Combat Outpost Tangi in the Tangi Valley, Afghanistan, Aug. 31, 2009. (Staff Sgt. Teddy Wade/DoD)

Source-Differentiated Air Quality System to Safeguard the Respiratory Health of US Military Personnel Deployed in Southwest Asia, Djibouti, and Afghanistan

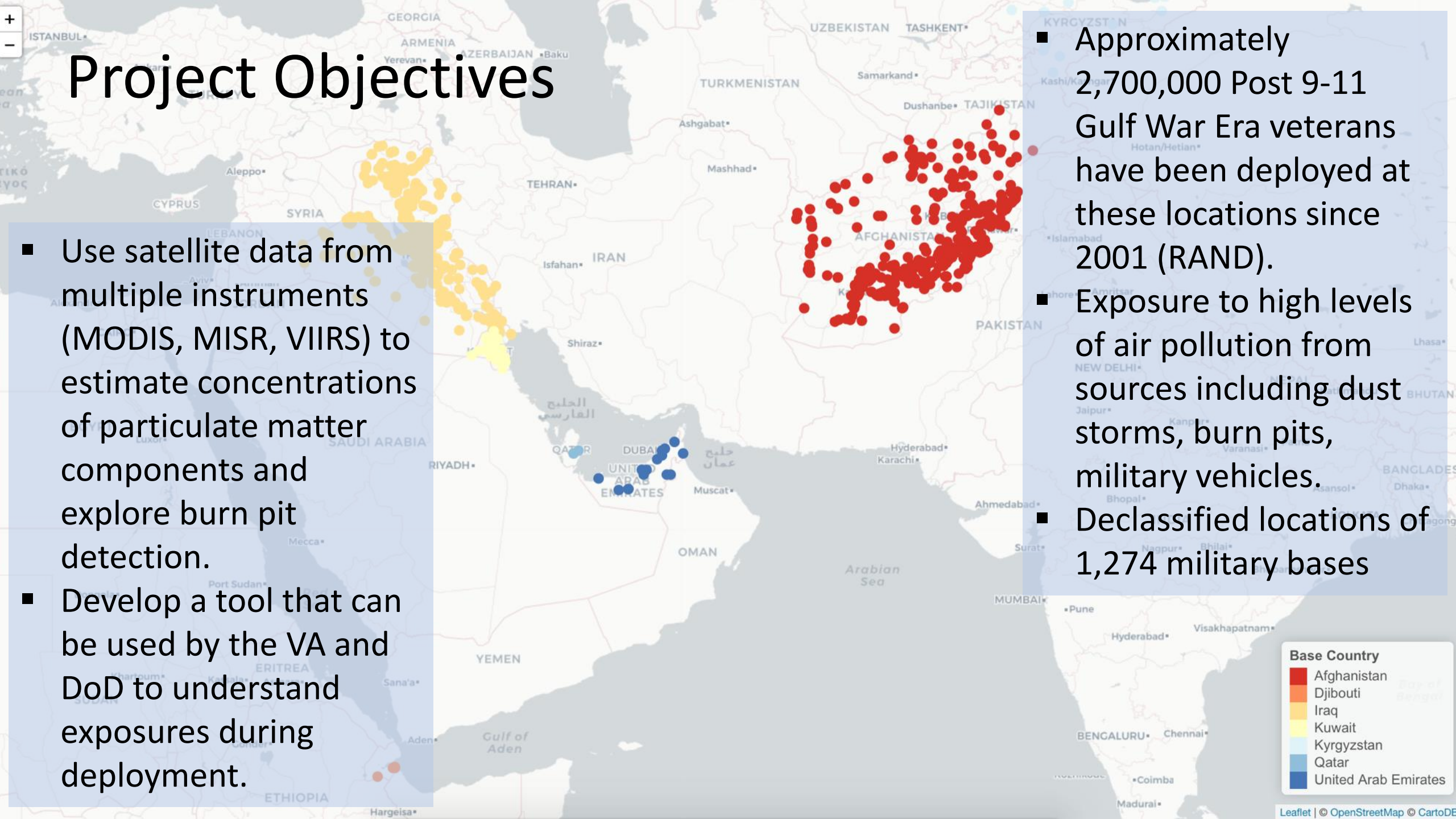
Meredith Franklin
University of Southern California
University of Toronto

September 19, 2022

Project Objectives

- Use satellite data from multiple instruments (MODIS, MISR, VIIRS) to estimate concentrations of particulate matter components and explore burn pit detection.
- Develop a tool that can be used by the VA and DoD to understand exposures during deployment.

- Approximately 2,700,000 Post 9-11 Gulf War Era veterans have been deployed at these locations since 2001 (RAND).
- Exposure to high levels of air pollution from sources including dust storms, burn pits, military vehicles.
- Declassified locations of 1,274 military bases

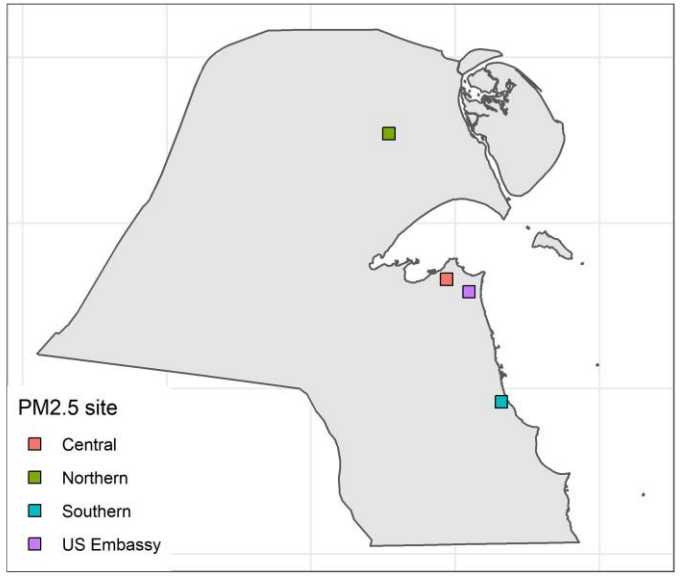


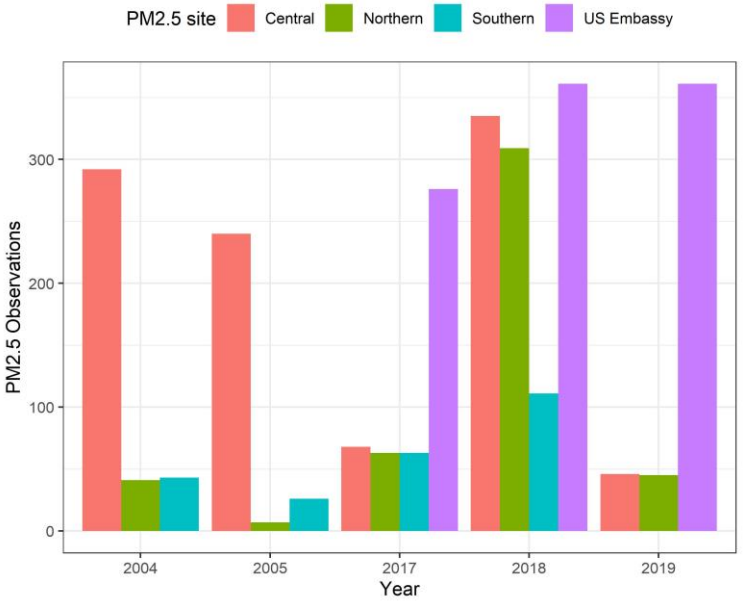
Key Outcomes

- Air Quality Monitoring
- MAIAC model estimates of $PM_{2.5}$ at 1km resolution
- Source differentiated $PM_{2.5}$ estimates from GEOS-5 and MERRA-2
- Burn pit detection with MODIS Fire and VIIRS Active Fire
- Application being used by VA and DoD for clinical and research purposes
- Started ARL 3 exited at ARL 8

Air Quality Monitoring in Kuwait and Qatar

- Characterization of Particulate Matter (PM_{10} and $PM_{2.5}$ 2004-2006) for three Sites in Kuwait
  - PM_{10} ranged from 65.8 to 92.8 µg/m^3, $PM_{2.5}$ ranging from 30.8 µg/m^3 to 37.6 µg/m^3
- Since 2018 $PM_{2.5}$ and PM_{10} at two sites by co-I Petros Koutrakis' group (daily mass and XRF, ions, ICPMS).
  - One co-located at AERONET site (Kuwait U), other south of Kuwait city.
- Since 2020 monitoring at Doha Qatar (delayed due to covid)





MAIAC and MISR models – $PM_{2.5}$

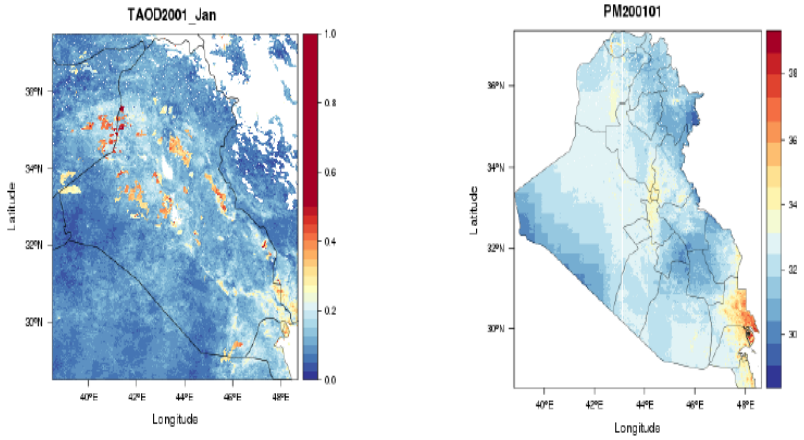


Figure 1. MAIAC AOD and resultant $PM_{2.5}$ estimates over Iraq and Kuwait.

Li, J., Garshick, E., Hart, J. E., Li, L., Shi, L., Al-Hemoud, A., Huang, S., Koutrakis, P. (2021). Estimation of ambient PM2.5 in Iraq and Kuwait from 2001 to 2018 using machine learning and remote sensing. *Environment International*, *151*, 106445.

Instrument	Model	N	R^2
MISR	Overall	542	0.48
	Kuwait	271	0.51
	U.A.E	138	**0.66**
MAIAC	Overall	3334	0.53
	Kuwait	1863	0.48
	U.A.E	642	**0.65**

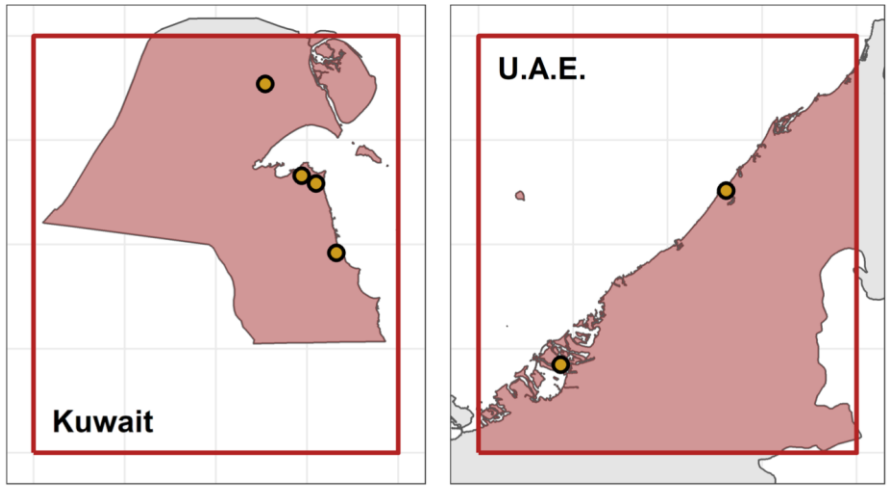
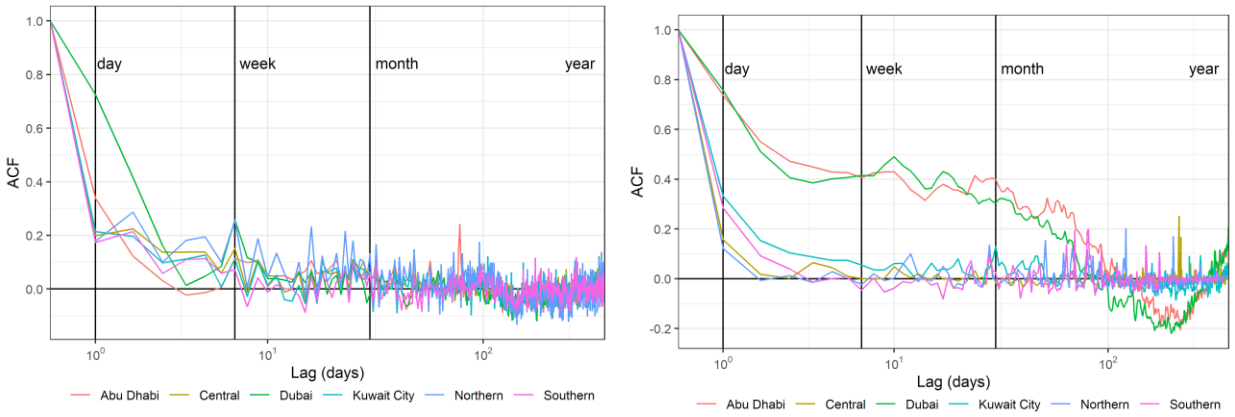
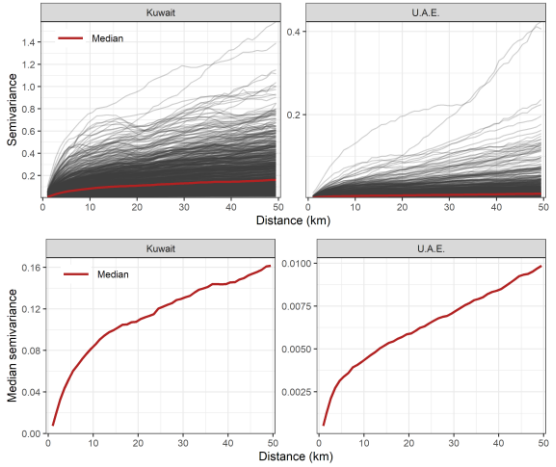


Figure 2. Areas within each country where temporal and spatial autocorrelations for MAIAC AOD were evaluated (shaded pink) and the $PM_{2.5}$ monitors (yellow circles) in each country.

Chau, K., Franklin, M., Lee, H., & Garay, M. (2021). Temporal and Spatial Autocorrelation as Determinants of Regional AOD-PM 2.5 Model Performance in the Middle East. *Remote Sensing*, *13*(3790), 1–18.

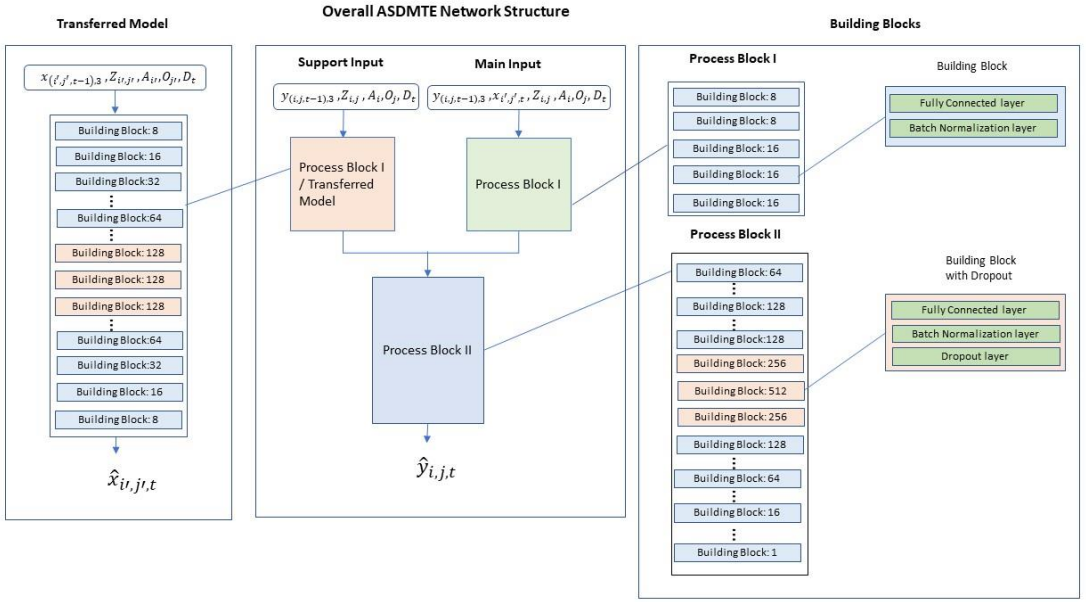


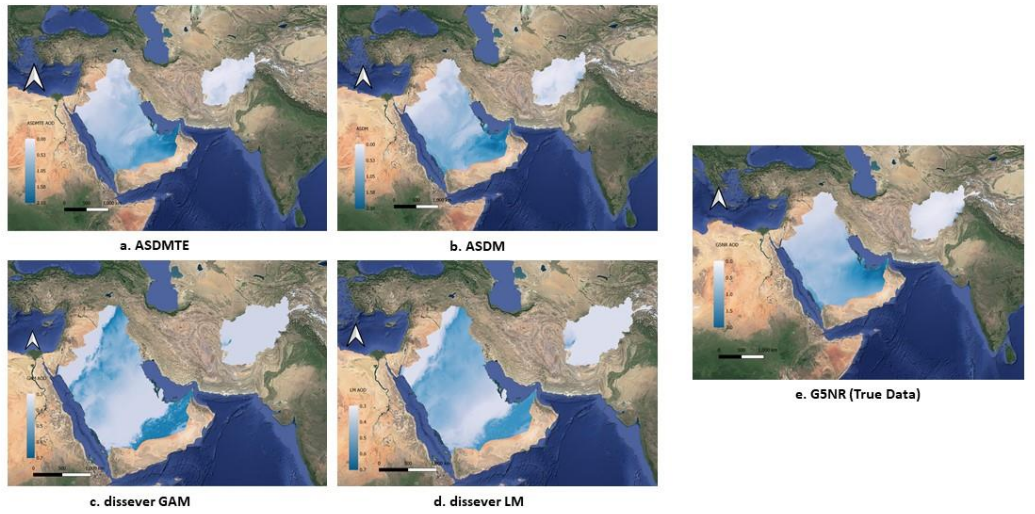
Addressing spatial -> and <-temporal autocorrelation important



Source-differentiated $PM_{2.5}$ from GEOS-5 and MERRA-2

- The Goddard Earth Observing System Model, Version 5 (GEOS-5) Nature Run (G5NR) is a satellite-based two-year simulation which provide high-resolution (7km) aerosol data
- Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2), a reanalysis produced by NASA's Global Modeling and Assimilation Office(GMAO), can provide longer period of data (2000-2018), but in much lower resolution (50 km)
- WE developed a deep-learning model to downscale MERRA-2 from 50km to 7km training on G5NR data
- *Both G5NR and MERRA-2 provide data on PM dust, sulfates, carbons*

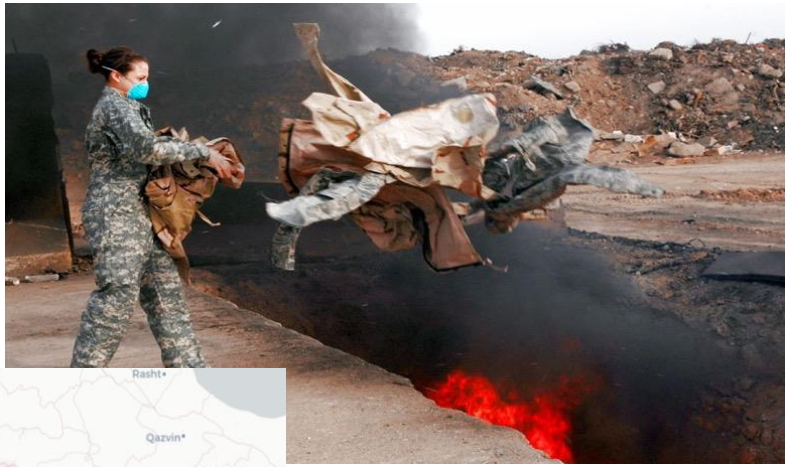


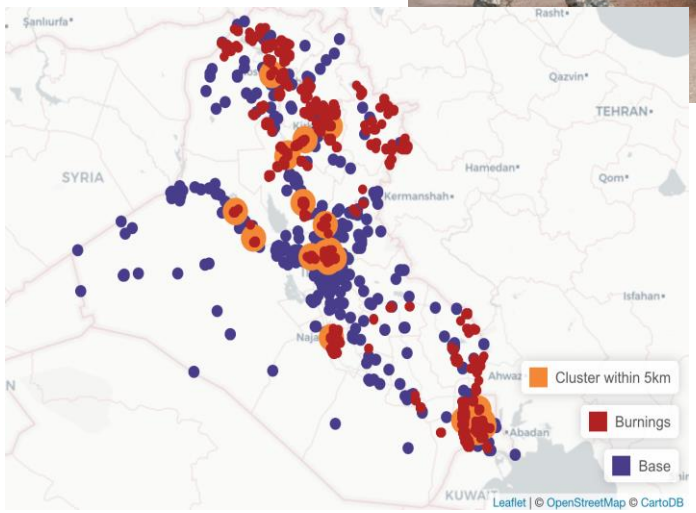


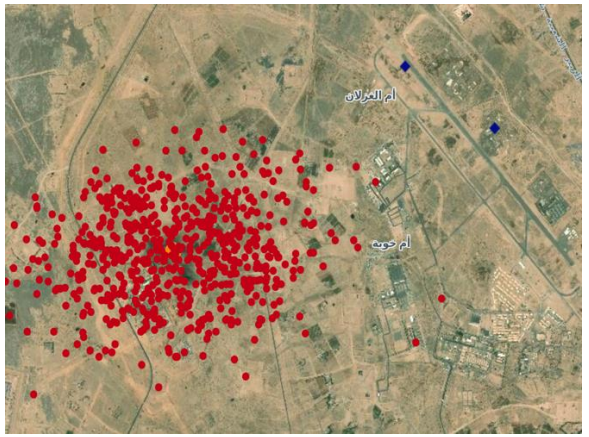
Wang, M., Franklin, M., & Lianfa, L. (2022). Generating Fine-Scale Aerosol Data through Downscaling with an Artificial Neural Network Enhanced with Transfer Learning. *Atmosphere*, *13*(255), 1–18.

Burn Pit Detection

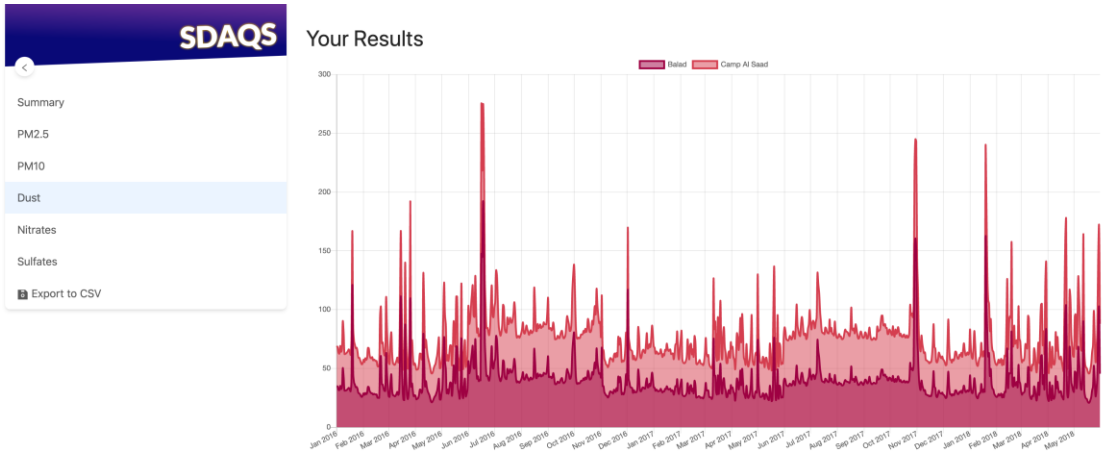
- Records of the locations and durations of burn pits were not routinely taken.
- MODIS active fire with hierarchical density-based clustering to detect persistent thermal sources annually.
- Identified persistent sources within 5 km of known base locations.
- Validated with imagery where possible (much of the imagery in the region is blurred)
- Identified bases with most thermal detections 2002-2012
  - Chindit, Steelback, Camp Hutch, Al Saad appear frequently







Application/Uses



- All generated $PM_{2.5}$ estimates have been linked with the bases
- A software tool was developed to disseminate the data
  - Searchable by base name
  - Displays bases on map
  - Shows charts of the concentrations
  - Allows data to be exported
- Researchers at the VA are using it for epidemiological studies
- VA clinicians using it to understand exposures for patients with respiratory disease