

Development of an Intermediate Computational Meteorology Course

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Background and Project Objectives

- Currently one undergraduate computational/programming class in the meteorology program: MTEOR 227
 - Teaches introductory programming through Fortran
 - Introduces data analysis and meteorological plotting in Python
 - Lacks coverage of several useful aspects of Python programming in meteorology (due to lack of time)
- More advanced skills in programming are in demand
 - Well-tested and scientifically-valid research scripting
 - Physical calculations and statistical analysis of large datasets
 - Handling many different types of data from models and observations
 - Scientific figure creation for research publications and presentations
 - Collaborating on resource creation with teams of scientists
- Specific Objectives:
 - Provide an outline for a course to follow MTEOR 227 that teaches intermediate-level computational concepts using Python, with emphasis on practical skills needed in coursework, research, and operations
 - Develop full set of materials for two course modules
 - Make these materials available for use within the ISU Meteorology Program and the broader community

Course Development Process

- Review existing literature and freely-available resources
- Interview and discuss with experts in the field about how to best provide students with the skills they need
- Write course outline and initial course materials
- Create content for the two course modules as interactive notebooks and text documents in Jupyter Lab
- Publish materials on GitHub for easy access and collaboration

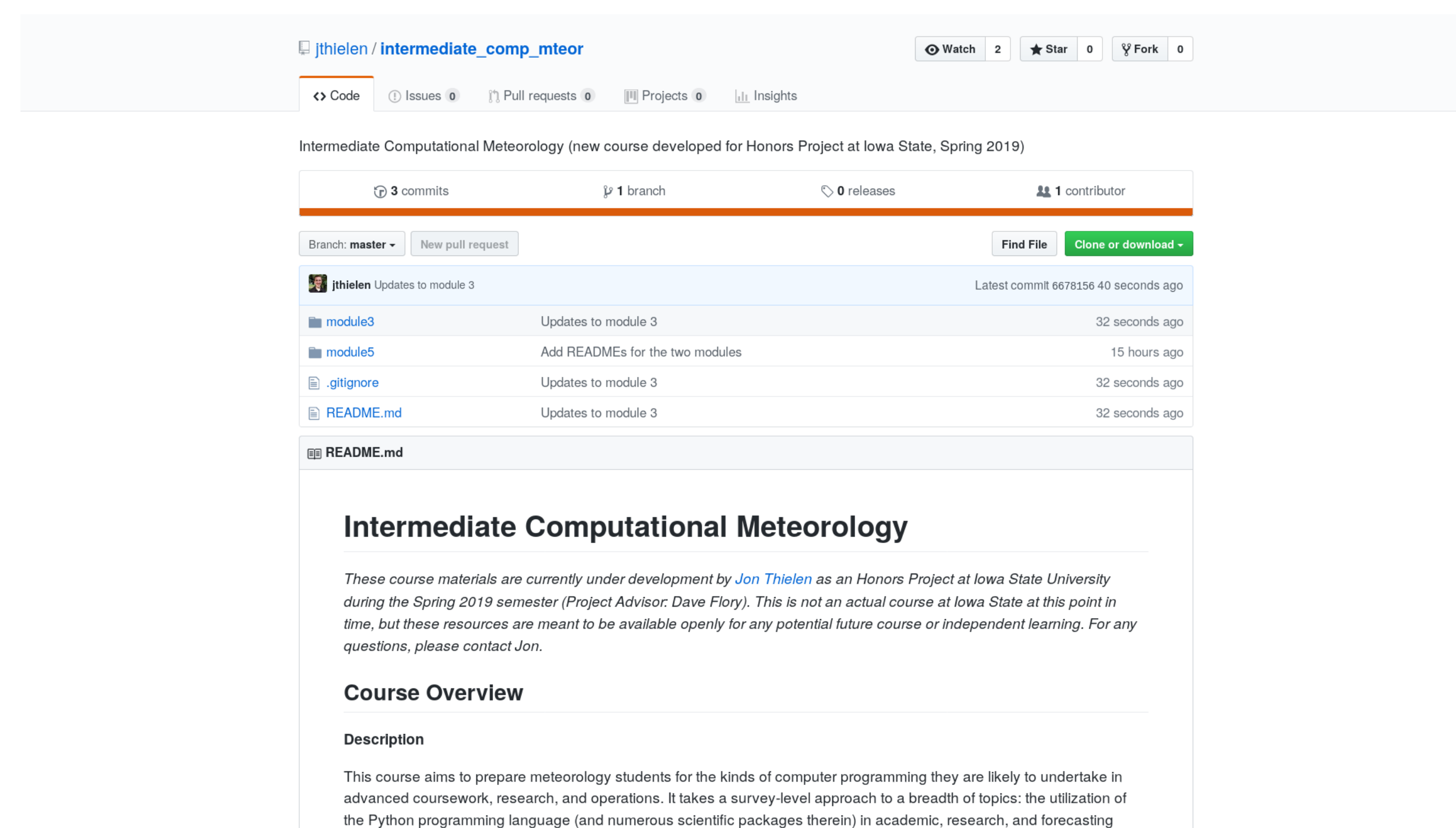


Figure 1. Screenshot of the course GitHub page, through which all course materials were developed and made available online

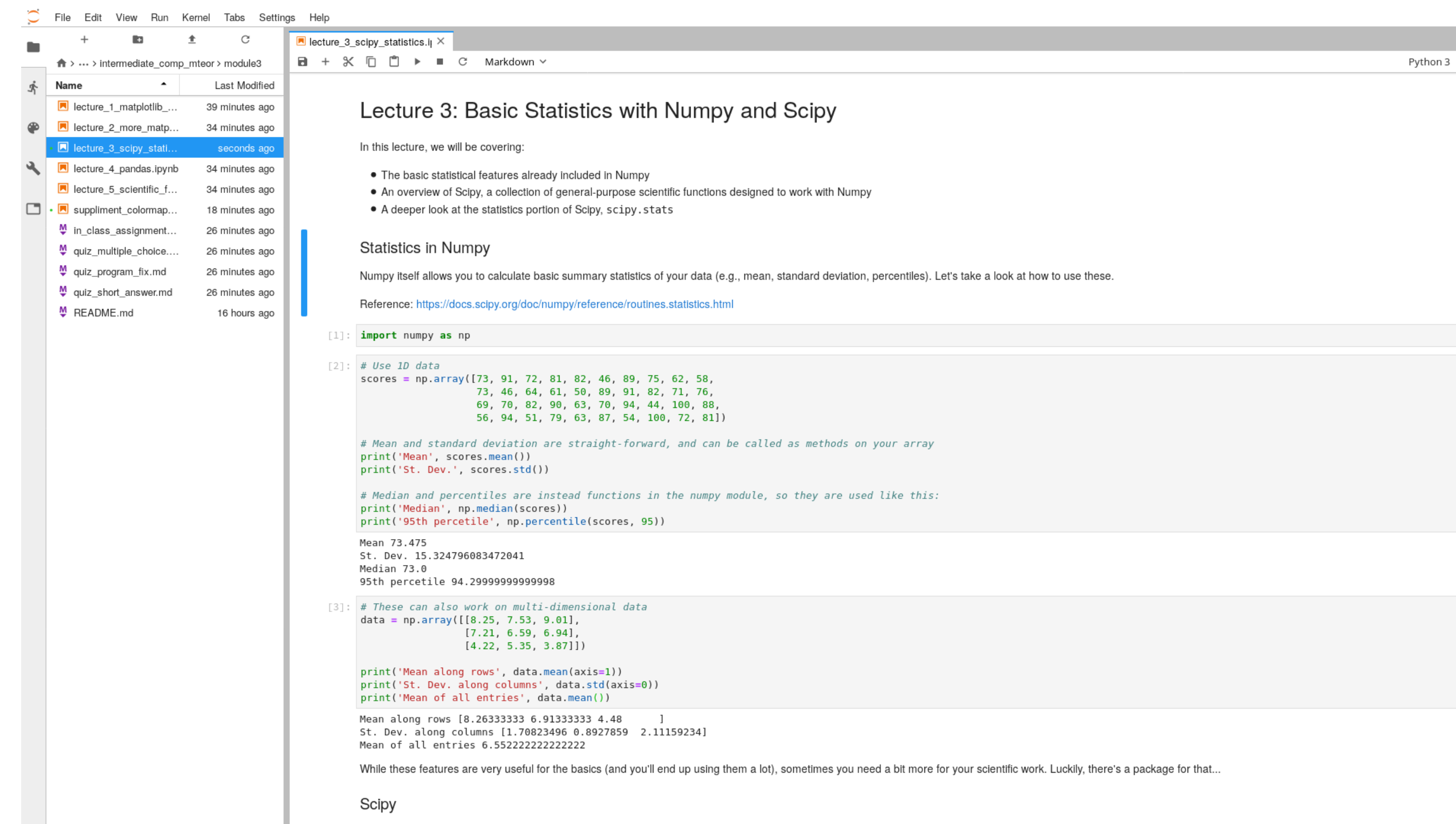


Figure 2. Example of a lecture notebook within the Jupyter Lab interface.

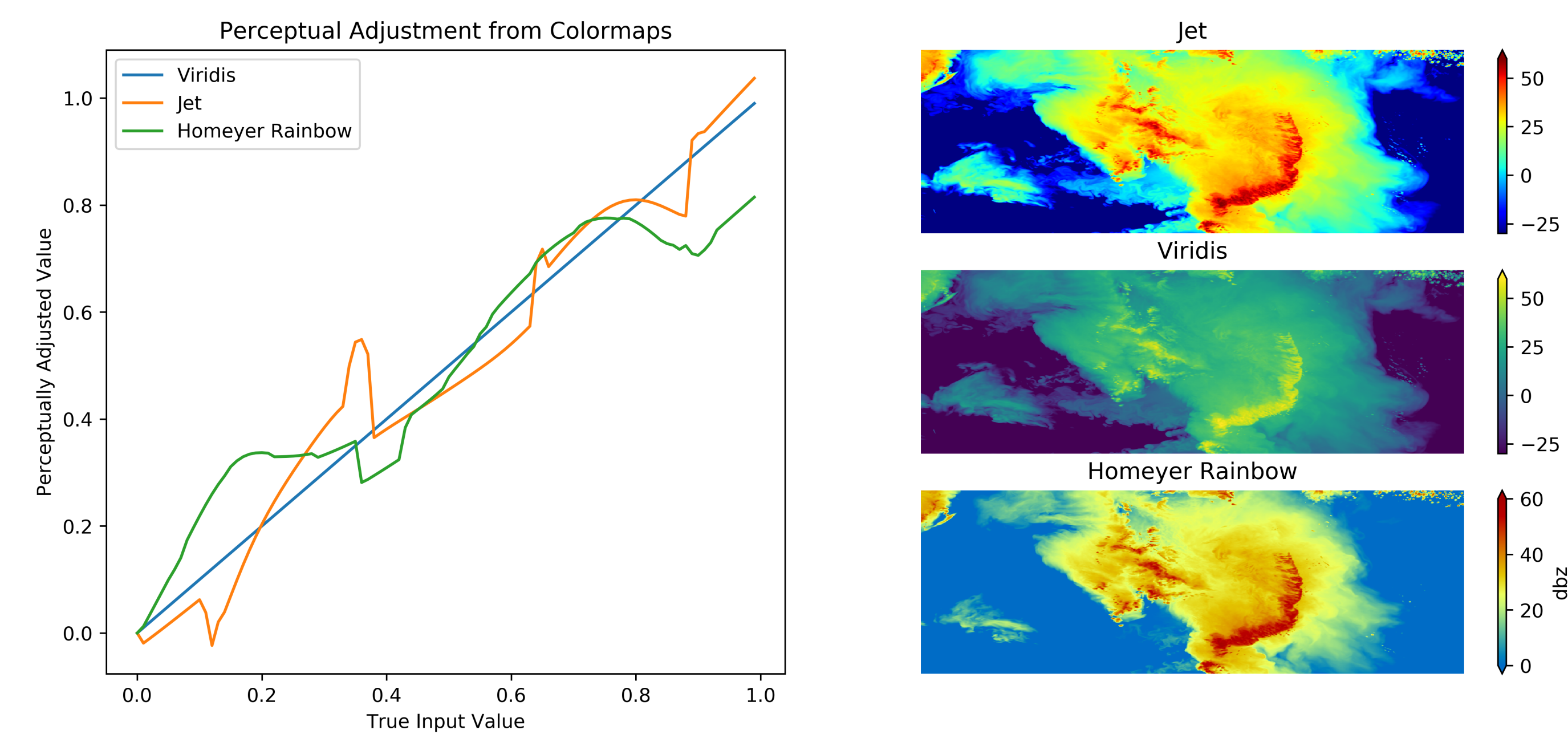


Figure 3. Demonstration of colormaps and perceptual-uniformity from Module 3.

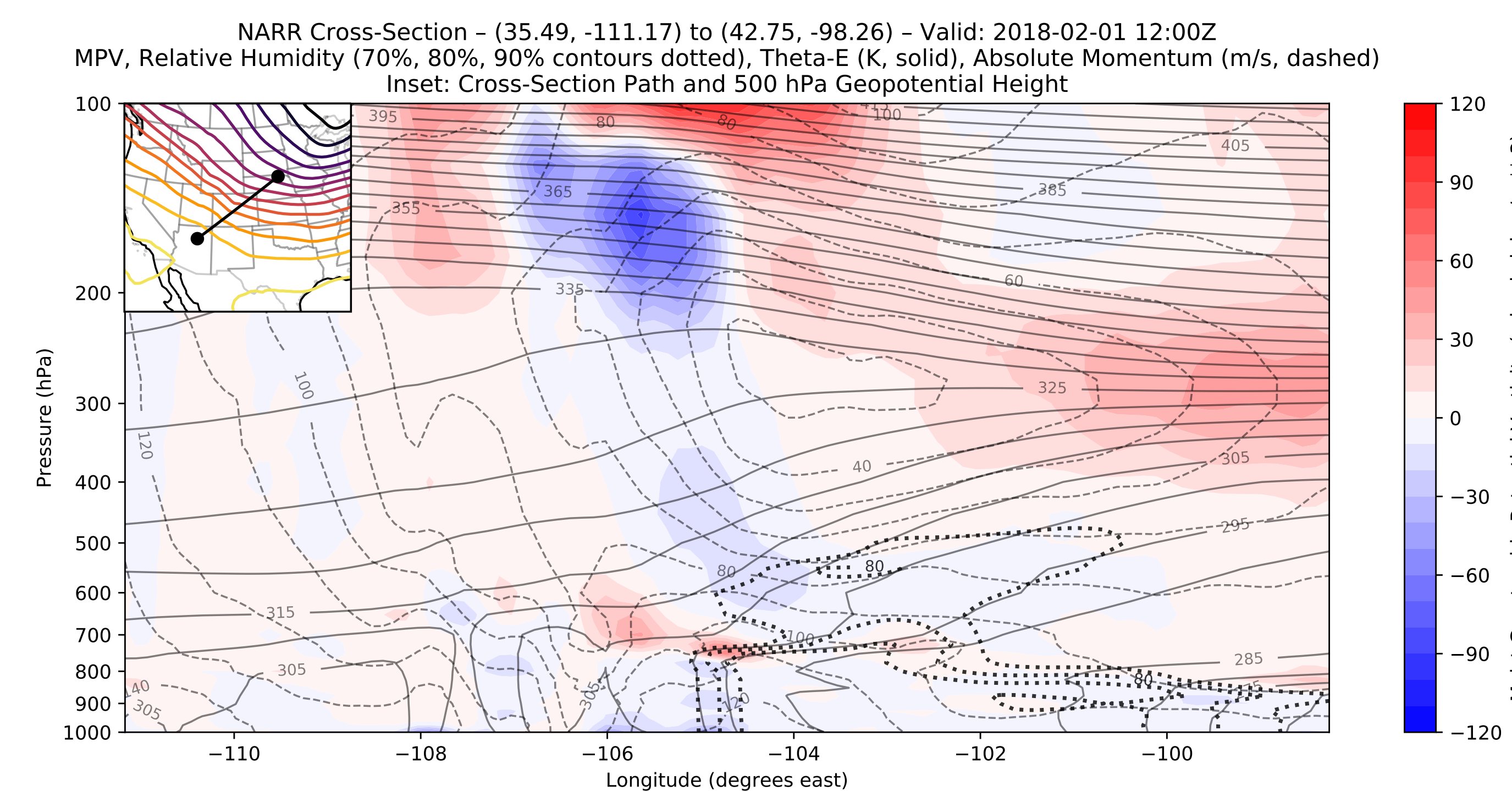


Figure 4. Cross-section plot from Module 4 demonstrating calculation of Moist Geostrophic Potential Vorticity (MPV) and other common cross-section quantities.

Outline of Course Topics

- Module 1: Intermediate Python
 - Jupyter notebooks, Python scripts, and Python environments
 - Numeric arrays, list comprehensions, generators, objects, and anonymous functions in Python
 - Procedural, object-oriented, and functional paradigms
- Module 2: Version Control and Open Development
 - SSH, bash, and standard command line utilities
 - Version control, Git, and GitHub
 - Code documentation, software testing, and code reviews
- Module 3: Statistical Analysis and Figure Creation for Publications
 - Creating publication-quality figures with Matplotlib
 - Statistical analysis using Scipy and Pandas
 - Best practices for scientific figure creation
- Module 4: Meteorological Calculations and Basic Numerical Methods
 - Using xarray and MetPy for meteorological calculations
 - Implementation of calculations from literature
 - Standard numerical methods (such as integration, differentiation, interpolation, and smoothing)
- Module 5: Tacking Practical Problems in Operational Meteorology
 - Real-time data access and archive data retrieval
 - Common meteorological data formats
 - Details of working with common operational data types
 - Objective analysis techniques

Conclusions

- With a survey-level approach, this course can provide a robust background in the skills most needed by students
- Personal experience as an undergraduate has greatly aided my perspective on the tools available and skills needed in this area
- Current outline and collection of resources provide foundation for future completion and implementation of the course

Interested accessing the full collection of course materials from this project? Check out

https://github.com/jthielen/intermediate_comp_mteor

