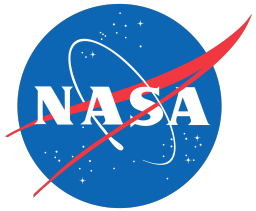


AIRS Applications & User Services: A Summary of Efforts and Plans for FY19

Sharon Ray
AIRS Applications Development / User Services Lead
Jet Propulsion Laboratory, California Institute of Technology
October 2018

Joao Teixeira, Tom Pagano, Eric Fetzer, Bjorn Lambrigtsen
Steve Licata, Paulo Penteado, Jeff Hall
Vince Realmuto, Stephanie Granger, Alireza Farahmand, Heidar Thrastarson (JPL)
Emily Serman (USC/JPL)

Applications

Overview

Flu – Drought – Fire

Volcanic Plume Detection

User Services

User Guide Upgrade

Visualization

NEW SVS Visualization - *Gravity Waves*

Demo - AIRS products in GIBS & Worldview

AIRS Applications In Play

Weather	**Weather prediction centers world-wide**	
Aviation	**Washington DC VAAC** • *SO2 alert* **Support to Aviation Control Service (supports Toulouse VAAC)** • *Daily global SO2 BT Diff* • *SO2 load (BIRA/NILU Prata retrieval)* • *Ash index* **NOAA Rapid Update Cycle Rapid Refresh Model** • *Volcanic ash detection* ● **SO2 & Dust Detection for Plume Detection Rapid Response**	**2017 Earth Science Senior Review Subcommittee** AIRS data are of significant importance to FAA and the aviation community (sulfur dioxide, volcanic plumes).
Drought	● **US Drought Monitor**	
Wildfire	● **Fire Danger Assessment System**	
Health	● **Influenza Forecasting** **Dengue** **Zika**	

● In development

ARL Levels and AIRS Applications

1	2	3	4	5	6	7	8	9
Basic Research Baseline Ideas	**Application Concept** Invention	**Proof of App Concept** Viability Established	**Initial Integrn & Verification** Prototype/Plan Includes Dec Sup activities	**Validation in Relevant Environ** Potential Determined	**Demonstation in Relevant Environ** Potential Demonstrated	**Prototype in Decn Making** Functionality Demonstrated	**Completed and Qualified** Functionality Proven	**Operational** Sustained Use
	Dengue **Zika** **Temperature Inversion** **Cold Air Aloft**	**Volcano Rapid Response** **Flu Forecast Model**	**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
- Ideal to have applications in a range of levels
- Not expected projects start at ARL 1 and end at ARL 9
- Can help determine if staff needed for future ARL level

AIRS & Influenza

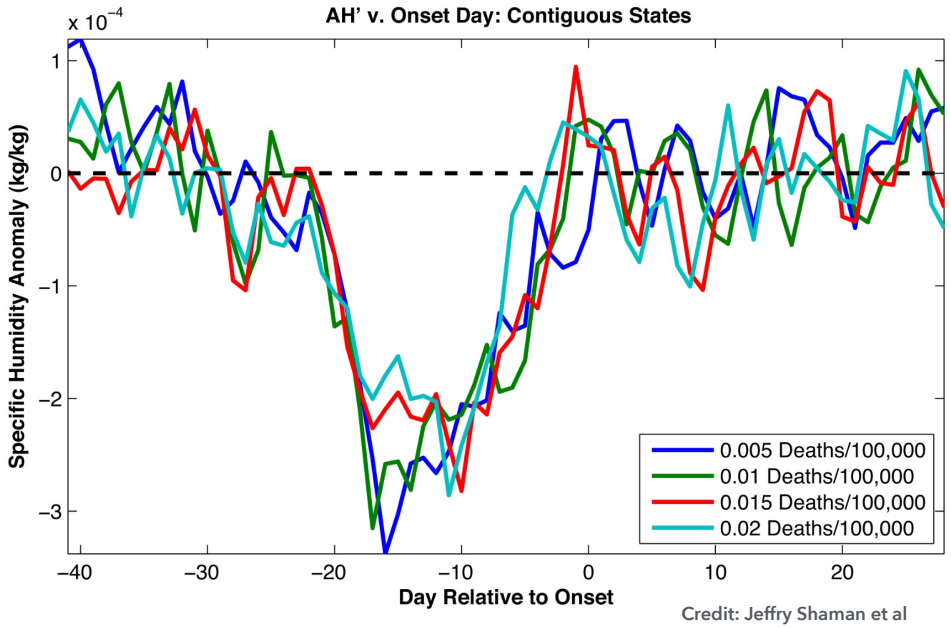
Heidar Thrastarson, Joao Teixeira (JPL)
Emily Serman (USC/JPL)

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

Increased wintertime flu-related mortality in US associated with anomalously low absolute humidity levels that precede outbreaks

JPL Flu Forecasting Model
Runs quasi-operationally, driven by humidity & flu data; City, state, regional scale; Results confirm humidity-flu connection

Credit: State Records, New South Wales (1919)



Credit: Jeffry Shaman et al

Decision-maker involvement in your application

Applications > Decision-makers

Get decision-makers involved early

- Ask questions
- Better understand DM needs, expectations, criteria, process
- Get inside advice, recommendations, data
- Develop application tuned to meet/enhance DM needs (avoid bad pathways)
- Build awareness of your application with DM
- Establish trust - you listened

Enroll them as a “partner” early in the process

Improve potential for success

LA County Dept. of Public Health
Acute Communicable Disease Center

Meeting

Understand LAC process for flu decision support

Understand what LAC needs and how to provide it

Potentially build a collaboration

LAC – Surveillance/aggregation of data; Develop protocols for response

Let them know about JPL flu model

LAC not familiar with Shaman papers & humidity connection to flu

Outcome

LAC will share aggregated flu data with JPL flu team (ILI @ city level, 1 week lag time)

JPL flu team will send weekly flu forecasts in “mock trial” for evaluation during upcoming flu season

Center for Disease Control and Prevention

Meeting

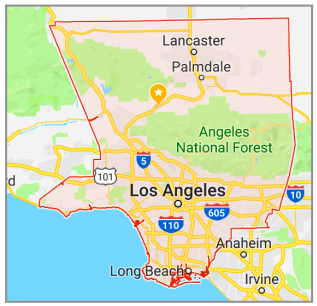
Understand CDC process for flu decision support to improve utility of JPL model

Introduce JPL model

CDC Flu Challenge details

What we learned

- **Since 2014-15 flu season flu forecasting officially in CDC decision support; “Surveillance data only tells what's happening, not where we're going”**
- **Seasonal onset, peak week, short term prediction**
- **Flu Challenge: 25 teams, 30 models**
- **Simple ensemble = blend of all models**
- **New ensemble = make historical forecast of 2011-2012 season to determine weighting. Only 6 models in New ensemble; Smart ensemble uses PDFs (too complicated for messaging at this time)**
- **Simple ensemble results shown weekly to CDC leadership**
- **The top performing model out-performs historic surveillance models EXCEPT for 4-week forecast**
- **2017-18 season: First time CDC used forecasting in public communication (onset and peak). Provided same messaging to state & local agencies.**



LA County Public Health

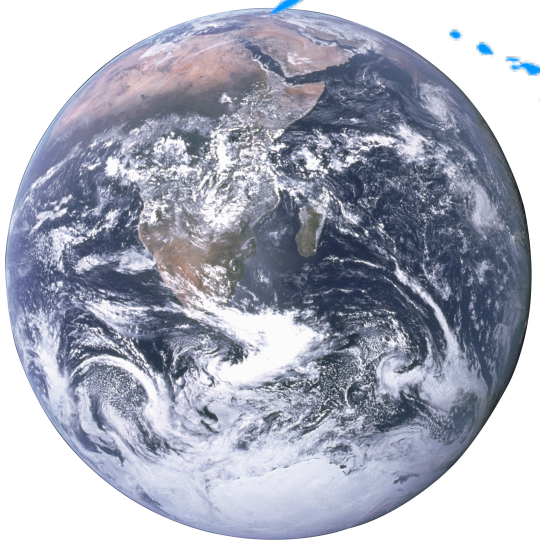
- Applies CDC guidelines
- Gathers additional local data with which to apply recommendations

State and Local

- Provides decision making & actions (close school, etc)

National — CDC

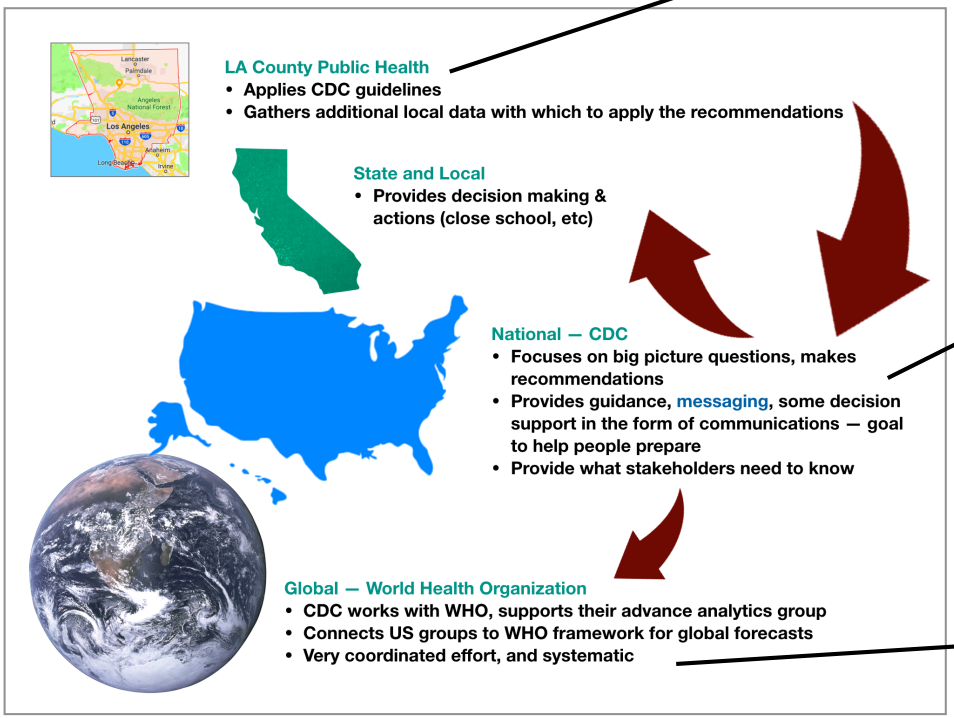
- Focuses on big picture questions, makes recommendations
- Provides guidance, messaging, some decision support in the form of communications — goal to help people prepare
- Provide what stakeholders need to know



Global — World Health Organization

- CDC works with WHO, supports their advance analytics group
- Connects US groups to WHO framework for global forecasts
- Very coordinated effort, and systematic

JPL, LA County & CDC — Pulling it all together



Improving the Flu Model

LA County Public Health — Mock trial

- **Provide JPL with weekly city data**
- **Evaluate JPL weekly model output**

National Impact

CDC — Flu Challenge

- **Participate in flu challenge**
- ***Goal*: Inclusion in flu ensemble presented weekly to CDC leadership**

Global Impact

CDC — WHO connection

- **Global flu forecasting**

Creating contacts, establishing credibility

Applications - Good enough is ok

Los Angeles County Dept of Public Health

“The idea of trying to forecast flu, a novel way to forecast, is exciting. If it was reasonably accurate it could be exciting. We could have a press release, we could get people to get vaccinated.”

– Prabhu Gounder, Medical Epidemiologist
Acute Communicable Disease Control, County of Los Angeles Public Health

Center for Disease Control and Prevention

WHEN DO YOU TRUST A FLU FORECAST?

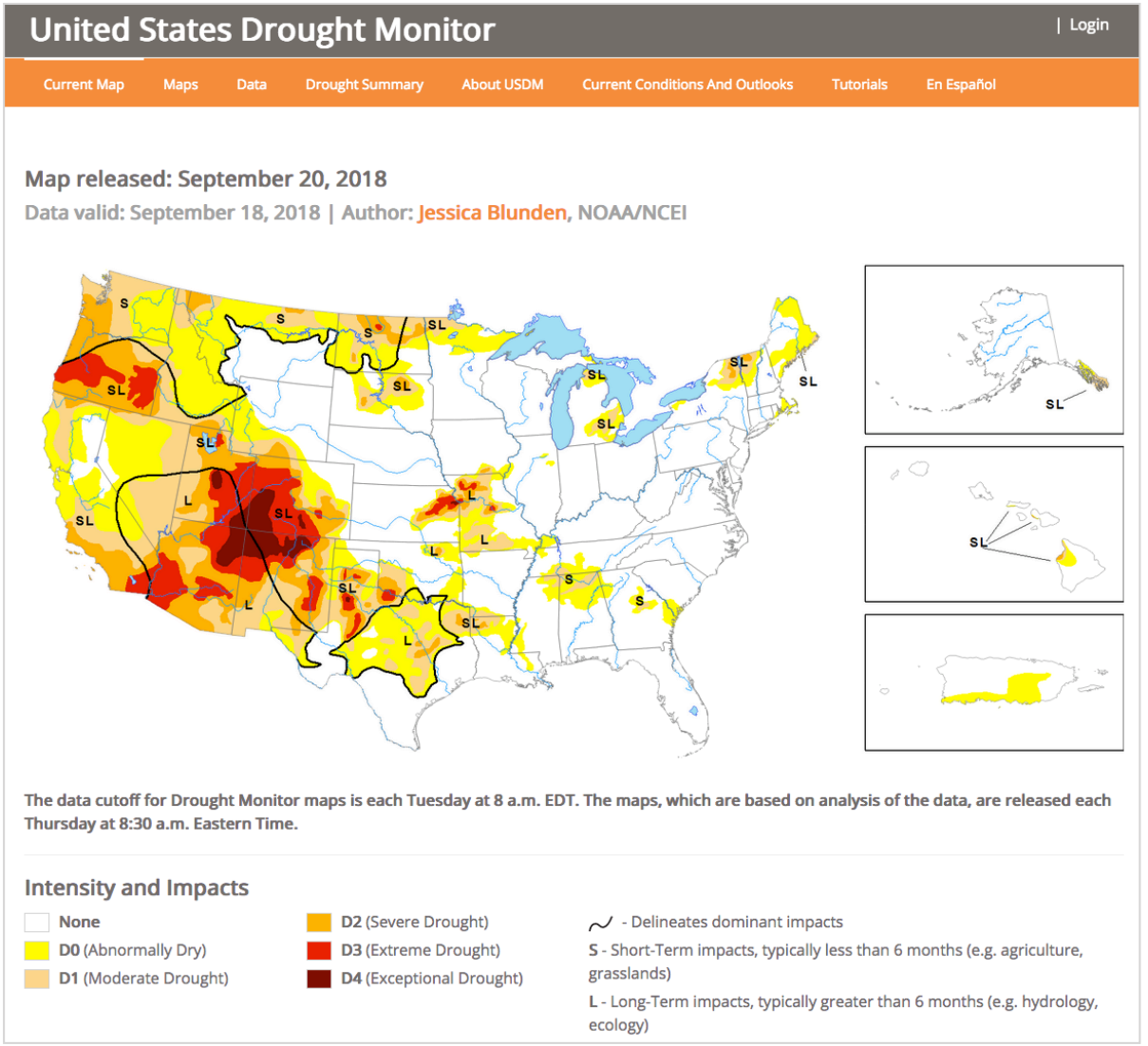
“When a flu forecast has shown itself to be better than the historic forecast. When a flu forecast has done well over the last few years. Those are the types of messages we use…We’re also looking at calibration. Is the flu group correct N% of the time? It gets us away from having to impose a threshold. If we waited for the perfect forecast, we wouldn't put anything out, we'd never publish anything.”

– Matthew Biggerstaff, Research Epidemiologist, Applied Research and Modeling Team
Epidemiology and Prevention Branch, Influenza Division
Centers for Disease Control and Prevention

AIRS & Drought

Stephanie Granger,
Alireza Farahmand (JPL)
Ali Behrangi (Univ. of Arizona)

- U.S. policymakers use USDM in drought discussions, drought relief allocations
- AIRS-derived drought products show early detection lead times of up to two months ahead of precip only
- Vapor Pressure Deficit, Relative Humidity, Surface Air Temperature
- July 2017 – Probationary period begins: AIRS products in weekly USDM



AIRS & Drought – *What's New*

USDM - End of probationary period

- **No formal USDM evaluation at probation end**
- **AIRS to remain in USDM product pool**

Next Steps

Spatial statistical data fusion (SSDF) with AIRS & SNPP CrIS of T, RH, and VPD (Peter Kalmus, Amy Braverman JPL)

- Gridded (0.5 or 0.25 degrees), daily, day, night
- Demonstrably lower bias and variance (compared to ground truth from NOAA's Integrated Surface Database, ISD)
- Include uncertainty estimates produced by the SSDF
- Potential utility in fire, drought, and agriculture (TBD) applications

Explore NOAA STAR taking over production of VPD

Transition to CrIS

USDM targets – meetings at least 2x/year

AIRS & Wildfire

Fire Danger Assessment System

Using satellite observations to map global wildfire risk

JT Reager, Alireza Farahmand,
Natasha Stavros (JPL)
Jim Randerson (UCI)

- Build formal relationship between JPL and operational fire science community (for guidance/input)
- Create publicly available global fire-potential data product
- *Question*: Can AIRS VPD-fire, and relationship between VPD, drought & fire contribute to determination of fire-risk?

AIRS & Wildfire Stakeholders

National Interagency Fire Council
US Forest Service

– *What's New*

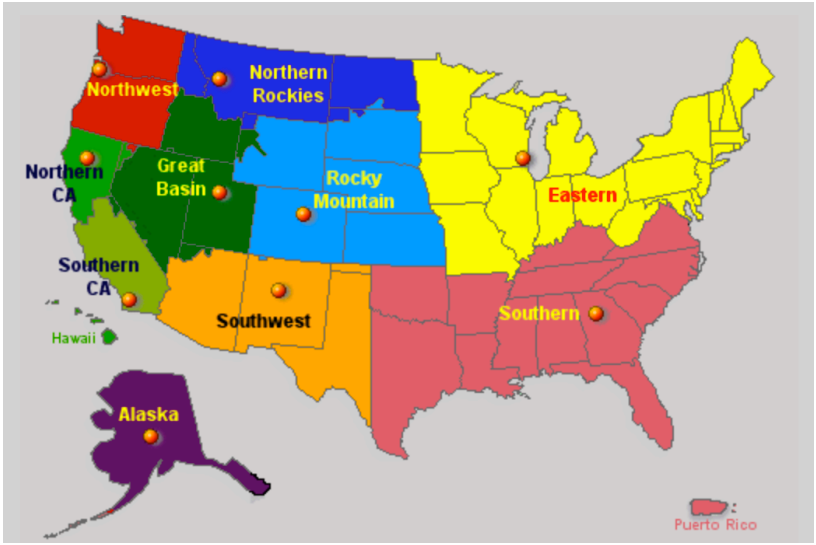
Status

- **GACC-level fire risk model finished, paper submitted to GRL & under review**
- **Gridded 1/4 degree fire risk model finished. First draft of paper in review by co-authors, will submit soon**

Plans

- **Share products with stakeholders**
- **Provide gridded product to NIFC** (org in charge of fire risk models)
- **May provide gridded product to US Forest Service**

Geographic Area Control Centers (GACCs)



United States divided into 11 geographic areas for incident management and mobilization of resources

AIRS & Volcanic Plume Detection Rapid Response

Eyjafjallajökull glacier and the ongoing volcano eruption from Hvolsvöllur on April 17th, 2010
Credit: Boaworm

AIRS & Volcanic Plume Detection

Sharon Ray, Vince Realmuto, Eric Fetzer, Bjorn Lambrigtsen, Steve Licata, Paulo Penteado, Jeff Hall (JPL)

Unique contribution:

1. **Can confirm eruptions in remote areas**
2. **Track long-lived ash clouds** (days after eruption)

What we've completed:

- Triggering algorithm 1.0, web page, image products
- Automated rapid response system (dev site)
- Determined two key decision support pipelines

What's New —

Improved detection algorithm

Problem— too many false positives

Improved triggering threshold plus additional threshold (mean SO2 BT DIFF)

Improved imagery

SO2 BT DIFF, Dust Score, Total Cloud Fraction, Cloud Top Height

Improved web page

Less cluttered, improved graphic elements

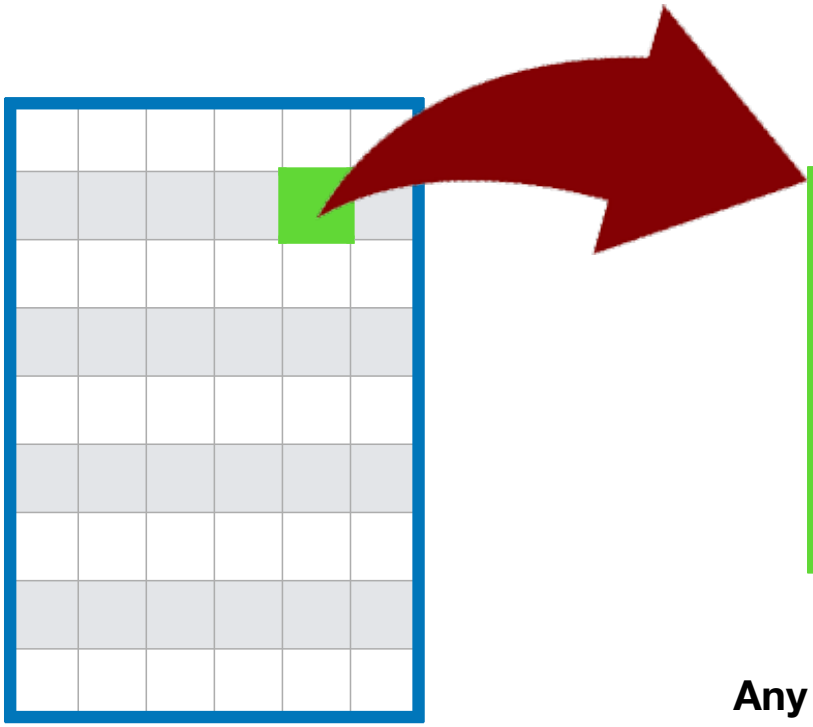
Reviewers site

Seeded with select plume events

- **240 AIRS Level 1B granules examined daily in NRT**
- **Plume Event detection operates on a granule at the subregion level**
- **Subregion size determined smallest unit to capture a plume** (~ 220km x 220km)

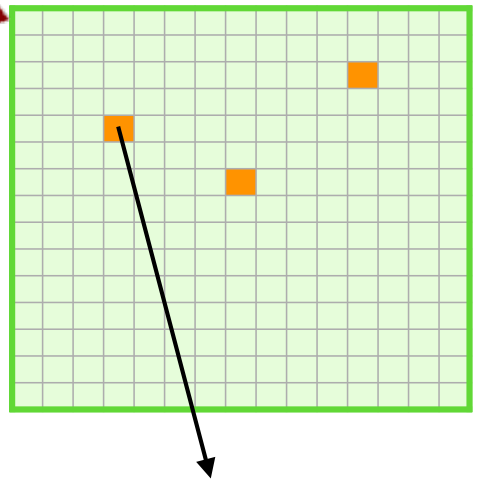
Granule

- Divided into 6x9 subregions
- 54 subregions/ granule



Subregion

- Divided into 15x15 L1B footprints
- 225 footprints/subregion



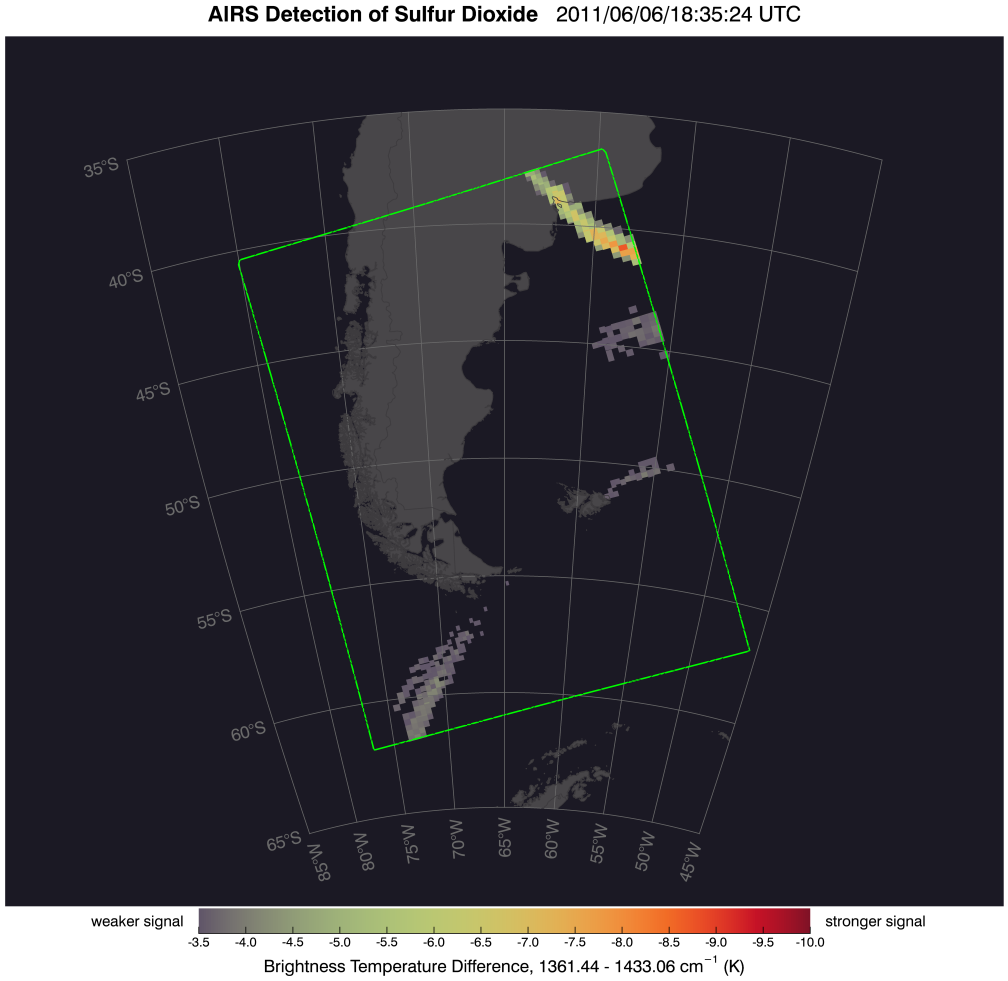
Any footprint with SO2 BT Diff < -5.0 K is tagged as an SO2 event

Plume Event Declared when two conditions met in subregion:

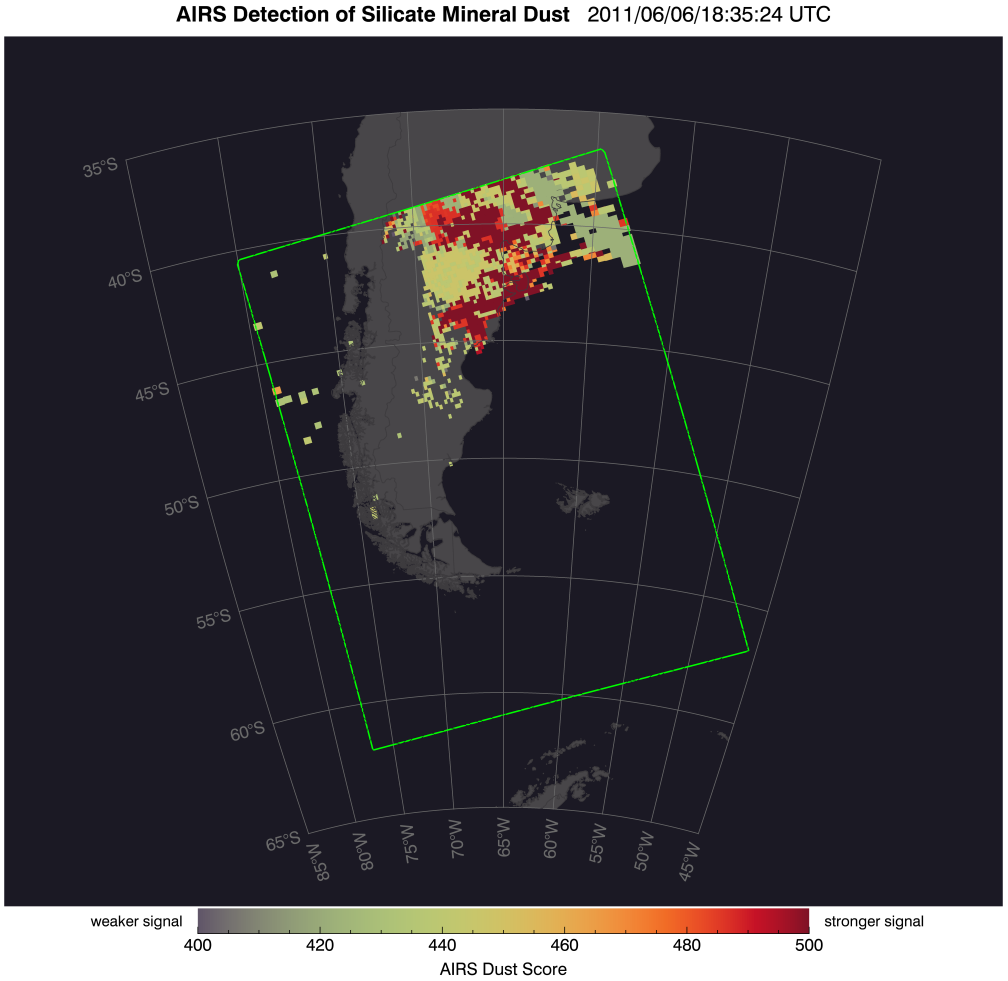
1. **>= 20 SO2 events**
2. **Mean value of all SO2 events <= -5.5 K**

Puyehue Cordon Caulle Eruption, Chile

SO2 BT Difference



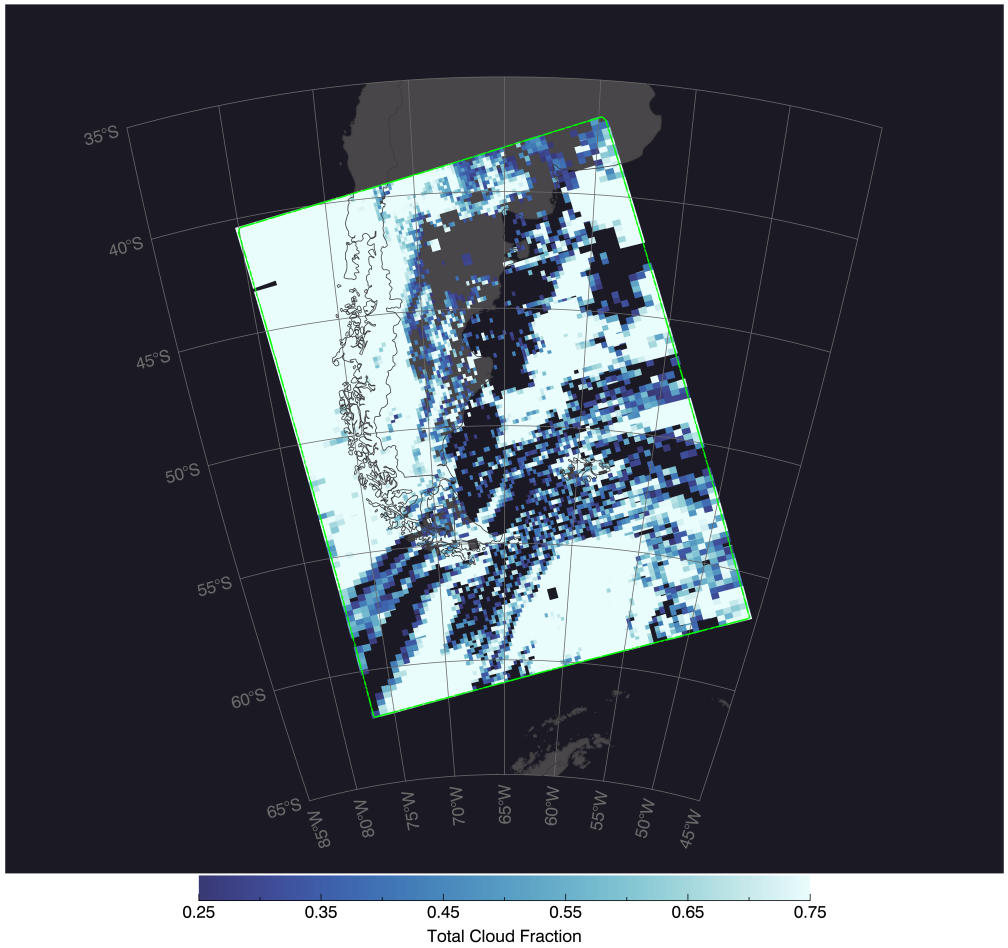
Dust Score



Puyehue Cordon Caulle Eruption, Chile

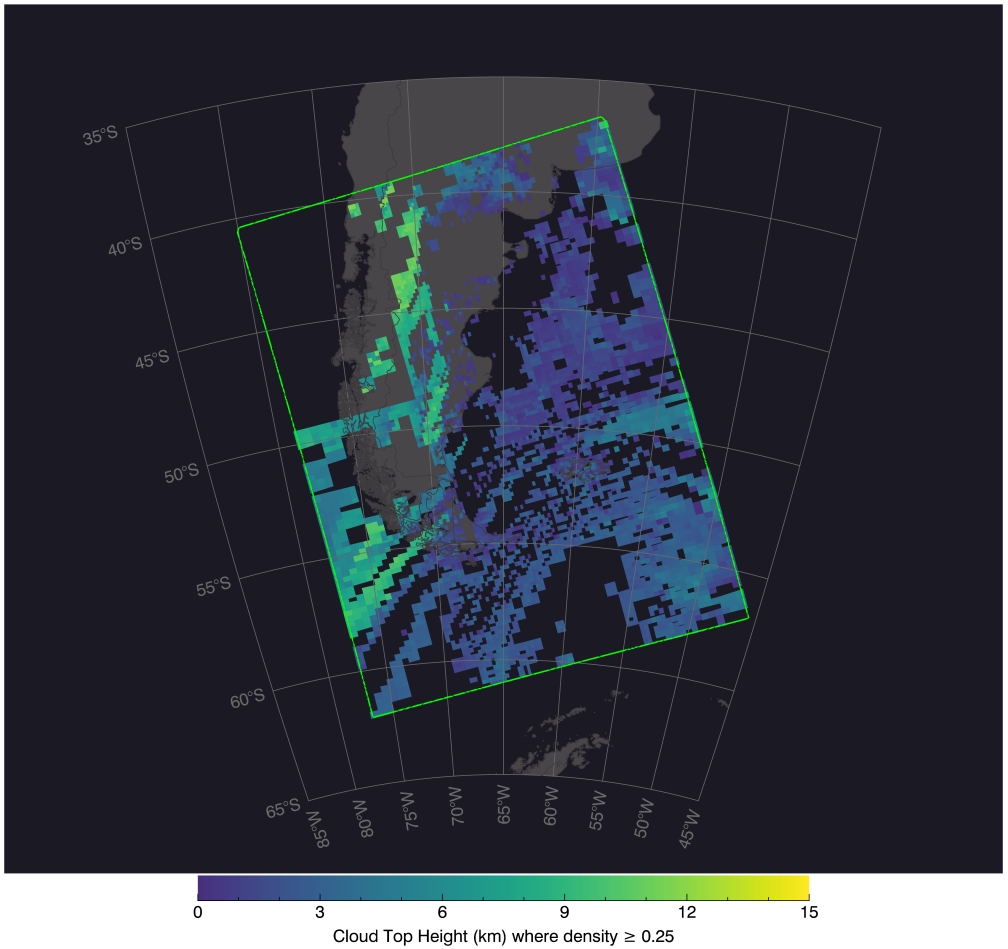
Total Cloud Fraction

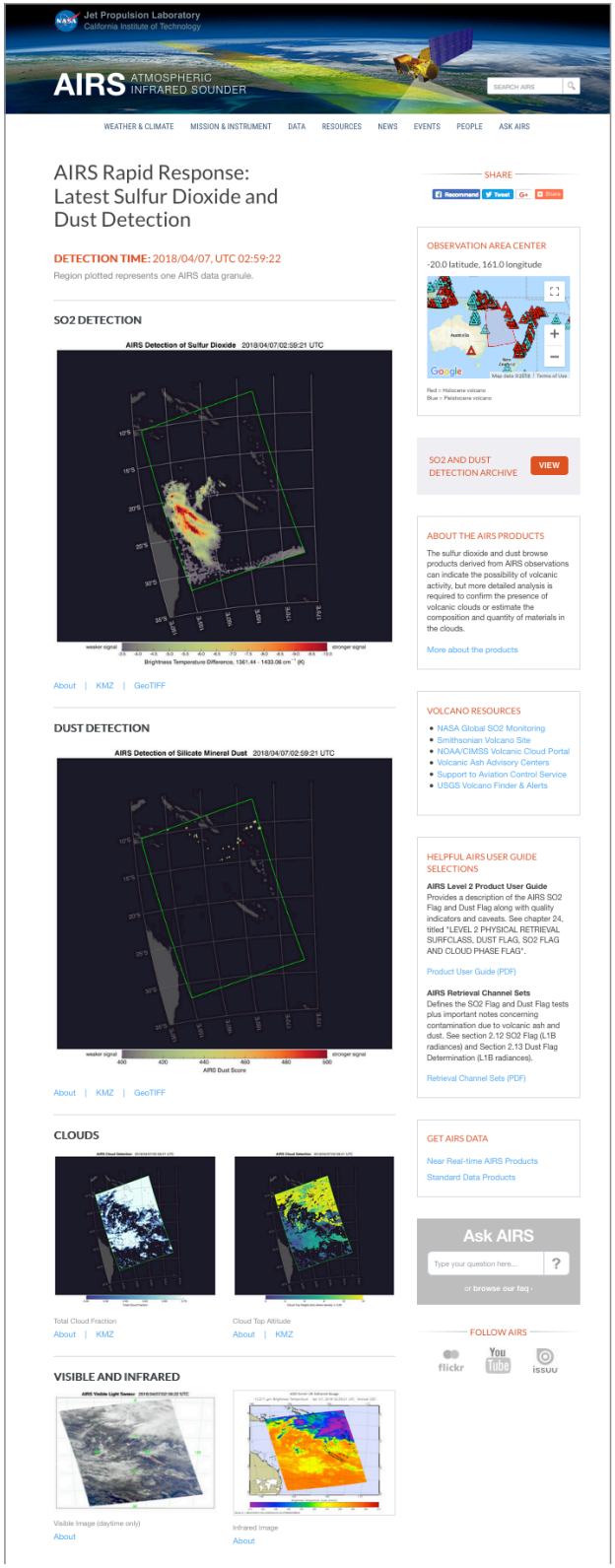
AIRS Cloud Detection 2011/06/06/18:35:24 UTC



Cloud Top Height

AIRS Cloud Detection 2011/06/06/18:35:24 UTC





Plans

1. **Volcano community review web page/products**
2. **Incorporate feedback**
3. **Add Worldview NRT upload**
4. **Awareness**
   - SO2.nasa.gov
   - Earth Observatory
   - Volcano Clouds list
   - NASA Applied Sciences
   - NOAA/NESDIS Hazards
   - NASA Worldview "Themes" page

AIRS can do more:

- **Provide detailed information on composition of volcanic plumes/clouds**
- **State of the atmosphere (temperature and water vapor profiles) over the lifetime of the plumes**

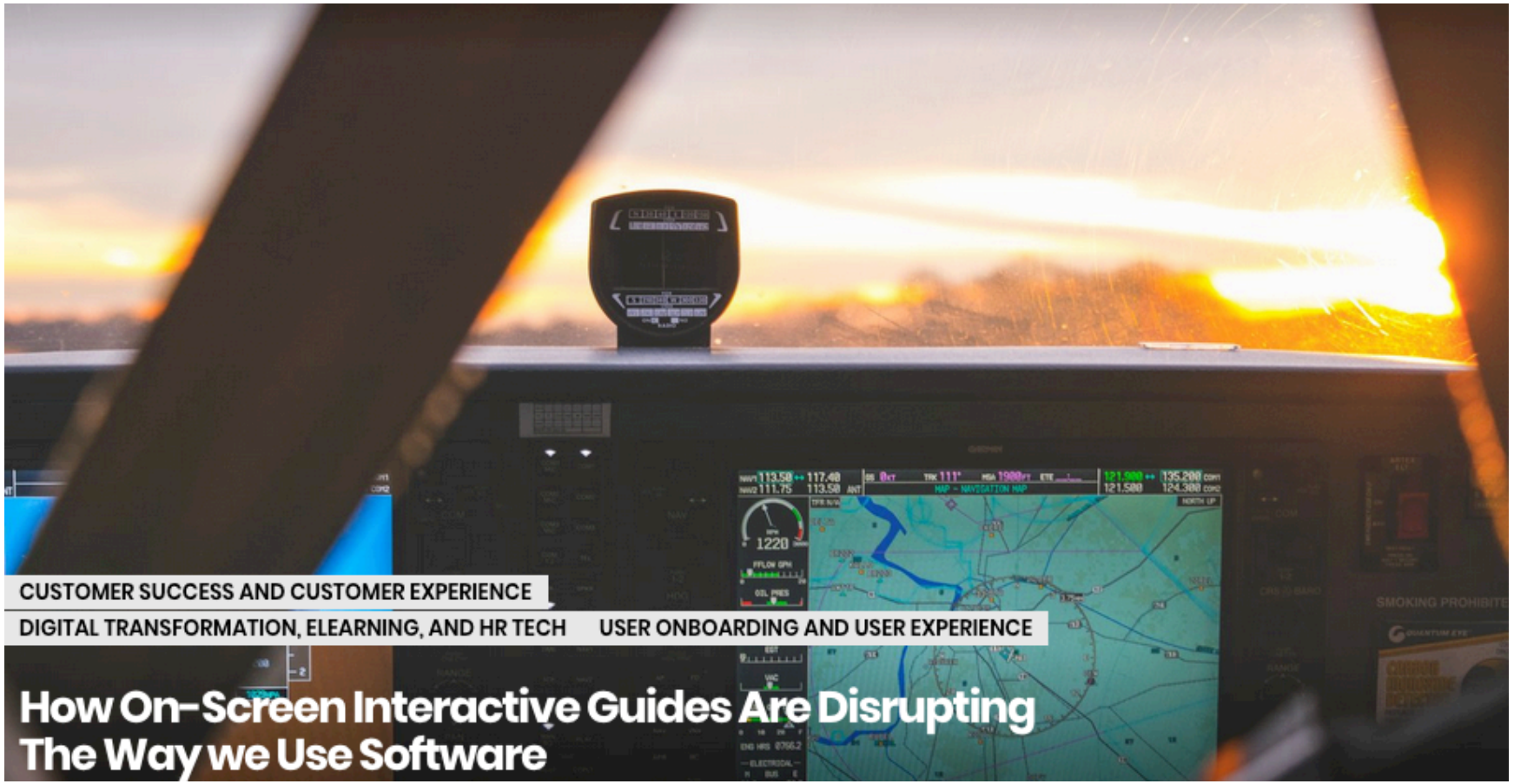
  Can improve trajectory/dispersion models used to forecast aviation hazards — analogous to hurricane trajectory models

  Benefits can be realized through retrospective studies of the AIRS archive

  We are trying to motivate such studies by showcasing the AIRS products on the AIRS Volcano site

User Services — AIRS User Guides Upgrade

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



User Guides Upgrade

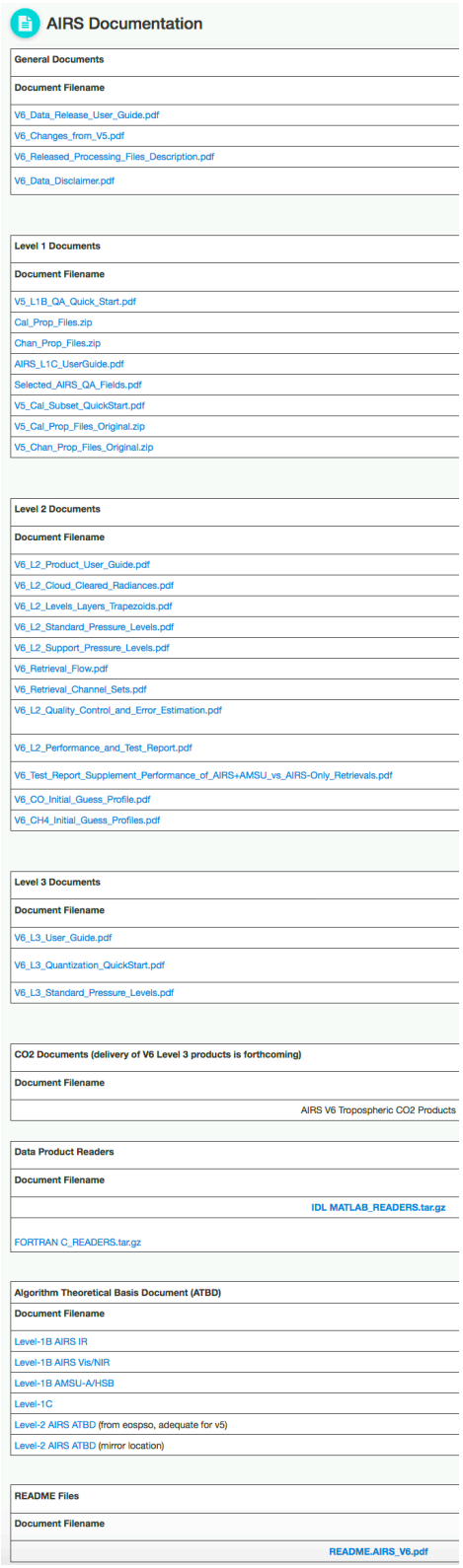
Ed Olsen – Maintained through 1/2018
Re-evaluate content, organization, delivery

Existing Limitations

Not machine searchable
Static presentation

Opportunity

“The negative factor of bombarding a busy end user with too much information has been turned into the positive of fulfilling a need.” - Swipeguide.com, The Future of Instructions



AIRS Documentation

General Documents
Document Filename
V6_Data_Release_User_Guide.pdf
V6_Changes_from_V5.pdf
V6_Released_Processing_Files_Description.pdf
V6_Data_Disclaimer.pdf

Level 1 Documents
Document Filename
V5_L1B_QA_Quick_Start.pdf
Cal_Prop_Files.zip
Chan_Prop_Files.zip
AIRS_L1C_UserGuide.pdf
Selected_AIRS_QA_Fields.pdf
V5_Cal_Subset_QuickStart.pdf
V5_Cal_Prop_Files_Original.zip
V5_Chan_Prop_Files_Original.zip

Level 2 Documents
Document Filename
V6_L2_Product_User_Guide.pdf
V6_L2_Cloud_Cleared_Radiances.pdf
V6_L2_Levels_Layers_Trapezoids.pdf
V6_L2_Standard_Pressure_Levels.pdf
V6_L2_Support_Pressure_Levels.pdf
V6_Retrieval_Flow.pdf
V6_Retrieval_Channel_Sets.pdf
V6_L2_Quality_Control_and_Error_Estimation.pdf
V6_L2_Performance_and_Test_Report.pdf
V6_Test_Report_Supplement_Performance_of_AIRS+AMSU_vs_AIRS-Only_Retrievals.pdf
V6_CO_Initial_Guess_Profile.pdf
V6_CH4_Initial_Guess_Profiles.pdf

Level 3 Documents
Document Filename
V6_L3_User_Guide.pdf
V6_L3_Quantization_QuickStart.pdf
V6_L3_Standard_Pressure_Levels.pdf

CO2 Documents (delivery of V6 Level 3 products is forthcoming)
Document Filename
AIRS V6 Tropospheric CO2 Products

Data Product Readers
Document Filename
IDL MATLAB_READERS.tar.gz
FORTRAN C_READERS.tar.gz

Algorithm Theoretical Basis Document (ATBD)
Document Filename
Level-1B AIRS IR
Level-1B AIRS Vis/NIR
Level-1B AMSU-A/HSB
Level-1C
Level-2 AIRS ATBD (from eospso, adequate for v5)
Level-2 AIRS ATBD (mirror location)

README Files
Document Filename
README.AIRS_V6.pdf

Content, Organization

- Use existing guides as basis - what do we have, what do we need?
- Determine pain points
- Mine AskAIRS archive
- Use cases
- Video, audio, graphics
- Partner with Doc Services, JPL UI/UX expert

New Format — The Digital User Guide

- Machine searchable
- Stats of user traffic: track usage, bounce rates, popular pages
- Link to other places in the DUG
- Include voice, imagery, animations
- Available through variety of devices
- PDF availability

Opportunity

- Good product documentation an important role in customer satisfaction
- Enhance the customer journey and build loyalty
- If we make AIRS data easier to use & understand > grow user base

Considerations

- Hosting
- Maintenance and updates
- GES DAAC

User Services

Upgrade User Guides > Upgrade Web Site

Data Users Stats, 2004–present

969 Current registered AIRS Data Users
894 Questions submitted via AskAIRS
1530 Questions submitted via email

August 2018 Web Site Stats

3324 Users
4084 Sessions
87% New Users
61% US, 3.9% China, 3.75% India

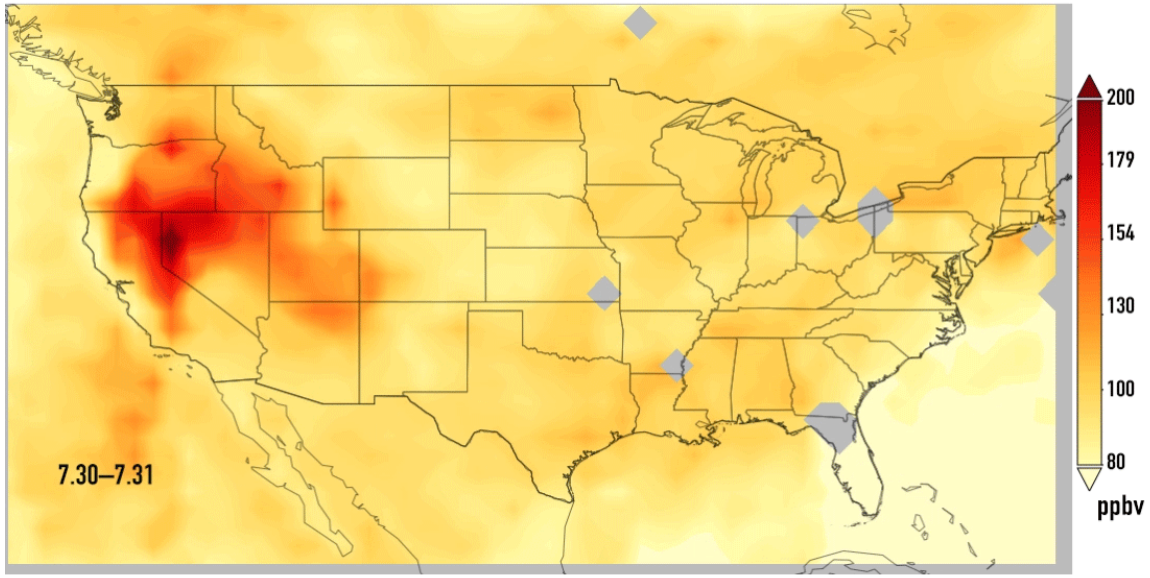
AIRS in the News

JPL News release

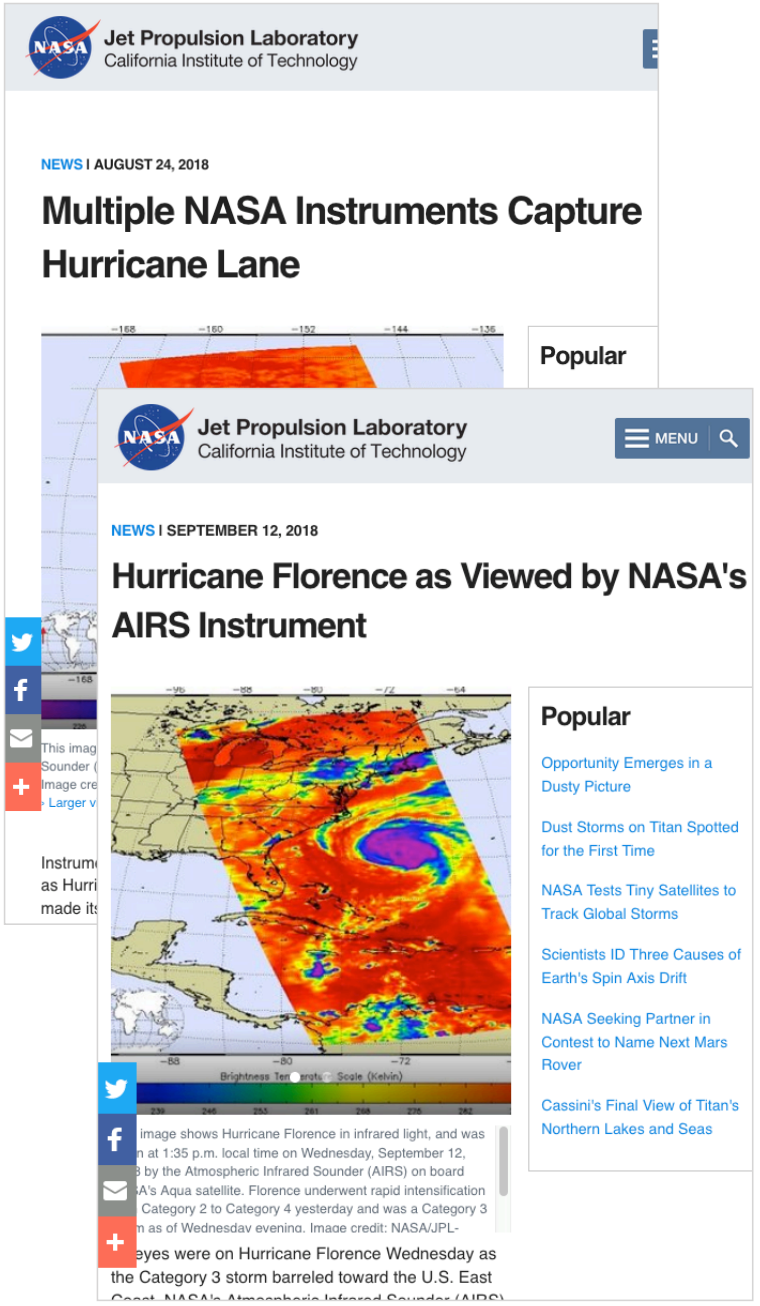
Carbon Monoxide from California Wildfires Drifts East

- Time series shows transport across US from 7/29 –8/7
- News release received excellent online coverage: USA Today, Newsweek, Google News, numerous media outlets
- Led to several media requests for interviews

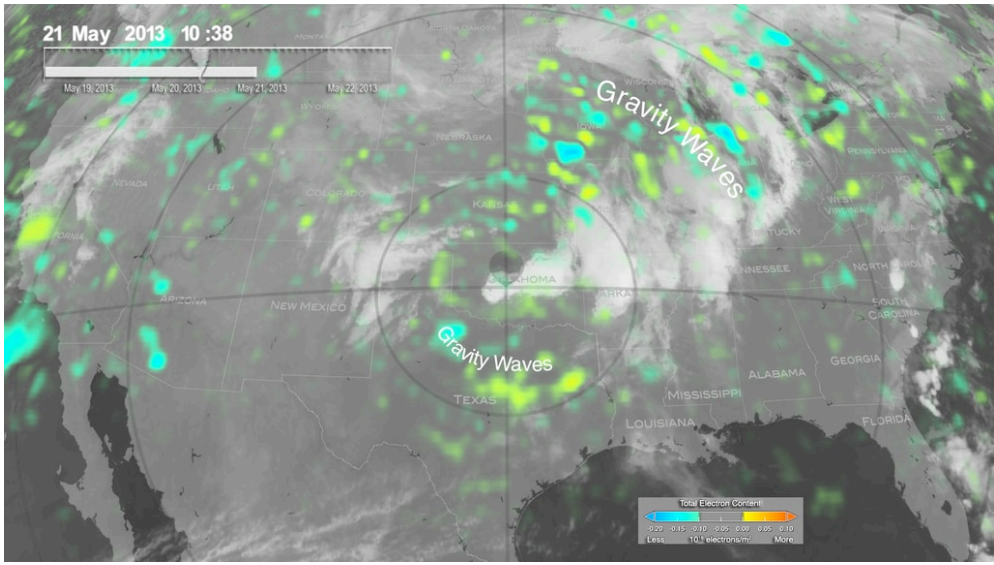
https://www.jpl.nasa.gov/news/news.php?feature=7214



Hurricane News Releases



New Visualization
GRAVITY WAVES
Lori Perkins @
GSFC Scientific Visualization Studio



Tornado – Moore, Oklahoma in May 2013

- **AIRS detects gravity waves in troposphere and stratosphere 12 hours before deadly EF5 tornado in Moore, Oklahoma**
- **Stronger waves detected 11 hours later**
- **Propagated through stratosphere and mesosphere until reaches ionosphere (traveling ionospheric disturbance)**
- **Tornado, gravity waves produced by long-lived storm system**

Data
- **NAVSTAR/World-wide GPS Receiver Network/Total Electron Content (TEC) 5/19-23/2013**
- **Aqua/AIRS/Brightness Temperature Variance 5/20/2013 8:30, 19:30**
- **CPC (Climate Prediction Center) Cloud Composite 5/19-23/2013**

"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)

Multi-sensor observations of TIDs and GWs can provide a unique perspective on ionosphere-atmosphere coupling

Visualization Credits

Lori Perkins (NASA/GSFC): Lead Data Visualizer
Eric Fetzer (NASA/JPL CalTech): Scientist
Sharon Ray (NASA/JPL CalTech): Project Support
Jie Gong (USRA): Scientist
Jia Yue (University of Maryland): Scientist
S. Irfan Azeem (National Science Foundation (NSF)): Scientist
Dong Wu (NASA/GSFC): Scientist
Tom Pagano (NASA/JPL CalTech): Project Support
Carol Rasmussen (NASA/JPL CalTech): Writer

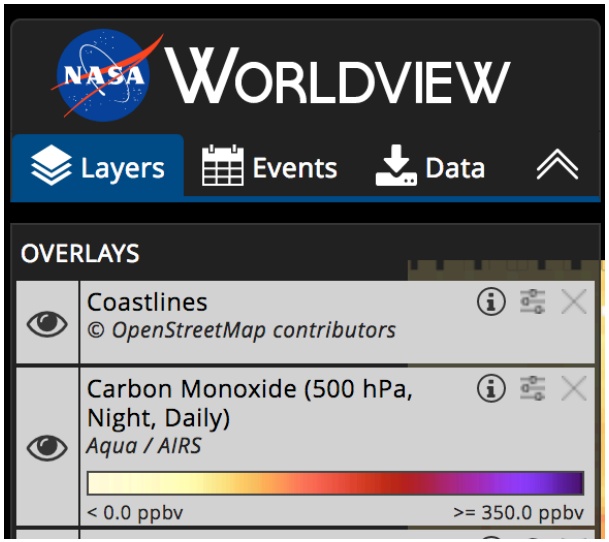
AIRS Level 2 NRT on Worldview!

https://worldview.earthdata.nasa.gov/

***Teams*: JPL, LANCE, GIBS, Worldview**

Paulo Penteado JPL
Jeff Hall JPL
Feng Ding GSFC
Matt Cechini GSFC
Ryan Boller GSFC

New Visualization Algorithm	New Visualization Rules	Color bars to GIBS format	LANCE Updates AIRS Processing Pipeline	GIBS/Worldview Updates AIRS Product Suite



Surface Air Temp
Surface Skin Temp
Surface Relative Humidity

Carbon Monoxide 500 hPa
Methane 400 hPa

Relative Humidity 500 hPa
Relative Humidity 700 hPa
Relative Humidity 850 hPa

Air Temperature 500 hPa
Air Temperature 700 hPa
Air Temperature 850 hPa

Sulfur Dioxide Brightness Temp Diff
Dust Score
Total Cloud Fraction
Cloud Top Height

Up Next

1. GIBS - Replace AIRS NRT with Science Quality L2 data
2. Reprocess to create GIBS historic archive of AIRS products from BOM