



WORLD
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WEATHER CLIMATE WATER

Global Campus Innovations

**Volume III – Collaboration in Education
and Training**

ETR-27



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CONTENTS

Introduction	2
<i>Patrick Parrish</i>	
1. Developing and implementing a virtual workshop: <i>Meteorology in the framework of disaster risk reduction – Interaction between National Meteorological and Hydrological Services and decision-makers</i>	3
<i>Daniela D’Amen and Matias Menalled</i>	
2. D-A-CH-cooperation: An example of efficient and well-targeted training	8
<i>Wilfried Jacobs</i>	
3. Transboundary partnerships for capacity development and effective coastal zone management	14
<i>Maria Mamaeva, Vladimir Zhigulskiy, Alina Nazarova, Nikolay Bobylev, Michail Shilin, Esa Hamalainen, Sari Nyroos, Olli-Pekka Brunila, Riku Varjopuro and Janne Saarikoski</i>	
4. Multi-partner innovations in forecast uncertainty training.....	19
<i>Andrea Smith, Bryan Guarente, Francis Wu and Stephen Kerr</i>	
5. Collaborative efforts to increase efficiency and leverage expertise in hydrology.....	33
<i>Maria Mamaeva, Galina Pryakhina and Mikhail Georgievsky</i>	
6. Adaptation of existing training material from the international community for the purposes of the German Meteorological Service.....	37
<i>Wilfried Jacobs</i>	

Introduction

Patrick Parrish

The WMO Global Campus Initiative is first and foremost about finding new ways to collaborate. Collaboration brings greater capacity, but also a greater number of perspectives and insights to serve innovations. This volume brings together chapters focused on a number of ways to use groups of collaborative partners to foster innovation:

- D'Amen and Menalled report on the development and delivery of a virtual workshop involving disaster risk reduction (DRR) partners from national meteorological and hydrological services and disaster response agencies.
- Jacobs describes how three European countries with language and geographic affinities work together to address their learning requirements in operational meteorology, generating great savings in time and effort.
- Mamaeva et al. describe an interdisciplinary and cross-border collaboration to address workplace requirements for sustainable shore development in the transboundary coastal zone of the eastern Baltic region.
- Smith et al. provide the story of an international and intercontinental collaboration to design and develop a series of self-directed training resources on forecasting uncertainty with ensemble prediction system products.
- Mamaeva et al. highlight the benefits of collaboration and cooperation between a hydrological university and national hydrological and meteorological service to ensure that university graduates gain important practical skills during their studies.
- Jacobs describes the challenges and significant benefits of adapting existing educational resources on radar meteorology to a new country and climate regime and making these adaptations available to the international community.

For a general introduction to the entire publication and to innovation processes, please refer to Volume I.

1. Developing and implementing a virtual workshop: *Meteorology in the framework of disaster risk reduction – Interaction between National Meteorological and Hydrological Services and decision-makers*

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Abstract

This chapter describes a virtual workshop for the promotion of effective coordination between National Meteorological and Hydrological Services (NMHSs) and decision-makers for the issuance of early warnings for disaster risk reduction and management in Argentina. The virtual workshop was developed by the Argentinian National Meteorological Service (SMN). Its development and implementation followed the guidelines of the World Meteorological Organization (WMO) regarding the role of NMHSs in the reduction of disaster risk, on the basis of the Hyogo Framework for Action 2005–2015 and the Sendai Framework for Disaster Risk Reduction 2015–2030. The steps in the virtual workshop are summarized, and its applicability to civil protection for disaster risk reduction at national and sub-national levels is demonstrated. Incorporating country-specific participatory tools that ensure fluid communication among participants will enhance the global applicability of the virtual workshop format as a new and powerful tool to raise the awareness of disaster risk reduction among NMHSs and emergency agencies.

Keywords: Virtual workshop, disaster risk reduction, National Meteorological and Hydrological Services, emergency agencies

1.1 Introduction

In 2017, the Argentinian National Meteorological Service developed the virtual workshop *Meteorology in the framework of disaster risk reduction: Interaction between National Meteorological and Hydrological Services and decision-makers*. The workshop was targeted at the National Meteorological and Hydrological Services (NMHSs) and emergency agencies of Regional Association III (South America) of the World Meteorological Organization (WMO). Its main objective was to strengthen coordination among different institutions involved in disaster risk management in the Region by promoting effective sharing of meteorological information among different users for disaster risk reduction (DRR). To this end, the Argentinian National Meteorological Service created an office to integrate the social science dimensions of disaster risk management in its operations so as to be able to properly orient decision-makers in relevant national institutions involved in DRR, such as Civil Protection and Defence.

The virtual workshop followed the WMO guidelines regarding the role that NMHSs should play in disaster management, on the basis of the Hyogo Framework for Action 2005–2015 and the Sendai Framework for Disaster Risk Reduction 2015–2030. The workshop promoted the coordination of NMHSs in the Region in all aspects of disaster risk management, in particular the process of issuing early warnings. To benefit fully from the virtual workshop, the user needs to learn how to use official meteorological information. In addition, there should be good collaboration between the NMHS and emergency agencies of each country.

The following pages describe the experience and lessons learnt from a four-week virtual workshop, which could be useful for other countries that want to improve their DRR processes or intend to incorporate its dynamics in their operations. The main steps involved in the development of the workshop platform are also described.

1.2 Virtual workshop design

The virtual workshop featured five steps.

The first step was the constitution of a working team in each country. The working team was composed of three members: one each from the partner NMHS, the National Civil Protection and the Local Civil Protection agencies in each country of WMO Region III. The tasks to be carried out were properly articulated and shared among the members of the team. This was to promote collaboration among representatives of government agencies involved in different aspects of risk management. Each country was given a time limit within which to clarify the tasks and make a PowerPoint presentation. In addition, the Argentinian team, using guiding questions, facilitated forum discussions among countries. A unique aspect of the workshop was that the Argentinian team worked as tutors and at the same time as participants, having previously performed the same tasks that were requested of the other teams. This not only enhanced the clarity of the tasks that were to be accomplished, but also enabled the Argentinian National Meteorological Service to share its work experience with the National Civil Protection and Provincial Civil Defence agencies.

In the second step, during a workshop for the tutors, it was proposed that each participant would make a presentation on the activities of his or her place of work. Each presentation was to focus on the mission, competences and structure of the institution to which the participant belonged. The presentation was also to stress the working relationships that existed between each NMHS and the emergency agencies, such as the National Civil Protection and Provincial Civil Defence, operating in each country, and to describe their organigrams. The purpose of the approach, which included the contextualization of the various institutions involved in disaster risk reduction in each country, was to share experiences among the WMO Regional Association III (RA III) countries and to share information on the status of legislation regulating state intervention in disaster risk management in different countries. The outcome of the second step was a comprehensive document that reflected different aspects of national early warning systems in the same PPT document (see Figure 1.1).



Figure 1.1. The virtual workshop: one of the outcomes of STEP 2

In the third step, which followed the initial presentation, each team was asked to collect information on the forecast products that could be used in integrated risk management and to generate a flow chart for the channels of communication that each institution had in place. From these materials, the participants from each National Civil Protection agency prepared a chart that associated each forecast product from the NMHSs with actions (internal and external) that the agency implemented (see Figure 1.2). This was done to explore potential synergies among the different Defence and Civil Protection agencies in their use of meteorological information and forecast products in their own activities. It was also to show how NMHSs incorporate the perspective of the emergency agencies in the construction of forecast products and to verify the extent to which meteorological information was focused on forecast users. In addition, the exercise at this stage provided some information on the next steps to improve the users' comprehension of meteorological information, with emphasis on the need for coordination among the participants from different agencies. Thus, the virtual workshop was not only an opportunity to share and exchange experiences, but also a concrete way to share work experiences from a DRR perspective.



Figure 1.2. Virtual workshop: one of the outcomes of STEP 3

The fourth step involved an activity that integrated what had been produced in previous steps. Each team was asked to select a high-impact meteorological event that had happened in its country and for which there was adequate information. Members of the NMHS in each team then reconstructed the forecasts that were issued for the event while members of Civil Protection and Defence agencies detailed the actions taken on the basis of the information provided at different times. In this way, the participants had to reconstruct what had happened in the event and then to analyse the products that were issued by NMHSs and the actions that were later implemented by the Civil Protection and Defence agencies. This task once again required joint work among members of different institutions. While the meteorologists had to make a brief description of the event and recover the various forecasts issued by NMHSs, members of emergency agencies had to recover their files related to the forms of organization and intervention they had made during the event. Then, they had to link that information with the different components of DRR. In this way, the forecasts at different meteorological scales and products issued by NMHSs were associated (see Figure 1.3).

Impactos

- **Municipios de la Provincia de Buenos Aires afectados (total 38):**
 - Luján, Lobos, San Antonio de Areco, Salto, La Matanza y Arredóes, Balcarce, Berisso, Ensenada, Bragado, Campana, Capilla Del Señor, Capitán Sarmiento, Castell, Chacabuco, Chivilcoy y Escobar, Esaltación De La Cruz, Lomas de Zamora, Mercedes, San Miguel del Monte, Pila, Pilar, Quilmes, Saladillo, General Viamonte, Zárate, Pergamino, Baradero y 25 de Mayo, Navarro, Castell, Dolores, Chascomús, Saladillo, Pergamino, Zárate y Rauch.
- **Organismos involucrados en las tareas de asistencia de manera directa:**
 - **Por la Provincia de Buenos Aires:**
 - Jefatura de Gabinete de Ministros, Ministerio de Salud, Dirección Provincial de Emergencias Sanitarias, Ministerio de Seguridad, Policía Bonaerense, Superintendencia de Seguridad Sinistral, Dirección General de Defensa Civil, Ministerio de Asuntos Agrarios, Secretaría General de la Gobernación, Comisión Provincial de Guardavidas, Ministerio de Desarrollo Social, Dirección Provincial de Emergencias, Ministerio de Infraestructura, Autoridad del Agua, Dirección Provincial de Saneamiento y Obra Hidráulica, Organismo Provincial para el Desarrollo Sostenible, Grupo Banco Provincia, 4 Federaciones de Bomberos Voluntarios de la Provincia de Buenos Aires
 - **Por la Nación:**
 - Jefatura de Gabinete de Ministros, Ministerio de Desarrollo Social, Ministerio de Seguridad, Ministerio de Defensa, Servicio Meteorológico Nacional, Servicio de Hidrografía Naval, Instituto Nacional del Agua
- **Rutas cortadas por agua en la calzada:**
 - Ruta 50 entre RN 7 (Vedia), RP 65 (Grafi. Arenales), Ruta 32 tramo Pergamino-Salto, Ruta 45 entre Ruta 31 y La Angelita cortada por construcción de alcantarilla aliviadora, Ruta 191 entre Arrecifes y Salto, Ruta 29 cortado entre General Belgrano y Ayacucho, Ruta 65 entre Los Toldos y 9 de Julio, proximidades al cruce Ruta 70
- **Rutas habilitadas pero con presencia de agua en calzada:**
 - Ruta 51 entre Ruta 30 y Ruta Nacional 5, Km 182,5, a 7 Km de Ruta 30, Ruta 46 y Acceso a Morse, Ruta 30 tramo Las Flores-Rauch, Ruta 30 altura Chivilcoy.
 - Tránsito asistido. . Ruta 29 en km 172. . Ruta 41 altura municipio de San Antonio de Areco. . Ruta 41 km 240. Tránsito asistido.
- **A nivel periodístico la cifra de damnificados que se maneja es de 20.000**

Fuente: Informe sobre evolución y estado de situación Inundaciones en la Prov. de Buenos Aires, elaborado por la Dirección Provincia de Defensa Civil, Ministerio de Seguridad, Gobernación de la Provincia de Buenos Aires.

Figure 1.3. Virtual workshop: one of the outcomes of STEP 4

This activity allowed practitioners to put into practice one of the central tenets of DRR by focusing not only on the response, but also on strengthening the implementation of actions in the stages before and after a meteorological event. Thus, it contributed to the review of the WMO guidelines on the role of NMHSs in DRR. There was also interaction among different institutions carrying out the task. This aspect of the virtual workshop consolidated the previous tasks and enabled further understanding of the theoretical basis of DRR. It also brought out some challenges that may be encountered in translating these aspects of DRR into practice due to complex interaction of the multiple factors contributing to disasters.

The final phase of the virtual workshop started with video discussions among the participants to review the content and its relevance for the first regional workshop. The purpose was to share perceptions about the process, lessons learnt and challenges, as well as concerns that could be critical inputs for future workshops on disaster risk management. At the beginning of the discussions, the most significant difficulties in integrated risk management were exposed. Common challenges mentioned during the video discussions included current legislation, the organizational structure and the imperative for intra- and inter-institutional coordination. Thus, we recommend that this strategy of video discussion should be an integral part of the workshop since it is difficult to find out the opinions of participants in a purely virtual format.

In addition to the video call, an online SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of the virtual workshop approach was undertaken among participants to evaluate the benefits of the exchanges that took place among countries in the Region and to get participants thinking about the success factors and challenges of the workshop. Furthermore, regional challenges that could affect the future application of the workshop methodology in the Region were evaluated. The SWOT analysis and feedback from participants from different countries indicated that the use of participatory tools and good communication among participants are critical to the success of the virtual workshop for disaster management at the regional level. This workshop also made it possible to explain the importance of the development of other workshops at a regional level as they facilitate the sharing of work experiences. In this regard, the workshop served as a forum for the exchange of experiences at regional level between NMHSs and emergency agencies. It also

fostered the sharing of theoretical material to help focus the products of NMHSs on specific users. Thus, the virtual workshop has been adopted as a new and powerful tool for DRR among NMHSs and emergency agencies of RA III.

The workshop outcomes, however, pointed out the need for advances in the generation of meteorological products and specific actions in the four components of DRR: prevention, preparedness, response and reconstruction.

At the end of the virtual workshop the original materials prepared by the members of each working team were consolidated into a final document to reflect the experience of the four weeks.

1.3 Conclusion

This chapter highlights the novelty of integrating social sciences with meteorological information in disaster risk reduction and management among NMHSs through a virtual workshop methodology. It also shows the value of getting NMHSs and emergency agencies to work together in DRR, as practically demonstrated for RA III. We hope that other professionals in different Regions of WMO will find this virtual workshop methodology useful to enhance their approach to DRR.

The final workshop report is available [here](#) and on the WMOLearn portal.

2. D-A-CH cooperation: An example of efficient and well-targeted training

Wilfried Jacobs, German Meteorological Service (Deutscher Wetterdienst)

Abstract

This chapter describes the reasons and strategies for the establishment of the D-A-CH cooperation for training weather forecasters primarily in three central European countries. D-A-CH involves the German, Austrian (including the Central Institution for Meteorology and Geodynamics (ZAMG) and, starting in 2020, Austro Control) and Swiss meteorological services, with additional support from the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). The goal is to organize one blended-learning course each year, using a multi-week online phase to cover a range of weather phenomena, and a one-week classroom phase to delve deeper into a single topic and provide more opportunities for forecasting exercises. The D-A-CH cooperation, by sharing resources and alternating leadership in training development and delivery, is expected to generate substantial savings for the participating meteorological services—up to 15 weeks of personnel time for the service acting as the course lead, and up to 19 weeks of savings for those not leading in that year.

2.1 Challenge for services

Enabling forecasters to do their jobs according to rapidly changing requirements is a continuous challenge for training. Forecasters do not need only scientific competence but also the ability to put manifold information into a complete and logical conceptual model of significant weather developments, often under time pressure, and to issue forecast products that are tailored to the needs of individual customers. Forecaster training has to be offered regularly because each service has to fulfil international ISO and WMO standards.

2.2 Opportunities and challenges of international cooperation

Although services may have powerful resources to overcome these challenges, each service needs help from the others. Many training projects and institutions offer high-quality training material about many different topics, as well as trainers and technicians with high-level expertise and a modern and powerful infrastructure. However, several challenges remain. Forecasters have to cover different regions with different climates, and forecast products must be tailored to the demands of customers in different countries and industries. The technical equipment and facilities at different locations have to be taken into account in the training process. The biggest challenge in meeting international needs is the diversity of the workforce itself, with different background knowledge and cultures. Not all participants in international training seminars have the same first language. Because translation often cannot be offered, many courses have to be delivered in English, in which not all participants are proficient.

2.3 Why D-A-CH courses?

Despite these challenges, international cooperation is an important resource for forecaster training. However, it makes sense to define regions that have similar conditions and similar working techniques. For decades, a close partnership has existed between the weather services of Germany, Austria and Switzerland (D-A-CH). Analogous to the successful cooperation of the Nordic Meteorological Competency Training (NOMEK), the three directors of these services met in 2016 and decided to extend D-A-CH cooperation to include

forecaster training, because the requirements and forecasting techniques are rather similar within the D-A-CH community and because this cooperation would lead to a win-win situation due to its synergies.

2.4 Brief history and organizational matters

The European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) is also very interested in forecaster training in Central Europe, especially in the use of the new products of Meteosat Third Generation satellites, whose launch is scheduled for 2021. In order to ensure training of as many forecasters as possible, EUMETSAT has agreed to provide financial support for travel.

In June 2017, the D-A-CH expert team met for the first time in Langen (with members from ZAMG, MeteoSwiss, the Meteorological Training Centre and the Central Forecasting Unit of the German Meteorological Service (DWD) and EUMETSAT). Austro Control, responsible for Austrian air navigation, joined D-A-CH in 2020. During this meeting, the target group (forecasters with knowledge of synoptic meteorology), the learning objectives, the learning platform and the forecasting timescale (very short-range forecasting and nowcasting) were established. The group decided to offer a blended seminar (an online phase followed by a classroom phase). The general course structure, the tasks and responsibilities of the participating services and milestones were drafted.

Although satellite products will be an important part of the course content, all aspects of routine work will be included. However, products of the Meteosat Third Generation (MTG) satellite will play an increasing role as the launch time of MTG approaches. The training course will cater to up to 20 forecasters in the classroom and additional participants during the online part.

The spoken language will be German since forecasters from Austria, Germany and Switzerland are being targeted. Because a considerable amount of high-quality training material already exists in English, and in order to be flexible to training requirements from other WMO Members, the expert team decided to use training material in English. This will ensure that training materials can be offered to a broader community as well as integrated easily into D-A-CH courses.

In October 2017, the team met again in Langen and discussed how to organize its work and responsibilities. For each topic, one leading service will coordinate the corresponding online part (for example, reviewing the content and contacting trainers) and the classroom phase (Figure 2.1). The responsible trainer in the training unit will make decisions about the teaching methods.

In January 2018, the group met in Vienna. The training topics, the course schedule and milestones with responsible people were specified. The European Virtual Organization for Meteorological Training (EUMETCAL) agreed to organize the course platform.

In December 2018, the expert team worked on the training development plan (TDP), and documents regarding the enabling skills (NWP, radar, satellite) were used in order to train in accordance with the WMO guidance. However, due to organizational reasons, the first course schedule was postponed by about six months. Figure 2.1 shows the final schedule for the classroom phases and the lead service for each year.

During an online meeting, in February 2019, open points were clarified, such as budget, experts for training, cooperation with Austro Control and the time for the course announcement.

2.5 Training concept

A course will be offered every year. Each online phase covers all course topics for that year: (a) cyclones, fronts, strong precipitation; (b) fog, stratus, drizzle and freezing drizzle; (c) summer convection. From 2020 onwards, (d) foehn winds, orographic induced waves, and turbulence will be added. Each topic will last two weeks (2x3 hours working time, including overview of the topic and self-guided and interactive learning) ending with an evaluation of the results.

One of these topics in 2019, cyclones, fronts and strong precipitation, provided preparation for the classroom phase. It is not practical to cover all topics during a classroom phase of only one week. Longer forecasters' absence cannot be managed by the services. On the other hand, forecasters need also regular training in the other topics in order to handle all high-impact weather situations throughout the year.

The online phase on summer convection will be delivered in three steps. In the first step, the physical background of all relevant structures of summer convection and their identification will be explained. With this knowledge, the forecaster chooses the suitable conceptual model (on life cycle and weather impact) in order to gain valuable hints on severe convection, such as region and probable time period, as early as possible. For instance, typical features of hodographs (vertical wind shear), radar signatures (such as radar echo in a bow form) and the probable weather impact (such as hail or heavy wind gusts) are discussed. In the second step, the applications during the different forecast timeframes—6–24, 2–6 hours (early warning), and up to 2 hours (nowcasting)—will be demonstrated. These applications include how and when to apply the different data sources for the identified forecasting problem. The last step consists in practice and homework.

In preparing the classroom phase (18–22 November 2019, in Vienna), different categories of fronts (such as cold fronts, split fronts, warm fronts and frontal substructures) and special subspecies were considered in respect to physics, 3-D structure and identification in satellite images. Regarding rapid cyclogenesis and different kinds of occlusions, the 3-D view, characteristics of rapid cyclogenesis, life cycle and diagnosis using satellite products were discussed. In connection to the topic on strong precipitation, typical weather situations and their regional variations were considered, with emphasis on using radar products and NWP forecasts. In the final step, the warning process played an important role. Case studies were used frequently for demonstration purposes and interactive exercises were included.

During the classroom phase the focus was on a single topic. Figure 2.1 contains the preliminary schedule, topic, leading institution and location of the classroom phase.

18–22-November 2019	Autumn 2020	Spring 2021	Spring 2022 (TBD)
Cyclones, fronts, strong precipitation Lead: ZAMG, Vienna	Fog, stratus, drizzle Lead: MeteoSwiss, Zurich	Summer convection Lead: German Meteorological Service (Deutscher Wetterdienst (DWD)), Langen	Waves, foehn, turbulence, icing Lead: Austro Control, Vienna

Figure 2.1. Schedule, leading institution and venue of classroom parts

The main goal of the classroom phase is to take an active learning approach. More than 50% of classroom time consists of group work and presentations by the participants. Only nine hours per week are reserved for presentations by the trainers. During the breaks further discussion and exchange of experiences and ideas are expected.

2.6 D-A-CH cooperation in the context of the international training community

Many services have asked for forecaster training, in particular to develop skills for using radar, satellite and NWP products for high-impact weather. Too often this type of training is developed at different training institutions independently of each other, leading to duplication of effort. We hope that the synergy of our D-A-CH seminars will help to improve this situation.

Although international courses are frequently offered under the umbrella of EUMETCAL and EUMeTrain, two other broader European cooperative training programmes, the D-A-CH courses will be tailored to the needs of Central European countries and to the climate of the middle latitudes, similarly to NOMEK courses for the northern European countries, and SEEMET courses for southeast Europe. The expert team plans to open these courses and resources also to the WMO Global Campus community. We support increased communication and cooperation among different training institutes, and the D-A-CH cooperation could be seen as an additional step in this direction.

2.7 Estimated benefits for each D-A-CH member

Synergy enables the D-A-CH-group to offer a new course every year: (a) four topics during the online phases, using interactive training methods and assessments; and (b) one week in the classroom focused on one topic in order to go deeper into practice and to encourage students to do project work and to exchange experiences and expertise.

In addition to the main benefits (improving the service's image, learning from each other, having more highly skilled forecasters issuing better forecasting products, and being better able to protect people) the benefit stemming from reduced effort can be remarkable. Even using existing training material, the total training workload of all services is quite high (estimated to be 28 weeks). However, through the cooperation of D-A-CH members, personnel costs for each service are reduced by about 15 to 19 weeks. The table below summarizes the amount of work (estimated in working weeks without interruption) in one year.

Estimation of personnel resources and of saving for each service (Austro Control [from 2020], DWD, MeteoSwiss, ZAMG) per year

<i>Activity</i>	<i>Working time for all (4) services (in weeks)</i>	<i>Working time per service (in weeks)</i>	<i>Savings for each service (in weeks)</i>
Meetings (preparation and evaluation)	4	1	0 (services work synchronously)
Online phase (e.g. development, monitoring, evaluation)	$4 \times 3 = 12$	3	9 (services work mainly asynchronously)
Classroom phase (e.g. development, organization, delivery, travel and stay, evaluation)	$6 + 3 \times 2 = 12$	2 (not leading) 6 (leading)	10 (not leading) 6 (leading)
Sum	28	6 (not leading) 10 (leading)	19 (not leading) 15 (leading)

Each year the D-A-CH team will arrange one face-to-face and one online meeting. The preparation, the meetings themselves, the evaluation and minutes require about one working week from each service. The workload will not differ significantly from service to service, yielding equal benefit for each of them because they are working synchronously. A significant benefit comes during the online phase. The workload for each topic is estimated at three weeks. The total workload for all services can be estimated at twelve weeks. Because each service concentrates mainly on one topic (equivalent to working asynchronously) the benefit for each service results in nine weeks of saved effort.

During the classroom phase, the estimated workload for all services is similar to the online phase (twelve weeks). If a service is not leading a topic, however, the work is limited to two weeks: to travel, to deliver some lectures and to monitor the participants' progress. However, the conception and organization of the classroom phase creates a workload for the leading service of about six weeks.

The table above shows a total workload for all cooperating weather services combined of 28 weeks, equivalent to € 78 000 (according to German conditions). However, the workload distribution among the D-A-CH partners yields significant savings for each service. Every fourth year, when the service has the lead, the saving is about 15 weeks (equivalent to about € 42 000), and over the next three years, when the service is not leading, up to 19 weeks saving is achieved (equivalent to about € 53 000).

An additional benefit comes from working with EUMETSAT, which covers the forecasters' travel costs, equal to about € 4 000 for each service. The total benefit per year and for each service amounts to about € 46 000 (leading service) and € 57 000 (not leading service).

As more course development processes are established and course materials are reused, it is likely that personnel cost savings will decrease. However, this cooperation will certainly remain beneficial for many years to come.

These numbers cover only the savings in personnel and travel costs. It is more difficult to quantify the benefits of an improved image, more skilled trainers, forecasters and training managers, and of protecting people.

2.8 Conclusions

- The benefit of D-A-CH countries' cooperation greatly exceeds the investment for each service;
- D-A-CH can be seen as a model for cooperation in other regions of the world. It could also be seen as a resource for bigger training bodies such as EUMETCAL, and even the WMO Global Campus, by using and offering training expertise, material, resources and facilities;
- More forecasters can be trained yielding better forecast products with positive impacts on many people.

3. Transboundary partnerships for capacity development and effective coastal zone management

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Abstract

This chapter reports on an ongoing initiative to promote sustainable use and management of transboundary coastal zone resources through effective collaboration among experts in the region, with emphasis on the eastern Gulf of Finland which encompasses the Russian and Finish cross-border areas. A consortium of experts has been put in place and has developed a three-year project (Getting Ready for the Cross-Border Challenges: Capacity Building in Sustainable Shore Use – GET READY) with the objective of developing an innovative, skilled and well-educated workforce in the cross-border area. The partnerships that will be established will promote skills development and life-long learning by providing problem-oriented training based on the case-study method, implementing interdisciplinary approaches, and using e-learning. The project will foster cooperation between businesses and enterprises, educational institutions and scientific and research institutions by establishing joint educational activities, preparing development plans and encouraging innovation in the cross-border area for the sustainable development of the transboundary coastal zone.

Keywords: collaboration, international collaboration, transboundary collaboration, sustainable shore use, coastal zone management, emerging content areas, case-study strategies

3.1 Introduction

Sustainable use and effective management of the coastal zone cannot be implemented without strong cross-border cooperation involving common approaches and a shared understanding of strategies, technological decisions and scientific progress. This is only possible through the joint efforts of a highly qualified workforce, who have the necessary knowledge and professional competencies in a variety of areas, including coastal zone management, climate change adaptation and applied hydrology. So, professional education and training of students, professionals and decision-makers becomes a priority for the region. This can be realized by developing and running educational and training programmes for a wide range of audiences, benefiting from the accumulated experience and the best practices of the stakeholders involved in developing the coastal zone.

This chapter reports on a partnership-building initiative at the international level which offers an example of what can be achieved if environmental risks of a coastal region are tackled through collaborative efforts of institutions and experts. The focus is the cross-border region of the eastern Gulf of Finland.

3.2 The challenge

In the coastal zone of the eastern Gulf of Finland, on both the Russian and Finnish sides, new ports have been constructed as part of the rapid development of the coastal infrastructure. The operation of the ports ensures intensification of the exchange of goods, raw materials and intellectual information between the countries of the eastern and western Baltic, which is a prerequisite for sustainable development of the Baltic region as a whole. At the same time, the coastal zone of the eastern Gulf of Finland is recognized as a valuable natural ecosystem, which is highly sensitive to the impacts of global warming. Development of the "coastal technosphere" in this area is accompanied by a number of environmental risks, including those occurring at a transboundary level: transformation of natural coastal landscapes, less species diversity in biological communities, fragmentation of the integrated terrestrial and marine biotopes, stress effects of noise, thermo-pollution, appearance of alien species, among others. The challenge is ensuring the sustainable development of the coastal region in the face of its environmental problems and the need for its rapid economic growth.

3.3 Overview of the project

An international consortium of partner organizations from Finland and Russia (see the authors' affiliation) was created. It brought together research institutes (carrying out scientific research and development), businesses (dealing with production and implementing innovations driven by science) and universities (providing a qualified workforce via education and training programmes). There are comparative advantages for all involved parties, with such diverse backgrounds and experiences that contribute to the effectiveness and sustainability of the international partnership. They include:

- Businesses using the educational and scientific capabilities of leading universities and research institutes to enhance their products and services;
- Universities and research institutes ensuring that their research, development and educational activities address the needs of businesses.

All the members of the consortium recognize that education and training are the basis for sustainable development.

Eco-Express-Service LLC takes the leading role in the consortium for managing collaborative efforts aimed at developing and using the scientific, industrial and intellectual potential of Finland and Russia in the cross-border region. The three-year project developed by the consortium, Getting Ready for the Cross-Border Challenges: Capacity Building in Sustainable Shore Use (referred to as GET READY), was awarded funding as part of the Cross-border Cooperation Programme 2014–2020: South-East Finland – Russia (<https://www.sefrcbc.fi/>), within the thematic objective "Support to education, research, technological development and innovation".

In the preparatory stage, the partners agreed upon the management system and defined the communication and information flows. Also, a visibility and communication plan was agreed that would provide transparency and wide dissemination of the project's results. A Project Steering Committee, composed of external environmental experts from local authorities, was appointed to provide guidance on how to maximize the outcomes of the project for society and other stakeholders. The consortium also approved a detailed project workplan, which contained progress indicators and reporting procedures.

The primary objective of GET READY is to develop an innovative, skilled and well-educated workforce in the cross-border area. The wider objective is to increase the readiness of the cross-border region to overcome existing and expected challenges by sharing examples of best practices and applying innovative solutions for the sustainable use of the coastal zone.

3.4 Roles of the partners

GET READY involves a variety of activities, including a work package on education and training. The members of the consortium are motivated and recognize the benefits that will derive from carrying out the activities in the project plan. The following is a summary of the contributions that will be made by each of the partners (Figure 3.1) to the success of the work package.

The universities and institutions that are part of the GET READY consortium are expected to develop and implement the professional education and training programmes of the project. A specially created Russian-Finnish Centre for Education, Research and Innovations in Coastal Zone Management will also be involved. The establishment of this centre will be coordinated by Eco-Express-Service LLC, which is a private company with extensive experience in monitoring and implementing large hydrotechnical and dredging projects in the Baltic Sea (e.g. Ust-Lugaharbor and Bronka port). Eco-Express-Service LLC conducts research and develops know-how in the field of eco-friendly engineering. It is interested in developing cooperation with scientists and educators around the region on the understanding that sustainable development can be only provided by collaborative efforts.

The State Hydrological Institute (SHI) of Roshydromet is the leading Russian research institute for the study of surface-water resources. Its research activities include (a) assessing the impact of climate change on natural conditions, hydrological characteristics and water resources; (b) creating and developing technologies for the maintenance of databases; and (c) developing automated technologies for data collection and processing. In addition, SHI participates in international activities through organizations such as WMO and the United Nations Educational, Scientific and Cultural Organization (UNESCO). It established the WMO International Data Centre on Hydrology of Lakes and Reservoirs (HYDROLARE) in 2009. The State Hydrological Institute will contribute to GET READY by carrying out a training needs analysis and then running development courses on applied hydrology, water resources, and training for trainers and management.

The Department of Ecological Safety and Sustainable Development of Regions at St Petersburg State University (SPbSU) is an important component of the partnership dealing with science-business education and training. The Department will develop new curricula, use methodical approaches to stakeholder training, and prepare teaching materials and manuals. Participation in the project will intensify the exchange of scientific information and best practices with Finnish partners. As a result of the exchange of information, a database of best practices in the field of sustainable coastal management will be compiled for use in the educational process at SPbSU.

The Kotka Maritime Research Centre (KMRC) is an international research centre carrying out interdisciplinary applied research to improve maritime safety, prevent accidents and protect the marine environment. The expertise of its staff is built upon the joint research done at the University of Helsinki, Aalto University, University of Turku and the South-Eastern Finland University of Applied Sciences (XAMK). The role of KMRC in GET READY is to study the possibilities for digitizing environmental management tools for ports in the eastern Gulf of Finland. This will involve analysing, classifying and summarizing existing digital tools and

data to promote the digitalization of environmental management systems used in ports. Additionally, a workshop and two short training courses will be organized in cooperation with XAMK.

The University of Turku (UTU) is a multidisciplinary research and education institution. In GET READY, the Brahea Centre at UTU will focus on research and education covering maritime transport and logistics, regional development and environmental management in the Baltic Sea region. The development and planning of training programmes, with a focus on new and innovative learning approaches, is at the core of the education and development activities of the Brahea Centre. GET READY will provide opportunities for UTU's researchers and education experts to further develop the multidisciplinary knowledge base and conduct advanced training on integrated coastal zone management and marine spatial planning. In this way, UTU will contribute to the societal interaction and regional development of the Gulf of Finland.

The South-Eastern Finland University of Applied Sciences (XAMK) is renowned for its research, development and innovation activities aimed at fostering sustainable regional development and well-being, improving regional economic competitiveness, and promoting national and international innovations. Participation in a cross-border cooperation project supports the fulfilment of these goals. In addition, such cooperation enables knowledge sharing between project partners and their respective regions and provides opportunities to make new contacts and develop stakeholder relations. In the course of the project, the expertise of the research personnel will also be enhanced. The envisaged knowledge sharing between partners and regions is vital for fruitful cooperation now and in the future.

The Finnish Environment Institute (SYKE) is both a research institute and a centre for environmental expertise. It is committed to protecting the environment and applying cross-disciplinary research to problem-solving. As a result, SYKE contributes to policy formulation and implementation at local, national and international levels and is experienced in a range of policy fields, including biodiversity, waste, climate and water. For GET READY, SYKE will focus on: (a) improving skills in marine and coastal planning and (b) improving skills in preparing and using inventories, and assessing coastal and underwater biotopes (such as wetlands, mollusc settlements, fish spawning places and nurseries) and the impact of human activities on those biotopes. Through GET READY, SYKE will strengthen its networking with Russian organizations that work to improve the environmental status of the Gulf of Finland.

3.5 Concluding remarks

The benefits of establishing an innovative, skilled and well-educated workforce for sustainable development in the cross-border area of Finland and Russia, that could be replicated in many WMO Regions, include:

- Promoting skills development and life-long learning by providing problem-oriented training based on the case-study method, implementing interdisciplinary approaches, and using e-learning facilitated by different institutions (SPbSU, KMRC, UTU, XAMK);
- Fostering cooperation between businesses and enterprises, educational institutions and scientific and research institutions by establishing joint educational activities, preparing development plans and encouraging innovation (EES, SHI, SYKE).



Figure 3.1. The kick-off meeting of the GET READY project partners with the Managing Authority of the Cross-border Cooperation Programme, on 12 March 2019, in Lappeenranta, Finland. GET READY is an international consortium of scientific and research institutions, universities and the private sector working together to support education, sustainable development and innovation.

4. Multi-partner innovations in forecast uncertainty training

Andrea Smith and Bryan Guarente, The COMET Program, University Corporation for Atmospheric Research; Francis Wu and Stephen Kerr, Meteorological Service of Canada

Abstract

The COMET Program and the Meteorological Service of Canada (MSC) recently collaborated with numerical weather prediction experts from EUMETCAL (an education and training programme within the European Meteorological Services Network, EUMETNET) to create the online curriculum *Forecast Uncertainty: EPS Products, Interpretation, and Communication*. The curriculum was inspired by the 2014–2016 EUMETCAL training priority areas: understanding Ensemble Prediction Systems (EPSs) and their output, forecasting high-impact weather and effectively communicating probabilistic information. The Meteorological Service of Canada’s multi-year cooperative agreement with COMET was an ideal vehicle for creating easily-accessible lessons that would benefit many global partners.

The curriculum was designed by COMET and MSC staff, with EUMETCAL and other agencies contributing NWP expertise and ensemble datasets. This effort represented a unique partnership between separate funding agencies (MSC) and those providing in-kind expertise and products (EUMETCAL and others). The overarching goal was to create an online EPS and probabilistic communication curriculum that could be successfully used by any National Meteorological and Hydrological Service (NMHS) forecaster.

To achieve this goal, the series was designed with the following features:

- NWP Expert Group determination of common EPS map and chart types;
- Use of generic, conceptualized EPS products in addition to exposure to specialized and/or region-specific products;
- A primer on the fundamentals of EPS functionality and statistics, for beginners and NMHS staff in the process of implementing EPSs;
- Case studies that span several meteorological phenomena, several geographic regions and several different forecast and communication processes.

The result is a well-rounded seven-lesson treatment of EPS products, how to interpret them, how to communicate about them and how to integrate them into the forecast and service delivery process. The series is highly rated by MetEd users, and is available in English, Spanish and French for general accessibility.

4.1 Introduction

Numerical weather prediction (NWP) developers created ensemble prediction systems (EPSs) over 35 years ago, and the meteorological community first transitioned their output into operational use in 1992. Since then, EPSs have become commonplace in some National Meteorological and Hydrological Services (NMHSs) and within the private forecasting sector. However, many NMHSs have yet to adopt EPSs, or are still in the process of implementing their usage.

Ensemble prediction systems are sophisticated NWP systems that produce many outcomes. Instead of running an NWP model once, as with deterministic model runs, scientists run a model many times using slightly different conditions or physics packages or a combination of many different models (Figure 4.1). As such, EPSs allow us to envision multiple possible forecast outcomes and determine the likelihood of those outcomes, providing a more detailed level of service to decision-makers and the public.

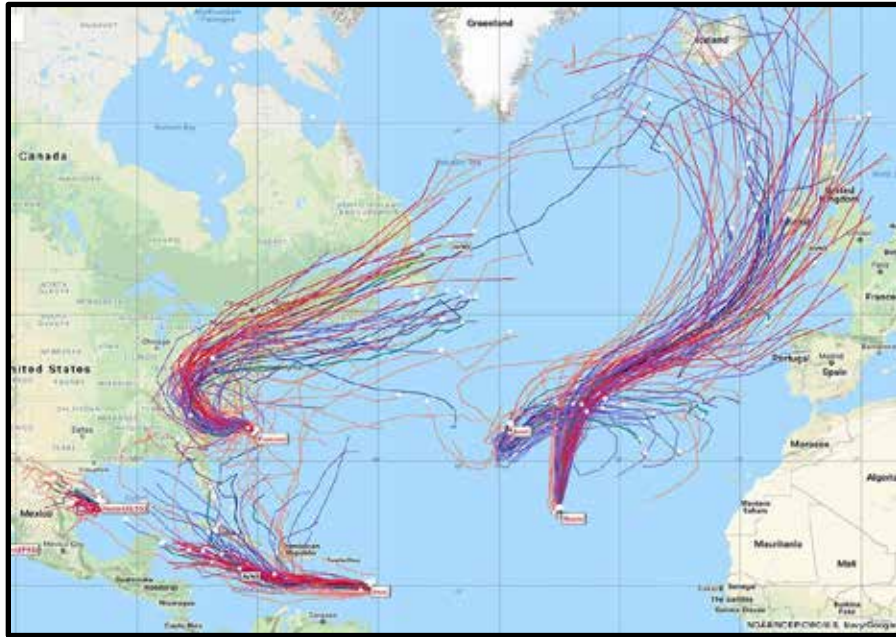


Figure 4.1. Ensemble storm tracks from several different global EPSs for 13 September 2018 12Z model runs

Some EPSs have ten or fewer “members”, or individual model run solutions, while others may contain more than sixty. As one can imagine, tens of possible individual solutions for dozens of different weather variables create a very large dataset. Interpreting these possible solutions and efficiently integrating them into the forecast process requires different statistical approaches. The most likely solution and specific thresholds of concern, such as the probability of temperature below freezing, are two common examples of EPS statistics. These statistical approaches have varying levels of complexity, and each has limitations that a forecaster must understand if he or she is to accurately use the products and then communicate the uncertainty to stakeholders. For NMHS offices that previously issued deterministic, single-value forecasts, the move to utilizing this large and specialized amount of EPS output can be daunting, to say the least.

To address the looming training needs associated with EPS implementation, the Meteorological Service of Canada (MSC), EUMETCAL (an education and training programme within the European Meteorological Services Network, EUMETNET) and other partners convened an NWP working group to brainstorm training options that would serve not only the NMHS represented by the group, but any NMHS that would be adopting EPSs over the next decade or two.

The working group met several times in person and virtually between 2015 and 2017. The group's initial efforts included cataloguing existing EPS training, outlining common learning objectives or competencies typically required upon EPS implementation, and discussing funding vehicles.

After much discussion and assessment, the team prioritized the following learning objectives (LOs):

1. Recognize key differences between deterministic and probabilistic modelling approaches;
2. Interpret common EPS product charts and maps, and understand the statistical approaches used to create them;
3. Evaluate NWP and EPS product strengths and weaknesses with respect to the forecast scenario and end-user information needed;
4. Integrate EPS information with other meteorological observations and model output in the forecast process;
5. Effectively communicate probabilistic forecast information to end users.

Existing materials from the various NMHSs represented did not adequately meet all of these objectives, and much of the existing training was too agency-specific or region-specific to be applicable to various users. Additionally, reaching the broadest possible audience in a cost- and time-effective way was a top priority for the group. Thus, the working group decided to design new EPS and communication distance-learning materials in partnership with MSC and The COMET® Program. The remainder of this chapter further describes the *Forecast Uncertainty: EPS Products, Interpretation, and Communication* series curriculum and instructional design, the materials delivered and their effectiveness, and recommendations for future multi-institute training collaborations of this nature.

4.2 Organizational collaboration

COMET has produced geoscience training for over 30 years, and houses over 600 lessons across 20 different topic areas on its freely available MetEd website. MetEd has over 600 000 registered users and is widely accessed by NMHS staff, educators and geoscience stakeholders.

The Meteorological Service of Canada and COMET have partnered for over 20 years through a cooperative agreement within which COMET provides instructional design and scientific support service to create learning materials with MSC subject matter experts. These materials are then published on MetEd, and many are translated into French. COMET also translates many of the lessons into Spanish to reach the widest audience possible.

The working group agreed to harness MSC-COMET's successful and longstanding training collaboration to create EPS and communication materials that would be accessible by all NMHS and the public. The Meteorological Service of Canada provided cooperative agreement funding for COMET and MSC training, scientific and development staff time, while various working group member agencies provided in-kind contributions of subject

matter expertise and meteorological data/products for case studies. The following list highlights in-kind contributors:

- The Spanish State Meteorological Agency (AEMET), subject matter expertise and data/products;
- The German Meteorological Service (DWD), subject matter expertise and data/products;
- The Finnish Meteorological Institute (FMI), subject matter expertise and reviews;
- The European Centre for Medium-range Weather Forecasts (ECMWF), subject matter expertise and data/products;
- Latvian Environment, Geology and Meteorology Centre (LVGMC), subject matter expertise and reviews;
- The Irish Meteorological Service (Met Éireann), subject matter expertise and reviews;
- The Swedish Meteorological and Hydrological Institute (SMHI), subject matter expertise and reviews;
- The UK Met Office, subject matter expertise and reviews;
- The University of Manchester, subject matter expertise and reviews;
- The United States National Weather Service (NWS), subject matter expertise and data/products.

These institutions contributed best practices or theory-based lessons to one or more case studies, or provided case event details and refined how technical and meteorological concepts were presented. The next section outlines the training series objectives and instructional approaches.

4.3 Series curriculum and design

To meet the working group objectives discussed earlier, COMET instructional designers worked with working group experts to outline the following curriculum components:

- A reference guide to the most common EPS products – fulfils LOs 2 and 3;
- A lesson on best practices in communicating forecast uncertainty – fulfils LOs 4 and 5;
- Regional case studies – fulfils LOs 2–5.

Original plans included addressing LO 1, Recognize key differences between deterministic and probabilistic modelling approaches, within the reference guide to common EPS products. However, it quickly became clear that the reference guide should stand alone and

a separate *Introduction to EPS Theory* lesson would be more appropriate to ensure a thorough understanding of what an EPS is, how it and its output are constructed, and how it differs from and can complement deterministic output. *Introduction to EPS Theory* serves as the first lesson in the curriculum and contains a pre-test and post-test to ensure understanding of the topics (see Figure 4.2).

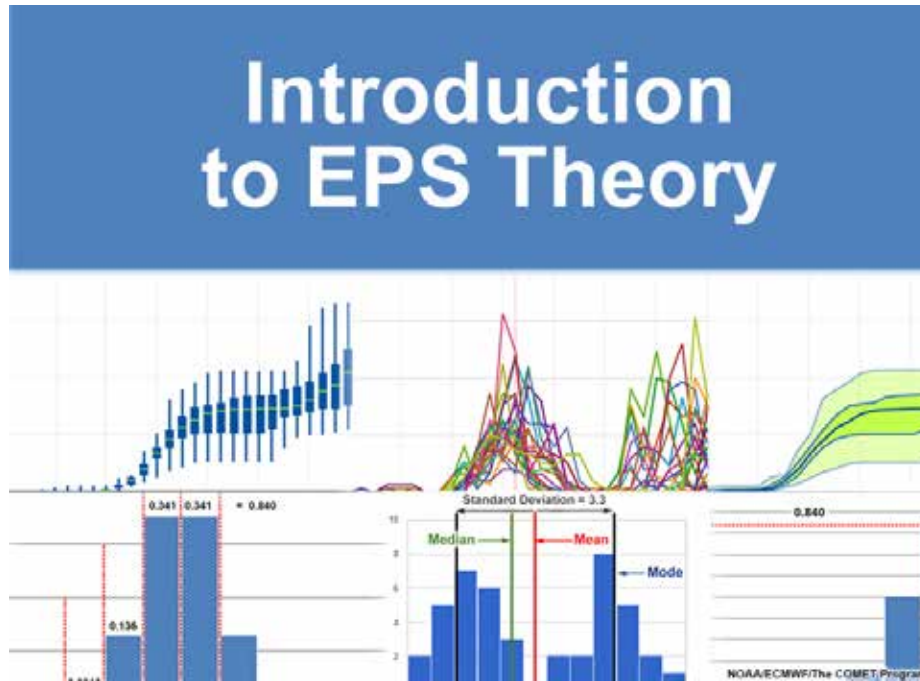


Figure 4.2. Main webpage imagery for *Introduction to EPS Theory* lesson

The EPS Products Reference Guide fulfils LO 2, Interpret common EPS product charts and maps, and understand the statistical approaches used to create them, and LO 3, Evaluate NWP and EPS product strengths and weaknesses with respect to forecast scenario and end-user information needed (see Figure 4.3).

The products chosen for the reference guide were familiar to all agencies represented in the working group and could be used in all regions and/or climates. A variety of point products and areal products were chosen so that both gridded and specific point forecasts could successfully be addressed:

- Mean and spread;
- Box and whisker EPSgrams;
- Shaded percentile EPSgrams;
- Spaghetti maps;
- Ensemble trajectories;
- Plume diagrams;

- Probability of exceedance/occurrence;
- Extreme forecast index (EFI) and shift of tails (SOT);
- Climatological percentiles.

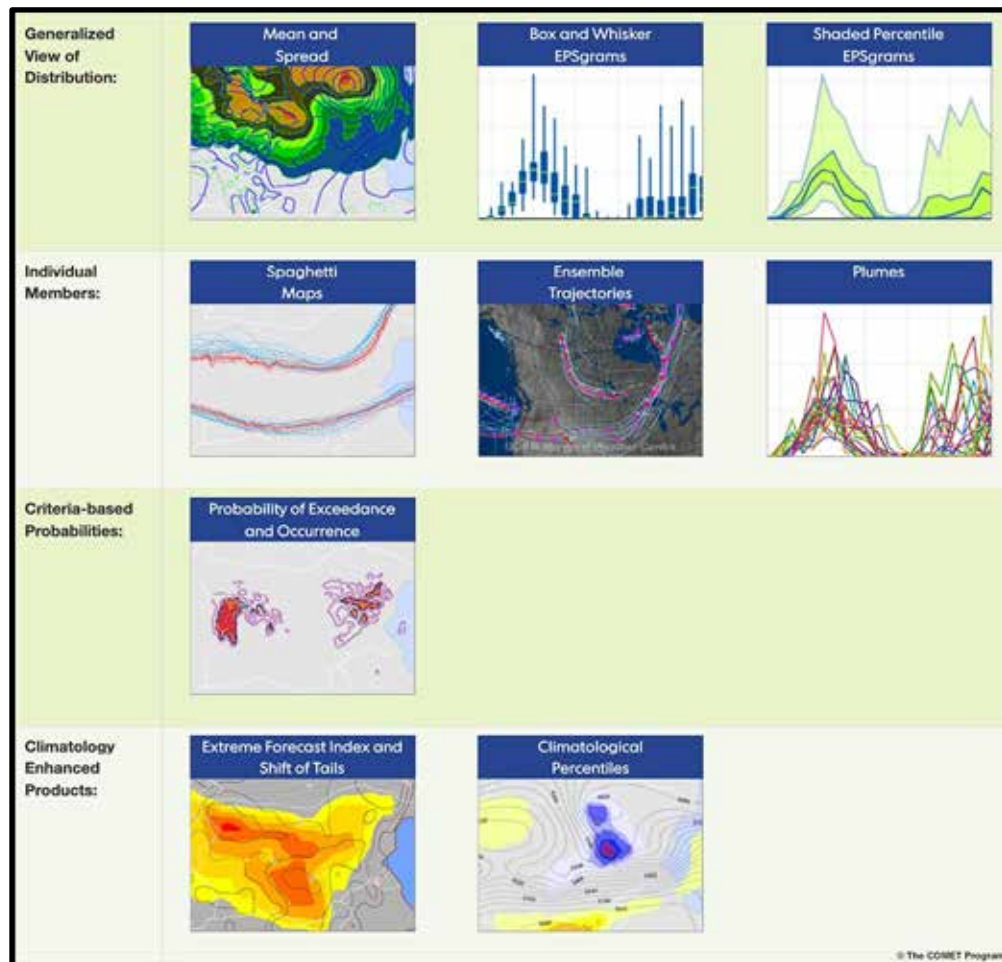


Figure 4.3. Screenshot of EPS Reference Guide webpage menu

To further ensure that the EPS reference guide applied to as many NMHS as possible, EPS product imagery was generalized and idealized. Country-specific information, such as background geographical maps and NMHS-designed thresholds, was removed from the primary EPS products featured in each category, and uncomplicated statistical distributions were selected for presentation (see Figure 4.4). This allowed learners to focus on the underlying statistical concepts and on how to interpret any EPS product of that type.

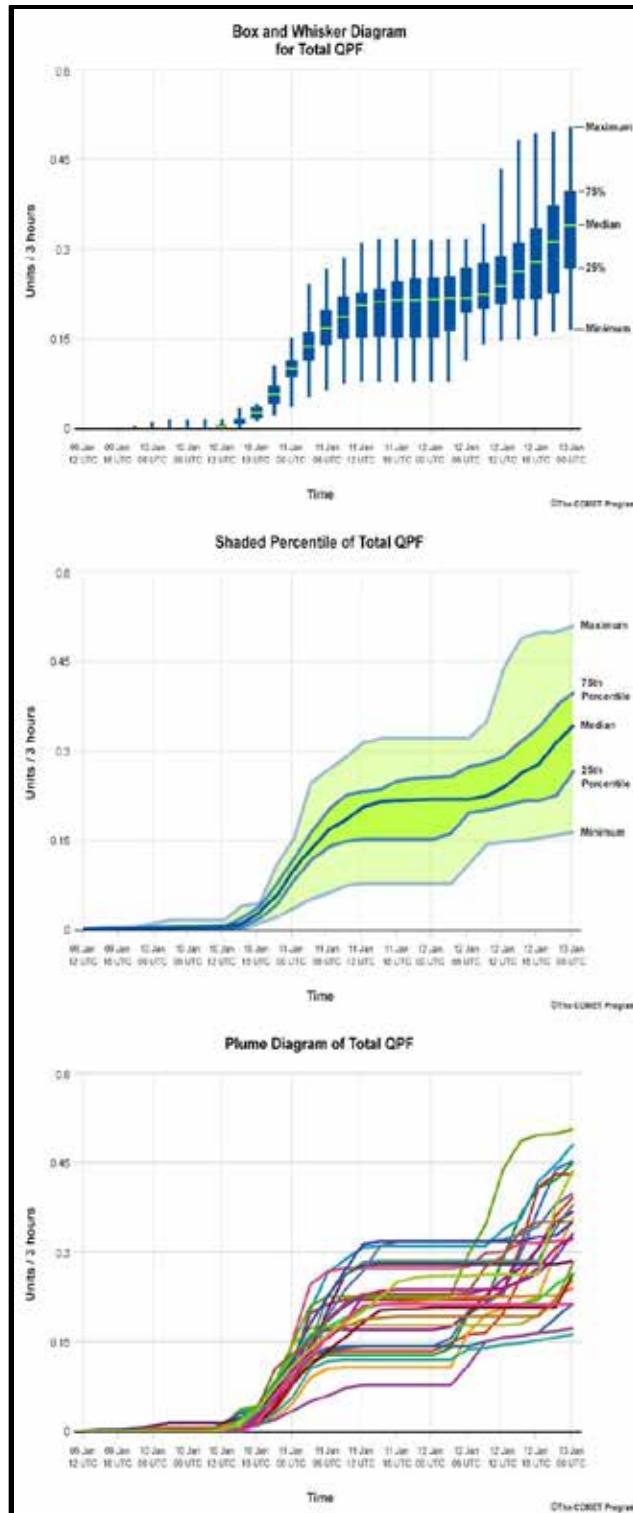


Figure 4.4. EPS point forecast products, all generalized and idealized using the same dataset

Specific, real examples from various agencies were presented in the culminating Examples subsection within each product type, to showcase commonalities and subtle variations (see

Figure 4.5). By grouping the products into several common product-type applications, the working group effectively created the opportunity to add more EPS products to the guide in the future.

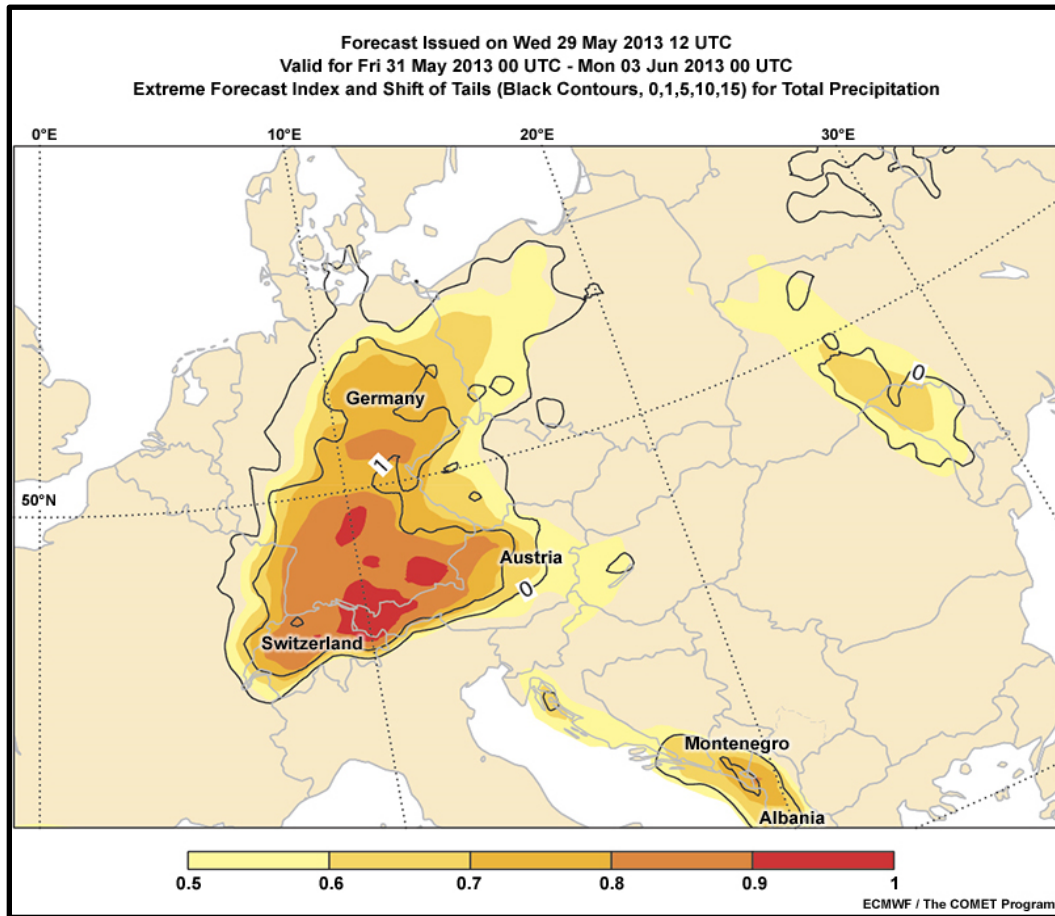


Figure 4.5. Example of agency-specific product: ECMWF Extreme Forecast Index and Shift of Tails

The reference guide is listed as an optional component for curriculum completion, as learners may already be comfortable interpreting and using some of the products but not others. In light of this, learners may pick and choose which output they would like to learn or refresh their knowledge of, effectively using it as a job aid. There is no pre-test or post-test associated with the reference guide.

The third lesson in the series, *Communicating Forecast Uncertainty*, fulfills LO 4, Integrate EPS information with other meteorological observations and model output in the forecast process, and LO 5, Effectively communicate probabilistic forecast information to end users (see Figure 4.6).

Communicating Forecast Uncertainty

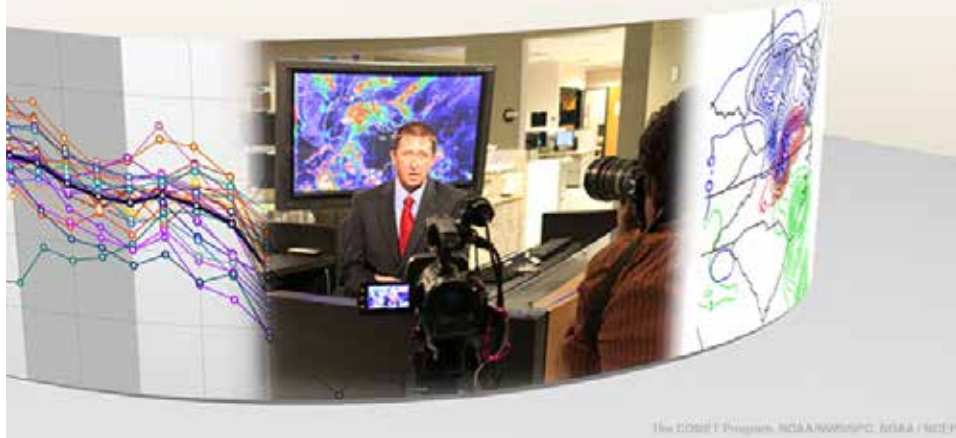


Figure 4.6. Main webpage imagery for *Communicating Forecast Uncertainty* lesson

This lesson works through determining various end users' forecast information needs and which EPS products are best suited to delivering that information and introduces a North American heavy snow event. Learners then analyse the snow event forecast situation and interpret related EPS products before receiving a primer on uncertainty communication best practices. The lesson culminates with learners applying the communication best practices to effectively communicate the forecast information to two end users with very different forecast concerns. The end user situations were selected to provide focus on event magnitude, event timing or event impacts, or some combination of the three. Varying the end user type allowed broad representation across the common call-in or weather briefing questions a forecaster may need to be prepared to answer. One end user situation required a specific threshold amount of precipitation to make a decision. This represented a common decision-maker need and allowed learners to practice tailoring forecast information beyond the standard available charts and map output. A pre-test and post-test accompany the lesson.

Several regional case studies constitute a capstone experience. The working group wanted learners to be able to explore a variety of weather events relevant to their region. Instructional designers in the group agreed that the case studies should represent a variety of forecast situations, from long-term to short-term, and a variety of related stakeholder concerns. Thus, four different optional case-study lessons were created: a European heavy snow event, a North American winter storm event, a German freezing rain event and a heat wave event over the Iberian Peninsula (see Figure 4.7).



Figure 4.7. Main webpage imagery for all four case-study lessons in series

The European heavy snow lesson focuses on medium- to short-range products and forecast processes and concludes with ski-industry stakeholders and decision-makers who have threshold-based information needs. The North American winter storm lesson presents medium- to short-range products and forecast processes and concludes with a simulation in which learners communicate with the public via social media and must deal with their reactions. The Germany freezing rain lesson highlights short-range products and integration of observations, and culminates in communications with stakeholders in the transport industry. Finally, the Iberian Peninsula heatwave lesson focuses on long- to medium-range products and concludes with issuing heat-related warnings and advisories based on the likelihood of meeting local temperature thresholds. Together, these lessons offer learners practice scenarios from a variety of regions, weather types, forecast ranges and end user interaction. Learners can complete all four lessons for a well-rounded view, or one or two that are particularly relevant to their position and/or agency.

These case studies, and the reference guide and lessons before it, were designed with case-based best practices in mind, and each features multiple opportunities for learners to perform the following:

- Explore new concepts and confirm their understanding with checkpoint questions;
- Practice the relevant types of meteorological analysis and communication methods;
- Apply these new skills to further, novel cases and events.

The next section discusses training series usage and reception in the NMHS community.

4.4 Series usage statistics and ratings

Table 4.1 describes global usage of the series lessons originally published in English, as well as those translated into French and Spanish. The number of total user sessions in the lessons since their publication is noted and then further broken down into the two most

common user groups of NMHS and Education sector (primarily university faculty and students).

Table 4.1. Total online lesson sessions, sessions by NMHS users, sessions by education sector users and average lesson rating for *Forecast Uncertainty: EPS Products, Interpretation and Communication* in English (blue-shaded rows), French and Spanish

<i>Lesson title</i>	<i>Publication date</i>	<i>Total sessions</i>	<i>NMHS users</i>	<i>Education sector users</i>	<i>Average rating (out of 5)</i>
Communicating Forecast Uncertainty	Mar. 2016	2 922	1 138	434	4 stars
Communiquer l'incertitude de la prévision	Sept. 2016	49	27	8	4 stars
Cómo comunicar la incertidumbre de las predicciones	Jul. 2018	187	40	53	4 stars
Communicating Forecast Uncertainty: European Case	Mar. 2017	392	128	44	3 stars
Cómo comunicar la incertidumbre de las predicciones, caso europeo	Aug. 2018	84	9	11	5 stars
Introduction to EPS Theory	Mar. 2017	1 388	533	268	4 stars
Introduction au SPE	Jan. 2018	34	18	10	5 stars
Teoría básica de sistemas de predicción por conjuntos (EPS)	Nov. 2017	156	22	63	4 stars
EPS Products Reference Guide	Mar. 2017	1 020	441	136	4 stars
Guide de référence des produits issus de SPE	Jan. 2018	20	12	4	No ratings
Guía de referencia para los productos de los sistemas de predicción por conjuntos (EPS)	Nov. 2017	152	43	15	No ratings
Interpreting and Communicating EPS Guidance: British Columbia Winter Storm	Mar. 2018	369	88	60	4 stars

<i>Lesson title</i>	<i>Publication date</i>	<i>Total sessions</i>	<i>NMHS users</i>	<i>Education sector users</i>	<i>Average rating (out of 5)</i>
L'interprétation et la communication de données issues d'un SPE: tempête hivernale en Colombie-Britannique	Mar. 2019	10	5	0	5 stars
Interpreting and Communicating EPS Guidance: Iberian Heat Wave	Mar. 2018	364	82	91	4 stars
Cómo interpretar y comunicar la información de guía de los sistemas EPS: ola de calor en la península ibérica	Dec. 2018	55	11	13	5 stars
Interpreting and Communicating EPS Guidance: Germany Winter Event	Mar. 2019	154	59	28	4 stars

Lessons published more recently, as expected, show less usage than those that have been available online for longer. The vast majority of lessons published were rated four or five out of five, consistent with most NWP training material available on the MetEd website. Only the European heavy snow case-study lesson received fewer, three stars, primarily due to two post-test questions that initially malfunctioned (the post-test issue has since been resolved). Selected free-response feedback is listed below for English-language lessons.

Introduction to EPS Theory

"Such a module on eps theories was long overdue. It's somewhat basic, but important topics were definitely included! I liked how the different forecasting interpretation methods were discussed using statistics, weather maps, graphs, and their significance to the modeling."

"As a forecaster, understanding the differences in deterministic versus probabilistic model data is invaluable. This was a good course to review and improve basic understanding of the two, as well as for learning about products I hadn't used before."

EPS Reference Guide

"Useful information, and not too detailed."

Communicating Forecast Uncertainty

"A useful refresher, can be applied to any meteorological service."

"Helped me to understand the two-way communication better between end users and forecaster".

"...provides good illustrations of the diversity of needs of differing user groups."

Interpreting and Communicating EPS Guidance: case-study lessons

"Good overview of Interpreting and Communicating EPS Guidance. Looking forward to more modules like this in the future!"

"Great use cases and examples, interaction is good, and very applicable."

"A nice way of highlighting the right selection and correct interpretation of ensemble products. Learning by doing is in this case certainly the best approach. Just make sure you know about the basics (what EPS products are around/what can you take from them) before diving in".

"Great idea, great use of data ... but where do we go to get it."

The ratings and free-response comments suggest that the lessons are useful to a broad variety of learners in the community and cover topics that are generally relevant to forecasters' processes and duties.

4.5 Discussion and summary

Overall, the *Forecast Uncertainty: EPS Products, Interpretation, and Communication* series provided lessons that were relevant to a variety of NMHS, educational and other users in the community. The curriculum design required that key, core EPS and communication principles be mastered while allowing flexibility with regard to which region, weather and climate type, and forecasting role learners would like to practice within the case lessons. Common EPS products, their interpretation, and communication best practices were covered in the core required lessons, and many opportunities to practice integration of the underlying concepts were provided via the case studies, achieving the original goals of the working group. Average learning, as shown in total pre-test and post-test scores, ranged between 13% and 21% improvement, and lesson ratings and commentary suggested a broadly applicable, informative learning experience for learners (Table 4.2).

Table 4.2. Mean pre-test and post-test scores for required and optional lessons/lesson groups in series. Case-study lessons were grouped to allow a more meaningful sample size from which pre-test and post-test scores could be calculated, as the lessons are designed similarly and only a fraction of users complete the tests.

<i>Lesson title</i>	<i>Mean pre-test score</i>	<i>Mean post-test score</i>
Communicating Forecast Uncertainty	69%	82%
Introduction to EPS Theory	64%	81%
EPS Products Reference Guide	N/A	N/A
Interpreting and Communicating EPS Guidance: Case Event Lessons	53%	74%

The working group format with broad representation from multiple NMHSs proved valuable in determining common learning objectives and common EPS products that would be relevant to learners across the globe. The funding mechanism from one agency, supplemented by in-kind contributions of case-study material and expertise from other agencies, worked well for all partners. The Meteorological Service of Canada was able to assist in the production of several well-received training opportunities that benefited its forecasters and met the goals of its cooperative agreement, while keeping development and review time to a minimum, thus representing a cost saving over recent production efforts. Other working group agencies benefited by helping to create learning materials relevant to their forecasters and regions, and from having MSC and COMET organize and manage the training development efforts, which represented time and cost savings and avoided individual contracts. The working group approach also provided valuable networking opportunities to all involved and allowed members to gain knowledge of how other NMHSs are conducting the forecast process with respect to NWP and EPS.

The development of these lessons took several years, from working group inception to publication of the final case-based lessons. Case-study construction, including gathering of case event data and visualization of products from previous events, was particularly time-consuming. A recommendation for others creating similar case-based learning materials is to decide on the number and type of cases as early as possible, so that case data can be easily archived by a number of parties in the following corresponding season.

Communication with such a large contributing group was sometimes challenging, even with advanced web conferencing capabilities. Face-to-face working sessions are suggested whenever possible, including convening group meetings after hours at larger conferences where most contributors will already be present.

5. Collaborative efforts to increase efficiency and leverage expertise in hydrology

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Abstract

This chapter highlights the benefits of collaboration and cooperation between a university (St Petersburg State University) and an operational service (the National Meteorological and Hydrological Service of the Russian Federation) in hydrology that could be replicated in many WMO Regions. Tangible results from its implementation, as presented, indicate that graduates from the University acquired practical skills from associating with the hydrological and meteorological service. In this regard, they work better as hydrologists, weather forecasters, climatologists or scientists than their counterparts who did not go through the collaborative training scheme. Some plans for future upgrading of the project for universal application are discussed.

Keywords: hydrology, collaboration and cooperation

5.1 Introduction

Hydrometeorology (including hydrology, oceanography and climatology) is very knowledge-intensive and depends on innovations and technologies driven by universities, scientific institutions, businesses and industries. In addition, researchers in the field are expected to be able to communicate their scientific results to a wide range of stakeholders and to manage projects and people. This requires very close collaboration between all parties involved in collecting and processing hydrometeorological data, making forecasts and developing the science and technologies that underpin hydrometeorology. However, over the years, there has been little or no collaboration between academic institutions and operational organizations in the area of hydrometeorology. This often leads to poor practical skills for university graduates who eventually work as hydrologists, weather forecasters, climatologists or scientists.

To address this challenge, the National Meteorological and Hydrological Service of the Russian Federation (Roshydromet) provides its facilities, equipment and expertise to academicians and university students (Figure 5.1). For example, the State Hydrological Institute of Roshydromet (SHI), being the central federal scientific institution for the comprehensive study of natural waters, signed a cooperation agreement with St Petersburg State University (SPbSU) which covers many joint activities. The closest long-term and fruitful cooperation within the framework of the agreement is carried out by the Department of Land Hydrology of the Institute of Earth Sciences at SPbSU (hereafter referred to as the Department).

5.2 The collaboration programme

The Department was founded in 1918 and was the instigator of higher hydrological education in the country. At the time of its creation, the Department was part of the Petrograd Geographical Institute, but in 1925 became part of Leningrad University (now SPbSU). The era of cooperation between SHI and the Department began when Prof. V.G. Glushkov, as the director of SHI, was head of the Department for five years after its

creation. He was one of the founders of the world-famous Soviet hydrological school, and a bay of the northern island of Novaya Zemlya is named after him.

Currently, the Department has a hydrometeorology programme that leads to a bachelor's or master's degree. Two new master's programmes have been launched. They are (a) *Hazardous hydrological phenomena: from monitoring to decision-making* (2017) and (b) *Hydrosphere and atmosphere: modelling and forecasting* (2018). Typically, the Department has about 5–10 master's students per year. Also, graduates of the Department can apply for a PhD as part of the geography programme and can choose a topic under the guidance of a member of staff. Every year, 2–3 PhD students are supervised by the Department staff members.

One of the distinctive features of the teaching process in the Department is an individualized approach to teaching and supervision of students because of their small number (about 5 to 6 undergraduate students). Also, emphasis is placed on developing scientific analysis skills and the ability to do research. Over the past 20 years, the Department has trained more than 150 specialists, half of whom are currently working as hydrologists in various organizations, including, of course, SHI.

5.3 Beneficial collaboration initiatives

The collaboration between the Department and SHI has resulted in the following joint activities:

- Typically, 1–2 PhD students at SHI run specialized training sessions for undergraduates in the Department. This helps disseminate SHI knowledge and experience, whilst enabling the PhD students to become more confident in teaching and communicating science;
- Every year, 2–3 students from the Department gain experience by participating in operational and research activities at SHI;
- Every year, third-year BSc students from the Department carry out laboratory work at the Marsh Station, the Main Experimental Base (MEB) of SHI, located in Illichevo village, 60 km from St Petersburg (Russia) (Figure 5.2). The facilities at the experimental base include the following laboratories: hydrophysical, hydraulic, remote-sensing methods and GIS (formerly laboratory of aero-methods), as well as straight-line 140-meter and circular calibration pools and installations for metrological research. The channel laboratory was created to study the patterns of development of channel processes, the development of methods for calculating and forecasting channel deformations in the design and construction of bridges, power lines, gas and oil pipelines, water intakes and pumping stations, among other tasks. During the one-day excursion to the experimental base, students become familiar with its function and scientific activities. The SHI Valday Branch, together with the Department, organizes an annual summer school. Second-year BSc students from the Department (5–8 students), along with students from other specialized universities, undergo practical training. In addition to becoming familiar with the work of the SHI Valday Branch, they observe runoff sites and the elements of the water balance;
- Every year, SHI scientists supervise the course and graduation work (BSc and MSc) of two to four students from the Department in the field of hydrometeorology;

- Specialists from SHI participate in the certification commissions of SPbSU. This helps ensure educational quality and formulate directions for future topics of students' research;
- Specialists from SHI and staff of the Department participate in joint research projects and externally funded activities of both organizations. Undergraduate and post-graduate students of the Department are thus attracted to these projects and activities including field work and research;
- Students from the Department have free access to the SHI Library and Data Archive where they can find valuable information and materials needed for their studies. Hundreds of methodological recommendations, guidance books and regulations on hydrological collection and processing of observation data and reference materials are made available to students;
- Staff members from SHI and the Department participate in organizing committees of scientific conferences planned by both organizations, as well as being involved in the joint organization of conferences;
- Staff members from SHI and the Department jointly publish scientific articles. In the last two years, six scientific cited articles have been published;
- Specialists from SHI participate in the development of curricula and work programmes for disciplines associated with the Department's educational programme in hydrometeorology.

5.4 Discussion and conclusion

Due to the wide range of activities that are offered, SHI is attracting qualified personnel (four new members of staff employed by SHI in the last two years) and providing topics and guidance for research carried out by PhD students and young scientists. At the same time, cooperation with SHI is an extremely important and necessary feature of the educational process of the Department. Consequently, the Department holds a leading position amongst the higher educational institutions of the Russian Federation that train specialists in hydrometeorology. This collaboration allows the Department to:

- Raise the educational process to a new professional level;
- Keep abreast of current scientific trends and developments in Russian hydrometeorology, including the use of the latest specialized equipment;
- Attract students to research projects and other activities at all stages of the educational process;
- Have direct contact with a potential employer leading research in the field of land hydrology.

The cooperation agreement has an automatic renewal clause (it is automatically extended after expiry unless otherwise decided). Thus, cooperation will continue and develop. Employees of the Department, together with specialists from SHI, are constantly searching for new ways to improve the educational process.

At present, SHI and the Department are discussing the development of a unique course on managerial practice for master's students. In this course, students will become acquainted with the structure of SHI and Roshydromet and the distinctive ways in which they function. In particular, they will learn about the activities of various SHI departments and how to implement large research projects (including preparation of tender documentation); deliver and manage research projects; work with customers; and report and communicate results.

In 2019, SHI celebrated its 100 years of existence. More opportunities and directions for cooperation were explored during the anniversary conference in December 2019 thanks to the wide participation of academic and research staff from both SHI and the Department.



Figure 5.1. Roshydromet (State Hydrological Institute) provides its facilities, equipment and expertise to students of the Department of Land Hydrology, St Petersburg State University.



Figure 5.2. Students at the SHI experimental station.

6. Adaptation of existing training material from the international community for the purposes of the German Meteorological Service

Wilfried Jacobs, German Meteorological Service (Deutscher Wetterdienst)

Abstract

Self-directed learning through online resources has been shown to be effective, but this is true only when the materials are developed by training experts with the required skills for working in this medium. For many organizations, such development efforts are beyond available budgets and staffing, and reuse of existing resources is the only option. However, while the reuse of quality open educational resources developed by others promises great benefits, these resources are often not designed appropriately for the organization, climate, geography and culture of those who wish to reuse them. This chapter describes the effort to adapt learning materials to meet local needs, while saving significant overall resources in the process.

6.1 General challenge

Forecasters at *Deutscher Wetterdienst* (DWD) and other services need both scientific and social competences in order to do their jobs successfully, even under time pressure. A forecaster has to evaluate a significant amount of individual information and integrate it to produce a forecast product of high quality that meets the individual customer's needs. After training and an examination, forecasters receive a license that is in accordance with the International Organization for Standardization (ISO) norms. However, we must train forecasters regularly so that they can keep their license. We perform evaluations at irregular time intervals; these are carried out by external auditors in order to check whether our training is in accordance with the WMO regulations. The big challenge for each service is to provide efficient training for many forecasters within a short time to enable them to do their job successfully. A conflict arises from the limited financial and personnel resources on one side and the competency requirements on the other. The only solution for this conflict is e-learning as a support for training.

Another target group for DWD training efforts is students at the Diploma University of Applied Science. After the Diploma, they undergo further training and examination in order to become licensed forecasters. However, one must bear in mind these students' lower pre-knowledge in comparison to routine forecasters who are working in shifts.

6.2 Concepts at DWD in the past and remaining challenges

For several years DWD has promoted e-learning training not only for more efficient training in terms of personnel and finances but also for higher acceptance by forecasters, trainers and decision-makers. Efficient training means finding a compromise between a training event's length and flexibility (time, location, individual student) and effectiveness. We currently train our forecasters every third year, but it is always a challenge to do so. Moreover, our goal for the future is to train our forecasters every year.

We see blended seminars (online training monitored by a trainer, followed by a classroom phase) as a very viable format. However, we cannot take many forecasters out of a shift at the same time; nor do we have enough trainers for running many blended seminars, due to the costs of travelling. Therefore, we also offer pure online training so that forecasters can

keep their license (after passing an online examination). Pure online training requires high pedagogical competencies of trainers and of the training modules' designers.

To develop from scratch an e-learning module that satisfies these demands is extremely time-consuming and expensive. Highly experienced experts estimate the time to prepare a professional training module of one hour to be about 800 hours, equivalent to about € 56 000 and even € 80 000 for outsourcing (according to German conditions).

In the case of inadequate in-house personnel resources, outsourcing would be the only alternative. However, the challenge in outsourcing is the companies' limited skill in meteorology. The training target group of forecasters is relatively small compared to the target group for, for example, a commonly used software package, so outsourcing companies have not developed the relevant knowledge base. *Deutscher Wetterdienst* would need to invest a lot of working time to guide the company accordingly, which would increase the actual cost of employing it. Therefore, DWD will avoid developing e-learning modules from scratch.

In order to use e-learning more efficiently, DWD has often resorted to using existing materials, such as those from EUMeTrain, EUMETCAL courses, the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), the COMET Program (COMET) and libraries. Because the material of these training bodies already exhibits high quality science and design, we have used it for e-learning in our training centre and at the forecasters' working places without adaptation, due to the financial and personnel constraints that DWD experienced in 2018. However, the material often differs from the forecasters' working conditions, in terms of forecast products, region, climate and weather, forecasting process and customer needs. We see the structure and pedagogical concept as a first step to e-learning at DWD, but at the cost of lower acceptance by users and poorer learning results.

6.3 Present projects and plans

A better personnel situation since 2019 has enabled us to avoid this deficiency. As already pointed out, COMET offers a huge choice of excellent learning modules. We have decided to use this potential for our own purposes. We consider a learning duration of not more than three hours as most appropriate, from the organizational point of view and for simplification of the adaptation process in this early phase of our project. As a first step, experts at DWD from the departments of Basic Forecasts and Aviation and from the training centre reviewed COMET modules according to the following criteria (see the table below):

- Topic and module description (as provided by COMET) → meeting our requirements?
- Level (according to COMET) → target group (students, experienced forecasters)?
- Publication date → still useful, updates necessary?
- Priority according to the departments of Basic Forecasts and Aviation;
- Comments, also pedagogical aspects.

We selected eight COMET modules for close consideration (see the table below). We decided to start, as a first step, with only one module, *Radar Signatures for Severe Convective*

Weather, which achieved the highest ranking. On the basis of the logical structure and the scientific content, the new assistant for e-learning creates the adapted digital training module. We perform continuous evaluation during adaptation of the material. We expect to optimize the entire process, resulting in a more efficient design of e-learning modules. Figures 6.1 and 6.2 illustrate the structures of Radar Signatures for Severe Convective Weather, the COMET design and the DWD-adapted design, respectively.

Because forecasters at DWD must have Level B2 in English (Upper Intermediate, EF-SET 51–60) we can create our material in English. We can, therefore, offer these materials to the WMO Global Campus community and weather services with a climate comparable to that of Germany.

Selection process of COMET modules (selected modules are shown in italics)

<i>Topic</i>	<i>Description</i>	<i>Level</i>	<i>Priority for Basic Forecasts</i>	<i>Priority for Aviation</i>	<i>Comments</i>
Dynamically Forced Fog	Fog frequently forms in response to dynamically forced changes in the boundary layer. This module examines dynamically forced fog in the coastal and marine environment, focusing on advection fog, steam fog, and west coast type fog. The focus of the module is on the boundary layer evolution of air parcels as they traverse trajectories over land and water. The module also examines mesoscale effects that affect the distribution of fog and low-level stratus over short distances. A general discussion of forecast products and methodologies concludes the module.	2	2	1	Published by COMET in 2005. Good for students; they should be trained after Radar Signatures for Severe Convective Weather
<i>Radar Signatures for Severe Convective Weather (selected)</i>	This resource is intended for use as a job aid by operational weather forecasters in live warning situations and as a reference tool to better understand some aspects of severe thunderstorm warning events. Thumbnail images show typical representatives for sixteen radar reflectivity and velocity signatures as well as three primary severe	3	1	1	Published by COMET in 2010. Also, according to wishes of the training centre. Responsible experts for scientific content:

<i>Topic</i>	<i>Description</i>	<i>Level</i>	<i>Priority for Basic Forecasts</i>	<i>Priority for Aviation</i>	<i>Comments</i>
	storm types. Each signature links to content describing detection techniques and conceptual and diagnostic information to help determine storm severity. The majority of the examples shown are southern hemisphere storms in Australia; examples from the northern hemisphere are noted.				Central Forecasting Unit and the training centre
NWP	1 module	1-2	1	1	Later step
Remote Sensing	1 self-paced distance course	2	1	1	
Synoptic	1 self-paced course	1-2	1	1	Later step
Aviation	3 modules	3x2	-	3x1, 1x2	Later step

Welcome: This resource is intended for use as a job aid by operational weather forecasters in live warning situations and as a reference tool to better understand some aspects of severe thunderstorm warning events.

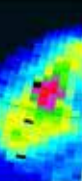
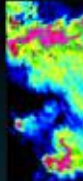
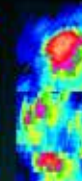
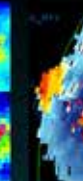
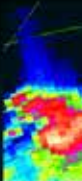
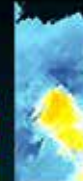
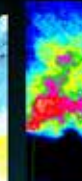

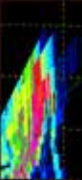

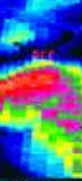
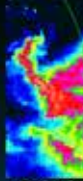
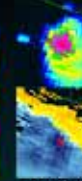
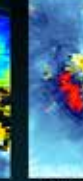
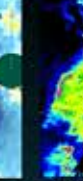
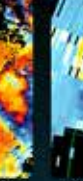
Thumbnail images on this page show typical representatives for sixteen radar reflectivity and velocity signatures as well as three primary severe storm types. Each signature is seen as a proxy for thunderstorm severity, and is initially identified through pattern recognition skills.

Note that the majority of the examples used are Australian. Examples from the northern hemisphere are noted within a signature's description.

Select one of the signatures; each is presented in three sections. The **Detection** section provides confidence that you have indeed identified a certain signature on your radar display. Equipped with such confidence, the **Conceptual Model** section aims to impart background knowledge on how the signature might have formed and how it relates to other processes and elements within a severe thunderstorm. The **Diagnosis** section provides some guidance on how "severe" or "strong" your specific signature might be within the range of all possible signatures of its kind.

All sixteen signatures shown in this resource can be attributed to at least one of three generic storm types. Overviews of each of these storm archetypes are contained in the Storm Types Conceptual Models.

Radar Signatures Suggesting Potential Thunderstorm Severity

UPPER-LEVEL SIGNATURES	MID-LEVEL SIGNATURES	MULTI-LEVEL SIGNATURES
 <p>50 dBZ Echo Top Height</p>  <p>Anomalous Storm Propagation</p>  <p>Single Cell</p>  <p>StormTop Divergence</p>	 <p>Three Body Scatter Spike</p>  <p>Mid-level Mesocyclone</p>  <p>Forward Flank</p>	 <p>Weak Echo Region (WER)</p>  <p>Bounded Weak Echo Region (BWER)</p>  <p>Very High Reflectivity</p>
LOW-LEVEL SIGNATURES		
 <p>Tight Low-level Reflectivity Gradient</p>  <p>Hook Echo</p>  <p>Low-level Convergence</p>  <p>Damaging Low-level Winds</p>  <p>Bow Echo</p>  <p>Low-level Mesocyclone</p>		

RADAR SIGNATURES
for
SEVERE CONVECTIVE WEATHER

[← back to signatures](#)

50 dBZ Echo Top Height

[Detection](#)
[Conceptual Model](#)
[Diagnosis](#)
[References/Addendum](#)

Figure 6.1. Screenshots from the COMET webpage. Top: First page of the training module *Radar Signatures for Severe Convective Weather*; bottom: Heading and structure (after clicking on the image at the top left)

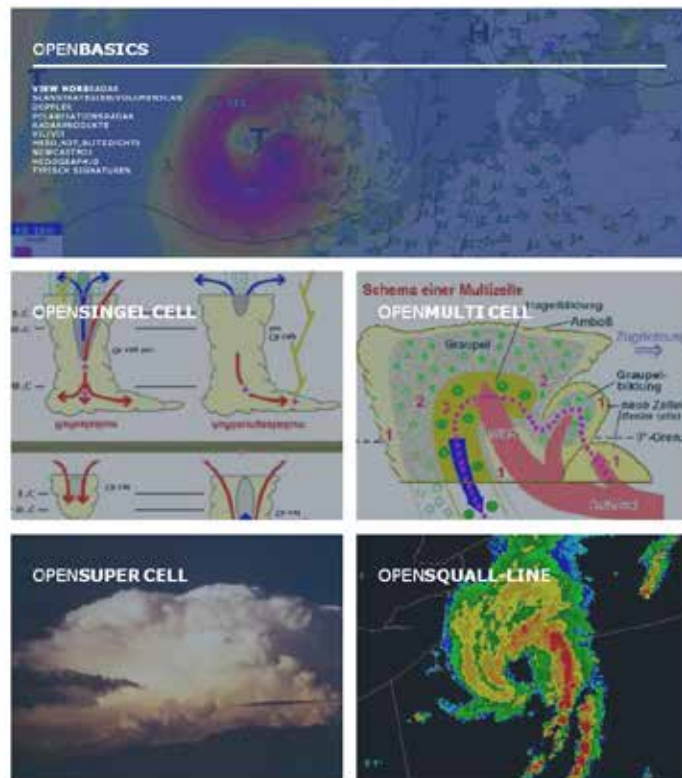


Figure 6.2. Cover page and module structure after adapting the COMET material to DWD requirements. By clicking on one of the topics, the student can access content related to that topic (for example, OPENBASICS opens the introductory content)

6.4 Benefit for DWD and the international community

EUMETCAL and DWD estimate that about 800 hours are needed to develop a training module that is comparable to a COMET one. We estimate personnel time to adapt COMET modules to DWD requirements at about 50% of this, that is about 400 hours, because the COMET modules already have an advanced structure, design and learning concept; DWD will have only to include examples and cases utilizing locally available data products, relevant to regional climate and weather conditions, and reflecting the local working environment and practices as well as customer needs. The savings resulting from adapting existing material is equivalent to € 28 000 (according to German conditions) for each COMET module. We expect that the adaptation process will run more efficiently in future, which will further reduce personnel costs.

With an operational Global Campus E-Library, DWD could retrieve material not only from the training bodies listed above but also from the Global Campus community (while respecting copyrights). However, DWD can also offer its adapted material/modules to the Global Campus for international training in regions with conditions comparable to Germany. It is up to meteorological services to adapt the material according to their demands and to offer it to the training community, yielding training material for sub-areas (according to WMO areas) under the umbrella of the Global Campus. It would make sense to include the

names of all experts involved in producing both the original and adapted modules in order to promote the exchange of experiences, knowledge and material, which could also simplify the organization of new training events by, for example, identifying experts who might be able to contribute.

This example of adapting COMET modules can give us an idea of how other services and training institutions may share training materials. If we establish close communication and cooperation throughout the international community, we could achieve even higher efficiency due to increased synergy. For instance, training institutes with comparable requirements can exchange training courses (or parts of them). The need to adapt to local requirements will thus be further reduced, yielding the benefits that we explained in this chapter.