DYNAMICAL STATISTICAL METHODS OPERATIONAL SYSTEMS USED IN FINLAND FOR LOCAL FORECASTING PURPOSES

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1. General views on dynamical-statistical forecasting methods

Dynamical-statistical methods are used for the interpretation of dynamical forecasts of certain elements in the synoptic scale (resolution 100 - 150 kilometres or more) in terms of local weather elements not forecast directly or in a satisfactory way by a dynamical model. This is performed by a statistical coupling of the results of numerical analyses (in some cases even observations) or forecasts (the predictors) with simultaneous observations of local weather (the predictands). Sufficient data must be examined in deriving the statistical relationships (normally at least 5 years, 10 - 15 years or more is recommended).
The following types of methods may be used:

(i) PPM - the perfect prognosis method; in this case the inter-relation between numerical analyses (or the corresponding predictors from observed data) and the simultaneous observations to be forecasted locally are determined; the predictors as derived directly from operational forecasts are then used as input to the statistical relations to derive a corresponding local forecast. It is implicitly assumed that the operational forecast to be input to dynamical-statistical schemes are perfect.

(ii) MOS - the model output statistics method; this is a method in which the inter-relation between numerical forecasts and simultaneous (subsequently) observed data is determined; the method may thus take into account any systematic errors in the dynamical forecasting methods, but in practice may be difficult to use correctly as long series of numerical forecasts should theoretically be available after each change to the model so that new statistical relationships can be derived.

(iii) SCM + IOS - a statistical correction method plus independent output statistics ; this is a hypothetical compromise between the first two alternatives, which could be very practical in Europe where numerical products from many centres (ECMWF, Washington, Moscow, Bracknell, Offenbach, Paris, Rome, Stockholm) are likely to be widely available within 1 - 2 years in GRID code form. However, detailed information on the behaviour of the models will not be generally available to recipients.

In the United Stated, complex versions of MOS are now used as routine, with large numbers of predictors (in some cases smoothed or otherwise transformed for a better fit). The predictors may come from several of the different models run operationally at NMC Washington, and sometimes forecast elements valid 12 - 24 hours after the verifying time of the forecast are used . In Europe PPM methods have generally been used, although it is recognised that dynamical forecasting models indeed have systematic errors; these are partly model dependent but often similar in a number of different models.

2. Operational system used in Finland

A small group responsible for the development of dynamical-statistical forecasting methods was set up within the Finnish Meteorological Institute in 1972. The objective was to implement operational forecasting methods to give primarily improved surface wind forecasts for the icebreaker services required to keep Finnish ports open around the year. The first routine forecasts were issued on 1 January 1973. Such forecasts have since then been issued regularly 2 - 4 times daily around the year, providing wind forecasts up to 30 hours for various users. The special working group also started to develop temperature and visibility forecasting methods, and was aiming at completely automated TAF and MAFOR forecasts within 3 - 5 years. However, the work of the group ceased in 1976 for various reasons. At present the setting up of a new group with similar tasks is seriously being considered by the Institute; such a group might also be responsible for developing methods related to the use of ECMWF products in Finland. The software tools and data files created by the original group are naturally still available for possible future use.

The operational forecasting system developed in Finland some five years ago and put into operation on 1 January 1973 is based on a mixed PPM / MOS concept. The dynamical model used for forecasting the predictors uses the Swedish three-parameter balanced model (Bengtsson et al. 1971). The grid used for the forecasts (and the corresponding analyses used for the determination of the dynamical-statistical schemes) is a polar-stereographic grid with a 150 km mesh at 60^{o}N. For a description of the statistical surface wind prediction model see Lange 1973. For a more general presentation of surface wind forecasting techniques, reference is made to

Carter 1975.

The model forecasts have been issued regularly for seven sea areas (two in the Gulf of Finland, one in the northernmost part of the Baltic Sea and four in the Gulf of Bothnia), three inland stations (Helsinki, Jyväskylä and Rovaniemi) and three coastal stations

(Utö, Katajaluoto and Ulkokalla). Typical messages constructed automatically by the computer for local and regional wind forecasts are illustrated below.

ZCZC

FXF13 EFKL 050730

EXP STAT FCAST OF SURF WINDS BASED ON ESWi 150 KM BC NP 73090500 + 30

	VALID	06	12	18	00	06
LOCAL	EFHK	12003	19005	23007	24008	24010
	EFJY	11002	17005	17007	22004	28006
	EFRO	12007	15003	10010	06009	05012
	UTÖ	18014	19011	23015	29022	29029
	KATAJ	17004	19006	24015	26015	24017
	ULKOK	17018	15010	11012	////	02015

=OHMZ=

REGIONAL	07309	10508				
	A1	00000	21006	22008	28009	27011
	A2	18005	19006	25009	27008	26010
	A3	18008	19007	24009	29012	29016
	A4	14005	19008	22008	28012	28016
	A5	14005	17008	21009	29010	31012
	A6	14007	16006	19004	27006	33009
	A7	16010	15008	10007	05009	01011 =

In this forecast the five figure groups give winds in the form dddff (direction in degrees, speed in metres per second), starting from 0800 local time on 5 September 1973.

These objective forecasts are checked by an experienced forecaster before distribution (in order to avoid discrepancies between these and the normal forecasts disseminated through the media). The forecasters corrected some 20 per cent of the forecasts and managed to improve these slightly in the winter of 1973. The mean error of the vector for the corrected forecasts being 3.47, 4.15, 5.11 and 6.02 m/s for the 12, 18, 24 and 30 hour forecasts, as compared to 4.32, 5.31, 6.11 and 6.32 m/s for the original model forecasts. In 1974 there was a greater improvement (the vector error being 4.29, 5.19, 5.43, 6.18 m/s as compared to 5.18, 6.98, 7.52 and 9.04 m/s). The main reason for this were systematic errors in the dynamical forecasts over western Scandinavia and the automatic forecasts could probably have been improved by using a more sophisticated MOS technique. This, however, would have required a considerable amount of forecast data which was not available. An alternative approach would have been to apply a statistical correction on the dynamical model's output before input to the PPM system.

This statistical surface wind forecasting scheme, as used by the Finnish Meteorological Institute, is from the meteorological point of view very straightforward, with only the geostrophic wind at 1000 mb as a meteorological predictor. The only additional possible predictor available from the relatively simple dynamical model was the mean vertical velocity between 1000 and 500 mb (and, theoretically, also the 500 mb geopotential height). It is not likely that the inclusion of such predictors would have improved the local wind forecasts significantly.

A comparison between Finnish and Swedish wind forecasts for various coastal stations has also indicated that the magnitude of the errors in these forecasts is quite similar. However, as output of more sophisticated dynamical models with a better vertical resolution becomes available for routine operations, improved local forecasting schemes for the surface winds and other weather elements of importance could, and should, be evolved in Finland as well as in other European countries.

References:

Bengtsson, L., and L. Moen, 1971 : An operational system for numerical weather prediction. Satellite and computer application to meteorology. WMO No. 283, pp 63-88.

Carter, M., 1975 : Automated Prediction of Surface wind from Numerical Model Output. Monthly Weather Review, Vol. 103, pp. 866-873.

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