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Multi-source satellite data facilitating disaster management during the 2003 forest fires in Portugal

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Introduction

After devastating forest fires in central Portugal in July and August 2003 forced the Portuguese government to declare a public calamity for the affected districts, the "International Charter on Space and Major Disasters" was activated on August 4, 2003. The purpose was to obtain and analyse satellite data of raging forest fires in Portugal centred at 39° 30' N and 8° 00' W during the first days. Until August 22, when the Charter Call was closed, the estimated fire scars covered up to 300,000 hectares. The major causes for Portugal's worst fires in 20 years were persistent dryness, high air temperatures up to 48° C and strong winds which frequently changed direction. Most of the fires were assumed to be human induced.

The project management for Charter Call 43 was taken over by the German Remote Sensing Data Center (DFD), which is part of the German Aerospace Center (DLR). To provide an overview of the forest fires and burned areas, different satellite images were ordered, processed, geocorrected and analyzed. A large scale overview was realized with NOAA-AVHRR, TERRA-MODIS and ENVISAT-MERIS. On August 4 and August 14 the micro-satellite BIRD (DLR), dedicated to fire recognition, provided two valuable scenes of the burning areas. For a more detailed survey of the worst affected areas, eleven SPOT and several IKONOS images were analyzed. The feedback from the local authorities confirmed that the combination of satellite imagery with different spatial and temporal resolutions can effectively facilitate on-site crisis management.

Satellite imagery for disaster mitigation

The "International Charter on Space and Major Disasters" aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through authorized suppliers and users. Each member agency has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property (Charter-Link 2003). Since July 2002 the DLR has committed itself to support the Charter activities as a Project Manager. During the disastrous flooding of the Elbe and Danube rivers in summer 2002 the Project Management as well as the value adding of satellite imagery was taken over by the Applied Remote Sensing Cluster Institutes of DLR.

During the devastating forest fires in Portugal the local authorities requested the support of the "International Charter on Space on Major Disasters" to get an overview of the fast changing fire locations. According to the Portuguese civil protection authorities, there were hundreds of forest fires at the same time, and the fire fighters concentrated their forces only on forest fires more than 50 ha in area.

Response Times

Near-real time information and data are necessary for an effective crisis management. This means a time scale of only a few hours. Reducing the total response times for acquiring, processing, analyzing and delivering satellite imagery has to be the main task for the Charter activities.

The acquired imagery (SPOT, ENVISAT-MERIS, IKONOS) for this Charter Call were provided through the agencies concerned mostly within 24 hours. Considering the complexity of the individual production steps, this response seems to be very fast, but for developing forest fires, these data sets are not fast enough for hotspot and fire detection, although adequate for follow-up and damage assessment.

Near-real time hotspot detection was realized through an adapted algorithm applied to NOAA-AVHRR data within DLR. This value added product was delivered 2 to 5 hours after the satellite overpass. In future this response time has to be reduced by an automated processing chain for the fire detection, to avoid manual processing. Although the spatial resolution is low, the NOAA-AVHRR product was very useful for the daily overview of the situation in Portugal (see figure 1).

The imagery of the DLR satellite BIRD was also used for the fire detection and analysis. A temperature and energy release product enabled the crisis management team to classify the fire intensity as well as the extent of the fire scars (see figure 2). Comparable, medium and high resolution imagery were used for subsequent damage assessment. A general overview of the affected area was obtained from ENVISAT-MERIS imagery (see figure 3), a more detailed analysis was done with SPOT and IKONOS data (see figure 4) based on NOAA-AVHRR and ENVISAT-MERIS results.

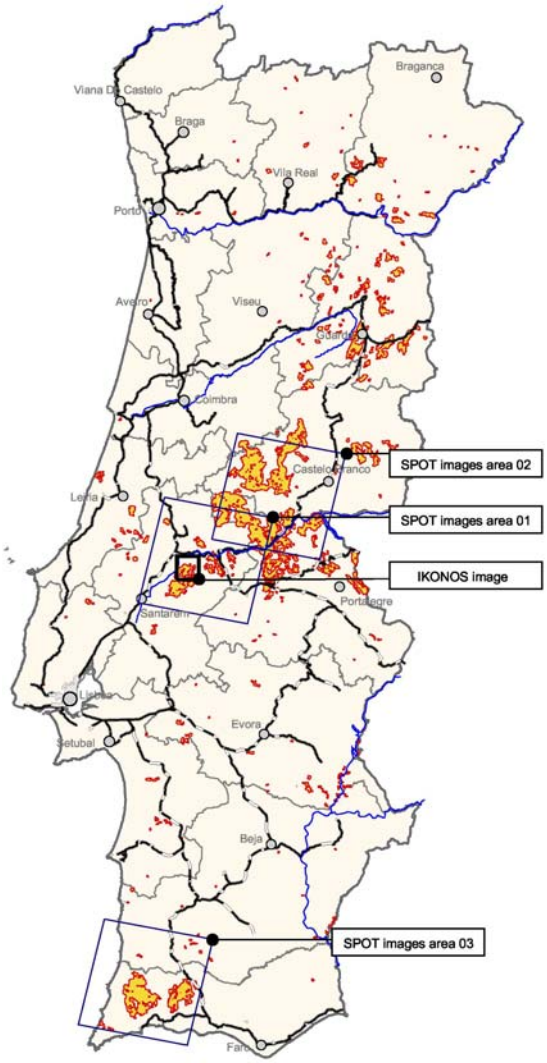

Figure 1 Burned areas and derived from NOAA-AVHRR are shown in orange with a red outline. The SPOT coverage and the IKONOS image (Figure 3) are indicated by the boxes.

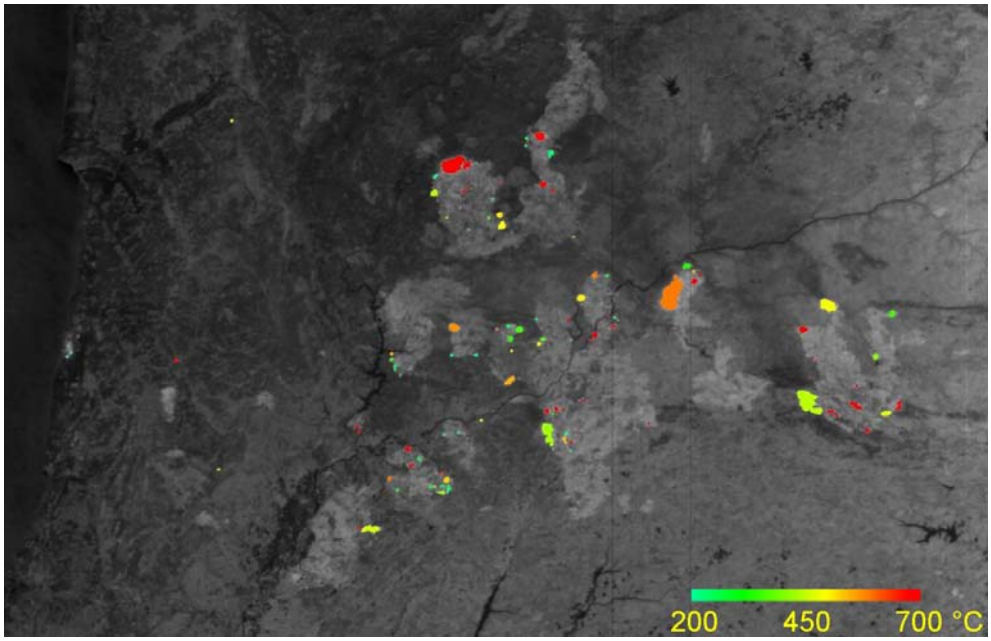

Figure 2 BIRD satellite imagery of Central Portugal on August 4, 2003 (clipout displays 200 km x 130 km; fire scars appear in a light grey and covers approximately 200.000 ha; © DLR Berlin-Adlershof)

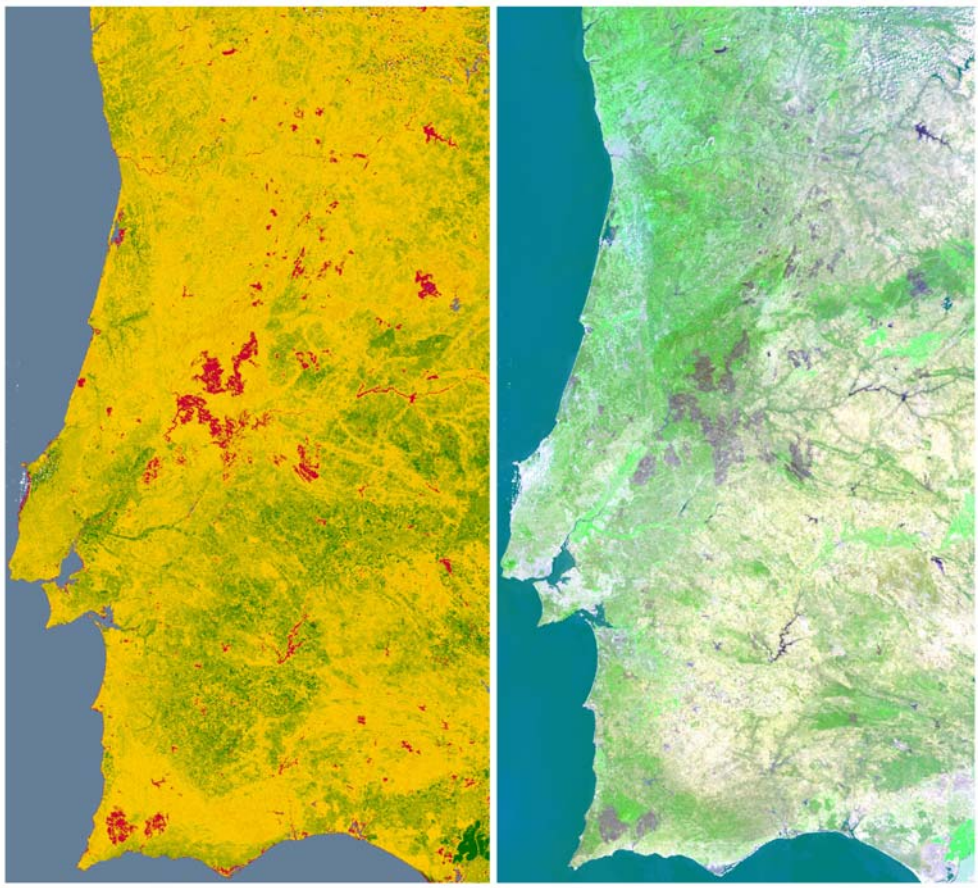

Figure 3 ENVISAT MERIS imagery, August 20, 2003 – with different colour coding. On the left side the rectified red channel is presented, on the right side a RBG image with MERIS channel 8, 10, 2. Burned areas are displayed in red (left) and grey (right)

ENVISAT-MERIS data were delivered by ESA-ESRIN as level 2 products via network. The best acquisition delivery time was about 7 hours. Level 2 products include e.g. 13 spectral reflectances ranging from 300 nm to 900 nm, vegetation indices and meta-data. The typical size of one product is about 180 MB. For deriving maps showing burnt areas the BEAM-software of ESA was applied. After projecting the data to UTM, overlaying costal boundaries and using a land-sea mask RGB imagery were optimized for enhancing burnt areas (see figure 2). Best results were obtained using channel 8, 10 and 2 for red, green and blue respectively. The MERIS flags for clouds and water were also taken into account.

On the left side of figure 2 one can see the colour coded "rectified red channel". "Rectification" means to combine the information of the blue MERIS channel at 442 nm with the red or near infrared channel at 681nm or 865nm. This processing is done in order to minimise the difference between those rectified channels and the spectral reflectances that would be measured at the top of the canopy under a standard geometry of illumination and observation. In other words, "rectification" is a form of atmospheric correction. The rectified channels are used as input for the calculation of the MERIS Global Vegetation Index (MGVI). For the identification of burnt areas, the rectified red reflectance channel was tested and showed relativley good results. It was found that all burnt areas had negative values as well as inland waters. As seen in figure 2 burnt areas are color coded in red and can clearly differentiated from inland waters by their structure.

Figure 4 IKONOS imagery of Pinheiro Grande (Central Portugal) on August 17, 2003

The response time table (see Table 1) lists most of the acquired and delivered data sets. Additionally, the table is divided into DFD internal and total response times. All listed data sets were delivered as geocorrected imagery as previously agreed in consultations with the Authorized User. Normally, the aim of a fast transmission has highest priority. In some cases (e.g., SPOT on August 10 and 16 or ENVISAT-MERIS on August 20) the imagery were used only for damage assessment; therefore the delivery was not extremely time critical.

Table 1 Response time table for the delivery of satellite images during Charter Call 43 – Portuguese Forest Fires

sensor	**acquisition**		**received at DFD**		**transferred to user**		**response time [h]**	**response time [h]**
		MESZ		MESZ		MESZ	(DFD internal)	(total)
BIRD	04.08.03	14:03	05.08.03	16:15	05.08.03	21:30	5:15	31:13
NOAA-AVHRR	06.08.03	4:45	06.08.03	15:12	06.08.03	21:00	5:48	16:15
NOAA-AVHRR	06.08.03	16:18	07.08.03	9:56	07.08.03	11:55	1:59	19:55
NOAA-AVHRR	07.08.03	4:34	07.08.03	10:02	07.08.03	11:06	1:04	6:32
ENVISAT-MERIS	07.08.03	13:19	07.08.03	19:30	07.08.03	20:28	0:58	7:09
SPOT 4	07.08.03	13:27	08.08.03	17:42	09.08.03	0:05	4:23	20:38
NOAA-AVHRR	07.08.03	16:06	08.08.03	16:34	08.08.03	19:05	2:31	2:59
NOAA-AVHRR	08.08.03	4:23	08.08.03	5:19	08.08.03	7:47	2:28	3:24
ENVISAT-MERIS	08.08.03	12:48	11.08.03	15:59	11.08.03	17:15	1:16	76:28
SPOT 2	08.08.03	13:33	11.08.03	18:36	11.08.03	19:20	0:44	77:47
NOAA-AVHRR	08.08.03	15:54	08.08.03	16:15	08.08.03	19:05	2:50	3:11
NOAA-AVHRR	09.08.03	4:12	09.08.03	4:59	09.08.03	13:14	8:15	9:02
SPOT 5	10.08.03	13:44	11.08.03	19:58	12.08.03	17:14	21:16	51:30
NOAA-AVHRR	11.08.03	5:30	11.08.03	6:19	11.08.03	9:41	3:22	4:11
NOAA-AVHRR	11.08.03	15:20	11.08.03	16:10	11.08.03	17:38	1:28	2:18
NOAA-AVHRR	12.08.03	15:08	12.08.03	16:02	12.08.03	18:41	2:39	3:33
NOAA-AVHRR	13.08.03	5:07	13.08.03	5:49	13.08.03	10:53	5:04	5:46
SPOT 4	13.08.03	13:12	14.08.03	18:11	14.08.03	21:45	3:34	32:33
NOAA-AVHRR	14.08.03	4:56	14.08.03	11:56	14.08.03	15:23	3:33	10:27
BIRD	14.08.03	14:21	14.08.03	19:45	14.08.03	23:43	2:58	9:22
SPOT 5	16.08.03	13:29	20.08.03	16:55	20.08.03	19:45	2:50	102:16
IKONOS	17.08.03	12:16	18.08.03	10:10	18.08.03	17:54	7:43	29:28
NOAA-AVHRR	18.08.03	4:11	18.08.03	8:05	18.08.03	9:30	1:25	5:19
ENVISAT-MERIS	20.08.03	13:11	20.08.03	19:38	21.08.03	18:25	5:14	22:47

Conclusion

The shown examples demonstrate the possibilities and also limitations of satellite imagery derived crisis information products. An efficient, meaningful and real-time application is only possible through international cooperation as the "International Charter on Space and Major Disasters" as well as an increasing standardization and automation of products and processes. A satellite based disaster monitoring and rapid damage mapping actions can be useful for the crisis management, if the response times can further be reduced. This can successfully be done through an early-warning and effective coordination among all actors in the satellite data acquisition, value adding and information dissemination chain.

The effort undertaken for the Charter activities in Portugal including the response times and the feedback from the Authorized User, helped to mitigate the disastrous impact of the forest fires and demonstrate a successful integration of satellite based crisis information products.

Bibliography

Charter-Link October 2003: http://www.disasterscharter.org/main_e.html