Advanced procedures for volcanic and seismic monitoring APHORISM

Advanced PRocedures for volcanIc and Seismic Monitoring

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Summary

- Project Overview
  - Concept and Objectives
  - Methodology
  - Work Plan
  - Consortium presentation
- Project Implementation
  - Management structure
  - Milestone and review
- Potential Impact
  - Strategic impact
  - Dissemination

Project Overview

- Call Identifier FP7-SPACE-2013-1
- Funding scheme Small or medium-scale focused research project
- Proposal number 606738
- Activity 1.1-07_GMES Remote Sensing Methods
- 36 months
- 7 partners, from Italy, France, Spain, UK, Switzerland
- Coordinator: Istituto di Geofisica e Vulcanologia (INGV)

Project Overview

Concept and Objectives

APhoRISM is aimed at

- developing innovative Copernicus products derived from the integrated use of Space- and Ground-based data to support the management and mitigation of seismic and volcanic risk
- providing new tools for managing seismic and volcanic crisis
- exploiting available and upcoming (e.g. Sentinel missions) instruments for achieving better performances in terms of accuracy and quality.

Project Overview

Methodologies

Two methodologies for satellite Earth Observation (EO) and ground data integration are proposed:

1- The first concerns the development of products for volcanic ash detection and estimation.

2- The second concerns the generation of maps of seismic damage.

Project Overview

MACE - Multi-platform volcanic Ash Cloud Estimation

- A new set of ash cloud products for volcanic crisis management.
- Integration of all the available information on volcanic ash clouds in the widest possible spectral range, from VIS to MW.
- Ash detection is extended to the case of cloudy atmosphere or steam plumes.

Project Overview

MACE - Multi-platform volcanic Ash Cloud Estimation

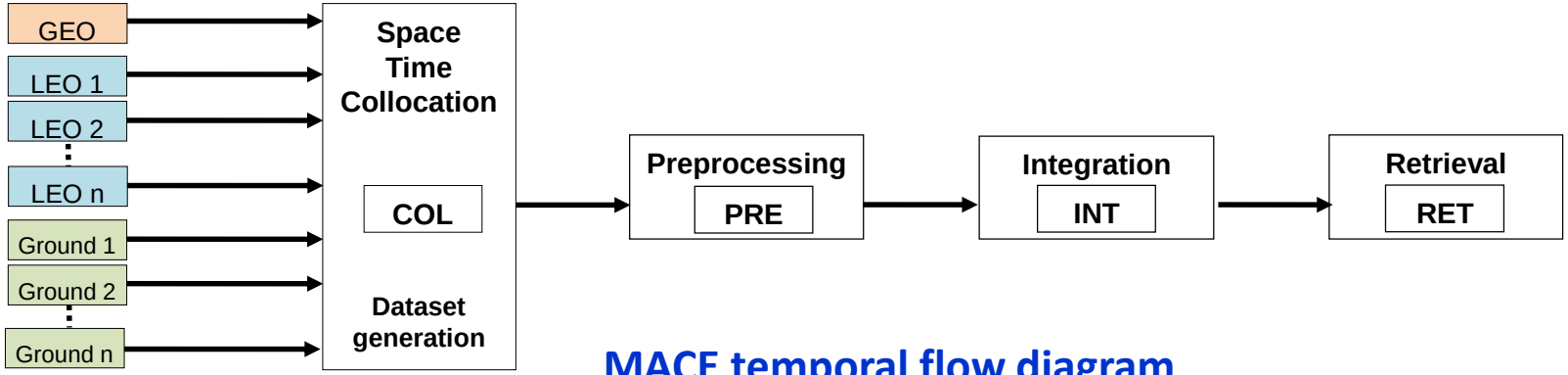
The basic idea of MACE is to provide the best achievable volcanic ash products by continuous update and integration of all the ash retrievals obtained using GEO and LEO satellites and ground-based systems.

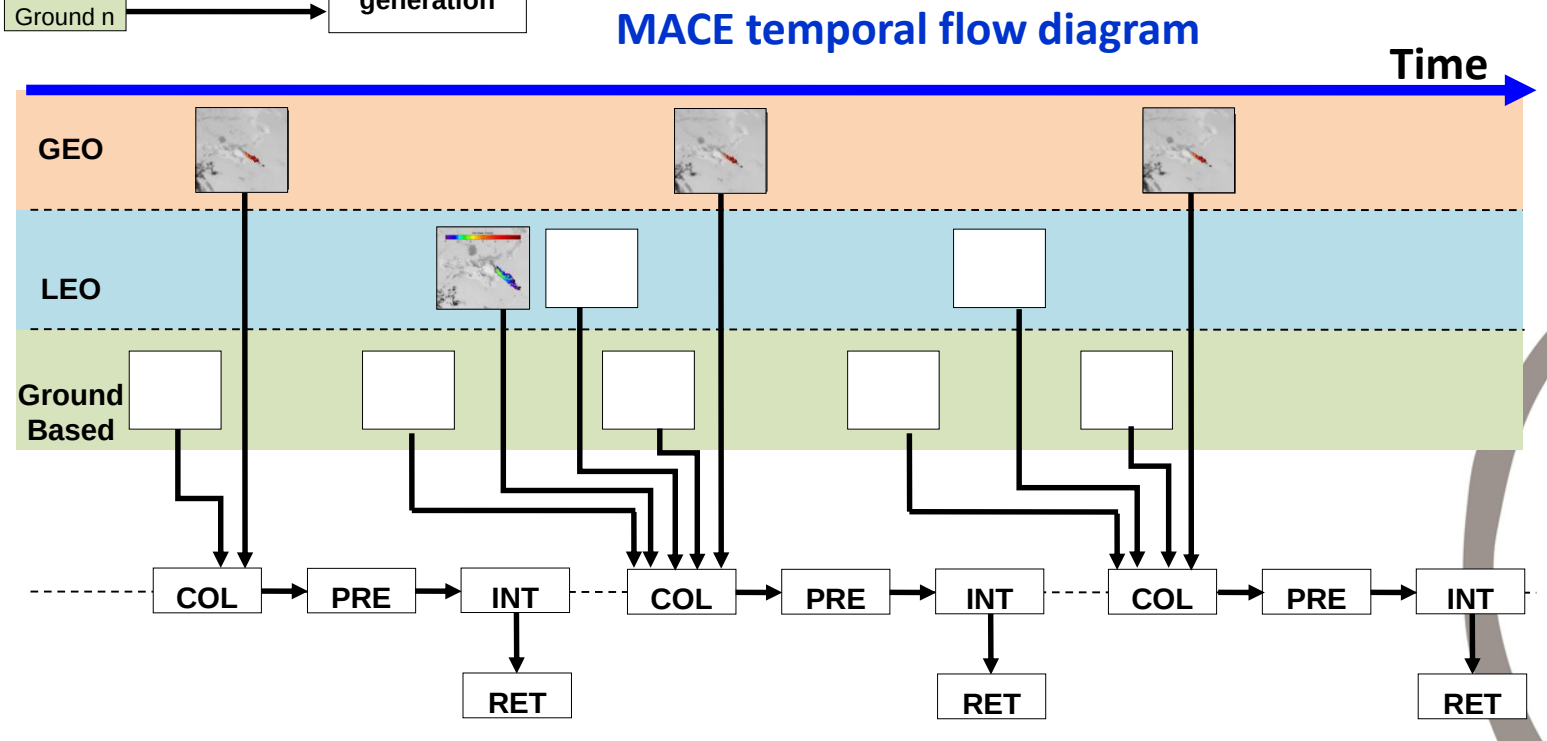
Input products:

GEO and LEO space- and ground-based retrievals in VIS-TIR-MW spectral range

Project Overview

MACE - Multi-platform volcanic Ash Cloud Estimation





Project Overview

MACE - Multi-platform volcanic Ash Cloud Estimation

Test events

MACE ash products will be tested on three recent eruptions representative of different eruption styles in different clear or cloudy atmospheric conditions :

- Eyjafjallajokull (Iceland) 2010
- Grimsvotn (Iceland) 2011
- Etna (Italy) 2011-2012

Validation

Satellite sensors ash products retrievals are compared in the MACE integration that can be seen as a continuous validation process.

Project Overview

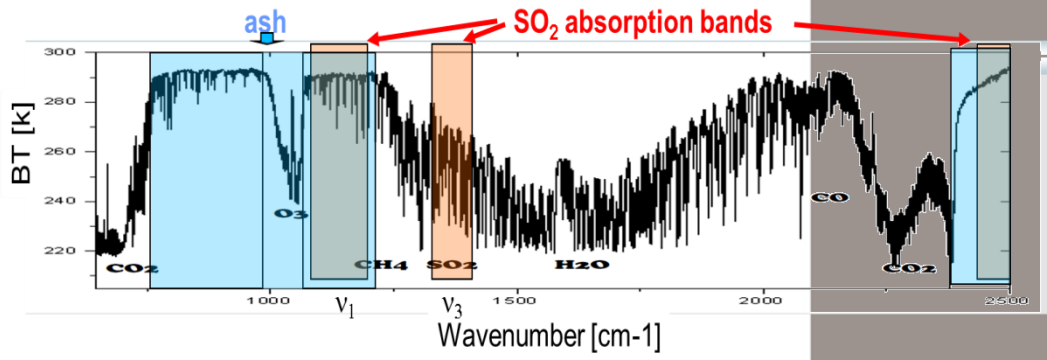
MACE - Multi-platform volcanic Ash Cloud Estimation

sensor	new sensor		notes	mission
SEVIRI	**FCI**	Eumetsat's Flexible Combined Imager embarked on the MTG-Imager (MTG-I)	additional channels with better spatial, temporal and radiometric resolution	**SENTINEL-4**
IASI	**IRS**	Eumetsat's InfraRed Sounder (IRS) embarked on the MTG as part of the SENTINEL 4 mission	IRS Full Disk data every 60 minutes, with a spatial resolution of 4 km	
MODIS	**OLCI** **SLSTR**	Ocean Land Colour Instrument Sea and Land Surface Temperature Radiometer	VIS-TIR spectral range with higher SNR and spatial resolution for volcanic aerosol and ash cloud detection and retrievals	**SENTINEL-3**
MERIS	**OLCI**		OLCI additional 6 bands in the NIR spectral range	
AATSR	**SLSTR**		SLSTR dual view for stereo matching retrieval of volcanic plume altitude	
C-band SAR			continuity of C-band SAR systems ERS-1, ERS-2, ENVISAT and Radarsat data	**SENTINEL-1**

Optimal Estimation Ash Retrieval from IASI

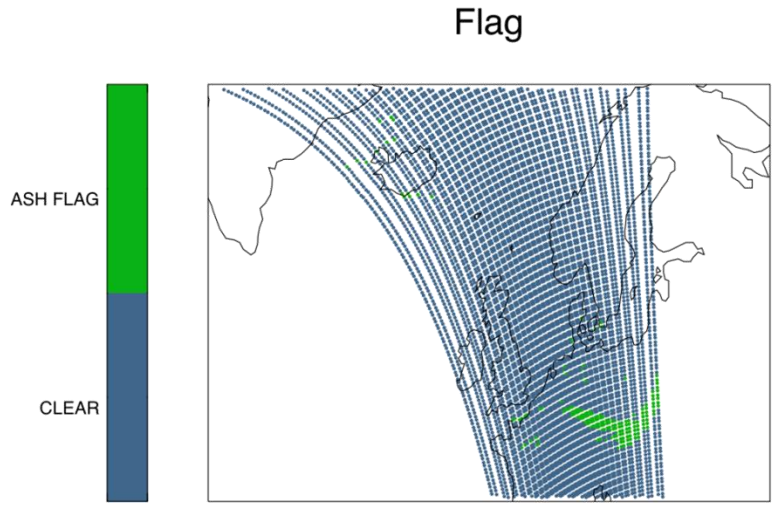
IASI

- Nadir infrared Fourier transform spectrometer (FTS) on MetOp.
- Low earth orbit; spectral range from 645 – 2400 cm^{-1} (4.17 – 15.5 µm) with high resolution (spectral samples every 0.25 cm^{-1}); footprint diameter of 12 km.
- Provides near global coverage every 12 hours

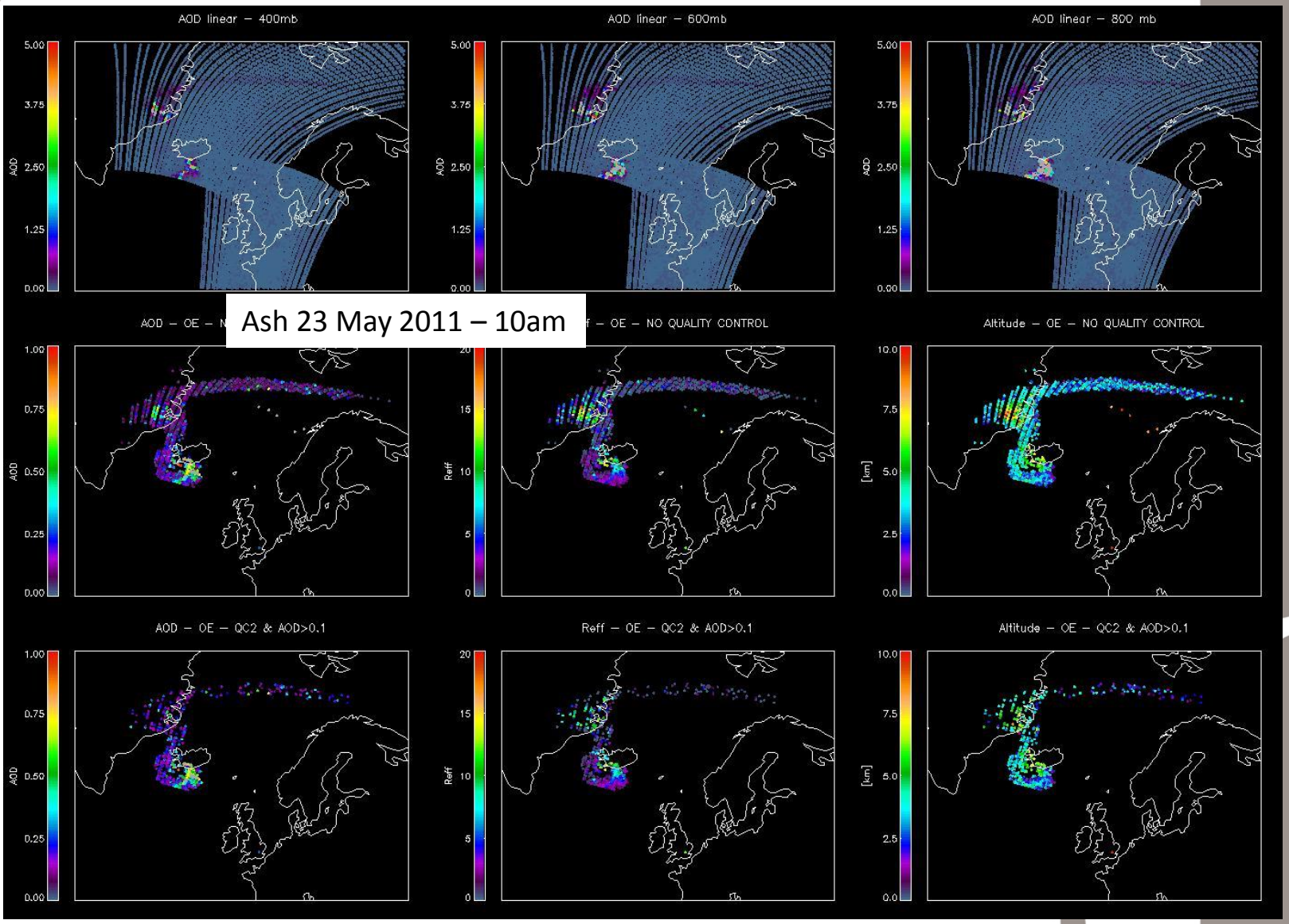


Retrieval

- Pixels are flagged for the presence of ash by a linear retrieval of AOD (assuming 3 plume heights), using a covariance matrix containing all variability from 'clear' scenes.
- **Full optimal estimation retrieval** applied to flagged pixels includes:
  - Fast forward model adapted to include an single infinitely thin ash layer (based on ORAC)
  - Covariance matrix containing inaccuracies in simulating IASI spectra
- Retrieved Properties – **Ash optical depth, effective radius, plume height and surface temperature**
- Provides **full error budget**

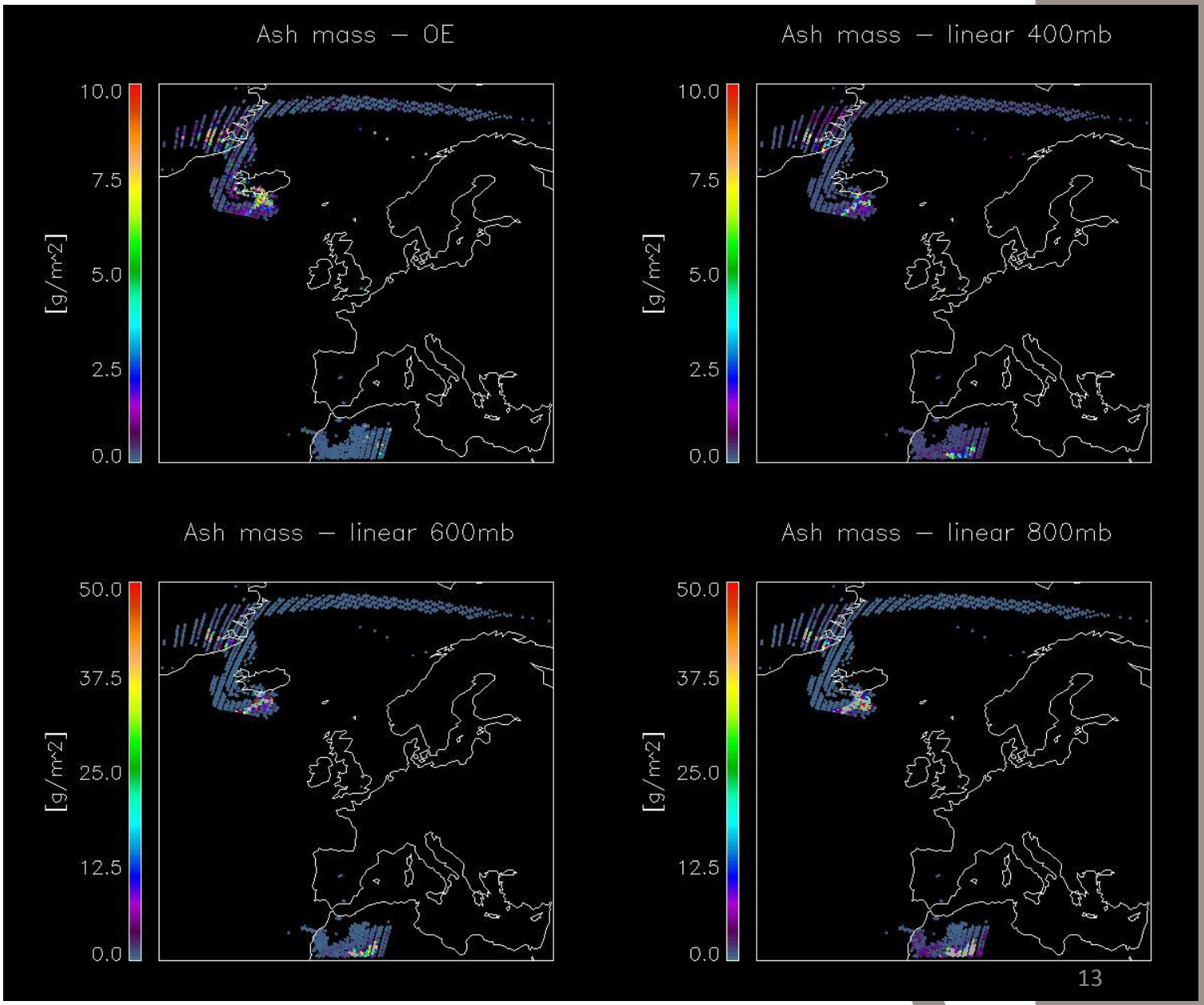


Example: Grimsvötn eruption, 2011

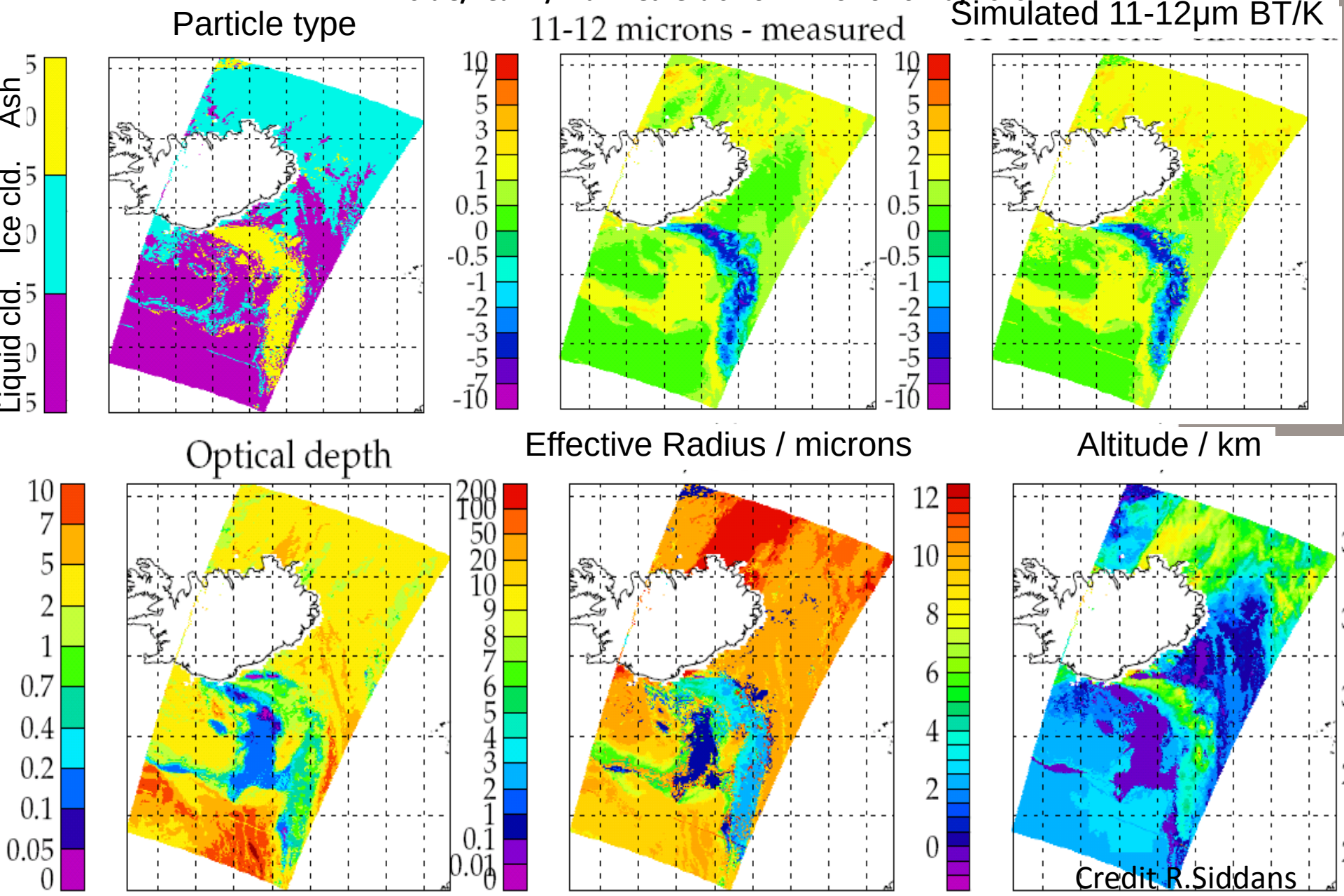


example of the products from the retrieval (Top 3= AOD from linear retrieval flag at different plume heights, Middle 3 = AOD, Reff and plume height, Bottom 3 = AOD, Reff and plume height with a quality control applied)

example of the outputs from the retrieval being converted to ash mass



example of the AATSR retrieval outputs
Oxford-RAL Retrieval of Aerosols and Cloud (ORAC):
Visible/near-ir/mid-ir retrievals from AATSR on 6 May 2010.



Project Overview

APE - A Priori information for Earthquake damage product

- a novel procedure addressing the detection, analysis and estimate of changes to buildings and infrastructures
- a procedure providing maps of damage due to earthquakes
- APE aims at reducing false alarms on satellite change detection maps, which originate from different factors (e.g. shadows and sun illumination in optical images, changes in looking angle, and speckle in SAR images)

Project Overview

APE - A Priori information for Earthquake damage product

Using an integrated approach with a set of a-priori information and surface change detection maps by satellite images (optical and/or SAR)

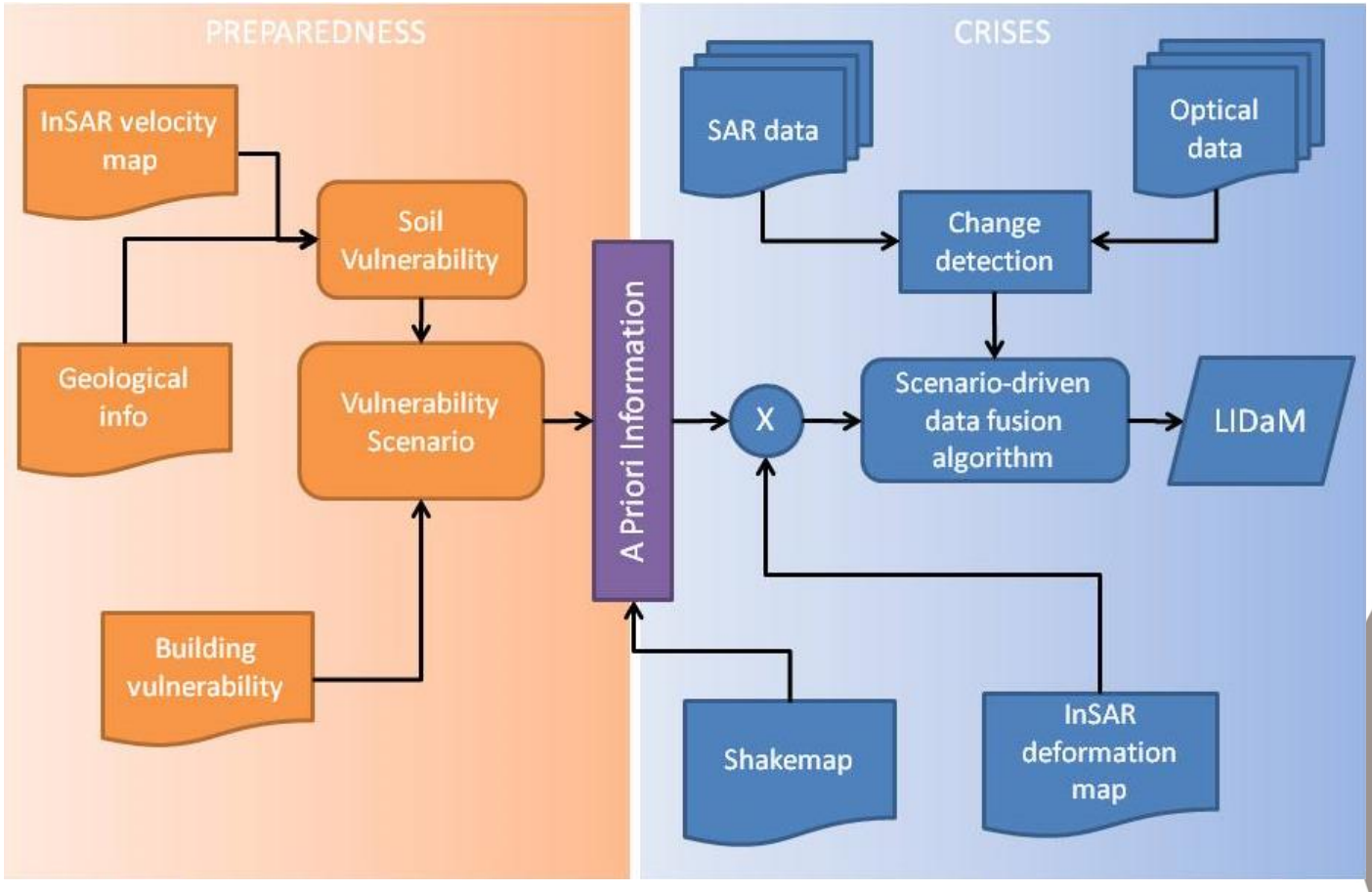
A-priori information is derived from:

- soil vulnerability scenarios (preparedness phase):
  - InSAR velocity maps (from Persistent Scatterers Interferometry (PSI)
  - geological information (site effects, microzonation, slope instabilities)
- building vulnerability to finalize the Vulnerability Scenario
- Shakemaps for selected test areas

Project Overview

APE - A Priori information for Earthquake damage product

Outcome: LIDaM – Likelihood Index Damage Map



Project Overview

APE - A Priori information for Earthquake damage product

Test event

The method will be tested on the 2009 L'Aquila (Italy) earthquake

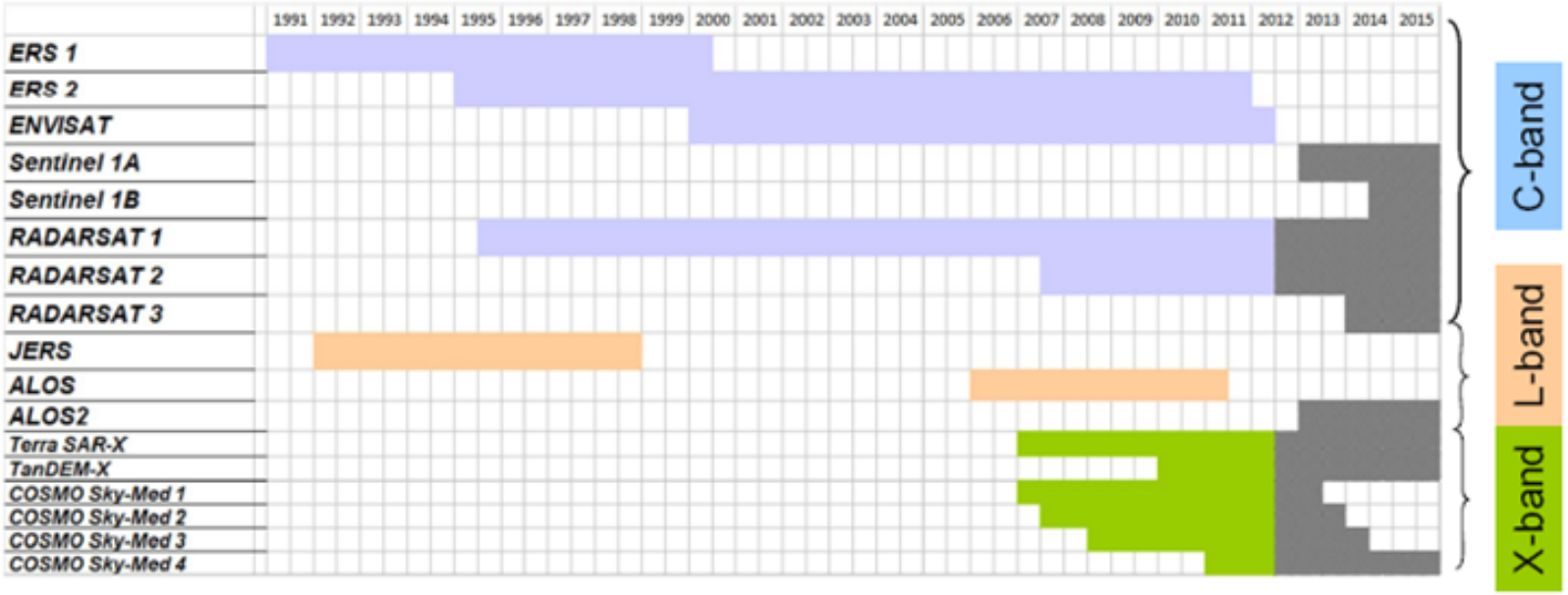
Validation

The validation of the procedure will be performed, possibly, on a non European case study,

- the 2010 Haiti earthquake ??
- the 2003 Bam, Iran earthquake ??
- or more recent earthquakes: Pakistan 2013, Iran 2012, China 2012, Turkey 2011, China 2011, …

Project Overview

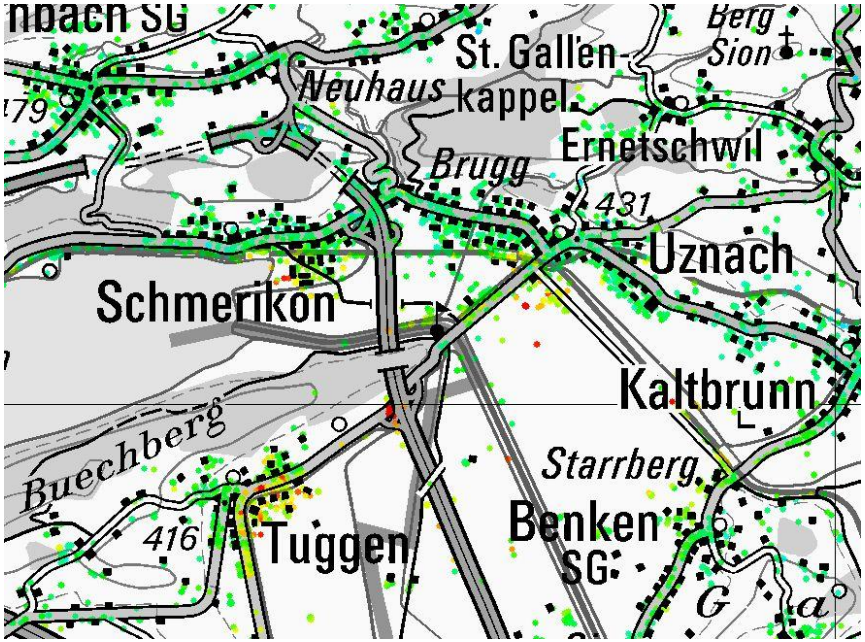
APE - A Priori information for Earthquake damage product



- Optical VHR satellite:
  - QuickBird
  - WorldView 1&2
  - GeoEye
  - Ikonos
  - Pleiades

Soil vulnerability logic

- PSI → deformation rate (mm/year-scale)
- Subsidence is indicator for "thick loose material" subject to compaction
- → increased liquifaction probability



Mean displacement rate
2002-2010 (ENVISAT)

Seismic hazard mapping

Gamma may contribute to the seismic hazard mapping work using its experience on backscatter change and coherence

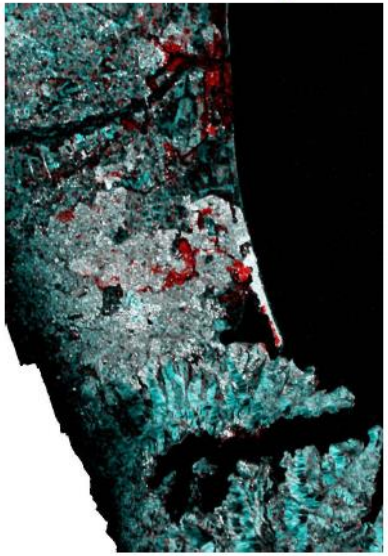
Christchurch, NZ

GAMMA REMOTE SENSING

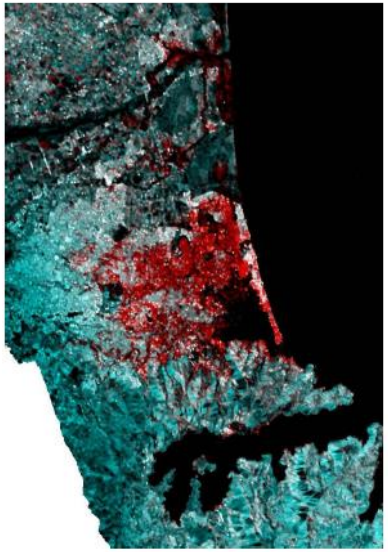
Coherence loss in built up area indicates damage

red: interseismic coherence, green/blue: co-seismic coherence

M7.0 on 4-Sep-2010



M6.1 on 22-Feb-2011



Project Overview

Consortium presentation

1	ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA	INGV	Italy
2	Centre Tecnologic telecomunicaciones de Catalunya Former CONSORCI INSTITUT DE GEOMATICA (IG)	CTTC	Spain
3	BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES	BRGM	France
4	UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA	DIET	Italy
5	GAMMA REMOTE SENSING RESEARCH AND CONSULTING AG	GAMMA	Switerland
6	THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF OXFORD	UOXF	United Kingdom
7	ALMA SISTEMI SAS DI DI IORIO ALESSIO & C	ALMA	Italy

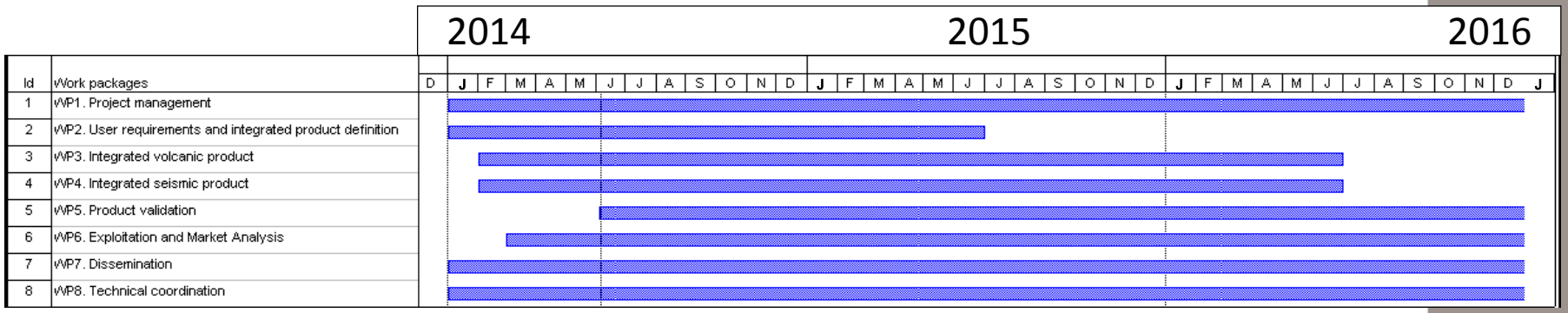
Project Overview

Work Plan

WP n.	Title	Leader
1	Project management	INGV
2	User requirements and integrated product definition	BRGM
3	Integrated product for supporting volcanic crises	INGV
4	Integrated product for supporting seismic crises	DIET
5	Product validation	IG
6	Exploitation and Market Analysis	ALMA
7	Dissemination	IG
8	Technical Coordination	INGV

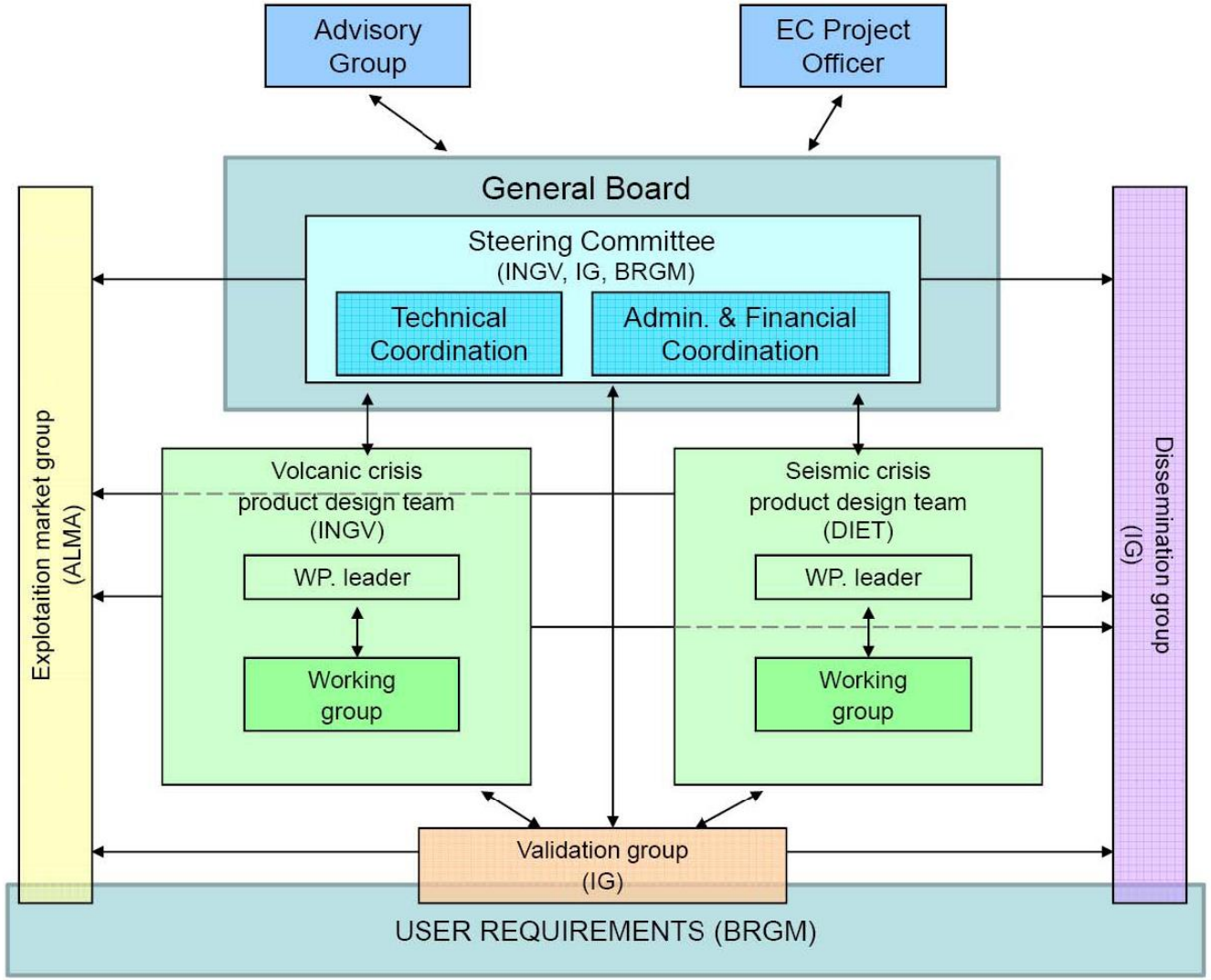
Project Overview

Work Plan



Project Implementation

Management structure



Project Implementation

Milestones and Reviews

MS n.	WS Name	WP n.	Delivery
MS1	User requirements	WP2	12
MS2	GEO, LEO, and ground-based products generation in clear and cloudy sky conditions	WP3	18
MS3	Velocity and soil vulnerability maps, change detection Methodology Assessment	WP4	18
MS4	Generation of Integrated Volcanic Ash products	WP3	30
MS5	Generation of integrated Seismic Products	WP4	30
MS6	Validated Volcanic Ash Product	WP5	36
MS7	Validated Seismic Product	WP5	36
MS8	Risk Management Capability	WP8	20

Project Impact

Strategic impact

- APhoRISM aims at addressing the needs of the EU to develop advanced technologies, best practices and tools to provide affordable and more effective solutions to specific priority areas.

- European actions to preserve the human habitat and its economic activities from the environment emergencies have been performed for achieving more effective methodologies and solutions.

- Safety of civil aviation and impact management of earthquake damages are two priority areas. This is testified by the impact of recent dramatic events in Iceland (volcano eruption in 2010) and L'Aquila (Earthquake 2009), and outside Europe.

Project Impact

Strategic impact

- APhoRISM has then received letters of endorsement from:

  - Italian Dept. of Civil Protection,
  - Meteo France and the
  - Department of Urban Environment System (Japan)

- The Meteo France Volcanic Ash Advisory Center is designated by the International Civil Aviation Organization to provide expertise to civil aviation in case of significant volcanic eruptions

Impact: MACE

MACE methodology impact on the European air traffic scenario will be assessed by the following main factors:

- **Frequency and extension of the catastrophic event;**
- **Economic impact of the event on the European market;**
- **Improvement over the current adopted methods.**

Considering severe events like the 2010 volcanic eruption in Iceland may happens on a average of 30 years, the direct impact on the European air transportation market can be estimated in 46,7 M€/year but the overall indirect impact on the travel industry in Europe may account up to 300 M€ per Year.

The APHORISM proposed methodologies can provide much better and precise assessment for the sake of the decision maker with important consequences on the time duration and covered area of the air ban.

MACE is estimated to provide between 7 to 10% better performance with respect to the currently used methodologies; the actual figure of the improvement with regard the current used methodologies will be assessed during the project implementation and input to the evaluation of the impact to the European market.

The target end user of the MACE methods will be the Volcanic Ash Advisory Centers (VAACs). Potential end-user , e.g. air lines, airport and national flight authority will also be analyzed.

Impact: APE

For the damage assessment tool APE two areas of interest have been identified matching with the intermediate and final product of the methodology:

1. **Intermediate product "vulnerability scenario"**
   - **Private insurance market for householders**
   - **Urban Planners**
2. **Final Product LiDAM**
   - **Emergency response mainly concerning Civil Protection operability**
   - **Damage assessment for both public bodies and private insurance companies**

Vulnerability scenario can be used to drive premium prices for earthquake household insurance companies with the result of minimizing the risk of default in case of severe events.

For emergency response the market analysis will focus on the improved operative response of the Civil Protection to seismic event while damage assessment will be assessed mainly on the private insurance market.

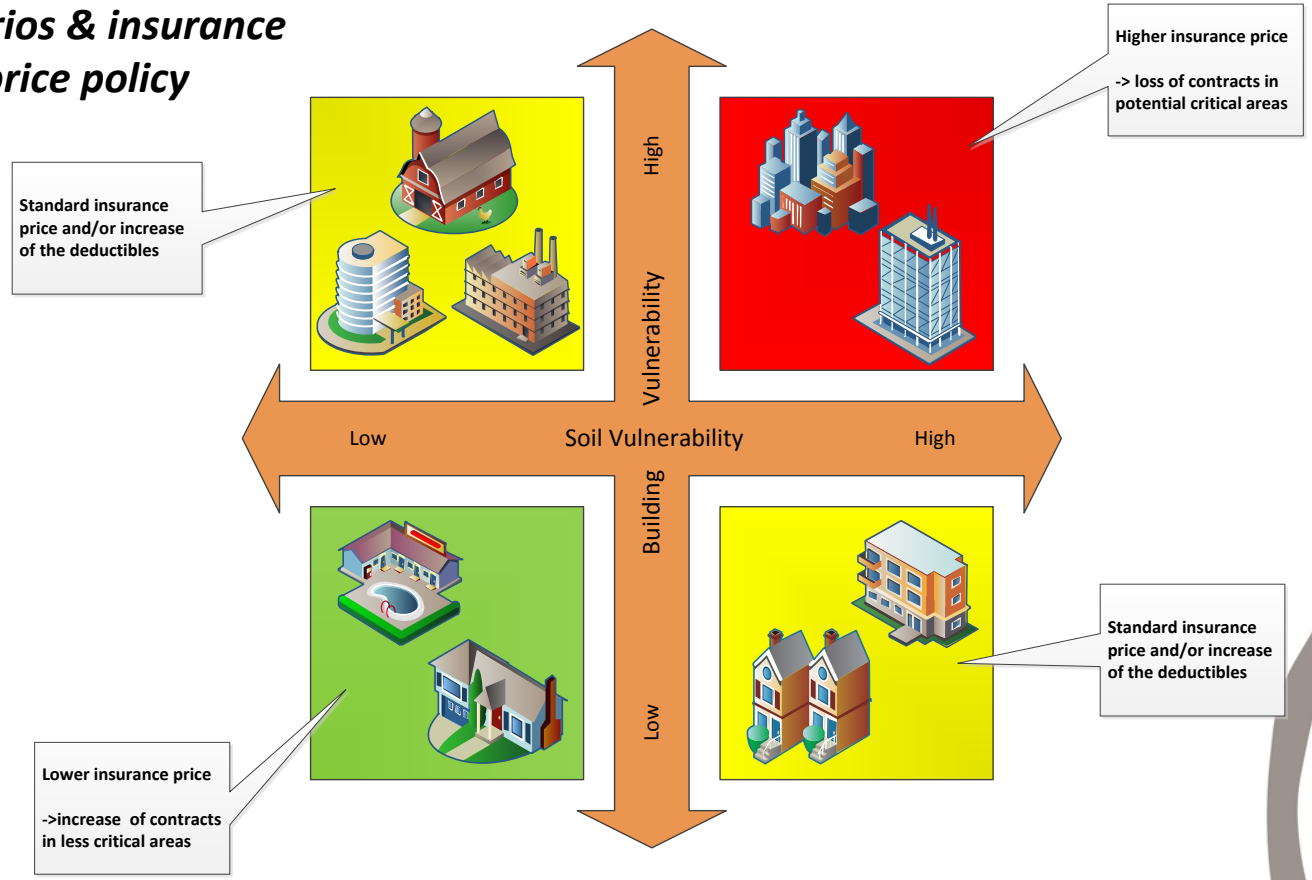
The target end user for APE will be:

- **Private insurance companies (European, US and Japan markets)**
- **Italian Civil Protection (coordination with other European Civil protection will be assessed)**
- **Public bodies in charge of damage assessment (e.g. Dep. Of Urban Environment System, Japan)**

APE vulnerability scenarios

To support insurance price polices at local scale:

Vulnerability scenarios & insurance price policy



Dissemination

Project dissemination

- to whom?

  - to Technical Audience
    - through specialized workshops, scientific papers, newsletters

  - to User Community
    - end-user events or conferences

  - to Istitutional Audience
    - specific conferences and/or workshops of EU Space sector

  - to the wider Public
    - project website, newsletters

APHORISM
ADVANCED PROCEDURES FOR VOLCANIC AND SEISMIC MONITORING

Thank you

ALMA Sistemi sas

- ALMA Sistemi sas di Di Iorio Alessio & C is an Italian SME established in 2005 providing high level consultancy in the space and defence market.
- ALMA provides services in
  - Business Development & Market Analysis
  - Project and Proposal Management
  - System and Software Engineering (EO, image processing, Check-out systems).
- ALMA has contributed in behalf of its international clients to a number of key space projects funded by the European Commission, European and Italian Space Agencies.
- Past research projects: HORUS (ESA), PAGIS (ASI), WHERE (ASI)
- On going projects: APHORISM (FP7), ITACA (FP7)
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