NOAA/NESDIS

GOES

Enhancements

The GeoSatSignal and HRPT-reader LUT361 series

with a supplement of the LUT361 series from Meteo Maarssen

MM06

INTRODUCTION
Traditional gray-scale images don’t show a lot of details. But on Infra-red channels every pixel does represents a thermal value. Since Infra Red is based on heat or thermal radiation each gray tone can be connected to a specified to a thermal value. There are 256 gray-tones on each image in a range of +56 C to -110 C. This results in a 0,6 C step for each gray tone. Whit this knowledge we can improve the images from the satellites, just by replacing the requested gray for any other colour.

White and light gray tones are usual cold temperatures. But differences in the thermal radiations are hard to see if the temperatures are close to each other. The solution to get a higher contrast is to replace some gray tones. By example: If we want to have a better contrast for extremely cold cloud-tops in a range of -60 C to -80 C then we replace the gray-tones into any other gray or even another colour. Now we can see the differences in thermal radiation in much better contrast and detail.

The enhancements are designed for use with the GOES satellites, but can be used for Meteosat 8 as well.The LUTs in this distribution are based on the official NOAA enhancements, but prepared for use with GeoSatSignal. Several enhancements are available for studying the weather. There are not only enhancements for cyclones, overshooting thunderstorms and supercels, but also for fog, fire detection and seasonal weather.

Each enhancement comes with a brief description for its use and a technical diagram showing the relation of the thermal radiation and its colour of gray value. Most definitions are adapted from NOAA, except for the unenhanced and the Meteo Maarssen versions. The description of the fog LUT comes from G. Ellrod (NOAA), with thanks.

For more details see:

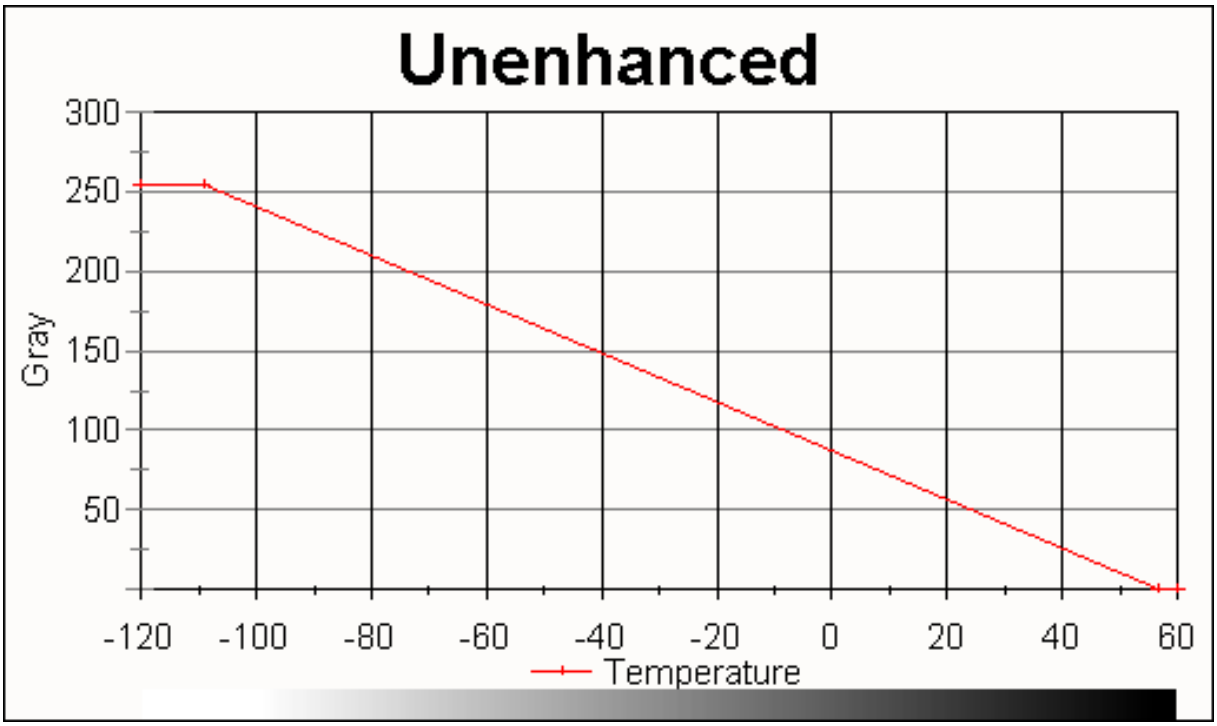
http://www.orbit.nesdis.noaa.gov/smcd/opdb/enh/enh.html

SETUP
Expand all files to the directory/folder from GeoSatSignal. They should appear on the processing-tap from the jobsetup menu and popup at "CLUT".

INFRARED
Infrared images are thermal based and can't never be used to determinate clouds only. It is a themal issue that could is given as white and warm as black in the frames. The LandSea-red CLUT gives scales only down from 5 C. This could be possible warmer near surface clouds and fog. From around -5 to 5 C are colours light green for continents and light blue for waters. This are most of the time lower clouds or broken cloudfield.
But surface is changing to colours from clouds if surfacetemperatures are 5 C or less. Be warned that during winter/nighttime your images could display clouds when they do not exist in that cases if themperatures are falling down to 5 C or less. See always a visual image for sure if available.

CLOUDTOPS, PRECIPITATION AND WEATHERRADAR
Frontal systems do have often high clouds on top. Basicaly are this thick clouds known as Nimbostratus and Cumulonimbus. The last one are showerclouds and are often visible behind coldfronts as well. This kind of clouds gives more often precipitation, but it doesn't mean that the precipitation reaches always earth's surface. Use of this CLUTS gives more a indication of possible rain. Light colours indicate a possibility of light precipitation and dark colours revers to heavy precipitation. But again: This high clouds are normaly thick cirrusclouds at a 300 hPa-level (10 km/30.000 ft). They often give snow at high atmospheric levels. It doesn't reach the ground, it vaporized during it's fall downwards.

You should also take a look at the weatherradar from your local weatherservice if you want to know for sure if any precipitation occurs in your neighbourhood. But beware that weatherradar could give false echo's too. Drizzle or light rain can't often be seen, either with weatherradar or with satellite pictures. Because the rainfal is to light to give echos and drizzle is often comming from low altitude clouds (stratus) and they are to warm to detect with false colour frames from satellites too.



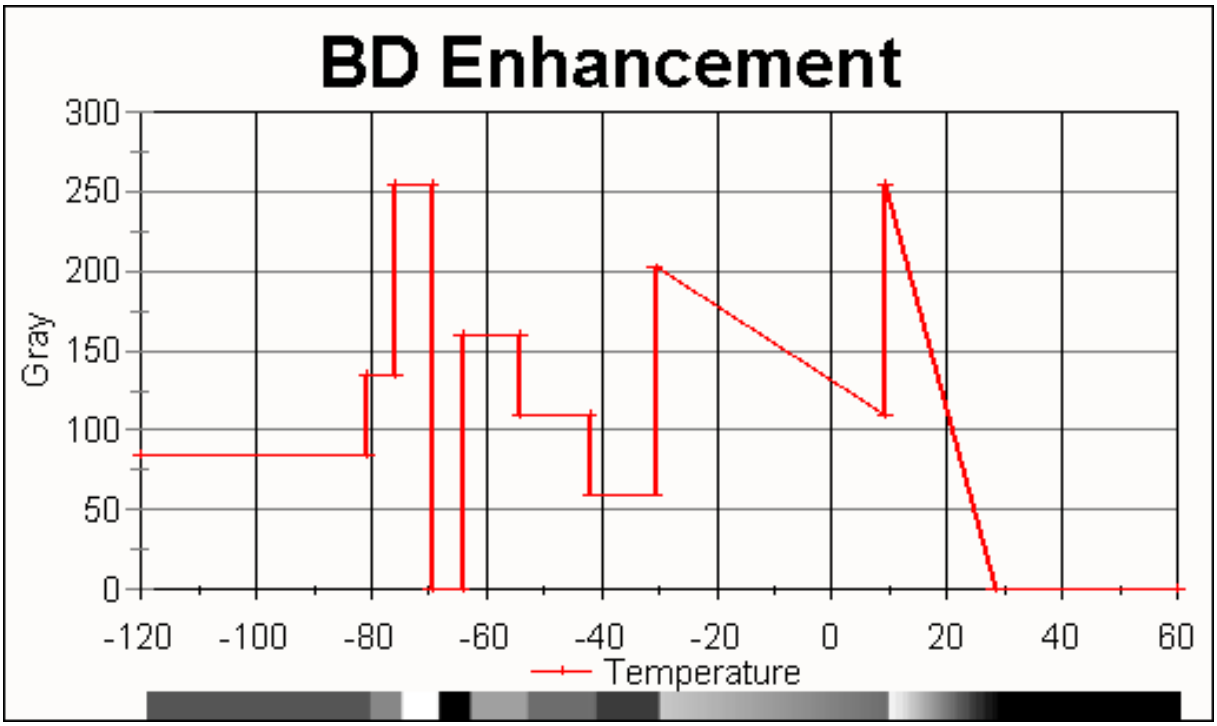
The IR sensors on board the weather satellites measure the amounts of infrared energie emitted by the earth and the atmosphere because the amount of energy emitted depends on the temperatures of the surfaces. IR imagery is essentially a picture of the surface and cloudtops temperatures potrayed in black, white and gray tones. Warm appear as black and cold as white.
On most display systems the gray scale of an IR omage is composed of 256 gray shades, ranging from white (coldest) to black (warmest). The data correlates temperature with gray shade in a simple relationship, shown in the upper graph. This simple gray-scale can be improved to show better some details. The enhancements can used to show up this details, as cold cloudtops, just by replacing the original shades of gray. And this what the enhancements intend to do: Show details for some particular weather phenonema.

The gray-scale starts with black (RGB 000-000-000) and ends with white (255-255-255).

Each enhancement comes with a description for its use and how it is build up. The graphs shows us the relation between the gray shade and the correponding temperature. Below each graph is the LookUp Table (LUT) shown. Some are improved with colors and they are shown too on the LUT-bar.

The range for the LUT is from +56.8 C to -109,0 C. The extended LUT for GeoSatSignal has a range of +60 C to -120 C. The range -120 C to -109 C and 56.8 C to 60 C are not used in the LUT, but they are shown in the graphs and listed in the tables. This to complete the full range of the extended 361 pixel wide LUT (-120 to +60 C) for GeoSatSignal offered in this package.

LUT: -

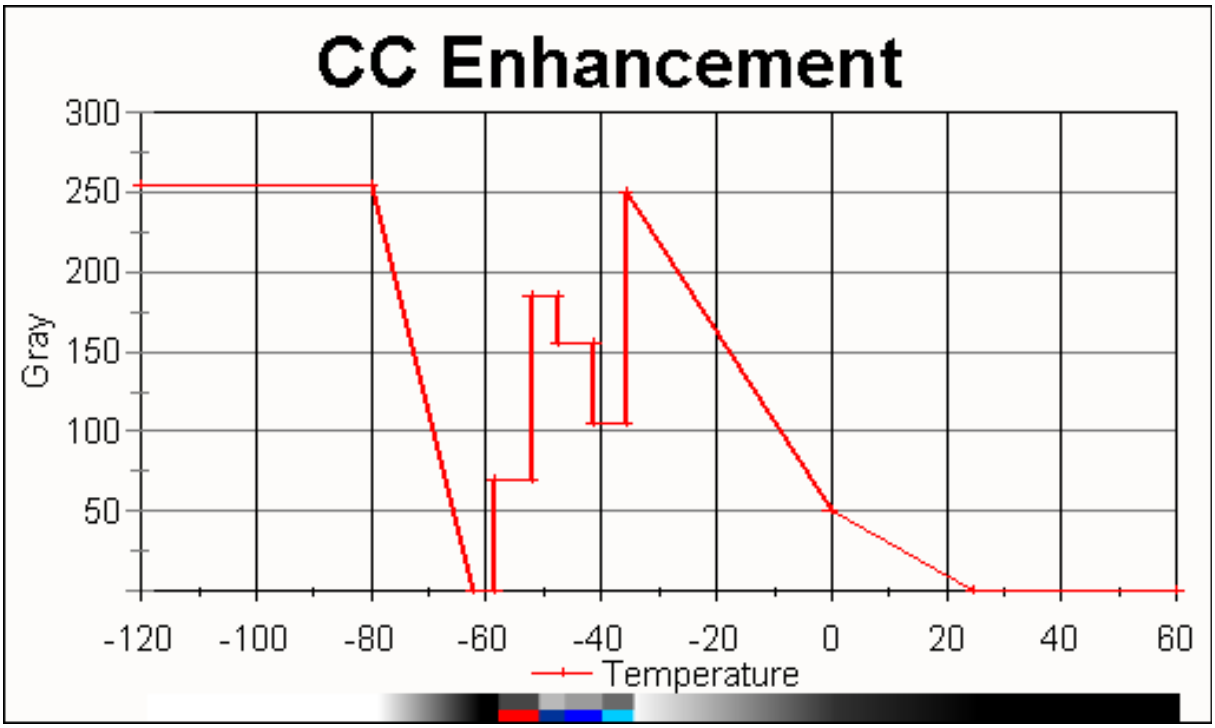


The BD enhancement curve for thermal IR imagery is the most complicated of all the main black and white enhancement curves. The complication is the result of the recurring series of grey level steps as the brightness temperature decreases. This curve is usually displayed to measure the intensity of tropical cyclones that contain eyes. This curve highlights certain temperatures in the eye and eye wall of the storm system known to be related to the intensity of a hurrcane. Dvorak (1984) developed a technique for measuring the intensity of these tropical cyclones by comparing the warmest spot within the eye and the warmest cloud top temperature within the cold cloud ring surrounding the eye. The greater that difference, the more intense the tropical cyclone. This curve facilitates those estimating tropical cyclone intensity by highlighting the differences between the eye temperature and that of the cold cloud ring by performing severe contrast stretches in both warm and cold portions of the enhancement curve.

Compare the structure of the tropical cyclone eye with the BD enhancement to that with no enhancement. Notice that the eye does not show up as well with the BD as with the MB enhancement. This does not matter since how well the eye is defined (and thus intensity estimates) can only be measured by viewing changes using the same enhancement.

LUT: LUT361BD-bw.bmp

Seg no	Gray	Temp	Comments
1	000-000	60.0 to 28.3	Little or no information
2	000-255	28.3 to 9.4	Low clouds
3	109-202	9.2 to -30.5	Cirrus outflow pattern
4	060-060	-30.7 to -41.9	Dark gray
5	110-110	-42.2 to -54.0	Medium gray
6	160-160	-54.4 to -64.0	Light gray
7	000-000	-64.4 to -69.5	Black
8	255-255	-69.9 to -75.7	White
9	135-135	-76.2 to -80.6	Top medium
10	085-085	-81.2 to -120.0	Top dark

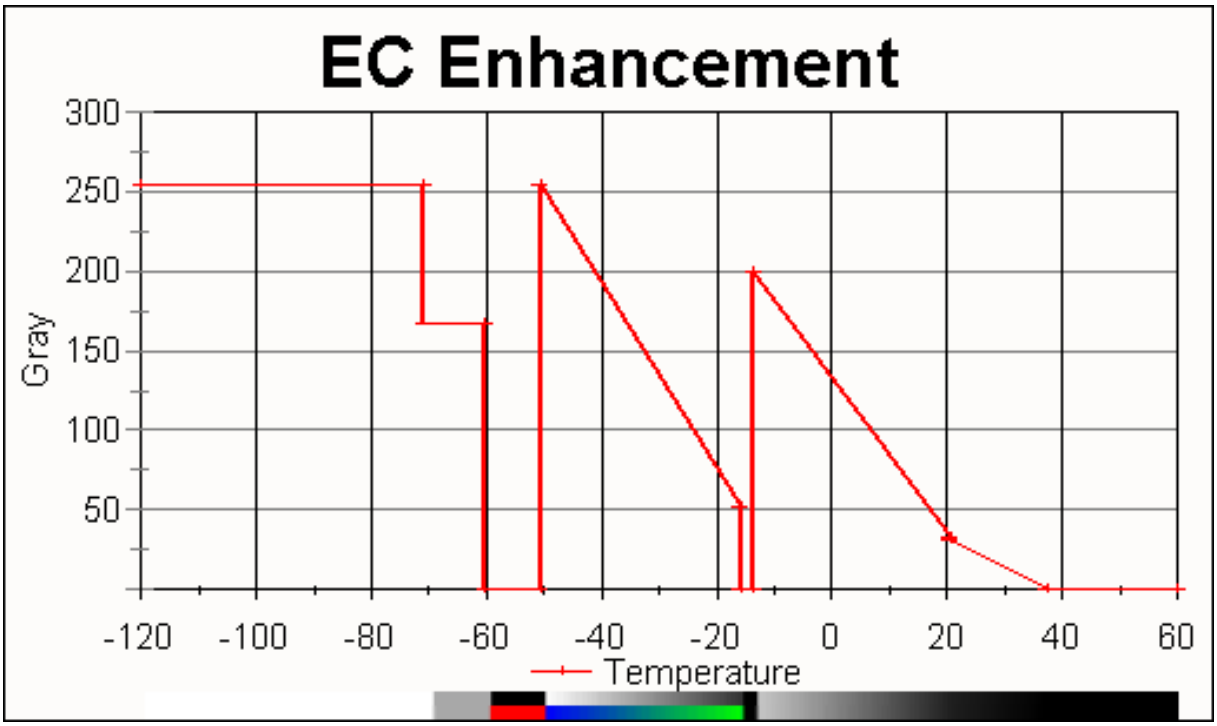


The CC enhancement curve is similar to the MB curve, but is modified for use over colder northern latitudes in winter.

Description of colour version: *The first 5 enhancement levels are: -36 to -42 C (light blue), -42 to -47 C (thistle), -48 to -52 C (dark blue), and -53 to -58 C (red).*

LUT: LUT361CC-bw.bmp (gray-scale)
LUT: LUT361CC-cc.bmp (color)

Seg no	Gray	Temp	Comments
1	000-000	60.0 to 24.8	Little or no information
2	001-050	24.7 to -0.1	Low level features
3	050-250	-0.2 to -35.2	Mid level enhancement
4	105-105	-35.2 to -41.1	Cirrus/thunderstorms
5	155-155	-41.4 to -47.4	Cirrus/thunderstorms
6	185-185	-47.6 to -52.1	Cirrus/thunderstorms (light gray)
7	070-070	-52.5 to -58.4	Cirrus/thunderstorms (dark gray)
8	000-000	-58.8 to -62.1	Cirrus/thunderstorms (black)
9	000-255	-62.5 to -80.0	Overshooting tops (repeat gray)
10	255-255	-80.6 to -120.0	White

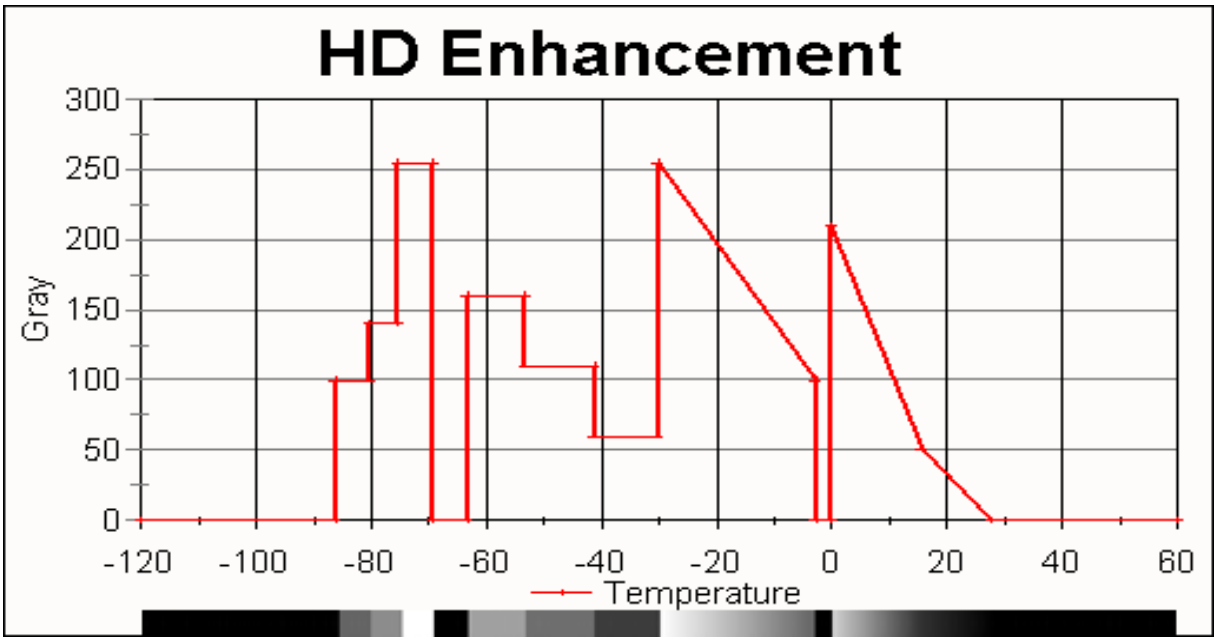


The EC enhancement curve is designed for general purpose use during the cool season.

Description of colour version: *The green and blue regions highlight the cloud top temperature range normally associated with cool season precipitation (-15 to -50 C); the red and gray enhancements represent -51 to -6 C and -62 to -70 C convective cloud tops, respectively.*

LUT: LUT361EC-bw.bmp (gray-scale)
LUT: LUT361EC-cc.bmp (color)

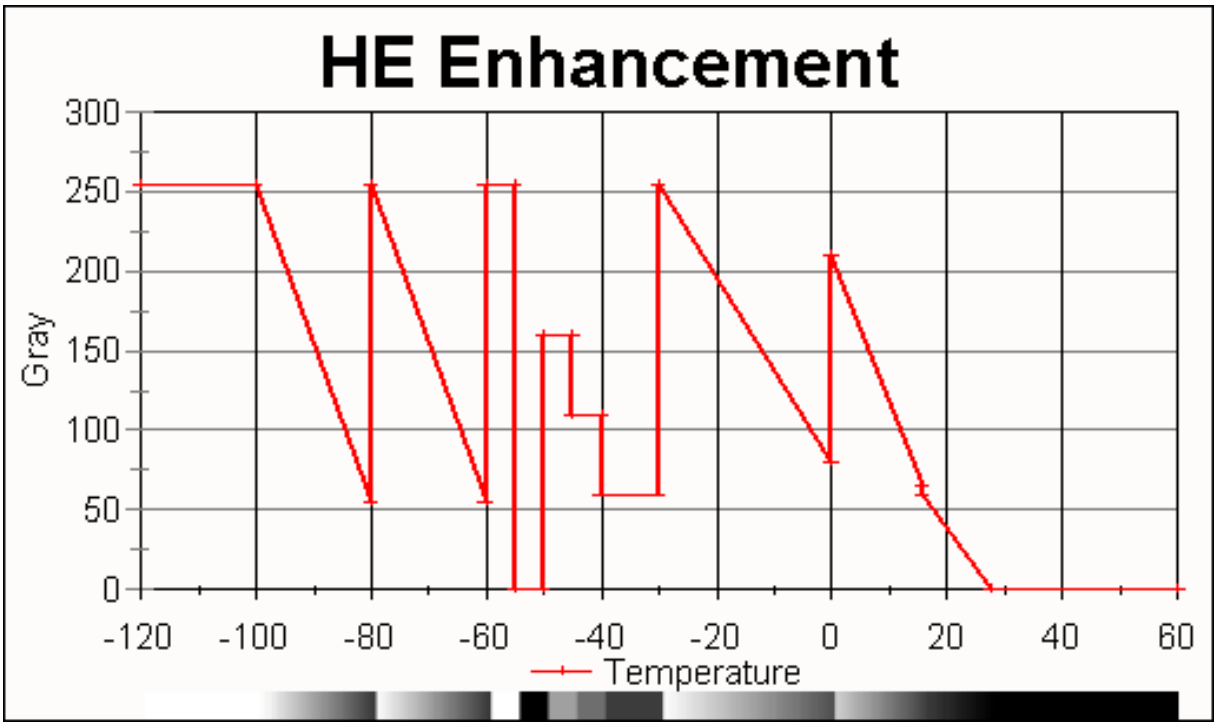
Seg no	Gray	Temp	Comments
1	000-000	60.0 to 37.3	Little or no information
2	001-032	37.2 to 20.8	Land and water features
3	033-200	20.6 to -13.3	Water and low clouds
4	000-000	-13.5 to 15.8	Low/middle cloud benchmark
5	052-255	-15.9 to -50.3	Mid/high clouds)*
6	000-000	-50.6 to -60.2	Convective cloudtops
7	168-168	-60.6 to -70.4	Convective cloudtops
8	255-255	-70.8 to -120.0	Coldest cloudtops
			)* Cool season precipitation



The HD curve is a modification of the HC curve (not included) to provide low cloud information, the freezing level, mid-tropospheric fronal systems, and tropical storm classification data. The portion of the curve for temperatures colder than -30.7 C is nearly identical to the BD tropical storm curve.

LUT: LUT361HD-bw.bmp

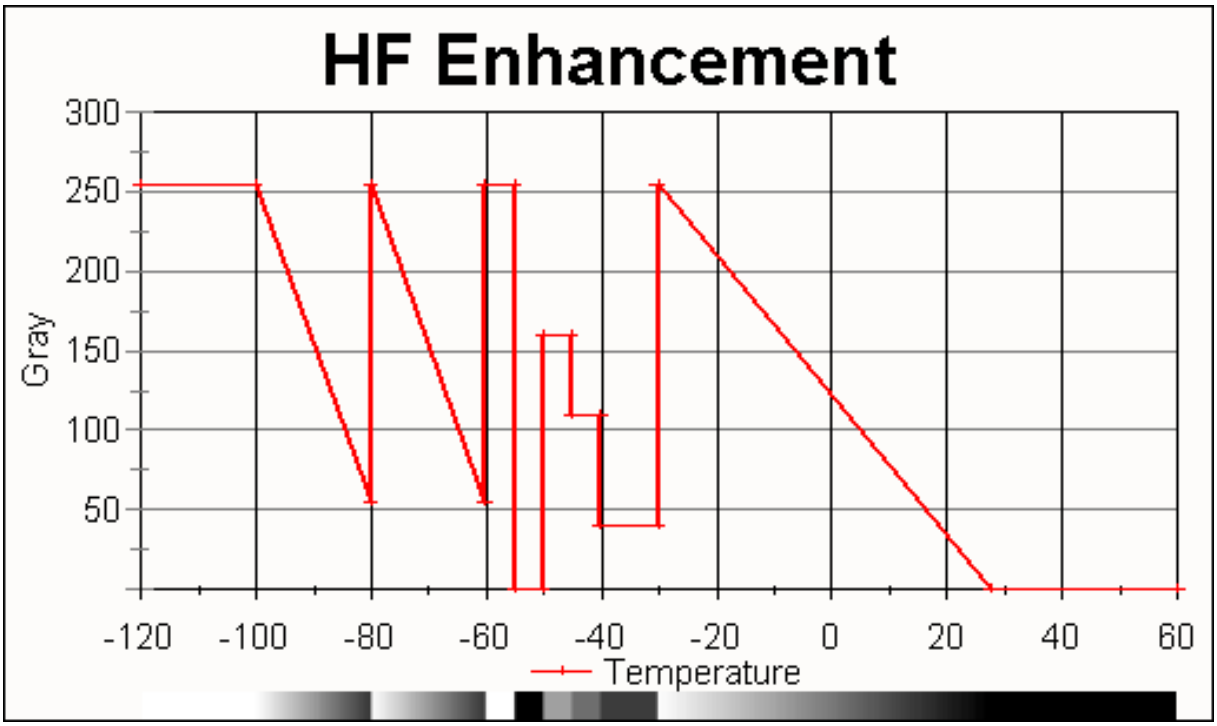
Seg no	Gray	Temp	Comments
1	000-000	60.0 to 27.8	Little or no information
2	000-050	29.7 to 15,8	Land and water
3	050-210	15.3 to 0.3	Water and low clouds
4	000-000	-0.2 to -2.7	Freezing zone
5	100-255	-3.2 to -30.2	Mid-tropospheric fronts
6	060-060	-30.7 to -41.2	Cloudtops
7	110-110	-42.2 to -53.2	Cloudtops
8	160-160	-54.2 to -63.2	Cloudtops
9	000-000	-64.2 to -69.2	Cloudtops
10	255-255	-70.2 to -75.2	Cloudtops
11	140-140	-76.2 to -80.2	Cloudtops
12	100-100	-81.2 to -86.2	Cloudtops
13	000-000	-87.2 to -120.0	Cloudtops



The HE curve is used principally by weather offices in the western United States. It provides good enhancement of a wide variety of cloud types, but is somewhat complex, and may be difficult to use at first. It enhances low and middle level clouds common along the Pacific Coast of North America in two separate gray shade ranges. The freezing level is easily determined, an advantage for aviation users concerned with icing. Step wedge regions display very cold infrared cloud top temperatures associated with thunderstorms and frontal systems in 5 degree increments down to -60 C. Two additional "repeat grey" segments define cloud top temperatures colder than -60 C.

LUT: LUT361HE-bw.bmp

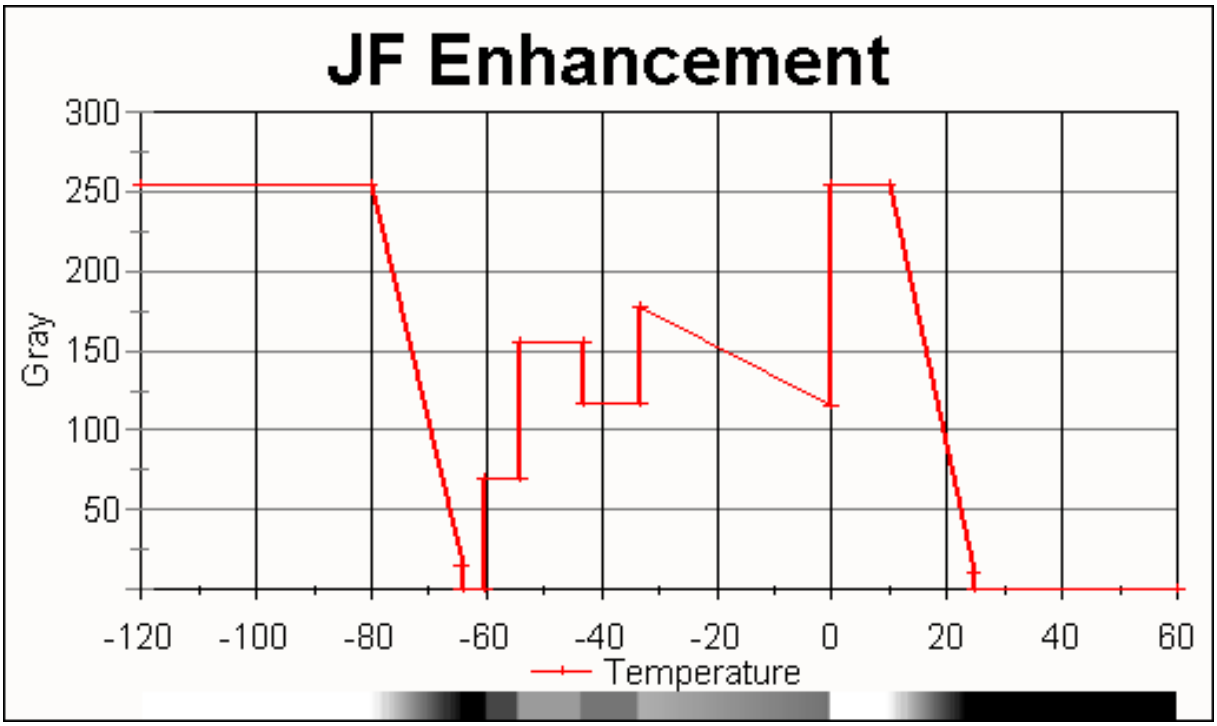
Seg no	Gray	Temp	Comments
1	000-000	60.0 to 27.8	Little or no information
2	001-060	27.7 to 15.9	Land and water
3	065-210	15.7 to 0.1	Water and low clouds
4	080-255	-0.1 to -29.8	Mid tropospheric fronts
5	060-060	-30.1 to -39.8	Cloudtops
6	110-110	-40.1 to -44.8	Cloudtops
7	160-160	-45.1 to -49.7	Cloudtops
8	000-000	-50.0 to -54.7	Cloudtops
9	255-255	-55.0 to -59.9	Cloudtops
10	055-255	-60.2 to -79.5	Cloudtops
11	055-255	-80.0 to -99.4	Cloudtops
12	255-255	-100.4 to -120.0	No information



The HF curve is the most current of the "H" series of curves, and is used principally by weather offices in the western United States. It provides good enhancement of low and middle level clouds common along the Pacific Coast of North America. Step wedge regions display very cold infrared cloud top temperatures associated with thunderstorms and frontal systems in 5 degree increments down to -60 C. Two additional "repeat gray" segments define cloud top temperatures colder than -60 C.

LUT: LUT361HF-bw.bmp

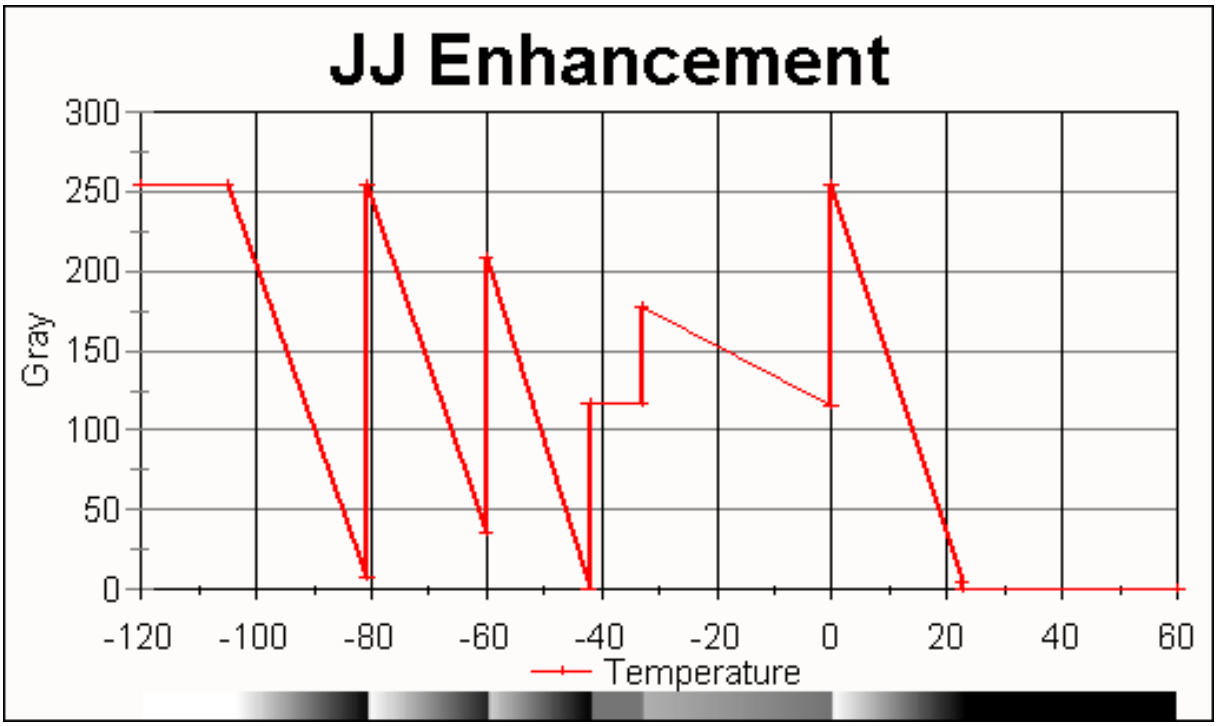
Seg no	Gray	Temp	Comments
1	000-000	60.0 to 27.8	Little or no information
2	000-255	27.7 to -29.8	Low and middle clouds
3	040-040	-30.1 to -39.8	Dark gray
4	110-110	-40.1 to -44.8	Medium gray
5	160-160	-45.1 to -49.7	Light gray
6	000-000	-50.0 to -54.7	White
7	255-255	-55.0 to -59.9	Black
8	055-255	-60.2 to -79.5	Repeat gray
9	055-255	-80.0 to -99.4	Repeat gray
10	255-255	-100.4 to -120.0	No information



The JF curve is a hybrid enhancement scheme used to highlight both sea surface temperatures, and cold cloud tops associated with thunderstorms and other weather systems. It is somewhat simpler to interpret than the later JJ curve. The coldest portion of the curve (less than -33 C) is nearly identical to the general-use MB curve. Maximum enhancement is provided at the warm end (25 to 10 C) to depict sea surface temperatures and warm low clouds in tropical and sub-tropical areas.

LUT: LUT361JF-bw.bmp

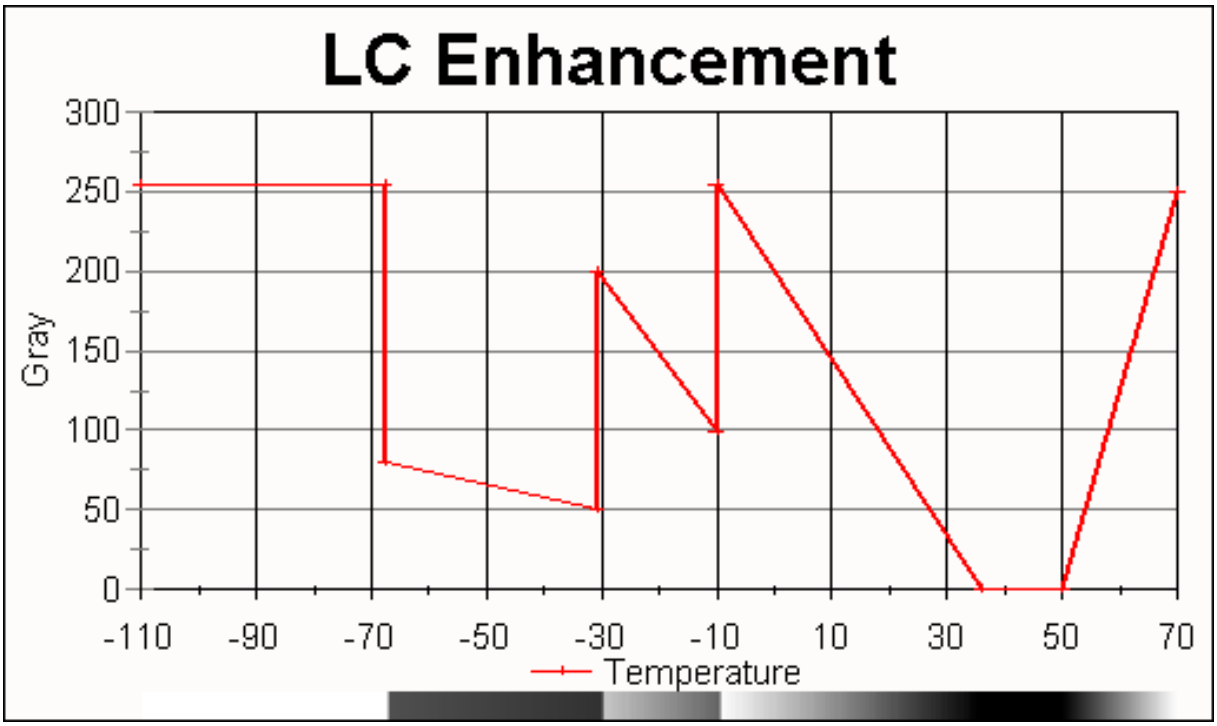
Seg no	Gray	Temp	Comments
1	000-000	60.0 to 24.8	Warm water and land
2	010-255	24.7 to 10.2	Water temperature gradient
3	255-255	10.0 to 0.1	Buffer zone
4	115-177	-0.1 to -32.9	Middle clouds/freezing level
5	117-117	-33.2 to -42.7	First level contour
6	155-155	-43.0 to -53.7	Thunderstorm
7	070-070	-54.0 to -59.9	Thunderstorm
8	000-000	-60.2 to -63.6	Thunderstorm
9	015-255	-64.0 to -80.0	Overshooting tops
10	255-255	-80.4 to -120.0	Very cold cloudtops or white



The JJ curve is used to highlight both sea surface temperatures, and cold cloud tops associated with thunderstorms and other weather systems. Maximum enhancement is provided at the warm end (23 to 0 C) to depict sea surface temperatures and low clouds. The presence of a freezing level break point is important for aviation users interested in icing conditions. Multiple, steep, ramp enhancement ranges provide considerable detail within cold cloud tops such as thunderstorms, but it is difficult to determine the actual temperatures with any accuracy.

LUT: LUT361JJ-bw.bmp

Seg no	Gray	Temp	Comments
1	000-000	60.0 to 24.8	Warm water and land
2	010-255	24.7 to 10.2	Water temperature gradient
3	255-255	10.0 to 0.1	Buffer zone
4	115-177	-0.1 to -32.9	Middle clouds/freezing level
5	117-117	-33.2 to -42.7	First level contour
6	155-155	-43.0 to -53.7	Thunderstorm
7	070-070	-54.0 to -59.9	Thunderstorm
8	000-000	-60.2 to -63.6	Thunderstorm
9	015-255	-64.0 to -80.0	Overshooting tops
10	255-255	-80.4 to -120.0	Very cold cloudtops or white

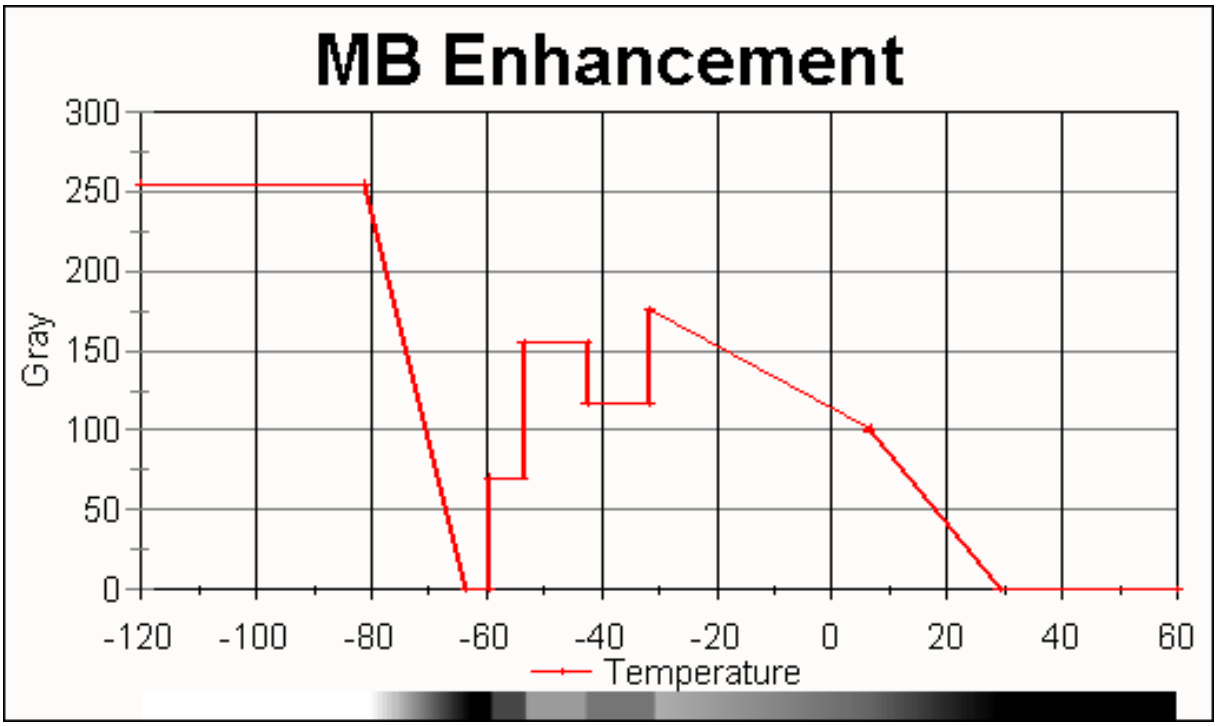


The LC curve is used on images from the 3.9 micron shortwave infrared channel (CH2) of GOES and channel 3 of Meteosat. It provides maximum enhancement in the temperature range where fog and low clouds typically occur (36 to -9 C). Another enhanced thermal range is from -10 to -29 C, the region of precipitation generation in mid-latitude weather systems. Since CH2 is sensitive to "hot spots," a steep, reverse ramp is found at the warm end (68 to 50 C) to show any observable fires as white. There is no enhancement at the very cold end (-30 to -67 C), due to the instrument noise normally present at these temperatures.

LUT: LUT361LC-bw.bmp

Seg no	Gray	Temp	Comments
1	250-000	70.0 to 50.2	Fires
2	000-000	50.1 to 36.1	Little or no information
3	000-255	36.0 to -9.4	Fog/low clouds/surface features
4	100-200	-9.9 to -29.4	Middle clouds/cirrus
5	050-080	-30.7 to -67.4	Cold clouds/no enhancement
6	255-255	-67.4 to -110.0	No information

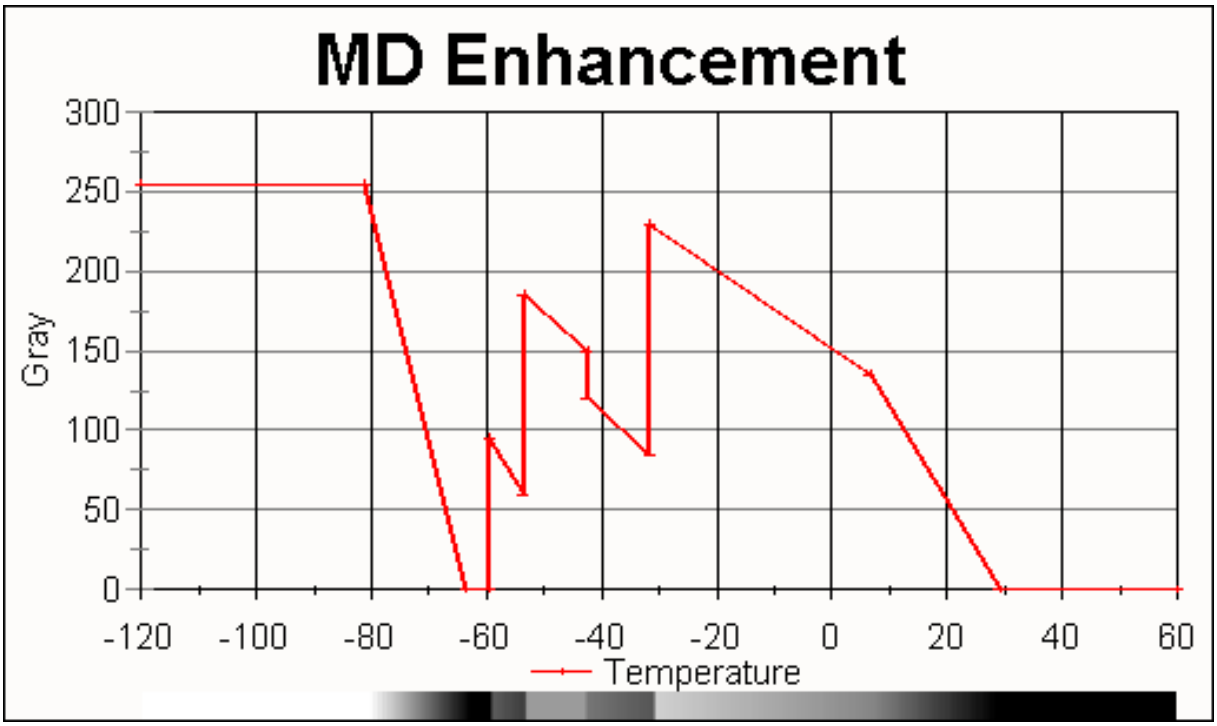
Note: *This CLUT is not supported in GeoSatSignal.*



The MB enhancement curve for thermal IR imagery artificially defines brightness values for temperatures of less than -35 C. This curve is the most widely used in the meteorological community because of the way cold cloud tops are highlighted. In this curve the grey scale is altered to make the very cold, high, overshooting cumulonimbus or thunderstorm cloud tops stand out. The effect is a contoured pattern in the cloud top that highlights areas of intense and/or potentially severe weather. For temperatures above -35 C the MB enhancement is similar to the ZA enhancement. However, for the temperature range of -35 to -60 C, there is a general decerease in assigned output brightness values with decreasing temperature. Note that for temperatures below about -60 C, the curve is severely stretched across all brightness values. Details of storm top structure for cloud tops that reach these very cold temperature levels can be easily emphasized with the MB curve.
Compare the structure of the tropical cyclone cloud tops with the MB enhancement to that with no enhancement.

LUT: LUT361MB-bw.bmp

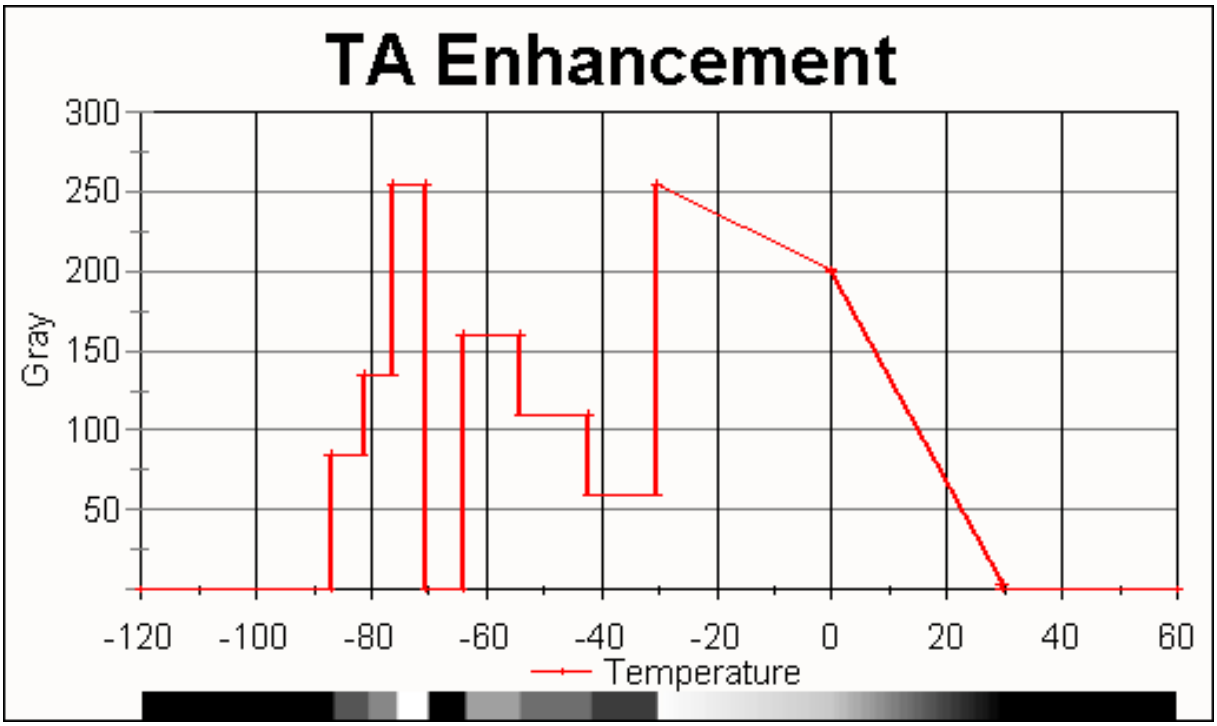
Seg no	Gray	Temp	Comments
1	000-000	60.0 to 29.3	Warm water and land
2	000-100	29.2 to 6.8	Surface features/warm clouds
3	101-176	6.7 to -31.2	Middle clouds
4	117-117	-31.6 to -42.3	Middle clouds/freezing level
5	155-155	-42.5 to -53.3	Cirrus/thunderstorm
6	070-070	-53.6 to -59.4	Cirrus/thunderstorm
7	000-000	-59.7 to -63.1	Cirrus/thunderstorm
8	000-255	-63.5 to -80.5	Overshooting cloudtops
9	255-255	-80.1 to -120.0	Very cold cloudtops or space



The MD curve is a modification of the popular, general use MB enhancement scheme. It is intended for warm season use, and provides improved enhancement within the gray "step wedges" that depict "warm top" convection (Segment number 4, 5, 6). An additional improvement is better delineation of warm low clouds (30 to 7 C). The middle cloud range is somewhat broader than the MB, and enhancement of details is minimized. Otherwise, it is the same as the MB curve.

LUT: LUT361MD-bw.bmp

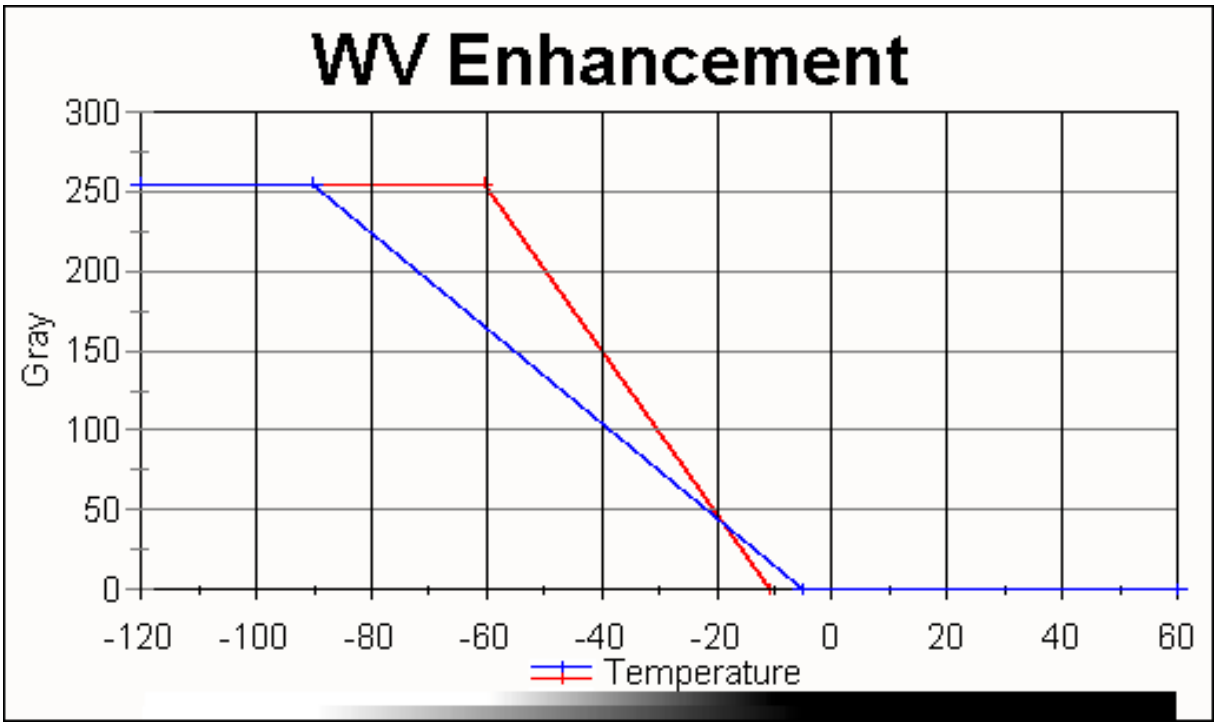
Seg no	Gray	Temp	Comments
1	000-000	60.0 to 29.3	Warm water and land
2	000-135	29.2 to 6.8	Surface features/warm clouds
3	135-210	6.7 to -31.2	Middle clouds
4	085-120	-31.6 to -42.3	Middle clouds/freezing level
5	150-185	-42.5 to -53.3	Cirrus/thunderstorm
6	060-095	-53.6 to -59.4	Cirrus/thunderstorm
7	000-000	-59.7 to -63.1	Cirrus/thunderstorm
8	000-255	-63.5 to -80.5	Overshooting cloudtops
9	255-255	-80.1 to -120.0	Very cold cloudtops or space



The TA curve is a combination of the CA curve (warm portion) (not included) and the HD curve (colder portion). The linear part of the curve is to improve land/water/low cloud contrast. The coldest part of the curve is in the same temperature ranges that are used for precipitation estimates and tropical storm classifications.

LUT: LUT361TA-bw.bmp

Seg no	Gray	Temp	Comments
1	000-000	60.0 to 29.8	Little or no information
2	004-200	29.7 to 0.1	Water and low clouds
3	201-201	-0.1 to -30.1	Mid tropospheric fronts
4	060-060	-30.3 to -41.9	Cloudtops
5	110-110	-42.2 to -53.7	Cloudtops
6	160-160	-54.0 to -63.6	Cloudtops
7	000-000	-64.0 to -69.9	Cloudtops
8	255-255	-70.4 to -75.7	Cloudtops
9	135-135	-76.2 to -80.6	Cloudtops
10	085-085	-81.2 to -86.3	Cloudtops
11	000-000	-87.0 to -120.0	Maximum cold



There are two WV curves, the old style and the new style. The old style WV curve (red line in graph, and the upper bar) is used for the 6.7 micron water vapor channel (CH3) on GOES. The only temperature range that is enhanced is between -10 C and -60 C. This is the most important range because it shows middle and upper tropospheric moisture patterns that relate to significant features such as: jet streams, upper troughs, dry slots, and deformation zones. Temperatures colder than -60 C are shown as white, and temperatures warmer than -10 C are displayed as black. The latter condition is very rare, and occurs mainly in the subtropics.
It is recommended to use the new style, because satellites are calibrated for them. The new style supports a larger temperature range -5 C to -90 C (blue line in graph and lower bar). Using of old style can give unexpected results. There is also a nice color enhancement available, see page ..

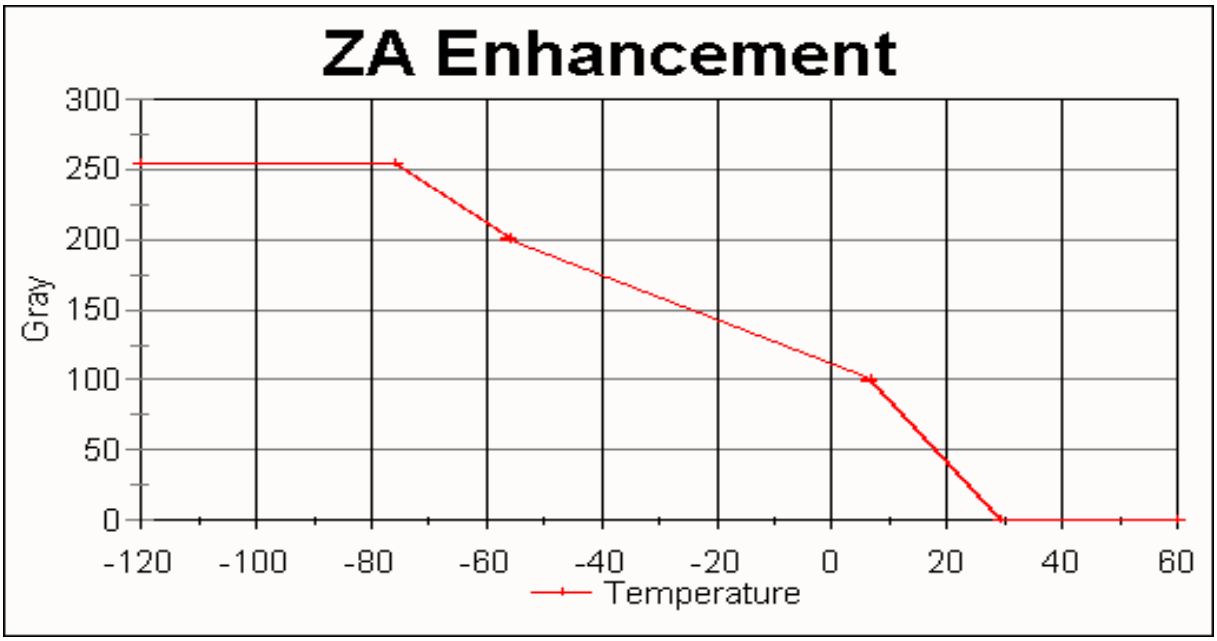
LUT: LUT361WVo-bw.bmp (old style)
LUT: LUT361WVn-bw.bmp (new style)

Seg no	Gray	Temp	Comments
1	000-000	60.0 to -10.7	Little or no information
2	000-255	-10.8 to -60.2	Moister or cold clouds
3	255-255	-60.5 to -120.0	Cold clouds or space

Specifications for old style.

Seg no	Gray	Temp	Comments
1	000-000	60.0 to -5.0	Little or no information
2	000-255	-5.1 to -90.0	Moister or cold clouds
3	255-255	-90.1 to -120.0	Cold clouds or space

Specifications for new style.

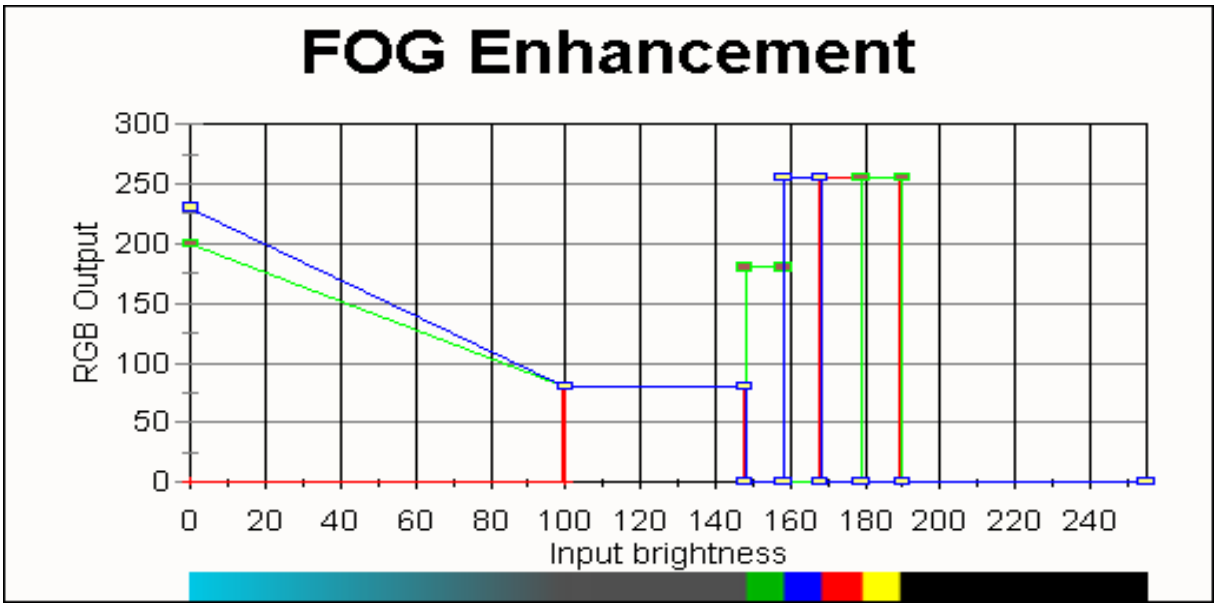


A general smoothed enhancement for general-purpose infrared enhancement technique.

LUT: LUT361ZA-bw.bmp

Seg no	Gray	Temp	Comments
1	000-000	60.0 to 29.3	Little or no information
2	000-100	29.2 to 6.8	Surface features/low clouds
3	101-200	6.7 to -55.7	Mid/upper level clouds
4	201-255	-55.7 to -75.2	Cold clouds/thunderstorm
5	255-255	-75.7 to -120.0	Little or no information

COLOR ENHANCEMENTS



A special fog depth color enhancement based on the temperature difference between GOES IR Band 2 (3.9 :m) and Band 4 (10.7 :m) shows approximate depth of low level clouds and fog. The color steps show increasing cloud depth, from green (0 - 200 m) to black (> 500 m). The cloud depths obtained from this product are valid only for single cloud layers.
The difference in brightness temperature (or brightness) can be enhanced by simply contrast stretching the resulting image (use a factor of 10). The temperature difference threshold (3.9 :m- 10.7 :m) is -2 C or colder for fog/stratus (closer to 0 C for very cold conditions). Values between -2 and +2 are normally cloud-free. Large postive values would represent cirrus clouds.
The Meteosat 8 IR channels (9 = 10.8 :m; 3 = 3.9 :m) can be used in the same way as GOES for nighttime detection of fog.

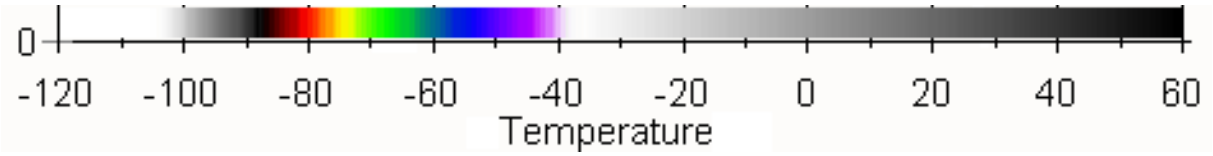
LUT: LUT256FOG.bmp

Seg no	Input	T (9-3)	Red	Green	Blue	Feature
1	000-100	-13 to -3	000	200-080	230-080	Cirrus
2	101-148	-3 to +2	080	080	080	No Clouds
3	149-158	2 to 3	000	180	000	Low cloud <200 m
4	159-168	3 to 4	000	000	255	Low cloud 200-300 m
5	169-179	4 to 5	255	000	000	Low cloud 300-400 m
6	180-190	5 to 6	255	255	000	Low cloud 400-500 m
7	191-255	>6	000	000	000	Low cloud >500 m

Note: *This CLUT is not supported in GeoSatSignal.*

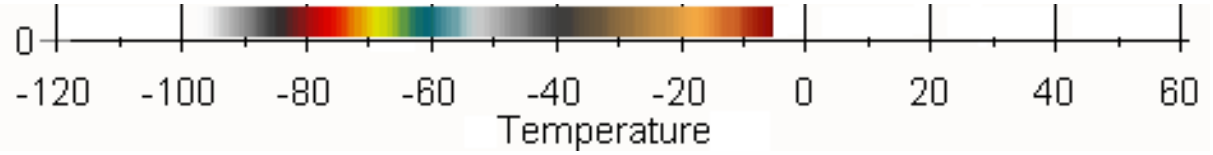
INFRARED RAINBOW

LUT: LUT361ir-rb.bmp



WATER VAPOUR RAINBOW

LUT: LUT361wv-rb.bmp

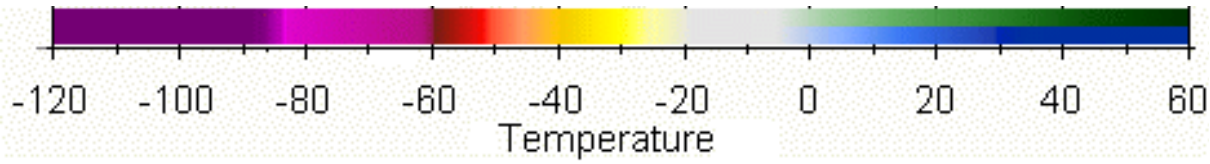


COLOR ENHANCEMENTS FROM METEO MAARSSEN

Standard CLUTs are in a range of -60 C to +40 C; but digital data do have a range of -120 C to +60 . The lowest temperatured in the earths atmosphere are around -80 C. The new rainbow version is offering the whole extended range. This gives users the oppertunity to view also the very cold cloudtops. Actually this CLUT has a range of -120 C to +60 C. Pink and purple are used for the extended temperatures from -60 C to -120 C. Also the color dept has been improved. The rainbow versions should be used for IR channal and supports the landsea masks.

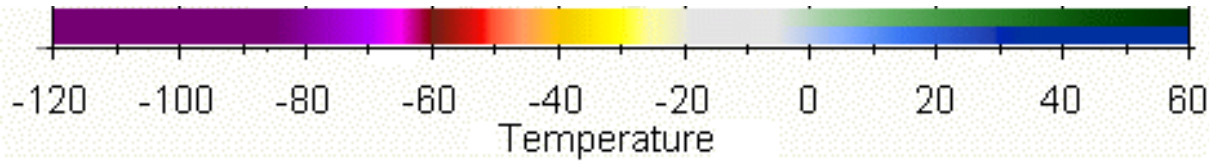
INFRARED RAINBOW

LUT: LUT361ir-lrit-cc.bmp



INFRARED RAINBOW

LUT: LUT361ir-hrit-cc.bmp

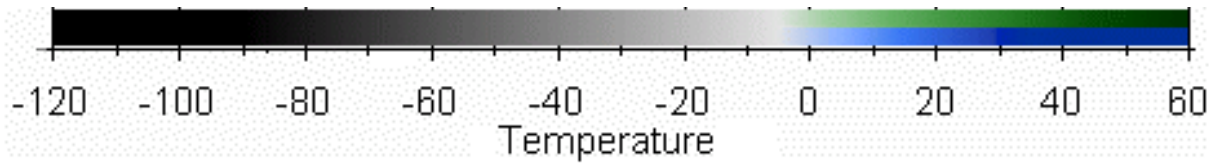


Both enhancements are designed for use with IR channels. LRIT data is slightly degreeded and the LRIT-lut version gives a better smoother result. The LRIT version can be used for the HRIT and/or PDUS data too, but the HRIT version do give more details on cold cloudtops.

These CLUTs can be used to determinate could cloudtops and features on land and sea.

INFRARED GRAY

LUT: LUT361ir-lrit-bw.bmp



This enhancement can be used as basement for the radar images available from Meteo Maarssen.

WATER VAPOUR GRAY

LUT: LUT361wv-bw.bmp