Ship-based High Resolution Doppler Lidar (HRDL) measurements in the Gulf of Mexico:

Data summary and observations related to space-based lidar performance

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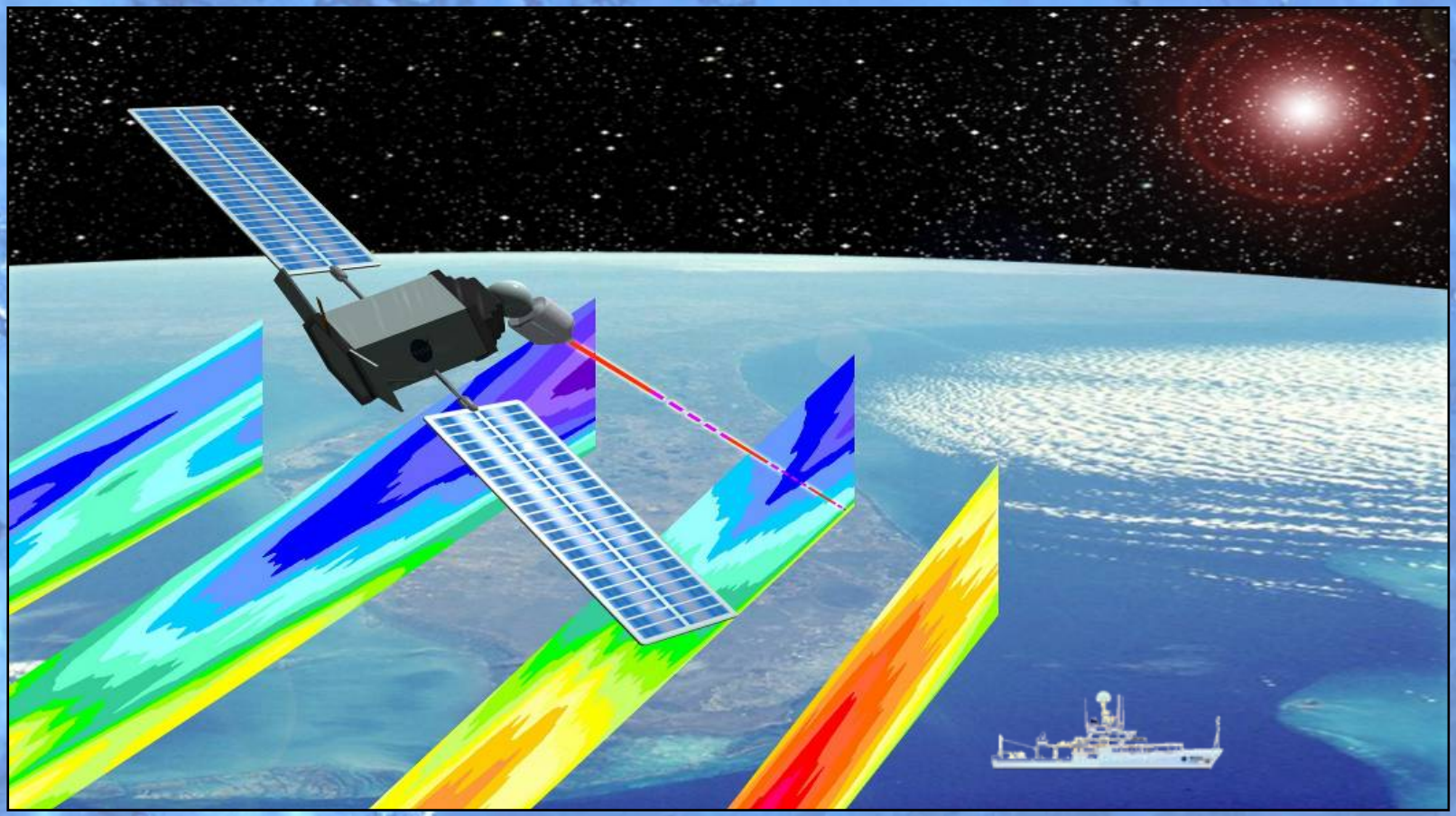
We agree on a need for global measurements of winds

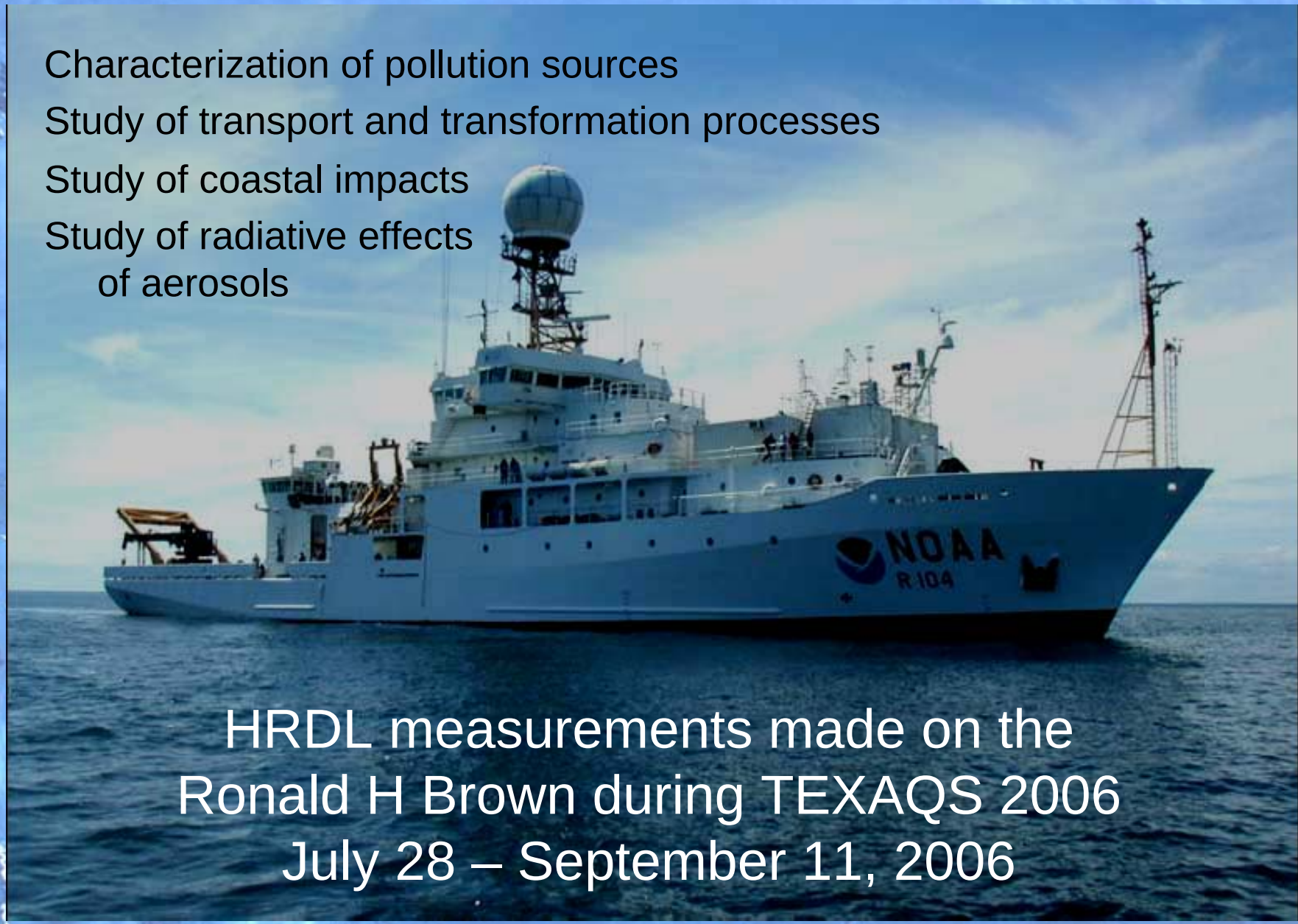
It is helpful to understand the effect of variability in the small-scale wind fields on expected performance.

HRDL measurements are being used to characterize the off-shore winds for use in space-based lidar performance predictions.



NOAA/ESRL's Ship-based Doppler lidar deployments: 2004-2006

Experiment Name	Location	Instrument	Experiment Dates
ASAP 2004-Close Connections	??	MOPA	June 22-July 23, 2004
NEAQS 2004	Northeast U.S. coast (Maine down to Boston)	HRDL	June 30- August 12, 2004
RICO	Off the coast of Barbuda/Antigua	MOPA	December 29, 2004- January 24, 2005
ASAP 2005-Emma	Off the coast of Bahamas	MOPA	May 13-25, 2005
TexAQS 2006	**Galveston Bay/Gulf of Mexico**	**HRDL**	**August 1-September 11, 2006**



Characterization of pollution sources

Study of transport and transformation processes

Study of coastal impacts

Study of radiative effects of aerosols

HRDL measurements made on the Ronald H Brown during TEXAQS 2006 July 28 – September 11, 2006

TexAQS 2006 – Proposed Instrumentation on RV Brown

- Photolysis rates (j-values) Spectral radiometer
- Ozone (O3) UV absorbance
- Ozone NO chemiluminescence
- Carbon monoxide (CO) Nondispersive IR
- Carbon dioxide (CO2) Nondispersive IR
- Sulfur dioxide (SO2) Pulsed UV fluorescence
- Nitric oxide (NO) Chemiluminescence
- Nitrogen dioxide (NO2) Photolysis/chemiluminescence
- Total reactive nitrogen oxides (NOy) Au tube/chemiluminescence
- Peroxyacyl nitric anhydrides (PANs) GC/ECD
- Alkyl nitrates (RONO2) GC/MS
- Nitrate radical (NO3); Dinitrogen pentoxide (N2O5) Cavity ring-down spectrometry
- Nitric acid (HNO3) Mist chamber/IC
- Water vapor (H2O) Nondispersive IR
- Continuous Speciation of VOCs PTR-MS/CIMS
- VOC Speciation GC/MS
- Formaldehyde (HCHO) CHD fluorimetry
- Radon (Rn) Radon gas decay
- Seawater/atmospheric CO2 Nondispersive IR
- Enhanced measurement of radiative fluxes Spectral radiometers
- Aerosol optical depth MicroTOPS
- Irradiance Portable Radiation Package (PRP)
- Size-resolved aerosol composition and gravimetric mass Impactors (IC, XRF, and thermal-optical OC/EC)
- OC/EC On-line thermal optical
- Ionic Aerosol Composition Particle In Liquid Sampler (PILS)-IC
- Aerosol Size and Composition Aerosol Mass Spectrometer
- Organic function groups FTIR
- Aerosol scattering (400, 550, 700 nm) TSI Model 3563 Nephelometer
- Aerosol absorption (400, 550, 700 nm) Radiance Research PSAP
- Aerosol number CNC
- Aerosol size distribution Twin DMAs and an APS
- Aerosol light scattering hygroscopic growth f(RH) Twin TSI 3563 nephelometers
- Aerosol size hygroscopic growth g(RH) Tandem DMAs
- Aerosol light extinction hygroscopic growth f(RH) Cavity ring-down spectrometer
- Total and sub-micron aerosol extinction Cavity ring-down spectrometer
- Ozone/aerosol vertical profiles O3/Aerosol Lidar (OPAL)
- Wind/temperature vertical profiles 915 MHz wind Radar
- **High-resolution BL winds/aerosol Doppler Lidar (HRDL)**
- Wind profiles/microscale turbulence C-band radar
- Temperature/relative humidity profiles Radiosondes
- Surface energy balance (fluxes) Eddy covariance (bow mounted)
- High resolution BL turbulence structure Doppler mini-Sodar

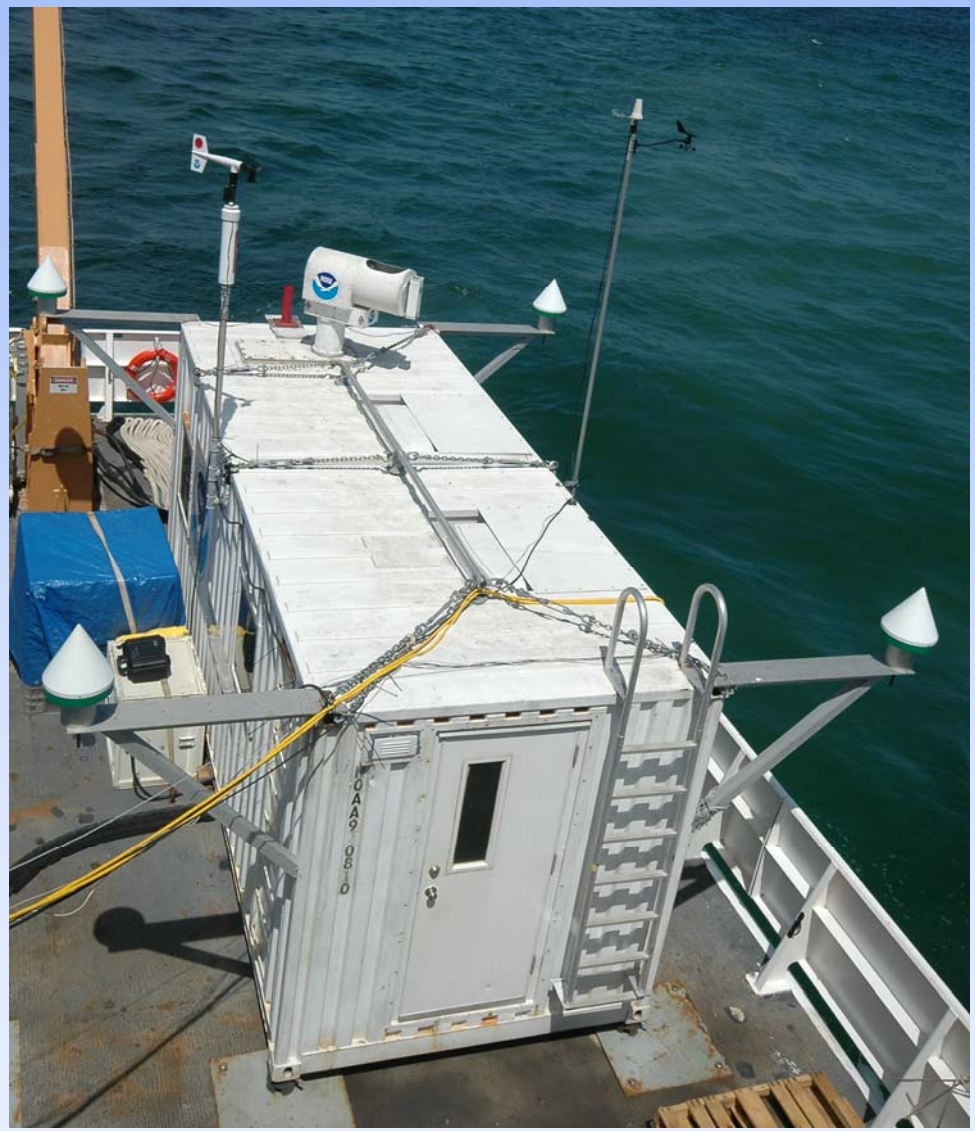
Characterizations of the Gulf/Bay with HRDL data

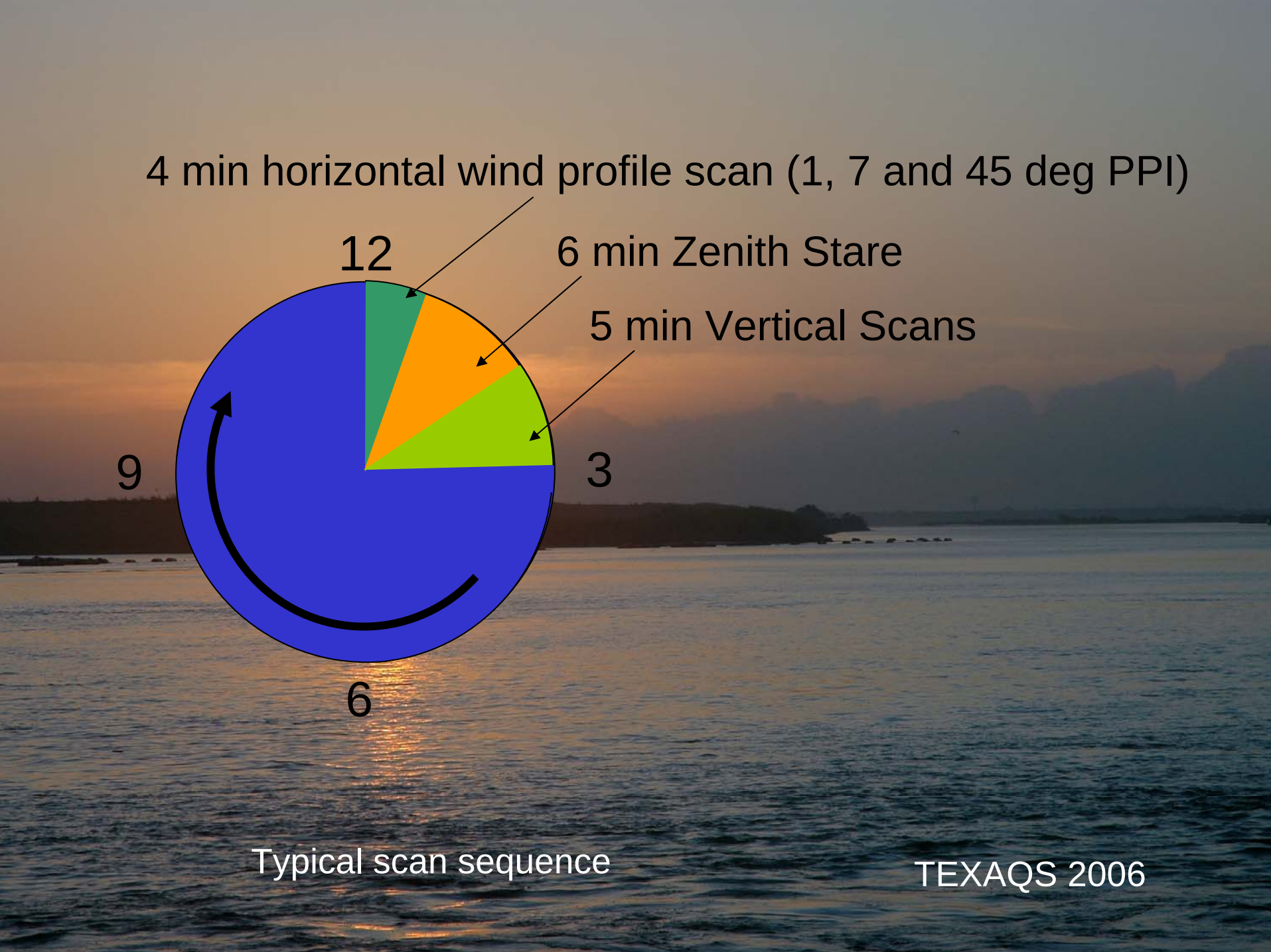
- **Winds and turbulence information**: used to determine the potential performance, including errors, based on sample rate/volumes, etc, in space-based Doppler lidar measurements.
- **Cloud coverage**: used to determine the percentage of time a satellite can make measurements at each altitude in this area.
- **Aerosol measurements**: used to determine the expected levels of return signal available in this region
  - **Closure** in aerosol studies at 355 nm using ozone profiling lidar (OPAL), cavity ring-down, and in-situ instruments. Will attempt to scale the backscatter and extinction numbers to HRDL wavelength for comparison studies.
  - **Comparisons** with CALIPSO and HSRL

High Resolution Doppler Lidar (HRDL)

Wavelength	2.02 micron
Pulse Energy	2-3 mJ
PRF	200 Hz
Max Range	3-8 km
Range Res.	30 m
Beam rate	2 Hz
Precision	10 cm/s
Scanning	Full Hemispheric

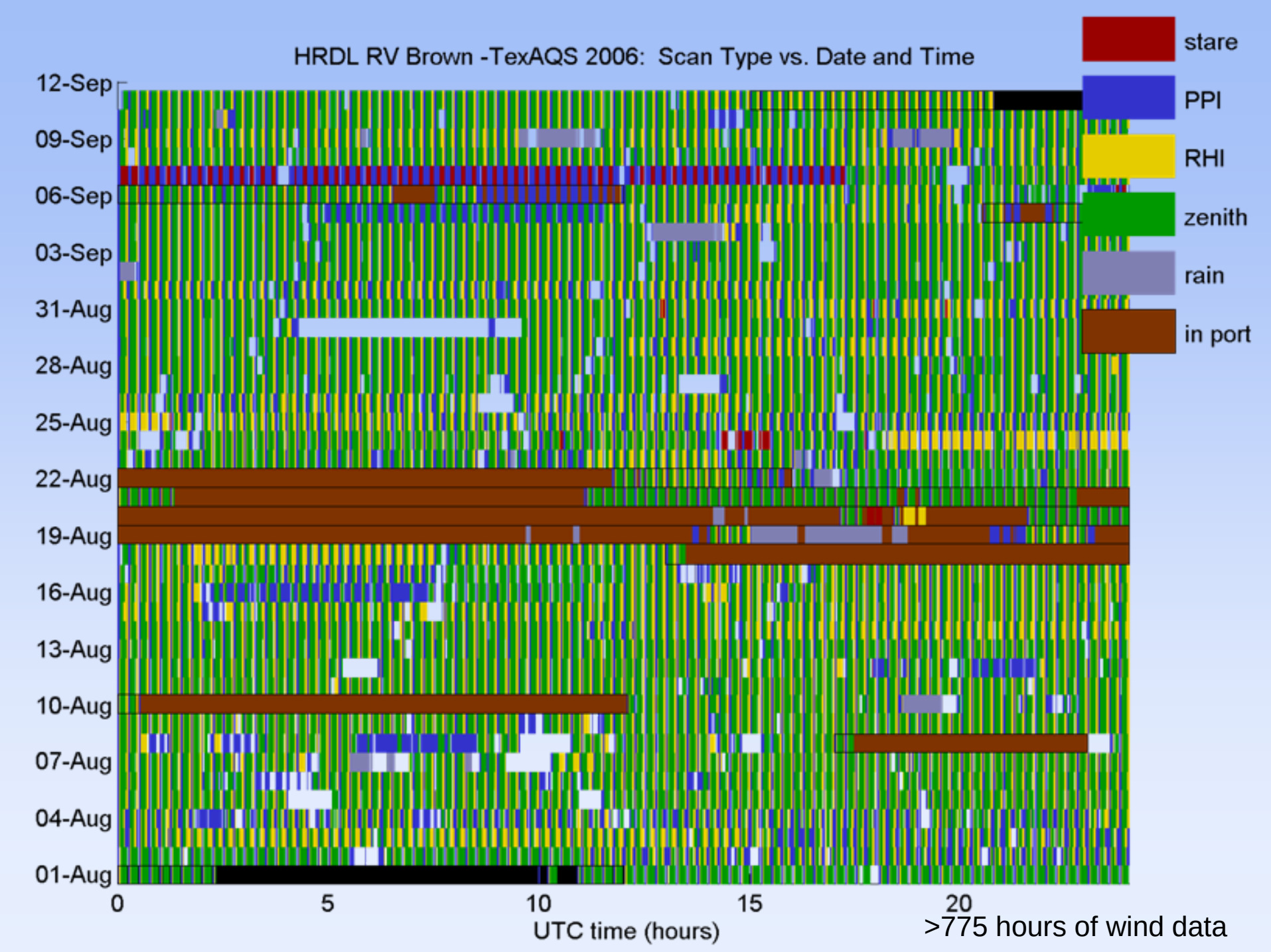
New pump diode arrays
New crystal thermal control



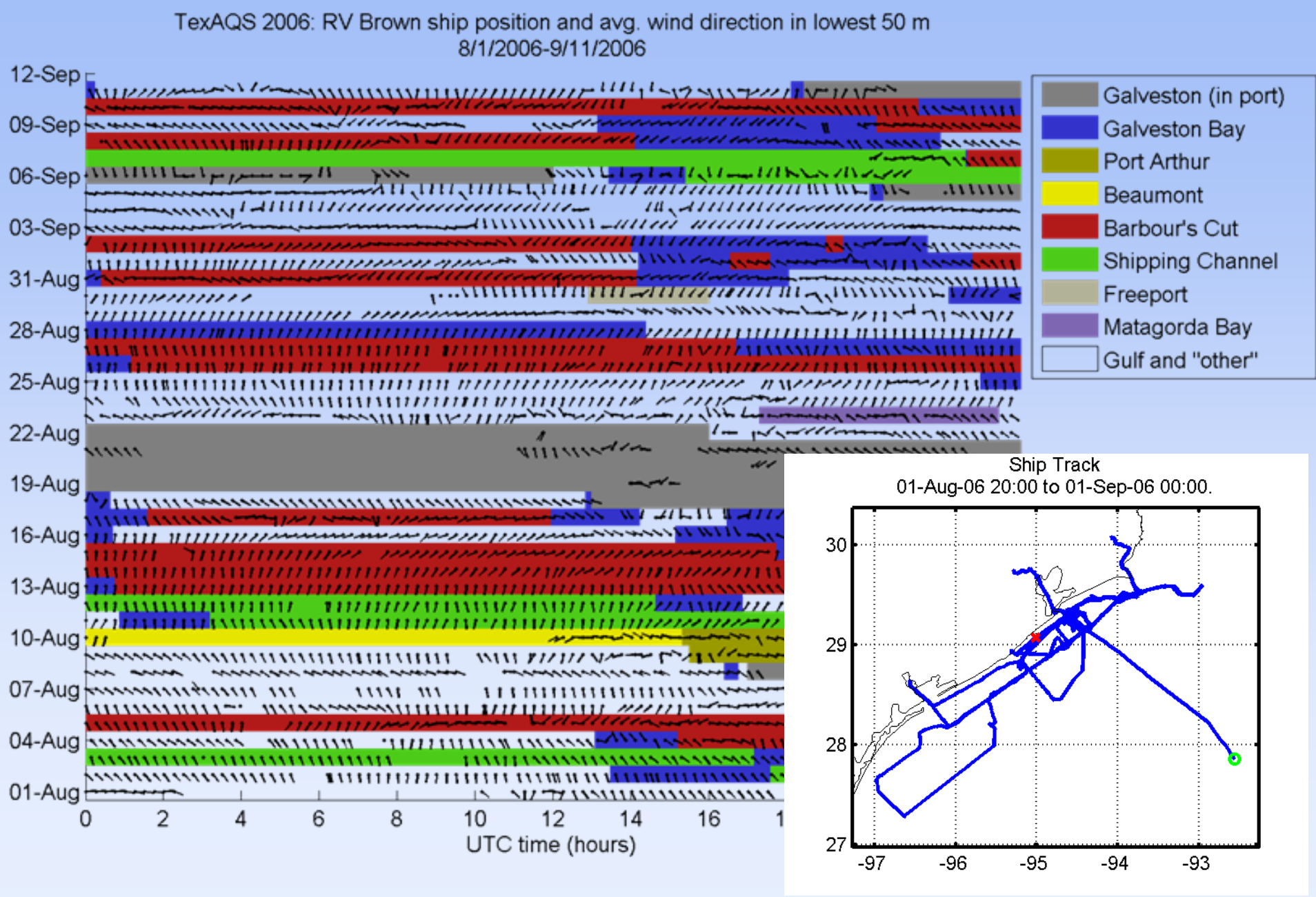


Typical scan sequence

TEXAQS 2006



>775 hours of wind data

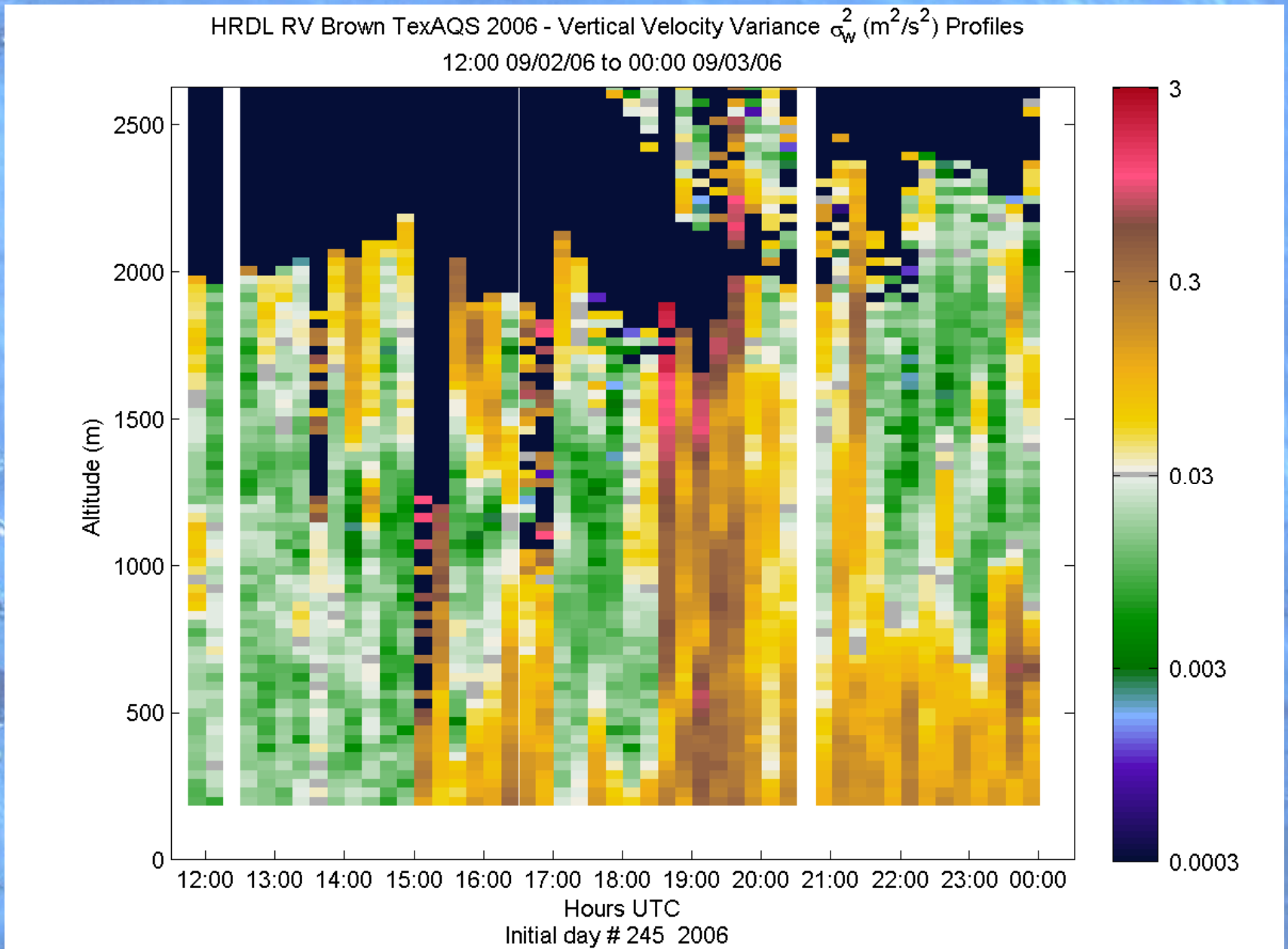

TexAQS 2006: RV Brown ship position and avg. wind direction in lowest 50 m
8/1/2006-9/11/2006
12-Sep
09-Sep
06-Sep
03-Sep
31-Aug
28-Aug
25-Aug
22-Aug
19-Aug
16-Aug
13-Aug
10-Aug
07-Aug
04-Aug
01-Aug
0
2
4
6
8
10
12
14
16
UTC time (hours)
Galveston (in port)
Galveston Bay
Port Arthur
Beaumont
Barbour's Cut
Shipping Channel
Freeport
Matagorda Bay
Gulf and "other"
Ship Track
01-Aug-06 20:00 to 01-Sep-06 00:00.
30
29
28
27
-97
-96
-95
-94
-93

Basic HRDL Data Products during TexAQS 2006

- Mean wind speed and direction.
- Average return signal strength
- Small scale mixing strength

posted every 15 minutes during the cruise to:
http://esrl.noaa.gov/csd/ors/data_pages/TexAQS06/hrdl/

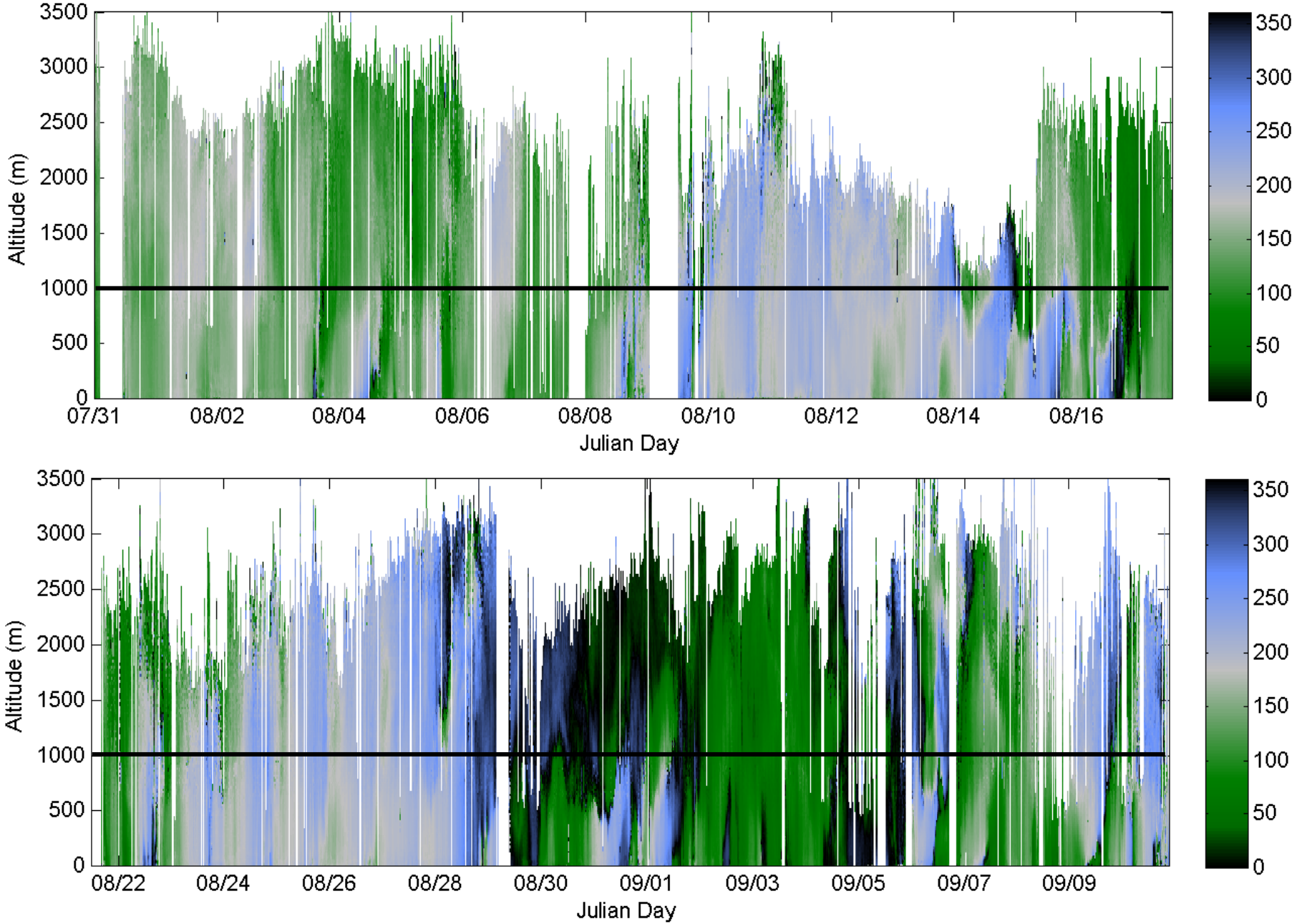
HRDL: TexAQS 2006 data posted to web page



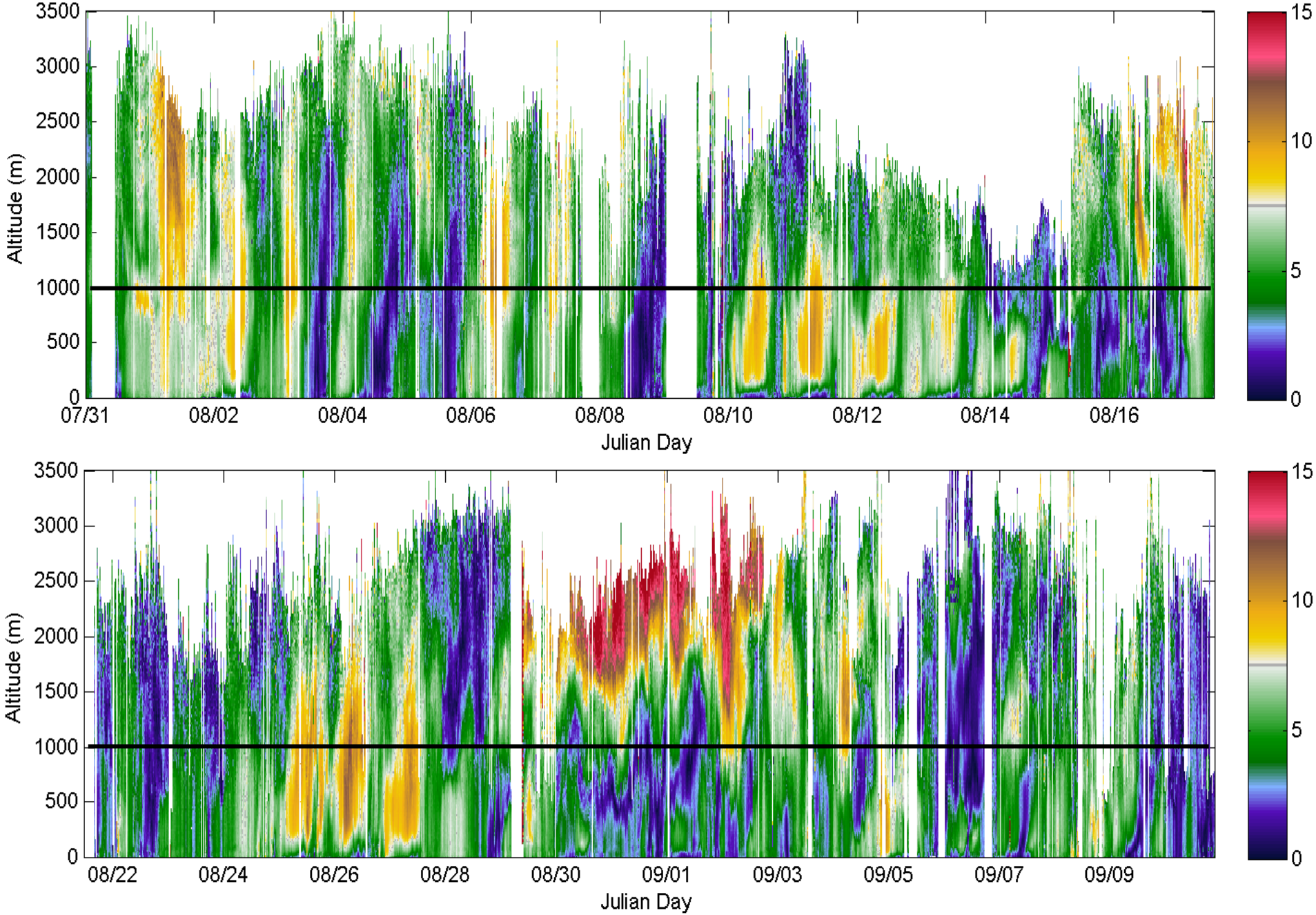
HRDL TexAQS: Additional products from post-processing

- Aerosol and mixed layer (i.e. Boundary layer) heights
- Horizontal small-scale mixing strength
- Vertical profiles of relative aerosol strength (layering information) – maybe this will lead to backscatter(?)
- Speed and directional shear information and statistics
- Information about boundary layer dynamics such as rolls, surface streaks, etc.

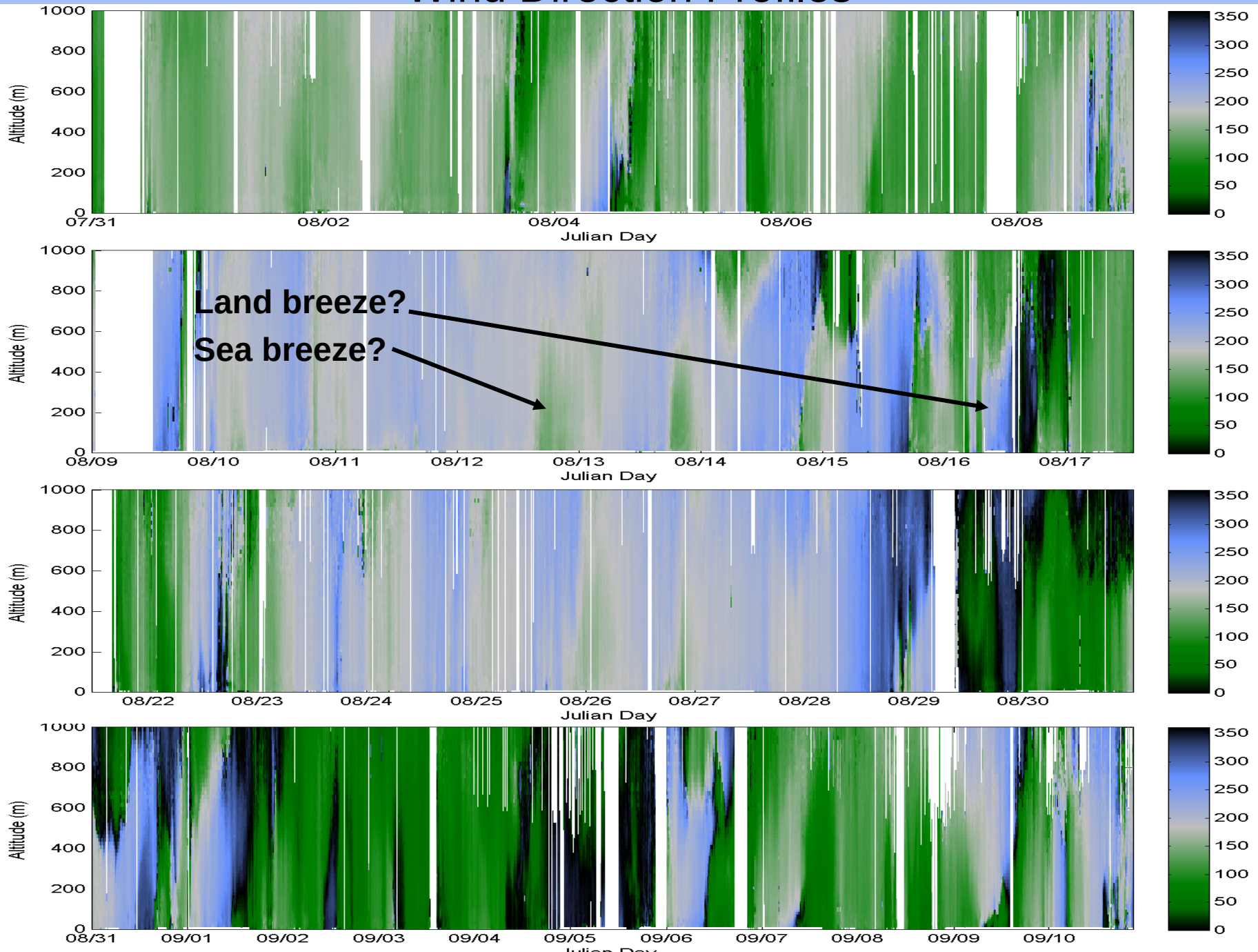
TexAQS 2006 – HRDL mean wind direction profiles



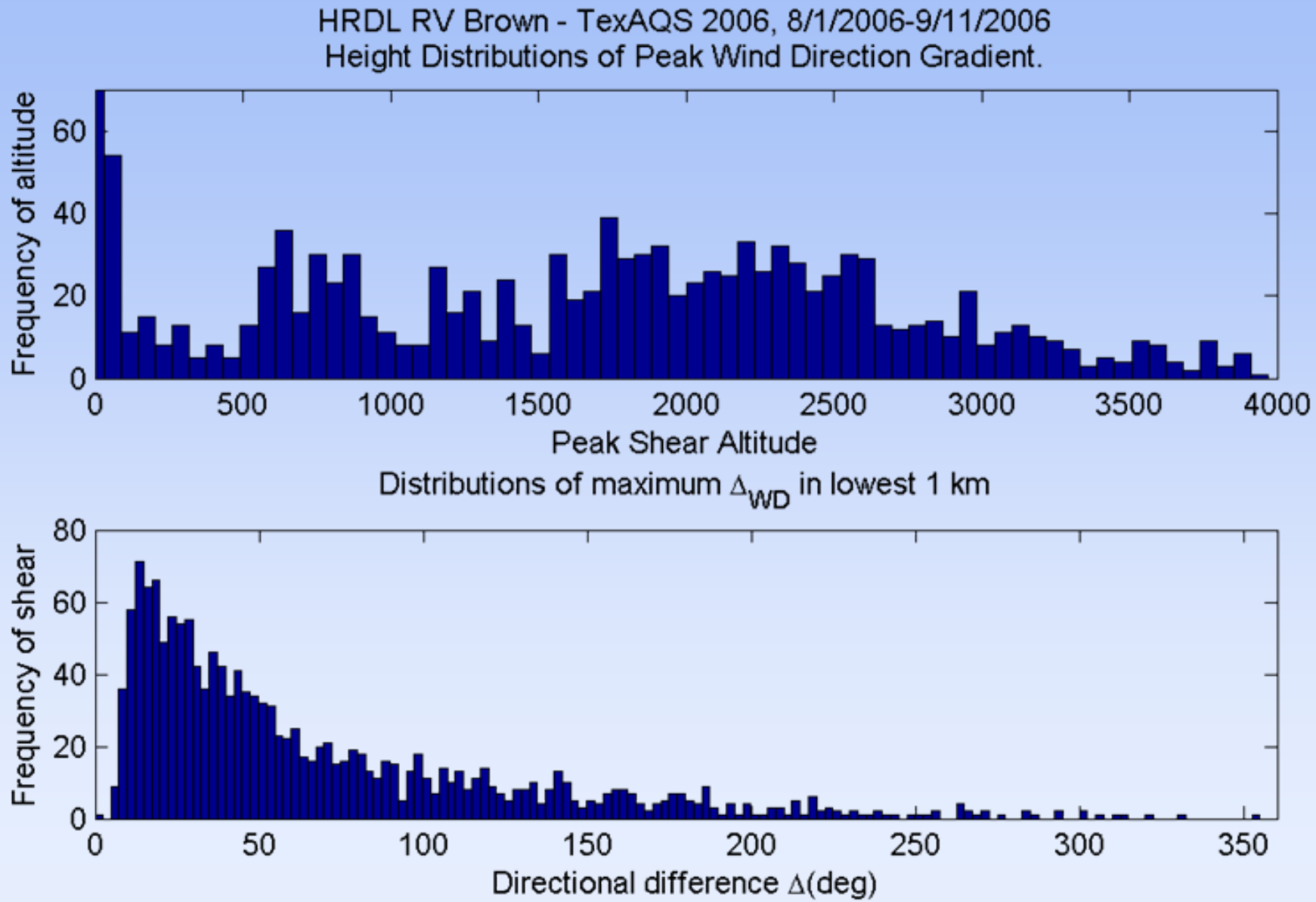
TexAQS 2006 – HRDL mean wind speed profiles



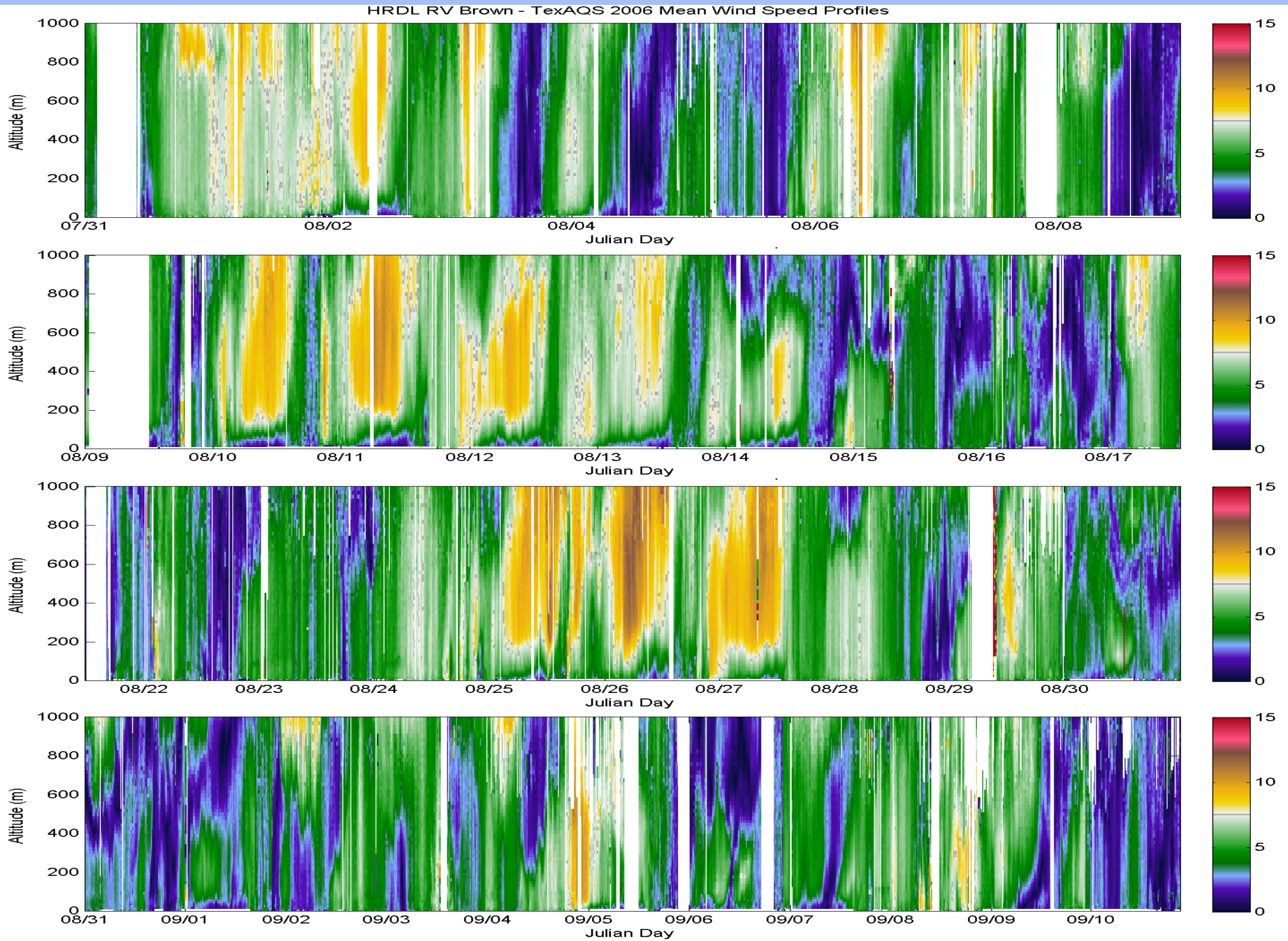
Wind Direction Profiles



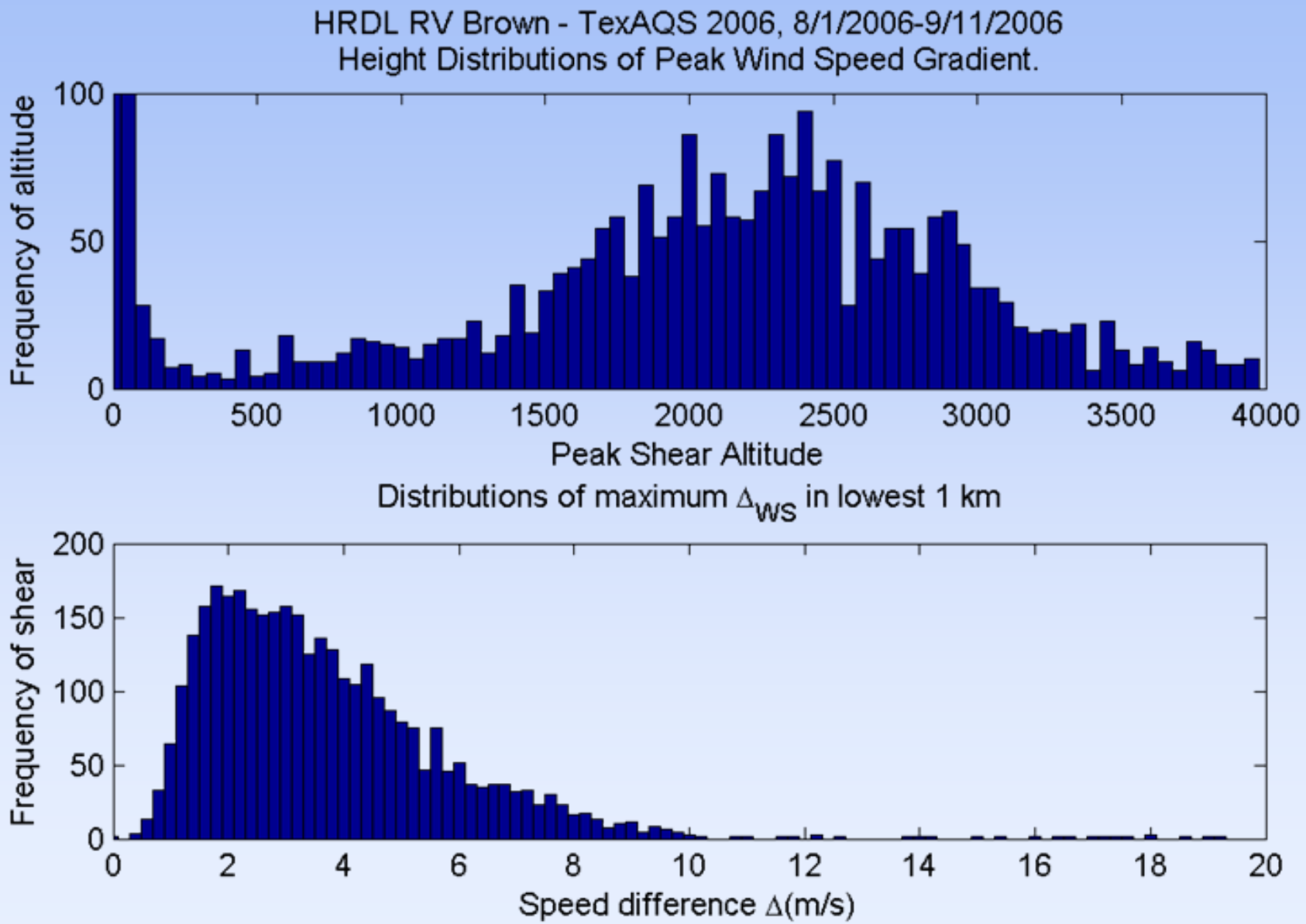
TexAQS 2006 –Directional Shear Distributions



Wind Speed Profiles



TexAQS 2006 – Wind Speed Shear Distributions



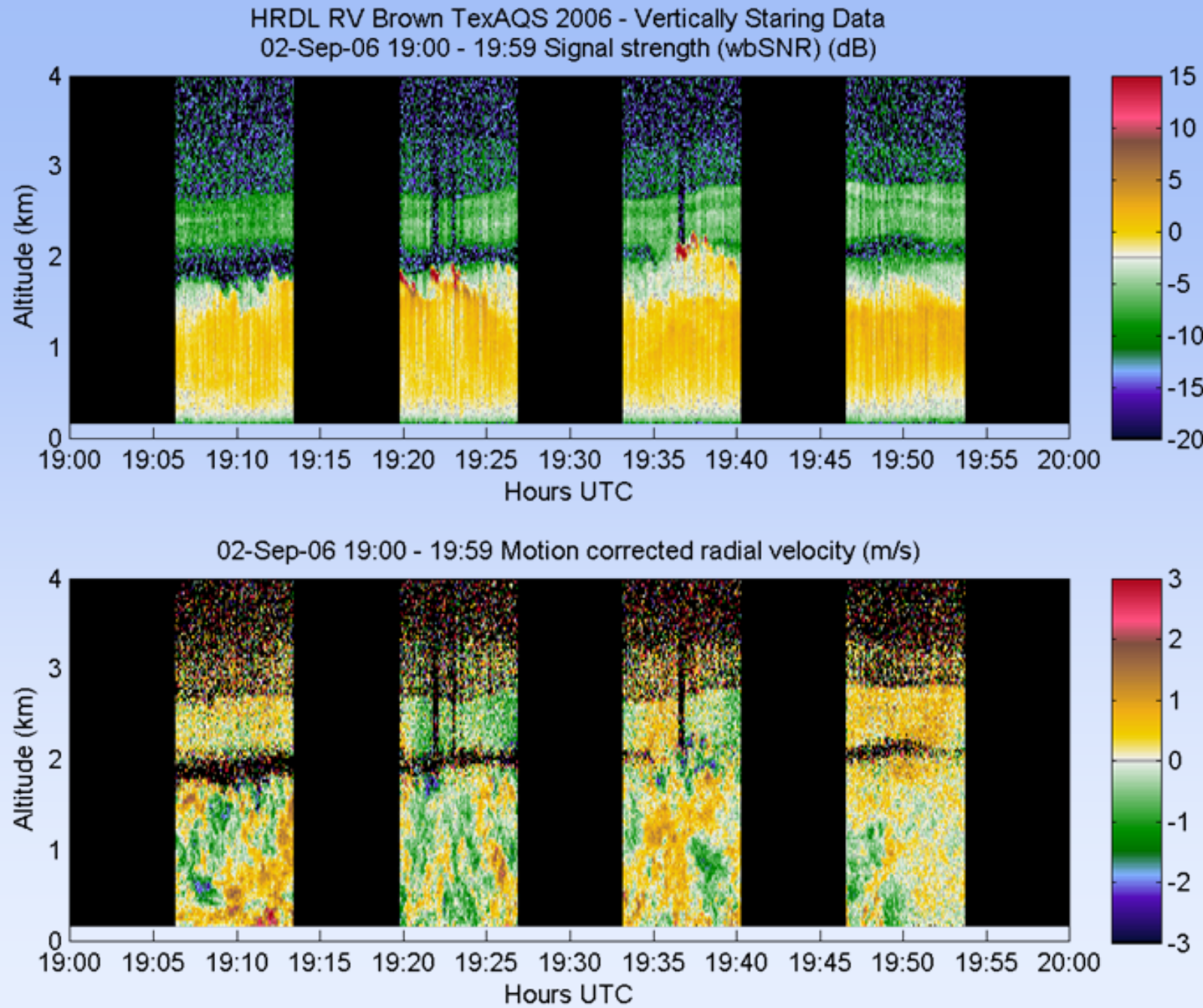
HRDL: Zenith/Vertical stare Data

New improvements to scanner controls allow this scan to be part of the automatically repeated pattern

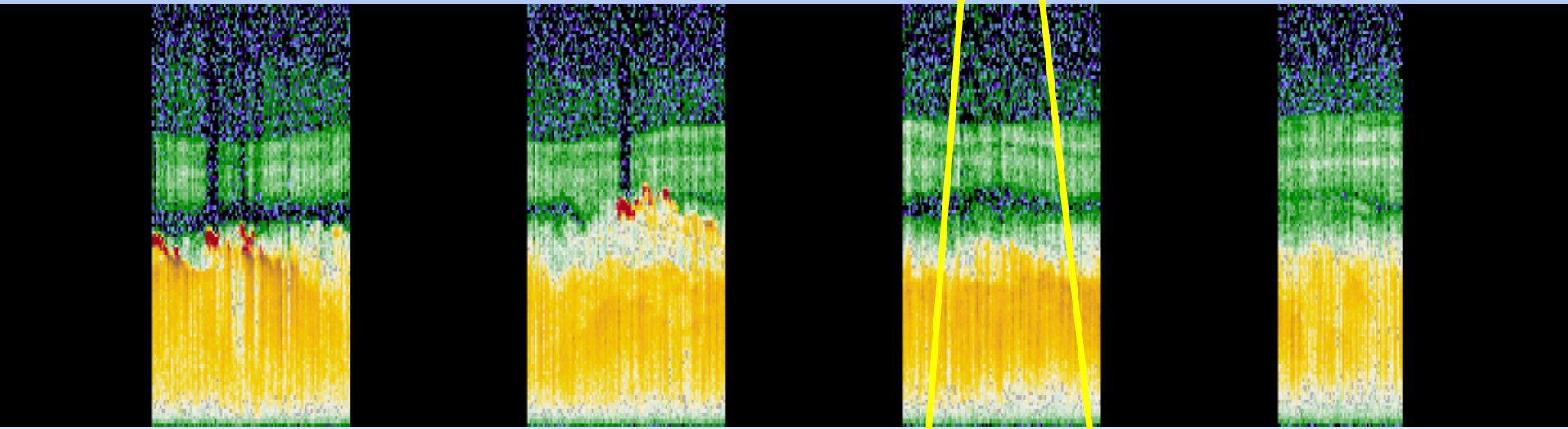
This means we can provide information on…

- Return signal strength
- Aerosol & cloud layer(s)
- Mixing heights
- Turbulence
- Gravity waves

HRDL: Zenith/ Vertical stare Data Aerosol layer(s)

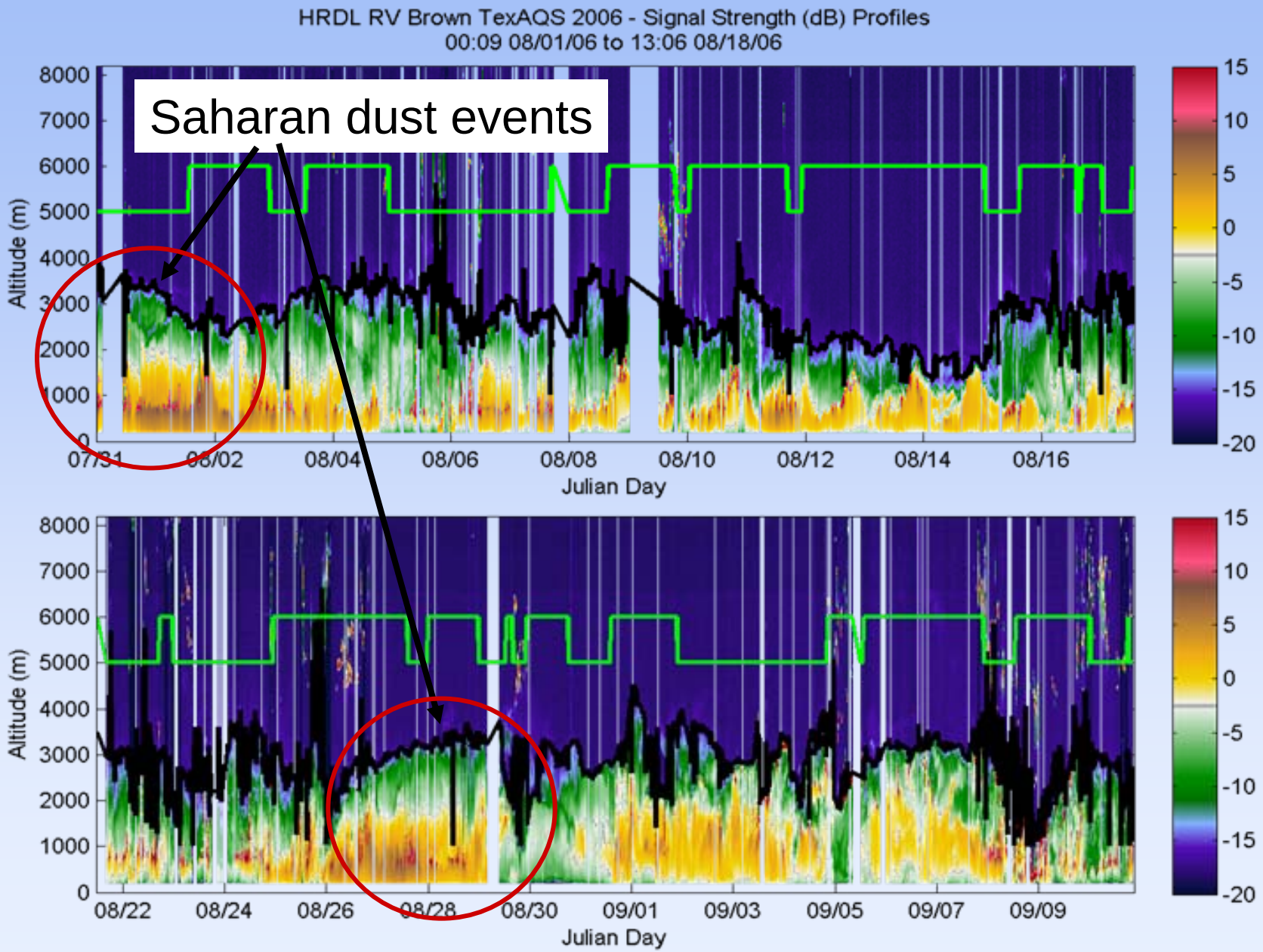


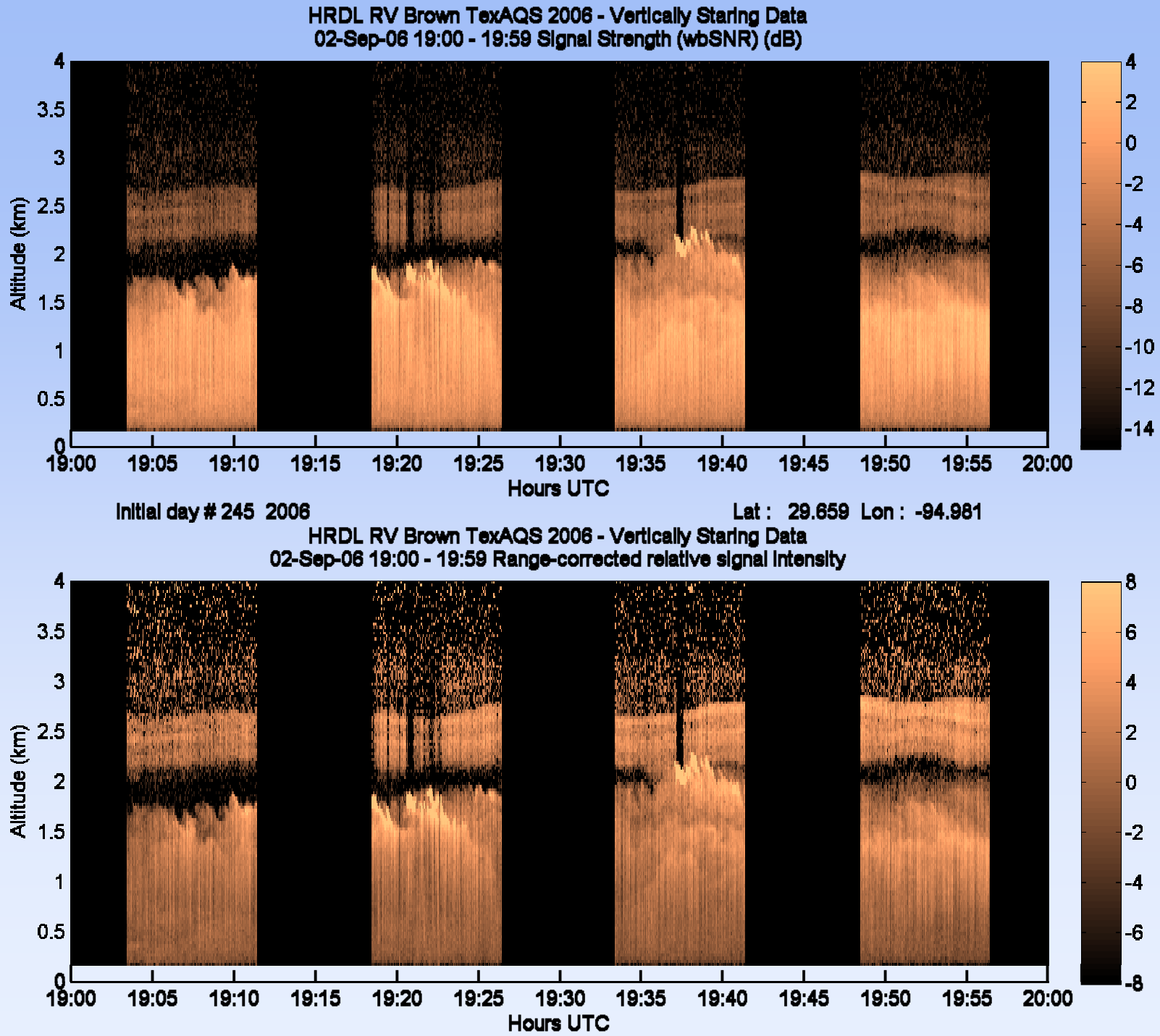
Zenith Stare Signal Return



"Hey, what do the aerosol layers look like?"

HRDL-TexAQS 2006: Zenith Return Signal Strength





SNR

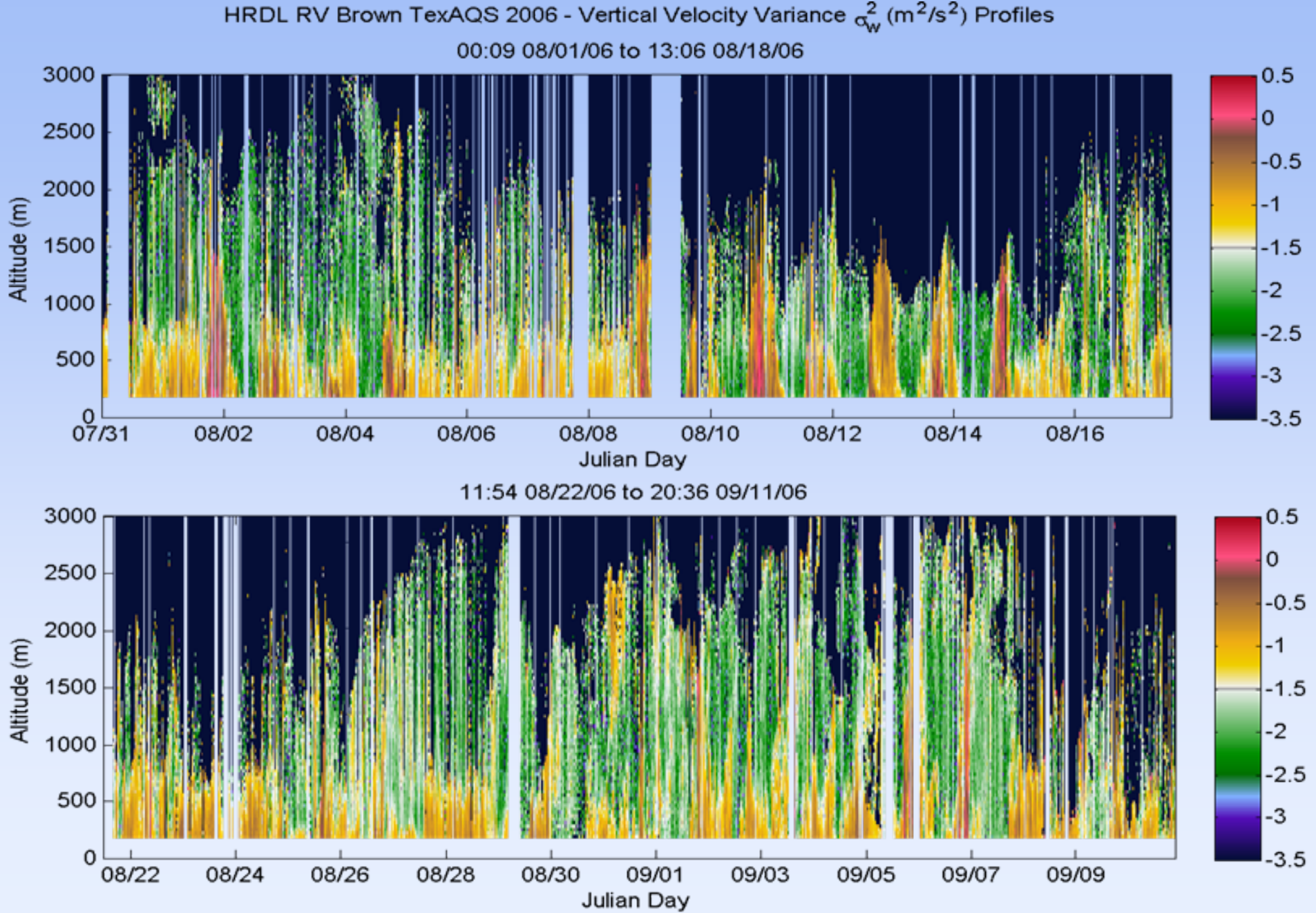
↑

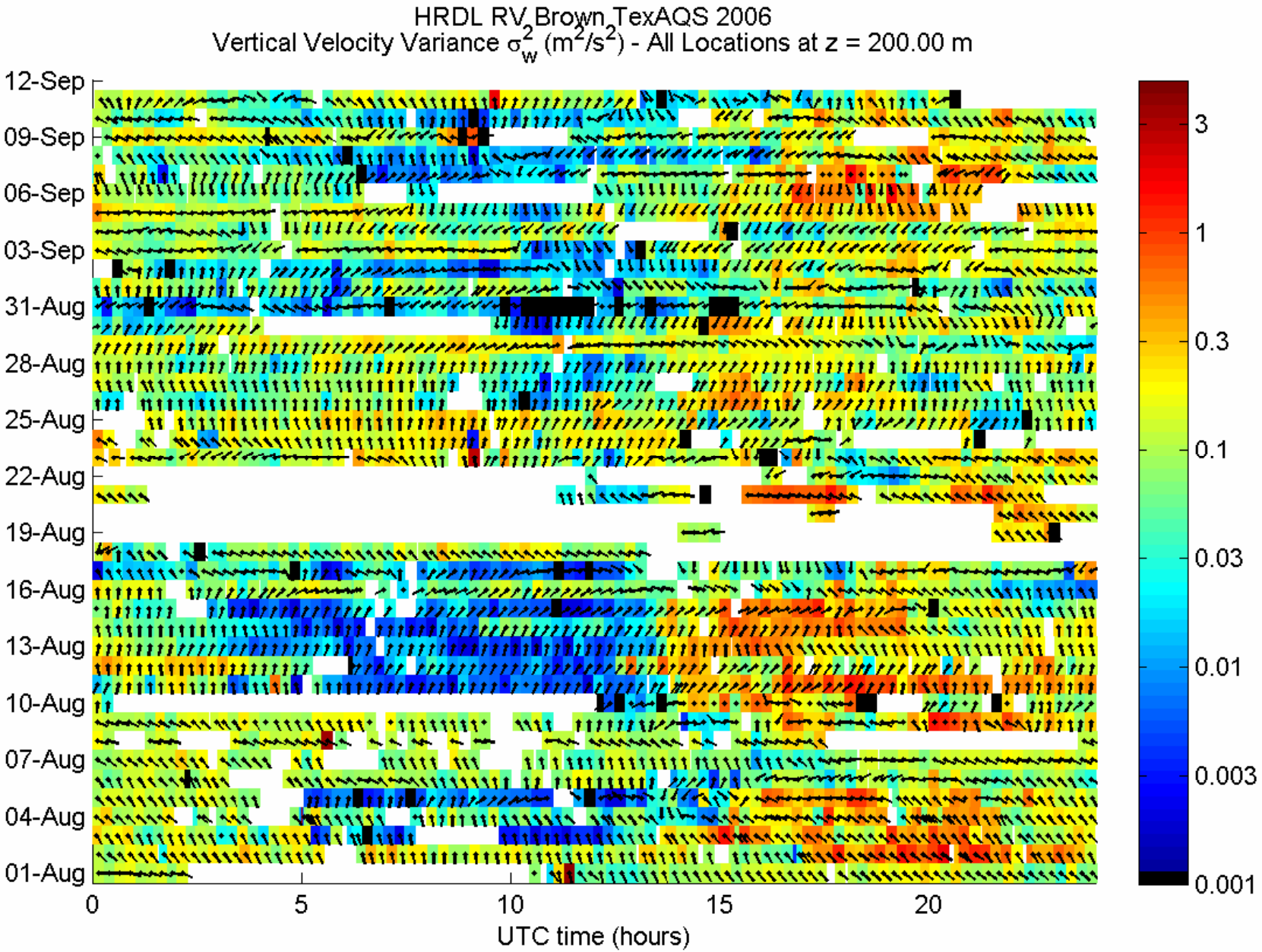
Zenith Stare Signal Return

↓

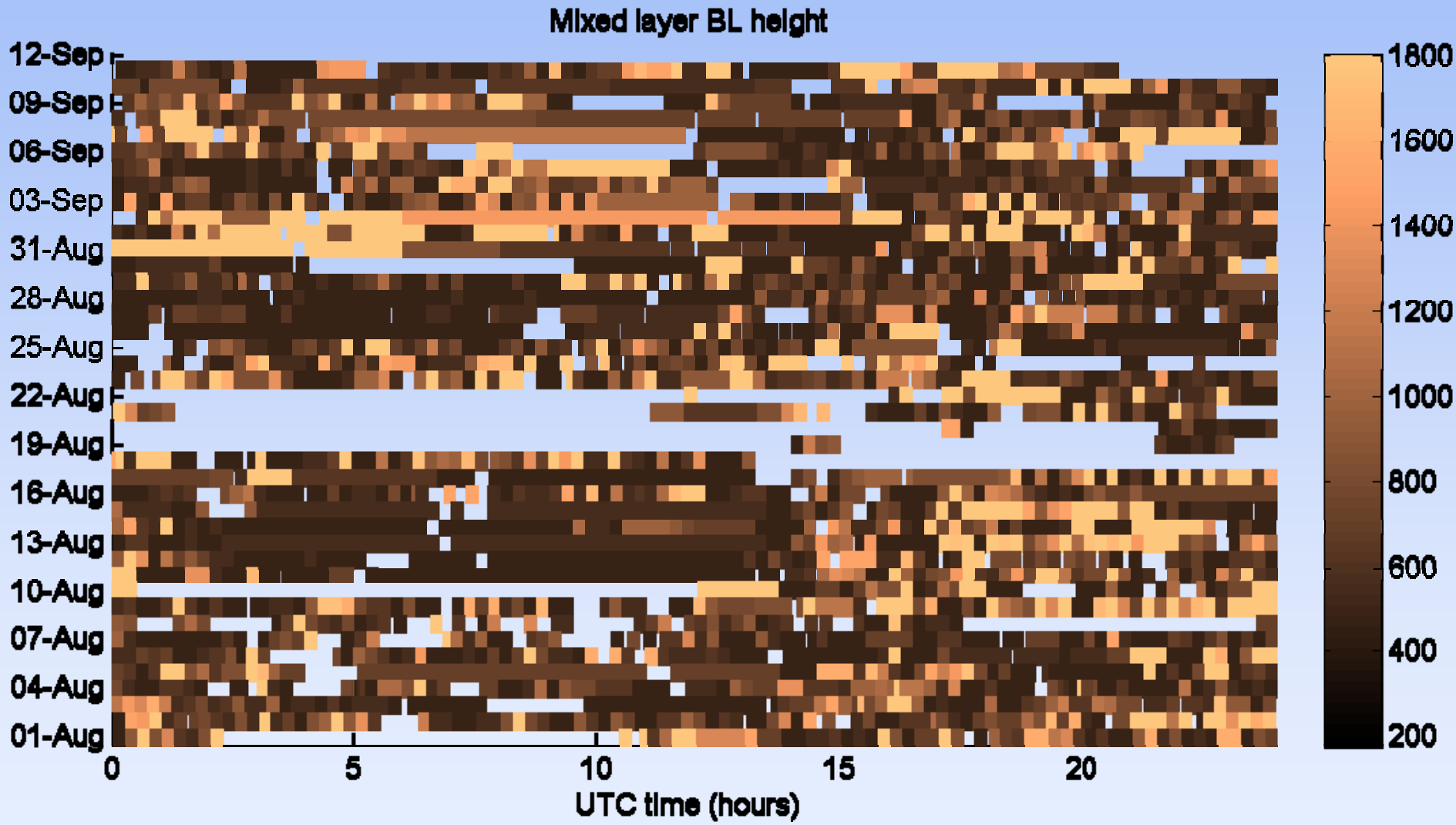
Relative back-scatter

HRDL-TexAQS 2006: Zenith Vertical Mixing Strength

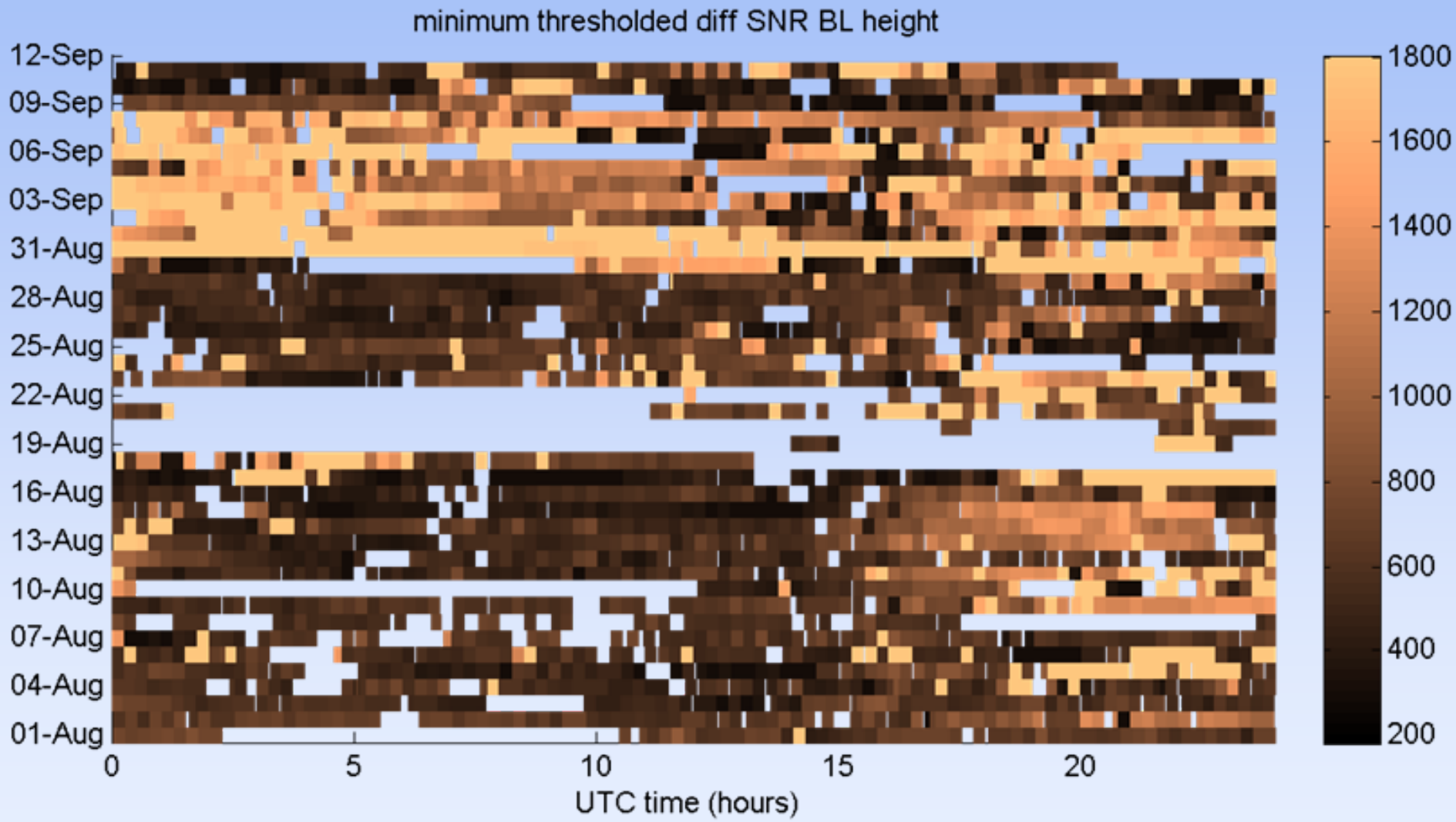



HRDL RV Brown TexAQS 2006
Vertical Velocity Variance σ_w^2 (m^2/s^2) - All Locations at z = 200.00 m
12-Sep
09-Sep
06-Sep
03-Sep
31-Aug
28-Aug
25-Aug
22-Aug
19-Aug
16-Aug
13-Aug
10-Aug
07-Aug
04-Aug
01-Aug
0
5
10
15
20
UTC time (hours)
3
1
0.3
0.1
0.03
0.01
0.003
0.001

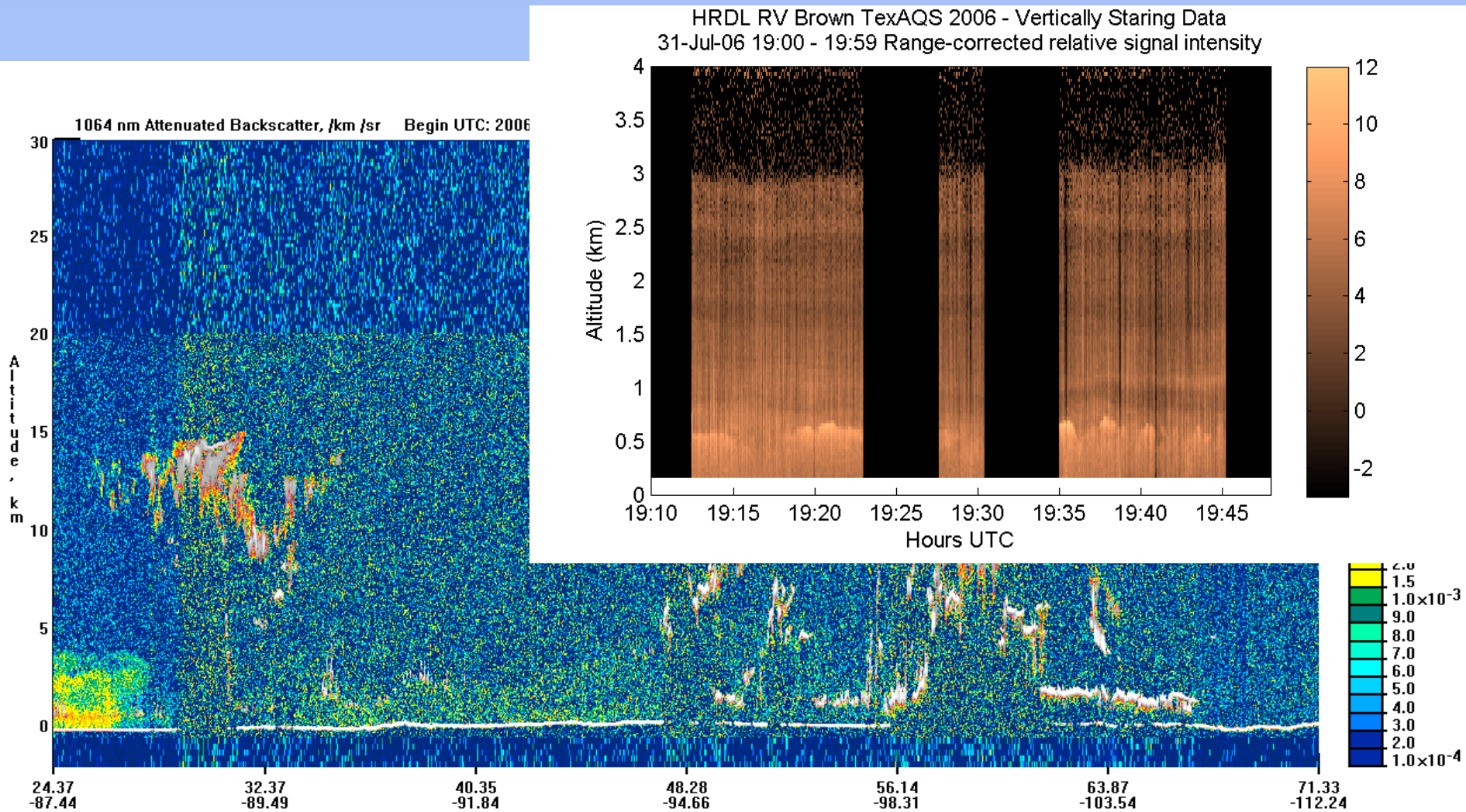
HRDL TexAQS – Estimates of boundary layer height



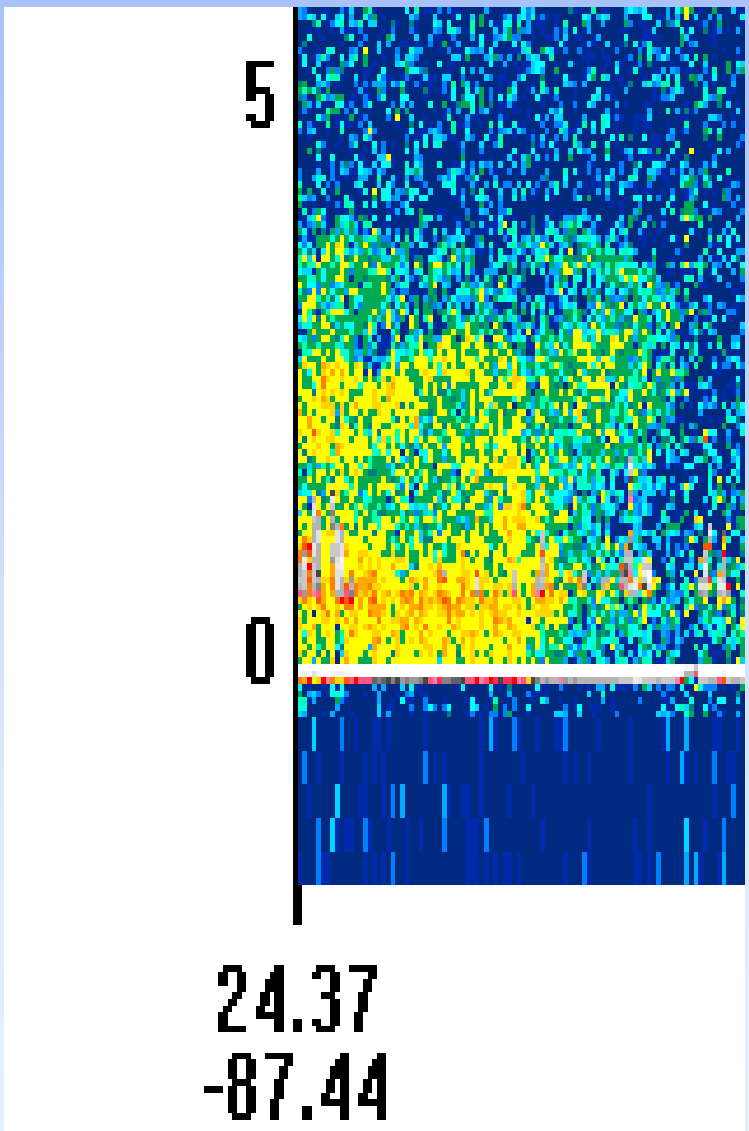
HRDL TexAQS – Estimates of boundary layer height

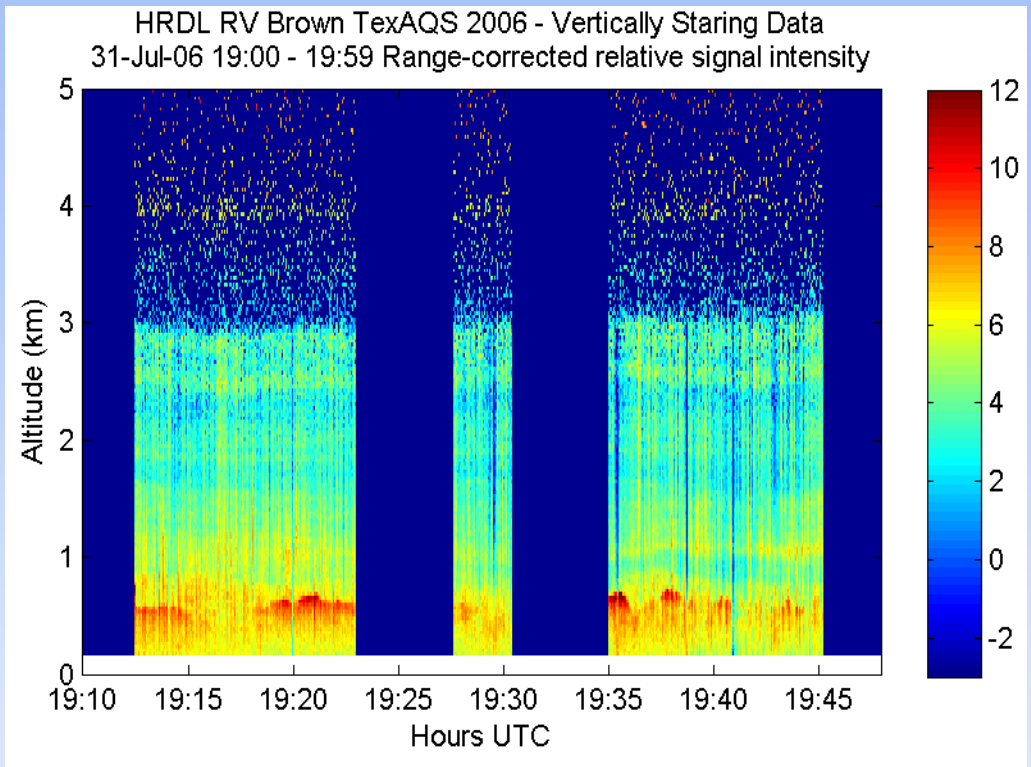


CALIPSO/HRDL Comparison



CALIPSO/HRDL – July 31, 19:18

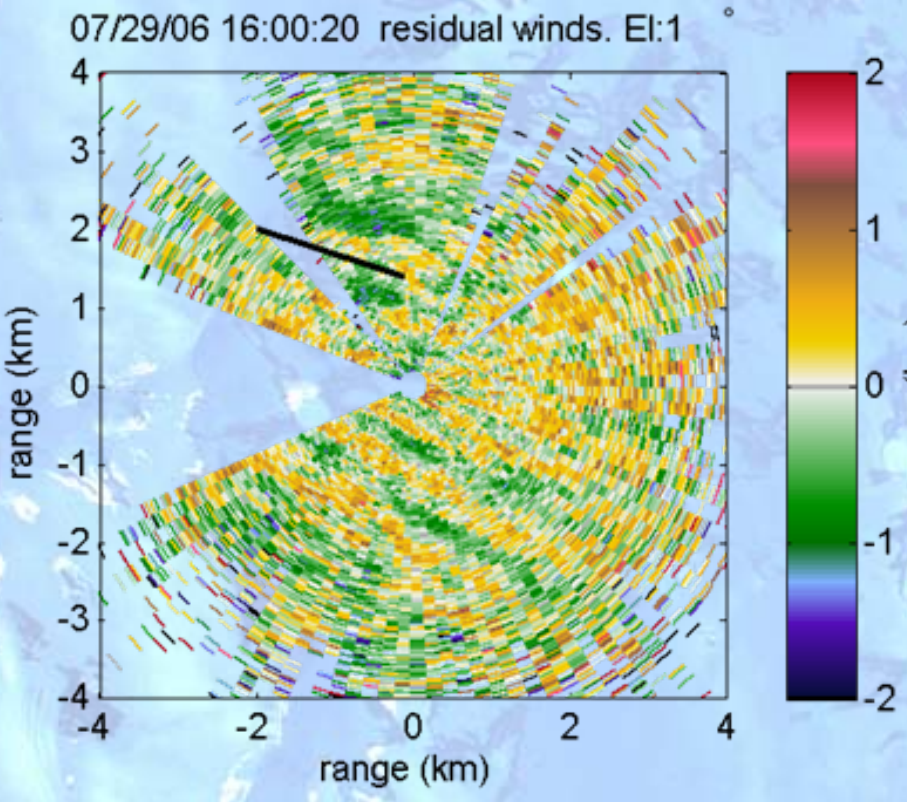


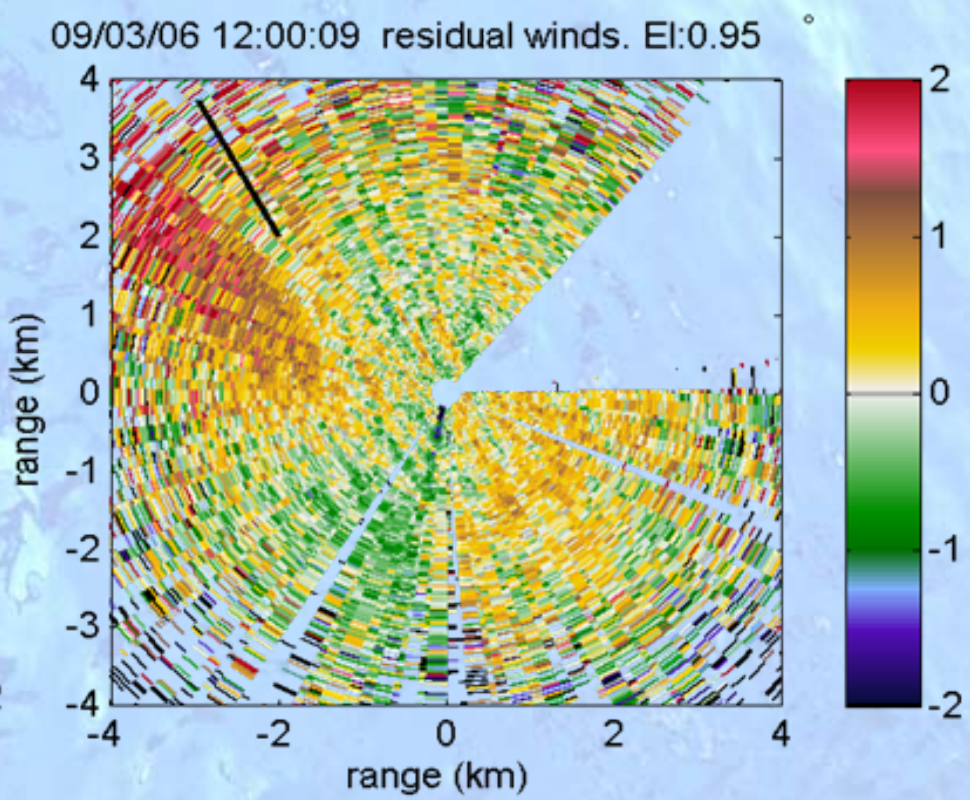


HRDL Lat: 26.318

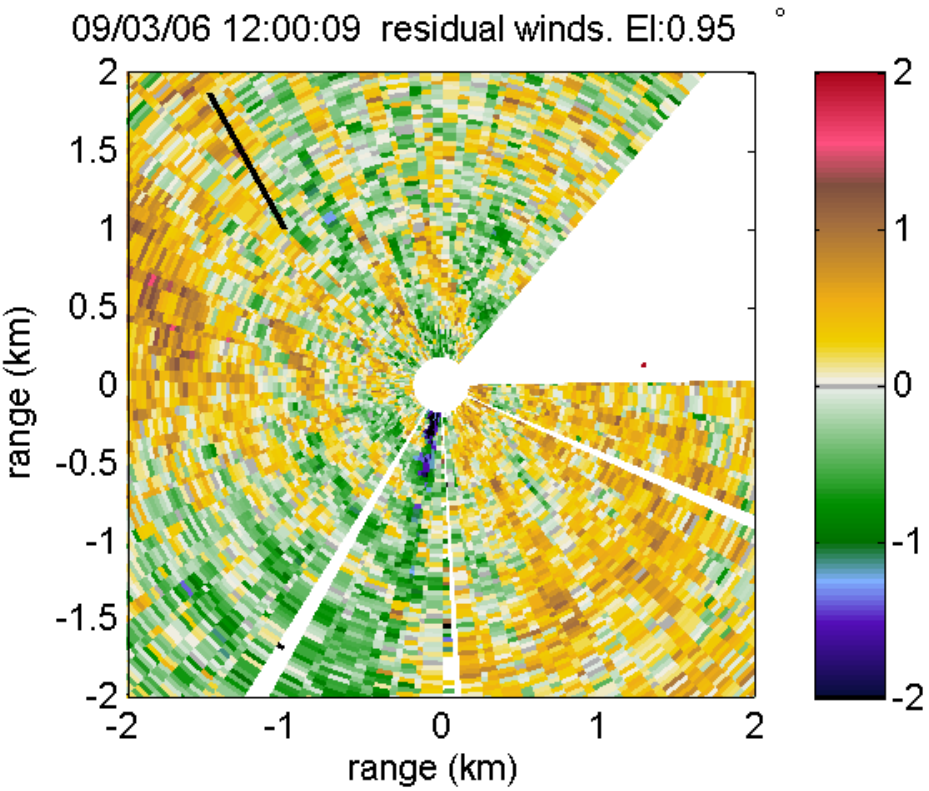
Lon: -87.84

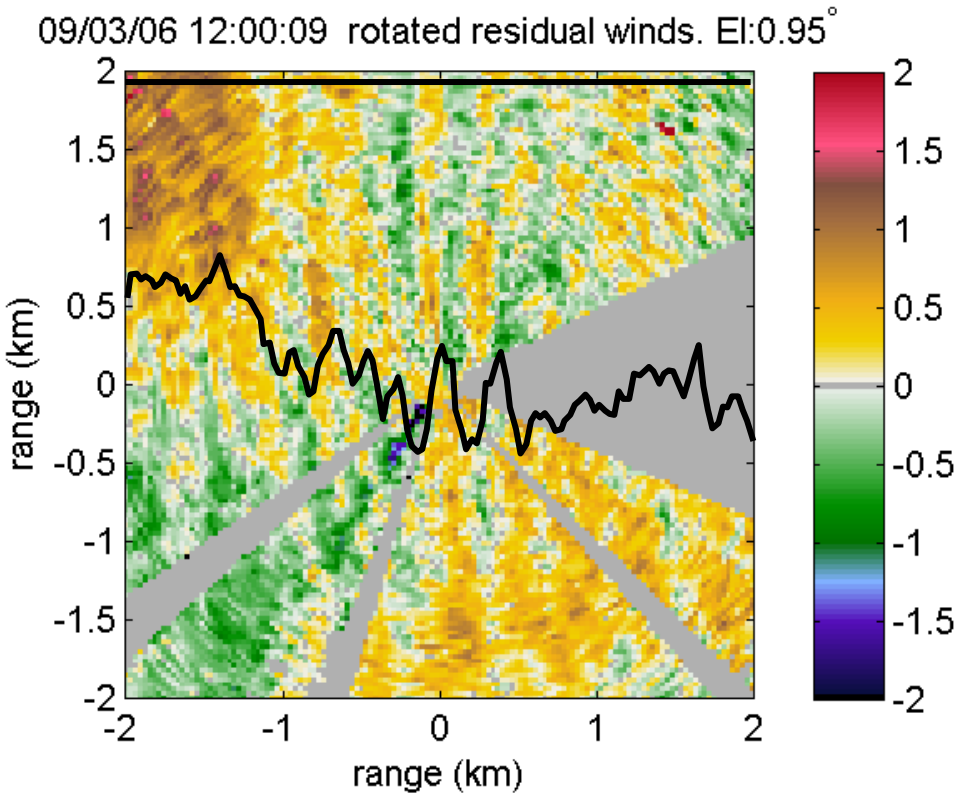
Surface Dynamics





Surface Dynamics





Why are we interested in surface streaks?

- We have observed increases in horizontal velocity variance linked to the streaks → corresponding increases in vertical variance likely.
- Effects on the surface energy budget (modeling)
- Usually Correspond to directional shear – which also ads to coherent bandwidth

Up next…

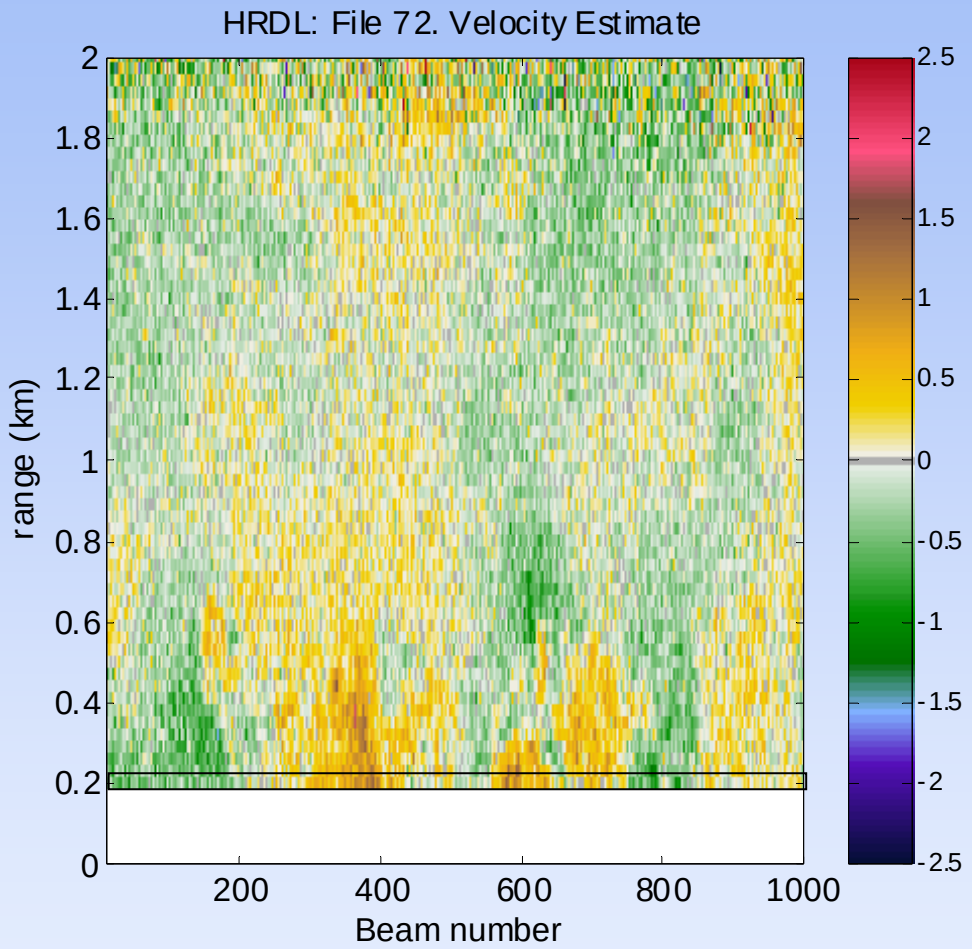
- Boundary Layer Heights
- Quantify the effects of these conditions on space-based lidar CNR & wind estimates.
- Comparisons of HRDL with HSRL and CALIPSO –characterize the relationship between 1 and 2 micron backscatter in this area.
- Streak Analysis and integration of HRDL data with models

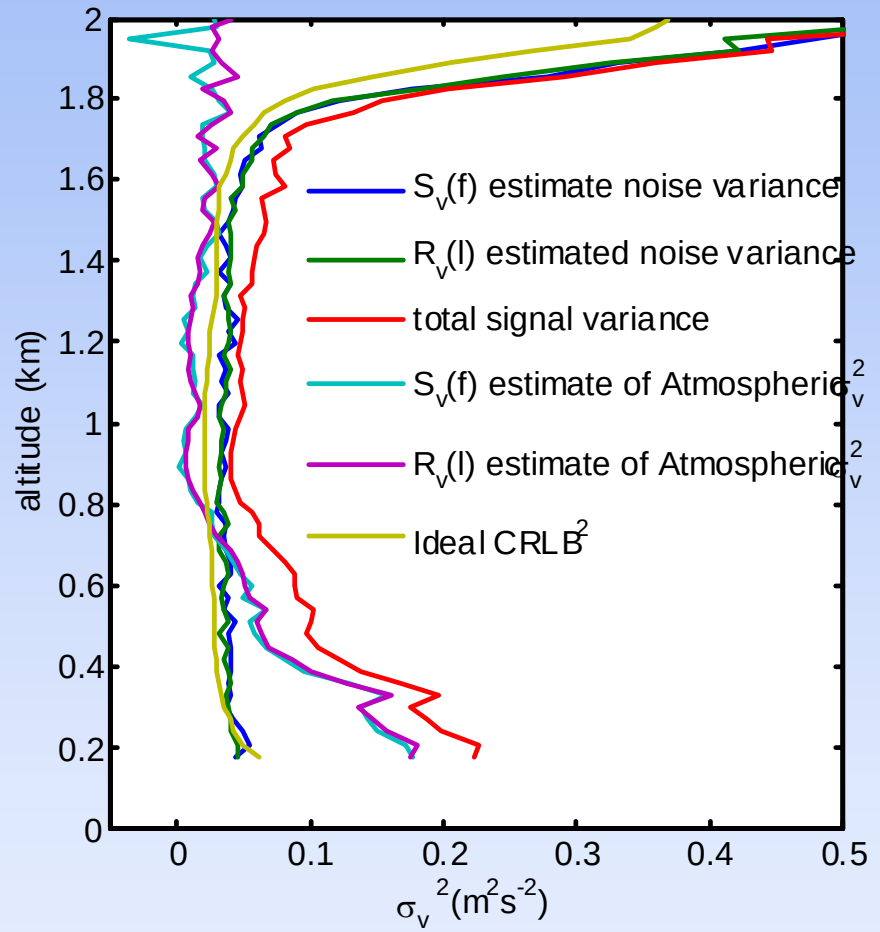

T = 95° F
RH = 97%


Thank you

extras

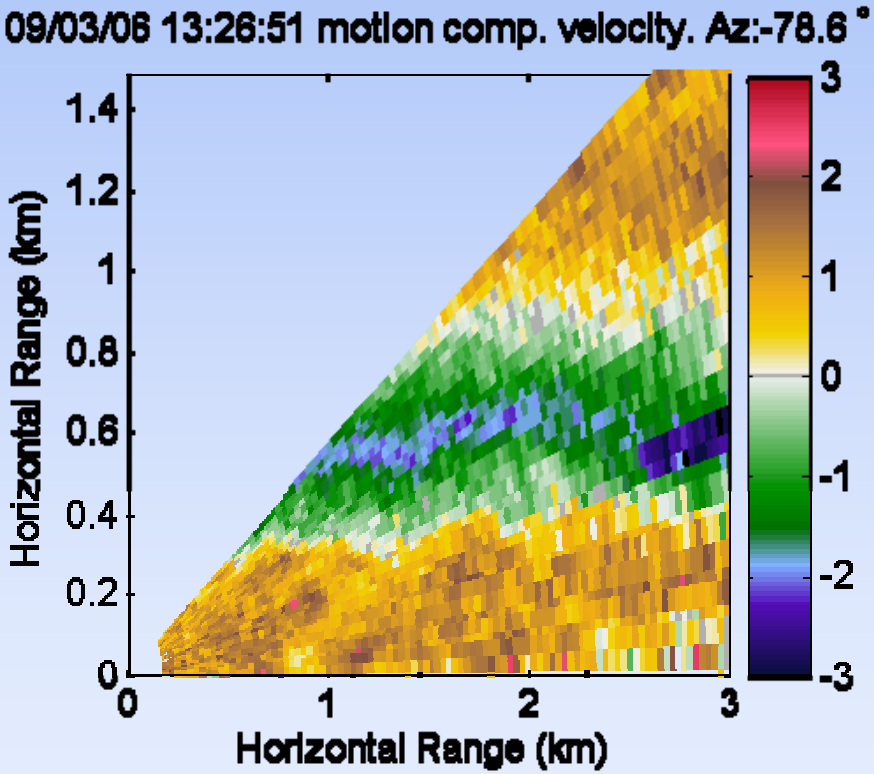
Estimating Velocity Variance

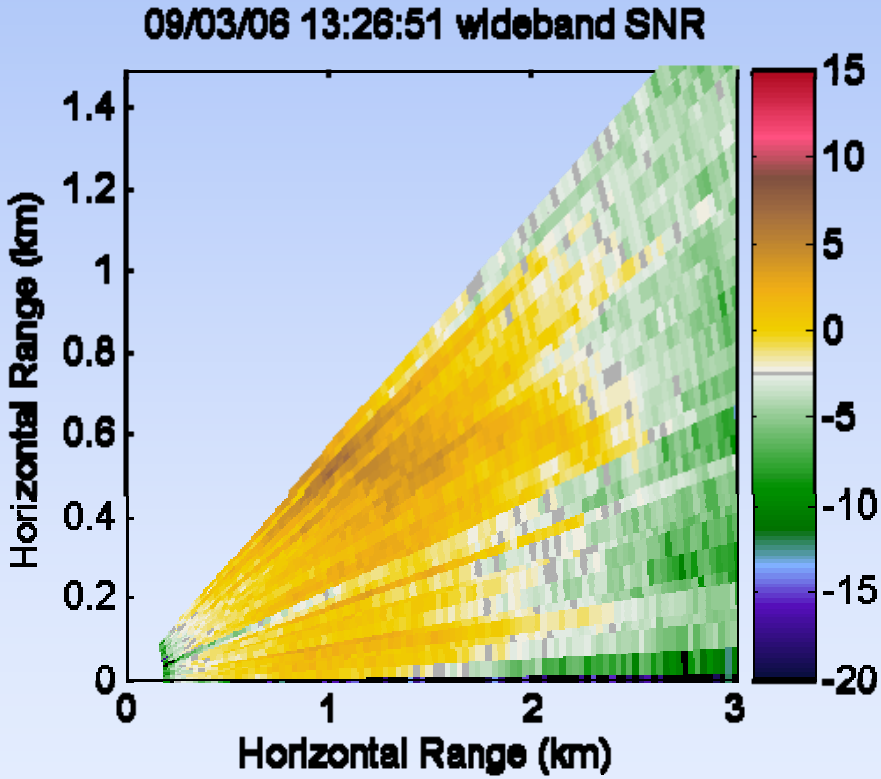


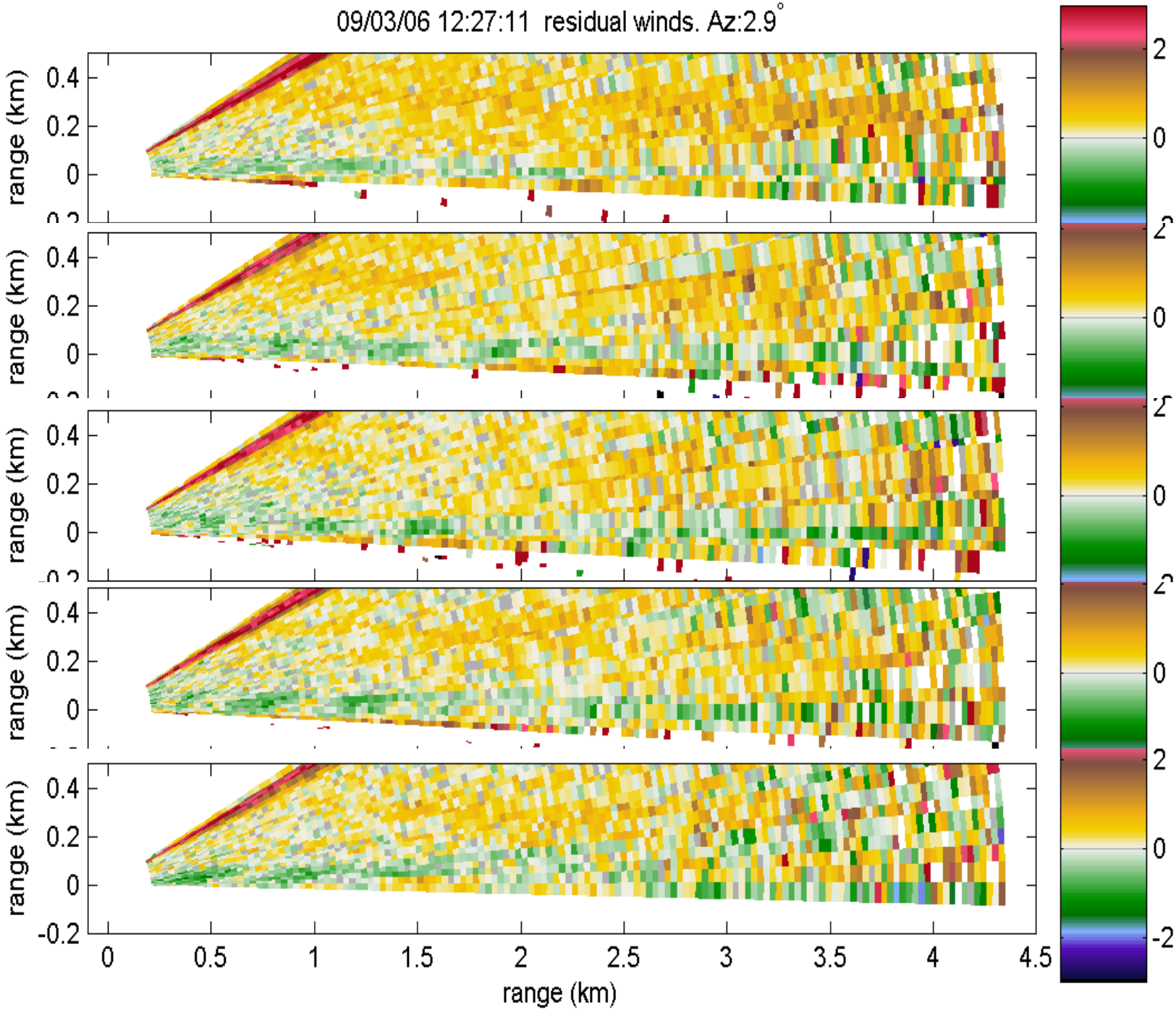


$$\sigma^2_{v-atmospheric} = \sigma^2_{v-total} - \sigma^2_{v-instrument}$$

“RHI” Scans: Shear visualization (can see turbulence too)






09/03/06 12:27:11 residual winds. Az:2.9°
range (km)
0.4
0.2
0
-0.2
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
range (km)
2
0
-2