# EXTREMES



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# HOW TO USE THIS BOOK

This book is divided into six sections: Engine, Action, Extremes, Watching, L Climate, and Change. Engine gives an overview of Earth's atmosphere and its global systems. Action explains the workings of general weather phenomena, such as clouds, rain, and snow. Extremes looks at devastating weather events, including tornadoes, hurricanes, and drought. Watching covers the science of meteorology, from ancient times to today. Climate tours the climate zones of the world. The final section, Change, provides a compelling portrait of our relationship with Earth and the effects of climate change. Each section is broken down into chapters devoted to particular subjects. Each chapter begins with an introduction to the subject (right), providing a general overview, then the subject is explored in detail in the pages that follow (examples are below). Special features, called "Insights" (far right), look at the evolution of our knowledge about weather and climate through text, illustrations, charts and graphs, maps, and photographs.

### Section and chapter heading This indicates the broad theme and specific area under discussion.

Global locator map discussed below it.

This pinpoints the location of the key regional examples

• 70 ACTION WATER



Glaciers





Illustration

A graphic cutaway illustration

shows the inner workings of

a physical phenomenon.

### Feature box

Photographs or illustrations, and text, highlight an interesting aspect of the topic being explored.

Timeline This provides information about key developments

through the ages.

Where appropriate, diagrams are included to illustrate complex concepts

INTRODUCTORY FEATURE

TRACKING WEATHER

Diagrams

GLACIERS ACT







## or profiles several examples of the subject under discussion.

This panel explains processes

Fact file

### Global Changes

vidence of global warming



Satellite photography Images taken from space provide unique perspectives on Earth.

### INSIGHTS



Introductory text

This provides a

of the subject.

general overview





### Charts and graphs These group data and present statistics and forecasts in an easy-to-understand format.

### Photograph

GLOBAL CHANGES

An evocative photograph shows a landform or feature that is representative of the subject matter under discussion



### World map

This shows the global distribution of a feature being profiled, and is accompanied by text that discusses the feature in more detail.

### FACT FILE

Stages of a storm A typical thunderstorm grows, reaches maturity, and decays in under an hour. Occasionally, more intense, severe storms last much longer. They all pass through three distinct stages.



Towering cumulus Condensing water to make the cloud heats the air. Updrafts prevail within the cloud and the cloud rapidly grows in height.



Mature The updraft spreads out and forms the anvil when striking the stable stratosphere. A downdraft forms where air is cooled, lowering the freezing level. Precipitation begins falling.



Dissipating Eventually, downdrafts predominate, shut off the supply of warm air, and the cloud dissipates.

## Thunderstorms continued

The power in a thunderstorm is immense. Energy is released when water vapor condenses and rain falls out. The amount of energy generated during an average thunderstorm is about 10 times the energy produced by the world's largest hydroelectric dam. Most of this energy heats the air, but a small fraction drives the strong winds of the thunderstorm.

Overshooting top The strongest updrafts have caused this part of the cloud to punch through the tropopause and into the stratosphere.

Anvil top Rising air in cloud tends to spread out when it reaches the tropopause, forming a flat top.

Vault This egg-shaped region at the heart | of the storm has the strongest updrafts. The vault looks dense to the naked eve but appears as an empty space in a radar image because the droplets in the vault are too small to reflect a radar signal.

Upper-altitude flow Winds at this high altitude tend to blow around the cloud.

Mid-altitude flow Some of the wind at | this level is drawn into the cloud. Rain falling from above evaporates, making this air cooler and more dense, so it sinks, feeding the downdrafts.

Flanking line This line of | smaller convective clouds may grow into thunderstorms or be drawn into the parent cloud.

Low-altitude flow Wind at this level is warm and often humid. This air rises and condenses to form the cloud. The condensation heats the air making it buoyant and feeds the undrafts

> Tornado Powerful tornadio winds are formed by the concentration of rotating flow from a much larger area.

Heaviest hail The zone of heaviest hailfall is marked here in green. The larger hailstones form when crossing over and falling to the sides of the vault.

Heaviest rain The zone of heaviest rain is marked here in purple at the level of the

Roll cloud These horizontal clouds sometimes form at the leading edge of a

Lightning Thunderstorms are defined by the presence of lightning. Most lightning occurs within clouds. Lightning that strikes the ground can start fires and kill people unlucky enough to be caught in the open.

Inside a thunderstorm This illustration of a supercell thunderstorm shows all the major components. All thunderstorms have updrafts and downdrafts. Severe storms have a complex structure, where downdrafts reinforce updrafts. Some storms occur in an environment where the wind direction changes with height, initiating horizontally rotating winds within the storm.

> **Mammatus** These pendulous globules of cloud hang from the underside of the anvil. They form when a very high concentration of condensed water is present and are associated with severe storms. These clouds are the only clouds that grow downward.

Shelf cloud This horizontal

Gust front The gust front is the leading edge of the outward-spreading air created wh downdraft reaches the ground.

### FACT FILE

Thunderstorm organization Flow rising up a mountain favors a single storm. Sometimes a group of storms persist when the spreading downdrafts initiate new convection. At other times, a weather front organizes storms into a line.



Single storm This is an isolated thunderstorm. The spreading anvil has cast a shadow onto lower clouds to the left. Smaller convection clouds flank the sides of the thunderstorm.



Storm cluster Here, three overshooting tops from a cluster of thunderstorms cast shadows on the anvil cloud. In the tropics, such clusters can be the seed for a tropical cyclone.



Squall line A cold front has created a line of thunderstorms, with developing storms on the right. Dissipating storms are on the left, where anvil tops have merged to form a single broad deck of high cloud.