

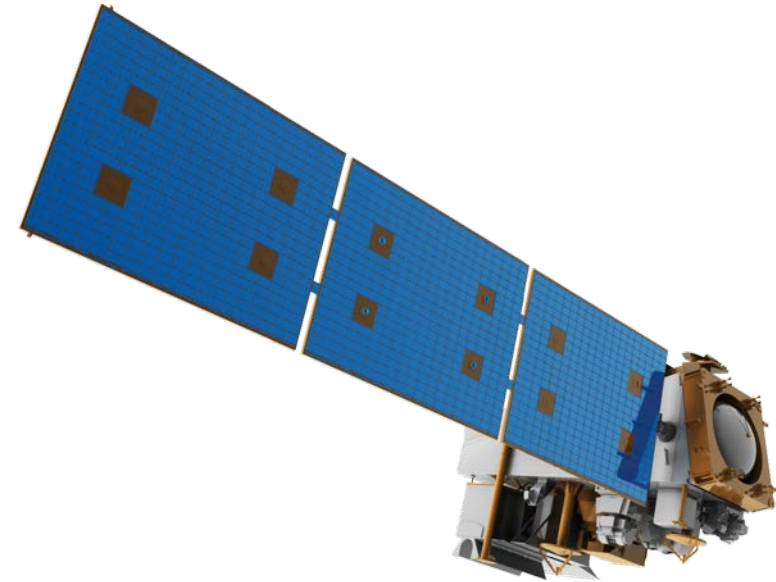
Infrared Cloud Detection Without a Long-wave Band?

Bryan Karpowicz (NASA/GMAO/UMBC), Erin Jones (NOAA/STAR/CISESS/UMD), Chris Burrows (ECMWF)

Question to answer: can we do cloud detection without a LW band?

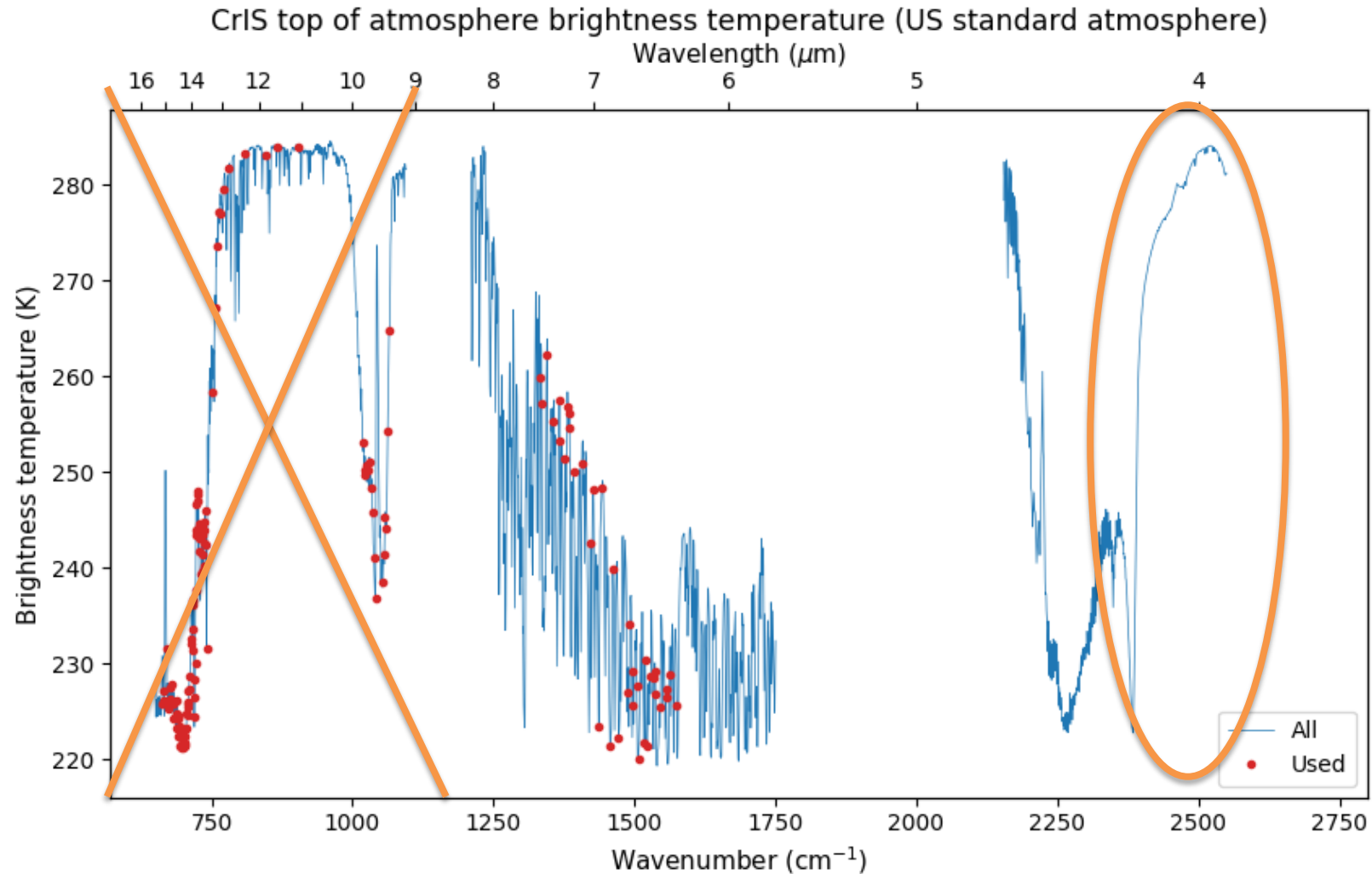
First, why would we want to??

1. Low cost instrument concepts without the long-wave band.
This is being discussed as an idea for future constellations of small satellites (e.g., CIRAS, MISTiC). For this to be a realistic prospect, we need to show that it would be **possible** to do cloud detection without a LW band. This would be a strong message to data providers.
2. CrIS onboard S-NPP has lost the use of its LW band, so we cannot currently assimilate channels in the MW and SW bands which are still operating. It would be good to start using it again!



The hope....

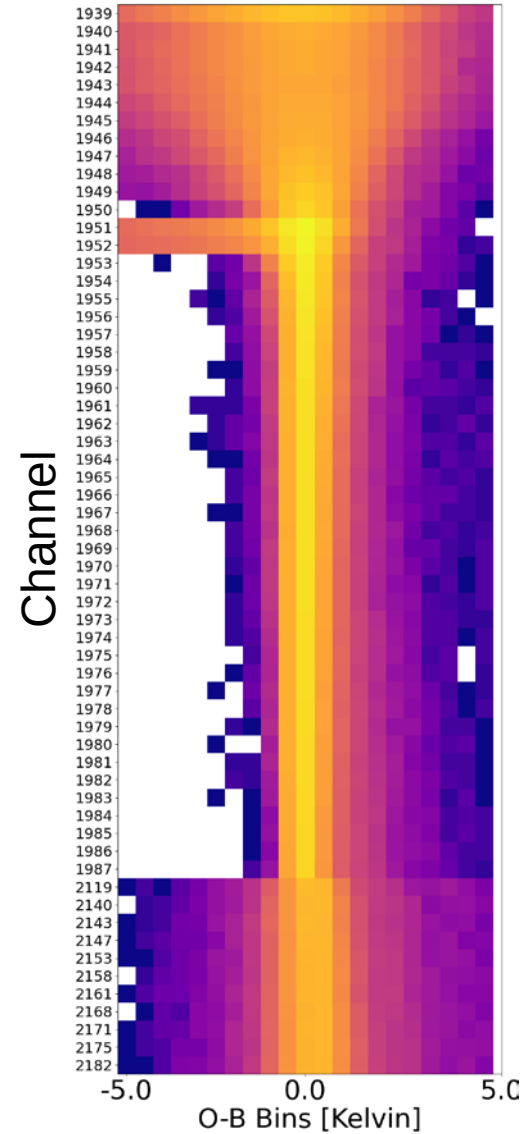
- We would like to make use of the clean CO₂ band in the SW band to inform the cloud detection. It is a very clean part of the spectrum in terms of absorption, but is affected by solar radiation and NLTE effects.



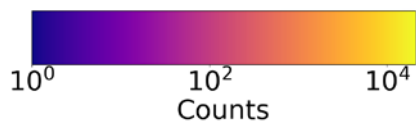
Top of Atmosphere

Clear O-B Histograms (LW detection)

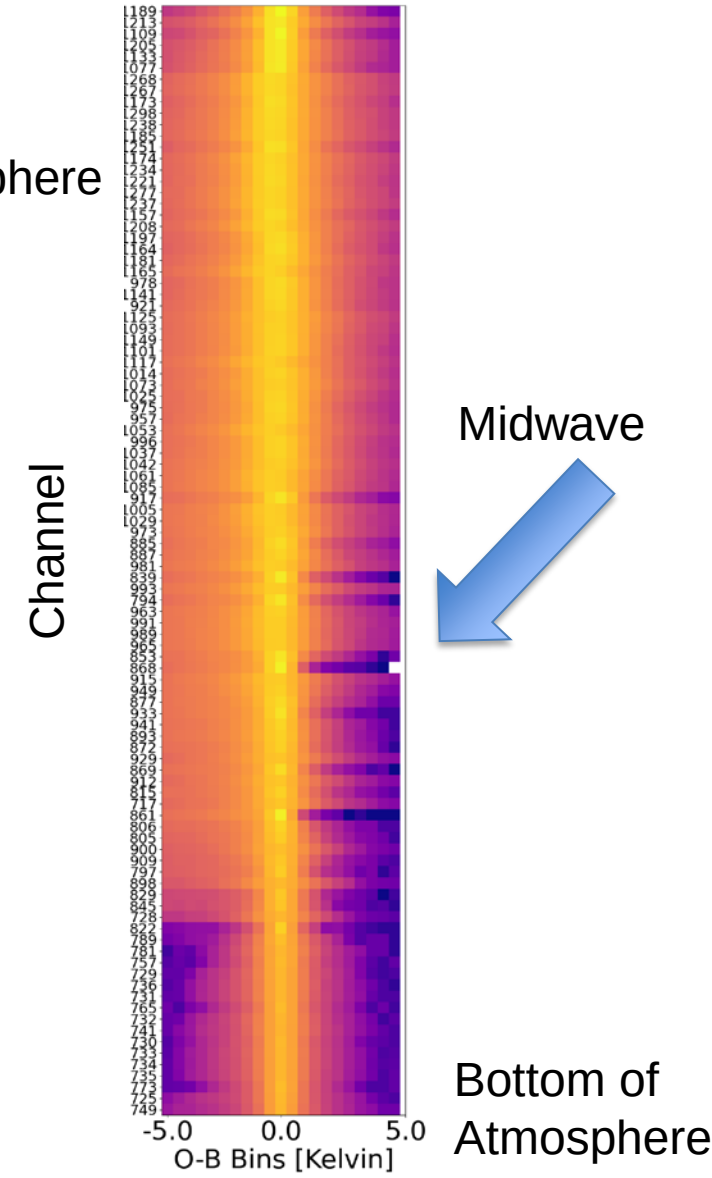
- Further into the stratosphere fewer clouds sensed
- Distribution of O-B wider spread towards upper atmosphere



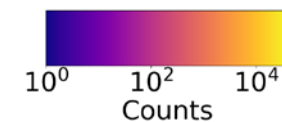
Bottom of Atmosphere



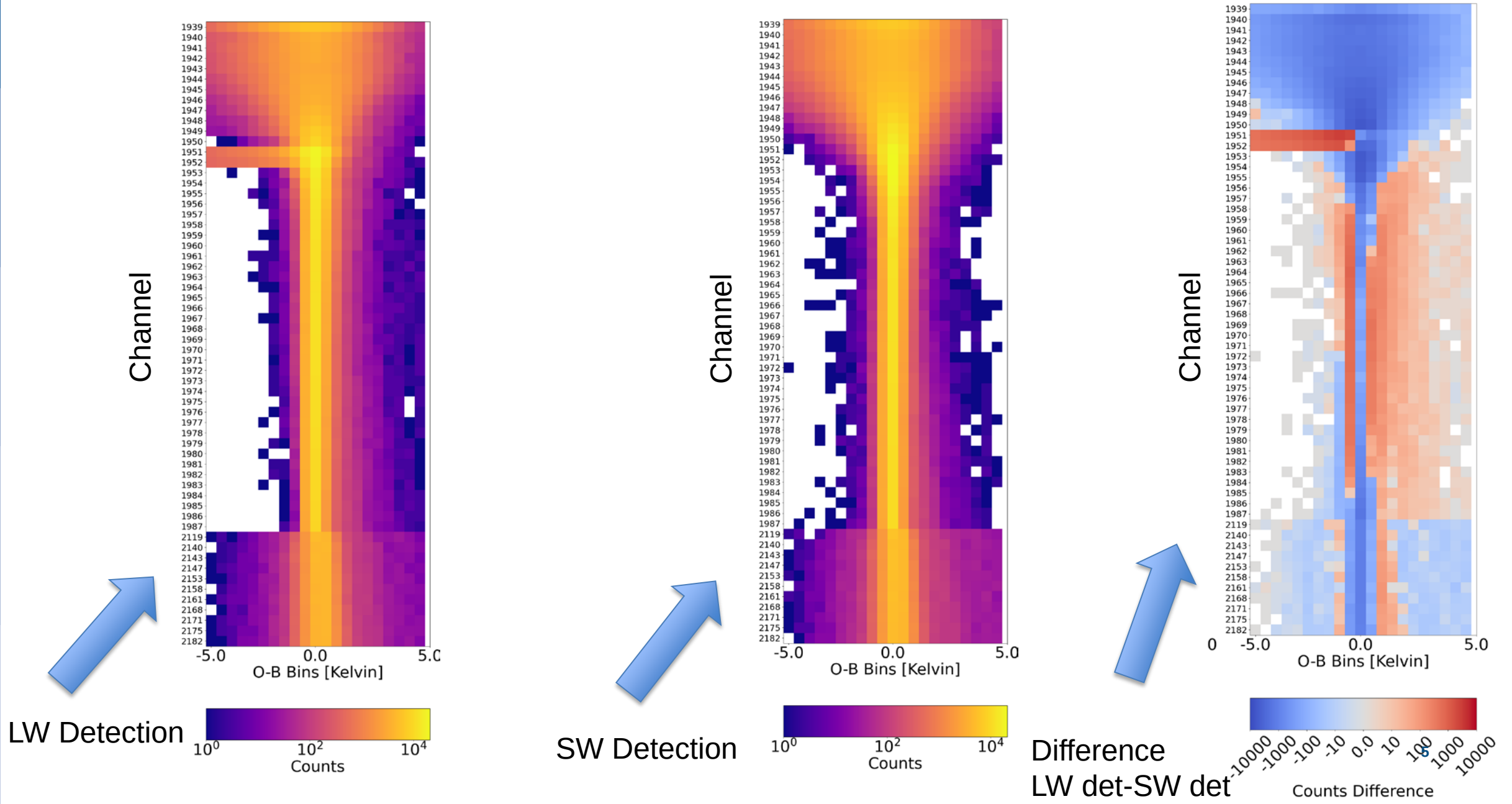
Top of Atmosphere



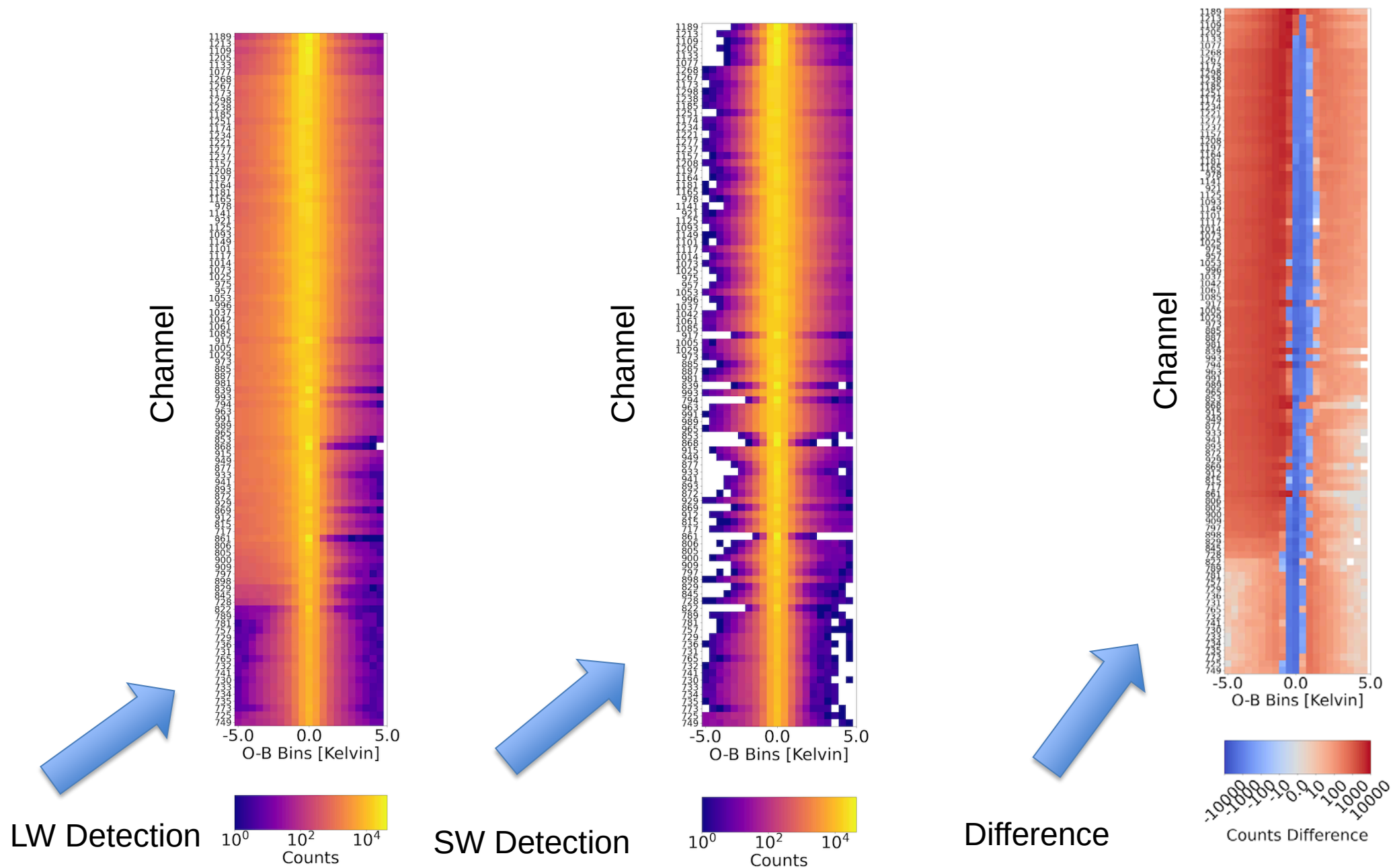
Bottom of Atmosphere



Clear O-B Histograms Using SW Cloud Detection (SW histograms)

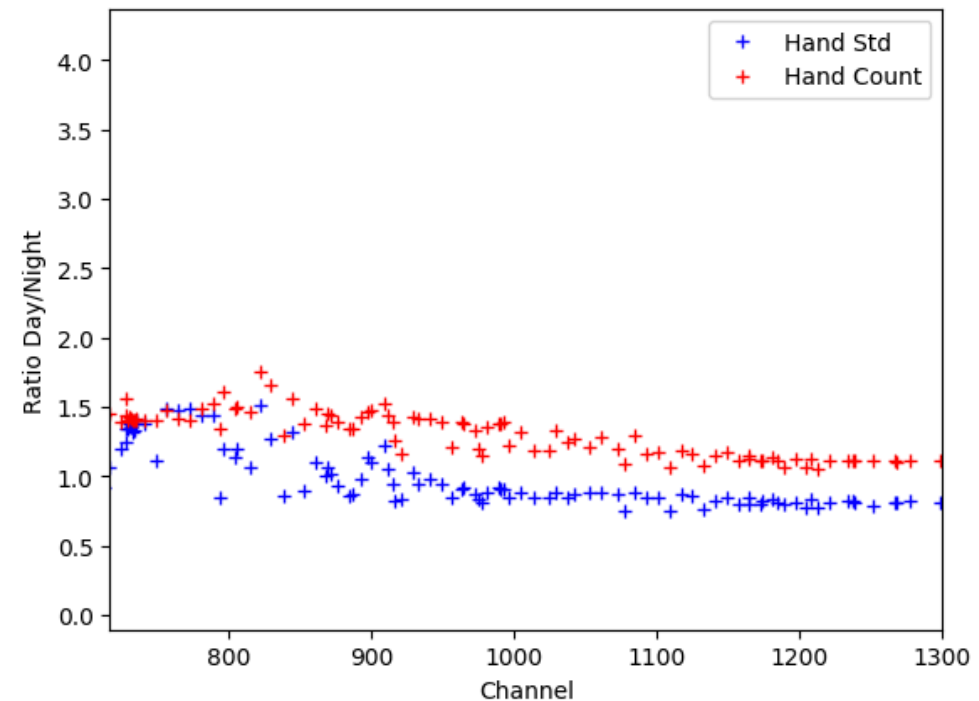
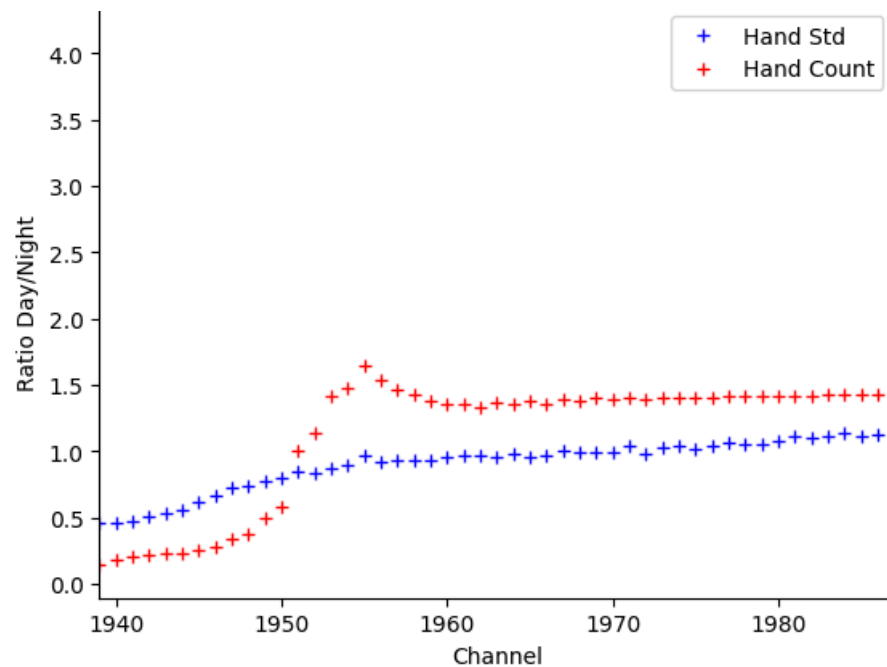


Clear O-B Histograms Using SW Cloud Detection (MW Histograms)



Day/Night Differences

- Early iterations using SW only for cloud detection resulted in some undesirable day/night differences in the MW
- Adding some MW channels with little/no water vapor sensitivity seemed to have tamed this, but still some day night variability (true for LW detection also)



And now for something completely different...

A couple of questions:

- Can a hyperspectral IR sensor with no LW band be effectively assimilated in the IFS (in clear-sky conditions)?
- Can SW channels be used for cloud detection in assimilation experiments?

And a couple of OSEs:

- Actually, more than a couple of OSEs... We started some experiments to test SW assimilation and SW-based cloud detection
- Experiments use 49r1, T399 resolution in Northern Hemisphere warm season
- CADS used for cloud detection; no CADS code changes
- Changes made to:
 - Cloud detection namelist: iterating on using CrIS SW channels for cloud detection
 - Bands assimilated (e.g. blacklisting CrIS LW channels)
- **An important note: these experiments are ongoing!** There are no OSE results yet using the “latest and greatest” CADS namelists for SW-based cloud detection!

Some experiment results: Obs impacts

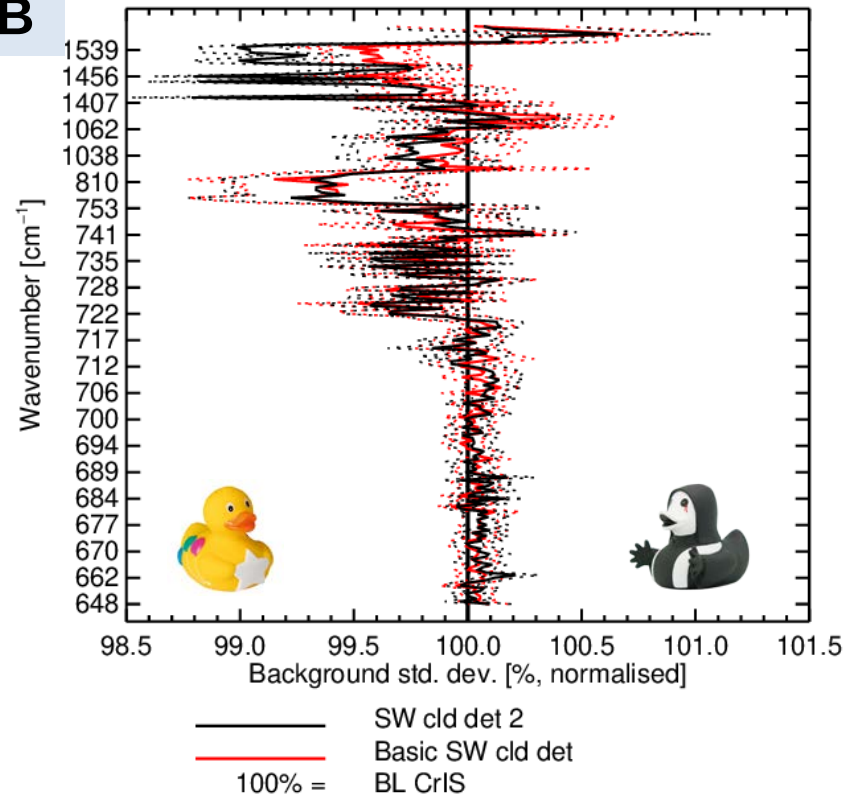
In this set of experiments:

- Control = No CrIS observations
- Experiment 1 = Baseline SW-based cloud detection
- Experiment 2 = Circa 22 Feb 2024 SW-based cloud detection

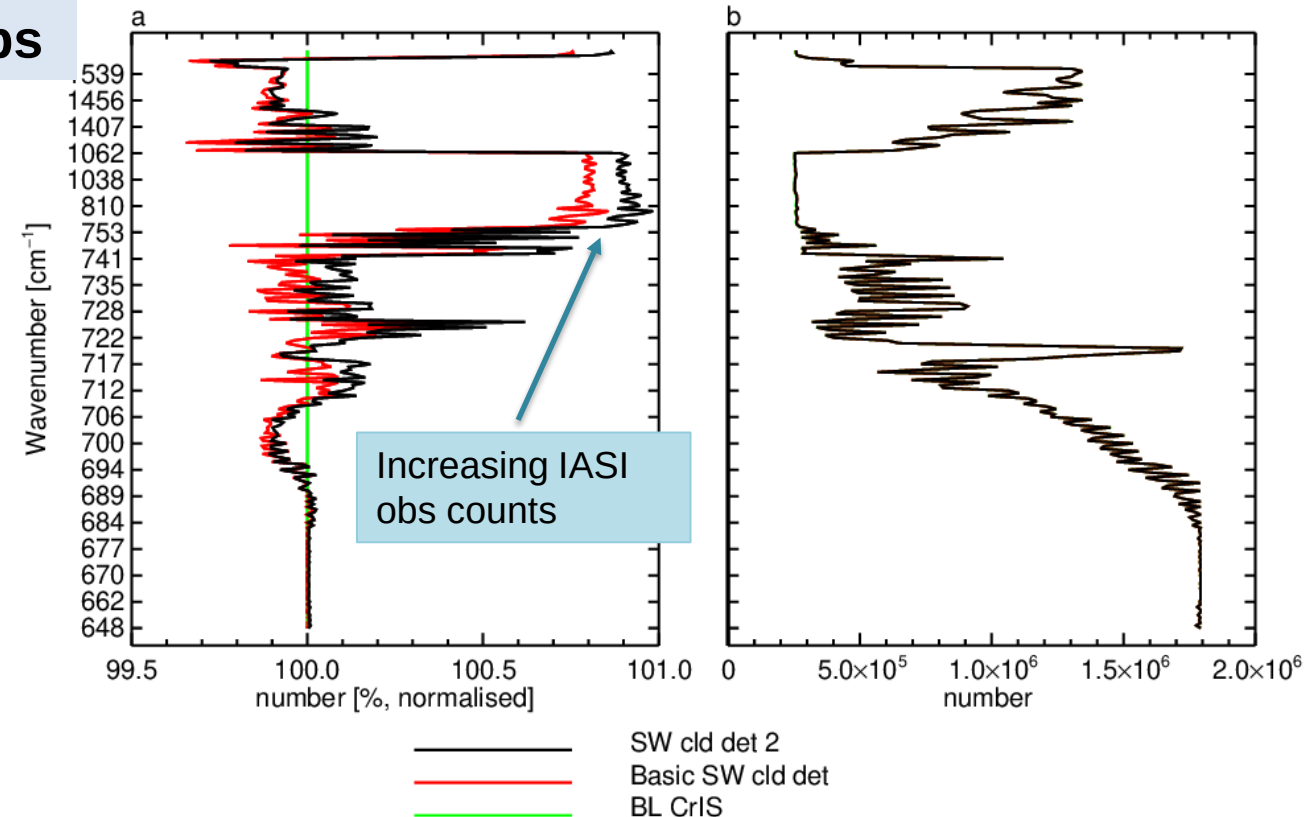
IASI obsats

Instrument(s): METOP-B,C – IASI – TB Area(s): N.Hemis S.Hemis Tropics
From 00Z 7-Jun-2023 to 12Z 26-Jun-2023

OmB



N.Obs



Obs stats for IASI are generally neutrally impacted or improved in experiments

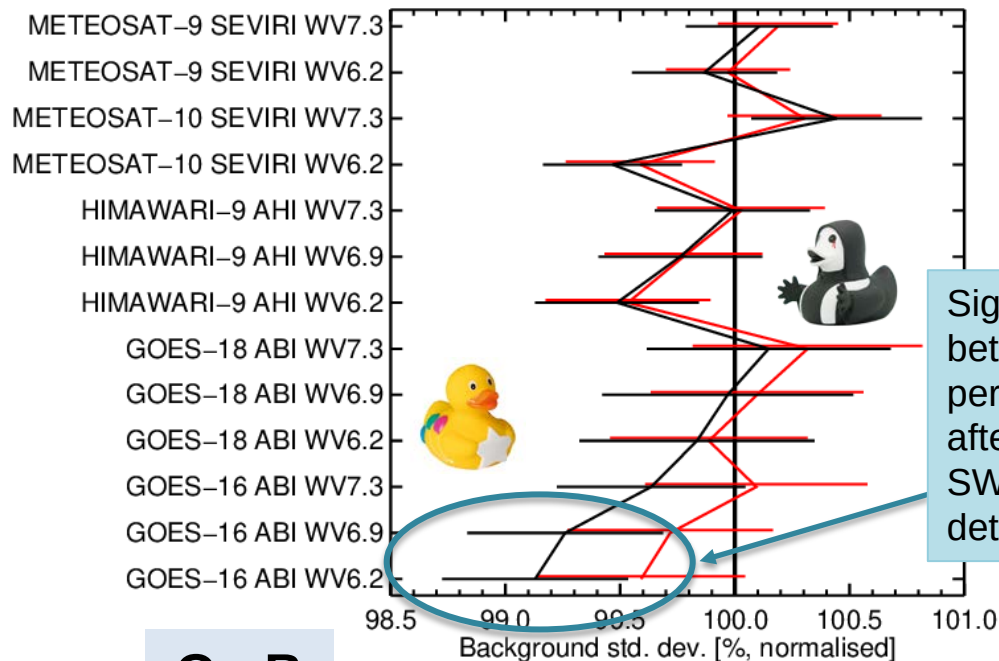
Some experiment results: Obs impacts

In this set of experiments:

- Control = No CrIS observations
- Experiment 1 = Baseline SW-based cloud detection
- Experiment 2 = Circa 22 Feb 2024 SW-based cloud detection

GEOS obsats

Instrument(s): GOES-16,18; HIMAWARI-9; METEOSAT-10,9 – ABI AHI SEVIRI – TB
Area(s): N.Hemis S.Hemis Tropics
From 00Z 7-Jun-2023 to 12Z 26-Jun-2023

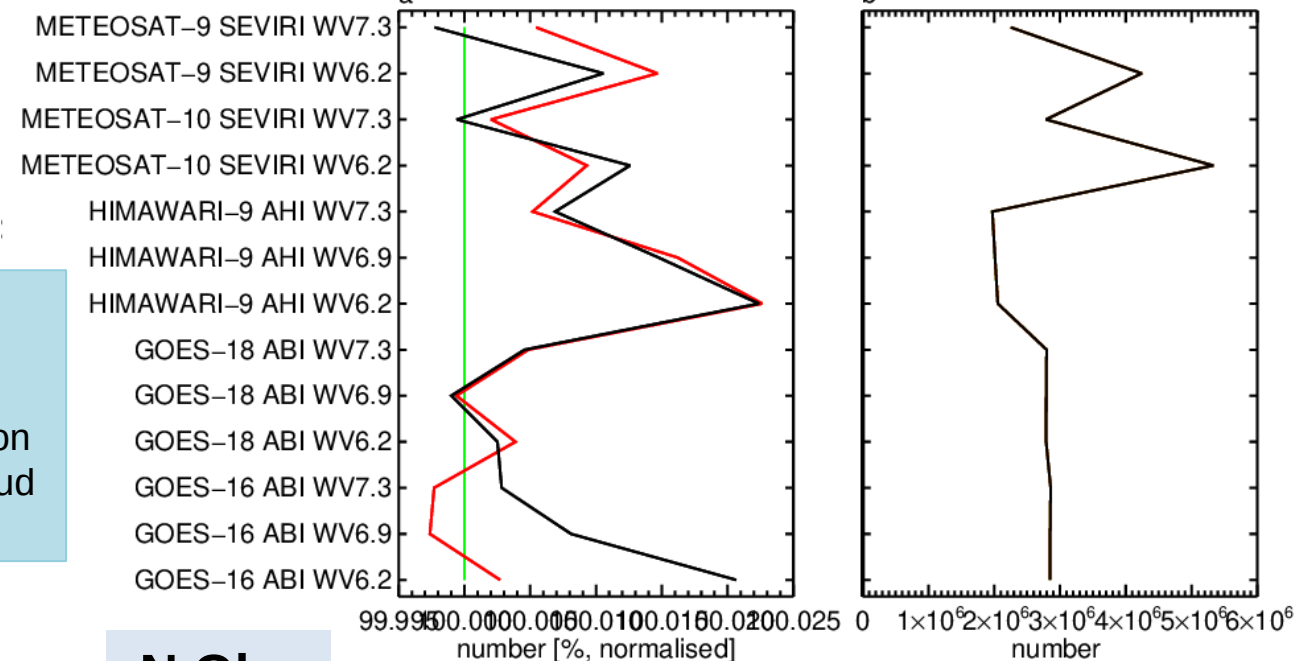


OmB

— SW cld det 2
— Basic SW cld det
100% = BL CrIS

Significantly better ABI performance after iterating on SW-based cloud detection

Instrument(s): GOES-16,18; HIMAWARI-9; METEOSAT-10,9 – ABI AHI SEVIRI – TB
Area(s): N.Hemis S.Hemis Tropics
From 00Z 7-Jun-2023 to 12Z 26-Jun-2023



N.Obs

— SW cld det 2
— Basic SW cld det
— BL CrIS

Obs stats are generally neutrally impacted or improved for geostationary sensors in experiments

Some experiment results: Obs impacts

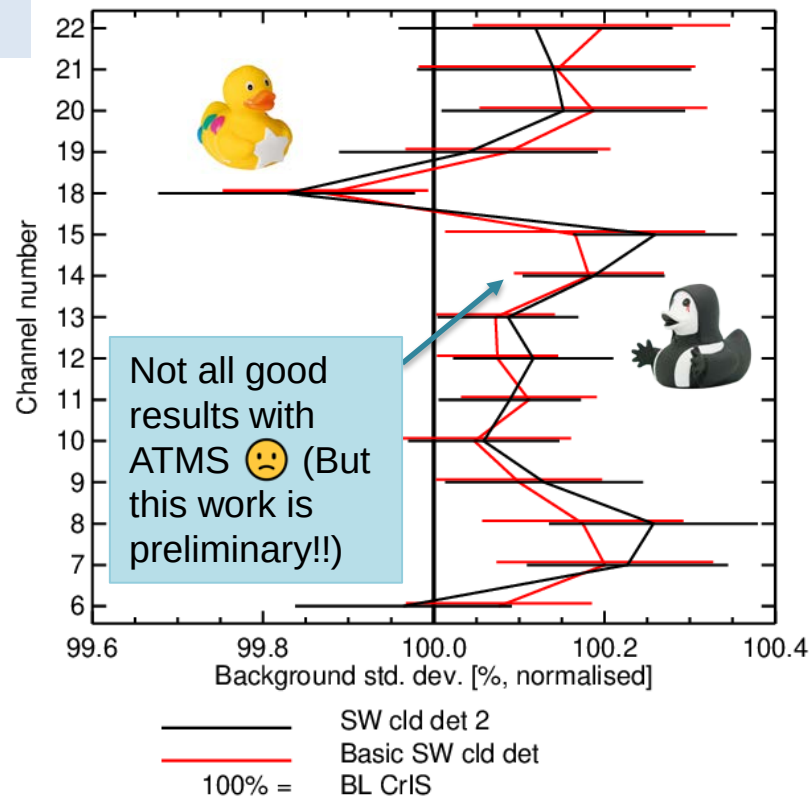
In this set of experiments:

- Control = No CrIS observations
- Experiment 1 = Baseline SW-based cloud detection
- Experiment 2 = Circa 22 Feb 2024 SW-based cloud detection

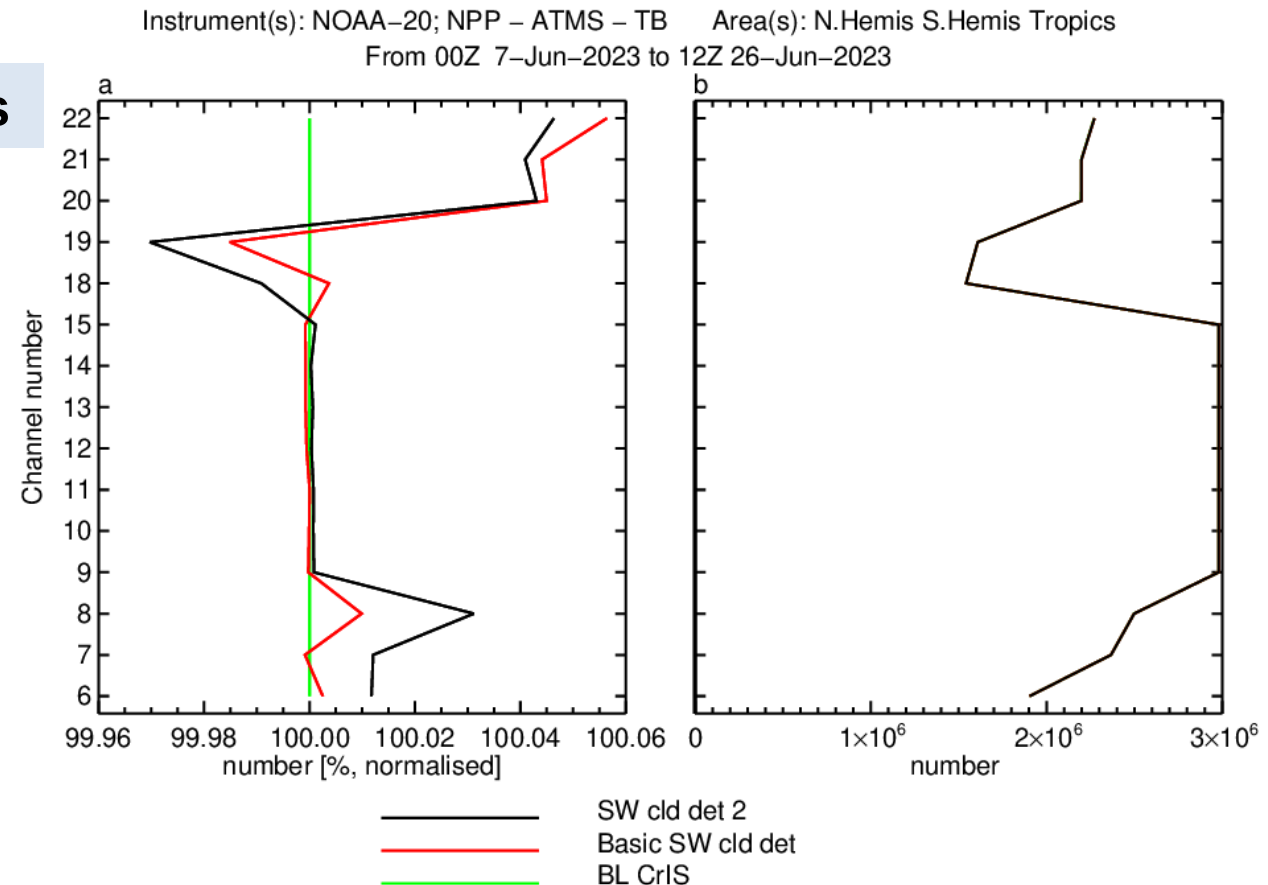
ATMS obsats

Instrument(s): NOAA-20; NPP – ATMS – TB Area(s): N.Hemis S.Hemis Tropics
From 00Z 7-Jun-2023 to 12Z 26-Jun-2023

OmB



N.Obs



Impacts mixed for ATMS; obs counts increase for some channels, but so do OmB standard deviations (e.g. for high-peaking channels – possibly related to increased CrIS obs errors at these levels impacting cloud detection)

Some experiment results: Forecast impacts

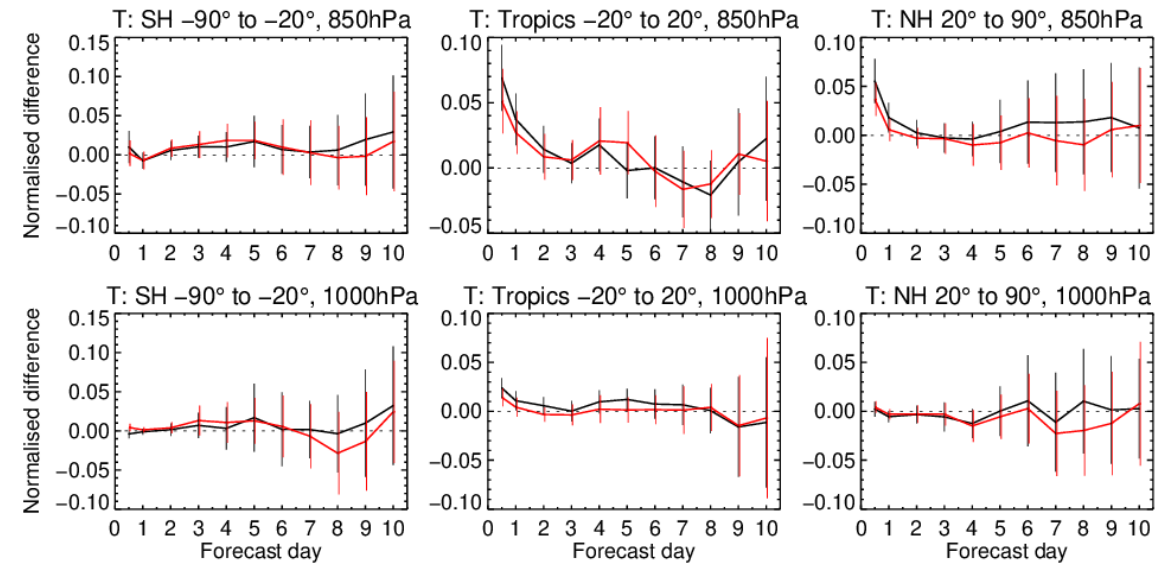
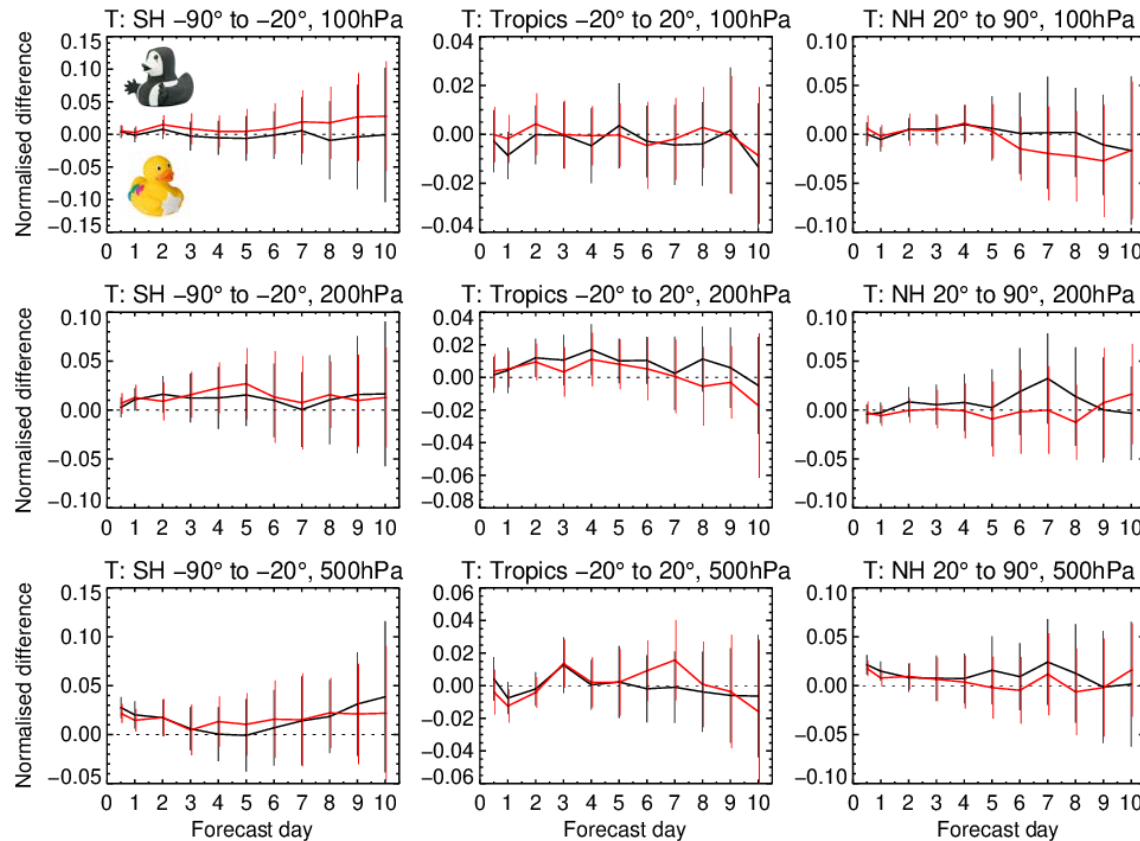
In this set of experiments:

- Experiment 1 = Baseline SW-based cloud detection
- Experiment 2 = Circa 22 Feb 2024 SW-based cloud detection

Temperature Forecast

7-Jun-2023 to 26-Jun-2023 from 20 to 39 samples. Verified against 0001.

Confidence range 95% with AR(2) inflation and Sidak correction for 8 independent tests.



Mostly neutral impacts seen on the temperature forecast – there is some degradation at 12-24 hours, most notably at 850 hPa in the Tropics

Conclusion

- A SW-based cloud detection scheme **holds promise**
 - Initial findings are encouraging
 - More work is still required for experiment using latest detection configuration
- This work is important for the use of SNPP-CrIS and other potential future sensors that lack LW bands
 - Initial results suggest that a SW + MW instrument can have neutral impacts
 - Experiments are still ongoing to verify this over a longer time period
 - The benefits that may be gained by exploring this further are worth the effort