Optimizing the use of existing federal data to improve the atmospheric dispersion forecasts for an effective emergency response

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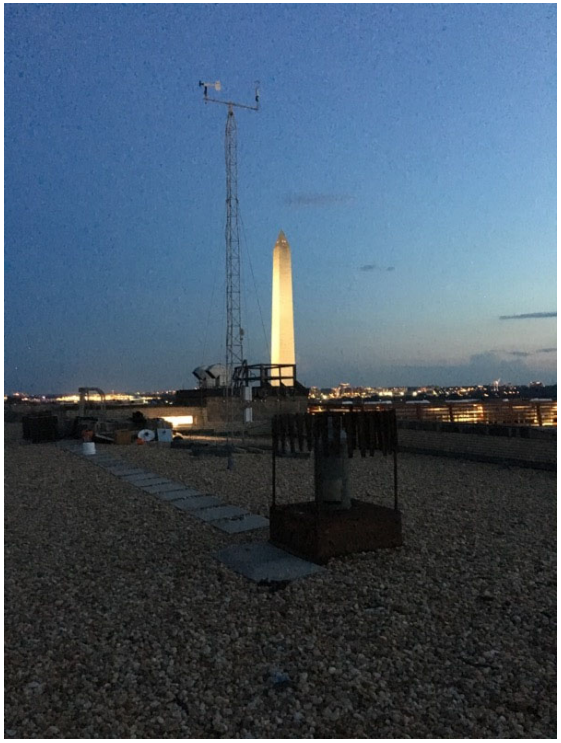
Background, Objectives & Methodology

- **UrbanNet** (formerly DCNet) is a meteorological network in Washington D.C. operated by NOAA / ARL since 2003. The focus of UrbanNet is the provision of real-time meteorological observations:
  - Support development of weather prediction models;
  - Provide observations for atmospheric transport and dispersion models.
- **The main goal** is to investigate the inclusion of local observations to adjust numerical weather predictions and its impact on conventional dispersion modeling in urban areas for emergency response and other important applications such as GHG emissions estimates .
- **The present study** focuses on enhancing the predictions of the WRF model using UrbanNet and airport data in Washington, D.C area to generate meteorological outputs to drive HYSPLIT simulations.

- Site: HCHB station (38.894^{0}N, 77.033^{0}W)
- NWS stations: DCA and IAD airports
- Dispersion model: HYSPLIT
- Data: wind, temperature
- Study period: July, 2017
- Meteorological model: WRF

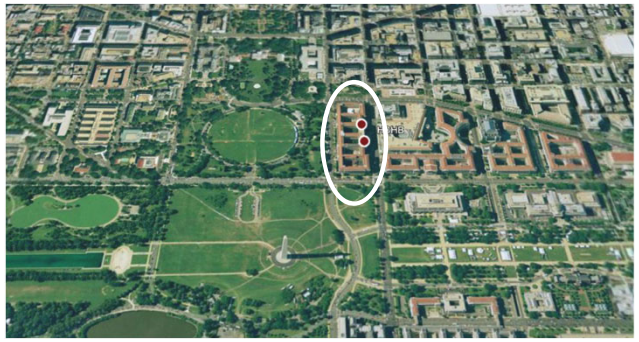


U.S. Department of Commerce Herbert C. Hoover Building (HCHB) site

- Please attend Praveena Krishnan's presentation: **11A.3** – UrbanNet: The NOAA Air Resources Laboratory's Observing Program.

HCHB station

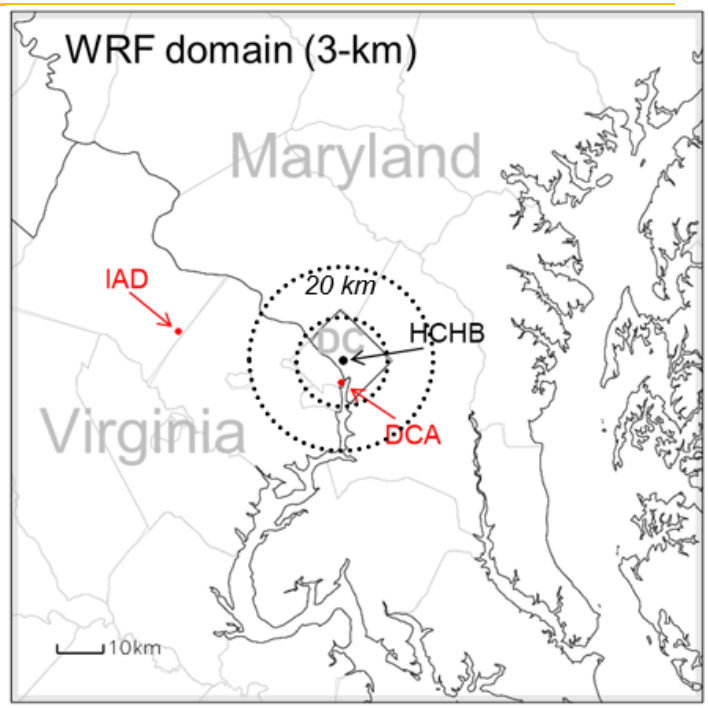
- HCHB was installed in 2003; data archiving began in 2004.
- HCHB has primary (Hoover-North) and secondary (Hoover-South) monitoring stations.
- This site serves as the central point within the NCR (National Capital Region).
- Monitoring towers were sited to provide 10 m observations above the HCHB rooftop.
- Building height is ~ 25 m above ground level.
- The meteorological variables are measured at high temporal frequency (10 Hz), then reported as 15 min averages.



Model description & configurations

- **WRF model**

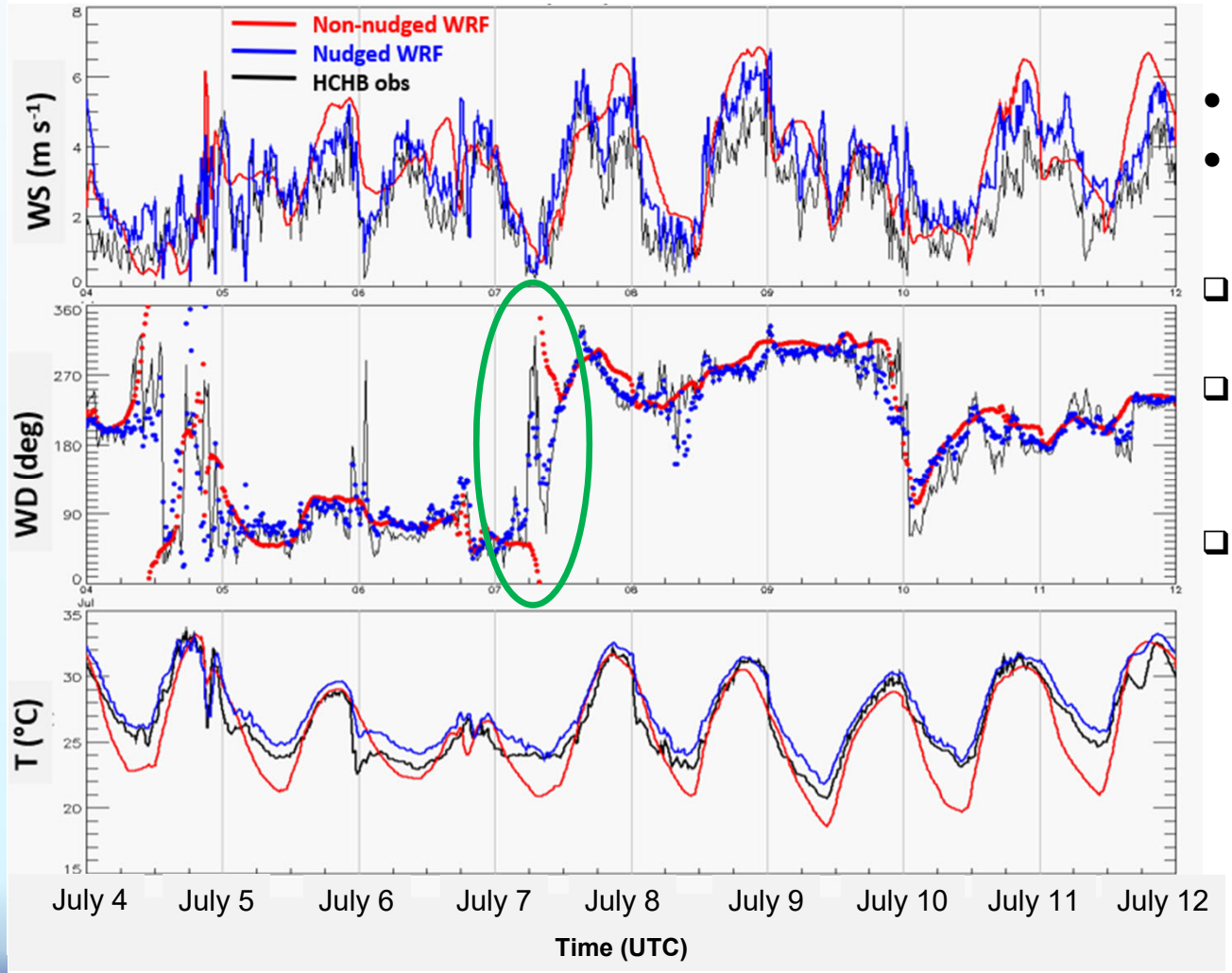
- Version 4.2.2
- Output each day 00 – 23 UTC, 15-min output frequency
- Daily run at 18 UTC, 30-hr run including 6-hr spin-up
- Nudging variables: u- & v-component of wind, temperature
- Observations inserted at height = 35 m AGL
- Vertical layers: 33 (1st layer thickness = 16m)



- **HYSPLIT model**

- Version 5.2.1
- Conc grid 0.01 x 0.01 deg (~1 km)
- 50,000 computational particles over 3 hours continuous release
- Unit emission (g/hr), Release height at 25 m
- HYSPLIT simulations for hypothetical releases were conducted using non-nudged and nudged WRF meteorological fields.

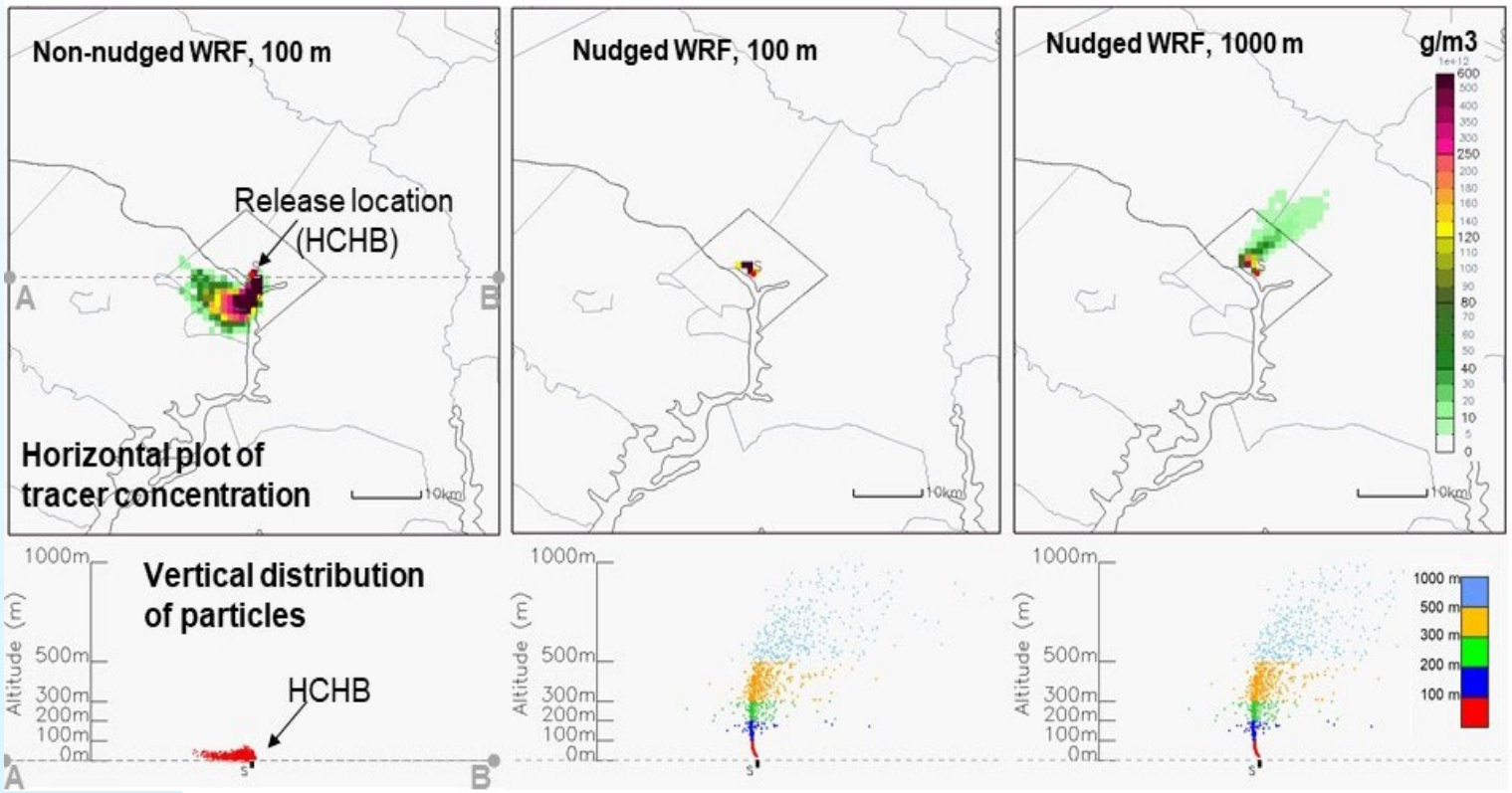
Comparison of observed and modeled WS, WD, and T using non-nudged and nudged WRF



- Height of the HCHB data: ~ 35 m AGL
- 3rd WRF layer: ~ 44 m AGL

- ❑ Nudged simulations provide results closer to the measurements.
- ❑ The observational nudging significantly reduces the temperature forecast bias at night time.
- ❑ A significant inaccuracy in wind direction predictions using non-nudged WRF on July 7th in the early morning.

HYSPLIT simulations using non-nudged and nudged WRF

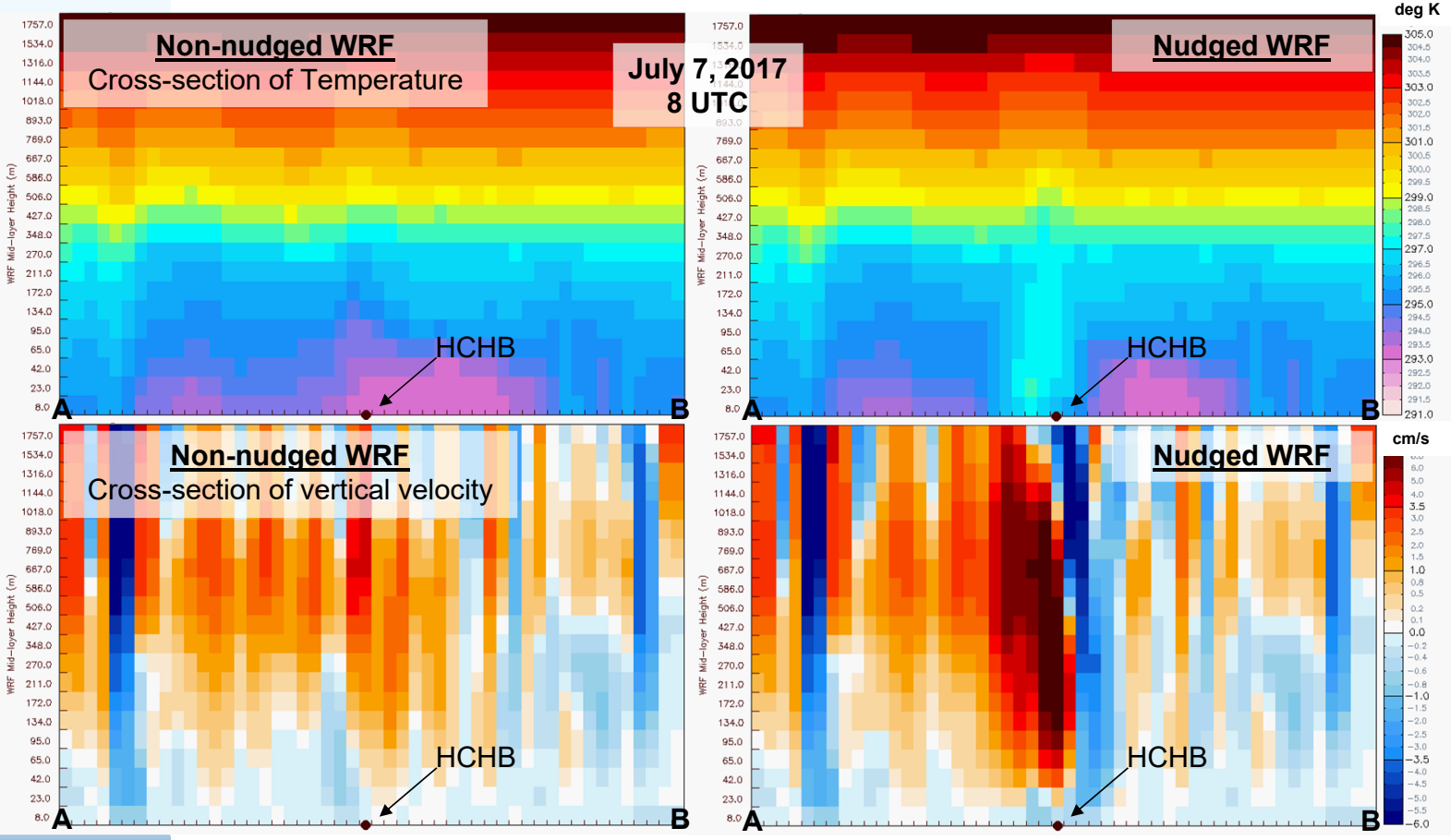


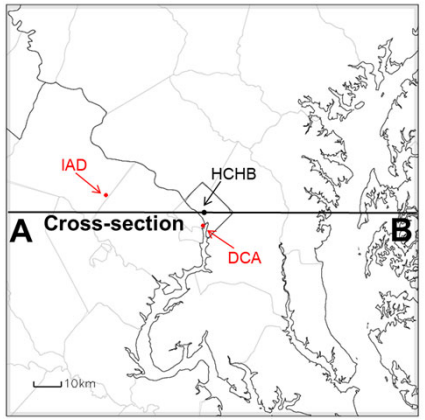
HYSPLIT simulations:

- July 7th, 2017 at 08:00 UTC (simulation started at 05:00 UTC);
- Left: Using non-nudged WRF;
- Middle: Using nudged WRF with concentrations averaged over a vertical layer from 0 -100 m AGL;
- Right: Using nudged WRF with concentrations averaged over a vertical layer from 0 -1000 m AGL.

- The direction of the predicted plume using non-nudged and nudged WRF are significantly different.
- HYSPLIT runs using non-nudged WRF kept the particles near the surface (<100 m AGL).
- HYSPLIT runs using nudged WRF induced a dispersion of particles to higher altitudes (>1000 m AGL).

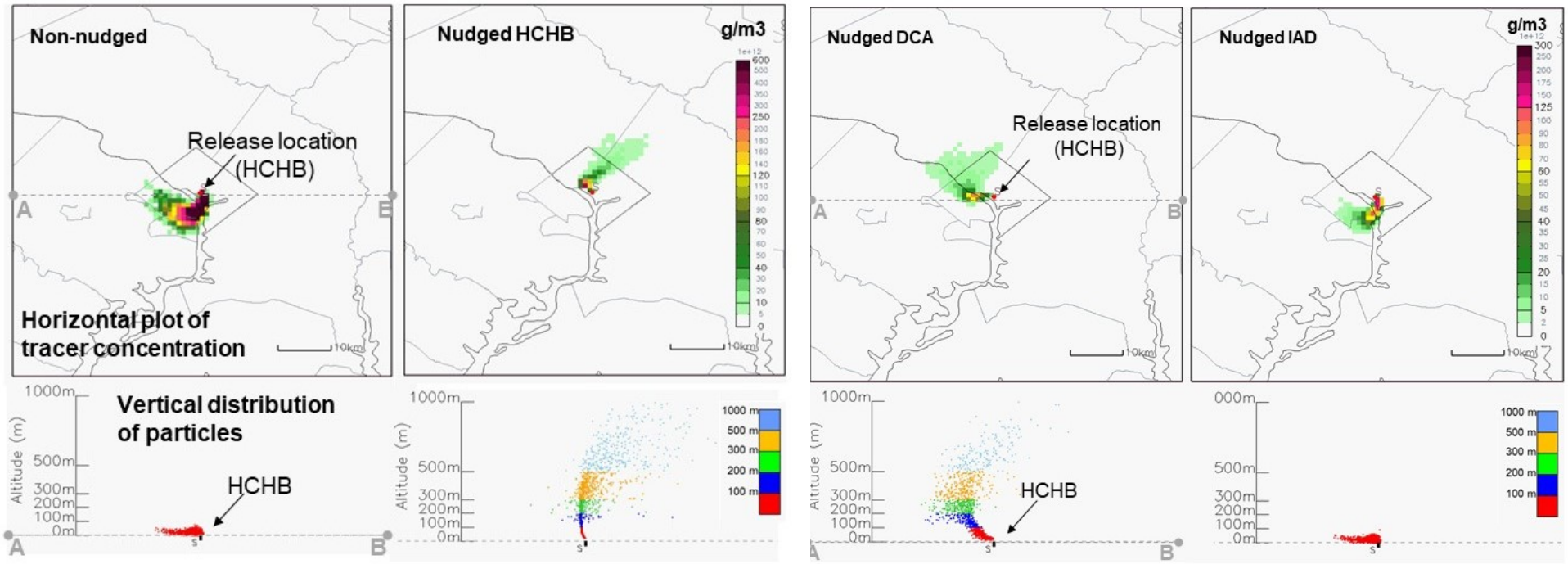
Cross-section of temperature and vertical velocity





- Nudged WRF produced a higher temperature near the HCHB station (0 – 500 m AGL);
- Significantly higher vertical velocity above and west of the HCHB site.

Comparison to NWS station (DCA & IAD)



HYSPLIT simulations:

- July 7th, 2017 at 08:00 UTC (simulation started at 05:00 UTC);
- Using non-nudged WRF, nudged WRF with HCHB, DCA and IAD data.
- Hourly DCA and IAD surface data were ingested into WRF at the surface model layer.
- DCA is located 5 km south of the HCHB station.
- IAD is located 35 km northwest of the HCHB station.

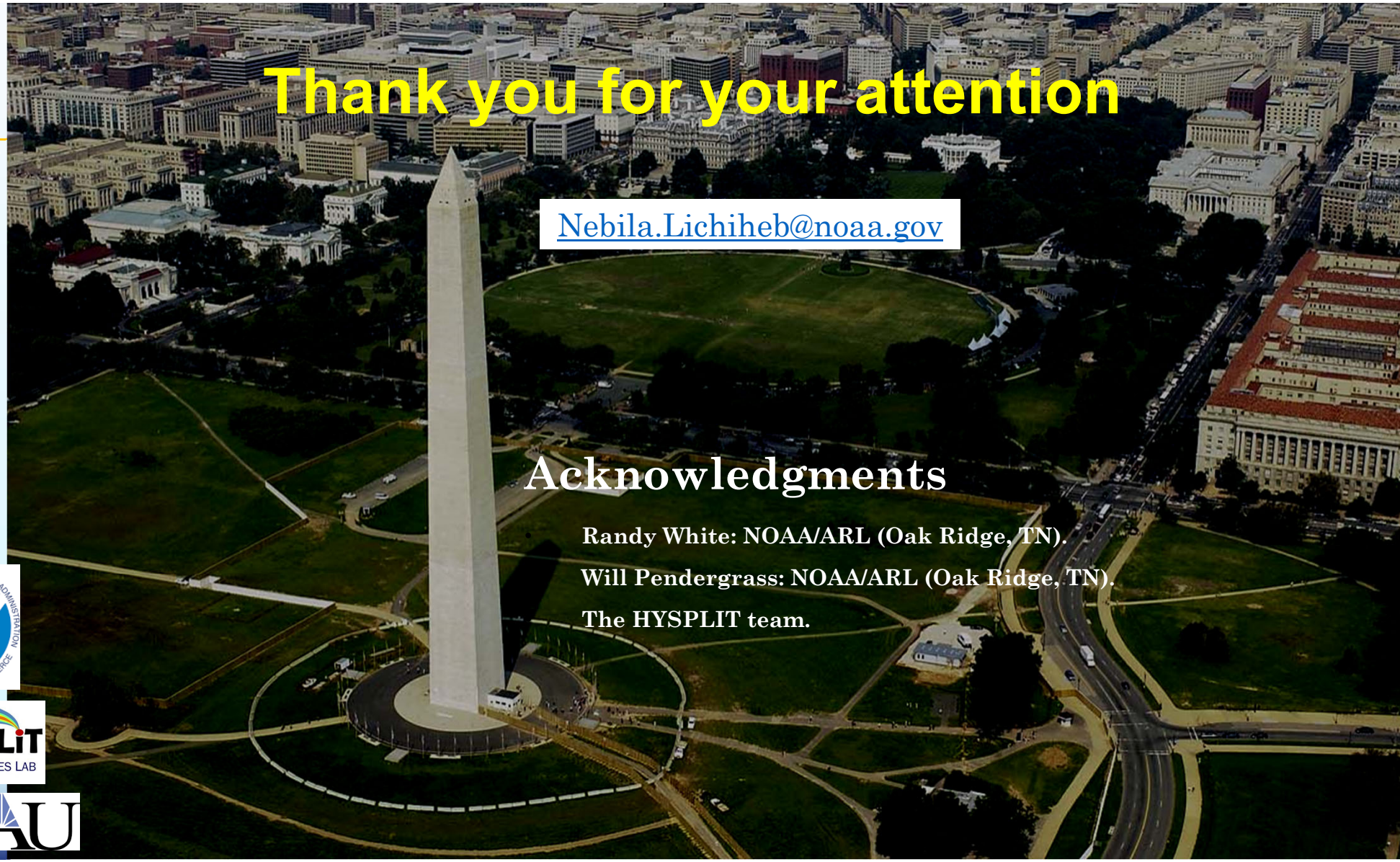
Conclusions

- WRF observational nudging successfully adjusted wind and temperature data towards the HCHB observations, especially in the early morning hours.
- HYSPLIT simulations using non-nudged versus nudged fields showed significant differences in the pattern and direction of the dispersion plume, with an evidence of increased mixing height when using local data.
- The use of the data from the DCA airport to nudge WRF model provided HYSPLIT simulations very similar to the ones using HCHB data: strong evidence that local data are essential to improve the accuracy of dispersion modeling.

Future work

- Include analysis of Tracers of Opportunity dataset to evaluate the transport and dispersion simulations;
- Combine tower and LIDAR data to better describe the vertical wind profile and the urban PBL structure: Collocate LIDAR systems with existing tower stations;
- Perform additional WRF nudging configurations using local data from several UrbanNet locations;
- Implement an urban canopy model in WRF to consider the heterogeneity of the urban structure.

Lidar system installed at the HCHB site



Thank you for your attention

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The HYSPLIT team.