ESMF and Curator Update

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NOAA Environmental Software Infrastructure and Interoperability Group
NOAA/CIRES
CCSM Software Engineering Working Group
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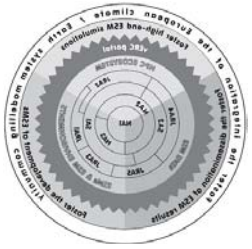


ESMF in CCSM4 and CESM1

- ESMF component interfaces are included in CCSM4 and CESM1
  - atmosphere, sea ice, ocean, land, and ice sheet components
  - active/data/dead versions
- ESMF interfaces do not change internals of model components
- These interfaces define the standard ESMF initialize, run, finalize methods and pass fields through ESMF State objects
- ESMF is tested as part of standard CCSM test suite
- Still in progress: ESMF integration with uni-processor build and ice sheet configuration

To get ESMF:
Standard installations on bluefire, jaguar, other platforms
Website: http://www.earthsystemmodeling.org

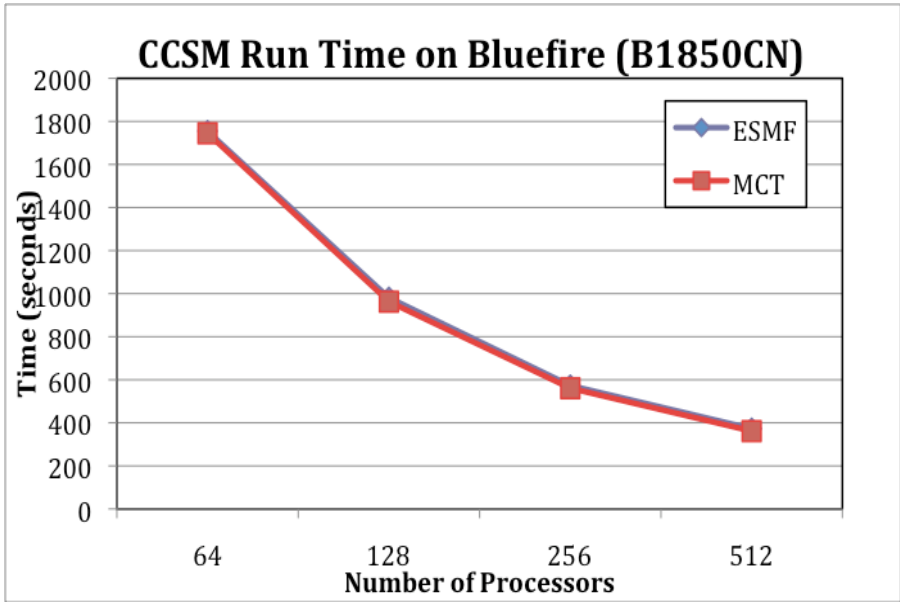
Why Use ESMF?

- Link with other ESMF components (NASA GEOS-5, NOAA FIM, NEMS and MOM4 codes, DoD COAMPS, watershed and coastal models)
- ESMF has leap years correctly implemented, not present in native CAM timekeeping
- *Potential* for using other ESMF capabilities:
  - web service coupling (prototype is CAM linked to Soil Water Analysis Testbed - SWAT)
  - OpenMP support at the component level
  - automatic generation and archival of metadata describing simulations
  - scalable on-line interpolation weight generation and regridding

To use ESMF with CCSM4/CESM:
Set USE_ESMF_LIB to TRUE in build config file
Set COMP_INTERFACE to ESMF in build file

Performance analysis of ESMF components (bluefire)

- Platform: IBM Power 575, bluefire, at NCAR
- Versions: CCSM_4_0_0_beta42 and ESMF_5_0_0_beta_snapshot_01
- CCSM compset: B1850CN (pre-industrial, Carbon Nitride biochemistry in CLM) includes the atmospheric model CAM, the land model CLM, the ice model CICE, the ocean model POP2 and a coupler
- Resolution: f09_g16, 1.25 degree x 0.9 degree global grid with 17 vertical levels for both the atmospheric and land model, i.e. 288x192x17 grid. The data resolution for the ocean model is 320x384x60.

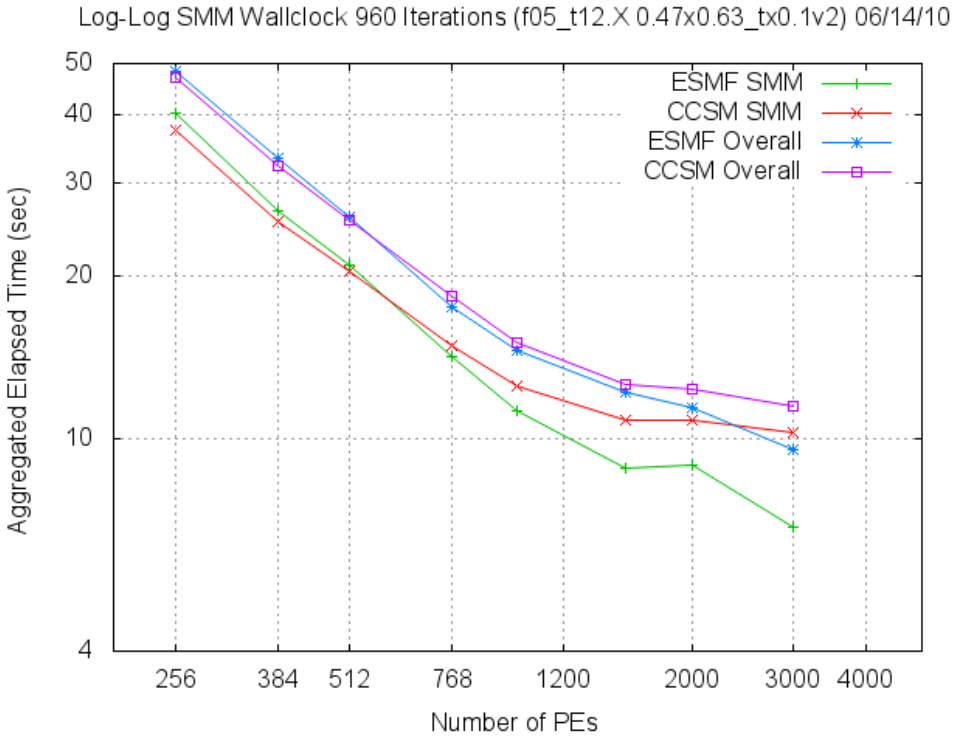


- Result: No changes to internal component code for ESMF version. Run time differences between ESMF and non-ESMF are within 3% to roundoff
- Comparable results on the Cray XT4, jaguar, at ORNL

Complete performance report at:
http://www.earthsystemmodeling.org/metrics/performance

Performance analysis of ESMF SparseMatMul

- Replaced CCSM4/CESM1 atmosphere -> ocean remapping with ESMF SparseMatMul based remapping in CPL7
- This substitution was not yet made in the component overhead comparison (previous slide) and could further reduce the ESMF end-to-end run time



- Versions: ESMF: 400rp2, MCT version 2.7.0, CCSM: ccsm4_0_rel08 (the April 1st release)
- Resolution: f05_t12 (fv 0.47x0.63 atmosphere/land, tripole 0.1 ocean or 576x384 atmosphere/land and 3600x2400 ocean)
- Configuration: Dead components

Regridding methods ESMF 5.0.0r

Features:

- Parallel and scalable algorithms
- Bilinear or higher order (patch recovery), prototype first order conservative methods
- Regridding is based on unstructured mesh code for flexibility of grid representation
- New faster tree-based search (order of magnitude faster than old search)

Methods of accessing regridding:

Online

- Subroutine calls which calculate weights during run
- Can produce weight array or feed weights directly into ESMF sparse matrix multiplication for complete on-line regrid operation

Offline

- Application which generates netCDF weight file from two netCDF grids
- Currently split into two applications, one for logically rectangular grids (offline) and one for cubed sphere grids (offline cubed sphere).

Regridding Capabilities

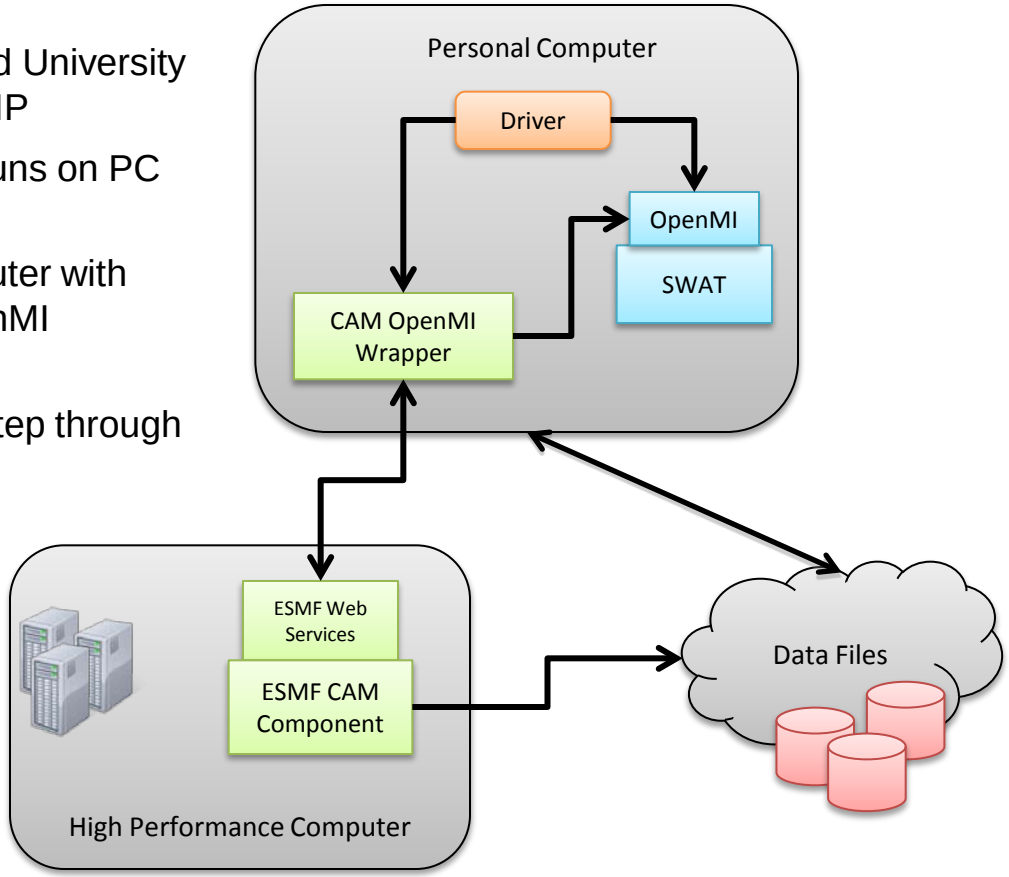
- Roughly, where source and destination grid types are both supported the regridding operation is supported.
- Regridding between 2D and 3D grids is not supported.
- ESMF logically rectangular periodic/higher order weights are currently used in CCSM4
- First order global conservation is currently applied as a correction (O'Kuinghttons et al. 2010)

Grids and capabilities	Description	Online	Offline	Offline cubed sphere
2D structured grids	Logically rectangular			
	Logically rectangular periodic			
2D unstructured grids	Triangles			
	Quadrilaterals			
	Cubed sphere			
3D structured grids	Logically rectangular			
3D unstructured grids	Hexahedrons			
Regridding	Bilinear			
	Patch			
	Conservative bilinear			
	Conservative patch			
Masking	Destination			
	Source			
	Ignore unmapped points			
Pole options	Full circle average			
	N-point average			
	No pole			

Supported	Not currently supported
Limited functionality, format may change	
Not tested, functionality available	

CAM-hydrology coupling with ESMF web services

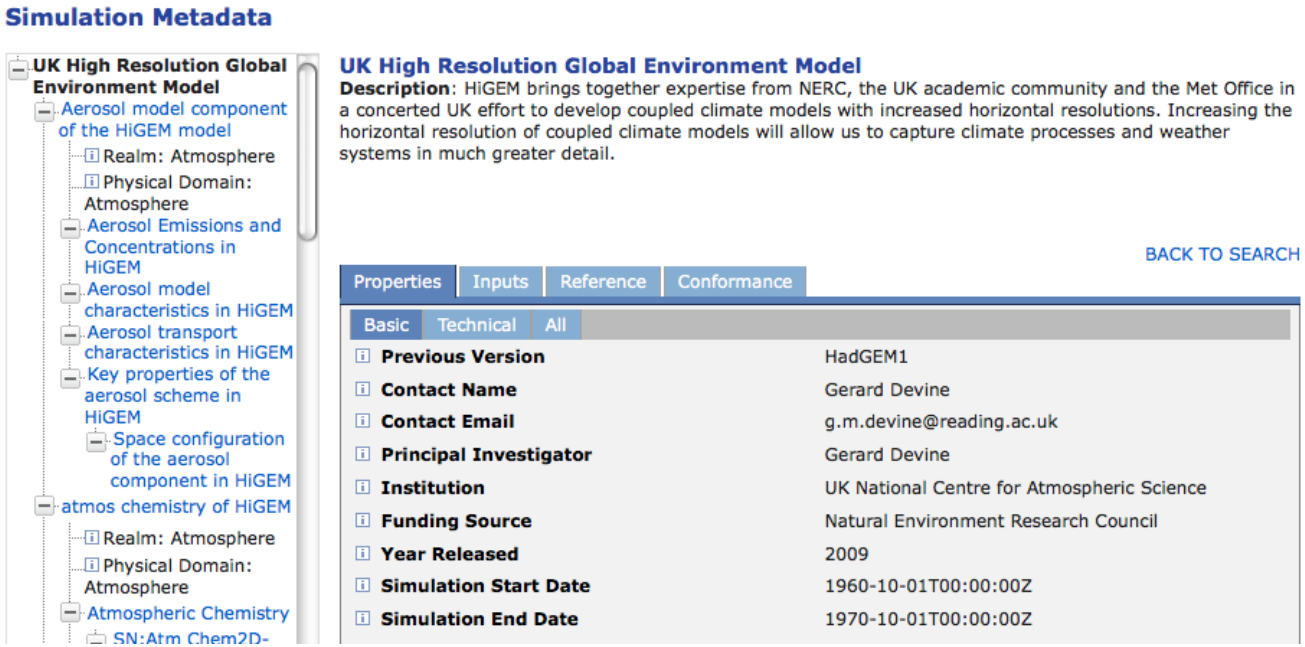
- Goal: develop a prototype coupling between a high performance atmospheric model and a watershed model
- Collaboration between NESII team and University of South Carolina, funded by NOAA GIP
- SWAT (Soil Water Analysis Testbed) runs on PC with OpenMI standard interface
- CAM runs on high performance computer with ESMF interface, standard ESMF-OpenMI connector
- Driver uses OpenMI interface to timestep through models
- Access to CAM across the network provided by ESMF web services
- CAM output data written to NetCDF files and streamed to CAM wrapper via ESMF Web Services
- Resulting output files archived to Earth System Grid science gateway



- Prototype complete, see Saint et al. 2010

Metadata Preparations for CMIP5

- Goal: Search and browse the climate model metadata being produced for the Coupled Model Intercomparison Project 5 (CMIP5) within the Earth System Grid (ESG).
- The metadata is arriving in the form of XML files from an online questionnaire developed by the E.U. METAFOR project. This is converted and displayed.
- METAFOR model metadata is becoming a community standard.
- Sylvia Murphy NESII lead, funded by NASA , NSF Curator and NOAA GIP



Automated Execution and Documentation for CCSM4

- Goal: Run CCSM4 through the Purdue CCSM Portal and archive both data and metadata back to the Earth System Grid portal (ESG)
- Leverages a graphical interface to CCSM workflows developed at Purdue University
  - CCSM Portal configures cases and submit jobs to a local supercomputer
- Tasks involved:
  - Update the Purdue GUI/portal for CCSM4 (Purdue)
  - Climate Model Intercomparison Project 5 (CMIP5) attribute packages being added to ESMF
  - New module planned for CCSM4 that can utilize these packages and write CMIP5 metadata automatically – which can then be ingested into Earth System Grid (probably not ready for CMIP5)
- Sylvia Murphy/Kathy Saint NESII leads
- Funded through NCAR's TeraGrid initiative in collaboration with NCAR VETS and Purdue University

http://www.purdue.teragrid.org/ccsmportal

On-line governance tools for community modeling

- New Curator “Commodity Governance” or CoG project funded through NSF
- A collaboration of climate scientists, software developers, computer scientists, and political scientists, and historians (NOAA NESII, GFDL, University of Michigan, University of Colorado)
- Focuses on tool development for managing model and component intercomparison projects and training classes
- Pilot projects getting support through CoG are
  - Summer school on atmospheric modeling (SSAM, Randall, July 19-21, 2010)
  - 2012 summer colloquium on comparison of dynamical cores (Jablonowski)
- CCSM4 is a potential case study for social scientists

Summary

- ESMF interfaces are in CCSM4 and CESM1 and can be run with negligible overhead
- ESMF sparse matrix multiply is a scalable option for CCSM4/CESM1
- ESMF parallel regridding is built on a very general base and is slowly building out specific capabilities
- Multiple application projects are beginning to use the CCSM ESMF interfaces
- These prototype new capabilities:
  - Coupling with PC-based models
  - Automated documentation of simulations
  - Workflows that span configuration of the model to data archival

Thanks to …

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- TeraGrid/National Science Foundation through NCAR CISL
- Modeling Analysis and Prediction Program/NASA

References

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