Medium-Range Forecasting for the Number of Daily Forest Fires

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ABSTRACT

In an earlier work, the authors introduced an objective forecast model for a 24-h prediction of the number of daily forest fires based on a 2-day lag autoregressive model. The meteorological inputs required for this model (temperature and geopotential height at 850 and 700 hPa and dewpoint at 850 hPa) may be predicted by a medium-range numerical weather forecast model such as that of the European Centre for Medium-Range Weather Forecasts. These predicted meteorological elements may be used to extend the range of daily forest fire forecasting. Since the forest fire forecast model is based on a categorization (type of day), an error in the meteorological predictions may not be an error in the predictive model. A meteorological error will only imply error for the model if it produces a change in the type of day (category).

The forecast range for the number of forest fires per day has been extended to five days with this new model. Moreover, assuming that the weather forecast is perfect, a validation of the prediction model for forest fires is carried out.

1. Introduction

The problem of forest fire forecasting is usually solved by fixing fire risk indices (FRI) (Palmieri and Cozzi 1983; Haines 1988; García Diez et al. 1993, 1994). These FRI are calculated using several meteorological elements (temperature, humidity, atmospheric stability, wind, etc.). Thus, a meteorological forecast implies a prediction of FRI. However, this prediction is only qualitative, because a high fire risk does not necessarily imply a high number of forest fires for a particular day.

It is important that an objective method for forecasting the number of forest fires per day be readily available. This issue has been considered in García Diez (hereafter referred to as GD) et al. (1994), in which a meteorological objective model for 24-h predictions of the daily number of forest fires is developed, based on a 2-day lag autoregressive model. In this method, the atmospheric stability e of the lowest layer and the saturation deficit D at the lowest pressure level at 0000 UTC are required to forecast the number of fires taking place during the subsequent day. Using standard meteorological forecasting, it is possible to obtain e and D several days earlier. These values may be used to extend the forest fire forecast model. In this paper, a method is presented for forecasting the number of forest fires over a zone up to 5 days in advance.

2. Preliminary considerations: 24-h prediction

In GD et al. (1993, 1994), it is shown that in meteorological terms, the type of day may be evaluated in terms of stability e at the lowest layer and the saturation deficit D at the lowest pressure level, which are defined as

$$e = S_{700} - S_{850} \tag{1}$$

$$D = L(q^* - q)_{850}, \tag{2}$$

where $S = C_pT + gz$ is the dry static energy or Montgomery potential (GD et al. 1994; Rivas et al. 1994), L is the latent heat of condensation, q is the specific humidity, q^* is the saturated specific humidity, and the subscripts are pressure levels. Evaluating e and D at 0000 UTC, we can assign the type of day following the classification established in Table 1. If a large series of days is considered, it has been observed (GD et al. 1994) that the type I days have the higher number of forest fires (very high risk), followed by the type III days (high risk), type IV days (low risk) and type II days (very low risk). Notice that notation for the type of day is not associated with the level of fire risk.

However, from the aforementioned result we cannot deduce that, for example, all type I days will have a higher number of forest fires than all type III days. This

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TABLE 1. Classification in types of day and respective ⟨DFR⟩ values.

Type	Name	e (kJ kg^{-1})	D (kJ kg^{-1})	⟨DFR⟩
I	unstable dry	$\leqslant 6$	$\geqslant 12$	4
II	unstable moist	$\leqslant 6$	<12	1
III	stable dry	>6	$\geqslant 12$	3
IV	stable moist	>6	<12	2

is because the number of forest fires in a day d not only depends on the present weather $W(d)$, defined by the type of day, but also on past weather [PW(d)]. Formally, our predictive equation has been established as

$$\mathrm{PNF}(d) = \mathrm{PW}(d)W(d), \tag{3}$$

in which PNF(d) is the predicted number of fires during a day d.

Consequently, in GD et al. (1994) PNF(d) was expressed in an operative sense by

$$\mathrm{PNF}(d) = \left[0.3\frac{\mathrm{RNF}(d-2)}{\langle\mathrm{DFR}(d-2)\rangle} + 0.7\frac{\mathrm{RNF}(d-1)}{\langle\mathrm{DFR}(d-1)\rangle}\right]\langle\mathrm{DFR}(d)\rangle, \tag{4}$$

where RNF($d - 2$) and RNF($d - 1$) are the registered number of fires during the two preceding days and ⟨DFR($d - 2$)⟩, ⟨DFR($d - 1$)⟩, and ⟨DFR(d)⟩ are the corresponding *present weather normalized values* of the DFR. For any month, for example, DFR for each type of day is given by

$$\mathrm{DFR} = \frac{\text{number of fires}}{\text{number of days}}. \tag{5}$$

Here ⟨DFR⟩ is calculated by first considering the respective time average $\overline{\mathrm{DFR}}$ for each type of day during a calibration period (1980–85) unconnected with the testing period for the model (1986–93), over several zones of Galicia (northwest Spain), and for a type I day the ⟨DFRI⟩ is given by

$$\langle\mathrm{DFRI}\rangle = \frac{\overline{\mathrm{DFRI}}}{\sum_j \overline{\mathrm{DFR}}_j} \quad \text{for} \quad j = \mathrm{I, II, III\ and\ IV}. \tag{6}$$

This is similar for the other types.

The values of ⟨DFR⟩ are 4, 3, 2, and 1 for the types of day I, III, IV, and II, respectively (GD et al. 1994). The bracketed value in (4) is precisely the *past weather* for the day d, [PW(d)]. All factors (known or unknown) of low variability such as fuel, fine fuel, type of forest, soil, incendiarism, previous drought over the zone, etc., which could have played an important role as notable contributions for RNF($d - 2$) and RNF($d - 1$), are included in PW(d) and, consequently, are also considered for day d. Thus, the model takes into account the previous reality as an initial *closed* factor for each day. In this way, the model includes in a quantitative sense considerations such as fuel and fine fuel (Deeming et al. 1977). The time series of PNF(d) and RNF(d) for Galicia during July, August, and September of 1993 reveal an explained variance (R^2) for this model of 0.82 (Fig. 1). Similar results were obtained for other years (GD 1994).

3. Medium-range prediction model

a. 1–5-day forecast

Using (4), we can estimate, at 0000 UTC of a day d, the number of forest fires during d. Consequently, it is a 24-h prediction. The use of (4) to forecast the number of forest fires for the day $d + 1$ requires knowledge of RNF(d) and ⟨DFR($d + 1$)⟩. If data for both were known, then the number of forest fires for day $d + 1$ [PNF($d + 1$)] could be predicted:

$$\mathrm{PNF}(d+1) = \left[0.3\frac{\mathrm{RNF}(d-1)}{\langle\mathrm{DFR}(d-1)\rangle} + 0.7\frac{\mathrm{RNF}(d)}{\langle\mathrm{DFR}(d)\rangle}\right]\langle\mathrm{DFR}(d+1)\rangle. \tag{7}$$

Since RNF(d) may be replaced by PNF(d) [calculated using (4)], then knowledge of only ⟨DFR($d + 1$)⟩ is needed for PNF($d + 1$), which can be predicted with standard meteorological elements. In this way, a 48-h prediction is obtained.

For the day $d + 2$, it can be written

$$\mathrm{PNF}(d+2) = \left[0.3\frac{\mathrm{RNF}(d)}{\langle\mathrm{DFR}(d)\rangle} + 0.7\frac{\mathrm{RNF}(d+1)}{\langle\mathrm{DFR}(d+1)\rangle}\right]\langle\mathrm{DFR}(d+2)\rangle, \tag{8}$$

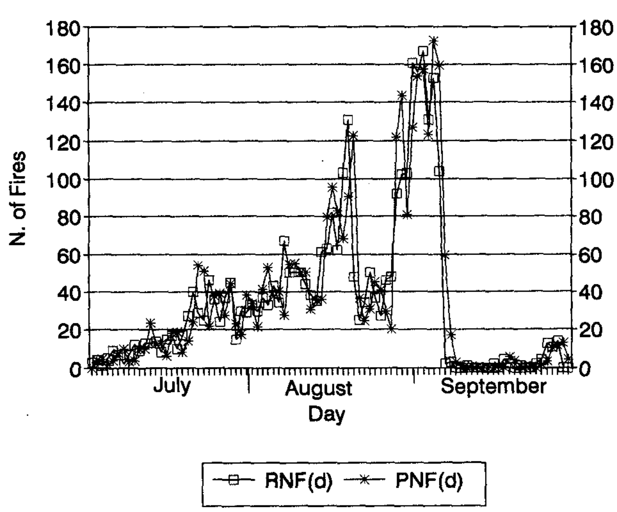

FIG. 1. Time series of predicted [PNF(d)] and registered [RNF(d)] number of forest fires per day for July, August, and September 1993 in Galicia.

where RNF(d) and RNF(d + 1) could be replaced by PNF(d) and PNF(d + 1), calculated using (3) and (4). Again, only the meteorological prediction ⟨DFR(d + 2)⟩ is required.

In this way, we can successively estimate the number of predicted forest fires along the days $d + 3$, $d + 4$, etc. The only requirement is that the predicted daily values for ⟨DFR⟩ be known. The equations for a five-day forecast are shown in Table 2.

b. The prediction of ⟨DFR⟩

As it is stated in section 3a, the prediction equations are operative only if the ⟨DFR⟩ values are known. This requires the prediction of the type of day (the prediction of e and D). Since e depends upon T and z at 850- and 700-hPa levels and D depends upon T and T_d at 850 hPa, the prediction of ⟨DFR⟩ requires only the prediction of these meteorological elements. Consequently, we must use a medium-range weather forecast model for this purpose.

It is well known, however, that the medium-range forecast for T, z, and particularly T_d (or q), are not perfect. Thus, the predicted (e, D) values may be erroneous, implying an erroneous type of day assignment and, hence, an erroneous ⟨DFR⟩. Figure 2 shows how the errors (here qualitatively represented as circles centered on the exact value) in (e, D) may imply changes in the type of day. The prediction absolute error in (e, D) is variable since it depends upon the prediction range, forecasting model, initial conditions, etc. However, if the absolute error in (e, D) is represented as the radius of the circles in Fig. 2, then such an error is not always relevant because it does not modify the ⟨DFR⟩ value. Clearly, not all predictive errors in (e, D) are relevant.

The possibility of error in the type of day assignment decreases with the number of types of day. Consequently, it is convenient to use the minimum number of types of days (levels of forest fire risk) compatible with a high-resolution power in fire activity. If, for example, three types of day (A, B, and C) were established in a hypothetical model, the best partition would be one verifying ⟨DFRA⟩ ∝ 3, ⟨DFRB⟩ ∝ 2, and ⟨DFRC⟩ ∝ 1, respectively. In general, for n types of day, the best partition is present when respective ⟨DFR⟩ values are proportional to n, $n - 1$, $n - 2$, . . . , 1 (normalization equally spaced). Evidently, in order to obtain the best normalized values, the partition could be different for each geographical zone (microclimatic effect). However, in a temporal sense, this appreciation is not relevant.

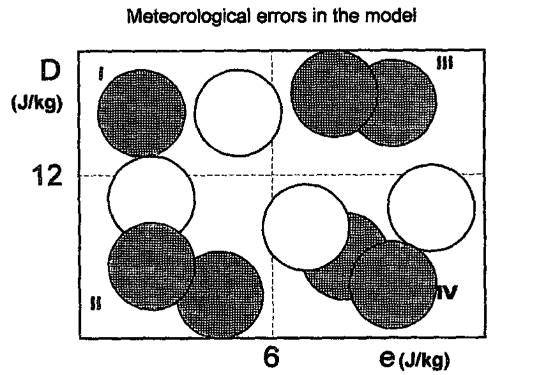

FIG. 2. An error in (e, D) forecast does not always imply an error in the type of day assignment. Circles, centered on the correct values, denote errors due to meteorological predictions. Only in a few cases (white circles) is the error relevant.

To determine the intrinsic validity of the model, a correct meteorological prediction [i.e., that the predicted (e, D) values are the registered values] may be assumed. This is not possible in real time, but it may be a good method for deducing the validity, per se, of our model.

The output of the predictive equations for a season is presented in Table 3. To interpret this table, consider

TABLE 2. Forecast equations for d at 0000 UTC and respective forecasting range.

Equation	Range (h)
$\mathrm{PNF}(d) = \left[0.3\frac{\mathrm{RNF}(d-2)}{\langle\mathrm{DFR}(d-2)\rangle} + 0.7\frac{\mathrm{RNF}(d-1)}{\langle\mathrm{DFR}(d-1)\rangle}\right]\langle\mathrm{DRF}(d)\rangle$	0–24
$\mathrm{PNF}(d+1) = \left[0.3\frac{\mathrm{RNF}(d-1)}{\langle\mathrm{DFR}(d-1)\rangle} + 0.7\frac{\mathrm{PNF}(d)}{\langle\mathrm{DFR}(d)\rangle}\right]\langle\mathrm{DFR}(d+1)\rangle$	24–48
$\mathrm{PNF}(d+2) = \left[0.3\frac{\mathrm{PNF}(d)}{\langle\mathrm{DFR}(d)\rangle} + 0.7\frac{\mathrm{PNF}(d+1)}{\langle\mathrm{DFR}(d+1)\rangle}\right]\langle\mathrm{DFR}(d+2)\rangle$	48–72
$\mathrm{PNF}(d+3) = \left[0.3\frac{\mathrm{PNF}(d+1)}{\langle\mathrm{DFR}(d+1)\rangle} + 0.7\frac{\mathrm{PNF}(d+2)}{\langle\mathrm{DFR}(d+2)\rangle}\right]\langle\mathrm{DFR}(d+3)\rangle$	72–96
$\mathrm{PNF}(d+4) = \left[0.3\frac{\mathrm{PNF}(d+2)}{\langle\mathrm{DFR}(d+2)\rangle} + 0.7\frac{\mathrm{PNF}(d+3)}{\langle\mathrm{DFR}(d+3)\rangle}\right]\langle\mathrm{DFR}(d+4)\rangle$	96–120
$\mathrm{PNF}(d+5) = \left[0.3\frac{\mathrm{PNF}(d+3)}{\langle\mathrm{DFR}(d+3)\rangle} + 0.7\frac{\mathrm{PNF}(d+4)}{\langle\mathrm{DFR}(d+4)\rangle}\right]\langle\mathrm{DFR}(d+5)\rangle$	120–144

TABLE 3. Output of predictive equations for Galicia in 1993, showing predicted number of fires (PNF), registered number of fires (REG), and ⟨DFR⟩ for each day.

Year	Month	Day	⟨DFR⟩	REG	PNF d	PNF $d+1$	PNF $d+2$	PNF $d+3$	PNF $d+4$	PNF $d+5$
1993	July	1	2	0						
1993	July	2	2	0						
1993	July	3	2	3	0					
1993	July	4	4	4	4	0				
1993	July	5	4	1	5	5	0			
1993	July	6	3	5	1	3	3	0		
1993	July	7	3	9	4	1	3	3	0	
1993	July	8	3	7	8	4	1	3	3	0
1993	July	9	4	2	10	11	5	2	4	5
1993	July	10	3	7	3	7	8	4	1	3
1993	July	11	2	12	4	2	5	5	3	1
1993	July	12	2	9	10	4	2	5	5	3
1993	July	13	2	13	10	10	4	2	5	5
1993	July	14	4	13	24	19	21	8	4	10
1993	July	15	3	14	13	18	15	15	6	3
1993	July	16	3	8	13	12	18	15	15	6
1993	July	17	2	15	7	9	8	12	10	10
1993	July	18	3	17	18	9	13	12	18	15
1993	July	19	3	10	19	19	9	13	12	18
1993	July	20	2	17	8	12	13	6	9	8
1993	July	21	2	27	14	8	12	13	6	9
1993	July	22	2	40	24	15	8	12	13	6
1993	July	23	3	29	54	37	22	12	18	19
1993	July	24	4	25	51	75	49	29	15	24
1993	July	25	3	46	22	36	55	37	22	12
1993	July	26	3	36	38	21	36	56	37	22
1993	July	27	3	24	39	40	21	36	55	37
1993	July	28	3	37	28	38	40	21	36	56
1993	July	29	4	45	44	35	51	53	28	48
1993	July	30	2	15	23	23	18	26	26	14
1993	July	31	2	30	17	23	23	18	26	26
1993	August	1	3	29	38	25	35	34	27	38
1993	August	2	3	33	34	40	25	34	34	27
1993	August	3	2	30	21	22	26	17	23	23
1993	August	4	3	37	41	32	33	40	25	34
1993	August	5	4	33	53	57	43	44	53	33
1993	August	6	4	43	38	52	56	43	44	53
1993	August	7	4	34	40	36	52	56	43	44
1993	August	8	3	67	28	31	28	39	42	32
1993	August	9	3	50	55	27	30	28	39	42
1993	August	10	3	50	55	58	27	31	28	39
1993	August	11	3	50	50	54	57	27	31	28
1993	August	12	3	44	50	50	54	58	27	31
1993	August	13	2	38	31	33	33	36	38	18
1993	August	14	2	35	35	30	33	33	36	38
1993	August	15	2	61	36	36	30	33	33	36
1993	August	16	3	63	80	53	54	45	50	50
1993	August	17	4	82	95	111	71	72	61	67
1993	August	18	4	62	83	92	110	71	72	61
1993	August	19	4	103	68	82	93	110	71	72
1993	August	20	4	131	91	66	82	93	110	71
1993	August	21	4	48	123	94	67	82	93	110
1993	August	22	2	25	36	63	47	33	41	46
1993	August	23	2	34	25	33	62	47	33	41
1993	August	24	2	50	31	25	34	62	47	33
1993	August	25	2	37	45	32	25	33	62	47
1993	August	26	2	27	41	47	32	25	34	62
1993	August	27	2	46	30	40	46	32	25	34
1993	August	28	1	48	20	15	20	23	16	12
1993	August	29	3	92	121	63	44	60	69	48
1993	August	30	4	102	143	171	83	59	80	93
1993	August	31	3	103	81	103	126	62	44	60

TABLE 3. (*Continued*)

Year	Month	Day	⟨DFR⟩	REG	PNF d	PNF $d+1$	PNF $d+2$	PNF $d+3$	PNF $d+4$	PNF $d+5$
1993	September	1	4	161	127	106	139	169	83	59
1993	September	2	4	156	154	130	107	139	169	83
1993	September	3	4	167	158	156	129	107	139	169
1993	September	4	3	131	123	118	117	97	80	104
1993	September	5	4	153	172	165	157	156	129	107
1993	September	6	2	104	80	87	82	79	78	65
1993	September	7	2	2	96	79	86	82	79	78
1993	September	8	2	3	33	98	79	86	82	79
1993	September	9	2	0	3	23	97	79	86	82
1993	September	10	2	0	1	3	26	98	79	86
1993	September	11	2	1	0	1	3	25	98	79
1993	September	12	2	0	1	0	1	3	26	98
1993	September	13	2	0	0	1	0	1	3	26
1993	September	14	2	0	0	0	1	0	1	3
1993	September	15	2	0	0	0	0	1	0	1
1993	September	16	2	2	0	0	0	0	1	0
1993	September	17	1	0	1	0	0	0	0	0
1993	September	18	1	4	0	1	0	0	0	0
1993	September	19	2	2	6	0	2	0	0	0
1993	September	20	2	0	4	6	0	2	0	0
1993	September	21	2	1	1	3	6	0	2	0
1993	September	22	2	0	1	0	3	6	0	2
1993	September	23	1	0	0	0	0	2	3	0
1993	September	24	2	2	0	0	1	0	3	6
1993	September	25	2	4	1	0	0	1	0	3
1993	September	26	2	13	3	2	0	0	1	0
1993	September	27	2	11	10	4	2	0	0	1
1993	September	28	2	14	12	11	4	2	0	0
1993	September	29	2	0	13	11	11	4	2	0
1993	September	30	2	0	4	13	11	11	4	2
		Mean		34.1	35.9	35.8	35.1	34.8	34.4	34.3
		STD		40.5	41.0	40.0	37.2	37.1	35.7	33.8
		CV		1.2	1.1	1.1	1.1	1.1	1.0	1.0

the example of 12 August 1993. For this day, PNF(d + 5) = 31—that is, the prediction of Galicia forest fires established for this day 5 days earlier (7 August at 0000 UTC) was 31 forest fires over Galicia. Similarly, PNF(d + 4) = 27 was established on 8 August, PNF(d + 3) = 58 on 9 August, and PNF(d) = 50 was carried out the same day (12 August at 0000 UTC). The registered number was 44. During the period of 31 August to 6 September, very high fire activity was registered, and the model presents, in general, a good performance. On 7 September, a strong fall in RNF(d) was registered, and the model presents a false alarm (an error in radiosonde sounding data could be possible). Two days later, the model presented the best results for PNF(d). In general, the higher errors occurred when the fire activity presented a strong fall. In the opposite sense—that is, for strong increasements in RNF(d)—the model exhibits an acceptable performance (28–31 August). Both types of error are characteristics, in general, of autoregressive processes.

In the last lines of Table 3 are included the mean, standard deviation (STD) and the coefficient of variation (CV) for each forecast range. Similar values of these statistics were found for all forecast ranges.

Graphically, these results may be seen in Fig. 3, in which the predicted values versus registered values for different forecast ranges have been plotted. For each registered value, there appears the corresponding predicted value. The straight line ($y = x$) represents the exact prediction; all predicted values above it are erroneous by excess, and consequently they could be interpreted in terms of "false alarm." The values under it indicate a "underprediction" (in this case an insufficiently antifire management policy would be developed), which is more dangerous. This graphic presents several advantages. For instance, it visualizes whether the model presents the same level of quality in high and low fire activity, whether there are symmetric forecast errors, etc.

These results, taken together with high values for the squared coefficient of correlation between predicted and registered forest fire series (Fig. 4), confirm the validity of our predictive model. Values of R^2 for the period 1986–93 are included in Table 4.

4. Model verification

It is well known in daily meteorological forecasting that there are few meteorological elements that exhibit

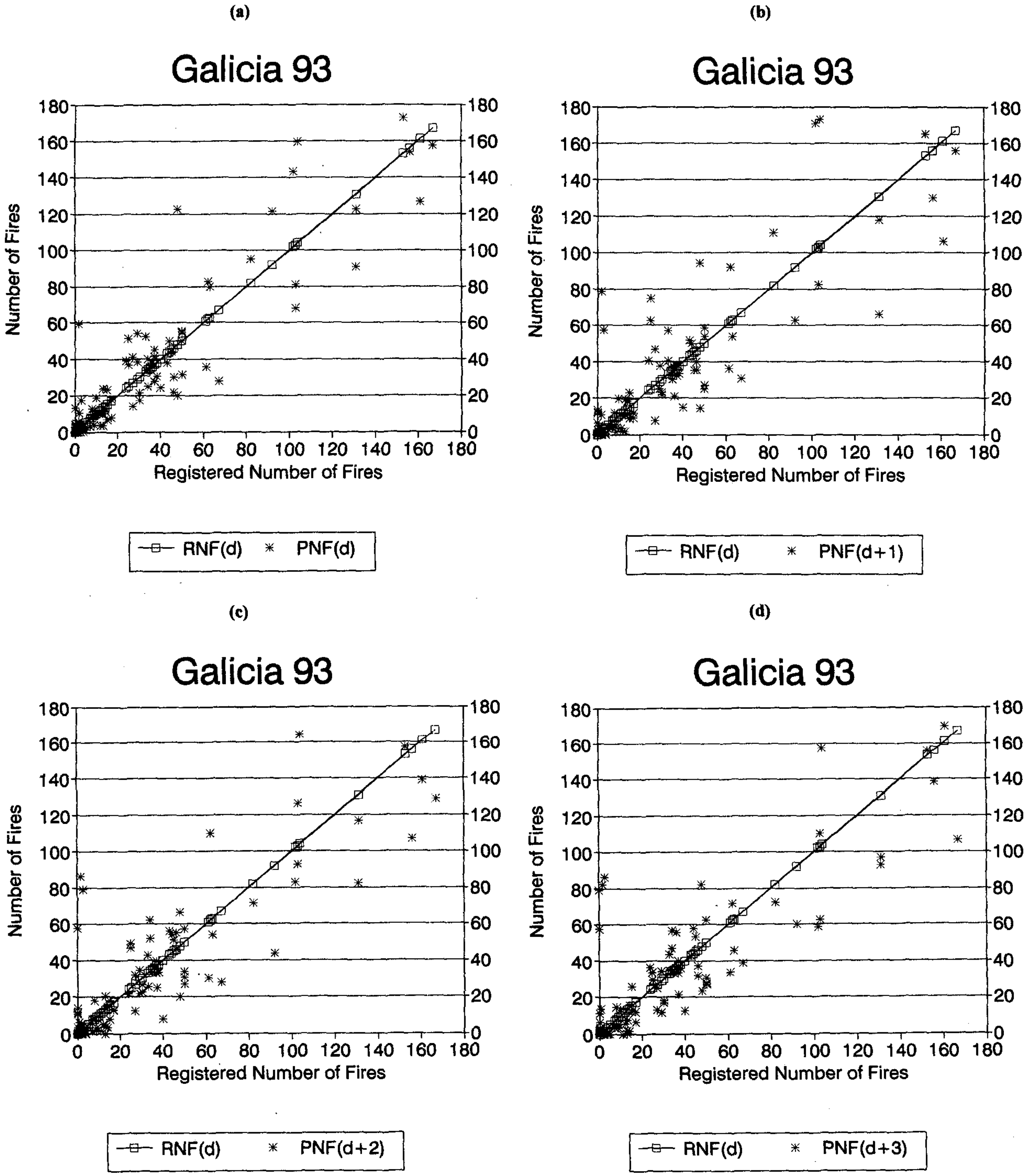

FIG. 3. Predicted values (PNF) versus registered values (RNF) for several forecast ranges: (a) d, (b) $d + 1$, (c) $d + 2$, (d) $d + 3$, (e) $d + 4$, (f) $d + 5$. Straight line is the correct prediction.

low daily variability. In this case, the *trivial prediction or simple persistence model,* based on the hypothesis of low daily variability, may be applied with very good results. The trivial prediction considers as a forecast value for tomorrow the value registered today. In this application, as noted in Table 3, this prediction presents (in general) very acceptable results, due to the persistence in the daily number of fires for two consecutive days. Our model includes this persistence when two consecutive days are of the same type; if RNF(d − 2)

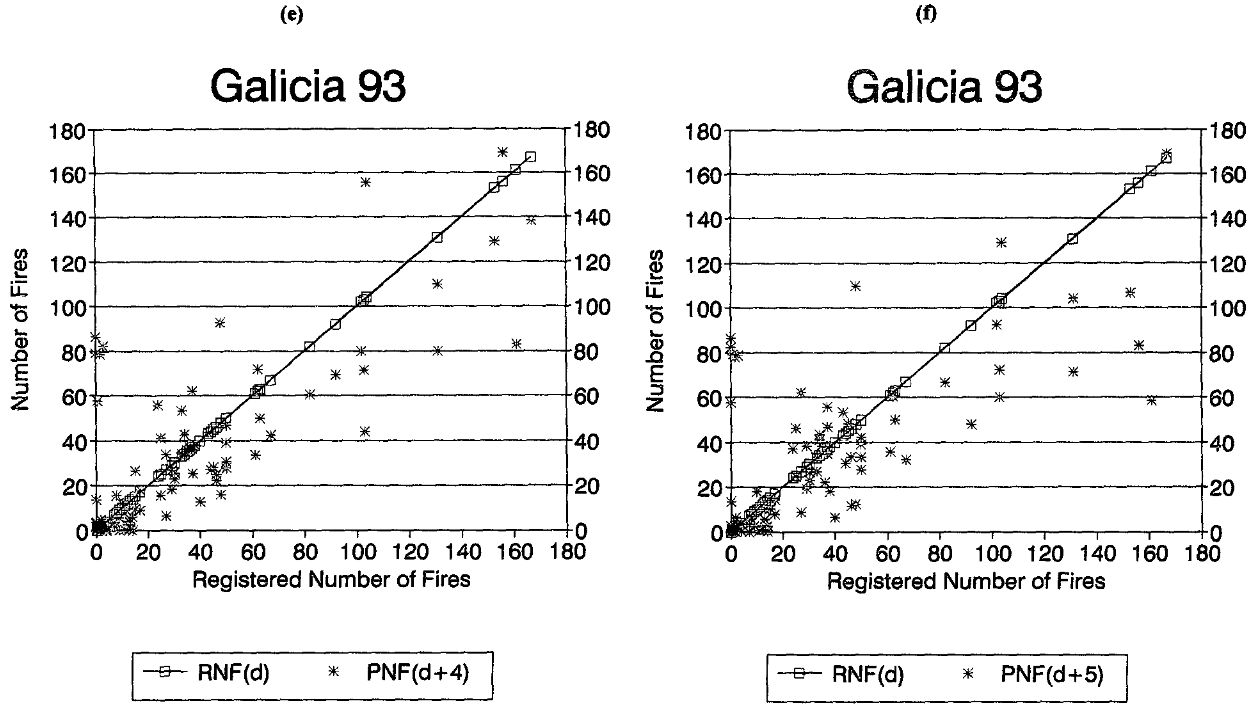

FIG. 3. (*Continued*)

= RNF(d − 1) and ⟨DFR(d − 2)⟩ = ⟨DFR(d − 1)⟩ = ⟨DFR(d)⟩, then PNF(d) = RNF(d − 2) = RNF(d − 1). In this sense (and only in this sense), the trivial prediction may be considered a reference level, and consequently, the quality of our forecasting method may be expressed in a comparative sense to trivial prediction.

Figure 4 shows the R^2 values for several forecast ranges. Notice that in the model, R^2 decreases in a smooth linear form when the range of prediction is successively higher than strong skill noted for the trivial prediction. As it can be seen, the model presents a quasi-constant quality level for $d + 1$, $d + 2$, and $d + 3$. This means that the model is temporarily stable for these ranges, which is an important property from a general point of view in prediction theory.

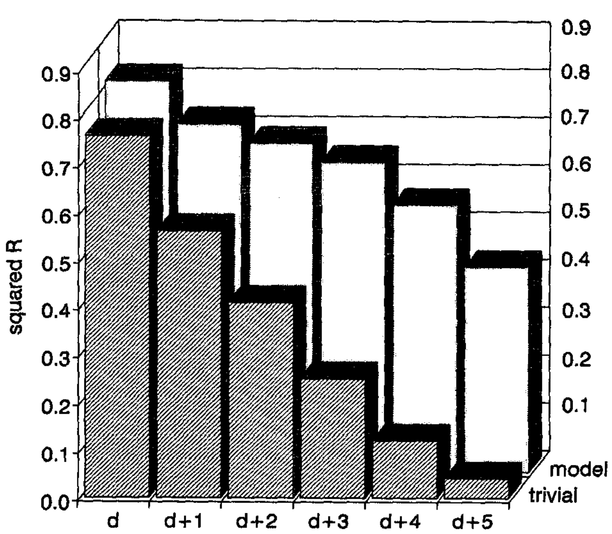

FIG. 4. Values of R^2 for the model versus the trivial prediction for each range prediction.

5. Inclusion of a third factor

On the basis of knowledge of the type of day for 1, 2, . . . , 5 days forward, available from medium-range meteorological predictions, our method for the prediction of the number of forest fires may be modified with the inclusion of a third factor. In fact, as the assignation of the type of day is based on data corresponding to 0000 UTC, the assumption of the respective type of day is correct only if during the subsequent 24 hours the type of day is the same. In other words, a day categorized as type I at 0000 UTC may be not type I a few minutes later. This possibility is more realistic when a day is followed by a different type of day (quick weather change). On the contrary, this possibility is negligible when two consecutive days are of the same type at 0000 UTC.

For example, 2 August at 0000 UTC is a type III day, (⟨DFR⟩ = 3), and 3 August (at 0000) is a type IV day, with ⟨DFR⟩ = 2 (Table 3). The change of day type from III to IV was registered during 2 August, but when? It is unknown what the proportion of the day was type III and what proportion was type IV.

TABLE 4. Values of R^2 for several ranges in Galicia. Model (mod) and model corrected (corr).

Range	d		$d+1$		$d+2$		$d+3$		$d+4$		$d+5$	
Year	Mod	Corr	Mod	Corr	Mod	Corr	Mod	Corr	Mod	Corr	Mod	Corr
1986	0.66	0.73	0.46	0.53	0.38	0.40	0.34	0.35	0.32	0.31	0.24	0.26
1987	0.75	0.83	0.57	0.68	0.47	0.54	0.39	0.43	0.28	0.33	0.20	0.24
1988	0.81	0.83	0.73	0.74	0.72	0.70	0.72	0.68	0.68	0.68	0.62	0.66
1989	0.55	0.64	0.32	0.40	0.21	0.26	0.14	0.16	0.10	0.12	0.07	0.09
1990	0.72	0.74	0.54	0.55	0.40	0.45	0.32	0.40	0.30	0.37	0.29	0.34
1991	0.65	0.65	0.47	0.44	0.48	0.30	0.10	0.20	0.23	0.13	0.18	0.07
1992	0.64	0.64	0.48	0.48	0.36	0.36	0.30	0.27	0.23	0.18	0.14	0.14
1993	0.82	0.80	0.73	0.69	0.68	0.62	0.65	0.55	0.56	0.46	0.43	0.43
Mean	0.70	0.73	0.54	0.56	0.46	0.45	0.37	0.38	0.31	0.32	0.27	0.28

Thus, it seems convenient to introduce a third factor, $P(d)$, in the initial predictive equation (3) to produce a corrected model expression, in the form

$$\mathrm{PNF}(d) = \mathrm{PW}(d)W(d)P(d), \tag{9}$$

where $P(d) = 1$ if the type of day is the same (constant) during day d, and $P(d) \neq 1$ if the type day changes between d and $d + 1$. For this case, an average $\langle\overline{\mathrm{DFR}(d)}\rangle$ for day d is given by

$$\langle\overline{\mathrm{DFR}(d)}\rangle = \frac{\langle\mathrm{DFR}(d)\rangle + \langle\mathrm{DFR}(d+1)\rangle}{2}. \tag{10}$$

The results confirm, in general, that this additional factor does not increase R^2 significantly. In Table 4, R^2 values are presented for the *model* and *model corrected.*

In conclusion, these small differences prove that the assignment of type of day for day d based on radiosonde data at 0000 UTC is sufficient. Moreover, since the $\langle\mathrm{DFR}(d + 1)\rangle$ required in (10) is the predicted value for $d + 1$ from d at 0000 UTC (prediction that may include a possible error), this conclusion eliminates even the possibility that such an error might eventually affect the prediction.

6. Summary and conclusions

In this work, a medium-range prediction model for the daily number of forest fires has been developed. This prediction model is an iterative method that delivers forecasts over prescribed time ranges. The forecasting range has been extended to 5 days and is based on 1) a 2-day lag autoregressive model of the daily number of forest fires during the preceding two days and 2) the predicted values of temperature, geopotential height, and humidity at 700 and 850 hPa, obtained by a medium-range weather forecast. It must be noted that an error in the predicted meteorological elements does not always imply an error for the forest fire forecast. This is because meteorological elements are introduced in the model through a categorization of only four classes called types of day, defined according to static stability and saturation deficit. Statistical tests have confirmed that the type of day determined from the 0000 UTC radiosonde was sufficient for determining the *present weather* $W(d)$ of a day d.

In this framework, a new and more precise forest fire management policy, based on the medium-range forecast values of the number of forest fires over a zone, may be established.

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