American Meteorological Society
University Corporation for Atmospheric Research

TAPE RECORDED INTERVIEW PROJECT

Interview of Joachim P. Kuettner

October 21, 1994

Interviewer: Will Kellogg

Kellogg: This is Joachim B. Kuettner being interviewed on the 21st of October at NCAR, in his office, and as I mentioned to Joach, to begin with, there are at least three reasons for doing this interview now. First is your 85th birthday, which is just a celebration of which is just taking place this week, and the Joachim B. Kuettner Symposium was held at NCAR. This was a very memorable event, as I am sure you know, and all your friends know.

Kuettner: Such as my _____ were.

Kellogg: Those tapes were recorded too. You had many good speakers coming for that. Then, there was a previous interview conducted by us on Hessam Taba on behalf of the WMO, but that was in 1988. It was some time ago.

Kuettner: Was it that long?

Kellogg: It was a good interview. It was written up in the WMO bulletin. It appeared in the October 1989 issue of the WMO bulletin, and it is, I thought, a pretty good interview, but I want to give you a chance if you wish to upgrade, add to it, or whatever you wish, if you would like to. Although it seems to be pretty good as it stands, there is one general weakness in that interview as I see it, Joach, that was that Taba didn't ask you very much about your scientific life, and that is, they mentioned in passing your interest in various things such as atmospheric electricity, mountain waves, orographic clouds, tropical convection, and more recently the rule of the oceans, which is something I think has crept into your scientific life since 1988.

I may be wrong, but you correct me if you wish, and anything else that you would like to talk about. So Joach, we can start it any way you want. First of all, are there any things that you would like to add about your early life and work, the period covered by Taba's interview, which you might like to add to.

Kuettner: I really don't have that interview much in my memory, so I don't know what to add to this.

Kellogg: I think it gave a pretty good outline of what you have been doing, what you have done. I enjoyed reading it a lot.

Kuettner: Much of the work started with the activity as a glider pilot. That's the question that you begin to ask if you use the atmospheric updrafts, and I think much of the work that I did later, addressed—it is probably with every scientist like that. It addressed some early experiences. So even if you, even if you not immediately attack these problems, and maybe 20-25 years later that you come back to them. Like, for example, the cloud streets was something that, I mean, was discovered by glider pilots, the mountain waves were discovered and the conclusions to which so many people jumped immediately an explanation.

Kuettner: Obviously _____ you like to get somewhat of an investigation before you make your judgment, and also the atmospheric electricity, these are the things that happened like the time after World War II that I spent on the Zugspitze Observatory.

That observatory is, it is the highest peak in the Northern Alps that sticks out like a thumb, and whenever a thunderstorm goes by, you are hit by lightning in this observatory.

If this goes on for year or so, they need to ask questions, and for example in this case, I was curious whether there is special polarity to these lightnings.

Kellogg: Anyway, what do they carry, positive or negative charges to the earth?

Kuettner: Yes, yes, and it so happens in a radio station next door, there was an American radio station, for military station, there was a young man, whom I played with, violin sonatas, in the hotel a little under the top, called "Schneefernerhausen."

Kellogg: Not ____________?

Kuettner: No, it is the Schneefernerhaus, near Garmisch-Partenkirchen.

Kellogg: Oh, I see.

Kuettner: __________ but we did that. We played Mendelssohn together and so on, and he said, "Well, I have to decide now whether I will become a violinist, or will I become a radio repairman." Because he had to learn to repair radios at this time. And so, he made me a little device. It was just a diode. That gave me the…

Kellogg: A diode.

Kuettner: That could give me the polarity. And, there were always negative in the sense of negative charge came down, and this went on a whole year. I don't know how many thunderstorms. I would think 30 or 40, and you get, under these conditions, you might know that, you might know that, you get point discharges that are called in the mountains "St. Elmo's Fire."

Kellogg: I've heard of them.

Kuettner: And if the field is negative, then they are enormous, they are meters long, and in fact, they look fantastic, but of course I never wanted to go to the roof and watch them, because in the middle of a thunderstorm you might be hit. Now after this year, seeing that the field was always negative, I said well I'm safe if I go up there. I went up there, out of the fingers came these long point discharges that looked like nails, as if you had long nails.

Kellogg: I'm glad you are still with us, Joach.

Kuettner: And then for the first time, just when I was up there, a positive lightning hit down, and it shocked me really, and the next year, I found out that about 50% of the lightning were positive. So you can never conclude from one season, you know?

Anyway, that got me in atmospheric electricity, and then I made models of the charge generation…

Kellogg: Models of the charge generation within the cloud.

Kuettner: Yes. Then you get deeply involved in such a field, and sometimes you get stuck in it.

It's why I have had so many specialties.

Kellogg: One of the lecturers at your symposium earlier this week was of course Bernie Vonnegut, who is very much into atmospheric electricity, and makes a point that there are both polarities, the thunderstorms are both polarities on occasion.

Kuettner: Yes, lightning. It is really only through the lightning that works that we have built in the last five or ten years that we have displayed _____, and also at NCAR, that you see that, by far the majority are negative charges brought down, but in a certain stage of the squall line, a positive, a reversal of the field seems to occur in the wake of the thunderstorm; you don't know really why.

Kellogg: In the wake of a thunderstorm?

Kuettner: Yeah, in the wake of a front or squall line.

Kellogg: Behind the squall line.

Kuettner: Yes.

Kellogg: That's curious, and you don't know why?

Kuettner: No. There are speculations such as more cirrus that has been formed, but these things record only ground strokes. The major activity is really at higher levels.

And other things fully explained, but I'm not really active in this field anymore.

Kellogg: When you were active in it, did you do any flying in and around thunderstorms to probe it?

Kuettner: No, I never did, but you know that at NCAR it was done.

We see the Explorer sailplane… Actually I got the Explorer sail plane through the chief pilot of Pan American, who had a rich friend that made a scientific foundation, and they gave it to me, and at that time I was at NOAA, and I gave it to NCAR, and it has been there ever since.

Kellogg: It is still flying, the Explorer sailplane?

Kuettner: It is still flying, and it has the great advantage that it is a metal plane. As a consequence, you sit as a pilot in the front of the cage.

Kellogg: Oh yes.

Kuettner: On modern sailplanes, fiberglass sailplanes, you don't do that, and it is dangerous to fly into thunderstorms with these ships.

Kellogg: You mentioned in connection with your soaring experience, which is kind of a leitmotif throughout your life I guess, the convective lines. You gave a talk about that at NCAR quite a few years ago, convective lines, streets, cloud streets, which I guess glider pilots use to suggest where to go to get the updrafts, but also used it on some fundamental work on that, I believe. Tell us a little bit about that.

Kuettner: Well, I think I started with this in Boston at the Air Force Cambridge Research Center, and like probably in your case, too much of your scientific work is done on the side. You have really to do something else. So that was just side work that I did privately. But there were so many of these cloud streets that you could actually use as a glider pilot to make long distance flights. You don't have to circle all the time. You could fly straight under them.

Kellogg: These were over land, as well as over water?

Kuettner: Yes, over land as well as over water, usually in outbreaks of cold air. It traveled out so that the wind profiles were completely different from what people thought. General opinion was that if the wind has a wind shear; in other words it increases same as height, then the cloud streets are formed under these conditions in the direction of the wind, of the—I would not say the surface wind, but it's interesting none of these conditions, the wind direction doesn't change with height much, it has to do with the thermal _____.

Now I saw these cloud streets from my window, and we had a radiosonde station there, and we looked at the wind profiles, and there was nothing of that shear. What you saw was a curved wind profile, like a jet. Whenever that appeared in the convective boundary layer, the cloud streets formed.

Kellogg: You mean there was a maximum wind at some level.

Kuettner: Precisely, and of course that raises an interesting thread of __________. And so, I developed a theory at this time that extended ______ the mechanism is very simple, no it is not so simple… It is so that in the well-known wave equations that applies to convection to mountain waves through everything, there is this Scorer Parameter.

Kellogg: What parameter?

Kuettner: Scorer, the English scientist.

Kellogg: The English scientist. Yes, I know, Scorer.

Kuettner: He became a close friend of mine. Anyway, but what happens is that if you have marginal stability, in another words it is not stable that would create waves, and it is not yet unstable, which would maybe create cumulonimbus, you are in a marginal state there, very indifferent equilibrium, then the curvature term is actually an inertial term and the wind has the opposite effect than the buoyancy term that creates these clouds.

: They have opposite signs. I mean the curvature is so strong, it is possible for the, well, it is an inertial term. I could go into it, but I don't want to, it is too long. Anyway, that term contacts the other one. There is only one way to get around this term for convection to start that is to line up in the direction of the wind because then the rotation in these cells, convective cells, are normal to this term. In that direction, there is no counteraction against the buoyancy. So, you, among the many, many directions that it can be taking, among the many, many forms of cells that was one of the things that Bernard really already discovered that had no preferred orientation. He didn't know why, but here you could see the reason was that the ______ provides a ______ the convection, and so the cells have to orientate themselves in a direction in which this term is not felt, and, I think people are still not quite convinced that this is correct, because shear is easier to handle, but shear can also cause it. Only, it doesn't occur in the atmosphere. The linear shear is very rare.

Kellogg: Linear shear.

Kuettner: Yes. This is a linear shear term that is also in there. It is actually much weaker than the curvature term. But it's kind of an involved theory, and I think maybe some people did not understand.

Kellogg: In what time period did you publish on this subject?

Kuettner: Over a long time. Because it was before the satellite age, which you predicted so well, that you really…

Kuettner: Before that, we, you did not know how the atmosphere really looked from above. There I wrote a paper about the advanced structure of the atmosphere. I estimated that there would be a very large part of the cloudiness would show a street-type development.

Kellogg: Even before we had satellites.

Kuettner: Yes, before satellites.

Kellogg: You could see them from a glider, from an aircraft too probably.

Kuettner: Yes, yes. Yes, they are being used by gliders all of the time, but you could not really estimate how frequent they are, whether they occur over the oceans and so on. So that was just before that. Then, when the satellite age came, I should have proved that the, that they are widespread, that this is correct, but instead, I got into this Space Age and left meteorology, you know.

I told you about that.

And so when I joined the Mercury Project, project, it was such an exciting and high-pressure thing, that I forgot about all of the clouds. But later on, when this was over, and the Apollo Project had been finished, I returned to meteorology, and then I wrote the theoretic paper about it. So it went over a long time.

Kellogg: The theoretical paper would have been around …

Kuettner: In the 70's.

Kellogg: In the 70's, 1970's.

Kuettner: Yes, yes, I think I wrote two.

: Yes, I wrote in the 70's. I could give a list of publications if you need it, I have…

Kellogg: I think giving a rough indication of the time period, just for, do you remember what journal it was in just in case somebody wants to refer to it? Where did you publish? You don't need to go into great detail, but I just thought somebody might like to follow up on this.

Kuettner: No, I could find that quickly. The first one that I mentioned was in 1959 and **Tellus.**

Yes, it was a long paper, ____ pages or so. Then, after all of these manned space flight publications…

Kellogg: You would have wrote a great many papers on the manned space flight.

Kuettner: Oh yes, a lot.

Kellogg: Everybody wanted to know about that.

Kuettner: I think it is here, around this time. "Cloud banks in the atmosphere."

Kellogg: Clouds streets again, OK.

Kuettner: "….observation and theory," **Tellus**, 1971

It was again about a near 25 pages, yes.

Kellogg: Okay good, well that is a good lead if anybody wanted to follow-up on this.

Kuettner: There came a long intermission, and then we discovered ____________ gliding the thermal waves.

Kellogg: The thermal waves?

Kuettner: Gravity waves on top of these cumulus clouds, not only of the cumulus clouds, but on top of the cloud streets.

There again discovered by gliders because you could suddenly climb outside the clouds, which was very strange. And we investigated systematically—it was a project at NCAR, with various aircraft, sometimes three aircraft out over the ocean, with LIDAR so that you could see them. And it turned out they reached into the stratosphere. Just acting like mountains, as obstacles.

Kellogg: The cumulus cells were pushing up into the upper troposphere and acting like mountains.

Kuettner: Yes. They usually have an inversion on top, but you need a certain shear in order to get this obstacle affect. It is amazing how small the shear is that you need, and it almost occurs all the time. So when you see a cumulus, you just have a completely clear day, when glider pilots fly in the thermals the atmosphere is full of gravity base on top of them that you cannot see because they are so dry up there. So that has a little to do with this, but it is a new field, you know. Then we made numerical models with Terry Clark and you could see that convection starts as a certain spacing between clouds.

Then the gravity waves begin to form, and as they extend upwards, and fill the troposphere, they take on their own wave length, the natural wavelength, and that one feeds back into the boundary layer. The convective boundary layer can be very high, you know here, especially goes to 20,000 feet. It feeds back and reorganizes the convection _____.

You see there comes a downdraft that suppresses the uplift below, and so they begin to cooperate, they have a joint system.

Kellogg: I'm, going to interject by saying that I wish instead of just having a tape recorder we could have a video of your hands as you talk about these things. You are very expressive in your hands in describing these motions.

Now around here, we see of course the mountain waves form by the Rockies going out into the plain for many miles, hundreds of miles, I guess.

Kuettner: Yes, yes.

Kellogg: Is that related to the thing that you have just been describing? Those are probably driven by the motion over the mountains, isn't it?

Kuettner: You have a good point because you should not mix up these two systems and misinterpret them. So for example when we went with our aircraft, NCAR aircraft and NASA aircraft, we went to an area where we thought the wind profiles are right and so on. Let's say to Texas or Nebraska.

Kellogg: A flat area.

Kuettner: Always went at least 300 kilometers away from any mountains. And just as you said, he aircraft that make their ferry first into this area, pretty high, almost always measure the mountain waves. It's amazing how—they are probably trapped in a layer, but it is amazing how, if you go at 30,000 feet, westerly winds will always see the mountain waves in your records of vertical motion. And you don't see them; and they have a large wavelength. Much larger than the convection waves that I was talking about.

Kellogg: Yes.

Kuettner: And so they slowly die out, 200-300 kilometers. Now comes the cumulus fields, and suddenly they start again with a much smaller wavelength. But you can distinguish them.

Kellogg: Yes. It is interesting that you, as I have noticed for many decades as I come and go from Denver, as you fly back to Denver, the first sign that you are approaching Denver, which is long before you are landing, is the first bump of the mountain wave.

Kuettner: Isn't it?

Kellogg: Oh, yes, it's amazing how often that happens.

Kuettner: Yes.

Kellogg: Well now, of course you became first interested in these things as a glider pilot, and you were involved in the famous Sierra Wave Project. That was where you and I, we were at UCLA together. I was a graduate student just getting my PhD, and you were there with the Mountain Wave Project, and Jim Menninger worked with you and so forth.

Kuettner: Right.

Kellogg: And I remember getting to know you a little bit. We were working in quite different areas. You haven't talked much about mountain waves, the Sierra Wave Project, but we just touched on them now. You were really more interested in the waves that formed thermally away from the mountains it appears.

Kuettner: No, no. No, no. At that time…they were not discovered.

Kellogg: Oh, so, they weren't discovered, those.

Kuettner: Not yet.

Kellogg: I see.

Kuettner: No. The reason of the mountain waves was, that I was involved in the discovery of the mountain waves because they were discovered by glider pilots, and it was close to where I lived in Riesengebirge, and so the moment they were discovered, I taught myself to fly them, and actually nobody knew how high they reached, and nobody thought of using oxygen. Actually at this time there were no jets or nothing, so people didn't use oxygen, and I went with a glider up there, and the altimeter went only to 3 kilometers, 10,000 feet. However, I had a barograph and a thermograph underneath. It was an open glider, and I just tried to fly as high as it carries the wave. I had no idea how high it was. It was really 7,000 meters, 23,000 feet without oxygen, and the interpretation at this time of the lenticular lens clouds, ____________, was that it can't be on the lee side. I mean if you want to fly with a glider, you fly on the upward side of a mountain wave. On the downward side you have downdraft, and you can't fly there…

So, there were three interpretations from that. One was that this is a backwards tilted upwind from the upwind side of the slope, you know? Because the clouds were sitting in the lee, very high, so /maybe it was a tilt, a backwards tilt for some reason of the slope updrafts.

Second was it is a lee vortex that reaches very high. Now I explored it also with a glider, and this lee vortex, it doesn't reach that high. The third was that it could be a wave motion, and because it was discovered far away from a big mountain range, there was a possibility that there are waves in between, that really the large mountain range created it. Now in my dissertation I proved that.

Kellogg: That it was a wave.

Kuettner: That it is a wave motion, a lee wave, and in the second part, I established a theory of the mountain wave. It was the first one.

Kellogg: Yes.

Kuettner: It was used already as a critical ______________ without knowing the name of _____.

And that was in the beginning of WWII, and when I published it my colleagues of course, in Germany, and the Russians too knew of that work. But then with the catastrophe of the war, all of the scientific work was discontinued, and the journal, which was a famous journal at this time, I take it, was discontinued. The Americans never read the paper written in German. You know, I didn't know that when I came to America.

Kellogg: Yes I'm afraid Americans are very lazy when it comes to other languages.

Kuettner: And I didn't take the time to publish _____. Later on when the German scientific youth again began to work—it was scientifically such a catastrophe in Hitler's time—all of the great scientists were lost.

Kellogg: All of the what?

Kuettner: The great scientists.

Kellogg: Oh, yes.

Kuettner: Then these young people looked at the American literature that was _____ mainly, but it didn't read discontinued old journals. Nobody really, still now, knows about that.

But the group in California visited me on the Zugspitze. It was Dr. Klemperer, if you remember him. He was at Douglas in Los Angeles.

Kellogg: Yes, I remember him.

Kuettner: And he came over as a CIA man or something like that. He wanted scientific intelligence. He wanted to interview me because I had been, I had in a test department in the war, and we had among other things developed boundary layer controlled airplanes.

Kellogg: Boundary layer control for aeronautical purposes to control turbulence over a wing?

Kuettner: Right, it was controlled by blowing the boundary layer away from the surface, and at this rate you could get fantastic lift coefficients. It was, it is not being used for some reason, but it was a hot subject, and he wanted to know about it. Instead, we talked about gliding because he had the glider license number one.

Kellogg: Oh, he was a glider pilot, too.

Kuettner: Yes, he was famous, original glider pilot. Then he said well, we know about your work, the mountain wave, we want to start a project at UCLA. Can you come over to the U.S.? So I got into…

Kellogg: So Klemperer was the one who brought you. What was his first name?

Kuettner: Wolfgang.

Kellogg: It was Wolfgang. Because, he was a brother of Otto Klemperer, the conductor, I believe.

Kuettner: Yes.

Kellogg: Remarkable man. I remember meeting him on a number of occasions.

Kuettner: Yes, he was, a very intelligent guy.

Kellogg: Yes.

Kuettner: In all fields. He was a student of—why does the name not come to me.

Kellogg: Prandtl.

Kuettner: No, it was not Prandtl. The other guy who came to America.

Kellogg: Lettau?

Kuettner: No, no.

Kellogg: Lettau was in turbulence, of course.

Kuettner: Yeah, no he is Hungarian…

Kellogg: Well, don't worry about not being able to remember names because that's a problem that we all have…

Kuettner: You all have?

Kellogg: And, the expression is "let it drift in."

Kuettner: It's true; later it comes to you.

Kellogg: Wait until it comes to you.

Well, Joach, there is another area that is really in a sense quite a change from what you have been talking about, and that is the work that you have been doing more recently. You started with these big tropical international programs with BOMEX and all the alphabet soup of programs that were described in your earlier interview [with H. Taba]. But since then, there is the TOGA and there is the, the, the one that you just came back from—

Kuettner: CEPEX.

Kellogg: —which of course are much more recent, and they involve, as I understand it, the oceans, very much. Please update if you will on the reasons for these big international programs and what they hope to find, because I'm interested in climate change, of course, and the climate system, and so I would like to hear you summarize why we are working so hard in this area.

Kuettner: I didn't know much about this actually when I got first involved like it always is. It was so that the importance of sea-air interaction was recognized, and that was around 1969 or so.

Kellogg: This is not a new subject. Bjerknes and many others worked on air and sea interactions, but is it because of the need to incorporate more detailed information into the climate models that stimulated it, would you say?

Kuettner: Essentially, it was. I think Charney was at that time, very active to prove that extended forecasts are possible.

Kellogg: I remember.

Kuettner: Yes, and some people were involved in this; that two week forecasts should be possible, and actually the models seem to indicate that. But it was entirely dependent, the global models, on understanding the role of the oceans as a heat source of the general circulation.

Kuettner: So, I think it was Davidson, if you remember him?

Kellogg: Ben Davidson?

Kuettner: Ben Davidson designed this experiment; it was called BOMEX, in Barbados. 1969. And he wanted to take a cube of air of 500 x 500 km, and maybe _____through the tropopause, and measure all of the heat terms, advection terms, and so on, and see how, computing the water vapor of operations so ships around it and airplanes that flew every day.

Kellogg: A real 3dDimensional picture of this cube.

Kuettner: 3-dimensional picture. It was a small area compared to our later programs, but I had just come from NASA, and was at this time, as you may remember, we had something to do with each other at this time. I was the chief scientist from the satellite center. I think they always to have you as—

Kellogg: Yes, that was NOAA satellite center.

Kuettner: … I did that. So, since I knew Bob White from the time in Boston where we were at the same laboratory, and I had seen how field projects have to be prepared to the smallest detail if it should work, _____ how to do then, and Davidson died six months before the project. So Bob White said, "Can you take over this project?" I said I know nothing about sea-air interaction. He said well, I think you can learn that , and so I took over this project and I learned very fast about sea-air interaction, and found it also so interesting.

Kellogg: But you did know about big projects.

Kuettner: Yes, at that time I knew about that and that was probably _____, and it was a good learning experience because the ______ meteorological field projects were so _____ designed, or let's say, better conducted, compared to what I saw at NASA. Every detail was, but it's a different problem, _____ This is a very difficult laboratory, the atmosphere, but it needed even better planning. Well, since already GATE was already on the horizon; it was called TROMEX….I thought that would be a good exercise. I think BOMEX was not very well-conducted. I did my best, but I could see that the decision-making was not very well-designed. You could see, if you want to make your daily decisions, that how Herb Riehl and Charney would fight with each other, and the options were not prepared and so on .

Kellogg: Were you the director? Were you able to knock heads together and get them to agree? You had to, I suppose.

Kuettner: It was difficult at this time still because I knew that it should have all been prepared beforehand. Charney: we became very good friends, and I said why don't you act as a chief scientist now, and of course he wasn't really interested in doing it. He was interested in the work that he was doing, like all the others, too. He had a this "CISK" [*conditional instability of the second* kind] hypothesis at this time.

Kellogg: I remember.

Kuettner: So we agreed that we would put another four weeks at the end to chase the ITCZ, and see whether the CISK operates. So we had to go more to South America, North and South America. So we did that, but Charney was, in that regard, disappointed because he said on days where his own interest was not there, he said well, why don't you guys do what you want. Of course I cannot remember…that was hard to reverse that trend. Still the results were very interesting, but then came GATE you know, and…

Kellogg: That was very large.

Kuettner: He actually wanted to establish the heat action, how it works. And we could see that we need all scales from the planetary scale, down to the mesoscale, originally supposed to be over the Pacific. It would have been better, but it ended up over the Atlantic for political reasons I think, because the Russians would have had to go to _____, and the Europeans said that was too far away from us, and so that one was very carefully designed, and I practically _______________ scientists that existed in the world.

Kellogg: All what?

Kuettner: All the good scientists in the world. I had, so to speak, to my disposal. They came to Geneva; it was first operated out of Geneva. _______________ WMO and ICSU. They came for let's say three weeks, the convective people.

Kellogg: Were you living in Geneva yourself then?

Kuettner: Yes.

Kellogg: As a director.

Kuettner: Yes. Actually for two years we lived in, we moved the whole group to England. Because John Mason was a big supporter and wanted it there. It was interesting.

Anyway, that was very carefully prepared. There came situations like if you want to have the planetary scale presented in the Atlantic, we need ships to put radiosondes up, or NavAids wind measurement devices, on the planetary scales, and then we nested to smaller scales, synoptic scale, finally to the small scale. We counted the ships we needed…

END OF TAPE 1, SIDE 1

Interview of Joachim Kuettner

TAPE 1, SIDE 2

Kellogg: Okay, we were talking about GATE and the way that the project was designed.

Kuettner: What I wanted to say is that we came up with an estimate of 18 ships that we needed, and Smagorinsky was the chairman of the JOC at this time. He thought we should make an American study, and find out how many we needed.

Kellogg: Talk just a little louder, so that…

Kuettner: He also came up with this after the Russian's made an independent study, or came up with about the same number. So, but _____ and I made a plea to the nations that were involved, there were 75 nations involved, we made a plea for more ships, and we ended up with 40 ships. With these 40 ships, we could then cover all of the scales.

And so the project became very large, several thousand people, and of course, we also needed a lot of long-range aircraft to get out of the African continent influence.

Kellogg: They were based around Dakar, I suppose.

Kuettner: We were based in Dakar, but the ships were based in various harbors in South America. And there we had all options prepared. So we did not have to argue what we would do today. _____ option 4A is what we are talking about. If you don't know what that is, it's your own fault, you should have had … ____ preparation, that is why it worked so nicely I think.

And the decision making was always very democratic.

The main nations all could propose what they wanted to do. They came well prepared, and then we usually, at least I could manage to get them to agree. If this did not happen, it was very rare, then I would make the decision, and they obviously accepted it.

I think that gave so many results; GATE's still being worked on, especially on sea interaction, on radiation, on the cloud cluster development.

Kellogg: Yes.

Kuettner: And it gave actually the numbers that you need for the general circulation models.

Kellogg: . The most recent one is TOGA; there were others leading up to it though, which I think is, if I understand it right, there was even more emphasis on the oceans than there is on the structure of the water under the surface; nothing much had been done during GATE in that area, I don't think.

Kuettner: You see, that was the Global Atmospheric Research Program (GARP).

Kellogg: Yes.

Kuettner: And of course the oceanographers who owned these ships didn't like that, that they were just used for atmospheric measurements, so we had already engaged a pretty good oceanographic program, in fact, George ______ was a guy ______, who headed that up, and it was still an atmospheric program. In the meantime, you know with all of the models it had become clear that you need _____. And so, to record it—the ocean, the atmosphere in equal terms.

And it is really the first time that we worked that closely together.

Kellogg: The oceanographers and the meteorologists.

Kuettner: Yes. They were always separate. And it is really the first time that it was accomplished. It is mostly due to the two lead scientists, Roger Lucas from Hawaii, the oceanographer, and Peter Webster in the atmosphere.

Kellogg: Who was the oceanographer again?

Kuettner: Roger Lucas.

Kellogg: Roger Lucas?

Kuettner: University of Hawaii.

Kuettner: It was centered on the Western Pacific warm pool. And then, they also needed a lot of ships, I think they had 13 or something like that including Chinese ships, and they asked me to head up this project. They were somewhat reluctant because of my age, and I knew that it would be a tremendous strain.

Kellogg: Of course.

Kuettner: I said that I would lead it for the first year. In the meantime, they must find a successor, and so there was a search committee, which I had shared to find out who it could be, and we got Dave Carlson, who was an oceanographer, and he turned out to be, although he did not have much experience, he turned out to be magnificent.

Kellogg: Where was Dave Carlson based, where did he come from?

Kuettner: University of Oregon.

Kellogg: University of Oregon, okay.

Kuettner: Yes , and he is now the head of ATD.

Kellogg: Of what?

Kuettner: Of the Atmospheric Technology Division at NCAR.

Kellogg: Oh yes, oh that's Dave Carlson, yes. Well now did the same planning take place? I'm talking about TOGA-COARE now still. You must have started the planning, and then Dave Carlson took over…

Kuettner: Yes.

Kellogg: And how long, what, how long a period was that, from the planning to the time when it was actually accomplished?

Kuettner: Too short. I think it was two and a half years. You usually need three to four years for these big projects. It was even worse with the follow-up project of CEPEX, you know, that happened in the last year, where I was really in charge of it. You may not know what that is?

Kellogg: CEPEX.

Kuettner: CEPEX.

Kellogg: No, I don't think I do.

Kuettner: It is "Center of Equatorial Pacific Experiment." See the TOGA-COARE was concentrated in a small area, well, don't call it small, about maybe 500 km, in the center of the warm pool.

Kellogg: In the Western Pacific?

Kuettner: But in the meantime, ________________ had come up with the _____ idea, because this is an actual reported question. Why, of all oceans in the world, the sea surface temperature never exceeds 303.5 degrees, 3 or 4 occasionally. If you plot it, it is a cutoff like that. There must be some thermostat must prevent higher sea surface temperatures. Sea surface temperature has a big meaning for climate, I think you would be the first one to agree to that.

Kellogg: Oh, yes.

Kuettner: And so, the climate is somewhat constrained by that. The thermostat idea was originally a very simple one. It came from the many years of the ERBE satellite.

Kellogg: ERBE? (Asks spelling). I am saying some of these things for whoever has to transcribe.

Kuettner: ERBE. Energy, oh I forgot what it was for, but …

Kellogg: Earth Radiation, I think, or something like that, ERBE.

Kuettner: And, that indicated, that whenever the sea surface temperature rises somewhere, convection takes over, and shelters the ocean from the solar radiation, or the _____ radiation.

But the problem was that at the same time, with the sea surface, the super greenhouse effect operated, and it apparently was discovered at the same time, which gives a runaway effect in the long wave part of the spectrum, so that up to this point where the temperatures get that high, the water vapor does not play the important role, but when it comes to these temperatures around 30 degrees, according to the Clausius-Clapeyron equation.

Kellogg: Yes, mentioned the Clausius-Clapeyron equation, which shows how the energy required goes up very rapidly.

Kuettner: Very rapidly, _____, and now the ocean loses its capacity to get rid of its heat by radiation. Normally you would think that was, everybody thought that there was a main balance you know, the ocean radiates its heat out into space, where the water vapor is so intense now that it traps all of this heat, so the heat comes back except for a small amount, but it's enough to heat the ocean, and so more water vapor goes up, and at a certain point, which is very close to 300 degrees, at a certain point, the ocean can heat up as much as it doesn't get rid of the heat, it comes back from the water vapor. Now the other effect that I mentioned is short wave radiation, the solar radiation, that the cirrus clouds that form in convection, they spread very far in the _____, so that they would intercept this sort of radiation to counteract that runaway effect, which I was talking about that comes from the water vapor.

Kellogg: The first thing that you should have, what you call the super greenhouse.

Kuettner: Yes, yes, that is a super greenhouse. The greenhouse effect would be of course the trapping of heat.

Kellogg: Yes,

Kuettner: That it works unstably. And so that gave a very interesting theory, and here was a chance to measure that. Immediately after TOGA-COARE because all of these ships were still in the area…so it was a matter of extending certain measuring systems, including ships and aircraft.

Kellogg: And this agreement to extend TOGA-COARE been arrived at beforehand, or was it something that, that people took advantage of on the spur of the moment?

Kuettner: It was more on the spur of the moment. Actually, the National Science Foundation, Jay Fein, he came to me and said we have to do that next year, how can we do that, could you take that on, this project, because we don't think it can be successfully done on such short notice? The difficulty was that you now had to measure different sea surface temperatures. So you had to take the sea surface temperature gradient from the East Pacific to the West Pacific. Which meant that instead of working on 500 km, you had now to work over 4,000 km.

Kellogg: You had to extend your domain.

Kuettner: Yes, a very big domain, and so _____ ships, various instrumentation, integrated sounding systems, etc., and that thing became so exciting, and I got so interested in this, that now _____ and I writing papers about the results. As far as I can see they indicate that the thermostat is correct.

So it was was heavily attacked by many people because everybody saw that this __________________. So if you go into the warm pool, your _________________will increase because your ocean temperature is higher, it decreases.

Kellogg: But it's the cirrus cloud layer.

Kuettner: The cirrus clouds.

Kellogg: …is the key.

Kuettner: They take over.

Kellogg: I seem to remember that Ramanathan had this idea some time back, and he had been working on it.

Kuettner: Well, I thought that was a very fascinating project.

Kellogg: Yes.

Kuettner: And it was so focused, it wasn't so broad as GATE. GATE had 500 _____ projects from all countries that were taking advantage of all of the data we got.

Kellogg: I see.

Kuettner: And you had to accommodate them, we're second priority. Here we had a clearly focused experiment, and we got air cover like the ER-2 from NASA that could fly on top of the cells in the stratosphere, and the other aircraft below, and the evaporation measure at the sea surface. They flew 10,000 km at 100 feet, very dangerous, fantastic balance.

Kellogg: 100 feet, really just skimming the waves.

Kuettner: Very dangerous. You can so easily ditch at 100 feet.

Kellogg: Yeah. When did TOGA-COARE and CEPEX finish up?

Kuettner: Well, TOGA-COARE ended on the end of February, 1993, last year. And, CEPEX started I think on the 5th of March, about a week later.

Kellogg: I see. And that was in 1993, it, it, it, how long did CEPEX last?

Kuettner: Very short, only six weeks. In April it was finished.

Kellogg: Yeah. Now, in your previous interview, Joach, you mentioned the importance, that, you…

Kuettner: No, I'm not in a hurry.

Kellogg: Okay.

Kuettner: I just see that my wife's….

Kellogg: I think that we can wind it up in another 15 minutes.

Kuettner: Yes, that would work.

Kellogg: Anyway's.

Kuettner: Yeah, yeah.

Kellogg: You mentioned the importance of arranging for the data. Now, in the days of computers, of course, we are able to handle data a lot better than we could in the early days. What, in these most recent international programs, how is the data handled? Can you briefly summarize the flow of the data, where it's kept, and how it goes back out to the scientists? This has always been a big problem with NASA's space experiments of course. The handling of the data, and getting it out.

Kuettner: Yes. Let me go a little bit. That was the weakest part of the BOMEX project, that people could not get their hands on the data.

Kellogg: I've heard this.

Kuettner: Because it was not prepared. I didn't have time; it was half a year, and I had not much experience with that because NASA had its specialists in this area.

Kellogg: Wasn't it Josh Holland that came down to try and straighten this out?

Kuettner: Josh Holland tried it, and as far as he could, he did a very good job but the data was primarily available to his group.

For the others it was more difficult because there's this problem that special data are kept or processed by special people at universities. You cannot really force them to come up with the results at this time and make it available to the whole community. So in GATE we changed that. In GATE it was done, we still didn't have the speed that we have today, but the principle was so that we had I think we had five sub-programs. Let's take an example. The radiation sub-program was handled by the Soviet Union, and the data center was in Leningrad. Each of the participating nations had a national data center, but they had to give the radiation data to Leningrad. The oceanographic data went to France to Brest.

The convective data went to Washington and so on, and there was a schedule set-up, that within 18 months all of the data must be available to everybody in the world.

Kellogg: 18 months.

Kuettner: 18 months. _____ was 18 months, it is always under-estimated. But about two and a half years _____. Now here, things, of course, today can be done so much easier. For example all of the data that are have taken in the field, you call operational data, let's take all the soundings that are done, with whatever system, these soundings are immediately available, so at the end of the project, there is a certain part, a large part, that is already available.

Kellogg: Are we talking about, are we still talking about GATE?

Kuettner: No, I'm talking now about TOGA-COARE.

Kellogg: Oh, about the most recent one, okay.

Kuettner: Yes.

Kellogg: So this is an improvement.

Kuettner: A tremendous improvement. Still, there are so many special data.

Let's say a ship makes a certain type of measurement that the other ships cannot do, and these are very experienced oceanographers they were; this has to be calibrated, _____, will take me another half a year.

So what they did, they made a workshop with say 280 scientists, ______________________, two months ago, a two week workshop, with numerous work stations, I think 30 work stations, where in the discussion they could immediately go to the data to…

Kellogg: That's amazing, 280 scientists, gathered more than a year after the experiment was over…

Kuettner: Yes, yes.

Kellogg: To massage the data.

Kuettner: And compare.

Kellogg: That's amazing.

Kuettner: Yeah, that's a way to do…

Kellogg: I hadn't heard about that, that's never been done that way before has it?

Kuettner: No.

Kellogg: I didn't think so.

Kuettner: No.

Kellogg: And was CEPEX included in that…?

Kuettner: No, it was a separate thing, but CEPEX works the same way, and it has _____ integrated data center for all of the participating scientists, in La Jolla, at _____ Center for…

Kellogg: At Scripps.

Kuettner: And he has some fantastic people there. There, the data are not only collected, but they are already formatted, transferred to formatting that they have into a standard format…

And plotted on the same type of charts, of course they are in digital form, but I have seen it working for the first time in our workshop, the CEPEX workshop, which was just held last month in Santa Fe, and that is really amazing to me.

We asked the leader of that coop: Look we are getting these quantities. Let's put in our equation and see what comes out, and 3 minutes later it is plotted, and the equation _________________.

Kuettner: That's a big difference.

Kellogg: Yes. Those of us who lived a while find the computer age something astonishing, at least I do, as to what they can do with computers, and the young people who play on computers like with a big organ.

Kuettner: Isn't it? We cannot keep up with them.

Kellogg: They seem so at home using the computers. And it would be hopeless without that. Now one other, briefly. You were involved with STORM, which was another project, which occurred after the WMO interview. Just briefly tell us about STORM, because that was of course a mesoscale experiment here in the US off the Atlantic Coast.

Kuettner: Yes, the STORM project, the basic idea was very good. I remember when I first came back from some project, Bob White was still here is president of UCAR, and he immediately called me when I came back and said, look at this document, we have prepared here a mesoscale experiment we call it STORM. I want you to get involved in that. It resulted in an enormous effort in my opinion of the scientific community of the United States; in putting the program together in a form that can be handled practically, it was very ambitious. It required so many sophisticated measurements, and to cover the almost unknown mesoscale in all of these areas by a field experiment seemed to be very difficult.

Kuettner: That was the main idea of course, to create a field experiment to do that, and we wanted to do that in three phases. One was in the Central United States, and then a year later taking the US to the East Coast, and the year later to the West Coast with all kinds of expensive equipment like the wind profiler—you know, there was a network of profilers actually installed, 30 of them. .

Kellogg: And aircraft of course.

Kuettner: Yes, lots of aircraft, and there were a great number of meetings in which and kind of an experiment design effort of a large magnitude was done. It somehow fell into an unfortunate financial period in which new initiatives apparently were not successful. It's a similar thing like if you try something very big like the superconductor collider, you know? The plans went forward, but the budgets didn't get through.

And so the scientific community, I think that's my present judgment, got somewhat discouraged, that they put so much effort into something that drags its feet so long, and then they gave it a new name, and there was more push behind it, and more—it was called the "Weather Research Program," which in my personal opinion is a dumb title because it could be anything.

Kellogg: Yes, that's pretty broad.

Kuettner: It was already broad, and so now some good people are trying to revive this. I hope they are successful because it is a very good program.

Kellogg: It is largely NOAA that is sponsoring it?

Kuettner: Let's say supposedly, in a non-financial form, yes, it would be NOAA, but the other agencies, especially the National Science Foundation…

Kellogg: Is paying for it?

Kuettner: Well, all of the agencies…

Kellogg: Yes.

Kuettner: I think today you have more with the joint financing. The Department of Energy is very interested in this.

Kellogg: Yes, right.

Kellogg: Department of Defense probably?

Kuettner: Yes, and hydrologists are interested in it, and yes, of course…

Kellogg: NASA.

Kuettner: So it's a multi-agency affair, and I don't know what the latest status is. But Rit Carbone has given up his position as head of the Atmospheric Technology Division to take for NCAR over the leadership in this.

Kellogg: It may have a new life then?

Kuettner: Yeah. I hope it will, this time work.

Kellogg: Now STORM did take place as a field experiment for a short time several years ago.

Kuettner: You know that?

Kellogg: Yes, I read about it.

Kuettner: Yes. It was, well, the idea was that you have to start with a kind of a reversal _____, and experiment that is not too expensive, too ambitious, and prove that the design works…pretty expensive, and complicated instrumentation ______________________, for example, introduced a boundary layer array, nested instrumentation. And that one worked fine, but the big one still has not been proved _________.

Kellogg: It was pretty big to begin with. The final one will be even bigger, I guess.

Kuettner: Yes, much more.

Kellogg: Yes, yes. Well Joach, I think we've covered most of the important things; then [when] I get home I will think about our talk, and I'll remember all of the things that I forgot to ask you about. But it seems to me that this has been a very good way of updating your previous interview of six years, seven years ago, and I appreciate your lending yourself to this project to tape your experiences, which of course include a great many other people. Thank you, Joach. So I guess we will sign off now unless you have something more that you want to add?

Kuettner: No, it's a real pleasure. I wish I could interview you because I'm wondering what you think about these days.

Kellogg: Well, obviously yours and my paths have intersected off and on. They haven't run parallel very much, but they have certainly intersected through the years, and it's great fun for me to get brought up to date on some of these things that I read about, and hear about. So I guess we will call it a day then.

Kuettner: Good.

Kellogg: It's late in the afternoon…

Kuettner: Yes.

Kellogg: And thank you for your efforts. Switching off…

END OF INTERVIEW