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IN22A-07: Systematic Comparison of Ground-Based and Satellite Measurements using TOVS and Radiosonde Data

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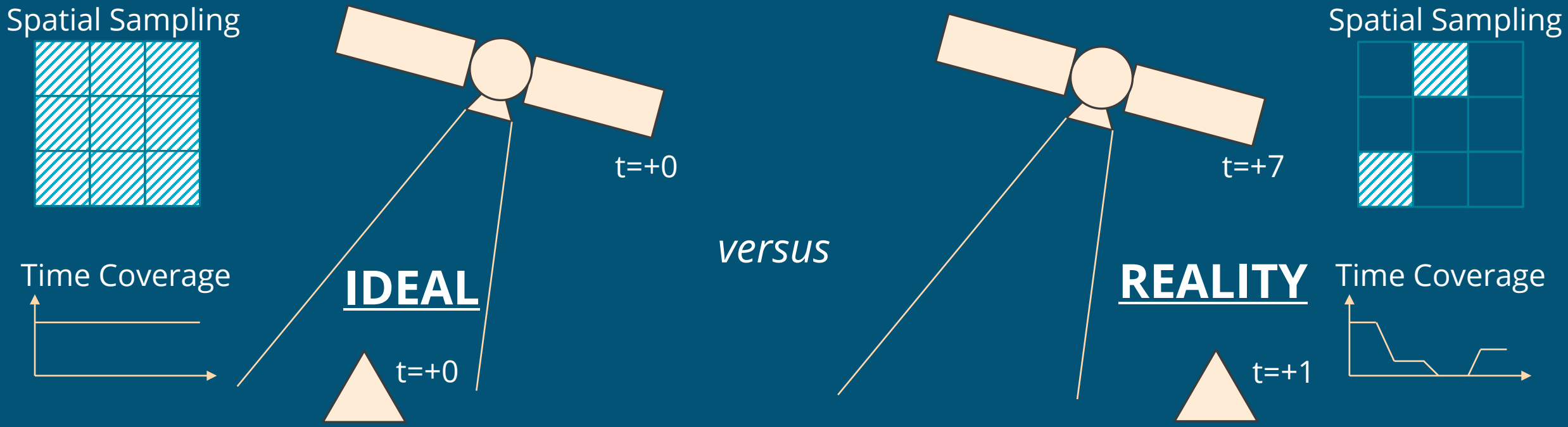
Motivation

- Comparisons between instruments (data products) would ideally have matching spatial and temporal resolution, sampling, and coverage
- Characteristics of the unaltered data informs the validity of comparisons and transformations (e.g., data completion)
- How do data observation from different systems compare?



Background

- Part of a larger research project looking at climate pathways, using the 1991 Mount Pinatubo eruption as the exemplar
  - **GC25H-0769**, "CLDERA: A Novel Foundational Approach for Attributing Impacts to Localized Source Forcings in the Climate", 12/13 at 14:45 – 18:15 CST

- While newer data are more complete and at higher spatial and temporal resolutions, the described challenges remain relevant
  - Focus on an earlier period of the "Satellite Era" to highlight data coverage gaps and data resolution challenges
  - Compare satellite data from TOVS and radiosonde data from IGRA
  - Apply statistical properties to characterize the comparison between data products

Comparisons at the daily, pointwise (station) level, examining effects of the spatial precision, pressure levels, and timing offset

TIROS Operational Vertical Sounder (TOVS)

- On-board TIROS (Television InfraRed Observation Satellite) series, NOAA-6 through 14
- Using NOAA-11 data: ~2x daily measurements for 1988–1994, at 1° x 1° gridded resolution, with 12 pressure levels from surface to 30 mb
- Product derived from suite of three component sensors (MSU, HIRS/2, SSU)

Image Credit: NOAA / NESDIS Center for Satellite Applications and Research

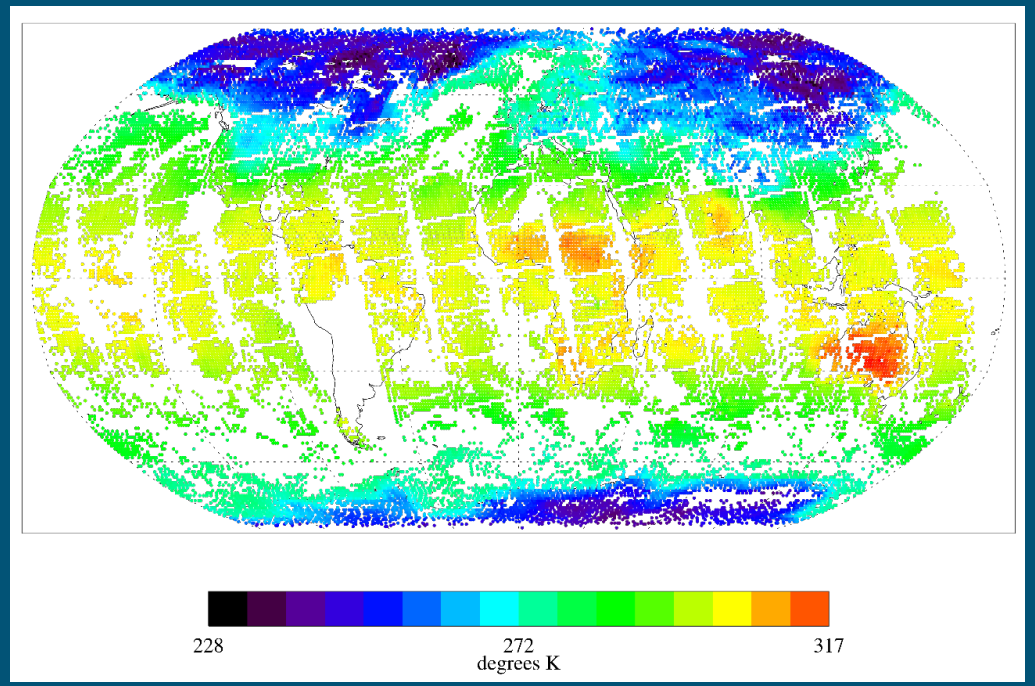


Image Credit: NASA EarthData GES DISC, TOVSADNH Dataset

Integrated Global Radiosonde Archive (IGRA)

- Archive of radiosonde and pilot balloon measurements from 1905 – present
- Using 874 stations, compiled from 33 data sources (w/ quality control)
- 1 – 4 measurements each day, standard pressure levels

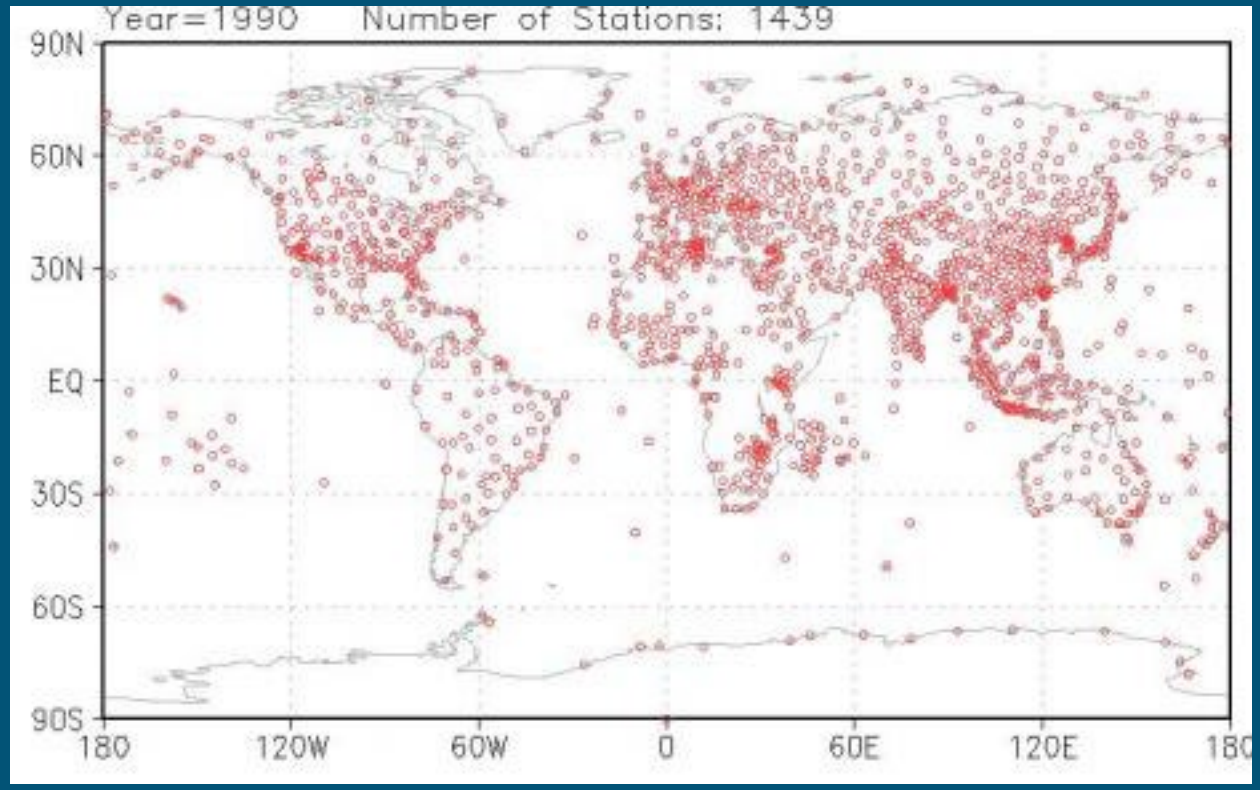
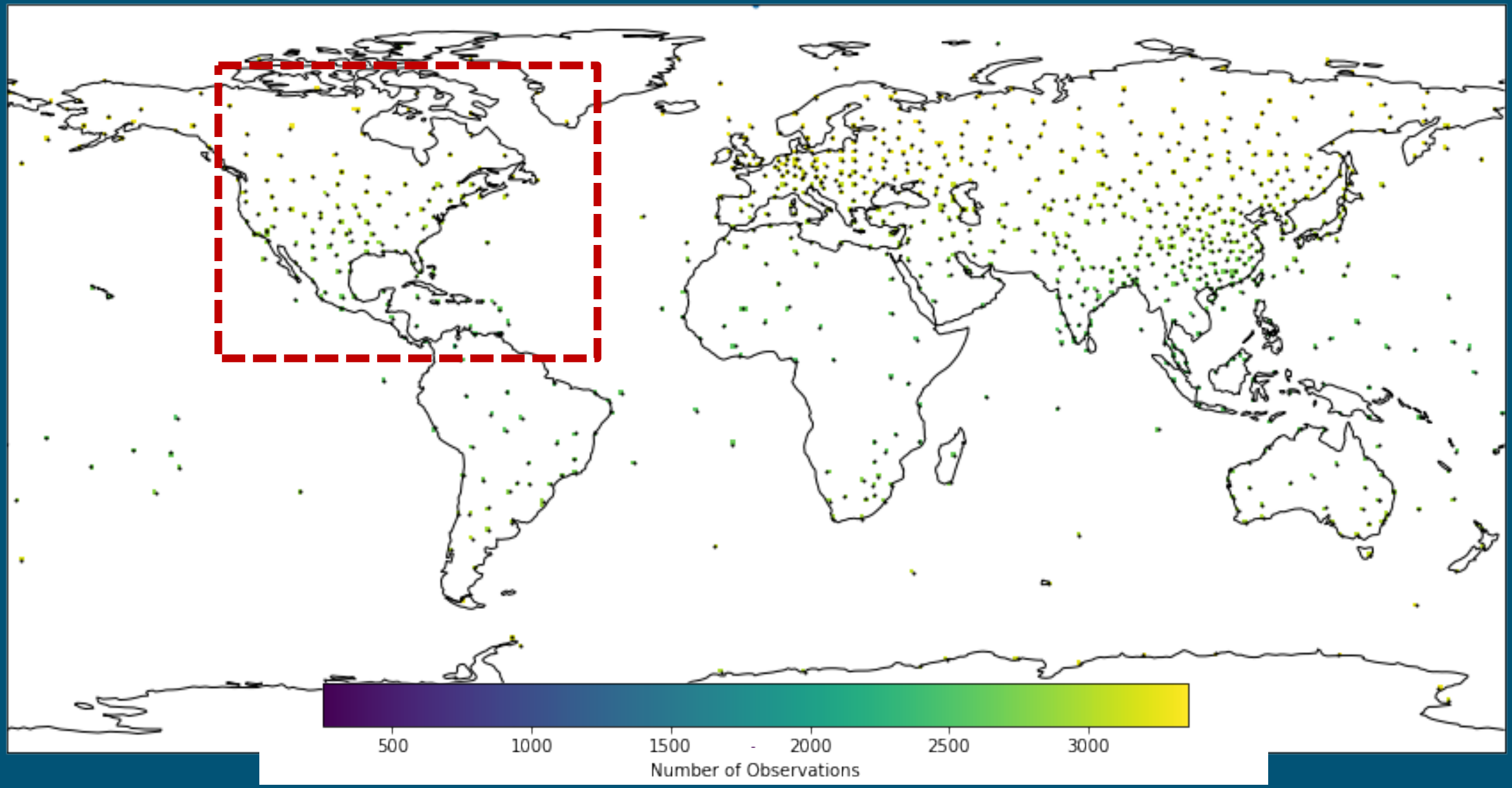


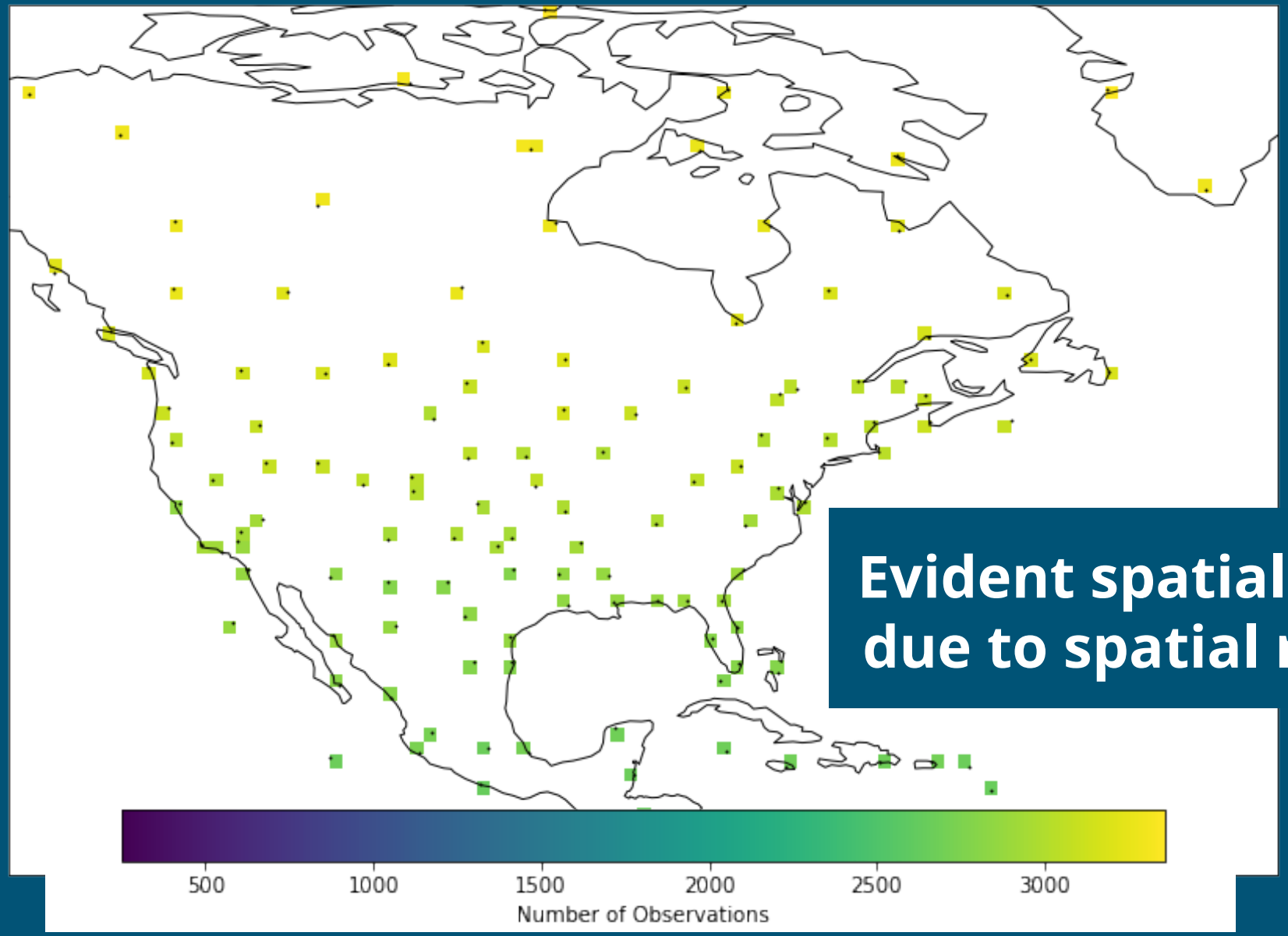
Image Credit: NOAA / NCEI IGRA Data Product

Image Credits: NWS Upper-Air Photo Gallery

TOVS and IGRA Collocations



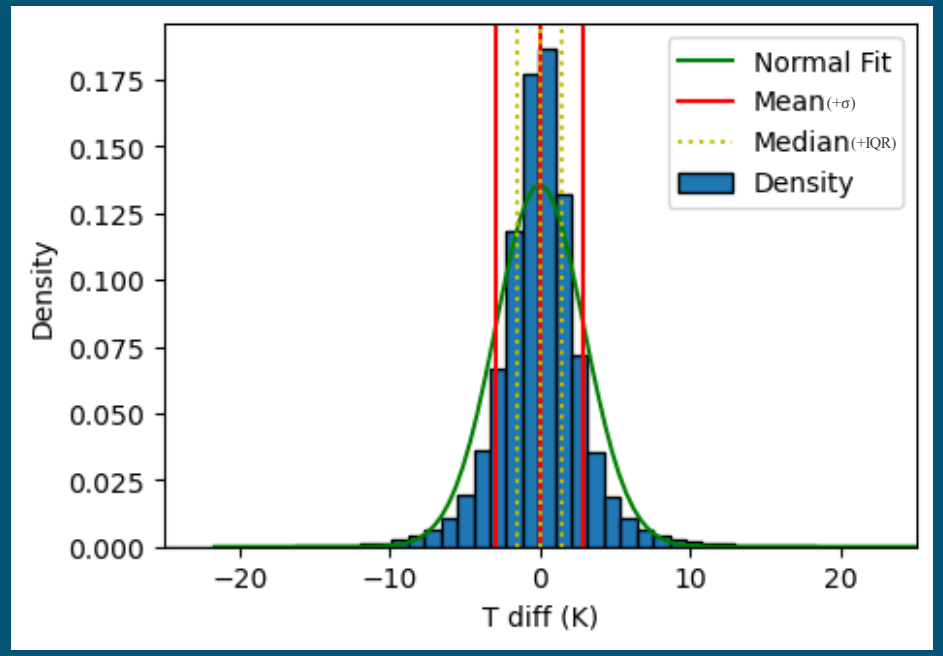
TOVS and IGRA Collocations

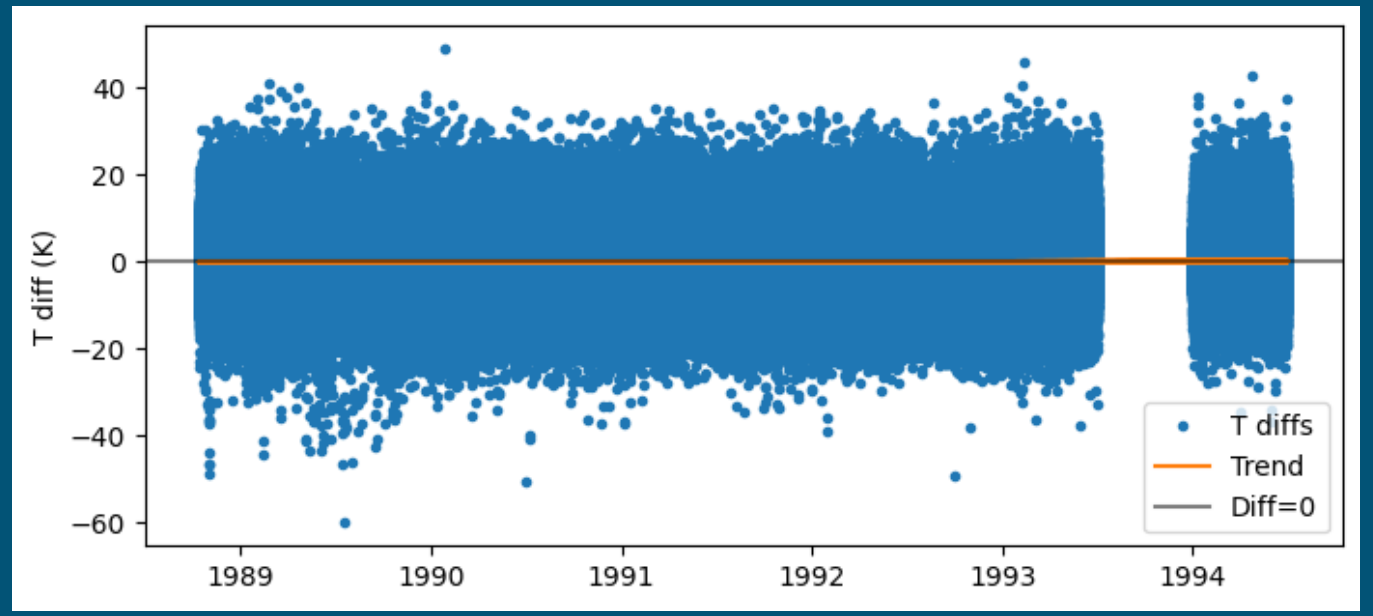


Evident spatial *ambiguity* due to spatial resolution

Overall TOVS and IGRA Comparison

- Differenced daily data over all stations and pressure levels (within 12-hour window of co-occurrence) shows good agreement
- Characterized using statistical properties of the difference between the measurements

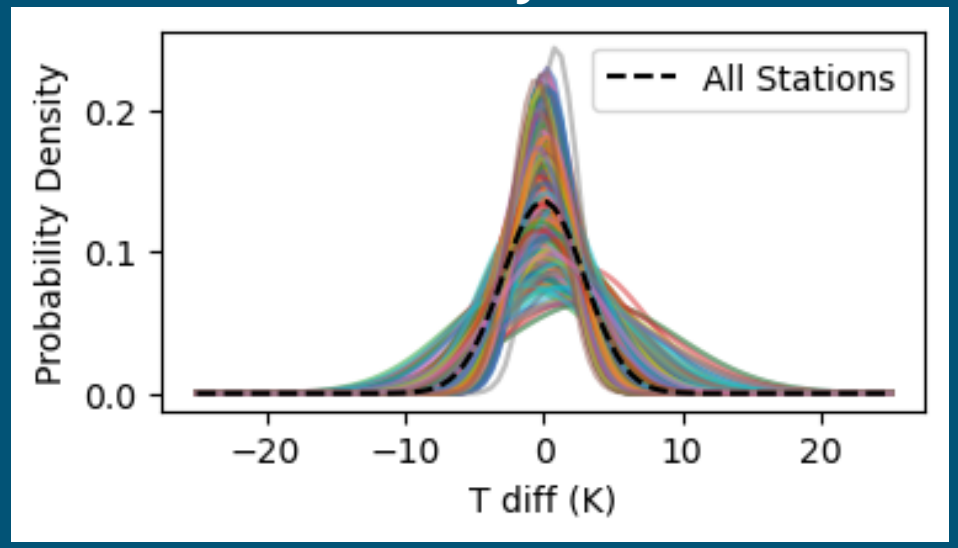


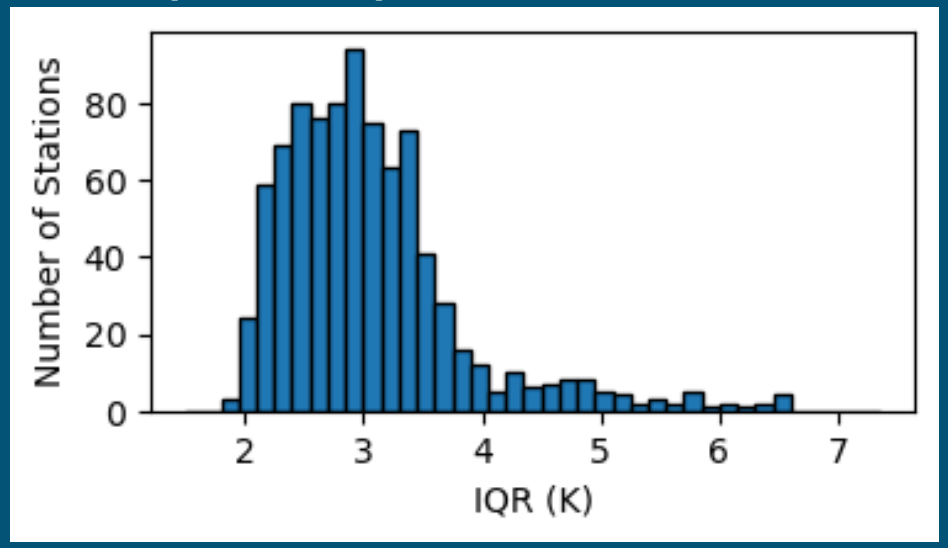


mean	std dev	rsme	num points	skew	kurtosis	Q1	median	Q3	IQR	slope	intercept
-0.025788	2.941396	2.941509	15624603	0.191251	6.1395	-1.477747	-0.01225	1.403714	2.881461	0.000063	-0.085978

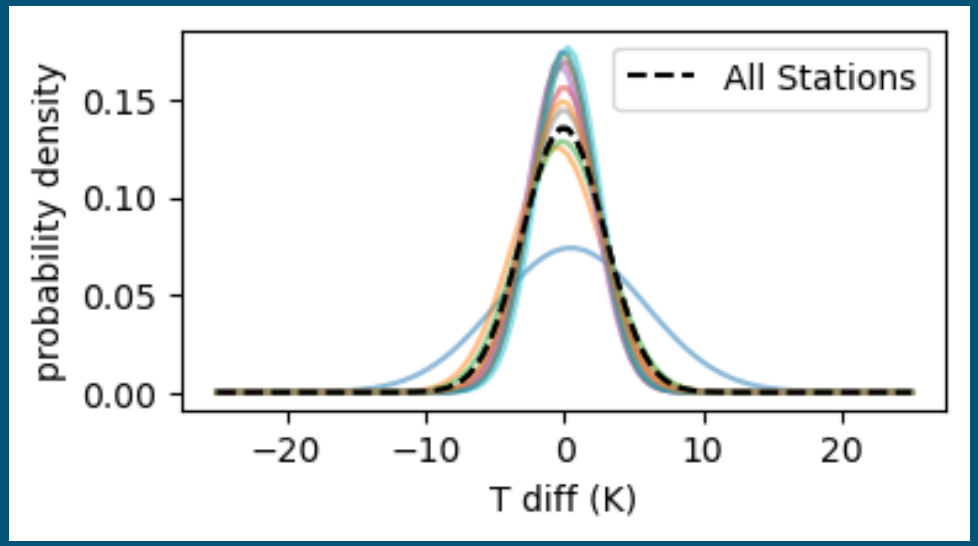
Variability from Radiosonde Stations and Pressure Levels

Differences by Radiosonde-TOVS Collocations (stations)



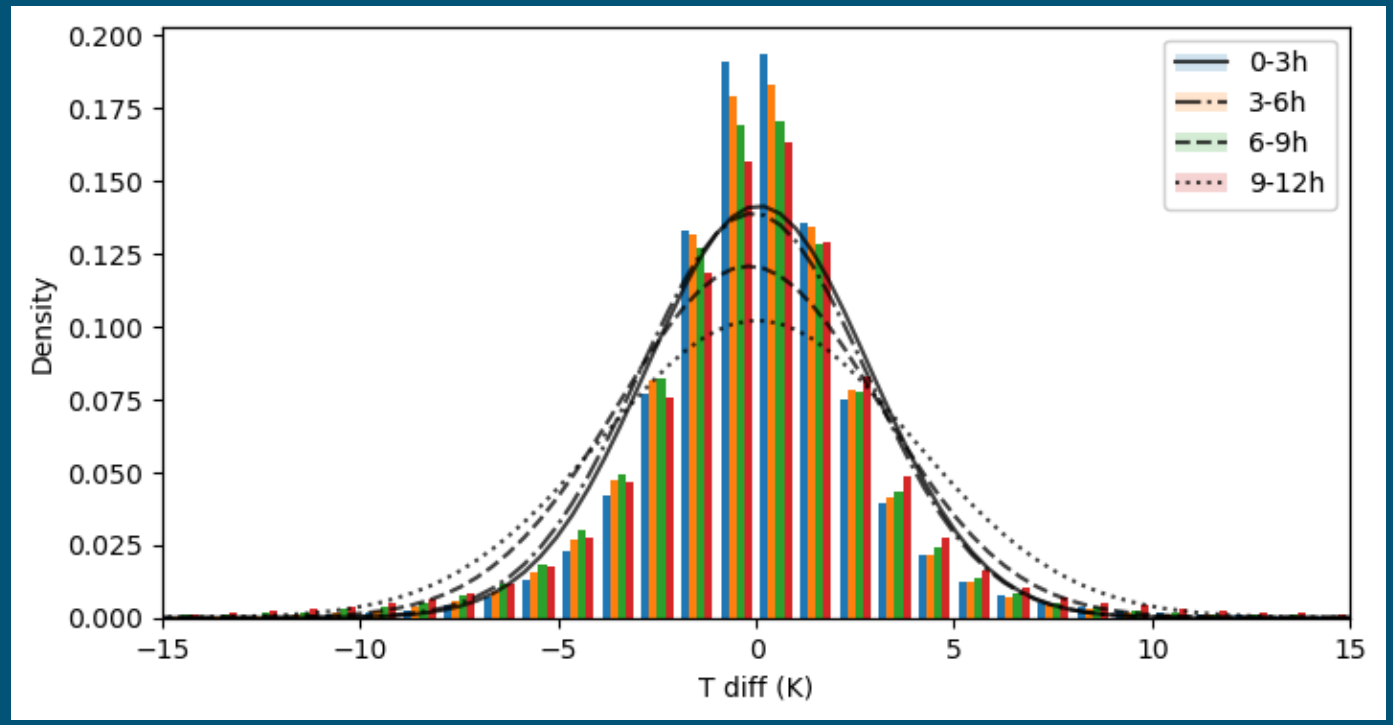


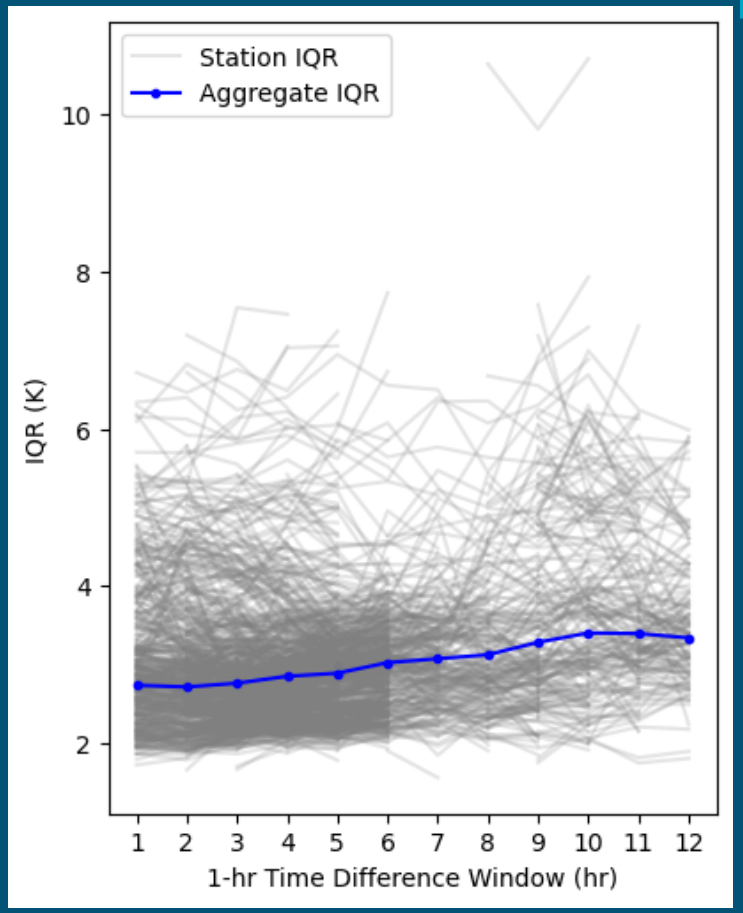
Differences by Pressure Levels



- Not all stations are equally well behaved, with higher spread in the difference compared to the overall dataset
- Limitations of the dataset, in vertical resolution by pressure level, show greater differences in near surface air temperature measurements

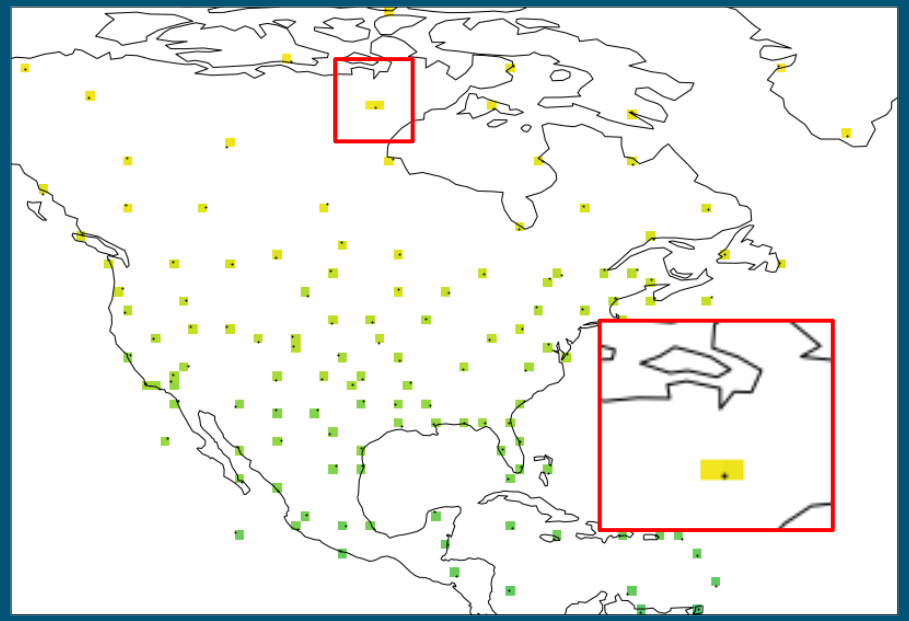
Effects of Co-incident Measurements

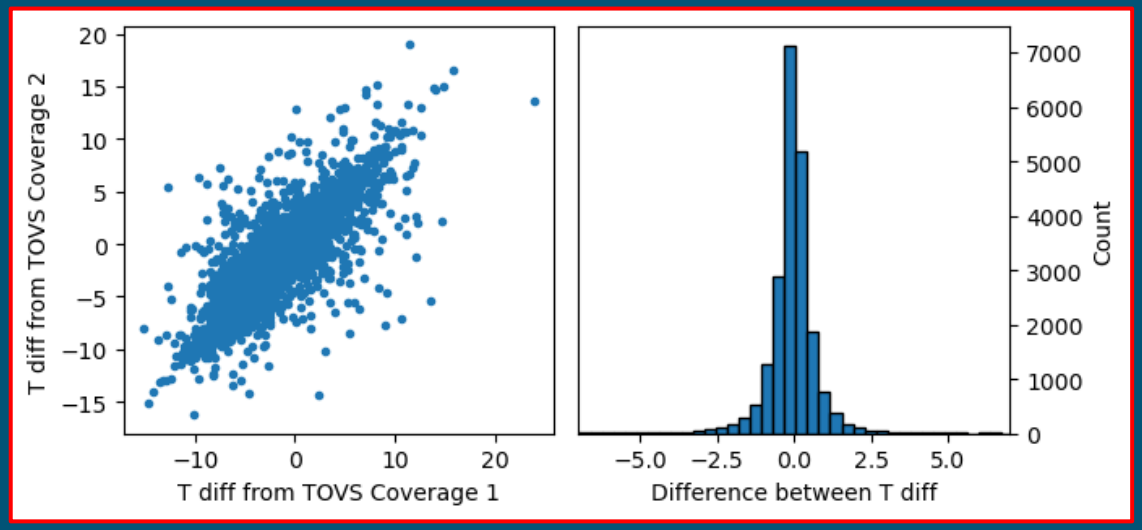


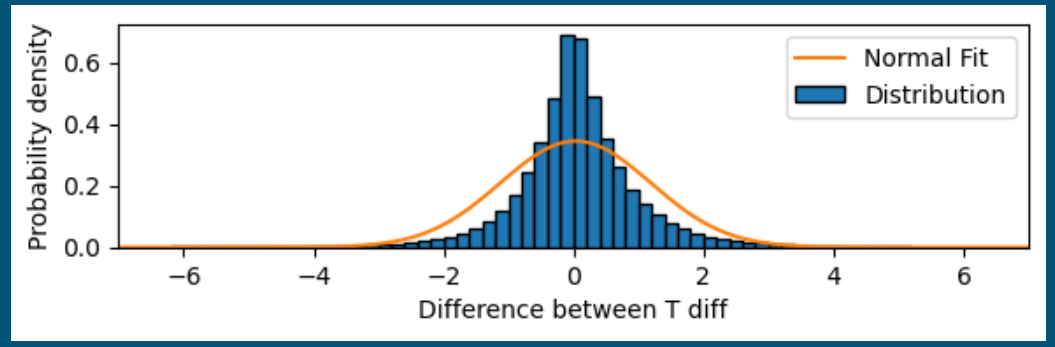


- Distribution in temperature difference for different duration time windows for co-incident measurements
- Variability due to radiosonde station has a dominant effect
- Tighter time window still reduces the variability, with the 1h window IQR being 10% smaller than that for 6h

Variability due to Spatial Ambiguity







- Consider pairs of radiosonde station and adjacent TOVS coverage
- Example comparison; distribution over all comparison pairs (21 station pairs)
- Unbiased behavior indicates spatially-smooth temperature behavior, while the variability highlights spatial resolution limitations

Conclusions

- Direct examination of radiosonde and TOVS air temperatures shows overall agreement, which matches with past comparisons
- Statistical metrics for measurement differences show significant variability in comparing at daily (compared with monthly) timescales
- Outlier radiosonde station data, or periods of outlier behavior for radiosonde stations, contribute significantly to the variability
- Closer time windows reduce the variability, but not as significantly as compared with improvements resulting from higher spatial resolution

Thanks for Listening!

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