Developing a SWIR/MWIR-based Cloud Detection in CADS

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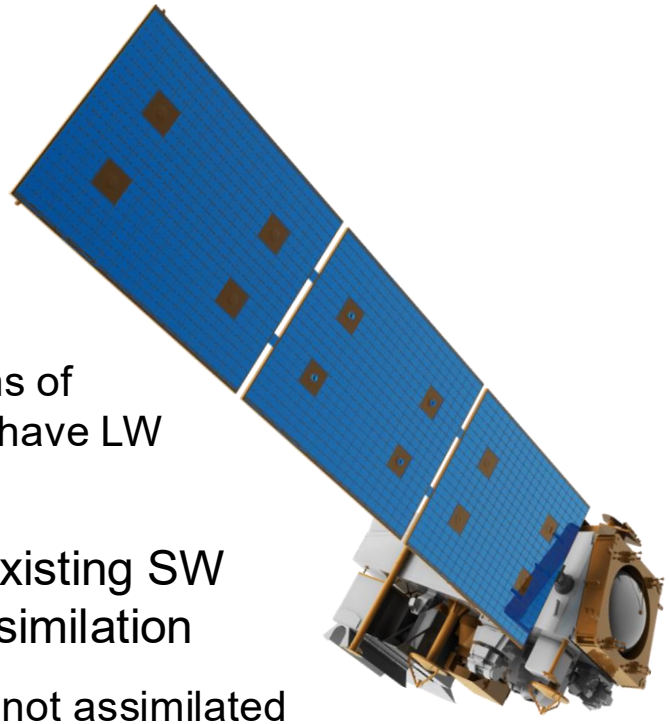
The Question: *Can we do cloud detection in the hyperspectral IR without a LW band?*



Some motivation:

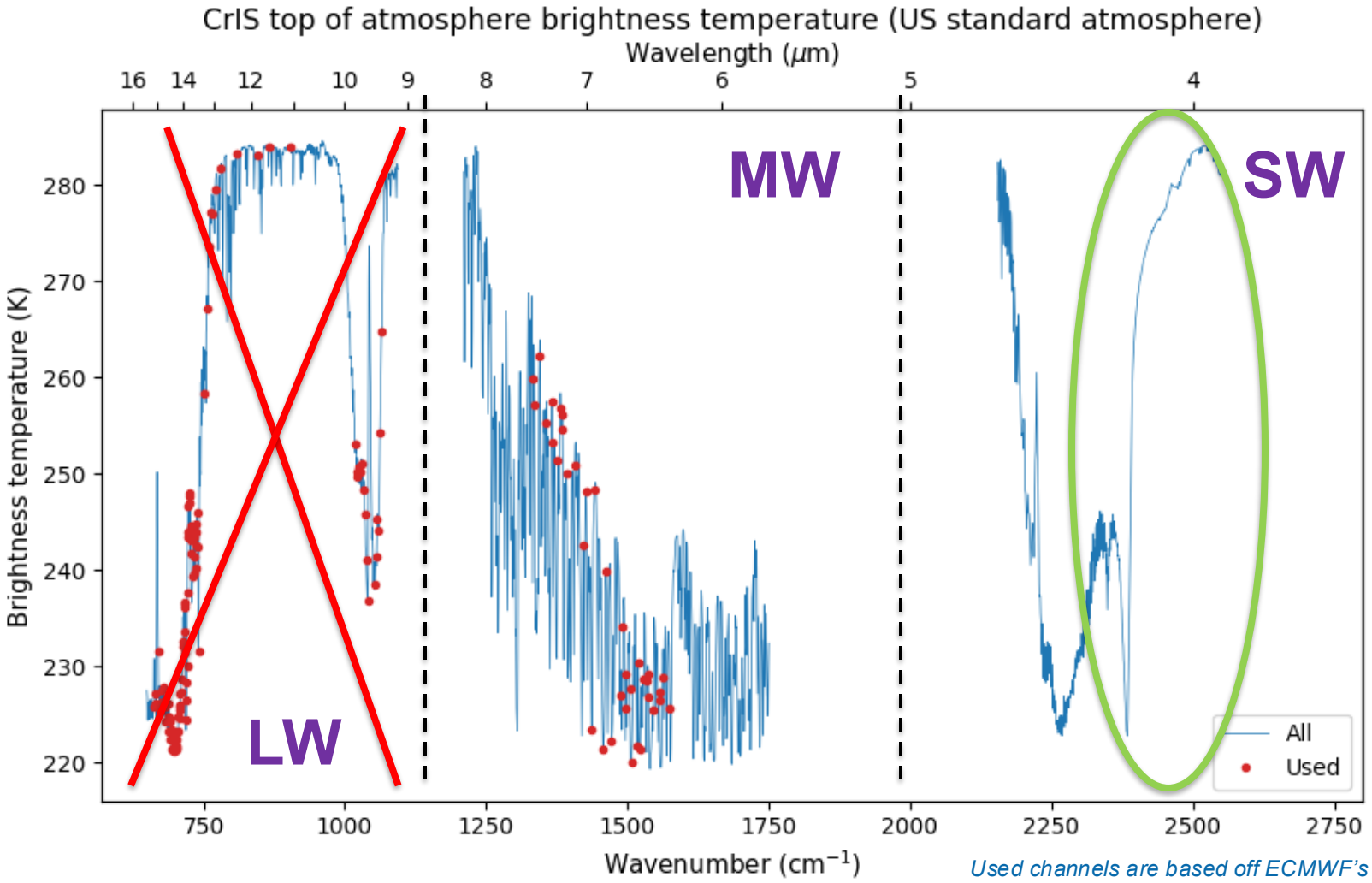
- There are low-cost instrument concepts without the long-wave band
  - There has been discussion for future constellations of small satellites (e.g., CIRAS, MISTiC) that do not have LW instrumentation
- Many centers do not currently take advantage of existing SW bands on hyperspectral IR instruments for data assimilation
  - S-NPP CrIS lost its LW bands, and is now largely not assimilated despite having operational MW and SW bands

For clear-sky data assimilation of hyperspectral IR to be feasible without a LW band, we need to show that it is be **possible** to do cloud detection without a LW band

The goal:

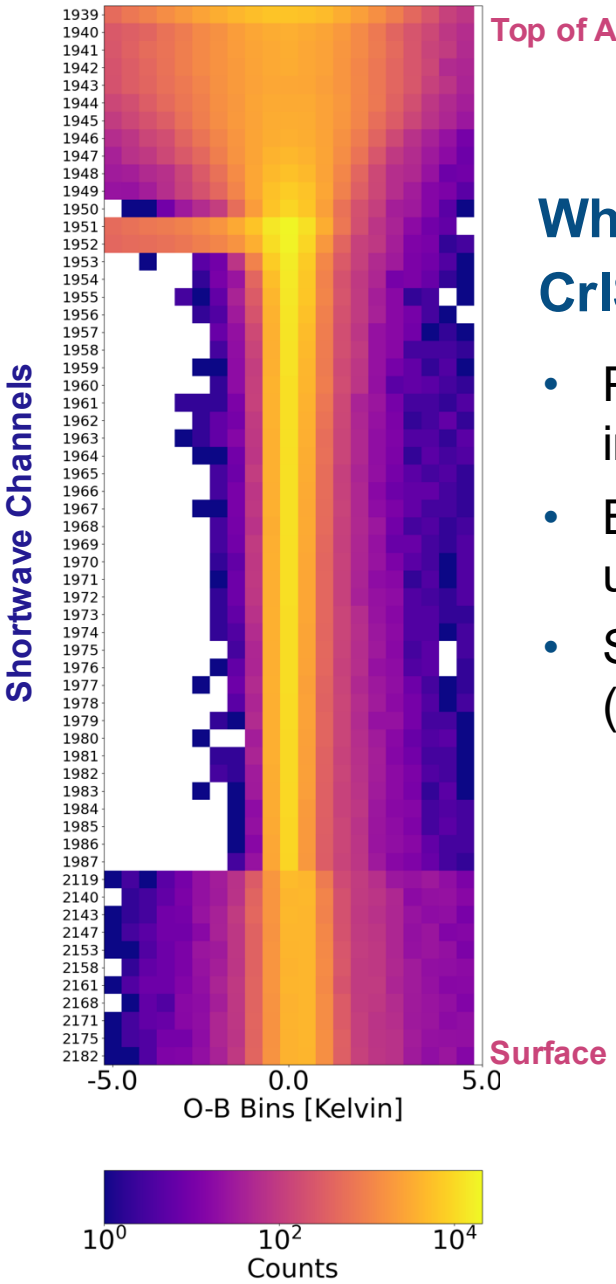
Make use of the SW CO_2 band (the R-branch) to inform the cloud detection for CrIS

- It's a clean part of the spectrum; not much interference from water vapor and trace gases
- It's not free of complications: the SW band is impacted by solar radiation and NLTE effects



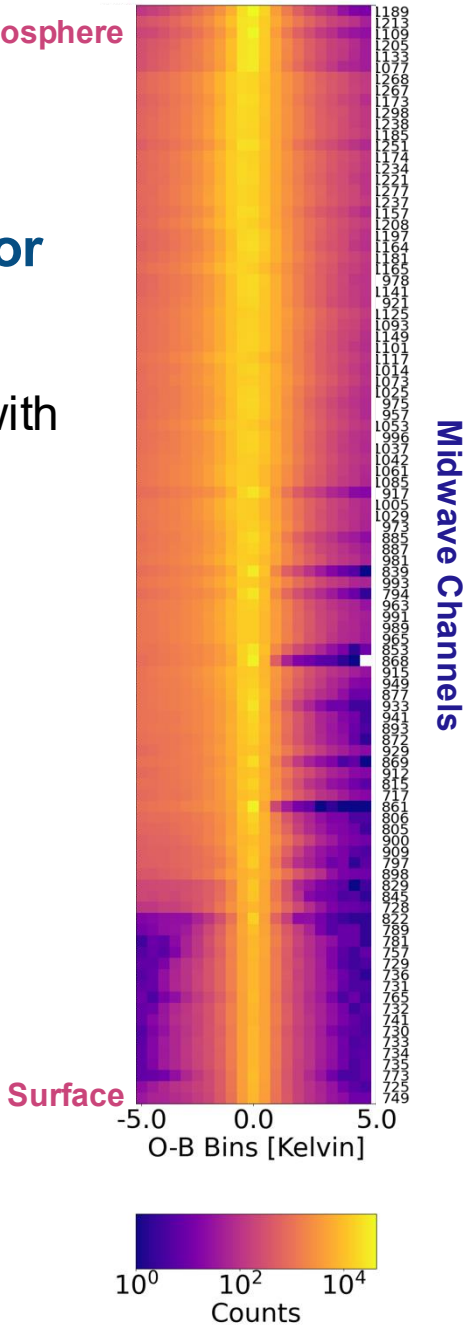
Used channels are based off ECMWF's system

Clear-sky OmB Histograms (LW Detection)

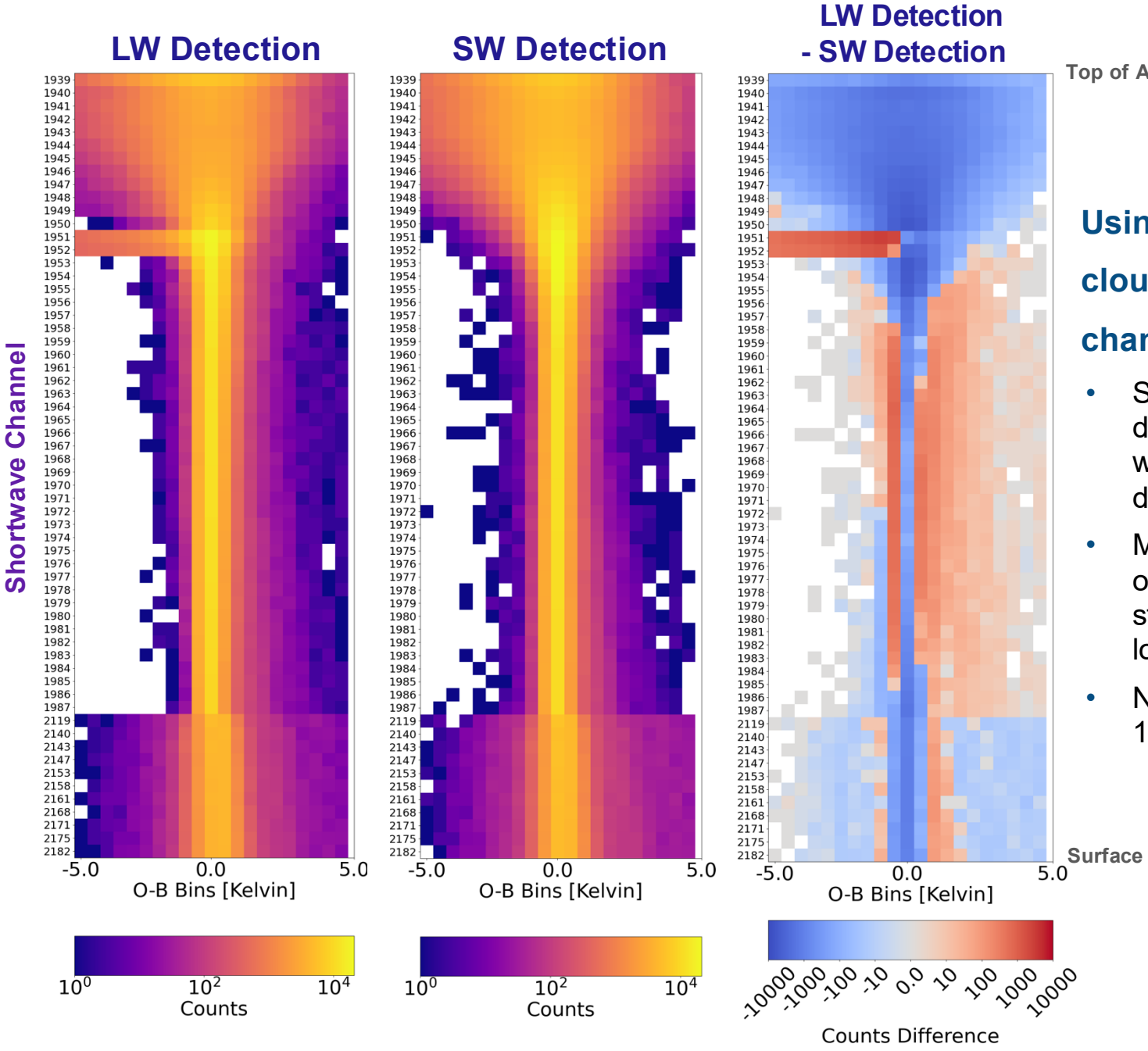


When only the LW band is used for CrIS cloud detection QC:

- Progressively fewer clouds sensed with increasing height in the stratosphere
- Broader distribution of OmB in the upper atmosphere
- Skewed OmB distribution in the MW (cold bias)



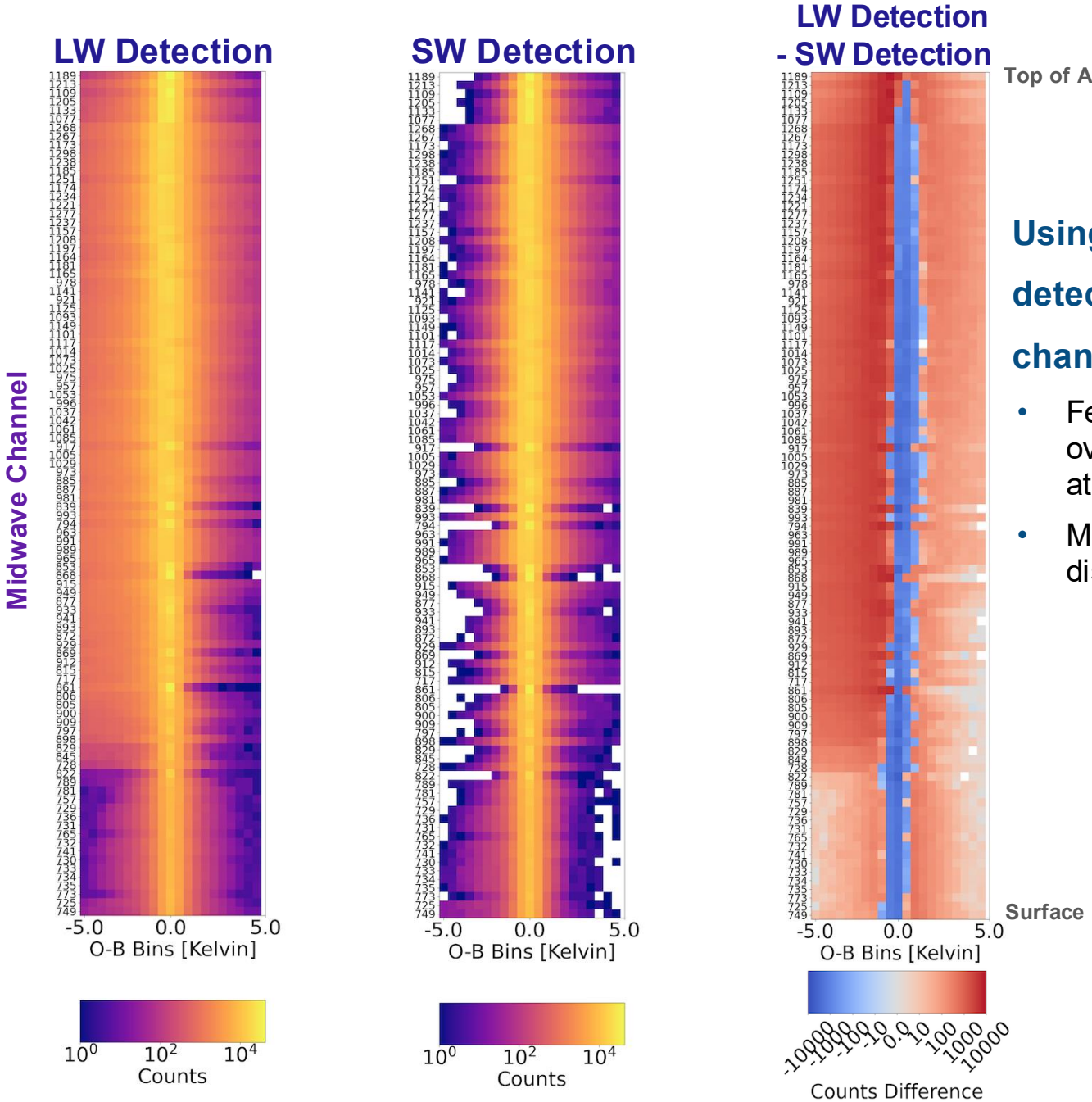
Clear-sky OmB Histograms (SW Detection)



Using a SW-based cloud detection for SW channels:

- Similar OmB distribution as seen with LW-based detection
- More clear observations in the stratosphere and at lower levels
- No cold tail around 1951-1952

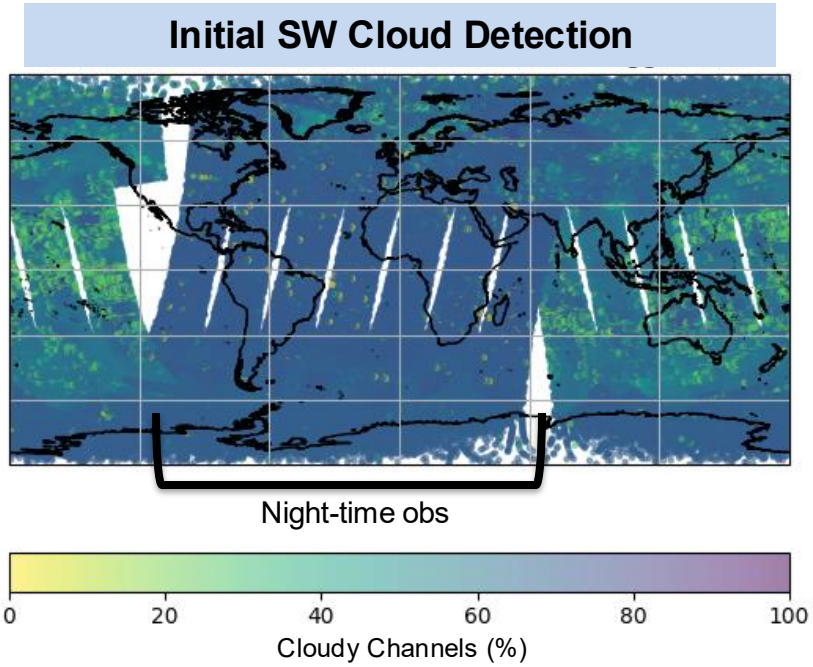
Clear-sky OmB Histograms (SW Detection)



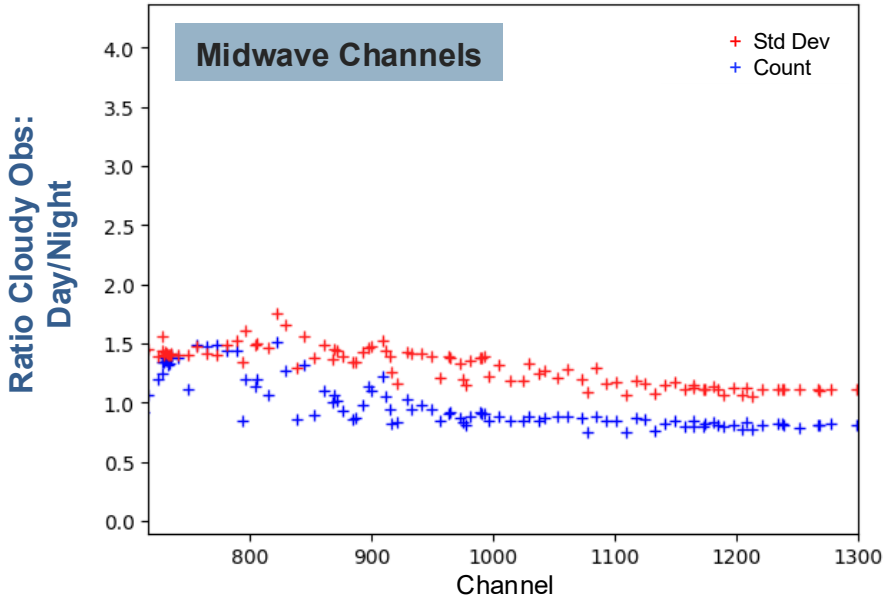
Using a SW-based cloud detection for MW channels:

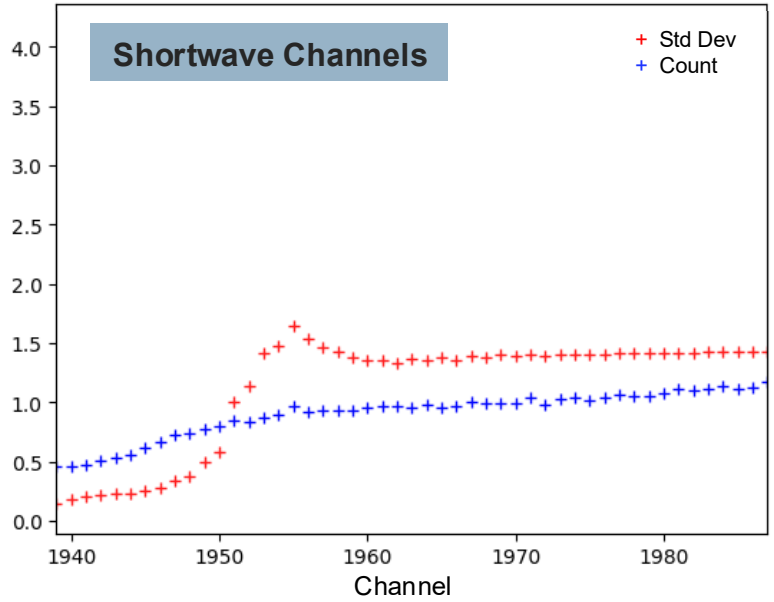
- Fewer clear observations over much of the atmospheric column
- More symmetrical OmB distribution (no cold tail!)

Cloud Detection: Diurnal Variation



- Early iterations of a SW-based cloud detection showed differences in day vs night cloud detection, especially in the MW
- Using some MW channels with little/no water vapor sensitivity improves, but does not eliminate, diurnal variation (which is ALSO seen in LW-based cloud detection)





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 ECMWF IFS version 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)

Some experiment results: Obs impacts

Experiments:

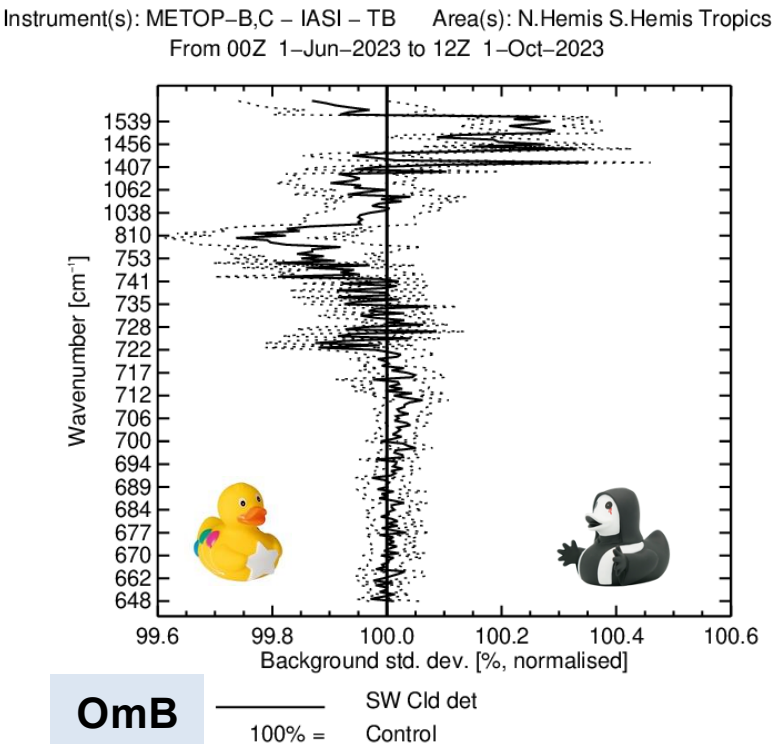
- Control * = LW-based cloud detection, no LW
- Experiment = SW-based cloud detection, no LW

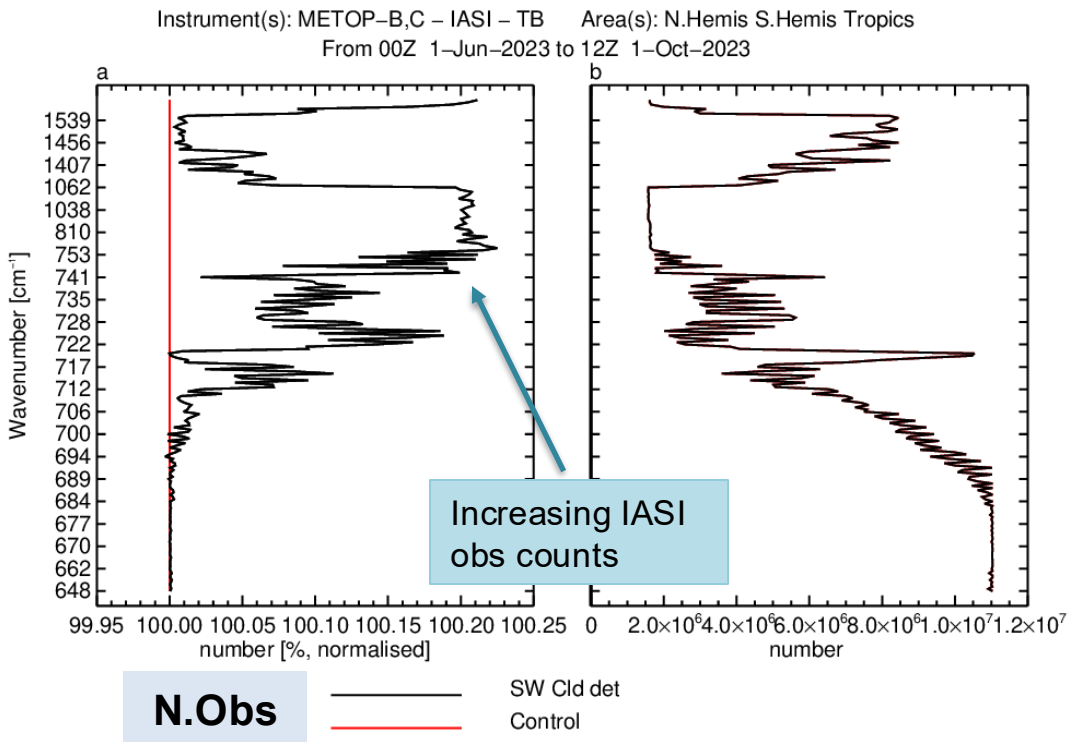
Happy Duck!

Emo Duck

IASI Obs Stats

* *An earlier version of these slides had incorrectly said the control denied all CrIS observations. This is not the case; the control denied CrIS LW observations, but used them for cloud detection for CrIS MW and SW observations.*





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

Some experiment results: Obs impacts

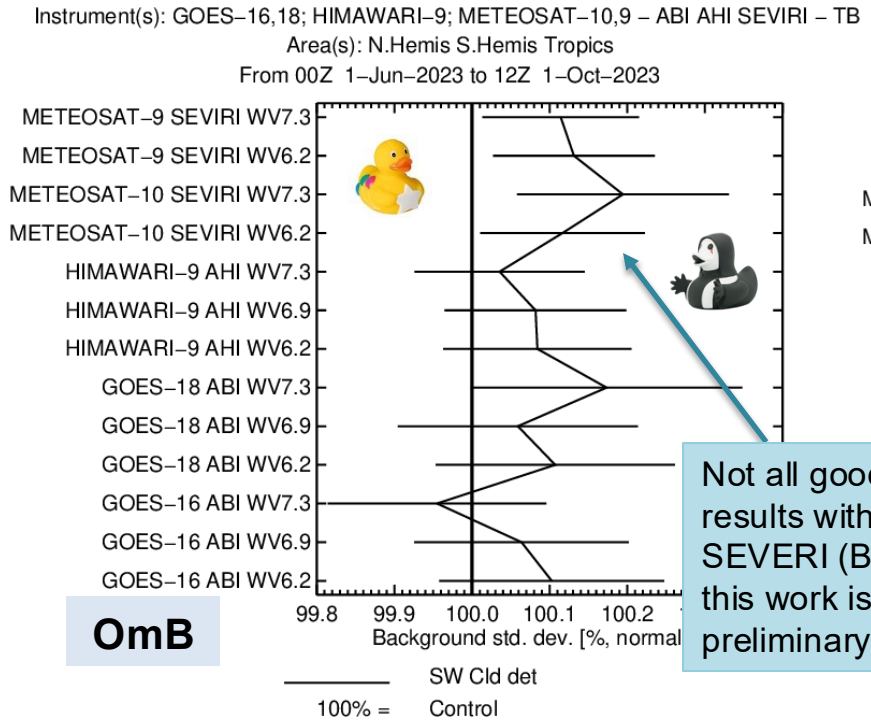
Experiments:

- Control = LW-based cloud detection, no LW
- Experiment = SW-based cloud detection, no LW

Happy Duck!

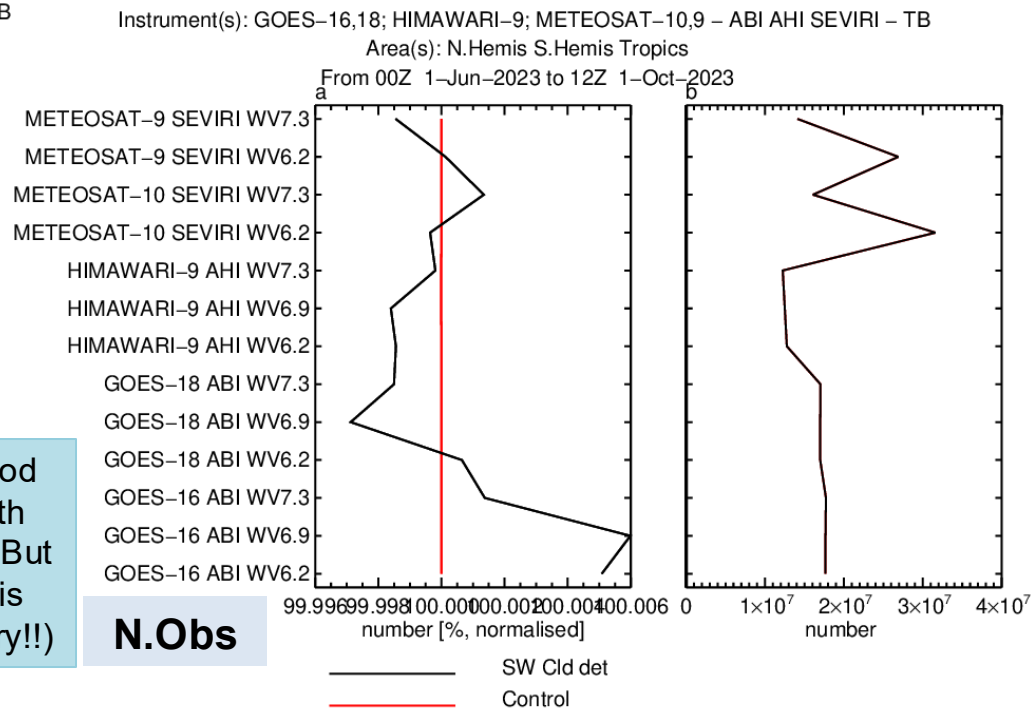
Emo Duck

GEOs Obs Stats



OmB

Not all good results with SEVERI (But this work is preliminary!!)



N.Obs

Obs stats are generally neutrally impacted for geostationary sensors, but there is some degradation for SEVIRI

Some experiment results: Obs impacts

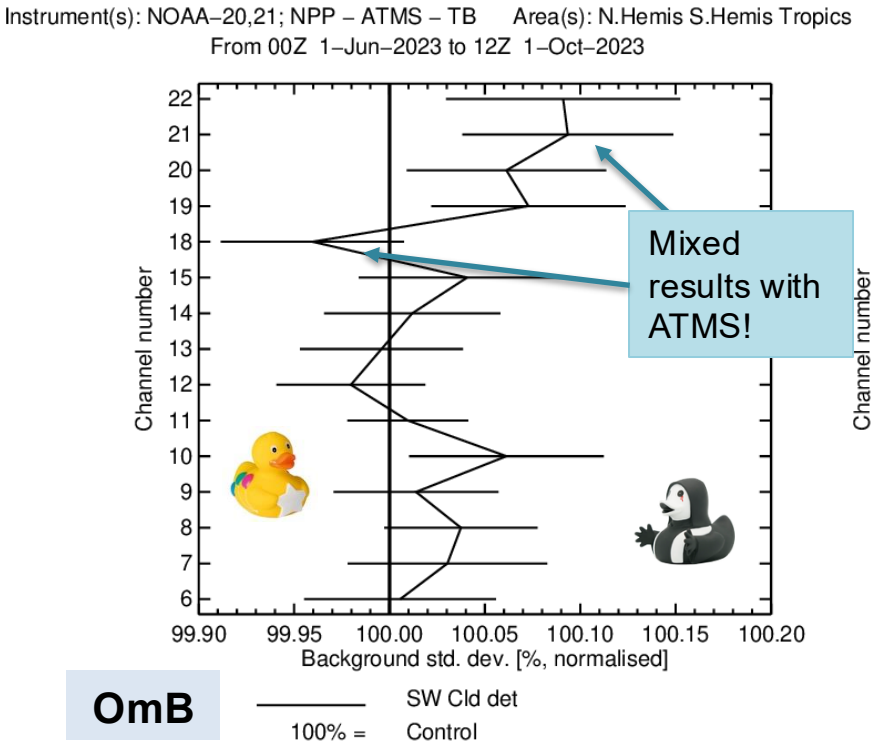
ATMS Obs Stats

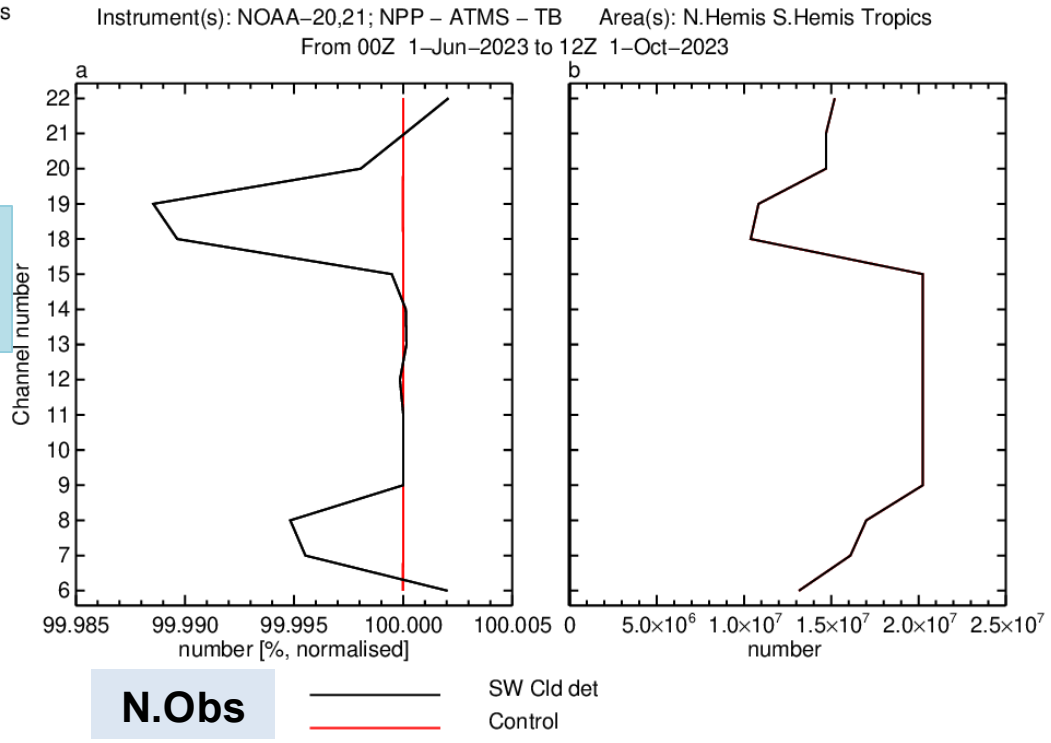
Experiments:

- Control = LW-based cloud detection, no LW
- Experiment = SW-based cloud detection, no LW


Happy Duck!


Emo Duck





Impacts mixed for ATMS; obs counts increase for most channels, but so do OmB standard deviations (e.g. for high-peaking channels)

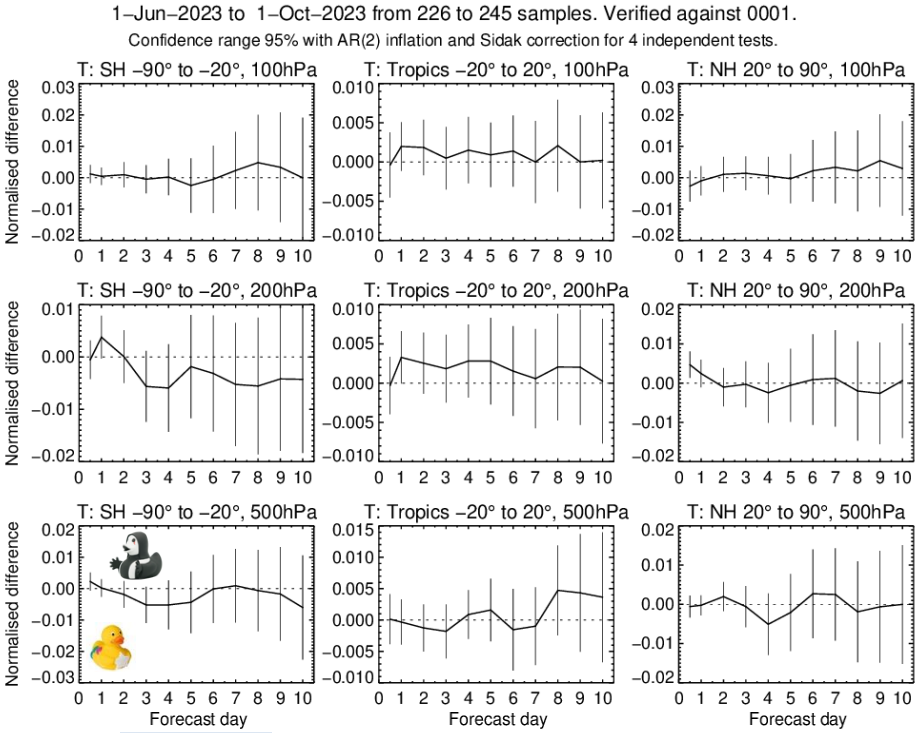
Some experiment results: Forecast impacts

Experiment = SW-based cloud detection, no LW

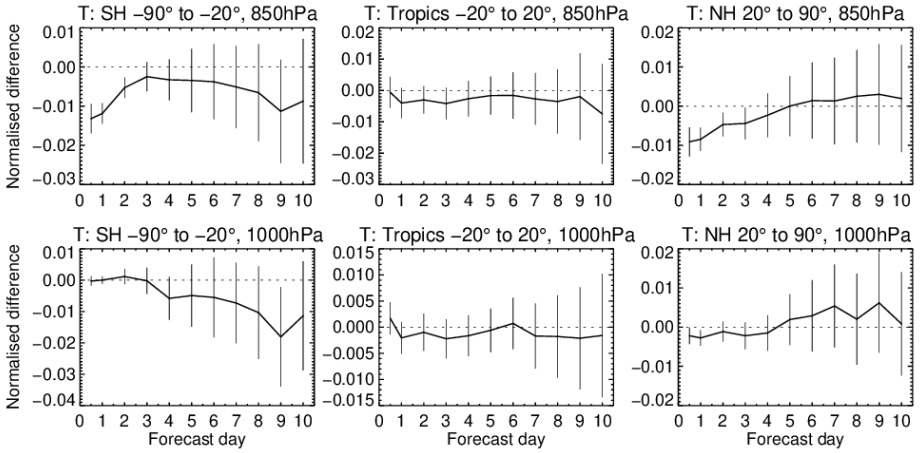

Happy Duck!


Emo Duck

Temperature Forecast



SH **Tropics** **NH**



SH **Tropics** **NH**

Mostly neutral impacts seen on the temperature forecast – there is some improvement in days 0-3, most notably at 850 hPa in the NH and SH

Conclusion

- A SW-based cloud detection scheme **holds promise**
  - Initial findings are encouraging
  - More work is still required to really do this (e.g. *only* the cloud detection was considered here)
- 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
  - The benefits that may be gained by exploring this further are worth the effort

Questions?

Ask Chris Burrows!

.... or email Bryan Karpowicz and/or myself