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Article

The role of the Italian scientific community in the first HyMeX SOP: an outstanding multidisciplinary experience

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Abstract

The first Special Observation Period (SOP1) field campaign of the HyMeX (HYdrological cycle in the Mediterranean EXperiment) program was held in fall 2012 and was devoted to the investigation of heavy precipitation and floods in the Western Mediterranean. Both the Italian research and operational meteorological communities actively participated by providing a valuable contribution through the organization of an *ad hoc* national Operational Centre. The paper presents an overview of this participation, resulting in a fruitful multidisciplinary experience able to build a bridge between academia, researchers, forecasters, end-users and decision makers. The benefits provided by the wide national involvement and the consequent possible national impacts and progress are discussed within the context of the complex organization of meteorology in Italy.

Keywords: HyMeX, Italian meteorology, heavy precipitation, flood, field campaign, NWP, research and operational synergy

1 Introduction

A better understanding and improved prediction of severe weather, especially in areas characterized by complex orography, represent urgent and challenging issues in the Mediterranean basin. The Italian territory extending into the middle of the Mediterranean Sea is prone to natural hazards associated with the water cycle, and to the consequent hydro-geological effects often related to its complex morphology (Lastoria et al., 2006; Salvati et al., 2010). Therefore, improving knowledge and forecasting of high-impact weather events is relevant not only for scientific research, but also for the socio-economical impacts in terms of operational and civil protection activities.

Several international research projects have recently tackled this issue, the last of which is HyMeX – HYdrological cycle in Mediterranean EXperiment (Drobinski et al., 2014). The first HyMeX field campaign, called Special Observation Period 1 (SOP1, Ducrocq et al., 2014), took place in fall 2012 from 5 September to 6 November. The general objective of the HyMeX program is to advance the scientific knowledge of water cycle variability in the Mediterranean basin, investigating phenomena distributed over a wide range of spatial/temporal scales, from the single meteorological event to inter-annual/decadal variability. In particular, the SOP1 was specifically addressed to improve the understanding and forecasting of the processes responsible for heavy precipitations and floods.

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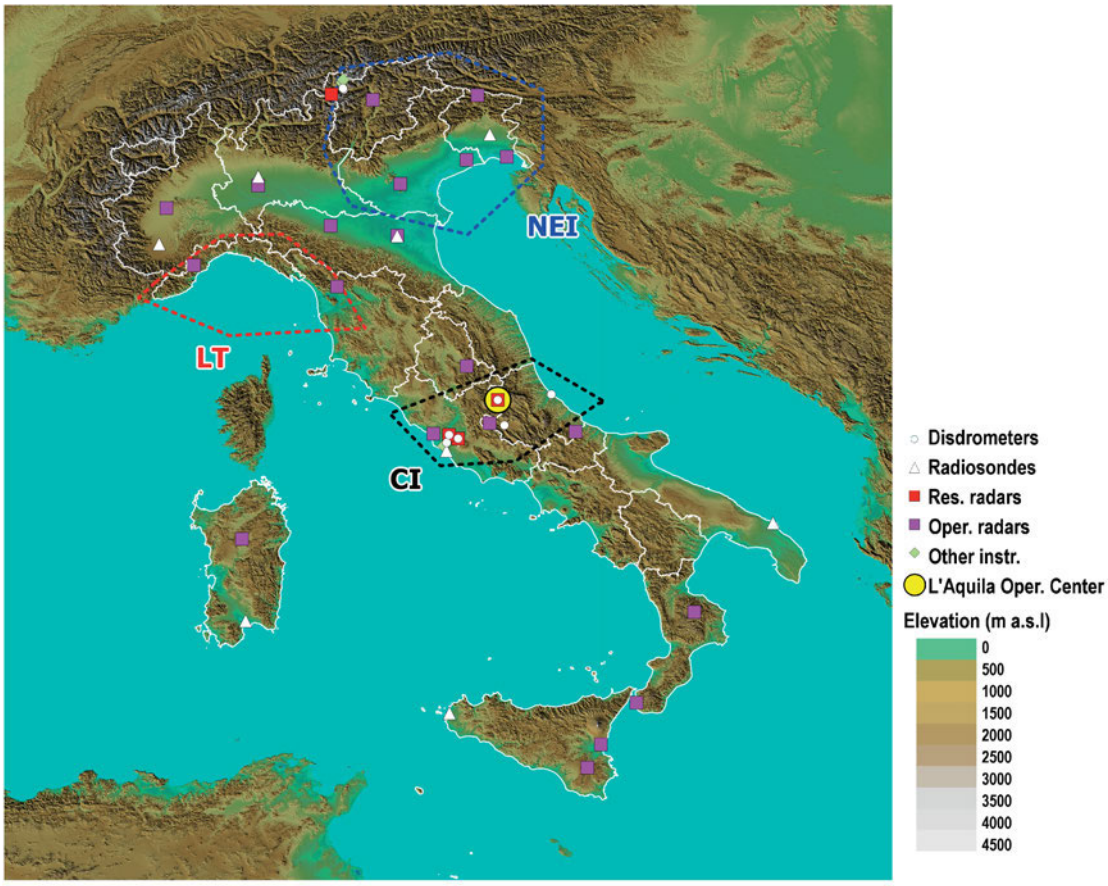

Figure 1: Map of Italy with the three areas (LT: Liguria-Tuscany; NEI: North-Eastern Italy; CI: Central Italy) identified as hydro-meteorological target sites during the SOP1. The locations of weather radars, radiosonde launching sites, disdrometers, and other instruments as well as the Operational Centre in L'Aquila are also displayed.

Among the target areas in the western Mediterranean basin monitored during the field campaign were three hydro-meteorological sites in northern and central Italy (Fig. 1). An Alpine site was selected in the region (north-eastern Italy) characterized by the maximum amount of mean annual precipitation (Isotta et al., 2013). The two other sites were selected in regions recently affected by heavy rainfall events, such as those occurring in fall 2011 that produced devastating effects in Liguria and Tuscany (see e.g. Rebora et al., 2013), as well as in central Italy (Ferretti et al., 2012). Indeed, similarly to the Alps, the Apennines, with steep slopes only 50–100 km from the coastline, can influence atmospheric motion at different scales. The Apennines are often responsible for triggering convective instability processes, which suddenly release energy and moisture gained through intense air-sea exchanges (Turato et al., 2004; Miglietta and Rotunno, 2012; Buzzi et al., 2014). Within small and densely urbanized watersheds present in most of the Italian territory, precipitation events persisting over the same area can result in dangerous floods in a relatively short time, sometimes leading to disastrous consequences (Borga et al., 2007; Silvestro et al., 2012; Marchi et al., 2013).

A large effort from the Italian community was put into the SOP1 campaign: Universities, Research Institutions and Regional Weather Services participated actively in the campaign, although no specific funding was available. A recent paper by Ferretti et al. (2014, FEA14 hereinafter) presents the monitoring and modeling activities undertaken by the Italian scientific community and offers an overview of the events that affected the Italian sites during the SOP1 period. In particular, FEA14 provides an evaluation of different model-based forecasting chains operating during the campaign for selected Intensive Observation Periods (IOPs). The present paper aims at describing the remarkable organizational efforts and daily activities at the HyMeX national Operational Centre (named VOC – Virtual Operational Centre), hosted by CETEMPS at the University of L'Aquila. The VOC was able to promote a fruitful collaboration among personnel from different Italian research institutions and operational centers. The valuable contribution provided to the campaign (Section 2) and the synergetic influence that the experiment exerted at a national level (Section 3.2) are discussed here within the context of the complicated situation of meteorology in Italy and of its foreseen development (Section 3.1).

Table 1: Italian institutions actively involved during the SOP1 and in the National Operational Centre activity (see acronym list).

RESEARCH INSTITUTIONS	UNIVERSITIES	OPERATIONAL SERVICES
CETEMPS,	L'Aquila,	LAMMA, ARPA-ER, ARPAV, OSMER
CIMA Foundation,	Naples (Parthenope),	ARPA-FVG, ARPA Piemonte, ARPAL
CNR (ISAC, IBIMET, IMAA),	Rome (La Sapienza),	Regional Functional Centers:
ENEA,	Padua,	Abruzzo, Umbria, Marche
ISPRA	Ferrara	DPC

2 SOP1: Role and contribution of the Italian community

HyMeX is an international long-term effort fostered by a French initiative. The HyMeX SOP1 was mainly supported by French institutions and agencies that made available logistic and operational facilities, including aircraft equipped with key instrumentation, to the international community involved. This context was favorable for an active participation of the Italian scientific community, which has been facing for years the important challenge of understanding and forecasting the mechanisms responsible for severe weather in the Mediterranean. Already before the campaign, the Italian community was active in the preparation of the scientific program and in the implementation of the operational plans. This activity included the identification of the target sites and of typical weather patterns over these regions, the definition of key processes to be investigated, the selection of dedicated instrumentation to be deployed within the target sites, and finally the planning of the most suitable flight tracks for monitoring different types of meteorological events.

During the SOP1, scientists and forecasters from more than 14 research and operational Italian institutions (Table 1) moved to the VOC on weekly shifts. Their duty was to support the main HyMeX Operational Centre (HOC) in Montpellier (France), providing their expertise in meteorological, hydrological and oceanographic modelling, forecasting and observational activities. NWP model outputs and nearly real-time observations were provided, analyzed and discussed. A comprehensive suite of high-resolution NWP models and ensemble prediction systems (see FEA14) was employed, in some cases even specifically implemented, at several national and regional institutions to provide forecasts for the SOP1.

Day-by-day decisions concerning operational activities were taken during videoconference discussions among the HOC and the other national centers, including the Italian VOC. Exploiting the expertise and knowledge of the local territory and meteorology, and the experience of forecasters from Italian regional centers, the VOC provided valuable support for detailed local weather predictions, weather reports and scheduling of additional observations. The contribution in planning the instrumented aircraft flights over Italy was particularly relevant considering the difficulty of the task. Two aircraft (detailed description in Ducrocq et al., 2014) operated from the Montpellier airport: a Falcon 20 equipped with radar and probes for cold microphysics measurements, and an ATR42 equipped with a lidar for water vapor and aerosol measurements in the lower atmosphere. Missions, tracks and take-off times for these aircraft had to be decided well in advance (within 1100 UTC of the day before the flight), thus requiring reliable deterministic and probabilistic predictions concerning the development of the convective systems to be monitored and documented. Among the Italian efforts during the campaign, a striking example of a valuable contribution was during IOP13, on 15 October 2012 (see details in FEA14), when the Falcon 20 flight covered the route between the Tyrrhenian and Adriatic Seas across the Central Italy site, passing twice over Rome. The flight coincided quite well in time with the passage of an intense convective line, complementing the observations from the CNR ISAC ground-based research dual polarization C-band radar in Rome.

The role of the Italian community was not only confined to operational support, but also included an extraordinary deployment of advanced research instrumentation (Fig. 1, more details in FEA14), complementing the operational monitoring. In particular, a dense instrument network installed over the Central Italy site (including radars, sodar, lidar and a disdrometer network, among others) was able to operate in synergy with the dedicated aircraft observations. This allowed for capturing the marine inflow feeding the precipitating systems and the microphysical characteristics of the convective systems developing and moving inland. During the campaign, CNR ISAC also provided the LINET (Betz et al., 2009) lightning activity maps over Italy. Moreover, several extra radiosoundings were launched in addition to the ordinary scheduled activity, in the standard GTS-WMO sites as well as in dedicated locations, upon request of the VOC. It is also worth stressing that the Italian National Civil Protection Department (DPC), in cooperation with the CIMA Research Foundation and other regional and national authorities, provided in near-real time the rainfall data collected from an observational network of 24 weather radars and about 3000 rain gauges (Fig. 2) mainly belonging to regional weather agencies. This data collection continued till after the end of the second SOP campaign held between January and March 2013. This represents an exceptionally dense and well-distributed monitoring system, which has never been available before in real-time over the whole of Italy in the context of a scientific field campaign.

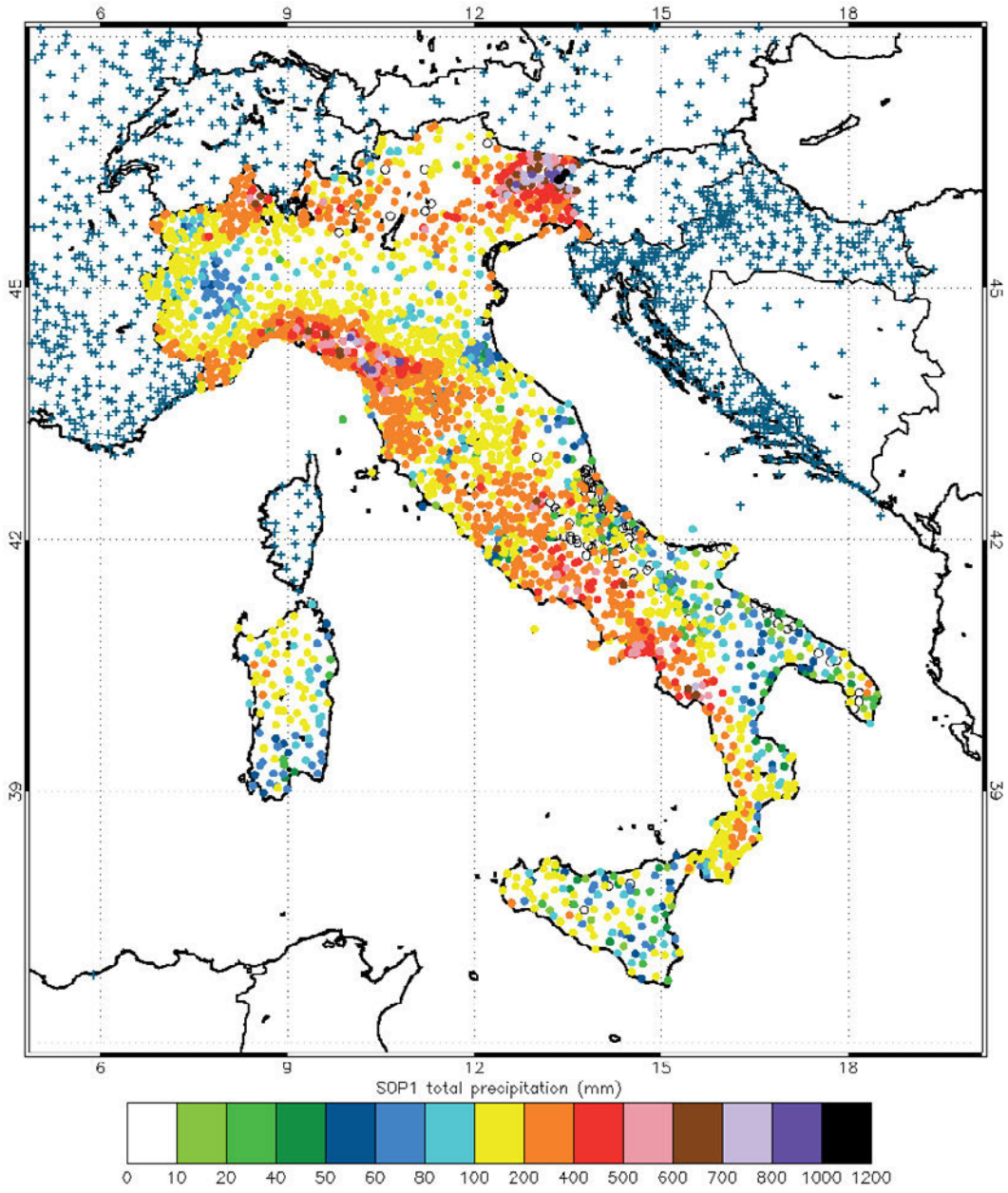

Figure 2: Total precipitation measured by the Italian dense rain gauge network available in real time, cumulated over the whole SOP1 period. Noteworthy is the largest amount of rainfall observed over the target sites.

The two-month SOP1 period was characterized by a positive rainfall anomaly with respect to climatology. Nine out of the sixteen IOPs dedicated to heavy precipitation events affected the Italian sites (Fig. 2). The importance and success of the national effort is even more evident considering that a relevant number of events with different characteristics and degree of predictability were documented. These events are currently under investigation in the framework of scientific collaborations fostered by the SOP1 experience (FEA14; Marsigli et al., 2014; Manzato et al., 2015 in addition to a number of contributions to recent conferences and several submitted papers).

3 SOP1 impact on national meteorology

3.1 Historical background

Before analyzing how the scientific Italian community has benefited from this international initiative, it is necessary to provide the historical background leading to the current complex and fragmented situation of Italian meteorology. This situation has been characterizing the national meteorology for a long time, at least from the beginning of the 20th century, as described in

Visconti and Marzano (2008, VM08 hereinafter) and in Palmieri (2000). After the First World War, around 1925, the meteorological sector was assigned to the Italian Military Air Force that assumed *de facto* the role of national weather service, thus becoming the Italian representative at the World Meteorological Organization (WMO) and at other European intergovernmental meteorological organizations (e.g. ECMWF, EUMETSAT). At present, this represents an exception in Europe where civil meteorological services operate. At the same time, regional meteorological centers started to develop in the early 1980s, so that forecasting and warning duties were distributed among the national military service, several civil regional services and, later, the DPC. Such a situation was finally structured and organized in 2004 by an Italian Prime Minister Directive, which established the national hydro-meteorological warning system. Unfortunately, the anomalous historical background has allowed neither a development of a specific academic educational trail, similar to other European countries, nor a suitable national funding for meteorological research (VM08). In fact, as far as academia is concerned, only a few specific courses in Meteorology and Atmospheric Physics at a few Italian universities have been instituted, mainly associated with physics departments. In this scenario, a breath of novelty is the recent decision by the Italian Government, still under discussion, for a re-organization of the meteorological services. In particular, the Law n. 100/2012 updated the duties of the DPC in terms of civil protection and thus revived the discussion about the challenge of coordinating the national and regional agencies in a "distributed" civil national meteorological service. A dedicated working group, coordinated by DPC, has already prepared a preliminary version of the Presidential Decree that should establish the organization of such a nationally distributed meteorological service. This Presidential Decree draft has been submitted to the Government and it is available for discussion among the Italian scientific and operational communities.

3.2 The SOP1 contribution

The field campaign required a huge effort in terms of coordination and logistics. This effort was neither supported by specific funding, nor by the direct involvement of the National Air Force Weather Service. Both these aspects had instead a significant role during previous international meteorological projects and experiments, such as ALPEX (Davies and Pichler, 1990) and the Mesoscale Alpine Programme field campaign (MAP, Bougeault et al., 2001). Similarly to HyMeX, both ALPEX and MAP involved a wide international scientific community, including a relevant Italian participation. However, differently from ALPEX and MAP, the Italian contribution to the HyMeX SOP1 was driven by a bottom-up process, completely based on in-kind resources. This unfortunately limited additional experimental activities and even a larger involvement, but it did not prevent positive outcomes.

In this context, the activity promoted by the SOP1 and coordinated by the *ad hoc* national Operational Centre represented a unique experience for most of the participants and an important test bed overall, stimulating, at least temporarily, the collaboration in the Italian meteorological community and thus reducing its fragmentation. Steered by the international framework, this was an opportunity for multidisciplinary activities characterized by an unprecedented cooperation (at least as far as the bottom-up process is concerned) among the meteorological, hydrological and oceanographic scientific and technical communities involved, with both modelling and observations. The large Italian participation to the SOP1 and to the VOC was heterogeneous: it included universities, research institutions, regional meteorological services as well as the national environmental agency (ISPRA) and DPC (see Table 1).

In addition to the international morning briefing between the HOC and the other national operational centers, a daily web conference was organized among all the Italian participants. This cooperation gathered together people not usually in contact during everyday professional activity because of the lack of collaboration among the currently scattered meteorological organizations. Scientists and forecasters were involved together in weather predictions as well as in the decision support process, by integrating modeling activities with the monitoring of the atmosphere and the Mediterranean Sea. Sharing personal know-how and expertise facilitated a gain in mutual confidence and the development of a bridge between academics, researchers, forecasters, end-users and decision makers. That means scientists dealing with NWP model development could share their knowledge with forecasters who act as end-users of their research products. Vice versa, forecasters directly provided feedback to scientists concerning model performance, usability, and suitability of graphical products. Moreover, it was an opportunity for forecasters to learn about different operational modes of other regional services, allowing discussions and feedbacks to be reported to their own centers. It is also worth mentioning the training opportunity for under-graduate and graduate students who took part in the decision making process, as well as in the international and national briefings. This process has led to new collaborations and scientific initiatives, currently on-going, in the context of the HyMeX program and SOP1 data analysis.

4 Concluding remarks

The experience gained during the HyMeX SOP1 field campaign and the activities planned for the upcoming years represent an important opportunity for exploiting the synergy within the Italian research and operational communities. Such a wide and close collaboration has never been experienced before in the fragmented context of Italian meteorology.

From the scientific research perspective, the availability of a unique database of observations and model simulations for the study of intense orographic precipitation will improve the knowledge and forecasting ability of high-impact weather events, a topic of scientific and socio-economical strategic relevance. The SOP1 terminated only two years ago and therefore only a few collaborative studies have been published so far. However, the number of submitted papers and recent contributions to conferences proves already the positive impact of the SOP1 experience and indicates that some collaborations generated or reinforced during the campaign, are proceeding and providing results.

From the Italian meteorological perspective, we believe and hope that this experience, quite extraordinary considering that it was undertaken without any specific national support and coordination, can be considered as an example in view of the forthcoming reorganization of the national civilian weather service. We hope that it will make the most out of the experience and contributions that the involved institutes demonstrated to be able to achieve. A relevant capability for monitoring activities, as well as an outstanding expertise in NWP models development and implementation have been demonstrated; the latter, in particular, in a context of ensemble probabilistic and multi-model forecasting which currently represents the state of the art of numerical weather predictions.

The first practical follow up, fostered by the collaboration established during the SOP1, is the organization of an informal group, now evolving towards a formal association of forecasters and researchers in the field of meteorology. This group aims at promoting with a bottom-up approach a shared idea of the civilian national meteorological service, providing a contribution to the ongoing discussion. The formation of a solid network among different subjects at a national level is essential to establish the collaborative environment where all expertise can interact and merge (e.g. scientific research, operational forecasting, warning and civil protection), as happened during the SOP1. However, to what extent the latter experience will really impact the organization of the distributed national meteorological service is difficult to foresee and will probably depend on how (e.g. bottom-up vs top-down) and to what extent the Italian meteorological community will be involved in the process.

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Appendix: Abbreviation list

ARPA – Regional Agency for Environmental Protection

ARPAL – Regional Agency for Environmental Protection of Liguria Region

ARPA SIMC – Regional Agency for Environmental Protection, Hydro-Climate-Meteorological Service (Emilia Romagna region)

ARPAV – Regional Agency for Environmental Protection of Veneto region

CETEMPS – Centre of integration of remote sensing Techniques and numerical Modeling for the Prediction of Severe weather

CIMA – International Centre on Environmental Monitoring

CNR – Italian National Research Council

DPC – Italian National Civil Protection Department

ECMWF – European Centre for Medium-Range Weather Forecasts

ENEA – Italian National Agency for New Technologies, Energy and Sustainable Economic Development

EUMETSAT – European Organisation for the Exploitation of Meteorological Satellites

HOC – HyMeX Operational Centre

IBIMET – Institute of Biometeorology

IMAA – Institute of Methodologies for Environmental Analysis

ISAC – Institute of Atmospheric Sciences and Climate

ISPRA – Institute for Environmental Protection and Research

LAMMA – Environmental Modelling and Monitoring Laboratory for Sustainable Development

NWP – Numerical Weather Prediction

OSMER ARPA FVG – Regional Meteorological Observatory, Regional Agency for Environmental Protection of Friuli Venezia Giulia region

VOC – Virtual Operational Centre

WMO GTS – World Meteorological Organization Global Telecommunication System

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