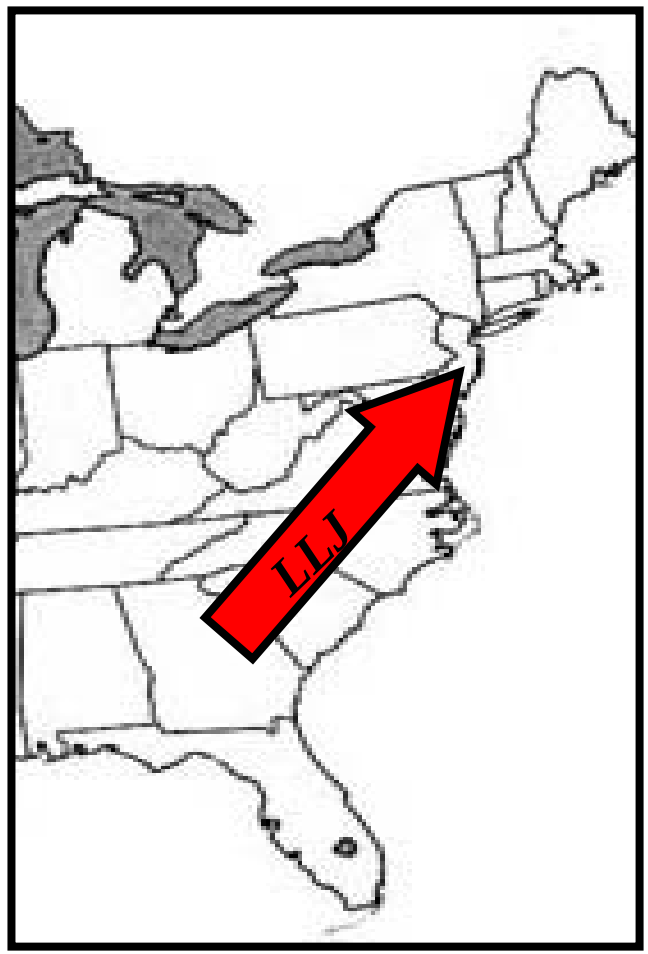
Why is the Low Level Jet Important to the Baltimore/DC Region?

MWAQC-TAC Meeting

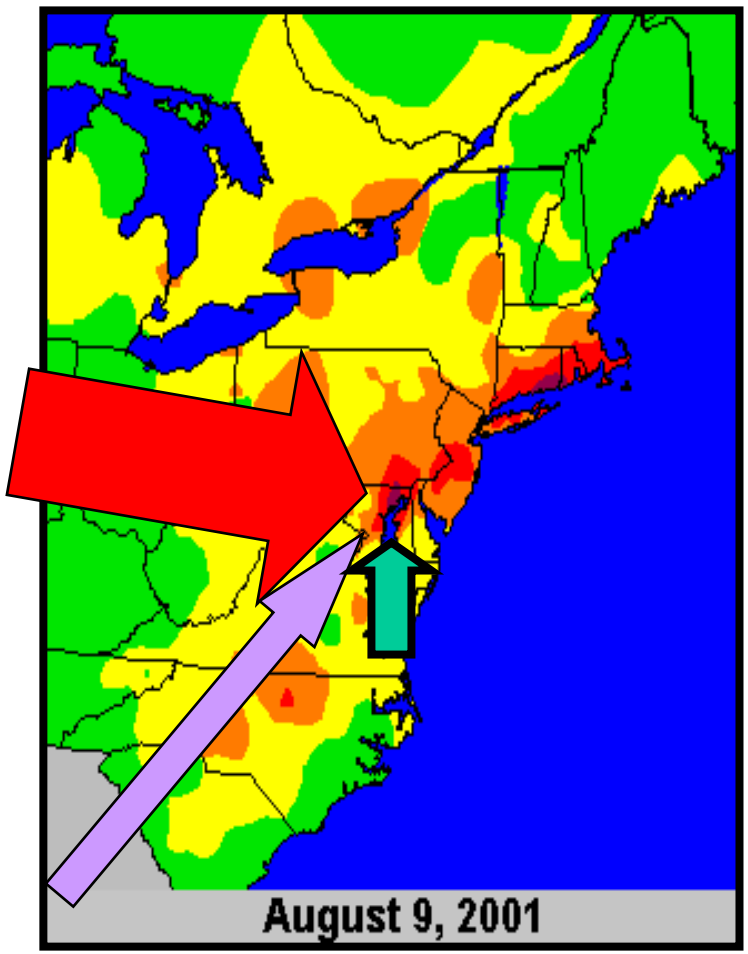
January 21, 2005

Outline

- Types of Transport
- LLJ Basics
- Why is it important?
- Examples:
  - Upper Air Profiler data
  - Lidar data
  - Modeled data
- Future Studies
- Conclusions



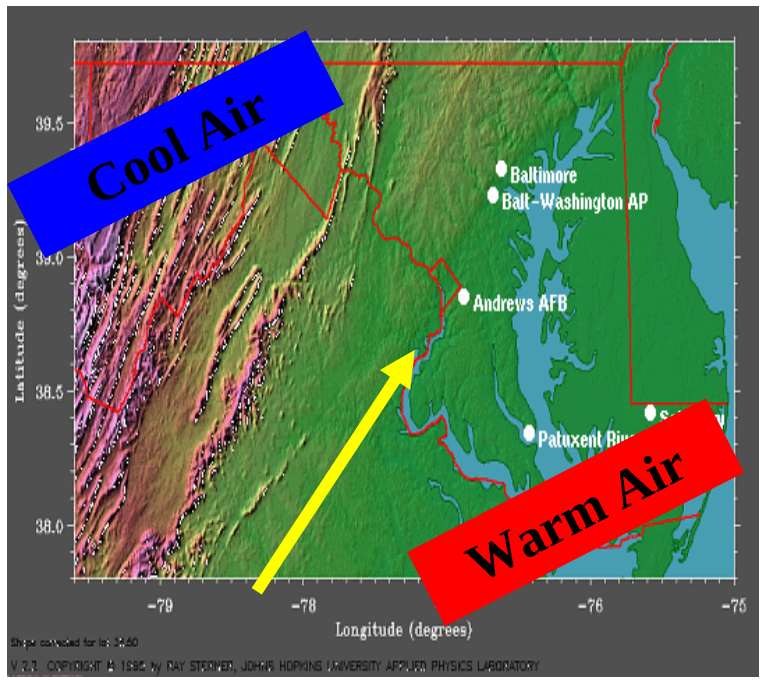
Three Types of Transport That Affect Maryland



- Short range
  - VA to MD to PA, etc.
- Long range (synoptic scale)
  - 100s of miles
  - Generally from W or NW
- Low Level Night-time Jets
  - 100s of miles
  - SW to NE along the Atlantic
- All types of transport move an “elevated reservoir” of ozone and ozone precursors into the Washington region

Low Level Jet (LLJ) Formation

- Forms between the Appalachian Mountains & Atlantic Ocean
- At sunset the ground cools/ air poor conductor of heat/air close to ground cools too (~100 meters)
- Air over the mountains cools more than the air at the same elevation near the coast
- This temperature gradient induces a southerly wind a few hundred meters above the ground



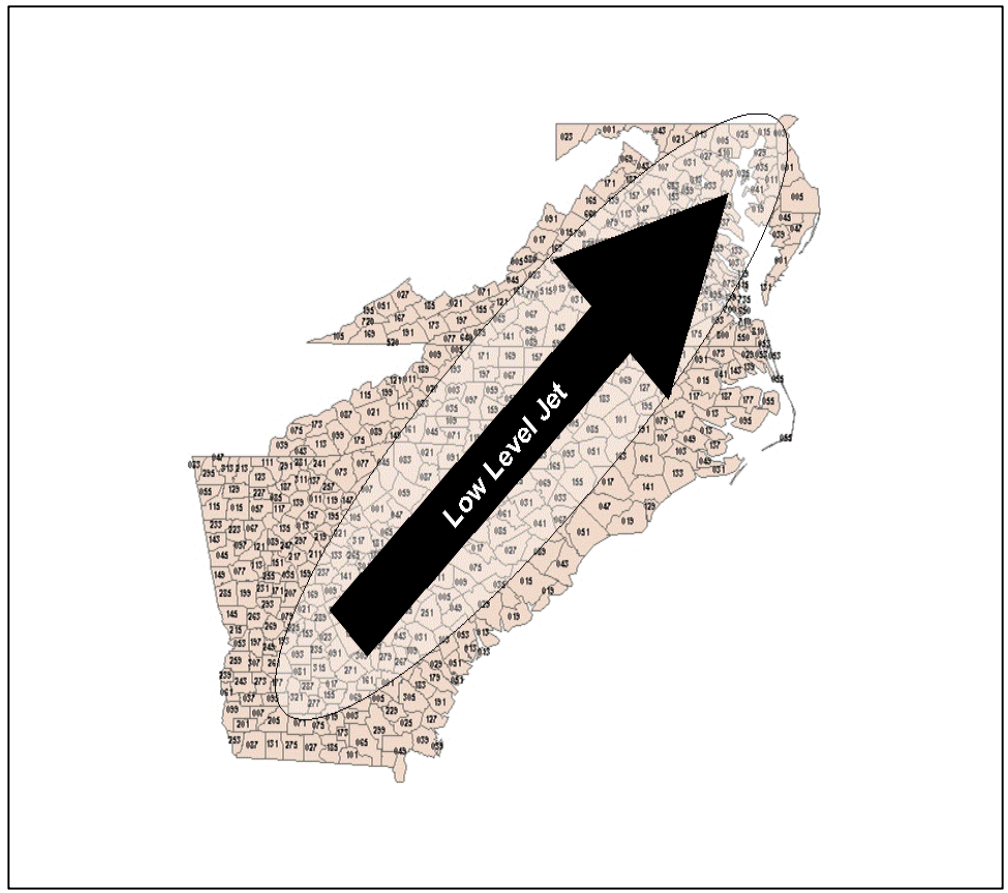
What pollutant levels are in the Low Level Jet?

- Still analyzing this issue
- Theory and recent work by Penn State and Millersville Universities around Philadelphia indicates that the low level jet transports significant pollutant concentrations

  (using laser technology called LIDAR and instruments suspended from tethered balloons)

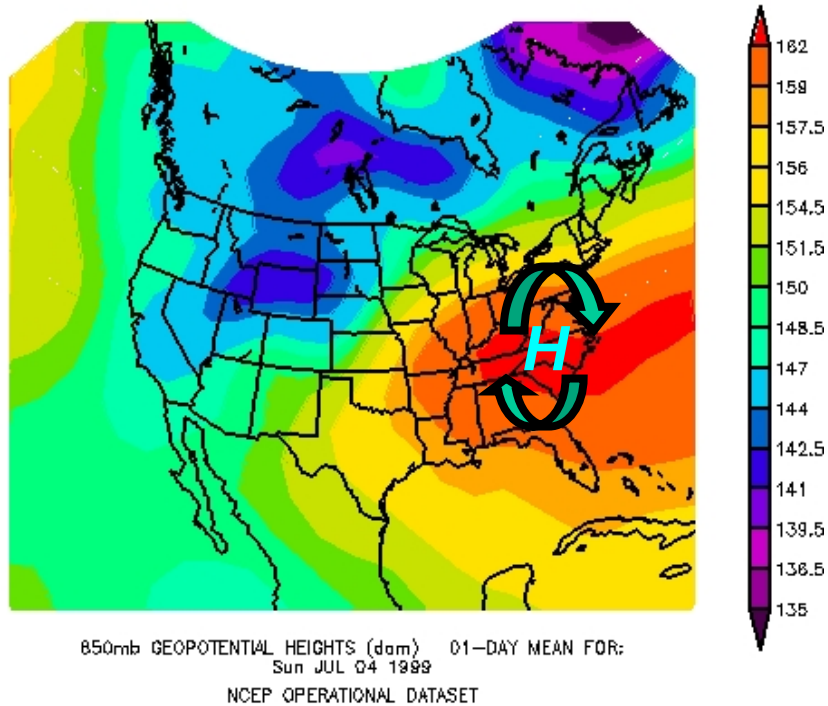
Area of Influence

- Pollutants in LLJ generally come from ground level sources such as vehicles and small businesses
- Chart reflects the area of influence pertinent to the Washington DC nonattainment area
- Expansion of control programs already in use to attainment and nonattainment areas in this region would reduce ozone loads in the Washington region



LLJ and Summer Weather

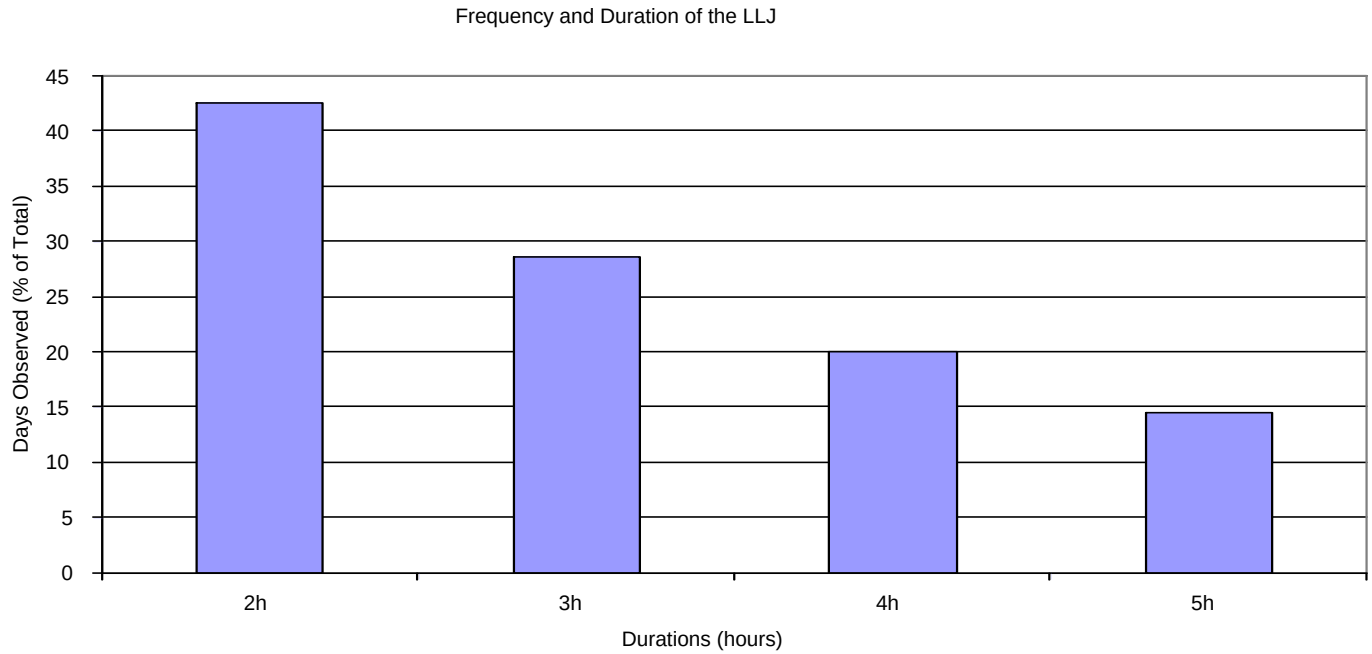
- LLJ usually develops when weather patterns conducive to high ozone occur
- “Bermuda High” sets up south of Maryland



LLJ Location

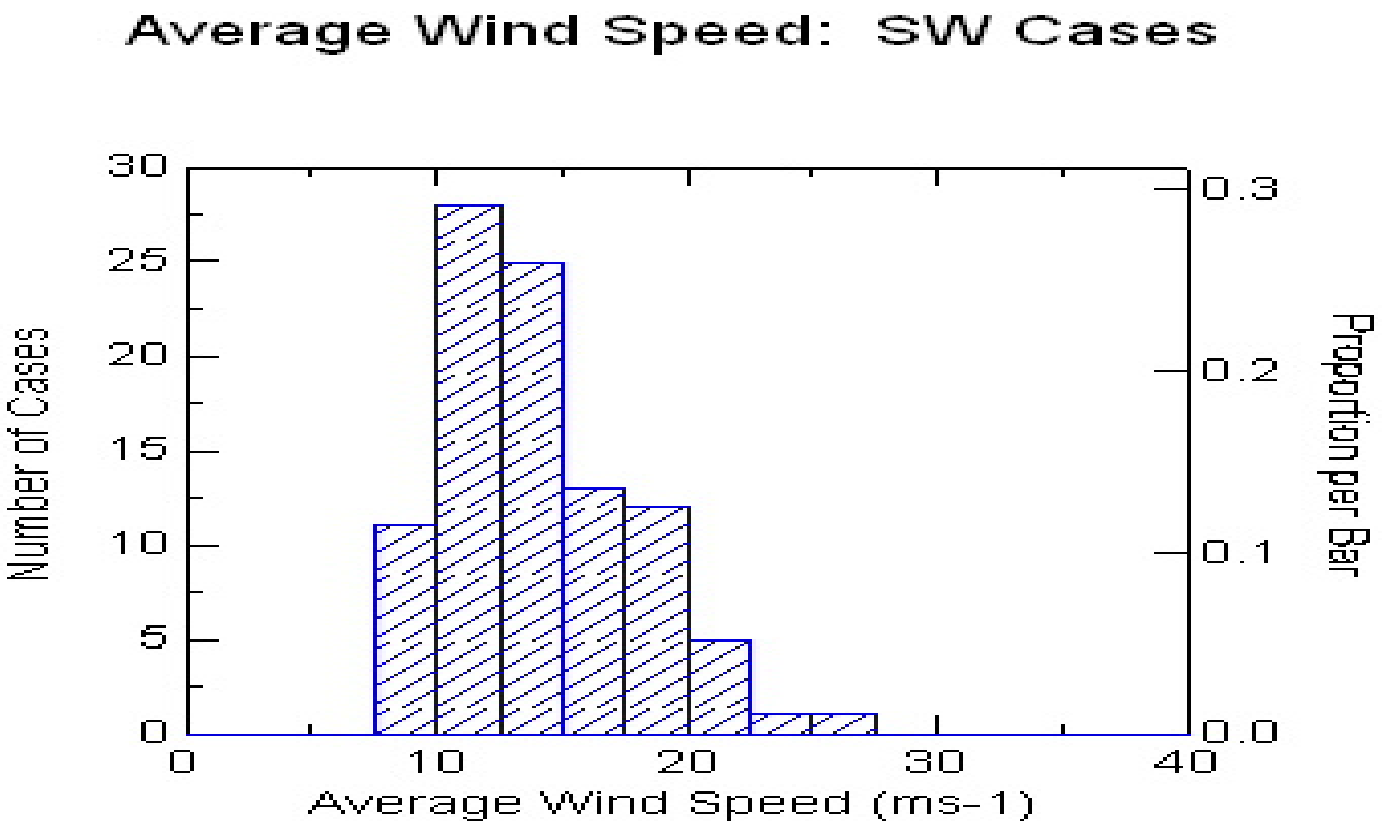
- LLJ forms just above the nocturnal inversion
- This well mixed layer is referred - “Residual Layer”
- Contains that day’s ozone and ozone precursors (aka Elevated Reservoir)
- Residual layer non-urban areas during high ozone episodes contain 80 – 110 ppbv per aircraft measurements

LLJ Duration



- Transport relevant threshold set at 5 hrs
- Short duration of 2 hrs are ~3 times as frequent

LLJ Characteristics

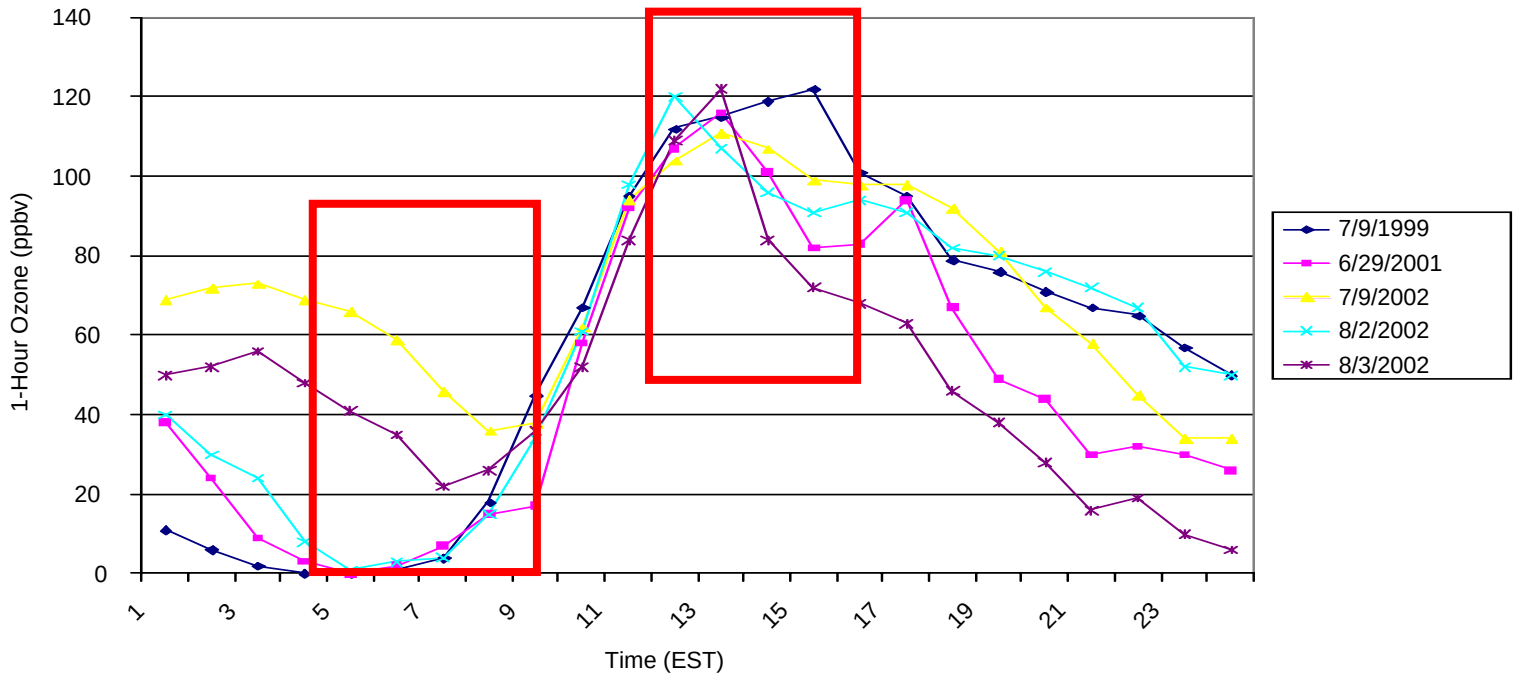


- Ribbon of fast moving air
  - Average wind speeds ~22 mi/hr – ~ 45 mi/hr

Research Implicates LLJ in Transport

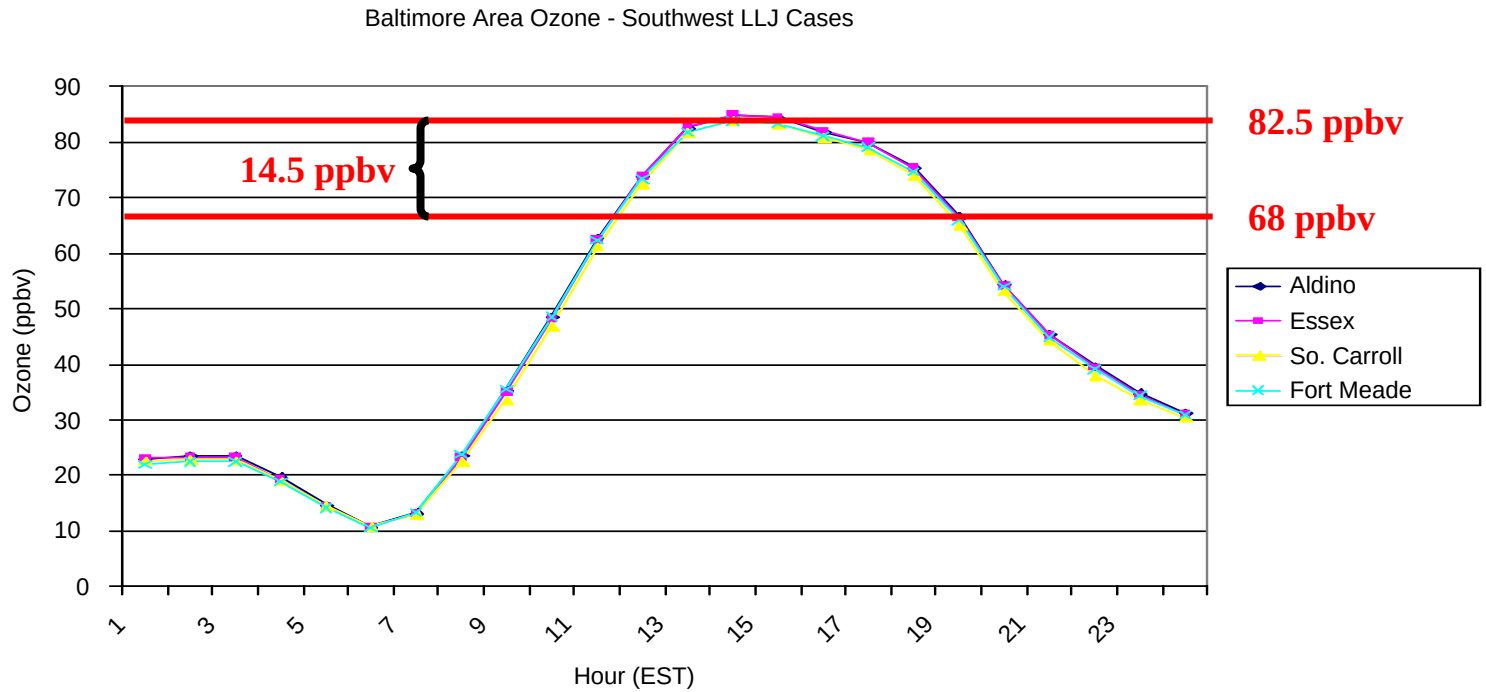
- Routinely occurs during high ozone episodes
  - 44% of LLJ cases are Code Orange for 8-hour ozone (>= 85ppbv)
  - 22% of LLJ cases are Code Red for 8-hour ozone (>=105)
  - 70% multi-day events (>=3 consecutive days at or above 85 ppbv for 8-hr average), experienced a LLJ
  - 42% of days days when the 8-hr average was >=105 ppbv, experienced a LLJ
- Transports both ozone and ozone precursors (NO_x and VOCs)
- Contains approximately 60 – 80 ppbv ozone based on lidar measurements

LLJ and Ozone Concentrations



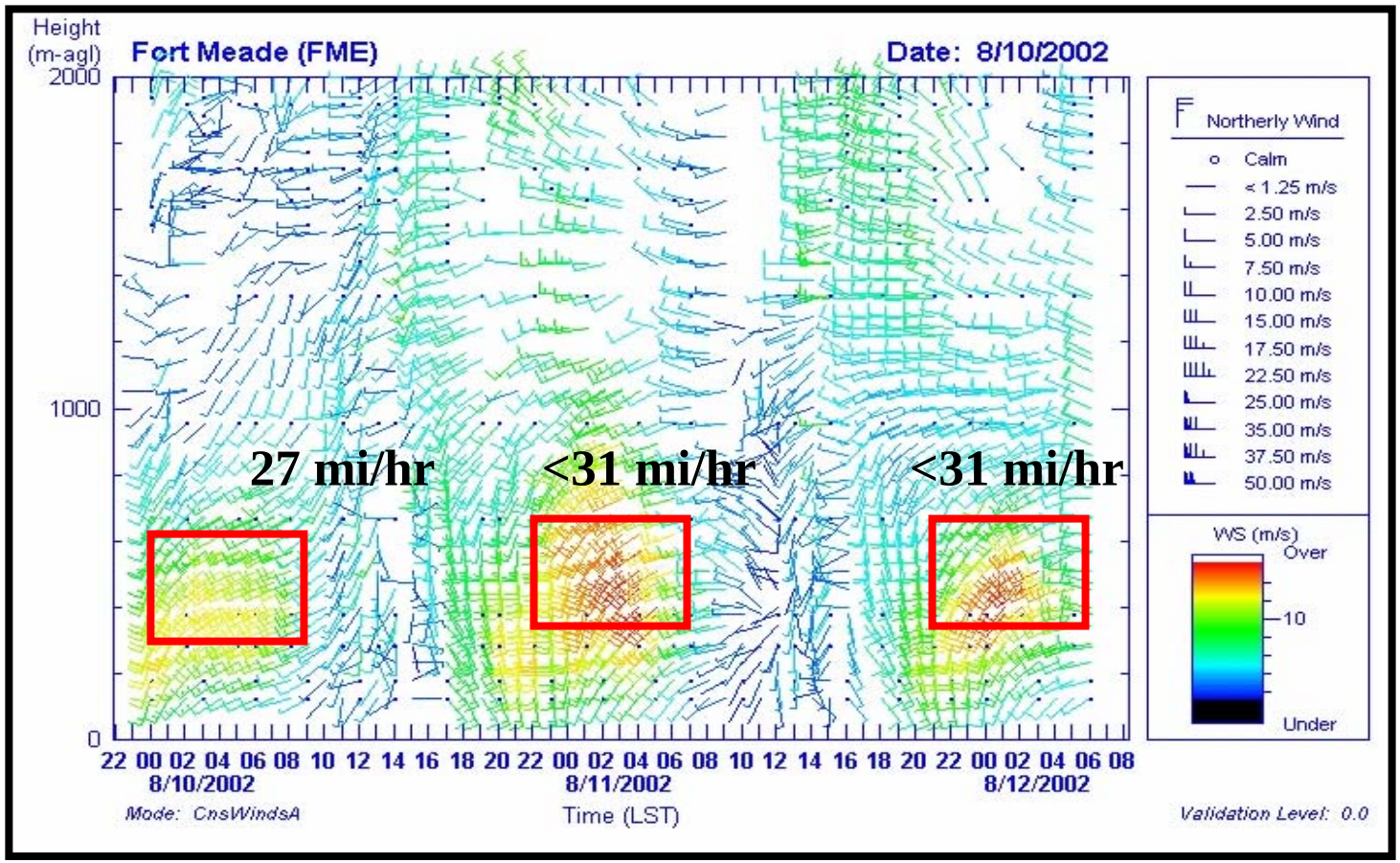
- Fort Meade ozone when a LLJ is observed

LLJ and Ozone Concentrations

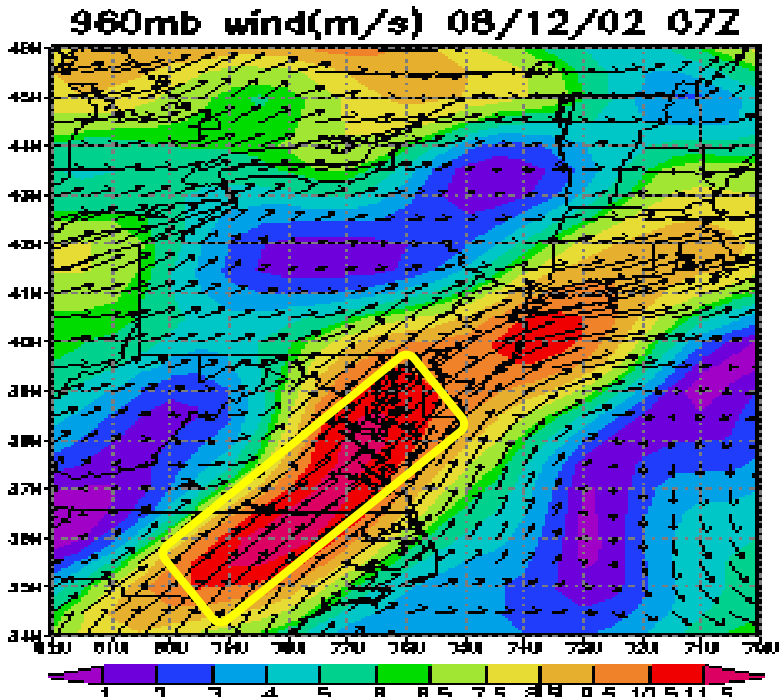


- The SW nocturnal LLJ is associated with high ozone
- The mean peak ozone for LLJ cases is 82.5 ppbv compared to 68 ppbv for all summer cases

Ft. Meade Profiler



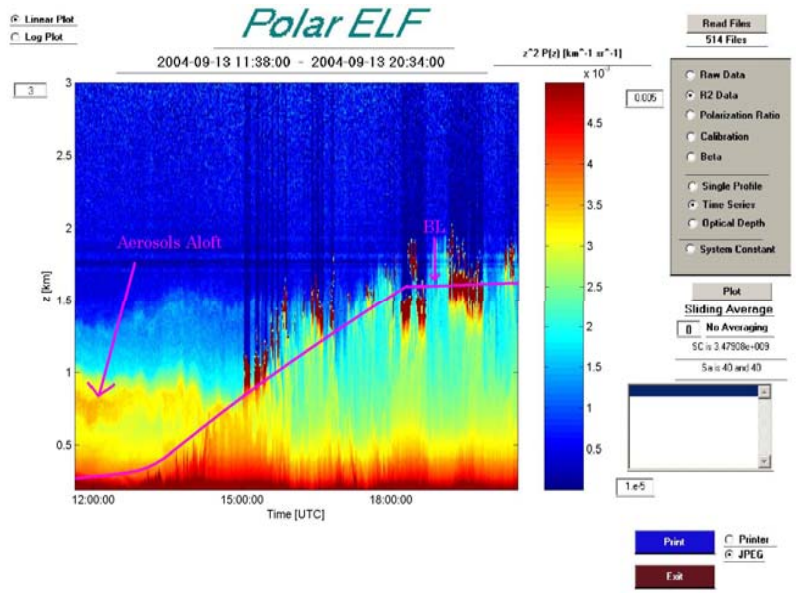
Modeled LLJ



- Rapid Update Cycle (RUC2) Model representation of the low level jet
- Can be predicted

Lidar

- Studies by the PSU using a lidar measured between 80 – 90 ppb of ozone being blown into Philadelphia at night.
- Ozone precursors
- This mixes down to the surface in the AM hours



Future Studies

- Early morning aircraft measurements in the LLJ
  - Due to flight restrictions will be flown over Virginia
- Deploy balloons when conditions are right
  - Vertical profile of ozone concentrations
- Lidar measurements
    - Ozone and ozone precursors

LLJ Conclusions

- Transports both ozone and ozone precursors
- Area of Influence is from Georgia up through Virginia
- Lidar has measured ozone concentrations in the 60-80 ppb range (1-hr: 125 ppbv and 8-hr: 85 ppbv)
- The mean peak ozone for LLJ cases is 82.5 ppbv as compared to 68 ppbv for all summer cases

Conclusions

- Research has shown that transport is a dominant factor in Washington DC nonattainment for both ozone and PM fine
- Searching to find how much is local and how much regional
- Modeling does poor job of simulating transport *and* the effectiveness of control strategies in reducing transport

Promote Successful Strategies

- Primary goal is to push multi-pollutant legislation to more stringent caps in a shorter timeframe
- Through interactions with EPA and other states promote wide-spread adoption of area and mobile source controls
- Adopt cost-effective programs in Washington region
- Investigate viable ozone strategies, especially those suitable for co-control of PM, for local reductions in the near term

Seek More Wide-spread Regional Solutions

- Continue research
  - Investigate transport
  - Push for effective transport control
- Implement cost-effective strategies regionally
- Seek federal assistance
  - More widespread use of proven controls
  - Pro-active programs in source sectors where states are pre-empted from regulation

Acknowledgements

- William Ryan
  - Penn State University
- Charles Piety
  - University of Maryland College Park