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Cover: 3d representation of a simulated squall line by the mesoscale model MESO-NH (resolution 2 km), image by Sylvie Malardel, Météo-France.

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Dear Reader,

Welcome to the tenth issue of the European Forecaster, newsletter of the Working Group on Cooperation between European Forecasters (WGCEF). We have a selection of articles, some of which were presented at the last meeting in Madrid and others that have been sent to myself or other members of the group directly. We encourage any reader to contribute in the interest of sharing information with other forecasters across Europe. Case studies of severe weather are always welcome. Contact information can be found at the back of the newsletter.

Our Madrid meeting in November was highly successful and again provided an informal atmosphere for members to discuss relevant matters. The pleasant sunny weather was a bonus, especially for some of the members from northern Europe where a taste of winter had already been experienced. A meeting report can be found in this issue.

The EMMA project was a particular discussion point in Madrid with members supporting a proposal to create a workable system as soon as possible to deliver the primary aim of exchanging information and dealing with disaster mitigation during severe weather events. An example where EMMA would have proved useful occurred in January 2005 when an intense low pressure brought damaging winds and flooding to some Scandinavian countries and Baltic States. Forecasters in the United Kingdom contacted their European counterparts before the storm struck and exchanged model information. Unfortunately, our Estonian colleagues received a great deal of criticism despite warnings being issued well in advance. WGCEF members were asked for advice and provided moral support. This is an example of where we can all work together.

Our website has been updated during the winter and thanks go to André-Charles Letestu for his hard work. The new address is: http://www.euroforecaster.org – just click on the logo.

The next meeting will be held in Utrecht, Holland following the 7th ECAM conference and 5th annual meeting of the European Meteorological Society (EMS). By this time, we will be celebrating TEN years of WGCEF following its creation by Manfred Kurz in 1995.
Introduction

The tenth annual meeting of the WGCEF was arranged by Ana Casals Carro of the Instituto Nacional de Meteorologia (INM) in Madrid, Spain and took place at the Hotel Alberto Aguilera in the heart of the city. Nick Grahame (Chairperson, United Kingdom) opened the meeting, welcomed the participants and extended thanks to Ana Casals and the INM for hosting the meeting. In total, there were 27 participants representing 16 Meteorological Services (see Appendix I) with many new faces. Also for the first time we welcomed a colleague from the United States, Robert Johns. Apologies were received from 8 members.

Official welcome by the Deputy Director of INM

The Deputy Director stated that the INM was honoured to be hosting the WGCEF meeting and wished for it to be successful. He explained his ideas about the role of the forecaster in the future with improved training needed to embrace new techniques and developments.

Report of the chairperson of the WGCEF

Nick Grahame announced that Otilia Diaconu had decided to retire as secretary of the group due to changing work commitments. Following discussion, it was agreed that the chairperson would take on the responsibility through the coming year if the workload remained manageable.

The group thanked Meteo-France for taking on the responsibility of publishing the newsletter on a semi-permanent basis. There were also plans for developing the website (discussed later).

Stronger links between WGCEF and the EMS were sought during the year and the chairperson was asked to chair a forecasting session at the EGS/EMS meeting in Nice in September 2004. Unfortunately the session had to be cancelled due to a lack of contributions.

It was noted that there was still no representative from the Danish Meteorological Service despite efforts from Liisa Fredrikson (Finland) and others to persuade them to supply a contact name.

Discussion of Newsletter No.8 and WGCEF website

Uncertainties about the funding and publication of the newsletter hindered progress initially but Bernard Roulet (France) eventually came to the rescue and set up an arrangement with Météo-France. Some of the articles from last years meeting were received rather later than planned but Newsletter No. 9 was finally distributed to members in September. The new style had been well received (being more in line with other 21st Century publications!). Bernard Roulet was hopeful that Météo-France would be able to print Newsletter No. 10 and asked members to provide him with photographs for the front cover.
André-Charles Letestu (Switzerland) explained that he was still having problems when updating the WGCEF website, mainly due to server problems in Finland. He suggested that perhaps a private company should take over the day-to-day running of the site and took an action to investigate if Meteo-Suisse would be happy to fund this venture. Members were encouraged to suggest a new name for the website and think about whether the name of the newsletter should be updated.

**EMMA update**

Frank Kroonenberg (Vice-chairperson, Netherlands) expressed concerns that the next planned phase of the EMMA project had become too complex and that the original aims of the system were being swamped. He suggested that the WGCEF should, as originators of the concept, make a positive statement to urge the project managers to set up a more basic operational system on a much shorter timescale so that it could at least deliver some fundamental objectives. All members agreed that this was important and a statement was drafted by the Chairperson and Vice-chairperson as the meeting proceeded.

**Contributions**

Nick Grahame reported that there had been an excellent response to a call for contributions. One of the aims of the group has always been to provide an informal atmosphere where members can present a short case study or report on recent work. The following subjects were presented:

- Ana Casals and Fermin Elizaga (Spain) – Forecasting Systems at INM and future plans
- Jenni Teittinen (Finland) – Exchange program between FMI and NSSL
- Claude Sales (Luxembourg) – Weather and ballooning in Australia
- Bernard Roulet (France) – Thunderstorm Forecast Verification over the Pyrenees
- Jean Nemeghaire (Belgium) – Hail detection using radar observations
- Thomas Krennert (Austria) – Convective storm developments
- Ana Casals (Spain) – Nowcasting and MSG cloud products
- Frank Kroonenberg (Netherlands) – Regional Satrep in the Netherlands as a guidance tool
- Dimitris Ziakopoulos (Greece) – Weather forecasting during the Athens 2004 Olympic Games
- Dirk Heizenreder (Germany) – Ninjo workstation project

All of the presentations generated some interesting questions and discussion. Those in powerpoint format have been subsequently copied on to a CD by Ana Casals (available on request) and some have been written up and included in this newsletter.

The group broke for lunch following Ana’s second presentation with some excellent food served.

**Plan of action for 2005**

Nick Grahame stated that the deadline for receiving articles for the 2005 newsletter should be set as 31st January with a view to publishing by 31st May 2005. All members of the group should aim to promote WGCEF activities and strengthen links with the EMS where possible. There should be opportunities in 2005 with the forthcoming ECAM conference. Also, the group must retain an influence on EMMA project strategy and presenting a unified front via an agreed statement would be the best way forward. A copy of the statement can be found in Appendix 2 and Frank Kroonenberg took an action to distribute this to all members and the EMMA project managers.
Date and place of next meeting

Frank Kroonenberg announced that KNMI would be delighted to host the next meeting on Saturday 17th September 2005 following ECAM2005 in Utrecht, Holland. This invitation was accepted by all members of the group. Further details will be put on the website and communicated to members by e-mail.

Any other business and closing of meeting

Liisa Fredrikson (Finland and ex-chairperson) told the group that she would be standing down as the Finnish representative due to other commitments. Nick Grahame thanked Liisa on behalf of the group for all of the hard work that she has put in over the last few years but suggested that she would always be welcome at future meetings.

Finally, Nick Grahame thanked Ana Casals once again for hosting a successful meeting. The group were then transported to the Instituto Nacional de Meteorologia to meet the operational staff on shift in the forecast room. The Instituto has a long and varied history and is set in lovely surroundings near to the centre of Madrid with stunning views of the city and distant mountains from the roof terrace. Before returning, the traditional group photograph was taken.

A very pleasant evening was then spent at a traditional Spanish restaurant where new and original members of the group plus our American guest enjoyed good food and wine.

Nick Grahame
Chairperson of WGCEF
Appendix 1

List of participants:
Ana Casals (Spain),
Nick Grahame (United Kingdom),
Frank Kroonenberg (Netherlands),
Dimitris Ziaikopoulos (Greece),
Edmond Van Loock (Belgium),
Jenni Teittinen (Finland),
Aurora Stan-Sion (Romania),
Claude Sales (Luxembourg),
Bernard Roulet (France),
Ángel Rivera (Spain),
Antti Pelkonen (Finland),
Jesús Patán (Spain),
Manuel Palomares (Spain),
Jean Nemeghaire (Belgium),
Janez Markosek (Slovenia),
Izolda Marcinioniene (Lithuania),
André-Charles Letestu (Switzerland),
Teodoro la Rocca (Italy),
Thomas Krennert (Austria),
Mateja Irsic-Zibert (Slovenia),
Sverker Hellström (Sweden),
Dirk Heizenreder (Germany),
Panagiotis Giannopoulos (Greece),
Liisa Fredrikson (Finland),
José Antonio Fernández (Spain),
Fermin Elizaga (Spain),
Robert Johns (USA).

Appendix 2

Statement from the WGCEF meeting 2004 on the implementation of the European Multiservice Meteorological Awareness system (EMMA)

The Working Group on Cooperation between European Forecasters (WGCEF) at its annual meeting in Madrid on 13th November 2004 wants to make the following statement on the EMMA programme.

The first initiative for European exchange of weather warnings was taken by the WGCEF in 2000. The EMMA programme resulted from this initiative. The WGCEF is very happy with the specifications and the pilot-system that came out as the result from this EMMA programme.

We are very grateful and impressed by the new EUMETNET-proposal that was made by the UK Met Office. This thorough proposal gives a very extensive number of actions to be taken before operational implementation can be set. It is this extensive nature of the actions in this proposal that worries the WGCEF. We want to stress that according to our opinion the actions in the next phase should only be limited and aimed towards the final operational implementation of the awareness system. Getting an operational European awareness system should be possible and aimed by the end of 2005 in our opinion.

Taking too much time before implementation might give the risk that this important initiative could be taken away from us by third parties.
Under the leadership of the Spanish Meteorological Institute (INM), the SAFNWC is being developed by a Project Team involving Météo-France, SMHI and ZAMG (Meteorological Institutes from Sweden and Austria respectively). The main goal is the development of Nowcasting products derived from both MSG and PPS (Polar Platform Satellite) satellite systems to be delivered to users as SW (software) Packages.

The SAFNWC is responsible for the development and maintenance of the appropriate SW Packages, as well as all related User's support tasks. The User's support is provided through a dedicated Help Desk. The SAFNWC also intends to be a Centre of Excellence for Nowcasting in EUMETSAT.

This project began in 1997 and products had been developed with other satellite data until 2002, when the MSG was launched. In 2002 the Initial Operations Phase was initiated, but the Full Operations Phase will not begin until 2007.

The MSG sensor called SEVIRI has 12 channels and has been producing data since 28th January 2004. During the testing phase, data received from versions MSG 0.0 and MSG 0.1 have been checked. Tuning has been performed on the SEVIRI images and the algorithms for the 12 products have been tested.

Since November 2004, the MSG 1.1 version has been distributed to users in 22 different countries. This new version is compatible with Linux and Silicon Graphics IRIS.

In March 2005 version MSG 1.2 will be distributed. This version will improve the quality of the products. From then on, requirements and proposals from the users to develop new products will be considered and executed.

Meanwhile, the EPS (European Polar System) will begin with the METOP 2 programme (note that METOP 1 has never been launched). Also the development of the PPS is being realised with the NOAA data. In July 2006 a new update including the new requirements will be distributed within MSG 2.0. At the end of 2006 a new update of the PPS will be distributed. The project will conclude with MSG 2.1.

Figure 2 below summarizes the products developed by the different countries involved in the project.
Cloud products (1,2,3) have been developed at Météo-France in Lannion. Precipitation products (4 & 5) have been developed in Sweden and Spain respectively. Air Mass products have been developed in Spain (6, 7 & 8) and Austria (12). The wind product (9) comes from Spain. The Thunderstorm product (11) comes from Météo-France, Toulouse. The automatic satellite image interpretation is an Austrian product. Sweden is in charge of the PPS part.

Cloud products
- Cloud Mask (CMa, 1)
- Cloud Type (CT, 2)
- Cloud top Temperature & Height (CTTH, 3)

Precipitation products
- Precipitating Clouds (PC, 4)
- Convective Rainfall Rate (CRR, 5)

Air mass products
- Total Precipitable Water (TPW, 6)
- Layer Precipitable Water (LPW, 7)
- Stability Analysis Imagery (SAI, 8)
- Air Mass Analysis (AMA, 12)

Wind product
- High-Resolution Winds (HRW, 9)

Thunderstorm product
- Rapidly Developing Thunderstorms (RDT, 11)

Conceptual Models product
- Automatic Satellite Image Interpretation (ASII, 12)

The following figures show several examples of the products available.

Cloud products

Figure 3: Cloud Mask (Cma)
Delineate all cloud-free pixels in a satellite scene with a high confidence. The product also provides information on the presence of snow/sea ice, dust clouds and volcanic plumes.

Figure 4: Cloud temperature and Height (CTTH)
Contains information on the cloud top temperature and height for all pixels identified as cloudy in the satellite scene.
Cloud products

Figure 5: Cloud Type (CT)
Detailed cloud analysis with information on the major cloud classes: fractional clouds, semi-transparent clouds, high, medium and low clouds (including fog) for all the pixels identified as cloudy in a scene.

Precipitation products

Figure 6: Precipitating Clouds
Probability of precipitation intensities in pre-defined intensity intervals.

Figure 7: Convective Rainfall Rate (CRR)
Precipitation estimated rate associated to convective clouds. The final output is a numerical calibrated product (in mm/hr) divided into classes in an image format.
**Air mass products**

Figure 8: Total Precipitable Water (TPW)

Total amount of liquid water, in mm, if all the atmospheric water vapour in the column from the Earth’s surface to the "top" of the atmosphere were condensed.

Figure 9: Layer Precipitable Water (LPW)

Water vapour contained in a vertical column of unit cross-section area in three layers in the troposphere: Low Layer (>840hPa), Middle Layer & High Layer (<437hPa). TPW is provided for validation purposes.

Figure 10: Stability air Imagery (SAI)

Provide estimations of the atmospheric instability in cloud-free areas. Among all stability indexes, Lifted Index (LI) has been chosen.

Figure 11: Air Mass Analysis (AMA)

Evaluates basic quantities describing air masses (upper and middle level humidity, mean temperature, atmospheric stability, cloud pattern, etc) to combine them into one integrated classification of the air mass.
The figures 12 below explain the use of the Help Desk.

**The Help Desk tool**  
http://nwcsaf.inm.es

- Supports the SAFNWC application providing a single entry for the SAF Users Group (SUG).
- Easy access, update and retrieval of all configuration items (documentation, SW, SPRs, actions, ...) by the Consortium Members.
- Friendly tool for SW recovery, Mail Box interaction (questions, comments), Software Problem Reports (SPRs), Real time products display. Documentation, FAQs, ...

**The Help Desk restricted to users area**

- Place where all SUG members are able to introduce questions or Comments to be answered by the SAFNWC project members.
- Frequent Asked Questions
- Documentation Data Base of the Project allowing the uploading and downloading of the documents, as well as a searching tool.
- To facilitate the work, Change Request sent by the user when a problem is detected in an applicable document.
- Topics of interest
- To access and receive the latest versions and patches for the SAFNWC software application.
- A SPR (Software Problem Report) is the way to the user report a defect detected when using the SW application. A SPR Software Modification Report describes the changes to be implemented in the code in order to solve the detected problem.

Ana Casals & Pilar Fernández
In Spain the National Forecasting System is organized as a group of eleven Regional Centres, a National Forecasting Centre, and a Defence Centre. Each of the Regional Centres is responsible for a determined area, as shows the picture 1:

All the centres are coordinated, and this coordination is established between the Regional Watching and Forecasting Groups and the National Forecasting Centre, or among the different Regional Groups when the forecast affects more than one region. Forecasting activities at any group are run 24 hours a day. The different tasks have been divided by range of prediction criteria.

Picture 2 shows how the coordination routine is organized and also the different ranges and responsibilities of each group.

The National Forecasting Centre Shift Leader is responsible of the coordination and must be aware of what is going on in all the RWFG. The NFC forecasters are represented inside the external ring. Beyond this external ring the RWFG forecasters are also represented. Each forecaster coordinates his/her own range of prediction.
OPERATIONAL PROCESS
Before the issue of the different bulletins an operational process must be done. The processes for the short range (repeated 4 times a day) and the medium range (once a day) are summarised in fig. 3.

**Figure 4** represents the main tasks performed nowadays by the different forecasting teams.
To do that, several tools are available and can be grouped regarding the general target as shows picture 5.

**Remote Sensing**

**Numerical Weather Prediction Models**

- **Radar**: National Composite, Identification, Monitoring & Extrapolation Radar Cells Tool, Tracking 2-D/3-D, VAD Doppler AS Wind Profiler, Automatic Warnings

- **Satellite**: McIDAS, Interactive Displaying, Customized Loops, Identification, Monitoring & Extrapolation of Meso-Scale Systems, Satellite Radar Composition/Rainfall Estimation From Bispectral Analysis, SAF Nowcasting MSG, SST (NOAA)

- **Lightning**: Automatic Warnings for Airports Operations, Objective Lightning Asignation to Convective Cells

The models used at INM are:

- **HIRLAM** 0.5° & 0.2° operational till March 2005
- **HIRLAM** 0.16° & 0.05° operational from March 2005
- **SHORT RANGE EPS** (DEVELOPING)
- **ECMWF DETERMINISTIC OPERATIONAL MODEL**
- **ECMWF WAVE MODEL**
- **ECMWF EPS**
- **ECMWF WAVE EPS**

As first and more used tool, Numerical Weather Models Outputs provide a sort of gridded variables.

Concerning nowcasting, the radar network is a powerful tool. There are 14 radar working both Doppler (8 elevations) and normal way (20 elevations up to 25°). They generate a volume of data each 10 minutes.
Based upon these data, the INM has developed several algorithms for monitoring and tracking severe convective cells. Next picture (number 8) is an example of an operational product based on the 3D analysis on 09th September 2004 at 16:10 UTC.

Many characteristics of the convective cells are presented (maximum reflectivity, thickness, echo top, etc.), including the extrapolation at 10 minutes intervals up to 1 hour in yellow (the previous cell path is in blue). The colour for each cell depends on the VIL density. "G" and "g", in red in the GR column,

To mention a useful application, often used by medium range forecasters, I will give you some flavour about the analogous method: from the current model run and those with similar characteristics of model reanalysis historical dataset, it is obtained a rainfall probabilistic forecasting. It provides the probability of precipitation over 0.5 mm, 2mm, 10mm, 20mm, also gives the forecast of precipitation for a 24 hour period and the maximum precipitation for the same period, as shows figure 9.

The National Forecasting Centre provides marine forecasts and gale warnings for the Mediterranean Sea and the Atlantic Ocean, while the Regional Groups are responsible of the coastal areas surrounding the Peninsula. Figure 10 contains the responsibility areas for the marine and coastal information.
The National Forecasting Centre is also responsible for the Aeronautical information, divided in three FIR/UIRs (Madrid LEMM, Barcelona LEBN and Canary Islands GC GC), as shows figure 11. SIGMETs, GAMETs, AIRMETs and a Low level Significant Weather chart for Spain (4 times a day) are issued. The Regional Groups provide Terminal Aerodrome Forecasts (TAF & TREND) and warnings for the Airports included in their responsibility area.

Since 1982 the INM issues Adverse Meteorological Phenomena Warnings. Those bulletins have been changing from 1982 to the current warnings broadcasted by Internet. Short range Warnings are available in the web site permanently. They aim to draw all situations, which can be dangerous till the 36 hours to come. Figure 12 summarises the phenomena for which a warning is issued, the different type of those bulletins and the responsibility of its emission, depending on the forecast range.
The climatic diversity of Spain forces to the election of very different thresholds for the different provinces, as can be seen in the figure 13, that shows the current thresholds (it would be similar to an orange level) for the amount of precipitation fallen in 12 hours.

The current short range warnings are made up on a map of Spain, which announces if a danger threatens one or more provinces. No colour indicates that no particular precaution is necessary. The province in danger is coloured in yellow and clicking on it, the warning bulletin is opened. This map is updated at least twice a day, at 10.30 and 19.30 or whenever it is need to.

Nowadays Spain joins the EMMA Group. All the thresholds have been changed, according to the four colours scale, but the new thresholds chosen for each area and each degree of danger, must be approved by the Civil Authorities.

The Warnings issued by the Regional Groups, are combined and displayed in a central website, elaborated in the National Forecasting Centre.

Ana Casals
INM Spain
Introduction

Météo-France have conducted a study of summer thunderstorm forecasts in the Pyrenees in order to evaluate the performance, the possibilities and the limitations of such forecasts in a mountainous area. A common criticism expressed by users is a perceived overestimation of the frequency of stormy days. The pertinence of this criticism is touched upon here.

Geographical overview

The Pyrenees are a chain of mountains that extend from the Atlantic to the Mediterranean Sea. The highest relief is situated in the central part with several peaks over 3000 m, the highest one is « Pico di Aneto » in the Maladeta Massif. France is subdivided into départements and each one is administered by a Prefet. Five départements contain a portion of the Pyrenees in their territory and these are from west to east: Pyrénées Atlantiques (64) with a meteorological station at Pau, Hautes-Pyrénées (65) with a meteorological station at Tarbes, Haute-Garonne (31) with a meteorological station at Toulouse, Ariège (09) with a meteorological station at Saint-Girons and Pyrénées-Orientales (66) with a meteorological station at Perpignan. The nearest station to the mountains is Saint-Girons (391 m).

Verification methods

This study verifies the occurrence of thunderstorms over high ground on the French side of the Pyrenees only between 1st June and 15th September. Comparisons have been made between the actual observations and previous forecasts for day D+0 to day D+4. Note that forecasters in this study are forced to provide a wholly deterministic forecast although some uncertainty or probability may be expressed in regular bulletins.

Forecasts issued by the National Centre in Toulouse cover the Pyrenees as a whole, so we consider observations covering the whole mountain chain (during 2002 and 2003) for verification purposes. Verification for each of the five local centres uses data covering only their respective departments. The check is based on satellite imagery and lightning network data.

Figure 2: NOAA 16 VIS image 2002/08/16 1332 UTC.
The thunderstorm cells over the mountains appear clearly. The dots mark the location of lightning strikes during the previous 30 minutes.
Climatology and results

Over the mountains, there is no daily occurrence climatology available but the monthly mean density of lightning gives an idea of the thunderstorm activity over the Pyrenees (see Fig 3). Of course the maximum occurs during July and August, the hottest months. Looking at the geographical details, one can notice that the maximum of lightning is just south of the border on the southern slope. Note also the maximum over Andorra and the western part of Pyrénées-Orientales, which may be explained by local wind climatology.

The results of this study, based on two summers' data, could not be considered as climatology but some facts must be mentioned.

On the scale of the whole mountain chain, the daily observed frequencies reached 50% in 2002 and 64% in 2003 (see figure 4). “Isolated” thunderstorm days – those lying between two days without thunderstorms - are very few; they represent only 10% of the thunderstorm days. On the other hand, series of consecutive thunderstorm days can be very long; the longest reaches 20 days from 5th to 24th August 2003. In comparison, the longest series of consecutive days without thunderstorms was only 8 days, from 30th June to 7th July 2002.

Within individual departments, the observed frequencies are logically lower than for the chain as a whole, with a mean of 51% of thunderstorm days.

One can notice the fact that the daily thunderstorm frequencies are very different from year to year ranging from 10% in 1980 to 28% in 1993 with a mean of 17% (a bit less than 1 day in 5). Note also that there is no clear correlation with the mean maximum temperature. For instance, the very hot summer in 2003 wasn’t particularly stormy at Saint-Girons, in contrast to the whole chain of the Pyrenees.

Regarding the area extent of thunderstorms during summer 2003, the cells were often spread over a large area of the chain and affected at least three departments in five. In only 5% of cases were thunderstorms limited to only one département.

It is interesting to compare these frequencies to those observed at a particular point like Saint-Girons in Ariege (09) at an altitude of 391m at the transition between plain and mountain.

Figure 3: Monthly mean density of lightning reaching the ground from 1998-2001

Figure 4: Observed frequencies of thunderstorm days in 2003 (%) for each department.

Figure 5: Frequency of thunderstorm days and mean maximum temperatures at Saint-Girons (09) from 1974 to 2003 during the summer months.
Are thunderstorm days predicted too frequently?

The simplest way to answer this question is to compare the forecast and observed frequencies for each date over the whole chain (see figure 6 below).

On the scale of the whole chain, this figure shows a similar behaviour in 2002 and 2003: the National Centre underestimates the thunderstorm frequencies especially for D+3 and D+4. The explanation for this decreasing trend with forecast lead time can be found in the “forecaster’s strategy”. In the short range, a missed thunderstorm situation is not acceptable considering the potential danger, so in case of doubt, a thunderstorm event is more likely to be forecast. In the medium range, the forecasters tend to keep in mind the increased uncertainty in numerical models and customer criticism, and therefore prefer no warning because they know that they have enough time over subsequent days to modify the forecast if necessary.

The next figure shows the same comparison between forecast and observed thunderstorm frequencies on a départemental scale. The results are similar for each local meteorological station so only the means are presented.

Figure 7 implies an overestimation at the very short-range (D+0 and D+1) but forecast accuracy is then at a reasonable level around D+2 followed by an underestimation for longer-range forecasts reaching 15% at D+4. Note the quasi-linear decrease of forecast frequencies with time. The above proposed explanation at the National Centre for this forecast decrease is even more noticeable on a local scale.

Forecast quality verification

Definitions of scores

For each forecast series, the following contingency table is established.

<table>
<thead>
<tr>
<th>Thunderstorm forecast</th>
<th>Observed thunderstorm</th>
<th>No thunderstorm</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>b</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>d</td>
<td></td>
</tr>
</tbody>
</table>
The good forecast rate (GF) is given by \( GF = \frac{a + d}{a + b + c + d} \).

The false alarm rate (FA) represents the ratio of bad forecasts when thunderstorms are forecast \( FA = \frac{b}{a + b} \).

The missed events rate (ME) represents the ratio of bad forecasts when no thunderstorms are forecast \( ME = \frac{c}{c + d} \).

It is clear that the lower FA and ME are, the better the forecasts are. In the next figures, FA and ME are expressed in terms of a percentage.

**Scores**

The level of 2/3 (66.66%) is considered as a threshold for the forecast quality.

On the scale of the whole chain, the rates of good forecasts are similar for both summers from D+0 to D+3. There is a steady drop with time but this is correlated with the drop in the quality of numerical weather products. For D+4, the scores are worse in 2003 compared to 2002. The explanation might be due to the unusually stormy character of the weather in the summer of 2003.

From D+0 to D+3, the forecast is reliable but at the expense of too many missed events.

On the scale of a department, the scores are very homogeneous and this is why only the means are shown. Note the high rates of good forecasts for D+0 and D+1. They show the value of local scale forecasts for these lead-times and even until D+2. The foreseeable limit of the phenomena is reached at D+3 when the good forecast rate becomes less than 2/3. The false alarm rate remains acceptable (less than 30% at D+1).

**Use of site specific thunderstorm forecasts**

For a hill-walker on a one-day trip, interest is often limited to a geographical scale of just a few kilometres. The following section will try to understand a customer’s point of view if he/she uses the departmental forecast as a site specific forecast. However, keep in mind that the forecasts sometimes try to...
distinguish the location of thunderstorms more precisely, for example between border crests or Piedmont. Verification of forecasts at this level of accuracy is beyond the scope of the study. Some mountain refuge guardians in the High Pyrenees have made daily observations during 2003. This allows calculation of daily thunderstorm frequencies at the precise point of each refuge. Frequencies of between 30 to 35% were derived – one day in three has thunderstorms. Scores similar to those shown previously in this article have been calculated. Again, they are very homogeneous with the same characteristics from one refuge to another. Figure 10 show an example. The false alarm rates appear high whatever the lead-time and this is the reason for customers’ claim. Refuge guardians also argue that these false alarms can badly affect tourism.

However the rate of good forecasts at D+0 and D+1 must be emphasized and one must also keep in mind the very low level of missed events. This last result is probably the most interesting because it indicates that a site specific forecast of no thunderstorms is particularly reliable for short range forecasts and this is important for public safety.

Conclusion and further work

This study only examines the accuracy of summer thunderstorm forecasts in the Pyrenees in the simplest possible way, but has yielded some interesting results. Firstly, it highlights the great variability of the frequency of thunderstorm days with geographical scale. Additionally, a very important year-to-year variability must be considered.

These results also allow us to counter, if not to entirely refute, the common criticism of too many thunderstorms forecast. On the scale of the whole Pyrenean chain, there is no tendency to overestimate the frequency of thunderstorm days. However, on the lower scale of a French department, there is a slight overestimation tendency in the short-range forecasts. This is probably due to the fact that forecasters are very careful not to miss these dangerous phenomena.

The calculated scores establish the relevance of a local forecast with good forecast rates until D+2. On the scale of the whole chain, the reliability is acceptable until D+3.

Further study could examine these ideas more deeply and thoroughly. Many other aspects beyond the scope of the current study could be explored. Firstly, the location of thunderstorms could be investigated at smaller scales, for example at the scale of valleys or mountain ridges. Then, once a thunderstorm has started, one could speculate as to whether the forecast succeeds in determining the growth of convection during the day. Many questions about the intensity, length and the spread of thunderstorms could also be addressed. Finally, it could be interesting to investigate the reasons for bad forecasts; are they similar at all lead times and are they linked to weather situations or numerical weather prediction model resolution? It could perhaps contribute to more objective formulation of uncertainty in order to improve the quality of forecasts.

Bruno Gillet, Christian Viel, Bernard Roulet, Météo-France
Ninjo - A Meteorological Workstation of the Future

Introduction

The Deutscher Wetterdienst (DWD) together with the Bundeswehr Geoinformation Office (BGIO), Meteo-Swiss, the Danish Meteorological Institute (DMI) and the Meteorological Service of Canada (MSC) have together developed a new Meteorological Workstation. The first operational version Ninjo 1.0 will be introduced in early 2005.

The main goal of the common Ninj o-Project is to replace and improve the several existing workstation systems which have been used for years since the early nineties for interactive display of meteorological data, product generation, monitoring of observations/warnings as well as research and training (Kusch 1994, Koppert 1997, Heizenreder 1999).

Meteorological workstations have to provide an “easy to use environment” to support forecasting and warning activities in an operational environment as well as research and education. This was the task of the ageing systems and will be the task of Ninjo as well. That is why Ninjo has to provide most of the capability of existing systems, deal with recently developed applications and integrate new ones as they become accepted into the operational environment.

Forecasters have been integrated from the very beginning of the project, to ensure that all important requirements of the operational forecasting activities are known. Most of the forecasters of course, would like to stick to their well known forecasting tools. However, the goal of the Ninj o-Project is to implement a new system that does (nearly) everything better than the ageing ones.

Since Ninjo is a multi-national project with five partners (Members of the Ninj o-Consortium), diverse hardware and software infrastructures, distributed development sites and local meteorological needs, a strong requirement is to build the software with a sound software architecture that could easily be adapted to the needs of the partners.

But it is not only the software architecture that influences the success of this international workstation project, it is also the management of the project. The management has to make sure that all requirements are incorporated, that resources are effectively used and the communication among the sub-projects is functioning effectively.
The NinJo Workstation

Requirements and specifications

User requirements were collected and structured at the very beginning of the project until August 2000. As a result, a high level requirement and specifications document was written at DWD (Heizenreder, 2000). These gathered requirements and specifications were the basis of the agreement between the five NinJo partners for the common NinJo project. During the course of the project, requirements and specifications were refined in more detail by all partners when the respective sub-project workpackages were initiated.

The following list shows NinJo’s main features described in the requirement documents:

- Geographical data;
- Integrated 2D and 3D visualization:
  - point data including: surface observations and soundings
  - Lightning data;
  - Gridded data;
  - Satellite and radar imagery;
- Bulletins
- Batch production incl. maps, diagrams and products
- Data decoding and management
- Graphical editor
- Data modification - both point and gridded data
- Monitoring and alerting for observations and NWP data

For each of the features a detailed requirement specification is written, which then has to go through a review process. On the basis of the requirement specification, the software design is created and the software is finally implemented, tested and evaluated. This is the process for each NinJo release. So each new NinJo release comes up with improved features taking the latest test and evaluation results into account.

Introduction of the NinJo Features

The NinJo workstation works on the basis of a client server architecture. The forecaster works with the client computer and is faced with the NinJo main window there. The client gets the actual data from one of the running servers. Products such as forecast maps or meteorological objects are stored on dedicated servers and can be accessed from anywhere.

The main window on the client can be configured with several scenes (main scene at the center of the screen and secondary scenes at the right border). Each of the scenes holds

Figure 2: NinJo main window with 3 scenes, the main scene (gridded data at the centre) and 2 secondary scenes (surface observations - top right, satellite image - bottom right)
several layers, where each layer is responsible for one kind of data (model, radar, satellite ...). Additionally to the main window, there are several secondary windows holding sounding displays, meteograms, text editors etc.

The described window structure was accepted by the users at the very beginning of the project as the best compromise between static windows such as DWD’s old legacy software MAP and extensive multi-window systems.

The user can combine all available data using several layers of the NinJo layer framework within the scenes of the main window. Each layer has its own layer button, which allows the user to switch on/off the visualization of the layer or to choose the data of the layer as well as the appropriate graphical attributes. At the left site of the main window a layer specific toolbar appears for the chosen layer.

Here the user finds buttons to reach functionalities often used.

There are 2 layers used nearly in all scenes: The “geovector layer” and the “georaster layer”. Using these layers the user can visualize rivers, towns, streets (geovector layer) or mountains, land use, etc. (georaster layer).

NinJo allows the integration of nearly all types of geographical information such as the Landsat image (Figure 3) showing parts of southern Germany with a maximum horizontal resolution of 50 m.

On top of the geographical data, model data or observational data are normally visualized.

NinJo will also come up with a graphical editor to create graphical meteorological objects such as...
fronts, weather areas etc. An on screen analysis is under development.

The Automatic Monitoring and Alerting system (AutoMon) of the NinJo is able to permanently monitor configured significant weather situations in observational data and model forecasts. It alerts the forecaster when configured thresholds are exceeded.

Synthetic satellite images will be generated for AutoMon to identify differences between observational data (satellite images) and model data.

The radar layer within NinJo will enable the forecaster to inspect not only the composite images but also the details of the cell detection algorithm used (numeric information provided with tables) and the single cell views to get information about the actual status of the convective systems monitored.

Figure 6: AutoMon window of NinJo

Figure 7: NinJo main window configured with one scene. Geographical data, observational data

Figure 8: Radar data, Cell detection, Single Cell view – Components of the planned NinJo Radar Layer.
The NinJo Project Management

With so many diverse partners associated with good meteorological knowledge and software development practices - requirement gathering, documentation, user testing, project planning, estimation, scheduling, reviews, evaluations - have to be in place.

Requirements are gathered amongst the consortium members and the work is assigned to individual teams. This allows access to a much larger pool of expertise and a much better critical review of the software. A big advantage of working within an international consortium is that petty issues (that can bog down a project) disappear and national pride provides incredible motivation. There is very strong commitment and support at all managerial levels within each organization for the project - often a key success factor.

The Project organization

The most important project body is the Steering Committee. It is responsible for the assignment of resources and the prioritization of tasks, planning, budget and risk management. Every partner appoints one member to protect the partners' interests.

The Project Manager, Hans-Joachim Koppert, completes the Steering Committee. He pulls the strings within the whole project, organizes the necessary work and controls the work of the software design, developer and architecture teams. His project office is located in Offenbach.

Although a lot of the Danish partners understand German, the project has switched the working language from German to English after DMI joined the project. This was “very much appreciated” by the MSC. The addition of the MSC created additional issues – distance, travel and time differences. With telephone, email and telecommunication networks, the distance and time is not such a hindrance. Such a substantial project would not have been contemplated 10 years ago before the advent of email and the internet. In fact, the 6+ hours of time difference promotes better planning and better communication as one tries to prevent emergencies.

Eight distributed Developer Teams and an additional Software Design Team are responsible for the development of all software packages. Each of the team has his own task, different from the other teams. The segmentation of the resources is the source of the project power.

The work packages are concentrated to single sites. The Berlin site is responsible for the software design and the software architecture, as well as the Graphical User Interface. The radar layer and the graphical editor is handled in Toronto, diagrams are programmed in Copenhagen, geographical data are handled by the Bundeswehr Geoinformation Office (BGIO) in Traben-Trabach. Offenbach is responsible for the satellite data, Zurich handles the data server and cross sections. This distribution of work packages is analogous to good software practices - interfaces are clear and well defined.

There is only one team that consists of members from all partners - the Software Design team. The team meets regularly to discuss software design issues in order to be able to integrate all requests from the partners. The chief designer, Sybille Haucke from the Berlin site, makes sure that there are no diverging design concepts. The software design principle, the separation of basic infrastructure components (framework) and specific applications (layers), makes software development “across the Atlantic” possible.

The Integration of the User

The user (forecaster, researcher) is the ultimate judge of NinJo’s success. Users have been integrated from the very beginning of the project. They helped formulate the requirement specifications and are integrated in the refinement phase of the respective work packages when we deal with GUI-components.
A very important NinJo project body is the Evaluation Group. It consists of forecasters and researchers of all partners and gives an immediate feedback to the developer teams concerning the latest NinJo release. The fruitful exchange of ideas within this group helps to identify bugs and problems within the software and helps to enhance the functionality of the system. Found problems and specifications of new features are discussed together with main members of the development team and the project management team during regular evaluation workshops, right after the latest NinJo release.

During the evaluation workshops, forecasters often indicate the need to have quick access to their use cases without too much clicking – NinJo has improved the User Interface with each version and the most important use cases are now only one click away. Through the evaluation team, forecasters have recognized that they are an important part of the development process and that their contributions make NinJo an even better tool.

The members of the Evaluation Group are appointed by the User Group which finally reports results and decisions of the evaluation process to the Steering Committee.

**Status of the NinJo project**

NinJo 1.0 will be introduced operationally in 2005. NinJo 0.9, which is the most recently evaluated version, features most of the required data types and servers.

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Weather and Ballooning in Australia

The 16th Hot Air Balloon World Championship was held in Mildura south east Australia, on the border of New South Wales and Victoria, in June 2004. More than 140 balloons, amongst them 87 competition balloons and fiesta balloons, were participating at the games. The three Luxembourg teams asked me to participate as a crew member and meteorologist.

Mildura has a population of 20,000 inhabitants and is situated at an altitude of 50m in a flat area near the Murray River, in between vineyards and national parks. Between Mildura and Victoria on the coast, there are 450km of bush land or grass fields. Westerly winds penetrate across this terrain and cold fronts coming in from the coast are still active as they reach Mildura. Despite this, Mildura has a climate of persistently dry grassland.

The annual total rainfall of 292mm is evenly distributed through the year. October is the wettest month (31mm).

The annual average minimum temperature is 10.3°C, varying from 4.3°C in July to 16.5°C in January. Four nights per year are below 0°C on average. The average maximum temperature is 23.6°C. There is an average of 77 days per annum where the temperature exceeds 30°C.

The prevailing wind direction is southerly in summer, whilst in winter the prevailing northerly wind in the morning tends towards the west in the afternoon. Days with strong winds (21 per year) are more likely occur in the late winter and spring months. During dry years, strong winds associated with cold fronts generate dust storms, particularly in spring and summer.

Ballooning in competition requires specific knowledge from the pilots but also from the crew. The pilots have to accomplish different tasks during the competition flight, as for example a 'fly in', where the pilot has to look for a starting place 4-6 km away and drop a marker on a cross of 10m. The
consultant meteorologist has to be accustomed to the local climate and weather conditions. His/her work is to produce a ‘nowcast’ for the next four hours. In Australia, a northern hemisphere forecaster has to change his habits since air moves in a clockwise direction around a low pressure and winds strengthen and back on the passage of fronts. Furthermore, the magnetic South Pole is not very far from Mildura, which means that most of the compasses do not working properly in that area. Orientation is difficult not only because of an unknown area but also because the sun moves across the northern half of the sky from east to west.

The weather conditions at our arrival on the 24th June 2004 were marginal, which made test flights impossible.

Wind: WSW 7-10kts.
Gusting: 15-20kts.
Temperature: 11.0°C
Min 6.8°C / max 15.1°C
Rel. hum. 83%
Dew point: 3.0-7.1°C
Clouds: sctCb-bknCu
Weather: rain shower
Pressure: 1018 hPa

Mildura city centre
24.06.2004
late afternoon.

Mildura Radar 24.06.04 19 40 UTC

Weather Information

Two main internet web sites are available for the meteorological information in this area.

From the Australian Numerical Model.

NMOC National Meteorological & Oceanographic Centre. The numerical model in use is GASP (Global Analyses and Prediction) with 85km horizontal resolution, 29 levels and 7 day forecasts twice a day, providing surface winds used in the global sea state prediction scheme.

The LAPS (Limited Area Prediction System) has a higher horizontal resolution of 37km. Some Meso-LAPS forecasts run with a horizontal resolution of around 12 km.
The influence of the high pressure in the Mildura area did not last for long. The wind speed was increasing and this increased the turbulence at ground level. The next flight was only possible in the evening of 29th following the passage of the cold front. A maximum wind of 160 kts at 35000 ft across the south-west coast of Australia was approaching Mildura.

Meanwhile, the organiser’s meteorological crew from the National Meteorological and Oceanographic Centre, Bureau of Meteorology, used the MSL Anal.ysis (hPa) and the National Weather Service (NWS) to monitor the changes. The forecast/measured winds at 0700 loc time show a close match, indicating the accuracy of the numerical models. The GFS (Global Forecast System) short range model, 3 hourly steps up to T+84, updated every 6 hours with resolution of 80 km. This model was very useful for low level winds. The actual wind is measured with a pibal and a ‘winds-way’ wind reader. This system indicates the wind direction and speed up to 5000 ft in increments of 100 ft.

Due to strong winds the days before, the first flight was only possible in the morning of 27th of June. The weather conditions were excellent; low wind speed at the ground (4-8kts) with a direction between 240° to 360° up to 1600 ft.

From the U.S. numerical model.

READY (Real-time Environmental Application and Display System).

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A further cold front passed through on 1st of July with a ridge of high pressure following. Winds of less than 5kts (between 280° and 320°) allowed the competition to continue and four tasks were completed.

Friday morning (2nd of July) was the last day of the competition with high pressure maintained, low wind speeds of 5kts and enough steering for four more tasks.  

Claude Sales
Introduction

Mid- and high latitude weather is characterized by contrasts that take place on a time scale of the order of a few days. Most of these changes in temperature, wind, weather and cloud cover are the effects of extra-tropical cyclones. These occur during all seasons, but are most frequent in the autumn and winter. The polar front is typically located at mid-latitudes and separates polar air masses from the mid-latitude air masses. Along the polar front the mid-latitude cyclone will develop in response to oscillations within the polar jet stream at upper levels.

Within the polar air a secondary frontal zone, limited to the lower troposphere, can form in winter and this is known as the arctic front. It separates extremely cold air across areas near the pole from less cold airmasses further south and frequently is fixed orographically to the immediate coastal fringes and the pack ice boundary. In addition, its position is greatly influenced by the extent of snow cover on continental land. As the baroclinic zone of the arctic front remains restricted to the lower troposphere, it does not appear useful to define ‘arctic air’ in addition to polar air. Also, it would be very difficult in individual cases to distinguish between air which actually comes from arctic regions and equally cold or colder air which originates far to the south within anticyclonic conditions over snow-covered continental land.

Classification of jet streams

According to the model of Palmen and Newton (1969), four air masses (tropical air masses (TA), mid-latitude air masses (MLA), polar air masses (PA) and arctic air masses (AA)) and three fronts or jet streams (subtropical, polar and arctic) are defined.

One of the most important result of my master’s thesis is represented in Table 1 and in Figure 1. The Palmen and Newton model was too simple when analyzing the European winter 2000-2001. North of subtropical jet stream there were two or three, sometimes even four, westerly jet streams observed at the same time across Europe.

According to Table 1, the Palmen and Newton model was valid in only half of the cases observed in Europe between 1st December 2000 and 31st March 2001. In almost every other case, three or sometimes four westerly jet streams were observed during this period.

<table>
<thead>
<tr>
<th>One front or jet stream</th>
<th>1/110</th>
<th>1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two fronts or jet streams</td>
<td>55/110</td>
<td>50%</td>
</tr>
<tr>
<td>Three fronts or jet streams</td>
<td>51/110</td>
<td>46%</td>
</tr>
<tr>
<td>Four fronts or jet streams</td>
<td>3/110</td>
<td>3%</td>
</tr>
</tbody>
</table>

Table 1. Observed fronts or jet streams across Europe, north of the subtropical jet stream between 1st December 2000 and 31st March 2001.
It is likely that sometimes there may be a subtropical front, a southern branch of the polar front, the polar front itself, a northern branch of the polar front and arctic front across the whole of Europe at the same time. It is not always easy to distinguish specific jets if there are several branches within a meridional cross-section across Europe (Fig 1). The most important features used to classify the fronts are: their location in a north-south direction with respect to other fronts, the specific location and height of the jet stream, and temperature of the air masses.

The polar jet stream can be split, for example, when a blocking high lies across northern Europe. In this case the jet stream deflected to the south is called the ‘southern branch’ of the polar jet (SPJ). On the other hand, the jet deflected to the north is called the ‘northern branch’ of the polar jet (NPJ). Each can co-exist because of the upstream bifurcation in the flow pattern at middle and upper levels of the troposphere, with downstream confluence then likely to the east of a block. The SPJ and NPJ are new conceptual models.

In almost every other case during the winter 2000-2001, three westerly jet streams were observed to the north of the subtropical jet stream. In these cases two branches of the polar jet were observed across the same meridian, in either a SPJ +PJ +NPJ or SPJ +SJ +AJ configuration (where PJ is the polar jet and AJ is the arctic jet). Very occasionally, in less than 3% of cases, there were four westerly jet streams observed.

Apparently two jet streams can also converge when one is located under the other. There appears to be only one jet stream, though there is in fact a SPJ +SJ or NPJ +AJ. A few cases involving localised jet streams linked to triple point disturbances and also easterly jet streams have been omitted in this study.

**The Arctic front**

The arctic front separates the cold polar airmass from even colder air of arctic origin. It is located to the north of polar front in winter. Arctic fronts occur frequently over the Arctic Sea, sometimes over Scandinavia, and sometimes reach as far south as the North Sea. Arctic fronts are not found in Finland during the summer.

The arctic front is typically a shallow tropospheric feature, with the strongest baroclinicity observed most often in the lowest layers up to 2-3 km above the surface. In the middle and upper troposphere baroclinicity is weak or absent. Normally the front lies below an extensive cold upper low or trough.
A short case study

An example of the appearance of airmasses, jet streams and fronts is presented in the case study of 11th December 2000.

The arctic jet stream is situated lower down in the troposphere and is also weaker than the polar jet stream (Figs 2, 3 and 4). The arctic front does not extend as high as the other frontal zones (Fig 4). It is important to be able to
detect arctic fronts and to be able to distinguish them from other frontal zones and troughs (Fig 5). Along all four frontal zones, baroclinic disturbances will develop. They can be analysed using the Norwegian frontal model. Thorough frontal analysis is important, especially in the nowcasting period (up to 12 hours).

Figure 4: Vertical cross section along the line I-I’ in Fig 2. and 3. Distribution of jet streams, potential temperature (K) within the frontal zones and airmasses based on the model of Palmen and Newton on 11th December 2000, 00 UTC.

Figure 5: Pressure distribution (solid lines, in hPa) and fronts in the surface field on 11th December 2000, 12 UTC. (AF: arctic front, NPF: northern branch of polar front, PF: polar front, SPF: southern branch of polar front).

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Initiation of Deep Moist Convection at WV-Boundaries

Vienna, Austria

For the operational forecaster one important precondition for the diagnosis and prediction of convective activity is the availability of observation tools with high temporal and spatial resolution. Remote sensing facilities mostly used by operational weather services are satellites, weather radar and lightning detection. Satellite images from the operationally used MSG are updated every 15 minutes, and every 10 minutes within a rapid scan – mode of METEOSAT-8. The visible channels show the earliest stages of convection as soon as the convective cell exceeds the spatial image resolution.

The onset of deep moist convection (DMC) can be observed in the WV channels which represent the humidity in a layer above approximately 600 hPa. It is possible to derive information about the atmospheric flow within this layer of the troposphere even when clouds are absent. Features in the WV image like grey and white zones and black stripes are caused by processes including differential advection in both the horizontal and vertical directions in different scales. Both large-scale and small-scale patterns may create conditions favourable for convection: cyclonic perturbation, cyclonic rotation centres and deformation zones.

The physical concepts behind synoptic and mesoscale cloud configurations shown in the WV satellite image can be well described with the non-hydrostatic quasigeostrophic theory using well-known parameters like relative vorticity and its advection, potential vorticity and many others. For small-scale features like the convective cells investigated here, hydrostatic considerations are more relevant.

Under the synoptic situation of an upper-level pressure ridge and a thermal ridge ("fair weather"), shallow convection (in the sense of "not deep", a capping inversion is not a necessary condition) appears especially over mountainous regions if a sufficiently moist surface layer and initial instability is existent. As comprehensive observations with the METEOSAT 7 WV channel showed, DMC developing from this shallow convection, preferably appears first at the transition zones between areas with dark/dry and bright/humid pixels, the so-called WV Boundaries (Krennert and Zwatz - Meise, 2003). It became clear, that different processes favour the onset of deep moist convection at boundaries in the WV image.

A possible approach towards an understanding of the mechanism is the separation of various components responsible for the onset of deep convection:

- The vertical stratification of the air column
- Entrainment
- Dynamic initiation
- Incoming solar radiation, diabatic heating

**The vertical stratification of the air column**

A basic item necessary for the understanding of the physical process of deep convection is the vertical stratification, especially in association with the vertical decrease of humidity.

A comprehensive investigation has shown that the critical area is widespread conditional instability in the low and middle troposphere. Near the surface a shallow layer of absolute instability can be found in nearly all cases. Often the high reaching conditional instability in the layer above is interrupted by very thin stable layers or weak inversions.
Usually radiosondes are not available at the exact location of deep convection, the temporal and spatial resolution of the soundings is far too coarse. Here, the use of WV channels can contribute significantly to the knowledge about upper tropospheric dynamics.

Since September 2003 two new MSG water vapour channels have become operationally available, offering better spatial and temporal resolution than the METEOSAT-7 WV channel. In this way an investigation of the differential vertical and horizontal moisture distribution (qualitatively) becomes possible. The MSG WV channels 5 and 6 display the humidity content in two different layers. Channel 5 has a maximum absorption at a wavelength around 6.2 µm, with the maximum signal being received from around 350 hPa. The WV channel 6 has maximum absorption at 7.3 µm, with a maximum signal from around 500 hPa. See the schematic in fig. 1.

The example of 28 April 2004 represents a typical case for the process of the onset of deep moist convection at WV - boundaries. The MSG high-resolution visible image (Fig. 2) shows a nearly cloud free environment with no frontal disturbance (in the “classical” sense) over the eastern part of Austria at 0930 UTC. Yet, shallow convection has already set in over the eastern Alpine mountains.

WV channel 6 is also able to display the position of shallow convection. Medium grey shading along the eastern alpine flank indicates the increase of relative humidity at middle tropospheric levels through convection and further convective transport of humidity to the upper levels of the troposphere (Fig. 3 and 5, 1115 UTC and 1230 UTC). Within two consecutive time steps three areas of deep moist convection, A, B and C, can be observed over the eastern Alps (Fig. 7). The MSG WV channel 5 represents the distribution of relative humidity at upper levels of the troposphere. The dark “dry” zones can be clearly distinguished from the brighter “humid” parts in the image. Higher potential instability is usually connected to an increasing vertical gradient of humidity, e.g. when a dry zone (dark in WV channel 5) is situated above a relatively moist zone (light grey in WV channel 6). Comparing Fig. 4 and Fig. 3 this initial condition is given over the eastern part of Austria. In Fig. 6 - 8 the growth of DMC at WV boundaries is shown.

Finally, the convective transport of moisture above 350 hPa can be seen in Fig. 8 (areas A, B and C).

The combination of the two MSG WV channels within a RGB composite demonstrates the mechanism more clearly. An area of increased potential instability can be identified qualitatively by the distribution of the horizontal humidity gradient at the two levels (Fig. 10, see also the colour table in Fig. 9 for interpretation). Along the transition zone between “dry” and “moist” upper air, deep convection occurs at the expense of the surrounding areas (fig. 10 - 12).
Figure 3: MSG WV 6, 28 April 2004, 1115 UTC

Figure 4: MSG WV 5, 28 April 2004, 1115 UTC

Figure 5: MSG WV 6, 28 April 2004, 1230 UTC

Figure 6: MSG WV 5, 28 April 2004, 1230 UTC

Figure 7: MSG WV 6, 28 April 2004, 1345 UTC

Figure 8: MSG WV 5, 28 April 2004, 1345 UTC

Figure 9: Colour table

Figure 10: MSG WV RGB -6/5/5, 28 April 2004, 1115 UTC
The MSG WV images provide primarily qualitative information about the humidity distribution, both vertical and horizontal.

**Entrainment**

Another effect that has to be taken into consideration is strong upward motion that causes turbulent entrainment, resulting in negative buoyancy (evaporation). It can be assumed that within the dry upper layer there is stronger entrainment than within the moist area.

**Dynamic initiation**

One possible source for DMC at WV - Boundaries can be found in the dynamic processes. Indeed some of the WV structures resemble cyclonic eddies being connected to vorticity and vorticity advection of the same magnitude as synoptic-scale frontal systems.

Operationally used models (like ECMWF) cannot resolve the structures on the scale under discussion, even though the WV-features are of a quite extended scale. A solution to this problem may be the use of operational LAM models like ALADIN. Here the parameters mostly show a better resemblance to the features in the WV images. However, the first appearance of deep convection at the narrow zone of the WV-boundaries cannot be explained properly with the help of numerical model fields alone.

Martin et al. (1999) describe cyclonic circulation which is only indicated in the WV image where favoured and non - favoured areas for deep convection are specified. But the problem under discussion concerns a different scale. Here, processes within a much smaller scale, namely the narrow transition zone between dry and wet areas in water vapour, seem to be of importance.

In this respect it can be summarised that:
- Convection in “fair weather” situations shows a distinct diurnal cycle of development and decay.
- The cells of DMC are initiated in the lower levels of the troposphere.
- Deep convection develops and decays much faster than the WV structures in which they are embedded.

A further approach towards the scale problem could be the derivation of the vorticity directly from the WV channels 5 and 6, respectively. Atmospheric motion vectors (AMVs), calculated from the two WV channels, show the dynamic behaviour in two different layers. In the case of fig. 13, no significant horizontal motion can be seen in the middle troposphere (green arrows). The dark stripes in WV channel 5 show a more distinct horizontal vector field in comparison to the layers below (fig. 14). This means that
a zone of increasing potential instability at higher levels is moving over a nearly stationary dome of humid air at middle levels. Additionally, a distinct cyclonic curvature is seen in the vicinity of the DMC. This mechanism is represented in all investigated cases.

AMVs, computed at two different levels of the troposphere, enable a new approach to investigate the dynamics of deep convective onset in relation to WV-boundaries. The behaviour of vertical and horizontal shear, vorticity and advection could be discussed and calculated independently from numerical models.

**Incoming solar radiation, diabatic heating**

One source for the initiation of convection is heating of the surface and adjacent air layers by incoming solar radiation during daytime. This heating process causes an absolutely unstable shallow layer near the surface where spontaneous convective overturning becomes likely.

If enough lifting energy is provided, the rising air parcel might reach condensation, leading to strong deep moist convection at the level of free convection in the case of conditional instability. If the lifted parcel starts from higher surfaces, e.g., mountain slopes, less energy is needed to reach the level of free condensation. This implies that shallow convection will start earlier from elevated surfaces.

Incoming solar radiation is absorbed differently in areas of dry or wet upper level humidity. While the visible part of the solar radiation (also known as “atmospheric window”) is not weakened remarkably by water vapour, there is considerable depletion in the near-IR band. According to Liou (2002), water vapour is the primary absorber in the near-IR, which contains about 50% of the incoming solar energy. The amount of solar energy reaching the surface is therefore reduced below the humid area relative to below the dry area in the WV image. Consequently, due to the differential energy of incoming solar radiation below dry and moist upper level layer, decreased diabatic heating at surface levels below a humid region and increased heating below a dry region in the water vapour is to be expected (see also the schematic in fig. 15).
The combination of all the single components is responsible for the initiation and the onset of DMC in this special synoptic environment. WV images have higher spatial and temporal resolution than the operationally used NWP model fields or the radiosondes. Areas with high probability for convection (diagnosed for example by a stability index) can be superimposed on the WV-image. If there are WV-boundaries in this area, then an even higher probability for the appearance of DMC can be expected and consequently have to be monitored with all available data sources. In this way, an improved technique for nowcasting the exact time and location of thunderstorms in “fair weather” may be provided to the operational forecaster.

References:


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The impact of political changes in the 1990's was, among other things, the catalyst for informal contacts between forecasters from Central Europe. In 2000, for example, a group of forecasters from two regional centres of the Czech Hydrometeorological Institute (CHMI) had an opportunity to visit the regional centre of DWD in Munich. It was very interesting to compare operational tools, software and model outputs, which are different on both sides of the border. Communication was in English which seemed to be a good solution for balanced and direct conversations without the use of an interpreter. Thanks to the friendly attitude of German colleagues, especially Klaus-Jürgen Tenter - at that time Head of Forecasting - (third from the left in Fig.3), we discussed many problems concerning our common profession in both an official and unofficial capacity. After this meeting, an idea about exchange of warnings for an area near our common border was born. Coincidentally at that time in WMO RA-VI, a pilot project for setting up a network for the bilateral exchange of severe weather warnings between neighbouring countries was proposed. For this reason our initiative was passed on to Wolfgang Kusch, coordinator of sub-group on regional aspects of public weather services in WMO RA-VI.

The goal was to test information exchange between forecasters speaking different languages and using diverse local area meteorological models (LM model in DWD, ALADIN in CHMI). In the years before, a standard coded report WAFOR was used to inform other meteorological services that a warning was issued. However it was only used occasionally and the code was somewhat complicated. We then decided to start up our own experiment after finding out that WAFOR was going to finish.

One possible way of overcoming the language barrier is to use a bilingual form sent by fax. The form used by regional forecasting offices in Strasbourg (Météo-France) and Stuttgart (DWD), and published in WMO documents, became our inspiration for a proposal of our own version in German and the Czech language. The forecaster has to designate dangerous phenomena and the area which is expected to be affected. It is also possible to add some other information such as precipitation totals etc. Contacts who could speak English were consulted about the content of the form. It was necessary to define types of dangerous weather, thresholds and the allocation of areas along the common border according to climatology and/or political division. Two areas of mutual interest were agreed, the Ore Mountains and Sumava Mountains (Bavarian Forest), and cooperation between the forecasting centres of Leipzig-Usti nad Labem and Munich-Plzen started during winter 2001 (see Fig.1 and Fig.2).

Figure 1: Bilingual form used by the regional forecasting offices of Leipzig (DWD) and Usti and Labem (CHMI) in season 2003/2004
Attention was focused on heavy precipitation, severe thunderstorms, wind gusts and adverse winter conditions from the point of view of road maintenance. Initially an attempt was made to adjust common thresholds but for some phenomena it was not possible (especially wind gust limits) due to the internal instructions of each national meteorological service. The content of the form is one of the topics for discussion at regular meetings at some of the regional offices (Leipzig 2001, Plzen 2002, Munich 2003, Usti nad Labem 2004). Forecasters meet every spring to discuss limits, case studies and statistics, exchange experiences with their own forecasting methods (for example an empirical-statistical formula for wind gusts during thunderstorms by Christian Freuer, fourth from the left in Fig.3) and maintain informal relationships. A new concept for the form had to be accepted in Munich, April 2003 (see Fig.3) because of a statistically derived set of dangerous weather phenomena for Germany as a whole. It was not possible to copy all of these thresholds for the Czech version of the form, so a new approach was selected. The main principle is that it is useful to send signals to colleagues when we expect severe weather near our common border following assessment of our local forecasting model, experiences and other inputs. The impact of such an event is likely to cause severe disruption, damage and/or loss of life in the area of interest. At this stage nothing else is arranged but the forecaster uses this information to aid his/her decision-making process. Note that each national warning system is operated independently.

The last meeting (at the time of writing) in Czech Republic (see Fig.4) confirmed that such cooperation is still alive and should continue even if CHMI and DWD are to participate in a new WMO RA-VI pilot project and eventually in the EMMA project. It is not a particular problem to complete a bilingual form and send it by fax but storage of the forms for verification purposes is more difficult. In future it would be useful to install an Internet or e-mail platform for the exchange of warnings and relevant synoptic information (model outputs). Forecasters are expected to continue to cooperate in case studies and for this purpose, it is desirable to nominate English speaking contacts for operational exchange of information (for example damage caused by severe convection, meteorological data from areas near the border, media reports etc.). For further cooperation it would be very desirable to replace present non-regular e-mail transfer of climatological data by a direct regular connection between database servers. On this matter, agreement between the headquarters of DWD and CHMI is necessary. A proposal for data format and a list of stations was presented by climatologist Jiri Hostynek. Another
area of cooperation seems to be road meteorology. Radek Tomsu presented a proposal for a new format of flash warning for winter road maintenance. This problem will be discussed in other working groups but the exchange of such warnings could become a matter for cooperating forecasting offices.

Participants of the last meeting agreed that this cooperation between DWD and CHMI should be publicised within the WGCEF newsletter and helped with the editing of this article. The next meeting is planned to be held in Leipzig during spring 2005.

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Figure 4: Usti nad Labem, May 2004 - from left to right: Radek Tomsu (Usti), Guido-Peter Wolz (Munich), Martin Novak (Usti), Jan Sulan (Plzen), Wolfgang Weber (Leipzig), Volker Wünsche (Munich), Jiri Hostyncek (Plzen).