

# Stereo Cloud Top Height Products for the GOES-R Era

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## Introduction

A stereo Cloud Top Height (CTH) product is generated using an algorithm that is based on matching images of the same or similar spectral bands acquired quasi-simultaneously by satellites from two or three different vantage points. The CTH is derived from the observed parallax between pairs of satellites.

Nominally, GOES-R will begin its life in orbit at a central location between two operating GOES-NOP spacecraft. This configuration will enable a near-full disk stereo-CTH product (Figure 1). With two operational GOES satellites in the eastern and western slots and coverage from another satellite such as TEMPO, a full CONUS stereo-CTH product can be made.

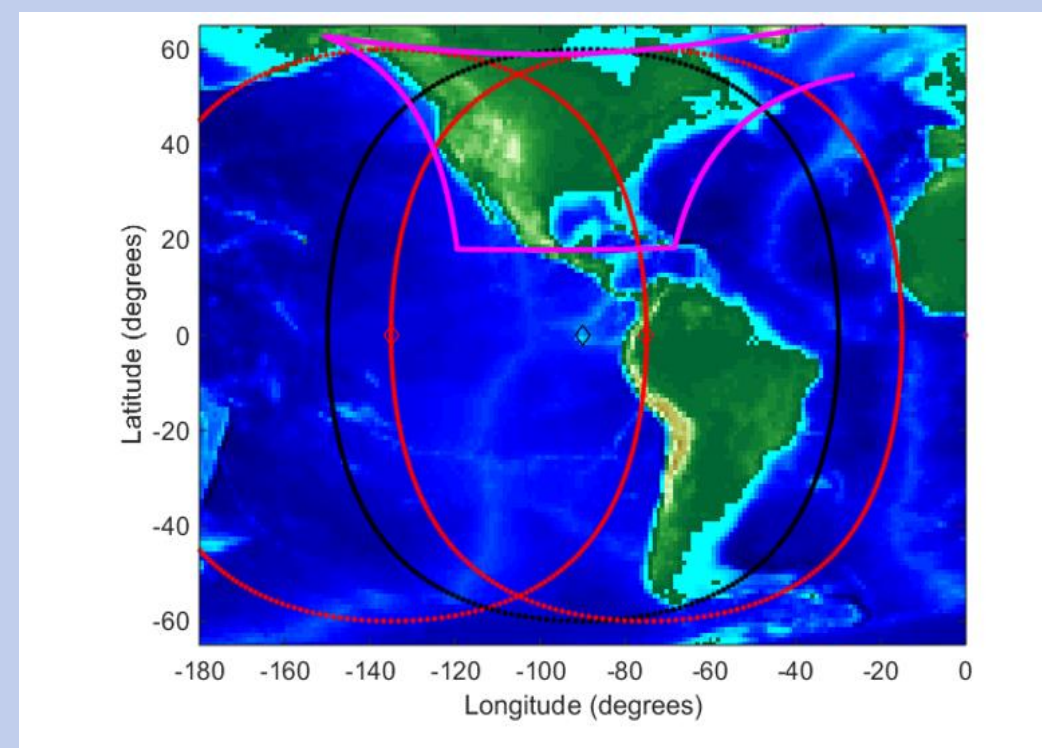


Figure 1. Two & Three Satellite Coverage

## Prototype Products

We have generated a stereo-CTH product during hurricane Sandy when all three GOES-NOP satellites were operating. The geographic coverage for the three-satellite and two-satellite stereo-CTH is shown in Figure 2 as an RGB composite image of GOES-15 (west), 14 (center), and 13 (east) for the VIS band. Each has been remapped into a common fixed-grid, that of GOES-14. The full stereo-CTH product is shown in Figure 3. The stereo-CTH values are generated every 10 VIS pixels, resulting in better than 10-km resolution for the product (the GOES-R operational L2 product specification).

Accurate Image Navigation and Registration (INR) is important for a seamless stereo-CTH product. INR biases, even at the sub-pixel level, will introduce a parallax bias. Figure 4 shows an example; the center image (green) is shifted east so that the composite coastline in this area is west (red) + east (blue) = purple.

In our prototype, a height adjustment to correct for INR biases is determined by calibrating the CTH over clear skies. A histogram showing the residual height assignment error is shown in Figure 5. The mean error is -1.4 m and the standard deviation is 170.7 m, which is compatible with the measurement accuracy specified for GOES-R operational L2 CTH product.

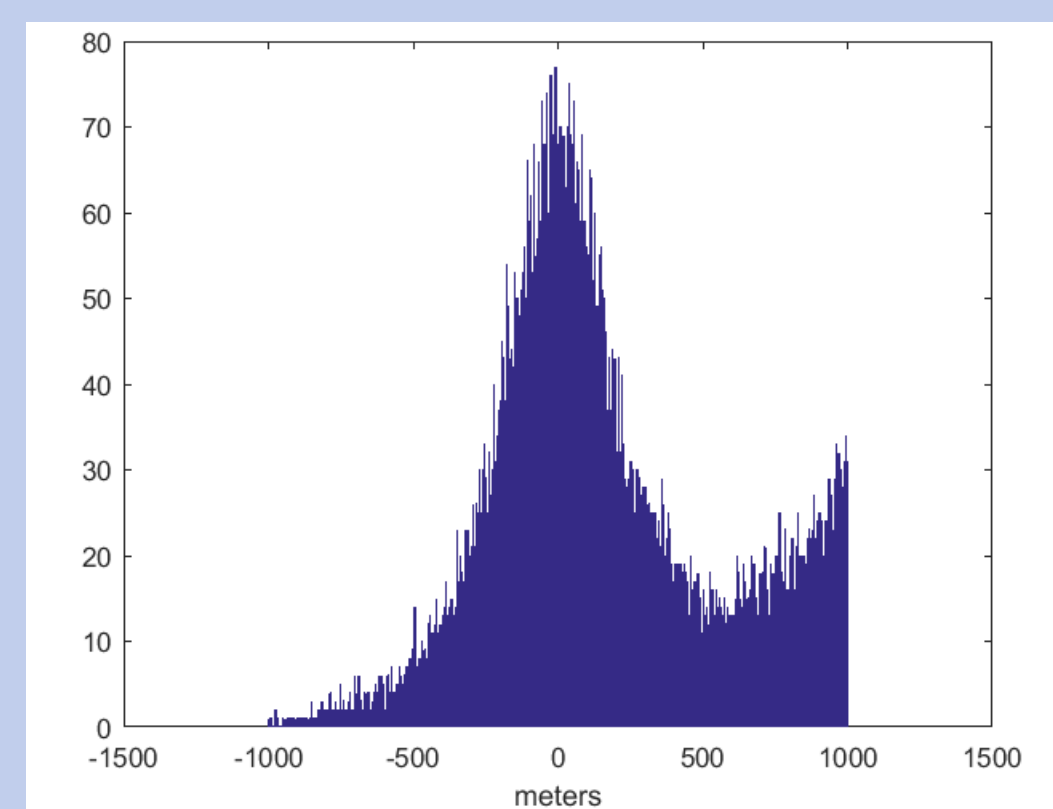


Figure 5. Height Assignment Error

Figure 6 shows a zoom-in on Mexico showing the elevation above Mean Sea Level (MSL) represented by markers; MSL assignments are placed only where the parallax indicates a height that is at least 300 m above ground level, which suppresses terrain parallax.

A zoom-in on Hurricane Sandy is shown in Figure 7; the cloud heights are as expected for a hurricane.

## Summary/Next Steps

A stereo-CTH product is generated using a conceptually simple algorithm, based on first principles, and without dependence on a forecast model's vertical temperature profile or an *a priori* lapse rate. The stereo-CTH is suitable as an operational product or as Cal/Val for GOES-R products.

Going forward, we intend to package our sample product in a netCDF file for distribution, create an IR stereo-CTH product, a Water Vapor height product, and explore the effectiveness of using non-GOES imagery as additional sources of parallax measurements.

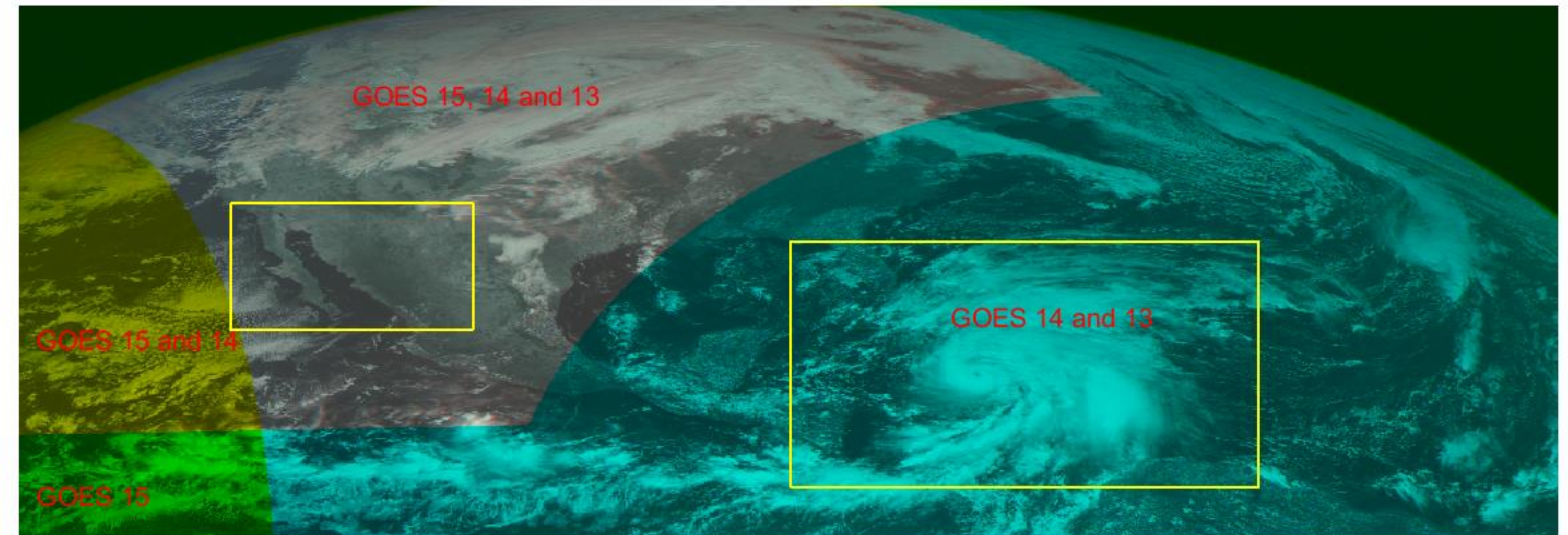


Figure 2. GOES 15, 14, and 13 VIS Composite Image

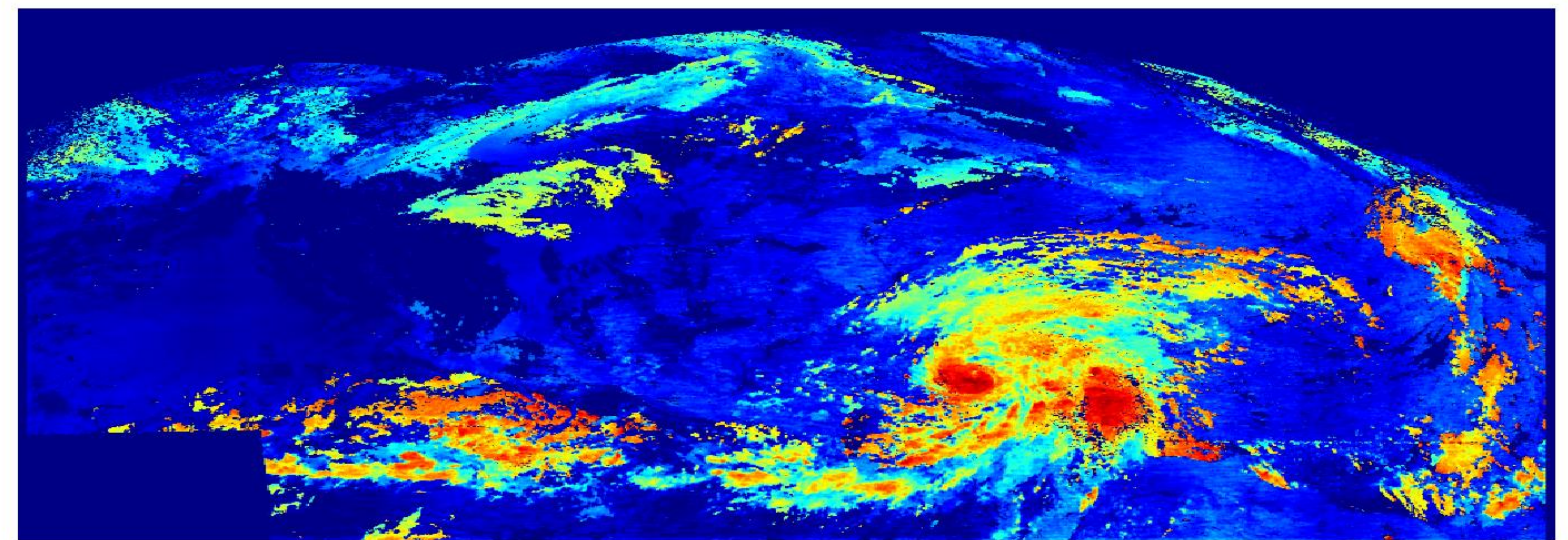


Figure 3. Stereo-CTH at 10-pixel Resolution for GOES VIS

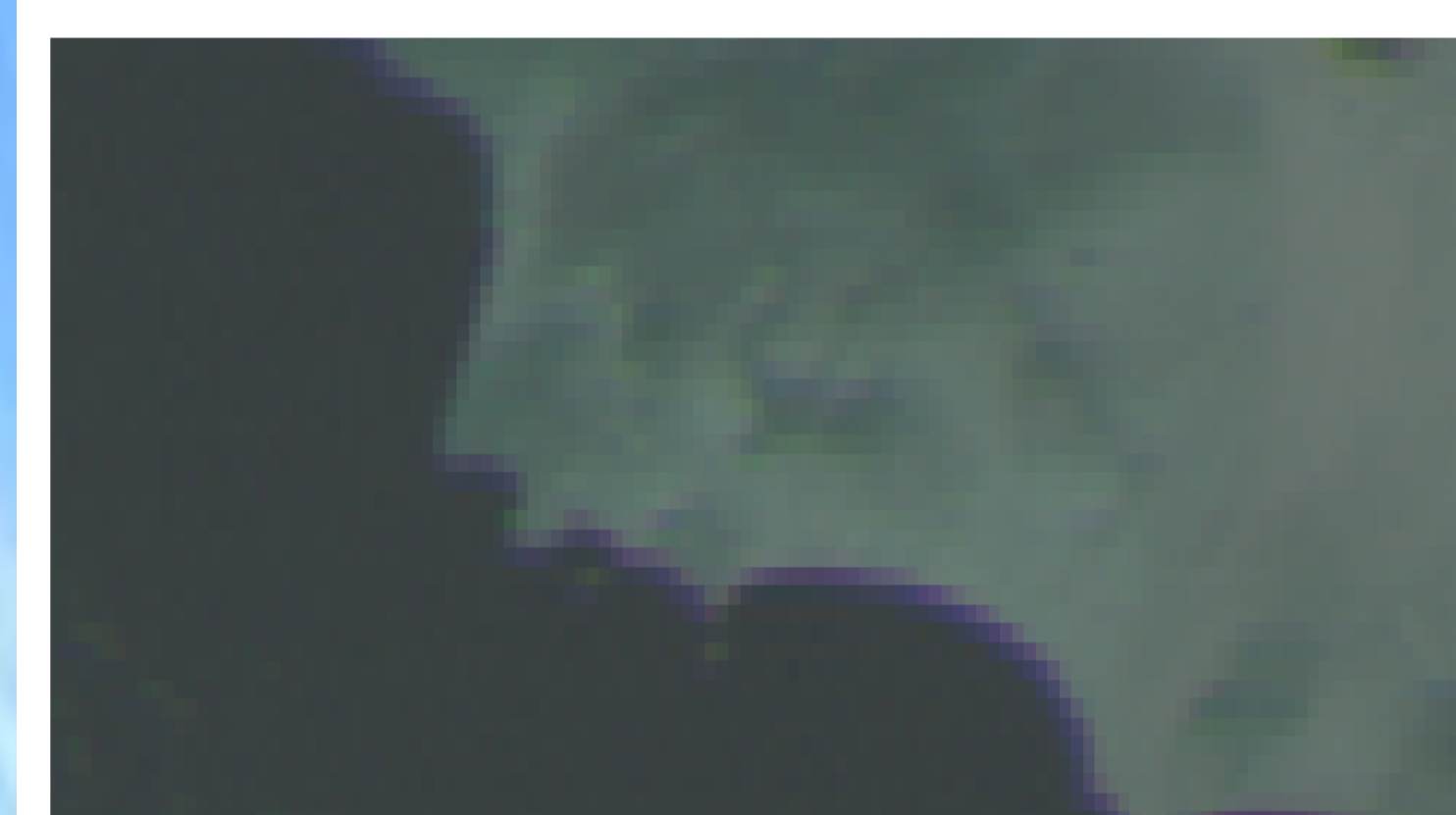


Figure 4. INR Bias seen in VIS Composite Image

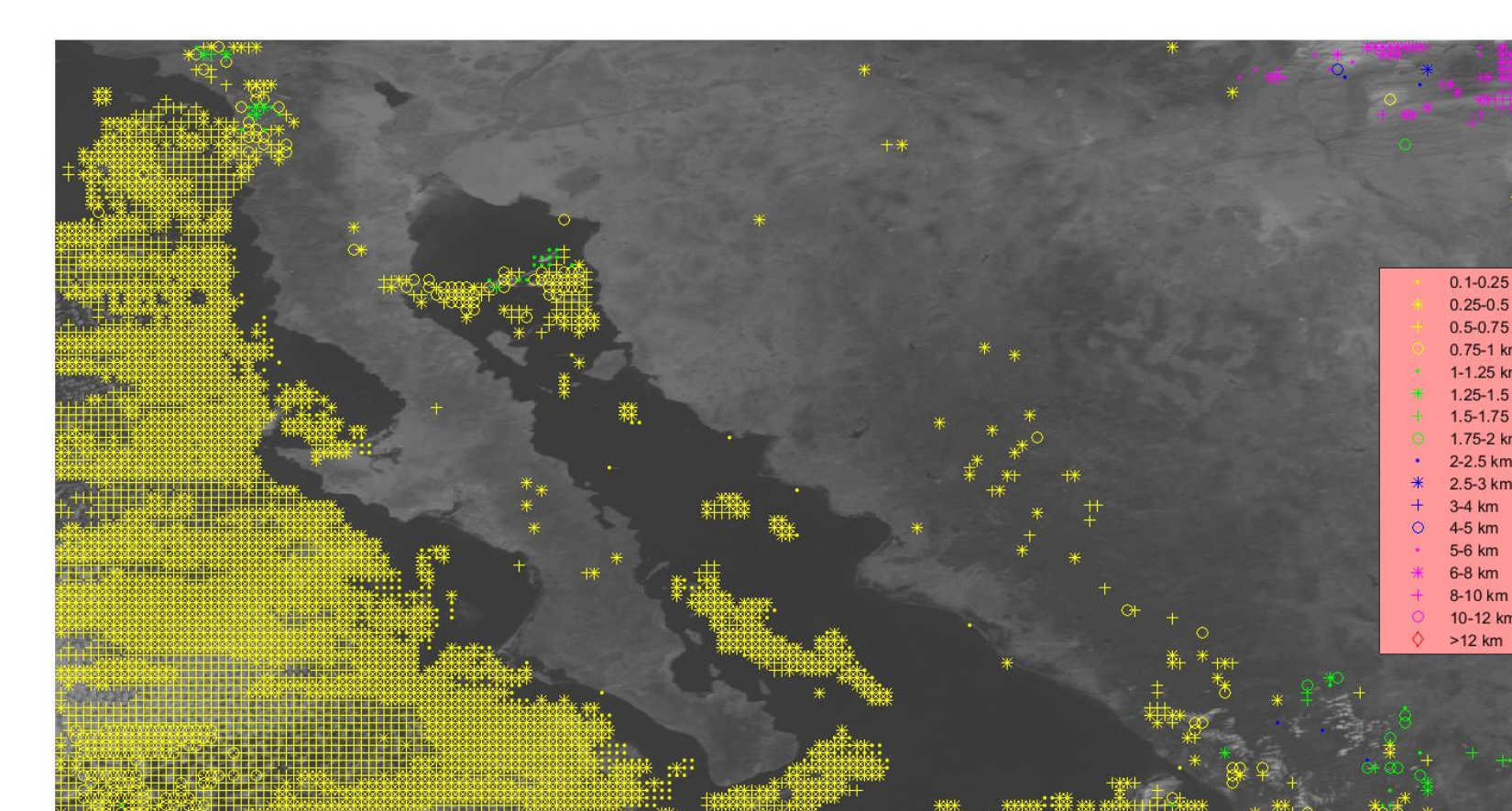


Figure 6. Three Satellite Stereo-CTH above MSL (VIS)

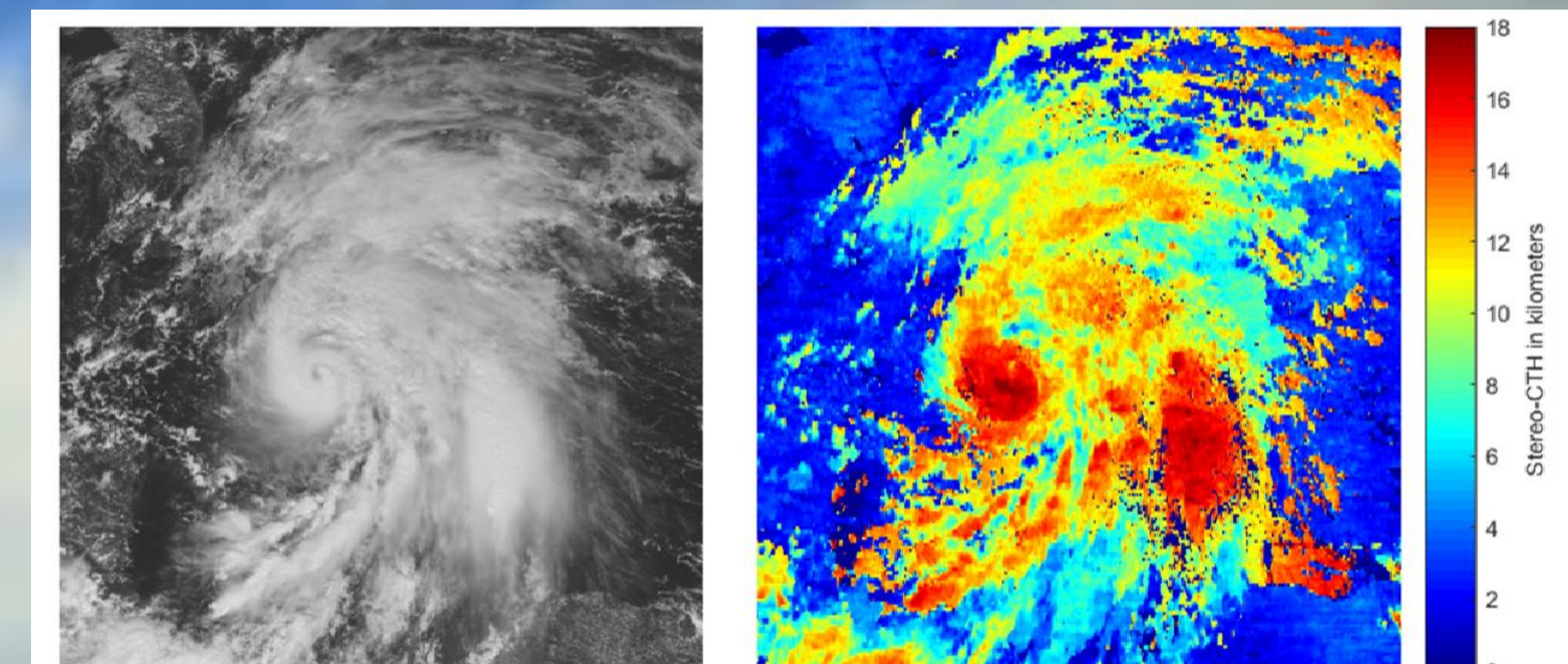


Figure 7. Hurricane Sandy