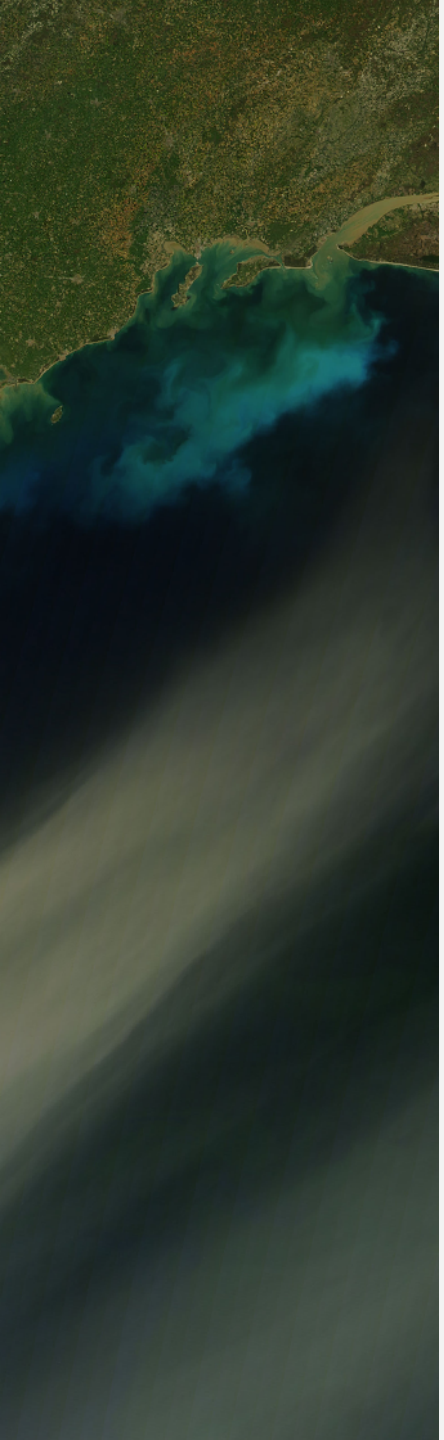


National Aeronautics and
Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Using Satellite Data to Enhance Evidence Based Public Health Efforts at the Local Level

Tabassum Insaf –New York State Department of Health

tabassum.insaf@health.ny.gov

William Crosson -Universities Space Research Association

bill.crosson@nasa.gov

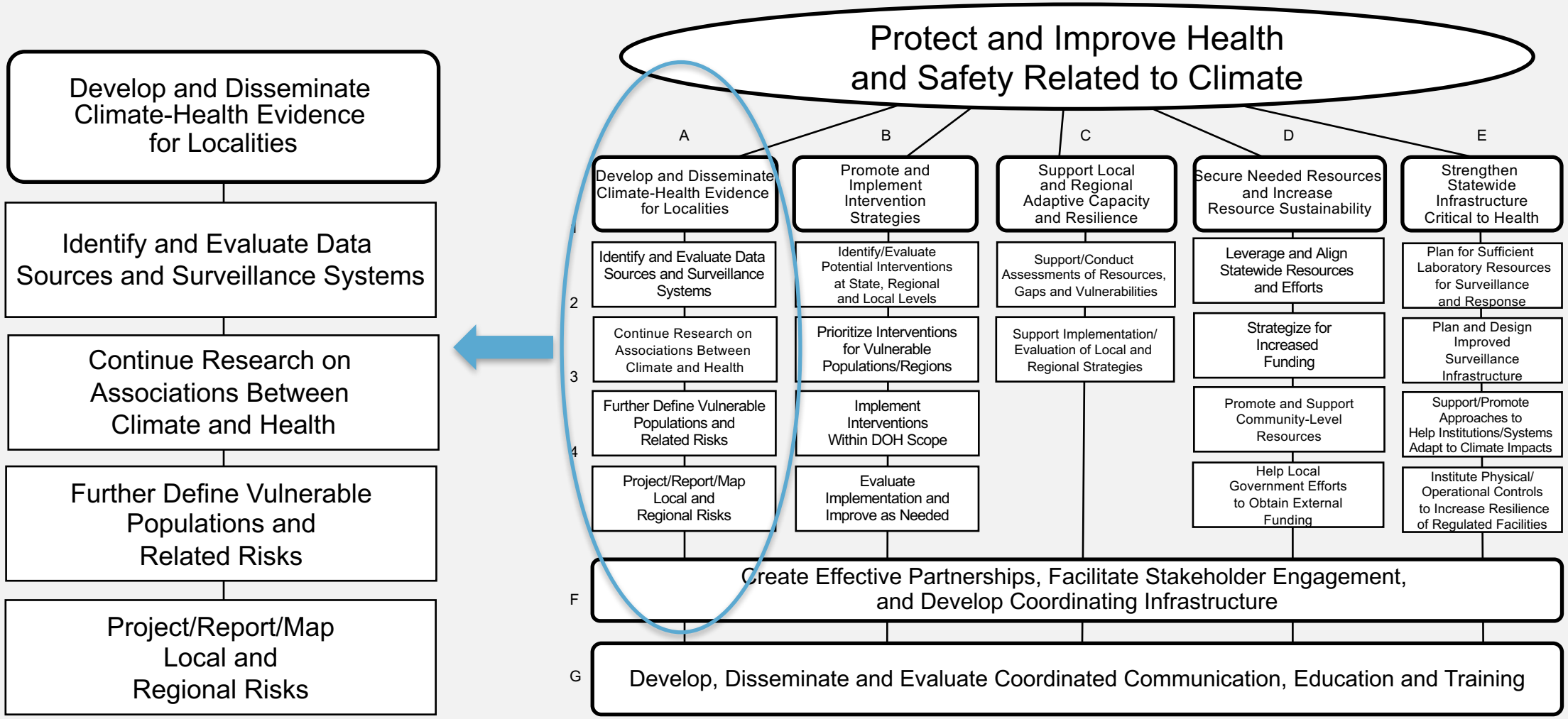
Mohammad Al-Hamdan -Universities Space Research Association

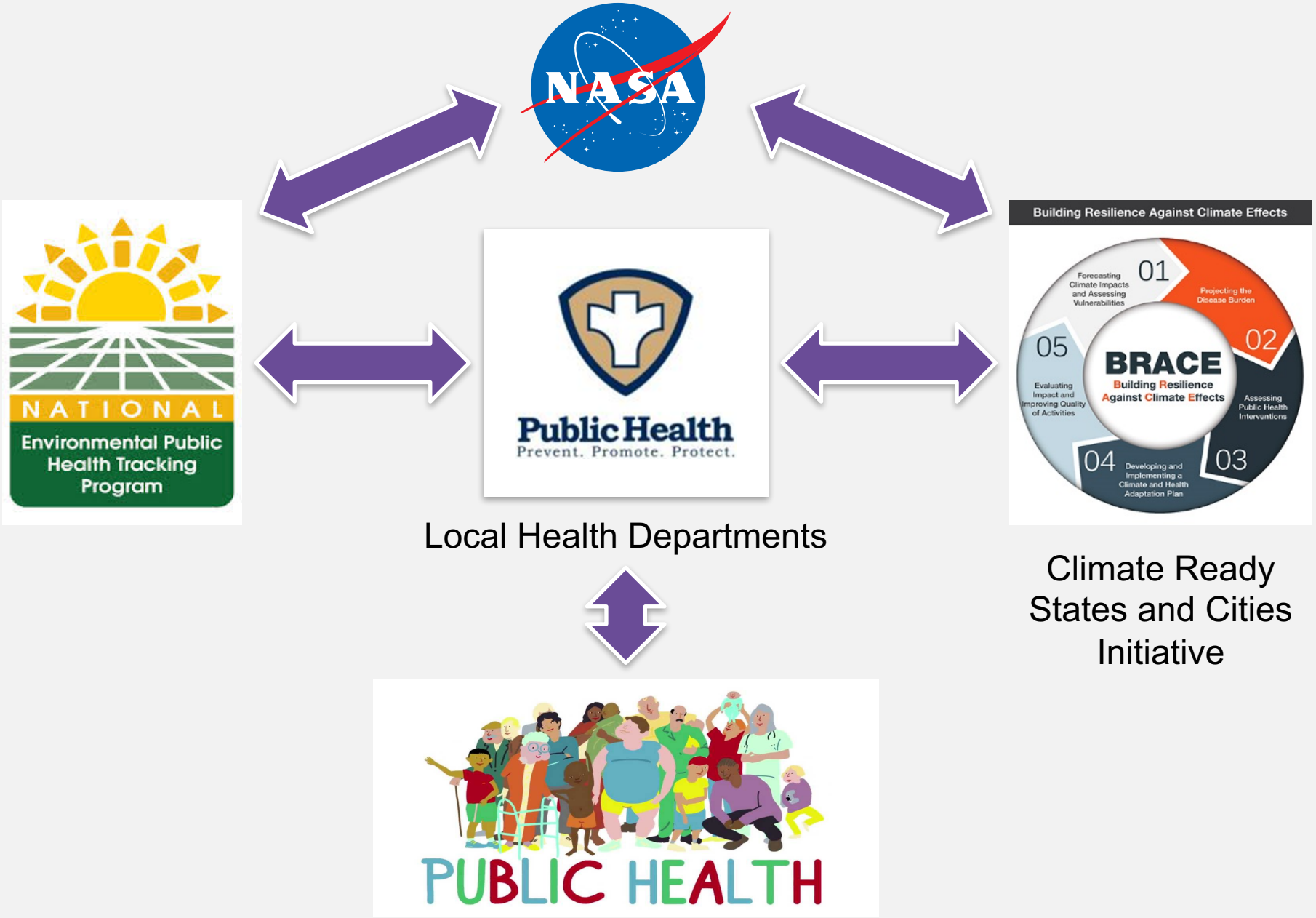
mohammad.alhamdan@nasa.gov

Integration of Satellite Data in State and Local Public Health Efforts

New York State Department of Health

Climate Adaptation and Mitigation Strategic Map: 2016-2021




NASA
NATIONAL
Environmental Public Health Tracking Program
Public Health
Prevent. Promote. Protect.
Local Health Departments
Building Resilience Against Climate Effects
01
Forecasting Climate Impacts and Assessing Vulnerabilities
Projecting the Disease Burden
02
05
BRACE
Building Resilience Against Climate Effects
Evaluating Impact and Improving Quality of Activities
Assessing Public Health Interventions
04
Developing and Implementing a Climate and Health Adaptation Plan
03
Climate Ready States and Cities Initiative
PUBLIC HEALTH

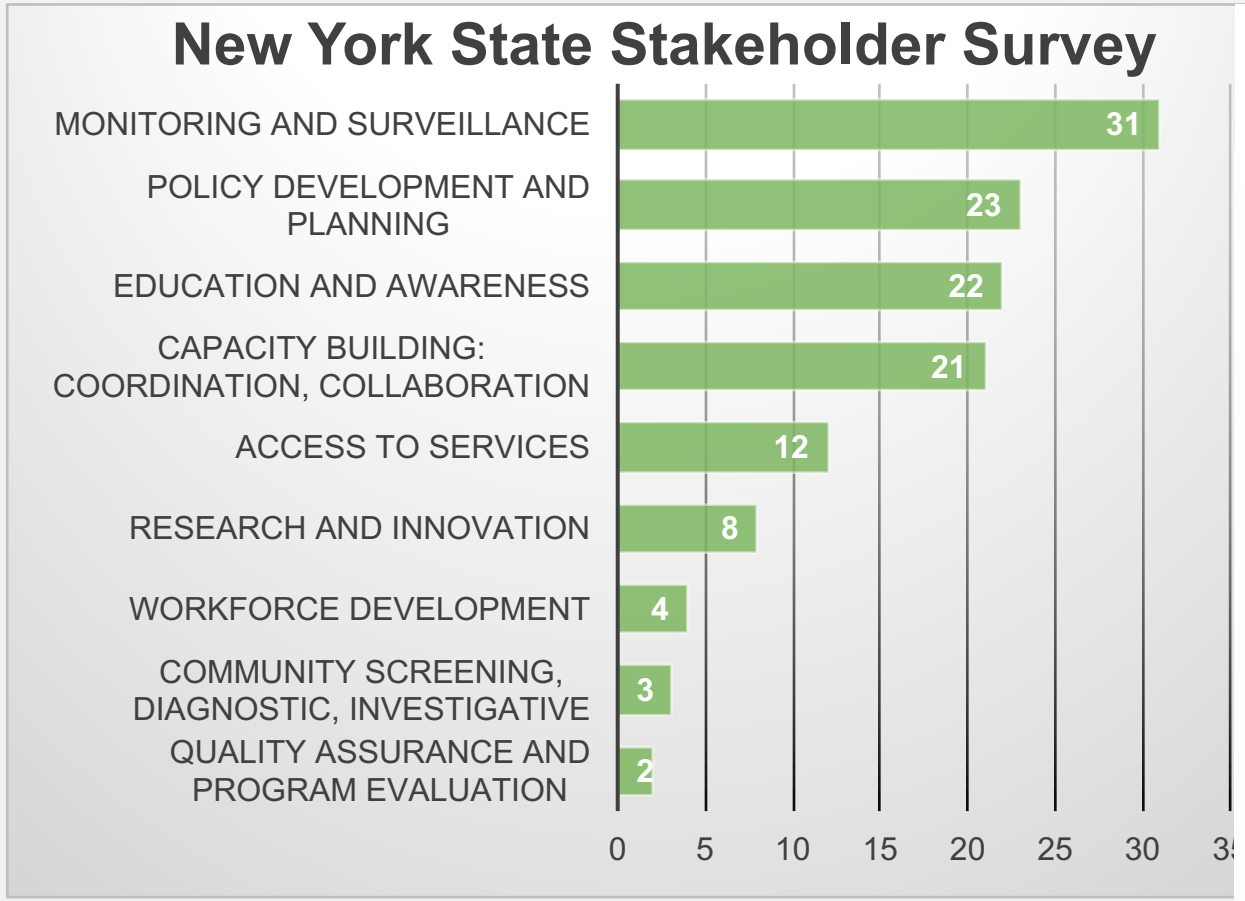
NYS Environmental Public Health Tracking Decision-Support Tool

Data and Tools

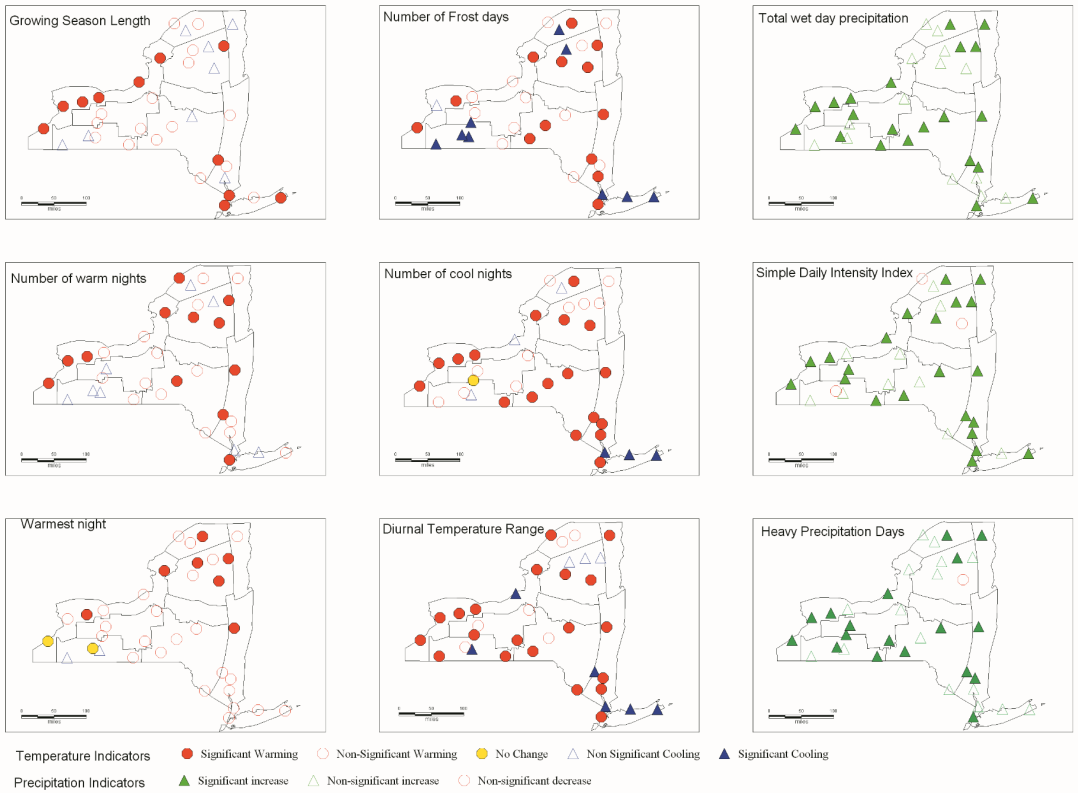
	Features	Access	Purpose
Tier 1	• Individual level data • Statistical tools • Mapping tools	Researchers and project staff in Center for Environmental Health	Research and Surveillance
Tier 2	• Finer geographic resolution at sub-county level • Data query tools • Query based data displays including map and charts	Role based access to public health professionals Access determined by program areas/data owners	Surveillance
Tier 3	• County level data and display • Simple data queries, maps, charts, and tables • Public health message	Open access	Outreach

Background Information/Outreach

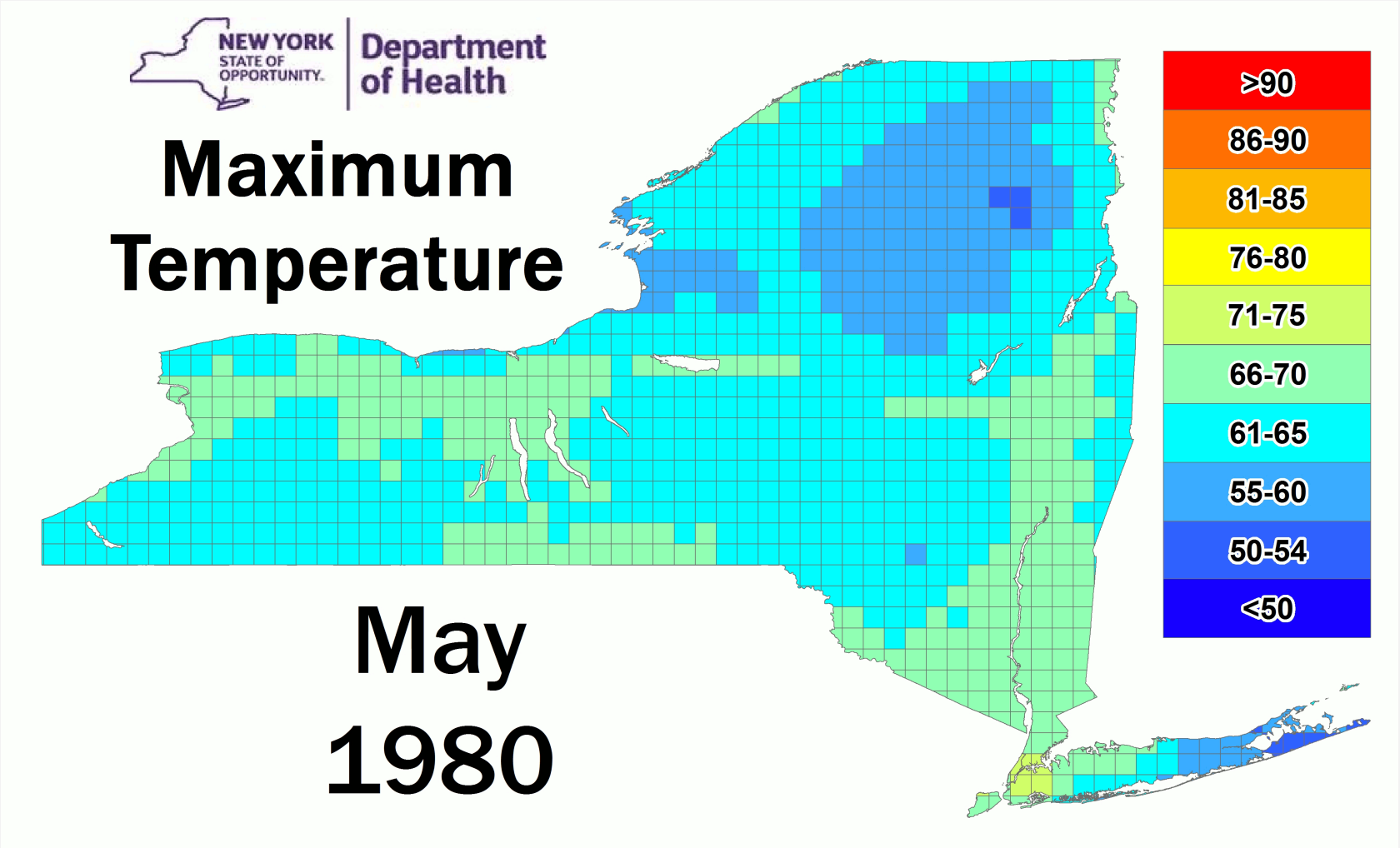
Establishing a Baseline



Climate trends in indices for temperature and precipitation across New York State, 1948–2008
-Insaf et al. 2013



Using Satellite Data for Public Health: NLDAS 12 km Grid



Schema for Linkage of Analytic Datasets

In Patient/Emergency Department Visit Data Points

Patient ID
ID Number**
Latitude*
Longitude*
ICD-9 Code (Primary and Other Diagnoses)
Age*
Sex*
Race*
Day of Admission*

Satellite Data (12 km grid) Polygon

Grid ID*
Latitude*
Longitude*
Daily Temperature metrics
Date (month, day, year)*

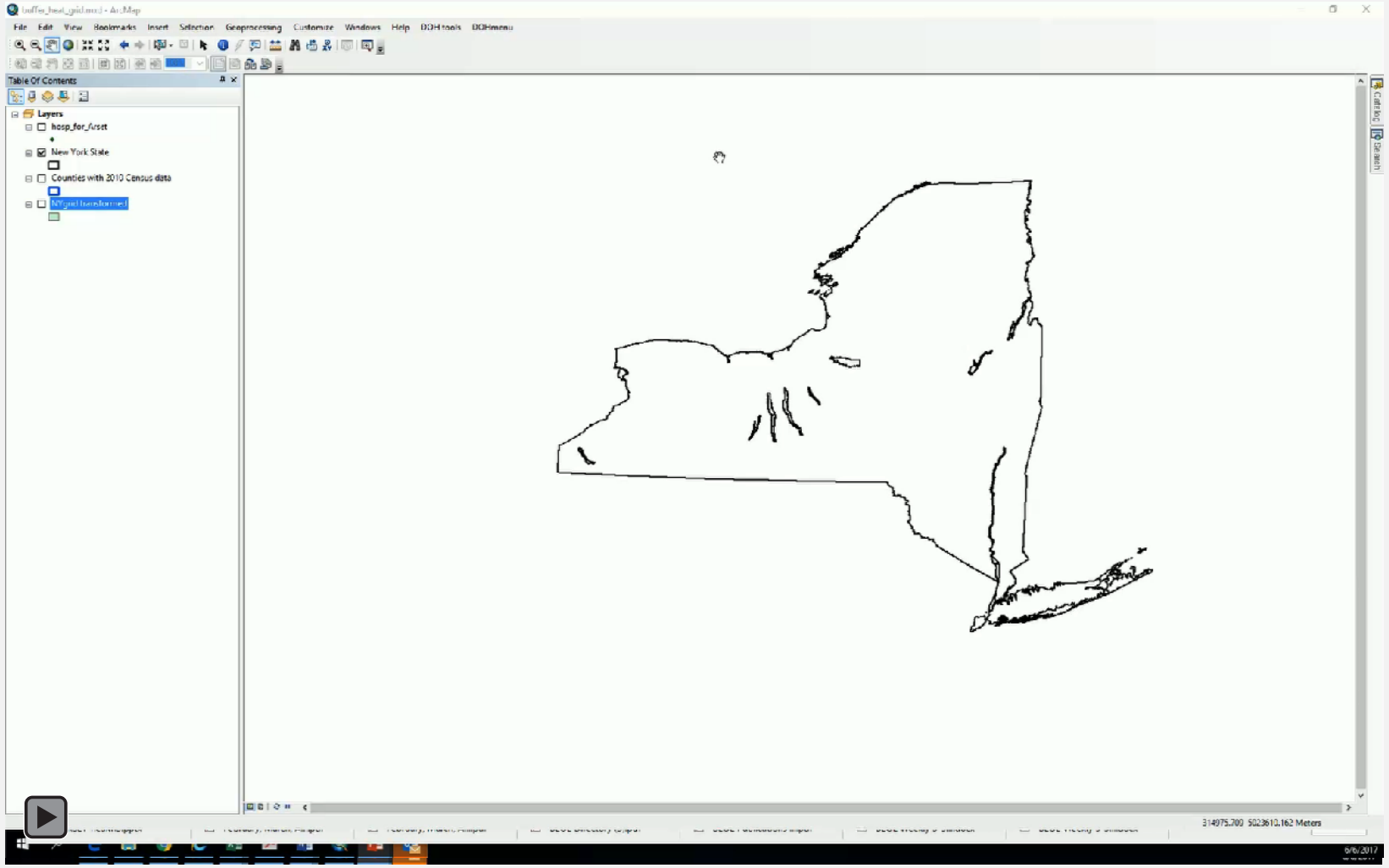
Census Data (GIS Data) Polygon

Block group number or ZIP Code*
% Pop below poverty
% Pop. less than high school level education
Other socio-economic variables

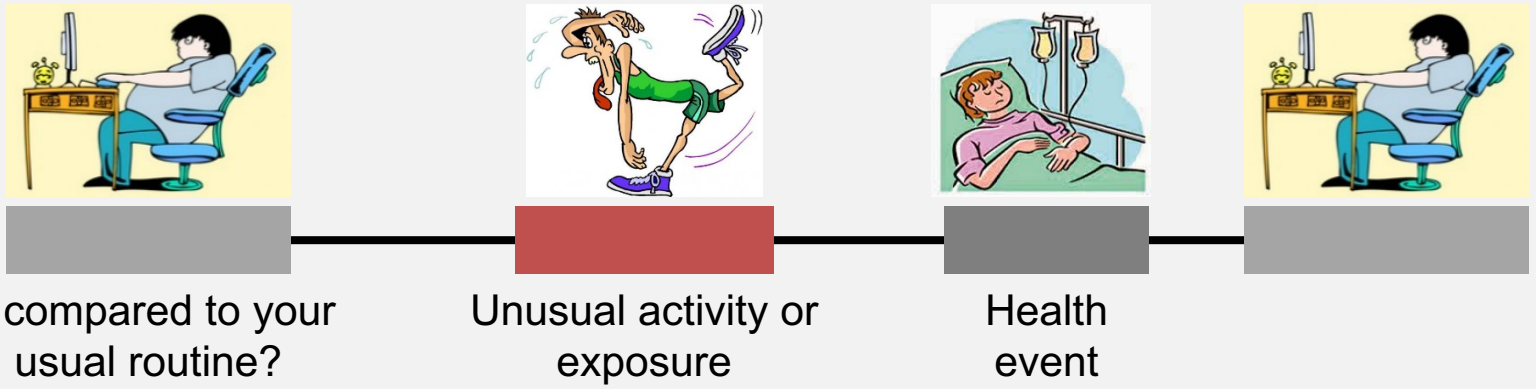
Linked Analytic Data

ID Number**
ICD-9 Code
Case or control
Same Day Exposure**
Previous Day Exposure**
Two Days Previous Exposure
Three Days Previous Exposure**
% Pop. below poverty
% Less than high school level education
Other socio-economic variables

Linking Health and Environmental Data in ArcMap

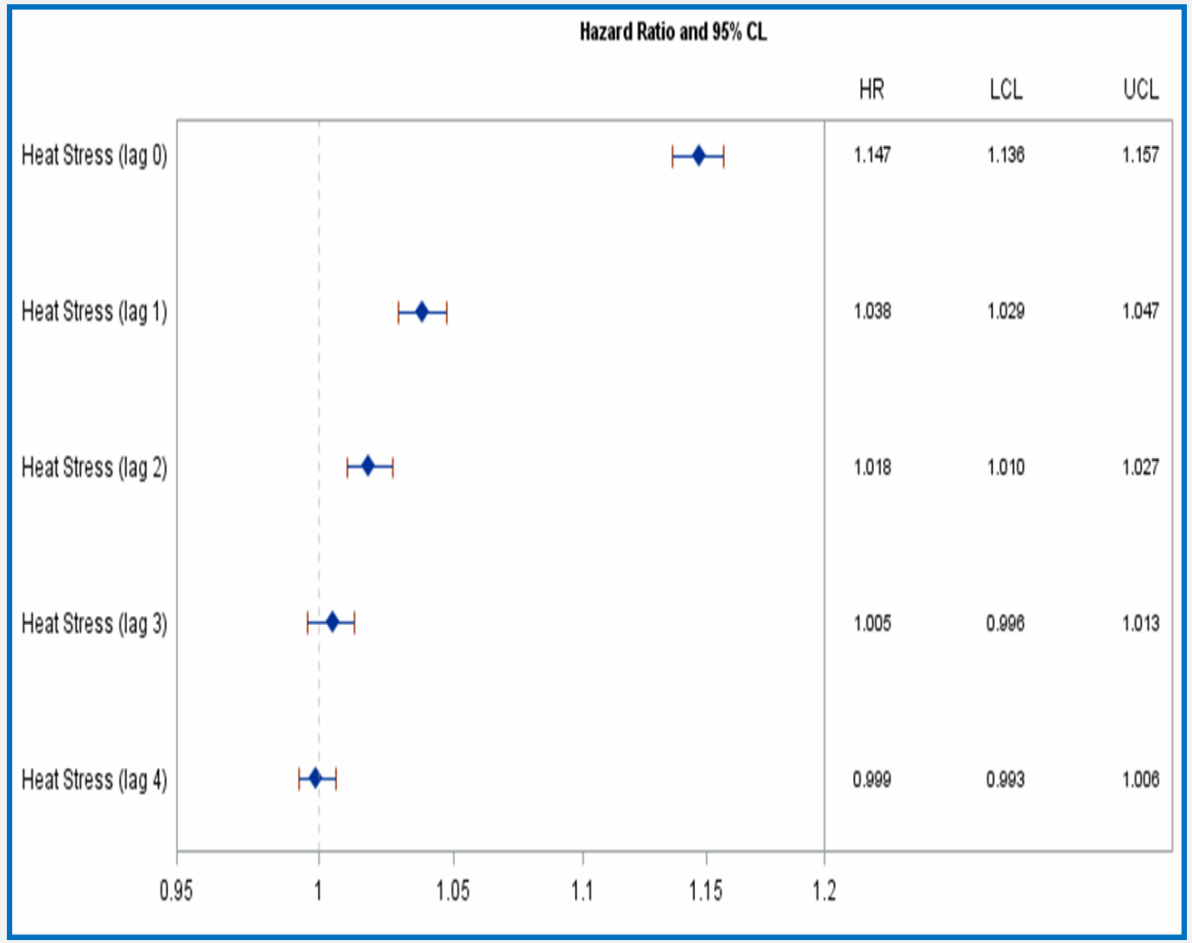


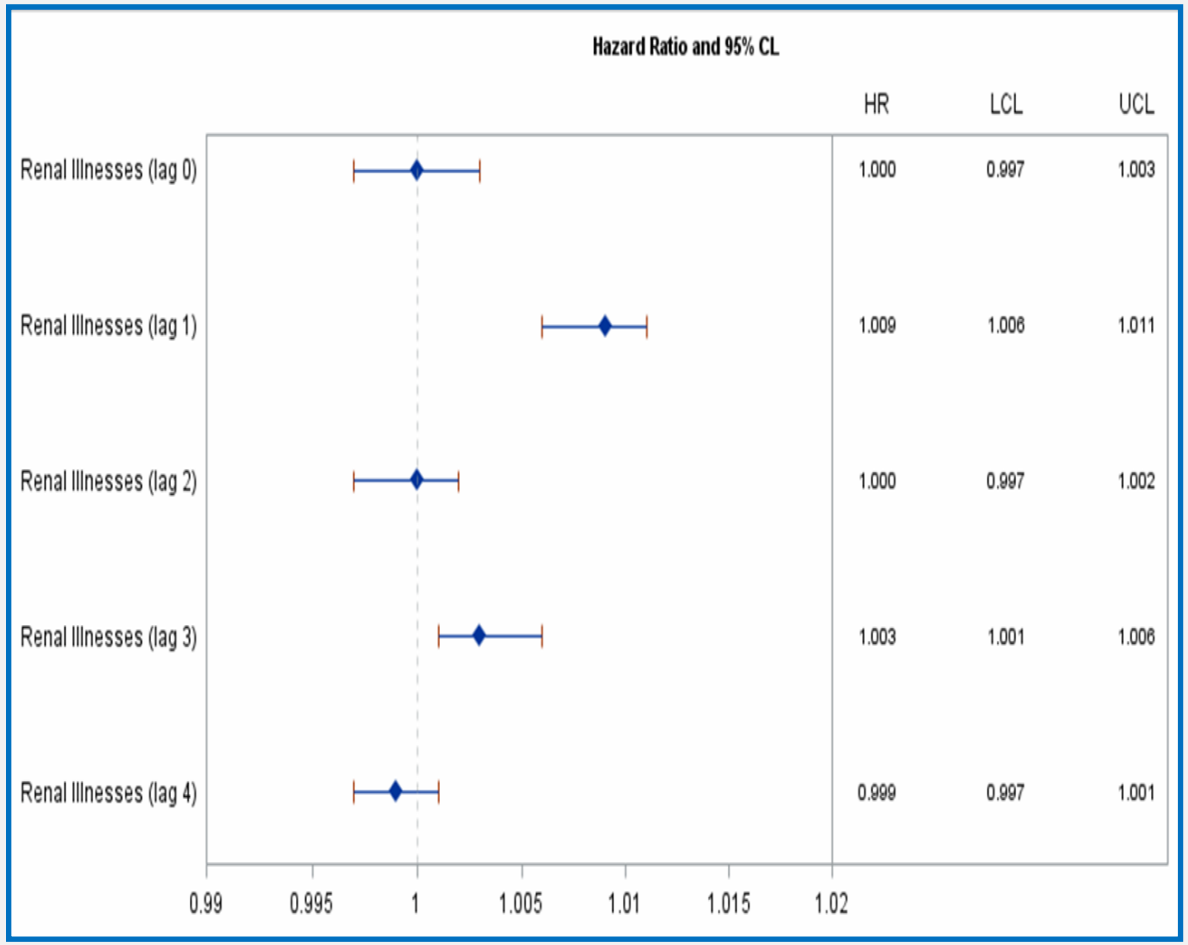
Case-Crossover Study



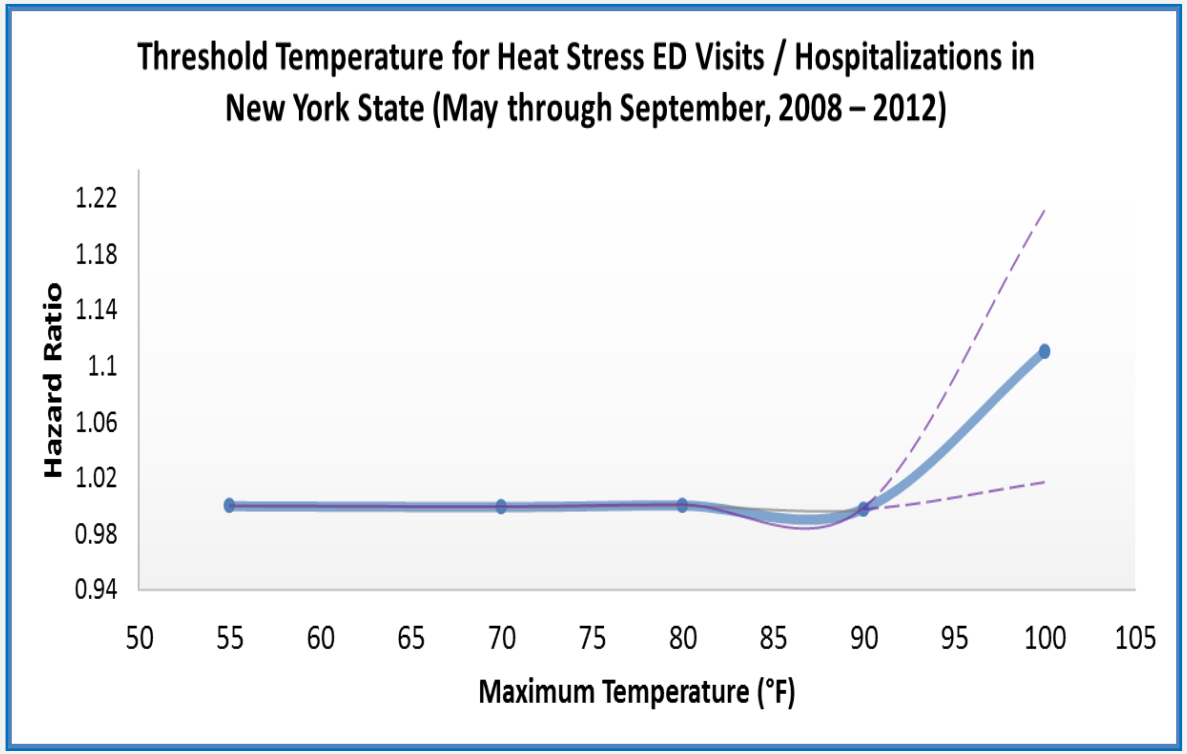
- Study of “triggers” <u>within</u> an individual
- “Case” and “control” component, but information of both components will come from the same individual
- “Case component” = hazard period which is the time period right before the disease or event onset
- “Control component” = control period which is a specified time interval other than the hazard period

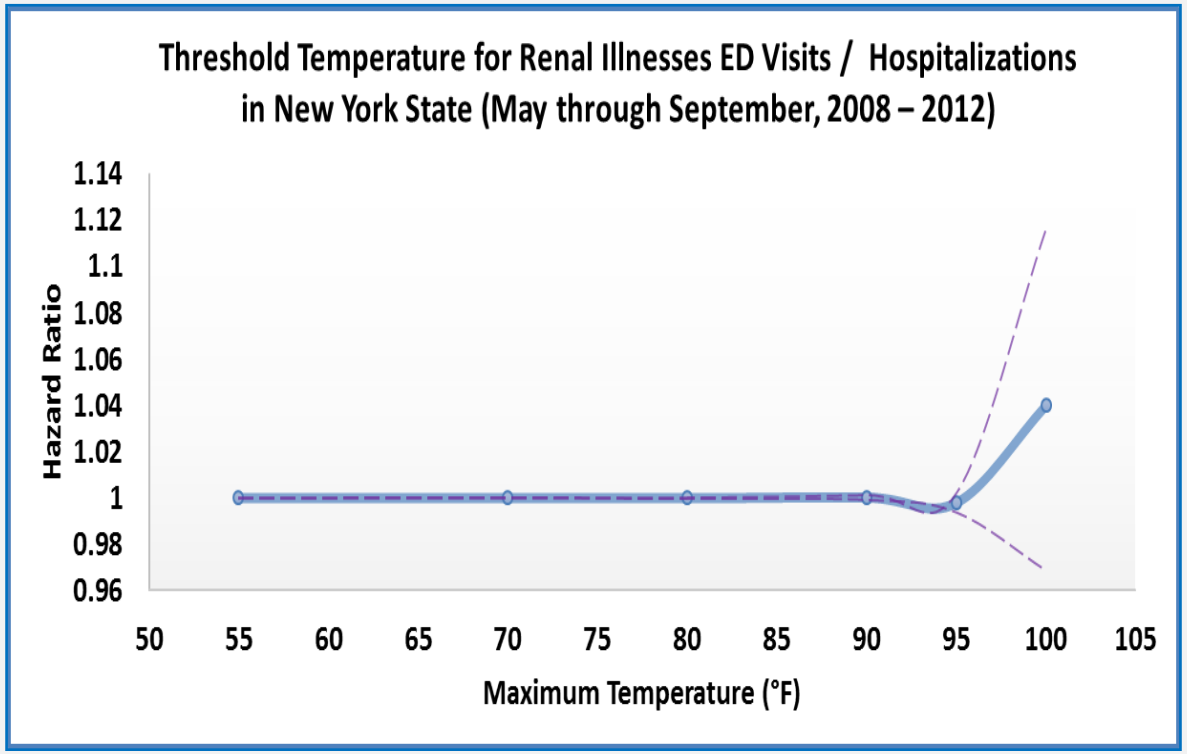
Association Between Heat Stress, Renal Illness, and Temperature





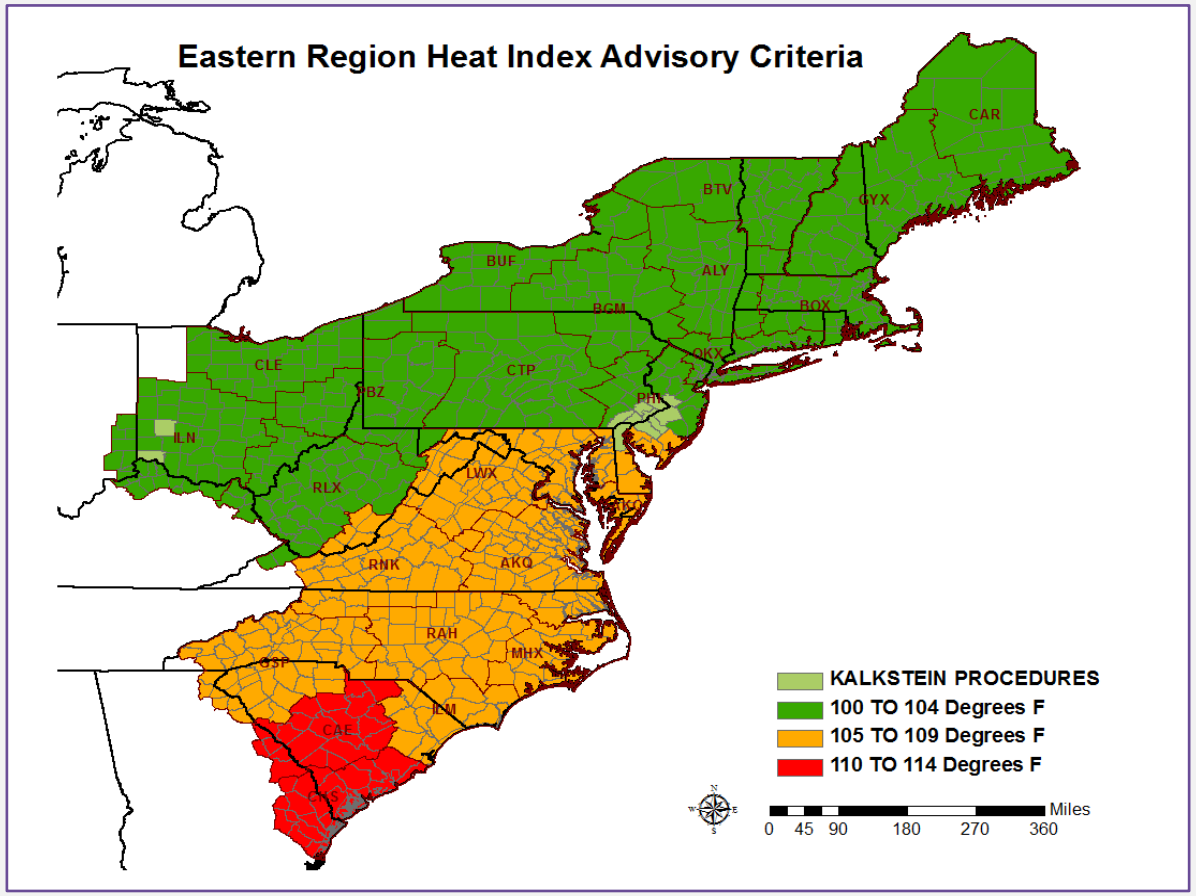
Threshold Analysis for Health Effects of Heat Events

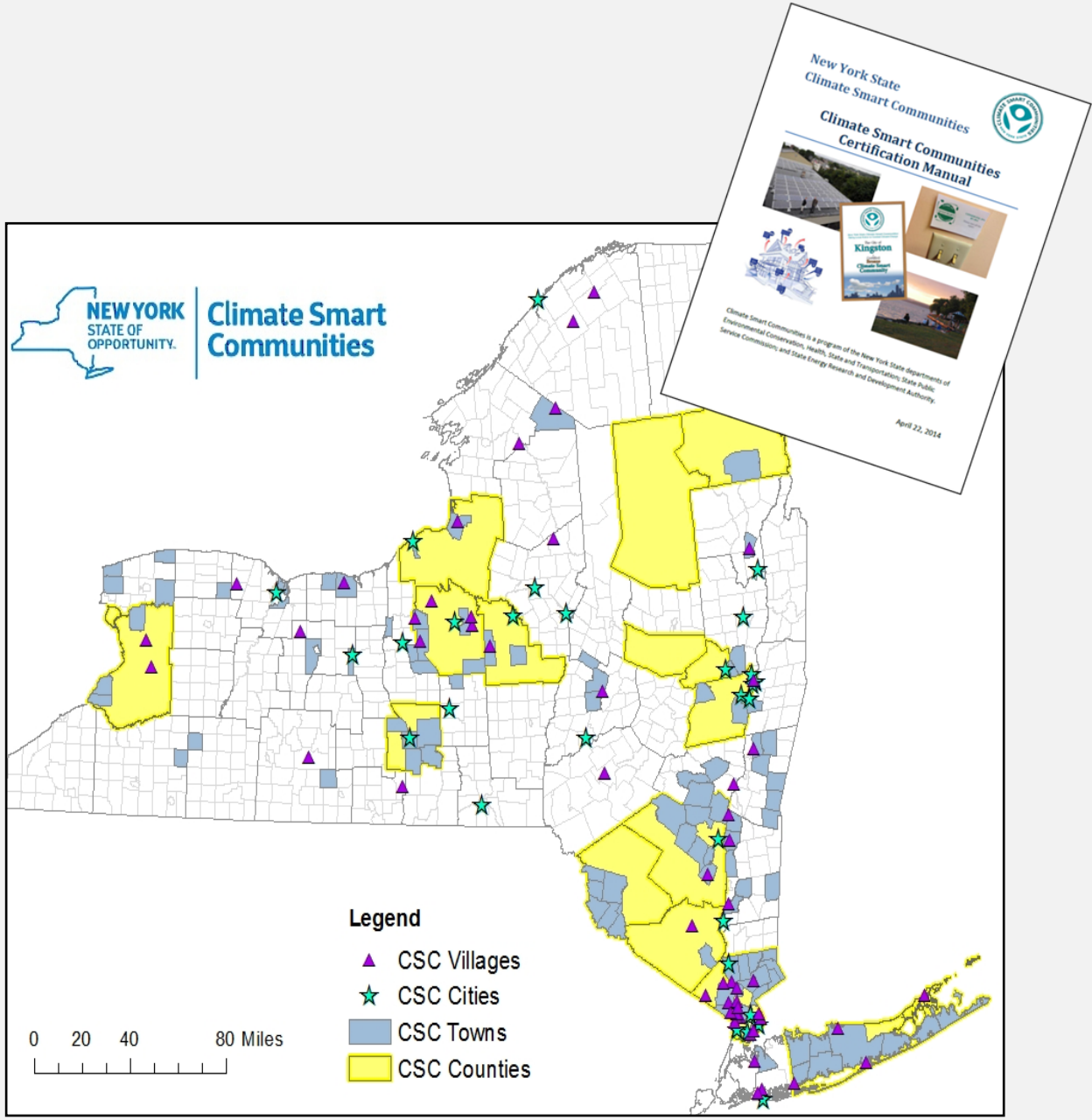




Engaging Stakeholders

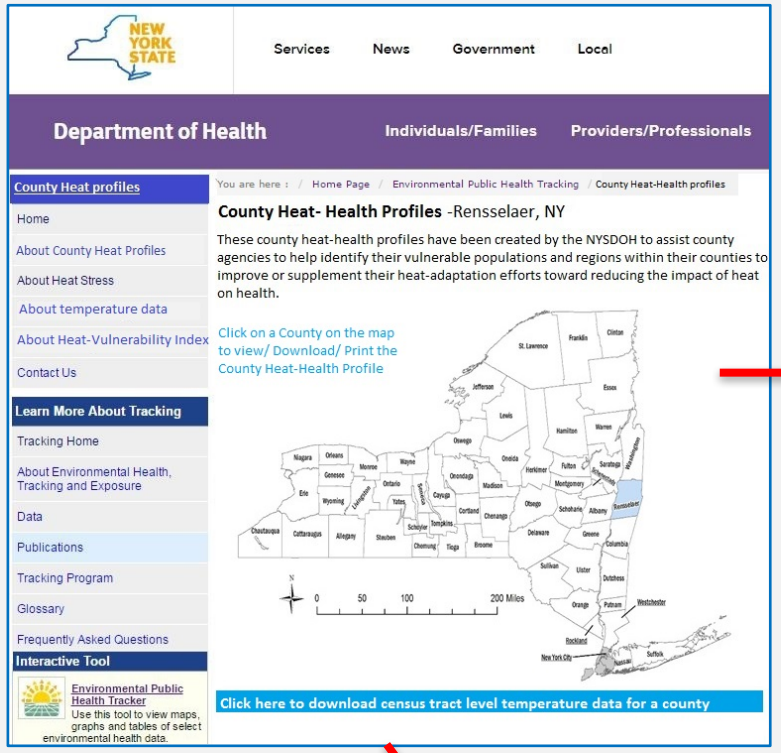
NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

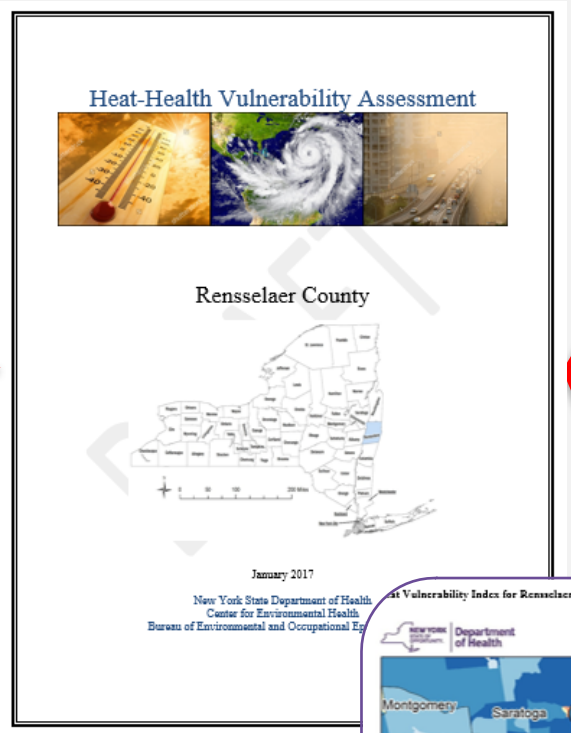


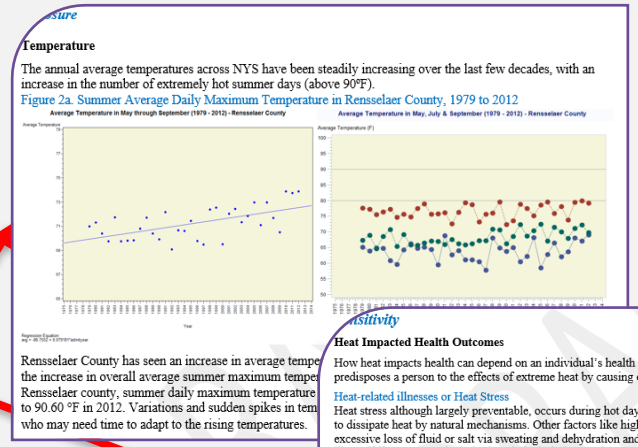


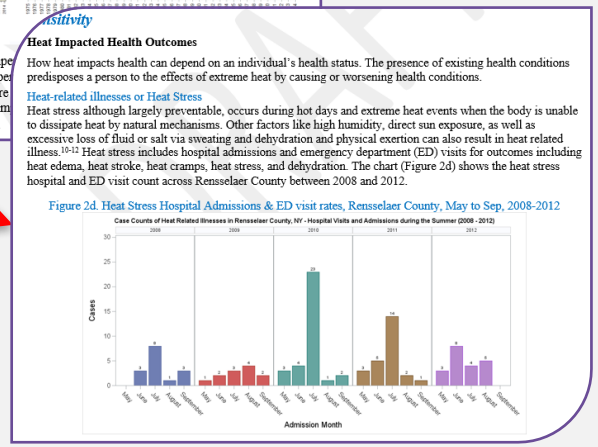
NYSDOH County-Heat Health Profiles

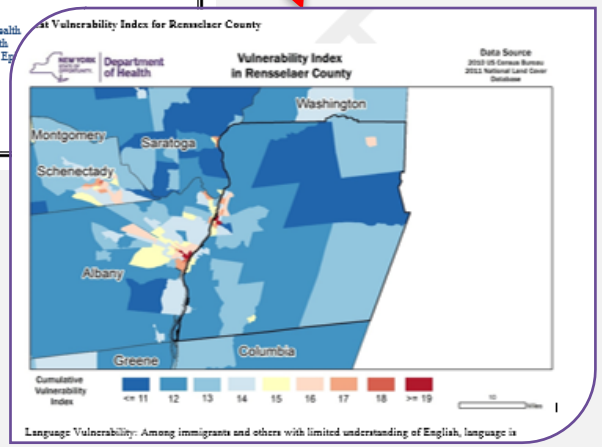
http://www.health.ny.gov/environmental/public_health_tracking/









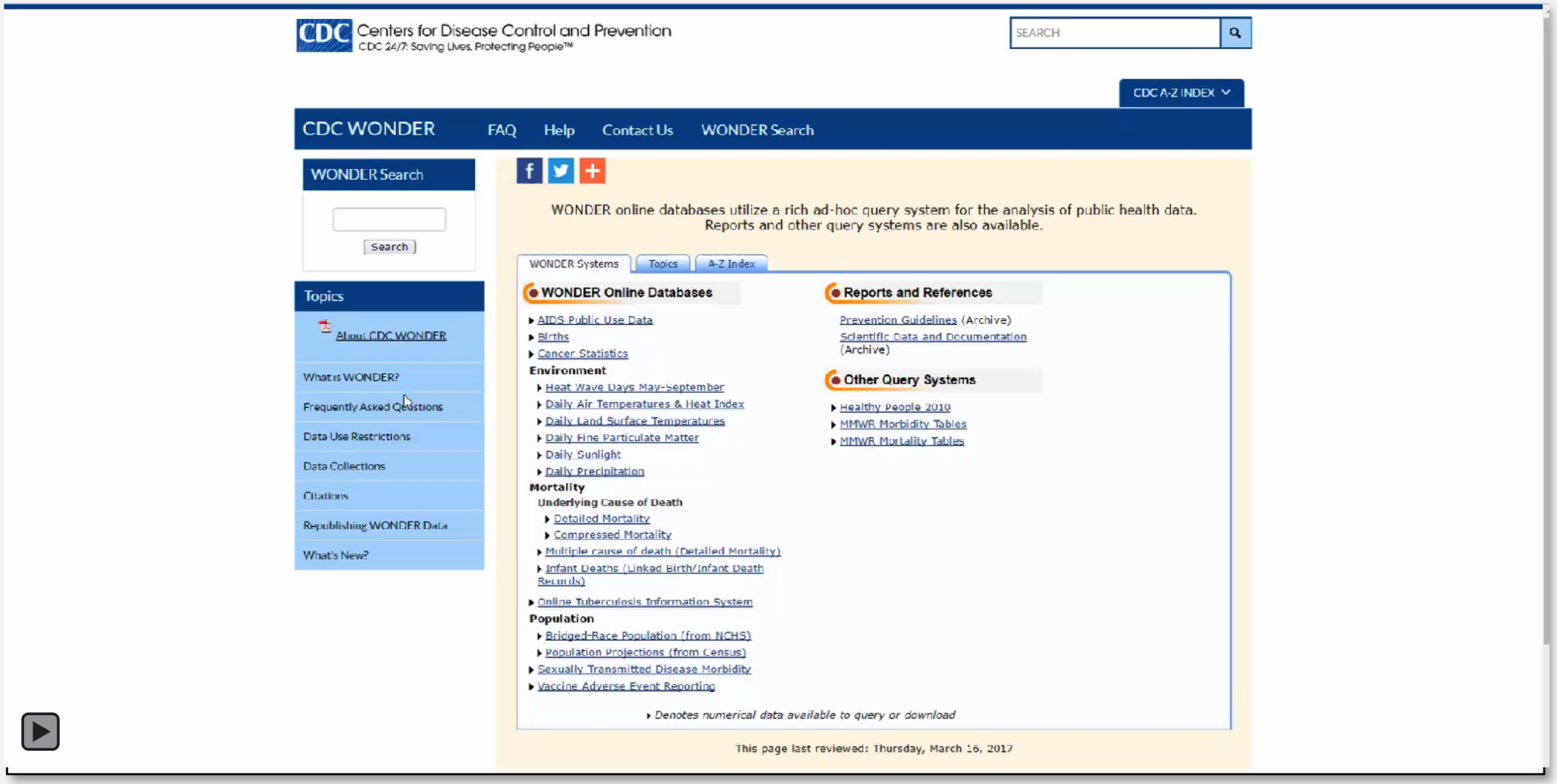


Downloadable data at census tract level

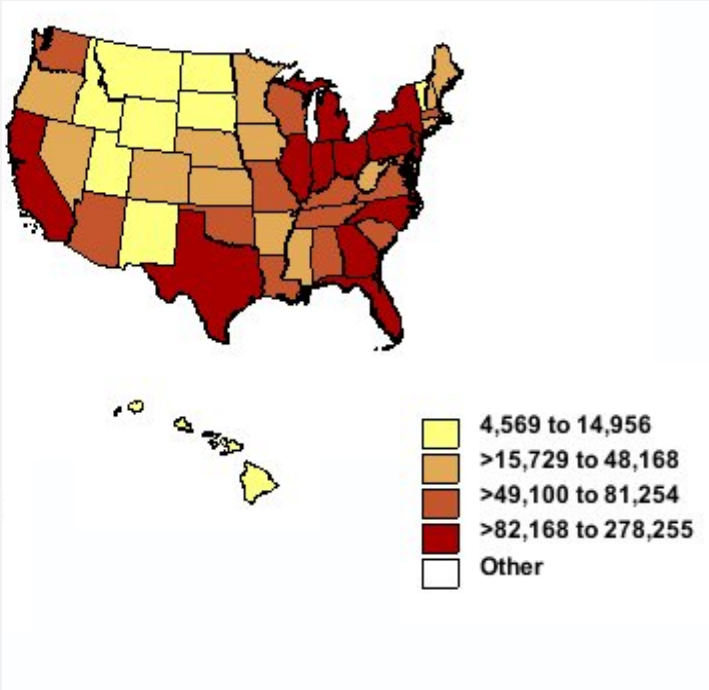
date	ndays	ID	COUNTYFP1	month	year	content	Indicator	measure	subgroup	subgroup_cat	output
1979-05-01	121	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	53
1979-05-02	122	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	52.2
1979-05-03	123	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	60.1
1979-05-04	124	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	58.5
1979-05-05	125	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	47.1
1979-05-06	126	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	52.2
1979-05-07	127	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	62.7
1979-05-08	128	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	75.9
1979-05-09	129	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	83
1979-05-10	130	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	81.7
1979-05-11	131	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	75.4
1979-05-12	132	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	70.3
1979-05-13	133	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	71
1979-05-14	134	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	61.6
1979-05-15	135	001014801	001	5	1979	heat	Max Temperature	degrees	Temperate above 90	0	70

Includes information on temperature exposure, heat impacted health and heat vulnerability in each county

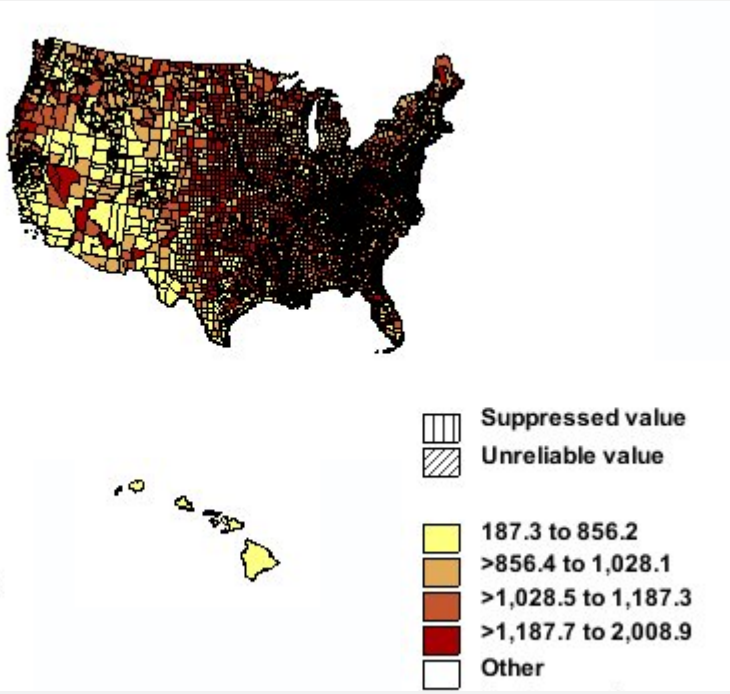
CDC WONDER: http://wonder.cdc.gov/



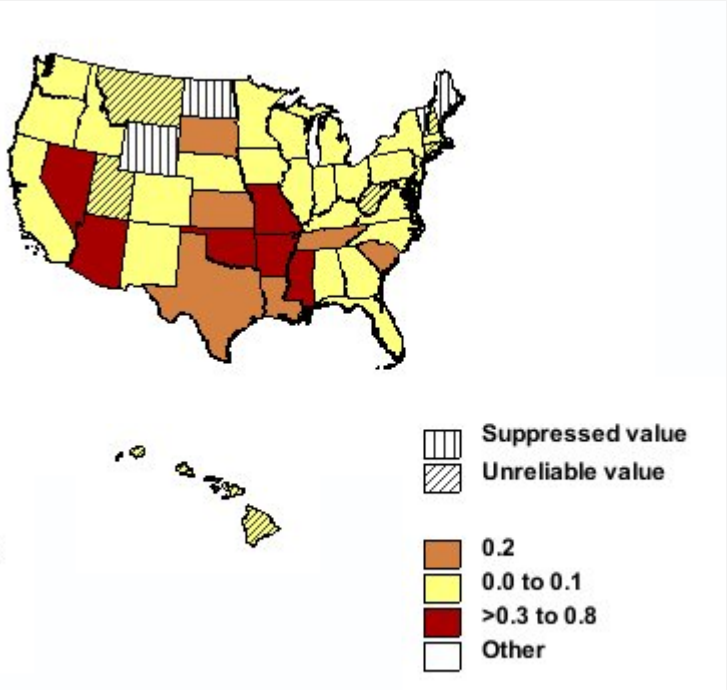
Health Outcome Datasets Available Through CDC WONDER



Respiratory Cancers
by State
1999-2013



All Causes Mortality
by County
1999-2015



Heat-Related Mortality
by State
1999-2015

Environmental Data Products

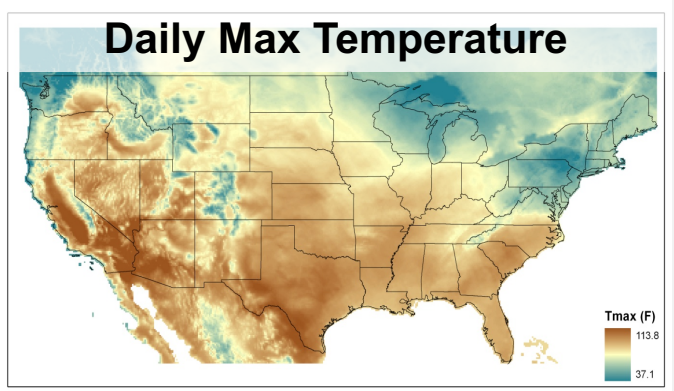
Introduction to NLDAS

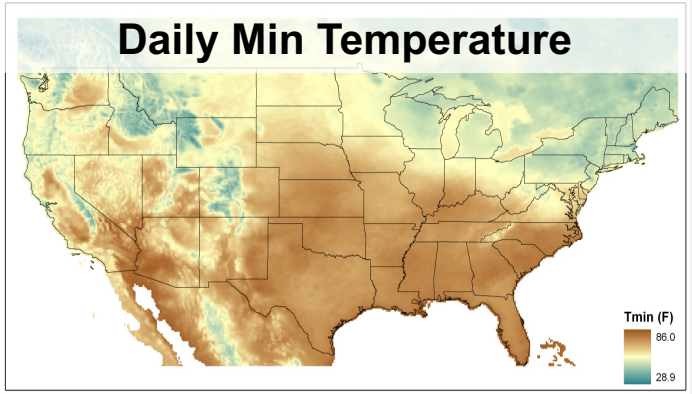
- North American Land Data Assimilation System (NLDAS) provides gridded meteorological data for the contiguous United States and parts of Mexico & Canada.
  - Combines three types of data:
    - Ground observations (National Weather Service stations)
    - Numerical weather model output
    - Satellite observations (GOES shortwave radiation) and radar/rain gauge rainfall
  - 1/8th degree latitude/longitude spatial grid (about 12 km)
  - NLDAS data are interpolated spatially and temporally from the North American Regional Reanalysis (NARR), which are at a 32 km spatial resolution and 3-hourly temporal frequency.
  - In creating NLDAS from NARR, air temperature, specific humidity and surface air pressure are adjusted to account for terrain height.
  - Hourly data are available from 1979-present.
- NLDAS data are available from http://www.emc.ncep.noaa.gov/mmb/nldas/

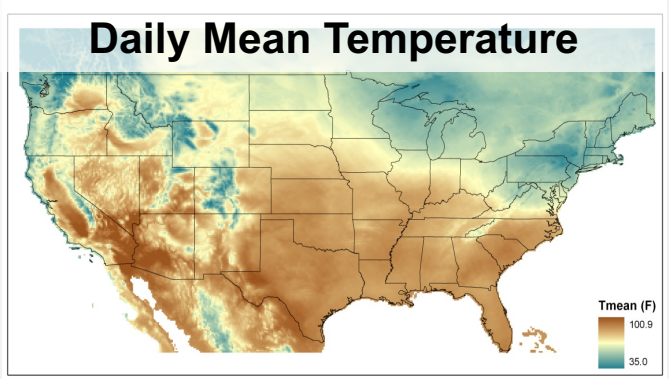
NLDAS-Derived Heat Metrics

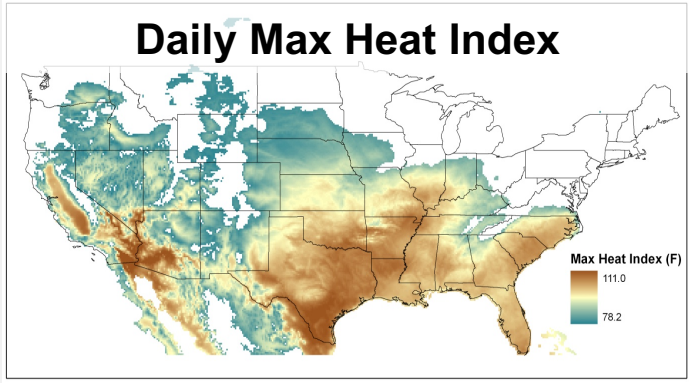
From hourly NLDAS data, we developed a set of daily heat metrics: daily maximum, minimum, and mean air temperature, daily maximum Heat Index (a measure of the combined effect of heat and humidity), and a newly-defined measure called Net Daily Heat Stress (NDHS).

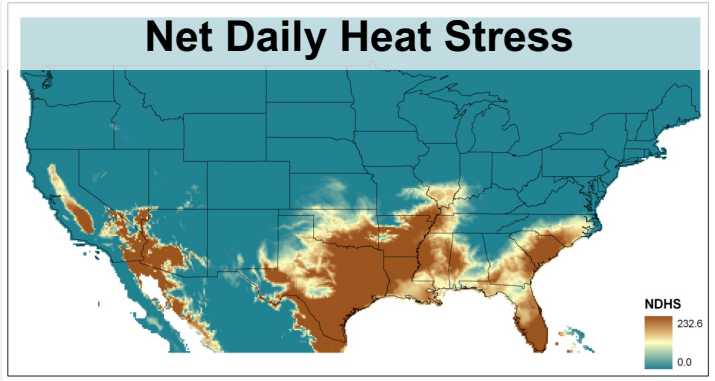
Examples of meteorological products derived from NLDAS July 1, 1986











Downscaling (‘Disaggregating’) Air Temperatures

- Rationale:
  - The NLDAS meteorological re-analysis provides hourly air temperature and other variables on a ~12 km CONUS grid. The resolution is in fact coarser since NLDAS is derived via spatial interpolation from the 32 km NARR. At this resolution, small-scale features such as the Urban Heat Island and near-coastal temperature gradients are not captured.
  - 1 km MODIS Land Surface Temperature (LST) data can be used to down-scale NLDAS daily maximum and minimum air temperatures.
  - Our approach is to use long-term means of MODIS Aqua LST (1:30 PM/AM local time) to capture the fine-scale (1 km) spatial pattern of daily maximum/minimum air temperature, and impose this pattern on 12 km NLDAS daily maximum/minimum air temperatures.

Downscaling Assumptions

- Except in cases of the passage of a warm or cold front, air temperature is driven primarily by the temperature of the surface, thus the spatial patterns of air temperature mimic the patterns of LST in a relative sense (although the magnitude of air temperature spatial variability is much lower than that of LST).
- Spatial patterns of air temperature at the sub-NLDAS scale (< 12 km) are nearly constant from day to day within the respective season, as these patterns are driven mostly by land use.
- Daily maximum (minimum) air temperatures occur during the early-mid afternoon (early morning), aligning well with the PM (AM) Aqua overpass.

These assumptions are met much more frequently during the warm season.

Downscaling Algorithm

1. Calculate standardized LST departures, Z_{HR}, from recent MODIS 8-day composite LST grids, in which the spatial means and standard deviations are calculated within a local neighborhood or 'moving window', the size of which can be varied. The standardized departures are calculated according to:

$$Z_{HR} = (T_{HR} - T_{HR,mean})/\sigma_{HR}$$

where T_{HR} = high-resolution (MODIS) LST, and $T_{HR,\ mean}$ and σ_{HR} are the mean and standard deviation, respectively, of high-resolution (MODIS) LST over the neighborhood.

- ZHR is calculated separately for daytime maximum and nighttime minimum temperatures.

Downscaling Algorithm

2. Compute the down-scaled daily maximum (or minimum) air temperatures for each day, T_{DIS}, based on the standardized MODIS daytime (or nighttime) LST departures:

$$T_{DIS} = T_{LR} + Z_{HR} \bullet \sigma_{LR} = T_{LR} + (T_{HR} - T_{HR,mean}) \bullet (\sigma_{LR} / \sigma_{HR})$$

where T_{LR} and σ_{LR} are the mean and standard deviation, respectively, of low-resolution (NLDAS) daily air temperatures over the neighborhood.

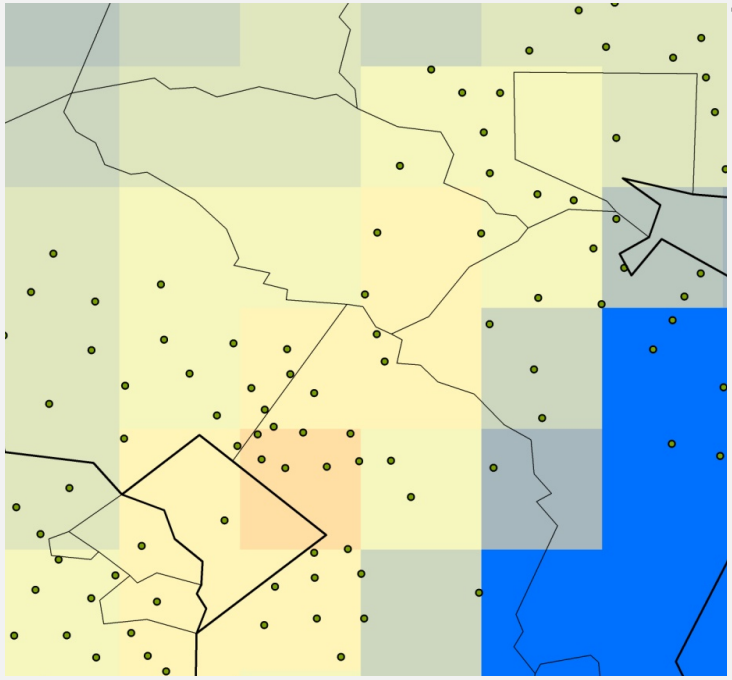
Downscaled Air Temperature

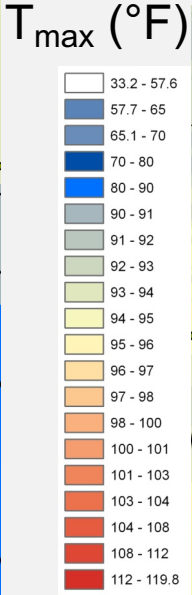
Results from application of the downscaling algorithm are illustrated below, which shows NLDAS daily maximum air temperatures, downscaled to a 1 km grid using MODIS LST data, for the Washington-Baltimore metropolitan area. Urban areas, which are not apparent warm anomalies in the NLDAS temperature image, are evident in the downscaled temperature image.

Daily Maximum Air Temperature from NLDAS, and downscaled to 1 km using MODIS LST for the Washington-Baltimore Metropolitan Area

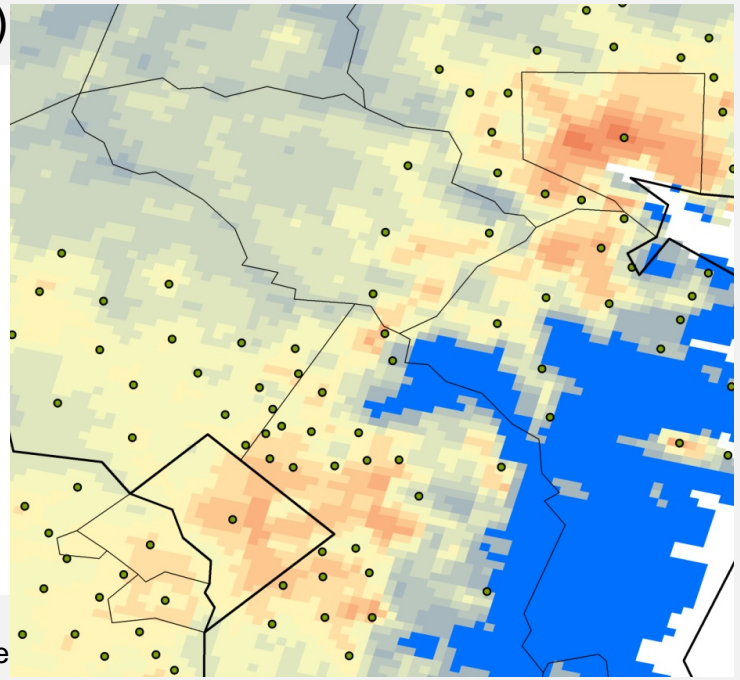
Green circles indicate urban centers

NLDAS 12 km





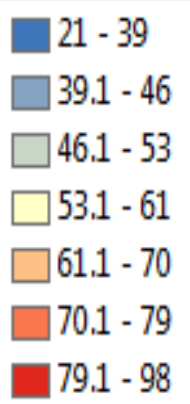
Downscaled to 1 km



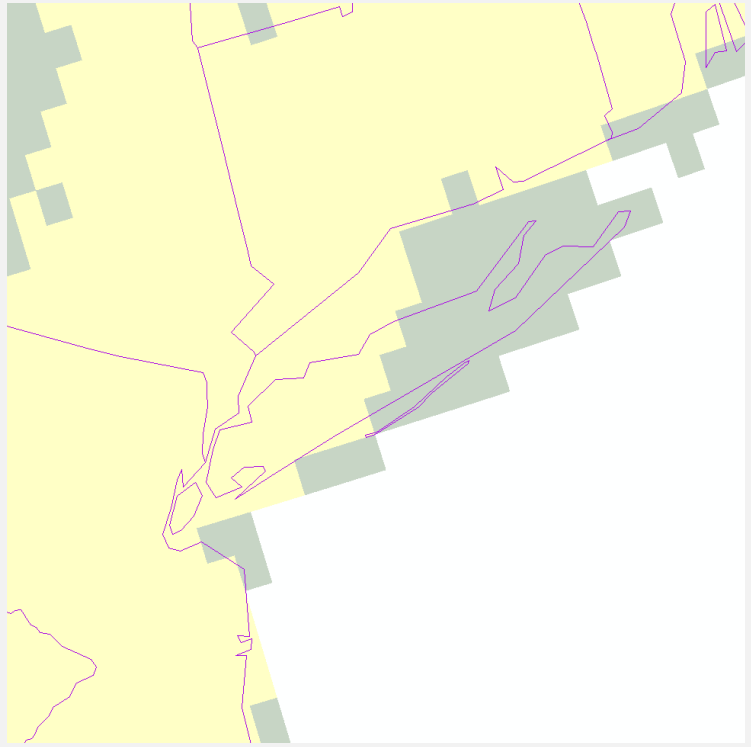
Downscaled Air Temperature

Daily Maximum Air Temperature from NLDAS, and downscaled to 1 km using MODIS LST for the New York City Metropolitan Area for May 2, 2005

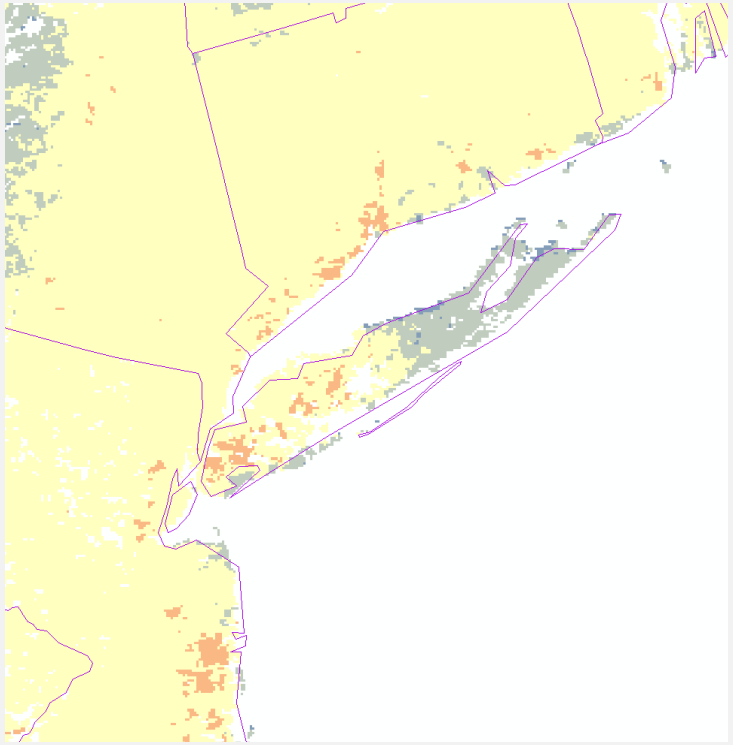
T_{max} (°F)
May 2, 2005



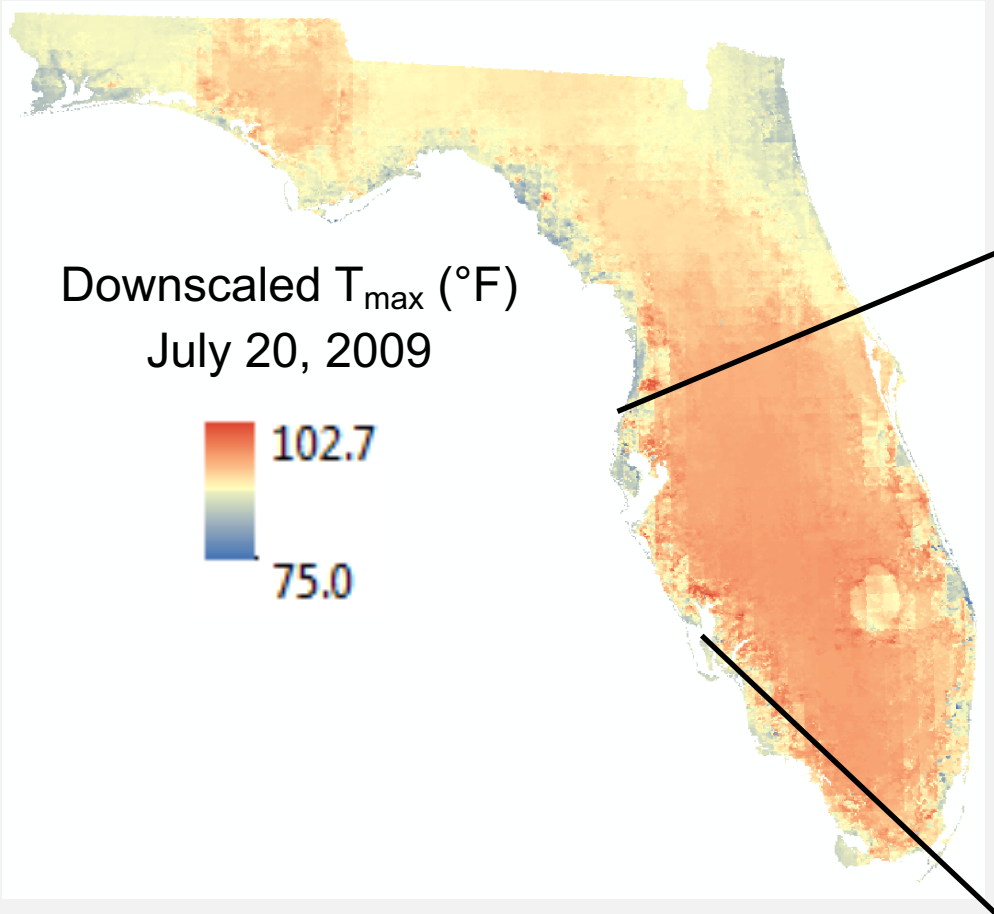
NLDAS 12 km



Downscaled to 1 km



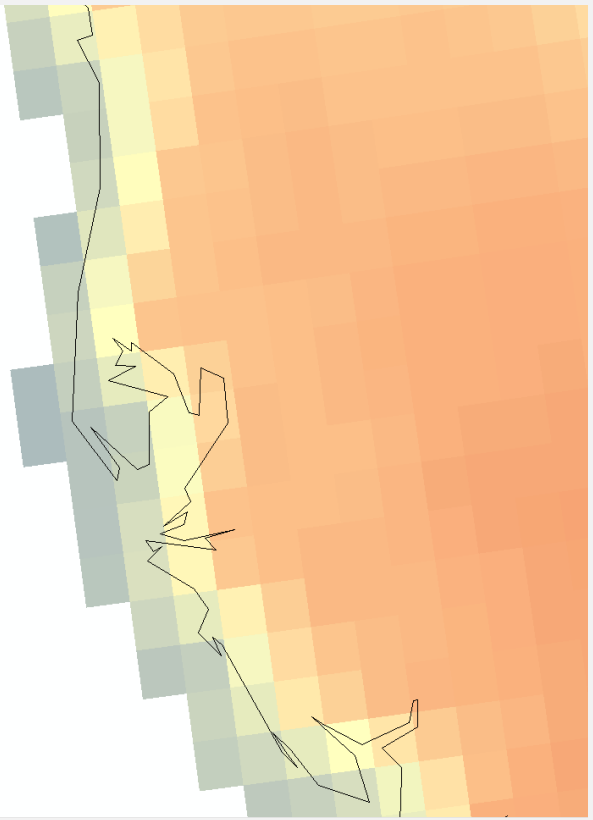
Florida Results



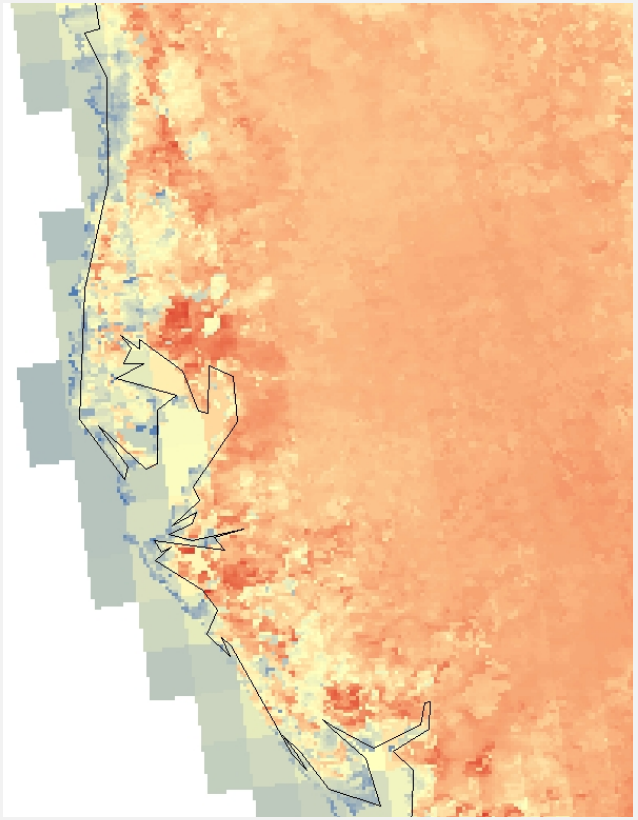
Tampa Bay Area

T_{max} - July 12, 2009

NLDAS 12 km



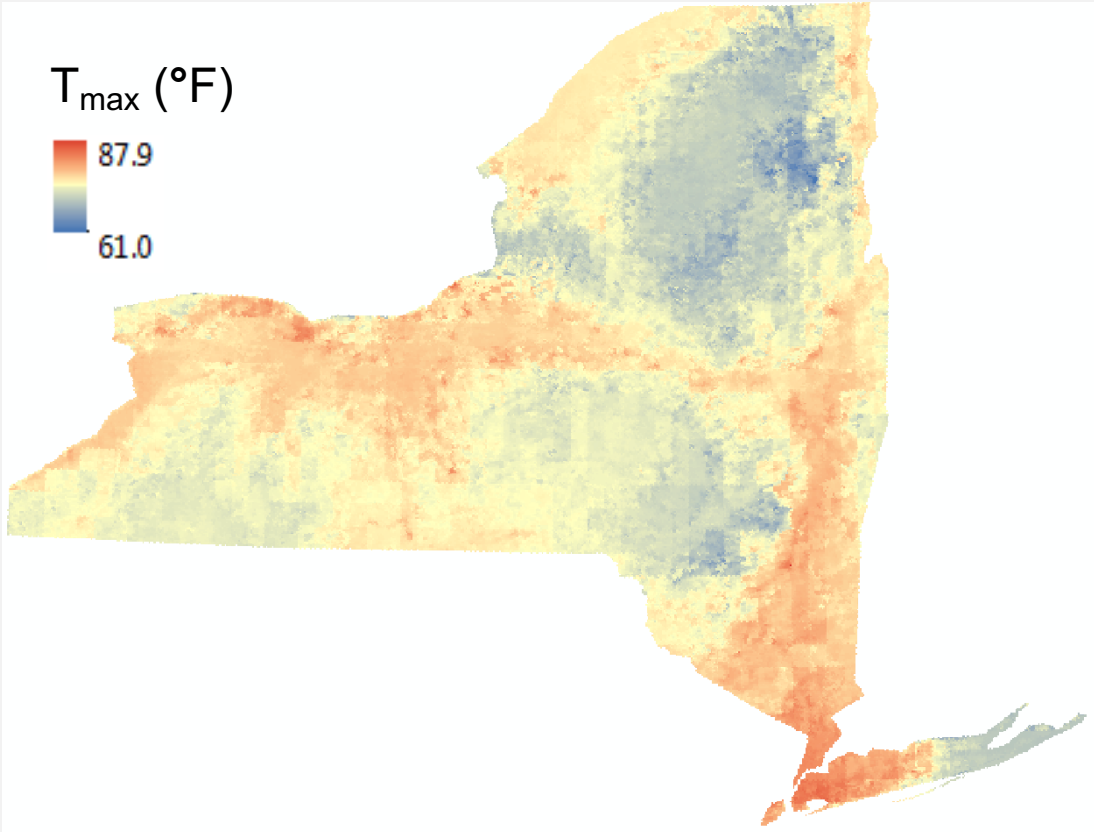
Downscaled to 1 km

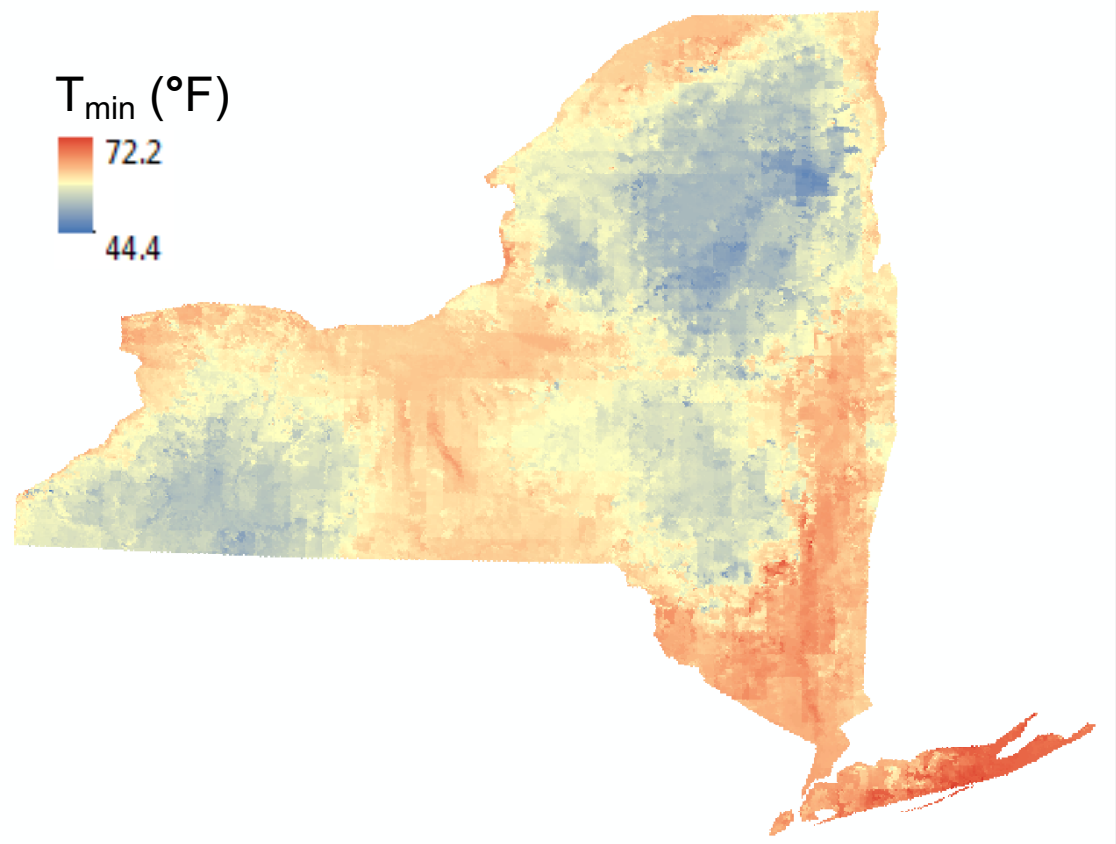


New York State Results

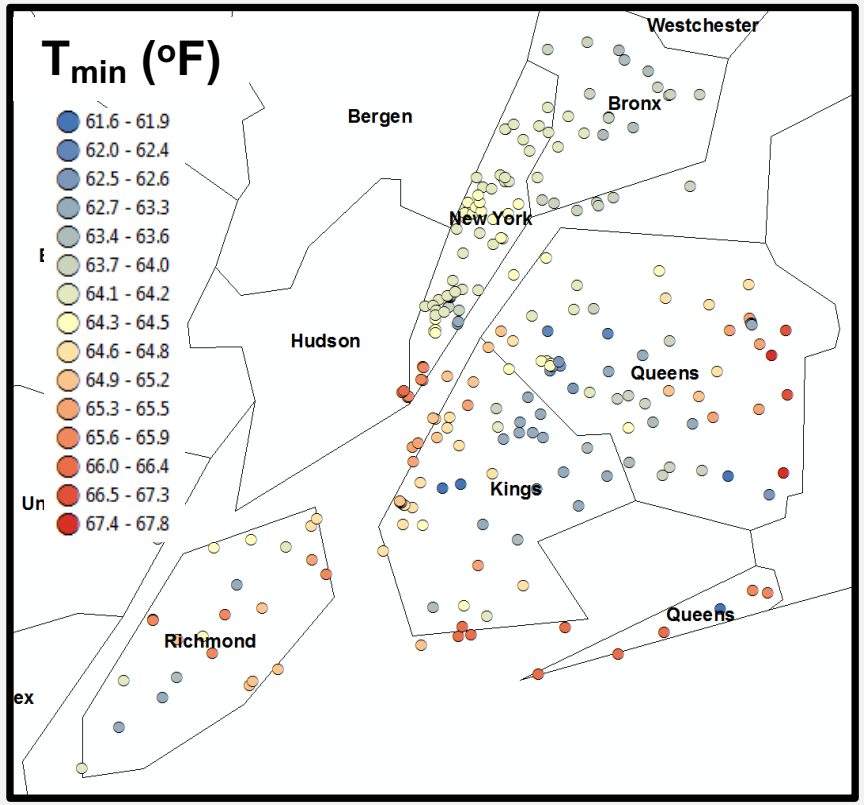
Downscaled T_{max}, T_{min}

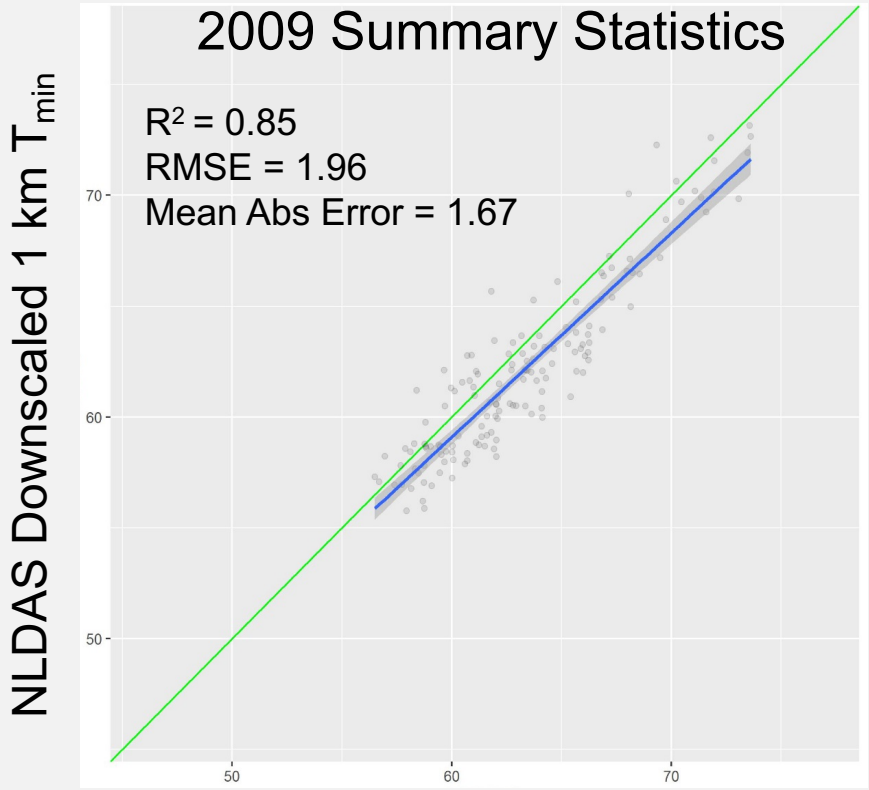
July 20, 2009





New York City Validation



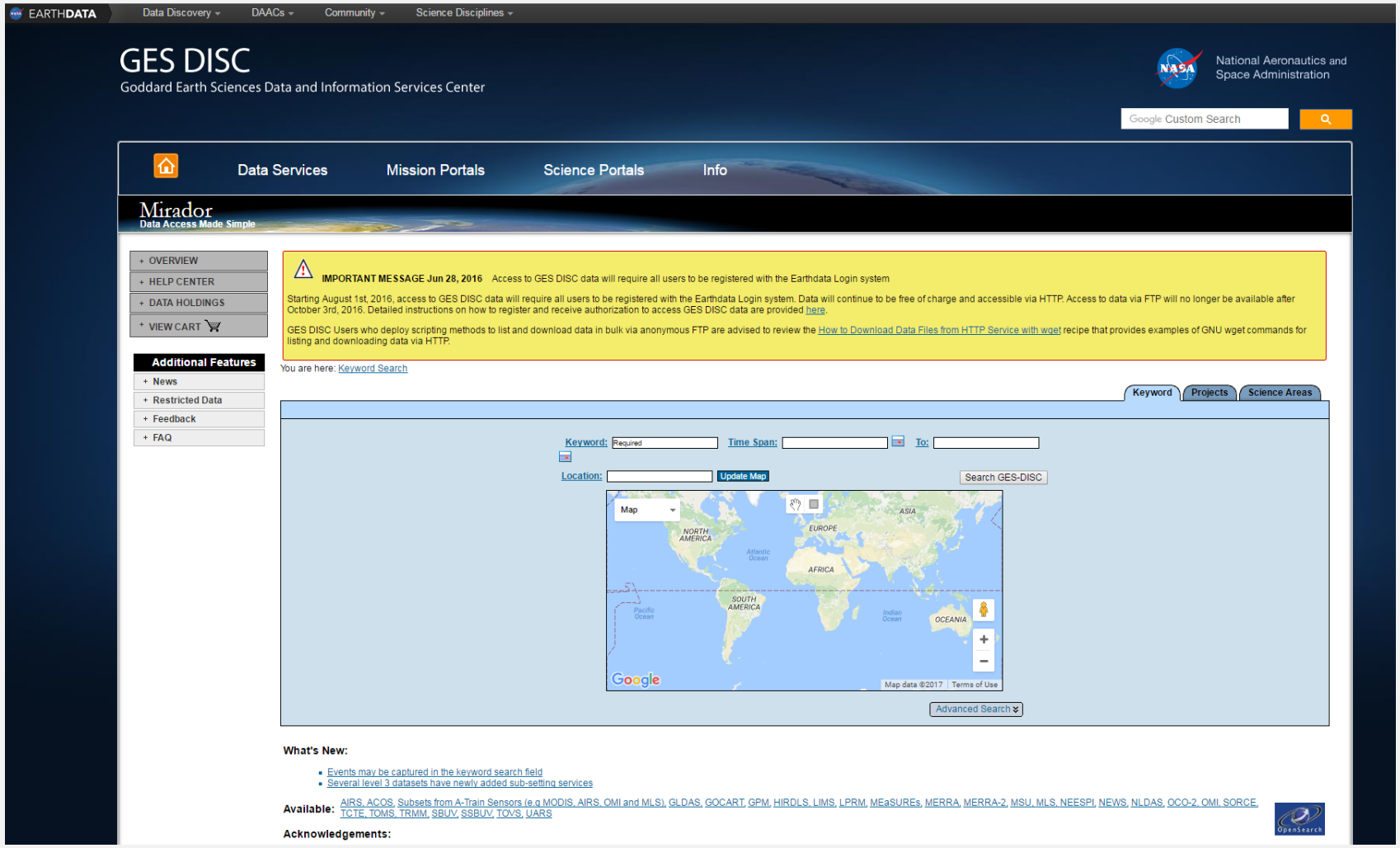


Downscaled Daily Minimum Temperatures have been linked to the locations of ground-based measurements made through the NYCCAS (New York City Community Air Survey).

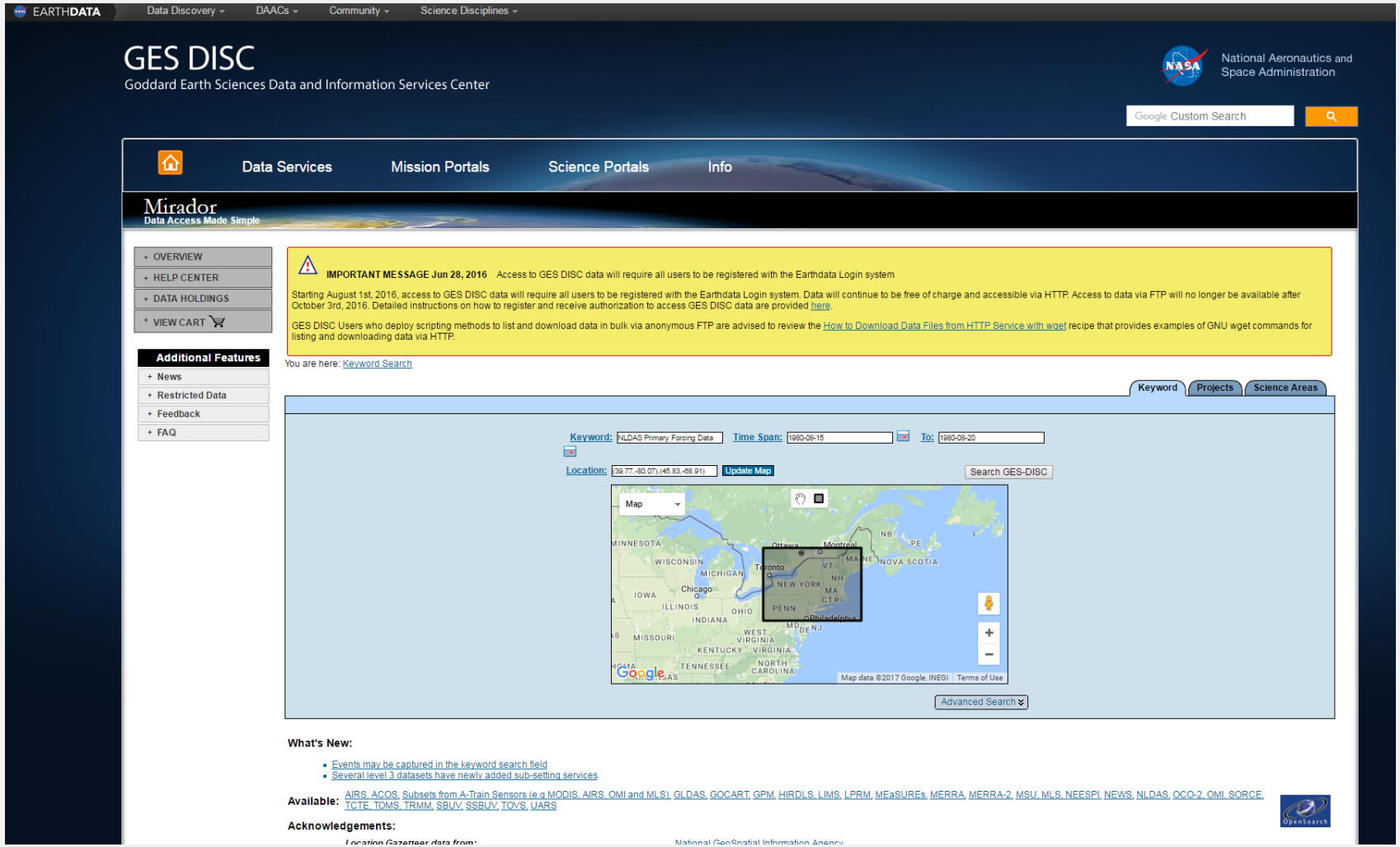
There is excellent agreement between the downscaled temperatures and ground-based measurements.

Downloading and Processing NLDAS Data

Downloading Data from Mirador: http://mirador.gsfc.nasa.gov/



Select Dataset, Period, Location



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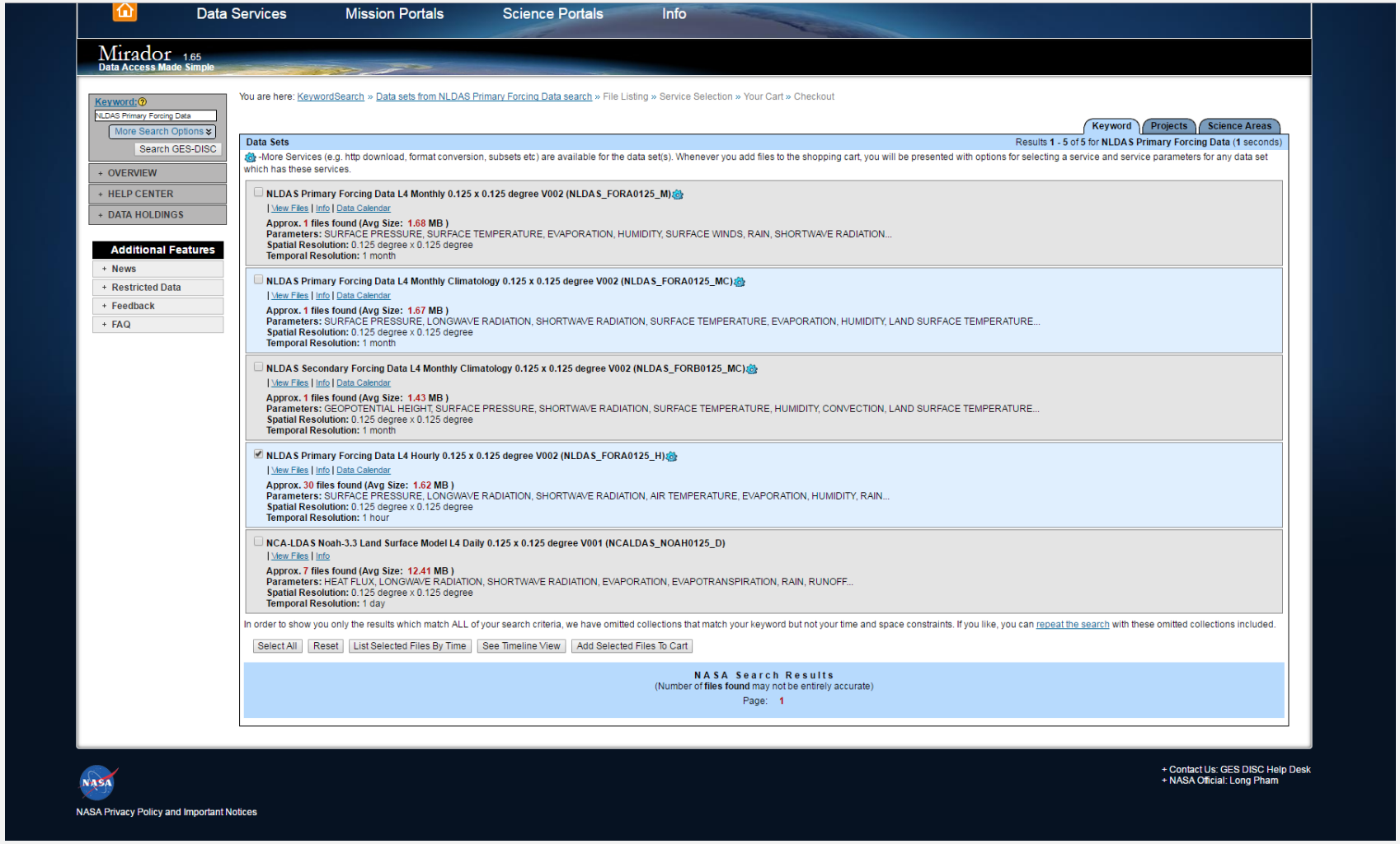

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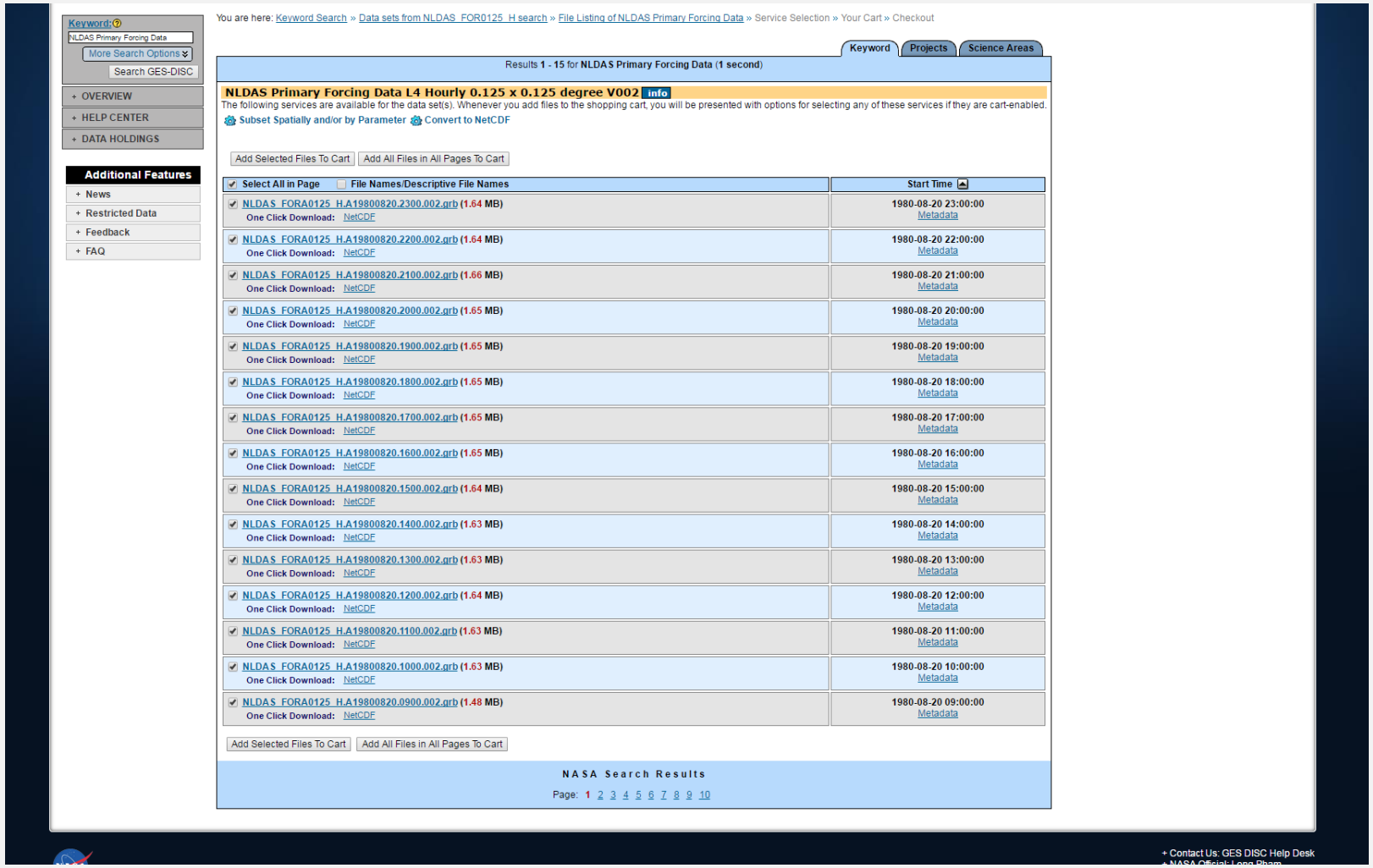
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Results 1 - 15 for NLDAS Primary Forcing Data (1 second)
NLDAS Primary Forcing Data L4 Hourly 0.125 x 0.125 degree V002 info
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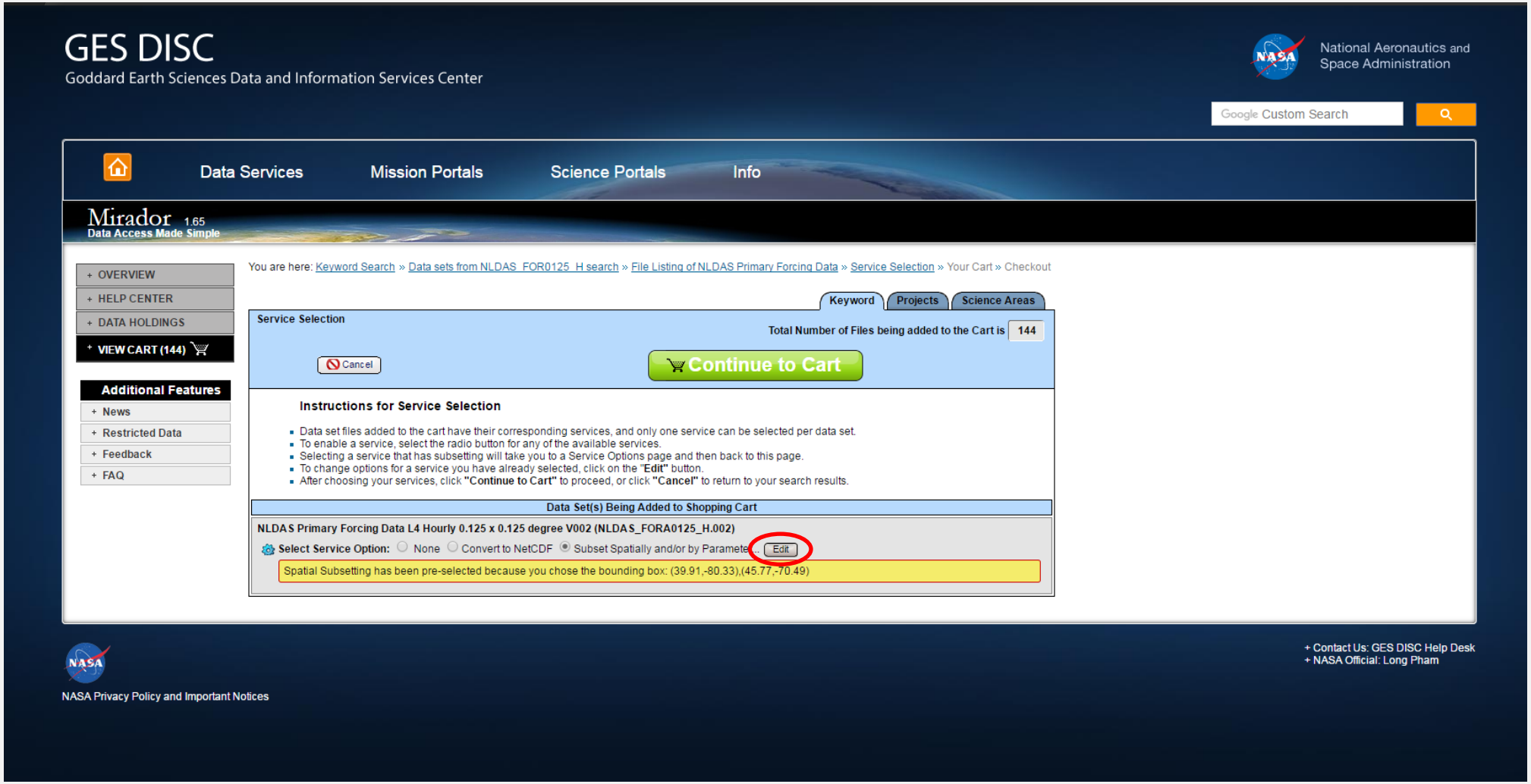

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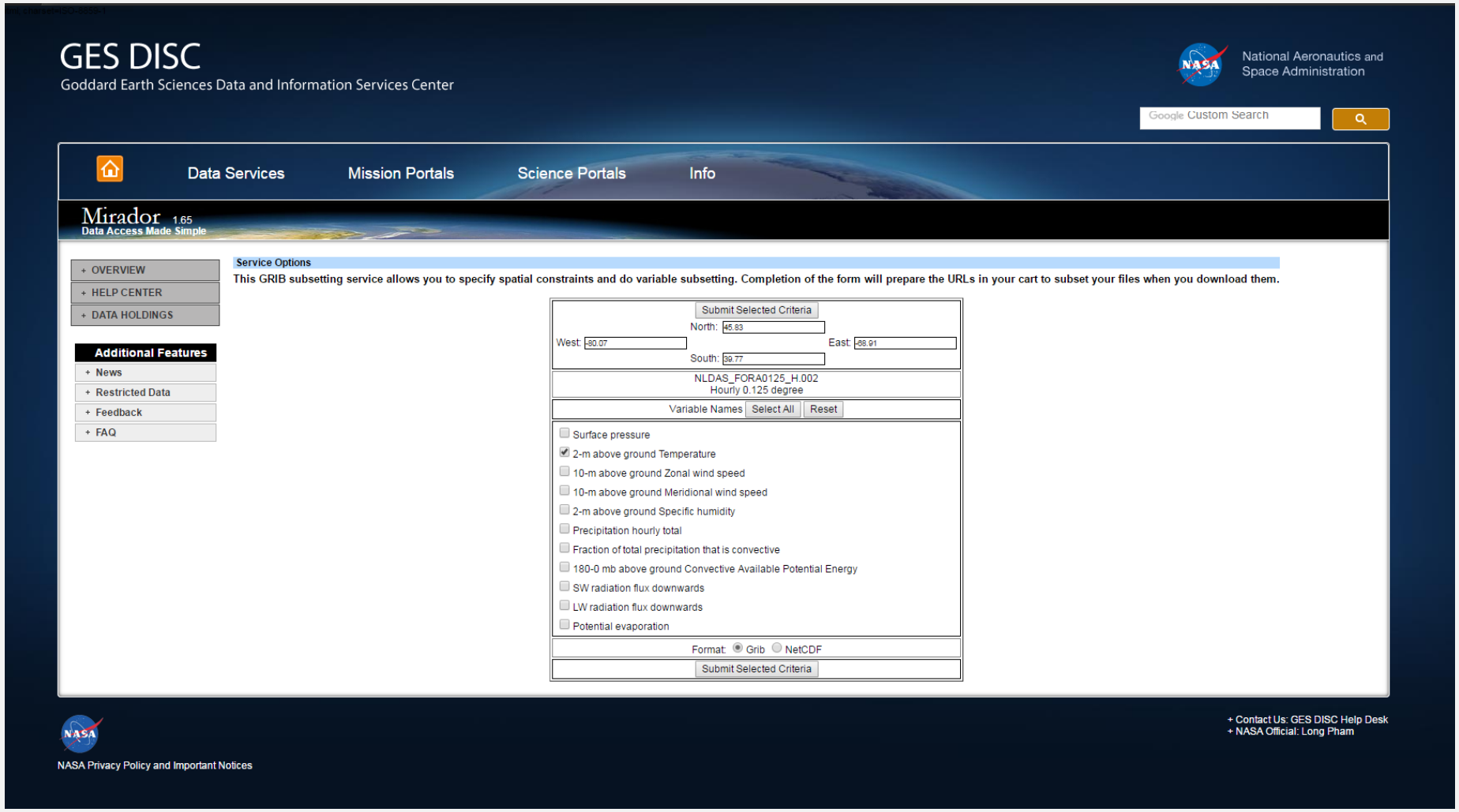

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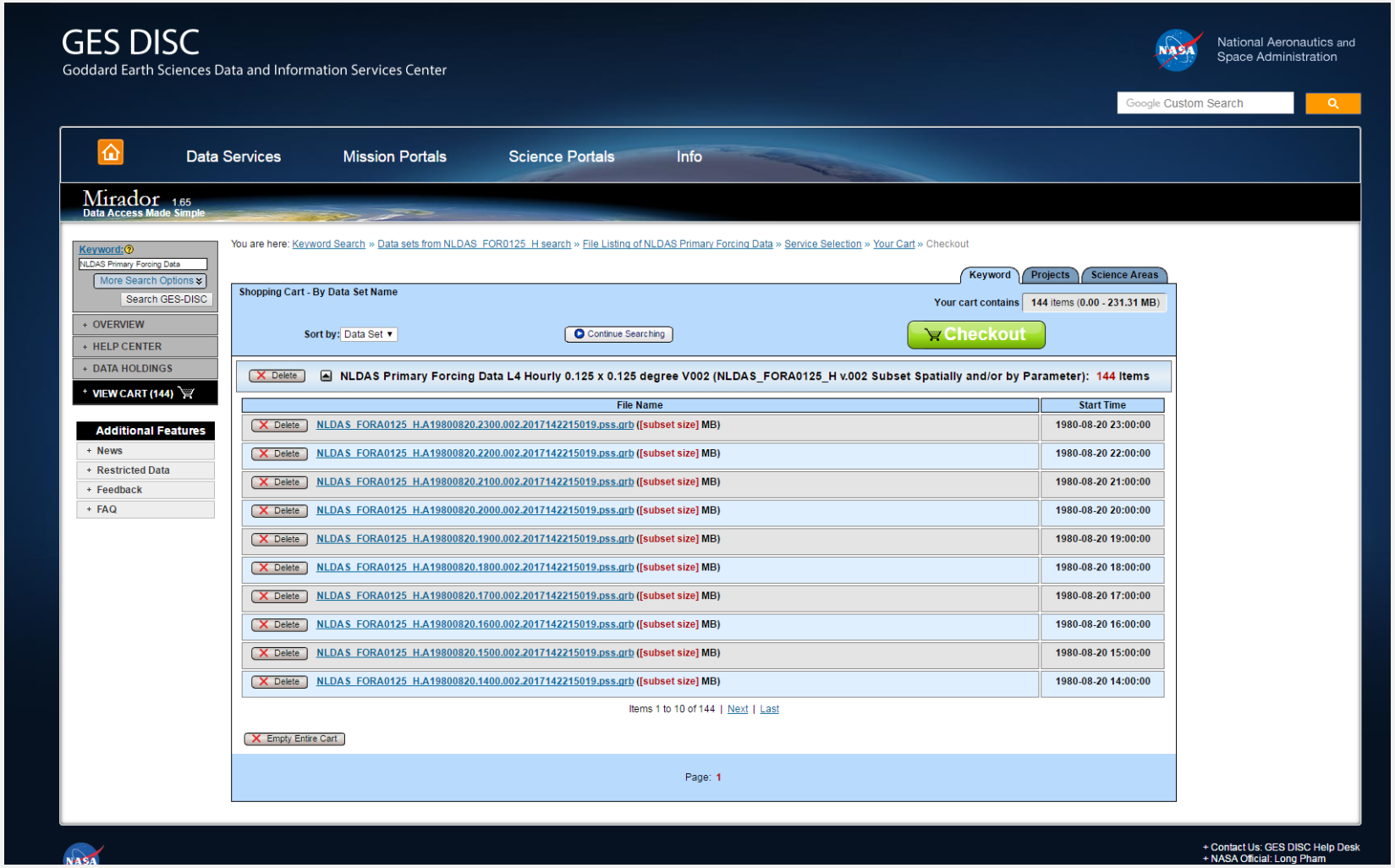
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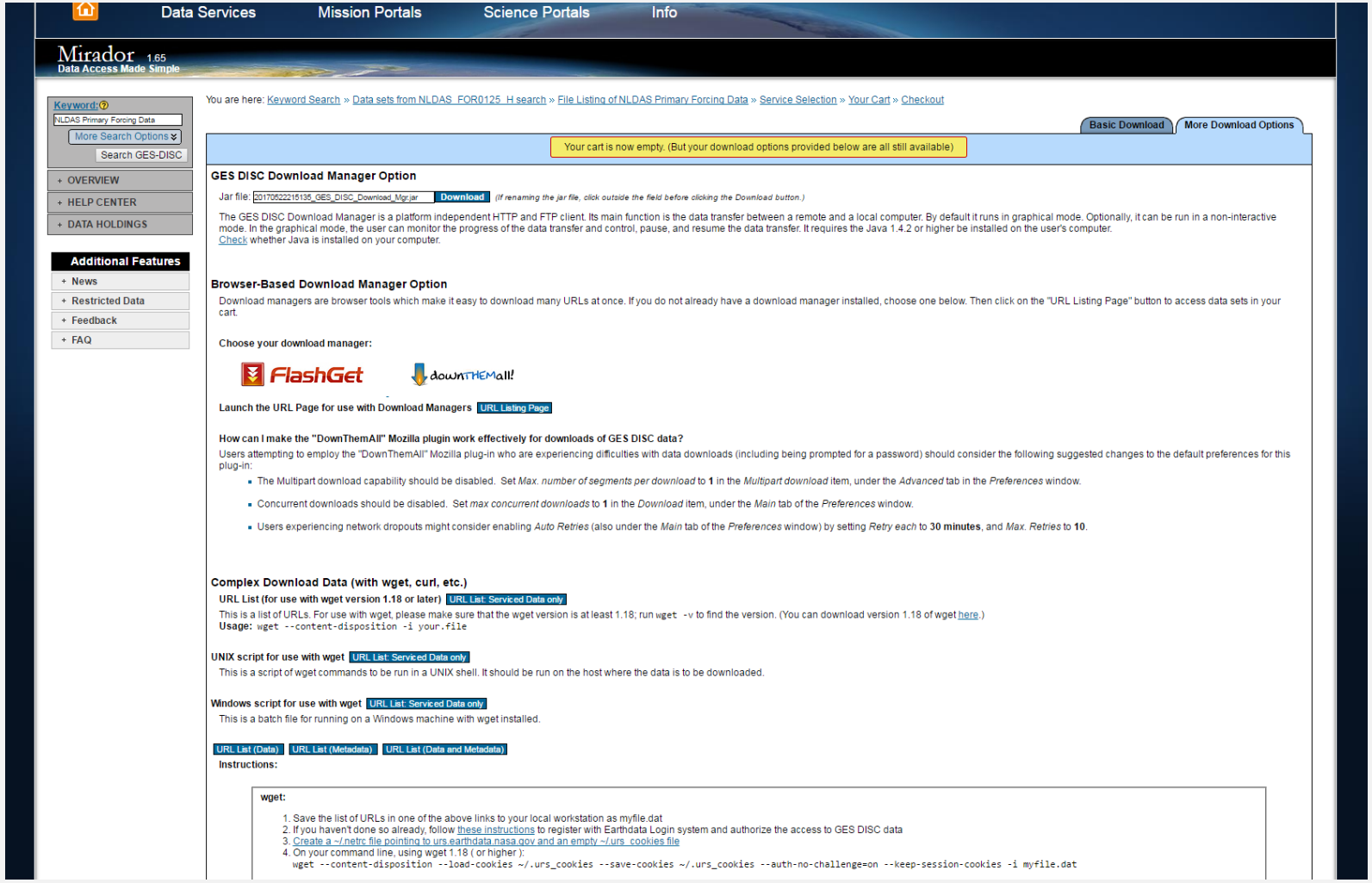
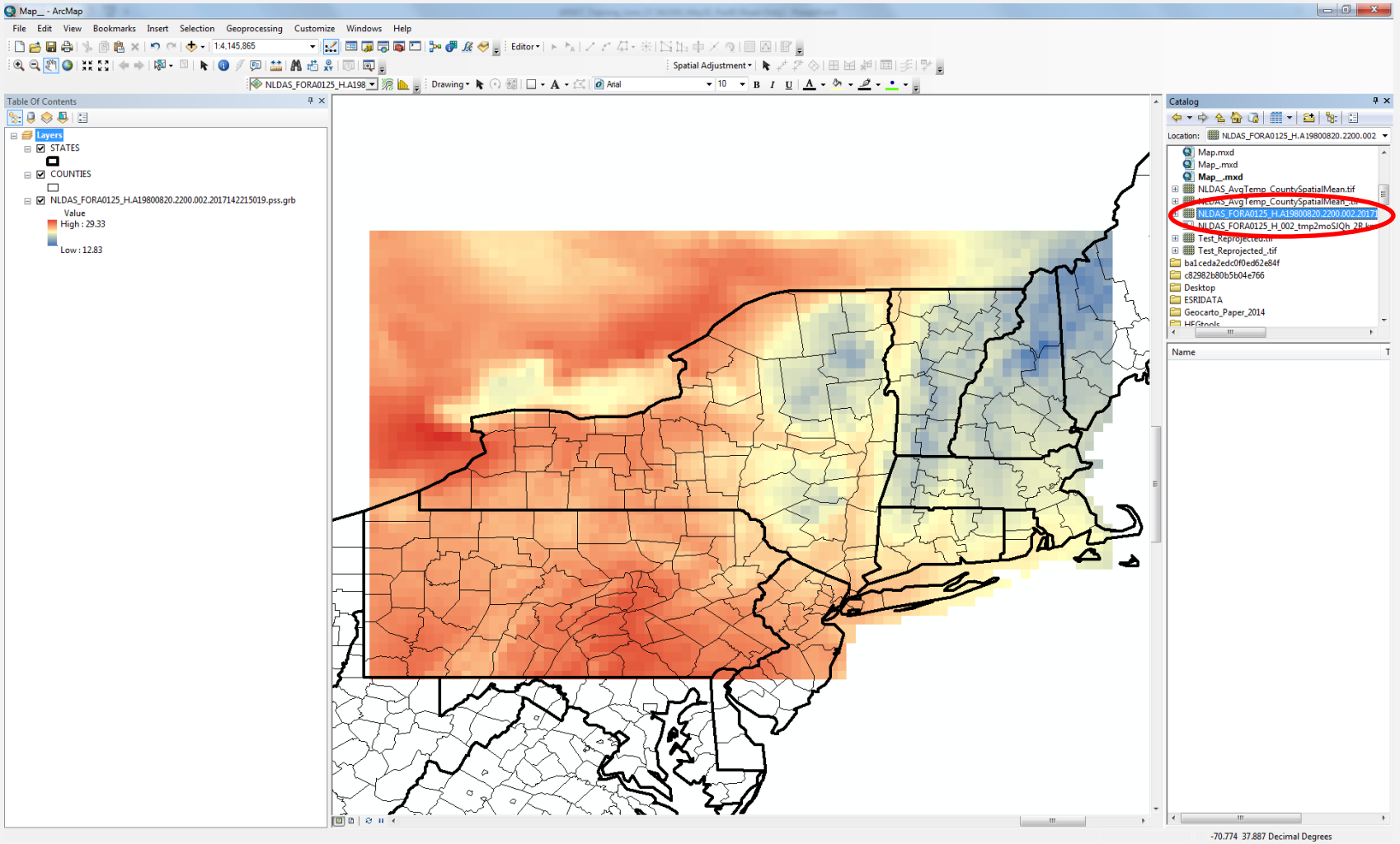
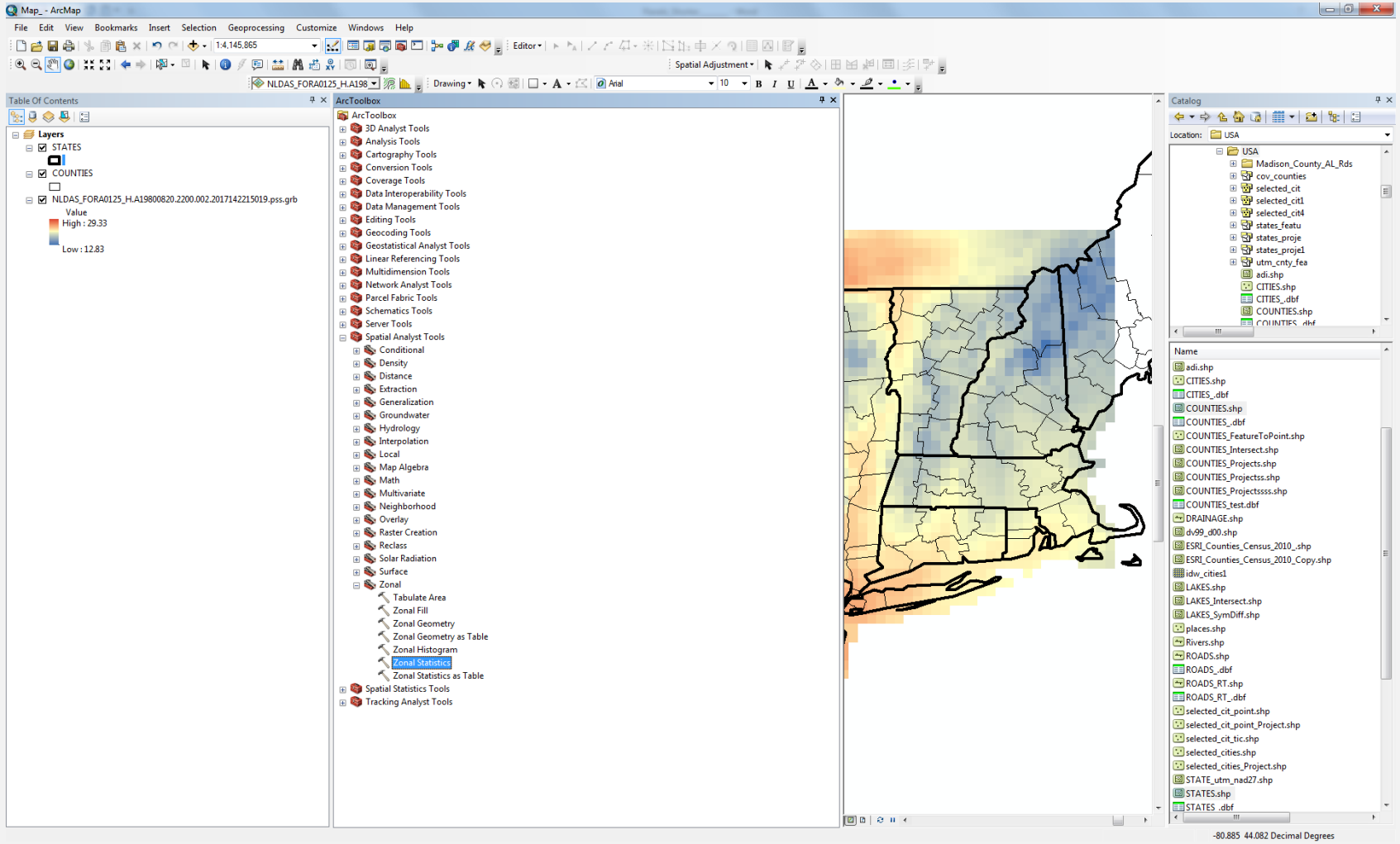


Import into GIS (ArcGIS used below)



Aggregating Gridded Data to County-Level in ArcGIS



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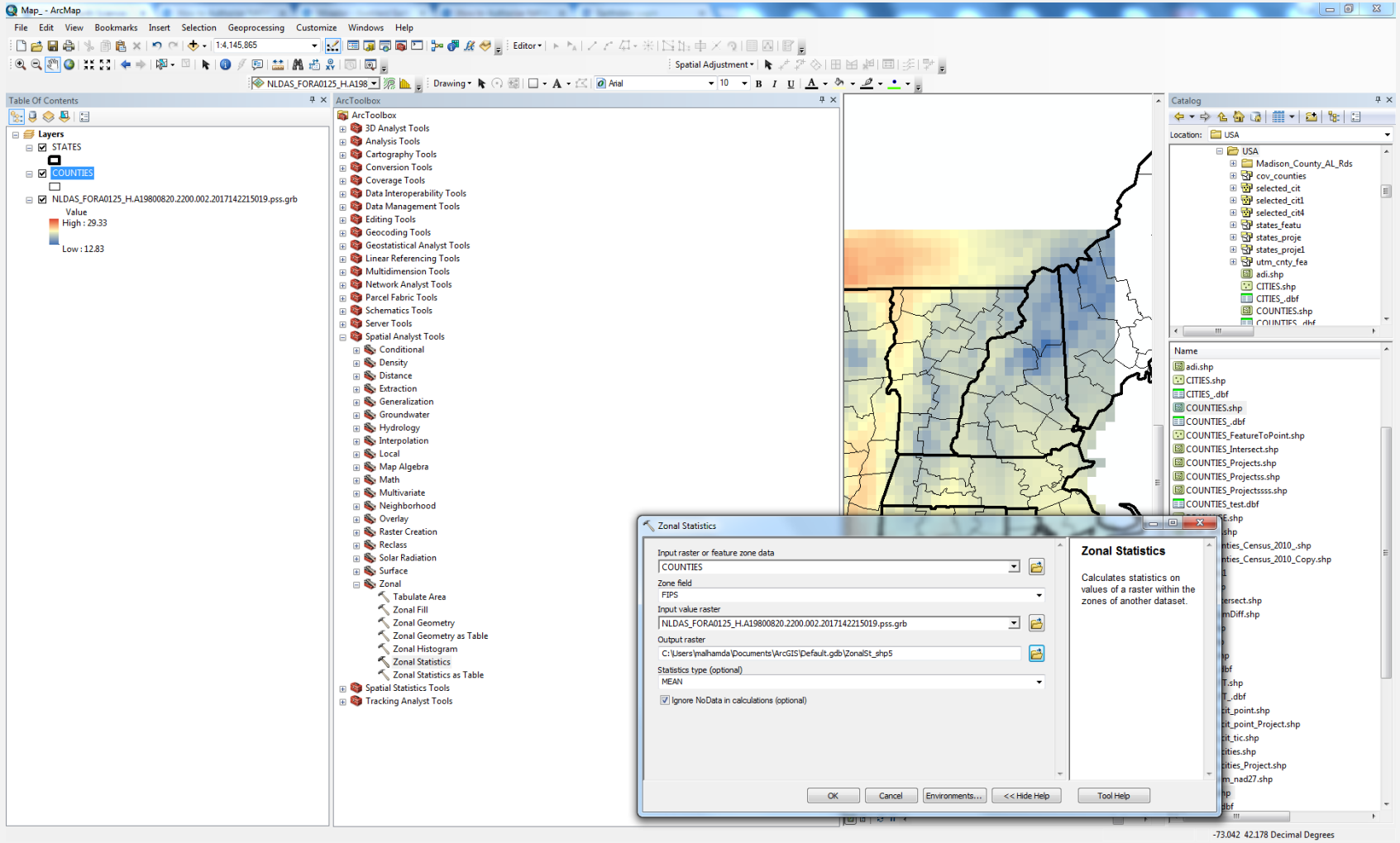

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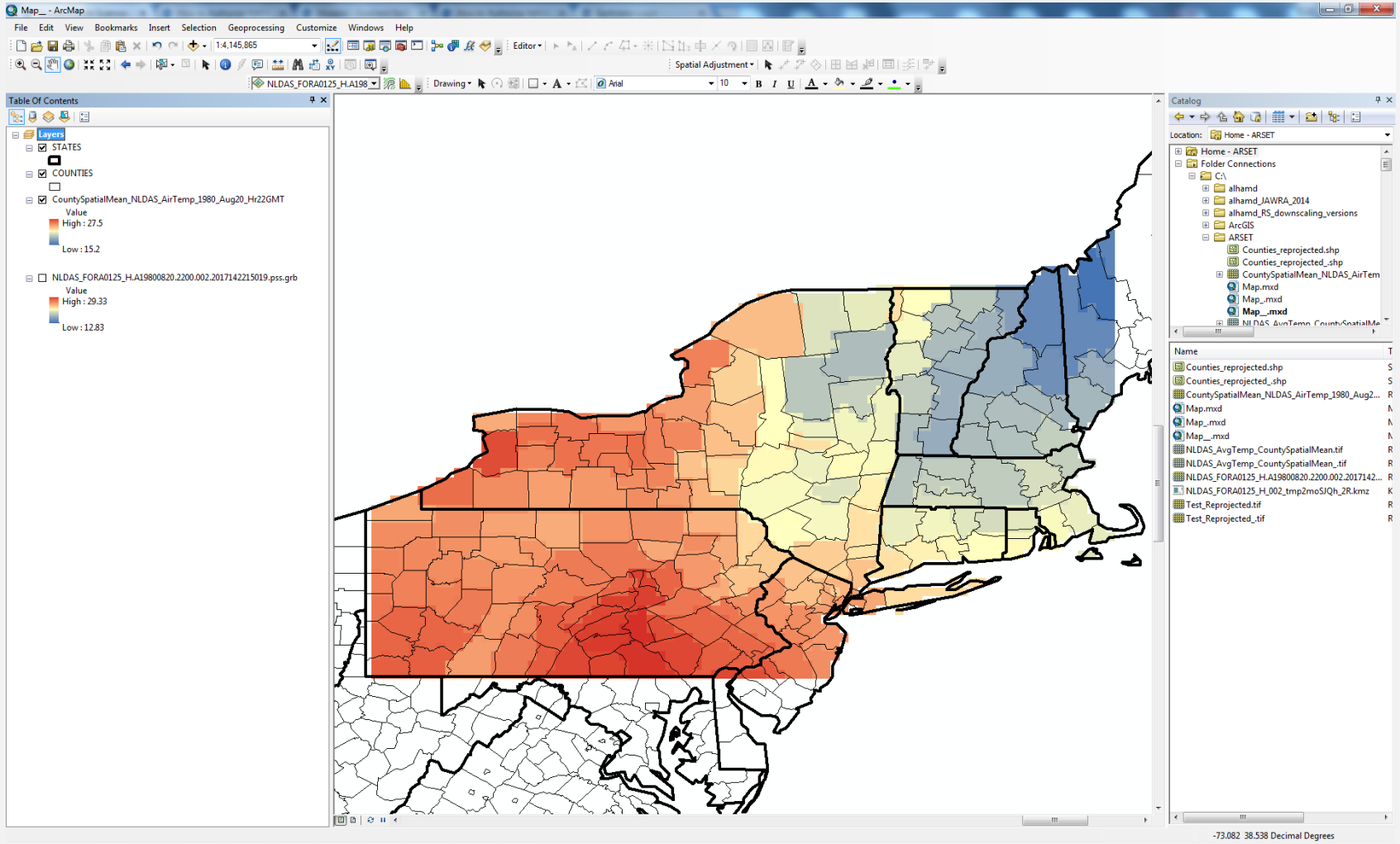
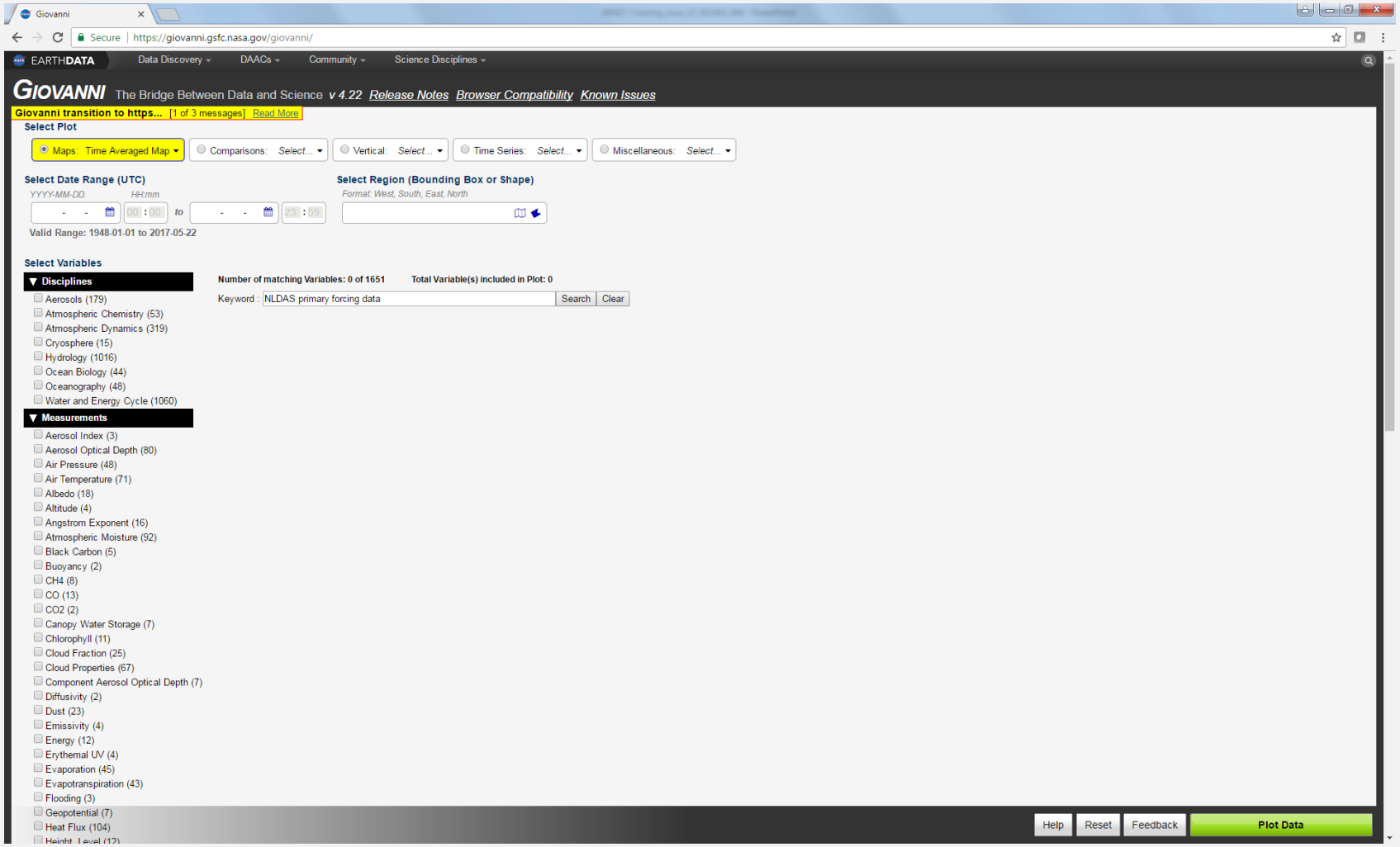


Plotting and Analyzing Gridded Data into Giovanni

http://giovanni.gsfc.nasa.gov/giovanni/



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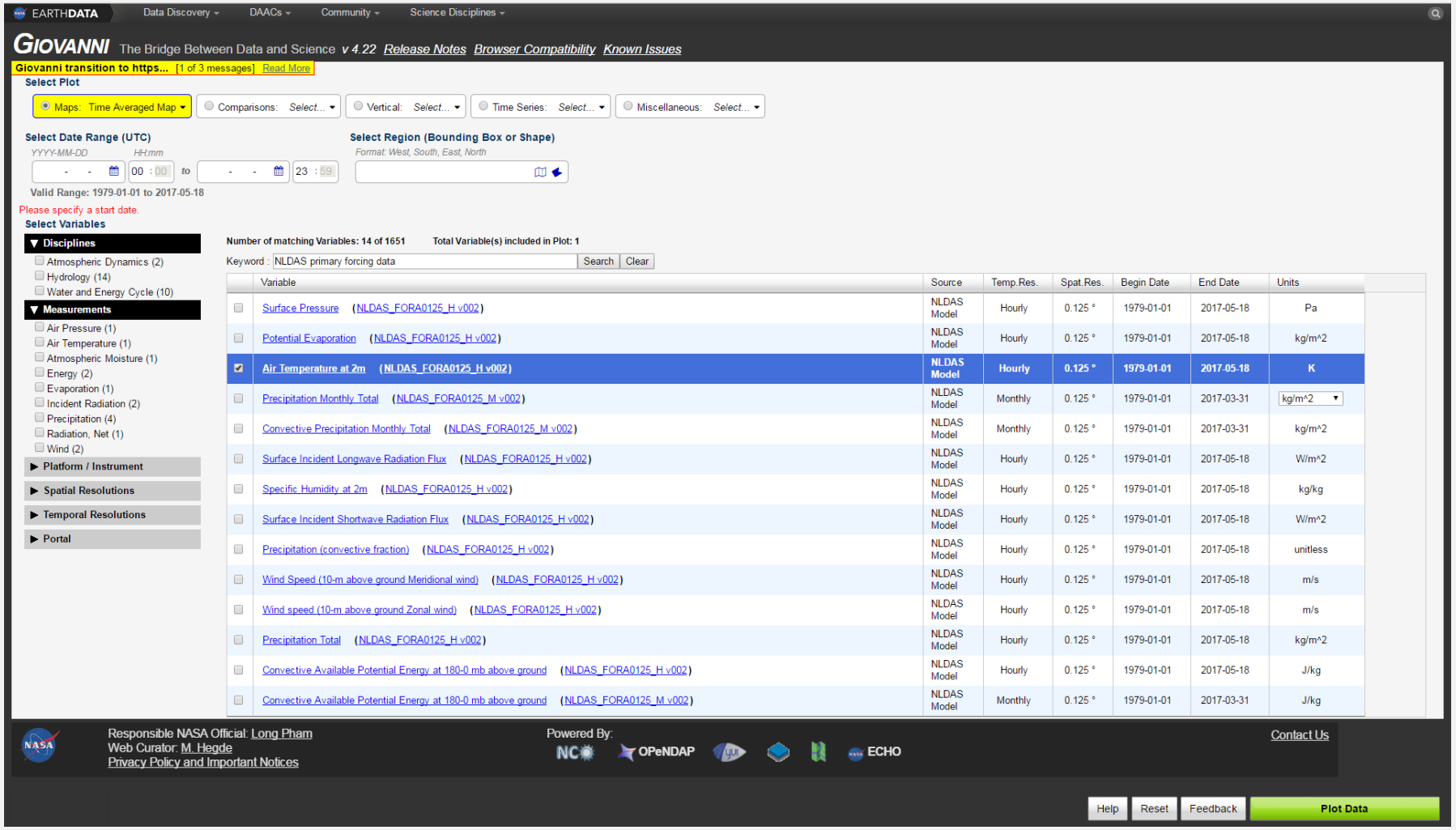

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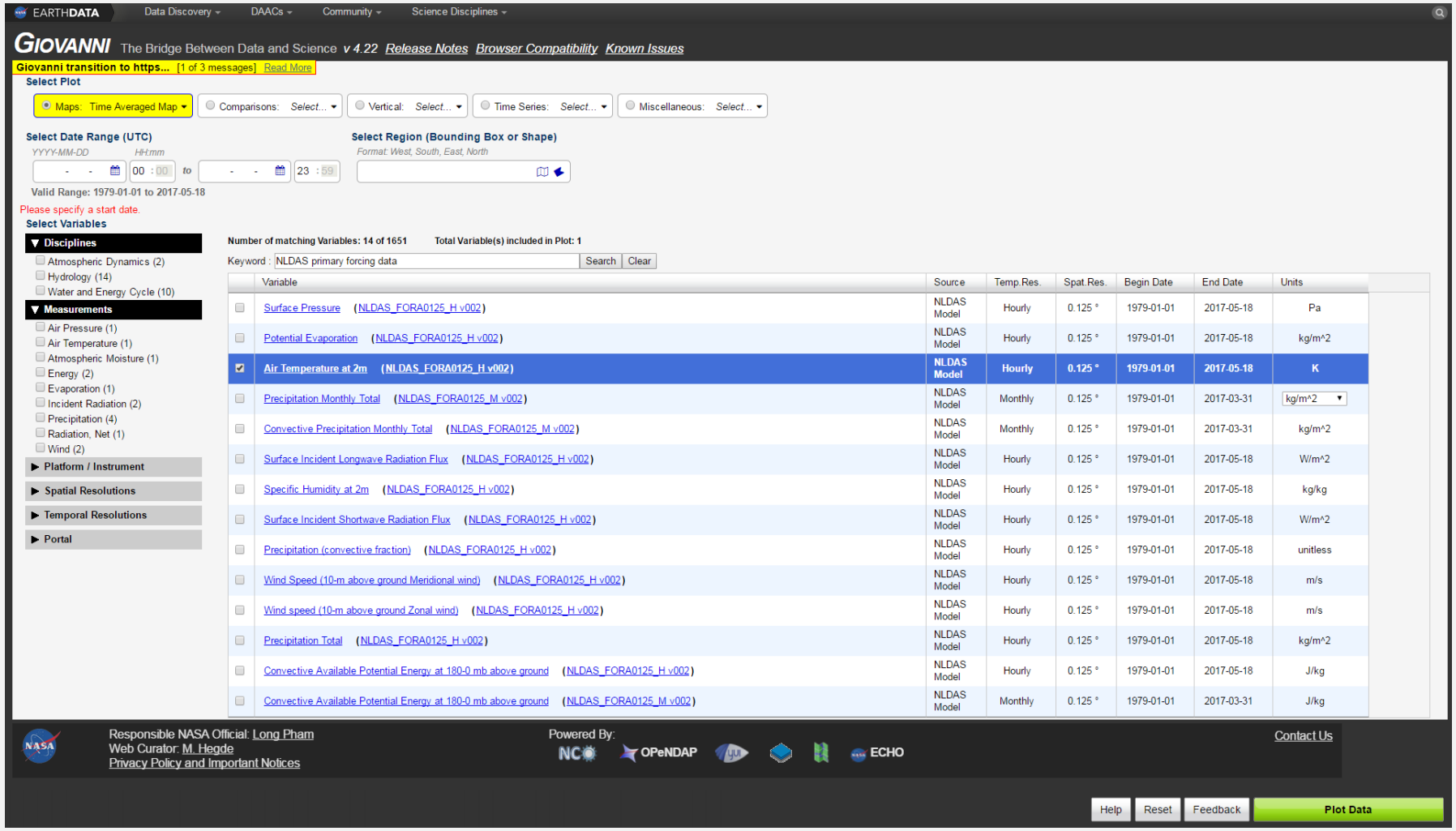

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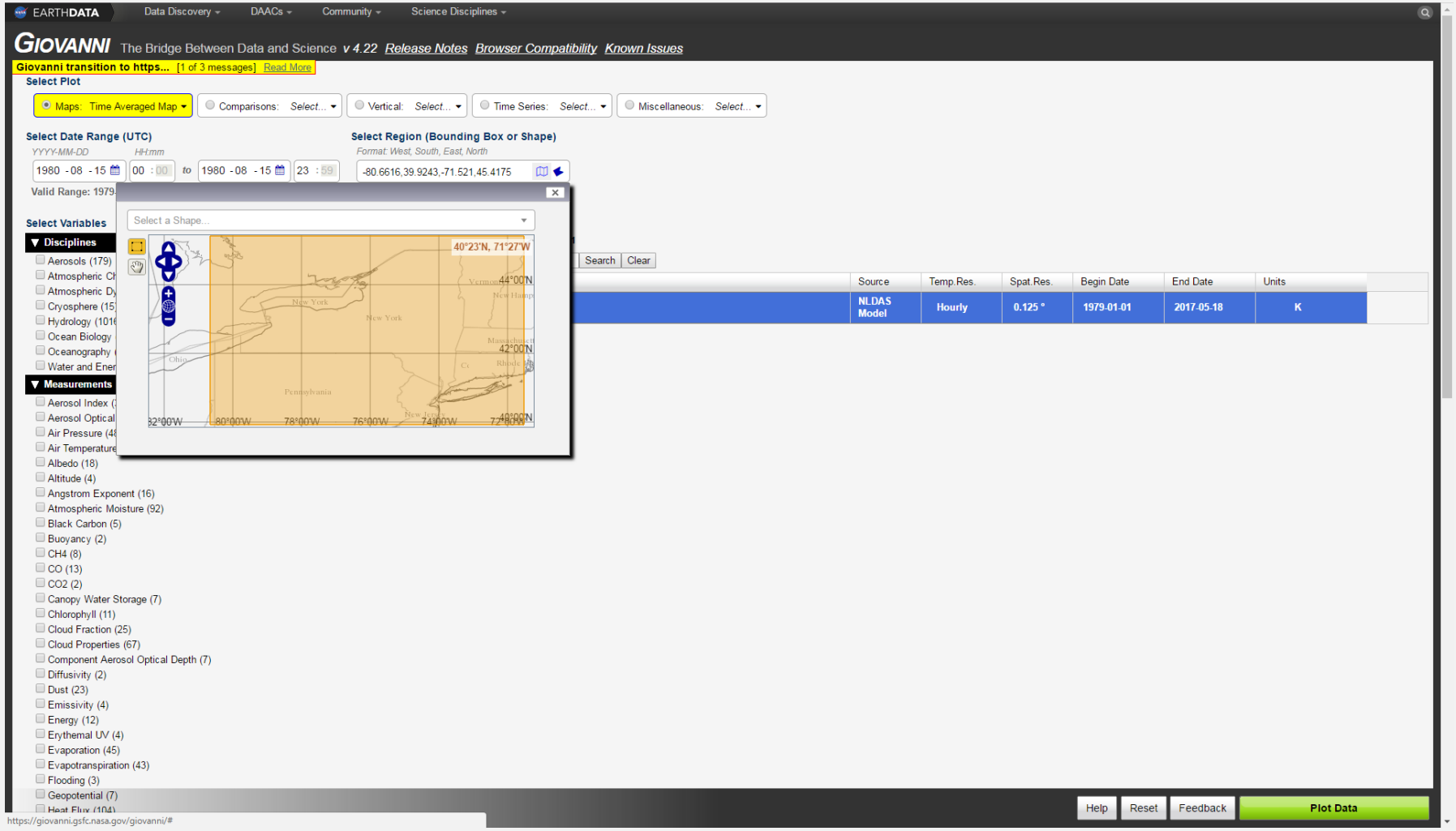
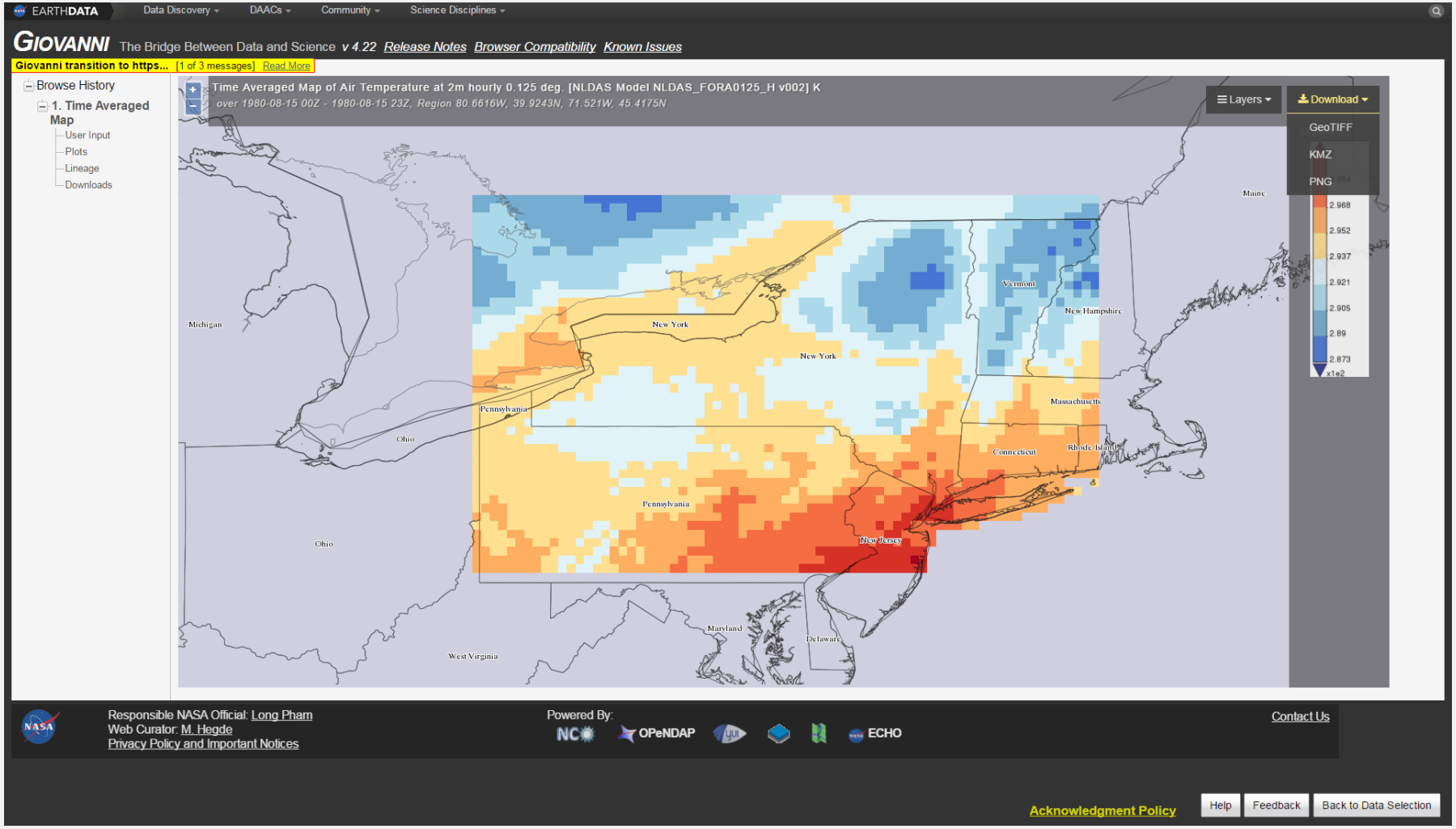


Plotting and Downloading in a Different Format



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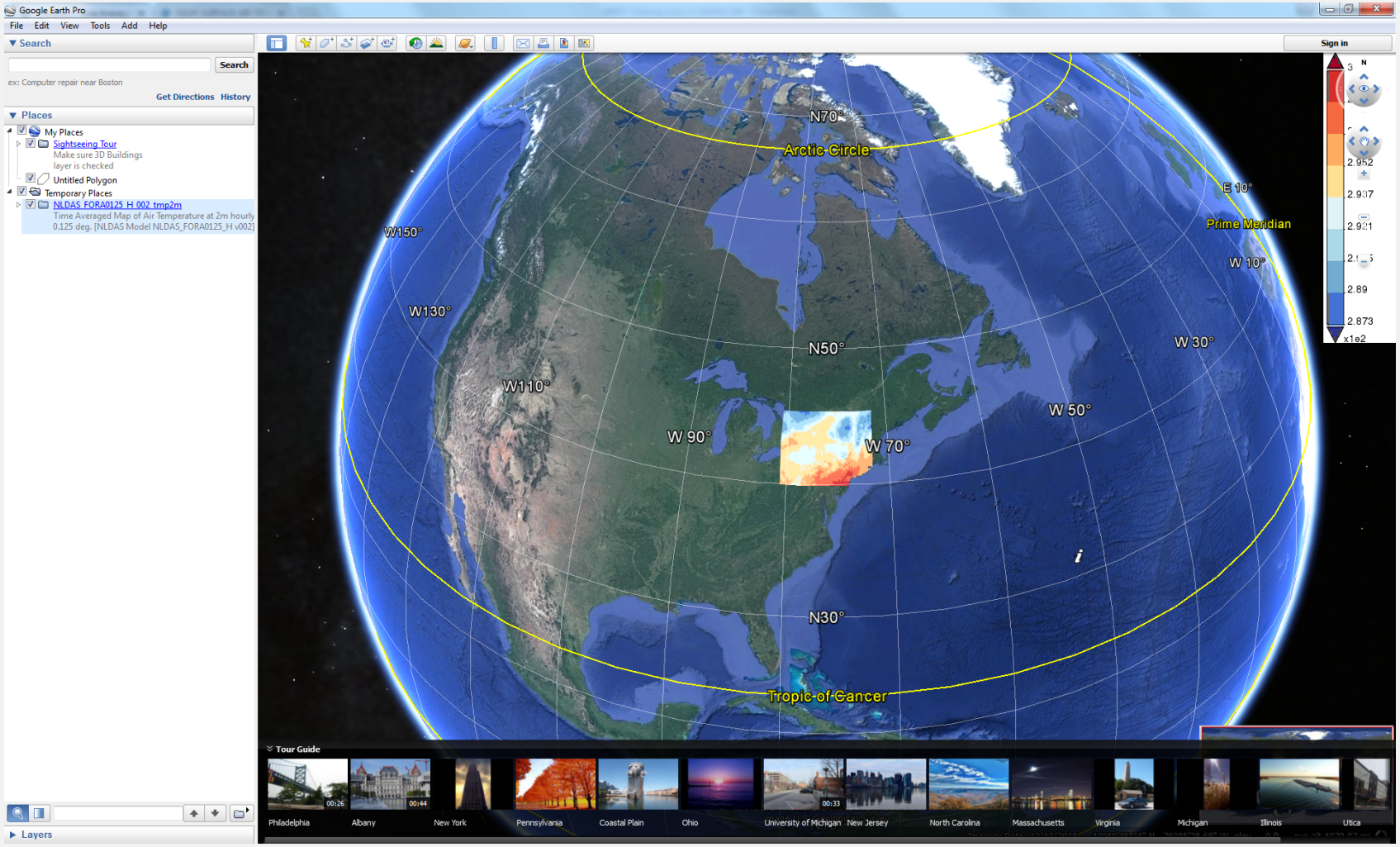
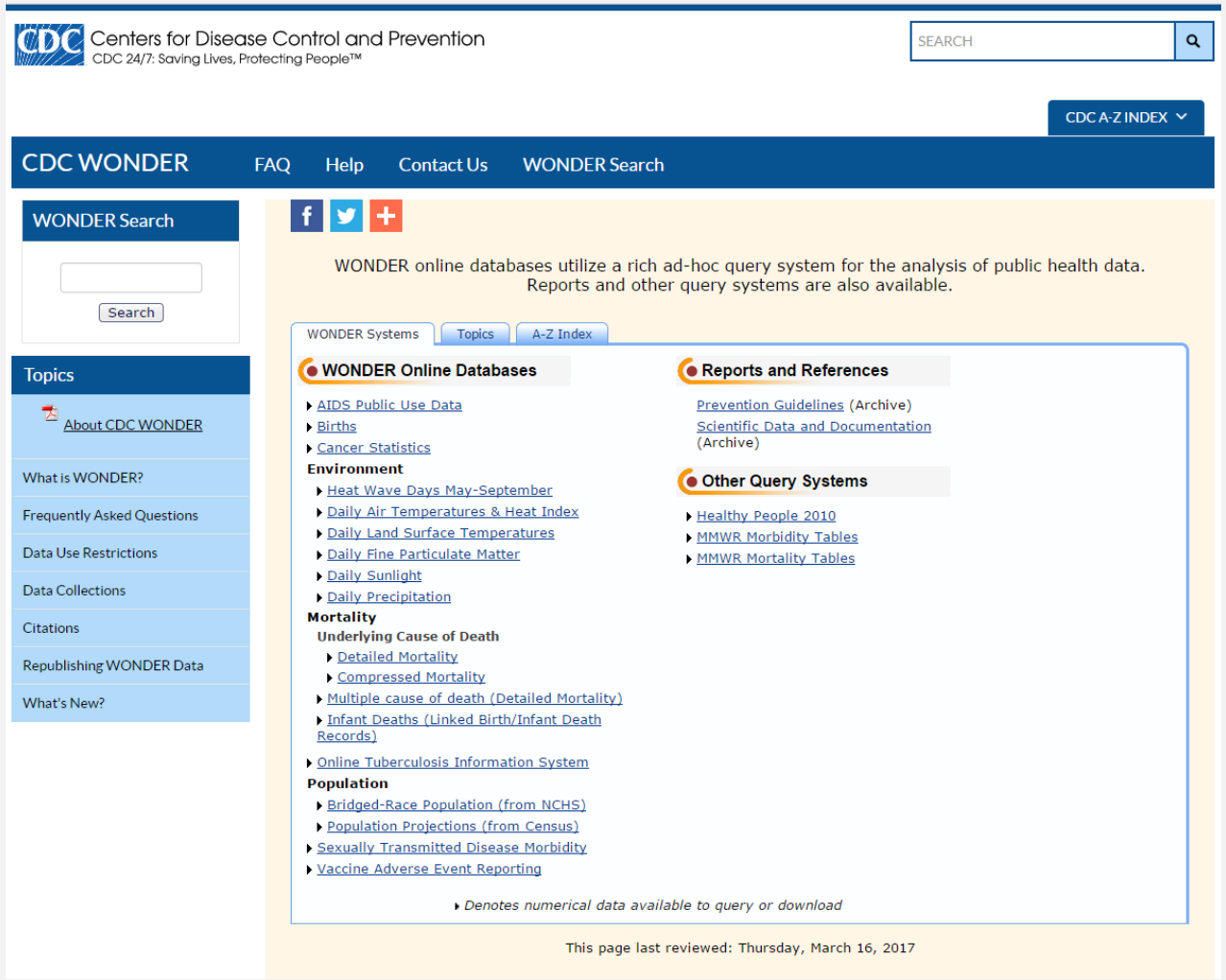


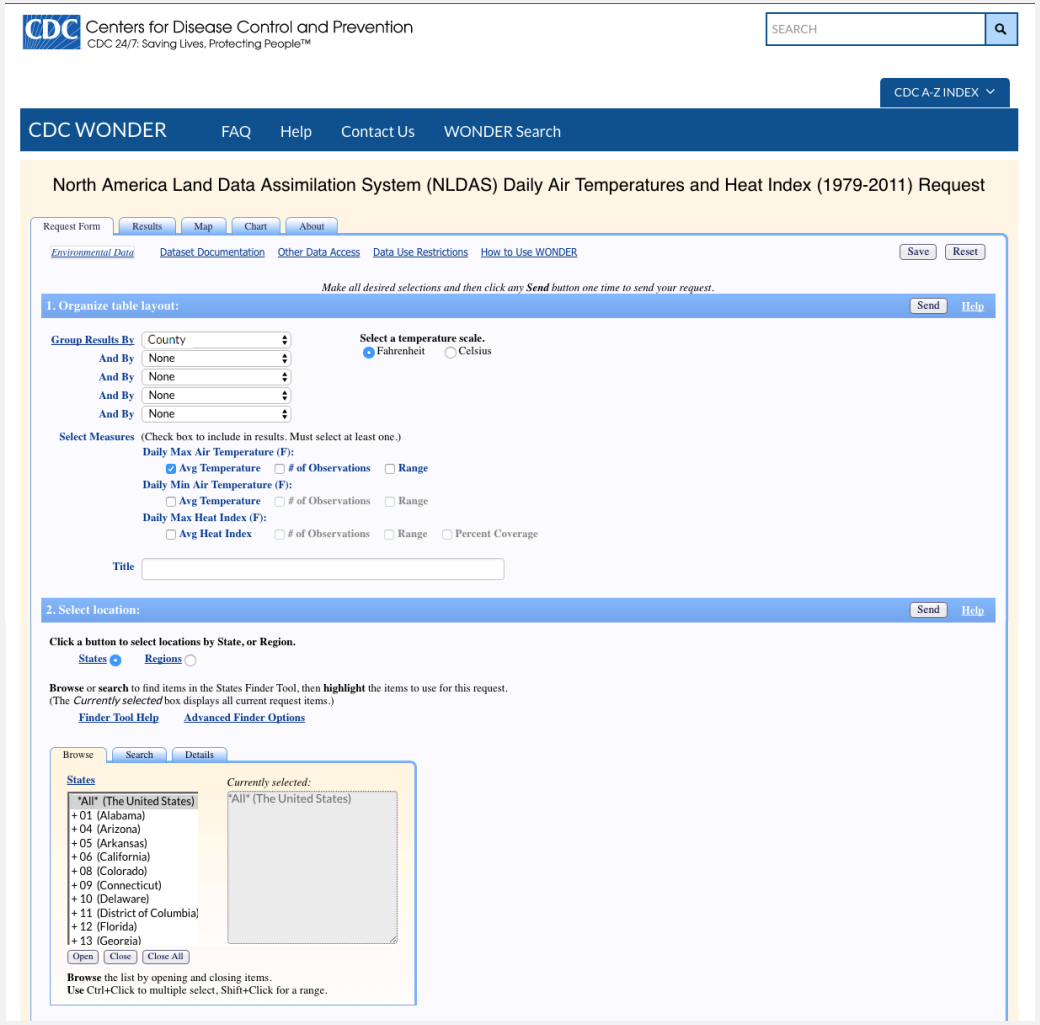
CDC WONDER Main Website

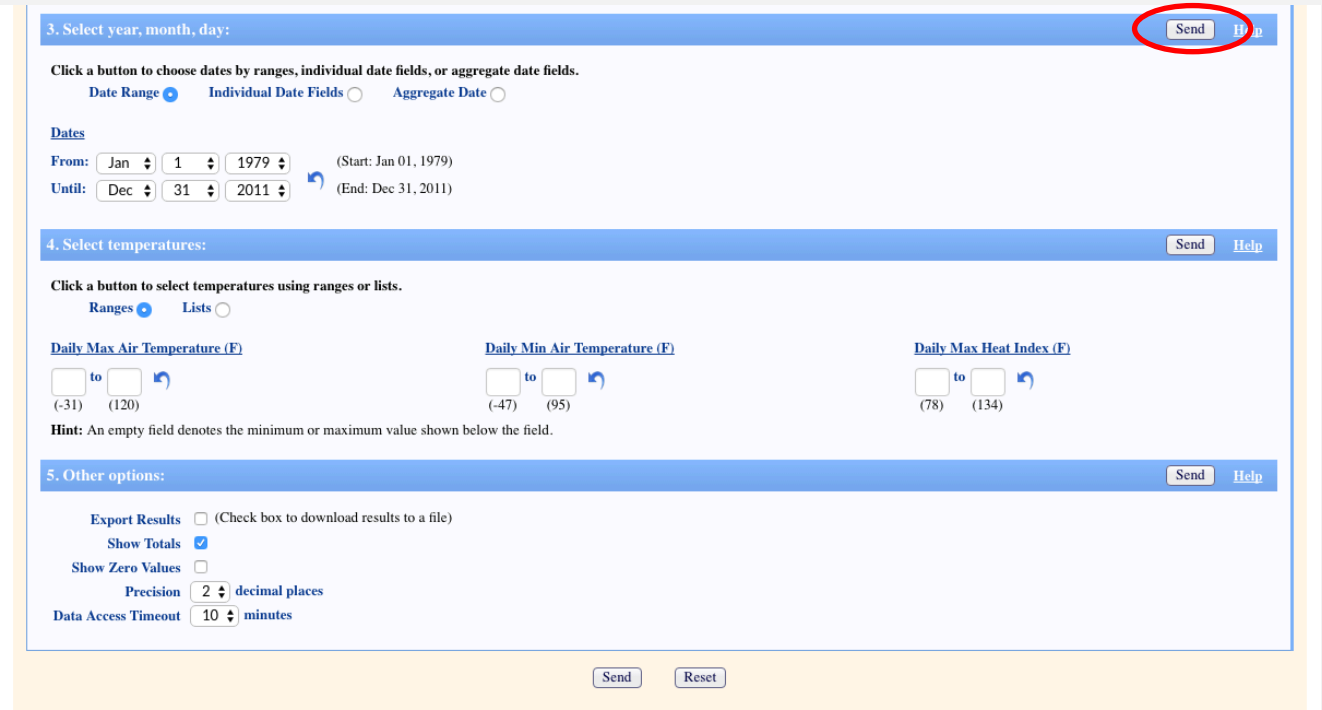
http://wonder.cdc.gov/



NLDAS-Derived Heat-Related Products on CDC Wonder

Now Available at http://wonder.cdc.gov/nasa-nldas.html/





CDC WONDER Tabular Results

North America Land Data Assimilation System (NLDAS) Daily Air Temperatures and Heat Index (2003-2008) Results

Request Form | Results | Map | Chart | About

Dataset Documentation | Help for Results | Printing Tips | Help with Exports

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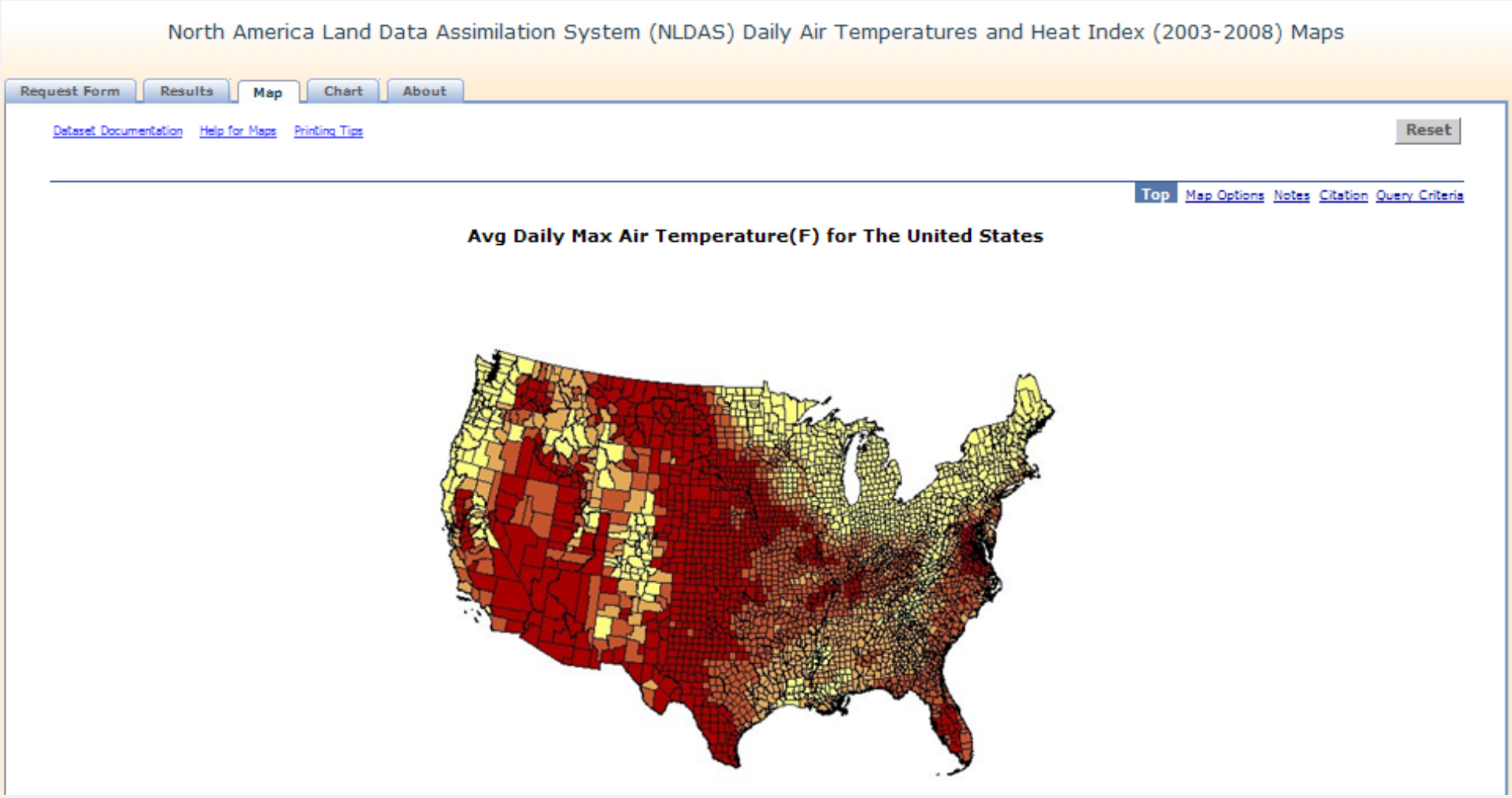
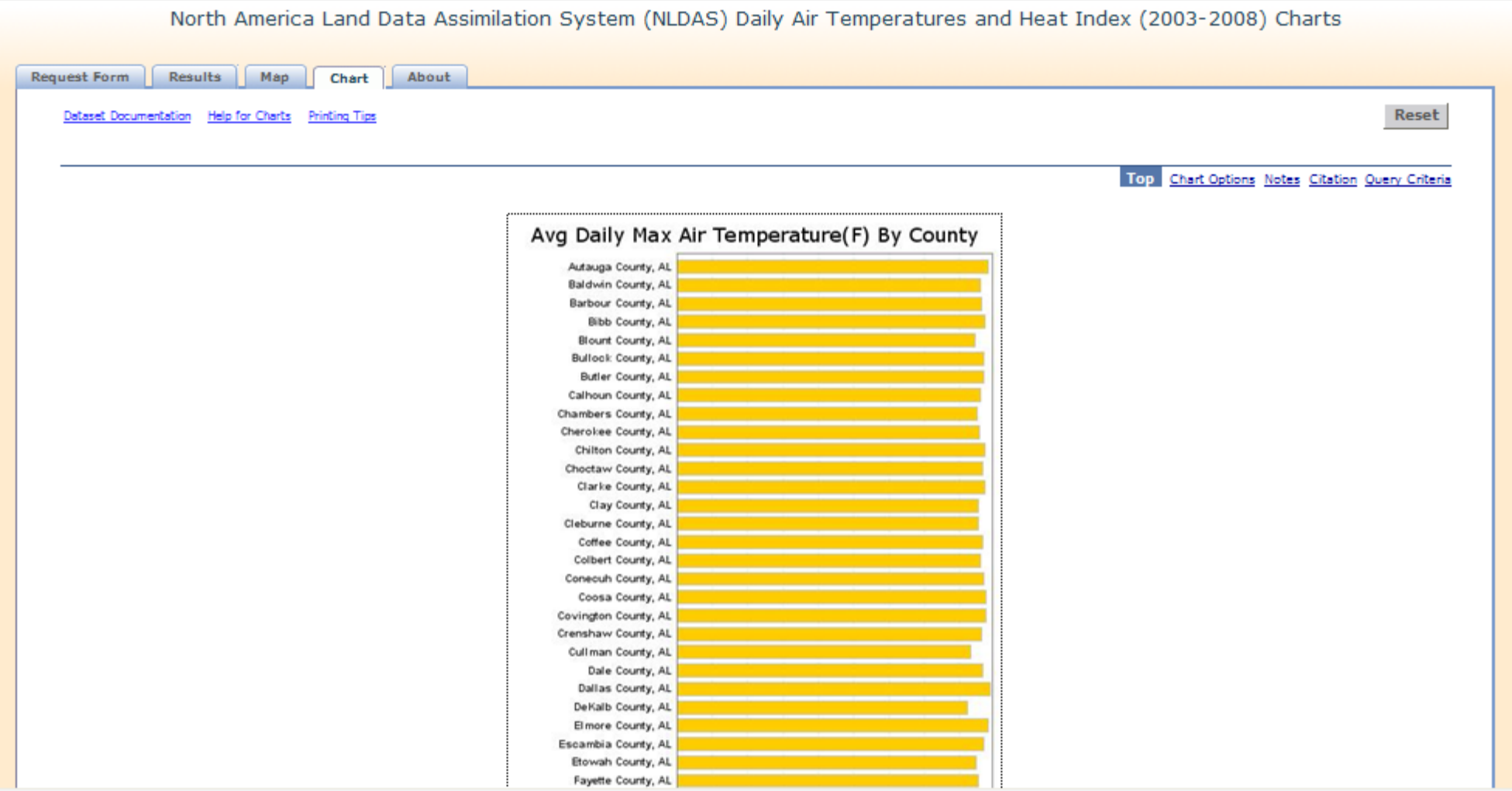
Top | Notes | Citation | Query Criteria

County	Avg Daily Max Air Temperature(F) # of Observations Range Standard Deviation
Autauga County, AL (01001)	87.85 11 (87.20 to 88.40) 0.43
Baldwin County, AL (01003)	85.82 26 (84.30 to 87.20) 0.61
Barbour County, AL (01005)	86.04 14 (85.50 to 86.60) 0.37
Bibb County, AL (01007)	86.92 9 (86.40 to 87.50) 0.31
Blount County, AL (01009)	84.20 10 (83.60 to 84.90) 0.43
Bullock County, AL (01011)	86.57 10 (86.10 to 87.30) 0.44

CDC WONDER Map Results



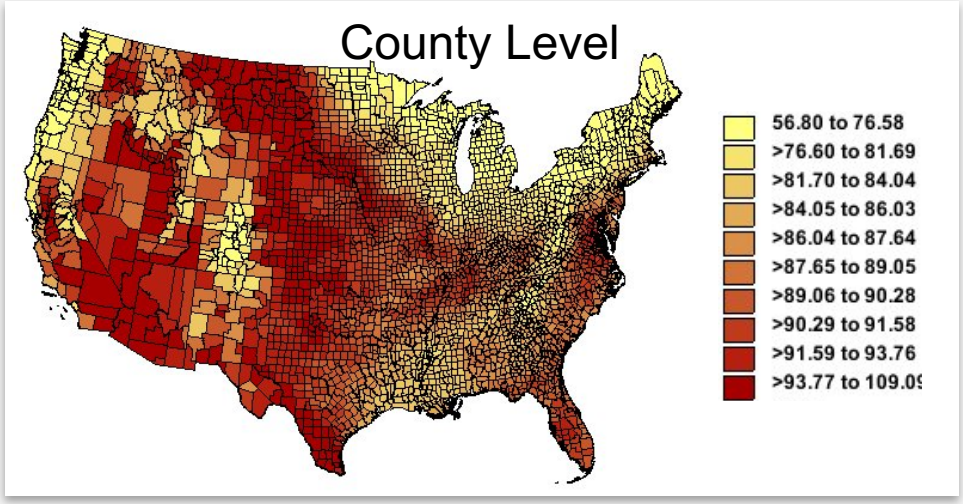
CDC WONDER Chart Results

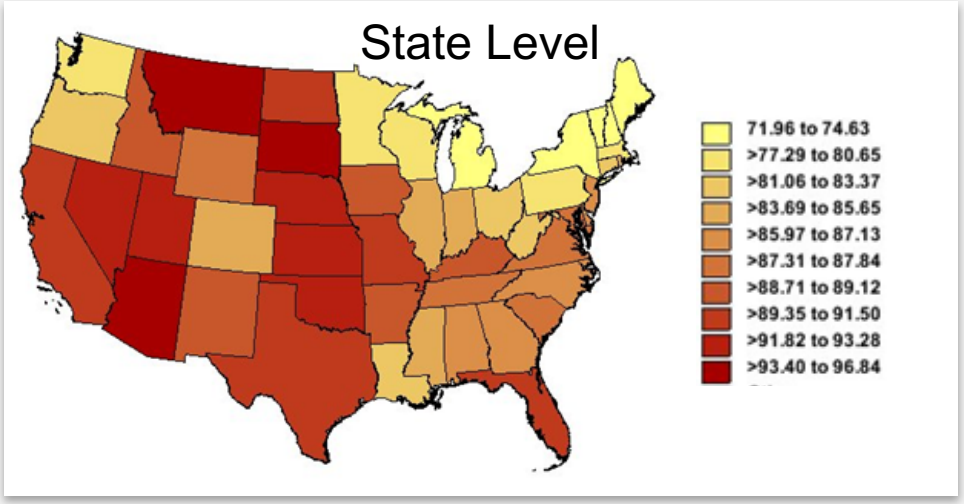


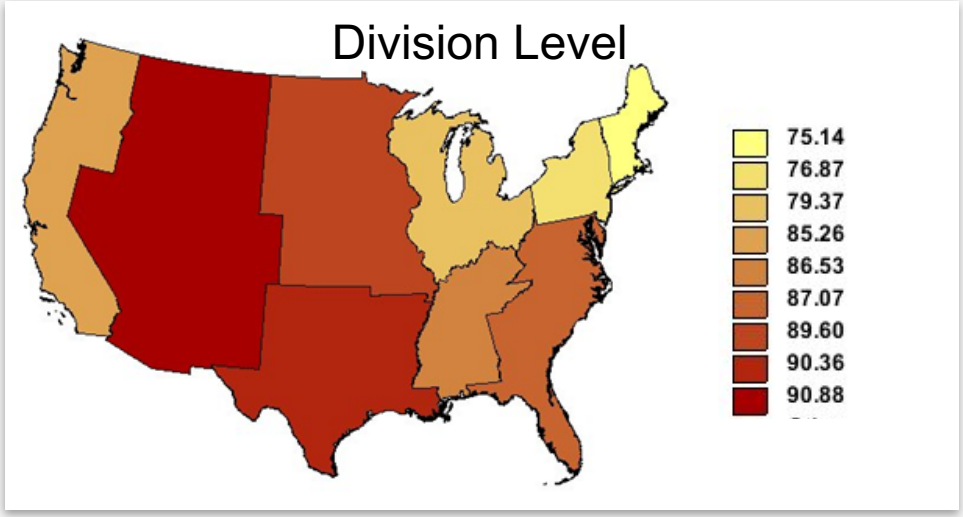
CDC WONDER Spatial Aggregation

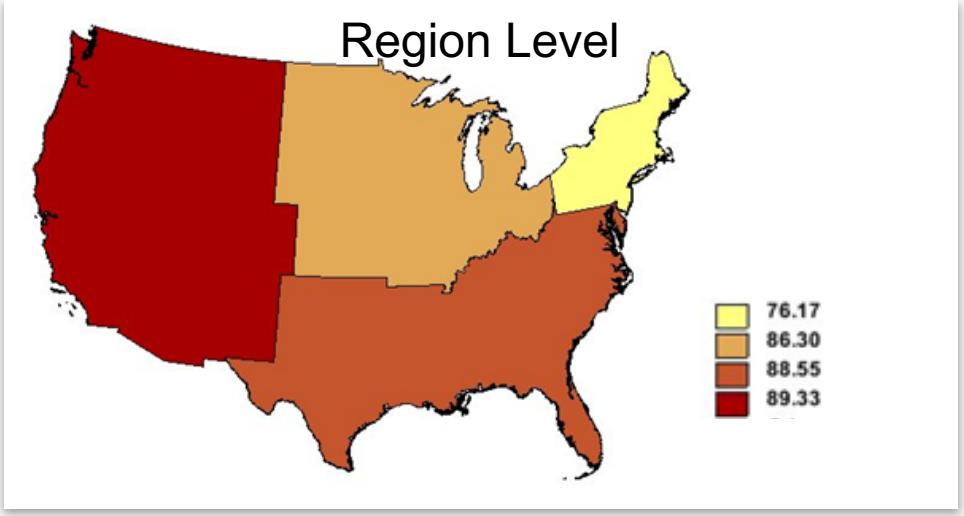
Average Daily Max Temperature (°F) for the United States

July 15, 2007





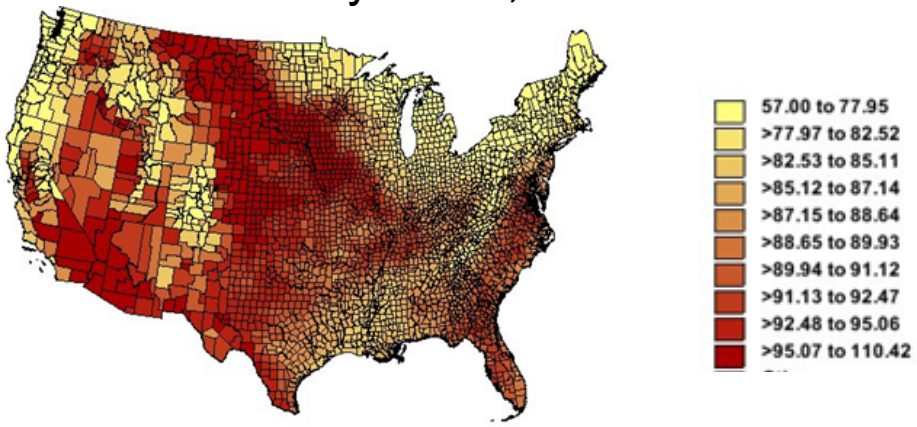


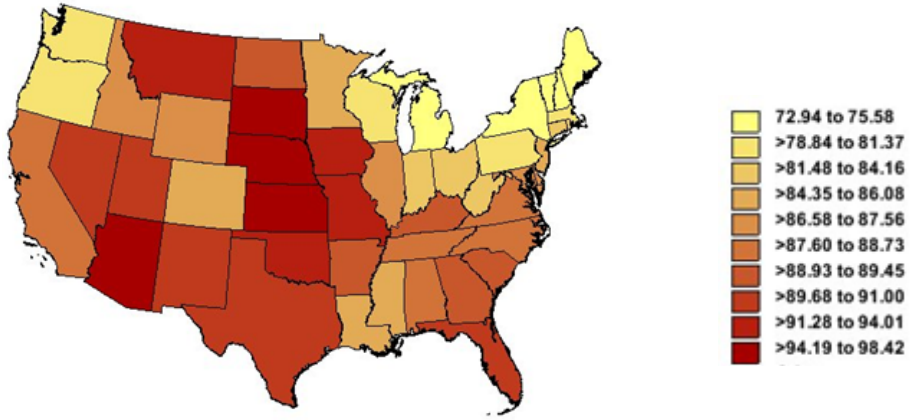


CDC WONDER Spatial/Temporal Aggregation

Average Daily Max Temperature (F) for the United States

July 15-17, 2017





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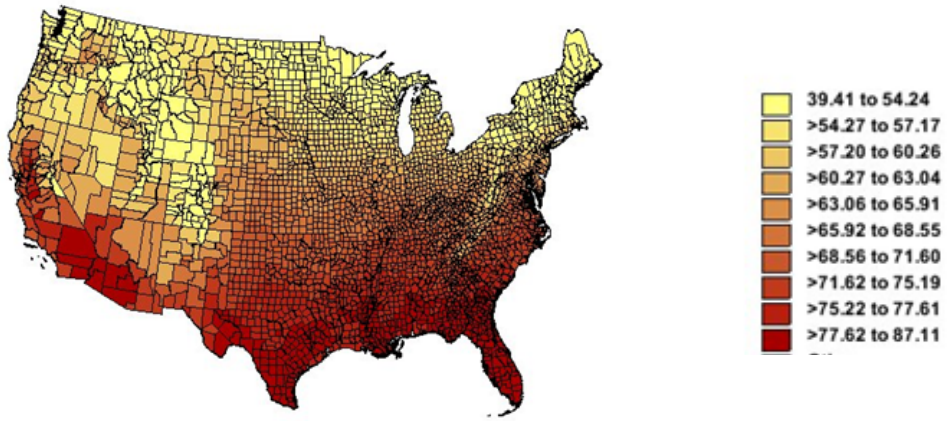
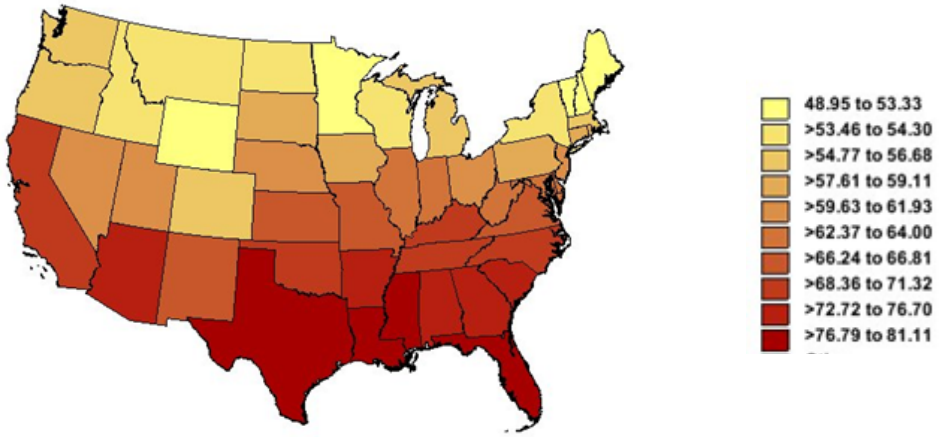
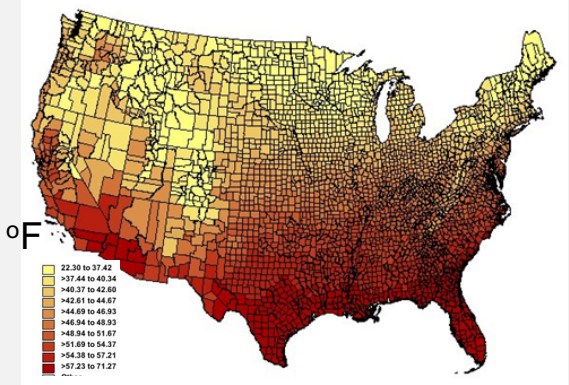




CDC WONDER Environmental Datasets Status

Avg Daily Min Air Temp



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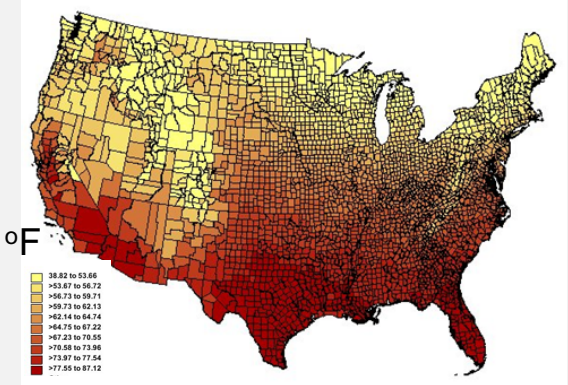

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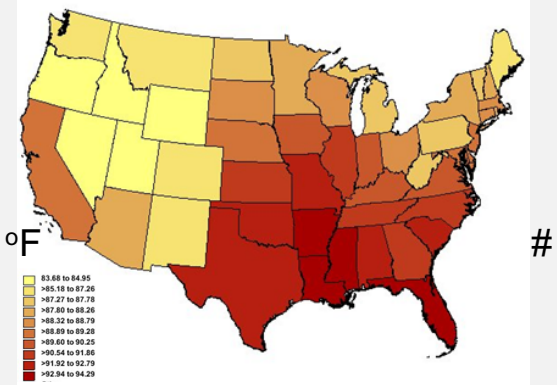
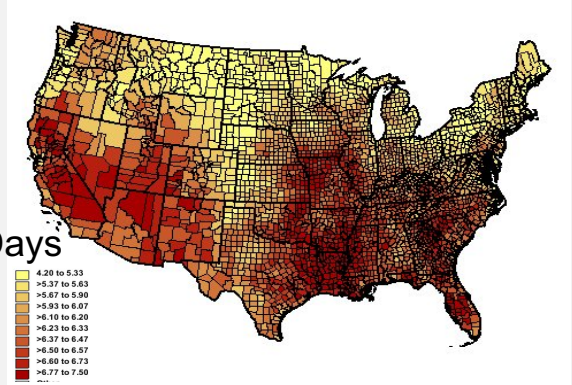


Avg Heat Wave Days Based on Daily Max. Temp.



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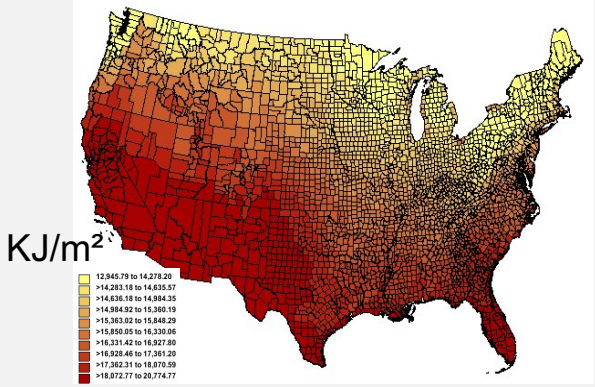
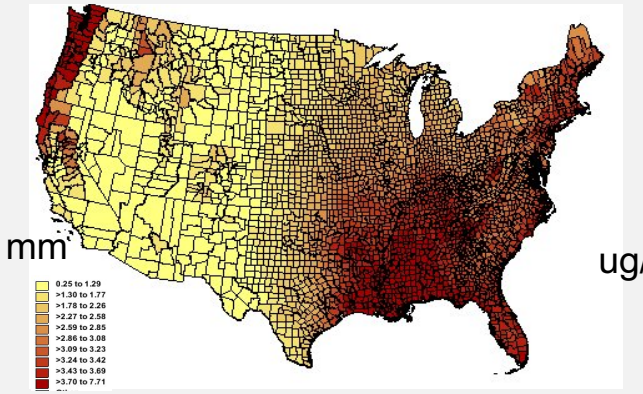


Avg Daily Precipitation



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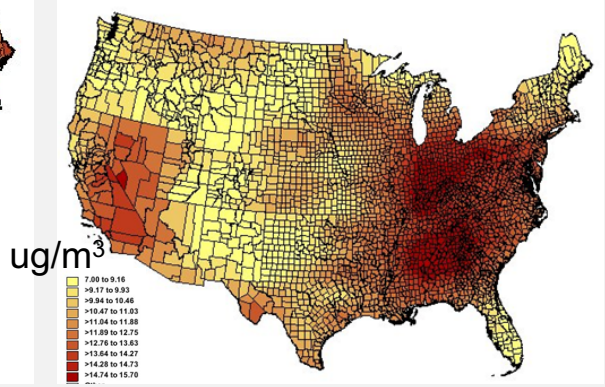
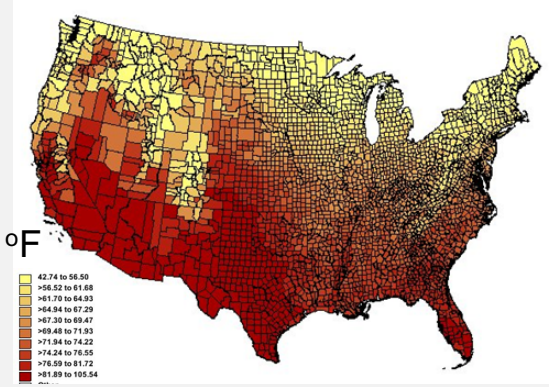
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