Visualizing the weather-climate connection

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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?"
  - Where? How? Reviewed? Curated? Annotated?
  - 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?

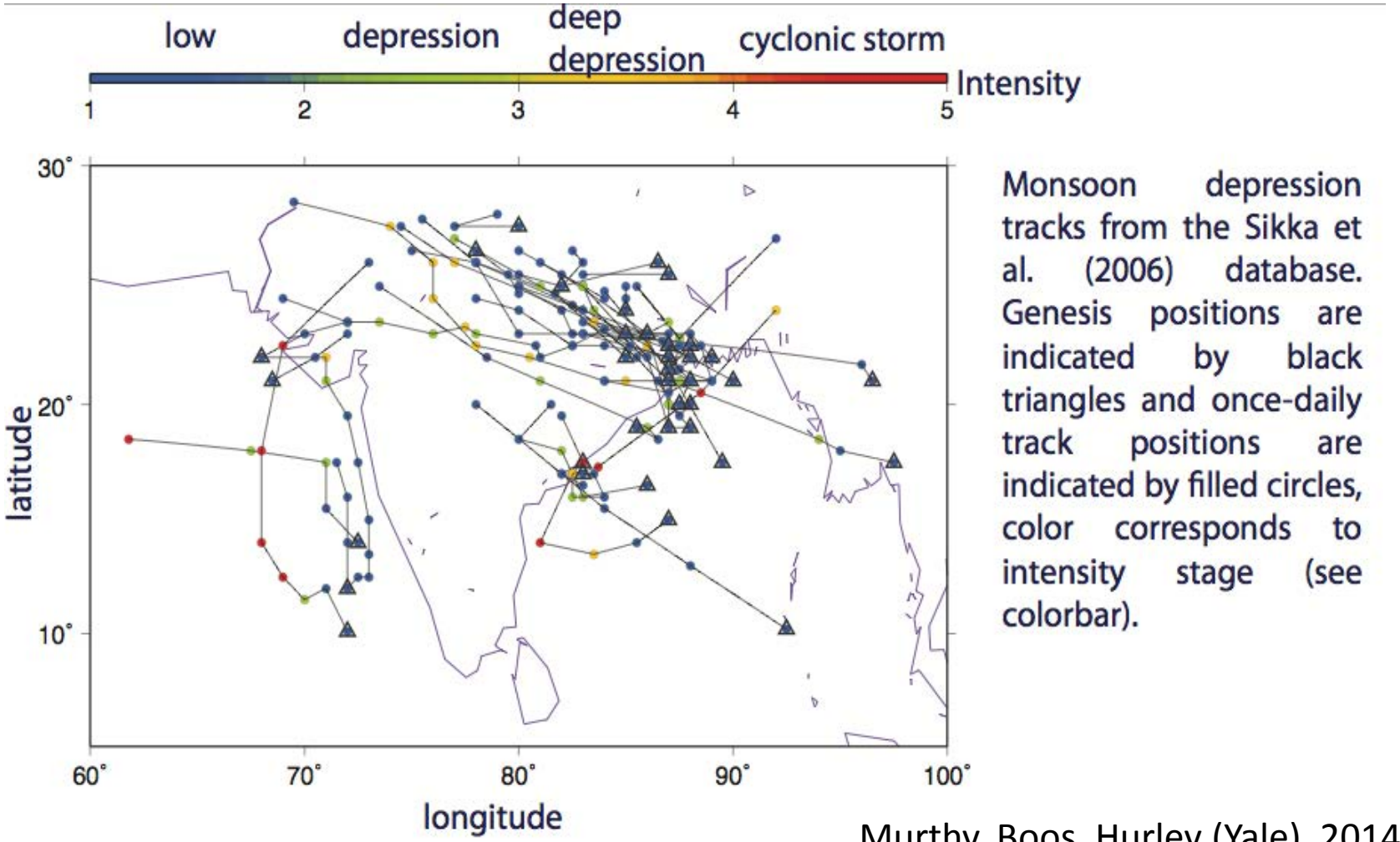
Sort of a vision

- 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

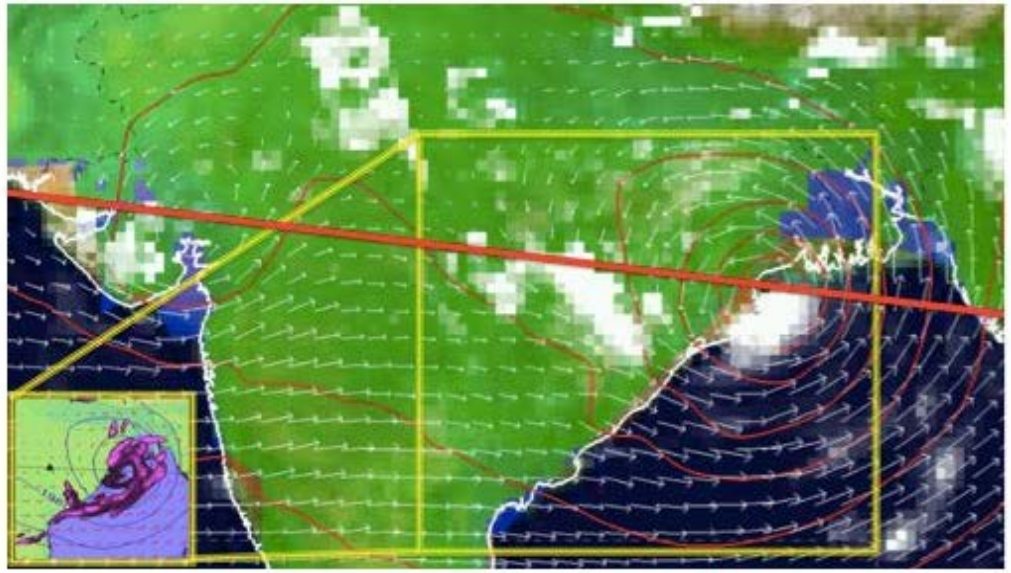
1. Weather causality in synoptic flows

- Indian monsoon depressions: why westward?



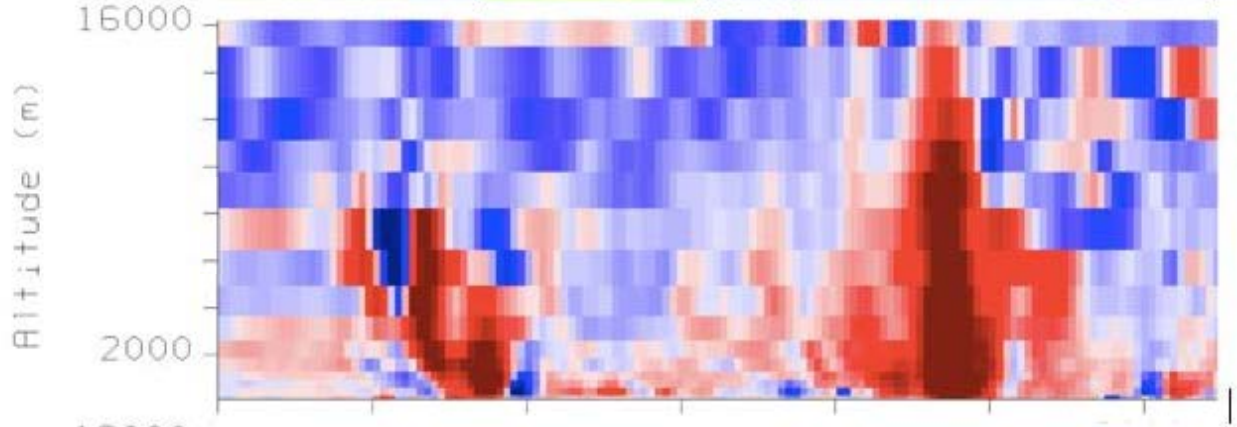
Monsoon depression tracks from the Sikka et al. (2006) database. Genesis positions are indicated by black triangles and once-daily track positions are indicated by filled circles, color corresponds to intensity stage (see colorbar).

Murthy, Boos, Hurley (Yale) 2014 QJ

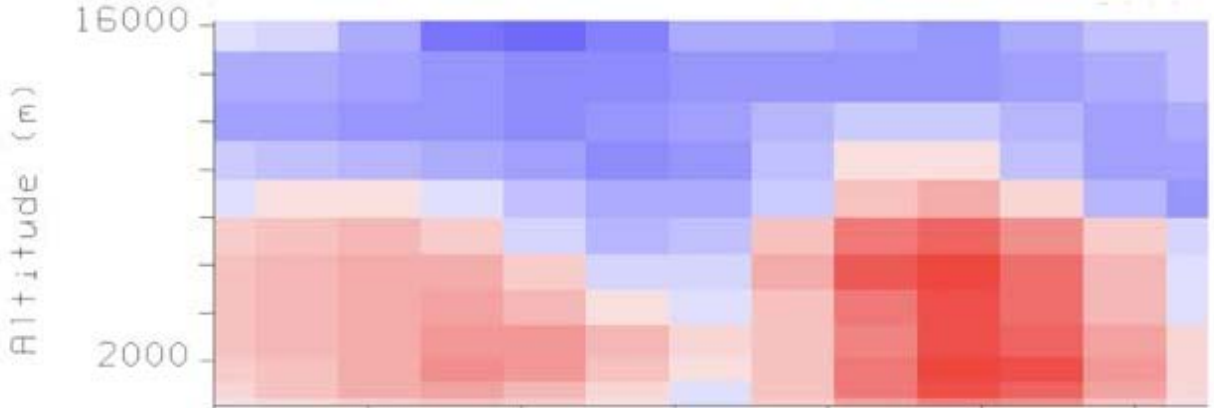


Sept 2008 case during YOT

Z850, V850, TRMM 3B42

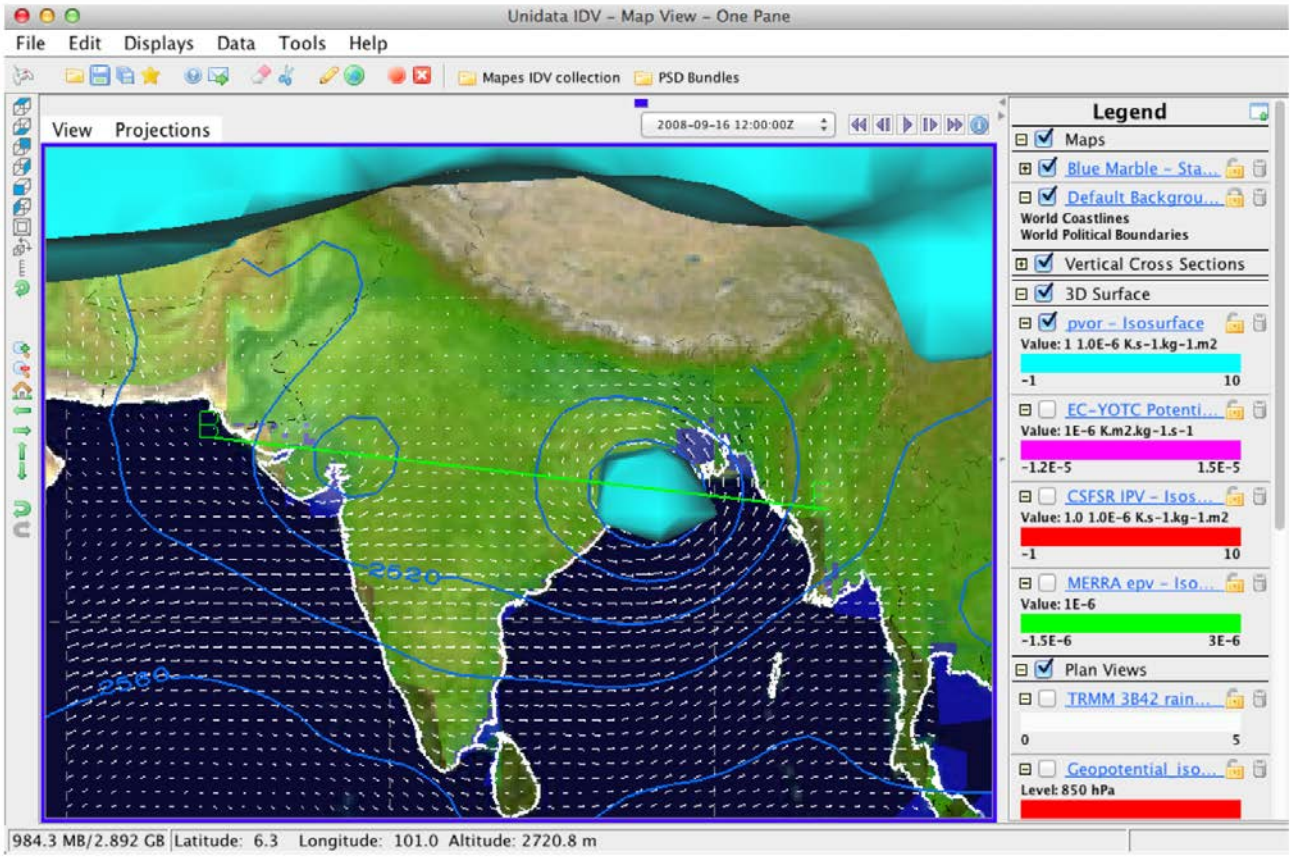


EC-YOTC 0.25deg vort

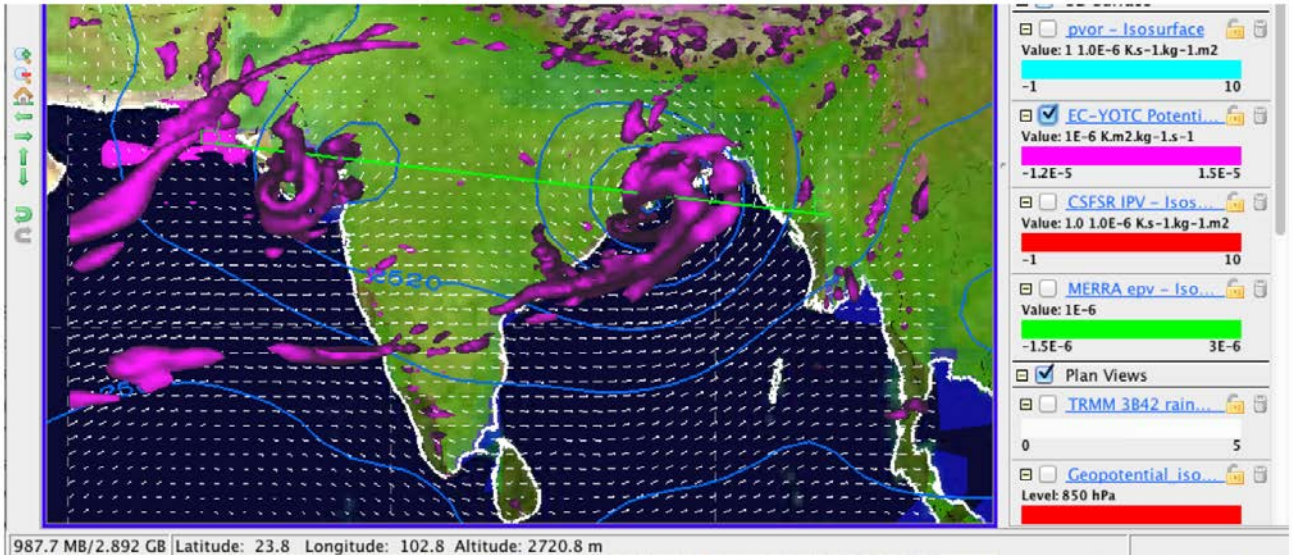


NCEP-NCAR 2.5deg vort

(Boos, Murthy, Mapes 201

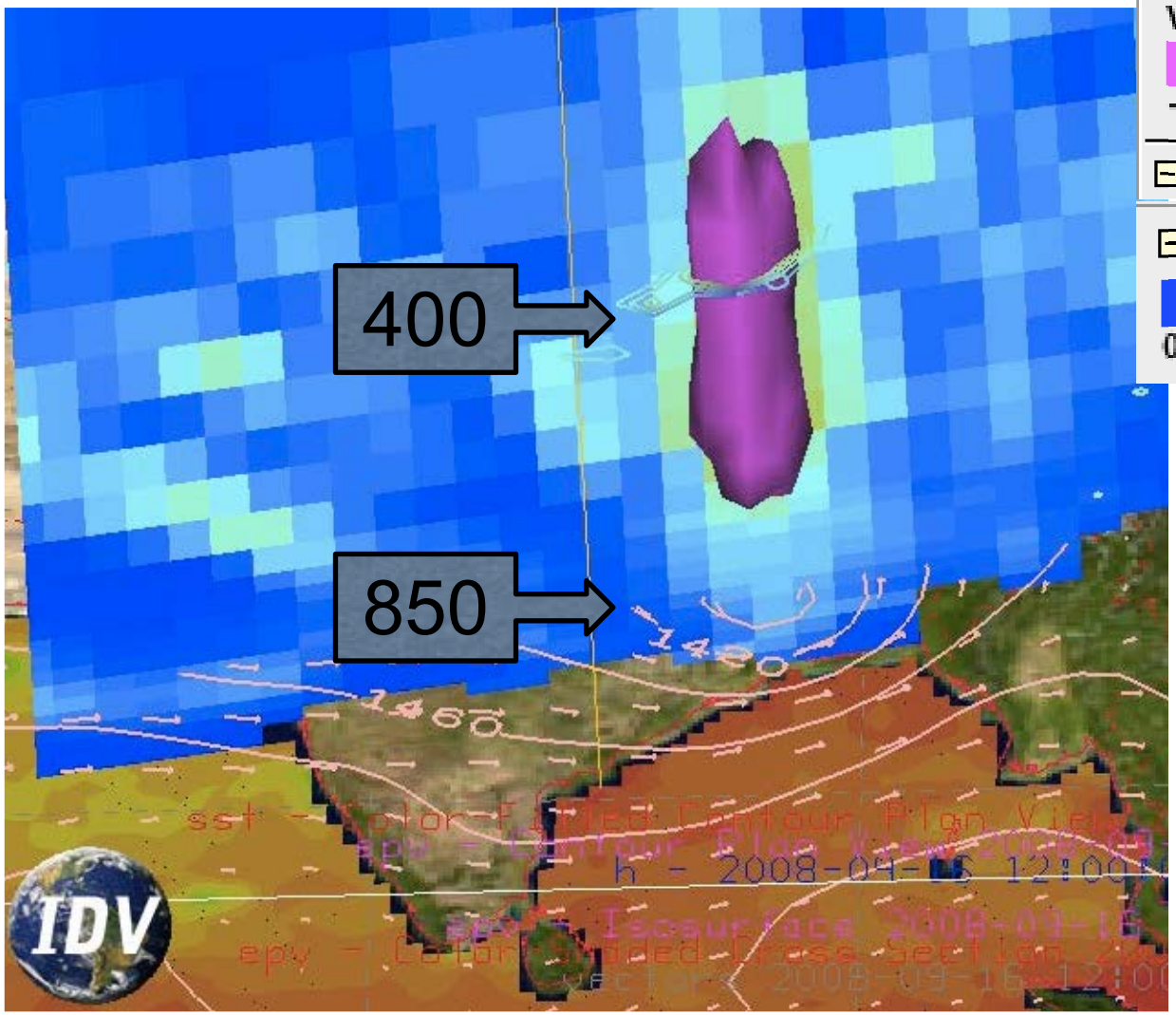


NCEP-NCAR 2.5deg PV



EC-YOTC 0.25deg PV

PV centered aloft...



3D Surface

epv – Isosurface

Value: 1.5E-6 K m2 kg-1 s-1

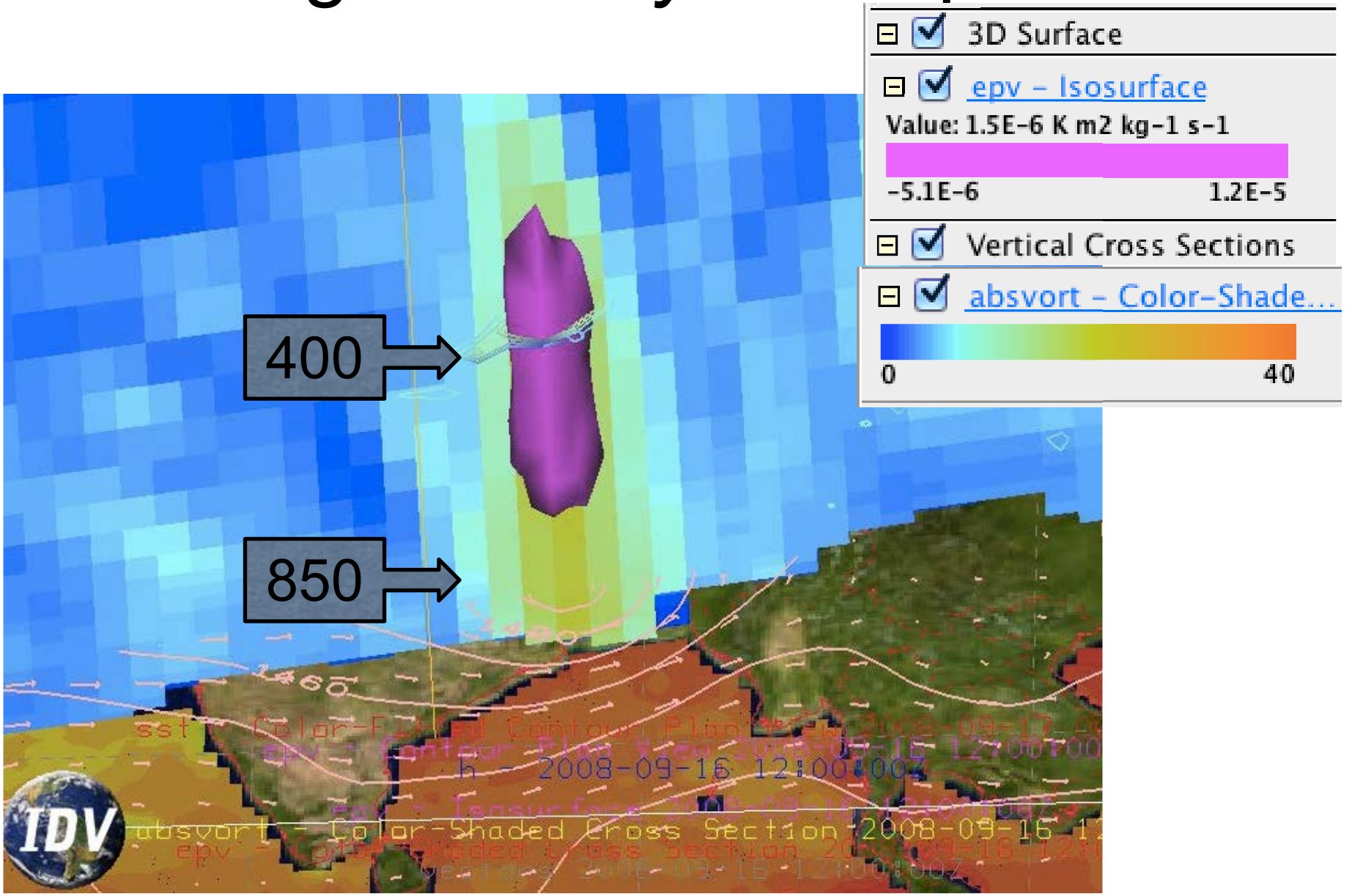
-5.1E-6 1.2E-5

Vertical Cross Sections

epv – Color-Shaded Cr...

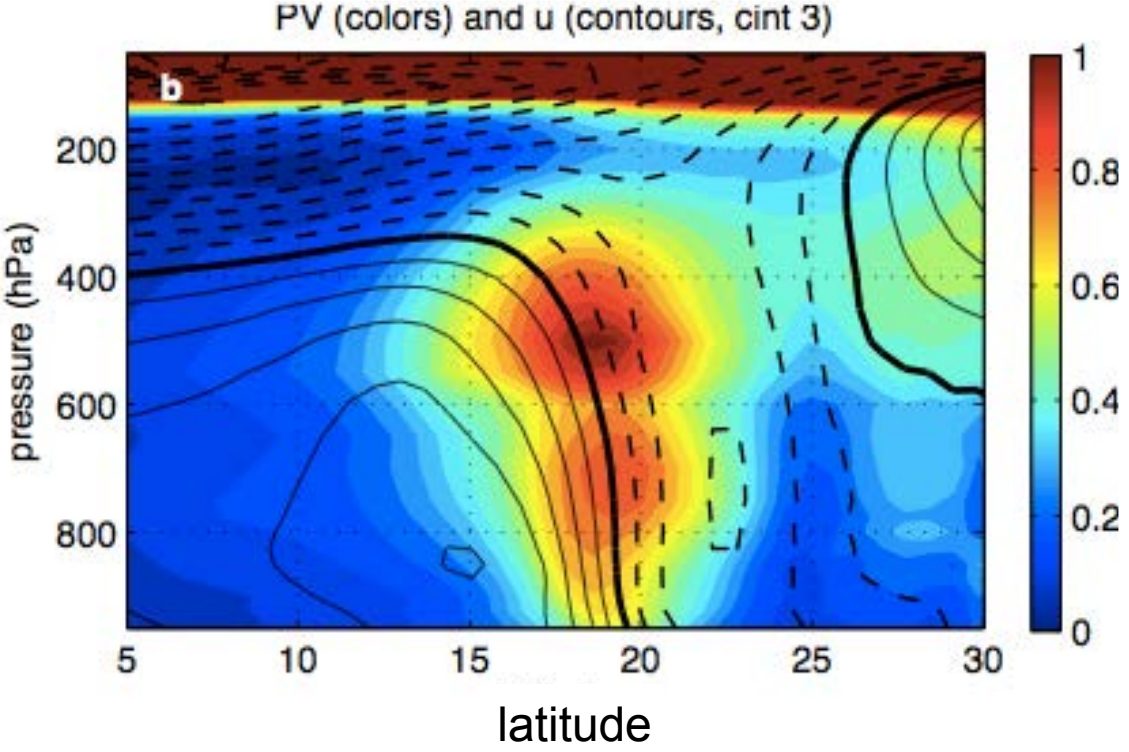
0 4E-6

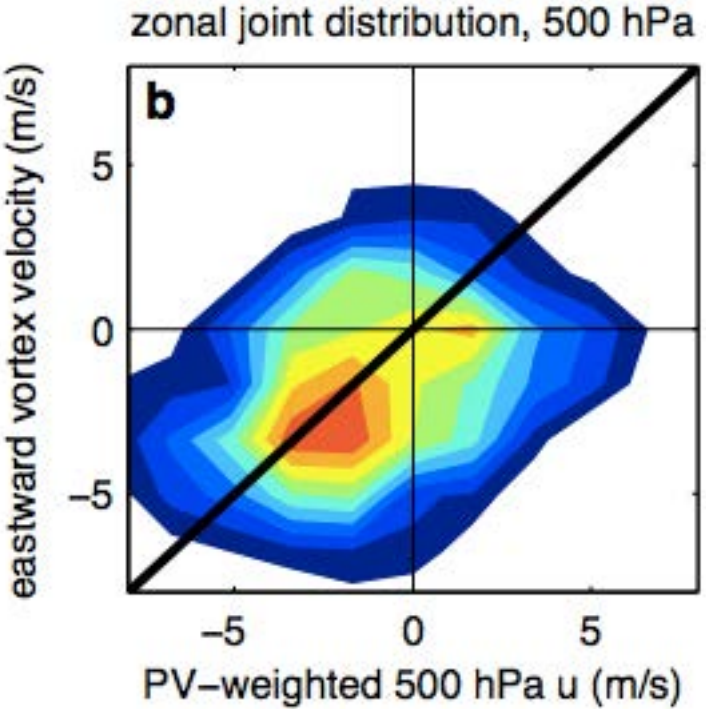
...although *vorticity* is deep



Vertical structure can be crucial

and delicate





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Adiabatic westward drift of Indian monsoon depressions

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CHAPTER XX

WESTWARD ADVECTION OF INDIAN MONSOON DEPRESSIONS

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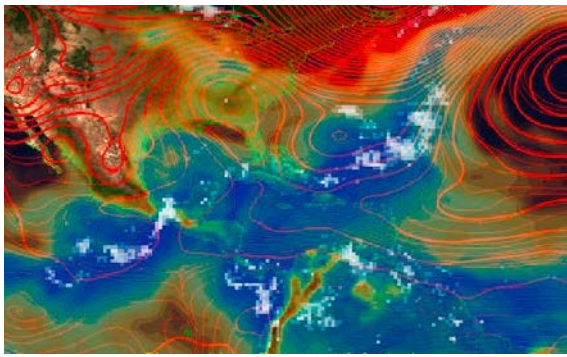
Rosenstiel School of Marine and Atmospheric Sciences, University of Miami,
Miami, FL 33149, USA

Linking weather to climate

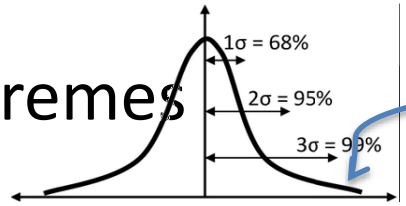
Examples

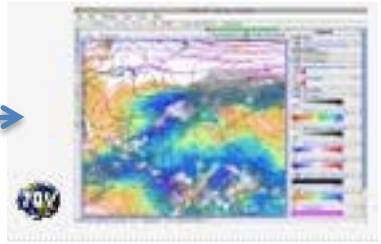
① Climatological mean: Carib May-June (cf. Mei-Yu)?

» from student Teddy Allen



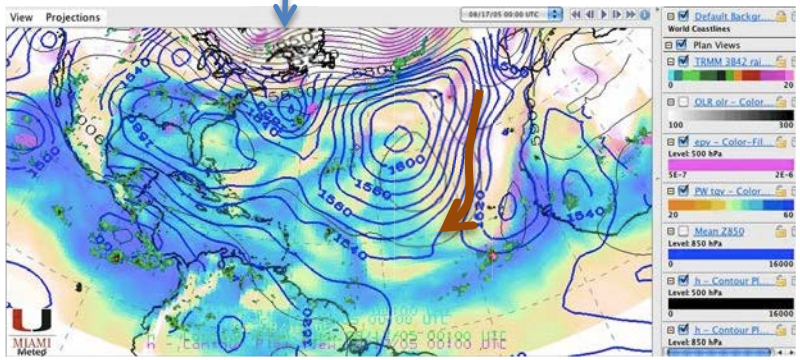
② Extremes

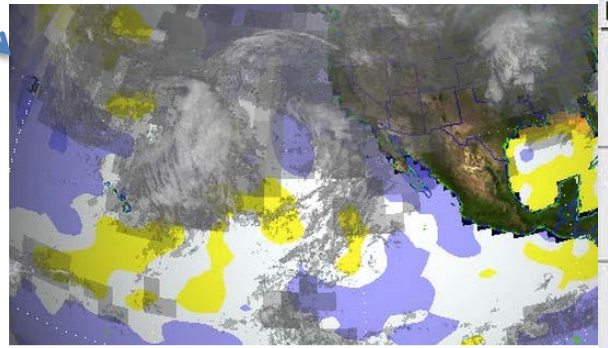




① Whole hurricane seasons

② Texture on hohum monthly anomalies (ENSO)

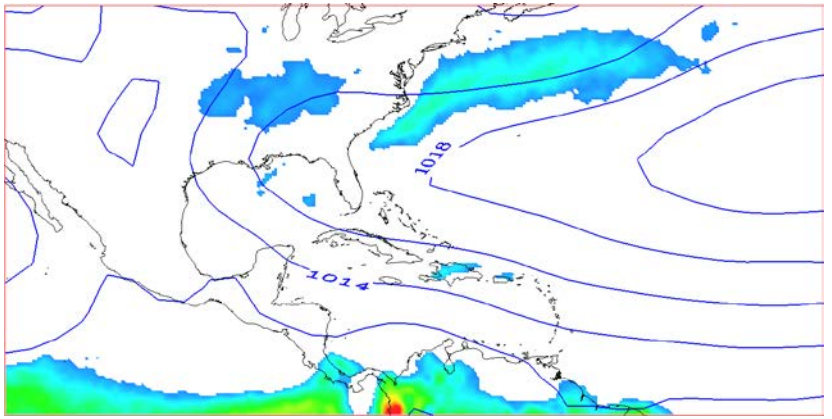




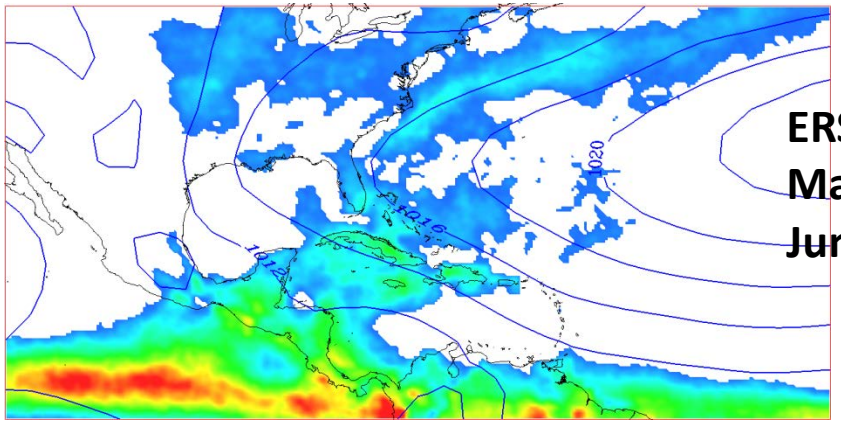
Climatological feature:

Caribbean Early Rain Season (ERS)

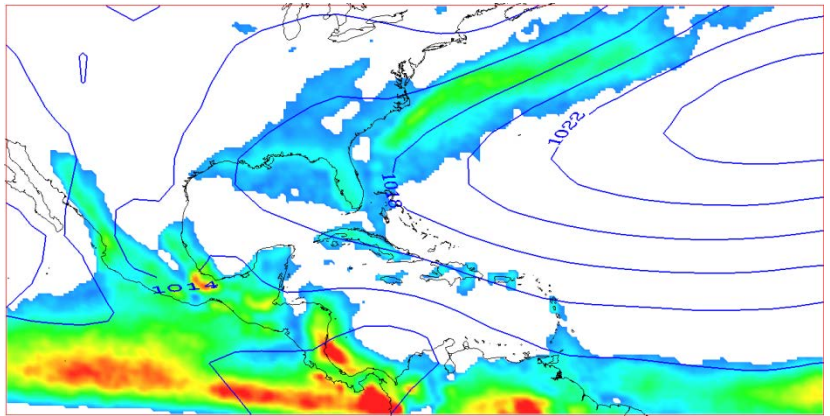
TRMM (>4mm/day), **SLP**



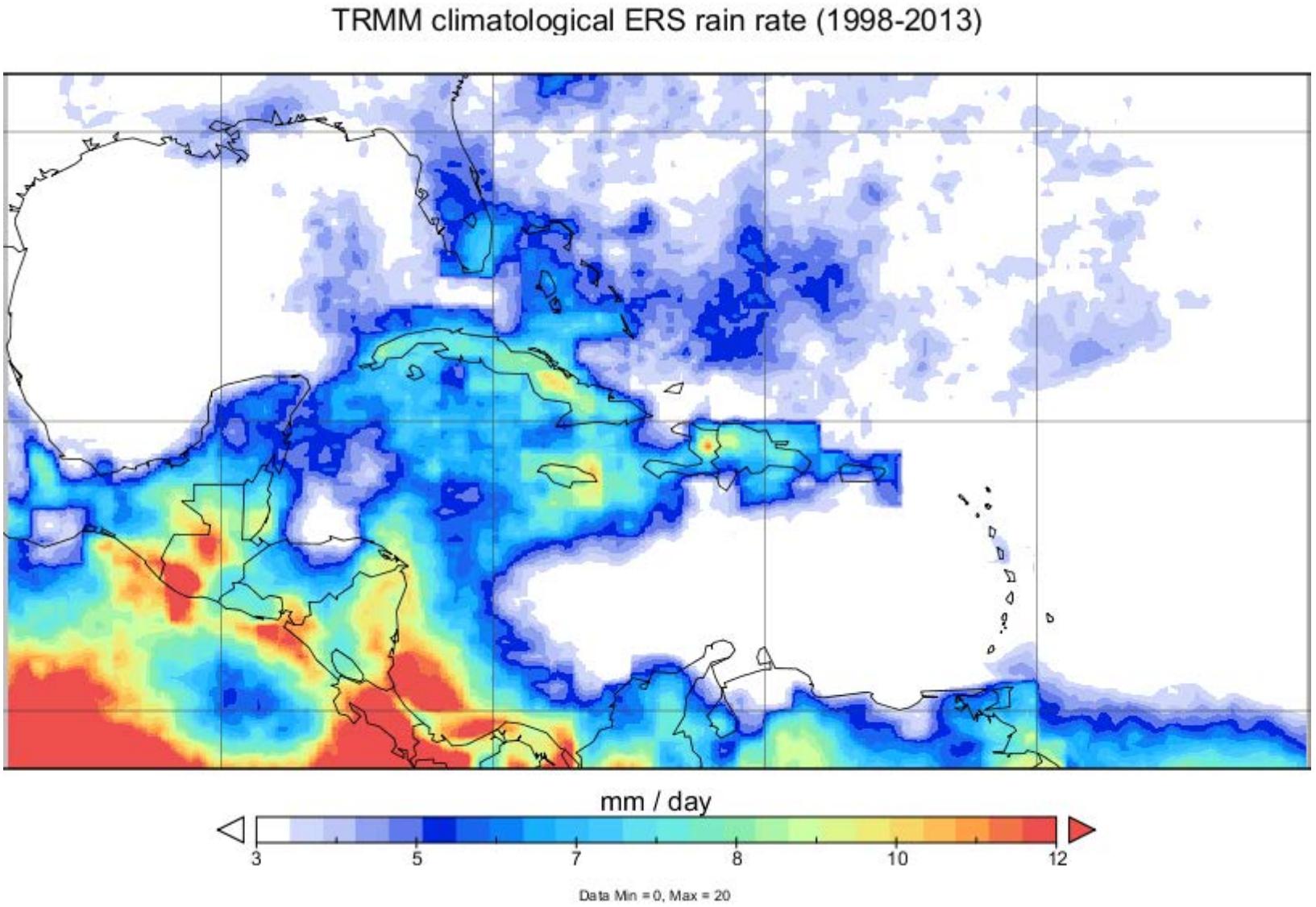
APRIL

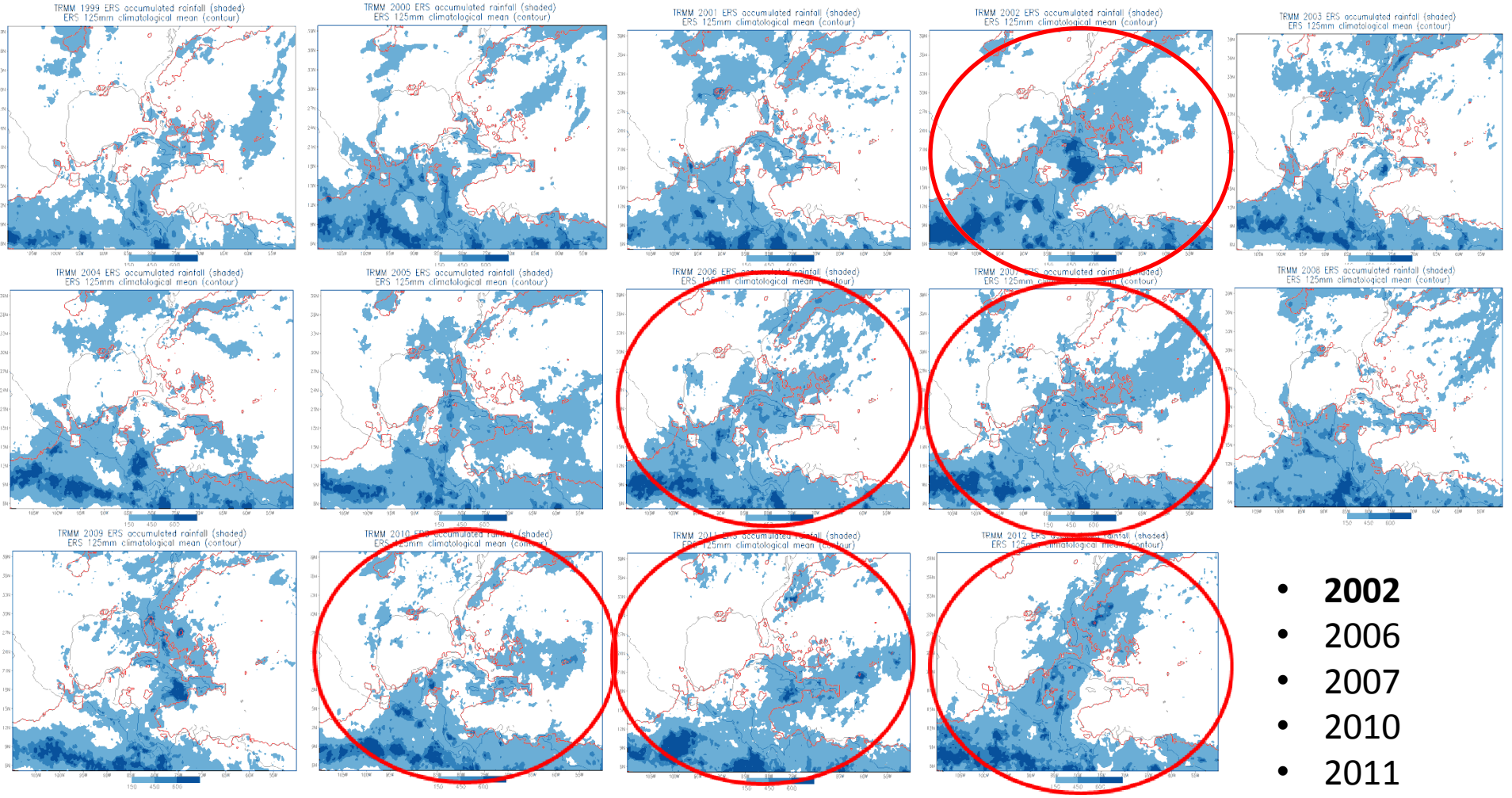


ERS May 15 – Jun 15



JULY


TRMM climatological ERS rain rate (1998-2013)
mm / day
3
5
7
8
10
12
Data Min = 0, Max = 20



- **2002**
- 2006
- 2007
- 2010
- 2011
- 2012

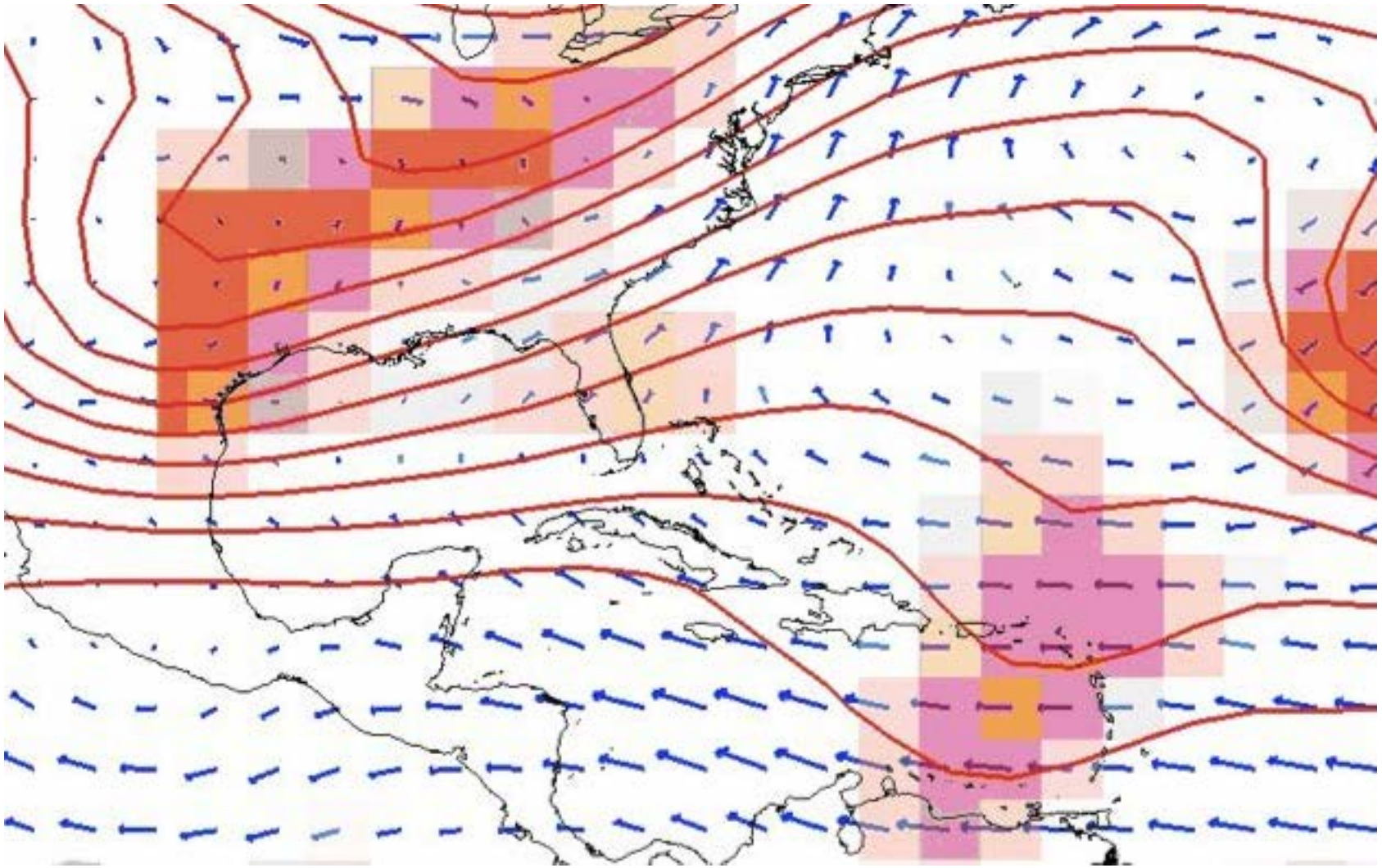
***SUBJECTIVE* CLASSIFICATION:**

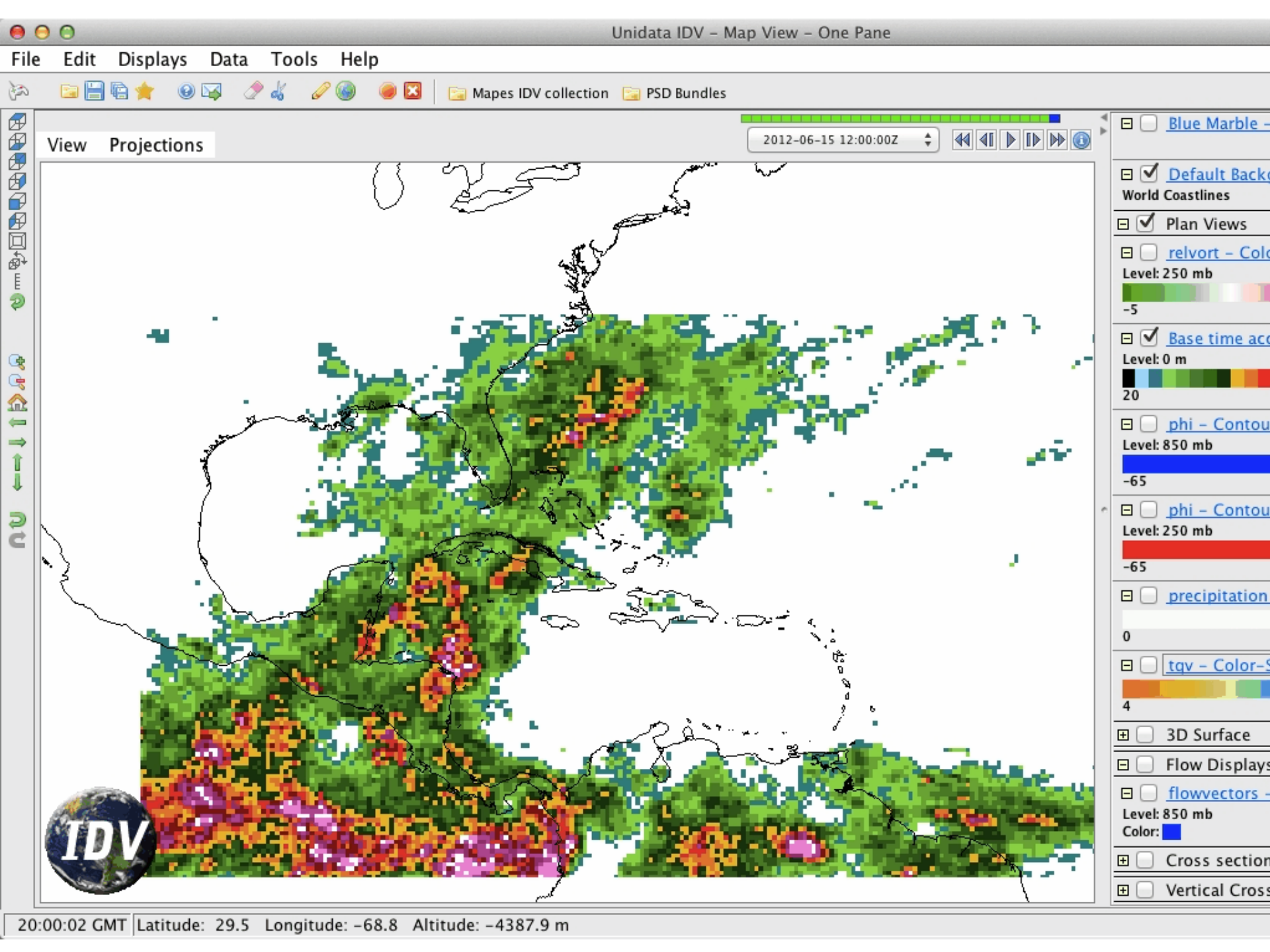
Annual rainband pattern and climatological accumulated rainfall visual comparison

Upper-level dynamics vs. moisture explanations?

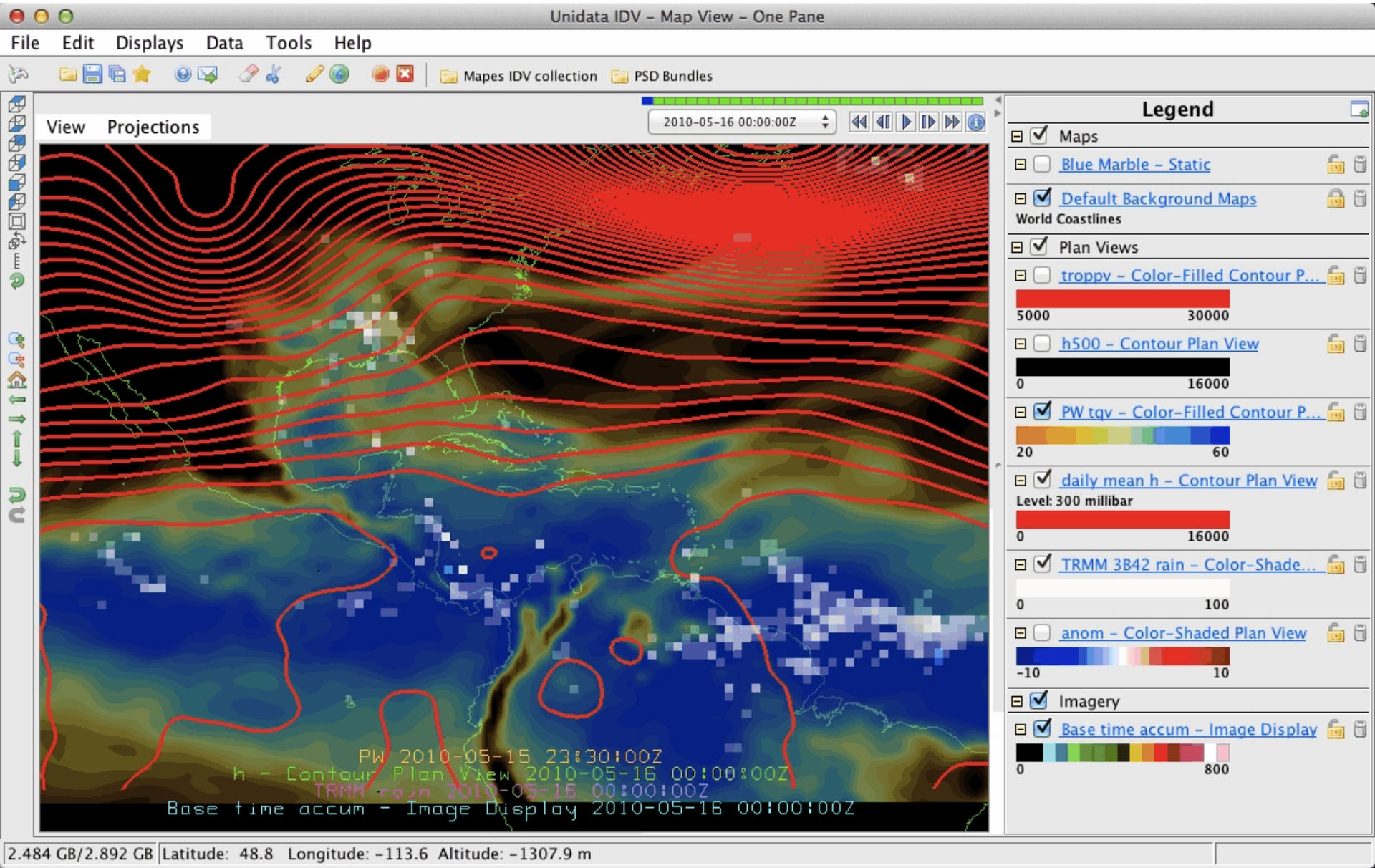
Z300 and vort300

800mb winds (& soon PW)

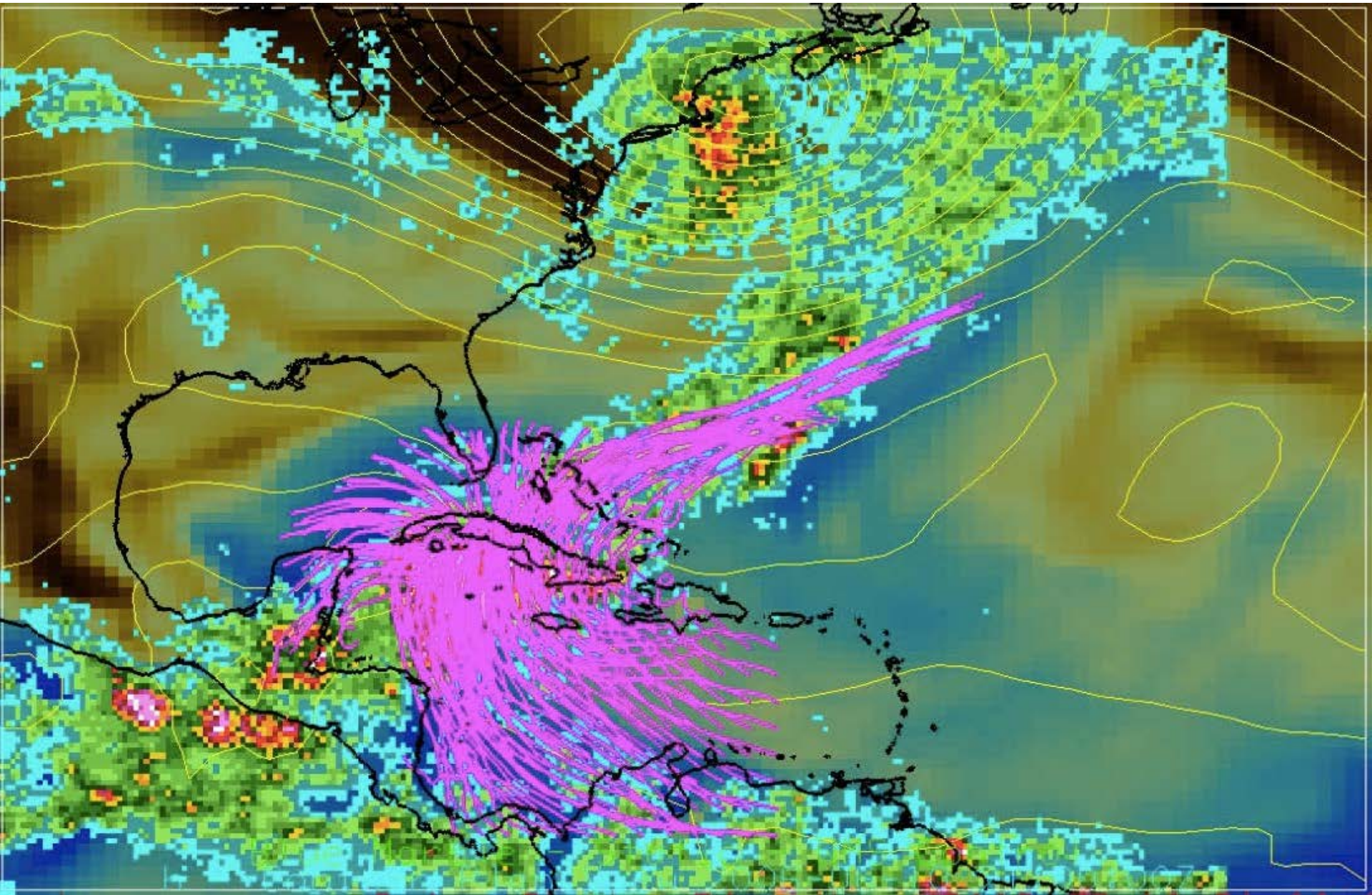



Unidata IDV – Map View – One Pane
File
Edit
Displays
Data
Tools
Help
Mapes IDV collection
PSD Bundles
View
Projections
2012-06-15 12:00:00Z
Blue Marble –
Default Backg
World Coastlines
Plan Views
relvort – Colo
Level: 250 mb
-5
Base time acc
Level: 0 m
20
phi – Contou
Level: 850 mb
-65
phi – Contou
Level: 250 mb
-65
precipitation
0
tqv – Color-S
4
3D Surface
Flow Displays
flowvectors –
Level: 850 mb
Color:
Cross section
Vertical Cross
IDV
20:00:02 GMT
Latitude: 29.5
Longitude: -68.8
Altitude: -4387.9 m

2010: Accumulation of daily



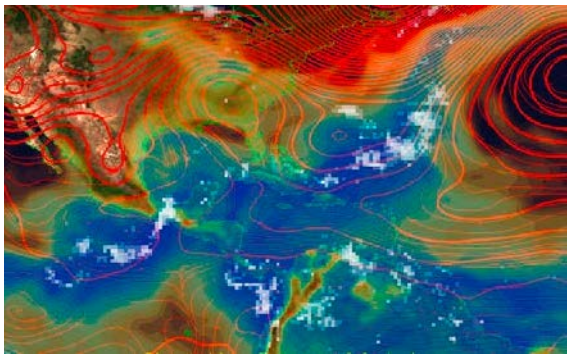
trajectory dy a useful clim. statistic?



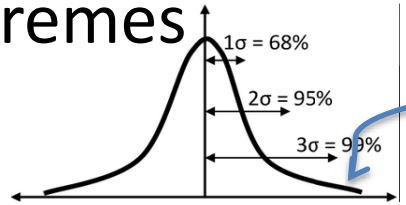
Linking weather to climate

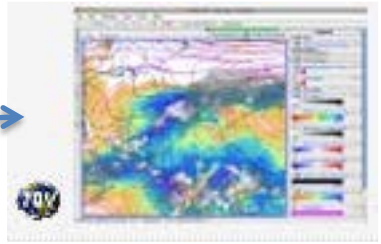
Examples (show n tell)

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



② Extremes





① Whole hurricane seasons

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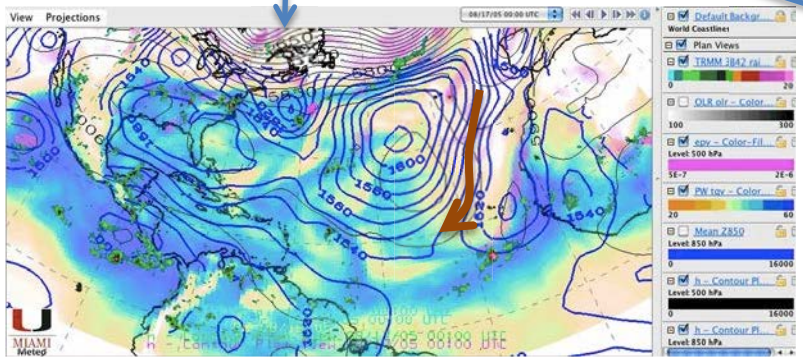
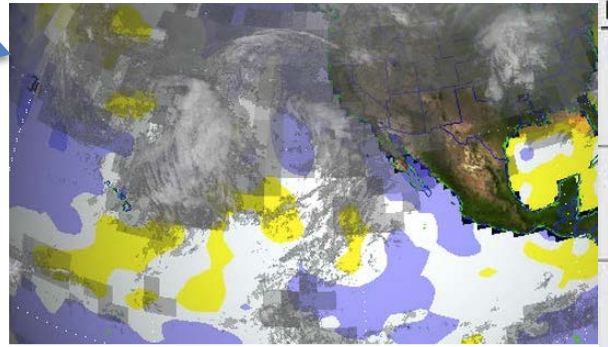
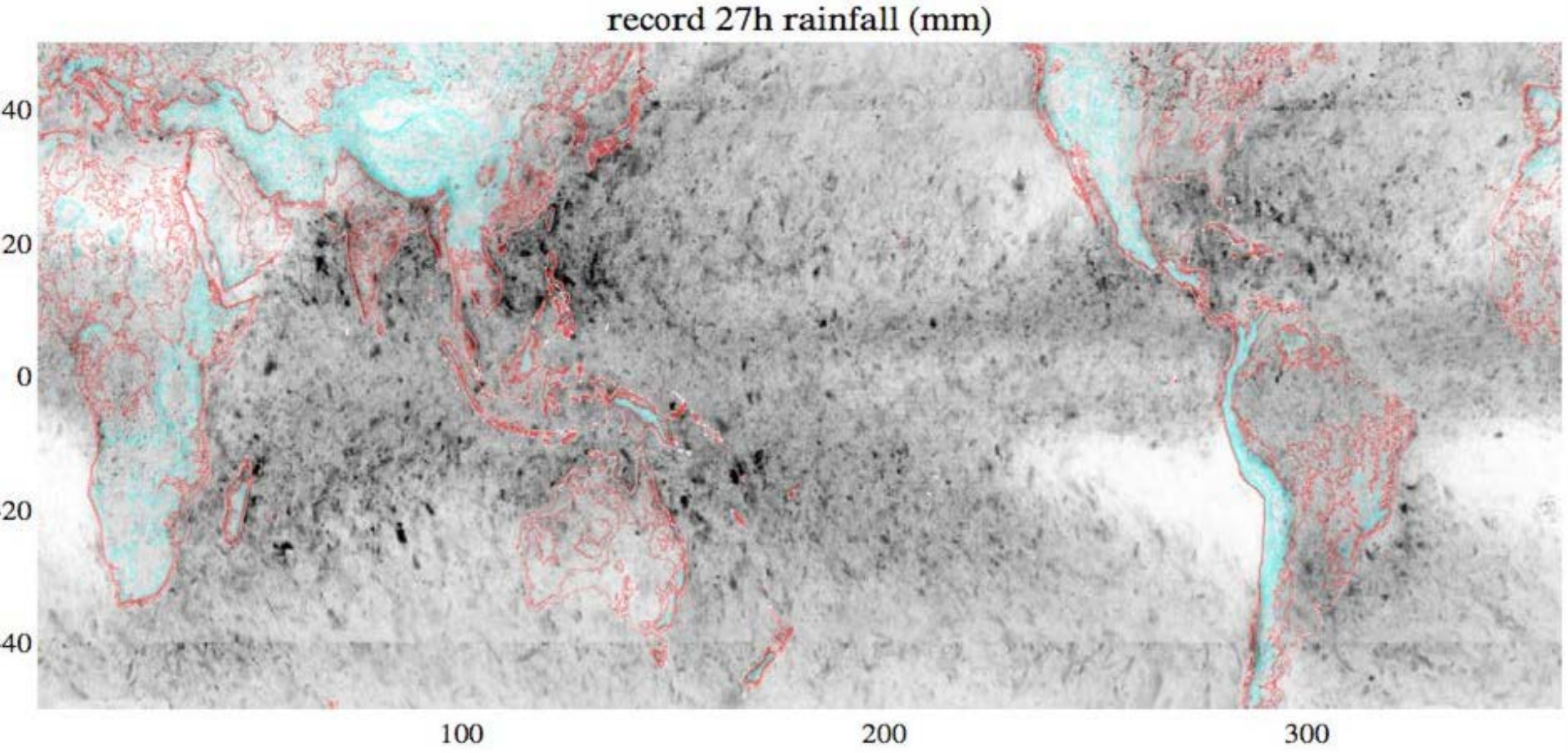


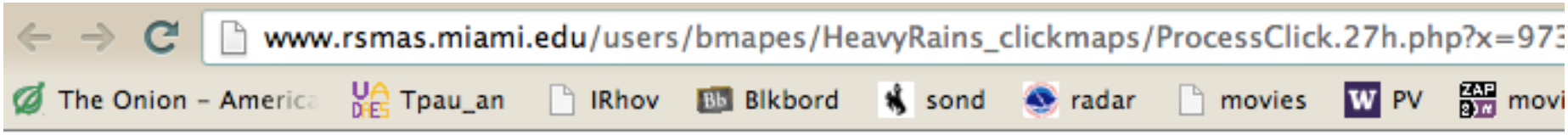


Click and pick: case studies of past decadal-record rain extremes



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

http://www.rsmas.miami.edu/users/bmapes/HeavyRains_clickmaps/index.html



Results of your click

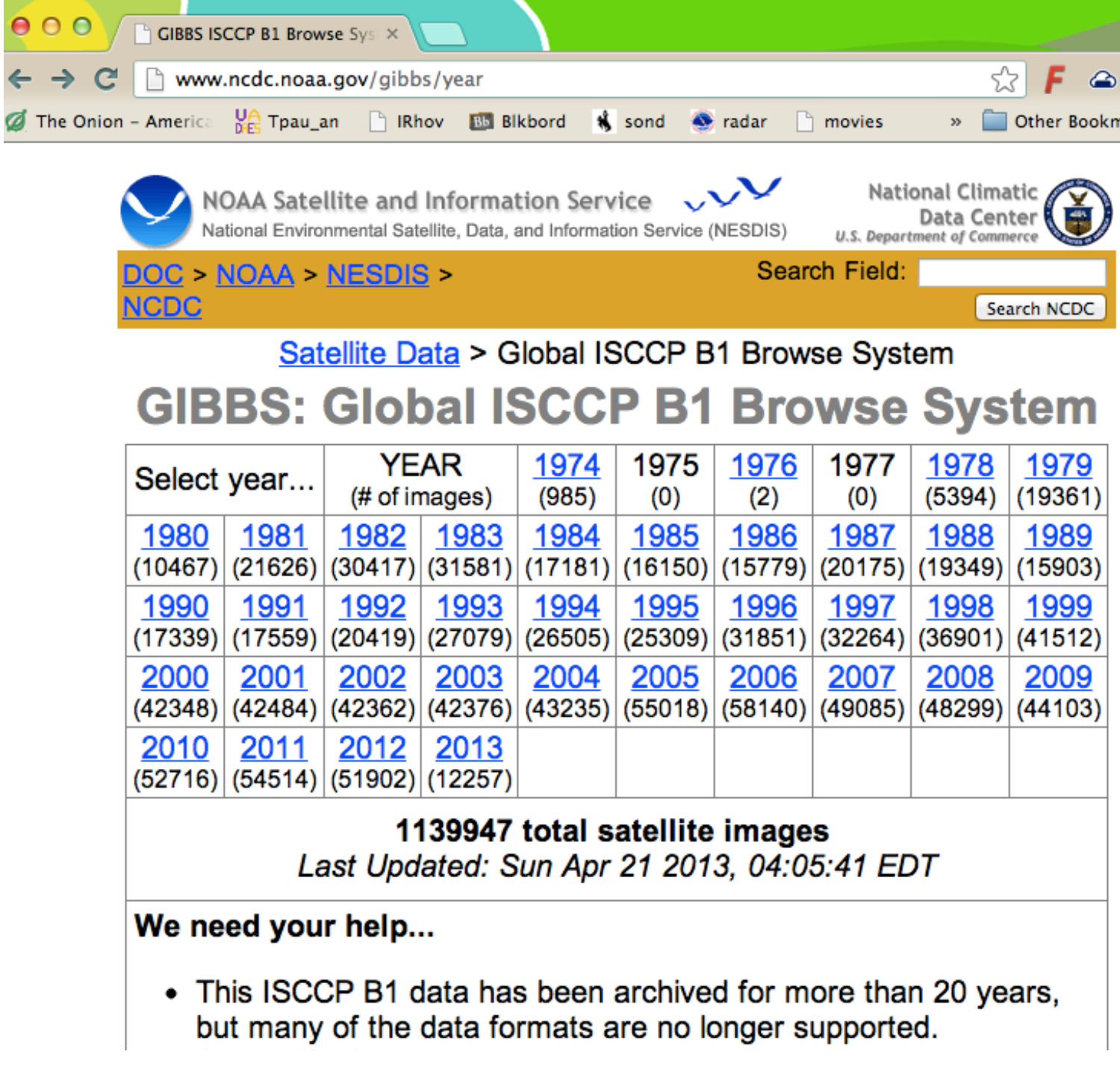
You chose the x,y point (486, 99).
Longitude 121.5, Latitude 25.125.
Your point has a record rainfall (in this dataset) of over 600 mm.

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

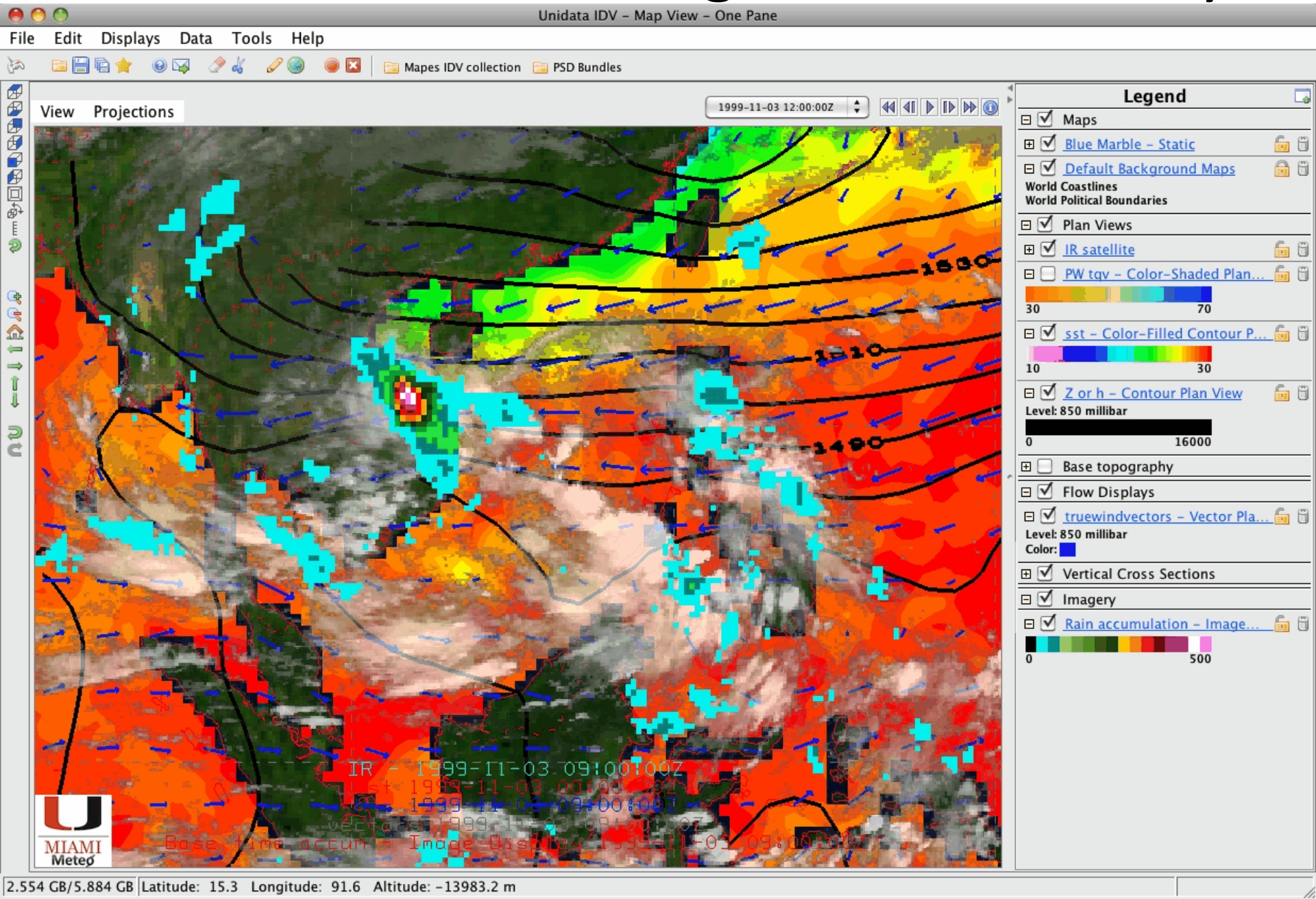
Want to see satellite imagery? Go here ←(GIBBS)

My Fave!

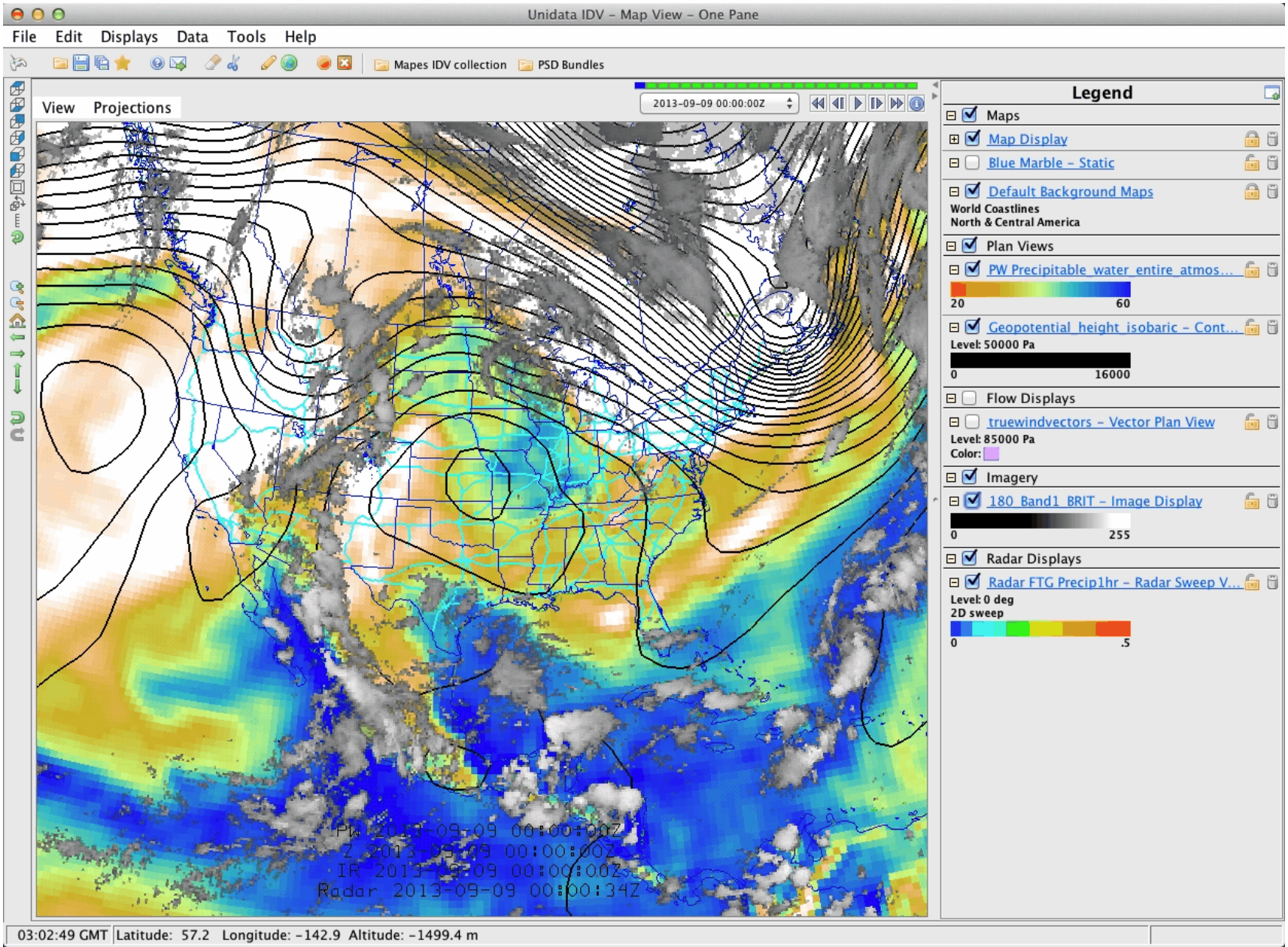
(Way back in like 2012)



Better than a few images – a case study!



Persistence of *pattern*- how measure?



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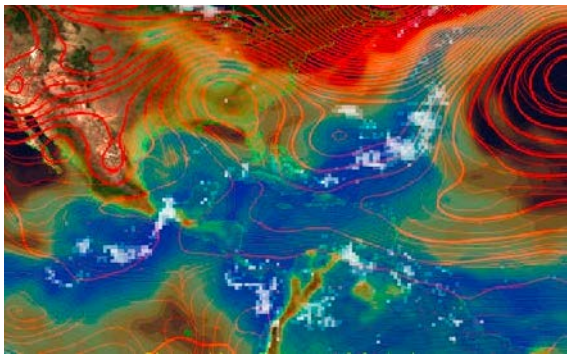
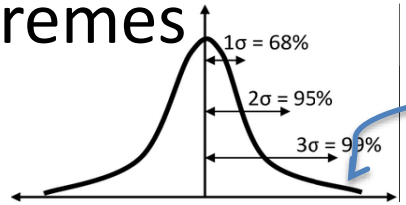
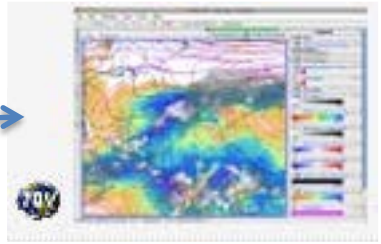


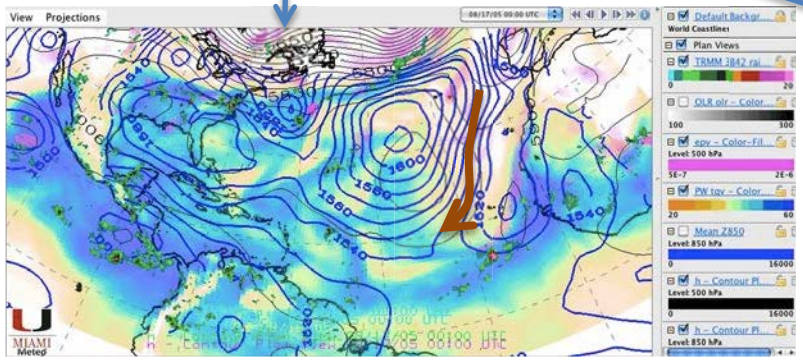
② Extremes

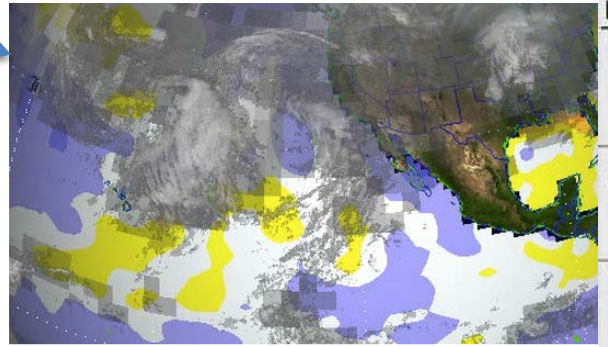




① Whole hurricane seasons

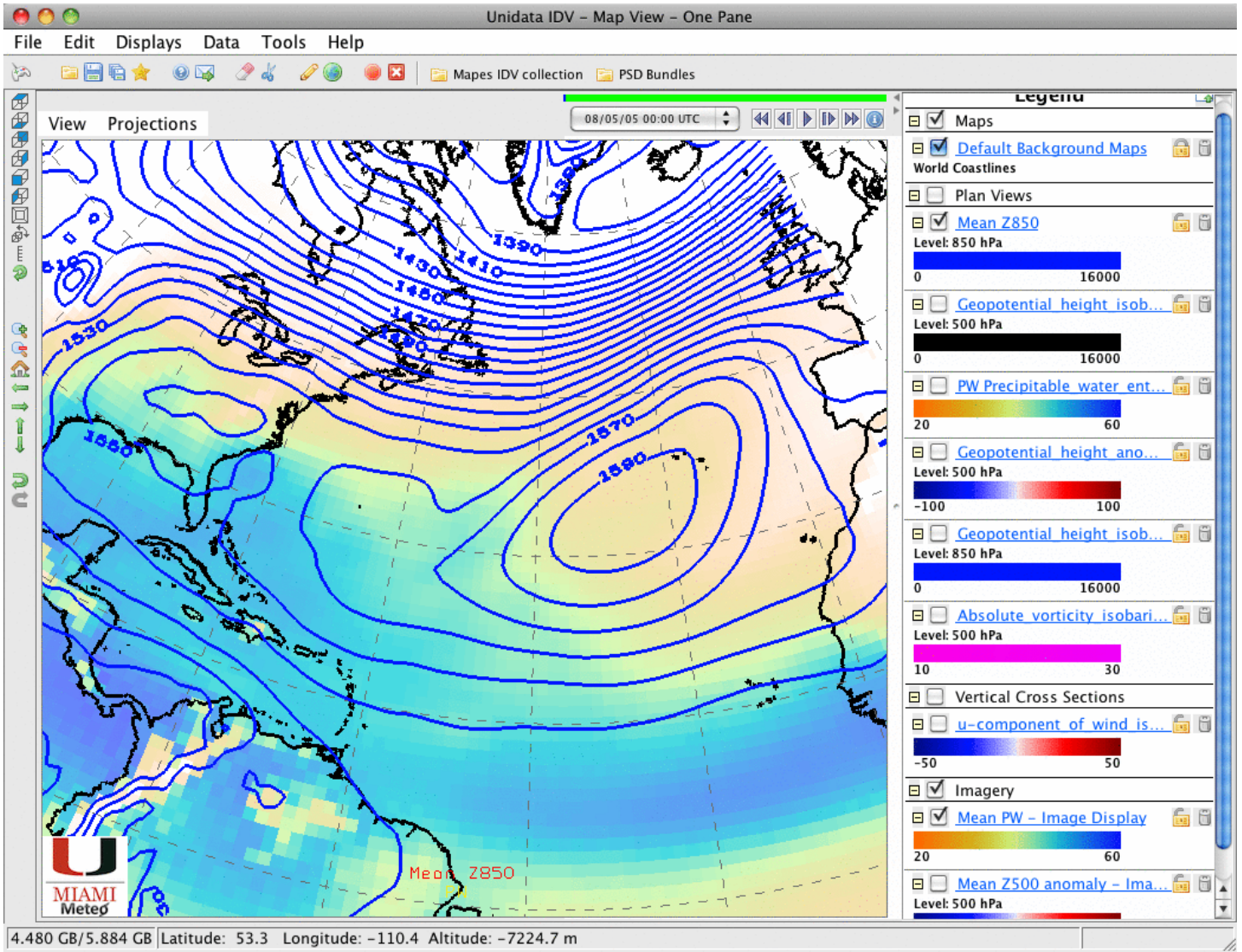
② Texture on hohum monthly anomalies (ENSO)



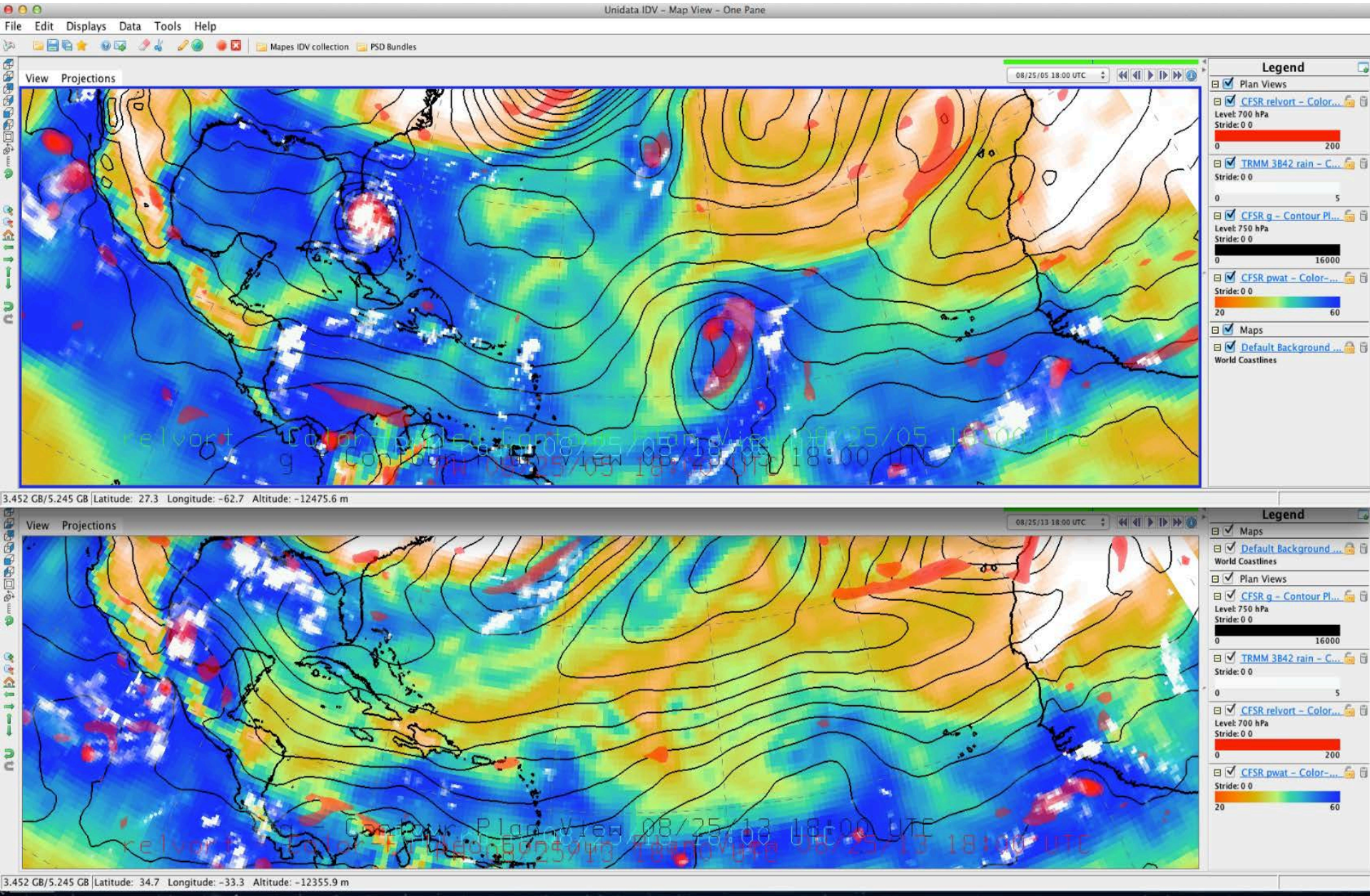


Whole hurricane seasons

- Dry injection? (trajectory length stats again?)

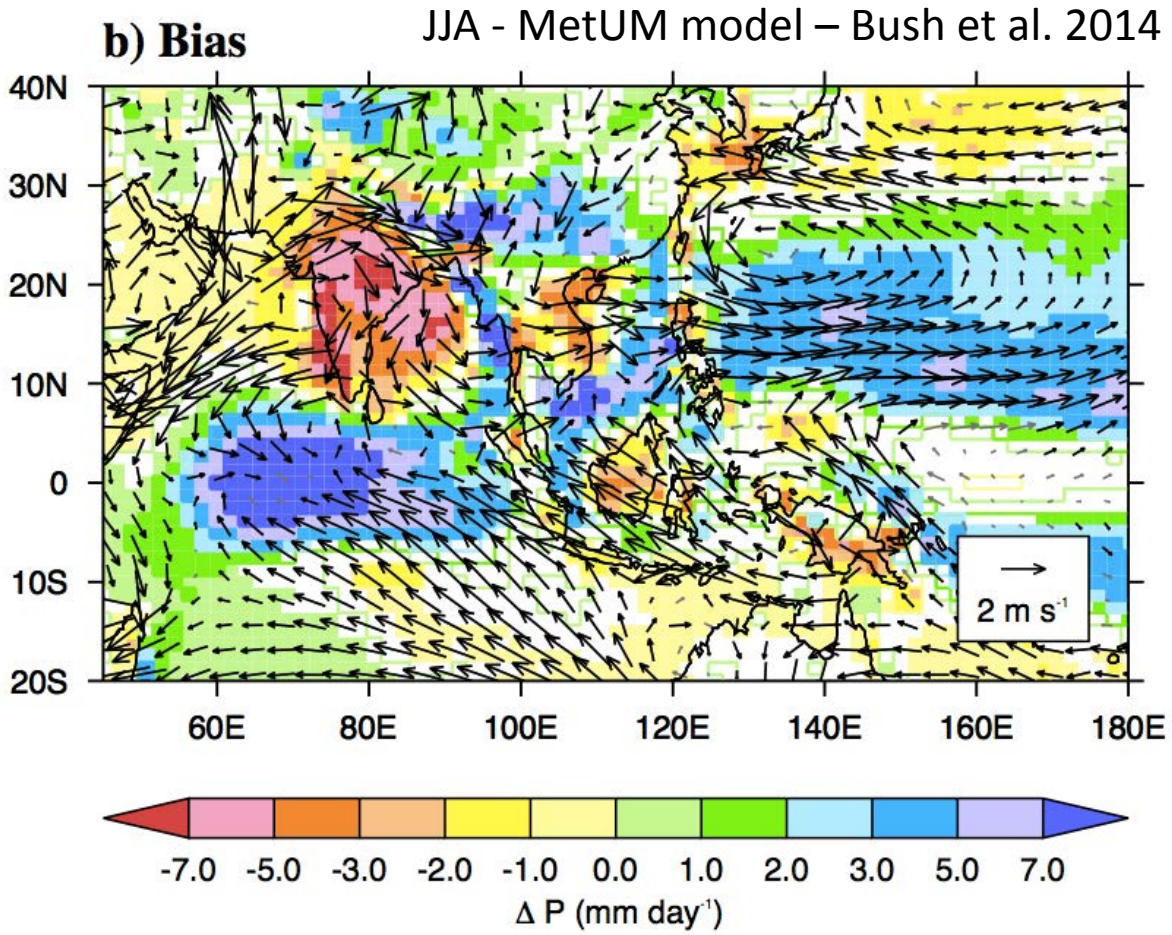


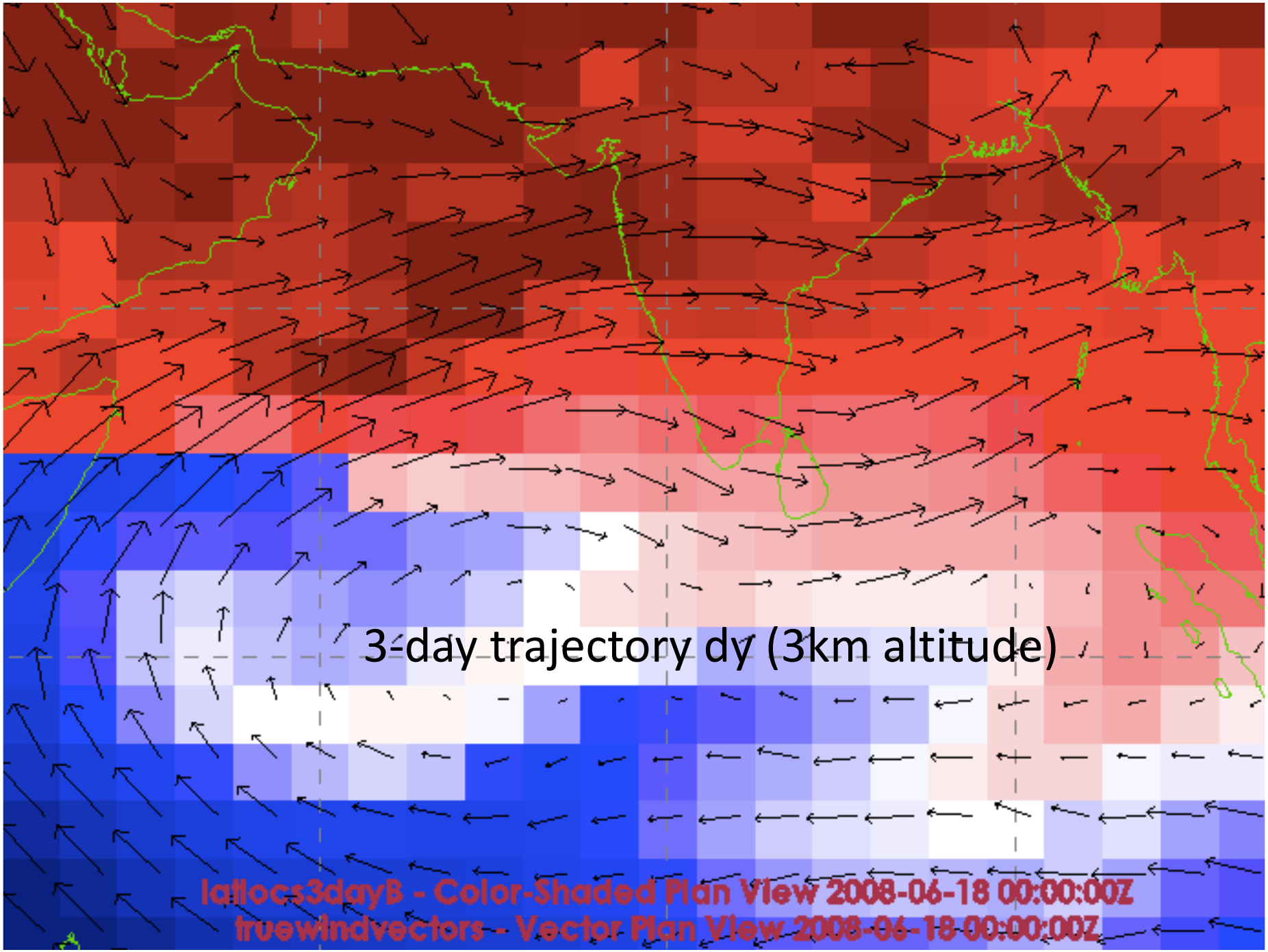
http://weather.rsmas.miami.edu/repository/entry/show/RSMAS-UM+Repository+for+atm-ocean+data+and+its+science/The+Mapes+IDV+collection/IDV+Bundles/Displays+of+remote+datasets+%28.xidv%29/4.+Historical+weather+cases/Oceans/2005-2013.AtlBasinHurrSeason.compareBIGLOOPS?entryid=c0ba4af1-5575-4c87-b711-70ad9f6457dd



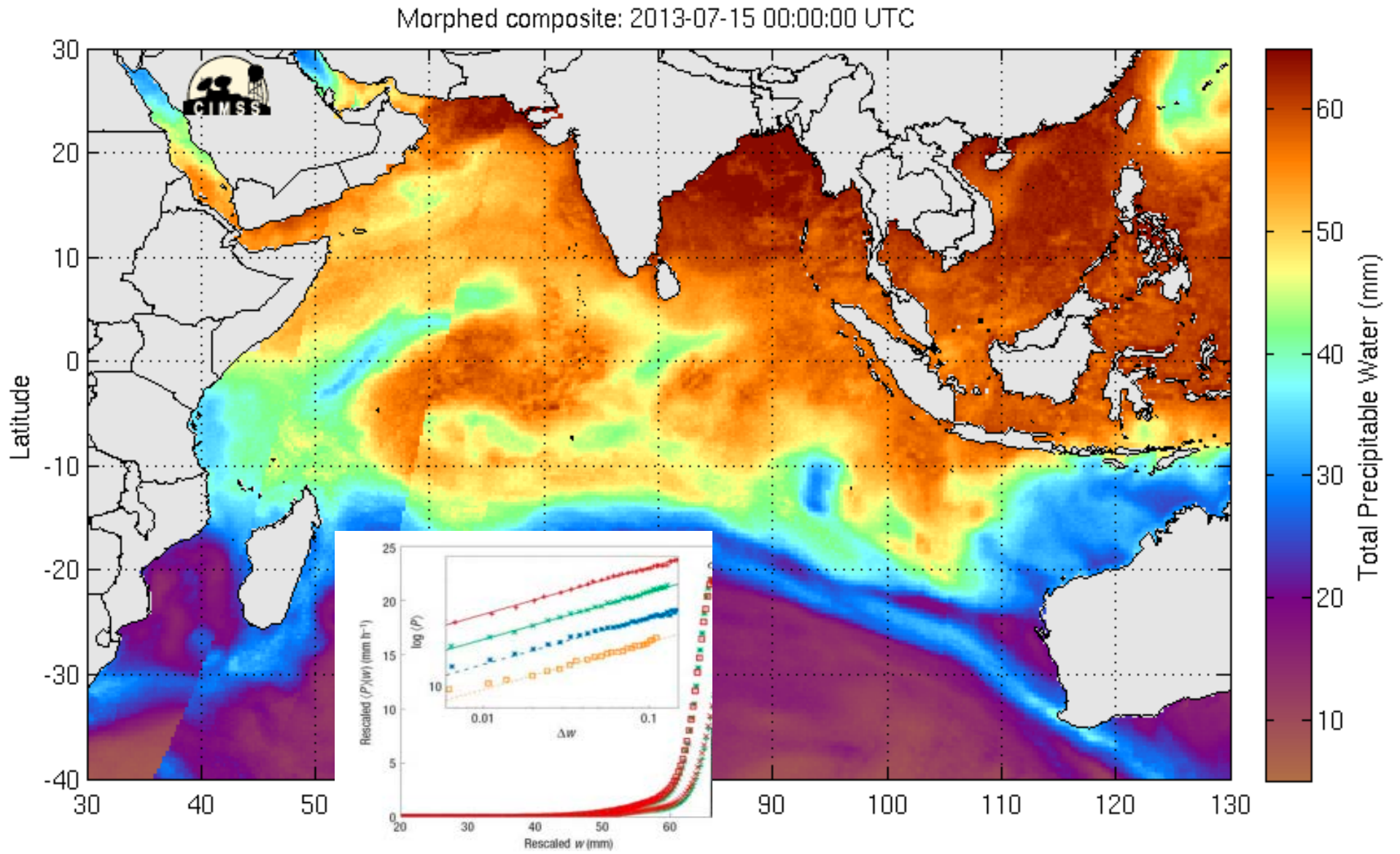
Trajectories, PW, and a climate error

- Common climate model bias pattern




3-day trajectory dy (3km altitude)
latlocs3dayB - Color-Shaded Plan View 2008-06-18 00:00:00Z
truewindvectors - Vector Plan View 2008-06-18 00:00:00Z

WEIO: natural laboratory of moisture-convection interaction



Moisture-limited west margin

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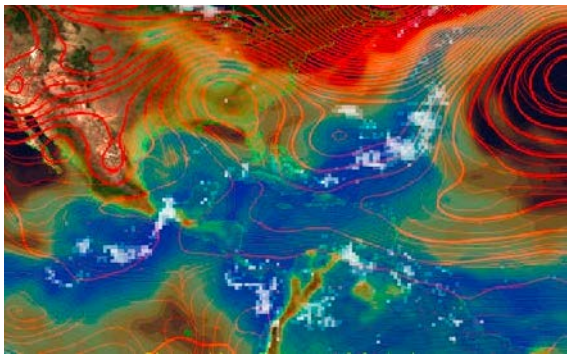
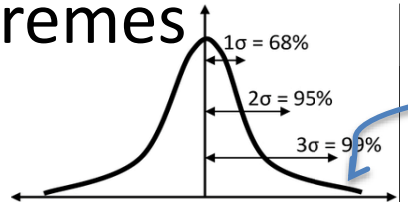
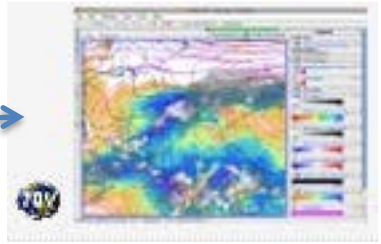


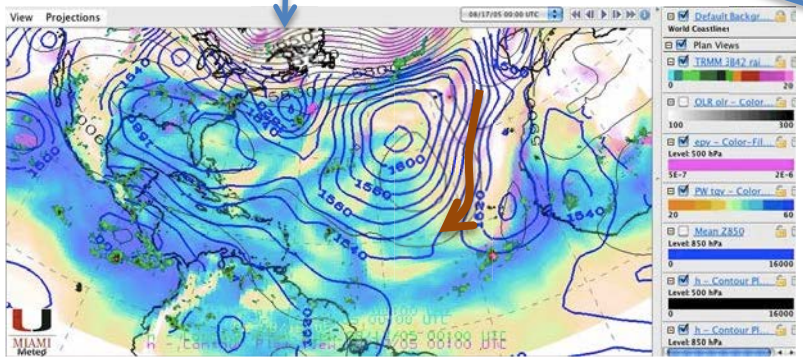
② Extremes

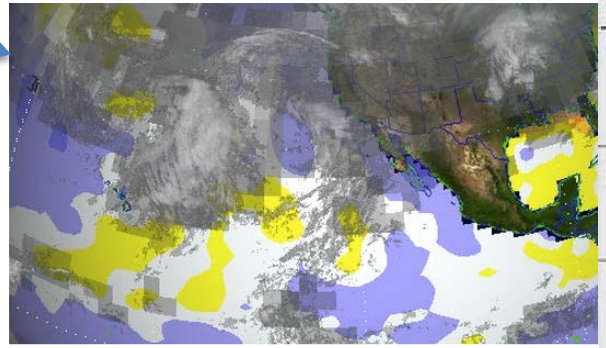


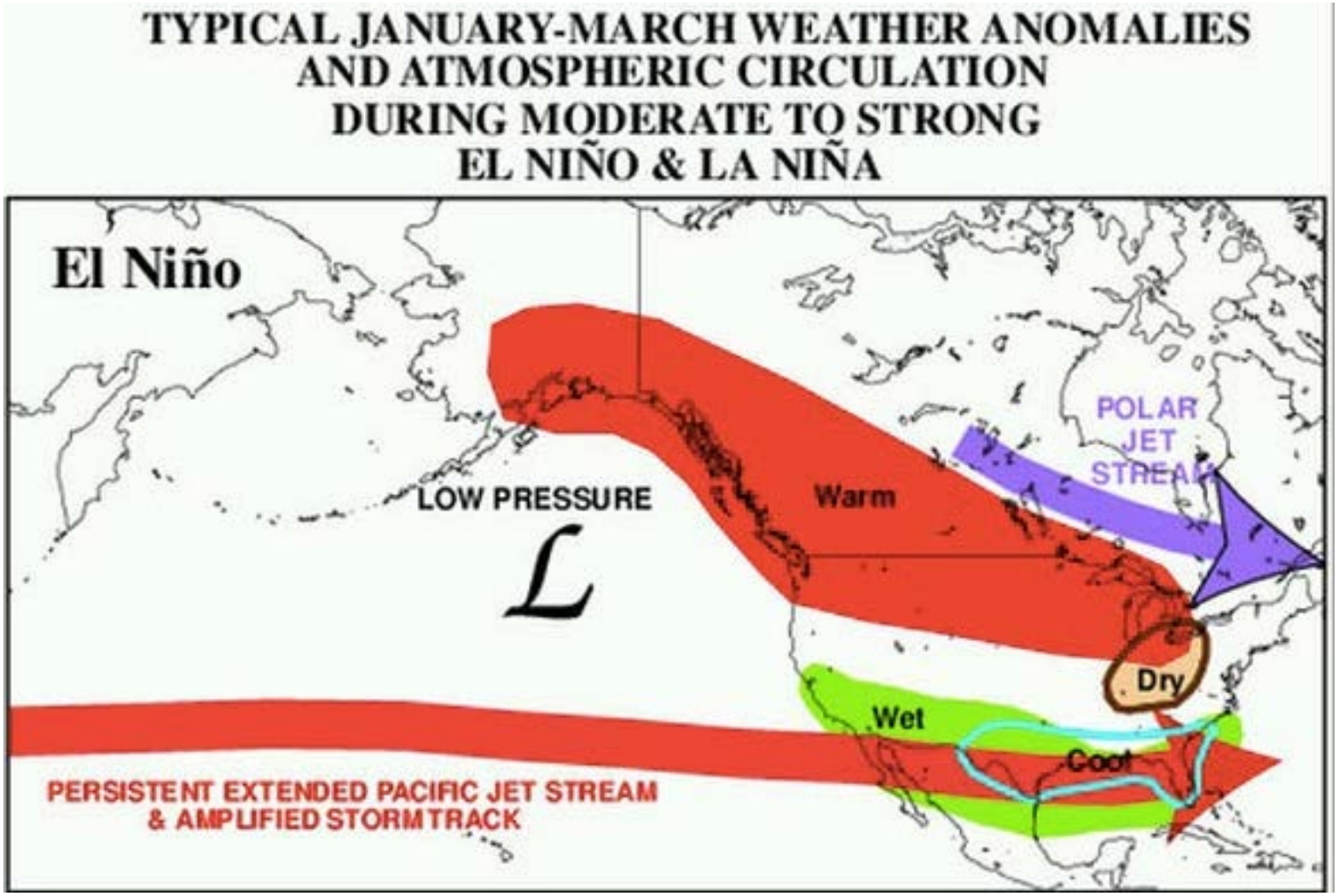


① Whole seasons

② Texture on hohum monthly anomalies (ENSO)



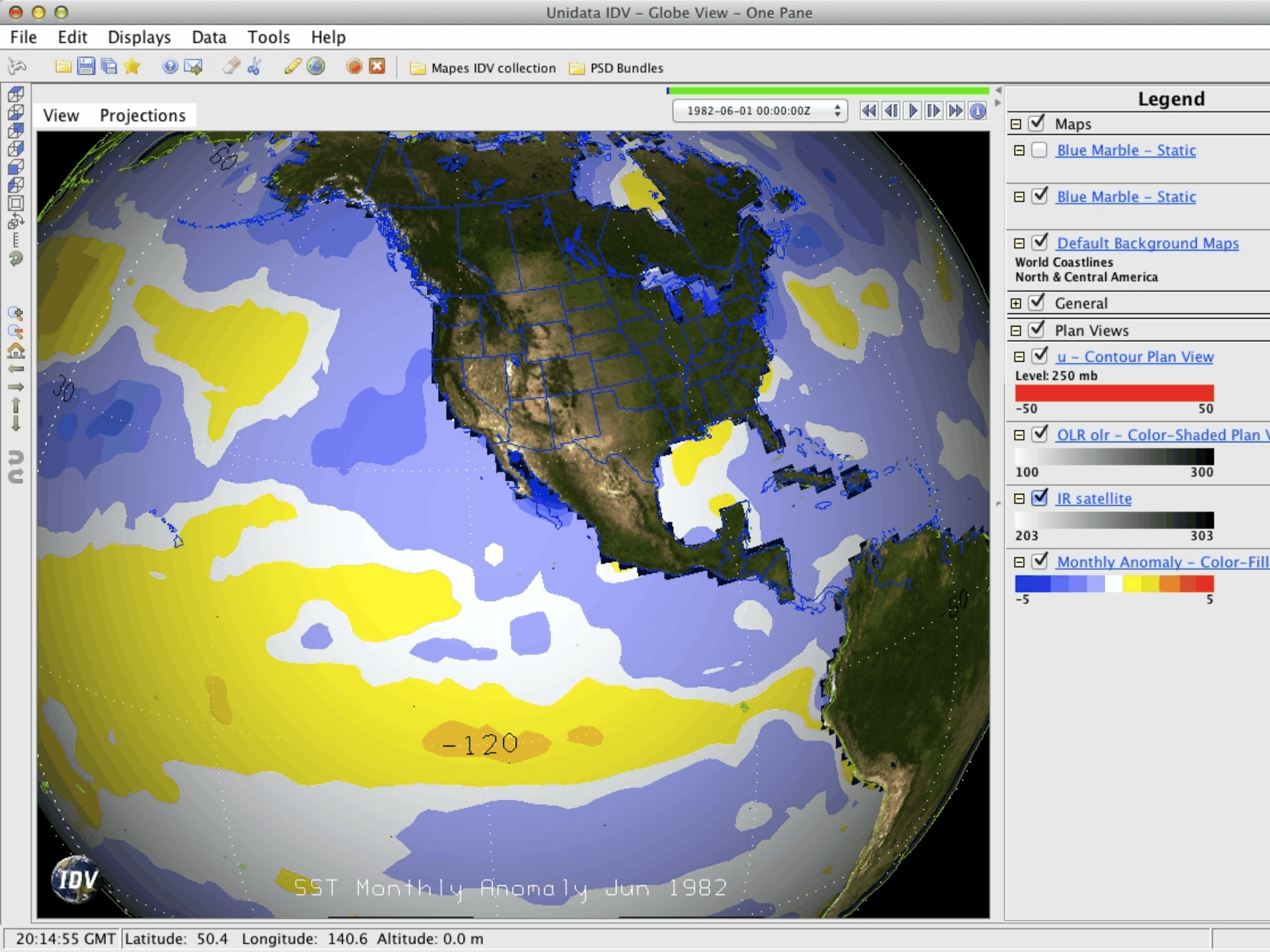




http://www.cpc.noaa.gov/products/analysis_monitoring/ensocycle/nawinter.shtml

Telescoping timeline

- Monthly SST anomalies
  - daily OLR and u (2.5deg)
    - 3-hourly IR sat (0.1 deg) on top
  - daily OLR and u (2.5deg)
- Monthly SST anomalies


Unidata IDV - Globe View - One Pane
File
Edit
Displays
Data
Tools
Help
Mapes IDV collection
PSD Bundles
View
Projections
1982-06-01 00:00:00Z
Legend
Maps
Blue Marble - Static
Blue Marble - Static
Default Background Maps
World Coastlines
North & Central America
General
Plan Views
u - Contour Plan View
Level: 250 mb
-50
50
OLR olr - Color-Shaded Plan V
100
300
IR satellite
203
303
Monthly Anomaly - Color-Fill
-5
5
60
30
-120
SST Monthly Anomaly Jun 1982
IDV
20:14:55 GMT
Latitude: 50.4
Longitude: 140.6
Altitude: 0.0 m

Software and process glimpse

The IDV: take a breath, get an orientation.

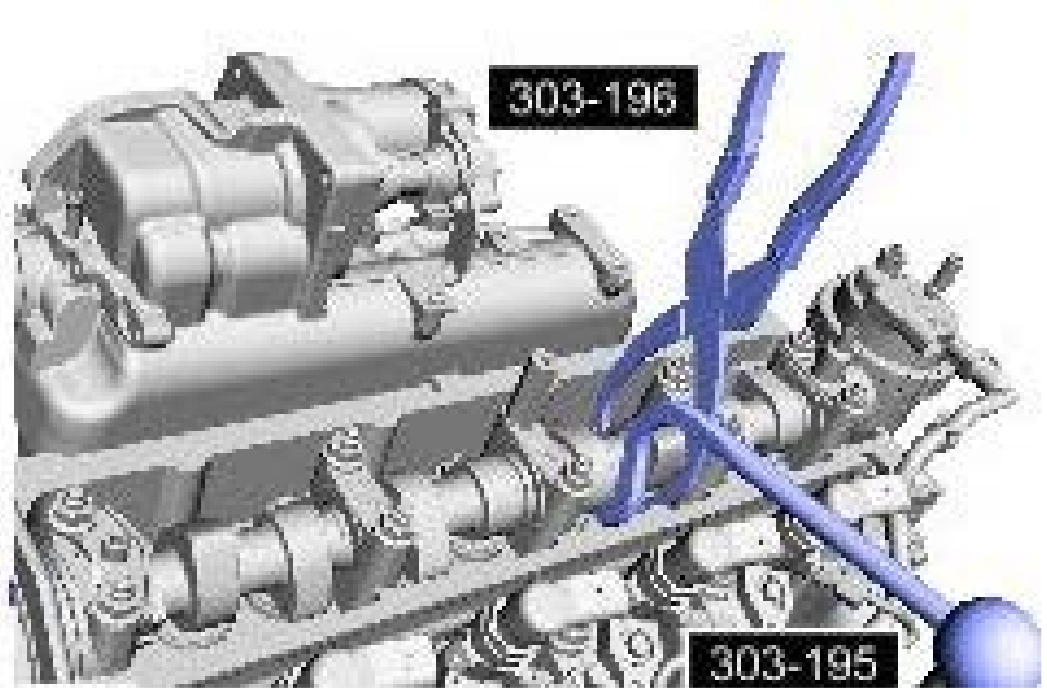
←It is this

←(with a few parts more like this)

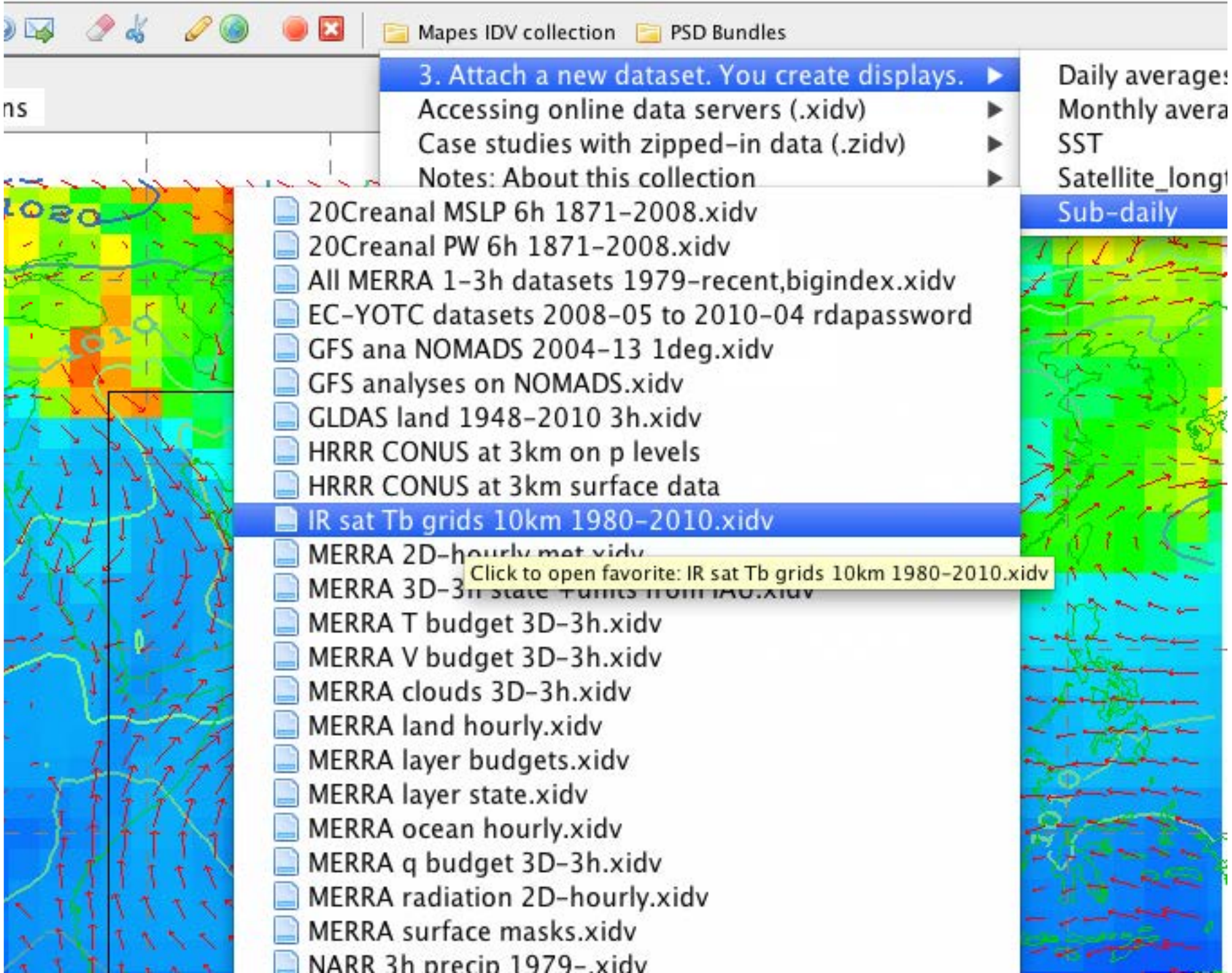
Not this→

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.


Mapes IDV collection
PSD Bundles
3. Attach a new dataset. You create displays.
Accessing online data servers (.xidv)
Case studies with zipped-in data (.zidv)
Notes: About this collection
Daily average
Monthly avera
SST
Satellite_long
Sub-daily
20Creanal MSLP 6h 1871-2008.xidv
20Creanal PW 6h 1871-2008.xidv
All MERRA 1-3h datasets 1979-recent,bigindex.xidv
EC-YOTC datasets 2008-05 to 2010-04 rdapassword
GFS ana NOMADS 2004-13 1deg.xidv
GFS analyses on NOMADS.xidv
GLDAS land 1948-2010 3h.xidv
HRRR CONUS at 3km on p levels
HRRR CONUS at 3km surface data
IR sat Tb grids 10km 1980-2010.xidv
Click to open favorite: IR sat Tb grids 10km 1980-2010.xidv
MERRA T budget 3D-3h.xidv
MERRA V budget 3D-3h.xidv
MERRA clouds 3D-3h.xidv
MERRA land hourly.xidv
MERRA layer budgets.xidv
MERRA layer state.xidv
MERRA ocean hourly.xidv
MERRA q budget 3D-3h.xidv
MERRA radiation 2D-hourly.xidv
MERRA surface masks.xidv

RSMAS-UM Repository for atm-ocean data and its science > The Mapes IDV collection

The Mapes IDV collection

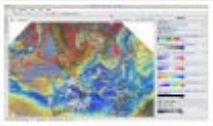
Welcome to the "back office" of the Ma

Please see http://www.rsmas.miami.ed

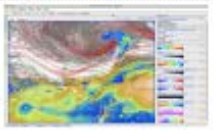
for the project's front face (a normal We

- Aggregations for more convenie
- IDV Bundles
  - 3. Attach a new dataset. You
  - Accessing online data servers
    - 1. Favorite current-weather
    - 2. Templates at 1 time. You
      - Current weather sources
      - Past weather archives
        - Americas-North

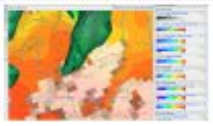
1888 "Schoolhouse Blizzard" 20Cv2 reanalysis



GFS 1deg vort PW SfcT TRMMrain 1999-now



MERRA,IR,TRMM



Subtropical upper jet-front in MERRA 2002-05-23

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, mix
  - Divide
  - Frontogenesis function from theta and the wind
  - Gaussian weighted hor. smoothing (default N=6

Stride | Settings

- 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 bluered 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 knowedge (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?