Model Priorities and Model Representational Perspectives: A Framework for Considering Future Development

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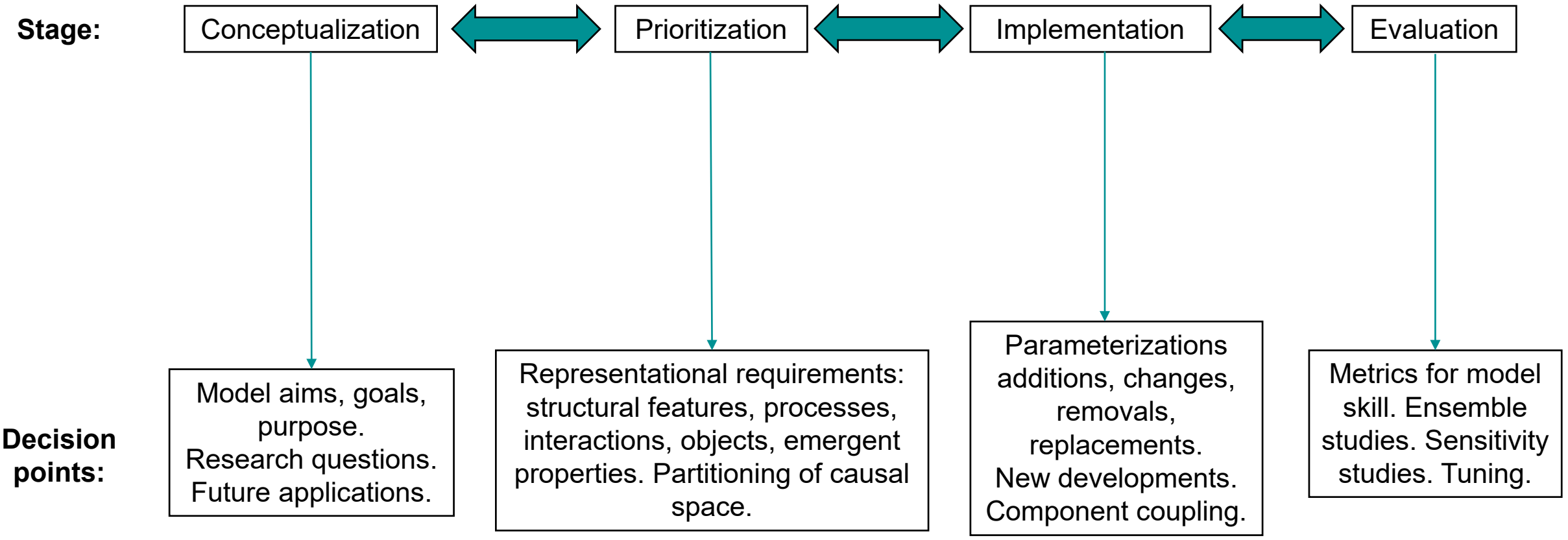
Approach: socio-philosophical interpretation of modeling practices.

Focus: influences (active &passive) on decision-making in model development.

Unit of analysis: individual research and development communities and unique associated features.

* *Note: This framework is an idealization. Contemporary model development rarely follows this formal structure. Stages are not sequentially ordered; there are iterations and feedbacks.*



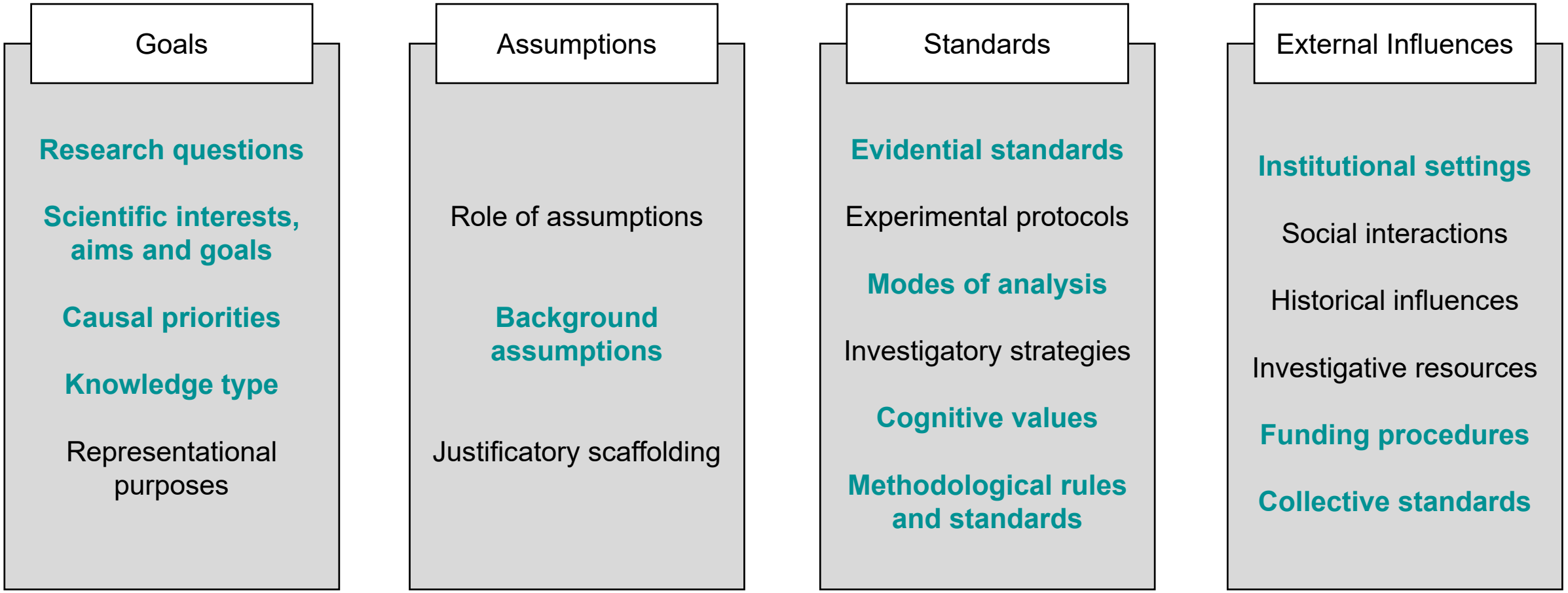
***Local epistemology** is the concept used to identify and understand influences on development.

A research community's local epistemology is composed of **the knowledge making features** of that community.

The components of a local epistemology are divided into: **goals, assumptions, standards and externalities**.

The **features** of a local epistemology are not fixed but in **flux through time**.

*Adapted from Longino 2002


Goals
Research questions
Scientific interests, aims and goals
Causal priorities
Knowledge type
Representational purposes
Assumptions
Role of assumptions
Background assumptions
Justificatory scaffolding
Standards
Evidential standards
Experimental protocols
Modes of analysis
Investigatory strategies
Cognitive values
Methodological rules and standards
External Influences
Institutional settings
Social interactions
Historical influences
Investigative resources
Funding procedures
Collective standards

Modeling aims

Representational requirements

Resolution

Institutional objectives

Process representation

Tuning priorities

Research questions

Emergent properties

Complexity vs. simplicity

Institutional structures

Regional priorities

Applications

Metrics for skill

CESM: Fundamental, basic science questions, process understanding, model use diversity.

GFDL CM4: Climate prediction questions (long-term dynamics).

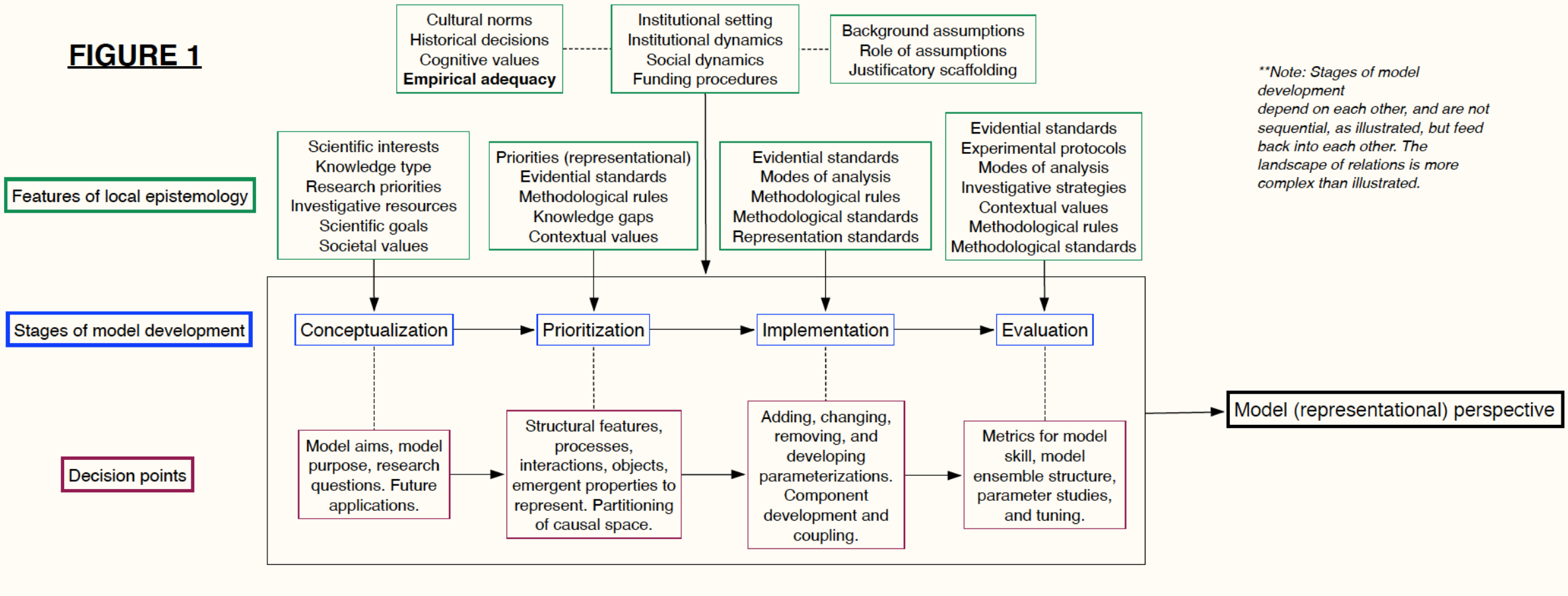
GFDL ESM4: Biogeophysical and biogeochemical impacts prediction questions.

Model E: Energy balance, energy flux and system forcing response questions (volcanoes).

E3SM: Long-term energy and resource prediction questions, utilization of high-powered computing infrastructure.

GEOS-5: Observation integration (from satellites), data assimilation.

FIGURE 1



***Note: Stages of model development depend on each other, and are not sequential, as illustrated, but feed back into each other. The landscape of relations is more complex than illustrated.*

Weather

What will the probability of precipitation be tomorrow?

Deterministic

Weather state of affairs

Synoptic storm tracks

Resolution

Initial values problem

Non-hydrostatic

Intial conditions analysis/reanalysis

Forecast accuracy

Climate

How will the climate system respond to volcanic aerosols?

Probabilistic

Mean weather/statistics

Energy balance/fluxes

Complexity

Forcing response problem

Hydrostatic

Long-term spun up equilibrium states

Hindcast validation

Models accurately represent certain features of the complex causal system at the expense of oversimplifying, obscuring or omitting other features of the causal space.

Models are perspectival.

How is the perspective determined?

The representational perspective a model occupies is a function of the interests, aims, and priorities of the research and development communities.

Externalities: influences from externalities can constrain model development and actively influence decisions.

Examples: CMIP (temporal); human resources; computing; collective standards, expectations (20th century, ECS); institutional objectives (prediction vs. process understanding); funding allocations.

Integration/unification: unified modeling is a perspectival integration problem across several dimensions (scientific/empirical, cultural/social, and technical/engineering).

Examples: SIMA, WACCM7/CAM7, ECMWF, WRF, CTSM.

Development vs. use: the representational priorities of development can fail to be responsive to the representational requirements of model users.

Example: regionally specific sea-level rise, HadGEM 360-day calendar, SRM studies, water cycle.

Scientific/epistemic integration: scientific aims, representational priorities, scientific perspectives and methods.

Social/cultural integration: blending of of research cultures, standards and practices for interdisciplinary effort.

Technical/engineering integration: integrating or unifying of instrument structures.

Relationships between different features of individual local epistemologies must be identified and mapped out.

Need to locate the representational perspective of one community from the viewpoint of the other—communities interested in same unique system but for different reasons, what conceptual issue brings those together.

This provides a structure for unifying cultures and knowledge/science.

*Perspectival/cultural integration:

1) Identification of cultural & perspectival features, points of incompatibility in terms of priorities, goals, standards, assumptions, etc.

2) development of joint necessary and sufficient conditions for model and research adequacy,

3) identification of a bi-directional scientific/conceptual bridge between community's research endeavors for the benefit all communities involved (a common mission),

4) identification of norms for collaborative activities that do not privilege the science or culture of one community over the other,

5) gradual collaborative conceptual change by modification of established scientific, methodological, and social traditions.

* Adapted from Fagan 2019

External influence: CMIP: long, computational expensive runs—Rep. requirement: long runs (WACCM to CAM or high-top CAM)

External influence: community needs: computationally cheap, useable model—Prac. requirement: flexibility, simplicity.

External influence: institutional objectives: sub-seasonal to decadal prediction, applications—Rep, requirement? Horizontal res?

External influence: SIMA aims…

What are the necessary and sufficient conditions for model adequacy for each involved community/aim?

Internal decisions (CAM): aims/interests: process understanding, experimental development? Rep. requirement? Also, for CAM-Chem and WACCM?

Primary: how important is CMIP comparatively? The answer to this will provide insight into 1) vertical resolution requirements for CAM, whether a unified version of the model is possible, etc. Importance of stratospheric chemistry for climate community aims.

Resolution question--→ unified modeling effort.

Need a shared criteria for determining how to set priorities; determining importance (shared community values).

CPTs—formal examination of how GFDL vs. NCAR treat the study of EDMF and CLUBB momentum transport with respect to the evaluation criteria, priorities, aims, etc.

This examination would help bring to light differences in the local epistemologies of GFDL and NCAR and provide insight into how development practices differ at the two institutions.