CLIMATE AND AGRICULTURE

FORECAST OF LATE SPRING AND EARLY AUTUMN FROSTS

(Fekete, 1979)

INTRODUCTION TO SOLVE PRACTICAL TASKS

Objective:

- Determination of characteristics about frosts
- Presentation and evaluation of frost forecasting methods

Late spring frosts, Southern-Alföld area: April-May

Early autumn frosts, Southern-Alföld area : September-October

Frost-forecasting methods

1. Synoptic frost-forecasts

They forecast early-morning frosts based on the detailed knowledge of the weather of large areas.

2. Local frost-forecasts

2a. Empirical, or climate forecasting methods

Principal base: radiation frosts occur with similar weather conditions.

- ✓ *Empirical rules*
- ✓ ***Empirical formulae (based on regression analysis)***
- ✓ *Physical forecasting methods*

Symbols of the meteorological elements and their meaning that are necessary for the forecast

T_{min} : early-morning minimum temperature measured in the thermometer house;

T^*_{min} : calculated minimum temperature;

$T_{(i)}$: temperature measured at the *i*th time ((i=1, if the observation occurred at 13 or 14 o'clock and i=2, if the observation occurred at 19 or 21 o'clock;

T^i_n : value of the wet temperature at the *i*th time;

T_d : dew point temperature at the evening observation;

T_1 : soil temperature in 5 cm depth at the evening observation;

T_2 : soil temperature in 10 cm depth at the evening observation;

T_3 : soil temperature in 20 cm depth at the evening observation;

H_i : relative humidity measured at the *i*th time;

n : total cloud cover measured in eighth at the evening observation;

$n_{a,k}$: joint cloud cover of the low-level and medium-high clouds at the evening observation;

n_a, n_k, n_m : joint cloud cover of the low-level, medium-high and high-level clouds at the evening observation;

t : length of the night (from the evening observation to the first half an hour following sunrise, in tenth hour);

In most cases not the accuracy of the predicted value is important, but whether - in case of freeze - the actual minimum temperature (T_{min}) and the forecasted minimum temperature (T^*_{min}) are at the same time smaller than a fixed value. In our calculations this fixed value was chosen 0.0°C. In this way, we say a prediction wrong, if

a. $T_{min} > 0.0°C$, but $T^*_{min} \leq 0{,}0°C$ (type I error of prediction)

b. $T_{min} \leq 0.0°C$, but $T^*_{min} > 0{,}0°C$ (type II error of prediction)

The amount of cases in groups *a* and *b* are the total number of erroneous predictions. According to examinations, the relative frequency of type II erroneous predictions (the errors considered more serious) are much more unstable.

A simple forecasting method for estimating the next day's minimum temperature:

Dew point method:

$$T^*_{min} = T_d$$

Namely, in this case the estimation of the next day's minimum temperature is the dew point temperature measured in the detection time. (The dew point can be determined by using the Assmann's psychrometer table.)

When determining the formula of the local frost forecasting methods, it is important:

1. taking into account the most influential meteorological parameters;
2. selection of the observational time *(i)*, from data of which the most accurate predictions can be made;

Input data: Szeged, 1991-1995, 5 years, April-May, daily data, i = 16, 19, 22, 01, 04 o'clock;

The rate of the night temperature decrease $(T_{min} - T^{(i)})$ were linearly associated to the following meterological parameters:

- ✓ $T^{(i)}_d$: dew point
- ✓ $e^{(i)}$: water vapour
- ✓ $H^{(i)}$: relative humidity
- ✓ $v^{(i)}$: wind speed
- ✓ $n^{(i)}$ and $n^{(i)}_a$: the amount of the total and low-level clouds
- ✓ $T^{(i)}_2$, $T^{(i)}_5$, $T^{(i)}_{10}$, $T^{(i)}_{20}$: soil temperatures measured in 2-, 5-, 10- and 20 cm depths

$$T_{min} - T^{(i)} = a_1 \cdot T^{(i)}_d + a_2 \cdot e^{(i)} + a_3 \cdot v^{(i)} + a_4 \cdot n^{(i)} + a_5 \cdot n^{(i)}_a + a_6 \cdot H^{(i)} + a_7 \cdot T^{(i)}_2 + a_8 \cdot T^{(i)}_5 + a_9 \cdot T^{(i)}_{10} + a_{10} \cdot T^{(i)}_{20} + a_{11} \quad (1)$$

- ✓ $T^{(i)}_d$ *:* dew point
- ✓ $e^{(i)}$: vapour pressure
- ✓ $H^{(i)}$: relative humidity
- ✓ $v^{(i)}$: wind speed
- ✓ $n^{(i)}$ and $n^{(i)}_a$: the amount of the total and low-level clouds
- ✓ $T^{(i)}_2$, $T^{(i)}_5$, $T^{(i)}_{10}$, $T^{(i)}_{20}$: soil temperatures measured in 2-, 5-, 10- and 20 cm depths

From here the predicted value of the minimum temperature:

$$T^*_{min} = T^{(i)} + a_1 \cdot T^{(i)}_d + a_2 \cdot e^{(i)} + a_3 \cdot v^{(i)} + a_4 \cdot n^{(i)} + a_5 \cdot n^{(i)}_a + a_6 \cdot H^{(i)} + a_7 \cdot T^{(i)}_2 + a_8 \cdot T^{(i)}_5 + a_9 \cdot T^{(i)}_{10} + a_{10} \cdot T^{(i)}_{20} + a_{11} \quad (2)$$

Partial correlation coefficients measuring the strength of the relationship between the drop in temperature and the variables taken into account indicate that among the 10 independent variables **only relative humidity, cloudiness and wind speed show significant correlation with the target variable (drop in temperature)** at the 95% probability level.

Out of the 5 observational time, the equation with the highest correlation coefficient occurred when using the data of 19 o'clock. For this reason, it is recommended to prepare the first local frost forecast on the basis of the 19 o'clock measurement data.

In the following, only the three parameters indicating significant partial correlation coefficient (relative humidity, cloudiness and wind speed) will be considered in the linear formula forecasting the early morning minimum temperature (T^*_{min}):

$$T^*_{min} = T^{(19)} + a_1 \cdot H^{(19)} + a_2 \cdot n^{(19)} + a_3 \cdot v^{(19)} + a_4 \qquad (3)$$

Constant values of the above equation are as follows:

$a_1 =$ 0,0901
$a_2 =$ 0,3164
$a_3 =$ 0,1255
$a_4 =$ -15,23

Those farms that make local frost forecasts, can count only their own observations for their own area.

$\Rightarrow$ it i necessary to assess simply the expected value of the most important parameters.

It is assumed that the mean value of a given parameter for the period from the observational time to early morning can be forecasted through an earlier period observation of this parameter. **For assessing the nigth mean values of relative humidity, cloudiness and wind speed, a simple and for all the three parameter a formula of identical structure is used**, which e.g. for the cloudiness is as follows:

$$\overline{n_{\acute{e}}^{*}} = a_1 \cdot (n^{(22)} - n^{(19)}) + a_2 \cdot \frac{n^{(19)} + n^{(22)}}{2} + a_3 \qquad (4)$$

Here $n^{(19)}$ and $n^{(22)}$ are the rate of cloud cover at 19 and 22 o'clock, respectively borultság mértéke, while $\overline{n_{é}^{*}}$ is the predicted mean cloud cover of the remaining part of the night, which was estimated by the following value

$$\overline{n_{é}} = \frac{1}{3} \cdot (n^{(22)} + n^{(01)} + n^{(04)}) \tag{5}$$

when calculating the constants of the formula.

In addition, a complex parameter, i.e. the difference of temperatures measured at 22 and 19 o'clock, as a fourth variable associated to the temperature decrease, was also considered $(T^{(22)} - T^{(19)})$. Assuming that the error of the forecasts made by using the formula (3) $(h_1 = T^*_{min} - T_{min})$ is related with the above four parameters as follows:

$$h_1 \approx h_1^* = a_1 \cdot (\overline{H_{é}^{*}} - H^{(19)}) + a_2 \cdot (\overline{n_{é}^{*}} - n^{(19)}) + a_3 \cdot (\overline{v_{é}^{*}} - v^{(19)}) + a_4 \cdot (T^{(22)} - T^{(19)}) + a_5$$

the predicted value of the minimum temperature can be made more accurate in the following way:

$$T_{\min}^{**} = T_{\min}^{*} - h_1^{*}$$

In the formula of h_1* used for improving the minimum temperature, the values of a_1, a_2, … , a_5 constants are as follows:

a_1 = -0,0273

a_2 = -0,0511

a_3 = -0,0291

a_4 = -0,2326

a_5 = 0,4748

When using the methodology, the following steps are suggested to follow:

1) If the Central Institute for Forecasts of the Hungarian Meteorological Service considers the actual weather situation dangerous in terms of developing frost, then it is suggested to make local frost forecast.

2) If the locally forecasted early morning minimum temperature is less than +2°C, then it is advisable, while if it is less than +1°C, then it is necessary to put into operation the tools protecting against frost in the occasion of the first forecast.

3) Observation of the weather events (especially the temperature and the parameters found in the formulae) should not be stopped in this case. In addition, if it is necessary, even following the second forecast, at 01 o'clock it is also possible to make a current assessment to the expected value of the cooling by using the regression coefficients.

Always look on the bright side of things!

We finished for today, goodbye!

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талыг нь үргэлж олж харцгаая

өнөөдөртөө ингээд дуусгацгаая, баяртай

让我们总是从光明的一面来看待事物吧！

今天的课程到此结束，谢谢！

دعونا ننظر دائما إلى الجانب المشرق من الأشياء!

انتهينا لهذا اليوم، وداعا!