Applying Lessons Learned from the Earth System Modeling Framework (ESMF)

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The Future of Statistical Post-Processing in NOAA and the Weather Enterprise

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Outline

- ESMF overview
- Challenges
- Building community software

Common Goals?

A series of reports and papers called for *common modeling infrastructure*, for example:

- NRC 1998: Capacity of U.S. Climate Modeling to Support Climate Change Assessment Activities
- NRC 2001: Improving the Effectiveness of U.S. Climate Modeling
- Dickinson et al 2002: How Can We Advance Our Weather and Climate Models as a Community?
- NRC 2012: A National Strategy for Advancing Climate Modeling

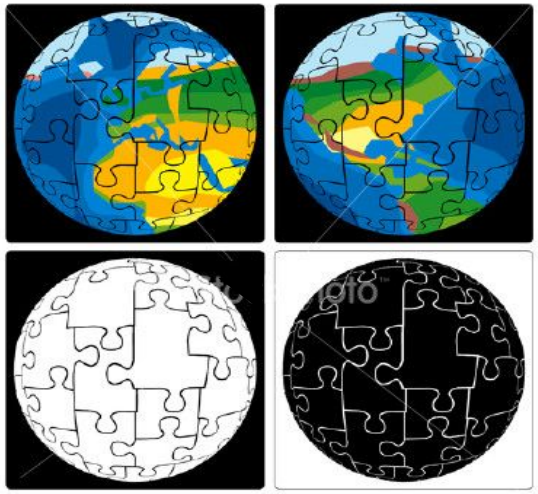
The motivation:

- Foster collaborative model development and knowledge transfer
- Lessen redundant code development
- Improve infrastructure quality and capabilities
- Support controlled experimentation
- Enable the creation of flexible ensembles for research and prediction

Sound familiar?

The Earth System Modeling Framework

The Earth System Modeling Framework (ESMF) was initiated in 2002 as a multi-agency response to calls for common modeling infrastructure.



ESMF delivered:

- Standard interfaces for model components
- High performance libraries and tools for time management, data communications, metadata and I/O, and *parallel grid remapping*

Metrics:
~5500 downloads

~3000 individuals on info mailing list

~40 platform/compilers regression tested

~6400 regression tests

~830,000 SLOC

http://www.earthsystemmodeling.org

ESMF Grid Remapping

Uniquely fast, reliable, and general – interpolation weights computed in parallel in 3D space

Supported grids:

- Logically rectangular and unstructured grids, point clouds/observations
- Global and regional grids
- 2D and 3D grids

Supported interpolation methods:

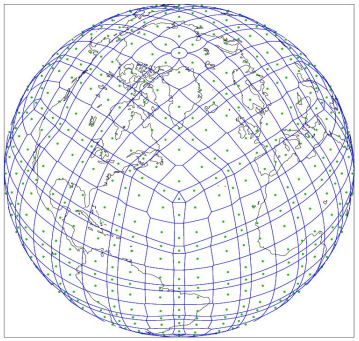
- Nearest neighbor, higher order patch recovery, bilinear and 1st order conservative methods

Options for straight or great circle lines, masking, and a variety of pole treatments

Multiple ways to call ESMF grid remapping:

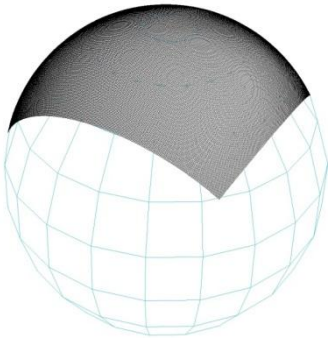
- Generate and apply weights using the **ESMF API**, within a model
- Generate and apply weights using **ESMPy**, through a Python interface
- Generate weights from grid files using **ESMF_RegridWeightGen**, a command-line utility

Some supported grids …



HOMME Cubed Sphere Grid with Pentagons
Courtesy Mark Taylor of Sandia

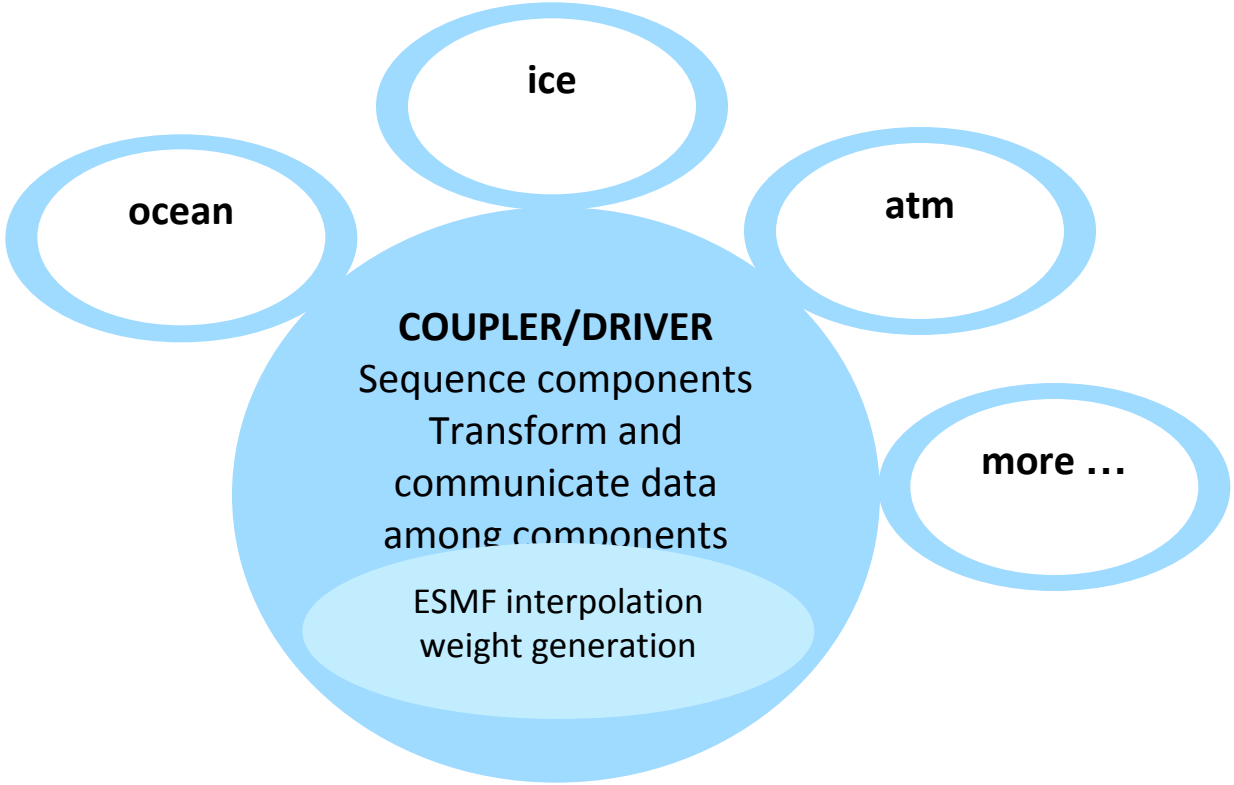
FIM Unstructured Grid



Regional Grid

Types of ESMF Use and Associated Capabilities

Modeling applications



1. Wrap components

- ESMF must represent model grids, fields, and time quantities (CESM, GEOS-5, ModelE, NEMS, COAMPS, NavGEM, NEMS/NGGPS…)

2. Remap grids

- ESMF generates and may apply interpolation weights

3. Construct couplers and coupled systems

- ESMF performs data communications
- Time, I/O, and utility operations, and
- Component operations and interactions

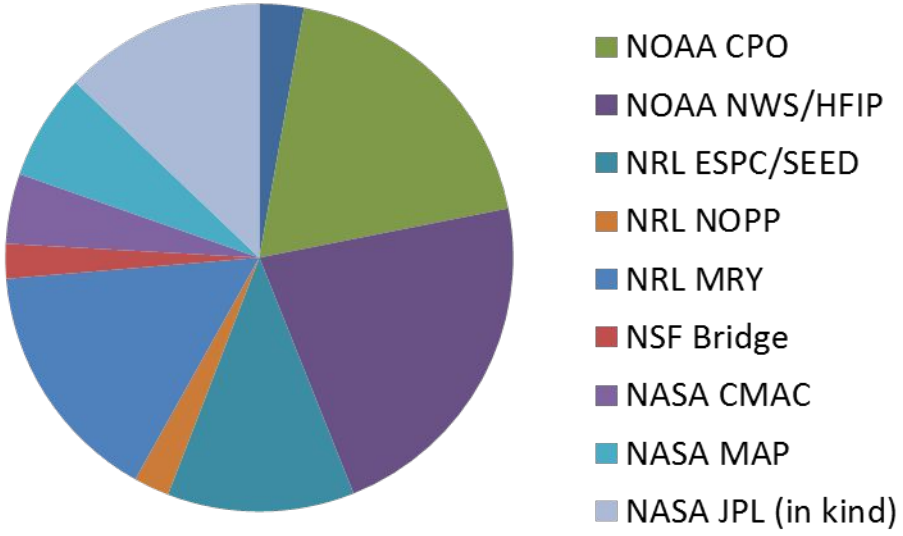
Data analysis and visualization applications

ESMF interpolation weight generation

NCL, PyFerret, DOE Ultrascale Visualization Climate Data Tools (UV-CDAT), IRIS (U.K. Met Office), GrADS team, Community Surface Dynamics Modeling System, plus hundreds of individuals

Governance and Partnerships

- Most development tasks come from user emails to ESMF support. Tasks longer than two weeks are prioritized by a Change Review Board.
- ESMF is directed by a multi-agency Executive Board. This body approves the ESMF Strategic Plan and defines the project's organizational structure and processes.
- Programmatic direction comes from an Interagency Working Group of project sponsors.



2015 funding profile

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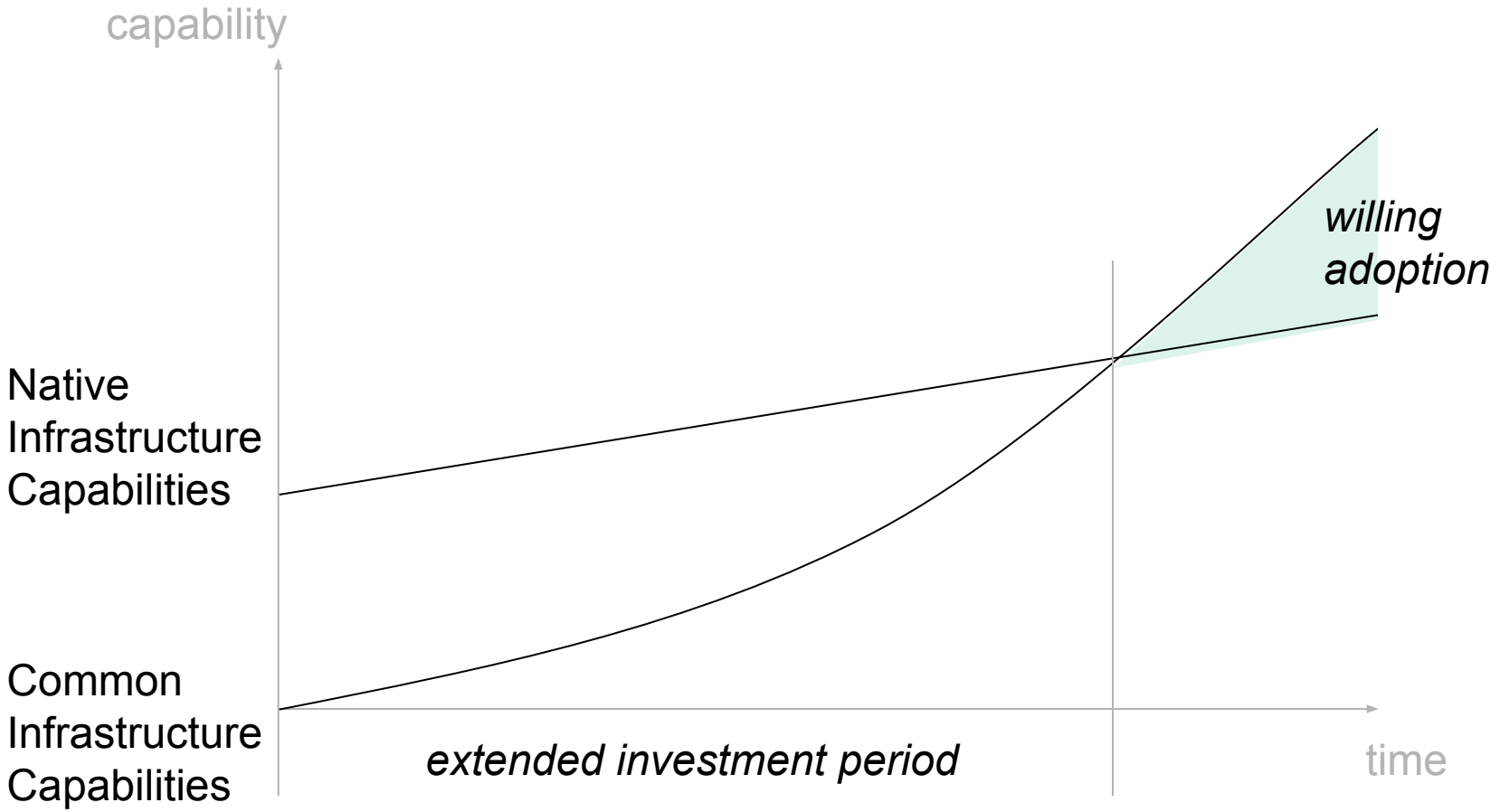
Challenges


capability
willing adoption
Native Infrastructure Capabilities
Common Infrastructure Capabilities
extended investment period
time

Challenges

1. The main motivation to replace existing, working, infrastructure is substantially increased capability over the status quo, and it can take an extended investment period to achieve this
2. There is a considerable design challenge in developing infrastructure that accommodates a huge variety of grids, calendars, options, and modes, yet retain its usability
3. The development of community infrastructure in a team not directly connected to any single system can result in “outsider” status, making adoption more difficult
4. A multi-agency infrastructure team must find an effective mechanism to consolidate and mediate the requirements of its multiple sponsors, and to sustain multiple funding sources

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Building a Common Vision

- Establish distributed, inclusive communication channels and a regular schedule for discussions.
- Establish and document a vocabulary, and vet it thoroughly.
- Use communication channels to survey the landscape and collectively document information about projects for collaboration or leveraging.
- Focus on as few as possible core documents to capture ideas and build consensus, leading to:
  - Collective statements of goals and values
  - Identification of areas in which new development is justified
  - The formulation of a scope and initial pilots

The emphasis at this point is on openness and inclusion, and building trust among a set of partners. Collectively developing definitional documents is a process that effects this.

Building a Product

- Establish an accessible, editable, sortable central document for tracking potential tasks.
- Identify a body of stakeholders and process for prioritizing tasks on a regular basis (typically every few months), using the task prioritization document.
- Use this process (change control or change review) to balance priorities with resources, and produce a development schedule with tasking.
- Implementation follows normal good pratices (documentation and testing as part of delivery).

The periodic task prioritization session, driven by users and resulting in a development schedule, is the foundation of community software management

- *It allows for joint ownership and decision-making*
- *It supports directed development without micro-managing it*

Building Across NGGPS

Opportunities for coordinating and leveraging efforts across NGGPS, in the form of core organizational documents:

Master List of NEMS/NGGPS Documentation:

https://docs.google.com/spreadsheets/d/1CLT66uzJrjrsY-um0jB5hU-Gfeh3_VCIJDA4-Ibmu5s/edit#gid=0

Code, Data, and Document Management for NEMS Modeling Applications and Suites

https://docs.google.com/document/d/1bjnyJpJ7T3XeW3zCnhRLTL5a3m4_3XIAUeThUPWD9Tg/edit#

Questions ?