Height Differences Between Flight Levels

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Federal Aviation Administration

Introduction

An analysis was performed on the geometric compression of RVSM flight levels and flight levels above the RVSM volume of airspace (up to FL450).

- The results show that the overall frequency of flight level compression is higher at flight levels above RVSM when compared to flight levels within the RVSM band.

- This presentation is intended to provide insight into the variation of geometric differences between flight levels of interest.

RVSM implementation

included an examination of the average FL differences.

It was determined that no specific allocation was required to account for the potential reduction of the geometric distance between adjacent FLs.

Meteorological Data

The height of a flight level can be determined by observational meteorological data.

The FAA works closely with the

- ✓ National Oceanic and Atmospheric Administration (NOAA), and the
- ✓ National Centers for Environmental Prediction (NCEP)

to maintain accurate and efficient processing of required input data.

1. The FAA currently uses Global Data Assimilation System (GDAS) data to model the geometric height of RVSM flight levels.
2. NOAA/NCEP GDAS model output makes use of Grid point Statistical Interpolation (GSI) system technology, real time observational data, ensemble and assimilation data systems.
3. This complex analysis is performed by NOAA experts and provides grid point analysis data for four daily times: 00Z, 06Z, 12Z, 18Z.

Flight Level Compression

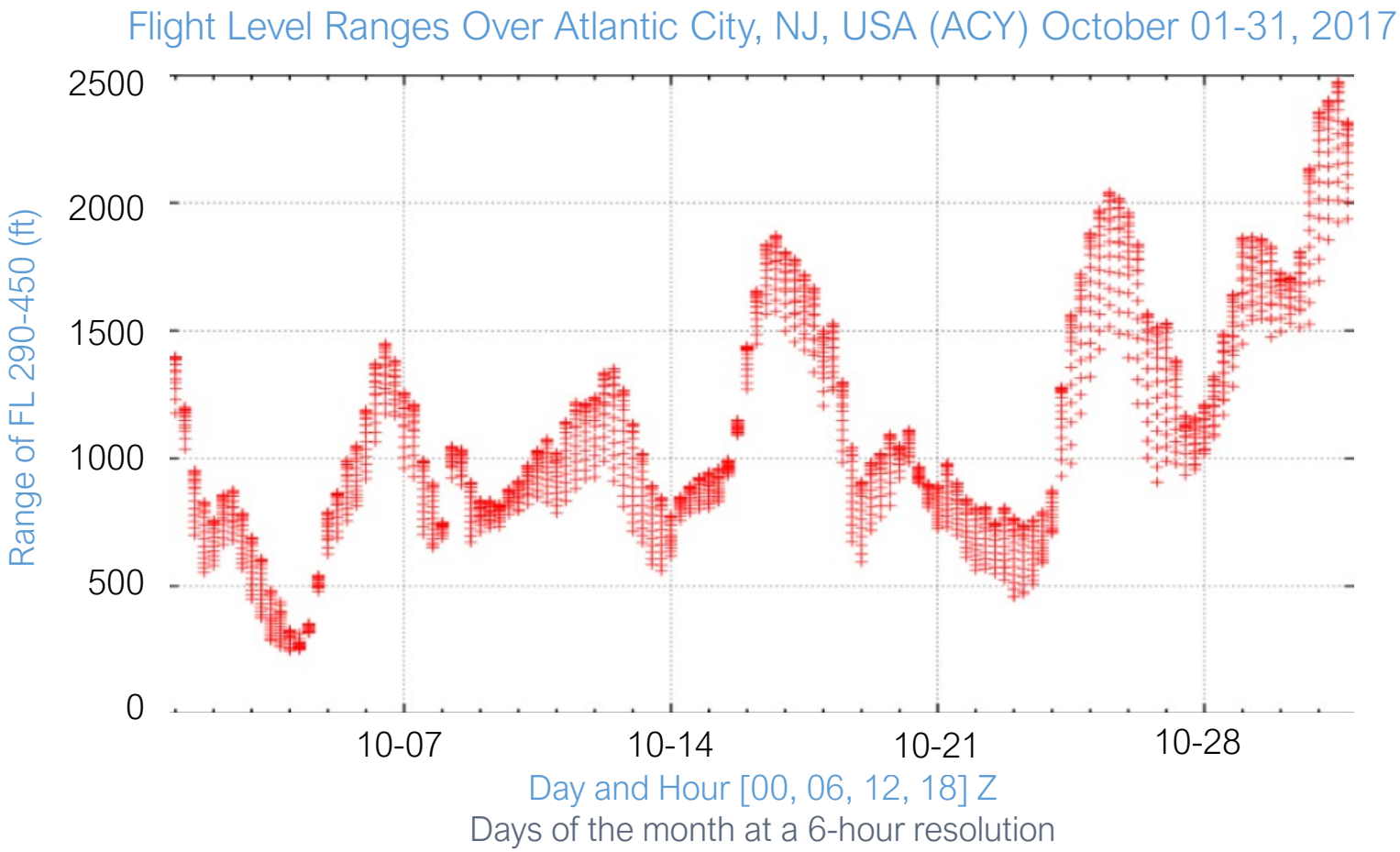
Daily heating and cooling of the atmosphere causes the geometric height of flight levels to rise and fall.

Nominally, these changes occur uniformly and the desired spacing of 1000 geometric feet is maintained.

Within a broad analysis area, temperature variation caused by solar heating will cause geometric vertical gradients on constant pressure contours.

The primary model parameter for FL height is temperature.

Flight Level Ranges within a 10X10 grid Centered at ACY



For each analysis time, the range of each FL was calculated from:

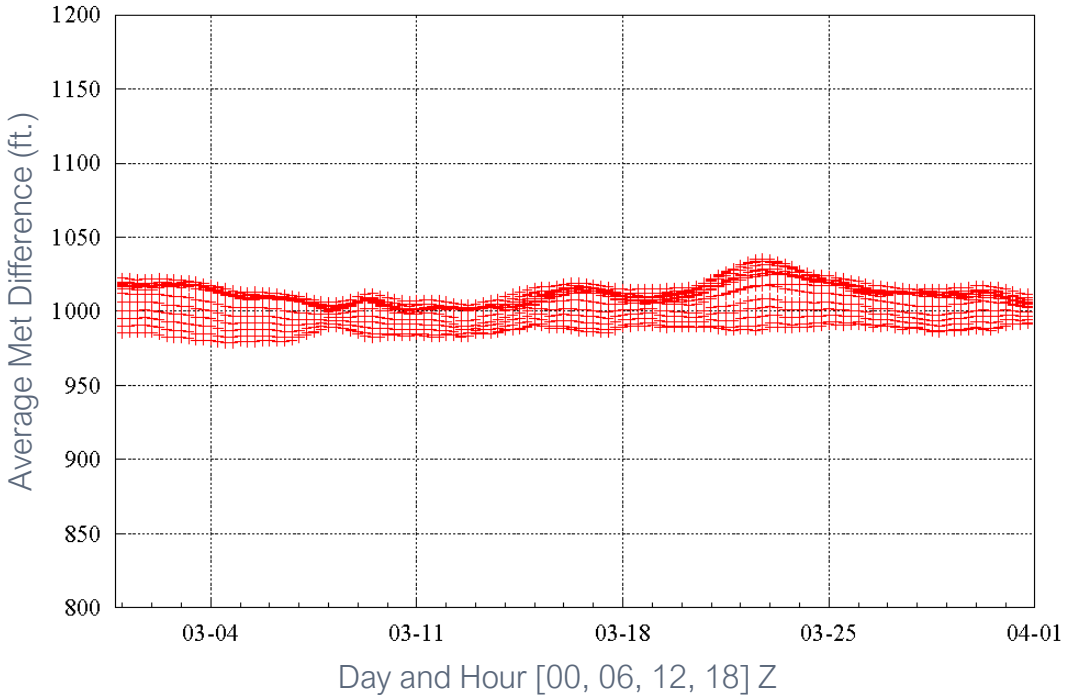
- degrees latitude [35, 45]
- degrees longitude [-80, -70]

The data represented in the figure are not anomalous and demonstrate that there can be significant geometric gradients on multiple FLs and the magnitude of those gradients is not always constant.

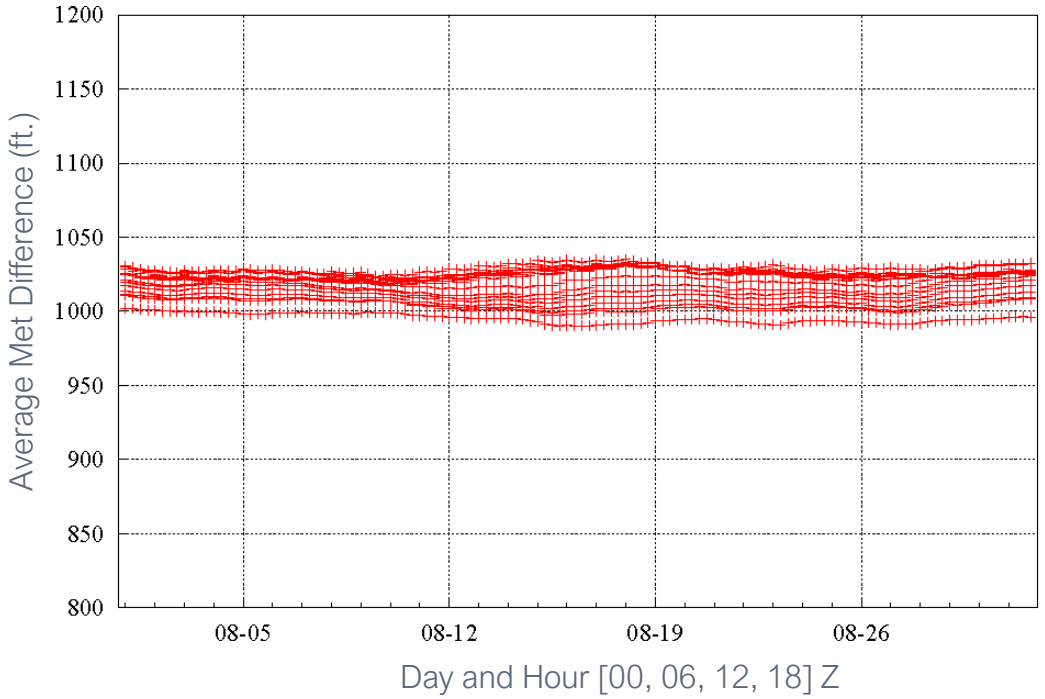
Compression can occur when the variation is not uniform across all FLs.

Average Difference Between Each Flight Level

Average Met Difference Between Flight Levels 290-450
March 2017



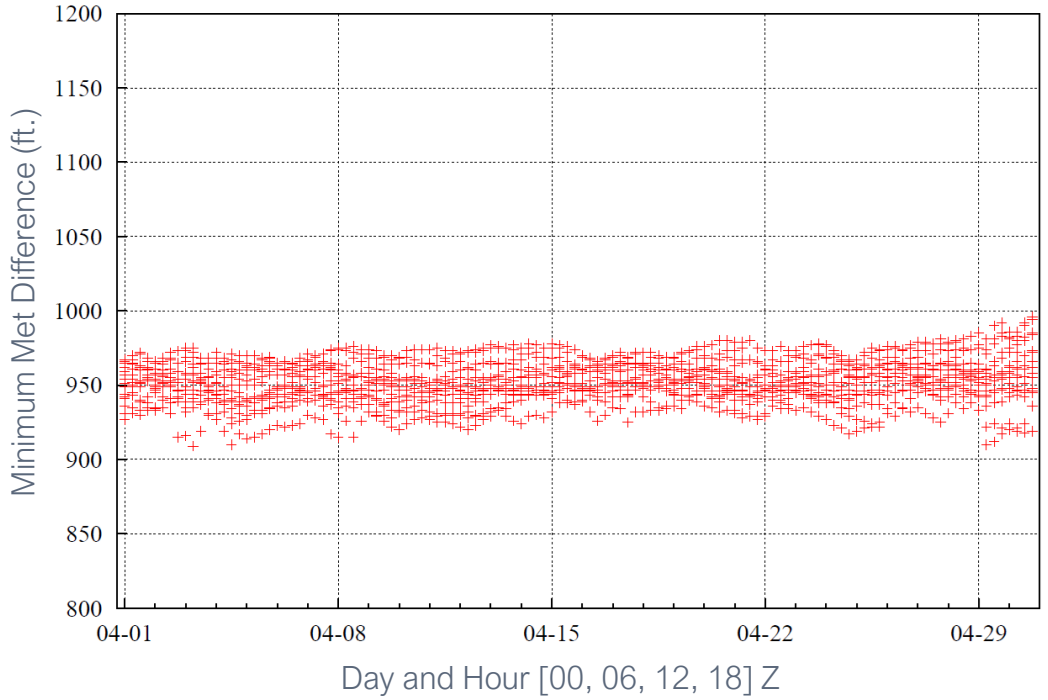
Average Met Difference Between Flight Levels 290-450
August 2017



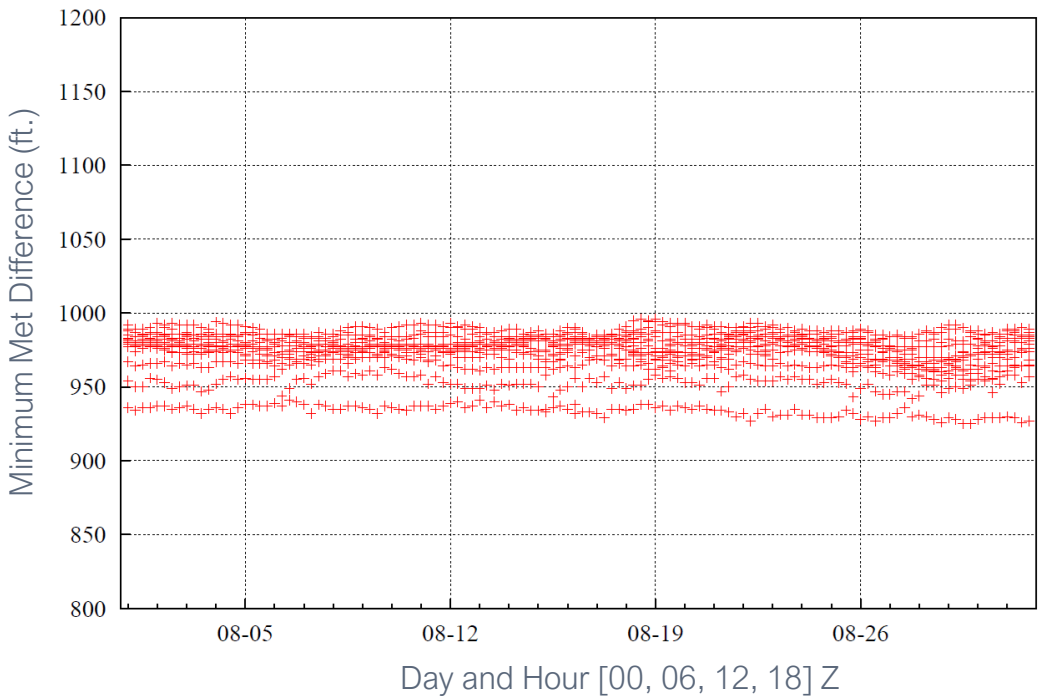
Data were compiled from a coverage area within a grid bounded by latitude [20,72.5] and longitude [-130, -60] at each of the GDAS report times.

Minimum Difference Between Each Flight Level

Minimum Met Difference Between Flight Levels 290-450
April 2017



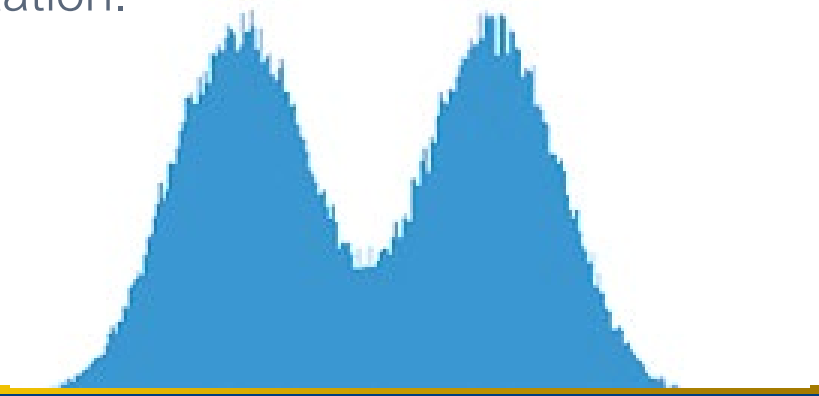
Minimum Met Difference Between Flight Levels 290-450
August 2017



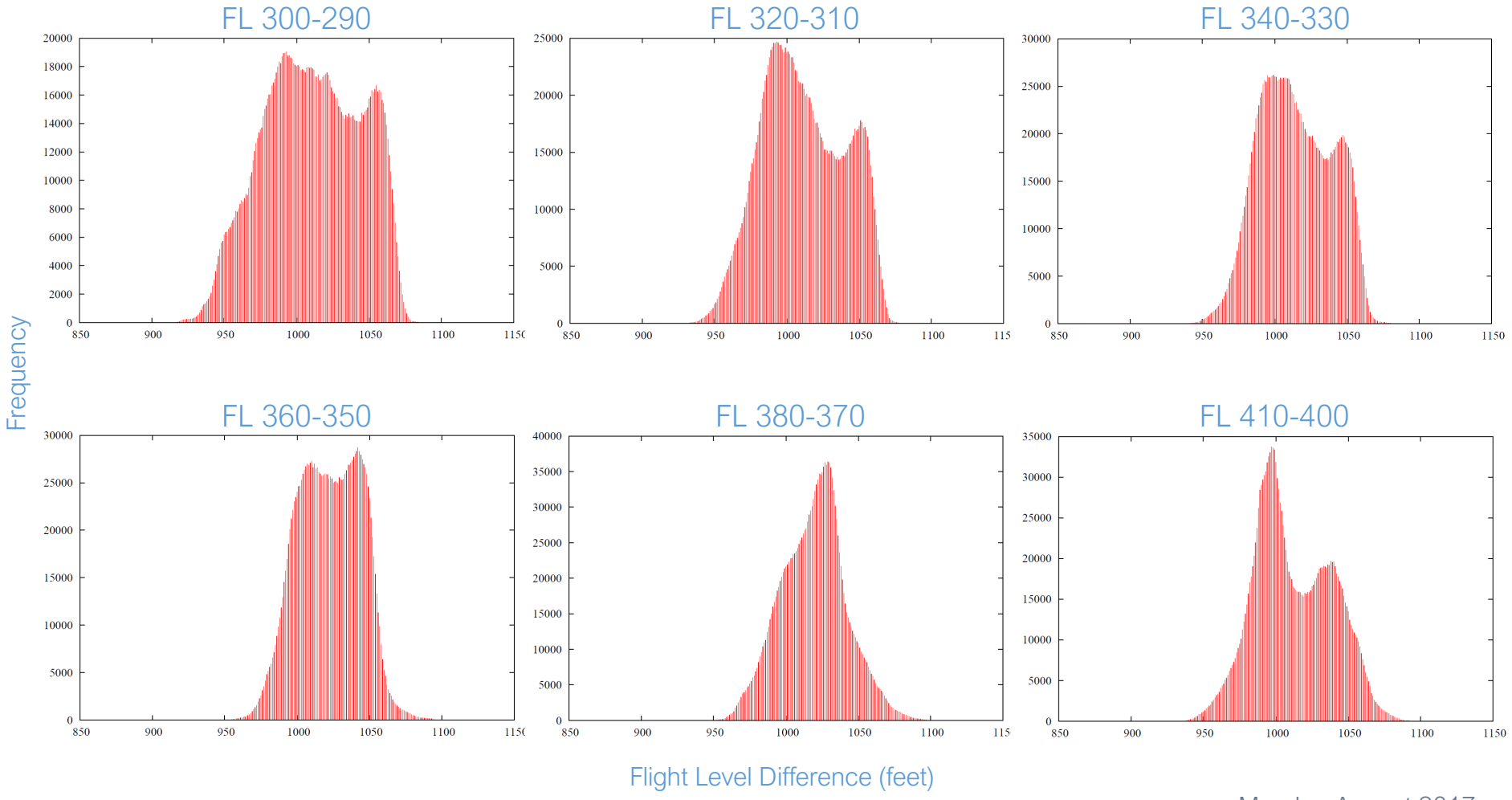
Distribution of Geometric FL Differences

A set of histograms was produced for each RVSM FL and flight levels above RVSM (FL420-450) to examine the distribution of geometric differences present within the data set.

- Most of the histograms exhibit a bimodal characteristic.
- The data contains a mixture of both geographic and temporal aspects that likely contribute to this result.
- The geographic aspect will be explored later in this presentation.



Distribution of Geometric FL Differences - RVSM Flight Levels

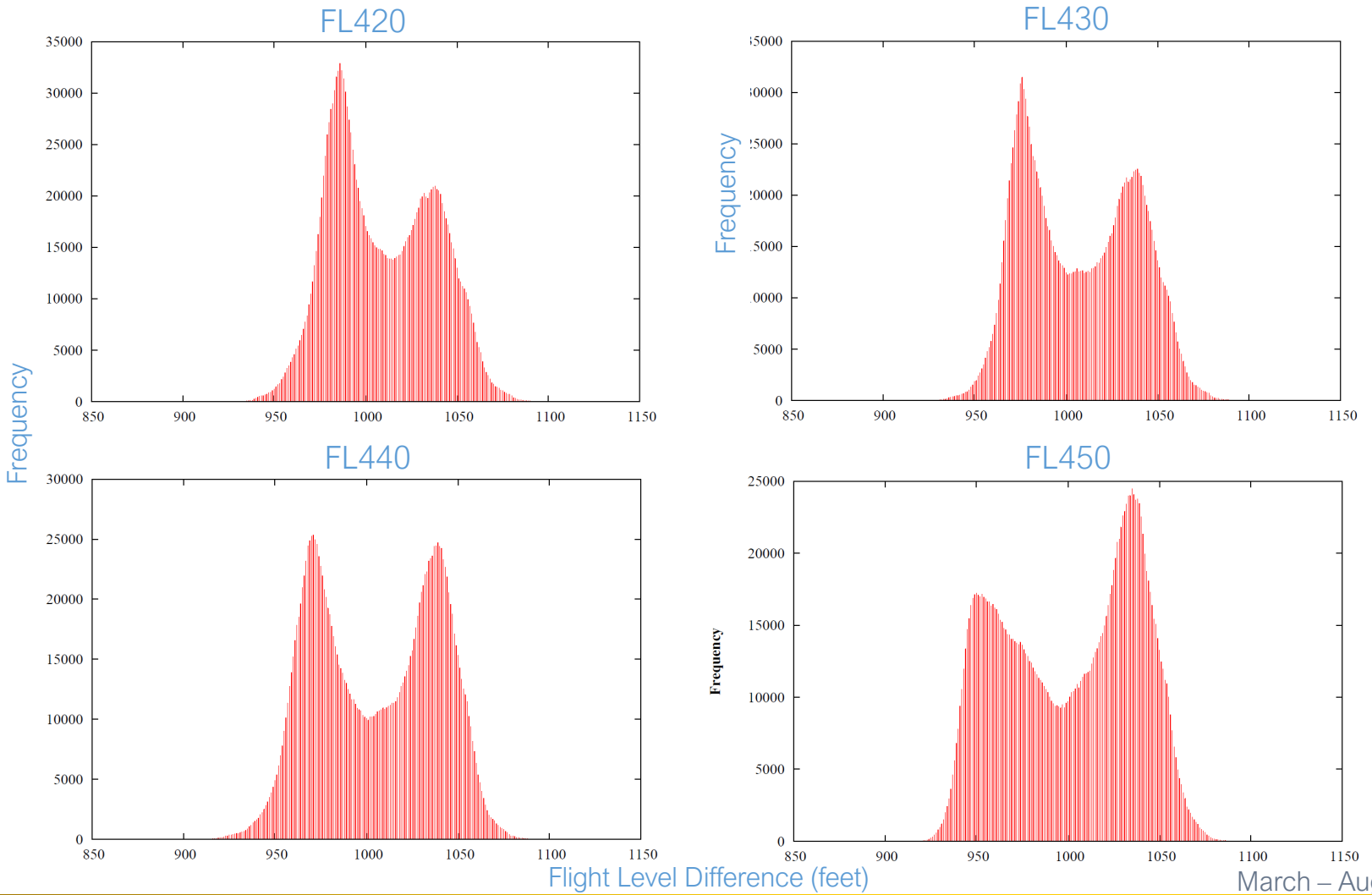


March – August 2017

Observations

- The data for each set of FL differences has a mean of approximately 1000 ft.
- Differences less than 950ft are relatively rare, most occur at low RVSM FLs.

Distribution of Geometric FL Differences Above RVSM (FL420 – FL450)



March – August 2017

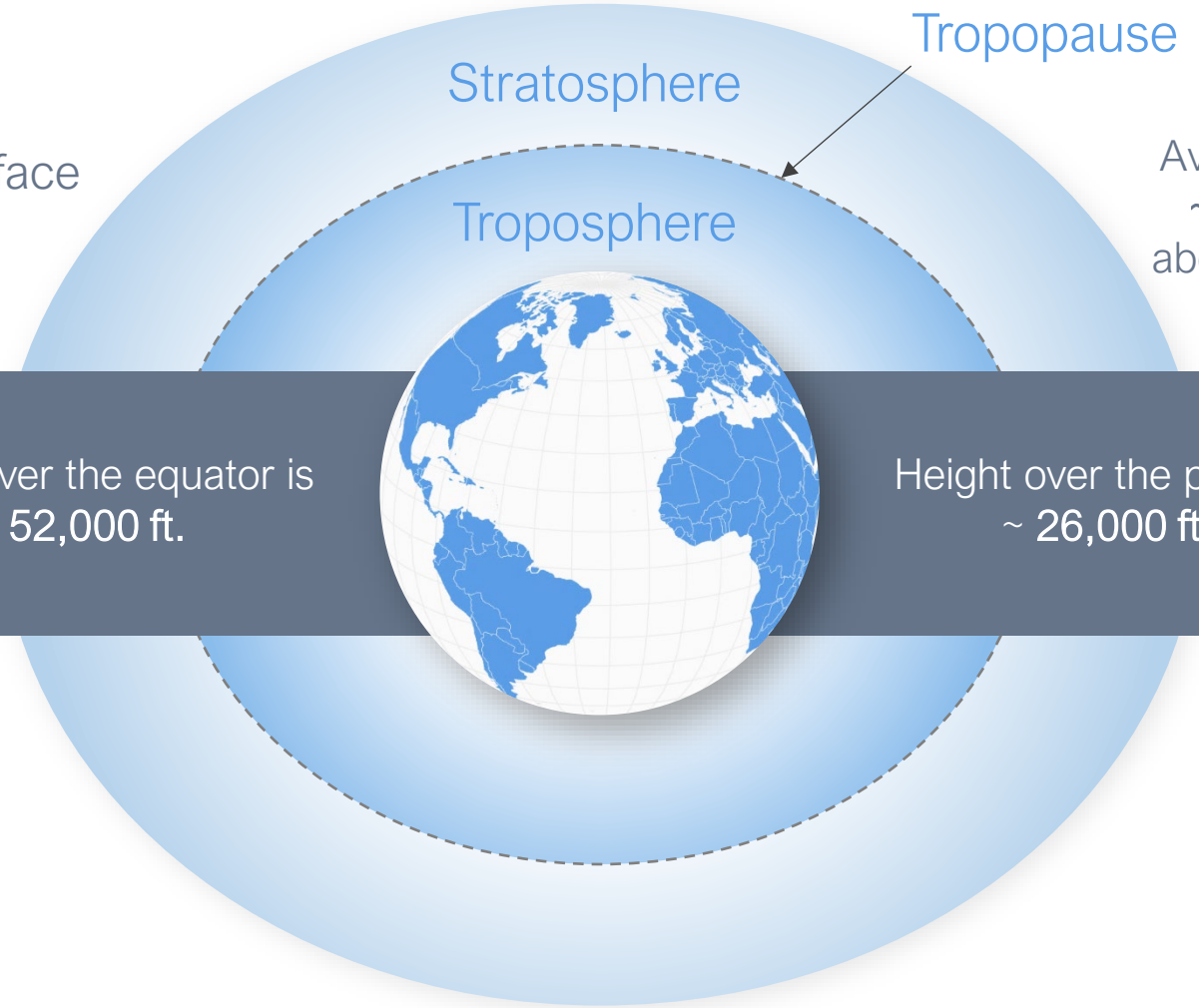
Observations

- The bimodal characteristic of the data is more pronounced
- There are more differences which are less than 950 ft.
- The mean, particularly at the highest altitude, seems to be moving away from 1000 ft.

Atmosphere Characteristics at Higher Altitudes

Troposphere

The troposphere begins at the Earth's surface and extends to an upper boundary known as the tropopause.



Average height is ~ 36,000 ft. at about 45° latitude.

Height over the equator is ~ 52,000 ft.

Height over the poles is ~ 26,000 ft.

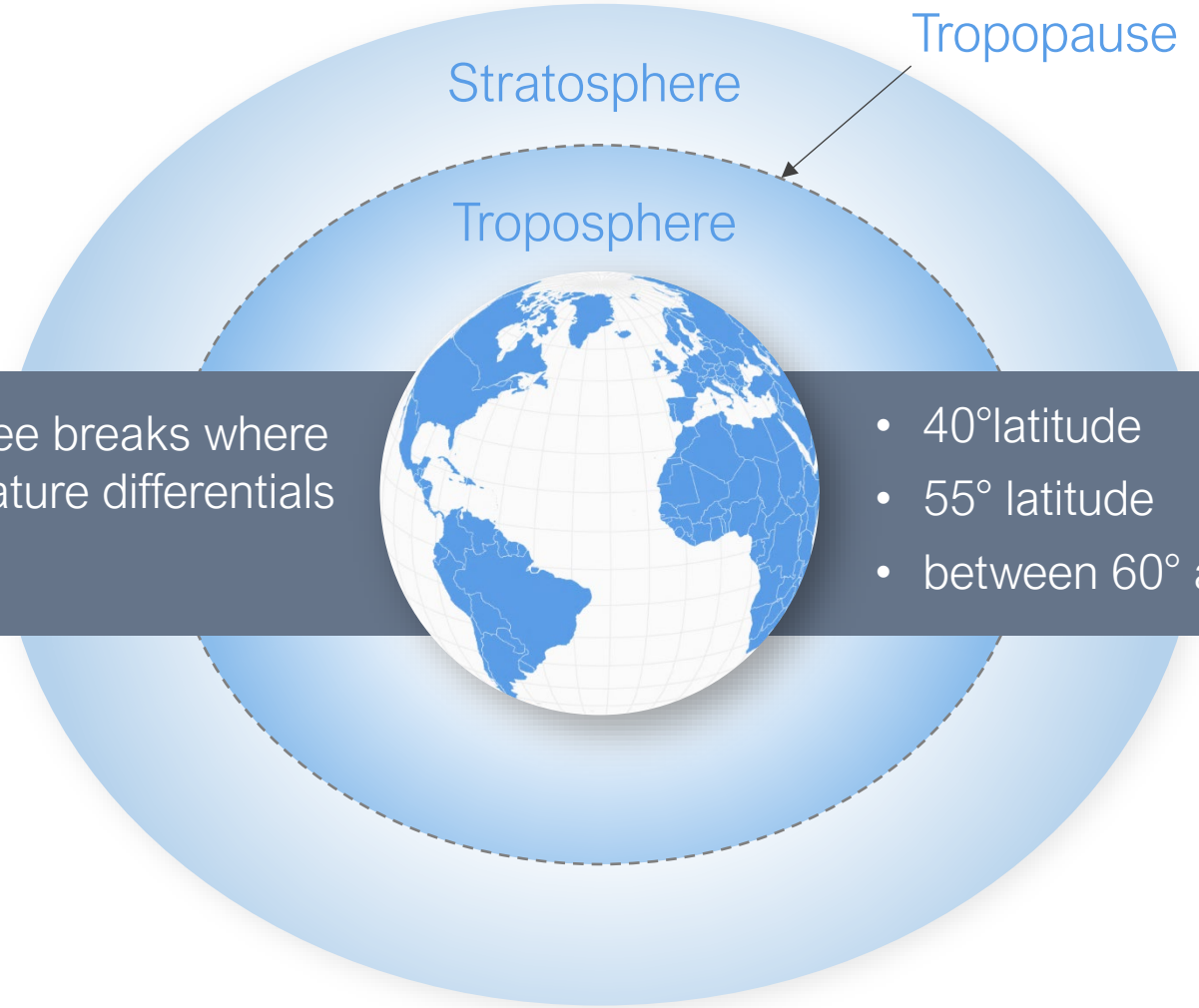
The height of the tropopause varies.

- It is highest at the equator
- And lowest at the poles.

Atmosphere Characteristics at Higher Altitudes

Temperature Variations

Within the troposphere, temperature decreases as altitude increases.



There are three breaks where large temperature differentials occur:

- 40°latitude
- 55° latitude
- between 60° and 70° latitude

The tropopause marks the point where this temperature decrease stops and temperatures either remain constant or begin to increase with altitude in the stratosphere.

Tropopause and Temperature Characteristics by Geographic Location

To explore the impact of the tropopause and related temperature characteristics, flight level differences were examined by geographic location.

City Name	Latitude
Miami	26.25°
San Diego	32.5°
Wichita	37.5°
New York City	41.25°
Seattle	47.5°
Fort McMurray	56.25°

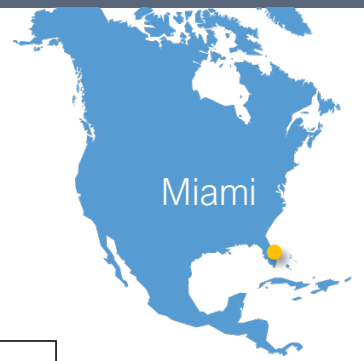
The data for RVSM FLs and the FLs just above RVSM (FL420 – FL450) were plotted separately.

To limit the temperature variation, data recorded during the month where the minimum FL difference point was observed were examined to limit the temperature variation.

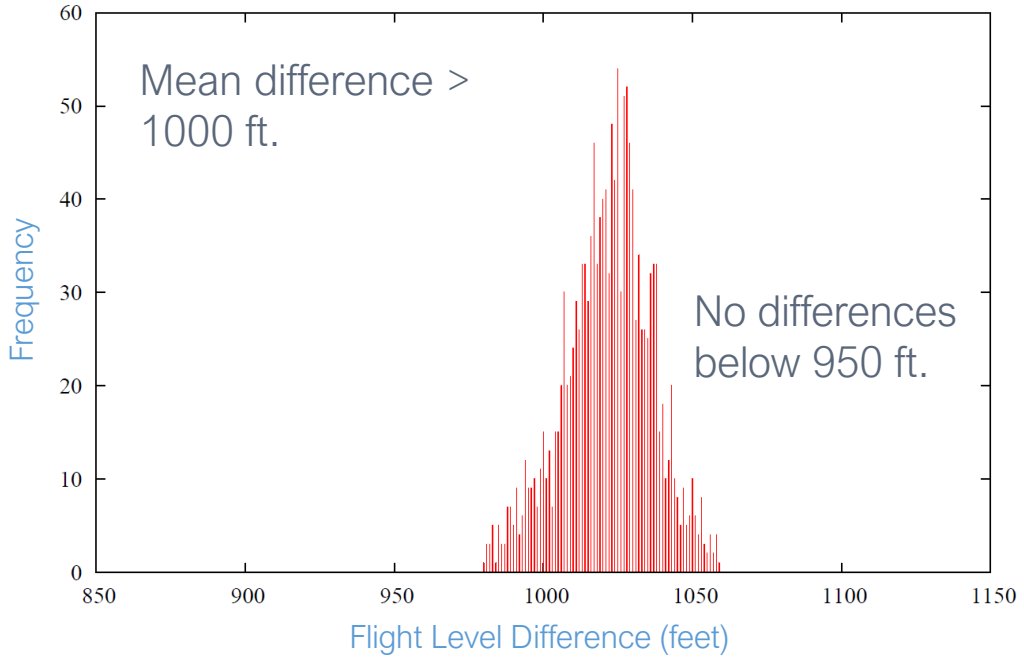
It was determined that March had the minimum FL difference point at 908 ft.

Tropopause and Temperature Characteristics by Geographic Location

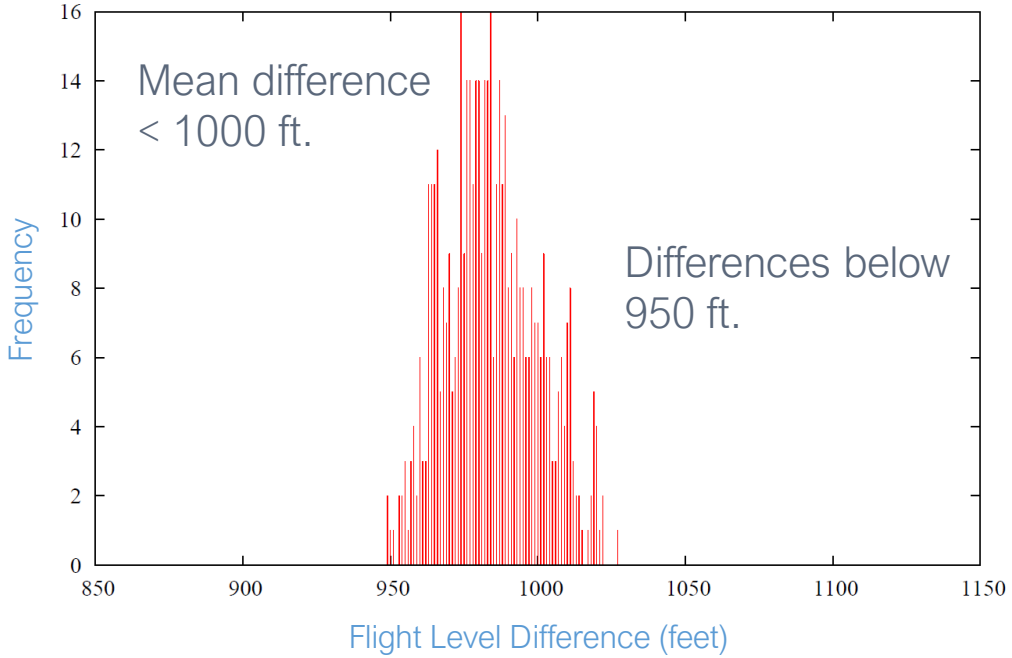
Southern cities in North America were first examined to explore areas where the tropopause would be expected to be higher and contained within the upper RVSM FLs.



RVSM Flight Level Differences Over Miami
March 2017



nonRVSM Flight Level Differences Over Miami
March 2017



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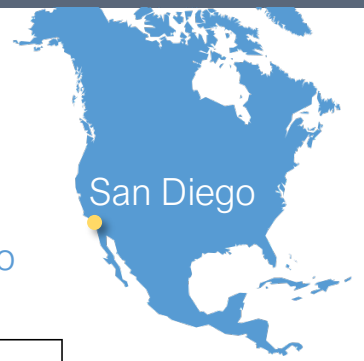
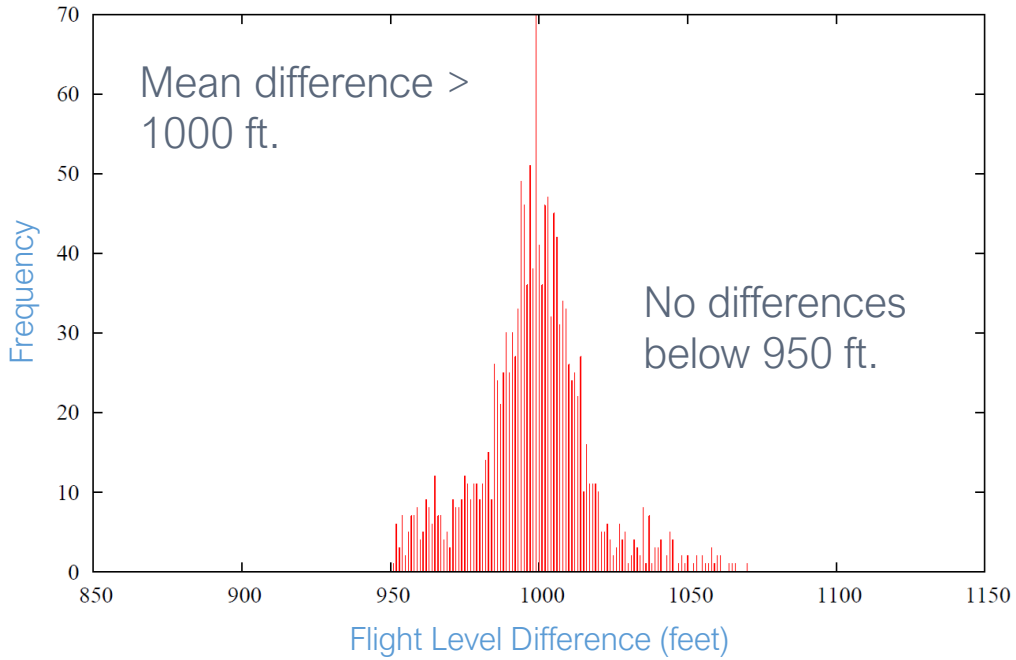
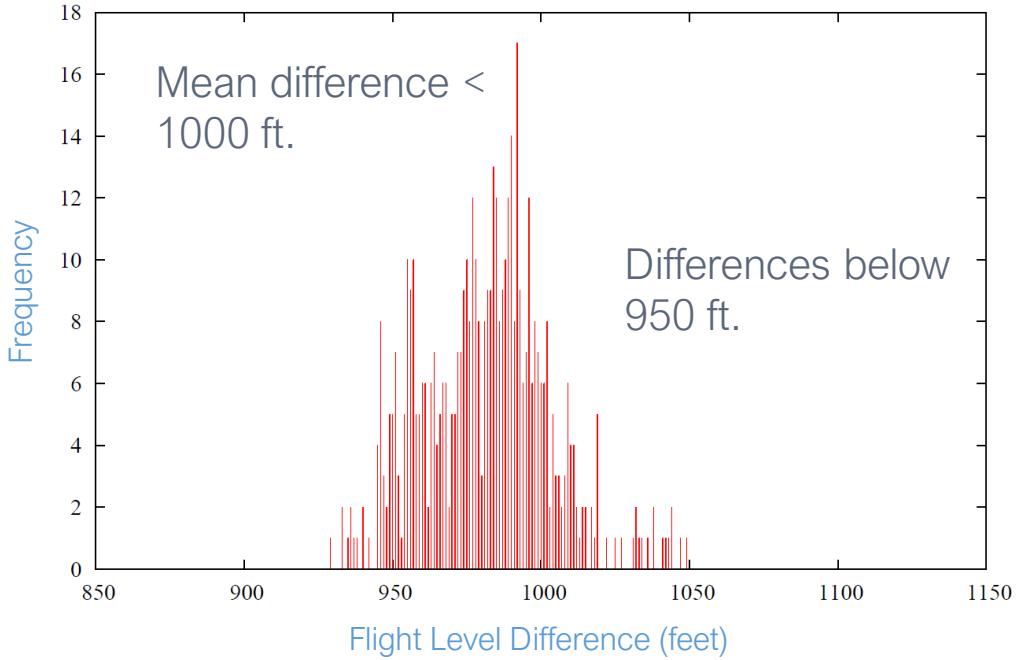


RVSM Flight Level Differences Over San Diego
March 2017



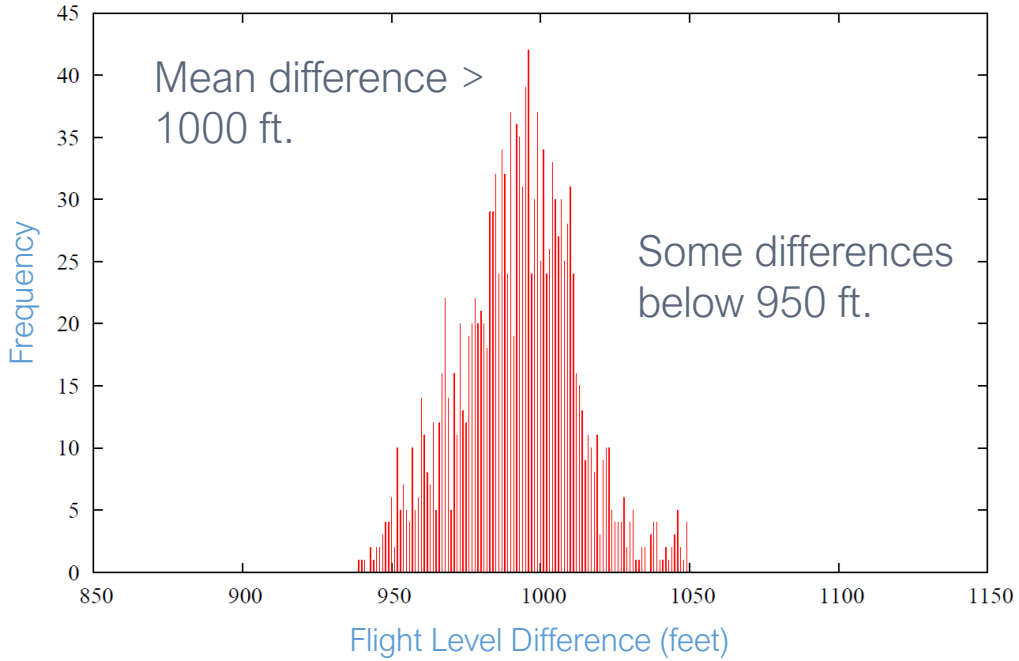
nonRVSM Flight Level Differences Over San Diego
March 2017



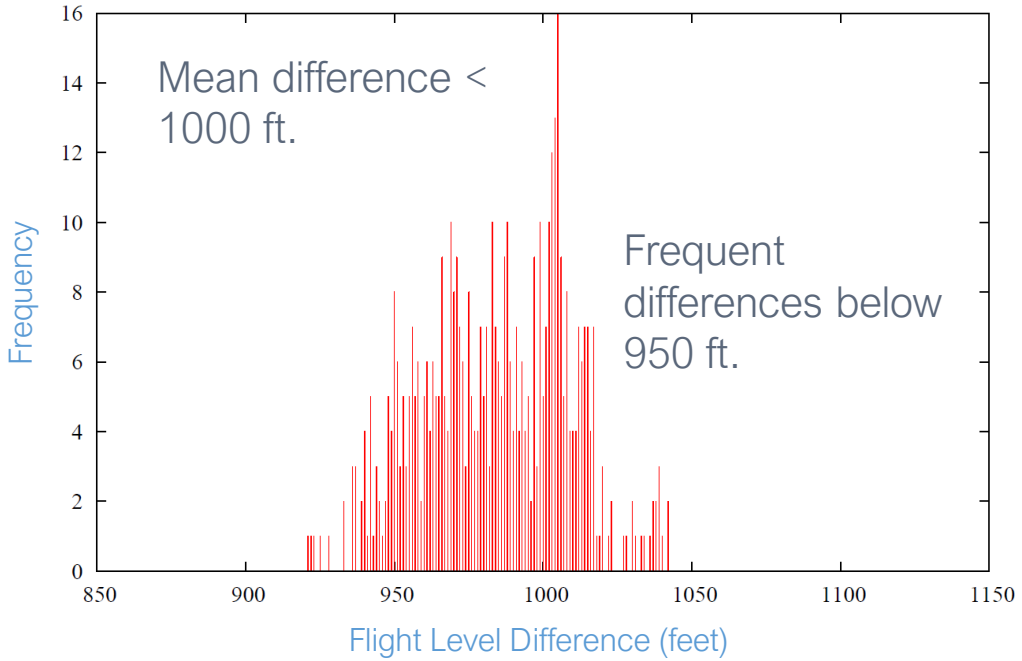
Tropopause and Temperature Characteristics by Geographic Location

A mid-continent North American location was next to explore an area where the tropopause begins to dip into the current RVSM levels.

RVSM Flight Level Differences Over Fort Wichita
March 2017

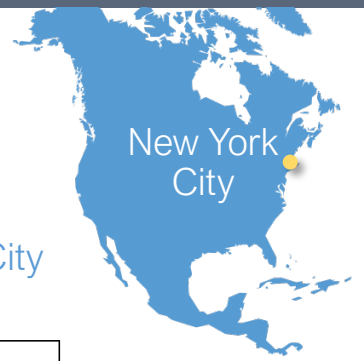


nonRVSM Flight Level Differences Over Wichita
March 2017

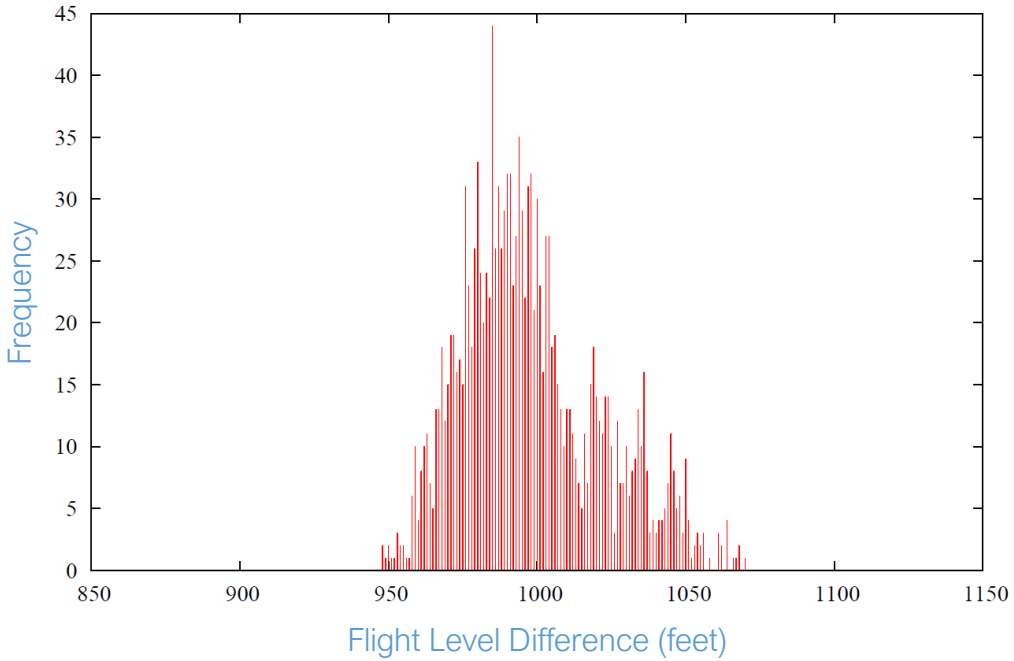


Tropopause and Temperature Characteristics by Geographic Location

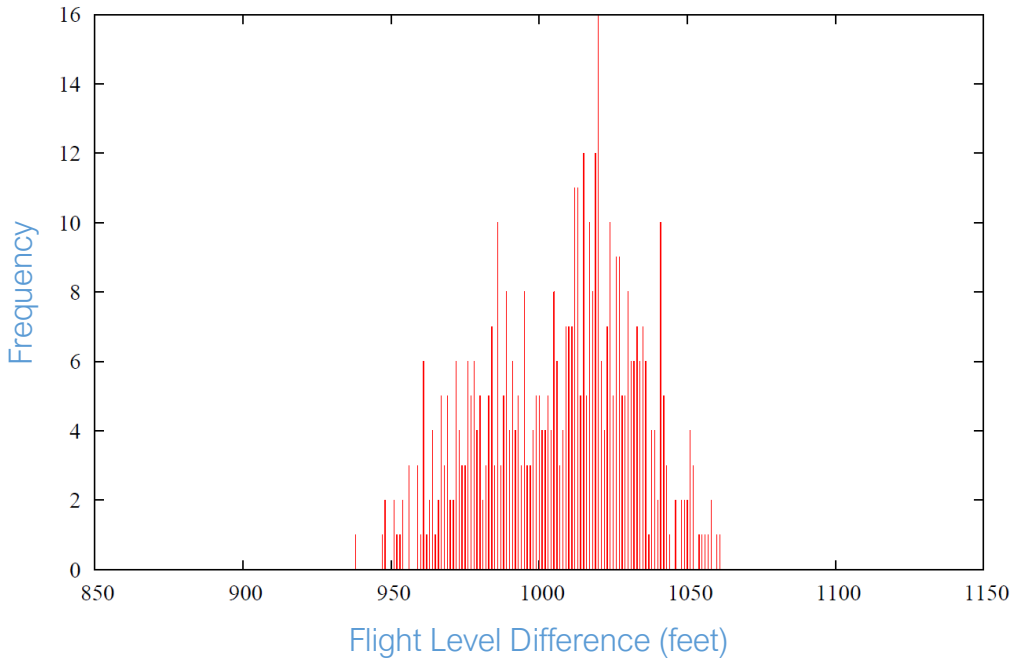
More northerly cites in North America were next examined to explore areas where the tropopause dips lower into the RVSM FLs.



RVSM Flight Level Differences Over New York City
March 2017



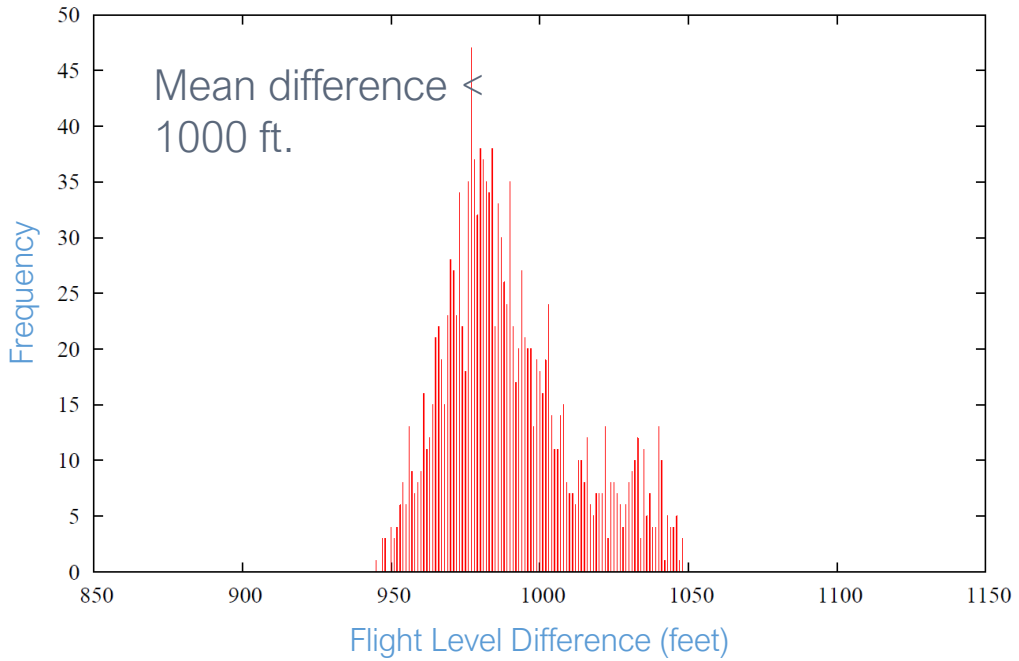
nonRVSM Flight Level Differences Over New York City
March 2017



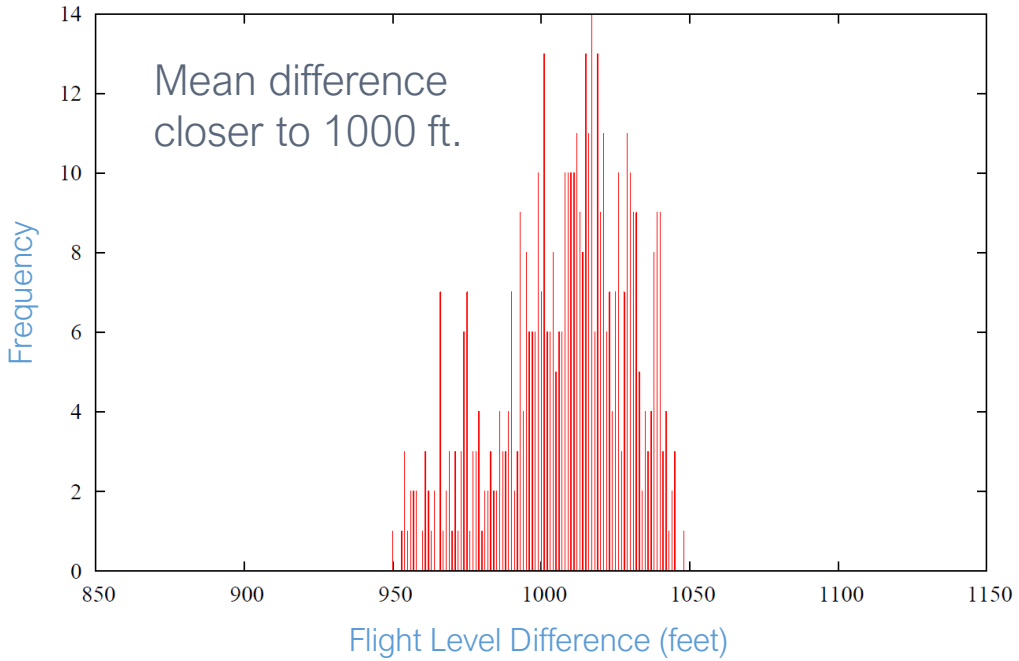
Tropopause and Temperature Characteristics by Geographic Location

More northerly cites in North America were next examined to explore areas where the tropopause dips lower into the RVSM FLs.

RVSM Flight Level Differences Over Seattle
March 2017



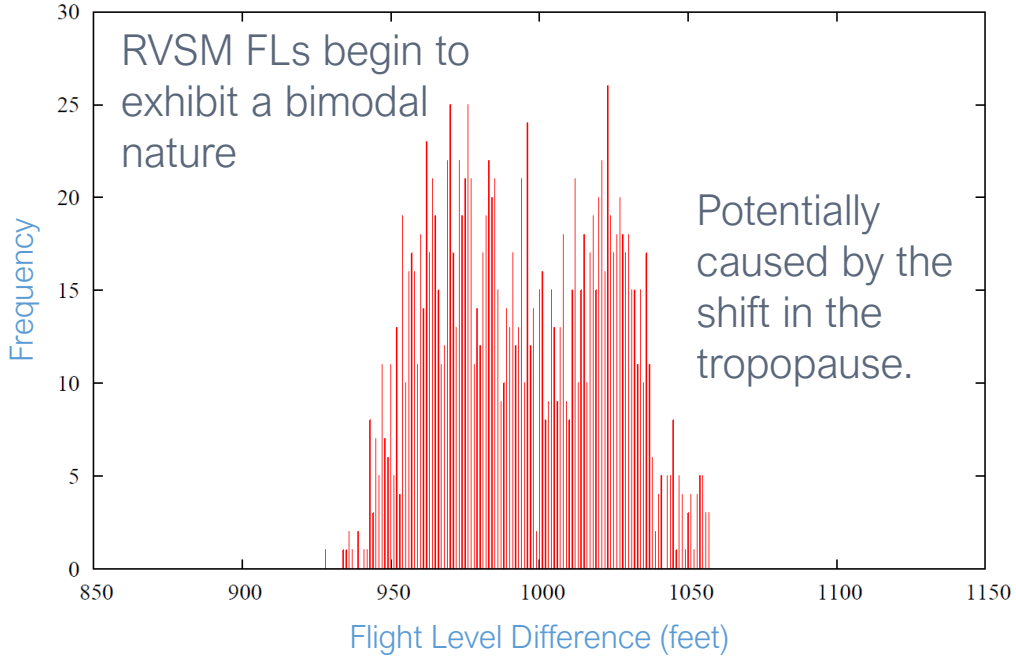
nonRVSM Flight Level Differences Over Seattle
March 2017



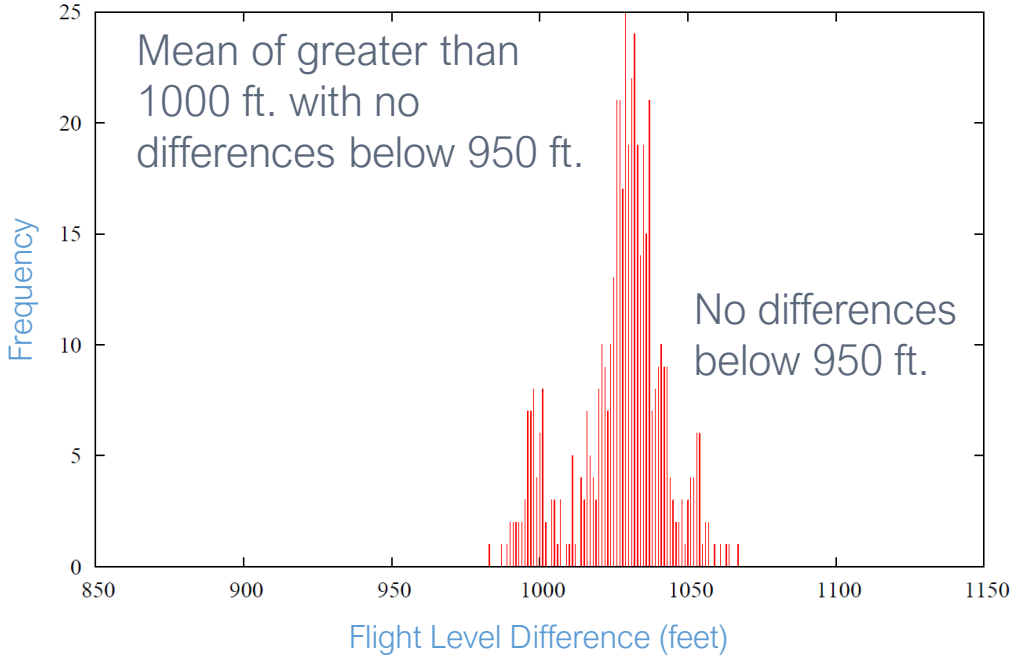
Tropopause and Temperature Characteristics by Geographic Location

A North American location in the northern portion of the analysis area was examined to explore an area where the tropopause is near the bottom of RVSM levels.

RVSM Flight Level Differences Over Fort McMurray
March 2017



RVSM Flight Level Differences Over Fort McMurray
March 2017



Conclusion

- RVSM FLs as well as the FLs immediately above RVSM levels were examined to evaluate compression.
- The data from the RVSM levels were used to compare with results from the higher levels to determine if special consideration would be needed for operations at those altitudes.
- The overall frequency of FL compression within the analyzed data set bounded by latitude [20,72.5] and [-130,-60] is higher at FLs above the RVSM volume when compared to the RVSM volume.
- Implementers are encouraged to perform similar analysis with their regions of interest using their MET models as appropriate.