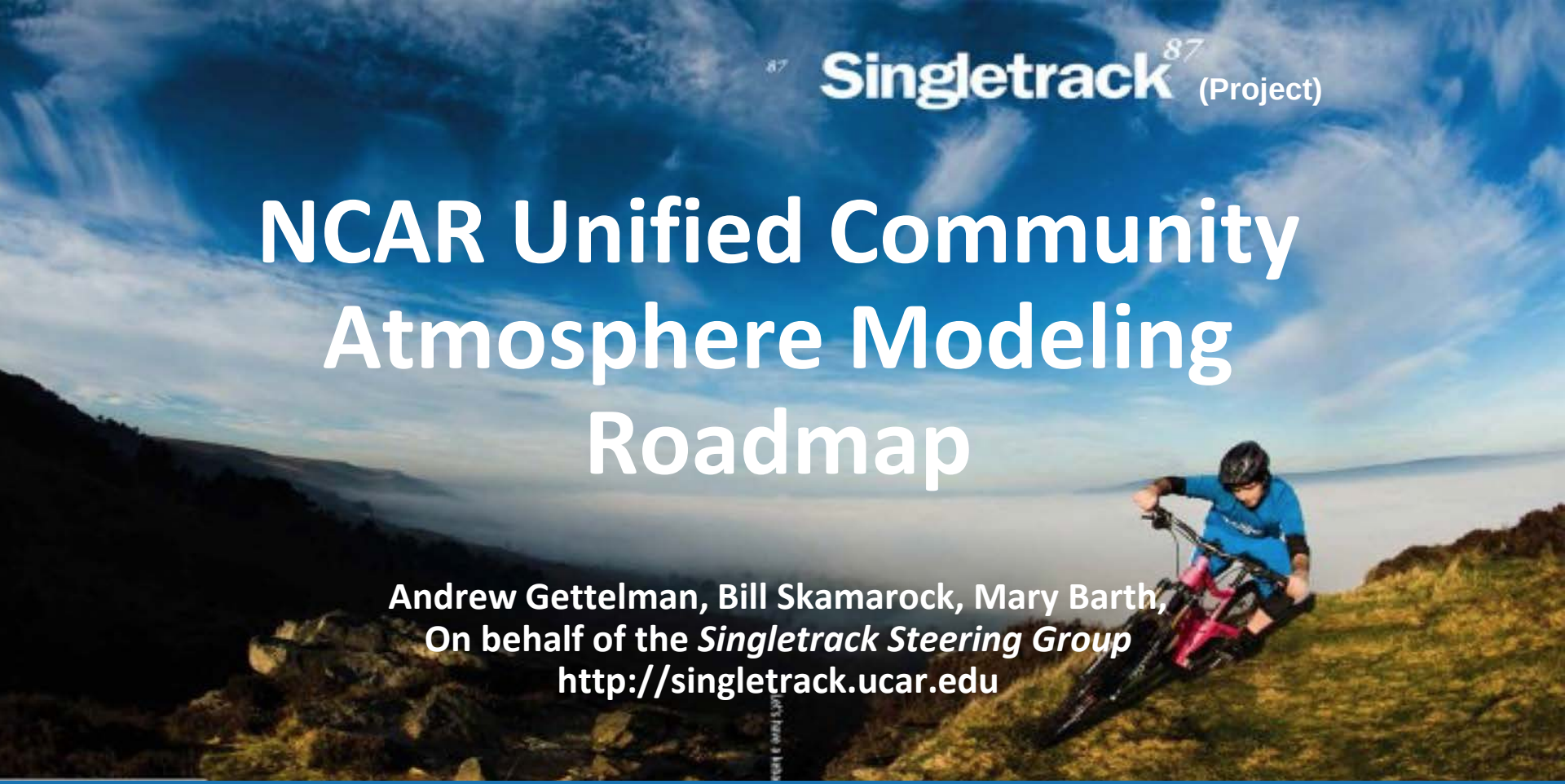


(Project)

NCAR Unified Community Atmosphere Modeling Roadmap

Andrew Gettelman, Bill Skamarock, Mary Barth,
On behalf of the *Singletrack Steering Group*
http://singletrack.ucar.edu

Singletrack is a project (started early 2018) to develop a strategic vision and roadmap to unify the community *atmospheric* modeling efforts co-led and supported by NCAR (CAM & WACCM/WACCM-X, MPAS, WRF).

Goal: a Unified *community* atmosphere model *within* an Earth System Model

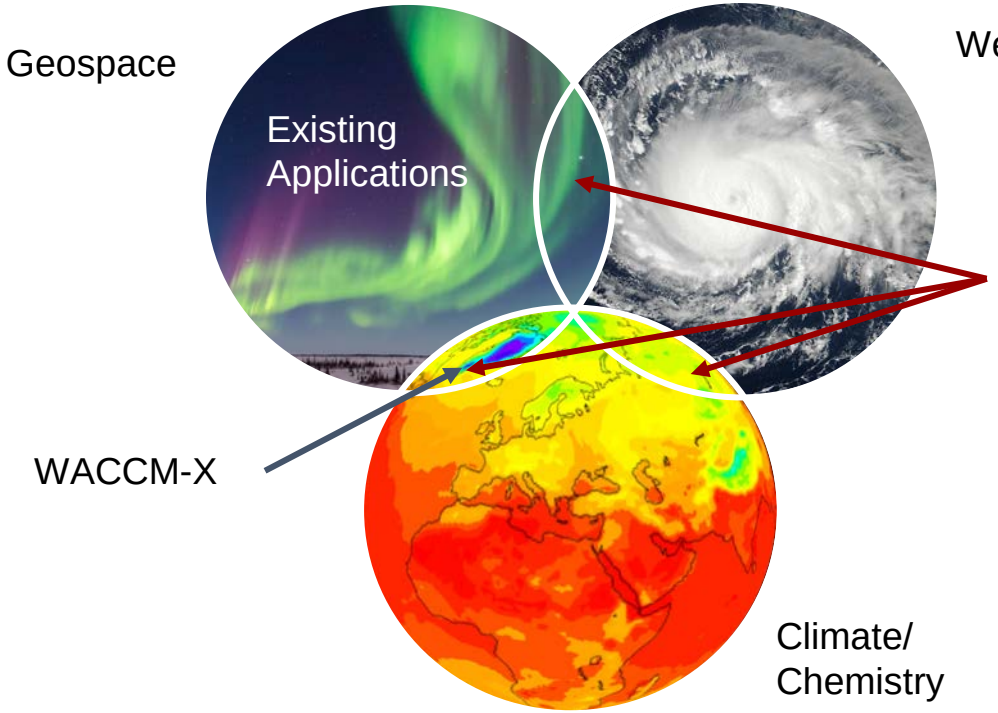
Singletrack motivation:

(1) Frontier science goals require new simulation capabilities
(2) Increasing overlap in climate, weather, geospace and chemistry applications
(3) More efficient use of development, support and infrastructure resources

Singletrack goals are aligned with 2018 NCAR advisory panel and 2017 NSF Site Visit Team (SVT) recommendations

Singletrack Vision

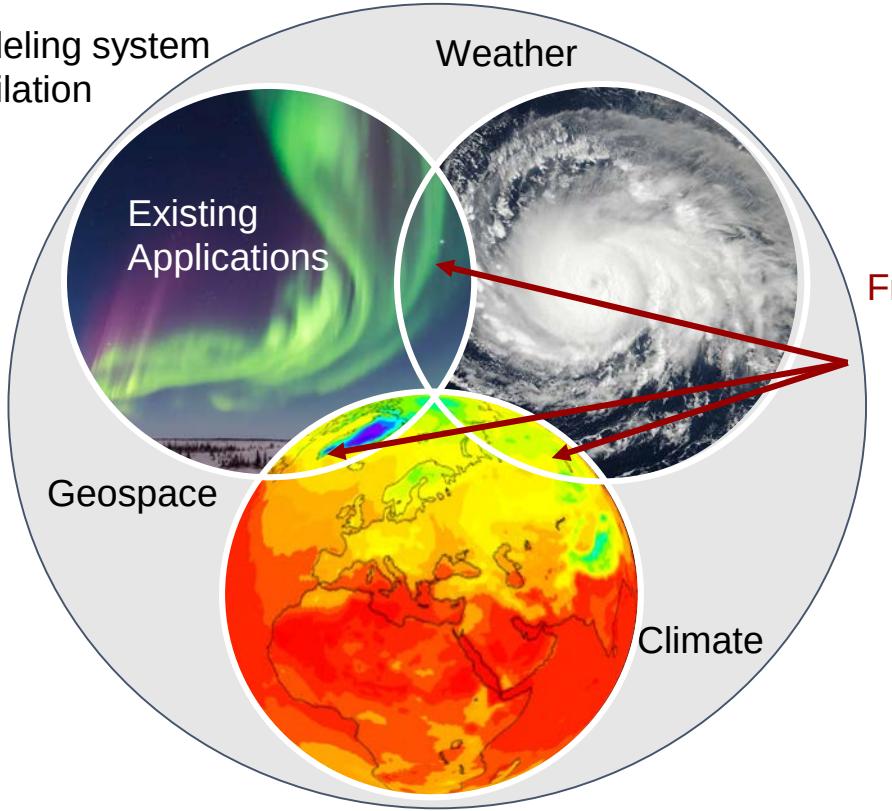
Support Existing and Frontier Applications



Singletrack Vision

Unified atmospheric modeling system

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



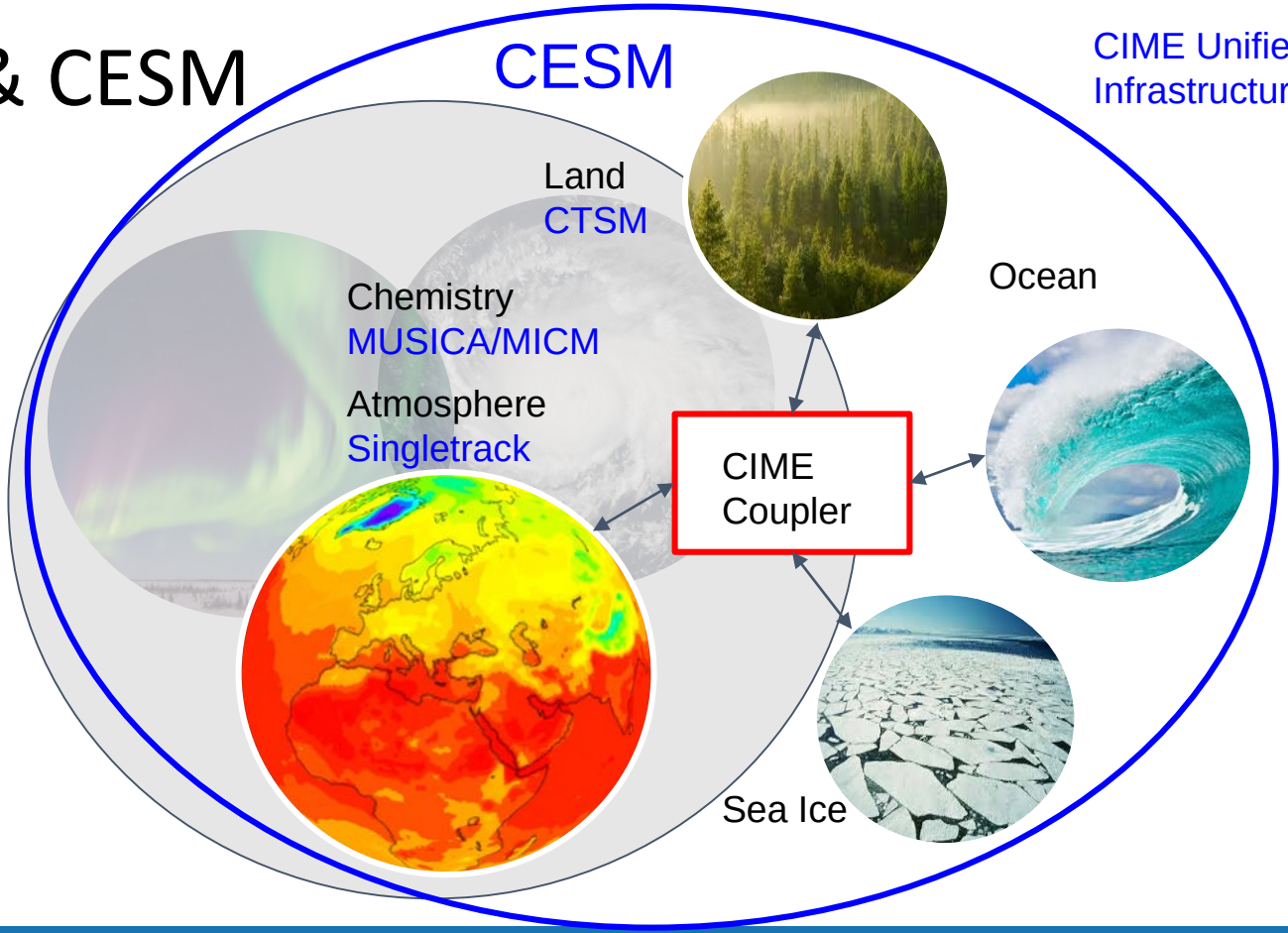
Frontier Applications

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

Singletrack & CESM

Singletrack : CAM
CTSM : CLM

Singletrack could be viewed as a way to define the target atmosphere model for CESM3

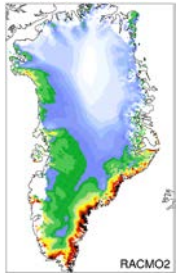


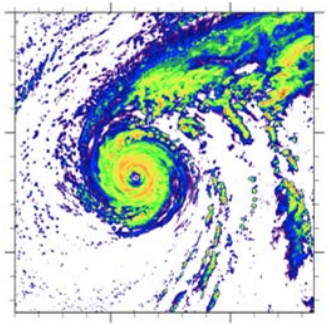
Examples of Frontier Science Goals that could be achieved with Singletrack

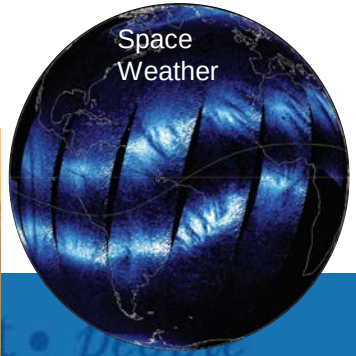
- Coupled Simulations at the Weather Scale
- Extreme weather under climate change
- Polar Prediction
- Air Quality
  - Urban scale to regional scale to global scale
- Integrated Geospace modeling
- Prediction: Subseasonal to Seasonal (S2S) to Decadal
  - Intra-seasonal (MJO), And interannual (ENSO)
-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


Hydrology Extremes

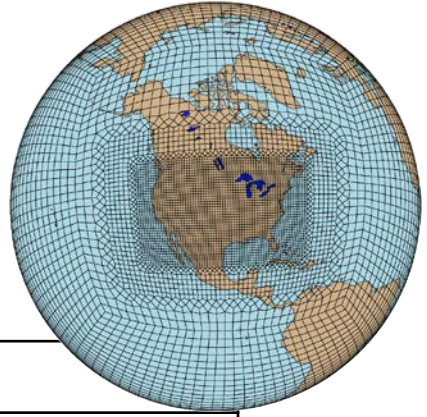
Polar




Tropical Cyclones



Singletrack target configurations for goal examples



Topic	Example Application	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

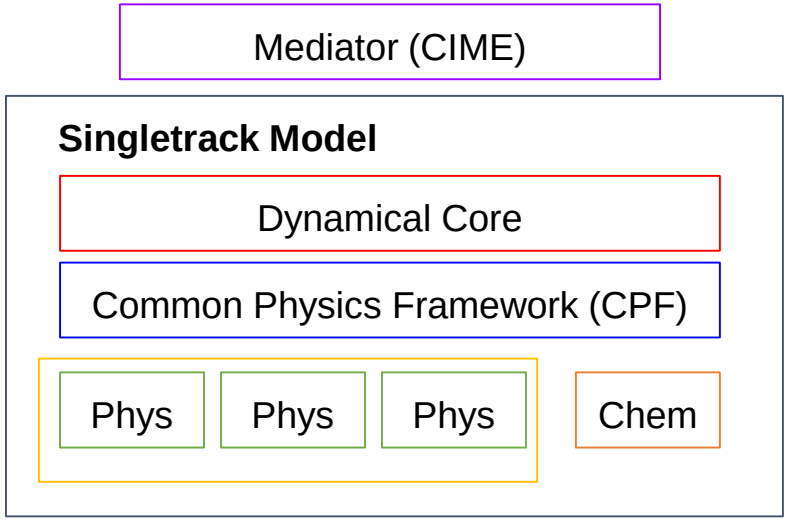
Singletrack: Modular Structure

Configure for different applications

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

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

Singletrack can be thought of as a structure/framework, or a single model



Physics 'Suite'
(CAM6, WRF-Forecast, Geospace)

Chemistry Modules
(MUSICA/MICM)

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: Draft vision/plan presented at WRF/CESM meetings
- June: Initial document release: http://singletrack.ucar.edu
- July-Sep: Incorporate feedback

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

Extra: Applications Details

Singletrack and CESM

- Singletrack group includes key CESM atmosphere stakeholders
- A ‘singletrack’ model could be configured like CAM (global, uniform)
  - Designed to meet climate applications
  - Maintain existing capabilities: A ‘traditional’ CESM user would see minimal impacts/changes
- CESM would have expanded capabilities (Frontier Applications)
  - Better Diagnostics for weather, Data Assimilation, etc.
- CESM will have access to WRF physics (with Common Framework-CPF)
- WRF/MPAS will have access to CESM physics (via CPF)
- CESM will have access to the MPAS dynamical core for high-resolution (convection-permitting) simulations within a full ESM configuration
- MMM would continue to support stand-alone MPAS & WRF until all applications can be achieved within a ‘Singletrack’ framework

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

Singletrack Applications

Application Examples and Configurations

Topic	Example Application	Configuration
Weather	Tropical Cyclones	3km refined mesh, coupled ocean, forecasts
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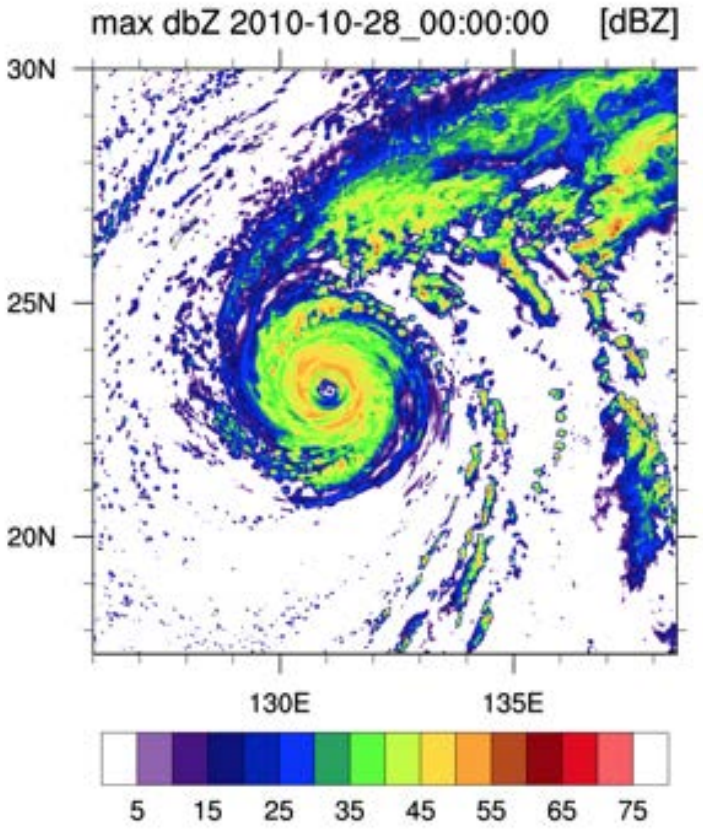
Applications: Weather

Tropical Cyclones

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

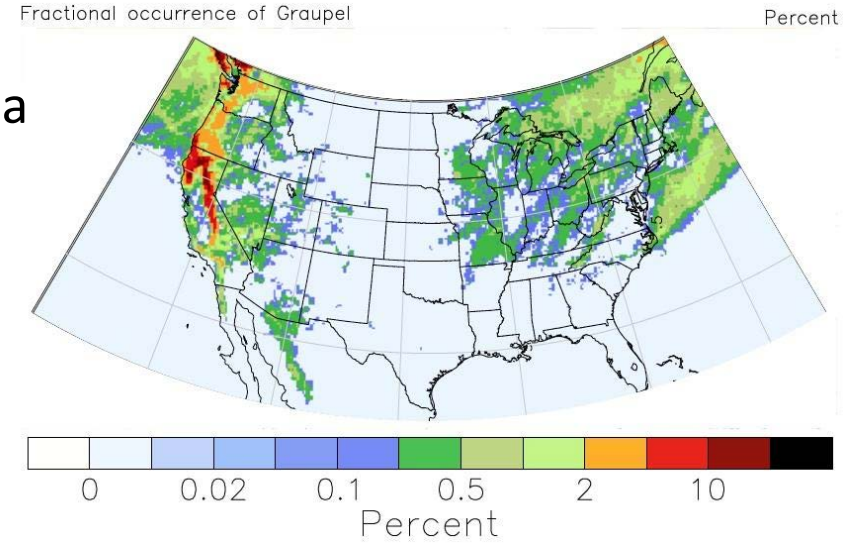
Also applies to MCS (convection) and S2S sub-seasonal prediction (MJO)



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



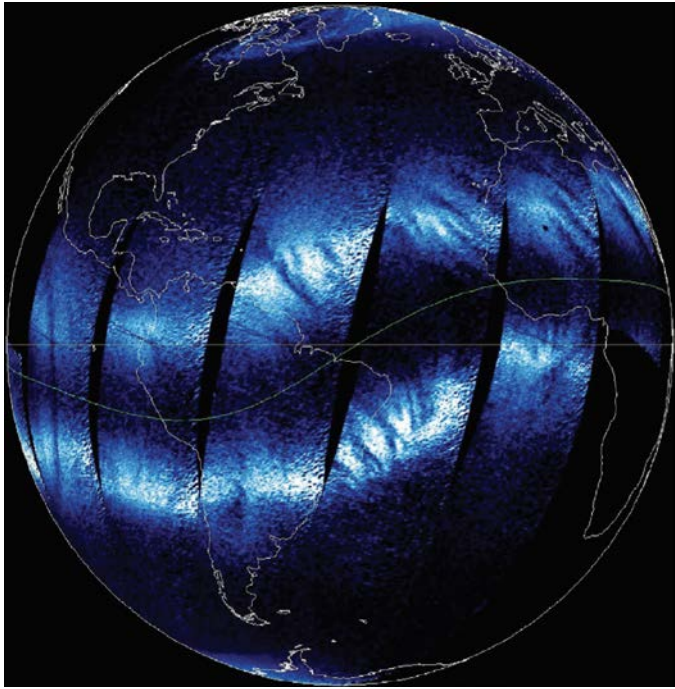
Also applies to floods, hydrology, droughts (up to seasonal). Prediction as well as climatologies of extreme hydrological events

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

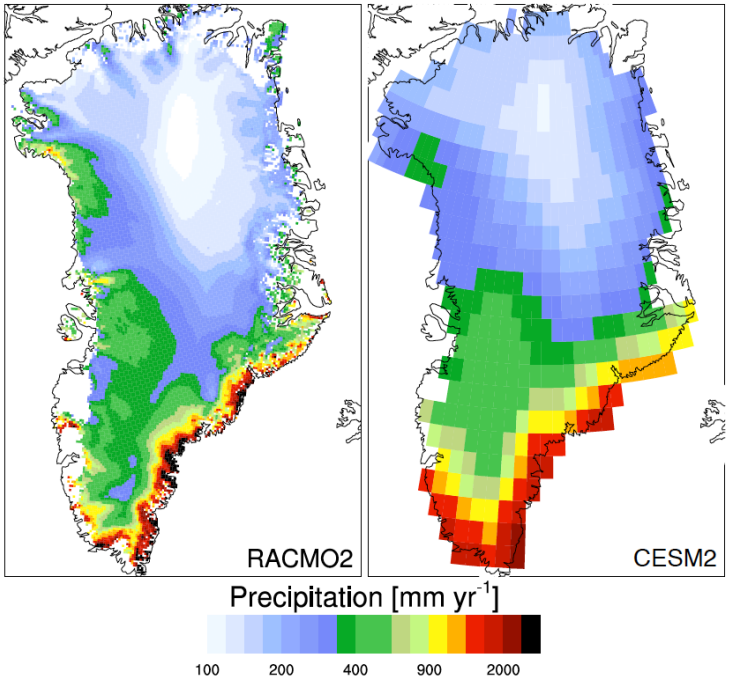
- Represent air quality in urban regions
- Interactions between atmospheric chemistry, weather and climate

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

Delhi, March 2018

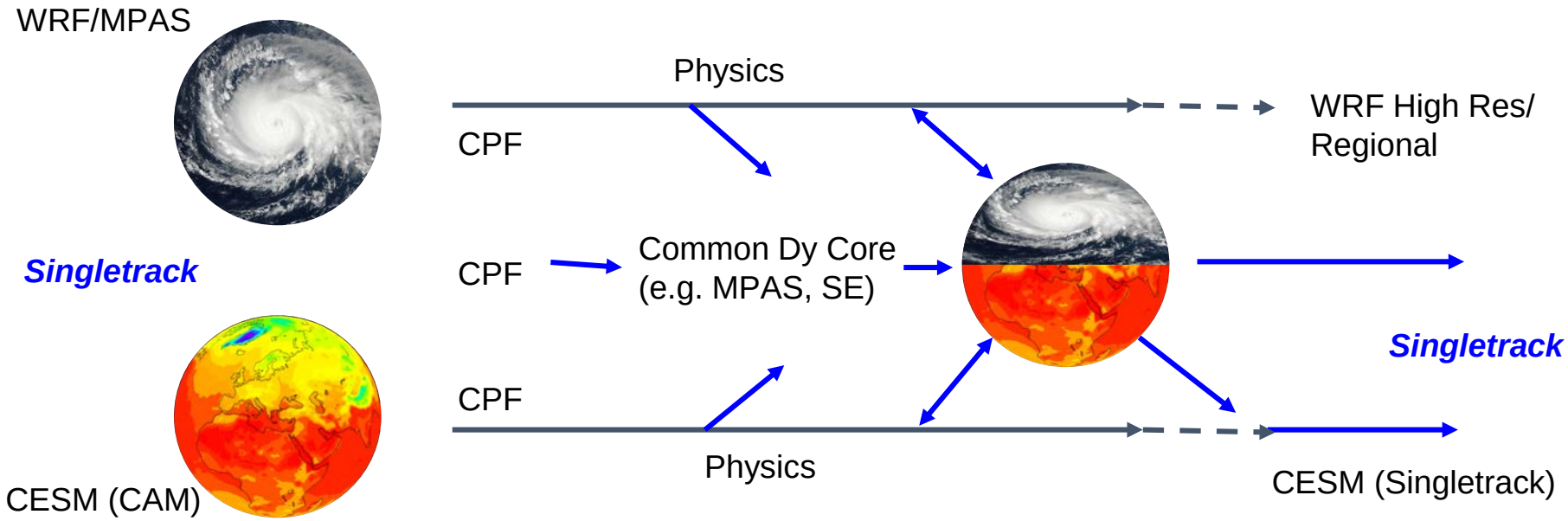
Applications: Polar

- 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.

Singletrack Community model evolution



Proposed Development Steps	Put CPF in CAM & WRF	Physics from CAM & WRF	Test applications in CAM & WRF

CESM v. WRF Organization(2018)

CESM Advisory Board

Chief Scientist

Scientific Steering Committee

Working Group 1

Internal Co-Chair | External Co-Chair

WG Liaison

Working Group 2

Internal Co-Chair | External Co-Chair

WG Liaison

Software Engineering Working Group

WRF Research Applications Board

Chief Scientist

Physics Review Panel

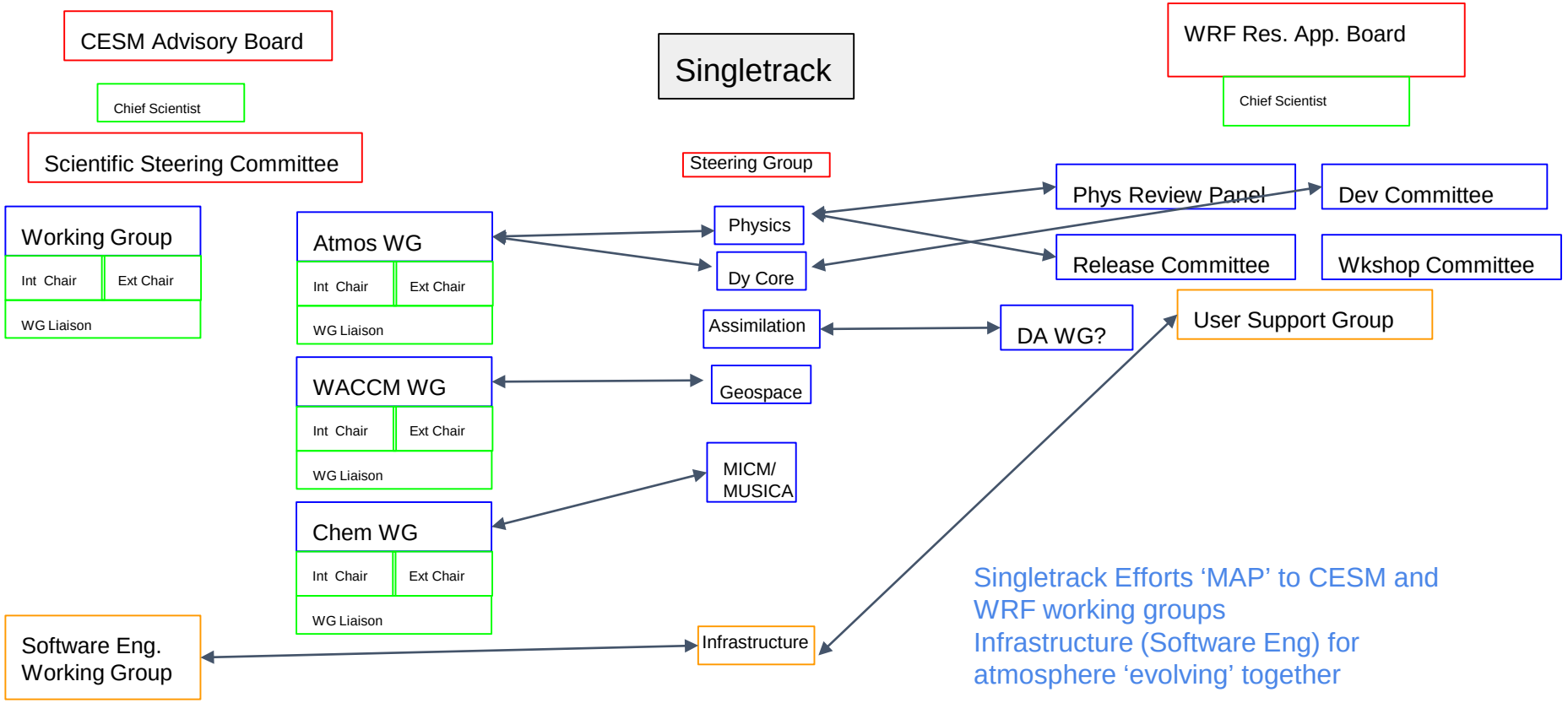
Developers Committee

Release Committee

Workshop Planning Committee

User Support Group

Singletrack: Relation to Existing Models



Singletrack Efforts 'MAP' to CESM and WRF working groups
Infrastructure (Software Eng) for atmosphere 'evolving' together