Summary and Status of the JPSS Initiatives

Presented by: Chris Barnet
Science and Technology Corporation

With contributions from: Mitch Goldberg (JPSS), Antonia Gambacorta, Nadia Smith, Jonathan Smith, Jim Davies (SSEC), Tom King (STAR), Bill Sjoberg (JPSS),
and many more

2016 STAR JPSS Annual Meeting, NCWCP Bldg.
Wednesday, Aug. 10, 2016 (Session 6, 13:20)

My focus: application dependent characterization of NUCAPS

- NOAA is investing in a number of JPSS Sounding Initiatives
  - Goal is to demonstrate new applications with S-NPP
    - Focus is on applications with high societal value
    - These are not the "easy" applications
  - 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. NUCAPS in AWIPS-II: training & improvements
  2. Aviation Weather Testbed (AWT): Cold Air Aloft (N.Smith was 11:00, this session)
  3. Hazardous Weather Testbed (HWT): Convective Initiation (Next talk: Bill Line)
  4. Hydrometeorology Testbed (HMT): Pacific field campaigns
  5. Carbon Monoxide and Methane evaluation (Session 11: A. Gambacorta, N.Smith, B. Pierce, G. Frost)
  6. Use of NUCAPS in NWP applications (G. Chirokova, was 11:45, this session)

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 early 17th century
  - I lived and hiked in this region for ~10 years
    - This is my analogy of “the valley of death” our products need cross

Initiatives directly support JPSS end-to-end Science Approach

- See Mitch Goldberg's Session.1 talk for more details
- These activities specifically address:
  - Algorithms & Cal-Val
    - **Develop algorithms** that meet requirements
    - Develop **tools to visualize /validate the products**
    - **Characterize the product**, understanding and correcting outliers
    - Provide science and R2O **maturity artifacts** (Enterprise Life Cycle)
    - Campaigns for **unique validation opportunities**
  - User Readiness
    - Projects to that lead to **improvement in NOAA products**
    - PG Initiative Process for **improved user interactions** (HWT, HMT testbeds)
    - Training on **how to best use our products** in key applications
  - Science
    - To **meet user needs** (*e.g.* understanding/documenting the 2015/16 El Nino)
    - Use of Direct Readout to test new algorithms or to further **reduce latency**

The JPSS initiatives: a recipe for validation and R_2O

- Put yourself in the user's environment
  - Listen to exactly how they interpret the data
    - This requires institutional knowledge of their application
      - *e.g.*, 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”
    - The answer will depend on the application
- The sounding community assumes retrievals would be useful 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 a mean slightly above zero.
      - Small biases (due to a-priori) can obliterate impact
    - We need to efficiently convey our vertical co-variance and minimize our biases

Initiatives have led to potential improvements to NUCAPS

- Forecasters preferred that NUCAPS **remain independent of models**
  - expressed concern when I said we were considering using model as a-priori
- We could **improve our surface parameters** with additional measurements
  - Could use the NASA MEaSURES MODIS/ASTER emissivity climatology (Borbas, SSEC)
    - Should improve NUCAPS lower tropospheric soundings **over land**
  - Retrieval optimization:
    - Forecaster observation worked well dry regions (did not need correction)
    - Implies that we need to re-look at surface sounding channel selection
    - Maybe employ NASA AIRS SW/LW surface methodology – **may improve moist scenes**
- We need to **improve our quality control** (QC)
  - Original QC was developed to demonstrate that we met requirements
    - Some "green" scenes are bad, some "red" scenes are good
  - We need QC that is tailored for AWIPS application
    - Even where our performance is marginal, these data might have unique value
- Explore **other forms of visualization**
  - Could we display NUCAPS cloud retrieval (height, amount) on the skew-T?
  - Line width or colors could reflect accuracy (larger errors below cloud levels)
  - Some indication (on skew-T or in 1 page user guide) of vertical resolution
    - Provide guidance on whether or not we see capping inversions, etc.

Initiative # 1 / 5

AWIPS-II NUCAPS training module & AWIPS improvements

POCs: Brian Motta (NWS), Dan Nietfeld (SOO at Omaha WFO, now OAR/ESRL/GSD),
Scott Lindstrom (CIMSS)

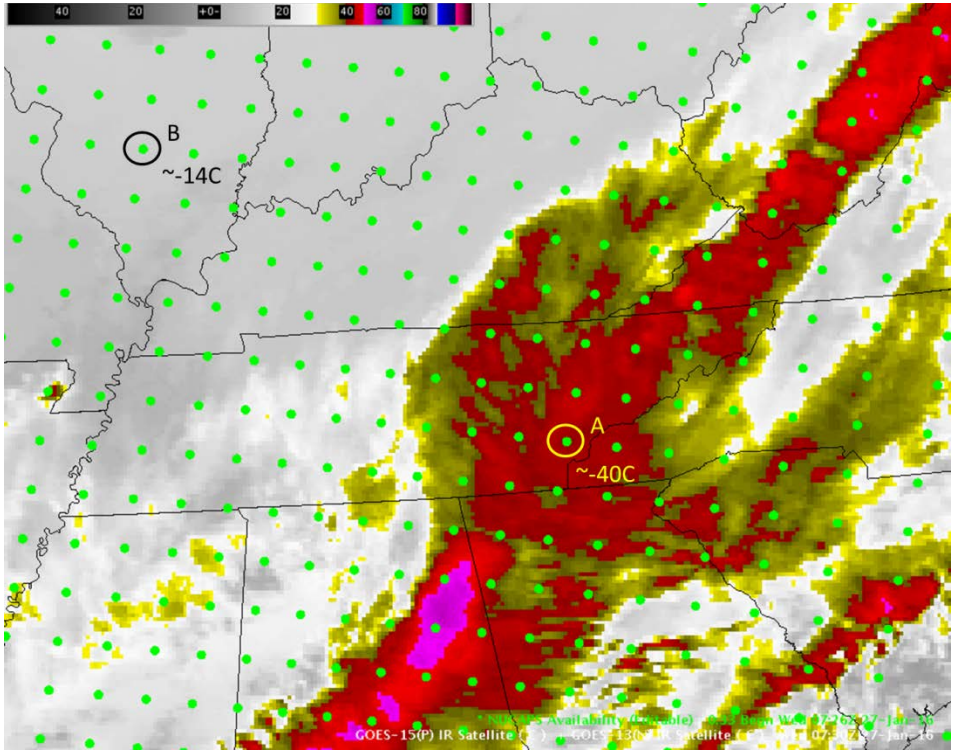
AWIPS-NUCAPS training module and improvements

- 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:
  - http://cimss.ssec.wisc.edu/goes/goes-r/training/recordings/NUCAPS/player.html (click here)
  - Describes that soundings are smoother than RAOBS
  - Illustrates how to modify NUCAPS to local conditions
- Forecasters have evaluated improved visualization
  - AWIPS "Plan View" and "Volume Browser" displays
- We learned that forecasters always make corrections of soundings to local conditions.
  - led to a new JPSS sounding initiative (PI: Dan Lindsay, CIRA) to automate the correction process

An Example:
An e-mail exchange with Kris White,
(Huntsville WFO)
and discussion with Kathryn Shontz,
(JPSS program (now OSGS))

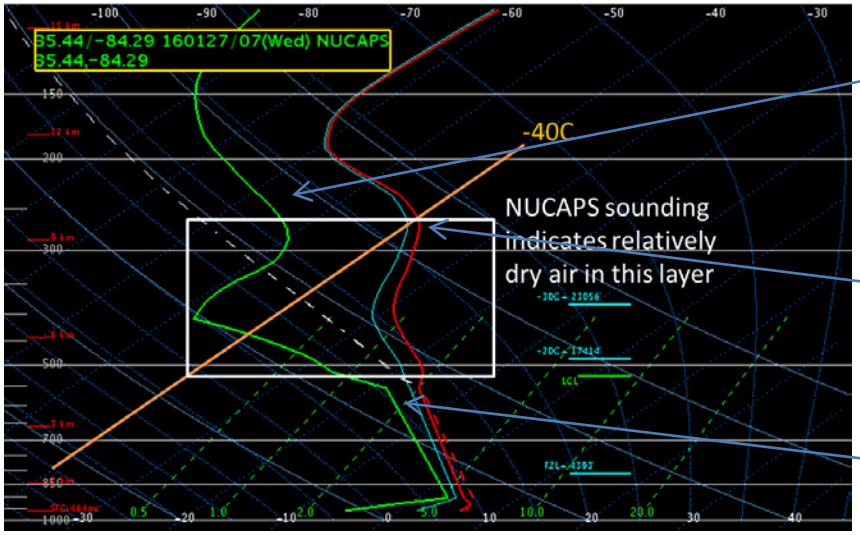
GOES 10.8 µm image
Jan. 27, 2016, ~7:30 UT

- Red region is ~-40 degC BTs, location of sounding “A”
  - Probably cirrus blowing off of tops of severe convection (purple region) SE of Huntsville
- Location “B” has ~-14 degC BTs
  - Most likely lower level
- Gold colored clouds are probably intermediate levels of convection.



Sounding "A"

- Original question: Why does NUCAPS show dry layer at -40 degC level?



There is a moist level at 9 km (300 hPa)

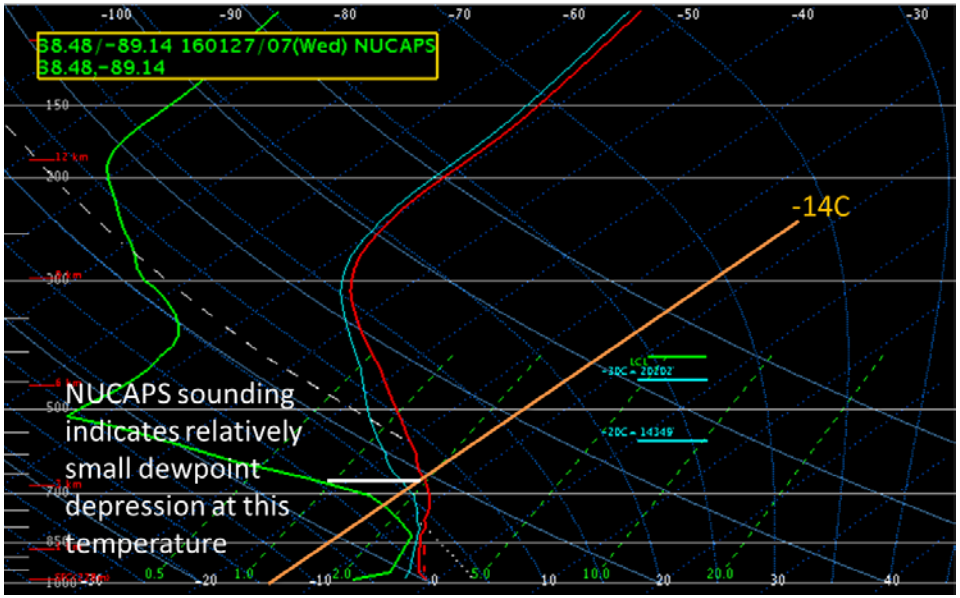
-40 degC corresponds to local maximum in T(p) and minima in q(p)

Bottom cloud top (top of saturation) is closer to -20 degC

- Our interpretation:
  - Diagnostics shows that this case is rejected, extremely cloudy: ~75% in FOR (60-85% in FOVs) at 230 hPa and ~20% at 600 hPa (15-40%)
  - NUCAPS is relatively insensitive to the upper cirrus cloud
    - probably too thin or very cold, easy to cloud clear
  - NUCAPS is significantly different than GFS in this region (not shown)

Sounding “B”

- Where location “B” is consistent with GOES image, top of cloud ~-14 degC



- The amount of cloud is less important than the spatial variability and thermal contract (difference between cloud temperature and surface (or lower cloud deck) temperatures.
- Comparisons to the microwave product would be valuable within the forecasting environment.

  - NUCAPS case is also extremely cloudy, but upper cloud deck is thin (~0% at 230 hPa and lower cloud deck is overcast 100% at 670 hPa (not variable)
    - This case probably should have been rejected, but wasn’t

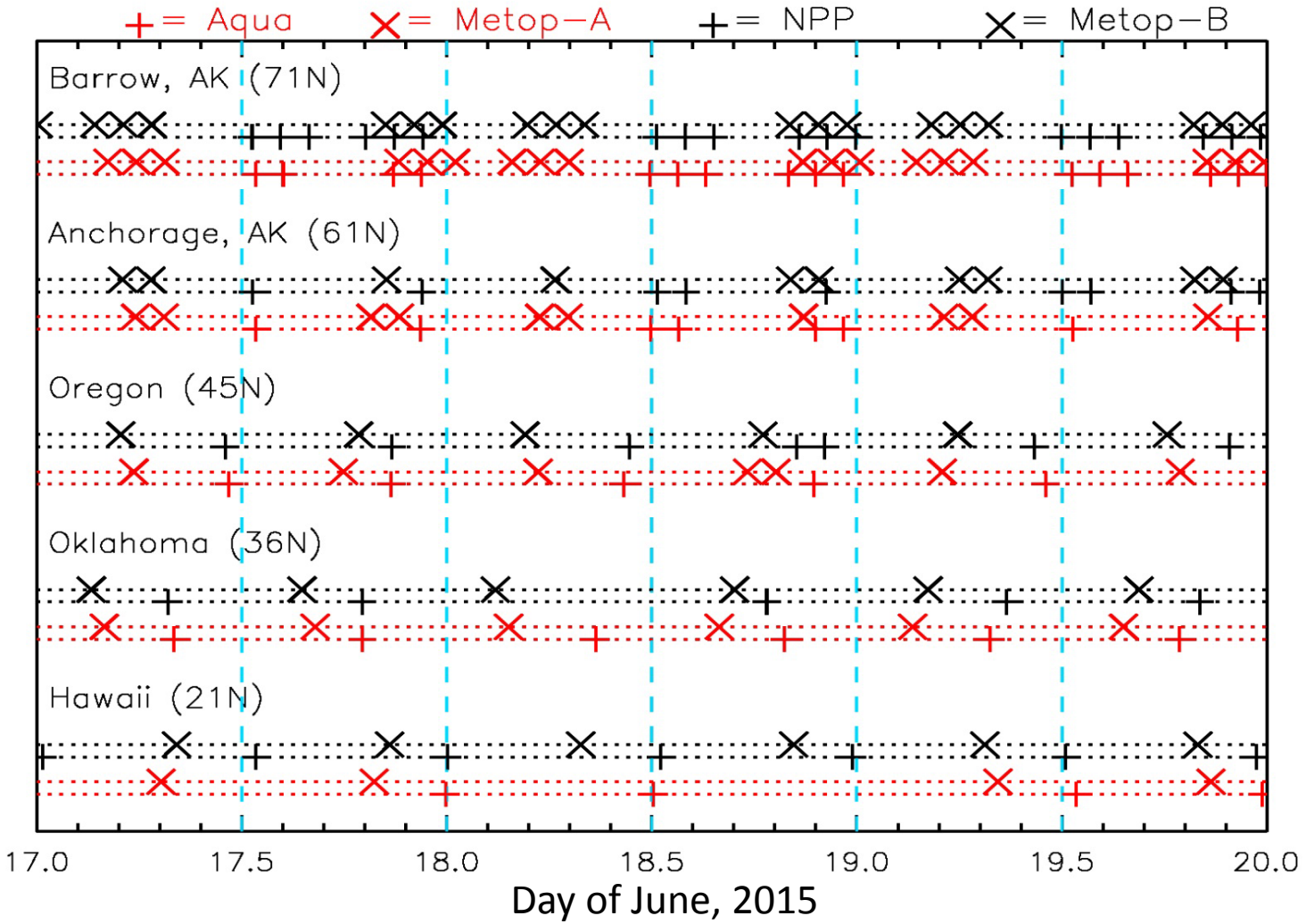
Why is this discussion important?

- Focusing on individual cases helps to illustrate the strengths and weaknesses of NUCAPS
  - Comparison of NUCAPS retrievals (or high resolution IR spectra) with broadband images requires some care
- Interaction between forecaster and developer leads to a better understanding of both imager and sounder information
  - It is always surprising to me (as a developer) how NUCAPS is actually used and, in this case, compared (*e.g.*, to imagers)
  - ***These cases rely more heavily on ATMS***
    - We need to evaluate these cases for CrIS-only systems
      - important given issues with ATMS
      - These kinds of cases are extremely valuable
  - ***Should be used as training examples***
  - Should be used to tailor and improve NUCAPS
    - Understanding these cases are more important to the user than global statisics
  - ***Important to retain and reprocess these cases for verification*** of future upgrades

Future Plans for AWIPS

- NUCAPS-Metop-A & B NOAA IASI/AMSU/MHS retrievals into AWIPS-II
  - Same algorithm as CrIS/ATMS, but 4 hours earlier
  - Version for CSPP direct broadcast is in work,
    - should be operational in mid-2017
- Unfortunately, NUCAPS-AIRS/AMSU is not operational at NOAA (it is a NASA product)
  - It is run-able within the science code.
  - We are considering putting it into CSPP (FY2018)

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)

Initiative #2 / 5

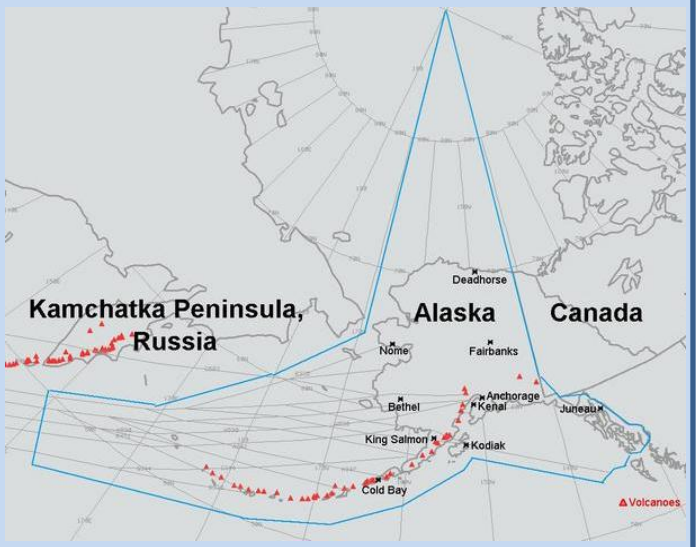
Aviation Weather Testbed: Cold Air Aloft

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



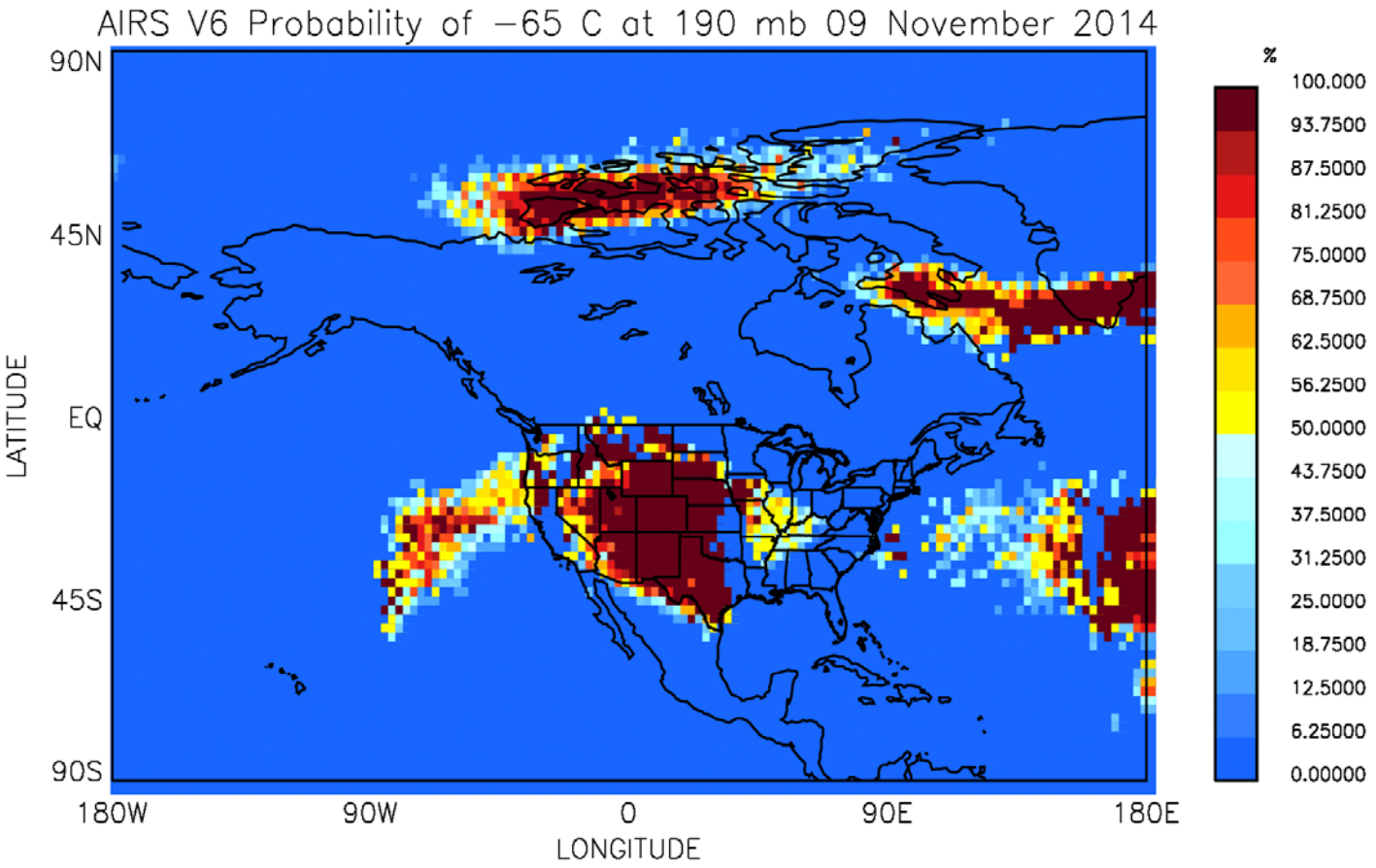
- Anchorage Flight Information Area (FIR) encompasses 2.4 square million miles
- Anchorage Airport was ranked 3rd worldwide for throughput cargo (90% of China to USA) and 1st in the USA for cargo poundage (5.9 Billion lbs)

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
- We are investigating if the large areas of cold air aloft off the west USA coast (Hawaii flight track) is important
  - We believe it is real, the tropopause dips down
- 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

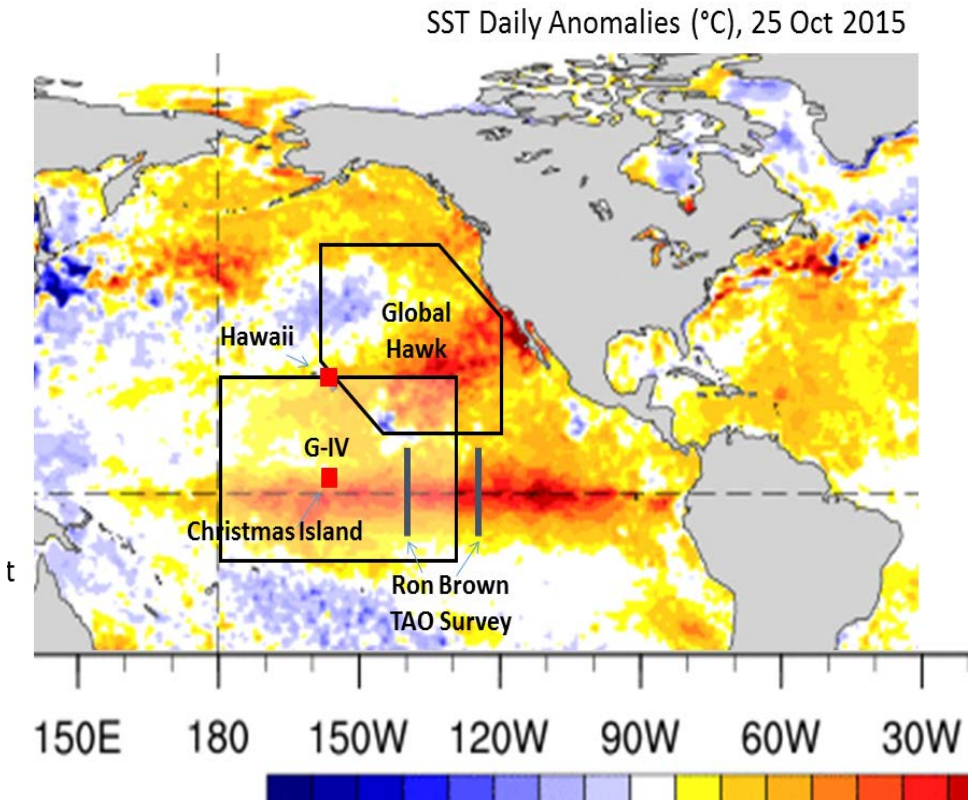
Hydrometeorology Testbed: El Nino Rapid* Response Field Campaign

* Campaign went from white paper proposal to implementation in less than 2 months

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

Planned Implementation Strategy

- Gulfstream-IV: Divergent outflow and jet extension processes in central and eastern tropical Pacific
- Global Hawk: 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



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

- NOAA G-IV deployed from Honolulu International Airport
  - Twenty-two 8-hour flights, Jan. 21 through 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)
  - 55-63,000', ~65 dropsondes/flight
- 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)

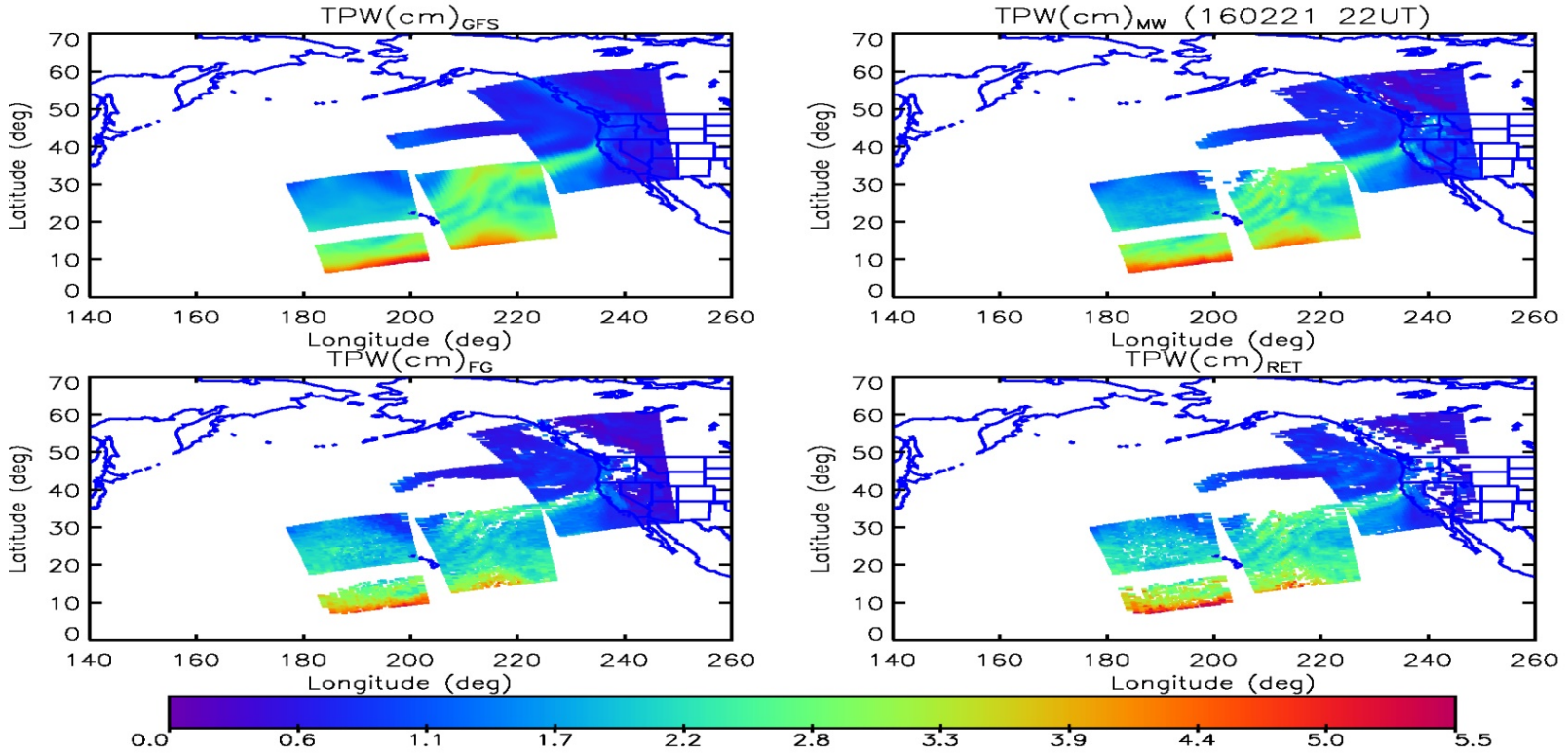
For more information, see field campaign website:
http://www.esrl.noaa.gov/psd/enso/rapid_response/

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 flight forecasters during the planning telecon
  - Process 1:30 pm overpass (~0:30 UT, 14:30 HST, 19:30 EST)
    - Provide scientists an in-flight snapshot at proposed dropsonde locations
- Use archive data (~24 hours later) to re-process entire Pacific domain and provide comparison between retrievals (MW-only and IR+MW), co-located GFS, and dropsondes
  - 1st comparison of dropsondes and satellite sounding
    - Valuable for next days flight planning discussion
    - Capture meta data for campaign archive
  - Employed NUCAPS science code to provide addition diagnostics

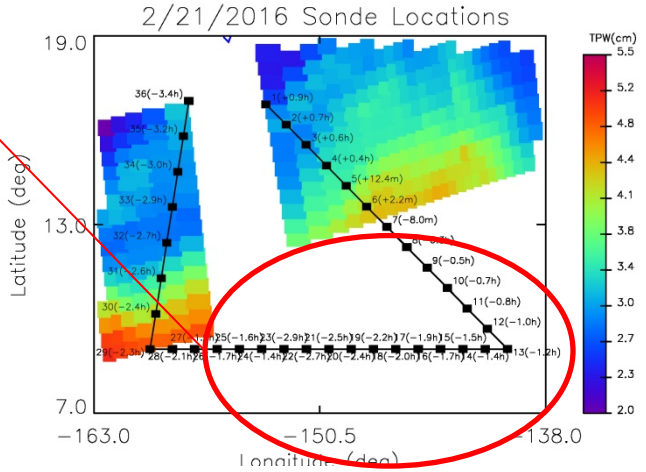
Example of DB coverage

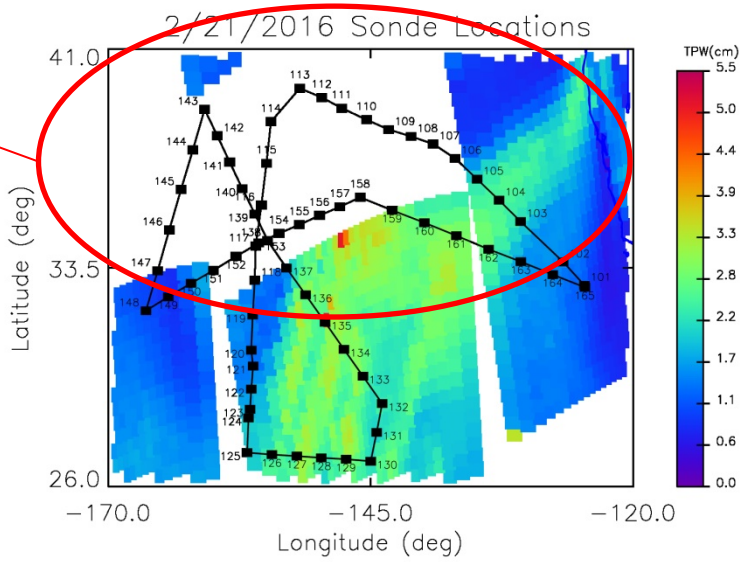
- Feb. 21, 2016 pm coverage from both Corvallis and Hawaii
  - Periodic problems with “antenna shadowing” on NPP
  - Also see missing granules due to ATMS GEO problems



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
  - Loss of 2 acquired granules because CrIS requires these data for calibration
- On most days Corvallis antenna didn’t “see” far enough west for Global Hawk coverage

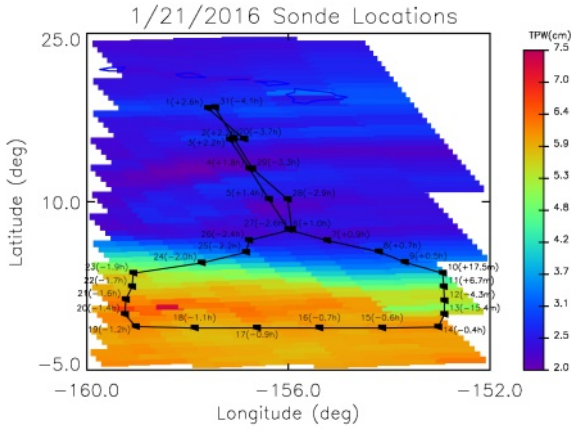


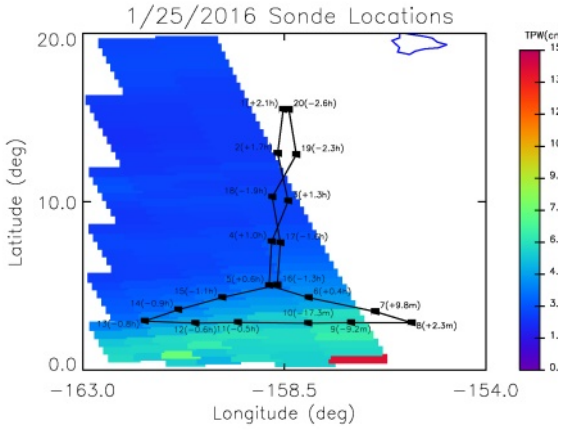


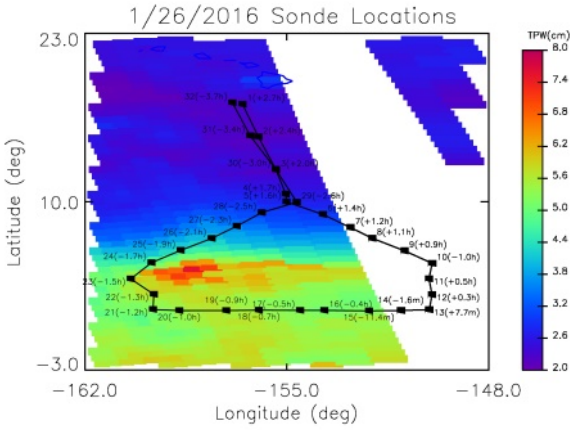
Some lessons learned for flight planning

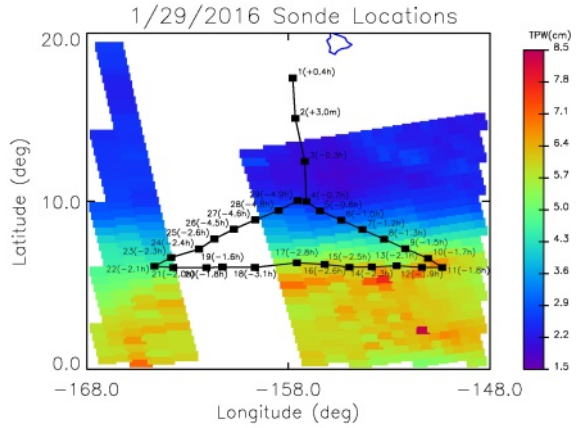
- Demonstrated we could routinely process direct broadcast NPP data
  - total latency (satellite obs to skew-T plots @ aircraft) of $\leq$ 45 minutes
- But for flight planning there is already a plethora of data
  - Real time T(p), q(p) can complement the other data
    - Mostly used to help to decide which forecast model was most representative of current conditions.
    - DB skew-T plots did help guide flight plan
      - at end of mission after trust was established
  - But we need to be able to 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
    - Morning orbit gave them a preview of the planned dropsonde data acquisition
- Valuable insight into forecaster opinions of satellite soundings
  - They are aware and concerned with our *a-priori* assumptions
  - They assumed, incorrectly, that we could not handle outliers
  - At the "grass roots" level, forecasters became aware of satellite capabilities and limitations.

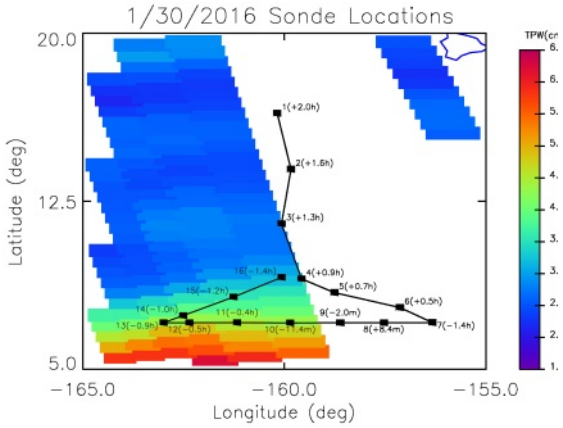
Post-processing from archive: Jan. 21 through Feb. 2

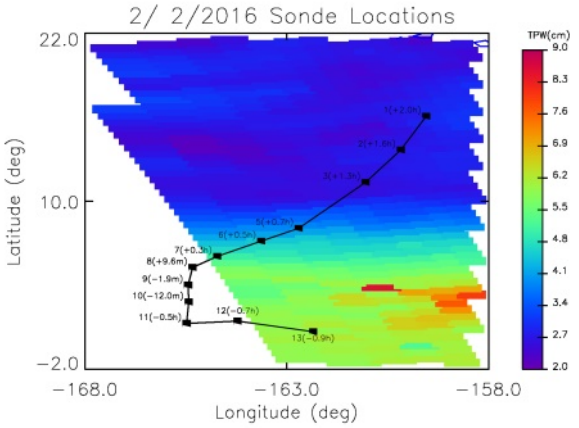




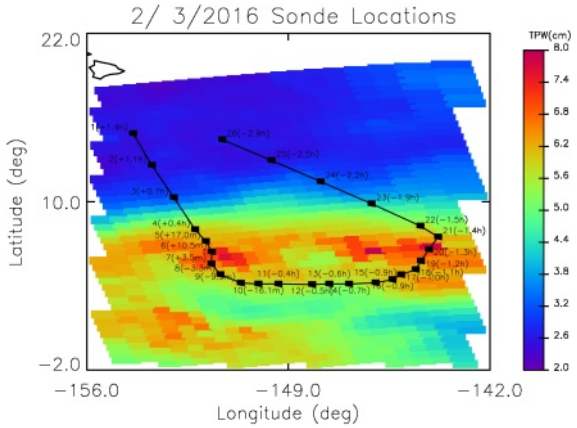


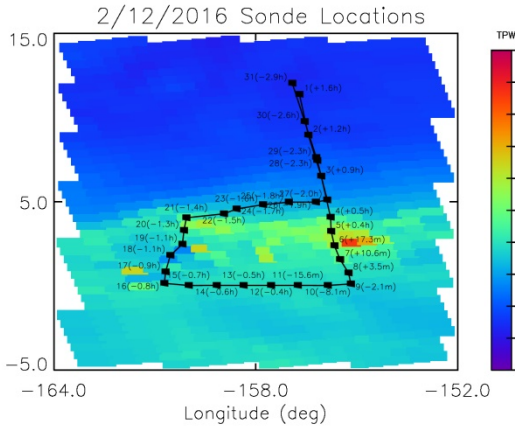


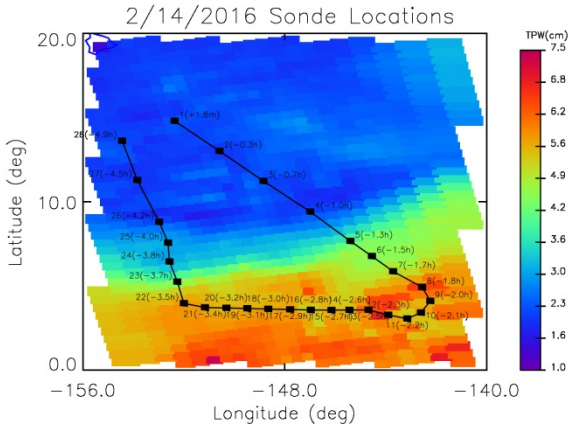


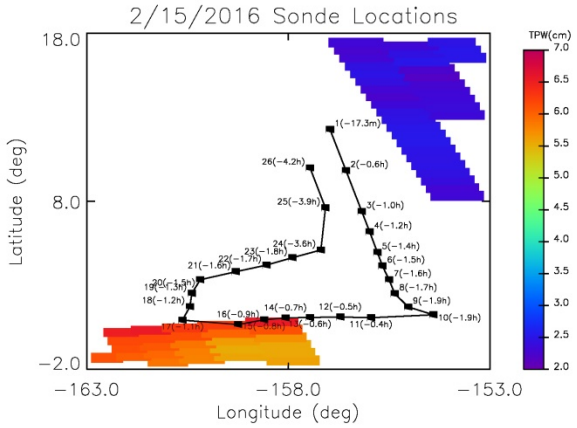


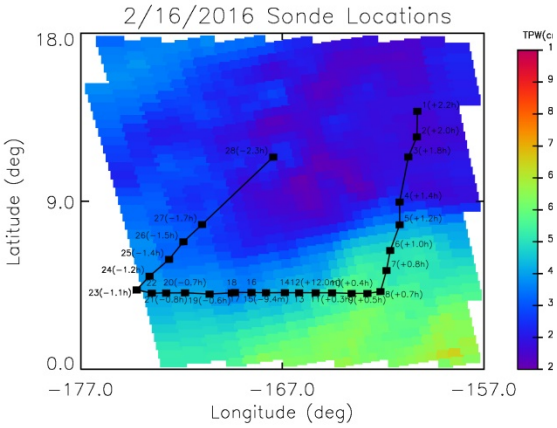
Feb. 3 through Feb. 17 post-processing

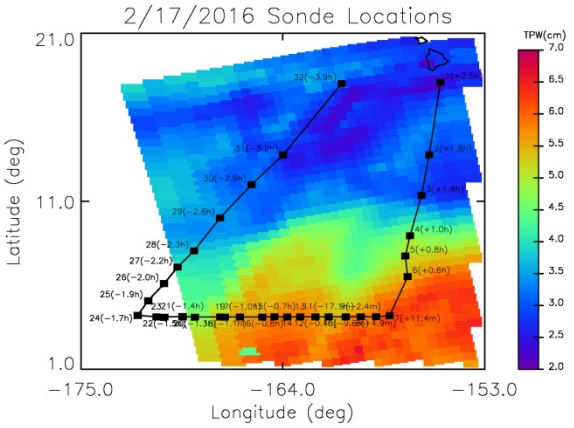




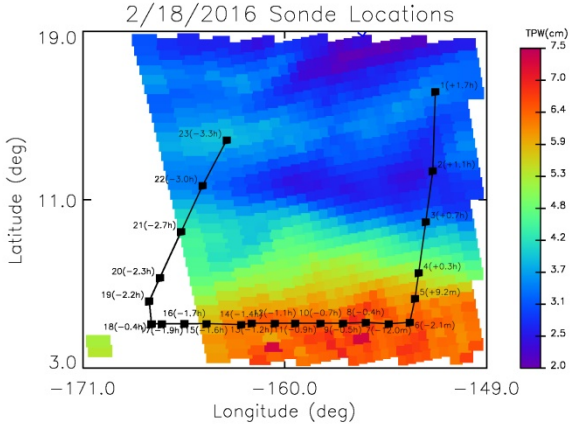


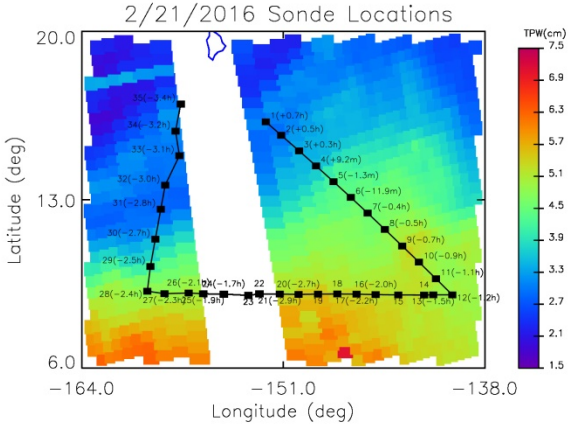


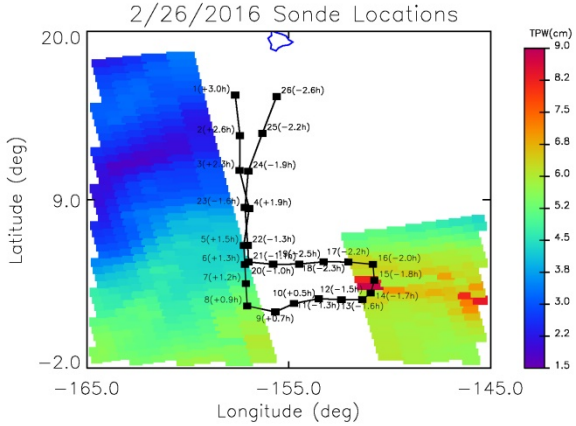


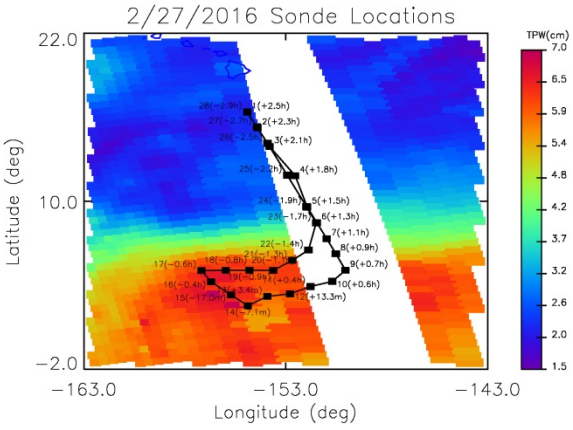


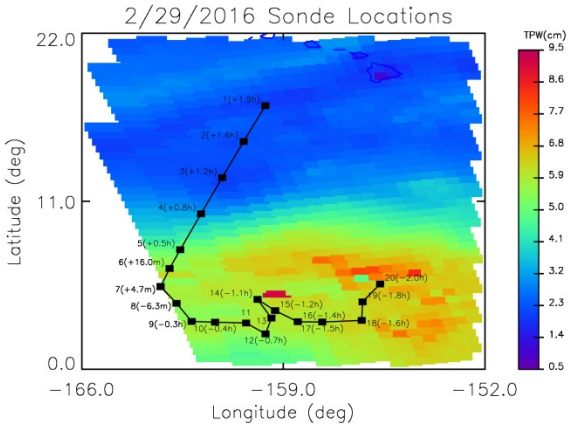
Feb. 18 through Mar. 1 post-processing

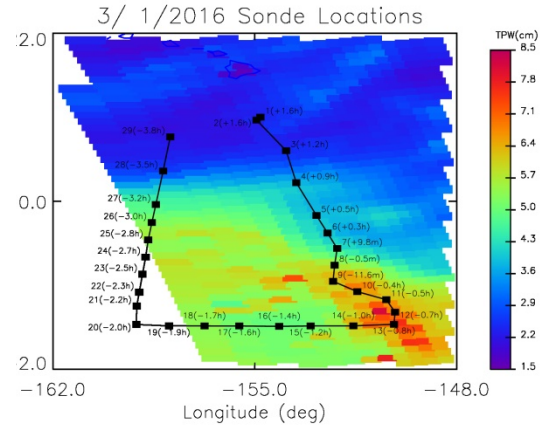




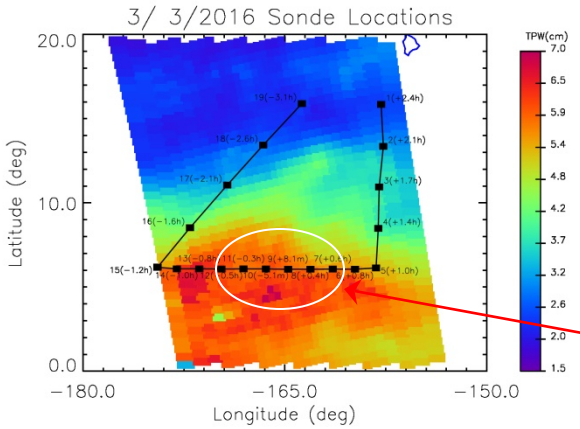




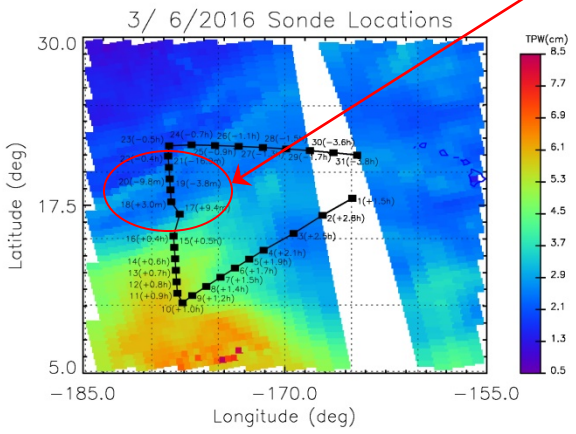


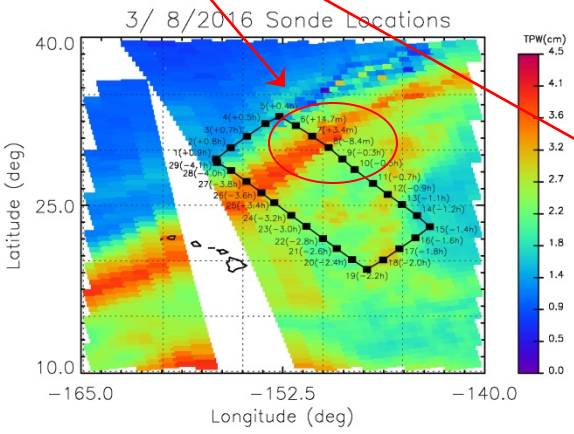


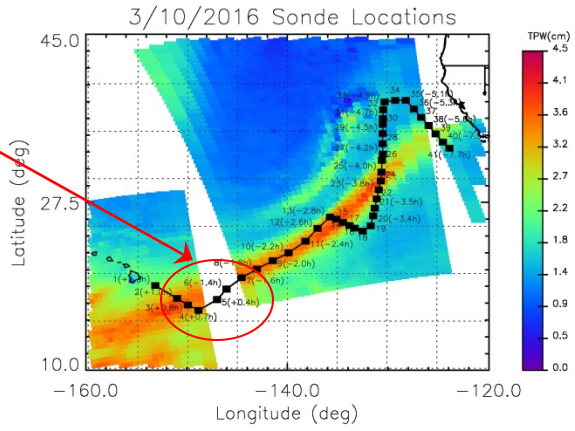
Mar. 3 through Mar. 10 post-processing



- Final week saw the development of a intense atmospheric river
  - A survey of developing mesoscale frontal wave associated with intensifying closed low north of AR
- We targeted drop-sondes to coincide with satellite overpass time



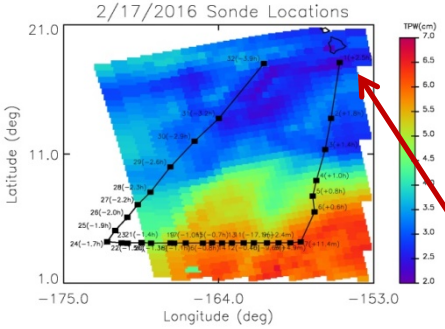




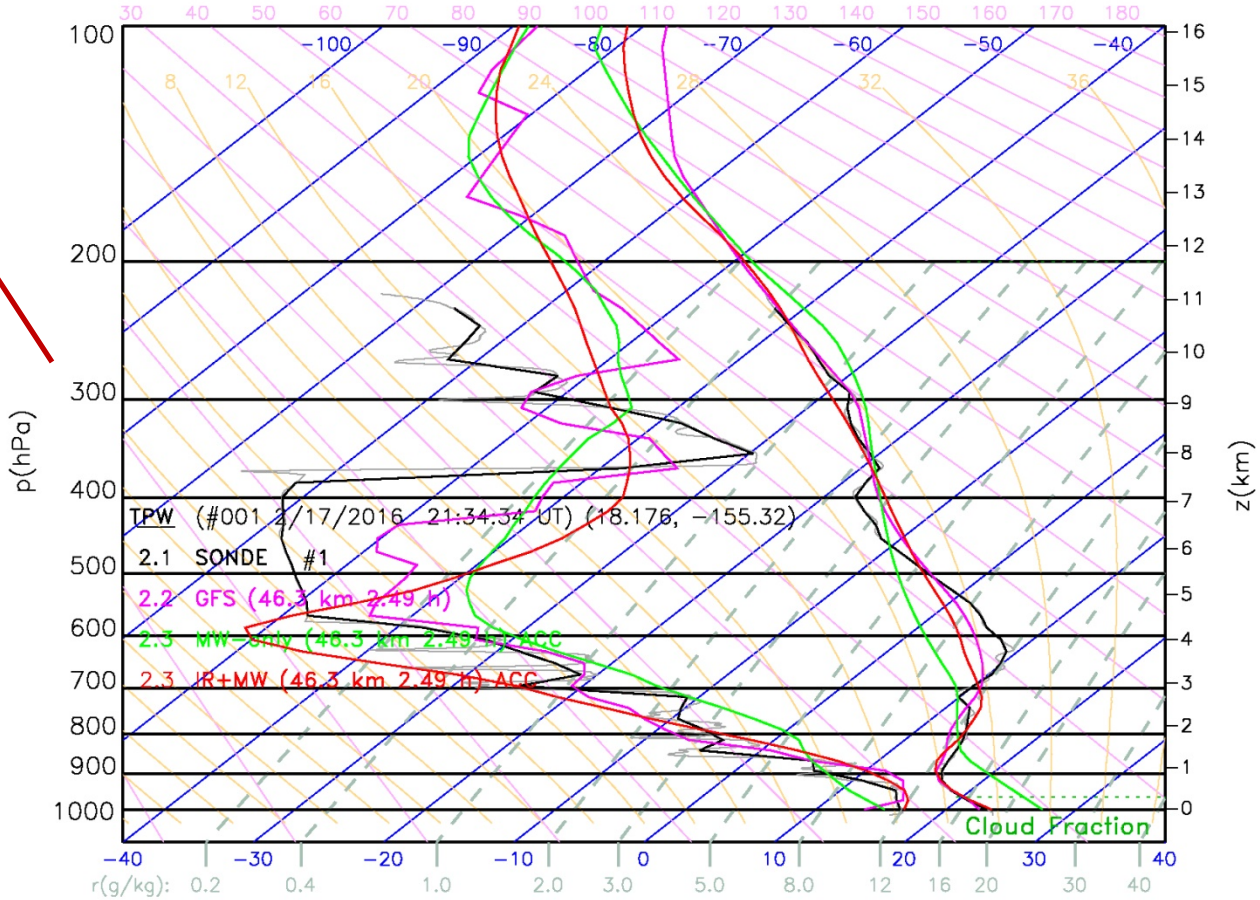
Summary of acquired datasets for validation

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

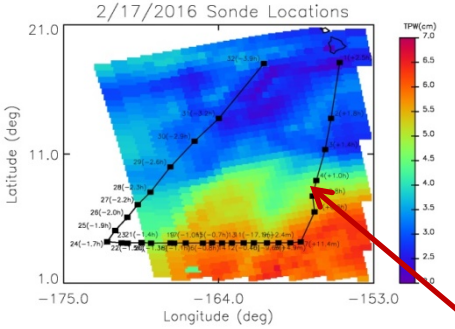


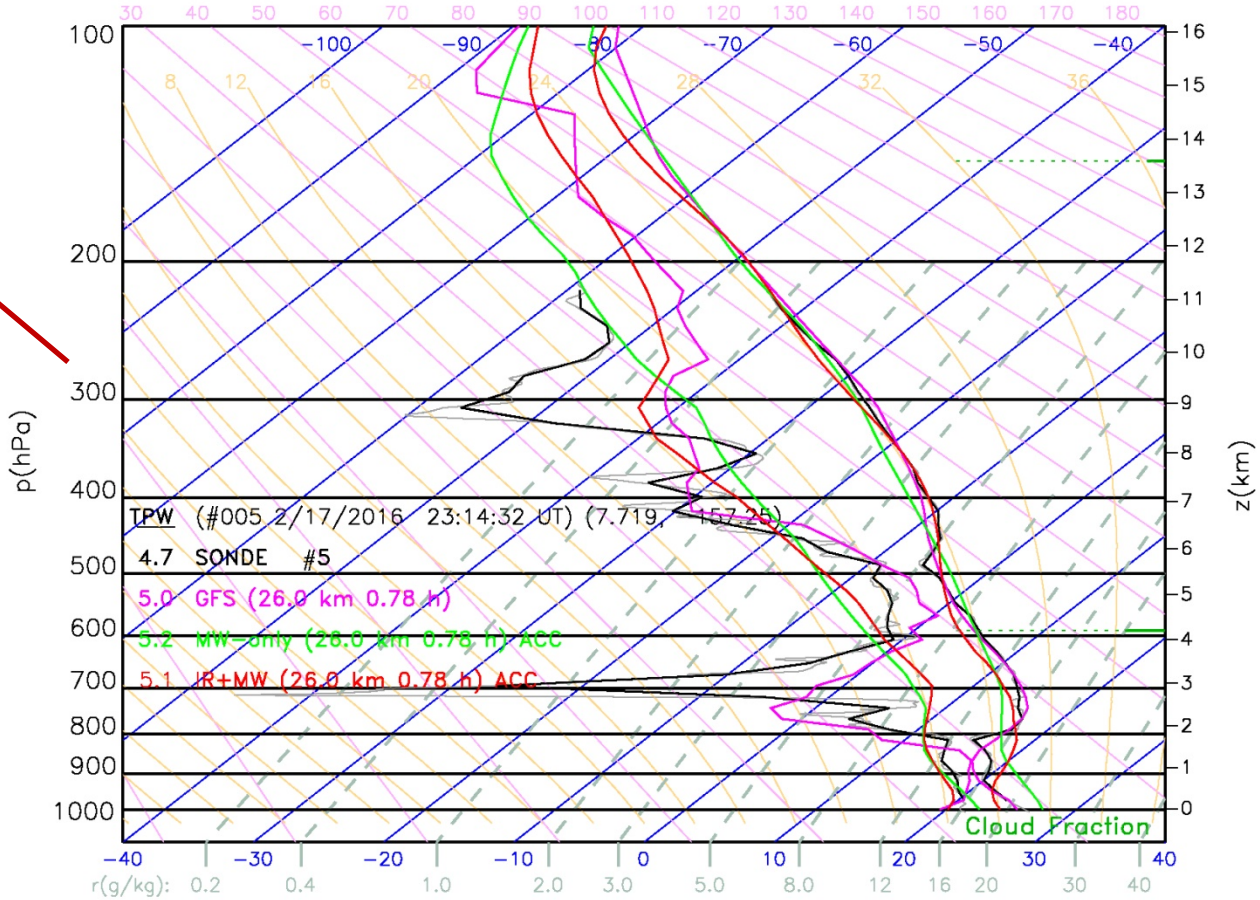
IR+MW tends to capture vertical T(p) and q(p) structure better than MW



For an explanation of our Skew-T plot – see he backup slides

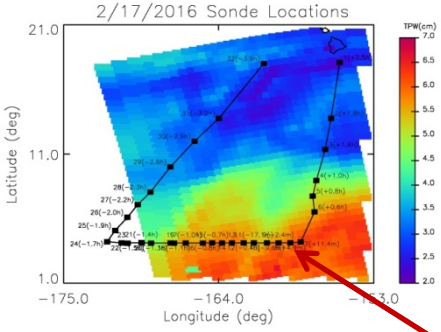
Feb. 17, Sonde #5: 0.8 hours before overpass time



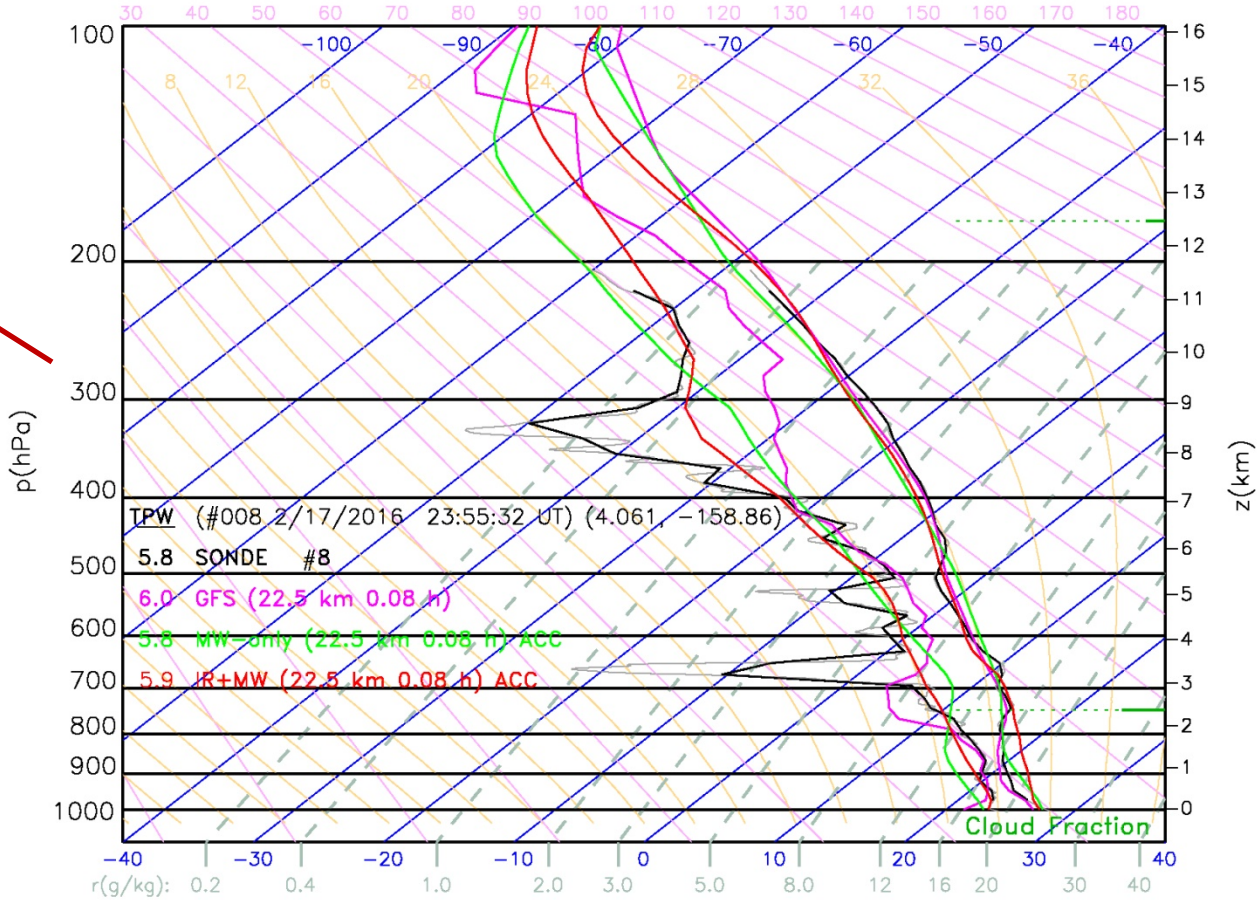


But obviously doesn't have the vertical resolution of a sonde or GFS

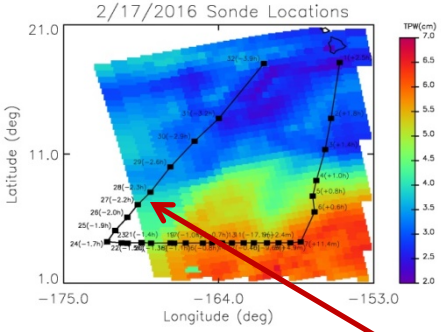
Feb. 17, Sonde #8: near overpass time



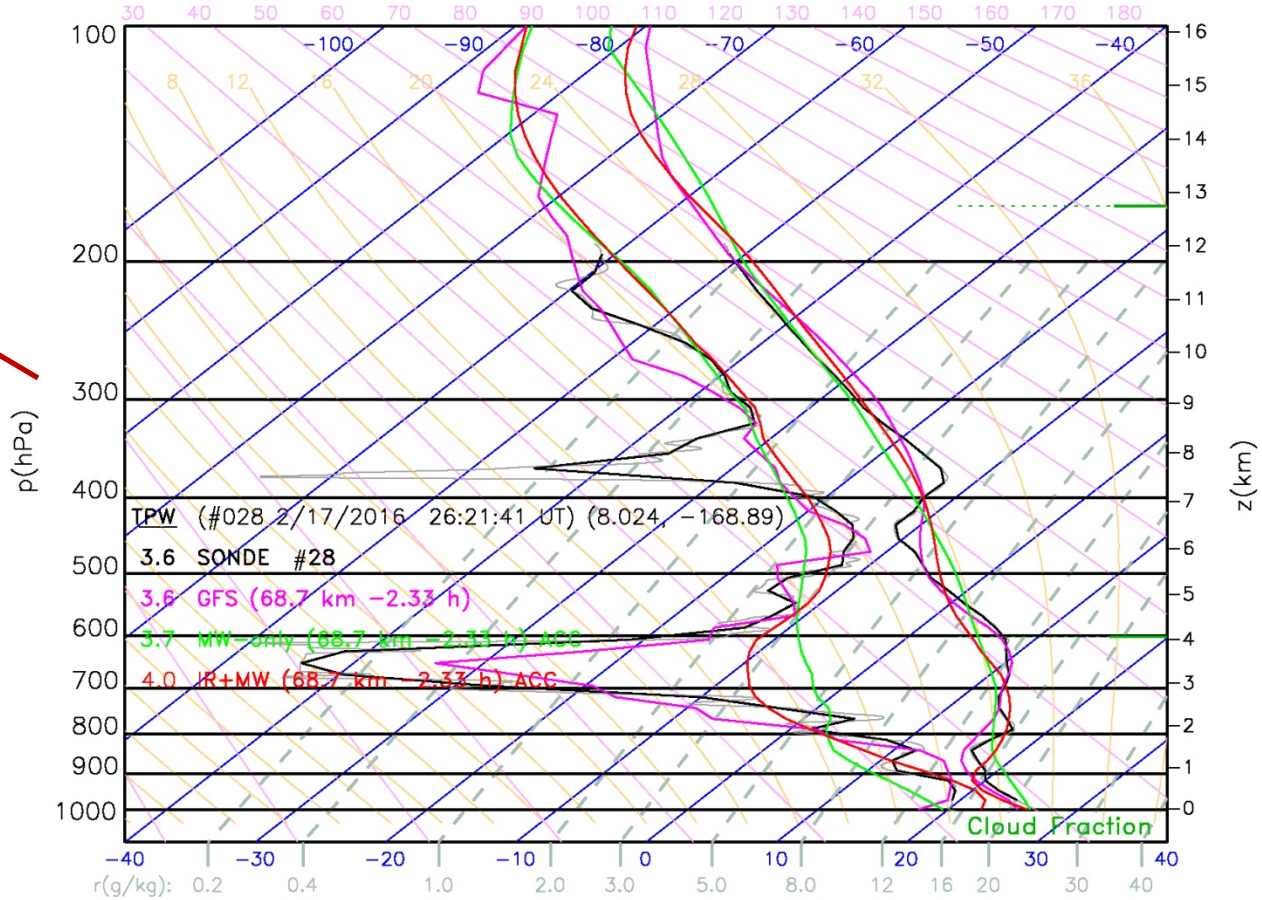
NUCAPS is capturing large scale vertical structures



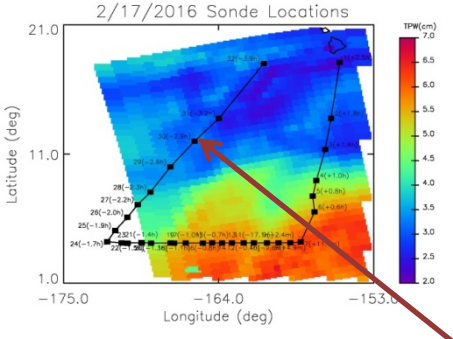
Feb. 17, Sonde #28: 2.3 hours after overpass time



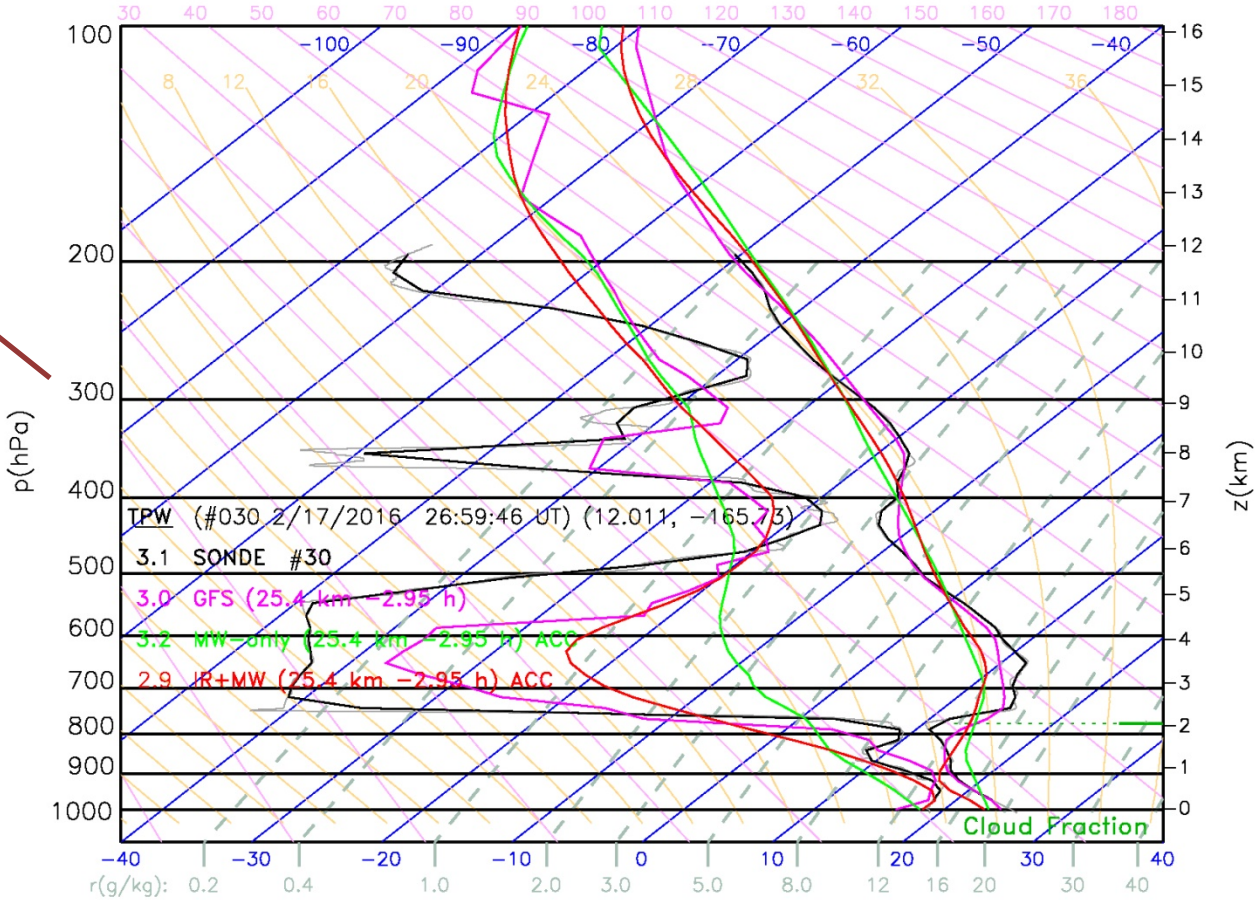
thin layers can be used to estimate vertical response



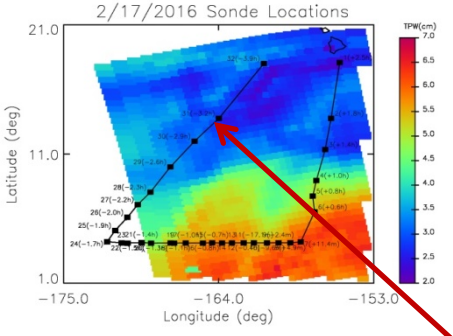
Feb. 17, Sonde #30: 3 hours after overpass time



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

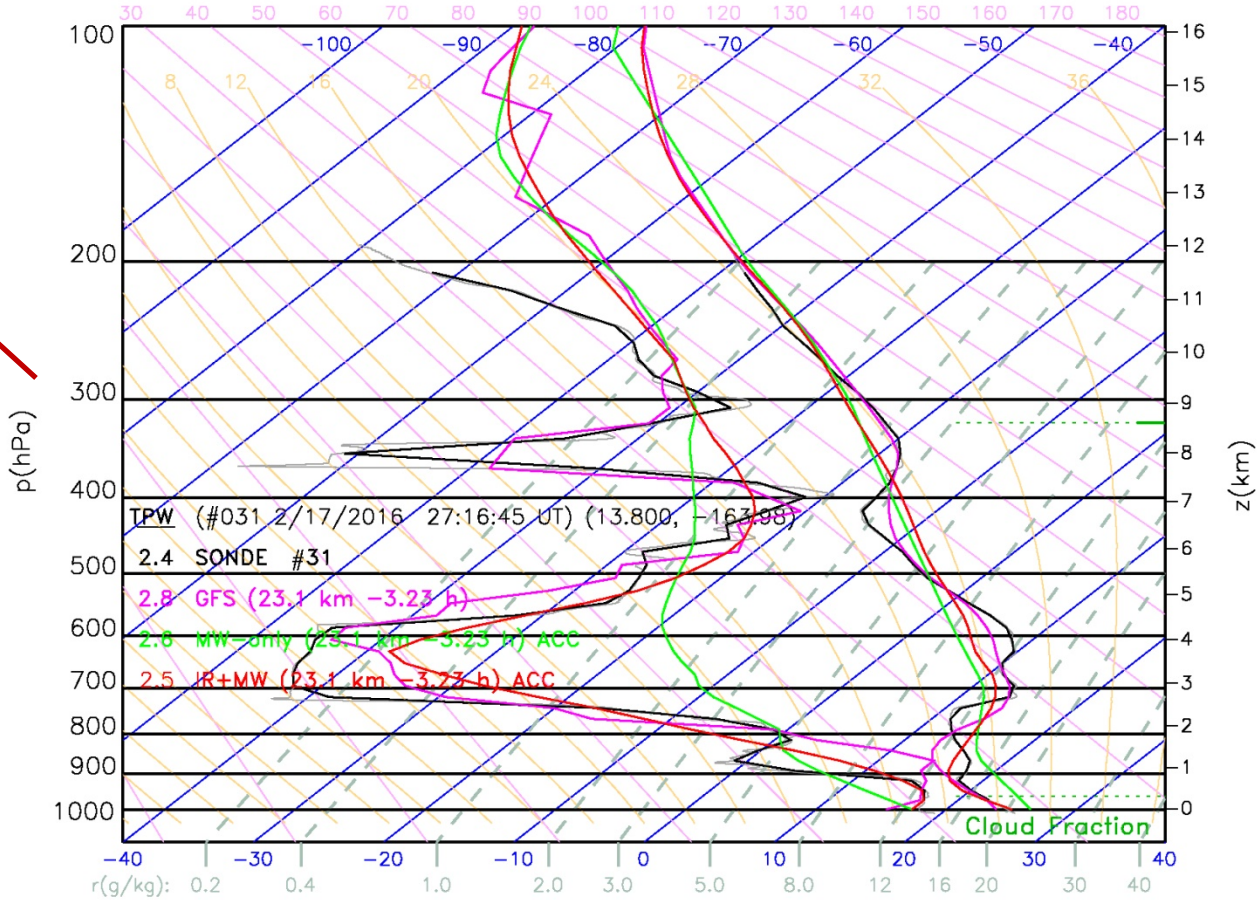


Feb. 17, Sonde #31: 3.2 hours after overpass time



But why did this case do so much better?

This will be the focus of the averaging kernal analysis that Antonias showed earlier today



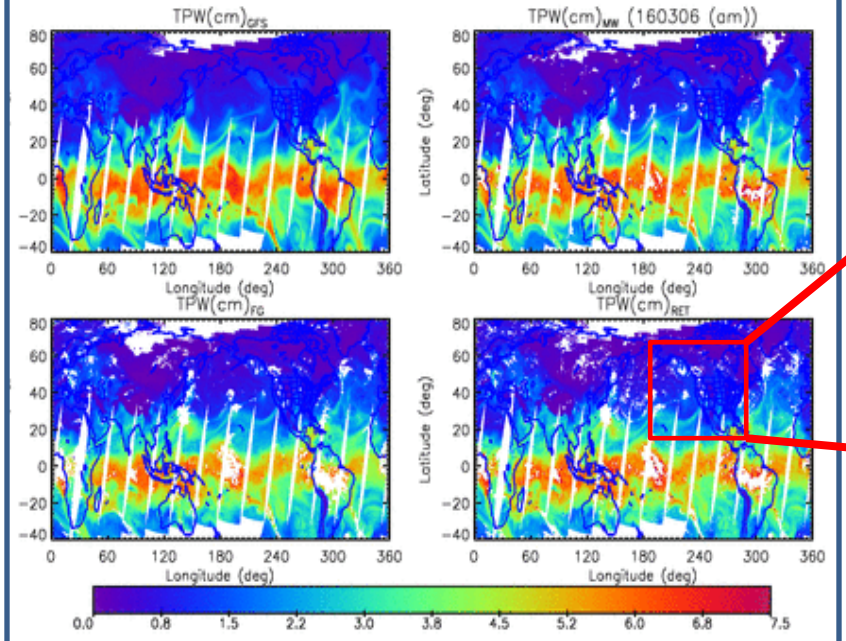
Specific ENRR research topics enabled by these data

- Assess satellite sounding vertical resolution
  - Characterize marine inversions, moist layers aloft
- Assess ability to see moisture extremes
  - 2015/16 El Nino outside of NUCAPS climatology training
  - Can test sensitivity to *a-priori* assumptions
- Support the scientific goals of the field campaign
  - Use of satellite data to test skill of GFS to targeted observations
    - Is USA forecast sensitive to specific regions (e.g., ITCZ outflow)
    - What spatial sub-setting approach would enhance skill.
  - Add NUCAPS to datasets that document the thermodynamic environment of the 2015/16 El Nino
    - Unique value to answer questions on tropical moisture transport
    - Complements the *in-situ* data investment of this field campaign

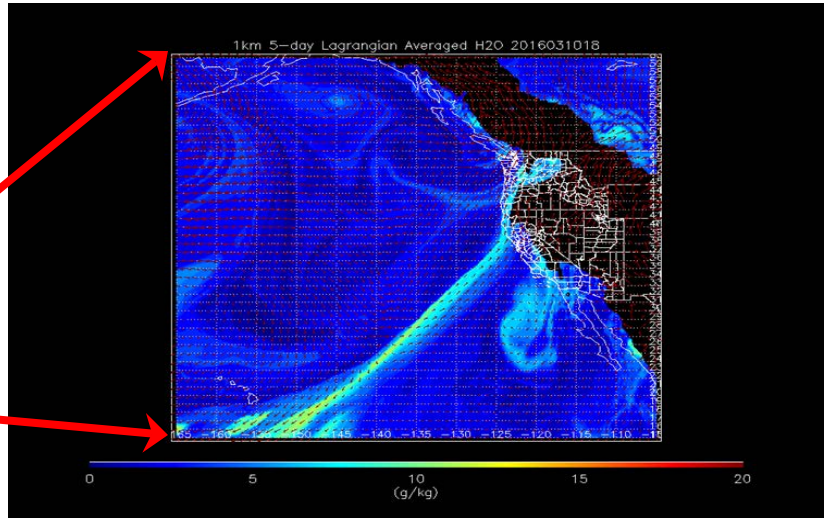
A preview of a recent scientific analysis

- Lagrangian analysis of NUCAPS water vapor (and CO) and can add unique insight into the moisture and pollution transport
- Complements *in-situ* data.

NUCAPS products show moisture in a "Eulerian" frame of reference



Reverse domain filling (RDF) uses modeled transport in "Lagrangian" reference frame to understand origin of moisture at high spatial resolution



RDF analysis of RAQMS courtesy of Brad Pierce, NOAA/STAR

Use of NUCAPS in NWP applications

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

Summary

- I have not yet crossed “the valley of death”
- I am certainty within the valley
  - Going up I-25 would have been easier!
  - 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

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
- CCR = Cloud Cleared Radiances
- CIRA = Cooperative Instituite for Research in the Atmosphere
- 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

For each flight day we provide 3 files on the ENRR campaign google drive

- Each fight day, given by yymmdd, there will be 3 file files
- File = yymmddnpp_am_vs_gfs.pdf contains my analysis of the NPP satellite “am” soundings processed from direct broadcast data
  - “am” overpasses are ~11 to 12 UT over Hawaii region.
  - I am routinely providing this file within ~1 hour of satellite overpass
  - Files contain maps, cross-section plots, and skew-T’s at positions along planned dropsonde locations
  - These can be used for pre-flight guidance.
- File = yymmddnpp_pm_vs_gfs.pdf is similar the the “am” file but contains the “pm” overpasses
  - “pm” overpasses are ~23 UT to ~01 UT, again ~1 hour latency
  - These could potentially be used for in-flight corrections to dropsonde locations; however, Hawaii antenna does not fetch data far enough southward
  - Since dropsondes are not available, they are not included in this file
- File = yymmddnpp_pm_vs_g4dropsondes.pdf contains the full satellite coverage for the flight day and comparisons to the G-IV dropsondes.
  - I am using archive data which has a latency of 1 to 2 days, thus this is a hindsight product
  - Can be used for post-flight validation of dropsondes an GFS
  - These are measurements and never will never be included in the forecast or re-analysis (of any NWP center, because we are retrieving in cloudy conditions and models assimilate only clear radiance)
  - **Therefore, these can supplement your in-situ measurements**

Access to the Satellite Data

- The yymmddnpp_pm_vs_g4dropsondes.pdf file gives you an idea of what is satellite data is available over campaign doman
  - NOTE: we globally have 324,000 soundings per day, so I am still limiting the retrievals to a box in the Pacific
  - I could also process non-flight days, if that is useful.
- Our archived satellite files are a packed binary format (1 file for 8 minutes or ~2000 km x 2000km containing 1800 soundings);
  - In the past I converted these to ASCII
    - I strip out exactly the measurements you want
  - For example, Nathalie Gaggini (ESRL/PSD) received some files for her AGU presentation last December with just T(p) and q(p) for the troposphere within 200 km radius of R.H. Brown
  - If you have an ftp site where I could push data to we could do something similar.
    - I would need to know more about what data you want (what products, lat/long range, etc) so I don't overwhelm you with a bunch of stuff you don't want.
    - We can also do other data formats

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

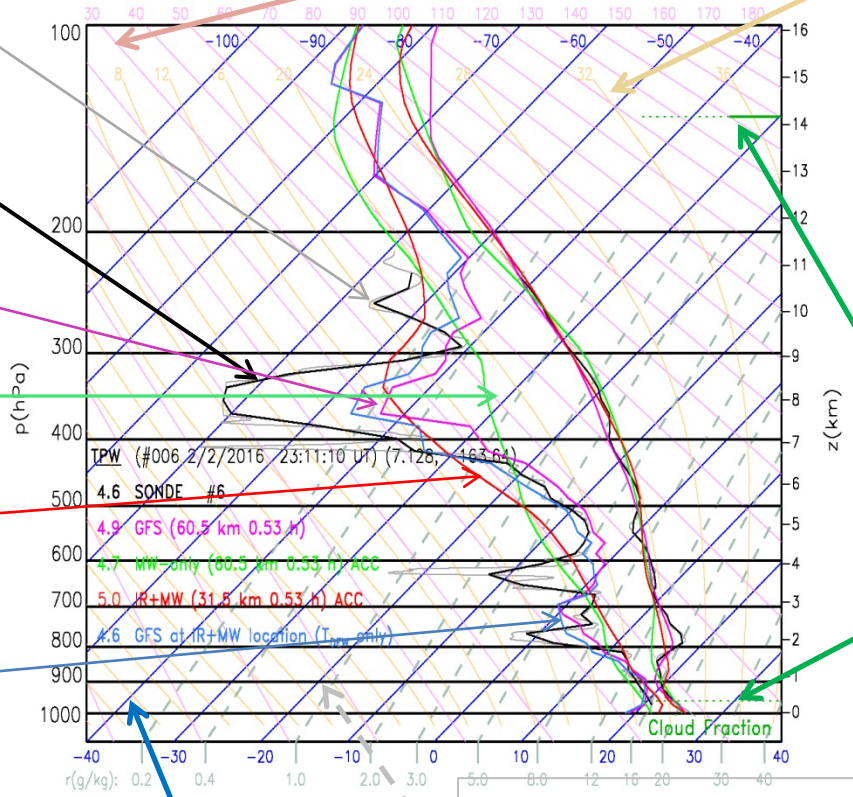
Black line: smoothed dropsonde

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

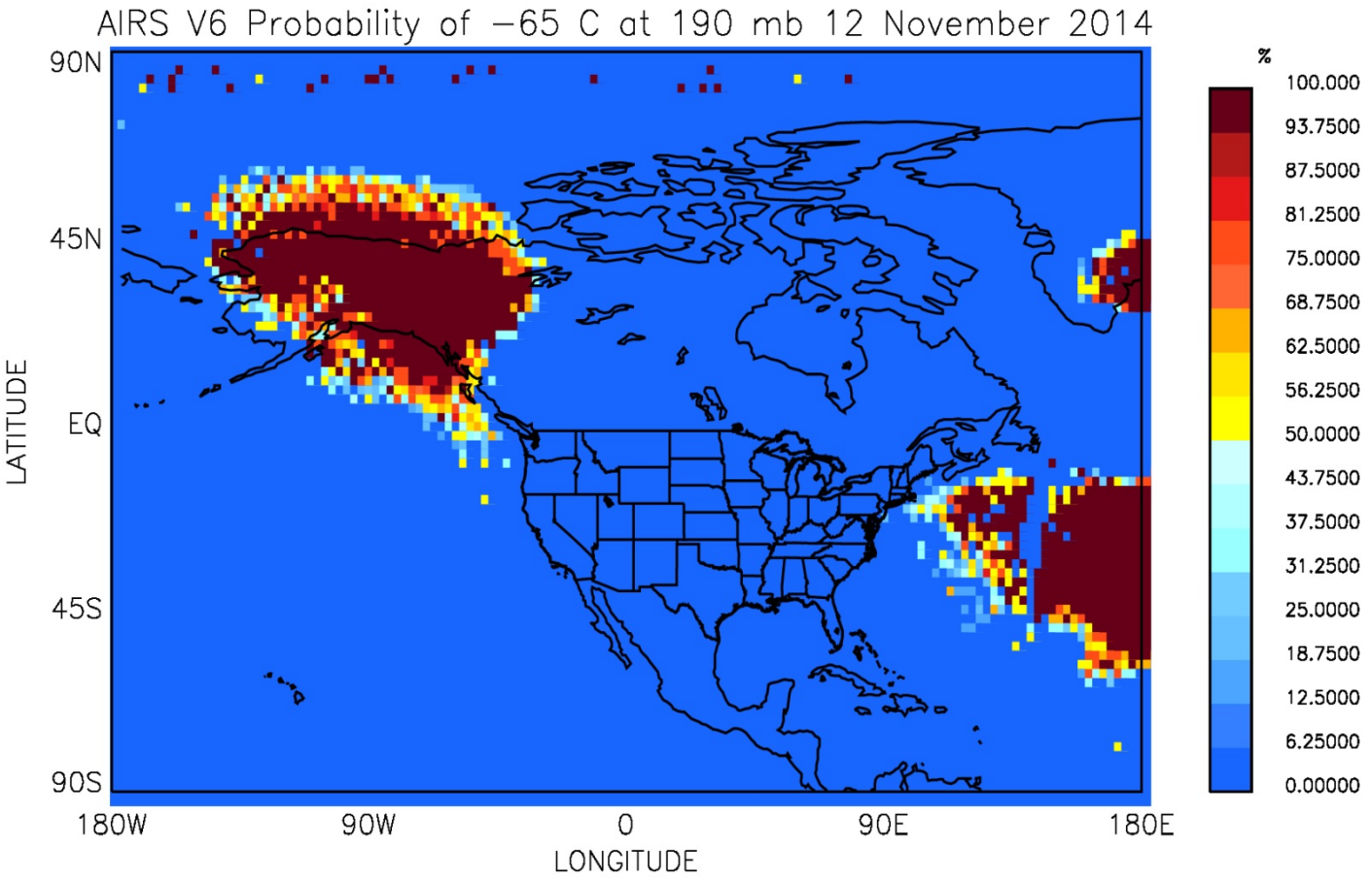
Temperature of saturation shown for saturation mixing ratios (0.2 to 40 g/kg) are in faint blue/purple dashed lines

Daily Cold Air Loft frequency of occurrence (single frame)

Used AIRS Level.2 Support Product

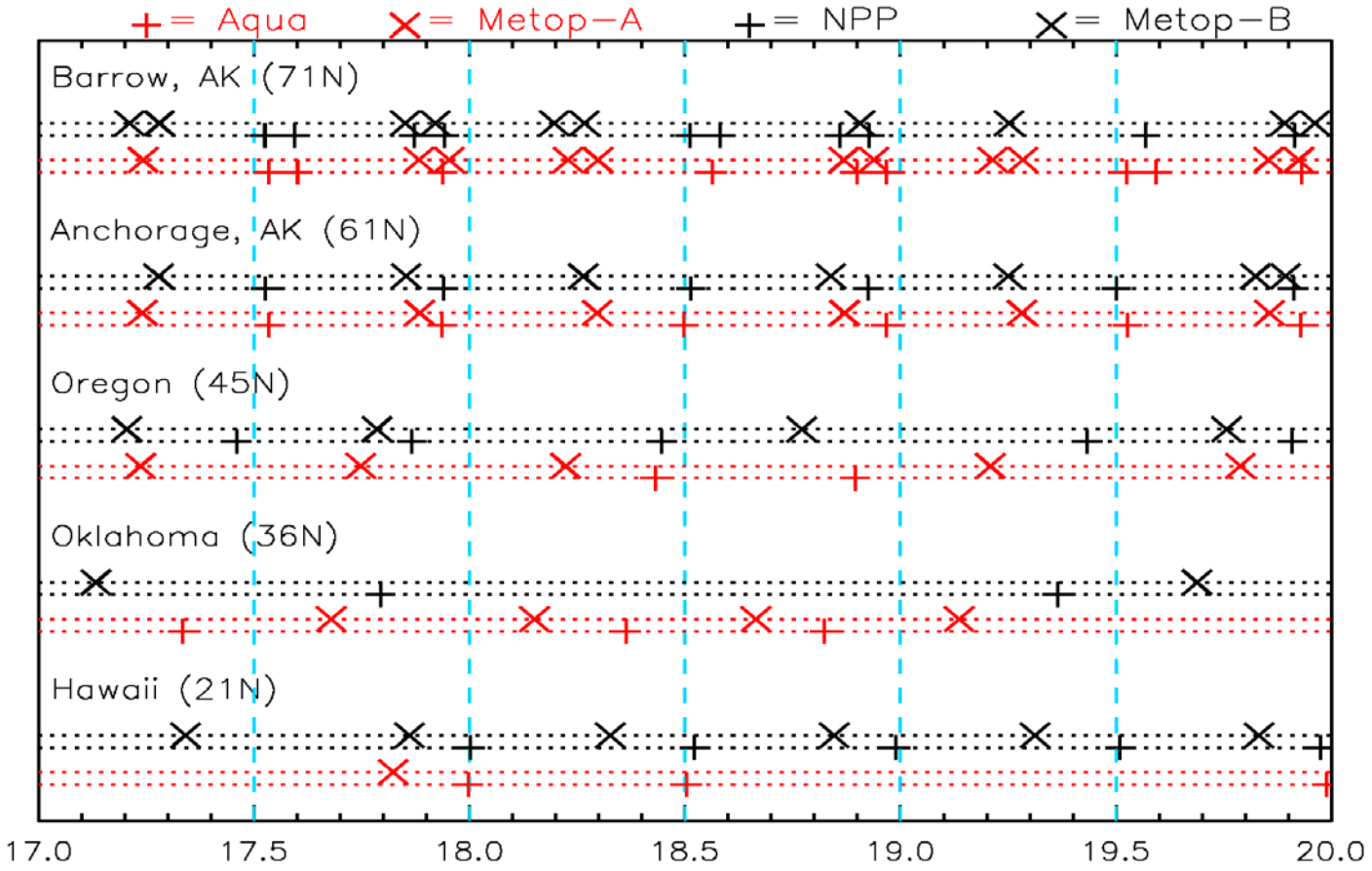
Counted occurrences of T(190mb) ≤ -65 degC in a 1x1 deg grid

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



Analysis and graphics by C. Francoeur, STC

Constellation of satellites allows more observations between RAOBS



Day of June, 2015

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

If we included NOAA AMSU/HIRS there would be even more soundings

These are overpasses with satellite elevation > 45 deg (FOR 4-27)