
FIVE THINGS THAT CHANGED
WEATHER FORECASTING FOREVER

1
00:00:01,040 --> 00:00:05,040
[sound of rushing wind]

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00:00:09,040 --> 00:00:13,040
Narrator: It was just four years after the Soviet Union had launched Sputnik …

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00:00:13,040 --> 00:00:17,000
News reel: Today a new moon is in the sky, a 23-inch metal sphere

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00:00:17,000 --> 00:00:21,000
placed in orbit by a Russian rocket … Narrator: and the space race was

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00:00:21,000 --> 00:00:25,000
ramping up into full gear. The first weather satellite,

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00:00:25,000 --> 00:00:29,040
launched on Apr. 1, 1960, TIROS-1,

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00:00:29,040 --> 00:00:33,000
enabled us to see weather – at least in the form of cloud cover –

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00:00:33,000 --> 00:00:37,040
across the globe. For the first time – we could see

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00:00:37,040 --> 00:00:41,040
today’s weather from space, which provided clues about what tomorrow had in store.

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00:00:41,040 --> 00:00:45,040
With each passing year, we

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00:00:45,040 --> 00:00:49,000
we gain more confidence in our weather forecasts,

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00:00:49,000 --> 00:00:53,040
compulsively checking out the hourly forecast before heading out the door,

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00:00:53,040 --> 00:00:57,040

or scanning weather radar in real time,

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00:00:57,040 --> 00:01:01,000
or eyeing the 10-day outlook for next weekend’s plans.

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00:01:01,000 --> 00:01:05,040
Our ability to predict the weather, though still imperfect,

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00:01:05,040 --> 00:01:09,040
would astound our recent ancestors.

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00:01:09,040 --> 00:01:13,040
But not that long ago, weather forecasts were much, much murkier,

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00:01:13,040 --> 00:01:17,040
and recent improvements have made revolutionary contributions

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to not just picnics and daily commutes, but farming,

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00:01:21,040 --> 00:01:25,000
worldwide economics, construction projects, military strategy,

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00:01:25,000 --> 00:01:29,000
and travel by air and sea.

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We talked to pioneers in the field, who in some cases

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00:01:33,040 --> 00:01:37,040
have lived the lion’s share of the history of modern weather forecasting.

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Out of that, we want to share five things, mostly from the US satellite era,

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00:01:41,040 --> 00:01:45,040
that changed forecasting forever.

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But first we'll start a little further back into the past …

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Uccellini: Throughout the history of what is now the National Weather Service,

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threats to life has been one of the main drivers

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00:01:57,040 --> 00:02:01,000
for us to even exist.

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00:02:01,000 --> 00:02:05,040
The initial organization that started weather services

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in the United States was the Signal Corps which took on

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00:02:09,040 --> 00:02:13,000
the responsibilities to observe weather and be able to provide

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00:02:13,000 --> 00:02:17,040
indications of what could happen

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00:02:17,040 --> 00:02:21,000
that afternoon or the next day.

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00:02:21,000 --> 00:02:25,000
Narrator: After the Civil War, the Great Lakes were a main highway for commerce,■After the Civil War, the Gre

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00:02:25,000 --> 00:02:29,000
and ships frequently sank in surprise storms.

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00:02:29,000 --> 00:02:33,000
Uccellini: Telegraph lines made it possible to get weather information in real time

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00:02:33,000 --> 00:02:37,040

time that could all be brought together to provide indications of squalls passing over the lakes.

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00:02:37,040 --> 00:02:41,040
So that's the creation of the Signal Corps.

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00:02:41,040 --> 00:02:45,040
Then you move forward in time, in 1888, for example,

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there were two major blizzards that affected the United States.

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Narrator: These blizzards were barely forecast,■These blizzards were barely forecast,

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00:02:53,000 --> 00:02:57,000
and hundreds of people lost their lives.

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00:02:57,000 --> 00:03:01,000
Uccellini: There was a general push to get the weather services out of the military Signal Corps■There was a g

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00:03:01,000 --> 00:03:05,040
into a civilian agency. And that was probably the last straw

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00:03:05,040 --> 00:03:09,000
straw for many of those who really wanted this to happen and it became much more emphatic.

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00:03:09,000 --> 00:03:13,040
Narrator: Then the weather disasters of the 1900s – ■Then the weather disasters of the 1900s –

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00:03:13,040 --> 00:03:17,040
like the surprise Long Island Express Hurricane in 1938

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00:03:17,040 --> 00:03:21,040
and a major tornado outbreak in 1974 –

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00:03:21,040 --> 00:03:25,040
spurred interest in new technologies,

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00:03:25,040 --> 00:03:29,040
like Doppler radar, that could give a local or regional view of developing weather.

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00:03:29,040 --> 00:03:33,040
But it was really the view from on high

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00:03:33,040 --> 00:03:37,040
that brought the world's weather forecasts together.

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00:03:37,040 --> 00:03:41,040
[sound of applause.] Not many people know that during John F. Kennedy's

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famous speech to Congress in 1961,

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he not only set this audacious goal:

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00:03:49,000 --> 00:03:53,040
Kennedy: First, I believe that this nation should commit itself to achieving the goal,

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00:03:53,040 --> 00:03:57,000
before this decade is out, of landing a man on the moon

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00:03:57,000 --> 00:04:01,000
and returning him safely to the Earth.

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00:04:01,000 --> 00:04:05,040
Narrator: He also called out for the development of nuclear rocket, and a worldwide system

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00:04:05,040 --> 00:04:09,000
of communications satellites, and …

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00:04:09,000 --> 00:04:13,040
Kennedy: Fourth, an additional 75 million dollars – of which 53 million dollars is for the Weather Bureau –

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00:04:13,040 --> 00:04:17,040

will help give us at the earliest possible time a satellite system

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00:04:17,040 --> 00:04:21,000
for world-wide weather observation.

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00:04:21,000 --> 00:04:25,000
Narrator: TIROS-1 and 2 had already launched before the Kennedy speech,

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but a long series of TIROS satellites followed after,

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00:04:29,040 --> 00:04:33,040
which were then complemented by the Nimbus program – a set of satellites

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00:04:33,040 --> 00:04:37,040
designed not just to take pictures, but to actually measure aspects

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00:04:37,040 --> 00:04:41,040
of the atmosphere from hundreds of miles away –

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00:04:41,040 --> 00:04:45,040
including temperature, wind speed, and water vapor.

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00:04:45,040 --> 00:04:49,040
Scientific progress is often slow, building incrementally.

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00:04:49,040 --> 00:04:53,040
But sometimes science makes giant leaps,

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00:04:53,040 --> 00:04:57,040
literally overnight. For the field of weather forecasting

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00:04:57,040 --> 00:05:01,040
this happened one night in 1969,

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00:05:01,040 --> 00:05:05,040
just three months before the first humans landed on the moon.

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00:05:05,040 --> 00:05:09,040
It was the night the team behind the NIMBUS 3 satellite

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00:05:09,040 --> 00:05:13,000
received their first global set of data.

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00:05:13,000 --> 00:05:17,040
Smith: We stayed up all night and plotted these data on a map.\h

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00:05:17,040 --> 00:05:21,040
Hand plotted them when we got the computer.

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00:05:21,040 --> 00:05:25,040
Just reams of paper with numbers on them, latitude, longitude, temperature values,

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00:05:25,040 --> 00:05:29,000
altitude and things. It was pretty exciting

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00:05:29,000 --> 00:05:33,000
because it looked very real, just like a real weather map. But this just came from the satellite.

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00:05:33,000 --> 00:05:37,000
Nothing else, just the satellite data.

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00:05:37,000 --> 00:05:41,040
Narrator: When morning came, they brought their weather map to the director of operations

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00:05:41,040 --> 00:05:45,040
of the National Meteorological Center.\h

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00:05:45,040 --> 00:05:49,040
Smith: He says, “Oh my God,” he said, “we've been taking flak from the airlines this morning because we

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00:05:49,040 --> 00:05:53,040
mis-forecast where the jet stream was going to be.

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00:05:53,040 --> 00:05:57,000

And our flights to Asia, were not making

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00:05:57,000 --> 00:06:01,040
their destination … because of the strong headwinds and so on

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00:06:01,040 --> 00:06:05,000
that we didn't forecast.” And he says,

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00:06:05,000 --> 00:06:09,000
“Your satellite data shows it. Shows right where it is."

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00:06:09,000 --> 00:06:13,040
Narrator: The TIROS and Nimbus satellites and other■The TIROS and Nimbus satellites and other

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00:06:13,040 --> 00:06:17,040
low-orbit satellites that followed, circle round the Earth,

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00:06:17,040 --> 00:06:21,040
getting different views all the time. But now let’s talk about the view

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00:06:21,040 --> 00:06:25,000
from ten times higher up.

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00:06:25,000 --> 00:06:29,040
Mandt: The geostationary program is primarily been a visual imagery program■The geostationary program is p

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00:06:29,040 --> 00:06:33,040
basically flying above the equator at the same rate

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00:06:33,040 --> 00:06:37,040
as the Earth spins. So to a person on the Earth, it appears that it's stationary,

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00:06:37,040 --> 00:06:41,040
and what that allows you to do is see the Earth from the same vantage points

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00:06:41,040 --> 00:06:45,040
continuously. So you could basically take movies. So you can update

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00:06:45,040 --> 00:06:49,040
the picture every 30 seconds, if you want.

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00:06:49,040 --> 00:06:53,000
When you loop those, you get a sense of the motion of the weather.

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00:06:53,000 --> 00:06:57,000
Uccellini: We forget the days where the TV folks■We forget the days where the TV folks

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00:06:57,000 --> 00:07:01,000
who were talking about a storm being out in the Atlantic couldn't even show where it was,

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00:07:01,000 --> 00:07:05,000
just that the Hurricane Center is tracking it. Papers have been written about how

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00:07:05,000 --> 00:07:09,000
the geostationary satellite was probably the most important

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00:07:09,000 --> 00:07:13,000
observing system with its ground processing in the history

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00:07:13,000 --> 00:07:17,000
of advancing the Hurricane Center because

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00:07:17,000 --> 00:07:21,000
it gave them the situational awareness of where that storm was,

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00:07:21,000 --> 00:07:25,000
where it was going, and the intensity changes

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00:07:25,000 --> 00:07:29,000
as it was moving in real time.

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00:07:29,000 --> 00:07:33,000
It was just an amazing eye-opening experience for the Hurricane Center.

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Narrator: So geostationary satellites give us, literally,

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00:07:37,000 --> 00:07:41,000
the big picture. But from a data standpoint, it’s usually been

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00:07:41,000 --> 00:07:45,000
the low orbit satellites, usually in a polar orbit,

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that are the workhorses of the weather fleet.

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00:07:49,000 --> 00:07:53,000
Mandt: So the polar orbiting satellites compliment the geostationary ■So the polar orbiting satellites complimer

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00:07:53,000 --> 00:07:57,000
are basically flying at little over 500 miles up. And when you're at that altitude

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00:07:57,000 --> 00:08:01,000
you can sense what's in the atmosphere

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00:08:01,000 --> 00:08:05,000
to a lot higher resolution. And for weather forecasting,

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00:08:05,000 --> 00:08:09,000
you really want to understand the state of the atmosphere,

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00:08:09,000 --> 00:08:13,000
primarily temperature and water vapor, and winds.

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00:08:13,000 --> 00:08:17,000
Twice a day, each satellite is giving a really detailed measurement of the atmosphere

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00:08:17,000 --> 00:08:21,000
and its state, which is the beginning then to understand

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00:08:21,000 --> 00:08:25,000
what is the state of the global atmosphere to then project

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00:08:25,000 --> 00:08:29,000
it forward to produce a weather forecast.

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00:08:29,000 --> 00:08:33,000
Narrator: The early Nimbus satellites began our legacy of low-orbit data collection,■TSo the early Nimbus sate

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00:08:33,000 --> 00:08:37,000
but one of the biggest leaps came fromm our ability to measure

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00:08:37,000 --> 00:08:41,000
literally thousands of different frequencies of energy, representing

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00:08:41,000 --> 00:08:45,000
an all-weather profile of the atmosphere.

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00:08:45,000 --> 00:08:49,000
[engine noise] For NASA Goddard Space Flight Center’s Ed Kim,

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00:08:49,000 --> 00:08:53,000
that all-weather view is never far from his mind.

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00:08:53,000 --> 00:08:57,000
Kim: I have a vested interest■I have a vested interest

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00:08:57,000 --> 00:09:01,000
in helping improve weather forecasts.

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00:09:01,000 --> 00:09:05,000
The hobby of, of flying and the work of improving weather sensors

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00:09:05,000 --> 00:09:09,000
is a nice combination. They really go hand in hand.

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00:09:09,000 --> 00:09:13,000
When you're flying around and looking at clouds or looking at weather patterns as you're flying in an airplane,

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00:09:13,000 --> 00:09:17,000

it's hard not to think about … what a microwave sensor

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00:09:17,000 --> 00:09:21,000
would see when it's trying to look through that cloud over there to the right.

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00:09:21,000 --> 00:09:25,000
So everybody's probably familiar with radio transmissions.

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00:09:25,000 --> 00:09:29,000
You have a transmitter, you have a receiver, maybe when you were kids you played with walkie-talkies

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00:09:29,000 --> 00:09:33,000
or you listen to the radio in your car, there's a transmitter somewhere and the receiver is in your car.

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00:09:33,000 --> 00:09:37,000
Microwaves sounders are just the same thing.

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00:09:37,000 --> 00:09:41,000
They're just different radio frequencies. So, you might ask well,

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00:09:41,000 --> 00:09:45,000
what is the receiver receiving? It's actually receiving natural signals

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00:09:45,000 --> 00:09:49,000
that are emitted by the gases in the atmosphere itself.

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00:09:49,000 --> 00:09:53,000
All natural objects …

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00:09:53,000 --> 00:09:57,000
Everything emits a very tiny amount of microwave energy.

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00:09:57,000 --> 00:10:01,000
And those microwave frequencies happen to allow you to

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00:10:01,000 --> 00:10:05,000
detect the condition of the atmosphere. And so …

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00:10:05,000 --> 00:10:09,000
then you can construct the vertical temperature,

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00:10:09,000 --> 00:10:13,000
we call it a profile, a vertical temperature structure of the atmosphere.

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00:10:13,000 --> 00:10:17,000
The primary reason that you have both

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00:10:17,000 --> 00:10:21,000
the microwave and the infrared is that

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00:10:21,000 --> 00:10:25,000
the microwave sensors, in general, for the most part can, see through clouds.

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00:10:25,000 --> 00:10:29,000
Just the fact that you could see through the clouds and still figure out the structure of the atmosphere was a gig

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00:10:29,000 --> 00:10:33,000
Combined the microwave data and the infrared data

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00:10:33,000 --> 00:10:37,000
provide that really critical vertical

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00:10:37,000 --> 00:10:41,000
structure information of the atmosphere to the weather forecasters.

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00:10:41,000 --> 00:10:45,000
Essentially the most critical information

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00:10:45,000 --> 00:10:49,000
they need for weather forecasts.

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00:10:49,000 --> 00:10:53,000
Narrator: So we have a non-stop visual recon of the planet from geostationary satellites, ■So we have a non-s

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00:10:53,000 --> 00:10:57,000

and highly detailed atmospheric measurements from polar orbiters.

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00:10:57,000 --> 00:11:01,000
But … all that data coming down

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00:11:01,000 --> 00:11:05,000
wouldn’t mean much without the quantum leaps in computing power

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00:11:05,000 --> 00:11:09,000
we’ve seen over this time period, and the massive amounts of work

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00:11:09,000 --> 00:11:13,000
that have gone into creating computer models of weather and our atmosphere.

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00:11:13,000 --> 00:11:17,000
One of the pioneers in this field

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00:11:17,000 --> 00:11:21,000
is Eugenia Kalnay, who after escaping

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00:11:21,000 --> 00:11:25,000
a brutal crackdown on academia in Argentina,

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00:11:25,000 --> 00:11:29,000
became the first woman to graduate from MIT in meteorology,

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00:11:29,000 --> 00:11:33,000
and has possibly the most often cited paper in all of the Earth sciences.

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00:11:33,000 --> 00:11:37,000
One of her major fields of study has been the ensemble forecast –

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00:11:37,000 --> 00:11:41,000
basically comparing bits of forecast model information

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00:11:41,000 --> 00:11:45,000
against each other to figure out what’s working and what’s not.

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00:11:45,000 --> 00:11:49,000
Kalnay: This method allows you to determine ■This method allows you to determine

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00:11:49,000 --> 00:11:53,000
whether each observation is good or bad.

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00:11:53,000 --> 00:11:57,000
If it helps the forecast or it makes it worse.

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00:11:57,000 --> 00:12:01,000
And I realized that we could do that with

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00:12:01,000 --> 00:12:05,000
every observation and determine whether it was

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00:12:05,000 --> 00:12:09,000
beneficial or detrimental, we could take away

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00:12:09,000 --> 00:12:13,000
the detrimental observations and only use the beneficial ones.

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00:12:13,000 --> 00:12:17,000
And that improved the forecast quite a lot –

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00:12:17,000 --> 00:12:21,000
substantially.

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00:12:21,000 --> 00:12:25,000
Not not just a little bit that you cannot see,

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00:12:25,000 --> 00:12:29,000
but for eight days, the forecast is better.

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00:12:29,000 --> 00:12:33,000
So that I feel, I feel

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00:12:33,000 --> 00:12:37,000

very happy about that result.

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00:12:37,000 --> 00:12:41,000
Narrator: Before the ensemble, she says, the National Weather Service ■Before the ensemble, she says, the N

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00:12:41,000 --> 00:12:45,000
would calculate a forecast for 15 days, but only show

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00:12:45,000 --> 00:12:49,000
three days to the public. But in the 1980s, we made a major leap.

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00:12:49,000 --> 00:12:53,000
Kalnay: That was the first time that the human forecasters

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00:12:53,000 --> 00:12:57,000
there make a forecast for five days because

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00:12:57,000 --> 00:13:01,000
they show that all the ensemble forecast were similar.

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00:13:01,000 --> 00:13:05,000
The TV meteorologists immediately,

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00:13:05,000 --> 00:13:09,000
some, the most advanced of them,

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00:13:09,000 --> 00:13:13,000
immediately realized that they could give

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00:13:13,000 --> 00:13:17,000
forecast much longer than three days.

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00:13:17,000 --> 00:13:21,000
Narrator: So now we have the data, and we have the computers and the models to run on them –

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00:13:21,000 --> 00:13:25,000
but that still doesn’t do us any good if we can’t get the data down from the satellites,

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00:13:25,000 --> 00:13:29,000
processed, and then out to the people who need it.

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00:13:29,000 --> 00:13:33,000
Mandt: We're sitting here at the NSOF building. It's really the operation center■We're sitting here at the NSOF

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00:13:33,000 --> 00:13:37,000
for all of our NOAA satellites. So, behind me you can see the floor

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00:13:37,000 --> 00:13:41,000
where not only do we fly the geostationary satellites, the polar orbiting satellites,

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00:13:41,000 --> 00:13:45,000
including JPSS-1 which is now called NOAA-20.

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00:13:45,000 --> 00:13:49,000
The primary purpose of this building then is to fly

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00:13:49,000 --> 00:13:53,000
the satellites and then take the data from those satellites and process it

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00:13:53,000 --> 00:13:57,000
and be able to put out the products for the nation.

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00:13:57,000 --> 00:14:01,000
The data that flows from all of the satellites produces a lot of the products

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00:14:01,000 --> 00:14:05,000
that are used in the weather forecasting that everybody sort of uses

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00:14:05,000 --> 00:14:09,000
every day and may not really understand where it's coming from.

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00:14:09,000 --> 00:14:13,000
But this is the heart and soul of what the nation gets for weather forecasting.

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00:14:13,000 --> 00:14:17,000

The nice thing about working in this business is we know it's helping people, it's helping people over the world.

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00:14:17,000 --> 00:14:21,000
And all the countries of the world collaborate very well together

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00:14:21,000 --> 00:14:25,000
in sharing this data because it's all of mutual benefit.

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00:14:25,000 --> 00:14:29,000
Narrator: But the getting those forecasts out is still not the end of the line. ■But the getting those forecasts out

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00:14:29,000 --> 00:14:33,000
In emergency weather situations, the right people have to get the right information to make critical decisions.

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00:14:33,000 --> 00:14:37,000
Uccellini: Well, one of the new areas ■Well, one of the new areas

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00:14:37,000 --> 00:14:41,000
that the Weather Service is fully engaged in

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00:14:41,000 --> 00:14:45,000
is the idea that making a forecast and a warning

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00:14:45,000 --> 00:14:49,000
is not good enough.

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00:14:49,000 --> 00:14:53,000
And there's a whole range of decision makers, there's organized decision makers, government agencies

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00:14:53,000 --> 00:14:57,000
at the federal, state, and local levels, all work together to save lives and property.

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00:14:57,000 --> 00:15:01,000
And then you've got individuals, everybody with a cell phone now

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00:15:01,000 --> 00:15:05,000
is a decision maker. They can download all this stuff

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00:15:05,000 --> 00:15:09,000
and decide whether they're going to evacuate or not, right?

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00:15:09,000 --> 00:15:13,000
So we're into human factors now. We're into social science. So this combination of physical and social science

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00:15:13,000 --> 00:15:17,000
science is really a big deal for us in … how we meet the needs

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00:15:17,000 --> 00:15:21,000
of the emergency management community.

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00:15:21,000 --> 00:15:25,000
If we all want to get down to societal benefits, this is what we've got to do.

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00:15:25,000 --> 00:15:29,000
We've embarked on this over the last six, seven, eight years

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00:15:29,000 --> 00:15:33,000
and it's starting, it’s starting to work.

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00:15:33,000 --> 00:15:37,000
The part of the mission to protect life and property is really the driver,