CLIMCAPS

+

Community Long-term Infrared Microwave Combined Atmospheric Product System

Nadia Smith, Chris Barnet

Why CLIMCAPS can have value in the study of OLR

NASA ROSES
#80NSSC18K0975 release of V2 (2021) with PI Barnet
#80NSSC21K1959 release of V3 (2024) with PI Smith

What is CLIMCAPS?

NASA Continuity Sounder Product

AIRS Science Team Heritage Algorithm for IR + MW sounders

- **CrIS+ATMS** on **SNPP** (doi: 10.5067/62SPJFQW5Q9B) 2015/11/02 to 2021/05/21
- **CrIS+ATMS** on **NOAA-20** (doi: 10.5067/LESQUBLWS18H) 2018/02/17 to present
- **AIRS+AMSU** on **Aqua** (doi: 10.5067/JZMYK5SMYM86) 2002/08/31 to 2016/09/25
- **AIRS-only** on **Aqua** (doi: 10.5067/ILFPVBTDHTDL) 2002/08/31 to present

Suite of atmospheric state parameters – profiles of temperature, moisture, trace gases, cloud top pressure, cloud fraction, emissivity – with error estimates and information content metrics

Long-term (2002-present) record of the 3-D atmospheric state, clouds and surface parameters

CLIMCAPS retrieval products

Retrieved Variable	Units
Temperature	Kelvin
Water Vapor	molec/cm^2
Ozone	molec/cm^2
Carbon Dioxide	mol/mol
Carbon Monoxide	molec/cm^2
Cloud fraction	%
Cloud liquid water	molec/cm^2
Cloud top pressure	Pa
Methane	molec/cm^2
Nitric Acid	molec/cm^2
Nitrous Oxide	molec/cm^2
Sulphur Dioxide	molec/cm^2
Surface emissivity	n/a
Surface reflectivity	n/a
Surface temperature	Kelvin

Derived Variables
Methane mass mixing ratio at 400 hPa
Cloud top temperature
Carbon monoxide mass mixing ratio at 500 hPa
Geopotential height
Ozone mass mixing ratio
Relative humidity
Specific humidity
Total column cloud liquid water
Total column ozone
Total precipitable water

Include OLR in V3?

Sources of a-priori estimates

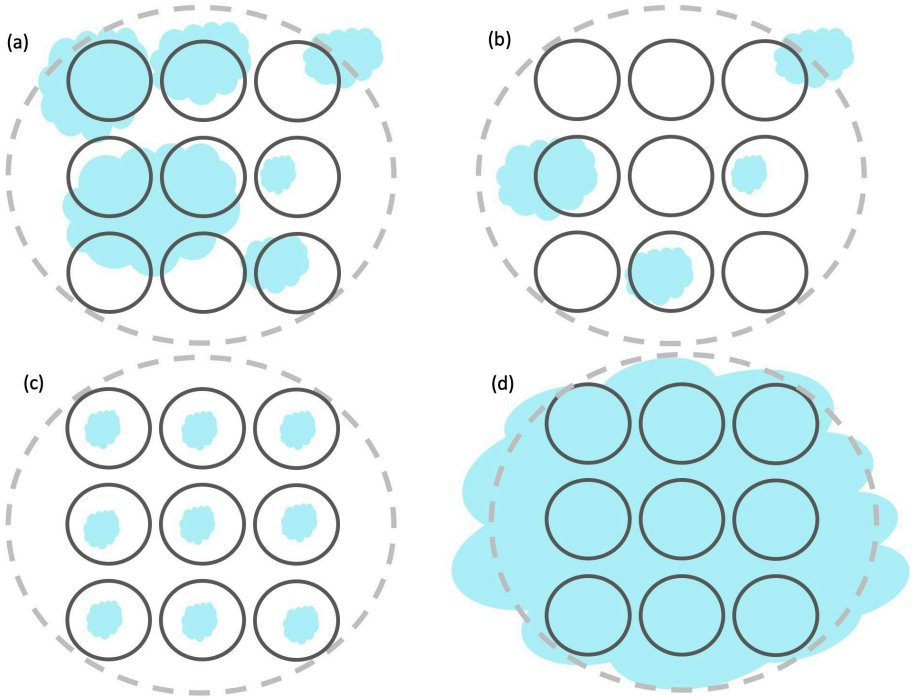
MERRA-2 (GMAO, https://doi.org/10.5067/WWQSXQ8IVFW8)

Various climatologies

CAMEL (Combined ASTER and MODIS Emissivity https://doi.org/10.5067/MEASURES/LSTE/CAM5K30EM.002)
Masuda ocean emissivity

Cloud Retrievals and Cloud Clearing

CLIMCAPS retrieves atmospheric state variables from cloud cleared radiances



(a)-(b) Retrieved profiles represent clear-sky portion of field-of-regard (FOR, 3 x 3 fields-of-view) around the cloud fields.

We additionally retrieve the FOR cloud top pressure for up to two layers of cloud, and 9 x cloud fractions for each field-of-view.

(c)-(d) Cloud clearing (and subsequent state retrievals) fail in scenes with uniform cloud cover.

We characterize the random and systematic uncertainties caused by clouds at each scene.

Yue et al. 2022: *Evaluating the consistency and continuity of pixel-scale cloud property data records from Aqua and SNPP*, AMT, https://doi.org/10.5194/amt-15-2099-2022

Smith, Yue & Barnet (in prep): *A review of the CLIMCAPS cloud clearing method – theory and practical implications*

Smith & Walther (2022): *Error Analysis of CLIMCAPS cloud retrievals using CLAVR-x*, AMS Collective Madison Meeting, 16th Conference on Cloud Physics

Publications / Resources

CLIMCAPS Level 2 data records are available at GES DISC (https://disc.gsfc.nasa.gov/)

PEER REVIEWED

Smith & Barnet, 2019: *Uncertainty Characterization and Propagation in CLIMCAPS Remote Sensing*, https://doi.org/10.3390/rs11101227

Smith & Barnet, 2020: *CLIMCAPS observing capability for temperature, moisture, and trace gases from AIRS/AMSU and CrIS/ATMS*, AMT, https://doi.org/10.5194/amt-13-4437-2020

TECHNICAL

Monarrez et al. 2020: NASA S-NPP and NOAA-20 (JPSS-1) CLIMCAPS CrIS and ATMS Level-2 Products User Guide: File Format and Definition (https://docserver.gesdisc.eosdis.nasa.gov/public/project/Sounder/CLIMCAPS.V2.README.pdf)
Wang et al. 2020: Test Report of Performance of CLIMCAPS-SNPP and CLIMCAPS-JPSS1 retrievals (https://docserver.gesdisc.eosdis.nasa.gov/public/project/Sounder/CLIMCAPS.V2.Test.Report.pdf) (focus on temperature and water vapor)

HOW-TO GUIDES

CLIMCAPS Science Application Guides

- *How to use and interpret CLIMCAPS retrieval products*
- CLIMCAPS wiki pages: https://airs.jpl.nasa.gov/data/guides-docs/climcaps-science/
- PDF document: https://docserver.gesdisc.eosdis.nasa.gov/public/project/Sounder/CLIMCAPS_V2_L2_science_guides.pdf

Contents

CLIMCAPS Science Guide

CLIMCAPS Instrument Configurations

This section contains descriptions of the spaceborne Atmospheric Infrared Sounder (AIRS) and Cross-track Infrared Sounder (CrIs) platforms. A table comparing AIRS and CrIS is also included.

Read More...

List of Retrieved Variables

On this page two tables are provided. The first contains units, fieldnames and vertical grid details for the CLIMCAPS primary atmospheric observations. A second table contains this same information for key derived variables.

Read More...

Retrieval Method

This section covers algorithm flow, cloud clearing, pressure levels and layers, and channel subsets.

Read More...

Geophysical Retrieval Products

This section provides a list of retrieved variables and covers details relating to the retrievals of carbon dioxide, methane, temperature, water vapor, ozone, and carbon monoxide.

https://docserver.gesdisc.eosdis.nasa.gov/public/project/AIRS/Overview_of_the_AIRS_Mission.pdf

	CLIMCAPS	AIRS-team V7
Instruments	AIRS/AMSU (Aqua) CrIS/ATMS (SNPP, JPSS-1)	AIRS/AMSU/HSB (Aqua)
Retrieval Method	Hybrid Optimal estimation (OE) approach with Singular Value Decomposition regularization on cloud-cleared radiances on AIRS 3x3 fields of regard (FoR)	Least squares estimation using Singular Value Decomposition regularization on cloud-cleared radiances on AIRS 3x3 FoR
Retrieval profiles	Temperature, water vapor, O_3, CO, CH_4, CO_2, HNO_3, SO_2, and N_2O (see this table)	Temperature, water vapor, O_3, CO, CH_4 (see Table 3)
Retrievals in cloudy atmospheres?	Yes, in partly cloudy atmospheres but not homogeneous FoR	Yes, in partly cloudy atmospheres but not homogeneous FoR
A-priori for T, H_2O and O_3	MERRA-2 reanalysis	Neural network (NN) first guess of clear-sky radiances, temperature, and water vapor layer amount, using overtime and latitude-dependent O_3 layer amount climatology
A-priori for other trace gas profiles	Climatology	Climatology
A-priori error propagation	Both diagonal and off-diagonal terms of error covariance matrices are propagated for temperature, water vapor and ozone; only diagonal terms of the error covariance matrix are propagated for all other trace gas species	Only diagonal terms of the error covariance matrix are propagated for all retrieval variables
Infrared spectral channels	Channel subsets are selected for each retrieval variable used in OE	Over 500 IR channels are used in non-linear regression Channel subsets are selected for each retrieval variable
Latency	1 month delay due to dependence on MERRA-2	Near real-time; No dependence on reanalysis product
Averaging Kernels	Averaging kernels for each FoR in state vector elements for temperature, water vapor, O_3, CO, CH_4, CO_2 and HNO_3	Averaging kernels for each FoR in state vector elements for temperature, water vapor, O_3, CO, and CH_4
Cloud Clearing	Cloud clearing using clear sky radiance estimate from MERRA-2; no iteration on clear sky radiances	Clear sky radiances estimate initially based on NN stochastic cloud clearing followed by sequential estimates based on clear sky radiances from retrieved state
Cloud retrievals	Two layers of clouds for each FoR. Cloud fractions for each layer are retrieved in each field-of-view (FoV). Cloud-top pressure is retrieved for each FoR (3x3 FoVs).	Two layers of clouds for each FoR. Cloud fractions and cloud-top pressure for each layer are retrieved in each field-of-view (FoV). Ice cloud optical thickness, phase, and effective radius for each FoV

CLIMCAPS on the GES DISC data cloud

Fall 2021: GES DISC migrated the full CLIMCAPS data record to the Earthdata Cloud.

Summer 2022: CLIMCAPS team will develop use-cases to run on CLIMCAPS data in the Earthdata cloud with the goal to:

1) demonstrate and promote the appropriate method for regridding and analyzing CLIMCAPS data in climate applications
2) learn from our user community about their needs in the cloud
3) (barring catastrophic failure) share this guidance and code from the CLIMCAPS Team to CLIMCAPS data users in an effort to practice open science principles.

Build on work by the AIRS sounding team

- Mehta & Susskind, 1999: OLR from TOVS Pathfinder
- Moy et al., 2010: Comparison of measured and modeled OLR for clear-sky ocean and land scenes using CERES and AIRS
- Susskind et al., 2011: Contributions to climate research using the AIRS Science Team v5 products
- Susskind et al., 2012: Interannual variability of OLR as observed by AIRS and CERES
- Susskind et al., 2012: AIRS products explain the close relationship between OLR anomalies and the El Niño Index
- Lee et al., 2017: Changes in OLR over Arctic as depicted by AIRS, CERES and MERRA-2

Questions we can address with CLIMCAPS

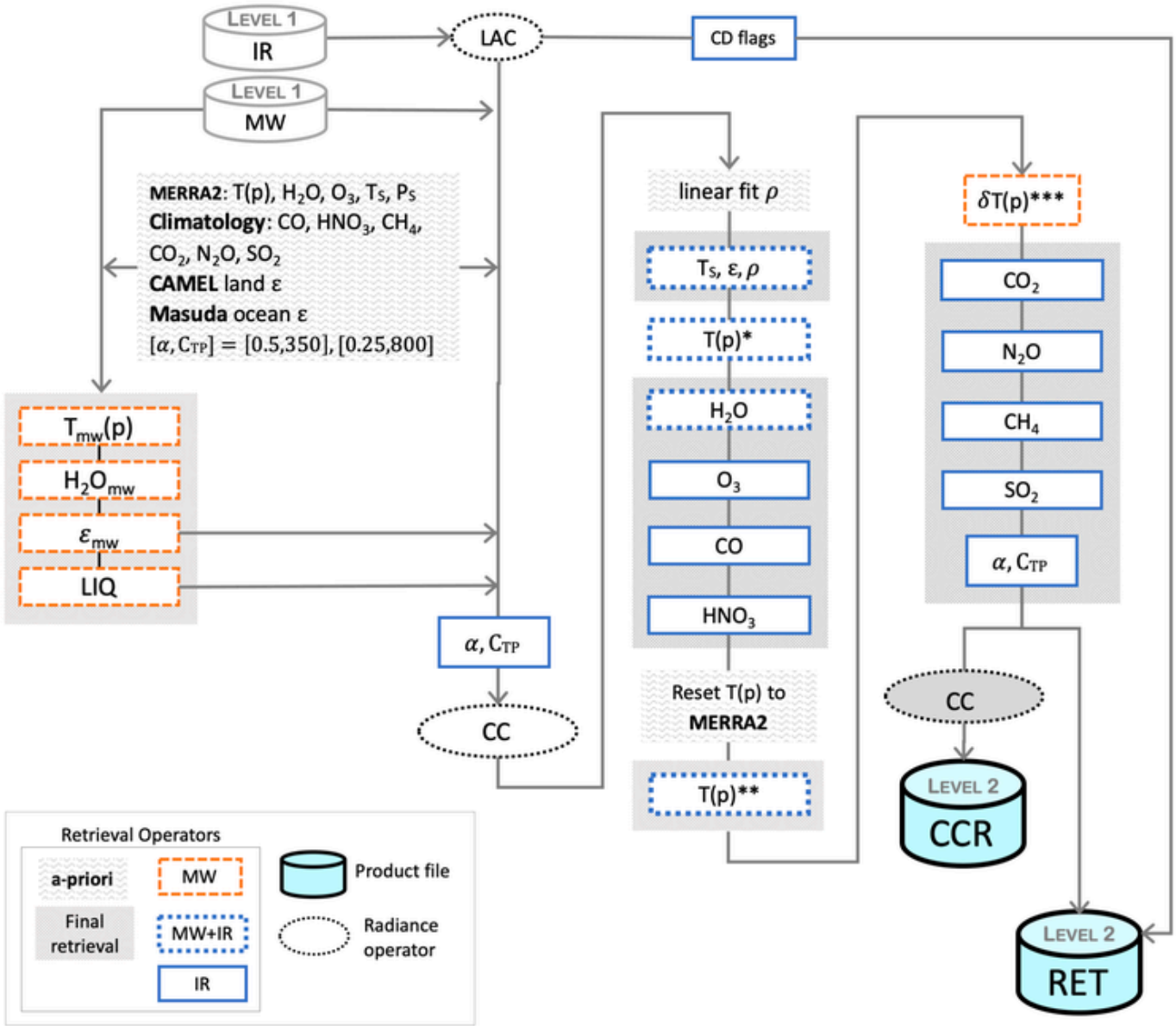
- How sensitive is OLR to instrumentation? Compare OLR calculated from CLIMCAPS-Aqua and CLIMCAPS-JPSS.
- Can we continue the AIRS OLR record with CrIS?
- How important is AMSU (microwave measurements) to the accuracy of OLR calculations? Compare OLR from CLIMCAPS-Aqua and CLIMCAPS-AIRSonly
- Can we quantify cloud radiative forcing? Are CLIMCAPS cloud retrievals accurate enough to allow the calculation of 'cloudy' OLR?
- Compared to MERRA-2, how much do CLIMCAPS observations improve OLR?

Thank you

nadias@stcnet.com

CLIMCAPS V2 algorithm outline

Sequential Optimal Estimation



https://airs.jpl.nasa.gov/data/guides-docs/climcaps-science/climcaps-science-guide/retrieval-method/flowchart