Date: Mon, 18 Aug 1997 08:40:50 -0400
From: BLETTAU@NSF.GOV
Organization: National Science Foundation
To: llettau@awod.com
CC: blettau@NSF.GOV
Subject: Among The Magi - Chapter 1

<P>The super theoreticians, the university men, were full of ideas of what might be done on the high Polar Plateau. However, they both were about ten years from retirement and not interested in learning the problems related with the establishment of a field site in such a hostile environment. The government men had the experience for establishing the station, its supply line and anticipatory knowledge of what to expect at 11,000 feet and -115 deg F. The possibility that I might be one of those scientists to winterover at this extreme camp to gather valuable data began to swell within me.

<P>Lettau and Schwerdtfeger previously submitted suggestions concerning a study of the Great Antarctic Inversion in a letter to the National Science Foundation. It was a letter of suggestions of what might be done, not a proposal. They did not want the logistics responsibility. They might have been over cautious since the University of Wisconsin's Geology and Geophysics Department jointly with the Polar Institute of Ohio State University were already extensively involved with the traverses.

<P>An overview of the Great Antarctic Temperature Inversion was known from work by Kirby Hanson and Paul Dalrymple. First of all, a temperature inversion is a common evening phenomenon, especially during a winter evening, anywhere in the world. The heat radiation cooling of the ground surface sends heat by way of long wave radiation out to space. With not much heat returning to the surface from the moisture, clouds, and air, the net radiation, that heat energy remaining from losses compensated by gains, algebraically adds to a net loss. The ground temperature cools rapidly and the air just above the ground also loses heat and cools but each successive layer above is warmer until the cooling versus warming reaches zero. The resulting temperature inversion is just that, a layer of air where the temperature rises with height above the ground inverse from the normal daytime solar heating pattern.

<P>In the Antarctic on the High Plateau, Lettau and Schwerdtfeger named this layer of air the Great Antarctic Inversion. Kirby and Paul's data showed this inversion over the South Pole to stand some 2000 feet above the snow surface with the temperature at that level to be a warm maximum of -40 deg F and the snow surface measuring a minimum between -80 deg F and -100 deg F.

<P>The Lettau and Schwerdtfeger letter praised the standard radiosonde and RADAR measurement techniques used for normal observation as quite sufficient to arrive at a general picture of the temperature and wind structure over the polar cap at a number of international stations. However, the two professors pointed out several difficulties. The routine aerological radio soundings were launched with large balloons that pass very quickly through the lower layers of the atmosphere. Never seen was the fine structure of the great inversion. The details needed for physical and mathematical analysis were unobtainable in this fashion.

<P>Routine balloon radio soundings were launched every day at twelve hour intervals. That time span "is so large that characteristic temporal variations of the great inversion and their relation to changes in cloudiness, wind shear, and net radiation remain unknown. Almost completely lacking is direct information on the spatial variations of the inversion structure on the Antarctic continent."

<P>Such a thorough study of the changing features of the great inversion and its spatial variation and extent over the high Polar Plateau would certainly improve the general understanding of the behavior of inversions everywhere in the world. In the Antarctic all things were also so well defined and the extreme conditions such as the clear sky, the high altitude, the long night, and the isolation from contributing sociological intrusions would enhance observation of the complicated features not visible to mankind before.

<P>Other features such as mirages, the propagation of sound, light, and other electromagnetic disturbances remained somewhat unexplained in detail and this type of study would have potential toward such an understanding. I remember from Lettau's micrometeorology class stories of World War II accounts that explosions were heard from the war front many miles away causing terror in towns when the fearful immediacy of military action was not so eminent and actually far away. A person standing in a barnyard on cold nights often can hear sounds clearer from farther away. A temperature inversion very definitely is related to this phenomenon.

<P>Lettau and Schwerdtfeger proposed specialized radiosondes monitoring temperature and humidity with fast revolving, mechanical microbarographs and attached Soumi-Kuhn net-radiometers. Special slow rising balloons would carry the instrument package aloft at a rate not to exceed one hundred metres per minute. The normal lift velocities of such balloons were between 350 and 1000 metres per minute. The desire was to keep the inversion monitoring system within the inversion as long as forty minutes before reaching the altitude of 3000 metres. Daily routine observations were to be eliminated in favor of successive serial ascents on specially picked days. The chief meteorologists in the field would be expected to

understand the theory thoroughly and know what they were looking for.

<P>"Sound wave recordings of explosions 'ad hoc' released at the surface and at adequately chosen heights" were proposed as an original method of obtaining more information about the structure of the great inversion. A pilot study of the great inversion at South Pole using routine data already in possession at the Department of Meteorology at Wisconsin was suggested. They also suggested that the design and preliminary testing of a radiosonde system to be used could be done at the University. Finally Lettau and Schwerdtfeger wrote, "Needless to say that the two undersigned are willing, and anxious, to take charge of the evaluation and further elaboration of the results of the special inversion soundings, if and when an observational program of the proposed kind becomes reality."

<P>Hard decisions followed. RADAR was out. The small station planned for the terminus point of the second year of the Queen Maud Land traverse could not count on the power necessary to operate a sensitive RADAR unit. An additional building also would be required. Heat to outlying buildings was not possible. The need for a separate heating plant and additional oil supplies all contributed to the cancellation of RADAR. That was a major loss before a scientist even went into the field.

<P>The sounding system for the inversion study had to keep the aneroid barometer as a check for the height of the balloon and provide necessary data for the triangulation of balloon movement needed for the determination of the wind's speed and direction. An immediate theoretical conflict emerged from these constraints. In an inversion the interrelationships of pressure, temperature, and density of air were to be studied, not used to determine other parameters.

<P>An old fashioned manual system of triangulation suddenly looked pretty effective and independent. Two theodolites manned by the two meteorologists proposed for this assignment could do the task while leaving all other observations for automatic recorders. Each scientist would measure elevation (the angle from the horizon up to the balloon package) and azimuth (the horizontal angle swept clockwise from a preestablished base line to the position of the radiosonde) every thirty seconds. These data with needed trigonometric calculations could give independent heights and distances, the spatial positions, of the balloon carrying the instruments floating in the moving air. The change in the spatial position would yield the wind speed and direction.

<P>All three polar-experienced men expressed concern for both the instruments' abilities to function in the anticipated air temperature of -100 deg F and possibly even colder as well as the ability of the

human observers to remain unfrozen long enough to obtain the necessary data. Each balloon flight was expected to last thirty to forty minutes. Preliminary work before a balloon watch was also required. The expected rapid repeat of all outdoor work with little or no warmup time demanded by the study that required serial launches spelled too much frostbite for the men and thermal fatigue of metal parts of the instruments. Metal would become brittle and break like glass at the expected temperatures. Paul Dalrymple, a pioneer of wind chill studies for the U. S. Army, rattled off a considerable number of devastating facts with regard to the exposure of humans and their uncontrollable severe heat losses. Perhaps observation shelters could be developed permitting the observer to remain in warm comfort or at least remain out of the wind. Mort Rubin would look into it.

<P>The base line between the two theodolites should be as far apart as possible. If the balloons were tracked for 3000 metres (nearly 10,000 feet), a base line of nearly two miles was desirable. That distance was too far away to walk back and forth in the severe cold. The greatest fear was for the loss of direction or personal orientation should a sudden change of wind occur and cause visibility in the polar night to suddenly reduce even in the slightest because of ice crystals or snow in the air. The greatest loss of life in the polar regions had occurred when a person lost his way, even a short distance from the door of the main camp building, and froze to death. Kirby, Paul, and Mort, all with polar experience, encouraged the shortest possible distance between theodolites.

<P>Objection! This idea was striking at the very heart of the great inversion experiment. The most exciting and valuable discoveries were anticipated from the wind data. How the wind changed its speed and direction with respect to height and correlated with the temperature at each exact measured altitude demanded a base line of maximum length. The wind displayed the mechanical exchanges of energy with the snow surface. The wind showed the movement of sensible heat across the Polar Plateau. The wind moved the moisture, the ice crystals, the snow. The wind had to be measured as accurately as possible. Without a proper baseline, the University professors pleaded, the study would not be able to formulate worth-while theory and never would be able to confront old misleading theories.

<P>Paul Dalrymple spoke of his plans to place a one hundred foot micromet tower that would give the detailed temperature and wind structure to that height. He desired to be the chief meteorologist on the first year of this expedition for the balloon project and remain to establish the tower. All men here believed the Great Antarctic Inversion was considerably higher than Dalrymple's proposed tower. He strongly lobbied for the longest base line possible but

not at the expense of the observers.

<P>Struggling to preserve the longest possible base line, Prof. Lettau suggested a small hut with its own heating system such as Admiral Byrd used at Advanced Base on his 1934 expedition. Such an isolated hut could be maintained by one scientist. By living at a mile or more distance, communication could easily be maintained. During good weather, isolation could be broken with visits back to the main camp. I thought to myself, "I can do that." Dalrymple stared at me as if he read my youthful enthusiasm and abruptly interrupted, "Byrd almost died!"

<P>This was the method of science, an endless struggle between the artistic brush strokes of theoretical science, the ideal sought, and the limiting frame, the reality that accepts what cannot be done. In the Second Byrd Antarctic Expedition (1933-1935) this same tension was most prevalent. In its day it was the most elaborate technologically equipped expedition with the highest scientific goals. It was the first expedition to adopt seismic soundings as a method for a large scale systematic mapping of the sub-ice topography. Special techniques maintained sensitive, delicate, complicated instruments that elevated the entire observational scope for all time in the Antarctic. Tracked vehicles, used for the first time, enabled research teams to extend the field of their studies and probe in more remote areas than ever before. Aerial reconnaissance established the boundaries of the Ross Ice Shelf and confirmed that the Ross Sea and Weddell Sea were not connected.

<P>On this Second Byrd Expedition meteorology received major attention. The desire to establish an inland substation, Advanced Base, at the foot of the Queen Maud Mountains some four hundred miles south of Little America II was vital to meteorological research. However, the hardships of establishing Little America II, the struggle of Misery Trail, the severe weather, and frequent equipment failures caused delays and put the entire plan for a substation inland in jeopardy. With it the hopes and dreams of all meteorologists were also jeopardized. A station that distance away would have given significant pressure differences to establish cyclonic and anticyclonic activity as it developed while it slid down or scaled the icecap. Polar dominance of global weather was believed starting with the establishment of the Polar Front theory by the original Norwegian theorists, Vilhelm Bjerknes, Jacob Bjerknes, and Halvor Solberg.

<P>Events forced Admiral Byrd to settle for the Advanced Base only one hundred twenty miles from Little America. This little station could only support one man. Byrd chose himself for the arduous task in isolation and solitary confinement. He wintered alone from March until mid August. A life supporting heater produced excess carbon

monoxide gas under poor ventilation and the vital radio needed to correlate meteorological changes between Advanced Base and Little America added to the carbon monoxide poisoning. The meteorological task he bravely set out to achieve by bearing all physical and psychological hardship for the sake of science nearly killed him.

<P>A compromise over the base line for the Great Antarctic Inversion study set the distance at one thousand feet. At all stations one hut was always set aside as emergency quarters with a year's supply of food and fuel, it's own electrical and heat generator and room for all party members, albeit cramped. The fear always was the loss of the main camp to fire. At one hundred below zero flexible fire hoses and liquid water supplies would be inadequate to fight a fire. Now proposed was such an emergency camp built one thousand feet from the main camp. It would house the needed observational dome for the second theodolite. A small electric heating system would operate through an electric cable from the main camp. Such a cable would also carry needed communication between the camps. The electric heating system would be independent of the emergency heating system. That would preserve that system as well as save fuel. Heavy liquid diesel fuel was relatively easy to bring via a ship with an icebreaker escort to McMurdo Base, but to airlift absolutely every item including that fuel and every weather balloon from McMurdo to the high Antarctic Plateau was incredibly costly.

<P>I sat in awe listening to the give and take between the ideal and the real. In a sense, everything about the Antarctic was ideal. No immediate urgent national need demanded a presence in the Antarctic and for the Archie Bunkers, the Great Antarctic Inversion had a low priority. Such is the work of basic research. Industry rarely touches it. Little of it is practical. The discoverers rarely see the practical use of their own work. The inventors of the cathode ray tube searching for the connection between electricity and light had no knowledge that their invention gave the economical fluorescent light. The men who bent that cathode ray in a magnetic field discovered the mass of the electron, and later used it to measure the mass of many atomic particles, but they never dreamed that their invention would be in everyone's home as a television set.

<P>The cost of these proposed projects? I learned much later the price tag to the U. S. Navy was $200,000.00 per man to keep him alive for one year at Plateau Station. What is the reason for such basic research? Was it worth it? A little of the reason comes out in admiral Byrd's book Alone. Byrd wrote: "I am finding that life has become largely a life of the mind. Unhurried reflection is a sort of companion. Yes, solitude is greater than I anticipated. My sense of values is changing, and many things which before were in solution in my mind now seem to be crystallizing. I am better able to tell what in the world is wheat for me and what is chaff. . . . my views about

man and his place in the cosmic sphere have begun to run something like this:"

<P>"If I had never seen a watch and should see one for the first time, I should be sure its hands were moving according to some plan and not at random. Nor does it seem any more reasonable for me to conceive that the precision and order of the universe is the product of blind chance. This whole concept is summed up in the word harmony. For those who seek it, there is inexhaustible evidence of an all-pervading intelligence." (Richard E. Byrd, Alone, Ace Books, Inc., New York, 1938, p.108) And a hymn he played over and over again as a favorite during his isolation was, "Oh Holy Night, the stars are brightly shinning. Tis the night of our dear Savior's birth." (Byrd, Alone, p. 139) The reality of risk with the lure of polar research gripped me. Basic research had its value. But things of value came with a price. In paying that price I would grow as a human being. I would also grow as a child of my Lord, for He already paid the ultimate price.

<P>Even with the proper caution, a great risk to human life was real. Real limitations did indeed curtail some of the hopes of Lettau and Schwerdtfeger. Still everyone was enthusiastic for this basic research project. Lettau and Schwerdtfeger hoped for the best available data on temperature inversions this earth could provide. Dalrymple, Rubin and Hanson gave all the practical advice experience could provide to achieve the best possible results safely. Dalrymple and I truly were excited to go get it. Paul's was an enthusiasm tempered with experience and knowledge. Mine was young and foolish. I had already learned in this initial meeting more about science than in any single science class. I also learned that every note taken in the classroom and every idea remembered would be invaluable.

<P>Mort Rubin turned the discussion to inter station communication problems. Part of the Lettau-Schwerdtfeger Proposal called for a continual analysis of weather systems moving into, across, or out of the Antarctic continent. The rates of movement of these weather systems were to be plotted and communicated to the scientists at the new station to provide advisory information to assist them with their serial balloon launchings. Such inter station coordination was anticipated to be difficult.

<P>Such specialized analysis of continental weather was not done except to provide the military with weather advisories for their supply operations during the summer months. It could be done but many of the stations were established by foreign nations and language would be a barrier. The Great Antarctic Inversion study would go into the field the very next austral summer. The temporary station on the high plateau would be in existence for only two years. Coordination would be difficult to organize in such a short time.

<P>Men at the National Science Foundation didn't believe spatial variation of a microscale phenomenon such as an inversion would be important. The region was too near the geomagnetic pole, the position where the earth's magnetic field lines enter the earth's surface. Near the planned position of the new station, auroral phenomena were very active and interfered strongly with communications rendering them uncertain for the desired immediate data exchange. Scientific news releases would be given to all foreign governments active in Antarctica and perhaps on site extemporaneous exchanges might develop.

<P>The position of the station became an issue. The terminal position of the second year of the Queen Maud Land traverse was not exactly fixed. Schwerdtfeger felt that a perfect laboratory condition for the Great Inversion Study would exist by placing the station on the ridge line of the High Plateau. With the station right on the ridge, which in this case is flat, down sloping cold heavy drainage winds would not be present to affect the study examining the development of the temperature inversion.

<P>Cold drainage winds, called katabatic winds, cascaded down the slippery slopes of icecaps like Greenland or Antarctica. The strong katabatic winds of Antarctica received world wide attention through the famous writing of Douglas Mawson from Australia titled Home of the Blizzard.

<P>For the Australian Antarctic Expedition, 1911-1914, Sir Douglas Mawson established a station at Cape Denison on the coast of Adelie Land. It was there, during the months of May and June, frequent hurricane force winds in excess of eighty miles per hour blew steadily. Sometimes these winds blew for several days at a time, always down the slope from the inland High Plateau and seemingly not related to cyclonic activity from the sea. In his book Mawson showed several pictures of men leaning into the steady wind at angles more than forty-five degrees turned down from the vertical with their feet riveted into wind driven snow polished surface ice by Swedish crampons with inch and a half teeth. These winds began suddenly and ended as suddenly as they began.

<P>The textbook explanation of these katabatic winds originated with H. H. Hobbs and was part of anticyclonic circulation formations over polar icecaps. Warm air rose from the surrounding ocean waters. Then it moved upward and inward aloft over the polar cap, became cool, and sunk in the central region of the icecap. For Greenland and Antarctica that region is their respective glacier high plateau. Then this heavy cold sinking air surged outward and accelerated down the icy slopes and reached hurricane force as Mawson observed at Cape Denison. Similar recordings were made at other coastal stations

since the Australian Expedition in 1911.

<P>These outbursts of cold air in the Northern Hemisphere were believed to be the trigger that set off the main frontal cyclones of the Atlantic. This theory spawned the interest of meteorologists in the polar regions. Their belief followed reasoning like this: if one can understand polar weather, then weather everywhere might be predictable. The katabatic out flowing winds, based only on coastal observations, became the model for low level wind flow over all polar icecaps.

<P>Prof. Lettau pointed out that although katabatic winds were a dominant feature along the Antarctic coast where ice slopes were steep, his own study recently presented for publication using some of the data collected by Dalrymple at South Pole Station in 1958 showed a wind flow not as simple as that presented by Hobbs. Katabatic winds were not so all dominating on the entire continent. He identified light katabatic winds existing only in the lowest twenty feet above the snow surface. These winds were directed down slope, steady, stronger than the prevailing winds, but short-lived. Larger scale weather systems easily disturbed these katabatic winds. In the interior of the Antarctic, these winds were weak due to the nearly level but slightly sloped ice dome at the South Pole. According to Lettau's findings, katabatic winds could not account for the general low level wind circulation over the polar ice dome. (Heinz H. Lettau, A Case Study of Katabatic Flow on the South Polar Plateau, pages 1-11 in Volume 9 of Antarctic Research Series, Studies in Antarctic Meteorology, Morton J. Rubin, Editor, American Geophysical Union, 1966)

<P>Continuing the discussion in the Rathskeller, interrupted only when a pitcher of beer became empty, Lettau pointed to the contradictions within the Hobbs-katabatic theory for large scale polar air circulation. Sinking air is usually representative of anticyclonic circulation. Anticyclonic flow, the common wind pattern for a high pressure region, inhibited cloud formation and prevented precipitation from occurring. Also strong out flowing katabatic winds would transport surface snow away from the center of the ice dome and outward to melt in the sea. Together, the sinking air and the out flowing air would reduce the polar cap. The Hobbs-katabatic wind theory, accepted as a rule of law in the Compendium of Meteorology and likewise expressed as a law in almost every textbook of weather and geography, simply could not exist as a climatological feature for an icecap with the stability and longevity of either Greenland or Antarctica.

<P>Other results, also generated from Dalrymple's micrometeorology data and taken at Amundsen-Scott Station, hinted at a new approach. Lettau spoke of thermal winds formed by the extremely stable and

stratified inversion layer. The inversion phenomenon was widespread over the icecap. These thermal winds, caused by a horizontal temperature gradient, would alter the ambient or normal wind established by the pressure gradient and the earth's spin. Lettau and Schwerdtfeger expected that the wind speed and direction near the snow surface would be forced to turn around the ice dome according to the thermal wind hypothesis. These turning thermal winds of the inversion predicted only a minimum loss of snow and greatly increased the longevity of the icecap when compared with the Hobbs-katabatic simple down sloping and outward winds.

<P>Schwerdtfeger further explained that this inversion wind, if it existed, would be locked to the slope and shape of the ice dome. These winds would create a low level anticyclonic circulation over the ice dome. As a cold core shallow high pressure region, the inversion winds would also establish a cyclonic circulation pattern aloft. A circumpolar cyclonic wind pattern aloft would enhance precipitation, continually adding to the polar cap.

<P>This aspect of the Great Antarctica Temperature Inversion was revolutionary and Mort Rubin, with emotional excitement, recognized its value as a solution to many unsolved problems. On a global scale, it always was a mystery why, with the earth's strong green house heating, there still were the two major icecaps of Greenland and Antarctica.

<P>This phenomenon, in the minds of Lettau and Schwerdtfeger, may have escaped detection because of current data analysis techniques. Instruments were designed to measure expected phenomena and no one ever looked for these inversion winds before. Balloons carried their instruments through the inversion so fast that details needed to identify the proposed wind effects were not visible even if looked for.

<P>This grand finale of theoretical interpretation gave high purpose to future polar exploration at the proposed austere isolated small station in the center of the unexplored High Plateau of Antarctica. Our meeting adjourned with Dalrymple saying to me: "You still want to go South? You're too little." I suggested my small surface area was easier to keep in thermal equilibrium. I bicycled back to my apartment at Hasse Towers with my head swimming over the awesome project planned for the deep south, over even the remotest possibility that I might personally be involved, and over too much beer!

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