density stratification (see Fig. 2) is set up, limiting vertical convection to that layer. Continuing heat losses to the atmosphere are now derived from a much shallower layer (about 10 m) than the usual mixed layer (about 60 m), and the temperature profiles show dramatically the effects of net heat flux to the atmosphere. This cooling process will continue until the entire mixed layer assumes neutral stratification.

From the 18-hour temperature drop in the surface layer of the ocean, the total heat loss can be calculated as 210 ly/day. We can summarize the heat and precipitation budgets as follows.

Ocean:	
Heat storage change	− 210 ly/day
Atmosphere:	
Total heat flux	246 ly/day
Net radiation	− 60 ly/day
Total:	− 24 ly/day
Ocean:	
Evaporation	+ 3 mm
Net dilution	+ 43 mm
Precipitation	+ 46 mm
Atmosphere:	
Precipitation (observed)	17.5 mm

This shows that the heat budget, neglecting advection, can be balanced within about 10 percent. This is definitely within the uncertainty of our STD measurements, while the heat flux calculations made by using the refined bulk equations may be no better than ± 20 percent. Also, the precipitation calculated from the dilution of the top layer is slightly more than 2½ times as high as that observed with the rain gauge. This shows the difficulty of obtaining representative precipitation data aboard ship. It is well known that shipboard rain gauge measurements are inadequate. We suggest that the method outlined above may provide a more reliable precipitation estimate in some situations.

The method presented here for obtaining oceanic heat flux measurements and precipitation estimates independently of meteorological techniques seems to us specifically applicable to tropical regions and experiments such as the global atmospheric research program (GARP) Atlantic tropical experiment (GATE). A method of providing reliable estimates of heat, mass, and momentum transport across the air-sea interface during a meteorological event is essential. The observations show that on the time scale of a few hours, significant cooling and freshening occurs only over the wave-mixed layer. This allows the temperature of the ocean surface to become much lower than in the case where the heat loss is derived from the entire mixed layer. Since the stratification is stable, the ocean surface remains cool, inhibiting further atmospheric convective development. This air-sea feedback mechanism, which tends to limit the development of atmospheric convective systems, is important to the energetics of the tropical atmosphere. Therefore, this mechanism must be considered if a reliable prediction of long-term atmospheric behavior is to be made.

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10. F.O. is grateful for the invitation to be a guest on board the R.V. *Professor Zubov* and for the hospitality given him on the ship, especially to Captain O. V. Andrjeyevskiy and the chief scientist, Dr. M. A. Petrosiants. It was a great pleasure to work with the entire crew, especially the physical oceanography group under the leadership of B. G. Borisov. We also appreciate being provided with the surface meteorological data.

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Electrical Breakdown Caused by Dust Motion in Low-Pressure Atmospheres: Considerations for Mars

Abstract. *Electrification of agitated dust can cause visible breakdown in a carbon dioxide atmosphere at low pressure in a laboratory experiment. Dust storms on earth become electrified, with accompanying breakdown phenomena. Martian dust storms may reduce the atmospheric conductivity by capturing fast ions on particles, and, by electrifying, may cause discharges in the relatively low pressure atmosphere.*

Agitated dust is well known to become highly electrified due to surface processes which are poorly understood and are generally referred to as triboelectric. This occurs on all scales, from the microscale as in electrostatic office copying to the scale of dust storms. In laboratory experiments blown dusts have been found to electrify to breakdown voltages with charges estimated up to 10^4 e per particle (*1*). Dust devils and storms are known to be accompanied on occasion by point discharge from the earth, with typical values for the local electric field of the order of 1000 volt/m and space charge concentrations up to 10^6 e cm^{-3} (*2*). On larger scales, lightning has been observed and photographed in dust clouds, for example, in the phreatic eruption of the volcano Surtsey off Iceland in 1964 (*3*).

The potential difference required for breakdown in gases decreases with the gas pressure to a minimum at very low pressures. Typical Paschen curves indicate that potential gradients of only a few hundred volts per centimeter are required for spark breakdown in gases at pressures of the order of 10 mbar [for example, see (*4*)]. In an atmosphere at a lower pressure than the earth's, for example on Mars, the movement of dust might give rise more readily to electrical breakdown, possibly to phenomena that might be classed as glow discharges rather than sparks.

There are descriptions in the early literature of experiments in which electrical discharges were readily obtained in evacuated vessels by a variety of mechanisms; these involved frictional electrification either of materials within the vessel or of the walls (*5*). None of these, however, employed the movement of dust as a source of electrification. We performed an experiment to investigate whether dust becomes electrified when agitated in an atmosphere at an appreciably lower pressure than at the earth's surface, and whether any breakdown could be observed as a consequence. A 1-liter glass flask containing about 50 g of dried, well-dispersed sand in an atmosphere of CO_2 was evacuated to 10 mm-Hg. Two electrodes were sealed through the walls approximately 10 cm apart. When this flask is shaken vigorously, electrical breakdown phenomena are seen inside. The experiment must be performed in a dark room and the observer must be well adapted to the dark (a process taking at least 15 minutes). Observers have concurred that several modes of breakdown can be observed: (i) small sparks, (ii) discharges which appear to be several centimeters long and about 1 cm wide—both of these are relatively bright, and (iii) a faint extensive glow discharge. The dominant colors are in the blue to red parts of the spectrum. The sensitivity curves for scotopic vision are known to be shifted toward longer wavelengths relative to photopic vision, with the minimum perceptible brightness of the order of 10^{-4} mlam.

When a d-c potential of about 1200 volts was impressed between the two electrodes, similar discharges were produced without the necessity of any dust movement. Some estimate of the electrification occurring on shaking was also obtained. After agitation, it was observed that potentials as high as 500 volts appeared between the two electrodes. During the course of these experiments, the surface of the inside of the flask became coated with fine particles which adhered strongly.

We stress that this experiment is not intended to be an analog of the martian atmosphere; however, the possibility of related effects occurring there warrants consideration. The atmosphere near the surface of Mars is primarily CO_2 at a pressure of about 10 mbar. The surface is swept by severe winds and consequent dust storms which occasionally are of global dimensions (*6*) and which may affect the thermal structure of the atmosphere (*7*). Mariner 9 coincided with such a storm. Photoionization, which may contribute to the conductivity of the lower atmosphere on the light side, must be reduced on the dark side, and the conductivity of the lower atmosphere will be primarily due to fast ions caused by cosmic rays or, possibly, by radioactive material in the surface. The rate of production of fast ions may not greatly exceed corresponding values in the earth's atmosphere at about 10 mbar. High conductivity is then unlikely because of the capture of fast ions by dust particles, unless there is a very high anomalous rate of ion production. It seems reasonable to suggest that excitation of the atmosphere with emission in parts of the spectrum other than the visible, or even spark breakdown or glow discharges in the visible, might result as a consequence of the electrification of the dust in such storms.

Dust storms may play a finite but small role in the electrical budget of the atmosphere of the earth, which is primarily the balance between the earth-atmosphere current in fair weather and thunderstorm activity. We are considering what significance dust storms on Mars may have for the electrical budget of that atmosphere both by generating charge and by reducing the conductivity by the capture of fast ions.

Because of dust electrification an engineering problem could occur with a martian lander vehicle. Dust blown by or over such a vehicle may result in charge generation. Helicopters hovering near the surface of the earth can electrify rapidly due to blown dust, and breakdown phenomena occur. Surfaces exposed to moving dust rapidly become coated with fine particles, which adhere by means of Coulomb forces that greatly exceed the gravitational forces on them. Similar effects could occur with a lander vehicle, including the possibility of exposed lenses becoming coated, which would degrade visual data (*8*).

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Number of Germ Cells in Known Male and Known Female Genotypes of Vertebrate Embryos (Oryzias latipes)

Abstract. *The number of primordial germ cells in embryos of known genotypic sex was the same in XY males and XX females until the gonad became recognizable as testis or ovary. It has been claimed that the heterogametic sex chromosome causes the gonad to differentiate as a testis in mammals and as an ovary in birds as a result of earlier and more mitoses. This claim was not supported in the present study where a sex difference in numbers of germ cells was first noted during differentiation of oocytes in the XX embryos.*

The number of primordial germ cells has been thought to differ with sex (*1*). For example, in embryos of the elasmobranch *Raja batis*, counts were grouped around two numbers (256 and 512) which were claimed to correspond, respectively, to future males and females (*2*). Yet in a recent review of all data for vertebrates, Hardisty concluded that it is not clear whether these sex differences are "due to earlier or more rapid proliferation in the germ line of one sex or to differences in the number of primordial germ cells originally segregated" (*1*). In studies made over almost a century, a major difficulty has always been uncertainty as to the sex of an individual specimen prior to differentiation of the gonads. Of obvious value would be data for species in which the sex of every embryo is known from the time of fertilization.

Table 1. Numbers of germ cells in embryos and hatchlings of known genotypic sex in the d-rr strain of *O. latipes*.

Stage	Number of embryos/ hatchlings	Mean ± S.E.	Range
26-1	16XX/	32 ± 2.1	20–47
	16XY	34 ± 2.5	17–47
30	16XX/	32 ± 1.1	23–43
	16XY	35 ± 2.1	23–48
Hatching	16XX/	75 ± 11	23–198
	16XY	72 ± 6.3	28–107

Therefore, our study was undertaken with the Japanese killifish, *Oryzias latipes*, in which sex determination is of the XX-XY type, with the female homogametic and the male heterogametic (*3*). Special procedures (*4*) applicable to the d-rr strain, provided fertile XX males and YY males which were bred with XX females to produce zygotes known to be XX and destined to develop as females, or