Remote Sensing of Urban Land Cover/Land Use Change, Surface Thermal Responses, and Potential Meteorological and Climate Change Impacts

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City growth influences the development of the urban heat island (UHI), but the effect that local meteorology has on the UHI is less well known. This paper presents some preliminary findings from a study that uses multitemporal Landsat TM and ASTER data to evaluate land cover/land use change (LULCC) over the NASA Marshall Space Flight Center (MFSC) and its Huntsville, AL metropolitan area. Landsat NLCD data for 1992 and 2001 have been used to evaluate LULCC for MSFC and the surrounding urban area. Land surface temperature (LST) and emissivity derived from NLCD data have also been analyzed to assess changes in these parameters in relation to LULCC. Additionally, LULCC, LST, and emissivity have been identified from ASTER data from 2001 and 2011 to provide a comparison with the 2001 NLCD and as a measure of current conditions within the study area. As anticipated, the multi-temporal NLCD and ASTER data show that significant changes have occurred in land covers, LST, and emissivity within and around MSFC. The patterns and arrangement of these changes, however, is significant because the juxtaposition of urban land covers within and outside of MSFC provides insight on what impacts at a local to regional scale, the inter-linkage of these changes potentially have on meteorology. To further analyze these interactions between LULCC, LST, and emissivity with the lower atmosphere, a network of eleven weather stations has been established across the MSFC property. These weather stations provide data at a 10 minute interval, and these data are uplinked for use by MSFC facilities operations and the National Weather Service. The weather data are also integrated within a larger network of meteorological stations across north Alabama. Given that the MSFC weather stations will operate for an extended period of time, they can be used to evaluate how the building of new structures, and changes in roadways, and green spaces as identified in the MSFC master plan for the future, will potentially affect land cover LSTs across the Center. Moreover, the weather stations will also provide baseline data for developing a better understanding of how localized weather factors, such as extreme rainfall and heat events, affect micrometeorology. These data can also be used to model the interrelationships between LSTs and meteorology on a longer term basis to help evaluate how changes in these parameters can be quantified from satellite data collected in the future. In turn, the overall integration of multi-temporal meteorological information with LULCC, and LST data for MSFC proper and the surrounding Huntsville urbanized area can provide a perspective on how urban land surface types affect the meteorology in the boundary layer and ultimately, the UHI. Additionally, data such as this can be used as a foundation for modeling how climate change will potentially impact local and regional meteorology and conversely, how urban LULCC can or will influence changes on climate over the north Alabama area.

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Abstract

City growth influences the development of the urban heat island (UHI), but the effect that local meteorology has on the UHI is less well known. This paper presents some preliminary findings from a study that uses multitemporal Landsat TM and ASTER data to evaluate land cover/land use change (LULCC) over the NASA Marshall Space Flight Center (MFSC) and its Huntsville, AL metropolitan area. Landsat NLCD data for 1992 and 2001 have been used to evaluate LULCC for MSFC and the surrounding urban area. Land surface temperature (LST) and emissivity derived from NLCD data have also been analyzed to assess changes in these parameters in relation to LULCC. Additionally, LULCC, LST, and emissivity have been identified from ASTER data from 2001 and 2011 to provide a comparison with the 2001 NLCD and as a measure of current conditions within the study area. As anticipated, the multi-temporal NLCD and ASTER data show that significant changes have occurred in land covers, LST, and emissivity within and around MSFC. The patterns and arrangement of these changes, however, is significant because the juxtaposition of urban land covers within and outside of MSFC provides insight on what impacts at a local to regional scale, the inter-linkage of these changes potentially have on meteorology.
Additionally, data such as this can be used as a foundation for modeling how climate change will potentially impact local and regional meteorology and conversely, how urban LULCC can or urban LULCC can or will influence changes on climate over the north Alabama area.

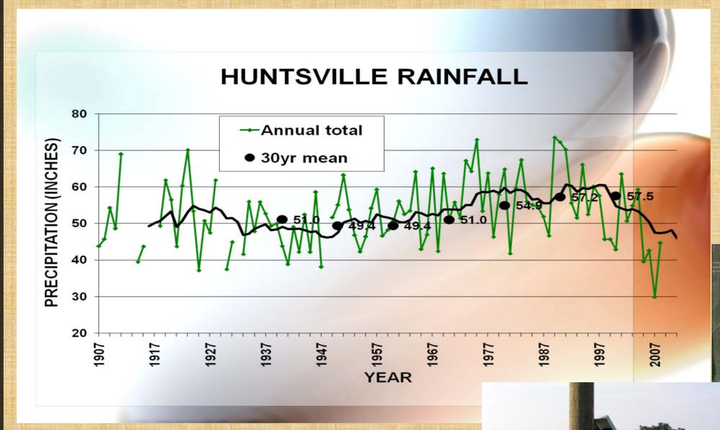
Background

Impacts of Climate Change at MSFC and Huntsville Metropolitan Area

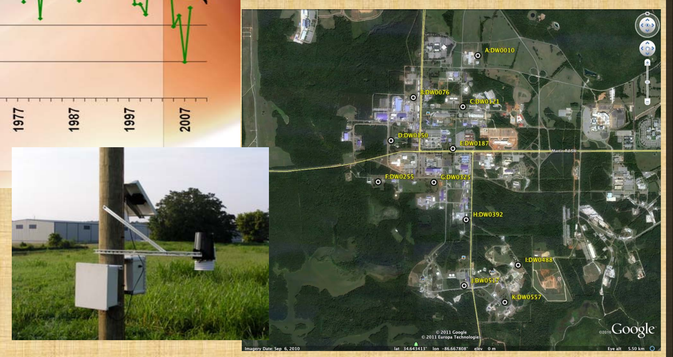
Expected Climate Change Indicators
- Extremes in temperature and precipitaion
- Prolonged periods of drought

Impacts to MSFC and Huntsville Metro Area
- Potential for localized flooding, wildfires, severe weather
- Extreme heat and air quality issues also enhanced by urban growth

Meteorological Data to Support Climate Analysis



To facilitate analysis of short- and long-term impacts of meteorology, 11 weather stations have been installed across the MSFC property. These data are transmitted by radio to a database for real-time support to the MSFC Facilities Office and the National Weather Service office located in Huntsville.

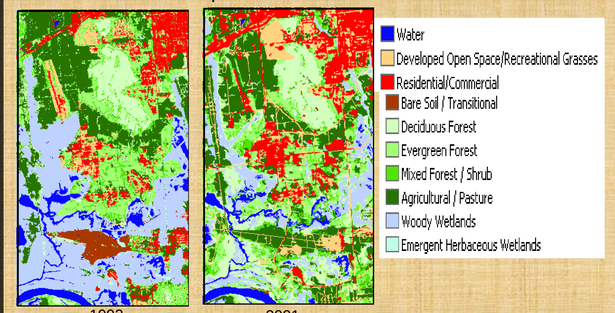


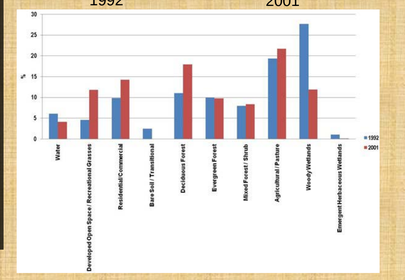
Davis weather stations provide reliable, accurate measurements of basic weather parameters (temperature, relative humidity, wind, precipitation) at low cost. Data are transmitted at ~7minute intervals.

Land Surface Temperature/Urban Heat Island Analysis

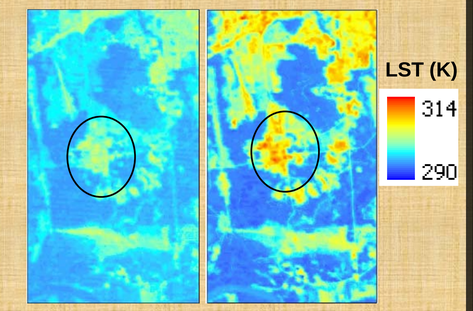
To develop a baseline for current and further analysis of the Urban Heat Island (UHI) effect over MSFC and Huntsville as a function of land cover/land use change and urban growth, historical and present -day NASA satellite data are being evaluated. Additional analysis of remote sensing data will continue using data acquired in the future for comparison with past and current datasets.

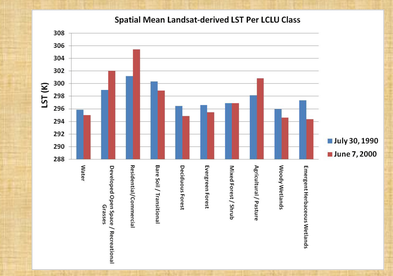
Land Cover/Land Use classifications of MSFC derived from Landsat National Land Cover Data (NLCD) 30m spatial resolution



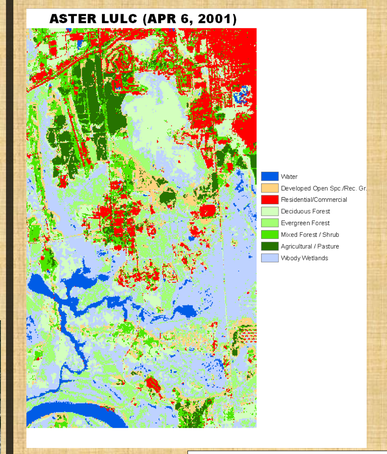


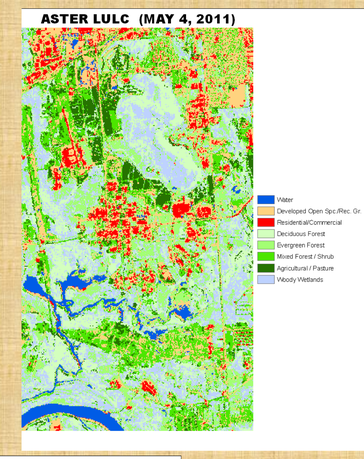
LSTs for the MSFC area derived from NLCD Data 60m spatial resolution

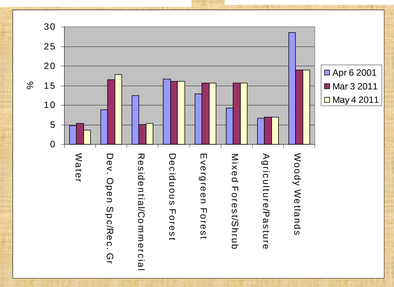




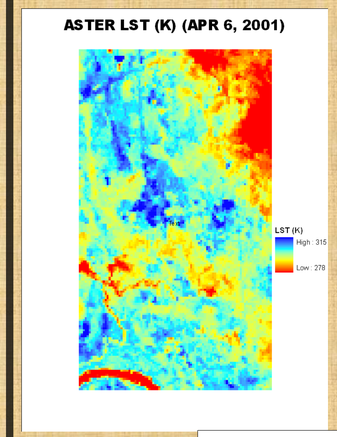
Land Use/Land Cover Change derived from ASTER data 15m spatial resolution

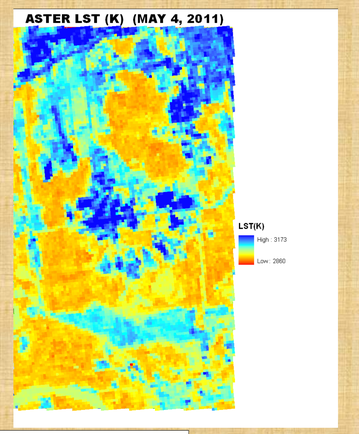


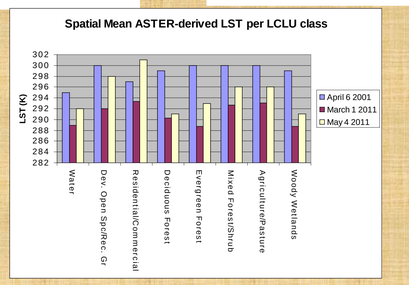




LSTs for the MSFC area derived from ASTER 90 m spatial data







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