Scientific Benefits of Spatial Resolution for Next Generation Infrared Hyperspectral Sounder Instruments

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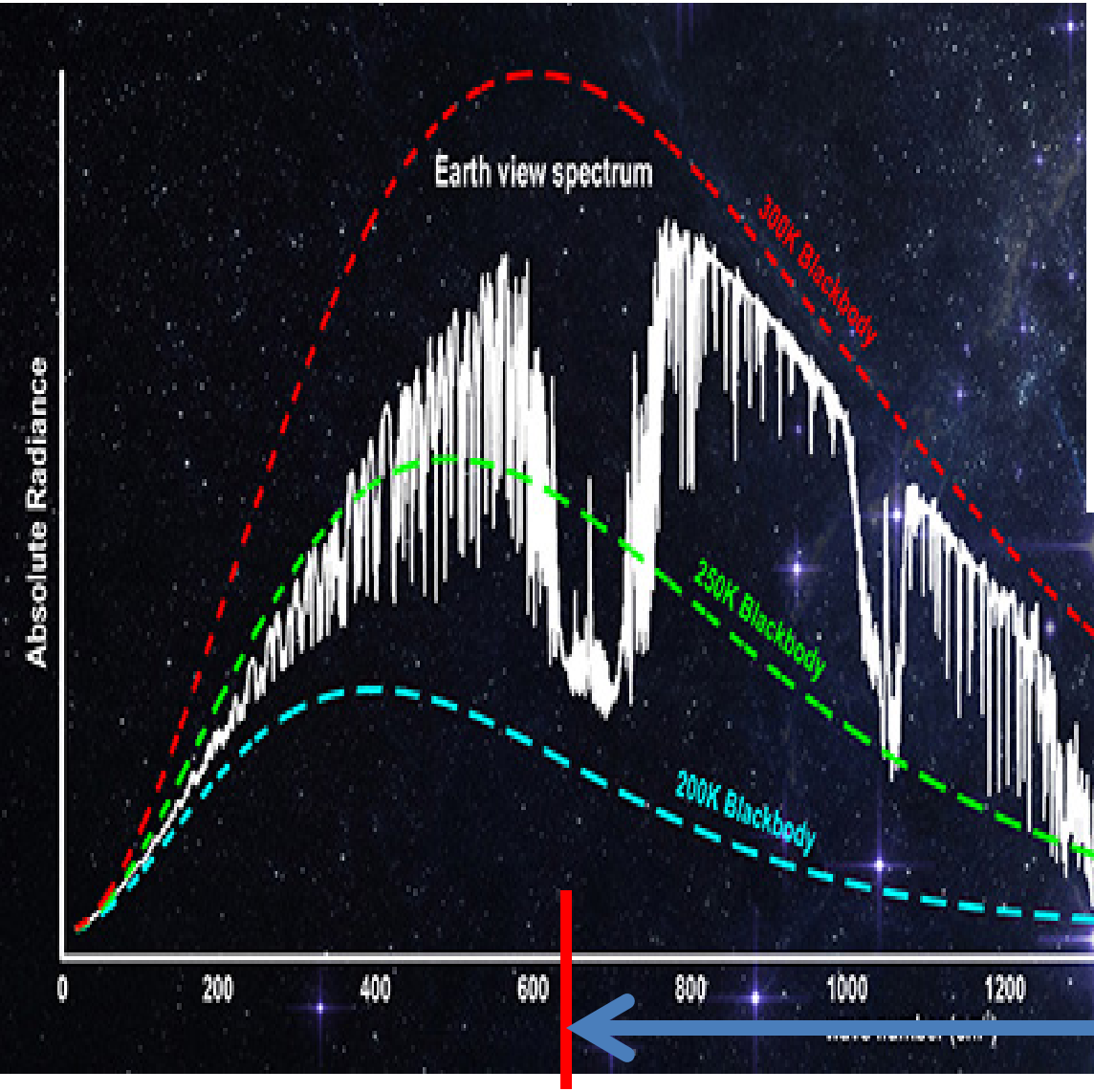
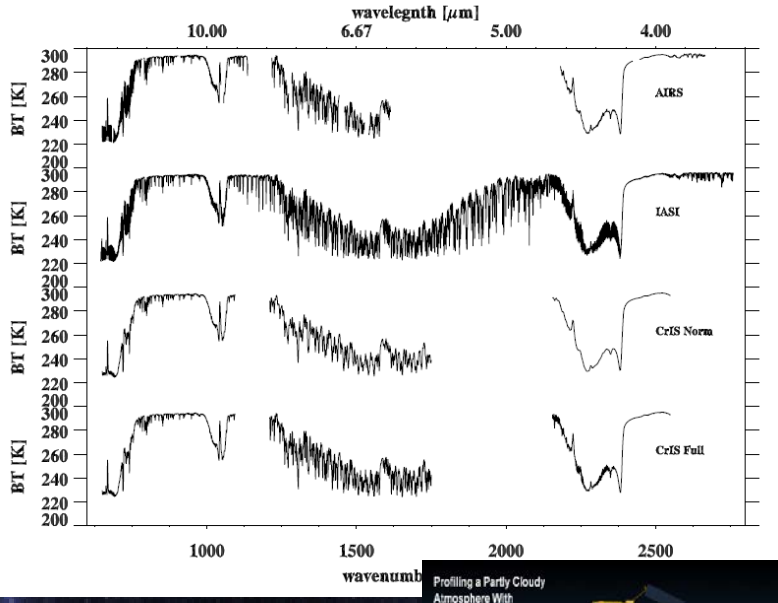
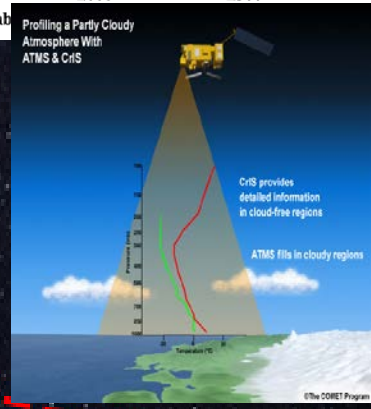
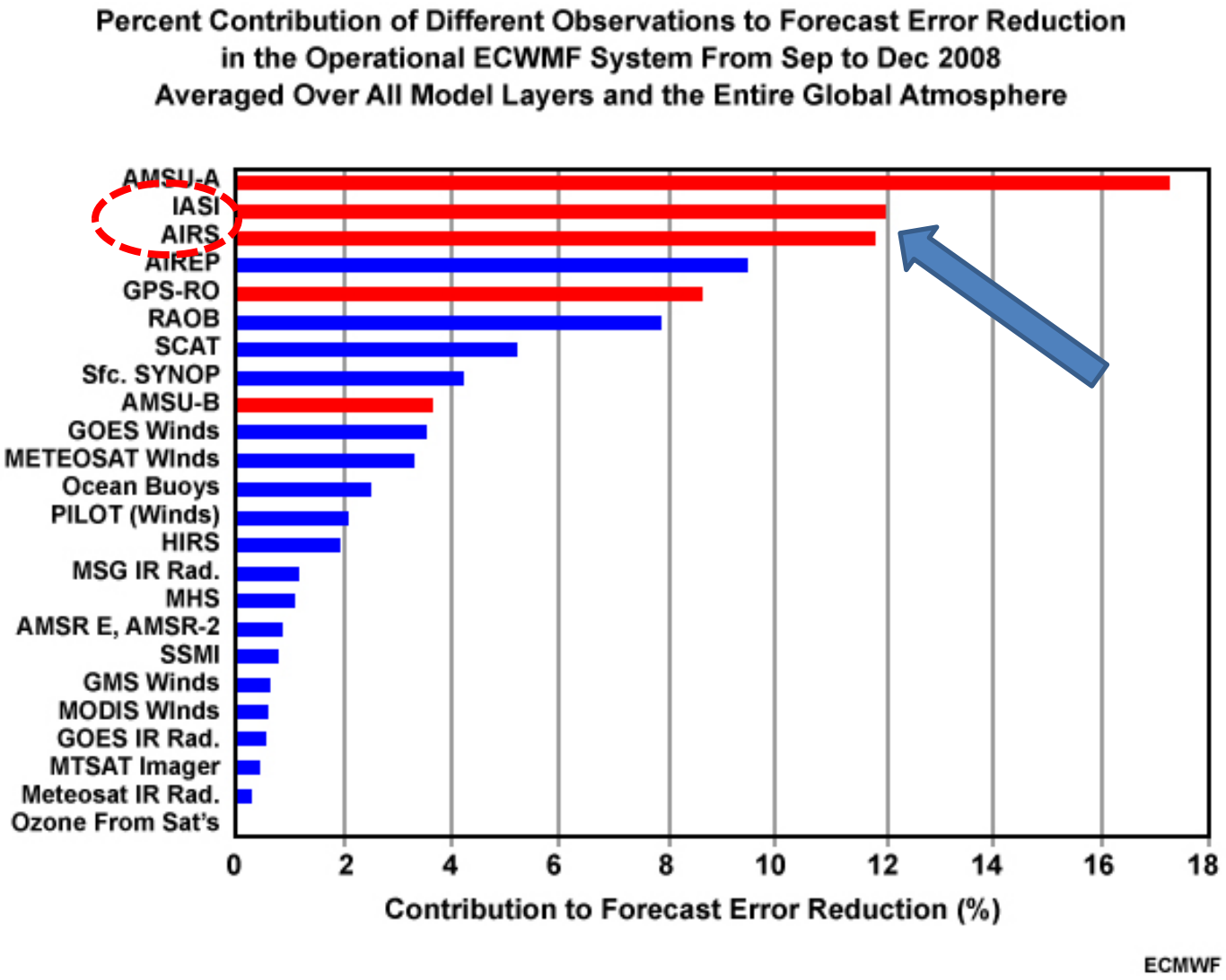
AIRS, CrIS, and IASI





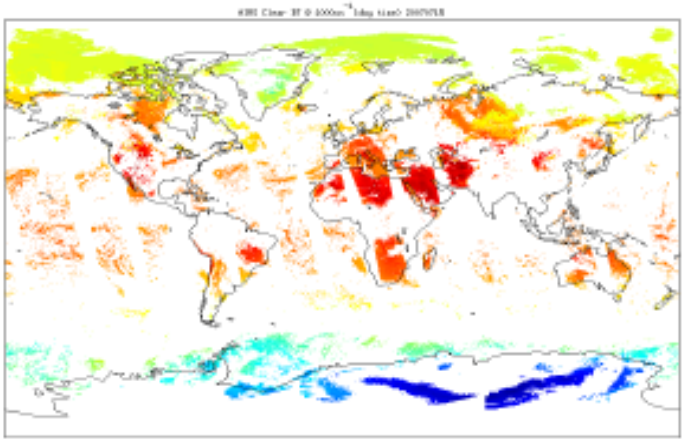


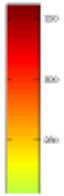
Satellite Impacts on NWP Models



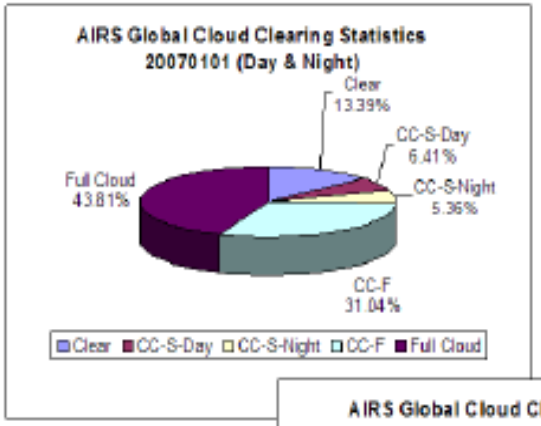
Copied from NACR COSMET Program

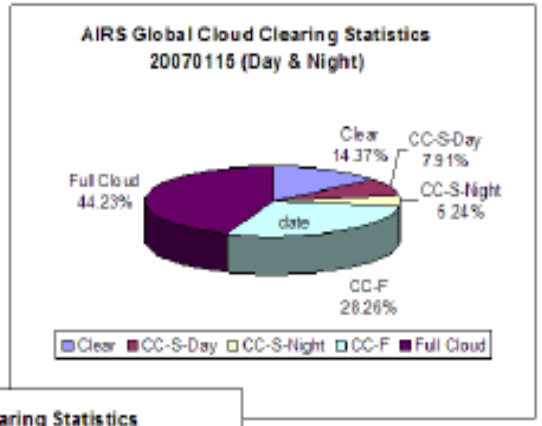
Current Infrared Hyperspectral Sounder greatly impacted by clouds due to large FOV size

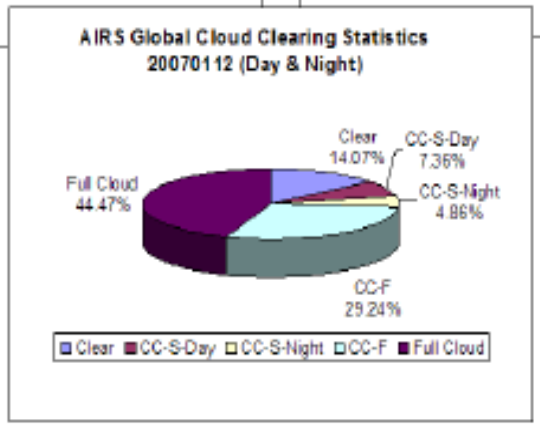




AIRS Global Cloud Clearing Statistics

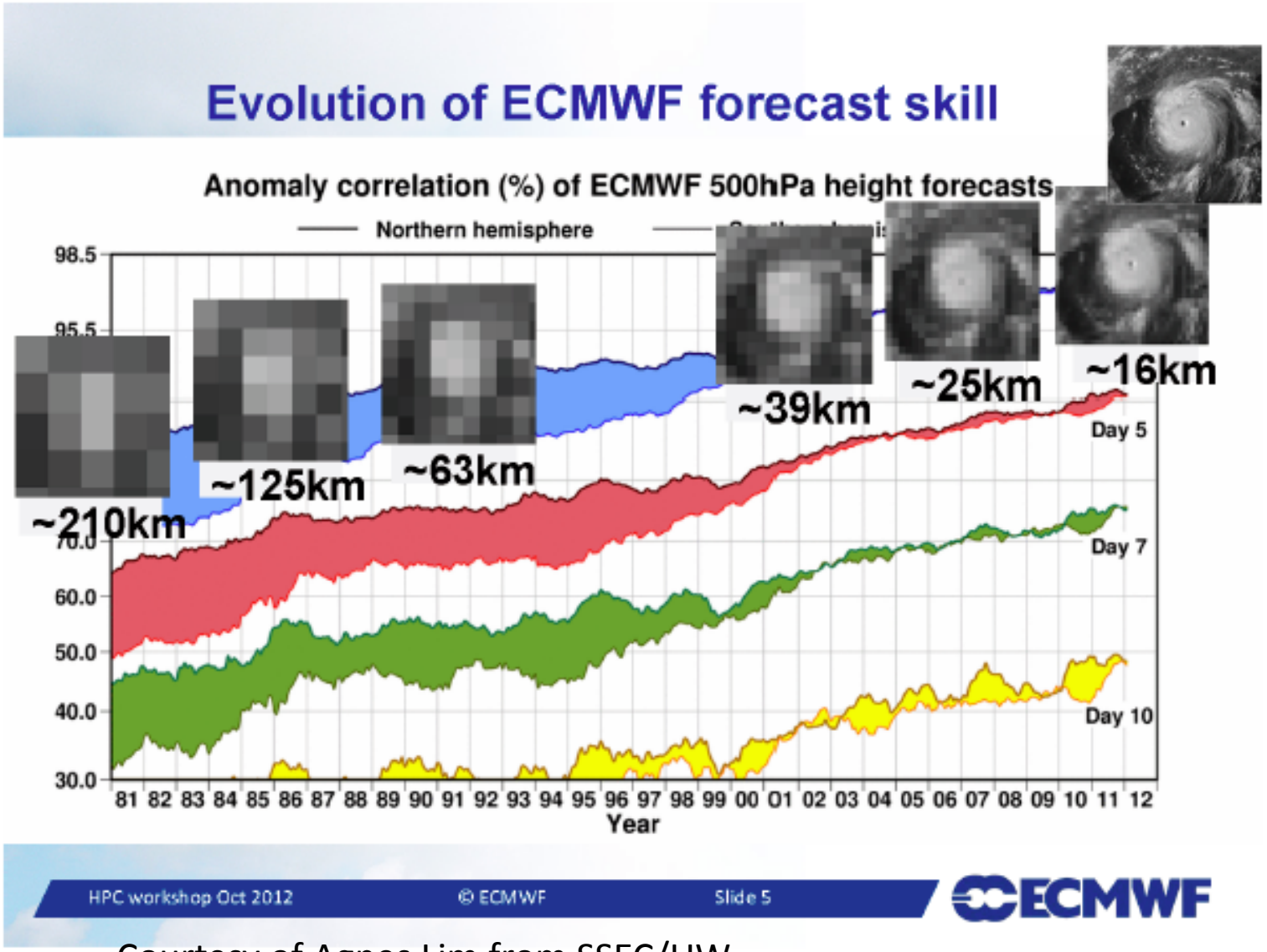






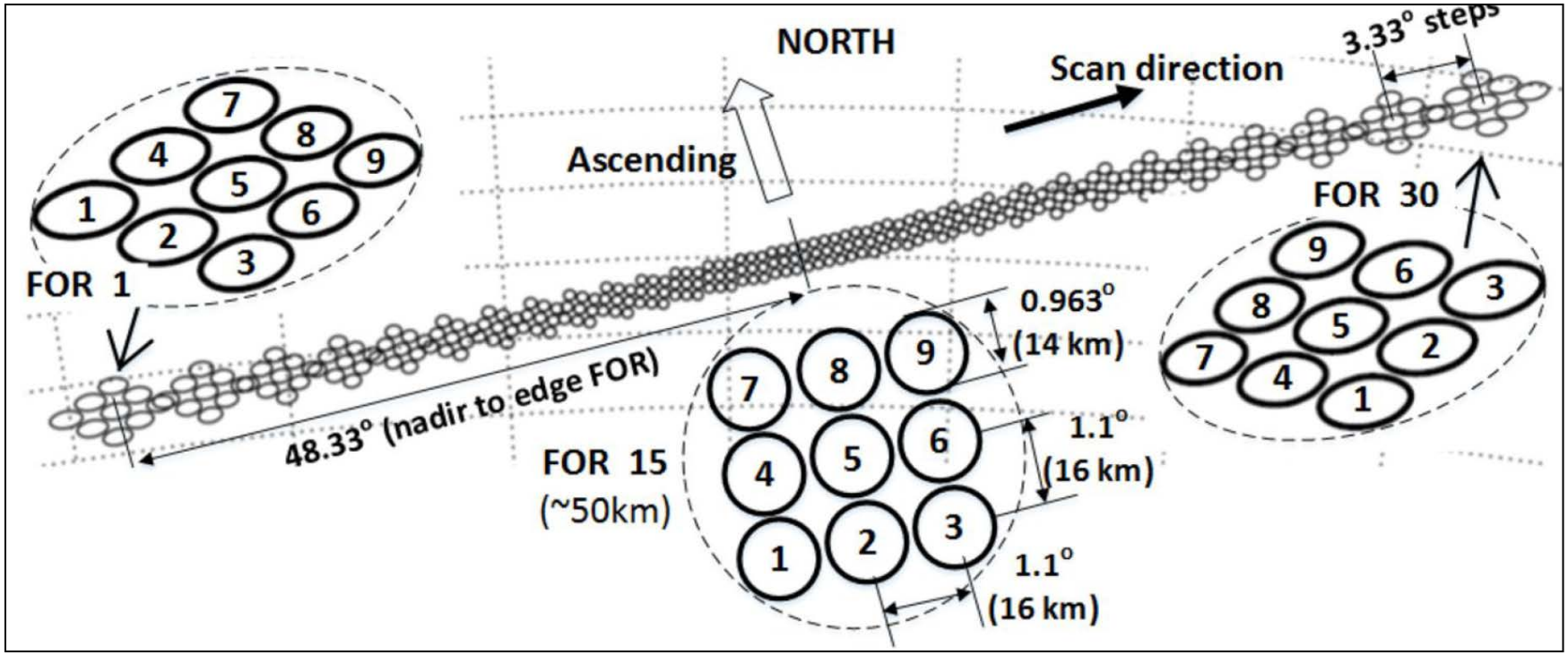
Courtesy of Agnes Lim from SSEC/UW

Evolution of NWP Model Resolution



Courtesy of Agnes Lim from SSEC/UW

BUT CrIS FOV sizes keep the same for Suomi NPP ➔ JPSS-1 ➔ JPSS-2



CrIS uses 3X3 Detector Arrays, each of which corresponds 14 km at nadir.

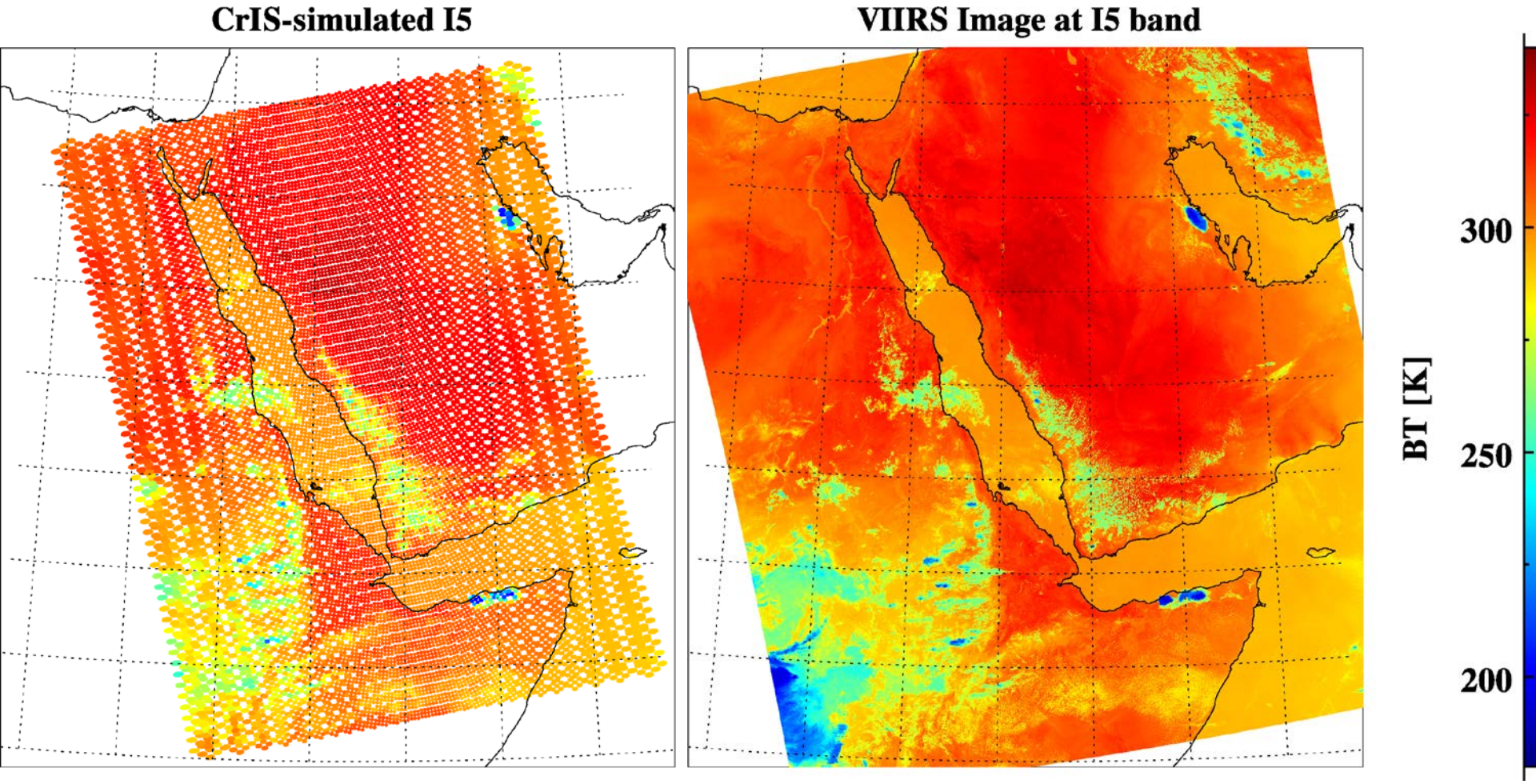
Motivation

- To evaluate possible scientific benefit of improving CrIS FOV spatial resolution
  - It is expected that clear sky measurements will increase.
  - But how much?

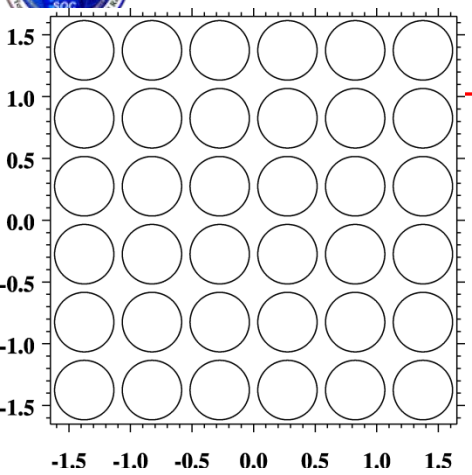
- Question 1: If we keep the total FOV number unchanged (each field of regard still include 3X3 FOVs), how do CrIS clear sky measurements increases with FOV spatial resolution?
  - 14km ➔ 7km

Question 1: Under the same FOV spatial resolution (for example 7km), how do CrIS clear sky measurements increases with a different configuration?
  - 3x3 ➔ 6x6

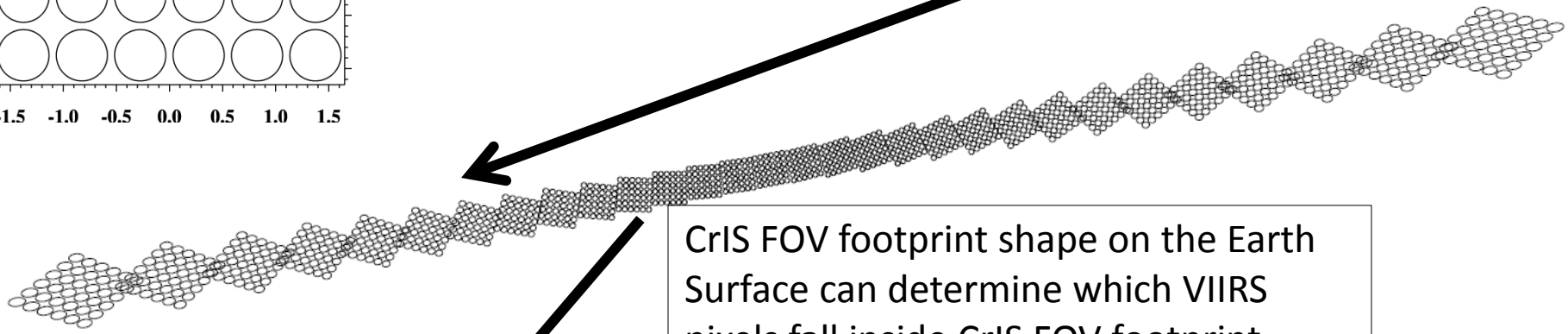
Using VIIRS to Characterize CrIS FOV



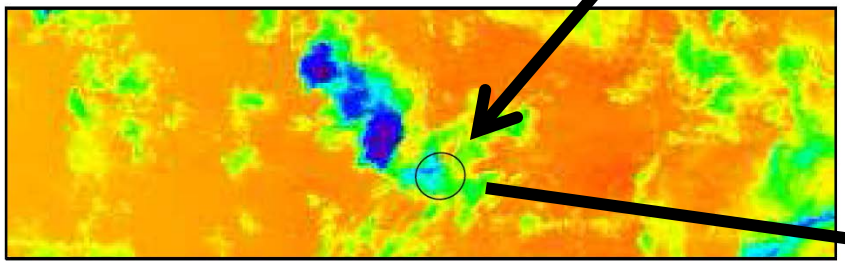
Method



Using new detector angles as inputs for CrIS Geolocation Algorithm and compute CrIS FOV lat, lon, and shape projected on the Earth

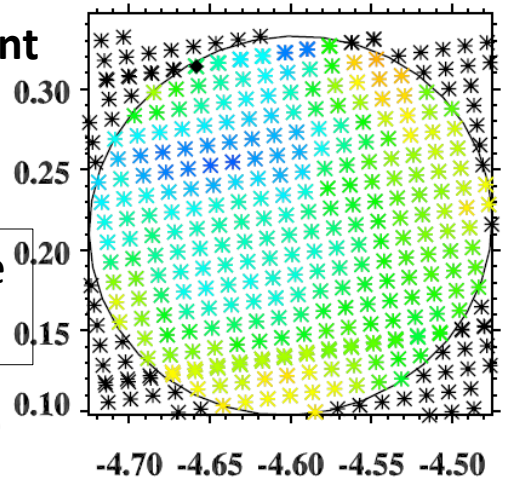


CrIS FOV footprint shape on the Earth Surface can determine which VIIRS pixels fall inside CrIS FOV footprint



VIIRS Pixels

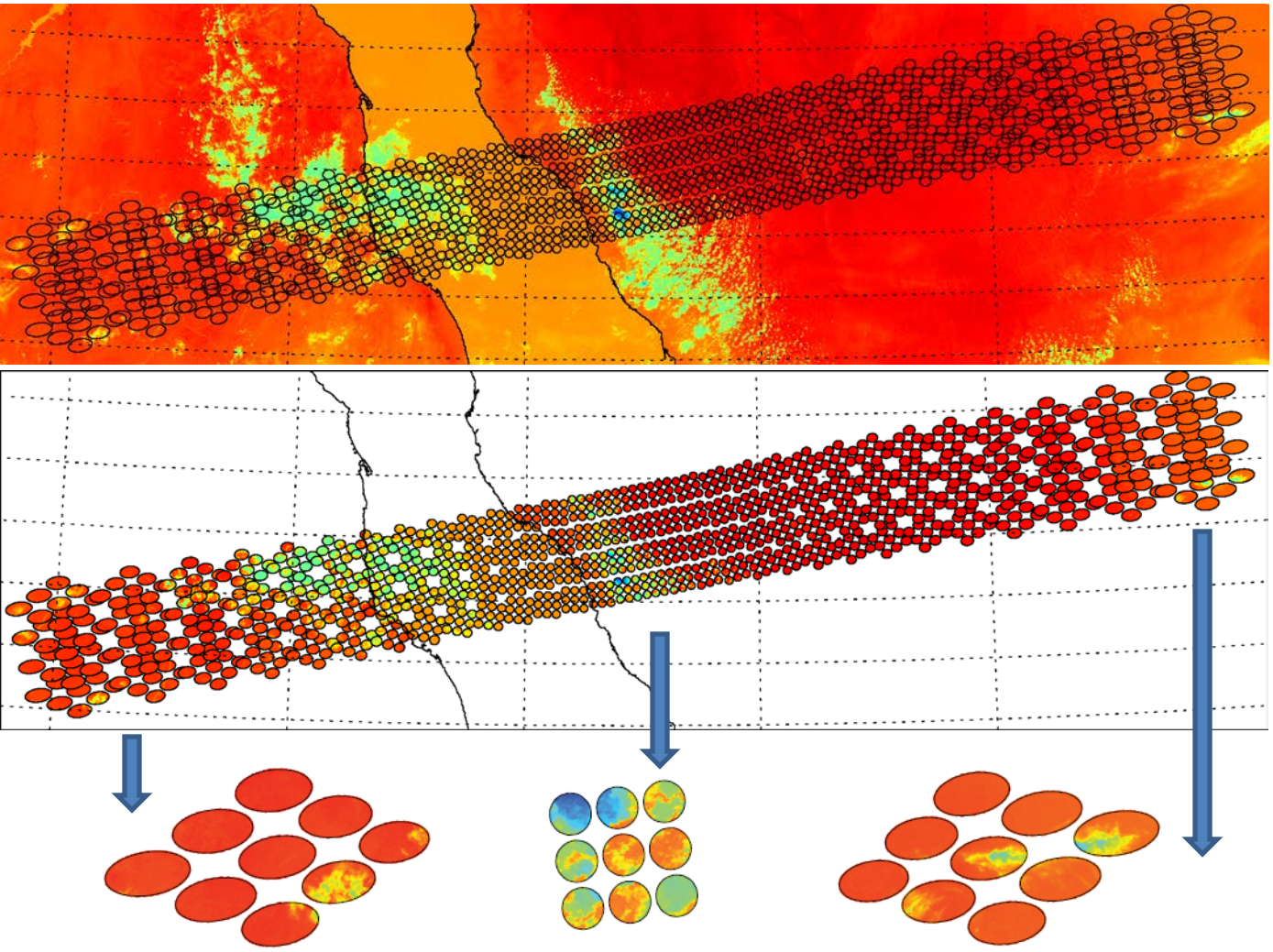
CrIS FOV footprint

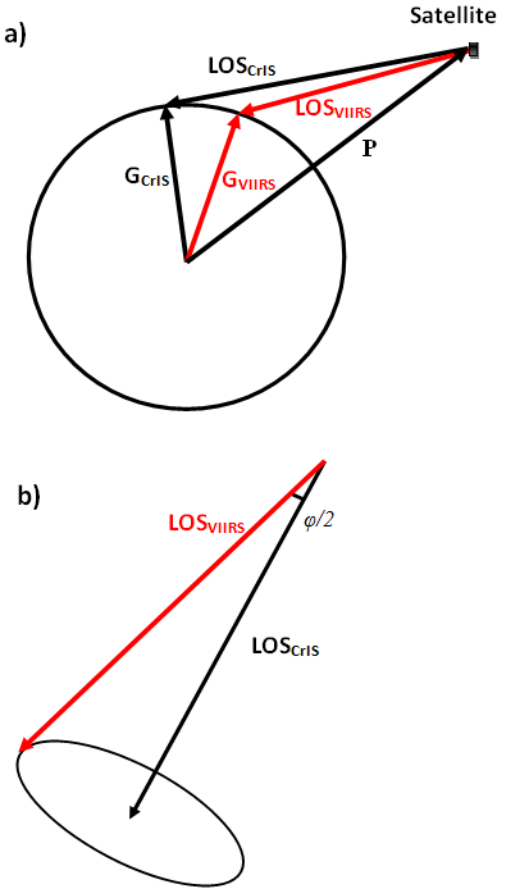


VIIRS cloud mask products are used to determine cloud fraction in each CrIS footprint ;

If all VIIRS pixels within CrIS FOVs are indicated as confidently clear, the CrIS FOVs are treated as clear.

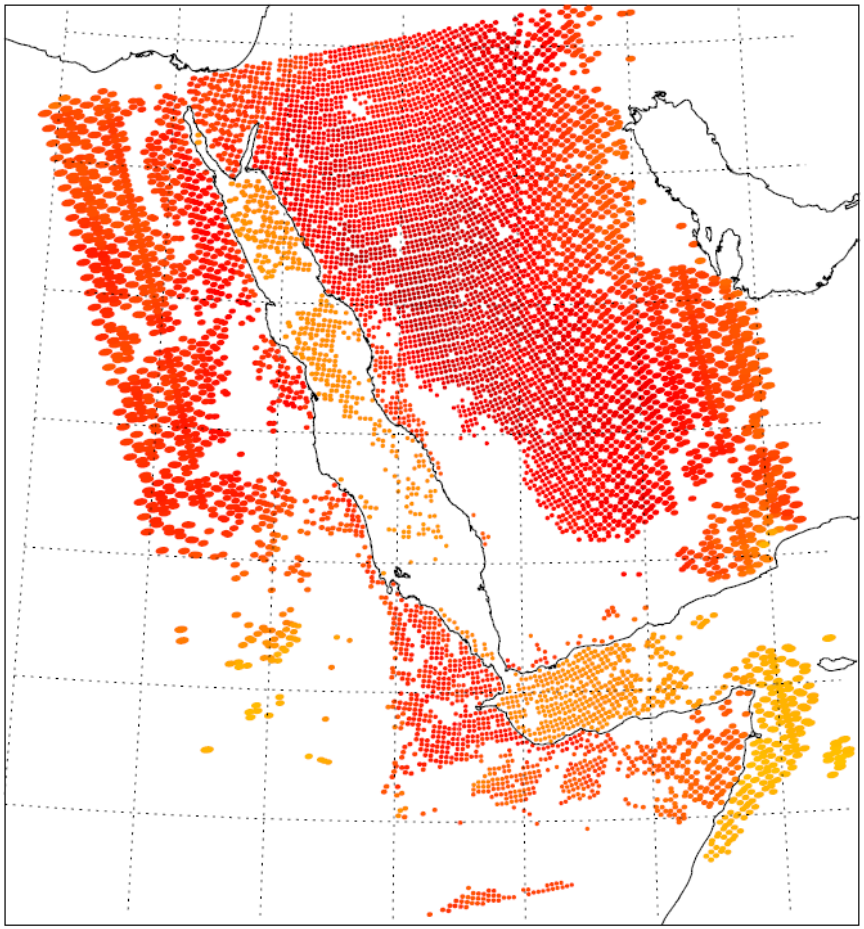
Fast and Accurate Collocation Scheme

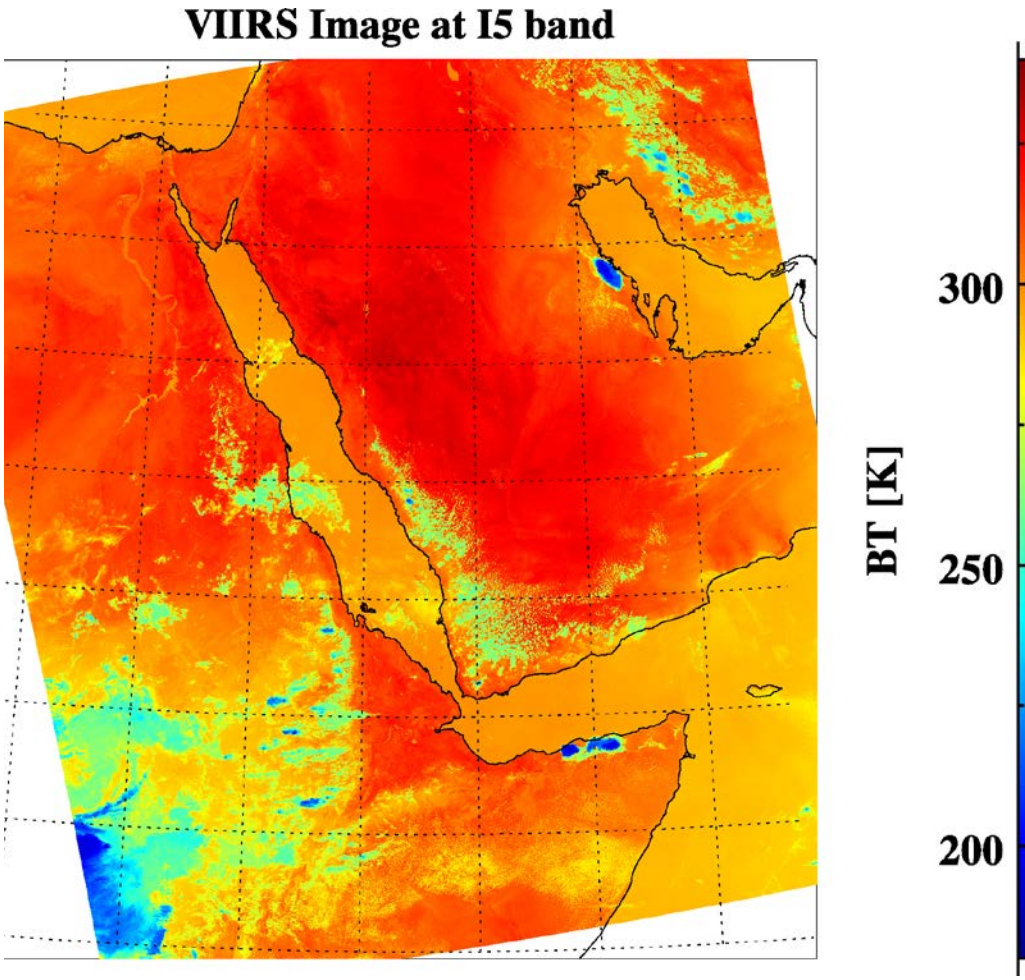




Wang, L., D. A. Tremblay, B. Zhang, and Y. Han, 2015: Fast and Accurate Collocation of the Visible Infrared Imaging Radiometer Suite Measurements and Cross-track Infrared Sounder Measurements. Remote Sensing (submitted).

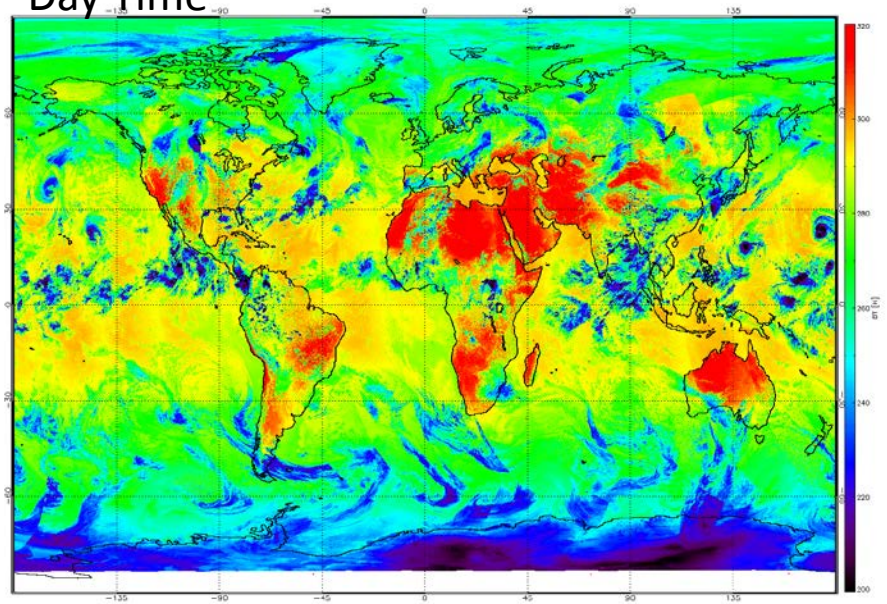
CrIS Clear Sky FOVs Detected by VIIRS Cloud Mask



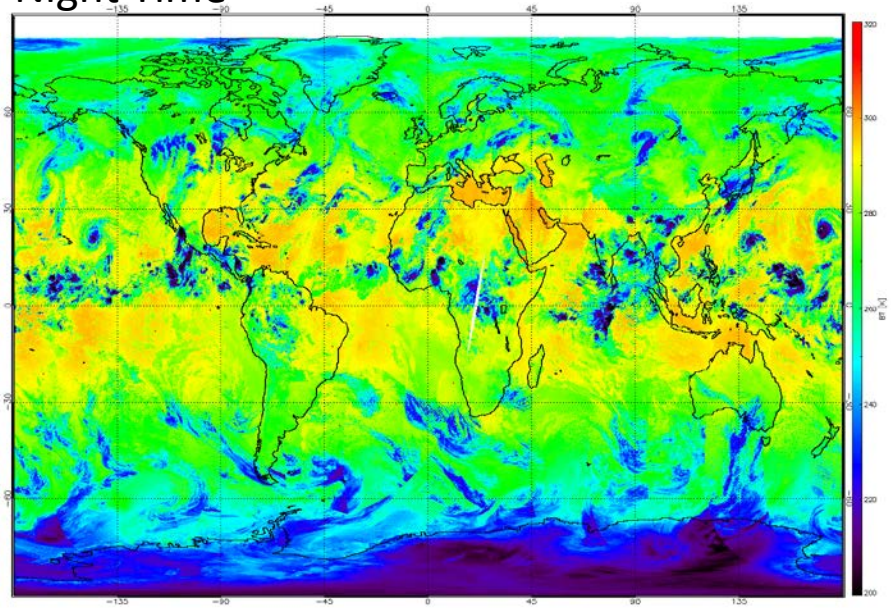


VIIRS on 09/05/2015

Day Time

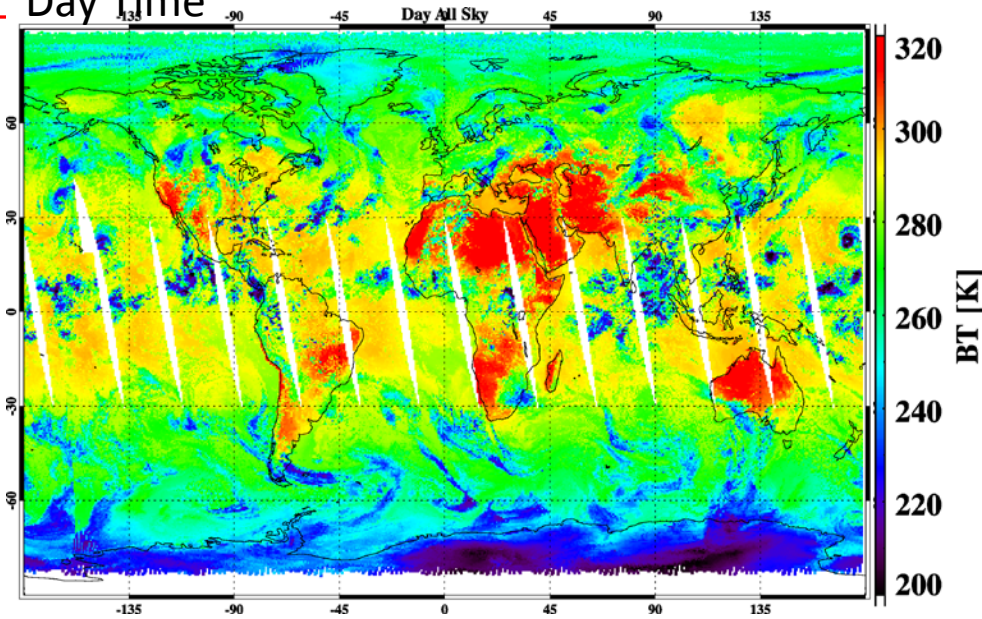


Night Time

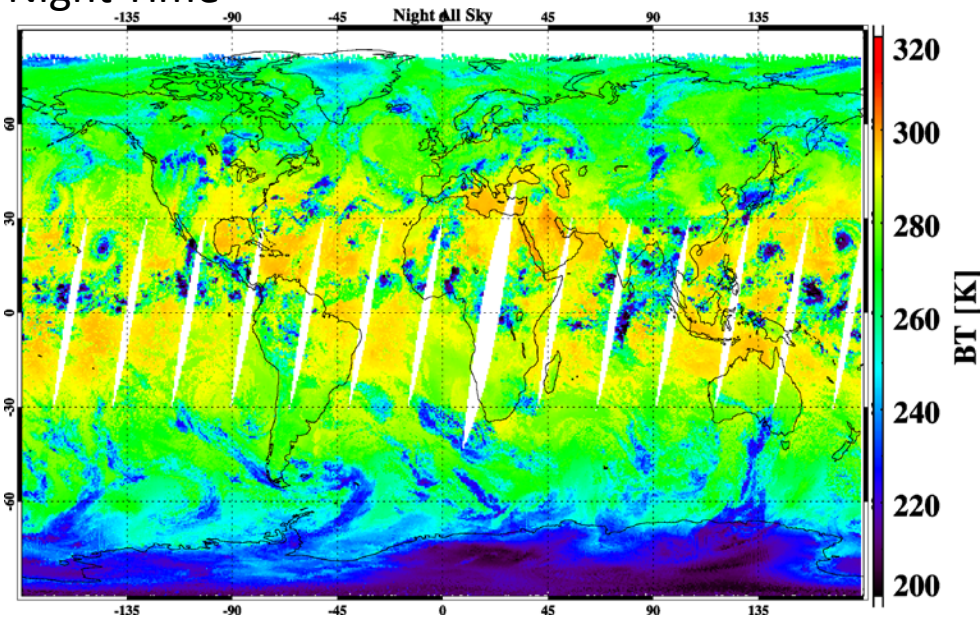


CrIS

Day Time

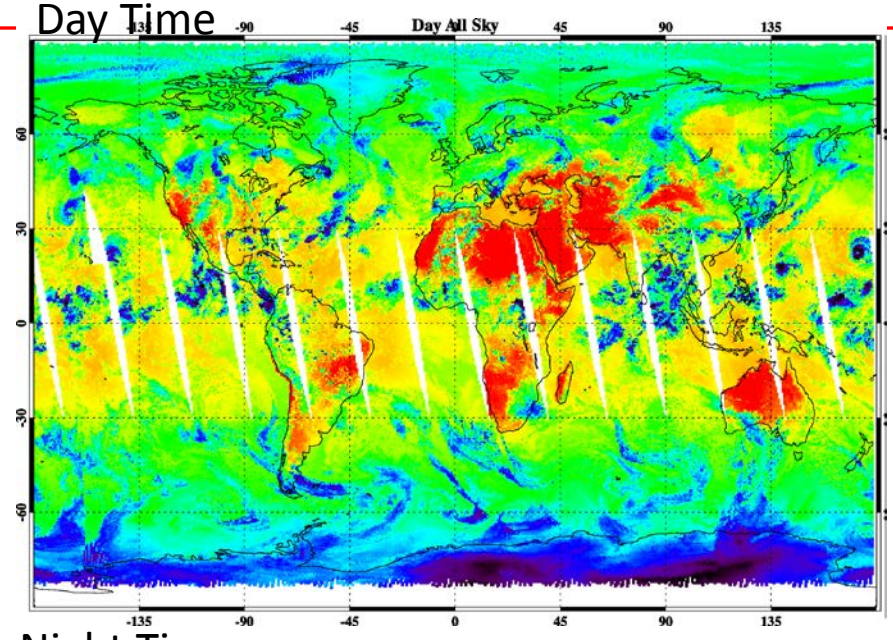


Night Time

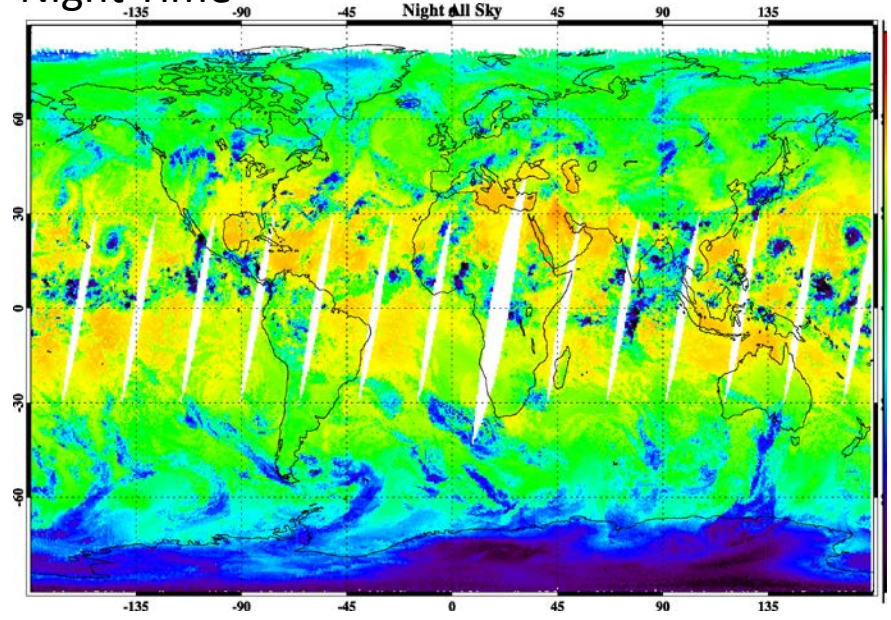


CrIS

Day Time

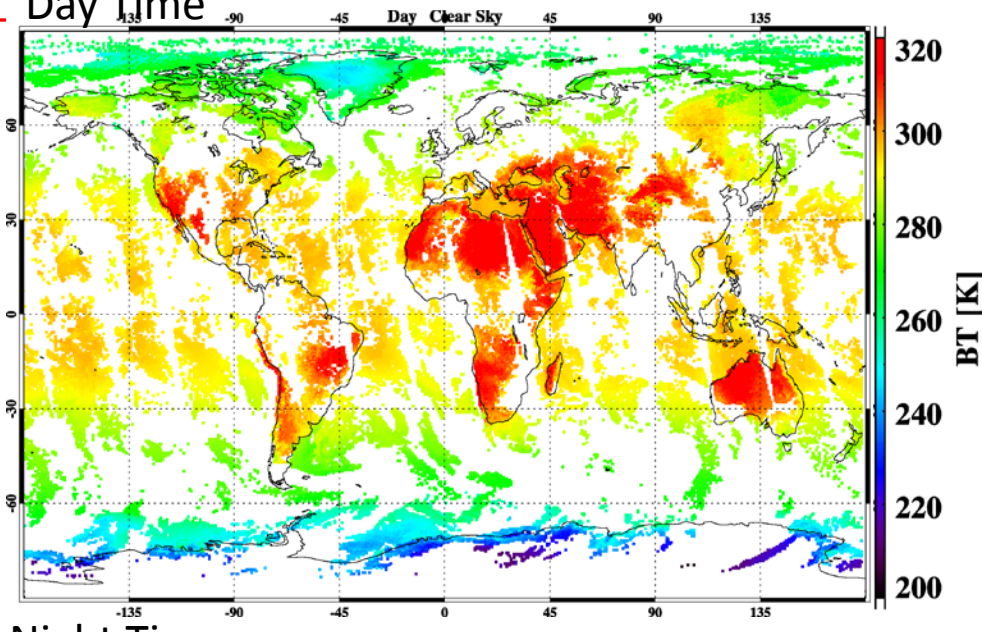


Night Time

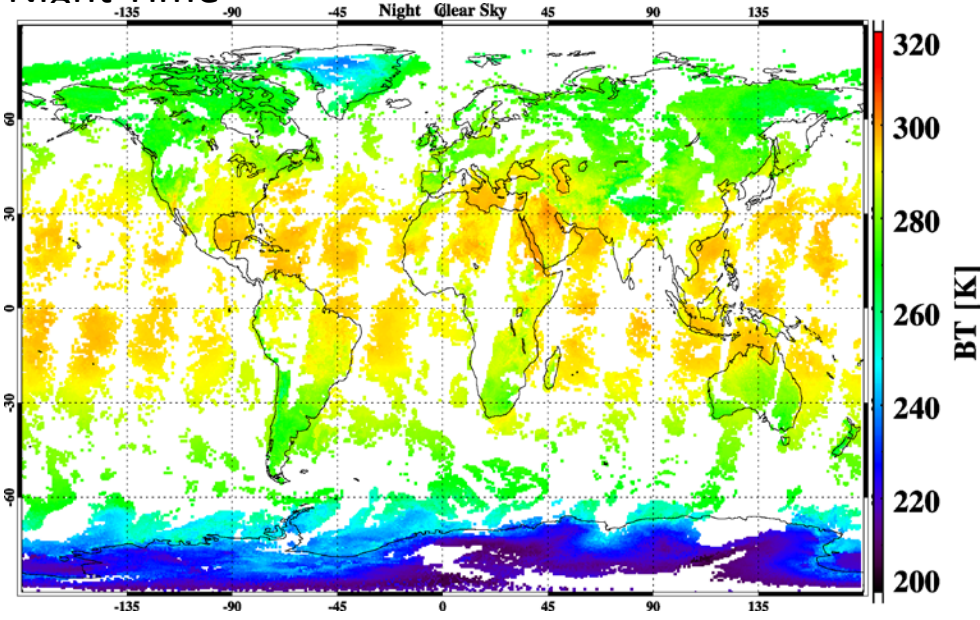


CrIS Clear

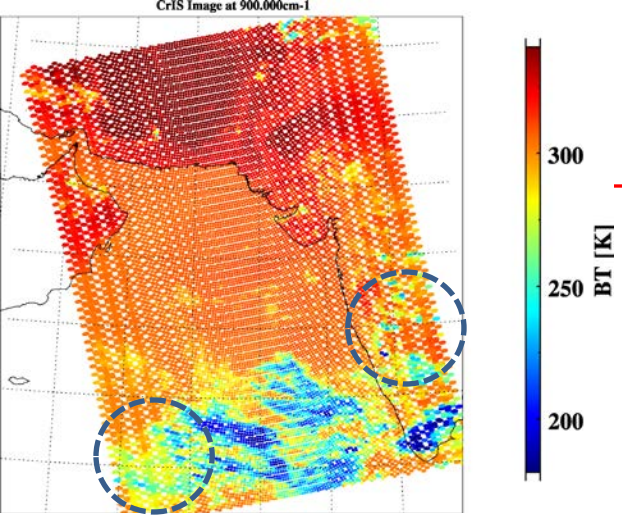
Day Time



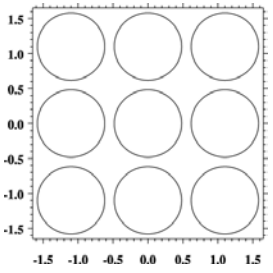
Night Time



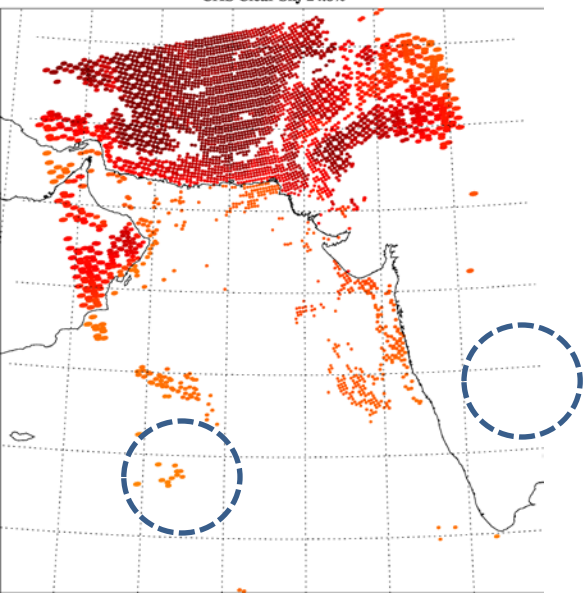
Preliminary Results

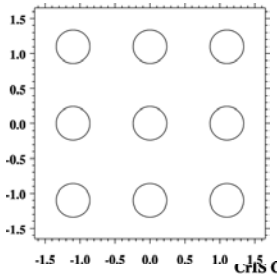


Reducing CrIS FOV size apparently adds more clear sky pixels. Especially at cloud hole region, the clear FOVs show up, which are important for weather predication models.

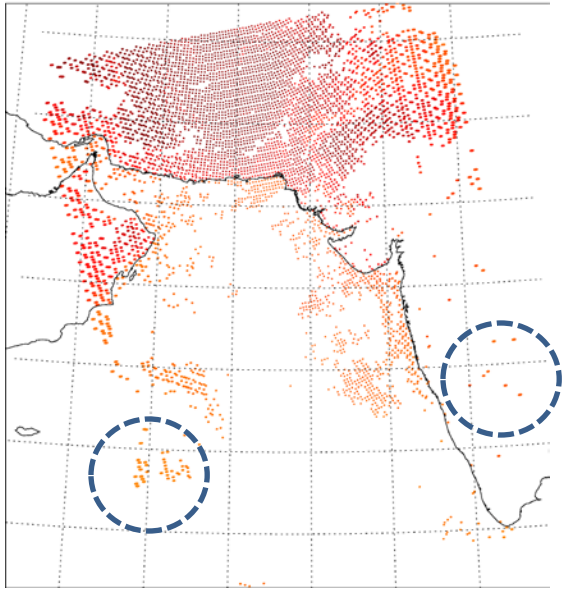


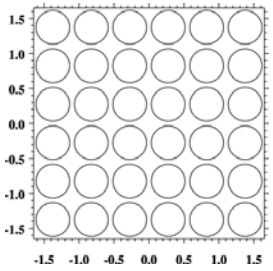
3X3
14km



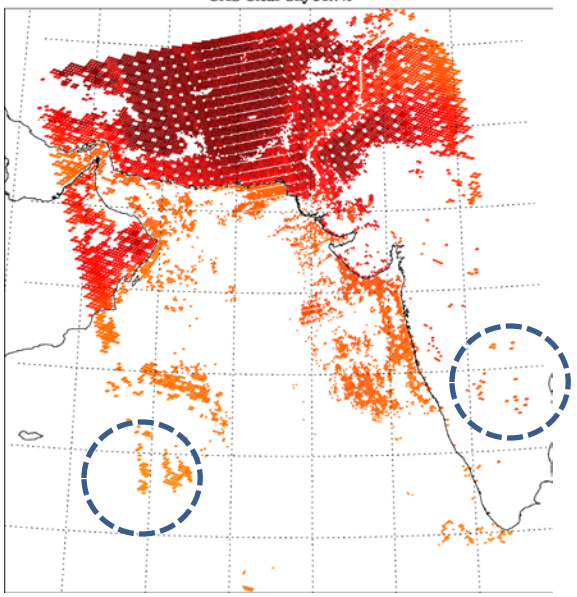


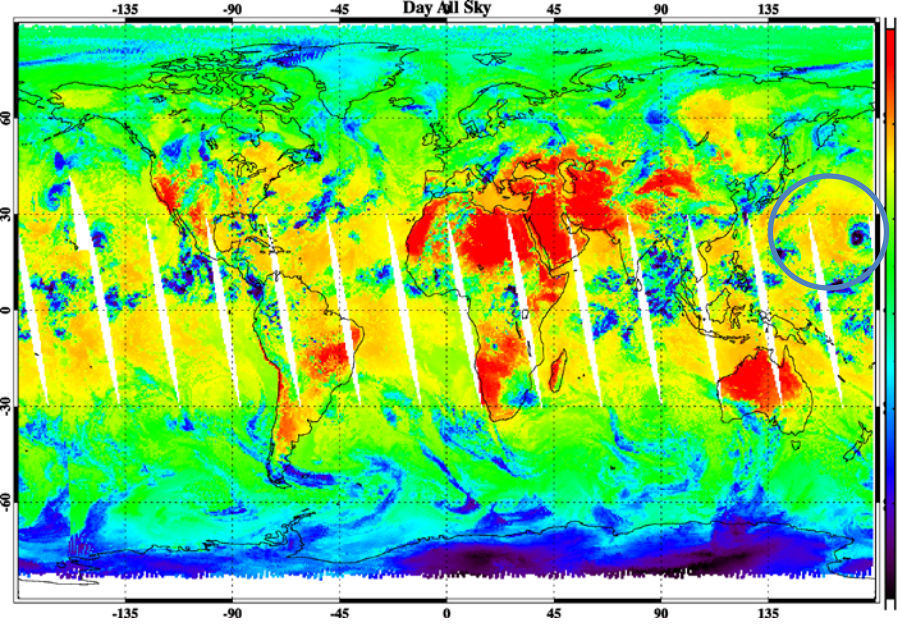
3X3
7km



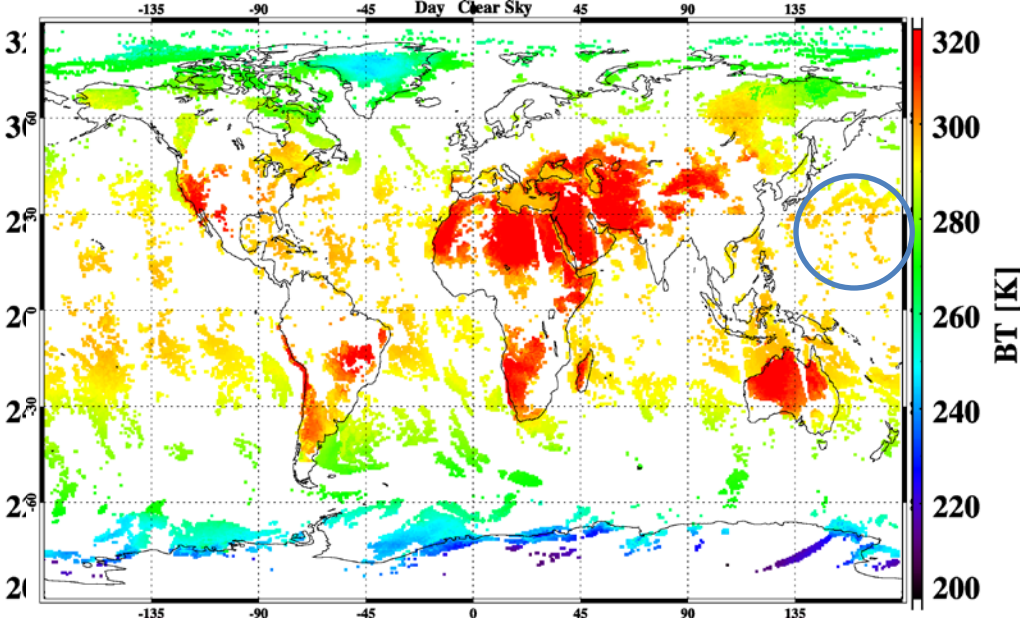


6x6
7km



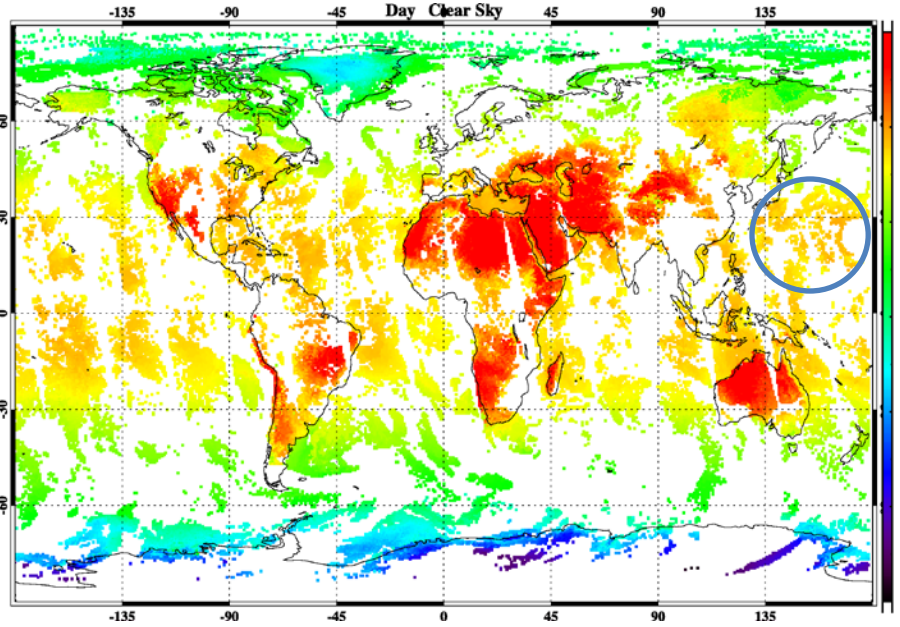


CrIS measurements, All Sky

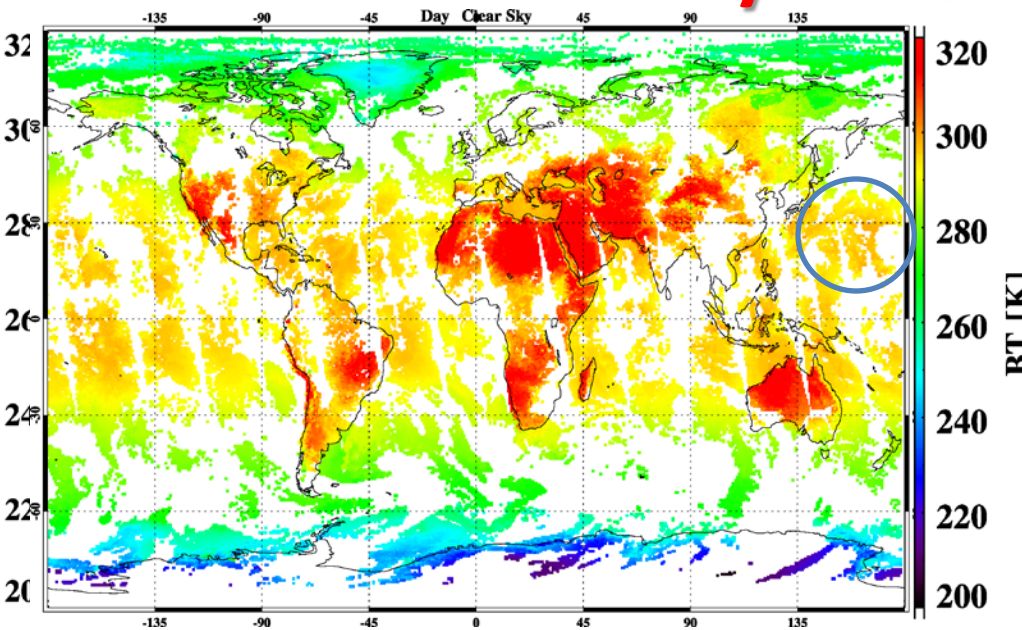


3X3 in 14km, Clear Sky

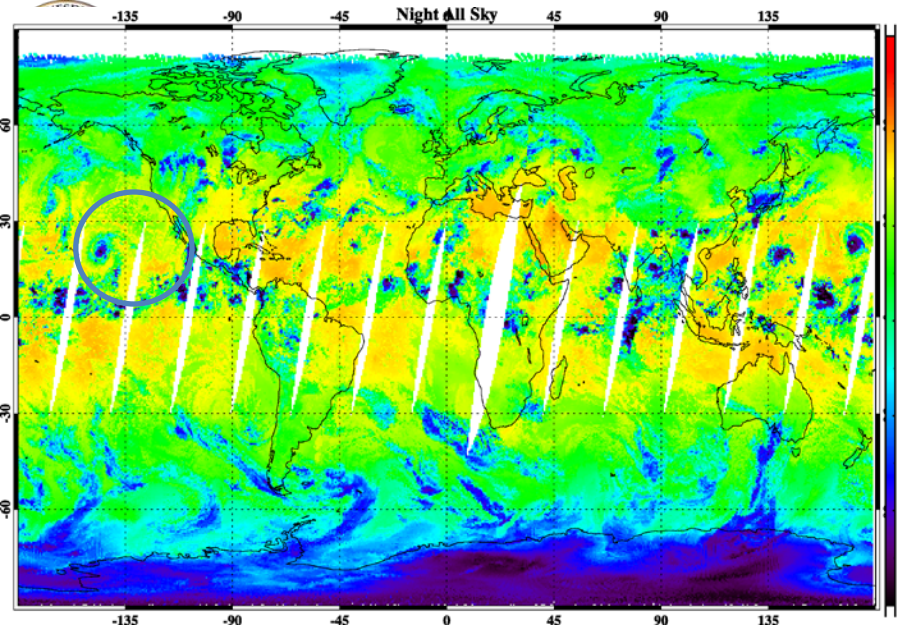
Day Time



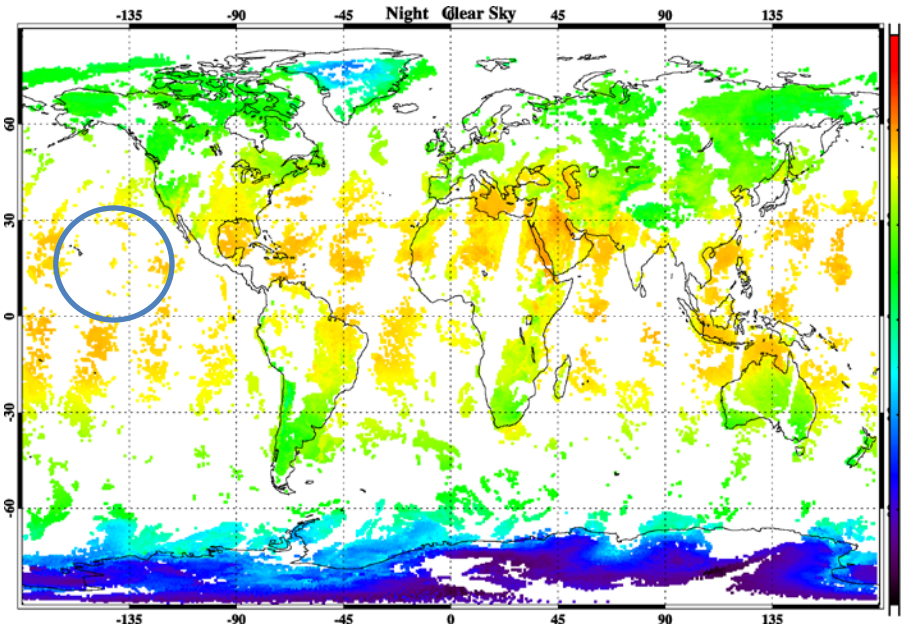
3X3 in 7km, Clear Sky



6X6 in 7km, Clear Sky

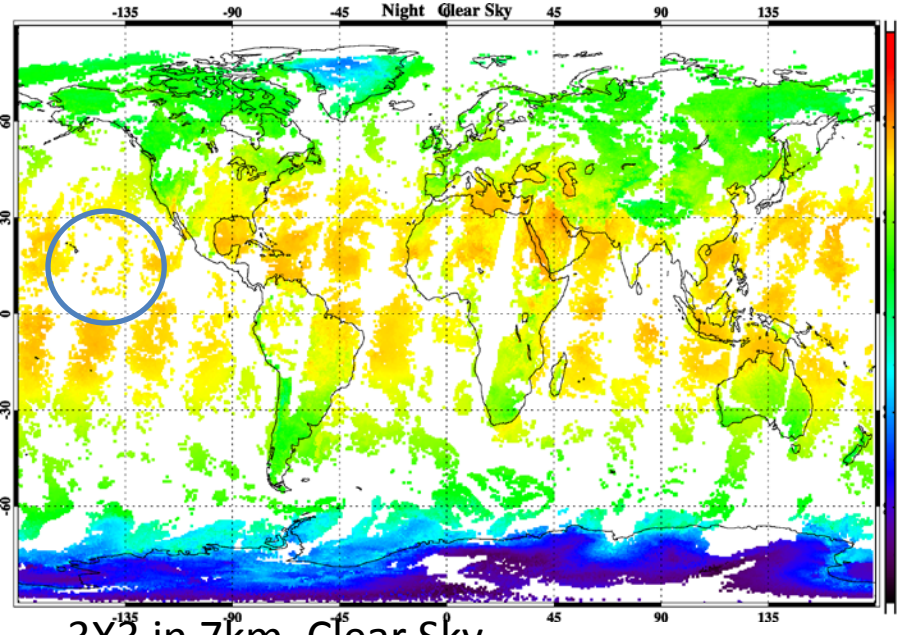


CrIS measurements, All Sky

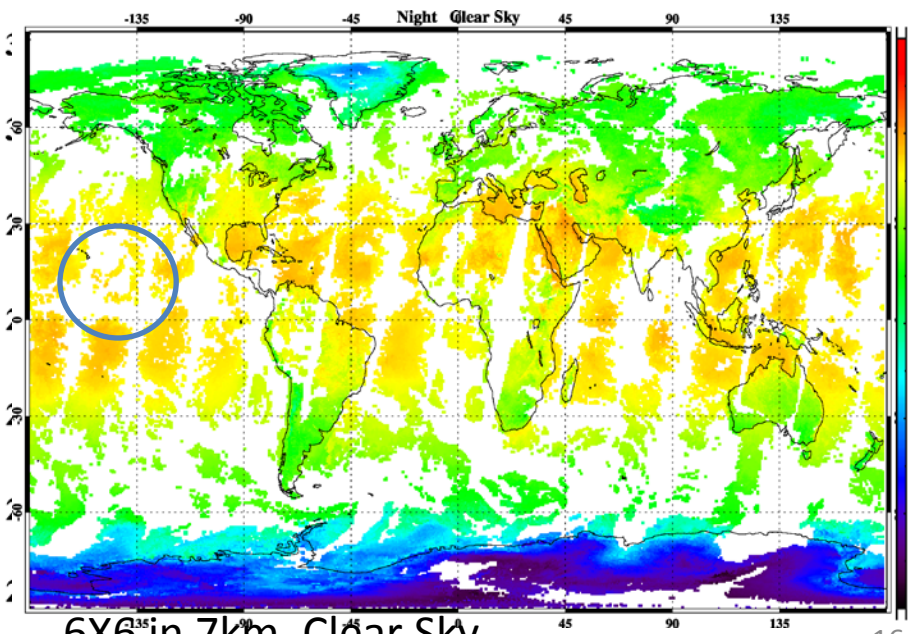


3X3 in 14km, Clear Sky

Night Time



3X3 in 7km, Clear Sky



6X6 in 7km, Clear Sky

Global Statistics (In term of FOV)

	Total FOVs	Clear sky FOVs	Percentage of clear sky FOVs	Increasing Factor of clear sky FOVs
3x3 in 14km	2917080	381383	13.07%	1
3x3 in 7km	2917080	546390	18.73%	1.432654313
6x6 in 7km	11668320	2186460	18.74%	5.732977086

Percentage of clear sky FOVs: Number of clear sky FOVs/Number of total FOVs

The increasing factor of cloud-free measurements is defined as N2/N1

N1 : the number of clear sky CrIS FOVs under 3x3, 14.0 km configuration

N2 : the number of clear sky CrIS FOVs under proposed configuration

Global Statistics (in term of FOR)

Configuration	Total FOR number (N)	Clear FOR number (at least one clear FOV within FOR) (C)	C/N
3x3 in 14km	324120	80276	0.247673701
3x3 in 7km	324120	116329	0.358907195
6x6 in 7km	324120	142179	0.438661607

This is the way that NWP center uses the CrIS data. In each FOR, only use the one clear Sky FOVs. Increased clear FORs directly impacts how much data are assimilated in models.

Preliminary Conclusion and Future Work

- Since operational data assimilation of hyper-spectral radiances for NWP models still relies primarily on cloud-free data, the number of clear sky measurements are significant for NWP models.

- Using VIIRS radiances and cloud mask to check CrIS measurement statistics, we studied the statistics of CrIS clear FOV number under different configuration.

- The results are encouraging. It does indicate the number of clear sky measurements increased with improved FOV spatial resolution and increased FOV size.

- The future work will include more detailed statistics and how these changes are related to scene uniformity and instrument noise.