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**Press Release**

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# Weather 2.0: Extreme Weather Forecast in Particular Can Be Improved

**COPS Project of the University of Hohenheim and KIT Supplies New Fundamental Knowledge / Press Conference Takes Stock of the Largest Project for Precipitation Forecast Worldwide / http://cops/uni-hohenheim.de**

**At a joint press conference today, meteorologists of the University of Hohenheim and KIT pointed out that extreme weather forecast may be improved considerably. This statement is based on new fundamental knowledge obtained from the largest research project for precipitation measurement worldwide. COPS - this abbreviation stands for "Convective and Orographically Induced Precipitation Study" – had turned the Black Forest into a gigantic, multi-national outdoor laboratory for a period of four months. After four years of evaluation, most important results were now presented at the press conference.**

Asked how thunderstorms develop, the researchers around Dr. Volker Wulfmeyer switch on a lava lamp. As soon as the base heats up, red, viscous liquid climbs up inside. At the top, it agglomerates, cools down, and descends in the form of a lump down towards the edge of the lamp.

Local thunderstorms develop in a similar way, as shown by the researchers using cloud photographies in fast motion. Above the mountains of the Black Forest, clouds agglomerate, form towers of up to twelve kilometers in height, and dissolve again in strong rain. "The principle is the same," says Professor Dr. Wulfmeyer. "Only the processes relating to the clouds and precipitation are much more complex."

**Forecast Sees Rain at the Wrong Place and the Wrong Time**

This is no exaggeration of the weather expert. Heat and humidity transports as well as the properties of vegetation and shapes of the terrain play a decisive role in the formation of clouds and precipitation. The availability of water is highly important. In fact, the processes are not yet known in the very detail. As a consequence, weather forecasts are incorrect time and again. Especially forecasts of extreme rain.


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“The forecast often postulates large areas with equally high amounts of precipitation. In reality, heavy rainfalls occur locally only. Computer models seldom predict correctly when and where the rain falls,” explains Professor Dr. Wulfmeyer.

For illustration, the meteorologist opens two maps of the Black Forest on the computer screen. One shows the precipitation forecast by previous models. The other displays the measurements made by the researchers. Both maps differ considerably: Prognosis and reality are far away from each other.

One cause is the so-called upwind/downwind effect: “In the computer model, rain on the mountain side facing the wind is strongly overestimated, while rain on the downwind side is underestimated. When our research project started, reality and forecast sometimes differed by 100 percent.”

Another error: “In the forecast, thunderstorms mostly occur in the early afternoon. We have shown that they mostly occur in the evening.”

It was demonstrated by simulations of very high resolution that flow conditions and the structure of individual thunderstorm cells are not reproduced with sufficient accuracy due to the small spatial dimension of the standard forecast models. Consequently, no precipitation was simulated or the wrong amount of precipitation was modeled at the wrong time and the wrong place.

**The More Extreme the Weather, the Worse the Forecast**

New computer models master this effect much better, but not yet satisfactorily, says Professor Dr. Wulfmeyer. “The problem is that the models become the more unreliable the more intense the thunderstorms are,” the meteorologist quotes from the research report.

At the same time, extreme weather is most dangerous, as it is associated with hazards due to flooding, hailstorms, and squalls.

**Multinational Research on the Ground, in the Air, and from Space**

Through the COPS project, the scientists obtained a new understanding of the processes important to forecast. They identified the weaknesses in computer forecasts and tested new measurement

instruments, whose data can be input in models for better prognoses.

But it was a long way to this finding. For three months, Professor Dr. Wulfmeyer, together with Professor Dr. Christoph Kottmeier from KIT, had turned the region from the Black Forest to the Vosges Mountains into a gigantic outdoor laboratory. They had been supported by scientists with nine research aircraft and one research airship. The ground had been covered by a network of more than 100 research stations.

The latest measurement instruments had been installed at five super-sites at exposed locations in the COPS region. Sometimes, only a single prototype worldwide had been available. Even the weather satellites in space started to work more intensely. Their imaging frequency was increased by a factor of three.

The region had been selected carefully by the researchers: “We looked for a challenge” emphasized Professor Dr. Kottmeier. “Low mountain ranges, such as the Black Forest, are highly important to thunderstorm formation. At the same time, the mechanisms triggering thunderstorms over the mountain ridge are so complex that they have been understood the least so far.”

At certain times, up to 300 scientists participated in the largest project for precipitation measurement worldwide. All meteorological institutions from Germany and many others from seven nations in the world were involved. COPS stands for “Convective and Orographically Induced Precipitation Study“.

**New Fundamental Knowledge Prepares Ground for New Forecast Quality**

Now, researchers demand nothing less than a new generation of measurement technology and computer models for future weather forecasts. “The economic relevance and our research results clearly show that the investment is more than justified,” says Professor Dr. Wulfmeyer. “Our results enable meteorological services to improve their forecasts significantly.”

The ground was prepared by projects like COPS: “In cooperation with the users, we conducted fundamental research, determined methodological errors, tested new measurement instruments, and trained a new generation of meteorologists that will now leave the

universities to start practical work."

Meanwhile, more than 50 scientific papers have been published by Professor Dr. Wulfmeyer and Professor Dr. Kottmeier together with this new generation of young scientists. The most important results are summarized in a special issue of the renowned Journal of the Royal Meteorological Society.

**Prognosis Needs New Measuring Instruments – and Computer Models to Process the Data Measured**

What the weather prognosis will look like in the future can be seen on the laptops of the researchers today already. In a 3D model, they can make the humidity waft through the air and interact with the vegetation cover or mountain ridge. In fast motion, the sun rises, heats up the air and ground, air flows pass around hills and low mountains, and rain falls from clouds onto the ground.

Four requirements on future weather observation and forecast may be derived from the project:

- New measurement parameters have to be considered in addition.
- A denser measurement network has to be applied.
- New computer models have to integrate this additional information.
- Multi-model systems have to bundle several computer models.

**1st Requirement: Standard Use of New Measurement Instruments**

In the opinion of the researchers, many of the prototypes applied during COPS should be used as standards. Among them are Lidar instruments that also supply information in a cloud-free atmosphere. But also measurements by GPS satellites are required: "These are the satellites that indicate the position to the navigation systems in our cars. At the same time, they supply valuable information about air humidity, from which strong rainfall may develop," explains Professor Dr. Kottmeier.

Research aircraft also turned out to be valuable. They sometimes flew down to Portugal or far into the Atlantic to record the initial conditions of thunderstorm development. "To warn of extreme weather in due time, such systems are used all over the world. Planes of aviation companies might be equipped with additional sensors for wind and humidity measurements."

**2nd Requirement: Extending Measurement Networks**

The COPS researchers also demand a considerable increase in the number of measurement stations in areas known for local and regional weather phenomena at least. These stations should be connected to a network covering entire Europe. “The measurements are the basis on which weather forecast is made,” explains Professor Dr. Kottmeier.

Recently, a big step forwards was made by establishing the new radar measurement network of the German Weather Service. “But we think that the limits of accuracy have not yet been exhausted.”

**3rd Requirement: Computer Models Have to Work Closer to Nature**

The researchers emphasize that new computer models should simplify less and also simulate processes that so far have been reproduced to an insufficient degree only. “During the COPS project, we found that plants have a very strong influence on thunderstorm formation due to evaporation and the reflection of sunlight. In computer models, however, local vegetation cover is hardly considered,” says Dr. Andreas Behrendt, the coordinator of the COPS project.

In this respect, the research project performed pioneer work. “We need new instruments that make more measurements and new computer models that take them into account,” summarizes Professor Dr. Wulfmeyer.

**4th Requirement: Bundling Various Computer Models**

In the opinion of the researchers, future computer models will produce new findings, but also have certain weaknesses and strengths. Hence, the scientists want to bundle various computer models for making probability statements relating to the weather.

“Future weather prognoses will have to indicate how certain or uncertain they are,” says the Head of the COPS Operation Center, Dr. Christian Barthlott. “When several models come to the same result, it is a forecast of high probability. If calculation results differ considerably, it is needed to underline that the prognosis has a high uncertainty.”

For this purpose, meteorological services will have to combine their models and data beyond state borders. “From the scientific point of

view, there is no reason why models should end at state borders. Thunderstorms also do not stop at the border," emphasizes Professor Dr. Wulfmeyer. "Sectionalism and atmosphere research do not fit together. We are very pleased that weather services increasingly start to use the valuable resources hidden in the measurement data and forecasts of their neighboring countries."

**High Economic Benefit**

In view of the victims and immense costs of damage to infrastructure due to thunderstorms, the researchers consider the high research and development expenditure to be more than justified. "If we want to reduce costs and to take precautions, we have to be able to predict much more precisely and reliably when which weather events are to be expected where and at what intensity," says Professor Dr. Kottmeier.

Forecasts must be improved not only for weather, but also for climate prognoses. "COPS revealed methodological errors of computer models, which have limited the accuracy so far," says Professor Dr. Wulfmeyer. "But if we want to prepare for climate change, the worldwide trend is hardly sufficient. We have to regionalize the climate prognoses with a higher resolution than before in order to determine how the climate will develop in individual regions. COPS research has made a decisive contribution."

**Background Information on COPS:**

The COPS (Convective and Orographically Induced Precipitation Study) measurement campaign is part of the World Weather Research Programme of the World Meteorological Organization of the United Nations. All about 20 meteorological institutions in Germany and the leading research centers of seven other nations participate in COPS. COPS is part of the priority program 1167 "Quantitative Precipitation Forecast" funded by the German Research Foundation (DFG). It is coordinated with the TRACKS measurement program of the Helmholtz Association of National Research Centers and the Forecast Demonstration Project D-PHASE World Weather Research Program.

**es on a knowledge triangle that links the tasks of research, teaching, and innovation.**

This press release is available on the internet at www.kit.edu.