AMMA Downstream and the Atlantic Seedling Hurricane Experiment (ASHE)

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Why Investigate Eastern Atlantic Hurricane Formation?

• African easterly waves create 90% of intense Atlantic hurricanes.

• Fewer than 10% of easterly waves spawn named tropical cyclones. Why?

• Evolution processes are poorly understood, but recent work indicates importance of both large-scale and mesoscale processes.

• Cyclogenesis occurs over remote eastern and central Atlantic and has been poorly documented by direct observing platforms.
Objectives

1. To address significant gaps in our knowledge and observations of the early hurricane development processes in the eastern North Atlantic, which cover a range of time and space scales, by:
   - Taking advantage of the AMMA observations over Africa to well define the upstream and easterly wave structure;
   - Investigating the scale interactions that lead to hurricane formation, with particular attention to wave accumulation and mesoscale interactions;
   - Investigating the role of external parameters, such as energy from the ocean surface and the impact of Saharan dust on moist convection.

2. To further develop UAV technology for use as an environmental observing system and provide ground truth information for satellite remote sensing observations
Hurricane Development in Eastern North Atlantic

So what makes hurricanes develop here?

• Constrained to a narrow latitudinal band;
• Extends from Africa to the Windward Islands
• Source of many major hurricanes that have effected the US
Easterly Wave Statistics

ECMWF, Criteria: $\zeta > 0.5 \times 10^{-5}$, Last > 2 days, Travel > 1000 km

Thorncroft and Hodges (2001)

Note:

- The development area off the African coast;
- The minima in frequency and development through the Caribbean;
- The strong relationship with eastern Atlantic Hurricane formation.
Reasons for Wave Development off African Coast

- Available moisture (e.g. Thorncroft and Hodges 2001);
- Wave accumulation (Holland and Webster 2004)

Note:
- The maximum easterly flow at the African coast,
- The decrease in easterlies extending to the Windward Islands,
- The strong relationship with hurricane formation.
Wave Accumulation

When Rossby-mode waves move into regions where the zonal flow is becoming more easterly towards the east (dU/dx<0):

• The wavelength decreases;

• The group speed decreases and may go to zero, leading to trapping (requires westerly winds); and,

• The energy density and vorticity increases.

Webster and Chang (1997)

The observed easterly wave development and hurricane formation zones in the eastern North Atlantic are closely aligned with the region of wave accumulation from the mean zonal flow.

This will be a major focus of Downstream AMMA and ASHE
Mesoscale Interactions

Development, interaction and role of mesoscale vortices

Boundary layer, especially impacts of cold downdrafts

Establishing the ocean flux connection
Experimental Concept

• Obtain data suited to a detailed theoretical and modeling study of the genesis and non-development processes.

• Tie into existing experimental programs
  – AMMA (Upstream)
  – NOAA’s Summer Hurricane Program
  – TCSP (Summer 2005, will provide valuable lead information on wave accumulation and mesoscale processes)
Proposed Observing Systems

- Utilize current satellite systems (broad view)
- Driftsondes (wave-scale view)
- NOAA/HRD Aircraft (detailed view)
- Aerosonde (extended monitoring of bdy layer and mesoscale)
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- Improved understanding of the complex interactions leading to cyclogenesis from easterly waves in the eastern Atlantic
- Test of potential new observing systems.

THANK YOU