NOAA Aerosols and Ocean Science Expeditions (AEROSE): Ocean-Based Campaigns Supporting NOAA Satellite Remote Sensing

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Acknowledgments

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- The **NOAA Joint Polar Satellite System (JPSS-STAR) Office** (M. D. Goldberg, L. Zhou, et al.) and the **NOAA/STAR Satellite Meteorology and Climatology Division**
  - **STAR soundings team**: A. Gambacorta, L. Zhou, Q. Liu, T. Reale, C. Barnet, A.K. Sharma, W. W. Wolf , B. Sun, F. Tilley, C. Tan, F. Iturbide-Sanchez, T. King,M. Pettey, C. Brown, et al. (STAR)

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      - Saharan Air Layers (SAL) and Hadley Cells
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    - IR Emissivity Model Development and Validation

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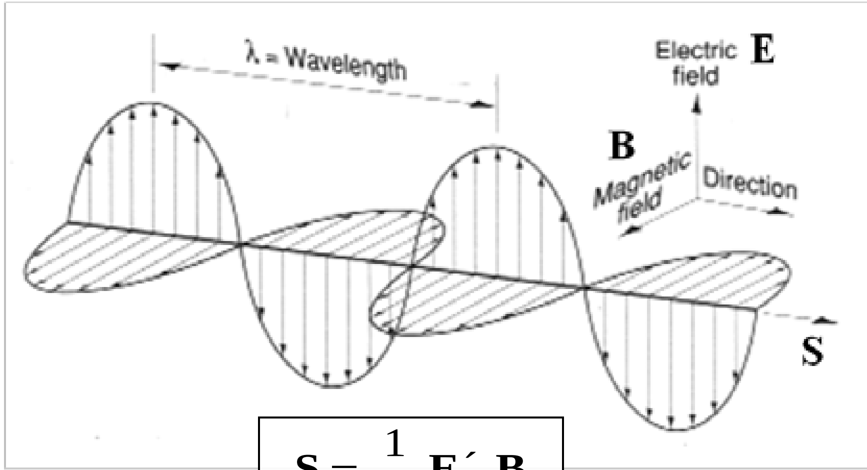
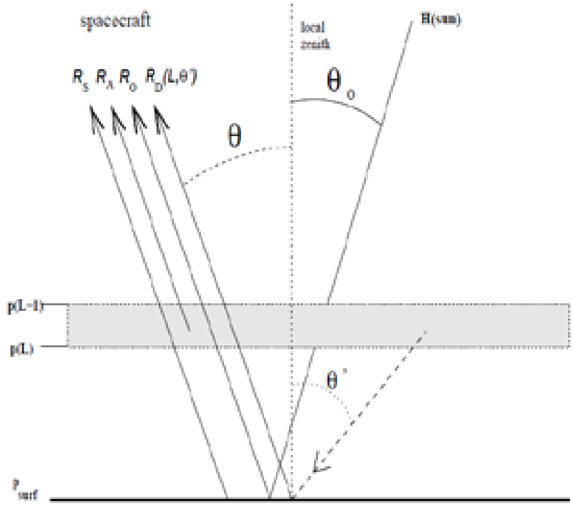
SATELLITE CALIBRATION/VALIDATION (CAL/VAL) OVERVIEW

Remote Sensing vs. *In Situ* Sensing

- A **measurement** is considered ***in situ*** (Latin for "in place") when the sensor is in *direct material contact* with the medium being measured
  - Example sensors: thermometer, anemometer, hygrometer, tongue, nose
  - Example observing systems: RAOB, met station, buoy, CTD, XBT
- A **remotely sensed measurement**, on the other hand, is, strictly speaking, one that is obtained through *electromagnetic (EM) radiative transfer.* EM radiation propagates through empty space, and thus a measurement is obtained "remotely," i.e., not in direct contact.
  - Example sensors: radiometer, spectrometer, Radar, Lidar, telescope, microscope, eye
  - Example observing systems: Satellite based (downlooking), surface based (uplooking)

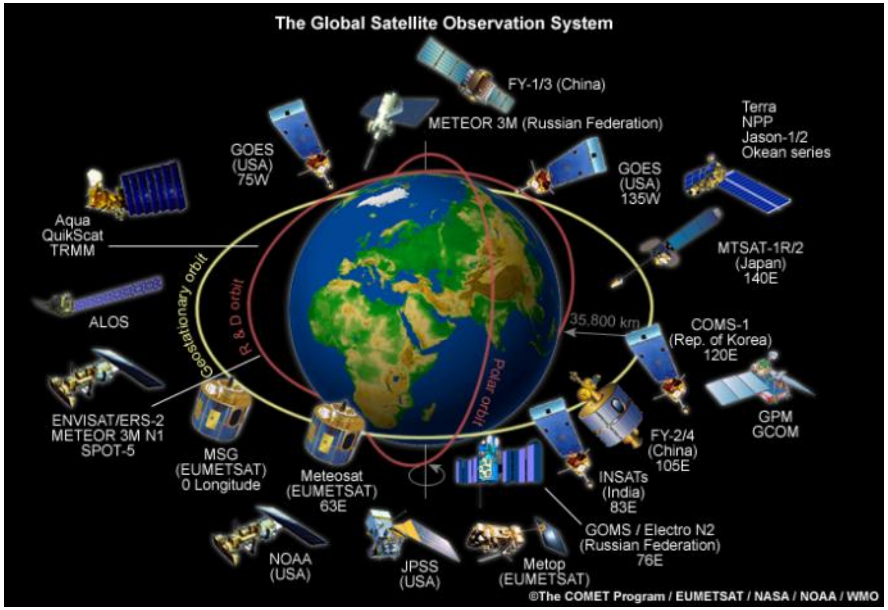


$$\mathbf{S} = \frac{1}{\mu_0}\mathbf{E} \times \mathbf{B}$$



Satellite Measurements Provide Global Data

Environmental Satellite Constellation

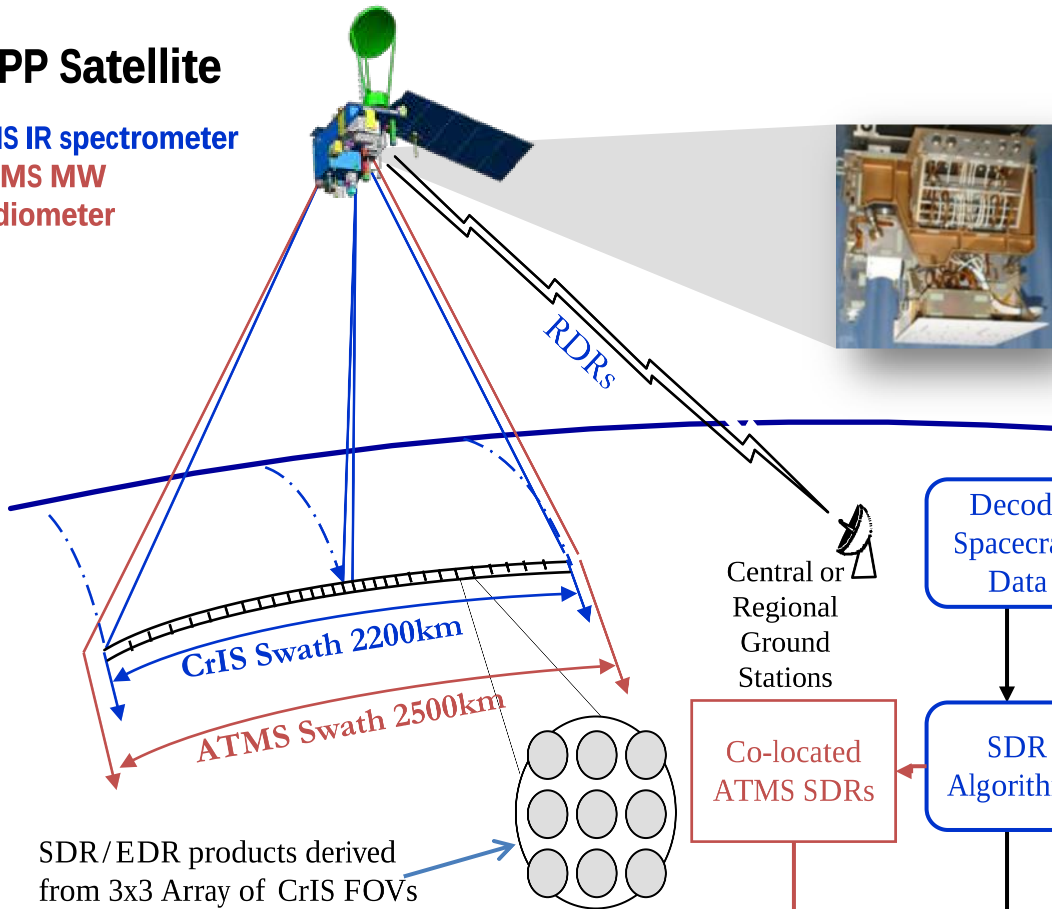


- **Raw Data Records (RDRs)**
- **Sensor Data Records (SDRs)**
  - Calibrated, geo-located spectral radiances
  - Infrared (IR)
  - Microwave (MW)
  - Solar/Optical (VIS)
  - Active (e.g., lidar, radar)
  - Passive (e.g., radiometer, spectrometer)
- **Environmental Data Records (EDRs)**
  - Retrievals via inversion
  - Soundings (temperature, moisture, trace gas)
  - Sea surface temperature, salinity, height, ocean color
  - Aerosols (dust, smoke)
  - Clouds
  - Radiation budget

Operational Environmental Satellite Passive Sensor System Example: Suomi NPP (SNPP) CrIS/ATMS Sounder System

SNPP Satellite

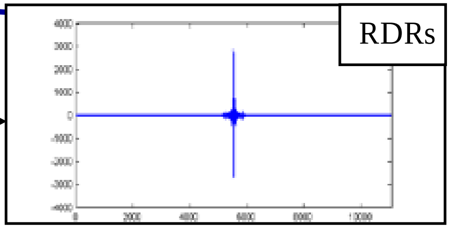
- CrIS IR spectrometer
- ATMS MW radiometer



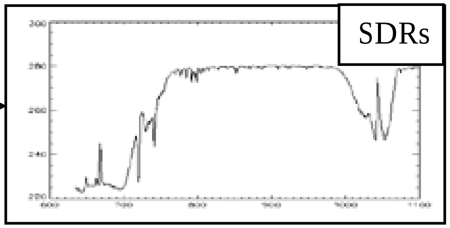
SDR/EDR products derived from 3x3 Array of CrIS FOVs (each at 14-km Diameter) matched to ATMS footprint

***RDR* = Raw Data Record**
(e.g. CrIS Interferograms)
***SDR* = Sensor Data Record**
(e.g. Calibrated IR Spectra)
***EDR* = Environmental Data Record**
(e.g. Atmospheric Temperature and Moisture Profiles)

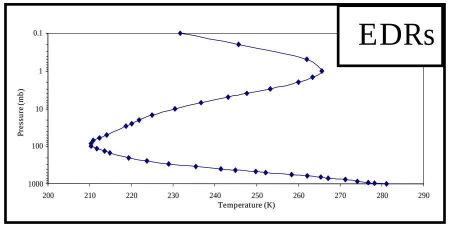
Decode Spacecraft Data → RDRs



SDR Algorithms → SDRs; → Co-located ATMS SDRs



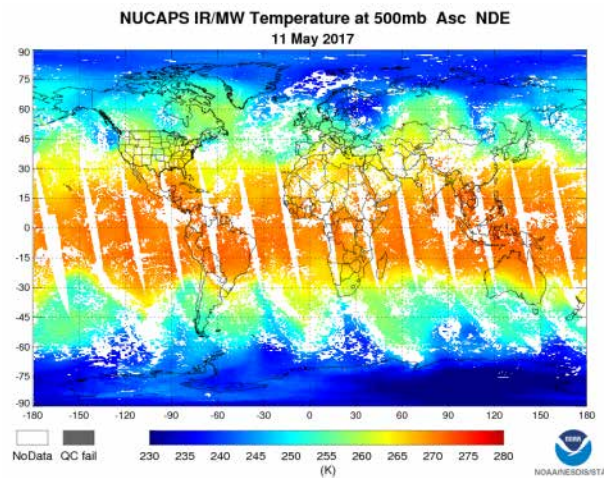
Co-located ATMS SDRs → EDR Algorithms → EDRs

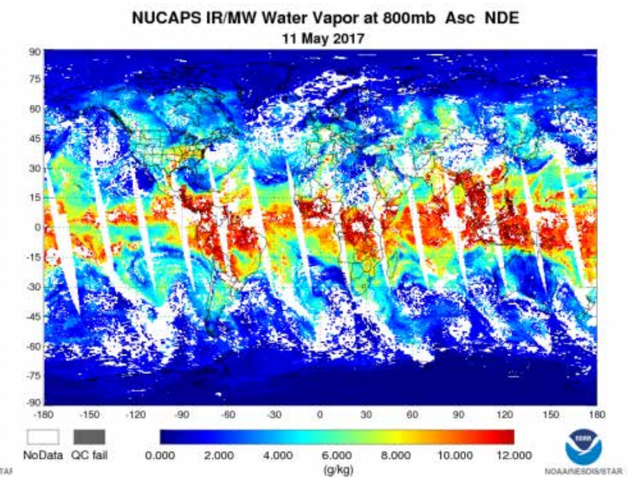


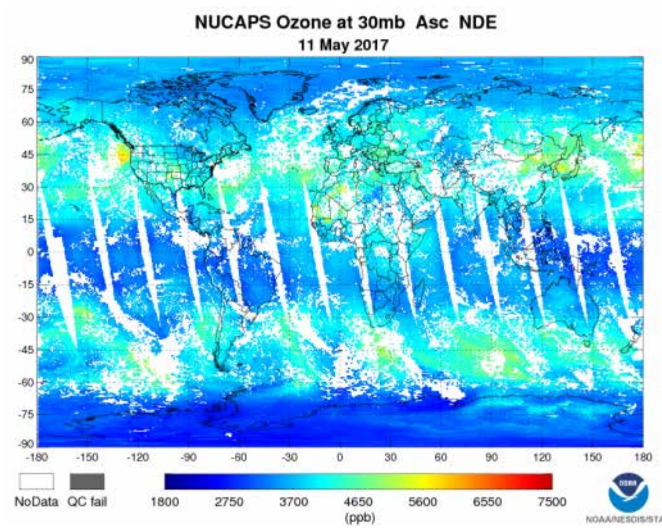
Courtesy of Chris Barnet (STC, Inc.)

NOAA Unique Combined Atmospheric Processing System (NUCAPS) Algorithm

- **Operational algorithm**
  - NOAA Enterprise Algorithm for CrIS/IASI/AIRS (*Susskind, Barnet and Blaisdell,* IEEE 2003; *Gambacorta et al.*, 2014)
  - Global non-precipitating conditions
  - Atmospheric Vertical Temperature, Moisture Profiles (**AVTP**, **AVMP**)
  - **Trace gases** (**O_3**, CO, CO_2, CH_4)
- **Users**
  - **Weather Forecast Offices (AWIPS)**
    - Nowcasting / severe weather
    - Alaska (cold core)
  - NOAA/CPC (OLR)
  - NOAA/ARL (IR ozone, trace gases)
  - NOAA TOAST product (IR ozone)
  - Basic and applied science research (e.g., *Pagano et al.*, 2014)
    - Via NOAA Data Centers (e.g., CLASS)
    - Universities, peer-reviewed pubs







Long Term Monitoring

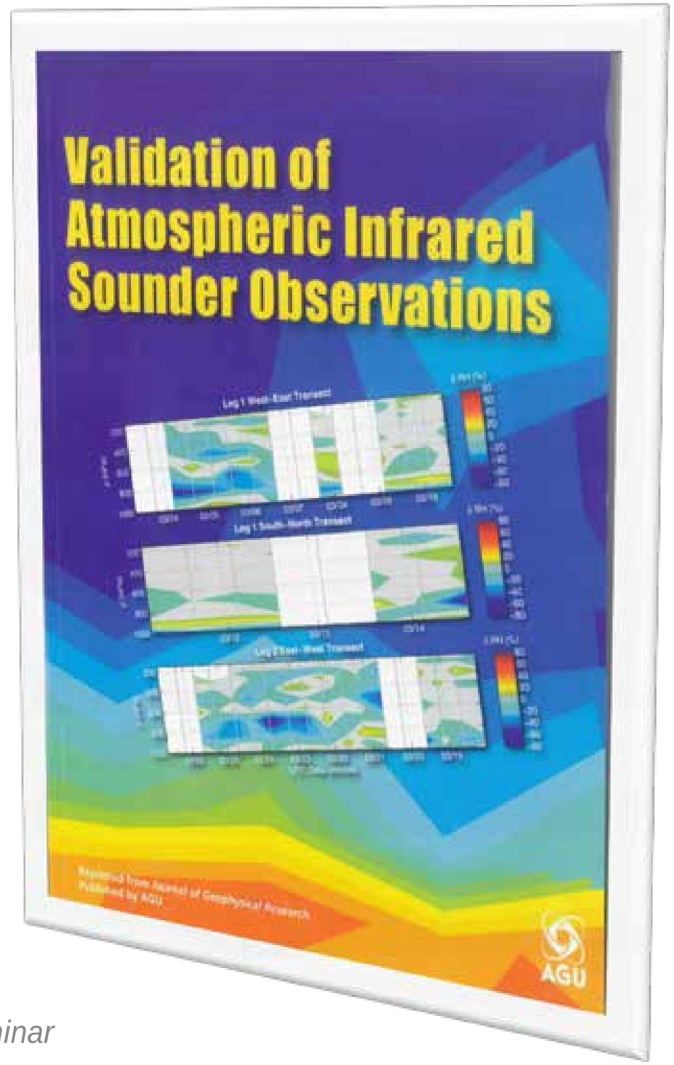
http://www.star.nesdis.noaa.gov/jpss/EDRs/products_Soundings.php

http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/index.html

Calibration/Validation (Cal/Val)

- **Validation** is "the process of ascribing uncertainties to… radiances and retrieved quantities through comparison with **correlative observations**" (*Fetzer et al.*, 2003)
  - "Correlative observations" refers to an independent measurement (*in situ* or remotely sensed) used as a **baseline** or "**truth**"
- EDR cal/val supports monitoring of SDRs and cloud-cleared radiances
- EDR cal/val enables development/improvement of algorithms

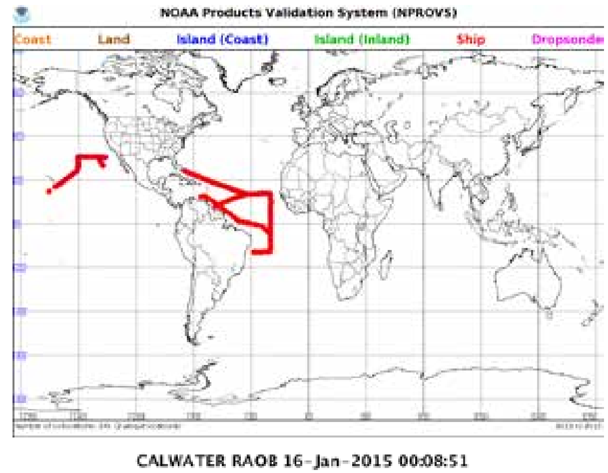
Cover of ***JGR Special Section on AIRS Validation*** featuring figure from *Nalli et al.* (2006) ship-based campaign paper in that issue.

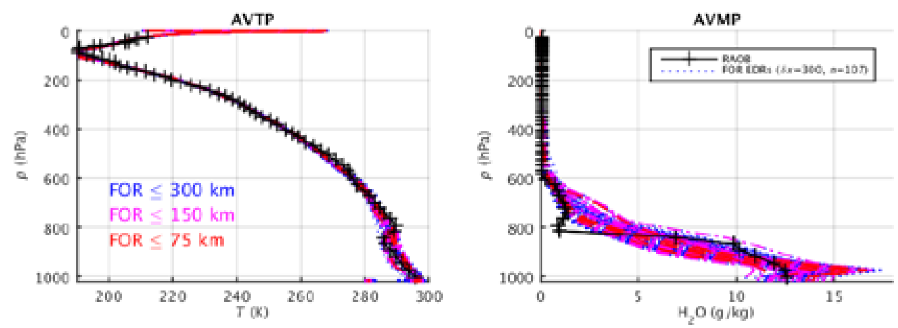


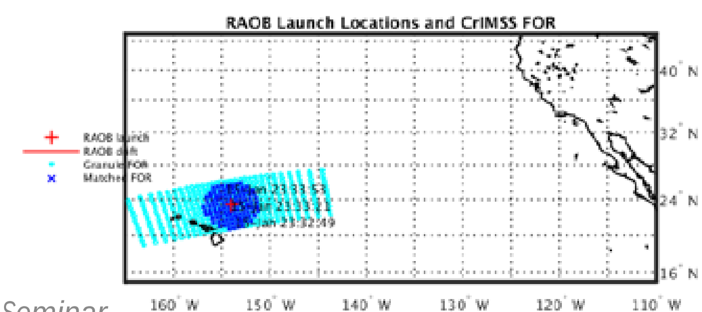
NOAA Validation Datasets and Tools

- **STAR Validation Archive (VALAR)**
  - Dedicated/reference and intensive campaign RAOBs
  - SDR/TDR granule-based collocations within 500 km radius acquired off SCDR (past 90 days) or CLASS (older than 90 days)
  - Trace Gas and O_3 EDR validation
  - Rigorous coarse-layer (1-km, 2-km) product performance measures based on statistical metrics corresponding to Level 1 Requirements detailed in *Nalli et al.* (2013)

- **NOAA Products Validation System (NPROVS)** (*Reale et al.*, 2012)
  - Performs global RAOB collocations for multiple satellite platforms
    - Conventional WMO RAOBs
    - Dedicated/reference (NPROVS+) (*Sun et al.* 2017)
  - HDF5-formatted Collocation Files facilitates GRUAN RAOB matchups within VALAR
  - NRT monitoring capability
  - Satellite EDR intercomparison capability
  - Java based graphical user interface tools for monitoring (PDISP, NARCS, ODS)







IR Sounder Validation Methodology Hierarchy

(e.g., *Nalli et al., JGR Special Section,* 2013)

1. **Numerical Model (e.g., ECMWF, NCEP/GFS) Global *Comparisons***
   - Large, truly global samples acquired from Focus Days
   - Useful for sanity checks, bias tuning and regression
   - Limitation: *Not* independent truth data

2. **Satellite Sounder EDR (e.g., AIRS, ATOVS, COSMIC) *Intercomparisons***
   - Global samples acquired from Focus Days (e.g., AIRS)
   - Consistency checks; merits of different retrieval algorithms
   - Limitation: Similar error characteristics; must take rigorous account of averaging kernels of both systems (e.g., *Rodgers and Connor,* 2003)

3. **Conventional RAOB Matchup *Assessments***
   - WMO/GTS operational sondes launched ~2/day for NWP
   - Representation of global zones, long-term monitoring
   - Large samples after a couple months (e.g., *Divakarla et al.,* 2006; *Reale et al.* 2012)
   - Limitations:
     - Skewed distribution toward NH-continents
     - Mismatch errors, potentially systematic at individual sites
     - Non-uniform, less-accurate radiosondes
     - RAOBs assimilated into numerical models

4. **Dedicated/Reference RAOB Matchup *Assessments***
   - *Dedicated* for the purpose of satellite validation
     - Known measurement uncertainty, optimal accuracy
     - Minimal mismatch errors
     - "best estimates" or "merged soundings"
   - Reference sondes: CFH, **GRUAN** corrected RS92/RS41
     - Traceable measurement
     - Uncertainty estimates
   - Limitation: Small sample sizes, geographic coverage
   - E.g., **ARM sites** (e.g., *Tobin et al.,* 2006), **AEROSE**, **CalWater/ACAPEX**, BCCSO, PMRF

5. **Intensive Field Campaign *Dissections***
   - Include dedicated RAOBs, some *not* assimilated into NWP models
   - Include ancillary datasets (e.g., ozonesondes, lidar, M-AERI, MWR, sunphotometer, etc.)
   - Ideally include funded aircraft campaign using IR sounder (e.g., NAST-I, S-HIS)
   - Detailed performance specification; state specification; SDR cal/val; case studies
   - E.g., **SNAP, SNPP-1,-2, AEROSE, CalWater/ACAPEX**, JAIVEX, WAVES, AWEX-G, EAQUATE

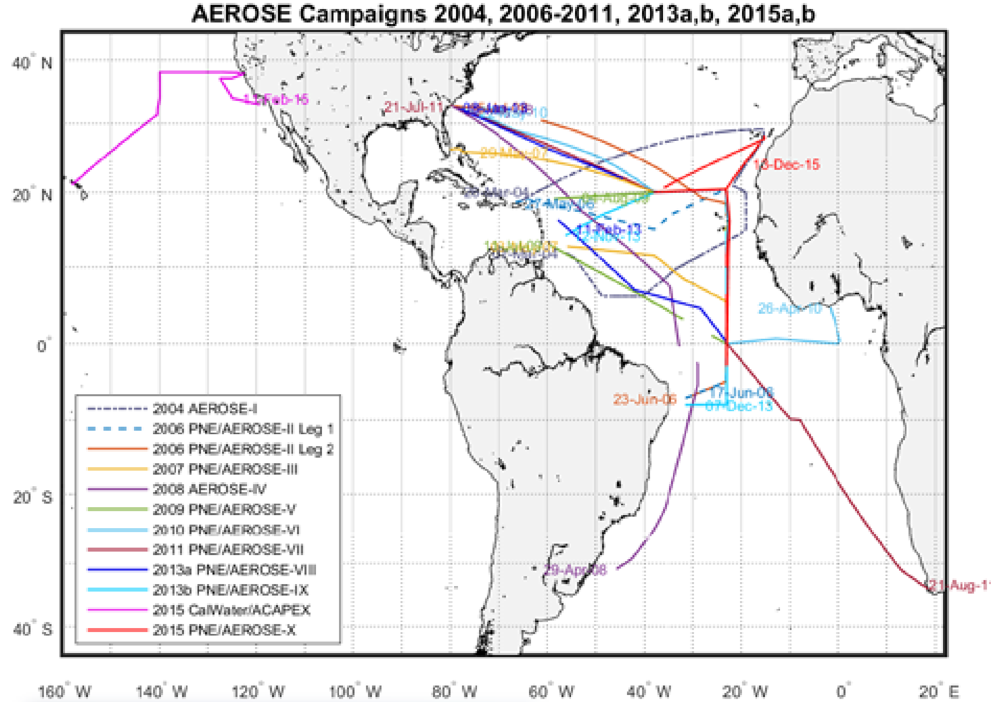
NOAA Aerosols and Ocean Science Expeditions (AEROSE): Ocean-Based Campaigns Supporting NOAA Satellite Remote Sensing

AEROSE DATA AND SCIENCE OVERVIEW

AEROSE Campaigns

- **NOAA/NCAS Aerosols and Ocean Science Expeditions (AEROSE)**
  - **Collaborative ship-based trans-Atlantic intensive field campaigns** (*Morris et al.* 2006; *Nalli et al.* 2011)
  - Recent campaigns (conducted since the **launch of SNPP satellite**)
    - **2013a** (NOAA Ship *Ronald H. Brown,* Jan-Feb 2013; 38 days)
    - **2013b** (NOAAS *Ronald H. Brown,* Nov-Dec 2013; 30 days)
    - **2015 CalWater ARM Cloud, Aerosol and Precipitation Experiment (ACAPEX)**
      - In Jan-Feb 2015, AEROSE collaborated in the CalWater/ACAPEX campaign (NOAA Ship *Ronald H. Brown,* Pacific Ocean, 30 days)
    - **2015** (NRV *Alliance* , Nov-Dec 2015; 30 days)
    - **2017** (NOAAS *Ronald H. Brown,* Feb-Mar 2017; 37 days)

- **AEROSE** has yielded an unprecedented collection of *in situ* measurements
  - **Saharan air layer (SAL)** and associated African dust and smoke outflows over the tropical Atlantic Ocean
  - Pacific Ocean **atmospheric rivers (ARs)** off coast of California
  - Important for satellite sounder validation because sounders are meant to provide information under "challenging" weather conditions
  - **Ocean-based dedicated RAOBs form an important component of the overall JPSS Intensive Cal/Val (ICV) effort** (*Nalli et al.* 2011, 2013; *Xie et al.* 2013)



Ocean-Based Intensive Field Campaigns

- **Unique Advantages**
  - **Earth's surface is ≈70% ocean**
  - **Oceans drive climate and weather**
  - **Satellite data makes biggest impact over oceans** given paucity of data
  - **Ocean surface is radiatively uniform, well-understood** and **easier to specify** than land surfaces

- **Campaigns of Note**
  - ***1995 OTIS Cruise***
    - LUMCON RV *Pelican*
    - Gulf of Mexico
    - First IR surface spectra
  - ***1997 Combined Sensor Program***
    - NOAA Ship *Discoverer*
    - Tropical Western Pacific Ocean
    - First MAERI prototype
  - ***AEROSE 2004–present***
    - NOAA Ship *Ronald H. Brown*
    - NATO RV *Alliance*
    - Tropical Atlantic Ocean
  - ***CalWater/ACAPEX 2015***
    - Jan-Feb 2015, NOAA Ship *Ronald H. Brown*
    - Central Pacific Ocean

NATO RV *Alliance*

AEROSE Partnerships

- **Participating Institutions**
  - **Howard University NOAA Center for Atmospheric Sciences (HU/NCAS)**
  - **NOAA/NESDIS/STAR**
  - University of Miami/RSMAS
  - NOAA/ESRL/PSD
  - NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory (AOML)
  - NOAA Pacific Marine Environmental Laboratory (PMEL)
  - DOE Atmospheric Radiation Measurement (ARM) Program
  - STC, Inc.

- **Synergism**
  - **Low Cost – Low Risk**
  - Engages broader science community on specific problems
  - All parties gain access to all data

AEROSE EDR Cal/Val Contributors

NAME	INSTITUTION	COLLABORATION
N. Nalli, Q. Liu, T. Reale B. Sun, F. Tilley, C. Barnet, A. Gambacorta, C. Tan, F. Iturbide-Sanchez, T. King, H. Xie, L. Zhou, R. Spackman, N. Hickmon, et al.	NOAA/NESDIS/STAR, JPSS DOE ARM STC, Inc.	RS92 Rawinsondes NUCAPS/GOES-R EDR Cal/Val NOAA IASI, AIRS Cal/Val IR Radiative Transfer NPROVS CalWater/ACAPEX
V. Morris, E. Joseph M. Oyola, E. Roper, K. Olayinka, et al.	HU/NCAS SUNY-Albany	Aerosol and Chemistry Radiation Measurements Ozonesondes Helium
R. Lumpkin, C. Schmid, R. Perez, G. Foltz,	NOAA/AOML	PNE Chief Scientists TAO Moorings CTDs, XBTs
P. Minnett M. Szczodrak, M. Izaguirre	UM/RSMAS	M-AERI MW Radiometer All-sky camera
D. Wolfe et al.	NOAA/OAR/ ESRL/PSD	Vaisala Sounding System; Surface Flux Measurements; Vaisala Ceilometer

AEROSE Goals

Science goals of AEROSE include (*Morris et al.* 2006; *Nalli et al.* 2006, 2011)

1. **Observation of dust and smoke aerosol distributions during trans-Atlantic transport**, including physical and chemical evolution over space and time.

2. **Observation of Saharan and sub-Saharan outflows** and their **impact upon the regional atmosphere and ocean** during trans-Atlantic transport.

3. **Assessment of satellite products** and numerical models for resolving and studying the above processes.

Eos, Vol. 87, No. 50, 12 December 2006

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12 DECEMBER 2006
PAGES 565–580

Measuring Trans-Atlantic Aerosol Transport From Africa

PAGES 565, 571

An estimated three billion metric tons of mineral aerosols are injected into the troposphere annually from the Saharan desert [*Prospero et al.*, 1996]. Additionally, smoke from biomass burning sites in the savanna grasslands in sub-Saharan Africa contribute significant quantities of smaller-sized aerosols [e.g., *Hobbs*, 2000]. These windswept aerosols from the African continent are responsible for a variety of climate, health, and environmental impacts on both global and regional scales that span the Western Hemisphere. Unfortunately, in situ measurements of aerosol evolution and transport across the Atlantic are difficult to obtain, and satellite remote sensing of aerosols can be challenging.

The trans-Atlantic Aerosol and Ocean Science Expeditions (AEROSE) are a series of intensive field experiments conducted aboard the U.S. National Oceanic and Atmospheric Administration (NOAA) ship *Ronald H. Brown* during the Northern Hemisphere spring (March 2006) and summer (June-July 2007) and proposed follow-on cruises in alternating seasons through 2010. The ongoing AEROSE mission focuses on providing a set of critical measurements that characterize the impacts and microphysical evolution of aerosols from the African continent as they transit the Atlantic Ocean.

The three central scientific questions addressed by AEROSE are as follows: (1) What is the extent of physical and chemical evolution in the mineral dust and smoke aerosol during trans-Atlantic transport? (2) How do Saharan and sub-Saharan aerosols affect the regional atmosphere and ocean during trans-Atlantic transport? (3) How can these unique aerosol measurements be used to resolve or improve remote sensing algorithms and models of the above processes?

While there have been a variety of aerosol campaigns that have encountered mineral dust or smoke, few have focused on Saharan dust as well as sub-Saharan smoke, and none has sought to characterize the evolution of these aerosols during long-range transport as a function of season. Thus, a comprehensive suite of aerosol measurements and size-segregated sampling were performed during each AEROSE cruise to characterize the evolution of the mineral dust mass distribution with respect to number density and chemical composition.

Project Overview

AEROSE-I was a 27-day cruise conducted during March 2004. A combination of climatological and near-real-time satellite observations, along with meteorological forecasts, helped steer the vessel into one of the largest (with respect to spatial extent) dust storms ever observed during that time of the year (Figure 1a). The AEROSE science team

V. MORRIS, P. CLEMENTE-COLÓN, N. R. NALLI, E. JOSEPH, R. A. ARMSTRONG, Y. DETRÉS, M. D. GOLDBERG, P. J. MINNETT, AND R. LUMPKIN

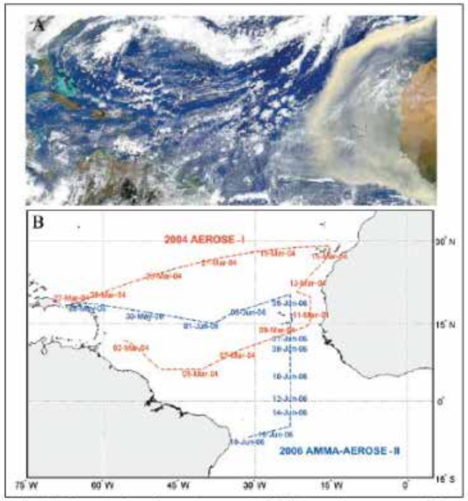
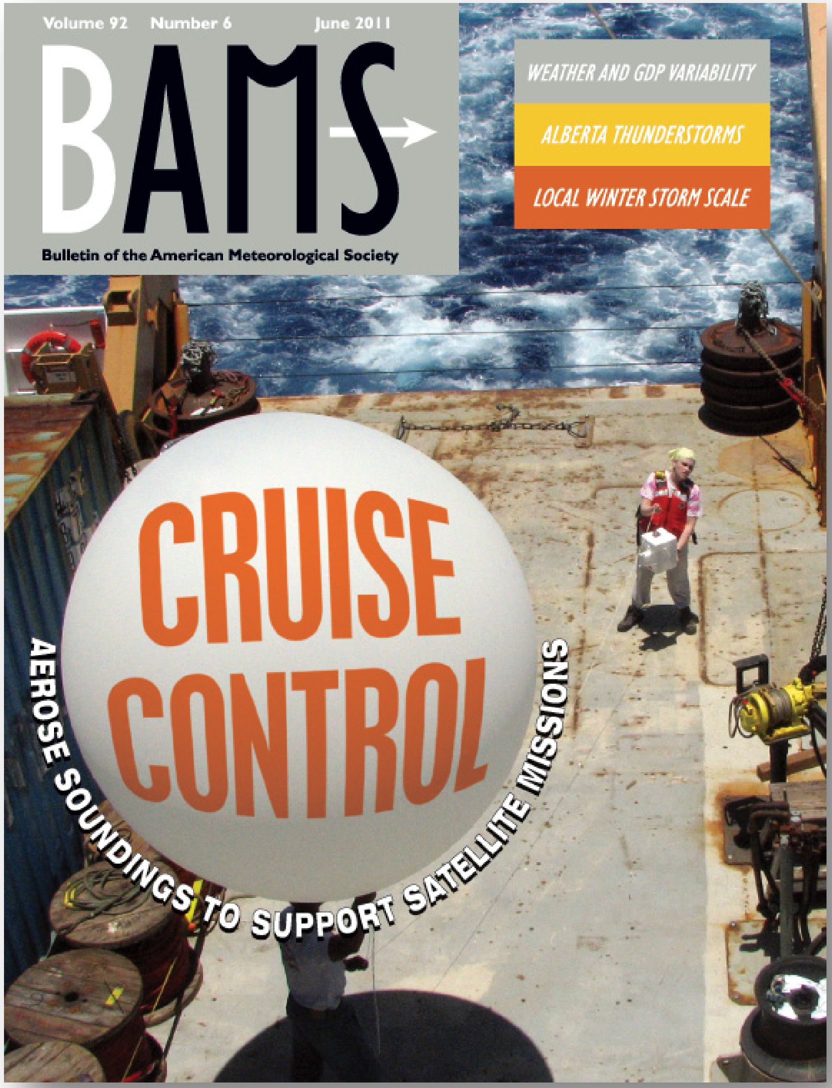


Fig. 1. (a) Moderate Resolution Imaging Spectrometer (MODIS) true color average image (5–6 March 2004) of the Saharan dust plume crossing the North Atlantic Ocean during AEROSE. (b) Cruise tracks of the Ronald H. Brown for the 2004 AEROSE-I and Leg 1 of the 2006 AMMA-AEROSE-II.

AEROSE Featured in *BAMS*

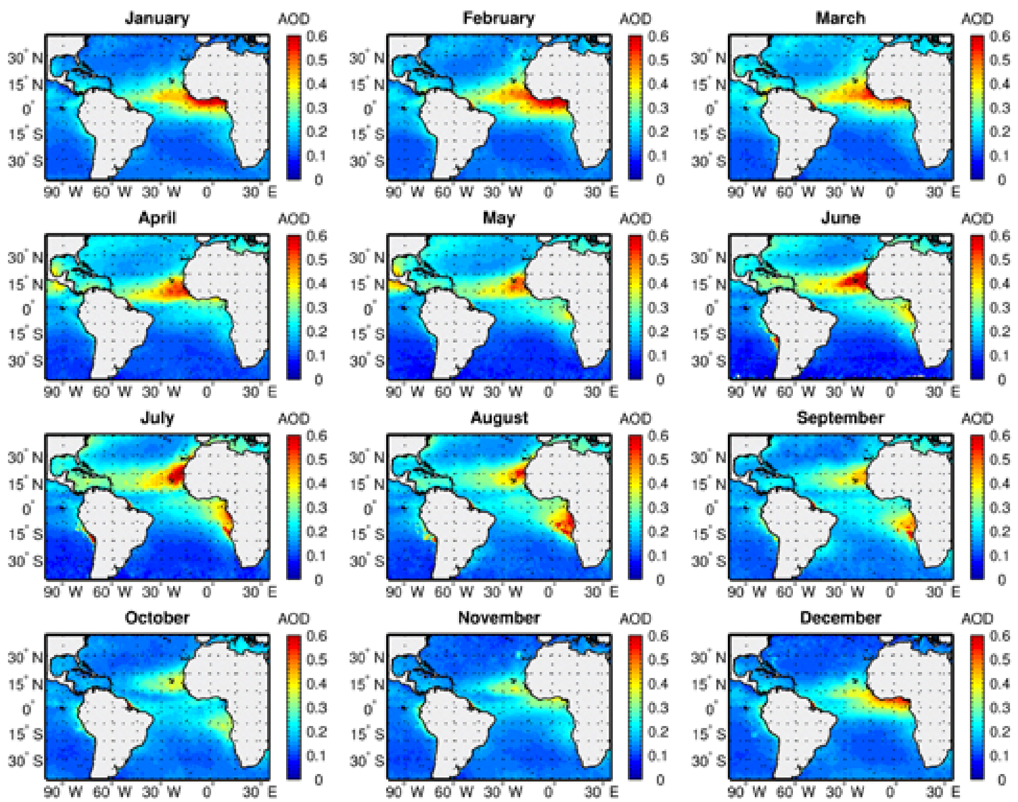


- A comprehensive **overview paper** describing **AEROSE** (*Nalli et al.*, 2011) was published as a Science Article in the **June 2011 issue** of the ***Bulletin of the American Meteorological Society (BAMS)***
- The AEROSE paper got the cover photo and headline
- Science topics of interest are highlighted, with emphasis given to satellite cal/val (JPSS, IASI and GOES-R)

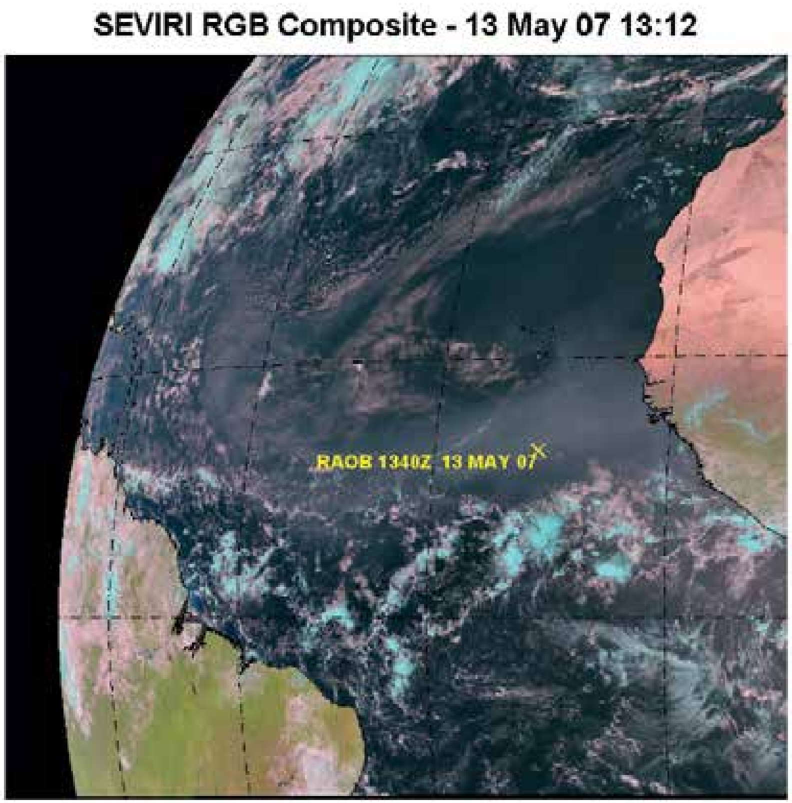
Dust and Smoke Aerosol Outflows

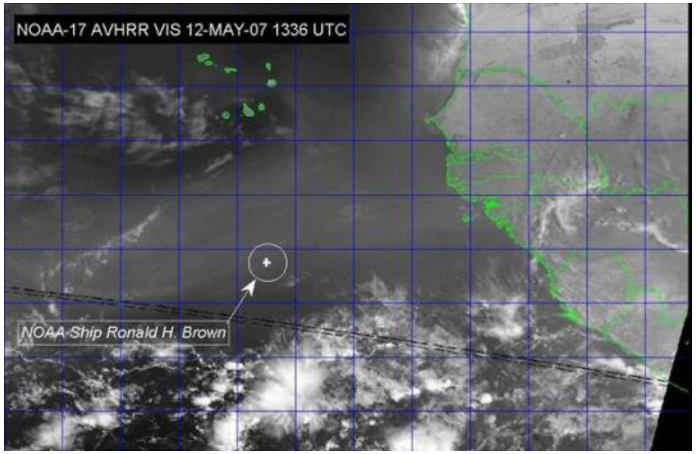
- **~100–400 Tg of mineral dust** are injected into the atmosphere from the Sahara annually (*Prospero et al.* 1981).
  - Peaks during NH summer and springtime
  - Coarse-mode aerosols, often transported within easterly trade winds well across the Atlantic north of the ITCZ
  - Westward flow accounts for the 30–50% of the dust output
  - Most readily detected by satellite sensors
- **Smoke from biomass burning** from sub-Saharan Africa also contribute large quantities of smaller-sized aerosols
- These have a significant impact on the chemistry, meteorology and climate dynamics of the tropical North Atlantic (e.g., radiation balance)
- Due to absorption/scattering, they also **impact infrared radiances**, and thus geophysical retrievals (e.g., *Nalli and Stowe* 2002; *Weaver et al.* 2003)

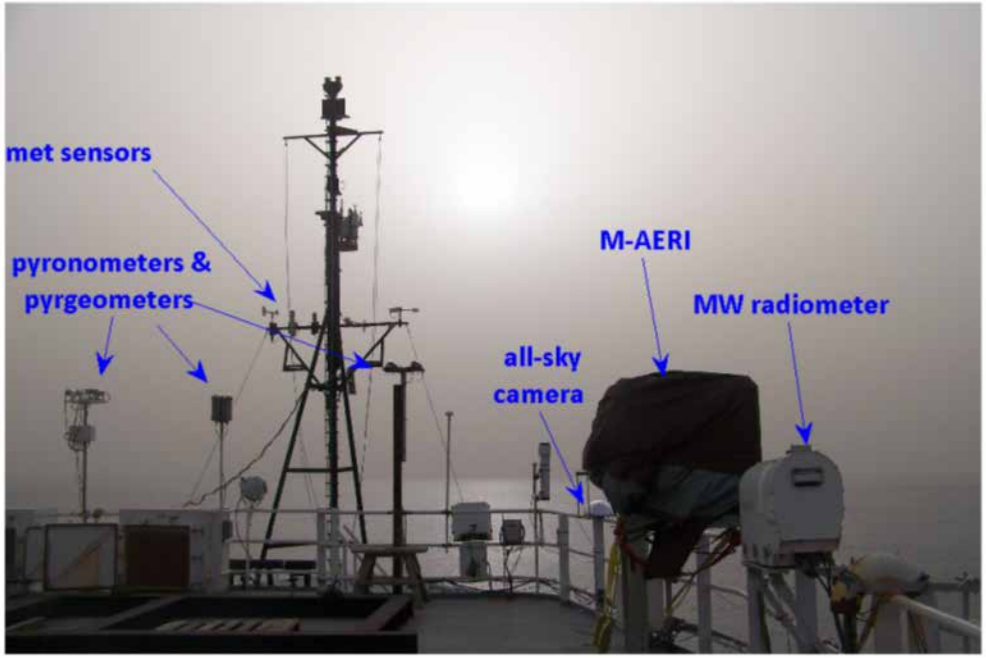
AVHRR PATMOS-x AOD Climatology



Dust Outflow Event – 12-15 May 2007

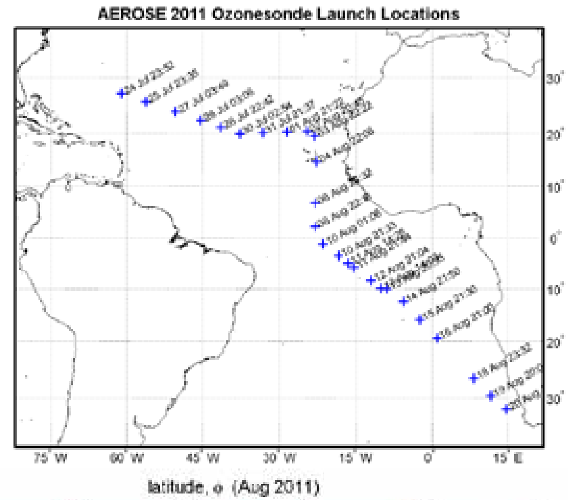


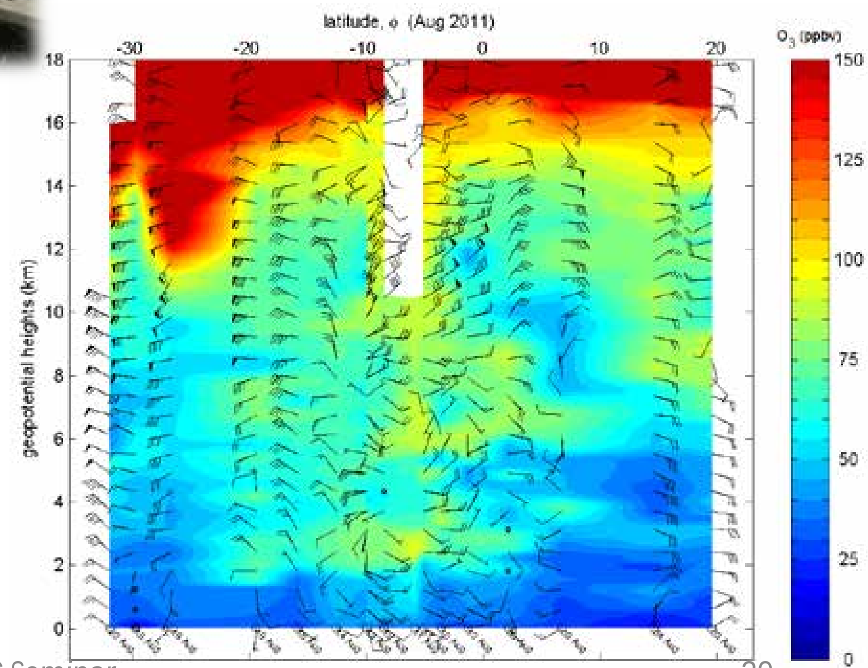




Aerosol Impact on the Chemistry of the Tropical Atlantic Atmosphere

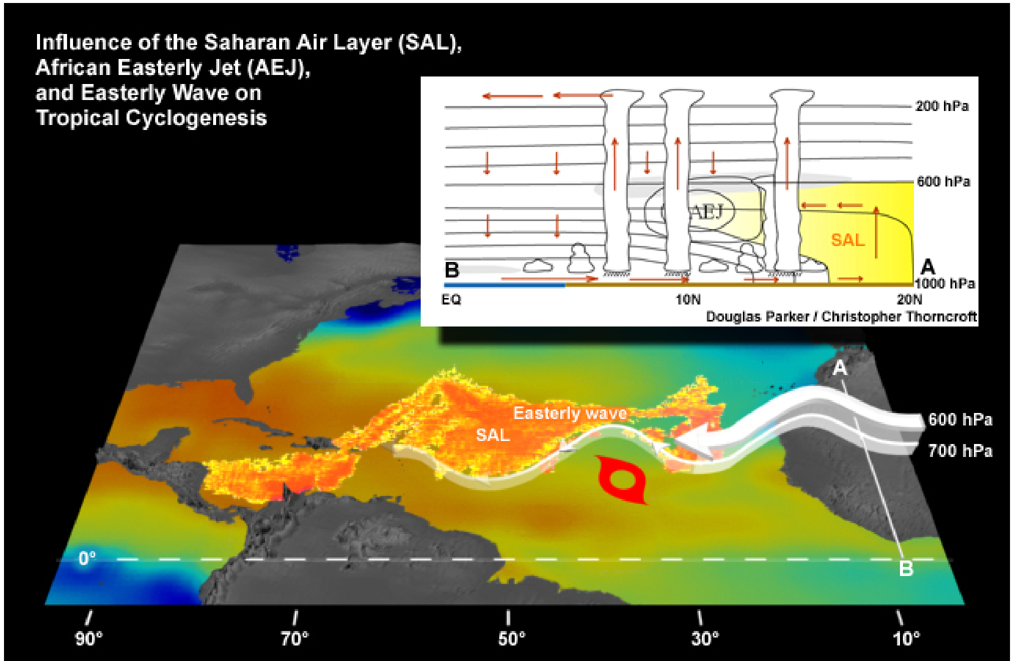
- Surface **aerosol-gas reactions** and transport
- **Tropospheric ozone**
  - Smoke aerosol precursors (CO) from African and South American biomass burning
    - Horizontal advection via easterlies
    - Vertical transport via tropical deep convection
  - Lightening in deep convection – NO_x precursor formation
  - Stratospheric intrusions





Moisture Transport: Saharan Air Layers and Hadley Cells

- **Saharan Air Layers (SAL)**
  - Synoptic to mesoscale **stable layers of dry, warm air of desert origin**
  - **Advect across the Atlantic Ocean**, often accompanying high levels of Saharan dust aerosols (*Carlson and Prospero* 1972).
  - These **stabilizing conditions** may **suppress hurricane activity** over the Atlantic (e.g., *Karyampudi and Pierce* 2002; *Dunion and Velden* 2004; *Wong and Dessler* 2005; *Evan et al.* 2006; *Sun et al.* 2008; *Shu and Wu* 2009), and may also be self-sustaining as a result of reduced radiative cooling in the layer



http://www.goes-r.gov/users/comet/tropical/textbook_2nd_edition/media/graphics/sal_genesis.jpg

- **Hadley Cells**
  - **Global/synoptic scale circulation cells** consisting of uplift along the ITCZ axis and associated poleward divergence aloft
  - **Subtropical subsidence** causes drying and warming, leading to deep columns of dry air with stabilizing tropospheric inversions at their bases (“advection–condensation model”; *Pierrehumbert et al.* 2007)

Moisture Transport: Atmospheric Rivers (ARs)

- **Atmospheric Rivers (ARs)** are narrow channels of moisture transport that are associated with midlatitude storm systems and that can extend thousands of km offshore (e.g., *Dettinger et al.* 2015; *Dacre et al.* 2015; *Ramos et al.* 2016)
  - Important for forecasting coastal precipitation (e.g., the West Coast)
  - "**Drought busters**" (*Dettinger* 2013) after the record **2012–2015 California drought** (e.g., *Swain* 2015)
- Understanding of ARs is important for **forecasting West Coast precipitation**, and given **California droughts** of recent years, ARs are a hot topic of current research
- **Satellite sensors** are tools whereby both **SAL** and **AR** phenomena can be observed synoptically; this is another reason why **validation in these regions is highly desirable**

Figure from CalWater2 whitepaper (courtesy of Ryan Spackman, STC)

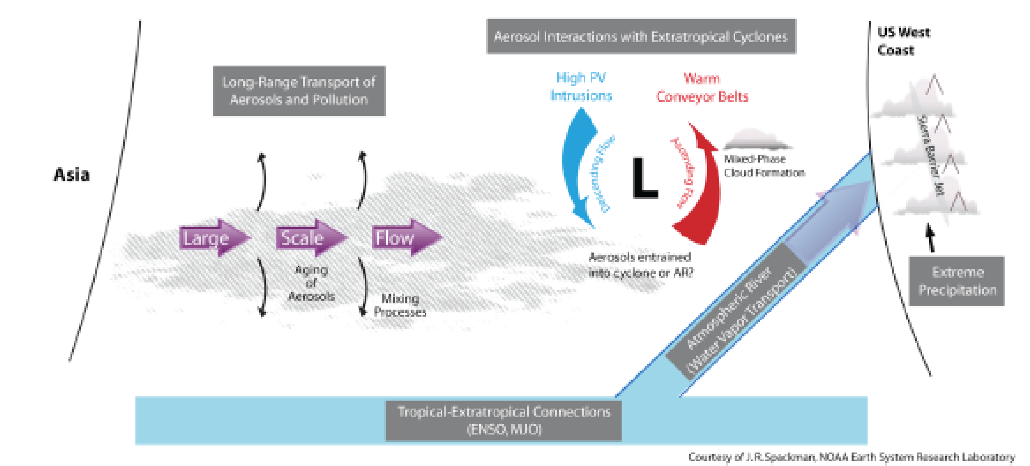


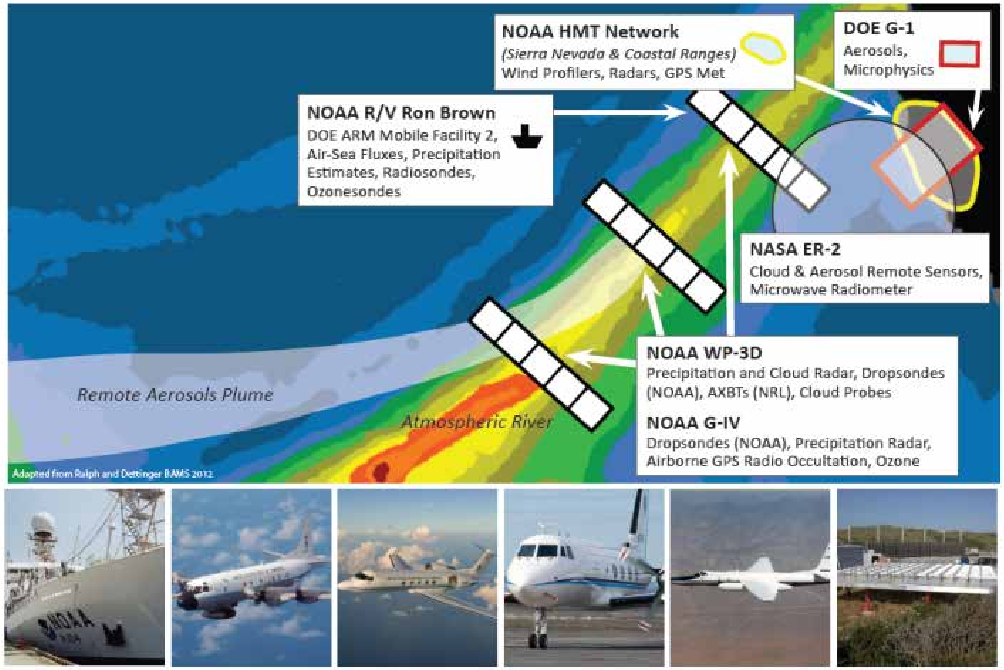
Figure 1. Conceptual framework for CalWater 2 science goals. The proposed observational strategy includes airborne and ship-based assets over the central and eastern Pacific complemented by ground-based measurements along the U.S. West Coast.

2015 CalWater/ACAPEX Campaign

- **California's water (CalWater)** is influenced by extreme precipitation events associated with
  - **Atmospheric Rivers (ARs)**
  - **Aerosols** from local and remote sources

- **CalWater 2015** was a multi-institutional intensive field campaign to obtain a suite of observations for gaining understanding of these phenomena
  - Aircraft-based data
    - NOAA P-3
    - NOAA G-IV
    - DOE G-1
    - NASA ER-2
  - Land-based networks
    - NOAA Hydrometeorology Testbed (HMT) mesonet sites
  - **ACAPEX/AEROSE** sub-campaign, NOAA *Ronald H. Brown,* AMF2
    - Leg 1: Honolulu to San Francisco
    - Leg 2: San Francisco to San Diego

Figure from CalWater2 whitepaper (courtesy of Ryan Spackman, STC)

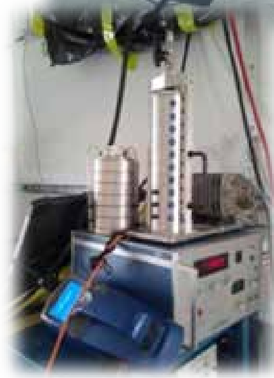


ACAPEX photos courtesy of Jon Gero (UW/CIMSS)

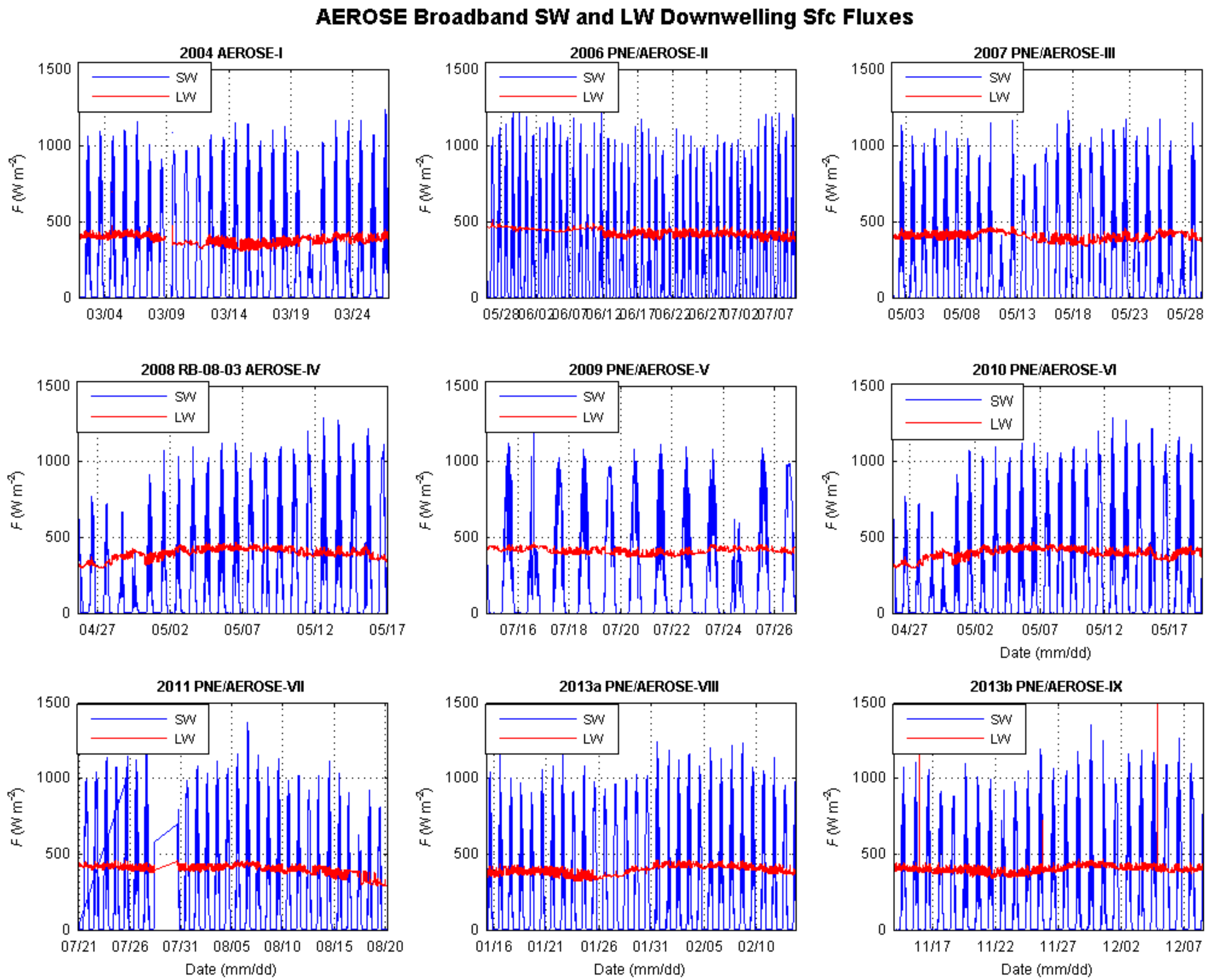
Data (1/5): *In situ* Gas & Particle Measurements

- TECO (Thermo Electron Corp.) Measurements
  - Ozone Photometer: Ambient gas-phase O_3
  - CO IR Spectrometer: Ambient gas-phase CO
  - NO_x Chemilumenence Analyzer: Ambient NO + NO_2
  - SO_2 Fluorometer: Ambient gas-phase SO_2
- Chemical and Bulk sampling
  - Uses quartz and Teflon filters
- Condensation Particle Counter
  - Enlarges particles via condensation for easy counting
- Laser Particle Counter
  - Measures aerosol number density
- QCM (Quartz Crystal Microbalance) Cascade Impactor
  - Measures aerosol mass density



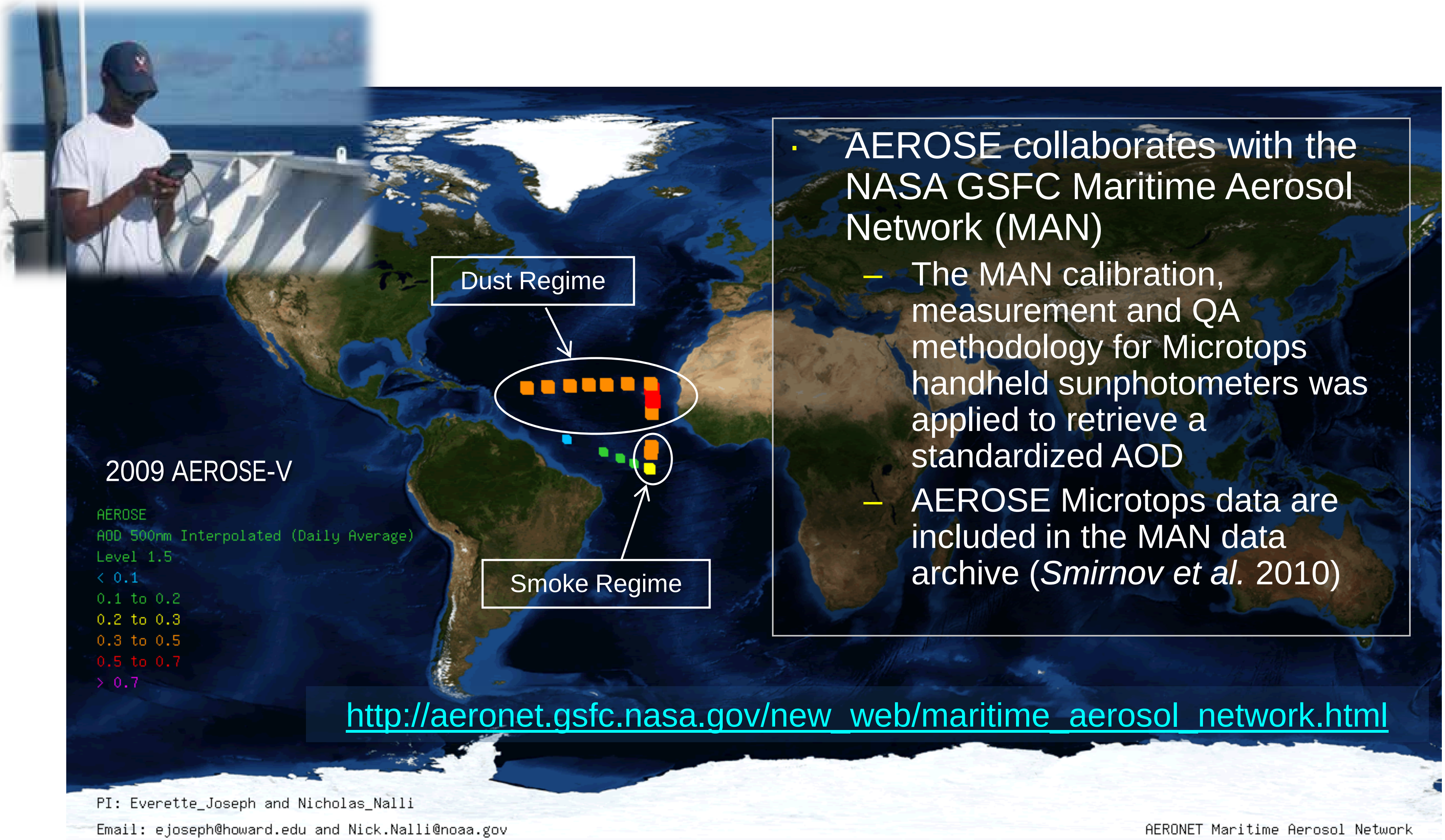


Data (2/5): Broadband Radiometer Fluxes



Data (3/5): Microtops Sunphotometer

GSFC Maritime Aerosol Network (MAN)

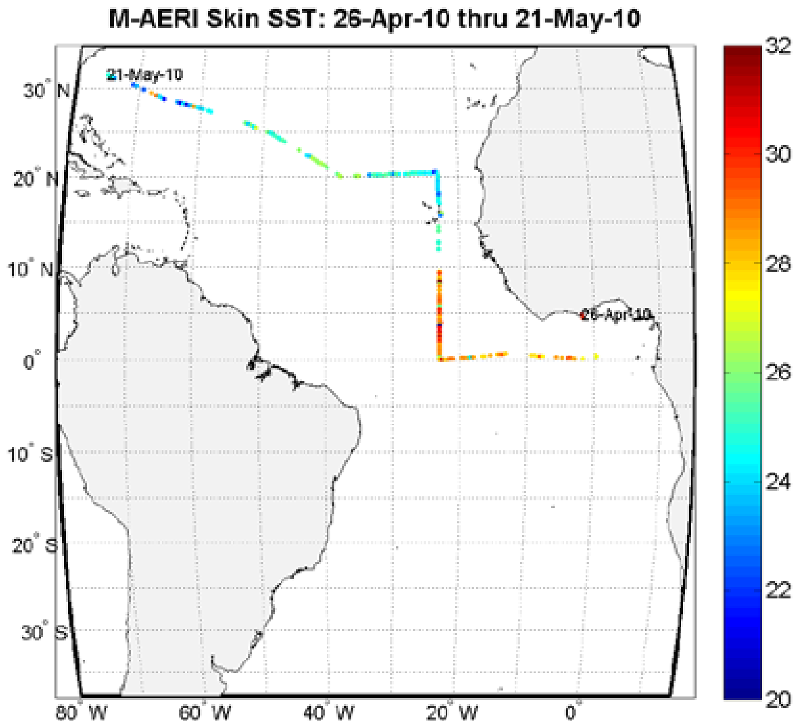


- AEROSE collaborates with the NASA GSFC Maritime Aerosol Network (MAN)
  - The MAN calibration, measurement and QA methodology for Microtops handheld sunphotometers was applied to retrieve a standardized AOD
  - AEROSE Microtops data are included in the MAN data archive (*Smirnov et al.* 2010)

http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html

Data (4/5): Marine Atmospheric Emitted Radiance Interferometer (MAERI)
(Minnett *et al.* 2002)

- **Ship-based FTS** that measures downwelling and upwelling calibrated IR spectra (*Minnett et al.* 2001)
- High accuracy calibration using 2 NIST-traceable blackbodies
- Derived (EDR) products
  - **High accuracy skin SST** derived from semi-opaque spectral region (~7.7 µm) (*Smith et al.* 1996)
    - **Skin SST** is an important **state parameter** and "ground truth"
  - Retrievals of lower tropospheric profiles at turbulent time scales (e.g., *Szczodrak et al.* 2007)
  - Ocean surface spectral emissivity (e.g., *Hanafin and Minnett* 2005; *Nalli et al.* 2008b)



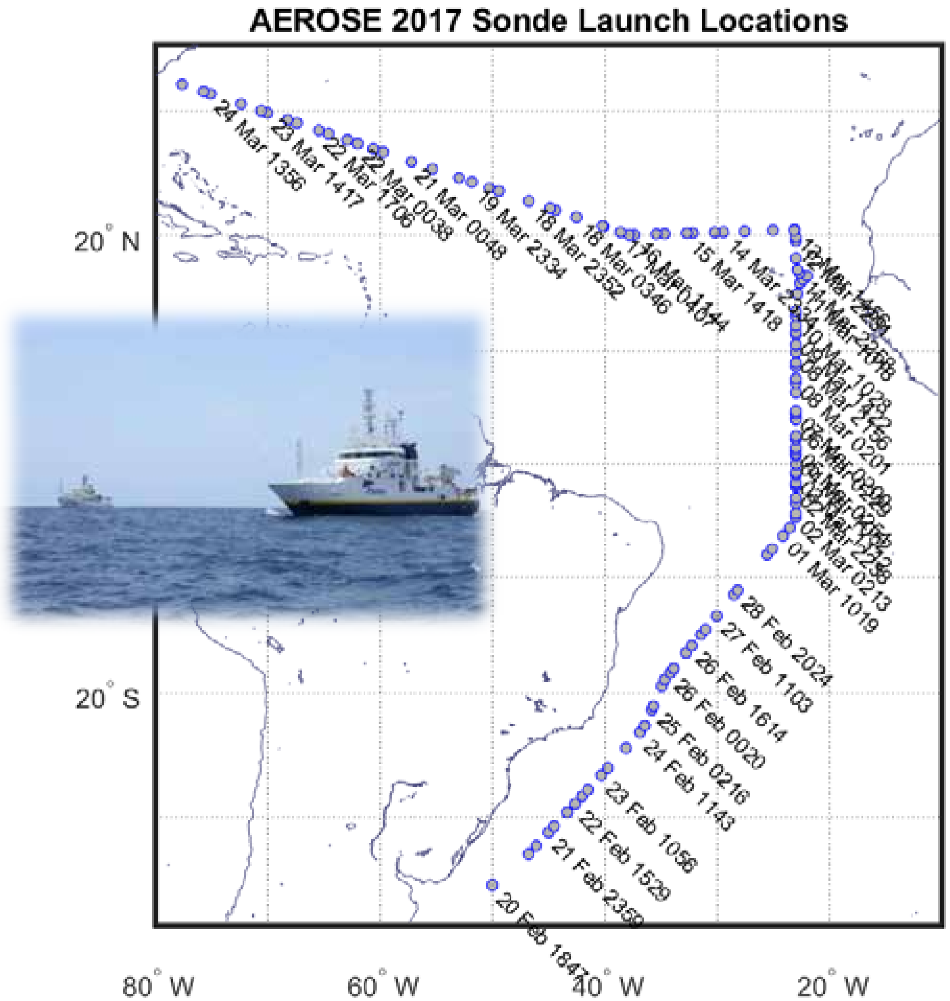
Data (5/5): Dedicated Radiosonde Observations (RAOB): *PTU*, O_3

- **Vaisala RS92/RS41 GPS rawinsondes**
  - **Launched coinciding LEO environmental satellite overpasses**
    - **Suomi NPP (CrIS/ATMS)**
    - **MetOp-A and -B (IASI)**
    - **Aqua, A-Train (AIRS)**
  - Pressure, temperature, humidity, *PTU(z)*, GPS winds and altitude
  - *Not* uploaded into GTS (i.e., ***not* assimilated**)
  - **1295 total ocean-based soundings acquired**
    - 111 RS41 soundings in Feb-Mar 2017

- **ECC Ozonesondes** interfaced with RS92
  - Measure $\mathbf{O_3(z)}$ partial pressure
  - ~1/day during SNPP overpasses
  - **195 full or partial O_3 soundings to date**
    - 13 O_3 soundings in Feb-Mar 2017

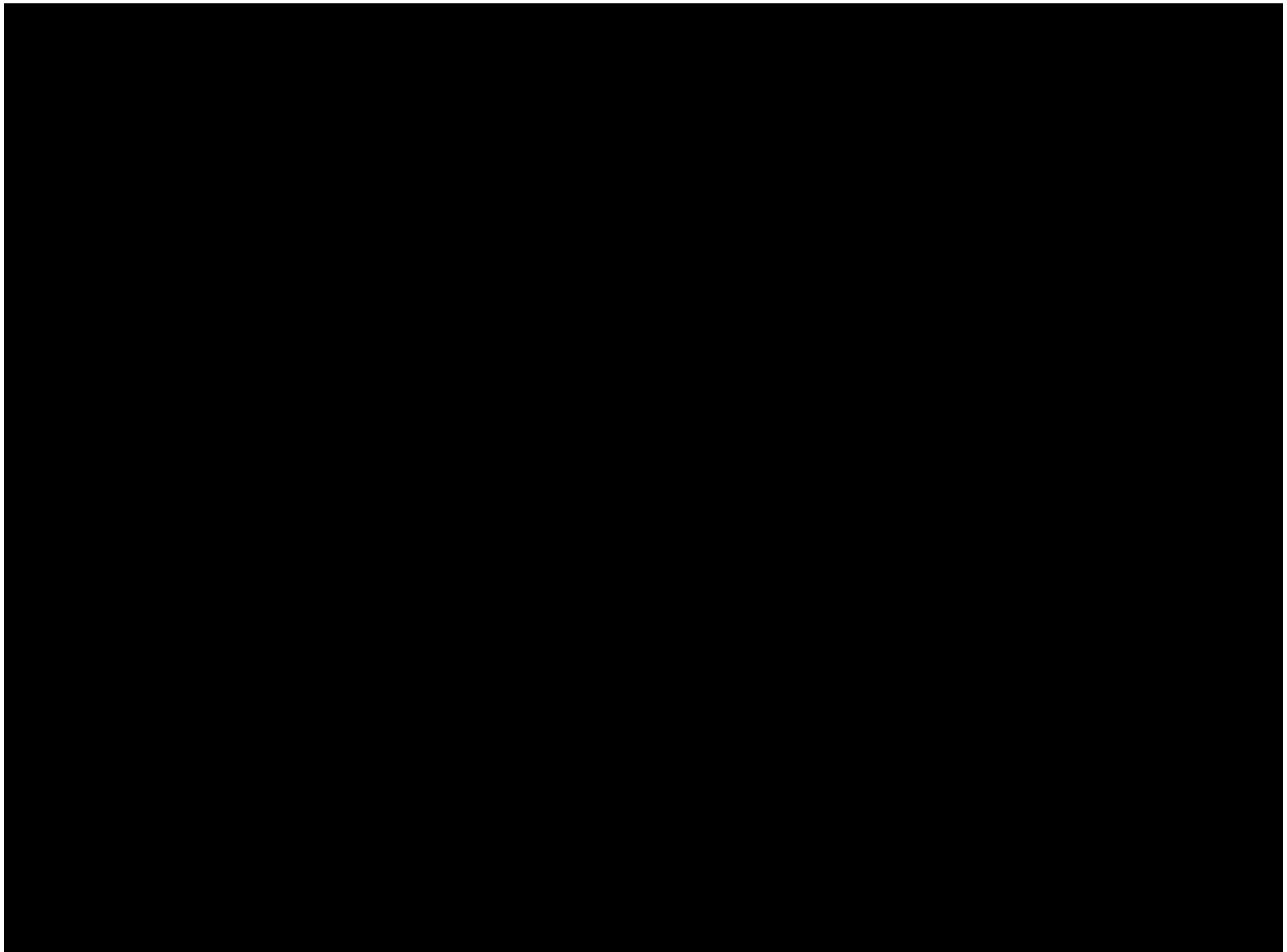
2017 AEROSE Campaign (SNPP Year-5)

- The **2017 NOAA AEROSE** took place onboard the NOAA Ship *Ronald H. Brown*
  - 19 Feb to 25 Mar 2017
  - Montevideo, Uruguay to Charleston, SC
- **117 Vaisala RS41-SGP, RS41-SG** and **RS92-SGP** radiosondes launched
  - **111 full or partial soundings** were obtained
  - Dedicated sondes were launched for **SNPP** and **MetOp** overpasses
    - These will provide another **fully independent truth dataset**
      - not assimilated
      - decoupled from land-based sites
    - These data will also automatically collocate with **GOES-16** (**GOES-R**), thereby allowing "two for the price of one" validation opportunities
- **13** full or partial **dedicated ozonesoundings** were obtained from **ECC ozonesondes** interfaced with Vaisala RS92-SGP rawinsondes



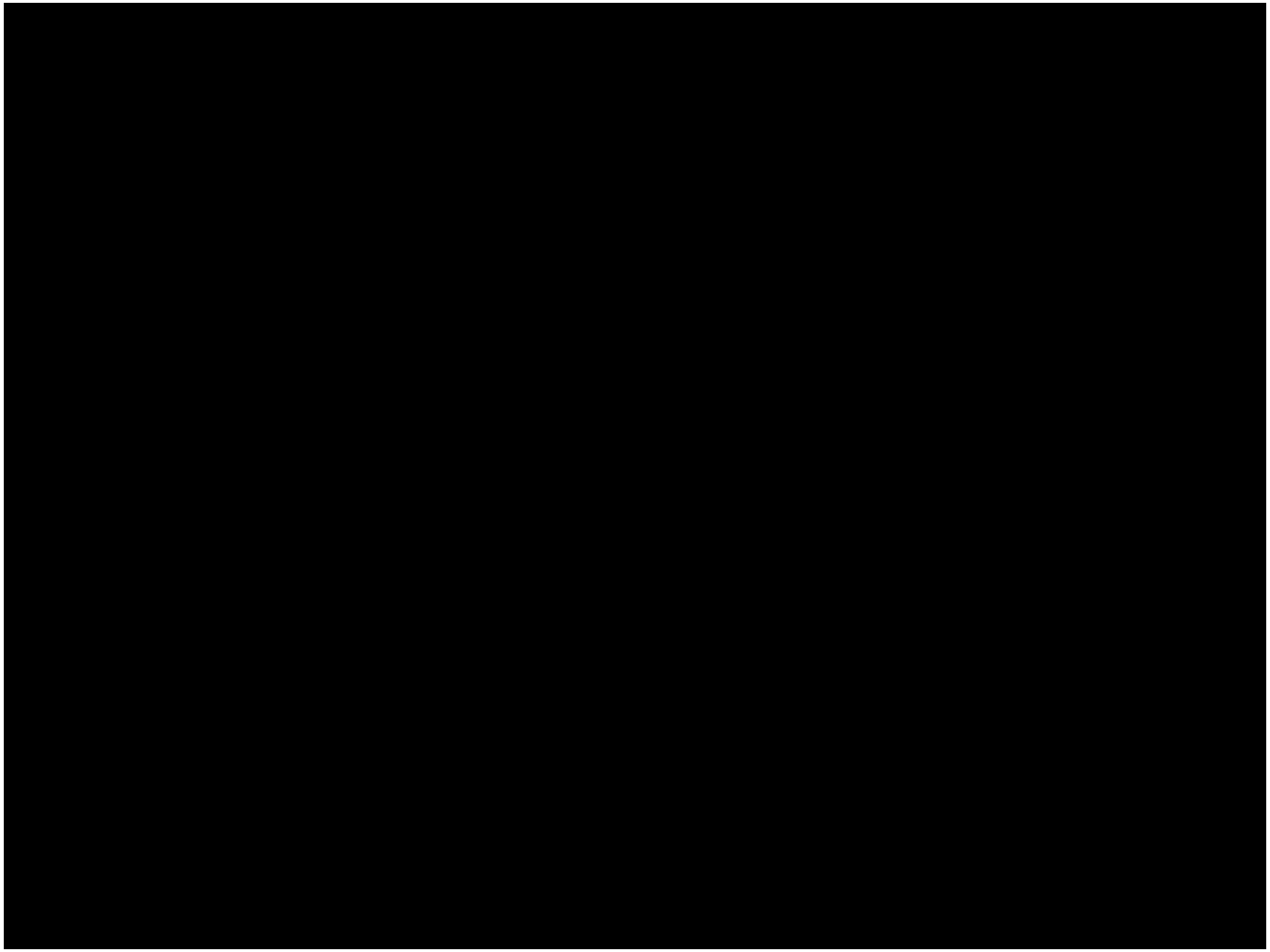
AEROSE SNPP-Dedicated Ozonesonde Launch (1/2)

AEROSE-X (Dec 2015, NATO RV *Alliance*)



AEROSE SNPP-Dedicated Ozonesonde Launch (2/2)

AEROSE-X (Dec 2015, NATO RV *Alliance*)

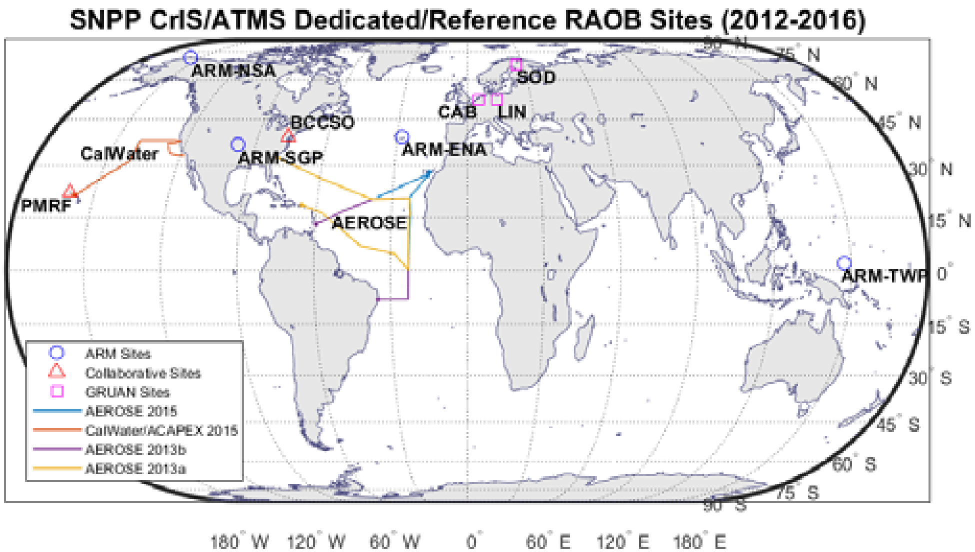


NOAA Aerosols and Ocean Science Expeditions (AEROSE): Ocean-Based Campaigns Supporting NOAA Satellite Remote Sensing

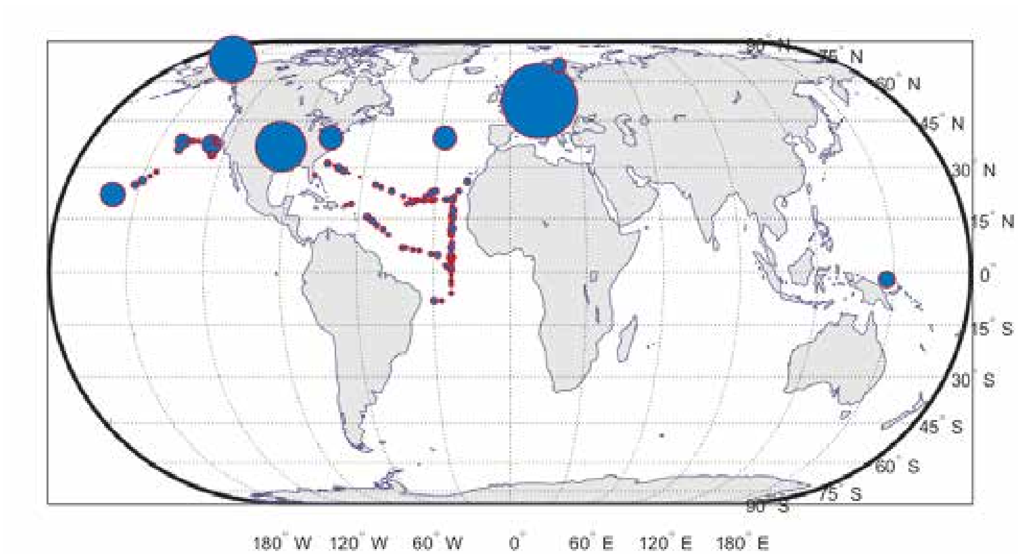
AEROSE SCIENCE HIGHLIGHTS

SNPP NUCAPS *T*/H_2O Global Validation

Dedicated/Reference RAOB-Retrieval Collocation Sample



JPSS SNPP-Dedicated and GRUAN Reference RAOB Sites



Geographic Histogram

FOR Collocation Criteria

$\delta x \leq 75$ km, $-60 < \delta t < 0$ min

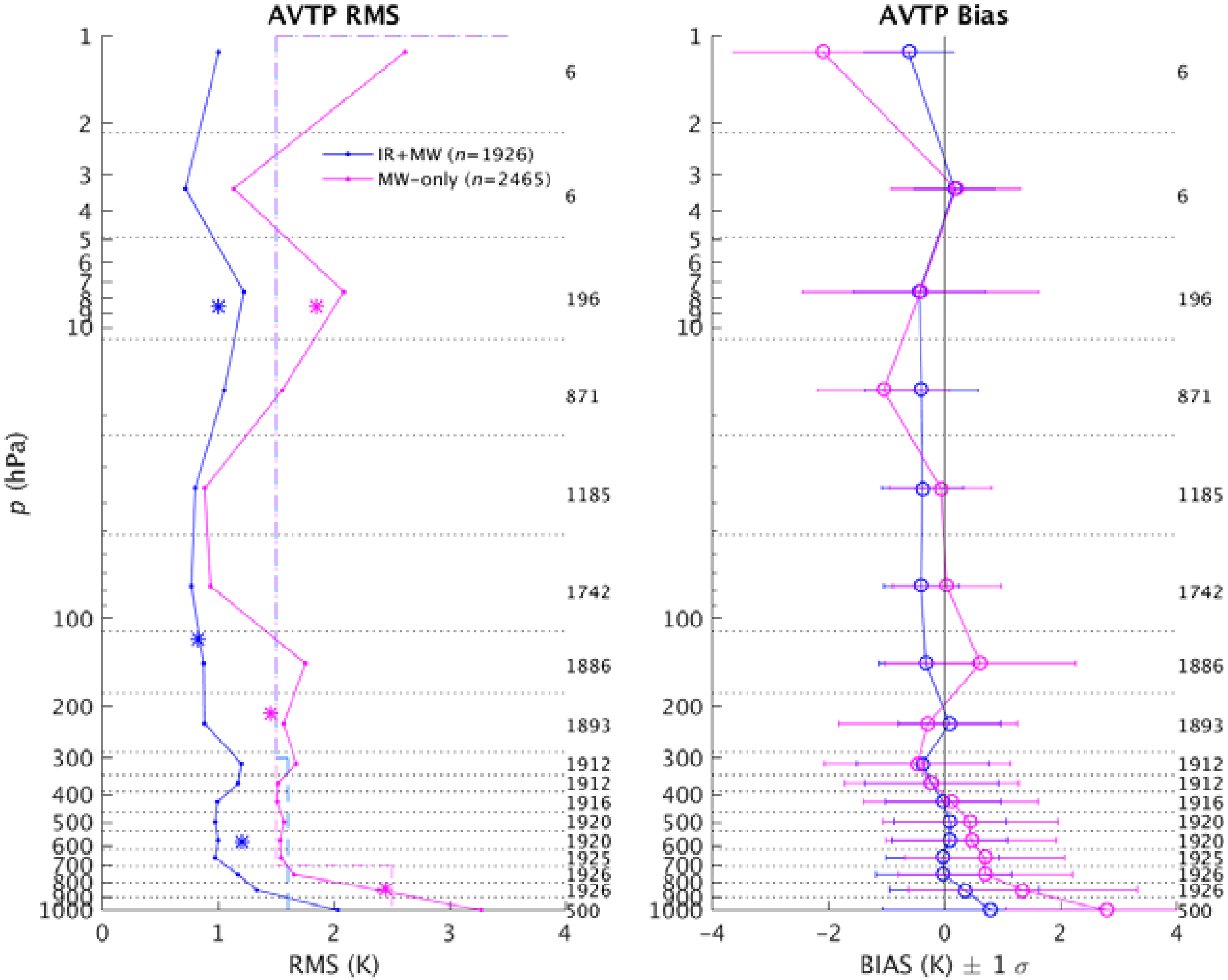
NUCAPS (v1.5 Nom-Res CrIS) AVTP Coarse-Layer Statistics
Dedicated/Reference RAOB Collocation Sample

AVTP Versus RAOB

** Broad-Layer Stats (Per JPSS Level 1 Requirements)

IR+MW
MW-Only

IR+MW Yield = 63.3%



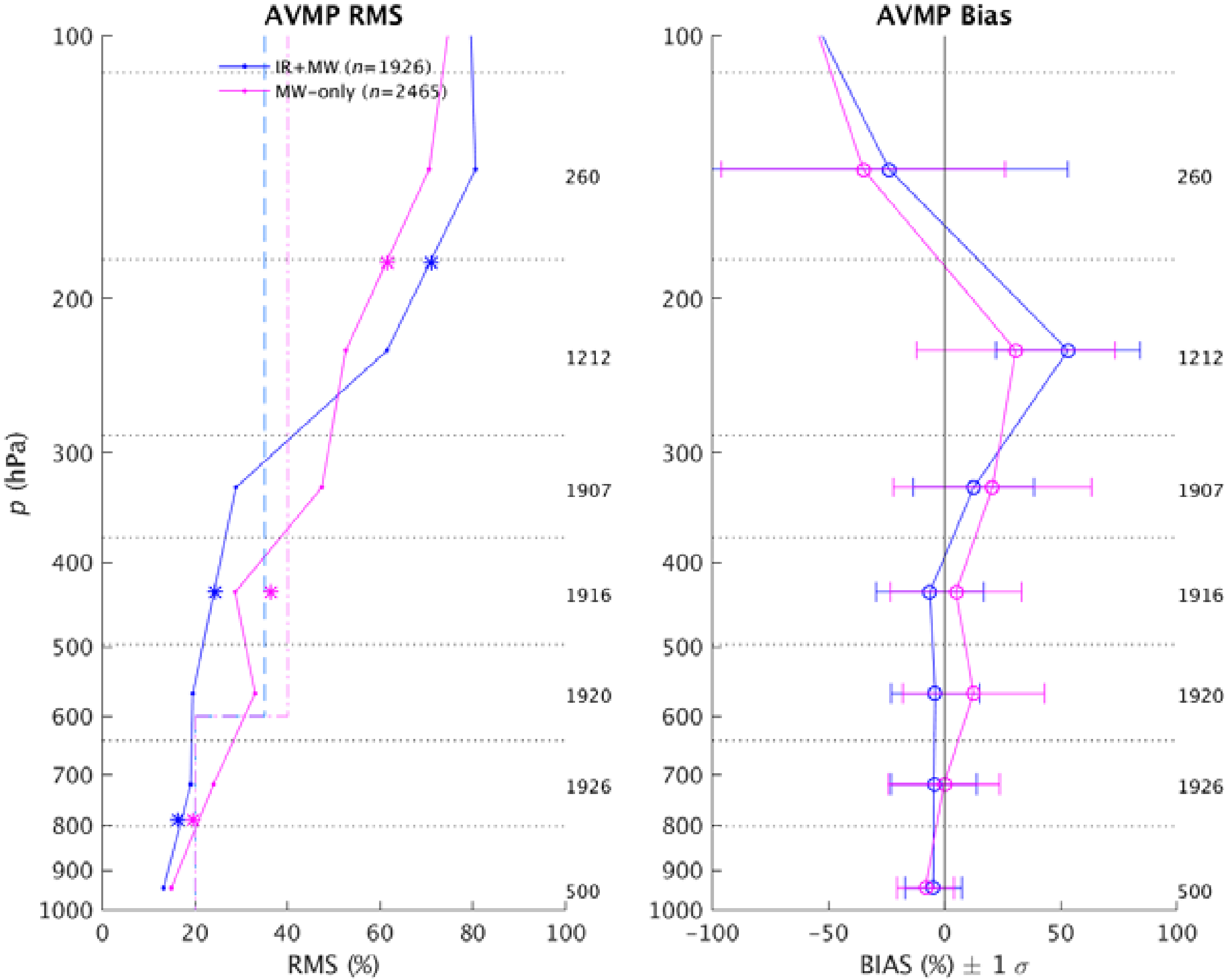
NUCAPS (v1.5 Nom-Res CrIS) AVMP Coarse-Layer Statistics Dedicated/Reference RAOB Collocation Sample

AVMP Versus RAOB

** Broad Layer Stats (Per JPSS Level 1 Requirements)

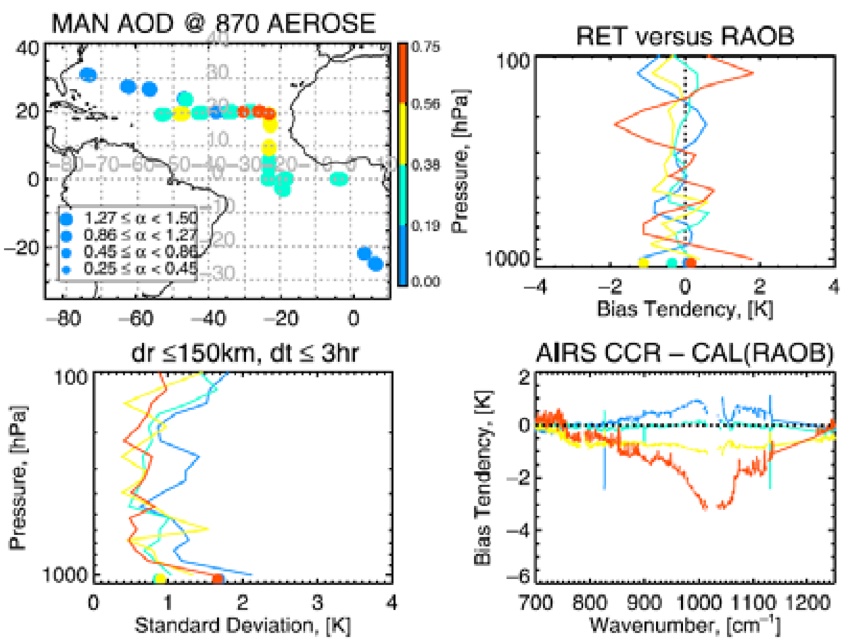
IR+MW
MW-Only

IR+MW Yield = 63.3%

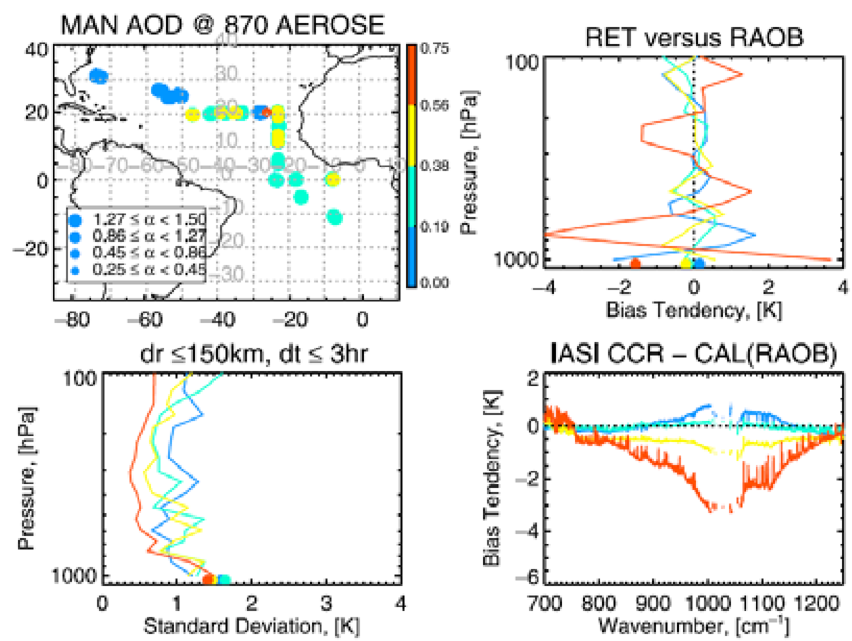


Aerosol Impact on IR Profile Retrievals
(*Maddy et al.* 2012)

Aqua AIRS

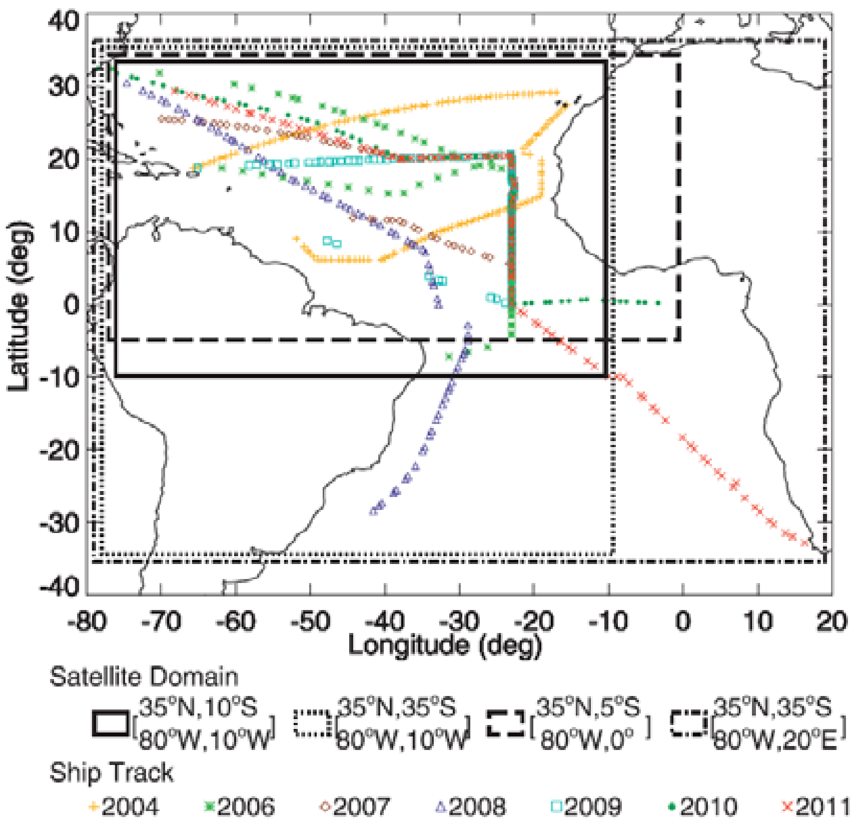


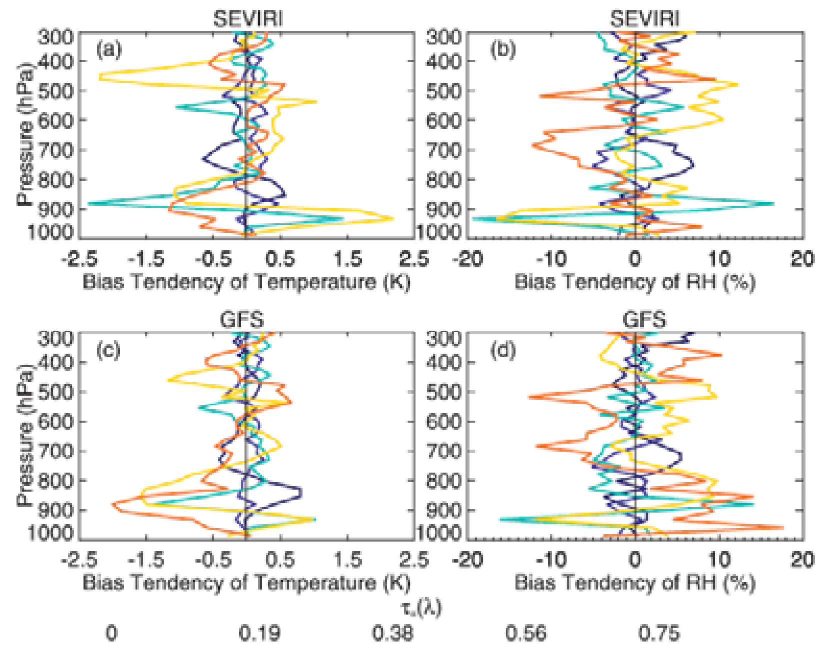
MetOp-A IASI

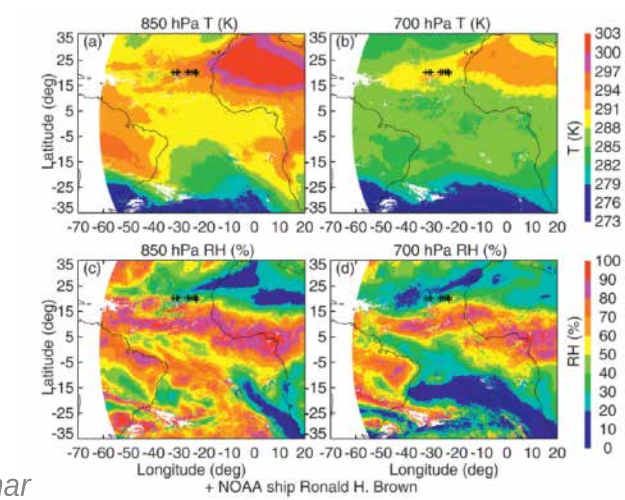


Figures taken from *Maddy et al.* (2012)

GOES-R Pre-Launch Validation (*Xie et al.* 2013)

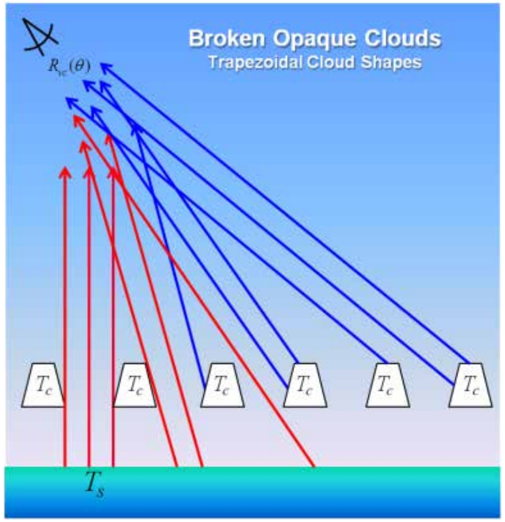


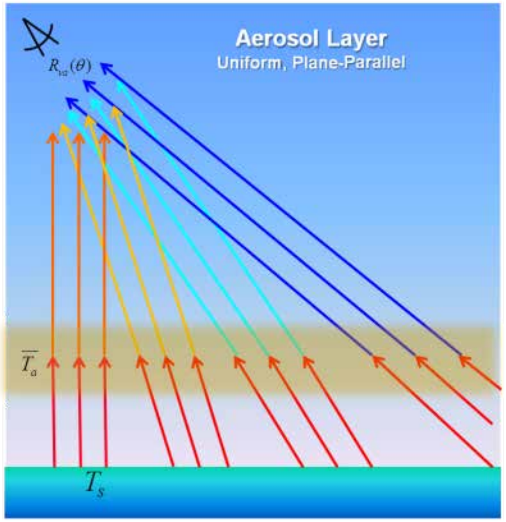


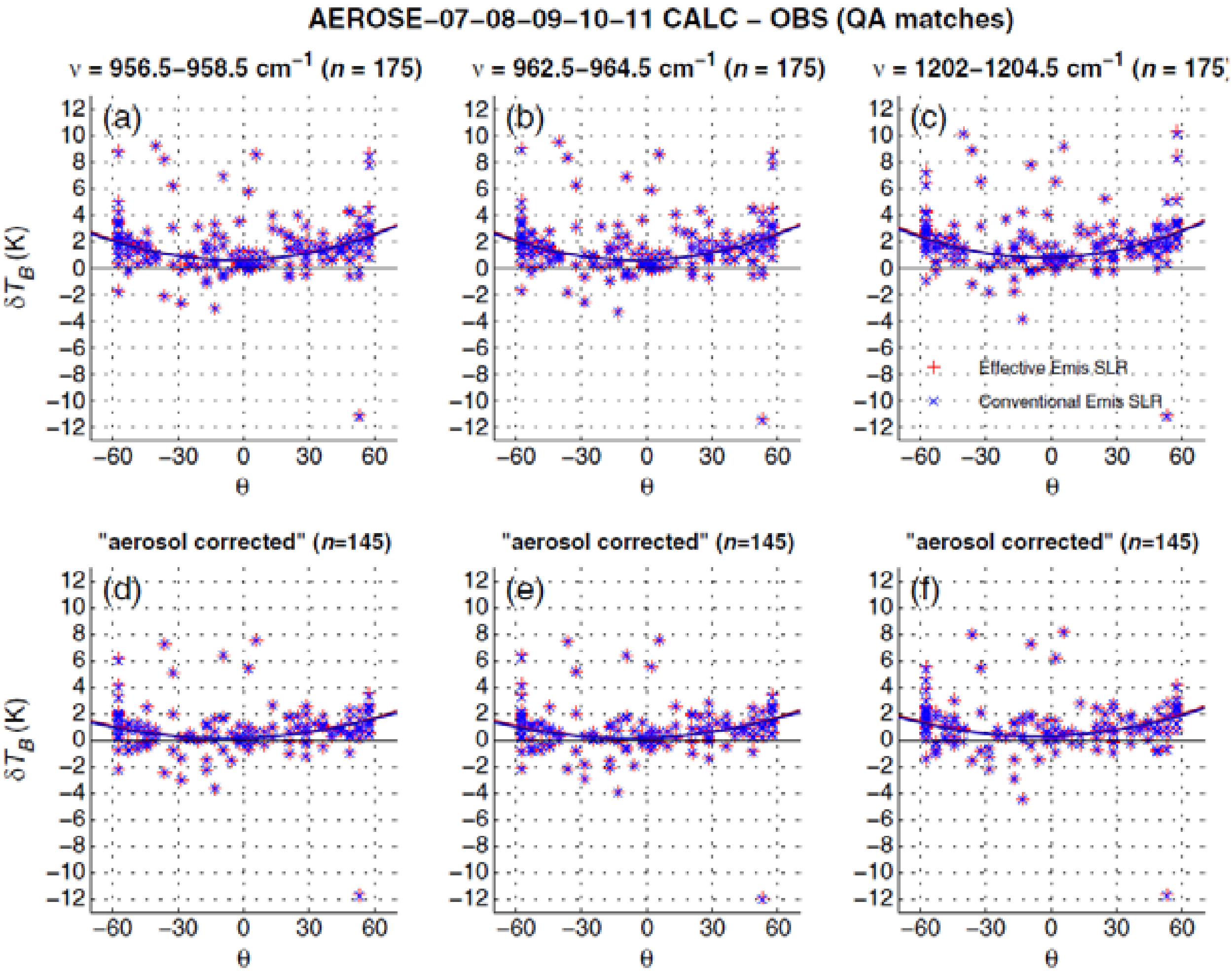


Figures taken from *Xie et al.* (2013)

Cloud/Aerosol Contamination in calc (LBL) – obs (CCR)





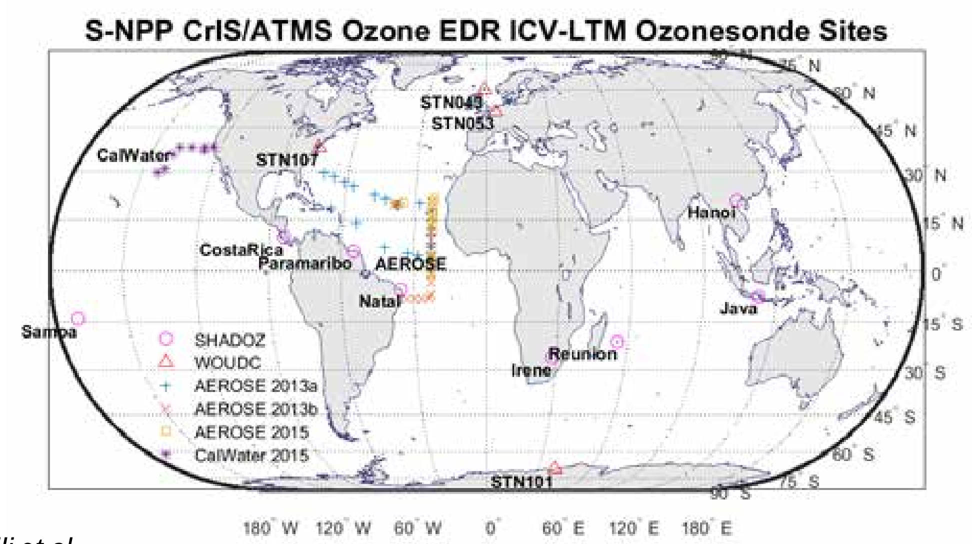


After *Nalli et al.* (2012, 2013)

SNPP NUCAPS O_3 Global Validation

Ozonesonde-Retrieval Collocation Sample

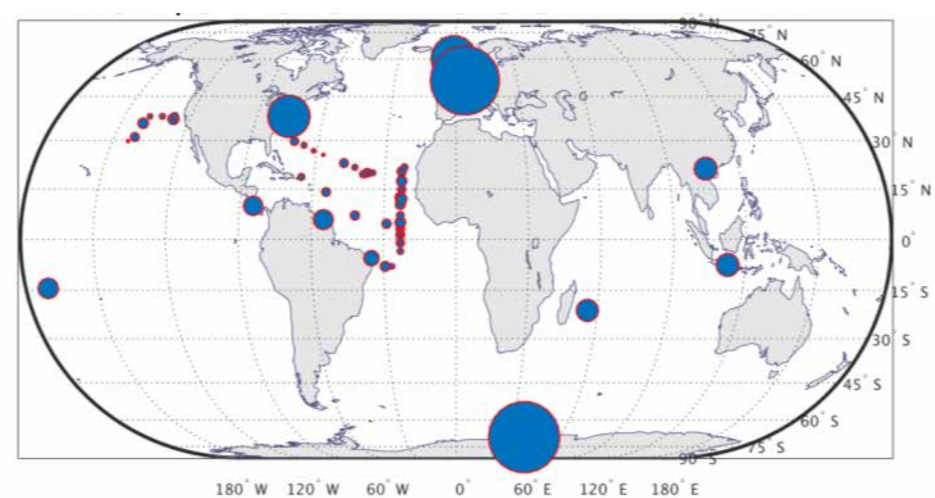
- **Collocated ozonesondes** for **O_3 (ozone) profile EDR**
  - **Dedicated Ozonesondes**
    - **NOAA AEROSE** (*Nalli et al.* 2011)
    - **CalWater/ACAPEX 2015**
  - **Sites of Opportunity**
    - **SHADOZ** (*Thompson et al.* 2007)
      - Costa Rica
      - Hanoi
      - Irene
      - Java
      - Natal
      - Paramaribo
      - Reunion
      - American Samoa
    - **WOUDC**
      - STN043
      - STN053
      - STN107
      - STN101



From Nalli et al. (2017)

Geographic Histogram (Equal Area)

FOR Collocation Criteria: $\delta x \leq 125$ km, $-240 < \delta t < +120$ min

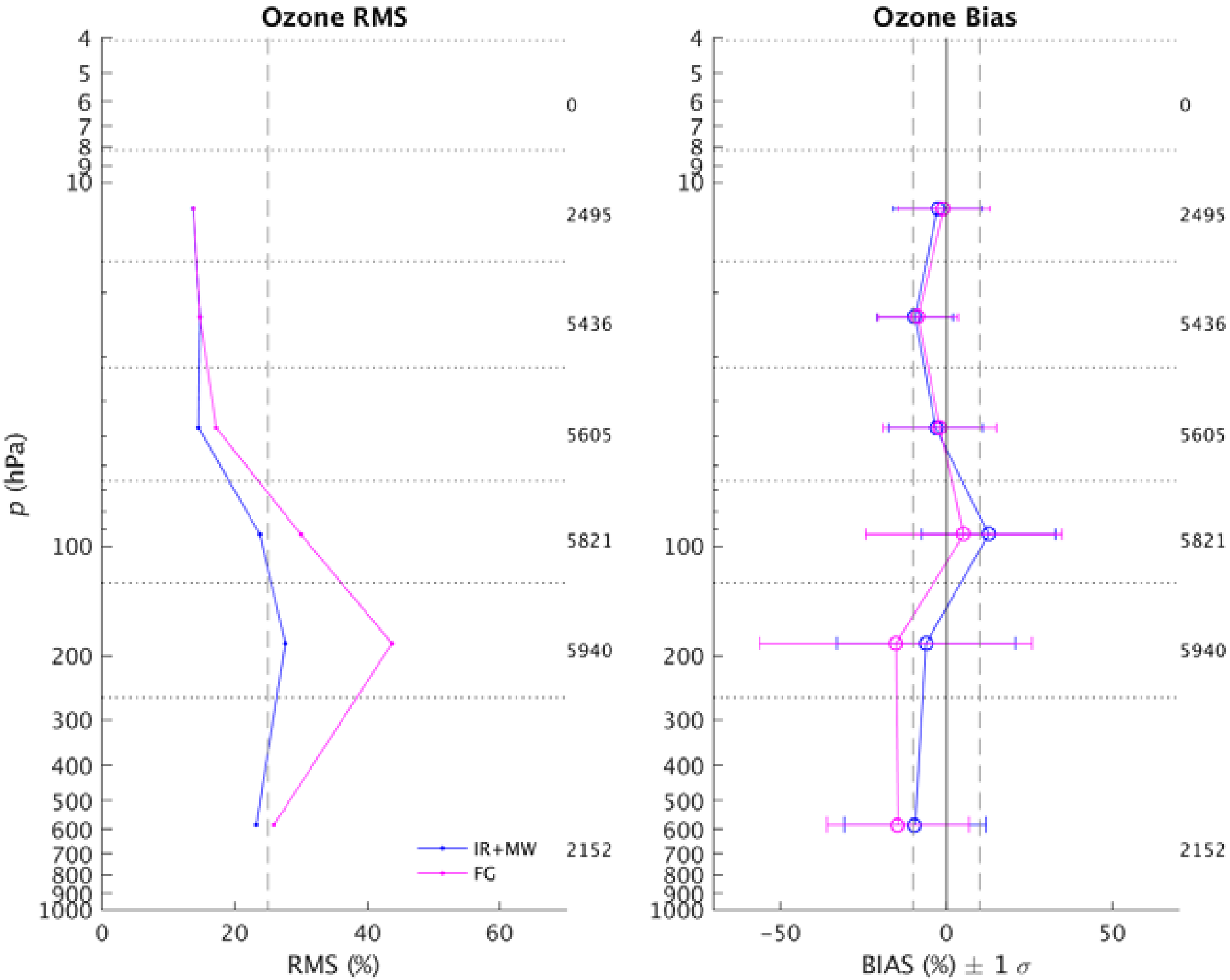


NUCAPS IR Ozone Profile EDR Validation

Global Ozonesondes (Including AEROSE SNPP-Dedicated)

Retrieval and *A Priori* First Guess

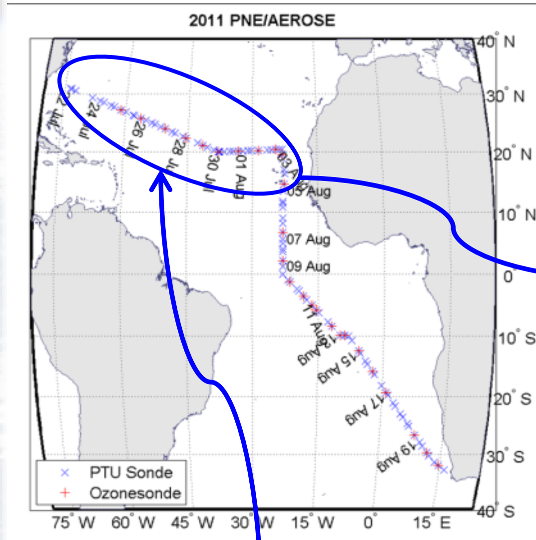
IR+MW Yield = 62.2%



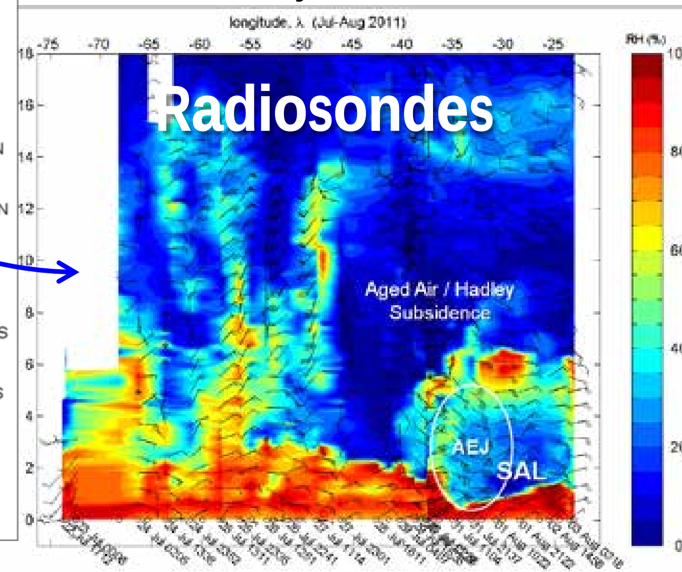
From Nalli et al. (2017)

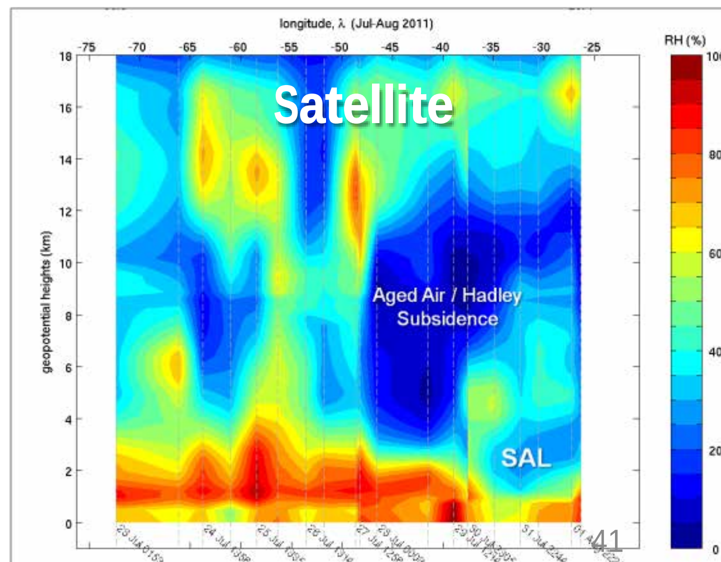
Using Satellite EDRs as Observations

Radiosonde Launches



Humidity Cross-Sections

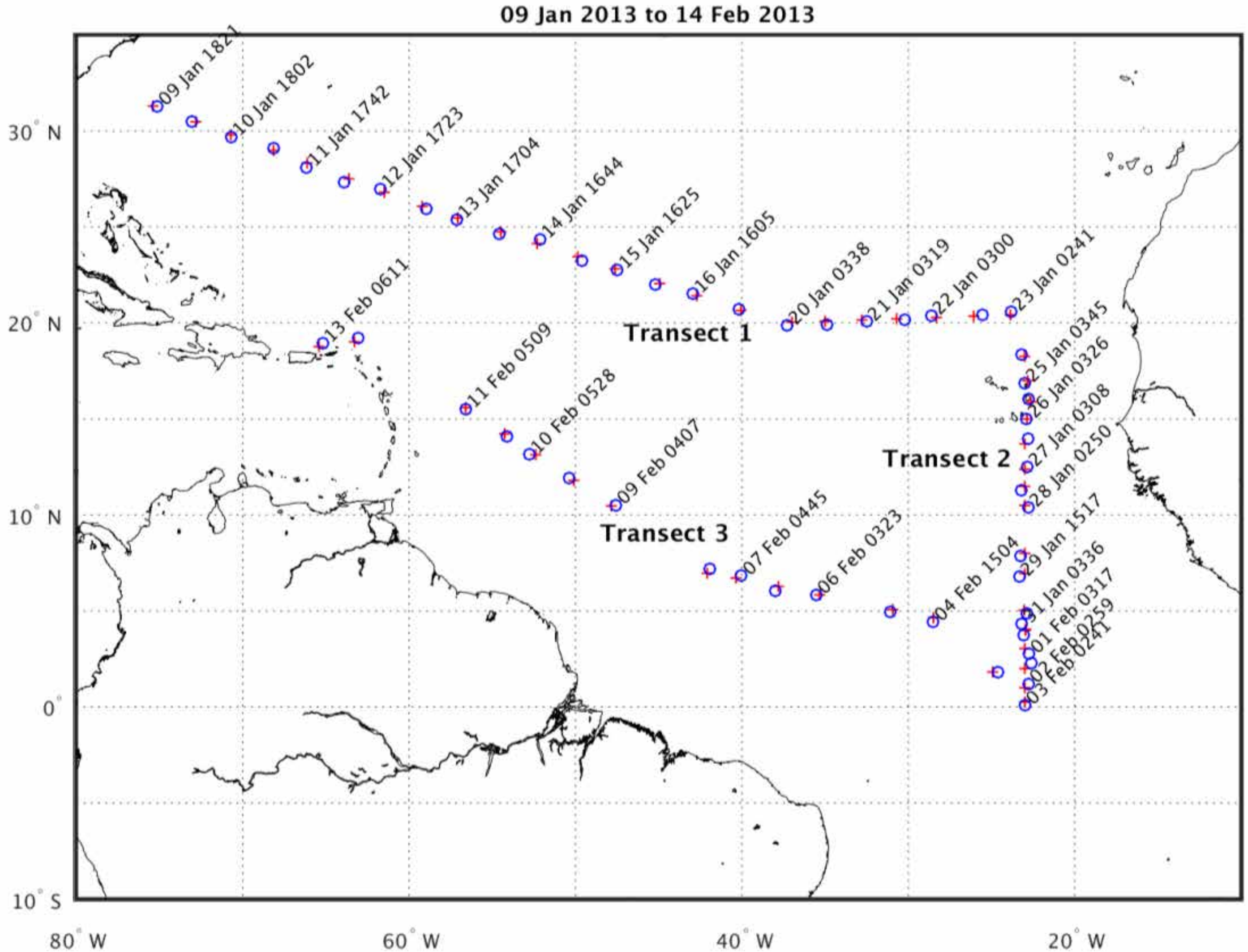




Dry Transport: Saharan Air Layers, Hadley Cells

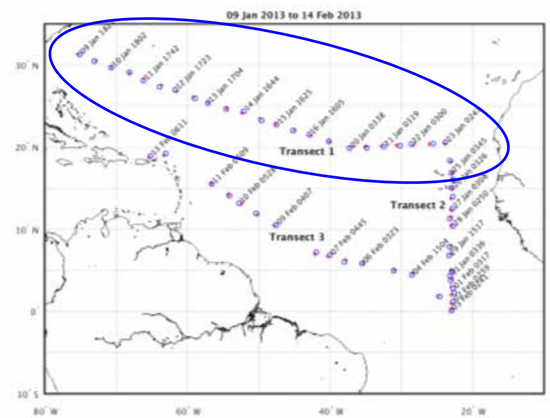
2013 AEROSE Radiosonde Launches (Jan-Feb 2013)

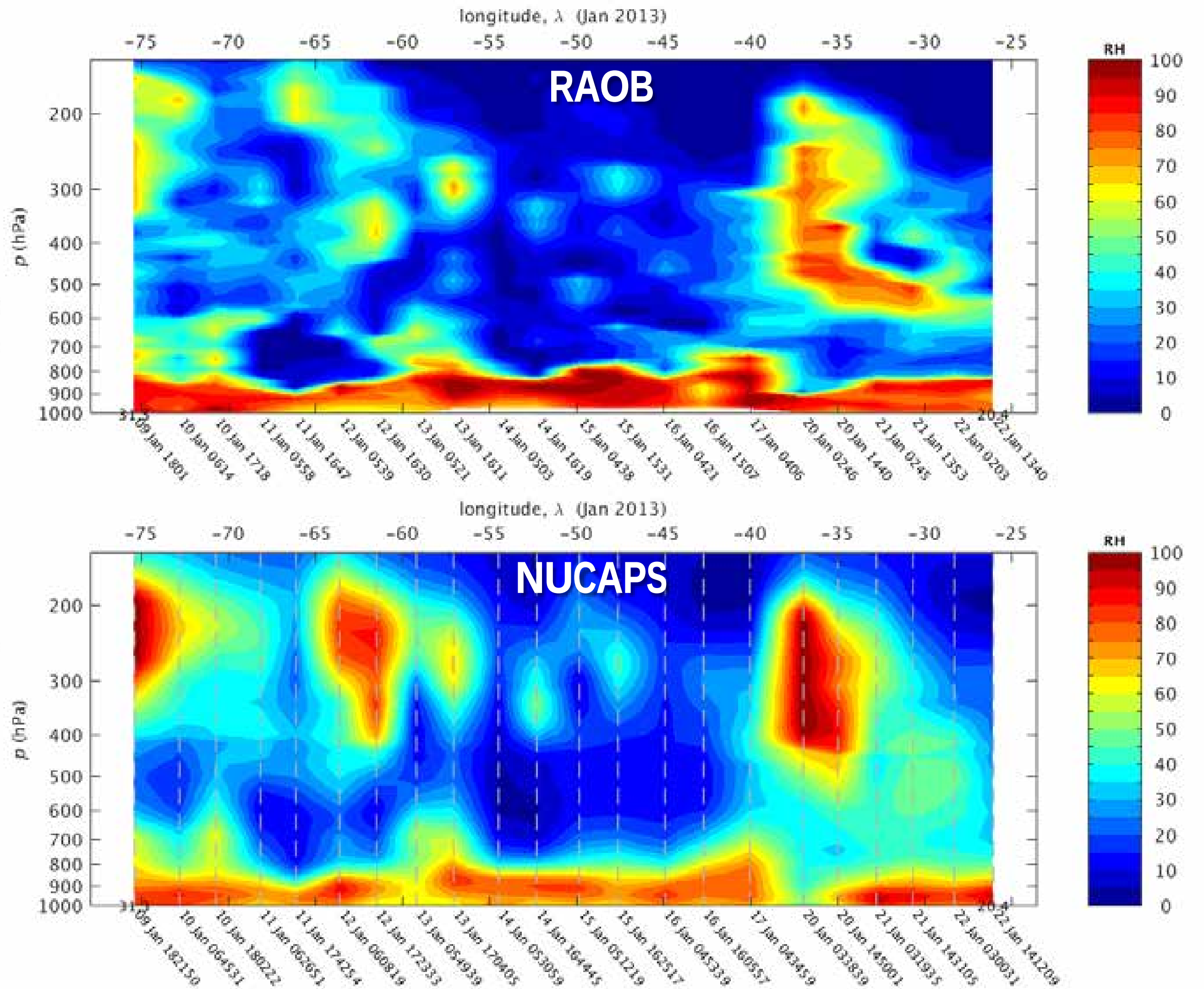
+ RAOB launch
o nearest FOR



Zonal RH Cross-Section (SAL, Hadley Cell)

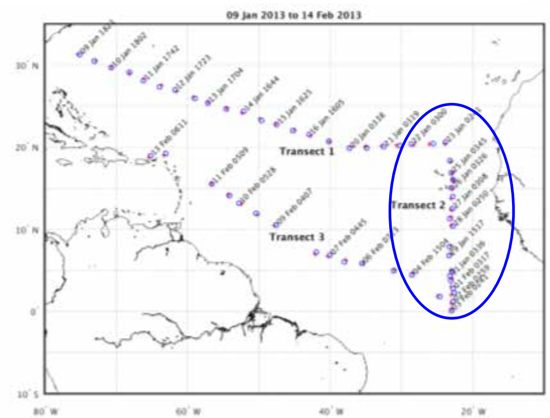
2013 AEROSE NW-SE Transect 1 (All Cases)

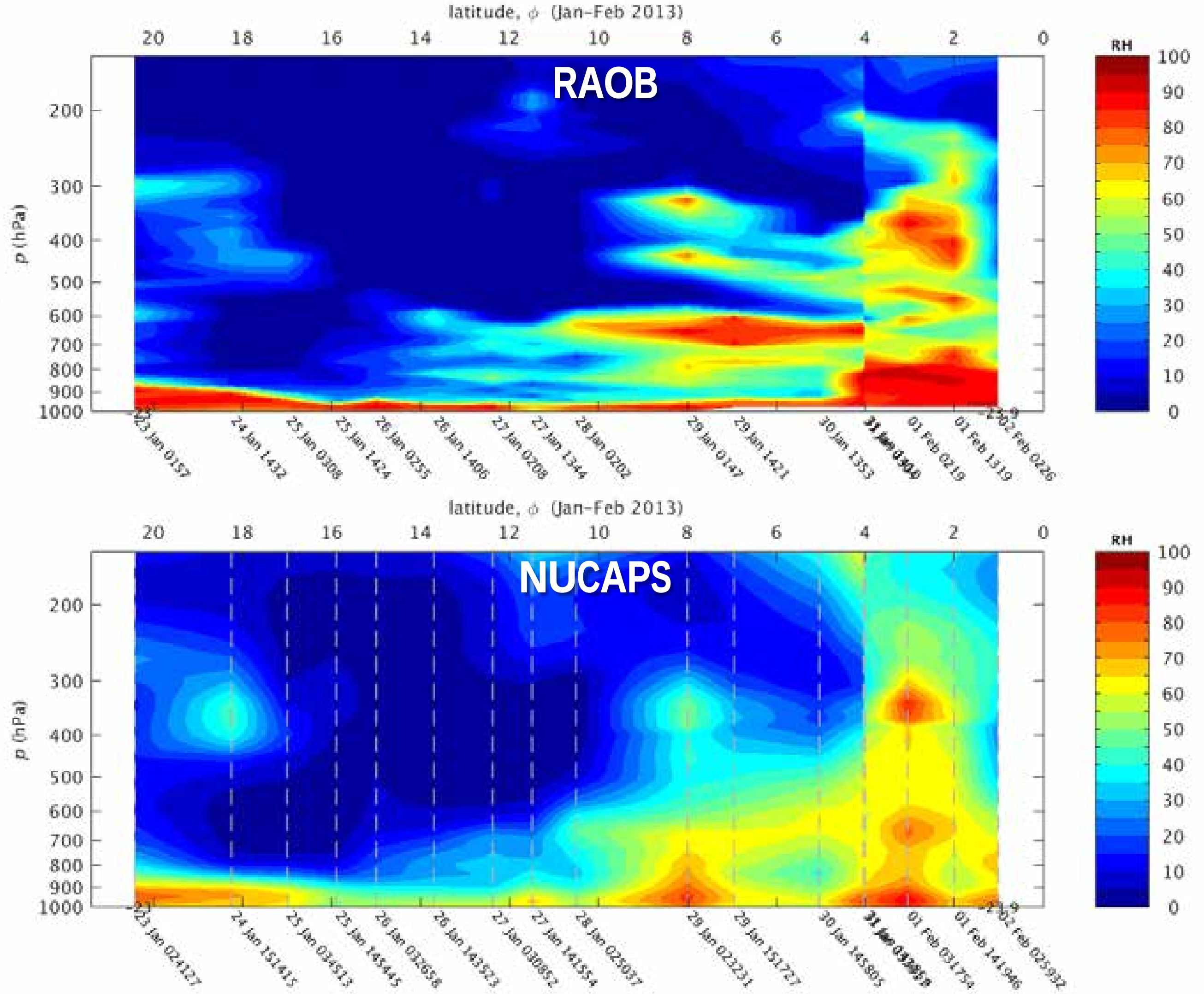




Meridional RH Cross-Section (SAL, Hadley Cell)

2013 AEROSE N-S Transect 2 (All Cases)

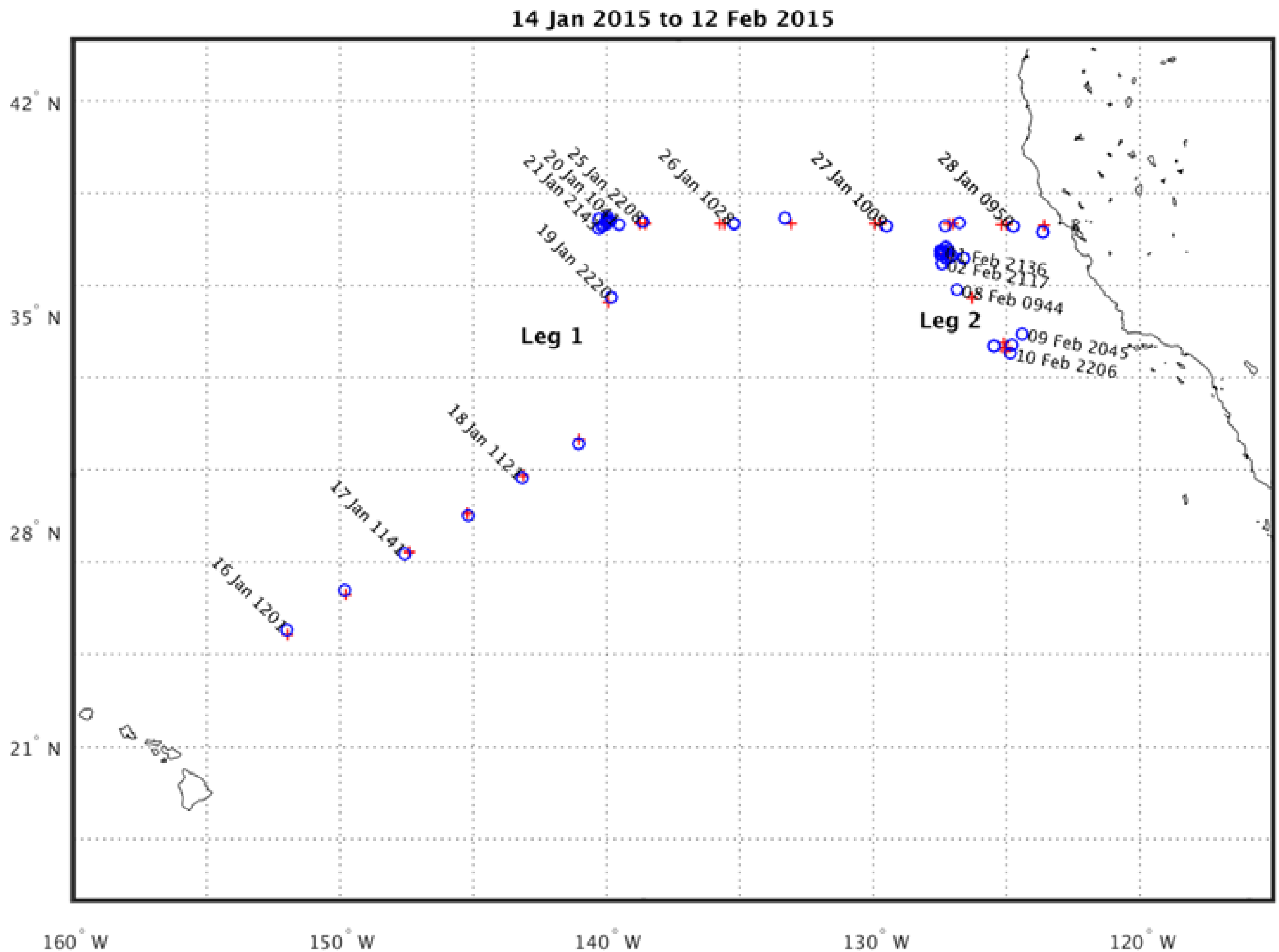




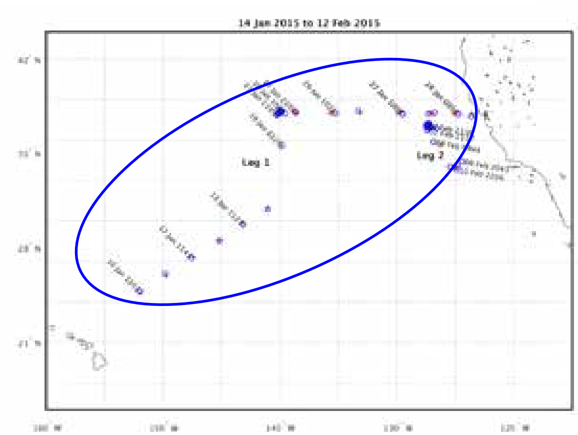
Moist Transport: Atmospheric Rivers

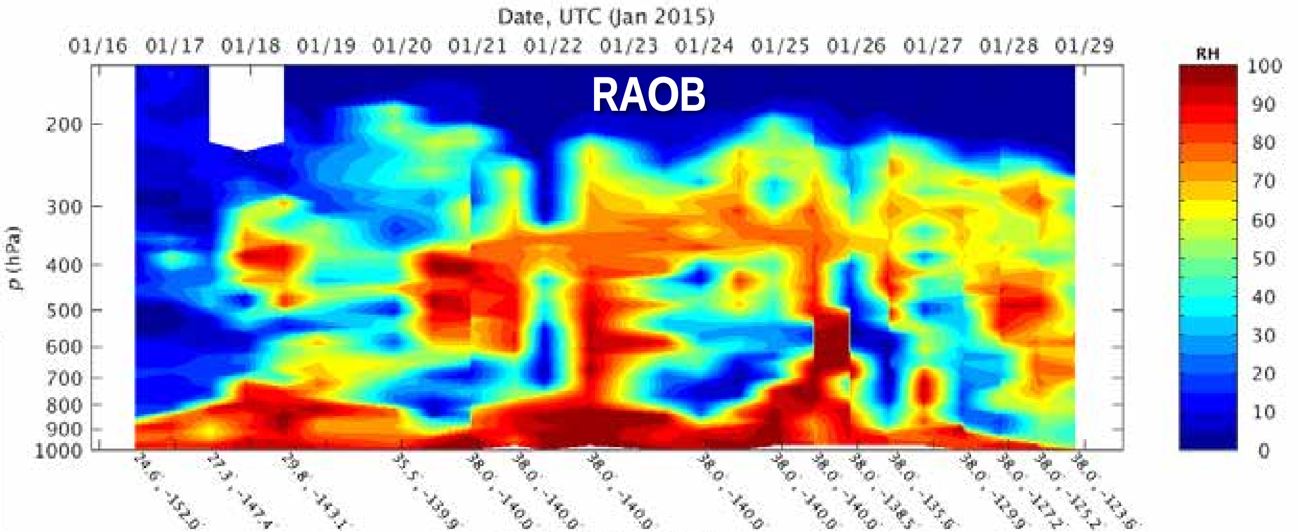
2015 CalWater/ACAPEX Radiosonde Launches (Jan-Feb 2015)

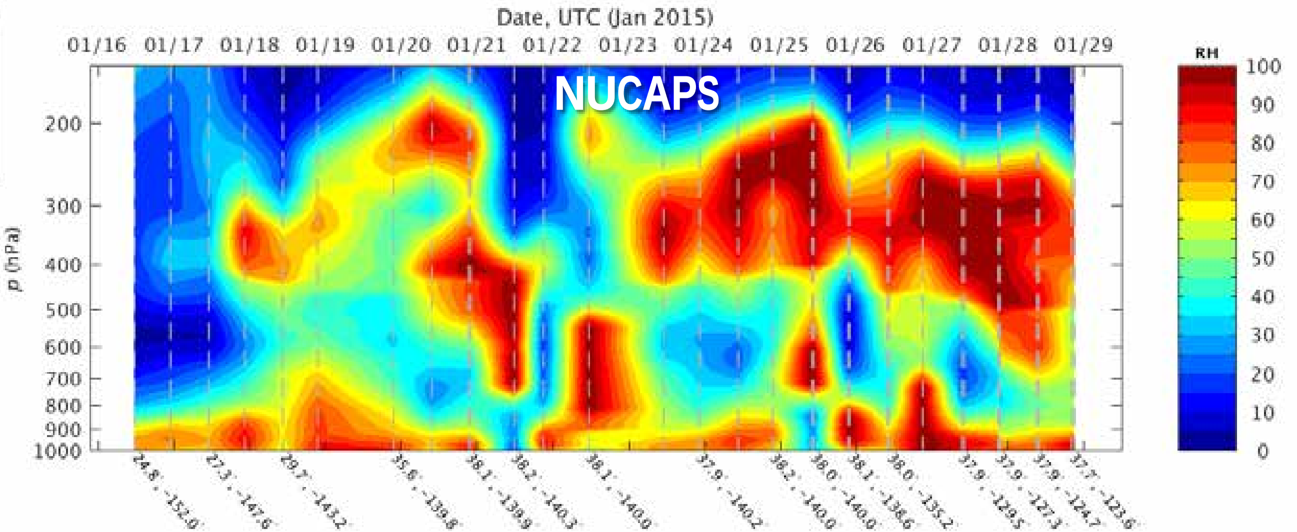
+ RAOB launch
o nearest FOR



Temporal RH Cross-Section (AR Environment)
2015 CalWater/ACAPEX Leg 1 (All Cases)

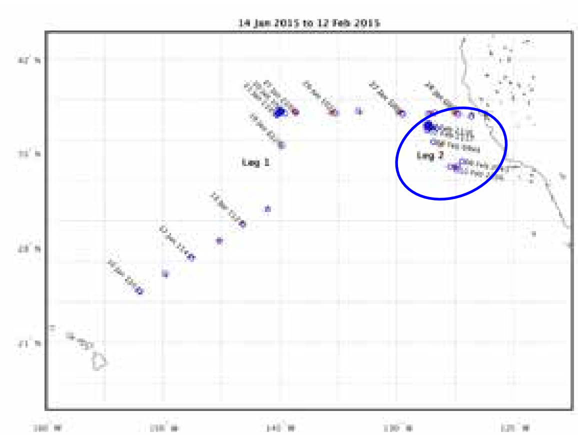


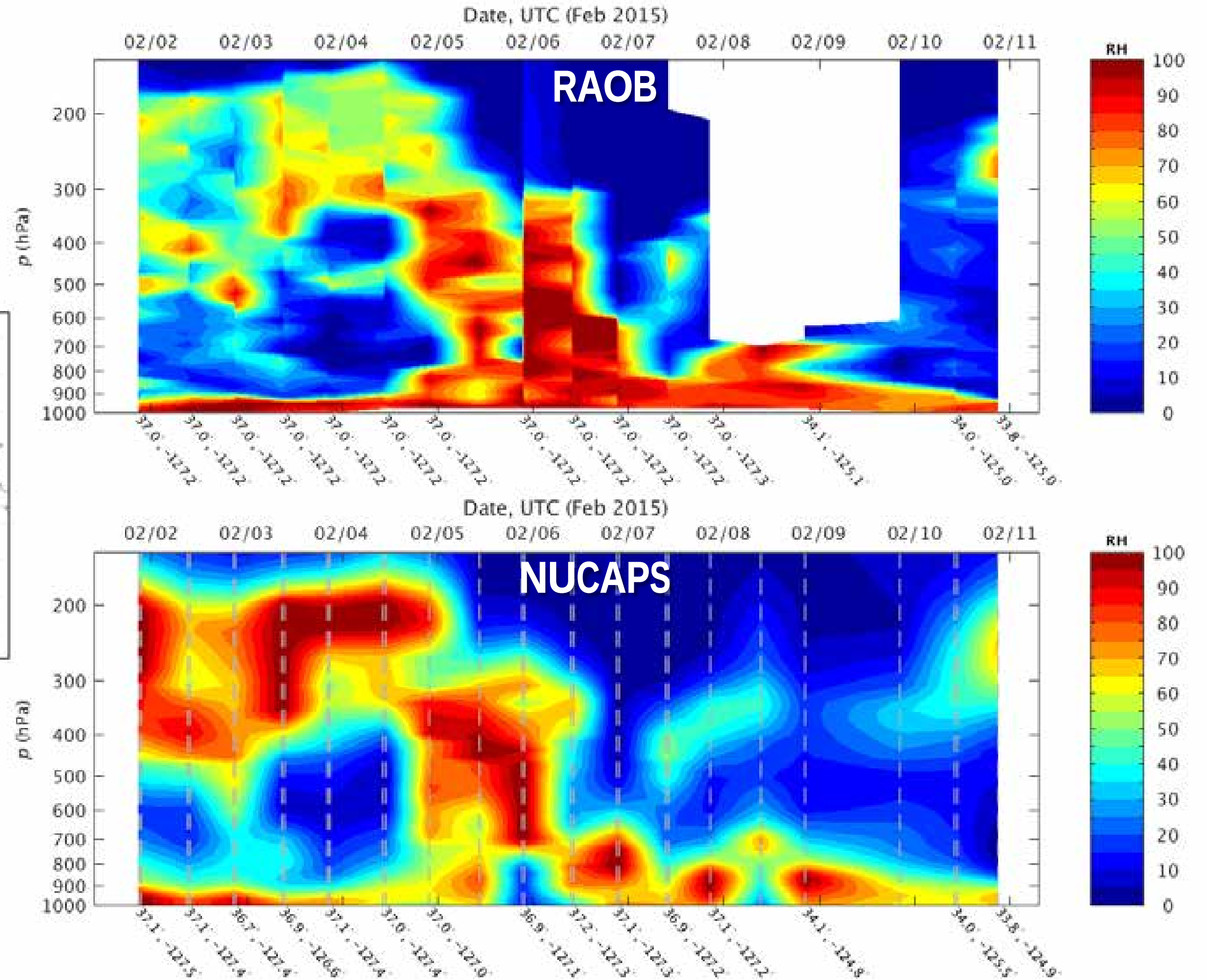




Temporal RH Cross-Section (All Cases)

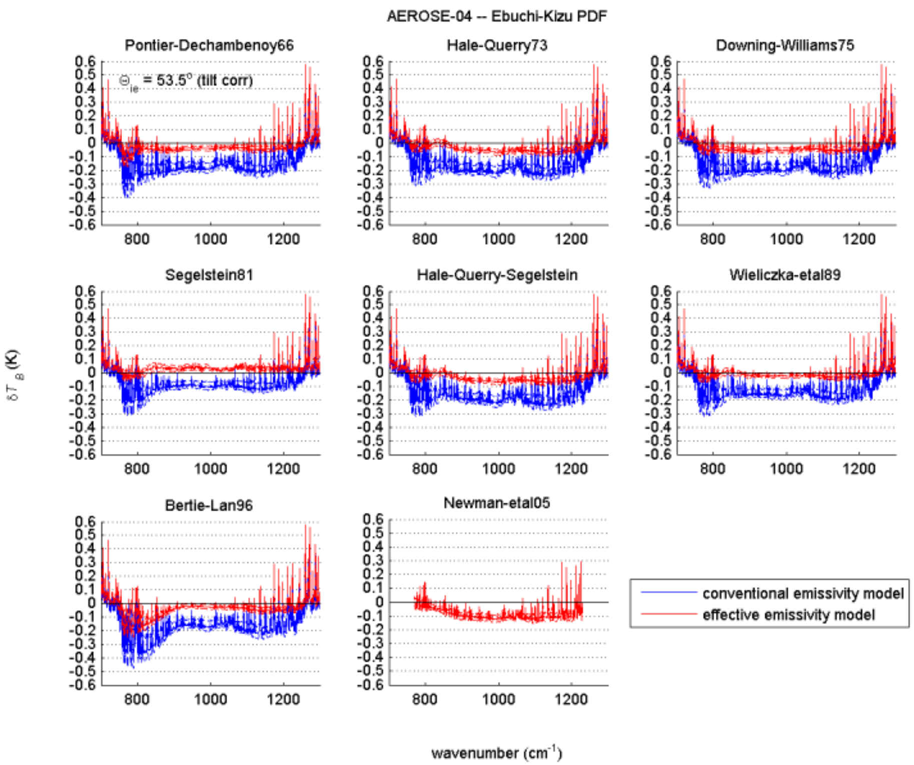
2015 CalWater/ACAPEX Leg 2



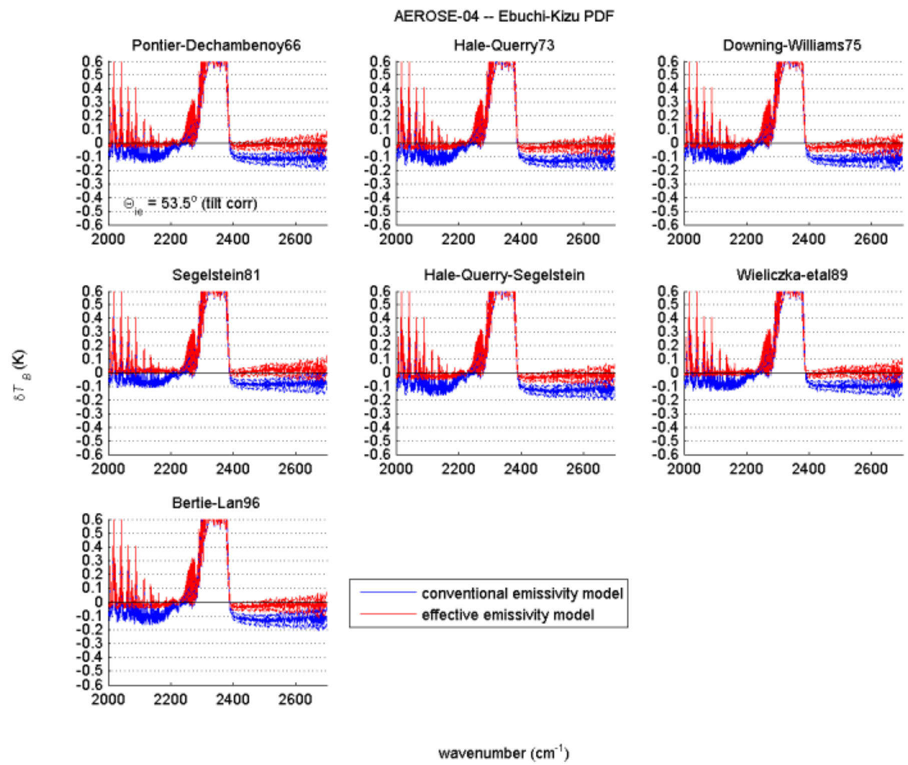


CRTM IR Surface Emissivity Model Development and Validation

LWIR calc (LBL) – obs (MAERI)



SWIR calc (LBL) – obs (MAERI)



Data taken from 2004 AEROSE campaign (after *Nalli et al.* 2008)

NOAA Aerosols and Ocean Science Expeditions (AEROSE): Ocean-Based Campaigns Supporting NOAA Satellite Remote Sensing

THANK YOU!
QUESTIONS?

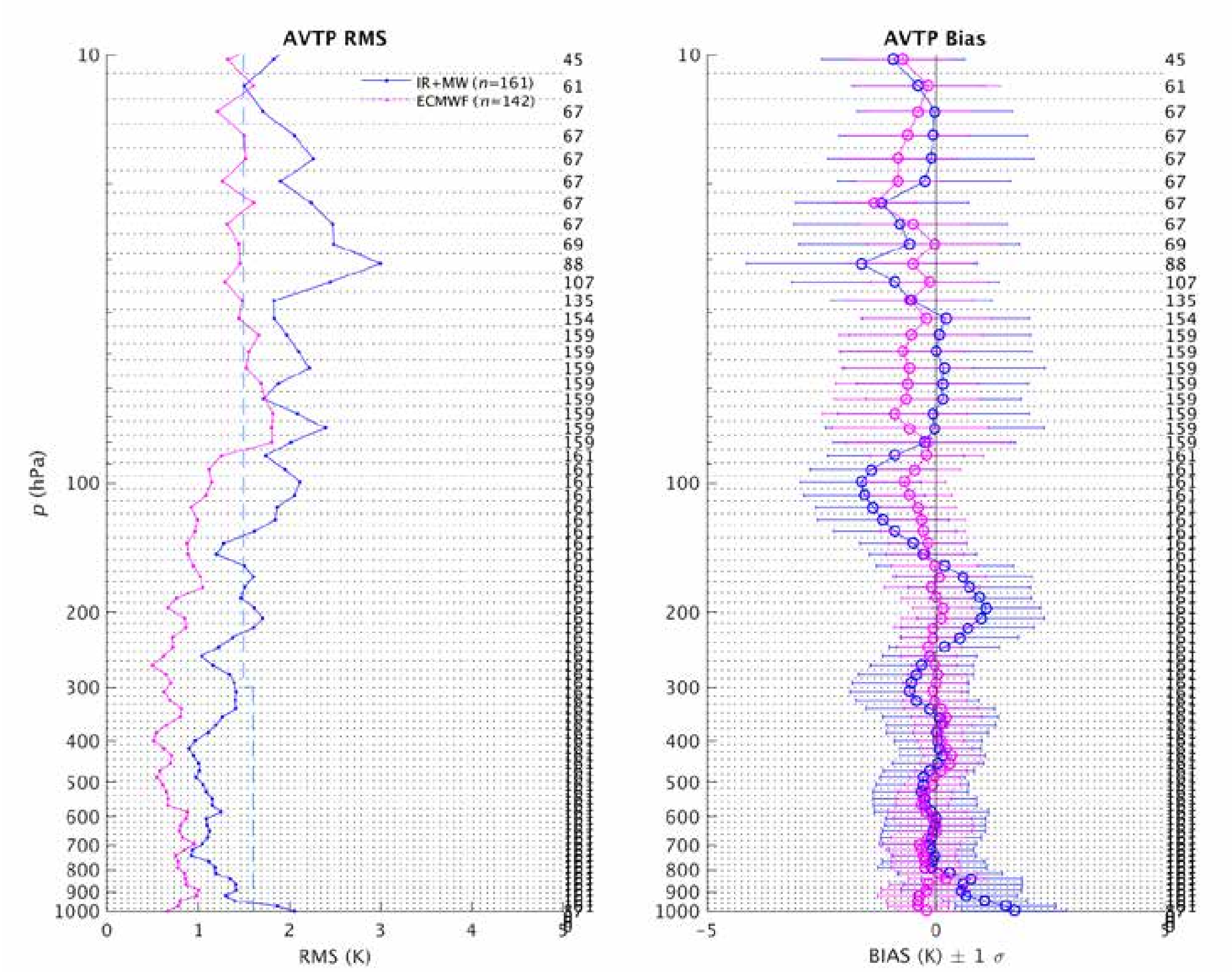
NOAA Aerosols and Ocean Science Expeditions (AEROSE): Ocean-Based Campaigns Supporting NOAA Satellite Remote Sensing

EXTRA SLIDES

AVTP Statistical Summary (SAL, Hadley Cell)
2013 AEROSE RAOBs (Accepted Cases), 100 RTA Layers

Accepted FOR within 75 km radius

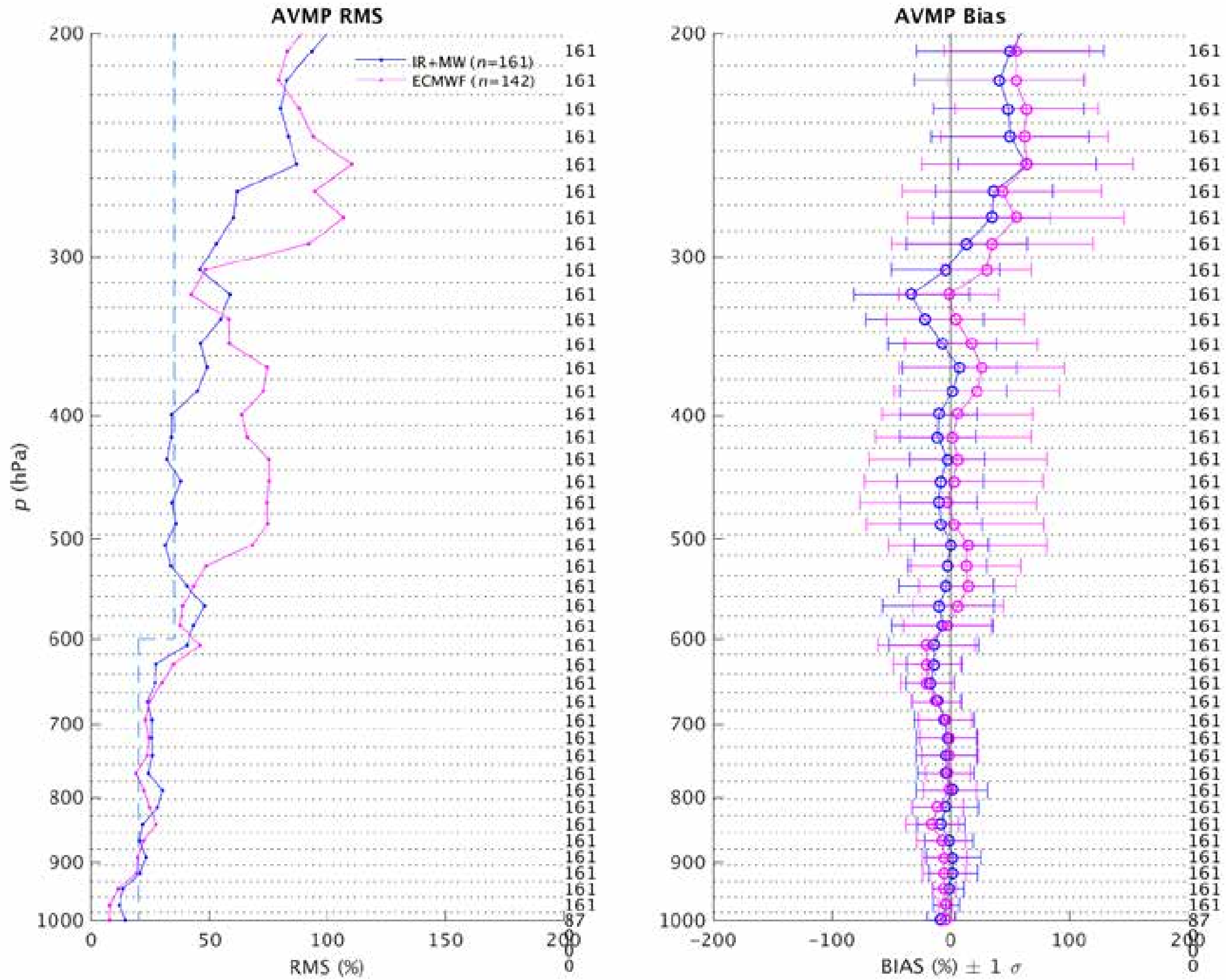
Launches 0–70 min prior to overpasses



AVMP Statistical Summary (SAL, Hadley Cell)
2013 AEROSE RAOBs (Accepted Cases), 100 RTA Layers

Accepted FOR within 75 km radius

Launches 0–70 min prior to overpasses

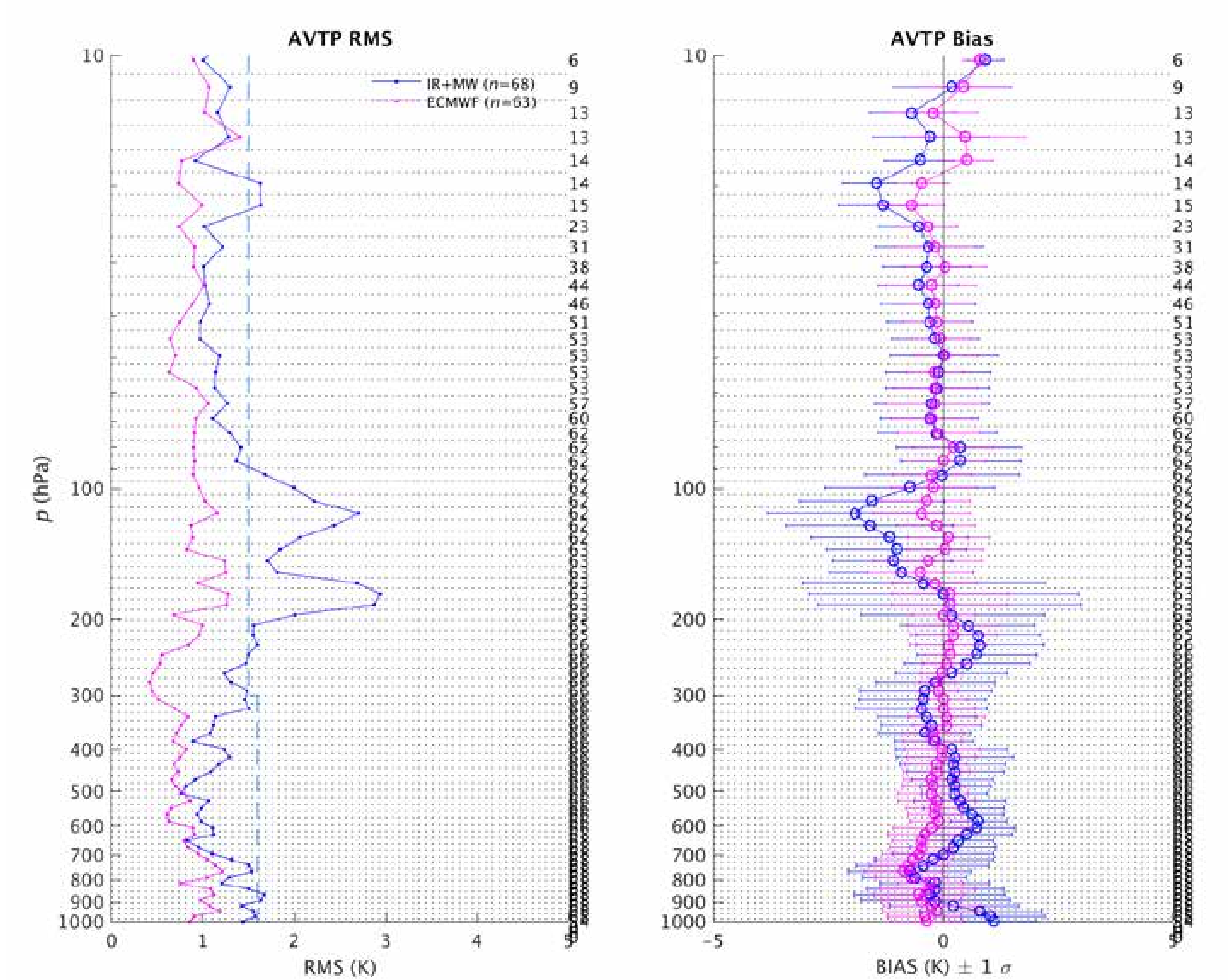


AVTP Statistical Summary (AR Environment)

2015 CalWater/ACAPEX RAOBs (Accepted Cases), 100 RTA Layers

Accepted FOR within 50 km radius

Launches 0–70 min prior to overpasses



AVMP Statistical Summary (AR Environment)

2015 CalWater/ACAPEX RAOBs (Accepted Cases), 100 RTA Layers

Accepted FOR within 50 km radius

Launches 0–70 min prior to overpasses