

# Surface fluxes, boundary layer heights, and mixing strength in Galveston Bay and the Gulf of Mexico

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with help from

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HRDL operators and data processors

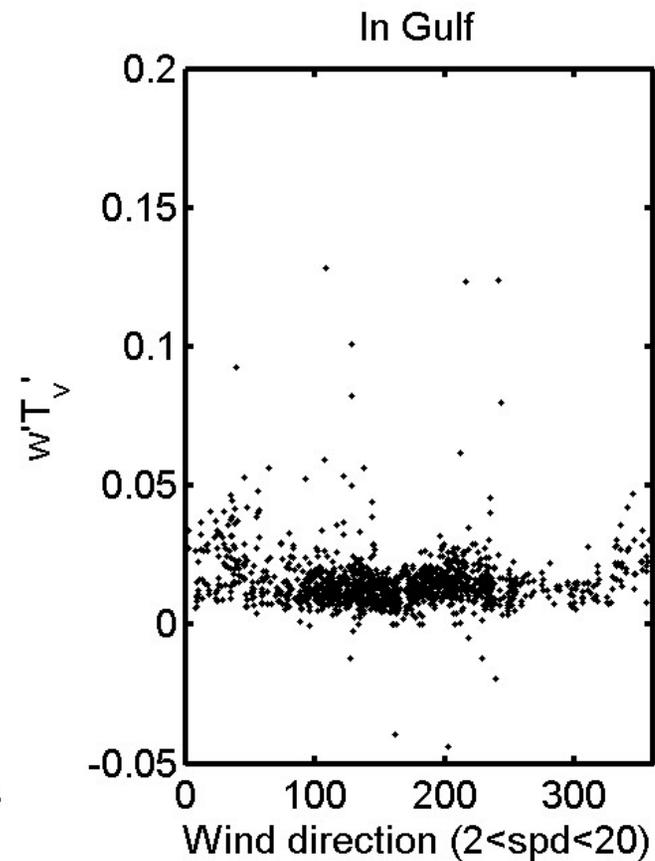
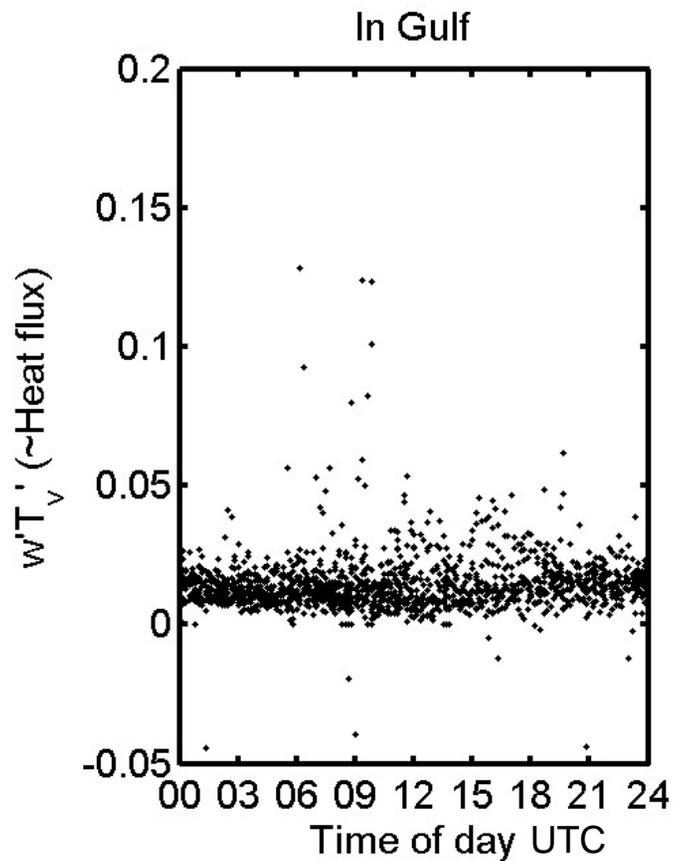
RHB sonde launchers

and many others

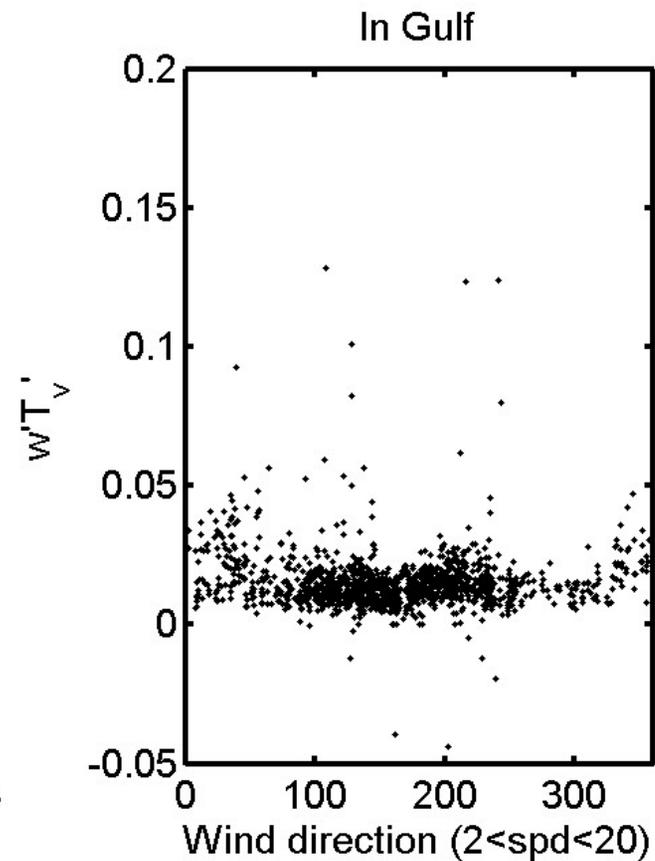
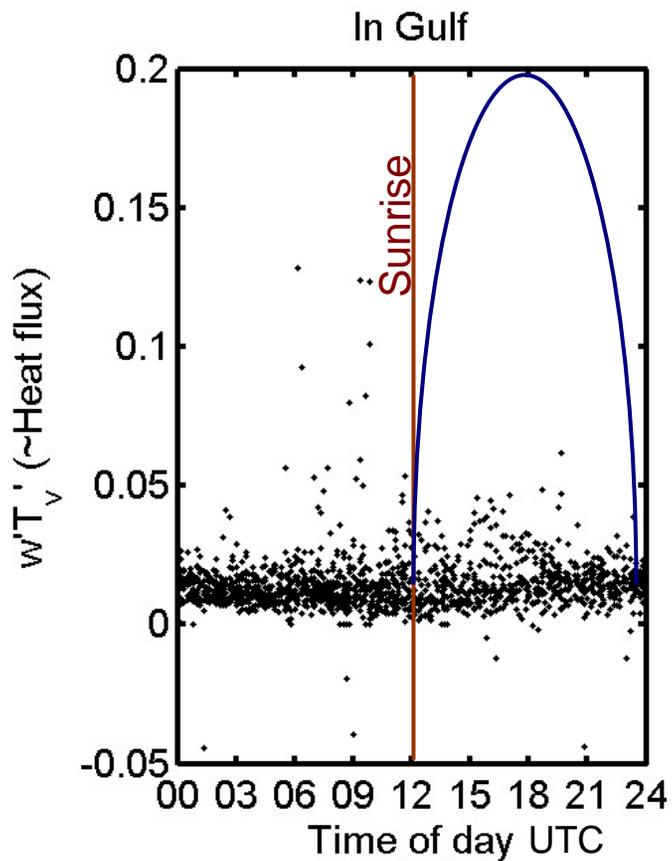
# Surface fluxes over water

- Surface fluxes (especially heat flux) drive the marine boundary layer
- Few previous measurements
- Findings
  - Water temperature warms during the day and cools at night in the Gulf and Bay, in phase with the air temperature
  - Heat flux is almost always positive, day and night
  - A (well?)-mixed layer of reasonable depth is almost always present

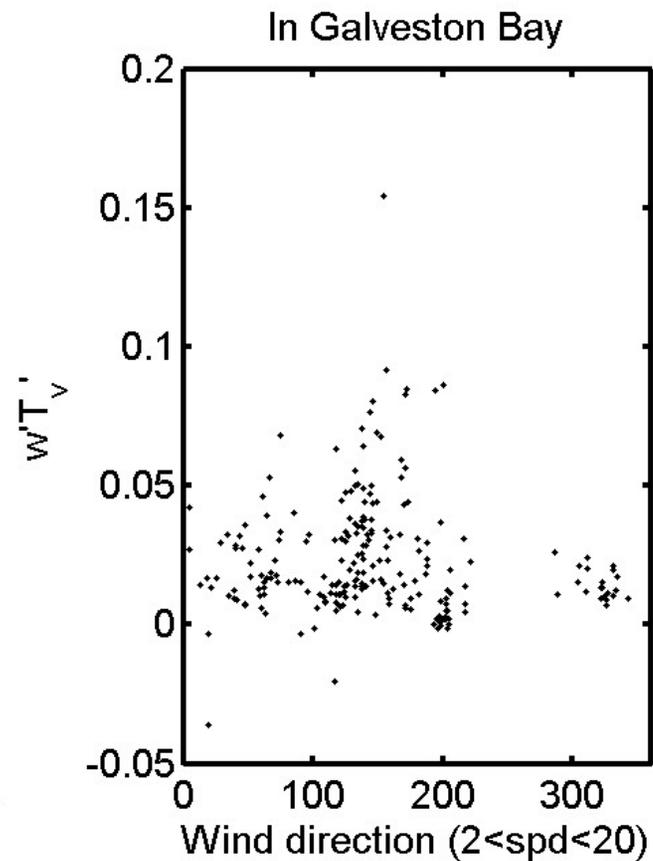
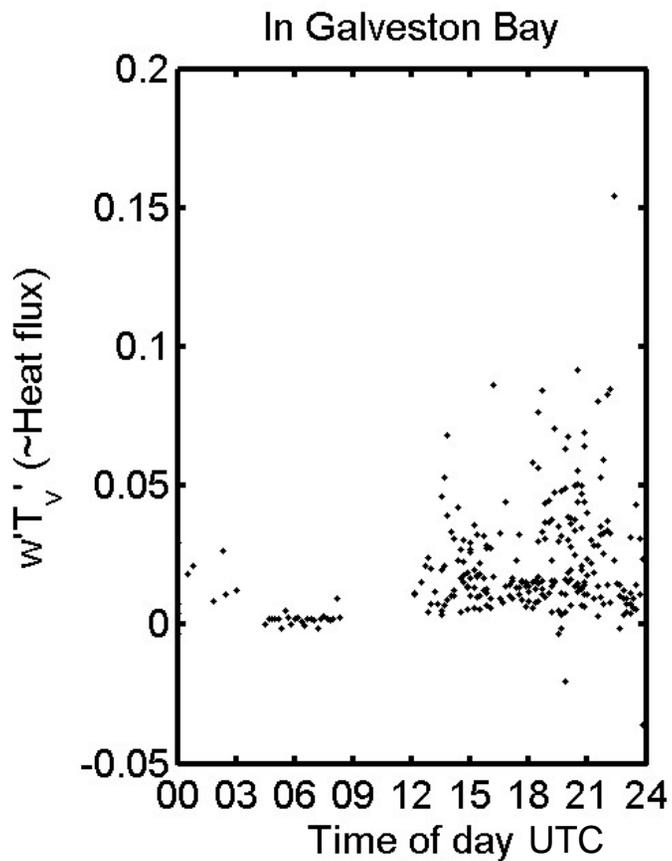
# Heat flux in the Gulf



# Heat flux in the Gulf



# Heat flux in Galveston Bay



# Boundary layer terminology (brief)

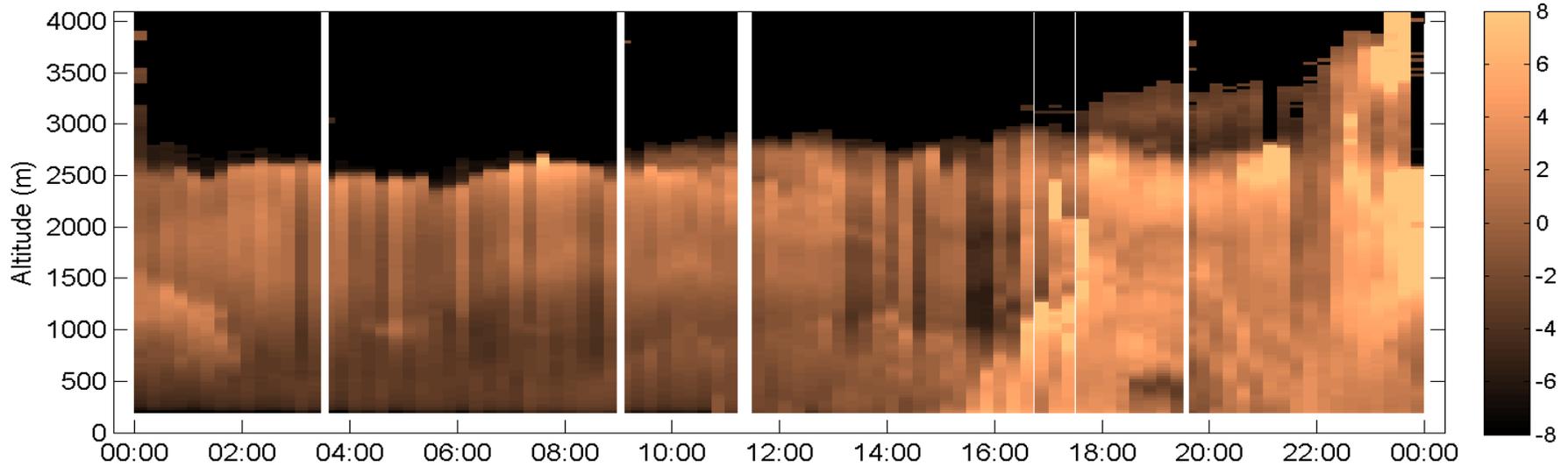
- Different instruments measure different physical quantities and are interpreted to produce various types of heights
- “**BL height**” is general but ambiguous – sometimes all definitions agree!
- “**Mixing height**” = the height to which some surface-emitted constituent is mixed on a time scale of ~1 hour
- “**Aerosol layer height**” = the height of a (surface-based) layer of different aerosol content

# What BL height measurements do we have?

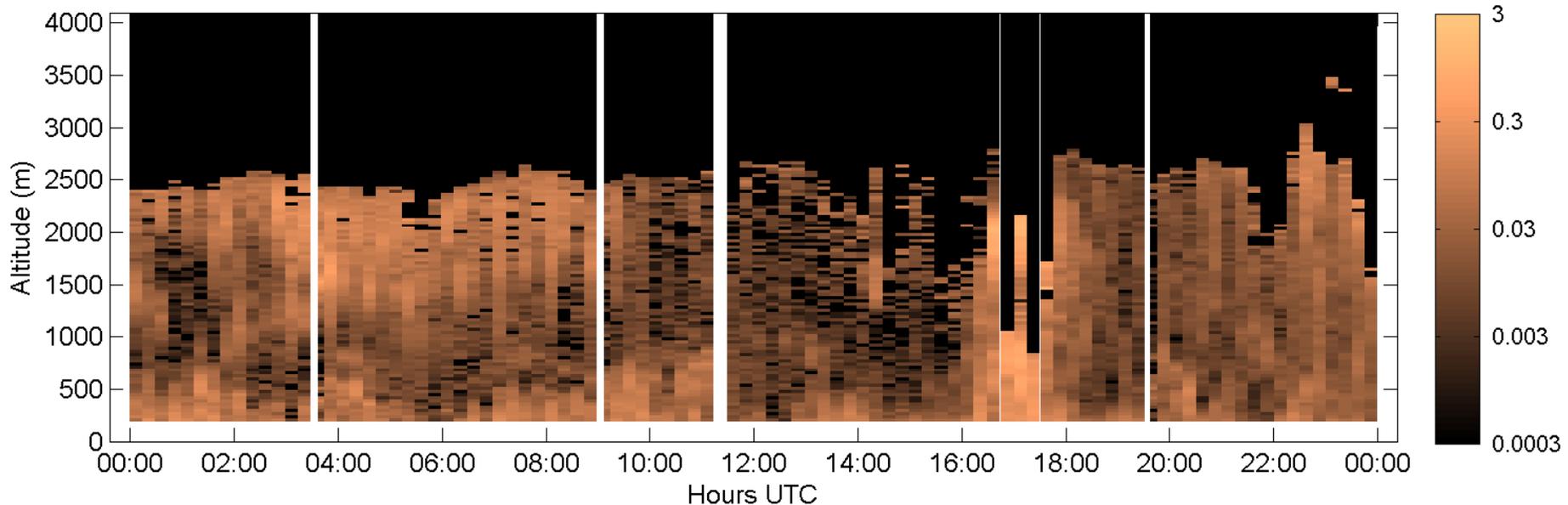
- Land-based wind profilers
- Ship-based lidar
- Ship-launched radiosondes
- Lidar aircraft
- In-situ aircraft soundings
- Land-based sondes
- Others....

# BL heights from ship-based lidar (HRDL)

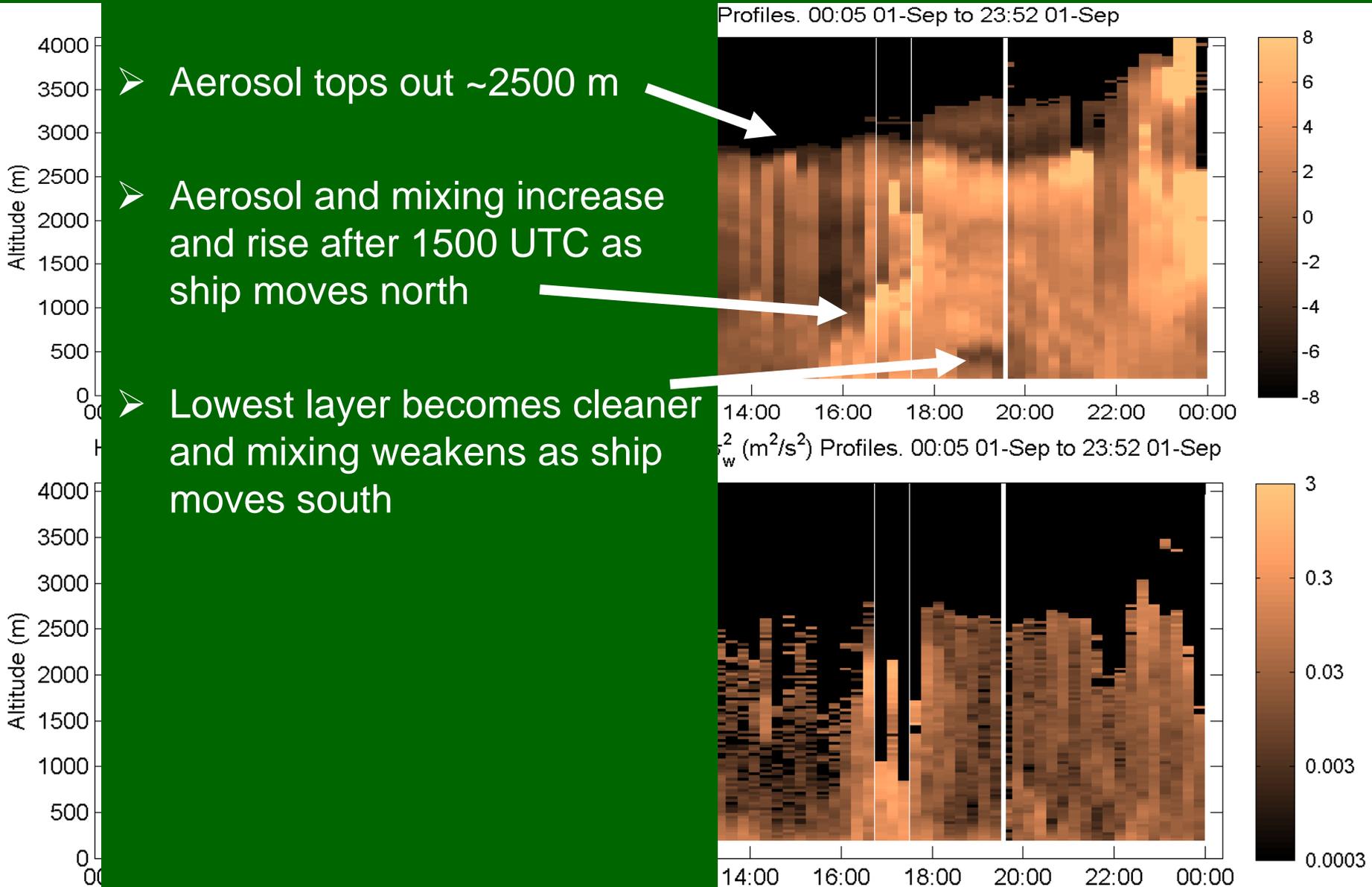
HRDL RV Brown TexAQS 2006 - Relative Aerosol Profiles. 00:05 01-Sep to 23:52 01-Sep



HRDL RV Brown TexAQS 2006 - Vertical Velocity Variance  $\sigma_w^2$  ( $m^2/s^2$ ) Profiles. 00:05 01-Sep to 23:52 01-Sep

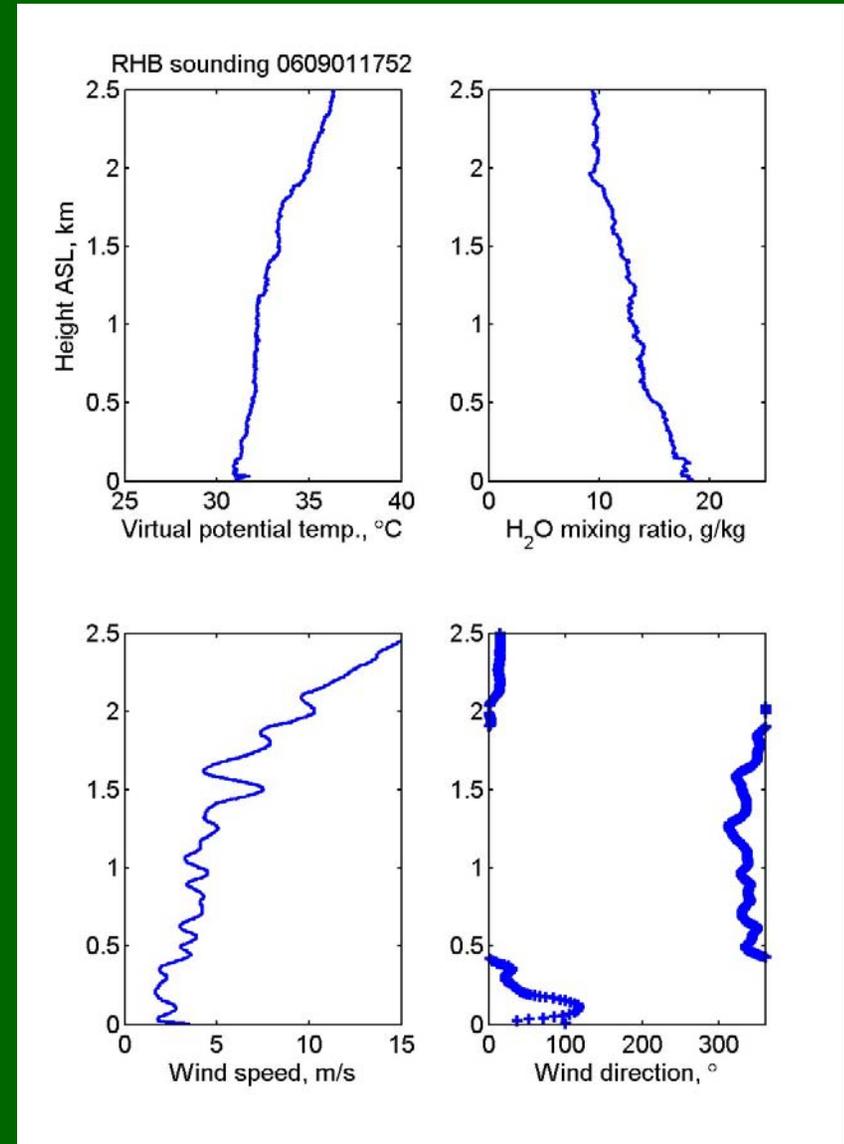


# BL heights from ship-based lidar (HRDL)



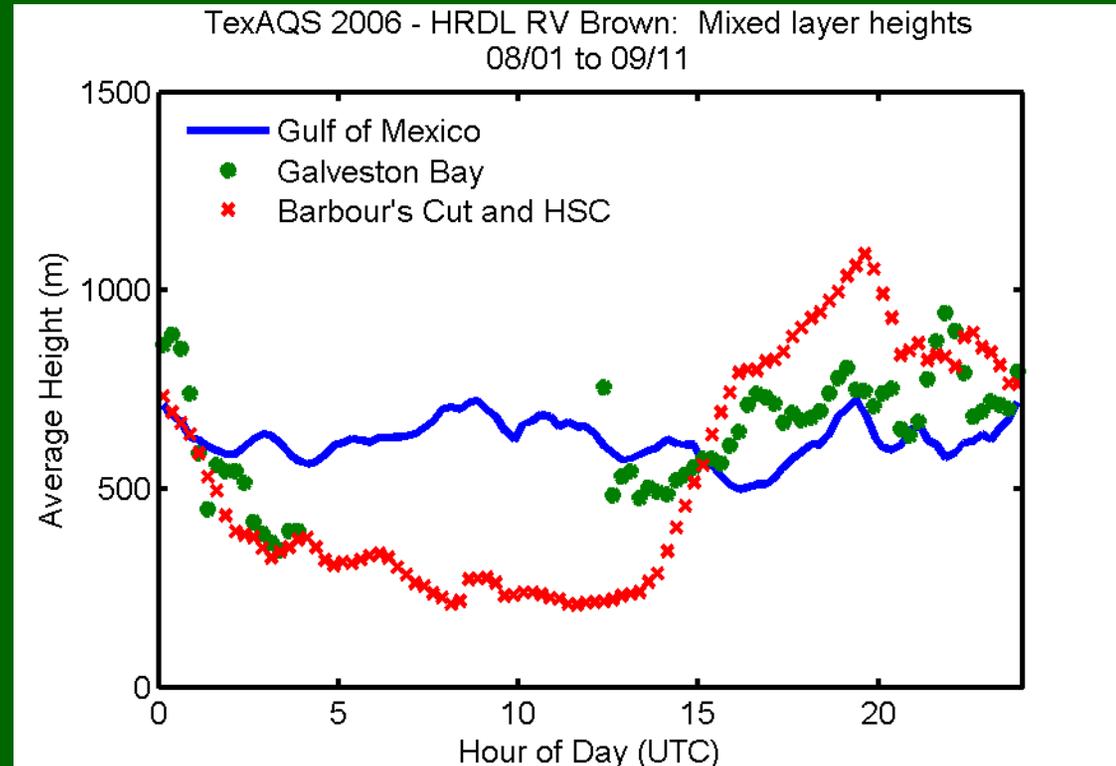
# BL heights from ship-launched radiosondes

- 1 September 18Z at Barbour's Cut, near time and place of peak ozone observed at the ship for the entire campaign (>170 ppb)
- Note multiple layers with "tops" at 200, 1200, 1800 m

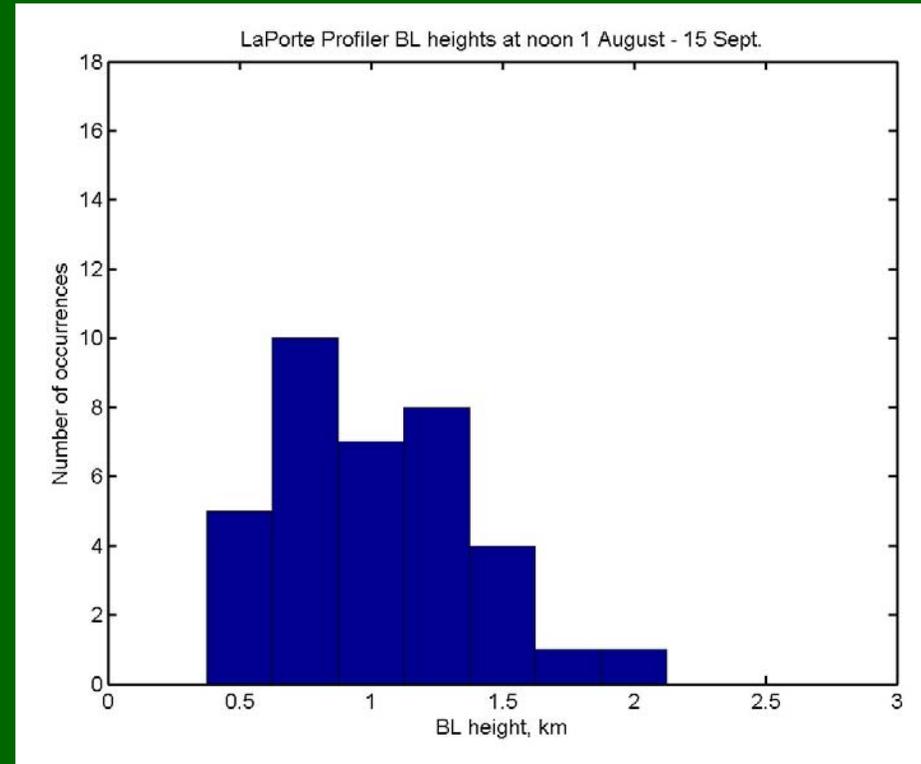
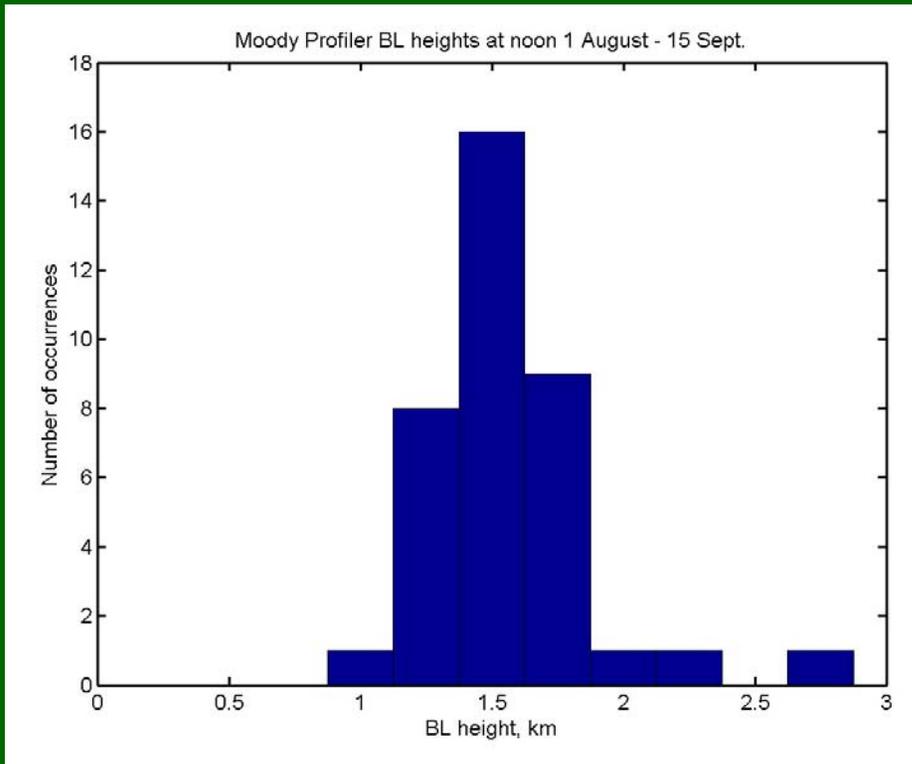


# Mixing heights over the Bay and Gulf

- Average mixing heights from a combination of lidar techniques
- Some diurnal cycle in Bay averages (including some land influence)
- BC and HSC are strongly influenced by surrounding land



# BL height distributions at midday from Moody and LaPorte profilers



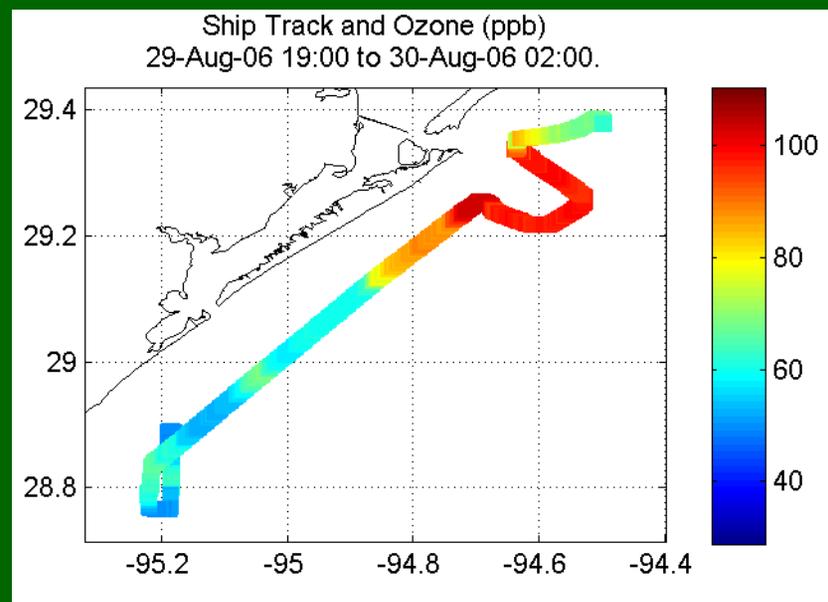
- Lower heights, broader distribution, and lower confidence at LaPorte

# Are mixing heights lower over Galveston Bay?

- Yes, generally lower than over nearby land at midday
- Mixing height often not well defined due to “soft” top
- Difficult to perfectly remove land influence, especially when ozone is high
- For example, Sept. 1
  - ozone peak is on the edge of a reduction in mixing height – is this water or land?
  - LaPorte profiler BL height ~1.5 km
- Generally BL heights over Bay are 500-600 m at midday
- LaPorte profiler BL heights 500-1800 m at midday

# Are BL structure anomalies associated with ozone and/or aerosol events?

- 29 August ozone and aerosol offshore
- Unusually low heat flux and turbulence in plume (blob) from Houston
- Aerosol layer is deep (~1.5 km)
- LaPorte BL height max 1.3 km
- Sounding is near-neutral up to ~500 m and only slightly stable above that – difficult to define BL height



# Summary

- BL over water is almost always weakly mixed, with positive heat flux and 500-600 m depth
- Mixing heights are generally lower over Galveston Bay than over nearby land at midday
- Boundary layer behavior is complex
- Good news:
  - We have lots of measurement resources
  - Surface measurements are representative of a deeper layer than in New England
  - We're available to consult and collaborate