Consiglio Nazionale delle Ricerche

NextData

un sistema nazionale per la raccolta, conservazione, accessibilità e diffusione dei dati ambientali e climatici in aree montane e marine

Project of Interest "NextData"

Proposal for a research project

Topic (number and title): Topic number 4, 'Armonizzazione dei dati esistenti ed eventuale conduzione di nuove misure di parametri idro-meteorologici e dei deflussi in bacini montani appenninici, concentrando l'attenzione sui siti campione, e messa a disposizione dei relativi dati in archivi coerenti con gli archivi del Progetto NextData'

TITLE OF THE PROPOSED PROJECT: Experimental hydrological database for Apennine basins

Project duration: 2013-2015
start date (before 31 January 2014): 7 January 2014
end date (no later than 30 September 2015): 30 September 2015

Scientific coordinator of the proposed project: Dr. Tommaso Moramarco

CNR Institute coordinating the proposed project: Research Institute for Geo-Hydrological Protection (CNR-IRPI)

Participating units, indicating the scientific responsible for each unit and the motivation for the inclusion in the proposal (in particular, illustrating whether and how the expertise of non-CNR partners is not available at CNR):

Unit 1 (CNR coordinating Institute): Research Institute for Geo-Hydrological Protection (CNR-IRPI); scientific responsible: Dr. Tommaso Moramarco.
CNR-IRPI has a consolidated experience in the analysis of hydro-meteorological data, flood formation processes, and development of hydrological-hydraulic modelling addressed to flood and drought hazard assessment also for ungauged basins. Moreover, CNR-IRPI has been involved for more than twenty years in research programs aimed to real time flood forecasting and optimal systems for water resources management. The team is involved in several research projects in the frame of Italian and European programs dealing with the matters of hydrological cycle also in a context of climate change.

Unit 2: University of Padova, Department of Land, Environment, Agriculture and Forestry (UniPD); scientific responsible: Prof. Marco Borga.
The University of Padova (UniPD) has a long experience in the hydro-meteorological monitoring field, mainly in mountain areas as the one selected as second pilot area of the project. The longstanding and fruitful cooperation with CNR IRPI in the hydrological monitoring and hydrological processes makes UniPD the most suitable partner to achieve the expected outcomes of the project.

1. GENERAL INFORMATION

Abstract of the proposed project

The project aims to the development of a Hydro-meteorological Management Database, based on collation and organisation of hydro-meteorological time series (precipitation, temperature, discharge) of two pilot Apennines basins. The Hydro-meteorological Database will be

complemented using radar rainfall estimates, soil moisture conditions and extensive streamflow information from ground-based measurements and remote sensing observations. The data will be quality controlled, geo-referenced and processed in order to obtain accurate estimates of hydrological variables for flood event analysis and for runoff regime assessment. An intermediate objective of the project will be the identification of methodologies for the quality control of the information gathered by the hydro-meteorological network. The Database will be used to provide data for the development of climate change scenarios through a model suite including Global Circulation Models (GCMs), downscaling techniques and hydrological models.

Main goals of the project

The objective of the project is the development of a Hydro-meteorological Management Database (HMD) as a component of the "Network of Excellence" that NextData aims to get for the hydro-meteorological monitoring of mountains areas. HMD will be developed on the basis of the collection of hydro-meteorological time series (precipitation, temperature, discharge) of two pilot Apennines basins that will be quality controlled, geo-referenced and processed in order to obtain accurate estimates of hydrological variables. HMD will be complemented using radar rainfall estimates, soil moisture conditions and extensive streamflow information from ground-based measurements and remote sensing observations. An intermediate objective of the project will be the identification of methodologies for the quality control of the information gathered by the hydro-meteorological network. Use of HMD will provide climate scenarios through a chain formed by Global Circulation Models (GCMs), downscaling techniques and hydrological models.

Under this umbrella, HMD besides to have the characteristic of a relational database of ground and satellite data, will be structured as a WEB-GIS platform allowing, on the one hand, the most wide sharing and participation of data by WEB and, on the other hand, a better use of data itself by GIS, the latter applied mainly for the identification of temporal-space pattern of hydrological variables and the inventory of thematic maps. To sum up, HMD will be a tool to manage and make available hydrological data, to share the products of the project in an easy and fast way thus providing a robust support for studies on the hydrological cycle of whatever basin in Apennines areas.

Expected results of the project

The expected results can be identified as in the sequel:

1) Collection, quality control and development of climate data archives.
2) Collection of hydro-meteorological data concerning historical flood events occurred in the pilot areas.
3) An integrated numerical package for weather radar rainfall estimation at the ground and for integration with existing raingauge data for extreme floods.
4) Archive of radar-derived rainfall estimates for extreme flood events.
5) Assessment of the existing monitoring networks adequacy for monitoring extreme floods; proposal of the required updating in the pilot basins.
6) Monthly campaigns of monitoring of soil moisture in hillslope and flow velocity in river sites of two pilot areas.
7) Collection and analysis of soil moisture time series data based on ground-based measurements and retrieved by satellite.
8) Procedures for soil moisture mapping at different spatial and temporal scale. Characterization of spatial-temporal soil moisture variability by statistical and geostatistical methods and identification of the main factors affecting this variability at different scales.
9) Procedures for discharge monitoring also for high floods by measuring the surface flow velocity. Characterization of discharge-flow depth relationship at a river site.
10) Procedures for post-flood surveying focused on assessment of flood peaks estimations at multiple locations on the river network.

11) Analysis of the climate variability of the available hydrologic series for the main variables (precipitation and temperature) and identification of actual trends (if any) for possible meteo-hydrological scenarios expected in the next decades, also in terms of runoff. For the latter, a continuous hydrological model will be come up with for the pilot areas.
12) Collection and analysis of time series of selected climate models (Hadcm3, PCM, ECHAM5, etc.) for the baseline period and for future climate scenarios at pilot areas.

Role of the different units

Unit 1: the CNR-IRPI will coordinate the project and will actively develop the planned activities. In particular, Unit 1 will plan and carry out the campaign of measurements and create the experimental climate database product for NextData. IRPI will collect and analyze hydro-meteorological data by also addressing the matter of streamflow measurements at river sites and soil moisture data from ground measurements and satellite. Analysis of actual and future climate scenarios will be the object of the Unit commitment as well. Finally, IRPI will be involved in the post-flood field documentation and post-event campaigns.

Unit 2: the University of Padova (UniPD) will focus the work on the Magra river basin. The contribution of Unit 2 will be mainly focused on i) the analysis of radar-rainfall estimates and ii) post-flood surveys, with the development of procedures for the operational application of the techniques in the context of extreme floods monitoring. Specific case studies in the two pilot areas will be organised and developed. Unit 2 will collaborate with the Coordinator mainly within the activities planned for WP1.a, WP1.b, WP1.c, WP2.a, WP2.d, WP2.e and WP2.f.

2. DETAILED PROJECT DESCRIPTION

State of the art and motivations

Hydrology is a science founded on observation. At catchment scale, meteo-hydrological data integrate a wide range of drivers and a diversity of characteristics (e.g. vegetation, geology, soils and topography). It is by comparing observations from different sites, that hydrologists develop an understanding of hydrological processes and responses. This understanding is embedded in, or underpins, models, guidance and advice provided to water managers and decision makers. The quality of this advice is clearly dependent on the accurate estimation of the main hydrological variables (streamflow, rainfall, temperature, evapotranspiration, soil moisture, ecc). These hydrological variables are, in addition, of paramount importance in the context of climate change, which is expected to alter the runoff production mechanisms, i.e. the flood regime is modified by the increasing frequency of extreme events, among them the flash floods. The Report of Intergovernmental Panel on Climate Change (IPCC, 2001; 2007) on potential effects of climate change highlights that "flood magnitude and frequency are likely (a 66-90% probability) to increase in most regions, and low flows are likely to decrease in many region". Mountain basins, which are both poorly covered by the hydro-meteorological network and key areas for water resources and hydrologic hazard management, require a targeted effort on hydrological monitoring (Grayson and Blöschl, 2001). Owing to these reasons, the new monitoring techniques (ground and remote sensing) for key hydrologic variables such as rainfall and temperature, on the one hand, and soil moisture and river discharge, on the other hand, are critically important in mountain areas. Moreover, the new technologies (radar, remote sensing), which are very attractive for the derivation of spatially distributed hydrological information, require the data validation with ground measurements. On these bases, a reliable hydrometeorological network is essentials for the water resources management, for the advance in the knowledge of the runoff generation process fundamental both for water resources management and for the Civil Protection activities of prevention and mitigation of the hydraulic-hydrologic risk.

The temporal and spatial characterization of the rainfall patterns at small scales is of fundamental importance to better understand the dynamics of the hydrological cycle and the triggering of hazards.Thus, gathering existing weather radar observations for the estimation of rainfall variability in space and time may provide key information to increase the quality of rainfall estimates over a wide range of spatial and temporal scales (Borga et al., 2011). This may also inform techniques, often based on geostatistical methods (Rodriguez-Iturbe and Mejia, 1974; Bacchi and Kottegoda, 1996; Tsintikidis et al., 2002), which aim to identify areas which are poorly covered by the actual network. In particular, for each topographic region (mountain, hilly and plain) it would be possible to identify the areas where the rainfall monitoring network density should be increased, taking also into account the need for weather radar calibration.
Another critical issue is linked to the natural spatial variability exhibited by many soils at the field and at the basin scale. In this case, it is fundamental to characterize the soil moisture space-time variability to model the hydrological response of a basin as well as land-atmosphere interactions. In fact, the root-zone soil moisture is considered as a key-variable controlling surface water (evapotranspiration, infiltration and surface runoff) and energy exchange between the land surface and the first layer of the atmosphere. Moreover, it was shown by many studies that for Mediterranean catchments soil moisture is the main factor controlling the flood formation process as well as erosion processes (Brocca et al., 2010).
An additional key quantity is the discharge at a river site, whose assessment is typically based on the availability of flow velocity measurements as well as of the cross sections surveys of the river reach. In practice, the river streamflow is continuously estimated by converting local stage records into river discharge values through a rating curve (Barbetta et al., 2013) whose accuracy is linked to the streamflow measurements range (Moramarco et al. 2004). Two key aspects have been identified in the literature in this concern. The first is the use of new radar technologies for flow velocity measurements which permit, on the one hand, to shorten the measurement time and, on the other hand, to execute the measurement also during high flow when conventional monitoring techniques fail (Corato et al., 2011). The second aspect is the execution of post-flood surveys which permit the estimation of peak flows at multiple sites along the river network (Borga et al., 2008).

Detailed description of the project, including the work plan, deliverables and milestones (explicitly indicating the activities of the different years)

The proposal will be structured into two Work Packages addressing:
1) the collection, organization and analysis of the available hydro-meteorological and climate data for the characterization of the meteo-climate evolution in Apennine mountain areas;
2) extensive experimental campaigns for soil moisture monitoring in hillslope portions and streamflow measurements at multiple river sites.
The project will implement its activities across two different Pilot River Catchments which are located in the Umbria and Tuscany/Liguria regions territory. The choice for these two basins is due to the availability of a large hydrological dataset. Besides, both basins are of interest in terms of water resource management and hydrological protection, also in a context of climate change, and the two participating Units have been investigating on these matters since almost a couple of decades. Therefore, the project partners are familiar with the current state and prevailing conditions in the pilot areas and have identified the relevant issues to be tackled during the proposal drafting phase. Finally, it is worth noting the location of two basins is easy to reach and this is an asset to carrying out ground measurement campaigns.
The main characteristics of the pilot areas are described in the sequel

Upper Chiascio River Basin (410 km^2): The basin is located in the Umbria region territory, with an Apennine climate, elevation ranging from 320 to 1550 m a.s.l. and mean slope of 24%. The length of the main channel is 33 km. Mean annual precipitation is 1050 mm and the mean annual temperature is 13.0 °C. Higher monthly precipitation values generally occur during the autumn-winter period. The hydro-meteorological network consists of eight rain-gauges, two hydrometric stations operating since 1998 and one soil moisture station working since 2009.

Magra River Basin: The basin is split between Liguria and Tuscany, with elevation ranging from 0 to 1910 m a.s.l. Mean annual precipitation is 1750 mm (with a monthly peak occurring on October and November) and the mean annual temperature is 13.9 °C. The monitoring network includes 55 raingauges and temperature gauges and 9 streamgauges, and two weather radar antennas. A detailed post-event survey is available for this basin after the flood occurred on Oct. 25, 2011.

The hydrological time series will be collected from dataset available for the two pilot basins and refer to a different spell according to management procedures of monitoring as well as the sort of hydrological variable. Specifically, for the Chiascio basin, sub-hourly series supplied by the Regional Hydrological Service of Umbria, and partly by IRPI, are available for a period of 25 years. For the Magra basin the sub-hourly series refer to a shorter period of 10 years and are supplied according to the location of stations by Regional Hydrological Service of Tuscany and ARPAL (Agenzia regionale per la protezione dell'ambiente ligure). To supplement, daily time series of rainfall and temperature lasting, on average, 70 years, belonging to the National Hydrological Service will be gathered for both basins as well.

WP1. Collection, organization and analysis of the available hydro-meteorological and climate data for the characterization of the meteo-climate evolution in the study areas.

A thorough and harmonized data screening will be first undertaken to identify and collect hydrometeorology data (rainfall, temperature, evapotranspiration, soil moisture, discharge, etc.). These data will be quality assured, processed and analyzed to achieve the required level of temporal and spatial resolution useful for analysis concerning the hydrological cycle. In case of data gaps coherent methodologies for filling and using proxy calculations will be commonly developed across the two pilot areas and the methodology will be made transparent so that possibilities of replicating it in areas different from the pilot ones. In addition, it will be established the adequacy of the existing monitoring network with particular emphasis to climate quantities of interest for the hydrological cycle. In a context of climate change, it will be also explored the evolution of the hydrological cycle through the analysis of the climate variability of the available hydrologic series and the ones provided by climate models downscaled ad hoc for the two pilot areas. For the latter, the monthly and daily climate time series will be gathered from available websites, e.g., https://esg.llnl.gov:8443/ WCRP CMIP3 (World Climate Research Programme, Coupled Model Intercomparison Project) and they will be selected for those climate models most representative of study areas and identified on the basis of ground measurements. Rainfall, temperature and soil moisture time series will be preliminarily selected, and other hydrological variables might add according to the objectives of NExtData project.

All the available hydrological-meteorological data, both past and expected in the short, medium and long term will be gathered into a geo-database following common specifications and in according with the standard of NextData. For that, additional dataset available (E-OBS, GPCC, GPCP, etc.) will be considered as well. Therefore, WP1 will be addressed through:

a. The identification of meteorological and hydrometric stations along with the corresponding metadata characterising the maintenance features;
b. Definition of the archive organisation, collection of the available hydro-meteorological data (precipitation, snow, temperature, soil moisture, water level, discharge, etc.) and data entry into a geo-referenced database.
c. A comprehensive approach for the pilot areas, encompassing post-flood field documentation, radar-rainfall estimation and model based consistency check of rainfall and discharge data..
d. Identification of antecedent wetness conditions of two pilot basins for flood events.
e. Analysis of the adequacy of the hydro-meteorological network to monitor the variables of the hydrological cycle.
f. Analysis of the climate variability of the available hydrologic series for the main variables (precipitation and temperature) and identification of current trends (if any). For the latter, a continuous hydrological model will be come up with for the pilot areas.
g. Collection of time series of selected climate models (Hadcm3, PCM, ECHAM5, etc.) for the baseline period and for future climate scenarios at pilot areas.
h. Analysis of climate scenarios time series for the characterization of the climate evolution and the ensuing runoff regime. Dynamic and statistic downscaling techniques will be applied for the climate change scenarios.

WP2. The realization of extensive experimental campaigns for soil moisture monitoring in hillslope portions and streamflow measurements in river sites

It is considered essential to accomplishing the targets of the project to organize ground measurements campaigns concerning soil moisture and discharge which will complement the dataset.
As regards soil moisture content estimates, these can be obtained by ground measurements, satellite data and hydrologic modelling. A multidisciplinary approach considering the integration of all the three techniques would allow overcoming the drawbacks of applying a single methodology, providing an effective monitoring of soil moisture content variability at the different scales. The added value of field campaigns is that they can address the assessment of soils hydraulic characteristics thus improving the understanding of runoff response under different geological, land use and saturation soil conditions.
For this activity a period of 24 months is planned during which soil moisture measurement campaigns in the two pilot areas using, in particular, instruments based on Time Domain Reflectometry (TDR) technology will be carried out. Additional information coming from satellite data will be gathered and make available for the dataset. In particular, Surface soil moisture data (~5 cm depth) will be obtained from active and passive microwave satellite sensors that are available for free. Specifically, the coarse resolution (~20 km) soil moisture products obtained from the Advanced SCATterometer (ASCAT) and the Soil Moisture Ocean Salinity (SMOS) mission will be collected for the study areas. The high resolution (~100 m) soil moisture products delivered from the ESA Sentinel-1 sensor, to be launched in 2014, will be analysed as well.
As far as the flow velocity measurement at river site is concerned, campaigns of measurements for different flow conditions will be carried out in order to obtain a consistent database for the analysis of discharge estimate methods. The campaign will last 24 months during which current meters and a portable radar system for the surface flow velocity measurements will be used. Considering that there is a robust relationship between the surface velocity, the maximum velocity and the mean flow velocity these three variables will be monitored and inserted in the dataset. In addition topographical surveys of river sites of interest for the pilot areas will be done as well. The technique will be implemented during high-intensity flood events to complement flood estimates obtained by

means of post-flood surveys. Therefore, the second stage will be developed according to the following steps:

a. Identification of experimental areas for soil moisture monitoring through TDR.
b. Collection of soil moisture estimates through remote sensing data and comparison with ground-based measurements.
c. Selection of river sites for streamflow measurements by conventional and "non-contact" radar sensors for surface velocity measurements.
d. Monthly campaigns for soil moisture and flow velocity quantities.
e. Development of accurate discharge-stage relationship for the river sites of interest in pilot areas.
f. Development of procedures for flood peak estimation based on post-flood surveying and velocity monitoring.

References

- Bacchi B., Kottegoda N.T. (1996). 'Identification and calibration of spatial correlation patterns of rainfall', Journal of Hydrology, vol. 165; p. 311-348, ISSN: 0022-1694.
- Barbetta S, Franchini M, Melone F, Moramarco T (2013). Enhancement and comprehensive evaluation of the Rating Curve Model for different river sites. J of Hydrology, Volumes 464–465, 25 September 2012, Pages 376-387
- Borga M., Gaume E., Creutin J-D., Marchi L. (2008). 'Surveying flash flood response: gauging the ungauged extremes', Hydrological Processes, 22(18), 3883-3885, DOI: 10.1002/hyp.7111.
- Borga M., Anagnostou E.N., Bloschl G., Creutin J-D. (2011). 'Flash flood forecasting, warning and risk management: the HYDRATE project', Environmental Science & Policy, 14, 834-844.
- Brocca L., Melone F., Moramarco T., Wagner W., Naeimi V., Bartalis Z., Hasenauer S. (2010). 'Improving runoff prediction through the assimilation of the ASCAT soil moisture product', Hydrol. Earth Syst. Sci., 14, 1881–1893
- Corato G., Moramarco T., Tucciarelli T., (2011), Discharge estimation combining flow routing and occasional measurements of velocity, Hydrol. Earth Syst. Sci., 15, 2979-2994
- Grayson R., Blöschl. G. (2001). 'Spatial patterns in catchment hydrology: observations and Modelling', CUP Archive, August 6.
- IPCC, 2001. Third Assessment Report. Climate Change (2001): Synthesis Report. Cambridge University Press, UK, 397pp.
- IPCC, 2007. Fourth Assessment Report. Climate Change (2007): Synthesis Report. Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.) IPCC, Geneva, Switzerland. pp 104.
- Moramarco T., Saltalippi C, Singh V.P. (2004). Estimation of mean velocity in natural channels based on Chiu's velocity distribution equation. Journal of Hydrologic Engineering, 9(1), 42-50
- Rodríguez-Iturbe I., Mejía J. M. (1974), 'The design of rainfall networks in time and space', Water Resour. Res., 10(4), 713–728, doi:10.1029/WR010i004p00713.
- Tsintikidis D., Georgakakos K. P., Sperfslage J. A.; Smith D. E., Carpenter T. M. (2002). 'Precipitation Uncertainty and Raingauge Network Design within Folsom Lake Watershed', Journal of Hydrologic Engineering, 7(2), 175–184, http://dx.doi.org/10.1061/(ASCE)1084-0699(2002)7:2(175).

Work Plan, Milestones and Deliverables

Milestones	Deliverables	Activity WP involved	Date
Kick-off meeting			2/15/2014
Hydro-meteorological archive organisation	Report on: Data collection and analyses for the main hydrological variables of two pilot areas	WP1.a WP1.b WP2.a WP2.c	4/30/2014
Historical flood events inventory	Report on: Post-flood field documentation	WP1.c	6/30/2014
Climate model selection	Report on: Selection of Global Circulation Models (GCMs) and acquisition climate time series for baseline period and future scenarios	WP1.g	7/30/2014
Hydro-meteorological time series quality analysis	Report on: Control, processing and analysis of hydro-meteorological time series also by filling the possible gaps	WP1.f	9/30/2014
Hydrologic model setup	Report on: Come up with continuous hydrological model for the two pilot areas	WP1.f	10/30/2014
Hydrological surveys	Report on: Soil moisture measurements by Time Domain Reflectometry and flow velocity by radar sensor (2014)	WP2.d	12/30/2014
Monitoring network optimization	Report on: The existing network and adequacy assessment	WP1.e	2/28/2015
Radar rainfall estimation procedures	Report on: Radar rainfall estimation procedures for extreme floods	WP1.c	4/30/2015
Extreme events	Report on: Procedures for flood extreme events	WP2.f	5/30/2015
Hydrological surveys	Report on: Soil moisture measurements by Time Domain Reflectometry and flow velocity by radar sensor (2015)	WP2.d	7/30/2015
Soil moisture and discharge observations	Report on: a) Soil moisture observation retrieved by satellite and ground measurements b) Discharge observation at river sites	WP2.b WP2.e	7/30/2015
Climate change scenario characterization	Report on: Climate evolution and runoff regime	WP1.d WP1.f WP1.h	8/30/2015
Hydro-meteorological Database	Integrated GIS Platform Data Base for NextData		9/30/2015

Motivations for the required budget and budget on a unit and year-by-year basis

The required budget derives from a careful assessment of developing the activities involved in the project. A sound cost-effectiveness ratio, in particular the ratio between estimated costs and expected results, is coherent with the activity that the project aims to develop. The ability to properly and comprehensive deal with crucial issues for the hydro-meteorological monitoring in mountain areas, as the Apennines, depends on the data availability and their climate representativeness. To this end, an accurate representation of hydrological cycle for these areas can be achieved through different stages of activity, each one having different cost of accomplishment and will require the involvement of human resources that will be used at different technical-specialist level, for the collection, monitoring and evaluation, as well as for the processing of data and information and the development of applications. This will entail costs due to investments in data acquisition and analysis, software, research grants and personnel. Details are provided for the two Units in the sequel.

Unit 1 (CNR-IRPI, coordinating Institute):
a) The cost of personnel is referred to four researchers covering 40% of total budget per year and corresponding to a total of 4 person-months per year. In particular:
- Dr. Tommaso Moramarco will serve as principal investigator and will commit 2 person-months of effort to this project. He will primarily be responsible for coordinating the project, planning the campaign of measurements and creating the experimental climate database product for NextData.
-Dr. Silvia Barbetta will commit 2 person-months of effort to this project and will be involved in the collection and analysis of hydro-meteorological data by also addressing the matter of streamflow measurements at river sites.
-Dr. Luca Brocca will commit 2 person-months of effort to this project and will primarily be involved for the collection and analysis of the hydro-meteorological data with a particular focus on soil moisture data from ground measurements and satellite. Analysis of actual and future climate scenarios will be the object of his commitment as well.
-Dr. Lorenzo Marchi will commit 2 person-months of effort to this project and will primarily be involved for post-flood documentation.

b) One research grant holder will be hired to work on this project. This individual will commit 4 calendar months per year. The research grant's primary focus will be on collection climate data and analysis, campaign of measurements, climate scenarios, and database setup.

c) Travel and accommodation is required for personnel and research grant holder considering the campaigns of measurements that will be done for soil moisture and streamflow velocity and the participation in the meetings of the project.

Unit 2 (UniPD)
a) One research grant holder will be hired to work on this project. This individual will commit 4 calendar months per year and 100% of his or her time to this research. The research grant's primary focus will be on collection and elaboration of weather radar data for the two pilot areas, procedures for post-flood surveys.

b) Travel and accommodation is required for personnel,the research grant holder and a PhD student for the campaigns of measurements that will be executed for post-flood surveys and for the participation in the meetings of the project. The PhD student is William Amponsah, enrolled in the PhD Course "Territorio, Ambiente, Risorse e Salute" of the University of Padova.

	first year	second year
Unit 1 (coordinator) CNR-IRPI	**35000 €**	**35000 €**
Unit 2 UniPD	**15000 €**	**15000 €**

Please attach the curricula and the list of relevant publications of the project coordinator and of the responsibles of each participating unit, and the summary budget table in attachment.

Signatures:

Project coordinator:
Dr. Tommaso Moramarco

Director of the CNR Institute coordinating the proposal:
Dr. Fausto Guzzetti