PROMIS 600; AN OPERATIONAL SYSTEM FOR VERY SHORT RANGE WEATHER FORECASTING IN SWEDEN

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SUMMARY

PROMIS 600 is an operational system especially for very short range weather forecasting. The workstation, which has been set up in Norrköping, is a big step in the realization of PROMIS 90; the Swedish weather service system of the 90's. PROMIS 600 will test several aspects of very short range forecasting, as the observation system, mesoscale analysis and forecasting methods, workstation and methods of dissemination of new forecast products. During spring 1989 a realtime test of its operational workstation has been conducted and PROMIS 600 will during the autumn be incorporated in the regular weather service. The achievments of the technical systems of PROMIS 600 have been gained as a joint project between Swedish industry and the Swedish Meteorological and Hydrological Institute. The main contractor of the PROMIS 600 system, including the doppler radars and the PROSAT system is Ericsson Radar Electronics AB.

1. INTRODUCTION

The Swedish Meteorological and Hydrological Institute (SMHI) is developing a system called PROMIS, which stands for a PRogramme for an Operational Meteorological Information System. In the inital study of PROMIS 90, (Bodin et al , ref 1), An increasing demand was identified from varius sectors of the society for very short range and detailed forecasts, wich should be effectively disseminated and tailored to customers needs (Liljas, ref 2).

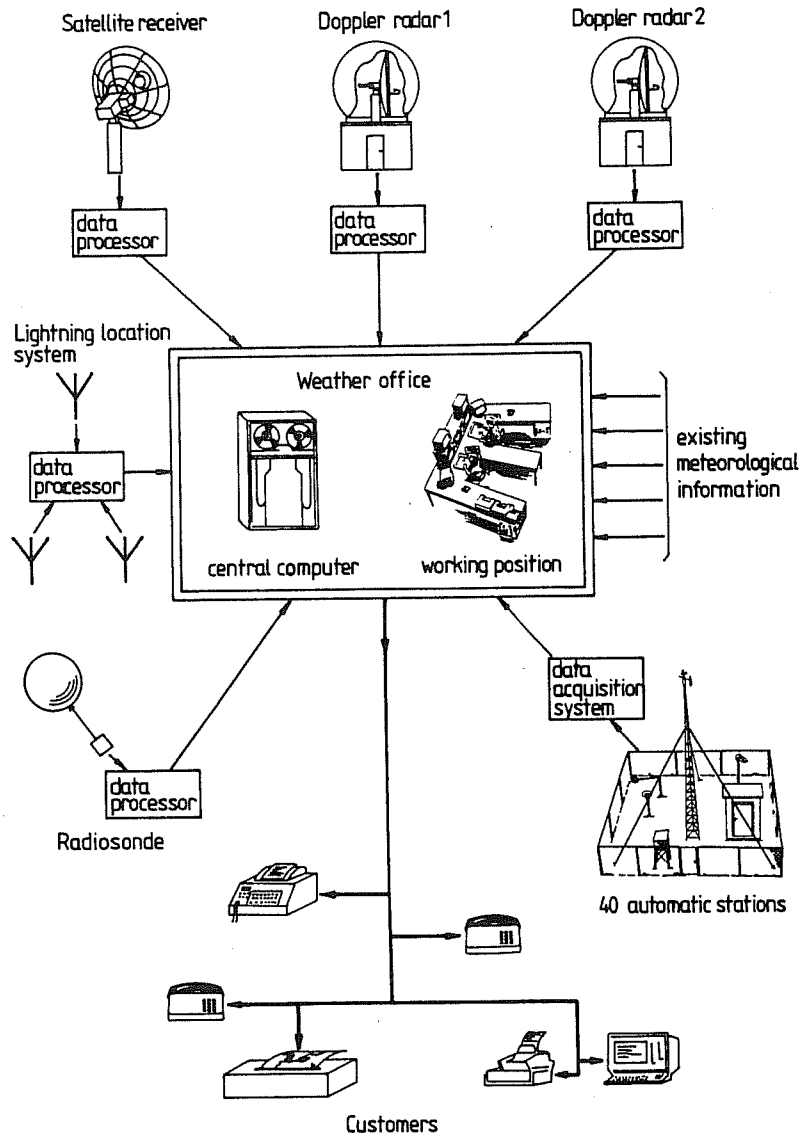
In order to accomplish the very short range part of PROMIS 90, which covers the complete weather service, including short range (1-2 days) and medium range (3-10 days) weather forecasting, a pilot station for very short range forecasting, PROMIS 600, has been built up in Norrköping at the headquarters of SMHI. On its colour graphic monitors, meteorological data from different sources can be displayed on five spatial scales ranging from an area covering europe to the local scale, which covers a small portion of southeast Sweden. Forecasters may display the various data on common map projections (on the smaller scales lakes and roads are included) and animate and zoom any product it will.

During spring 1989, PROMIS 600 was subjectively evaluated by forecasters in an quast-operational enviroment. The primary forecasting area is located within an area around Norrköping with a radius of approximately 200 km. (Observational data with high resolution are available within a radius of about 120 km). During the test-period, the workstation was used to issue very short range forecasts of precipitation. The forecasters agreed in that the ability to monitor mesoscale phenomena in detail was improved by using the PROMIS 600 system. In the extension, this also has important impacts on the nowcasting and very short range forecasts.

Already today, the volume of the incoming meteorological data is very large (the PROMIS 600 system is producing around 3000 images each day) and it will probably grow substantially during the 90's. The diverse data will place heavy demands on computers and storage devices, but also on the forecasters. In order to handle the enormous data stream, the forecasters have to determine the "meteorological problem of the day" to be able to eliminate some classes of products. But even after an elimination procedure, there will still be problems with the selection and integration of meteorological data. A successfull mixture of variuos data will undoubtly be challenge for the next years to come. Another great problem to face is also the meteorological understanding of the processes and the scale-interaction, a point which was stressed by the forecasters during the test-period.

2. MAJOR COMPONENTS OF PROMIS 600

Nowcasting and very short range forecasting demand an observation system based on remote sensing techniques (satellits, Doppler radars etc) and a dense network of automatic stations with a high frequensy of updating. The short time scale also puts heavy demands on rapid communication, processing and dissemination of various forecast products. The design of the PROMIS 600 technical systems reflects these requirements and in the figure below, an overview of the technical system is given.



The observational data are displayed to the forecasters in alphanumeric or graphical form. The forecaster has also access to various mesoscale analysis and forecasts. The research and development in this area has been performed in cooperation with the universities and the Swedish military weather service.

The dissemination system is also of great importance. When we have produced sufficiently accurate, site or area specific forecasts, we must be able to deliver this information to the customers who need it to make correctly and timely decisions. This is especially important for the emergency services. Therefore, the development of customer-tailored dissemination techniques and formats has a high priority in the PROMIS 600 project.

3. THE OBSERVATION SYSTEM

The observation system forms the base for PROMIS 600.

The data sources are:
- automatic station network
- Doppler weather radars
- satellite data subsystem,"PROSAT"
- lightning location network
- conventional meteorological information

3.1 The automatic station network

A network of 40 automatic stations is established in PROMIS 600. All stations are equipped with sensors for wind, temperature and humidity. In addition, a number of stations measure cloudbase and visibility.

Data from the sensors are collected and preprocessed locally by an Automatic Data Acquisition Terminal (ADAT) and transmitted via telephone to the acquisition computer ADAC (Automatic Data Acquisition Central). The stations deliver data every 15 minutes.

The observational data are displayed in a conventional, "synoptic form" or as time-series for each parameter or combination of parameters.

3.2 The doppler weather radars

Two 5 cm, 0.85° 3-d>B beamwith, dual pule repetition frequency (dual PRF) scanning Doppler radars are so far included in the observation system. The radars are localized in Norrköping and at Arlanda Airport north of Stockholm. Recently an additional Doppler radar has been installed on the island of Gotland. These radars will also be incorporated in the PROMIS 600.

The radars can operate in Doppler amplitude (non-Doppler) mode. Both modes are used during each data collection cycle and the mode selection is controlled by a computer. The amplitude mode is for the largest measuring range (radius 240 km), while the Doppler mode measuring only within a radius of 120 km around the radar.

The radars make three dimensional scans and they have the capability of reducing ground clutter echoes by blocking the Doppler spectral channels near zero radial velocity and utilize a 32-pulse Fast Fourier Transform (FFT) processing technique to provide radial velocities for each PRF. Even the amplitude mode is relatively free from ground clutter echoes, due to a developed algorithm for suppressing ground echoes.

The radars display images of the following basic parameters:
- reflectivity at several CAPI levels and maximum values
- precipitation intensity and accumulated precipitation
- radial velocity, PPI and CAPI levels
- turbulence
- echoe top heights

Vertical cross-sections may also be obtained. The composite image of the two radars is at present only displaying maximum values of the reflectivily, but will in near future also display pseudo-CAPI reflectivities with a fixed geometric boundary between the radars. Ohter methods of merging data from radars will also be investigated.

3.3 The satellite data system

The satellite data subsystem, PROSAT (PRocessing system for meteorological SATellite data), was installed in the early part of 1988 and consists of an antenna/receiving system and an advanced processing system.

The system handles both high resolution NOAA and Meteosat data. The products from PROSAT are images on different scales from 1000 x 1000 km (1km resolution) to 4000 x 4000 km (8km resolution), all in polar stereographic projection. Colour composite images (for Meteosat (VIS in Red, VIS in Green and Ch4 in Blue), cloud and precipitation classifications, cloud top and surface temperatures are some of the standard products.

3.4 The lightning location system

A lightning location network, LPATS (the Lightning Position And Tracking System) is since last year covering the whole of Sweden. The system utilizes Time-Off-Arrival (TOA) technique and the information from six optimally located detection stations are received in real time and compiled by a central analyzer in Norrköping.
The detected Cloud-to Ground (CG) strokes (mean CG strike location error is less then 5 km in PROMIS 600 area), its polarity and time displayed to the forecaster at the workstation.

4. ANALYSIS AND FORECAST METHODS (METEOROLOGICAL MODELS)

The meteorologist at the workstation needs effective tools for analysis and forecasting of the mesoscale weather systems. Due to operational demands, e g short computing times, general three-dimensional approach to mesoscale forecasting. Simple methods for interpretation of the new observational information and for analysis of small scale features have been developed together with a number of specialized forecasting models, which still are able to catch the most essential atmospheric processes. The forecasting method also involves the use of subjective judgements from the meteorologists.

In the following a broad survey is given of some of the analysis and forecast methods that have been developed for PROMIS 600. The operational tests will reveal the meteorological merits and drawbacks of the varius software moduls.

- **The Vorticity Advection Model, VAM.** This model is based on the advection of a vorticity that evaluated from a mesoscale analysis of the pressure of the sea surface analysis. The vorticity is advected by a flow which is determined from a large scale numeric forecasting model LAM (Limited Area Model). The VAM model is adaptative in the sense that an optimal wind for the advection is determined for each time the model is used. The results are modified by other processes by use information from LAM (VAM-B). The results show that the model generally gives satisfactory forecasts up to 6 hours and even up to 12 hours. (Ref.3).

- **The Small Area Model, SAM,** is a model that is based on the same concept as a model developed by Danard. The output from the model is mesoscale wind fields in the lowest layers. Analysis of the air pressure at the level of the sea surface, temperature in the lowest atmospheric layer, vertical stability, topography and roughness of the erth atmospheric layer of heat and momentum, and is processed until a quasi-stationary state is reached. The model has turned out to give valuable information on the wind conditions in the lowest layer. (Ref.4.)

- **The Air Mass Transformation model, AMT**, consist of a system for processing an one-dimensional boundary layer model along a trajectoria given by the analysis system and also by a forecast model. This trajectoria thus includes both a past and a future time-interval. Forecasts are given by the AMT-model to some arbitrarily given points in time and space of the conditions in the atmospheric boundary layer. (Ref.5.).

- **A statistical forecast model, POP** (from Probability of Precipitation), can be used for areal probability forecasts of a geophysical parameter, for instance precipitation. To broadly illustrate the concept: a relationship between the precipitation climate at a number of geophysical locations, the respective surrounding topography and the part of the area that covered by water is developed. By statistical methods, the probability of precipitation can be expressed. Information on the synoptic situation is taken onto account. The probability is expressed by values computed in a grid, and this information can consequently be displayed by a map.

- **Estimation of accumulated precipitation by use of radar** Information and data from automatic stations. Precipitaion is estimated for a specified time interval, generally one hour. The hourly accumulated fields are then summed up to give 3 hour totals daily totals e.c.t. As input the estimation models serves radar data fields with as high updating as possible from the normal mode (information from the doppler mode can also be used) and precipitation data from the automatic stations with a time resolution of one minute. (Ref.6.).

- **The mesobeta- and mesogamma analysis systems.** An analysis system for the mesobeta scale (20km - 200km) has been developed and taken into operational use - examples are given in the illustrations presented in this section. The analysis system is based on statistical interpolation (also called optimum interpolation). Non-isotropic correlation functions have been developed in the analysis of parameters in the lowest atmospheric layer. A multivariate scheme has been developed for analysis of vertical profiles. The mesobeta analysis system operates presently on a 3 hour basis. (Ref.7.)

5. THE WORKSTATION AND OPERATIONS

The very short range forecasts will partially depend on how well the data can be displayed in an optimal, integrated form. For this reason the display system is very important and considerable time has been devoted to the development of the graphical display software. In the design of the workstation, great care has also been taken to ensure good enviromental and ergometrical conditions.

The workstation of PROMIS 600 consists of an alphanumerical terminal for control, menu handling and editing, and a colour graphic monitor with a "mouse" and a graphic tablet for presentation, animation and combination of "pixel images" (radar and satellite data) and "graphic images" (lines, symbols, etc) as different plots, analysis and forecast products.

Forecasters can view the various products on five different spatial scales: the European-scale, the Scandinavian-scale, the southern Sweden-scale, the regional--scale - East (the eastern part of southern Sweden), and the local scale - the PROMIS 600 area. All scales have common map projections and on the smallest scales, map backgrounds of big lakes and roads are included as options. A topography background will also soon be implemented. The distribution of the various products on different scales are schematically illustrated below.

	RADAR Norr-Köping	RADAR Compo-site	NOAA	METEO-SAT	LLS	OBS
P600	X		X			X
EAST	X	X	X		X	X
SSWE			X		X	
SCAN			X		X	X
EURO				X		

	ANA-LYSIS Sur-face	ANA-LYSIS Height	FORE-CAST Sur-face	FORE-CAST Height
P600	X	X	X	X
EAST	X	X	X	
SSWE	X	X	X	
SCAN	X	X	X	X
EURO	X	X		

The display system is easy to handle by a forecaster and allows him to concentrate solely on meteorological problems. A key to this is the flexibility of menu selection system. In PROMIS 600 the mostly used products are defined as "standard products" and they can be reached through the predefined Direct-Function-Keys (DFK) at the keyboard. As DFK are also some other important image manipulation functions defined, as animation and overlays. Using the zoom factor, and the forward and backward looping at desired speeds of the selected images can be preformed. Other products, including the predefined standard prodcts and order products, e.g parameters from the AMT-model and time-series may be reached through the menu selection tree.

The system is very flexible regarding the application of different overlays. On a satellite or radar image it is possible to add up four different graphic overlays, which could include e g variuos analysis and forecasts, wind observations and extrapolations of selected overlays on or off.

With a draw-function it is possible to preform interactive image manipulations. Conventional fronts and symbols as well as text may be added to an image and the product then be specially designed for various customers. This function will be further developed in a production-distribution system, which will be used as a complement system to PROMIS 600 workstation.

The production-distribution system is also installed at the other four regional weather offices in Sweden, where analysis and forecast products, satellite and radar information can be recived on the system. In the future, much of the interactive man-computer forecast production will be managed on this system.

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