[S6-08_Imasu]

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Investigation of loading an infrared sounder on a geostationary satellite by the infrared sounder subcommittee of the Next Generation GEO/Mission Investigation Team (NGG/MInT)

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Outline

1. Organizations
2. Review of past/future infrared sounders
3. Observing System Simulation Experiment (OSSE)
4. Feasibility study on the imaging FTS by JAXA
   based on TANSO-FTS on GOSAT

[Reference]
Imasu et al., Investigation of Loading an Infrared Sounder on a Geostationary Satellite by the Next Geostationary Satellite Mission Study Group Subcommittee, *J. Remote Sens. Soc. Japan*, **41**, 469-477, 2021.

GOSAT：Greenhouse gases Observing SATellite
TANSO-FTS : Thermal And Near Infrared Sensor for carbon Observation - FTS

1. Organizations

" Remote Sensing Subcommittee under the Task Force (TF) on the Future Space System Development" was established in 2013
「今後の宇宙開発体制のあり方に関するタスクフォース(TF)・リモートセンシング分科会」
地球観測に関わる日本国内の23の学会にまたがる組織として2013年設立

- It is supported by 23 academic societies relating to the earth observation in Japan
- For summarizing user requirements for satellite remote sensing and future mission plans

Sub-organization:
"NGG/MInT: Next Generation GEO/Mission Investigation Team"
サブ組織:「将来の静止衛星観測に関する検討会」

- For discussing the future geostationary-satellite based sensor development
- It consists of four subcommittees, imager, IR sounder, lightning sensor, and MW sensor

"Infrared Sounder Subcommittee"
「赤外サウンダー分科会」

- For the feasibility study on the infrared sounder onboard Japanese geostationary satellites
- Detailed review of past infrared sounders
- Observing System Simulation Experiment (OSSE)

2. Review of past/future infrared sounders

[Background]
- Operation of Himawari-8, 9 will end around 2029
- Follow on program must be started in 2023
- World Meteorological Organization (WMO) recommends a hyperspectral sounder (HSS) as one of the onboard equipment for geostationary satellite
- Most of the HSS currently in operation are FTS (TANSO-FTS, IASI, CrIS, HIRAS, ...)

[Geostationary satellite]
= 1980s ～ =
- Filter type sounders on GOES (USA) and INSAT (India)
= 1990s ～ =
- HES/GOES-R series (NOAA) ... canceled in 2006
- GIFTS/GOES-R series (NASA, Wisconsin U) ... canceled in 2006

= 2010 ～ =
- GIIRS/FY4 series (in 2016, China)
- IRS/MTG-S (in 2022, 2024, ESA)
- ABX (L3Harris)
- GEO-XO (GOES-R follow on) (during 2030-2050, NOAA)
  (ABX is a candidate of Phase-A study started in 2021)
- GEO-Ring (global network)

(Imasu et al., 2021)

Sensor	IRS	GIIRS	ABX	IASI	TANSO-FTS, -FTS-2
Satellite	MTG-S	FY-4A	—	Metop-A, -B, -C	GOSAT, GOSAT-2
Launch	2024	2016	—	2006, 2012, 2018	2009, 2018
Orbit	Geostationary	Geostationary	Geostationary	Polar	Polar
Spectral band	MWIR: 1600–2250 cm^{-1} LWIR: 680–1210 cm^{-1}	VIS: 0.55–0.75 μm MWIR: 1650–2250 cm^{-1} LWIR: 700–1130 cm^{-1}	VIS: panchromatic Day/Night opt. band MWIR: 1210–1750 cm^{-1} or 1650–2250 cm^{-1} LWIR: 680–1120 cm^{-1}	SWIR: 2000–2760 cm^{-1} MWIR: 1210–2000 cm^{-1} LWIR: 645–1210 cm^{-1}	NIR: 12900–13200, 12950-13250 cm^{-1} SWIR: 5800–6400, 5900-6400 cm^{-1} SWIR: 4800–5200, 4200-5200 cm^{-1} TIR: 700–1800, 700-1800 cm^{-1}
Orbital height	36000 km	36000 km	36000 km	817 km	666 km, 613km
Sampling interval	0.625 cm^{-1}	0.625 cm^{-1}	0.625 cm^{-1}	0.25 cm^{-1}	0.2 cm^{-1}
IFOV (Nadir)	4 km	VIS: 2 km IR: 16 km	VIS: 0.6 km IR : 4 km	12 km	10.5 km, 9.7km
SNR/NEdT/NEdN	NEdT < 0.17-0.9 K@280 K	VIS: SNR > 200 MWIR: 0.1–0.14(1) LWIR: 0.5–1.1(1)	NEdN: 0.05–1 mW/m^2 sr cm^{-1}	NEdT < 0.5 K@280 K	SNR > 300-400
Observation area and freq.	Full disk : 60 min LAC: 15 min	5000km x 5000km over China: 60 min (Firster mode opt.)	Full disk : 30 min LAC: 2.5 min	29 rep. cycle 2200 km swath: 8 sec	6 rep. cycle (3 sub-rep. cycle) Local time: 13:00
Grid points	160×160 (Array)	32×4 (Array)	VIS: 2048×2048 IR : 128×128 (Array)	2×2 (Array)	1 (Point sensor)
Integration time	10 sec	N/A	N/A	0.151 sec	4 sec

3. Observing System Simulation Experiment (OSSE)

[Method]

- Meteorological data : ERA5 (Hersbach et al. 2020)
- Assimilation system based on a weather forecast model of JMA
- Inputs : Radiances simulated by RTTOV for a Hyperspectral Infrared Sounder on a geostationary satellite, the Himawari

[Conclusion]

It was shown that the accuracy of precipitation forecasting is improved by assimilating the water vapor profile observed by the infrared sounder mounted on the geostationary satellite

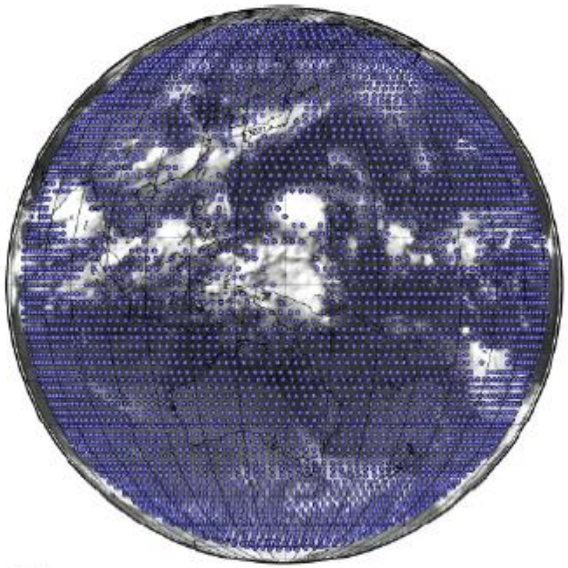
[References]

Okamoto et al., Assessment of the Potential Impact of a Hyperspectral Infrared Sounder on the Himawari Follow-On Geostationary Satellite, *SOLA*, **16**, 162−168, doi:10.2151/sola.2020-028, 2020.

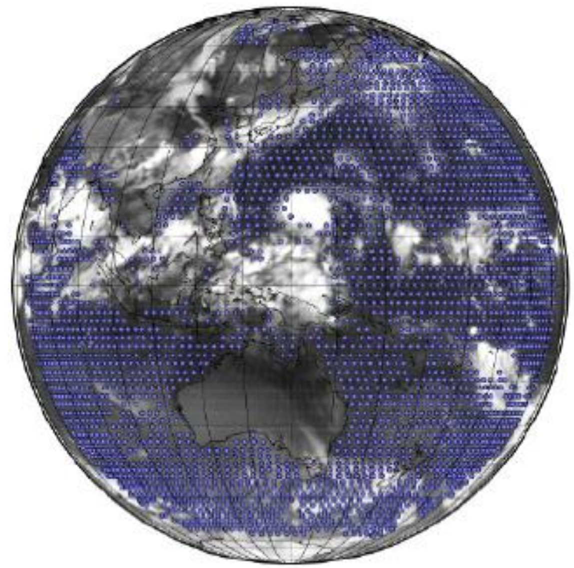
岡本幸三他, ひまわり8･9号後継衛星検討のためのハイパースペクトル赤外サウンダーの数値予報インパクト調査, *測候時報*, **87**, 99-150, 2020.

【Case 1】Global : Tropical cyclones

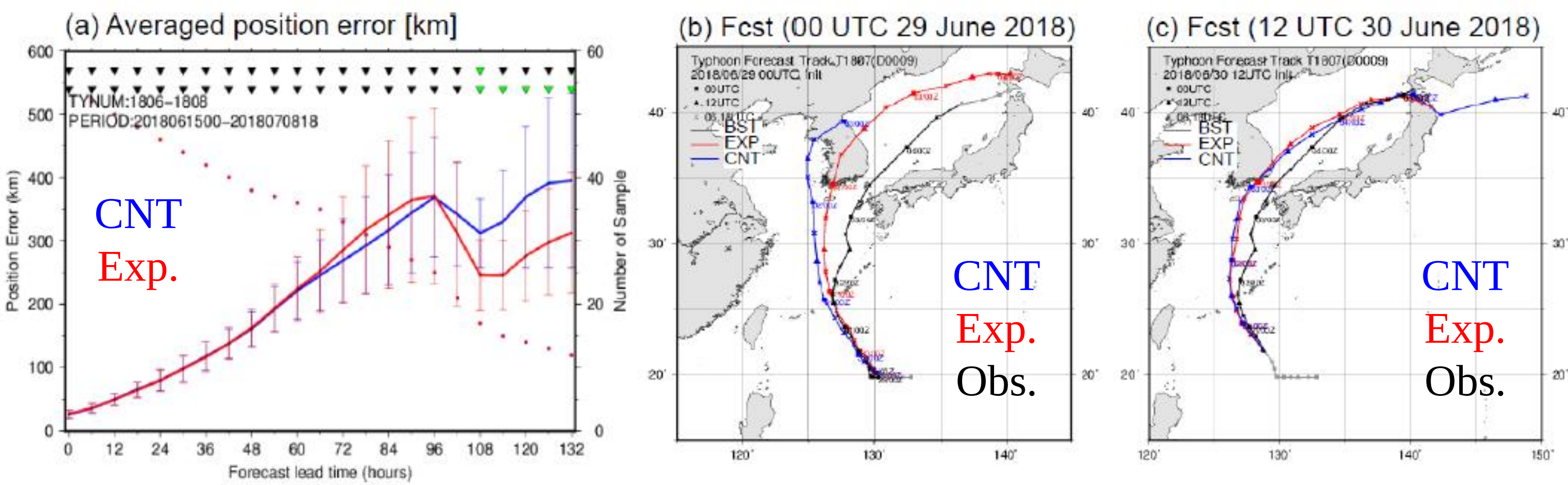
Temperature ～250 hPa (14.260 μm)



Humidity ～850 hPa (5.092 μm)

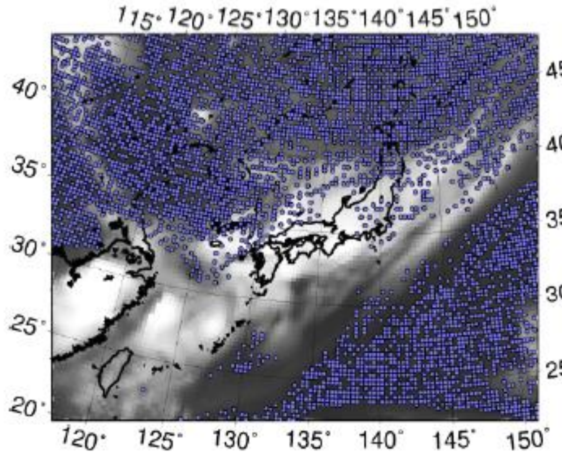


Assimilation results : Forecasted location (Okamoto et al., 2020)

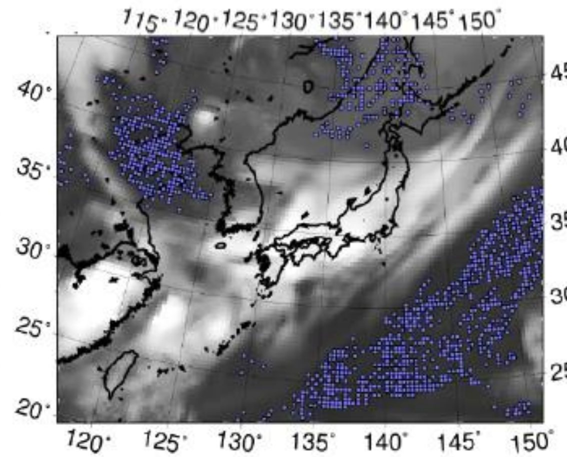


【Case 2】Regional : Heavy rainfall

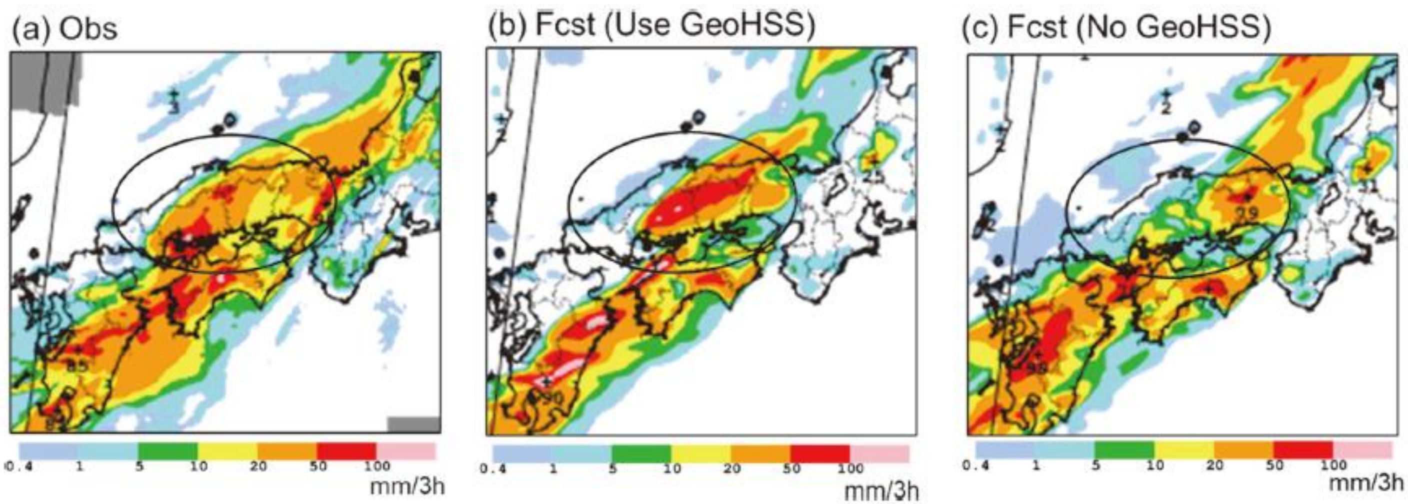
Temperature 150 - 250 hPa



Temperature 850 - 1000 hPa



Assimilation results : Precipitation (Okamoto et al., 2020)



Improvement of the heavy rainfall in the Chugoku region of western Japan as a results of enhanced southwesterly moisture flow off the northwestern coast of the Kyushu Island

4. Feasibility study on the imaging FTS by JAXA based on TANSO-FTS on GOSAT

[Requirements]

- Administrative needs by MOE for the measurements of Greenhouse Gases particularly for detecting diurnal variations (rush hour, nighttime peaks, and so on)

[Proposal]

- An Integrated system for both weather prediction and GHG measurements

[One possible solution]

- Geostationary system based on the GOSAT main sensor, TANSO-FTS
- JAXA started feasibility study for it.

[Difficulty]

- Orbit height: 600 km --> 36,000 km --> light intensity: 1/3,600
- It is difficult to increase the effective beam diameter

[Approaches]

- Afocal optics (afocal ratio: Max.3 to avoid degradation of interference efficiency)
- Increasing integration time (10 sec similar to IRS/MTG-S)
- Expanding IFOV (4, 8, 12, 16 km)

* Assuming "Scene shot noise" : "System noise" = 2:1

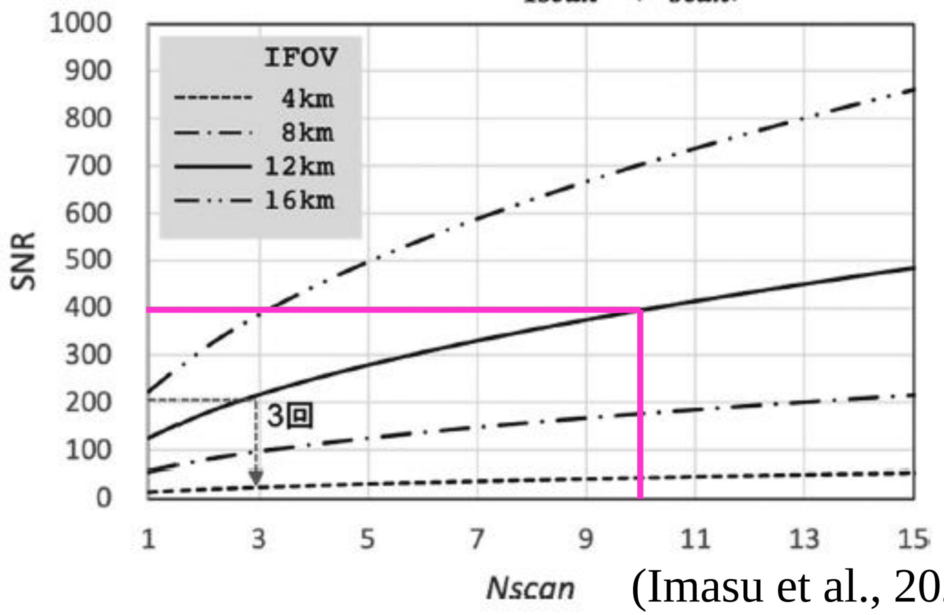
Imaging FTS based on TANSO-FTS on GOSAT

	TANSO-FTS	Scaling conditions for GeoHSS			
Orbital height	666km	36,000km			
Polarization	Yes	Non			
Afocal ratio	1	3			
Effective beam diameter	64mm	73mm			
Sampling interval	0.2cm^{-1}	0.625cm^{-1}			
Integration time	4sec	10sec			
IFOV	10.5km	4km	8km	12km	16km
Light intensity ratio	1	0.012	0.046	0.104	0.185
SNR_{1scan}	> 400	13.9	55.5	124.8	221.9

[Conclusion]
- Difficult to satisfy the requirements from WF and GHG at the same time

[Realizable solution]
- Time-sharing operation for WF and GHG
- Localization of measurements considering the importance of the data

$$SNR = SNR_{1scan} \times (N_{scan})^{1/2}$$



(Imasu et al., 2021)

Future works

［Observing System Simulation Experiment (OSSE)］
- Simulating retrieval processes assuming ILSF (instrumental line shape function)
- Impact analyses for the time-sharing observations and localizations of measurements on the weather forecasting

［Feasibility study on the imaging FTS by JAXA based on TANSO-FTS on GOSAT ］
- Optimization of integration time, IFOV, sampling interval, spectral resolution
- Better detector performance
- Improving the pointing system

Thank you !

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