UNIVERSITY OF HOUSTON
ORAL HISTORY OF HOUSTON PROJECT

Interview with: Dr. Bernard Rappenglueck
Interviewed by: **Carla Curtis**
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CC: We are at the University of Houston in the office of Dr. Bernard Rappenglueck, Associate Professor for Atmospheric Science. This is Carla Curtis and we are conducting an interview for the Center for Public History. Good morning, Dr. Rappenglueck.

BR: Good morning, Carla.

CC: You are here doing a specific study on air quality control. Could you elaborate on what the study is about?

BR: O.K., that is correct. During this summer, we will have a very big campaign in the Houston area and it will be carried out in August and September. There will be different various measurement sites, ground measurement sites, also airborne measurements will be carried out and we will have the Ronald Brown from _____, a ship which will be cruising in Galveston Bay and the purpose of this investigation is just let's say a follow-up of the previous study in the year 2000, was called Texas 2000. Right now, this campaign will be called Texas 2 and we will be looking into what has happened in between since 2000. Maybe emissions have changed in the Houston area. We've got a lot of emission sources, traffic sources, industrial sources, and maybe there have been some changes. We also want to verify the emissions so we can properly use them in atmospheric air chemistry modeling and we want to have a closer look into some processes in air chemistry. So, we will have a supersite here on the U of H campus in particular and we will have a variety of measurements for specific compounds so that we

can really check specific reaction changes that are involved with precursor compounds such as NO- nitrogen oxides and hydrocarbons which will react during the day and also during the night time with other compounds and will also be fertilized by the sunlight and will form secondary species and radicals as well. Those species will react further on and eventually produce secondary species such as ozone and air oxyacetone nitrites which are a combination of NO and hydrocarbons, and which may be transported out of the Houston area and may have an effect, have an impact, on both vegetation and human beings just down wind of the emission sources. And so, this is the bottom line we are looking at during this campaign in this year – looking into the emissions of the Greater Houston area with all its diversity, checking what sort of compounds are being emitted and how much and what are they going to produce. And here at U of H, we have got a very advanced air chemistry modeling – it is called CMAC – and this model is able to describe explicitly specific compounds within the hydrocarbon complex, for instance, so we can more easily trace back those compounds to emission sources and investigate their fate during those reactions in the atmosphere.

CC: If the equipment is going to be here at the University, how would you track emission sources, plants along the Ship Channel?

BR: O.K., we will not only have this supersite here at the U of H campus. There will be other sites as well. For instance, the Ship Ronald Brown will cruise close to the Ship Channel. We will also have access to the data sets of the auto GCs and the ground signs that are located over there in the Ship Channel. We will have aircrafts flying over the Ship Channel and over the Houston area. And so, we will put all this data together, being closer to the emission sources, for instance, having those sites there, and being a little bit

far away so we can investigate the photochemical processing. This will occur, for instance, here at the U of H campus. There will be another site at the Williams Tower in the Galleria Area, so there may be further processing going on. And so, we will have a broader picture of the Houston area. And we will investigate specific compounds that we know are released from those areas – ethylene, propylene, and 1,3-butadiene, for instance or aromatic components from traffic and we will just investigate their fate along trajectories in the atmosphere. So, meteorology ties in on this problem and we will also have specific investigation in meteorology, we will have, for instance, radiosonde launching as well. So we really retrieve information within the boundary layer during the daytime or we can have a look into the development of the boundary layer so we can see what will be the distribution of those species.

CC: You said this originated from the study done in Texas 2000.

BR: Yes, this was the very first thought so before there was not matched activity here in the Houston area and so it was the first approach to get an idea of what is the air quality in Houston. Some high ozone winds were observed. Some high short-term ozone winds. And there were also some aircraft measurements and they took hydrocarbon samples and they observed that those samples, those results, were somehow higher than expected. And so, there were some sort of differences between those measurements and the emission inventory at that time.

CC: But what they were reporting was different than what they were finding?

BR: Yes, there were some discrepancies, let's put it this way. So, the model was not able using this emission inventory to validate those concentrations that were found.

CC: Do you know what prompted this study originally?

BR: This one, in Texas 2?

CC: The original one in Texas 2000 and then also Texas 2.

BR: I am not quite aware of this history because I am relatively new to the Houston community. And so, Texas 2000 is almost 6 years ago. And I thought it was a combination within different sponsoring agencies just NSF and DOE who wanted to initiate scientific project without any other ideas- just scientific project. And this Texas 2 study is a combination of various sources who are just interested and there are some fans coming from PCQ, from HARC- Houston Advanced Research Center- and also from EPA. There are some groups coming from NOA with their own funds and some other specific universities who just want to join together because Texas 2 laid the foundation or gave some sort of impetus for the local government to initiate a specific research also including Texas scientists. And since the year 2002, 2003, we have got an atmospheric science group here at U of H and this was a consequence of the Texas 2000 study. So basically, this study will also be coordinated by scientists here in the Texas and the Houston area.

CC: O.K., and so you are going to end up taking additional measurements and you now also have the equipment to see specific compounds more than ...

BR: Yes. For instance, we can see some very short time intermediates, radicals, OH radicals. We will have this type of instrumentation here on the Moody Towers which is very important because OH is being produced in the reaction between ozone and water vapor and sunlight, and OH is the driving force in atmospheric chemistry which will attack a variety of compounds in the atmosphere, for instance, hydrocarbons, and will lead to degradation of those hydrocarbons and those hydrocarbons will be able to initiate

oxidation ofNO to N02 which will be photolysed and subsequently form ozone. So, this species which have a very short atmospheric lifetime, this is the first time that those species will be measured here. Also, apart from those species, it is very important to have a look into the nighttime chemistry. This was not a focus in Texas 2000 because nighttime chemistry is also associated with nitrogen oxides and also with ozone. And we have a lower boundary layer during the night time. So, a lot of those species will be kept below this inversion layer during the nighttime. Other species will remain above this inversion layer. For instance, if you have got ozone, it will stay above the inversion layer and will be stable because NO, which is emitted from the ground from traffic, will not interfere, will not react with this ozone because we have got an inversion layer. So, this ozone will be stored. It is in a so-called residual layer. It will just be stored. And during the following day when we have got more sunlight, this inversion layer will eventually break up during the morning hours and so we will have additional transport coming from precursors from ozone from the previous day which will be mixed into the fresh emissions. So, this is something that happens during the night time and this is something which will be a new focus in this investigation. We will have long path _____ measurements from the Moody Towers. This is a method which uses specific light which will be absorbed by specific compounds and this light will be sent out from the Moody Towers for instance and will be reflected by other towers in the downtown area or the Williams tower. So, you can measure the species which are located within this pathway of this light B. And so, you can measure what is going on along this way and especially during the night time when we have got low inversion ---·' sometimes lower than the tallest skyscrapers. So, we will retrieve information from two different layers – the

boundary layer during the nighttime and also the residual layer above the inversion layer. So, this is something that is new compared with the study in Texas 2000.

CC: The mayor had conducted a study on air quality in Houston and they focused on two specific chemicals – benzene and 1,3-butadiene. Is that found more in the Ship Channel area or is that still found all throughout Houston?

BR: Those are two specific compounds and benzene is basically related to traffic. So, traffic, you will find throughout the Houston area, for sure. Basically along the highways.

CC: So, benzene is not just for oil companies, refineries . . .

BR: Not the real focus of those refineries. Benzene may be emitted by any type of fuel but the major source is exhaust coming from the traffic. 1,3-butadiene is basically emitted from companies dealing with plastics and rubber and so it is also located in the Ship Channel because we have got other companies over there and they are only refineries.

CC: Chemical plants?

BR: That is it. Exactly. And so, those two species are important for, let's say, more or less two different reasons. O.K., they come from different sources. Benzene is a very important compound in terms of formation of cancer and it is not that reactive but it can be accumulated in the human's body and eventually produce cancer. So it is important to check, for instance, long-term values of benzene, for instance, annual values, annual means. And it is not very reactive in terms of photochemistry; whereas, 1,3-butadiene is, on the one hand, unhealthy, on the other hand, it is reacting fast. So, it may produce other species on a local basis. Other species such as carbonyls or ozone or whatsoever

which may be also unhealthy or their combination among themselves may be even more unhealthy.

CC: Does 1,3-butadiene also cause cancer?

BR: Yes, in the long run, but it has not been established in that way as it has been for benzene.

CC: And what about the ethylene or propylene?

BR: In terms of atmospheric chemistry, they are very important because they are very fast reacting species. They have got the double bond, they are _____ and for this reason, they react fast, they will break down easily. They react with OH. They also react with ozone. So, once they appear, they will be removed rapidly.

CC: They don't stay in the atmosphere?

BR: That is it. They will not be transported. They will produce a zone in terms of a very short-term ozone peak. And you can easily observe this kind of peak just depending on the wind direction. We have already seen those things at the Moody Towers just depending on the wind direction, you will all of a sudden see a high ozone event. This is the most important impact of those species in terms of photochemistry and producing species that have a longer lifetime and that are more unhealthy than ethylene and propylene themselves.

CC: Now, you also work with the Texas Commission on Environmental Quality.

BR: Yes.

CC: Have they changed their emissions standards at all since 2000 or will this study help to . . .

BR: The bottom line is that this study will definitely help. It always takes a long time to establish new emission inventories and once those new emission inventories are available, some years have passed already so this is definitely a big step - having this campaign and being available to validate emission inventories.

CC: Well, it has been reported that the standards in Texas are different than standards in other states. Is this not a country-wide regulation or each state makes their own emissions standards?

BR: I am not really aware of what is going on in the different states. As far as I know, there should be common standards, yes, but I do not really know the details about this.

CC: Are any of these new chemicals that you all are finding linked to any health hazards- the ones that you are being able to identify now.

BR: Yes, there is a broad range ofthose. We have got precursors that are unhealthy- just depending on the concentrations, maybe benzene. There are also other solvents. There may be CO if you are just close to the traffic and you get too much of it. So, it just depends where you are located and what species you are looking to. Basically, as long as the precursors are concerned, it is benzene of major concern and 1,3-butadiene. We will not look into halogenated compounds but those are not . . . they have some slight impact on the ozone but it is not the focus of this study.

CC: Hyalogenic compounds?

BR: Hyalogenic. They are some chlorinated compounds.

CC: So, what new ones have you already identified?

BR: They are not really new ones in this sense.

CC: Well, but I am saying, that were not identified in Texas 2000.

BR: Yes, I know what you mean but we are not looking into real new ones as far as precursors or secondary species are concerned. We are looking into those intermediates, those radicals, for instance, that are helping to produce other compounds but they are really short-term compounds and, again, they have not been measured during Texas 2000. They are just helping to produce other compounds and we need the information about those certain compounds to validate the model, to validate the processes so that we can forecast the secondary compounds such as ozone with a higher accuracy in the future.

CC: And you were talking to me earlier about Dr. Byun who had invented the new . . .

BR: Ion.

CC: He invented a new algorithm?

BR: Yes. Let's say he is the father of specific air chemistry modeling. He developed it at EPA and this model is able to describe explicitly some hydrocarbons. Usually, those hydrocarbons . . . well, you can measure a huge number of hydrocarbons and _____ which are located in the Ship Channel, usually measure 50 or 60 pounds, basically, 56 compounds, but if you are taking those compounds into a model, it will take you a really long time to calculate all those specific reaction chains. And so, usually what they do is they lump specific hydrocarbons into specific groups of almost the same reactivity. So, we are looking into , into fast-reacting _____and ethylene and propylene are just summed up with other _____and so you don't have specific information on those. This is the same for aromatic compounds. So, on one hand, we have got benzene, for instance, but the higher aromatic compounds are usually lumped together. So, we don't have specific information but we want to know the specific impact coming from specific compounds because here in Houston, we've got specific sources for ethylene and

propylene and we want to know their fate not only in the atmosphere but also in the model. So, this model is the first model who is able to check the specific pathways of those hydrocarbons and this is really important.

CC: So, it actually breaks them down even further?

BR: Yes. Not all of those but if you want to look into specific ones, you can extract this information from the hydrocarbons from the lumped hydrocarbons.

CC: And this will detail the study even further?

BR: Yes, because previously, we did not have this tool.

CC: And what are the plans with the reports? What do they plan to do with this information?

BR: Well, we are hoping that this campaign will be successful and afterwards, we are going to present those results. We are scientists and we will write publications and we will present the results in conferences. We will also have communications with the mayor. We are hoping that ... well, we don't know the results yet. We are just observing the atmosphere. We are hoping that there will be an interesting discussion going on later on and it will help to better the air quality situation here in Houston.

CC: So, you all will be making recommendations?

BR: Not detailed recommendations because we are looking into those specific species and we will try to trace back them to evaluate their impacts and given those observations, we will make visible what is going on here in Houston so that everybody is able to understand and everybody can come up to their own conclusions and their own recommendations because they will be just observations.

CC: And those around refineries can move fast!

BR: Maybe.

CC: And so, this is basically something that EPA is also interested in?

BR: For sure. Yes, definitely.

CC: You also had mentioned before about refinery emissions were underestimated. That is something that you still see happening or have you not gotten that far enough to monitoring?

BR: It is complicated, to tell you the truth because refineries have specific emissions, let's say, standard emissions, but sometimes there are also some high emissions - some, let's say, releases- that are causing some peak events but those releases that are done on an irregular time schedule cannot be really estimated or assessed in an easy way because they are irregular and you cannot easily model those events because they happen just within a couple of minutes or half an hour and you cannot forecast those releases - you can't have a specific background emission inventory and we are going to validate once again the sort of emission inventory. But apart from this emission inventory, we have additionally those releases.

CC: Do you have the equipment to be able to validate the leaks that come out on a daily basis or will it just be planes flying over to see what is emitting?

BR: There will be an additional project. There will be a group coming from Sweden and there will be a project called Solar Fluxes and they have got an instrumentation based on a remote sensing that is able to detect fluxes, area fluxes, from specific sources and to detect hydrocarbon fluxes, not only hydrocarbon concentrations but also hydrocarbon fluxes. They want to set up the instrumentation at specific sites in the Ship Channel and also at power plants just to have a closer look into those emissions

and in combination with those other measurements- aircraft and ground-based measurements - we will try to reconcile those emissions.

CC: So, that would include the leaks?

BR: Yes, definitely.

CC: Were they measured at all in 2000?

BR: Not really. It was, let's say, just a first approach to get an idea and afterwards, the community became aware of those problems.

CC: Have any been fixed, to your knowledge?

BR: I am not aware of those developments.

CC: So, these new instruments they have, were they more accurate than what we have had in the past?

BR: Well, this sort of instrumentation did not exist at that time.

CC: It is new?

BR: It is new.

CC: And it was invented in Sweden?

BR: I think so, it was basically developed . . . it is the leading group over there.

CC: Is it used throughout the world or is this the first time it will be used . . .

BR: It has been used in various places and specifically also in refineries in Sweden and it has also been used in Mexico City, the campaign. So, in the meantime, it is an established method but it is a very new thing here in Houston.

CC: So, it hasn't been used very much in this country?

BR: No.

CC: This report, I will be very interested to read. Just to go into this study more, how many people are working on this project?

BR: Oh, well, I cannot tell you exactly those numbers. Here at U ofH ... well, it includes more or less 10 groups, I guess, and the overall number of all the people coming and going because they will not stay all the time - there will be exchange of personnel stuff ... including our personnel, it will be about 50 or 55 people.

CC: And they will be from where?

BR: There are some from Texas A&M, from Rice, from _____, from University of New Hampshire, from Penn State University, from Georgia Tech, from Portland State University, from UCLA. I am hoping I have ...

CC: That is half the United States!

BR: Yes, basically.

CC: I understand Texas 2000 was more international.

BR: It was. Let's put it this way: Most of the scientists or almost all of the scientists during Texas 2000 came from other states within the U.S. There were some collaborators coming from Europe as well but it was a smaller fraction. So, I think it was about 90% U.S. scientists but maybe almost none or a very small fraction coming from Texas.

CC: Will there be international scientists besides yourself and Dr. Byun?

BR: To Texas 2?

CC: Yes.

BR: I think there will be a couple of them but basically, the science groups will come from the U.S. apart from this Solar _____ Flux measurements because this will be provided by a Swedish group. All the other groups are U.S. groups.

CC: So, this is an international effort to try and study air quality?

BR: Yes but again, it will only be one group coming from abroad. So again, 90%, I guess, will be coming from the U.S. and more from Texas this time, definitely.

CC: So, Texas has decided to be included?

BR: Yes, definitely.

CC: If the report is not favorable, do you see any political ramifications from it being published? I know you are a scientist.

BR: Well, we are talking about publications in scientific journals, so I guess this is all about science.

CC: But if the public wants to read the scientific journal, they are welcome to?

BR: Yes.

CC: Politicians won't be spouting our air quality.

BR: You will hear more during the campaign, I guess, during August and September.

CC: About what is happening on the ...

BR: Yes. Right now, I think it is good not to talk too much about it because we are just, let's say, very busy in setting everything up and there are some, let's say ... we are a little bit nervous about it because everything has to go smoothly, right? This is important.

CC: So, the actual measuring hasn't started, it is just in the stages of setting up right now?

BR: Yes, we have to organize several things because we invited several scientists coming to this place and so we are going to host them, we are going to organize everything and this takes a lot of time and is not that easy. As far as our instrumentation

is concerned, we are already in the process of setting them up and they will work perfectly.

CC: Of course. I have no doubt. Do we have a number of students working on this?

BR: Yes. We have a couple ofthem, I guess, will be around 10, I guess.

CC: This is a larger department than I originally thought.

BR: Well, we are attractive right now during the summer so we have got some summer research going on and we definitely need help from students. It is not only taking care of the instrumentation. We have got let's say some advanced students who will be in charge ofthat instrumentation but, for instance, we will have regular radiosonde launchings on campus as well. So, during August and September, we will have two radiosonde launchings a day and during 15 days, for instance, where we expect higher zone levels, we will have additionally 4 radiosonde launchings. So, all together, 6 radiosonde launchings on those 15 days. And this takes some time. You have to prepare the balloon. You have to organize different things and we will need some students doing this. And you cannot have only one student doing this 24 hours a day, so we definitely need a student pool.

CC: And this will be going on 24 hours?

RB: More or less, yes, you are right.

CC: It sounds interesting. How do they prepare ... it is a natural hot air balloon? RB: No, it is a balloon filled with helium and it will pop up somewhere in the atmosphere, 15, 20 kilometers height and that is it, so we can retrieve information about meteorology, temperature, wind speed, wind direction, relative humidity from those different altitudes. This is very important because we want to study the diurnal variations

of the boundary layer and also the evolution of the land sea breeze system because this is really important for the distribution of those primary and also secondary compounds because the land sea breeze system, well, it just flows more or less in parallel to I-45 from the southeast to the northwest basically but it is also being influenced from the larger scale meteorology. And so, each day may be different. It is not always clear how far in land this land sea breeze circulation may go. It is just going to the Houston area somewhere down wind the Houston area. So, this is something important to study and also having those radiosonde launchings.

CC: When you say it goes down wind, it changes the down winds depending on whether we are getting winds from the north, south, east or west, is that correct?

BR: Yes. Sometimes we have got a larger scale situation, so this means we have got some stronger winds just from northerly directions and they are fighting against the land sea breeze air circulation and sometimes the land sea breeze system does not go that far north of Houston. So, it is an interaction between those small scale and larger scale systems.

CC: So, if it does down 45 most ofthe time and even though you live near the Ship Channel, a lot of the toxic air quality could end up down at The Woodlands? So, it could end up further down to north Houston? Is that correct?

BR: Yes, this may be possible.

CC: So, this air quality would affect everyone in Houston because we don't know where it is going to end up?

BR: You know, it has local impact. It may have regional impact. It may also have larger scale impact. So, depending on the lifetime of those different species, they will

have an impact at different scales. So, you cannot exclude specific regions that may be untouched or unaffected by those emissions. Maybe you will not be affected by those primary precursors but maybe you will be affected by the secondary species.

CC: And, of course, vegetation is always affected?

BR: Yes, because vegetation cannot escape. It has to stay outdoors every day, 24 hours.

CC: Well, I appreciate you taking time out of your busy schedule and giving me the time to interview you for this project. I appreciate it and I hope if we have any other questions, I can come ask. I look forward to seeing the demonstrations in August and September.

BR: O.K., you are welcome and thank you very much for this interview.

CC: Thank you.