LARGE-PRINT
ENGLISH SCRIPT OF
NCAR AUDIO TOUR FOR ADULTS

101. WELCOME: BY NCAR DIRECTOR, TIM KILLEEN

(listen to the blended voices and weather effects)

TIM KILLEEN: Hello, I'm Tim Killeen, Director of the National Center for Atmospheric Research—also known as NCAR. NCAR is a national science laboratory that studies the atmosphere, the sun, and the weather. How much do you know about weather and climate? You can learn more here at NCAR, through our exhibits and printed information. With this audio guide, you can also hear firsthand from scientists about their cutting-edge research. You might want to begin your tour by watching a brief video, an excellent introduction to NCAR. The viewing theater is at the end of the hall, past the tornado exhibit. On behalf of NCAR and its parent organization UCAR, I hope you enjoy your visit.

102. TOUR INTRODUCTION

NARRATOR: As you begin your tour, you'll see an audio tour symbol and a number next to many of the exhibits. Enter the number using the keypad on your player. You can go in any order you choose. Enjoy your tour.

103. TORNADO

(listen to the sounds of a tornado)

NARRATOR: You're hearing the fierce winds of a tornado. Inside a tornado, you'll find the strongest, most destructive winds on earth. They can reach 300 miles an hour. Bob Henson is an NCAR writer, meteorologist, and tornado expert.

> **HENSON: . . . Wind can do amazing things in a tornado. You can have a piece of straw or hay, if it's blowing end on end—all that force is focused on that tiny end of straw, and it can go through a tree.**

NARRATOR: What's the formula for a tornado? A tornado happens when warm, moist air rises rapidly in a thunderstorm and begins to rotate. This exhibit lets you get

a close look at the swirling air patterns of a tornado without putting yourself in harm's way. Like a real tornado, this one is constantly changing. You may see a little tendril of cloud at first. In seconds it can become a full-blown vortex. The air in a tornado rises quickly. As it twists upward, it pulls in more air from all directions. The air spirals inward faster and faster, creating tremendous spin. At NCAR, researchers (some call them storm chasers) get very close to real tornadoes in an attempt to better understand and predict these winds. Bob Henson is one.

> **HENSON: I've been a tornado tracker and chaser for about 24 years, and during that time I've seen about 25 tornadoes. . . . The tornado itself is a tiny fraction of the time you're out there looking at the weather. . . . On the other hand, it's a very intense few minutes. . . . It seems as if the entire storm often is focused on that one event, that one sliver of cloud that's dipping down from the sky. It's very compelling, and mesmerizing really. . . .**

104. MICROBURST

NARRATOR: Squeeze the bulb at the top of this exhibit. See the downward burst of sinking fluid in the tank? That's

what a microburst does in the atmosphere. Microbursts are the most severe kind of wind shear—a change in wind speed or direction. When an airplane meets a microburst, rapidly shifting winds can cause the plane to lose air speed and drop dangerously. Until the 1980s, microbursts posed a deadly threat to aircraft. NCAR's research helped create a Doppler radar system that detects microbursts in time to alert planes before they're in danger. No crashes due to microburst winds have occurred at any airports that have installed this detection system. Kim Elmore worked on this project at NCAR. He is now at the National Severe Storms Laboratory. Kim describes a microburst this way:

> **ELMORE: Imagine you're at an airport on one of these moving walkways and some maniacal controller begins to increase the speed of this walkway. . . . If the person speeds up the walkway, you'll have to slow down to maintain the same rate of progress. . . . On the other hand, imagine that this same maniacal person slows it down, . . . you'll have to pick up your speed to maintain the same rate of progress. . . . The issue for an airplane is how quickly can it speed up and slow down? We can do it pretty quickly, but an airplane doesn't have nearly that kind of . . . flexibility.**

105. EL NINO

NARRATOR: Massive floods . . . . droughts. . . . wildfires. . . . We often hear that something called El Nino is behind these extreme weather patterns. But what is it, exactly?

El Nino is a cycle of shifting air pressure and wind that causes tropical waters in the eastern Pacific Ocean to get warmer. During an El Nino event, the sea surface in parts of the Pacific warms by 2 to 7 degrees Fahrenheit. This increase might seem small. But it takes place over an enormous area, as you can see by the red areas on the hologram map. This shift in temperature causes the weather to change around the world—everything from wildfires in Indonesia to flooding in California.

Fishermen off the coast of Ecuador and Peru first noticed the warmer waters hundreds of years ago. Because it happened around Christmas time, they called it El Nino (for "the [Christ] Child"), in Spanish. As

recently as the 1980s, these global weather cycles still caught us by surprise. That's changed, thanks in part to years of research by NCAR scientists and their international collaborators. Now there is a global network in place that detects developing El Nino events in their earliest stages. That gives countries some time to prepare, and thus helps reduce some of the inevitable consequences.

106. MESA LAB ARCHITECTURAL MODEL

NARRATOR: This is a model of NCAR’s Mesa Laboratory. On the walls above the model, you’ll see photographs of the lab, set against the Rocky Mountains. NCAR’s founder, Walter Orr Roberts, collaborated with architect I.M. Pei on the design. For Pei, who had until then designed buildings primarily for urban settings, the project was a dramatic departure. Pei explains:

> **PEI: But really this is a spectacular site. In fact, it was so exceptional that when I first saw it, I was really inhibited by it. I say, how can anyone build a building on this piece of land? . . . It’s a very challenging site. . . .**

p. 7

> **First concern of course—how can you build here? The question of scale—these are the foothills of the Rocky Mountains. Incredible scale. No building, not even the Empire State, would be able to compete with it.**

NARRATOR: Pei looked to the example of ancient Puebloan cliff dwellings in the American Southwest, such as Mesa Verde, to solve the problem. He used local stone to give the buildings the distinctive pink color of the surrounding foothills. Also, notice in the photographs that from a distance there's no visible division between the floors of the building. As a result, the Mesa Lab appears as a single, unified structure against its backdrop. Pei's design choices give the lab a timeless quality. This special quality made the building a perfect choice for the futuristic 1973 film "Sleeper." If you've seen the movie, you may remember that Woody Allen rappels down from the top of the Mesa Lab.

107. SOCIETAL IMPACTS

NARRATOR: Here at NCAR, some scientists study the effects of weather and climate on humans—and vice-versa.

The ultimate goal is to help people better respond to the Earth's changing environment. As global climate changes, such research is becoming increasingly important. Alaska is a great place to look for a signal, or indicator, of climate change, because it's where the signal is the strongest, and it's an incredibly sensitive ecosystem. Heidi Cullen—an NCAR scientist before joining the Weather Channel as its climate expert—explains:

> **CULLEN: . . . There's incredible indigenous forecasting skill within the Alaska native community. . . . Alaskan natives have been looking at cloud patterns for hundreds of years . . . and what's been seen is that relationship between an Alaskan native and the weather has been changing. . . . The ability to forecast the weather is no longer as easy as it used to be. And so the sense is that global warming has really changed the weather patterns in Alaska.**

NARRATOR: NCAR scientists also advise local communities on how to respond to climate variations.

> **CULLEN: . . . One of the scientists . . . has been working with seed companies . . . in Zimbabwe. . . . If you have an El Nino forecast coming out, you know that it's going to . . . lead to a decrease in rainfall in**

> **Zimbabwe, for example, that seed companies would then encourage farmers to buy drought-resistant seeds.**

108. AIRPLANE MODELS

NARRATOR: Look above you. These are models of NCAR research aircraft. They're flying laboratories. They're also the adventurers of the airplane world. Some fly more than 9 miles high—well above commercial planes—to collect air samples. They routinely fly into the kinds of severe weather most pilots try to avoid. The trips aren't always comfortable. Scientist Elliot Atlas has flown on more than 40 research flights between Denver and Greenland while working at NCAR.

> **ATLAS: . . . . We had to stop along the way, between Denver and Greenland, into Canada, as it turned out, a place called Churchill, which can experience some of the coldest, absolutely coldest winter conditions that I've ever experienced. Temperature is minus 30 degrees, winds of 80 miles an hour. . . . Inside the aircraft we'd freeze. Anything left on the floor of the aircraft would freeze up. . . . The power would have problems. . . . And that . . . made it extremely difficult. At the same time, it was an extraordinary experience, flying north into the arctic in wintertime.**

NARRATOR: Now, look down at the floor. See the window into the floor below? That's the computer room and it's our next stop. Just follow the ramp to your right.

109. COMPUTER ROOM

NARRATOR: Behind the glass wall are supercomputers doing trillions of math calculations per second, 24 hours a day. This is global science in action. These computers can tell you everything from ice-age conditions 18,000 years ago to the multiple paths of a forest fire. Climate models use mathematical equations to model the atmosphere and oceans and show what the climate may be in the future—or what it has been in the past. An enormous amount of data is involved in such predictions. Working day and night, it might take these computers 2 weeks to project 100 years of climate. But without them, the calculations wouldn't be possible.

All the information is stored in NCAR's data library, the

mass storage system in this room. It holds more climate data than almost anywhere else on earth. The data represent more information than is in 2 billion paperback books. These days, computer output is sometimes so complex that we can only understand it by seeing the calculations as computer animations. To see some of the newest animations developed by NCAR staff and their colleagues, look at the images on the large TV monitor and in the photos around you.

110.   INTRODUCTION TO CLIMATE DISCOVERY

NARRATOR: Climate research is at the heart of NCAR's mission. This exhibit is called Climate Discovery and it's divided into three main parts: Climate Now, Climate Past, Climate Future. It represents the most up-to-date thinking of today's scientists about climate and climate change.

Climate is a word that we hear discussed a lot. But what is it, really? Climate is weather over time. Yet it's not quite

that simple. Earth's climate is an incredibly complex system that's been changing over millions of years. The displays up ahead break the complex topic into its component parts. Spend as much time as you like here. You'll learn what climate is—and how it changes.

111. CLIMATE NOW

NARRATOR: Climatic change is nothing new. It has been happening since the beginning of Earth itself. But now our climate is changing much faster than in the past. How do we know this?—Warren Washington is a senior scientist at NCAR:

> **WASHINGTON: . . . We have noted that the atmosphere is warming up over the last 30 or 40 years. It has increased by roughly half of a degree centigrade, or a degree Fahrenheit, globally averaged. However, the warming that we see in the higher latitudes in the wintertime, for example, over Alaska, has been very dramatic. . . . We're finding the Arctic Sea ice is shrinking with time. We're finding that vegetations that are not normally growing in, for example, Alaska or northern Canada are now growing—just because the climate system has changed.**

NARRATOR: Why is the atmosphere warming?

> **WASHINGTON: As we increase the amounts of greenhouse gases. . . . We can actually change the climate. . . . In England, for example, spring comes a month earlier now than it used to.**

NARRATOR: The scientific community believes that the increasing greenhouse gases come primarily from people's use of fossil fuels. To hear more about greenhouse gases, press the green Play button.

NARRATOR: Greenhouse gases are gases that have an effect on the planet's radiation—especially what we call infrared or terrestrial radiation. And the greenhouse gas that is affecting the atmosphere the most is carbon dioxide. Carbon dioxide is a natural gas. But it's being enhanced in the atmosphere by the burning of fossil fuels. Ozone and methane are also greenhouse gases. And, like carbon dioxide, these gases have also been increasing in our atmosphere.

112. CLIMATE FUTURE

NARRATOR: What does NCAR's research tell us about the future of our climate?—Warren Washington:

> **WASHINGTON: . . . If we keep burning fossil fuels at the rate that we're burning them now, then by the year 2100, the globe will essentially warm up roughly 3 to 6 degrees centigrade. . . .**

NARRATOR: That's about 5 to degrees Fahrenheit, roughly the same as the change from the last ice age. How will the increase in temperature affect other parts of our climate?

> **WASHINGTON: . . . We can expect hotter days . . . all times of the year. Snow storms will probably have more moisture in them, and therefore, there will be more rain and snow. . . . We can also expect droughts to be more prevalent. That might seem like a paradox—but just keep in mind that in the summertime, you're going to have warmer temperatures, and even though the precipitation will have increased, the evaporation will increase even more, so that that will have a drying effect on the soils—the sort of summertime droughts that . . . could have a big effect . . . on crops.**
>
> **Climate change is an intergenerational problem. Now, the question for anyone who is looking at this exhibit is whether or not they have a partial responsibility . . . to**

keep this planet reasonable and good and hospitable for future generations.

113. CLIMATE PAST

NARRATOR: Along this wall is evidence of Climate Past. As you explore this exhibit, you'll see tree rings, an ice core, a meteorite, and fossils. These clues to the past show that climate has changed continuously since Earth began more than 4 billion years ago. To understand Earth's ancient climate, scientists known as paleoclimatologists read signals from the past.

Now find the model of an ice core. Researchers recover ice cores like this from ancient glaciers in Antarctica and Greenland. Tiny air bubbles trapped in the ice tell us what the weather was like 10,000 and even 100,000 years ago.

Now find the tree trunk slab. This is a section of a Ponderosa pine from the foothills above Boulder. It's more than 400 years old. You probably know that the number of rings on a particular tree represents the age of that tree. But

the ring patterns also show clues about past climate. Notice that some of the rings are thick and some are thin. In a year when growing conditions are good, trees grow wider rings than when growing conditions are poor. Researchers looking at local trees like this one have discovered that 2002 was the driest year in the Boulder area since 1725. In the end, each clue from the past contributes data that help scientists reconstruct climate history.

114. EARTH'S ATMOSPHERE MURAL

NARRATOR: This is an illustration of the Earth's atmosphere, a thin, transparent blanket of several different layers of air. When we look into the sky on a clear day, the atmosphere appears infinite. But in fact, it's only a thin skin hugging the planet. Imagine the skin of an apple—that's how thin the atmosphere is in comparison to Earth.

Find the bottom layer of the atmosphere on the illustration. That's the troposphere. It's where we live and where most of our weather occurs. Our atmosphere keeps us warm by

trapping some of the sun's heat. But it also shields us from the full impact of the sun's radiation. Notice the temperature indicator on the right side of the diagram. The temperature initially falls as you leave the Earth. But look what happens to the temperature in the upper layers of the atmosphere.

Now, find the plus and minus signs in the upper atmosphere. These are electrically charged ions. When they are excited by the energy from solar storms, they can produce arcs of colored light that we know as the Northern and Southern Lights. But the show comes at a price: the same solar energy can also damage satellites and even affect power grids on Earth.

You've probably heard of the ozone layer; it's one of the most important components of the atmosphere. To hear why, press the green Play button:

Ozone is both protective and harmful, depending on where it's located. In the troposphere, ozone is commonly called

bad ozone. Why is it bad? Tropospheric ozone is an air pollutant. Emitted by vehicles and smokestacks, it damages crops and human health. But higher up, in the stratosphere, is a natural ozone layer. You can see it on the illustration. It absorbs some of the sun's ultraviolet light before it can harm living things on Earth. You may have heard this layer has been damaged by industrial use of chemicals like CFCs, or chlorofluorocarbons. Science and industry are working to reduce the damage, to make the ozone layer whole again. You might want to go down the stairs and take a closer look at the illustration. When you're ready to continue, our next stop is two short flights down. Take the stairs or elevator to the end.

115. ART GALLERIES I AND II

NARRATOR: It's time to take a short break from weather and climate. Enjoy the art displayed on the walls of the cafeteria. The work you see is part of the NCAR Community Art Program. Artists from around the globe are encouraged to submit their work for consideration.

We've exhibited just about everything—oils, acrylics, photographs, quilts, pen and paper sketches, mixed media—even a few artistically painted doors. Spend as much time here as you'd like. Our gallery exhibitions change regularly, so please, come back again.

116. CRAY COMPUTER AND CONCLUDING REMARKS

NARRATOR: You're looking at the Cray 1A, the first supercomputer ever used for research. Seymour Cray, the visionary designer who invented this machine in the 1970s, went on to develop other, faster supercomputers. All were masterpieces of technology and visual design. NCAR scientists saw the potential for Cray's new technology early on. The supercomputer would help process the massive calculations that global climate research requires. NCAR played a pivotal role in the development of supercomputers for scientific research. In appreciation, Cray's company donated this landmark machine to NCAR.

p. 20

We're nearing the end our tour. When you're ready to head back upstairs, press the green Play button to listen to a concluding message.

NARRATOR: Research at NCAR and the universities we work with has shaped our understanding of Earth's climate, weather, and the Sun. There are still many things we don't know about our planet's complex and delicate system. We do know that our climate is changing. And we know that humans play a role in this change. The climate our great-grandchildren experience will likely be different than our own. But the story of our climate's future is not yet written. Decisions we make now will shape the climate to come.

Please go to the NCAR Science Store to return your player and headset. Afterward, we invite you to stay awhile at NCAR and explore all the other Mesa Lab exhibits. If you're hungry, stop by our cafeteria. It's open for breakfast

and lunch on weekdays, and has beautiful views of the mountains and plains. If you'd like to head outside and experience the weather for yourself, walk along our Weather Trail behind the lab. We hope you've enjoyed your time here and welcome you to visit NCAR again in person, or virtually, via the Web.

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