VISUAL ANALYTICS FOR CLIMATE AND TEXT ANALYSIS

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Oak Ridge National Laboratory
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11 April 2012
VISUAL ANALYTICS FOR CLIMATE MODEL ANALYSIS

Chad A. Steed, Galen Shipman, Peter Thornton, Daniel Ricciuto, David Erickson, and Marcia Branstetter

This research is sponsored by the U.S. Dept. of Energy, Office of Science under the Climate Science for a Sustainable Energy Future (CSSEF) project.
CLIMATE DATA DELUGE
CLIMATE DATA DELUGE

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Wednesday, April 11, 12
CLIMATE DATA DELUGE
CLIMATE DATA DELUGE
• Current climate data analysis techniques are limited
• Increasing quality, quantity, and number of parameters
• New uncertainty metrics
• Limited linkage to decision support algorithms
• Methods to display and analyze data have not kept pace with modeling and data collection advances
• Users are forced to reduce the problem to fit the tools

Fig. 2. The volume of worldwide climate data is expanding rapidly, creating challenges for both physical archiving and sharing, as well as for ease of access and finding what’s needed, particularly if you are not a climate scientist. The figure shows the projected increase in global climate data holdings for climate models, remotely sensed data, and in situ instrumental/proxy data.

Overpeck et al., Science 331, 700 (2011)
VISUAL ANALYTICS

After Keim et al. 2008
Parallel Coordinates

The polygonal line with segments connected to the parallel axes for $\mathbb{R}^n$ represents the point $C = (c_1, \ldots, c_N) \in \mathbb{R}^n$. 
VISUAL PATTERNS IN ||-COORDS

[Diagram showing visual patterns in ||-coords with graphs for Year vs. IH and MPG vs. HP.]
CLM4 POINT ENSEMBLE

Grid Location for the Harvard Forest Eddy Covariance Flux Tower
(42.5378N, 72.1715W)
Averaged values for May over 10 years (1995-2004)

CLM4 Parameter Variables

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<th>Parameter</th>
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<tr>
<td>$F_{\text{max}}$</td>
<td>none</td>
<td>maximum fractional saturated area</td>
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<tr>
<td>$F_{\text{drai}}$</td>
<td>$m \ s^{-1}$</td>
<td>decay factor for subsurface runoff with depth</td>
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<tr>
<td>$S_{y}$</td>
<td>none</td>
<td>average specific yield</td>
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CLM4 Output Variables

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<tr>
<td>runoff</td>
<td>$mm \ s^{-1}$</td>
<td>total runoff</td>
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<tr>
<td>$LH$</td>
<td>$W \ m^{-2}$</td>
<td>latent heat flux</td>
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<td>$SH$</td>
<td>$W \ m^{-2}$</td>
<td>sensible heat flux</td>
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<tr>
<td>$BTRAN$</td>
<td>none</td>
<td>transpiration scaling factor</td>
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<tr>
<td>$GPP$</td>
<td>$gC \ m^{-2} \ s^{-1}$</td>
<td>gross primary productivity</td>
</tr>
<tr>
<td>$TLAI$</td>
<td>$m^{2} \ m^{-2}$</td>
<td>total leaf area index</td>
</tr>
<tr>
<td>$TOTVEGC$</td>
<td>$kg \ C \ m^{-2}$</td>
<td>total vegetation carbon</td>
</tr>
<tr>
<td>$TOTSOMC$</td>
<td>$kg \ C \ m^{-2}$</td>
<td>total soil organic matter carbon</td>
</tr>
</tbody>
</table>
CLM4 ANALYSIS WITH EDEN: INITIAL PLOT
CLM4 ANALYSIS WITH EDEN: INITIAL PLOT
CLM4 ANALYSIS WITH EDEN: HIGHLIGHTING OUTLIERS

Showing 134 tuples (14 selected)
CLM4 ANALYSIS WITH EDEN: REMOVED OUTLIERS
CLM4 ANALYSIS WITH EDEN: BI-MODALITIES
GLOBAL CLM4 ANALYSIS
GLOBAL CLM4 ANALYSIS
CLM4 ANALYSIS ON EVEREST

1000 simulations, 81 parameters, 7 output variables
11,520 x 3,072 (35 million) pixels
CLM4 ANALYSIS ON EVEREST

1000 simulations, 81 parameters, 7 output variables
11,520 x 3,072 (35 million) pixels
This research is sponsored by the Dept. of Homeland Security S&T under the Southeast Regional Research Initiative (SERRI) project number 89970.
MOTIVATION

• DHS Fusion Center Analysts face data overload
  • Too many sources
  • Relevant hits can be overlooked

• Objective:
  • Improve analysis of search hits using interactive visualization techniques
  • Capture interactions to re-rank hits to improve likelihood of finding relevant information
GRYFFIN
REPORT REPOSITORY

Apache Lucene
lucene.apache.org

Apache Tika
tika.apache.org

HTML  TXT  Word  PDF  ODT

Tika

Lucene Index

Search Service
Local doctor links spill to symptoms. 2010.11.2
Oil well device may have been flawed. 2011.3.5
U.S. may reject off-shore drilling permits due to ruling. 2011.3.4
U.S. drops bid to explore oil in Eastern Gulf. 2010.12.1

Gulf shrimping grounds reopened near BP oil spill well: NOAA. 2011.2.1

Testimony indicates poor cementing of drilling rigs is a... 2010.11.9

Offshore drilling needs urgent reform, U.S. panel says. 2011.1.11

Oil–spill investigators: ‘This was an entirely preventable... 2011.2.18
Houma Today (Louisiana) – http://www.houmatoday.com/article/20110218/WIRE/110218

Halliburton admits skipping test on Gulf well cement. 2010.10.29

Study shows no change in the number of Slope oil spills. 2010.12.10

U.S. splits up offshore regulators after oil disaster. 2011.1.20
Local doctor links spill to symptoms.
Oil well device may have been flawed.
U.S. may reject off-shore drilling permits due to ruling.
U.S. drops bid to explore oil in Eastern Gulf.
Gulf shrimping grounds reopened near BP oil spill well: NOAA.
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### Unlabeled Search Results

<table>
<thead>
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<th>Date</th>
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<td>Local doctor links spill to symptoms.</td>
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<td>Oil well device may have been flawed.</td>
<td>2011.3.5</td>
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<tr>
<td>U.S. may reject off-shore drilling permits due to ruling.</td>
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<td>Oil spill investigators: ‘This was an entirely preventable...</td>
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<td>Houma Today (Louisiana) - <a href="http://www.houmatoday.com/article/2010218/WIRE/110219">http://www.houmatoday.com/article/2010218/WIRE/110219</a></td>
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<td>2010.12.10</td>
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<td>2011.1.20</td>
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</table>

Last search returned 226 hits.
GRYFFIN CLIENT OVERVIEW
TEMPORAL VIEW

Unlabeled Search Results

Officials concerned another oil spill could contaminate drinking water. 2010.12.5
KSLS Salt Lake City (Utah) - http://www.ksl.com/?mid=148&amp;sid=13536895

U.S. issues new guidance for offshore drilling. 2010.12.19

With eyes on Gulf, BP Alaska pipes remain at risk. 2010.11.2
ProPublica (Alaska, National) - http://www.washingtonpost.com/wp-dyn/content/article/2010/11/02/AF...

Hydrofluoric acid risk at oil refineries. 2011.2.24
ABC News and Center for Public Integrity (National) - http://abcnews.go.com/Blotter/hydrofluoric-acid-r...

U.S. icebreakers can't handle Alaska oil spills: official. 2011.2.11

Shell ordered to operate 360,000-barrel-a-day pipeline at reduced pressure. 2010.11.24

Contaminated soil removed from old gas station site. 2010.11.10

Oil pipeline explosion kills 28 in Mexico. 2010.12.20

Drillers used diesel in ‘fracking,’ report says. 2011.2.1

137 oil wells out of compliance. 2011.3.5

Drinking water ban ends near Kalamazoo River. 2010.11.8

Mexico violence costs $350K daily in natural gas losses. 2010.11.12

Mexico pipeline thieves trigger big fuel spill. 2011.2.9

Last search returned 226 hits.
TEMPORAL VIEW

Unlabeled Search Results

Officials concerned another oil spill could contaminate drinking water.  

With eyes on Gulf, BP Alaska pipes remain at risk.  

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2010.11.24

Contaminated soil removed from old gas station site.  
2010.11.10
Unlabeled Search Results

Rolls-Royce confirms faulty part caused Qantas flight explosion. 2010.11.12
Enbridge Pipeline 6B could be turned back on by November 24. 2010.11.23
Singapore Airlines pulls 3 A380s due to engines. 2010.11.10
Regulators move to combat potential engine-oil fires. 2010.11.22
Rolls-Royce Trent 900 users should focus on oil pipes, EASA says. 2010.11.24
Second 'frac' spill worries officials. 2010.11.24
Bismarck Tribune (North Dakota) – http://www.bismarcktribune.com/news/local/article_ad40e1b8-
Prison evacuated after suspicious device found. 2010.11.2
Repairs from gas well leak completed. 2011.1.4
Cross Timbers Gazette (Texas) – http://www.crosstimbersgazette.com/local-news/1300-repairs-f-
EPA steps in after Illinois oil spill. 2010.12.20
Grass fire consumes more than 8,000 acres. 2010.12.15
Portales News-Tribune (New Mexico) – http://www.pntonline.com/news/fire-23657-acres-grass-
Alyeska may briefly start pipeline to prevent freeze. 2011.1.11
'Fracking' disposal sites suspended, likely linked to Arkansas ear... 2011.3.4
Associated Press (Arkansas) – http://www.huffingtonpost.com/2011/03/06/fracking-arkansas-ear
Diesel pipeline burst sends fuel shooting into air. 2011.3.21
Six New England companies face fines for chemical reporting violations. 2010.11.3
Elliott Ditch spill cleared. 2011.1.19
Mosque bomb suspect placed '85 airport explosive. 2011.2.1
ATSB plan to prevent exploding Airbus A380 engines. 2010.12.3
Spilled diesel flows into wetlands, creek 25 miles south of Forks. 2011.2.24
Chemical company charged with pollution. 2011.1.20
Gaddafi strikes oil areas, Arabs weigh peace plan. 2011.3.3
Oil company agrees to pay $4.1M for contaminated water. 2010.12.17
<table>
<thead>
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<td><strong>EPA steps in after Illinois oil spill.</strong></td>
<td>2010.12.20</td>
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<tr>
<td>EPA steps in after Illinois oil spill. Two pipeline companies have until December 25 to clean an area near Lockport, Illinois, contaminated by an oil spill the week of December 12, the U.S. Environment Protection Agency (EPA) said. The EPA issued an order to West Shore Pipe Line Co. and Buckeye Pipe Line Co. to respond to a spill near a Citgo refinery. The recent demand from the EPA comes after about 500 barrels of oil spilled from a 12-inch – 1 – pipeline owned and operated by the two companies. The leak was stopped on the same day it was reported, but not before oil reached a nearby wetland. The EPA said it was working with Illinois officials to examine air and other environmental quality concerns.</td>
<td></td>
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<tr>
<td>Grass fire consumes more than 8,000 acres.</td>
<td>2010.12.15</td>
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<tr>
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TERM-FREQUENCY VIEW & LIST OVERVIEW BAR
SANDBOX VIEW
DEEPWATER HORIZON
CASE STUDY
INITIAL VIEW
Unlabeled Search Results

US Department of Labor's OSHA fines San Antonio manufacturing company for serious workplace... 2011.2.22
F-35 tests suspended after airborne glitch. 2011.3.11
I-75 ramp shut down due to crash, oil spill. 2011.3.15
Tsunami damage estimate for Santa Cruz rises. 2011.3.15
- Testimony indicates poor cementing of drilling rigs is a widespread problem. 2010.11.9
Striker refinery incident under investigation. 2010.11.11
Contaminated soil removed from old gas station site. 2010.11.10
Qantas: 40 engines on A380s need to be replaced. 2010.11.18
Blaze ignites at BGE substation. 2010.11.18
Shell ordered to operate 360,000-barrel-a-day pipeline at reduced pressure. 2010.11.24
Rig worker on break missed signs of trouble. 2010.12.8
Driller denies that it contaminated Texas aquifer. 2010.12.8
Fire causes chemical scare. 2010.12.29
Pirates: Ship released, another taken. 2010.12.29
Small oil spill contained at Port Canaveral. 2010.12.30
Alyeska may briefly start pipeline to prevent freeze. 2011.1.11
Study: sulfolane found in North Pole vegetables gardens. 2011.1.18
Chemical company charged with pollution. 2011.1.20

oil (652) said (463) s (292) from (271) pipeline (180)
were (174) fire (167) have (158) spill (155) water (140)
AFTER ONE RE-RANKING
AFTER ONE RE-RANKING

Wednesday, April 11, 12
Scientists find massive damage from BP oil spill in Gulf of Mexico. 2010.12.27
Toxic heavy metal found in Louisiana Gulf oysters. 2011.2.15
Beached barge cleanup costs reach $5.3 million. 2011.2.8
U.S. sues companies for spill damages. 2010.12.15
NOAA opens more Gulf waters to fishing after BP spill. 2010.1.15
California city charts course in tsunami's wake. 2011.1.23
Study shows no change in the number of Slope oil spills. 2010.1.10
Rig worker on break missed signs of trouble. 2010.1.2
Local doctor links spill to symptoms. 2010.1.2
Pirates: Ship released, another taken. 2010.1.29
Study measures contaminated Gasworks Park sediment, groundwater. 2011.3.9
U.S. drops bid to explore oil in Eastern Gulf. 2010.12.21
Officials concerned another oil spill could contaminate drinking water. 2010.12.5
U.S. may reject off-shore drilling permits due to ruling. 2011.3.4
Aging oil rigs, pipelines expose Gulf to accidents. 2010.1.14
BP oil spill IT systems lacked key alarms. 2011.1.6
Coast Guard figures at least 75 more days, $7.5 million to get... 2010.12.21
Mexico pipeline thieves trigger big fuel spill. 2011.2.1
Testimony indicates poor cementing of drilling rigs is a... 2010.11.9

| Department (63) | November (64) | Spokesman (64) | March (64) | Leak (60) | Federal (58) | BP (56) | Oil (18) | Spill (9) | Found (6) | Berm (5) | Food (5) | Said (5) | Deep (4) | Gulf (4) | Chemicals (4) | Consumed (4) | Which (4) | Animals (3) | Boom (3) | Chain (3) | Coast (3) | Louisiana (3) | Mexico (3) | Report (3) | Scientists (3) | Sea (3) | Toxic (3) | 8 (2) | Ashore (2) | Author (2) |
|----------------|---------------|----------------|------------|----------|-------------|---------|----------|---------|----------|--------|---------|---------|---------|---------|---------|----------------|----------------|---------|-----------|---------|--------|----------|----------------|----------|-----------|-------------|--------|----------|------|----------|----------|
AFTER SECOND RE-RANKING

**Unlabeled Search Results**

- Louisiana oil rig catches fire. 2010.12.2
- Tanker spills oil into Long Beach harbor. 2011.2.22
- Oily sheen cleanup continues along coastline. 2011.2.23
- EPA and U.S. 2011.2.27
- Oil companies evacuate Egypt staff on safety concerns. 2011.3.31
- Sunken tugboat spilled 800 gallons of diesel fuel into the... 2010.12.14
- Study: sulfonate found in North Pole vegetables gardens. 2011.3.18
- Coast Guard: Gulf sludge likely caused by river sediment. 2011.3.21
- Pipeline spill response plans faulted. 2010.11.24
- Major oil companies evacuate employees. 2011.2.21
- Houston pilots halt vessel boarding as fog cuts visibility. 2011.3.4
- Houston ship pilots delay boarding as fog limits visibility. 2011.2.24
- DOT proposes $423,600 fine against Chevron for pipeline leak. 2010.11.2
- Mexico finds 4 more illegal pipeline taps. 2010.12.30
- Fog halts ships at Houston-Texas City; 74 wait. 2011.2.22
- Guam shipyard salvage not going as originally hoped. 2011.2.3
- Spill II even bigger than Chevron thought. 2010.12.4
- 'Big Blue' update: Water being pumped out so waste oil tanks can... 2011.1.9

**Sandbox**

- NOAA opens more Gulf waters to fishing after BP spill. 2010.11.15
- U.S. sues companies for spill damages. 2010.12.15
- Toxic heavy metal found in Louisiana Gulf oysters. 2011.2.11
- Scientists find massive damage from BP oil spill in Gulf of Mexico. 2010.12.21
- Toxic chemicals found deep at oil spill site. 2010.11.2
- Berms and boom were largely ineffective responses to oil spill... 2011.1.12
- Oil traces found in Gulf food chain, scientists say. 2010.11.9

**Used (44) would (44) bp (43)**
- crews (43) report (43) hazardous (42)
- off (42) area (41) barrels (40)
- down (39) drilling (39) epa (39)
- shut (39) air (38) all (38)
- before (38) during (38) engines (38)
- under (38) day (37) some (37)

Last search returned 226 hits.
CONCLUSIONS

• Developed in collaboration with domain experts
• Re-ranking increases likelihood for finding relevant items
• Enhancements for geospatial and temporal views
• Extensions to consume and search dynamic text streams
VISUAL ANALYTICS FOR CLIMATE AND TEXT ANALYSIS

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Oak Ridge National Laboratory

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11 April 2012