Unifying the Observation Assimilation Strategy in a Global NWP System

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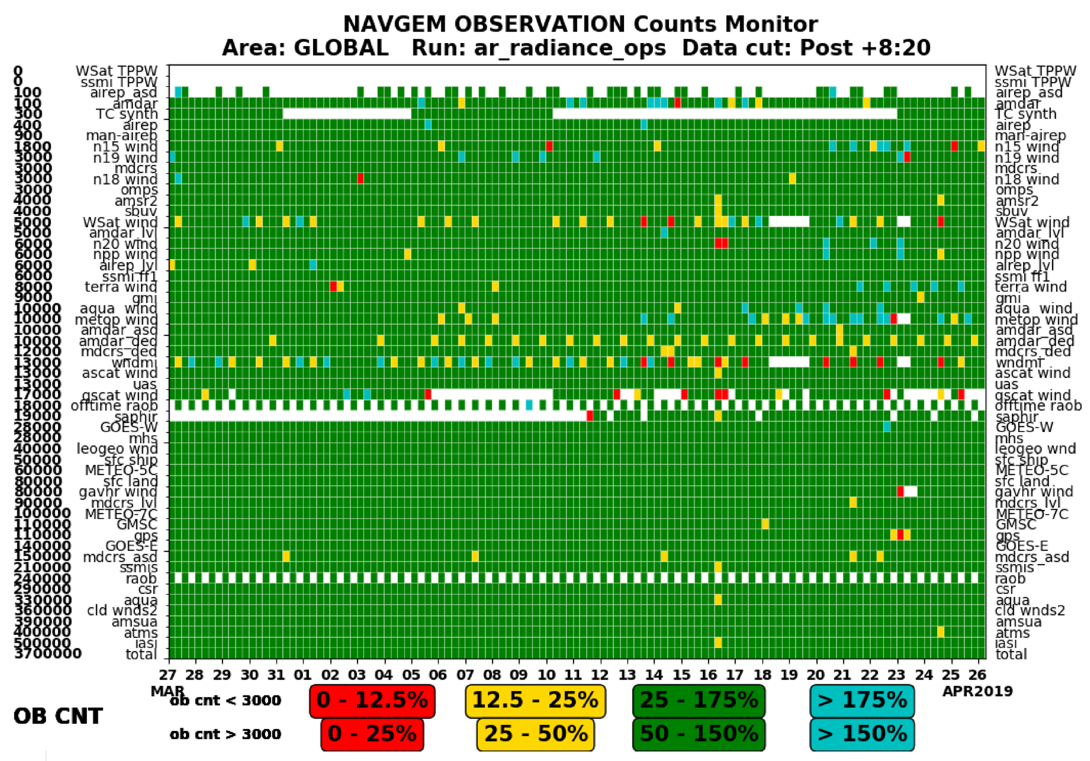
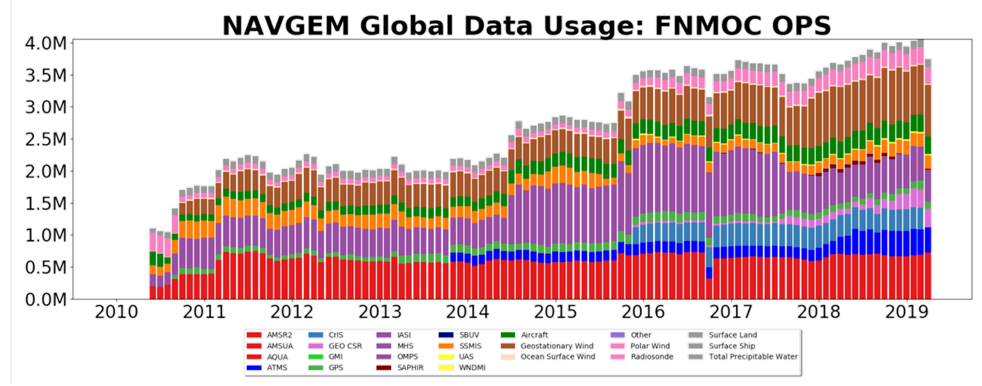
Core Systems

- NWP systems:
  - Navy Global Environmental Model (NAVGEM)
  - Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®)
  - Navy Environmental Prediction sysTem Utilizing the NUMA corE (NEPTUNE)
- DA Systems:
  - NRL Atmospheric Variational Data Assimilation – Accelerated Representer (NAVDAS-AR)
  - Joint Effort for Data assimilation Integration (JEDI)

The Naval Research Laboratory (NRL) currently develops and delivers operational environmental forecasting systems to Fleet Numerical Meteorology and Oceanography Center (FNMOC). The global NAVGEM and mesoscale COAMPS® systems use a hybrid-4D-Var and 3D-Var assimilation schemes respectively. The next generation model being developed is NEPTUNE. This NEPTUNE system is targeting JEDI architecture for assimilation responsibilities.



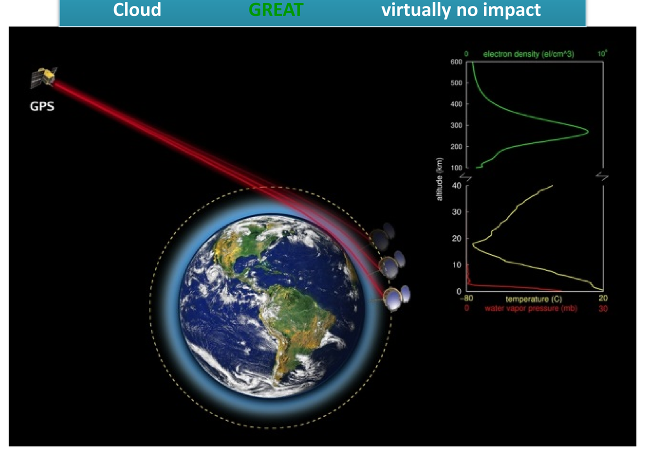


Data Usage

The amount of data assimilated by the environmental systems is growing rapidly quadrupling in the last decade. The strategies for using this data need to be re-examine for reusability and portability. This all aligns very will with the JCSDA JEDI initiative and the processing chain and assimilation strategy at NRL is being developed and refactored when necessary to abstract functionality concepts from components and allow them to be used in common for the various data types used. Further, components like the Interface for Observation Data Access (IODA) will be critical to allow multiple functionalities and applications to use the environmental data streams for unique problems.

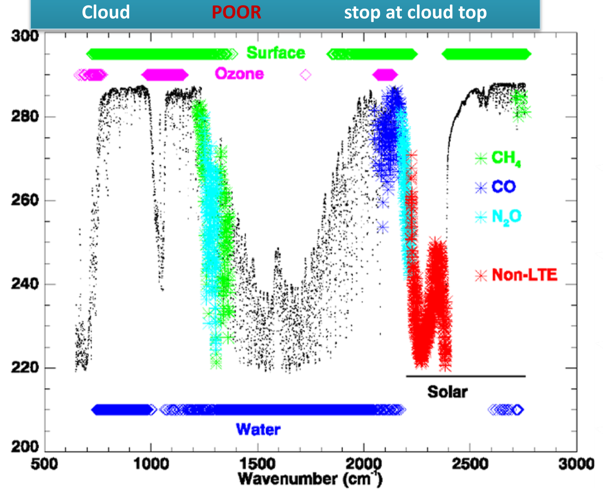
GPS-RO

Horizontal	POOR	200km
Vertical	GOOD	~8km-60km x200m
Cloud	GREAT	virtually no impact



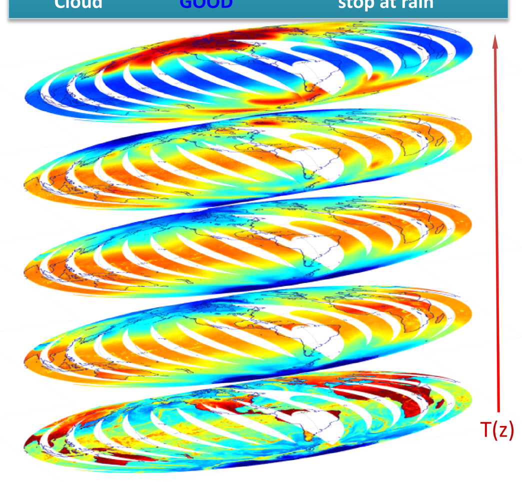
Infrared

Horizontal	GREAT	10km
Vertical	GOOD	surface-40km x2km
Cloud	POOR	stop at cloud top



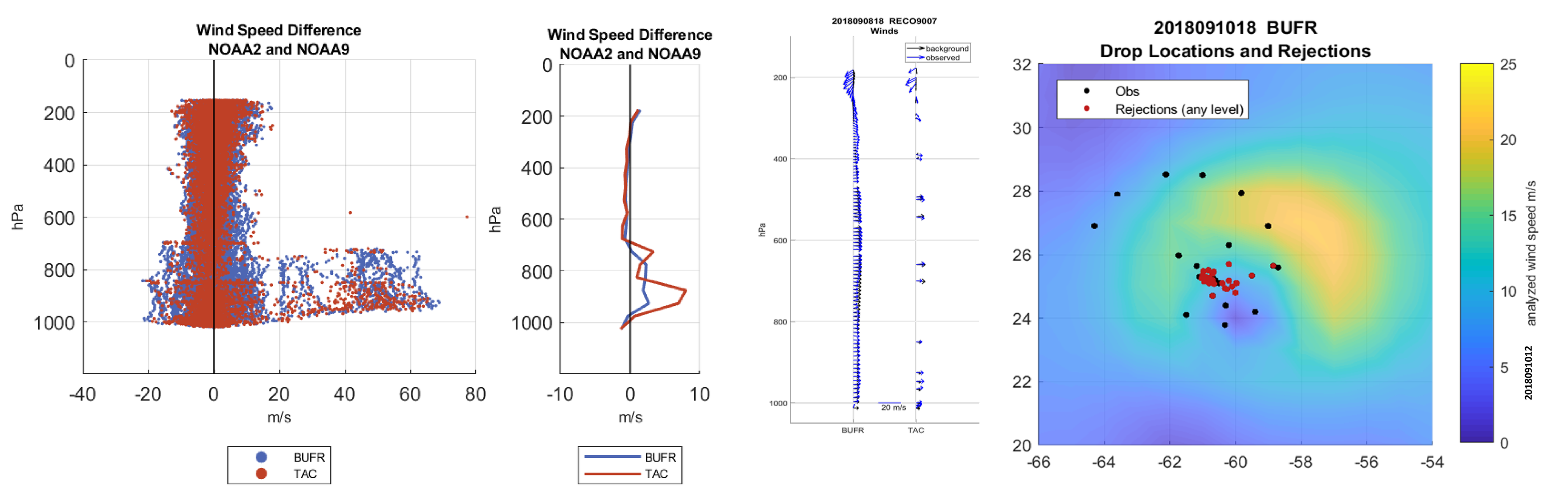
Microwave

Horizontal	GOOD	25km
Vertical	GREAT	surface-90km x5km
Cloud	GOOD	stop at rain



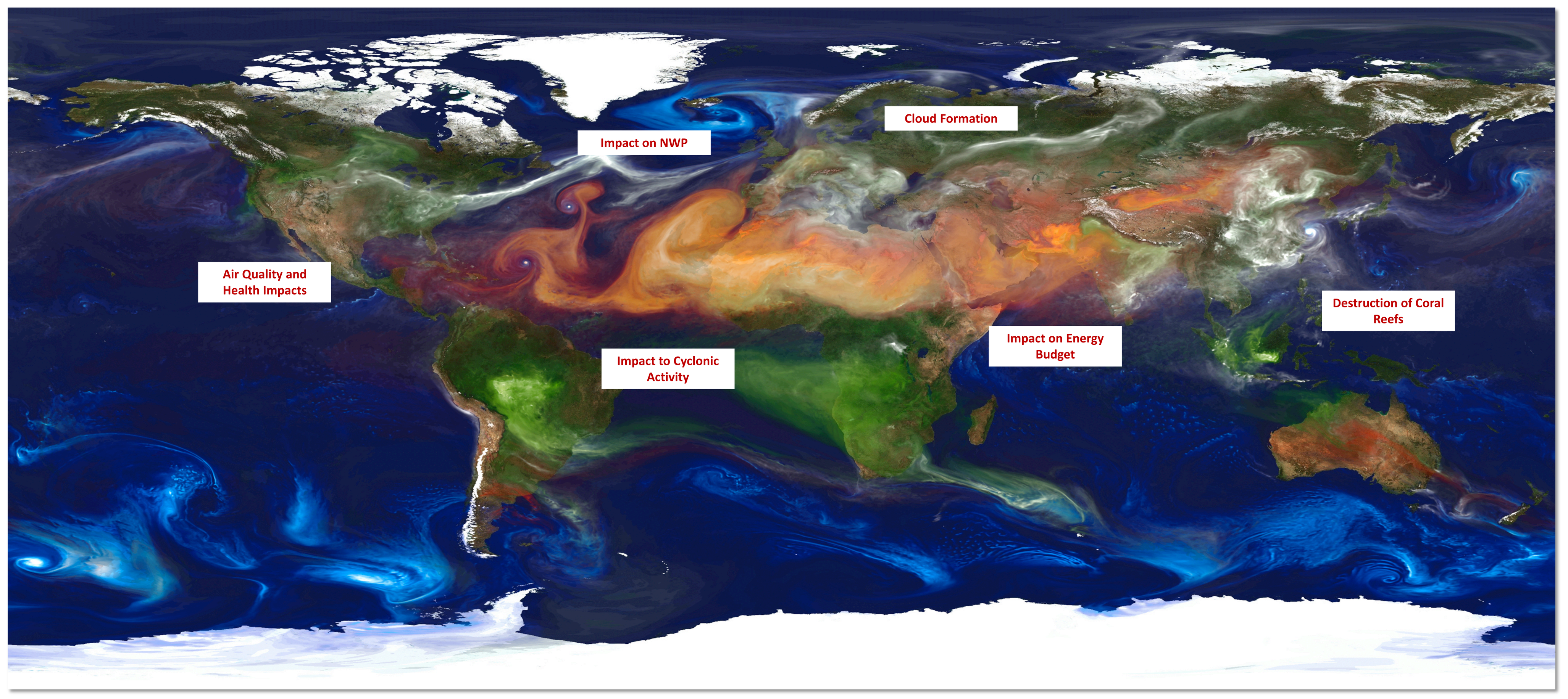
Strategies Observation Synergy

Observations from *in-situ* and satellite platforms, and from various environmental systems like oceanic or ionospheric, all contain common traits. The handling of the ingest and the basic understanding of the measurement is required, but a focus on defining common attributes the data have in common and defining these into families is a focus going forward. This was actions on the family of attributes can be constructed to do various operations such as data thinning and error assignment can then be made by the particular application.



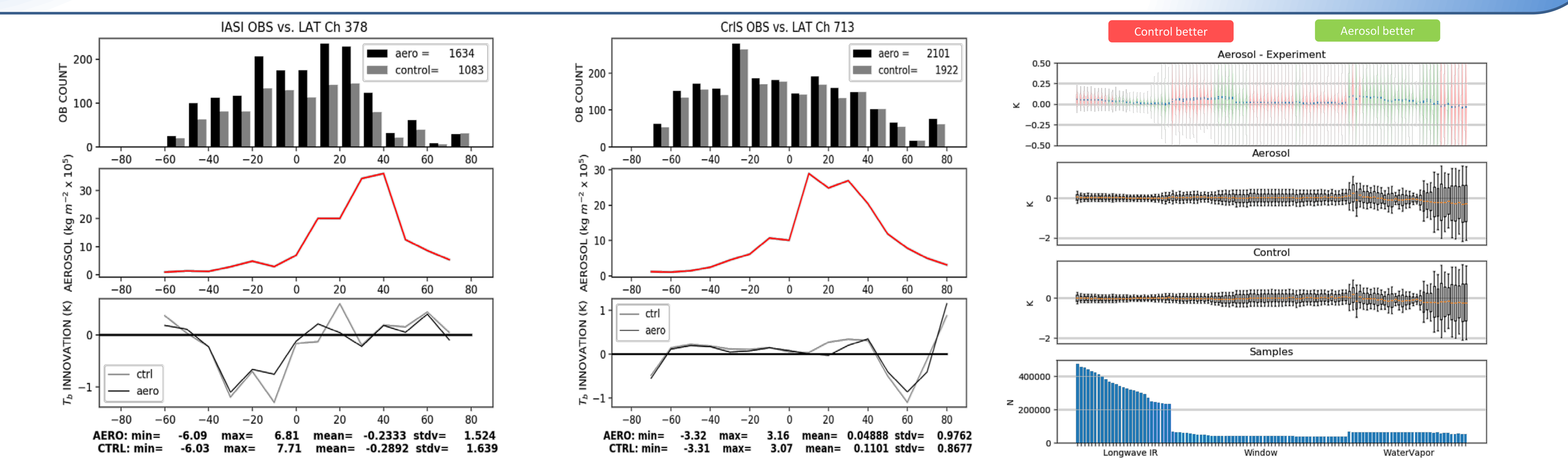
Commercial Data and Small Satellite Era

Environmental observation, particularly in the U.S. are increasingly reliant on commercial providers and the evolving small satellite era. These data will be large in volume, with poorly defined sources and fluctuating quality control approaches. Further we may expect format changes as companies (providers) may fail or be acquired. An adaptive strategy, and potentially artificial intelligence (AI) approaches to identify and if possibly remedy issues should be fully explored, and systems should readily adapt to new data types and be equipped with bias and error mitigation.



Aerosol Impacts

The Navy Aerosol Analysis Prediction System (NAAPS) has been combined with the NAVGEM NWP and assimilation system. This allows to test the impact of aerosol on the various radiance assimilation. Here the NAAPS aerosols analysis is inserted in the analysis and is passively advected creating background trajectories with aerosols for the next assimilation cycle. Overall impacts are small, while large aerosol events dominate the impacts. The system has performed robustly and the next iterations involve refining the aerosol coefficient tables in the CRTM. Work is ongoing and showing great promise to examine the ability to adjust the CRTM to better match NAAPS aerosol specification.



All-Sky Radiances

A focus to increase observation usage is on enhancing the all-surface and all-sky capability. The microwave all-sky assimilation is being adopted rapidly and growing impact is shown by ECMWF (Geer, Baordo et al. 2017), while an approach for the infrared has been implemented at JMA (Okamoto, McNally et al. 2014, Okamoto 2017) where a cloud affect C_A is defined:

$$C_A = \frac{|B - B_{clear}| + |O - B_{clear}|}{2}$$

a common strategy is appealing to be used for both the microwave and the infrared.

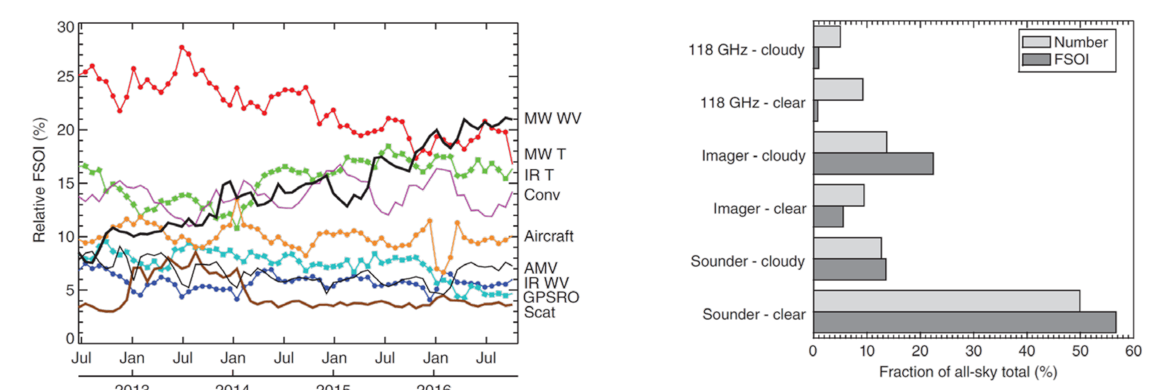


Figure 1. Forecast Sensitivity to Observation Impact (FSOI) in the ECMWF operational system from June 2012 to October 2016, averaged in 25 day bins, normalized so total impact is 100%; section 3 gives details. Acronyms are given in the Appendix. [Colour figure can be viewed at wileyonlinelibrary.com].

Figure 8. FSOI (dark grey bar) and number of observations (light grey bar) for the nine all-sky instruments, broken down by type of channel (118 GHz temperature/cloud, sounder or imager) and by whether or not the observation (or the model equivalent) is affected by cloud or precipitation. Statistics have been accumulated over 20 July to 20 August 2016 and are given as percentages relative to the total across the nine all-sky instruments.

Geer, A. J., et al. (2017). "The growing impact of satellite observations sensitive to humidity, cloud and precipitation." Quarterly Journal of the Royal Meteorological Society 143(709): 3189-3206.

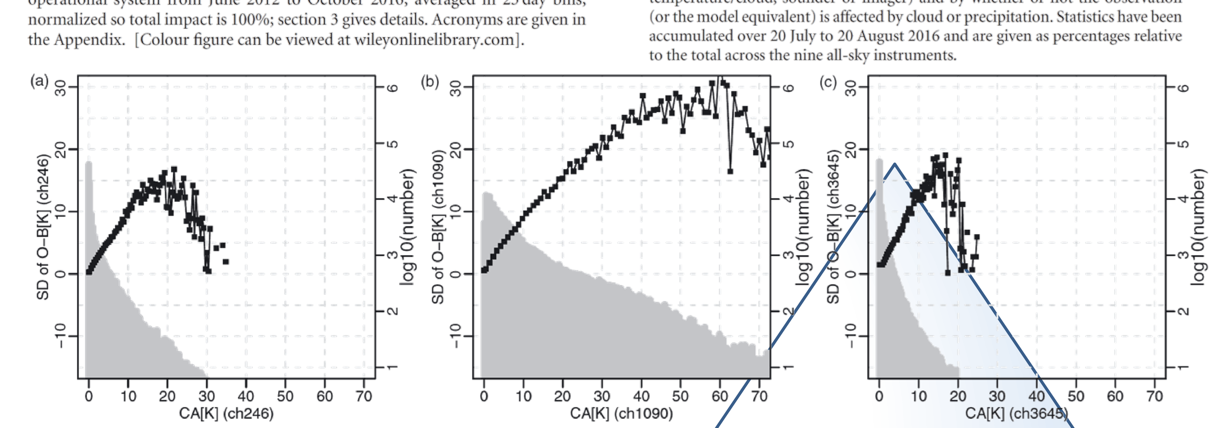


Figure 7. SD of O−B at (a) channel 246, (b) channel 1090, and (c) channel 3645 as a function of C_A. The sample number in each C_A bin is shown by grey bars and right axis.

Okamoto, K., et al. (2014). "Progress towards the assimilation of all-sky infrared radiances: an evaluation of cloud effects." Quarterly Journal of the Royal Meteorological Society 140(682): 1603-1614.

Conclusions & Future Directions

- All-sky radiance treatment which is consistent between IR & MW
- Aerosol impact on radiances; as well as extinction assimilation
- Approaches to radiance bias correction to address analysis biases
- Continuous data processing; increased data usage
- Exploration of signals-of-opportunity and new sensor technologies