CIRA

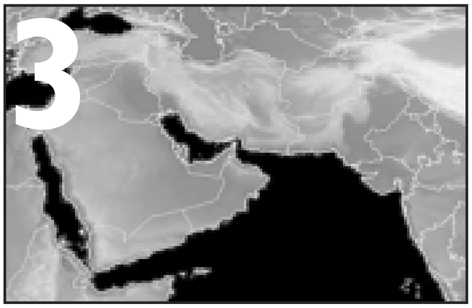
GATHERING CLOUDS:
CIRA'S Role in the Battlefield and on the Home Front

VOLUME 19
SPRING 2003

Colorado State University

Knowledge to Go Places

Contents



Cover photo courtesy of U.S. Department of Defense

Editor

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Publications and Printing, Colorado State University

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Bernadette Connell, Doug Fox, Cliff Matsumoto, Donald Reinke

A Cloud Hangs Over Iraq

By Donald Reinke and John Forsythe

In the Spring 2002 issue of the CIRA magazine, Ken Eis presented an overview of CIRA research in his article, "Weather Impacts Homeland Defense and the War on Terrorism." Since that time, CIRA has made a significant contribution to one of the highest priority research themes – the timely and accurate detection and forecasting of clouds from meteorological satellite data. This article provides an overview of global satellite-based cloud research and CIRA's contribution to this important area of study.

Those Troublesome Clouds

Clouds can be a show-stopper for a wide range of DoD and "intelligence" operations. Opaque clouds will prevent passive optical or infrared systems from seeing objects near the ground from an aircraft or space-based sensor. Conversely, opaque clouds will impede a ground observer who is trying to view objects in the upper atmosphere or space. Cloud cover has actually become more critical in the last decade as the distance above ground that pilots fly to avoid ground fire has increased. Even "thin" clouds (clouds that are nearly invisible to the naked eye) can prevent important surveillance systems from "seeing" through the atmosphere.

Another application of cloud cover is in the simulation of weather impacts on current and future DoD systems. Every system that is built and deployed is first run through a series

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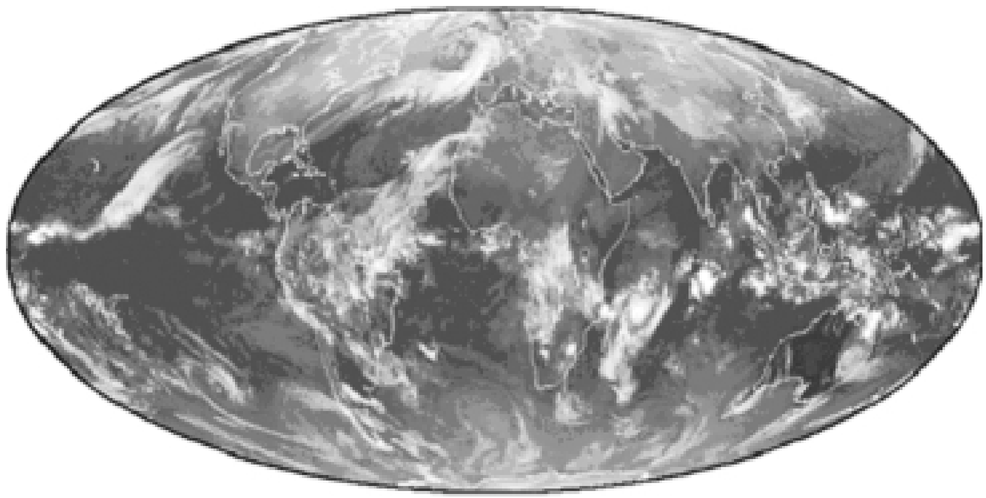

Figure 1. Example of satellite imagery from the CHANCES global infrared "merged" image. This image is constructed from up to 8 different meteorological satellites and shows the composite infrared data that are available for one hour. The light areas represent the coolest temperatures while darker areas are warmer. This image is the cloud cover at 01:00 UTC. Note that it is close to mid-day, local time, in Australia and the land is already very warm (dark).

Fellowships in Atmospheric Science and Related Research

The Cooperative Institute for Research in the Atmosphere at Colorado State University (CIRA) offers a limited number of one-year Associate Fellowships to research scientists including those on sabbatical leave or recent Ph.D. recipients. Those receiving the awards will pursue their own research programs, collaborate with existing programs, and participate in Institute seminars and functions. Selection is based on the likelihood of an active exchange of ideas between the Fellows, the National Oceanic and Atmospheric Administration, Colorado State University, and CIRA scientists. Salary is negotiable based on experience, qualifications, and funding support. The program is open to scientists of all countries. Submitted applications should include a curriculum vitae, publications list, brief outline of the intended research, a statement of estimated research support needs, and names and addresses of three professional references.

CIRA is jointly sponsored by Colorado State University and the National Oceanic and Atmospheric Administration. Colorado State University is an equal opportunity employer and complies with all Federal and Colorado State laws, regulations, and executive orders regarding affirmative action requirements. In order to assist Colorado State University in meeting its affirmative action responsibilities, ethnic minorities, women and other protected class members are encouraged to apply and to so identify themselves. The office of Equal Opportunity is in Room 101, Student Services Building. Senior scientists and qualified scientists from foreign countries are encouraged to apply and to combine the CIRA stipend with support they receive from other sources. Applications for positions which begin January 1 are accepted until the prior October 31 and should be sent via **electronic** means only to: Professor Thomas H. Vonder Haar, Director CIRA, Colorado State University, humanresources@cira.colostate.edu. Research Fellowships are available in the areas of: **Air Quality, Cloud Physics, Mesoscale Studies and Forecasting, Satellite Applications, Climate Studies, Model Evaluation, Economic and Societal Aspects of Weather and Climate.** For more information visit www.cira.colostate.edu.

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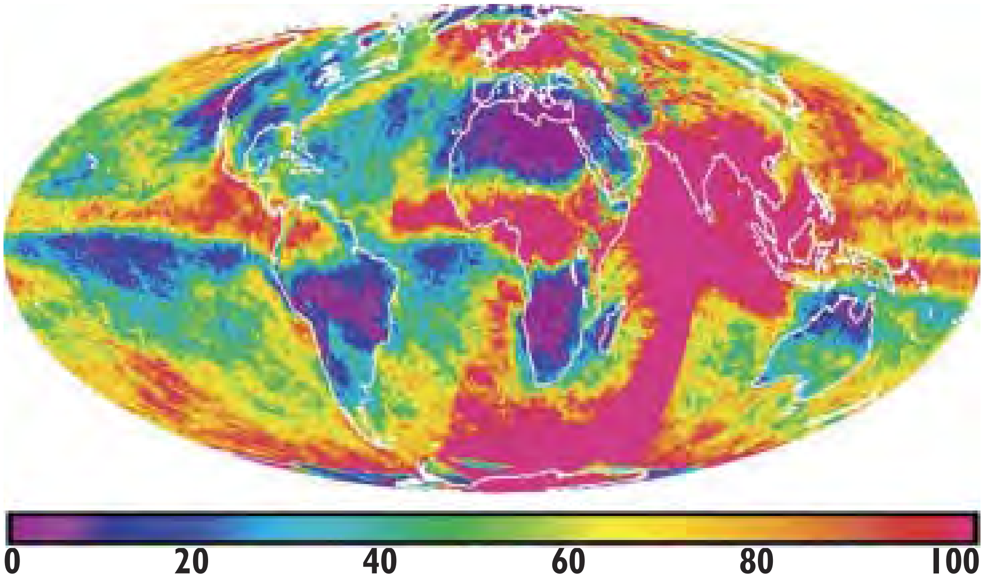

Figure 2. Example of a global cloud climatology produced from the CHANCES global database. The colors represent the frequency of occurrence of cloud (%) for the month of July, 1998 at 1200 UTC.

of simulators that attempt to depict the effects of the atmosphere, to include clouds, on the effectiveness of that system. The results of such tests might indicate that a specific system will work quite well in an area that is normally void of opaque clouds, but is ineffective in a region that is persistently cloudy. Simulators will also be given information about the diurnal cycle of clouds in a certain region, providing a sense of what time of day would be best to use a surveillance system that is hampered (or protected) by clouds.

One often overlooked application of cloud information is the identification of regions where the occurrence of clouds might be used to hide covert activities. Simulations of cloud cover can often provide a good indication of when and where a specific object may be hidden, or an operation might be attempted, under the cover of clouds.

Perhaps the most significant impact of clouds is in the arena of aerial or space surveillance. It should be apparent to anyone who has followed the recent activities in Iraq, that we rely heavily on our ability to collect visual and infrared images from remote platforms. Such activities can be severely limited by cloud cover. These important data are often the only source of information for tracking the movements of people or objects, or to identify changes in physical facilities at various locations. The ability to make efficient use of aircraft, UAV, or satellite surveillance is essential for monitoring the locations of facilities that may be involved in the production of banned substances or devices, or buildings that house weapons or other military assets. One of the most important factors in the success of such information gathering ... is cloud cover.

Under the sponsorship of the DoD Center for Geosciences / Atmospheric Research (CG/AR), CIRA has developed a series of global and regional scale cloud products that have a direct application to DoD operations, as well as to the peace-time planning and simulations community.

We are past the point of providing DOD planners the ability to avoid cloud cover. With the proper information, we can now use cloud cover as a force multiplier.

CIRA Cloud Research

For the past two decades, CIRA has maintained its status as one of the top centers of research in satellite meteorology and satellite-derived global cloud products. In the past, the emphasis has been on long-term climate studies and improvements to the detection of clouds, water vapor, and precipitation from global satellite imagery. More recently, CIRA has devoted a significant effort to improving our ability to detect and forecast the occurrence of clouds in select regions of the globe where more conventional observations of cloud (i.e., from surface weather observers) are not available, or are not reliable.

Clouds are arguably the single most important control mechanism for atmospheric heating and cooling. They are, in effect, the thermostat that controls the amount of radiation that arrives at Earth's surface (heating) or is allowed to escape to space (cooling). The impact of clouds on global warming or cooling, for example, can be many orders of magnitude greater than the impact of rising carbon dioxide levels. Unfortunately, we do not have sufficient measurements of the global distribution of clouds to assess their impact on the warming (or cooling) of the planet. It is in this light that CIRA has spent the past two decades gathering satellite data to contribute to a statistical sample of the change in global cloud cover. During this time span, CIRA has ingested and stored one of the largest collections of digital meteorological satellite data in the world.

More recently, CIRA, under the sponsorship of the CG/AR, has leveraged off of this large volume of archived satellite imagery to produce a unique set of "Regional Cloud Products." These products are providing new insights into the distribution of clouds over specific geographic regions, with unique distributions of land, water, soil types, and surface elevations. This area of research has also provided new analysis and forecasting tools for both civilian and military applications.

In this short overview, we will look at some of the applications of CIRA cloud research to the current conflicts in Afghanistan and Iraq.

Weather Satellites and Cloud Climatologies: A Bit of History

Our primary source of global cloud observations is from a worldwide fleet of meteorological satellites that are owned and operated by many nations who freely share their data.

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A Cloud Hangs Over Iraq *(continued from page 4)*

These "Weather Satellites" have provided us a perspective on Earth's clouds for over 40 years. The detection of clouds from satellite is a large topic, and approaches to this problem are discussed by two of the leading authorities on the subject, Dr. Stan Kidder (CIRA Research Scientist) and Dr. Thomas Vonder Haar (CIRA Director) in their joint text book "Satellite Meteorology" (Kidder and Vonder Haar, 1995).

In the 1980s, CIRA was one of the key members of a team of world-wide researchers who created the International Satellite Cloud Climatology Project (ISCCP; Rossow and Schiffer, 1991). This global effort began the systematic task of watching clouds from space over the entire planet and creating an archive of their occurrence at a time and space resolution of 3-hr and 280-km. A "cloud climatology" is a mosaic of individual cloud detections from all available satellite imagery. Cloud climatologies can be created by hour, location, season, weather pattern, or by a particular type of cloud. By summing up cloud detection results based on time, space, or physical constraints, we learn about the natural occurrence and variability of clouds. Data from both geostationary and polar orbiting satellites have been used to create satellite cloud climatologies. CIRA has continued as a key member of the ISCCP team, collecting data for the project from the United States Geostationary Operational Environmental Satellite (GOES) program since 1983.

The history of early satellite cloud climatologies is summarized in Reinke et al (1992). While there have been cloud climatologies derived from surface observations (Warren et al, 1986), Reinke et al (1992) showed that only the satellite has the large spatial coverage to show cloud variability on scales larger than a few kilometers. A barrier problem until recently has been the tremendous volume of satellite data required to complete a global cloud climatology at high space and time resolution

In 1994, a small business partner teamed with CIRA to develop a data processing system that was used to produce a unique global cloud product called CHANCES. The Climatological and Historical Analyses of Clouds for Environmental Simulations (CHANCES) global cloud database expanded upon ISCCP by using higher spatial and temporal resolution. CHANCES used a similar approach to ISCCP, however it was produced at a global resolution of 1-hr and 5-km (Figures 1 and 2). This database provided the DoD simulations community with the first opportunity to run global cloud simulations to examine the effectiveness of systems that had to perform in any geographic location. These so called, "All-Weather" systems could then be evaluated on a global backdrop of clouds – and the associated weather conditions.

Since the development of this unique CHANCES database, satellite cloud climatologies have seen a continual expansion in their application. Hall et al (1998), in follow-on work to his Master's Thesis at CSU, illustrated an application of the CHANCES results for DoD forecasters over Eastern Europe. Climatologies of specific types of clouds, such as cumulus and cirrus are continually being created and improved with the latest sensors and research results. Climatologies of clouds from a forecast model can be created and then compared to satellite-derived products to assess and improve the model's representation of clouds. Topographic impacts on areas of preferred cloud formation and cloud occurrence under different synoptic flow regimes have been recent topics of study at CIRA which apply cloud climatologies. Further details on these areas can be found in the journal paper in preparation by Reinke et al (2003).

Our focus in recent research has been on an application of the CHANCES database cloud detection to smaller "regional" scale variations in cloud. An example is our recent work over the Middle East region. This is a challenging region for cloud detection that includes desert and snow-covered high mountains, two notoriously difficult surfaces over which to detect clouds. The high time resolution is a key asset of the CHANCES database for determining variations in regional scale cloudiness. This area has previously suffered from a lack of consistent geostationary

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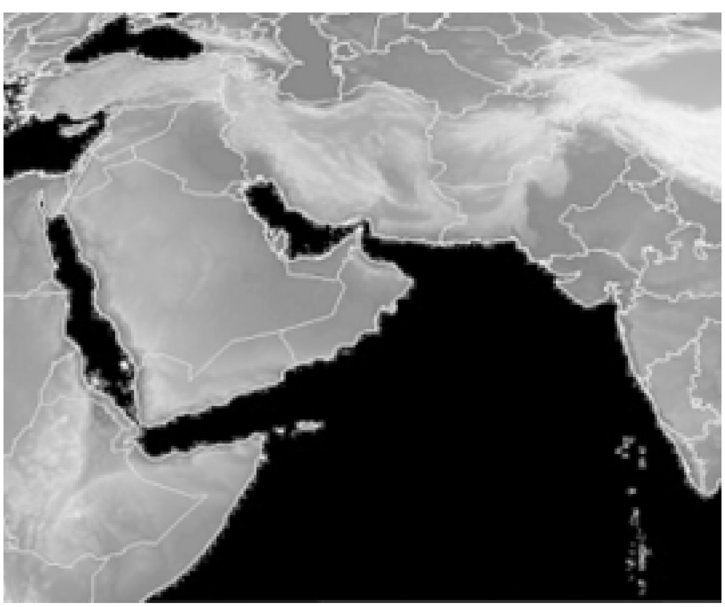

Figure 3. Data from the GTOPO30, 1-km, global, elevation database.

Figure 4. Data from the 1-km, global, Global Land Cover Characteristics database.

A Cloud Hangs Over Iraq *(continued from page 5)*

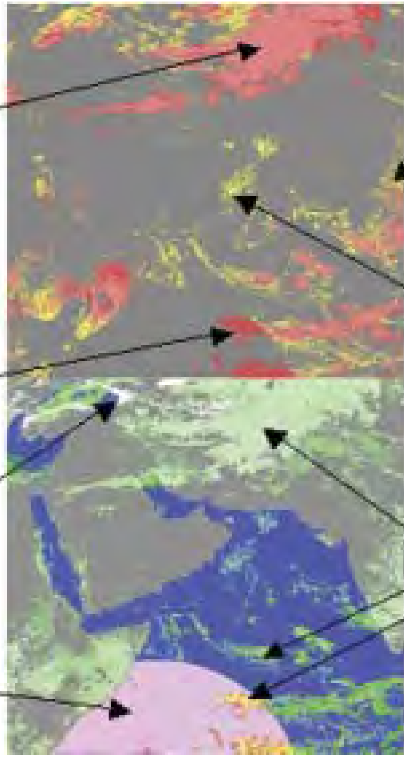

Figure 5. Example of the regional products database image for one hour. The database contains all of the cloud and situational information that was produced by the regional products cloud analysis program.

satellite coverage, making the production of cloud climatologies difficult. The placement of the Meteosat-5 satellite at 63º East over this region in mid-1998 through present, has made possible new high space and time resolution cloud products.

Global Meteorological Satellite Data

The data used in our recent studies are visible and infrared (11 micron) imagery from the CHANCES database. Most of the imagery over this sector is from the Meteosat-5 satellite which has a sub-satellite point of 63º E. These data were assimilated into the CHANCES database format at a 1-hr and 5-km temporal and spatial resolution.

A 1024 X 1024 pixel sector (covering an area of approximately 5120 X 5120 km) over the Middle East), was extracted from the global database. Examples of this sector can be seen in Figures 3 and following.

Infrared image sectors were extracted for each hour (on the hour) and visible image sectors were extracted for the hours of 0500 UTC - 1200 UTC inclusive.

In addition, two ancillary data sets were used as input to the data processing. The GTOPO30 1-km resolution global elevation database was used to construct a first-guess surface temperature field (Figure 3). The “Global Land Cover Characteristics” database (GLCC) was used to identify land type for the purpose of assigning an expected diurnal temperature change curve (Figure 4).

Clouds Over Iraq and the Middle East

A description of the data processing can be found in Reinke, et. al., 2003, and will be available soon in a more detailed paper that is currently under review. In summary, cloud products are generated in the following steps:

Global meteorological satellite data are collected at CIRA via the direct readout of data through the CIRA satellite earthstation antennas or via high-speed Internet links with other world-wide earthstations. CIRA ingests, processes, and stores approximately 50GB of data per day.

These data are processed to produce calibrated and quality-controlled images that are combined to produce a global mosaic of all of the available satellite data for a given hour (the basis for the CHANCES global satellite database).

The region of interest is extracted from the global database. This sector is used for two applications. First, the data are used to build a “background” image that represents the scene that would be viewed under cloud-free conditions. Secondly, the images are processed to identify cloud and clear regions. Individual hourly images are used to produce statistics of cloud/clear probabilities and other cloud products. Figure 5 shows a summary of the cloud and other “situational” information that is extracted from the regional product images.

After cloud detection was completed, several cloud-related products were produced. Examples of some of the products produced to date include:

1. Frequency of occurrence and PDF

A frequency of occurrence image was built for a given hour of the month by simply constructing the percentage of time that each pixel was cloudy for that hour. Figure 6 shows an example of a Frequency of Occurrence image and the PDF plot.

2. Cloud/clear interval

This product is produced by constructing a table that shows the number of occurrences of cloudy or clear intervals for a range of interval distances. Figure 7 provides an example of this product.

3. Conditional climatologies

This product is produced by determining the probability of a pixel being cloudy at a subsequent hour if it is cloudy/clear at the present hour. An example of this product is shown in Figure 8. For decades, operational forecasters have used conditional Climatology tables, based on cloud data from surface reporting stations, as a cloud forecasting tool. This probability does not take into account whether the pixel of interest changes categories during the intervening hours (see “Persistence Probability” below).

4. Persistence probabilities

Similar to the conditional probability, this product gives the probability that a cloudy or clear pixel will persist for a given period of time. Figure 9 shows an example of this

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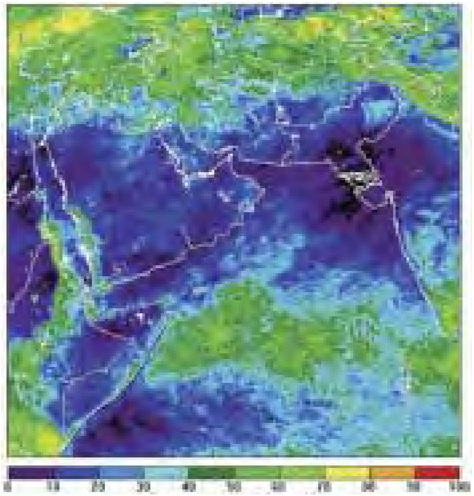

Figure 6. Example of a Frequency of Occurrence of Cloud product. Colors represent the percent of the time that clouds were detected at 0900 UTC (near noon local time) during January of 2001.

type of product. Persistence Probability tables have also been constructed from surface observations, and used operationally to determine how long clouds (or clear conditions) will persist before changing to a clear (cloudy) condition.

Summary Comments

The "War on Terror" can, in some way, be thought of as a very serious game of hide-and-seek. Aerial and space surveillance has, and will, play a critical part in this effort. For the foreseeable future, clouds will continue to have an impact on our ability to use surveillance to monitor activities, both here at home and abroad. Clouds will also impact our ability to carry out "high technology" warfare, when it becomes necessary. Even with the advent of GPS-guided "all-weather" systems, our reconnaissance systems must be able to, first, locate the potential targets. With this backdrop, CIRA will continue to push the limits of our understanding of clouds, in an effort to make them more of a "friend" than "foe" in the war on terror.

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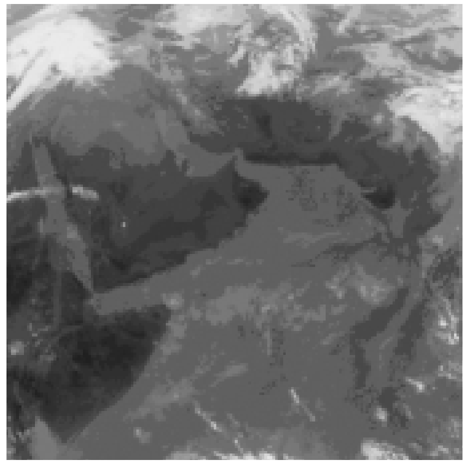

Figure 7. Infrared image from the Middle East sector, for 0900 UTC January 1st 2001 that was used to construct the "cloud/clear interval" plot.

Connell, B. H., K. J. Gould, and J. F. W. Purdom, 2001: High resolution GOES-8 visible and infrared cloud frequency composites over Northern Florida during the summers 1996 - 99. *Wea. and Forecasting,* **16,** 713-724.

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Rossow, W.B., and R.A. Schiffer, 1991: ISCCP cloud data products. *Bull. Amer. Meteor. Soc.,* **72,** 2-20.

Vonder Haar, T.H., D.L. Reinke, K.E. Eis, J.L. Behunek, C.R. Chaapel, C.L. Combs, J.M. Forsythe, and M.A. Ringerud, 1995: Climatological and Historical Analysis of Clouds for Environmental Simulations (CHANCES) Database. Final Report prepared for Phillips Laboratory under Contract No. F-19628-93-C-0197, July 1995.

Don Reinke is a CIRA Research Associate. He has 20 years of experience as an Air Force meteorologist, including an assignment as a combat weather observer with the 1st Air Cavalry Division in Vietnam. He has been with CIRA since leaving the Air Force in 1986. John Forsythe is a CIRA Research Associate who has been one of the leaders of the global cloud research programs at CIRA for the past 10 years. John was one of the key architects of the original CHANCES database.

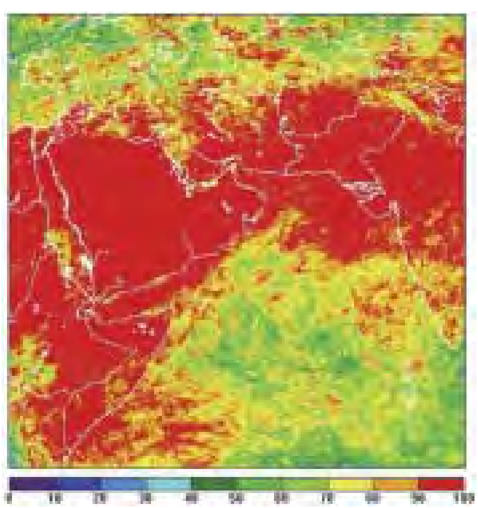


Figure 8. Example of a "Conditional Probability" product, which depicts the probability of a location being clear at 1200 UTC if it is clear at 0900 UTC.

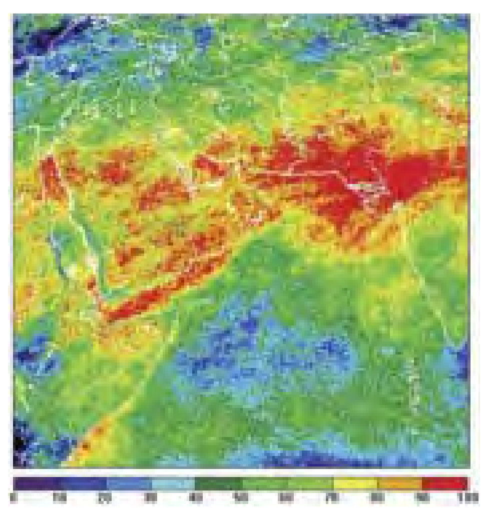


Figure 9. A "Persistence Probability" product depicts the probability of a location being clear at 2100 UTC if it is clear at 0900 UTC. (Note: This product can also be used to determine how long it has been since a surviellence system was able to "see" a particular location.)

CIRA's Participation and Contribution to the GLOBE Program Will Continue

In a February 28, 2003 news release, NASA announced that a partnership between UCAR (University Corporation for Atmospheric Research) and Colorado State University was selected as the winning proposal for operation of the GLOBE Program. CIRA, along with the Atmospheric Science Department and CSMATE (Center for Science, Mathematics and Technology Education) at CSU, comprise the CSU team that helped craft the proposal that was awarded $26 million from NASA over the next 5 years to maintain and enhance the Internet-based international science education program. Students and teachers in grades K-12, supported by research scientists, participate in hands-on experiments and other measurements to learn about the environment and increase their interest in science, technology, and mathematics.

NASA's Office of Earth Science issued a Cooperative Agreement Notice soliciting offers for operation of GLOBE on October 15, 2002. Fourteen offers were received and reviewed by a panel of experts. "This selection represents a demonstration of . . . a competitive sourcing selection based on the high qualifications of UCAR and Colorado State University, and the expertise they bring to the table," said Ron Birk, Director of NASA's Earth Science Applications Division.

"GLOBE has contributed to the improvement of student achievement in science and mathematics of over a million children around the world; it has also assembled a promising data base of Earth science measurements for Earth system research," said GLOBE Program Manager Dixon Butler. "NASA looks forward to working with UCAR <and CSU> to grow and strengthen the program, so that it will unite many more of the world's children in their efforts to understanding our constantly changing planet," he said.

"GLOBE has contributed to the improvement of student achievement in science and mathematics of over a million children around the world; it has also assembled a promising data base of Earth science measurements for Earth system research,"

The CIRA GLOBE Systems team has been involved with the Program since its inception in 1994. They designed, developed, and implemented the GLOBE website, database, and all of the key data distribution functions, and continue to support, maintain, and enhance the core hardware and software systems for the Program. The CIRA team has been integral to the growth of the Program from an initial 450 U.S. schools to more than 12,000 participating schools in 101 countries. Over 20,000 teachers have attended GLOBE workshops and GLOBE students have reported over 8 million measurements worldwide. There are now over 12 GB of data stored in the GLOBE database and this amount is expected to grow by ~3 GB per year.

The proposal was entitled *Inspiring the Next Generation of Explorers: The GLOBE Program*, with Dr. Cliff Matsumoto as the CIRA principal investigator. As CIRA Director, Thomas H. Vonder Haar noted, Dr. Matsumoto is "ably supported by Dr. Renate Brummer and a core of other CIRA scientists/software experts who have pioneered and sustained the core GLOBE system for the last 7 years under NOAA auspices. This core group brought special strength to our proposal."

CIRA, together with their UCAR and CSU partners, look forward to leveraging emerging technology and innovative visualization techniques, and implementing integrated science and education approaches in the classroom to enhance and elevate the Program to a new level over the next 5 to 10 years. For a first-hand look at the GLOBE website, go to: http://www.globe.gov.

CIRA Communiqué: Employee News

National Science Foundation Special Creativity Award

Richard Johnson, a professor in the Atmospheric Science Department at CSU, and a frequent collaborator in CIRA projects, was recently awarded a National Science Foundation Special Creativity Award. The award is an esteemed honor and is presented to an investigator whose work is found to be especially innovative or unique. There is no application or nomination process for the award because it is a means for NSF officers to guarantee the continuation and encourage the expansion of exceptional work already underway and funded by NSF. The additional monies- in this case, an extra $400,000- is a boon to Johnson's efforts and will provide support for additional work through 2005. At present, the focus of Johnson's research is a study of severe storms and flooding in the tropics, middle latitudes and monsoon regions. In gaining a better understanding of these precipitation systems, researchers will be able to improve regional forecasting. The next area of concern now supported by the extra funding, will be upper level jet streams to examine problems associated with turbulence.

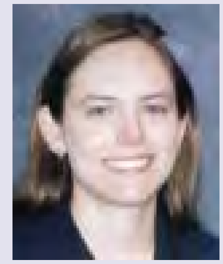
Professor Stephens Named to American Geophysical Union

The American Geophysical Union (AGU) has just announced that Professor Graeme Stephens from the Atmospheric Science Department at CSU has been named a Fellow. He was officially presented the honor at the AGU's annual meeting in Nice, France in April. Stephens, a CIRA partner through his work in the CloudSat program, as well as several other projects, is among a very small number of scientists to receive this honor. In fact, only .1% of the AGU's 38,000 members attain this level of recognition, which acknowledges renown in one or more of the geophysical sciences. "Dr. Stephens is renowned in the scientific community throughout the world as a leader in research regarding the role of hydrological processes in climate change and in the use of satellites to study the atmosphere," said Steven Rutledge, professor and head of Colorado State's Atmospheric Science Department. "He is very deserving of this prestigious fellowship and recognition among his peers."

NOAA's Forecast Systems Lab Annual Web Award Winners

FSL announced the following winners of the 2002 FSL Web Awards. CIRA employees Ali Zimmerman, Maureen Murray and Lisa Gifford were all recognized for their exceptional work.





Best Appearance: *Ali Zimmerman (left) and Maureen Murray (center) – International Division Web Site: http://www-id.fsl.noaa.gov/*
Best New Site: *Lisa Gifford (right) – ADDS PIREP Applet: http://adds.aviationweather.noaa.gov/projects/adds/pireps/java/*

Welcome

Luke Coffin – Student Hourly, Supervisor: Marilyn Watson, Start Date: September 23, 2002.

Melissa Hailes-Stacklin – Student Hourly, Supervisor: Loretta Wilson, Start Date: September 17, 2002.

Johnny Luo – Post Doctoral Fellow, Supervisor: Tom Vonder Haar, Location: Ft. Collins, Start Date: January 13, 2003.

Chris Marshall – Student Hourly, Supervisor: Lance Noble, Start Date: September 9, 2002.

Racheal Massey – Student Hourly, Supervisor: Mike Hiatt, Start Date: March 24, 2003.

Ben Riebau – Non-Student Hourly, Supervisor: Doug Fox, Start Date: February 17, 2003.

Shuxin Yin – Student Hourly, Supervisor: Doug Fox, Start Date: March 24, 2003.

Farewell

Ryan Cabell – Non-Student Hourly, Supervisor: Tomi Vukicevic, Last Day: January 31, 2003.

Charles Butler – Non-Student Hourly, Supervisor: Bret Schichtel, Last Day: December 24, 2002.

Amy Colella – Student Hourly, Supervisor: Bonnie Antich, Last Day: November 1, 2002.

John Cunning – Research Associate IV, Supervisor: Cliff Matsumoto, Last Day: January 31, 2003.

Christopher Davey – Student Hourly, Supervisor: Ken Eis, Last Day: January 24, 2003.

Kelly Dean – Research Associate II, Supervisor: Don Reinke, Last Day: March 31, 2003.

Julie Demuth – Non-Student Hourly, Supervisor: John Knaff, Last Day: November 15, 2002.

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Melissa Hailes – Student Hourly, Supervisor: Loretta Wilson, Last Day: February 28, 2003.

David Howard – Research Associate III, Supervisor: Cliff Matsumoto, Last Day: October 18, 2002.

Jonathan James – Non-Student Hourly, Supervisor: Marilyn Watson, Last Day: September 20, 2002.

Ron Kahn – Research Associate III , Supervisor: Michael Biere, Last Day: December 31, 2002.

Matt Knipp – Non-Student Hourly, Supervisor: Cindy Combs, Last Day: April 14, 2003.

Tim Lyons – Student Hourly, Supervisor: Nan McClurg, Last Day: November 29, 2002.

Matt McClurg – Student Hourly, Supervisor: Mike Hiatt, Last Day: April 10, 2003.

Nan McClurg – Research Associate II, Supervisor: Don Reinke, Last Day: March 31, 2003.

Darren McKague – Research Scientist, Supervisor: Tom Vonder Haar, Last Day: April 1, 2003.

Yelena Pichugina – Research Associate I, Supervisor: Rob Newsom, Last Day: February 28, 2003.

Robert Samuels – Student Hourly, Supervisor: Nan McClurg, Last Day; July 31, 2002.

Bret Schichtel – Research Scientist II, Supervisor: Doug Fox (will still be at CIRA but as a National Park Service employee starting February 1, 2003.

Frank Tower – Research Associate II, Supervisor: Mike Biere, Last Day: September 30, 2002.

Bard Zajac- Non-Student Hourly, Supervisor: Louie Grasso, Last Day: November 30, 2002.

NOAA's Forecast Systems Lab Employee of the Month – March 2003

Jim Frimel, a CIRA employee based in the Forecast Systems Lab in Boulder, has been selected as FSL's Employee of the Month for March 2003. As a member of the Aviation Division's Development and Deployment (DAD) Branch, Jim has been working with his colleagues to develop and implement new capability for the FAA and DOT. According to the Aviation Division chief Mike Kraus, Jim is "an imaginative, consistent, and detail-oriented developer who makes steady progress day in and day out." Specifically, Jim has was recognized for his efforts in supporting the TMU (Traffic Management Unit) project at the Fort Worth Air Route Traffic Control Center.

2002 CIRA Research Initiative Awards

The ceremonial awarding of the 2002 CIRA Research Initiative Awards last fall included (top photo, from left to right) Dave Watson, Bernadette Conell and Hiro Gosden. And from our Boulder CIRA office, Associate Director Cliff Matsumoto hands awards to Gerald Browning (center photo) and Jim Frimel (bottom photo).

Thomas H. Vonder Haar Elected to National Academy of Engineering

University Distinguished Professor and CIRA Director, Thomas H. Vonder Haar, received notice on February 14, 2003 that he is among 77 engineers to be elected to the National Academy of Engineering (NAE). According to the official news release, "Election to the National Academy of Engineering is among the highest professional distinctions accorded an engineer. Academy membership honors those who have made "important contributions to engineering theory and practice, including significant contributions to the literature of engineering theory and practice," and those who have demonstrated accomplishment in "the pioneering of new fields of engineering, making major advancements in traditional fields of engineering, or developing/implementing innovative approaches to engineering education."

Vonder Haar was recognized for his work in studying the Earth's radiation balance and its relationship to climate.

Vonder Haar was recognized for his work in studying the Earth's radiation balance and its relationship to climate. After completing his graduate work at the University of Wisconsin, Vonder Haar accepted a teaching position in the Department of Atmospheric Science at Colorado State University. In 1980, he successfully launched CIRA as a joint institute of NOAA and has served as Director since its inception. Vonder Haar's reputation at the University grew steadily over the years, and he was awarded the distinction of University Distinguished Professor in 1994.

To celebrate Professor Vonder Haar's election to the NAE, a reception was organized at CIRA in late February. Many colleagues and friends from the Department of Atmospheric Science, as well as the College of Engineering, attended the reception including Atmospheric Science Department Head, Steven A. Rutledge, and Engineering Dean, Neal C. Gallagher. CIRA Deputy Director, Ken Eis introduced Professor Vonder Haar and noted that membership in the NAE is a very exclusive honor; in fact, total U.S. membership numbers only a little over 2,000.

Vonder Haar thanked CIRA staff, researchers and other colleagues for their support and recognized that it was in working together that much of the successful research was completed.

In photo at left, CIRA Deputy Director, Ken Eis, introduces Dr. Vonder Haar at the celebration reception. At right, University Distinguished Professor Emeritus, Dr. Jack Cermak, chats with Dr. Vonder Haar. It was Professor Cermak's nomination that resulted in the honor for Vonder Haar.

911 Dispatch Cards for Natural Disasters Still Popular

By John Weaver with Mary McInnis-Efaw

Under the auspices of the VISIT program (Virtual Institute for Satellite Integration Training) spearheaded by NOAA, a number of researchers at CIRA have been engaged in training efforts that transfer advances in research to the hands-on world of National Weather Service forecasters. John Weaver, a member of NOAA's RAMM Team based at CIRA, has been involved with many such training efforts during his 23 years at the institute.

One such training effort came in the aftermath of the devastating flash flood that affected Fort Collins, Colorado the night of 28 July 1997. At the time of the event, Weaver was also volunteering with the Fort Collins Office of Emergency Management (OEM). In the weeks and months that followed, Weaver worked with local responding agencies to explore and identify the "failure points" during that unprecedented event. One of the weaknesses identified was that the 9-1-1 dispatch center was entirely overwhelmed by the amount of incoming emergency calls, and related radio traffic. As the events of that July night were reviewed, Weaver and his OEM colleagues began to develop the idea for a training program that dispatchers might use to better prepare for emergencies during a natural disaster. Clearly such an effort would be a great fit as a part of Weaver's association with both CIRA and NOAA.

Emergency worker tries to reach a submerged hydrant while other workers rescue trapped residents during the July 1997 flood event.

The calls during the busiest two hours of the event arrived at a rate of one call every 8.5 seconds, in an environment where the five dispatchers were already bogged down with flood and non-flood emergencies. CIRA/RAMM researchers sought to investigate whether these deficiencies were peculiar to the Fort Collins OEM, or if this was common to emergency management offices throughout the country. A survey of dispatch centers and/or emergency managers in 20 states followed, and it was found that many were similarly unprepared for natural disasters. From the survey, researchers compiled a comprehensive list (to the 90th percentile) of most frequently asked questions during a number of different natural disasters. With the problem identified, a joint effort between the City of Fort Collins Office of Emergency Management, the National Weather Service, NOAA, FEMA and CIRA was launched.

For further information on the NDIC, please see
http://www.cira.colostate.edu/fflab/frontrange.htm
to access information, photos, etc from the flood of 1997, and
ftp://ftp.cira.colostate.edu/weaver/NDIC_Html/1start_ndic.htm
to view the cards themselves.

Although the response on the part of emergency dispatchers was impressive that night, their lack of experience with natural disasters specifically left them ill-equipped to deal with the types of calls they received.

In its first incarnation, the solution came in the form of a Powerpoint presentation which operated like a flow chart. These Natural Disaster Information Cards (NDIC) were used in teletraining courses funded by VISIT for emergency offices around the country. Dispatchers could choose a type of natural disaster (blizzards, floods, lightning, hail, or tornadoes) then follow the sequence of cards/screens to learn how best to handle the call and what sound advice to dispense. The system later evolved to an HTML format to simplify the use of the system. The cards are now being used in many offices across the country in a number of different ways. The most frequent usage for the cards is for in-house training, followed closely by 9-1-1

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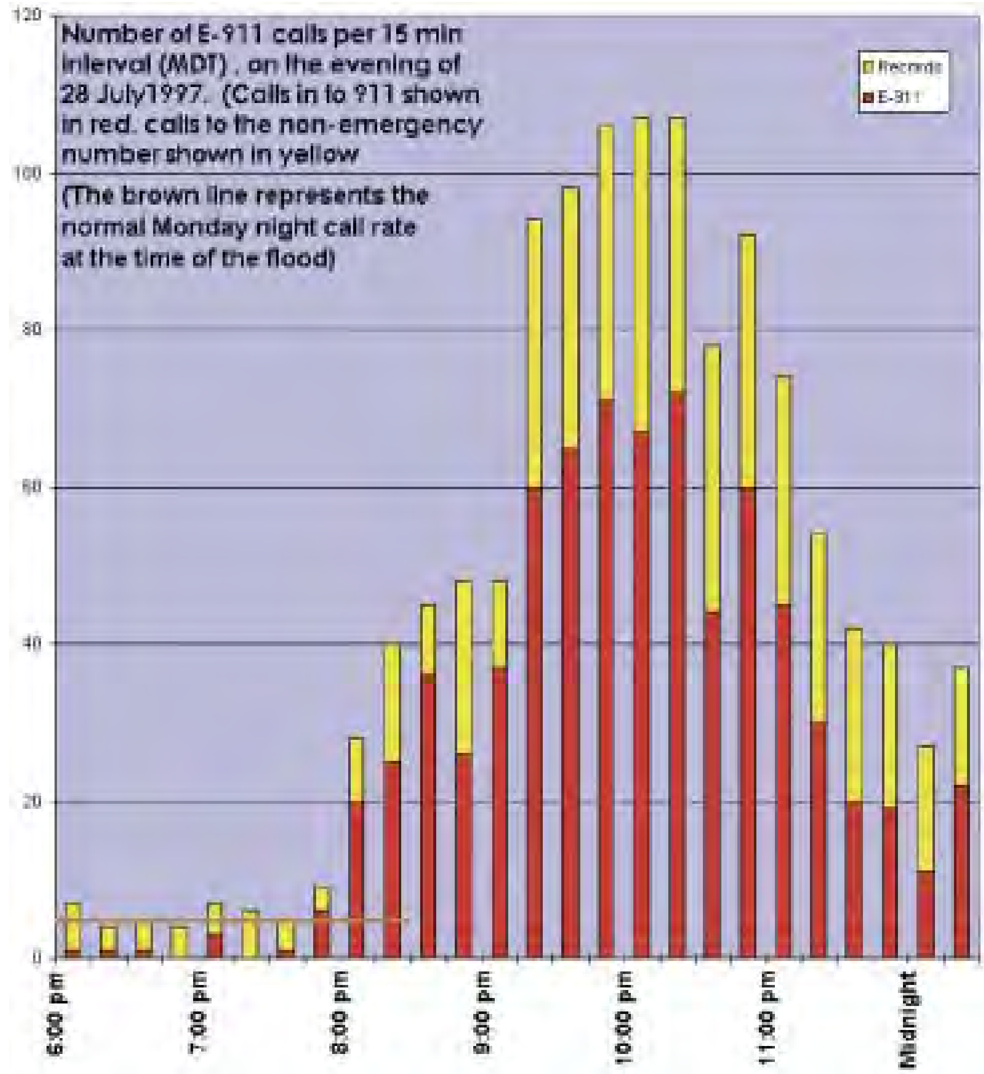
911 Dispatch Cards *(continued from page 12)*

a review for dispatchers on the morning of the day of an anticipated event. As one might imagine, events occur too quickly in real-time for the system to be useful without this prior review, though the advice is available quickly in the event that a call taker forgets specifics. The system has been popular enough that the cards have been featured in several dispatch magazines to further publicize its usefulness.

Though the card system was completed in 1999, many refinements have been added in subsequent years. Also, interest in the program surged after the terrorist attacks of September 11th, and much thought was given to expanding the cards for use in other types of emergencies. Weaver has been contacted by any number of private companies asking permission to either expand the system for other emergencies, or to incorporate the system, as it stands, into whatever programs they are developing. Because the system has been in the public domain since its inception, these requests have been easily accommodated.



Emergency call volume during the July 1997 Fort Collins flood event.

USAGE:

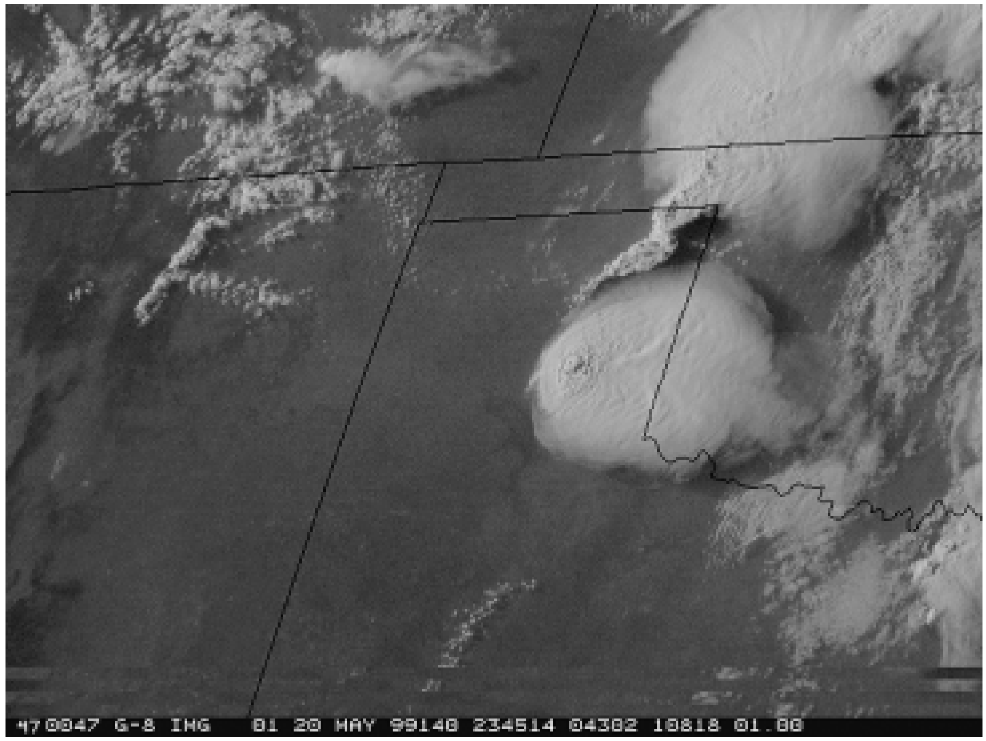
1. **In-Service Training.** General weather knowledge from a dispatch perspective.
2. **Pre-Event Review.** To review specific problems and procedures for a day on which a dangerous event is expected.
3. **Emergency Directions.** A guide that can be used in real-time to answer specific questions.

Samples of the 911 Dispatch Cards used in training by dispatchers to respond to callers' most frequently asked questions during emergencies and natural disasters.

Dryline Thunderstorm Development

By Lewis D. Grasso

Thunderstorm development is associated with a variety of boundaries in the Earth's planetary boundary layer. Along with cold fronts and warm fronts, low-level thunderstorm outflows can trigger new thunderstorms. Although different from a boundary, some terrain features are known to be a preferred location for the initiation of thunderstorms. Another type of boundary that can trigger thunderstorms is a dryline. Drylines have been studied extensively in the Great Plains of the United States during spring and early summer.



Satellite imagery of a thunderstorm developing along a dryline in the Texas panhandle on May 20, 1999.

Dryline Observations

Air masses in the planetary boundary layer of the Earth's atmosphere are separated by boundaries: warm fronts, cold fronts, and drylines, for instance. When a warm front passes an observing station, both the temperature and dewpoint temperature increase. When a cold front passes an observing station, both the temperature and dewpoint temperature decrease. In contrast, when a dryline passes an observing station not only will the temperature remain the same or increase, but also the dewpoint temperature usually decreases significantly. At times, gusty westerly winds develop during the passage of a dryline.

Observations indicate there are two horizontal length scales associated with a dryline: 100 km and 10 km. The larger length scale – 100 km – identifies a dryline environment. The dryline environment describes the gradual decrease of surface dewpoint temperatures from 20 °C in central Oklahoma to -2 °C within the Texas Panhandle. The smaller length scale –10 km – describes a dryline zone and is contained within a dryline environment. A dryline zone describes the relatively large horizontal gradient of surface dewpoint temperatures: 18 °C over a 10 km distance, for example. Identification of a dryline zone is a recent method of denoting the location of a dryline. Furthermore, thunderstorm development typically occurs within the dryline zone. Even though a dryline environment may exist over a region, a dryline zone may be absent.

Drylines can appear in the warm sector of an extratropical low pressure system. As a region of low pressure moves eastward from the Rocky Mountains, relatively hot and dry air advects northeastward from the desert southwest to western Texas, Oklahoma, and Kansas. South to southeasterly flow from the Gulf of Mexico transports warm moist air over eastern Texas, Oklahoma, and Kansas. Both air masses-one hot and dry, the other warm and moist-merge in a confluence zone over central portions of the southern plains. That is, not only does the dryline environment contain a horizontal dewpoint temperature gradient, but also a confluent wind field.

Drylines in the Great Plains of the United States are typically positioned from south to north. Terrain contours of the Great Plains are approximately oriented in the north-south direction; that is, surface elevation generally increases from east to west in the Great Plains. As a result, the depth of the moist layer flowing northward from the Gulf of Mexico decreases from east to west. Sloping terrain gives rise to a relatively diffuse eastward gradient of dewpoint temperatures along the western edge of the moist layer. In fact, the diffuse dewpoint temperature gradient is a dryline environment.

Air on the west side of a dryline originates over the elevated plateaus of the southwest United States and northern Mexico. Prior to the onset of the summer monsoon over the desert southwest, dewpoint temperatures are relatively low. Afternoon high temperatures typically range between 30 and 35 °C; as a consequence, the boundary layer can become several kilometers deep. During summer, hot and dry air over the southwestern United States is replaced by the cooler and moister monsoonal flow. As indicated by satellite images, springtime westerly flow changes to southerly flow during the summer. Because of the moister monsoonal flow, the dewpoint temperature gradient associated with the dryline environment decreases. That is, onset of the summer monsoon signals the end of the development of drylines.

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Dry Thunderstorm Development *(continued from page 14)*

Remote Sensing

In addition to planes, cars, and surface stations, remote sensors have also been employed to provide measurements of a dryline. Some examples of remote sensors are weather satellites, National Weather Service (NWS) Doppler radars, and Doppler lidar. Each sensor has strengths and weaknesses; nonetheless, additional information is provided about a dryline.

Weather satellites have several different channels that are used to study a dryline. Prior to the development of cumulus along a dryline, two infrared channels can be combined to improve detection of the location of a dryline. Brightness temperatures in infrared images are reduced by the presence of water vapor in a cloud-free field of view. A moist cloud-free boundary layer to the east of a dryline appears cooler than the dry cloud-free boundary layer to the west of a dryline. Some infrared channels are more sensitive to water vapor than others; therefore, the combination of channels can provide an improved image for detecting the western edge of a moist layer associated with a dryline. Water vapor images provide characteristics of the winds in the upper troposphere. Identification of upper level jets – along with the axis of maximum winds – is possible; in addition, regions of rising and sinking motion can be detected. Visible and infrared images show regions of blowing dust to the west of drylines. Visible images are also valuable for providing a continuous view of cumulus clouds along the entire length of a dryline; on the other hand, Doppler radars will detect only a segment of a dryline. Unlike visible images, a cloud-free dryline may appear as a fine line when viewed by a Doppler radar.

"Cumulus Contestus" over Limon, Colorado. (Image ID: wea00093, Historic NWS Collection. Photographer: Cruse/Crowley)

Thunderstorm Development

Identification of a dryline environment is an important forecasting issue. Processes that occur in the dryline environment may lead to the development of a dryline zone. Although the dryline zone contains a greater horizontal dewpoint temperature gradient-relative to the dryline environment, the most important characteristic of the dryline zone is upward motion. If conditions are favorable, upward motion may lead to convective initiation: thunderstorms. Even though the resulting thunderstorms produce beneficial rains to agricultural regions of the southern plains, such storms can produce outflows in excess of 25 m/s, hail that can damage crops and structures, and tornadoes. As an example, the severe and tornadic thunderstorms that formed in Kansas and Oklahoma on 26 April 1991 were associated with a dryline.

All of the methods used to denote the position of a dryline may yield drylines in different locations. That is, a dryline zone may be located several tens of kilometers east of the 8 or 9 g/kg water vapor mixing ratio isohume. If the 8 g/kg water vapor mixing ratio isohume is used to denote a dryline, then thunderstorm initiation may occur east of a dryline. In other words, because of the arbitrary methods used to denote the location of a dryline, thunderstorms may appear to develop several tens of kilometers east or west of a dryline.

Nowcasting thunderstorm development along a dryline can be challenging for forecasters. Thunderstorm initiation can be suppressed by the presence of an overlying inversion. At times, however, the overlying inversion might be completely eroded, and convective inhibition may be zero. Even though convective inhibition might be zero, convective development may continue to be suppressed along a dryline. Afternoon vertical profiles of temperature typically exhibit neutral stability – constant potential temperature – from the surface to about 2 km. Due to the neutral stability, upward lifting encounters little resistance. After the lifting condensation level is reached, a parcel can rise freely; that is, the lifting condensation level is the level of free convection, according to parcel theory.

One assumption contained in parcel theory is an absence of mixing a parcel with the environment. Consider the following situation:

Assume the potential temperature is constant from the surface to 2 km; further, assume the water vapor mixing ratio is constant from the surface to 1 km followed by a marked decrease in the layer from 1 km to 2 km. According to parcel theory, a parcel is lifted from the surface to the lifting condensation level – assumed to be 2 km – while maintaining the surface water vapor mixing ratio value. In contrast to parcel theory, when mixing of a parcel with the environment is taken into account, then the potential temperature of the parcel will remain the same from the surface to 2 km: The layer is neutrally stable. Water vapor mixing ratio values will also remain the same, but only from the surface to 1 km. Within the layer from 1 km to 2 km the environmental water vapor mixing ratio decreases, and mixing of the parcel with the environment will decrease the water vapor mixing ratio of the parcel. Due to mixing, the lifting condensation level will increase, and condensation may occur at a temperature that is cooler than the environment. In other words, mixing can result in positive values of convective inhibition that upward motion along a dryline is unable to overcome. As a result, thunderstorm development will be suppressed.

An extended version of this article will appear in the *Encyclopedia of Atmospheric Sciences.*

CIRA Mission

The Cooperative Institute for Research in the Atmosphere (CIRA), originally established under the Graduate School, was formed in 1980 by a Memorandum of Understanding between Colorado State University (CSU) and the National Oceanic and Atmospheric Administration (NOAA). In February 1994, the Institute changed affiliation from the Graduate School to the College of Engineering as part of a CSU reorganizational plan.

The purpose or mission of the Institute is to increase the effectiveness of atmospheric research of mutual interest to NOAA, the University, the State and the Nation. Objectives of the Institute are to provide a center for cooperation in specified research programs by scientists from Colorado, the Nation and other countries, and to enhance the training of atmospheric scientists. Multidisciplinary research programs are given special emphasis, and all university and NOAA organizational elements are invited to participate in CIRA's atmospheric research programs. Participation by NOAA has been primarily through the Oceanic and Atmospheric Research (OAR) Laboratories and the National Environmental Satellite, Data, and Information Service (NESDIS). At the University, the Departments of Anthropology, Atmospheric Science, Biology, Civil Engineering, Computer Science, Earth Resources, Economics, Electrical Engineering, Environmental Health, Forest Sciences, Mathematics, Physics, Psychology, Range Science, Recreation Resources and Landscape Architecture, and Statistics are, or have been involved in, CIRA activities.

The Institute's research concentrates on global climate dynamics, local-area weather forecasting, cloud physics, the application of satellite observations to climate studies, regional and local numerical modeling of weather features, and the economic and social aspects of improved weather and climate knowledge and forecasting. CIRA and the National Park Service also have an ongoing cooperation in air quality and visibility research that involves scientists from numerous disciplines. CIRA is also playing a major role on the NOAA-coordinated U.S. participation in the International Satellite Cloud Climatology Program (part of the World Climate Research Programme).

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