SYNERGIE AS A POWERFUL INTEGRATED TOOL FOR GLIDING METEOROLOGY

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Abstract:

Synergie is the operational tool used daily by the whole forecasting community in Météo-France, national and regional centers. This important piece of software has been developed by Météo-France and corresponds to a 45 men-year investment. Synergie provides the forecaster with an integrated, friendly, multi-window and evolutive environment, which ailows him to handle and interact with any kind of data (satellite and radar images, conventional observations, soundings, numerical weather prediction models). Its high level of tailorability enables any functional configuration.

Thanks to Synergie, the new numerical models developed at Météo-France (such as the 10Km resolution Aladin model), the ever-growing mass of terrestrial and satellite observations are now more extensively accessed and investigated.

The meteorological assistance to gliding competitions requires a high level of expertise on high resolution meteorological data. This is an example of the fields of application of Synergie, through the best possible real time investigations in model and/or soundings data. The main features of Synergie will be demonstrated at the conference, as well as the specific use of this system for gliding meteorology.

1. Introduction

The SYNERGIE Program comes from a Météo-France project of Meteorological Workstation for weather monitoring and forecasting, targeted to operational weather forecasters. This project was introduced during the 1993, 1994, 1995 and 1996 AMS/IIPS Conferences (Voidrot et al., 1993; Bénichou et al., 1994, 1995, 1996). Synergie is now a 45 man-year development software. It has been partly put into operations in the French national and regional meteorological centers in June 1994. The full implementation of the system was achieved in 1996. The Synergie Program was launched in 1996 after the preceedding project was closed, and aims at perennial development and implementation of integrated tool for decision-helping and interactive production in the Météo-France national and regional centers.

Synergie has now become a central tool, which helps the duty forecasters in their daily routine job as well as in specific assistances (Lefort & Peries, 1995). Synergie has been successfully implemented during the Soaring pre-Championships in St-Auban (France), where it was used

by French meteorologists for forecasting and daily briefings to the pilots. This paper will emphasize the main features of the Synergie system and focus on its application to local assistance as gliding meteorology.

2. Synergie as an evolutive tool for decision helping in meteorology

2.1 Scope of Synergie

The implementation of a new tool such as SYNERGIE in the Météo-France services must be understood as a will of homogenization, optimization and modernization of the operational forecasting offices, in a particular political context: Météo-France trust in the human expertise and on the added value that it can bring to the final product. In these conditions, the development and maintenance of a powerful and integrated tool for operational forecasting is critical for helping the forecasters facing the ever-growing amount of raw data to process and synthesize every day.

Synergie has to address the needs of very various kinds of forecasters. Hence it must enable operational forecasting (investigation, analysis) work at any scale from the global approach down to the very local assistance.

2.2 Any kind of data is in Synergie

A major purpose of the Synergie project was to integrate all the data into the same system in order to hasten the extraction of information and allow the forecaster to use and/or combine any type of data at any step of his work: understanding, analysis, forecasting, as well as production.

Today, Synergie can handle any classical type of data, such as:

- bulletins, messages
- numerical observations from professional or automatic weather stations - satellite images
- radar imagery
- vertical soundings
-T4 formatted graphical documents - static data (geographic contours...)
- meteorological fields (4D) from numerical weather prediction models
- any expertise data derived or produced by the forecasters (guidance, local forecasts, local weather elements, marine or aviation forecasts...)

2.3 Synergie features

Synergie offers any classic feature one operational forecaster may expect from a meteorological workstation. The graphical environment is both intuitive and friendly, thanks to a highly graphical user-interface, a multi-window environment, and the ability to work on two (or more) physical screens. The system aims both decision helping and interactive production.

Therefore the main features can be divided into three categories:

2.3.1 Standard manipulations

This involves all the features that are available in most Synergie windows:

- zoom in and zoom out cleverly (that means more data or more accuracy when zooming in)
- give the position of the cursor in lat-lon and the corresponding relevant value of the visualized data (e.g. field value for model, cloud type for satellite, rain rate for radar,...)
- animate any type of data (if relevant): radar, model fields, satellite images, lightning impacts, observation plottings...
- overlay any types of data (radar, satellite, model, observations, ...) and activate any previous feature (zoom, loops,...)
- print windows or whole screen from Synergie.
- save and play macro-commands: it is possible to save or to run a macro containing any number of Synergie windows and even pre-programmed loops on pictures or model fields.
- annotate any visualization window

2.3.2 Visualization features

Visualization features correspond to specific Synergie sub-applications. In each sub-application, specific features can be activated:

- model output visualization (atmospheric and wave models): visualization, vertical cross-section of the forecast atmosphere, simulated vertical profiles,...)
- observation plottings: visualization, vertical profile from sounding stations or commercial aircraft,. . - vertical profiles from soundings (soon profilers): visualization, stability index,...
- time series from terrestrial observations (soon from model outputs): combination with model output statistics and climatological values,...
- alphanumeric and graphic visualization
-radar imagery: visualization, interactive rainfall estimation on any time-period, thresholding,...
- lightning impact: visualization, lightning density maps on any time-period,...
- satellite imagery: geostationary and polar orbiting images visualization, multi-channel compositions, color enhancement,...

New sub-applications are regularly developed to ingest new types of data.

2.3.3 Interactive Production features

Interactive production features also correspond to specific sub-applications. They enable the forecaster to work in an interactive, (geo) graphical and meteorological environment and fill meteorological databases containing the Météo-France expertise, from which tailored products may be derived for any kind of end-users. By spring 1997 all the corresponding sub-applications are not yet available but the aim of the Synergie Program is to provide any kind of forecaster (national, regional, marine, aviation,...) with specific and adequate sub-application, under a general constraint of homogeneity and consistency in the developments as well as in the meteorological data generated by the forecasting community on the Synergie workstations.

2.4 Software Development strategy

New developments are performed according to an iterative scheme of requirements/ development/validation. The new features are generally gathered and integrated

into intermediate versions of the software. The last version at the time this paper was written was the Synergie 2.4 release. A major Synergie 3.0 release is under preparation and will be made available for summer,1997 at all the Météo-France Synergie sites.

It was desirable to make Synergie a general software able to meet most of the various needs of the forecasters. On the other hand, almost every forecaster within a National or Regional Center has a specific duty to perform. Hence the idea of providing any forecaster with a specific Synergie configuration tailored to his actual duty. Therefore, the concept of Synergie family, as a set of preset software designed for specialized forecasters was born. Any Synergie software may be seen as a set of general purpose and specific data and features, with a fitted "universal" user interface.

Besides, once the set of data and functionalities are defined and selected, the user can tailor the software to his own preferences or needs. He can also very easily define personal macro commands in order to save mouse clicks and go faster to the specific view of the data he uses to look at.

2.5 Hardware implementation

The Synergie system is based on Unix equipment and relies on a server-client architecture at any Synergie site. Météo-France has chosen SUN Microsystems in 1993 for his operational implementation.

2.5.1 At Météo-France

By May, 1997, Météo-France runs about 20 servers and 70 stations implemented on 17 geographical sites (6 of them in the overseas territories), which corresponds to a $3M investment over the 1994-1995 period. All equipment is planned to be replaced after 1998. The general principle is to implement a (double) server at each geographical site, the power of the server depending on the number of local client stations.

Hence the need for powerful lines to provide these servers with the relevant data: all the regional offices in France are connected to the national center of Toulouse through dedicated 384 k Bytes (and more) lines. Renting a line to France-Telecom for a limited period is possible: this solution has been chosen for implementing Synergie workstations at the World Gliding Championships in St-Auban (1996 and 1997).

2.5.2 Synerqie implementation abroad

Export versions of SYNERGIE can easily be derived from reference versions and implemented anywhere in the world wherever data are available in a WMO format. The commercialization of the SYNERGIE-Export Package is performed through the SOFREAVIA[2] company on the basis of an agreement with Météo-France.

SYNERGIE is now implemented in Indonesia, Niger, Honduras, French Guyana (French Space Center), and in Morocco; it will be soon installed in Philippines, Maurice...

3. Operational use of Synergie for fine short range forecast like assistance to gliding

3.1 Meteorological requirements for gliding

The specificity of the meteorological assistance to gliding is in the scale of the information required by the pilots from the forecasters. Gliding pilots need very precise meteorological information at a very fine scale, particularly during a competition (cloudiness, types of clouds with height of the base of the low cloud, wind, temperature...). In fact, they want to know the atmosphere's movements at the scale of their glider (wind, vertical velocity and types of the fine scale ascending movements). Therefore, the meteorological assistance to gliding competitions requires a high level of expertise with regards to meteorological data.

3.2 The very fine and short range forecast

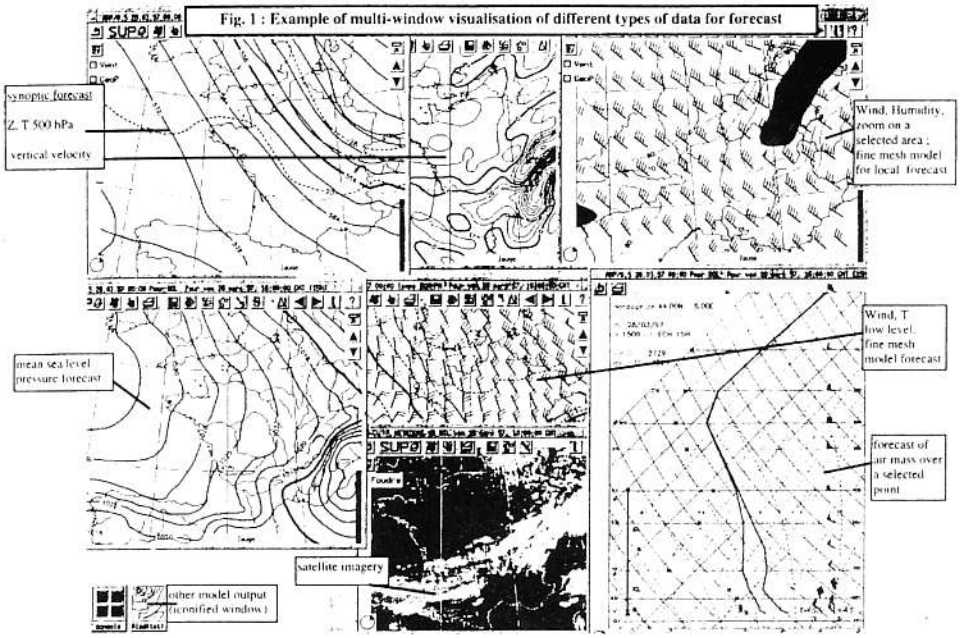
3.2.1 Generalities

In spite of the improvements to the numerical forecast, the present numerical models can't give information as accurate as required by gliding pilots. It is also very difficult for the human forecaster to control scales. However, the experienced forecaster can bring much useful information for gliding, and that is all the more true as he has all the available meteorological data, as he can investigate. Nowadays, with the improvement of the numerical models (increasing of the resolution), with satellite and radar observations, the forecasters have to cope with more and more meteorological data. Operational workstations like SYNERGIE have been developed to help the forecasters to better deal with the whole set of available meteorological information. Figure 1 shows an example of multi-windows visualization of different types of data useful for short range forecast (synoptic model's output, fine mesh model's output, satellite imagery, forecast air-sounding). Note that some windows show different superimposed parameters (geo-potential and temperature, wind and humidity).

3.2.2 The forecast process

For mean latitudes, the weather is always conditioned by the synoptic circulation; the days where the air mass only evolves with local conditions with no influence of the general circulation are very exceptional. That means a very fine mesh forecast like forecast for gliding, even for very short range (forecast for the day), requires at first a very good forecast of the synoptic circulation before making a forecast of the local conditions' evolution. How will be the winds in the whole troposphere at the different levels, how will evolve the temperature and humidity fields (advections or no advections), what will be the dynamics of the atmosphere and the influences of the vertical movements due to this dynamics on the air mass (more or less unstable...), all these questions have to be taken into account. Even in summer anti-cyclonic conditions, the synoptic circulation has to be perfectly controlled by the forecaster. Otherwise, a forecast like the only air mass evolution with the diurnal low level temperature and humidity often leads to important errors for gliding.

The synoptic forecast is based on the global (coarse mesh) model (in France, the French model ARPEGE). For very short range forecast, like assistance for gliding competition, the numerical models are not always very powerful (particularly because of the lack of observation in the analysis phase); so the model's output have to be estimated by the forecaster. The first job for the forecaster is to check



some output on paper; so, the forecaster can extract from the model what it can't give directly for final forecast.

It is difficult to show in this paper examples of the elaboration of forecast by using the SYNERGIE workstation (would require many figures, color super-impositions, ...); an example will be presented at the conference with, if possible, a demonstration on SYNERGIE. However, the figures 2 and 3 present an example of another type of model's shortcoming; the figure 2 shows the surface pressure field over France on may 1997 at 12 UTC (top), and the synoptic verti-

the model's analysis and first range forecast (by example 3h forecast) with all the available observation data, essentially the satellite imagery, but also some conventional observations not taken into account by the numerical analysis (for example the pressure tendency). All the observations arriving continuously (for example, every half an hour for satellite imagery), include important information that the forecaster analyses in nearly-real time; then he can make a critical comparison between these data and the models' output valid for the earliest terms. This investigation work allows him to detect some failure or drift in the model's forecast, to confirm or not, a possible anomaly detected previously in the different available parameter's forecast; so the forecaster can rectify the model's forecast. For this confrontation between model's output and observation data, the SYNERGIE workstation is a very powerful system, for example by giving the possibility of any kind of super-impositions, interaction or loops...

The gliding forecaster has to extract from the synoptic forecast the influences of the general circulation over the air mass, such as: temperature and humidity advections at the different levels (high troposphere, mid-troposphere, low levels), the changes of vertical structure due to the possible synoptic vertical velocity. Then, he has to forecast the air mass evolution according to the local conditions (diurnal evolution, geographical influences...). Of course, the present fine mesh model (in France the ALADIN model, 10 km horizontal resolution 27 levels) is a precious tool, but the primary weather forecast from the model is not good enough. The human expertise is still necessary; the climatological knowledge of the region, a good knowledge of the model's behavior, allow the forecaster to add value to the final forecast. The workstation gives the possibility to the forecaster to have access to the full set of meteorological data, and specially to the complete numerical forecast (all the levels, all the parameters), and to better investigate the model's output than he could do with only

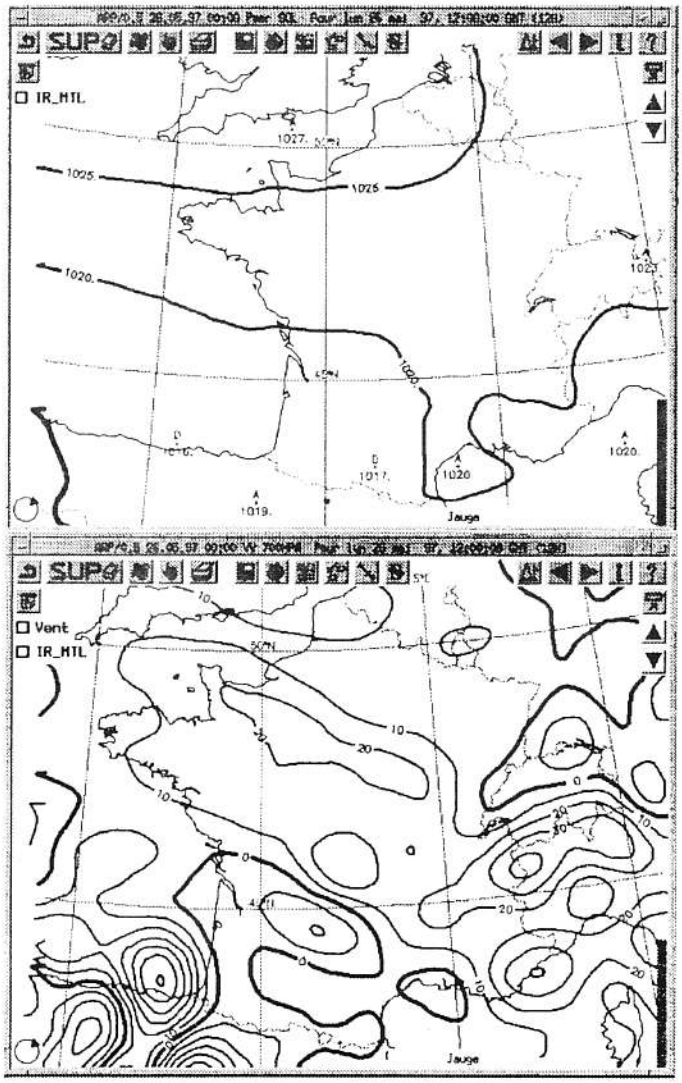


FIGURE 2. Top, mean sea level pressure (hPa); Bottom, vertical velocity (0<for ascent movement, >0 for subsiding movement; 12 h forecast, base May 1997 00UTC valid 12 UTC.

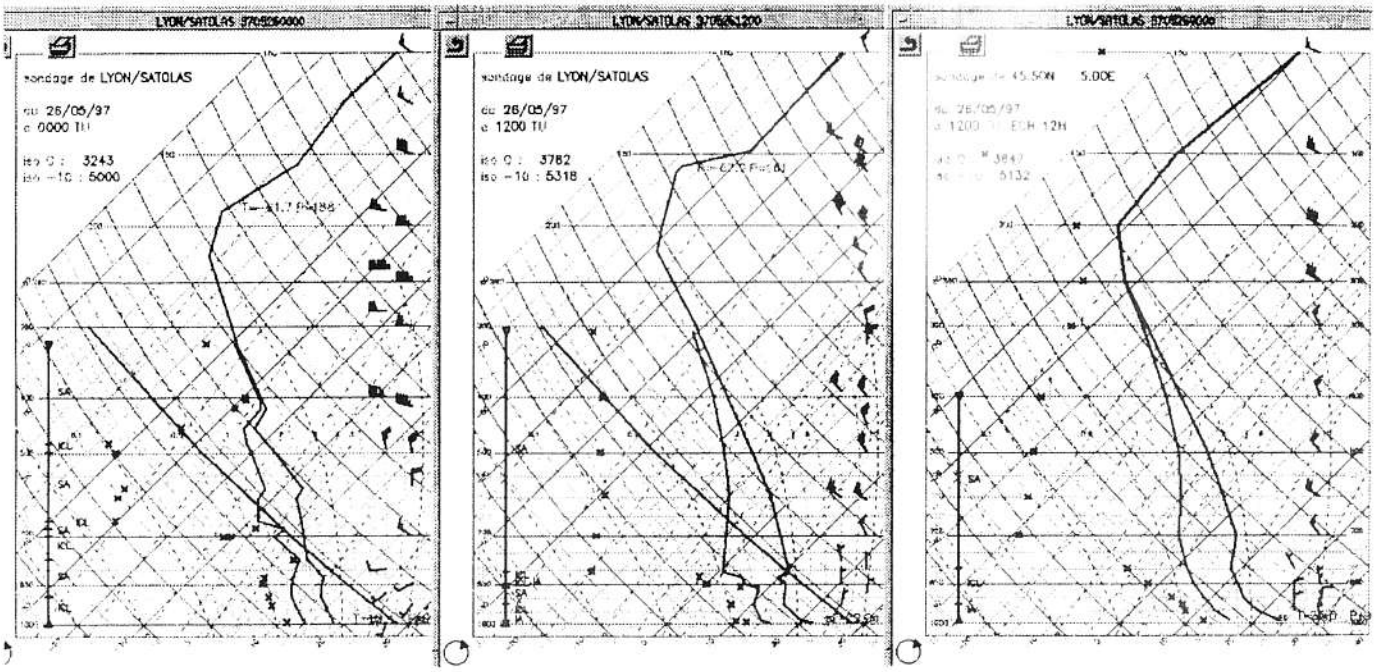


FIGURE 3. Lyon sounding; left, observed on May 26, 1997, 00UTC; center, observed the same day at 12UTC; right, as forecast by the model based on May 26, 1997 at 00UTC for 12UTC the same day.

cal velocity as forecast from the ARPEGE model based on may 27 at 00 UTC for the same day at 12 UTC; these charts show that France is under anti-cyclonic conditions, with subsiding motion over the Lyon region and the Alps. At 12 UTC, the Lyon sounding has become more stable, but the vertical profile in the low levels is smoothed on the forecast (fig. 3, right) compared to the observed air mass (fig. 3, center). This default, due to the vertical resolution in the low levels is well known by the forecasters; the knowledge of the existence of a synoptic subsiding and of the observed air mass at 00 UTC can allow to forecast a more stable layer around 850 hPa; this is important for gliding forecast.

4. Summary

Meteorological forecast requires an important investigation and a synthesis work on very numerous data. Nowadays, the forecasters have to cope with more and more meteorological data; so the risk is great they get bogged down in this mass of information. Operational workstations have been developed to help the forecasters to deal with the whole available meteorological information.

Today with SYNERGIE the forecaster provides an integrated friendly, multi-window and evolutive environment, which enables him to handle and interact with satellite and radar images, conventional observations, upper air soundings, and numerical weather products. The high level of tailorability of this system enables any functional configuration. Thanks to SYNERGIE, the new numerical models developed at Météo-France, in particular the new fine mesh model ALADIN (10 km horizontal resolution), the incessantly growing mass of observations (with the enhancement of satellite and radar imagery...), are now more extensively accessed and investigated.

The meteorological assistance to gliding competitions requires a high level of expertise and high resolution meteorological data. This expertise is possible with the access to all the available model output that is to say the different parameters at different levels, for many time steps, and from the synoptic model then from he local model. The possibilities of animation, zoom, super-imposition, vertical cross-section, vertical profile, as well as the possibilities of combinations of observation data with models parameters improve significantly the forecast's methods. This investigation work allows the forecaster to add value to the primary numerical forecast, especially for very fine short range forecast like assistance to gliding competition, for which the models are not powerful enough.

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