Mapping and modeling desertification and its impact on aeolian dust and human health in Central Asia

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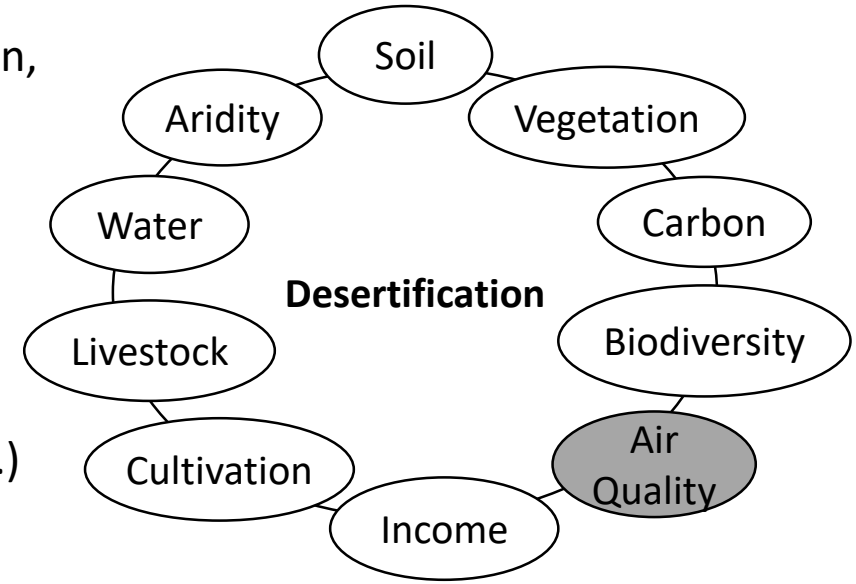
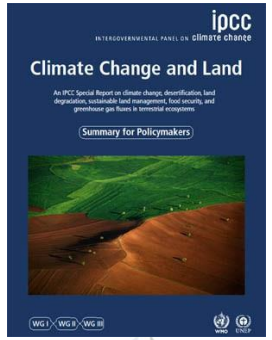
Proposal team

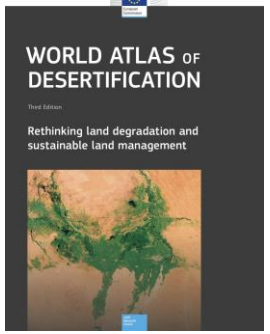
- Xin Xi (PI)
  - Assistant Prof., Dept. of Geological and Mining Engineering and Sciences, Michigan Technological University
  - PhD in Atmospheric Sciences, Georgia Institute of Technology (2014); BSc in Geoinformatics, Beijing Normal University (2007).
- Shan Zhou (co-I)
  - Assistant Prof., Dept. of Social Sciences, Michigan Technological University
  - PhD in Public Policy, Georgia Institute of Technology (2016); BSc in Environmental Science, Beijing Normal University (2007).
- Sabur Abdullaev (collaborator)
  - Head of Laboratory of Physical atmosphere, S.U.Umarov Physical-technical institute, Academy of Science of the Republic of Tajikistan.
  - Caretaker of the only AERONET site in Central Asia
  - Lead of Tajik-German joint Central Asian Dust Experiment (2014-16)
- We look forward to collaborations with CARIN scientists

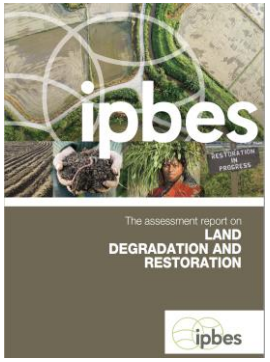
Study region

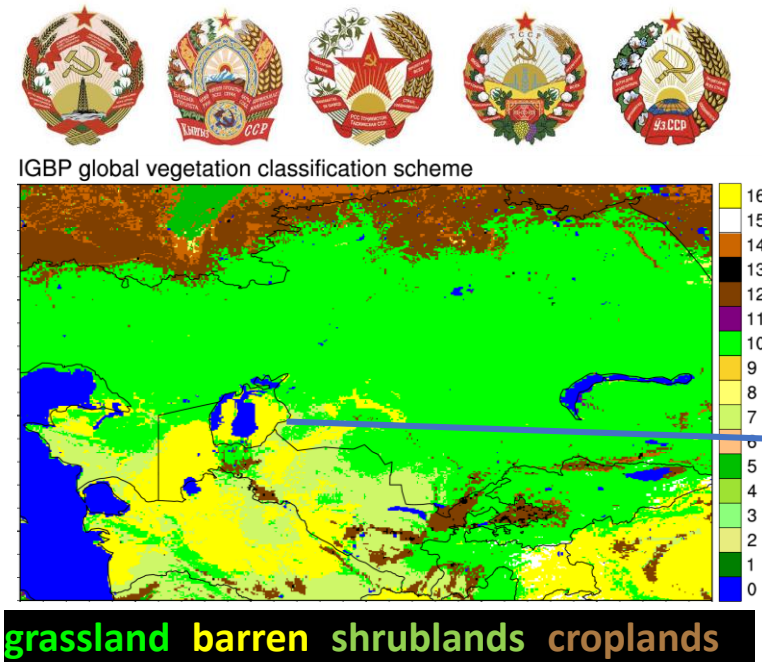
- Five former Soviet states: Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan, Tajikistan.
  - Semiarid and arid climate
  - Climate variations and change
  - Desertification (formation of Aralkum, salinization, overgrazing, deforestation, etc.)



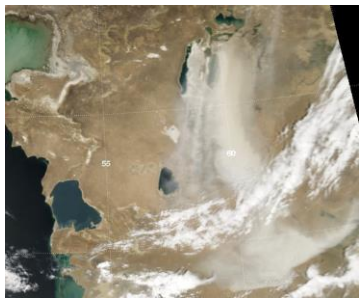






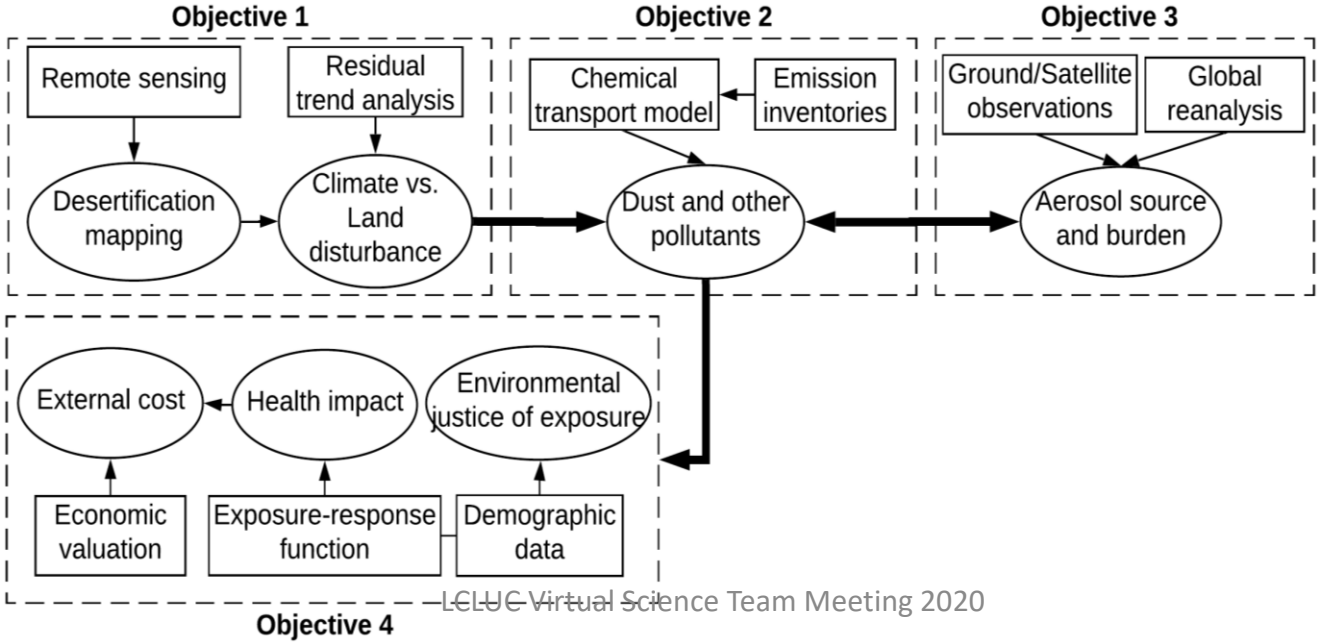


! Air pollution and health impact has not been considered in the economic valuation of desertification.



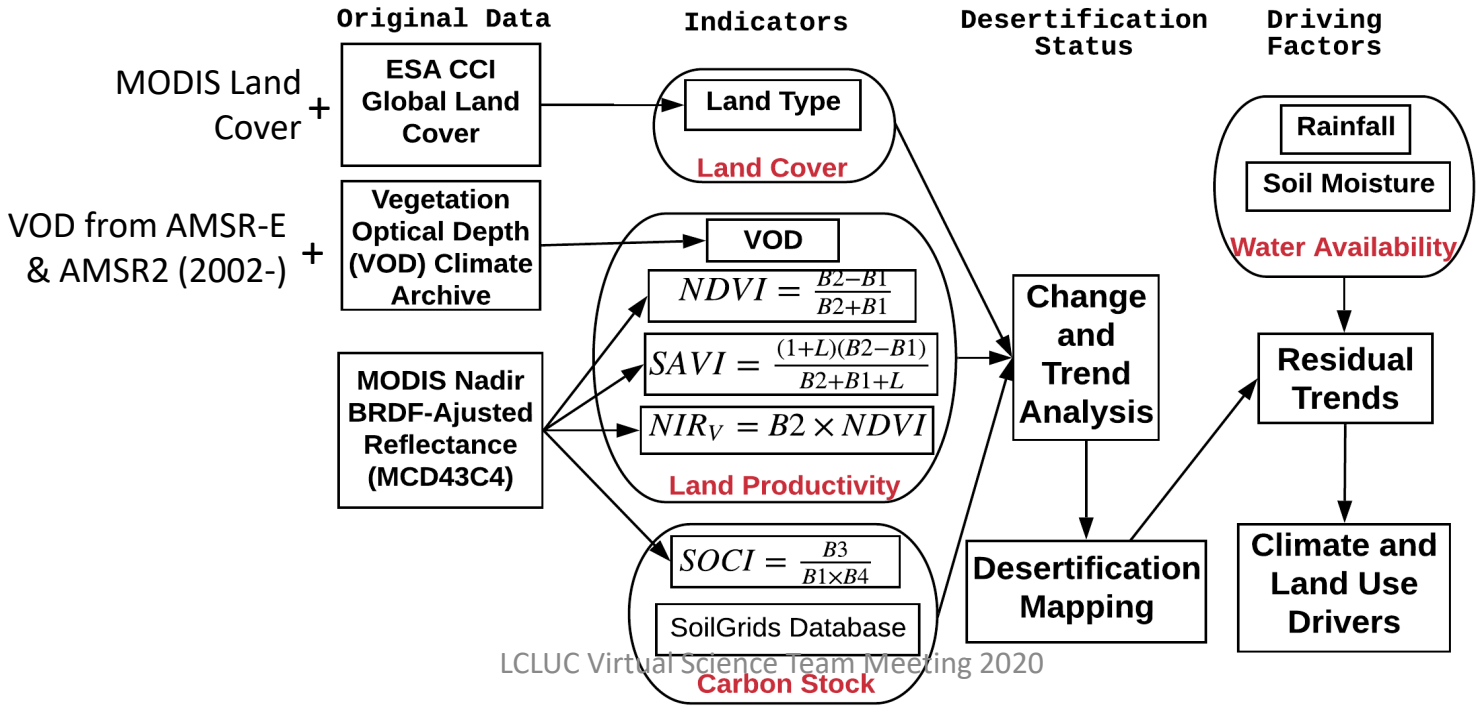
Objectives

- **Goal:** Assess the status and drivers of desertification and the impact on aeolian dust, outdoor air quality, and human health.
- **Objectives**
  - Map the spatiotemporal dynamics of desertification, and determine the roles of climate and socioeconomic drivers;
  - Quantify the contribution of desertification to aeolian dust and PM pollution;
  - Synthesize surface observations, remote sensing, and global model reanalysis to characterize the spatiotemporal variability of aeolian dust;
  - Assess the environmental justice and health impact of exposure to PM pollution.
- **Approach**: desertification-pollution-impact pathway



Obj 1. Desertification Mapping

- ***Question: What are the current extent of desertification and driving factor(s)?***
- Previous studies: Klein et al. 2012; de Beurs et al. 2015; Le et al. 2016
- UNCCD Land Degradation Neutrality Indicators
  - Land cover: ESA CCI (1992-2018, 300m), MODIS (2001-2019, 0.05° or 500m)
  - Land Productivity: VOD (ecosystem structure), NDVI and SAVI (adjusted for soil background), NIR_V (related to FPAR and GPP, even for sparse vegetation)
  - Carbon Stock: soil organic carbon index
- Separating the climate and anthropogenic drivers of desertification
  - Residual trends analysis (Wessels et al. 2012)



Obj 2. Dust and air quality modeling

- ***Question: To what extent does desertification contribute to the region's aeolian dust and air pollution?***

- Case study of Aralkum dust event on May 26-28 2018
  - WRF-Chem dust-only
  - Evaluation by ground and satellite observations on plume evolution

- Extended simulation (a full year)
  - WRF-Chem fully coupled online chemistry
  - Three experiments: Control, no dust from desertification areas, no dust from human-driven desertification areas

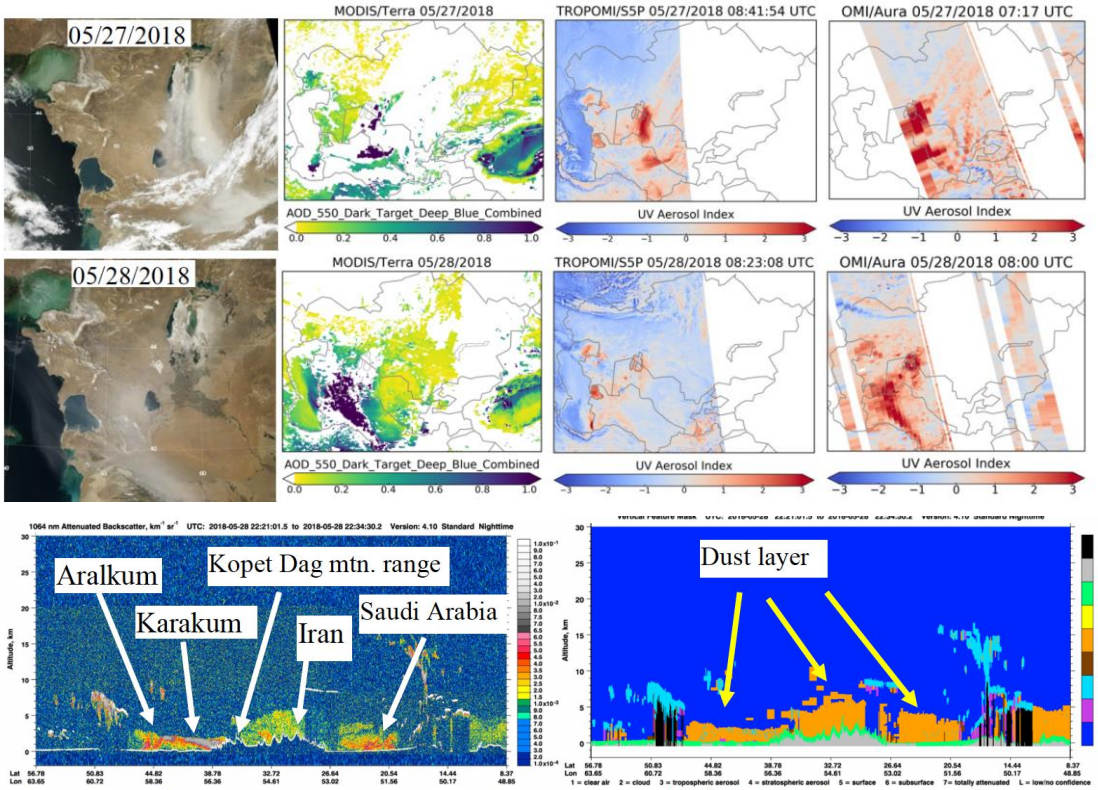


Figure 5. CALIPSO 1064 nm total attenuated backscatter (km^{-1} sr^{-1}) (left) and vertical feature mask (right) on May 28 2018. Separate dust systems are detected in Iran and Saudi Arabia.

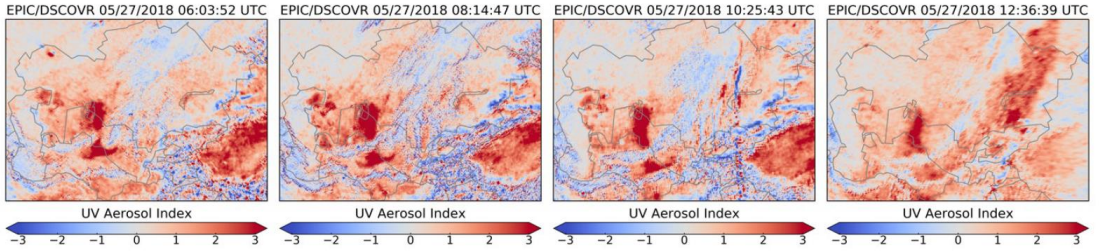
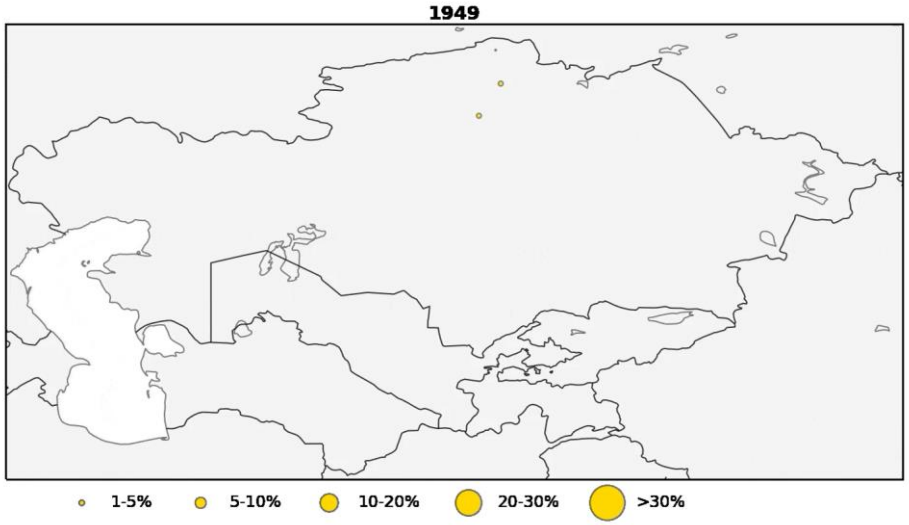


Figure 6. EPIC/DSCOVR (nearly) hourly UVAI on May 27 2018 (only four frames are shown).

Obj 3. Aeolian dust characterization

- ***Questions: How do climate variations and desertification affect the long-term dust activity?***
- Analysis of dust variability, trend, and climatic sensitivity from long-term observational and model datasets.
  - Weather station reports from NOAA Integrated Surface Database (ISD)
  - Deep Blue aerosol optical depth from MODIS (2000-) and VIIRS (2012-)
  - UV aerosol index from OMI (2004-)
  - EOF and SEM analysis of global aerosol analyses (MERRA2, CAMS, NAAPS)



Global aeolian dust variations and trends: a revisit of dust event and visibility observations from surface weather stations

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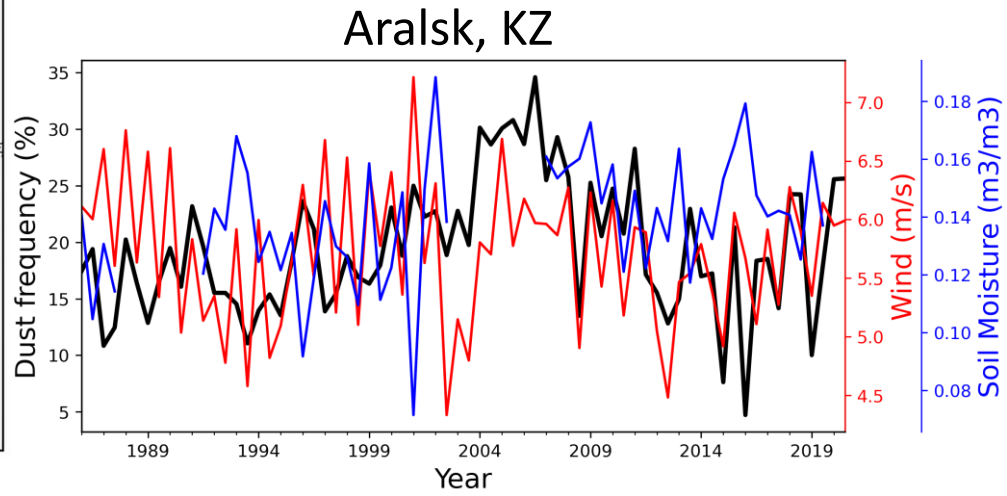
Xi, ACP, under review

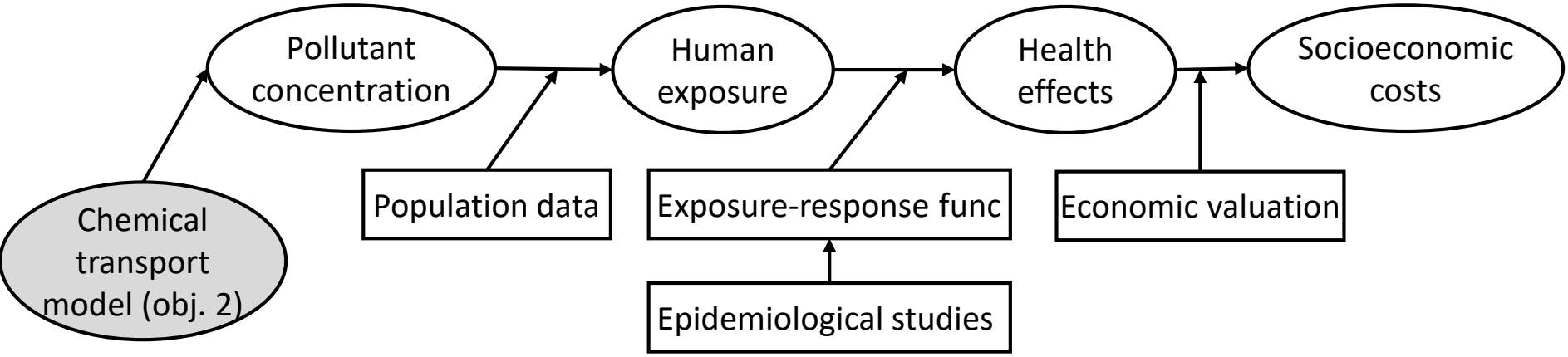


R(dust, wind) = 0.7

R(dust, soil moisture) = -0.45

Obj 4. Health and societal impact

- ***Question: What are the health and socioeconomic impacts of desertification-induced air pollution?***
- Environmental justice of air pollution
  - The health burden of desertification-related PM pollution not only varies by the spatial pattern of PM concentrations, but also depend on the socioeconomic status
  - measured by the association between population-weighted pollutant concentration and demographic characteristics (e.g., age, race, income, poverty, education, etc.)
- Economic valuation of health-related external cost of air pollution



- Questions?
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