Meteorological conditions associated with the occurrence of instability lines in Argentina

Maria Luisa Schwarzkopf-Altinger wurde in München geboren und lebt seit 1953 in Argentinien. Sie studierte Meteorologie an der Universität von Buenos Aires. Seit 1961 ist sie am selben Institut tätig. Frau Schwarzkopf stellte ihr Wissen an vier nationalen Segelflugwettbewerben als meteorologische Beraterin zur Verfügung. Sie besitzt seit 1965 das Segelfliegerbrevet.
Als geschätzte Referentin hatte sie an den OSTIV-Kongressen in Junin und Leszno teilgenommen. Zusammen mit E. R. Lichtenstein erhielt sie 1963 für ihren Vortrag «Squall-lines is an aid for long distance glider flights in Argentinia» das OSTIV-Diplom. Frau Schwarzkopf ist seit 1958 verheiratet und Mutter von drei Kindern. HS

Maria L. Schwarzkopf and Dr. E. R. Lichtenstein Department of Meteorology. University of Buenos Aires Argentinia. Paper presented at the XIth OSTIV Congress 1968 Leszno, Poland

1. Abstract

In the central and northern part of Argentina the precipitation is generally due to convective processes during the warm season. This convection appears as organized squall-lines in connection with many synoptic perturbations. Forecasting instability-lines is a difficult problem because of their sudden development and the associated severe weather conditions.
An attempt is made to aid forecasting by considering the statistical data for the ten year period 1958—1967. The data were selected for 12 GMT and the instability line activity for the following 24 hours was taken into account. Preliminary statistical results are given here, for some selected parameters: surface dew-point, Showalter Index, pressure tendency and north-south wind component at 850 mb.
The study will be continued by including other parameters like vertical wind shear and thermal advection.

2. Introduction

The regime of precipitation in the central and northern part of Argentina has a predominant convective character, at least during the warm half of the year. In the flat region of the country this convection frequently takes the form of large instability lines in relation to passing synoptic disturbances. The importance of the instability lines conforming the weather sequence in this country has been described in (5). On the other hand squall-line forecasting is a difficult problem for its sudden development and its associated severe weather conditions.
An attempt is made to aid in forecasting by considering the meteorological conditions associated with the occurrence of instability lines. For this purpose the saquall-line activity was studied for the ten year period 1958—1967, inside the test area limited by 30 and 40 degrees south and 55 and 65 degrees west. **(Fig. 1)** One

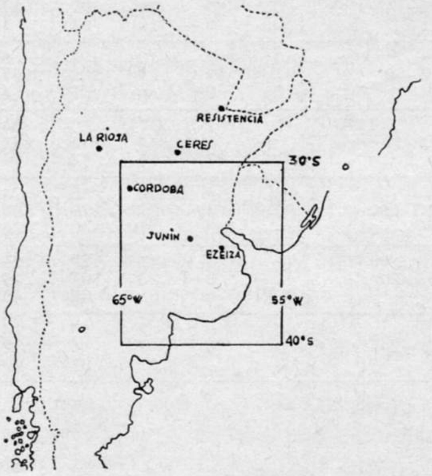

Fig. 1. Geographical position of the test area.

finds 606 days with squall-line activity, which represents a mean probability of 16.5 % to find any activity during 24 hours. The seasonal variation of this probability is seen in Table 1, and the monthly distribution of this probability is shown in Fig. 2, by the full curve.

Table 1. Percent frequency of days with instability lines.

Summer 13%	Winter 2%
Autumn 16%	Spring 17%

The number of days on which the activity began (formation) was also taken into account. For this purpose all days were counted on which at 12 GMT no activity was present and during the following 24 hours

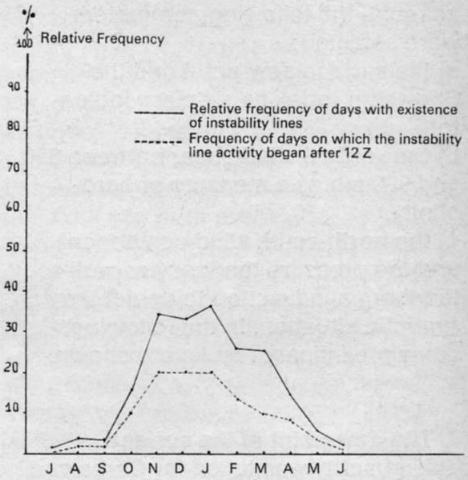

Fig. 2. Annual march of relative frequency of days with instability line activity.

a) instability-line activity developed inside the test area and/or
b) an instability line moved into the test area.
The mean probability for squall-line formation during 24 hours is 9.4 %.
The broken curve in **Fig. 2** gives the annual march and Table 2 depicts its seasonal variation. These values describe the importance of the instability

Table 2. Percent frequency of days with formation of instability lines.

Summer 18%	Winter 1%
Autumn 8%	Spring 11%

lines in conforming the meteorological events in Argentina. In the following this activity will be connected with the associated meteorological conditions. For this purpose the statistical data for 12 GMT for the same ten year period were considered, in connection with the occurrence of squall-line activity during the following 24 hours.

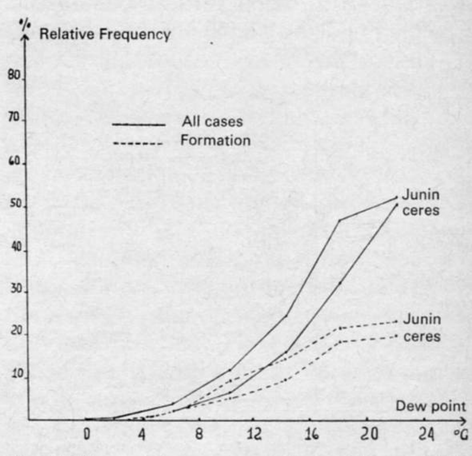

Fig. 3. Percent frequency of days with instability lines in relation to the surface dew-point.

3. Selection of parameters

Instability lines develop and persist under certain atmospheric conditions (1), (2), (4). One may refer to air-mass characteristics, the general baroclinity and synoptic situation. Taking this into account, the following parameters were selected:

a) the surface dew-point and the Showalter Index as air-mass indicators,

b) the vertical wind shear between 850 and 500 mb as a measure of baroclinity,

c) the north-south wind component and the pressure tendency as well as the thermal advection to depict the synoptic situation. In the following, some preliminary results are shown.

4. The dew-point at the surface

This quantity was taken for Ceres and Junin (Fig. 1). Ceres is on the northern edge of the test area at the entrance of the warm and moist air masses and Junin is situated in the center of the test area. **Fig. 3** gives the results, showing some relationship. If the dew-point at Junin goes above 20° C, the probability of finding squall-line activity during the next 24 hours is three times that of the mean. No activity is seen for dew points below 0° C at Junin. Ceres shows a similar dependence, but the percent frequencies lie somewhat lower, for the reason that high dew-points are more common at Ceres than at Junin (Table 3).

Table 3. Numbers of days with different dew-point at Ceres and Junin.

Dew-point	0	1–4	5–8	9–12	13–16	17–20	21–24
Ceres	145	291	422	727	893	885	289
Junin	254	441	646	838	838	541	64

The beginning of the activity shows a similar behaviour. The percent frequency doubles the mean probability if we have favorable dew-points.

The dew-point is a useful parameter in forecasting squall-lines but specially during the warm season, other parameters should be included.

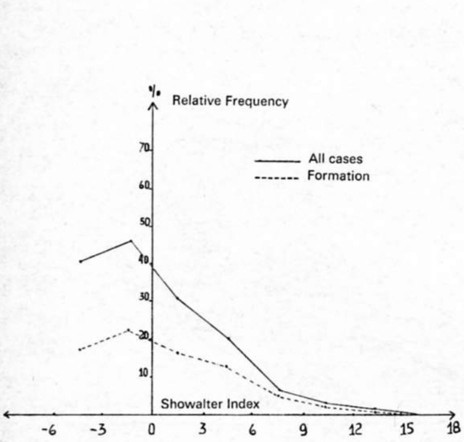

Fig. 4. Percent frequency as a function of the instability index.

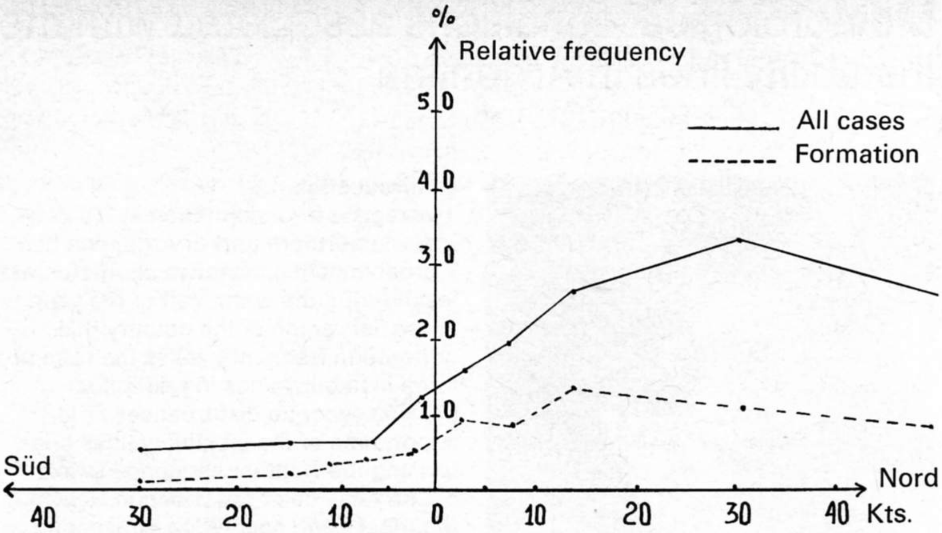

Fig. 6. Percent frequency as a function of the north-south wind component at 850 mb for Ceres.

Table 4. Distribution of frequencies as a function of the surface dew-point at Junin and the 24-hours pressure tendency at La Rioja for all cases.

°C \ mb	−20.0 −16.1	−16.0 −12.1	−12.0 − 8.1	−8.0 −4.1	−4.0 −0.1	0.0 4.0	4.1 8.0	8.1 12.0	12.1 16.0	16.1 20.0	20.1 24.0	24.0
−3– 0	0 0 –	0 3 –	0 15 0	0 35 0	0 69 0	0 66 0	0 25 0	0 16 0	0 15 0	0 6 0	0 4 0	0 0 –
1– 4	0 3 0	0 5 0	0 21 0	1 72 1	1 117 1	0 93 0	0 66 0	0 39 0	0 14 0	0 7 0	0 5 0	0 1 0
5– 8	0 1 0	0 11 0	2 29 6	4 122 3	6 167 4	4 149 3	3 80 4	1 60 2	1 22 5	0 5 0	0 4 0	0 1 0
9–12	0 0 –	1 6 17	7 44 16	30 175 17	34 244 14	15 207 7	5 93 5	2 51 4	1 22 5	1 7 14	0 0 0	0 1 0
13–16	0 0 –	4 4 100	10 27 37	58 192 30	74 300 25	33 180 18	16 86 19	4 36 11	1 10 10	0 13 0	0 1 0	0 0 –
17–20	1 1 100	0 0 6	13 23 56	59 107 55	105 219 48	49 128 38	14 44 32	8 18 44	1 4 25	0 1 0	0 0 –	0 0 –
21–24	0 0 –	0 0 –	2 3 67	13 16 81	13 32 40	4 7 57	2 6 33	0 1 0	0 0 –	0 0 –	0 0 –	0 0 –

Table 5. Distribution of frequencies as a function of the surface dew-point at Junin and the 24-hours pressure tendency at La Rioja for formation of squall-lines.

°C \ mb	−20.0 −16.1	−16.0 −12.1	−12.0 − 8.1	−8.0 −4.1	−4.0 −0.1	0.0 4.0	4.1 8.0	8.1 12.0	12.1 16.0	16.1 20.0	20.1 24.0	24.1
−3– 0	0 0 –	0 3 0	0 15 0	0 35 0	0 69 0	0 66 0	0 25 0	0 16 0	0 15 0	0 6 0	0 4 0	0 0 –
1– 4	0 3 0	0 5 0	0 21 0	1 72 1	1 117 1	0 93 0	0 66 0	0 39 0	0 14 0	0 7 0	0 5 0	0 1 0
5– 8	0 1 0	0 11 0	2 29 6	4 122 33	5 167 3	3 149 2	2 80 2	1 60 2	0 22 0	0 5 0	0 4 0	0 1 0
9–12	0 0 –	1 6 17	5 4 11	28 175 16	25 244 10	11 207 5	5 93 5	1 51 2	0 22 0	0 7 0	0 0 –	0 1 0
13–16	0 0 –	2 4 50	8 27 30	39 192 20	42 300 14	20 180 11	5 86 6	1 36 3	1 10 10	0 3 0	0 1 0	0 0 –
17–20	1 1 100	0 0 –	8 23 33	29 107 28	52 219 24	21 128 16	4 44 9	2 18 11	0 4 0	0 1 0	0 0 –	0 0 –
21–24	0 0 –	0 0 –	1 3 33	5 16 31	4 32 12	1 7 14	2 6 33	0 1 0	0 0 –	0 0 –	0 0 –	0 0 –

5. The Showalter Index

The 12 GMT mean of the Showalter Indexes from Ezeiza, Córdoba and Resistencia were computed daily. The results are given in Fig. 4. The curves are very similar to those of the surface dew-point. If the Showalter Index lies above 15 no activity occurs during the following 24 hours. With values about 0 the probability rises to 46 % for all cases and to 22 % for formation only. With respect to forecasting what was said for the surface dewpoint may be repeated here. It is seen that air mass characteristics alone are not decisive; other factors must be present.

6. The 24-hours pressure-change

The 24-hours pressure tendency of La Rioja (Fig. 1) was selected to give a quantitative estimate of the synoptic disturbances. La Rioja is situated to the west of the test area in a region where the interdiurnal pressure-change acquires a maximum. The difference of the 12 GMT pressure from that of the previous day was computed.

Fig. 5 shows the percent frequency for all cases as well as for formation for the next 24 hours. It is interesting to note that the curves show a maximum, which is situated in the interval of −4 to −8mb/24 hours for all cases and at −8 to −12mb/24 hours for formation.

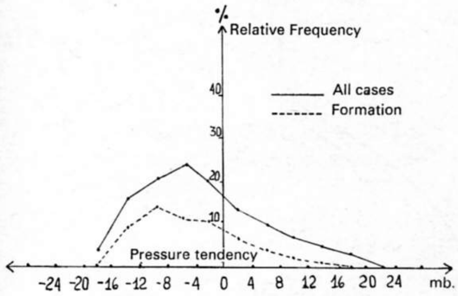

Fig. 5. Percent frequency of squall-line as a function of the 24-hours pressure tendency at La Rioja.

This is due to the fact that very large pressure falls are associated with rather fast moving disturbances, which have not enough time to bring warm moist air masses into the test area. This also confirmed by the mean tendencies which are −1.6mb/24 hours for all cases and −2.4mb/24 hours for formation.

7. The north-south wind component

This parameter was selected, taking into account that instability lines frequently develop, in connection with low-level jets that move poleward (1). These advect a narrow tongue of moist air favorable for convective activity. The wind at the 850 mb level at Ceres was taken for the years 1960–1967. The probability of finding squall-lines rises with increasing north component (Fig. 6), but this parameter does not seem to be decisive, for the highest frequency of 33 % is less than the mean for January and only equals that of the summer (Table 1).

8. Surface dew-point combined with pressure tendency

A combination of the dew-point at Junin and the 24-hours pressure tendency at La Rioja may be seen in Tables 4 and 5. Here we see a systematic growth of the values in the region of high dew-points and falling pressures. These frequencies are much higher than those obtained with only one of both parameters. We have 161 days (in ten years) for which the probability of squall-line activity is above 50 %.

9. Future research

It is intended to continue this study by introducing new parameters, like the vertical wind shear and the thermal advection. The parameters already tested will also be revised to find better relationships. For instance it will be studied whether better results are obtained with the Showalter Index by taking the mean of Cordoba and Ezeiza alone, or simply the value given by one of both stations or by selecting the lifted index. Those parameters or predictors which show the best correlation with squall-line activity will be taken, combined and presented graphically to aid in forecasting.

10. Acknowledgement

The authors wish to thank Mr. Jorge Nuré for his careful help in the computation of the data.

References

(1) J. G. Breiland «Meteorological Conditions associated with the Development of Instability Lines», Journal of Met., Vol. 15, No 3 (1951).

(2) E. J. Fawbush, R. C. Miller and L. G. Starret «Empirical Method of Forecasting Tornado Development» Bull. Am. Met. Soc., Vol. 32, No 1 (1951).

(3) D. House «The Mechanics of Instability Line Formation» Journal of Met., Vol. 16, No 2 (1959).

(4) C. W. Newton «Structure and Mechanism of the Prefrontal Squall-line» Journal of Met. Vol. 7, No 3 (1950).

(5) M. L. Schwarzkopf and E. R. Lichtenstein «Squall-lines as an Aid for Long Distance Glider Flights in Argentina» OSTIV Public. No 7.

Résumé

Dans le centre et le nord de l'Argentine, pendant la saison chaude, les précipitations sont généralement causées par la convection. Ce phénomène se produit le plus souvent sous forme de lignes de grains en relation avec des perturbations synoptiques. Il est important de prévoir la formation de lignes d'instabilité en raison de la soudaineté de leur développement et des mauvaises conditions météorologiques qui leur sont associées.

Une tentative est faite ici, de faciliter cette prévision en prenant en considération les données statistiques de la décade 1958–1967. Les données utilisées ont été choisies pour 12 h. GMT et en considérant l'activité des lignes d'instabilité qui fut observée dans les 24 heures qui suivirent. Des résultats statistiques préliminaires sont indiqués ici, pour quelques paramètres sélectionnés: point de rosée à la surface, tendance de la pression barométrique et composante nord-sud du vent à 850 mb.

Cette étude sera poursuivie en incluant d'autres paramètres, tels que le gradient vertical du vent et l'advection thermique.

Eichenberger

Zusammenfassung

In Zentralargentinien und im nördlichen Landesteil werden Niederschläge in der warmen Jahreszeit durch Konvektionsströmungen verursacht. Diese Erscheinungen zeigen sich als geordnete Instabilitätslinien in Verbindung mit verschiedenen synoptischen Störungen.

Durch die rasche Entwicklung und durch die schnelle Verschlechterung der Wetterlage beim Auftreten von Instabilitätslinien ist es sehr schwierig, dafür eine Prognose zu stellen. Mit dem vorliegenden Bericht wird versucht, mit der Hilfe von statistischen Angaben der Jahre 1958–1967 die Grundlagen zu Prognosen bei diesen speziellen Wetterlagen zu verbessern. Die verwendeten Daten beziehen sich auf 12 h GMT. Die Aktivität der Instabilitätslinien wurden in den darauf folgenden 24 Stunden beobachtet und ausgewertet.

Die statistischen Ergebnisse wurden im Bericht für verschiedene ausgewählte Parameter ausgewertet, nämlich: Taupunkt am Boden, Showalter-Index, für die barometrische Drucktendenz und für die Windkomponenten auf der Druckfläche 850 mb.

Diese Studie wird mit der Verwendung von anderen Parametern fortgesetzt wie vertikaler Windgradient und thermische Advektion.

Sulzer