Analysis of Upper-Air, Ground and Remote Sensing Data for the Atlas Field Campaign in San Juan, Puerto Rico

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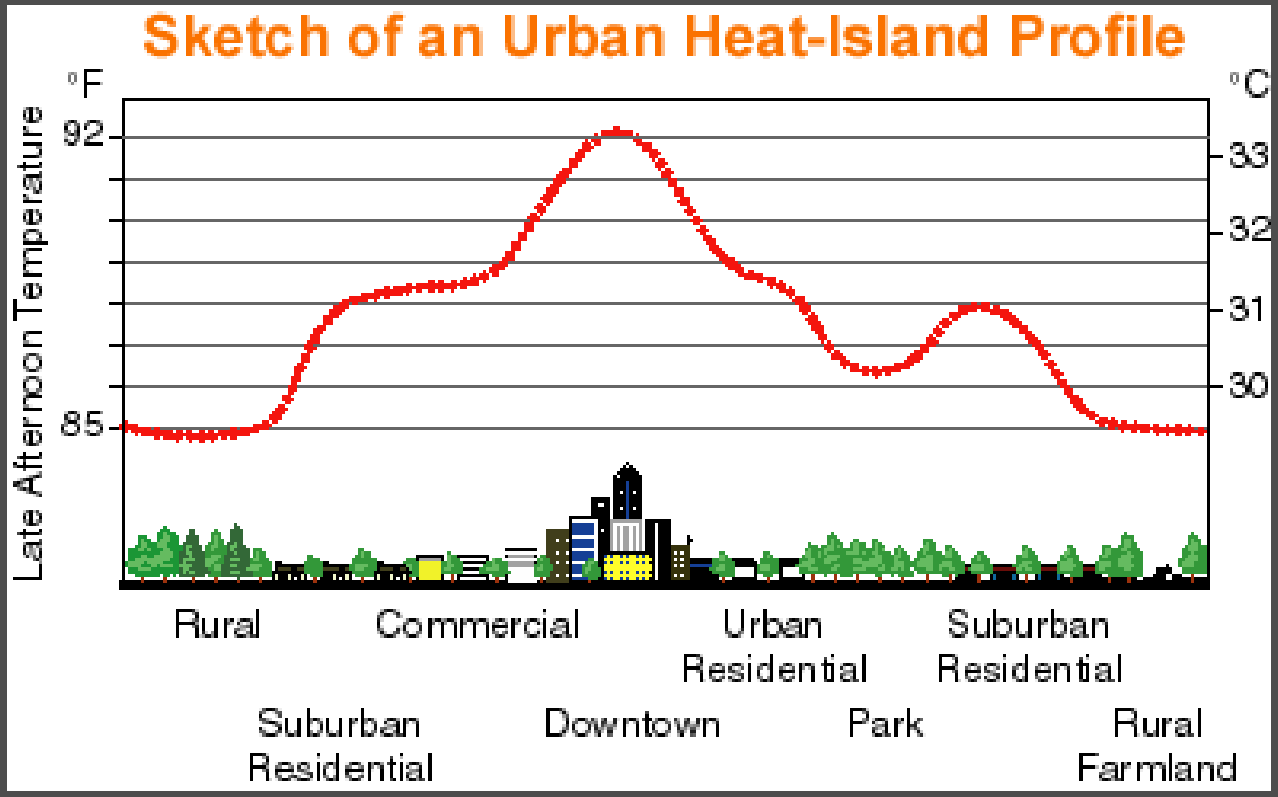
Outline

- OBSERVATIONAL MEASUREMENTS AND ANALYSES
  - Urban Heat Island (UHI) Climatology
  - Satellite and Airborne Images
  - Modeling Experiments
- ATLAS MISSION
  - Description
  - Analysis of synoptic and upper-air data
  - Network of Stations
  - Analysis of Surface Station Data
- SUMMARY

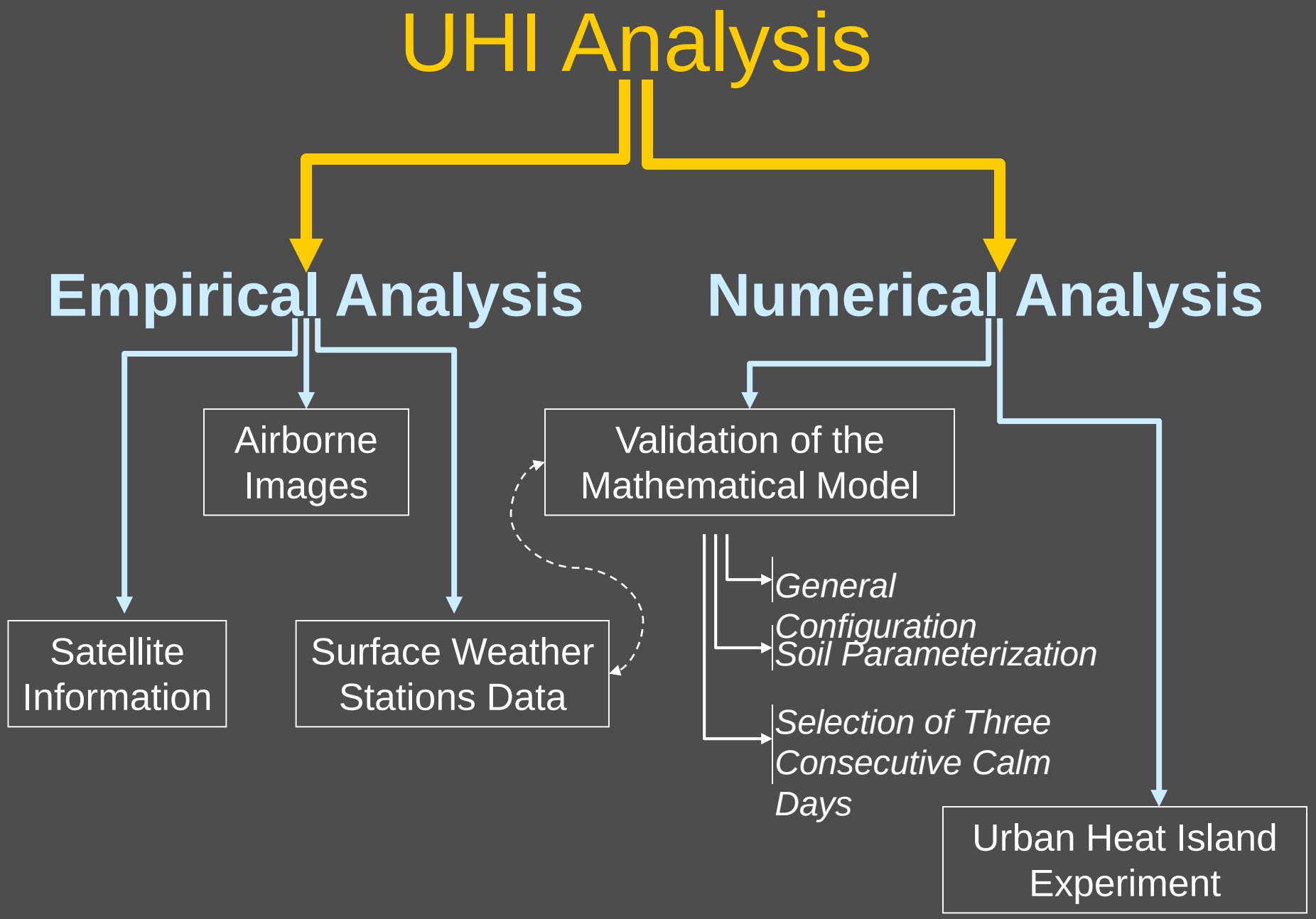
Urban Heat-Island Effect



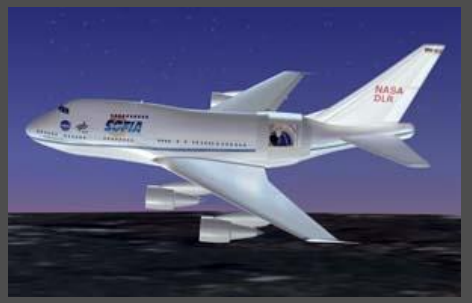
Can be defined as the dome of elevated air temperatures that presides over cities in contrast to their cooler rural surroundings.

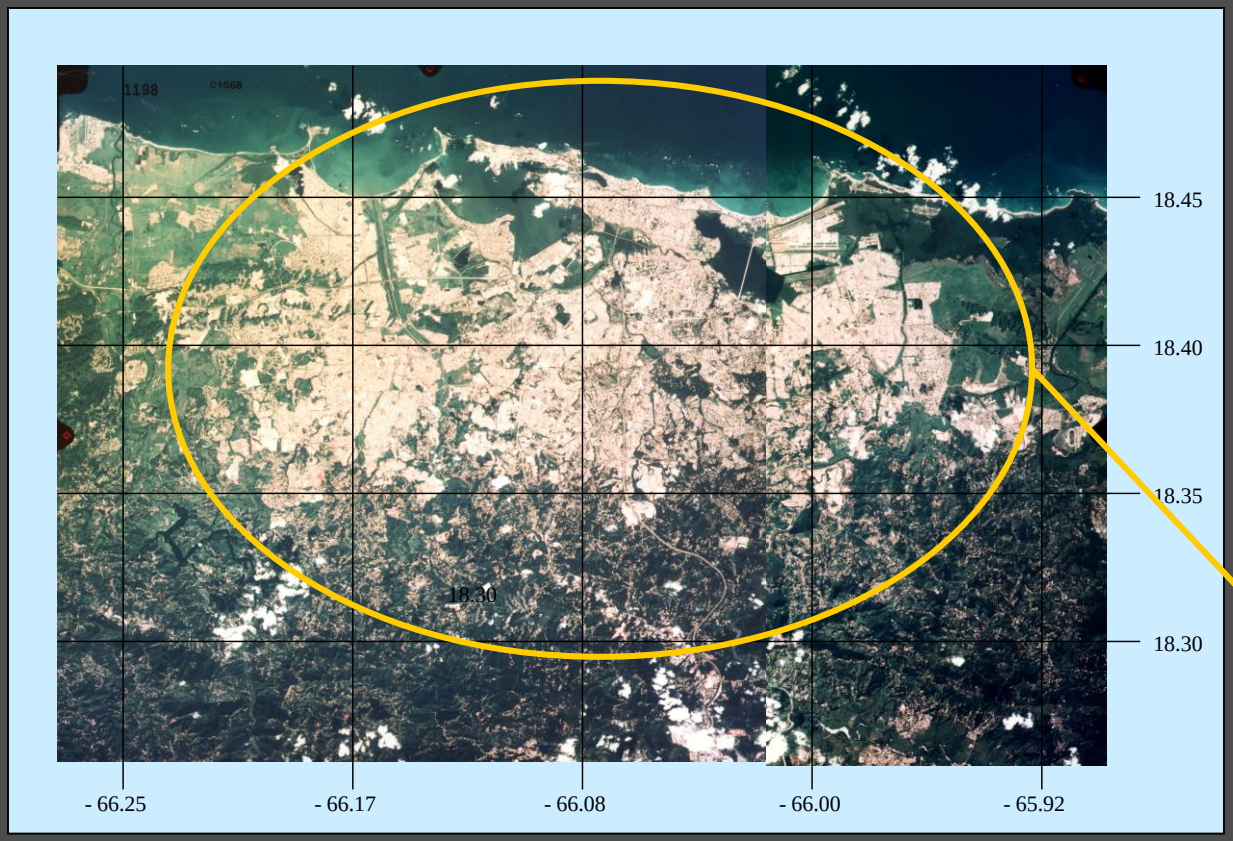
UHI: The Case of SJU-PR

Station Locations


UHI Analysis
Empirical Analysis
Numerical Analysis
Airborne Images
Satellite Information
Surface Weather Stations Data
Validation of the Mathematical Model
General Configuration
Soil Parameterization
Selection of Three Consecutive Calm Days
Urban Heat Island Experiment

Airborne Images





Size of the Urbanized Area of San Juan
308 km^2

Sensor - Airborne-Ocean-Color-Imager
Time - December 11, 1993
Altitude - 19.8 km altitude
Performed by - NASA-Ames Research Center

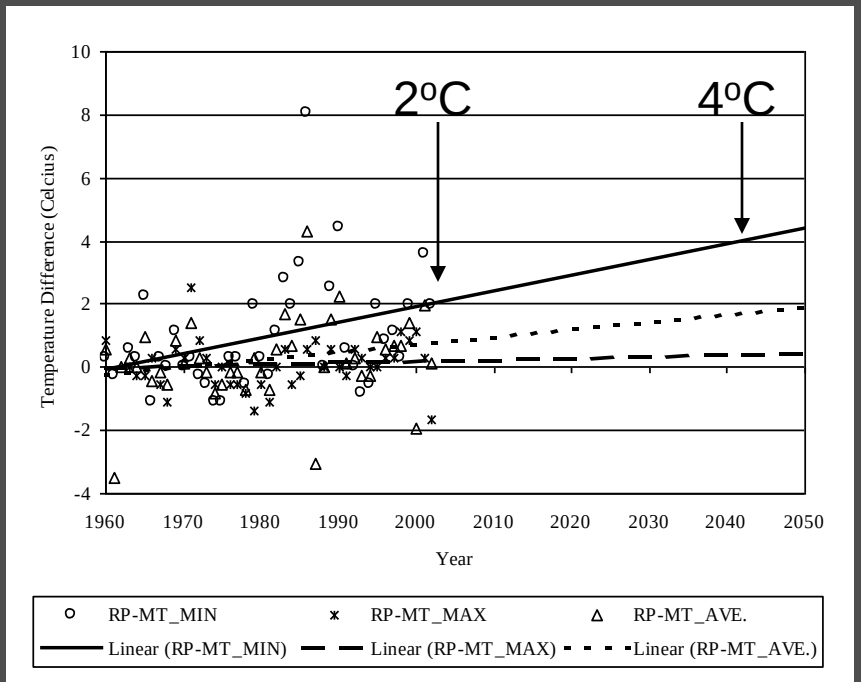
dT(U-R) = Urban – Rural (ºC)

air temperature at 2-meters above the ground

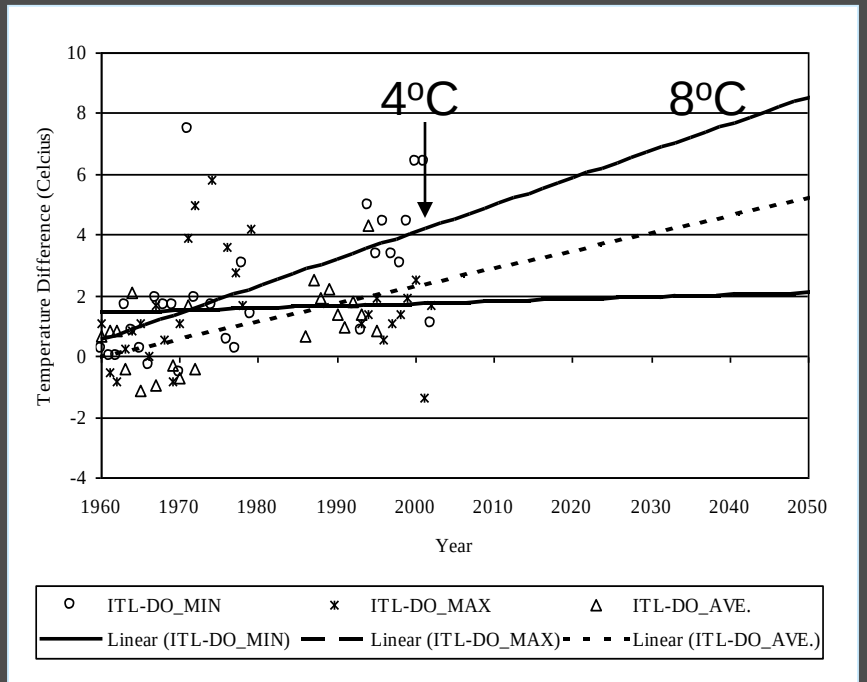
Daily Average of the Year

			Temperature Difference for each year		
		LINEAR EQUATION	1960	2000	2050
ITL_DO	dT MIN	= 0.0889x - 173.7	0.44	3.90	8.35
	dT MEAN	= 0.058x - 113.76	-0.09	2.22	5.11
	dT MAX	= 0.0075x - 13.2	1.40	1.60	1.98
RP_MT	dT MIN	= 0.0499x - 98.001	-0.20	1.80	4.29
	dT MEAN	= 0.0238x - 46.913	-0.27	0.69	1.88
	dT MAX	= 0.005x - 9.9085	-0.11	0.09	0.34
dT MIN AVERAGE			***0.12***	***2.85***	***6.32***
dT MEAN AVERAGE			***-0.18***	***1.45***	***3.49***
dT MAX AVERAGE			***0.65***	***0.85***	***1.16***

Inland

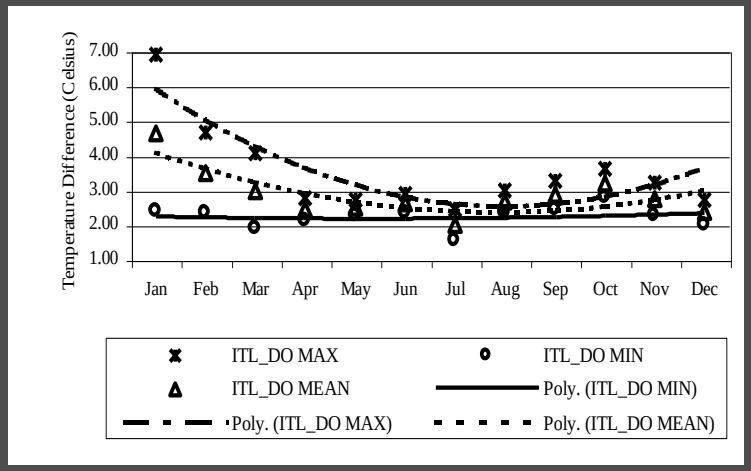


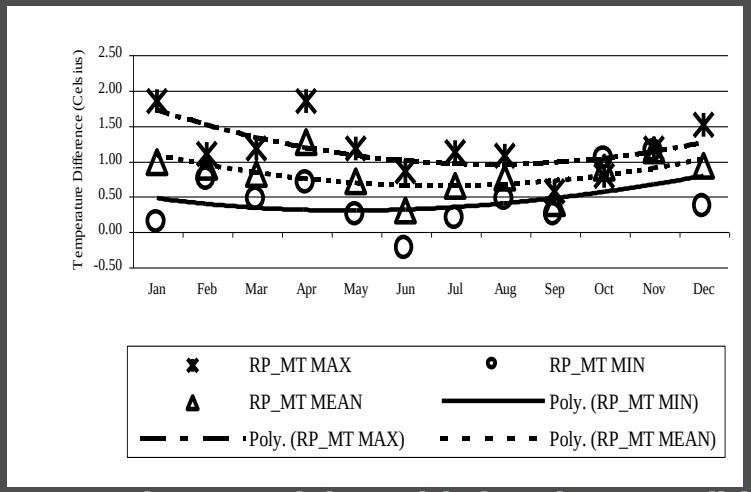
Coastal



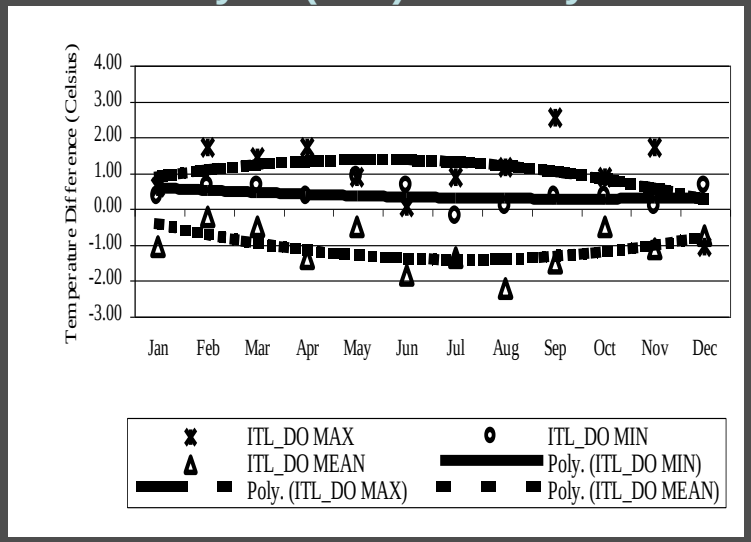
Climatological analysis

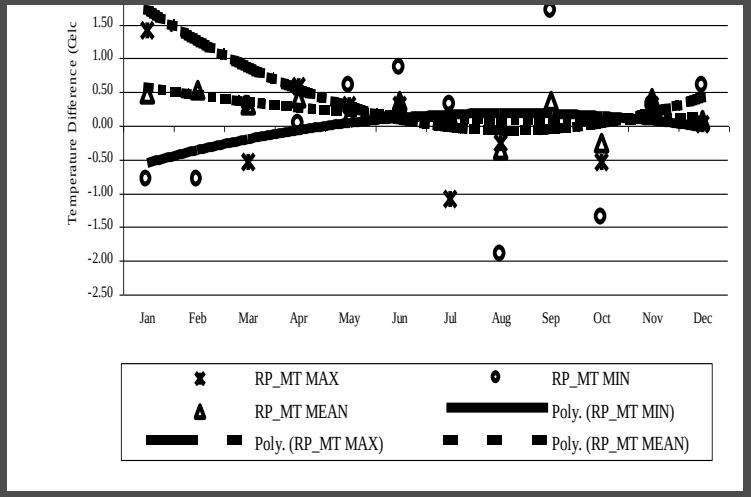
Monthly dT(U-R) for the year 1998 for coastal areas (a) and inland areas (b)





Monthly dT(U-R) for the year 1960 for coastal areas (a) and inland areas (b)

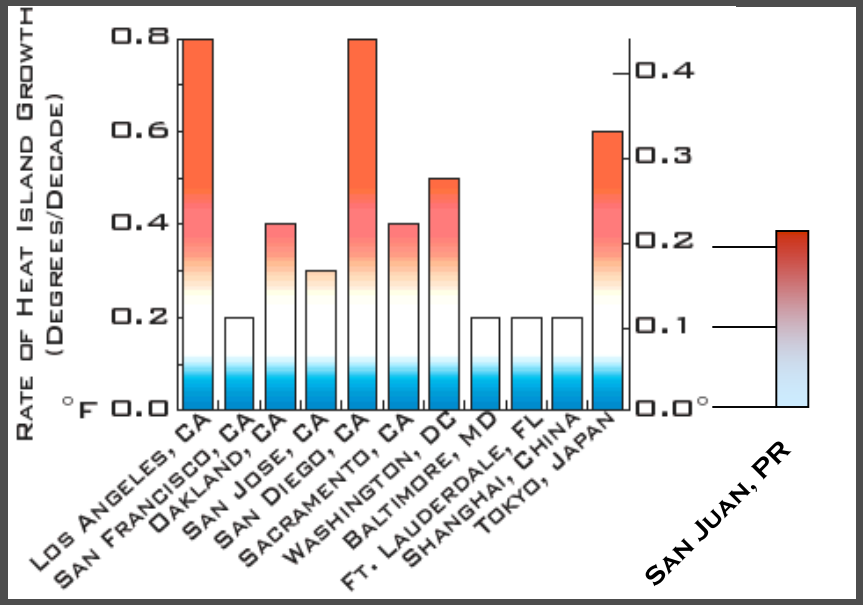




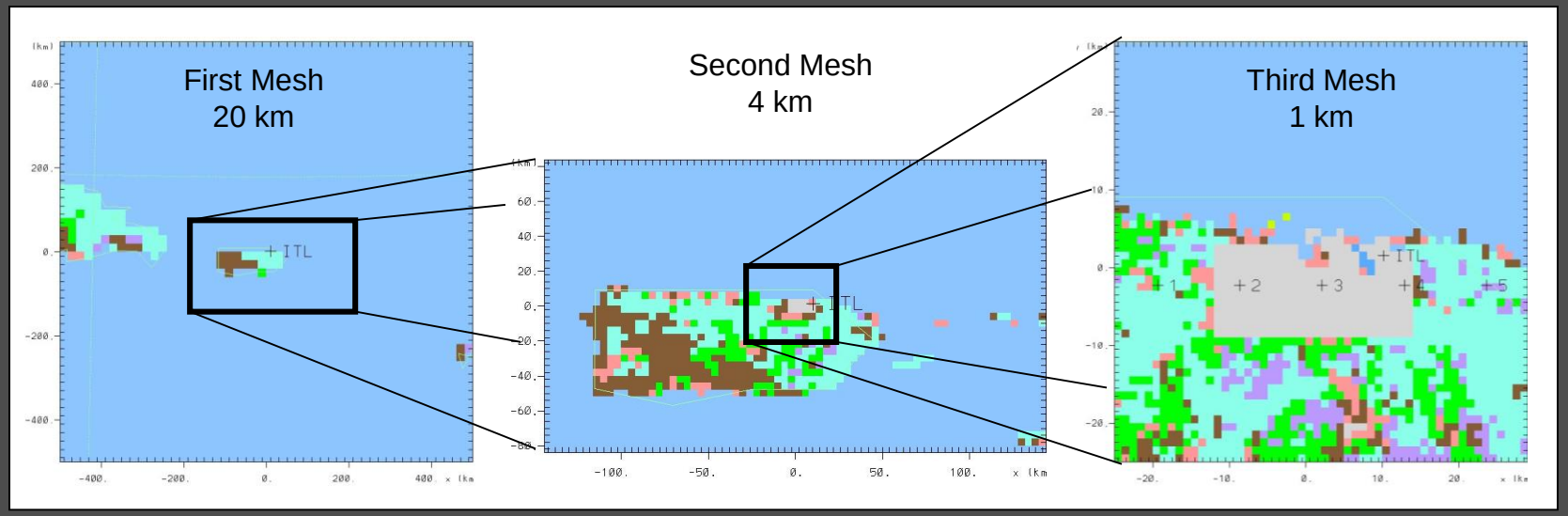
Coop Surface Weather Station Summary

- The average MEAN temperature of the urban canopy air at 2 meter above ground for the coastal and inland area is over 1.84^{o}C higher than the surroundings north rural areas.
- The empirical analysis revealed the existence of a permanent urban heat island effect present in the MASJ during the complete year, which is more noticeable on the winter season.
- According to the linear regression for the last forty years the UHI is increasing at a rate of 0.21^{o}C/decade.

Urban Heat Island Group
LAWRENCE BERKELEY LABORATORY



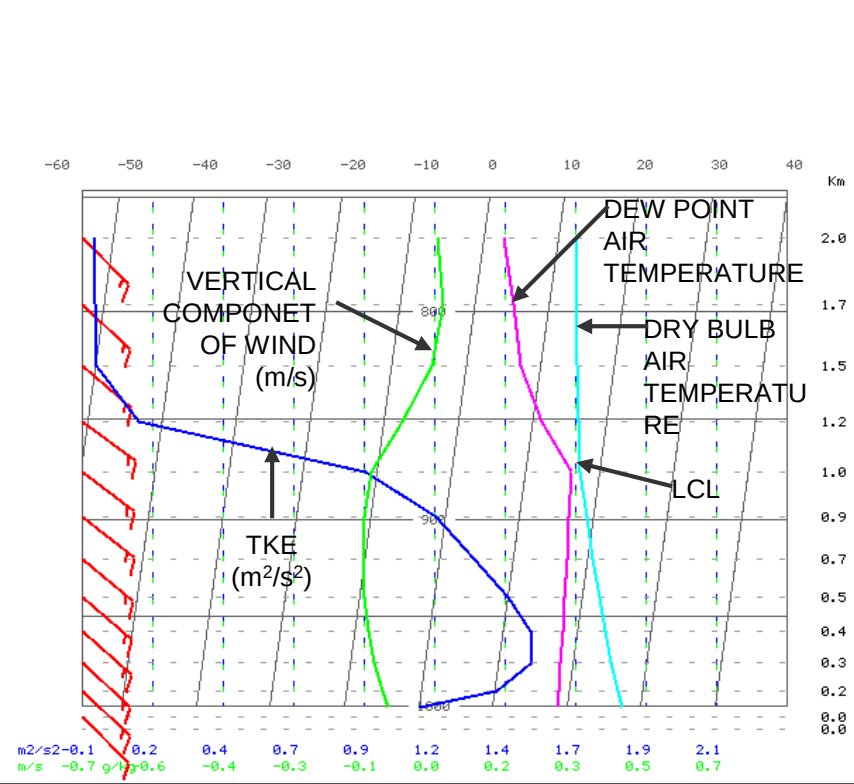
General Configuration of the Model



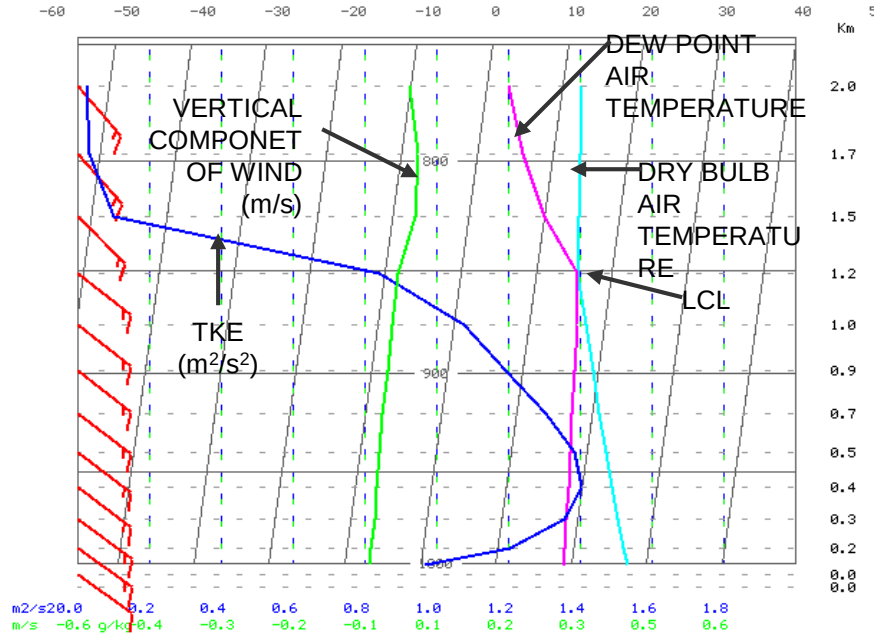
- Vertical Domain – 20km
- Radiative Lateral Boundary Conditions and a lid as a top boundary conditions.
- Water Vapor is the only water phase represented in the model.
- 72h integration initialized on 1200UTC 24 January 1998.
- The prognostic soil model (LEAF2) is activated with 10 levels for a total depth of 1 meter.

UHI–X Results

18:00 GMT, January 26, 1998

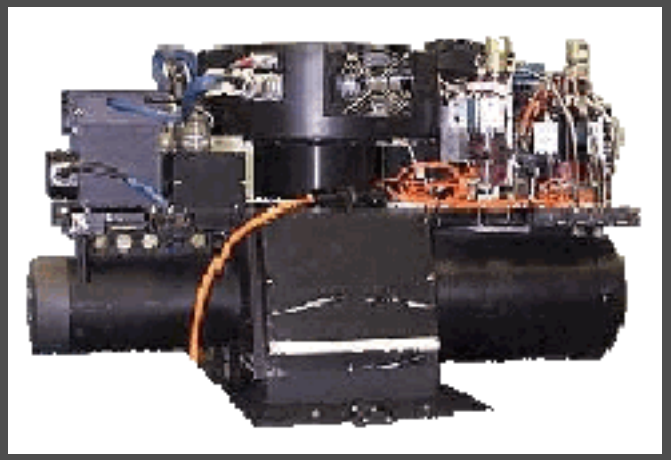


Primitive Scenario



Present Scenario

RS-ATLAS Campaign



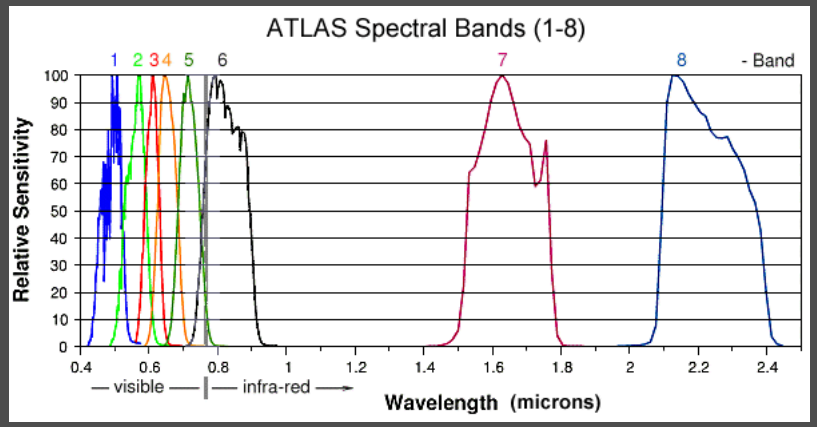
The Airborne Thermal and Land Applications Sensor (ATLAS) from NASA/Stennis operates in the visual and IR bands. It flies on a Lear 23 jet for flexibility and produces high resolution images of value to observe UHI.

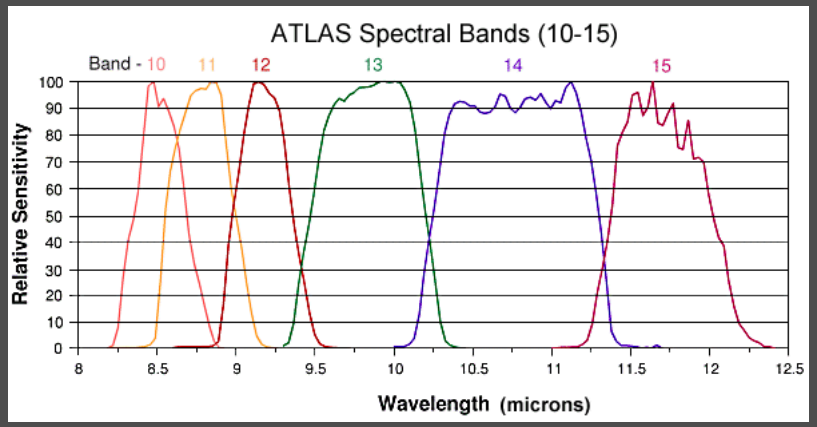
Empirical UHI Analysis: The ATLAS Mission in San Juan, Puerto Rico

Mission Objectives

- To investigate the relationship between urban growth, land cover change, and the development of the urban heat island phenomenon over a tropical coastal city; San Juan, Puerto Rico.
- Study the overall effects of urban development on surface energy budget characteristics across the urban landscape through time at nested spatial scales from local to regional.

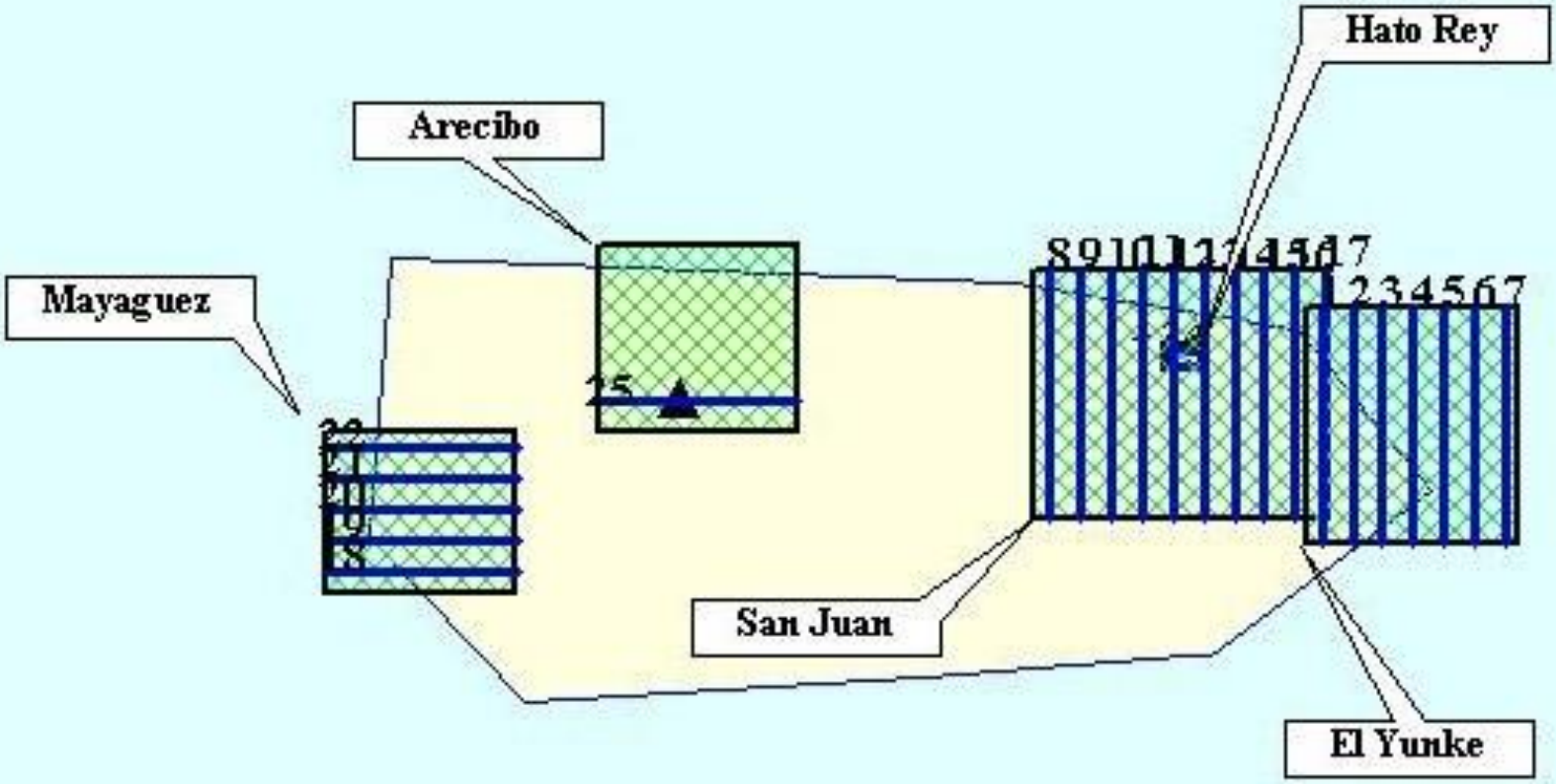
ATLAS Spectrum





ATLAS visual and IR spectrum. The mission also operated a 9 inch Zeiss camera for high resolution photographic work.

Flight Plan



Mission Details

Dates:	February 6-18, 2004
Instrument:	ATLAS / Zeiss camera on a Lear 23 jet
Flight path:	San Juan Metro in 5m and 10m resolution, El Yunque Rain Forest, Arecibo Observatory, and Mayaguez in 10m resolution
Personnel:	UPR (students, faculty and staff), NASA, CUNY, NAIC, others.
Ground Equipment:	Several
Processing:	Processed data will be available after September 2004

Ground Support

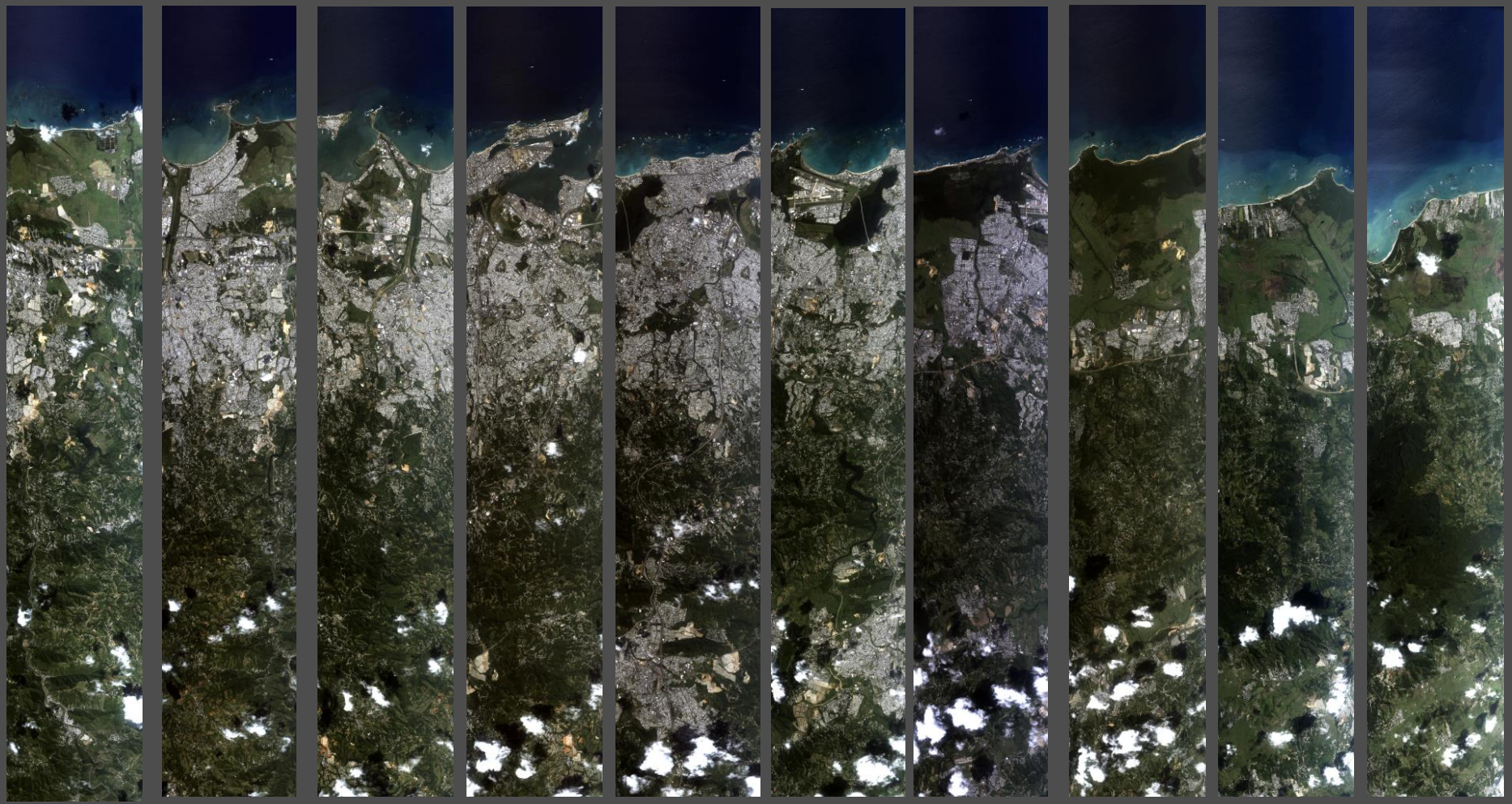
- Radiometers
- Weather stations
- Sounding balloons
- Two-color Lidar
- IR Camera
- GPR
- Satellite passes
- Coastal observations

- Used along the flight area to record local conditions.
- These measurements employed local students and faculty and also served as a teaching/training tool.

Summary of SJAM

Day	Lines	Flight	Time (UTZ)	Resolution
Feb 11	18-22	Mayaguez	13:27-14:03	10 meters
Feb 11	23-24	Hato Rey Day	14:22-14:36	5 meters
Feb 13	1-7	El Yunque	17:54-18:49	10 meters
Feb 13	23-25	Hato Rey & Arecibo Night	23:59-00:29	5 meters
Feb 16	8-17	San Juan	14:03-15:29	10 meters

ATLAS images: Flight 5 lines 8-17



8 9 10 11 12 13 14 15 16 17

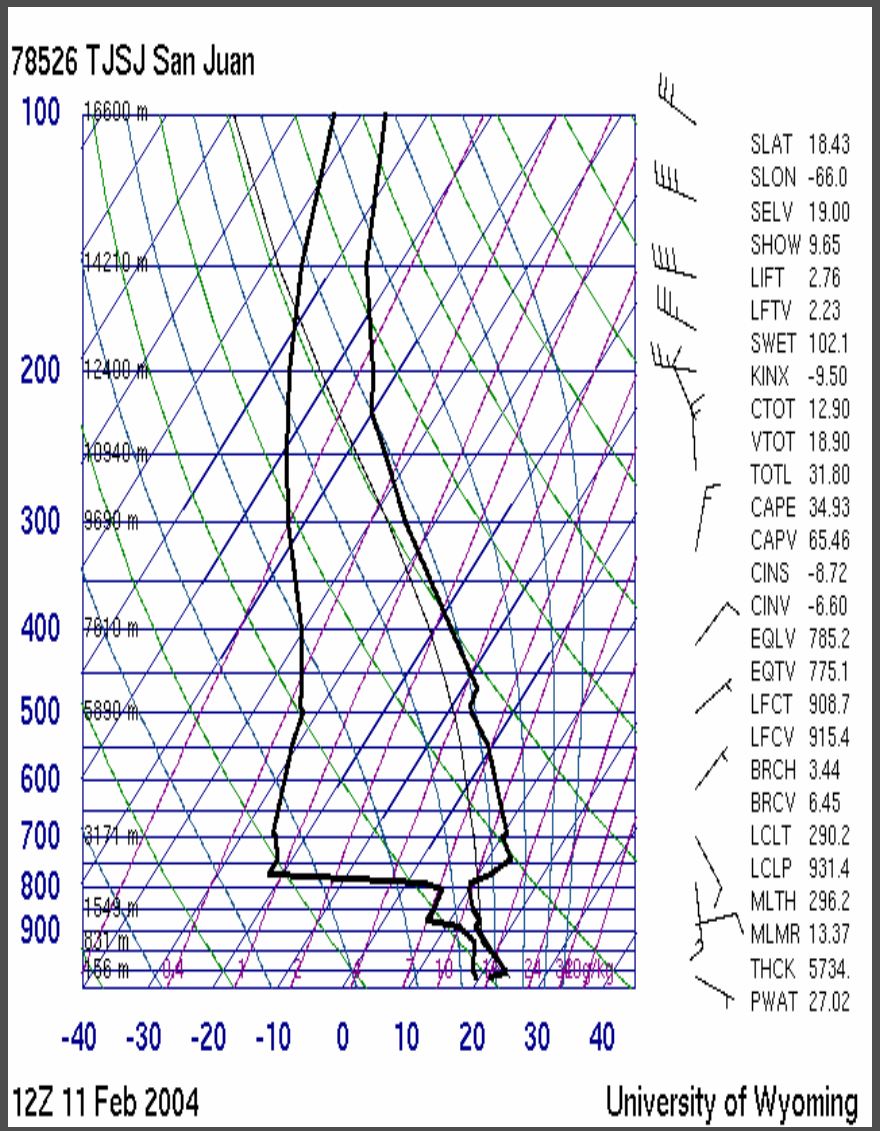
Sample of ATLAS images for San Juan

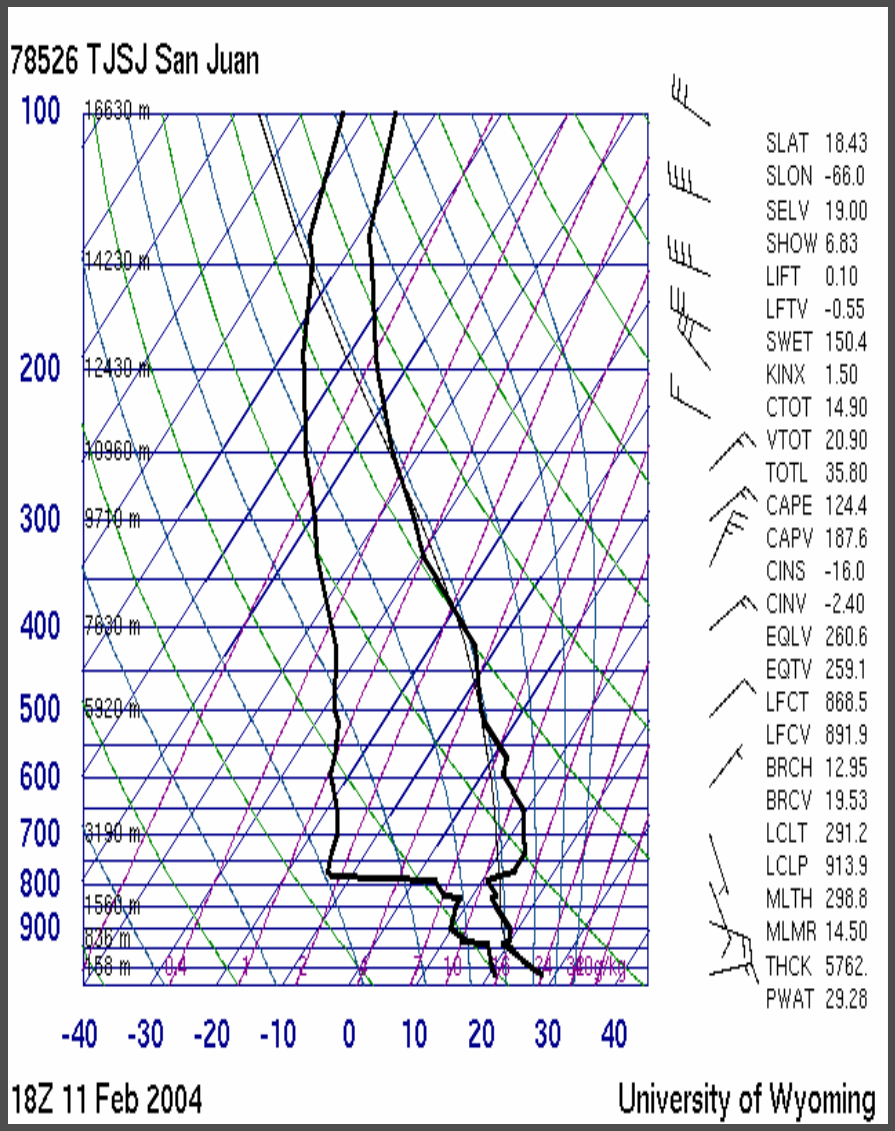
Visible (left) and false color (right) images of the ATLAS sensor taken at 10 meters February 16, 2004.

Sample of ATLAS images for San Juan

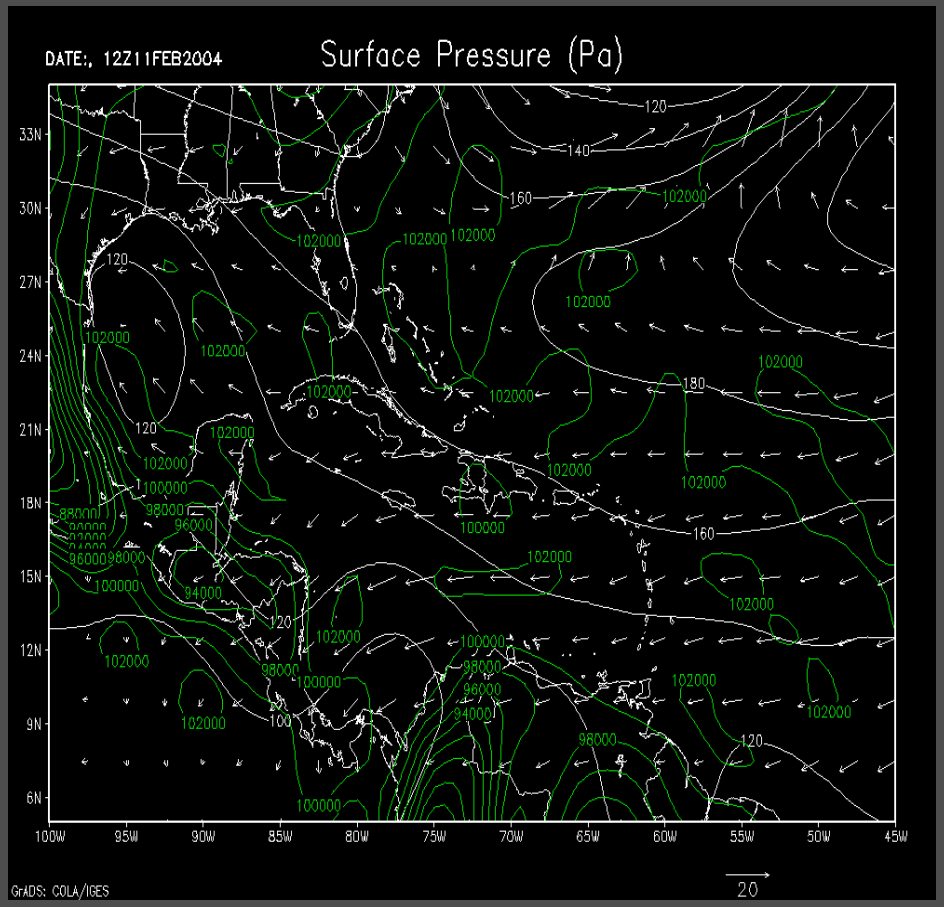
Visible (left) and infrared-12 (right) images of the ATLAS sensor taken at 10 meters February 16, 2004.

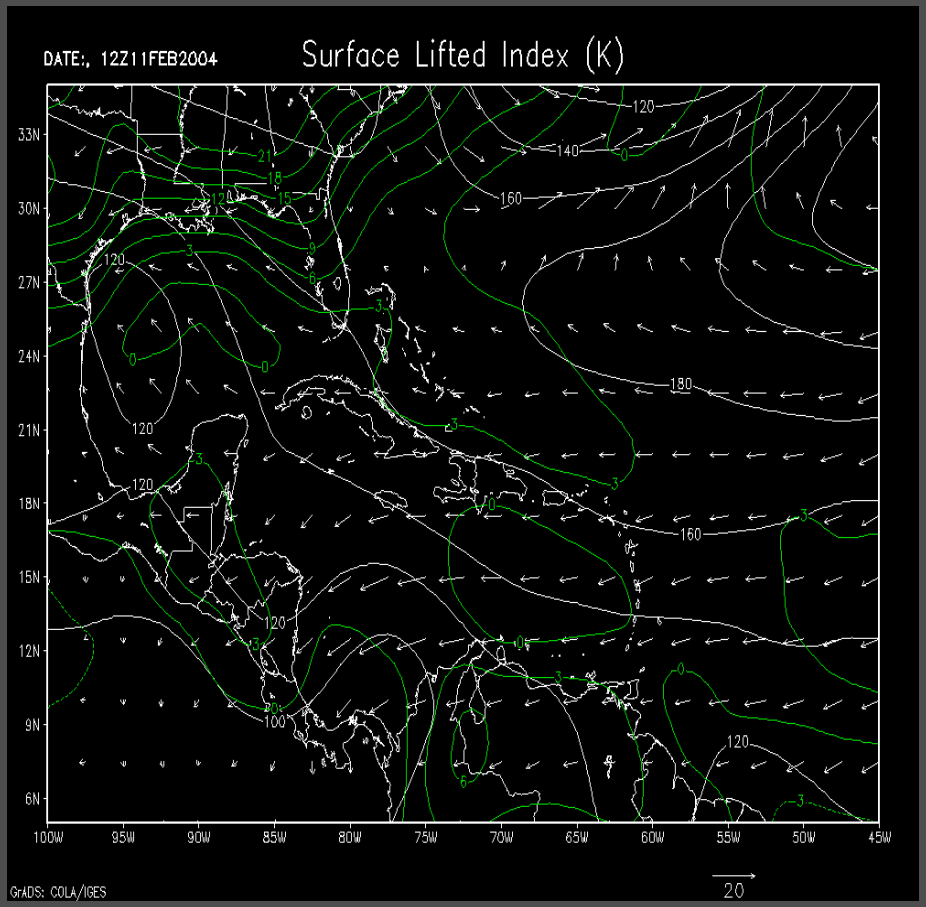
Upper air data from San Juan for February 11, 2004 at 12UTZ(a) and 18UTZ(b)

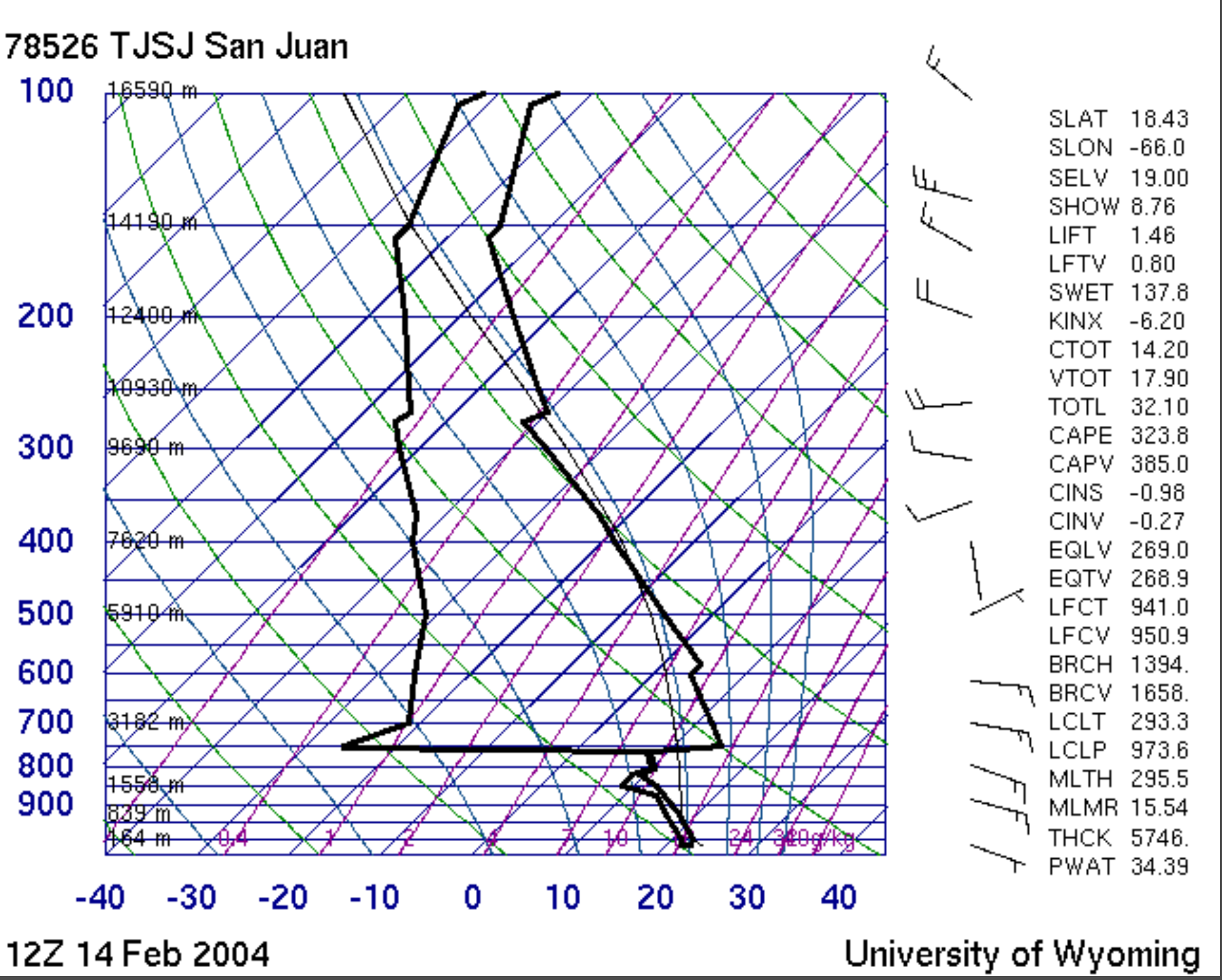


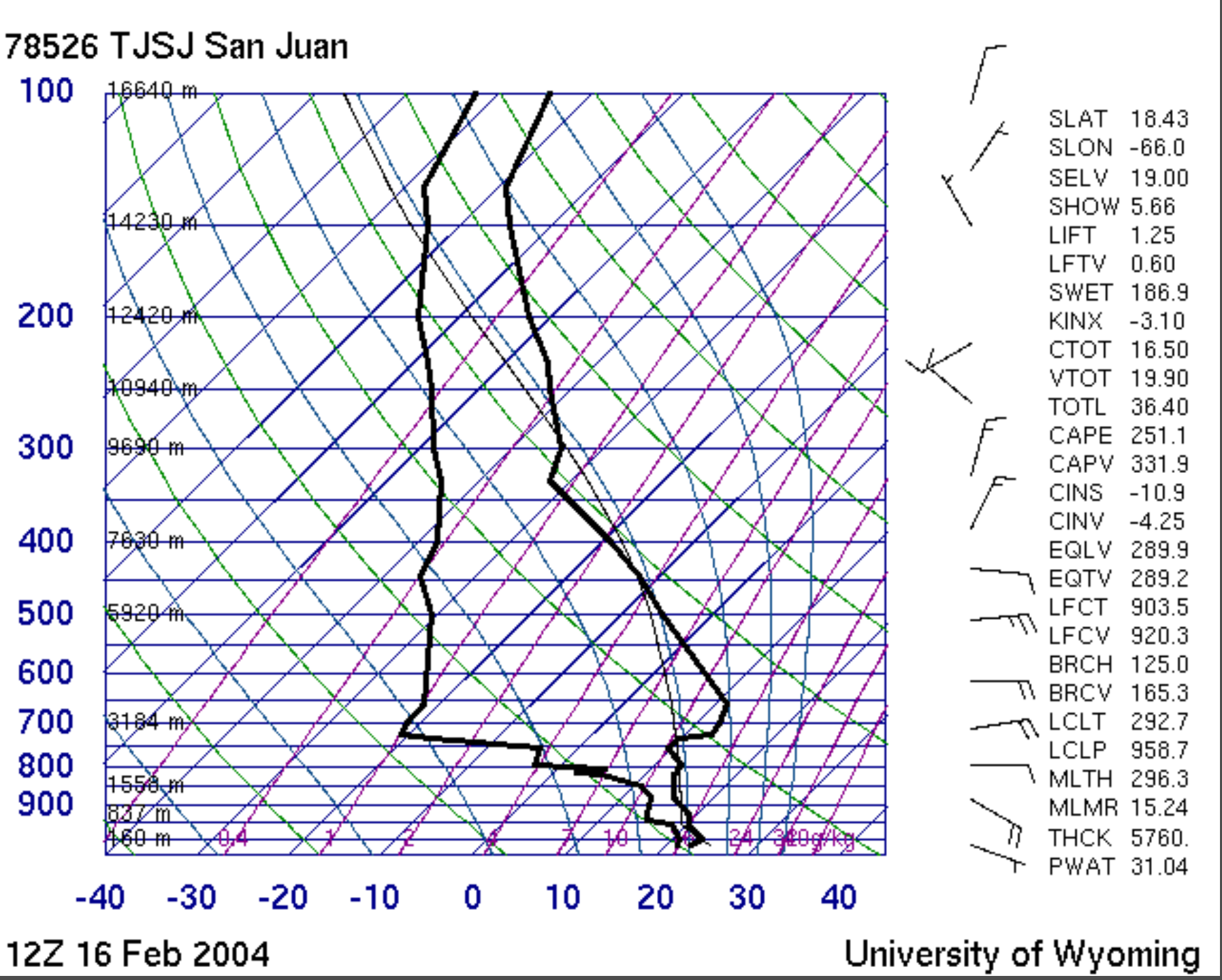


NCEP surface pressure in mb (a) and surface lifted index in K (b) for February 11, 2004 at 12 UTZ






78526 TJSJ San Juan
100
200
300
400
500
600
700
800
900
16590 m
14190 m
12400 m
10930 m
9690 m
7620 m
5910 m
3182 m
1558 m
829 m
164 m
0.4
1
2
4
7
10
24
-40
-30
-20
-10
0
10
20
30
40
SLAT 18.43
SLON -66.0
SELV 19.00
SHOW 8.76
LIFT 1.46
LFTV 0.80
SWET 137.8
KINX -6.20
CTOT 14.20
VTOT 17.90
TOTL 32.10
CAPE 323.8
CAPV 385.0
CINS -0.98
CINV -0.27
EQLV 269.0
EQTV 268.9
LFCT 941.0
LFCV 950.9
BRCH 1394.
BRCV 1658.
LCLT 293.3
LCLP 973.6
MLTH 295.5
MLMR 15.54
THCK 5746.
PWAT 34.39
12Z 14 Feb 2004
University of Wyoming


78526 TJSJ San Juan
100
200
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400
500
600
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800
900
16640 m
14230 m
12420 m
10940 m
9690 m
7630 m
5920 m
3184 m
1558 m
827 m
160 m
0.4
1
2
4
7
10
16
24
32
40g/kg
-40
-30
-20
-10
0
10
20
30
40
SLAT 18.43
SLON -66.0
SELV 19.00
SHOW 5.66
LIFT 1.25
LFTV 0.60
SWET 186.9
KINX -3.10
CTOT 16.50
VTOT 19.90
TOTL 36.40
CAPE 251.1
CAPV 331.9
CINS -10.9
CINV -4.25
EQLV 289.9
EQTV 289.2
LFCT 903.5
LFCV 920.3
BRCH 125.0
BRCV 165.3
LCLT 292.7
LCLP 958.7
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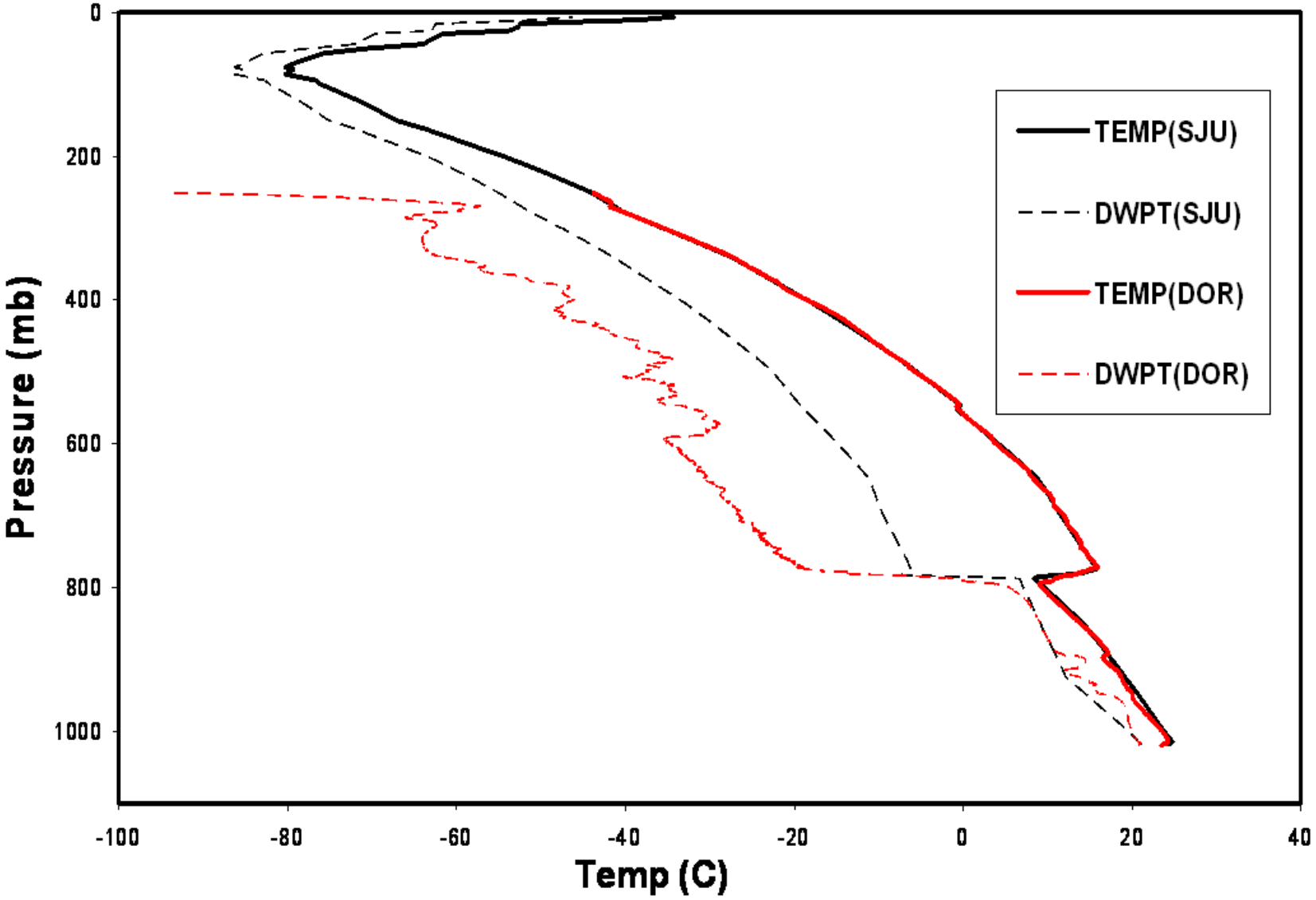
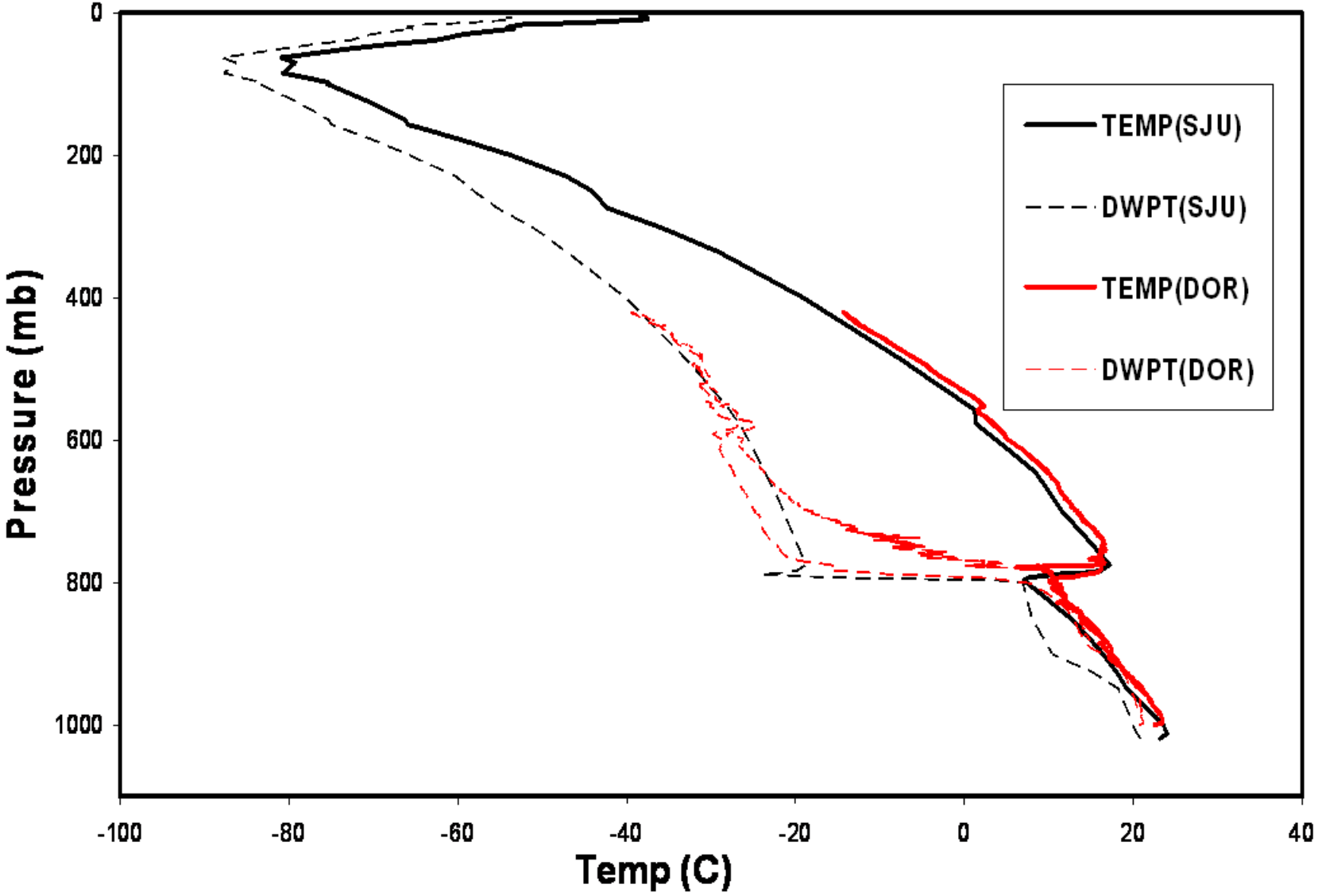
MLMR 15.24
THCK 5760.
PWAT 31.04
12Z 16 Feb 2004
University of Wyoming

Feb 14 04
00 UTZ
SJU/DOR



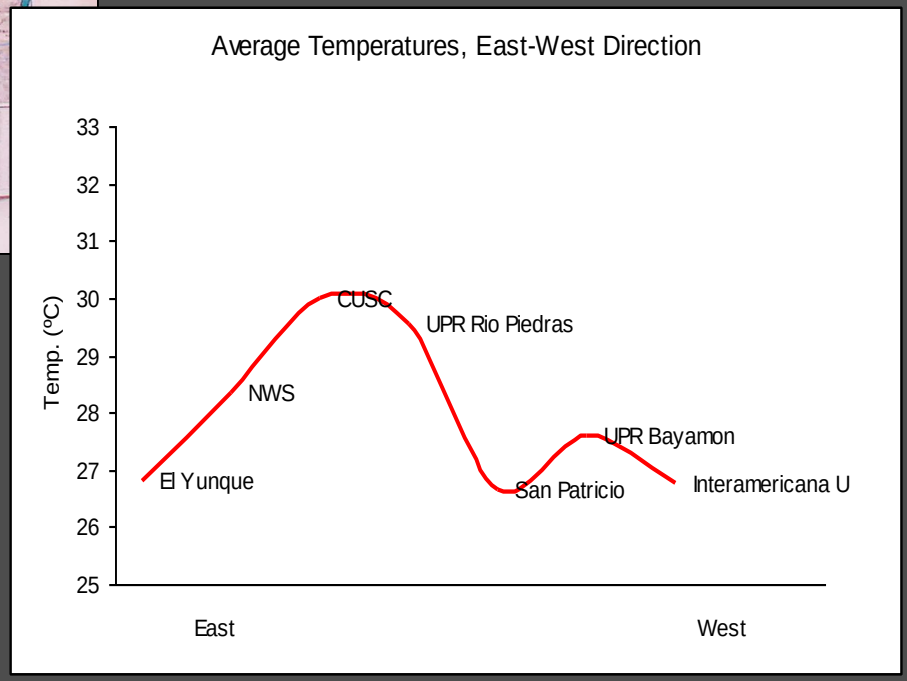
Feb 14 04
06 UTZ
SJU/DOR



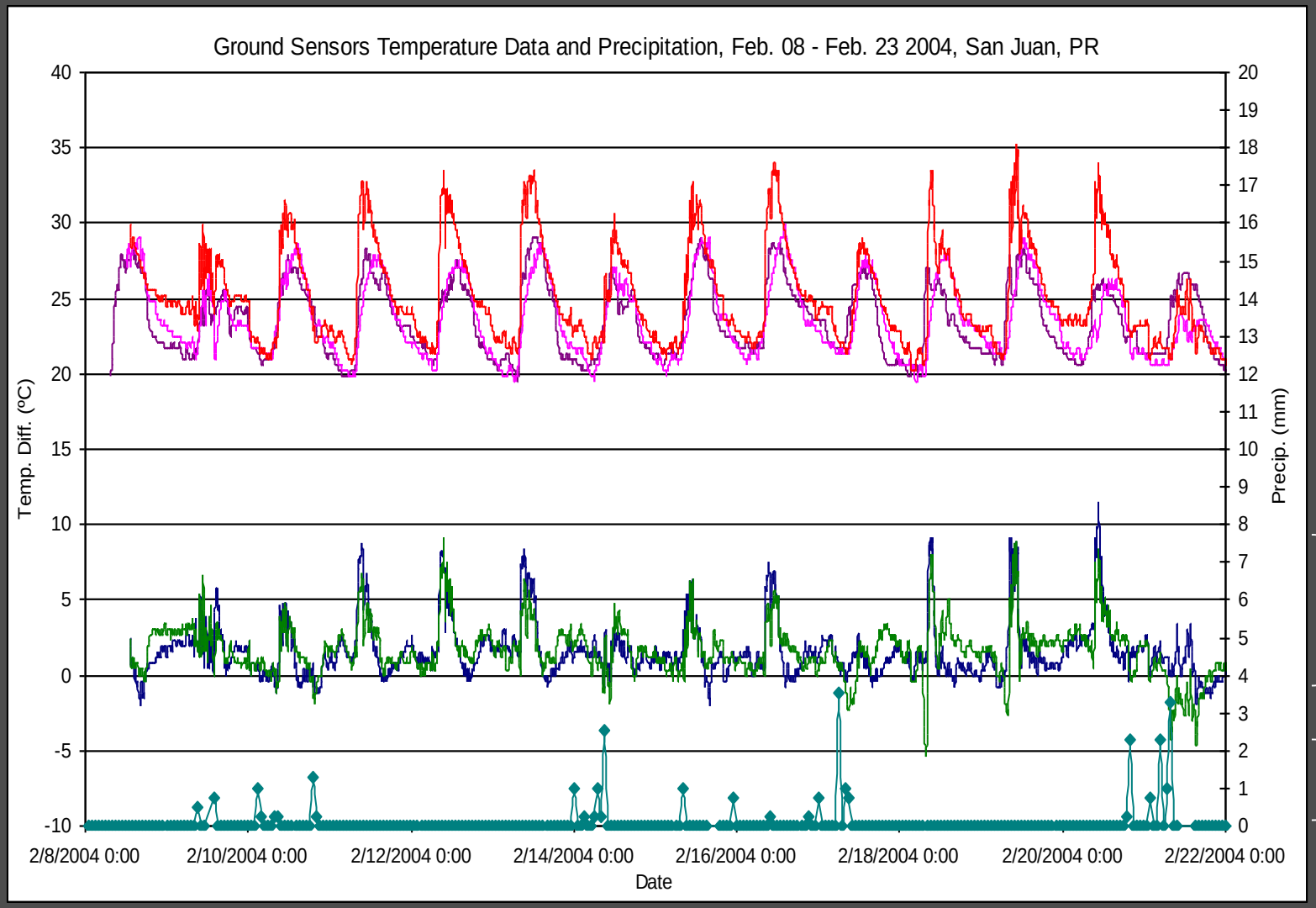
Ground Sensors location and the SJU UHI

The Urban Heat Island effect is defined as the dome of elevated air temperatures that presides over cities in contrast to their cooler rural surroundings.

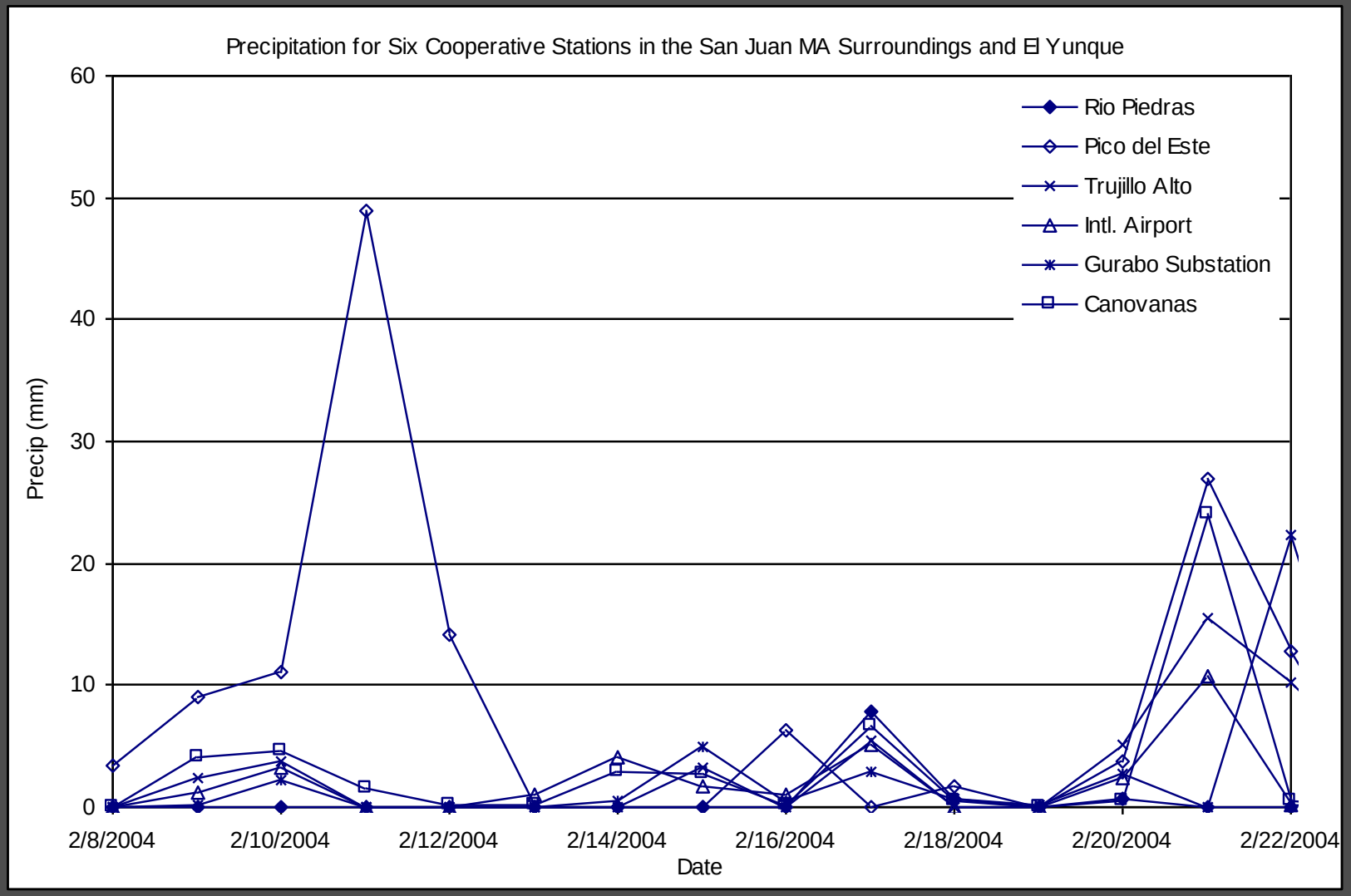
The weather station and temperature sensor data show preliminary indications of an Urban Heat Island in the metropolitan area of San Juan, P.R. and its surroundings.



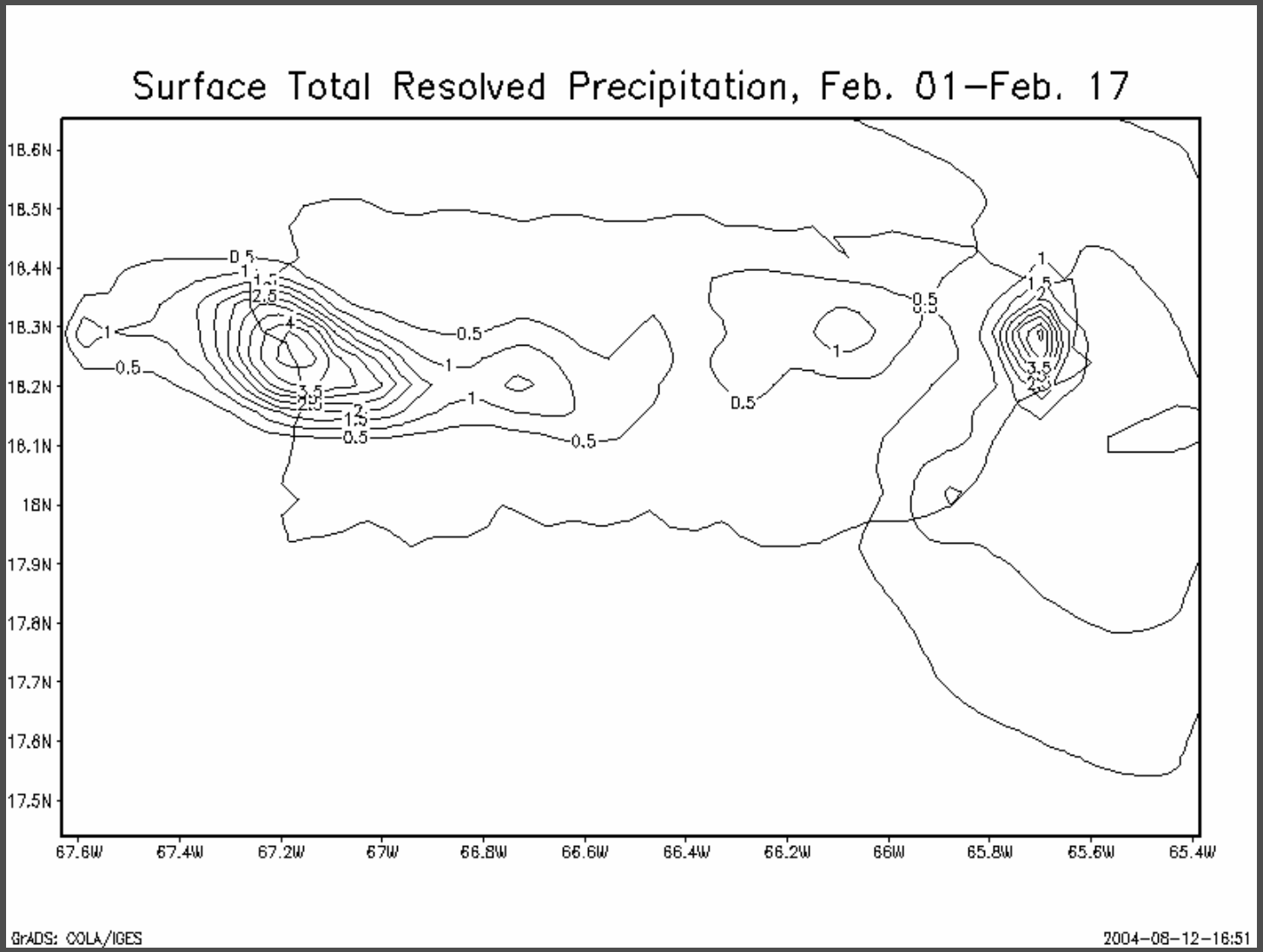
Temperature and precipitation observations



Precipitation observations



Predicted precipitation information



Summary of Synoptic data

- February 10-17, 2004 presented an unusually dry and calm atmosphere around PR as indicated by the Condensation Levels, Lifted Index, and the CAPE.
- Comparison of RW data at different times and space indicates very minor disturbances due to location with changes in moisture content along the day.
- Urban landscape may be motivating local drier conditions.
- Conditions were optimum for data collection and eventual modeling.

Summary of Ground observations

oThe ground equipment data show some tendency of a pronounced Urban Heat Island in the San Juan Metropolitan Area

oA dome of elevated temperatures appears over the densely constructed area of San Juan as opposed to the surrounding sub-urban, residential, and rural areas

oThe Heat Island is more intense than the cool island when comparing the rural area of El Yunque with the downtown commercial area of Santurce

oThe occurrence of precipitation, even in small amounts, significantly affect the pattern of the Urban Heat Island in San Juan, PR.

Ongoing and future research work

- Complete processing of ATLAS data.
- Develop and test a new urban module to be incorporated into the regional/mesoscale RAMS model. The module will consist of a much improved urban canopy representation of San Juan that will calculate both thermal and mechanical forcings (e.g. thermal emissivity of urban properties –like rooftops- and wind funneling between buildings, respectively) within the urban boundary layer more realistically.
- Develop a remote sensing tool to observe surface temperatures and heat fluxes in tropical locations.
- Quantify and predict the effects, if any, of San Juan's urban growth on climate conditions island wide.

Acknowledgements

- **NASA-EPSCoR** program of the University of Puerto Rico at Mayaguez(UPRM)
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- **NASA Global Hydrology and Climate Center (NGHCC)**, Huntsville, AL
- **NOAA-CREST** program
- **EOS Data Gateway (EDG) and the Land Processes Distributed Active Archive Center(LP DAAC)**