



Experimental System of ADS-B Height Monitoring in Japan

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ASE Workshop 2017
The FAA William J. Hughes Technical Center
17-19 October 2017





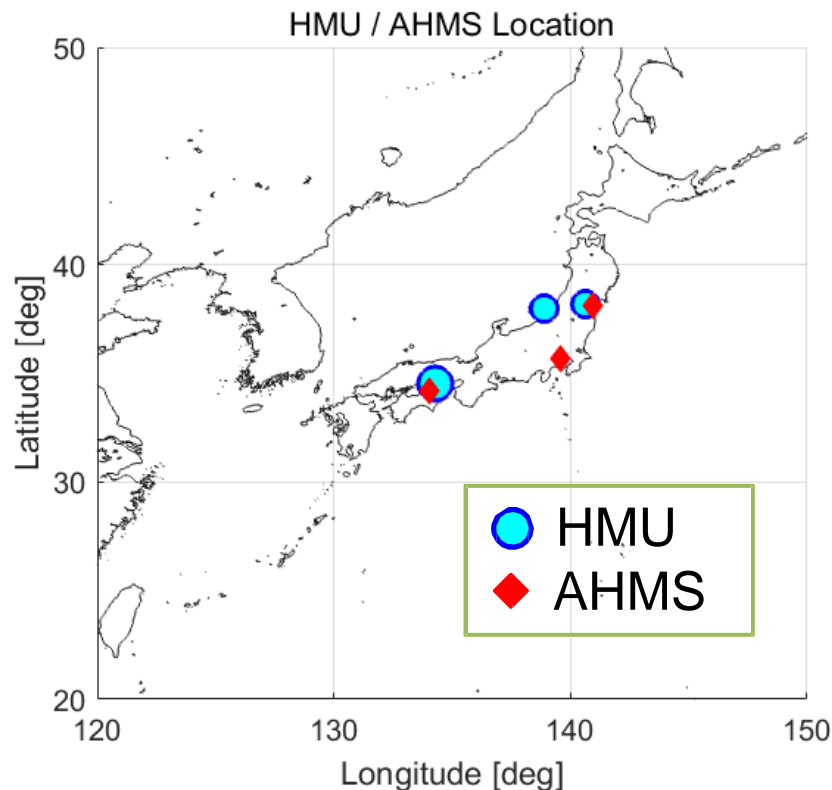
Background



- In Japan, JASMA (Japan Airspace Safety Monitoring Agency) is conducting Aircraft Height Keeping Performance Monitoring as an RMA.
- 3 **HMU**'s (**Height Monitoring Unit**) are in operation.
 - Setouchi (R~40NM), Niigata (R~30NM), Sendai (R~30NM)
- Each HMU measures aircraft geometric height with 5 ground stations. (**MLAT (Multi-Lateration)** technique; as AGHME)
- On the other hand, **ADS-B Height Monitoring System (AHMS)** uses GPS geometric height information contained in ADS-B messages from aircraft.

AHMS Experimental System in Japan

- ENRI is conducting research on AHMS performance in Japan.
- 3 ADS-B receiver stations are installed as an experimental system.
 - Takamatsu (Setouchi), Chofu (Tokyo), Iwanuma (Sendai)



ADS-B receiver station



Major Error Sources for ASE calculation



According to ICAO WG reports (RMACG, SASP), there are several error sources for ASE calculation.

“Large-scale Study of the Use of Automatic Dependent Surveillance-Broadcast Data for Monitoring Aircraft Altimetry System Error”, Separation and Airspace Safety Panel (SASP) Meeting Of The Working Group Of The Whole (WG/WHL)/19-WP/16, Montreal, Canada, 23 May to 3 June, 2011.

(1) Incorrect Height Datum of GPS Height

HAE (Height Above Ellipsoid) or HAG (Height Above Geoid)

No information for discrimination is contained in ADS-B messages!

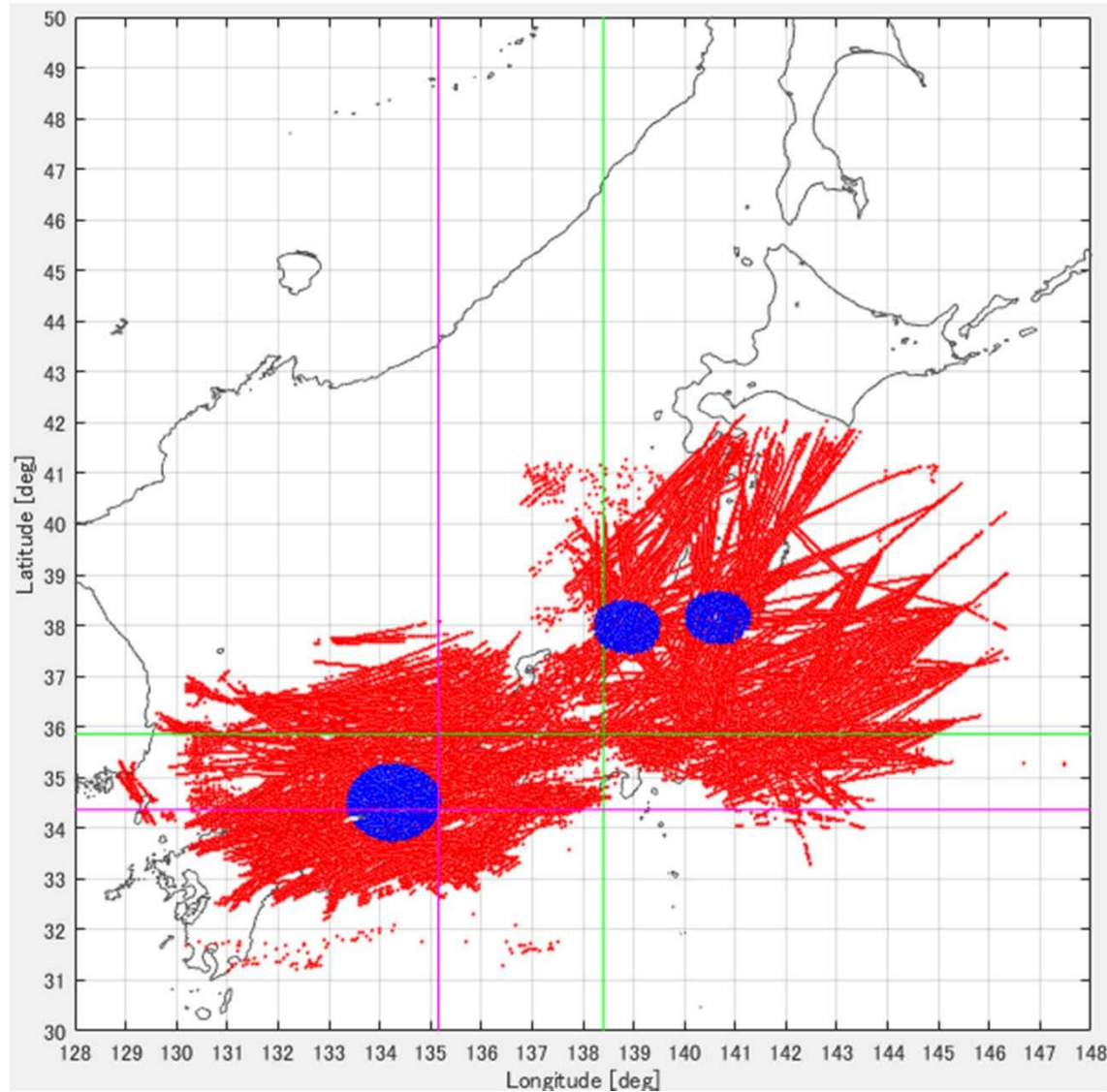
(2) Meteorological Data Error

Numerical data used to convert Barometric Altitude to Geometric Height

(3) Quantization Error

Barometric Altitude and GPS Height in ADS-B messages are broadcast in 25 ft quantization

Experimental System – Coverage -



Aircraft Track Plot
(for 1 day)

- AHMS (ADS-B)
- HMU (MLAT)

Plot Data Using

Select ADS-B Data Type

☒ ADS-B Data CSV
E:\WorkDir\Exec\01ADS-BWCSVOut\Exec\WCSV

☐ ADS-B Merge CSV
E:\WorkDir\Exec\01ADS-BWCSVOut\Exec\AA_CSV

HMU File Path: E:\WorkDir\Exec\Data\HMUCsv

AA: FFFFFFFF

Datetime: 20161001 04 - 20161001 06

Lon: 128 - 148

Lat: 28 - 48

☐ View Geoid[Rt]

☐ View GeometricAlt[Rt]

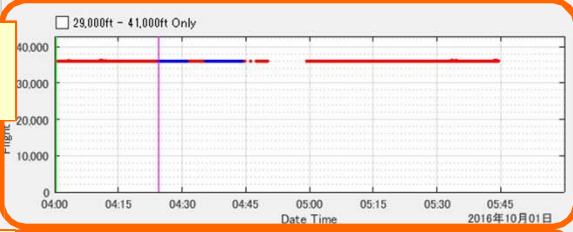
ADS-B Data:

Date	AA	Lat	Lon	FlightLevel	GeometricAlt	hPa
2016/10/01 04:00:24	FFFFFF	39.9030	143.9009	35975	37642.98	227.5700
2016/10/01 04:00:26	FFFFFF	39.9013	143.8972	35975	37643.32	227.5700
2016/10/01 04:00:27	FFFFFF	39.9004	143.8952	35975	37643.51	227.5700
2016/10/01 04:00:28	FFFFFF	39.8992	143.8929	35975	37643.72	227.5700
2016/10/01 04:00:29	FFFFFF	39.8983	143.8910	35975	37643.90	227.5700
2016/10/01 04:00:32	FFFFFF	39.8953	143.8846	35975	37644.48	227.5700
2016/10/01 04:00:33	FFFFFF	39.8953	143.8846	35975	37644.48	NaN

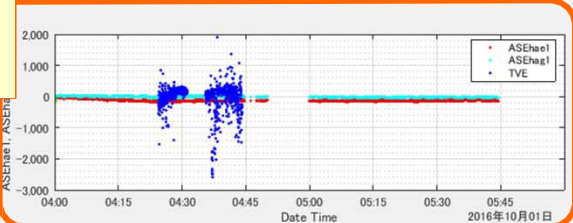
HMU Data:

Date	AA	Lat	Lon	FlightLevel	Geome
2016/10/01 04:24:28	FFFFFF	38.6036	140.9255	36025	3
2016/10/01 04:24:29	FFFFFF	38.6031	140.9234	36025	3
2016/10/01 04:24:30	FFFFFF	38.6022	140.9209	36025	3
2016/10/01 04:24:31	FFFFFF	38.6017	140.9192	36025	3
2016/10/01 04:24:32	FFFFFF	38.6009	140.9171	36025	3
2016/10/01 04:24:33	FFFFFF	38.6001	140.9149	36025	3
2016/10/01 04:24:34	FFFFFF	38.5996	140.9129	36025	3

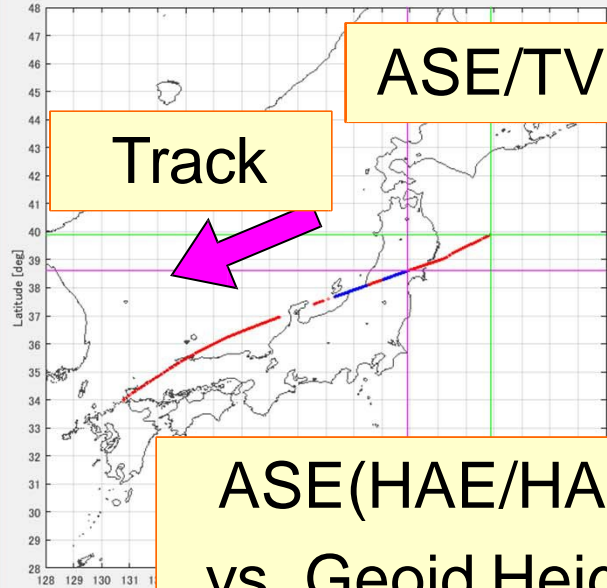
Baro. Alt



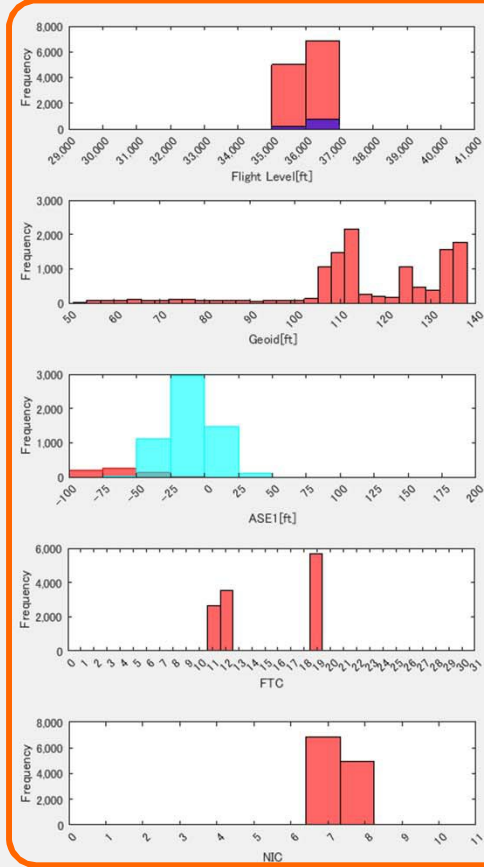
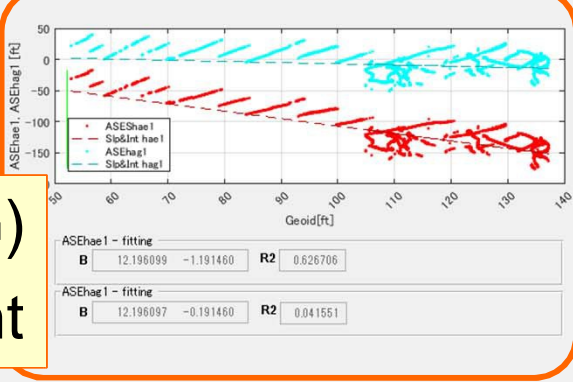
ASE/TVE



Track



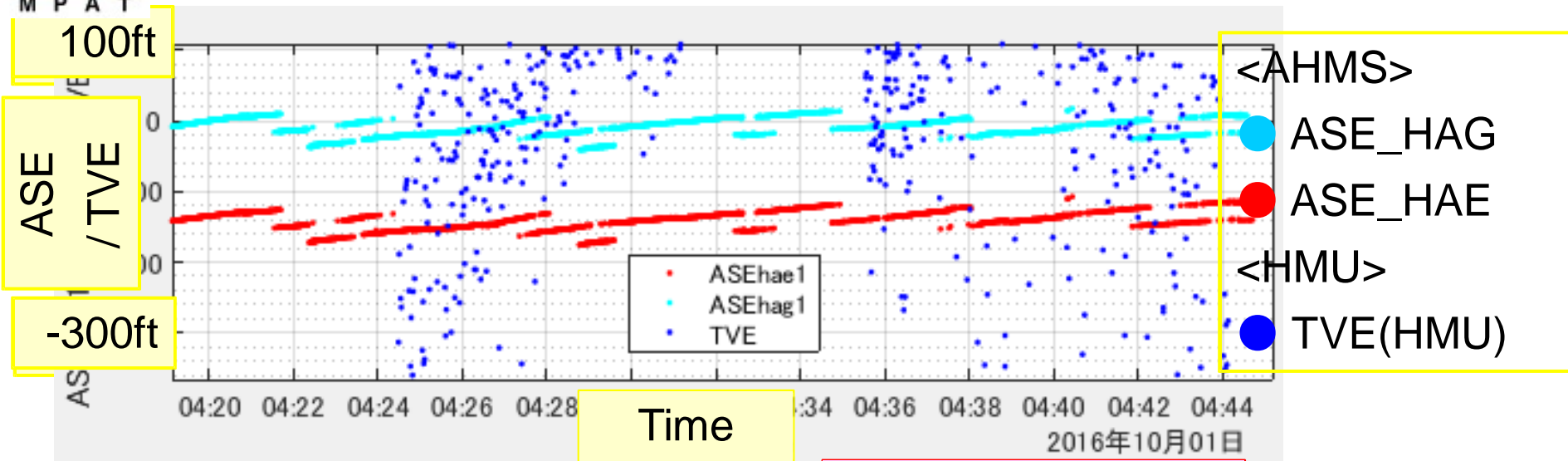
ASE(HAE/HAG)
vs. Geoid Height



Frequency Distribution

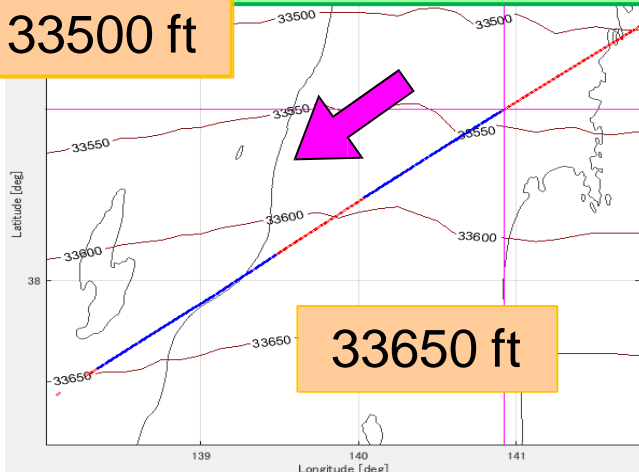


Preliminary Results – an airframe – (1)



Geometric Height in
Meteorological Data@FL360

33500 ft

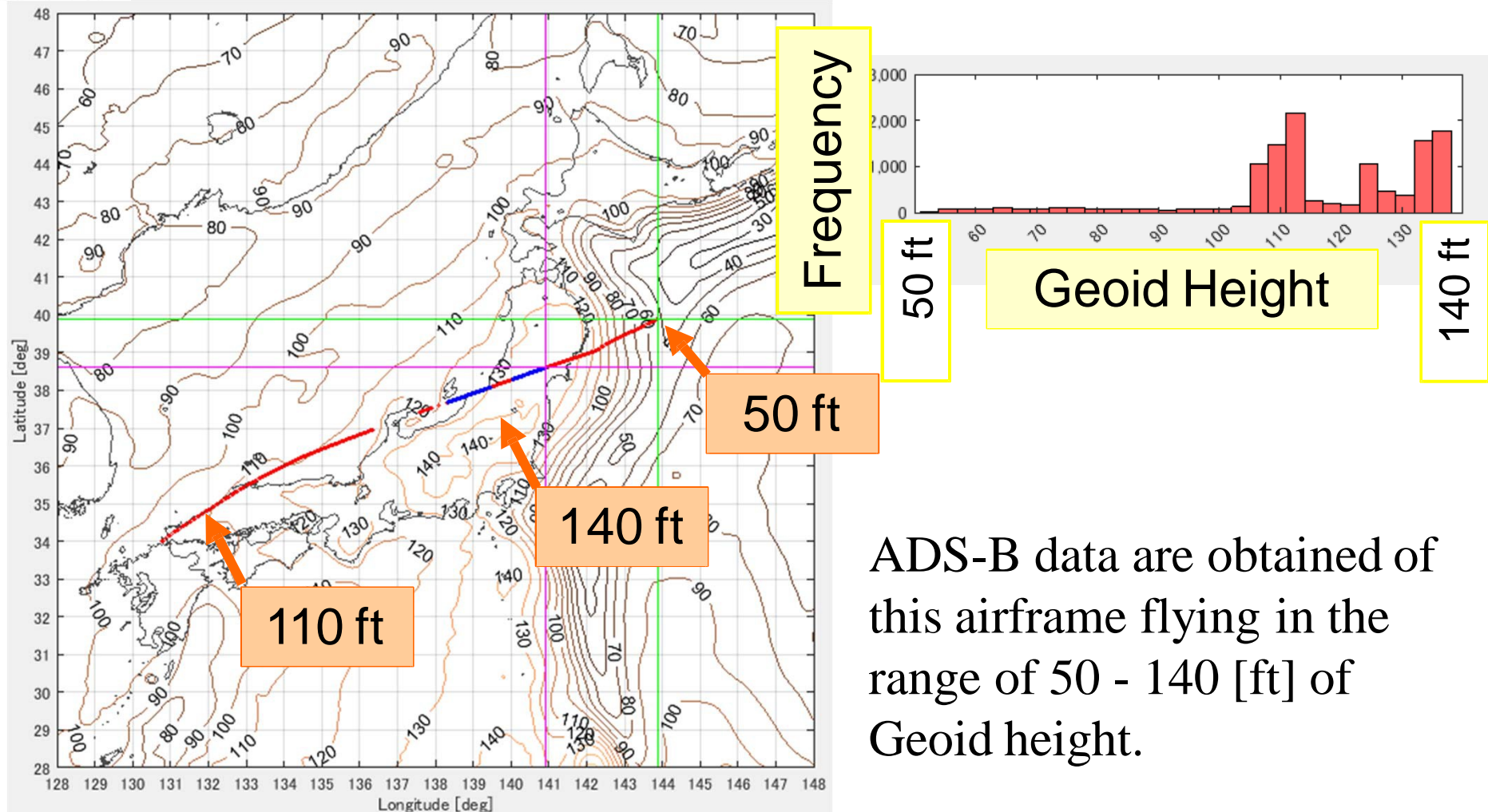


$ASE_{\sigma} = 17 \text{ [ft]}$

Std. Dev. ASE_{σ} of AHMS is smaller
than that of HMU (MLAT)

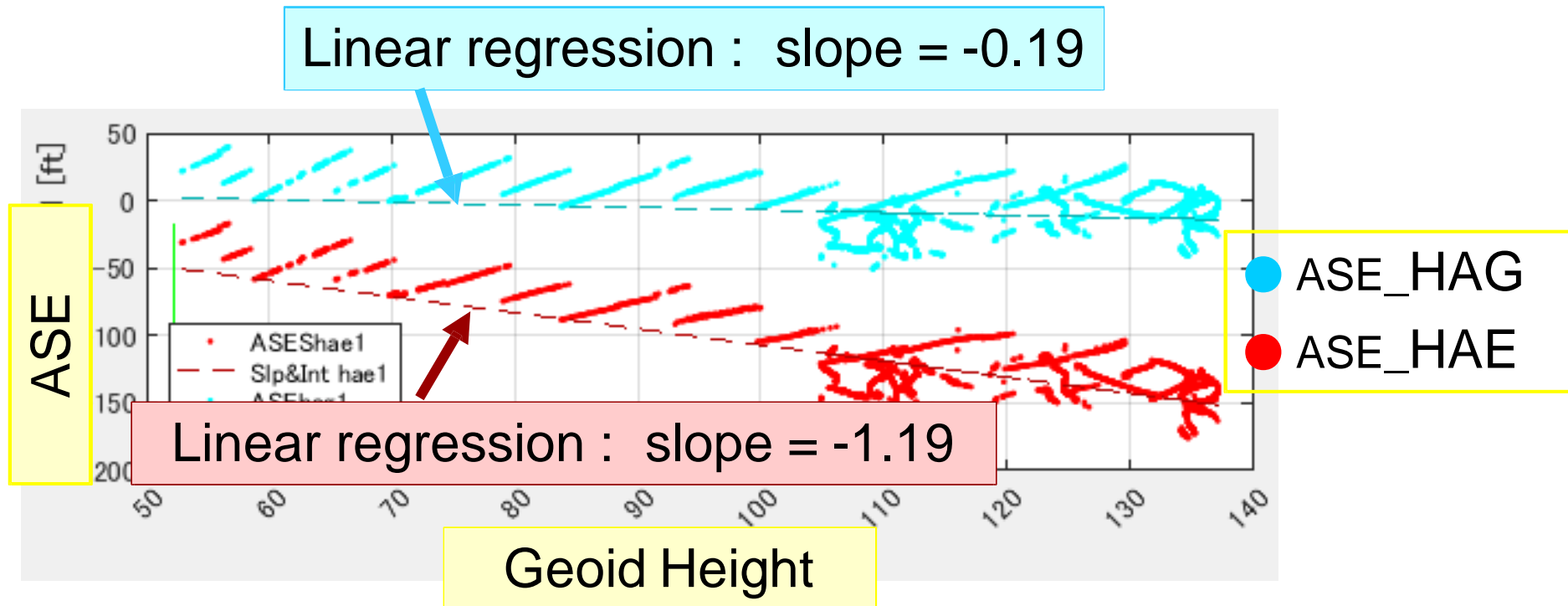
Quantization Error is recognized

Preliminary Results – an airframe – (2)



ADS-B data are obtained of this airframe flying in the range of 50 - 140 [ft] of Geoid height.

Preliminary Results – an airframe – (3)



ASE value is assumed to be stable.

➡ GPS Height of this airframe is determined as HAG

ASE value of this airframe (averaged) = -10 ft.



Summary



ENRI is developing AHMS Experimental System

 ADS-B receiver station are installed for research.

Items undertaken

- **Modification of ASE calculation**
 - Interpolation of Meteorological data
 - Conversion from Geo-Potential height to Geometric height
- **Statistical Analysis of Many Aircraft**
 - Sortation by Aircraft Group (e.g. B772, B744-5, A320, etc)
- **Detection of Non-compliant Aircraft ($ASE > 245$ ft)**
 - ... considering the ASE distribution due to measurement error