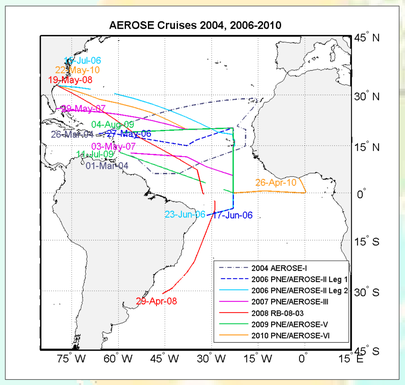
2010 NOAA Aerosol and Ocean Science Expedition (AEROSE) for CrIMSS Marine Proxy Data

Nicholas R. Nalli,[1,2] C. D. Barnet,[1] E. Joseph,[3] V. R. Morris,[3] D. Wolfe,[4] P. J. Minnett,[5] H. Xie,[1,6] G. Guo,[1,2] and M. G. Divakarla[1,6]

[1]NOAA/NESDIS/STAR [2]Dell Services Federal Government, Inc. [3]NCAS/Howard University [4]NOAA/ESRL/PSD [5]RSMAS/Univ. of Miami [6]I.M Systems Group, Inc.

AEROSE

- The **Aerosols and Ocean Science Expeditions (AEROSE)** are a series of trans-Atlantic intensive atmospheric field campaigns conducted aboard the NOAA Ship *Ronald H. Brown (RHB)* (*Morris et al.* 2006).
  - AEROSE-I (March 2004; 4 weeks)
  - PNE*/AMMA*/AEROSE-II (June-July 2006)
    - § Leg 1 (4 weeks)
    - § Leg 2 (4 weeks)
  - PNE/AEROSE-III (May 2007; 4 weeks)
  - RB-08-03 Interhemispheric Transit descoped mission (Apr-May 2008; 3 weeks)
  - PNE/AEROSE-V (July-August 2009; 4 weeks)
  - **PNE/AEROSE-VI** (Apr–May 2010; 4 weeks)
- As part of the **NOAA/PNE** mission, AEROSE has grown to become an unprecedented collection of *in situ* measurements of the Saharan air layer (SAL) and associated African dust and smoke outflows over the tropical Atlantic Ocean, including
  - Transport, microphysical evolution and regional impacts
  - Regional atmospheric chemistry and marine meteorology



PNE/AEROSE Collaboration

- **Participating Institutions**
  - Howard University NOAA Center for Atmospheric Sciences (HU/NCAS)
  - NOAA/NESDIS/STAR
  - University of Miami/RSMAS
  - NOAA/ESRL/PSD (formerly NOAA/ETL)
  - NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory (AOML)
  - NOAA Pacific Marine Environmental Laboratory (PMEL)
- **Synergism**
  - **Low Cost – Low Risk**
  - Engages broader science community on specific problems.
  - All parties gain access to all data.
  - AEROSE is a key component of the PNE cruises. NOAA's allocation of ship time onboard the *Ronald H. Brown* for PNE/AEROSE cruises is fully optimized.

NAME	INSTITUTION	COLLABORATION
N. Nalli, C. Barnet, H. Xie, T. King, G.Guo, M. Divakarla, T. Reale, J. Wei, W. Wolf, M. Goldberg, et al.	NOAA/NESDIS/STAR	RS92 Rawinsondes; CrIMSS/GOES-R Proxy Data and Pre-Launch EDR Validation; NPROVS
E. Joseph, V. Morris Grad Students	HU/NCAS	Aerosols; Chemistry; Radiation Budget; Ozonesondes; Helium
R. Lumpkin C. Schmid	NOAA/AOML	PNE Chief Scientists; TAO Moorings; CTD, XBTs
P. Minnett, M. Szczodrak, M. Izaguirre	UM/RSMAS	M-AERI Measurements; MW Radiometer; All-sky camera
D. Wolfe B. Otto	NOAA/OAR/ESRL/PSD (formerly NOAA/ETL)	Vaisala sounding system; Surface Flux Measurements; C-Band Radar; Wind Profiler; Sea Space Satellite Uplink
T. Pagano, E. Fetzer **AIRS Science Team** W. Feltz, R. Knuteson	JPL UW/CIMSS	AIRS/IASI validation rawinsonde support ('07,'08) AIRS validation rawinsonde support ('04,'06)

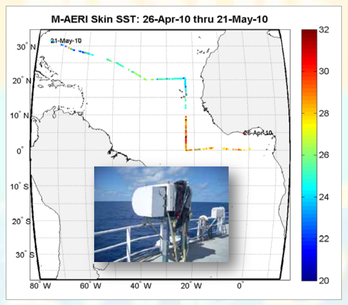
Correlative Data

Dedicated Radiosonde Observations (RAOBs)

- **Vaisala RS92 GPS rawinsondes** (RS80/90 in 2004) launched coinciding with LEO environmental satellite overpasses (viz. Aqua and MetOp)
  - RS92 sondes measure
    - § Pressure, temperature, humidity, *PTU(z)*
    - § Wind speed and direction, *u*(*z*), *v*(*z*)
    - § GPS altitude, *z*(*t*)
  - Typically ~4/day (~01:30, 09:30, 13:30, 21:30)
  - 2004, 2008–2010 not uploaded into GTS (i.e., ***not assimilated***)
  - **578 PTU soundings** to date (75 successful '10 launches)
- **Ozonesondes** interfaced with RS92
  - Measure **O_3(*z*)** partial pressure
  - ~1/day during MetOp/Aqua overpasses
  - **89 O_3 soundings** to date (19 successful '10 launches)

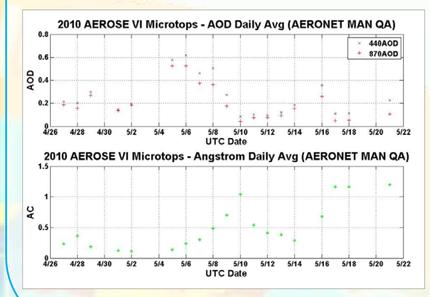
Marine Atmospheric Emitted Radiance Interferometer (M-AERI)

- Ship-based **FTS** systems designed to sample downwelling and upwelling calibrated IR spectra near the surface (*Minnett et al.* 2001).
- High accuracy **calibration** is achieved using 2 **NIST-traceable blackbodies**.
- Derived products
  - **High accuracy skin SST** derived from semi-opaque spectral region (~7.7 μm) (*Smith et al.* 1996)
    - § Skin SST is a state parameter necessary for forward calculations.
  - Continuous retrievals of lower tropospheric profiles at turbulent time scales (e.g., *Szczodrak et al.* 2007)
  - Retrieval of ocean surface spectral emissivity (e.g., *Hanafin and Minnett* 2005; *Nalli et al.* 2008b)



Other Shipboard Data

- **Microtops Sunphotometer**
  - Multi-channel raw data provides information on changes in total column aerosols
  - Since 2009, the AEROSE Team collaborated with the **NASA/GSFC AERONET Maritime Aerosol Network**.
- **Ceilometer** (basically a low power lidar) backscatter measurements provide information about aerosol vertical distributions
- Broadband pyranometers and pyrgeometers (downwelling LW and SW Fluxes)
- *In situ* gas & particle measurements
- Ship meteorological and oceanographic measurements

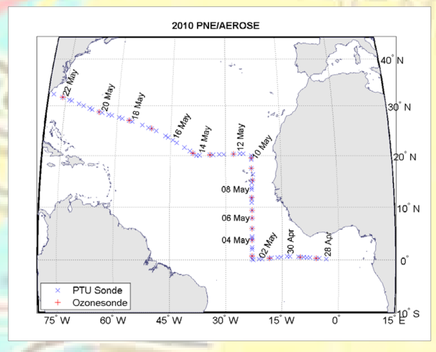


2010 Trans-Atlantic Cross-Sectional Analyses

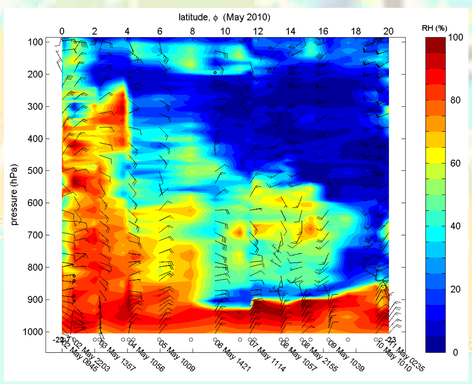
AEROSE Proxy Dataset

- **JPSS CrIMSS EDR Validation** (cf. Poster #633, *Barnet, Nalli et al.*)
  - AEROSE 2010 has been selected for a pre-launch phase test of deployment of **scientific validation campaigns** of opportunity, and to be used as a field campaign proxy dataset to be developed by NOAA/MIT/LaRC.
  - **CrIMSS SDR proxy data** will be derived from IASI matchup granules (see figures) that have been obtained from the **NESDIS/STAR IASI Operational Product Processing System**.
  - The **AEROSE domain** is of scientific interest **germane to the CrIMSS mesoscale-synoptic observing mission**.
    - § Saharan air layer (SAL) and distribution of tropical water vapor
    - § Dust and biomass burning aerosols
    - § Tropospheric ozone dynamics
- The figures below show **trans-Atlantic RH** and **O_3 cross-sections** obtained from RAOB (top row) alongside those obtained from STAR IASI retrieval matchups (bottom row), revealing the ability of hyperspectral IR sounders for observing meteorological features of interest as a qualitative validation demonstration.

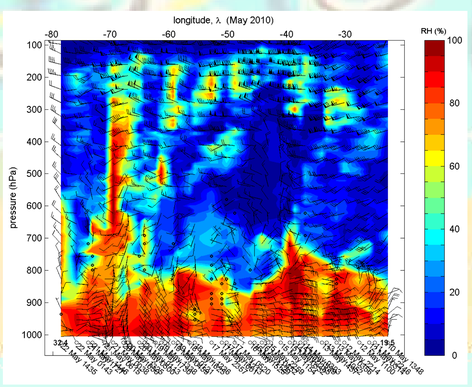
RAOB Launches



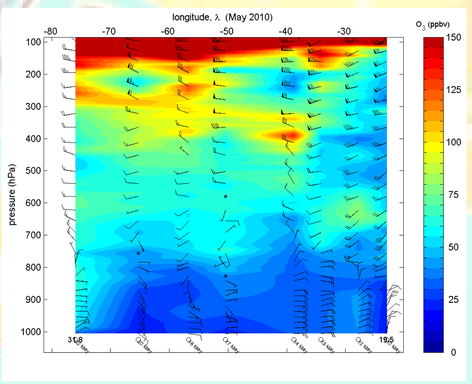
RAOB RH – S-N Transect (23°W)



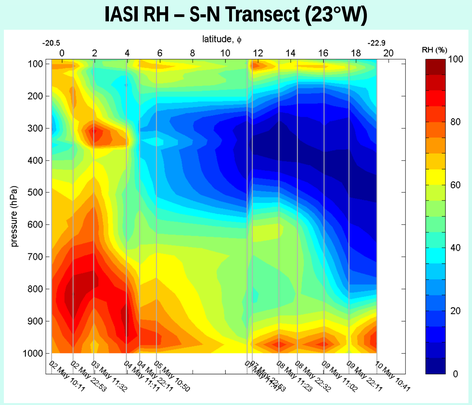
RAOB RH – E-W Transect



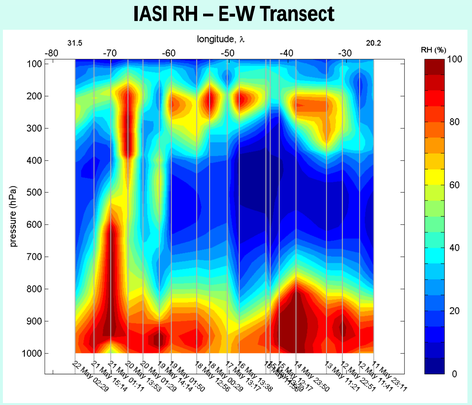
RAOB O_3 – E-W Transect



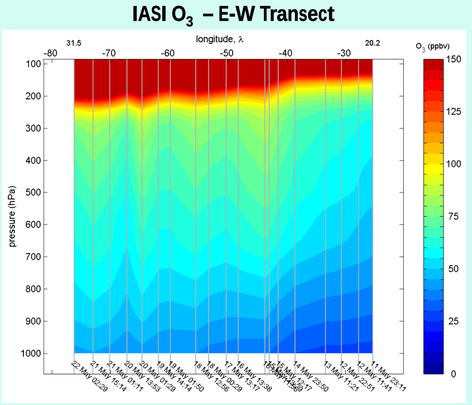
IASI RH – S-N Transect (23°W)



IASI RH – E-W Transect



IASI O_3 – E-W Transect



Summary

- The **PNE/AEROSE** intensive campaigns continue to compile a multiyear set of ship-based, marine *in situ* **cross-sectional correlative measurements** over the **tropical Atlantic Ocean**.
  - The 2010 campaign added to the current data inventory from 2004, 2006–2009
- The cruise domains span **a region of meteorological interest** in terms of the SAL, tropical storm formation, and tropospheric ozone/carbon/aerosol chemistry and transport.
  - There are numerous interdisciplinary applications of these data.
  - These features are objects of interest for the satellite sounder missions, thus validation is desirable.
  - Ocean-based correlative data has distinct advantages for satellite cal/val.
- **2010 AEROSE highlights** include
  - 2 zonal and 1 meridional cross-sections
  - Unique sampling of the Gulf of Guinea
  - Preliminary **IASI L2 x-sections** show **reasonable coherent space-time agreement** w RAOB x-sections
    - § Surprisingly good tropospheric ozone agreement – appears legit
    - § Not surprisingly, a very shallow (~0.5 km) SAL "dry filament" was missed
- The AEROSE intensive campaign data are being used for constructing **empirical marine proxy data** for **NPP CrIMSS EDR** and **GOES-R ABI pre-launch** validation.

Future Work

- **Manuscript on PNE/AEROSE campaigns** (general overview with emphasis on meteorological highlights and sounder cal/val) in 2nd review for ***BAMS*** (*Nalli et al.*).
- Construct 2010 AEROSE CrIMSS Marine Proxy Data Set (w/ G. Guo, M. Divakarla, T. King).
  - AVTP, AVMP validation over open ocean, within and without Saharan air layer, dust, smoke
  - IP validation: vertical ozone profiles, skin SSTs
- Completion of 2010 AEROSE GOES-R Proxy Data Set, including SEVIRI, AIRS/IASI granules (w/ H. Xie, T. Zhu).
  - SEVIRI/GOES-R ABI legacy profile TPW validation and demonstration; SAL detection (w/ H. Xie, J. Li)
- Unfortunately, plans for the 2011 PNE/AEROSE have become less certain due to budget shortfalls leading to suboptimal rationing of sea time on the *Ron Brown*.

Acknowledgements

- The Howard University **NOAA Center for Atmospheric Sciences (NCAS)**, **Serving Institutions Educational Partnership Program** supported by
  - The NOAA Minority Serving Institutions Educational Partnership Program
  - National Science Foundation Career Grant (ATM-9703167)
  - NASA Grant (NG-1224)
- The **NOAA Joint Polar Satellite System (JPSS)** Office
- The **NOAA GOES-R Algorithm Working Group** (M. D. Goldberg)
- The **PIRATA Northeast Extension** Project; **R. Lumpkin** and C. Schmid (NOAA/AOML)
- **W. W. Wolf , T. King** and P. Clemente-Colón (NOAA/NESDIS/STAR)
- T. Pagano (JPL) and **the AIRS Science Team**
- **M. Szczodrak** and M. Izaguirre (UM/RSMAS); E. Roper (Lincoln Univ.)
- **The many students**, who participated in, and contributed to, the success in the campaigns, especially **A. Flores, C. Stearns, M. Oyola**
- The officers and crew of the *Ronald H. Brown*
- *The views, opinions and findings contained in this report are those of the authors and should not be construed as an official NOAA or U.S. Government position, policy or decision.*

Selected References

Morris, V., P. Clemente-Colón, N. R. Nalli, E. Joseph, R. A. Armstrong, Y. Detrés, M. D. Goldberg, P. J. Minnett and R. Lumpkin, 2006: Measuring trans-Atlantic aerosol transport from Africa, *Eos Trans. AGU*, **87**(50), 565–571.

Nalli, N. R., P. Clemente-Colón, V. Morris, E. Joseph, M. Szczodrak, P. J. Minnett, J. Shannahoff, M. D. Goldberg, C. Barnet, W. W. Wolf, W. F. Feltz, and R. O. Knuteson, 2005: Profile observations of the Saharan air layer during AEROSE 2004, *Geophys. Res. Lett.*, **32**, L05815, doi:10.1029/2004GL022028.

Nalli, N. R., P. Clemente-Colón, P. J. Minnett, M. Szczodrak, V. Morris, E. Joseph, M. D. Goldberg, C. D. Barnet, W. W. Wolf, A. Jessup, R. Branch, R. O. Knuteson, and W. F. Feltz, 2006: Ship-based measurements for infrared sensor validation during Aerosol and Ocean Science Expedition 2004, *J. Geophys. Res*, **111**, D09S04, doi:10.1029/2005JD006385.

Nalli, N. R., et al., 2010: Multi-year observations of the tropical Atlantic atmosphere: Multidisciplinary applications of the NOAA Aerosols and Ocean Science Expeditions (AEROSE), *Bull. Amer. Meteorol. Soc.*, in 2nd review, Jan-11.

Nalli, N. R., P. J. Minnett, E. Maddy, W. W. McMillan, and M. D. Goldberg, 2008: Emissivity and reflection model for calculating unpolarized isotropic water surface leaving radiance in the infrared. 2: Validation using Fourier transform spectrometers, *Appl. Optics*, **47**(25), 4649-4671.

Szczodrak, M., P. J. Minnett, N. R. Nalli, and W. F. Feltz, 2007: Profiling the lower troposphere over the ocean with infrared hyperspectral measurements of the Marine-Atmosphere Emitted Radiance Interferometer, *J. Atmos. Ocean. Tech.*, **24**, 390-402. DOI: 10.1175/JTECH1961.1

Corresponding Author:
Dr. N. R. Nalli, *Dell Services, Federal Government, Inc. – NOAA/NESDIS/STAR*
5211 Auth Road, Camp Springs, Maryland 20746, USA
E-mail: Nick.Nalli@noaa.gov | Voice: 301-316-5006