ARAM Paper #1.1

Urban Air Mobility

Emerging Opportunities for the Weather Community

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Vision of the 60s . . .

https://www.youtube.com/watch?v=tTq6Tofmo7E

Courtesy of Warner Brothers

Today's vision . . .

https://www.uber.com/us/en/elevate/

Courtesy of Uber Air

Urban Air Mobility (UAM)

Why such a buzz now?

- Emerging technologies
  - battery energy storage capacity
  - distributed electric propulsion & rotor design
  - vertical takeoff & landing
  - composite materials & manufacturing
  - automation & eventually autonomy
- Market analyses show huge potential

Predicted UAM market (2035)

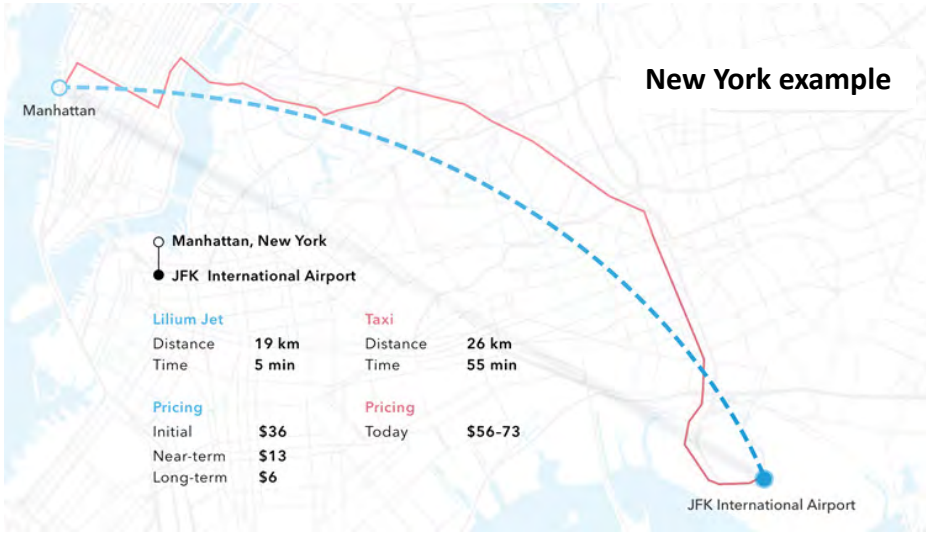
Expected benefits

- Increased mobility & reduced commuting time
- Reduced congestion & pollution
  - low emissions & noise

Use cases

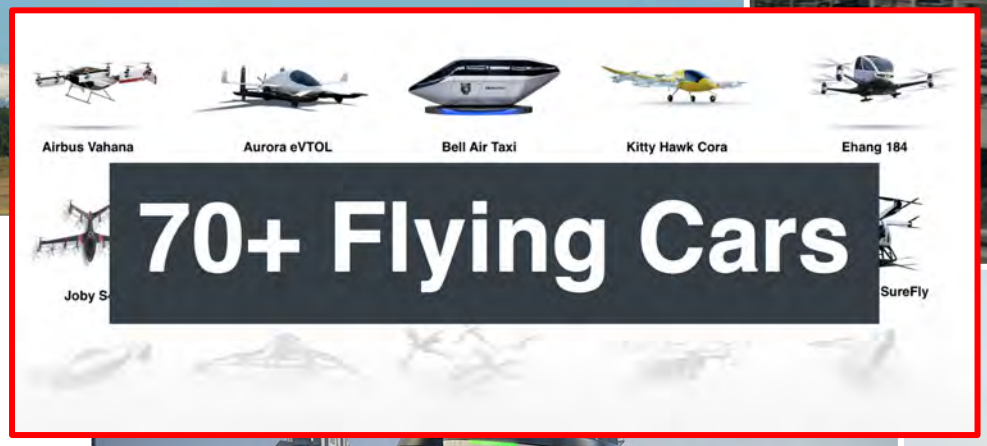
- Scheduled & on-demand aerial ride services
  - fixed shuttle routes & point-to-point
- Air ambulance
- Air cargo & local delivery
- Personal flying vehicles

New York example



Kitty Hawk . . . New Zealand (2018)

Volocopter . . . Dubai, UAE (2017)

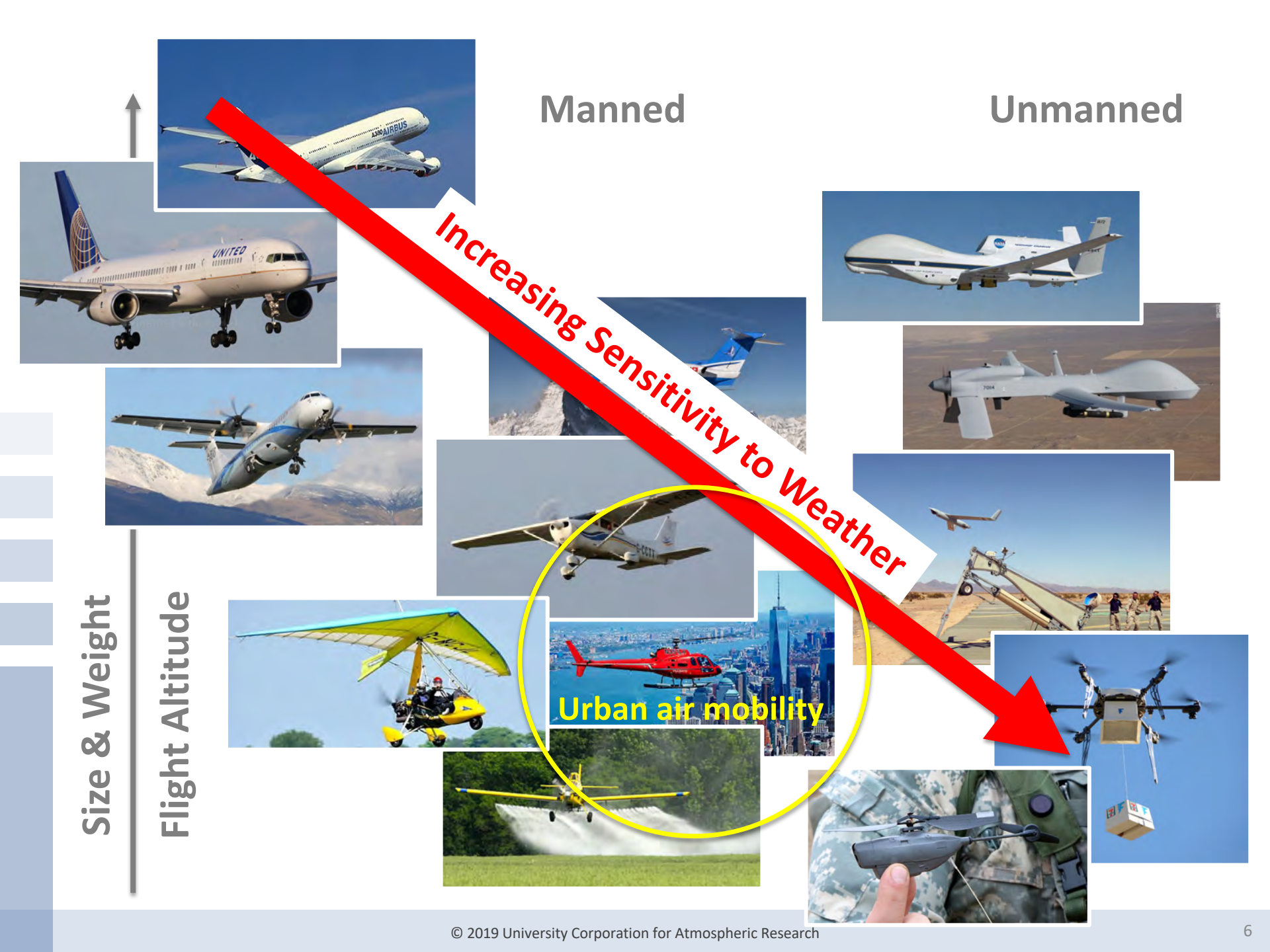


eHANG . . . South Korea (2018)

Airbus, Audi & Italdesign PopUp concept . . .

Lots of challenges . . .

. . . including weather (although not explicitly spelled out)



Weather Sensitivities

Safety, efficiency & reliability

- Inclement weather can affect all of them
- Hazards include wind & turbulence, temperature, ceiling & visibility, precipitation & lighting, icing, etc.

Infrastructure

- Climatic regimes guide infrastructure needs, aircraft design, & fleet mixture to maximize reliability

Operations

- Weather guidance needed for safety & comfort of passengers (both during transfer & aerial ride), performance of aerial vehicle & impact on operations
- Need to understand operationally critical thresholds

Particular challenges

- Added complexity in strong gradient environments like complex terrain, land/sea contrasts, extreme heat, etc.
- Urban environments with localized flow around buildings
- Visual versus instrument meteorological conditions

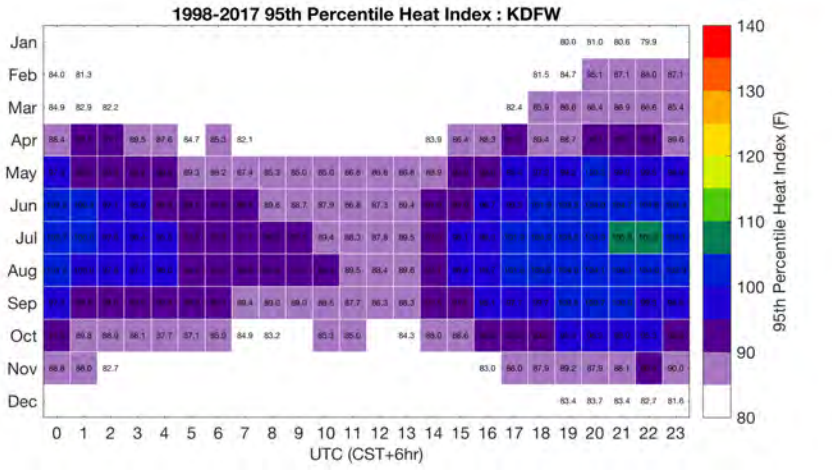




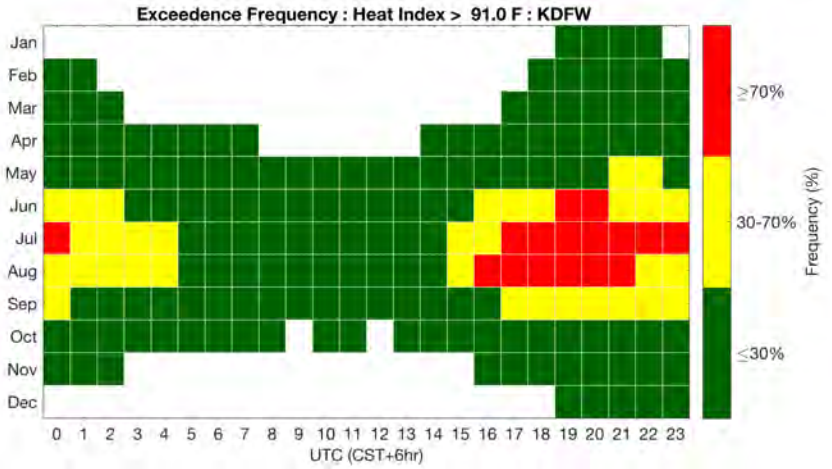
Planning – Climatologies

- Heat Index (1998 – 2017 KDFW)

95th Percentile

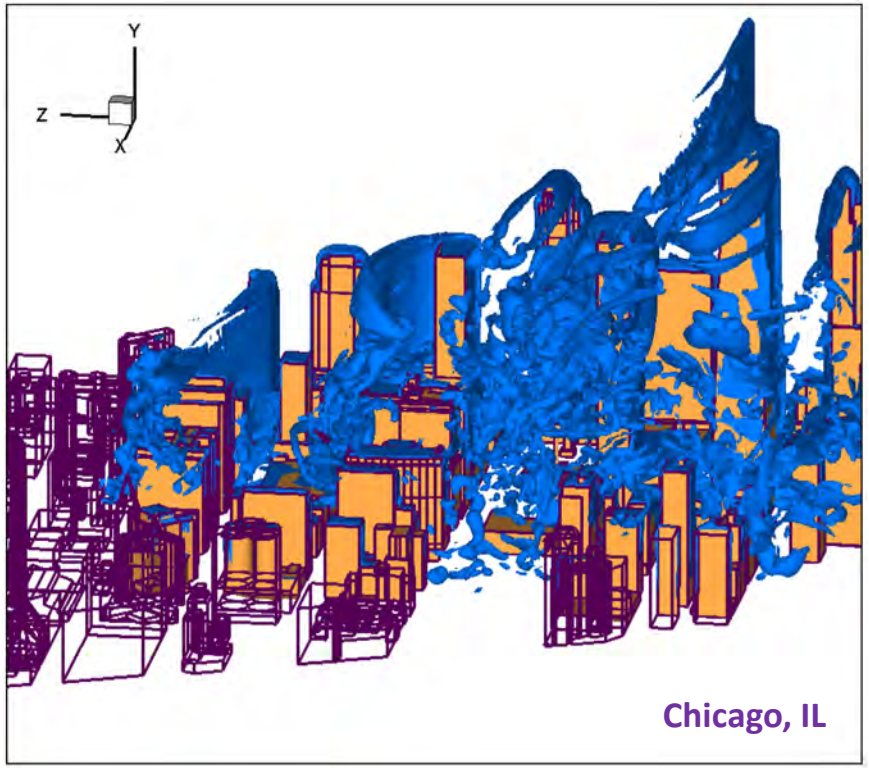


Frequency of heat index exceeding 91 F



Execution – Actual weather

- Vortex shedding off tall buildings in urban setting



Weather Guidance

Observations

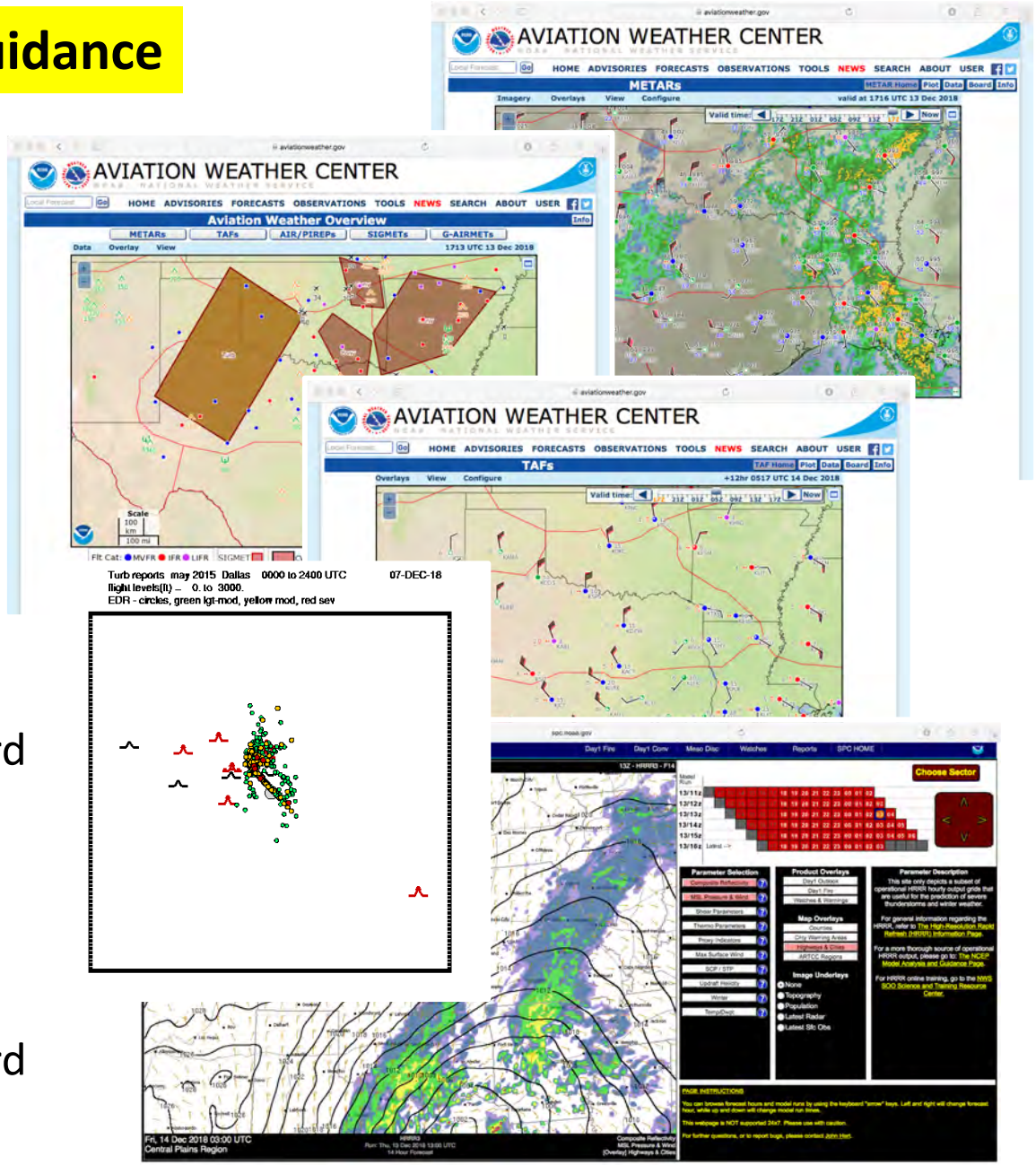
- METAR & others
- Radar (MRMS, CIWS)
- Satellite (VIS, IR, WV)
- Lightning
- Radiosonde
- Aircraft (ACARS, PIREPs, in-situ EDR)

Analyses

- RTMA
- Aviation weather hazard diagnosis products

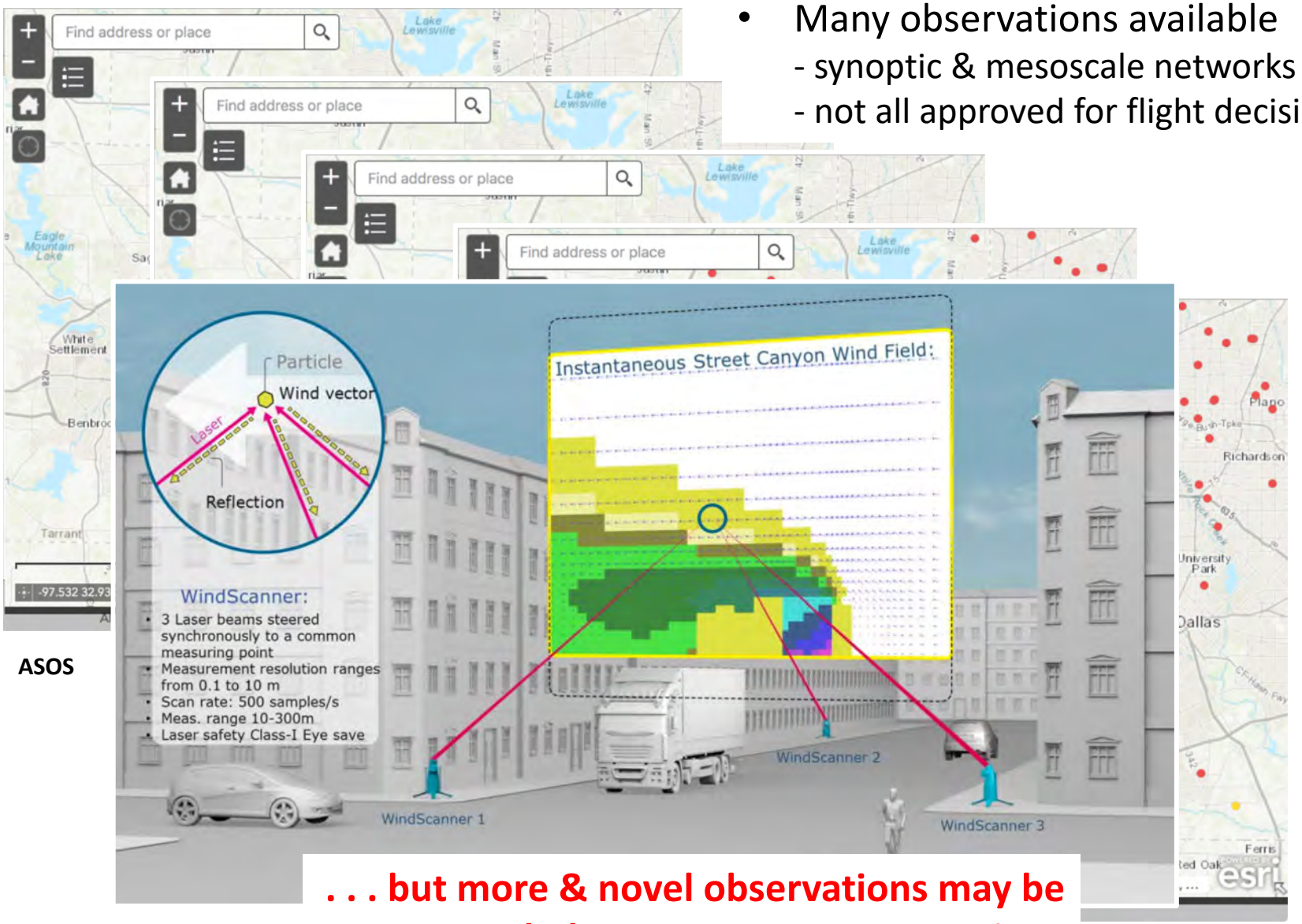
Forecasts

- TAF
- HRRR
- Aviation weather hazard forecast products



Wind observations in urban setting

- Many observations available
  - synoptic & mesoscale networks
  - not all approved for flight decisions



ASOS

. . . but more & novel observations may be needed to support UAM operations

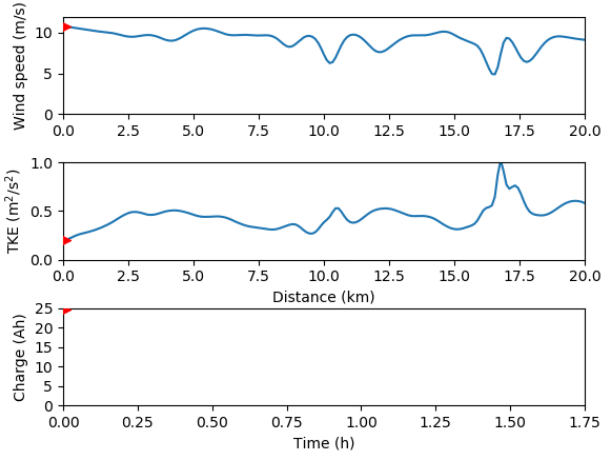
Opportunities

Observation

- Onboard weather sensing
  - connectivity to share data in real time
- Enhanced urban networks to capture micro scales around vertiports

Prediction

- Building resolving modeling to resolve airflow in cityscape
  - multi-scale modeling, coupling mesoscale with large-eddy simulations (LES)
  - improved urban boundary layer representation & diurnal cycle
  - faster processing using GPU & other methods
- Ensembles to capture prediction uncertainty



Translation

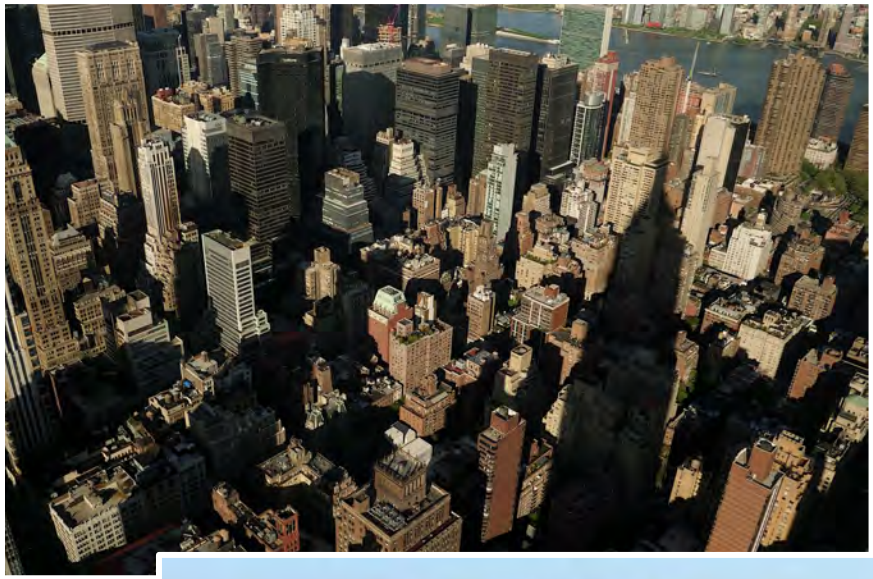
- Understanding weather impacts on operations
  - impacts along flight path & avoidance routing
- Modeling of power consumption, emission & noise pollution

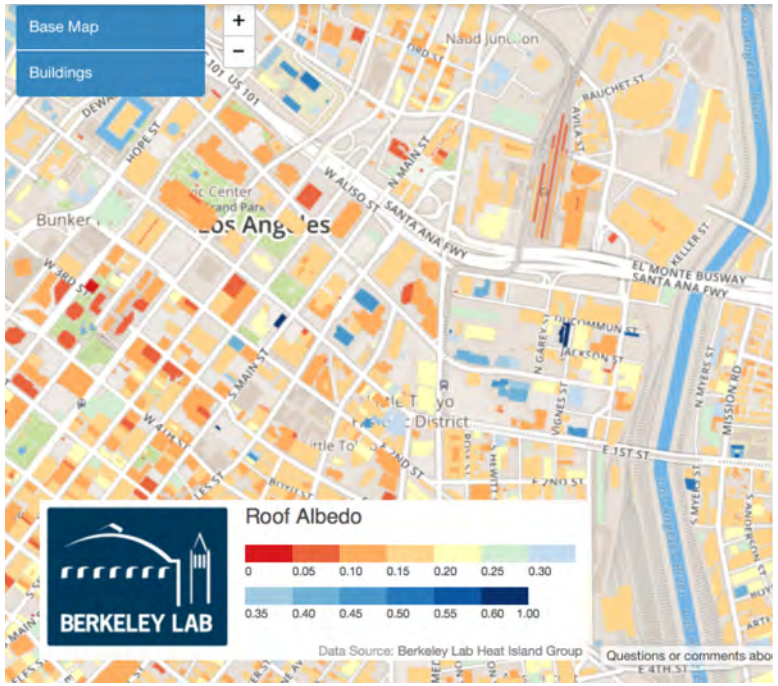
Change

- Ever evolving conditions with climatic changes

Urban boundary layer challenges

- Representation of urban landscape
  - buildings, surfaces, vegetation, etc.
- Representation of relevant processes
  - sun angle, cloud coverage, differences in local heating, wind & turbulence, moisture, pollution, etc.
  - processes across multiple scales





Points to Remember

UAM is happening

- Timeline may be optimistic, but industry is moving fast & progress is visible

UAM is sensitive to weather

- Sensitivity increases with decreasing size of aircraft
- Particular weather challenges in urban environments

UAM provides opportunities for weather community

- Collection of additional meteorological data
  - sensors on aerial vehicles can provide real-time weather data aloft
  - benefits from enhanced ground-based urban observing infrastructure
  - validation of prediction capabilities
- More observations yield improved understanding & prediction capabilities
  - advances in meso- & micro-scale toward building-resolving modeling
  - need to understand minimum complexity required for given weather situation
- Creation of tailored, location & time-specific weather guidance
  - translation of weather to operational impacts & constraints
  - weather impacts along flight path & avoidance routing