Weather Challenges
for Advanced Aerial Mobility in Urban Environments

With a particular focus on winds

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Vertical Flight Society
Webinar #2: Weather Systems
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Weather Impacts

Ground Operations – Vertiports
• Servicing of aircraft
• Transferring passengers or cargo

Air Operations – Urban Setting
• Takeoff/departure & approach/landing
• Transition from vertical to horizontal flight
• En-route weather impact avoidance
• Noise generation & propagation
Geographic Influences
• Latitude
  - solar radiation, temperature, etc.
• Major water bodies
  - sources of moisture
• Mountains
  - range of altitude, air density, etc.
• Landcover gradients
  - differential heating

Other Influences
• Diurnal & seasonal cycles
  - atmosphere, vegetation, etc.
• Weather systems
  - winds, clouds, precipitation, etc.
• Cityscape
  - local-scale wind & turbulence
Variety of Winds

Thermodynamic Circulations
• Differential heating throughout day
  - land & water
  - mountain & valley

Pressure Gradients
• Frontal boundaries
• Downslope windstorms

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Thunderstorms
• Outflows & gusts
• Tornadoes

Cityscape
• Wind channeling
• Turbulence from buildings

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Windy Cities

What Matters Most?

• Sustained winds or gusts
• Spatial variance across metropolitan area
• Winds or turbulence across cityscape
Regional Wind Variation

Wind Roses

Los Angeles - KLAX
Van Nuys - KVNY
Fullerton - KFUL
Chino - KCNO
Costa Mesa - KSNA
Avalon - KAVX
Oxnard - KOXR

Traffic and nearby places

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Regional Wind Variation

Wind Speed >10 knots

- Los Angeles - KLAX
- Oxnard - KOXR
- Van Nuys - KVNY
- Fullerton - KFUL
- Chino - KCNO
- Avalon - KAVX
- Costa Mesa - KSNA
- Lancaster - KWJF

Seasonal Cycle
Diurnal Cycle

50 Miles
Regional Wind Variation

Los Angeles - KLAX

Oxnard - KOXR

Van Nuys - KVNY

Fullerton - KFUL

Lancaster - KWJF

Chino - KCNO

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Costa Mesa - KSNA

Gust frequency

Seasonal Cycle

Diurnal Cycle

50 Miles

Two Harbors

Catalina Island

Essential Fish Habitat...
Urban Wind & Turbulence – Dallas, TX

Urban Prediction Challenges

• Very dynamic environment within/above cityscape
  - significant diurnal & seasonal variability
  - vortex shedding around buildings
  - flow channeling in street canyons

• Building-resolving simulations

July TKE based on FastEddy simulations (5 m resolution)

Diurnal cycle of wind speed profiles

Substantial turbulence caused by buildings
Dynamic Environment

- Diurnally varying stability & wind speed/direction
- “plumes” show vertical wind component
  - green = updraft, purple = downdraft

Convective boundary layer
July 12 LT

Stable boundary layer
July 06 LT
Weather Sensitivities

- Weather affects safety, efficiency & reliability of aviation, including urban air mobility
  - both unmanned & aerial ride sharing vehicles
  - smaller vehicles more affected than larger ones
- Range of weather conditions can be hazardous
  - “hazardous” depends on type of vehicle
- New hazards emerging in urban landscape
  - significant wind & turbulence around buildings

Observing Infrastructure

- Variety of networks, sensors, data quality, etc.
- Pretty good coverage to capture synoptic & mesoscale weather phenomena
- Inadequate to capture micro-scale flow & turbulence in urban setting
- Urban micro-scale networks only slowly emerging
Analysis, Nowcast & Forecast Products

- Routine guidance for aviation geared towards general & large transport flight operations - focus on airports & en route
- Limited guidance for aerial operations at low levels & in complex landscapes - TAF not covering off-airport & urban - HEMS tool could be enhanced but needs micro-weather input
- Current NWP models cannot resolve scale of relevant flow processes - space/time resolution way too coarse