

# CLIMCAPS maintenance

## Product upgrades and Science

PI: Nadia Smith (NS) | Co-I: Chris Barnet (CB)



### Funding History: Forging a Future with ROSES

**2015–2018 (PI CB):** NASA ROSES #NNH15CM66C (~1 FTE) to develop CLIMCAPS retrieval code and set of a-priori estimates.

**2018–2021 (PI CB):** NASA ROSES #80NSSC18K0975 (~1 FTE) to set-up and operationalize CLIMCAPS for Aqua, SNPP and JPSS.

**2021–2024 (PI NS):** NASA ROSES A.52 #80NSSC21K1959 (~1 FTE) to support upgrade of CLIMCAPS retrieval code, application development and stakeholder engagement to improve product quality and design.

[1] Discovered an error in Level 2 product after questions from end-users

[2] Collaborated with Sounder SIPS to:

- fix errors in post-processor
- implement a **radically simplified L2 and L3 product re-design** for *ease-of-use* and to promote *correct interpretation* in science studies and applications
- support stakeholder science studies with beta-products ahead of operational release

## Improved Product Documentation

- **Smith & Barnet (2023)**: Practical implications of CLIMCAPS cloud clearing and derived quality metrics. Earth and Space Science. <https://doi.org/10.1029/2023EA002913>
- **Smith & Barnet (2023)**: CLIMCAPS – A NASA long-term product for infrared + microwave atmospheric soundings. Earth and Space Science. <https://doi.org/10.1029/2022EA002701>
- **Smith & Barnet (2024)**: CLIMCAPS V2.1 Science Applications Guides. GES DISC CLIMCAPS landing page.

**[1] Explored new operational applications:** CLIMCAPS CO profile retrieval assimilation as follow-on to MOPITT CO in chemical transport models

- **Gaubert et al. (2024):** Nonlinear and non-Gaussian Ensemble Assimilation of MOPITT CO. *JGR-Atmospheres*, <https://doi.org/10.1029/2023JD040647>

**[2] Participated in novel science studies:** CLIMCAPS O<sub>3</sub> was evaluated as part of the International Tropospheric Ozone Assessment Report-II (TOAR-II). This was the first time a NASA sounder product was included in the evaluation as described in this paper:

- **Gaudel et al. (2024):** Tropical tropospheric ozone distribution and trends from in situ and satellite data. *Atmospheric Chemistry Physics*. <https://doi.org/10.5194/egusphere-2023-3095>

# ... CLIMCAPS Stakeholder Engagement continues

**[3] Investigated fecundity of CLIMCAPS greenhouse gas retrievals:** Inter-comparisons and science quality studies of CLIMCAPS CO<sub>2</sub>

- Kulawik, Smith et al. (in prep): A characterization of CO<sub>2</sub> retrieval capability from IR sounders. AMT

**[4] Teamed-up with sounder community members** to explore the new GES DISC cloud environment using NASA Open Science principles.

- Smith, Merelli & Berndt, [NASA Openscapes Champions Lesson Series](#), April - June, 2023. ([see NASA Sounder Science Team Meeting 2023 for a summary of our Open Science work](#))

**[5] Served as Chair of the GES DISC Users Working Group 2021–2024** (member since 2018)

**[6] Continue to study and improve data pathways for efficient information delivery**

- Berndt & Smith (in prep): Against the grain – how complex products can transition from the archives to stakeholder applications. *Perspectives of Earth and Space Scientists* (+ AMS annual meeting presentation)

# Product Science Applications

**[1]** Emulated real-time NUCAPS capability using AIRS spectra with offline CLIMCAPS code. Paired with operational NOAA NUCAPS from CrIS, **we demonstrated value of multi-temporal soundings in weather applications**

- **Berndt, Smith & Barnet (2023):** Integrating NASA Aqua/AIRS in a real-time NUCAPS science-to-applications system to support severe weather forecasting. Earth and Space Science. <https://doi.org/10.1029/2022EA002725>

**[2]** Used CLIMCAPS overlapping water vapor retrievals from Suomi-NPP and JPSS-1 to **emulate 3-D tropospheric winds**

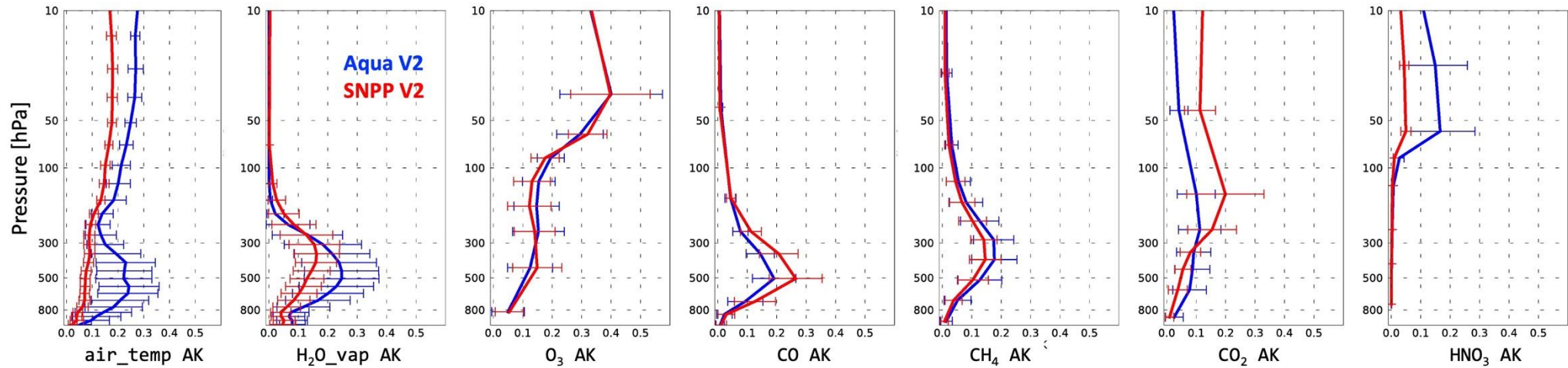
- **Ouyed, Smith, et al. (2023):** Global 3-D water vapor feature-tracking for horizontal winds using hyperspectral infrared sounder data from overlapped tracks of two satellites. GR. <https://doi.org/10.1029/2022GL101830>

# A new approach to retrieval code upgrades

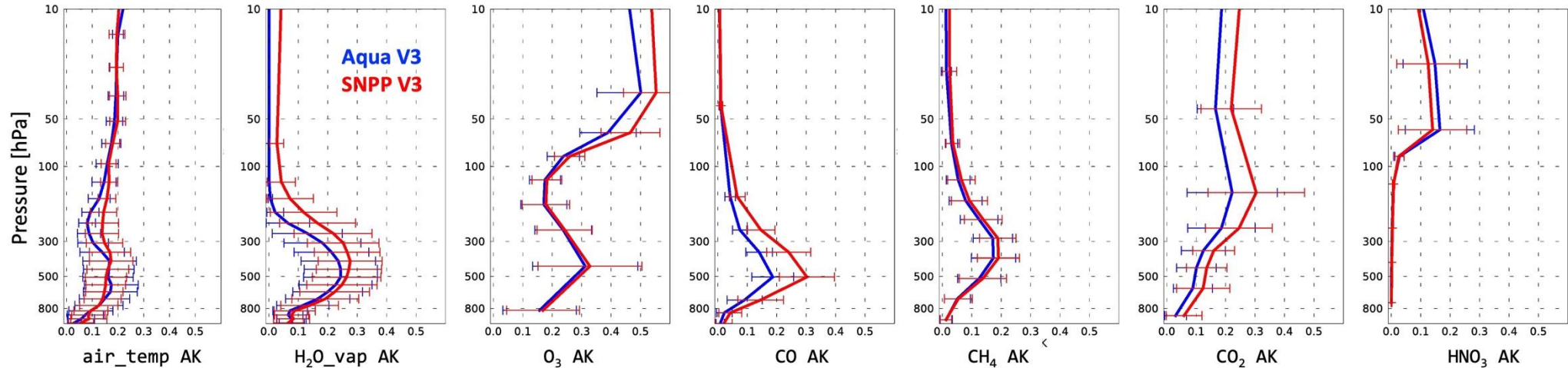
We were able to develop this novel approach only *because* the CLIMCAPS multi-decadal V2 product exists and outputs a range of error metrics and information content quantities.

We're using the program-of-record + offline experimental capability to develop methods that could take us past the deadlock of intercomparison stats (bias + RMSE)

(a) CLIMCAPS-Aqua vs. CLIMCAPS-SNPP V2 information content



(c) CLIMCAPS-Aqua vs. CLIMCAPS-SNPP V3 information content



**Smith & Barnet (2024):** An information content approach to addressing instrument differences. EGUSphere. <https://doi.org/10.5194/egusphere-2024-2448>

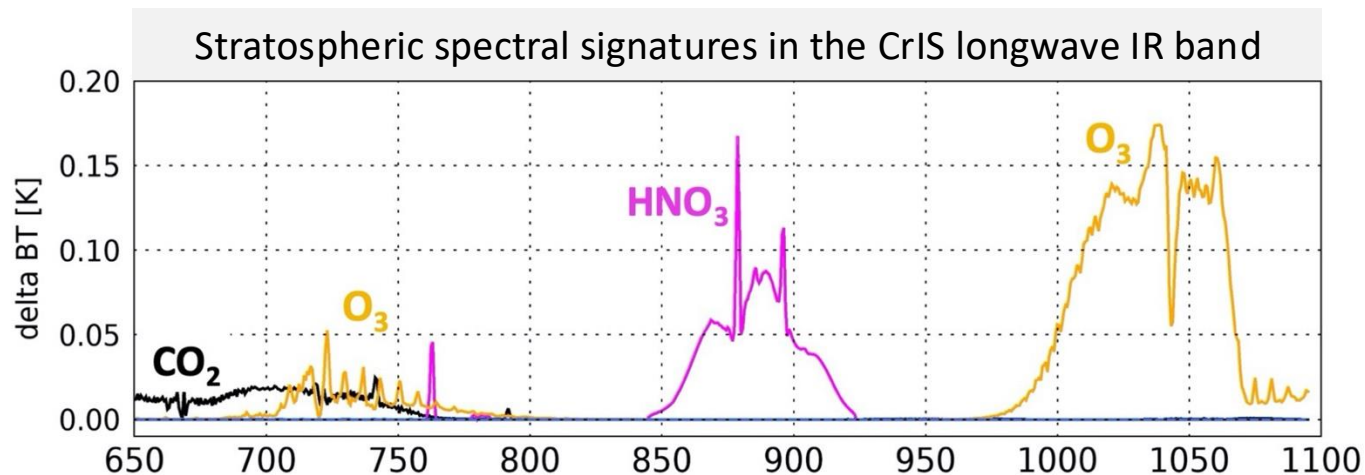
## [1] Investigated retrieval capability of new instrument concept

...by testing and demonstrating the relative value of CrIS SW, MW and LW with co-located ATMS

- **Barnet et al., (2023):** Evaluating the value of CrIS shortwave-infrared channels in atmospheric-sounding retrievals. *Remote Sensing*, <https://doi.org/10.3390/rs15030547>

## [2] Improving retrieval capability + developing new products

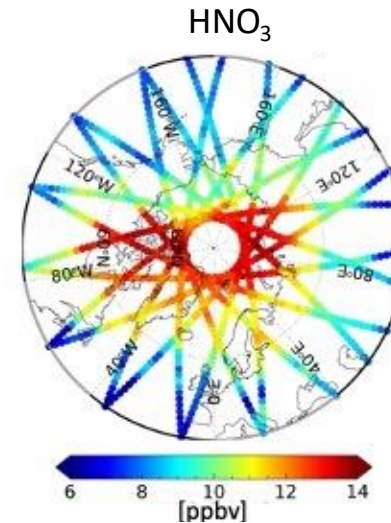
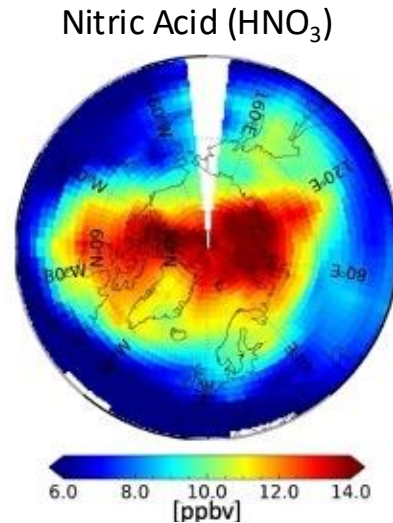
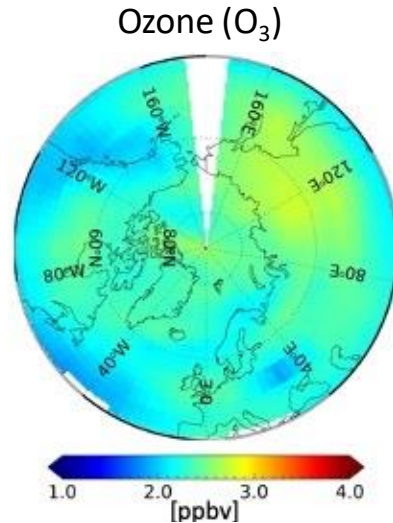
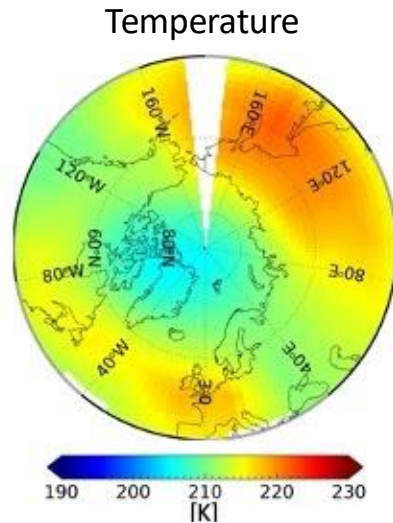
Is it possible to monitor Polar Vortex chemistry with CLIMCAPS in a post-MLS era?



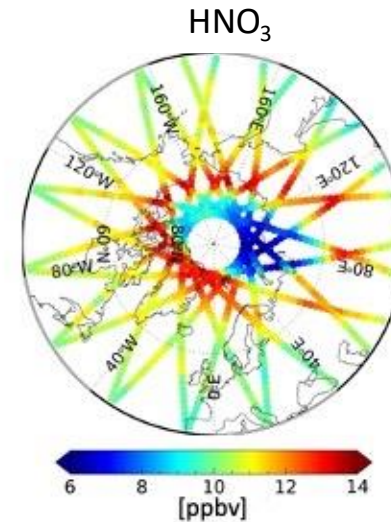
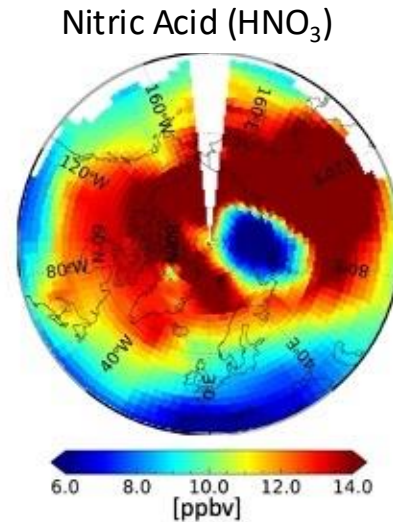
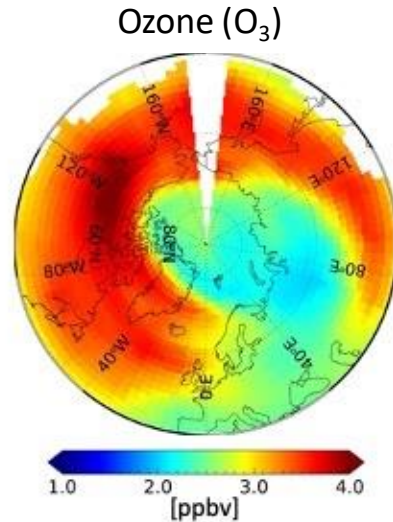
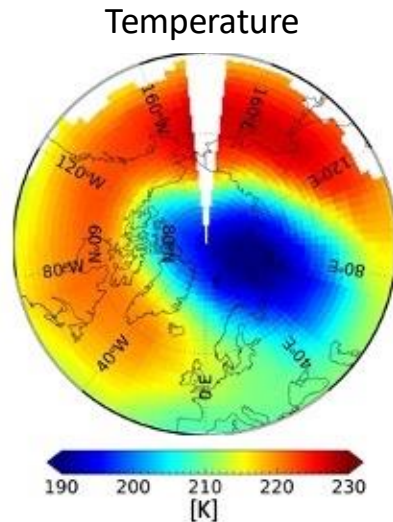
# ... CLIMCAPS Sounder Science continues

CLIMCAPS observations of stratospheric chemical ozone loss in the extra-tropics (**Smith et al. in prep**)

Pre-Vortex  
5 Nov 2019



Mid-Vortex  
2 Feb 2020s



CLIMCAPS

MLS



# Summary

- CLIMCAPS is a multi-instrument, multi-satellite, multi-decadal retrieval system characterizing the [vertical atmospheric state + clouds + surface] globally
- CLIMCAPS harbors and manifests decades of NASA expertise and innovation in sounding science (it is built on the legacy AIRS retrieval system – **hats off to Joel Suskind et al.**)
- In 2018, CLIMCAPS was selected (via NASA peer-review system) as *the* Aqua continuity algorithm to continue NASA sounding capability with SNPP and JPSS+
- In 2021 (ROSES A.52), CLIMCAPS was selected as one of a handful of legacy systems to be maintained as a core NASA product.

- We modernized the product in a big way

Product maintenance is so much more than just code fixes

- We made significant gains in understanding (and overcoming) instrument differences
- We worked within the community to address their questions, test application viability, address science questions, improve retrieval quality and build capacity
- We demonstrated real-time capability in support of NOAA NUCAPS activities
- We published work in sounding science, algorithm design, product intercomparisons and data product applications
- We participated in community forums to help shape the present and future for sounding products and science

**We managed a peaceful transition of power!** Next-generation PI (Smith) enabled and supported by Legacy PI (Barnet)

# What's next

- ROSES Y1: product evaluation and algorithm improvements
  - ROSES Y2-Y3: product re-design delivery (V2.1) + SIPS implementation
- Release of CLIMCAPS V3 delivery stalled as PI ROSES funding ran out ahead of SIPS implementation
- As a solely ROSES funded effort, continuation of CLIMCAPS advancement and maintenance is uncertain as ROSES cycles change
  - As of right now:
    - CLIMCAPS V2.1 is the last version that will run operationally at GES DISC
    - CLIMCAPS V2.1 runs on AIRS+AMSU (Aqua 2002-2016) and CrIS+ATMS (SNPP 2016-2018)+(JPSS-1 2018-2024+)
    - As soon as the JPSS Level 1B products transition to new version (~2025/2026), CLIMCAPS will stop being generated at GES DISC, which will interrupt NASA's sounding climate data record and prematurely end a multi-decadal characterization of the atmospheric state
    - CLIMCAPS V2.1 record (2002–2026?) will remain archived at GES DISC



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| Thank you |  
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