The Utility of CSPP LEO Atmospheric Sounding Products

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What is CSPP Low Earth Orbit (LEO)?

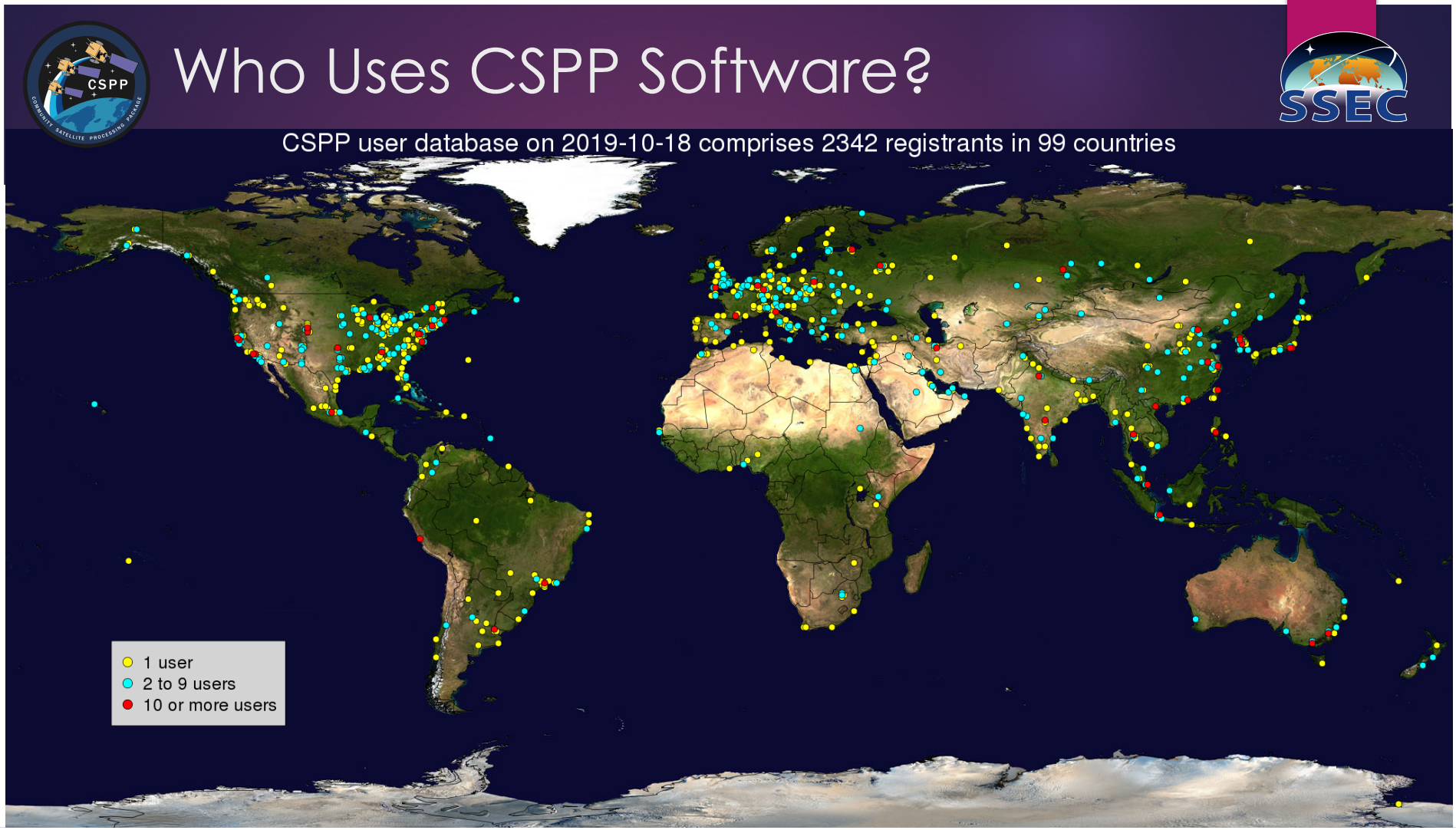
- The Community Satellite Processing Package (CSPP) is a collection of **freely available software** for processing data from Low Earth Orbit (LEO) meteorological satellites.
- CSPP supports the creation of **calibrated observational data, geophysical derived products, and mapped images** from visible, infrared, and microwave sensors.
- The CSPP project is based at the **Space Science and Engineering Center** at the University of Wisconsin-Madison and is funded **by NOAA JPSS Program Office.**
- Project Website:

  http://cimss.ssec.wisc.edu/cspp/

Satellites and Sensors Supported by CSPP LEO

- CSPP LEO supports processing of data from these satellite/sensor combinations:
  - ***NOAA-20 and Suomi NPP VIIRS, CrIS ATMS***
  - ***Metop-A/B/C AVHRR, IASI, ASMU-A, MHS, HIRS***
  - ***NOAA-18/19 AVHRR, AMSU-A, MHS, HIRS***
  - ***Terra and Aqua MODIS, AIRS***
  - ***GCOM-W1 AMSR-2***
  - ***FY-3B/C/D VIIR, MERSI-2***
- Data source is usually **Direct Broadcast** (DB) from the spacecraft. However, archived data are also supported (e.g., NOAA CLASS).

Who Uses CSPP Software?



CSPP LEO Software Package	Product Description
SDR	S-NPP and NOAA-20 VIIRS, CrIS, and ATMS geolocated and calibrated earth observations (NOAA algorithm).
Polar2grid	Reprojected imagery (single and multi-band) in GeoTIFF and AWIPS formats.
Hydra	Interactive visualization and interrogation of multispectral imagery and hyper spectral soundings.
VIIRS ASCI	VIIRS imager aerosol optical depth, cloud properties, sea ice, and volcanic ash (NOAA algorithm).
VIIRS Active Fires	VIIRS imager wildfire detection (NOAA algorithm).
VIIRS Flood Detection	VIIRS imager flood detection (NOAA algorithm).
HSRTV	Hyperspectral infrared sounder retrievals of temperature and moisture profiles, cloud properties, total ozone, and surface properties.
MIRS	Microwave sounder retrievals of temperature and moisture profiles; surface properties; snow and ice cover; rain rate; and cloud/rain water paths (NOAA algorithm).
CLAVR-x	Multispectral imager retrievals of cloud properties; aerosol optical depth; surface properties; ocean properties (NOAA algorithm).
NUCAPS and NUCAPS-IASI	Combined hyperspectral infrared sounder and microwave sounder retrievals of temperature and moisture profiles, cloud cleared radiances, and trace gases (NOAA algorithm).
IAPP	Combined infrared sounder and microwave sounder retrievals of temperature and moisture profiles, water vapor, total ozone, and cloud properties (NOAA algorithm).
ACSPO	Multispectral imager retrievals of sea surface temperature (NOAA algorithm).
Sounder Quicklook	Projected 2D maps of temperature and water vapor retrievals, and Skew-T profiles for individual atmospheric profiles.

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Want to find out more about CSPP LEO?

ITSC22 POSTER 1p.02 Liam Gumley

- "CSPP LEO for JPSS, Metop, NOAA, and FY-3 satellites: New features and enhancements"

International ATOVS Processing Package (IAPP)

- IAPP retrieves atmospheric temperature and moisture, total ozone, and cloud top properties from ATOVS sounder data.

Heritage	Developed at CIMSS/SSEC by Hal Woolf, Jun Li, Chia Moeller, Tom Achtor et al.
Satellites/Sensors	NOAA-18/19 HIRS/AMSU/MHS; Metop-A/B HIRS/AMSU/MHS.
Products	Temperature and water vapor profiles; total column water vapor and ozone; cloud fraction; cloud top pressure and temperature; surface skin temperature and microwave emissivity.
Features	• Fast regression first guess; iterative nonlinear physical retrieval. • Also supports NOAA-15/16 (non operational).

IAPP Application

- CSPP supported the porting of IAPP heritage code developed by Hal Woolf and others at the University of Wisconsin after a request from Nathalie Selbach of Deutscher Wetterdienst (DWD)
- Satellite Application Facility on Climate Monitoring (**CM SAF**) of EUMETSAT
- Used IAPP for the CM SAF water vapour and temperature products and for Environmental Data Records until late 2017 due to the AMSU-A Metop-B Band 15 failure.

IAPP Application

```
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--scatter_plot -P 8 --pressure 200
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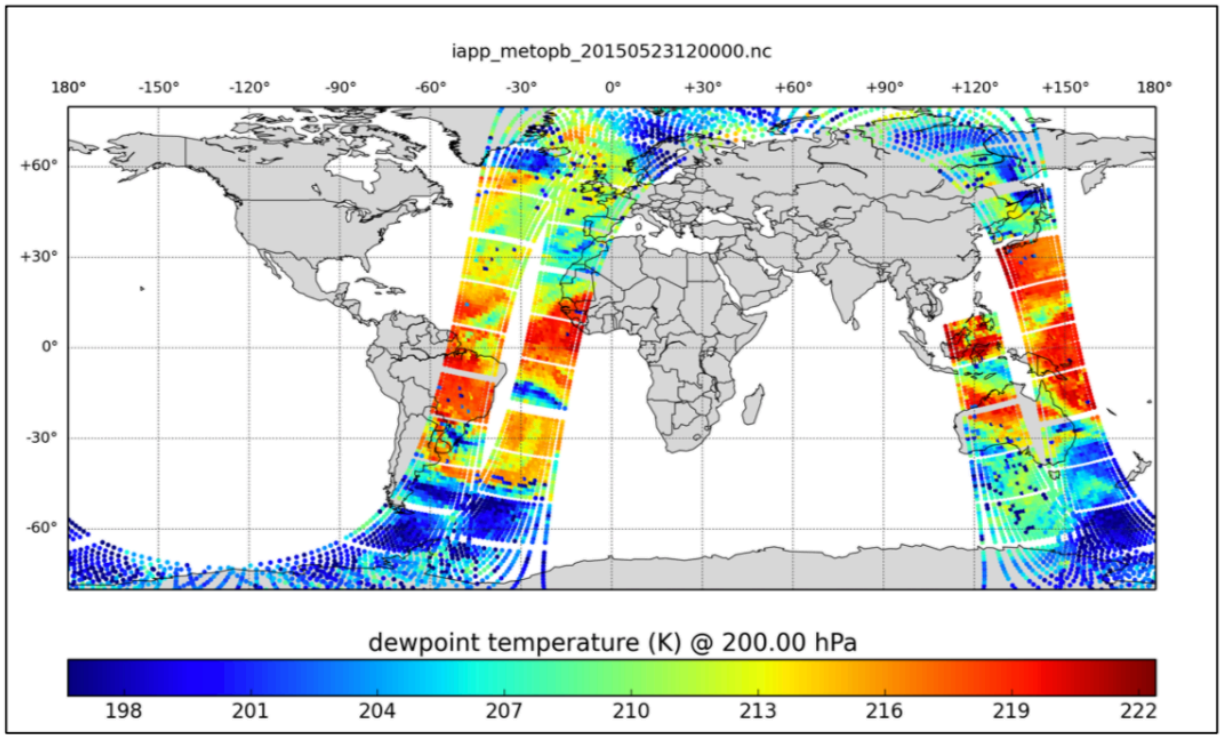
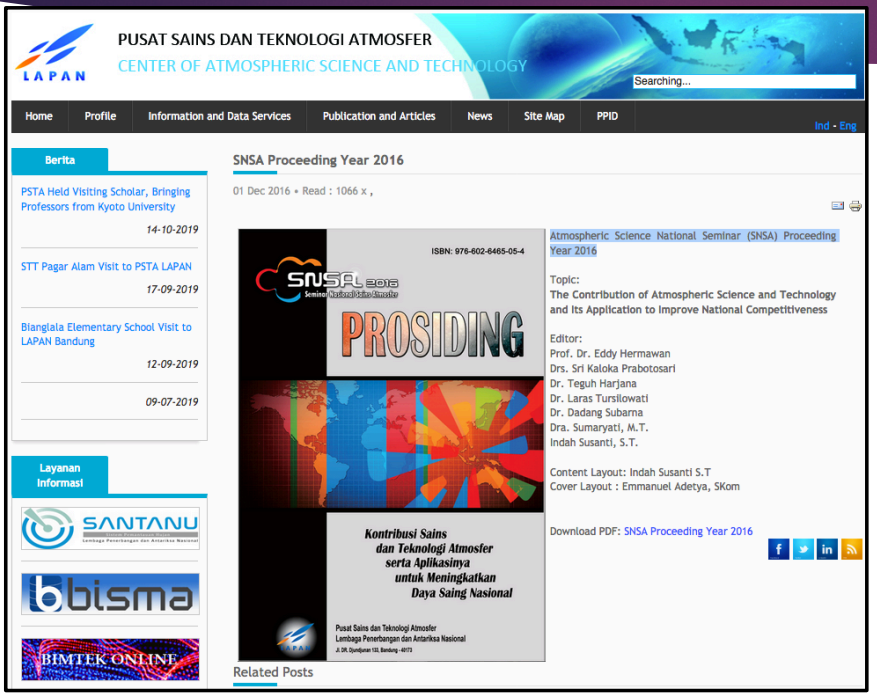


IAPP Application In Indonesia

Atmospheric Water Vapor



PENGOLAHAN DATA NOAA-19 UNTUK MENGHASILKAN DATA *WATER VAPOR MIXING RATIO* DENGAN MENGGUNAKAN *SOFTWARE* IAPP

B. Pratiknyo Adi Mahatmanto, Andy Indradjad, dan Noriandini Dewi Salyasari
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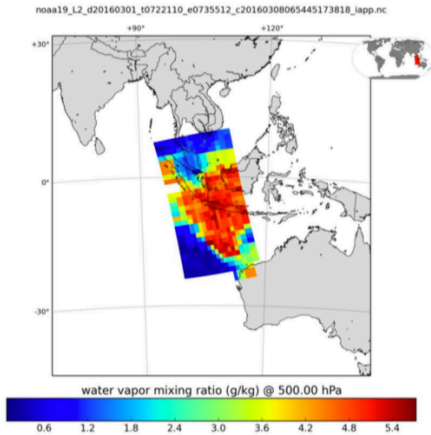
Abstract

Information about atmosphere condition of Indonesia especially water vapor mixing ratiois required. To obtain this informations could be done by analyze NOAA-19 data.Pekayon Remote Sensing Ground Station in Jakarta receive and analyze NOAA-19 data by using several software to process data from raw data until level 2 data. One of software used toobtain information ofwater vapor mixing ratio are CSPP-IAPP software.



Gambar 3. *Water Vapor Mixing Ratio* dari data NOAA-19 tanggal 1 Maret 2016 pada pukul 07.22 WIB

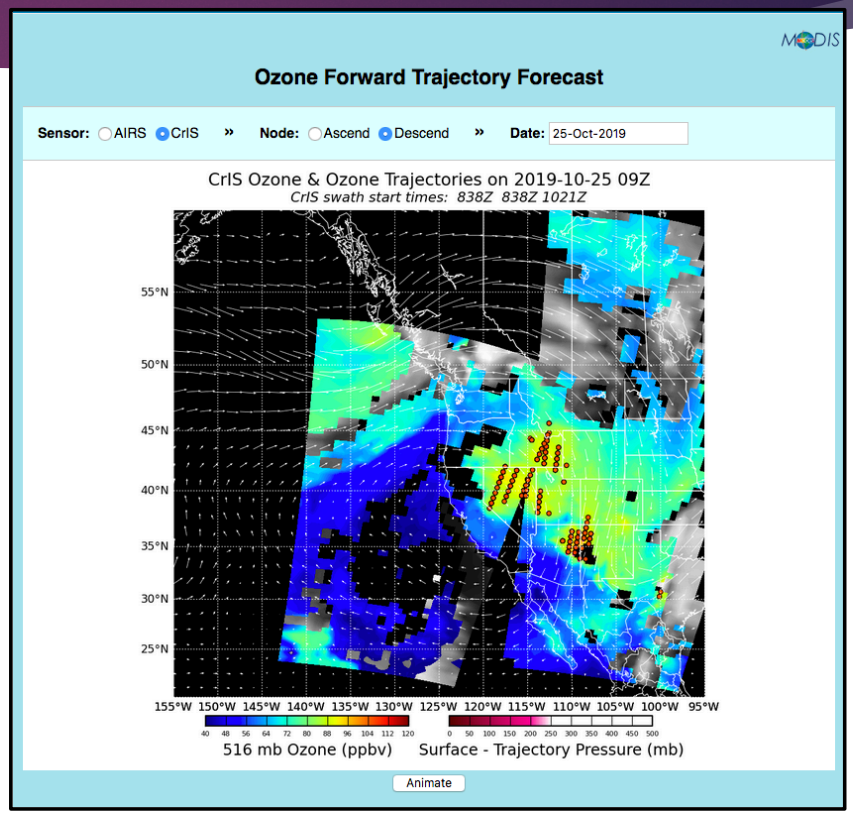
HSRTV or Dual Regression

- HSRTV (High Spectral Resolution Retrieval) creates temperature, moisture, and trace gas profiles, and cloud products.

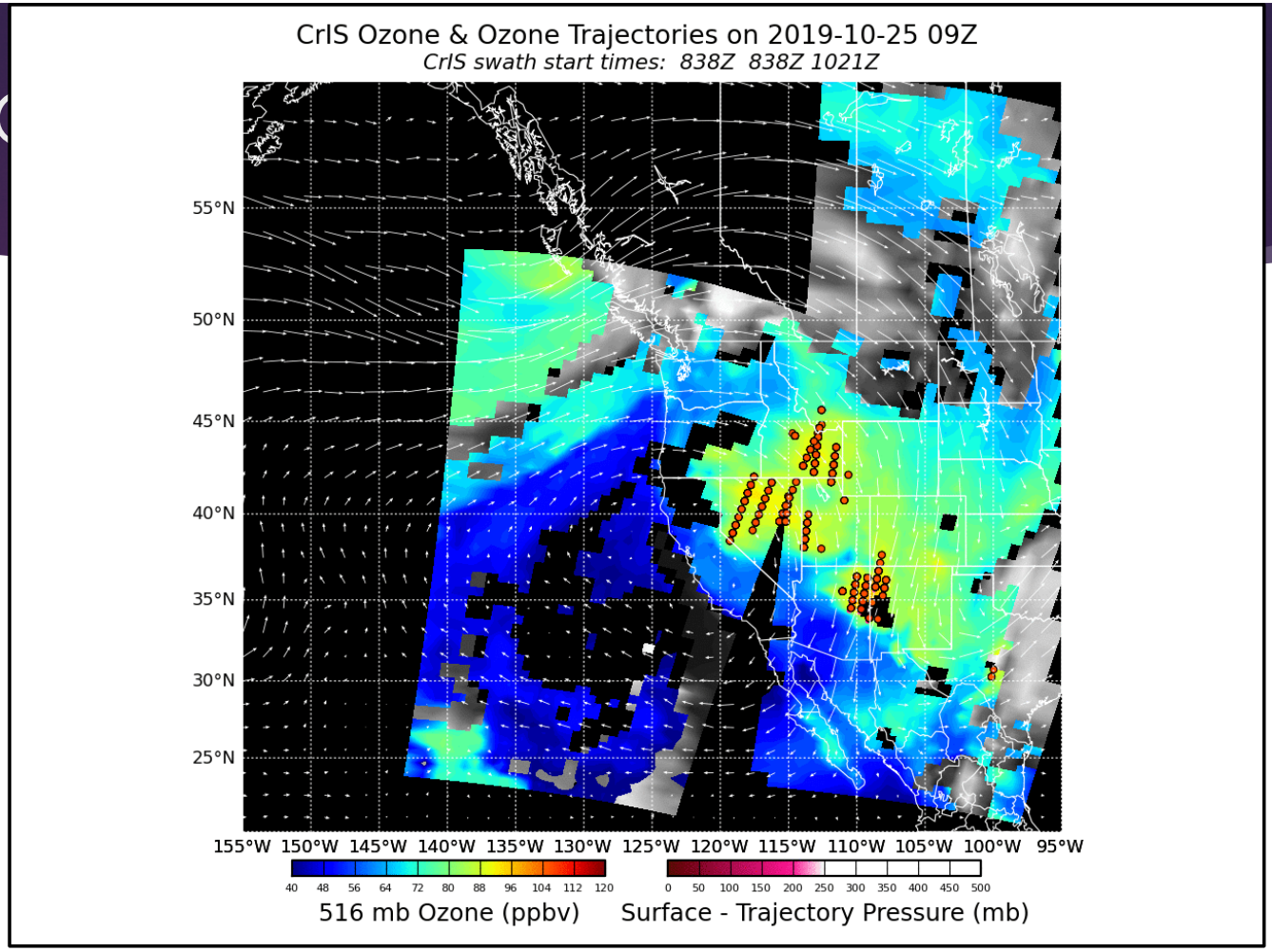
Heritage	Developed at CIMSS/SSEC by Bill Smith, Elisabeth Weisz, and Nadia Smith.
Satellites/Sensors	NOAA-20 and Suomi NPP CrIS; Metop-A/B IASI; Aqua AIRS.
Products	Single Field-of-View (FOV) retrievals of temperature, moisture, and ozone at 101 pressure levels; surface skin temperature and emissivity; total column water vapor and ozone; CO_2 amount; cloud mask; cloud top pressure and temperature; and cloud optical thickness in HDF5 format
Features	• Common multi-sensor algorithm. • Single field of view retrievals. • Fast regression physical retrieval algorithm.

CSPP HSRTV Retrieval Applications

- HSTRV ozone profiles used to identify stratospheric ozone intrusions
  - Initialize trajectories for forecasting movement of ozone in three dimensions
  - Trajectory model provided by Dr. Brad Pierce, Director of SSEC in Wisconsin



http://smoke.ssec.wisc.edu/idea-i-ozone-live-test/



Used in forecasting ozone air quality intrusions into the troposphere

Detecting and Attributing Episodic High Background Ozone Events

by Arlene M. Fiore, R. Bradley Pierce, Russell R. Dickerson, and Meiyun Lin

A summary of recent work by AQAST members that combines satellite products, in situ measurements, and models to detect and attribute observed episodic high-ozone events to three specific background sources: wildfires, stratospheric intrusions, and Asian pollution.

Arlene M. Fiore is with the Department of Earth and Environmental Sciences and Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY; **R. Bradley Pierce** is with the NOAA/NESDIS, Center for SaTellite Applications and Research (STAR), Advanced Satellite Products Branch (ASPB), Madison, WI; **Russell R. Dickerson** is with the Department of Atmospheric and Oceanic Science, University of Maryland, College Park, MD; and **Meiyun Lin** is with the Department of Atmospheric and Oceanic

The present formulation of the National Ambient Air Quality Standard (NAAQS) for ozone (O_3) considers the fourth highest daily maximum 8-hour average concentration to determine attainment status within specific areas. In order to achieve compliance with the 8-hour O_3 NAAQS, the three-year average of this statistic must not exceed the designated level, currently 75 parts per billion (ppb). The U.S. Clean Air Act Section 319 (b)(3)(B), however, recognizes that events can episodically exceed thresholds for O_3 and other NAAQS due to influences beyond the control of domestic air agencies. Such "exceptional events" can be exempted from counting toward regulatory decisions, such as non-attainment determinations, if air agencies can demonstrate that specific components of background O_3 led to the observed exceedance tion. While the ground-based and space-based measurements are usually provided on a daily basis, the in situ aircraft and sonde measurements in the examples below are generally not routinely available.

Wildfires

In early July 2002, lightning sparked several fires in central Quebec that consumed approximately 2.5×10^9 m^2 of forest. A massive smoke plume, visible from space (see Figure 1) was swept by the meteorological conditions to the heavily populated areas of the U.S. East Coast.[2] Coincident with the arrival of the smoke was an air pollution event in which ambient monitors in Maryland exceeded the O_3 NAAQS. Was the fire to blame?

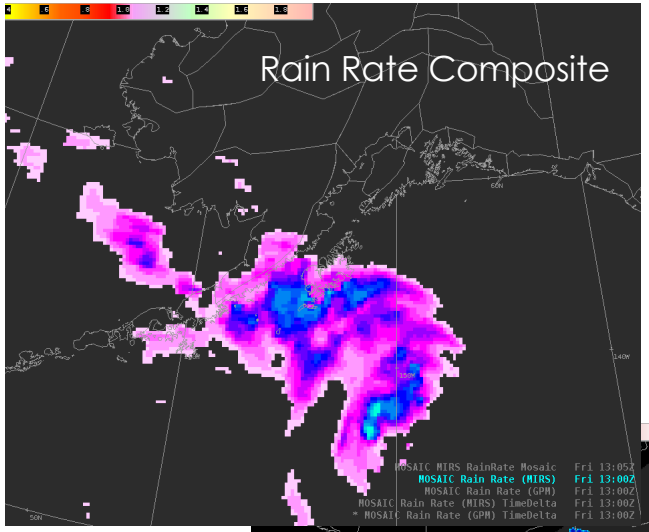
Microwave Integrated Retrieval System (MIRS)

- MIRS creates atmospheric profile, precipitation, and surface products from microwave sounder data.

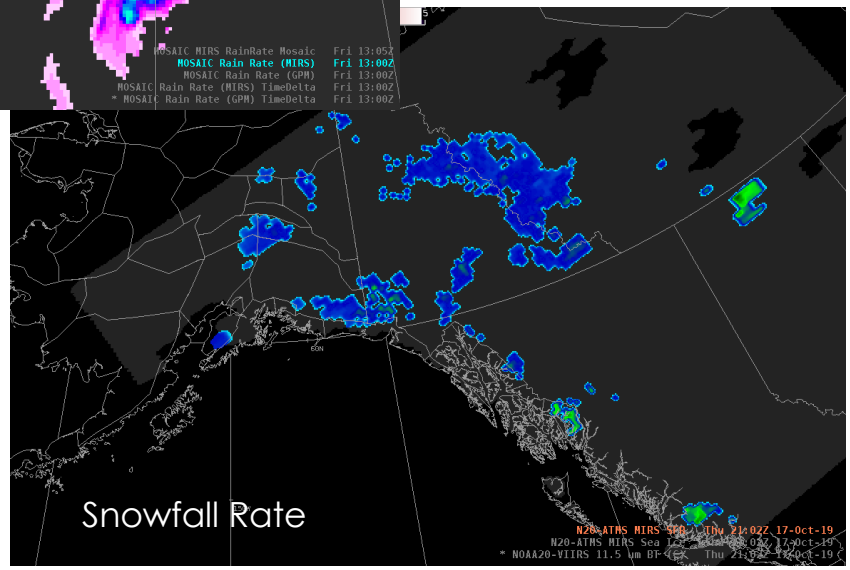
Heritage	Developed at NOAA/NESDIS by Quanhua (Mark) Liu and Chris Grassotti, et al.
Satellites/Sensors	NOAA-20 and Suomi NPP (ATMS); NOAA-18/19 (AMSU, MHS); Metop-A/B (AMSU, MHS)
Products	Temperature and moisture profiles, total precipitable water, surface skin temperature and emissivity, rain rate, cloud liquid water, rain water path, ice water path, liquid water path, sea ice concentration, snow water equivalent, and snow cover.
Features	• Multi-sensor common algorithm. • Physics-based retrieval. • Retrieves land and ocean products in all sky conditions.

MIRS Application Example

- Microwave products used in operational by the US National Weather Service Forecasters via Direct Broadcast
- Precipitation and Ice Surface retrieval products most popular
- Alaska Region MIRS Rain Rate and Snow Fall Rate composite of several passes (instruments) as viewed in AWIPS



17 October 2019



NUCAPS and NUCAPS-IASI

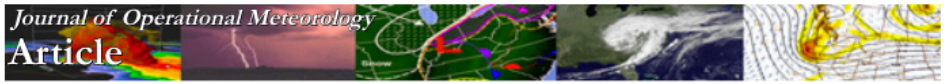
- NOAA/NESDIS/STAR Unique Combined Atmospheric Processing System (NUCAPS) retrieves atmospheric temperature, moisture, and trace gases from combined infrared and microwave observations.

Heritage	Developed at NOAA/NESDIS/STAR by Chris Barnet, Antonia Gambacorta, Nadia Smith, Tom King, Walter Wolf, Mark Liu et al.
Satellites/Sensors	NOAA-20 and Suomi NPP (CrIS, ATMS); Metop-A/B (IASI, AMSU)
Products	Temperature, water vapor, and ozone profiles; trace gas profiles including ozone, carbon monoxide, methane, carbon dioxide, nitrous oxide, sulphur dioxide; infrared and microwave surface emissivity; cloud cleared radiances.
Features	• Multi-sensor common physical retrieval algorithm. • NUCAPS is the official NOAA sounding product for JPSS. • Future version will support Metop-C (IASI/AMSU).

NUCAPS Applications – Cold Air Aloft

- Identifying regions of very cold pockets of air in the upper troposphere
- Jet fuel can be restricted if airplanes fly in very cold air for too long
- NUCAPS can provide information that fill gaps no other source can provide

Weaver, G. M., N. Smith, E. B. Berndt, K. D. White, J. F. Dostalek, and B. T. Zadovsky, 2019: Addressing the cold air aloft aviation challenge with satellite sounding observations. *J. Operational Meteor.*, **7** (10), 138-152, doi: https://doi.org/10.15191/nwajom.2019.0710



Addressing the Cold Air Aloft Aviation Challenge with Satellite Sounding Observations

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(Manuscript received 15 January 2019; review completed 14 June 2019)

NUCAPS Applications – Cold Air Aloft

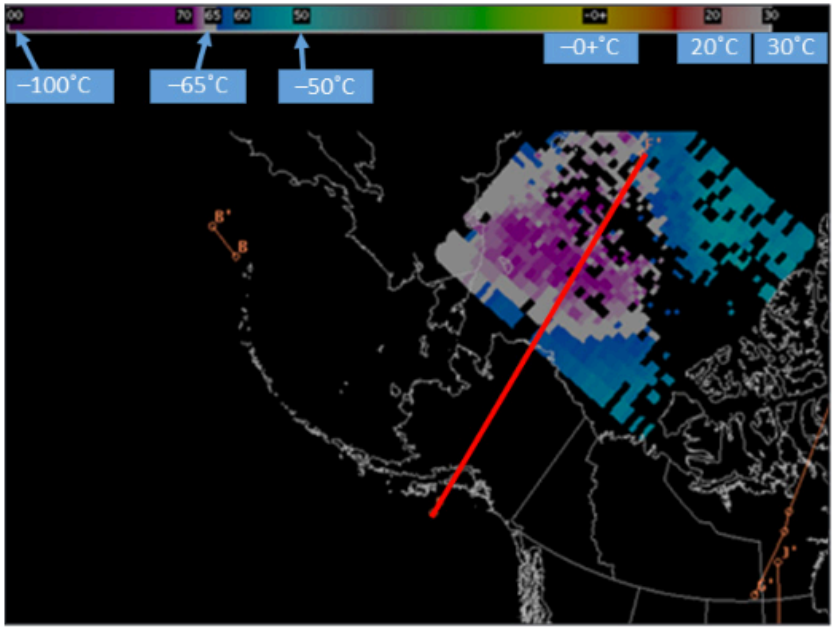

Figure 4. AWIPS-II plan view of the CAA NUCAPS temperature product at 212 hPa on 1700 UTC 8 December 2016. The CAA feature is identified where temperature observations are less than –65°C, indicated here in gray and purple colors.

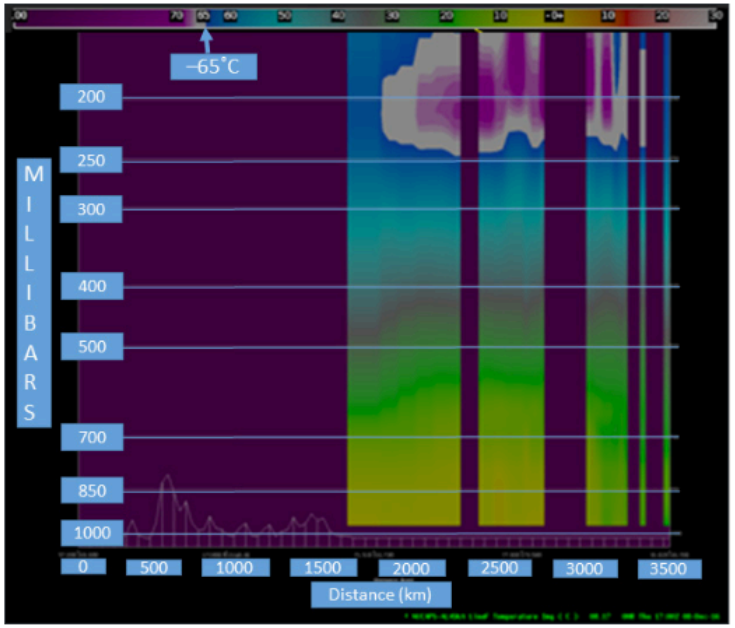

Figure 5. AWIPS-II cross section of the CAA NUCAPS product, 1700 UTC 8 December 2016. The cross section was derived from the red line overlaid on the image in Fig. 4. The color scale at the top of the image displays temperatures in degrees C and is the same temperature scale as in Fig. 4.

NUCAPS Applications – Real-time Atmospheric State

- **Hazardous Weather Testbed in 2018** Operational meteorologists evaluated NUCAPS direct broadcast soundings from S-NPP to determine if they helped in characterizing pre-convective conditions to improve severe weather forecasting.
- NUCAPS soundings from the S-NPP platform are available around 18:30 UTC, which is when Summer-time convection occurs.
- Taken From Smith, N., et al, (2019). 3.7 WHY OPERATIONAL METEOROLOGISTS NEED MORE SATELLITE SOUNDINGS, 99th AMS Annual Meeting, 15th Annual Symposium on New Generation Operational Environmental Satellite Systems Phoenix, AZ, 7 Jan 2019

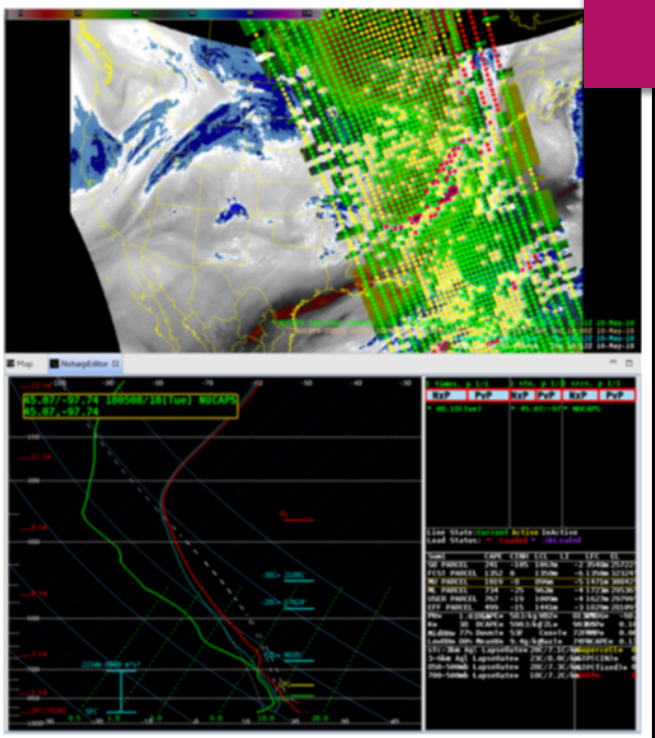

Figure 1: Example of NUCAPS availability (top) in AWIPS-II. Dots can be clicked by forecasters to display a skew-T diagram (bottom) for comparison to radiosondes and derived parameters. Color coding indicates data quality.

NUCAPS Applications – Real-time Atmospheric State

- Forecaster Feedback from Hazardous Weather Testbed:
  - *"NUCAPS is useful as a pre-storm analysis tool…to determine convective potential"*
  - *"The lower the latency time between the satellite pass and ingest of the soundings into AWIPS, the more likely I would be to use NUCAPS"*
  - *"Direct broadcast was very useful. When monitoring environmental changes before storms develop, the more recent the data, the better"*
  - *"NUCAPS needs to be offered as soon as possible to the forecasters. The faster we can translate that data and incorporate it into our severe forecast mindset, the better the public will be as we will have real data, not model derived, top-down that is not available anywhere else."*

CSPP Sounder Software Conclusions

- CSPP LEO Sounder Software packages are being used for a variety of applications including:
  - Climate studies
  - Real-time environmental forecasting – direct broadcast
    - Timeliness is essential
    - Swath coverage much better than radiosondes
    - Overpass times optimal for convective initiation
    - Multiple satellite/sensors supported means consistent retrievals and much better temporal coverage
  - Research
    - Scientific integrity quality of products
  - Encourages use because it is freely distributed!!!!!