Travels through the Jornada del Muerto: recent field campaigns and user evaluations of satellite retrievals

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AIRS Science Team Meeting
Wednesday, Mar. 23, 2016 (Session 04, 10:10 am)

Jornada del Muerto

- Jornado del Muerto means “journey of the dead man”
  - Located between Las Cruces and Socorro, New Mexico
    - High plains lava bed (a “malpais”) with little water or refuge
    - A reminder of the resolve of the Spanish settlers in the 17th century
  - I lived and hiked in this region for many years
    - This is my analogy of “the valley of death” we want to cross

My personal journey began as an algorithm developer

- While at NOAA, I developed ***Operational*** products
  - We leveraged research done by NASA and Universities
  - Archive and 24/7 support costs are large
  - Cost of systems requires that users be identified and justified
  - Also leads to coding standards, large inertia to algorithm changes
    - NOAA needs ownership of code, static files, ability to verify, validate, distribute, etc.
    - Difficult to handle data through "back-door" pathways.
  - Forced me to wrestle with the question "who are our users?"
  - And so began the jornado del muerto
- After leaving NOAA, in 2013, I worked at NOAA TPIO NOSIA-2 project
  - my perception was altered by ~40 interviews with product developers in many NOAA offices (NWS WFO's, RFC's, SPC, NCEP; OAR ESRL, NSSL, GFDL, ARL, PMEL; NMFS; NESDIS/NCDC)
    - NOAA "products" are things like TAF, NDFD, Warnings (Hurricane, Tornado, Coastal, Flood), Advisories (High Surf, Small Craft, Drought), Fish and habitat assessments, Monitoring products (Air Quality, GHG's), guidance to IPCC and so on.

TPIO = Technology, Planning and Integration for Observation
NOSIA = NOAA Observing Systems Integrated Analysis

TAF = Terminal Aerodrome Forecast
NDFD = National Digital Forecast Database

In the applications context, I am now wearing 3 hats

- Work with NASA (NASA NPP Sounding Discipline Lead)
  - Instrument and algorithm development role is clear
  - What is NASA's role for distribution of products?
    - Weather (new algorithms) vs. Climate (concepts, discovery)
    - Production of tailored products?
- Work with NOAA (NOAA SME for sounding)
  - Operational mandate is clear
  - What is NOAA's role for distribution of products?
    - Weather (real time) vs. Climate (re-processing)
    - Tailored products for NOAA to NOAA distribution.
    - Commercial distribution?
- Work with commercial entities (proprietary agreements)
  - STC is ***investing*** in Cubesat's, algorithm tailoring, etc.
  - Commercial world requires a ***return on investment (ROI)***
    - Cannot compete with free
  - Commercial entities can be in other nations.

What is my recipe for R_2O

- Put yourself in the user's environment
  - Listen to exactly how they interpret the data
    - This requires institutional knowledge of their application
    - Words we use many not convey the same meaning
  - Tailor product to their syntax and visualization
    - Utilize the user's metric of success
- If you never leave your cubicle, you'll have difficulty establishing your relevance

These concepts are adapted from Kloos 2016 Esri Arcuser newsletter "The ROI mindset for GIS Managers"

But you need to ask the right questions

- A question such as “Do you want high spatial resolution” will always be answered “yes”
  - Better to ask “Which is more important, spatial resolution or boundary layer sensitivity”
    - Answer will depend on application
- Our community assumes retrievals would be better for global or regional models
  - But are we listening to what they really need?
    - We do not have a stable a-priori.
      - Radiance assimilation has Gaussian shaped impact, with a mean slightly above zero.
    - We need to efficiently convey our vertical co-variance
  - My assessment: this will not occur in my lifetime

Will focus on a number of recent examples of the search for users

- NOAA investing in a number of JPSS Sounding Initiatives
  - Goal is to demonstrate new applications with S-NPP.
  - Secondary goal is to encourage interaction between developers and users to tailor soundings to applications
  - We currently have a number of active initiatives for sounding
    1. Hydrometeorology Testbed (HMT): Atmospheric Rivers
    2. Aviation Weather Testbed (AWT): Cold Air Aloft
    3. NUCAPS in AWIPS-II: training module & improvements
    4. Hazardous Weather Testbed (HWT): Convective Initiation
    5. NUCAPS Trace Gas Product Evaluation
- Will also show one example of a *possible* commercial transition of a application

NOAA used a NASA methodology

- NOAA-Unique Combined Atmospheric Sounding System (NUCAPS) Level-2 is based on AIRS v5
  - We wrote original project plan in Sep. 2003 for Aqua, Metop, NPP/JPSS, and GOES-R processing
    - Selected NASA algorithm as the most robust
    - NUCAPS is a distribution of both radiance and geophysical products
    - Decided not to compete with NASA AIRS Level-2 distribution
- Metop L2 algorithm has been Operational since 8/2008
  - Metop-A started with IASI/AMSU/MHS, AVHRR CCR (8/2012)
  - Metop-B operational on 11/2015 with AVHRR
  - Will continue to run both operationally (orbits interleaved)
- NPP L2 algorithm has been Operational since 4/2014
  - High resolution CrIS scheduled for fall 2016
- Operational maintenance budget is very small
  - All upgrades have to be justified, prioritized, and scheduled

Availability of NUCAPS (with latency)

- Apr. 18, 2014 NUCAPS operational at OSPO
  - Via DDS subscription in near real time (≤ 3h)
  - Via CLASS interactive webpage (~ 6h)
  - On-line/downloadable TAR files via CLASS ftp site (~48h)
- Sep. 2014 AWIPS-II implementation begins at ~100 NWS/WFO's
  - NUCAPS T(p) and H_2O(p) products can be displayed as skew-T and manipulated within AWIPS (≤ 3h)
- Feb. 24, 2015 NUCAPS operational at CSPP direct broadcast stations
  - Much better latency (~ minutes, if priority processing is done)
  - CSPP = Community Satellite Processing Package
  - Support field campaigns and science evaluations
  - Network of DB will be used to reduce latency to NWP
- Reprocessing of full mission CrIS+ATMS SDRs and NUCAPS at Univ. Wisconsin (JPSS funded)
  - V1.0 (2014 operational system) completed in Aug. 2015
  - V1.5 will be run in near future (July timeframe) and available via CLASS

Initiative #1 / 5

Hydrometeorology Testbed: El Nino Rapid Response Field Campaign

POCs: Chris Barnet (JPSS) & Ryan Spackman (NOAA/ESRL/PSD)

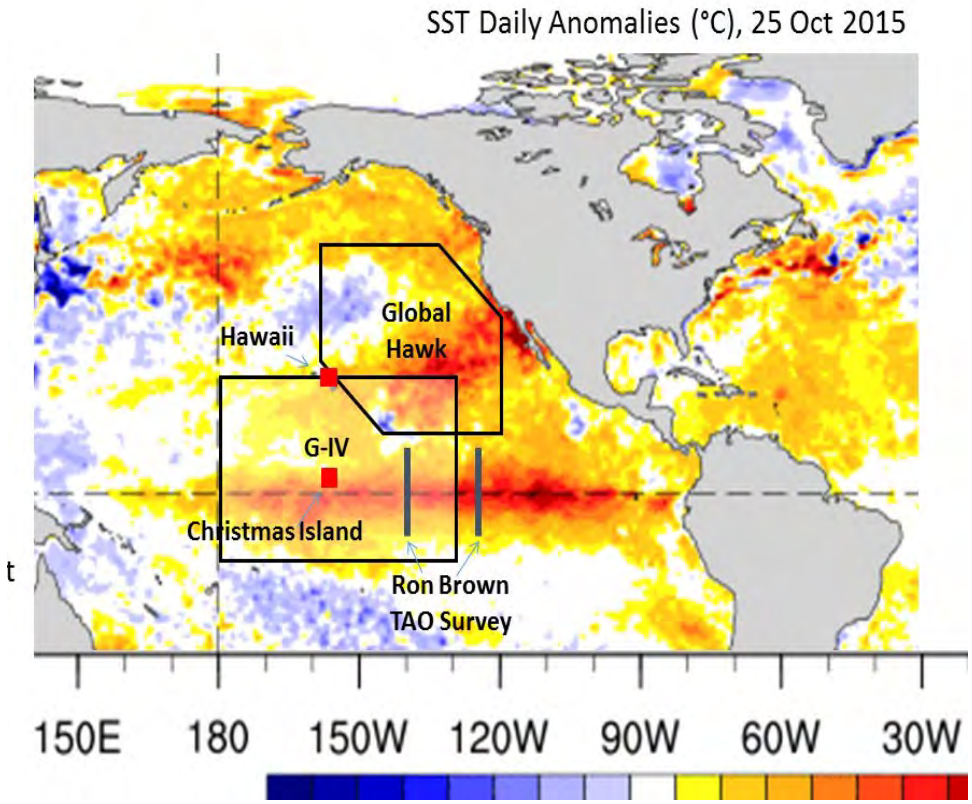
Campaign ran from Jan. 19th through Mar. 10th, 2016

- NOAA G-IV deployed from Honolulu International Airport
  - first science flight opportunity was January 21
  - Twenty-two 8-hour flights until March 10th
  - 41-45,000', ~25-35 dropsondes/flight
- Global Hawk (GH), part of SHOUT, deployed from NASA/AMES
  - Three 24-hour flights (2/15, 2/16 and 2/21, now completed)
  - 55-63,000', ~65 dropsondes/flight
  - HAMSR microwave retrievals (Bjorn Lambrightsen, PI)
- radiosonde launches at Kiritimati Isl., Kiribati (2N, 157W)
  - first radiosonde 1/26, 2pm HT, will continued though mid-March
  - Close to S-NPP overpass time (0,12Z), 1340 miles south of Honolulu
- NOAA Ron Brown departed Ford Island Tue. 2/16
  - 6 to 8 RS-92 sonde launches per day, continued through mid-March
- Two C-130's, one at each end of AR (Hickam HI and Travis CA)
  - Two flights made (2/18 and 2/21, now completed)

Field campaign website: http://www.esrl.noaa.gov/psd/enso/rapid_response/

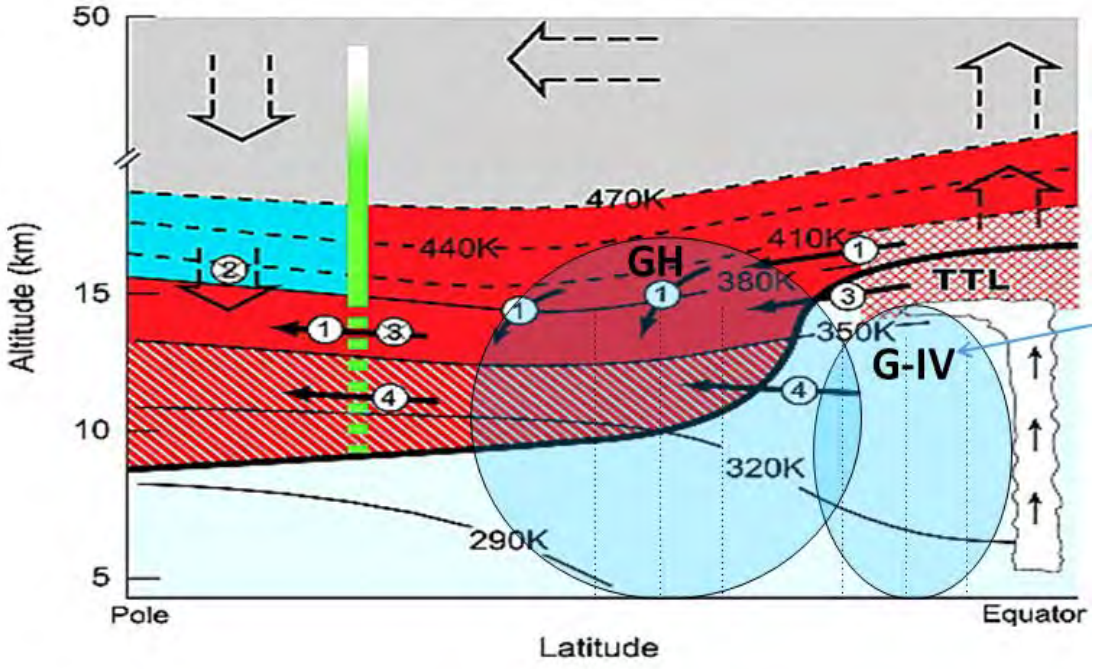
Planned Implementation Strategy

- G-IV: Divergent outflow and jet extension processes in central and eastern tropical Pacific
- GH: Coupling to mid-latitude weather with surveys in eastern Pacific mid-latitudes to evaluate impacts on US West Coast
- R.H. Brown: Survey of atmosphere and ocean conditions in eastern tropical Pacific



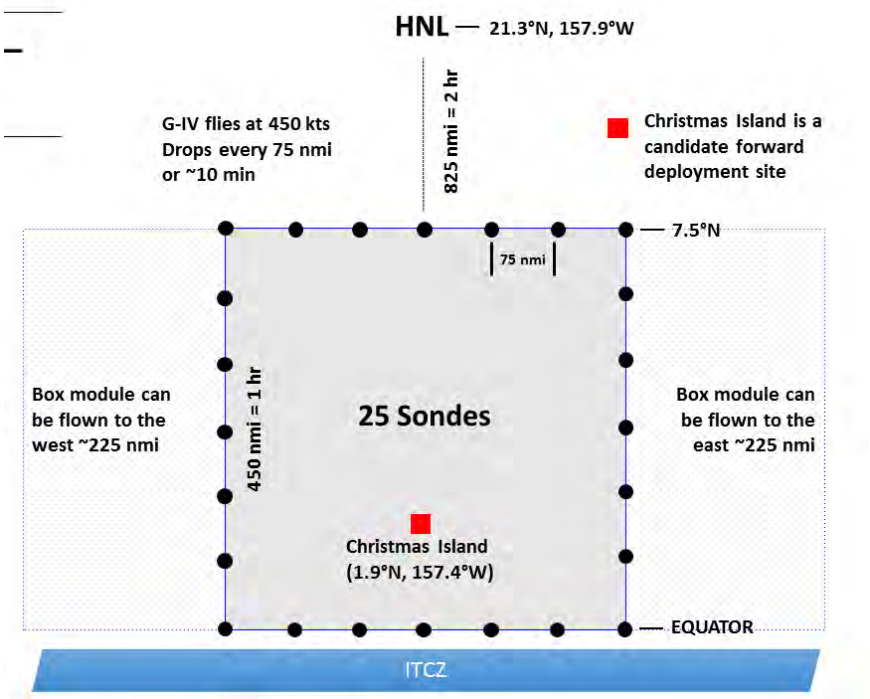
Meridional Perspective on Flight Strategies

- G-IV: Divergent flow aloft in central/eastern tropical Pacific should mostly be reachable by G-IV at altitude of 12-14 km and captured by dropsonde measurements
- GH: Survey the subtropical jet and deep tropics where convection may extend above G-IV altitude.



G-IV Flight Module
Deep Tropics

- Measure thermodynamics and wind field north of the ITCZ
  - sample organized tropical convection
  - poleward convective outflow
- Box module is 450 nmi square with 75 nmi dropsonde spacing
- G-IV performs box module in 4 hour at cruise altitude (41-45 kft)
- Expected total flight duration for pattern shown in ~8 hour (3500 nmi)

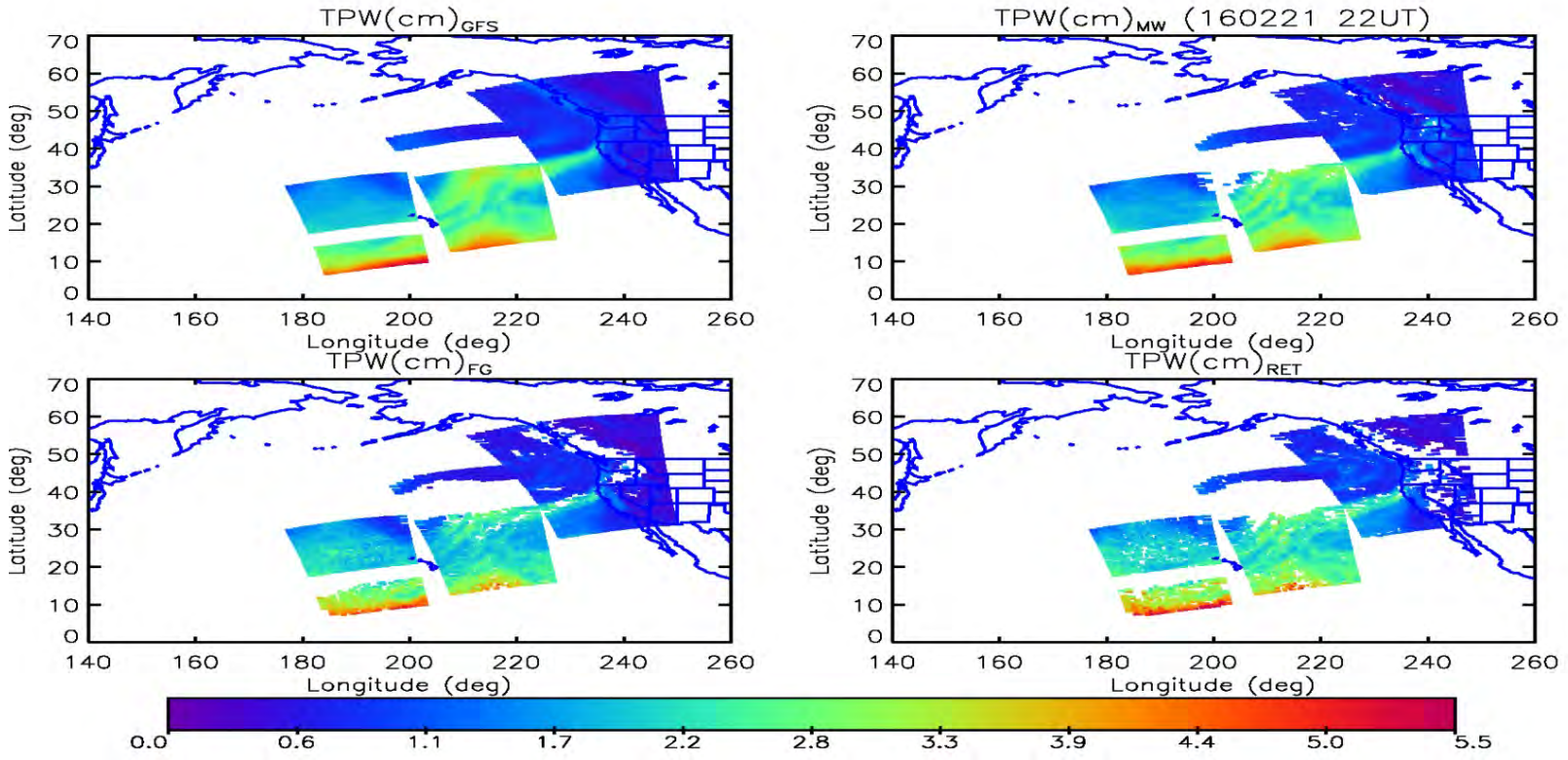


What we provided

- We performed the same kind of analysis we did for CalWater-2015 and CalWater-2014
  - Provided an overview document on satellite soundings and visualization methods to the campaign scientists
    - Selected pages (e.g., skew-T description) is at end of this document
  - Use both Honolulu HI & Corvallis OR direct broadcast sites
  - Process 1:30 am overpass (~12:30 UT, 2:30 HST, 7:30 EST)
    - Provide analysis to forecasters during the flight planning telecon
  - Process 1:30 pm overpass (~0:30 UT, 14:30 HST, 19:30 EST)
    - Provide to scientists in-flight to get a quick look at what to expect later part of the 8h flight
- Use archive data (~24 hours later) to process entire Pacific domain and provide comparison between retrievals (MW-only and IR+MW), co-located GFS, and dropsondes
  - 1st look to capture meta data for campaign archive

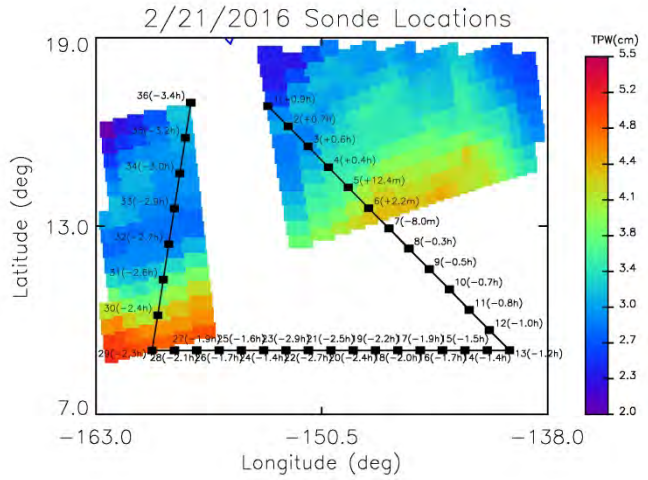
Example of DB coverage

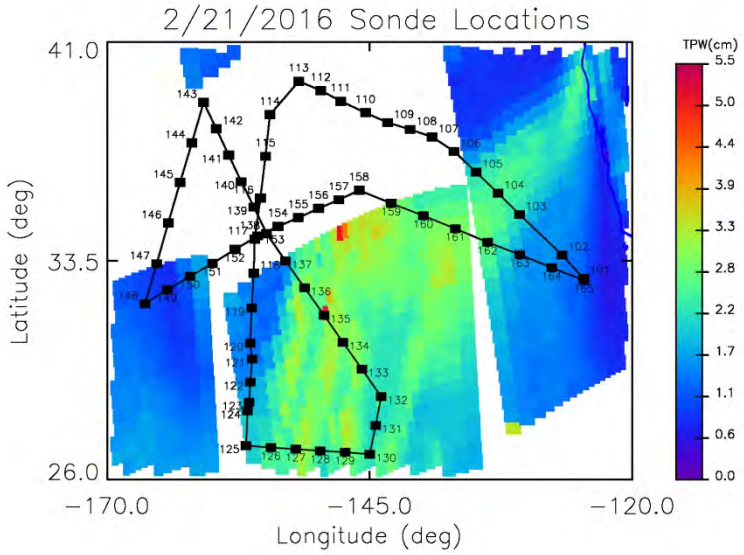
- Feb. 21, 2016 pm coverage from both Corvallis and Hawaii
  - Periodic problems with “antenna shadowing” on NPP
  - Also see missing granules due to ATMS GEO problems



Fetch of DB antenna was a problem for this campaign

- On most days the Hawaii antenna did not “see” far enough south to be useful for flight planning
  - Because CrIS requires data before/after for calibration
- On most days Corvallis antenna didn’t “see” far enough west for Global Hawk

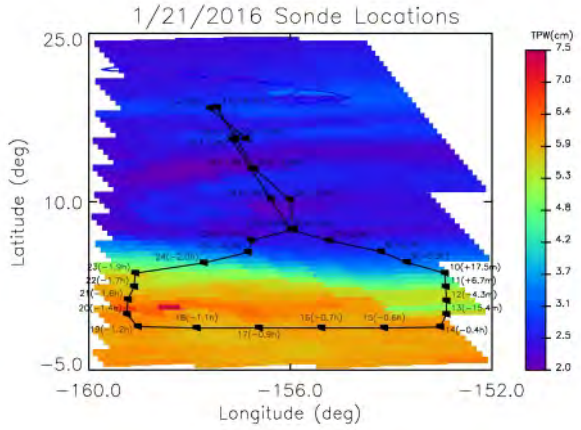


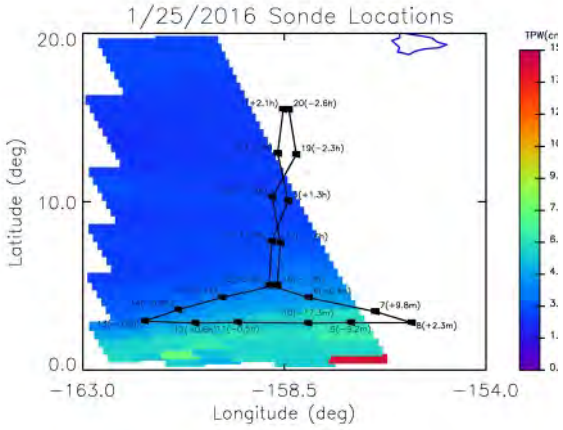


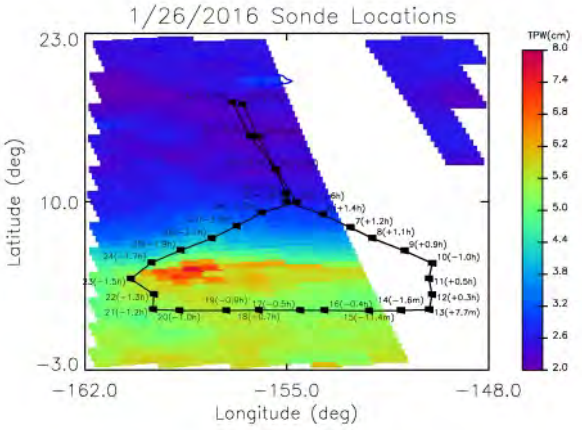
Some lessons learned for flight planning

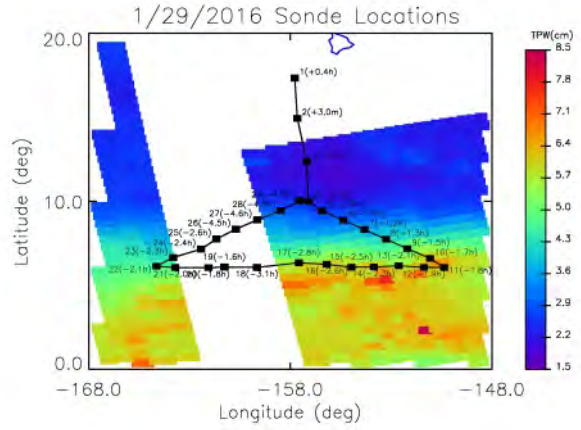
- We could routinely process direct broadcast NPP data with a total latency (satellite obs to skew-T plots) of 45 minutes
- But for flight planning there is already a plethora of data and forecasts
  - Real time T(p), q(p) can complement the other data
    - Lack of wind information was a big factor
    - Mostly used to help to decide which forecast model was most representative of current conditions.
  - But need to be answer questions like “do you believe that dry layer aloft” on a case by case basis
    - Individual skew-T’s were more valuable than cross-section visualization
- Valuable insight into forecaster opinions of satellite soundings
  - They are aware and concerned with our a-priori assumptions
  - They assume we cannot handle outliers (stick to prior)
- At the “grass roots” level made numerous forecasters aware of satellite sounders are capable of.
  - I need to incorporate their feedback into our documentation.

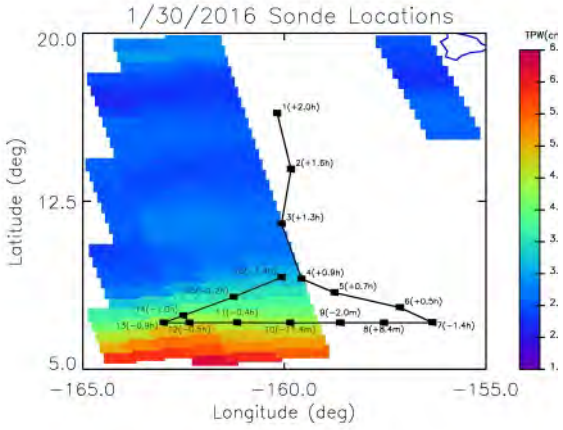
Post-processing from archive: Jan. 21 through Feb. 2

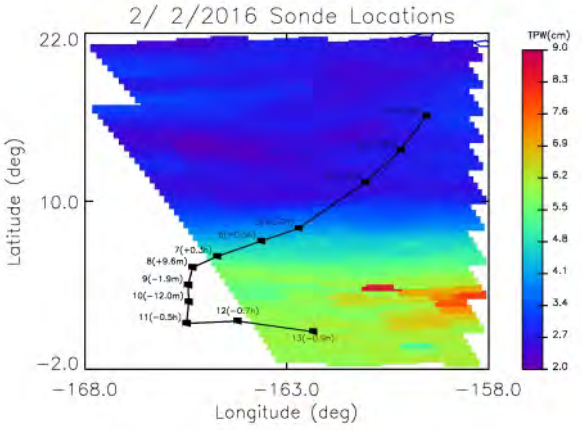




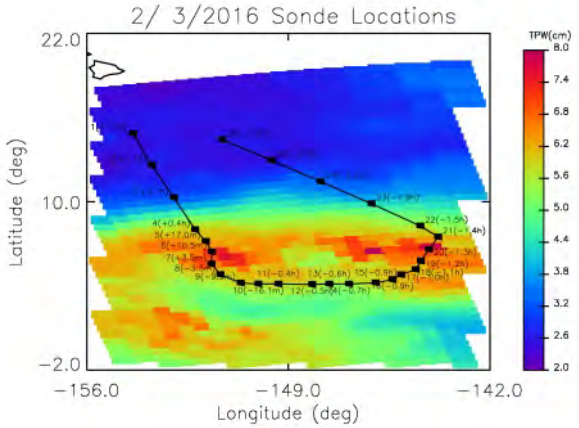


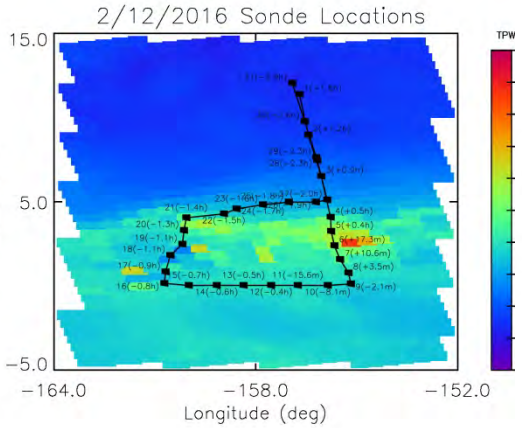


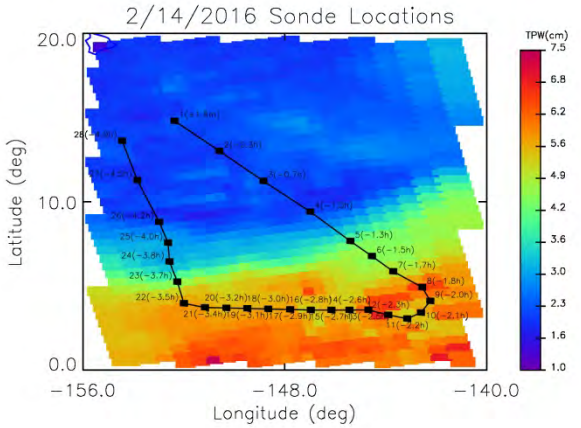


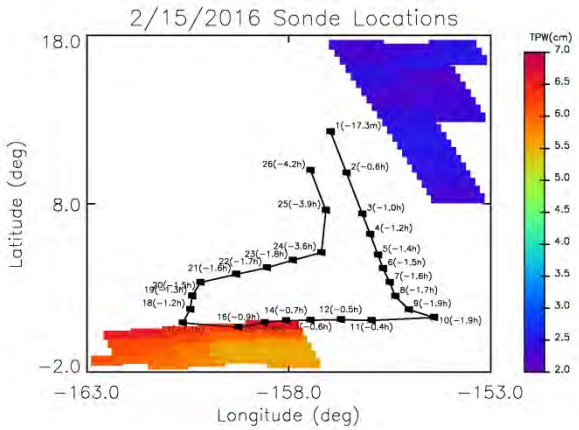


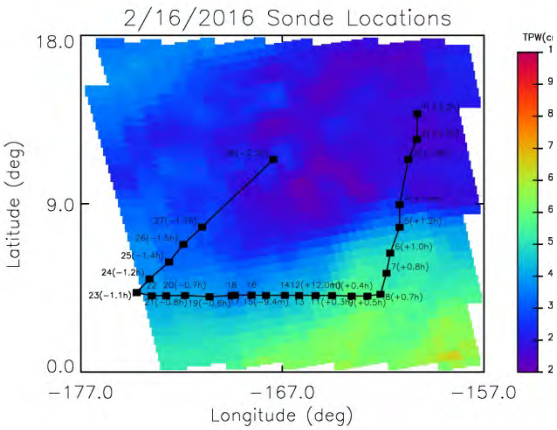
Feb. 3 through Feb. 17 post-processing

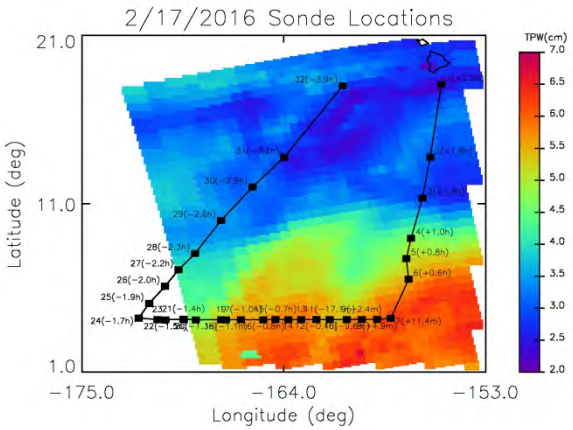




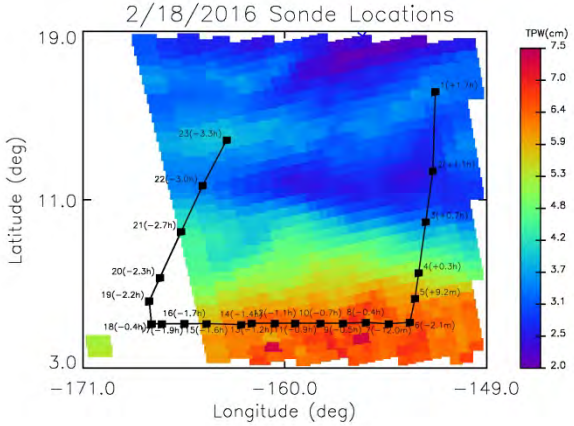


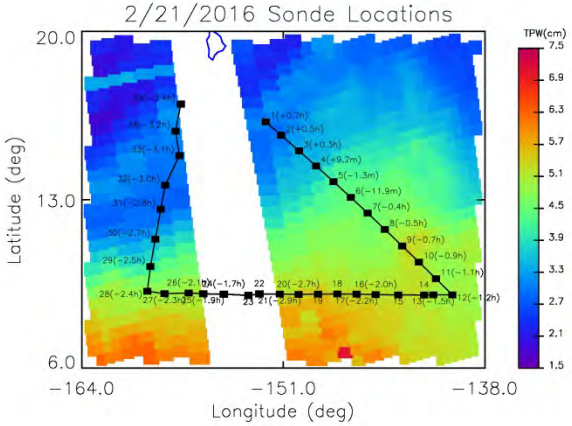


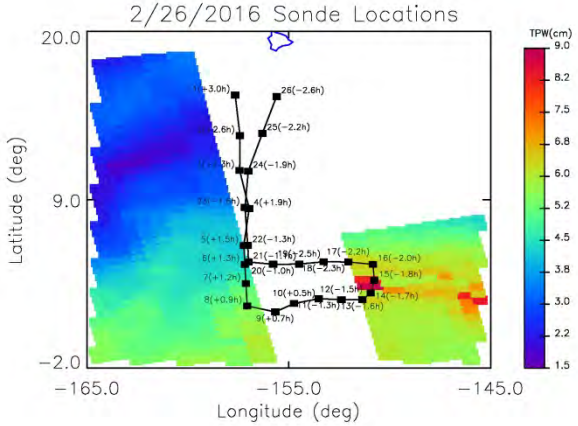


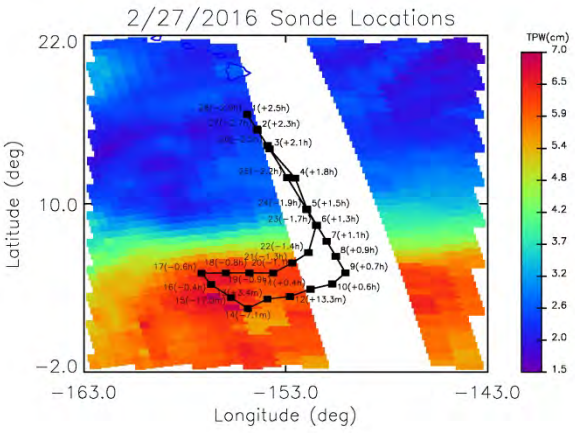


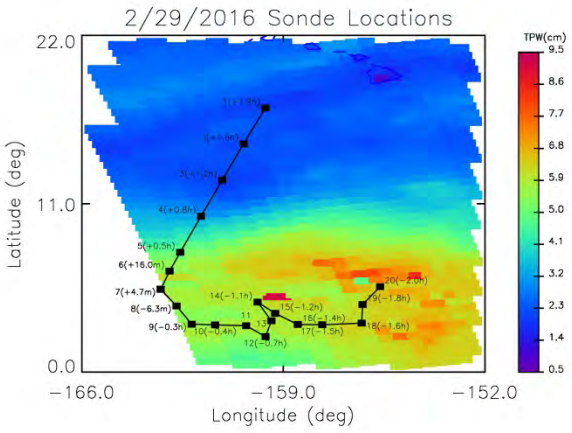
Feb. 18 through Mar. 1 post-processing

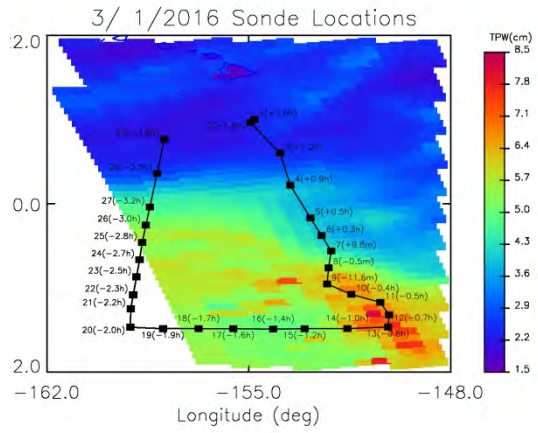




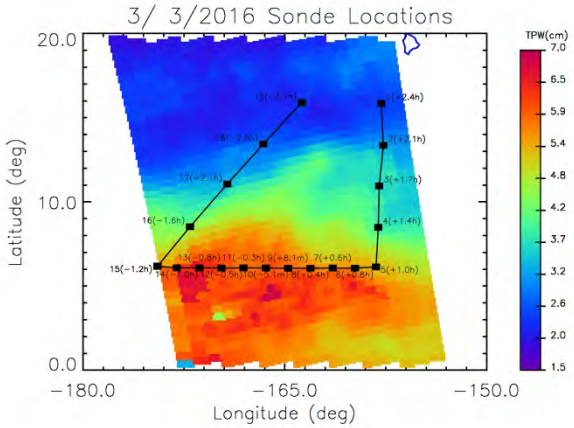


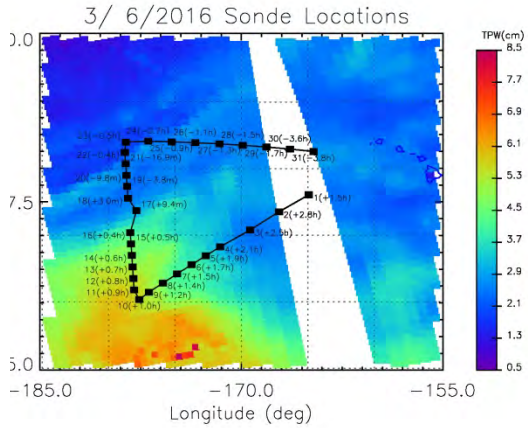


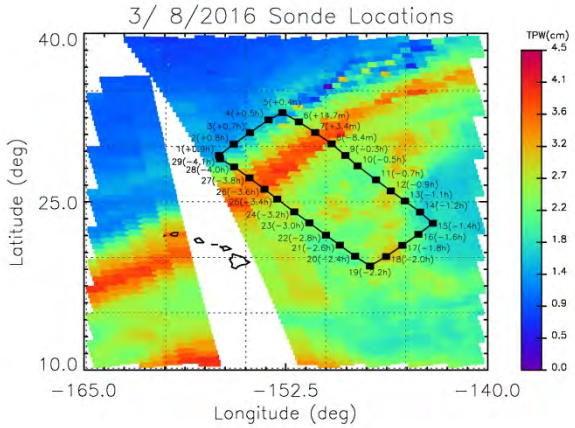


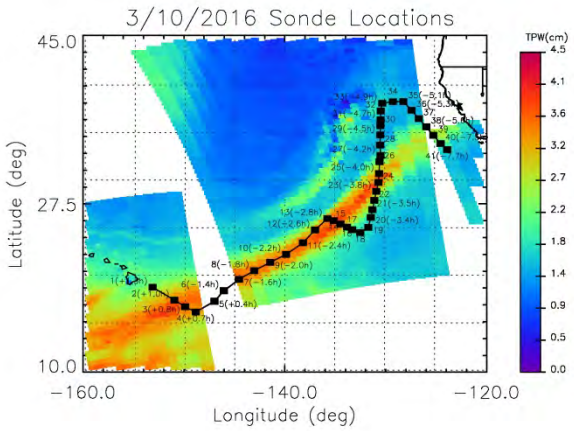


Mar. 3 through Mar. 10 post-processing





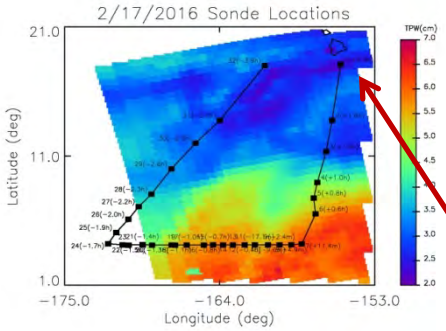




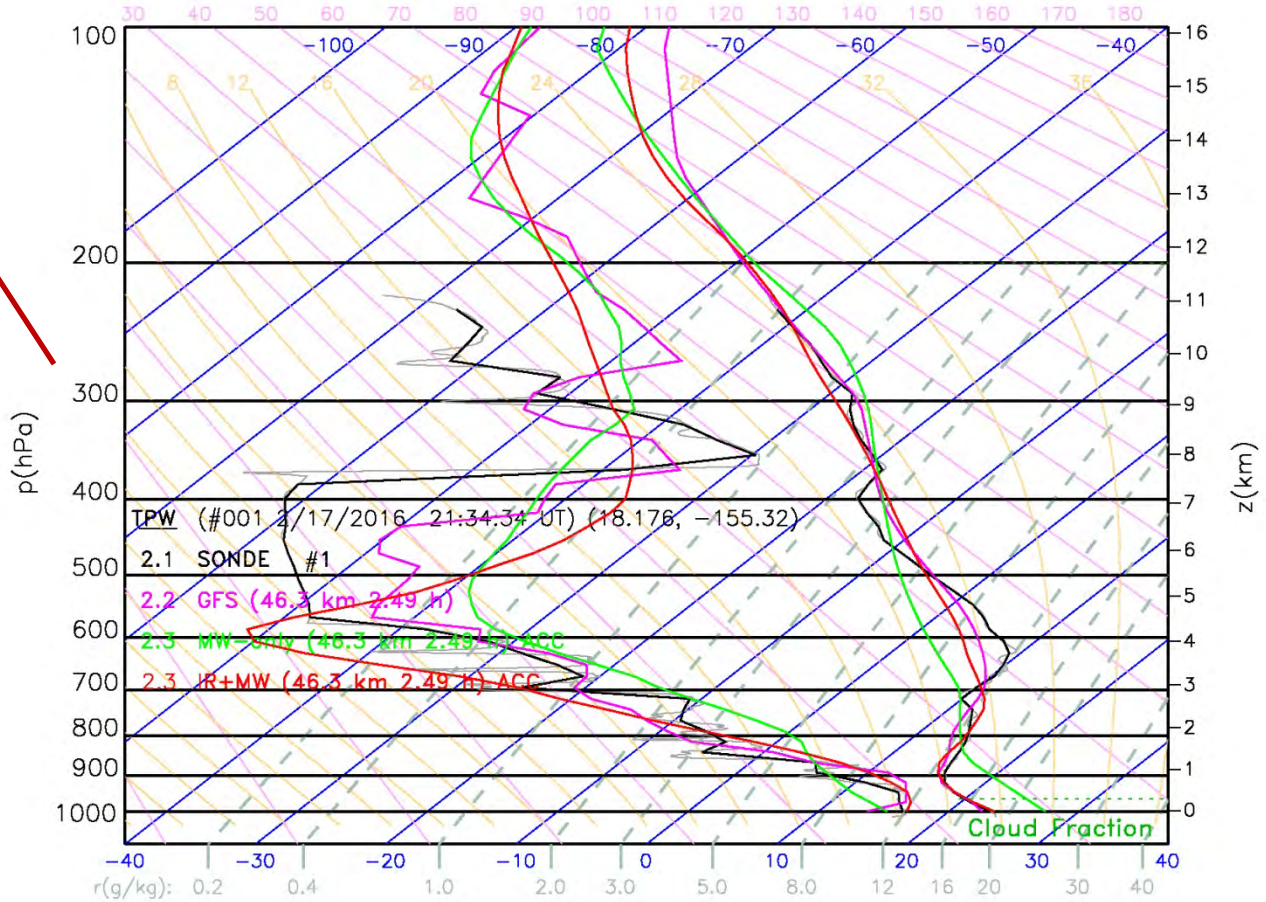
Summary of acquired datasets for validation

flight number	DB sites		flight date	total # sondes	match #skew	overpass sondes	useful match	# of GH sondes	# C130 sondes	RHB sondes	CXI sondes
1	HI	Thu	1/21/2016	31	31	11/12	-4.3 min				
2	HI	Mon	1/25/2016	20	17	08/09	-9.2 min				
3	HI	Tue	1/26/2016	32	24	10/11	-11.4 min				6
4	HI	Fri	1/29/2016	29	22	02/03	-0.3 hour				2
5	HI	Sat	1/30/2016	16	9	08/09	-11.4 min				2
6	HI	Tue	2/2/2016	13	8	07/08	+0.3 hour				2
7	HI	Wed	2/3/2016	26	26	07/08	+ 3 min				2
8	HI + CO	Fri	2/12/2016	31	31	08/09	-2.1 min				2
9	HI	Sun	2/14/2016	28	28	01/02	-0.3 hour		102		2
10	HI + CO	Mon	2/15/2016	26	4	01	-17.3 min	2			2
11	HI + CO	Tue	2/16/2016	28	27	14/15	-9.4 min	22	85	1	2
12	HI	Wed	2/17/2016	32	24	08/09	-2.4 min			5	2
13	HI	Thu	2/18/2016	23	18	05/06	-2.1 min			5	2
14	HI + CO	Sun	2/21/2016	35	32	05/06	-1.3 min	65		6	2
15	HI	Fri	2/26/2016	26	9	10/11	+0.9 hour			0	2
16	HI	Sat	2/27/2016	28	15	12/13	+3.4 min			1	2
17	HI	Mon	2/29/2016	20	20	07/08	+4.7 min			7	2
18	HI	Tue	3/1/2016	29	23	07/08	30 secs			7	2
19	HI	Thu	3/3/2016	19	19	09/10	-5.1 min			6	2
20	HI	Sun	3/6/2016	31	29	18/19	+3.0 min			6	2
21	HI	Tue	3/8/2016	29	29	07/08	+3.4 min			8	2
22	HI + CO	Thu	3/10/2016	41	38	05/06	+0.7 hour			7	2
total acquired			1102	593				89	187	144	89
total analysed			483		483						

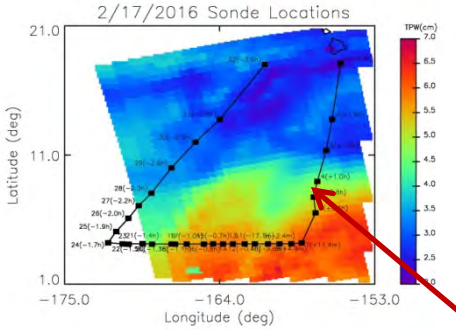
Feb. 17, Sonde #1: 2.5 hours before overpass time

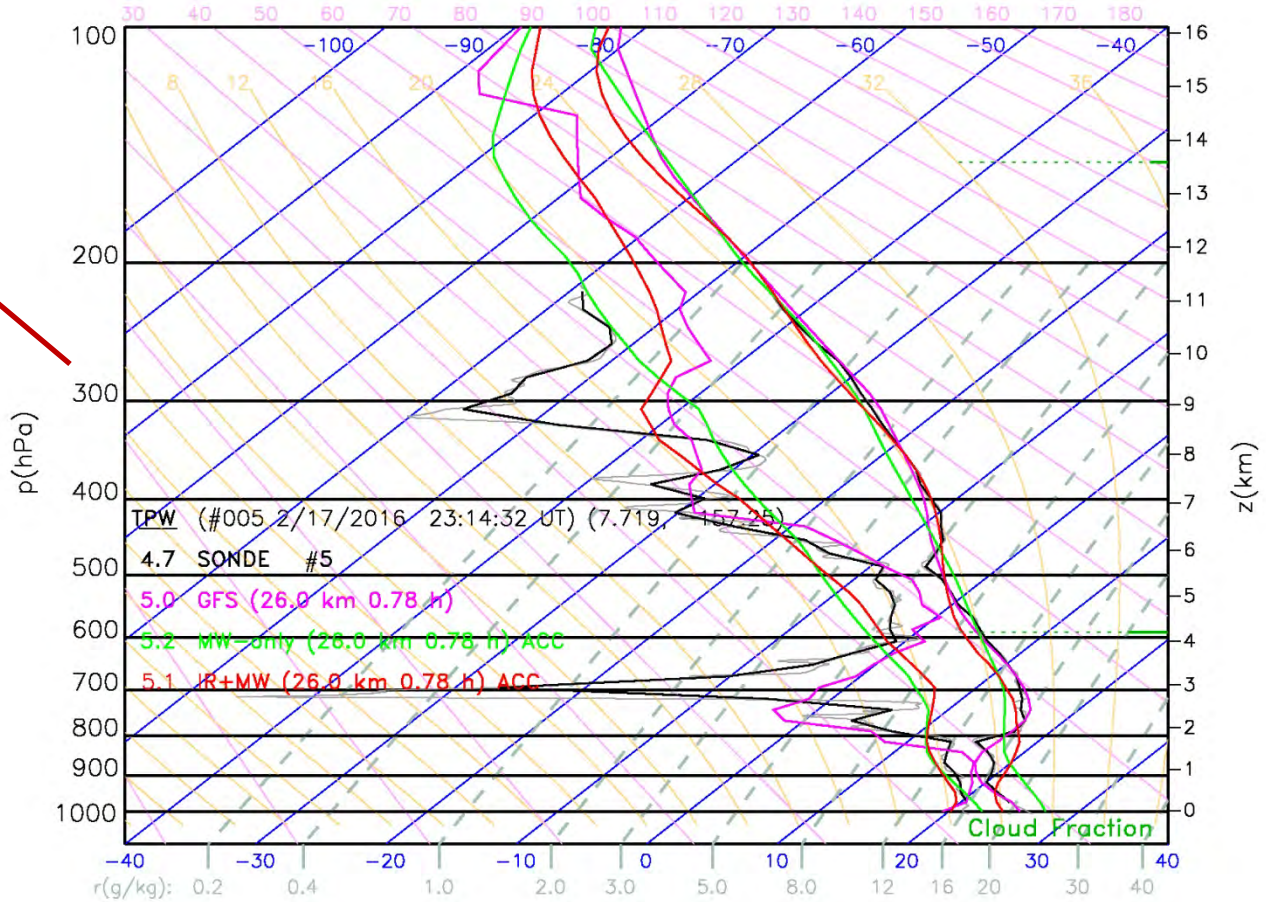


IR+MW tends to capture vertical T(p) and q(p) structure better than MW



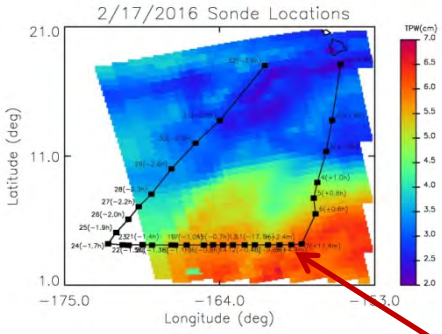
Feb. 17, Sonde #5: 0.8 hours before overpass time



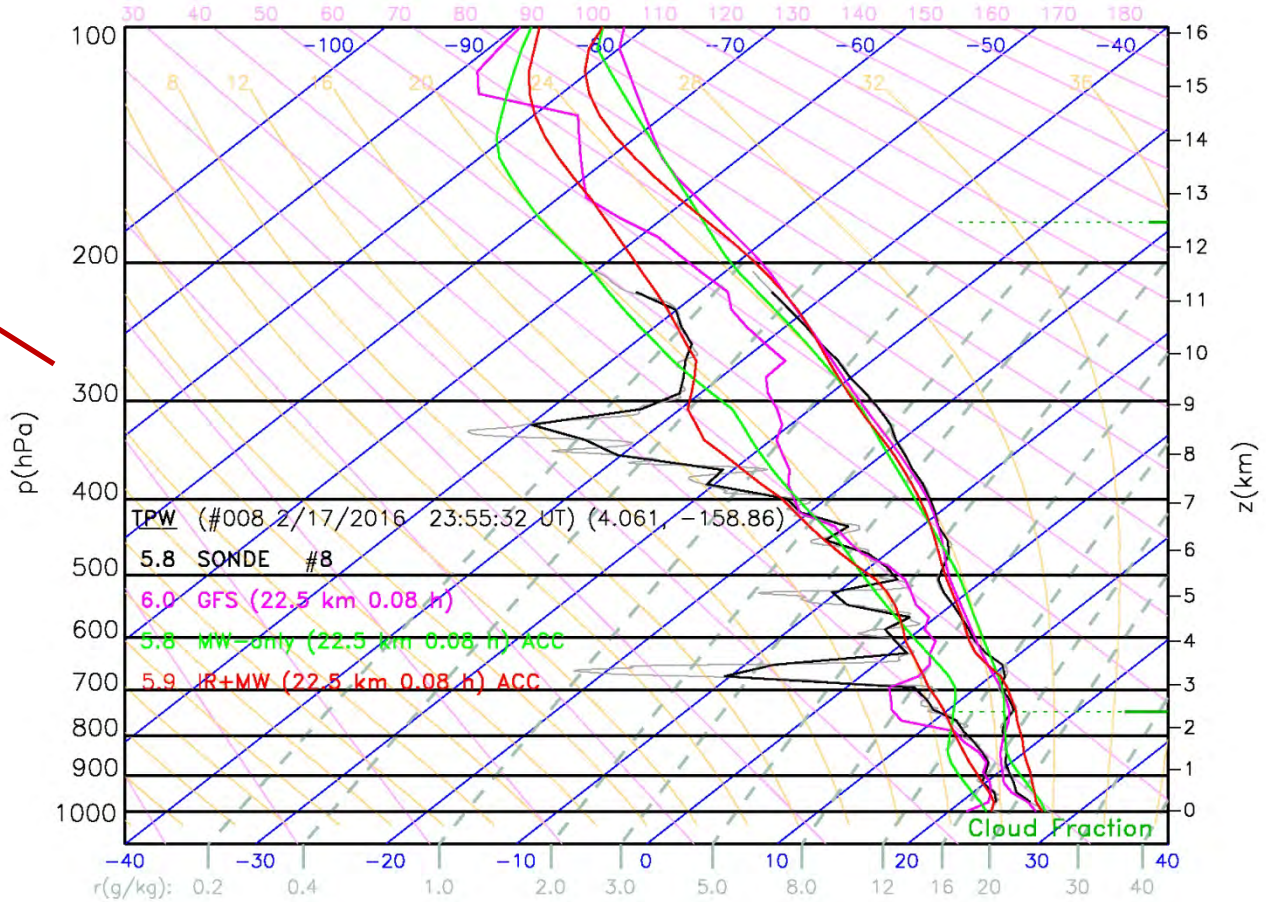


But obviously doesn't have the vertical resolution of a sonde or GFS

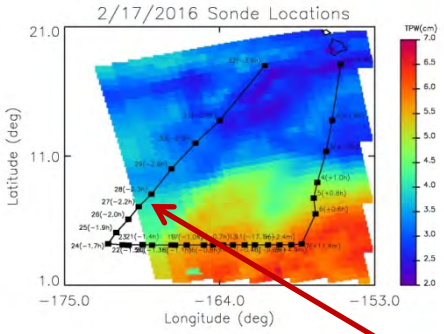
Feb. 17, Sonde #8: near overpass time



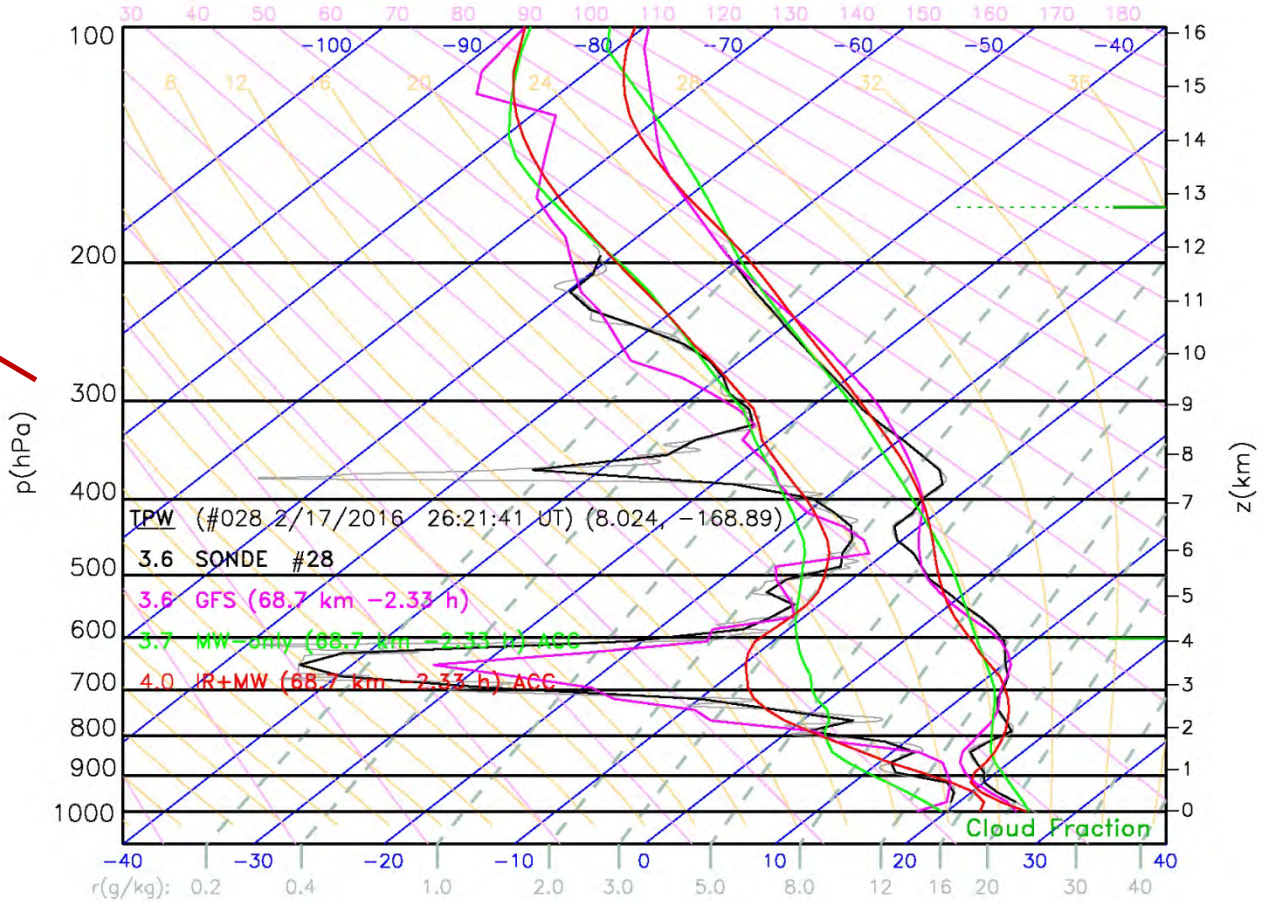
NUCAPS is capturing large scale vertical structures



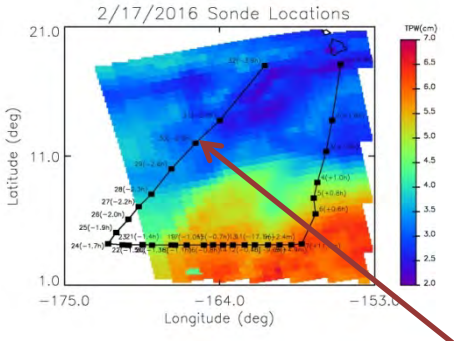
Feb. 17, Sonde #28: 2.3 hours after overpass time



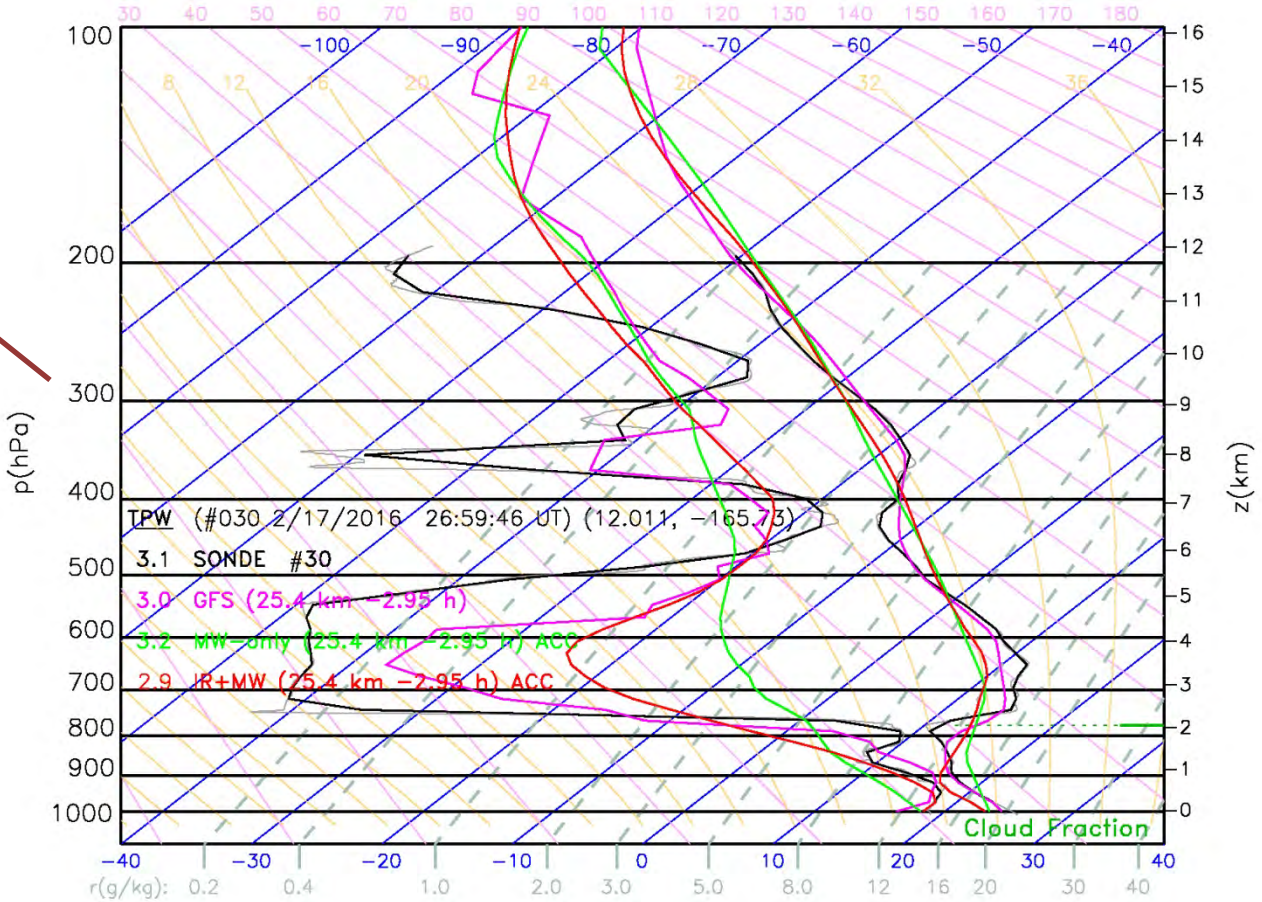
thin layers can be used to estimate vertical response



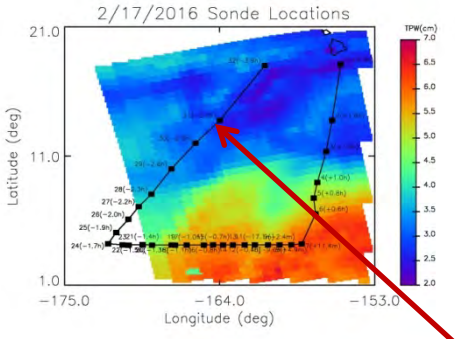
Feb. 17, Sonde #30: 3 hours after overpass time



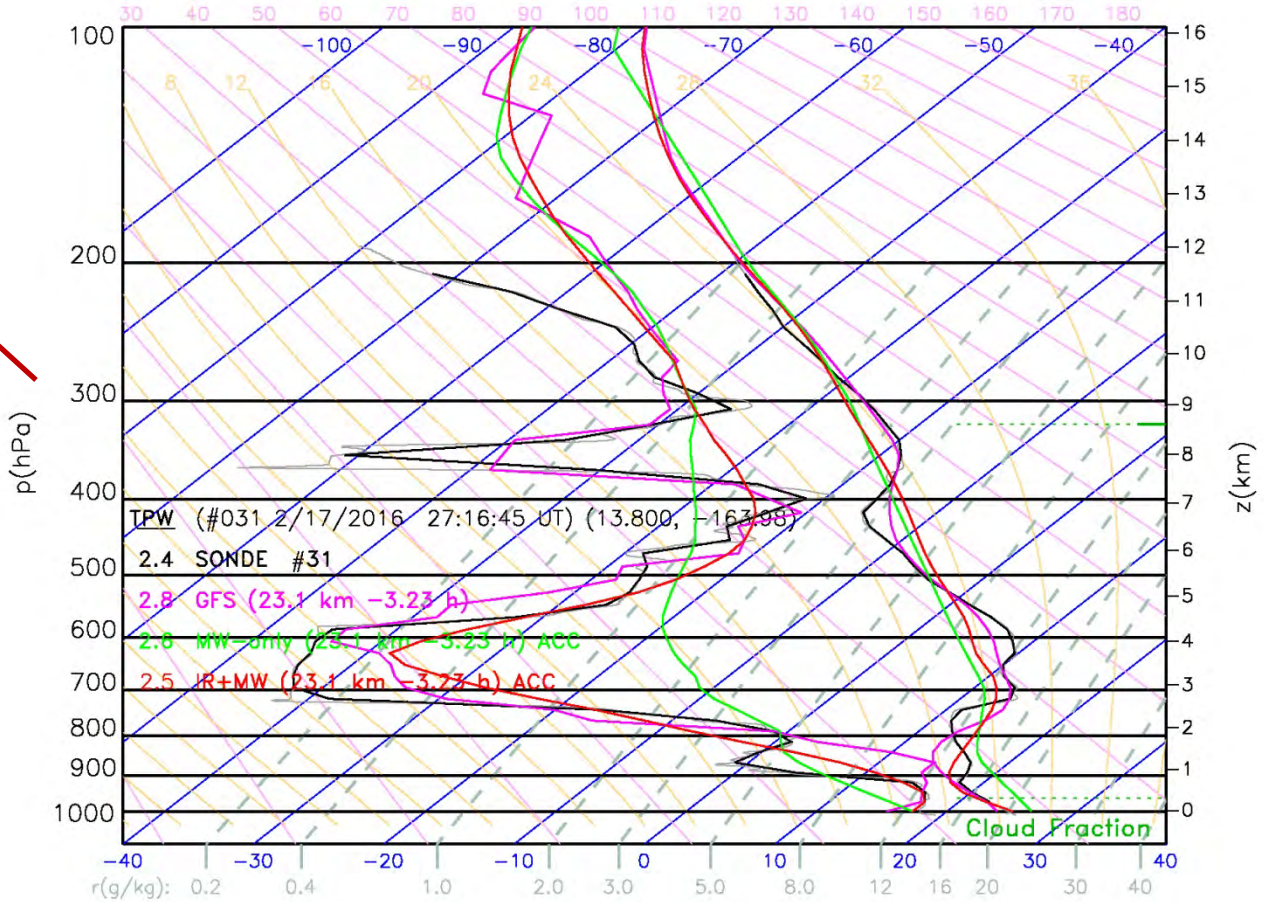
Again, vertical resolution of IR+MW tends to be better than MW-only



Feb. 17, Sonde #31: 3.2 hours after overpass time



But why did this case do so much better?



Specific research topics we will focus on

- Characterize algorithms in ocean regimes
  - Vertical resolution
  - Ability to see marine inversions, moist areas aloft
  - Improve our training: do statistics in user units (dew point)
- These data test our ability to see extremes
  - Moisture extremes along flight path
  - 2015/16 El Nino outside of NUCAPS training
  - Can test sensitivity to a-priori assumptions
- Support the scientific goals of the field campaign
  - Use satellite data to test skill of GFS on flight versus non-flight days
    - Is USA forecast sensitive to specific regions (e.g., ITCZ outflow)
    - What datasets could enhance skill.
  - Add NUCAPS to datasets that document 2015/16 El Nino
  - Use NUCAPS to help understanding of El Nino processes

Initiative #2 / 5

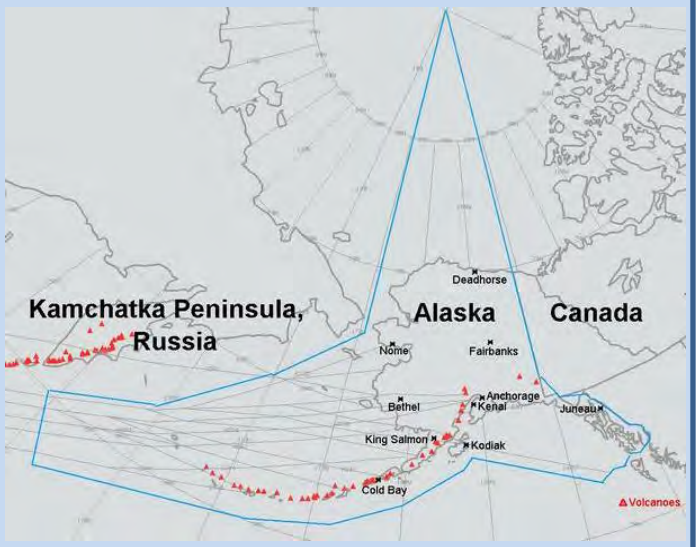
Aviation Weather Testbed: Cold Air Aloft

POC: Brad Zavodsky (NASA/SPoRT), Kristine Nelson (NWS/AR/ARS/CWSU/ANCHORAGE AK)

Aviation Weather Testbed
Cold Air Aloft

In Alaska, forecasters must rely on analysis and model fields and limited radiosonde observations (~4/day) to determine the 3D extent of the cold air aloft

- Airline fuel begins to freeze below -65 degC, need to issue pilot advisories
- Forecasters need to know spatial and vertical location of "bubble" of cold air aloft



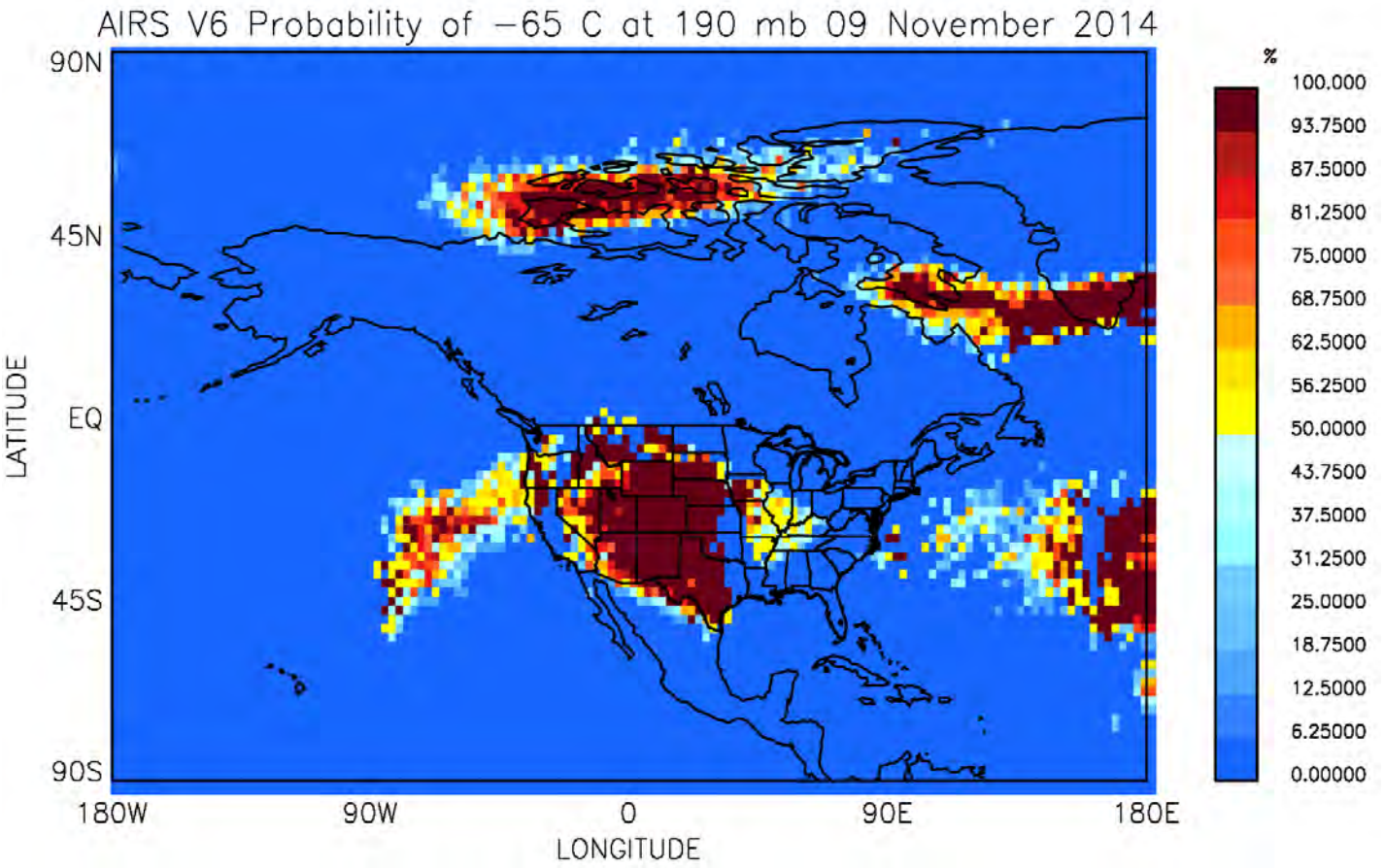
- Anchorage Flight Information Area (FIR) encompasses 2.4 square million miles
- Anchorage Airport was ranked 3rd worldwide for throughput cargo (90% of China to USA) and 1st in the USA for cargo poundage (5.9 Billion lbs)

Daily Cold Air Loft frequency of occurrence at 190 mbar

Used AIRS Level.2 Support Product

Counted occurrences of T(190mb) ≤ -65 degC in a 1x1 deg grid

Anchorage Center Weather Service Unit (CWSU) issued warnings on Nov. 11th to 14th



Analysis and graphics by C. Francoeur, STC

Summary of Aviation Weather initiative

- CrIS/ATMS easily sees the cold air aloft in our cross-sections and skew-T plots
  - Product has +/- 4 K differences f/GFS and is smoother
    - Vertical location can differ by ± 2000 feet (± 0.7 km)
    - Goal is to work with Alaska AWT/CWSU to develop better visualization of cold air aloft
    - Forecasters can account for biases
- GFS ingests CrIS and ATMS, is it good enough?
  - At 200 mbar many CrIS channels/scenes are used
  - Real time NUCAPS (8, 9.5, 11 and 20, 21.5, 23 Z) adds information between the model analysis times (0, 6, 12, 18Z) and gives forecaster more confidence

Initiative # 3 / 5

AWIPS-II NUCAPS training module & AWIPS improvements

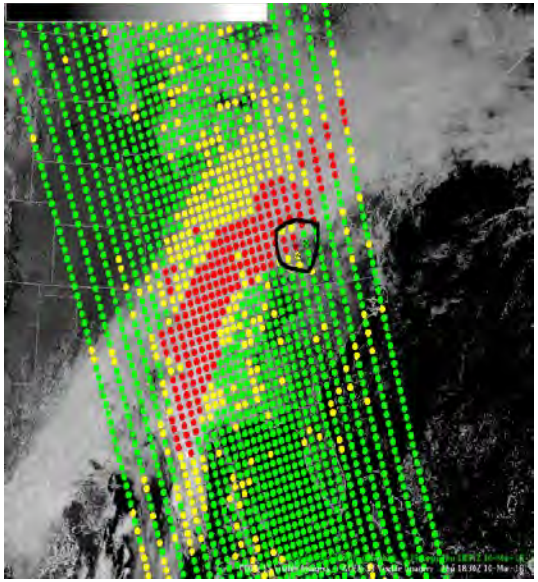
POCs: Brian Motta (NWS), Dan Nietfeld (SOO at Omaha WFO), Scott Lindstrom (CIMSS)

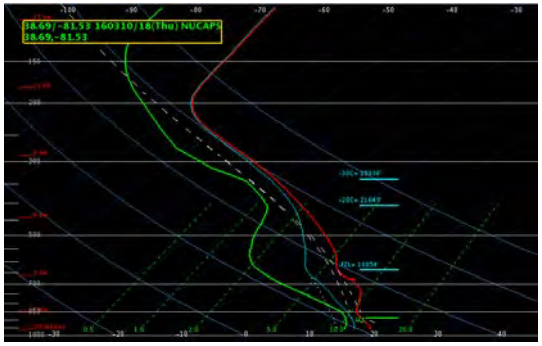
AWIPS-NUCAPS training module and improvements

- NUCAPS is now available in AWIPS-II (at ~100 WFO's)
  - AWIPS-II is visualization tool in USA forecast offices
- Articulated training modules can be viewed at:
  - https://www.youtube.com/watch?v=U-w6EBnOzb0
  - Describes that soundings are smoother than RAOBS
  - Illustrates how to modify NUCAPS to local conditions
- Forecasters have now asked for improved visualization
  - AWIPS "Plan View" and "Volume Browser" displays
- We learned that forecasters always make corrections soundings to local conditions.
  - led to a new JPSS sounding initiative (PI: Dan Lindsay, CIRA) to automate the correction process

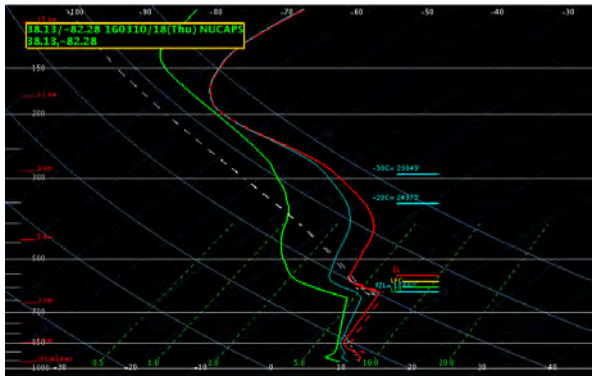
What NUCAPS looks like in AWIPS-II

- QC = Green (OK)
- QC = Yellow (Physical or regression ret failed)
- QC = Red (ATMS-only failed)

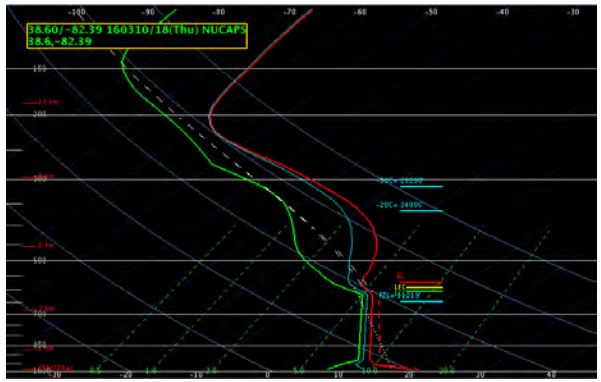




Green Scene



Yellow Scene



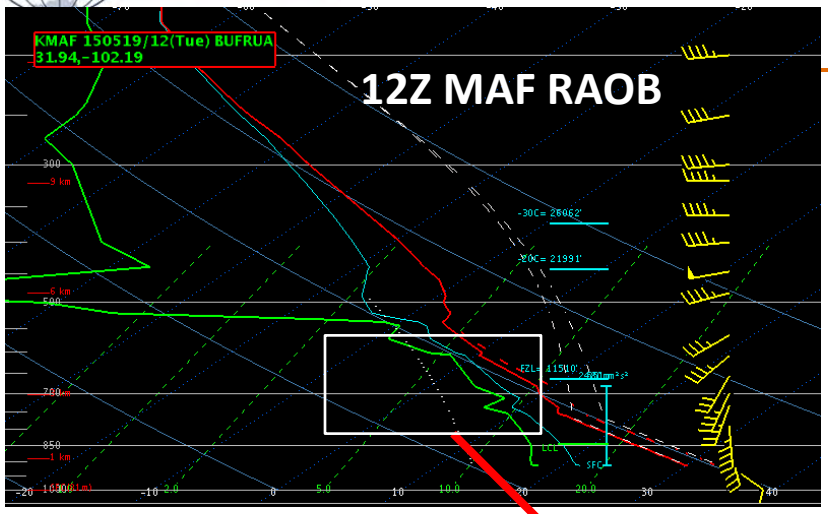
Red Scene

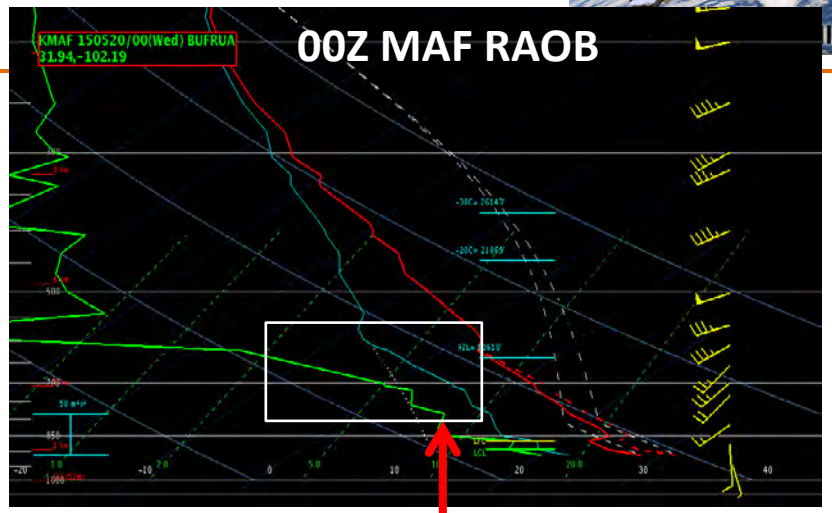
Initiative #4 / 5

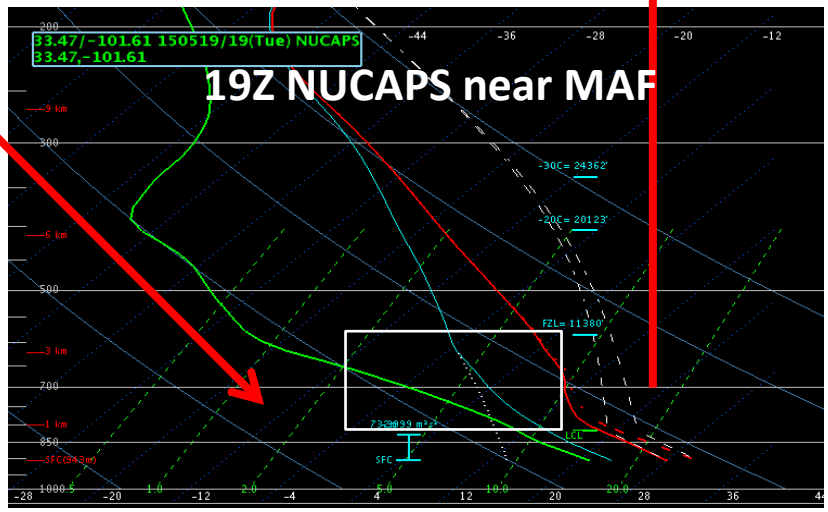
Hazardous Weather Testbed: 2015 Spring Experiment
Bill Line (NWS/SPC)

- Norman, Oklahoma (OK Univ./NOAA Facility)
- 5 NWS forecasters and 1 broadcaster ***per week***
  (**30 total**; and PI's)
- 5 weeks in May and June, 2015

Example Blog Post: "West Texas Soundings" May 19 – Midland, TX







"The drying of the air at 600-800 mb since 12Z is reflected by intermediate NUCAPS soundings."

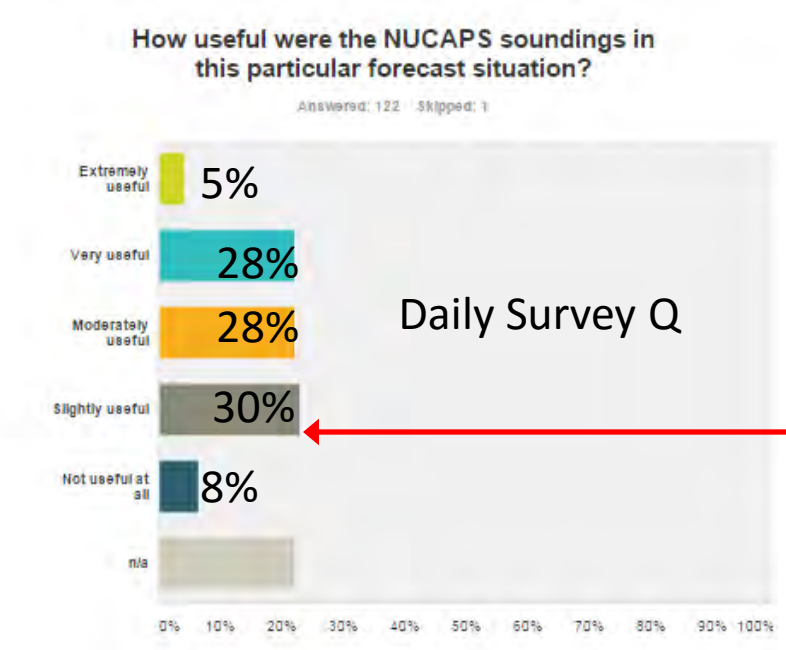
"Even if magnitude is off, drastic change and trend is significant & useful!"

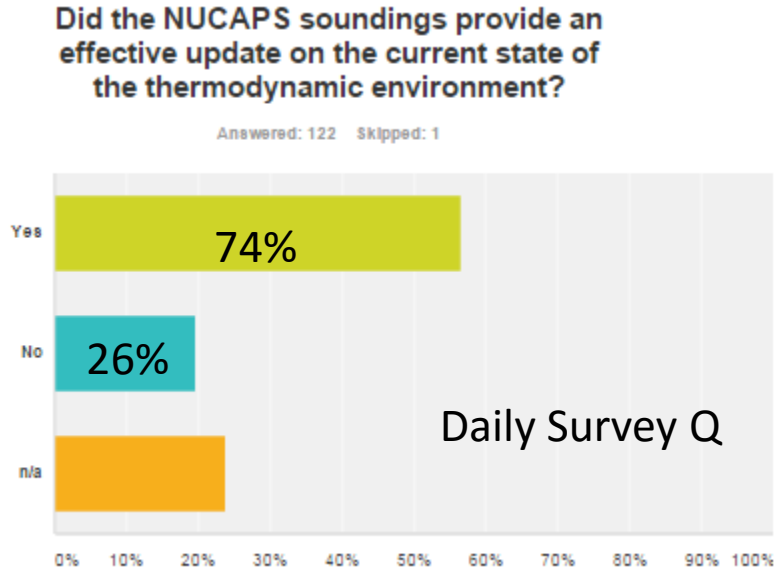
"The NUCAPS soundings are a good way to see changes in the airmass since the RAOB soundings have been taken."

Feedback from the 2015 HWT Spring Experiment

All participants answered that they understand the differences between space-based soundings and RAOBs

- Blog: http://goesrhwt.blogspot.com/search/label/NUCAPS
- "Tales" webinars: http://hwt.nssl.noaa.gov/ewp/
- Final Report: Coming soon





2016 Spring Experiment

- Will take place Apr. 18 through May 13, 2016
  - Enhanced developer/user interaction
  - Enhanced training
- Last week will coincide with Proving Ground User Readiness meeting in Norman OK
- Evaluate cross-section displays of NUCAPS
- Evaluate value of adding 9:30 orbit (NUCAPS-IASI)
- Evaluate computation of CAPE:
  - Evaluate subtleties of surface CAPE, mixing layer CAPE, maximum unstable CAPE, etc.

Initiative #5 / 5

NUCAPS Trace Gas Product Evaluation

POCs: Greg Frost (NOAA/ESRL/GSD),
Brad Pierce (NOAA/STAR)

NUCAPS Trace Gas Product Evaluation

- Initiative is based on 2 recently funded JPSS proposals.
  1. Greg Frost: “Understanding emissions and tropospheric chemistry using NUCAPS and VIIRS”
  2. Brad Pierce: “High Resolution Trajectory-Based Smoke Forecasts using VIIRS Aerosol Optical Depth and NUCAPS Carbon Monoxide Retrievals “
- Models are used to interpolate the sparse aircraft observations to the satellite temporal, spatial, and vertical sampling characteristics for detailed validation
- NUCAPS (and AOD f/ VIIRS) will be used within IDEA (Infusing Satellite Data into Envir. AQ Applications)

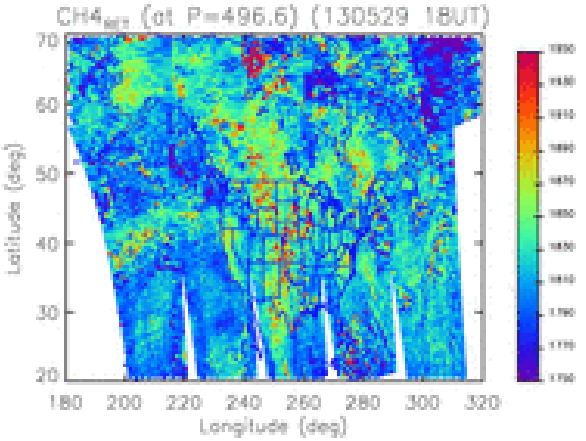
  http://www.star.nesdis.noaa.gov/smcd/spb/aq/

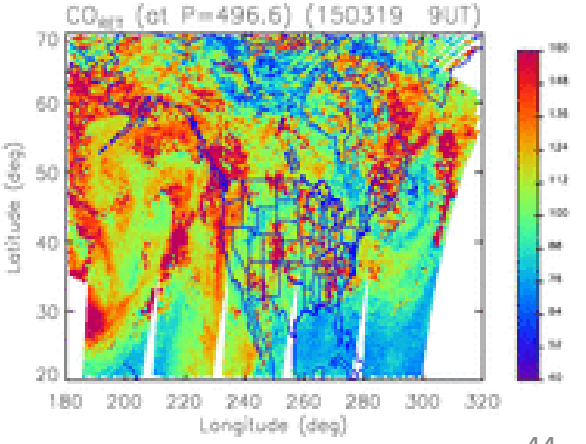
NUCAPS Trace Gas Product Evaluation

Hindsight Analysis: NOAA Field Campaigns

Note:
Ignored QC for graphics

- Senex: http://www.esrl.noaa.gov/csd/projects/senex
  - Senex ≡ Southeast Nexus
  - Summer 2013, SE USA
  - Focus on methane emissions associated with wildfires and unconventional nat'l gas operations in Texas and Pennsylvania
- Songex: http://esrl.noaa.gov/csd/projects/songnex/
  - Songex ≡ Shale Oil and Natural Gas Nexus
  - Spring 2015, Northwest USA
  - Begin with NUCAPS Carbon Monoxide
    - Requires full spectral resolution CrIS data
    - Use experimental version of NUCAPS
  - Also, methane emissions from oil and gas





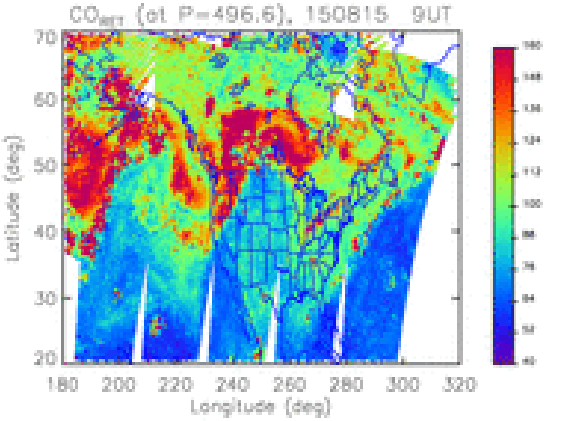
NUCAPS Trace Gas Product Evaluation

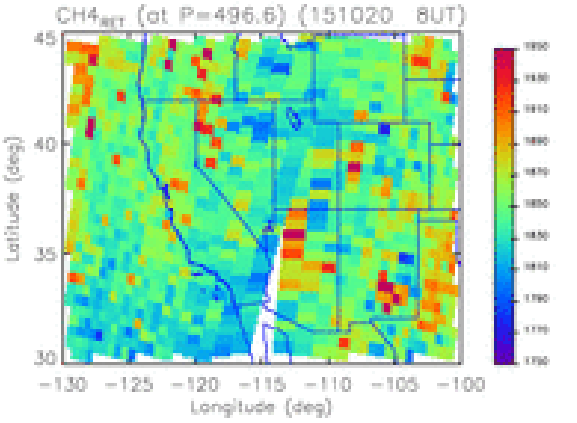
Sensitivity Analysis: Recent emissions

- Wildfire activity in western USA
  - Aug. 15-Aug. 31, 2015
  - Used as visualization demo for VIIRS AOD + NUCAPS CO blended products

    see: http://wms.ssec.wisc.edu/
- Recent methane leak from SoCalGas storage facility
  - Large leak at Aliso canyon storage facility, NW of Los Angeles
  - Began Oct. 23, 2015, sealed Feb. 18
  - released ≈50 t-CH_4/h in 1st 6 weeks
    - Local enhancements up to 25 ppm
  - Over 112 days released 97,100 t-CH4

Note:
Ignored QC for graphics



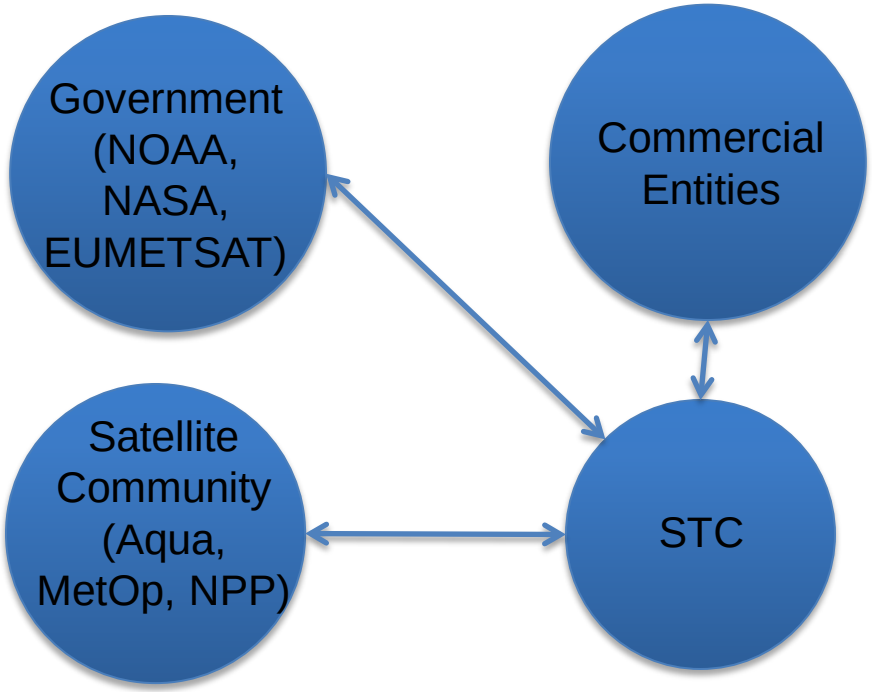


This is a mixture of validation and development of an application

- Thermal IR sounding of trace gases is a new application
  - Trace gases are now part of NOAA JPSS requirements
  - Users require averaging kernels (AKs)
- Users are fully engaged, using their own metrics
    - Spectral length analysis
    - Tracer-tracer correlations
- Working with users directly to tailor the products
  - Designing file formats to convey AKs
  - Working to improve characterization of products
    - Quality control

Example of a Potential Commercial Application

Drought Research at STC: Unique Position for R2O



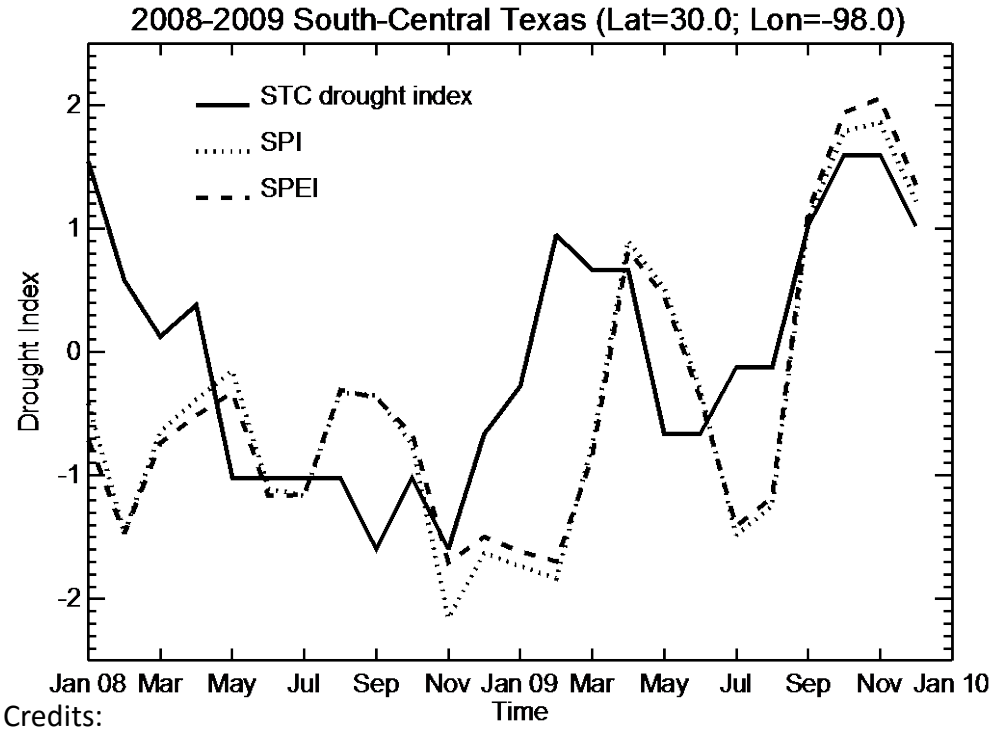
STC is positioned to contribute to the study of drought and develop decision aids for commercial users:

1. Investment in the science of drought
2. Broad connections with government and commercial satellite teams
3. Ability to market and distribute drought-related data and climate products to commercial entities

STC can act an as important link in the R2O chain by transitioning government developed drought products to the commercial world

- engage end-users to tailor products to their needs
- expand products to other platforms (international, commercial)
- include other products or resources
- maintain contractual obligations to those entities

Drought Research at STC: A Meteorological Drought Index



- STC is currently exploring commercial viability of a meteorological drought index developed for AIRS (Farahmand 2015 Sci. Report, next talk).
- The index can be extended to other hyperspectral satellite data, e.g., Metop-IASI, NPP-CrIS
  - use vertical information
- Incorporate multiple weather products which sample pre-drought conditions.
- Incorporate other data (e.g., wind speed) to improve robustness.
- Plan to study the global vs. regional skill in the drought index so as to direct future research.

Credits:

1. Farahmand, A., A. AghaKouchak and J. Teixeira 2015. A vantage from space can detect earlier drought onset: an approach using relative humidity. Scientific Reports v.5 10.1038/srep08553
2. NCAR/UCAR, 2013: Standardized Precipitation Index (SPI) for Global Land Surface (1949-2012). NCAR Computational and Information Systems Laboratory, Boulder, CO. [online at http://dx.doi.org/10.5065/D6086397.]
3. Vicente-Serrano S.M., Beguería S., López-Moreno J.I., 2010: A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. J. Climate 23(7), 1696-1718, DOI: 10.1175/2009JCLI2909.1.

Summary

- I have not yet crossed “the valley of death”
- I am certainty within the valley
  - My Jeep tires have big chucks cut out due to traversing the lava beds
  - I am beaten up by the bumpy ride
  - Jeep radiator is hot, gas and drinking water is low
  - Pretty sure I know my way out, but I’ve got to admit the vultures circling above me are of concern
- Navigating the world of NASA/NOAA/Commercial is still a big challenge that is undefined
  - Commercial could be a huge departure from our NASA/NOAA model.

THANK YOU!

QUESTIONS?

Acronyms

- AIRS = Atmospheric Infrared Sounder
- AMSU = Advanced Microwave Sounding Unit
- AR = Atmospheric River
- ATMS = Advanced Technology Microwave Sounder
- AVHRR = Advanced Very High Resolution Radiometer
- AWIPS = Advanced Weather Interactive Processing System
- AWT = Aviation Weather Testbed
- CrIS = Cross-track Infrared Sounder
- CIMMS = Cooperative Institute for Mesoscale Meteorological Studies
- CIMSS = Cooperative Institute for Meteorological Satellite Studies
- CSPP = (CIMSS) Community Satellite Processing Package
- CWA = (NWS) County Warning Area
- CWSU = (FAA) Center Weather Service Unit
- EUMETSAT = EUropean organization for exploitation of METeorological SATellites
- FOV/FOR = Field Of View/Regard
- GFS = (NCEP) Global Forecast System
- GSFC = (NASA) Goddard Space Flight Center
- HMT = Hydrometeorology Testbed
- HSB = Humidity Sounder Brazil
- HWT = Hazardous Weather Testbed
- IASI = Infrared Atmospheric Sounding Interferometer
- JPSS = Joint Polar Satellite System
- METOP = METeorological Observing Platform
- MHS = Microwave Humidity Sensor
- MODIS = MODerate resolution Imaging Spectroradiometer
- NASA = National Aeronautics and Space Administration
- NCEP = National Centers for Environmental Prediction
- NESDIS = National Environmental Satellite, Data, and Information Service
- NHC = (NCEP) National Hurricane Center
- NOAA = National Oceanographic and Atmospheric Administration
- NPP = National Polar-orbiting Partnership
- NWP = Numerical Weather Prediction
- NWS = National Weather Service
- NUCAPS = NOAA Unique CrIS/ATMS Processing System
- OPC = (NCEP) Ocean Prediction Center
- OSPO = (NESDIS) Office of Satellite and Product Operations
- SOO = Science Operations Officer
- SPC = (NCEP) Storm Prediction Center
- SPoRT = (NASA) Short-term Prediction and Research Transition Center
- STAR = (NESDIS) SaTellite Applications and Research
- STC = Science and Technology Corporation
- UMBC = University of Maryland, Baltimore County
- VIIRS = Visible Infrared Imaging Radiometer Suite
- WFO = (NWS) Weather Forecast Office
- WPC = (NCEP) Weather Prediction Center

Access to Satellite Data

- Normal operational downlink occurs through Svalbard Norway antenna (78d 14' N, 15d 24'E)
  - Latency for radiances to NWP and soundings to AWIPS is ~3 hours
  - Latency of soundings via NOAA/CLASS archive is ~1-2 days
- S-NPP also supports ***direct broadcast (DB)*** via 15 Mbps X-band antenna
  - We have an receiver in Honolulu
  - We have another receiver at Oregon State Univ, Corvallis Oregon
- Antenna can "see" satellite for ~1000 km radius
  - Latency of ~20-30 minutes for both radiance and soundings

DB receiver antenna atop the roof of the Honolulu Community College , Honolulu, HI

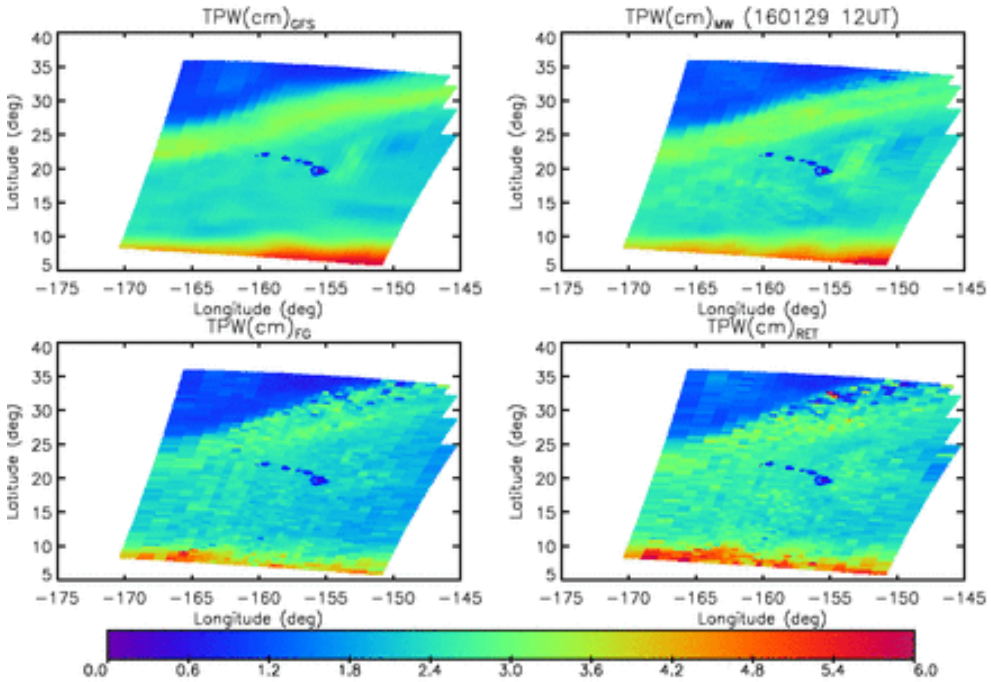
With Mitch Goldberg, S-NPP project scientist

NUCAPS Satellite Soundings

- NOAA-Unique Combined Atmospheric Product System (NUCAPS) provides 324,000 soundings per day
  - Exploits both microwave and infrared instruments to produce many atmospheric and surface products
    - Primary products are temperature and moisture profiles
    - Provide cloud and surface products
    - And trace gas products (O3, CO, CH4, CO2, SO2, HNO2, N2O, NH3)
  - NUCAPS exploits a technique known as cloud clearing to utilize infrared observations in partially cloudy regimes.
    - Accepted high quality retrievals over ~70% of the globe
  - A general introduction to satellite remote sounding and NUCAPS can be found by clicking here
- We are using the NUCAPS science code to support the El Nino Rapid Response Campaign
  - Enables full diagnostic capability
  - Can perform special processing and re-processing
  - Algorithm can be configured to be equivalent to any version of the operational system

NUCAPS DB Soundings

- Example coverage of DB at 1:30 am (1:30 HT, 6:30 EST, 11:30 UT) for Total Precipitable Water (TPW) computed by integrating our moisture profile
- Upper left is GFS forecast interpolated in time and space to satellite obs
- Upper right is our ATMS-only microwave product
- Lower left is an intermediate statistical retrieval product.
- Lower right is our final CrIS+ATMS product



Example of GFS and the 3 types of *real time* NUCAPS retrievals. Image "blinks" between QC-on and QC-off.

Be very careful when looking at data without QC. Our microwave retrieval (MW) fails dramatically in precipitating conditions and the infrared (FG and RET) fails dramatically when cloud spatial structure is uniform

A bit more information on the 3 different retrieval steps

- The microwave-only retrieval uses all 22 channels of ATMS to solve for profiles of T(p), q(p), cloud liquid water, and surface properties (skin temperature and spectral emissivity).
  - It fails in precipitating regions
- The statistical first guess is a constrained least squares fit between CrIS & ATMS measurements and ECMWF
  - Focus Days are: 6/18/2014, 9/15/2014, 12/20/2014, 3/21/2015
  - It is a static file that is used for the entire mission
  - It is the a-priori for the physical retrieval
- The final physical retrieval step uses both CrIS and ATMS to retrieve T(p), q(p), profiles of trace gases, skin temperature, spectral emissivity, cloud height and fraction, and cloud cleared IR radiances.
  - We employ a sequential approach with minimal dependence on external a-priori information.
  - The only non-satellite dynamic information is surface pressure from the GFS
    - terrain corrected using a static DEM

NUCAPS sees "snapshot" of entire field campaign domain

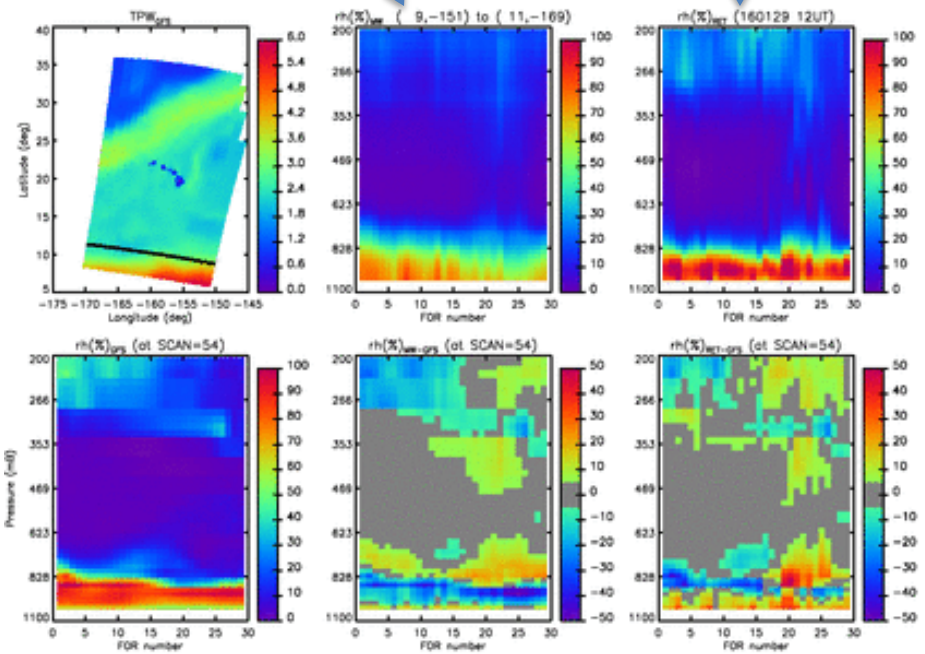
- A NUCAPS "scanset" is acquired in 8 seconds
- A "scanset" consists of 30 retrievals covering a ~2200 km wide swath
- ~100 scansets are typically acquired per overpass of a DB station
- These retrievals reveal structures many hours in advance of a model analysis (*i.e.*, CrIS/ATMS are not ingested yet)
- Differences shown in lower panels could be due to retrieval errors or GFS errors

NUCAPS Microwave RH Retrieval cross section along scanset shown as black-line in top left figure. Insensitive to non-precipitating clouds

NUCAPS Microwave + Infrared RH retrieval along same scanset. More sensitive to clouds but higher vertical resolution

GFS TPW Jan. 29, 2016 Co-located to 8 minutes of NPP data

GFS RH cross section (along scanset indicated on top left



Again, beware of data shown without QC

NUCAPS Microwave retrieval – GFS

NUCAPS Microwave + Infrared retrieval – GFS

How GFS in interpolated

- We use the satellite observing time to select 2 GFS files. Here are the pairs used

Table 3.3: AVN truth table

	0z	3z	6z	9z	12z	15z	18z	21z
index	0	1	2	3	4	5	6	7
anal #1	18z	00z	00z	06z	06z	12z	12z	18z
fcst #1	F06	F03	F06	F03	F06	F03	F06	F03
anal #2	18z	00z	00z	06z	06z	12z	12z	18z
fcst #2	F09	F06	F09	F06	F09	F06	F09	F06

- For example, at 23:30 UT we would use the 3 and 6 hour forecast from the 18z analysis.
  - The next orbit to the west at 1:00 UT would use the 6 and 9 hour forecast from the 18z analsis
  - Both of these would be shown on my maps

Our Skew-T plots

- We do our best to emulate traditional skew-T's but we needed to modify the figures because
  - Need to embed it into our satellite processing system
  - Our sounders do not measure wind speed or direction so we cannot include that information
  - We derive cloud top pressure and infrared cloud fraction (derived at 15 microns)
  - We can also derive CAPE, Lifting Index and other stability indices, but these are not currently shown on the plot.
- We want to display dropsonde at both full vertical sampling and also at the same sampling as our retrievals (~50 levels from 100 to 1000 hPa)
  - A thin grey line shows the full vertical sampling, thick black line is smoothed sampling
  - Sonde label shows sonde # (same as on map), sonde date and time, average latitude, longitude of the sonde
- We want to inter-compare dropsonde, GFS, and our accepted retrievals
  - Label shows spatial and temporal displacement from the sonde
  - Accepted retrievals (label="ACC") are spatially displaced from the dropsonde and might also be different locations for the microwave (MW) and infrared (IR+MW) retrievals
    - Displacement in time and space is shown in parenthesis
  - Sometimes there will be 2 GFS soundings shown – one for the MW-only and one for the IR+MW, if the locations are different
    - We use the pair of GFS profiles to estimate how much of the difference between MW-only and IR+MW retrievals is due to spatial differences

Annotated example of our skew-T plot

Dry adiabats ($T_0(\rho/\rho_0)^\kappa$, are shown as faint solid magenta for T_0 = 30 to 180 C (10 C steps)

Moist adiabats are shown in faint solid gold lines for T_0 = 8 to 36 C, 4 C steps

Grey line: full vertical sampled dropsonde

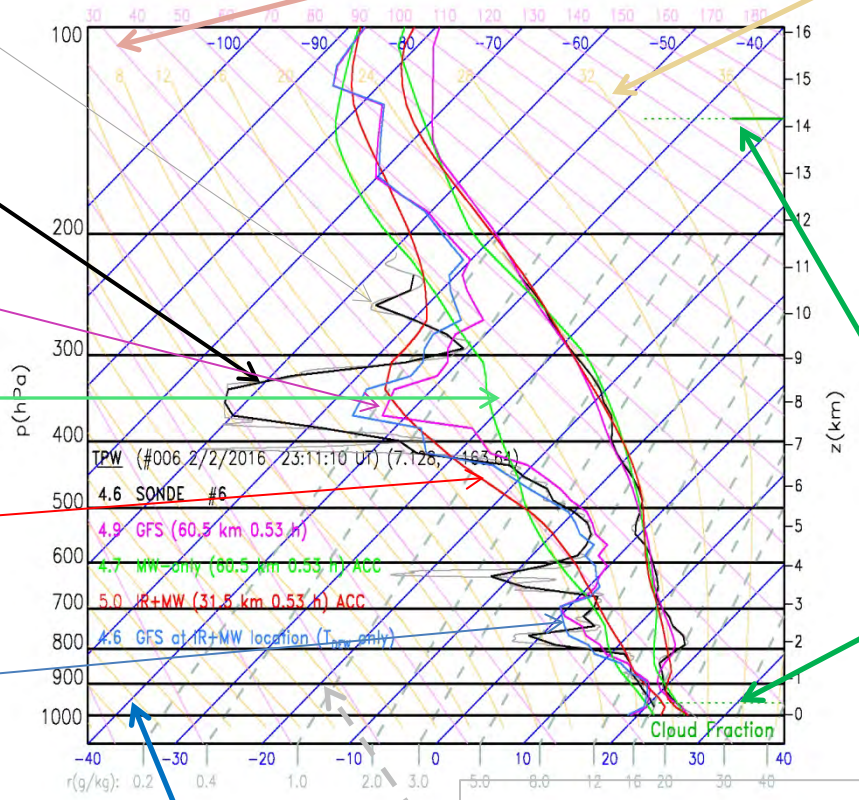
Black line: smoothed dropsonde

Magenta line: GFS at MW-only retrieval location and time

Green line: MW-only retrieval

Red line: IR+MW retrieval

Cyan line: GFS at IR+MW retrieval location if it is different than MW-only location



We show green line(s) at the cloud top pressure where the ratio of the solid to dashed lines is the cloud fraction over our 50 km footprint.

In this scene we identified 2 cloud layers:

Top cloud layer is at ~130 hPa (14.1 km) with ~40% cloud cover

Lower cloud layer is at 970 hPa (0.4 km) with negligible cover

Isotherms are in solid blue in degC

Temperature of saturation shown for saturation mixing ratios (0.2 to 40 g/kg) are in faint blue/purple dashed lines

Future Plans for NUCAPS
and
The Path Forward

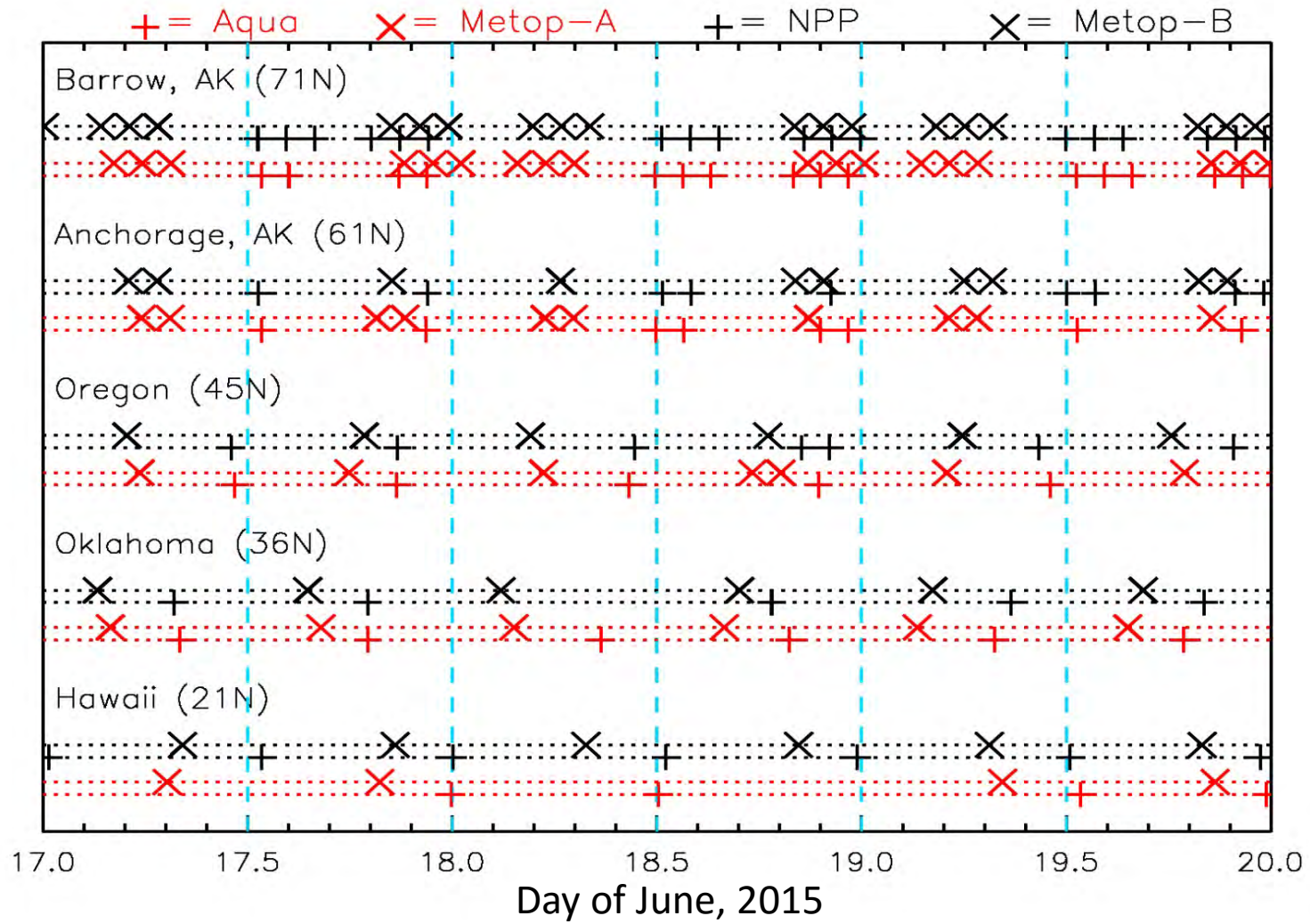
A number of funded initiatives with a NWS modeling focus

- Much of the NUCAPS retrieval skill comes from use of cloud cleared radiances (CCRs)
  - Jun Li (CIMSS) is doing a study of using NUCAPS CCRs
    - Hindsight analysis of H. Sandy (2012) and Typhoon Haiyan (2013)
  - John LeMarshall (Bureau of Met., Australia) also doing a study with JCSDA of impact of NUCAPS CCRs
  - Andrew Collard (NCEP) looking at using our algorithm directly (compute CCRs from CrIS radiances using model background)
- Emily Berndt (SPoRT) investigation of NUCAPS T(p), q(p), and O3(p) to study extratropical transition of hurricanes
  - Migrate AIRS/SEVIRI product to NUCAPS O3 with VIIRS RGB
  - conduct a product demonstration and assessment with the NHC, WPC, OPC forecasters
- Galina Chirokova (CIRA) will investigate use of VIIRS and NUCAPS to improve moisture flux estimates.
  - Detection of dry air intrusions are important for TC forecasting

Future Plans
The way forward

- Metop-A & B NOAA IASI/AMSU/MHS retrievals into AWIPS-II
  - Same algorithm as NUCAPS, but 4 hours earlier
- Metop-A & B NOAA IASI/AMSU/MHS retrievals into CSPP direct broadcast
  - In work, should be operational in mid-2016
- Unfortunately, AIRS is not in the operational flow at NOAA (it is a NASA product)
  - We are considering putting it into CSPP (FY2017)

Constellation of satellites allows more observations between 0Z & 12Z RAOBS



NPP/J-1 will be phased similar to Metop-A/B approx. 6 months after launch of J-1

(Used Aqua as proxy for J-1 in plot)

These are overpasses with satellite elevation > 32 deg (all FOR's)