



# Module #5b: Color Spaces



# Beyond the RGB color space

- RGB is useful for hardware implementations and is related to the way in which the human visual system works
- However, RGB is not a particularly intuitive way in which to describe colors
- Rather when people describe colors they tend to use
  - Hue**
  - Saturation**
  - Brightness**



# Cylindrical Coordinate Representations

- Cylindrical-coordinate representation of points in an RGB color model
  - Created as an attempt to be more perceptually relevant than the (X,Y,Z) model.
- Common representations
  - HSL (aka HLS): hue, saturation, and lightness
  - HSV (aka HSB): hue, saturation, and value (or brightness)
  - HSI: hue, saturation, intensity



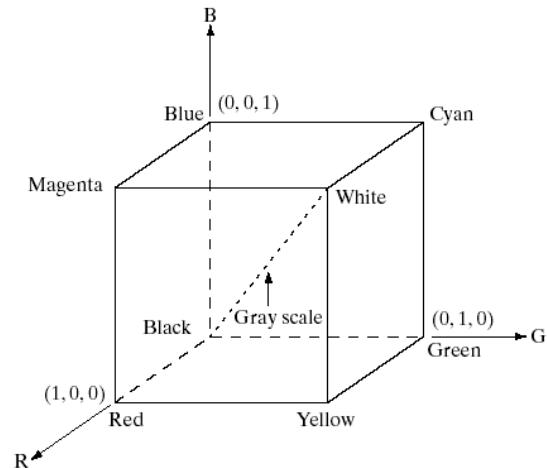
# The HSI Color Model

- The HSI model uses three measures to describe colors:
  - **Hue:** A color attribute that describes a pure color (pure yellow, orange or red)
  - **Saturation:** Gives a measure of how much a pure color is diluted with white light
  - **Intensity:** Brightness is nearly impossible to measure because it is so subjective. Instead we use intensity. Intensity is the same achromatic notion that we have seen in grey level images



# HSI, Intensity & RGB

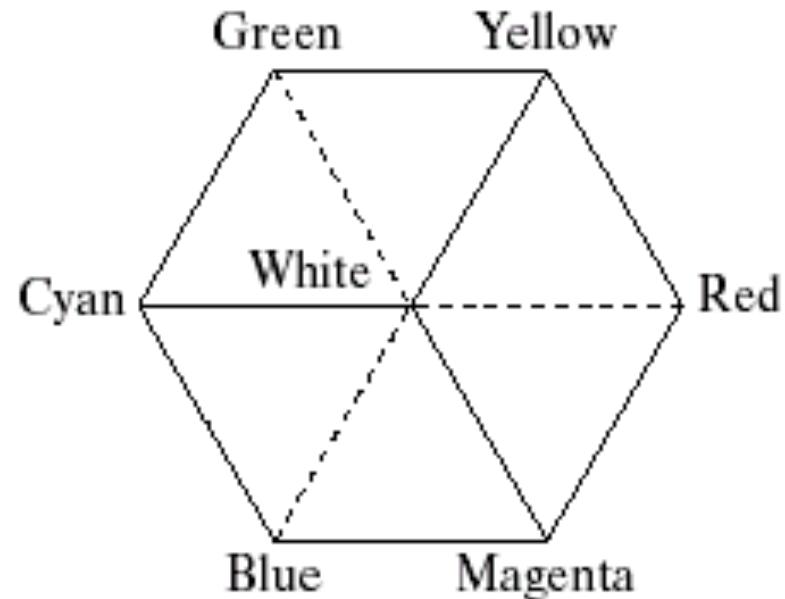
- Remember the diagonal on the RGB color cube that we saw previously ran from black to white
- Now consider if we stand this cube on the black vertex and position the white vertex directly above it





# The HSI Color Model

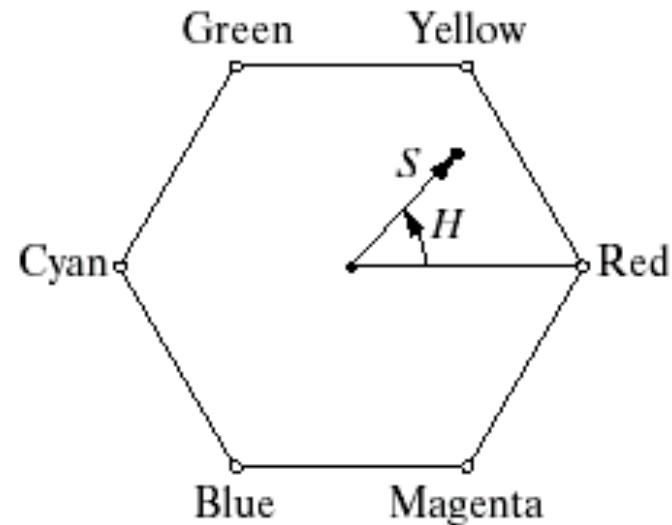
- Consider if we look straight down at the RGB cube as it was arranged previously
- We would see a hexagonal shape with each primary color separated by  $120^\circ$  and secondary colors at  $60^\circ$  from the primaries





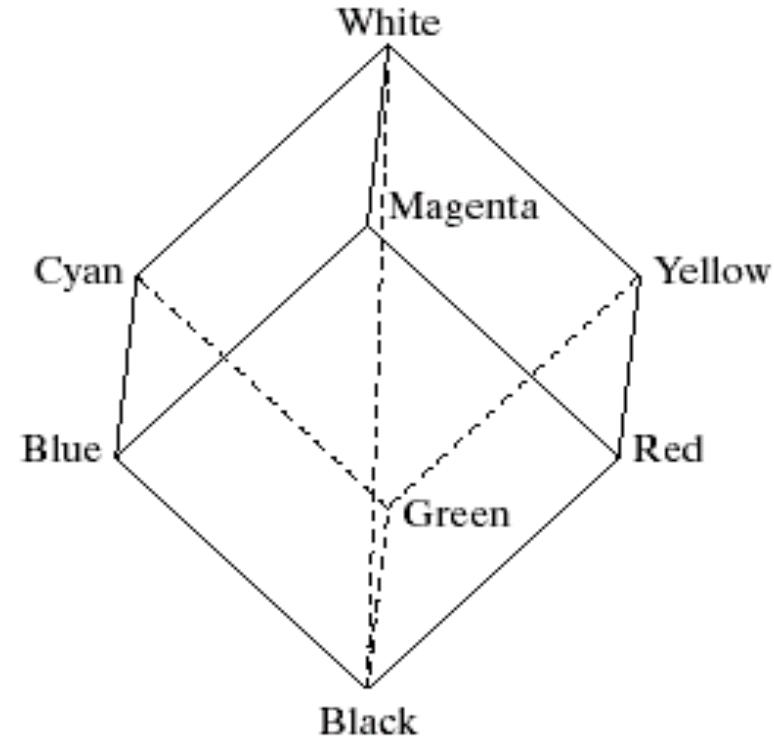
# The HSI Color Model

- Hexagonal shape and an arbitrary color point
  - The **hue** is determined by an angle from a reference point, usually red
  - The **saturation** is the distance from the origin to the point
  - The **intensity** is determined by how far up the vertical intensity axis this hexagonal plane sits



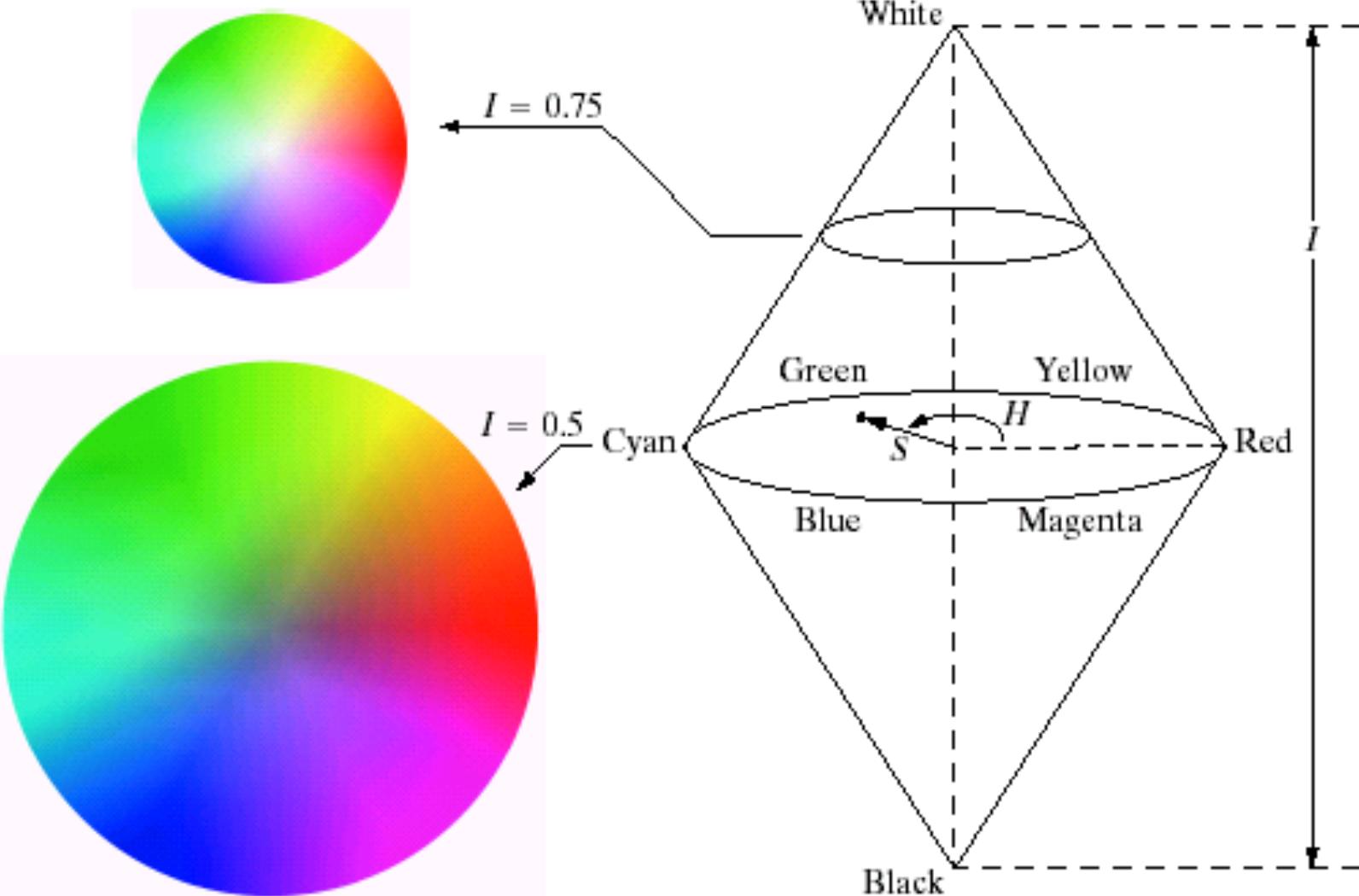
# HSI, Intensity & RGB

- Now the intensity component of any color can be determined by passing a plane perpendicular to the intensity axis and containing the color point



- The intersection of the plane with the intensity axis gives us the intensity component of the color

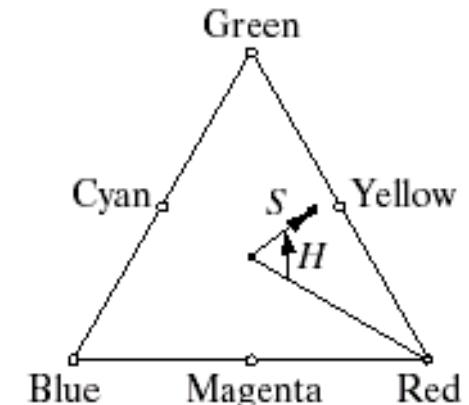
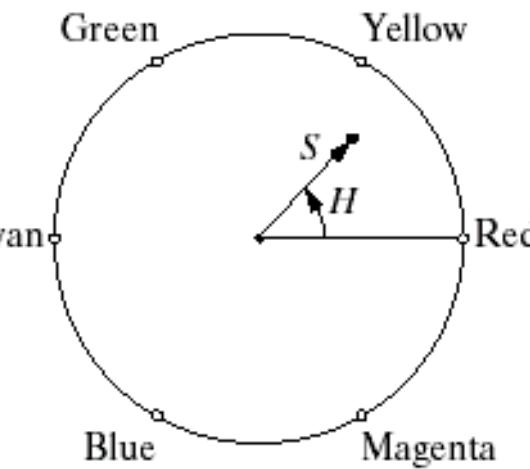
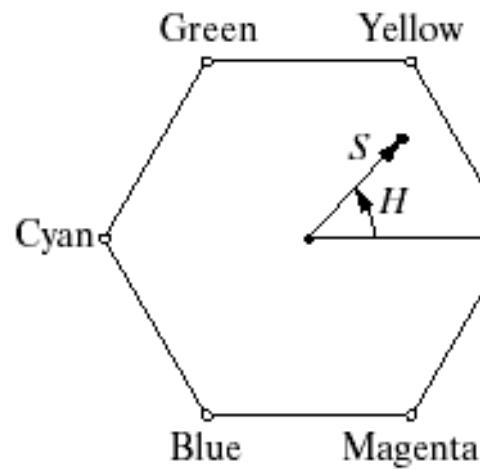
# HSI Model Examples



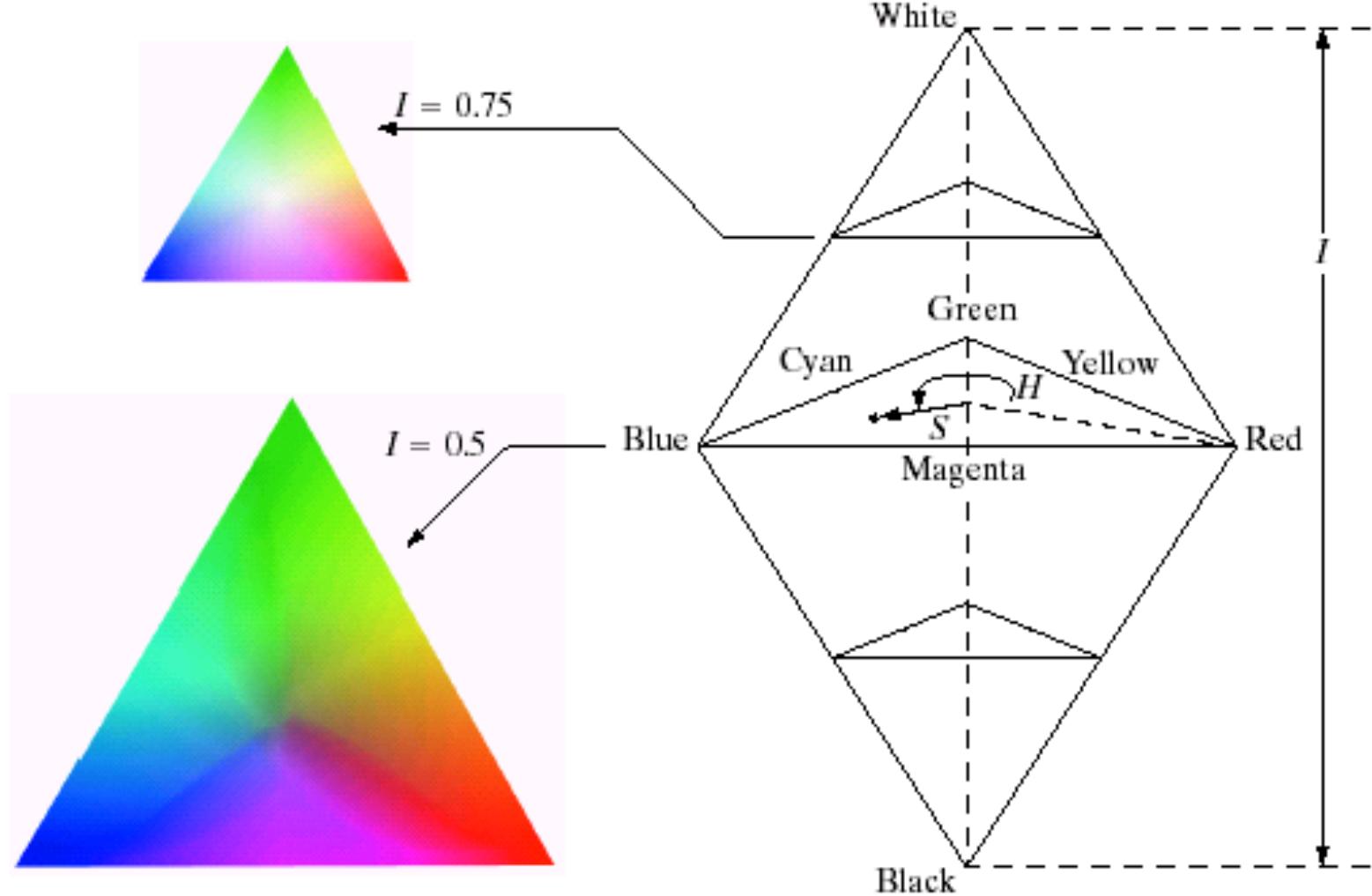


# The HSI Color Model

- Because the only important things are the angle and the length of the saturation vector this plane is also often represented as a circle

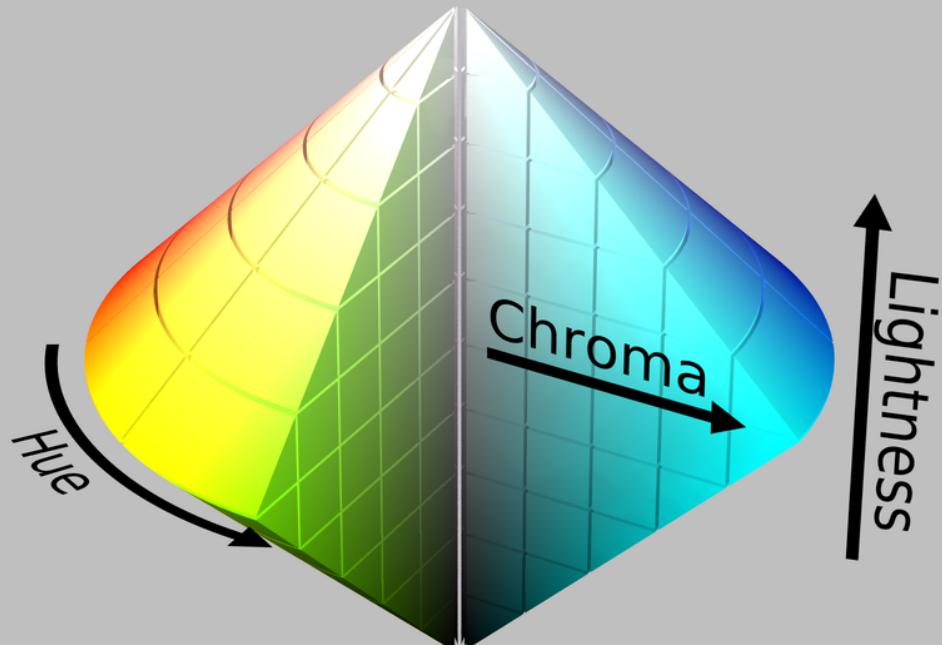
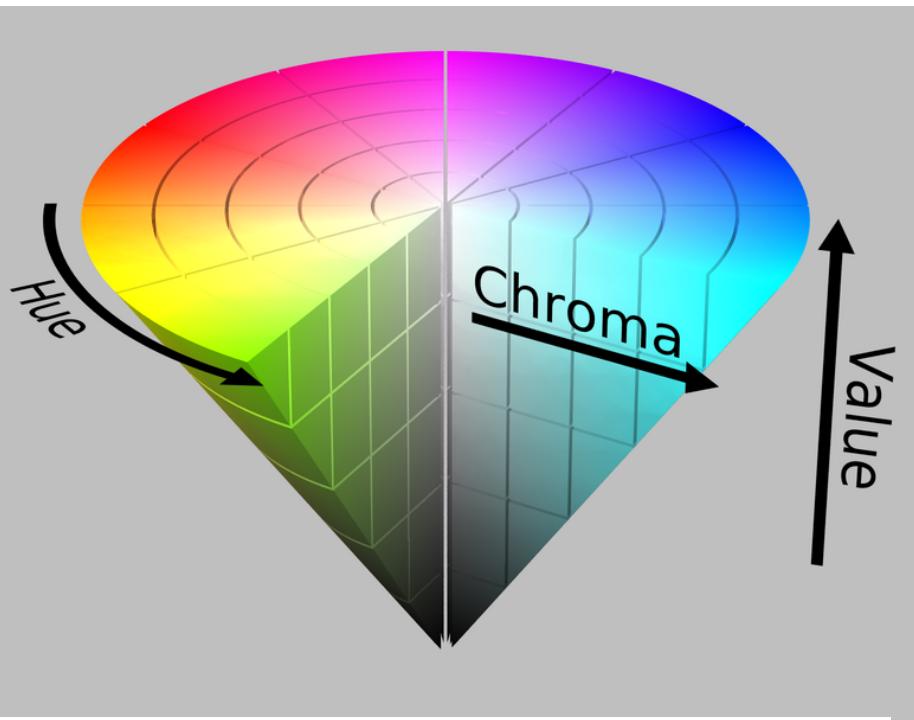


# HSI Model Examples





# HSV vs HSL



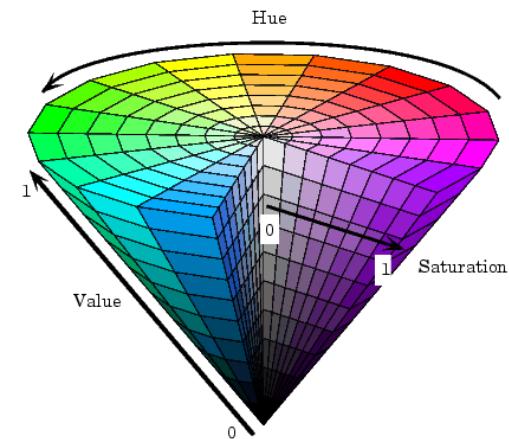
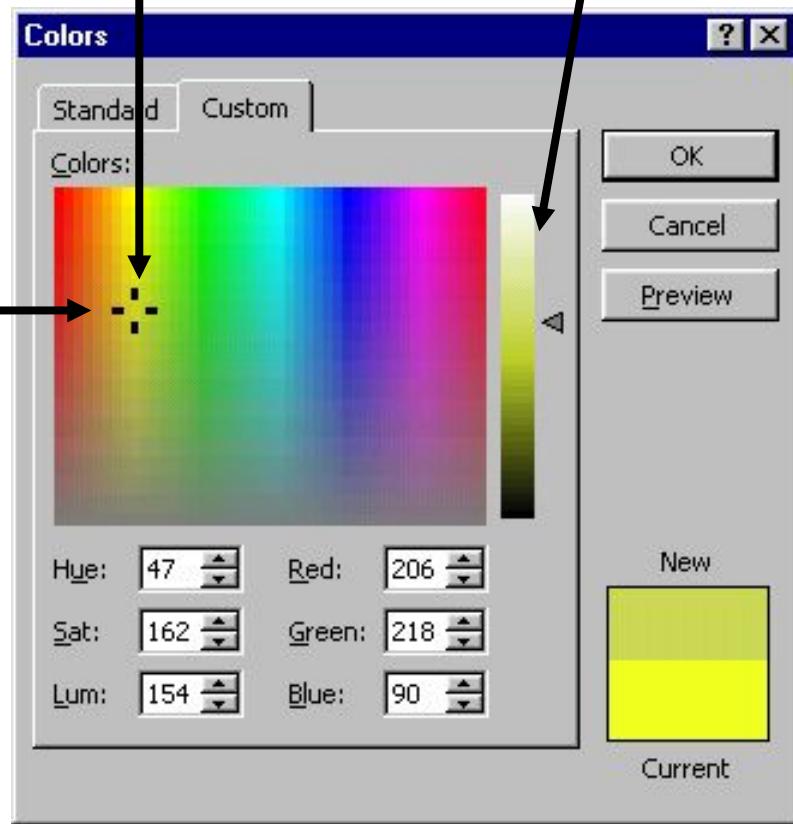


# HSV

Saturation

Value

Hue





# Saturation





# Example: Shifting hue



Shifted  $30^0$



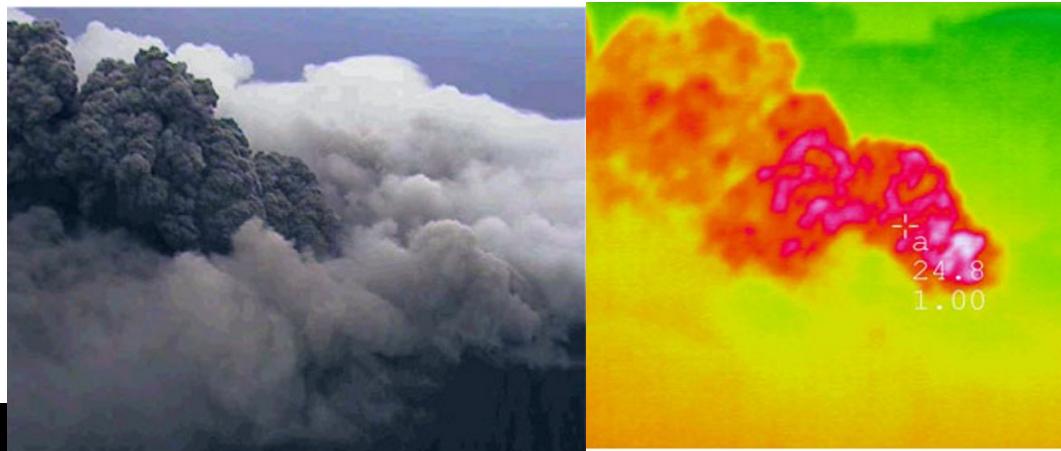
# CIELAB

- In 1976 CIE established CIELAB with coordinates  $L^*$ ,  $a^*$ ,  $b^*$
- The intention of CIELAB was to create a space which can be computed via simple formulas from the XYZ space, but is more perceptually uniform than XYZ
- $L^*a^*b^*$ 
  - $L$  closely matches human perception of lightness
  - $A^*$  &  $B^*$  represent color opponent channels



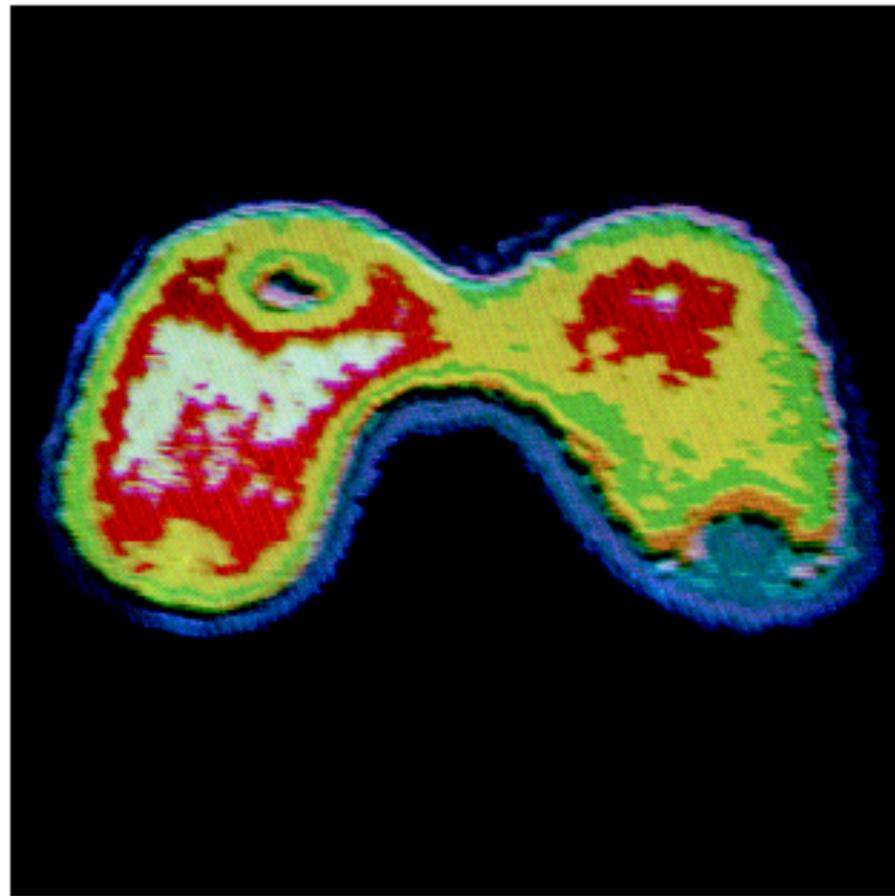
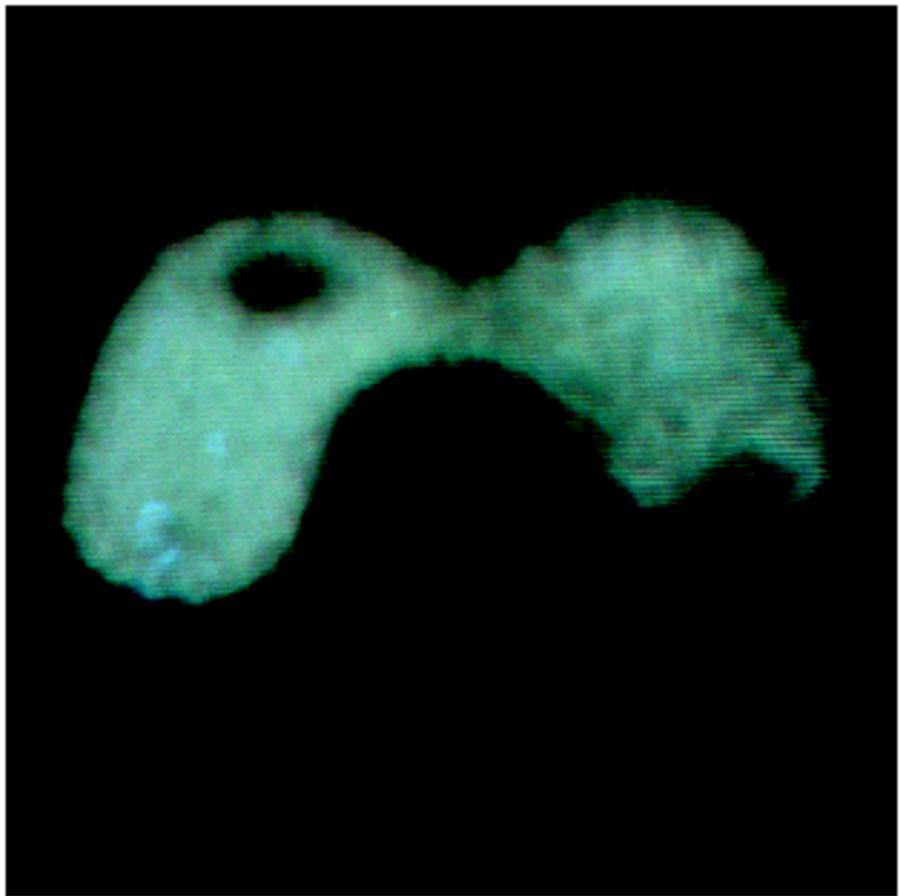
# Pseudocolor Image Processing

- Pseudocolour (also called false color) image processing consists of assigning colors to grey values based on a specific criterion
- The principle use of pseudocolor image processing is for human visualization
  - Humans can discern between thousands of color shades and intensities, compared to only about two dozen or so shades of grey



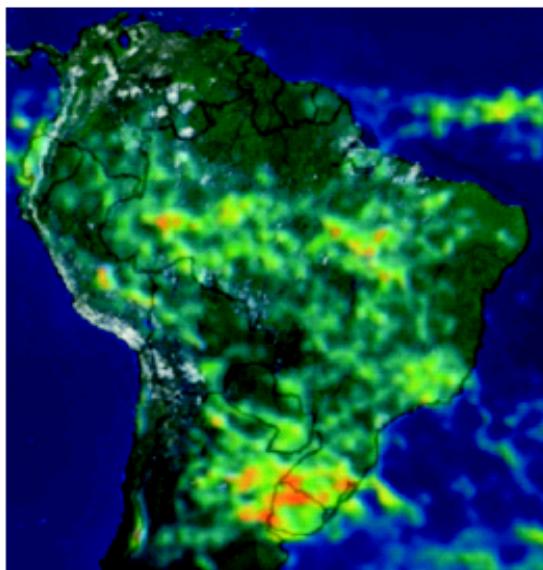
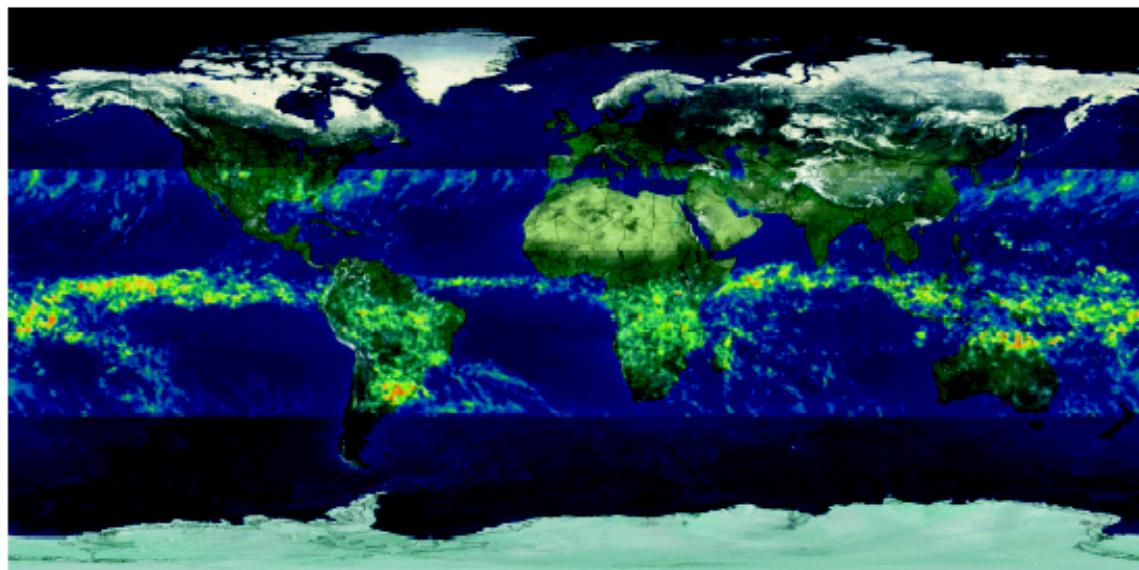
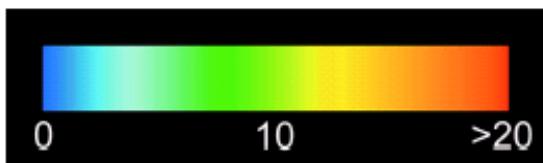
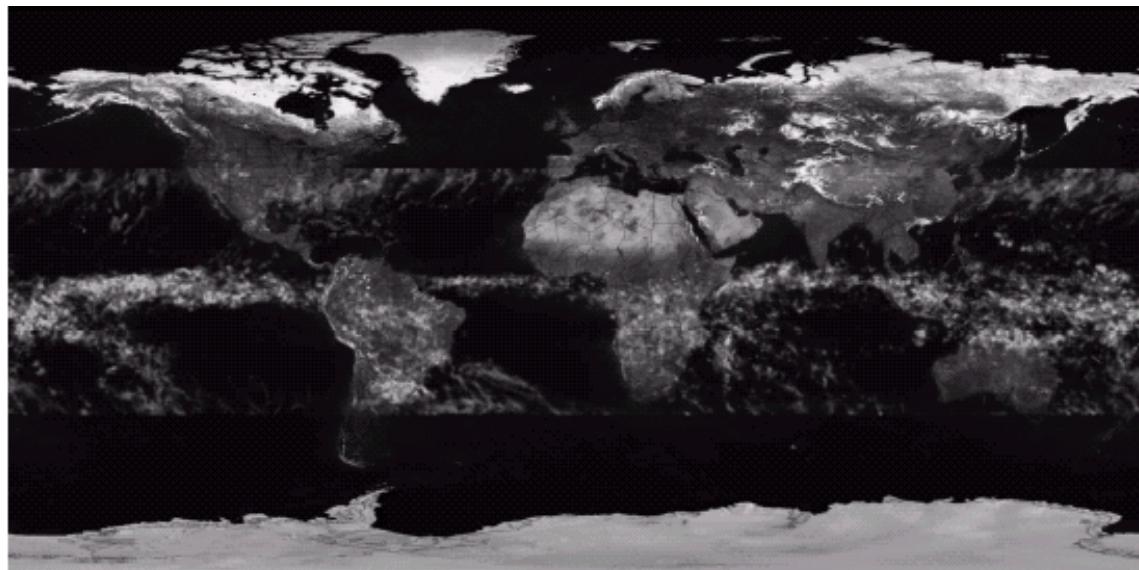


# Example





# Example





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