# Weather Broadcasting – the need for Forecaster Experience

**Manfred Kurz, Neustadt/Weinstraße, Germany**

## 1. Introduction

That is modern weather forecasting: Super computer produce a great amount and diversity of model output several times a day, covering nearly all scales and ranges – from the local forecast for a few hours up to forecasts world-wide for weeks or even seasons. The output can be further processed and tailored to the needs of the different customers, including the special requirements of weather broadcasting.

According to the results of verification, the accuracy of the model output is rather high. And therefore it is justified that many forecast products are not only produced fully automatically, but also transmitted to the customer without any stronger control by forecasters. That is valid also for weather broadcasting: The field animation used in the TV-shows is normally provided by automatic procedures without intervention by the forecaster responsible for the contents of the show.

Does it mean that we don't need weather forecasters with their experience in weather forecasting and also broadcasting any more, but only seller and presenter ? Looking into the verification results just mentioned, one could believe this since they show that forecasters are nowadays not more able to add much value to the purely automatically produced forecasts. Using these results, many National Weather Services have started to reduce the people involved in manual forecasting more and more. As another consequence there is the tendency of one or another forecaster to blindly rely on the model output and to forget all the knowledge about the weather learned before.

That is, however, a very dangerous way. The verification results are normally mean values for a month or even longer times. And therefore they cannot reflect the two or three greater model failures occurring every month. These failures are often significant since they concern not seldom hazardous weather situations like gale force winds, heavy thunderstorms or flash floods. In these situations the issue of warnings is absolutely necessary for the responsible authorities as well as for the public via a quick and reliable broadcasting, and this has then to be done by forecasters being able to do this without guidance or any other assistance by NWP products.

## 2. Deficits of the NWP models – advantages of the forecaster

The situations just mentioned belong mainly to the range of nowcasting and very-short-range forecasting, i.e. the time interval up to 12 hours. According to the findings of the COST action 78 (1) devoted to the improvement of methods for this period, there are especially three areas for which deficits exist in the numerical simulation, namely

- Fronts and cyclogenesis, especially the weather activity of fronts and the rapid intensification some cyclones undergo,

- Strong convection, especially the origin of meso-scale convective systems,
- Fog and low stratus.

That is valid today as it was 10 years ago as the COST action was started, and the problems with regard to the detailed forecasting of fog and low stratus are still so great that a new COST action was meanwhile launched.

What the forecaster has to do in order to intervene successfully in the forecasting process when a cyclonic development or the release of convection was not well simulated by the models ? Decisive for that is an own synoptic diagnosis, i.e. an assessment of the three-dimensional state of the atmosphere with regard to the processes going on in it and the potential for further development. The diagnosis must be based on the analysis of the atmospheric state. Since nearly all analyses are produced nowadays by numerical schemes, they have to be checked in order to detect deficits which could lead to failures of the simulation. As result of the diagnosis, the forecast can be formulated – either following the numerical guidance or differing from it in cases in which the numerical output appears doubtful.

Nowcasting is per se the domain of the human being, since he can bring abilities into play in this range making him superior to numerical methods:

- He can analyse more exactly with regard to some key observations (e.g. ships in data sparse areas),
- He is always quicker than the model runs, i.e. he already knows the real weather development when the new model output becomes available,
- He is able to recognise typical signatures and patterns in the data, and
- He has the ability to imagine alternative scenarios of the development (at least in the case of purely deterministic forecasts).

For the first two items the forecaster must have a quick access to all data, but also the time and the equipment to make some own analyses in order to check the quality of the numerical output.

In order to recognise typical signatures or structures, and to imagine alternative scenarios of the development, however, the forecaster must firstly know them. With regard to cyclo-genesis, it is surely not enough to only know the scheme of the life cycle of cyclones as described by Bjerknes and the “Bergen School” 80years ago. Not every low developing at the polar front follows strictly this cycle, some remain weak and disappear again, whereas other experience suddenly a rapid intensification. The cyclogenesis, on the other hand, must not start at the surface front in every case, but might also begin some distance apart from it in the cold or warm air. Ignoring this fact, may lead to a wrong analysis of the surface fronts. And concerning these fronts, their connection with the cloud and precipitation areas is not every time as simple as in the idealised scheme mentioned above. Also from this fact wrongly analysed fronts may result. It has to be stated, however, that many forecasters still get stuck nearly slavish on these old over-simplified schemes and try to explain all weather by far too much obscure front lines they draw into the surface map as only map they still analyse.

## 3. Methods of synoptic diagnosis

### 3.1 Diagnosis of cyclogenetic effects

For the real and physically correct diagnosis of cyclogenetic effects and the weather activity of fronts it is rather decisive to consider surface maps as well as upper air analyses and to realise the interactions between the different layers of the troposphere, especially between lower and upper troposphere. Since production of cyclonic vorticity by convergence is a prerequisite of cyclogenesis near surface, it is especially important to diagnose the forcing of ascending motion. Concerning the macro-scale, the quasi-geostrophic equations provide for that the statement that ascent has to be expected in areas with positive vorticity advection (PVA) aloft, maximised warm advection (WA) and/or maximised diabatic heating (e.g. in the case of condensation). With the aid of the so-called Q vector the two adiabatic effects can be replaced by one forcing only, expressed by the convergence of these vectors. In addition, the Q vector allows the diagnosis of frontogenetic and frontolytic effects in the horizontal wind field and the related transverse circulations which are often decisive for the weather activity of fronts.

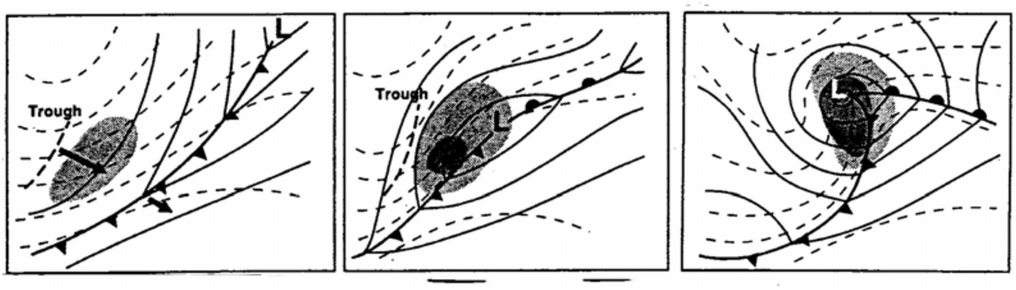



Fig. 1: Scheme of cyclogenesis due to approach and superposition of an upper vorticity maximum ( embedded in a trough) on a slower moving frontal zone in lower levels. Shading represents the region of appreciable positive vorticity advection (PVA) aloft. From Petterssen (1956).

It is well known that a strong or even explosive cyclogenesis is mostly the result of the interaction between two initially independent cyclonic systems in upper levels and near surface. Right structures aloft in which divergence causes the necessary pressure fall and the release of an ascending motion, are short progressively moving troughs and ridges and the entrance and exit regions of jet streaks where ageostrophic wind components along or across the current give rise to convergence and divergence, respectively. The conceptual model (CM) of the interaction has been developed by Petterssen (2) 50 years ago. According to this model shown in Fig.1, cyclogenesis has to be expected there where an area of significant PVA aloft approaches and finally superimposes a frontal zone or an already existing frontal wave in the lower troposphere. The PVA aloft is connected with divergence. Its effect is at first compensated by cold advection (CA) in the lower layers, but can become fully effective when the PVA spreads to the frontal zone and its fore part.

The same process can be monitored with the aid of analyses of the isentropic potential vorticity (IPV). This very effective diagnostic means was already used by Kleinschmidt in the 50 s of the last century, but was only moved in the centre of modern synoptic diagnosis by the famous paper of Hoskins, McIntyre and Robertson (3) from 1985. Fig.2 shows their conceptual model for cyclogenesis. When an upper positive IPV anomaly with its cyclonic circulation approaches and superimposes a frontal zone in the lower troposphere, the circulation can become effective also in the lower levels due to the reduced static stability. This leads to a wave-like deformation of the isotherms and by that to the origin of a positive anomaly of temperature and also IPV near surface which influences with its own circulation also the current aloft. Altogether a coupling results during which both anomalies increase until a new balanced state is reached. The release of great amounts of latent heat by condensation is especially important in this connection, since a direct increase of IPV and also vorticity in the lower layers is caused by this effect.

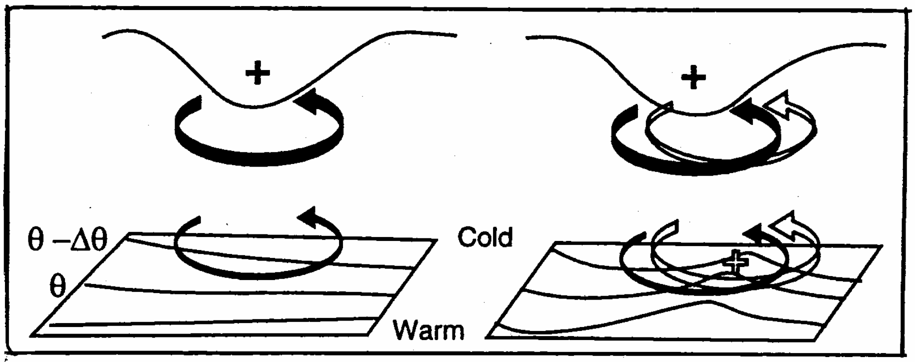
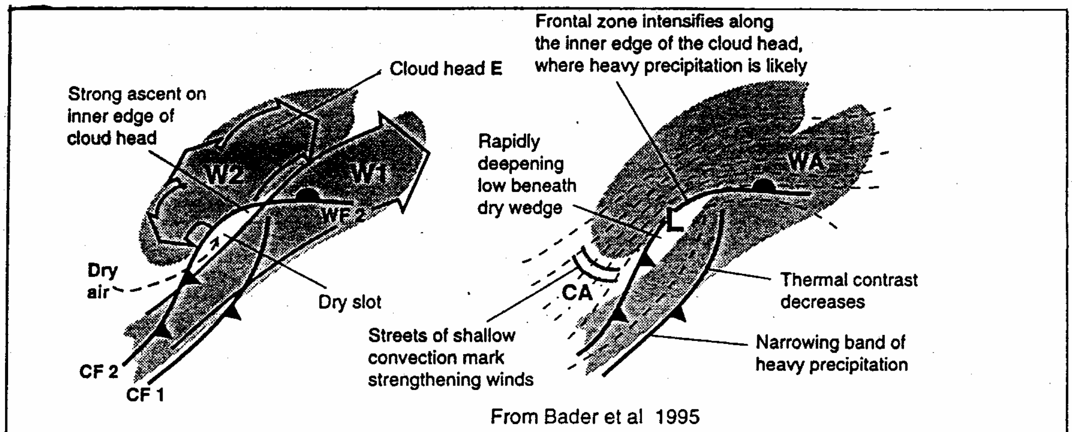



Fig. 2: Schematic picture of cyclogenesis associated with the arrival of an upper-level positive PV anomaly over a low-level baroclinic zone. The circulation induced by the upper-level PV anomaly is indicated by the solid arrows. The advection by the circulation leads to a warm temperature anomaly ahead of the PV anomaly. This warm anomaly induces the cyclonic circulation indicated by the open arrows. From Hoskins et al.(1985).

## 3.2 Diagnosis based on remote sensing data

Since the described diagnostic parameters are normally derived from numerical analyses or forecasts, their use might appear questionable in cases with significant errors in the model analyses. These are, however, the most important cases, since the also the forecasts by the model may become wrong. Then diagnostic means have to be used which are mainly based on observations. Very important in this respect are remote sensing data like the imagery of geostationary satellites and radar and lightning data.




Features This cloud signature is usually followed by explosive cyclogenesis .
Cloud head (leaf) E composed of rapidly ascending warm conveyor belt W2 is seen in imagery to be particularly broad and 'leaf shaped' with a sharp convex poleward boundary.
A pronounced and narrow 'dark zone' or 'dry slot' or 'dry intrusion' separates the cloud head from the polar front cloud band associated with W1. This dry slot is usually associated with a tongue of stratospheric air, recently descended into the troposphere which has high values of potential vorticity

Fig. 3: Conceptual model of explosive cyclogenesis: Cloud head and dry slot. From COST 78 (2001).

There are many conceptual models describing typical stages of the development of synoptic features based solely on satellite and/or radar data. A famous CM of this kind is that for strong or even explosive cyclogenesis (Fig.3). The characteristic feature of this model is a tongue of dry air aloft which approaches a frontal zone or wave disturbance in the lower troposphere. The forward march of the dry air can be detected and monitored in the images of the IR- or WV-channel of geostationary satellites. It reflects the advection of cyolonic vorticity (or IPV) aloft connected with upper divergence according to the schemes of Petterssen and Hoskins. As a reaction, a cloud structure develops above the surface low which is partly bent backwards and called a “cloud head”. It indicates the onset of ascending motion not only ahead, but also above and behind the surface low, so that the resulting lower convergence can lead to an intensification of the cyclonic vorticity of the low.

A prominent example of the successful use of this CM was the storm “Martin” on 27/28 Dec. 1999 which caused enormous damage and even loss of life in France. With the aid of this example the advantages of a manual nowcasting can be demonstrated. At the beginning there was the identification of a clear error in the numerical analysis of the surface pressure field for 00 UTC. Obviously due to a wrong “initial guess” a ship report was not accepted, and the apex of a frontal wave therefore analysed some 100 km further south compared with the manual analysis. That might appear as negligible. But comparing both positions with the numerically simulated vertical motion field at 500 hPa and the divergence at 300 hPa, it became clear that the numerically analysed frontal wave had a position not well suited for a further development, whereas the manually analysed wave had a good one. As the model forecasts based on this analysis became available, the observations from 03 UTC and a little bit later from 06 UTC were known and left no doubt that the numerical forecasts with respect to the development of this low were absolutely unsuitable. And the comparison with the satellite images in Fig. 4 - here from the WV-channel of METEOSAT – showed according to the just described CM that a coupling a la Petterssen or Hoskins was underway which must lead to a strong cyclogenesis due to the high moisture content of the warm air. All this was early recognised by the forecasters of Meteo France so that detailed gale warnings could be issued well in advance in spite of the bad numerical prognoses. With that they could make amends the problems with the storm “Lothar” one and a half day before as the warnings were issued late in spite of a good guidance by the French models.

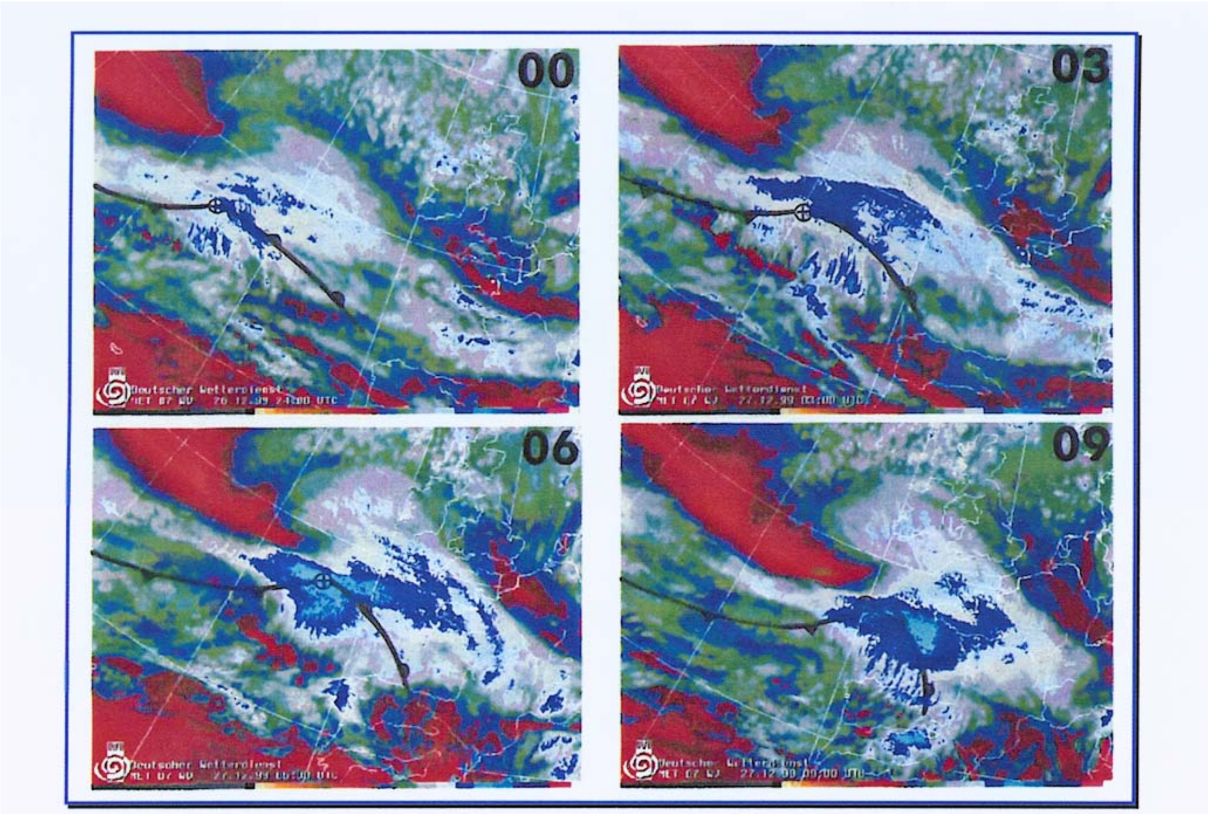



**Fig.4:** WV-images of METEOSAT from 27-12-99, 00, 03, 06 and 09 UTC with surface fronts and position of the surface low.

### 3.3 Diagnosis and forecast of strong convection

As regards the release of strong convection, it has to be stated that the model problems mainly result from deficits of the parametrisation of this process. That means, the numerical analyses and forecasts of the relevant basic fields like stability and vertical motion can be thoroughly correct, but the direct model output (DMO) might turn out to be wrong. Therefore an own diagnosis is absolutely essential on days with convection. Since strong meso-scale organised convection is mainly released not only by heating from the ground, but through additional lifting of the air, a comparison of the distribution of vertical stability with the forecast fields of vertical motion or quasi-geostrophic omega forcing is recommended. If the air is potentially unstable, the ascent, e.g. ahead of an upper short-wave trough, may lead not only to saturation, but also to a fully unstable lapse rate with respect to saturated air. The comparison of suitable indices or the vertical distribution of pseudo or equivalent potential temperature with the model omega has been proved therefore as superior to the pure model output in many cases with heavy thunderstorms.

On days with thermal release, the typical life cycle of convection is not well reflected by numerical models: Convective cloud with shower and thunderstorms appear much too early in the DMO and disappear also too early. A direct use of the model output is therefore not possible also in these cases.

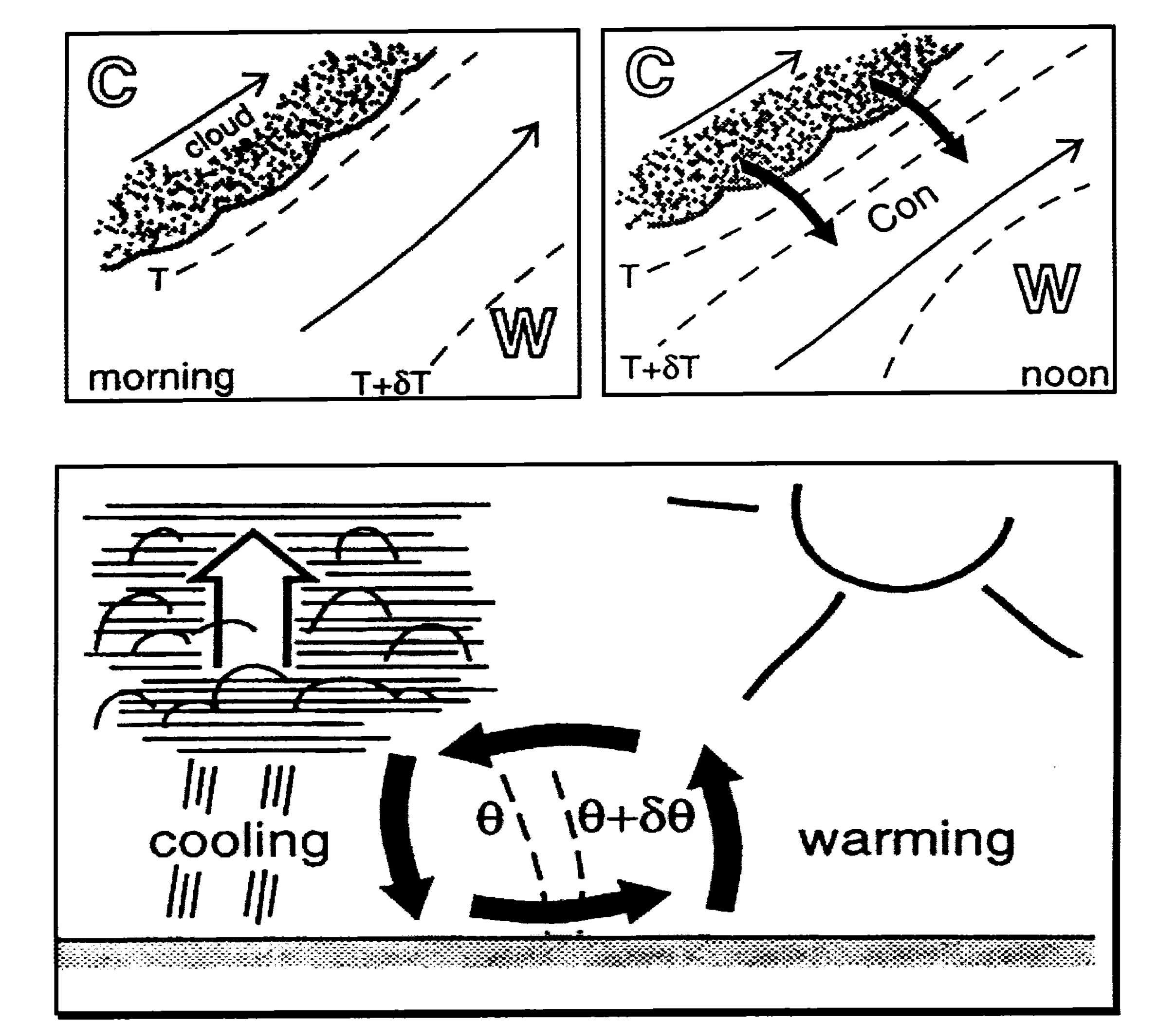



Fig.5: Conceptual model of the release of strong convection at the edge of cloud and precipitation areas. From Kurz (4)

Otherwise the use of satellite, radar and lightning data is essential for the nowcasting of strong convection. But also the surface observations should not be forgotten, since convergence lines in the surface wind field are the preferred place for the origin of the first convective cells. And convergence lines develop, e.g., there where great temperature differences are generated over a short distance within a short time. That is the case at the edge of cloud and precipitation areas over the continent during a summer day. As shown by the simple CM for this process shown in Fig.5, a solenoidally direct circulation is released by the increasing temperature contrast, through which a convergence line forms at the warm flank of the new frontal zone. The greater the temperature difference, the stronger is the circulation, and if the warm air is potentially unstable and moist enough, the ascent may lead to the release of the instability and the origin of convective clouds. At the end the convergence line may be transformed into a squall line which push forward into and through the warm air. The initiation of such a process can be early recognised by a careful monitoring of the temperature and wind fields at the edge of larger cloud and precipitation areas.

## 4 Conclusions

In conclusion, it has to be stated that the NWP models still show deficits in simulating some special, but significant weather situations and that therefore the experience of well educated and trained forecasters is still needed for weather forecasting as well as for a serious weather broadcasting. It is especially important in situations with hazardous weather in which the public has to be informed as quickly and reliably as possible. From this understanding two consequences follow:

- People interested to work in weather broadcasting must acquire the necessary theoretical and practical knowledge at the university and by special training courses to be organised by the Services or Companies concerned.
- There must be enough time and the necessary equipment to make the required own analyses and diagnoses and to compare them with the numerical output.

The synoptic diagnosis with the aid of the described means should be performed every day, not only when the model output appears doubtful. This has the advantage that it becomes possible to understand the numerically simulated weather development at least qualitatively, but it also allows to imagine some alternative scenarios based on the own diagnosis. If there are indications in this direction, the forecasts have to be altered accordingly.

That is, of course, necessary when the numerical output disagrees with the observed weather development from the very beginning or when weather systems appear in the observations which were not forecast by the models. Then often a simple extrapolation of the systems and processes visible in the data is enough for a forecast covering the next hours, taking into account the normal behaviour or life cycle of the synoptic features under consideration according to the results of the own diagnosis.

## 5 References


(1) COST 78: Meteorology – Improvement of nowcasting techniques, Final report. Edited by K.Lagouvardos, E.Liljas, B.Conway and J.Sunde. EUROPEAN COMMISSION EUR 19544 (2001)

(2)Petterssen, S.: Weather analysis and forecasting, Vol. 1, New York-Toronto-London: Mc Graw-Hill Book Company (1956)

(3) Hoskins, B.J.; Mc Intyre, M.E.; Robertson, A.W.: On the use and significance of isentropic potential vorticity maps. Quart.J.R.Meteorol.Soc. 111 (1985), pages 877-946

(4) Kurz, M.: Synoptic Meteorology, Deutscher Wetterdienst, Offenbach am Main (1998)