Outline:
I. Background
II. Outline of Method
   a. North/South Domains
   b. Strengths/Weaknesses
III. Protocols of the Aviation Community
   a. Standard Pressure Altitudes
   b. Representativeness
IV. Comparison of Methods
V. Required Accommodations
VI. Conclusion
Background

- Knowledge of convective cloud top altitudes is important to commercial and DoD aircraft in order for pilots to avoid such hazards as extreme turbulence, lightning and hail.

- The NRL Convective Cloud Top Height experimental product combines brightness temperature measurements from the infrared window channels (10.7 \( \mu \)m) of Geostationary satellites (under the reasonable assumption that the convective clouds are optically thick) and temperature profiles from the Navy Operational Atmospheric Prediction System (NOGAPS) to estimate the cloud top altitude.

- Geostationary data provide a near real time series product useful for monitoring the development/dissipation and advection of the mesoscale convective cells.
Procedure

1) Ingest geostationary IR data and create stitched image over domain of interest.
2) Determine closest temporal match to NOGAPS analysis and register to same domain.
3) For each pixel in the scene, loop downward from top of atmosphere until intersection with NOGAPS profile is achieved or pressure level exceeds 850 mb cutoff.
4) If an intersection is found, interpolate NOGAPS geopotential height to estimate cloud top height and terminate loop over atmospheric profile.
5) Merge cloud top height with background topography map, convert to jpeg format and transfer to NRL web archive.
**OCND Northern Domain**

<table>
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<th>GMS-5/GOES-10</th>
<th>Date: 04/05/01</th>
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<td>Time: 0330 Z</td>
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**Coverage Region:**
- Lon: 180-110W
- Lat: 40N-20S

**Case Statistics:**
- Average: 22.2 Kft
- Max: 53.5 Kft
OCND Southern Domain

GMS-5/GOES-10
Date: 03/26/01
Time: 1730 Z

Coverage Region:
Lon: 160E-130W
Lat: 20N-40S

Case Statistics:
Average: 24.6 Kft
Max: 53.9 Kft
**Strengths**
Over ocean (warm, stable background).
Optically Thick Clouds.
Tropical Profiles (well behaved lapse rates, well-defined tropopause).

**Weaknesses**
Over land (highly variable temperature background diurnally).
Optically thin clouds (leading to underestimation of true cloud height).
Profiles with strong mid-level inversions of temperature.

The figure above illustrates one of the benefits of using NOGAPS model profiles instead of the standard atmosphere when mapping satellite temperature to equivalent height. The model profile (blue) matches closely with the rawinsonde (green).
Above 10 Kft, the aviation community uses a common pressure altitude based on the measured barometric pressure at the level of the aircraft and the standard atmosphere relating pressure to height. These are sometimes referred to as Standard Flight Levels.

Although the altitudes derived by this method will be different than that those obtained using a representative sounding (owing to the availability of a more representative pressure/height profile in the latter case), safety is maintained as long as all aircraft “play by the same rules.”

These rules are not followed by the NRL IR/NOGAPS product, leading to misrepresentation of convective cloud top heights because they have not been converted to their equivalent “standard flight level” values.
Mapping to Standard Flight Levels

The figure above demonstrates why it is a bad idea to map the satellite brightness temperature directly to an equivalent height using a Standard Atmosphere profile. The relationship between T and Z is not well behaved.

The relationship between P and Z is much less variable over the same domain, as shown above (although even here the potential for errors of up to 4 or 5 Kft remain). The remapping should be done in pressure space.
**Proposed Adjustment to Current NRL CCH Product**

1) Convert IR brightness temperature to equivalent NOGAPS pressure level (as opposed to height).

2) Using a standard atmosphere pressure/height profile, interpolate NOGAPS pressure using the hypsometric equation to obtain the equivalent standard atmosphere (flight level) cloud top heights.

This will result in a modification to the original convective cloud height product such that reported cloud top heights reside in the same paradigm as aviation altitude measures.
Summary

• The NRL Monterey cloud height product is capable of providing accurate cloud top heights for convection over the OCND domains using model (NOGAPS) soundings.

• To account for aviation use of pressure altitudes, we propose to modify the CCH product by first converting satellite temperature to NOGAPS pressure, and using this pressure to interpolate to a corresponding standard atmosphere height.

• This correction is far more accurate than conversion directly from satellite brightness temperature to height using a standard temperature profile, as the relationship between temperature and height is not well constrained.

• Ongoing developments with this product include extension to new domains, revision of handling for convection penetrating the tropopause, extension to lower tropospheric cloud heights, and optically thin cirrus (e.g., via split window (10.7-12.0 μm) differencing techniques).