SINGLETRACK Project

NCAR Unified Community Atmosphere Modeling Roadmap

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On behalf of the *Singletrack Steering Group*

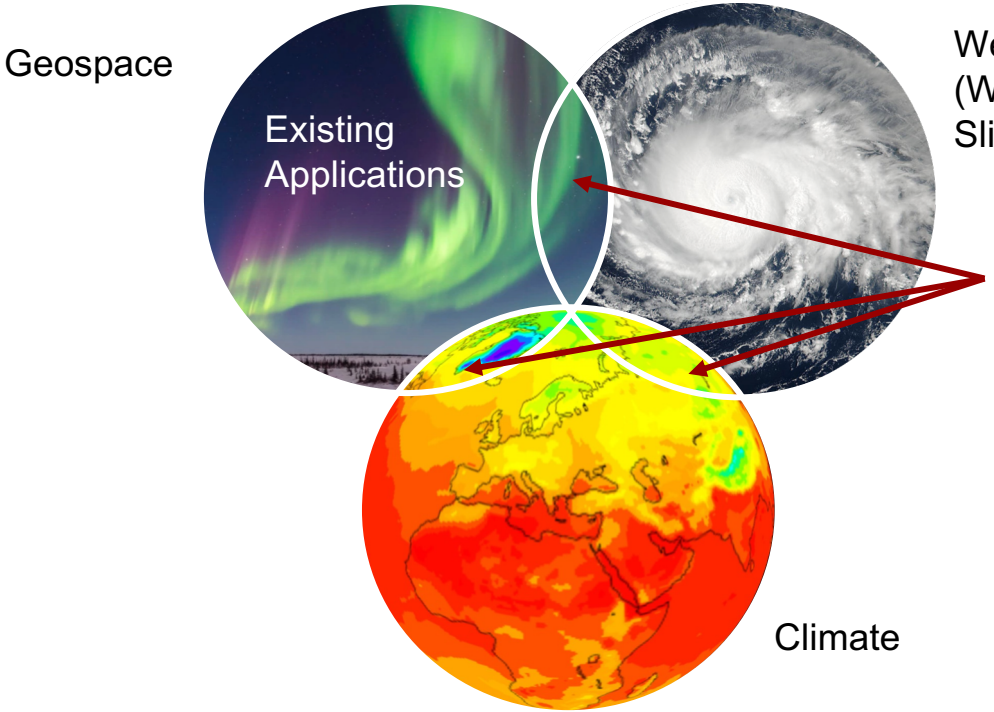
Singletrack is a project to develop a strategic vision and roadmap to unify and improve community atmospheric modeling efforts across NCAR. Goal: a Unified *Community* Atmosphere Model *within* Earth System Model.

Singletrack motivation:

(1) Frontier science goals require new simulation capabilities
(2) Increasing overlap in climate, weather and geospace science applications
(3) More efficient use of development and support resources
(4) A shared system and infrastructure to take maximum advantage of new computational platforms and architectures

Singletrack Vision

Support Existing and Frontier Applications



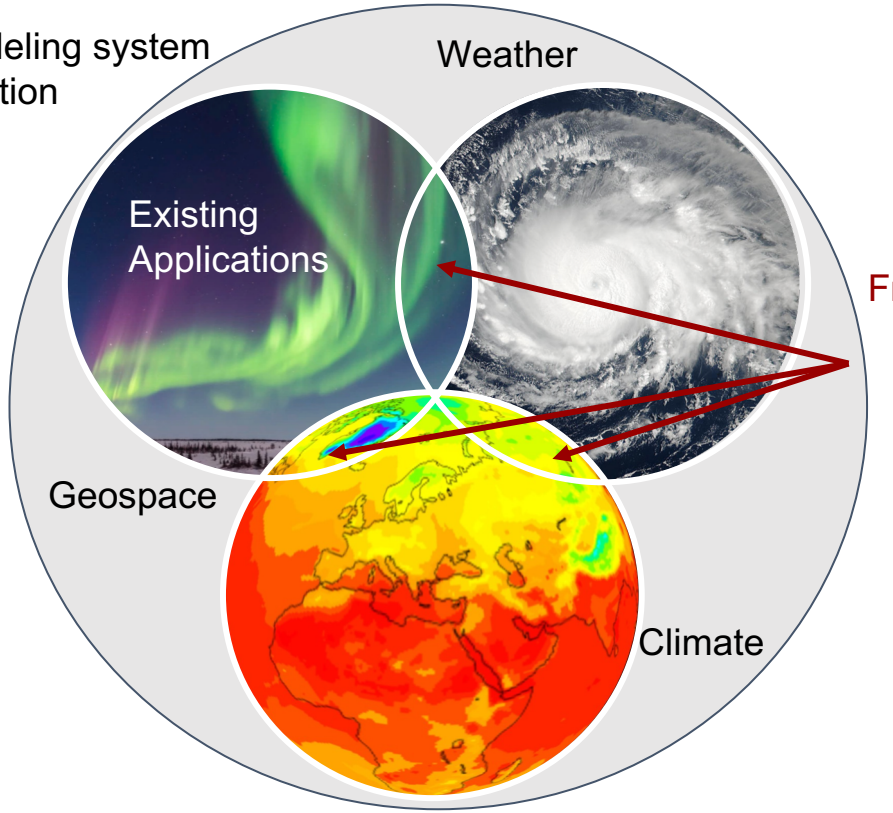
Frontier Applications

- Coupled Weather
- Climate Extremes
- Space Weather
- Air Pollution

Singletrack Vision

Unified atmospheric modeling system

- Initialization/Prediction
- Diagnostics
- Coupling in ESMs
- Small to Exascale
- Usability



Frontier Applications

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Singletrack Goals

- Unify Weather (WRF, MPAS), Climate (CAM), Geospace (WACCM-X), Chemistry (CAM-CHEM, WRF-CHEM) applications
- Enable future 'frontier' science across scales: Weather-Climate Interface
- Engage the weather/climate/geospace community in effort

Singletrack's purpose and goals are aligned with recommendations from the Jan 2018 NCAR advisory panel and 2017 NSF Site Visit Team (SVT)

The Singletrack Unified Model

The unified model will be composed of a set of interoperable components (e.g. dynamical cores, physical parameterizations, etc) that could be configured differently for different applications.

We will draw heavily from community science tools and models.

We will develop/use common infrastructure.

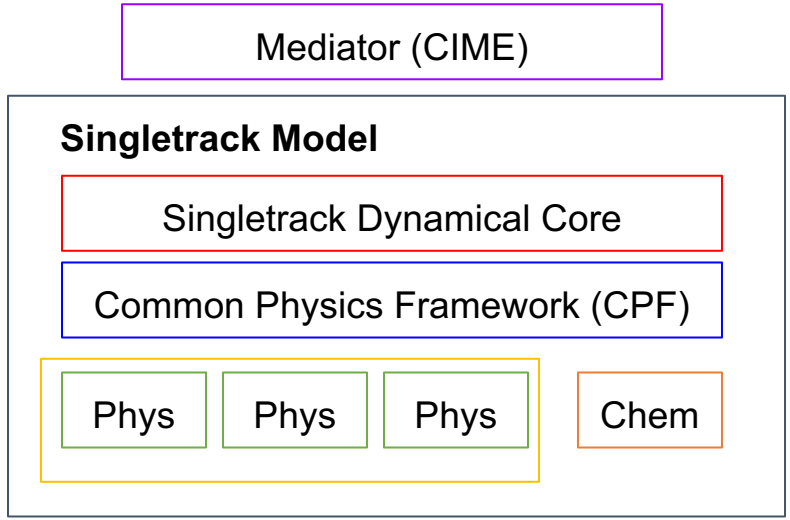
System will evolve over time towards a single shared mode with common components.

Singletrack: Modular Structure

Configure for different applications

Singletrack will use a Common Physics Framework (CPF) to link physical parameterizations (clouds, gravity waves, etc) to dynamics and a coupling architecture (land, ocean etc).

- Geospace will have it's own 'suite'
- Chemistry = set of physical parameterizations



Physics 'Suites'
(CAM6, WRF/MPAS, Geospace)

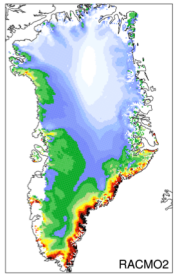
Chemistry Modules
(MUSICA/MICM)

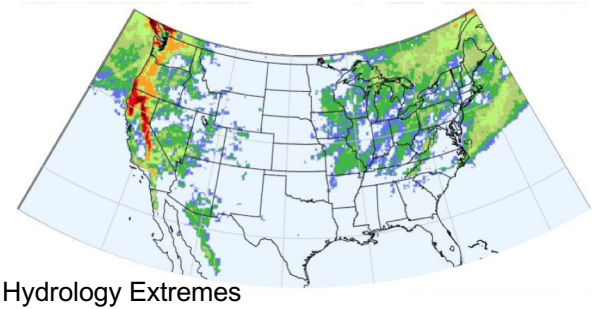
Singletrack and our existing community models

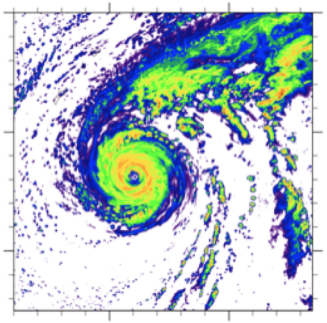
- CESM would have greatly expanded capabilities, while maintaining existing capabilities.
- CESM/CAM will have access to WRF physics, and WRF will have access to CAM physics through a shared common physics framework.
- CESM will have access to the MPAS dynamical core allowing for high-resolution (convection-permitting) simulations within a full ESM configuration.
- **We will continue to support stand-alone MPAS until all MPAS applications can be achieved within MPAS/CESM.**
- **We will continue active support of WRF for very-high resolution limited-area applications.**

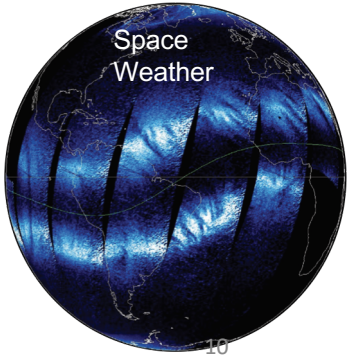
Frontier Science Goals

- Coupled Simulations at the Weather Scale
- Extreme weather under climate change
- Polar Prediction
- Air Quality
  - Urban scale to regional scale to global scale
- Integrated Geospace modeling
- Prediction: Subseasonal to Seasonal (S2S) to Decadal
  - Intra-seasonal (MJO), And interannual (ENSO)
- An Atmospheric Model in the coupled system
  - E.g. Land - Atmosphere Interactions









Singletrack Applications

Application Examples and Configurations

Topic	Example Application	Initial Target Configuration
Weather	Tropical Cyclones	3km refined mesh, coupled ocean, forecasts
Climate	Hydrologic Extremes	3km refined mesh, forecast and climate simulations
Polar	Arctic Prediction	10km refined mesh, coupled ocean, land, sea ice, land ice. Forecast and climate simulations
Geospace	Space Weather Prediction	25km global atmosphere to the ionosphere, forecast.
Chemistry	Urban/Regional Air Quality Prediction	Urban: <1km regional forecast. Regional: 3km refined global mesh, climate and forecast

Singletrack: Timeline

Past, Present, Future

- Jan-February: Organized, developed science goals, requirements
- March: Development of specific application examples
- April: Feedback from NCAR stakeholders
- May: Early stage community engagement/feedback
- May: Develop vision/applications, also a potential roadmap
- June: Discussions with NSF, UCAR BOT
- June: Solid vision/plan draft presented at WRF/CESM meetings
- July: Incorporate feedback, aim for 'release' of a draft plan

Singletrack: a *Community* atmosphere model

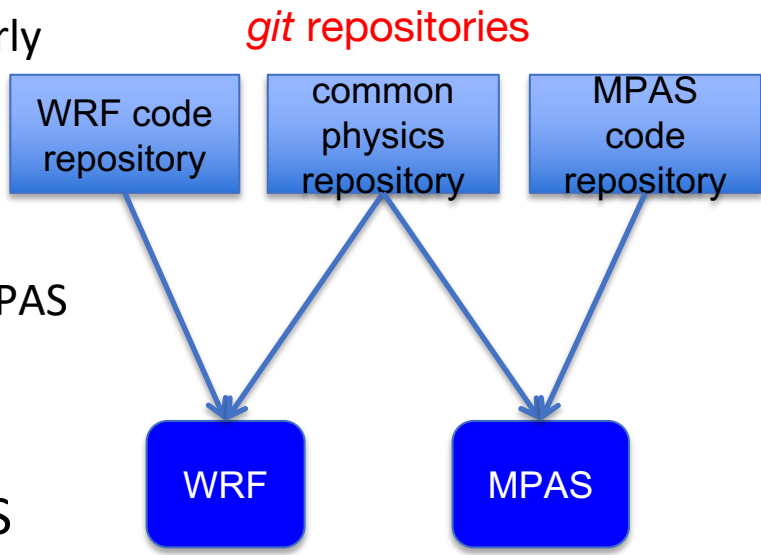
- Community Engagement in Planning, Definition, Applications
- Community Governance
- Improved usability
- A model for Research and Education: Suite of Simplified Models
  - Single Column to the Exascale
- Education/Training/Tutorials
  - Educate the next generation of scientists
  - Facilitate community interactions with NCAR modeling scientists
- Common interfaces/infrastructure
  - Aid community development, share components
- Diagnostic tools to incorporate observations & facilitate analysis

Singletrack and NOAA UFS: Shared Infrastructure

- MOA between NOAA and NCAR
- **Common Community Physics Package requirements compatible with NCAR Common Physics Framework**
- Singletrack compatible with Common Infrastructure for Modeling the Earth (CIME). Mediator development joint with NOAA
- **Use of git repositories**
- Common quality assurance testing
- User support: active and passive, leveraging existing practices and protocols

WRF/MPAS Consolidation and Singletrack

- Physics
  - Common repository for physics suites (nearly complete)
  - Compatible with CPF (in progress)
- Initialization
  - DART for initialization for both WRF and MPAS
  - MPAS initializing of WRF
- Postprocessing
- Support: online forum for WRF and MPAS
- Coupled modeling enabled for weather and regional climate (MPAS)



To Follow This Talk

- Dynamical Cores
- Physics
- Infrastructure
- Data Assimilation
- Unified Chemistry
- Land-surface Modeling

Discussion Thursday afternoon (3:30-4:30)

Extra: Applications Details

Singletrack Topical Areas

More detail is available on each one

Working Groups

- Dynamical Core
- Physical Parameterizations
- Data Assimilation
- Infrastructure
- Diagnostics/Observations
- Governance
- Education/Training/Tutorials

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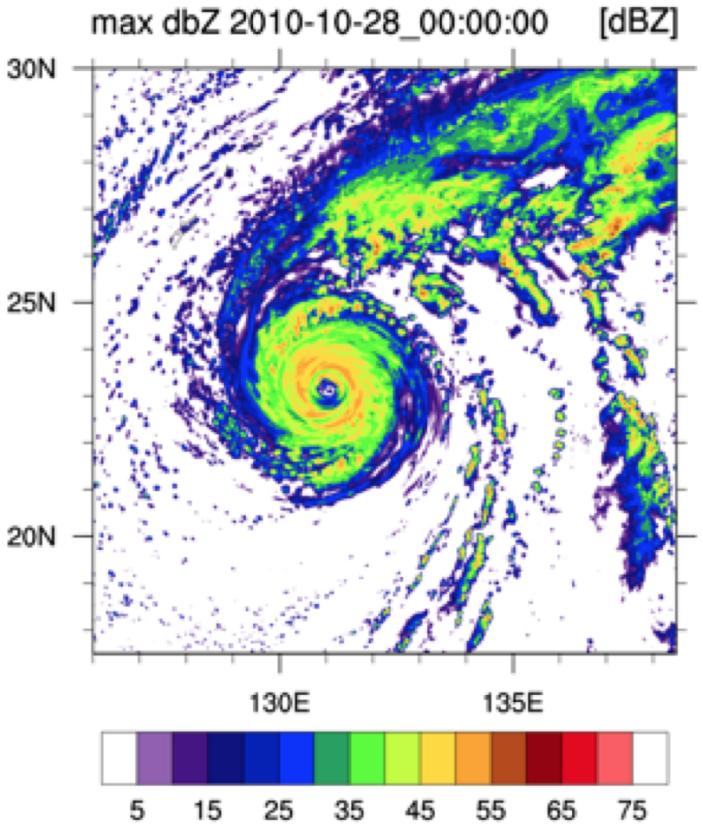
Applications: Weather
Tropical Cyclones

Simulate coupled weather phenomena in a coupled system at high (~3km) resolution. Example: tropical cyclones.

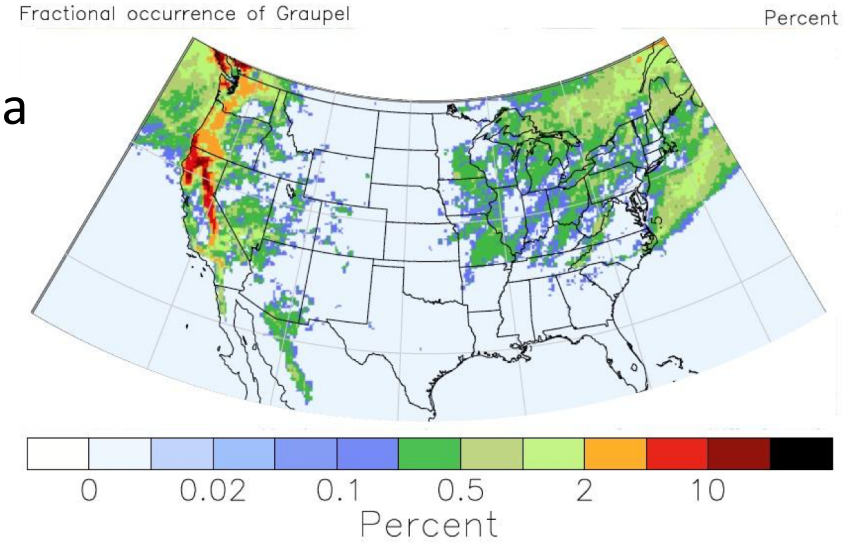
Also applies to MCS (convection) and S2S sub-seasonal prediction (MJO)



Applications: Climate

Hydrological Extremes

Simulate high impact weather extremes in a coupled system at high (~ 3km) resolution. Example: occurrence of graupel (extreme precipitation) in a 14km global model



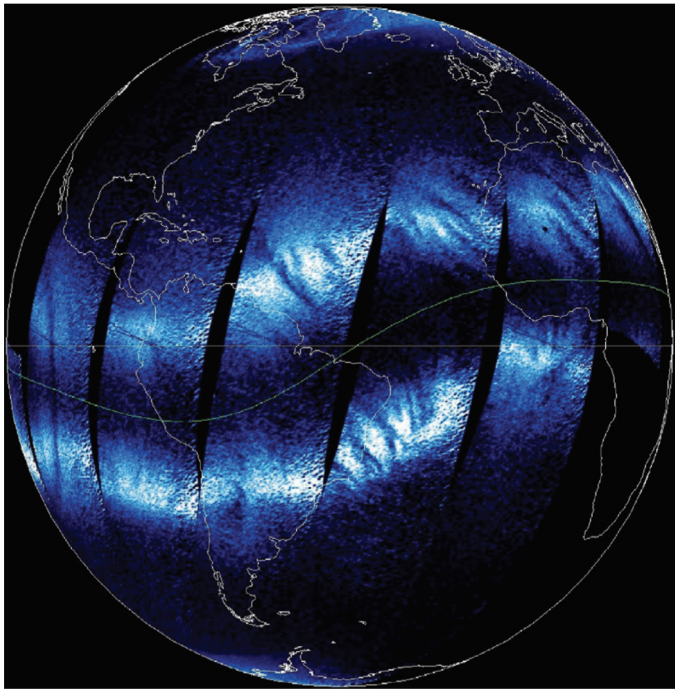
Also applies to floods, hydrology, droughts (up to seasonal). Prediction as well as climatologies of extreme hydrological events

Applications: Geospace

Space Weather Prediction

Simulate forced events in the upper atmosphere that affect human systems and climate. Example: Ionospheric plasma bubbles that disrupt radio waves (Communication, navigation)

Couple specialized geospace models on different grids to a deep atmosphere model



Applications: Chemistry

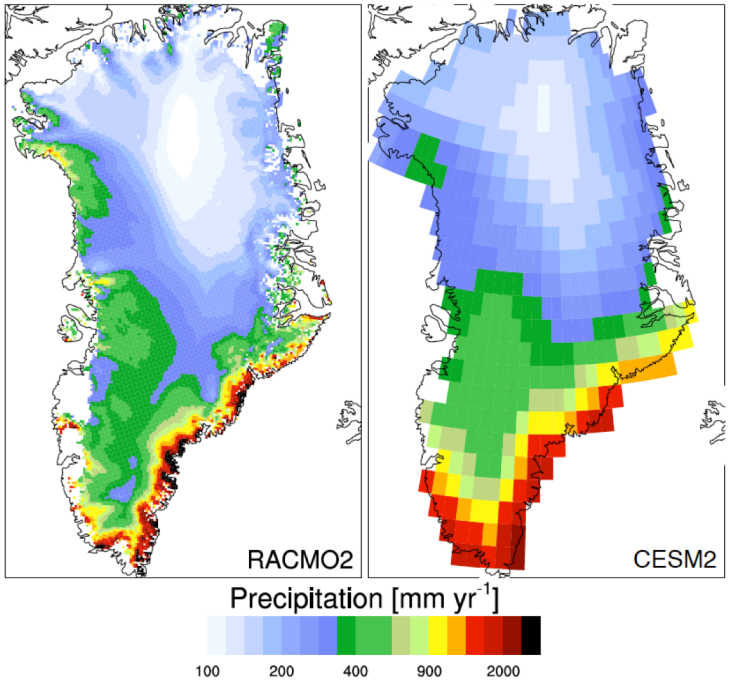
- Represent air quality in urban regions
- Interactions between atmospheric chemistry, weather and climate

Requires chemical modeling at fine horizontal (< 5km) and vertical (multiple layers in the urban canopy) resolution within a global modeling system.

Delhi, March 2018

Applications: Polar

- Simulate evolution of the Arctic environment
- Requires high resolution, but also a coupled system (especially to the cryosphere and ocean)
- Seasonal to Sub-seasonal (S2S) scale, but also Decadal scale



Target applications: 3km refined mesh forecast, 10-25 km climate simulations. Coupled ocean, land, sea ice, land ice.