

## **SIMs for meteorological training and assessment**

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### **Abstract**

Preparing forecasters to respond in extreme weather situations is a difficult task due to their limited occurrence. However, simulations offer a way to involve forecasters in practicing decision-making for even the most complex situations. This chapter describes the evolution of tools and processes for using simulators in forecaster training and assessment within an international collaborative community. The results have led to tools that anyone can easily use to create weather forecasting simulations, as well as many different applications for their use. Results and feedback have shown that simulations greatly enhance the practical side of courses and allow increased work on developing skills

### **The need for simulators in meteorological training**

Preparing KNMI forecasters to act in the best possible way during extreme weather situations is a particularly difficult task for trainers because serious extreme weather situations don't occur very often. KNMI's joint simulation training program began in 1980's with a group of new forecasters at the Dutch Storm Surge Warning Center who had never faced a serious storm surge situation but nevertheless had to be able to forecast the extreme storm surges in the North Sea. Originally, simulation sessions were run in a role play setting with an ordinary clock and a pile of weather maps which the forecasters used to create their forecast. People from the Dutch Storm Surge and Warning Service and trainers in an adjacent office took the role of the outside partners during these simulation sessions. Over time, the pile of paper weather maps evolved to a website, then into a Flash based simulator (Figure 1) and later into a PHP/HTML based simulator. Seeing the benefit of simulations, EUMETSAT, the UK Met Office, and the COMET programme developed their own simulation tools and uses of simulations for meteorological applications.

The use of the simulator has changed over the years. At first KNMI used this tool primarily for training sessions, but after the Bureau of Meteorology Australia shared their competency assessment plan for Queensland, KNMI developed simulator sessions to assess Aeronautical Forecasters (Figure 2). Today simulators are used in many countries and in many different capacities. Simulations are not only used to prepare and assess forecasters, observers and their customers for extreme situations, but also in training sessions about using new data types and the application of new theories and techniques. Trainers also use simulations to provide learners realistic events to work through and develop soft skills like communication with users and decision-making support.

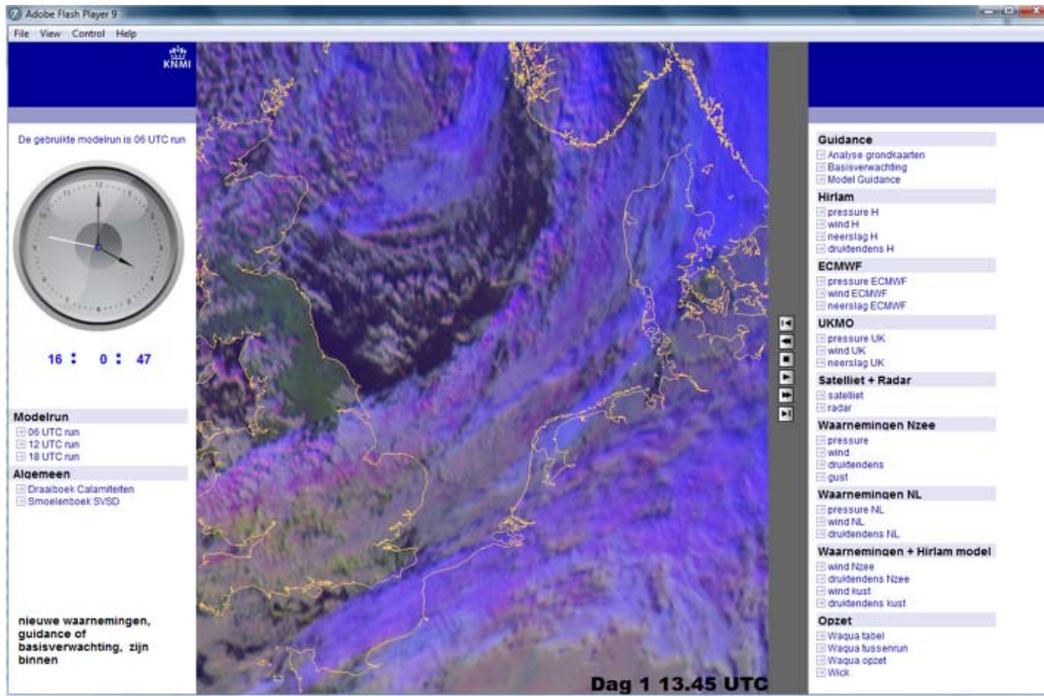


Figure 1. The first Flash simulator interface for an extreme high-tide event.  
 Source: KNMI

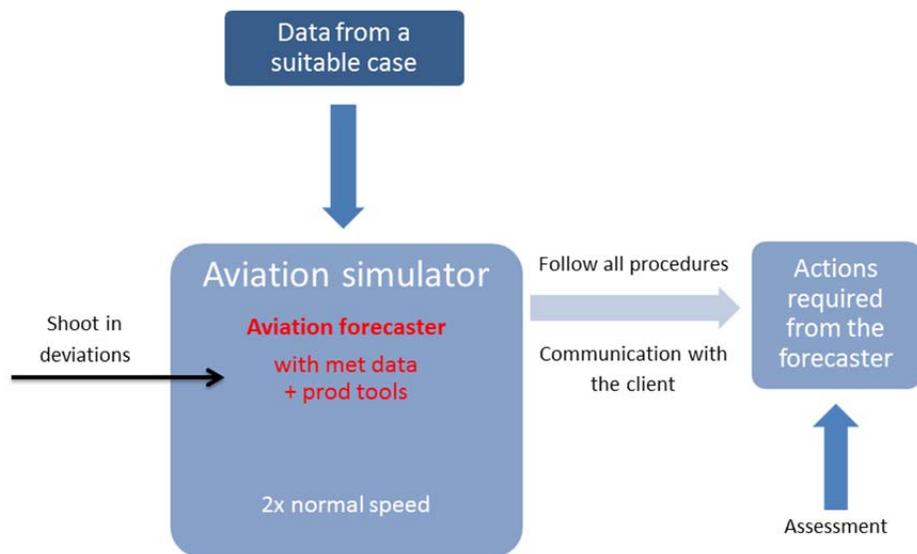


Figure 2. Schematic approach of a simulation exercise at KNMI  
 Source: KNMI

Learning with simulations

Daily life gives too little opportunity to gain relevant experience in dealing with low probability, high risk events. This makes it difficult to anticipate risks and develop competencies that lead to an effective team.

Gaining experience is learning! When participating in simulation exercises you experience processes and gain insights into:

- using procedures and processes appropriately
- collaborating and communicating with internal and external partners
- making decisions in a team setting during highly stressful situations

Learning must occur through both study and practice to prepare professionals to be fully competent to perform their job. During the study phase background knowledge is gained; during the practice phase the learner transfers knowledge into skills for the appropriate application of both theoretical knowledge and practical skills. During practice like that provided by simulations, learners become aware of the risks inherent in the situations they will encounter by observing the consequences of their decisions and actions. They also become aware of the things they don't know and need to learn.

Simulations<sup>1</sup> can be used as a tool to support the study and practice phases of learning. Simulations are an excellent tool to:

- find the gaps in learners' performance and see where they get things wrong. Problems might be found in meteorological background knowledge, the way procedures are followed or how they communicate with customers
- prepare learners for both normal and extreme situations. It is important to realize that people act differently in extreme situations than how they might in normal situations. When a dramatic situation happens, for instance a child drowning in a pool, one or two people may jump in the pool but many more will be watching and not doing anything. That can happen in your Weather Service too if people are not trained to perform under the stress of extreme situations!
- help assess whether your people are competent to perform their job

With simulators, you can create a safe environment for your learners where they can gain experience, be trained and be assessed.

### **Uses of simulations**

The weather forecasting training community has now used simulations in many new and innovative ways that the creator of the original KNMI simulator could never have dreamt of. We continue learning a lot from each other as new implementations are made!

Simulators allow data products to be connected to real-life applications, so that the use of meteorological data is taught in the context of performing a task. This has been a welcome

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<sup>1</sup> We use the term simulation to refer to the learning activity. The term simulator refers to the tools that make simulations possible.

shift for training on satellite applications, for example, in which teaching the production and capabilities of data products was frequently abstracted from the use of the products. This shift makes the training much more effective for continuing professional development and performance improvement.

The screenshot shows the EUMETSAT simulation interface. At the top left, the EUMETSAT logo is displayed with the tagline "Monitoring weather and climate from space". Below the logo, the current time is shown as 03:02:20. A vertical menu on the left contains buttons for "Introduction", "IR", "Airmass", "Dust", "Convection", "0001UTC Observations", "NWP - Surface wind", "NWP - 850hPa wind", and "NWP - 850hPa Temperature". Below the menu, it says "Data to 0300UTC". The main content area is titled "Welcome to the Simulation" and contains the following text:

The current time is displayed top left of the display.

When new data becomes available you will be given the opportunity to load it.

**Scenario:** There will be a meeting of the African Ministers responsible for Meteorology (<http://www.amcomet.org>) This meeting will take place at a temporary conference venue in North West Sudan. Ministers will fly to the conference from N'Djamena, Khartoum, and Luxor. You are forecasting for the event and the air travel. At this meeting ministers will be discussing the quality of meteorological services in the continent. ICAO and WMO will be represented by their Secretaries General.

You will also be providing a regional forecast for all of the region for the Al Jazeera TV and BBC World Service radio broadcasts.

**Non-routine forecast:** Flight forecast from N'Djamena, Khartoum, and Luxor to Nyala with Al Fashir as the alternate.

**System:** You will work with a web based simulator with access to a limited amount of data for this case.

**"Time out of time":** During the simulation there will be NO periods when the clock is stopped for you to reflect on how you are doing.

**Key learning objectives:** In this exercise you will:

- 1) Think about how you use observations and model data in the analysis and in the forecast
- 2) Think about how you can make statements about the quality of your forecast

At the bottom of the page, there is a map of Sudan and surrounding regions (Libya, Egypt, Red Sea). The map is titled "SUDAN AIRPORTS" and shows several locations: Wadi Halfa, Ash Shamaliyah, Dunqunabih, Al Bahr Al Ahmar, Port Sudan, Sawakin, Hayya, Tawfik, Nahr An Nil, and Kuraymah. A north arrow is also present.

Figure 3. One of the first training simulators with a simulation on how to use satellite imagines for forecasting dust.

Source: EUMETSAT



**Figure 4. Trainees using a training simulator**

*Source: EUMETSAT*

A simulation is also an excellent assessment tool for forecasters and observers working in aviation and other service areas because you are able to create similar assessment circumstances for all individuals who are tested—which meets the need for fair and consistent assessment practices. By observing the participants in a simulation and evaluating the products they make, you are able to collect evidence that the professionals are competent to do their job and ensure that all the required competences are assessed in an authentic context. This is different than the less authentic written test. You are also able to see whether learners are competent to do their jobs under the circumstances that really matter—extreme weather situations.

A word of caution: when using recent cases for simulations, it is possible that some people will remember what actually happened during that case and that will enable them to perform excellently on the assessment. Yet in the community's experience so far it has never been a complicating factor in the assessment process.

Anecdotal evidence gathered during KNMI simulations has shown that if you implement authentic assessments in the right environment and atmosphere and have provided participants the time to adapt to the possible new circumstances, most people will be absorbed by the tasks in the work environment and will forget they are engaged in a simulation.



**Figure 5. Forecaster in action in a simulation session.**

*Source: KNMI*

### **Collaborative evolution of meteorological simulators**

Simulations used to be very costly and time-consuming to produce. The original simulation concept and simulator developed by KNMI was shared within the global meteorological education training community for free use, with the condition that new experiences and improvements of the tool should be shared again within the same community. It turned out to be a great approach as it has resulted in a growing community using simulator tools for their training. EUMETSAT developed the tool for its own needs and created an easy-to-use JavaScript-driven simulator. Based on this version, a Moodle plug-in was developed in a joint effort by the UK Met Office, EUMETSAT and the South Africa Weather Service (SAWS) and offered back to the community. Finally, the COMET Program, using its own HTML-based development system, created a branching simulation tool for training forecasters in online lessons.

The core innovation that made this evolution possible has been the use of simple simulators to support training and assessment for forecasters and observers. This approach avoids the problem of building a custom system on an institutional display that is powerful, but unusable outside of the NMHS that created it. Most of these simpler simulators are basically image viewers plus a built-in clock that can be set to run by the trainer at a desired speed to control when data products are available and when decisions must be made by users. Some simulators can ask learners to perform tasks and some simulators are able to give personalized feedback based on the actions taken by the learners during the simulation session. Sample simulators demonstrating the variety of implementations in our community are:

- The UK Met Office, EUMETSAT and SAWS Moodle plugin for creating custom simulations is currently available by contacting [info@eumetcal.eu](mailto:info@eumetcal.eu).
- Many simulations made with this tool are available to the public at <https://training.tools.eumetsat.int/sims/index.htm>.

- "Baltic+ 2019" course simulation using Google Forms:  
[https://training.tools.eumetsat.int/sims/live/baltic+\\_2019fastloop/sim.html#](https://training.tools.eumetsat.int/sims/live/baltic+_2019fastloop/sim.html#)
- Servicio Meteorológico Nacional (SMN) uses simulations to train and assess forecasters and observers. Some of the examples available at <https://crf.smn.gob.ar/course/view.php?id=29> are a simulation for training and assessment of volcanic ash forecasters, training of Zonda (Foehn) conceptual model and a 3-D image of an observation site used for practice in meteorological observations.
- The COMET Program's simulation on communicating risks: The impact-based forecast and warning services approach: [https://www.meted.ucar.edu/wrn\\_sims/navmenu.php?tab=1&page=2-0-0&type=flash](https://www.meted.ucar.edu/wrn_sims/navmenu.php?tab=1&page=2-0-0&type=flash) (account creation is required)
- COMET's simulation that leverages social science to improve risk communications: [https://www.meted.ucar.edu/social\\_science/ss\\_201/navmenu.php?tab=1&page=2-0-0&type=flash](https://www.meted.ucar.edu/social_science/ss_201/navmenu.php?tab=1&page=2-0-0&type=flash) (account creation is required)

### **Challenges faced in implementing simulations**

One challenge in implementing simulations by the worldwide training community was the fact that not all trainers have programming skills. The first simulator tool with a built-in clock used by KNMI was able to show data at specific times and was built in Flash, using the programming language, ActionScript. ActionScript required a very steep learning curve for many institutions, and ten years later it became clear that Flash would disappear from use. The new EUMETSAT simulator tool was build using HTML and JAVA script, but even that turned out to be difficult to use for many.

As mentioned above, eventually the Met Office, with help from several partners, invested in a Moodle plugin that is designed to build simulators using drag-and-drop techniques, which nearly anyone can master (Figures 6 & 7). However, having this Moodle plugin available for the community did not mean that it could be implemented in every Moodle system. Because this plugin was created by a private company and was not part of the official Moodle.org plugin directory, other Moodle providers needed to determine if they could install it on their systems at a reasonable cost. This procedure would need to be repeated every time an update of the plugin was created to make it compatible with updates to Moodle. To mitigate this limitation, both UK Met Office and EUMETSAT have set up a Moodle server with the SIMS plugin installed and made it available to the community for creating a SIM. Once developed, the SIM can be exported to and used from another Moodle or internet site.

- Simulator

Overview page content

Banner image

Maximum size for new files: Unlimited, maximum attachments: 1

123.png

Start time: 2, March, 2017, 07, 00

Simulation length (hrs): 3

Pause classroom clock on startup: No

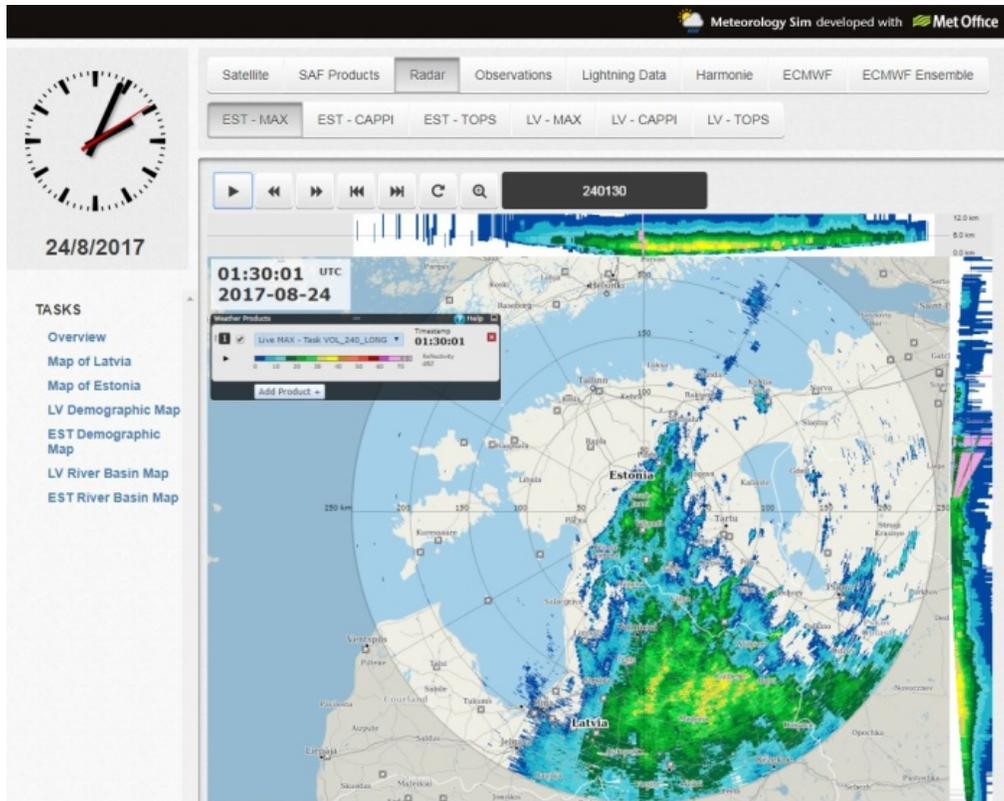
Time multiplier: 45

Tasks

Title	Task id/hm	Uri or drag/drop file	Display
METAR	020740	METAR.png	Anim pane
weather_on_board	020745	onboard.png	Anim pane
weather_maps	020715	amsla.png	Anim pane
weather_maps1	020715	A/n_1_201703020	Anim pane
sonding	020735	sond.png	Anim pane
fill the form	020800	https://goo.gl/fbrms/wh	Popup
Press at 10.45	021045	secunda-825i810	Popup
			Popup

Save

Figure 6. Moodle plugin with Drag and Drop menu to create a SIM interface.  
Source: EUMETSAT



**Figure 7. Example of a simulator interface for a simulation over the Balkan region**  
*Source: EUMETSAT*

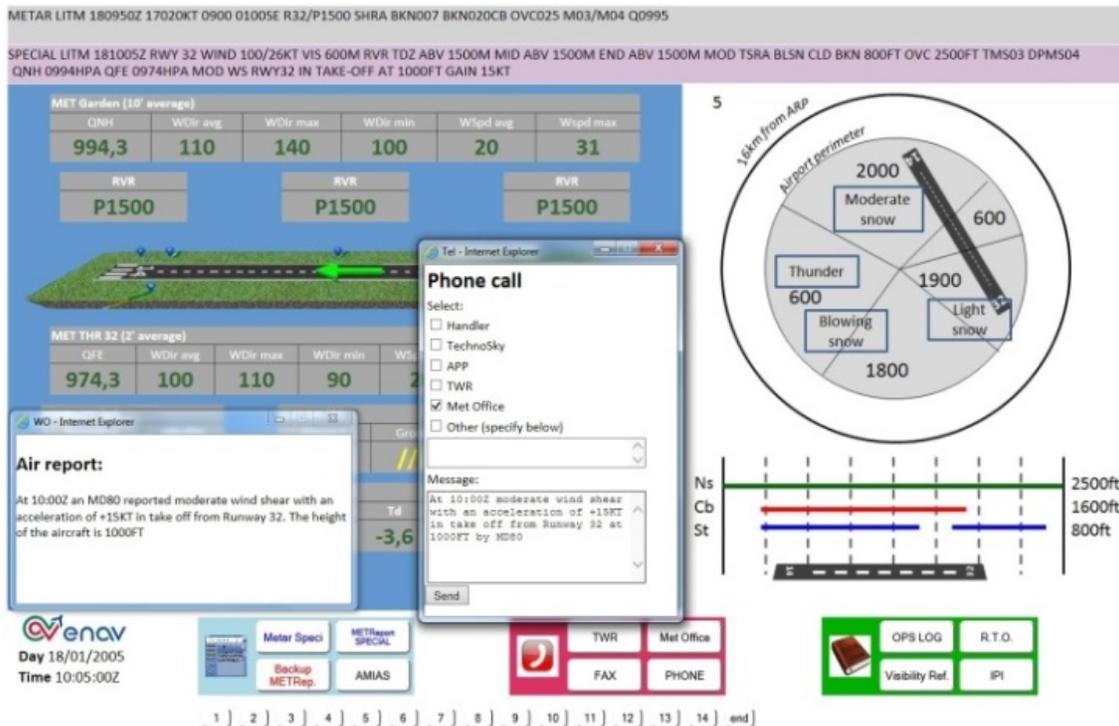
Another challenge related to using simulations is that it calls for pedagogical innovations. In recent years, we have noticed that too many trainers tend to focus on the technical requirements of building SIMS, and too little time on defining the needs, goals, and outcomes of the training. The result is that it often takes more work than expected to create a simulation, and not all the simulation sessions are as effective as hoped. The training goals and needs determine the tools appropriate for your training, and not the other way around. During the past couple of years, in cooperation with EUMETSAT, some train-the-trainer events have been organised. The goals of this training were to help participants learn how a simulator can be used in training and assessment and how to use the simulator building tool in the optimal way. During this training, participants inspire each other and begin collaborative projects. The participants go home with a training plan for a simulation training activity that includes a timed script for the training itself, and the early development of the simulation to be used for the training session.

Another challenge that KNMI has experienced is that at the start of each simulator session the differences between the working environment within the simulator tool and the normal forecast production tools can create some unease with learners. It is preferable to have either a simulator that is exactly the same as the tools used at work or a simulator tool that is completely different. If you allow time for the learners to adapt to a new simulator interface at the start of your simulation session, they will get used to it and work fine with it. Simulators that are similar to the normal forecast production tools, but have subtle differences in the way they are operated, tend to irritate learners during the exercise because they have to behave differently from their normal conditions. This may have a negative effect the learner performance in the simulation.

## Results

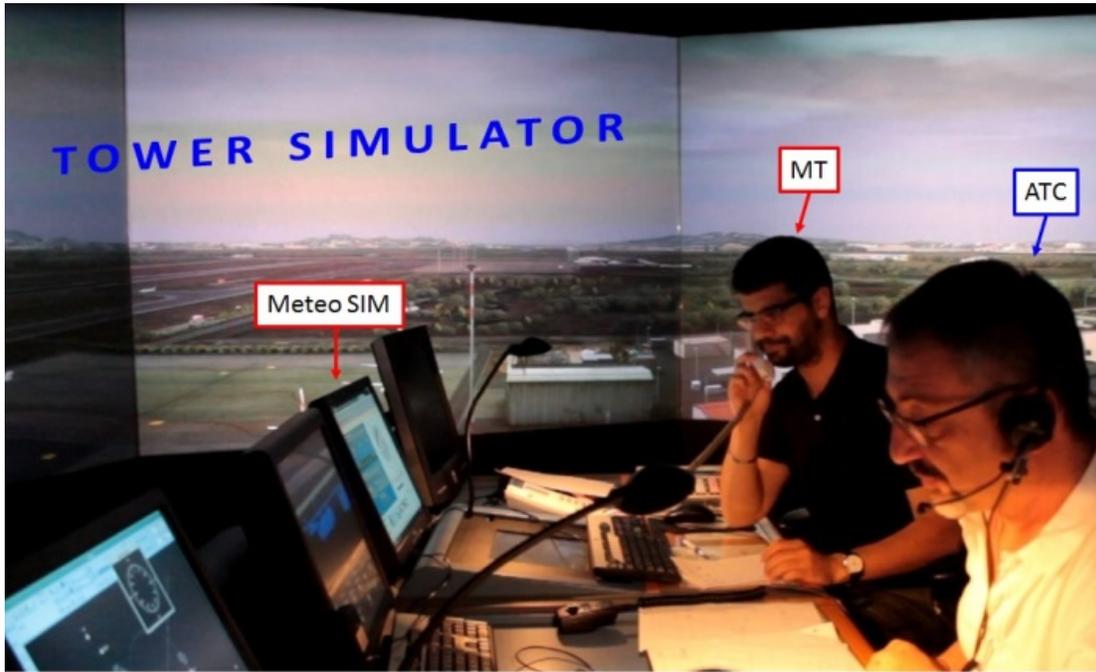
During training courses, participants have offered feedback that the simulations greatly enhance the practical side of the courses and allow them to work on developing their skills. An important element of simulation training is the debriefing after the simulation exercise. It enables participants to reflect on their meteorological and decision-making skills used during the simulation. In this context using standard meteorological competency frameworks like those offered by WMO-No. 1209 are useful in designing simulation experiences for either training or assessment. For example, the regional satellite training course "Baltic+ 2019" implemented *Google Forms* as the place where students entered their answers to specific tasks during a simulation. This allowed the facilitators to gather data and follow the progress of more than 20 participants in real time. The data was used during the debriefing to show the choices that the students made and provide feedback on the best approaches in communication with customers. Debriefing can be targeted at increasing a student's critical reflection skills.

Another aspect that has been discovered is that learning times can be shortened when including simulations in your training programme. Each simulation session can cover many different aspects of the job and, last but not least, online simulations can be used day or night, regardless of the weather conditions outside the window! ENAV, the Italian Civil Aviation provider, has revised its training procedures for the initial training of meteorological technicians (MTs) and included simulations at three different levels (Basic, Advanced and Operational). The simulators used in all these simulations reproduced the ENAV's operational suite (Figure 8) for MTs. Different weather conditions were designed to prepare the MTs to face every possible weather scenario. After the first course, results were well above expectations, not only because students were fully competent and ready to work under supervision in a short time (4 weeks), but also because all of them showed motivation and engagement during the entire course.



**Figure 8. ENAV's SIM interface for practice on coding and coordination procedures using popups.**

*Source: ENAV spa*



**Figure 9. Example of an integrated simulation MT-ATC for practice on an operational environment.**

*Source: ENAV spa*

When Servicio Meteorológico Nacional Argentina (SMN) started to implement simulations in their training they found that using these simulations provided better learning experiences. The idea of developing a simulation is challenging and motivating, and building simulations requires teamwork. The major asset for SMN is that building these simulations connects personnel from different departments to collaborate in developing the training and in learning to work together. Using simulators during training is catchy, and gave a new perspective on training (for example, active learning, student centered, competency based) within their institute. Others wanted to try it and now it is spreading on its own. In addition, the use of simulations for training has placed a greater importance of training within SMN. Altogether, it has given training a higher status.

### **Recommendations for further implementation**

One area for future development of simulations is the inclusion of realistic consequences in the simulation feedback on learner decisions. Realistic consequences may include an angry customer or even a serious accident or significant loss. With realistic consequences, learners will see the impacts of their actions and will have to reflect on different strategies and approaches to use in the future. Learners can repeat simulations, they can experiment with different strategies until they find the one that works best. This engages the natural learning process of making mistakes, reflecting, and trying something different that may be of use to even situations beyond those trained in the simulations.

Luckily there is also still a lot to invent in the development of new simulations. Integrating virtual reality and 360 images generates a new sensation of being immersed in the simulations. This will be SMN's challenge for the 2019 Meteorological Observations course (for WMO RA-III and RA-IV). They plan to continue developing modules in collaboration with training partners to stimulate innovation and to increase the use and reach of simulations.

As more people get involved in developing simulations you will see a wider variety of approaches, showing how people tackle problems in different ways. Many services are thinking of ways to engage trainees by creating new simulations. This can be done by encouraging learners to bring their own cases for training sessions on building simulations, thus co-creating the learning artefacts in cooperation with their trainers. SMN is now considering running a simulator competition in which participants will work in teams to produce the best simulator for a specific training purpose in one week. KNMI has good experiences with having a rotating team of assessors from the operational work-floor who prepare and assess the simulations.

### **Additional resources**

A brief summary about creating simulations prepared by Tsvet Ross-Lazarov, Bruce Muller and Patrick Parrish

[https://docs.google.com/document/d/1fWJsJdVPP-G7FtDhw8ebP\\_y17tEtREpj4xQTPfH2jUw/edit?usp=sharing](https://docs.google.com/document/d/1fWJsJdVPP-G7FtDhw8ebP_y17tEtREpj4xQTPfH2jUw/edit?usp=sharing)