

#### Principal Investigator: Ernie Lewis (BNL)





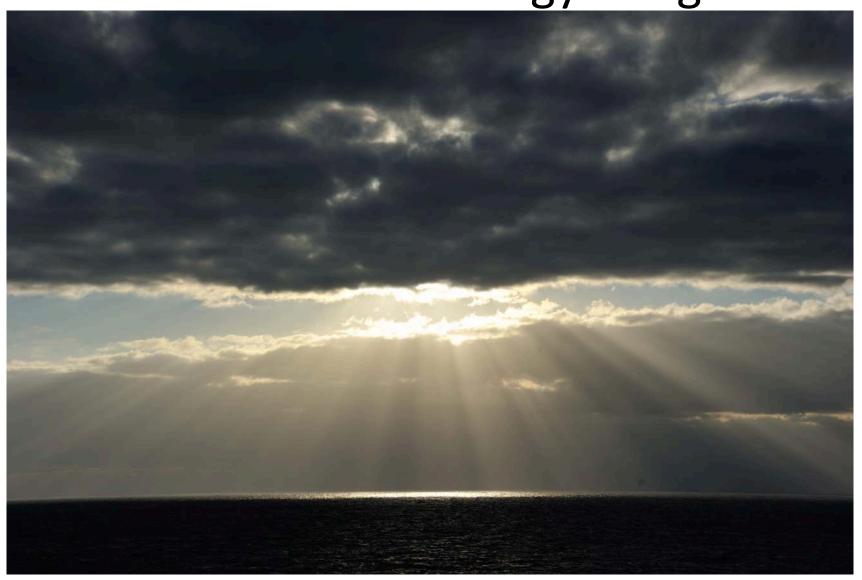
#### MAGIC Co-Investigators:

Bruce A. Albrecht, U. Miami Geoffrey L. Bland, NASA Wallops Charles N. Flagg, Stonybrook U. Stephen A. Klein, LLNL Pavlos Kollias, McGill U. Gerald Mace, U. Utah R. Michael Reynolds, RMR Co. Stephen E. Schwartz, BNL A. Pier Siebesma, KNMI Joao Teixeira, JPL/Caltech Warren Wiscombe, NASA GSFC Robert Wood, U. Washington Minghua Zhang, Stonybrook U.

Clouds Are Important to Earth's Climate System



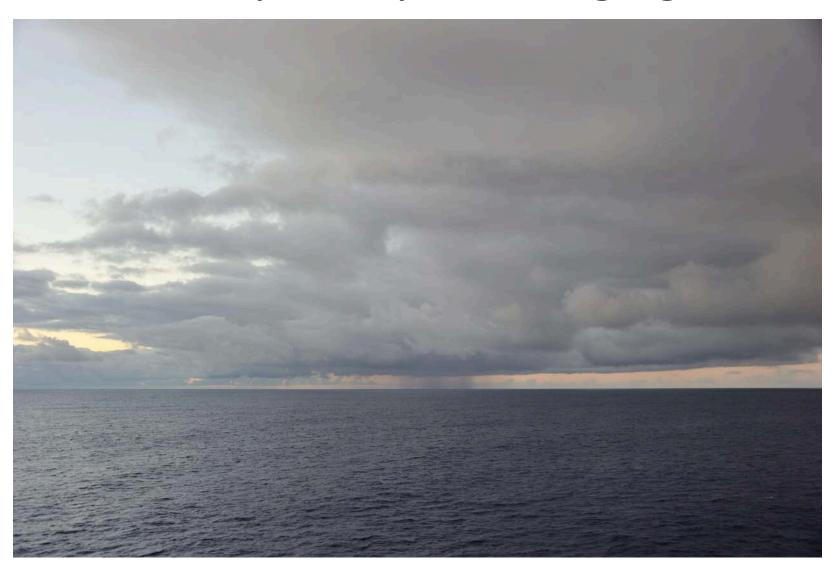
# Clouds Interact with Radiation and Affect Earth's Energy Budget



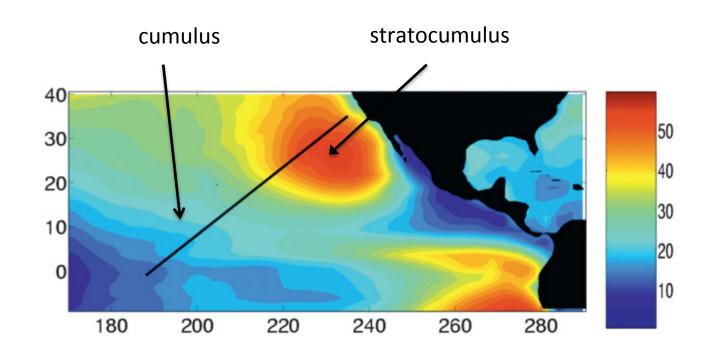
## Accurate Representation of Clouds in Climate Models Is Still Difficult



# Low Marine Boundary Layer Clouds are Especially Challenging

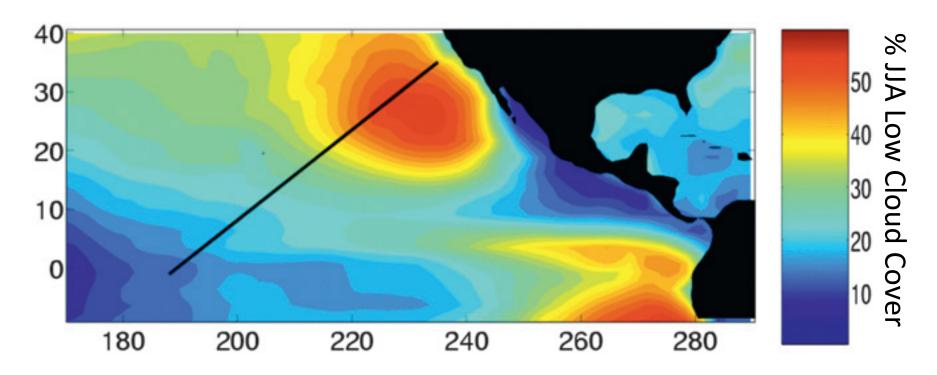


# The Transition from the Marine Stratus to the Cumulus Regime Is also not Well Characterized

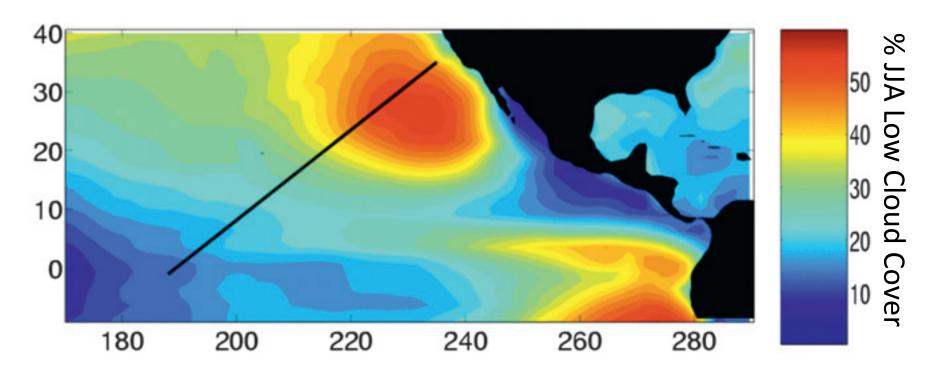


June-July-August average low cloud cover

#### Modelers Have Chosen Transects Along Which to Compare Models

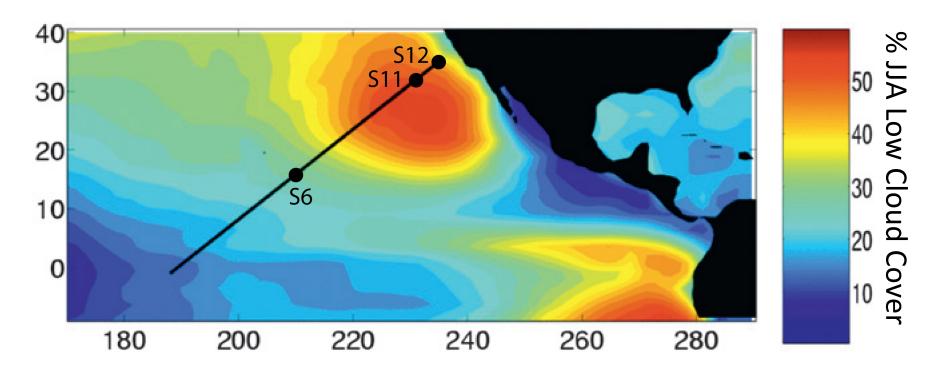


#### Modelers Have Chosen Transects Along Which to Compare Models



The GCSS Pacific Cross-section Intercomparison (GPCI) transect extends from near California to the equator.

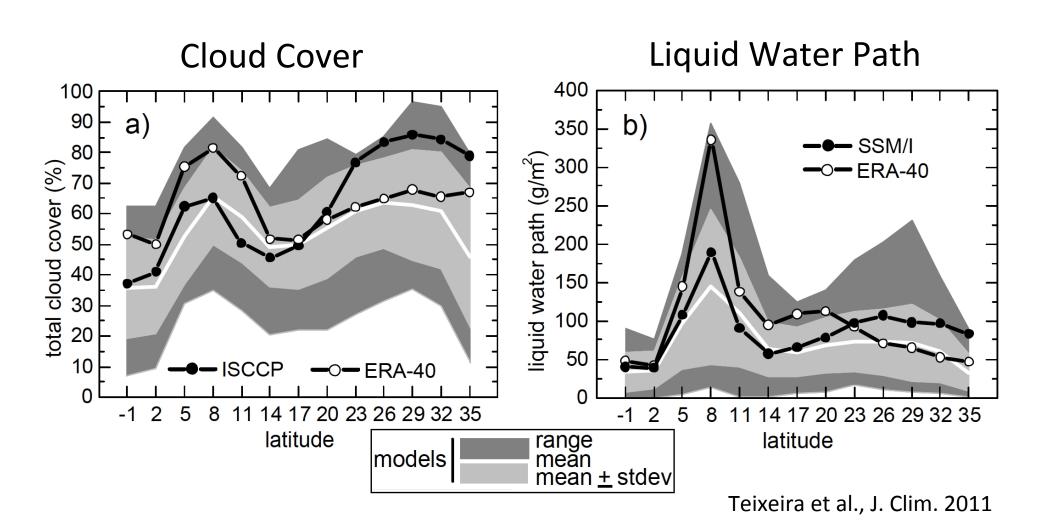
#### Modelers Have Chosen Transects Along Which to Compare Models



The GCSS Pacific Cross-section Intercomparison (GPCI) transect extends from near California to the equator.

Points S6, S11, and S12 are used by CGILS, another group of modelers.

# Intercomparison of 23 GCMs Shows a <u>Large</u> Range in Important Quantities Along the GPCI Transect



# The MAGIC Campaign Was Proposed to Provide Data To Constrain Models and Reduce These Uncertainties

#### MAGIC stands for:

**M**arine

**ARM** (Atmospheric Radiation Measurement Program)

**G**PCI (GCSS Pacific Cross-section Intercomparison)

Investigation of

**C**louds

#### The principal objectives of MAGIC are:

1) To improve the representation of the Sc-to-Cu transition in climate models by *characterizing* the essential properties of this transition using AMF2 on a ship that makes regular transects of the Pacific Ocean through this transition, and

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- 1) To improve the representation of the Sc-to-Cu transition in climate models by *characterizing* the essential properties of this transition using AMF2 on a ship that makes regular transects of the Pacific Ocean through this transition, and
- 2) To produce the observed statistics of these Scto-Cu characteristics corresponding to the deployment period along these transects.

## MAGIC takes place on the Horizon Lines Cargo container *Spirit*.



It all happens here.

#### MAGIC is a unique industry-DOE collaboration.





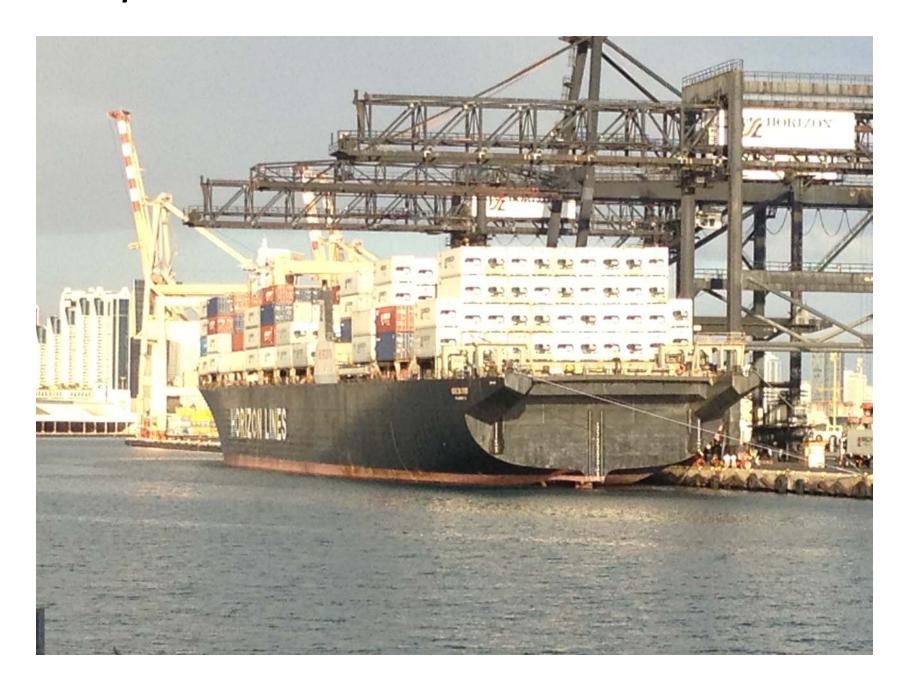
#### The Spirit is 272 m long.



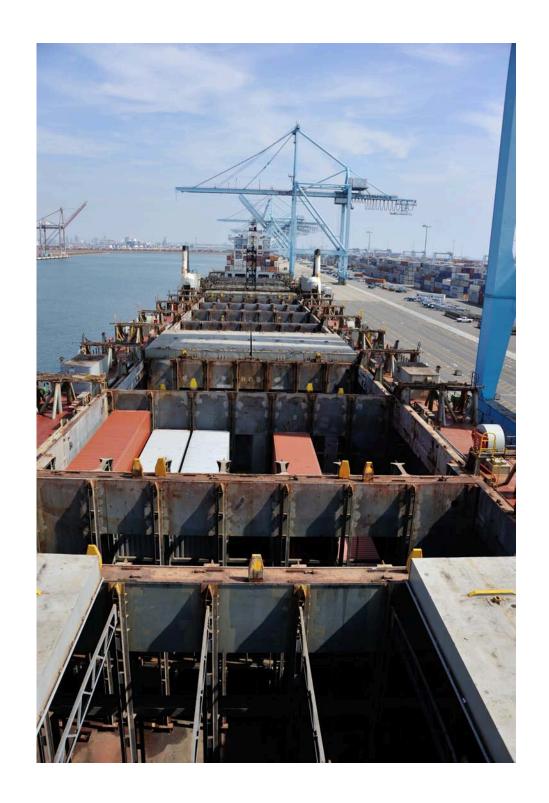
### The Spirit has a maximum speed of 22 knots.



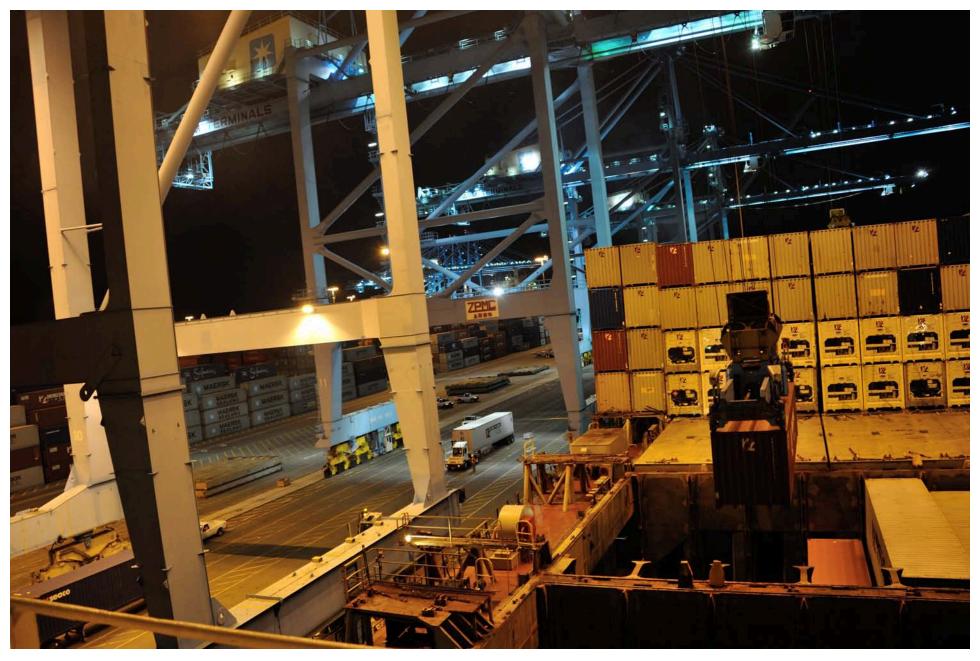
### The Spirit holds 1200 40-foot containers.



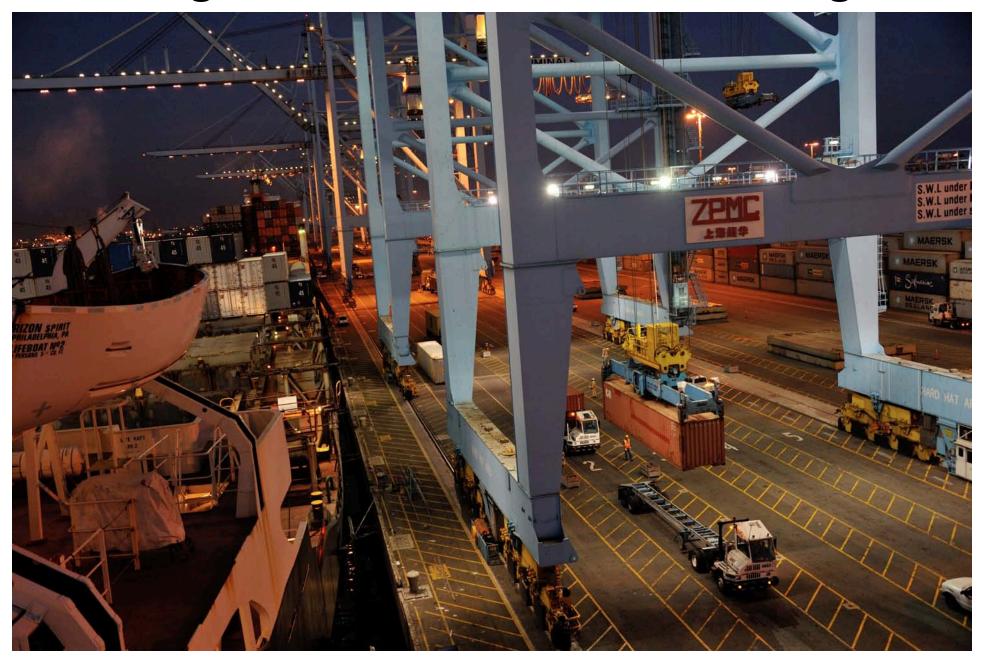
Looking back from the bridge of the *Spirit* 



#### Loading Containers in Port of Los Angeles



### Loading Containers in Port of Los Angeles

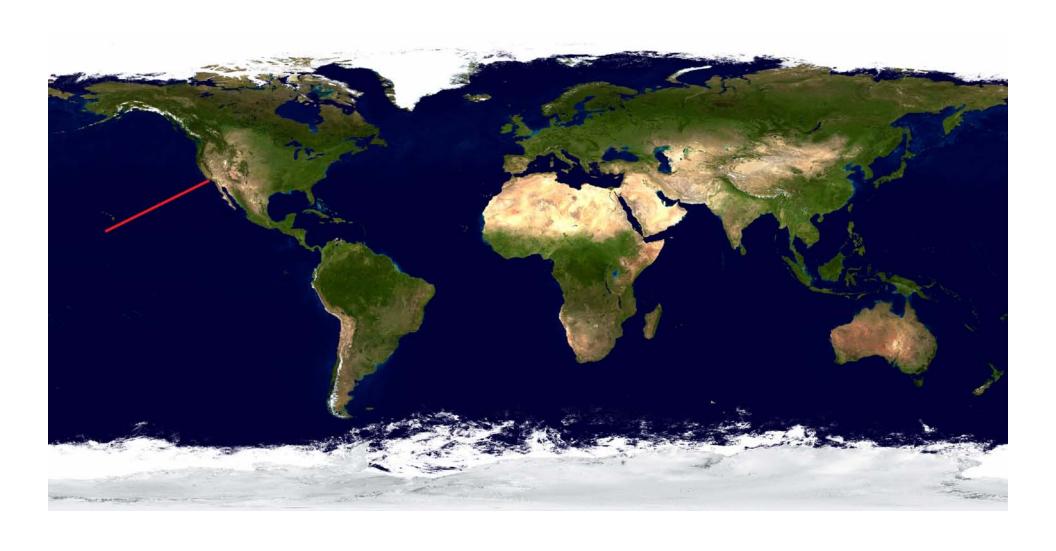


#### MAGIC is ARM's first true marine deployment.



### Los Angeles to Honolulu is 4100 km (2500 miles)

The Spirit makes one round trip every two weeks.

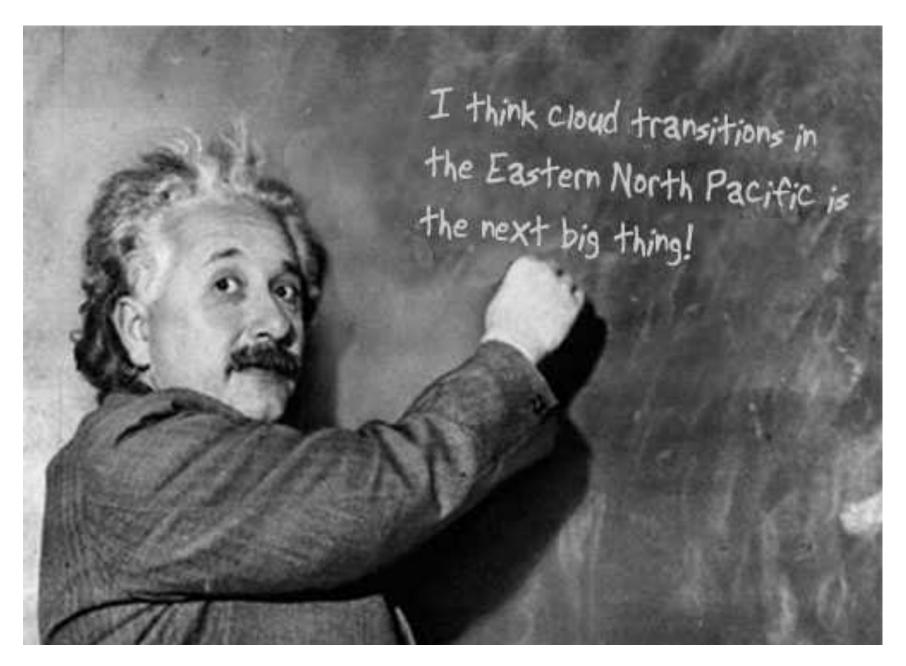


MAGIC started in September, 2012 and continued through October, 2013 (except for the time period January-May, 2013 when the *Spirit* was in dry dock).

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In total, there were ~20 round trips between Los Angeles and Honolulu.

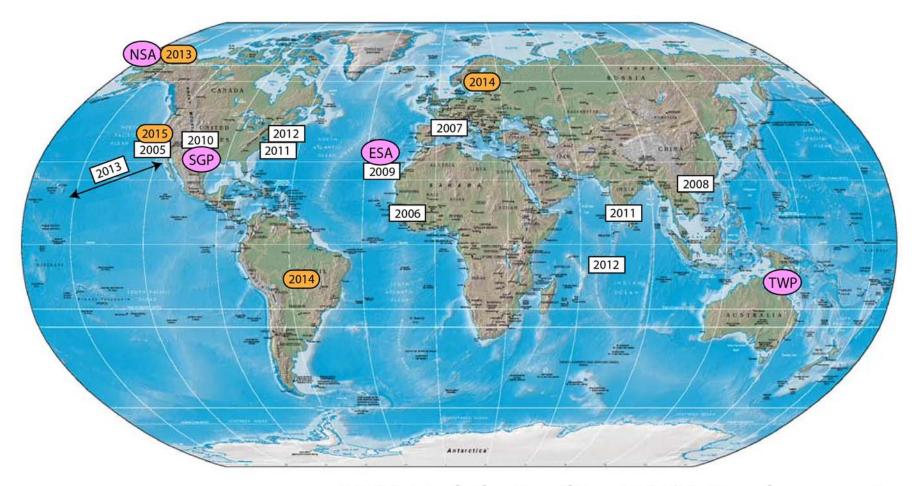
#### Everyone thinks it's a great idea!



MAGIC is funded and operated by the ARM Climate Research Facility, which consists of several fixed sites, several mobile facilities, an aircraft facility, and a data archive.



ARM operates all over the world.



#### **ARM Fixed Sites**

NSA: North Slope of Alaska SGP: Southern Great Plains (OK) TWP: Tropical Western Pacific ENA: Eastern North Atlantic

#### ARM Mobile Facility (AMF) Deployments

2005 Point Reyes, CA

2006 Niamey, Niger

2007 Black Forest, Germany

2008 Shouxian, China

2009 Graciosa Island, Azores

2010 Steamboat Springs, CO

2011 Long Island, NY

2011 Ganges Valley, India

2012 Gan Island, Maldives

2012 Cape Cod, MA

2013 Eastern North Pacific

#### <u>Upcoming</u>

2013 Oliktok Point, Alaska

2014 Amazon, Brazil

2014 Hyytil, Finland

2015 California Coast

## MAGIC uses AMF2, the Second ARM Mobile Facility

AMF2 consists of three vans of instruments and other modules.

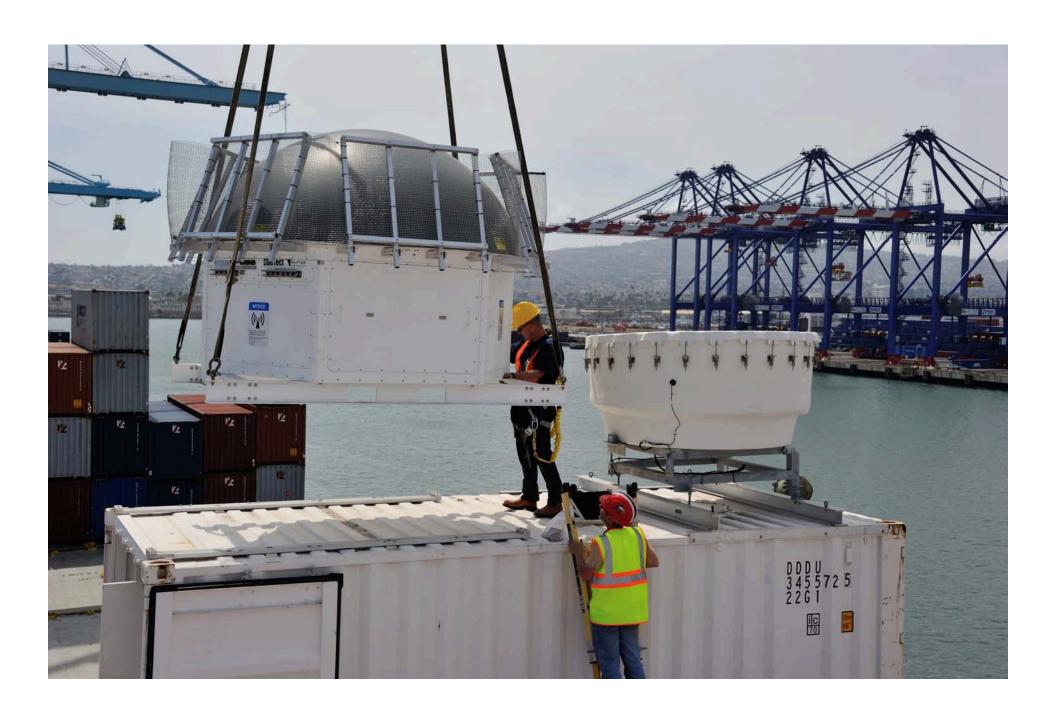


AMF2 in the Maldives

## AMF2 was installed on the Spirit.



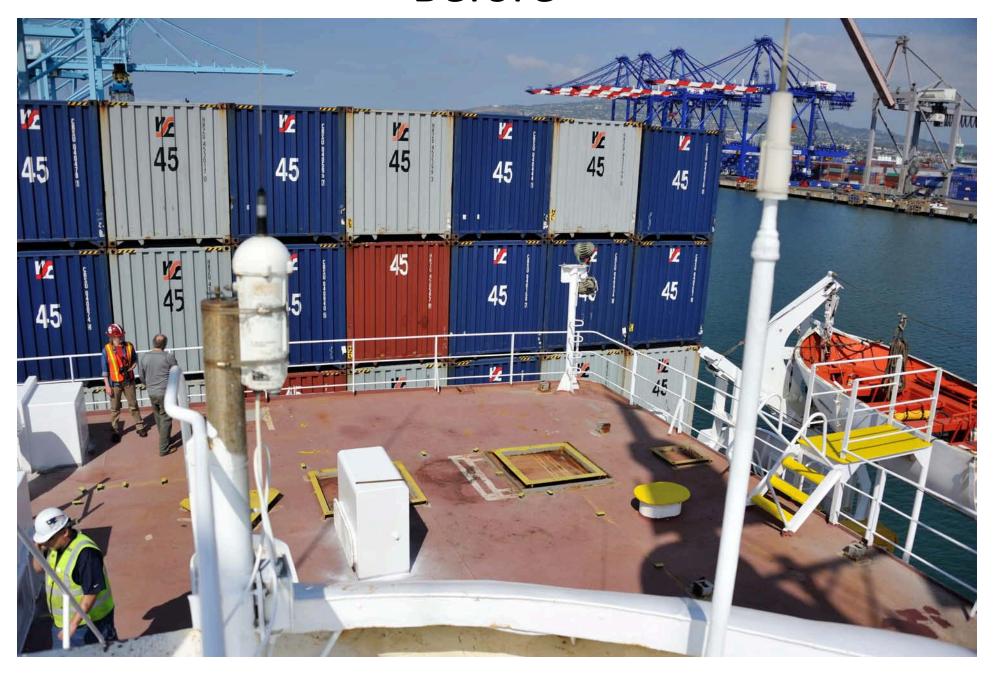




#### Vans were welded to the deck.

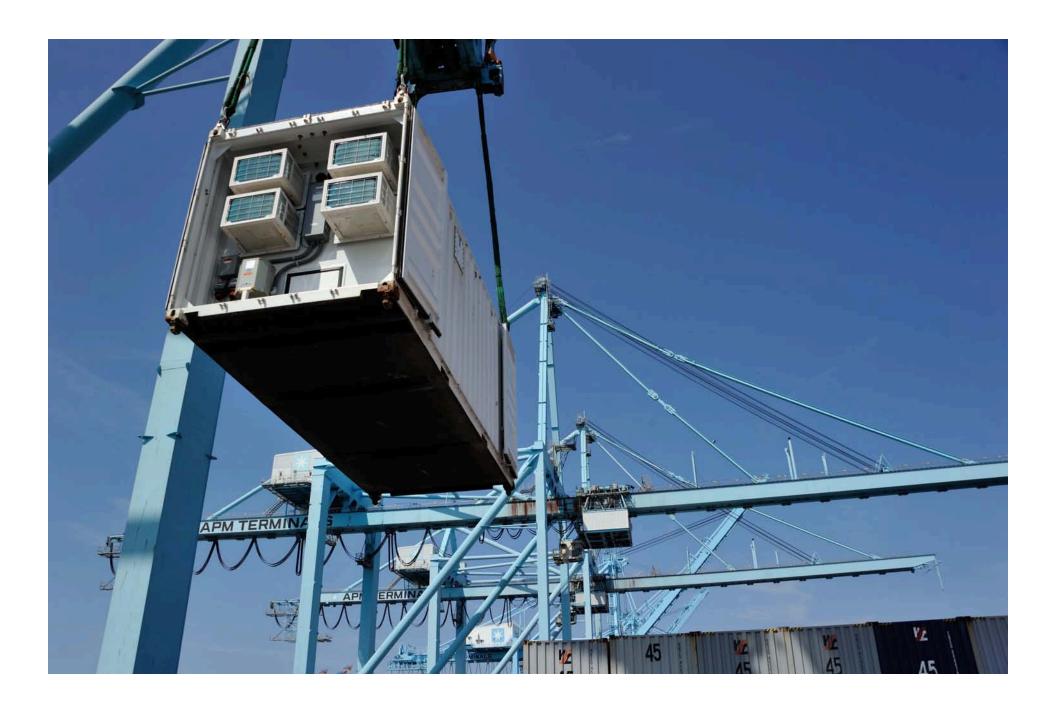


#### Before

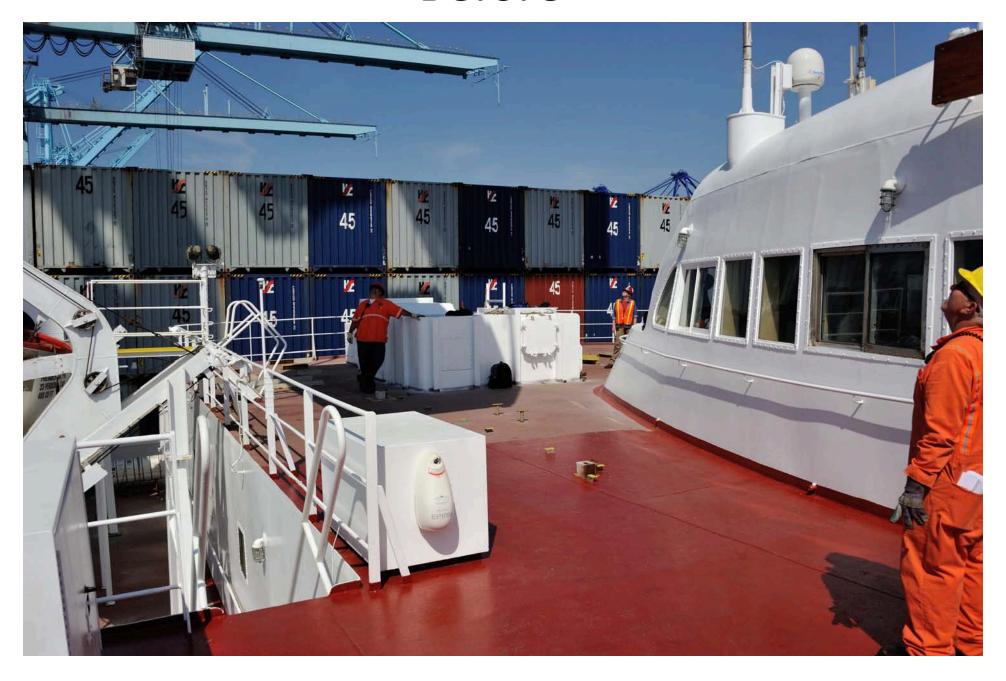


## After





## Before



# **After**



# Instruments were placed on roofs of vans.

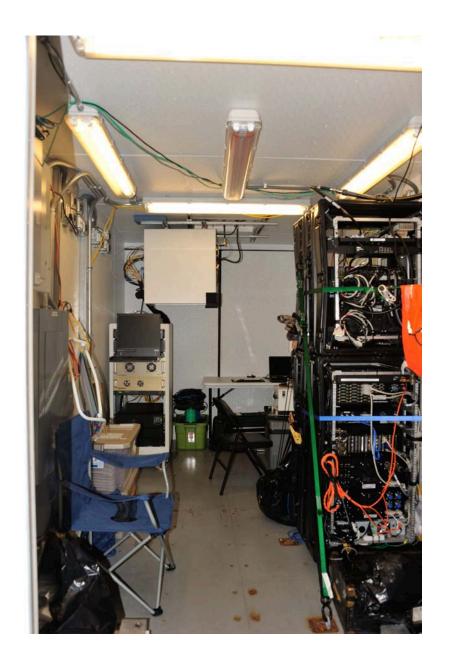


# Instruments were placed on roofs of vans.



#### Because the insides were full.

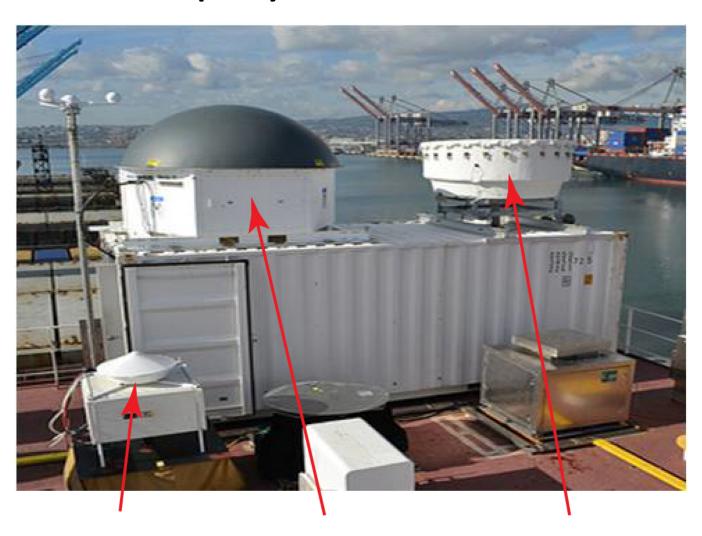




## Two ARM technicians live aboard the ship.



#### MAGIC Employs Three ARM Radars

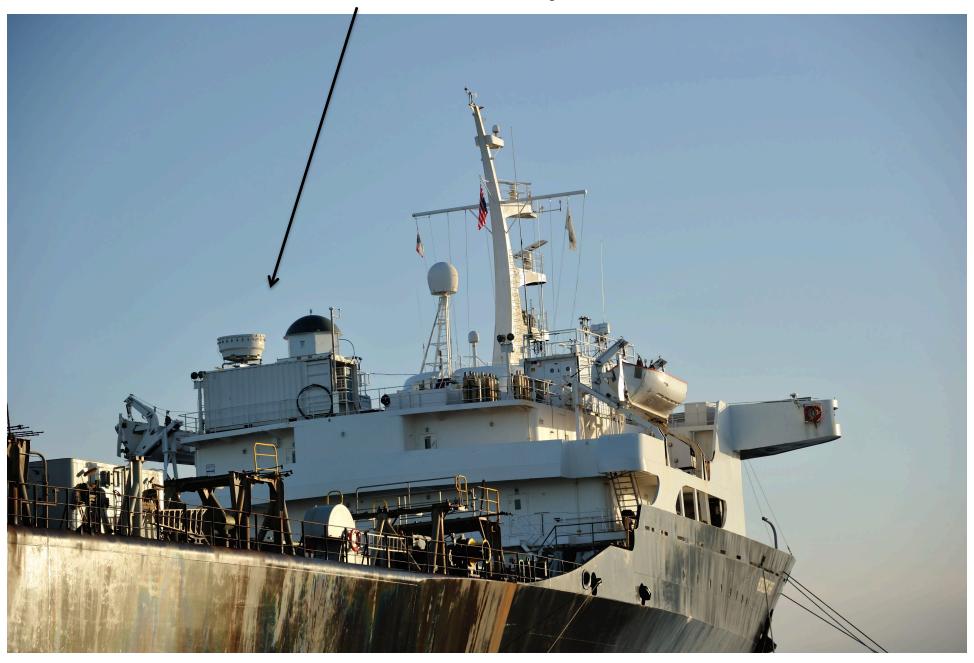


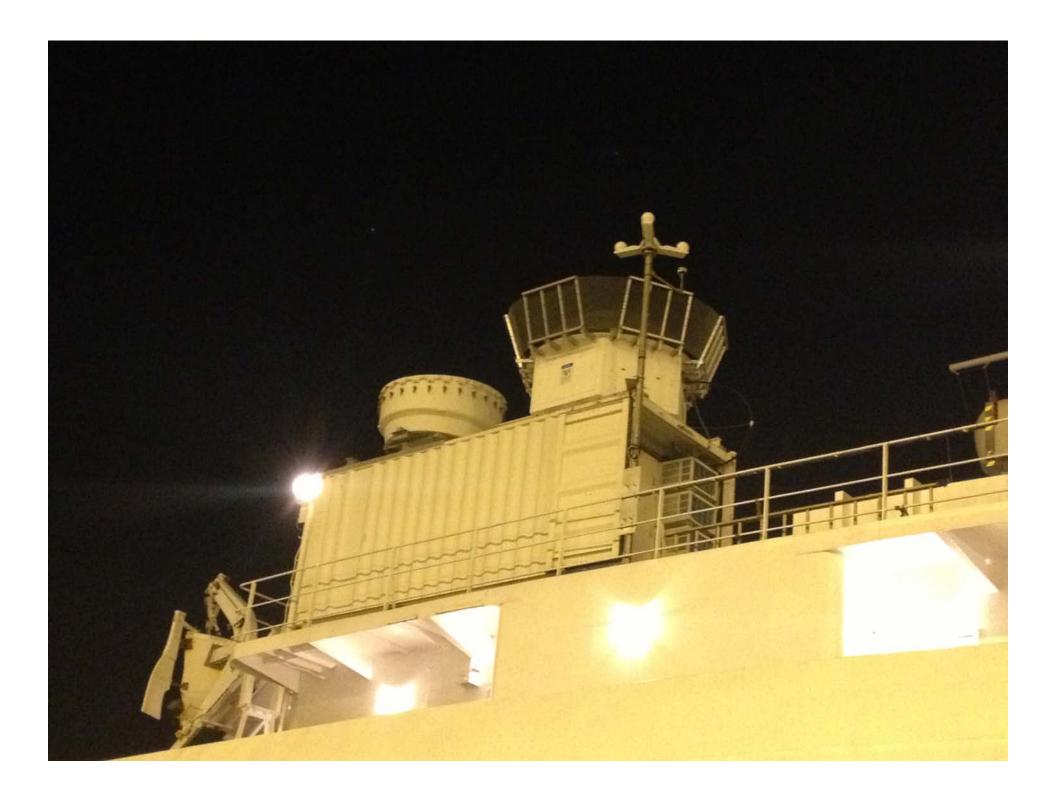
zenith-pointing W-band (95 GHz) on stable table

beam-steerable wind profiler (1290 MHz)

vertically-pointing Ka-band (35 GHz)

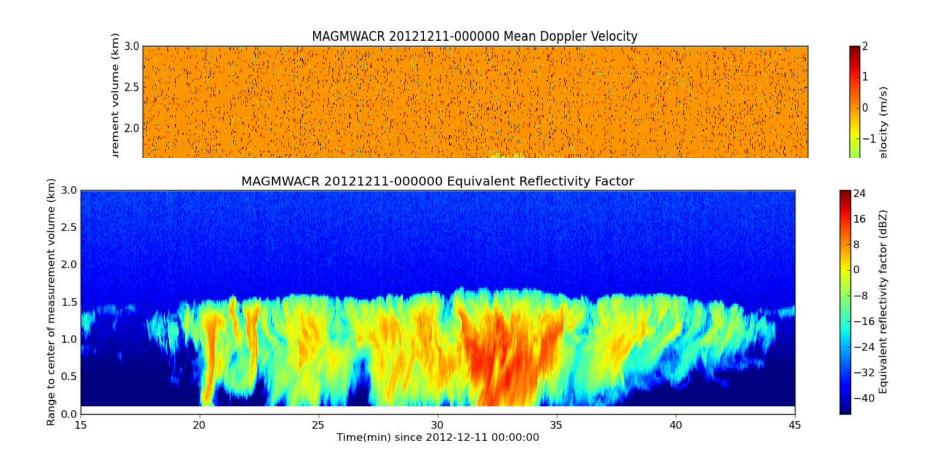
# Radars on *Spirit*







# Sample Radar Data



### Other Instruments Deployed During MAGIC



Microwave Radiometer 3 channel



Microwave Radiometer 2 channel



**ASSIST** 



**Total Sky Imager** 

## Other Instruments Deployed During MAGIC



Ceilometer



High Spectral Resolution LIDAR



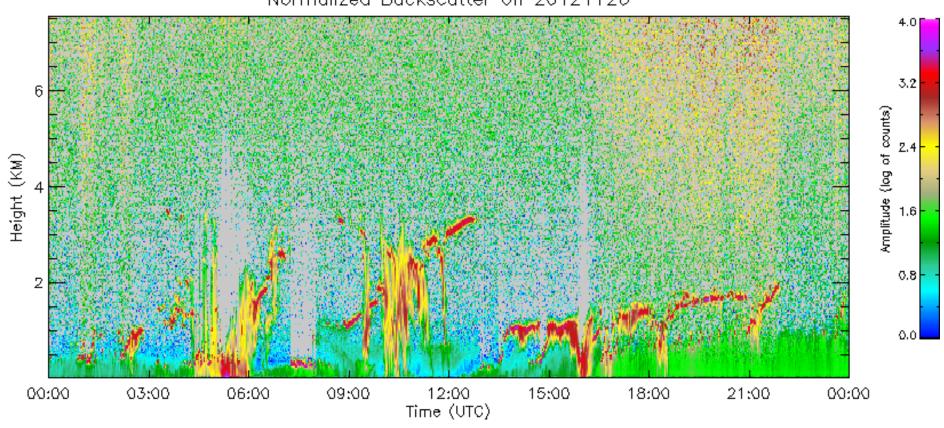
Disdrometers



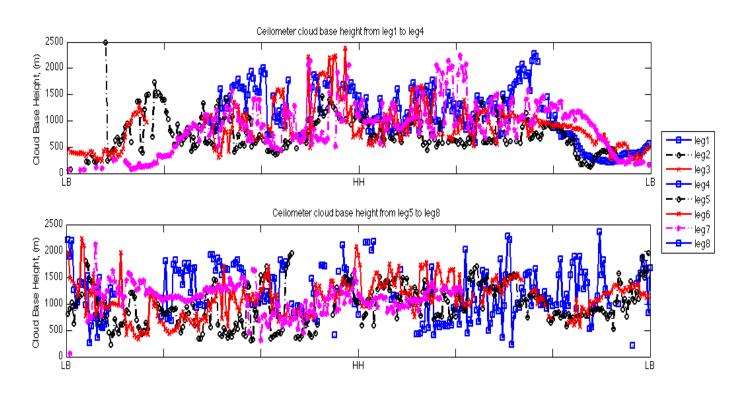
MultiPulse LIDAR

# Sample Ceilometer Data

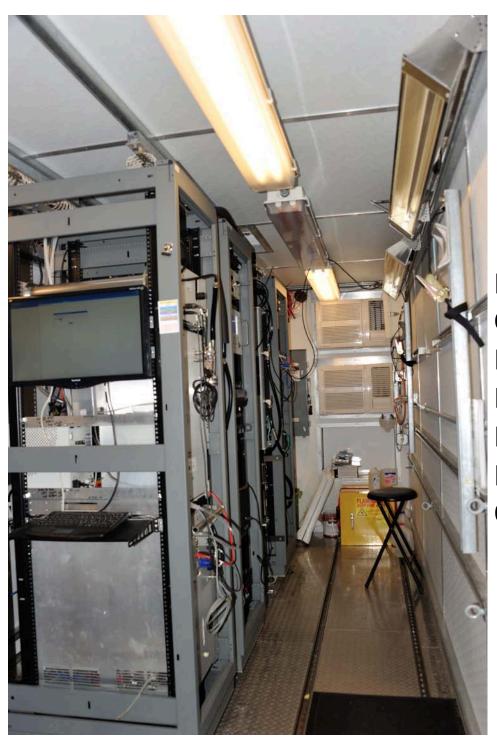
MAG M1 Ceilometer Range and Sensitivity Normalized Backscatter on 20121126



## Cloud Base Height from Ceilometer



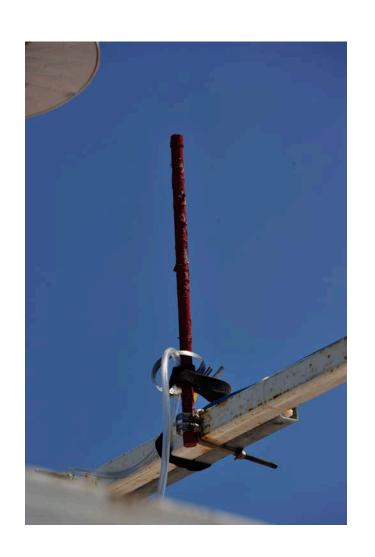
Leg01,	September 8-20, 2012
Leg02,	September 22-October 4, 2012
Leg03,	October 6-18, 2012
Leg04,	October 20-November 1, 2012
Leg05,	November 3-15, 2012
Leg06,	November 17-29, 2012
Leg07,	December 1-13, 2012
Leg08,	December 15-27, 2012



# Aerosol Observing System

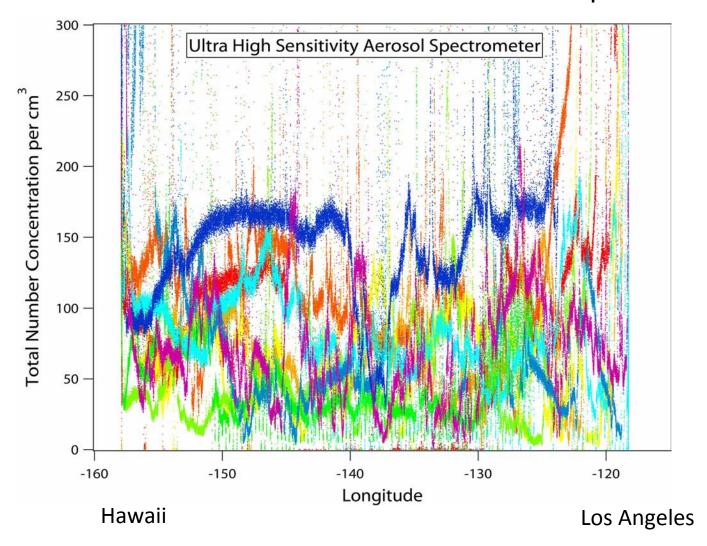
Particle number concentration (CPC) Cloud condensation nuclei (CCN) Particle Size Distribution (UHSAS) Light Absorption at 3  $\lambda$  (PSAP) Light Scattering at 3  $\lambda$  (Neph) Hygroscopic Growth (HTDMA) Ozone

# Aerosol sampling for later analysis by microscopy also occurred on some legs.



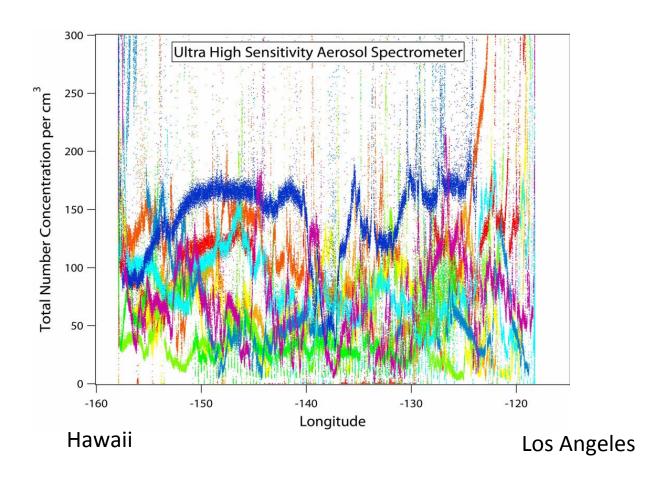


# Number Conc. of Particles with $D_{\rm opt} > 55$ nm

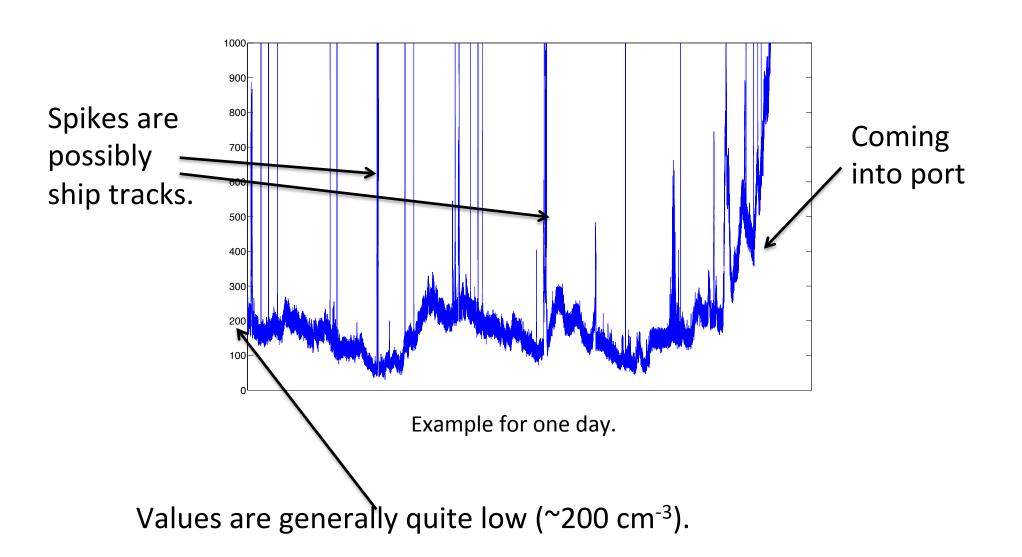


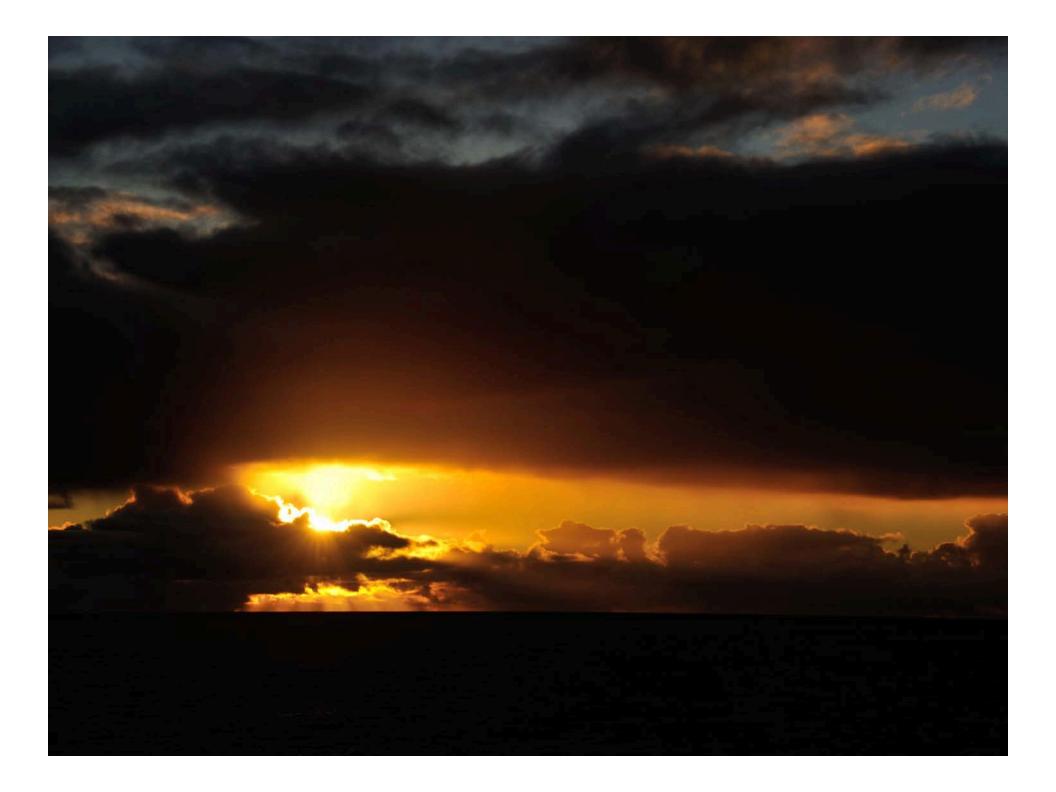
Each color represents measurements from a given transect.

- Number concentrations are generally quite low
- Much leg-to-leg variability
- No obvious longitudinal trend

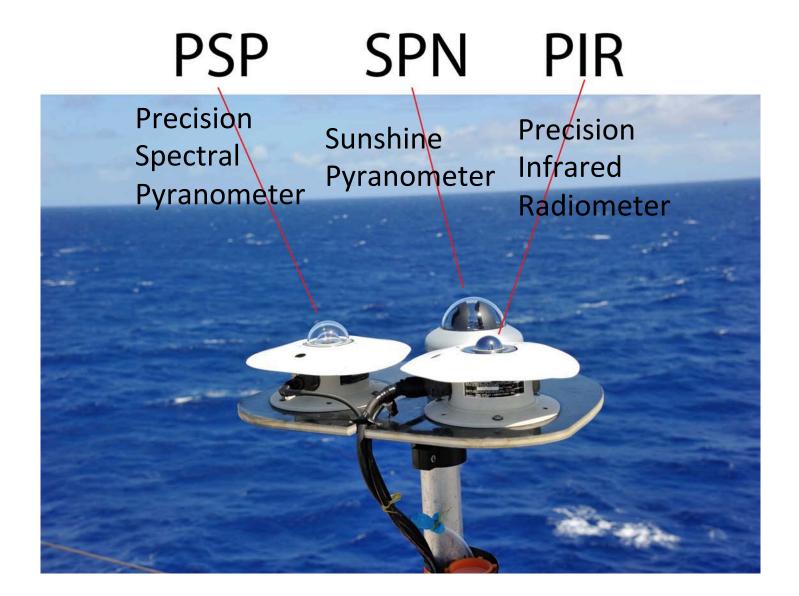


# Number Conc. of Particles with $D_{\text{mob}} > 10 \text{ nm}$





#### **Radiation Instruments**



#### Radiation Instruments





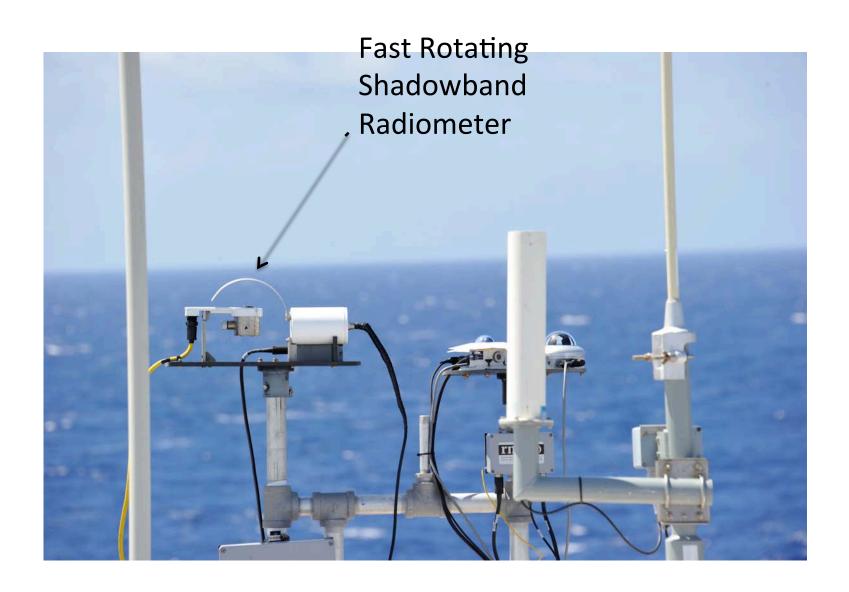


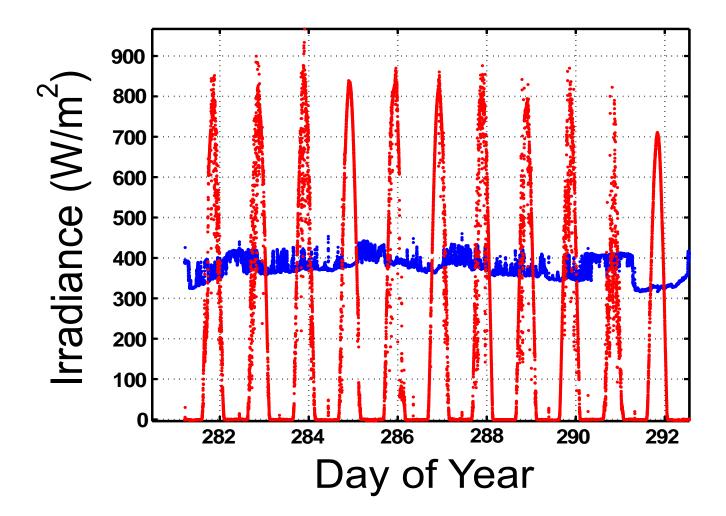
Solar Array Spectrophotometer

Solar Spectral Flux Radiometer

CIMEL Sunphotometer operated in cloud mode

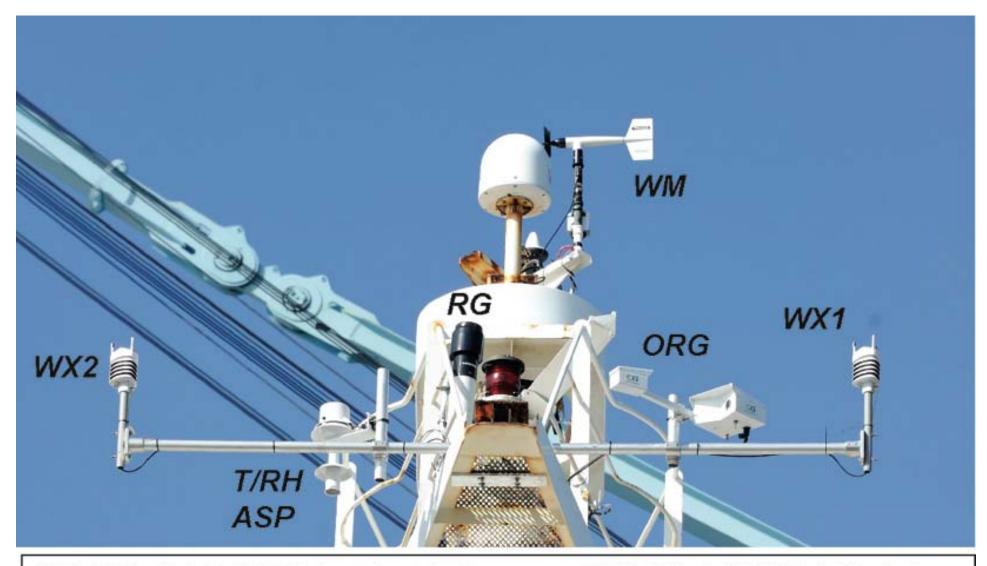
#### **Radiation Instruments**





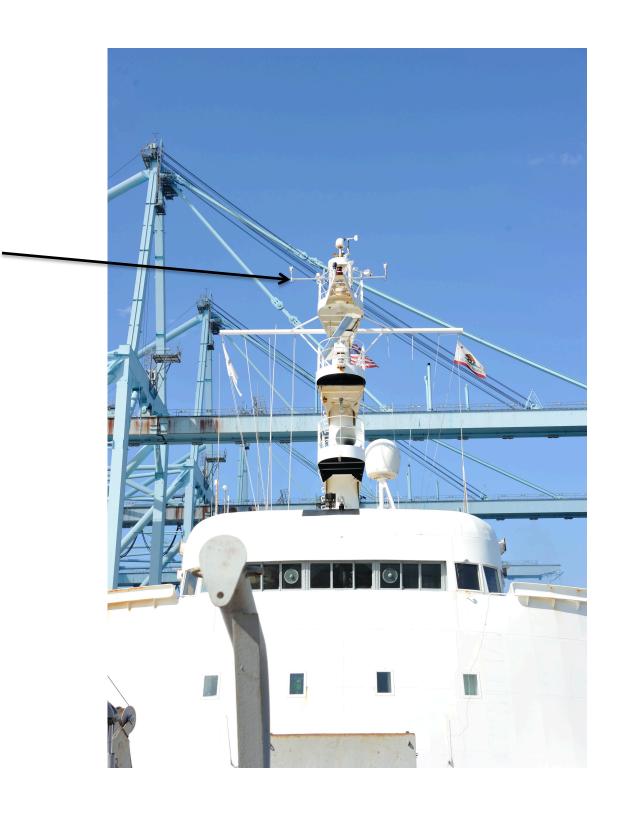
Solar (red) and Longwave (blue) Irradiance

#### Mast Meteorology System

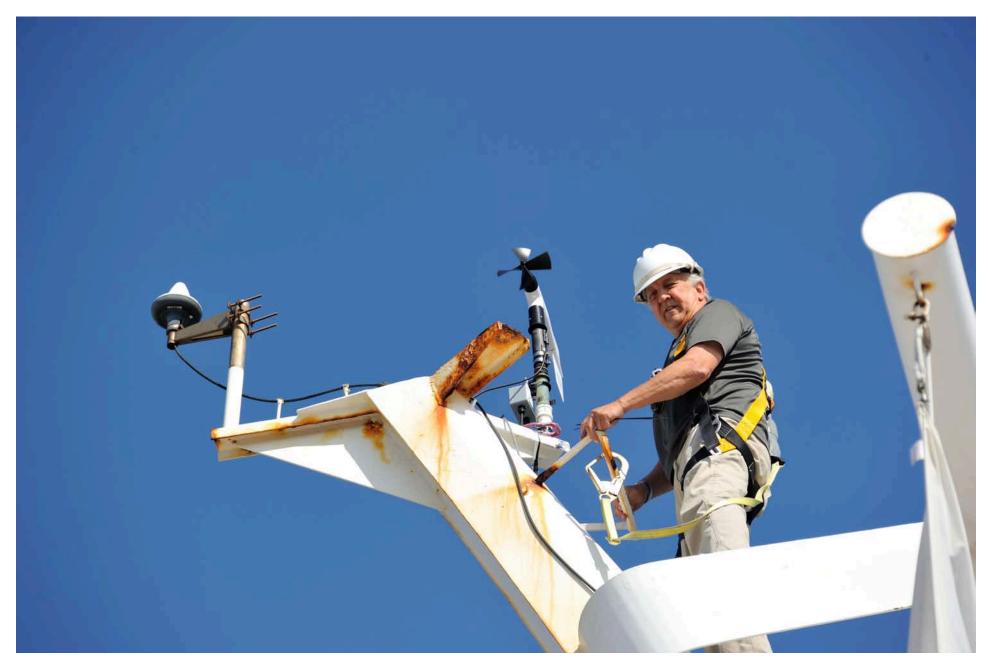


WX1, WX2 = Vaisala WXT520 (ws,wd,ta,rh,bp,ri) RG = Young 50203 Siphon Rain Gauge WM = Young 05106 Wind Monitor T/RH = Vaisala HMP155, ASP = Aspirator ORG = OSI Optical Rain Gauge

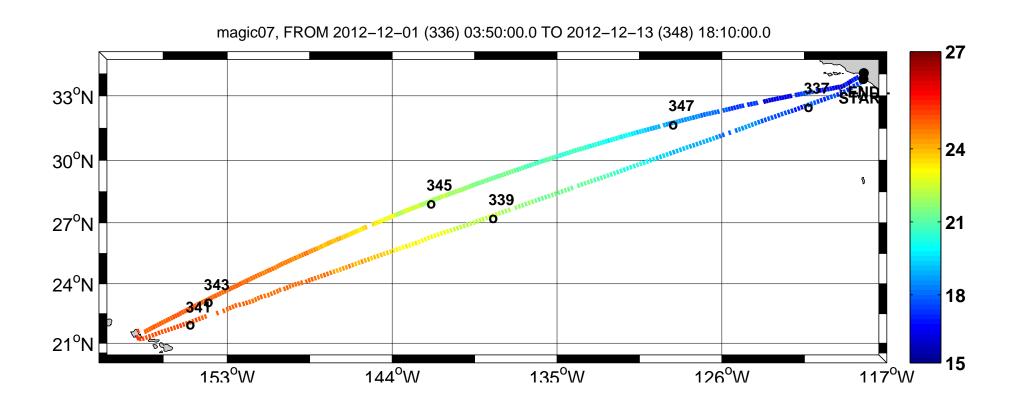
# Mast Meteorology System



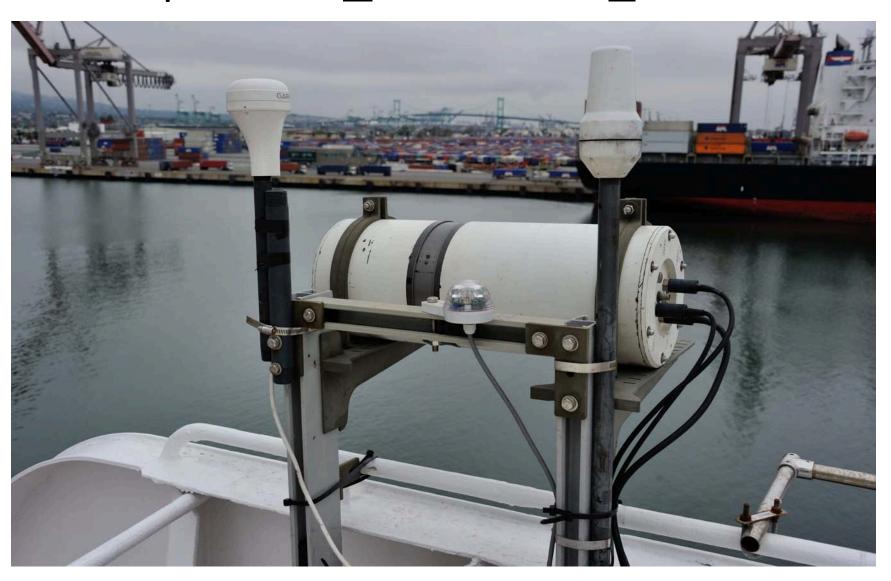
# Installing Mast Meteorology System



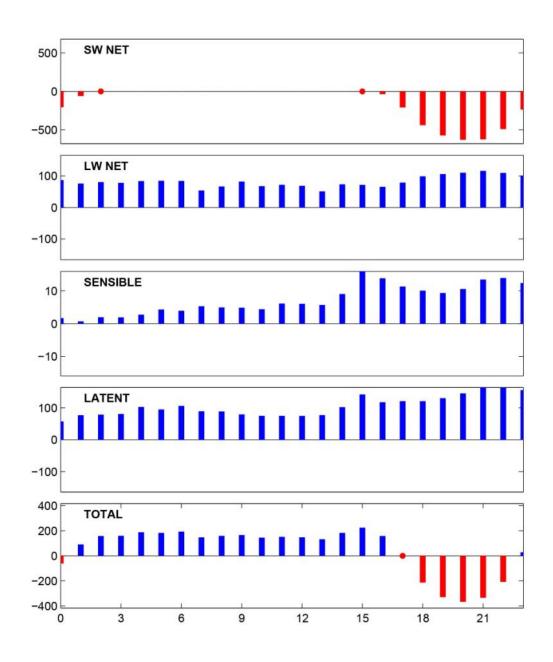
# Sea Surface Skin Temperature (SSST) Is Important for Fluxes



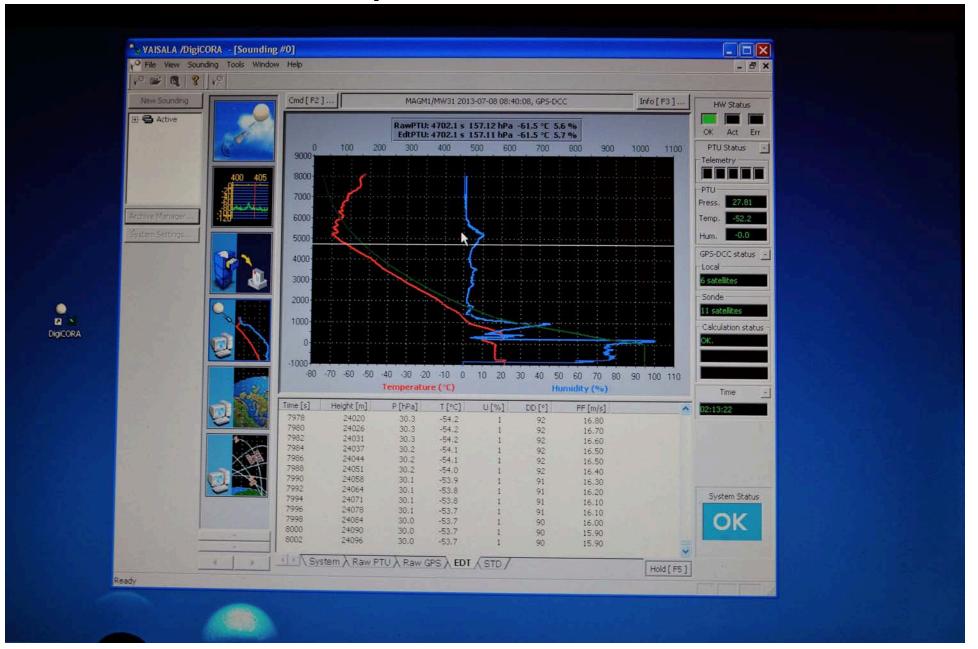
# ISAR - <u>I</u>nfrared <u>S</u>ea Surface Skin Temperature <u>A</u>utonomous <u>R</u>adiometer



#### Fluxes can be calculated from MAGIC data.



# Atmospheric Structure



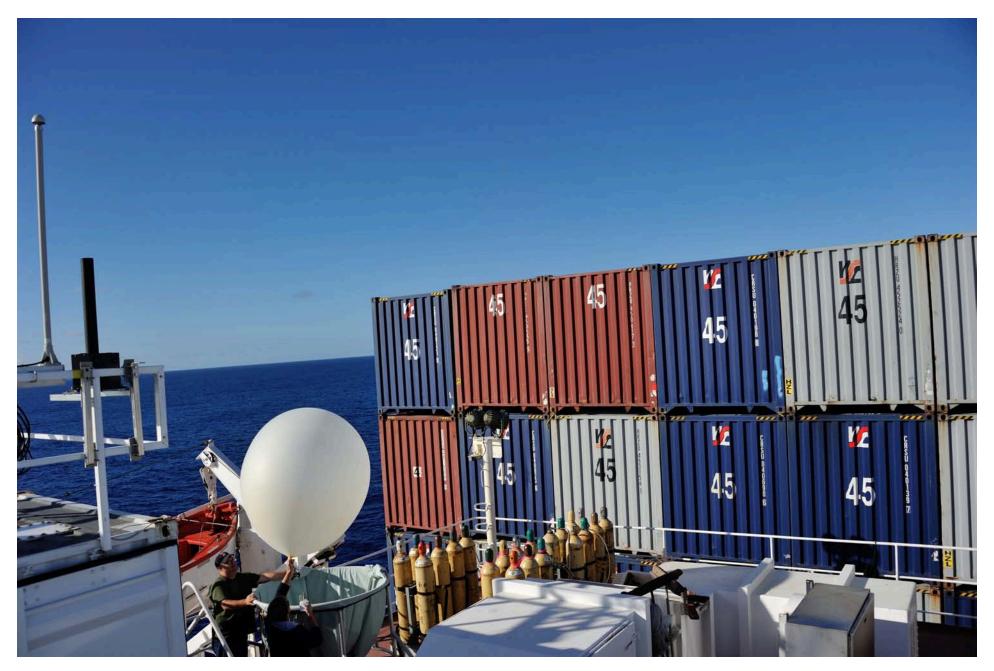
# Balloon soundings are launched 4 times per day.



# This is often a challenging endeavor.



#### Obstacles must be overcome.

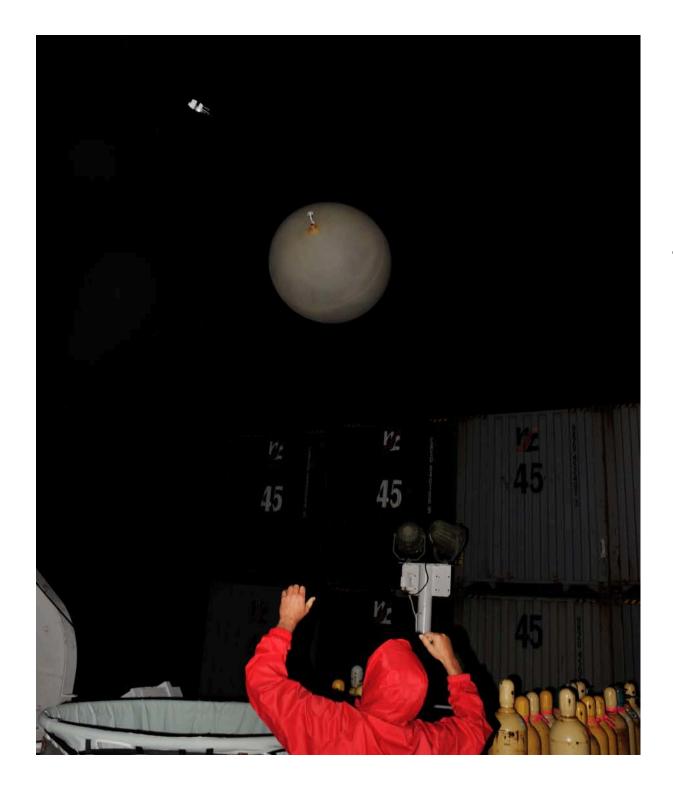




Successful launches occurred at relative wind speeds as high as 53 mph!

#### The success rate was ~80%, which is excellent!



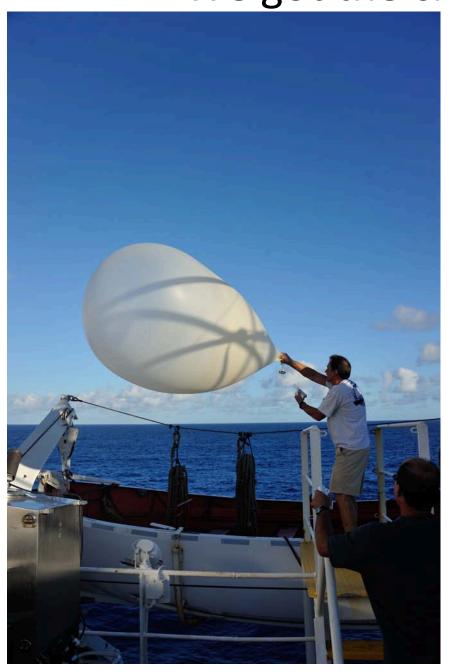


Technicians worked around the clock.

### MAGIC made nearly 600 sonde launches.

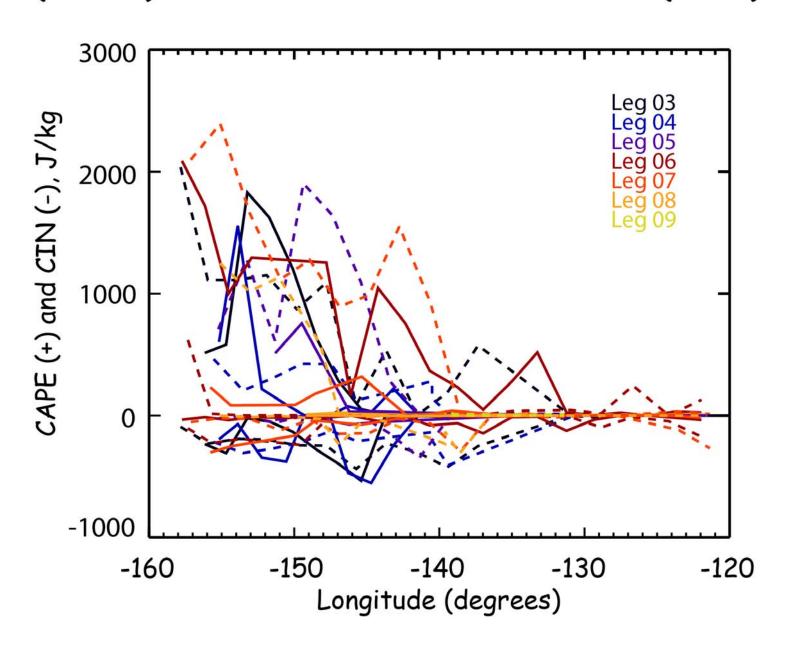


We got the crew involved too.



First Mate Eric Sincovich launching a balloon.

# Convective Available Potential Energy (CAPE) and Convective INhibition (CIN)



#### Safety Is Important to Us and to Horizon





# Life Aboard the Horizon Spirit



#### The *Spirit* has a crew of ~25 plus the Captain.



Captain Tom McCarthy



Captain Walt Rankin

Living quarters are comfortable.

Food is plentiful and good!

The crew are very supportive.





## **THURSDAY**

#### **Horizon Sprit**

Master McCarthy

VOYAGE # 204

ENROUTE LONG BEACH THURSDAY SEPTEMBER 6, 2012

#### BREAKFAST

ASSORTED CHILLED JUICES HOT OATMEAL & CREAM OR WHEAT CEREAL

CHILLED MORNING FRUIT ASSORTED COLD CEREAL

**CRISP BACON GRILLED SAUSAGE LINKS** 

EGGS OR EGG BEATERS TO ORDER \*\*\*\*\*\* FRIED \*\*\*\*\*\*\* POACH \*\*\*\*\*\*\* SCRAMBLED OMELETS \*\*\*\* CHEESE \*\*\*\* PEPPER \*\*\*\*\* MUSHROOM \*\* ONION \*\*\*\* HAM \*\*\*\* TOMATO BUTTERMILK BLUEBERRY PANCAKES WITH MAPLE SYRUP OR HONEY **BAKERS DANISH AND PASTRY** 

HOME FRIED POTATO'S

STEAMED RICE

COFFEE

TEA

Kool-Aid

FRESH MILK

Luncheon **NAVY BEAN SOUP** 

**VEAL CUTLETS WITH SAUCE ESPAGNOLE** GRILLED HOT DOGS OR CHILI DOGS WITH CHIPS ASSORTED COLD BAR

STEAMED RICE STEMMED PEAS AND CARROTS

FRENCH FRIES SAUTÉED BRUSSELS

SPROUTS BAKER'S CHOICE

COFFEE

TEA

Kool-Aid

FRESH MILK

Dinner SOUP DE' J OUR

BAKED BEEF BRISKET WITH SAUCE ESPAGNOLE **GRILLED HALIBUT FISH STEAKS WITH SAUCE MORNAY** ASSORTED COLD SALAD BAR

STEAMED RICE

LONG BRANCH POTATO'S

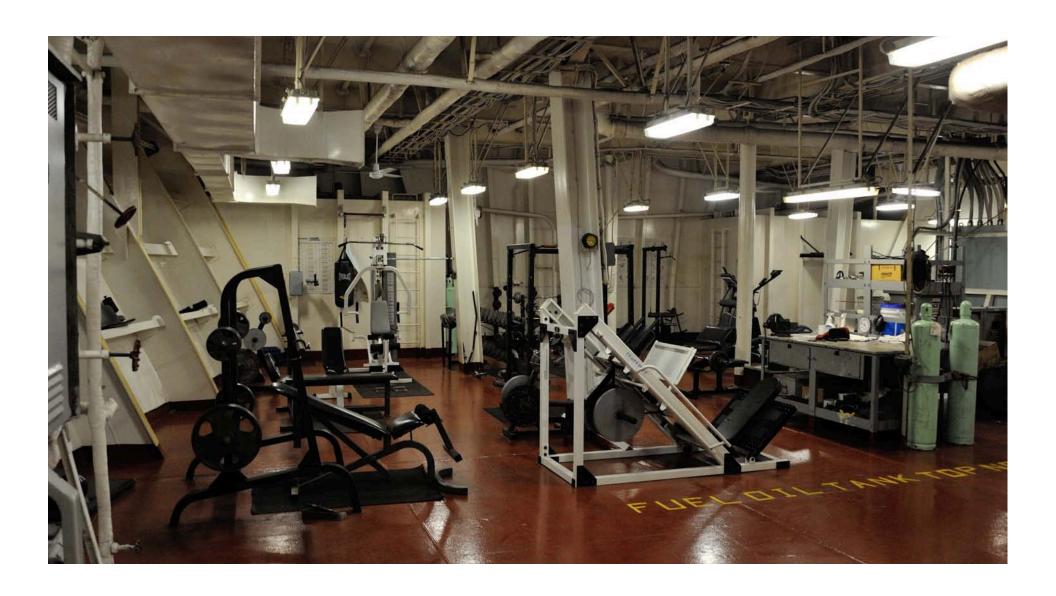
STEAMED MIXED VEGETABLES BAKERS BREAD & CAKE

STEAMED CUT CORN

COFFEE

Kool-Aid

FRESH MILK



#### Keeping Track of Time Can be Challenging



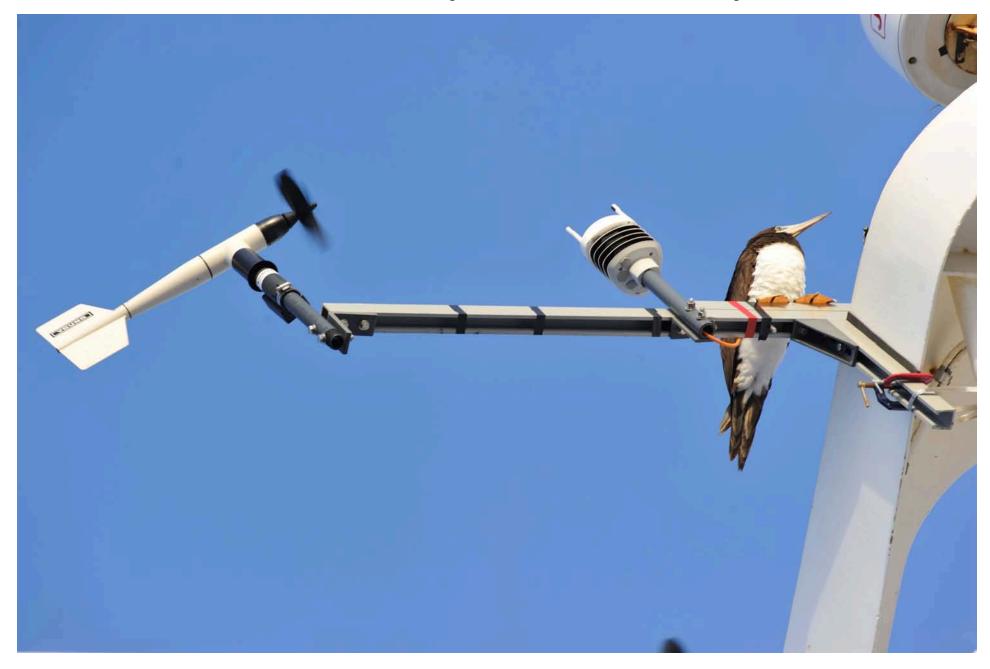
# Occasionally visitors appeared.



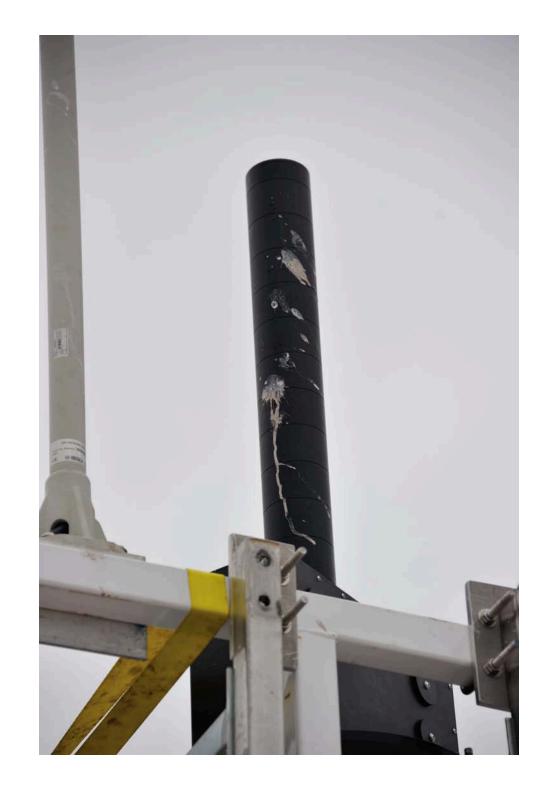
#### Some visitors looked us over.

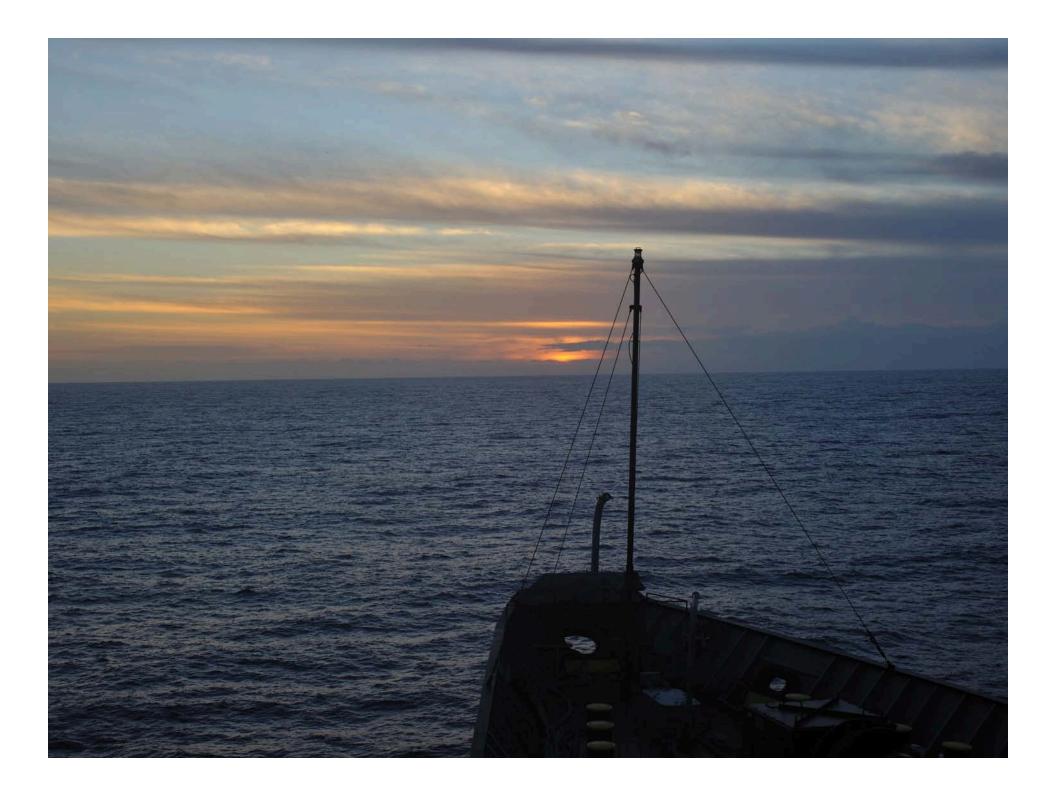


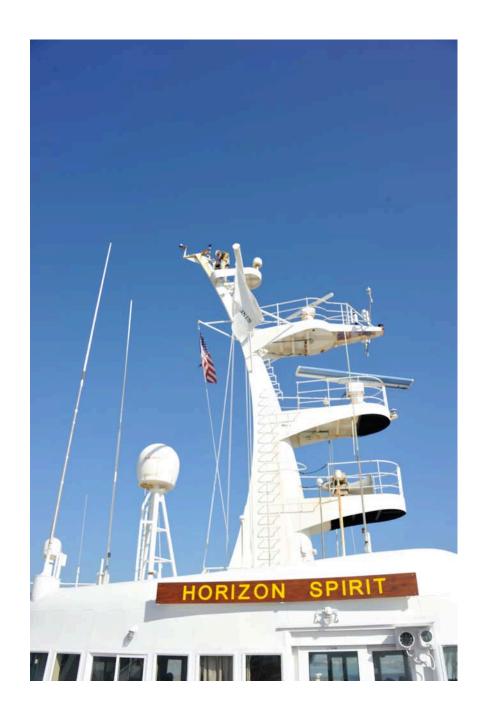
## Occasionally a visitor stayed.



Sometimes our visitors weren't very considerate of our optical instruments.





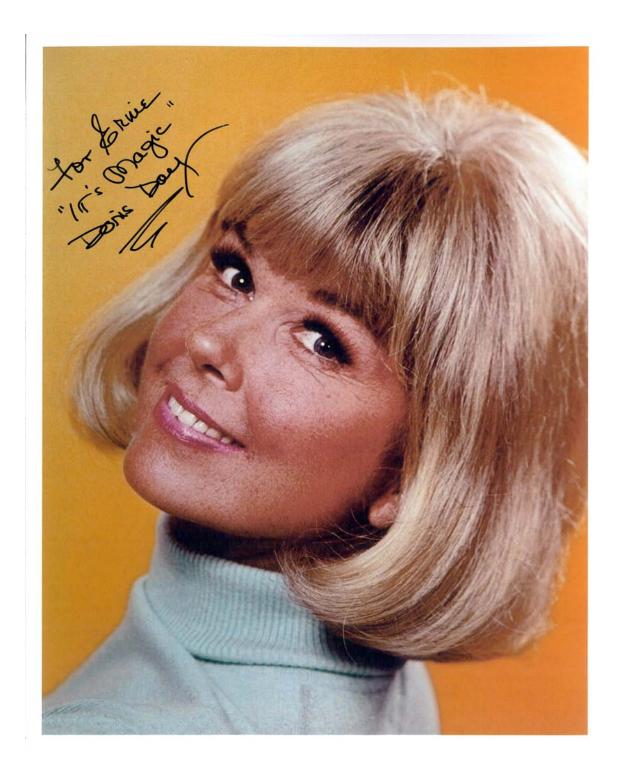


We thank Horizon Lines and the Captain and crew of the Horizon Spirit for their support and enthusiasm for **MAGIC!** 

MAGIC has obtained an unprecedented data set on <u>clouds</u>, <u>precipitation</u>, <u>aerosols</u>, <u>radiation</u>, and <u>atmospheric structure</u> in a climatically important marine region.







Doris Day had a hit song in 1948 with "It's Magic"

#### **Future Plans**

#### MAGIC-2: a full-year deployment of AMF2

Would not occur before 2016

Proposal has been submitted

#### **Future Plans**

#### MAGIC-2: a full-year deployment of AMF2

Would not occur before 2016 Proposal has been submitted

# MAGIC-Lite: a continued deployment of a small suite of instruments

Proposal will be submitted soon Instruments would allow computation of fluxes

