MTSAT-1R Intercalibration Monitor and Approach to Intercalibration using High Spectrum Resolution Sounder

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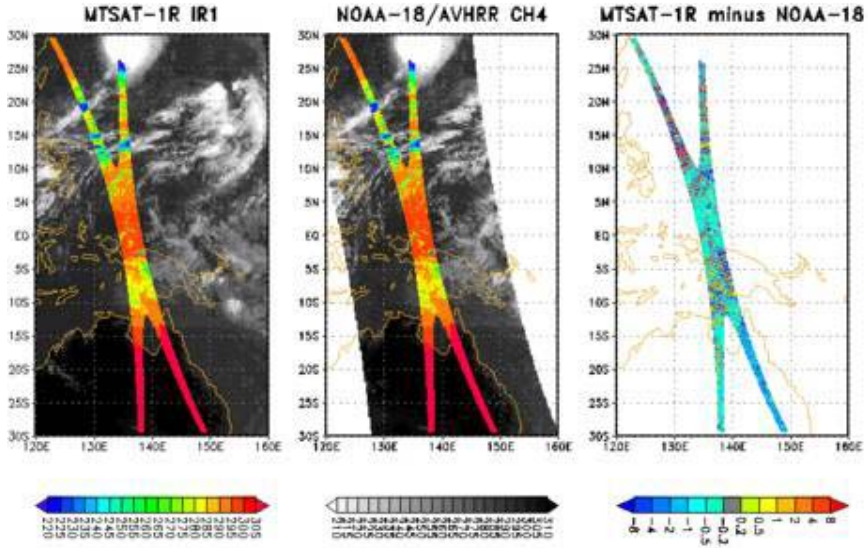
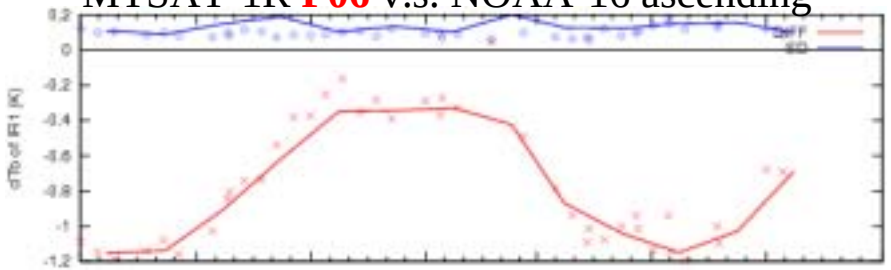
MTSAT-1R Intercalibration Monitor

Comparison images

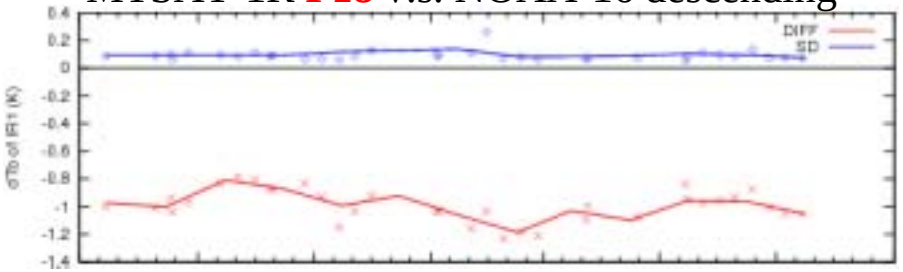


Temporal trends

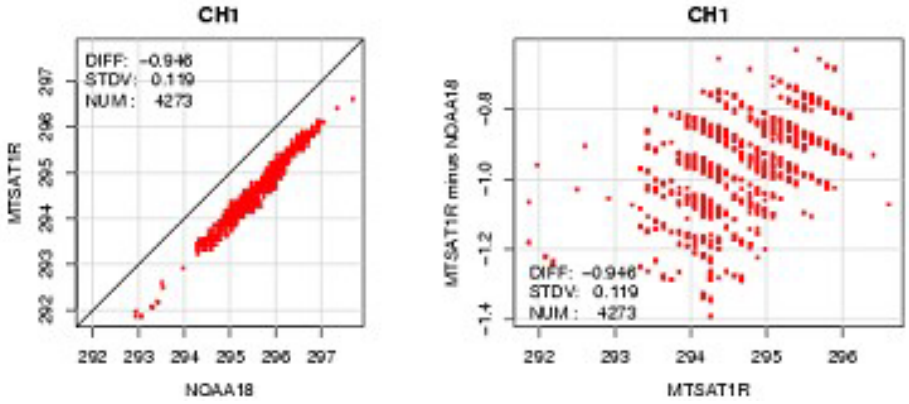
MTSAT-1R **F06** v.s. NOAA-16 ascending



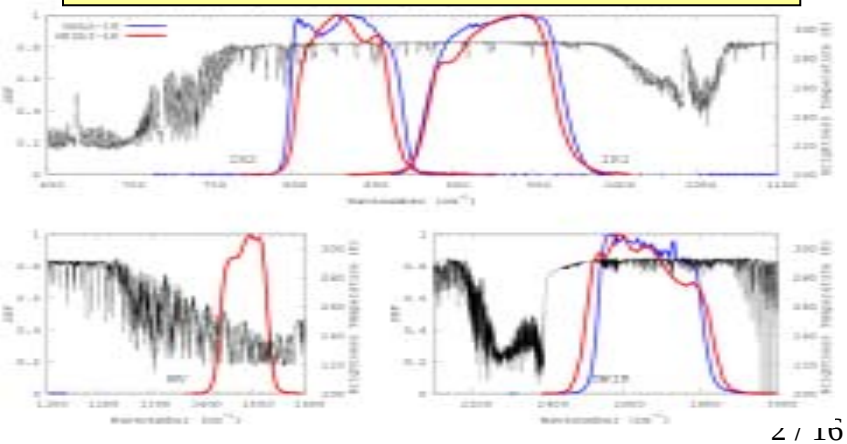
MTSAT-1R **F18** v.s. NOAA-16 descending



Scatter plots and statistics



Spectral Response Functions



MTSAT-1R Intercalibration (infrared)

- Comparison with AVHRR on NOAA16, 17 and 18 (GAC)
- Disclosed on the Internet
  - Categories
    - Clear sky comparison for warmer TB range
    - Smooth cloud top comparison for colder TB range
  - Images for each comparison for the latest two months
  - Statistics for last month
    - Each NOAA orbit (ascending and descending)
    - Scatter plots, mean differences, standard deviations
- Monitored on the Intranet
  - Images for each comparison since the MTSAT-1R operation
  - Statistics in addition to the disclosed Web page
    - Each and monthly statistics since the MTSAT-1R operation
    - Temporal variation charts (mean differences and STDV)

Match Up Conditions

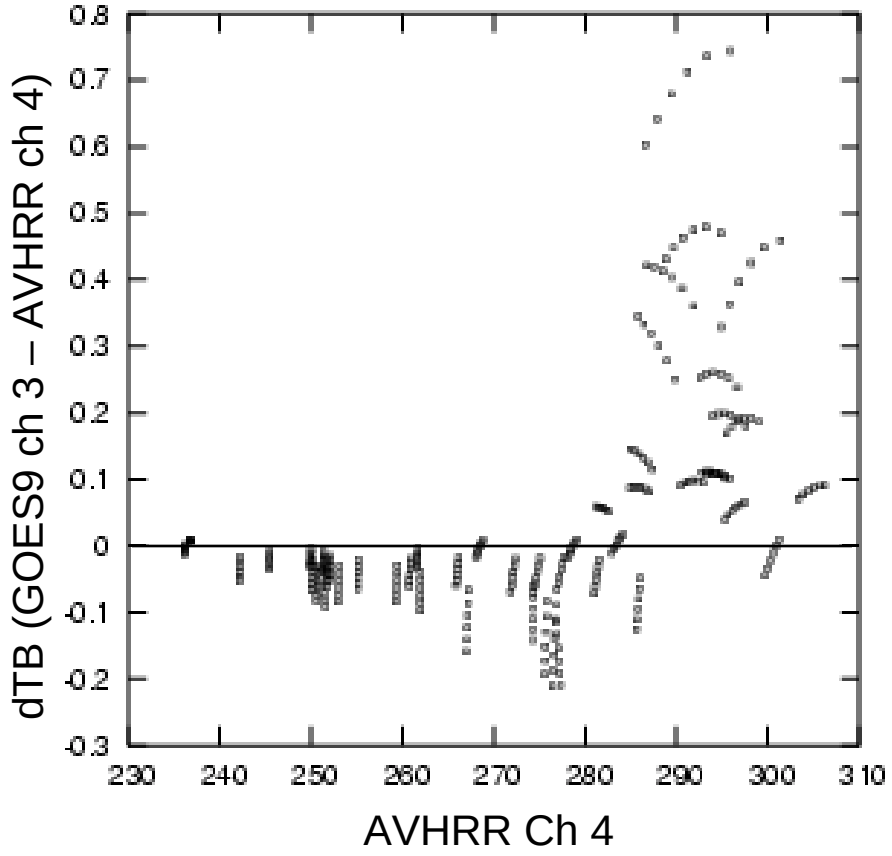
Comparison	Clear sky and ocean	Smooth cloud top
Domain	30 N to 30 S Ocean	30 N to 30 S
Position	Difference of observing positions between MTSAT-1R and NOAA < 3 km	Same as left
Time	Difference of observing times < 30 minutes	Difference of observing times < 5 minutes
Satellite zenith angle (SZA)	Difference of secant SZAs < 0.03	Same as left
Uniformity check	| Tb(target) – Tb(5x5 surrounding pixels) | < 0.2 K for MTSAT-1R IR1 and AVHRR Ch. 4	| Tb(target) – Tb(5x5 surrounding pixels) | < 3 K for MTSAT-1R IR1 and AVHRR Ch. 4
Tb range	none (Tb > 260 K due to the uniformity chk)	Tb < 260 K for MTSAT-1R IR1 and AVHRR Ch. 4

What's Available from MTSAT-1R Intercal.

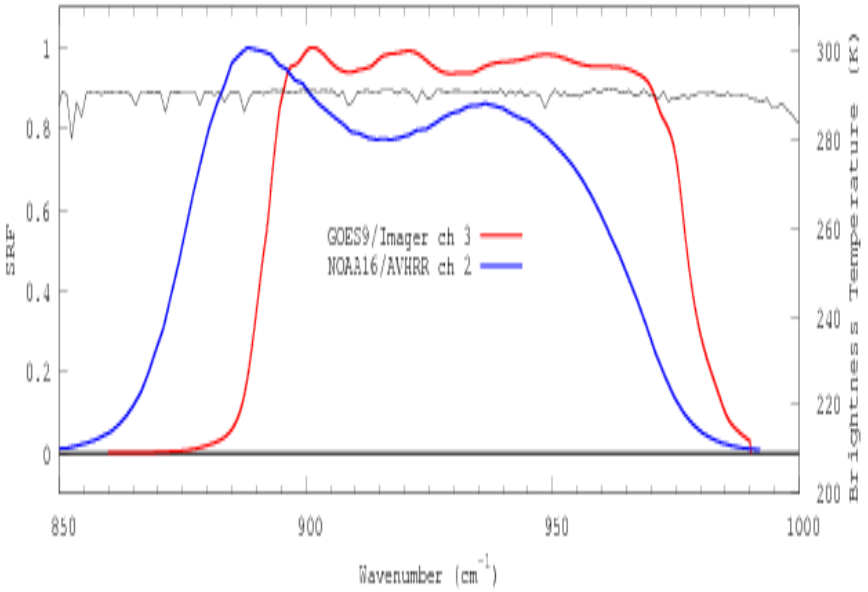
- Method
  - Information classified into warm and cold TB regions
  - No TB simulation using RT and NWP to mitigate SRF differences
- Temporal scale
  - Diurnal cycle (3 NOAA satellites), seasonal cycle and annual trend
- Only near nadir region compared
  - No scan, look or solar angle dependency (only night for 3.8 um channel)
  - No mirror angles or other sensor/satellite parameter dependency
- Statistics
  - Mean differences (and standard deviations)
  - No regression fitting
- Images
  - Map images for each comparison
  - No averaged comparison map
- Offline information
  - Charts of SRFs
  - No comparison of simulated TBs regarding sample atmospheric profiles

Why High Spectral Resolution Sounder (HSRS) Needed for Intercalibration?

Simulated TB comparison between GOES-9 ch 3 and NOAA16/AVHRR ch 4



SRFs of GOES-9/Imager ch 3 and NOAA16/AVHRR ch 4

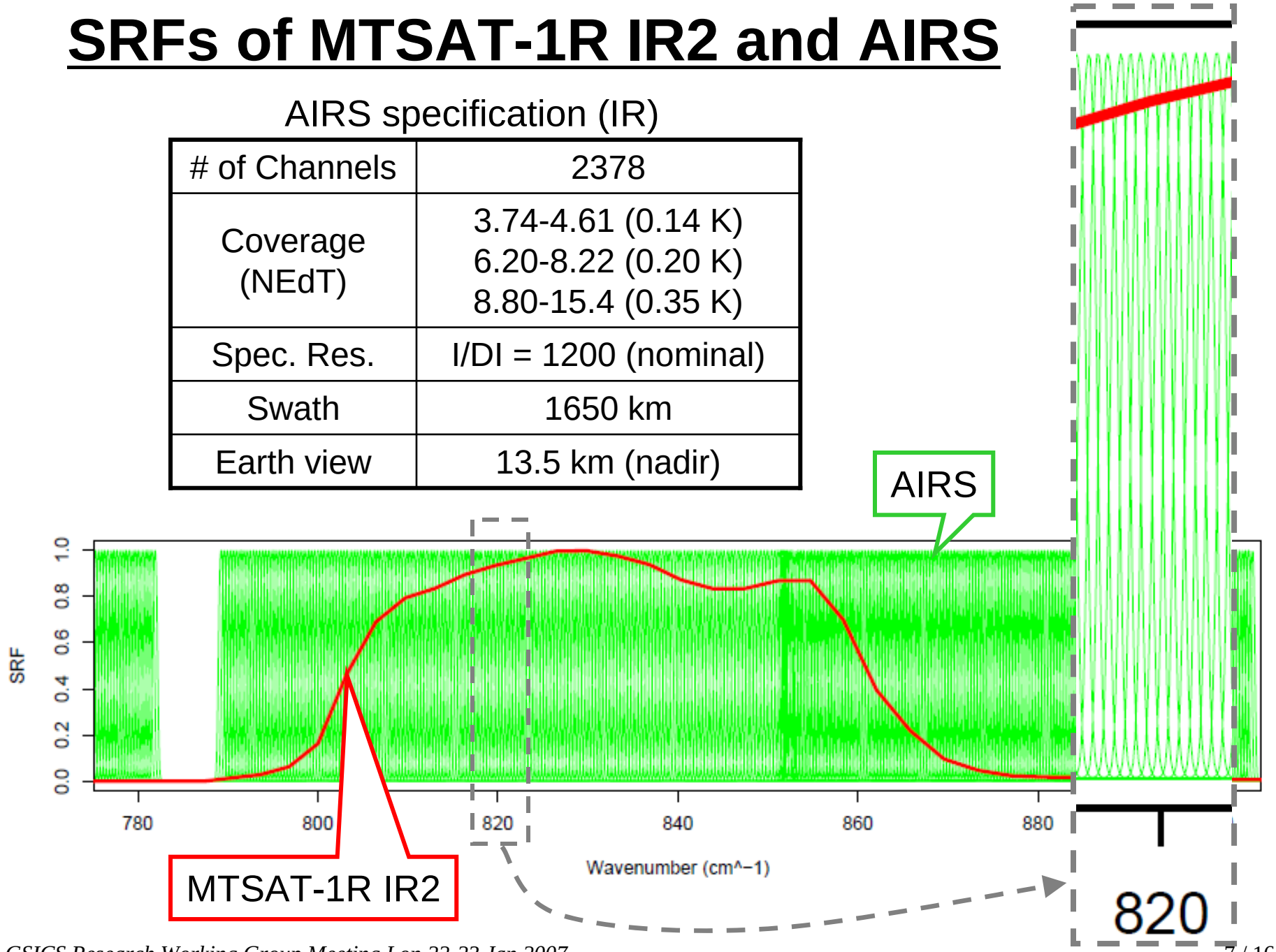


- TBs are computed by using simulated transmittances regarding the 48 UBMC atmospheric profile set with 6 incidence angles.
- The transmittances are computed by Paul van Delst by using LBLRTM with the HITRAN2000 spectroscopy database including AER updates.

SRFs of MTSAT-1R IR2 and AIRS

AIRS specification (IR)

# of Channels	2378
Coverage (NEdT)	3.74-4.61 (0.14 K) 6.20-8.22 (0.20 K) 8.80-15.4 (0.35 K)
Spec. Res.	I/DI = 1200 (nominal)
Swath	1650 km
Earth view	13.5 km (nadir)



Generation of Virtual Channel from HSRS

Radiance observed by a broadband channel is

$$I_b = \int S_b(\nu) I(\nu) d\nu, \qquad \text{where} \qquad \int S_b(\nu) d\nu = 1.$$

Radiance of a virtual channel (linear combination of HSRS radiances) is

$$I_b \approx \sum_i w_i I_i = \int \left\{ \sum_i w_i S_i(\nu) \right\} I(\nu) d\nu.$$

$$I_i = \int S_i(\nu) I(\nu) d\nu$$

$$\int S_i(\nu) d\nu = 1$$

They should be approximately equal for any *I(ν), then*

$$S_b(\nu) \approx \sum_i w_i S_i(\nu)$$

To obtain w_i, solve

$$\text{argmin} \;\; J(w_1, w_2, \cdots) = \int \left\{ S_b(\nu) - \sum_i w_i S_i(\nu) \right\}^2 d\nu.$$

where

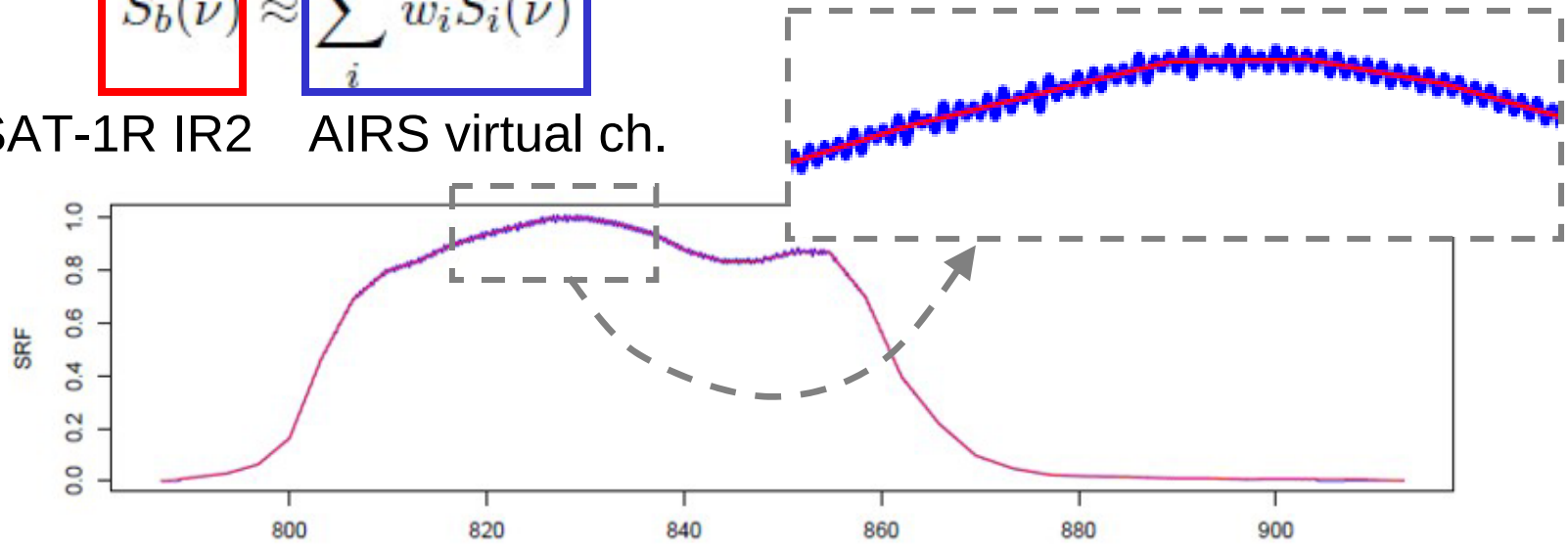
$$\frac{\partial J}{\partial w_k} = \int 2 S_k \left\{ S_b(\nu) - \sum_{i=1}^{n} w_i S_i(\nu) \right\} d\nu.$$

AIRS Virtual Channel for MTSAT-1R IR2

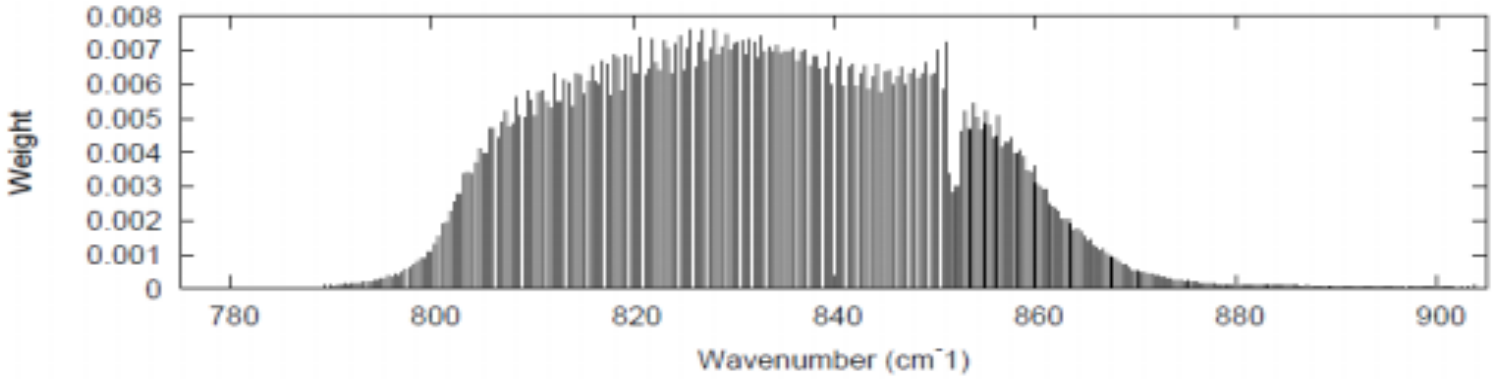
Spectral Response Functions

$$S_b(\nu) \approx \sum_i w_i S_i(\nu)$$

MTSAT-1R IR2 AIRS virtual ch.



wi : weights of AIRS virtual channel



Radiance and TB of Virtual Channel

Radiance of the virtual channel is obtained by combining HSRS radiances

$$I_v = \frac{\sum_i w_i I_i}{\sum_i w_i} \qquad \left(\text{or} \qquad I_v = \sum_i w_i I_i \qquad \text{if} \quad \sum_i w_i = 1 \right)$$

Inverse sensor Planck function is used to compute brightness temperature of the virtual channel

$$I_v = \frac{\int \sum_{i=1}^{n} w_i S_i(\nu) B(\nu, T_v) d\nu}{\int \sum_{i=1}^{n} w_i S_i(\nu) d\nu} = \frac{2hc^2(\bar{\nu}_v)^3}{\exp\left(\frac{hc\bar{\nu}_v}{KT_e}\right) - 1}$$

where $T_e \approx c_1 + c_2 T_v (+ c_3 T_v^2 + \cdots)$

Comparison of Simulated Radiance and TB

Comparisons of simulated radiances and TBs show that the virtual channel eliminate the SRF differences

Simulated radiances and TBs

	Radiance ($mW/m^2/sr/cm^{-1}$)	TB (K)
MTSAT-1R Channel IR2	110.91	289.23
Corresponding AIRS virtual channel	110.92	289.23

Simulated by LBLRTM (ver. 9.4) with HITRAN2000 and AER updates regarding the U.S. standard atmosphere

Unusable HSRS channels

Unusable channels known in advance

→ Weights and sensor Planck function without blacklist channels

$$I'_v = \frac{\sum_{i \notin \text{blacklist}} w'_i I_i}{\sum_{i \notin \text{blacklist}} w'_i} \qquad T'_v = B'^{-1}_v(I'_v)$$

Unusable channels obtained in practical (missing observations)

→ Weights and sensor Planck function without modification

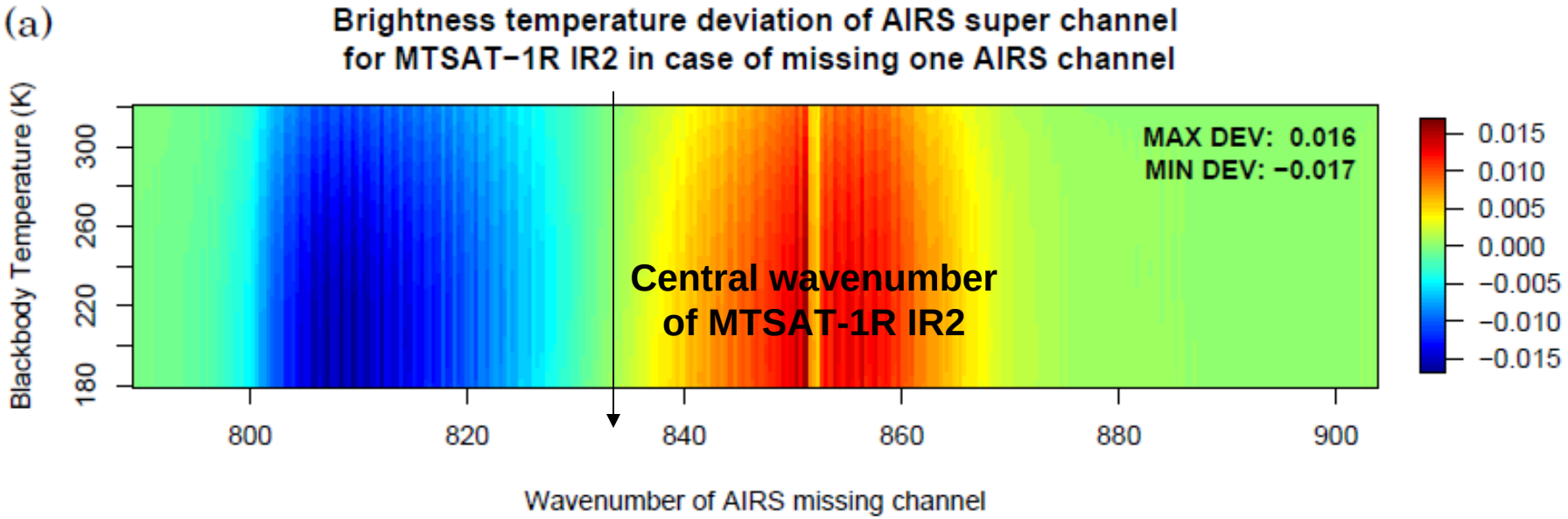
$$I''_v = \frac{\sum_{\substack{i \notin \text{missing} \\ i \notin \text{blacklist}}} w'_i I_i}{\sum_{\substack{i \notin \text{missing} \\ i \notin \text{blacklist}}} w'_i} \qquad T''_v = B'^{-1}_v(I''_v)$$

→ Brightness temperature deviation due to the missing observations

$$T''_v - T'_v = B'^{-1}_v \left(\sum_{\substack{i \notin \text{missing} \\ i \notin \text{blacklist}}} w'_i I_i \Big/ \sum_{\substack{i \notin \text{missing} \\ i \notin \text{blacklist}}} w'_i \right) - T'_v$$

Degradation by HSRS Missing Observation

Deviation caused by HSRS missing observations can be estimated in advance by assuming blackbody observation

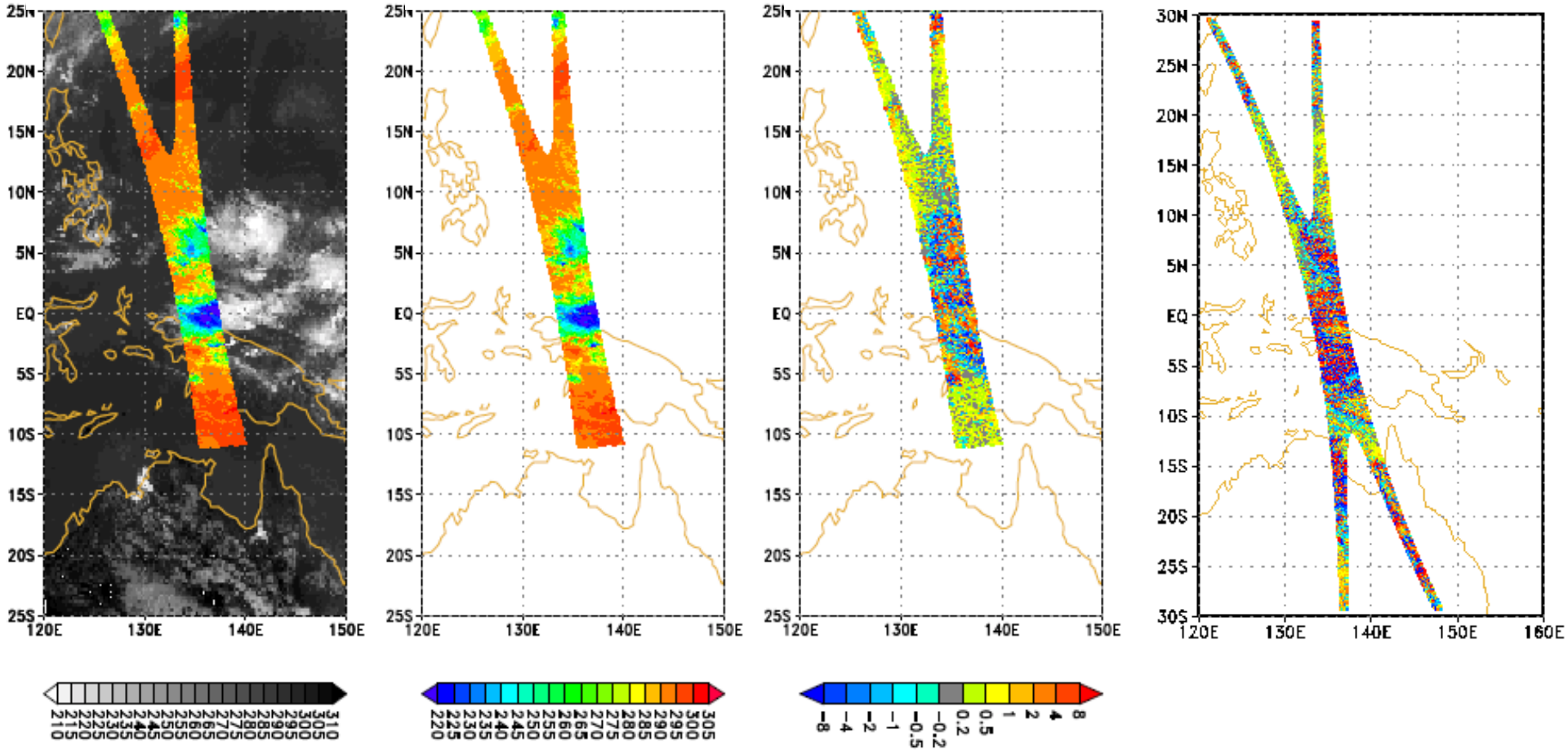


- One missing channel yields at most 0.017 K TB deviation of AIRS virtual channel for MTSAT-1R IR2
- A few missing observations in AIRS channels are acceptable to generate the virtual channel

Real Data Comparison (map)

MTSAT – NOAA18

MTSAT-1R IR2 | AIRS virtual ch | MTSAT – AIRS | AVHRR ch 5

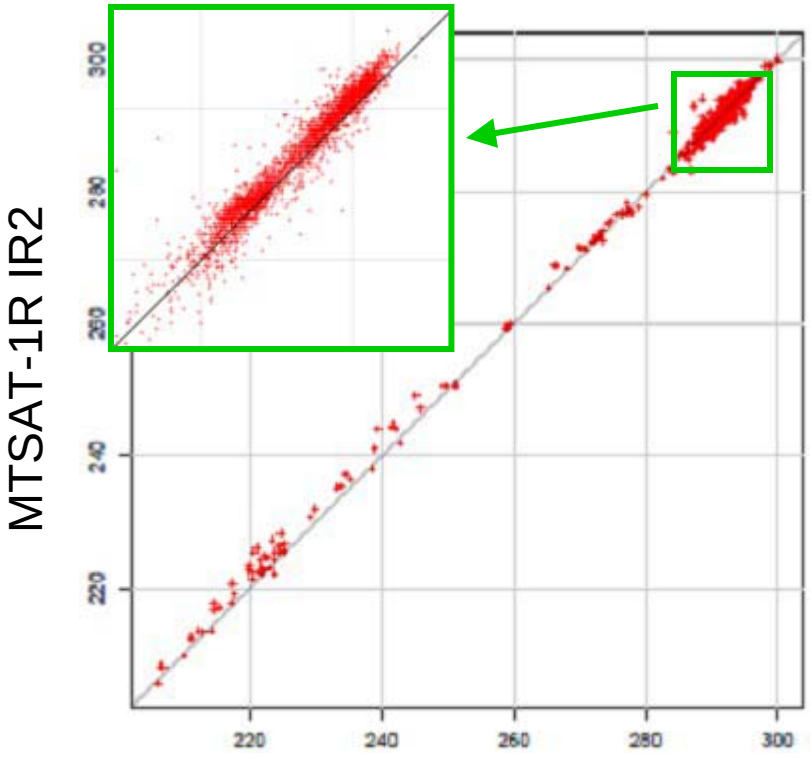


04:42 UTC, 2 Nov 2006

04:42 UTC, 3 Nov 2006

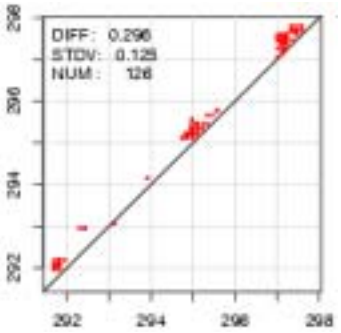
Real Data Comparison (statistics)

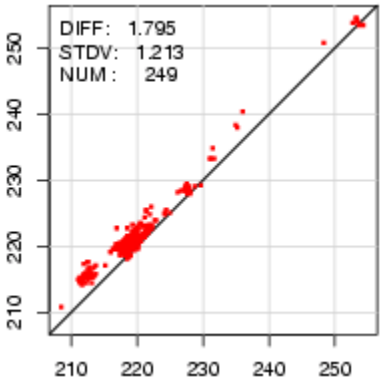
MTSAT-1R IR2 vs. AIRS virtual ch



MTSAT-1R vs. NOAA-18/AVHRR ch 5

Clear sky comparison





Smooth cloud Top comp.

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MEAN: +0.324 K (MTSAT-AIRS)
STDV:  0.551 K
CORR:  0.998
NUM :  3113
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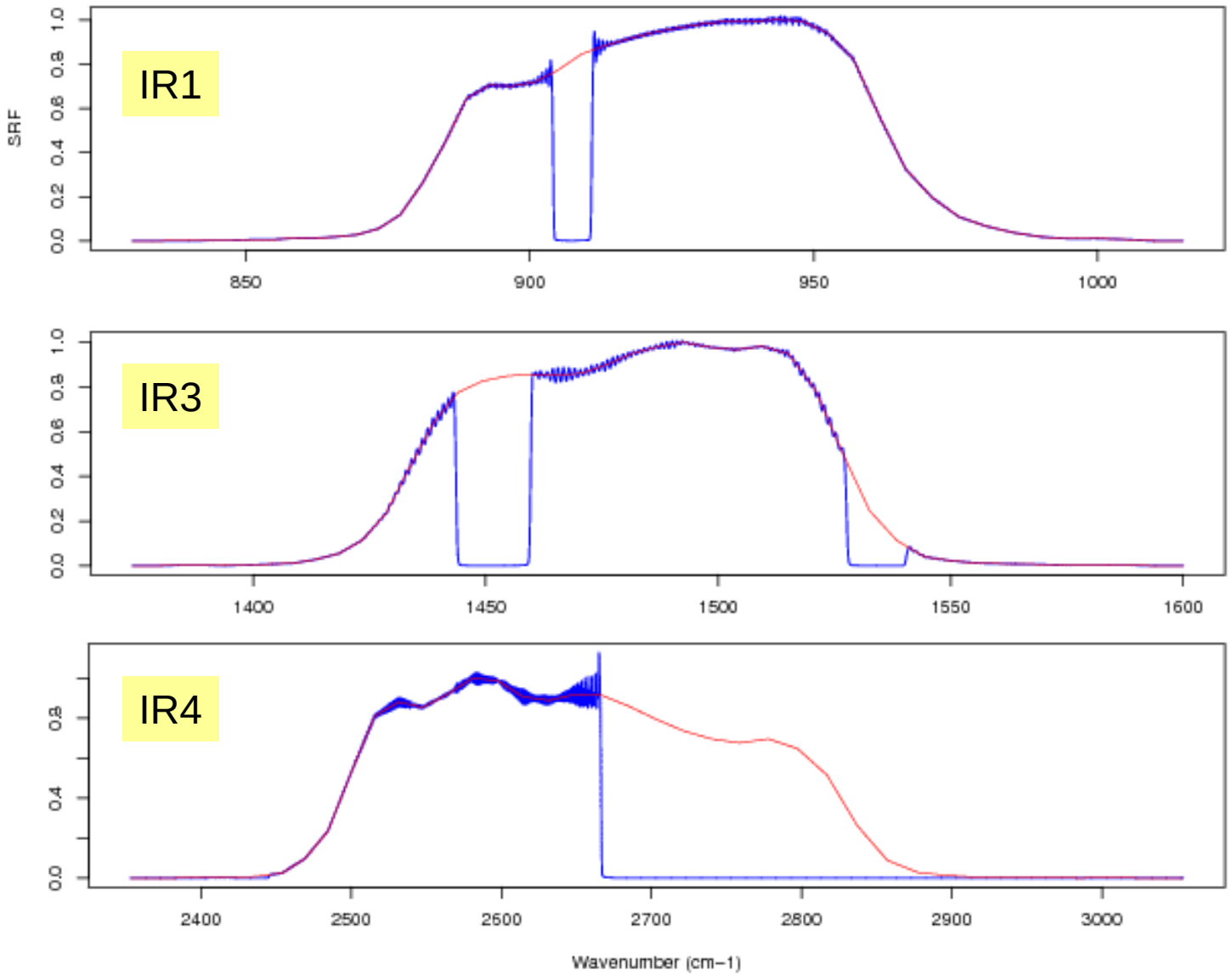
Elements of Intercalibration with HSRS

- Generation of virtual channel
  - SRFs of broadband and HSRS channels
  - Prior accuracy information regarding HSRS channels
  - Software to generate a virtual channel and its sensor Planck function
  - (optional) Evaluation of simulated radiances and TBs
  - (optional) Estimation of the impact of HSRS missing channels (Sensor Planck functions of the HSRS channels required)
- Conduction of inter-comparison
  - Usual inter-comparison tools
    - Data collection, condition check, statistics computation, drawing, Web pages, analyses and reports
  - Quality control system of HSRS data (NWP comparison?)
  - Software to compute TBs of the virtual channel
  - Or the TBs computed at a particular HSRS data center and delivered to save network traffic

SRFs of MTSAT-1R IR1, 3, 4 and AIRS virtual channels



Comparisons of simulated radiances and TBs

		IR1	IR2	IR3	IR4
TB (K)	MTSAT-1R	290.48	289.23	238.26	290.99
	AIRS virtual Ch.	290.53	289.23	237.95	290.92
	Difference	0.05	0.00	0.31	0.07
Radiance ($mW/m^2/sr/cm^{-1}$)	MTSAT-1R	97.23	110.91	5.06	0.477
	AIRS virtual Ch.	97.04	110.92	4.93	0.599
	Difference (%)	0.2	0.01	2.6	25.6

Simulated by LBLRTM (ver. 9.4) with HITRAN2000 and AER updates regarding the U.S. standard atmosphere

Comparisons of Real Observations

04:42 UTC, 2 Nov 2006