Satellite Image Interpretation

Material from *An Introduction to Satellite Image Interpretation* by E.D. Conway, The MD Space Grant Consortium, 1997. Chapters 3,6,7,9-12 and from KVH Ch. 5. Figure numbers below from KVH.

An **image** is a collection of pixels (picture elements) -- like photo in a newspaper. Each pixel has its own tone or color. Grayscale or color scale used to show varying intensity in each pixel

Types of images

Visible image -- highly reflective objects (clouds, snow, deserts) appear white, absorbing objects (e.g., ocean, forest) dark. Fig 5.1, 5.5 top, 5.6 top.

Issues: shadows Fig. 5.14

no data in nighttime

sunglint Fig 5.16 top

contrast over bright surfaces (e.g., clouds over snow)

Infrared image -- usually cold objects white, warm objects dark. Fig. 5.2, 5.5 bottom, 5.6 bottom.

Issues: contrast between cloud and surface if temperatures similar. Fig 5.18 bottom

Water vapor image -- 6 to 7.5 μm -- usually abundant/high moisture looks white, dry is dark. Fig. 5.3.

Issues: sometimes cannot distinguish between high-level (altitude) moisture and abundant moisture

Image Enhancement --

Method to highlight certain values (usually temperatures or brightness temperatures) within an image to emphasize certain phenomena of interest.

Unenhanced (linear) temperature scale -- gray scale for IR -- handout, examples in class

Several different enhancement curves (ZA, MB, BD) -- handout, examples in class

Sources of error in imagery

cloud displacement -- large view angle makes cloud appear to be in different location than it really is. Fig. 5.9

limb darkening -- large view angle makes temperatures appear colder because looking through thicker layer of atmosphere

navigation errors. Fig. 5.8

Identifying Cloud Types

Cloud formation closely related to stability (stratification) of atmosphere

unstable stratification => vertical motions => clouds with vertical development (cumuliform), showery precipitation. E.g., thunderstorms, cumulus, cumulonimbus

stable stratification => flat, layered clouds, drizzle or steady precipitation (stratiform clouds)

Features that aid in cloud ID

brightness -- thickness, height

texture -- lumpiness, shadowiness => vertical development

organizational pattern -- relationships to fronts in storm. Fig. 5.11

edge definition

size

individual shape

animations (clouds versus surface features)

Cases in which cloud ID is difficult

thin clouds

small clouds

clouds over snow/ice -- 3.7 μm channel helpful. Fig. 5.18 middle

multi-layered clouds

Large-scale cloud patterns (see handout)

Cloud patterns associated with winds

cloud streets

sea breeze Fig. 5.15

land breeze

thunderstorm anvils, blowoff Fig. 5.12 top (look in lower left corner of image)

katabatic winds -- winds off high-elevation ice sheets (common near Greenland, Antarctica)

mountain waves Fig. 5.13

thunderstorm outflow boundaries

Cloud patterns associated with jet streams

usually marked by cirrus shields or streaks. Fig. 5.11, HO

extra-tropical storms form in jet, first cloud “leaf” pattern then comma-shaped cloud. HO

closed versus open-celled clouds

ID ridges and troughs

water vapor imagery very helpful to ID jet

Synoptic-scale storm development

cold fronts -- cold air overtaking warm air. Usually vertically-developed clouds (cumuliform), sharp boundary, well defined. In winter over land can sometimes see warm/cold airmasses in IR image. Fig. 5.11

warm fronts -- warm air overtaking cold air. Wide band of mostly stratiform clouds. Sometimes hard to locate, amorphous. Fig. 5.11.

occluded front -- cold or warm front aloft. In images there are characteristics of both warm and cold fronts, sometimes hard to locate. If storm has spiral shape, often occluded front in spiral area (usually in NW part of storm in northern hemisphere).

stationary front -- boundary between cold and warm airmasses, boundary not moving (jet stream parallel to boundary)

Thunderstorms and severe weather

very bright clouds in vis, IR, water vapor. Middle of Figs. 5.1, 5.2, 5.3 shows Intertropical Convergence Zone (ITCZ)

often circular, globular, triangular (anvil)

individual lumps in a smoother cloud shield (blobs of colder IR temps) -- embedded thunderstorms

squall line -- thunderstorms along a nearly continuous line, usually ahead of a cold front or dry line (humidity front) Fig. 5.12

outflow boundaries -- curve of convective clouds moving away from dissipating thunderstorms, often trigger for new storms

mesoscale convective complex (or system) -- MCC or MCS -- large (100s of km) cluster of strong thunderstorms, often slow-moving => flooding.

tornados -- thunderstorm with triangular shape, better diagnosed with radar, doppler radar

tropical storms -- form in late summer season. Enhancement very useful tool for diagnosing strength. Direction of outflow cirrus often indicates storm movement.