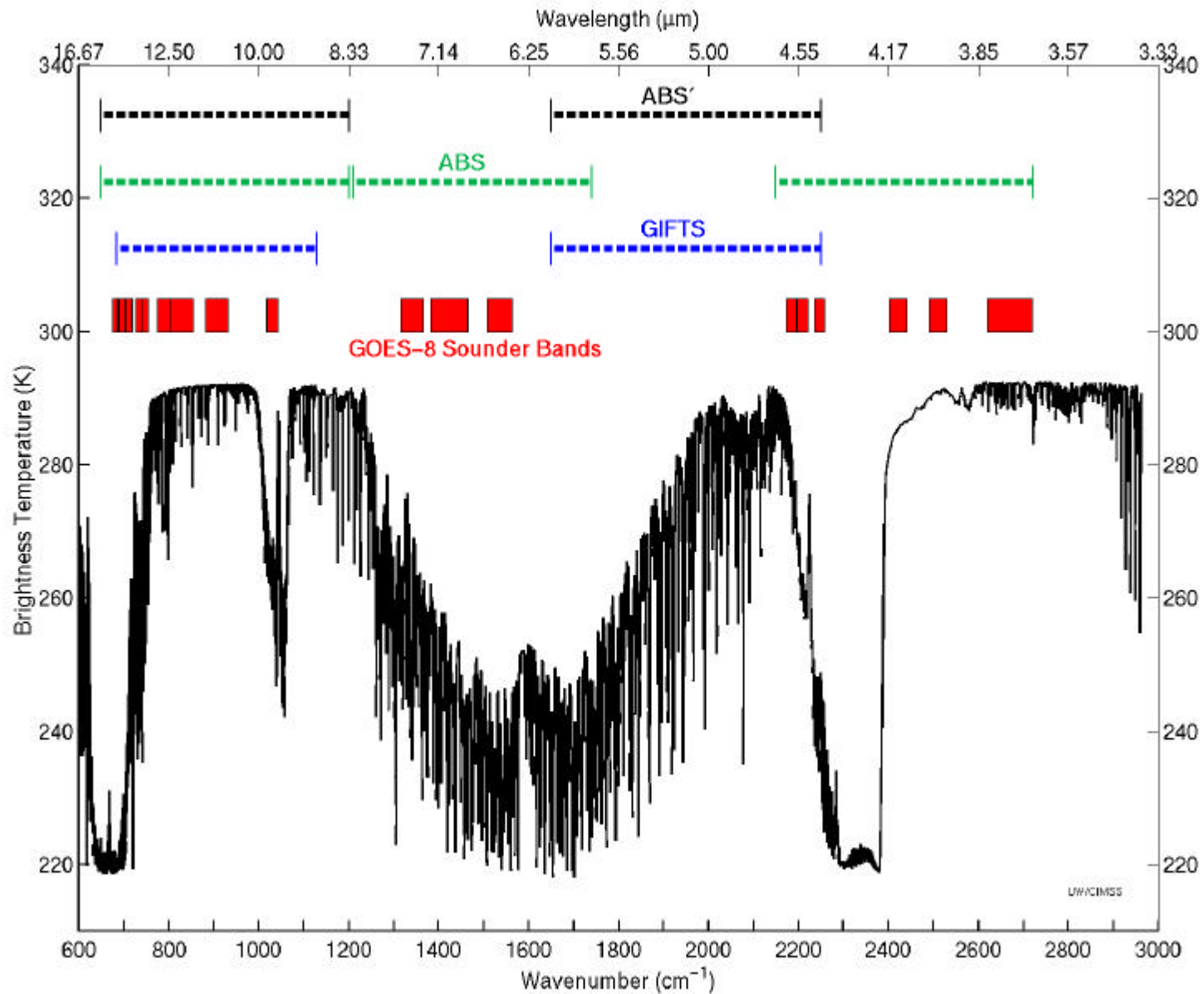
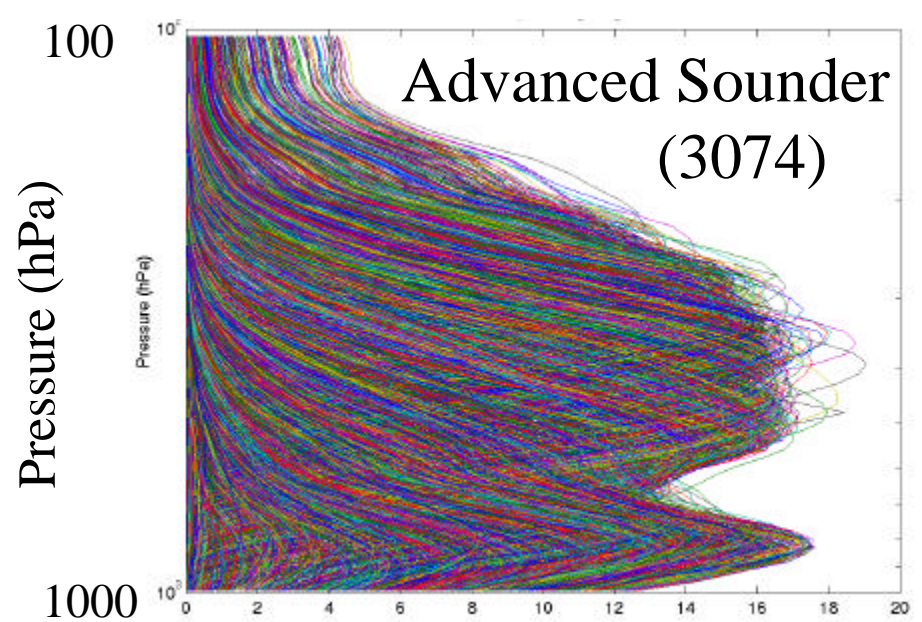
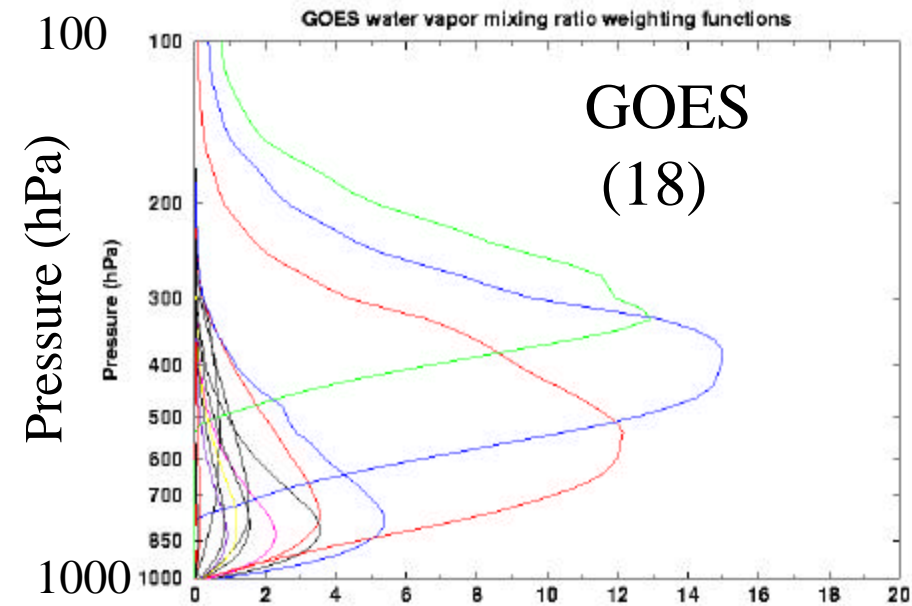


Information Content Analysis of Geostationary Broadband & Hyperspectral Measurements

- Simulated Measurements (# of channel):
 - VAS (12), GOES (18), G-18 (ABS 18), G-50 (ABS 50), ABS(~2000)
 - 6 Fascode atmospheres: Tropics; Mid-Lat Summer; Mid-Lat Winter;
 - Sub-Arctic Summer; Sub-Arctic Winter; Standard
- Information Content Analysis: (Ref. Purser & Huang 1993, Huang & Purser 1996)
 - Construct information matrix of GOES measurements using channel temperature and water vapor weighting functions (W) and instrument noises (E), also uses global model forecast error covariance of temperature and water vapor profiles (C_B). Define information matrix as
 - $(W^T E^{-1} W + C_B^{-1})^{-1}$
 - Define Vertical Resolution matrix from information matrix as
 - $(W^T E^{-1} W + C_B^{-1})^{-1} W^T E^{-1} W$
 - Number of Independent Pieces of Information of each satellite measurements is the **trace of Vertical Resolution Matrix.**



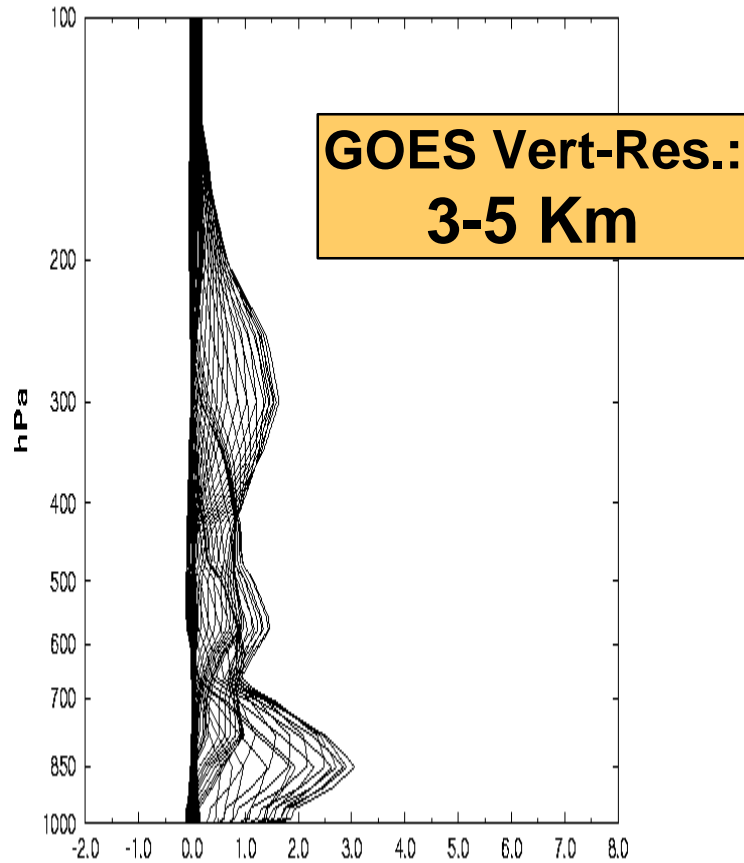
ABS Prime (ABS') -- consider using the shortwave side of the water vapor band.



Moisture Weighting Functions

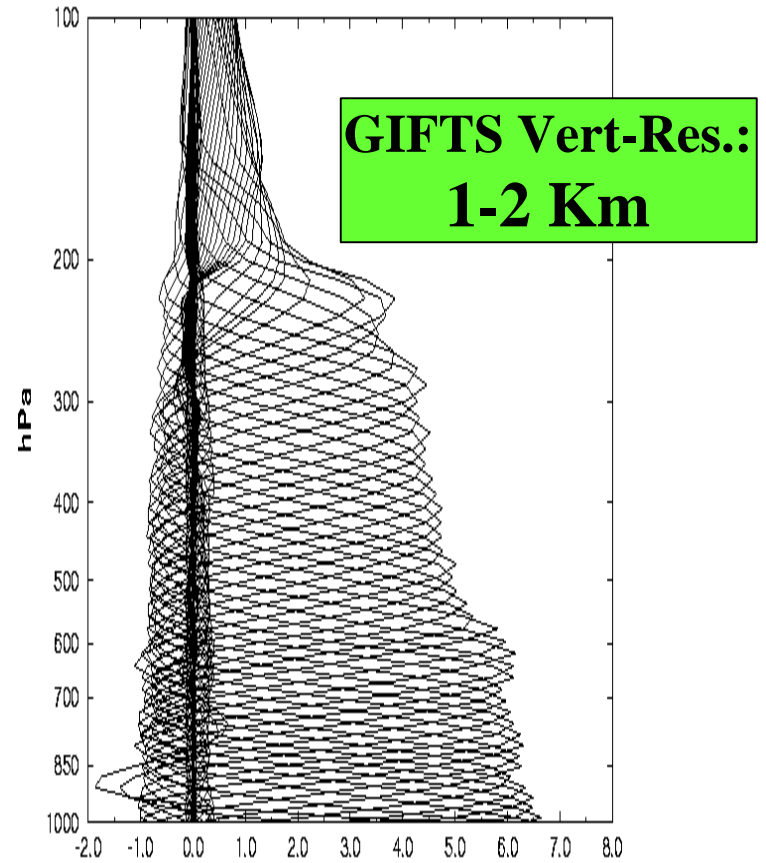
High spectral resolution advanced sounder will have *more and sharper weighting functions* compared to current GOES sounder. Retrievals will have better vertical resolution.

GIFTS and GOES Temperature Information Content Analysis



Current - GOES

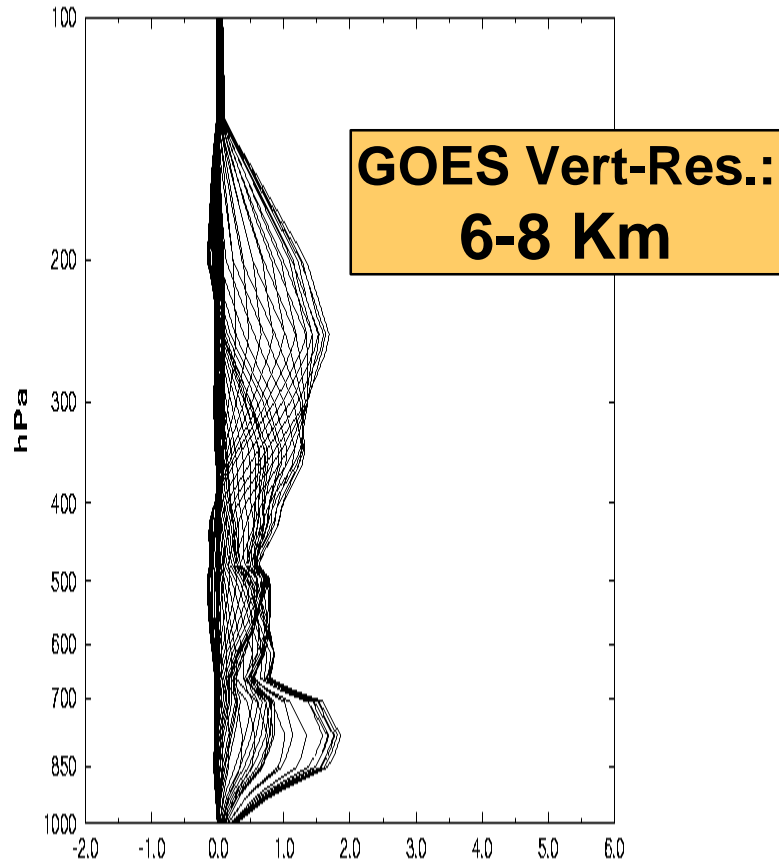
~3 Pieces



GIFTS

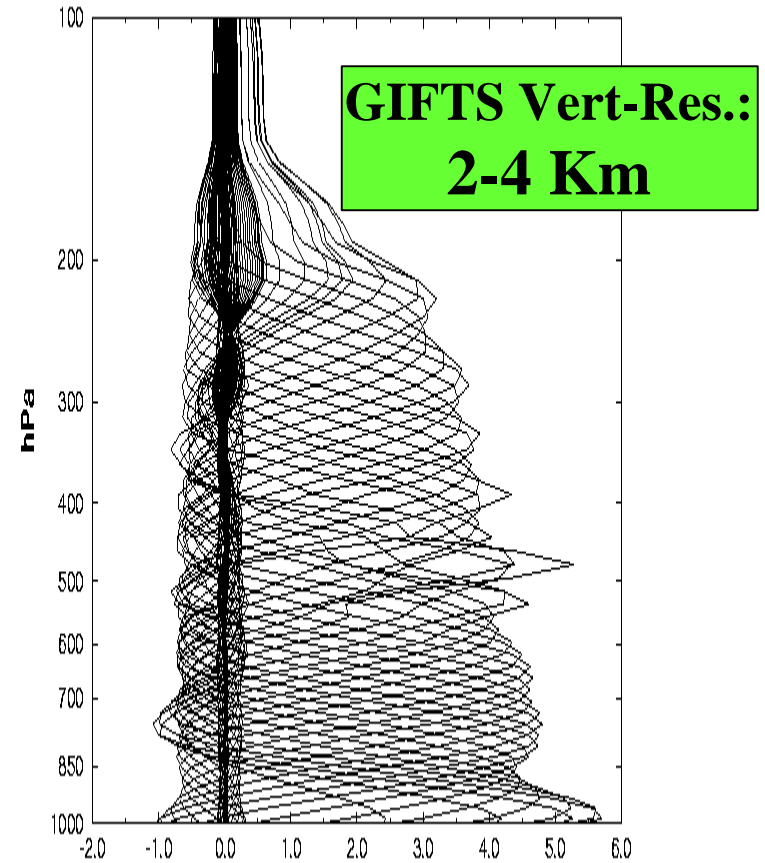
10-12 Pieces

GIFTS and GOES Water Vapor Information Content Analysis



Current - GOES

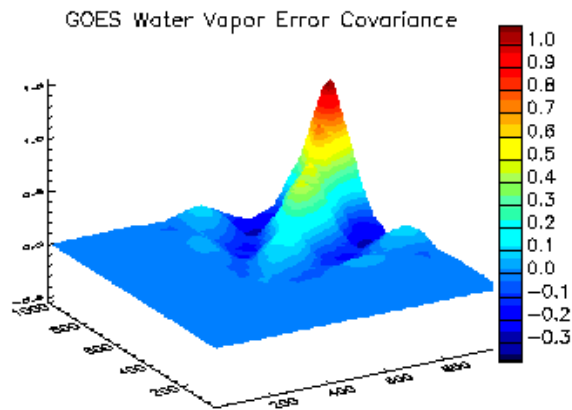
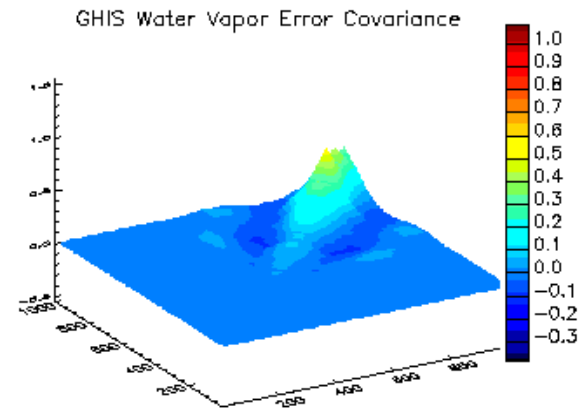
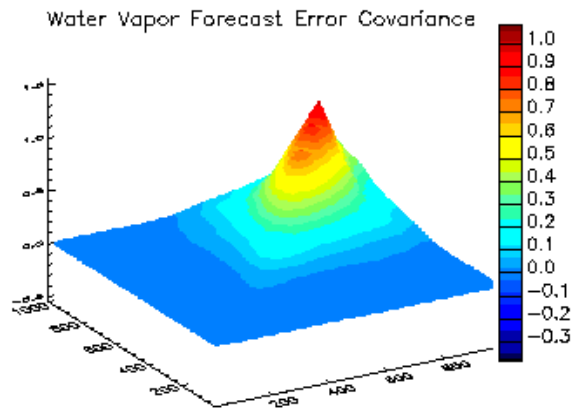
~2 Pieces



GIFTS

8-9 Pieces

The Use and Measure of Information Entropy



WATER VAPOR

GHIS Entropy Reduction = 1.02

GOES Entropy Reduction = 0.20

**GHIS has 5.08 times
as much information as GOES**

Information Content Analysis of GOES Single FOV Measurements - Results

- Temperature (0.1-1050 mb) Independent Pieces of Information for GOES and ABS ~ 2000 channel & noise of 0.3 K NEdT (@250 K) measurements

<u>Classes</u>	<u># of Pieces of Information</u>	
	<u>GOES</u>	<u>ABS</u>
• Tropics	4.3	15.1
• Mid-Lat-Summer	3.9	14.3
• Mid-Lat-Winter	3.0	13.6
• Sub-Arctic-Summer	3.3	13.7
• Sub-Arctic-Winter	2.9	13.9
• Global Mean	3.5	14.1

Information Content Analysis of GOES

Single FOV Measurements - Results

- **Water Vapor (0.1-1050 mb) Independent Pieces of Information for GOES and ABS ~ 2000 channel & noise of 0.25 K NEdT (@250 K) measurements**

<u>Classes</u>	<u># of Pieces of Information</u>	
	<u>GOES</u>	<u>ABS</u>
• Tropics	1.9	6.3
• Mid-Lat-Summer	1.9	6.3
• Mid-Lat-Winter	2.5	9.8
• Sub-Arctic-Summer	2.6	6.9
• Sub-Arctic-Winter	1.9	10.6
• Global Mean	2.2	8.0

Information Content Analysis of RAOB Measurements

- NOAA 88 Global RAOB Measurements (# of profiles):
 - 5505 profiles, 1988 , 4 seasons, Land & Ocean, Day & Night
 - Mid-Lat Summer (1071), Mid-Lat Winter (1072), Tropics (1085)
 - Sub-Arctic Summer (1250), Sub-Arctic Winter (1027)
- Information Content Analysis - Eigenvector Decomposition
 - Obtain eigenvectors from five classes' of temperature (150-1013 mb) and water vapor (300-1013 mb) profiles separately.
 - Obtain truncated temperature (water vapor) profile to the residual level of 0.25K (3%). The limited number (< total number of vector) of eigenvector used is considered as the number of independent pieces of information possesses by the RAOB measurements.
 - Number of Independent Pieces of Information of RAOB temperature and water vapor measurements is defined as the mean value of number of truncated vectors used that gives the residual error of reconstructed profiles within the RAOB measurement noise for each five classes.

Information Content Analysis of RAOB Single Profile Measurements - Results

- **Temperature Independent Pieces of Information for 150-1013 mb, and RAOB accuracy of ~ 0.3 K error**

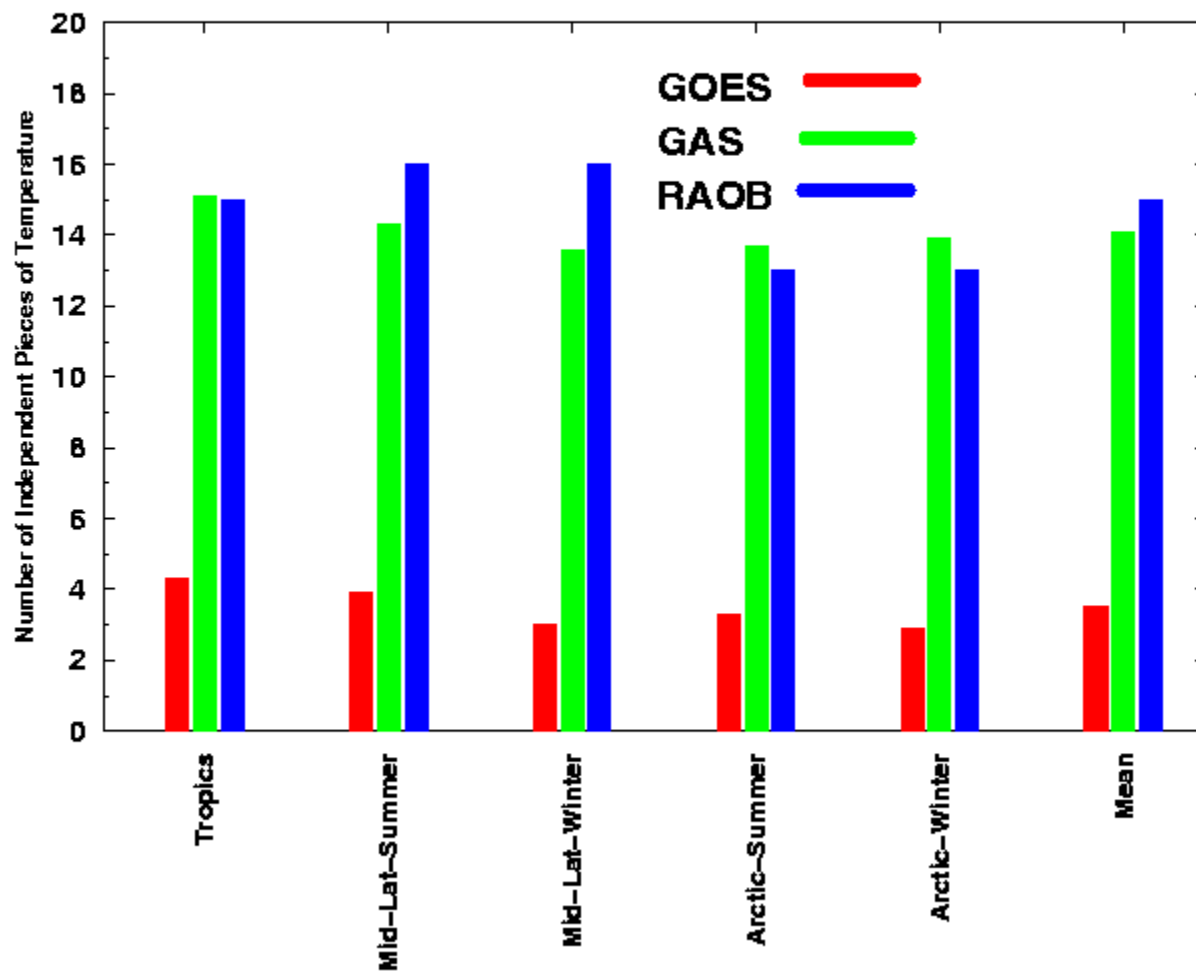
<u>Classes</u>	<u># of Pieces of Information</u>	<u>Residual Error (K)</u>
• Tropics	15	0.17
• Mid-Lat-Summer	16	0.33
• Mid-Lat-Winter	16	0.25
• Sub-Arctic-Summer	13	0.29
• Sub-Arctic-Winter	13	0.29
• Global Mean	15	0.27

Information Content Analysis of RAOB Single Profile Measurements - Results

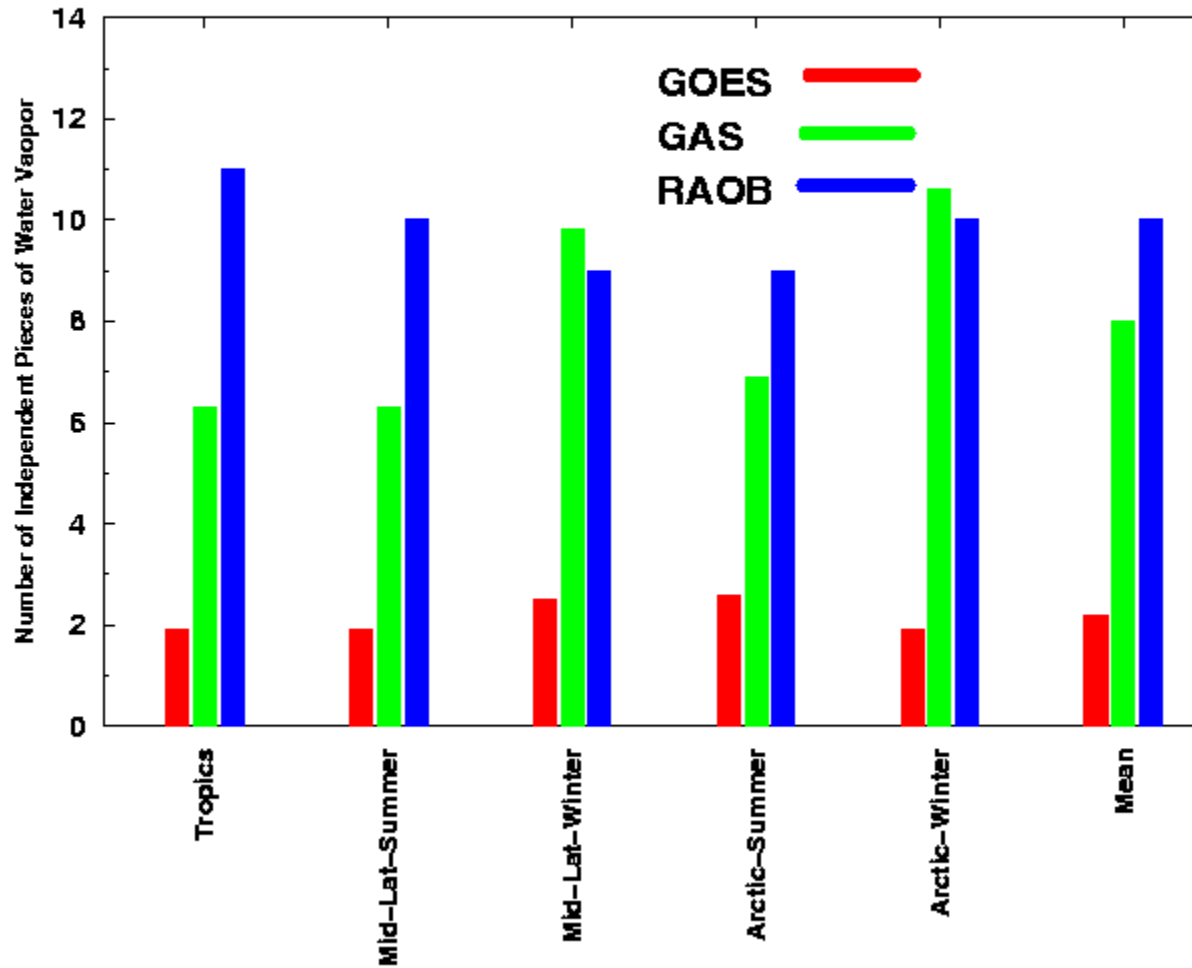
- **Water Vapor Independent Pieces of Information for 300-1013 mb, and RAOB accuracy of ~ 3 % error**

<u>Classes</u>	<u># of Pieces of Information</u>	<u>Residual Error (%)</u>
• Tropics	11	3.0
• Mid-Lat-Summer	10	3.0
• Mid-Lat-Winter	9	3.0
• Sub-Arctic-Summer	9	3.1
• Sub-Arctic-Winter	10	3.1
• Global Mean	10	3.0

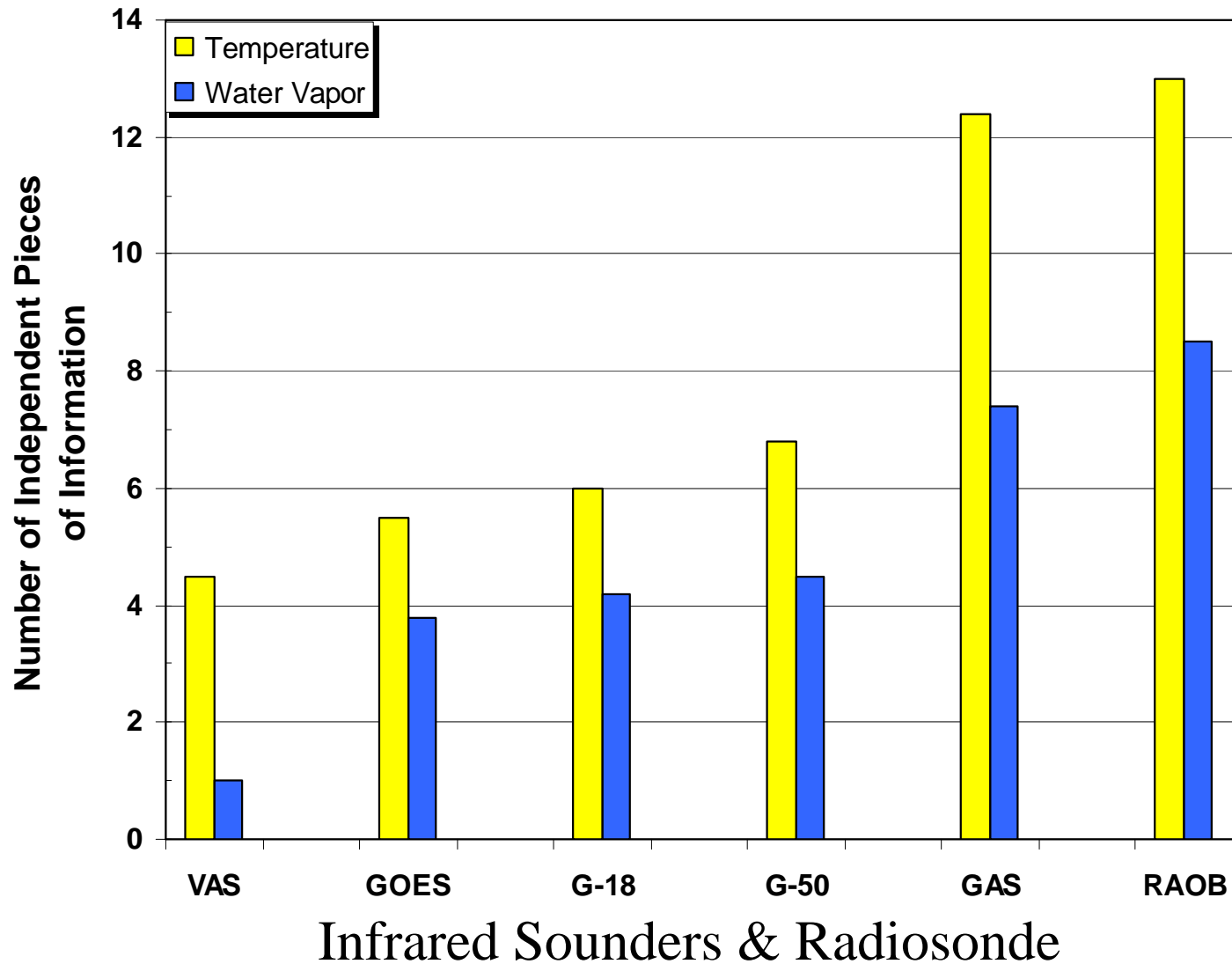
Geo Satellite & Radiosonde Temperature Information Single FOV or Single Profile



Geo Satellite & Radiosonde Water Vapor Information Single FOV or Single Profile



Information Content of Geo-Sounders Vs. Radiosonde



Temperature Information Content Comparison Geo Sounder Vs. Radiosonde

- Per day, CONUS (25-50 N; 68-128 W)
- Assume 30 % of cloud free FOVs (10 km) for Geo
- **Temperature Information per Day (TI/Day):**
 - **GOES** - $24 \text{ hr/day} \times 30,000 \text{ fov/hr} \times 30\% \times 3.5 \text{ TI/fov} = \mathbf{2,520K \text{ TI/Day}}$
 - **ABS** - $24 \text{ hr/day} \times 30,000 \text{ fov/hr} \times 30\% \times 14.1 \text{ TI/fov} = \mathbf{10,152K \text{ TI/Day}}$
 - **RAOB** - $2 \text{ hr/day} \times 100 \text{ profile/hr} \times 15 \text{ TI/profile} = \mathbf{3K \text{ TI/Day}}$
- **Conclusion:**
 - **GOES has $2,520K/3K=840$ times of RAOB information**
 - **ABS has $10,152K/3K=3384$ times of RAOB information**

Water Vapor Information Content Comparison Geo Sounder Vs. Radiosonde

- Per day, CONUS (25-50 N; 68-128 W)
- Assume 30 % of cloud free FOVs (10 km) for Geo
- **Water Vapor Information per Day (WVI/Day):**
 - **GOES** - $24 \text{ hr/day} \times 30,000 \text{ fov/hr} \times 30\% \times 2.2 \text{ TI/fov} = 1,584\text{K WVI/Day}$
 - **ABS** - $24 \text{ hr/day} \times 30,000 \text{ fov/hr} \times 30\% \times 8 \text{ TI/fov} = 5,760\text{K WVI/Day}$
 - **RAOB** - $2 \text{ hr/day} \times 100 \text{ profile/hr} \times 10 \text{ TI/profile} = 2\text{K WVI/Day}$
- **Conclusion:**
 - **GOES has $1,584\text{K}/2\text{K}=792$ times of RAOB information**
 - **ABS has $5,760\text{K}/2\text{K}=2880$ times of RAOB information**