Singletrack Unified Community Atmosphere Modeling Project
Assessment of Education/Tutorials

Purpose/Introduction

A community model requires involvement from the community, and that includes training people (especially students and early career scientists) to use the model, as well as broadly educating the next generation of scientists, and supporting scientific education with the model as a teaching tool. These functions are currently performed for the existing NCAR community models of the atmosphere: the Community Atmosphere Model (CAM) in the Community Earth System Model (CESM) and for the Weather Research and Forecast (WRF) model.

This document provides a vision of what a unified approach to education, training and tutorials might look like. The document starts with an assessment of current activities and capacities at NCAR. It then discusses new opportunities and a vision for an evolved approach. Finally we comment on implementation aspects (including funding) about how to get from where we are to where we want to be.

This document was developed by a cross-laboratory team including key leaders in WRF and CESM tutorials, and with the NCAR Office for Education & Outreach/Advanced Study Program.

Current Education and Training activities

Currently both WRF and CESM/CAM have a series of educational and tutorial activities surrounding their respective modeling efforts.

WRF

1. **WRF Tutorial**: MMM offers a basic WRF atmospheric model tutorial twice a year. Advanced-topic tutorials, such as WRFDA, MET (provided by DTC), and Chemistry (provided by NOAA), are offered once per year. The tutorials are a combination of lectures and hands-on practices. Participants appear to benefit the most from the practice sessions. This is especially true for new users. There is no funding for this activity. The tutorial is funded by collecting a registration fee for non-US university students, and no travel support is provided. The participants are from universities, federal and state agencies, government laboratories, and private industries. There are 60 students in each Basic WRF session, and since the WRF Version 3 release in 2008, these tutorials have trained over 1800 students and scientists. The training materials are available from the WRF web site.
2. **User Support**: MMM has previously provided this service primarily through wrfhelp email. The emails average about 350 per month. This user email service is being replaced by a public bulletin board (http://forum.mmm.ucar.edu/phpBB3) in the coming

months. In addition, MMM maintains a web site that provides other relevant information for users.

3. **Test Cases**: In the WRF model tar file, pre-configured test cases are available that include a suite of idealized simulations. Several real-case datasets are available for users to download and configure to run.
4. **Documentation**: MMM provides an NCAR Technical Note for WRF model Version 3 (the version 4 Technical Note is in progress), a User's Guide which is updated each year to incorporate modifications for each new release, and a web site that hosts an online tutorial, FAQs, references for model physics, and basic publications for the model.

CESM

CESM has several different educational and tutorial efforts. These include (1) the annual CESM tutorial, (2) a simplified modeling suite, (3) extensive documentation, and (4) user services with a bulletin board and liaisons.

1. **CESM Tutorial:** The CESM Tutorial brings about 80 researchers at all levels, but mostly young scientists to NCAR each summer for detailed education and training on Earth System Models and specifically on CESM. The total budget has been shrinking (due to DOE no longer supporting the tutorial, and trying to start their own). The current budget just supports accommodation in Boulder for students. In addition, this year the tutorial is being published as an interactive course by COMET, at a cost of around $20K. The CESM tutorial has served nearly 700 students since 2010, with some extra smaller on-site tutorials, and more online.
2. **User services:** CESM provides a primary user service method of a public bulletin board (https://bb.cgd.ucar.edu/). Both users and CESM staff answer questions, and there is a searchable archive of questions. In addition, CESM has a series of working groups for each component model, and some key applications (polar, climate variability). Most of these working group have a dedicated (or partial) liaison position, a support scientist (usually a project or associate scientist) who helps monitor the bulletin board to answer questions, as well as working with users directly.
3. **Simplified modeling suite:** CESM and CAM (the atmospheric model) are configurable in a number of different simplified frameworks with test cases for educational purposes. This starts with a Single Column Atmosphere Model (SCAM), and extends to idealized and simplified physics with the dynamical core, to aquaplanet, fixed SST GCM (uncoupled) to fully coupled Ocean-Atmosphere-Land GCM.
4. **Documentation:** CESM also provides extensive documentation. This includes a scientific description of each component, as well as user's guide for each component. CESM tutorial materials are also published.

Advanced Study Program (ASP)

1. **Colloquium**: ASP hosts colloquia designed for graduate students on subjects that represent new or rapidly developing areas of research for which good course material

may not yet be available. The colloquium brings together lecturers and graduate students to NCAR and generally includes about 25 student participants, and several lecturers from NCAR and the community at large.

2. **Visitor programs for graduate students and faculty**
    a. Each year, NCAR hosts 20-25 ASP graduate visitors; positions are available from from two months to up to a year. Students work on parts of their thesis, or final project equivalent, with guidance from NCAR scientists and engineers. Awards include per diem and housing in Boulder, travel to/from Boulder and advisor travel.
    b. ASP's Faculty Fellowship Program provides opportunities and resources for faculty, along with up to two students, to work in residence at NCAR for up to two months. Awards include per diem and housing in Boulder, travel to/from Boulder.
3. **Postdoctoral Fellowships:** The ASP postdoctoral fellowship provides opportunities to conduct independent research at NCAR. ASP fellows are part of a collaborative cohort of postdocs and early career staff at NCAR, are mentored by leading NCAR scientists and engineers, and receive professional development opportunities in writing, presentations skills, leadership, and outreach opportunities. NCAR makes ~ 8-10 awards per year.

Vision for Education/Training/Tutorials under Singletrack

Goals

There are two primary goals for a robust education and training program for a Unified NCAR Community Atmosphere Model (Singletrack).

- **Teaching people to use the model:** Ensure that the community can effectively and efficiently learn to use a singletrack model framework for both weather and climate studies.
- **Educating the next generation of scientists:** An important goal of the educational effort for Singletrack is to grow the community of uses by helping educate the next generation of scientists (Graduate Students and Post-Docs) in understanding the use, analysis and development of atmospheric numerical models.

Elements of a strategy

We would like to build upon the work that is currently done now to support and teach CESM and WRF. A strategy for a unified atmospheric model inside of an Earth System Model (ESM) framework would provide the functions of the current WRF and CESM tutorials. We could even continue to have 2 different tutorials, one focused on weather science and model configurations, and one focused on climate applications, as well as the other ESM components. Both tutorials could add functionality to cover both weather and climate aspects. In addition, the tutorials could have an extensive online component to reach students who cannot attend in person (due to

funds or to space limitations). The tutorials could also have an expanded discussion on diagnostics and analysis of model output.

In addition to the current tutorials and educational materials for WRF and CESM, we propose establishing new materials and tutorials for Singletrack. These efforts would utilize strengths across all of NCAR. This strategy for education surrounding a future unified 'Singletrack' model would have several elements:

1. **Simple model suite:** The unified atmosphere model itself should have a suite of simple model configurations. This would include: Single Column, LES, Limited Area Case, idealized physics, aquaplanet. Currently, these are not available in a single model system, but have most of the configurations between CESM and WRF. In order to make simpler configurations useful, the overall architecture should be usable and portable.

2. **Grad student fellowships in Atmospheric Modeling:** It would be helpful to have some dedicated funds to help support graduate students in atmospheric modeling and to help build long term relationships with faculty advisors in atmospheric modeling. These students would have to be tied to a university with an outside advisor, but work on projects related to a unified atmosphere model. This could be a targeted extension of the current ASP Graduate Student Visitor Program, perhaps supplemental funding to this program, with NSF funds and special call for model development/analysis fellowships to fund travel to NCAR for students and advisors. Adding tuition support and a summer stipend would encourage participation from smaller schools with limited financial resources and could broaden the community engaging with NCAR.

3. **Modeling Awards in the Early Career Faculty Innovators Program**: The Early Career Faculty Innovators Program is a proposed NCAR program with targeted awards for Early-Career Faculty and graduate students in strategic topical areas aimed at building new long-term research partnerships with the university community. The focus of this program is to invite in expertise that is not part of NCAR's core programs and to broaden participation in NCAR's research and training efforts. Atmospheric modeling could be a topical area.

4. **Undergraduate mentoring through SOARS:** Singetrack scientists will continue to mentor SOARS students. SOARS is a 10-week summer internship program at NCAR dedicated to broadening participation in the atmospheric and related sciences. Increasingly, SOARS alumni continue on into the Advanced Study program as graduate students and postdoctoral fellows and continue partnering with NCAR.

5. **Community engagement and Public Outreach:** This component would evolve over time. For a development phase of a unified atmospheric model, outreach efforts would target scientists (community engagement). This would start to help publicize the model

and engage the community, and would evolve into communities outside of the model development and user community in the geosciences.

Implementation Plan

Naturally, education and outreach should evolve over time with the unified atmosphere model. We envision a plan that would evolve and expands existing efforts over time. The steps for implementing a comprehensive plan could be:

1. **Hire a education/tutorials liaison for Singletrack.** The commitment to education and tutorials would work best if the unified modeling effort had a 'Education/Tutorials' coordinator. This would be a specific person (similar to a community Liaison for CESM) who would be a point person for organizing tutorials, testing simple model configurations and developing scripts, and assisting with any scholarship programs.

2. **Continue existing WRF, CESM Tutorials.** For 2019, common elements/talks to describe the atmosphere could be envisioned across tutorials. In addition we might harmonize planning in 2019 to put WRF and CESM tutorials back-to-back weeks. An educational liaison could facilitate this.

3. **Grow a 'unified atmosphere tutorial'**: over time there could be 2 weeks of tutorials. The CESM Atmosphere tutorial is more limited, but the WRF tutorial might evolve into an Atmospheric Tutorial. Note that there are separate tutorials for other components now being planned and executed (in Summer 2018 there are polar and Chemistry tutorials). We could start in 2019 or 2020 to focus after WRF/CESM tutorial as a topical workshop on a specific singletrack application (e.g. Polar, or Tropical Cyclones). Expanding tutorials around applications is a way to grow tutorials together.

4. **2019 Colloquium & Workshop on Atmospheric Physics:** A proposal exists for a 2019 ASP Colloquium and workshop focused on the atmosphere. This will target CAM6 and also have a singletrack theme spanning weather to climate. This is also designed to have an online component.

5. **Evaluate online tutorials.** Currently the 2017 CESM tutorial is being developed into a COMET educational module. It is proposed to extend this during the summer 2019 Colloquium on Atmospheric Physics. We will explore this as an option for future tutorials and 'topical' tutorials, across NCAR. This will also require getting metrics and feedback (which would be greatly helped with an education coordinator).

6. **Graduate Student Funding for Atmospheric Model Development:** We can propose themes on atmospheric modeling to ASP (Postdocs, graduate students) and the Future Innovations Program (Faculty, Grad Students). We could request supplemental funding for these programs specifically targeted at atmospheric modeling.

7. **Begin Education and Outreach Plan:** For a development phase of a unified atmospheric model, outreach efforts would target scientists (community engagement). Specific activities would include: (1) Atmos News Article, (2) Time in NCAR booth at AMS/AGU and, (3) Featuring Singletrack through the NCAR Explorer Series, with short videos produced by NCAR E&O. Efforts would align with the new NCAR Strategic Plan for Education & Outreach 2018-2024.[1]

8. **Broader education and outreach efforts:** Begin to think about outreach beyond just geophysical scientists, to those that might be using the model for applications or impacts (social scientists, engineers, policy makers). A broader effort might be part of NCAR outreach to stakeholders and expanding our efforts on societal impacts. A comprehensive approach to weather and climate would be valuable.

[1] https://ncar.ucar.edu/sites/default/files/NCAR%20EO%20Strategic%20Plan%202018-2024.pdf