AIRS Applications: Overview & Status + Volcanic Plume Detection

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October 2020

AWIPS workstation (Public Domain)

Spanish flu in 1918, Seattle Police Department
(Public Domain)

Texas drought 2013. (USDA photo by Bob Nichols. Wikimedia Commons)

Galunggung volcano eruption, Java Indonesia July 2006
Source: Wikimedia Commons (Public Domain)

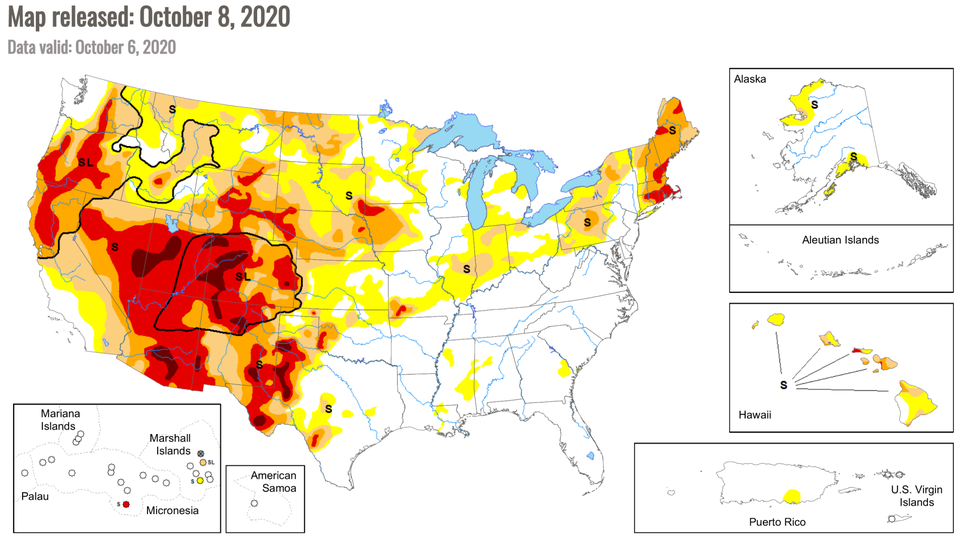
AIRS Applications In Many Domains

Weather	**Weather prediction centers world-wide**	
Aviation & Natural Hazards	**AIRS SO2 & Dust Detection for Volcanic Plume Rapid Response** **Support to Aviation Control Service (*supports Toulouse VAAC*; ESA funded)** ● Daily global SO2 BT Diff ● SO2 load (BIRA/NILU Prata retrieval) ● Ash index	**2017 Earth Science Senior Review Subcommittee** AIRS data are of significant importance to the FAA and the aviation community (sulfur dioxide, volcanic plumes).
Drought	**US Drought Monitor**	
Wildfire	**Fire Danger Assessment System**	*Not funded by AIRS*
Health	**Influenza Forecasting** Dengue Zika	

In FY21, AIRS applications reports for publication

Drought Onset Prediction & the U.S. Drought Monitor

Stephanie Granger, Alireza Farahmand (JPL)



United States and Puerto Rico Author(s):
Brian Fuchs, National Drought Mitigation Center

U.S. Affiliated Pacific Islands and Virgin Islands Author(s):
Denise Gutzmer, National Drought Mitigation Center

- USDM produced weekly by National Drought Mitigation Center **NDMC.** U.S. policymakers/ agencies refer to USDM in drought decision-making
- AIRS-derived drought products (NS RH & T, VPD) show **early detection lead times up to two months ahead** of precip only
- Since July 2017 – AIRS products delivered weekly to USDM authors and community
- **Work is underway for an AIRS "refresher" for USDM authors and user community**
- Provide use cases, best practices, materials (how-to guides, publications)
- **Support from NDMC** - guidance, access to authors and community, resources (social scientists)

AIRS L2 VPD now in V7

Next:

Visualize in NASA Worldview

Influenza Outbreak Prediction

Heidar Thrastarson, Joao Teixeira (JPL)
Emily Serman (USC/JPL)

Background

- Humidity conditions a leading explanation for seasonal behavior of flu outbreaks in temperate regions
  Shaman et al., 2010 , Shaman & Karspeck, 2012

- **JPL Flu Forecasting Model**
  - SIRS model: Susceptible-Infectious-Removed/Immune-Susceptible
  - AIRS near surface humidity, NCEP NS humidity forecasts, flu surveillance data
  - Runs quasi-operationally
  - City, state, regional scale
  - Model supports the humidity–flu outbreak connection

Completed

- Two flu seasons collaborating with LA County Dept of Public Health
  - LACDPH provides local influenza surveillance data, JPL shares forecasts in mock trial
  - LACDPH provides guidance on how to refine the model & present results
- JPL model outperforms LAC's existing approach (ie. comparing to previous seasons). Model better at capturing in-season trends, peak timing and strength.

Plans

- Begin third season collaborating with LA County Dep. Public Health, regular flu forecasts
- Forecast COVID-19 for Los Angeles area
- Prepping model to be part of the Centers for Disease Control's forecasting network
- Further engagement with potential operational users
  - Global nature of AIRS data and weather forecasts offers possibility of extensions to other regions of the world (e.g. South Africa)

AIRS in AWIPS – National Weather Service Advanced Weather Interactive Processing System

AWIPS workstation
(Public Domain)

About AWIPS

- Processing, display, and telecommunications system used by forecasters
- Integrates meteorological, hydrological, satellite, and radar data
- Distributes the data to 135 Weather Forecast Offices (WFOs) and River Forecast Centers (RFCs)

Forecasters expressed more satellite soundings would be valuable for increased spatial and temporal coverage to assess environment

NASA SPoRT (Emily Berndt) – facilitating integration of AIRS in AWIPS

STC (Nadia Smith) – overseeing AIRS integration into NUCAPS

Activities

- Set up AIRS NUCAPS in production
- Reformat, integrate, and test AIRS in AWIPS
- Assess at the Hazardous Weather Testbed Spring Experiment
- Summarize feedback from HWT, present at NASA Sounder Science Team Meeting Fall 2021

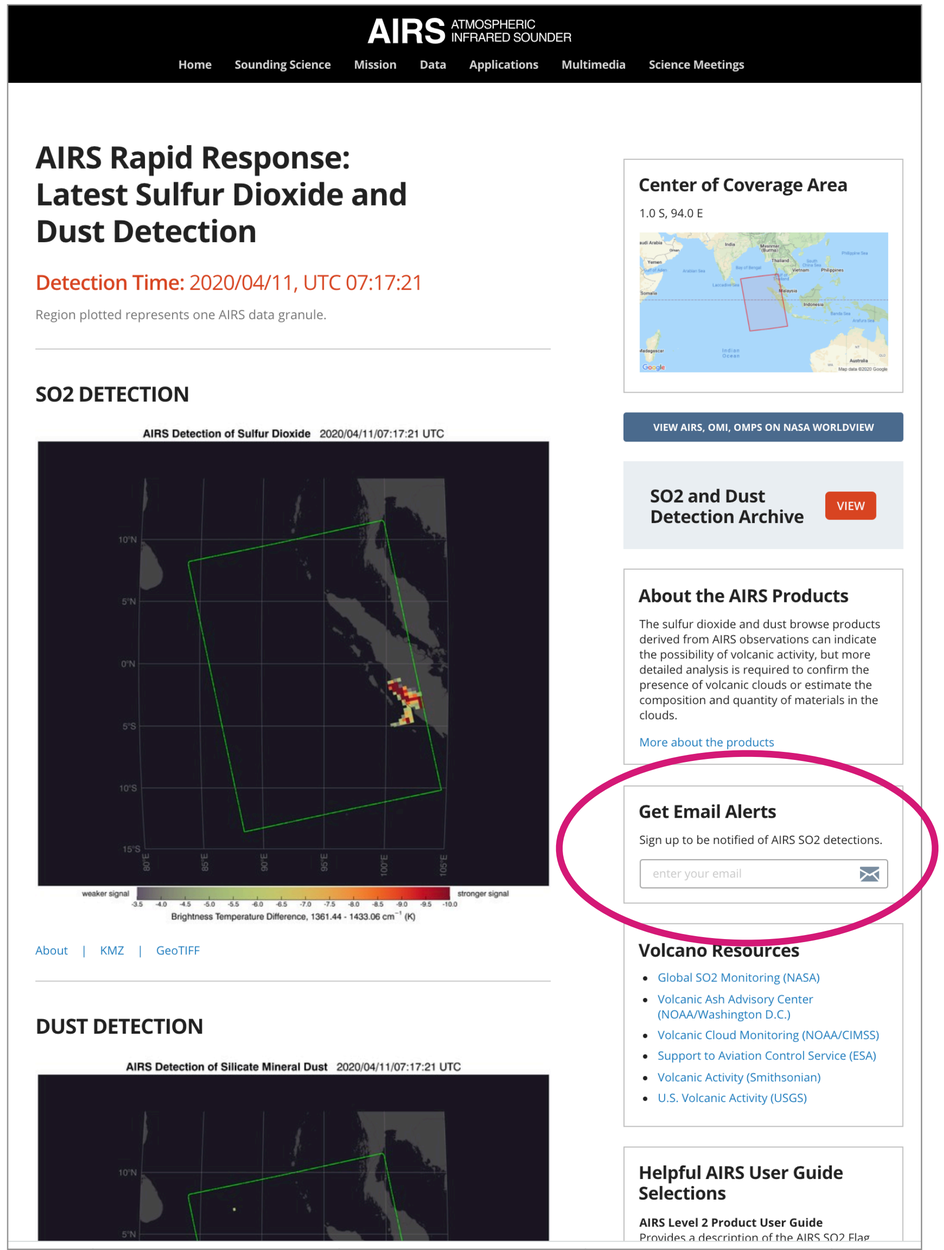
SO2 & Dust Detection Rapid Response for Volcanic Plume Detection

Sharon Ray, Vince Realmuto, Paulo Penteado, Steve Licata, Jeff Hall (JPL)

Scan incoming L1B NRT granule > Trigger on threshold breaches of SO2 > Provide imagery & email alerts

AIRS and Volcanic Plumes

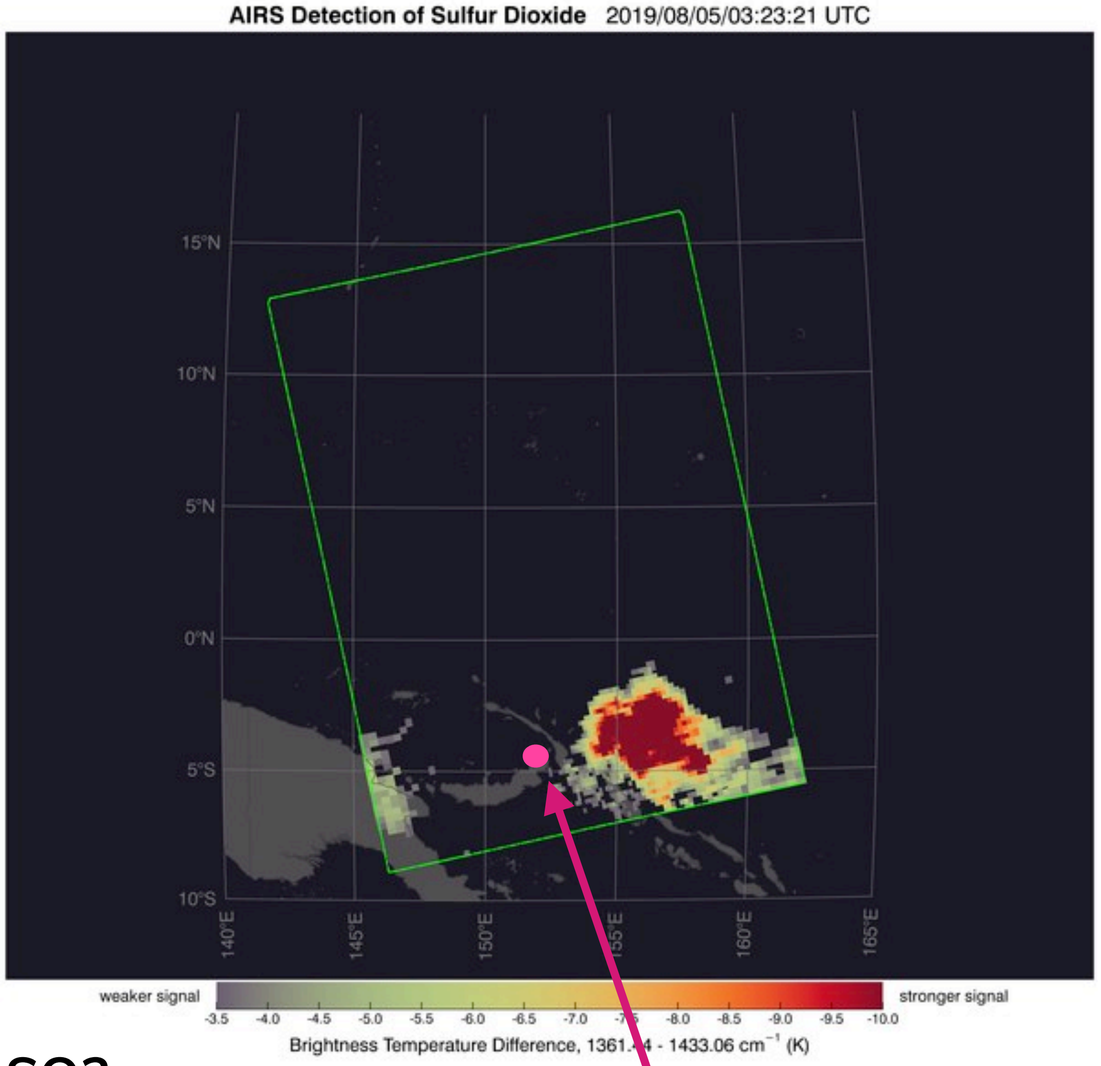
- Help track long lived plumes & corroborate volcanic eruptions
- Night-time and low-light (e.g., polar winter) detections (UV & SWIR detections require solar illumination)
- In high and dry conditions, AIRS can be more sensitive to SO2 signal than MODIS, VIIRS – *AIRS complements other SO2 sensing instruments*
- Low plumes will likely be missed by AIRS (water vapor masks the signal)



Ulawun, Papua New Guinea
Eruption began 8/3/19
Plume height 8/4 approx 19.2 km (63k ft)

All images 8/5/19

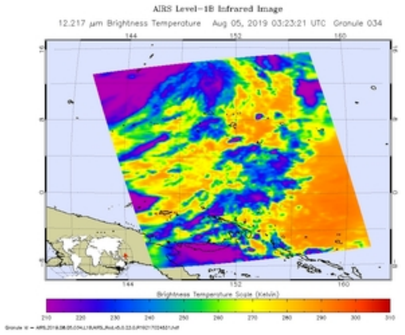
Visible image
if daytime acquisition



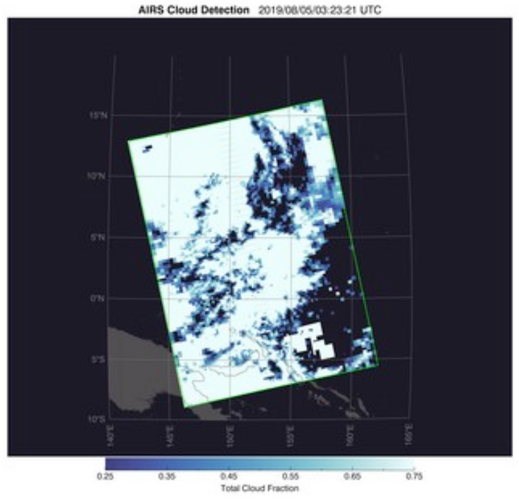
SO2

Mount Ulawun

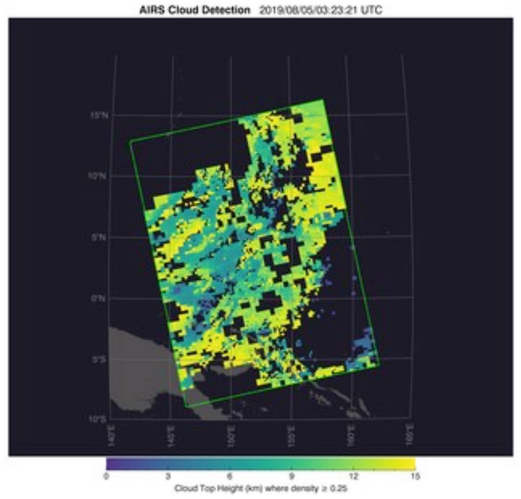
Dust
(Ash proxy)



Infrared



Total Cloud Fraction

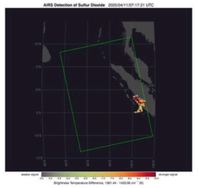


Cloud Top Height

Historical archive of AIRS volcanic plume detections

‹ Latest Sulfur Dioxide and Dust Detection

AIRS Sulfur Dioxide and Dust Detection Archive

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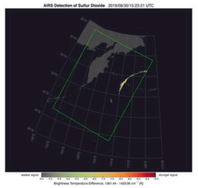
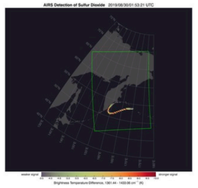
Granule 73, 1.0 S, 94.0 E




2019/08/30, UTC 15:23:22
Granule 154, 52.0 N, 163.0 E




2019/08/30, UTC 01:53:22
Granule 19, 58.0 N, 162.0 E

Get Email Alerts

Sign up to be notified of AIRS SO2 detections.

enter your email

Helpful AIRS User Guide Selections

AIRS Level 2 Product User Guide
Provides a description of the AIRS SO2 Flag and Dust Flag along with quality indicators and caveats. See chapter 24, titled "LEVEL 2 PHYSICAL RETRIEVAL SURFCLASS, DUST FLAG, SO2 FLAG AND CLOUD PHASE FLAG".

Product User Guide (PDF)

AIRS Retrieval Channel Sets
Defines the SO2 Flag and Dust Flag tests plus important notes concerning contamination due to volcanic ash and dust. See section 2.12 SO2 Flag (L1B radiances) and Section 2.13 Dust Flag Determination (L1B radiances).

Retrieval Channel Sets (PDF)

Coming Soon

Archive improvements:

- Search by date range & lat-lon, sort by time
- Re-make archive from BOM with improved detection criteria

Comparison View

- Allows imagery overlay
- Ex. Cloud image overlaid on SO2 image to see where SO2 signal impacted by cloud

The Algorithm

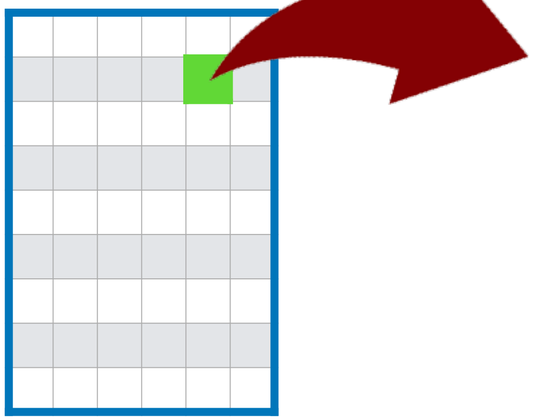
- Goal: Reduce false positives but maximize legit detections
- **AIRS Level 1B granules** examined **daily in NRT**, 240 granules/day
- Plume detection operates on a **granule** divided into **subregions** in which you check **footprints**
  - ***Subregion*** *strategy – designed to reduce false positives due to isolated SO2-positive footprints*

1

Incoming AIRS NRT L1B granule

2

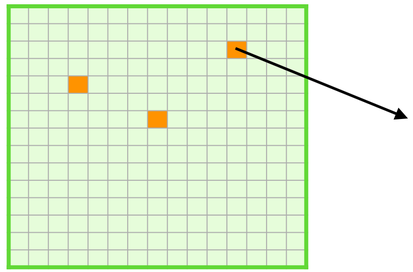
Granule divided into 6x9 subregions



Each subregion ~ 220 x 220 km

3

Subregion contains 15x15 AIRS native footprints



225 AIRS footprints/subregion

4

Each footprint examined for SO2

If SO2 Brightness Temp Diff < -4.5K then footprint flagged as containing SO2

5

Plume Event declared for subregion if:

1. At least 20 footprints meet detection threshold **AND**
2. Mean SO2 BT Diff value of all SO2 events <= -5.5k

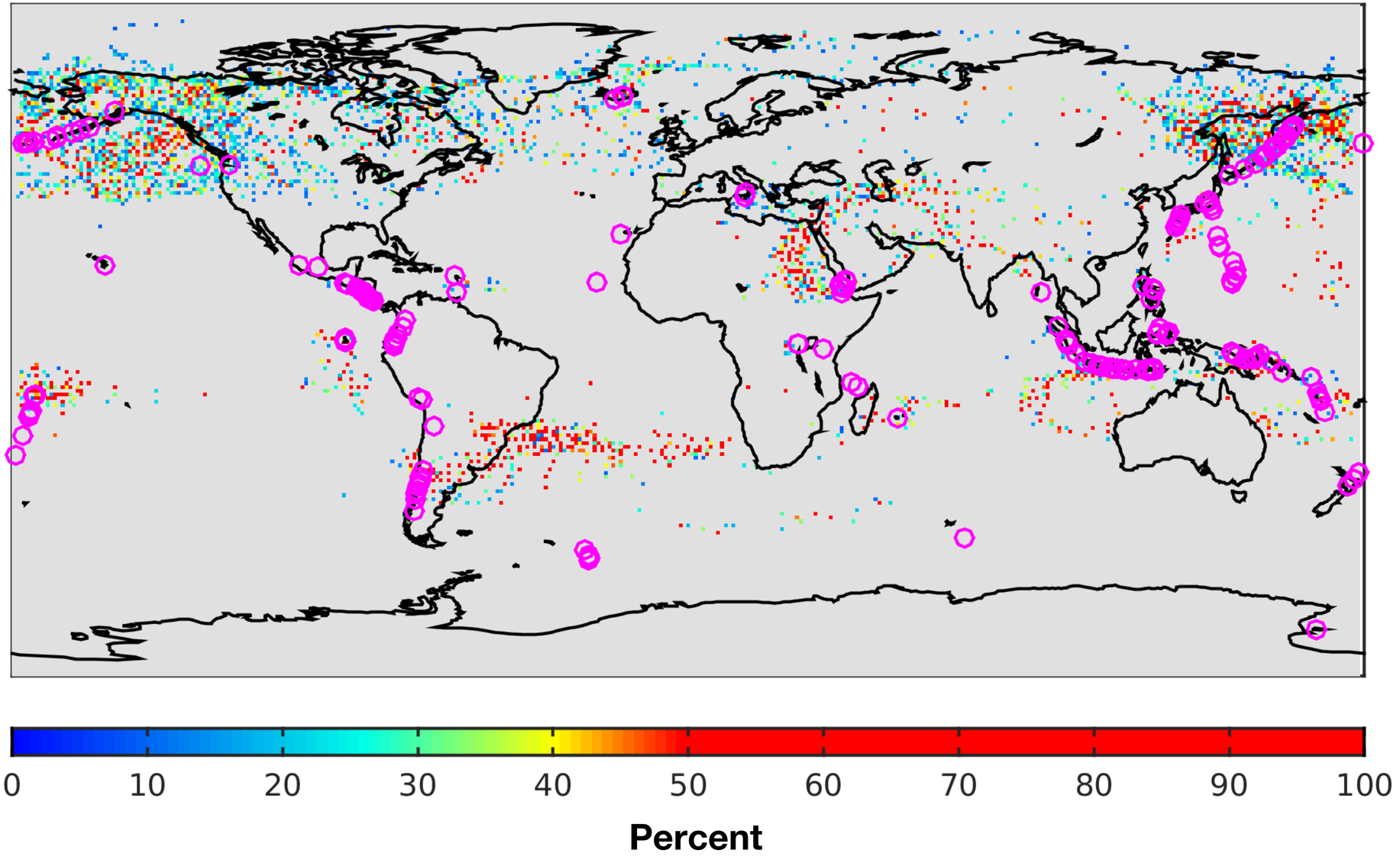
6

If a subregion determined to have a plume event, the alert is triggered for the granule

AIRS Sulfur Dioxide Events per Subregion

2007/01/01 to 2020/07/31, 4673 events

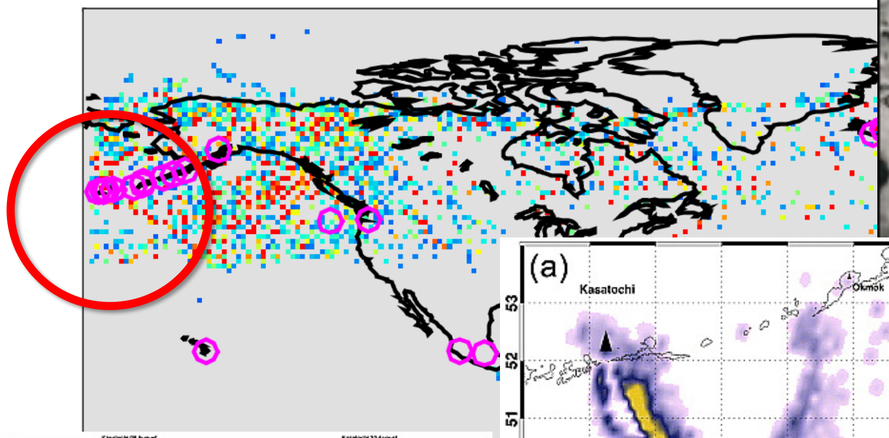
Detection Criteria per Subregion: (1) At least 20 FOVs with SO2 BTD < -4.5K; (2) Mean SO2 BTD of -5.5K over FOVs passing Threshold #1

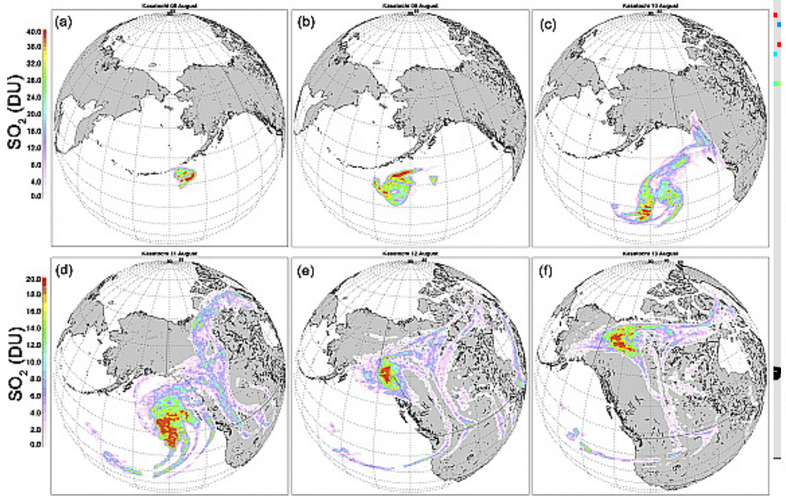


AIRS Sulfur Dioxi

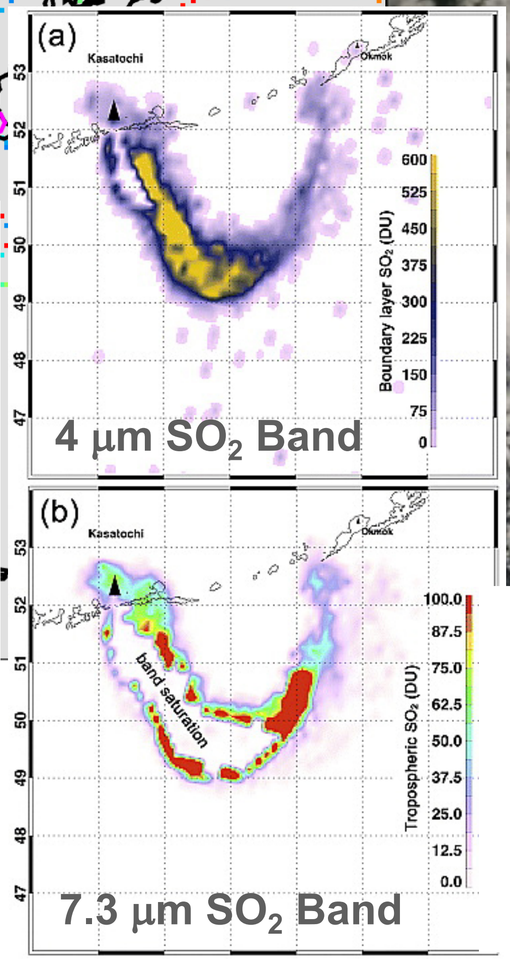
2007/01/01 to

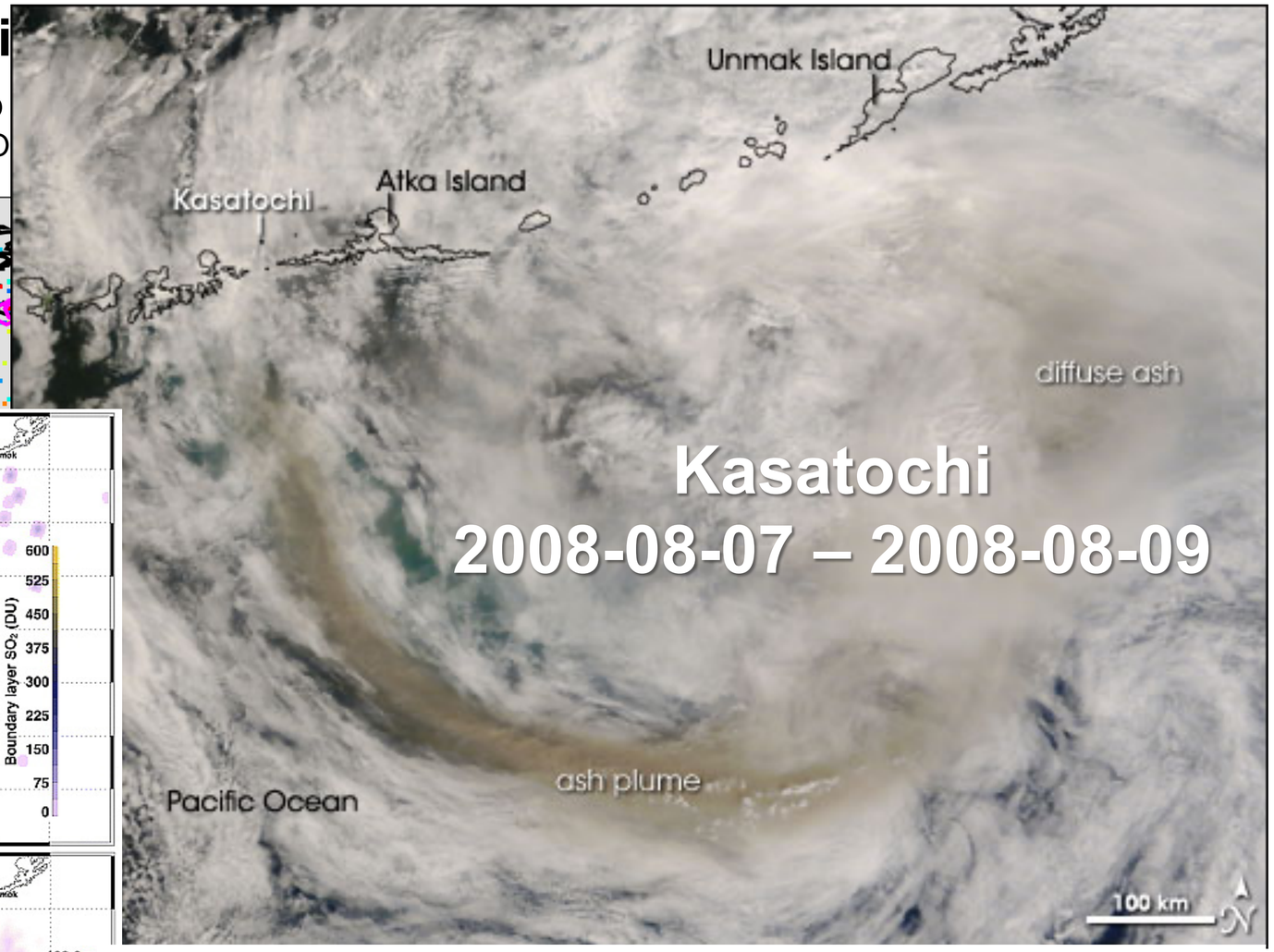
Detection Criteria per Subregion: (1) At least 20 FOVs with SO





Plume Dispersion
2008-08-08 – 2008-08-13
(*Prata et al.*, 2010)



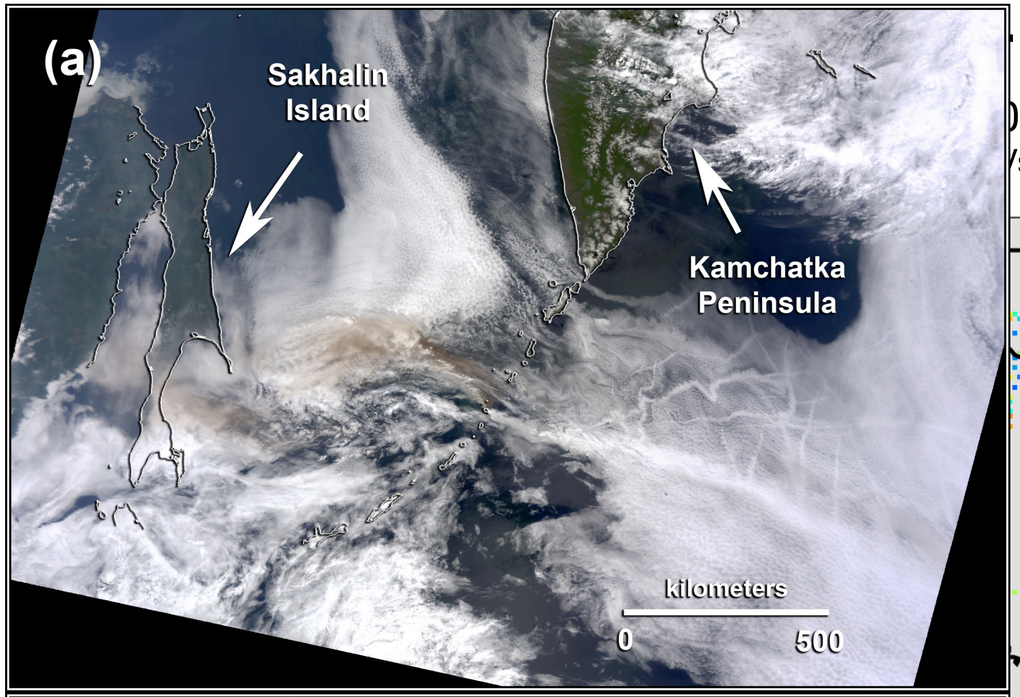


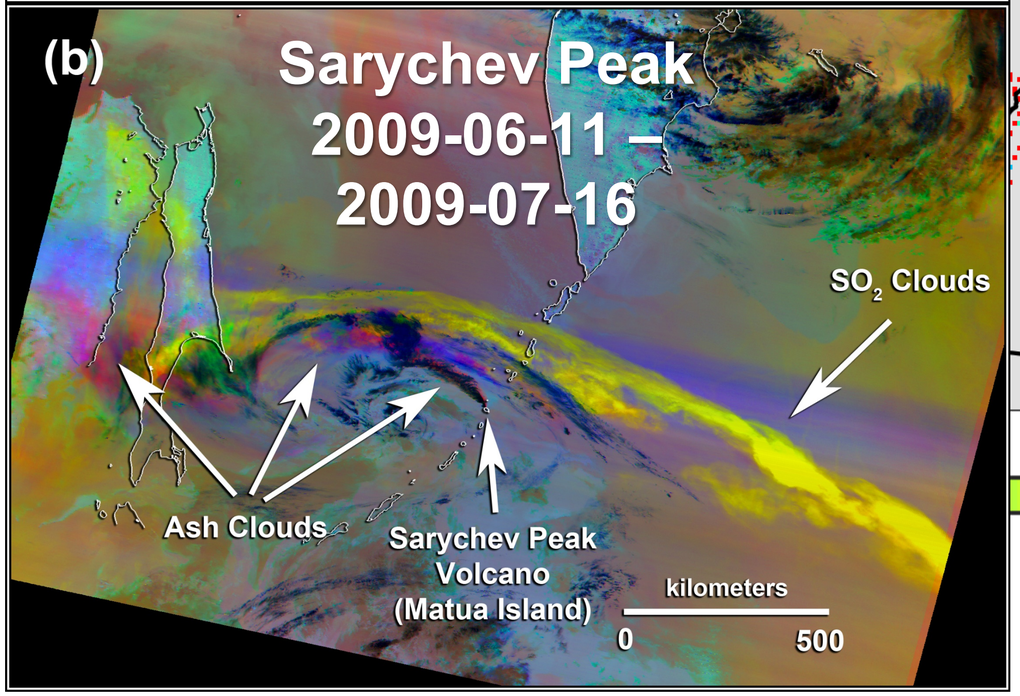
Kasatochi SO_2 Plume
2008-08-08, 1341 UTC
(a) Boundary Layer SO_2
(b) Tropospheric SO_2
(*Prata et al.*, 2010)

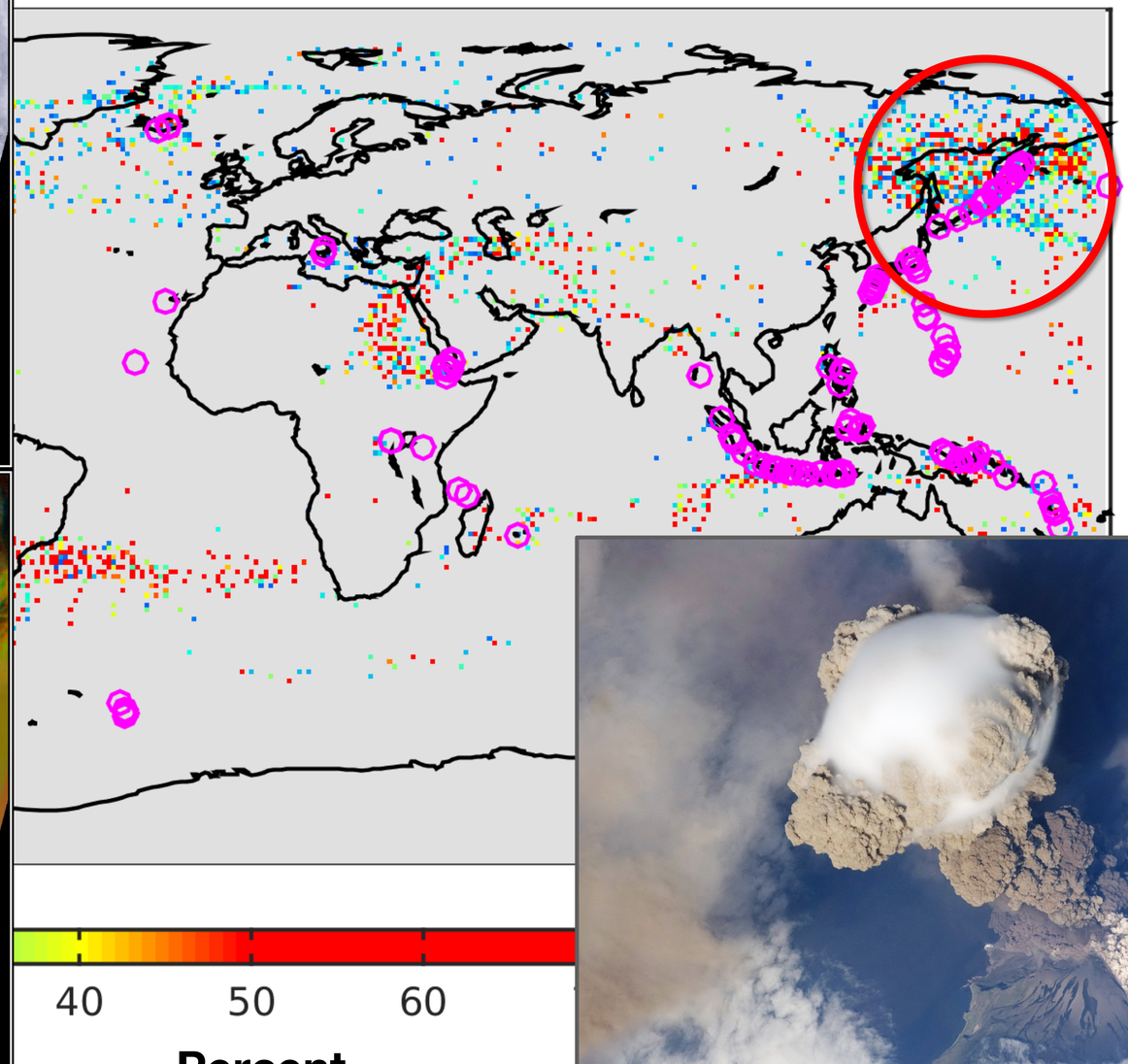
Dioxide Events per Subregion

01/01 to 2020/07/31, 4673 events

Vs with SO2 BTD < -4.5K; (2) Mean SO2 BTD of -5.5K over FOVs passing Threshold #1



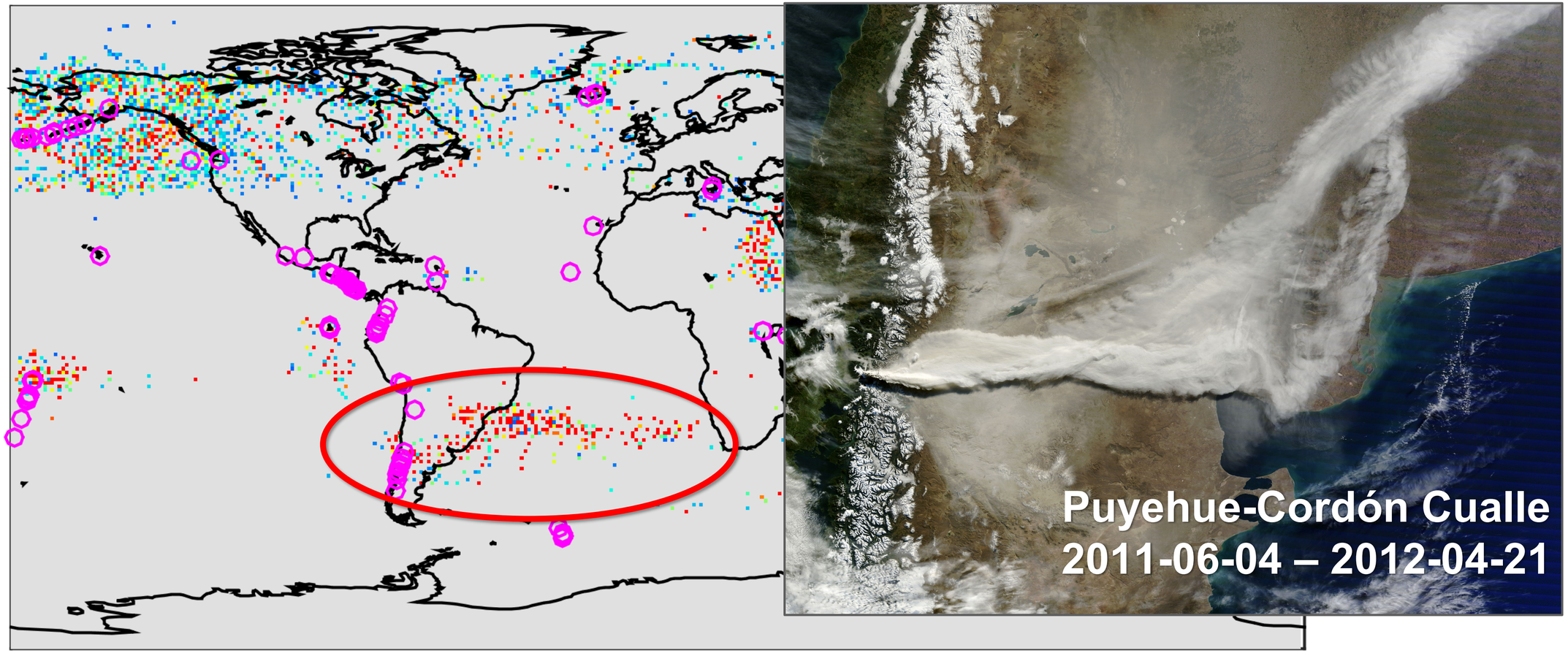


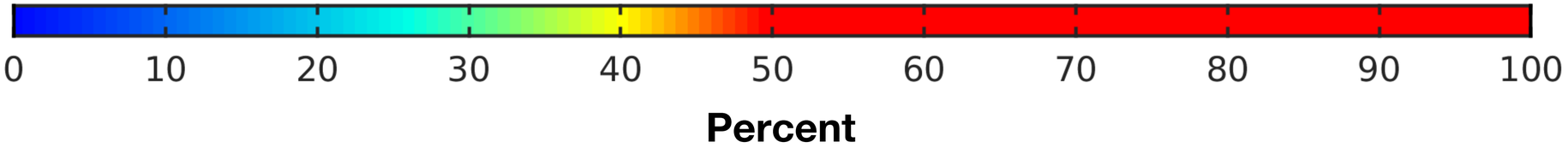


AIRS Sulfur Dioxide Events per Subregion

2007/01/01 to 2020/07/31, 4673 events

Detection Criteria per Subregion: (1) At least 20 FOVs with SO2 BTD < -4.5K; (2) Mean SO2 BTD of -5.5K over FOVs passing Threshold #1





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2007/01/01 to 2020/07/31, 4673 events

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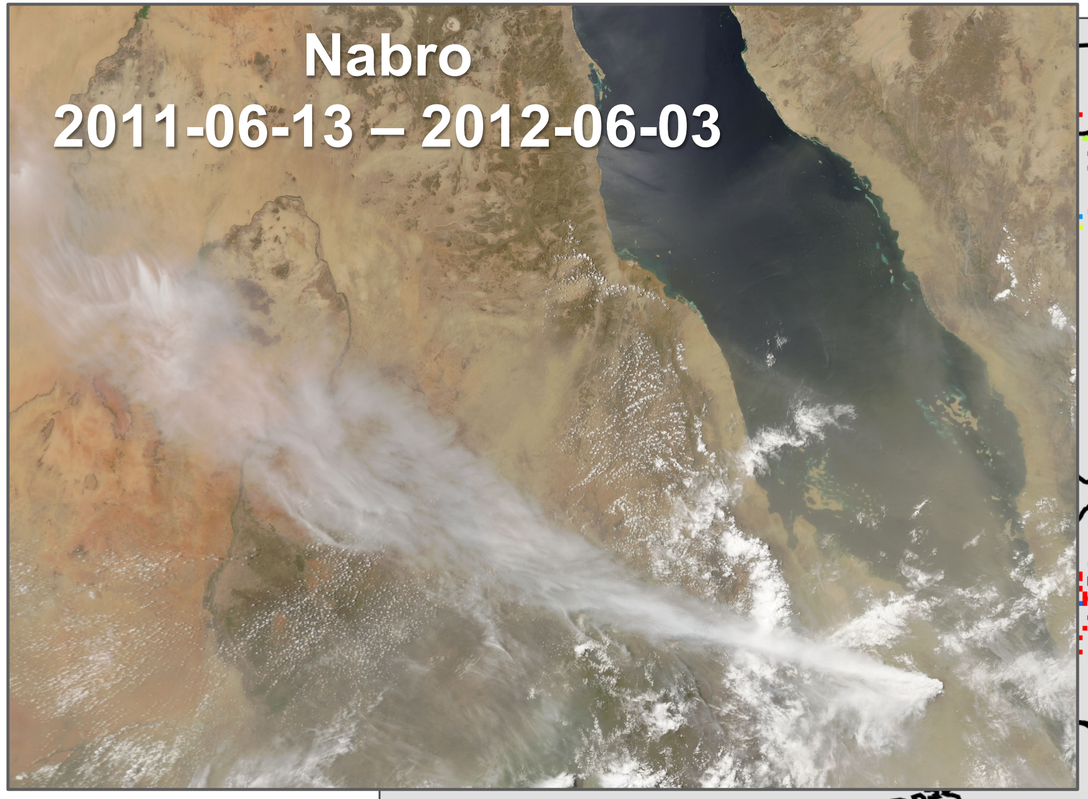
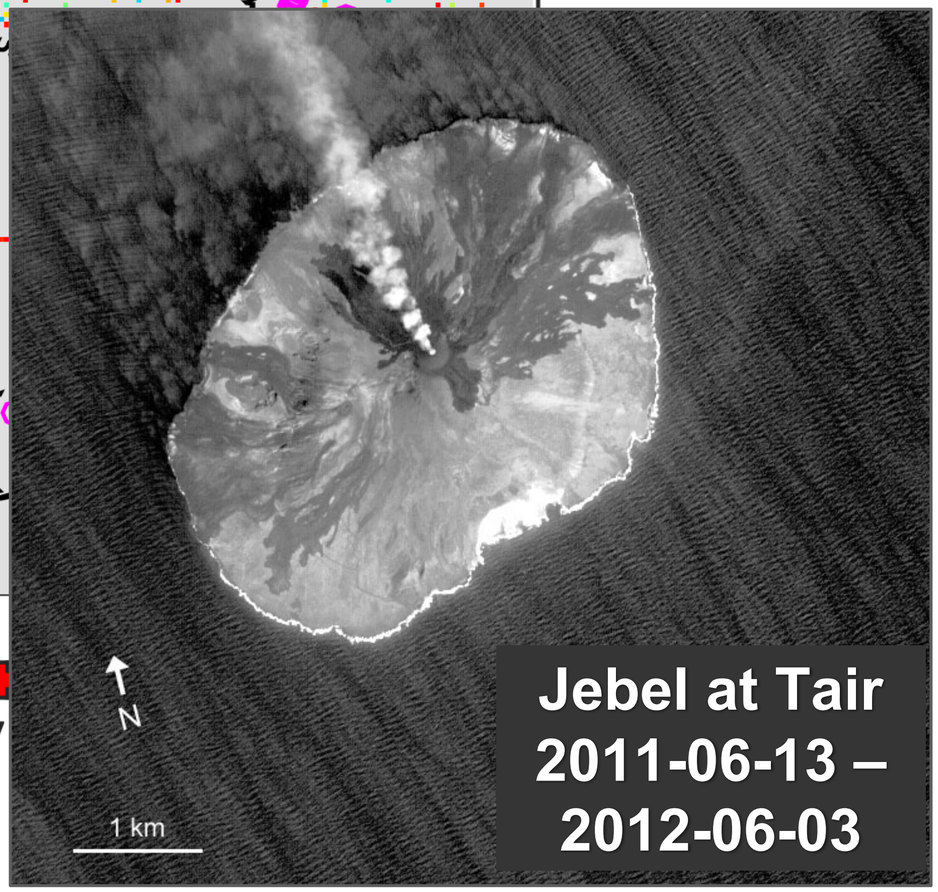
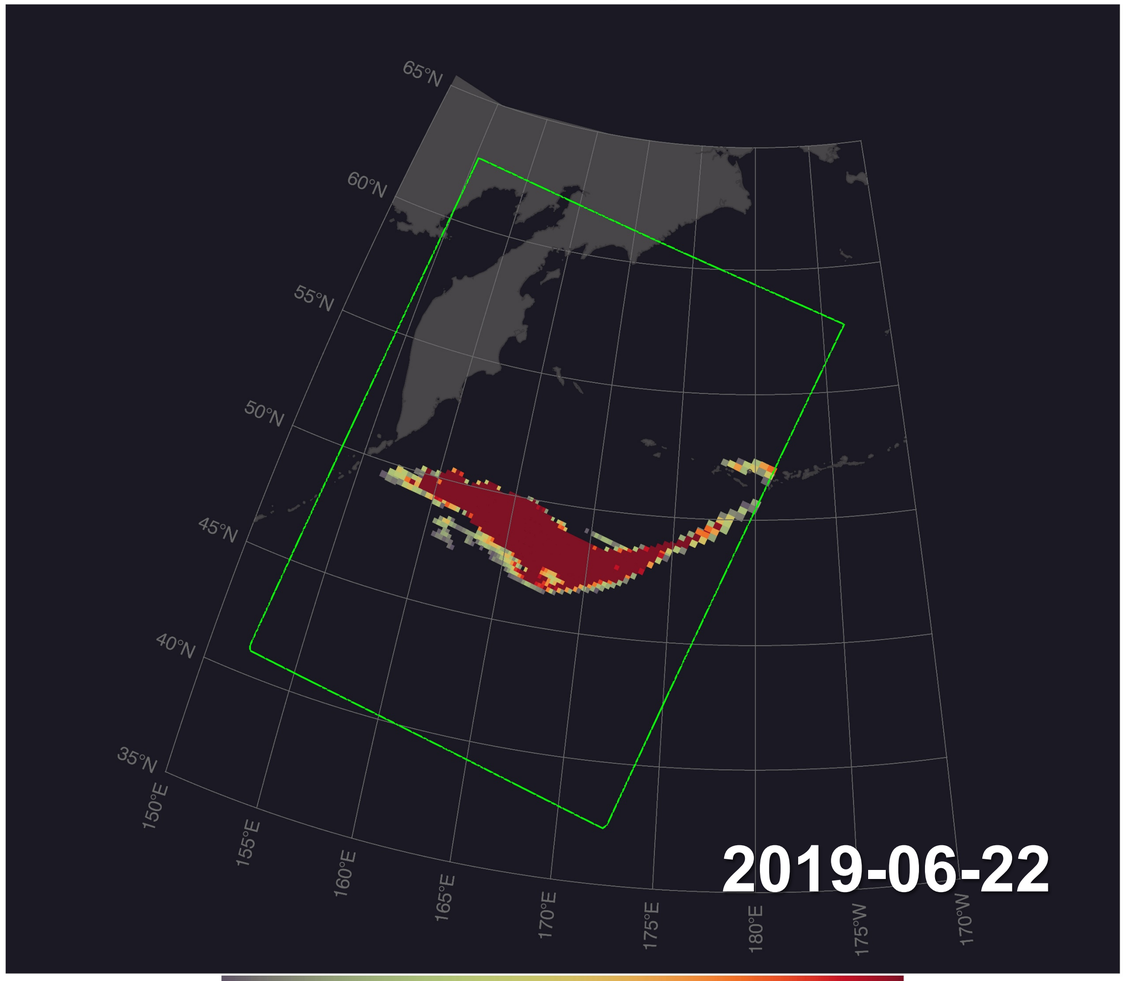


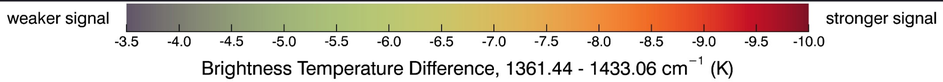


0 10 20 30 40 50 60 7

Percent

AIRS Detection of Sulfur Dioxide 2019/06/22/15:05:21 UTC



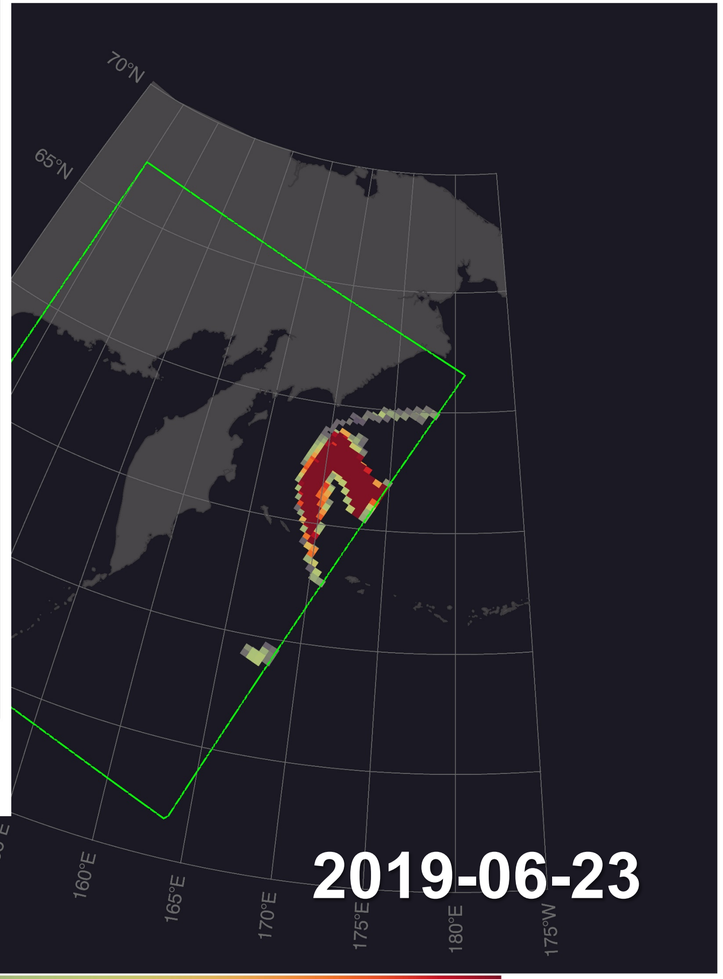


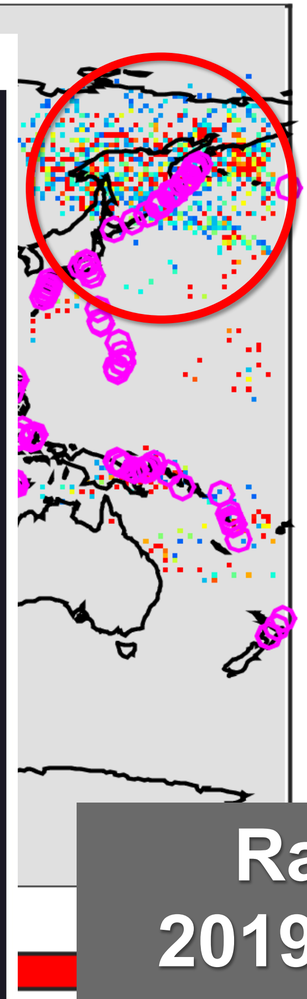
ide Events per Subregion

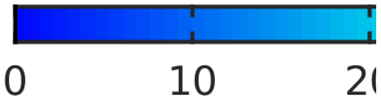
) 2020/07/31, 4673 events

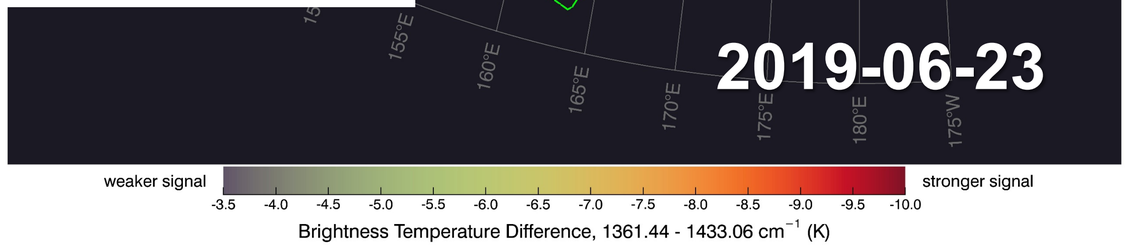
)2 BTD < -4.5K; (2) Mean SO2 BTD of -5.5K over FOVs passing Threshold #1

of Sulfur Dioxide 2019/06/23/15:47:21 UTC





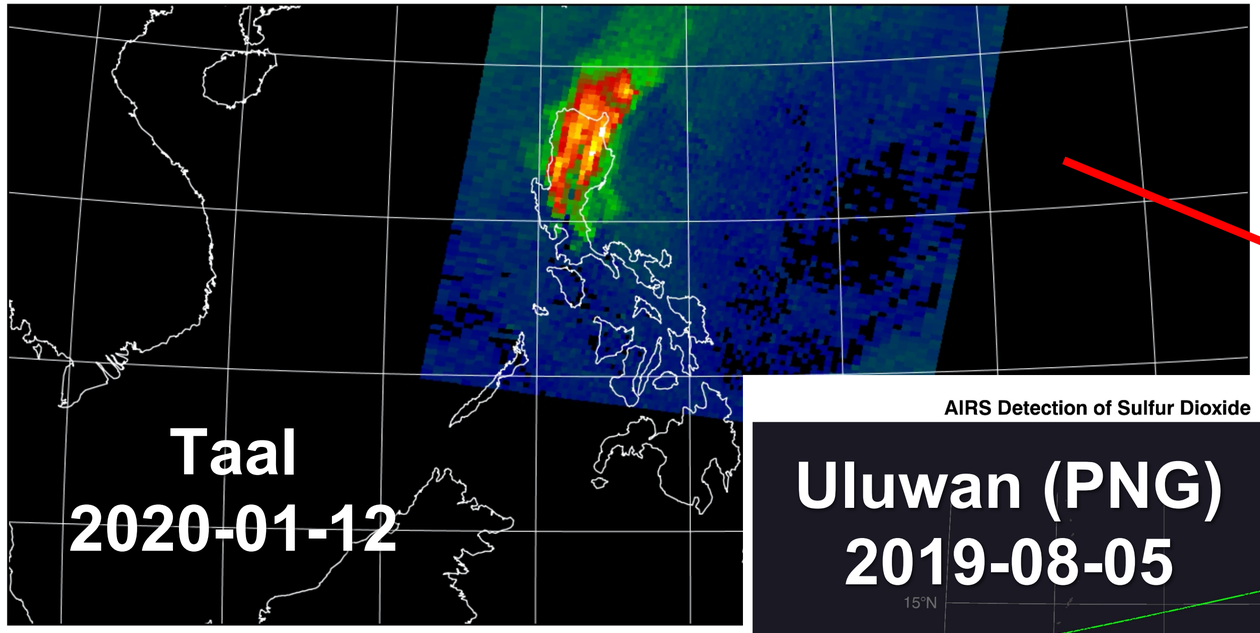




Raikoke
2019-06-22 –
2019-07-01

Taal | 2020-01-12 | 17:12:21

AIRS (Granule 173)



BTD_SO2 (K)

-20.00 -15.00 -10.00

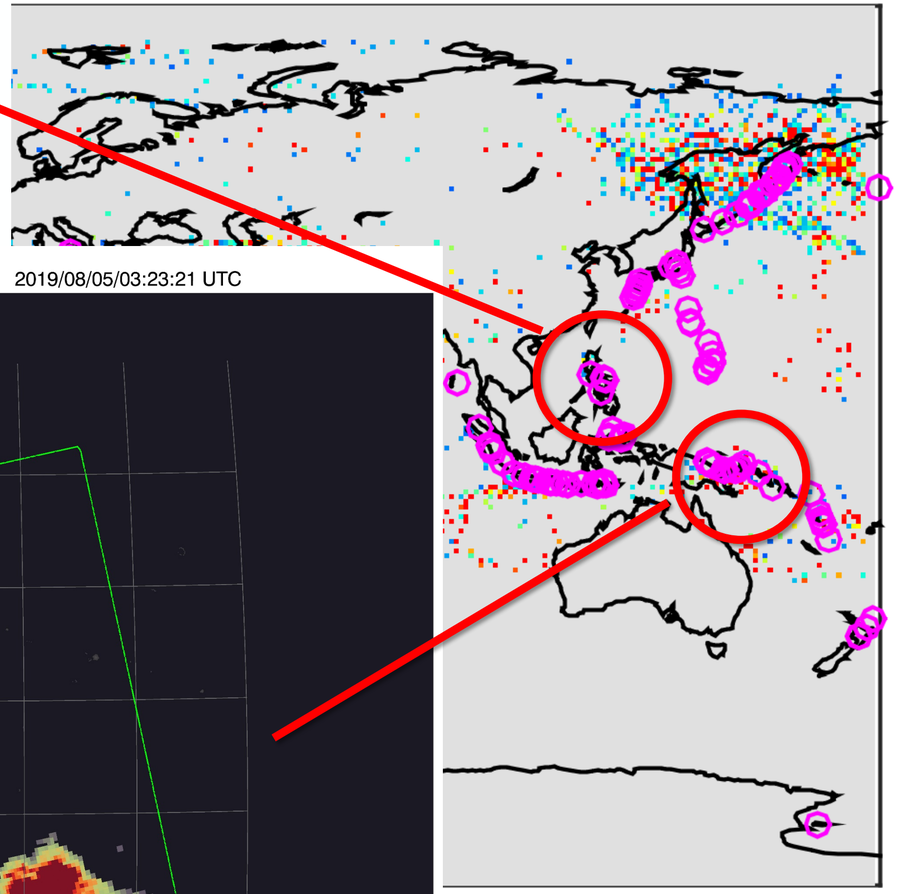
Data Min = -23.86, Max = 3.22

0 10 20

Events per Subregion

'07/31, 4673 events

< -4.5K; (2) Mean SO2 BTD of -5.5K over FOVs passing Threshold #1



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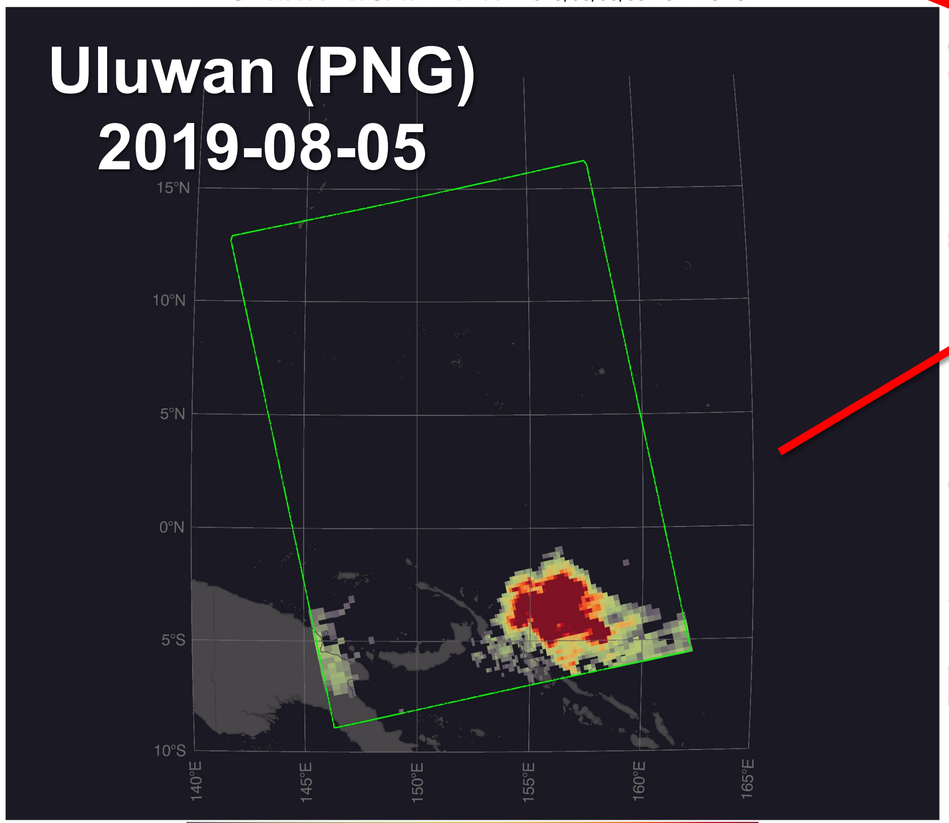
AIRS Detection of Sulfur Dioxide 2019/08/05/03:23:21 UTC



weaker signal stronger signal

-3.5 -4.0 -4.5 -5.0 -5.5 -6.0 -6.5 -7.0 -7.5 -8.0 -8.5 -9.0 -9.5 -10.0

Brightness Temperature Difference, 1361.44 - 1433.06 cm^{-1} (K)