GMI-IPS: Python Processing Software for Aircraft Campaigns

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Background

- The Global Modeling Initiative (GMI) supports the development of a state-of-the-art modular 3-D chemistry and transport model (CTM)
- The Atmospheric Tomography Mission (ATom) studies the impact of human-produced air pollution on chemically reactive gases in the atmosphere
- Airborne instruments onboard ATom campaign flights observe how atmospheric chemistry is transformed by air pollutants
- ATom air parcel measurements of key chemical species inform the CTM community about fine-scale atmospheric structures that matter to ozone (O3) and methane (CH4) budgets
- CTM communities to further determine how chemical species are affected by pollution

Motivation for GMI-IPS

- GMI activities relating to ATom flight campaigns call for interactivity between ICARTT and NetCDF data formats
- Data interpolation required in four dimensions (x, y, z, time) for 50+ quantities
- GMI simulation data needed for 40+ flight paths; this calls for software automation
- Analysis & visualization needed for flight tracks and background model data

Software Approaches

- GMI-IPS is a workflow-like software solution to science-driven requirements relating to GMI & ATom goals
- Python with numpy & netCDF interfaces
- Git source code management
- Inheritance deriving from base classes
  - ICARTT entry base class (time, press, lat, lon)
  - Instrument class types: MMS, MER
- Analysis with Matplotlib and mpl_toolkits

Numerical Methods

$$y=y0+(x-x0)\frac{y1-y0}{x1-x0}$$

1D linear interpolation from model time to UTC flight records

$$press3d=am*pt+bm*psf$$

3D model pressure

$$\bar{x}=\frac{\sum_{i=1}^{n} wi*xi}{\sum_{i=1}^{n} wi},$$

Weighted arithmetic mean for background curtain visualization

Trilinear interpolation from coarse model grid points to fine-resolution flight path points

$$f(x,y,z)\approx a0+a1x+a2y+a3z+a4xy+a5xz+a6yz+a7xyz$$

Workflows

Figure 1

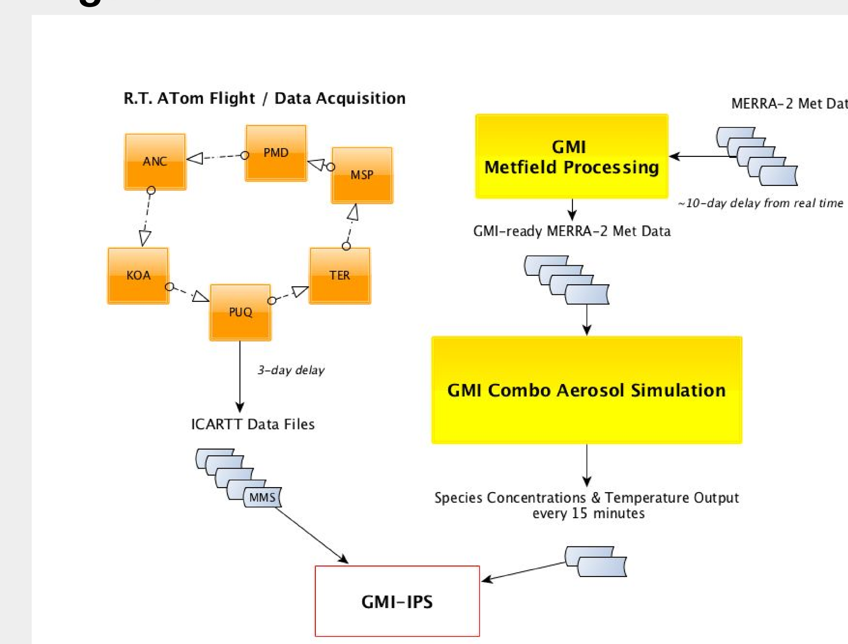


Fig. 1)

Shows the acquisition of ATom flight data side-by-side with GMI simulation processes. The GMI-IPS requires both ICARTT and NetCDF model data

Fig. 2)

The GMI-IPS internal workflow

Figure 2

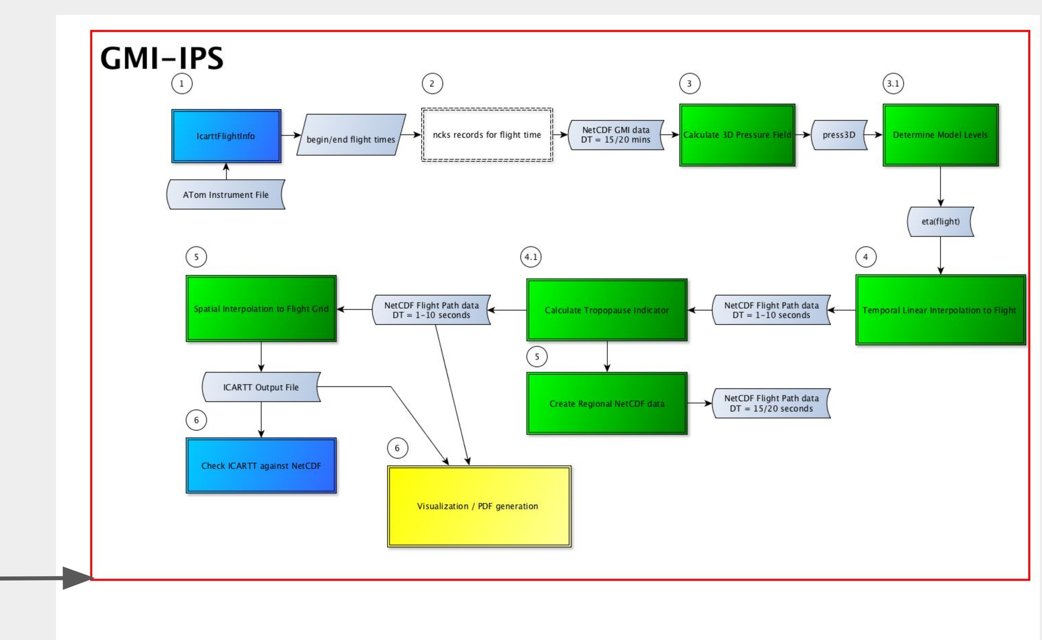


Figure 3

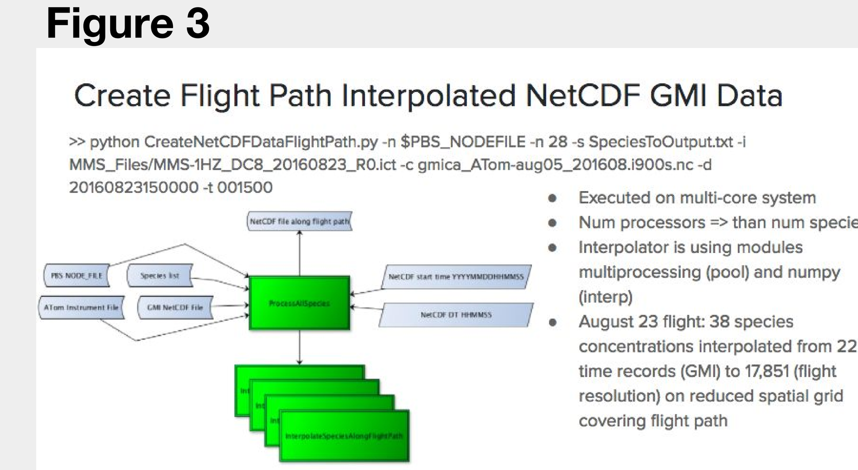


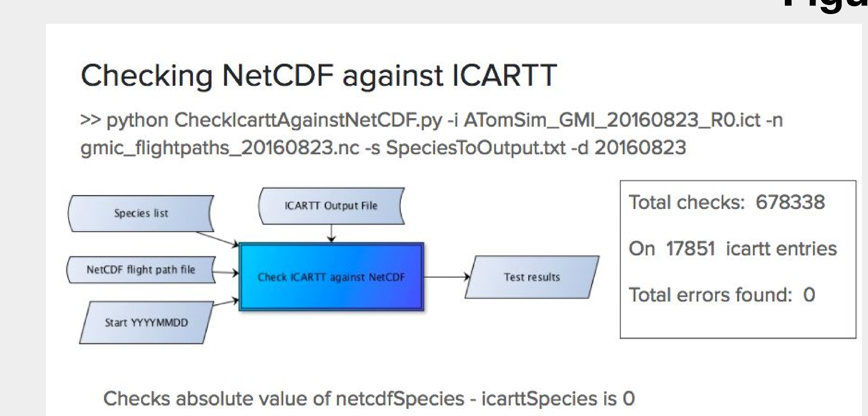
Fig. 3)

Data parallelization for model data interpolation to ATom flight resolution

Fig. 4)

The GMI-IPS performs data validation on ICARTT data

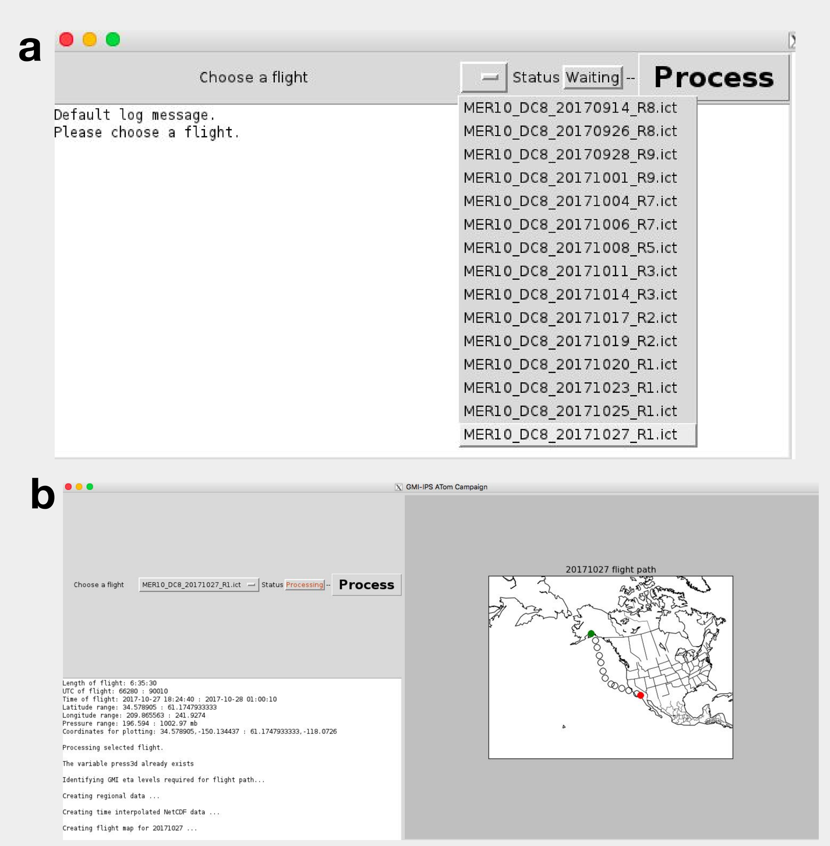
Figure 4



GMI-IPS Front End

- Proof of concept Tkinter GUI
- Workflow initiated by instrument ICARTT file selection
- Flight info & track available during data processing
- PDF analysis available after processing

a



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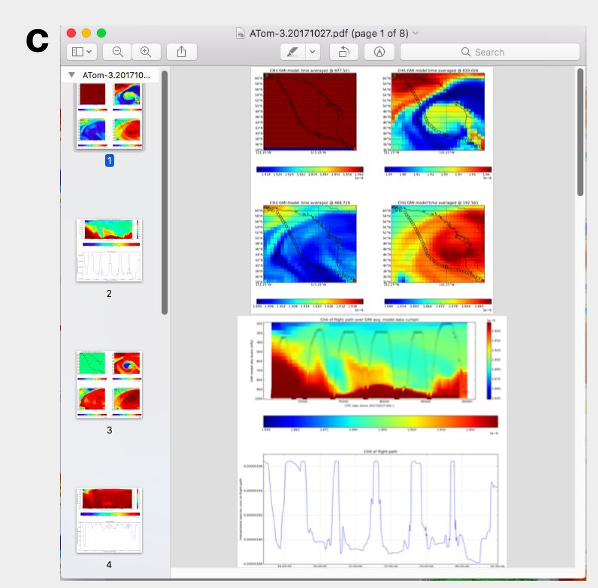

GMI-IPS Front End & PDF Analysis Packet
(a) Drop-down selection for MER ICARTT files for ATom-3 campaigns
(b) During processing, flight information and tracks are shown with start (green) and end (red) points (c) PDF analysis package for key species available after processing completes

Conclusions

- GMI-IPS ICARTT files approved via NASA LaRC for ATom-1, 2, & 3
- ATom O3 is reproduced well by the GMI-CTM in magnitude and variability
- GMI-IPS Front End will be used for ATom-4 campaigns in Spring 2018

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National Aeronautics and Space Administration