AMV height retrievals from stereo and IR techniques

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Outline

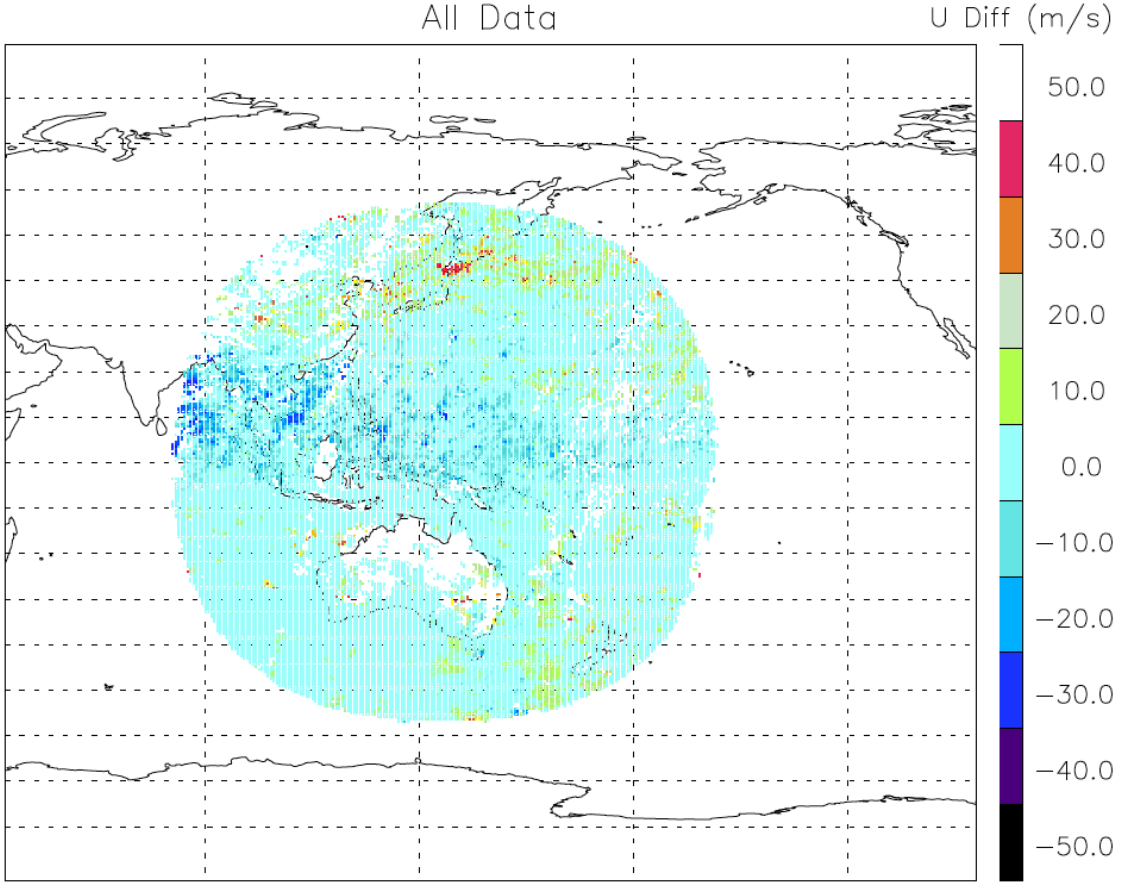
- MISR Cloud Motion Vector (CMV) Comparisons:
  - Himawari-8 AMV – MISR CMV comparison
  - GOES AMV – MISR CMV comparison
- Height differences: Are these the apple-apple comparisons?
- Stereo height retrieval from simulated IR cloud images
- Future work

MISR – Himawari-8

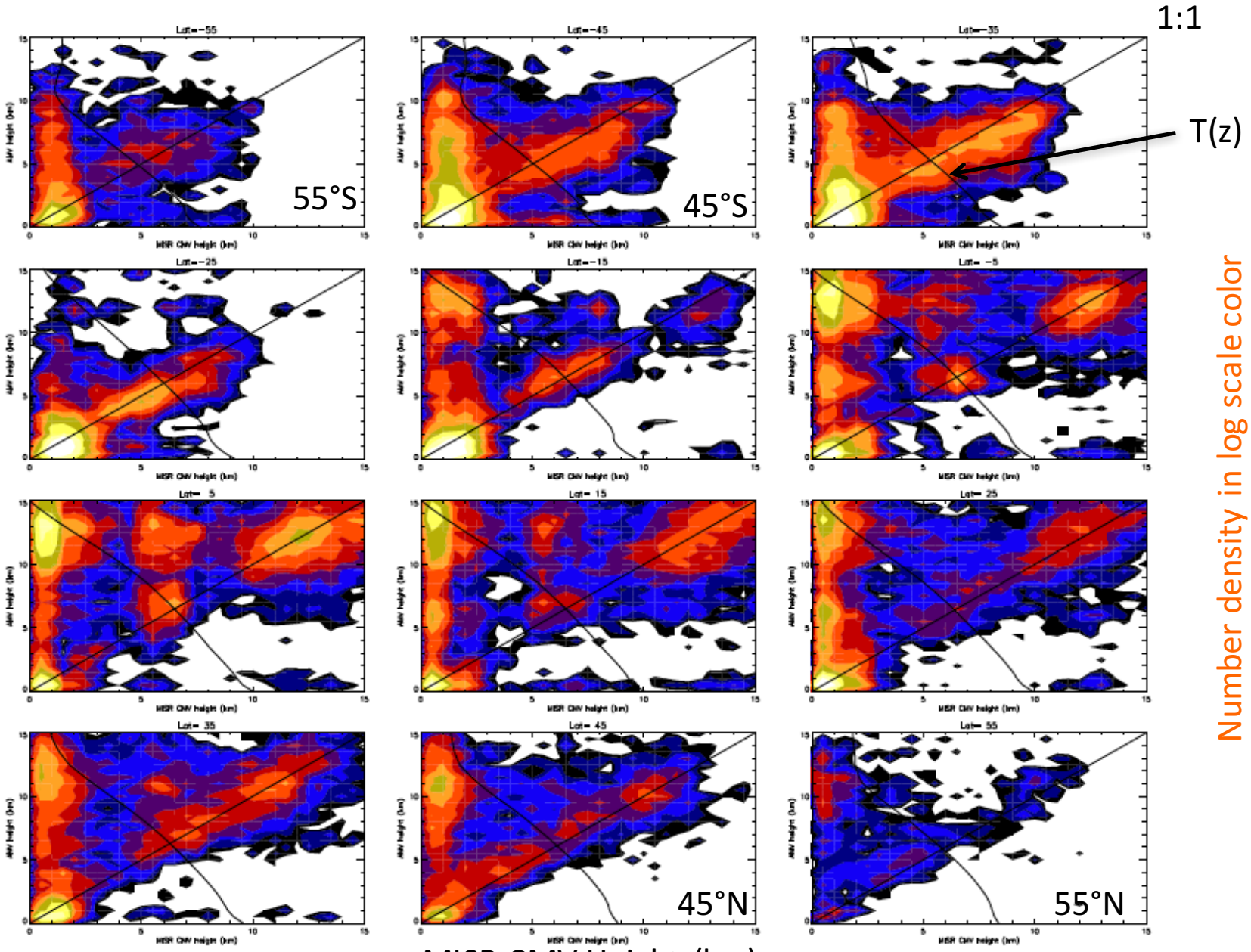
MISR, Himawari-8, and MERRA-2 Data

- Himawari-8 AMV
  - Winds from 10-min images
  - IR channel for height registration
  - 0.5 h within MISR time
  - MERRA-2 gridbox size
- MISR CMV
  - Winds from 9 images in 7 min
  - Stereo method for height
  - MERRA-2 gridbox size
- MERRA-2
  - 0.5° x 0.625°, L72
  - U, V, P, Z, T profiles
  - 3 hourly
  - Interpolated to 10:30 LT

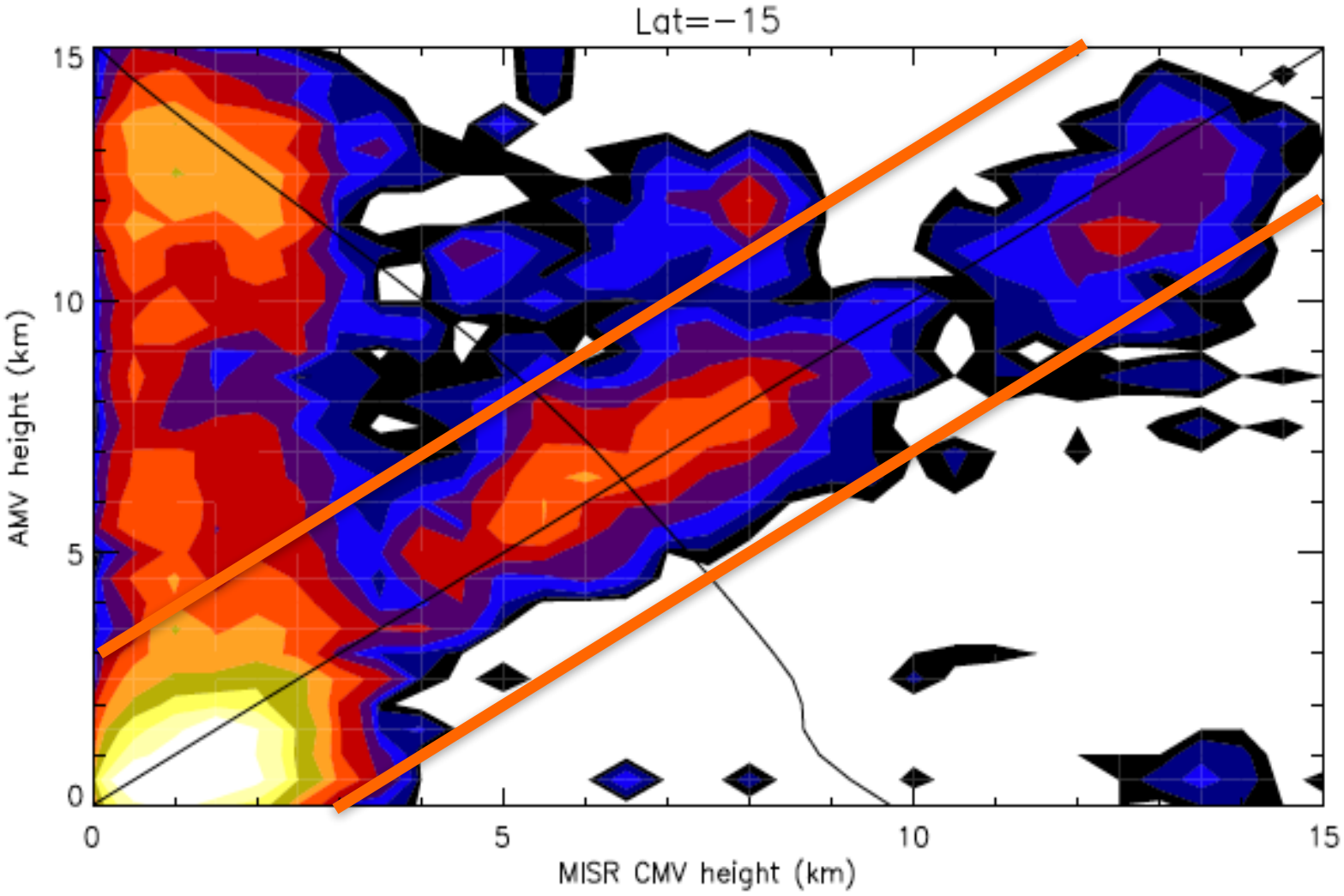
MISR – Hima U Wind Diff for 2015-08



MISR and Himawari Height Comparisons for 2015-08



MISR and Himawari-8 Height Differences



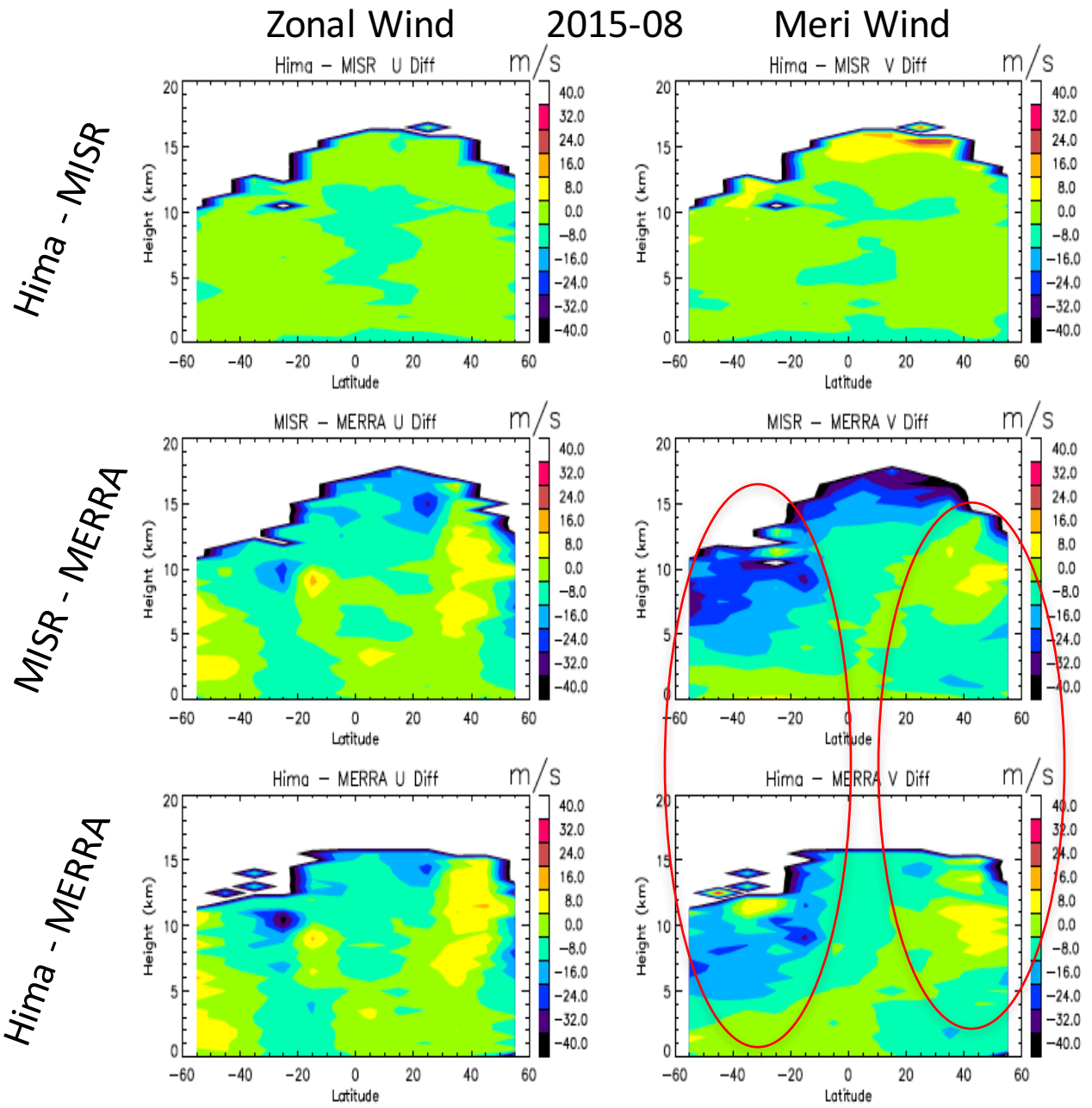
Reanalysis Winds are Too Zonal in the Extratropics!

Zonal Winds (U)

- Both MISR and Himawari winds suggest a faster summer-hemispheric polar jet (in cloudy-sky) than MERRA-2, consistent with previous MISR-ERA comparisons.

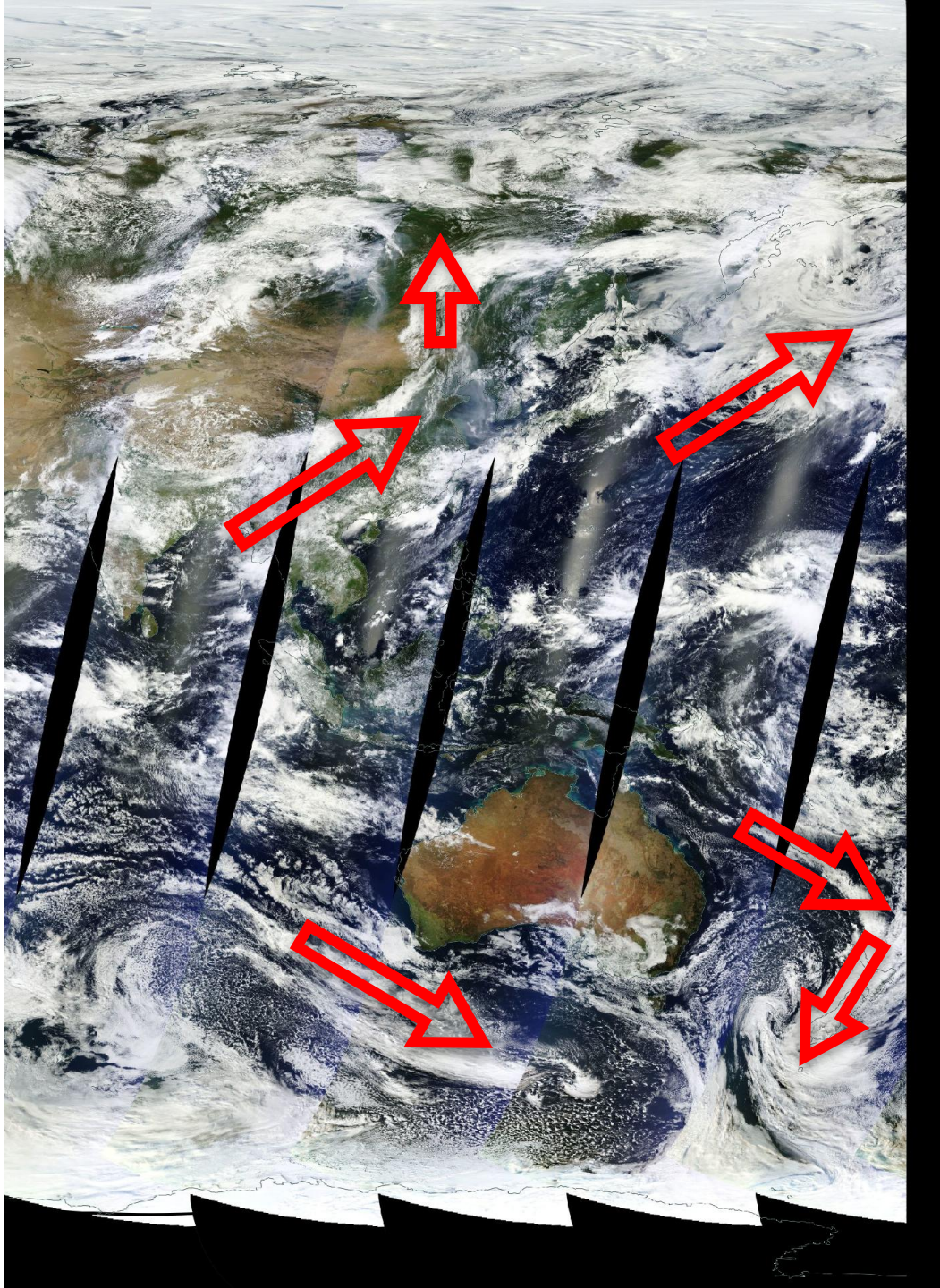
Meridional Winds (V)

- Stronger (cloudy-sky) poleward MISR and Himawari winds in the upper troposphere.
- Large MISR bias near the tropical tropopause.
- Large Himawari bias near the SH tropopause.



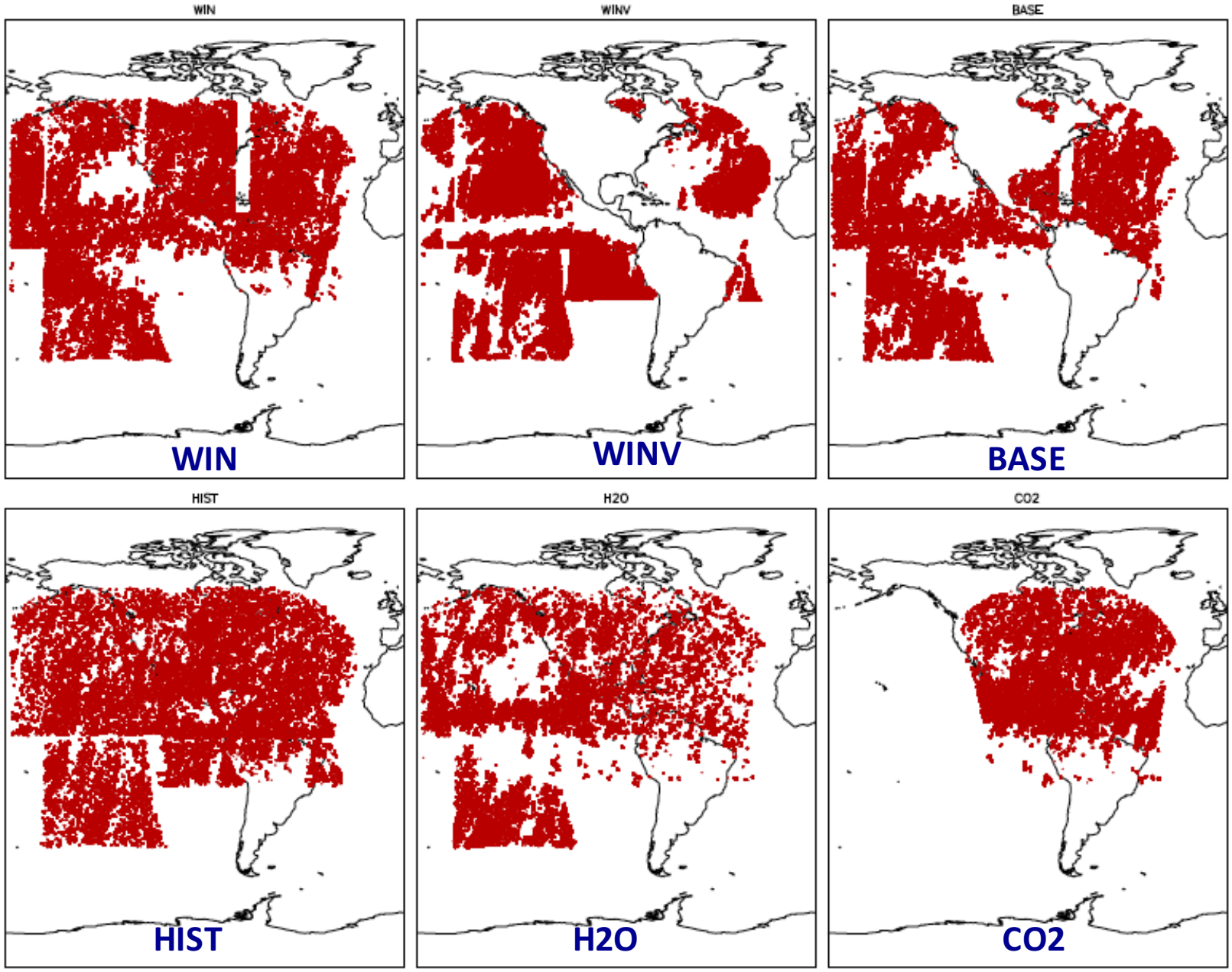
Importance of poleward moving systems

- Stratosphere-troposphere exchange
  - Water vapor, trace gas and aerosol transport
- Arctic warming
  - Heat transport
- Energetics of extrotropical cyclones and extreme weather
  - Cloud and precip processes
  - Formation of strong low-level jet



MISR - GOES

GOES AMV Retrievals by Different Height Assignment Methods (2010-08)



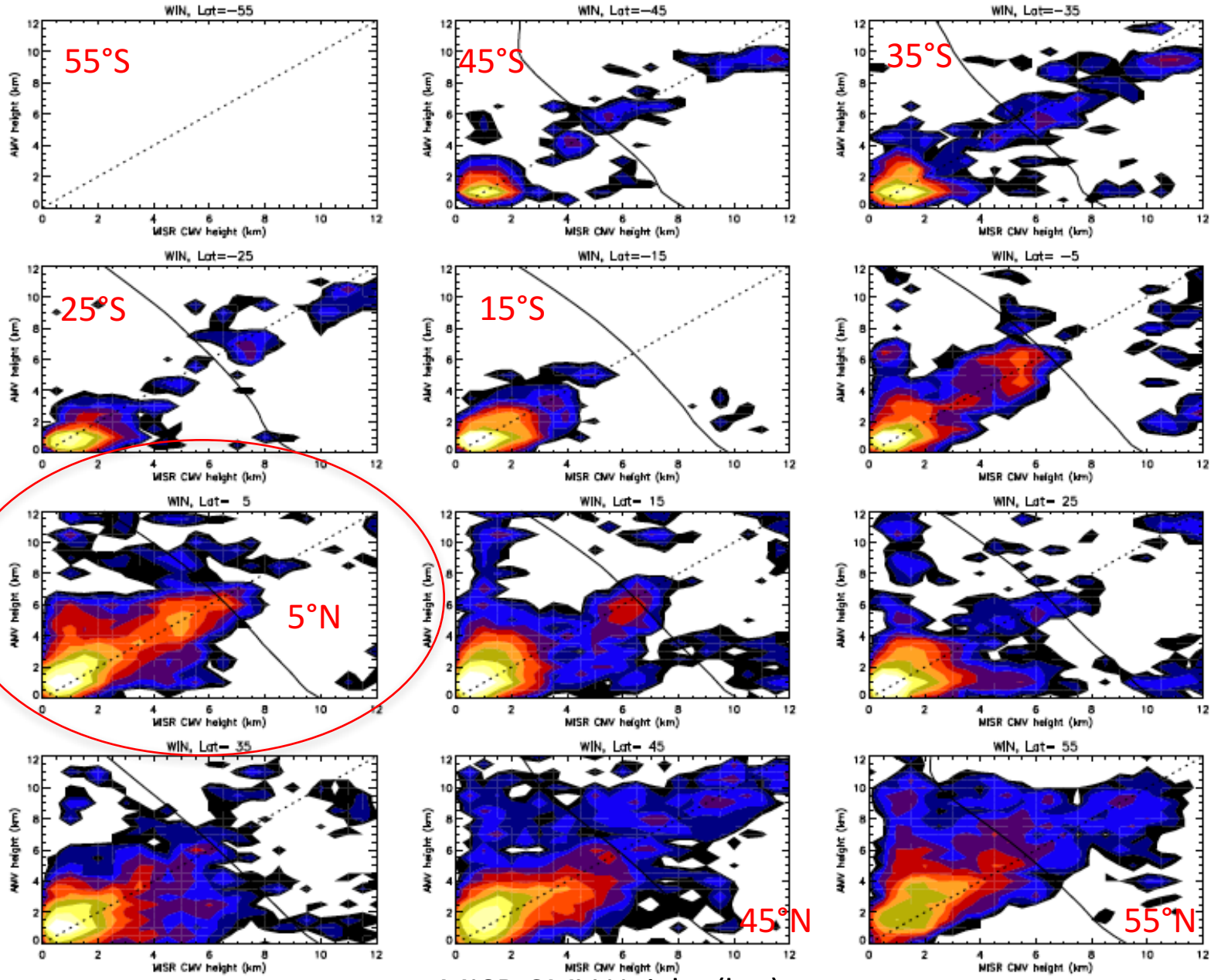
CIMSS Height Assignment Methods (IWW 2006)

ARA1/2/3	HARA1	HARA2	
IR	IR	WV	***H2O,WIN,CO2,BASE***
WV	IR	WV	***H2O, HIST***
VIS	IR (at same sp.res.)	n/a	***WIN,CO2,BASE***

Nieman et al.,JAM, 1993

1. H2O−Intercept Method (***H2O***)
2. Infrared Window (IRW) Channel Method (***WIN***)
3. CO2 Slicing (or CO2−IRW) Method (***CO2***)
4. Water Vapor Histogram Method (***HIST***)
5. Cloud Base Method (***BASE***)

MISR and GOES "WIN" Height Comparisons for 2010-08

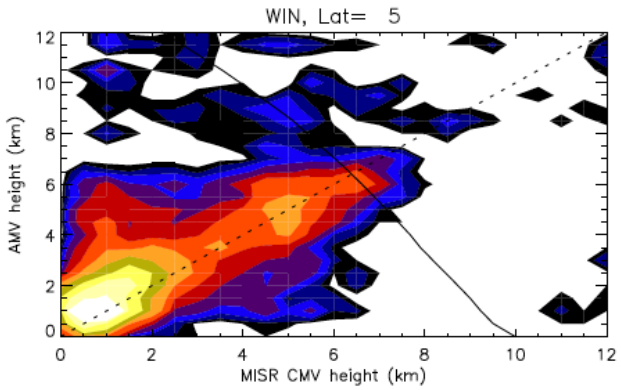


GOES Height from WIN Method (km)

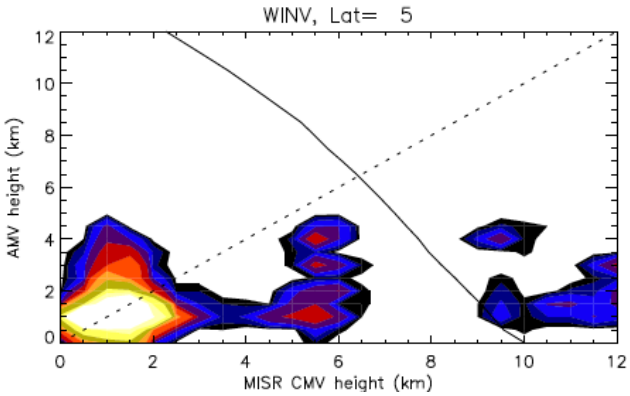
MISR CMV Height (km)

Number density in log scale color

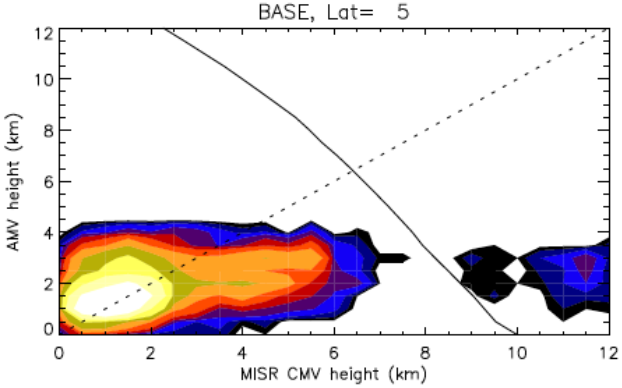
WIN



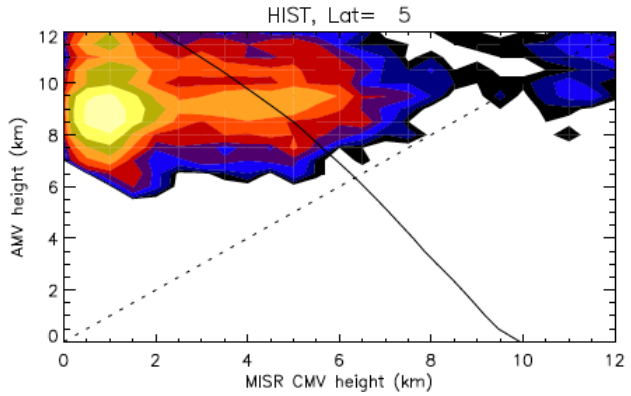
WINV



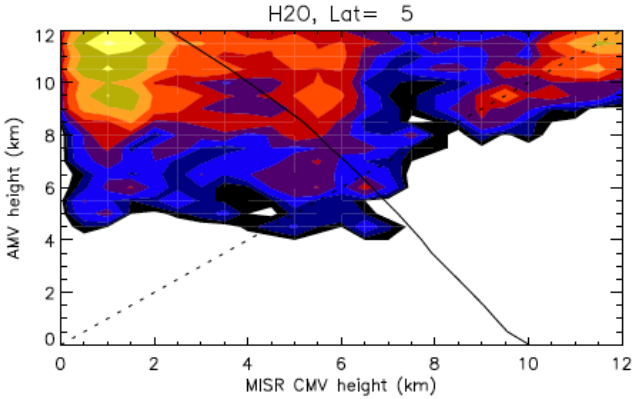
BASE



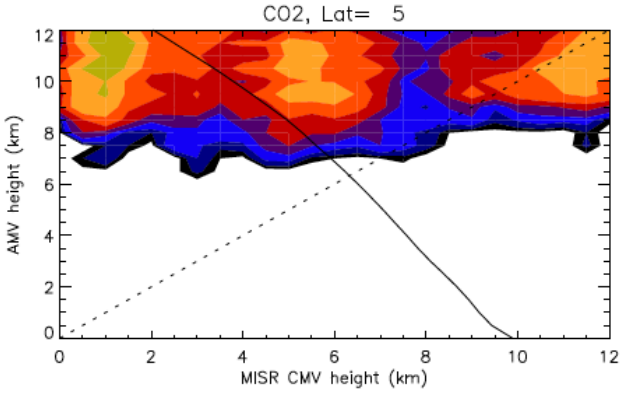
HIST



H2O



CO2

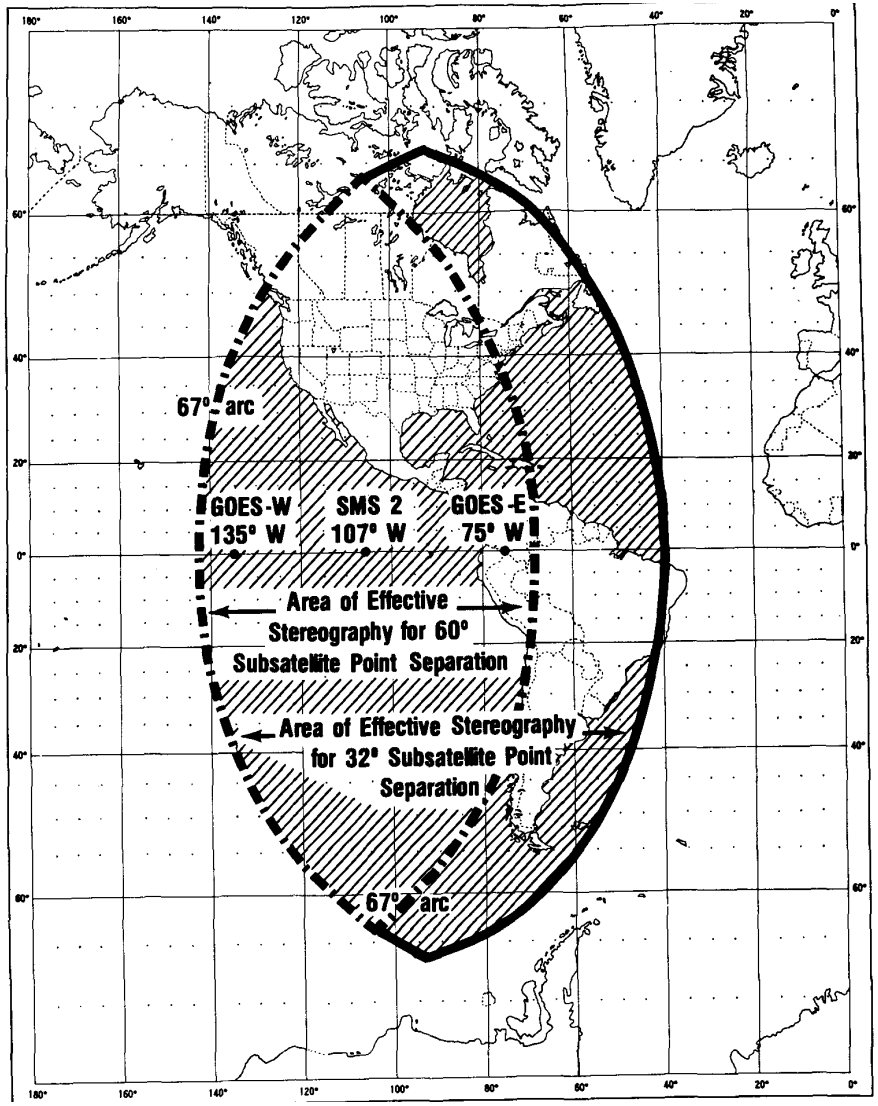


Comparisons of Stereo and IR Heights

Stereo Height	IR Height	Comments
VIS image	IR image	Not same clouds => Poorer MISR-GOES ht comparison
VIS image	VIS + IR images	VIS-IR pixel link => Better MISR-GOES ht comparison
VIS image	VIS image	N/A
IR image	IR image	✔

What’s the height of a cloud pattern?

2-GOES Concept

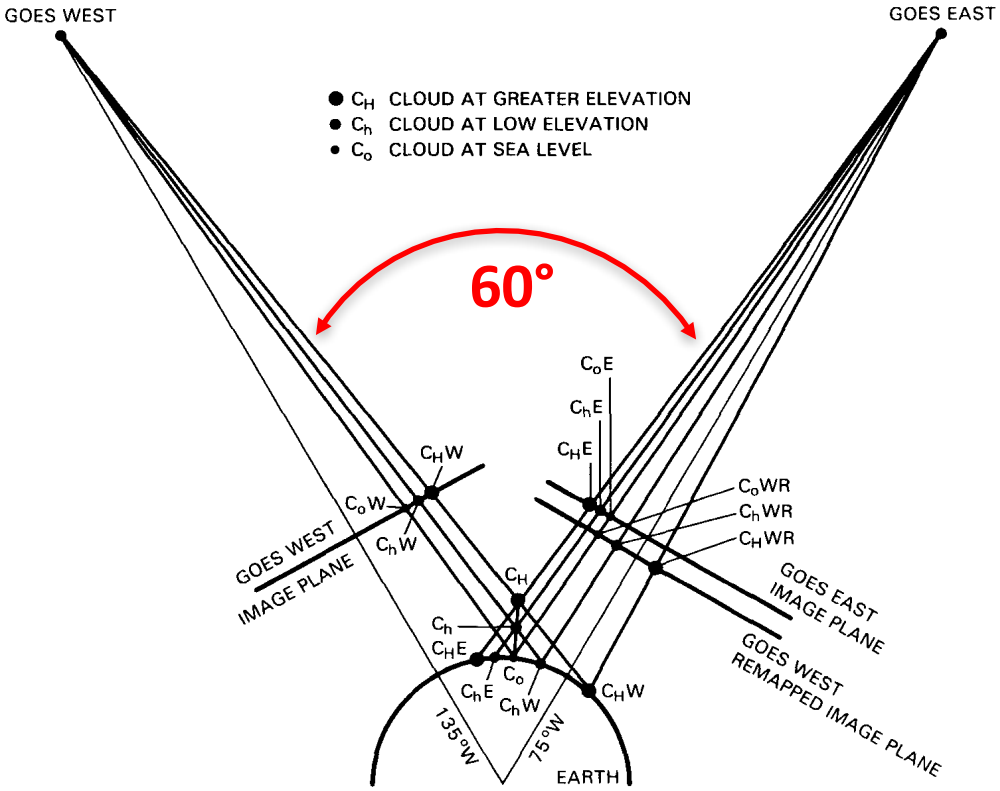


Shenk (1971) Apollo-6

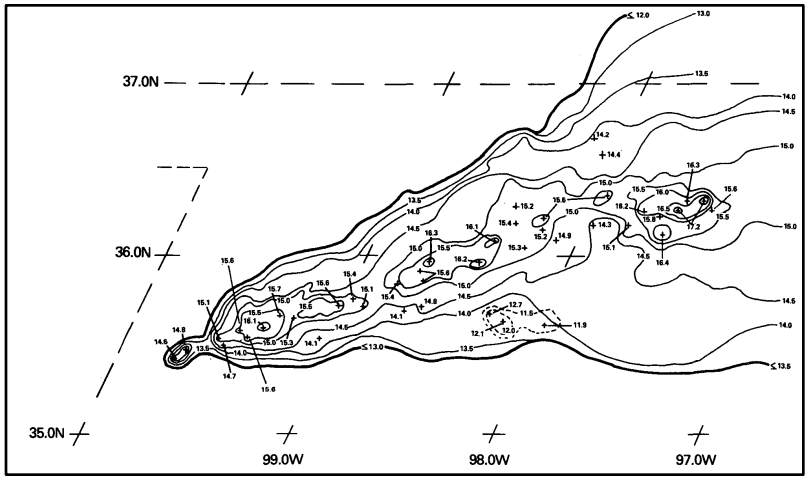
Hasler (1981)

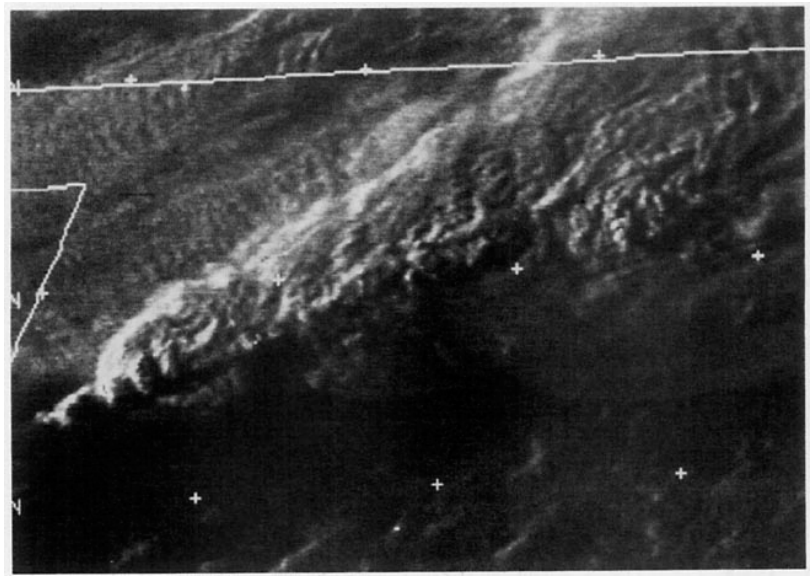
Black (1982)

Fujita and Dodge (1982)

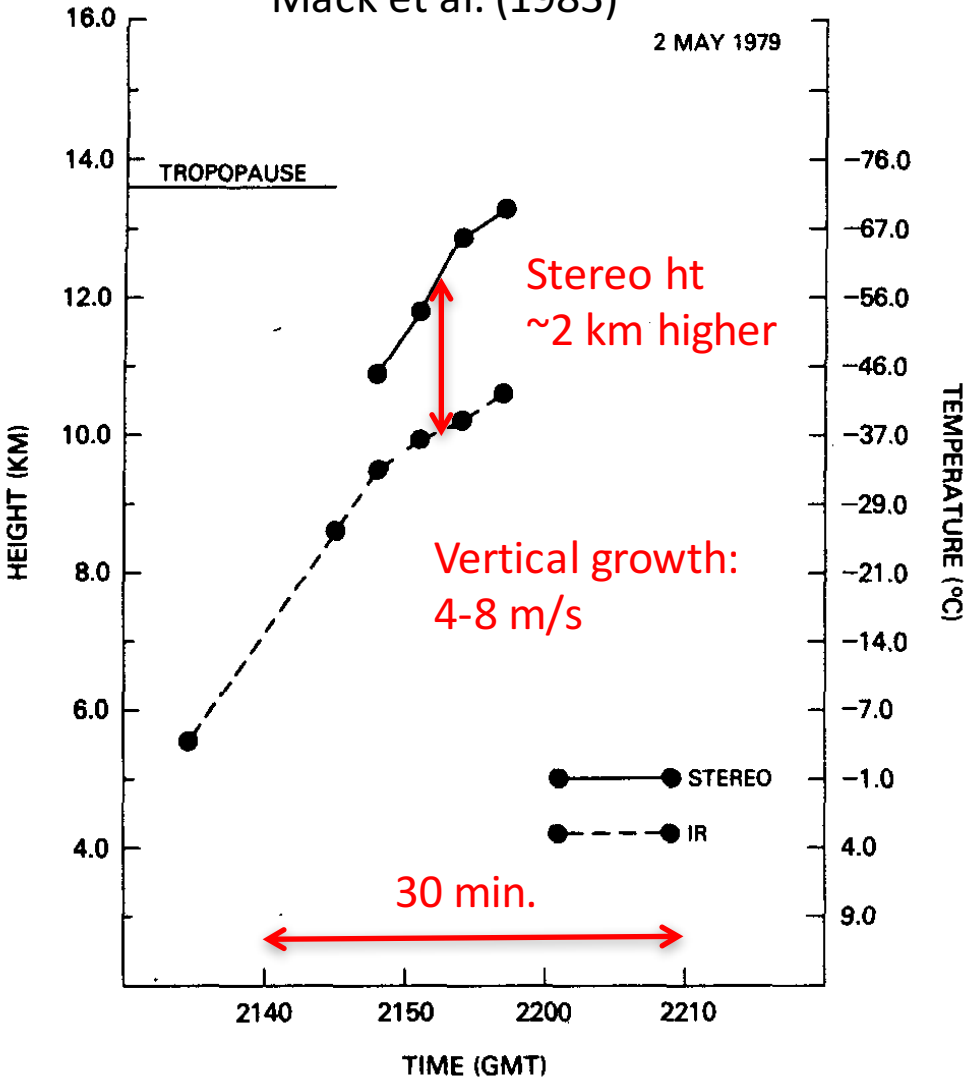


Stereo vs. IR Height from 2-GOES Retrievals





Mack et al. (1983)

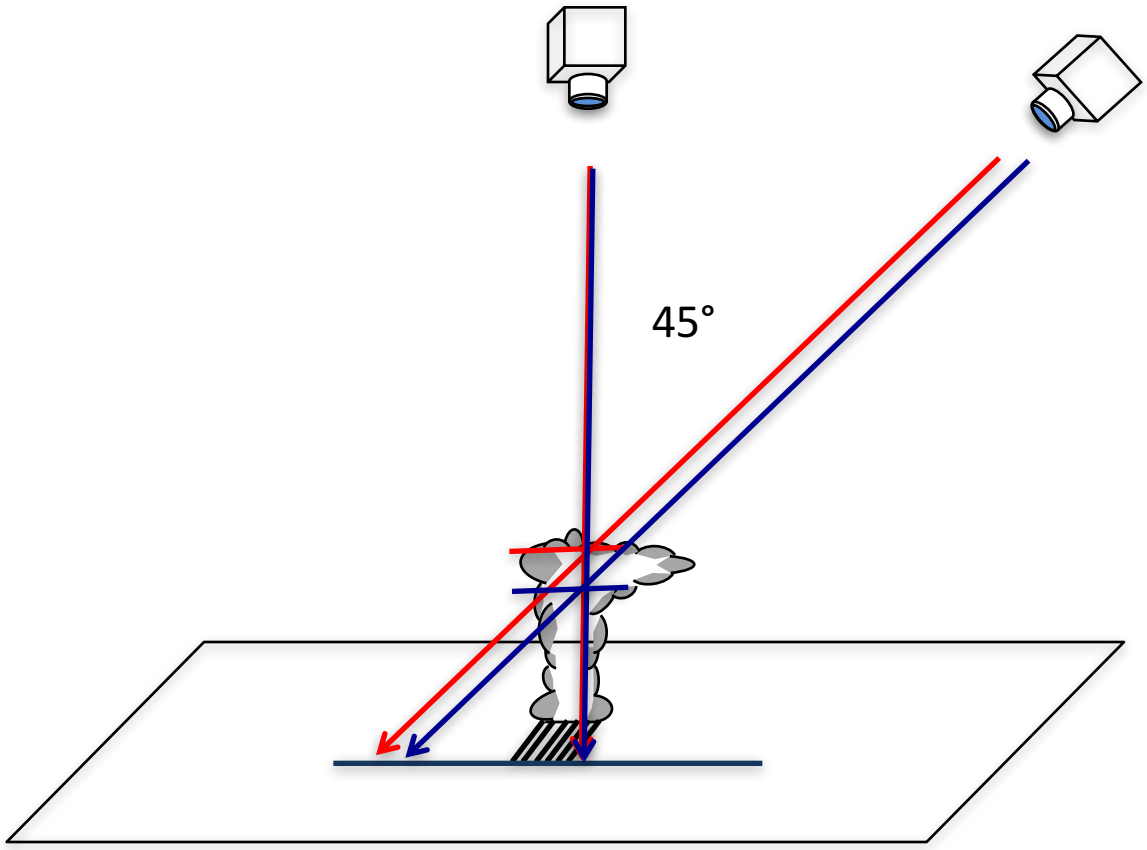


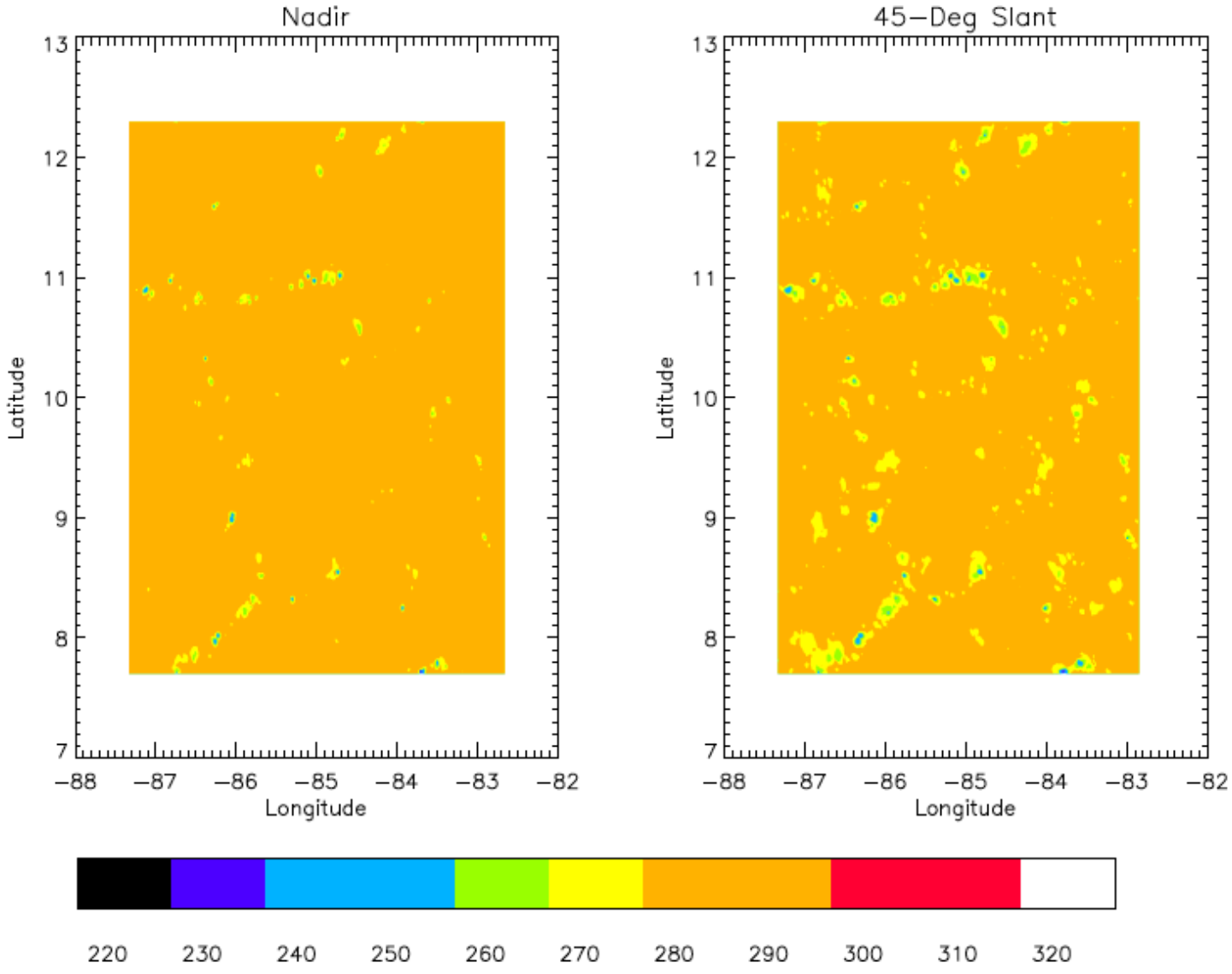
Questions

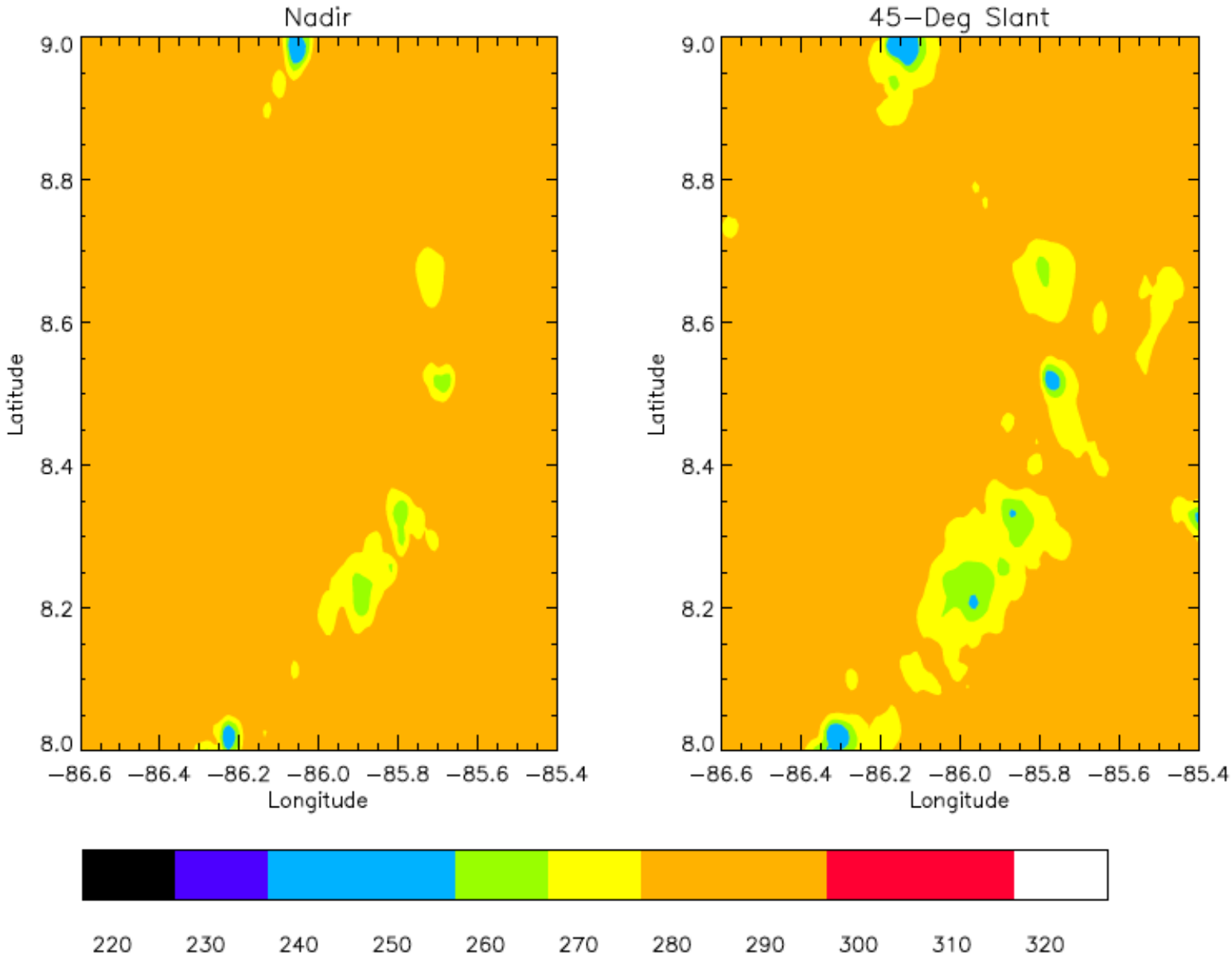
- What is the equivalent height of an IR pattern (EHIR), or AMV from IR channels?
- Does the EHIR depend on the fraction of cold pixels in a pattern?
  - Probably yes, based on pixel cluster studies.
- Is the stereo height of an IR pattern (SHIR) equal to EHIR?
  - Probably yes, if no strong pattern deformation (i.e., growth/decay, vertical motion).
- If SHIR = EHIR:
  - What cloud properties determine SHIR?
  - What are the skills of using cloud properties for SHIR/EHIR assignment?

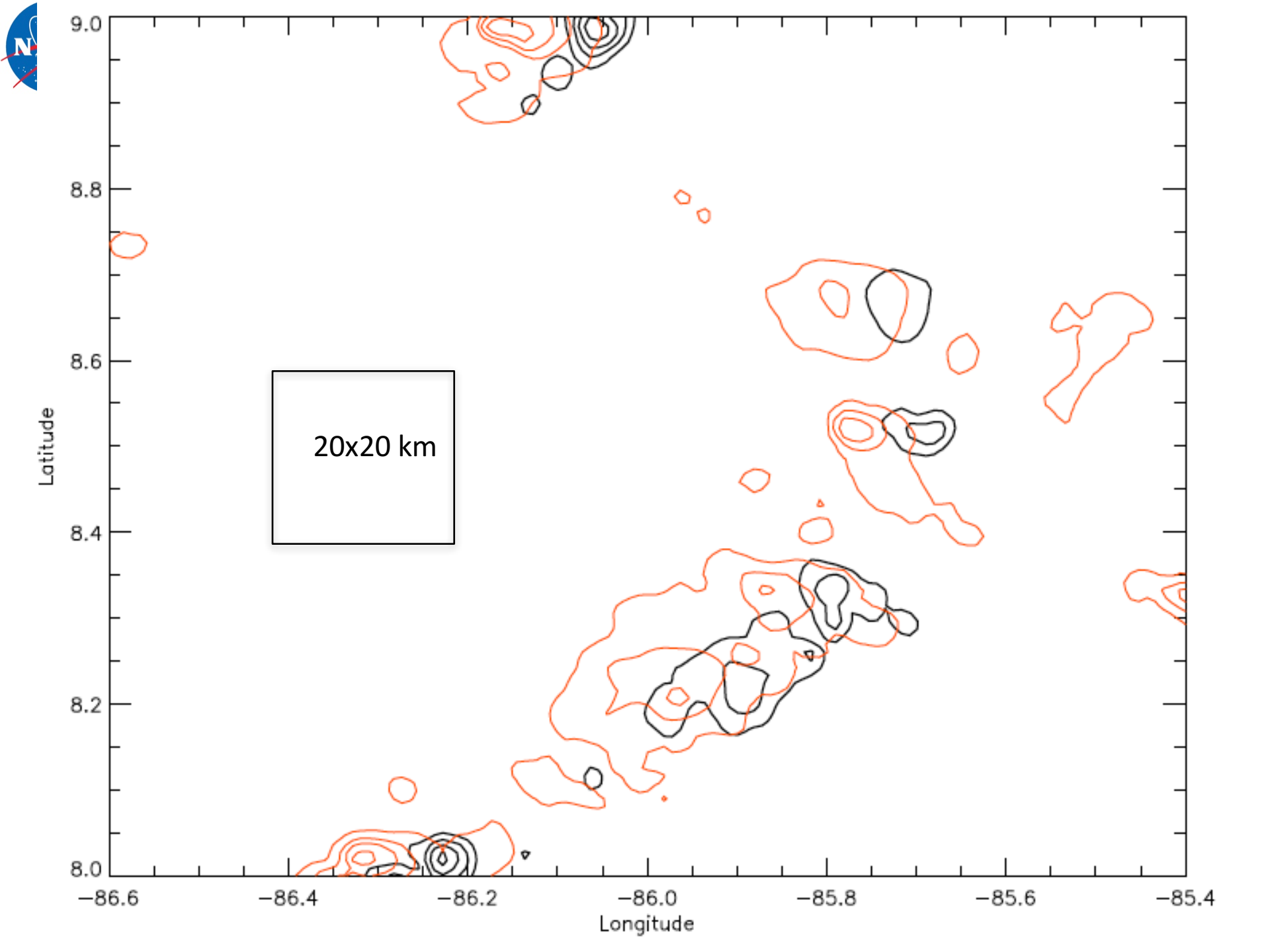
A Stereo Height Study with Simulated IR Cloud Images

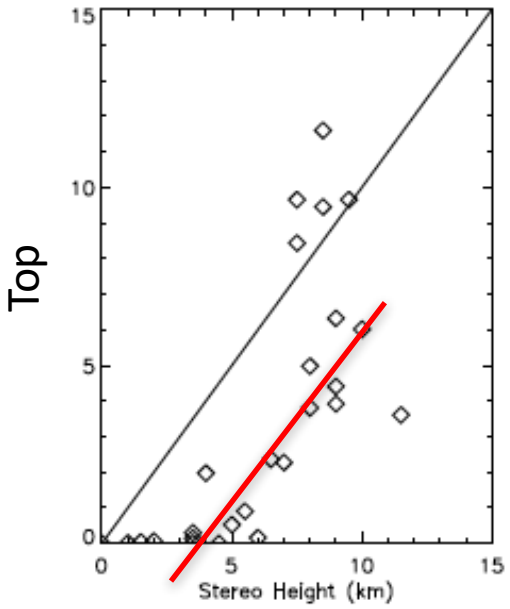
- Domain: 512 x 512 km
- Grid size: 1 km
- Nadir and 45° views
- No background winds
- Pattern matching size: 20 km
- CRTM calculations:
  - 11 µm
  - T(z), H2O(z)
  - Ice, Water, Rain, Graupel, Snow profiles
  - Penetration depth

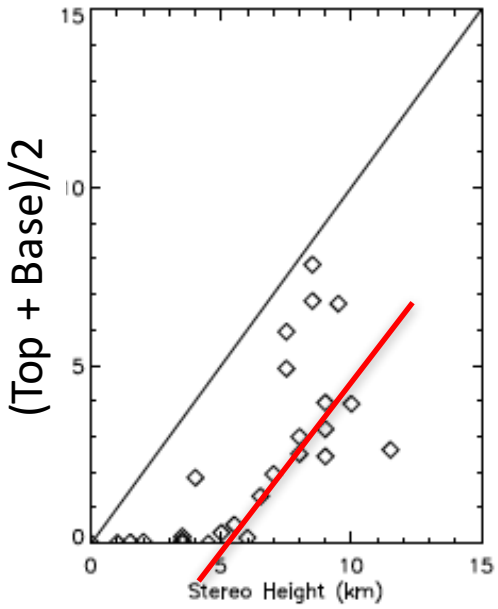


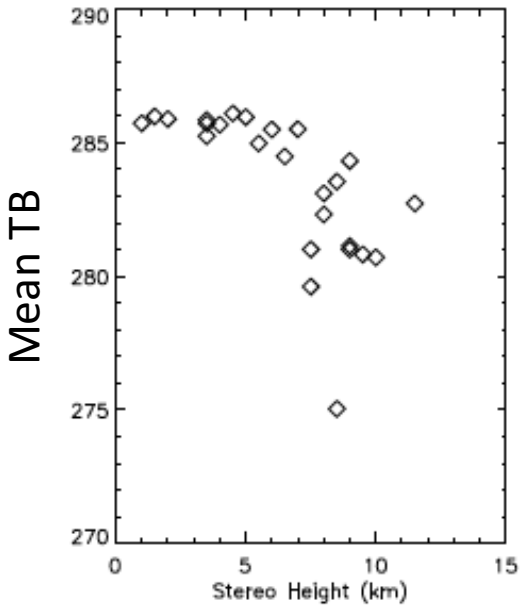

Nadir
45–Deg Slant
Latitude
Longitude
13
12
11
10
9
8
7
–88
–87
–86
–85
–84
–83
–82
220
230
240
250
260
270
280
290
300
310
320

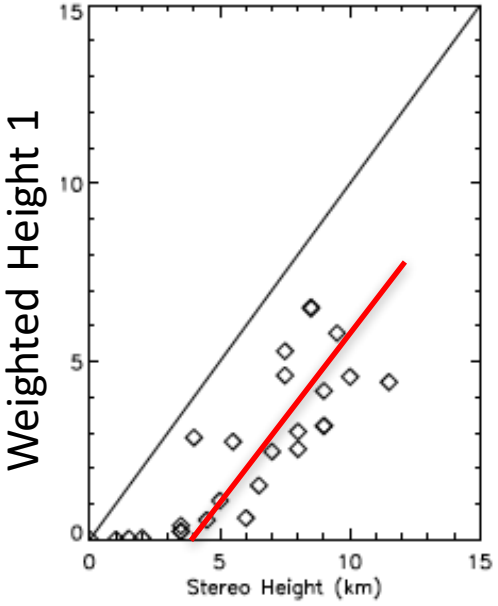

Nadir
45–Deg Slant
Latitude
Longitude
9.0
8.8
8.6
8.4
8.2
8.0
−86.6 −86.4 −86.2 −86.0 −85.8 −85.6 −85.4
220 230 240 250 260 270 280 290 300 310 320

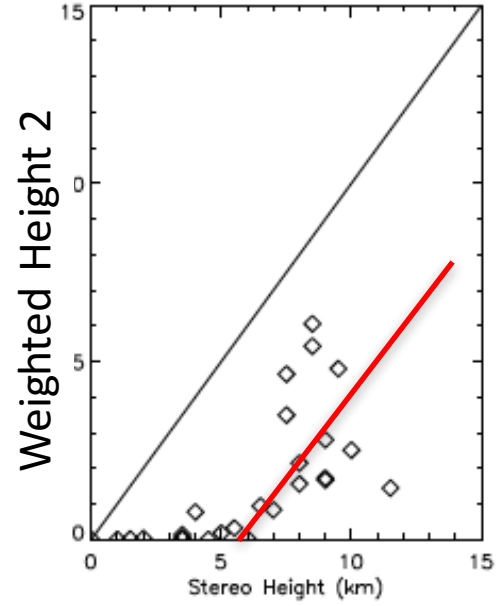

9.0
8.8
8.6
8.4
8.2
8.0
Latitude
20x20 km
−86.6
−86.4
−86.2
−86.0
−85.8
−85.6
−85.4
Longitude











Comparisons of Stereo Height with Model Cloud Heights

Stereo Height (km)

Weighted Height 1

$$mass(z) = \{Ice, Water, Rain, Graupel, Snow\}$$

Weighted Height 2

$$dTB/dm\,(z) = dTB/d\{Ice, Water, Rain, Graupel, Snow\}$$

Summary

- MISR CMV and AMV often feature different heights because of better IR sensitivity to cirrus clouds.

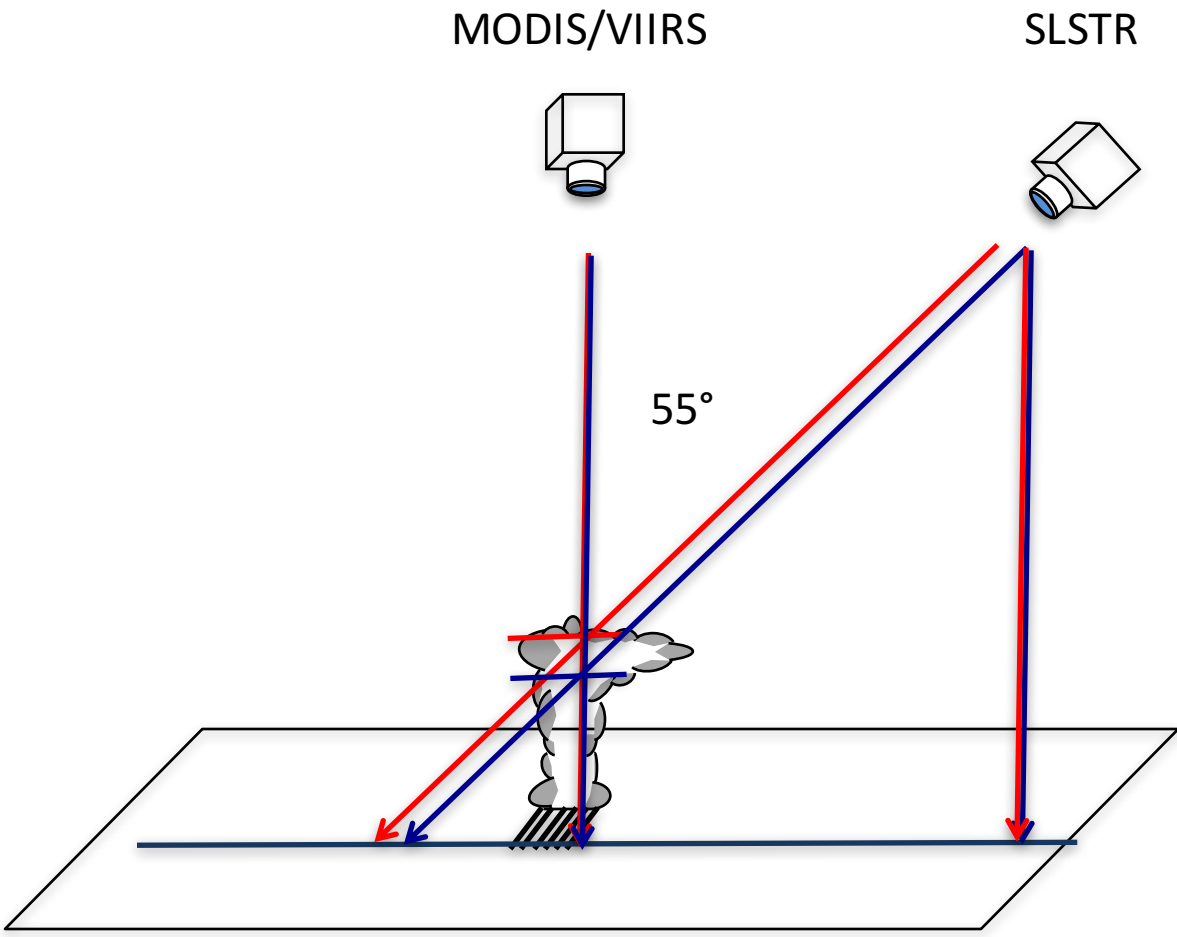
- For the CMV and AMV with height differences < 3km (the majority of samples), these winds agree well with each other, both suggesting MERRA-2 reanalysis winds are too zonal in the cloudy region.

- Stereo heights from simulated IR cloud images are better represented by the height weighted by mass profiles.

Future Work

- Sentinel-3 SLSTR (Sea and Land Surface Temperature Radiometer), to pair with MODIS/VIIRS images for AMV and height

- Compare stereo height retrievals with those from various AMV height assignment methods



Differences Between VIS and IR Stereo in Cloud Pattern Matching

	VIS	IR
Pixel Resolution	High	Low
Contrast of cloud pattern	High	Low
Dynamic range of intensity	Large	N/A
Penetration depth	Shallow	Deep
Coverage	Day	Day + Night