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Development and Impact Study of Community Satellite Data Thinning and Representation Optimization Tool

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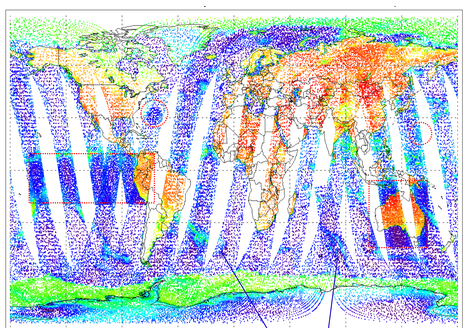
Abstract

A new satellite data thinning scheme, Community Satellite Data Thinning and Representation Optimization Tool (CSTROT), is developed to optimize satellite data thinning procedure in NCEP Gridpoint Statistical Interpolation (GSI) data assimilation for global and regional modeling systems. The main thinning strategy is based on the derived standard deviation (STD) of the satellite data that to be thinned. There are also several other options for thinning, representation and nesting schemes in CSTROT. The thinning for each sensor uses the union selections by several different channels, which can catch useful data information from different vertical levels and different atmospheric features, such as lower level temperature variations, middle level moisture tongue, and polar vortex at upper level. The new thinning tool has been implemented into the GSI system. The GSI analyses were performed to evaluate CSTROT scheme. High density observations was kept within data high variational regions, such as tropical cyclone and front systems. High density data can also be selected by giving the regions of interested areas. We are working on the GFS impact experiments to tuning and evaluate CSTROT scheme.

CSTROT: A new thinning tool for satellite data assimilation

Thinning of AMSU-A (N15+N19+Metop-A) Ch-2 Tb



❖**Objective of CSTROT:**

➢Develop a new thinning scheme to optimize satellite data usage in GSI data assimilation for both global and regional modeling systems.

❖**CSTROT Functions:**

➢ **Thinning options**:
- using Standard Deviation
- using regression
- by skipping points

➢ **Representation options**:
- Random points
- Closest point
- Averaging

➢ **Nested domain options:**
- by target regions
- by domain size

Ch-6 WV 6.25 μm + Ch-9 IR 10.8 μm

Analysis of AMSU-A N18 Brightness Temperature and STDV

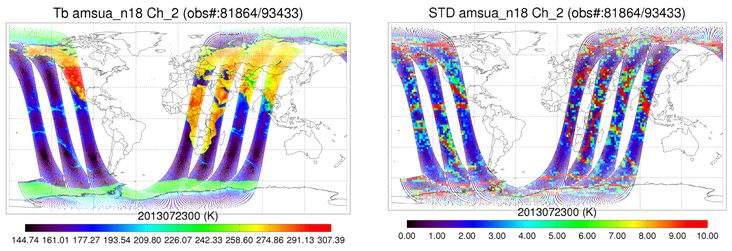


Figure 1. Brightness temperature and standard deviation of AMSU-A N18 Channel-2 at 0000 UTC July 23, 2013.

Report of the analysis of standard deviation

- AMSUA_N18 Tb Mean & STDV with All Data -

Channel	Tb_Mean[K]	STDV_Mean[K]	STDV70%[K]	STDV35%[K]	OBS Number
1	219.999	5.390	3.800	1.800	81864
2	213.321	5.970	3.800	1.800	81864
3	248.071	3.126	3.400	1.600	81864
4	259.550	0.958	2.100	0.900	81864
5	251.621	0.661	1.200	0.500	81864
6	235.827	0.547	0.600	0.250	81864
7	224.588	0.463	0.600	0.300	81864
8	217.195	0.406	0.600	0.300	79172
9	210.984	0.266	0.550	0.250	81864
10	214.461	0.285	0.500	0.250	81864
11	220.680	0.296	0.500	0.250	81864
12	229.409	0.368	0.450	0.250	81840
13	240.459	0.479	0.500	0.250	81639
14	251.554	0.707	0.500	0.250	81864
15	249.853	4.309	2.200	1.000	81864

Analysis of SEVIRI M10 Clear Sky Tb and STDV

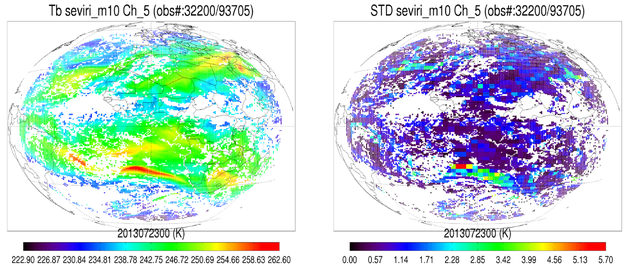


Figure 2. Brightness temperature and standard deviation of SEVIRI M10 Channel-5 at 0000 UTC July 23, 2013.

Report of the analysis of standard deviation

- SEVIRI_M10 Tb Mean & STDV with All Data -

Channel	Tb_Mean[K]	STDV_Mean[K]	STDV70%[K]	STDV35%[K]	OBS Number
1	288.52	0.83	0.90	0.30	24415
2	243.73	0.93	1.00	0.50	32200
3	262.86	0.75	0.60	0.30	24415
4	288.18	0.83	1.10	0.50	24415
5	265.76	0.52	0.55	0.25	24415
6	291.45	0.81	1.10	0.50	24415
7	290.48	0.80	1.00	0.50	24415
8	268.80	0.46	0.50	0.25	24415

➢Generated the CSTROT thinning report for AMSU-A N18 and SEVIRI M10 sensors, which include:
- o The analysis of Tb, STD and CSTROT thinning result for each channel,
- o Table report of mean Tb, STDV, and 70% and 35% population of STDVs,
- o The thinning channels selection is based on the report and the nature of channels.
- o There are options to remove higher density selections along coastlines and sea-ice edges.

CSTROT Thinning Results and GSI Analysis

OBS points kept with the union of Channel-02+04+10 Thinning

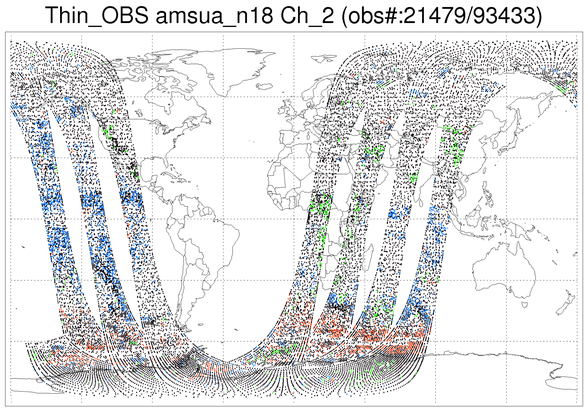


Fig. 3. The observation points selected by CSTROT thinning scheme based on the union of AMSU-A N18 channel 2, 4 and 10 selections. Black points are the same observation points selected by all three channels. Blue, green and red points are the additional observations selected by Ch-2, 4 and 10, respectively

➢It can be seen that Ch-2 selection can add additional observation points in cloudy and weather active regions, such as in ITCZ. The additional selection by Ch-4 gives more points over high altitude and sea-ice regions. Ch-10 responds to stratosphere temperature variation, which provides additional selections around the edge of strong polar vortex.

GSI analysis with CSTROT thinning

GSI O-A for AMSU-A N15+N19+Metop-A Ch-2

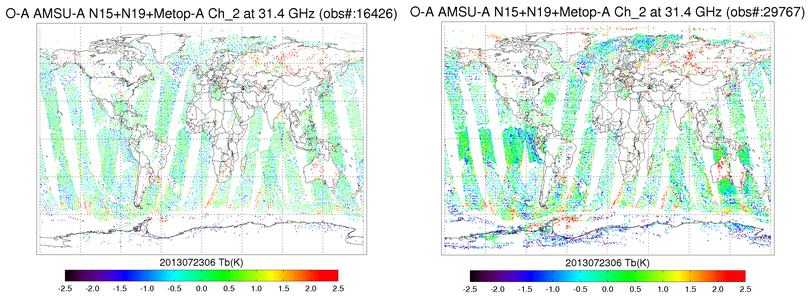


Fig. 4a. Current GSI 145-km Thinning at 0006 UTC 23 July, 2013

Fig. 4b. New CSTROT Thinning at 0006 UTC 23 July, 2013.

➢The comparison of two thinning schemes indicates that CSTROT thinning can provide more data and more increment of GSI analysis in weather active regions and selected areas.

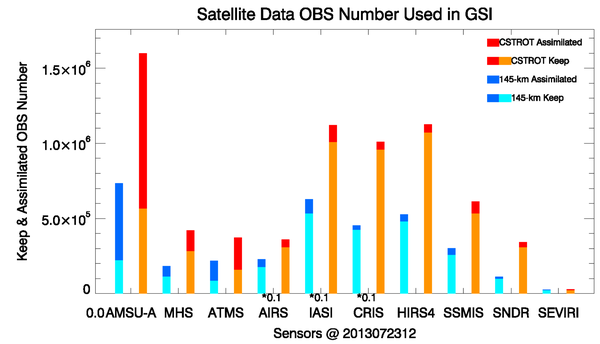


Figure 5. Comparison of kept and assimilated observation numbers between current GSI thinning and CSTROT thinning.

➢In this one cycle GSI analysis test, there are about 45% total satellite observations kept and assimilated by using CSTROT scheme.
➢The CPU time usage is increased for about 44%, which is proportional to the increase of the assimilated observation numbers.
➢More tuning is needed to reduce the selection number to the similar level as current GSI scheme.

Summary and Future Plan

- **Summary:**
  - ➢Developed a new satellite data thinning tool, CSTROT, with three basic thinning methods (thinning by STD, averaging and skipping), and each one can be combined with target and/or domain regions selections..
  - ➢The thinning function based on the union of selections by different channels to represent atmospheric variations at different levels.
  - ➢Removed big STD values due to the different observation time overlaying problem.
  - ➢Removed high density selection regions along coastlines and sea-ice edges.
  - ➢Analyzed satellite brightness temperatures STD, and created STD thresholds for 29 GSI assimilated sensors in the thinning_std.txt configuration file.
  - ➢Implement CSTROT scheme in GSI system, and performed comparison study. Compared with current GSI 145-km thinning mesh, the new CSTROT thinning can provide more data and more increment of GSI analysis in weather active regions and selected areas.
- **Future Plan**
  - ➢Keep working on the enhancement and tuning of CSTROT for all sensors and channels.
  - ➢Improve the thinning scheme to reduce the memory usage.
  - ➢Evaluate the new thinning scheme by performing GSI analysis and GFS impact experiments.

Acknowledgements

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