

COMPARISON OF THE RELATION BETWEEN SURFACE WIND SPEED AND
TEMPERATURE IN THE SOUTHERN PARTS OF THE ROSS SEA AND
WEDDELL SEA

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The two Antarctic meteorological stations, Little America (78.5°S, 163.9°W) in the south-eastern part of the Ross Sea, and Base General Belgrano (78.0°S, 38.4°W) in the south-eastern part of the Weddell Sea, are rather similar as regards to latitude and several other geographical characteristics. Therefore, it may be of interest to point out a well marked difference between both places with respect to the relation between surface wind speed and temperature during the polar winter.

Over level ground and in absence of any noticeable source of heat at the surface, wind speed (if < 6 Beaufort) and temperature are in general directly proportional to one another; as long as other variables remain constant, the inversion will be the stronger the smaller is the transport of heat from above by turbulent vertical mixing. This relation also appears in Little America in average values, while in Base General Belgrano there is a remarkable discontinuity between force 3 and 4 of the Beaufort scale, as can be seen in Table 1 which gives the means of temperature corresponding to different wind speeds. This somewhat surprising contrast demands further analysis.

Table 1 - Mean temperatures (C°) for different wind speeds
May-September, Little America (1929-34-40) and
Base General Belgrano (1955-56) (n number of observations)

Station	Beaufort							Mean Temperature
	Calm	1	2	3	4	5	6	
Little America	-41.1	42.5	39.6	34.7	28.7	25.0	23.3	-34.6
n	44	177	411	292	262	115	83	
General Belgrano	-30.6	33.8	32.8	30.9	35.0	31.4	28.6	-31.6
n	117	40	97	136	152	189	164	

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In the whole border zone of the Antarctic continent, there exists a close relation between wind direction and temperature which requires no comment. This relation makes it advisable to consider the winds from southerly directions separately from the northerly ones. For this purpose, the relatively small number of observations with the wind precisely westerly were taken as belonging to the group of southerlies, and those precisely easterly as to the group of northerlies; the variation of wind direction with height justifies such co-ordination, even if in singular cases the conditions may be different. Fig. 1 gives the result of the separate statistics.

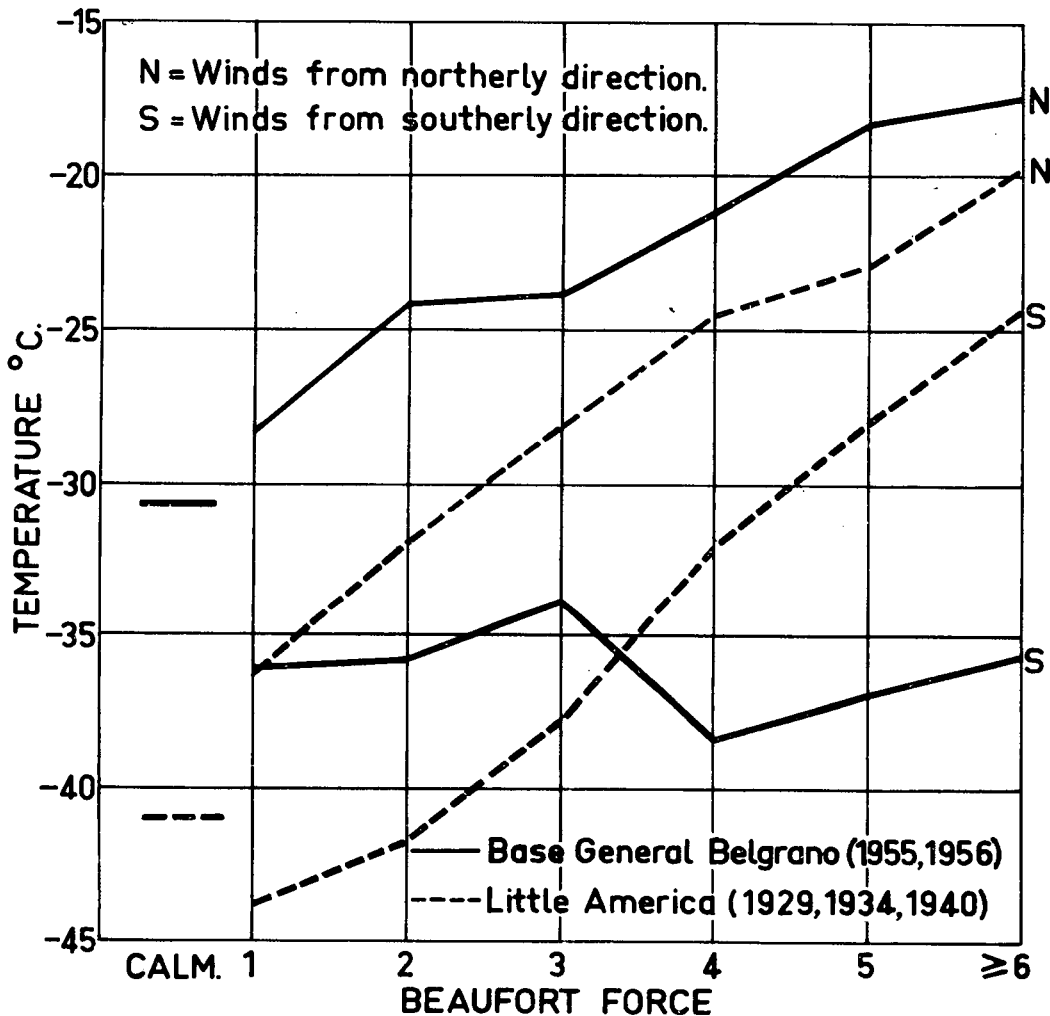


Fig 1. Mean temperatures for different wind speeds.
May - September

It can immediately be seen that in the region of Little America the relation between wind speed and temperature is almost the same for northerly and southerly winds, the latter being 5° to 10°C colder than the former. At Base General Belgrano the northerly winds on the whole show the same relation, but the winds of the southern sector have a completely different characteristic curve: south winds of force 4 to 6 are considerably colder than weaker winds from the same sector.

The question arises if the difference between the mean temperatures for force 3 and force 4 can be considered significant. Table 2 gives the affirmation.

Table 2 - Standard deviation (and standard error of the means) of temperatures (°C) with wind forces 3 and 4 Beaufort at Base General Belgrano

Wind	n	t_m	σ	σ_m
S 3	96	-33.9	8.4	.86
S 4	122	-38.4	6.5	.59

Nevertheless, as the anemograph of the station has been working only for a part of the period, it could be possible that the observations were biased by a personal error of the observers (over-estimation of wind speed when it was very cold). To show that this is not the case Table 3 gives a comparison of simultaneous observations at Shackleton base (77.9°S, 37.3°W), about 30 km ENE of Base General Belgrano itself, for the month of July 1956 (the only winter month for which simultaneous observations of the two stations were available to the author. Thus it can be accepted that the phenomenon is a real one in the southern part of the Weddell Sea.

Table 3 - Comparison of simultaneous temperature observations (°C) at Base General Belgrano and Shackleton base, July 1956, t_m and (n)

Station	Wind	force 1 to 3	> 4 Bft	Calm
General Belgrano (2 obs missing)	N	-30 (6)	-20 (14)	
	S	-34 (25)	-37 (33)	
	Calm			-34 (13)
Shackleton (3 obs missing)	N	-31 (6)	-24 (20)	
	S	-33 (27)	-35 (37)	
	Calm			- (0)

These facts can be explained by assuming that the winds in the lowest layers over the shelf ice of the Weddell Sea are due only in part to pressure gradient and friction effect, and for the remainder are of the katabatic type. Frequently, the pressure field may be quite weak, so that in the lowest layers the outflow of the colder air of the interior of the continent towards north can be fully developed; the normal speed of these currents may be force 4 or 5. When the pressure field definitely favours a southerly flow, stronger south winds appear. When the pressure field does not favour a southerly flow but is not strong enough to inhibit entirely the outflow of the colder air of the interior, winds of force 1 to 3 may be blowing; in such conditions the turbulent mixing with the higher layers and radiation effects of these layers when there are no southerly winds and therewith generally more cloudiness, bring along somewhat higher temperatures. Only when the synoptic situation imposes strong northerly currents (pronounced pressure gradients towards west), the baric winds (with friction component) assert themselves, entirely destroying the temperature inversion of the surface layer.

This conception can not be proved by a series of synoptic maps, as there are no stations which would make possible a meso-analysis of the pressure field. But it is in accordance with the general frequency distribution of the winds. Furthermore, by the same reasoning the considerable contrast in the mean temperatures of the two stations for calm and the low speeds 1 and 2 (Table 1) may be understood. In Little America there is a weak (or no) movement of the surface layer when radiation conditions (clear sky) prevail. On the contrary, under such circumstances in the south of the Weddell Sea a moderate wind is blowing from the southern sector, and a weaker movement (or none) predominates with the sky overcast.

Hence it is suggested that the cold southerly winds in the south of the Weddell Sea are mainly katabatic winds, of the same type as the famous persistent winds at the surface of the Greenland ice cap (east winds over western, west winds over eastern Greenland). But the interesting point here is that the katabatic winds appear in the region of Base General Belgrano, Shackleton (and presumably also Ellsworth) stations, at considerable distance from the slopes of the higher ground of the Antarctic continent, while the same type of wind does not appear, or at least not appear frequently and in pronounced form, at Little America. The understanding of this peculiarity may prove to be of value in the daily analysis of Antarctic weather conditions. According to the geographical descriptions available to the author, the plateau begins at a distance of the order of 200 km from the first named stations. So it appears that a broad stream of cold air of the interior gains kinetic energy descending over the slopes far south of the Weddell Sea and continues, by inertia, its movement towards north without much change for 200 km or more. If nothing were known about the topography of the region, the temperature-wind diagram alone would give notice of higher ground in the southern sector. It may be an important detail that the density of this air can be very great; singular values up to 1.58 kg/m^3 have been determined by means of pressure and temperature data of Base General Belgrano.