



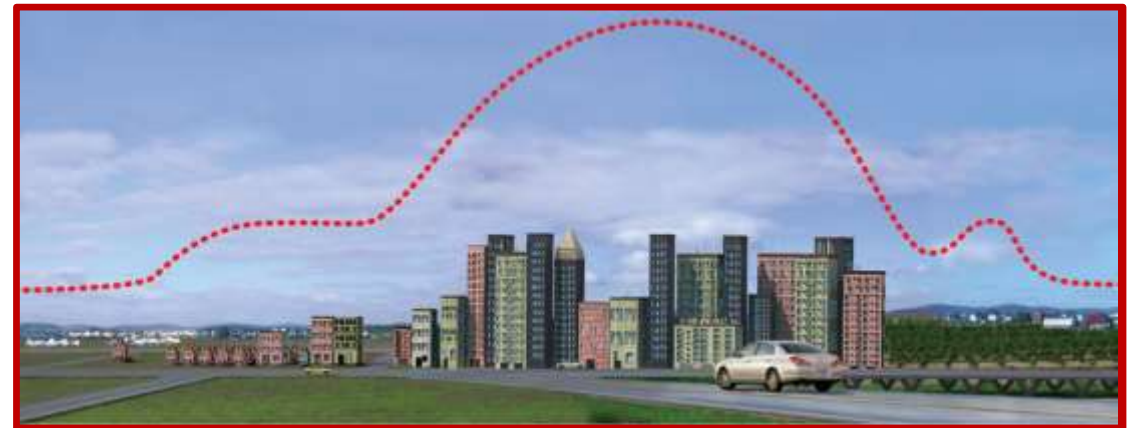
# ASSESSMENT OF SPATIO-TEMPORAL AND DIURNAL URBAN HEAT ISLAND INTENSITIES IN DELHI URBAN AGGLOMERATION USING A HIGH RESOLUTION WEATHER RESEARCH AND FORECASTING MODEL

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Monday, 13 December 2021



Credit: NASA



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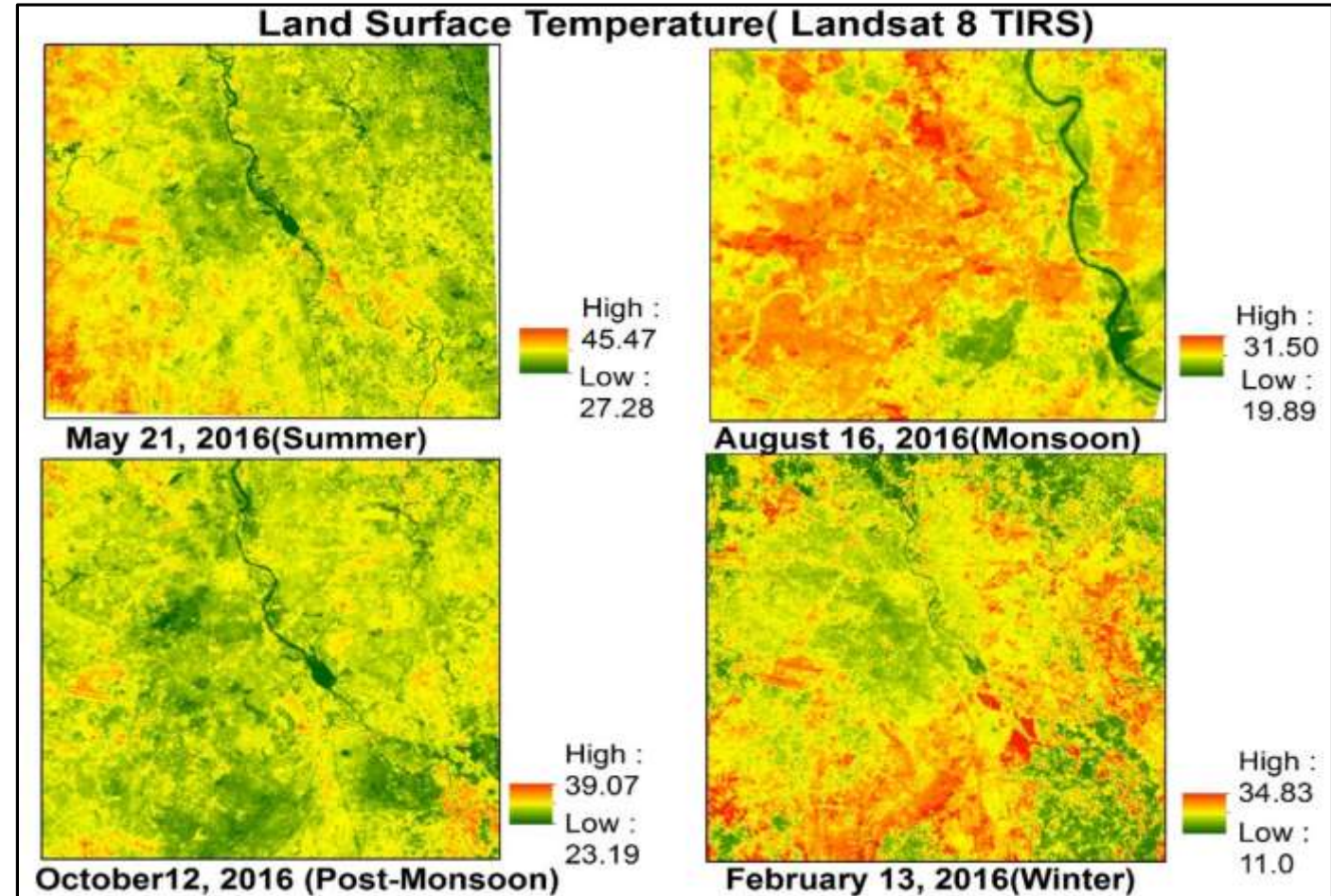


INDIAN INSTITUTE OF REMOTE SENSING, DEHRADUN



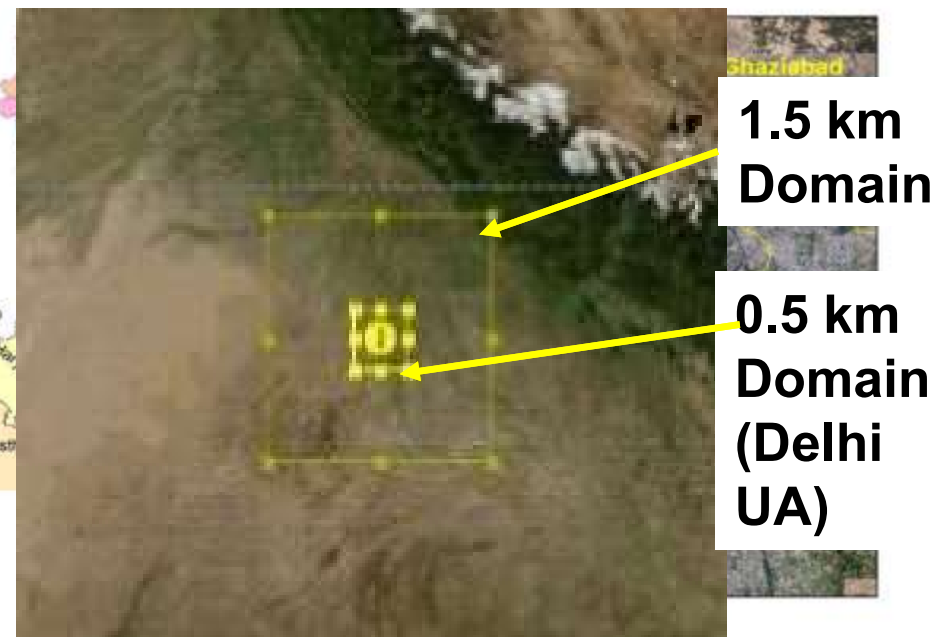
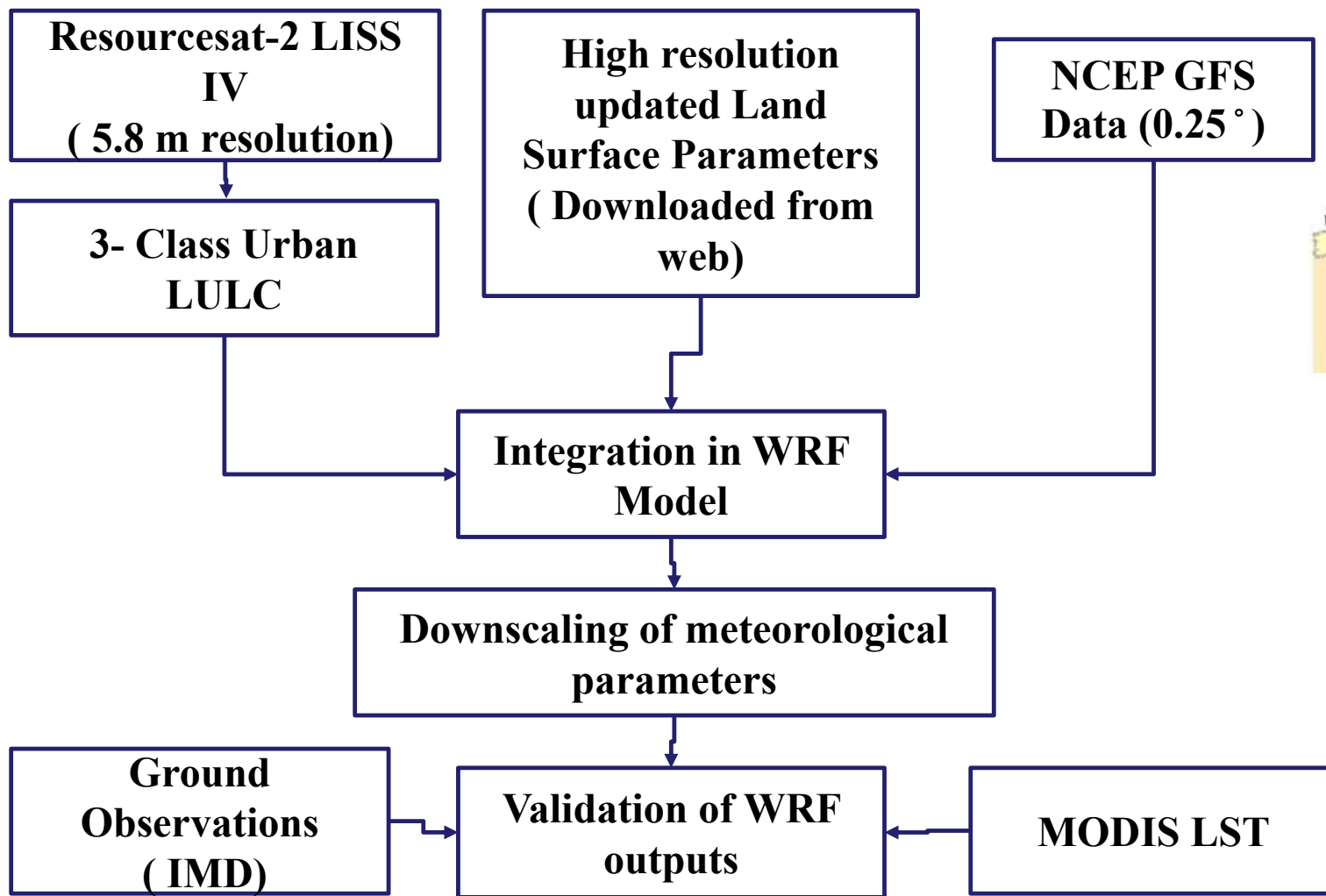
# THERMAL REMOTE SENSING

- Data Acquisition time?- usually do not coincide with maximum UHI
- Diurnal Profile ? - Widely used data - Landsat – Day time pass
- Cloud cover? – data gaps- decreases data utility
- High spectral, spatial and temporal resolution with same instrument?





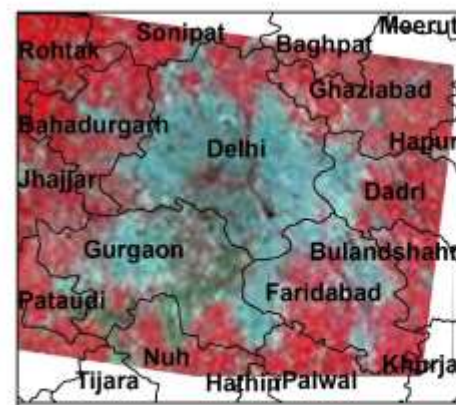
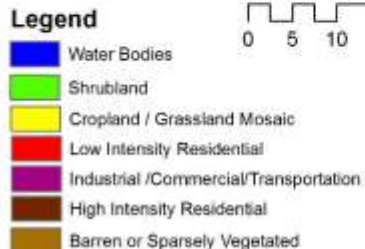
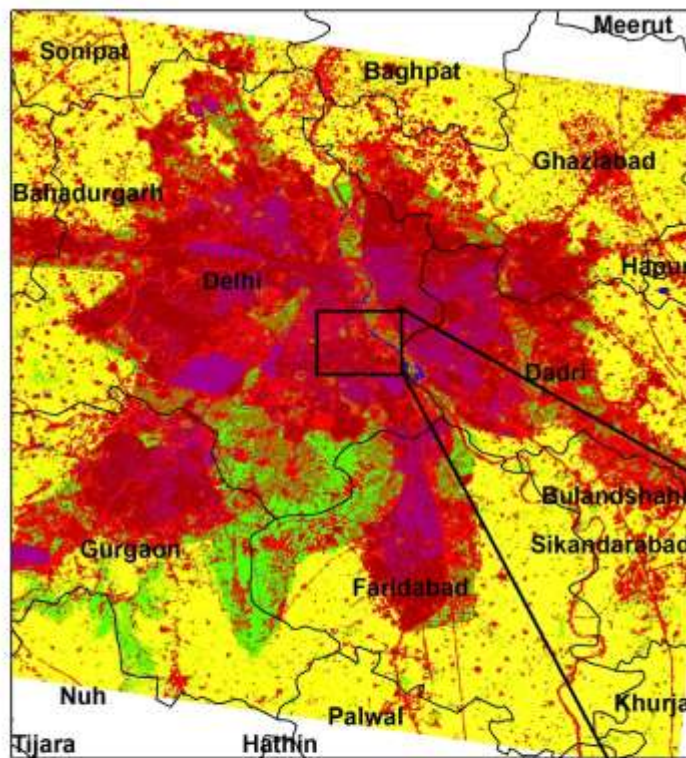
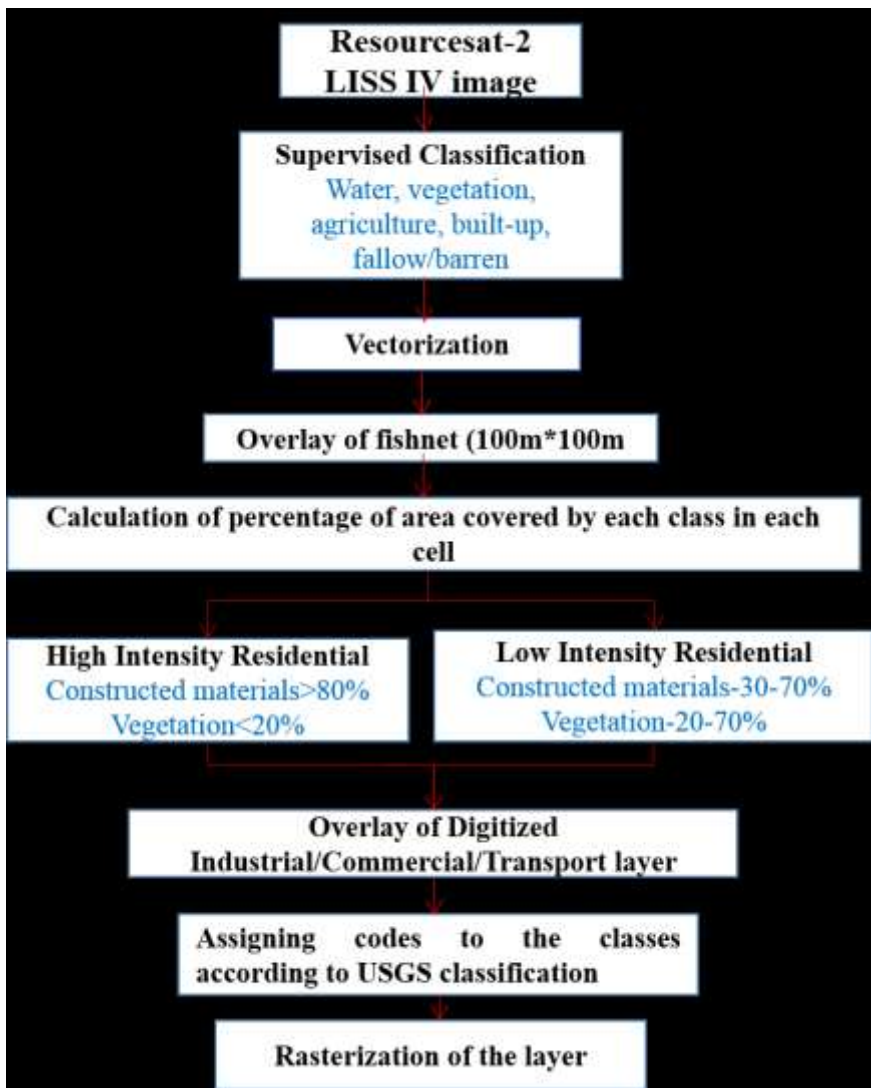
# DELHI UA (THIRD LARGEST UA OF THE WORLD) SELECTED FOR IMPLEMENTATION OF HIGH RESOLUTION INTEGRATED WRF-URBAN MODEL SIMULATIONS FOR UHI STUDIES



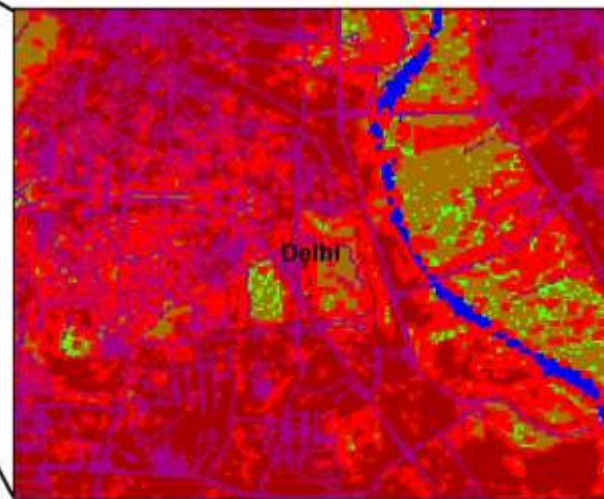
| Season  | Date of simulation   |
|---------|----------------------|
| Summer  | June 04-06, 2017     |
| Monsoon | August 08-10, 2017   |
| Winter  | December 15-17, 2017 |



## DELHI UA IS SURROUNDED BY AGRICULTURE CROP LAND , COMPOSITION OF WHICH CHANGES WITH SEASON.



False Color Composite of Satellite data



Zoomed view of Low Density Residential



# INTEGRATION OF URBAN LULC IN WRF-URBAN IMPROVES REPRESENTATION OF URBAN AREA IN URBAN CANOPY MODEL, IMPROVED MODEL PERFORMANCE.

| Simulations                                  | Pressure (mb) |      |        |      | Temperature at 2m (°C) |      |       |      | Wind Speed (m/s) |      |      |      |
|--|---------------|------|--------|------|------------------------|------|-------|------|------------------|------|------|------|
|  | MAE           | RMSE | MEAN   | STDV | MAE                    | RMSE | MEAN  | STDV | MAE              | RMSE | MEAN | STDV |
| Simulation 1<br>(Default LULC + Default LSP) | 1.56          | 1.80 | 991.54 | 2.07 | 1.05                   | 3.77 | 16.01 | 2.42 | 1.98             | 4.61 | 6.31 | 3.39 |
| Simulation 2<br>(Updated LULC + Default LSP) | 1.58          | 1.82 | 992.80 | 1.31 | 2.07                   | 3.42 | 14.73 | 2.44 | 2.10             | 3.72 | 3.10 | 2.51 |
| Simulation 3<br>(Default LULC + Updated LSP) | 1.22          | 1.48 | 991.98 | 0.93 | 1.28                   | 2.67 | 13.68 | 2.26 | 0.91             | 2.83 | 4.11 | 2.54 |
| Simulation 4<br>(Updated LULC+ Updated LSP)  | 0.30          | 0.94 | 991.47 | 0.85 | 1.04                   | 2.31 | 14.12 | 1.89 | 0.80             | 1.79 | 4.77 | 2.38 |

Source: Gupta et al., 2021



RESULTS: EVALUATION OF MODEL PERFORMANCE SHOWS HIGH CORRELATION AND IMPROVED RMSE VALUES FOR MODELED OUTPUTS.

| Temperature at 2m  |       |       |      |      |              | Relative Humidity at 2m |       |      |       |              |
|--------------------|-------|-------|------|------|--------------|-------------------------|-------|------|-------|--------------|
| Month              | Mean  | RMS E | MAE  | STDV | Correl ation | Mean                    | RM SE | MAE  | STDV  | Correl ation |
| June (Summer)      | 38.58 | 1.44  | 0.19 | 3.89 | 0.95         | 30.81                   | 3.25  | 1.5  | 10.07 | 0.96         |
| August (Monsoon )  | 30.24 | 2.45  | 1.41 | 2.68 | 0.64         | 88.07                   | 3.56  | 1.46 | 13.6  | 0.9          |
| Decembe r (Winter) | 14.62 | 2.31  | 0.61 | 4.87 | 0.86         | 73.84                   | 2.88  | 0.16 | 21.27 | 0.99         |

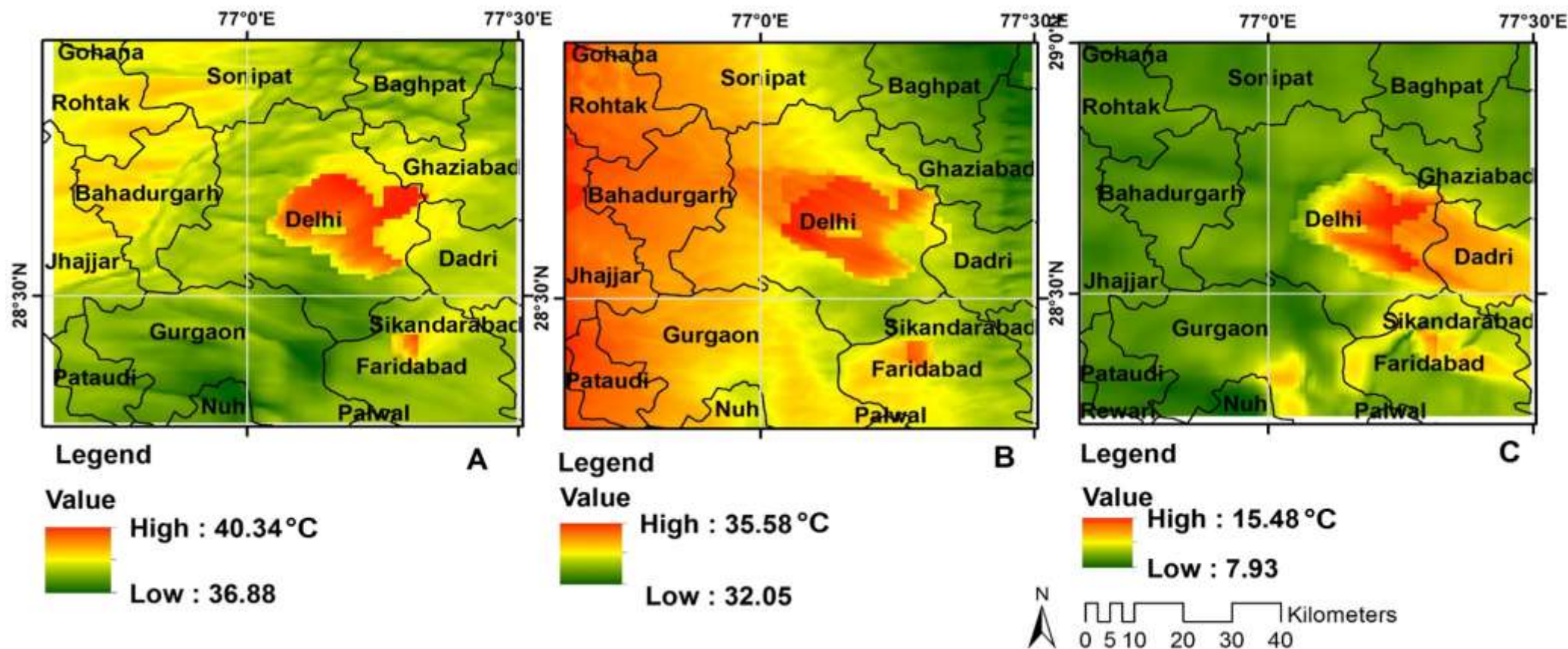


**EVALUATION OF MODEL PERFORMANCE WITH MODIS LAND SURFACE TEMPERATURE DATA (1 KM DAILY PASS)  
SHOWS SATISFACTORY PERFORMANCE OF MODELED OUTPUTS OF SURFACE TEMPERATURE. ~ 85% OF PIXELS WITH  
IN -1 TO +1 DEGREE DIFFERENCE RANGE.**

| RANGE     | Urban LULC- June |             | Urban LULC-August |             | Urban LULC-<br>December |             |
|-----------|------------------|-------------|-------------------|-------------|-------------------------|-------------|
|           | No. of pixels    | % of Pixels | No. of<br>pixels  | % of Pixels | No. of<br>pixels        | % of Pixels |
| <-2 to -1 | 27               | 1.75        | 291               | 8.91        | 201                     | 1.41        |
| -1 to 1   | 1316             | 85.51       | 1053              | 78.43       | 1043                    | 84.72       |
| >2        | 196              | 12.74       | 195               | 12.67       | 205                     | 12.87       |
| SUM       | 1539             |             | 1539              |             | 1539                    |             |



**RESULTS: UHI FORMATION CAN BE CLEARLY SEEN OVER DELHI UA ESPECIALLY DURING NIGHT HRS.**



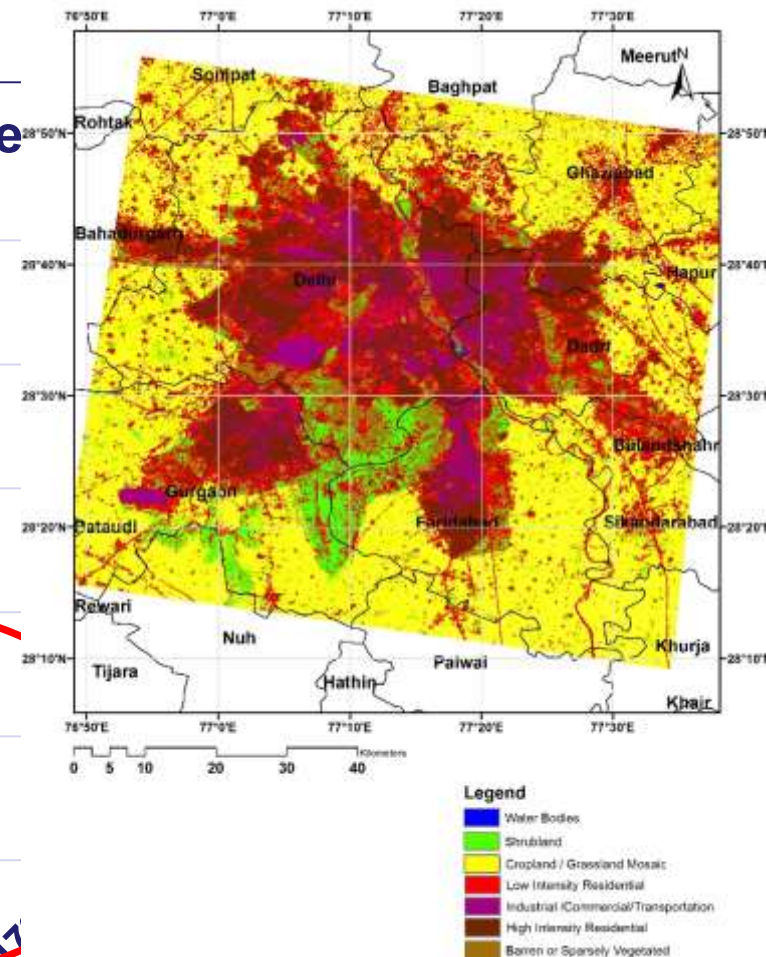
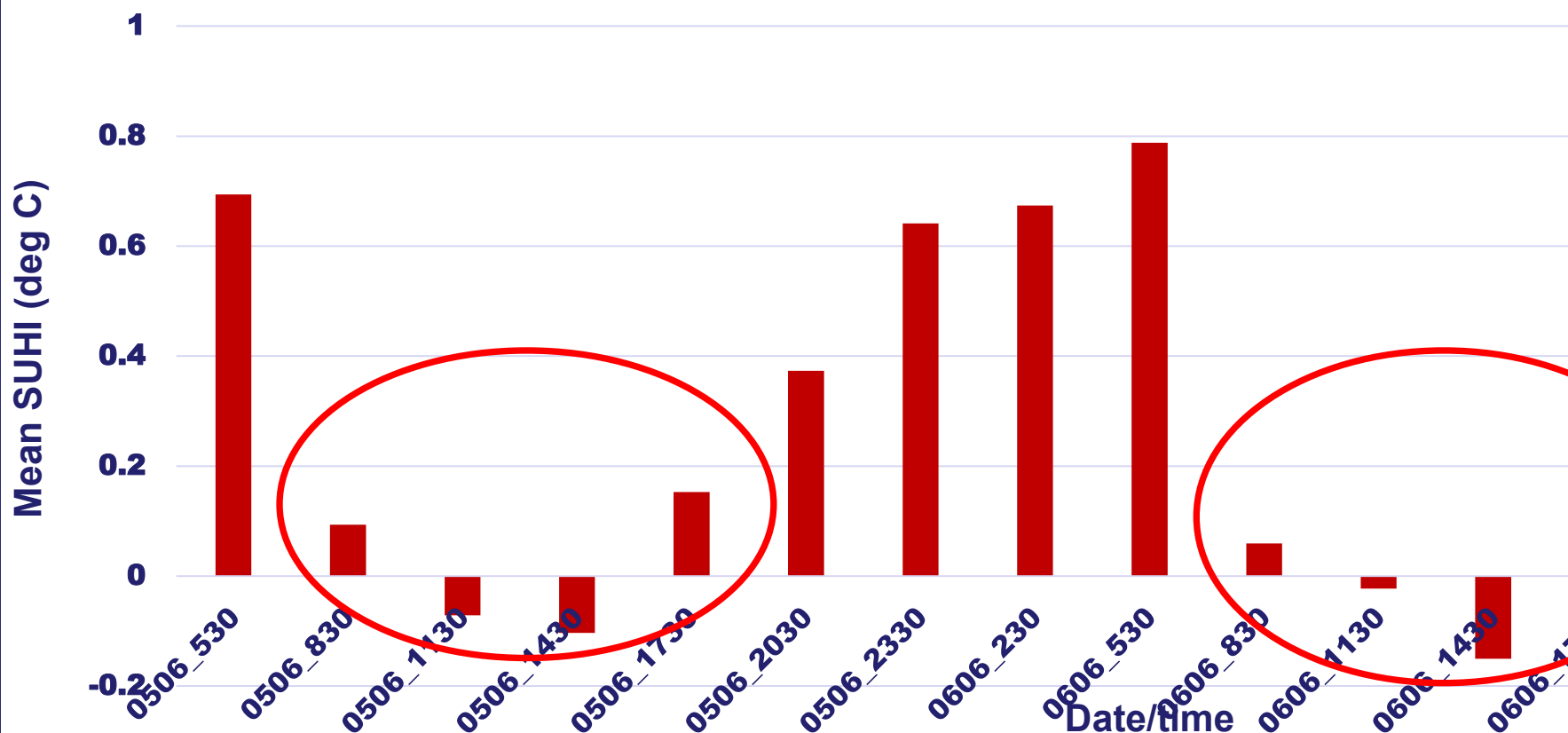
Spatial distribution of temperature at 2m (°C) over D02.

A. June 4th, 2017 20:30 IST, B. August 8th, 2017 20:30 IST, C. December 16th, 2017 23:30 IST



**RESULTS: FALLOW LAND/ BARE SOIL AREA IN SURROUNDINGS HEATS UP FASTER THAN URBAN AREA (LOW ALBEDO MATERIALS MOSTLY CONCRETE, ASPHALT) IN SUMMER SEASON, DISPLAYED NEGATIVE HEAT ISLAND INTENSITIES DURING 1130 TO 1430 IST.**

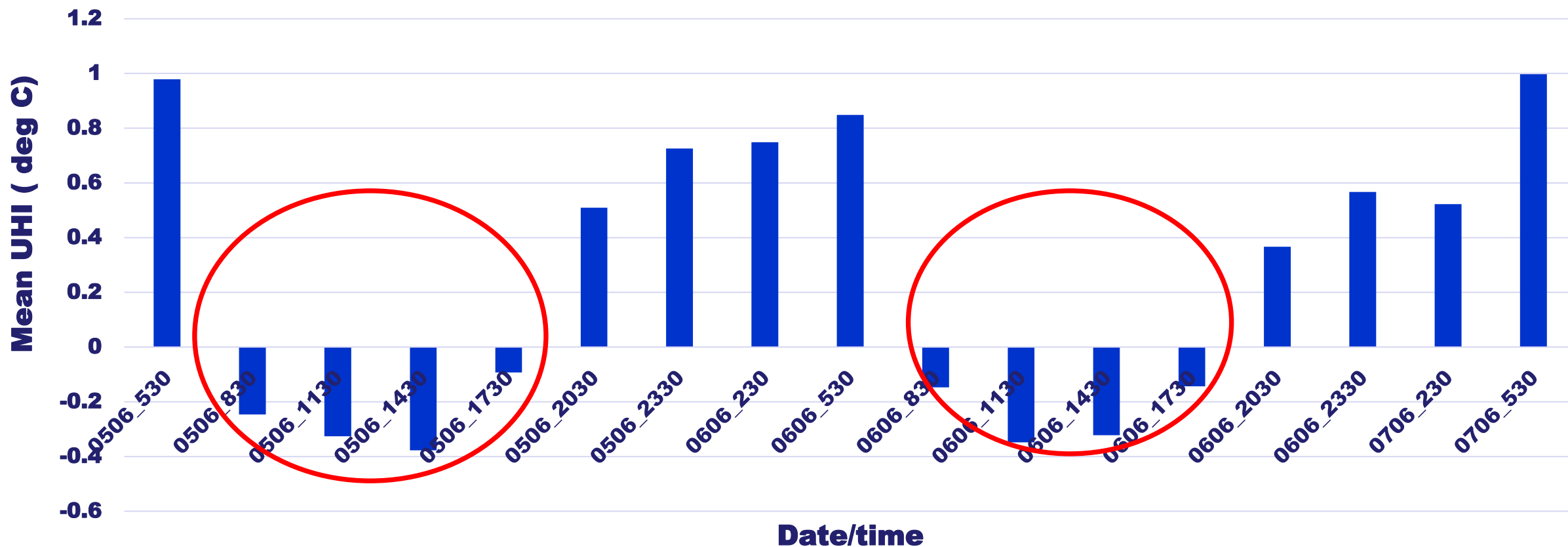
Diurnal Variation of Surface Urban Heat Island Intensity





**RESULTS: SIMILAR PATTERN OBSERVED FOR CANOPY LAYER HEAT ISLAND INTENSITIES (0830 TO 1730 IST) IN SUMMER SEASON .**

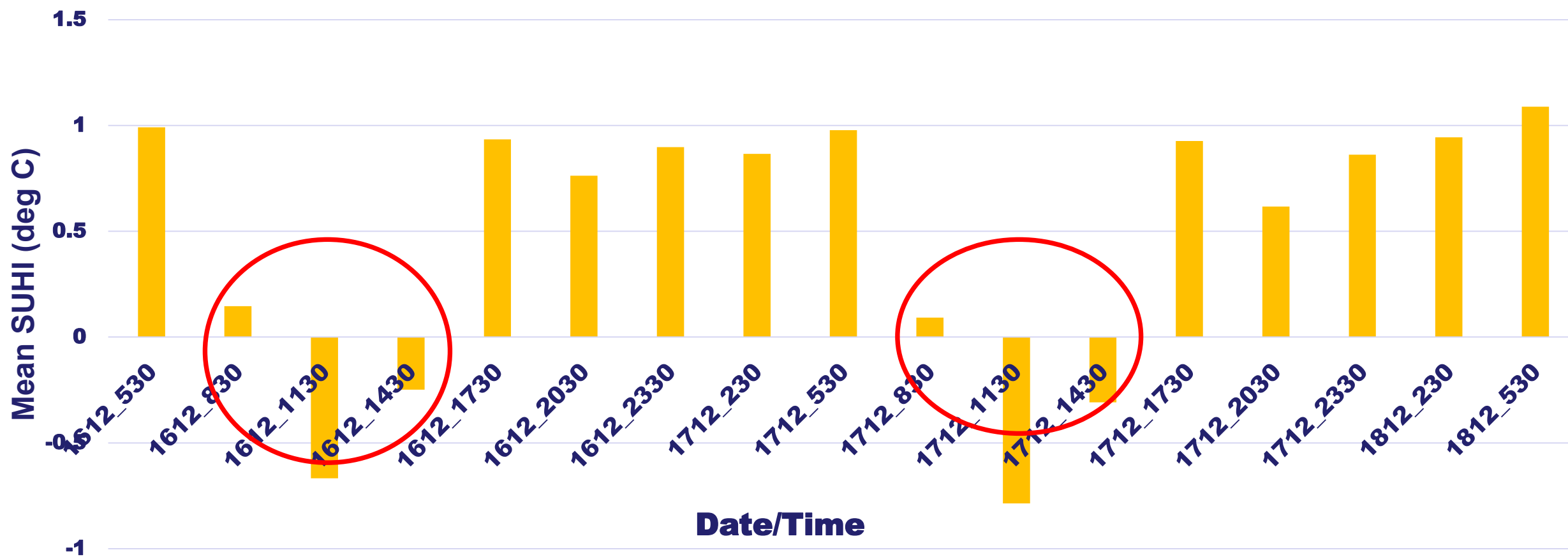
**Diurnal Variation of Urban Canopy Heat Island Intensities (Summer)**





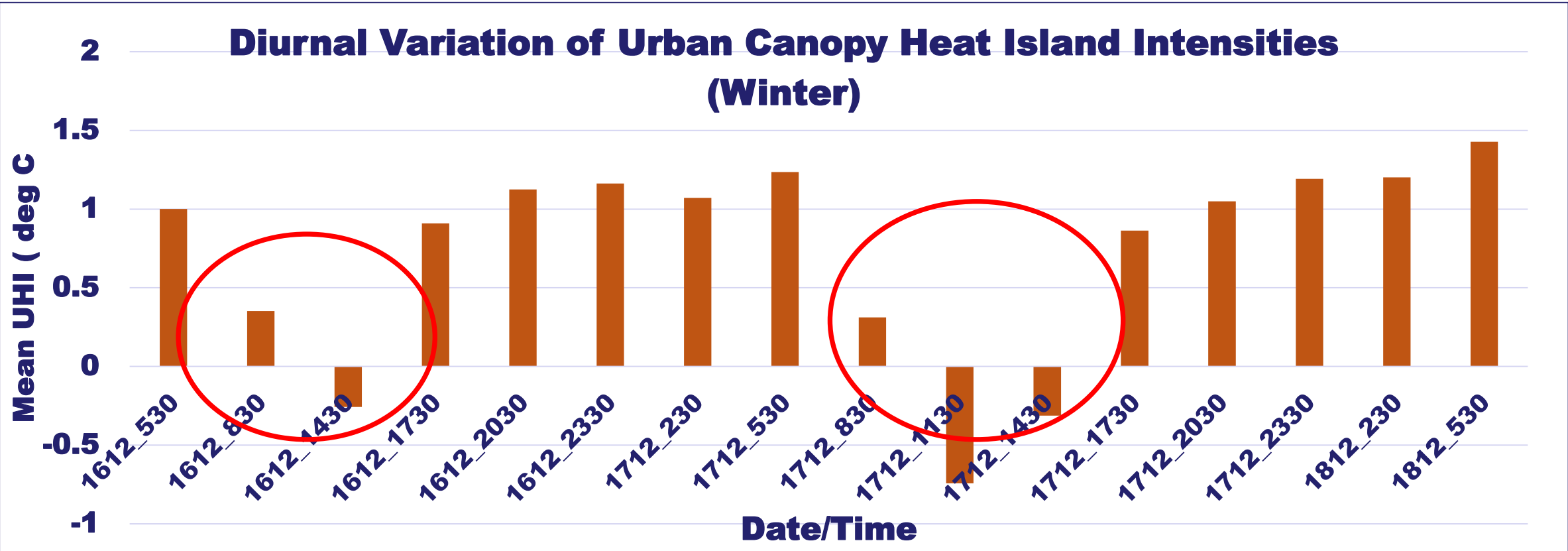
**RESULTS: IN WINTER SEASON, SHADING DUE TO 3D GEOMETRY OF URBAN AREAS AND INCLINED ELEVATION OF SUN CAUSES URBAN AREAS TO GAIN HEAT SLOWLY AS COMPARED TO SURROUNDING RURAL AREAS.**

### Diurnal Variation of Surface Urban Heat Island Intensities (Winter)





**RESULTS: LOWER SUHI AND CANOPY LAYER HEAT ISLAND INTENSITIES AT 1130 IST RAISES CONCERN FOR USE OF THERMAL REMOTE SENSING SATELLITES (PASS TIME 10:30 AM - 11:30 AM IST) FOR SUHI STUDIES ESPECIALLY IN ARID AND SEMI-ARID REGIONS LIKE DELHI WHICH IS SURROUNDED BY AGRICULTURE CROP LAND/SAND / BARE SOIL.**





# THANK YOU

Integrated WRF-urban model employed for assessment of SUHI and CLUHI provides complete diurnal profile for UHI studies and shows negative UHI at 1130 IST for Delhi UA, usual time of pass for thermal remote sensing satellites .

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