



# RICO Doppler Lidar measurements

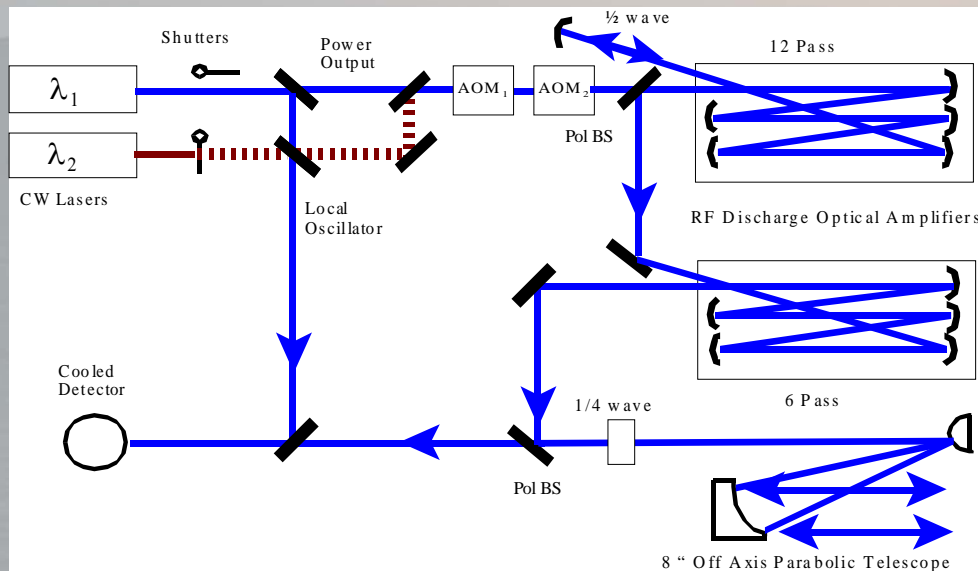
9 Jan – 25 Jan 2005

Alan Brewer, Sara Tucker, Janet Machol,  
Janet Intrieri, MJ Post, and Scott Sandberg

NOAA / ETL, CIRES & Zeltec

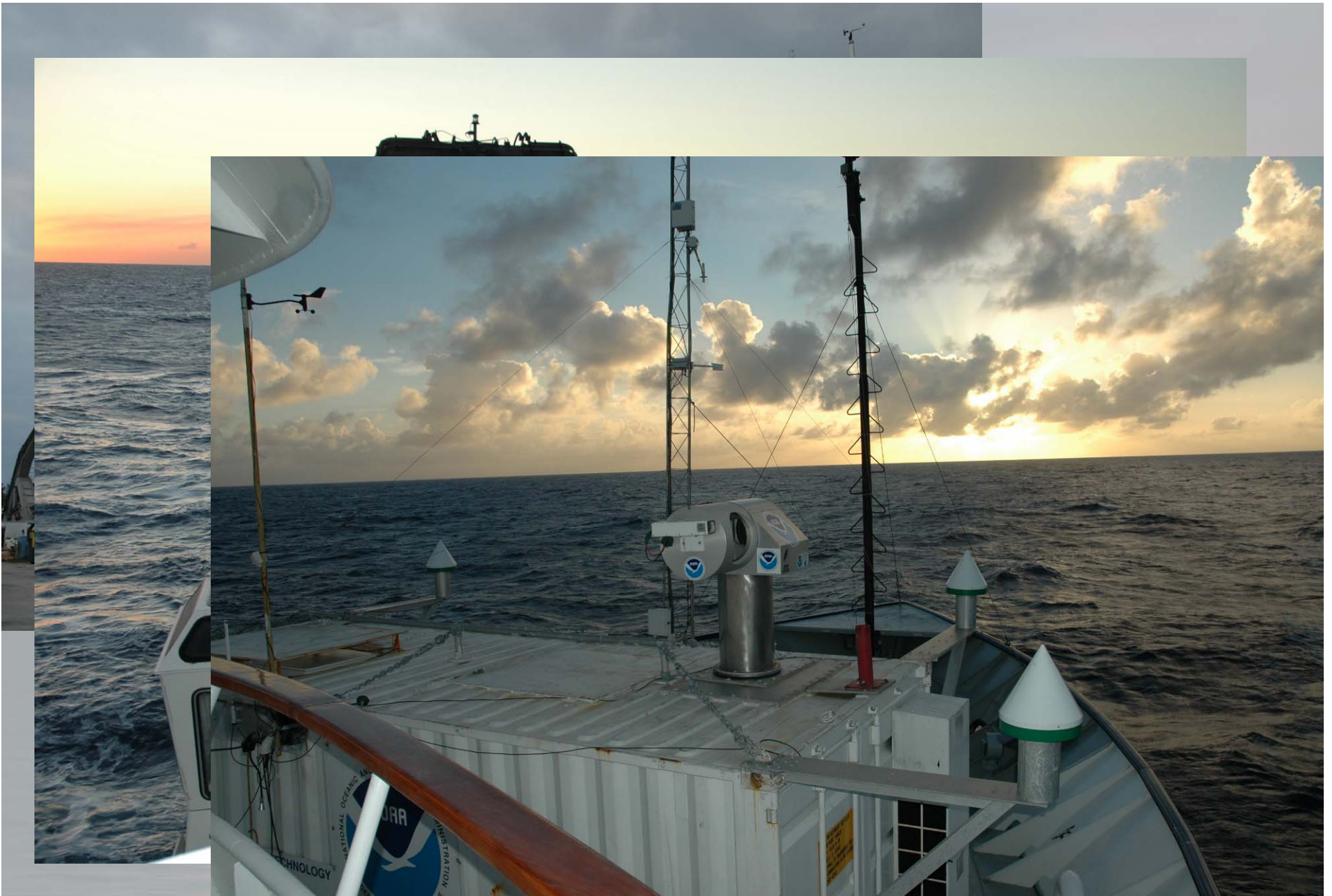
# The mini-MOPA Doppler Lidar

- CO<sub>2</sub> lasers and optical amplifiers (invisible and eyesafe)
- High pulse rate / low pulse energy
- Adjustable spatial and temporal resolution
- Optical scanner for full sky coverage



Pulse Energy	1 mJ
Pulse width	0.6 - 1.0 $\mu$ s
Laser PRF	280 Hz
Beam rate	2 Hz
Max Range	15 km
Velocity precision	< 15 cm/s
Wavelength	9.3 $\mu$ m (C <sup>12</sup> O <sub>2</sub> <sup>18</sup> )





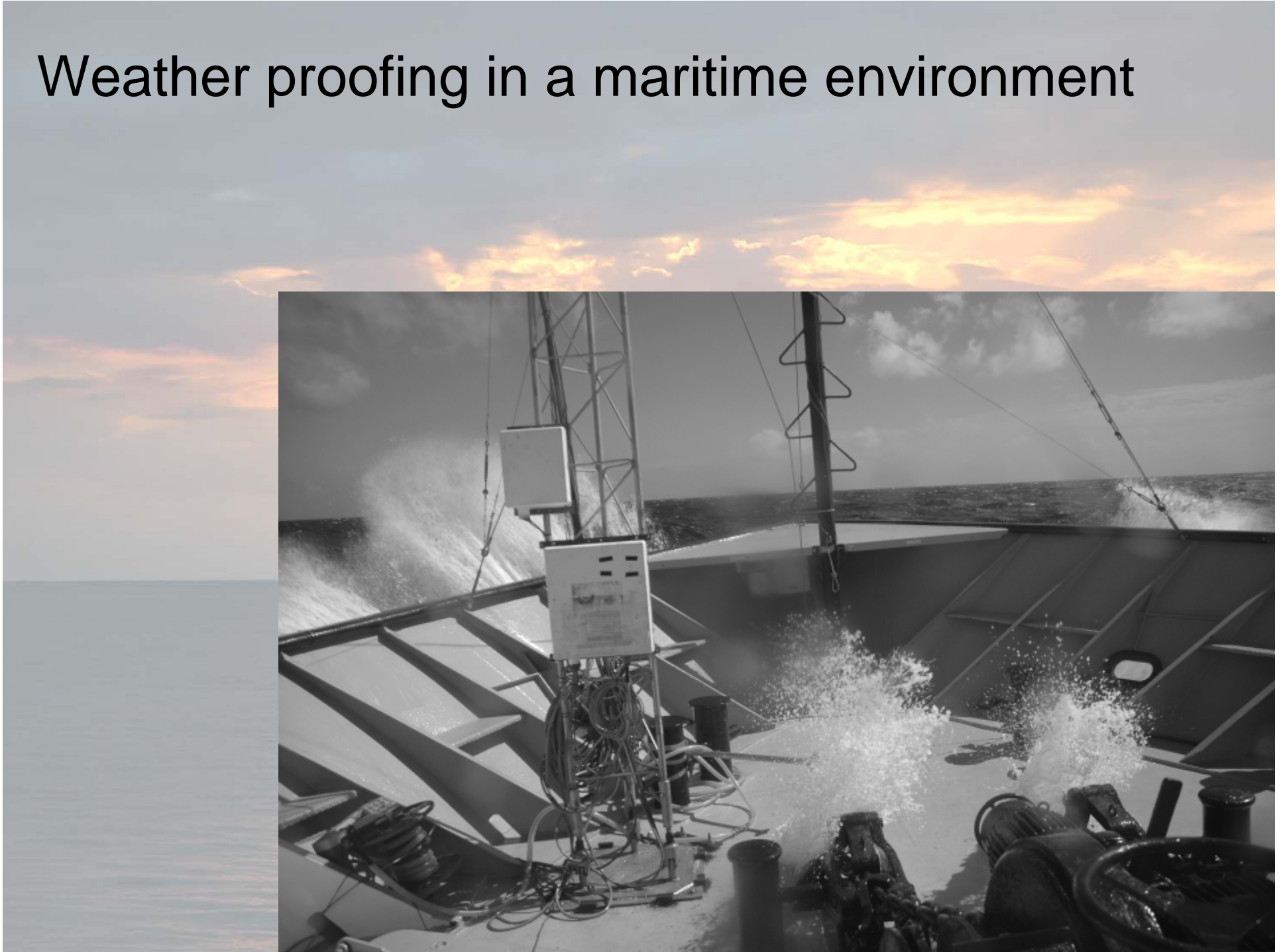
Pictures of the RV Seward Johnson

# Motion Compensation

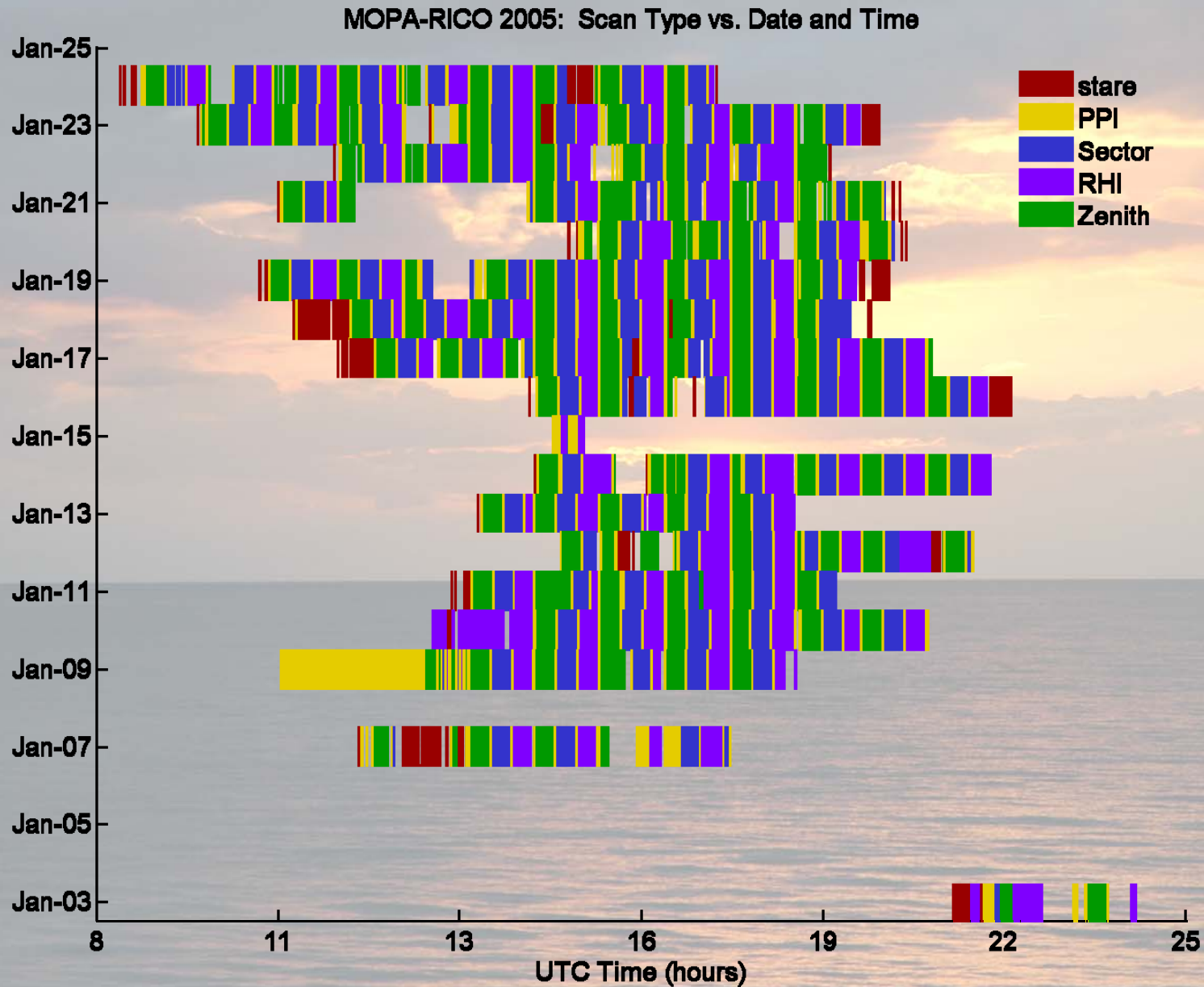




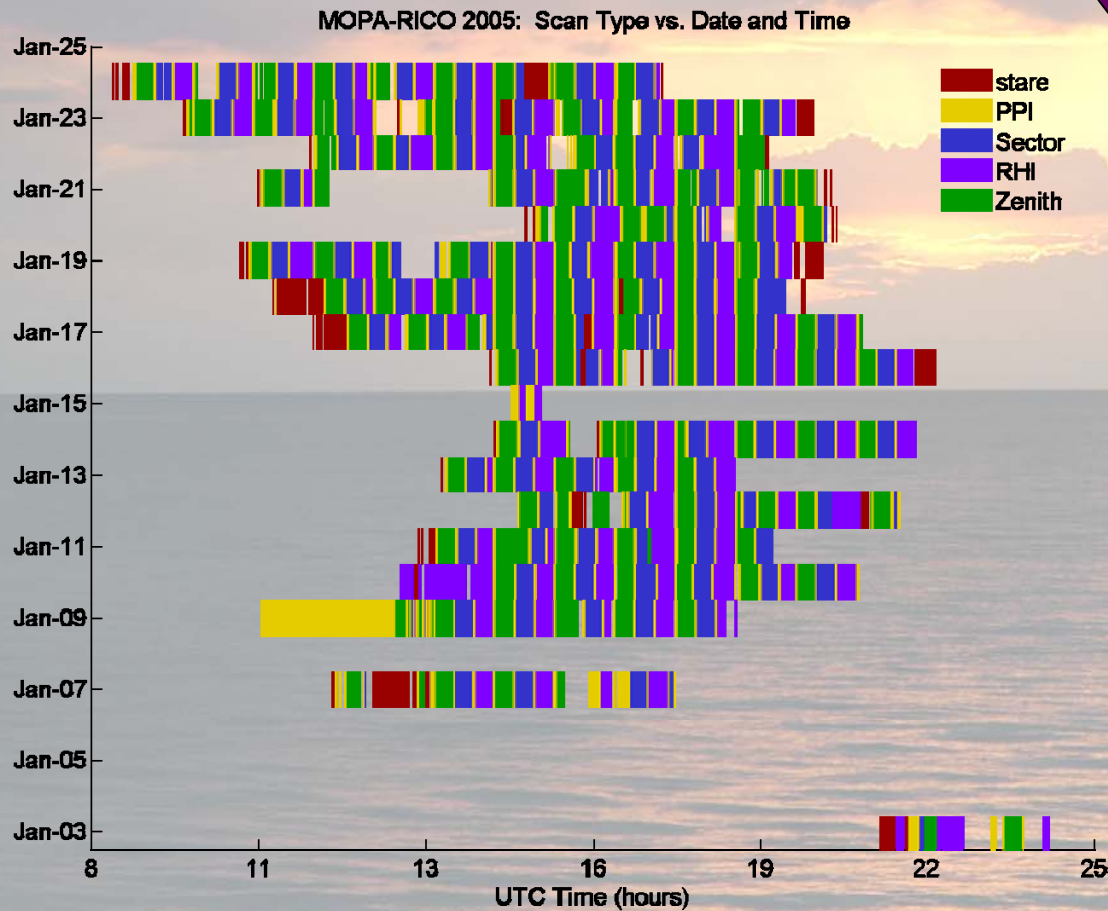
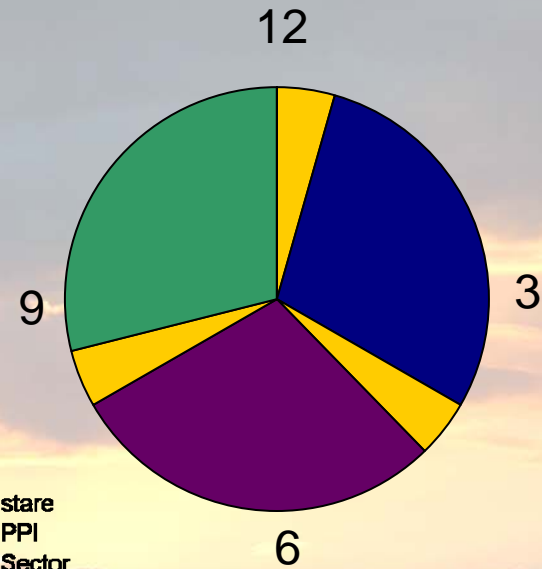
# Weather proofing in a maritime environment



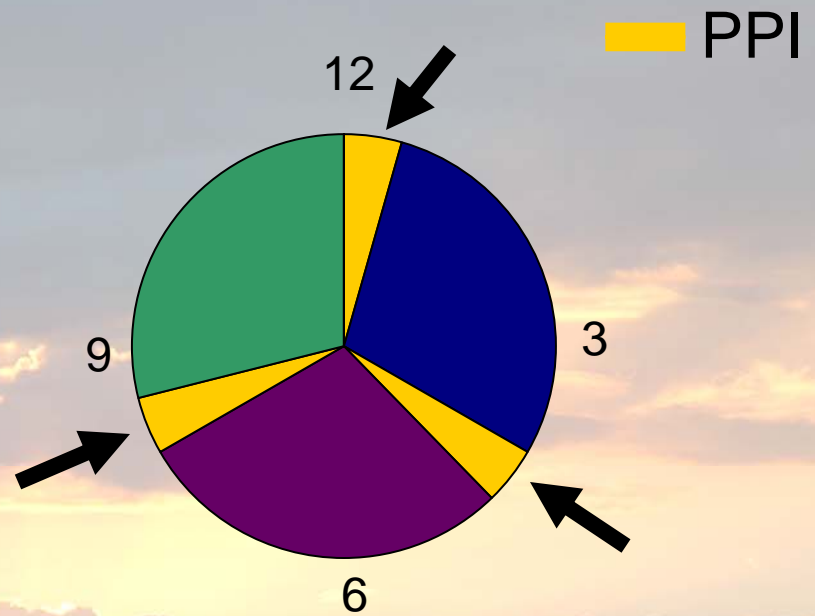
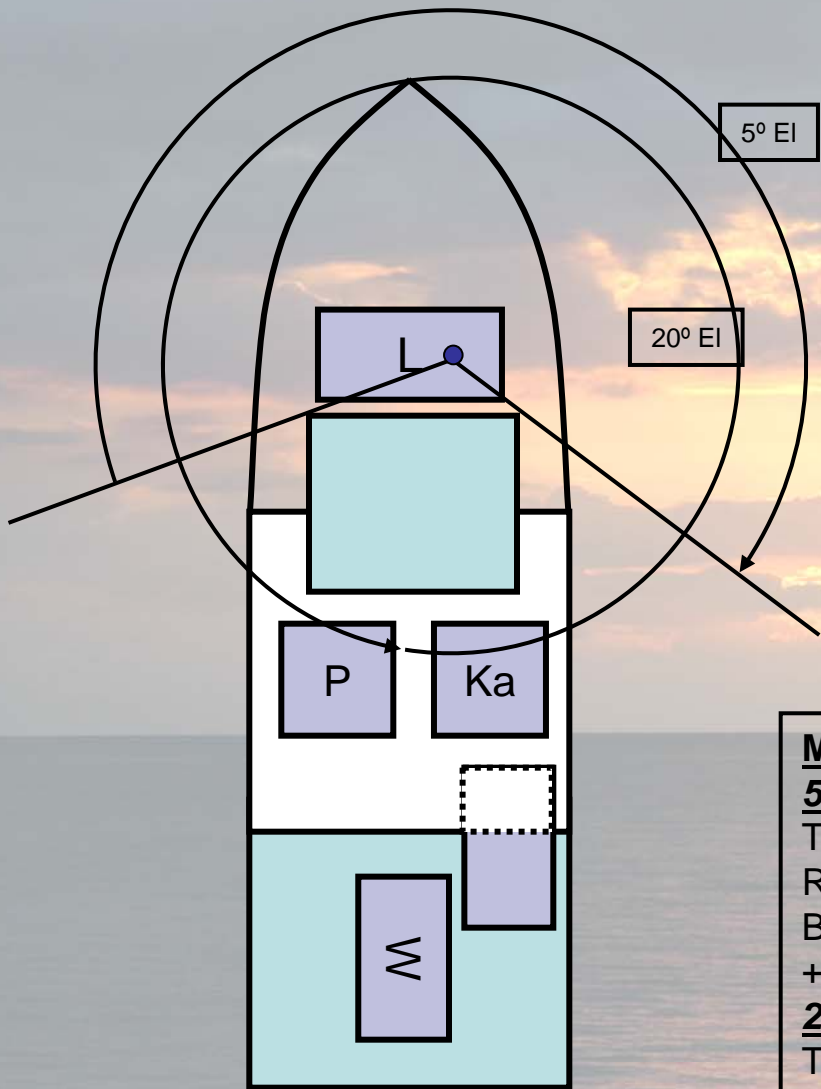
# Lidar Operation / Scan mode:



# Lidar operation schedule:



- Four Scan Modes:
1. PPI Wind profile
  2. PPI sector
  3. RHI starboard
  4. Zenith stare



**Mean Wind Scans**

**5° PPI**

Time = 90 s

Rate = 4°/s to the BL top (0 ~ 800 m)

+

**20° PPI**

Time = 60 s

Rate = 6°/s

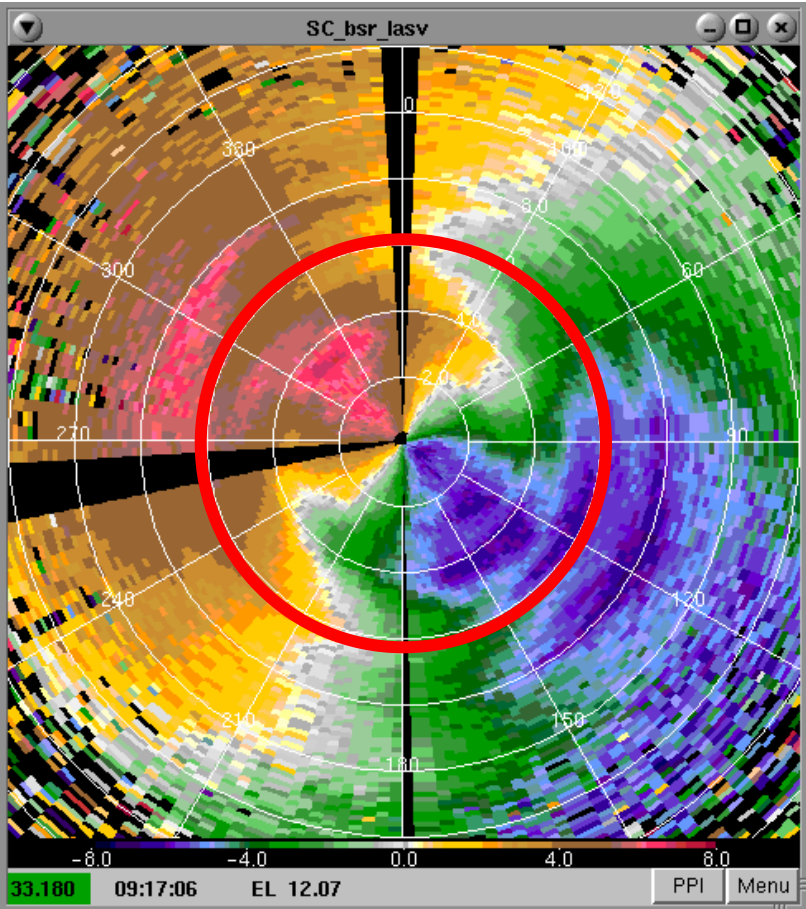
Total time = ~2.5 minutes

**Goal**

wind profile/ mean wind in hi-vert. res. (30 m) from the sfc  
Az. limits dependent on bridge.

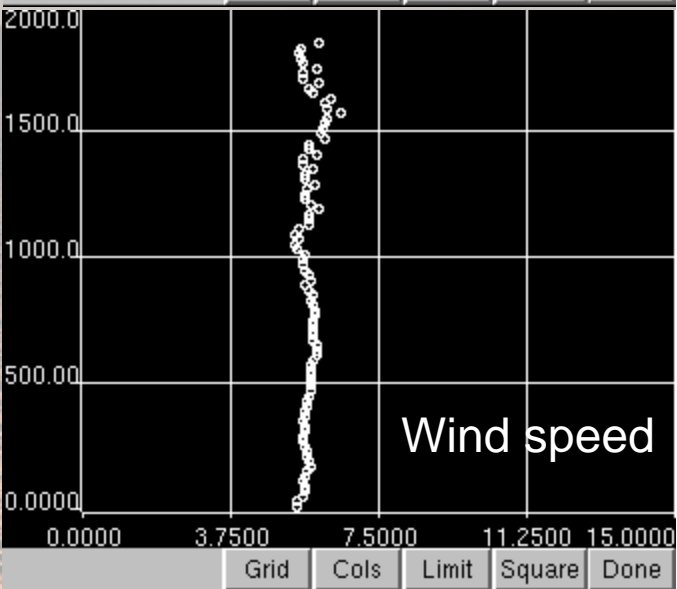
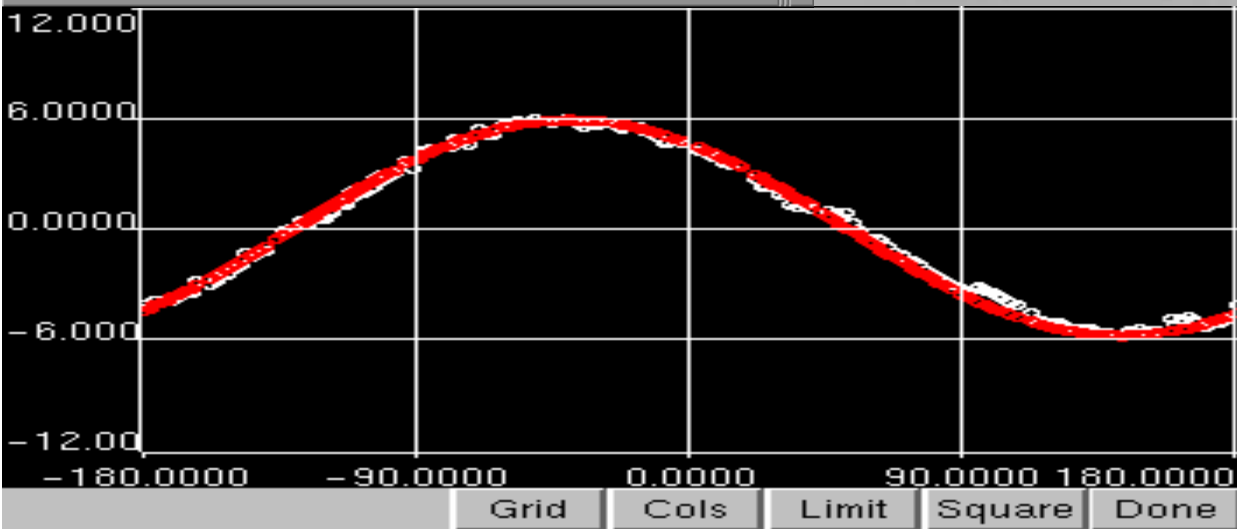
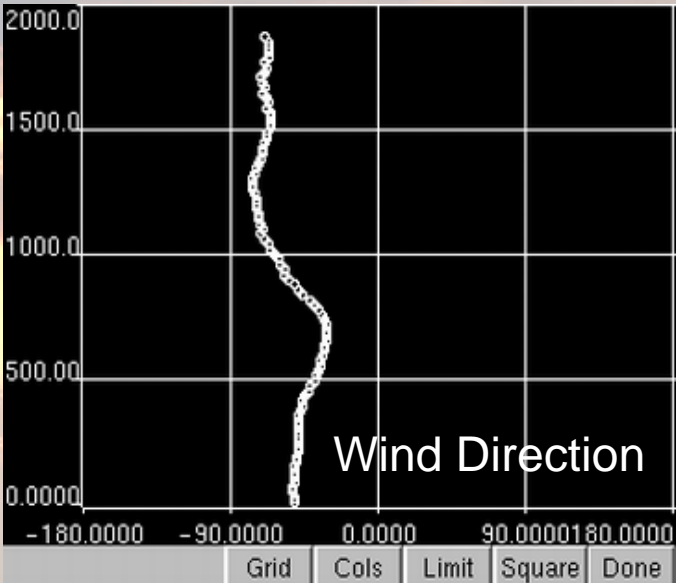
wind profile in medium-vert. res. (150 m) up to max range

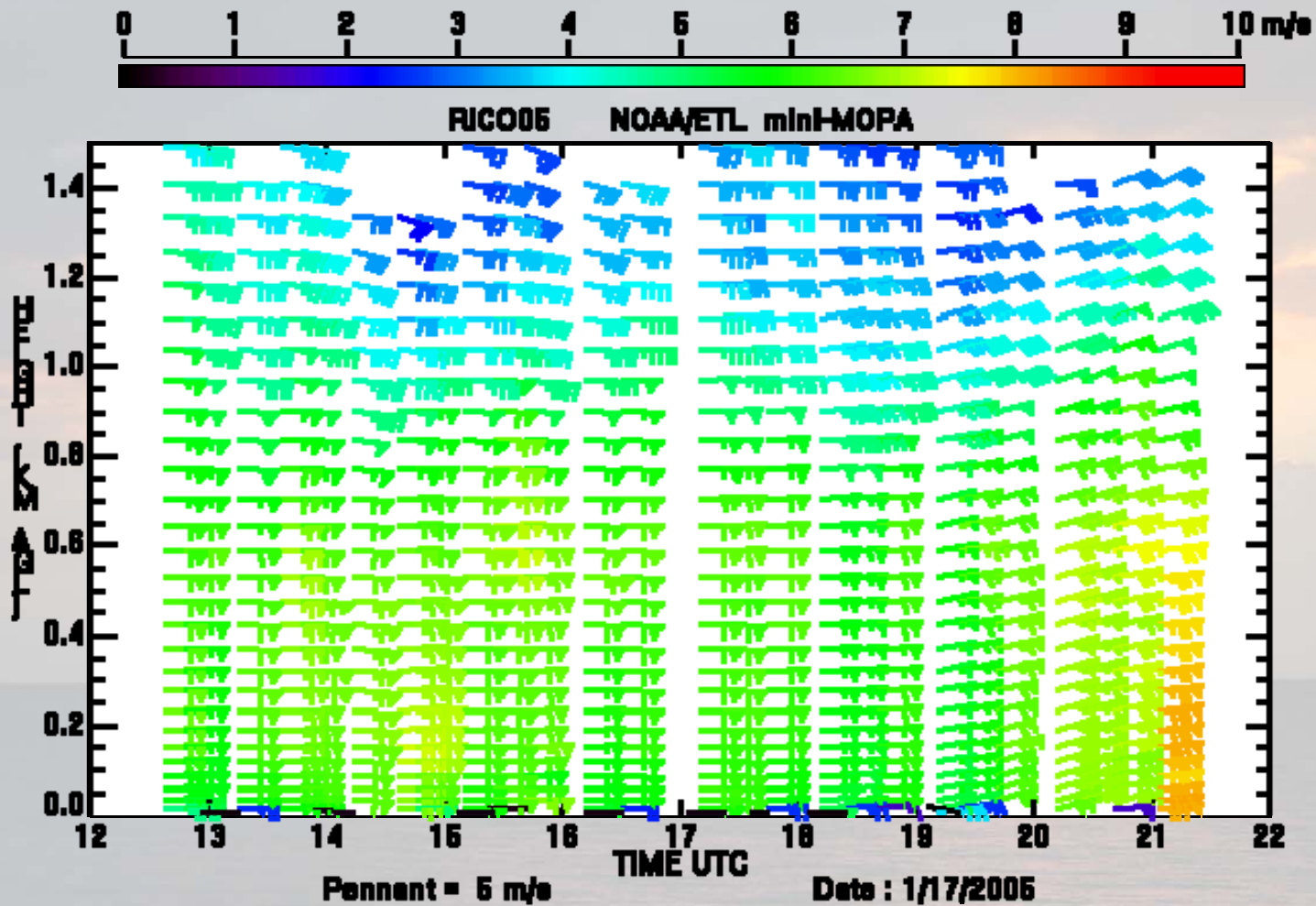




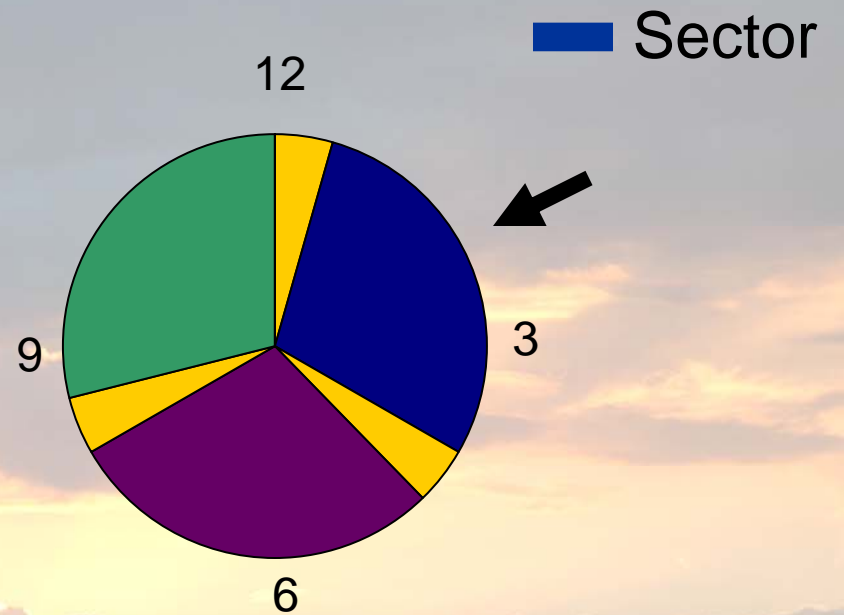
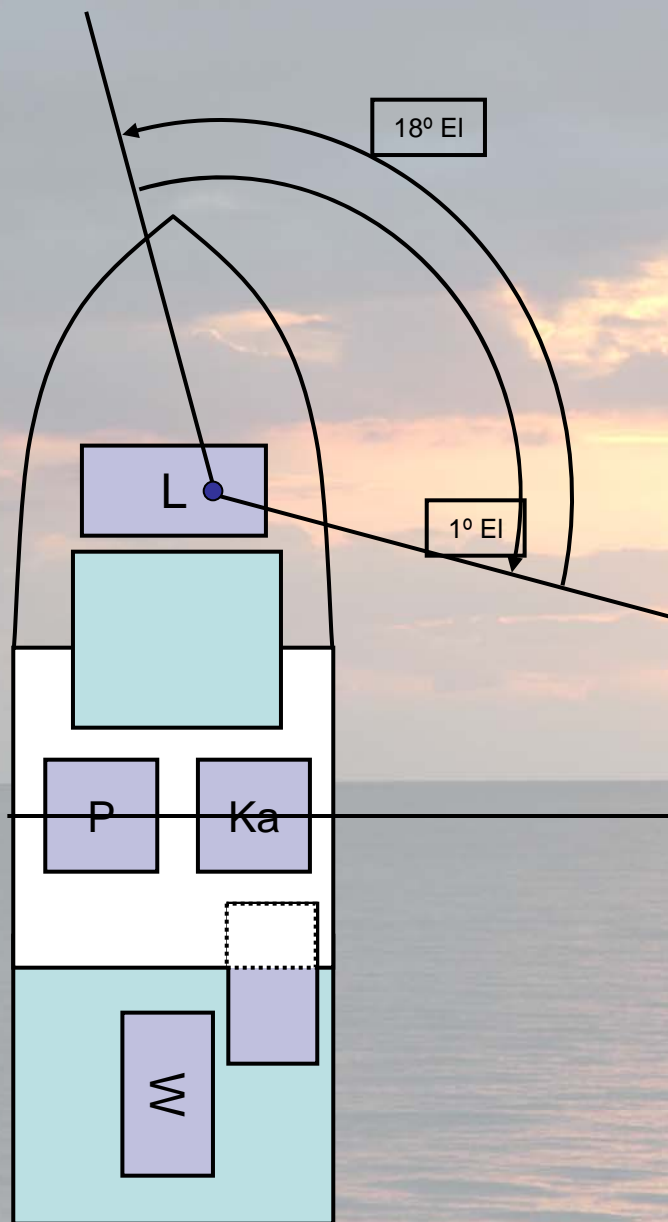
# Wind profiles from azimuth Scans (12 deg EL)

@ 12 deg EL  
 150m range ->  
 30m height res





Provides a wind profile 3 times an hour



**Sector Scans**

PPI's at 1° & 18° el.  
 over 120° wide az. sector  
 Rate = 3°/s

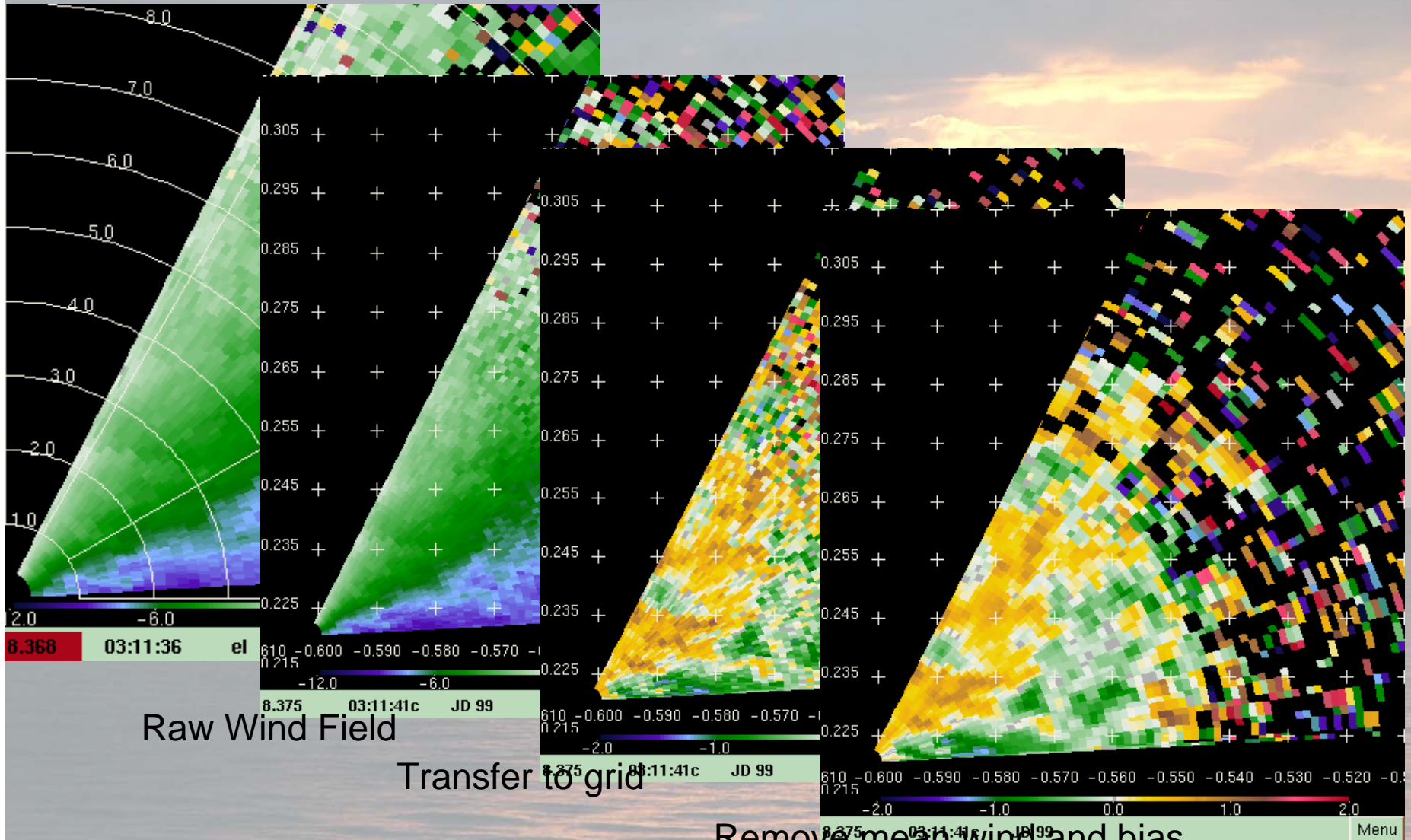
**Goal**

Wind flows &  
 Dynamic structures

Note: 1 box pattern every 80 s  
 for 12 patterns in ~16 minutes  
 Total scan time: ~17 minutes



# Residual wind (LOS) processing steps



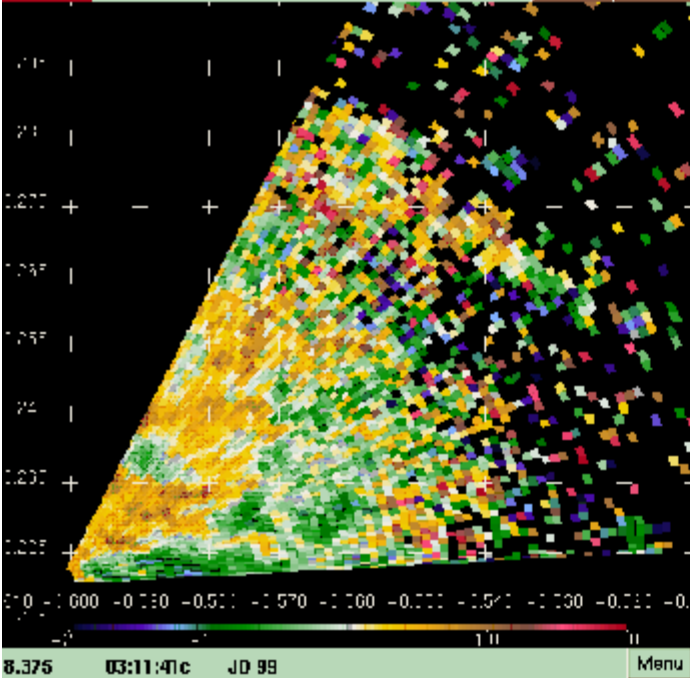
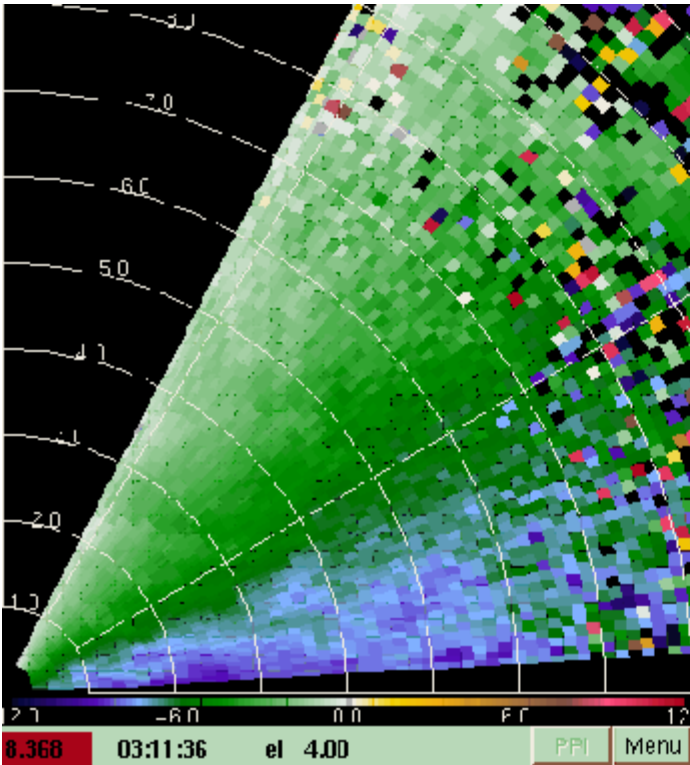
Raw Wind Field

Transfer to grid

Remove mean wind and bias

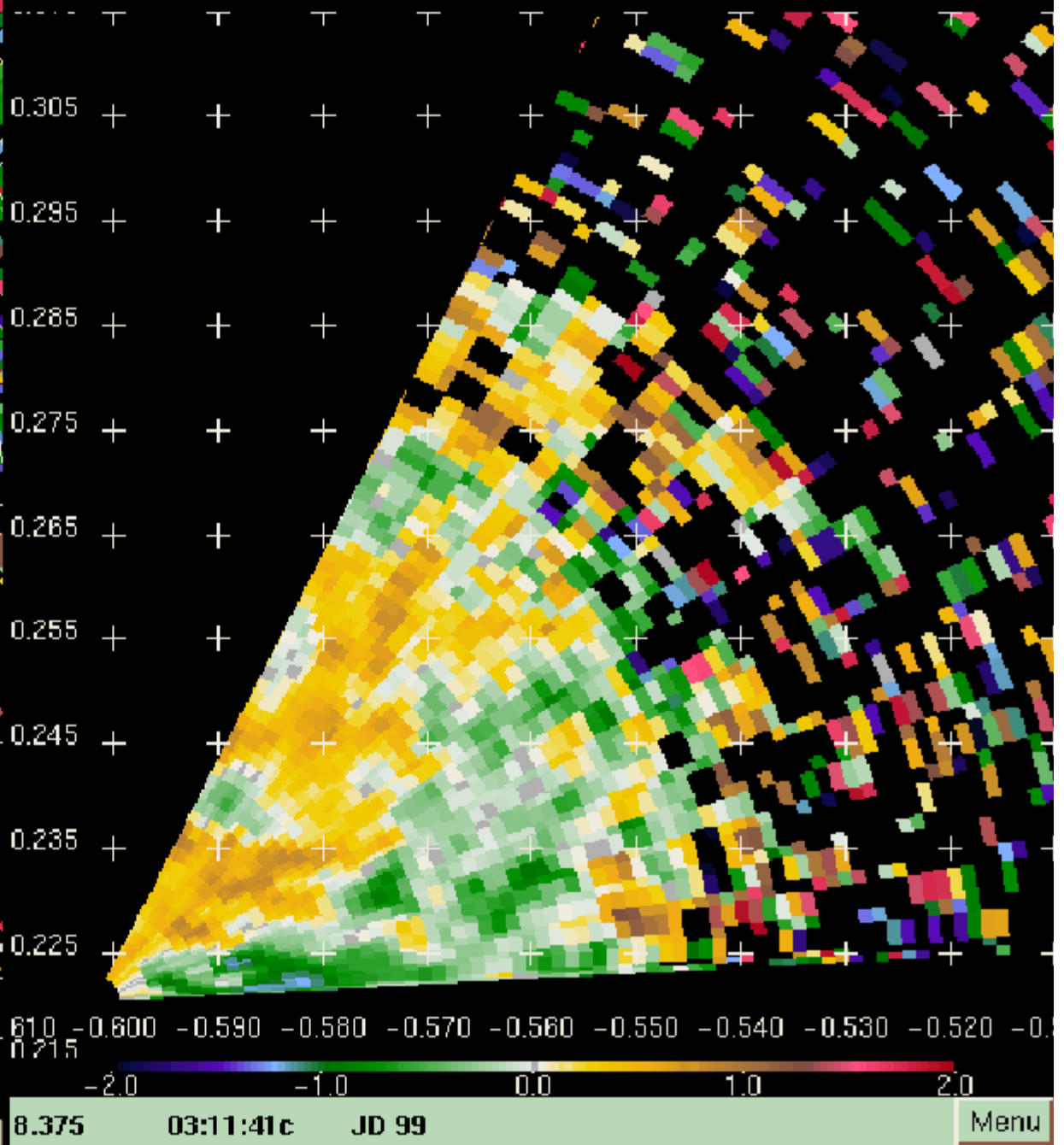
Filter residual wind

Elevation: 4 Degrees

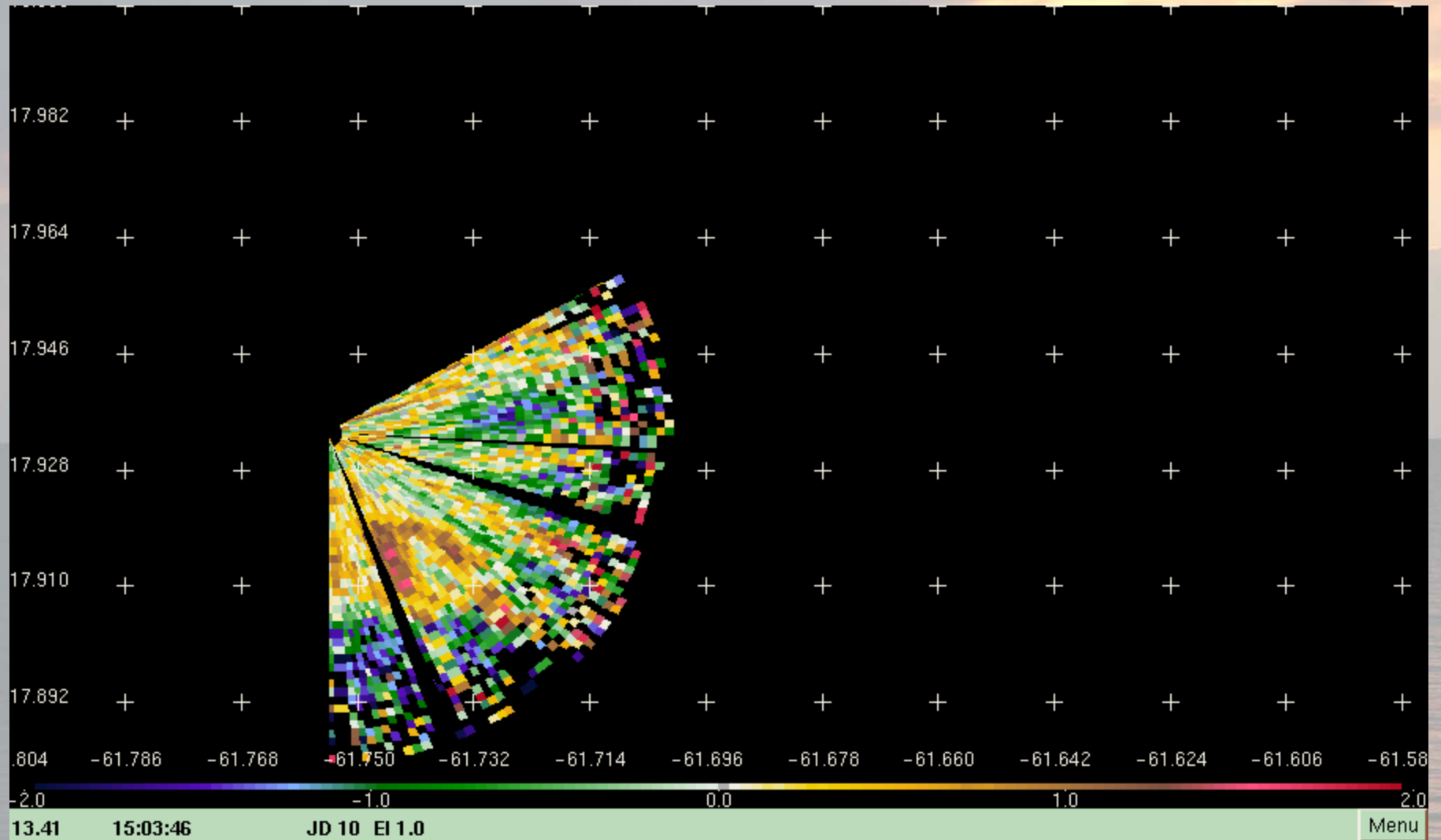


Elevation: 4 Degrees

Animation

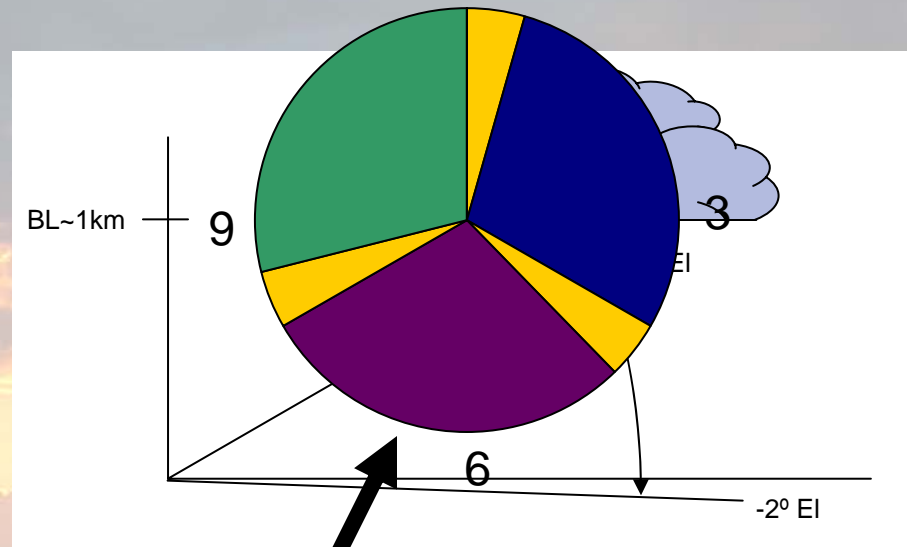
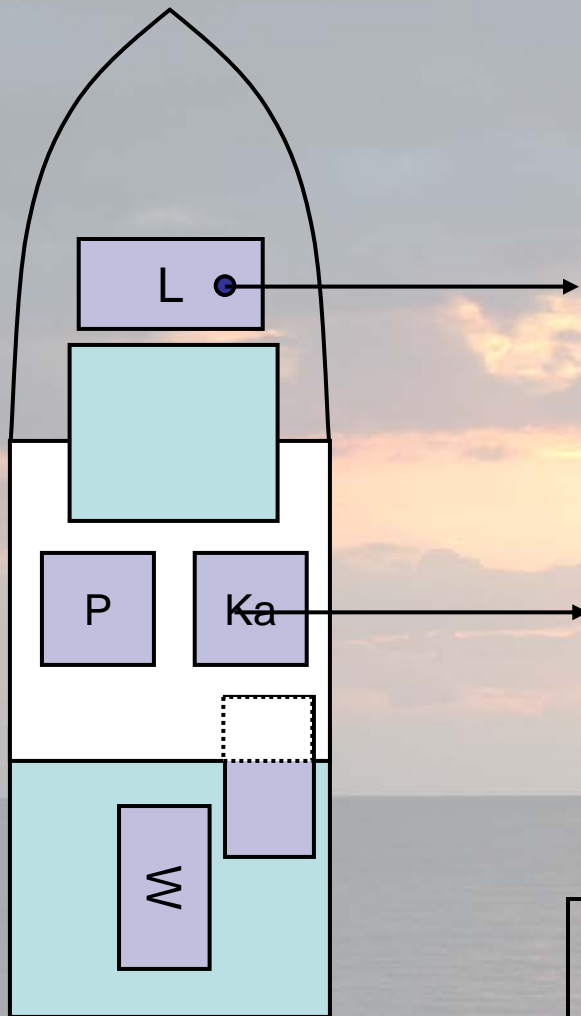


# Residual wind sector scan animation



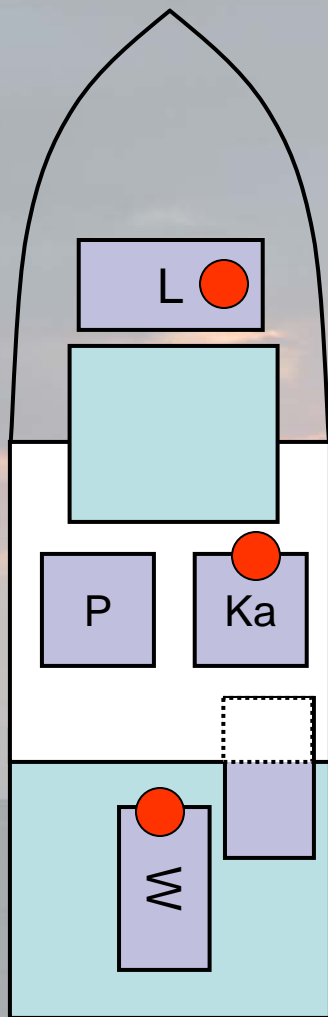


RHI



NOAA/ETL Lidar scanning strategies  
RICO-January 2005

Single-Angle Scans	Goal
<u>a. Radar RHI matches</u> At Ka-band az angle From -2° to 30° el. Total time: ~ 16 – 17 mins	Comparisons w/ Ka



NOAA/ETL Lidar scanning strategies  
RICO-January 2005



12

Zenith

3

**Single-Angle Scans**

***b. Vertical stare***

45 m pulses

@ 0.5 Hz

Total Time: ~16 – 17 mins

**Goal**

Comparisons w/ W & Ka  
for vertical cloud dynamics

# Web page

Mini-MOPA data from RICO - Mozilla Firefox  
http://www.etl.noaa.gov/et2/data/data\_pages/rico/

Optical Remote Sensing Division  
Environmental Technology Laboratory

RICO  
Rain In Cumulus over the Ocean Experiment

Field Project: Rain in Cumulus over the Ocean Experiment (RICO)

Mini-MOPA Lidar Data (posted on or before 5/18/2005)

January 2005

S	M	T	W	R	F	S
						1
2	3	4	5	6	7	8
<a href="#">9</a>	<a href="#">10</a>	11	<a href="#">12</a>	<a href="#">13</a>	<a href="#">14</a>	<a href="#">15</a>
<a href="#">16</a>	<a href="#">17</a>	<a href="#">18</a>	<a href="#">19</a>	<a href="#">20</a>	<a href="#">21</a>	<a href="#">22</a>
<a href="#">23</a>	<a href="#">24</a>	25	26	27	28	29
30	31					

[Lidar data summary and examples](#)

**Data Status**  
These profiles are posted as PRELIMINARY.

**Data Policy**  
We request that a proper acknowledgment to the "NOAA Environmental Technology Laboratory" accompany the use of this data in any publications and presentations. If the use of this data in a publication constitutes a major or reasonably significant aspect of an article, co-authorship by an ETL scientist is appropriate; please discuss any such planned use with the scientist listed below. We welcome collaborations and will lend our scientific expertise in interpretation and evaluation of the data.

Contact scientists: Sara Tucker ([Sara.Tucker@noaa.gov](mailto:Sara.Tucker@noaa.gov)) and Alan Brewer ([Alan.Brewer@noaa.gov](mailto:Alan.Brewer@noaa.gov))

**Link to:**  
[RICO home page](#)  
[ETL RICO page](#)  
[Mini-MOPA lidar](#)  
[Division Home Page](#)

Last updated: 18 May 2005

Experiment overview by day :  
Additional info for interpreting data

[http://www.etl.noaa.gov/et2/data/data\\_pages/rico/](http://www.etl.noaa.gov/et2/data/data_pages/rico/)







# Web page

mini-MOPA data from RICO - Mozilla Firefox

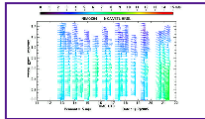
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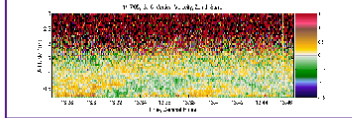
WebMail Weather FSL Weather People Yellow Pages HOB0 4-Channel Ex...

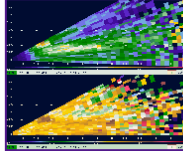
 **Optical Remote Sensing Division**  
Environmental Technology Laboratory 

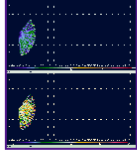
 **RICO**   
Rain In Cumulus over the Ocean Experiment

**RICO**  
Mini-MOPA Data - January 17, 2005

 [click here for lidar wind profiles](#)

 [click here for vertically staring lidar data](#)

 [click here for RHI Lidar animations](#)

 [click here for Sector lidar animations](#)

Link to:  
Done

Daily Page :

Data products from all scanning modes

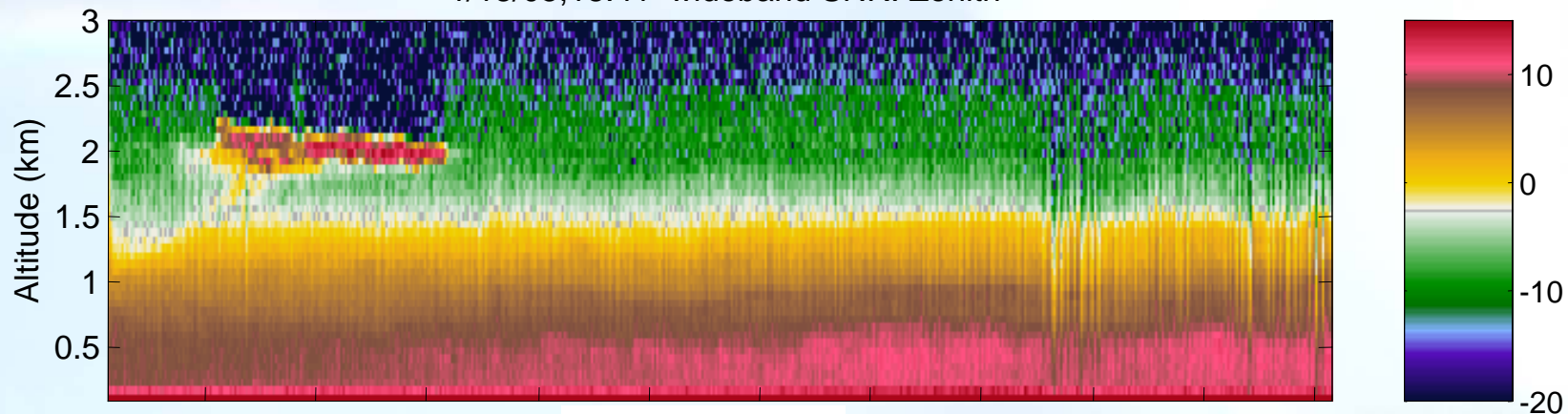
[http://www.etl.noaa.gov/et2/data/data\\_pages/rico/](http://www.etl.noaa.gov/et2/data/data_pages/rico/)

A photograph of a vibrant rainbow arching across a cloudy sky over a dark blue ocean. The rainbow's colors are clearly visible, transitioning from red on the left to violet on the right. The sky is filled with soft, grey clouds, and the ocean surface shows gentle ripples and small waves. The horizon line is straight and divides the image roughly in half.

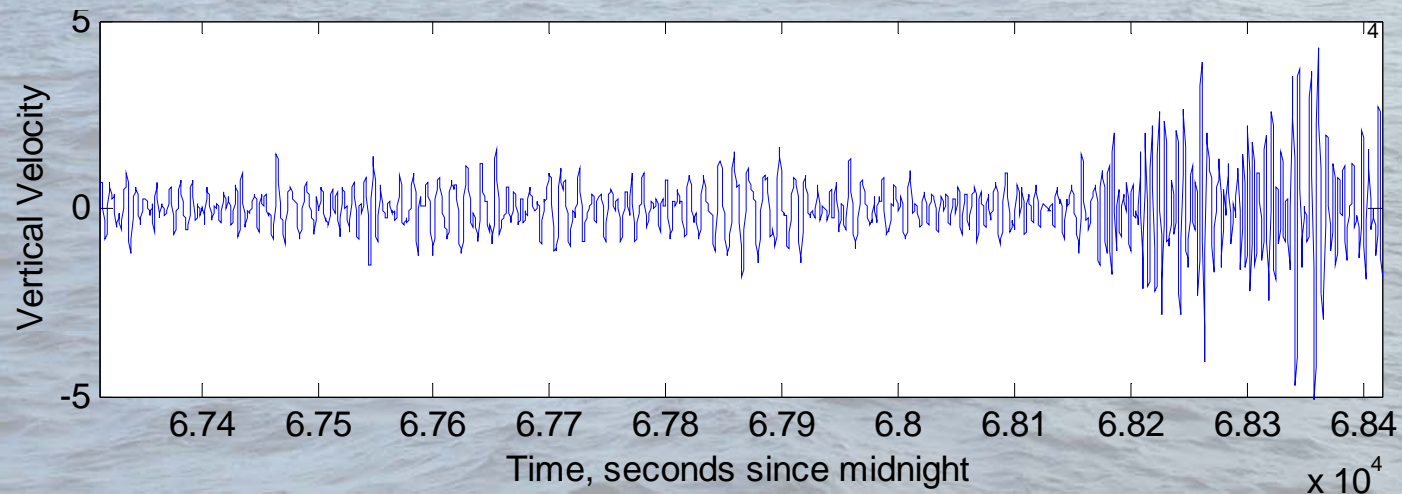
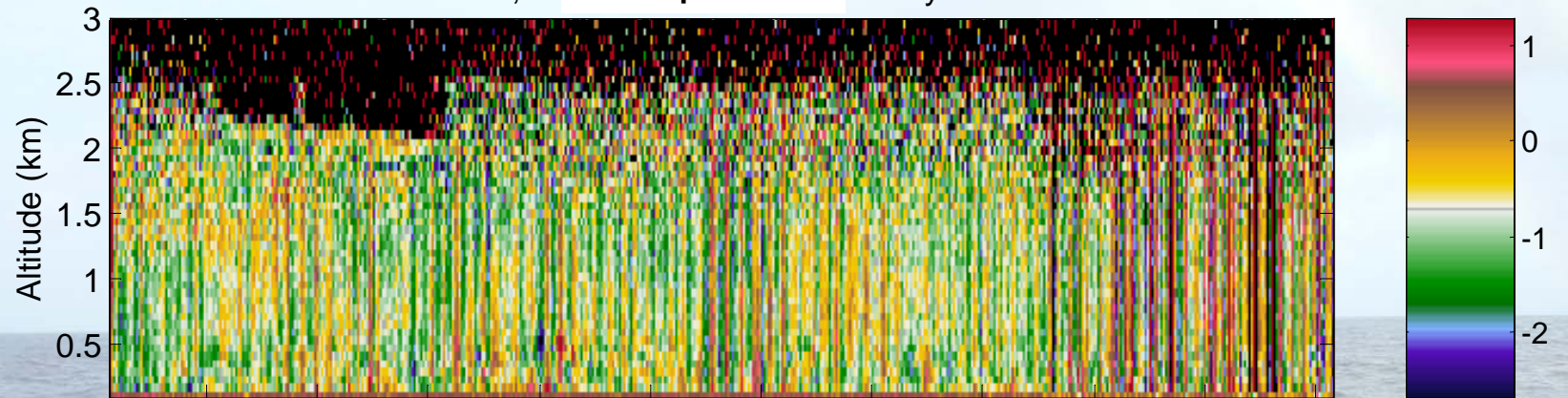
**Data Examples :**

**Vertically staring lidar data**

1/13/05,18:41 wideband SNR. Zenith



1/13/05,18:41 uncompensated velocity. Zenith





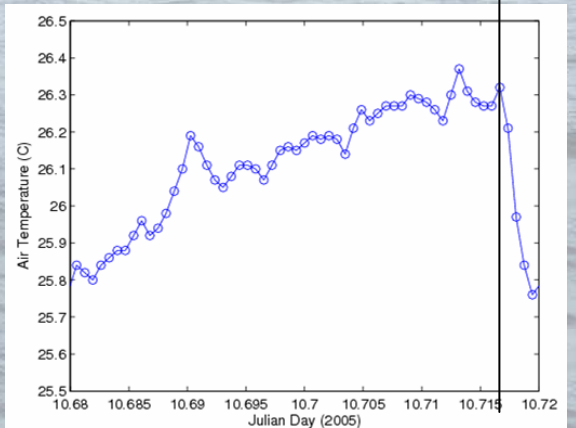
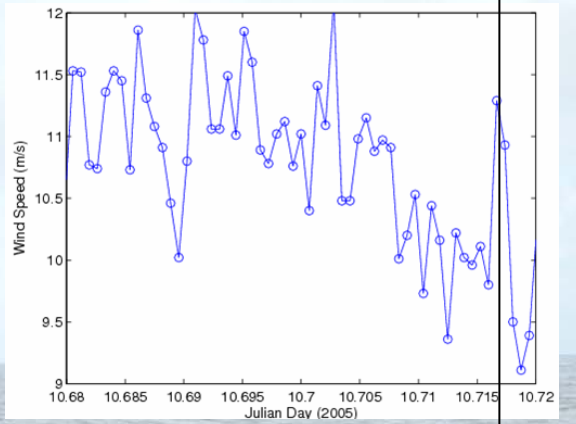
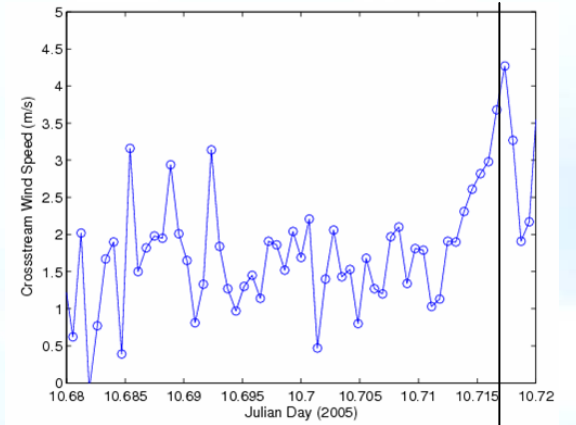
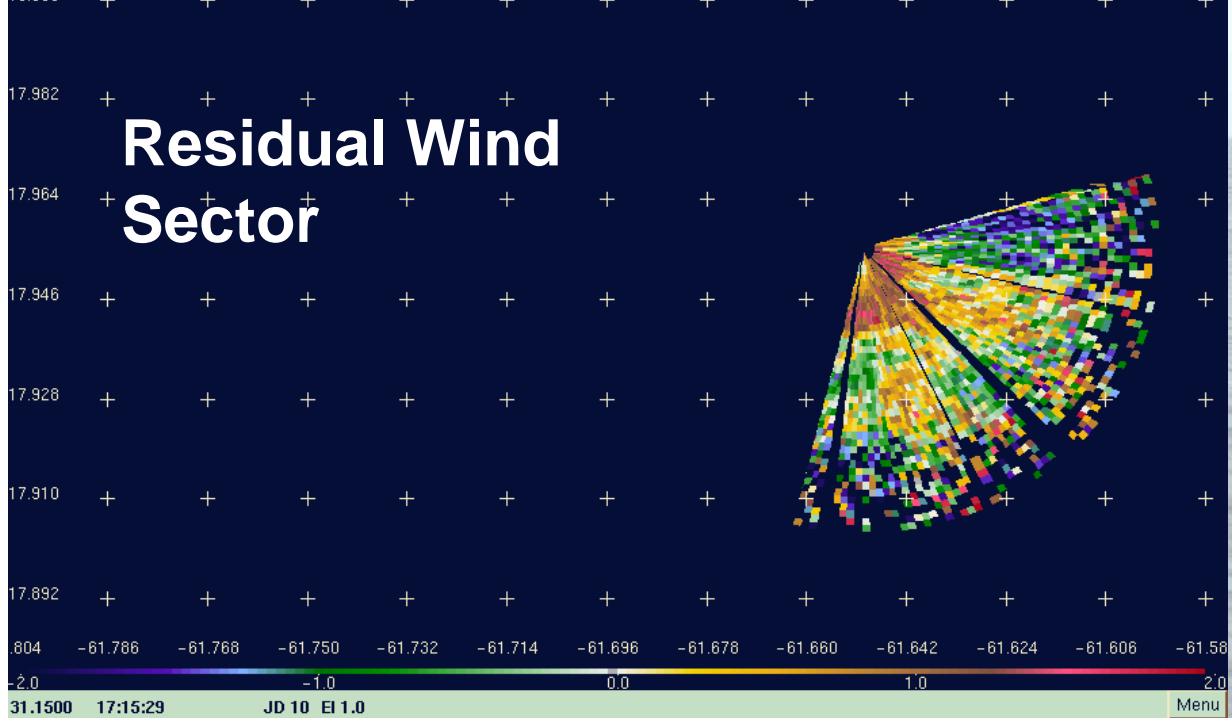
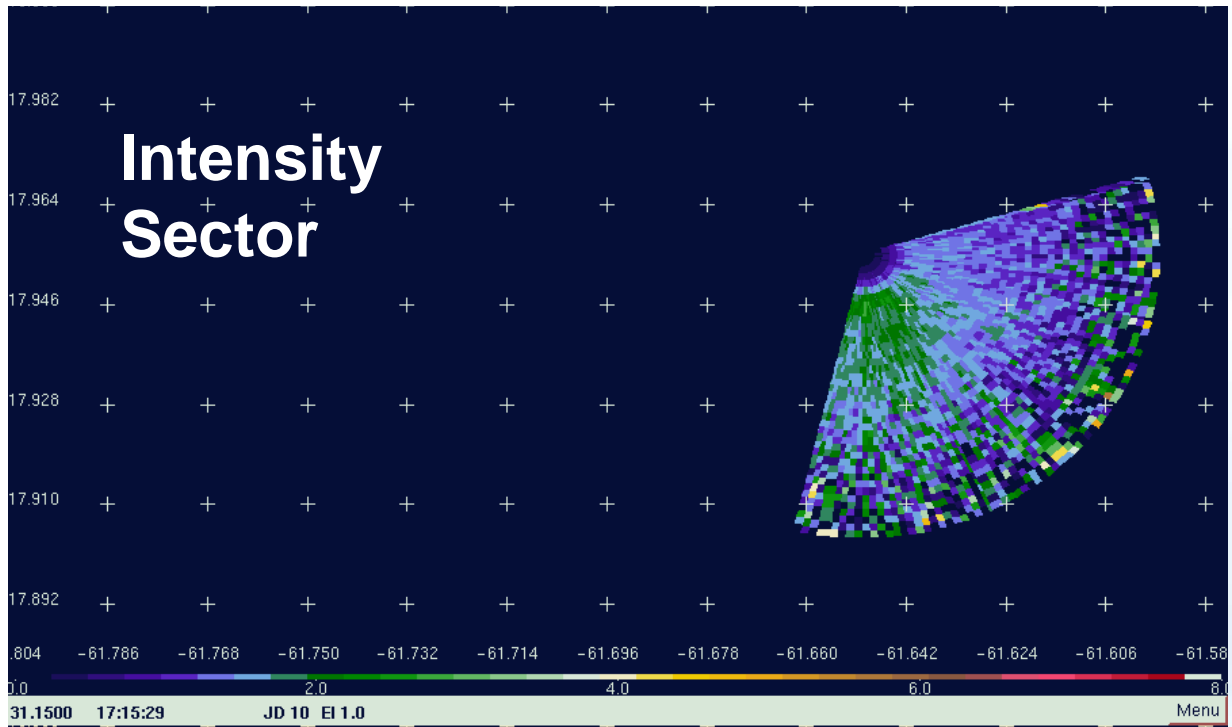
A photograph of a vibrant rainbow arching across a cloudy sky above a dark, choppy ocean. The rainbow's colors are clearly visible, transitioning from red on the left to violet on the right. The sky is filled with soft, grey clouds, and the horizon line is visible in the distance.

**Data Examples :**

**Precip outflow**

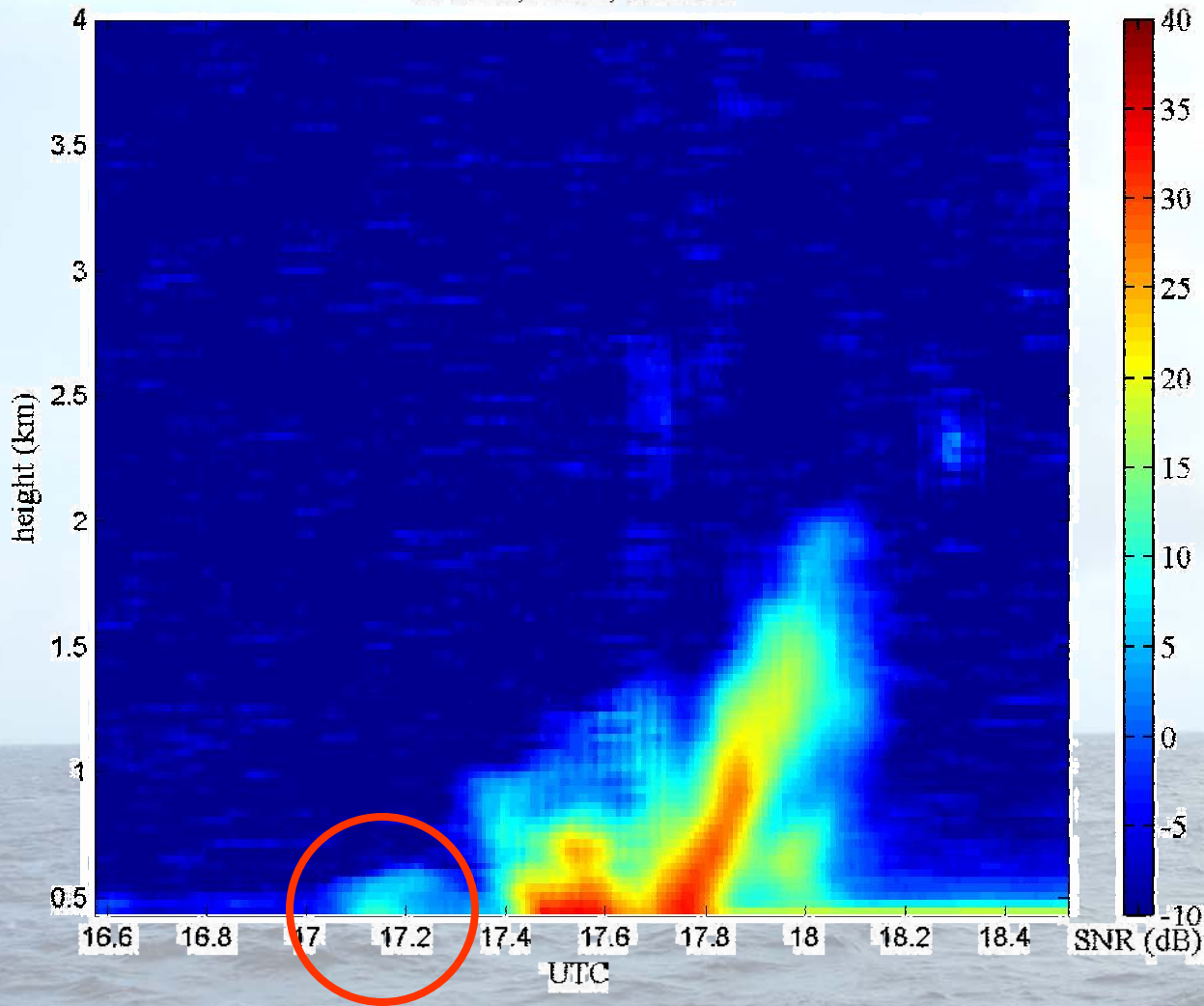
**1/10/2005 17:15**

**Sonic, X-Band, Lidar**



(C Fairall)

X-Band, RICO, Jan 10th



**Vertically staring X-Band intensity**



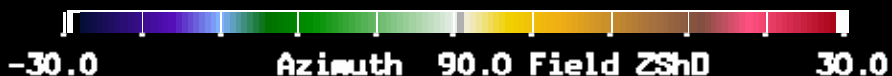
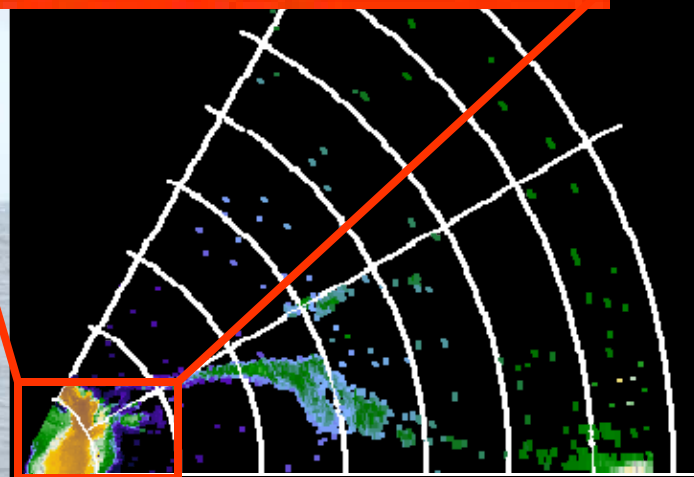
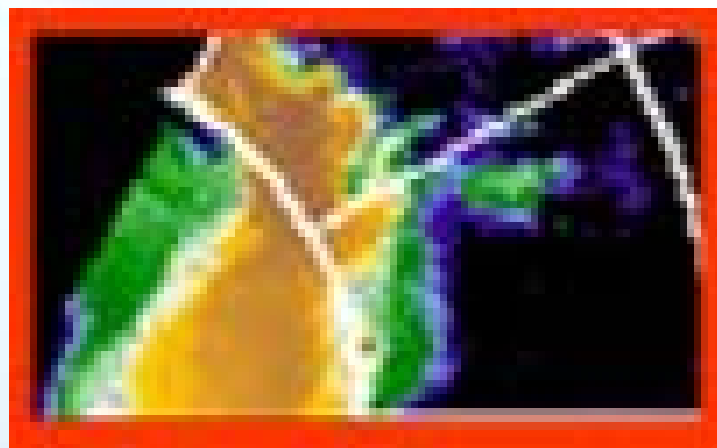
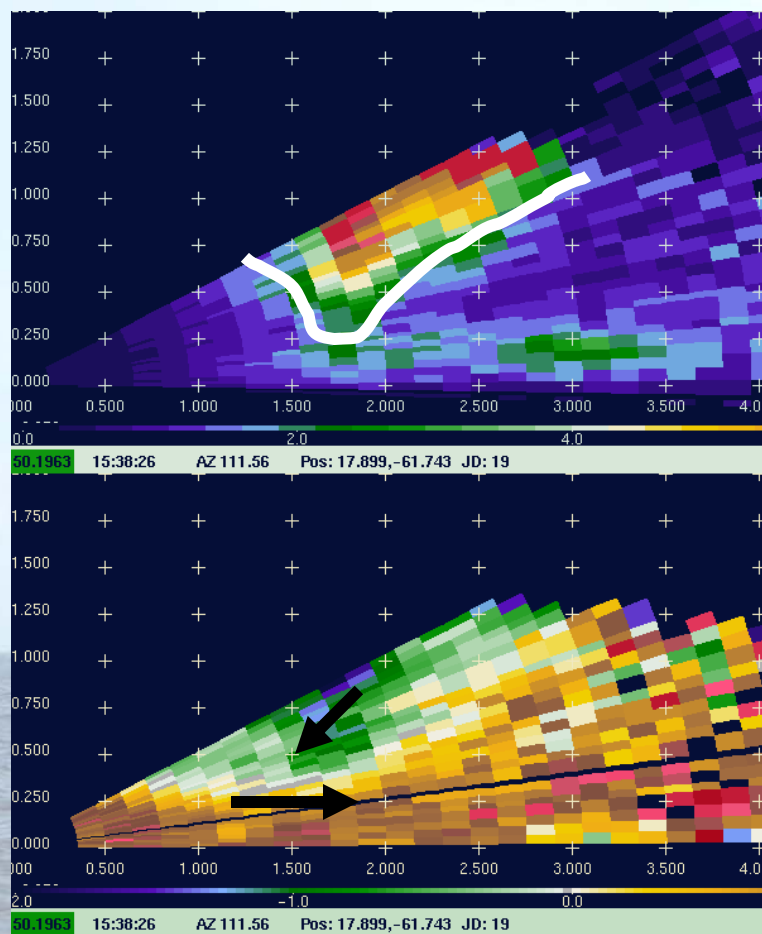
A photograph of a vibrant rainbow arching across a cloudy sky above a dark blue, choppy ocean. The rainbow's colors are clearly visible, transitioning from red on the left to violet on the right. The sky is filled with soft, grey clouds, and the horizon line is visible in the distance.

## Data Examples :

Lidar / Ka precip & cloud base comparison:  
15:38 1/19/2005

# Lidar / Ka precip & cloud base comparison:

15:38 1/19/2005



NOAA/ETL Range marks every 2 Km. 1/19/05 15:38:31  
K-Band Radar Viewport is 17 Km

A photograph of a rainbow over the ocean. The rainbow is a double rainbow, with the primary rainbow being much brighter and more visible than the secondary one. The sky is filled with soft, grey clouds. The ocean in the foreground is dark blue with small, choppy waves. The text is overlaid on the image in a bold, black, sans-serif font.

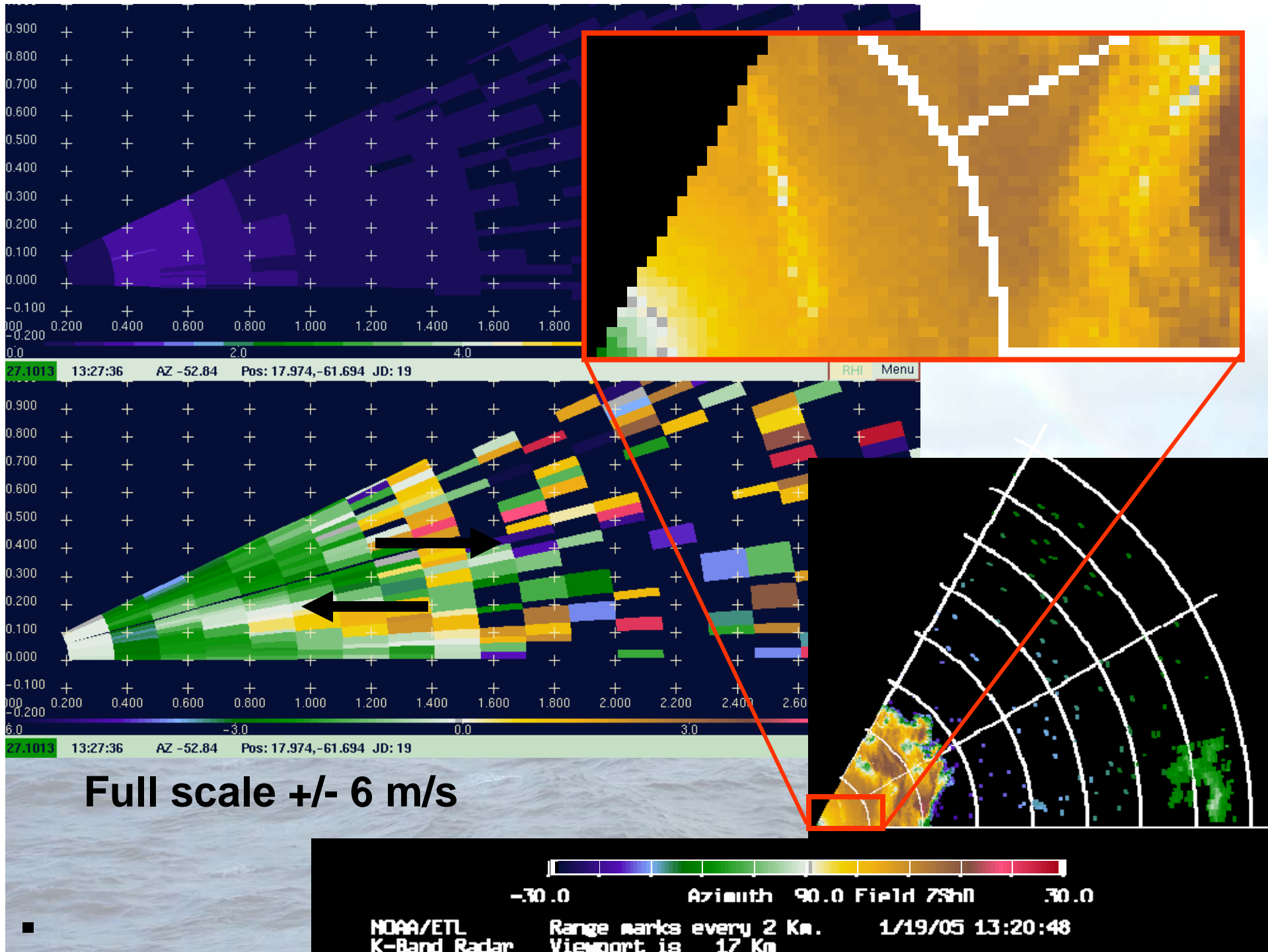
**Data Examples :**

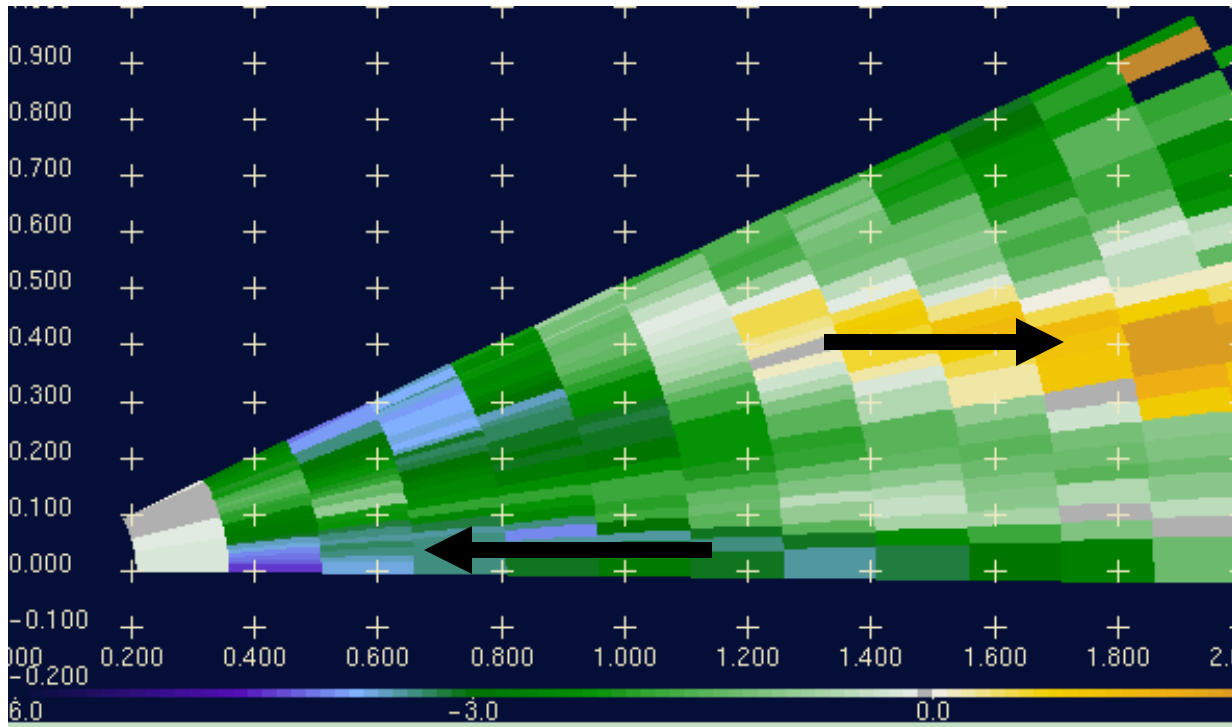
**Precip outflow**

**Lidar RHI & NOAA-K RHI**

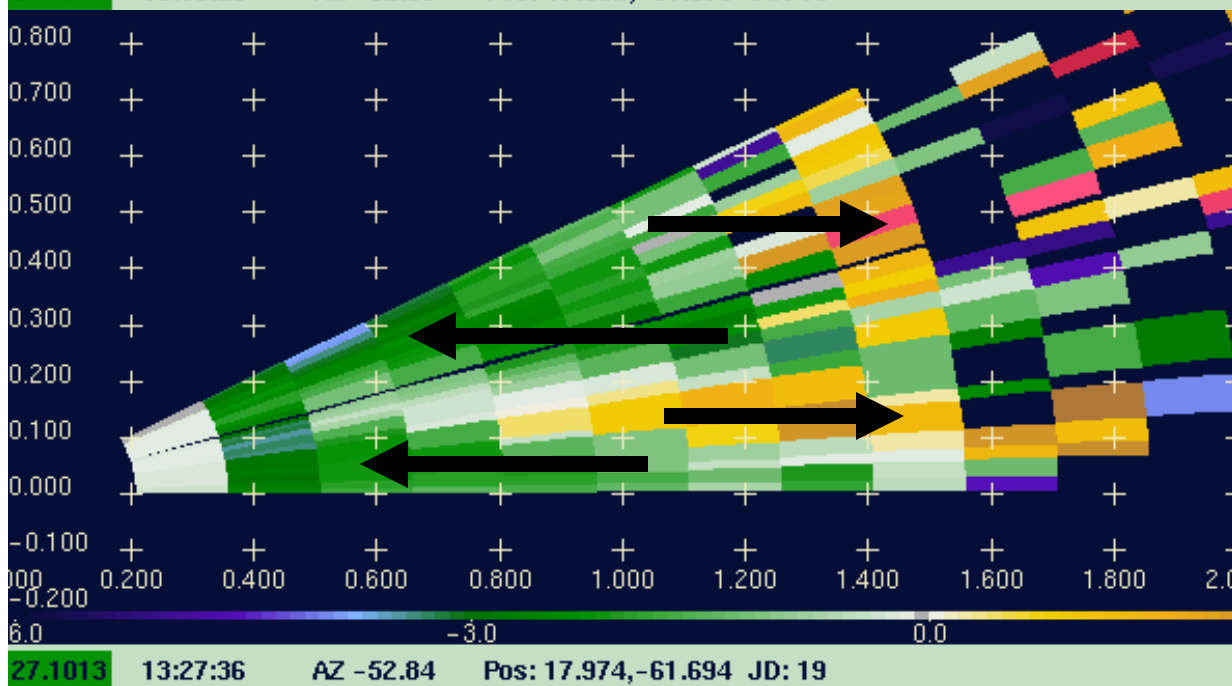
**1/19/2005 13:30**







**Start**



**End**



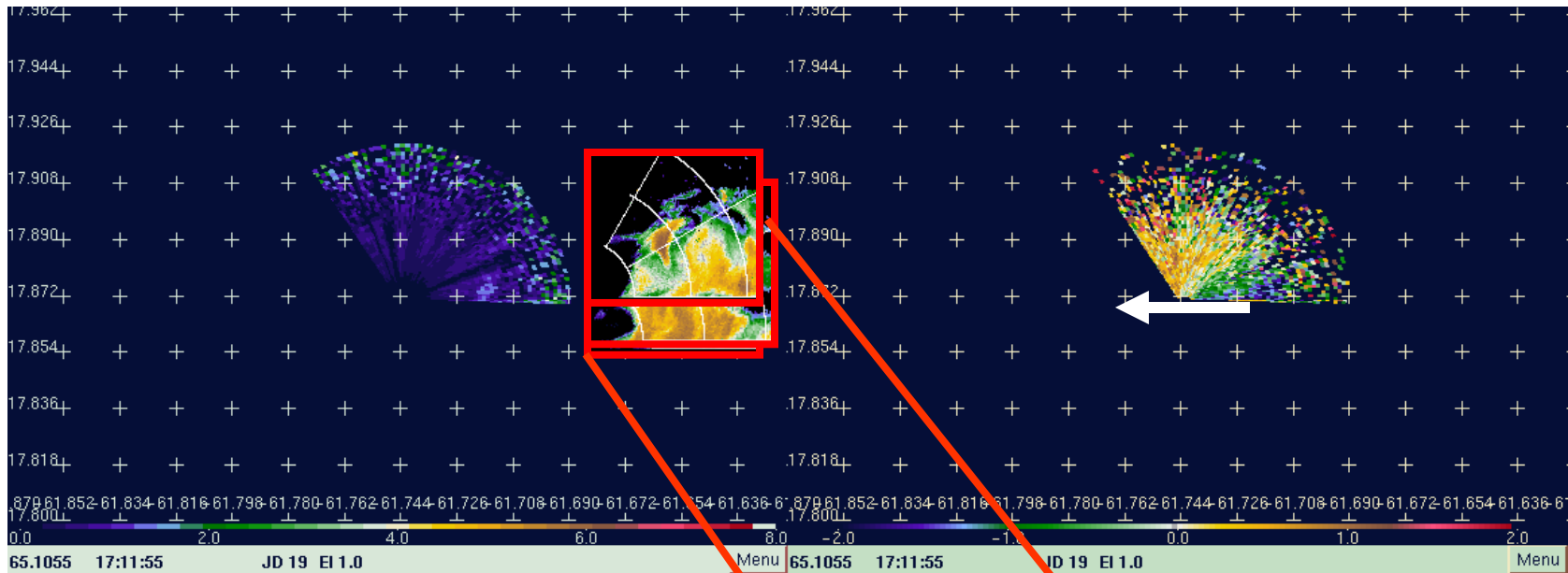
A photograph of a vibrant rainbow arching across a cloudy sky above a dark blue, choppy ocean. The rainbow's colors are clearly visible, transitioning from red on the left to violet on the right. The sky is filled with soft, white and grey clouds, and the horizon line is visible in the distance.

**Data Examples :**

**Lidar sector scan w/ Ka RHI**

**1/19/2005 17:20**

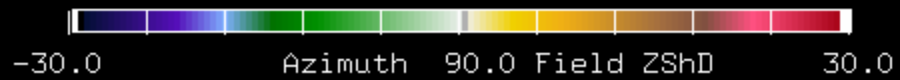
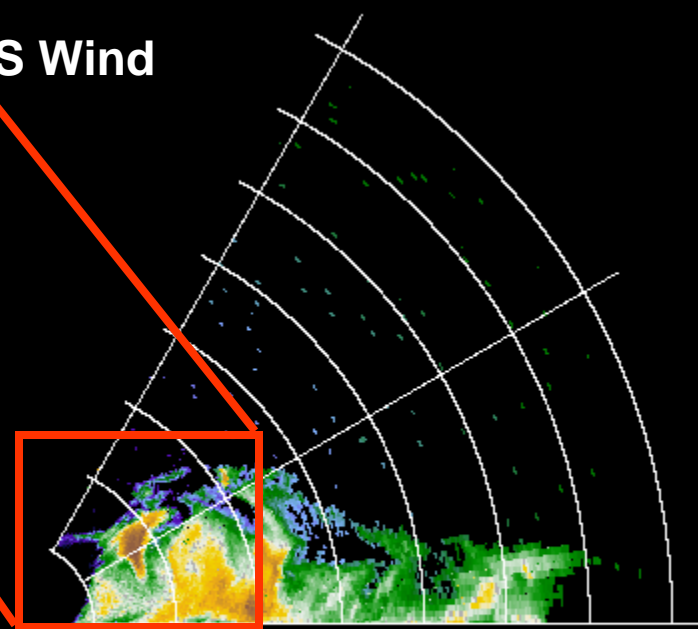




**Intensity**

**Resid LOS Wind**

**Lidar Sector Scan w/ Ka RHI**



NOAA/ETL Range marks every 2 Km. 1/19/05 17:12:32  
 K-Band Radar Viewport is 17 Km

A photograph of a rainbow arching over a dark blue ocean under a cloudy sky. The rainbow is positioned in the upper half of the frame, with its colors clearly visible. The ocean below is dark and textured with small waves. The sky is filled with soft, grey clouds.

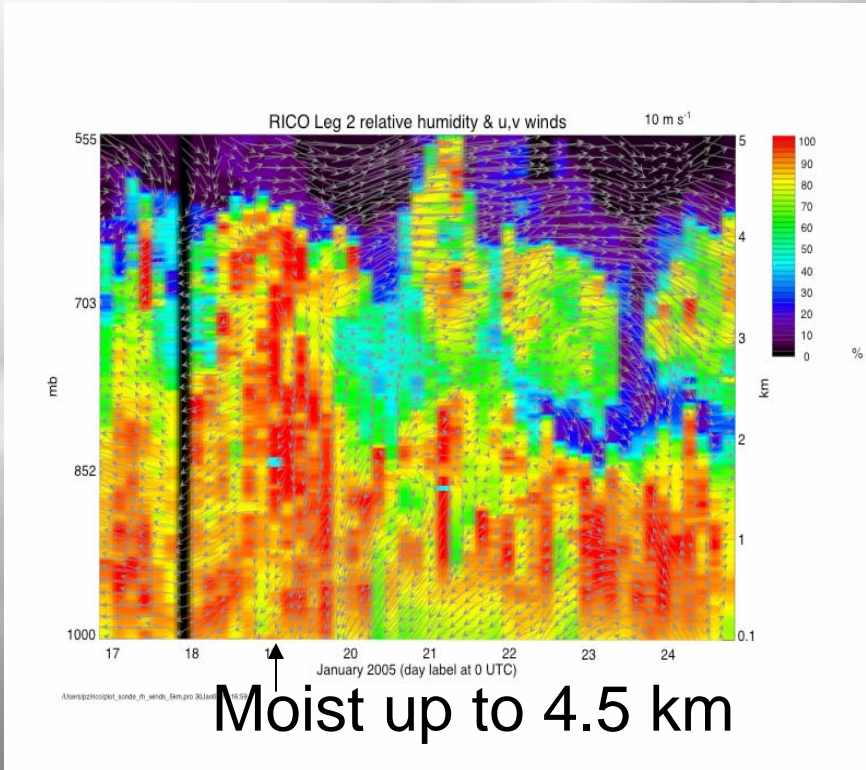
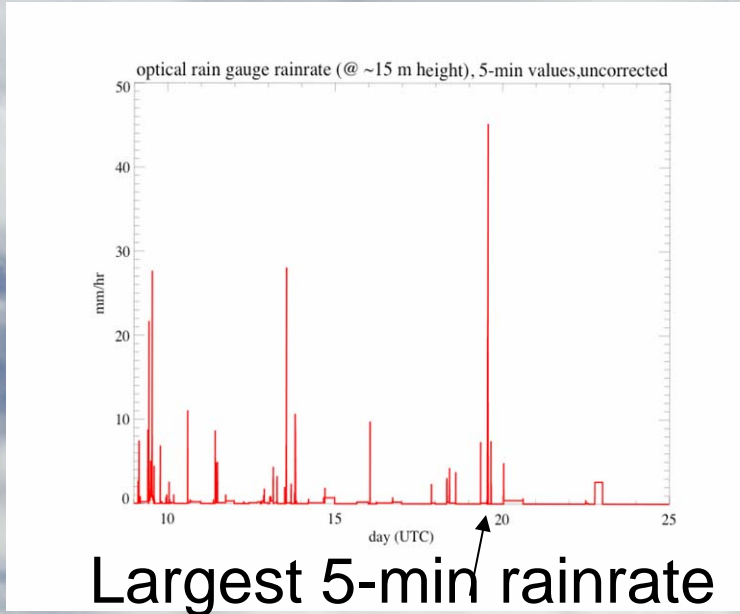
**Data Examples :**

**Combining datasets to look at  
convergence under a cloud**

**1/19/2005 16:30**

**SPOL, met, sondes, aerosol, NOAA-K, Lidar**

# January 19: Context



Aircraft in area

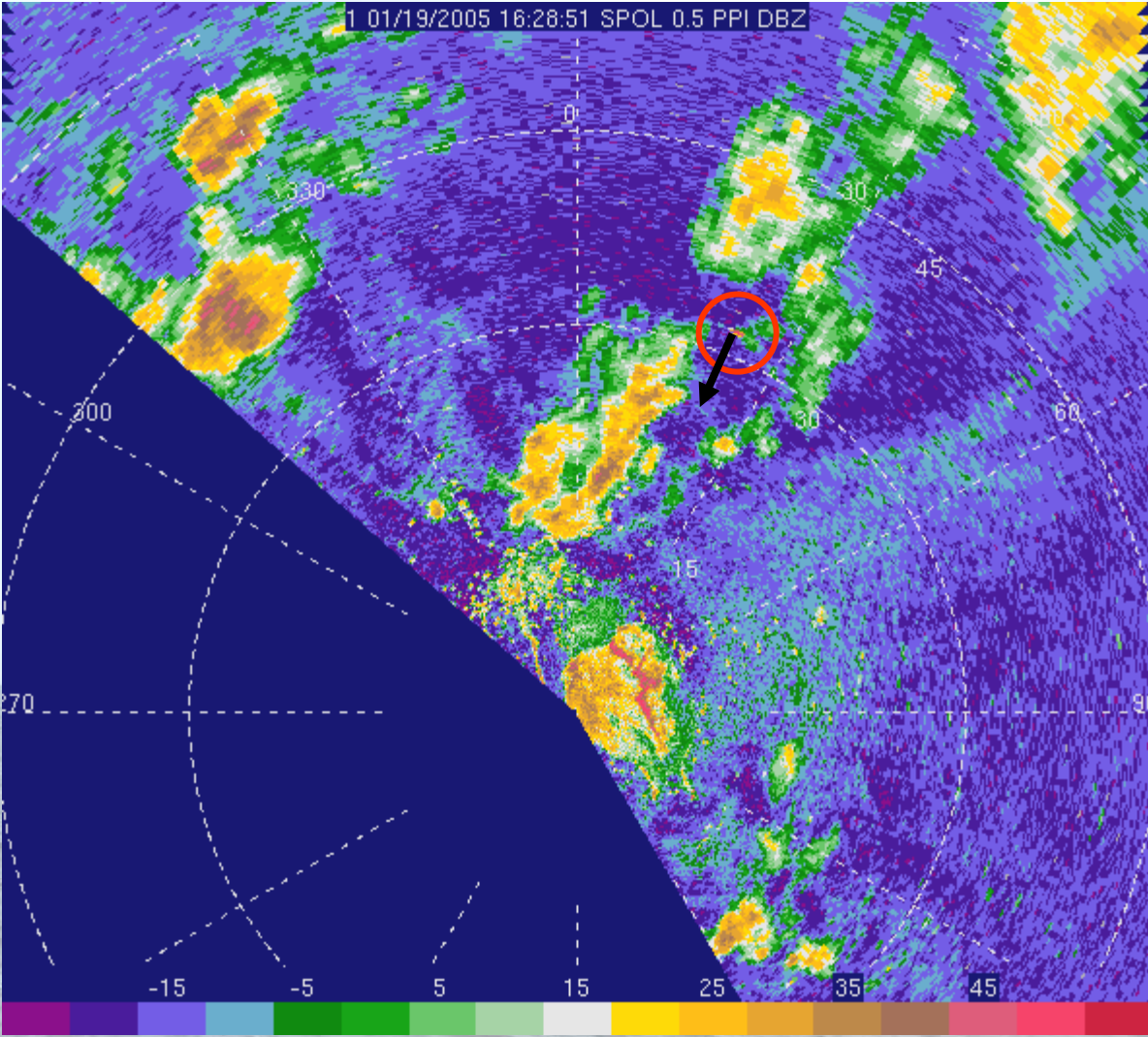
Foto @ ~ 15Z





Foto @ ~ 15Z

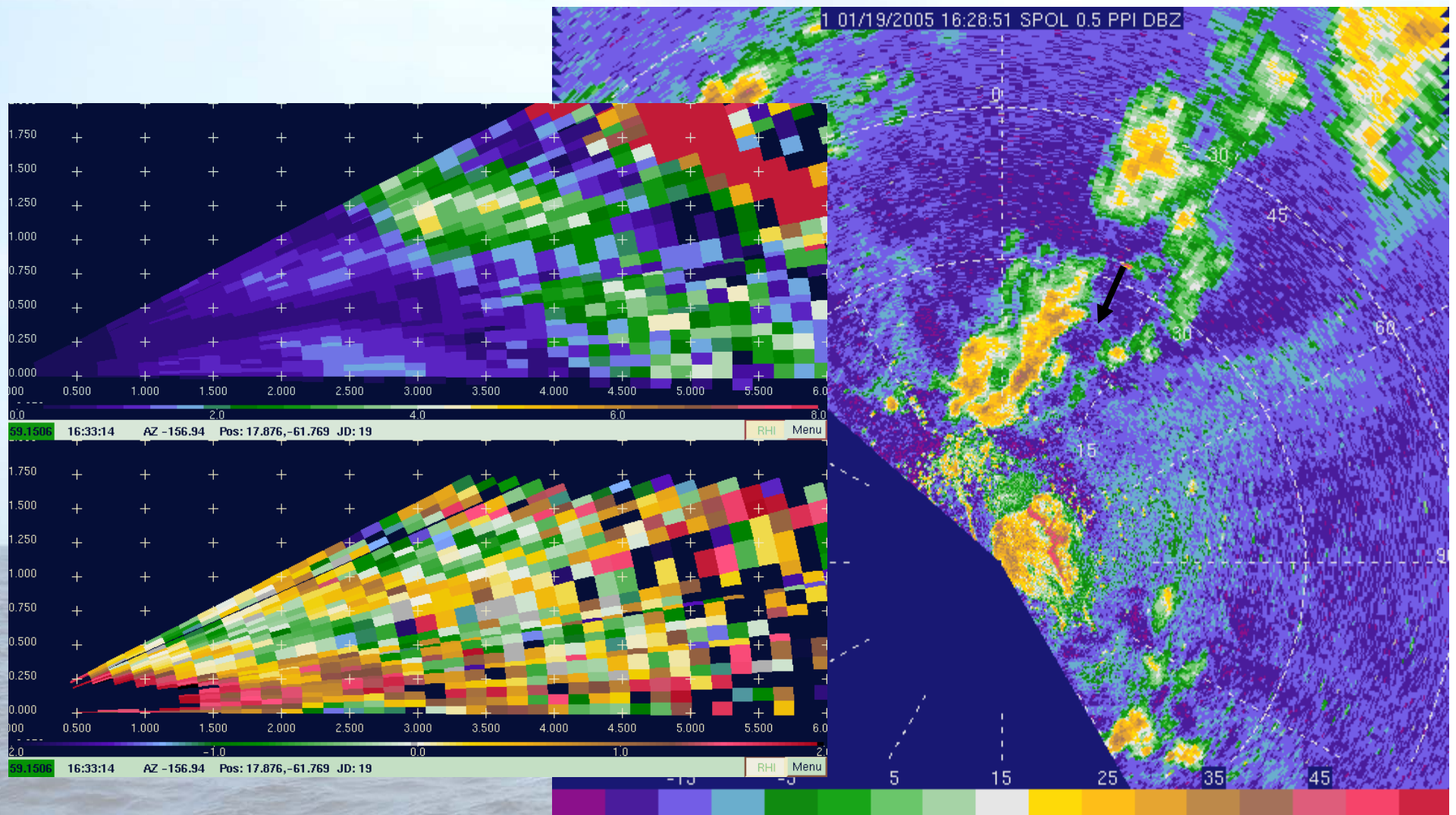
# Convergence below a cloud.



SPOL Image 16:28:51 1/19/2005

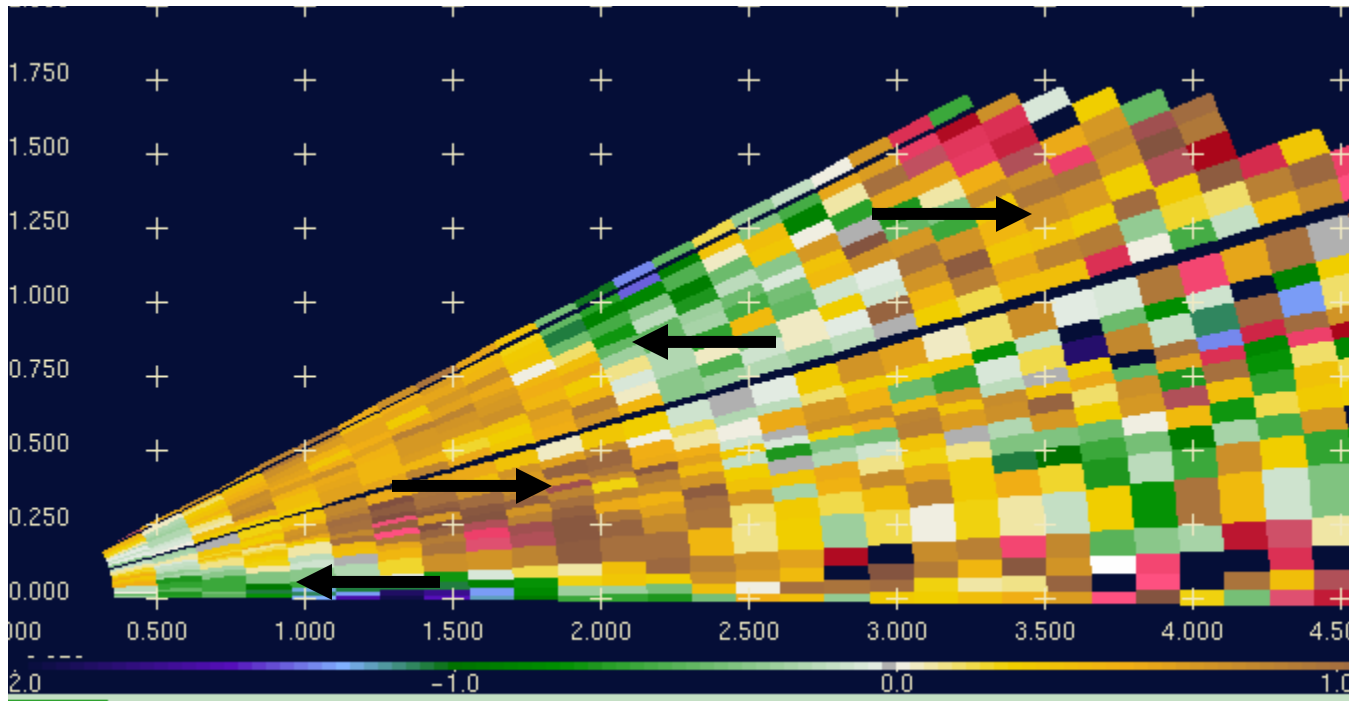


# Convergence below a cloud.

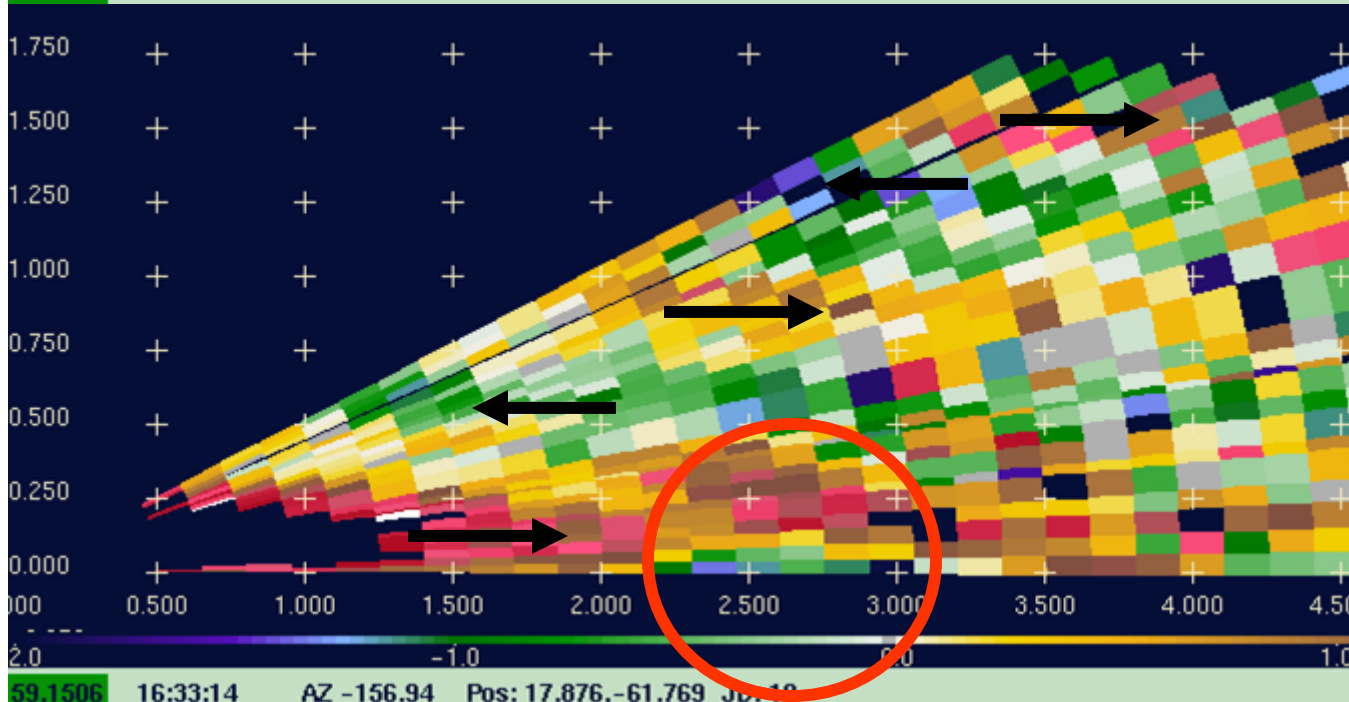


■ Lidar int & reswind 16:26:48 – 16:33:44





**Start**



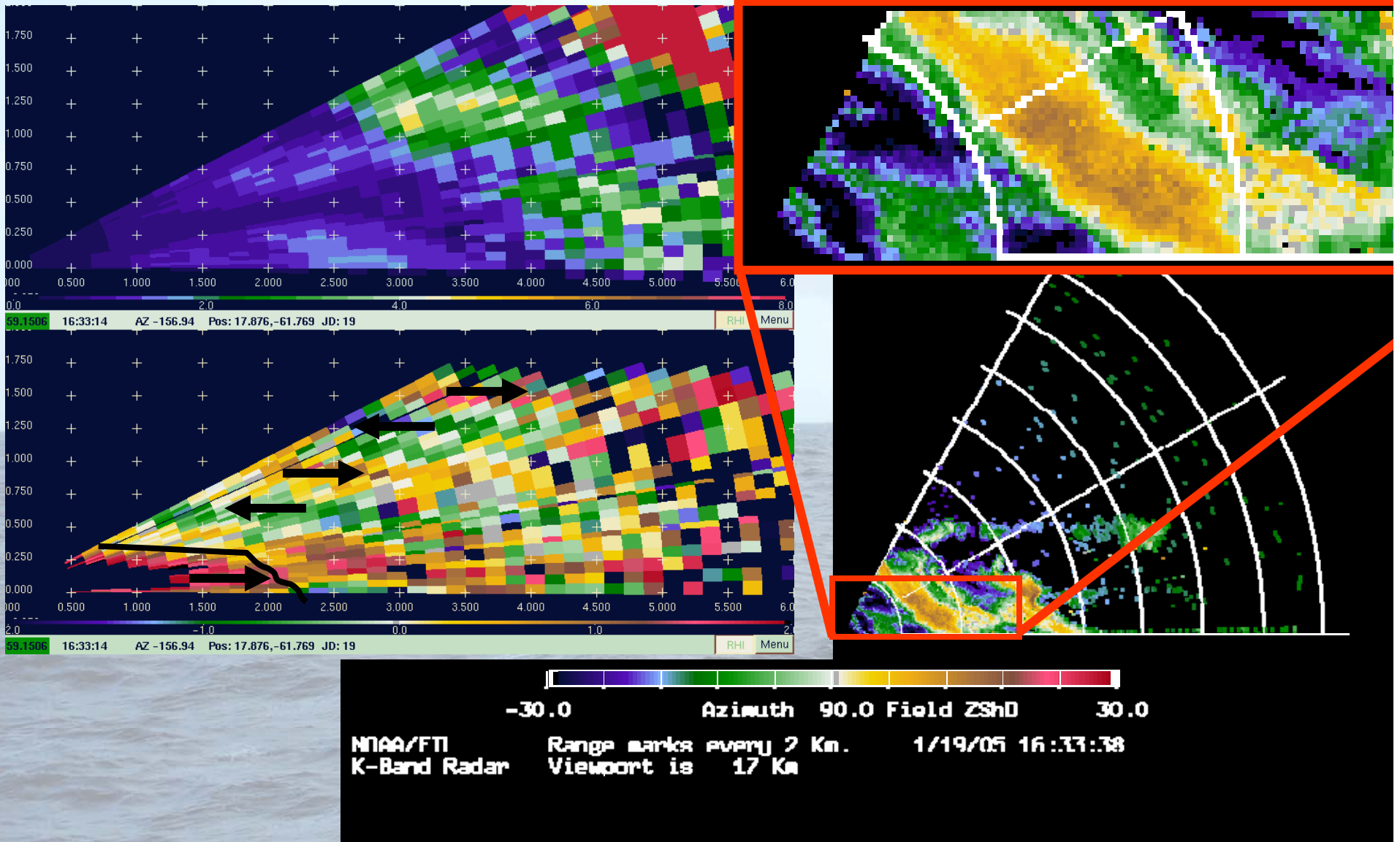
**End**



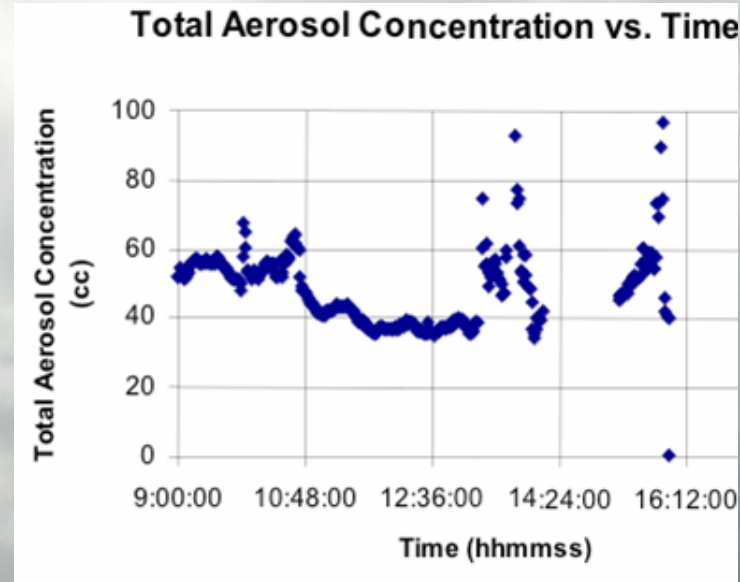
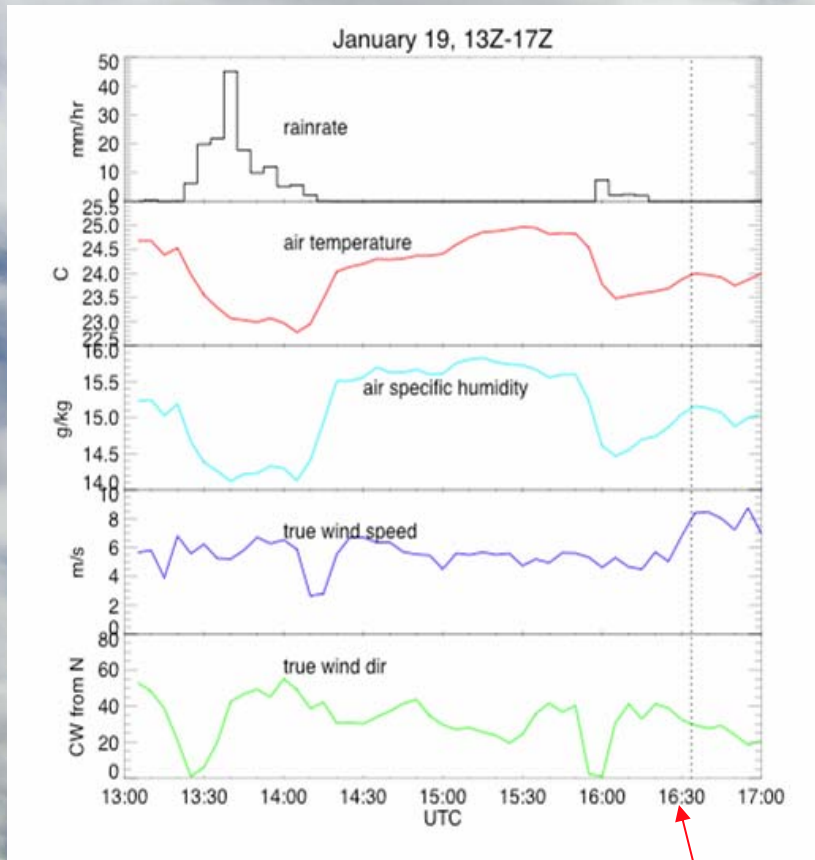
# Convergence below a cloud.

outflow below 250m

time:16:33



# January 19: Context



aerosol ~50cc, increases associated w/ precip (?)

**Time period of interest**

@ 16:30, surface wind speed increases, Air temp, q, increasing

Foto @ ~ 15Z



A photograph of a sunset over the ocean. The sun is a bright yellow circle on the horizon, with a gradient of orange and red in the sky above. The water is dark blue with small waves.

## **Conclusion:**

### **Data analysis**

**motion compensation**

**wind profiles**

**residual wind**

### **Data images available on web page**

**2 days complete w/ anim 1/17, 1/19**

[http://www.etl.noaa.gov/et2/data/data\\_pages/rico/](http://www.etl.noaa.gov/et2/data/data_pages/rico/)

