Annual Report 2019

European Severe Storms Laboratory

About the Laboratory

The *European Severe Storms Laboratory e.V.* (ESSL e.V.) was founded as a private, non-profit research organisation in December 2006. It is a spin-off of German Aerospace Centre DLR in Oberpfaffenhofen, and relies on the expertise of its international team.

In Europe, severe thunderstorms inflict an estimated annual damage of about 5 billion euro and lead to dozens of fatalities. ESSL wants to make Europe more resilient to severe weather by…

- Performing fundamental and applied research on severe convective storms in Europe;
- Operating the European Severe Weather Database, ESWD;
- Organizing the European Conferences on Severe Storms, ECSS.

The *European Severe Storms Laboratory – Science & Training* is a subsidiary of ESSL e.V. located in Wiener Neustadt, Austria, that pursues similar goals. It operates the Research and Training Centre, which is the venue of various courses, workshops and the ESSL Testbed. Its main activities are

- Operating the ESSL Testbed, a facility to evaluate new forecast-supporting tools;
- Organizing various courses for various target groups, including weather forecasters, to enhance their understanding of convective storms

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Foreword

Dear Reader,

the year 2019 was a year in which the European Severe Storms Laboratory has been very productive. As an example, the cooperation with partners in collecting severe storm reports for the European Severe Weather Database (ESWD) resulted in a total of 22216 new reports that were included (see Chapter 1). Moreover, the interest in ESWD data further increased: not only did ESSL receive more requests from non-members (46), the association was also joined by two new institutional full members and no fewer than six new Institutional Supporting Members (see Chapter 7).

Regarding research, ESSL and Munich Re finished the joint project ARCS on changes in convective extremes and their impacts in March. The final part of this project focused on a translation of severe weather probability to potential losses resulting from the most extreme events, described in more detail in Section 2.1. A follow-up project until December 2019 was granted to finish a number of tasks that could not be completed in the original project.

More applied research was done for EUMETSAT and ECMWF. EUMETSAT requested from ESSL to investigate the potential direct use of satellite sounder data by forecasters, having in mind that such data will become available at high spatial and temporal resolution as a result of the Meteosat Third Generation programme. ECMWF requested ESSL to study the computation and use of parameters CAPE and CIN.

In the area of training, ESSL was busy as well, in particular ESSL's senior trainer Dr. Tomáš Púčik, who taught or assisted with 5 courses at ESSL's Research and Training Centre in Wiener Neustadt, and gave two courses at the premises of ESSL member institutes. We were happy that Dr. Yvette Richardson, who is also a member of ESSL's Advisory Council, taught the Dynamics of Severe Convection course for ESSL in March. An important new target group for courses in 2019 were aviation meteorologists whom ESSL offered specialized courses tailored to their needs (see Chapter 5).

At the ESSL Testbed 2019, 41 participants contributed to the evaluation of a number of forecast-supporting tools, including sounder data from the IASI instrument provided by EUMETSAT and several nowcasting algorithms provided by the German weather service DWD.

The highlight of the year, in November 2019, the Polish Institute for Meteorology and Water Management IMGW and ESSL jointly organized the 10th European Conference on Severe Storms in the city of Kraków. The number of participants was well above expectation with 241 persons from 32 countries attending and sharing their latest research results (see Chapter 3). At the occasion of the ECSS conference dinner ESSL presented the Nikolai Dotzek Award to Dr. Robert Davies-Jones, renowned scientist who contributed greatly to our understanding of supercells and tornadoes.

On the administrative side, it was unfortunate that Dr. Kathrin Riemann-Campe had to inform the Executive Board that she would resign at the end of the year, because she could no longer

combine this work with her other commitments. At the occasion of the General Assembly in 2019, the Executive Board and the ESSL members present thanked her.

Financially, in 2019 ESSL remained in a situation with no noteworthy financial reserves. As a result of the reduced project funding, employment had to be reduced. The Treasurer, Alois M. Holzer, therefore has thankfully taken care of supervising the finances without payment. However, his overall involvement in ESSL has been strongly reduced, leading to a shift of a significant amount of administration and work to other persons including the Assisant to the Board, the Director, and others. Experience has shown that ESSL is able to manage this situation, it has led to a lower ability of the team to invest in developing new activities and interacting with important players. Moreover, the amount of effort that is now requested from the Treasurer without remuneration is not sustainable in the long term. Working to improve this situation is a top priority for ESSL.

Having said all this, it is my pleasure to present you this Annual Report, which constitutes a review of ESSL's achievements in its thirteenth full business year.

Wessling, 31 August 2020,

Dr. Pieter Groenemeijer
ESSL Director
Chair of the Executive Board

1 Severe Weather Data Collection

A key activity of ESSL is the collection of severe weather data in the European Severe Weather Database in cooperation with its partners throughout Europe. The data forms the starting point of many studies within and outside of ESSL.

1.1 ESWD Data Users and Partners

Users

ESWD data are used by a wide range of users. They include ESSL members who have access to the data as a benefit for members. In addition, ESSL receives a fair number of requests from potential new users, usually started by an e-mail sent to the address eswd@essl.org. In 2019 the number of such requests increased strongly compared to previous year. In 2017, ESSL received 21 such requests, in 2018 24 requests and in 2019 no fewer than 46 requests (Figure 1-1). Often, the requests come from students who would like to use parts of the database to support their study for a Bachelor or Master degree, or even their doctoral thesis research. ESSL's User Support employee Thomas Schreiner handles such requests. He provides them with data, which can be free of cost if the study is not driven by commercial interest and the student agrees to the User Agreement. Occasionally, there are also commercial parties, such as developers of risk models, who would like to access the data. They are invited to join the association as a supporting member, or to purchase ESWD data from ESSL.

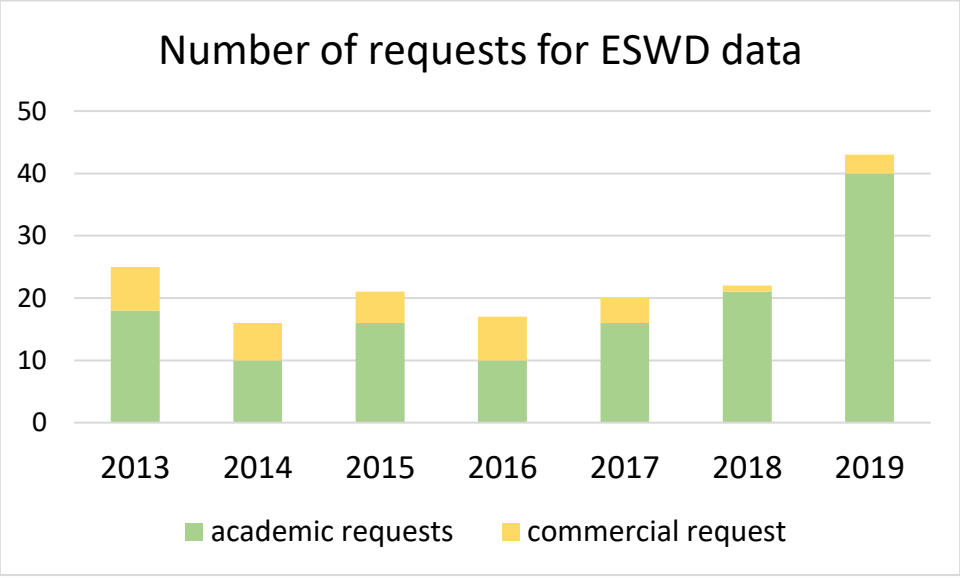

Figure 1-1. Number of requests for ESWD data by non-members.

1.2 Severe Weather in 2019

Event Types

In 2019, the ESWD was expanded with **22216** new severe weather reports (Figure 1-2), which is more than the 16428 reports for the previous year, 2018. This is probably due in part to an increase in the number of convective episodes in the spring and summer across Europe.

The most frequently reported severe weather phenomenon was severe wind gusts (12098 reports), followed by heavy rain (3944), large hail (3293), and damaging lightning (889).

Table 1-1. Severe Weather Reports collected in the European Severe Weather Database in 2019.

Report Type	**Number of reports**	**%**
Severe wind gusts	12098	54.4
Heavy rain	3944	17.8
Large Hail	3293	14.8
Damaging lightning strikes	889	4.0
Heavy snowfall/snowstorms	883	4.0
Tornadoes	797	3.6
Avalanches	231	1.0
Ice Accumulation	62	0.3
Lesser whirlwinds	19	0.1
Total	22216	

Table 1-2. Quality control levels of ESWD reports from 2019.

Quality Control level	**Number of reports**	**%**
QC0: as received	0	0.0
QC0+: plausibility checked	1809	8.1
QC1: report confirmed by reliable sources	20279	91.3
QC2: scientific case study	127	0.6

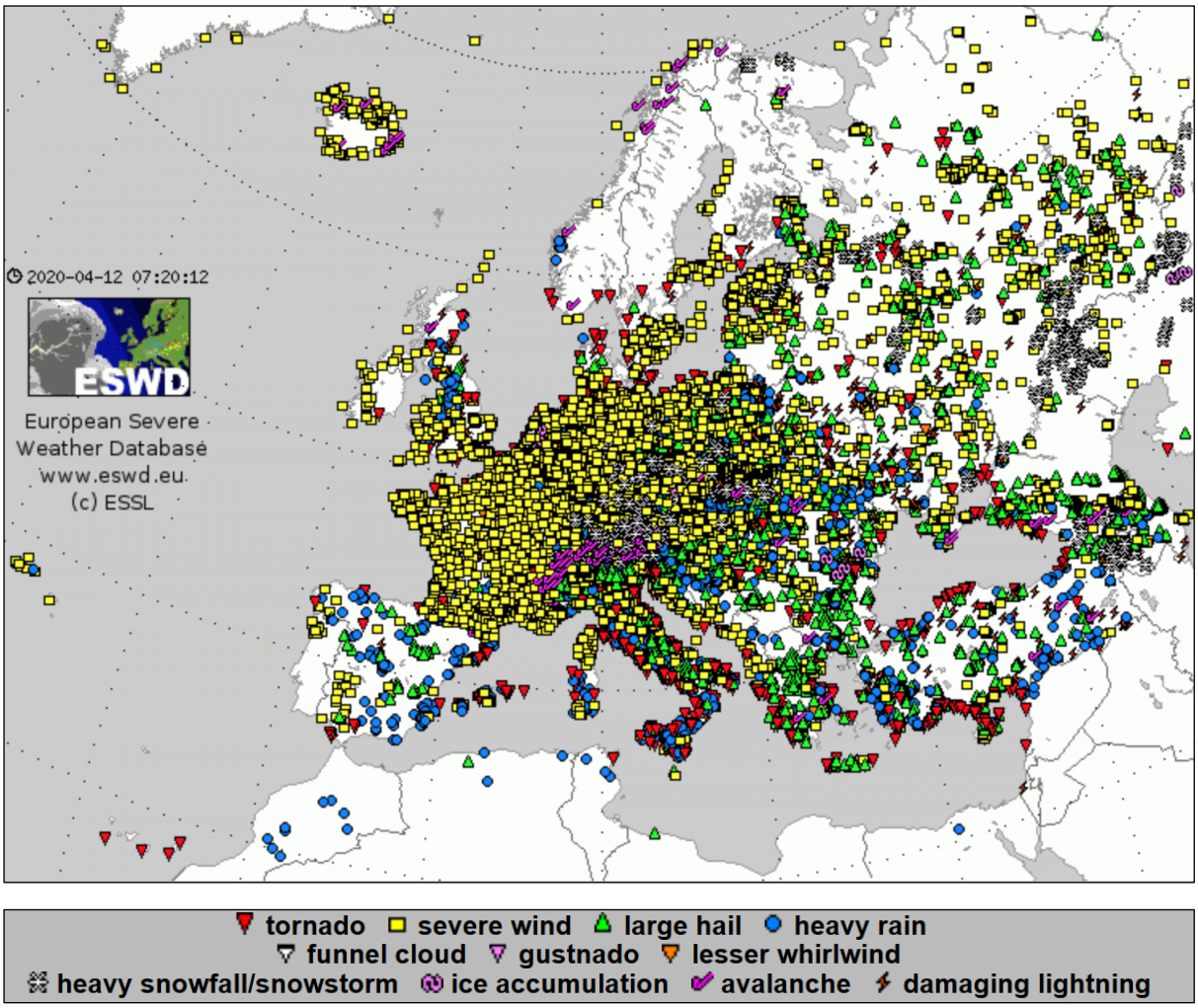

Figure 1-2. The 22216 ESWD reports of events occurring in 2019.

Quality Control

ESWD reports are checked for trustworthiness by a dedicated team at ESSL and by its ESWD partners. Any report that reaches ESSL from an untrusted source will initially be given the QC0 quality level, indicating that no check has been carried out. After checking, ESSL and its partners can assign any of three QC-levels to a report, based on the level of trustworthiness (plausible = QC0+, or confirmed by a reliable source = QC1) or whether – in rare cases – a full scientific case study has been carried out (QC2). Upgrading from one level to another is possible at any time as more or better information comes in to corroborate the report. All reports from 2019 have been upgraded at least to QC0+, QC1 or QC2 (Table 1-2).

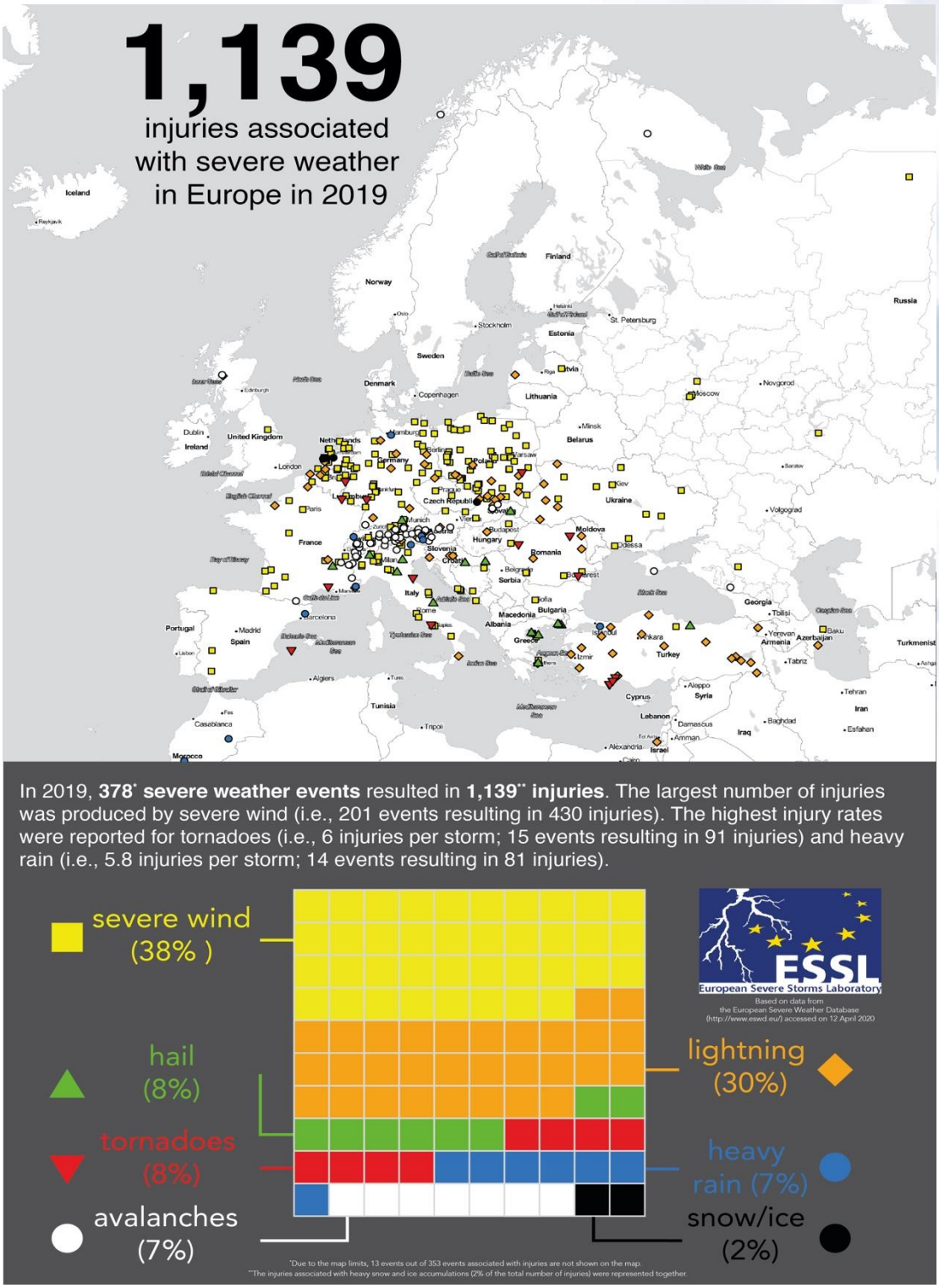

Figure 1-3. The spatial distribution of the ESWD severe weather reports in Europe, associated with injuries in 2019. Below, the percentage of injuries associated with each type of severe weather across the entire ESWD area, i.e. including Mediterranean Africa and Asia, and Central Asia (excluding categories < 1%).

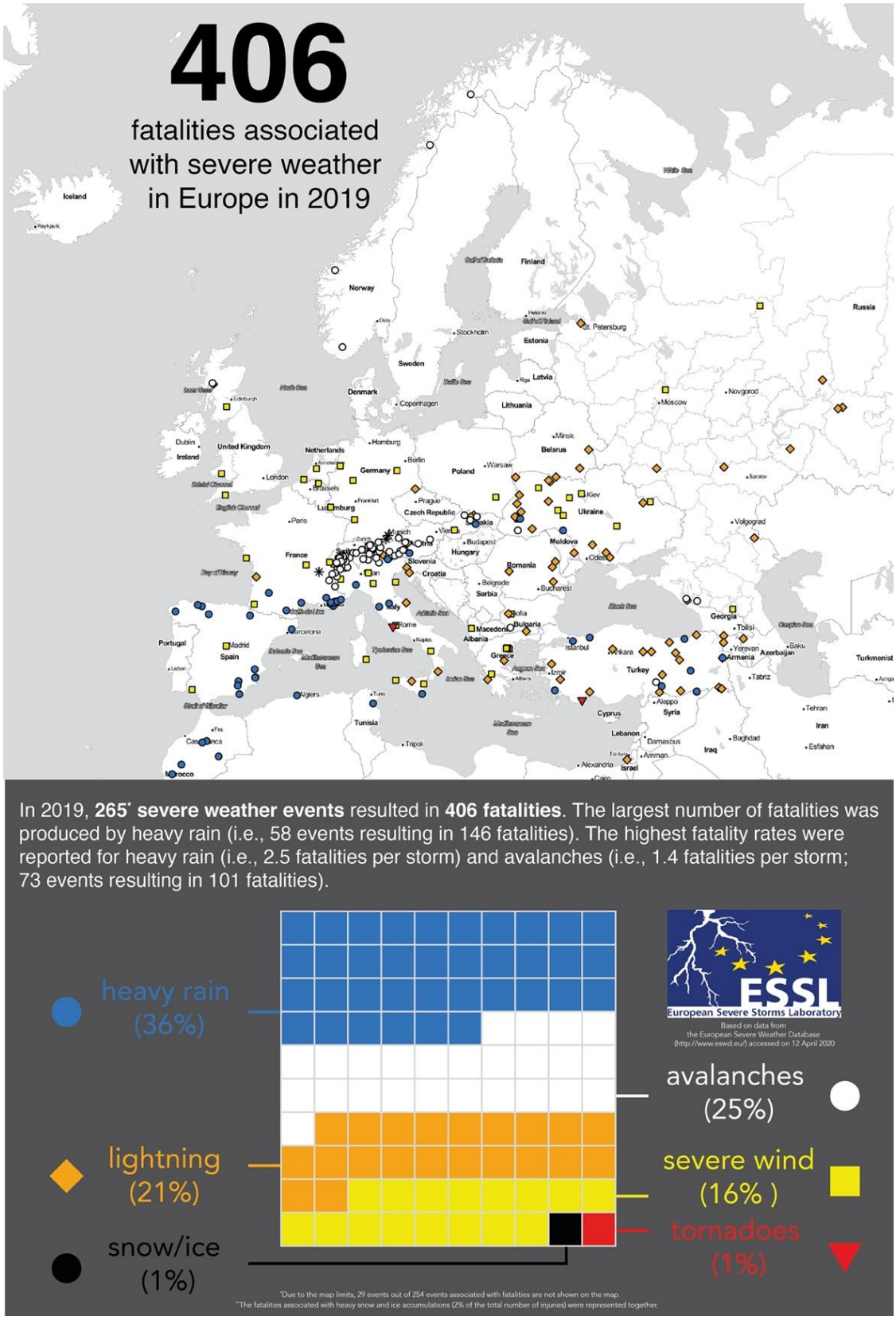

Figure 1-4. The spatial distribution of the ESWD severe weather reports in 2019 associated with fatalities. Below, the percentage of fatalities associated with each type of severe weather across the entire ESWD area, i.e. including Mediterranean Africa and Asia, and Central Asia (excluding categories < 1%).

Fatalities and Injuries

The severe weather reports of 2019 were associated with 1139 injuries (Figure 1-3) and 406 fatalities (Figure 1-4). Wind was responsible for 38% of the recorded injuries, and 16% of all recorded fatalities. Heavy rain and flash floods were responsible for 36% of the fatalities, but only 7% of injuries. Lightning caused 30% of injuries and 21% of fatalities. Many fatalities (25%) were also recorded from avalanches.

The single deadliest event involved 23 fatalities in floods at Tulun (Irkutsk, Russia) on 27 June. This was also the day with the highest number of (hydro-)meteorological fatalities. Other events with many fatalities include a heavy rain event that struck Morocco on 8 September resulting in 17 fatalities. The top ten of days with most fatalities (Table 1-3) shows that heavy rain and the resulting flash floods, primarily in June–September, were responsible for most fatalities in 2019. In addition, a windstorm in Greece on 10 July, and a series of avalanches in January in Germany and Austria and in May in Russia are listed.

	Event type(s)	**Date**	**Country**	**Region / Location**	**Fatalities**
1	Heavy rain Wind (2)	27 June	Russia Ukraine	Irkutsk Krehovychi	25
2	Heavy rain	8 September	Morocco	Errachidia	17
3	Heavy rain	24 July	Morocco	Marrakech-Tensift-Al Haouzi	15
4	Wind (5) Wind (2) Avalanche (1) Avalanche (1)	23 January	Italy Albania Germany Austria	Lazio Miot Bayern Tirol	9
5	Lightning	18 June	Turkey	Kastamonu	9
6	Wind (6) Lightning (2) Lightning (1)	10 July	Greece Turkey Russia	Chalkidiki Izmir Chelyabinsk	9
7	Heavy Rain (7) Lightning (1)	17 July	Turkey Russia	Düzce Saratov	8
8	Heavy Rain (8)	28 August	Morocco	Souss-Massa-Drâa	8
9	Avalanche	6 May	Russia	Altay Respublika	7
10	Heavy Rain (4) Heavy Rain (2)	4 June	Libya Tajikistan	Ghat Sughd	6

Table 1-3. Ten days with most fatalities in 2019 recorded in the ESWD.

2 Research

ESSL's research activities in 2019 focused on the changing risk of convective storms due to climatic change in the project ARCS, and a project on the application of the IASI infrared sounder data in the forecasting process.

2.1 Analysis of Risk of Convective Storms (ARCS)

Funded by: Munich Re and
German Ministry of Education and Research (BMBF)
Grant: EUR 323 000 (BMBF contribution)

Period: 1 April 2016 – 31 March 2019 (with Munich Re)
Carried out by: ESSL e.V., Weßling
Prolongation period: 1 April 2019 – 31 December 2019 (ESSL only)

In 2019, the original ARCS project that was co-funded by Munich Re ended on 31 March. ESSL successfully requested a prolongation of the project until 31 December 2019 to finish parts of the work that were not completed by the end of the project.

The last part of the original ARCS project strongly focused on estimating the changing impact of storms, in particular hailstorms. To do this, ESSL's Chris Castellano developed an event set generator. This algorithm triggers hailstorm tracks with a given length, width, orientation and hail size. These properties are taken from statistical distributions that take the environmental conditions and the most important cross-correlations among them into account. The coverage of hailstorms was modelled to correspond – in a statistical sense – to the climatological probability of hail as modelled by AR-CHaMo, i.e. the Additive Regression Convective Hazard Models developed at an earlier stage in the ARCS project. Each event set can be thought of as a microscale realization of the AR-CHaMo prediction, and when simulating a large number of such events, the occurrence of the most extreme realizations can be studied.

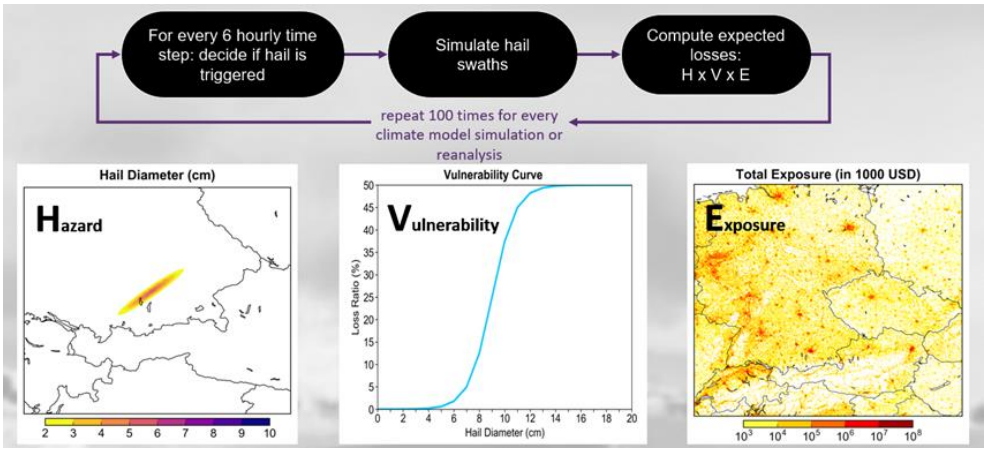

Figure 2-1. Illustration of the stepwise process with which events are generated and the damage caused by the respective event calculated.

Event sets were generated for the past by using reanalysis data as an input and for future climate scenarios by using input from regional climate models. The event sets can be combined with data of vulnerability and exposure of objects that can potentially be affected. This knowledge can be used to obtain estimates of the probability that damage of a particular amount will occur (Figure 2-1).

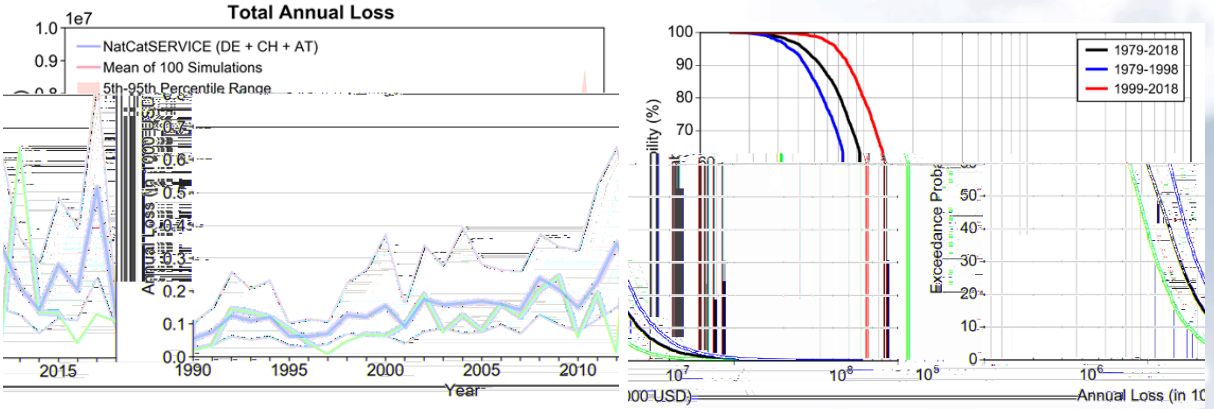

Figure 2-2. Left: a comparison between hail-related losses in Central Europe collected in the NatCatSERVICE database operated by MunichRe and the predictions of the ARCS event sets. Right: Exceedance probability of a given annual damage in the period 1979-2018 (black), as well as during the first (blue) and last (red) half of the period, highlighting an increase in risk from hailstorms.

Figure 2-2 illustrates how the expected annual loss by hail across Central Europe compares to the observed losses and how this has changed between the first and second half of the reanalysis period from 1979 to 2018. Figure 2-3 shows how the annual losses (left) and largest hail diameter (right) are expected to change, based on the event sets when applied to EuroCordex regional climate models.

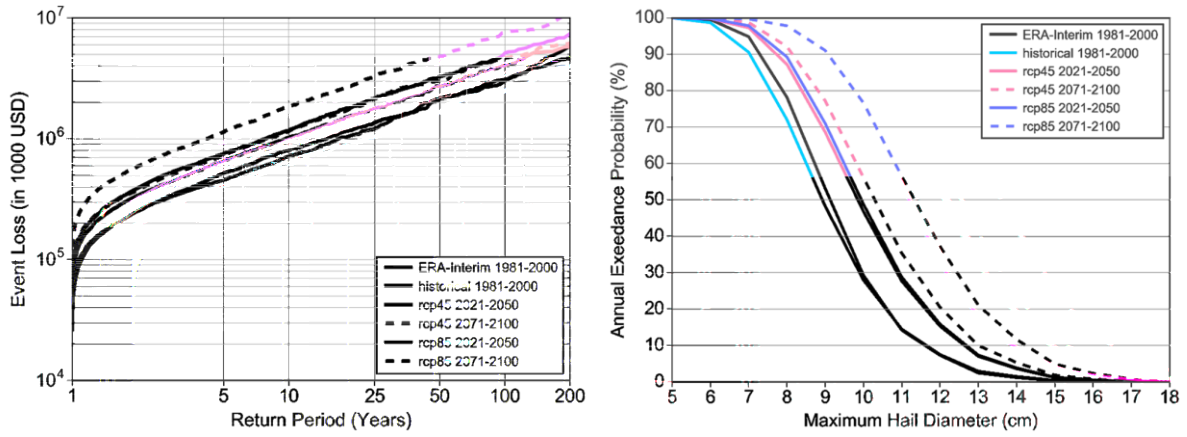

Figure 2-3. Changes in annual losses (left) and annual maximum hail diameter (right) to be expected under various climate change scenarios.

During the prolonged part of the ARCS project, ESSL developed a similar event set generator for tornado events and started a study on the effects of synoptic scale flow pattern changes on severe weather occurrence. This study will be completed within a new project, CHECC that starts in 2020.

2.2 Study on hyperspectral sounding for severe storm forecasting

Funded by: EUMETSAT
Period: January 2019 – January 2020
Carried out by: ESSL Science and Training, Wiener Neustadt

As part of the Meteosat Third Generation (MTG) mission, EUMETSAT will employ two geostationary sounding satellites (MTG-S) each carrying an Infrared Sounder (IRS) instrument. Similar data is already available from the Infrared Atmospheric Sounding Interferometer (IASI) instrument on the polar-orbiting Metop satellites. IRS and IASI sounder data can be used to generate vertical profiles of temperature and humidity throughout the troposphere.

For EUMETSAT, ESSL has assessed if these profiles can be used to support forecasting severe convective storms without first assimilating them into a numerical weather prediction (NWP) model. To that aim, ten severe weather case-studies were performed. Additionally, ESSL exposed 40 forecasters from European weather services to IASI data by integrating it into the ESSL Testbed programme of 2019. The data were to facilitate a direct comparison with NWP predictions: as coloured dots overlaid on shaded NWP fields (Fig 2-4), and in an interactive display of vertical soundings showing NWP and IASI data alongside each other (Figure 2-5).

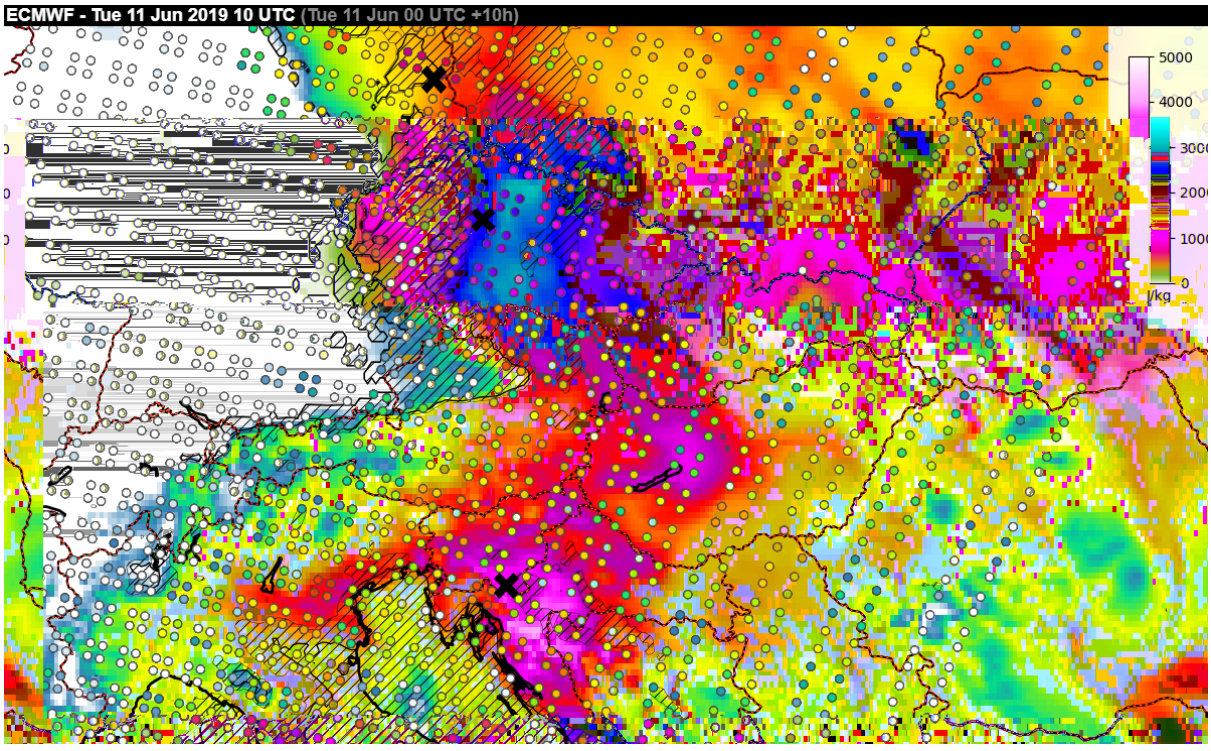

Figure 2-4. Comparison between model-simulated MLCAPE50 (background color) and that calculated from the retrieved IASI profiles (colored dots).

Almost all forecasters who used the IASI profiles at the Testbed found this type of product useful. They also indicated that a higher spatiotemporal availability would be helpful and for some this was even a requirement. This is important given the future availability of similar, but

more frequent, data from the MTG-IRS. There was a high level of agreement among forecasters that the IASI data should stay completely independent of NWP model forecasts, so that it is an independent source of information that forecasters can use to instantly verify NWP models. The most popular derived quantities from the data were CAPE (preferably mixed-layer CAPE), lapse rate of temperature, and total precipitable water. This information can guide the definition of L2 products at EUMETSAT.

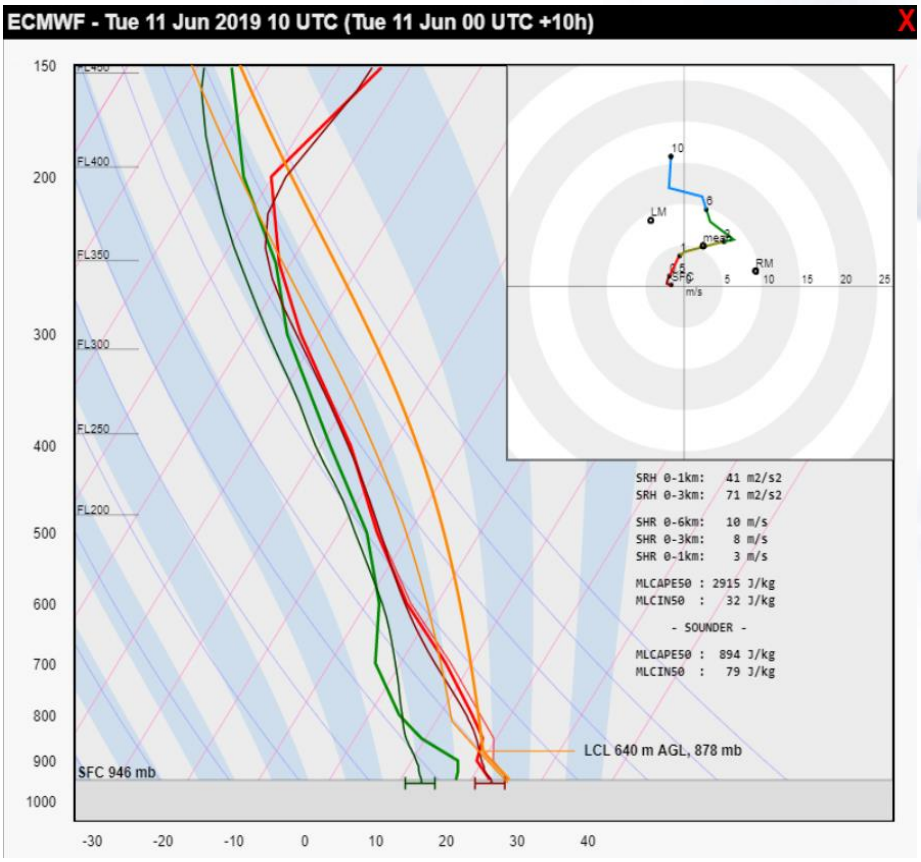

Figure 2-5. Comparison between temperature(red) and humidity (green) profiles from the ECMWF model (thick lines) and IASI data (thin lines). Also shown: ascent curves (yellow) and error bars (at the surface).

During the Testbed sessions and the case studies several characteristics of the IASI data were discovered. The detected temperature was typically found to be close to the NWP forecast valid at the same time and location. Exceptions are sharp inversions that cannot be fully resolved. Deviations of IASI from the modelled temperature close to the surface are usually confirmed by surface observations, i.e. they indicate an NWP model error, which is valuable information to forecasters. The humidity retrieved from IASI was often found to be less accurate than temperature, in the lowest troposphere, were underestimations often occurred in thunderstorm situations. Since thunderstorms are very dependent on low-level humidity, this limits the extent to which IASI can be used to anticipate them. Finally, it was noted that both temperature and humidity can differ substantially between two overpasses occurring soon after each other.

Since the data were received positively by forecasters, and the case studies have confirmed that the data can contribute to a better anticipation of thunderstorm development (or lack thereof), it is recommended to continue to explore the use of IASI data. More precisely, it is recommended to assess to whether the retrieval algorithms can be optimized for the correct detection of low-level humidity. Furthermore, IASI data can be combined with other observations such as in-situ measurements, LIDAR data and AMDARs, in order to obtain an improved observation-based data set. In order to simplify the comparison between IASI data and NWP models, difference fields of key parameters can be computed and visualized. Additionally, it is recommended that error estimates of the measurements are presented to forecasters throughout the retrieved vertical profile.

2.3 Study on CAPE and CIN forecast parameters

Funded by: ECMWF
Period: January 2019 – August 2019
Carried out by: ESSL Science & Training, Wiener Neustadt

ECMWF requested ESSL to present a review of the computation of Convective Available Potential Energy (CAPE) and Convective Inhibition (CIN) from NWP model data and to make an inventory of the currently implemented methods at various modelling centres such as ARPEGE, AROME, UM, HiRLAM, ICON, COSMO. The calculations differ regarding their intended use (for forecasters, model-internal use), choice of parcel (most unstable only, or also for a near-surface mixed-layer), whether entrainment is assumed in the parcel, whether the process is reversible or pseudo-adiabatic ascent, and whether the latent heat of freezing and disposition are accounted for.

In addition, forecasters were presented various varieties of CAPE and CIN at the ESSL Testbed and questioned regarding their preferences (Figure 2-6). ESSL also provided a code of the computation of various types of CAPE and CIN to ECMWF, which was tested with the IFS model data. It was noted that CAPE and CIN for the near-surface 50 hPa mixed-layer parcel and for the most unstable parcel contain some independent information all of which is valuable to forecasters. In parcel calculations, it is recommended to implement pseudo-adiabatic ascent to ensure that an underestimation of instability is prevented —which could occur if reversible ascent is implemented— and without accounting for latent heat of freezing and disposition.

ECMWF Technical Memorandum 852 reports in detail about the findings of the study:

Groenemeijer P., Púčik T., Tsonevsky I., and Bechtold P.: An Overview of Convective Available Potential Energy and Convective Inhibition provided by NWP models for operational forecasting

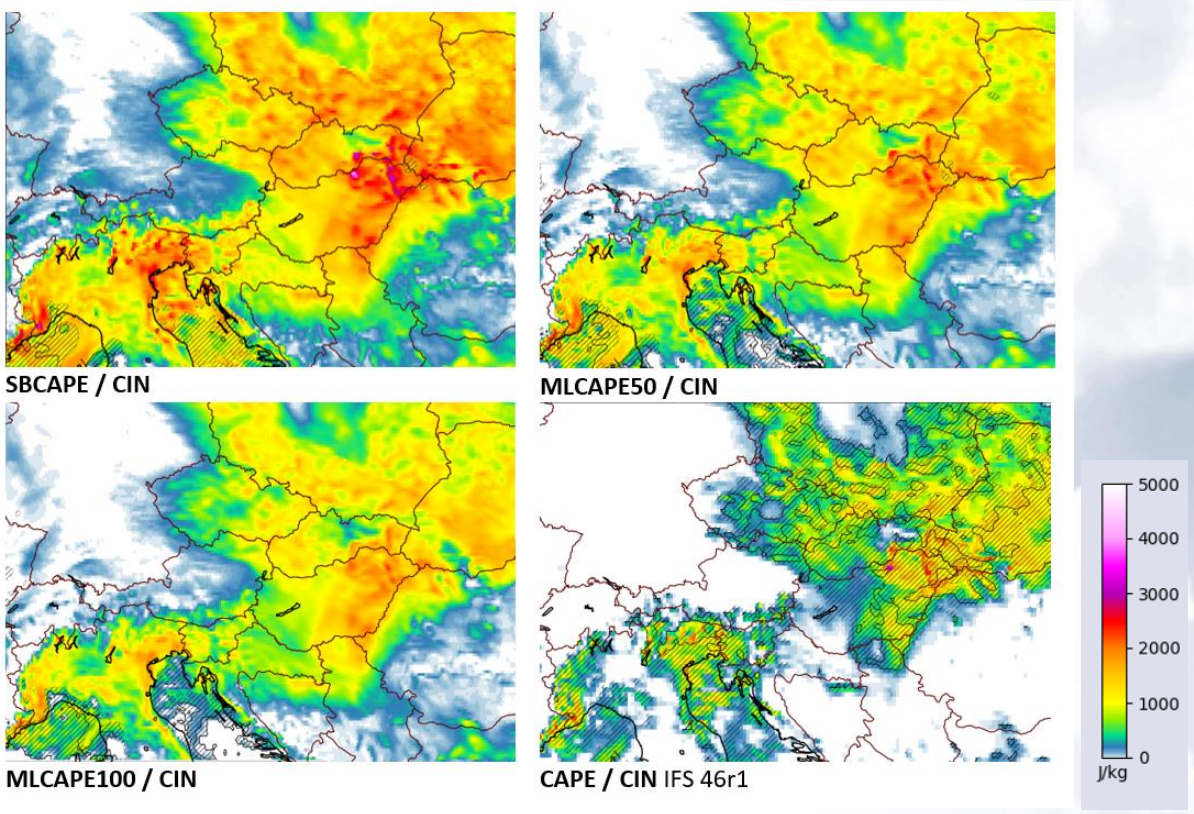

Figure 2-6. CAPE (colorscale) and CIN (hatched areas where > 50 J/kg) forecast for 30 July 2019 15 UTC (+39 h), for a surface-based (left top), 50 mb-mixed-layer parcel (right top), 100 mb mixed-layer (left bottom) parcel, and as implemented in ECMWF IFS cycle 46r1.

3 The European Conference on Severe Storms: ECSS2019

The Polish Institute of Meteorology and Water Management IMGW and ESSL jointly organized the 10th edition of the European Conference on Severe Storms in Kraków, Poland from 4 to 8 November 2019. The conference, of which Munich Re was the main sponsor, was a great success, with a new record of 241 participants attending and high-quality scientific presentations. Participants from 32 countries presented their research at the conference during 12 sessions. In total, 83 oral presentations were given and 134 posters were on display (Figure 3-2).

About 33% of the participants returned a feedback form. They graded the conference with a mean of 8.7 points out of 10. The main positive points of feedback were the high quality and diversity of the presented work, the great location of the venue right at the main square of the city, and the long coffee breaks allowing for discussion and networking.

Figure 3-1. Group photo of the ECSS2019 participants.

Points for improvement included a larger poster area, and more seats in the oral presentation room, which indeed turned out to be slightly too small because of the unexpectedly high number of participants.

As side meetings, the ESSL General Assembly and a Splinter Meeting of the EUMETSAT Convection Working Group (CWG) took place during the ECSS. In addition, Dr. George Bryan presented an introductory overview of the Cloud Model 1 (CM1), that was attended by a few dozen of people who wanted to learn more about its capabilities. The social programme on Wednesday included a tour to the impressive Wieliczka salt mines and a Conference Dinner in the centre of Kraków.

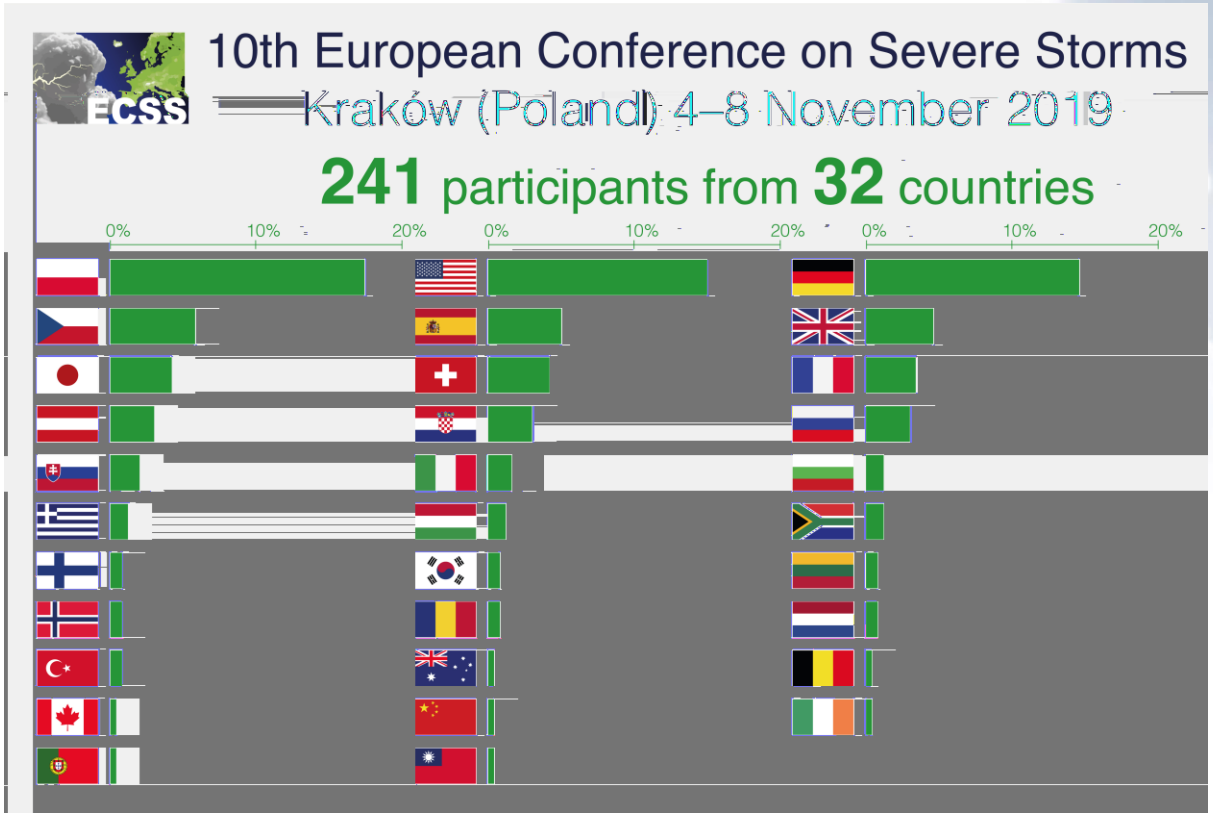

Figure 3-2. Origin of the participants of the ECSS2019 conference in Kraków.

3.1 Awards presented at the ECSS2019

The European Severe Storms Laboratory has two awards that it presents to outstanding scientists at each edition of the European Conference on Severe Storms: the Nikolai Dotzek Award to honor an outstanding contribution to the science of severe storms, and the Heino Tooming Award for pan-European collaboration in the severe storms research community.

Nikolai Dotzek Award

The awardee of the ECSS2019 Nikolai Dotzek Award is Dr. Robert (Bob) Davies-Jones (Figure 3-3) who was awarded for his many important contributions to the science of severe storms and related disciplines. Among his achievements is the development of a theoretical description of supercell thunderstorms and the role of helicity, and his contributions to ground-breaking field campaigns targeting tornadoes.

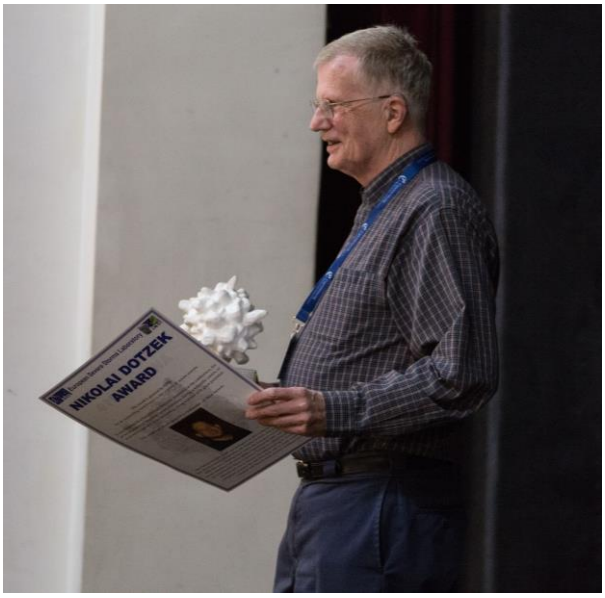

Figure 3-3. Dr. Robert Davies-Jones, awardee of the Nikolai Dotzek Award 2019.

Lifetime Achievement Heino Tooming Award

A special Lifetime Achievement Heino Tooming Award was given to Dr. Jean Dessens (Figure 3-4), for his important role in the initial phase of this conference series. We celebrated the 10th edition of the ECSS this year, a great opportunity to commemorate how the series of conferences started with the first European Conference on Tornadoes and Severe Storms in Toulouse in 2000, and how the conference has evolved through time.

Figure 3-4. Dr. Jean Dessens speaking after receiving the Lifetime Achievement Heino Tooming award. From left to right: Michou Baart de la Faille (ESSL), Jean Dessens, and Bogdan Antonescu, Pieter Groenemeijer and, Alois M. Holzer (all ESSL).

Awards for best Conference Contributions

In addition to the Nikolai Dotzek Award and the Heino Tooming Award, a number of outstanding posters and oral presentations were given, for which these presenters received an award after being selected by a jury or by the ECSS participants:

Award	Awardee(s)	Presentation title
Best Oral Presentation Jury Award	Jannick Fischer and Johannes Dahl	*Outflow surges in simulated supercell-like storms and their influence on tornado development*
Best Poster Jury Award	Shruti Nath and co-authors	*Towards automated multi-sensor thunderstorm warning suggestions*
Best Oral Presentation Audience Award	Enoch Jo and Sonia Lasher-Trapp	*Entrainment in supercells*
Best Poster Audience Award	Mateusz Taszarek, Natalia Pilguj, Juliusz Orlikowski, Artur Surowiecki, Szymon Walczakiewicz, Wojciech Pilorz, Krzysztof Piasecki, Łukasz Pajurek, Marek Półrolniczak	*Derecho evolving from a mesocyclone*

Platon Patlakas was awarded a Young Scientist Travel Award by the European Meteorological Society.

Travel support

In addition to the awards above, ESSL was able to support five participants to the ECSS from the income of abstract registration fees. Their participation fees were waived and their received a lump sum of € 500 as a contribution to their travel expenses.

4 ESSL Testbed 2019

The Testbed is ESSL's annually returning event that serves two aims: the evaluation of tools supporting the forecast or warning process and providing training in severe convection forecasting to its participants.

The ESSL Testbed 2019 took place during the weeks of 3–7 June, 24–28 June, 1–5 July and 15–19 July 2019 at the ESSL Research and Training Centre in Wiener Neustadt. During these four weeks, 41 participants took part in the Testbed in addition to 6 ESSL staff members. The participants came from 14 different countries: Austria, Germany, the Netherlands, Slovakia, Croatia, Portugal, Latvia, Bulgaria, Italy, Czechia, Poland, Cyprus, Slovenia, and the United Kingdom.

As in previous years, the participants used experimental forecast-supporting tools while making experimental forecasts and nowcasts, most of them to be issued in real-time so as to emulate an operational forecasting environment.

Figure 4-1. Participants of the ESSL Testbed 2019

This year, there was particular attention to the use of vertical temperature and humidity profiles of the IASI hyperspectral sounder as part of a larger study by ESSL for EUMETSAT. These profiles were compared to model forecasts (see section 0). In addition, ways CAPE and CIN can be computed were tested in cooperation with ECMWF (see section 2.3).

For the German Weather Service DWD, three products for nowcasting were evaluated, i.e. NowcastMIX, NowcastELEC, and NowcastSAT. NowcastMIX is DWD's state-of-the art cell-based nowcasting tool that provides an analysis of the severity of convective cells and provides

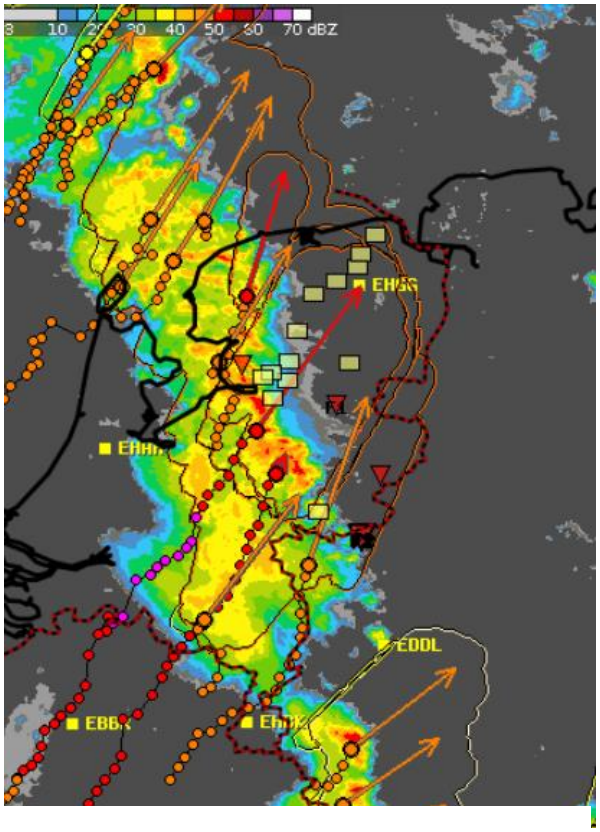

Figure 4-2. Left: A visualization of NowcastMIX with included ESWD reports during the next hour. Yellow rectangles denote severe wind gusts, red triangles tornado reports.

a forecast of their motion during the next 60 minutes. At the Testbed, participants and ESSL staff evaluated NowcastMIX by using it in real-time and, *a posteriori*, by comparing the forecasts with radar imagery and observations of severe weather collected in the ESWD. Figure 4-2 shows an instance where NowcastMIX gave good guidance regarding the severe weather risk, as all observed severe weather reports fall within the areas indicated by NowcastMIX.

NowcastSAT and NowcastELEC are two products that primarily use satellite and lightning detection data to analyze and predict the motion of severe storms across very large areas. The intended user group for these products includes the aviation sector. Figure 4-2 shows an illustration from ESSL's report for DWD about the evaluation at the Testbed, pointing out behavior of the NowcastSAT product.

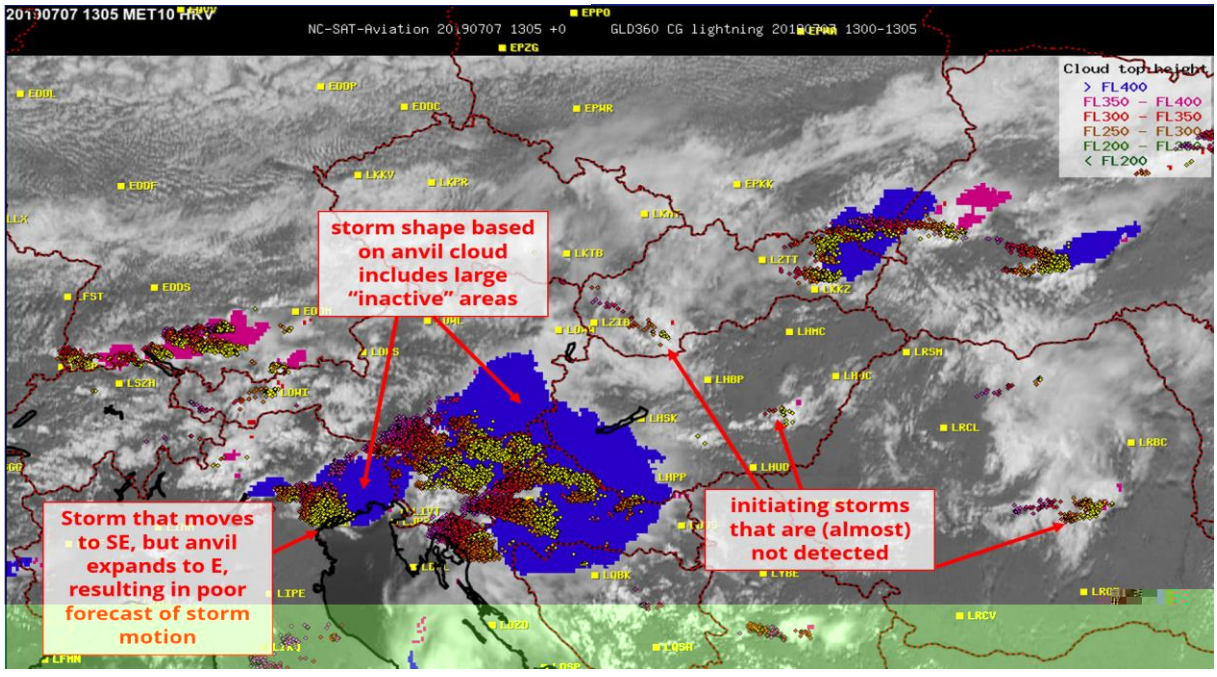

Figure 4-3. A visualization of NowcastSAT and included comments on its performance, from the ESSL report for DWD.

5 Training activities

In 2019, ESSL organized several courses on forecasting severe convective storms for forecasters and researchers, most of them hosted in Wiener Neustadt. In addition, three courses were organized on-site in Genoa, Italy, and Darmstadt, Germany.

Course:
"Forecasting Severe Convection II: Dynamics of severe convection" by Prof. Dr. Yvette Richardson (11–15 March 2019)

Figure 5-1. Participants of the course "Forecasting Severe Convection II: Dynamics of severe convection"

The busy training year started with a seminar specializing on the dynamics of severe convective storms and was taught by Prof. Yvette Richardson of the Pennsylvania State University. Dr. Richardson is also co-author of the textbook "Mesoscale Meteorology in Midlatitudes". In the morning lectures, participants were taught the ins and outs of mesoscale convective systems and supercells, which they had to apply in the afternoon when dealing with forecasting interesting past cases. There were many vivid discussions both during the lectures and during the practical exercises, reflecting the already high knowledge level of the participants.

Figure 5-2. Participants of the two spring aviation courses on forecasting severe convection.

Courses:
"Aviation Forecasting of Severe Convection" by Dr. Tomáš Púčik
(25–29 March 2019, 8–12 April 2019, 23–27 September 2019)

Spring continued with two courses lectured by Dr. Tomáš Púčik, both specializing on the aviation aspects of severe convective storm forecasting. Originally, only one course had been planned, but the large interest prompted us to include an additional seminar. The difference between the aviation and the "Forecasting severe convection" seminar is that we concentrate more on forecasting convective coverage, storm tops, point-based forecasting and hazards such as icing or lightning. In the standard seminar, more emphasis is put on

forecasting convective type and hazards, such as flash flooding. The point-based forecasting for airports when dealing with storms can be very tricky.

One of the exercises of the Aviation course was to make such point forecasts for a severe convective windstorm case on 10 August 2017. Demand for the course was so high that a third edition of the aviation course was held in September.

Figure 5-3. Participants of the autumn course on forecasting severe convection.

Figure 5-4. Afternoon exercises: applying the concepts discussed in the morning lectures at the Aviation Forecasting Severe Convection course.

Course: "Forecasting of Severe Convection" on site at ARPA-Liguria by Dr. Tomáš Púčik (6–10 May 2019)

Figure 5-5. Participants of the seminar held at ARPA-Liguria headquarters in Genoa.

In cooperation with ARPA Liguria, ESSL organised two seminars on forecasting severe convective storms, one in May and another one in October. Besides the forecasters from ARPA Liguria, also forecasters from other ARPA regional weather forecasting offices took part. The weather in May was rather cool without any convective activity, but the October version lived up to Genoa's reputation. Several thunderstorms occurred in the area during the week in very humid conditions and flash floods occurred close to Genoa. This offered a unique opportunity to discuss some of the taught material in the context of the ongoing storms.

Course: "Forecasting of Severe Convection I" by Dr. Tomáš Púčik (7 –11 October 2019)

In October, ESSL organized an edition of the course on forecasting severe convective storms for general weather forecasters. Compared to the aviation edition, more emphasis is placed on forecasting convective type and associated hazards, such as flash flooding. The participants received a detailed treatment of convective storm forecasting, starting from the basic ingredients to the interpretation of hodographs.

Figure 5-6. Participants of the Forecasting Severe Convection course.

Figure 5-7. Lectures and practical exercises during the autumn courses, whereby the whiteboard is used as much as the powerpoint slides.

Introductory Course: "Forecasting of Severe Convection" on site at EUMETSAT by Dr. Tomáš Púčik and Dr. Pieter Groenemeijer (29–30 April 2019)

Besides the week-long seminars, ESSL also provided a one-day introductory course at EUMETSAT upon initiative of Dr. Thomas August (EUMETSAT). This was done as a part of the project devoted to evaluating the usefulness of vertical profiles of temperature and humidity derived from the Infrared Atmospheric Sounding Interferometer (IASI) instrument in severe convective storm forecasting and nowcasting. The seminar consisted of morning lectures and an afternoon exercise. It was attended by EUMETSAT scientific staff including those involved with IASI and with new sensors to be deployed as part of the Meteosat Third Generation satellites. They were exposed to the basics of the ingredients-based forecast methodology for convective storms, convective types and forecasting associated hazards. The exercise demonstrated the value of having additional data of the temperature and humidity, such as those that can be provided by IASI, for nowcasting severe convective storms.

6 Publications and Communications

ESSL produced many scientific and other results in 2019, which lead to a high number of presentations and publications. Below, a list of all publications is given, with the names of ESSL-affiliated authors underlined.

6.1 Peer-reviewed scientific publications

Appeared in 2019:

- Mateusz Taszarek, John T. Allen, Tomáš Púčik, Pieter Groenemeijer, Bartosz Czernecki, Leszek Kolendowicz, Kostas Lagouvardos, Vasiliki Kotroni and Wolfgang Schulz, 2019:
  A climatology of thunderstorms across Europe from a synthesis of multiple data sources *Journal of Climate*, **32**, 1813–1837.
  https://doi.org/ 10.1175/JCLI-D-18-0372.1

- Anja T. Rädler, Pieter Groenemeijer, Eberhard Faust, Robert Sausen and Tomáš Púčik, 2019:
  Frequency of severe thunderstorms across Europe expected to increase in the 21st century due to rising instability
  npj Climate and Atmospheric Science, **2**, 30.
  https://doi.org/10.1038/s41612-019-0083-7

- Bogdan Antonescu, David M. Schultz, Hugo M.A. Ricketts, and Dragoș Ene, 2019:
  Theories on tornado and waterspout formation in ancient Greece and Rome
  Weather, Climate, and Society, **11**, 889–900.
  https://doi.org/10.1175/WCAS-D-19-0057.1

- Harold E. Brooks, Charles A. Doswell III, Xiaoling Zhang, Alexander Chernokulsky, Eigo Tochimoto, Barry Hanstrum, Ernani de Lima Nascimento, David M.L. Sills, Bogdan Antonescu, and Brad Barrett, 2019:
  A century of progress in severe convective storm research and forecasting
  Meteorological Monographs, **59**, 18.1–18.41.
  https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0026.1

- Bogdan Antonescu, Hugo M. A. Ricketts and David M. Schultz, 2019:
  100 Years Later: Reflecting on Alfred Wegener's Contributions to Tornado Research in Europe
  Bulletin of the American Meteorological Society, **100**, 567–578.
  https://doi.org/10.1175/BAMS-D-17-0316.1

- Tomáš Púčik, Christopher Castellano, Pieter Groenemeijer, Thilo Kühne, Anja T. Rädler, Bogdan Antonescu, and Eberhard Faust, 2019:
  Large hail incidence and its economical and societal impacts across Europe
  Monthly Weather Review, **147**, 3901–3916.
  https://doi.org/10.1175/MWR-D-19-0204.1

- John T. Allen, Ian M. Giammanco, Matthew R. Kumjian, Heinz J. Punge, Qinghong Zhang, Pieter Groenemeijer, Michael Kunz, and Kiel Ortega, 2019:
  Understanding hail in the Earth system
  Reviews of Geophysics, **58***,* e2019RG000665.
  https://doi.org/10.1029/2019RG000665

Submitted in 2019, appeared in 2020:

- Bogdan Antonescu, Tomáš Púčik, and David M.Schultz, 2020:
  Hindcasting the First Tornado Forecast in Europe: 25 June 1967.
  Weather and Forecasting, **35**, 417–436.
  https://doi.org/10.1175/WAF-D-19-0173.1

- Alexander Chernokulsky, Michael Kurgansky, Igor Mokhov, Andrei Shikhov, Igor Azhigov, Evgeniya Selezneva, Denis Zakharchenko, Bogdan Antonescu, and Thilo Kühne, 2020:
  Tornadoes in Northern Eurasia: From the Middle Age to the Information Era.
  Monthly Weather Review, **148**, 3081–3110
  https://doi.org/10.1175/MWR-D-19-0251.1

6.2 Scientific and Invited Presentations

Oral presentations

- Pieter Groenemeijer and Alois M. Holzer: **The European Severe Storms Laboratory – ESSL**, Invited talk at the Joint Research Centre, Ispra, Italy, 12 January 2019.

- Tomáš Púčik: **Above anvil cirrus plumes atop major European hailstorms of 2018**, EUMETrain Event Week on Convection, 20 – 24 May 2019. http://www.eumetrain.org/resources/cew2019_s1a.html

- Pieter Groenemeijer, Anja T. Rädler, Tomas Pucik, Chris Castellano, Eberhard Faust: **Analyse der Veränderungen des Risikos aus Unwettern in Europa: Vergangenheit, Gegenwart und Zukunft**, Invited presentation ZAMG, Vienna, 25 June 2019.

- Bogdan Antonescu, David M. Schultz, Hugo M. A. M. Ricketts, and D. Ene, 2019: **Theories on tornado and waterspout formation in ancient Greece and Rome**. 10th European Conference on Severe Storms, 4–8 November, Kraków, Poland.

- Alois M. Holzer, Pieter Groenemeijer, Thomas Krennert, Rainer Kaltenberger, Thilo Kühne, Thomas Schreiner, and Gabriel Strommer. **EWOB: A standard for international exchange of weather and weatherimpact observations from crowd-sourcing**. 10th European Conference on Severe Storms, 4–8 November, Kraków, Poland.

- Pieter Groenemeijer, Tomáš Púčik, and Thomas August, 2019: **Evaluating the use of temperature and humidity profiles from the IASI hyperspectral sounder for severe storm forecasting at the ESSL Testbed**. 10th European Conference on Severe Storms, 4–8 November, Kraków, Poland.

- Tomáš Púčik, Pieter Groenemeijer, Christopher Castellano, Anja Rädler, Thilo Kühne, and Eberhard Faust, 2019: **Large hail impacts and hail-related financial losses across Europe**. 10th European Conference on Severe Storms, 4–8 November, Kraków, Poland.

- Nataša Strelec Mahović, Petra Mikuš Jurković, Marko Blašković, Tanja Renko: **SEEMET -South-Eastern Europe Training Initiative.** 10th European Conference on Severe Storms, 4–8 November, Kraków, Poland.

- Tanja Renko, Nataša Strelec Mahović, Petra Mikuš Jurković: **Exceptional bura case at the end of February 2019.** 10th European Conference on Severe Storms, 4–8 November, Kraków, Poland.

- Tomáš Púčik: **When an umbrella is not enough**, Invited presentation at EUMETSAT, 19 November 2019, Darmstadt, Germany.

Poster presentations

- Pieter Groenemeijer, Alois M. Holzer, Martin Hubrig, Thilo Kühne, Rainer Kaltenberger, Juan de Dios Soriano, Lothar Bock, Délia Guitiérrez Rubio, Bas van de Ploeg, Gabriel Strommer, and Thomas Schreiner: **The International Fujita Scale: A Globally Applicable Scale for Tornado and Wind Damage Classification**. 10th European Conference on Severe Storms, 4–8 November, Kraków, Poland.

- Sorin Cheval, Aritina Haliuc, Bogdan Antonescu, Adrian Tișcovschi, Mihai Dobre, Florin Tătui, Alexandru Dumitrescu, Ancuta Manea, G. Tudorache, Anisoara Irimescu, and Mariu-Victor Birsan, 2019: **Information on severe storms in newspapers from the 19th century**. *10th European Conference on Severe Storms*, 4–8 November, Kraków, Poland.

- Mateusz Taszarek, John Allen, Tomáš Púčik, Pieter Groenemeijer, Bartosz Czernecki, Leszek Kolendowicz, Kostas Lagouvardos, Vasiliki Kotroni, and Wolfgang Schulz, 2019: **A Climatology of Thunderstorms across Europe from a Synthesis of Multiple Data Sources**. *10th European Conference on Severe Storms*, 4–8 November, Kraków, Poland.

- Tomáš Púčik, Petr Zacharov, and Pieter Groenemeijer: **Modifications to severe convective storm ingredients in the Alpine forelands for cases of strong and weak synoptic-scale flow.** *10th European Conference on Severe Storms*, 4–8 November, Kraków, Poland.

6.3 Reports

- Groenemeijer P., Púčik T., Tsonevsky I., and Bechtold P.: **An Overview of Convective Available Potential Energy and Convective Inhibition provided by NWP models for operational forecasting**, ECMWF Technical Memorandum 852, 2019/11. https://www.ecmwf.int/en/elibrary/19278-overview-convective-available-potential-energy-and-convective-inhibition-provided
- Groenemeijer, Pieter; Rädler, Anja T. Rädler; Castellano, Chris, et al., 2019: **ARCS (Analyse der Veränderungen des Risikos aus konvektiven Unwettern in Europa): Schlussbericht**, ARCS Final Report, https://doi.org/10.2314/KXP:1689024976
- Groenemeijer, Pieter: **Concise report on the evaluation of DWD Forecast and Warning products at the ESSL Testbed 2019**, ESSL Report 2019/01.

6.4 Notable press and other communications

1. **Tornado-Vorhersage: Meteorologen erforschen Entstehung von Superstürmen**, *Forschung Aktuell*, *Deutschlandfunk*, 20 March 2019. Radio interview with Pieter Groenemeijer and online article by Volker Mrasek. https://www.deutschlandfunk.de/tornado-vorhersage-meteorologen-erforschen-entstehung-von.676.de.html?dram:article_id=444115

2. **Am vorbit cu specialistul care anunță tornade în România de 10 ani**, *Vice Romania*. Interview with Bogdan Antonescu. https://www.vice.com/ro/article/43j3yw/specialistul-care-anunta-tornade-in-romania-de-10-ani

3. **Changing tornado behaviour in US bodes ill for Europe**, *The Irish Times*, 1 August 2019. https://www.irishtimes.com/news/science/changing-tornado-behaviour-in-us-bodes-ill-for-europe-1.3946709

4. **Zo'n tornado zie je hier maar om de drie jaar**. *De Standaard*, 12 August 2019. Interview with Pieter Groenemeijer by Yves Delepeleire.

5. **Moeten we ons in België ook zorgen maken om tornado's?** *Gazet van Antwerpen*, 12 August 2019. Interview with Pieter Groenemeijer by Yves Delepeleire.

6. **Nederland, Tornadoland: Die windhoos boven het IJ was spectaculair, maar geen uitzondering.** *De Volkskrant*, 11 October 2019. Interview with Pieter Groenemeijer by George van Hal. https://www.volkskrant.nl/wetenschap/die-windhoos-boven-het-ij-was-spectaculair-maar-geen-uitzondering~b5be42fa/

7. **Wenn Hagelkörner zur Gefahr werden**, *Forschung Aktuell, Deutschlandfunk*, 7 November 2019. Radio Interview with Tomáš Púčik and online article by Volker Mrasek https://www.deutschlandfunk.de/klimaforschung-wenn-hagelkoerner-zur-gefahr-werden.676.de.html?dram:article_id=462905

8. **Studie zu Blitzschlag-Opfern: Gefahr durch Gewitter wird unterschätzt**. *Forschung Aktuell, Deutschlandfunk*, 8 November 2019. Radio Interview with Thilo Kühne and online article by Volker Mrasek, https://www.deutschlandfunk.de/studie-zu-blitzschlag-opfern-gefahr-durch-gewitter-wird.676.de.html?dram:article_id=463024

9. **When an umbrella is not enough – discussing severe storms with Tomáš Púčik**, *EUMETSAT Science Blog*, Interview by Natalie Lunt with Tomáš Púčik, https://scienceblog.eumetsat.int/2020/02/when-an-umbrella-is-not-enough-discussing-severe-storms-with-tomas-pucik/

6.5 Social Media

ESSL is active on Facebook and on its Twitter account @essl_ecss. Through this account, ESSL posts and shares news regarding ESSL's research, Testbed, training and ECSS activities. As of writing, the number of Twitter account followers has increased in the last year to 1366 followers. 50 times ESSL tweeted a message, that had typically a few thousand impressions and were retweeted 430 times. ESSL's Facebook account was used to post 15 messages during 2019. More than 50,000 people visited the ESSL Facebook page and read the messages in 2019. ESSL plans to continue its social media presence during 2020.

7 Financial and Administrative Report

7.1 Employment and Payroll Accounting

In 2019, the European Severe Storms Laboratory e.V. employed two full time employees (the ESSL Director and one researcher), one part-time employee (ESWD quality control manager), and two so-called "Mini-Jobbers" (for programming and secretarial support), a form of minor employment according to German law. The joint Secretariat of ESSL e.V. and the European Severe Storms Laboratory – Science and Training was hosted by the latter and employed three persons part-time (the Assistant to the Board, and two employees for ESWD user support and ESWD quality control). Other tasks were taken over by voluntary workers (i.e. without payment): most importantly, the tasks of the three Deputy Directors and the Treasurer.

As in previous years, an external payroll accountant (Andreas Schnaubelt in Schongau, Bavaria) was mandated during 2019 to take care of paperwork and bureaucratic handling of taxes and social insurances, which would otherwise have exceeded ESSL's internal administrative capacity.

7.2 Auditing of the Annual Accounts

In accordance with the Articles of Association, ESSL's finances for 2019 were audited by the ESSL Advisory Council, based on the report on the annual accounts prepared by ESSL's tax advisor, Mr. Andreas Schnaubelt, Loewenstrasse 5, 86956 Schongau, Germany. This report states:

"Record of Income and Expenses

... during our work no indications occurred which would give raise for objections against the correctness of the record.

Financial Statements

... during our work no indications occurred which would give raise for objections against the correctness of the financial statements."

7.3 Financial Status 2019

European Severe Storms Laboratory e.V.

The accounting year was dominated by income from a project funded by the German ministry of Education and Research, i.e. the project ARCS. Furthermore, income from membership fees was important and necessary to cover overhead costs not covered by ARCS as well as costs for general ESSL activities not attributable to single projects. In addition, income from the successful ECSS also contributed to the ESSL budget. The detailed Annual Accounts for 2019 were presented to the ESSL Advisory Council and can be inspected in the original format and in person by each member at our secretariat. Digital copies of the full document can

alternatively be requested from the ESSL Treasurer. Attachment A1 provides a condensed version of these Annual Accounts.

2019 has seen a decline in project income. While in 2017 we could count on reliable income from 3 different scientific projects, in 2018 two projects were left, and in 2019 only one (ARCS). This led to a situation where liquidity reserves were consumed up, and where part of the business administration was taken over on a voluntary basis by the Treasurer, in order to save money for the scientific and training work.

As required by the German tax authorities, in the detailed accounting 'cost centres' distinguish between the ideational branch of ESSL (*Idealistic Purpose*, i.e. management of the association and its core activities) and its branches directly serving the statutory purposes of the ESSL (dedicated activities). No activities were booked under the commercial type branch (minor activities of this kind would have been permissible), thus easily fulfilling the requirements of the tax authorities.

The following key figures from the Annual Accounts characterize the business conditions in 2019:

ESSL obtained EUR 162,000 (2018: 140,048) in membership fees and EUR 167,594 (2018: 270,910) from scientific projects. ECSS income amounted to EUR 89,306.

Total income amounts to **EUR 421,840** (2018: 416,999).

Total expenses amount to **EUR 419,502** (2018: 431,898).

The dominant cost factors were personnel costs with EUR 241,534 (2018: 358,942), including taxes and social security, shared IT infrastructure and shared administration (with ESSL Science and Training) with EUR 80,393 (2018: 27,584) and travel expenses with EUR 14,230 (2018: 11,408). Costs for the tax advisor and external bookkeeping add up to EUR 6,320 (2018: 6,117).

The tight cooperation with the Austria-based association "European Severe Storms Laboratory – Science and Training" reduces costs for administrative work substantially, since common services and their associated costs are shared between the two associations. Personnel costs for the Assistant to the Board were paid through this ESSL subsidiary at first hand.

At the end of the business year, liquid assets at ESSL's bank accounts amounted to EUR 61,108 (2018: 97,159). At the end of the year 2019, accounts receivables amounted to EUR 21,687 (2018: 0), deferred expenses (payments made for future accounting periods) to EUR 1,500 (2018: 1,500), deferred income (payments received for future accounting periods) to EUR 19,895 (2018: 62,241). Comparing liquid assets with mean monthly expenses it can be seen that ESSL was running with a small reserve for about 2 months only.

The **annual result is a positive EUR 2,338** (compare: negative 14,899 in 2018, positive 21,621 in 2017, positive 4,169 in 2016, positive EUR 3,552 in 2015, negative EUR 3,957 in 2014, positive EUR 2,625 in 2013, negative 34,365 in 2012, positive EUR 7,093 in 2011, negative EUR 46,859 in 2010, positive EUR 60,599 in 2009).

The financial planning for 2020 foresees enough liquidity until the end of the year, as massive cost cuts were introduced starting January 2019 that will continue into 2020 (e.g. discontinuation of the working contract with the Treasurer, now working on a voluntary basis only). At the end of 2020 there will again be little reserves.

Subsidiary European Severe Storms Laboratory - Science and Training

The financial result of the subsidiary association "European Severe Storms Laboratory – Science and Training" (ESSL-ST) can be summarized as follows:

At the end of the business year 2019, liquid assets at its bank accounts amounted to EUR 23,019 (2018: 31,727). Of this amount, EUR 20,000 are a current reserve for the ESSL Testbed 2020. The current reserve of EUR 30,000 for 2019 was dissolved. The remaining annual result for the subsidiary association in 2019 was a positive EUR 3,019 (2018: negative EUR 1,687, 2017: positive 3,136; 2016: positive 3,156; 2015: positive 121).

The main income source were the ESSL Testbed, a study from EUMETSAT, and a basic funding from the provincial state of Lower Austria. The main cost factors were investments in new seminar infrastructure, office rental, IT infrastructure, IT running costs, invited lecturers and speakers, and personnel and travel costs. For the first time, finances of ESSL-ST were audited by an external auditor (Scheicher und Partner Wirtschaftsprüfungs GmbH Wiener Neustadt), as this was an obligation for receiving funding from the Government of Lower Austria.

The financial planning for 2020 again foresees a near neutral annual result.

7.4 ESSL Members

Members are at the core of ESSL and provide essential support to ESSL activities. Membership fees form an important source of income for ESSL. However, ESSL members are also important in catalysing the pursuit of the Association's goals. This type of support is sometimes provided in-kind and sometimes by financial support.

In 2019, ESSL was happy to welcome two institutional full members: *ARPAL —Agenzia Regionale Protezione Ambiente Ligure* and *TLUBN*— Thüringer Landesamt für Umwelt, Bergbau und Naturschutz. In additional, six new Institutional Supporting Members could be welcomed: *Berkshire Hathaway Specialty Insurance Company, Arcturus B.V., Descartes Underwriting, riskine GmbH, FCM - Fermat Capital Management, LLC,* and *GIE AXA*. The full member list as of 31 December 2019 can be found in Attachment A2.

7.5 Executive Board and Advisory Council

The Executive Board, the Advisory Council and the General Assembly, which consists of all full members, constitute the three bodies forming the ESSL. Figure 6-1 outlines some of their responsibilities.

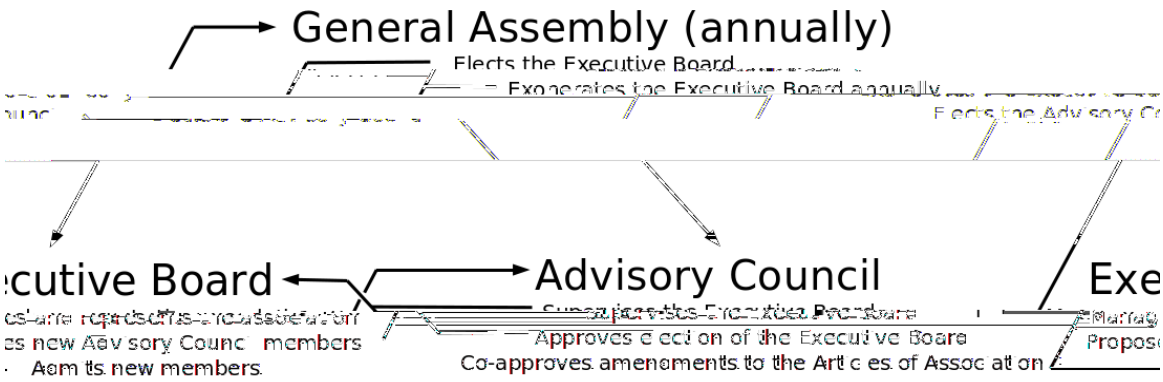

Fig. 6-1: Bodies of the ESSL. The Advisory Council consists of six members from two groups - three members each: (1) Science, (2) NMHS / EUMETNET.

Executive Board

In 2019, the Executive Board consisted of:

Dr. Pieter Groenemeijer, Director
Dr. Kathrin Riemann-Campe, Deputy Director
Dr. Bogdan Antonescu, Deputy Director
Ms. Michou Baart de la Faille, Deputy Director
Mr. Alois M. Holzer, Treasurer

These Executive Board members had been elected for a term until 31 December 2021. Dr. Kathrin Riemann-Campe, however, announced her withdrawal from the Executive Board effective from 1 January 2020 at the General Assembly.

Advisory Council

In 2019, the Advisory Council consisted of:

Dr. Martin Benko, chair (SHMÚ, Slovak Hydrometeorological Institute)
1 Jan. 2016 - 31 Dec. 2019 (first term), vice-chair since 1 Jan. 2016

Dr. Uwe Ulbrich (Freie Universität Berlin, Germany)
1 Jan. 2016 – 31 Dec. 2019 (first term)

Dr. Marina Baldi (National Research Council, Italy)
1 Jan. 2017 – 31 Dec. 2020 (first term)

Dr. Yvette Richardson (Penn State University, USA)
1 Jan. 2017 – 31 Dec. 2020 (first term)

Dr. Sorin Cheval (University of Bucharest, Romania)
1 Jan. 2017 – 31 Dec. 2020 (first term)

Mr. Thomas Kratzsch (DWD, Deutscher Wetterdienst, Germany)
1 Jan. 2019 - 31 Dec. 2022 (first term)

Appendix A1: Annual Accounts

The following presents in extract a copy of the "*Report on the Preparation of the Financial Statements for 2019*", as prepared by the financial auditor in Germany. Figures of the previous year were added for comparison.

		2019	2018
INCOME			
Membership fees institutional members and ESWD data fees		158.039,43	136.620,74
Membership fees personal members		3.961,06	3.427,62
Income from scientific meetings (ECSS)		89.306,36	0,00
Public project funding Federal Republic of Germany		167.594,46	188.052,36
Public project funding European Union		0,00	49.158,00
Applied research		0,00	33.700,00
Donations		190,00	1.100,00
German VAT on sales and refunds		2.748,97	4.940,06
Total income		**421.840,28**	**416.998,78**
EXPENSES			
Personnel		241.534,68	358.941,59
Depreciations		1.013,94	981,21
Costs related to scientific meetings (ECSS)		51.345,47	0,00
Travel costs		14.229,95	11.408,02
Office costs and insurance		615,72	1.231,16
Phone and data (internet) services		5.982,25	1.214,99
Tax advisor including software		6.320,02	6.116,52
IT infrastructure and shared administration	*) renamed, see below	80.393,08	27.583,82
Value added tax		4.593,35	6.712,55
Third party services and other		13.473,63	17.707,73
Total expenses		**419.502,09**	**431.897,59**
Result		**2.338,19**	**-14.898,81**

Assets and Liabilities

	2019	2018
Fixed Assets (office equipment)	1.097,00	1.366,00
Current Assets		
Receivables	21.687,36	0,00
Bank balances	61.108,56	97.158,64
Deferred Expenses	1.500,00	1.500,00
Assets total	**85.392,92**	**100.024,64**
Equity (own capital)		
Retained earnings brought forward	17.119,36	32.018,17
Remaining result of the year	2.338,19	-14.898,81
Deferred Income	19.895,00	62.240,53
Liabilities	46.040,37	20.664,75
Equity and Liabilities total	**85.392,92**	**100.024,64**

*) New label on request by the Advisory Council: "Third party services by ESSL Science and Training, Austria"

Appendix A2: Member list 2019

The following table shows all ESSL members as of 31 December 2019, sorted according to their ESSL-ID (which corresponds in ascending order to the beginning date of the ESSL membership). The new members who have joined ESSL in 2019 have an * next to their names. The 8 founding members who are still members are *printed in italic font*. The given country corresponds to the main residence or statutory seat, not necessarily their nationality.

ESSL has these five types of members:

INDF Individual Full Member
INDS Individual Supporting Member
INSF Institutional Full Member
INSS Institutional Supporting Member
HMEM Honorary Members

INDF	*Dr. Bernold Feuerstein*	*GERMANY*
INDF	*Dr. Pieter Groenemeijer*	*GERMANY*
INDF	*Alois M. Holzer*	*AUSTRIA*
INDF	*Dr. Maria-Carmen Llasat-Botija*	*SPAIN*
INDF	*Dr. Romualdo Romero*	*SPAIN*
INDF	*Dr. Martin Setvák*	*CZECH REPUBLIC*
INDF	*Dr. Fulvio Stel*	*ITALY*
INDF	*Jenni Rauhala*	*FINLAND*
INDF	Thilo Kühne	GERMANY
INDF	Helge Tuschy	GERMANY
INDF	Zhongjian Liang	GERMANY
INDF	Lionel Peyraud	SWITZERLAND
INDF	Thomas Krennert	AUSTRIA
INDF	Dr. Johannes Dahl	USA
INDF	Martin Hubrig	GERMANY
INDF	Dr. Oliver Schlenczek	GERMANY
INDF	Dr. Victor Homar Santaner	SPAIN
INDF	Dr. Sanjay Sharma	INDIA
INDF	Dr. Bogdan Antonescu	ROMANIA

INDF	Dr. Michael Kunz	GERMANY
INDF	Erik Dirksen	GERMANY
INDF	Dr. Christoph Gatzen	GERMANY
INDF	Dr. Kathrin Riemann-Campe	GERMANY
INDF	Dr. Koji Sassa	JAPAN
INDF	Dr. Tomáš Pučik	CZECH REPUBLIC
INDF	Dr. Patrick Marsh	USA
INDF	Marcus Beyer	GERMANY
INDF	Dr. Lisa Schielicke	GERMANY
INDF	Dr. Abdullah Kahraman	TURKEY
INDF	Dr. John Allen	USA
INDF	Dr. Anja T. Rädler	GERMANY
INDF	Dr. Darrel Kingfield	USA
INDF	Stavros Dafis	FRANCE
INDF	Michou Baart de la Faille	NETHERLANDS
INDF	Jannick Fischer*	GERMANY
INDS	Casper ter Kuile	NETHERLANDS
INDS	Jan Jacob Groenemeijer	NETHERLANDS
INSF	DWD, Deutscher Wetterdienst	GERMANY
INSF	EUMETSAT	GERMANY
INSF	AUSTRO CONTROL	AUSTRIA
INSF	ZAMG, Zentralanstalt für Meteorologie und Geodynamik	AUSTRIA
INSF	NMA, National Meteorological Administration of Romania	ROMANIA
INSF	FMI, Finnish Meteorological Institute	FINLAND
INSF	CHMI, Czech Hydrometeorological Institute	CZECH REPUBLIC
INSF	Institute for Hydrometeorology and Seismology of Montenegro	MONTENEGRO
INSF	DHMZ, Meteorological and Hydrological Service of Croatia	CROATIA
INSF	SHMU, Slovak Hydrometeorological Institute	SLOVAKIA
INSF	Consorzio LaMMA	ITALY
INSF	KNMI	NETHERLANDS

INSF	ECMWF, European Centre for Medium-Range Weather Forecasts	INTERNATIONAL
INSF	Croatia Control, Croatian Air navigation Services, Ltd	CROATIA
INSF	Cyprus Department of Meteorology	CYPRUS
INSF	RHMSS – Republic Hydrometeorological Service of Serbia	SERBIA
INSF	Institute for Meteorology and Climate Research	GERMANY
INSF	Met Office	UNITED KINGDOM
INSF	ARPAL – Argenzia Regionale Prodezione Ambiente Ligure*	ITALY
INSF	TLUBN - Thüringer Landesamt für Umwelt, Bergbau und Naturschutz*	GERMANY
INSS	Münchener Rückversicherungs-Gesellschaft AG	GERMANY
INSS	Willis Ltd	UNITED KINGDOM
INSS	Deutsche Rückversicherung	GERMANY
INSS	DLR - Deutsches Zentrum für Luft- und Raumfahrt	GERMANY
INSS	Guy Carpenter Limited	UNITED KINGDOM
INSS	RMS - Risk Management Solutions	UNITED KINGDOM
INSS	AccuWeather Enterprise Solutions, Inc.	USA
INSS	Renaissance RE Services Ltd	BERMUDA
INSS	CORELOGIC SARL	FRANCE
INSS	FM Global	USA
INSS	Nowcast GmbH	GERMANY
INSS	Impact Forecasting LLC - AON Central and Eastern Europe a.s.	CZECH REPUBLIC
INSS	Spekter GmbH	GERMANY
INSS	Berkshire Hathaway Specialty Insurance Company*	USA
INSS	Arcturus B.V.*	NETHERLANDS
INSS	Descartes Underwriting*	FRANCE
INSS	riskine GmbH*	AUSTRIA
INSS	FCM - Fermat Capital Management, LLC*	USA
INSS	GIE AXA*	FRANCE
HMEM	Birgit Büsing	GERMANY

HMEM	Gregor Dotzek	GERMANY
HMEM	Armin Dotzek	GERMANY
HMEM	Dr. Charles A. Doswell III	USA

ESSL has a partnership with the European Meteorological Society (EMS) through a Memorandum of Understanding, is member of the Climate Change Center Austria, and a participating organization in the GEO Group on Earth Observations.