



Products and Applications Development

Laura CANDELA
Earth Observation Unit

COSMO SkyMed Meeting

Mar, 21

ASI-CNES meeting - Paris

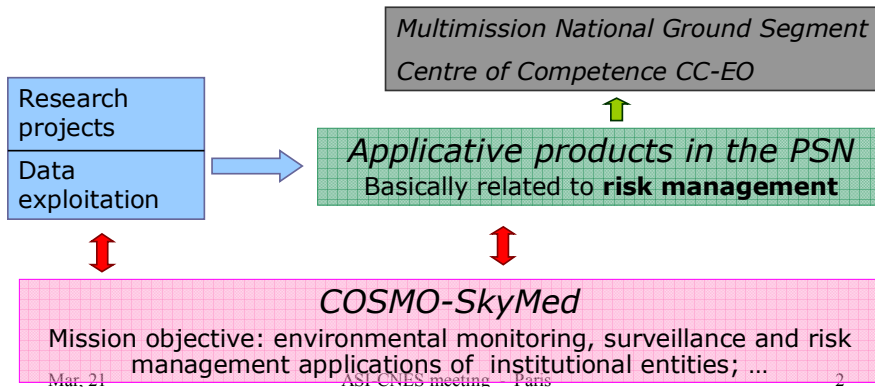
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Programs Products and Applications

Unit mission - *To improve with a continuative effort in the research and innovation fields the knowledge of the Earth system, to set up more and more reliable models for the forecast, the monitoring and the management of the natural and antropic phenomena, with a particular attention to **natural disaster**.*



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COSMO-SkyMed and Scientific research

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One must not forget that COSMO-SkyMed program has started with specific application requirements, while the scientific activities were generally seen as supporting the achievement of the mission requirements.

Two dedicated AO's were issued in 1999 and 2001 and the relevant results were, together with the identification of application priorities, the reference to define the EO policy and Plans within the new 2003-2005 National Space Plan.

Today scientific research is an integral part of the on-going activities focused on Applications definition and development.

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Research themes (1)

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The main themes covered by the two Science AO's and for which activities were performed in the 2000-2003 timeframe are the following :

- Thematic application survey
 - Urban applications
 - Marine applications
 - Earth surface characteristics and parameters.

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Research themes (2)

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- Performance analysis of algorithms for the “frame” mode
- Impact of atmospheric propagation on interferometric products
- Methodology and algorithms for polarimetric and interferometric data processing
- SAR and Optical data fusion
- Automatic tools for image interpretation and feature recognition
- Information extraction from multiple orbit SAR data
- SAR data compression algorithms
- COSMO-SkyMed products simulation
- Calibration approach and planning

Next steps

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A dedicated AO will be issued in 2005, dedicated to COSMO-SkyMed and SIASGE data exploitation, in order to fully investigate its potential.

Objective: to promote use of SAR data (X and X+L) of COSMO and SIASGE constellation, through the study and the development of level-2 innovative products and algorithms.

To study level-2 products can be very helpful for EO-based applications development (risk management, farming, security).

The relevant results will be intermediate level products (like coregistered set of X and L products, speckle-filtered, to be used for feature detection or to extract some kind of geophysical information), and technologies already based on C-band SAR data source that will be upgraded on new SAR sensors.

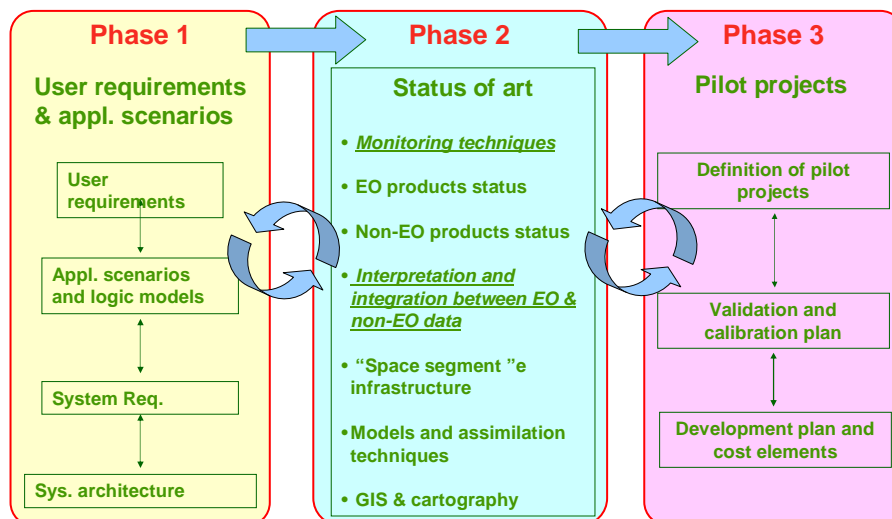
ASI approach to Applications development

According to National Space Plan priorities (i.e. risk management), the focus of the applicative products definition and development is on floods, landslides, forest fires, seismic & volcanic hazards and oil spill.

The preparatory phase (6 months, in 2004) was in charge of formalizing the institutional needs (our reference User is Civil Protection Department) and to translate them in system architectures to support the decisions related to risk management and to elaborate EO products to be used.

ASI aims to prepare the use of COSMO-SkyMed - starting from the experience gained with already existents SAR missions (ERS, Envisat and Radarsat) and of other systems, as the high resolution optical sensors to prepare Pleiades.

Preparatory phase logic



4 projects related to hydro-geological risk

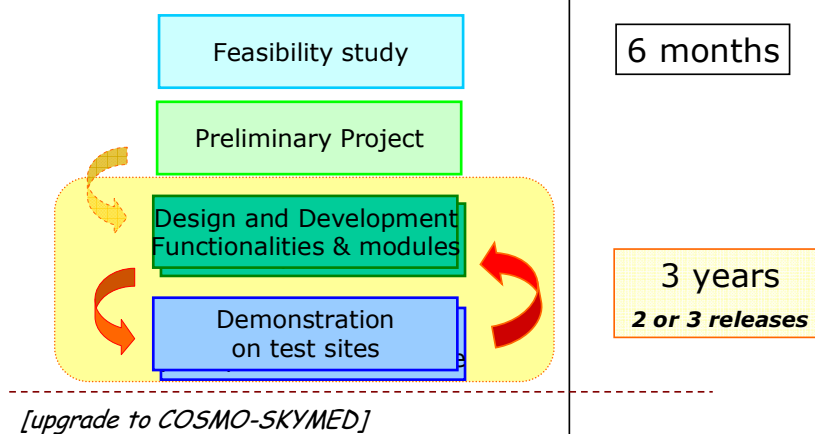


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Applications development plan



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Closing preparatory phase ...

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The adopted approach is 'user driven': the user requirements guide the design of each system in the framework of each application.

The applicative products are complex systems, that require routine comprehensive data gathering (EO and in-situ) to be ensured and systematically integrated with operational forecast models and decision-support systems.

The results of preparatory phase are the basis to activate a number of **pilot projects** for service consolidation development, implementation and demonstration to be started in 2005.

We have a strong partnership with the Italian Civil Protection – finalized to integrate the output of pilot projects in the National System of Civil Protection.

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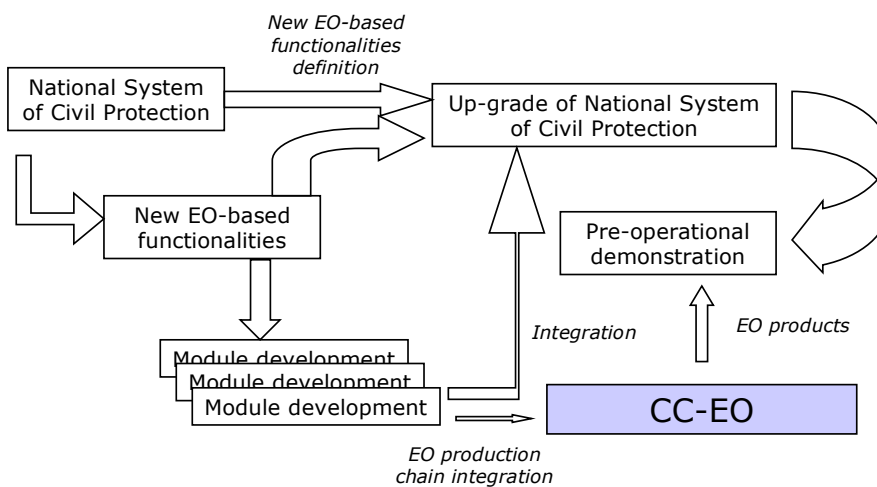
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Implementation logic EO for risk management



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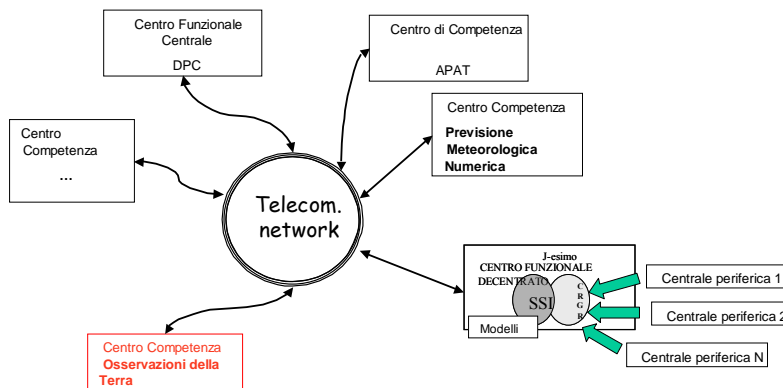
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The reference architecture

D.P.C. 27.02.2004

"Indirizzi operativi per la gestione organizzativa e funzionale del sistema di allertamento nazionale e regionale per il rischio idrogeologico e idraulico ai fini di protezione civile"



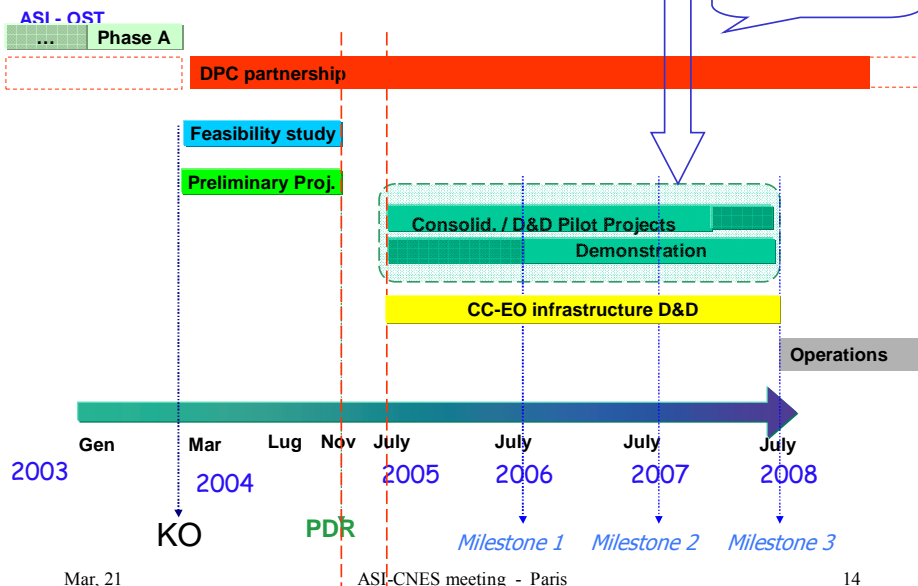
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Planning

COSMO-SkyMed data availability



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ASI & USERS partnership

- User as a key-actor
- National institutions (as a guide)
- Sub-national (operative) organizations (*demonstration*)

- Fundamental contributions:
 - User requirements consolidation
 - Auxiliary data availability for products validation
 - Active participation in demonstration phase
 - Service validation and assessment
 - Results divulgation contribution

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ASI as Centre of excellence

- The partnership between ASI and Civil Protection Department has been formalized through the ASI designation as *Centro di Competenza per l'Osservazione della Terra* (Centre of excellence for Earth Observation) in the Italian Civil Protection System.

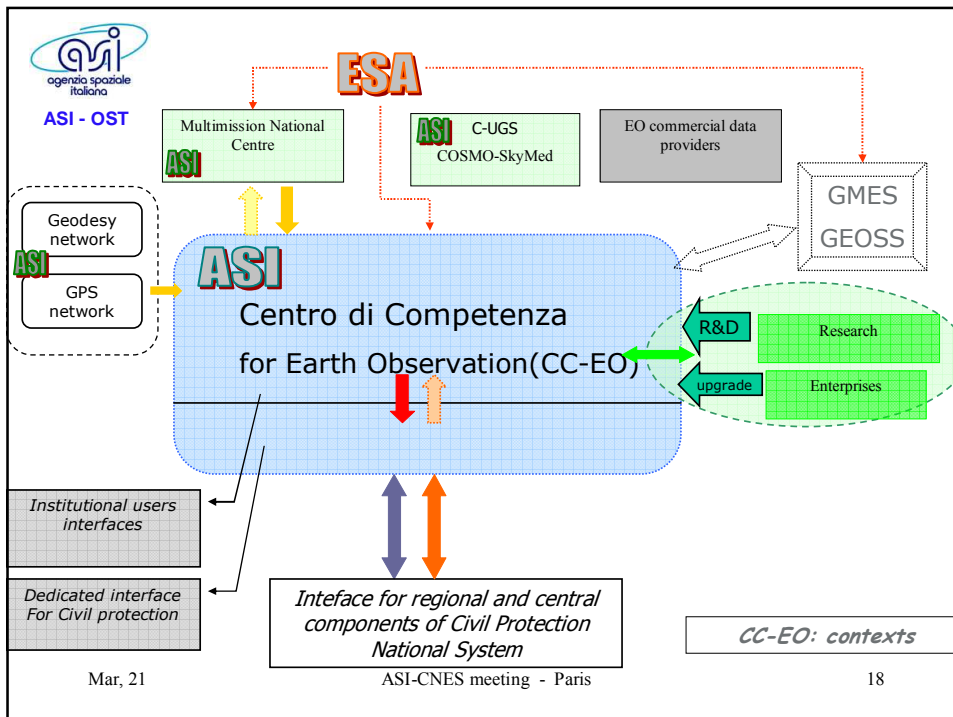
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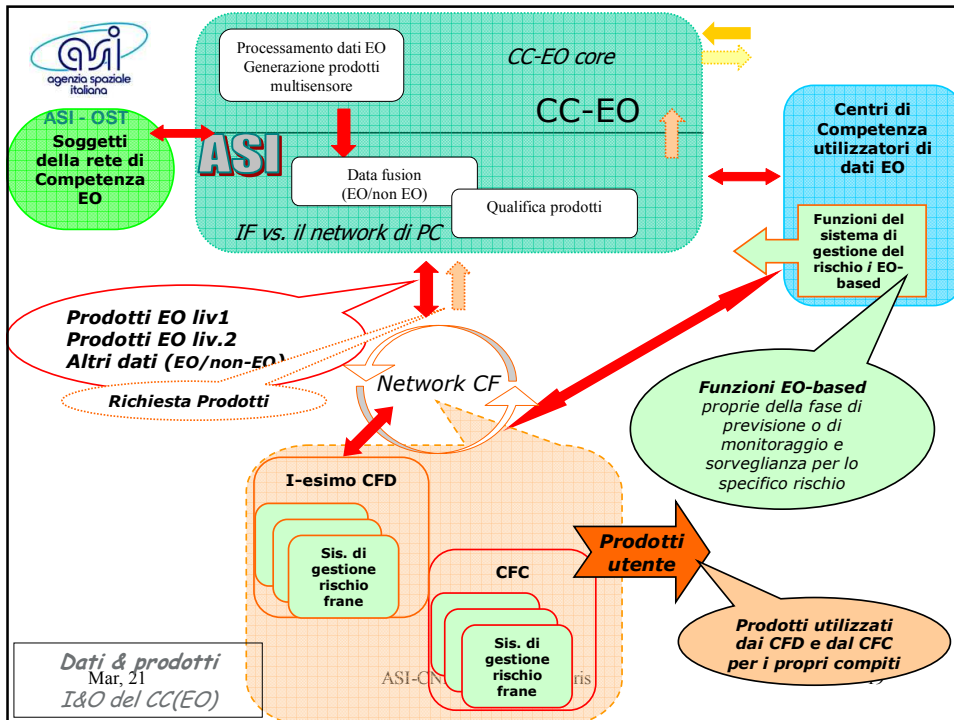
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ASI role

- ASI has the function to develop applications, based on EO data, for National System of Civil Protection, interfacing other spatial agencies and transferring in the national scenario information, knowledge, technologies.
 - ASI will deal with involvement and coordination between various thematic Centre of Competence, promoting R&D activities related to EO-based risk management
- ASI will produce and delivery products, services, informations and data based on EO data intended for prevision, monitoring and surveillance
 - ASI will develop service capabilities, building an infrastructure (the so called CC-EO) to support the delivery and putting together a network of EO competences.





An example

“National system for defence from floods”
Overview of program

Identifying the user requirements

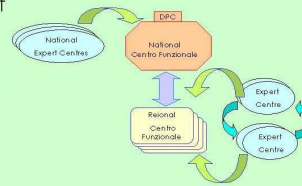
The Italian Decision Support system for Natural Hazards

The *Centri Funzionali (Functional Centres)* system will implement the decision support network for Civil Protection actions in natural hazard situations (DPCM 27/02/04).

The main task of the setting up of the Centri Funzionali is to systematically gather, on both national and regional scales, all the data, information and modelling capabilities in the meteorological and hydrological analysis.

The system is structured into a *National Centro Funzionale* at the Department of Civil Protection (DPC) and a series of *Regional Centri Funzionali*, one for each Region/Autonomous Province, that receive and process with appropriate modelling techniques the data provided and send the data and results of the elaborations to the *National Centro Funzionale*.

The system also includes various *Centri di Competenza (Expert Centres)*, either national and regional that provide information, elaboration or scientific contributions in specific fields (e.g. meteorology, Earth observation ...).



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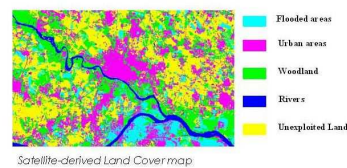
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Utility of EO in the activities of flood risk mitigation

Activities in the Deferred Time (TD):

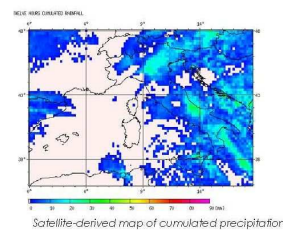
EO data can provide thematic maps necessary for the characterization of the territory and the design and parameterization of hydrologic and hydraulic forecast models (watershed elevation, river morphology, land use and vegetation, infrastructures).



Activities in the Real Time (TR):

EO can provide estimates of the meteorological and hydrological variables necessary for the continuous and intensive updating of the atmospheric and ground conditions of the areas under crisis (soil moisture, precipitation,...).

In the post event phase, EO maps of flooded areas and change detection can be used for damage evaluation and monitoring of residual risk



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From User requirements to EO products

User requirements

The User requirements are divided in three main groups:

- Thematic maps and data for direct use (DIR)
- Thematic maps and data to be assimilated in hydrological models (IDRO)
- Thematic maps and data to be assimilated in meteorological models (MET)

For each of these classes a list of 'desired' EO products has been derived on the basis of the information gathered also through questionnaires sent to a set of possible end-users (personnel of Centri Funzionali, local authorities).

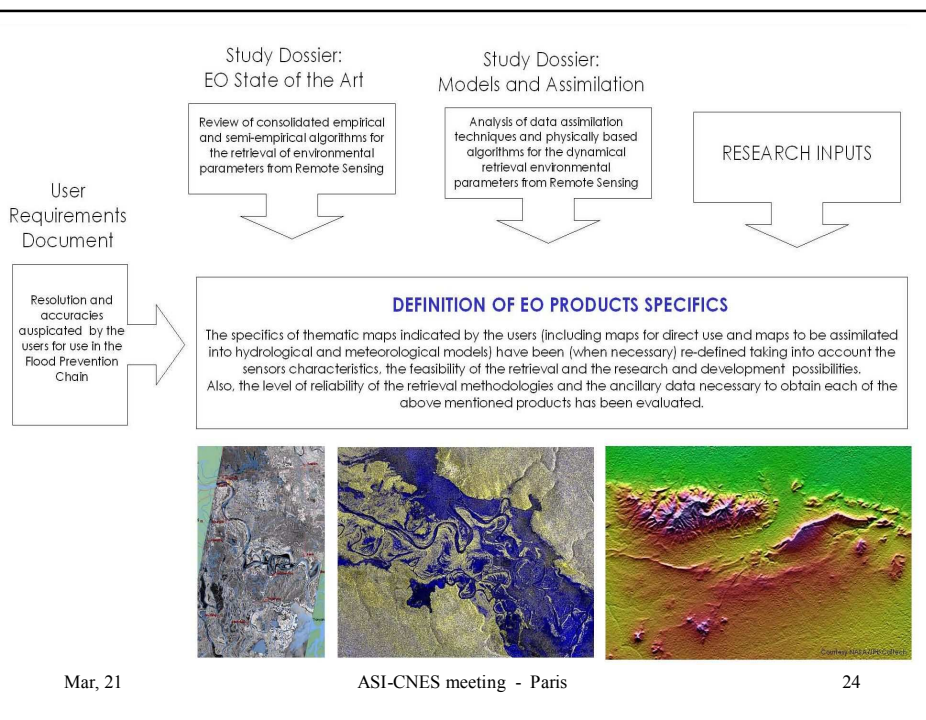
For each of the above maps, the specifics required by the users have been outlined in terms of spatial resolution, refresh rate, accuracy and latency with indication of minimal, optimal and 'threshold' values.

The feasibility of such requirements has then been investigated, evaluating the capabilities of the current and future EO missions and indicating the technological gaps and research necessities.

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EO Products

THEMATIC MAPS FOR DIRECT USE

- Map of Risk-prone elements
- Risk-prone areas high resolution DTM
- Risk-prone areas high resolution imagery
- Maps of flooded areas
- Damage maps
- Precipitation
- Forest fires extent
- Change detection
- Land use
- Vegetation cover
- Maps of infra-structures
- Snow cover
- Horizontal wind
- Vertical atmospheric water content
- Surface temperature
- Reservoir and lakes surface extent
- Cloud Cover
- Soil Moisture

THEMATIC MAPS FOR ASSIMILATION IN HYDROLOGICAL AND HYDRAULIC MODELS

- Precipitation
- Digital Terrain Model (DTM)
- Soil Moisture
- Vegetation indices
- Snow cover
- Land cover and surface characteristics
- Surface Temperature
- Air Temperature
- Radiation
- Evapotraspiration
- Pedology and Lithology
- Vertical atmospheric water content

THEMATIC MAPS FOR ASSIMILATION IN METEOROLOGICAL MODELS

- Digital Terrain Model (DTM)
- Leaf Area Index (LAI)
- Land use
- Climatological Albedo
- Soil Moisture
- Evapotraspiration
- Radiation
- Waves height
- Precipitation
- Vertical atmospheric water content
- Fractional cloud cover
- Surface Temperature
- Air temperature
- Horizontal wind
- Vertical wind
- Snow cover
- Snow depth

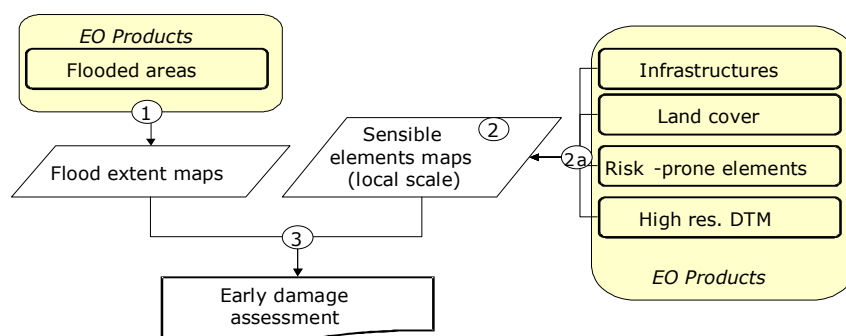
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Damage early assessment



Applicative Scenario :
TR.R3.I - C.F.R.
Functional Scheme :
Damage evaluation
Phase I -Early assessment

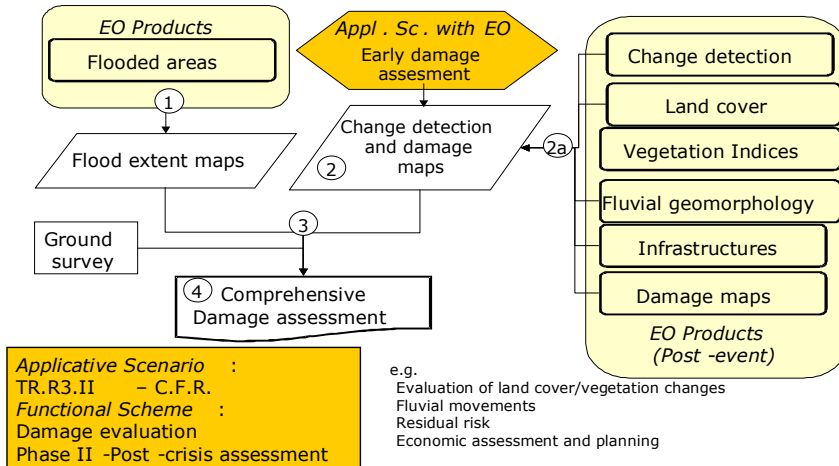
e.g.
Accessibility of infrastructures
Extension of flooded areas for the different crop type

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Damage *Post-crisis* assessment



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Land Cover maps

MAIN TECHNOLOGY	TRANSVERSAL TECHNOLOGY	PROBLEM	STATUS	Required Research Activities	Future developments
Supervised Classification applied to medium resolution multispectral data (e.g. Landsat 7 ETM+ data)	Data Fusion Integration with non-EO data Georeferencing Contextual Techniques	Cloud presence	Non-consolidated Products (research level)	YES	Operational use of Pleiades data
Supervised Classification applied to low resolution multispectral data (e.g. MODIS data)	Data Fusion Integration with calibration-data Georeferencing Contextual Techniques	Cloud presence, sub-sampling of the original raw data, calibration necessity on Mediterranean Basin	Consolidated Products (operational)	LOW	-

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Maps of flooded areas

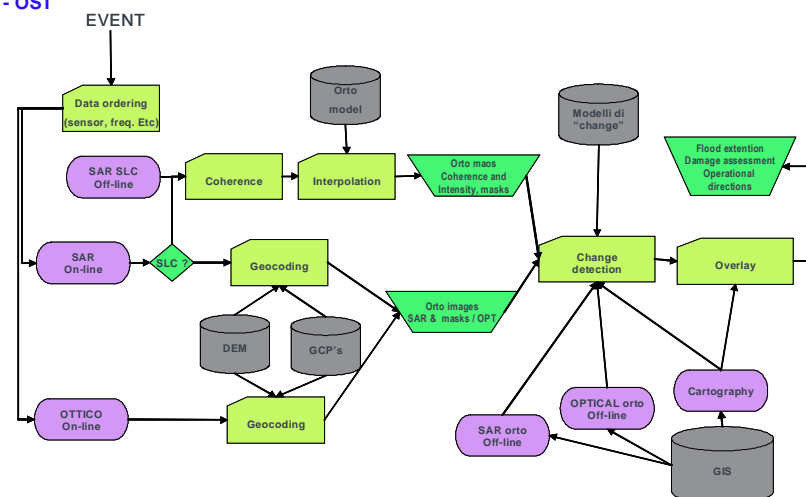
MAIN TECHNOLOGY	TRANSVERSAL TECHNOLOGY	PROBLEM	STATUS	Required Research Activities	Future developments
RGB composition of multitemporal optical data	Integration with non-EO data Georeferencing	Cloud presence, high purchase cost, long revisiting time	Consolidated Products	NO	Operational use of Pleiades data
SAR Interferometry, RGB composition	Integration with non-EO data Georeferencing	Low resolution, long revisiting time	Pre-operational Products	LOW	Operational use of COSMO-SkyMed and SAOCOM data
SAR Interferometry and Segmentation	Data Fusion Integration with non-EO data Georeferencing Contextual Techniques	Low resolution, long revisiting time	Non-consolidated Products (research level)	YES	Operational use of COSMO-SkyMed and SAOCOM data

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An operational processing chain proposed



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Space Segment Requirements

SENSOR TYPE (ACTIVE/PASSIVE)	SPATIAL RESOLUTION	SPECTRAL RANGE	RADIOMETRIC RESOLUTION	TEMPORAL RESOLUTION
PASSIVE	< 1 meter	Panchromatic Multi-spectral (Blue, Green, Red, Near Infrared)	8, 11 bits per pixel	0.5 – 6 hours
ACTIVE	< 1 meter	SAR X, C, L band	-	0.5 – 6 hours
PASSIVE	<1km	Infrared, MW	8, 11 bits per pixel	0.25 – 6 hours

COSMO-SkyMed Suitability

The damage mapping requires the following characteristics:

- the capability of very short response time and frequent revisit opportunities of a certain site
- high revisit time coupled with large spatial and spectral coverage, night/daylight and all-weather observations
- high spatial resolutions,

Most of the user needs have to be carried-out through a correct mix of Optical and SAR sensor observations.

The application should be based on multi-satellite Earth observation systems combined with a fast data reception capability. Such a provision of data on an operational basis with the associated implications of continuity and quality is an essential characteristic of the system.

COSMO-SkyMed, meet widely those requirements. If one adds Pleiades and SAOCOM the picture becomes almost complete.



COSMO projected use

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The utilisation of X-band is suitable for floods, landslides, volcanic and seismic risk management, and moreover for oil-spill detection and monitoring.

The proposed COSMO-SkyMed derived main products are:

- differential interferometric products (movements maps)
- soil moisture maps
- (wet) snow maps
- Risk prone areas, DTMs and elements
- flood maps
- land cover

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Conclusions

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ASI is developing competencies, technologies and user driven applications that have the objective to prepare the use of COSMO-SkyMed and of the systems (such as Pleiades and SAOCOM) for which there is access by means of agreements that include COSMO-SkyMed.

As it was defined at the beginning of the program as the main mission statement, and as it is resulting from the definition studies, the COSMO-SkyMed system can successfully support Risk Management applications.

To develop operational products based on COSMO-SkyMed, the teams propose to start investigating about extension of consolidated C-band technologies.

The COSMO - SkyMed system can also support other important environmental applications and the next cycle of studies is aimed to substantiate the above and define an other set of products and services to be subsequently developed.

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