Visualizing the weather-climate connection

Brian Mapes
RSMAS, University of Miami
mapes@miami.edu
My data-enabled research career

• Weather-adventure start: tropical field campaigns
  – Sold as climate (model) (improvement) process studies

• Grad work: Night shift on first, scarce Unix machine
  – c code to process airborne Doppler radar. (disdain for easy grids)
  – spitting out hand-formatted ASCII PostScript was graphics
    • color only on screen, raster coordinates

• Postdoc & post-postdoc: Rode wave of 4th-gen languages
  – Fast debugging = high productivity!
    • interpreted languages (multiline command line paste)
    • with instant graphification

• Faculty: Productivity slam (from research perspective)
  – Stuck with my ruts/strengths to remain competitive/funded
My data-enabled research career

– But...

• Teaching: UG Wx Analysis, G Applied Data Analysis
  – must text-coding skill stand btw. students and meaningful science?

• Wearying of one-off programming, data-collections mgmt.
  – wish computer interaction time created more lasting value

• Climate-weather split (monthly-hourly time chasm) frustrates
  – each culture seems a bit ungrounded sometimes

• Creeping doubts if my science is truly making progress
  – craft interests me more than content, some days

– Next IT wave ready (mostly... bright side: -ware is still soft)

• OpenDAP access mature (after past false starts)
  – Several reanalyses and satellite datasets for decades

• Tools (IDV & RAMADDA) mature (""")
  – Thanks to Unidata's decades of vision & work (& Don & Jeff still...)
Time for a next phase?

• Time=$: Is visualization (fundable as) science?
  – descriptive, semi-quantitative (~Synoptics)
    • Valuable, or too subjective? Much depends on quality.
      – Graphics & color are the "significance tests" of case work
      – Sampling of cases from statistical context, not ad hoc

• Is creating and sharing 4D data visualizations and their artifacts (stills, anims) "publication?"
  – Publishing the code: a standard? a service?
  – Valid evidence and warrant for scientific discourse?

• Is spatial visualization "Education?"
  – How to evaluate communication, distortions?
  – Relationship to the rigorous math, physics, statistics?
Sort of a vision

• just a half-written proposal, to be honest

• Roles for vis in the weather-climate gap
  – Causality studies in instantaneous data (weather)
  – Climate provenance of weather events
  – Weather texture on climate anomalies
  – Cumulative shows of climate impacts by timescale
1. Weather causality in synoptic flows

- Indian monsoon depressions: why westward?

Monsoon depression tracks from the Sikka et al. (2006) database. Genesis positions are indicated by black triangles and once-daily track positions are indicated by filled circles, color corresponds to intensity stage (see colorbar).
Sept 2008 case during YOT

Z850, V850, TRMM 3B42

EC-YOTC 0.25deg vort

NCEP-NCAR 2.5deg vort

(Boos, Murthy, Mapes 2014)
NCEP-NCAR 2.5deg PV

EC-YOTC 0.25deg PV
PV centered aloft...
...although vorticity is deep
Vertical structure can be crucial and delicate.
Adiabatic westward drift of Indian monsoon depressions

W. R. Boos*, J. V. Hurley, and V. S. Murthy

Department of Geology and Geophysics, Yale University, New Haven, CT, USA.

*Correspondence to: W. R. Boos, Yale University, P.O. Box 208109, New Haven, CT 06520-8109, USA. E-mail: billboos@alum.mit.edu

CHAPTER XX

WESTWARD ADEVECTION OF INDIAN MONSOON DEPRESSIONS

William R. Boos, Varun S. Murthy

Department of Geology and Geophysics, Yale University,
New Haven, CT 06511, USA
E-mail: william.boos@yale.edu

Brian E. Mapes

Rosenstiel School of Marine and Atmospheric Sciences, University of Miami,
Miami, FL 33149, USA
Linking weather to climate

Examples

① Climatological mean: Carib May-June (cf. Mei-Yu)?
  » from student Teddy Allen

② Extremes

① Whole hurricane seasons
  ② Texture on hohum monthly anomalies (ENSO)
Climatological feature:
Caribbean Early Rain Season (ERS)
SUBJECTIVE CLASSIFICATION:
Annual rainband pattern and climatological accumulated rainfall visual comparison

- 2002
- 2006
- 2007
- 2010
- 2011
- 2012
Upper-level dynamics vs. moisture explanations?

Z300 and vort300

800mb winds (& soon PW)
2010: Accumulation of daily
trajectory dy a useful clim. statistic?
Linking weather to climate

Examples (show n tell)

① Climatological structure: WAtl May-June (cf. Mei-Yu)?

② Extremes

① Whole hurricane seasons

② Texture on hohum monthly anomalies (ENSO)
Click and pick: case studies of past decadal-record rain extremes

(record 27h rainfall (mm))

(in TRMM 3B42 product: 3 hourly, ¼ deg)

http://www.rsmas.miami.edu/users/bmapes/HeavyRains_clickmaps/index.html
Results of your click

You chose the x,y point (486, 99). Longitude 121.5, Latitude 25.125. Your point has a record rainfall (in this dataset) of over 600 mm.

The date of this event was 10 / 15 /1998. 20 UTC

Want to see satellite imagery? Go here
My Fave!

(Way back in like 2012)

<table>
<thead>
<tr>
<th>Year</th>
<th># of images</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>10467</td>
</tr>
<tr>
<td>1981</td>
<td>21626</td>
</tr>
<tr>
<td>1982</td>
<td>30417</td>
</tr>
<tr>
<td>1983</td>
<td>31581</td>
</tr>
<tr>
<td>1984</td>
<td>17181</td>
</tr>
<tr>
<td>1985</td>
<td>16150</td>
</tr>
<tr>
<td>1986</td>
<td>15779</td>
</tr>
<tr>
<td>1987</td>
<td>20175</td>
</tr>
<tr>
<td>1988</td>
<td>19349</td>
</tr>
<tr>
<td>1989</td>
<td>15903</td>
</tr>
<tr>
<td>1990</td>
<td>17339</td>
</tr>
<tr>
<td>1991</td>
<td>17559</td>
</tr>
<tr>
<td>1992</td>
<td>20419</td>
</tr>
<tr>
<td>1993</td>
<td>27079</td>
</tr>
<tr>
<td>1994</td>
<td>26505</td>
</tr>
<tr>
<td>1995</td>
<td>25309</td>
</tr>
<tr>
<td>1996</td>
<td>31851</td>
</tr>
<tr>
<td>1997</td>
<td>32264</td>
</tr>
<tr>
<td>1998</td>
<td>36901</td>
</tr>
<tr>
<td>1999</td>
<td>41512</td>
</tr>
<tr>
<td>2000</td>
<td>42348</td>
</tr>
<tr>
<td>2001</td>
<td>42484</td>
</tr>
<tr>
<td>2002</td>
<td>42362</td>
</tr>
<tr>
<td>2003</td>
<td>42376</td>
</tr>
<tr>
<td>2004</td>
<td>43235</td>
</tr>
<tr>
<td>2005</td>
<td>55018</td>
</tr>
<tr>
<td>2006</td>
<td>58140</td>
</tr>
<tr>
<td>2007</td>
<td>49085</td>
</tr>
<tr>
<td>2008</td>
<td>48299</td>
</tr>
<tr>
<td>2009</td>
<td>44103</td>
</tr>
</tbody>
</table>

1139947 total satellite images

Last Updated: Sun Apr 21 2013, 04:05:41 EDT

We need your help...

- This ISCCP B1 data has been archived for more than 20 years, but many of the data formats are no longer supported.
Better than a few images – a case study!
Persistence of pattern - how measure?
Linking weather to climate

Examples (show n tell)

① Climatological structure: WAtl May-June (cf. Mei-Yu)?

② Extremes

① Whole hurricane seasons

② Texture on hohum monthly anomalies (ENSO)
Whole hurricane seasons

- Dry injection? (trajectory length stats again?)
Trajectories, PW, and a climate error

- Common climate model bias pattern

JJA - MetUM model – Bush et al. 2014
3-day trajectory dy (3km altitude)
WEIO: natural laboratory of moisture-convection interaction
Moisture-limited west margin
Linking weather to climate

Examples (show n tell)

① Climatological structure: WAtl May-June (cf. Mei-Yu)?

② Extremes

① Whole seasons

② Texture on hohum monthly anomalies (ENSO)
TYPICAL JANUARY-MARCH WEATHER ANOMALIES AND ATMOSPHERIC CIRCULATION DURING MODERATE TO STRONG EL NIÑO & LA NIÑA

http://www.cpc.noaa.gov/products/analysis_monitoring/ensocycle/nawinter.shtml
Telescoping timeline

• Monthly SST anomalies
  – daily OLR and $u$ (2.5 deg)
    • 3-hourly IR sat (0.1 deg) on top
  – daily OLR and $u$ (2.5 deg)
• Monthly SST anomalies
Software and process glimpse
The IDV: take a breath, get an orientation.

⇠It is this

⇠(with a few parts more like this)

Not this→
Don’t start from raw materials!
(Frustrations galore)
Rather, start from a prior user's success:

examine and adjust a complex bundle
A plugin: my favorites, colorbars, etc.

The Mapes IDV collection

A self-updating, ever-improving IDV "plugin" maintained by Prof. Brian Mapes
The collection's 'repository' part is at http://bit.ly/Mapes_IDV

Screencast introductions:

1. Mapes IDV collection- Why you want it (5 minutes)
2. Mapes IDV collection- How to get it (4 minutes)
3. Mapes IDV collection- Learn to create your own displays (10 minutes)

The IDV (Integrated Data Viewer) is a great tool, from a great organization (Unidata, part of UCAR). It is even better when you install this set of self-updating customizations (called a "plugin").

To install the IDV and the plugin, follow these directions:
The Mapes IDV collection

Welcome to the "back office" of the Mapes project.

Please see http://www.rsmas.miami.edu for the project's front face (a normal Web orientation).

Data Sources:
- Formulas
  - pr wtr.eatm.2008
  - Cached data
  - units fixer for MERRA 3-h
  - 3 day trajectories for June
- Fields
  - Maps
  - Grids
  - Mapes:
    - Advection of scalar S by vector C
    - Average across the levels of a grid at all points
    - Average along a grid column
    - Average along a grid row
    - Average along a grid row
    - Average of 2 scalars
    - Create Relative Humidity from Temperature, mixing ratio
    - Divide
    - Frontogenesis function from theta and the wind
    - Gaussian weighted hor. smoothing (default N=6)

Mapes suggestions:
- QG diagnostics
- Vertical velocity
- Basic synoptic fields
  - Temperature -30 to 35 <local>
  - SLP Blue thick 5mb <local>
  - Z contours thick=2 <local>
  - Big pink vectors <local>
- Anomalies
  - SST anomalies blurred centered 4C <local>
  - SST anomalies rainbow 4C <local>
- Vorticity and PV
  - thin abs. vort. contours <local>
  - Abs Vort blue-red centered <local>
  - Rel Vort blue-red -10 to 10 E-5 <local>
  - PV positive values <local>
  - Abs. Vort. 0-40 E-5 redscale <local>
- Clouds and rain
  - Column water
Conclusions

• Visualization can make the weather-climate connection clearer. Feels like knowledge (but isn't journal pubs!)

  – Caribbean early rains: upper trofs vs. PW
    • Lagrangian flow stats a useful addition to GC/climate diag?
  – Extremes: often persistence is key (again, via trajectories)
  – 2013 vs. 2005 hurricane season: long-traj dry injections?
  – WEIO/India monsoon bias: moisture-insensitive conv. schemes, playing out in a region with long airmass residence times?
    • great natural lab for NWP-type calibrations of this effect!
  – Climate anomalies (ENSO) may be prettier w/ texture

• Great IT ready at last! After being so long 'promising'
• Needs curation-type work and attention. What's that called?