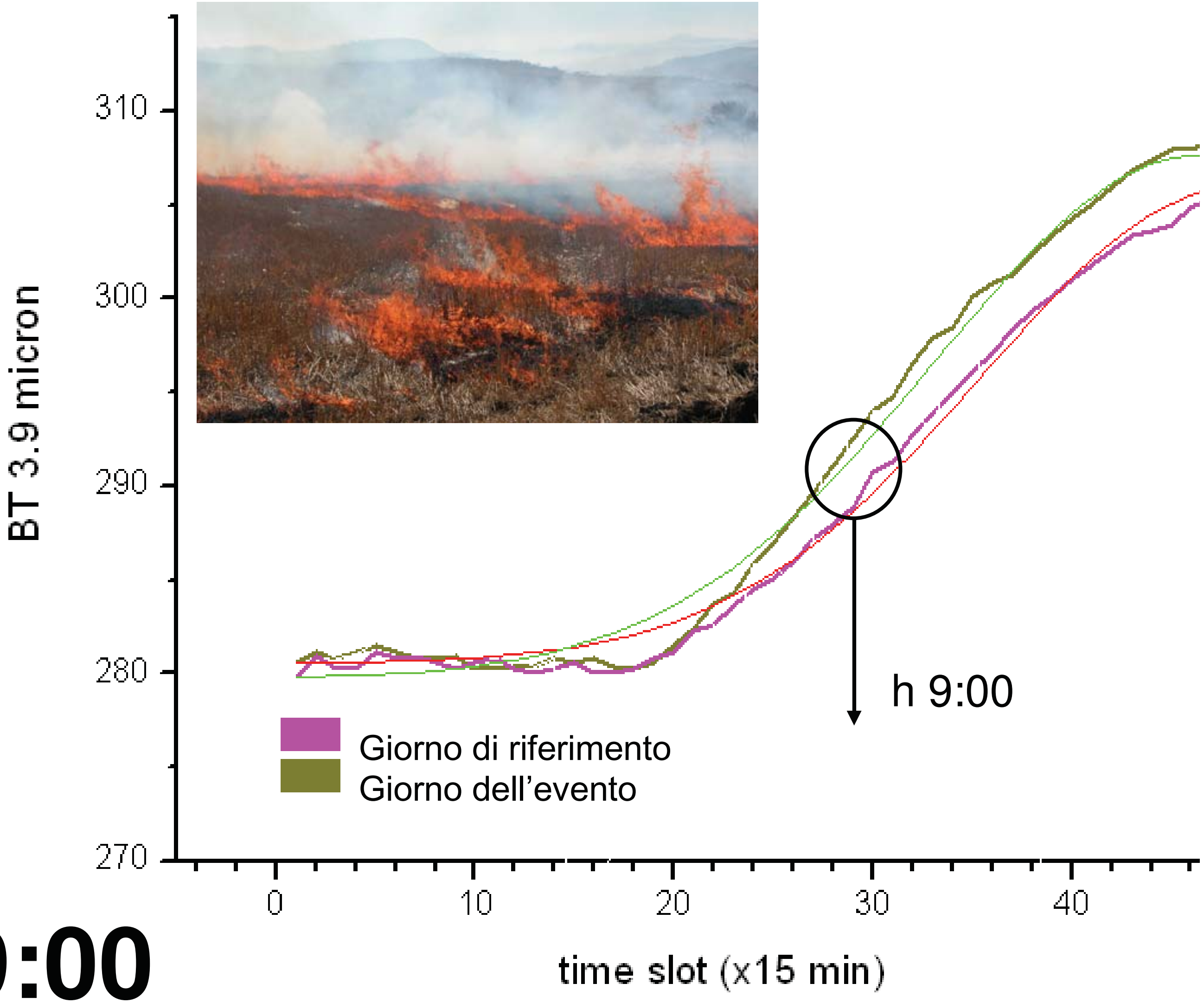
8:37

Individuazione tempestiva (<15 min) dei focolai di incendio (< 30m^2)

Potenza 29 Agosto 2005 – Incendi di stoppie controllati



Active fires on
about 20 sm



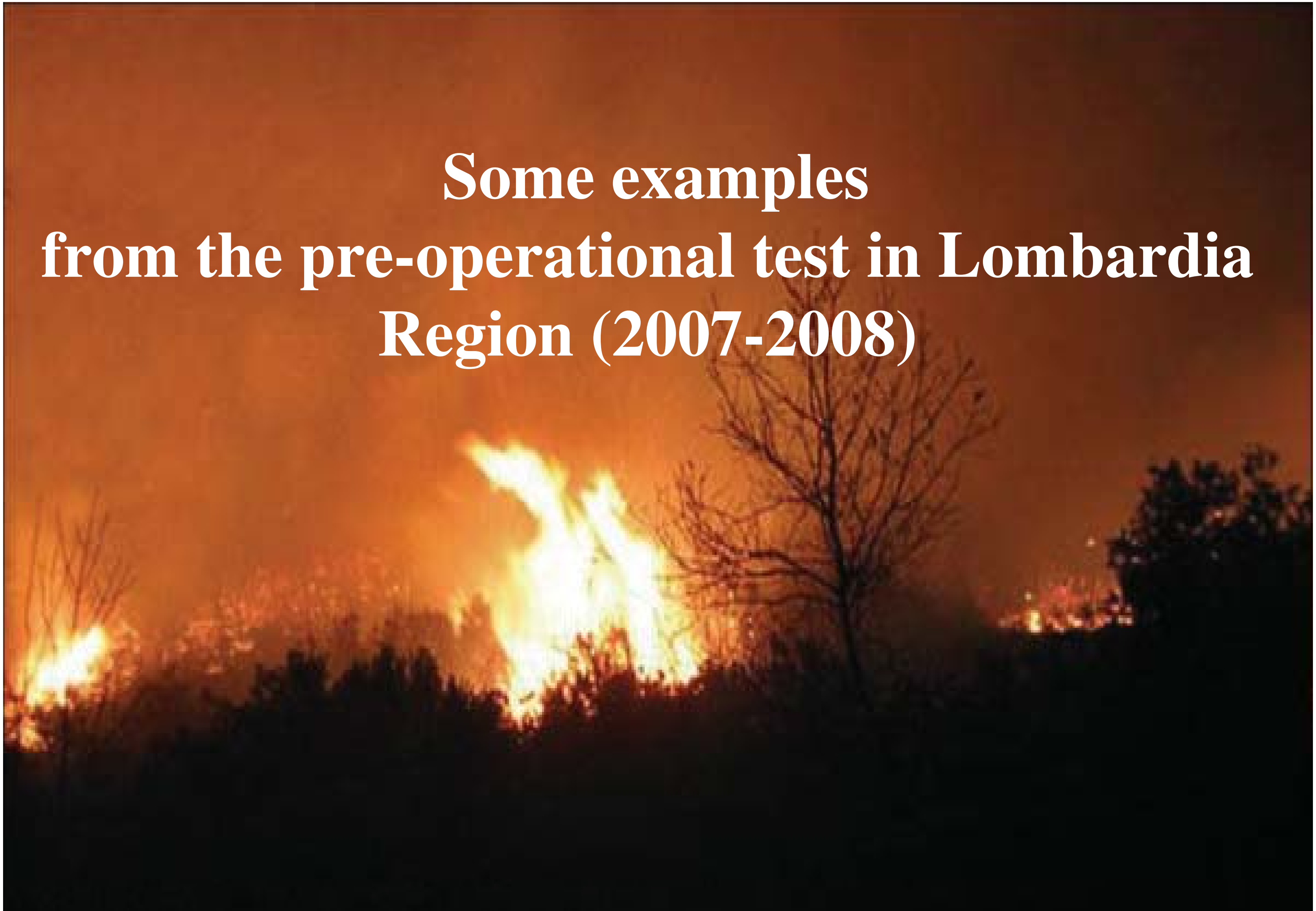
9:00

APPLICATIONS

to do fast:

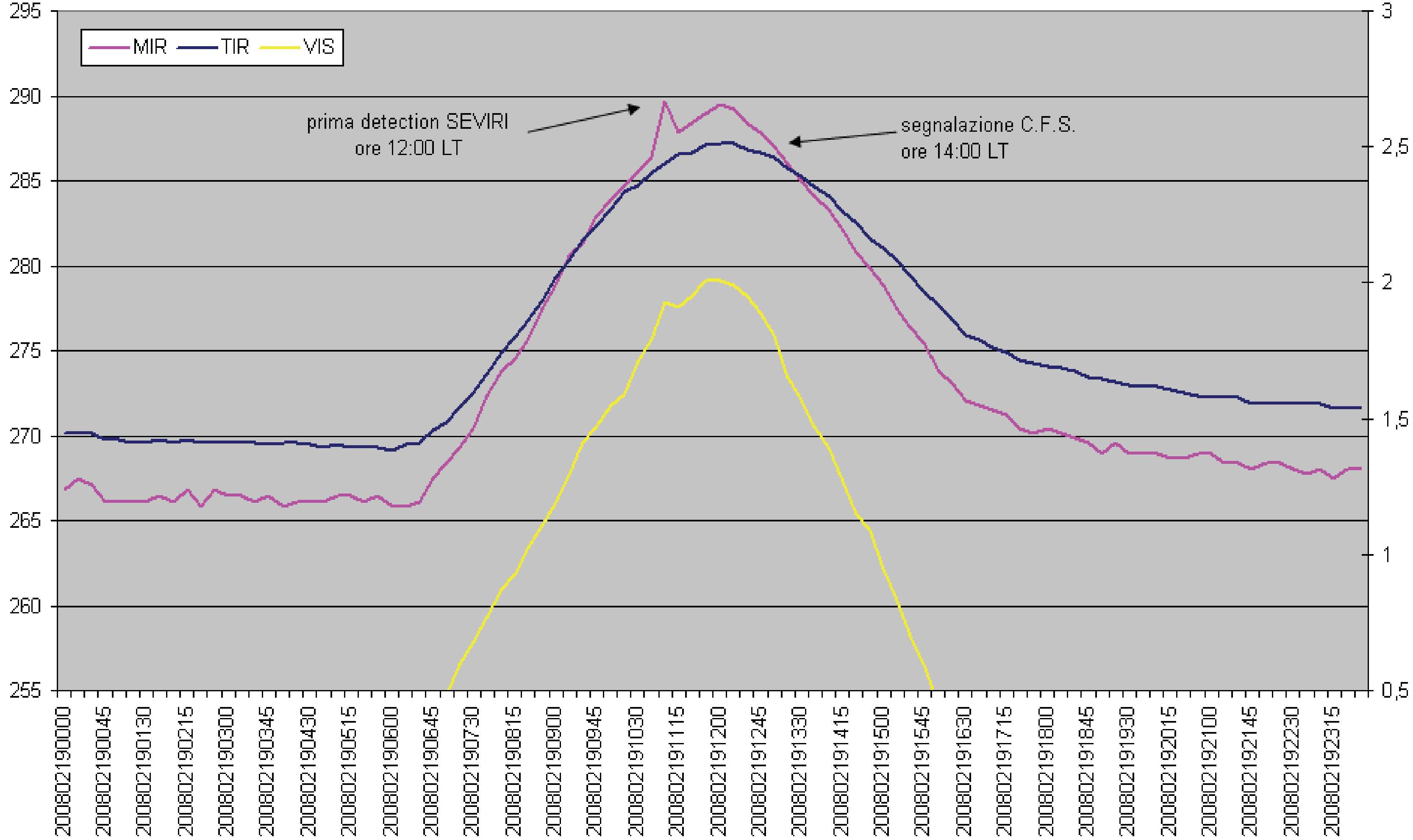
Improving timely detection of events

Some examples from the pre-operational test in Lombardia Region (2007-2008)

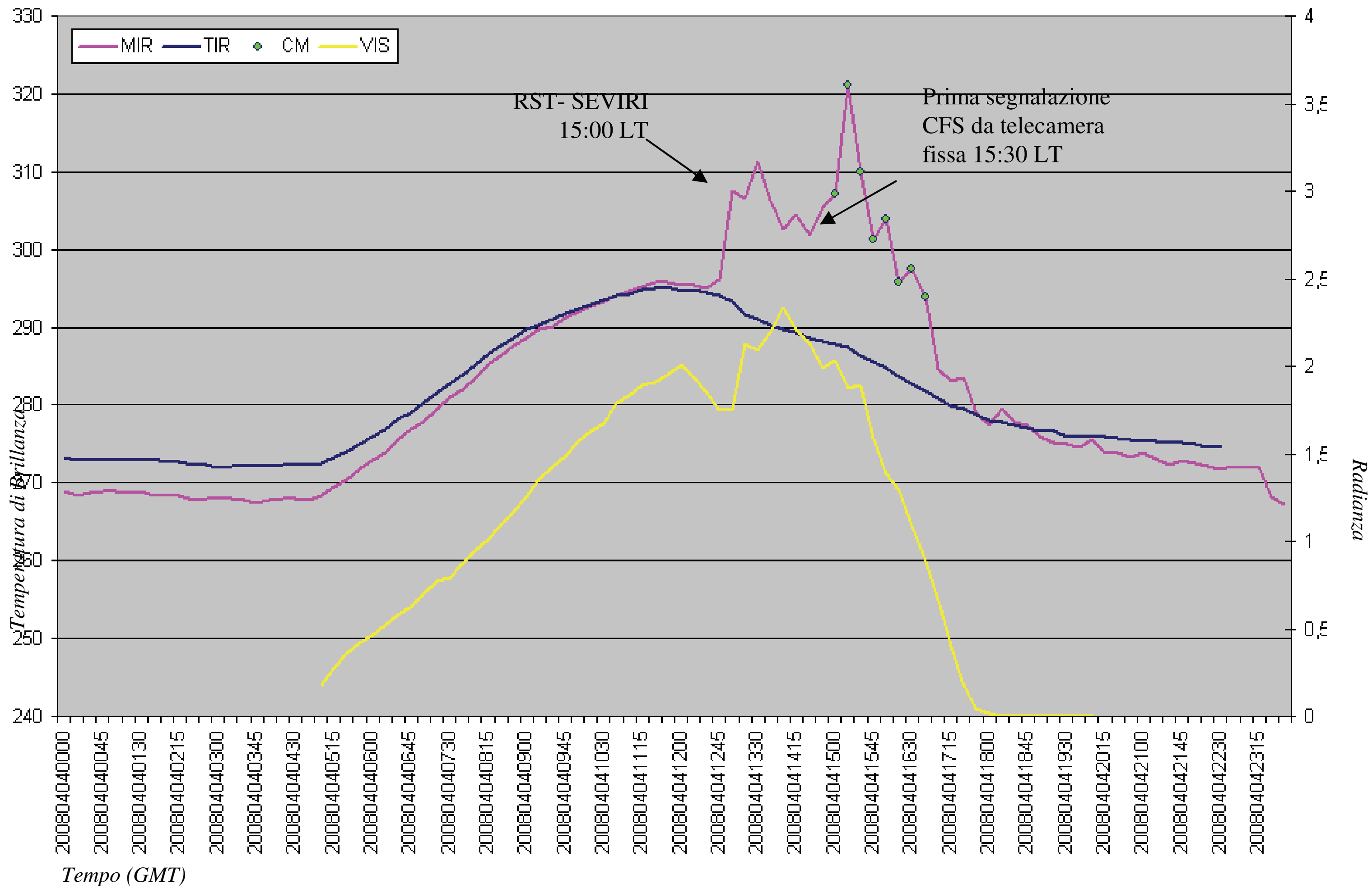


AVVISA · Protezione Civile · IReR · ERSAF · Università degli Studi di Milano Bicocca · DISAT · Università degli Studi della Basilicata · Difa · Dipartimento di Ingegneria e Fisica dell'Ambiente · LADSAT · imaa istituto di metodologie per l'analisi ambientale

Gazzaniga (BG) event on 19/2/2008
(2 h before alarm)



Bione (BS) event 4/4/2008
(30 min before VIS/IR ground camera)

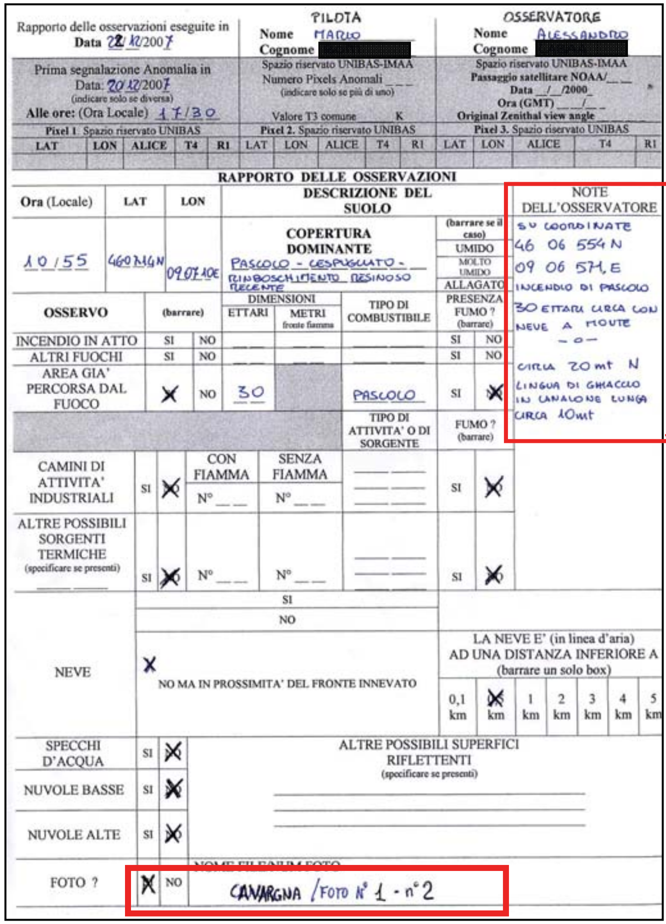


The Cavargna event on 20-21/12/07

AVVISA

Aereal report and photographs collected 8 days after

CAVARGNA



Rapporto delle osservazioni eseguite in Data 22/12/2007

PILOTA
Nome MARIO
Cognome [redacted]

OSSERVATORE
Nome ALESSANDRO
Cognome [redacted]

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)
Valore T3 comune ____ K

Spazio riservato UNIBAS-IMAA
Passaggio satellitare NOAA/___
Data __/__/2000_
Ora (GMT) ___/__
Original Zenithal view angle ______

Pixel 1. Spazio riservato UNIBAS					Pixel 2. Spazio riservato UNIBAS					Pixel 3. Spazio riservato UNIBAS				
LAT	LON	ALICE	T4	R1	LAT	LON	ALICE	T4	R1	LAT	LON	ALICE	T4	R1

RAPPORTO DELLE OSSERVAZIONI

Ora (Locale)	LAT	LON	DESCRIZIONE DEL SUOLO – COPERTURA DOMINANTE	(barrare se il caso)
10/55	46 06 554 N	09 07 10 E	PASCOLO - CESPUGLIATO - RIMBOSCHIMENTO RESINOSO RECENTE	UMIDO / MOLTO UMIDO / ALLAGATO

OSSERVO	(barrare)		DIMENSIONI ETTARI	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	X	NO	30		PASCOLO	SI	X

			CON FIAMMA	SENZA FIAMMA	TIPO DI ATTIVITA' O DI SORGENTE	FUMO ? (barrare)	
CAMINI DI ATTIVITA' INDUSTRIALI	SI	X	N° ___	N° ___	______	SI	X
ALTRE POSSIBILI SORGENTI TERMICHE (specificare se presenti)	SI	X	N° ___	N° ___	______	SI	X

NEVE: SI / NO / X NO MA IN PROSSIMITA' DEL FRONTE INNEVATO

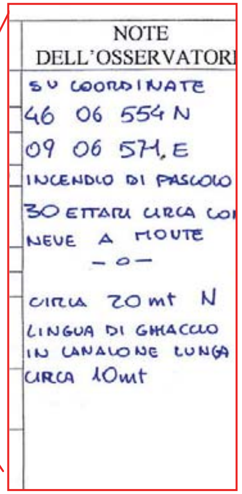
LA NEVE E' (in linea d'aria) AD UNA DISTANZA INFERIORE A (barrare un solo box)

0,1 km	X km	1 km	2 km	3 km	4 km	5 km

SPECCHI D'ACQUA	SI	X
NUVOLE BASSE	SI	X
NUVOLE ALTE	SI	X

ALTRE POSSIBILI SUPERFICI RIFLETTENTI (specificare se presenti)

FOTO ? X NO — NOME FILE/NUM FOTO: CAVARGNA /FOTO N° 1 - n°2

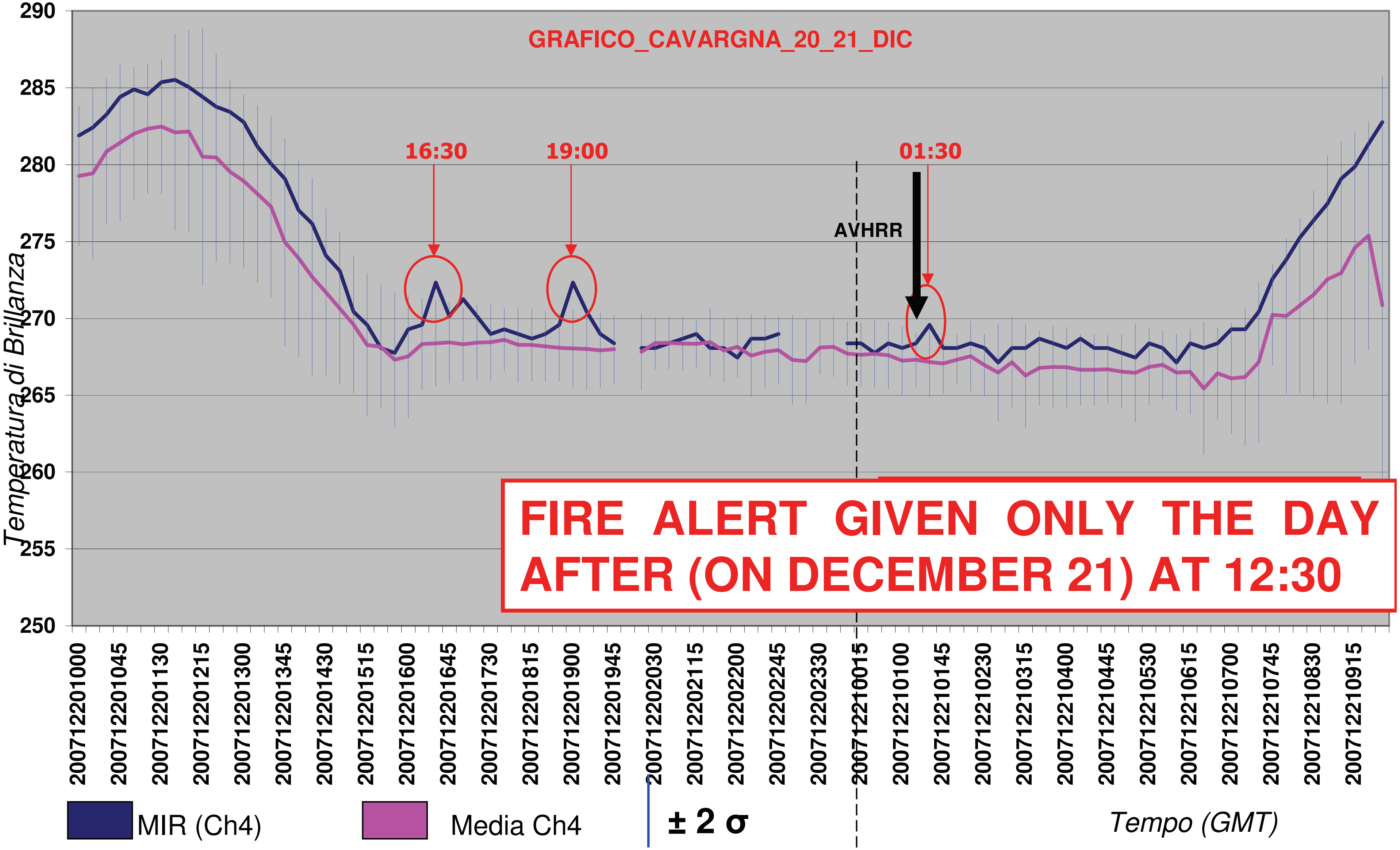


NOTE DELL'OSSERVATORE

SU COORDINATE
46 06 554 N
09 06 571, E
INCENDIO DI PASCOLO
30 ETTARI CIRCA CON
NEVE A MONTE
– o –
CIRCA 20 mt N
LINGUA DI GHIACCIO
IN CANALONE LUNGA
CIRCA 10mt

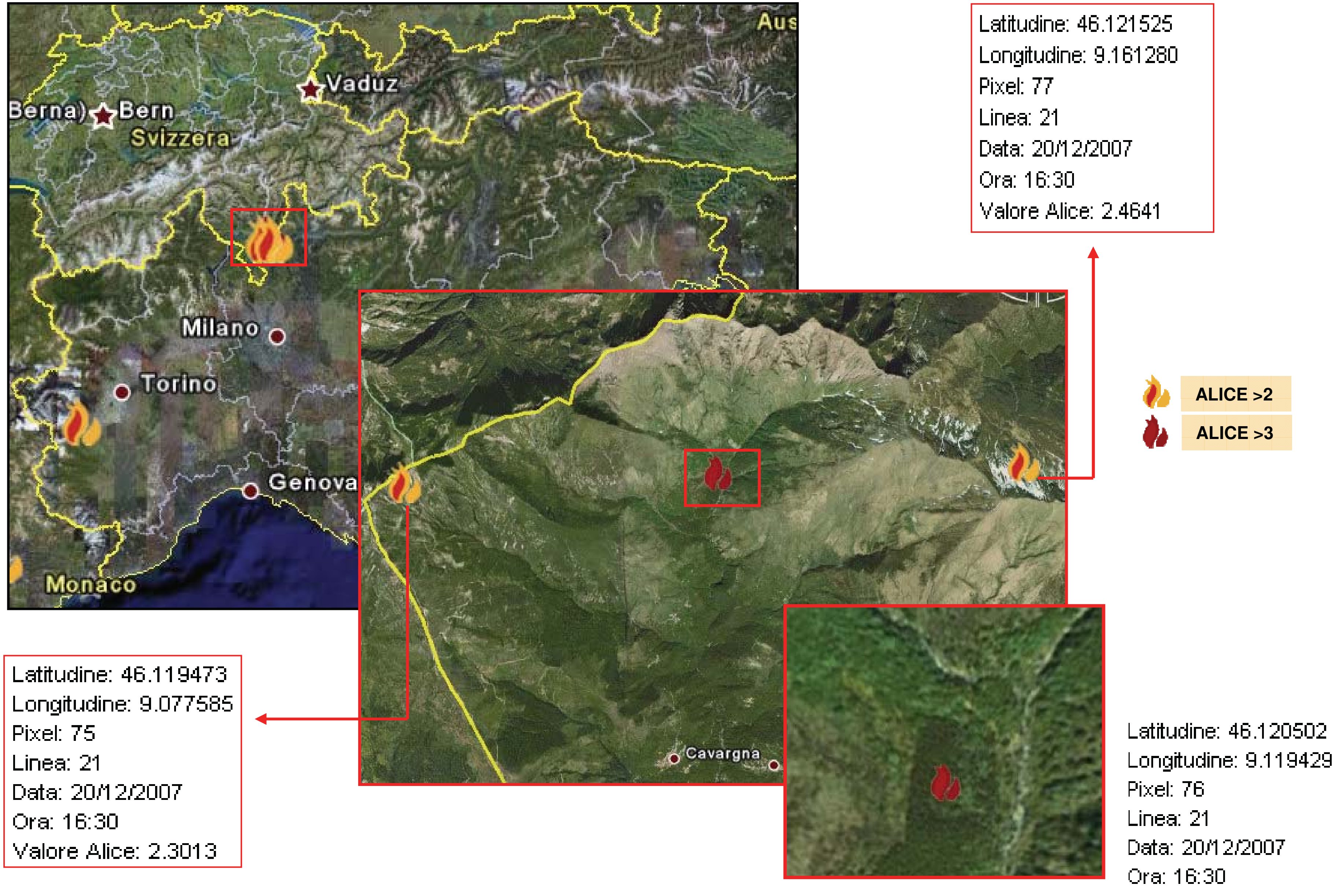
CAVARGNA 20 and 21 DICEMBRE 2007: MIR signal evolution

RST detection 20 hours before !



Automatic visualization system

DEC-20-2007 16:30



APPLICATIONS

to do more & better:

RST application to

Real-time monitoring of infrastructures

By Akintunde Akinleye
LAGOS, Dec 26 (Reuters) - Hundreds of people were burned alive on Tuesday when fuel spilling from a vandalised pipeline exploded in Nigeria's largest city, Lagos, emergency workers said. Crowds of local residents went to scoop up the petrol in plastic containers after an armed gang punctured the underground pipeline overnight to siphon fuel into road tankers. "The number of dead is confirmed at 269. We have retrieved all the bodies," said Abiodun Orebiyi, secretary-general of the Nigerian Red Cross. Another 160 people were taken to two hospitals in Lagos suffering from burns, another Red Cross official said. Shortly after the blast, hundreds of bodies, most burned beyond recognition, were scattered on the ground next to a ramshackle car workshop and a saw mill in the densely populated Abule Egba district. Some corpses lay rigid on the earth -- arms and legs thrust awkwardly in the air -- their clothes and skin burned off by the blast. Others were reduced to ash. It took firefighters equipped with leaking water hoses about six hours to extinguish the flames as hundreds of people came to watch.

about 2,000 people died over the last 10 years.

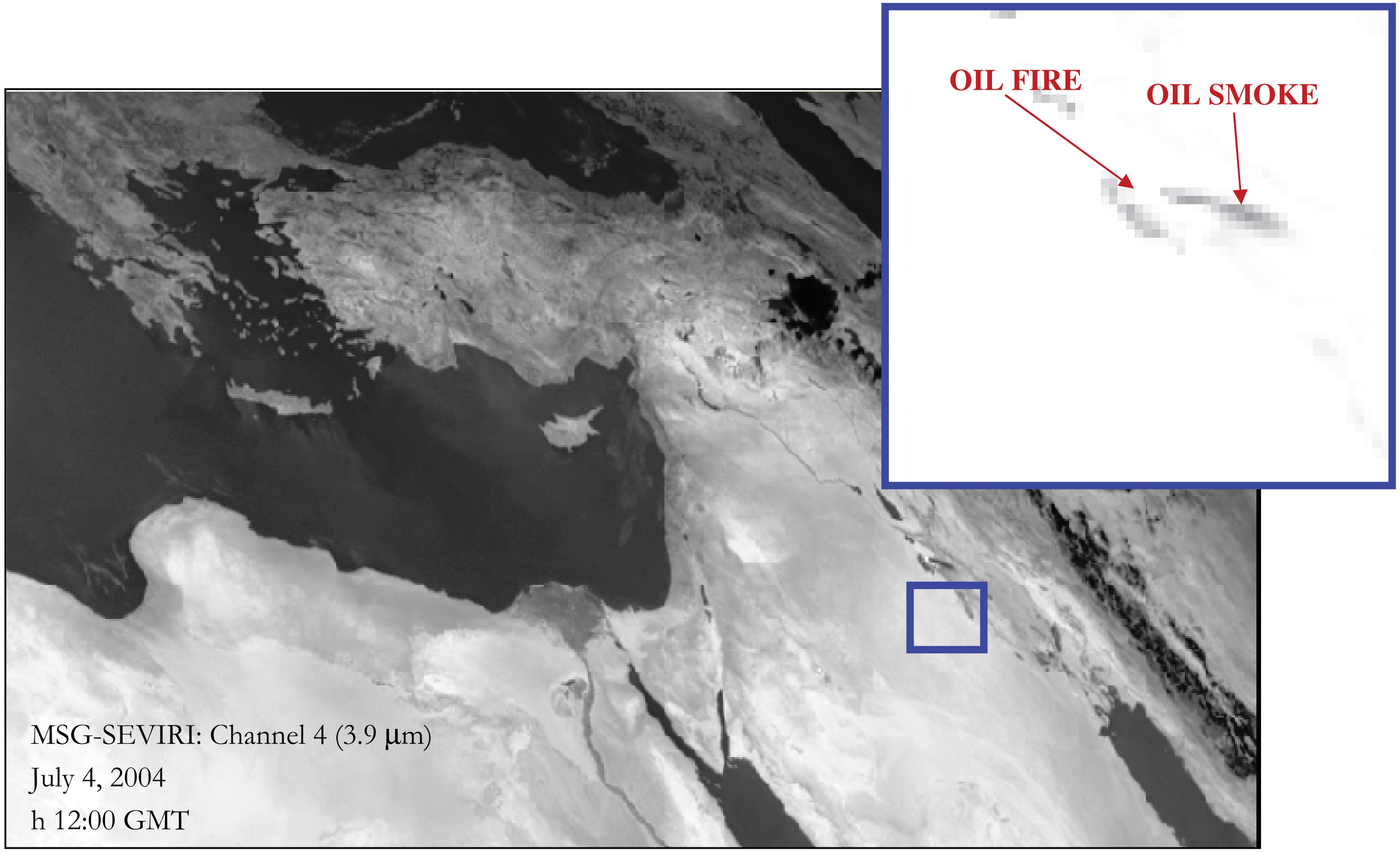
RST application to

Real-time monitoring of infrastructures

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

More than 300 sabotage since the Iraq war start

Sabotage to pipelines in Iraq (4 July 2004)



Sabotages to pipelines in Iraq (22 June 2005)

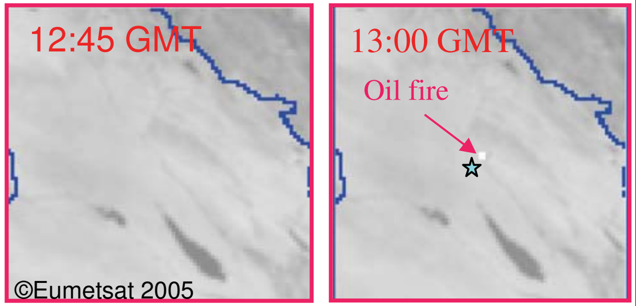
Real time identification and monitoring

Between 12:45 and 13:00 GMT a pipeline explosion, due to a sabotage along a known (☆) pipeline, is clearly visible over SEVIRI images.

MAP OF KNOWN OIL PIPELINES

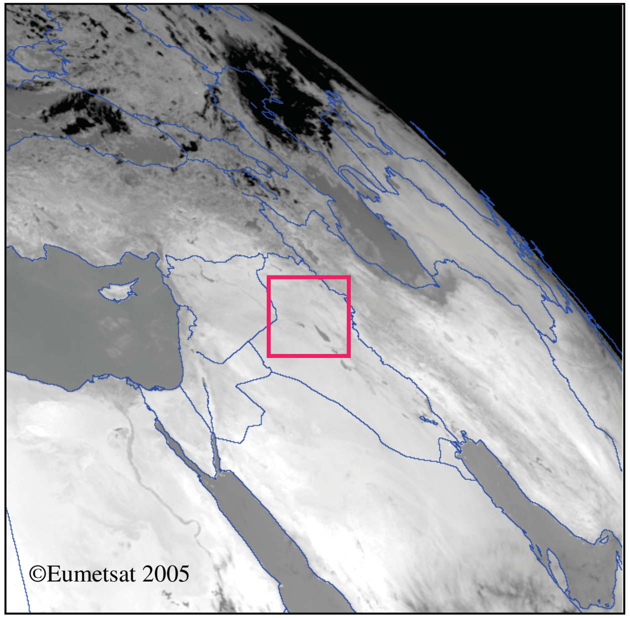
From:
http://www.iags.org/iraqpipelinewatch.htm

MSG-SEVIRI - Ch 3.9 μm



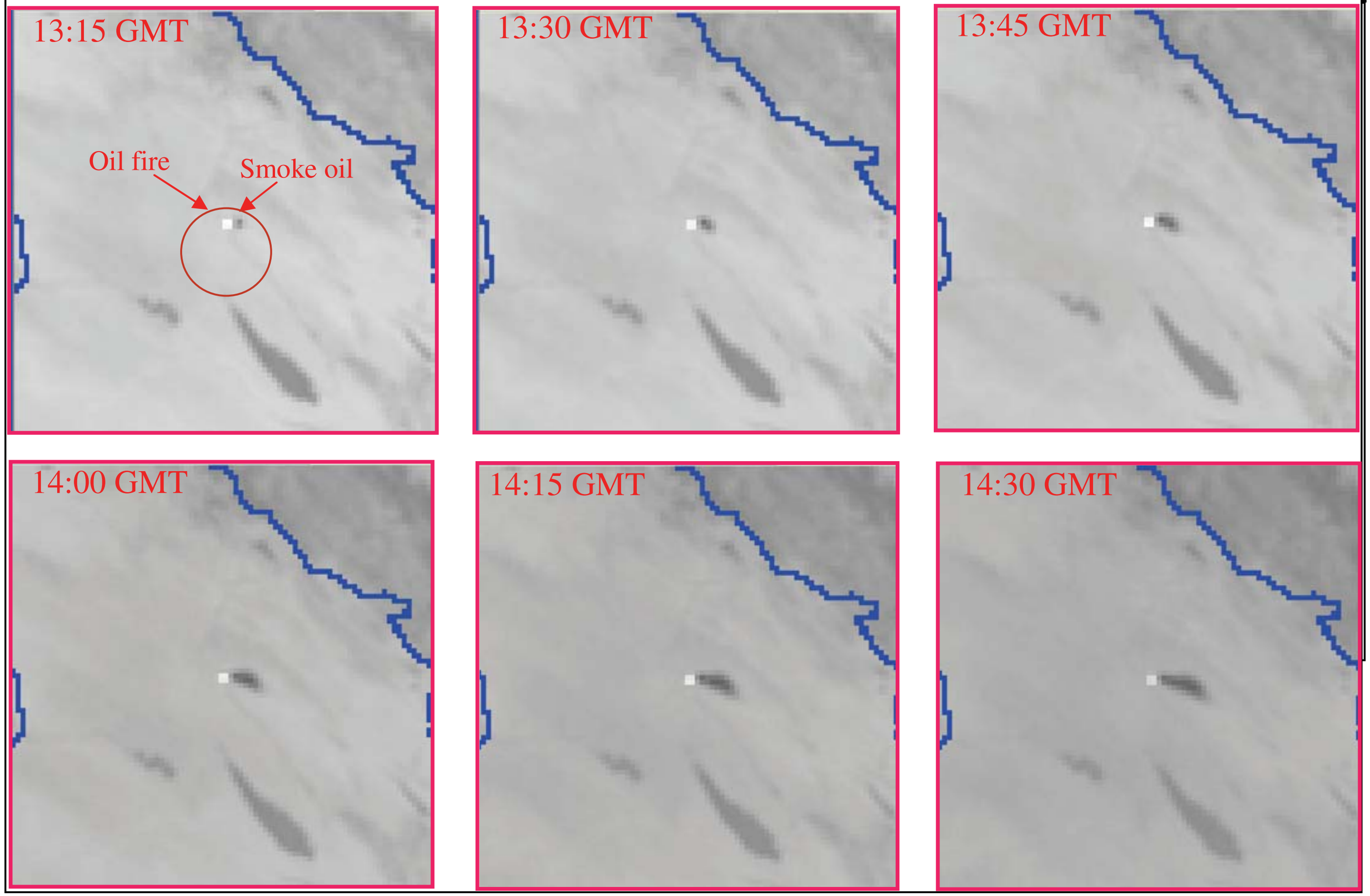
Shortly before the pipeline sabotage.

Immediately after the pipeline sabotage.



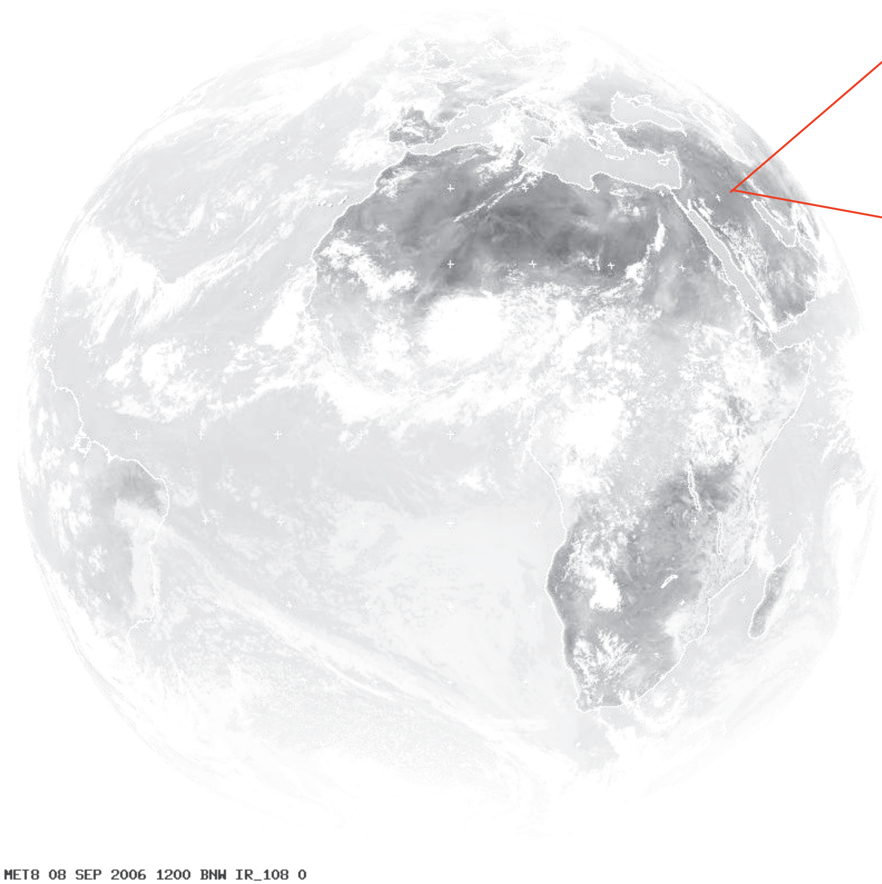
Sabotages to pipelines in Iraq (22 June 2005)
Real time identification and monitoring

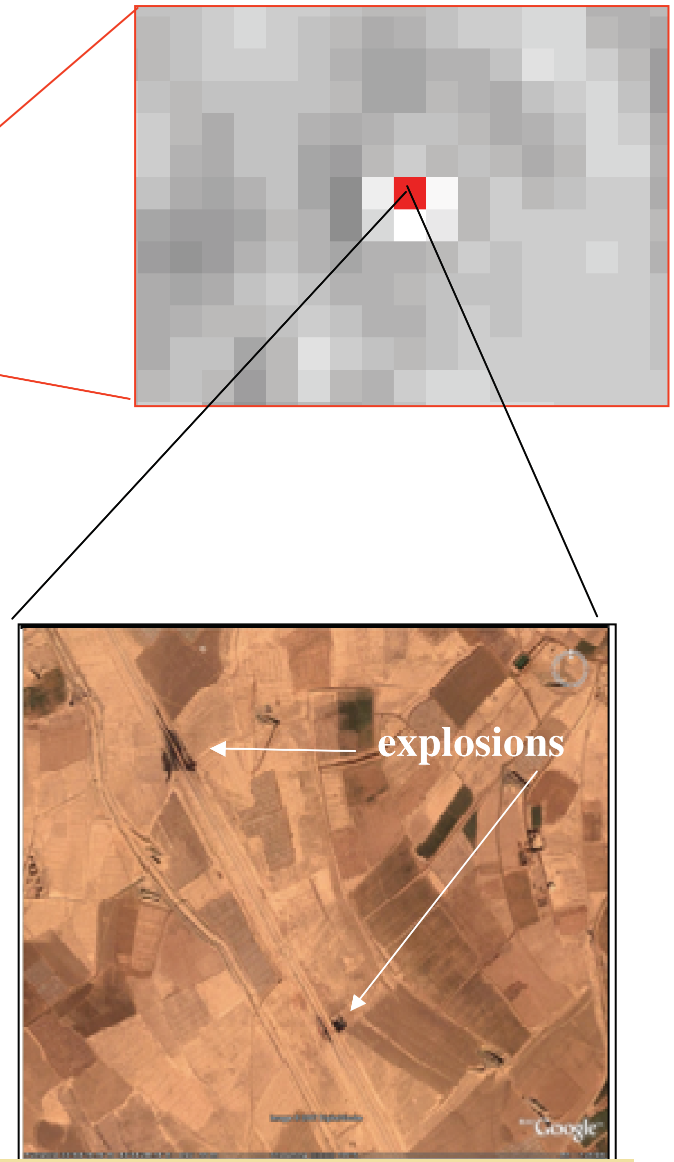
Monitoring (each 15 min)
fire and smoke evolution



RST results and integration: some examples

High **temporal** resolution

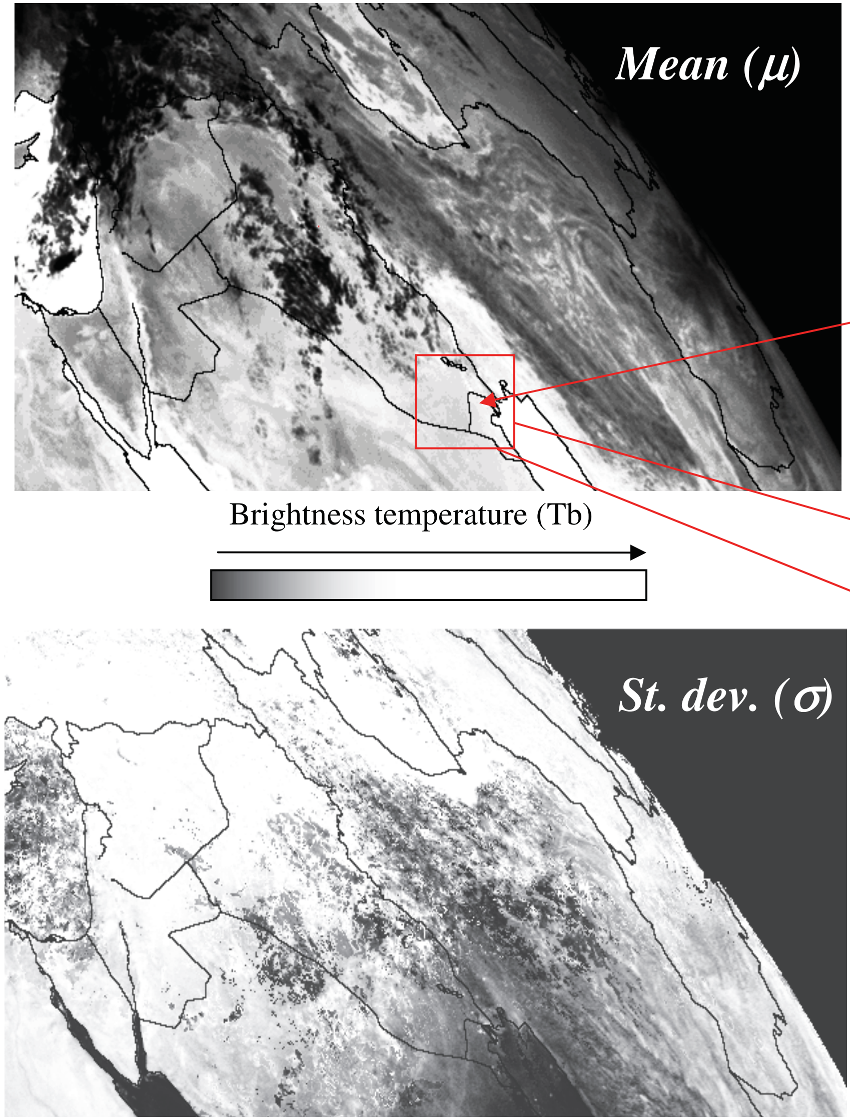




High **spatial** resolution

Sabotages to pipelines in Iraq (18 October 2005)

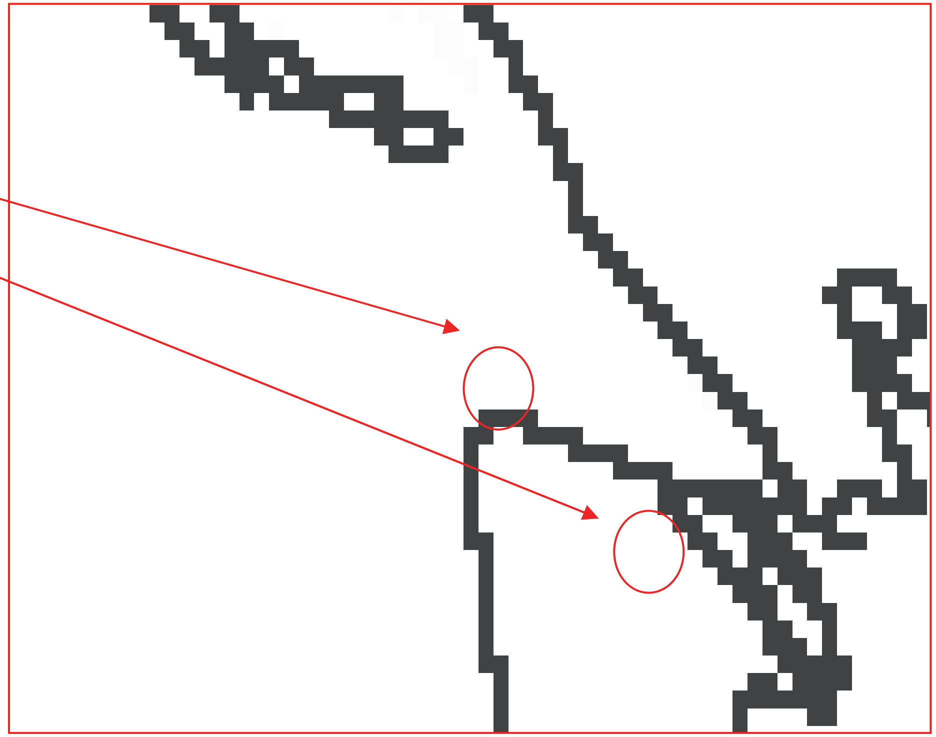
Identification for sure (false alarms elimination) by RST



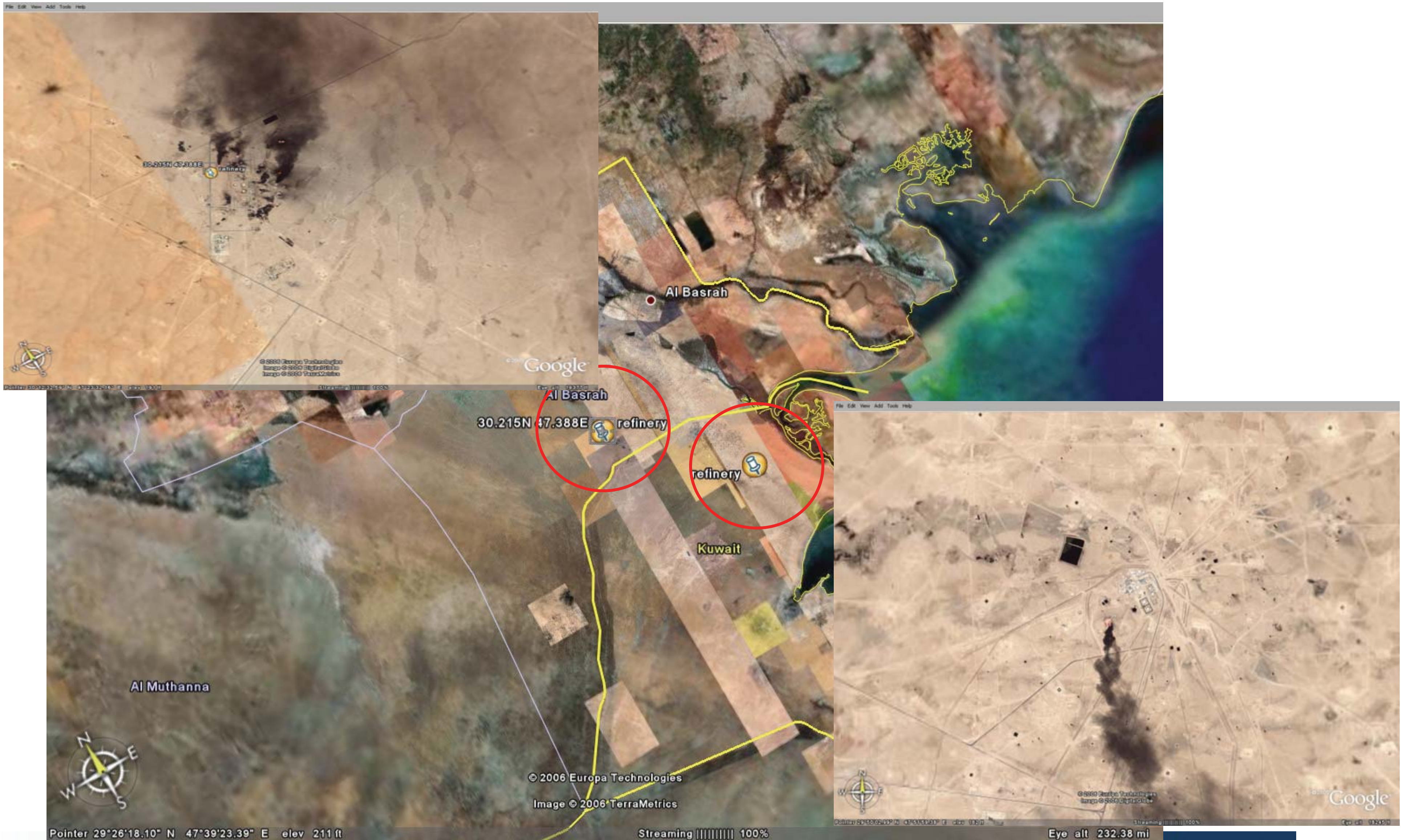
Reference fields

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

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



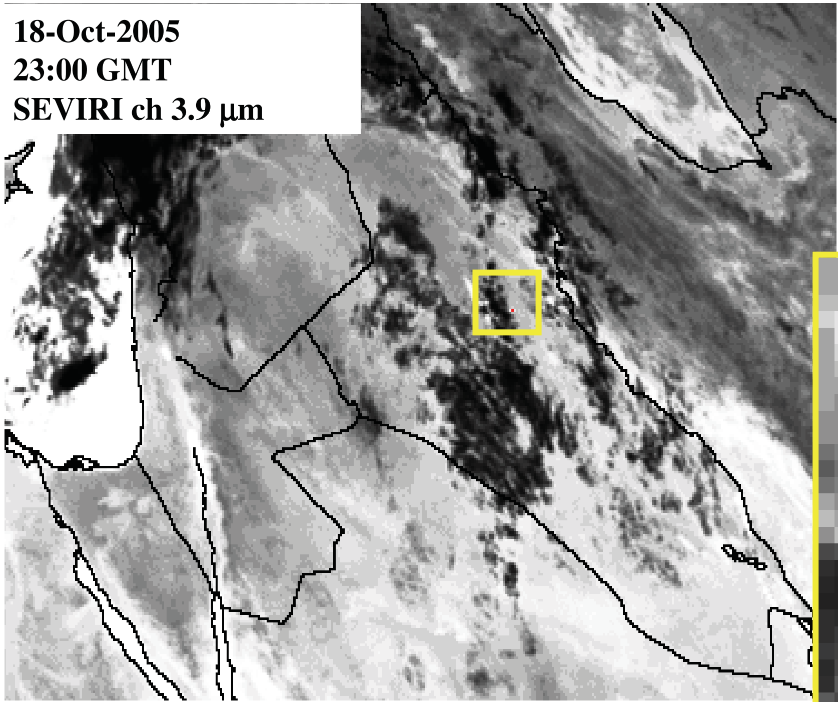
Sabotages to pipelines in Iraq (18 October 2005)
Identification for sure (false alarms elimination) by RST

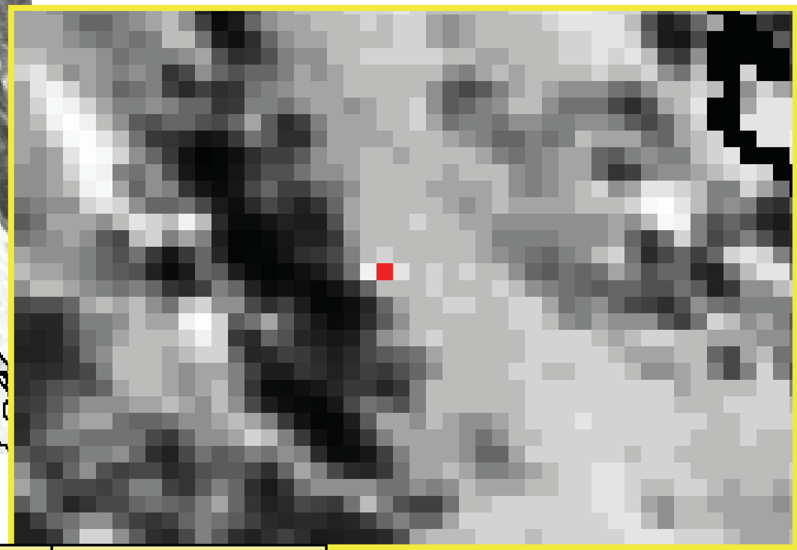


Sabotages to pipelines in Iraq (18 October 2005)

Identification for sure (false alarms elimination) by RST

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

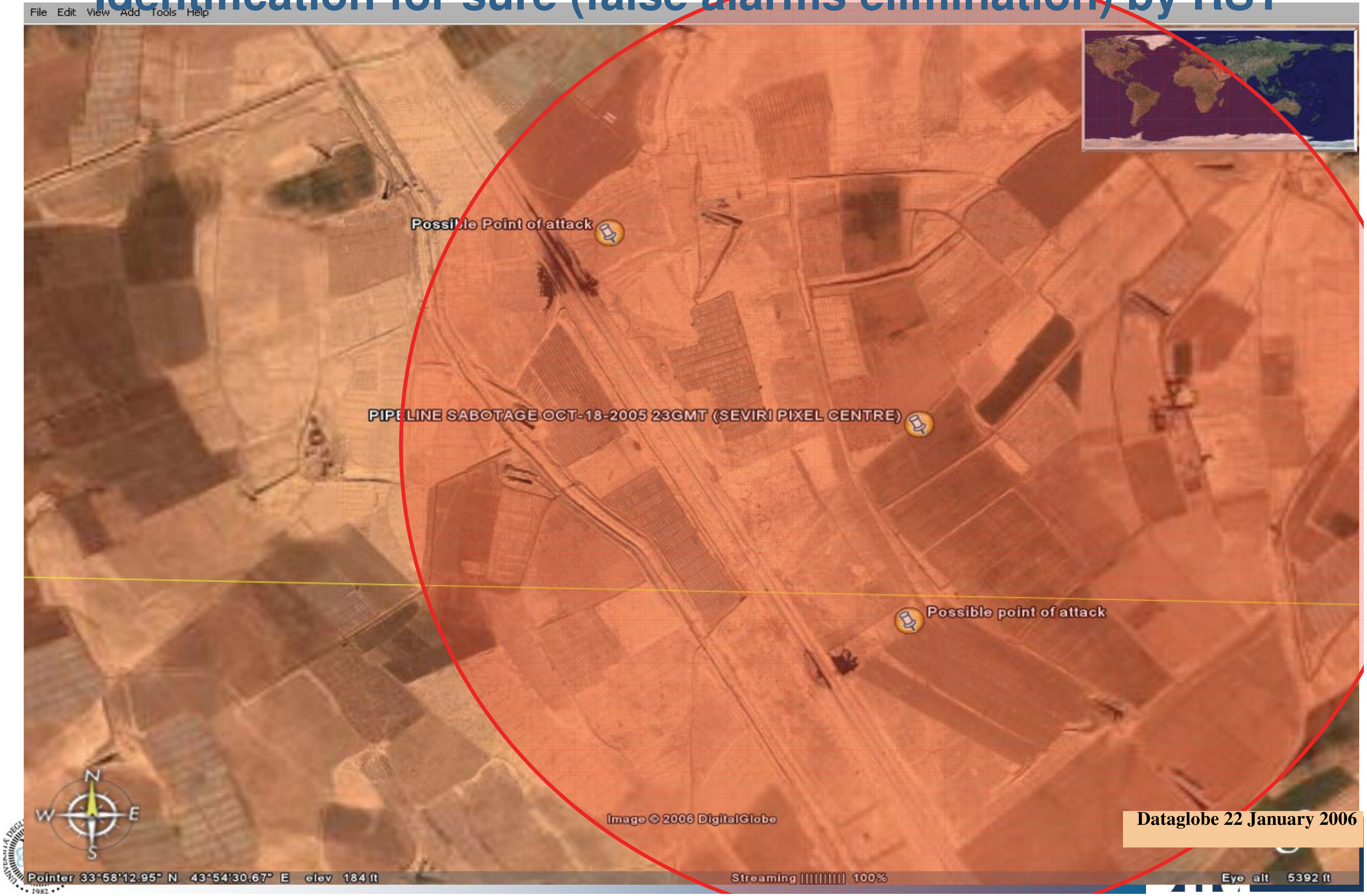




Hot spot	Tb (K)	µ (K)	σ (K)	ALICE (Tb – µ)/σ
Pipeline attack (detected) (Lat 33.972 Long 43.91)	285.66	281.58	2.60	**1.56**
Refinery (Lat 30.215N Long 47.388)	291.31	290.80	1.36	0.37

ALICE >1.5

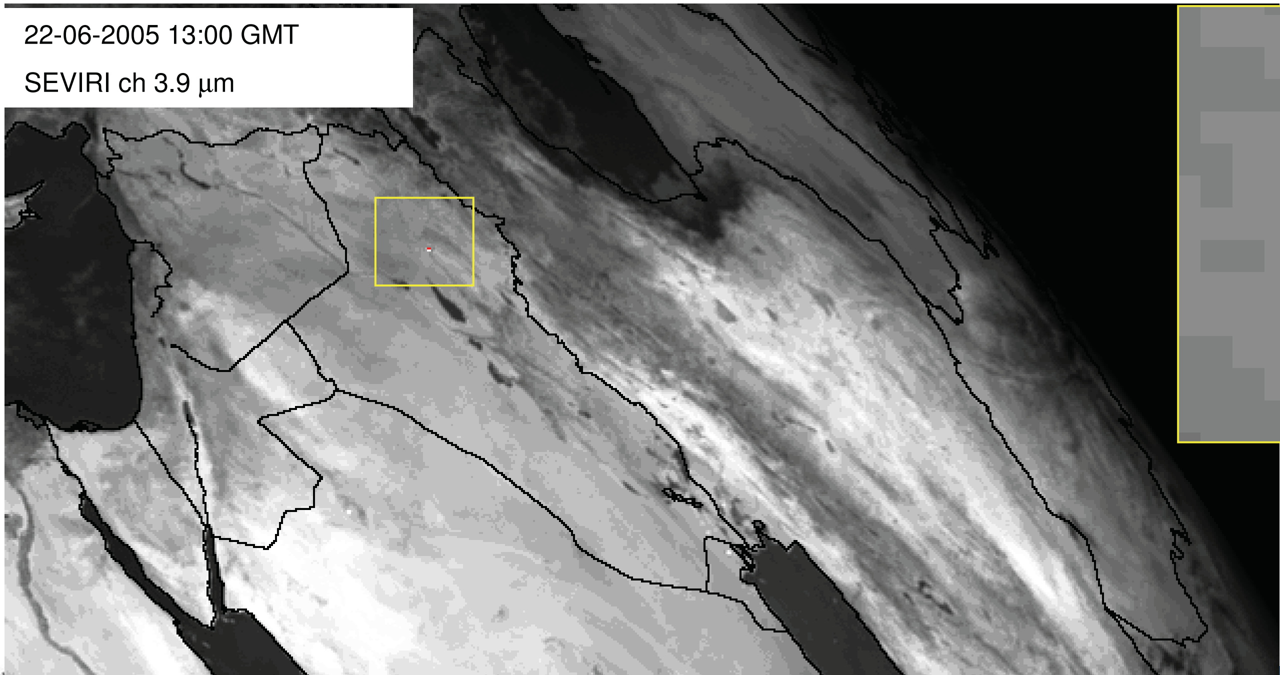
Sabotages to pipelines in Iraq (18 October 2005)
Identification for sure (false alarms elimination) by RST



The case of 22 June 2005 explosion: RST results

"**June 23, 2005** - attack on pipeline carrying crude from Kirkuk to Bayji, near al-Fathah..."
(http://www.iags.org/iraqpipelinewatch.htm)

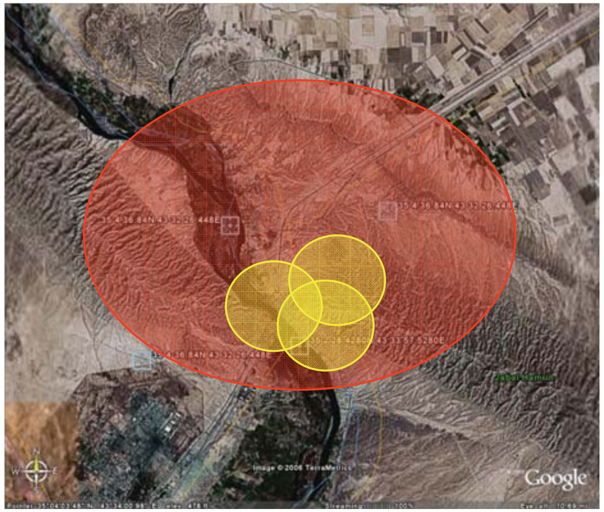
Detected by RST since 13:00 GMT of 22 June (the day before!)



$\otimes_{MIR}(\boldsymbol{r},t) > 2$

The case of 22 June 2005 explosion: integration

(unknown position in the IAGS attacks list)



UNIBAS: RST **timely detection** on SEVIRI images of the area affected by the explosion (large areas controlled without false alarms)

EUSC: MOD14 daily product on MODIS data to better collocate hot spots within the area previously identified by RST on SEVIRI.

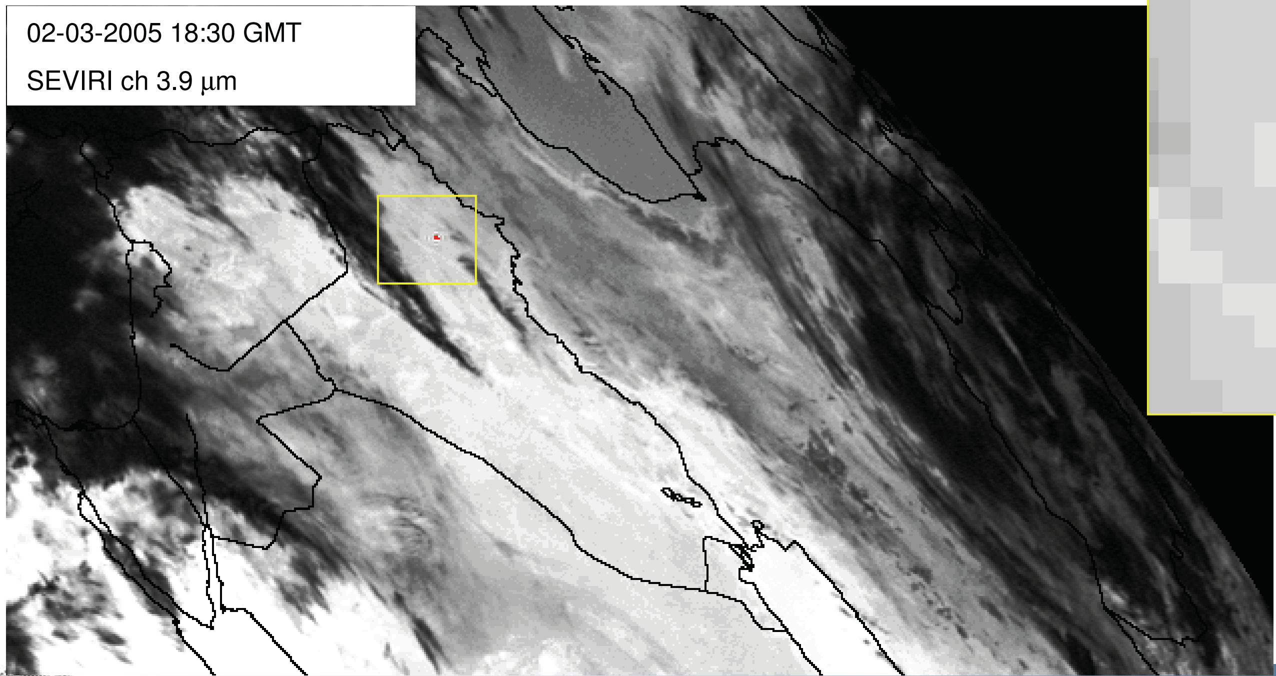
TNO: VHR image search for the intersection area (only **Quickbird** images of 9-9-2005 and 13-11-2005) for validation.

CRPSM: analysis on ASTER images for validation (ongoing)

The case of 2 March 2005 explosion: RST results

"**March 2, 2005** - 10pm (19:00 GMT) attack on gas pipeline to Bayji near Al-Safra 30 miles west of Kirkuk caused the shutdown of two of the Bayji power station's four turbines...."
(http://www.iags.org/iraqpipelinewatch.htm)

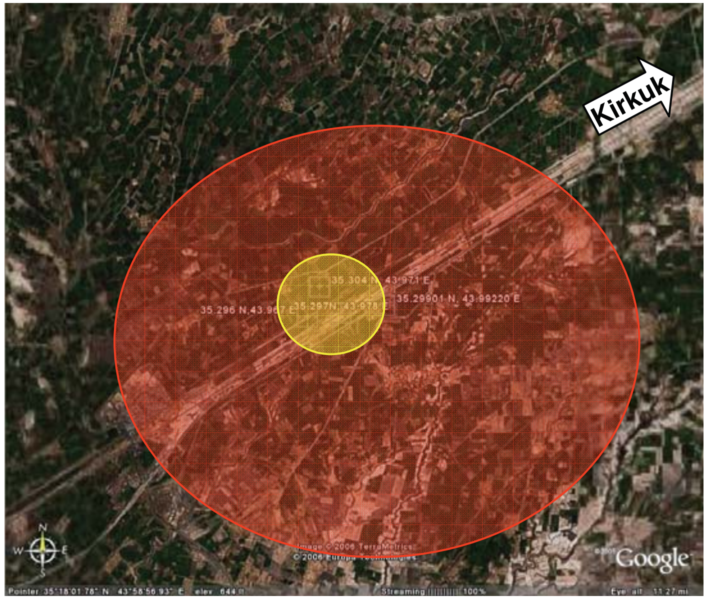
Detected since 18:30 GMT (**1/2 hour before !**)



$\otimes_{MIR}(\boldsymbol{r},t) > 4$

The case of 2 March 2005 explosion: integration

UNIBAS: RST detection on SEVIRI images of the area affected by the explosion



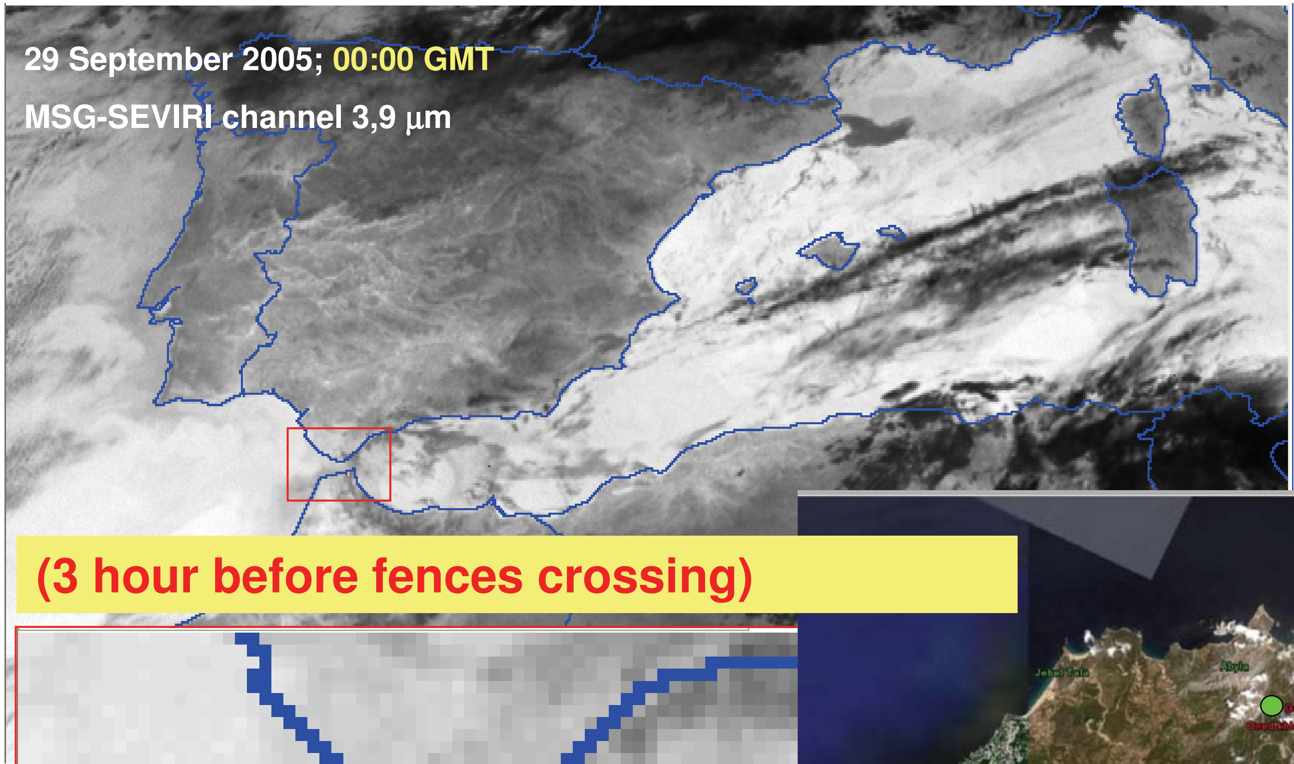
EUSC: hot spots on MODIS data within the area identified by UNIBAS.

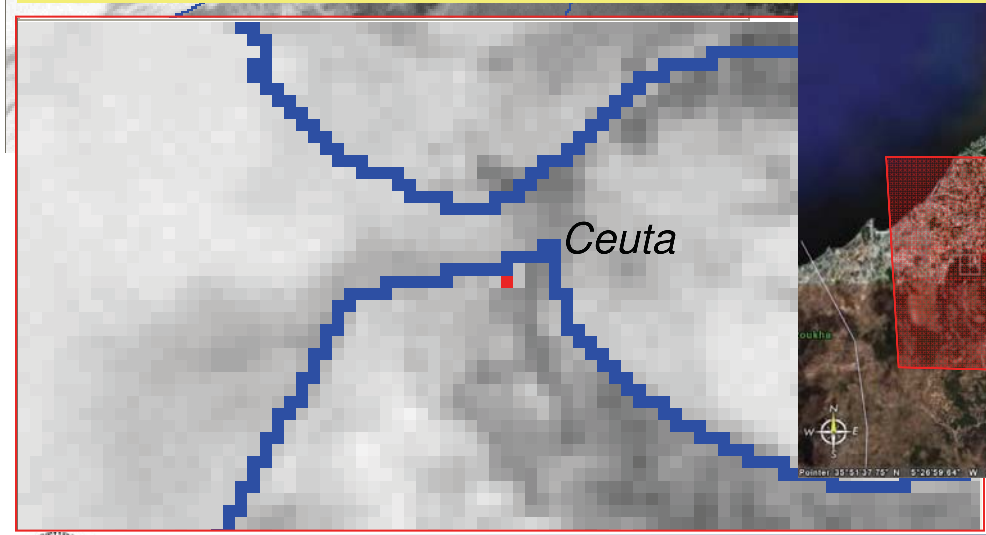
TNO: VHR image search for this area (**Quickbird** image of 05-08-2005, **Orbview** image of 22-04-2005, **Ikonos** image of 15-04-2001)

Monitoring populations
(and borders)

Attack to Ceuta e Melilla enclaves in Morocco

(Morocco, 29 September 2005)





SEVIRI hot spot   Campi rifugiati noti

Ceuta, September 29, 2005

[...At three o'clock in the morning a group of twenty Congoleses and some Costamarfileños crossed the two fences that separates Morocco from Ceuta. With them there have been other immigrants from different origins…]

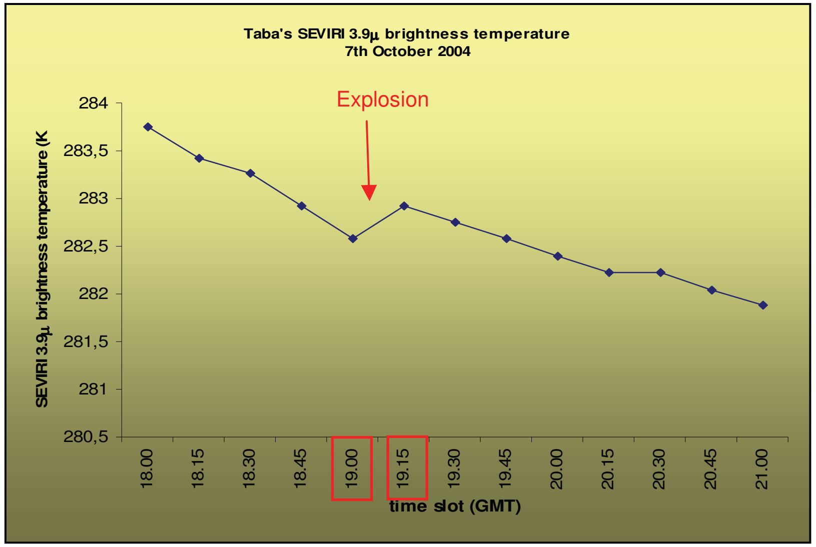
http://thistuesday.org

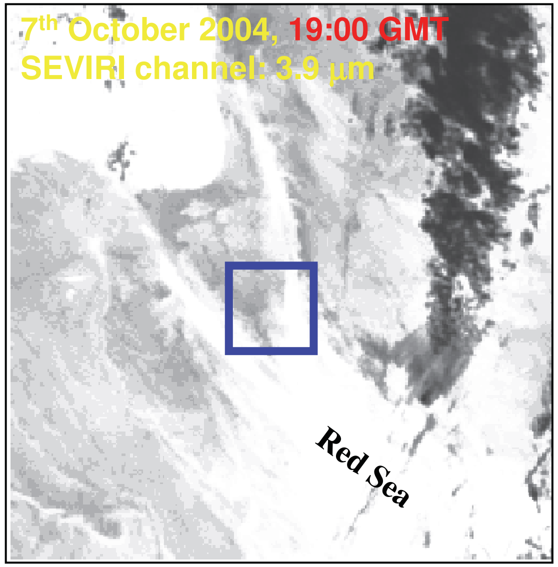
Other security issues

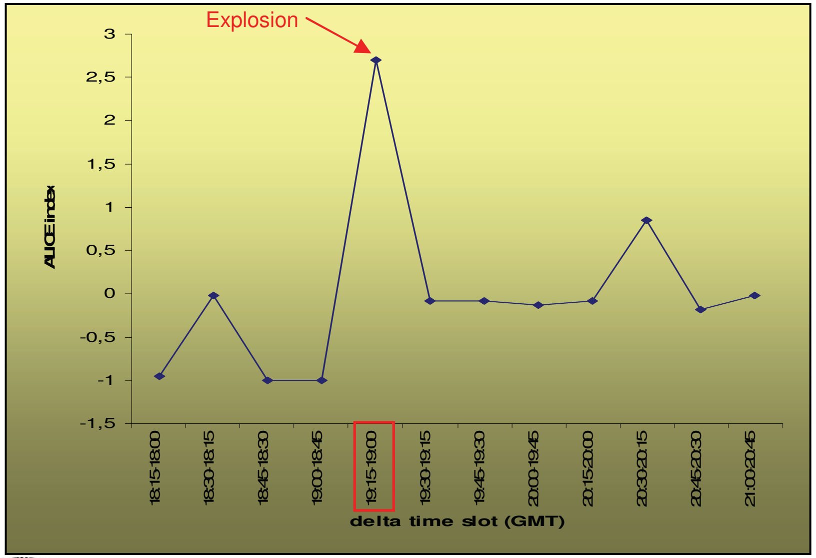
Other security issues

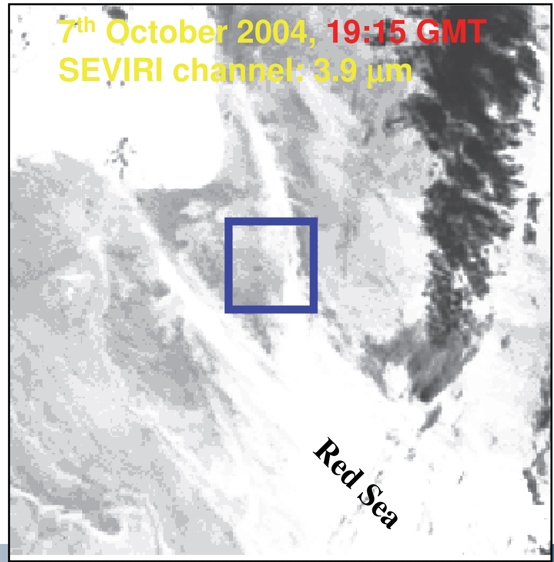
Explosion at the Hotel Hilton

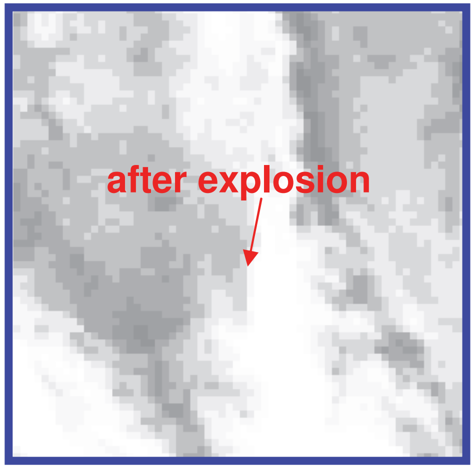
(Taba, Egypt, 7 October 2004)









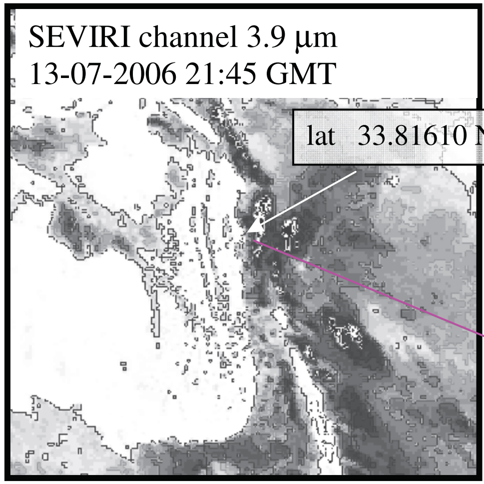


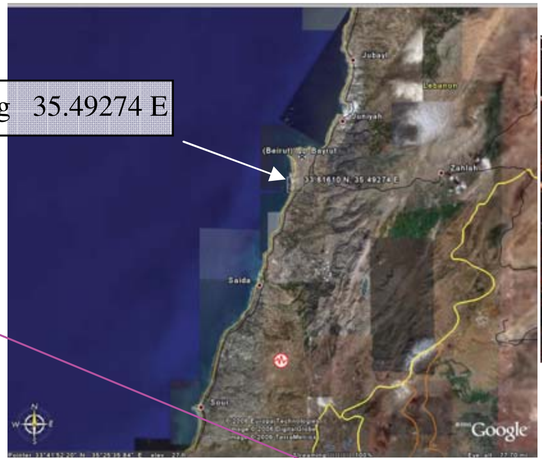
Dipartimento di Ingegneria e Fisica dell'Ambiente

Other security issues

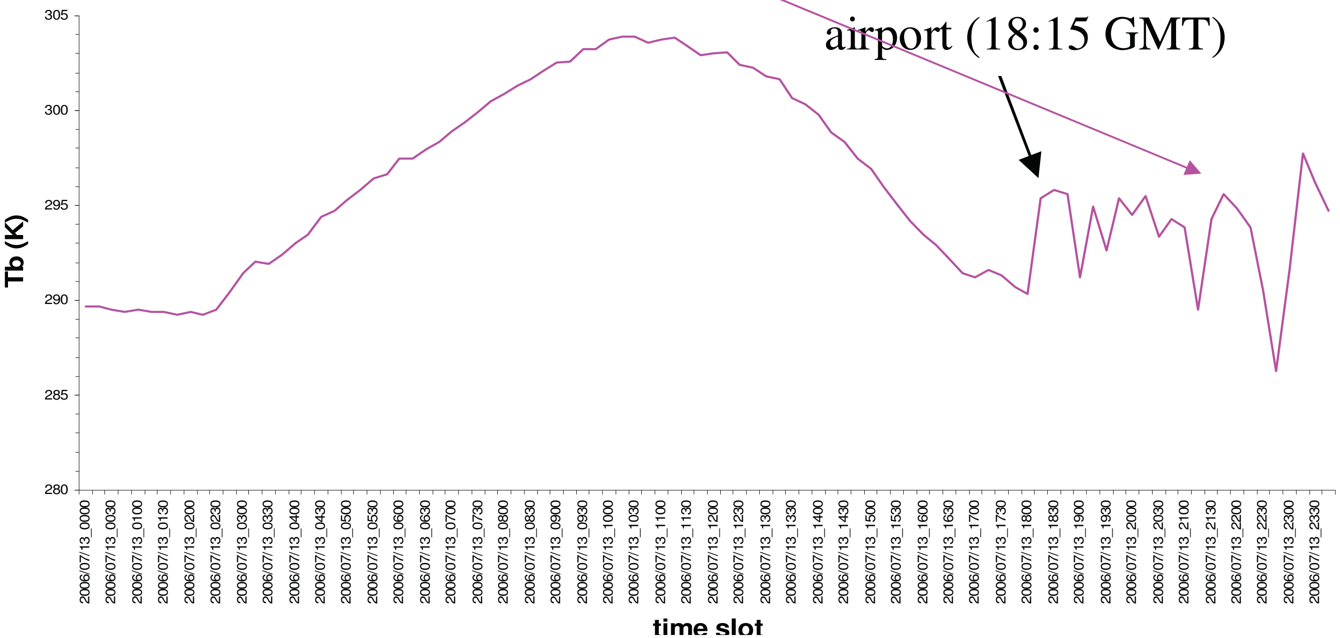
Attack to the Lebanon International Airport

Beirut 13-14 Luglio 2006

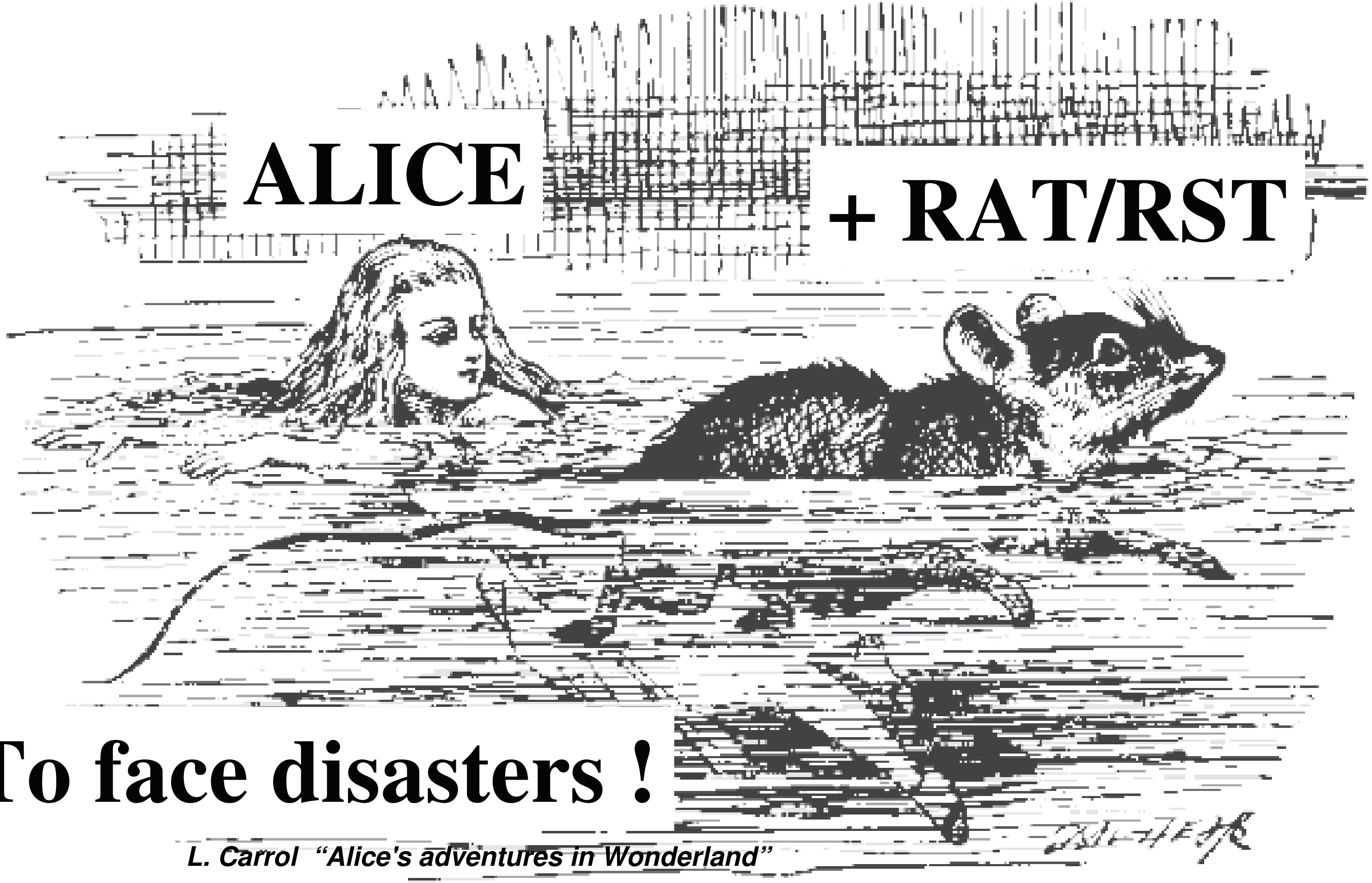




SEVIRI detection of attacks to Beirut airport (18:15 GMT)



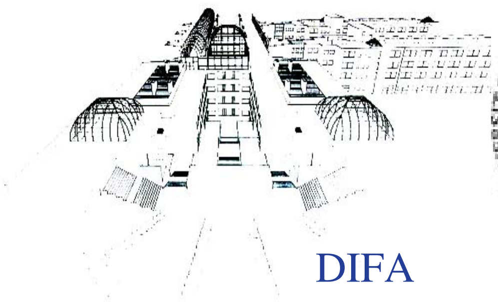
Lesson learnt ?



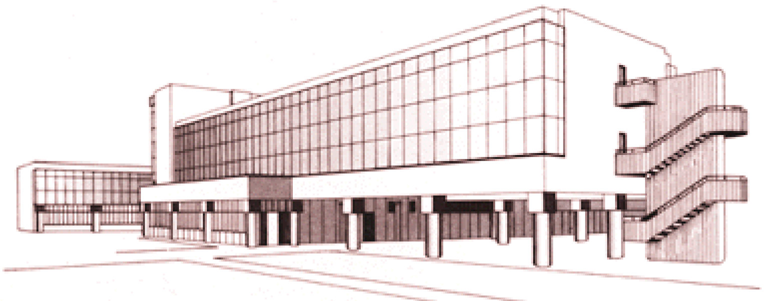
To face disasters !

L. Carrol "Alice's adventures in Wonderland"

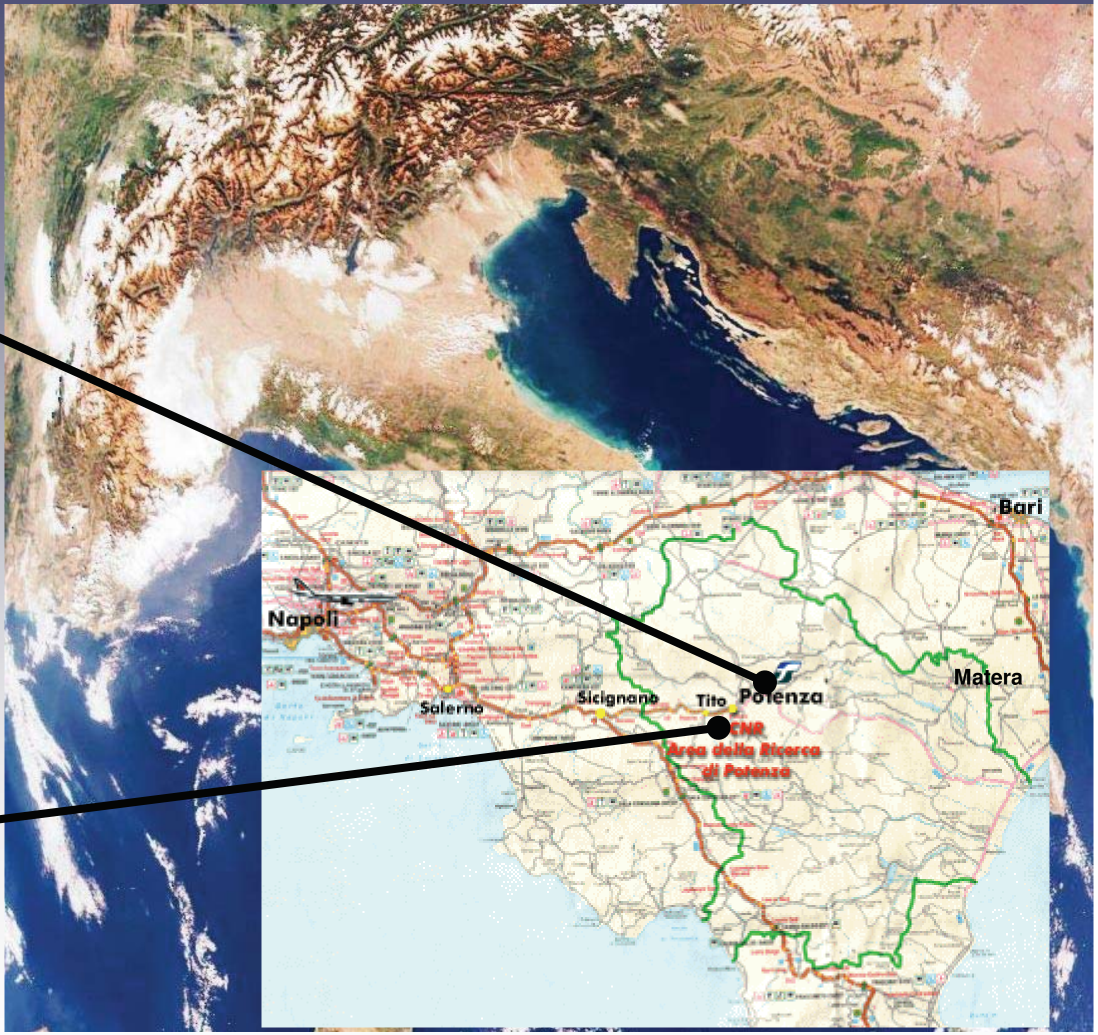
Where we are



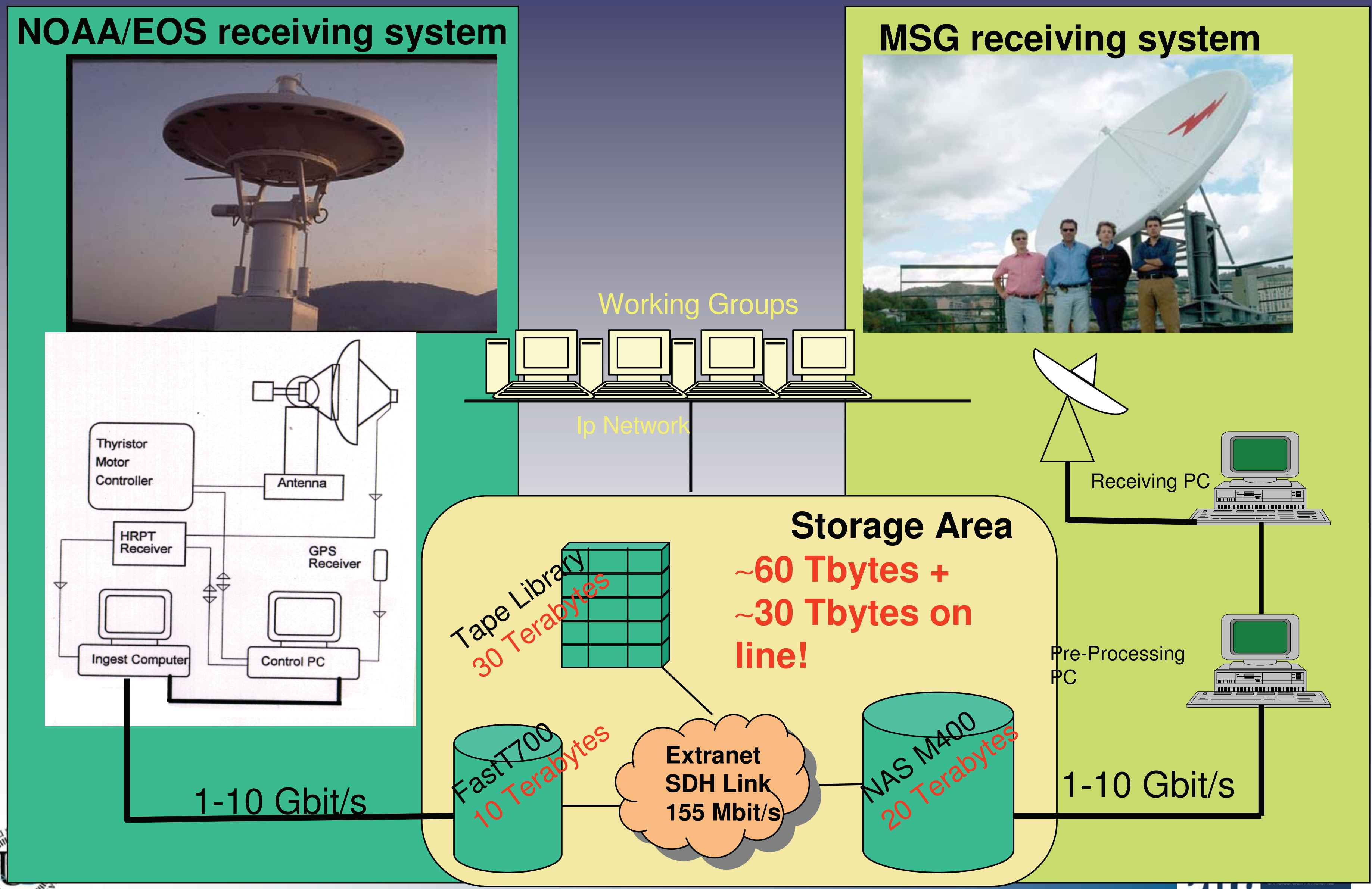
DIFA
University of Basilicata - Potenza



IMAA-CNR - Tito -(Potenza)

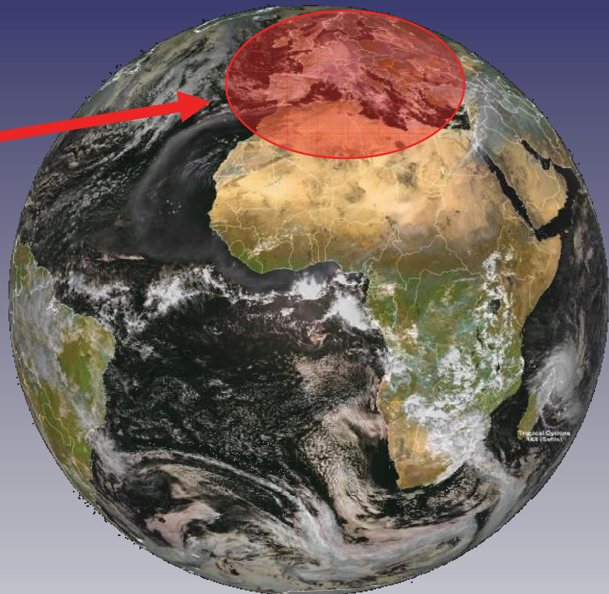


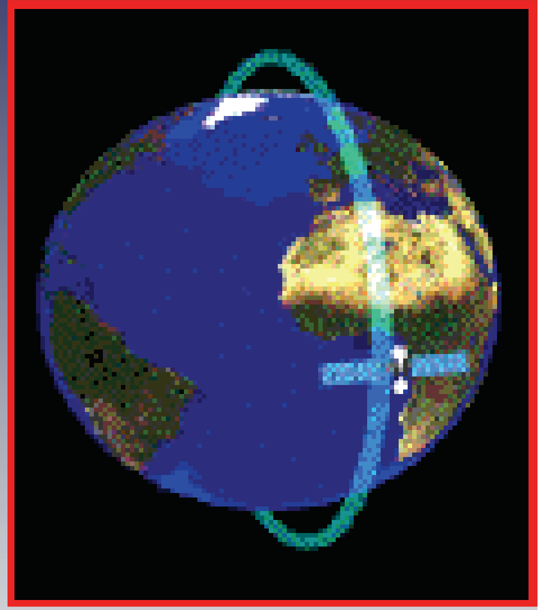
Receiving, Archiving & Processing Facilities for NOAA, EOS and MSG satellites



Space-Time coverage

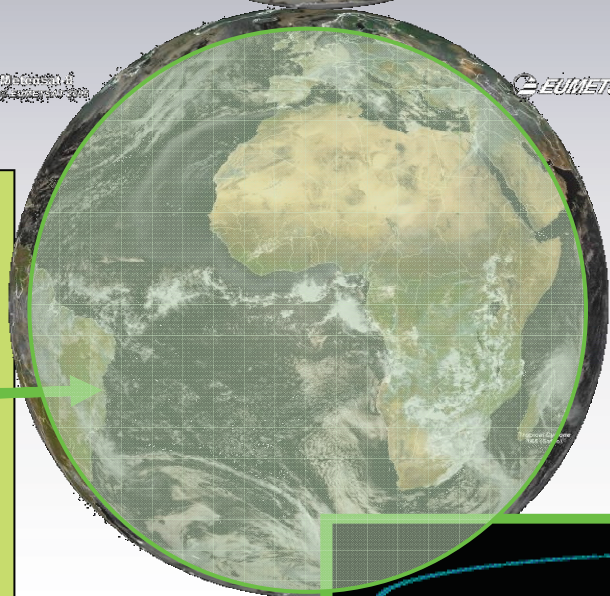
NOAA & EOS receiving station at IMAA



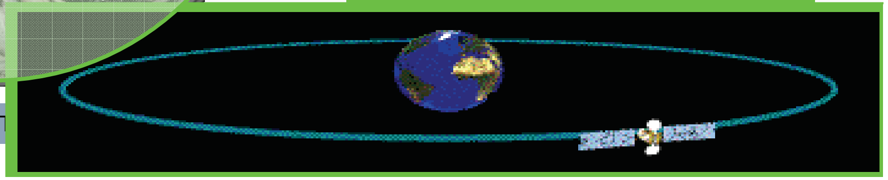


one image
each 3-6 hours

Meteosat & MSG receiving station at DIFA



one image
each15 minutes



entre for Theoretical Physics (ICT

join us !

(special opportunity to for student/researchers coming from AFRICA)

join us !

(special opportunities for students/researchers coming from AFRICA)

contact me immediately after the lesson if interested

Main published papers relevant to this topic

Main publication on RAT-RST approach
in International Journals and Books

1. V. Tramutoli: Robust AVHRR Techniques (RAT) for Environmental Monitoring: theory and applications. in *Earth Surface Remote Sensing II*, Giovanna Cecchi, Eugenio Zilioli, Editors, Proceedings of SPIE Vol. 3496, pp.101-113, 1998.
2. V. Cuomo, R. Lasaponara, V. Tramutoli: Evaluation of a new satellite-based method for forest fire detection *International Journal of Remote Sensing*, 22 (9), 1799-1826, 2001.
3. Pergola N, Tramutoli V., Scaffidi I., Lacava T., Marchese F.: Improving volcanic ash clouds detection by a robust satellite technique. *Remote Sensing of Environment* Vol. 90 (1), pp. 1-22, 2004.
4. Pergola N, Tramutoli V., Marchese F.: Automated detection of thermal features of active volcanoes by means of Infrared AVHRR records. *Remote Sensing of Environment* 93, 311-327, 2004.
5. Cuomo V., Filizzola C., Pergola N., Pietrapertosa C., Tramutoli V.: A self-sufficient approach for GERB cloudy radiance detection. *Atmospheric Research, 72 (1-4)*, 39-56, 2004.
6. A. Bonfiglio, M. Macchiato, N. Pergola, C. Pietrapertosa, V. Tramutoli: AVHRR Automated detection of volcanic clouds. *International Journal of Remote Sensing*, 26(1), 9-27, 2005.
7. Tramutoli, V., Cuomo, V., Filizzola, C., Pergola, N., Pietrapertosa, C.: Assessing the potential of thermal infrared satellite surveys for monitoring seismically active areas. The case of Kocaeli (İzmit) earthquake, August 17th, 1999, *Remote Sensing of Environment*, 96 (3-4), 409-426, 2005.
8. Lacava, T., Cuomo, V., Di Leo, E. V., Pergola, N., Romano, F. and Tramutoli, V., Improving soil wetness variations monitoring from passive microwave satellite data: the case of April 2000 Hungary flood. *Remote Sensing of Environment*, 96/2, 135-148, 2005.
9. Genzano N., Aliano C., Filizzola C., Pergola N., Tramutoli V.,A robust satellite technique for monitoring seismically active areas: the case of Bhuj - Gujarat earthquake. *Tectonophysics*, 431, 197-210, doi:10.1016/j.tecto.2006.04.024, 2006
10. Filizzola C, Lacava T, Marchese F, Pergola N, Scaffidi I, Tramutoli V. Assessing RAT (Robust AVHRR Technique) performances for volcanic ash cloud detection and monitoring in near real-time: the 2002 eruption of Mt. Etna (Italy). *Remote Sensing of Environment,* vol. 107, pp. 440-454 ISSN: 0034-4257. doi:10.1016/j.rse.2006.09.020., 2007.
11. Tramutoli V., Jasani B., Pergola N., Filizzola C., Casciello D., Lacava T. (2008). "Early Warnings and Alerts" in Remote Sensing from Space - Supporting International Peace and Security, Jasani, B., Pesaresi, M., Schneiderbauer, S., Zeug, G., editors, GMOSS Book Vol.1, Elsevier, 2008, (in press).
12. Lacava, T., Pergola, N., Sannazzaro, F., Tramutoli, V., Improving flood monitoring by RAT (Robust AVHRR Technique) approach: the case of April 2000 Hungary flood. *International Journal of Remote Sensing* (in press), 2008.

in Proceedings of International Conferences

1. Tramutoli, V: Robust Satellite Techniques (RST) for natural and environmental hazards monitoring and mitigation: ten years of successful applications. In *The 9th International Symposium on Physical Measurements and Signatures in Remote Sensing*, Shunlin Liang, Jiyuan Liu, Xiaowen Li, Ronggao Liu, Michael Schaepman Editors, Beijing (China), ISPRS, Vol. XXXVI (7/W20), pp.792-795, 2005. ISSN 1682-1750.
2. G. Mazzeo, F. Marchese, C. Filizzola, N.Pergola, and V. Tramutoli, "A Multi-temporal Robust Satellite Technique (RST) for forest fire detection" in Fourth International Workshop on the Analysis of Multitemporal Remote Sensing Images. 18-20 July, 2007, Louven, Belgium, in press.

write to me (valerio.tramutoli@unibas.it) for papers in e-form