→ THE ESA EARTH OBSERVATION Φ-WEEK

EO Open Science and FutureEO

12–16 November 2018 | ESA–ESRIN | Frascati (Rome), Italy

Near Real Time Fire Detection Service via the PROBA-V MEP

M. Arcorace (1,3), R. Cuccu (1,3), G. Rivolta (1,3), C. Orrù (1), L. Milani (2), J.M. Delgado Blasco (1,3)

(1) Progressive Systems Srl - Via Enrico Fermi, 62 - Frascati (Rome) - Italy
(2) University of Rome La Sapienza (DIET) - Via Eudossiana, 18 - Rome - Italy
(3) ESA Research and Service Support - Largo Galileo Galilei, 1 - Frascati (Rome) - Italy

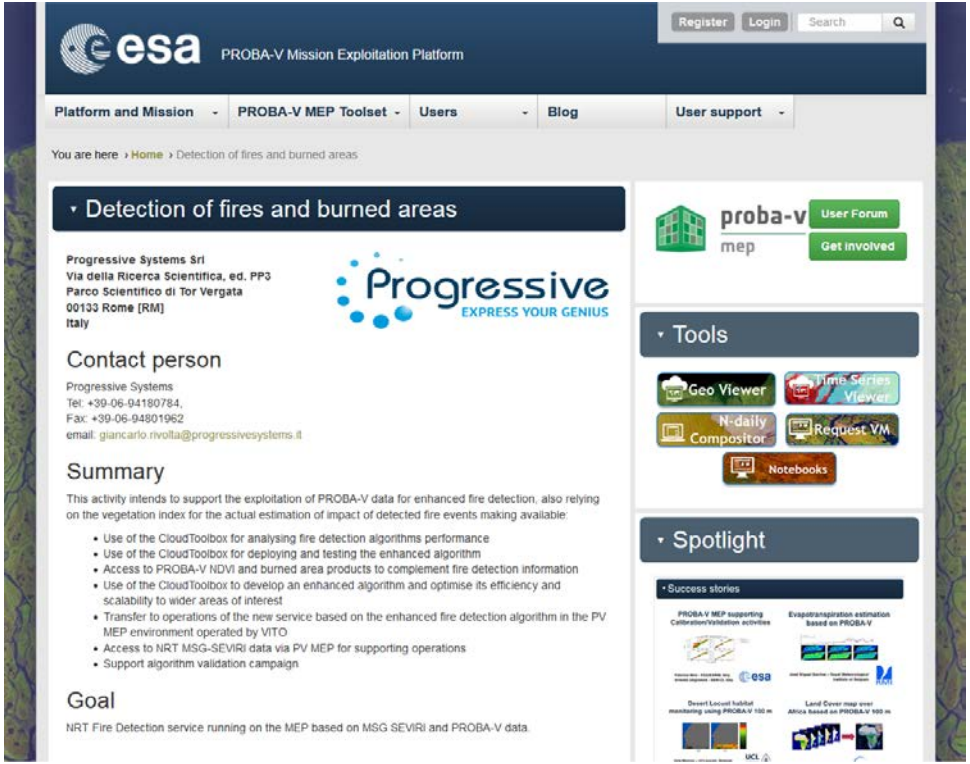
16/11/2018

Outline

1. Introduction
2. Background and objective
3. Algorithm
4. Infrastructure
5. Preliminary validation
6. Conclusion and way forward

About the project

- ✓ Research activity:
  - Detection of Fires and Burned areas
- ✓ An ESA funded project:
  - PROBA-V Mission Exploitation Platform Third Party Services (MEP-TPS)
- ✓ Actors:
  - Progressive Systems with the support of Sapienza University of Rome (research) & Centre de Suivi Ecologique (end user)



Starting point: the old MDIFRM service

- ✓ First Fire Detection service prototype in 2008
  - Multi-source Data Integration for Fire Risk Management (MDIFRM)
  - Provided by ESA RSS to CSE to cover the territory of Senegal
  - Near-Real Time MSG SEVIRI & Envisat MERIS derived data (MGVI)
- ✓ Potential improvements have been identified during the years:
  - Efficient Data management
  - Scalability
  - Better algorithm performance (detections, false alarms)
  - Use of PROBA-V data to enhance burned area detections
- ✓ In 2016 CSE requested to extend the fire monitoring over the ECOWAS region plus Mauritania and Chad (MESA project).

IEEE GEOSCIENCE AND REMOTE SENSING LETTERS, VOL. 7, NO. 1, JANUARY 2010 93

Multisource Data Integration for Fire Risk Management: The Local Test of a Global Approach

Malick Diagne, Moussa Drame, Carlos Ferrão, Pier Giorgio Marchetti, *Senior Member, IEEE*, Salvatore Pinto, and Giancarlo Rivolta

Abstract—**In this letter, we propose an algorithm to detect the presence of forest fires using data from both geostationary and polar-orbiting satellites. The very frequent acquisitions of the Spinning Enhanced Visible and Infrared Imager radiometer placed onboard the Meteosat Second Generation-9 satellite are used as main source for the algorithm, while the MEdium Resolution Imaging Spectrometer global vegetation index and the Advanced Along-Track Scanning Radiometer measurements are used to enhance the reliability of the detection. The problem is approached in a "global" way, providing the basis for an automated system that is not dependent on the local area properties. In cooperation with the Centre de Suivi Écologique (Dakar, Senegal), the proposed algorithm was implemented in a "Multisource Fire Risk Management System" for the Senegal area, as briefly described in this letter. A field campaign of one week was carried out in order to perform a validation of the system's detections, showing a good agreement with the fire coordinates measured on the ground. Furthermore, a consistency check was performed using data from the Moderate Resolution Imaging Spectroradiometer (MODIS) Rapid Response System, showing that more than 76% of high-confidence MODIS events are detected by the algorithm.**

Index Terms—**Decision support systems, fires, infrared measurements, Kalman filtering, remote sensing, risk analysis, time series, vegetation.**

I. Introduction

EVERY year, extensive areas of bush, forest, and grassland are consumed by arson fires, resulting in significant economic costs and environmental impacts and even in loss of life and property. An undetected fire in a remote location may cause significant damage to a sensitive ecosystem. An early fire detection and continuous monitoring system is therefore important to react in a timely manner, minimizing the impact of such events, and could provide a significant contribution to the whole land monitoring and burned-area management process.

This letter shows that it is possible to use data coming from both geostationary and polar-orbiting satellites in order to develop fire risk management systems and services. We propose to approach the fire detection problem in a "global" way, providing the basis for a system which can be initialized with a relatively small data set and reducing the dependence on the local area properties.

As a local test of such a global algorithm, an early version of the proposed fire detection system, over Senegal, has been deployed at the Centre de Suivi Écologique[1] (CSE, Dakar, Senegal) premises in order to allow the local experts to have full control over the detection algorithm. In this letter, we describe the infrastructure required for the realization of the multisource fire risk management system at the CSE premises.

In this letter, we focus on the detection aspect, which is one of the components of the management system [1]. The other issues, such as the estimation of temperature, extent, fire radiative power (FRP), and fire risk maps, will be addressed in future work.

II. System Requirements

Within the Enhanced Service Infrastructure Technology project, the CSE has defined the requirements for a multisource data integration system for fire risk management. The main system requirements are as follows:

1) detecting fires in real time (about 15–30 min of delay) with a high level of confidence;
2) estimating the extension of burnt areas;
3) sending an automatic notification as soon as a fire is detected;
4) enabling the user to manage all the steps of the fire detection system.

This system, developed in cooperation with the CSE, is an important step to foster the technology and knowledge transfer.

III. Data Sources

We assume that multisource data integration increases the interpretation capabilities and produces more reliable results than a stand-alone source. We hope as well to improve the accuracy, temporal coverage, and inference about the environment and associated risks.

The synergistic combination of Earth-observation (EO) data sources from polar-orbiting satellite sensors like the Environmental Satellite (ENVISAT)'s satellite MEdium Resolution Imaging Spectrometer (MERIS) and the Advanced Along-Track Scanning Radiometer (AATSR) with the frequent acquisitions provided by geostationary sensors like the Spinning Enhanced Visible and Infrared Imager (SEVIRI) ensures

Manuscript received August 26, 2008; revised December 22, 2008 and March 26, 2009. First published August 4, 2009; current version published January 13, 2010.

M. Diagne and M. Drame are with the Centre de Suivi Écologique, Dakar 15532, Senegal (e-mail: malick.diagne@cse.sn; moussa.drame@cse.sn).

C. Ferrão is with Critical Software, 3045-504 Coimbra, Portugal (e-mail: carlos.ferrao@cse.sn).

P. G. Marchetti is with the Earth Observation Programme of the European Space Agency, European Space Research Institute, European Space Agency, 00044 Frascati, Italy (e-mail: pier.giorgio.marchetti@esa.int).

S. Pinto is with the University of Salerno, 84084 Salerno, Italy (e-mail: salvatore.pinto@esa.int).

G. Rivolta is with Logica UK Ltd., KT22 7LP Leatherhead, U.K. (e-mail: giancarlo.rivolta@esa.int).

Digital Object Identifier 10.1109/LGRS.2009.2029926

[1]For further information on CSE, visit http://www.cse.sn/.

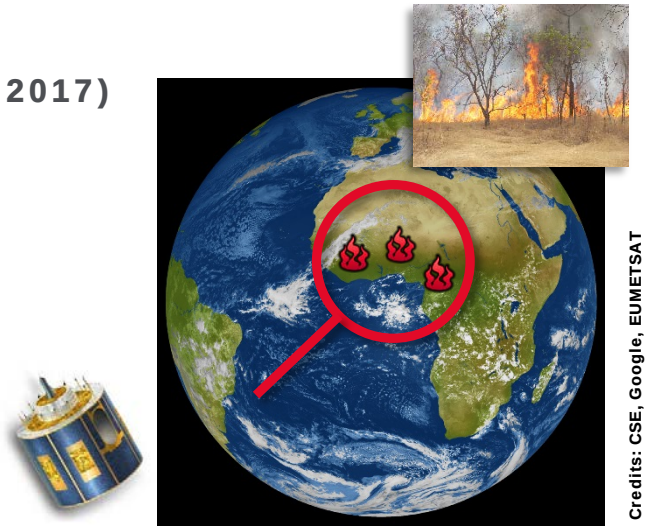
1545-598X/$26.00 © 2009 IEEE

Objective: a new fire detection service prototype

The Forest Fire Monitoring and Management (FFMM) service prototype fulfils the requirements identified during the analysis phase of the PROBA-V MEP Third Party Services Project (Task 3d).

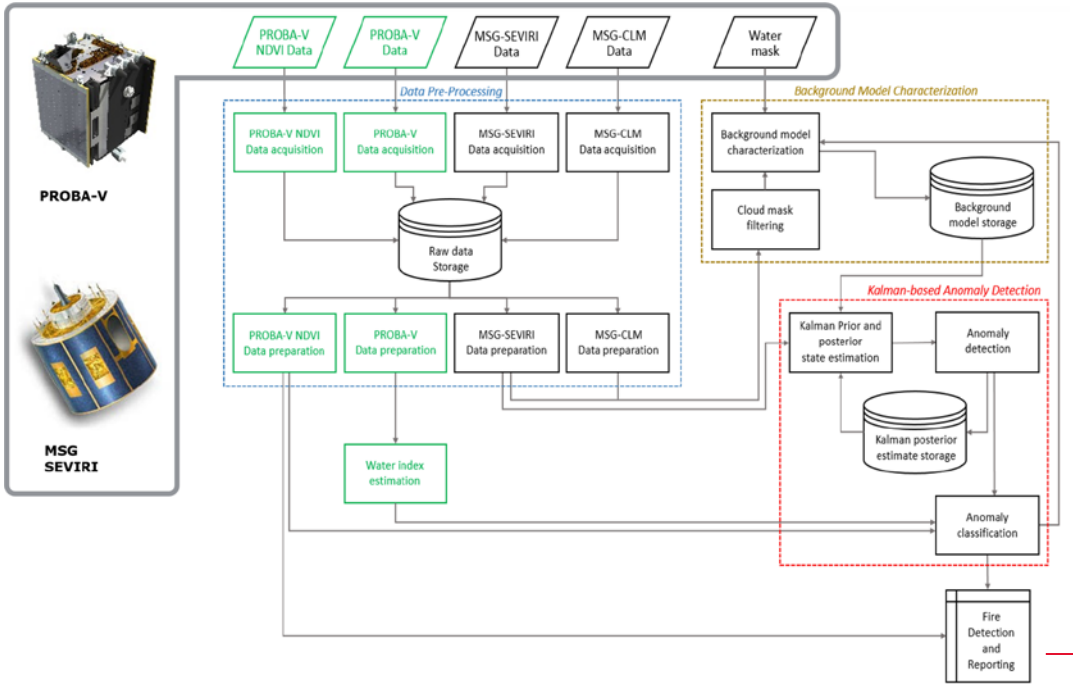
The project was structured in 3 phases:

1. **Initial analysis and requirements identification (Jan – Apr 2017)**
   - Use case and demonstration definition
   - Technical Specification
2. **Design and Implementation (May 2017 – Jan 2018)**
   - Design and implementation
   - Deployment in the PROBA-V MEP and acceptance test
3. **Validation and demonstration (Feb – May 2018)**
   - Field validation campaign
   - CSE staff training



Credits: CSE, Google, EUMETSAT

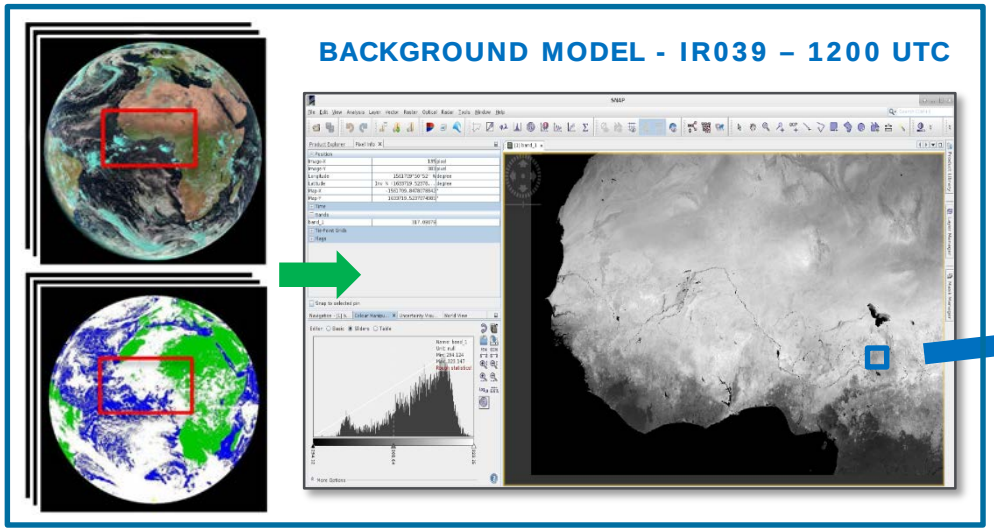
Forest Fire Monitoring and Management (FFMM)

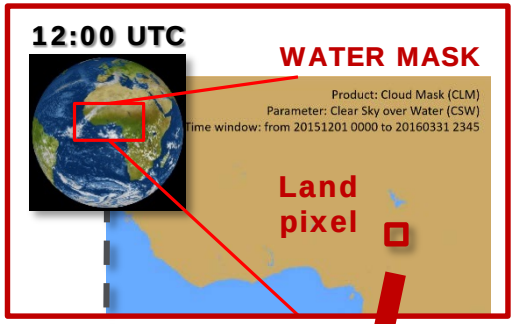


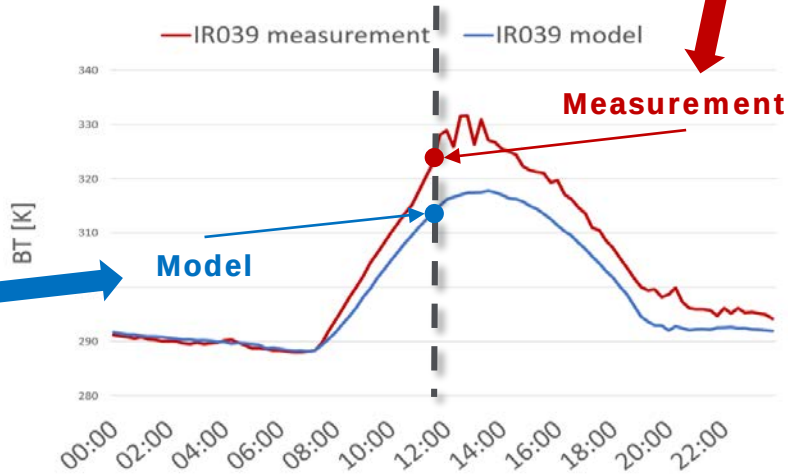
Credits: ESA, EUMETSAT

Background Model Characterization

- Modelling daily measurement cycle of a pixel in clear-sky conditions
- EUMETSAT's Cloud Mask products to filter out anomalies
- A water mask is also derived to reduce false alarms.





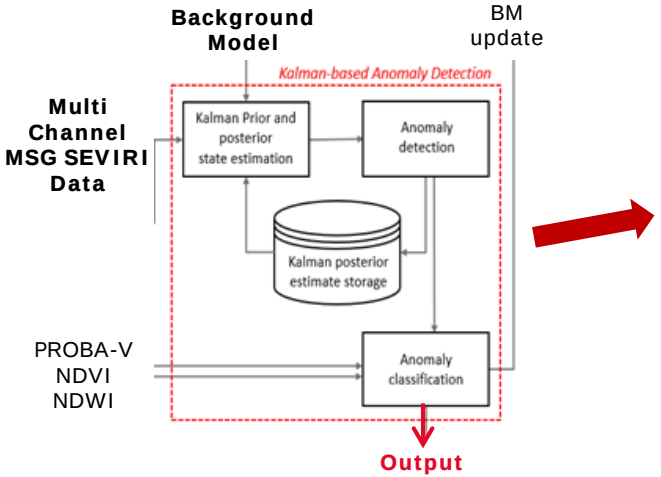


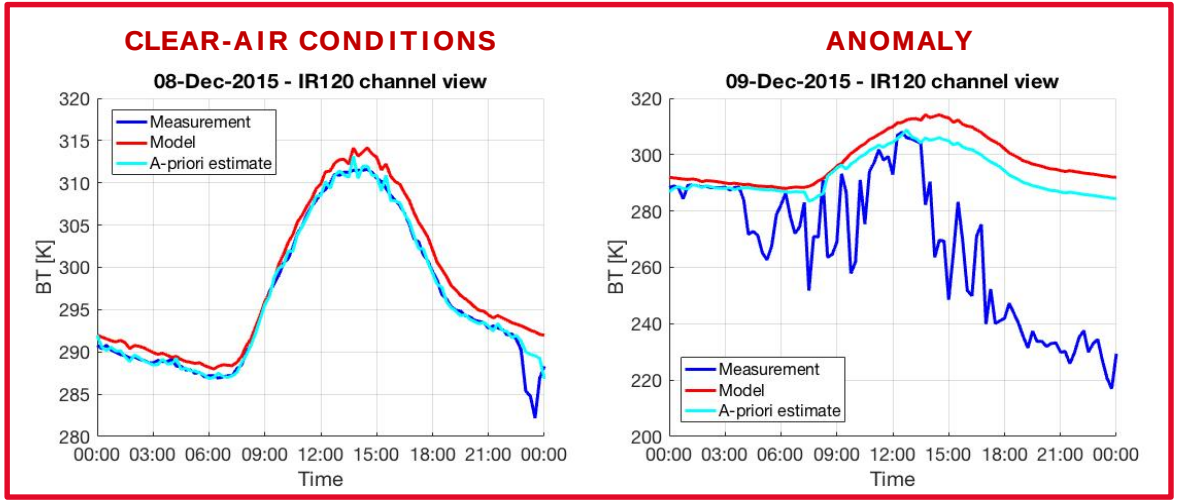
Credits: EUMETSAT

Algorithm (3)

Anomaly detection and classification: the Kalman filter

- The discrete Kalman filter equations are computed at each timeslot over land pixels.
- If the measurement significantly deviates from its expected value the filter identifies an anomaly.
- The anomaly is then classified as cloud or fire by using a combination of different empirical conditions on visible, NIR, MIR and TIR.





Algorithm (4)

Output of the service: detection of fires and burned areas

Hotspots vector and tabular files over user defined area of interest

Acquisition

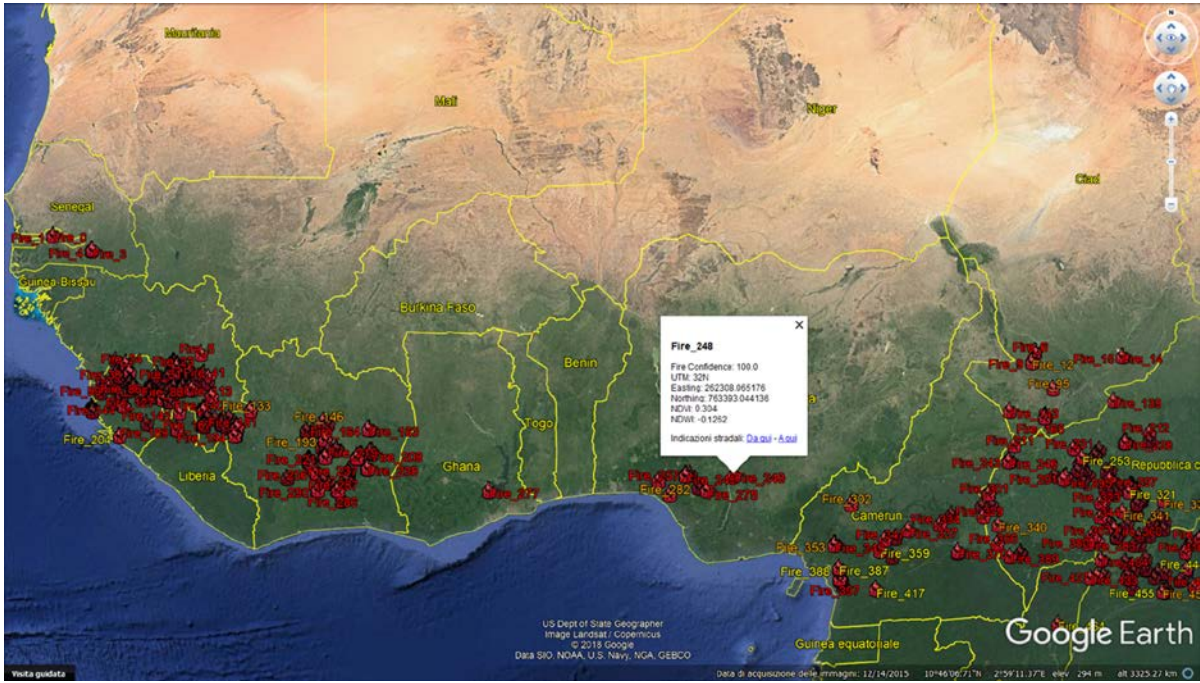
1. Date
2. Timeslot
3. Region
4. WKT

Hotspot

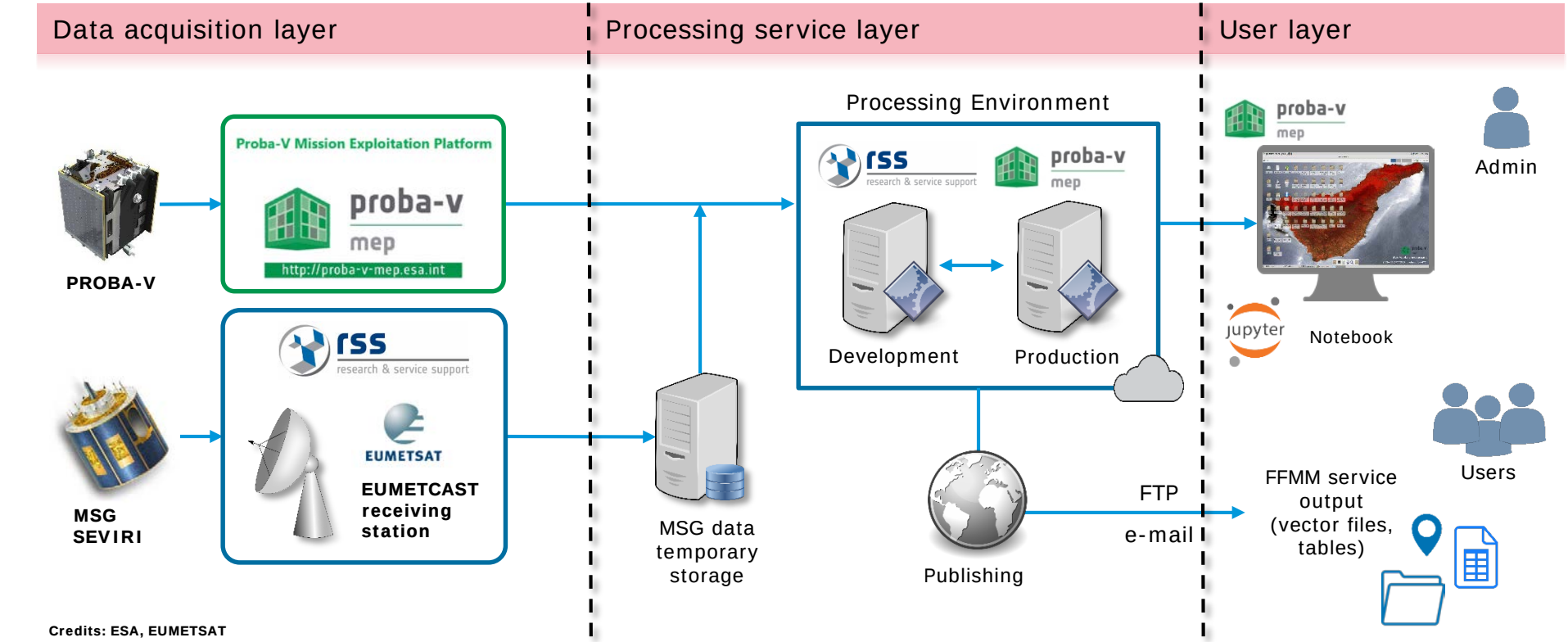
1. Latitude
2. Longitude
3. Confidence
4. UTM zone
5. Easting
6. Northing
7. NDVI
8. NDWI

Burned areas

Extracted from PROBA-V Burnt Areas including a fire occurrence product.



Resources / Infrastructure



Credits: ESA, EUMETSAT

Preliminary validation

Inter-comparisons with respect to similar modelled products

An inter-comparison with the EUMETSAT cloud mask product has shown promising results in terms of detecting clear-air scenarios with percentages of matching around 90% over the entire 3-month period.

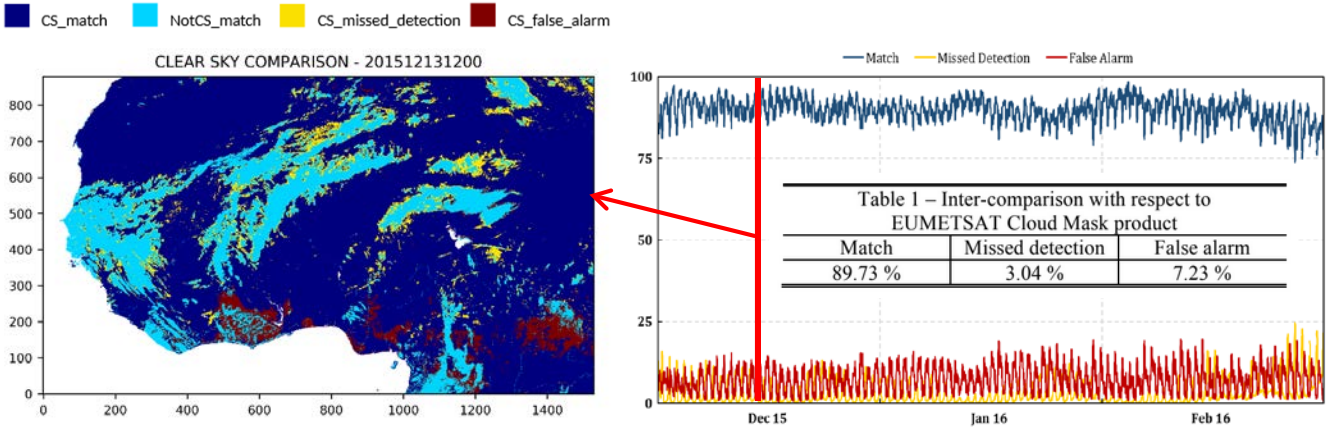


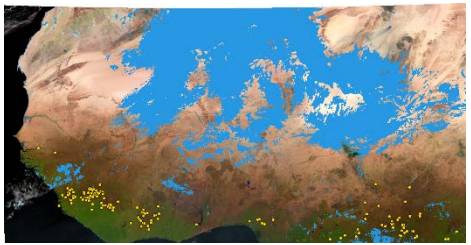
Table 1 – Inter-comparison with respect to EUMETSAT Cloud Mask product

Match	Missed detection	False alarm
89.73 %	3.04 %	7.23 %

See Milani et al. from IEEE Proceedings of 2018 IGARSS

EUMETSAT FRP | 20160129 12:00

FFMM hotspot| 20160129 12:00



Credits: EUMETSAT

Preliminary validation (2)

Field validation mission

Organized in collaboration with CSE:

- 5-day Field Validation Campaign
- From 26th to 30th of March 2018
- Two independent teams (driver, expert from CSE and Senegal Forestry Department)
- Four departments in South Senegal to cover

Challenges:

- Long distances to cover in a relatively short time

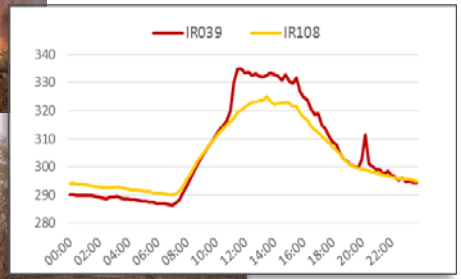
Credits: OSM, CSE

Preliminary validation (3)

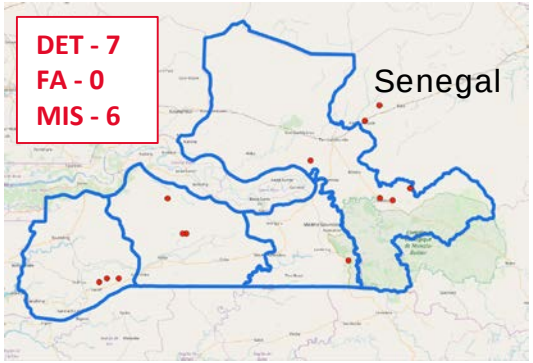
Field validation mission

- Validate active fires (on-going events)
- Validate Burned Areas identified in a certain common period by the PROBA-V BA product and the FFMM service (post event effects)

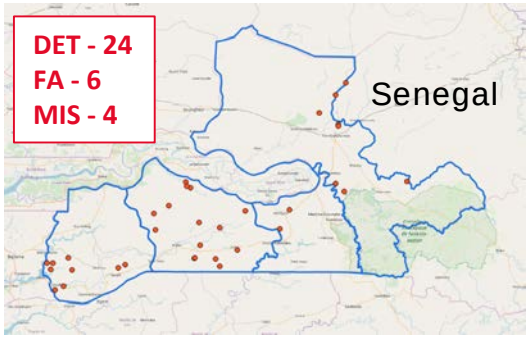
Daily Evolution of Brightness Temperature 11/03/2018



13 active fires observed



34 burned ares observed



Credits: CSE, Google

Conclusions

Achieved results and lesson learned

- ✓ The FFMM (Forest Fire Monitoring and Management) service prototype fulfils the requirements of the PROBA-V MEP Third Party Services Project.
- ✓ The service prototype has been deployed and tested in PROBA-V MEP with efficient data management, portability & scalability to larger areas.
- ✓ First investigations on clear sky classification of MSG scenes have shown a strong correlation with respect to EUMETSAT's Cloud Mask products.
- ✓ The Field Validation Campaign has provided a useful indication about the algorithm performance in terms of false alarms and missed detections

PROBA-V SYMPOSIUM
May 2018, Ostend, Belgium

IGARSS, July 2018
Valencia, Spain

Way forward

Future work

- ✓ Optimization of anomaly thresholds is required together with a more extensive inter comparison of fire detections with respect to other products (e.g. MODIS FIRMS).
- ✓ According to the user CSE, it will be essential to guarantee some of the service capabilities in operations such as the provision of NRT fire detection via SMS, FTP and e-mail.
- ✓ New features could be added to the FFMM prototype, such as integration of other sensors, burning area estimation, combusted biomass estimation.
- ✓ We currently seek for new opportunities to further develop the service and to find resources to deploy this prototype under a pre-operational configuration.

Thank you for your attention!

A special thanks to…

- **Centre de Suivi Ecologique (CSE):**
  Bathiery O., Bocoum O., Dieye A.M., Diop A.P., Diop I., Diouf A.A.,Ndao B., Toure A., Wele A.
- **Sapienza University of Rome:**
  Marzano F.S.

Contact:
giancarlo.rivolta@progressivesystems.it