MFE 659 Background 2: Forecasting

Weather Risk

- Generally weather risk is simply about cash flow or earning uncertainty caused by weather volatility.
- The uncertainty in cash flow or earnings comes from weather (precipitation, temperature, wind, moisture (humidity / dew point), sea state, etc.
- See also the Weather Risk Management Association (WRMA) => http://tinyurl.com/fin450-23

Opening Game NYC

- Rain in the forecast for the opening game of the 2009 World Series of baseball caused ticket sales (of the cheapest seats) to drop from $330 to $270 a few days before the game in New York City.
- Capacity 50,086 seats
- See http://tinyurl.com/fin450-24

Winter Storms: China 2008

- Series of winter storms
- 25 January - 6 February 2008
- Losses ¥80 Billion (and $11.7B USD)
- Losses Swiss Re - ¥8.8B ($1.3B USD)
- Travel - hotel, airlines, rail
- -7% Shanghai Composite Index?

Loss to Ski Resorts

Dave Schultz, Univ. Helsinki

- Winter storm, Front Range of the Rockies
- Many of the mountain roads were closed for two days.
- Given that the ski industry loses $800,000 an hour when I-70 is closed on a weekend, this storm had a significant economic/ societal impact.

Catastrophe (CAT) Risk

Weather risk is a different class of risk from catastrophic weather-related risk ... even though hurricanes, tornadoes and floods can “wipe out” events on a larger scale.

2008 Hurricane Season

- In 2008 Warren Buffet’s Berkshire Hathaway agreed to buy $4B 30-year Florida state bonds to supply Florida with cash if cumulative hurricane damages for the year exceeded $25B.
- Florida paid Berkshire $224M up front for the option
- http://tinyurl.com/fin450-26

Managing Weather Risk

- Managing weather related cash flow, earnings uncertainty.
  - weather derivatives
  - weather insurance

Weather Derivatives

- Structured tradable financial product for hedging
- Emerged in the U.S. late 1990s (energy - Enron, et al.)
- Index based (in situ weather) except hurricanes (Chicago Mercantile Exchange – CME's CHI)
- OTC (over the counter or off-exchange) (to counter party risk) or Exchanges (margins required)
- CME - monthly, seasonal (i.e., Dec - Feb)
- CME limited - 24 U.S., 10 Europe, 6 Canada, 6 Asia-Pacific
- Non-trivial to value (Monte Carlo simulations, forecasts)
- Comparatively small (900,000 shares CME) and illiquid

Weather Insurance

Weather insurance is another way to hedge against volatile weather. There are a variety of private and government based weather insurance programs that provide coverage

- Industry / Commercial - Ag, Transportation, Construction, Retail, Energy, Leisure, etc.
- Homeowners - hail, lightning, wind (aluminum siding), water
- Government - U.S. National Flood Insurance Program (NFIP)
- Lloyds of London
- NFIP => http://tinyurl.com/fin450-27

Rain Insurance (broker)

- This is part of a real quote for rainfall insurance from an unnamed broker ... the greater the minimum rainfall threshold the lower the rate and premium
- Outdoor events any three days within 16 Jan - 20 April, time window: 4 - 7 p.m.
- Limit: $1,095,000 ($365,000 per day)
- ≥ 0.10" rain, rate = 13.1%
- ≥ 0.20" rain, rate = 7.1% ($100K cover = $7.1K)
- ≥ 0.50" rain, rate = 3.5%

Rain Insurance (broker)

- Rainfall measured where?
- Nearest government in situ rain gauge, or
- Traveling weather observer (portable rain gauge)

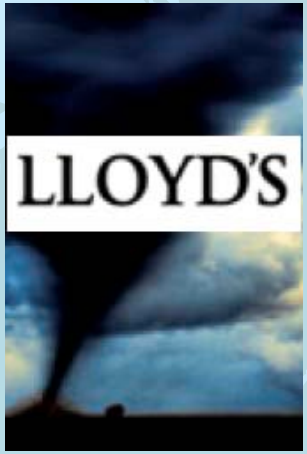
Transfer of Weather Risk to Global Reinsurers

A string of natural catastrophes wreaked havoc in 2008, costing the global economy $225 billion and leaving insurers with their second costliest year in history ...

Munich RE

Swiss Re

TOKIO MARINE GROUP



Major Losses in 2008

2008 global data compiled by Swiss Re.

	Number	Insured loss[6] (in USD m)
Natural catastrophes	**137**	**44 692**
Floods	44	2 059
Storms	62	39 288
Earthquakes	12	422
Droughts, bush fires, heat waves	2	500
Cold, frost	7	1 575
Hail	7	763
Other natural catastrophes	3	85

Weather Insurance in Semi-Arid India

- A weather insurance program co-sponsored by the World Bank for farmers in parts of India ... most interesting is the socioeconomic facets of when farmers decided to plant and whether they use weather insurance.
- Farmers in India affected by the Monsoon
- World Bank co-sponsored
- Income / cash flows / wealth
- Social networks
- Risk Aversion
- Rainfall / Land Characteristics
- http://tinyurl.com/fin450-28

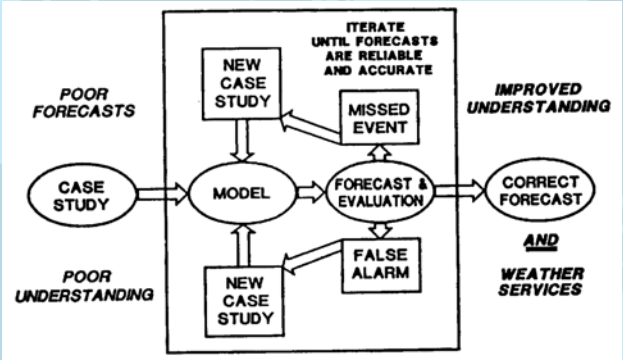
Questions?

LECTURE 1 PART II
DEVELOPMENT OF A FORECAST

- Forecasting is a scientific process and therefore subject to the scientific method.*
- The forecast is influenced by the order of presentation of information.
- There is an optimum order for the forecast process.

✶ What is meant by “scientific method?”

FORECASTING



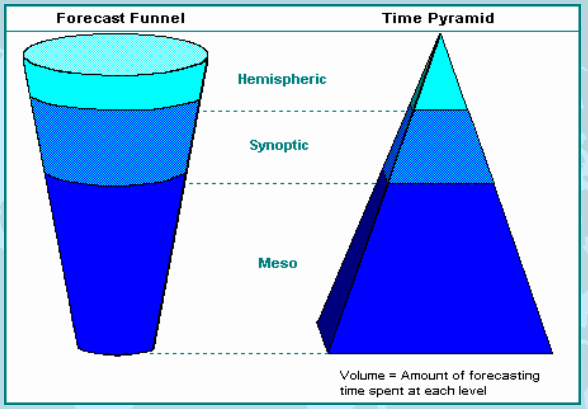
Weather Forecasting is an iterative process that is a prime example of the scientific method.

Development of a Forecast

Two principles are instrumental in the development of an efficient weather brief and an accurate weather forecast.

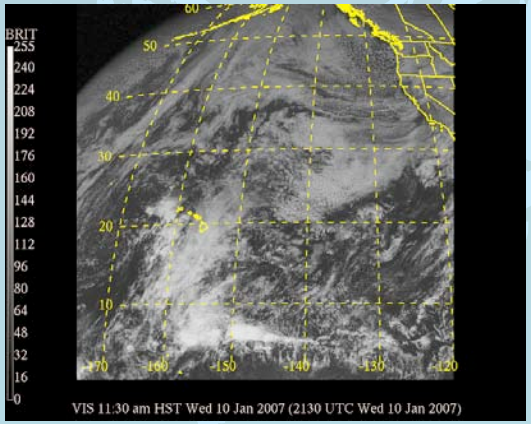
1. Past, present, future. Begin by reviewing the history of the recent weather that led to the current conditions. Then use the current conditions to evaluate the track record of recent model runs. Finally consult the latest model charts to develop a forecast for the future.
2. Large scale to small scale. Weather exists on a broad range of time and space scales. In preparing a forecast begin by reviewing the largest scale weather first, then working to smaller and smaller scale features (e.g., planetary scale, cyclone scale, front scale, thunderstorm scale).

The Forecast Context



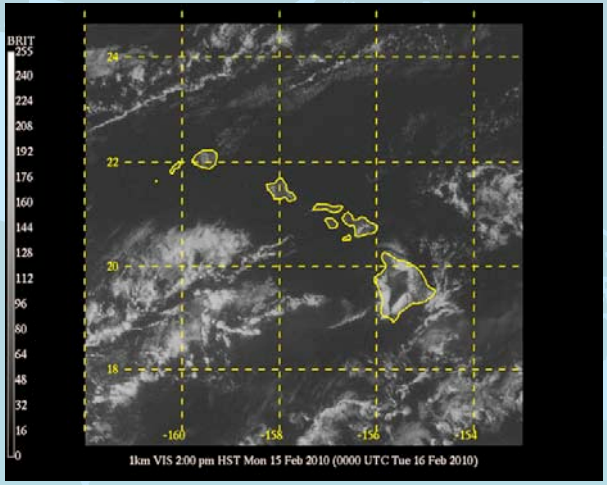
- Forecast Funnel – focus attention from the global scale on down to the local scale.
- Time Pyramid – gauge the amount of time that may be needed to assimilate the different scales of interest.

Visible



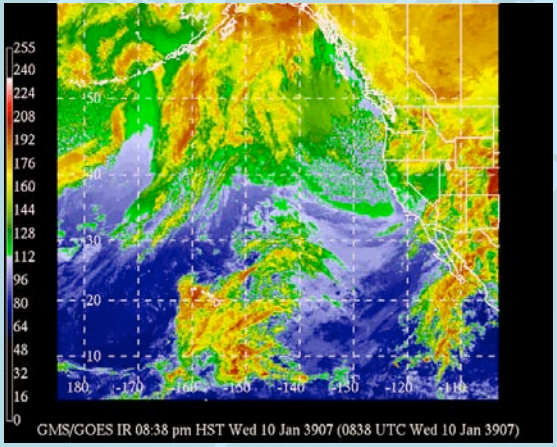
- 0.7 µm
- Day time only
- Determine Cloud Type
- Only image type to see low level clouds clearly
- 1 km max resolution

GOES-10 Visible



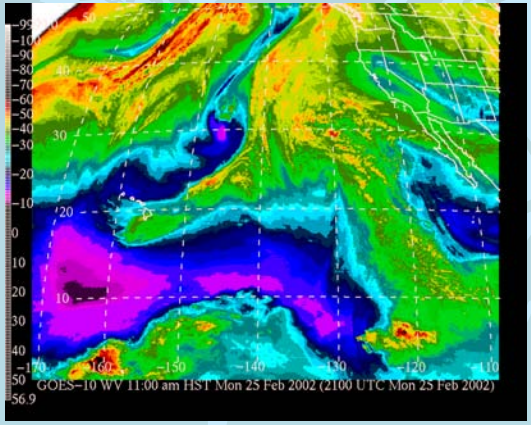
High resolution of visible imagery allows individual cumulus clouds to be seen.

Infrared



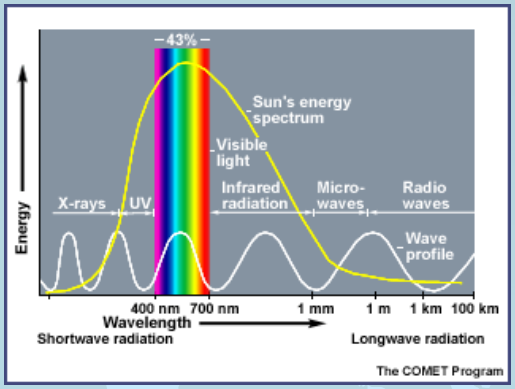
- Uses 12.5 µm window
- Uses IR to measure cloud top or surface temperature
- 4 km resolution
- Useful in determining appx. cloud top altitude
- Can often determine cloud type with this and visible imagery

Water Vapor Channel



- Detects water vapor above ~ 400 mb
- Uses IR (6.2 µm)
- Useful for determining degree of subsidence
- Useful for analyzing upper level circulations
- Detects liquid water as well
- Not useful for quantitative moisture calculations
- 8 km resolution

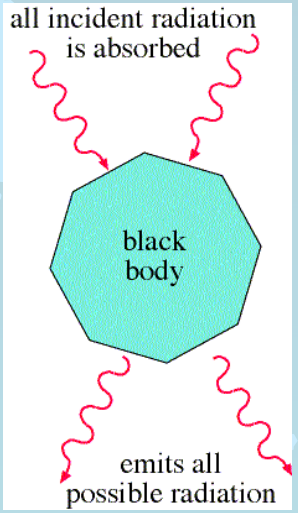
Radiation



- Radiation - energy leaving a body in the form of electromagnetic waves.
- Light is a form of electromagnetic radiation.
- The speed of light is ~ 3×10^8 m/s through a vacuum (slightly slower through air).

Radiation Concepts

- Blackbody - is a theoretical object that absorbs all incident radiation and emits the maximum possible radiation for its temperature (according to Planck's Law).
- Solar constant - Amount of solar radiation passing through a unit area at the top of the earth's atmosphere perpendicular to the direction of the radiation at the mean Earth-sun distance.



Planck's Law

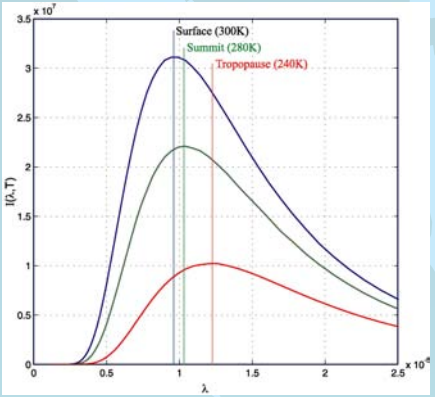
The amount of radiation emitted by a blackbody is described by Planck's Law

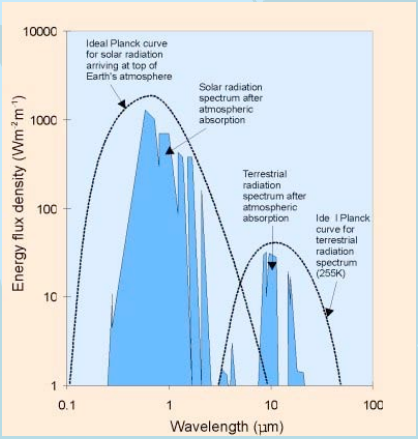
$$E_\lambda = \frac{2\pi hc^2}{\lambda^5\left[\exp\left(hc/k\lambda T\right)-1\right]}$$

.

- k is the Boltzmann constant, and is 1.38×10^{-23} J/K
- h is Planck's constant and is 6.626×10^{-34} Js
- c is the speed of light in a vacuum and is 2.9979×10^{8} m s^{-2}.
- Blackbody radiation is isotropic

Planck's Law and Black Body Radiation





Laws of Radiation

STEFAN BOLTZMAN LAW

$(E = \sigma T^4)$ (E is in Watts/m^2)

As T increases, E increases by a power of 4.

If T doubles, E increases by 16 times!

Does everything emit radiation?

WIEN'S LAW

$\lambda_{max} \sim 3000/T$ (λ_{max} is in μm and T is in Kelvin)

Wavelength of peak radiation emitted by an object is inversely related to temperature

Understanding Satellite Imagery
Laws of Radiation

1. All objects emit radiation (except at 0°K).
2. Hotter objects emit more energy per unit area than colder objects.
3. The hotter the object the shorter the wavelength of maximum radiation.
4. Objects that are good absorbers of radiation are good emitters of radiation.

Radiation Concepts

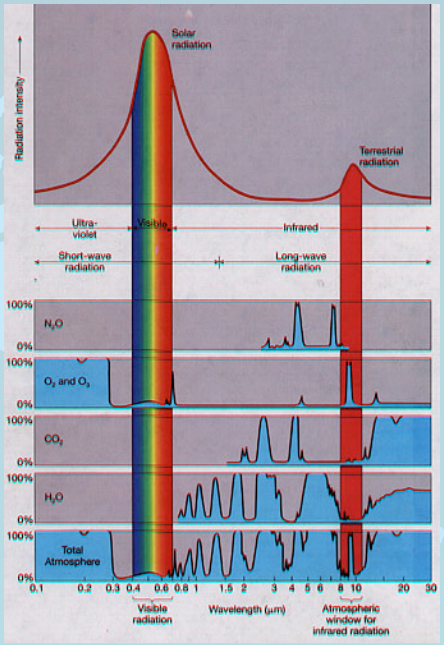
- Albedo: the ratio of reflected radiation to incident radiation
- Surface albedo varies
  - Spatially
  - Temporally

TABLE 2.3 Typical Albedo of Various Surfaces

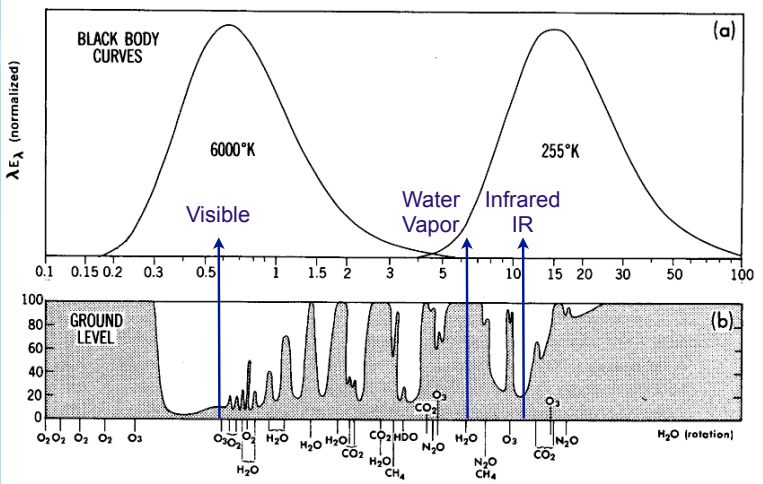
SURFACE	ALBEDO (PERCENT)
Fresh snow	75 to 95
Clouds (thick)	60 to 90
Clouds (thin)	30 to 50
Venus	78
Ice	30 to 40
Sand	15 to 45
Earth and atmosphere	30
Mars	17
Grassy field	10 to 30
Dry, plowed field	5 to 20
Water	10*
Forest	3 to 10
Moon	7

*Daily average.

Atmospheric Absorption and Emission – Radiation Windows



Satellite Channels



(a) Black body curves for the sun and Earth (wavelength in micron). (b) Percent absorption by the atmosphere as a function of radiation wavelength.

Satellite observations

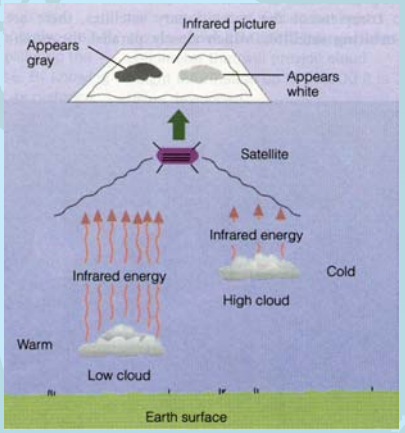
Satellites Instuments

Passive – Measure Emissions

- Cloud distribution
- Cloud top temperature
- Water vapor distribution
- Precipitation
- Surface properties (temperature, snow cover, vegetation, etc…)
- Soundings
- Cloud drift winds

Active

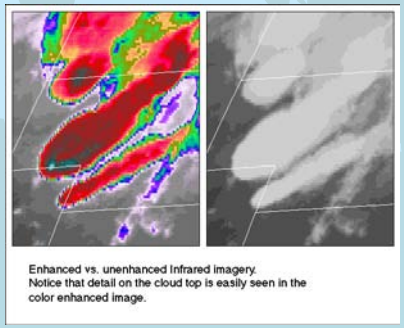
- Ocean surface height
- Precipitation
- Surface Winds



Satellite Passive Observations

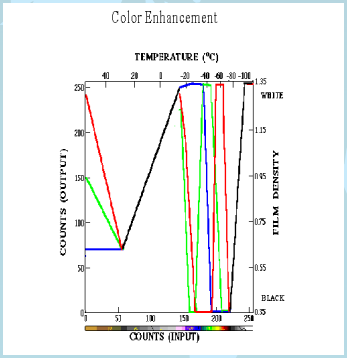
Why do we need enhancement curves?

- Important differences in satellite data are often within a small variation of gray shades!
- Level of important features can change by day, season, etc.
- Color can help distinguish features.

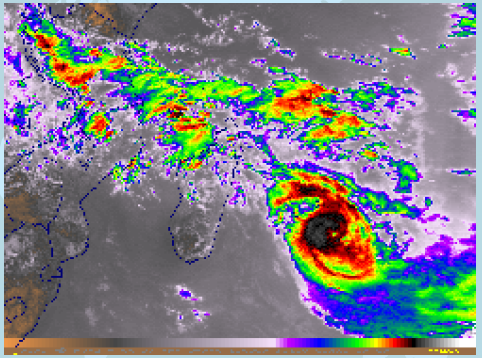


Enhanced vs. unenhanced Infrared imagery. Notice that detail on the cloud top is easily seen in the color enhanced image.

Color Enhancement

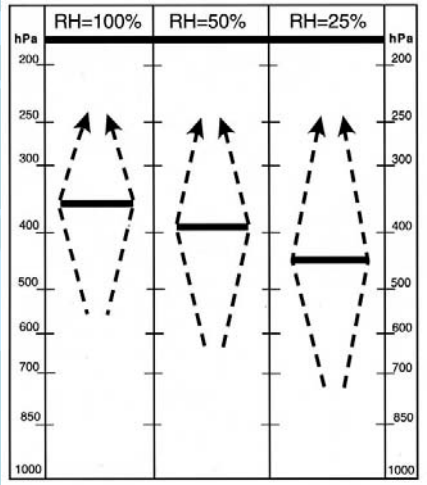


Enhancement curve



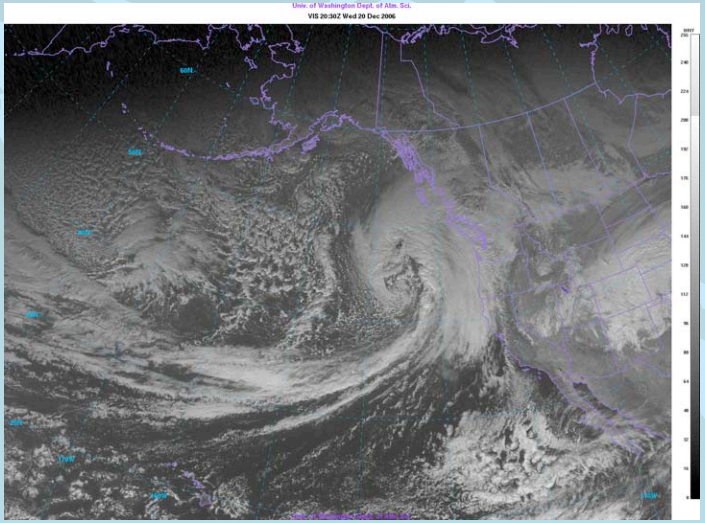
IR Image of hurricane

Water Vapor Imagery



From: Bader et al., Images in Weather Forecasting

Satellite Image Interpretation



Creating a Weather Briefing

1. Set the stage regarding the big picture and the past weather.
   - UW 500 mb NH loop and discuss long and short waves in the jet stream.
     - http://www.atmos.washington.edu/~ovens/loops/wxloop.cgi?npole_h500_anom5d+/-168//
   - Satellite Imagery - show a longer loop to show the history of the jet. Best for this is WV with model overlay:
     - http://weather.hawaii.edu/satellite/satanim.cgi?res=8km&chnl=wv&domain=pne&period=2880&incr=180&rr=900&banner=uhmet&satplat=mosaic&overlay=on
   - IR to see cloud top temp., sites with good IR color enhancements.
     - http://www.atmos.washington.edu/~ovens/loops/wxloop.cgi?ir_common+/24h/
     - http://www.atmos.washington.edu/~ovens/loops/wxloop.cgi?ir_east_common+/24h/
     - http://weather.hawaii.edu/satellite/satanim.cgi?res=4km&banner=uhmet&chnl=ir&domain=amr&size=large&period=1440&incr=30&rr=900&satplat=goeseast&overlay=off

Creating a Weather Briefing

2. Review current hazards/warnings etc. and focus in on these with the radar, balloon sounding data, and surface observations, etc.
   - Watches and Warnings: http://www.weather.gov/largemap.php
   - Radar Imagery: http://www.rap.ucar.edu/weather/radar/
   - Sounding Data: http://weather.uwyo.edu/upperair/sounding.html
3. Review model forecast maps. Recommended sites:
   - Navy: https://www.fnmoc.navy.mil/wxmap_cgi/index.html
   - UW: http://www.atmos.washington.edu/~ovens/loops/
   - NCEP: http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/
   - UH MKWC: http://weather.hawaii.edu/models/modelgraph.cgi?model=wrf&domain=d1&param=precip&orient=horiz

Creating a Weather Briefing

Some Additional Weather Server Web Sites

- http://www.atmos.washington.edu/~ovens/loops/
- http://weather.hawaii.edu/
- https://www.fnmoc.navy.mil/PUBLIC/WXMAP/index.html
- http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/
- http://www1.ncdc.noaa.gov/pub/orders/CDO737255788740.html
- http://weather.bgsu.edu/
- http://www.rap.ucar.edu/weather/
- http://www.jach.hawaii.edu/weather/