Mesoscale Organization in Summertime Cumulus-Coupled Stratocumulus Observed at the Eastern North Atlantic Observatory

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ASR Atmospheric System Research

Background and Goals

MARINE BOUNDARY LAYER CONVECTIVE COMPLEXES (MBLCC)

- Cumulus-coupled stratocumuli can organize into mesoscale structures of different sizes across the transition region and this organization may play a critical role in the **cloud radiative forcing** over the ENA and in other transition regions.
- During the ***organizing phase*** in the transition process, cumulus-coupling may be present in the form of **marine boundary layer convective complexes** (MBLCC)

- **Goals**
  - ✓ Identify the distribution of horizontal scales of MBLCC mesoscale organization.
  - ✓ Investigate physical processes associated with the organization, such as drizzle, wind, and surface fluxes.

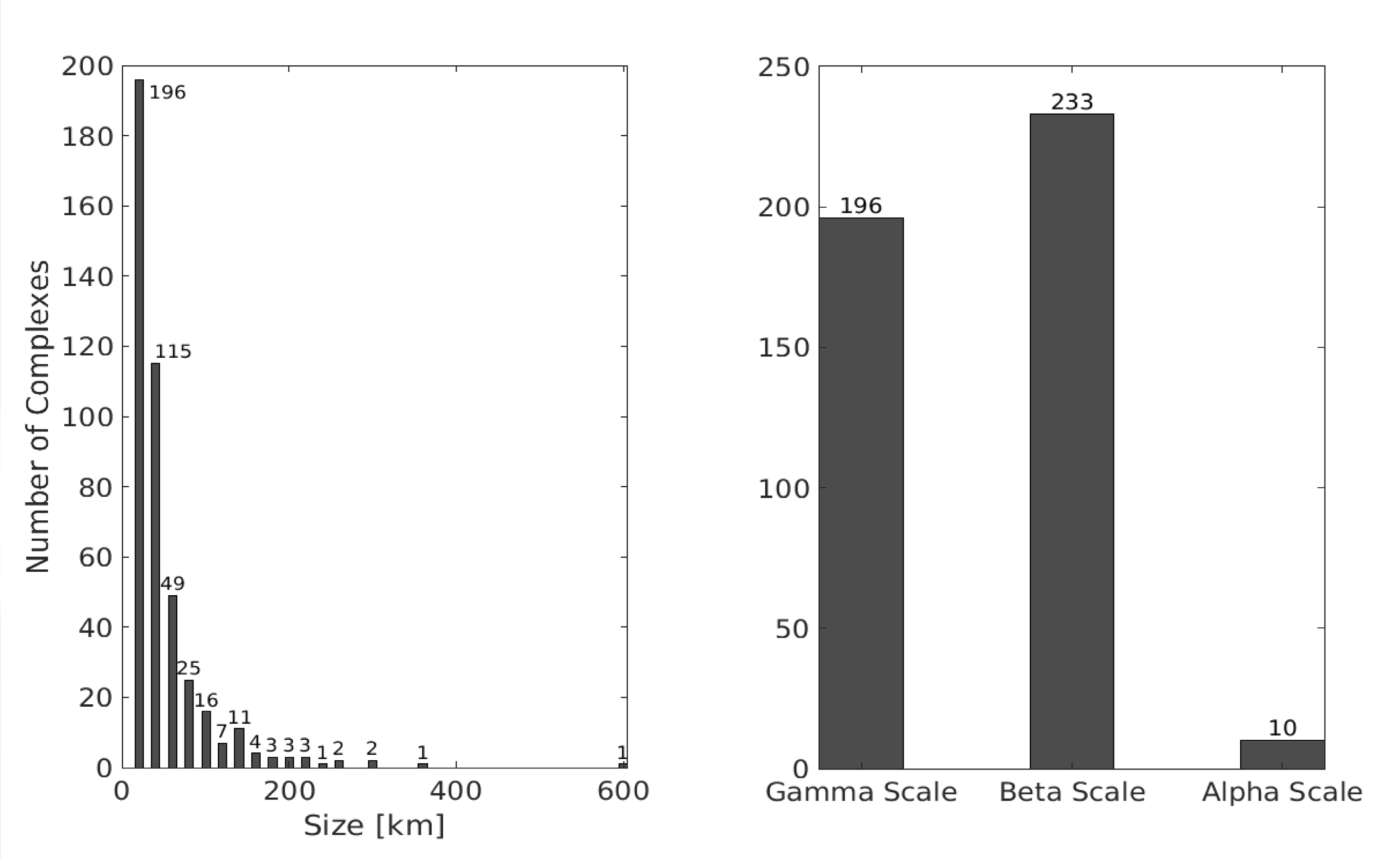

Fig 2: MBLCC size distribution (left) and numbers of structures per scale.

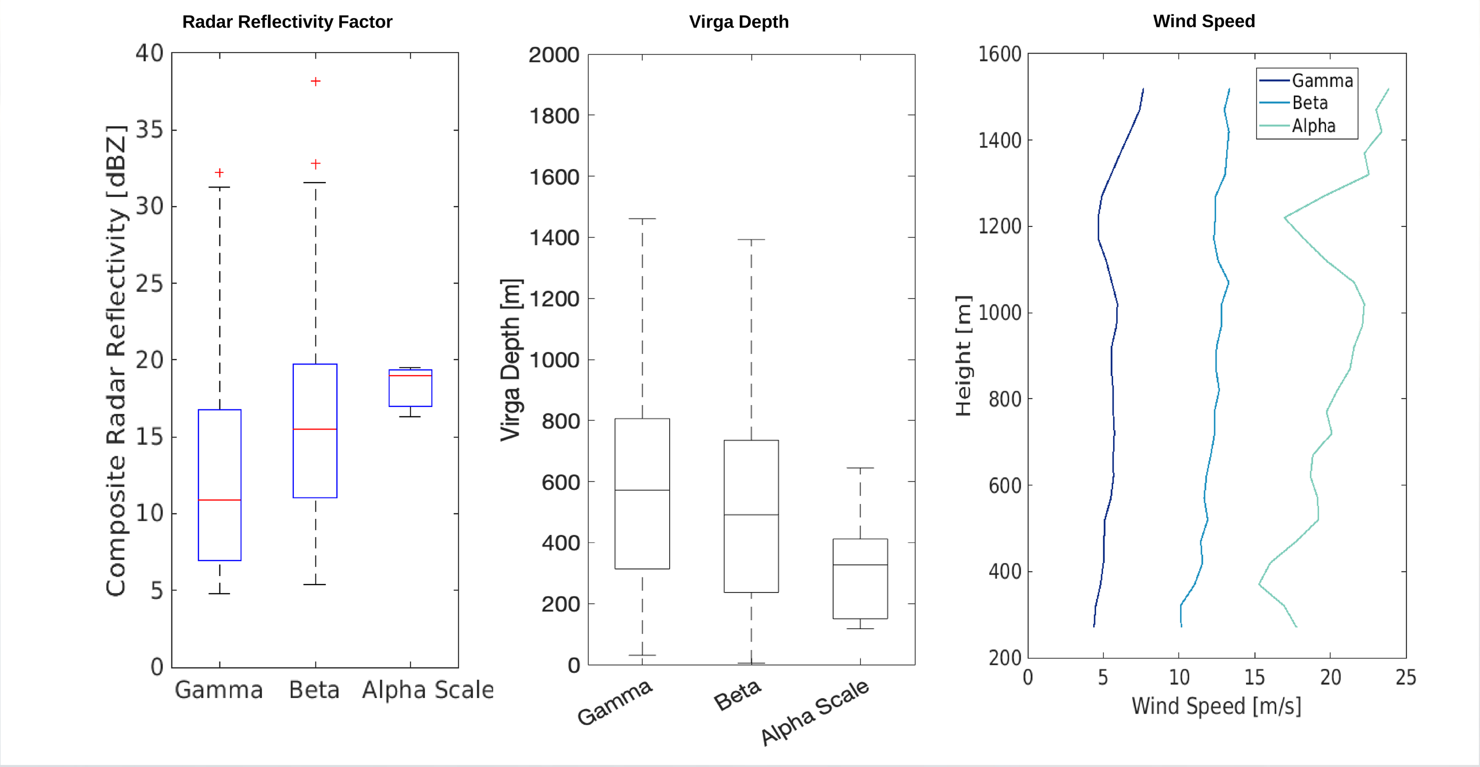

Fig 3: Comparison of average radar reflectivity factor (left), virga depth (middle), and wind speed among gamma, beta, and alpha scales.

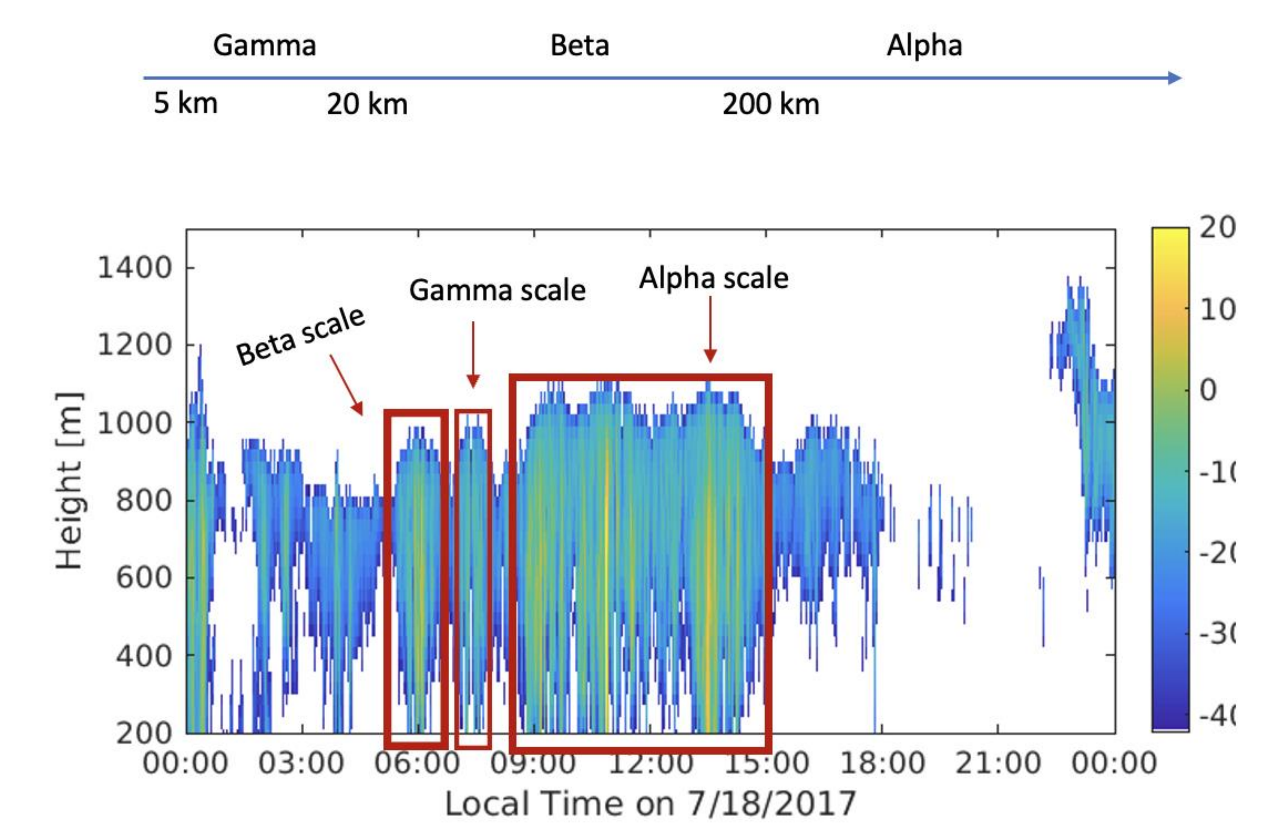

Fig 1: MBLCC scale example.

MBLCC Organization

Structures observed during 2016-2019 summertime

- **To identify MBLCC:**
  - 30-minute composite KAZR effective reflectivity profiles and appropriate thresholds applied.
  - <u>Time – space conversion</u> based on sub-cloud wind speed from wind profiler was used to determine sizes.
  - Possible island impacted data removed based on wind direction.
- A total of **439 structures identified**, with horizontal scales ranged from 2 km to nearly 600 km.

  45% gamma-scale ($2\ km \leq L < 20\ km$),
  53% beta-scale ($20\ km \leq L < 200\ km$),
  2% alpha-scale ($L \geq 200\ km$).

Mesoscale Comparisons

Radar reflectivity factor/ virga depth/ wind speed

- <u>As the scale increases:</u>
  - Larger radar reflectivity factor, which indicates **larger drizzle rate**.
  - Lower virga depth (difference between radar and optical cloud depth), indicating a **larger sub-cloud evaporation rate**.
  - Larger wind speed.
- **<u>Drizzle evaporation rate and windspeed are crucial in determining the mesoscale horizontal scale and organization of MBLCC over the Eastern North Atlantic.</u>**

Surface Thermodynamics

IMPACTS OF MBLCC AT THE SURFACE

- Conservative variable analysis used to examine vertical exchanges between the airmass near the ocean surface and the desiccated airmass in the elevated decoupled layer.
- The standard deviations in the θ_e computed over 30-minute periods were used as a measure of interactions between the surface air mass and the decoupled layer.
- A **high pass filter** was applied to thermodynamic variables to eliminate any changes due to diurnal cycles or other variations not associated with the cloud-event itself.
- The **<u>power spectral densities</u>** for equivalent potential temperature retain a **strong peak at the 24-hour frequency related to airmass modification on this scale.**
- Beta scale MBLCC exhibit larger σ_{θ_e} indicating larger vertical gradients in θ_e and/or greater mixing depths.
- σ_{θ_e} driven primarily by σ_q regardless of horizontal scale.

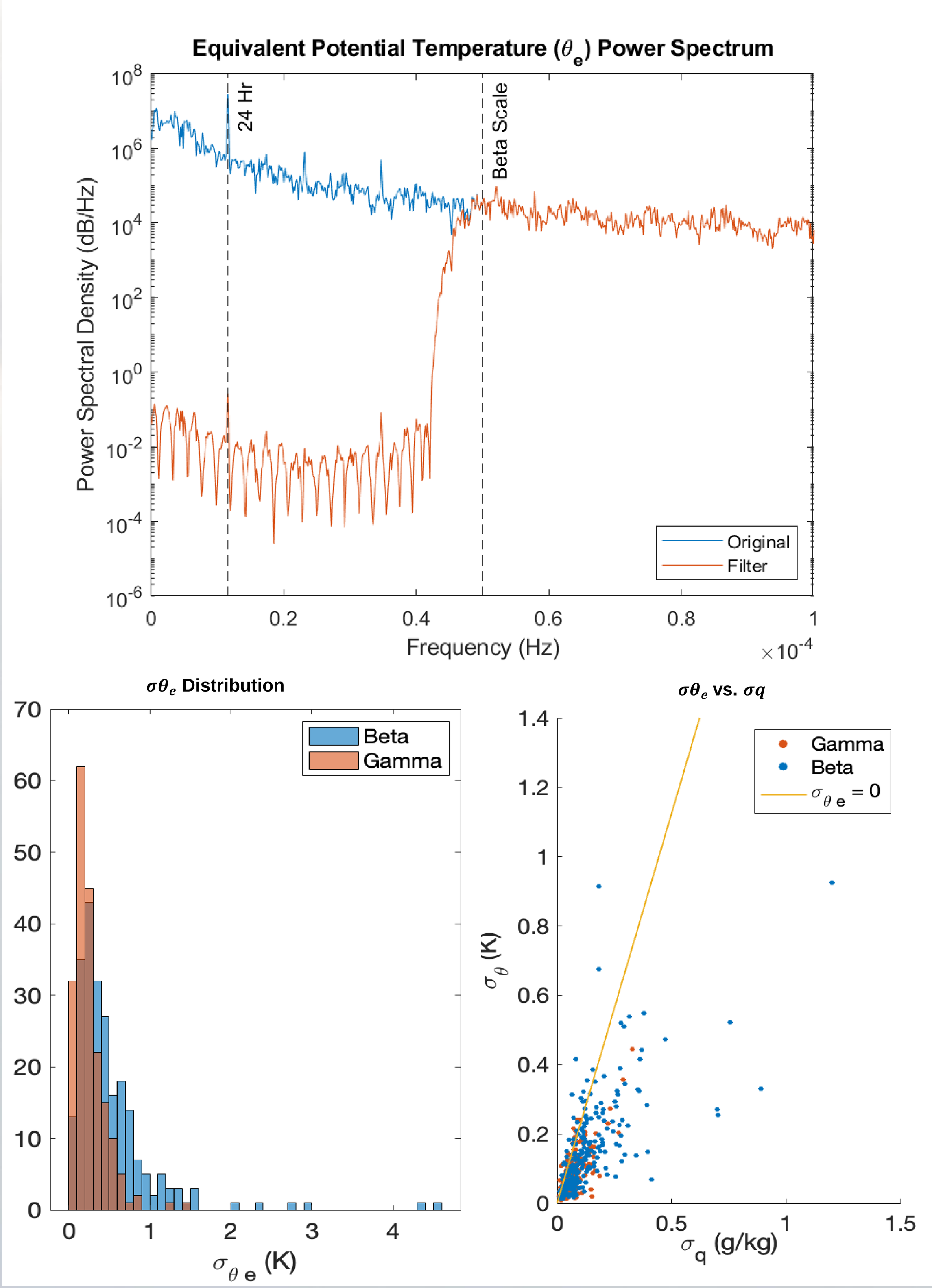

Fig 4: θ_e power spectral density (top), θ_e distribution by scale (bottom left), and standard deviation of specific humidity vs. potential temperature (bottom right).

Summary

- 98% of MBLCC structures are meso- gamma or beta scales.
- Larger drizzle rate, larger wind speed, and lower virga depth are associated with larger scales.
- Vertical exchanges between the surface and the decoupled layer are dominated by changes in water vapor concentration and more substantial as the horizontal scales of MBLCC increase from Gamma to Beta.

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