Local Climate Analysis Tool (LCAT)

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National Weather Service
Climate Services Division

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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.

- **How is the temperature in my town changing?**
  - **Data:** Homogenized station maximum temperature
  - **Analysis:** best practices for trend; rate of change
  - **Output:** statistics, plots, metadata

- **Should we expect floods during La Niña events?**
  - **Data:** Homogenized precipitation and river flow
  - **Analysis:** composites, risk assessment
  - **Output:** statistics, plots, metadata

- **How severe is the drought in my region this year?**
  - **Data:** Drought indices
  - **Analysis:** time series analysis
  - **Output:** statistics, plots, metadata

- **Which climate model performs best in my region?**
  - **Data:** Reanalysis and GCM fields
  - **Analysis:** downscaling, sensitivity tests
  - **Output:** statistics, plots, metadata

- **What are the projections for climate in my region?**
  - **Data:** GCM outputs
  - **Analysis:** downscaling
  - **Output:** statistics, plots, metadata
LCAT Process

- USER Question
- Field Officer uses LCAT
- Climate.gov publication
- Study saved in LCAT
- Local, Regional, SAT review of study
- Analysis submitted to LCAT 3-tier review
- Documentation/study Option

New requirement to IWG, SAT
Capability not in LCAT
Development Team
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
# 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.

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

## Climate Change Impacts
- **Team members:** NCDC and CPC
- Identify best methods for trend fitting and analysis of climate change
- Type of Analysis: OCN, EWMA, Hinge-fitting

## Climate Variability Impacts
- **Team members:** CPC and ESRL
- Remain consistent and transparent with CPC methods for climate variability
- Types of Analysis: Box and whisker plots

## Water Resources Applications
- **Team members:** CBRFC, WWA RISA
- Best practices for applications and climate studies for water resources
- Types of Tools: Water Resource Outlook tools: stream-flow variability, ensembles, etc

## Attribution of Extreme Events
- **Team members:** ESRL, CPC, and NCDC
- Best practices and tools to identify and communicate climate signal in extreme meteorological and hydrological events
- 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

Selection of Best Practices

Case study -- Local Rate of Climate Change

- SAT (trend) considered available practices for time series analysis and recommended three trend-fitting techniques
- Ensemble mean and variance provide additional information about the uncertainty inherent in the data and methods utilized in the analysis
- Development is ongoing and will be in coordination with internal NOAA offices (CPC, ESRL, NCDC) and external partners (state climatologists, RCCs, etc)
- Climate Study Reports 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) — 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

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

Stations

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

http://www.cpc.noaa.gov/trndtext.shtml
Enabled Studies
Climate Variability Impacts

- Identifies if 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 underlying distribution assumption of dependent and independent variables
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.

<table>
<thead>
<tr>
<th>Outcome of Above</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>P(x)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.034</td>
<td>0.095</td>
<td>0.180</td>
<td>0.235</td>
<td>0.224</td>
<td>0.140</td>
<td>0.065</td>
<td>0.018</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Sum(P[x])</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.008</td>
<td>0.042</td>
<td>0.138</td>
<td>0.318</td>
<td>0.553</td>
<td>0.777</td>
<td>0.917</td>
<td>0.982</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>1-Sum(P[x-1])</td>
<td>1.00</td>
<td>1.00</td>
<td>0.992</td>
<td>0.982</td>
<td>0.958</td>
<td>0.863</td>
<td>0.682</td>
<td>0.447</td>
<td>0.223</td>
<td>0.083</td>
<td>0.018</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>
LCAT will include links to relevant external climate analysis tools such as the National Water Resource Outlook webpage.
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
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

- 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?
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

- CO₂ 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)
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

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Function</th>
<th>Needed Data</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support for Weather-Ready Nation -</td>
<td>Analysis of extreme meteorological and</td>
<td>NCDC: Hail, lightening, tornado, height of storm cells, severe storm damages</td>
<td>Trends, composites, regressions (linear,</td>
</tr>
<tr>
<td>Climate Linkages</td>
<td>hydrological events</td>
<td>(1995/1950 – present)</td>
<td>logistics)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCDC: CFS reanalysis and forecast data (local globe-wide)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>WRCC: extension to ACIS extreme data series</td>
<td></td>
</tr>
<tr>
<td>Improving meteorological services</td>
<td>Validation of past meteorological forecasts</td>
<td>NCDC: NWS severe weather warning data base</td>
<td>Validation techniques: skill scores, sample</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>comparison tests, correlation</td>
</tr>
<tr>
<td>DOE user needs</td>
<td>Regional/local model analysis, validations</td>
<td>NCDC: CFS reanalysis and forecast data (local globe-wide),</td>
<td>Earth System Grid Federation Protocols, Open</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NMME model data sources</td>
<td>sources coding capabilities, Model validation</td>
</tr>
<tr>
<td></td>
<td>Regional/local analysis of climate related</td>
<td></td>
<td>methods</td>
</tr>
<tr>
<td></td>
<td>health problems</td>
<td>Health data (TBD)</td>
<td>Correlations</td>
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<td>CDC user needs</td>
<td>Regional/local analysis of climate related</td>
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<tr>
<td></td>
<td>health problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine and Fisheries</td>
<td>Regional/local data</td>
<td>Marine/fisheries/habitat data</td>
<td>TBD</td>
</tr>
<tr>
<td>Activity/Milestone</td>
<td>Scope summary</td>
<td>Responsible</td>
<td>Date</td>
</tr>
<tr>
<td>--------------------</td>
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</tr>
<tr>
<td>1. LCAT upgrade in response to beta-test</td>
<td>Navigation, data, methods, help support,</td>
<td>OCWWS/CSD &amp; contractors</td>
<td>09/30/12</td>
</tr>
<tr>
<td>2. Define final scope of LCAT operational deployment – phase I</td>
<td>Proposal, coordination, description of LCAT – phase I, solution on LCAT external/internal only utility</td>
<td>IWT, CSD, OST, CSPMs</td>
<td>10/15/12</td>
</tr>
<tr>
<td>3. Transition of LCAT from Apps server to NIDS host</td>
<td>Request, approval, upload of software, technical work, tests</td>
<td>CSD, CSD contractors, MDL, NIDS</td>
<td>11/30/12</td>
</tr>
<tr>
<td>4. Operational LCAT test completed</td>
<td>Benchmarking LCAT results, quality control, SATs approval</td>
<td>OCWWS/CSD &amp; contractors, IWT, SATs</td>
<td>12/31/12</td>
</tr>
<tr>
<td>5. Documentation of LCAT operational routines</td>
<td>Document of Computational routines, Document of Web Architecture, O&amp;M guidance,</td>
<td>OCWWS/CSD &amp; contractors, SATs</td>
<td>01/15/13</td>
</tr>
<tr>
<td>6. Developing LCAT training</td>
<td>Modules: Use of data, Time Series Analysis, Trends in Climate, Methods for Climate Variability Impacts</td>
<td>CSD</td>
<td>01/31/13</td>
</tr>
<tr>
<td>7. OSIP Gate 4</td>
<td>Documentation, O&amp;M staff support, ownership solution, etc.</td>
<td>CSD, CSD contractors, MDL, IWT</td>
<td>02/15/13</td>
</tr>
<tr>
<td>8. Operational Deployment</td>
<td>Announcement to the fields, outreach support (fact sheets, talking points, etc.)</td>
<td>CSD, MDL, Regional CSPMs</td>
<td>03/01/13</td>
</tr>
</tbody>
</table>