Improved Algorithms for Combining Satellite Imagery and Geographic Basemaps

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...clouds continue to cover the Northern half of the US and Canada...
Current Algorithm

- Infrared Brightness Temperature ($T_{ir}$) based cloud/no-cloud threshold
- Basemap is shown when pixels are warmer than $T_{ir}$ threshold
- Temperature based transparency is applied to “cloudy” pixels, where warm clouds are semi-transparent and cold clouds are opaque
Choosing a Brightness Temperature Threshold

295K

290K

285K

280K

275K

270K

265K

260K
Current Algorithm - Problems

- Exaggerates cloud coverage in higher latitudes
- Underestimates low-level cloud coverage in lower latitudes
- Seasonal variability
- Global Scale
New Algorithm

- Incorporates Surface Temperatures ($T_{sfc}$)
  - 6-hourly global products use surface observations over land and NCEP sea surface temperatures over oceans
  - 3-hourly global products use GFS surface temperatures over land and NCEP sea surface temperatures over oceans
GFS $T_{sfc}$ Land Temperatures (320-200K Black-White)
Combined $T_{sfc}$ Image (320-200K Black-White)
New Algorithm

- Incorporates Surface Temperatures ($T_{sfc}$)
- Temperature difference ($T_{sfc} - T_{ir}$) based cloud/no-cloud threshold
\( T_{sfc} - T_{ir} \overset{(-10 \text{ – 100 Black-White})}{=} \)
Choosing a Temperature Difference Threshold

\[ T_{sfc} - T_{ir} = 12 \]
$T_{ir} = 265K$

$T_{sfc} - T_{ir} = 8$

Globally
New Algorithm

- Incorporates Surface Temperatures \( T_{sfc} \)
- Temperature difference \( (T_{sfc} - T_{ir}) \) based cloud/no-cloud threshold
- Transparency based on \( T_{sfc} - T_{ir} \)
% = \sin((\pi/2 * (T_{\text{diff}} - T_{\text{thresh}} - 1)/110.))^{-6}

% = \tan^{-1}(((T_{\text{diff}} * (20 + \text{Const})/T_{\text{thresh}} - 20) + \pi/2) / \pi)
Current Algorithm - Problems

- Rapid surface cooling after sunset produces erroneous clouds
\[ T_{sfc} = 70F \]

\[ T_{ir} = 70F \]

\[ T_{sfc} - T_{ir} = 0 \]
Current Algorithm - Problems

- Rapid surface cooling after sunset produces erroneous clouds
  - Possible Solution – Adjust transparency curve based on date & time

- Values of $T_{sfc} - T_{ir}$ can be small for fog
  - Possible Solution – Adjust transparency curve based on relative humidity
Algorithm for Combining Visible and Infrared Data

- Visible and Infrared percentages are determined by day and time

\[
\text{Visible}(\%) = 80 \times (\sin(\text{Day}_{\text{pct}} \times \pi/2))^2
\]

\[
\text{Infrared}(\%) = 100 - \text{Visible}(\%)
\]

where: \( \text{Day}_{\text{pct}} = \frac{|\text{Time}_{\text{image}} - \text{Time}_{\text{noon}}|}{\text{Length}_{\text{day}}/2} \)
Visible and Infrared Percentages

- Infrared
- Visible

Time:
- Sunrise
- Local Noon
- Sunset

Percentage:
- 0
- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80
- 90
- 100

Graph shows the percentage of visible and infrared light over the course of a day, with peaks and troughs corresponding to sunrise, local noon, and sunset.
Algorithm for Combining Visible and Infrared Data

- Visible and Infrared percentages are determined by day and time
- Transparency based on Visible Albedo and Infrared Brightness Temperature
Availability of Applications and Basemaps

- New core supported application available in 2006
  - Similar to IMGFILT using FILTER=VISIR, VIS, IR, TDIFF ...
  - Work with NASA Big Blue Marble or Topography and Enhancement

- Global Basemaps available via ftp and possibly ADDE
  - 1 km NASA Big Blue Marble – RGB areas – 1 GB/area
  - 1 km Topography – 2 byte data – 2 GB/area
  - 1 km Topography with Lakes – 2 byte data – 2 GB/area
  - 1 km Land Sea Mask – 1 GB
  - 10 km Topography and Bathymetry – 9 MB
  - 20 km NASA Big Blue Marble and Bathymetry – RGB areas - 2 MB/area