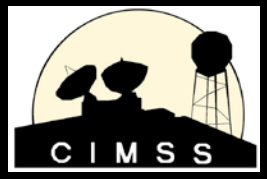
Utilizing Python as a scripting language for the McIDAS-V visualization package



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Quick Overview of McIDAS-V

- Free, open-source 3D visualization package under active development at SSEC/CIMSS
- Focused on meteorological data, but not limited to it
- User support provided by the McIDAS User Group (MUG) – ***anyone can create an account on the forum and get help!***
- Java-based architecture; ***easy to install on Windows/OSX/Linux***
- Based on several components (details coming)

McIDAS-V Supported Data

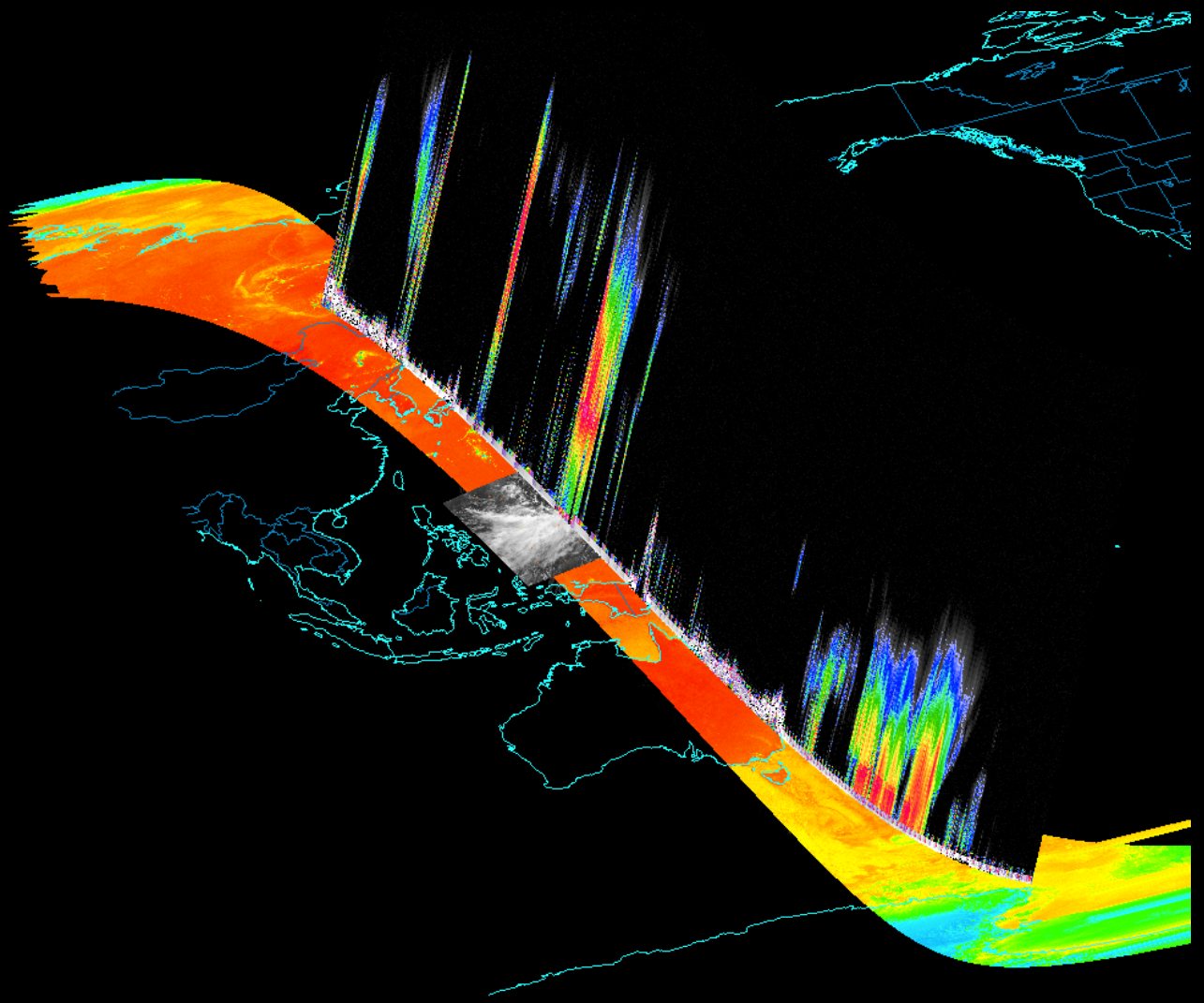
- Many supported data types:
  - Point data
  - Numerical weather model output in various formats (GRIB2, netCDF, GEMPAK, and more)
  - Satellite imagery, including hyperspectral via HYDRA
  - Radar (especially NEXRAD)
  - netCDF files that conform to CF conventions
  - Remote data access via ADDE, THREDDS
  - Lots more

McIDAS-V Functionality

- Data choosers let the user put any combination of these data into a display, then manipulate the display interactively
- Display is fully three-dimensional – especially useful for conventional radar as well as cross sections from e.g., CloudSat and CALIPSO

Example Image produced by McIDAS-V: putting the A-train in a single display!

- CloudSat vertically pointing cloud radar
- 89GHz vertically polarized brightness temperatures from AMSR-E
- 0.65 um reflectance from MODIS



Thanks to Prof. Ralf Bennartz (Vanderbilt/SSEC) for help producing this image

Quick History of McIDAS-V

- "Fifth-generation McIDAS" – the successor to McIDAS-X (though codebase is almost completely unrelated)
- Based on several components:
  - ***VisAD*:** Java component library for visualization of virtually any numerical dataset, developed at SSEC
  - ***Integrated Data Viewer (IDV)***: Extension of VisAD providing support for meteorological data sources and adding a GUI interface, developed at Unidata
  - ***HYperspectral-viewer for Development of Research Applications (HYDRA)***: Extension of VisAD focused on visualization of hyperspectral satellite data, developed at SSEC

In a nutshell, ***McIDAS-V*** is an extension of the IDV and VisAD that incorporates HYDRA and adds other features like Suomi NPP support, a dedicated support team, and…

- ***A new Jython scripting API !***
  - Under active development at SSEC
  - McIDAS-V previously had some scripting capabilities, but:
    - limited functionality
    - “Un-Pythonic”
  - New API is designed from ground up to ease automation of common workflows in McIDAS-V via a user friendly and well documented API.

Current status of scripting API

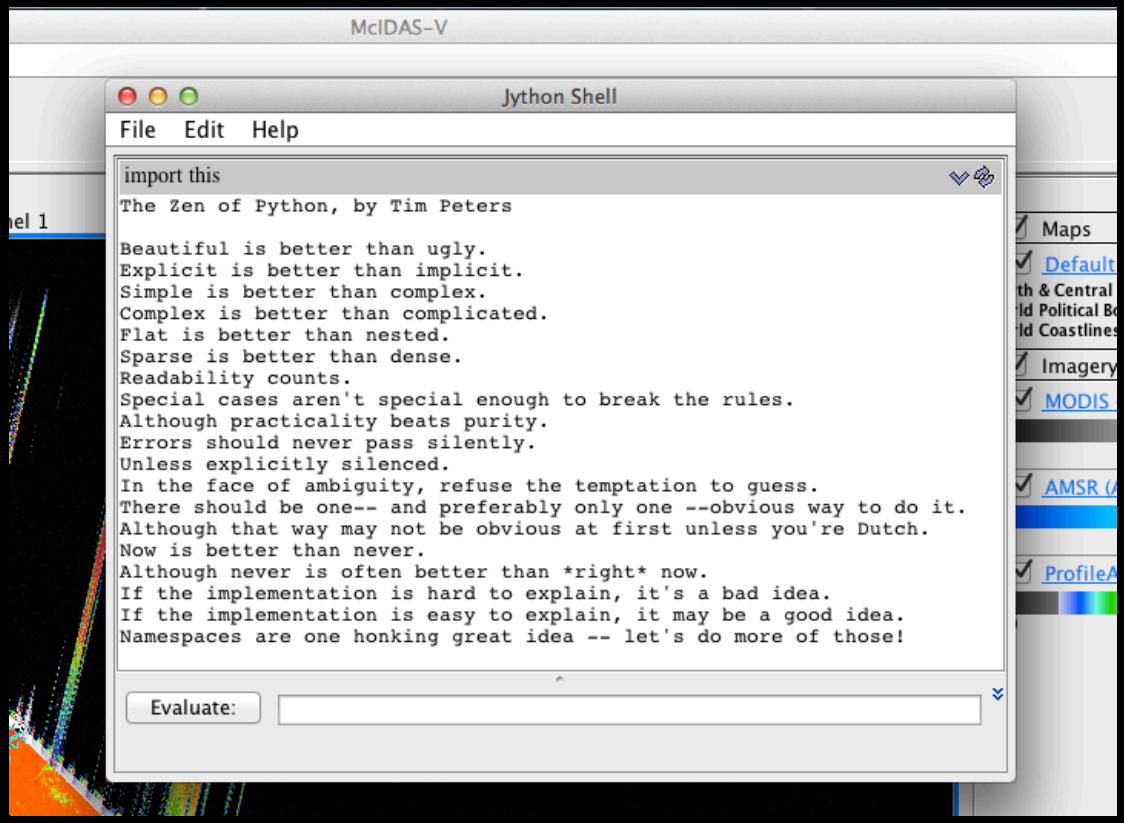
- McIDAS-V version 1.2, released in April 2012, included the first version of this new scripting functionality.
  - So far we have focused primarily on access to satellite imagery via ADDE
  - Extensive tutorials and documentation available on McIDAS-V website
- Scripting framework continues to be heavily developed. 1.3 and 1.4 releases include some new functionality:
  - **listADDEImages (find out what is on the server without downloading images)**
  - **Jython Shell improvements (keyboard shortcuts, easier to run scripts that are on disk)**
  - **Numerous stability improvements**

McIDAS-V scripting overview

- Users write scripts in the Python programming language
- Python scripts are interpreted in the Java-based McIDAS-V system via Jython, an implementation of the Python programming language in Java
- In addition to our new API, advanced users can call any piece of Java code in the McV/IDV/VisAD library. ***(Without having to actually write Java code).***

Users can run scripts in two modes:

- ***Interactively***: in a normal session of McIDAS-V by typing commands in the "Jython Shell"
- In the ***"background"***: from a terminal session. McIDAS-V boots, runs a script, and closes



Interactive mode

Simple example script

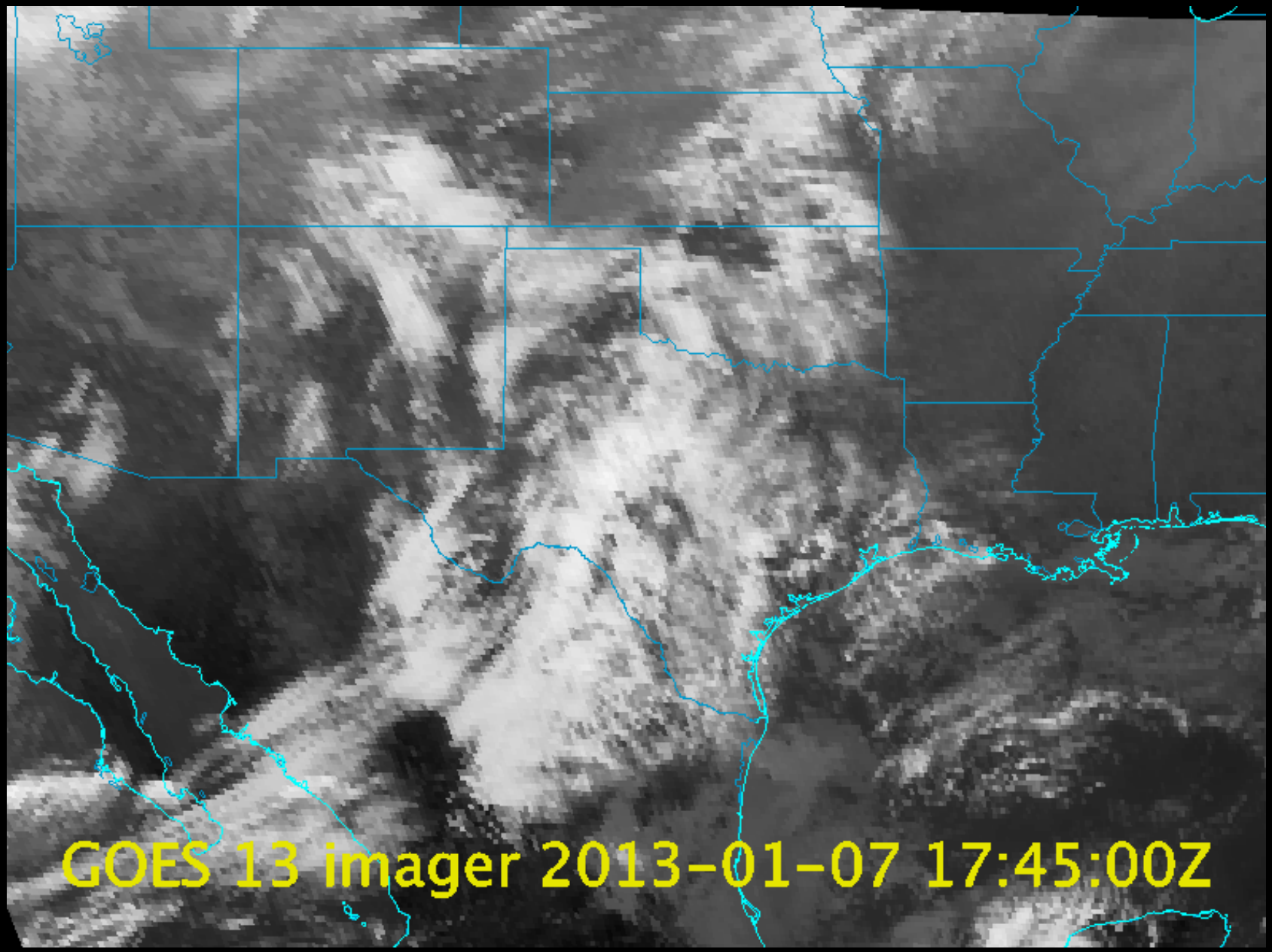
- Use the “getADDEImage” function* to get some satellite imagery.
- Put the data in a display.
- Add a descriptive label using metadata from ADDE.
- Change the map projection.
- Write out the image as a PNG.

- *(ADDE: Abstract Data Distribution Environment. Used heavily in McIDAS-X world. Main advantage: can get exactly the part of an image you need, nothing more.)

Example script.

austin_ir.py (~/Desktop/hiley_amspython_vscripting) – VIM

```
31 # specify the properties of the desired image.
30 params = dict(
29     # some ADDE-specific terminology is used here.
28     server='adde.ucar.edu',
27     dataset='RTIMAGES',
26     descriptor='GE-IR',  # GOES-EAST IR.
25     location=(30.2, -97.7),
24     place=Places.CENTER, # specify lat/lon of the center of the image.
23     size=(158, 332),     # number of pixels we want in x,y direction.
22     mag=(-3, -2),        # the "magnification", to skip pixels
21     position=0,          # gets the latest image
20     band=4,
19 )
18
17 # get a new 800x600 window.
16 window = buildWindow(height=600, width=800)[0]
15
14 # get the satellite image.
13 data = getADDEImage(**params)
12
11 # put the satellite image in the window.
10 layer = window.createLayer('Image Display', data)
 9
 8 # add a layer label using satellite metadata using Python dictionary syntax.
 7 label = "%s %s" % (data['sensor-type'], data['nominal-time'])
 6 layer.setLayerLabel(label, size=32, color='orange')
 5
 4 # change the projection.
 3 window.setProjection('US>States>N-Z>Texas')
 2
 1 # save the image.
 0 window.captureImage('/Users/mhiley/austin_IR.png')
~
austin_ir.py                                    32,6          All
```


GOES 13 imager 2013-01-07 17:45:00Z

API Design - principles

- Functions and methods should be named well so they have a predictable result
- Anywhere an arbitrary string is required - for example when specifying display type (image, contour, streamlines, etc.) – the user should be able to use the same strings found in the GUI labels
- Pythonic syntax wherever feasible

API design – key classes

- ***_Data:*** a piece of data, e.g. *u* and *v* model winds
  - Key metadata can be accessed via Python dictionary syntax
  - Can perform statistical analysis, do arithmetic operations, etc.
- ***_Layer:*** A piece of data that has been displayed (e.g. a streamline display of the model winds)
  - Can change some key layer properties like enhancement table
- ***_Window:*** A combination of multiple layers, e.g. wind streamlines plotted on top of a satellite image
  - Some key per-display properties you can set:
    - Display size
    - Lat/lon center point of image
    - Map projection
  - Can add text annotations and write image to disk

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```

Challenges – Implementation of new scripting API

- The foundation of the McIDAS-V codebase, the IDV, ***was built primarily as a GUI-based system***. For us developers, providing scripting-based access to IDV features can be challenging.
- But – this is precisely why our work is important – to shield end users from these complications!

Challenges – Jython limitations

- ***Current "final" release is only Jython 2.5.3***; Jython 2.7 is under development and it is unclear if we will see a Jython 3. (***Current stable CPython is version 3.3***).
- ***No NumPy!***
- Jython code significantly slower than native Java code.

Challenges – facilitating data analysis

- In McIDAS-V, all data is internally represented using the "***VisAD Data Model***": a generic way of representing virtually any scientific dataset
- We want scientists to do data analysis and algorithm development in McIDAS-V, but that means scientists need to learn this ***"VisAD Data Model"***, which can be seen as a pro or a con:
  - ***PRO:*** VisAD provides a powerful way to manipulate/analyze a huge variety of data types ***in a uniform way.***
  - ***CON:*** The VisAD learning curve can be steep (VisAD lingo can seem strange to scientists coming from a MATLAB/IDL world)
- ***Part of our work will be to fill the gap between VisAD and traditional science code however we can…*** solid documentation, helper functions, boilerplate scripts, user forum support

Conclusion

- ***New McIDAS-V scripting API*** promises to provide consistent access to a wide variety of meteorological data sources using the Python programming language.
- ***First edition of this scripting framework was introduced in version 1.2, and heavy development has continued since, and will continue for the foreseeable future.***
- ***McIDAS-V already has a wide variety of powerful tools available for both visualization and data analysis.*** Access to these tools via scripting will get better with every release.

Things you can do right now!!!

- Install McIDAS-V; it's easy and works on Windows/OSX/Linux; available for free at:
  - http://www.ssec.wisc.edu/mcidas/software/v/
- Create an account on the ***McIDAS-V support forum*** to get help from the developers, support team, and other users!:
  - http://dcdbs.ssec.wisc.edu/mcidasv/forums/

Thanks for listening!

Acknowledgements:

- McIDAS-V core "scripting team"
  - Becky Schaffer
  - Jonathan Beavers
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  - Tom Whittaker
  - Tommy Jasmin
  - Dave Santek
  - Jay Heinzelman
  - Barry Roth
- Users that keep pushing the boundaries of McV scripting:
  - Joleen Feltz
  - Hans-Peter Roesli (EUMETSAT)