15p.07

Using CIRAS and MicroMAS-2 to mitigate the data gap of CrIS and ATMS

Zhenglong Li[1], Jun Li[1], Pei Wang[1], Agnes Lim[1], Timothy J. Schmit[2], Jinlong Li[1], Frederick W. Nagle[1], Robert Atlas[3], Sid Boukabara[2], Thomas Pagano[4], William Blackwell[5], and John Pereira[6]
[1]Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin-Madison
[2]Center for Satellite Applications and Research, NESDIS/NOAA
[3]Atlantic Oceanographic and Meteorological Laboratory, NOAA, Miami, Florida
[4]Jet Propulsion Laboratory, Pasadena, CA, United States
[5]MIT Lincoln Laboratory, Arlington, VA, United States
[6]Office of Projects, Planning, and analysis, NESDIS/NOAA, Silver Spring, MD, United States
Email: zhenglong.li@ssec.wisc.edu

1. Introduction

- LEO satellites have been proven great success in global forecast.
- Most of existing LEO satellites are overdue, passed the expected end of life (Table 1).
- JPSS will be the only afternoon orbit from NOAA (Table 2)
- Potential data gap when there is only one SNPP/JPSS satellite in orbit from CrIS and ATMS.
- Can we use CubeSat microwave (MW) and infrared (IR) sounders to mitigate the data gap? Can MicroMAS-2/CIRAS be used to mitigate the data gap of ATMS/CrIS for local severe storm (LSS)? Can multiple MicroMAS-2/CIRAS be used to mitigate the data gap of ATMS/CrIS for LSS?
- For details of the high resolution nature run (HRNR), see poster #15p.06.

Satellites	Start	Expected end of life	Orbits
NOAA-15	1998	2001	5:00 pm
NOAA-18	2005	2009	3:00 pm
NOAA-19	2009	2013	1:30 pm
Metop-a	2006	2011	9:30 am
Metop-b	2012	2018	9:30 am
S-NPP	2012	2016	1:30 pm
Aqua	2002	2008	1:30 pm

Table 1. Existing LEO satellites

Satellites	Start	Expected end of life	Orbits
Metop-a	2006	2011	9:30 am
Metop-b	2012	2018	9:30 am
Metop-c	2018	2023	9:30 am
JPSS-1	2017	2024	1:30 pm
JPSS-2	2021	2029	1:30 pm

Table 2. Near future LEO satellites

CubeSat

- Micro-sized Microwave Atmospheric Satellite-2 (MicroMAS-2) – MIT Lincoln Lab
  - 12 channels (7 T + 3 Q)
  - Spatial resolution: 27 (T)/17(Q) km
- CubeSat Infrared Atmospheric Sounder (CIRAS) -- JPL
  - 625 channels
  - Spectral resolution of 0.6 – 1.0 cm^{-1}
  - Shortwave CO_2 1950 – 2450 cm^{-1}
  - Spatial resolution of 14 km

JPSS

- ATMS
  - 22 channels (11 T + 9 Q)
  - Spatial resolution: 35(T)/17 (Q) km
- CrIS
  - 1305 channels
  - Spectral resolution of 0.625/1.25/2.5 cm^{-1} for LWIR/ MWIR/SWIR
  - Spatial resolution of 14 km

Overall, CubeSat sounders do not have same quality as conventional sounders, but they are cheap and multiple units could be launched to enhance the data (coverage, temporal resolution etc).

2. Synthetic observation simulation

2.1 CubeSat orbit simulator

A LEO orbit simulator is develop to simulate CubeSat with different satellite altitude and inclination. Figure 1 shows MicroMAS-2 and CIRAS in polar orbits (sun-synchronous, inclination of 98.5 degree) and MicroMAS-2 in TROPICS orbits (inclination of 30 degree). Figure 2 shows the comparison to CrIS and ATMS orbits.

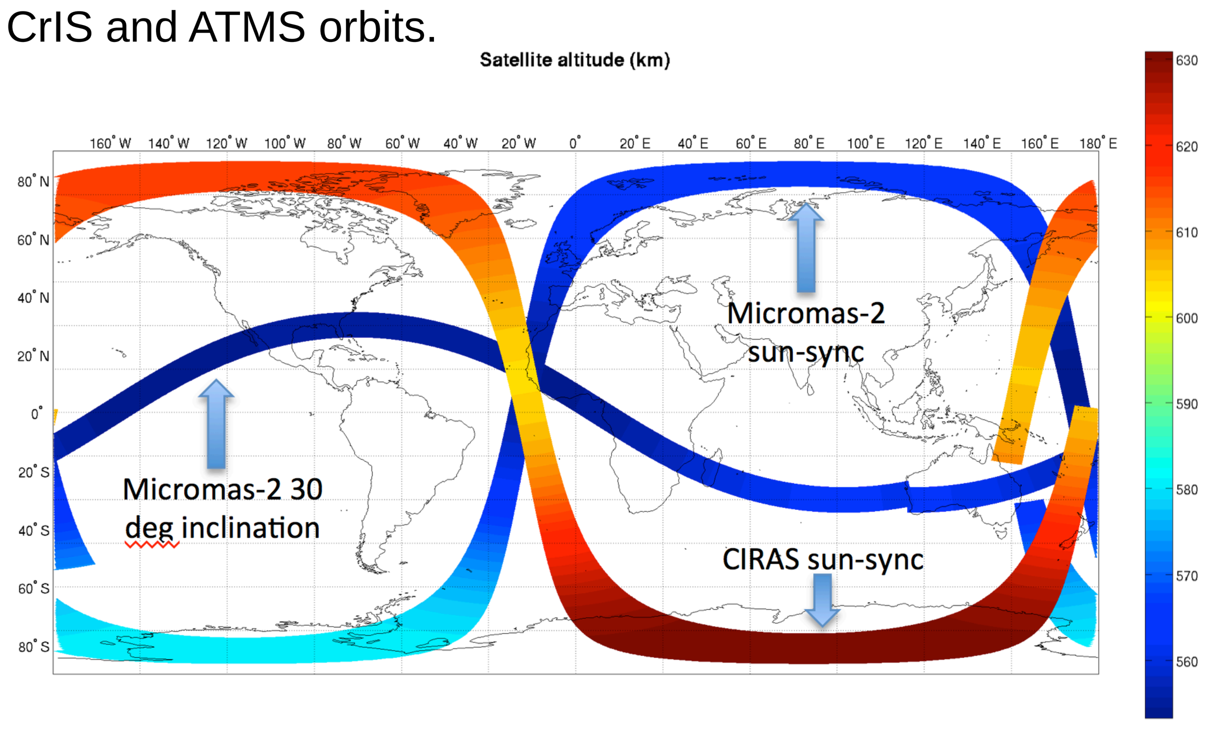


Figure 1. Satellite altitudes of MicroMAS-2/CIRAS in different orbits.

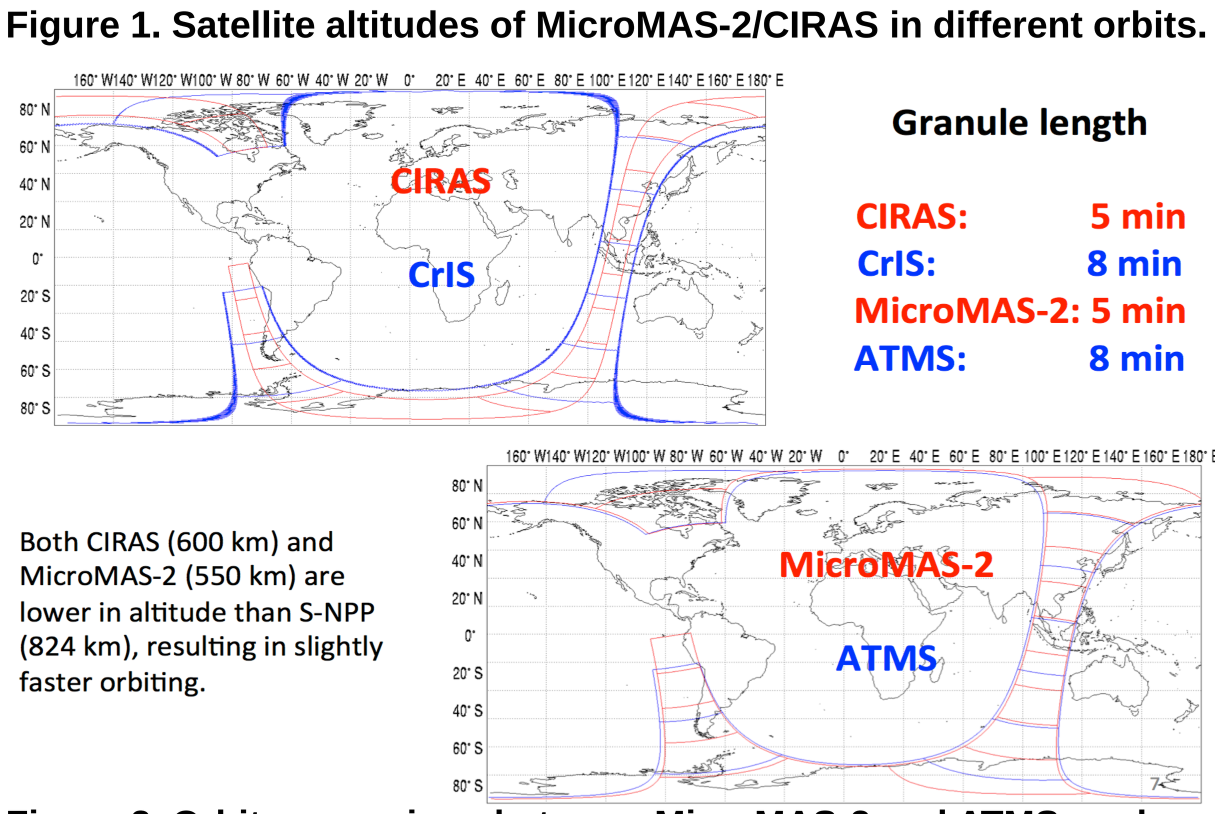


Figure 2. Orbit comparison between MicroMAS-2 and ATMS, and between CIRAS and CrIS.

2.2 Radiance simulation

- CRTM ODPS coefficients are developed by CRTM team to simulate radiances for MicroMAS-2 and CIRAS.
- Three MicroMAS-2/CIRAS are put into sun synchronous orbits:
  - one in same orbit as SNPP (1:30 pm overpass)
  - one in orbit 3 hours ahead (10:30 pm overpass)
  - one in orbit 3 hours later (4:30 pm overpass)
- Figure 3 shows the comparison of CIRAS to IASI and CrIS. And Figure 4 shows the comparison of MicroMAS-2 to ATMS for three common channels.
- RAOB is simulated to represent GTS, and AMSU-A/IASI from Metop-B are simulated to represent the existing capability from space.

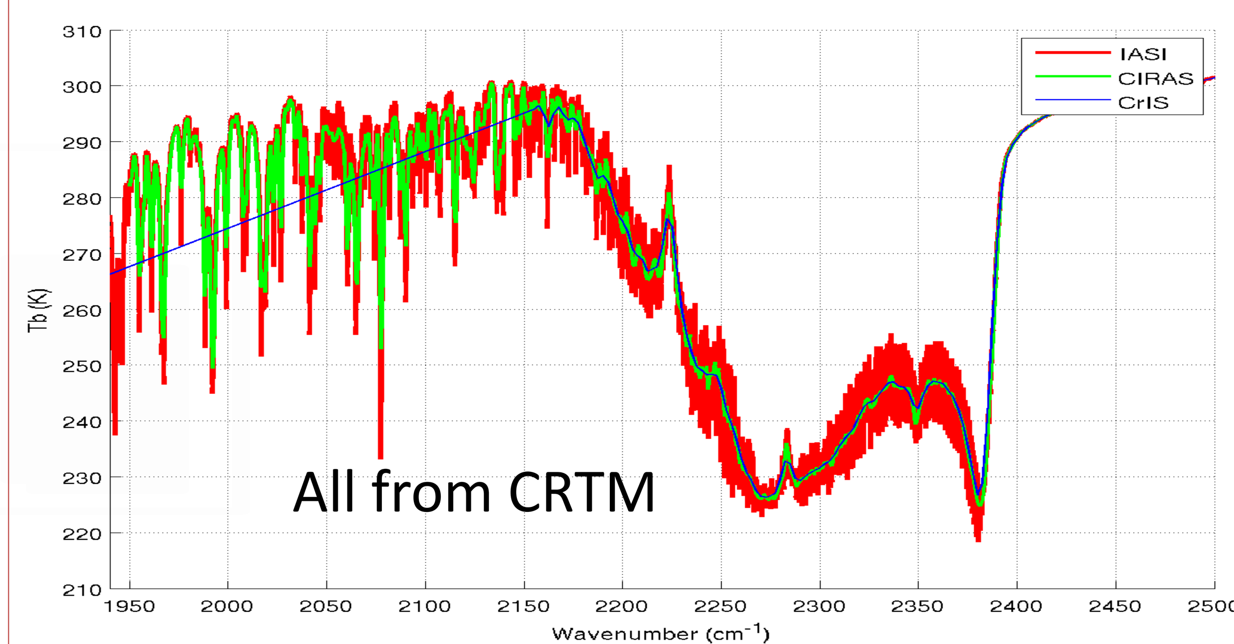


Figure 3. Simulated radiances from CIRAS, IASI and CrIS using US standard atmosphere profile.

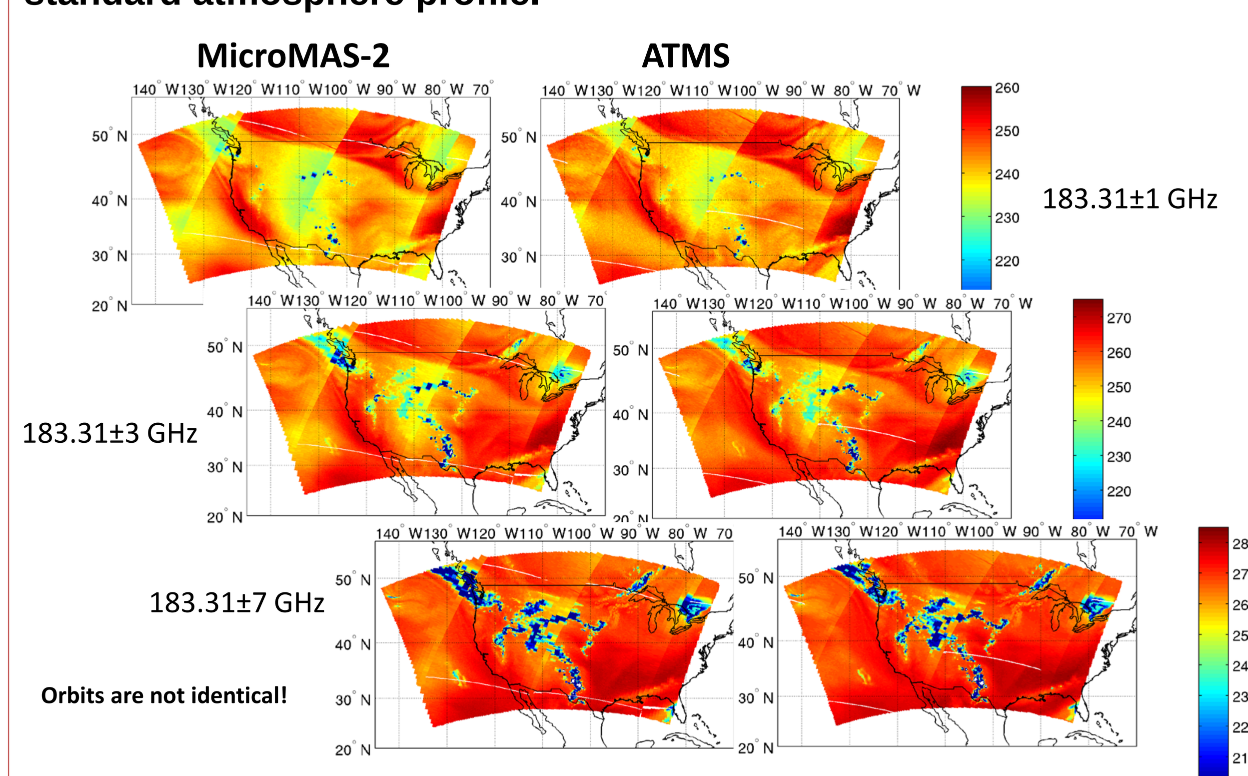


Figure 4. Simulated radiances for 3 common channels from MicroMAS-2 and ATMS using HRNR.

3. Assimilation experiments and impact study

3.1 Assimilation strategy

- Both MicroMAS-2 and CIRAS are new instruments, not immediately ready for assimilation in GSI.
- Linear relationship to convert MicroMAS-2 radiances (12 channels) to ATMS radiances (22 channels).
- ATMS channels well predicted will be directly assimilated; total 11 ATMS channels selected; converted to BUFR.
- Synthetic sounding retrievals conducted for CIRAS and CrIS and converted to PREPBUFR; Figure 5 shows the retrieval error.

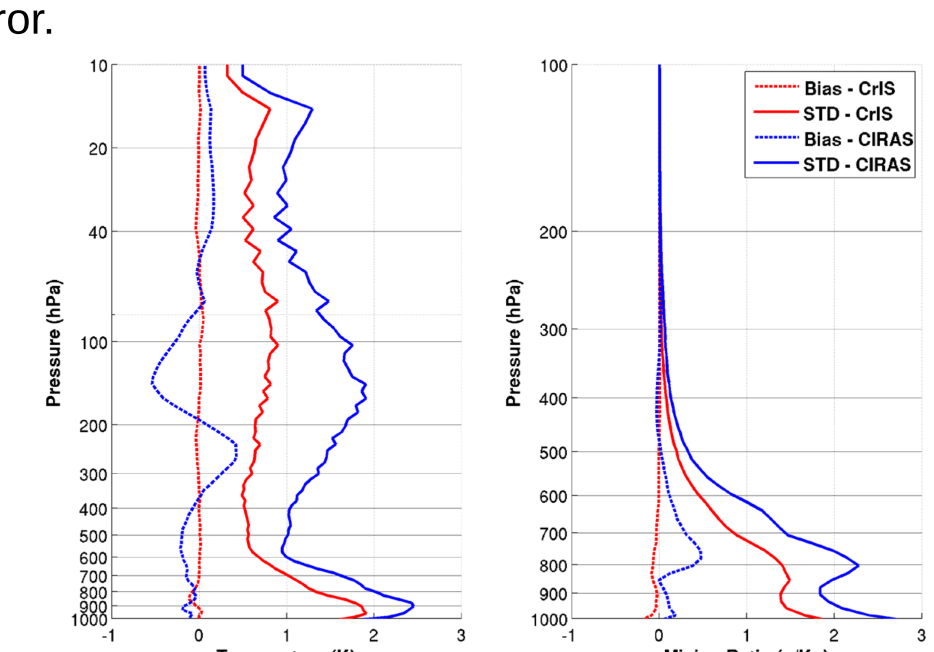


Figure 5. Retrieval validation of CIRAS and CrIS using HRNR.

3.2 Experiment design

- For details about assimilation and forecast models, and experiment design, see poster # 15p.06
- Two sets of experiments are carried out:

MicroMAS-2
- **GAP:** RAOB+AMSU-A of Metop-B + IASI of Metop-B
- **CNTL:** RAOB+AMSU-A of Metop-B + IASI of Metop-B + ATMS
- **MO1:** RAOB+AMSU-A of Metop-B + IASI of Metop-B + MicroMAS_130
- **MO2:** RAOB+AMSU-A of Metop-B + IASI of Metop-B + MicroMAS_130/430/1030

CIRAS
- **GAP:** RAOB+AMSU-A of Metop-B + IASI of Metop-B
- **CNTL:** RAOB+AMSU-A of Metop-B + IASI of Metop-B +CrIS
- **MO1:** RAOB+AMSU-A of Metop-B + IASI of Metop-B + CIRAS_130
- **MO2:** RAOB+AMSU-A of Metop-B + IASI of Metop-B + CIRAS_130/430/1030

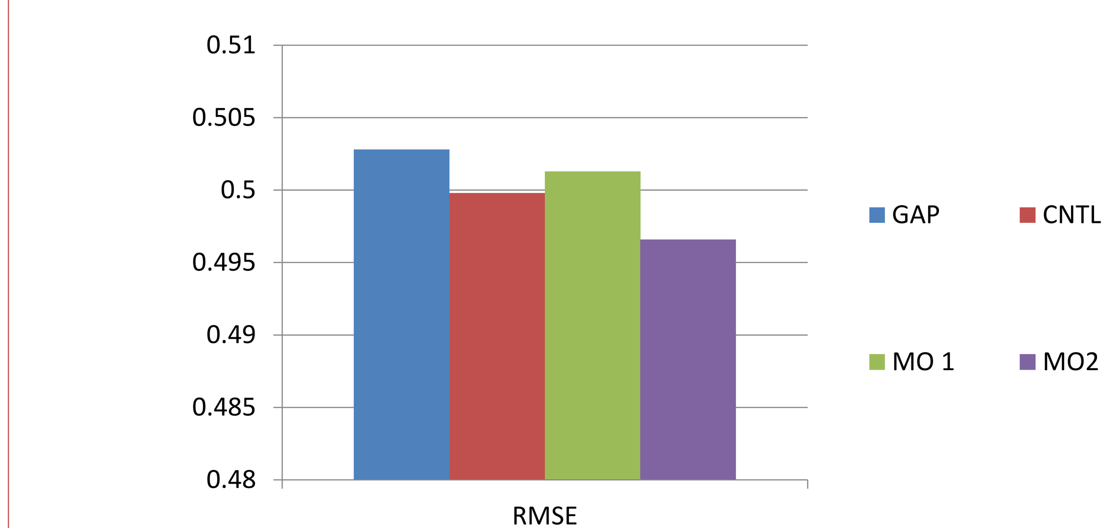
GAP: No CrIS and ATMS **CNTL:** Control **MO:** Mitigation Option

3.3 Impact study on LSS

A single normalized RMSE is used to evaluate the overall performance of the analysis and forecast. For more details, see Poster # 15p.06.

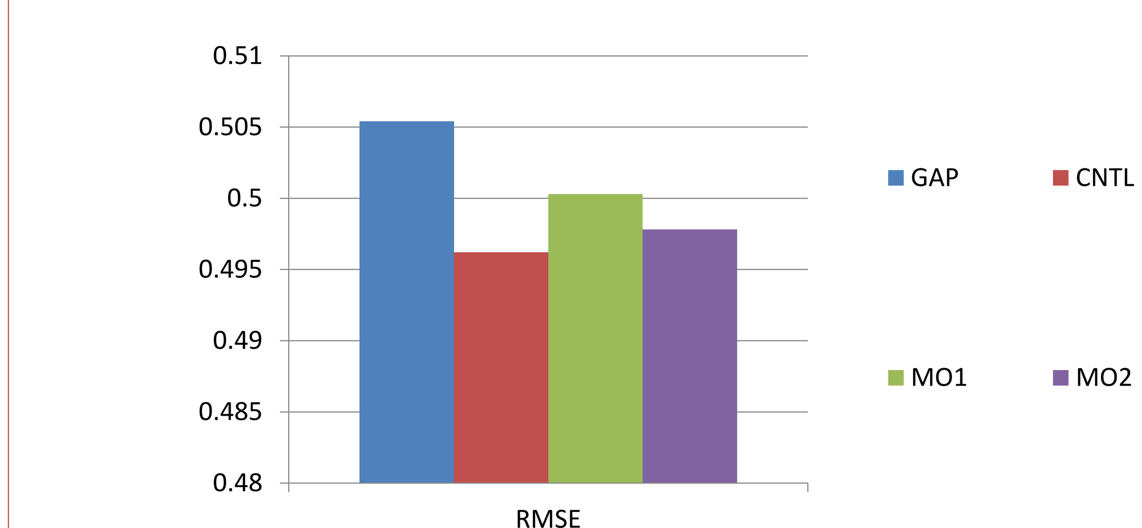
3.3.1 Impact of MicroMAS-2

	GAP	CNTL	MO 1	MO 2
RMSE	0.5028	0.4998	0.5013	0.4966
Percentage of error change from GAP	~	0.6	0.3	1.2



3.3.2 Impact of CIRAS

	GAP	CNTL	MO1	MO2
RMSE	0.5054	0.4962	0.5003	0.4978
Percentage of error change from GAP	~	1.8	1.0	1.5



4. Summary

- A Quick regional OSSE (r-OSSE) impact study of MicroMAS-2 and CIRAS on one local severe storm (LSS) case is carried out
- Results show that
  - 1 MicroMAS-2 is not as good as ATMS
  - 3 MicroMAS-2 show better impacts than single MicroMAS-2, even better than ATMS
  - 1 CIRAS is not as good as CrIS
  - 3 CIRAS show better impacts than single CIRAS, close to CrIS but still not as good as CrIS
- For this particular LSS case
  - three MicroMAS-2 are able to mitigate the loss of ATMS
  - 3 CIRAS are not able to mitigate the loss of CrIS, but more should be able to.
- Future work focuses on finding the optimal configuration (orbits and number of CubeSats) that can economically mitigate the loss of ATMS and CrIS.

5. Acknowledgement

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