Local Climate Analysis Tool (LCAT)

Marina Timofeyeva and Fiona Horsfall

National Weather Service
Climate Services Division

September 2012

What is the
Local Climate Analysis Tool (LCAT)?

- **Developed originally to support NWS field offices**
- **Online interactive tool**
- **For regional and local climate studies**
- **State-of-the-art station**
- **Best practices for climate analysis**
- **Variables beyond average temp and precip**

NWS Field Office Need for LCAT

- **Easy access to standardized, scientifically sound methodologies for local climate analysis to meet growing needs of users**
  - **Manipulate and interpret local climate data**
  - **Make weather-climate linkages for better forecasts**
  - **Characterize climate impacts on water and weather elements**

How does LCAT work?

LCAT uses principles of Artificial Intelligence in connecting human and computer perceptions on application of data and scientific techniques in multiprocessing simultaneous users' tasks
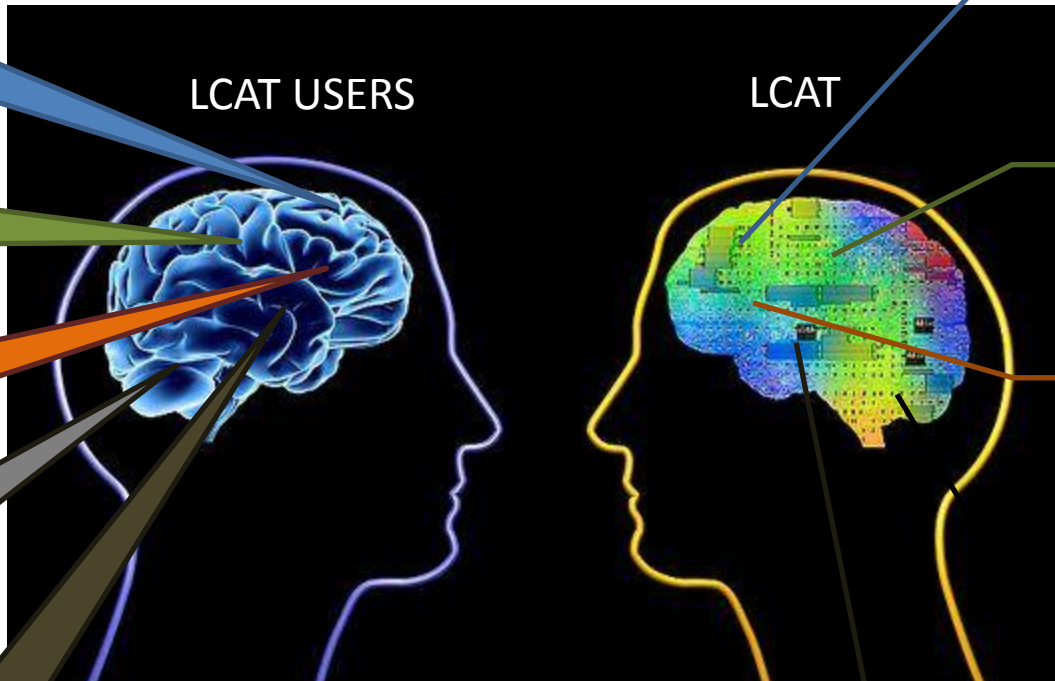
LCAT USERS

LCAT

How is the temperature in my town changing?

Should we expect floods during La Nina events?

How severe is the drought in my region this year?

Which climate model performs best in my region?

What are the projections for climate in my region?

Data: Homogenized station maximum temperature
Analysis: best practices for trend; rate of change
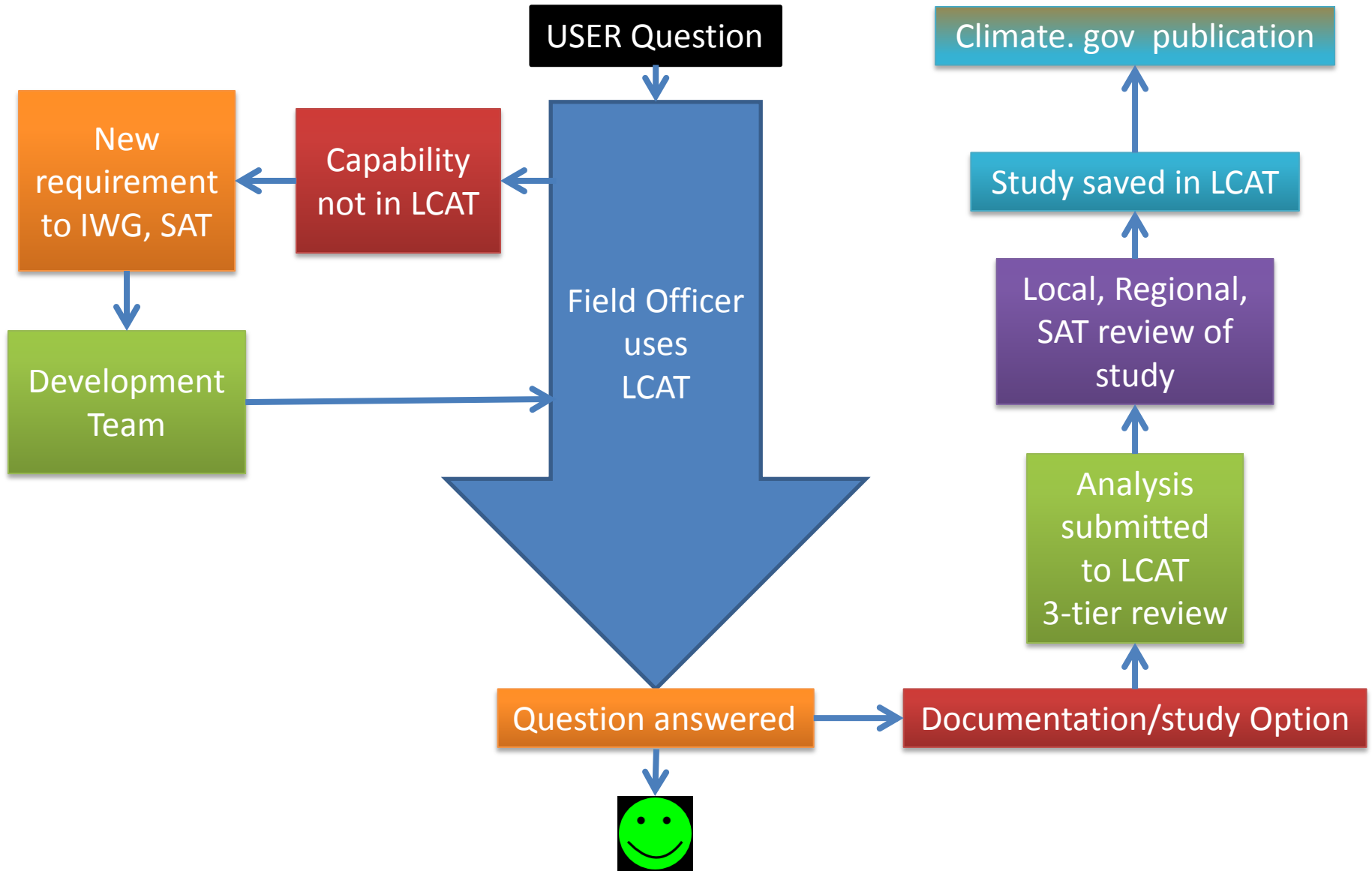**Output**: statistics, plots, metadata

Data: Homogenized precipitation and river flow
Analysis: composites, risk assessment
Output: statistics, plots, metadata

Data: Drought indices
Analysis: time series analysis
Output: statistics, plots, metadata

Data: Reanalysis and GCM fields
Analysis: downscaling, sensitivity tests
Output: statistics, plots, metadata

Data: GCM outputs
Analysis: downscaling
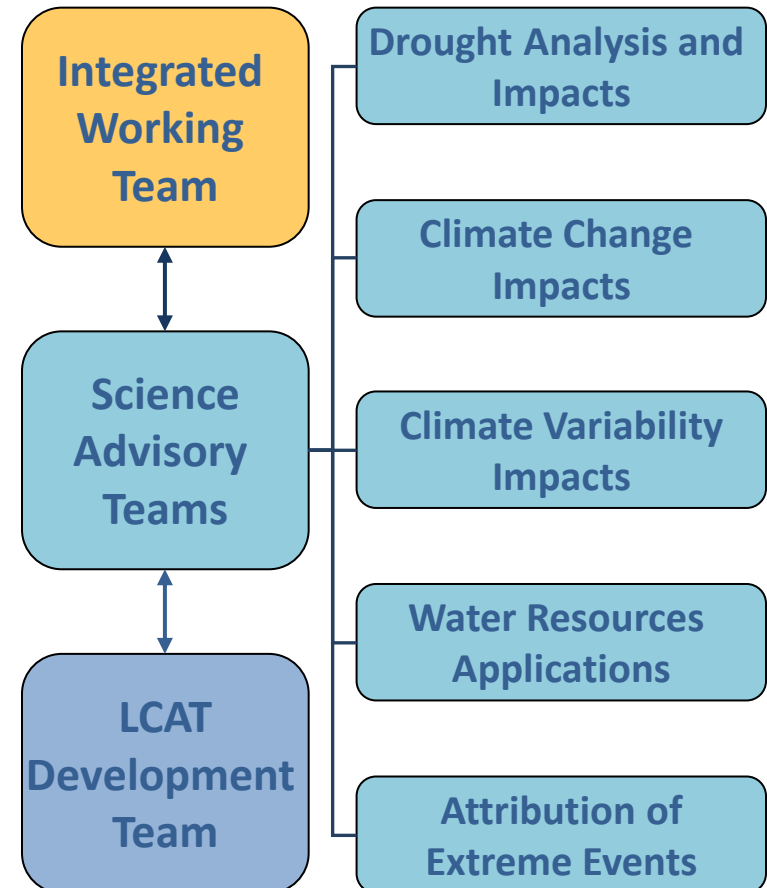**Output**: statistics, plots, metadata

LCAT Process

USER Question

Field Officer uses LCAT

Capability not in LCAT

New requirement to IWG, SAT

Development Team

Question answered

Documentation/study Option

Analysis submitted to LCAT 3-tier review

Local, Regional, SAT review of study

Study saved in LCAT

Climate. gov publication

What is the
Local Climate Analysis Tool (LCAT)?

The LCAT Process

➤ **The Integrated Working Team (IWT) identifies and communicates field requirements and assists in training development – NWS staff**

➤ **The Science Advisory Teams (SATs) are composed of subject matter experts that recommend and approve scientifically sound methodologies – subject-matter experts**

➤ **The LCAT Development Team (DT) organizes activities for the SATs and IWT, delivers training, and produces the tool – CSD, OST, and contractors**

Integrated Working Team

Science Advisory Teams

LCAT Development Team

Drought Analysis and Impacts

Climate Change Impacts

Climate Variability Impacts

Water Resources Applications

Attribution of Extreme Events

Five Science Advisory Teams

- **Science Advisory Teams are comprised of subject matter experts to research, review, and recommend ready-to-use methods, best practices, and tools for use in LCAT**

Drought Analysis and Impacts	Climate Change Impacts	Climate Variability Impacts	Water Resources Applications	Attribution of Extreme Events
• Team members: NCDC, CPC and NDMC, WRCC	• Team members: NCDC and CPC	• Team members: CPC and ESRL	• Team members: CBRFC, WWA RISA	• Team members: ESRL, CPC, and NCDC
• Identify best practices and tools for drought analysis	• Identify best methods for trend fitting and analysis of climate change	• Remain consistent and transparent with CPC methods for climate variability	• Best practices for applications and climate studies for water resources	• Best practices and tools to identify and communicate climate signal in extreme meteorological and hydrological events
• Types of tools: Drought portal drought atlas, drought impact reporter, etc	• Type of Analysis: OCN, EWMA, Hinge-fitting	• Types of Analysis: Box and whisker plots	• Types of Tools: Water Resource Outlook tools: stream-flow variability, ensembles, etc	• New science; tool will be developed as methods become available

LCAT allows users to define their analysis by selecting

- **Data (climate division or station)**
- **Time period of interest**
- **Climate variable**
- **Method(s) of analysis**
- **Output format**

Climate reports can be saved to contribute to attribution or other studies

LCAT current location:
https://apps.weather.gov/lcat/
 dev/index.php?lcatArea=lcat

Enabled Studies

Climate Change Impacts

Trend Performance

*Root Mean Square Error*

Hinge with anchor at 1975:	1.74
Exponentially Weighted Moving Average (Alpha=10):	1.39
CPC Optimal Climate Normal (10-Year Moving Average):	1.71

Ensemble Performance

Ensemble Standard Deviation 0.40

Rate of Change

Annual Rate of Change	0.047 Degrees F per year
Decadal Rate of Change	0.47 Degrees F per decade
Climatological Rate of Change	1.41 Degrees F per 30-year period

Time Series Analysis
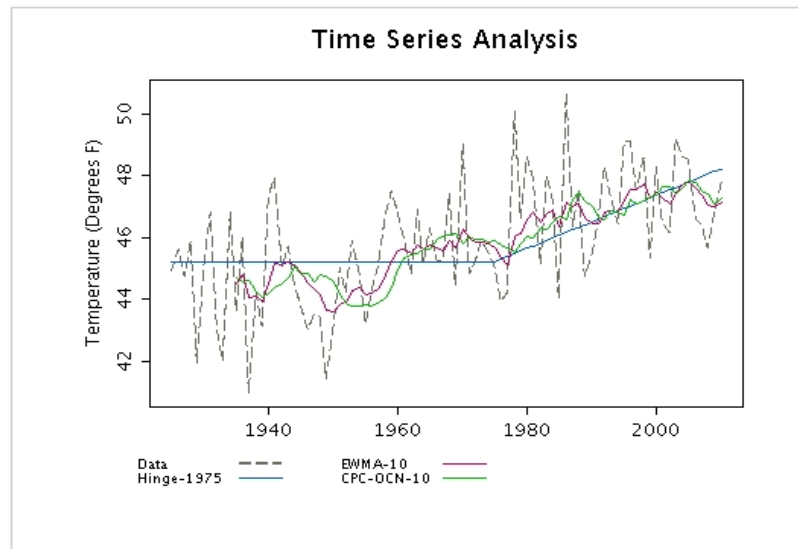
Trend Type			
Hinge	EWMA	OCN	Ensemble
• Best fit line (Slope = 0) 1950 – 1976 • Best fit line 1976 - 2010	Exponentially Weighted Moving Average	Optimal Climate Normal	Average of all trend values

Selection of Best Practices

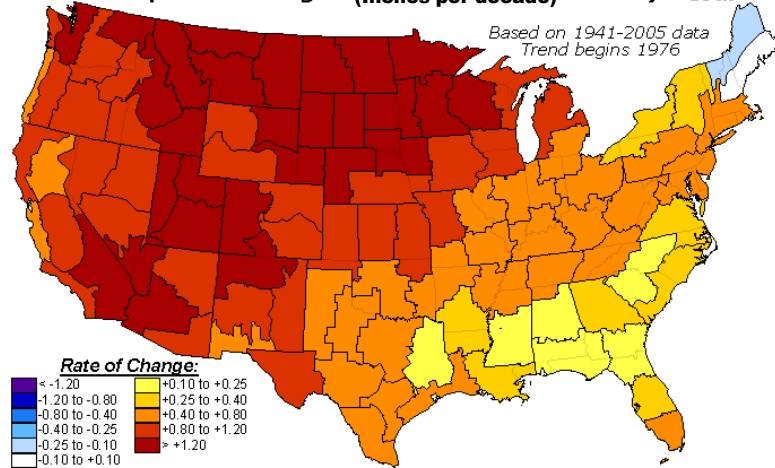*Case study -- Local Rate of Climate Change*

- **SAT (trend) considered available practices for time series analysis and recommended <u>three trend-fitting techniques</u>**

- **Ensemble mean and variance provide additional information about the <u>uncertainty inherent in the data and methods utilized in the analysis</u>**

- **Development is ongoing and will be in coordination with internal NOAA offices (CPC, ESRL, NCDC) and external partners (state climatologists, RCCs, etc)**

- **<u>Climate Study Reports </u>are generated by LCAT, and include all graphs and tables of the data analysis, along with the variables selected by the user**
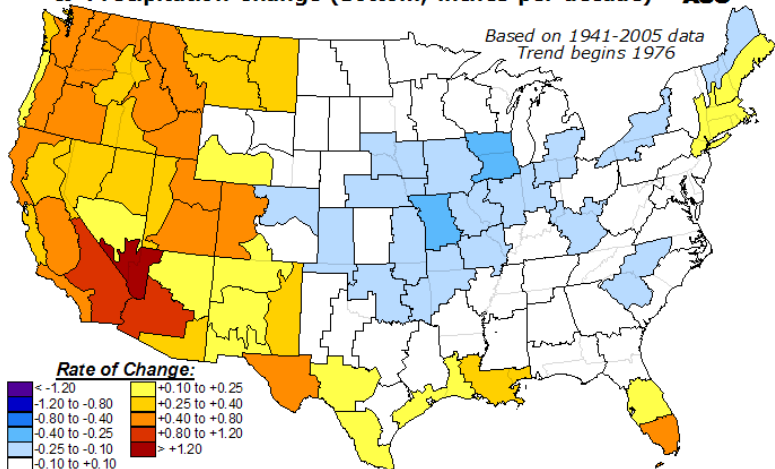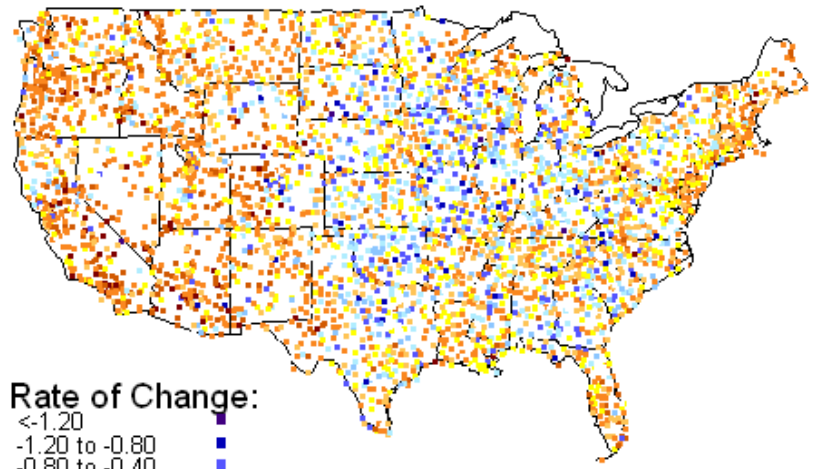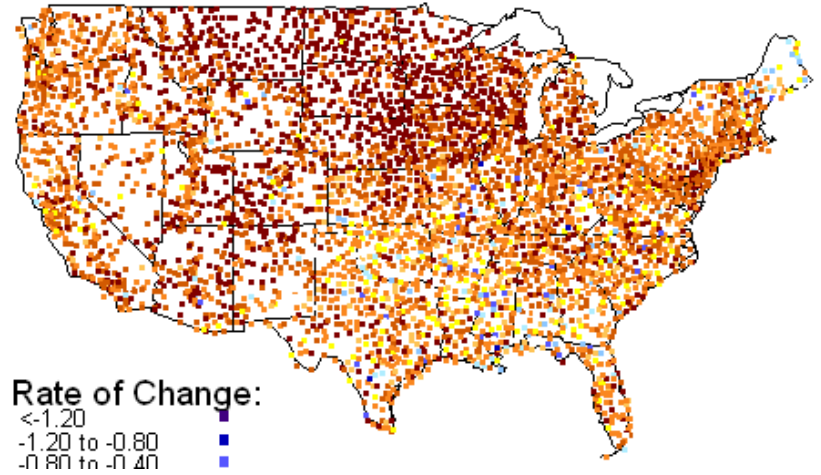
Testing LCAT Best Practices

Climate Division

Rate of Long-Term Trend Temperature Change (top: °F per decade) & Precipitation Change (Inches per decade) — e) — JFM

Based on 1941-2005 data
Trend begins 1976

Rate of Change:
< -1.20
-1.20 to -0.80
-0.80 to -0.40
-0.40 to -0.25
-0.25 to -0.10
-0.10 to +0.10
+0.10 to +0.25
+0.25 to +0.40
+0.40 to +0.80
+0.80 to +1.20
> +1.20

Rate of Long-Term Trend Temperature Change (top; °F per decade) & Precipitation Change (bottom; inches per decade) — ASO

Based on 1941-2005 data
Trend begins 1976

Rate of Change:
< -1.20
-1.20 to -0.80
-0.80 to -0.40
-0.40 to -0.25
-0.25 to -0.10
-0.10 to +0.10
+0.10 to +0.25
+0.25 to +0.40
+0.40 to +0.80
+0.80 to +1.20
> +1.20

Stations

Rate of Change:
<-1.20
-1.20 to -0.80
-0.80 to -0.40

Rate of Change:
<-1.20
-1.20 to -0.80
-0.80 to -0.40

http://www.cpc.noaa.gov/trndtext.shtml

Enabled Studies
Climate Variability Impacts

- Identifies is there is a relation between local climate element and climate variability event

- Use an analysis of conditional probability or frequencies of occurrence of at least two events together, commonly called composites

- Compositing is an alternative method to linear regression commonly used for comparison of two time series, but does not require any underlining distribution assumption of dependent and independent variables

Data Statistics

Mean:	45.90 Degrees F
Median:	45.7 Degrees F
Mode:	43.6 Degrees F
Standard Deviation:	1.654
Climatological Mean:	46.02 Degrees F
Tercile Low:	44.75 Degrees F
Tercile High:	47.2 Degrees F
Below Events:	21
Neutral Events:	22
Above Events:	18
Total Events:	61

Anomaly

Lower Category Anomaly:	-0.55 Degrees_F
Middle Category Anomaly:	-0.05 Degrees_F
Upper Category Anomaly:	0.29 Degrees_F

Trend Performance

No trends selected by user.

Composite Analysis

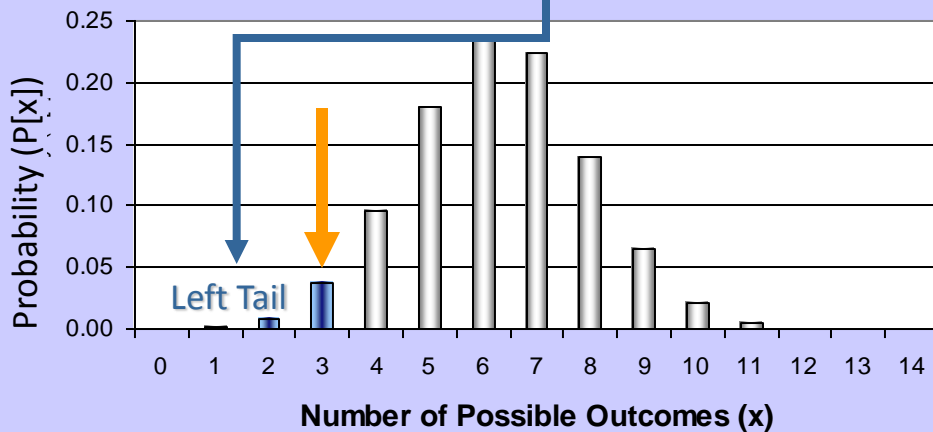Boxplot Analysis
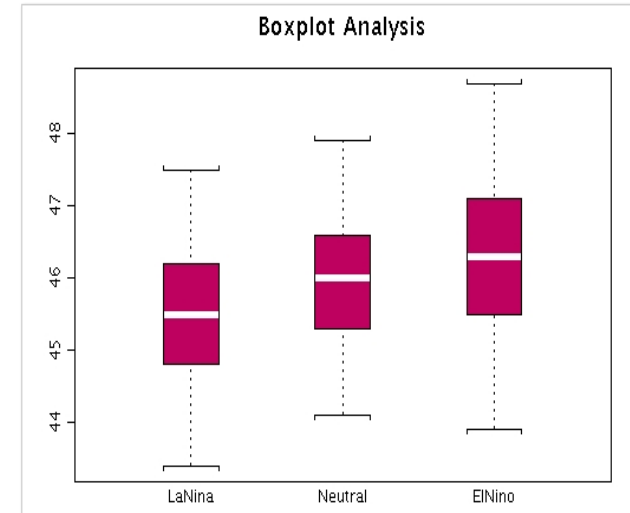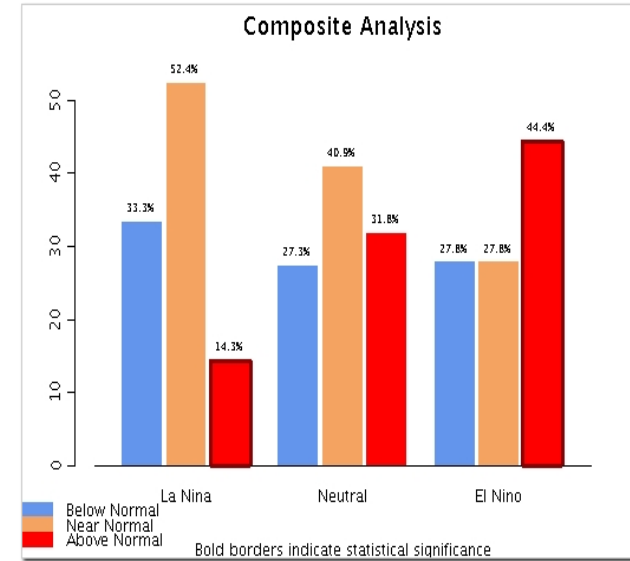
Testing CV Impact Significance

Test of composites statistical significance uses Hyper-Geometric Distribution for possible outcomes of climate variable category (B/A) observed within La Nina or El Nina sample

Helps to identify if there is a relationship between ENSO events and the category (Alternative Hypothesis)
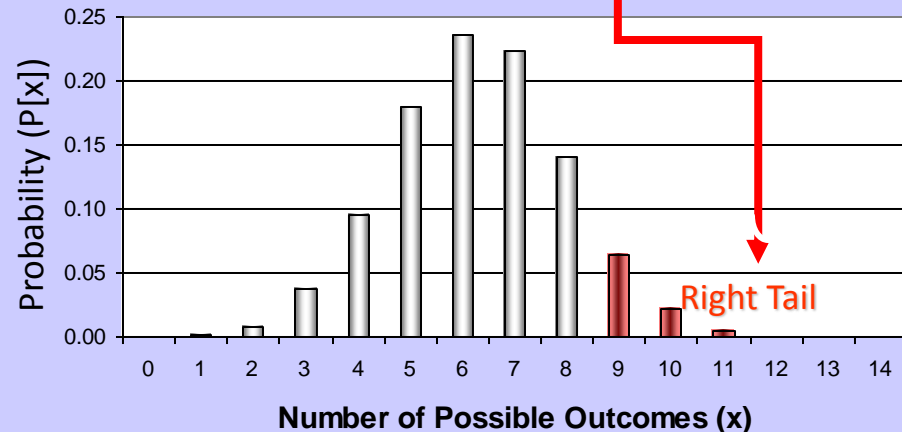
The one-tail test conducted at 90% confidence level for both tails

	Outcome of Above	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LaNina	P(x)	0.000	0.001	0.008	0.034	0.095	0.180	0.235	0.224	0.140	0.065	0.018	0.000	0.000	0.000	0.000
	Sum(P[x])	0.000	0.001	0.008	0.042	0.138	0.318	0.553	0.777	0.917	0.982	1.000	1.000	1.000	1.000	1.000
	1-Sum(P[x-1])	1.000	1.000	0.999	0.992	0.958	0.863	0.682	0.447	0.223	0.083	0.018	0.000	0.000	0.000	0.000

Probability of Number of Possible Outcomes for Above Normal Temperature during La Nina

Left Tail

Probability (P[x])

Number of Possible Outcomes (x)

Probability of Number of Possible Outcomes for Above Normal Temperature during La Nina

Right Tail

Probability (P[x])

Number of Possible Outcomes (x)

Water Resources Applications

LCAT will include links to relevant external climate analysis tools such as the National Water Resource Outlook webpage

Drought Analysis and Impacts

LCAT will include links to relevant external climate analysis tools such as the Drought Atlas (coming soon)

Currently Under Development

By September 2012

- **Trend communication between Climate Change & Climate Variability sections**
- **Additional output statistics displayed**
- **Enhancements to help buttons and references**
- **Personalized report labeling for easier reference**
- **Reference maps for Climate Divisions, County Warning Areas, and station locations**
- **Additional output formats available (comma-, space- or tab- delimited, XML, PDF and Excel)**
- **Analog signal years displayed (e.g., years that were La Niña or El Niño)**
- **Additional data sets:**
  - **Alaska and Hawaii stations**
  - **NCDC Climate Division Data**
  - **NOS Sea Level Stations**

LCAT FY13 plans

- **Tuning ONI index capability**
- **Addition of Climate Variability Indices (NAO/AO, SOI, MEI)**
- **Functional link between xmACIS data and LCAT**
- **Additional statistical analysis options (e.g., Multiple linear regression, logistic regression, PCA, etc.)**
- **User defined variable seasons (e.g. 2- , 4-month or 6-month periods)**
- **Increase of spatial options (e.g. county or state wide)**
- **Additional options for definition of climate variable (e.g., critical value)**
- **Multiple signal option combinations (e.g., Negative ONI with Positive AO)**
- **Drought studies (incorporation of drought data)**
- **Trouble Ticketing system implemented**
- **Functionality improvements**
- **Publication process available**
- **Additional data sets:**
  - **Pacific Island Data sets**
  - **Reanalysis data**
  - **Unique data sets**

LCAT Future

- **Incorporation of additional data sets (severe weather, snowfall, number of days with extremes, extreme time series, etc.) will enhance IDSS capabilities by providing integrated environmental services**
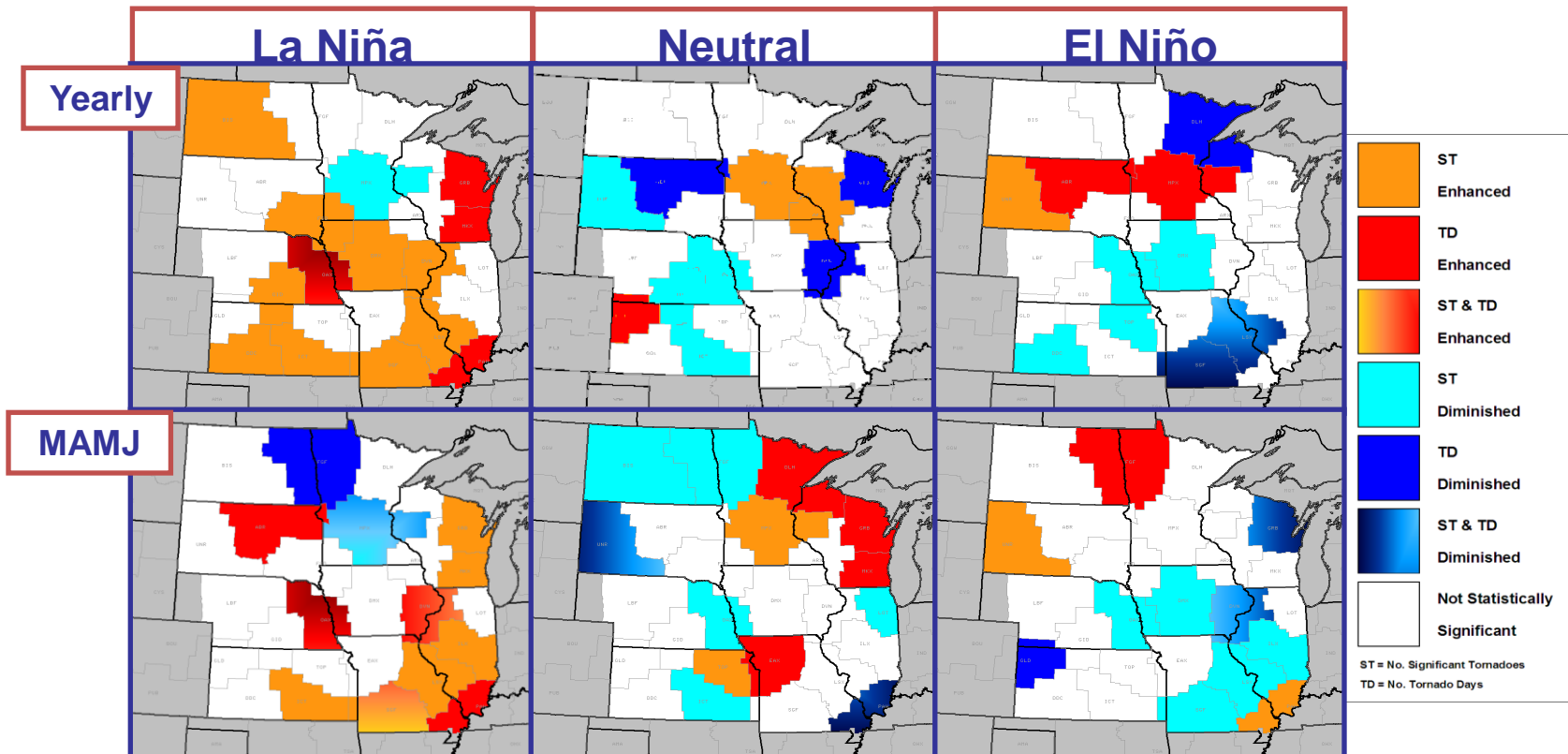
LCAT Future

- **To answer request to NWS from FEMA/WH**
  - **Capability to query database for historical information, trends and relationships to ENSO signals for high impact weather events for local, regional, and national geographical scales**
    - **Tornadoes, large hail, high winds (convective and non-convective), winter storms, blizzards, tropical storms and hurricanes, flooding, dust storms**
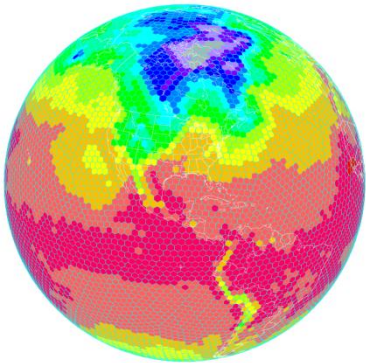 - **For use prior to and during high impact events**

LCAT Future

Coastal Zone-Based Coastal Counties

- **Water level (tides, etc.) and climate signals for coastal regions**
    - *What are water level extremes during El Niño or La Niña events?*
    - *Are there seasonal extremes?*
    - *Does the AO affect water levels on the NE coast?*

- **Relative humidity, upper air, storminess, lightning, tornadoes, hurricanes, snow, radiation**
    - *What is the trend in snowfall in the Pacific NW?*
    - *What is the average speed of the midlatitude jet over Kansas during ENSO neutral years?*
    - *What is the probability of a greater than average number of hurricanes during a La Niña year?*

Adapted from the University of Illinois WW2010 Project
http://ww2010.atmos.uiuc.edu

From NOAA
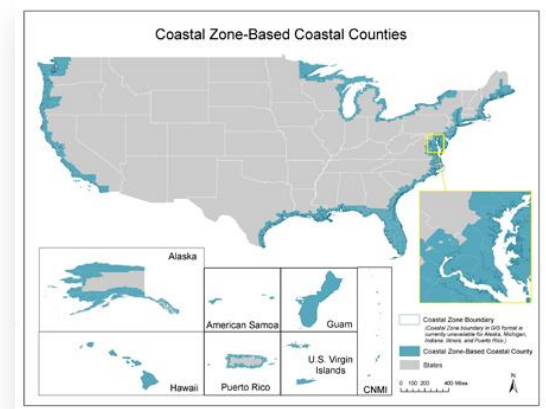
Gridded Data

- **Reanalysis data – CFSR**
  - **Grid point data**
 - **Averaging over a region**
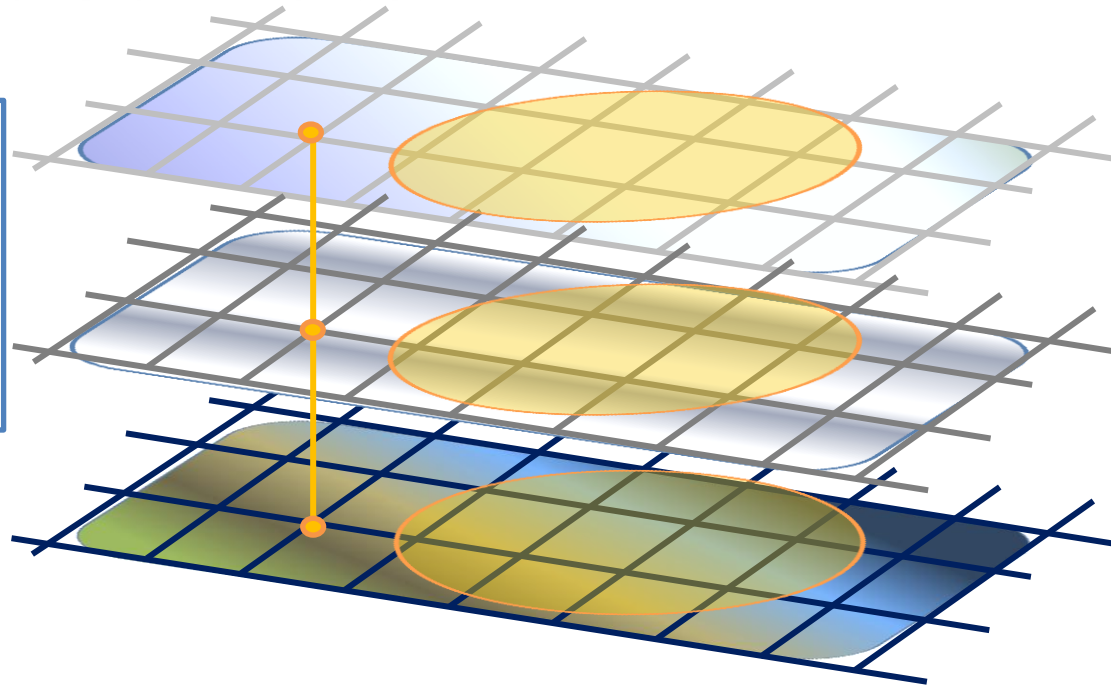
- **Model data at grid points and regions**
  - **CFSv2, FIM**
  - **7 models of the NMME – individual model output and ensemble average**
  - **CMIP / IPCC models – AR5**

LCAT Future

- **Data and analyses for energy industry support**
  - **What has been the maximum wind speed over the past 30 years?**
  - **What is the projection for the next 20-50 years?**
  - **What is the average daily cloud cover in a region during an El Niño winter?**
  - **What is the average radiation in the North East when the AO is in the negative phase?**
- **Validation/evaluation of climate model output/performance by region**
- **Analysis of regional trends in climate models**
- **Spatial correlations to climate phenomena**
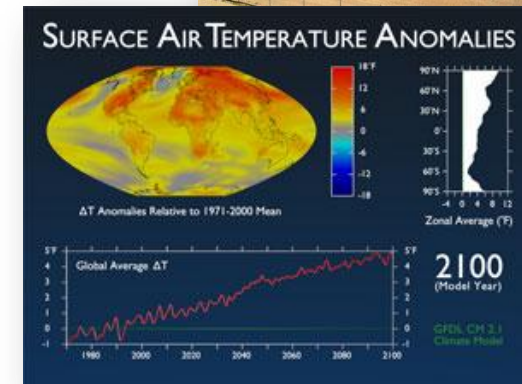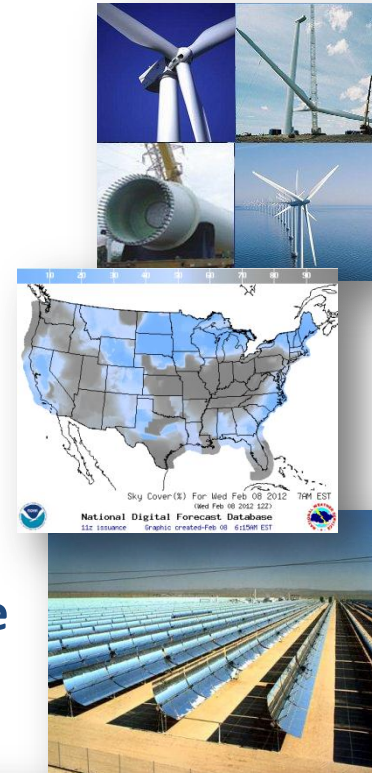
Other Potential Parameters

- **CO$_2$ emissions/trends**

- **Satellite data**

- **Biological/physical ocean data**

- **Ecological data for deriving relationships to climate signals (coastal, soil, demographics, vegetation)**

- ***NOAA Habitat Blueprint**: A framework to improve habitat for fisheries, marine life, and coastal communities*
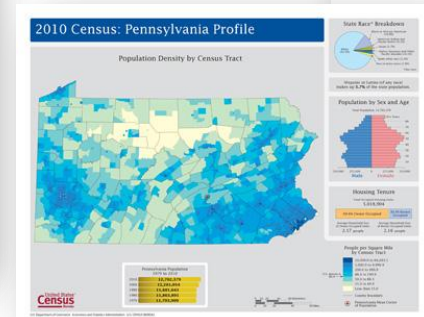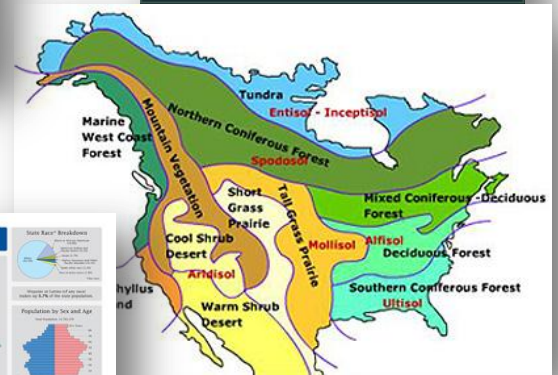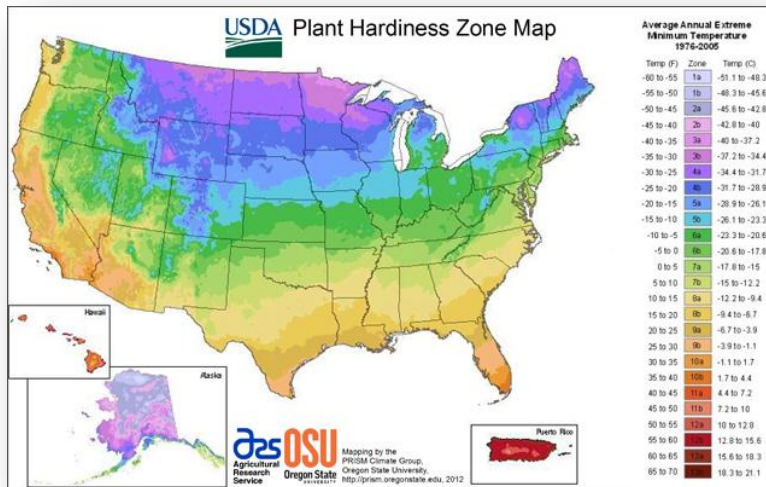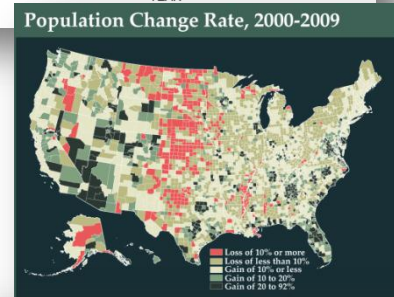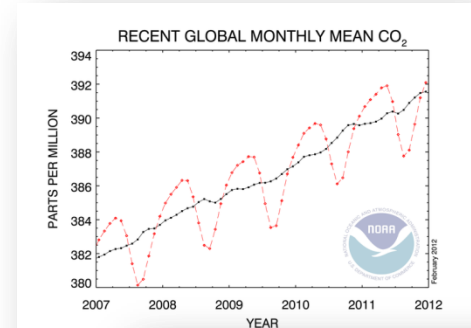
Other Potential Applications

- ## NOAA-CDC Partnership

  – **No-cost means for sharing local climate data with health researchers and decision makers to aid in characterizing climate variability and change impacts on health in local communities**

    - **What is the climatology of a region as it pertains to proliferation of a vector to spread Dengue Fever?**

    - **If the past winter was warmer than average, what is the probability of a spring drought that will provide a ripe environment for the mosquito carrying the West Nile virus?**

    - **Provide temperature, humidity, and air quality analyses to CDC for deriving relationship between climate and incidence of COPD (Chronic Obstructive Pulmonary Disease)**
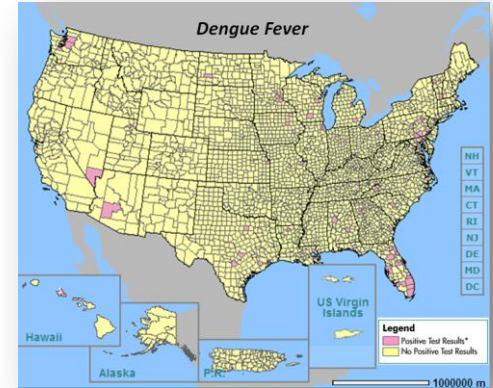
Dengue Fever
Vector + high temperatures, humidity, and low wind speed
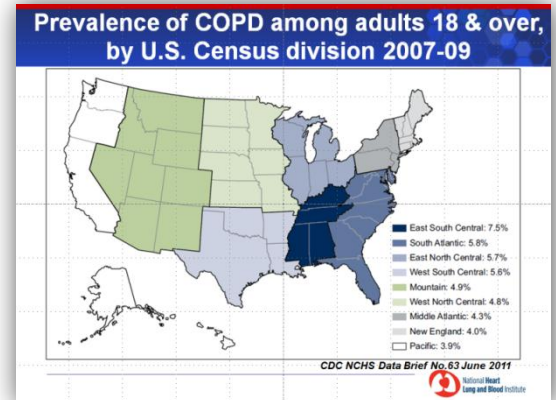
Other Potential Partnerships

- DOE
- NCDC
- USGCRP
- NOS
- Space Weather Program
- Marine Weather
- Marine Habitats
- Fire Weather Program
- NWS Corporate Board
- Tsunami
- NOAA Climate Test Bed

Summary of LCAT Strategic Steps

Purpose	Function	Needed Data	Methods
Support for Weather-Ready Nation - Climate Linkages	Analysis of extreme meteorological and hydrological events	NCDC: Hail, lightening, tornado, height of storm cells, severe storm damages (1995/1950 – present) NCDC: CFS reanalysis and forecast data (local globe-wide) WRCC: extension to ACIS extreme data series	Trends, composites, regressions (linear, logistics)
Improving meteorological services	Validation of past meteorological forecasts	NCDC: NWS severe weather warning data base	Validation techniques: skill scores, sample comparison tests, correlation
Supporting Climate Goals	Drought Studies	NCDC: extension to Drought – ACIS and drought indices	Sample selection/ statistical comparisons.
DOE user needs	Regional/local model analysis, validations	NCDC: CFS reanalysis and forecast data (local globe-wide), NMME model data sources	Earth System Grid Federation Protocols, Open sources coding capabilities, Model validation methods
CDC user needs	Regional/local analysis of climate related health problems	Health data (TBD)	Correlations
Marine and Fisheries	Regional/local data	Marine/fisheries/habitat data	TBD

LCAT Operational Deployment Plan

Activity/Milestone	Scope summary	Responsible	Date
1. LCAT upgrade in response to beta-test	Navigation, data, methods, help support,	OCWWS/CSD & contractors	09/30/12
2. Define final scope of LCAT operational deployment – phase I	Proposal, coordination, description of LCAT – phase I, solution on LCAT external/internal only utility	IWT, CSD, OST, CSPMs	10/15/12
3. Transition of LCAT from Apps server to NIDS host	Request, approval, upload of software, technical work, tests	CSD, CSD contractors, MDL, NIDS	11/30/12
4. Operational LCAT test completed	Benchmarking LCAT results, quality control, SATs approval	OCWWS/CSD & contractors, IWT, SATs	12/31/12
5. Documentation of LCAT operational routines	Document of Computational routines, Document of Web Architecture, O&M guidance,	OCWWS/CSD & contractors, SATs	01/15/13
6. Developing LCAT training	Modules: Use of data, Time Series Analysis, Trends in Climate, Methods for Climate Variability Impacts	CSD	01/31/13
7. OSIP Gate 4	Documentation, O&M staff support, ownership solution, etc.	CSD, CSD contractors, MDL, IWT	02/15/13
8. Operational Deployment	Announcement to the fields, outreach support (fact sheets, talking points, etc.)	CSD, MDL, Regional CSPMs	03/01/13