Data Fusion Visualization for NASA CAMP²Ex Field Campaign

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Abstract

NASA aircraft-based field campaigns, such as CAMP2Ex, deploy many instruments to study atmospheric properties -- aerosols, chemistry, cloud droplet sizes and so on. Data users are accustomed to viewing and analyzing the archived results from individual instruments.

But, data fusion is good! Data can be more useful - and archives more valuable - if corresponding measures across instruments can be easily seen in context together. (Where sulfate levels are high, is there a shift in droplet sizes, or in precipitation, or in incoming sunlight? Where did that happen?) Our collaboration of atmospheric science researchers and visualization people created a prototype synoptic dashboard visualization of one day's flight, animating 70+ aircraft and satellite measurements in 2D and 3D. We look forward to building better tools.

CAMP²Ex ?

The CAMP²Ex (Clouds, Aerosol and Monsoon Processes-Philippines Experiment) NASA-funded field study focusing on scientific questions: How do aerosols (pollution, smoke, salt) influence tropical precipitation? Do aerosol-induced changes in clouds and precipitation feed back to affect aerosols? How do aerosol particles and clouds influence the energy budget?

This involved coordinated observations from multiple platforms: two aircraft, a NASA P-3 and a SPEC Learjet; ground-based aerosol observations; and satellite imagery. Flights spanned during about ten weeks in Aug-Oct 2019, primarily over the ocean surrounding the Philippines, and included flying over, under and through convective cloud systems. The P-3 in particular carried instruments from about 18 different investigators. Data from this and other field campaigns are publicly archived (www-air.larc.nasa.gov). The global science team numbers over 100 researchers.

Prototype CAMP2Ex Dashboard

3D in Context

Forward camera

Nadir camera

Zenith dome camera

- aircraft + track
- HSRL "curtain"
- APR3 precip. radar
- AMPR radiometer
- Himawari optical

aircraft and altitudes not to scale

P-3 track over "day natural" (cyan=ice) Himawari image + satellite swaths

Ditto over 11μm brightness temp. + aerosol optical thickness

Cloud droplet size

CPI particle mugshots

Dropsonde

Time bar summarizes one day's ~8-hour flight. HSRL LIDAR curtain (violet-green-yellow) shows aerosols beneath aircraft's track, interleaved with APR-3 precipitation radar (peach-purplish). Dashes mark limits of the time-window visible in other plots.
Along timebar's top edge are satellite overpass & dropsonde time marks

Products of this work are available.

Prototype visualizations: http://hdl.handle.net/2142/110083

Accompanying paper: http://hdl.handle.net/2142/110095

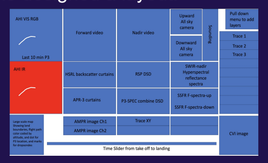
The Problem

Larry DiGirolamo, lead of the Radiation focus area for CAMP2Ex, brought a problem to the Advanced Visualization Lab group: even though the value of a field campaign stems from comparing information across many instruments, that was quite inconvenient to do with CAMP2Ex data. Even matching corresponding data samples from different instruments at the same time took significant work. Could we create a prototype visualization to demonstrate what could be possible -- a synoptic animation of key data gathered throughout a day's flight?

Such a synopsis could also make a handy index to the flight, making it simpler to pick out events worth more detailed study. Anything that would ease use of past archived data meant they more likely would get used.

Some solutions

Even on a large screen, space is precious. Which data values are most needed? Which should appear next to which? Could we save space by overlapping related measurements? DiGirolamo designed a layout:



… and he and his research group gave detailed advice on data labels, value ranges, and so on.

The groups brainstormed together on approaches, especially to 3D representation.

Prototype Implementation

- 3D animation: Houdini (commercial visual effects software with a learning curve) + python
- Made time-averaged versions of the aircraft track, to simplify creating a viewpoint path that follows the airplane
- 2D plots: python+matplotlib. Made plots in columns, then assembled with Nuke compositor
- Map imagery: python+GDAL
- Himawari sequence: 10-minute images, motion-interpolated to 1-minute with Nuke compositor
- Layout Sharing: RSP, valuable but not always available, swaps with LARGE droplet data when absent
- Did not try to use Learjet data, nor ground-based measurements
- Code from this prototype isn't being released (but see Future Work)

Future Work

The assembled CAMP2Ex science team received this prototype with enthusiasm and many suggestions. Our visualization team asked **what they'd like to see next.**

- Was interactivity important? *(yes)*
- Would they like to have ...
  (a) A comprehensive, self-contained software tool? *(possible, but a major project)*
  (b) A released library of python scripts and Jupyter notebooks, accessible enough that their research groups could adapt for their own data and presentation styles? *(could be a smaller project, completed much sooner)*

Many said Yes to one or both of (a) and (b). We'd like to undertake python-based software in the style of (b), **building this time on open source software** (perhaps WebGL for 3D). We'd hope to offer reasonably prompt display of any given point in time, and slower batch processing for creating animations.

Open problem: how to choose a good viewpoint for the 3D animation, either automatically or with simple manual controls. *(Hint: don't just look over the shoulder of the aircraft.)*

We hope this approach may be useful in other contexts too, and would welcome the chance to collaborate!

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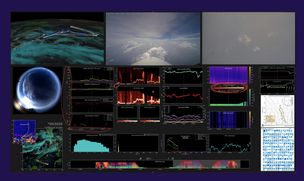
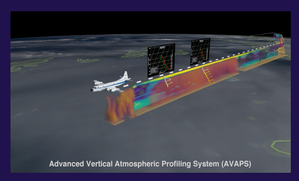
An early concept



Dashboard needing tweaks



3D "exposition", with dropsondes