AIRS Applications & More

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AIRS Applications Catalog – *FLUID!*

DROUGHT

USDM

AVIATION

Volcanic SO2 Detection in VAAC

Volcanic SO2 Loading in VAAC (Prata)

Volcanic Ash/Dust Loading in VAAC (Prata)

JPL Volcano Rapid Response - *improved detection and products*

FIRE

Fire Danger Assessment System

Indonesia Fires Seasonal Threshold

HEALTH

Influenza

Zika

Dengue Fever

AIR QUALITY

Temperature Inversions

Air pollution CO tracer

Ozone intrusion from stratosphere into troposphere in NAWIPS

The Four NASA Applied Science Application Areas

Promoting Earth observations data & models for…

Health & Air Quality

- Implementation of air quality standards, policy, & regulations for economic and human welfare, **particularly involving environmental health & infectious diseases.**
- Addresses issues of toxic and pathogenic exposure & health-related hazards & their effects for risk characterization & mitigation

Ecological Forecasting

- Analyze and forecast changes that affect ecosystems and to develop effective resource management strategies
- Primary user communities are natural resource managers (both land and marine) & those involved in conservation and sustainable ecosystem management.

Water Resources

- Water resources management related to water demand, supply, and quality.
- Includes five functional themes: **drought**; streamflow and flood forecasting; evapotranspiration and irrigation; water quality; and climate effects on water resources.

Disasters

- Improve prediction of, preparation for, response to, and recovery from natural and technological disasters
- Supports projects to enhance management practices and disaster reduction across disaster types, including floods, earthquakes, **volcanoes**, and landslides.

Wildfires absorbed by Disasters; No more Fire calls

risk assessments, policy analysis, business practices, and management strategies and actions associated with **wildland fires**, including before, during and after the fires.

BUDGET $35M

Health / Eco / Water: ~2/3 to ROSES

Disasters: total budget 5.5M (3/5 to ROSES, 2/5 response)

Applied Sciences Program
NASA Earth Science

NASA Applied Sciences and ROSES

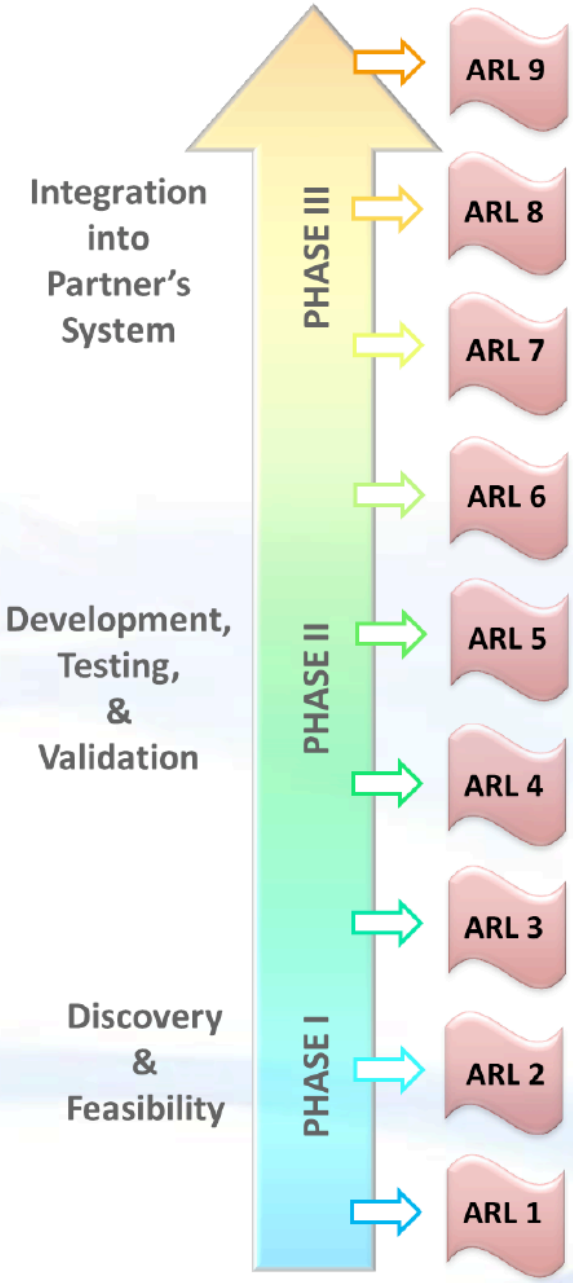
NASA defines applications as operational decision support.
How can we move AIRS data into operations?

NASA Application Readiness Level Metric

- Project teams asked to assess "**maturity**" of their Applied Sciences project on a regular basis, starting with the project proposal.

- NASA AS uses a shared cost model approach, JPL + a partner. Over time, balance of funding swings from JPL to partner.

The Application Readiness Level Metric



NASA Application Readiness Levels (ARLs)

The NASA Applied Sciences Program has instituted a nine-step Application Readiness Level (ARL) index to track and manage the progression and distribution of funded projects. This index is an adaptation of a scale used by NASA for managing technology development and risk (Technology Readiness Levels, TRLs), and reflects three main tiers of project research, development, and deployment. In general, ARLs 1-3 encompass discovery and feasibility; ARLs 4-6 address development, testing, and validation; and, ARLs 7-9 focus on integration of the "application" into an end-user's decision-making activity. Using this scale, project teams are being asked to assess the "maturity" of their Applied Sciences project on a regular basis, starting with the project proposal.

At the beginning of each project, project teams are asked to assess which ARL the project is starting at (**Start-of-Project ARL**) and also to project what level the project will reach upon completion (**Goal ARL**). Throughout the duration of most projects, teams are expected to re-assess their project's ARL on periodic basis (**LifeCycle ARL**), every August for a federal "**Fiscal Year ARL**" measure, and at the close-out of their award **(End-of-Project ARL).** It is not expected that all projects will start at ARL 1 and end at ARL 9, so please carefully read through the milestones that need to be met to achieve each ARL, and choose appropriately. In addition, while some projects may complete a few milestones out of phase with this generalized progression from ARL 1 to ARL 9 or may have project components at different levels, **a project's ARL is determined at any given time by the highest level for which all milestones preceding it have been completed in full.**

Definitions for each level and its associated milestones follow.

AIRS Applications ARL Levels

1	2	3	4	5	6	7	8	9
Baseline Ideas	Invention	Viability Established	Prototype/Plan	Potential Determined	Potential Demonstrated	Functionality Demonstrated	Functionality Proven	Sustained Use
Flu **Dengue** **Temperature Inversion** **Cold Air Aloft**		**Volcano Rapid Response**	**Wildfire FDAS (end of FY18)**			**Drought VPD**		**AIRS in Weather Prediction Systems** **SO2 @ VAAC/SACS for Volcanic Plume Detection**

ARL Level = highest level for which all milestones preceding it completed in full
ARL scale can help determine if staff needed with skills for future ARL level
Ideal to have applications in a range of levels
It's not expected that all projects start at ARL 1 and end at ARL 9

What determines success for the AIRS project?
At what ARL level do we want to exit?

How do we facilitate use of the application at the ARL exit point?

DON'T FORGET THE 80% SOLUTION

Planning for ROSES Applications Calls

- ARL scale provides a framework — provides path, context
- Focused on helping applications transition to a partner — the partner drives it through
- Who are our partners and what are they contributing?
- JPL R&TD designed to help get ready for the call

Strategy

1. Map our applications to ARL scale
2. Where can we involve partners?
3. What are potential exit points (ARL scale) for transition
4. Who are potential distributors? *USGS is huge*
5. Plan for calls
6. Leverage NASA AS capacity-building and training activities
7. New ideas - Feasible for AIRS?

Planning for ROSES

Health & Air Quality
Water Resources
Disasters
Ecological Forecasting

2015 Socioeconomic benefits – created VALUABLES consortium
2016 Food Security and Agriculture - created consortium

Agency-wide Offices
Western Water Applications Office (WWAO) at JPL
Food Security Office at GSFC
Disasters Office?

Calls – not so regular

How do you plan?

2011 Wildland Fires
17 awards, downselect occurred in 2014 where 9 selected.

2012 Health and Air Quality
Moved to ROSES 2013

2012 Ecological Forecasting
Feasibility studies selected, then down-select

2013 Cross-cutting Topics (moved to 2013 in 2012, then not solicited)
Select applications projects on topic(s) that span and involve many of the Applications themes

2013 Water Resources
9 awards, $12.5M over 4 years. advances the long-term (30-180 day) outlooks of water supply anomalies and their effective use by water managers, their organizations, and/or decision-makers.

2013 Health and Air Quality
9 awards, $9M over the 3 years
Solicitation wanted proposals to benefit US and globe, integrate obs into decision-making.

2015 Socioeconomic benefits
1 award (20 proposals). $3.5M over 5 years

2016 Ecological Forecasting
13 awards, $8.4M over 4 years

2016 Food Security and Agriculture
1 award, $15M over 5 years

2017 Health & Air Quality (due 11/17/17)
Expect 8-10 awards, $250-350K/year, max 3 years
Encourages use of TEMPO, MAIA

2018 Disaster Risk Reduction and Resilience
Mature applications ideas and proposals for integrating tools for assessment and response are strongly encouraged.

Planning for ROSES

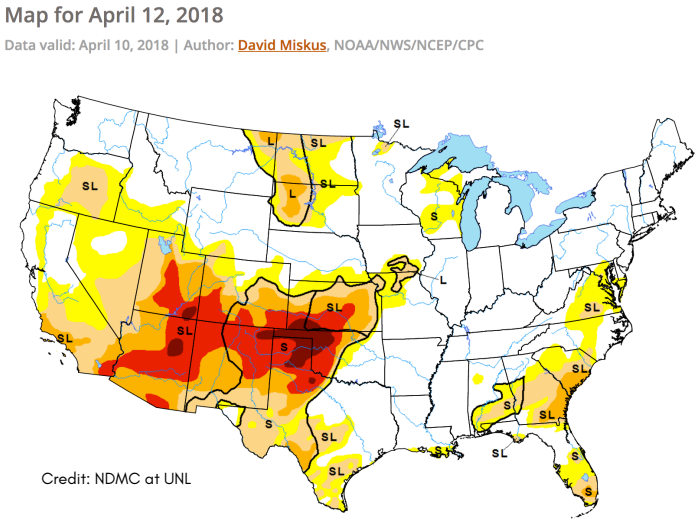
Sharon Kedar, JPL DPM for NASA Applied Sciences

Develop partnerships now

Check-in at mid-year

Look beyond ROSES

AIRS Applications Status

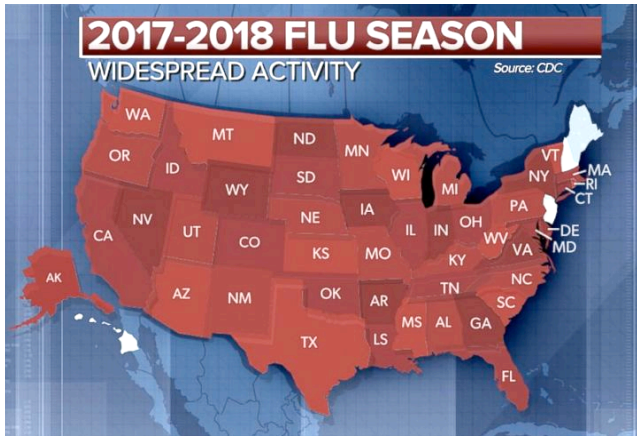


Credit: NDMC at UNL

Drought Onset Detection

AIRS-derived drought products have shown early detection lead times of up to two months

July 2017 – AIRS Vapor Pressure Deficit, Relative Humidity, Surface Air Temperature included in U.S. Drought Monitor (probationary period)



Credit: ABC News

Flu Forecasting

Flu forecasting system semi-operational

Now has run on 2 flu seasons

Credit: Rick Ray

Fire Danger Assessment System

Build formal relationship between JPL and operational fire science community for guidance/input

Create global fire-potential data product, make it publicly available

Can AIRS VPD-fire and the relationship between VPD, drought & fire contribute to determination of fire-risk?

Volcano Rapid Response

Photo : David Sarginson.

AIRS – Useful to Aviation

Full Report – 2017 Earth Science Senior Review Subcommittee

- Importance and utility of AIRS/AMSU was widely noted
- **Data are of significant importance to FAA and the aviation community (sulfur dioxide, volcanic plumes).**
- AIRS data are utilized in volcanic ash detection for the NOAA Rapid Update Cycle Rapid Refresh Model

European groups

Support to Aviation Control Service (SACS)
Provides NRT SO2 & volcanic ash to Toulouse & London VAACs
Uses AIRS SO2 BT DIFF
http://sacs.aeronomie.be/

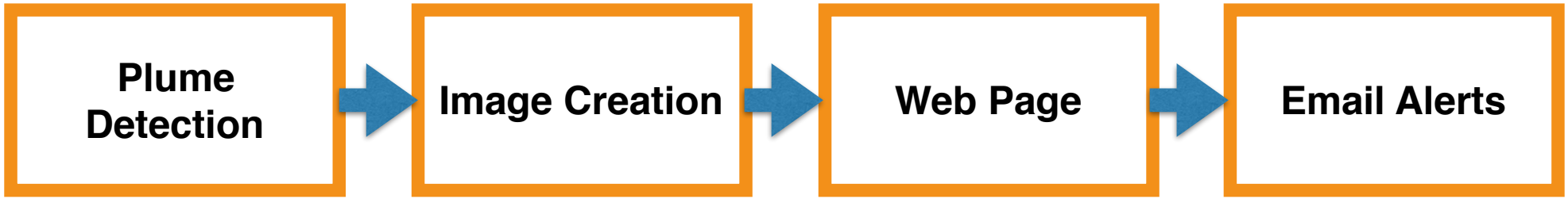
SAVAA Project (Support to Aviation for Volcanic Ash Avoidance) – NILU (Norwegian Institute for Air Research)
Uses AIRS SO2/Ash Loading (Prata/Bernardo retrieval method)
http://savaa.nilu.no/

Nicarnica
spin-off of NILU; private company providing airborne natural hazard info to aviation
Uses AIRS SO2/Ash Loading (Prata/Bernardo retrieval method)
https://nicarnicaaviation.com/calbuco-eruption-april-2015/

Automated plume detection rapid response system

Low-Cost Strategy

Use AIRS SO2 BT DIFF and Dust Score threshold breaches for rapid response detection of volcanic plumes



Plume detection algorithm

NRT data pulled from DAAC to JPL every hour

Scan each incoming L1B granule

Plume event declared for granule upon threshold exceedance of one of these conditions:

1. High # of SO2-only events
2. Lower # of SO2+Dust events (combined allows for lower threshold)
3. Extremely high # of Dust-only events (not likely, threshold set high)

——

SO2 is the driver, dust used in secondary way

High dust counts alone will not trigger plume alert, too many false positives
We can't yet differentiate between volcanic and non-volcanic dust sources without also checking for presence of SO2

AIRS volcanic plume detection algorithm

Incoming L1B Data Granule

- Available within 1-1.5 hours of satellite overpass
- Contain 90 x 135 AIRS radiance footprints (cross track x along track)
- Footprints 14 km diameter at nadir

Divide granule into subregions

- 6x9 subregions
- Subregion = 225 footprint (250 km x 250 km at nadir)
- Maximizes sensitivity to spatially localized volcanic plume
- Minimizes false alarms due to widely scattered random hits

Test every AIRS footprint in subregion

For each AIRS footprint:

Determine if footprint over ocean or land

Allows for future tuning of dust test

SO2-Only Test

Compare SO2 channel to non-SO2 channel. If SO2 brightness temperature difference exceeds threshold, increment SO2-Only counter

If SO2 Detected, then test for Dust in same footprint

If Dust Score > 380, increment SO2+Dust counter

Dust-Only Test

If Dust Flag indicates potential for dust AND Dust Score > 380, increment Dust-Only counter

Check all the subregion counter tallies: SO2-Only, SO2+Dust, Dust-Only

If any threshold exceeded, subregion has plume event

Dust-Only counter tally threshold set extremely high, only trips for very large events. SO2+Dust counter tally threshold is set lower than S2-Only and Dust-Only.

If any subregion has plume event, granule is flagged, plume event characterized, trigger is set

Create images, update web page, send email notification to community

Any subregion with plume event causes trigger to set. Code tests all subregions (even though it only takes one subregion to set the trigger) to allow for future fine-tuning of algorithm.

AIRS Volcanic Plume Imagery

Evidence of Activity — **SO2 BT DIFF, Dust Score**

Cloud Obstruction — **Total Cloud Fraction, Cloud Top Height, VIS, IR**

Available in JPG, KMZ, GeoTIFF

Volcano imagery to be produced by NASA LANCE NRT

viewable in NASA Worldview
archived in perpetuity on NASA GIBS

Loading — SO2, Ash & Dust (S. Hannon/S. DeSouza-Machado)

Coming soon...

Improvements

Imagery

SO2 BT Diff

Dust Score

Cloud Fraction

Cloud Top Height

Interface

Less cluttered

Better strategy for captions & text

More descriptive titles

Formats

JPG, KML, KMZ

Google Map

Add granule boundaries, enhance volcano locator

Infrastructure

More info transferred to web server to accommodate image and map updates & fixes

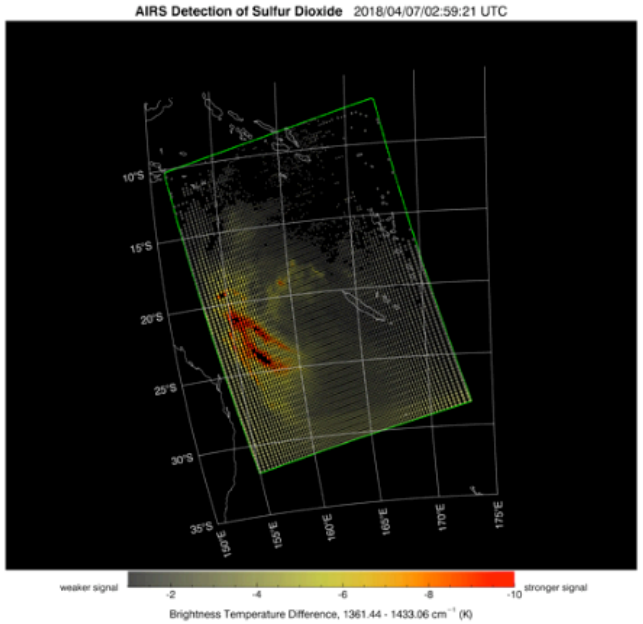
AIRS Volcanic Plume Detection Rapid Response Products

OBSERVATION TIME: 2018/04/07, UTC 02:59:22

Volcanic eruptions can release large volumes of sulphur dioxide (SO2) gas and pulverized rock, known as volcanic ash. Browse products of SO2 and silicate mineral dust derived from Atmospheric Infrared Sounder (AIRS) observations can indicate the possibility of volcanic activity, but more detailed analysis is required to confirm the presence of volcanic clouds or estimate the composition and quantity of materials in the clouds. AIRS flies aboard NASA's Aqua satellite over most of the globe twice per day, collecting data at approximately 1:30 am and 1:30 pm local time.

What the measurements imply

SO2 BRIGHTNESS TEMPERATURE DIFFERENCE



Sulfur dioxide brightness temperature difference is calculated by differencing the values reported between two AIRS channels, one that is sensitive to SO2 and one that is not. Larger differences imply greater SO2 absorption, which in turn implies a stronger volcanic signal. Please refer to the opening paragraph on this page for a better understanding of what this measurement implies.

GeoTiff and KMZ available soon

SHARE

Recommend | Tweet | G+ | Share

OBSERVATION AREA CENTER

-19.5 latitude, 162.5 longitude

MORE AIRS IMAGERY

- AIRS SO2 Index (F. Prata/NILU)
- AIRS plume detection archive

VOLCANO RESOURCES

- NASA Global SO2 Monitoring
- Smithsonian Volcano
- NOAA/CIMSS Volcanic Cloud Portal
- Volcanic Ash Advisory Centers
- Support to Aviation Control Service
- USGS Volcano Finder & Alerts

AIRS ARCHIVE

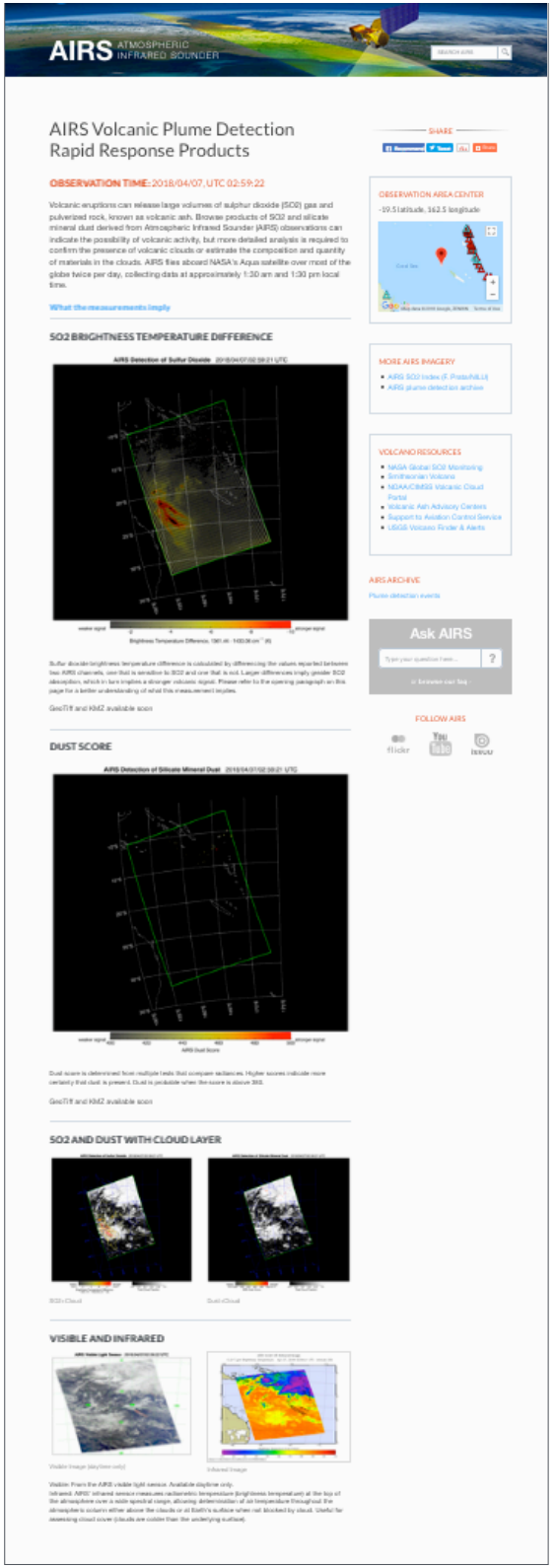
Plume detection events

Ask AIRS

Type your question here... ?

or browse our faq ›

FOLLOW AIRS



AIRS Sulfur Dioxide and Dust Detection Archive

2018/03/11, UTC 23:53:22, 239

21.0 latitude, 28.5 longitude

2018/03/10, UTC 04:29:22, 45

37.5 latitude, 128.0 longitude

2018/03/09, UTC 18:17:22, 183

-29.5 latitude, -65.5 longitude

2018/03/03, UTC 19:11:22, 192

31.5 latitude, -91.0 longitude

2018/02/19, UTC 07:05:22, 71

-0.5 latitude, 97.0 longitude

2018/02/19, UTC 19:23:22, 194

13.5 latitude, 95.0 longitude

2018/02/15, UTC 09:47:22, 98

39.5 latitude, -114.5 longitude

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)

Launching the AIRS SO2 & Dust Detection Web Page

Soft launch for select reviewers

Solicit reviews from colleagues

SO2.nasa.gov

Earth Observatory

Volcano Clouds list

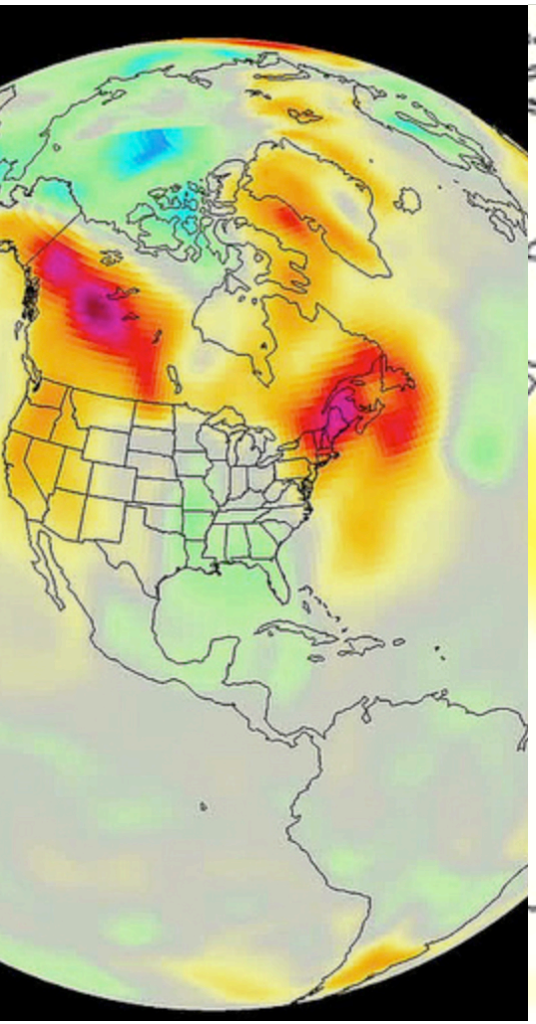
NASA Applied Sciences, NOAA/NESDIS Hazards

NASA Worldview “Themes” page

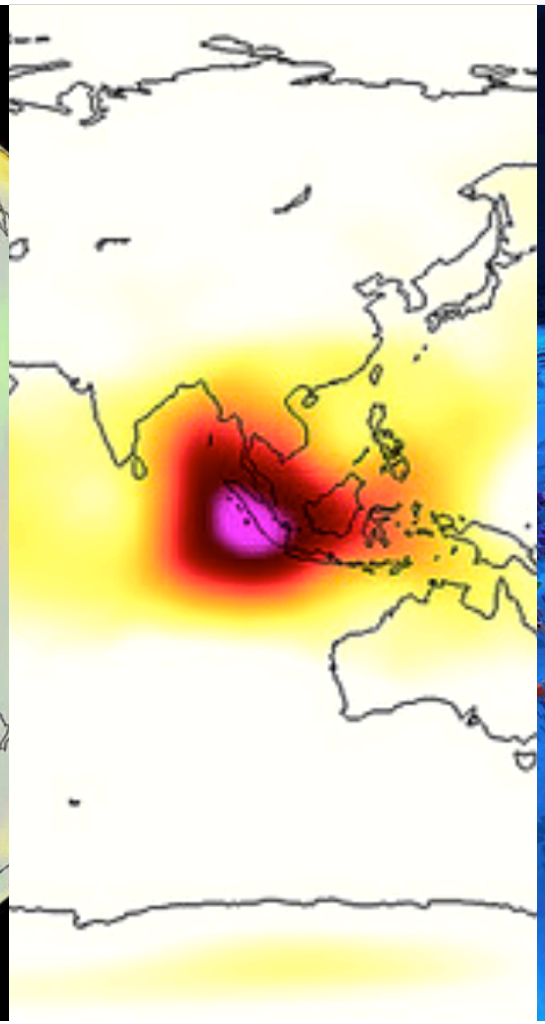
Rapid Response framework developed for volcano can be re-purposed to work with ANY AIRS data product

AIRS Rapid Response
Preparing now for future events

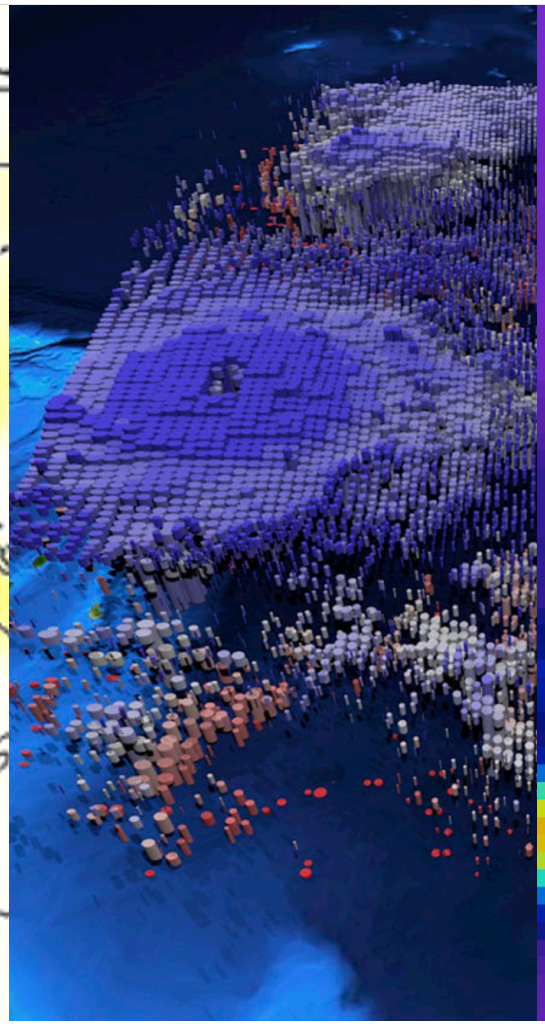
Polar Vortex



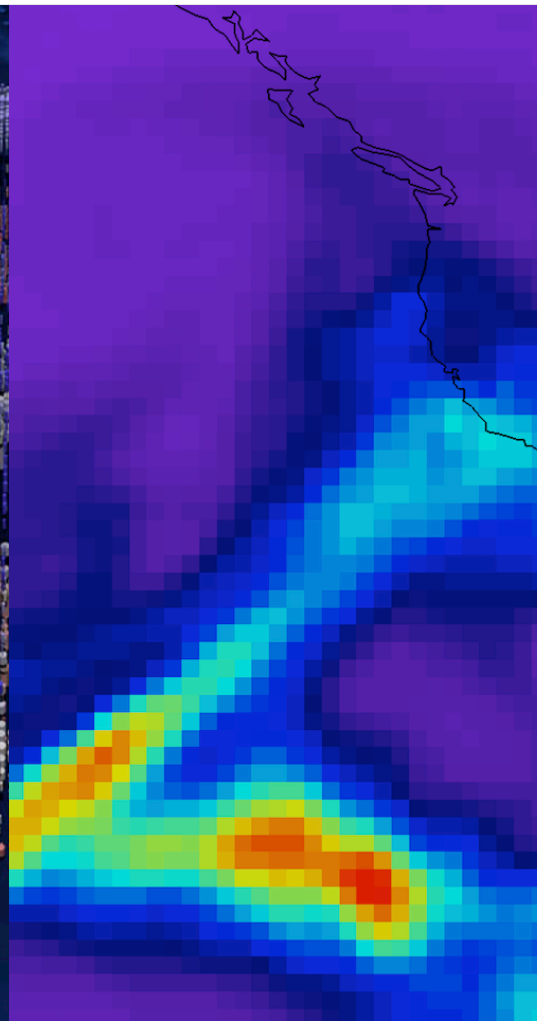
CO transport from wildfires



Supercell Storms



Atmospheric Rivers



What is AIRS unique contribution?

How do we visualize?

Media and/or Science product?

Automate

Improved visualization algorithm for AIRS imagery in NASA LANCE

Delivery to LANCE in progress

- **Improved resolution**
- **Orbit based vs granule based to fix granule-to-granule problem**

NEW

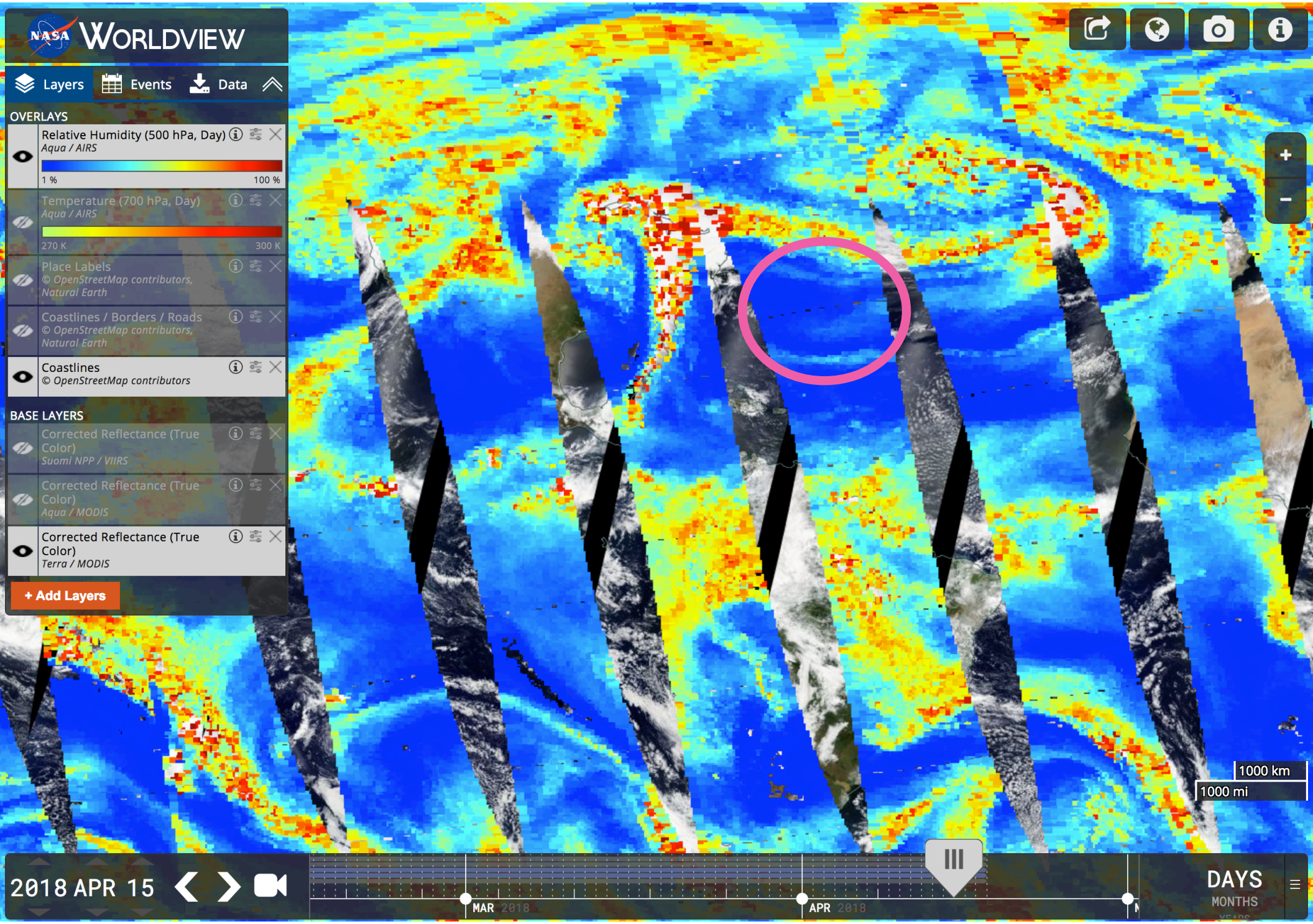
Surface Air Temp
Surface Skin Temp
Surface Relative Humidity
Carbon Monoxide 500 hPa
Methane 400 hPa
SO2 BT DIFF
Cloud Fraction
Cloud Top Height
NEW Absolute Humidity
H20MMR Total Column
H20MMR 500
H20MMR 700
H20MMR 850

IMPROVED

Relative Humidity 500, 700, 850
Temperature 500, 700, 850
Dust Score
Precip Estimate

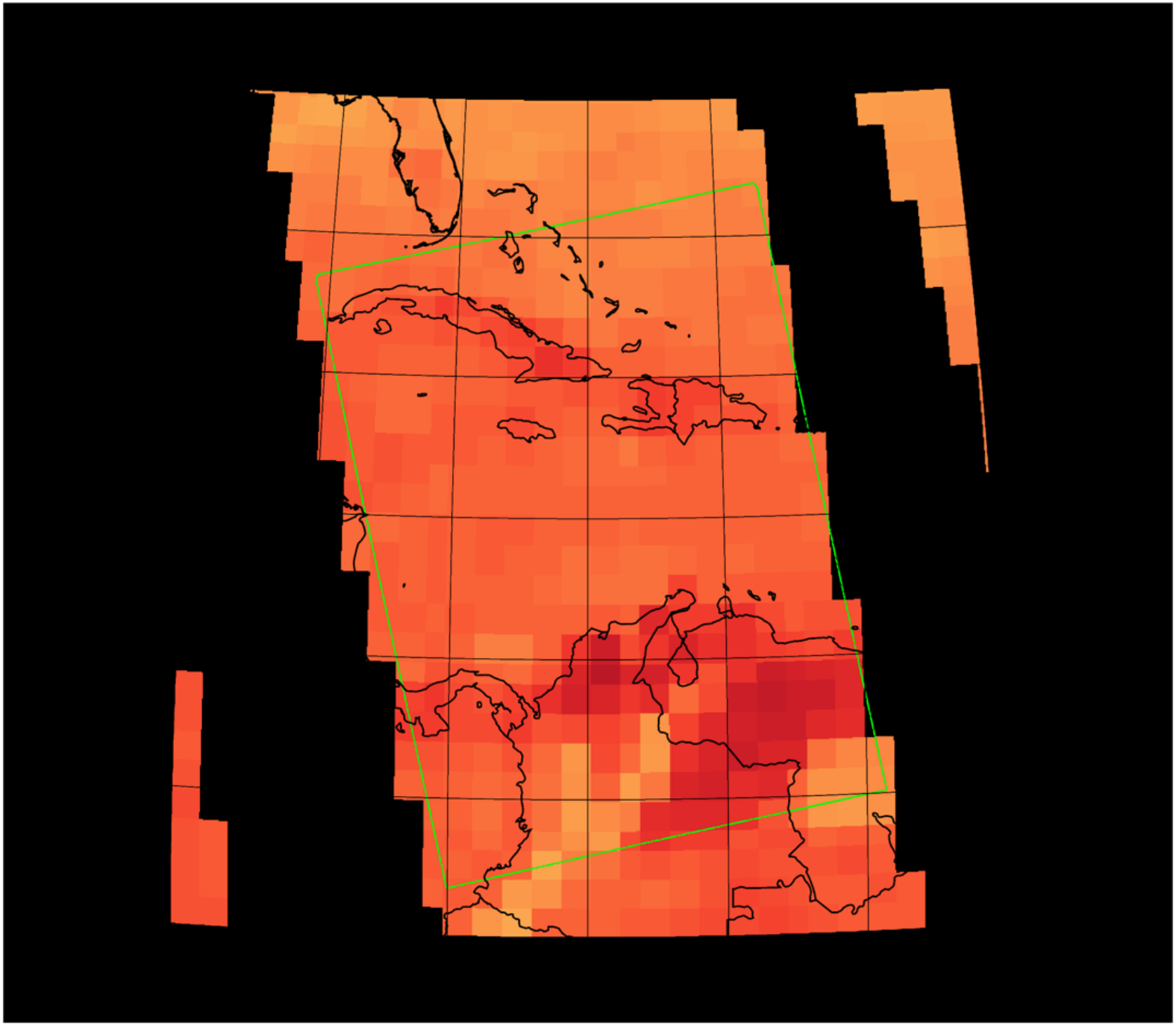
REMOVE

Relative Humidity 400, 600
Temperature 400, 600
Carbon Monoxide total column


NASA WORLDVIEW
Layers
Events
Data
OVERLAYS
Relative Humidity (500 hPa, Day)
Aqua / AIRS
1 %
100 %
Temperature (700 hPa, Day)
Aqua / AIRS
270 K
300 K
Place Labels
© OpenStreetMap contributors, Natural Earth
Coastlines / Borders / Roads
© OpenStreetMap contributors, Natural Earth
Coastlines
© OpenStreetMap contributors
BASE LAYERS
Corrected Reflectance (True Color)
Suomi NPP / VIIRS
Corrected Reflectance (True Color)
Aqua / MODIS
Corrected Reflectance (True Color)
Terra / MODIS
+ Add Layers
1000 km
1000 mi
2018 APR 15
MAR 2018
APR 2018
DAYS
MONTHS

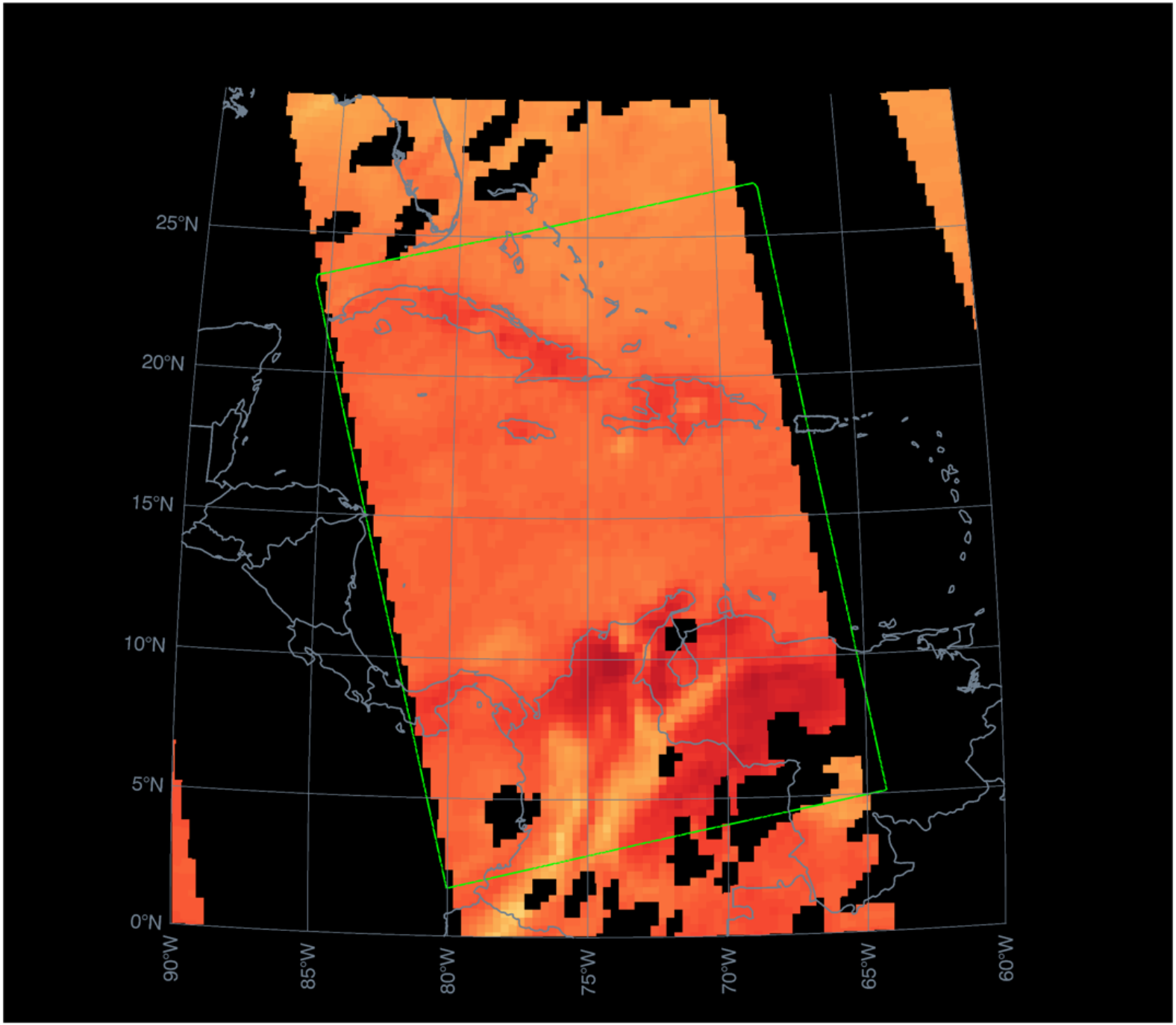
CURRENT

640x320



NEW

1280X640



GRAVITY WAVES — new SVS visualization in progress

"Multisensor profiling of a concentric gravity wave event propagating from the troposphere to the ionosphere"
Irfan Azeem (ASTRA LLC), Jia Yue (Hampton Univ), Lars Hoffmann (Julich), Steven D. Miller (CIRA), William C. Straka III (CIMSS), Geoff Crowley (ASTRA LLC)

Lori Perkins (SVS) working with Jia Yue, Jie Gong, and Irfan Azeem

Tornado – Moore, Oklahoma in May 2013

Destroyed parts of town, show before and after tornado

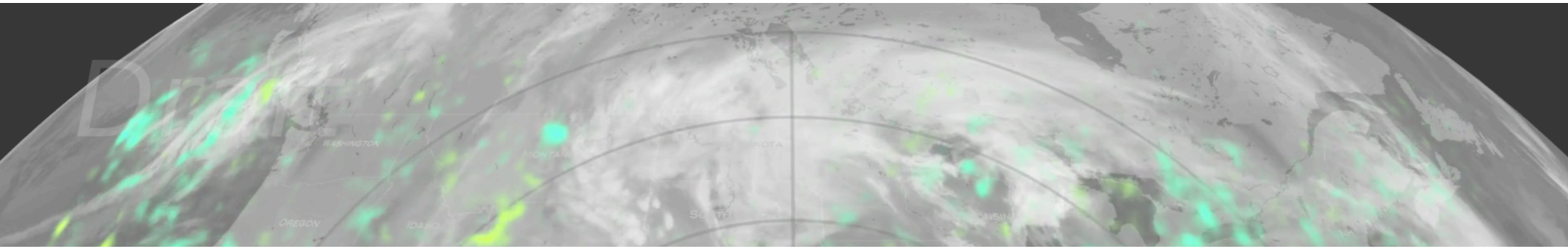
Show how tornado events excited atmospheric gravity waves

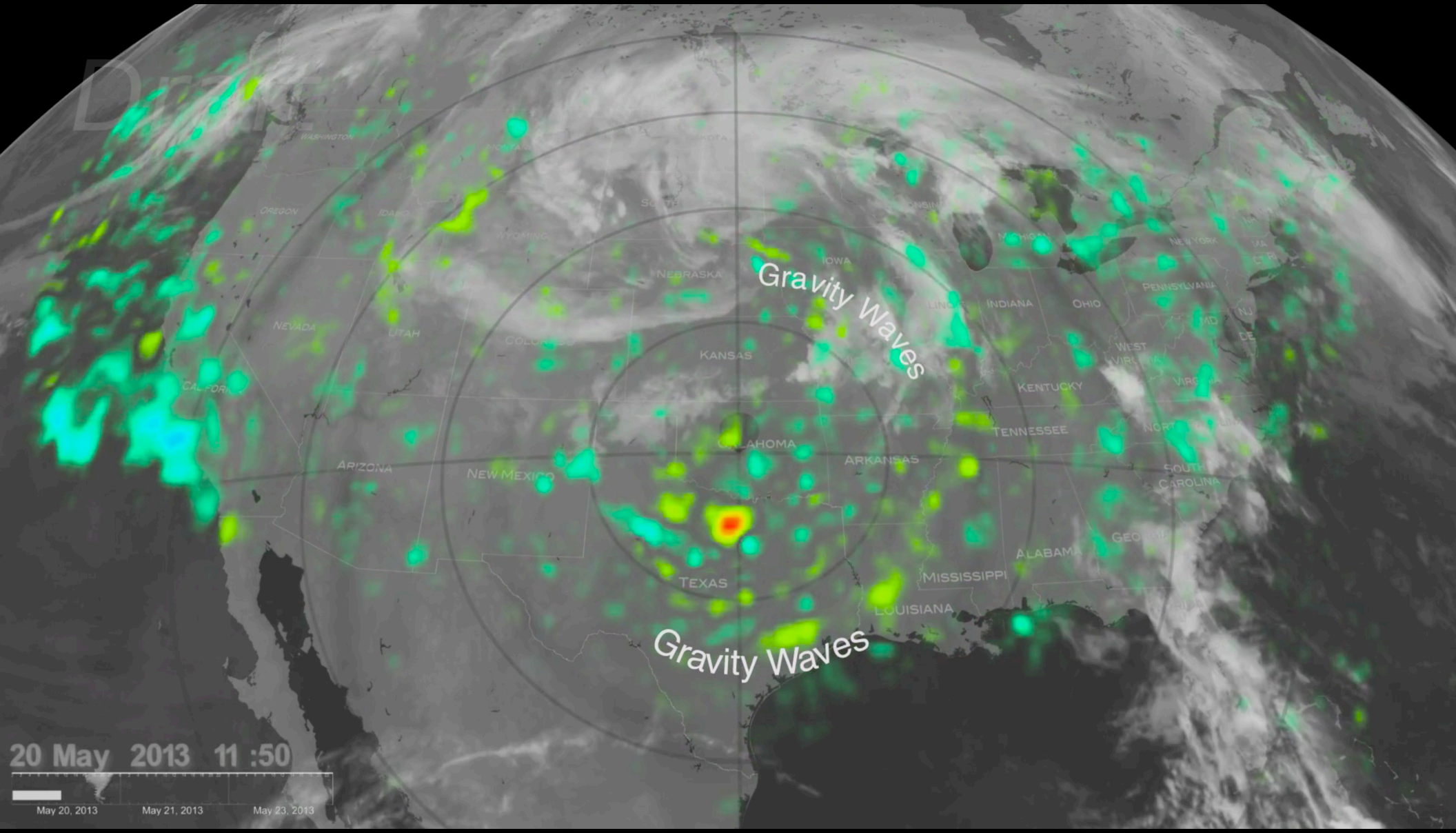
Propagated through stratosphere and mesosphere til reaching ionosphere (traveling ionospheric disturbance)
Multi-sensor obs of TIDs and GWs can provide a unique perspective on ionosphere-atmosphere coupling

Data

12 layers of the AIRS data between 18 and 41 km, at 2 time periods before the tornado hits
TEC data at 400 km before and after the storm hits

Draft movie completed




Gravity Waves
Gravity Waves
20 May 2013 11 :50
May 20, 2013
May 21, 2013
May 23, 2013
WASHINGTON
OREGON
NEVADA
UTAH
NEBRASKA
IOWA
KANSAS
INDIANA
OHIO
KENTUCKY
TENNESSEE
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
MISSISSIPPI
ALABAMA
LOUISIANA
PENNSYLVANIA
NEW YORK

AIRS User Guides - The Reinvention

Create a Digital User Guide

- Data gathered from user traffic provides a wealth of information
- Can track usage, bounce rates and the steps where end users linger
- Can gather feedback
- Machine searchable
- Could include voice, imagery, animations
- Available through variety of devices
- Could facilitate use of AIRS data, grow user community
- Should have a printable version
- Can still conform to rule of single location for master UGs at DAAC

User guides can and should be designed with the end user in mind, rather than being focused on the product.

Drought

Fire

Flu & VBD

Volcano Rapid Response

Rapid Response PV, CO, Storms, AR

GW Visualization

User Guides Upgrade

Image archiving @ LANCE/DAAC/GIBS