Current status of sea ice coupling in NEMS/NGGPS

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Outline

- Coupled sea ice in NEMS/NGGPS
- Bringing a component into NEMS
- The NEMS mediator and coupling
- Status: early results and next steps

Overview of Sea Ice in NEMS

- A team involving NCAR, NOAA EMC, NOAA ESRL, GFDL and others has developed a prototype of sea ice coupled to atmosphere/land and ocean components.
- The coupled code uses the **NOAA Environmental Modeling System (NEMS) infrastructure including the National Unified Operational Prediction Capability (NUOPC) driver.**
- The initial configuration includes:
  - NEMS mediator (coupler)
  - Modular Ocean Model 5 (MOM5) ocean
  - Los Alamos Sea CICE model
  - Global Spectral Model (GSM) atmosphere

This prototype can serve as an example of how other sea ice models may be coupled into NEMS applications.

NEMS Applications

- The NEMS infrastructure supports multiple applications, at different timescales, and involving different sets of components.
- The MOM-CICE-GSM coupling development is part of the **Unified Global Coupled System (UGCS)**, one of the applications based on NEMS.
- UGCS is expected to have weather, sub-seasonal, and seasonal scales.
- An initial version of MOM-CICE-GSM was delivered in August 2015 as UGCS 0.1. It was tested using 5 day runs.
- An updated version UGCS version 0.2 is being prepared for delivery. It is being tested using 15 day runs.

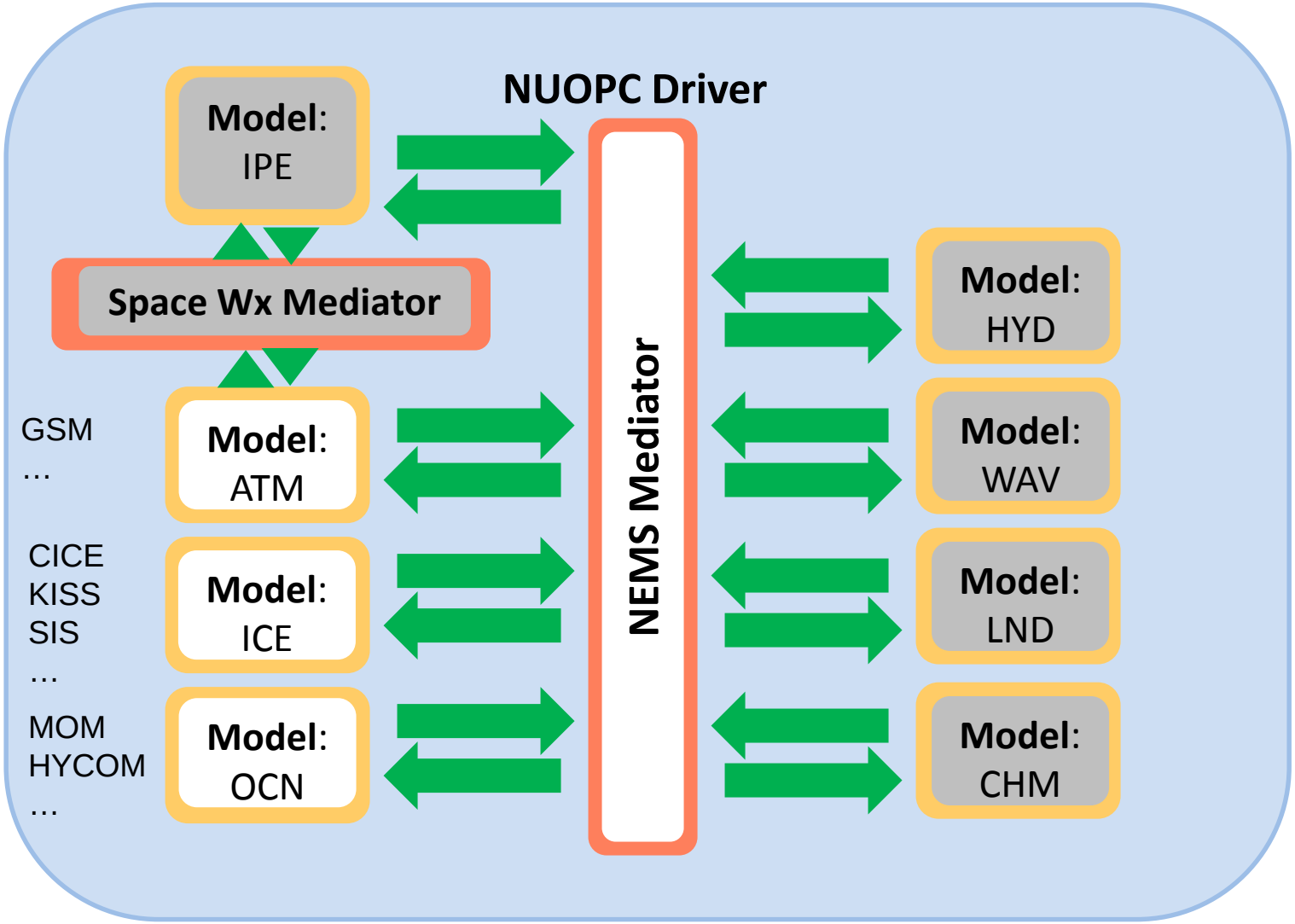
NEMS Mediator

- Currently supports ATM, OCN, ICE, LND, and HYD components.
- Slow (ocean) and fast (atmosphere and ice) coupling phases
- Performs the following functions:
  - Connects fields whose standard names match
  - Accumulates and averages atmosphere and ice fields between calls to the ocean model
  - Merges fields with a generic merge method that allows for weighting
  - Performs custom coupling operations, along with unit transformations
  - Performs interpolation (fluxes are mapped conservatively, states bilinearly, higher order also available)

More information about the mediator:
http://cog-esgf.esrl.noaa.gov/projects/couplednems/mediator_design

Worksheet of planned coupling fields across all modeling applications:
https://docs.google.com/spreadsheets/d/11t0TqbYfEqH7lmTZ7dYe1DSCh6vOUFgX-3qvXgce-q0/edit#gid=0

Components in NEMS



Bringing a Components into NEMS: Caps

The **NUOPC Model "cap" is a translation layer** on top of a model code that:

- wraps model data in ESMF data types and
- follows the NUOPC technical rules for behavior

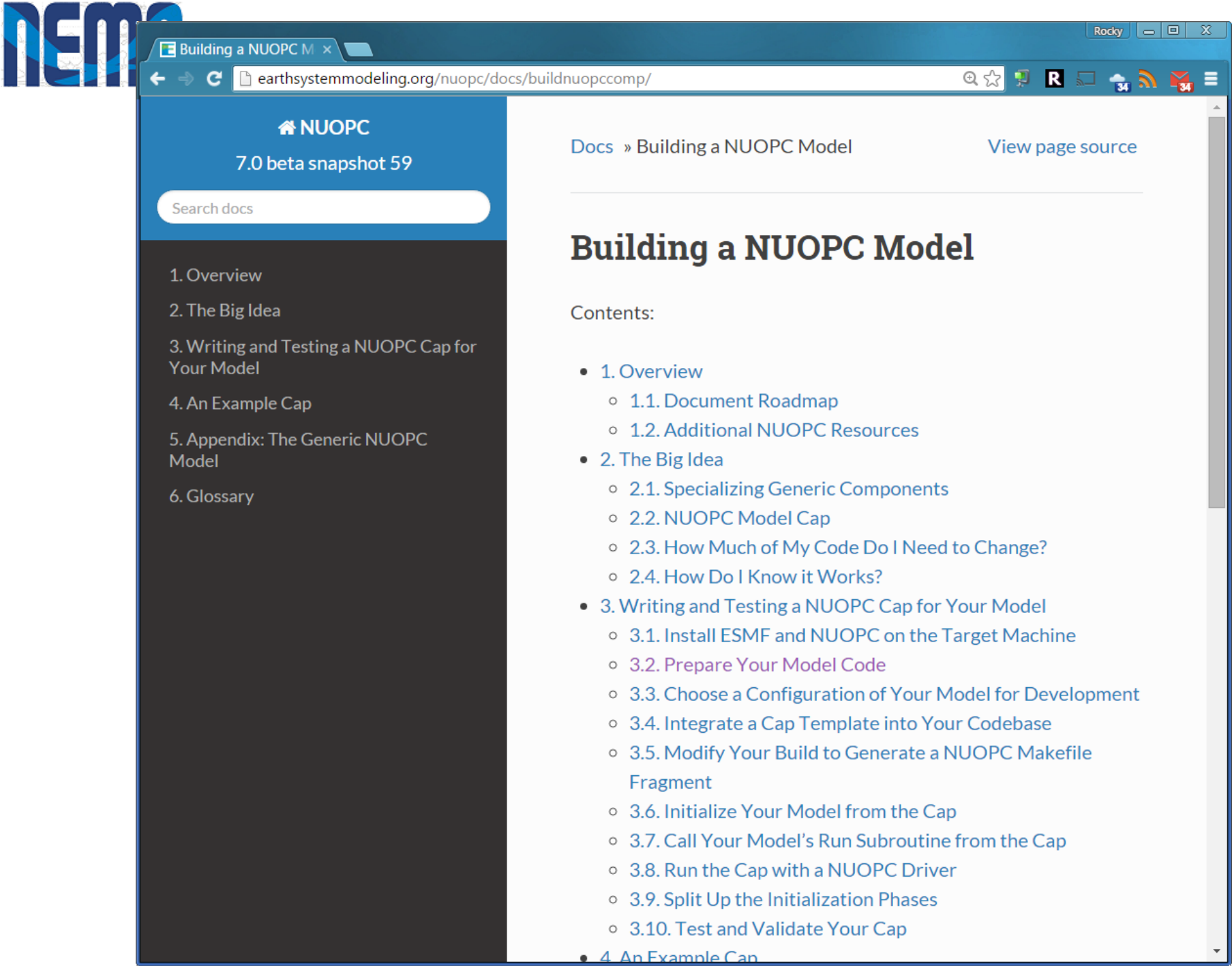
A cap is implemented as a Fortran module.

Each cap:

- Maps coupling fields to standard names and advertises them as imports and/or exports
- Creates an ESMF Grid or Mesh to describe the model grid
- Instantiates ESMF Fields and connect them to model data
- Initializes export fields

initialization sequence

- Provides a routine to advance the model by a timestep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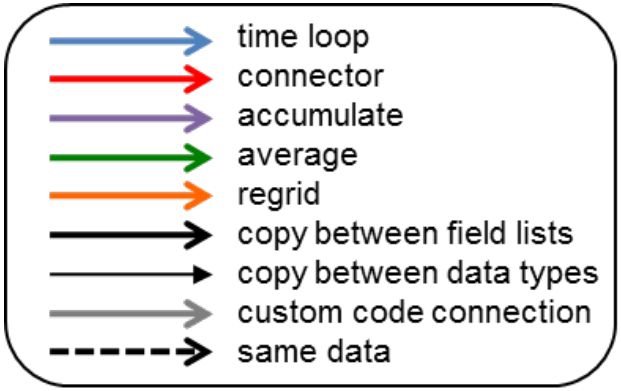
3.2. Prepare Your Model Code
3.3. Choose a Configuration of Your Model for Development
3.4. Integrate a Cap Template into Your Codebase
3.5. Modify Your Build to Generate a NUOPC Makefile Fragment
3.6. Initialize Your Model from the Cap
3.7. Call Your Model's Run Subroutine from the Cap
3.8. Run the Cap with a NUOPC Driver
3.9. Split Up the Initialization Phases
3.10. Test and Validate Your Cap
4. An Example Cap

NEMS Mediator: Control and Data Flow



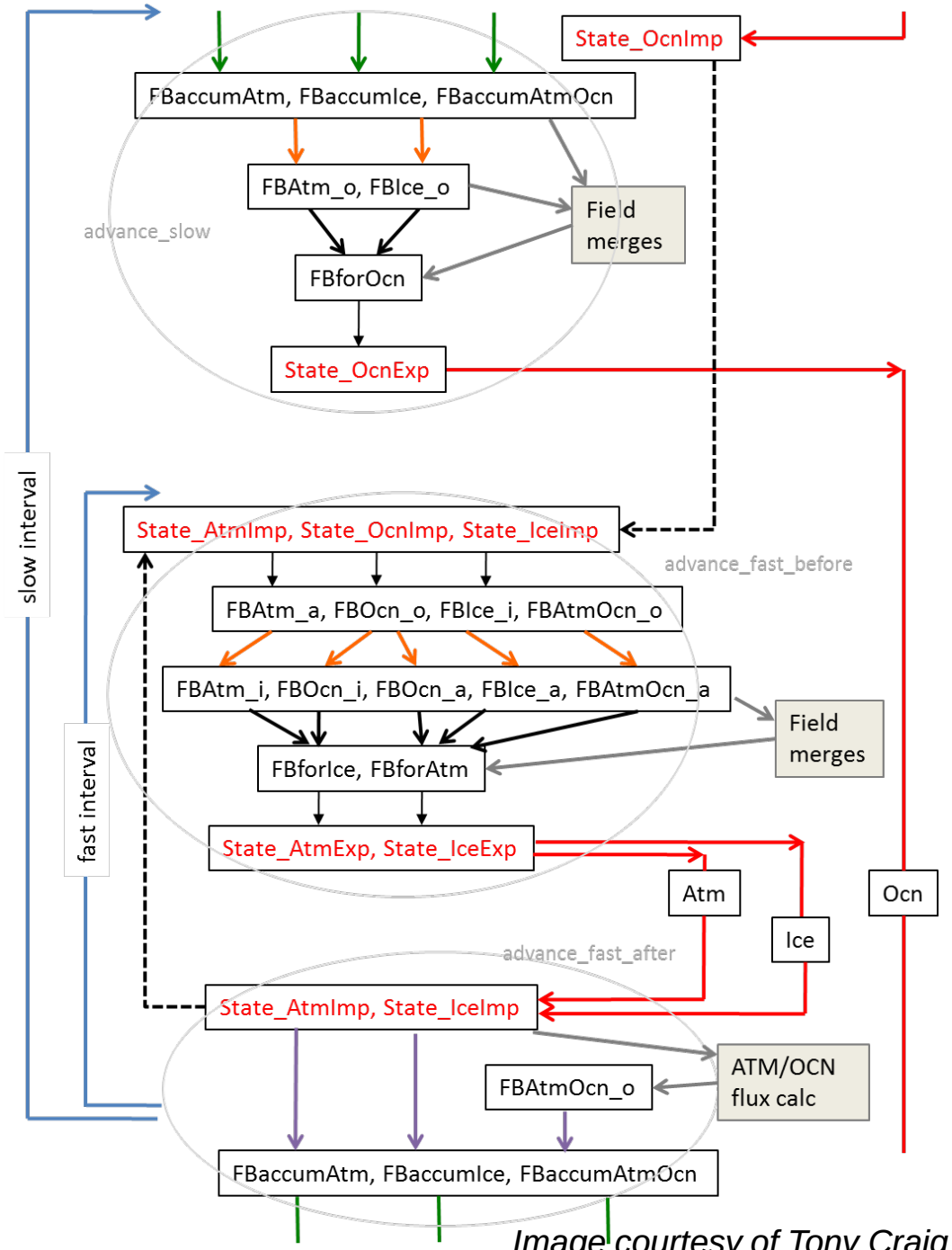
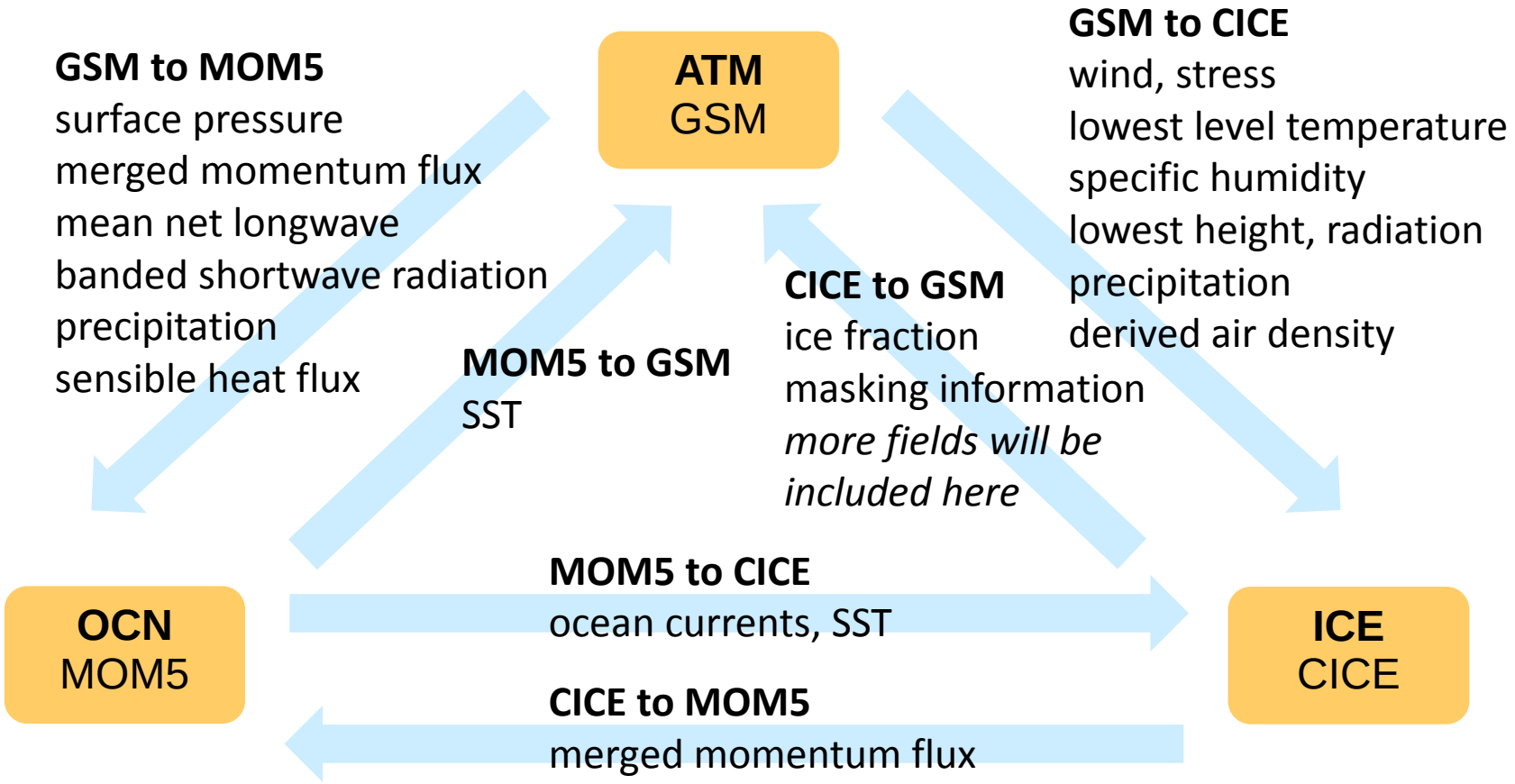


Image courtesy of Tony Craig

Status: UGCS Seasonal 0.1 Milestone

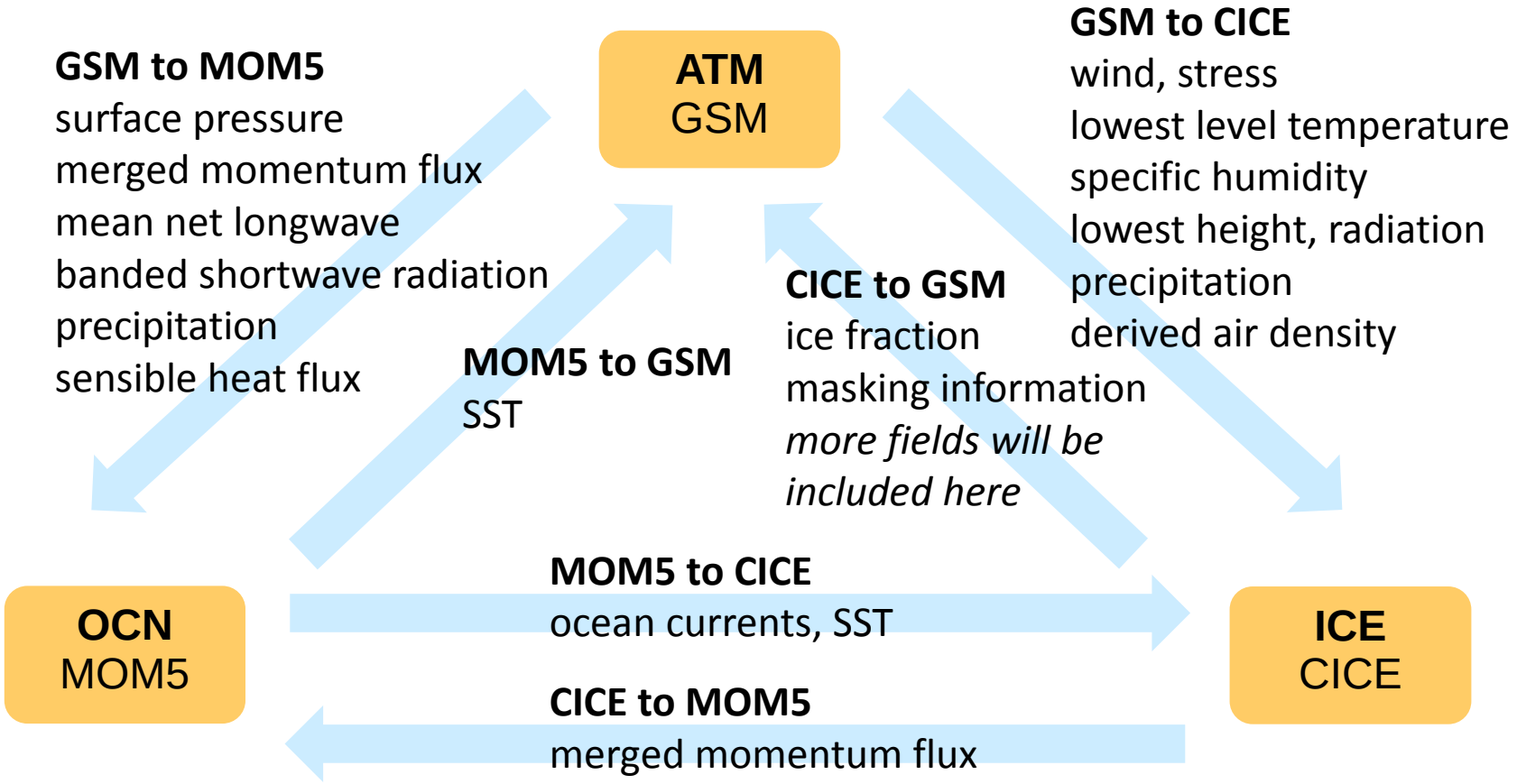
- Three-way coupled atmosphere-ocean-ice system with GSM (T126) - MOM5 and CICE (1 deg).
- Delivered June 2015.



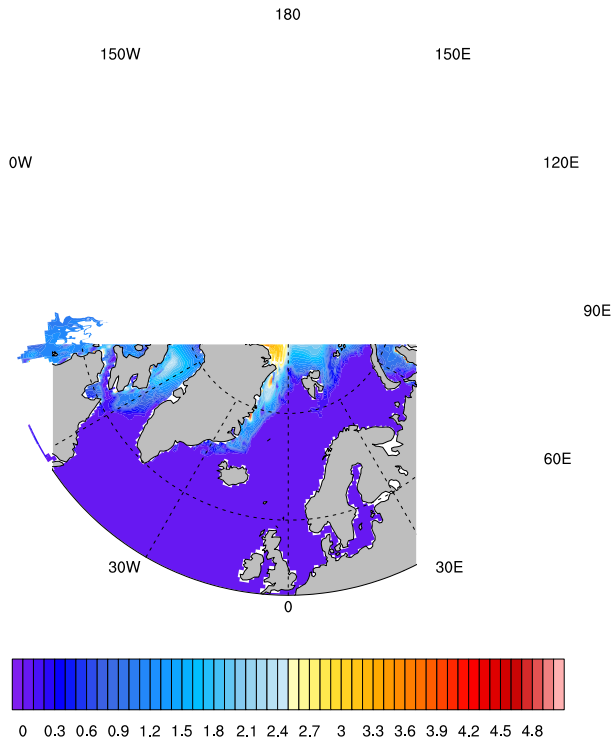
Status: UGCS Seasonal 0.2 Milestone

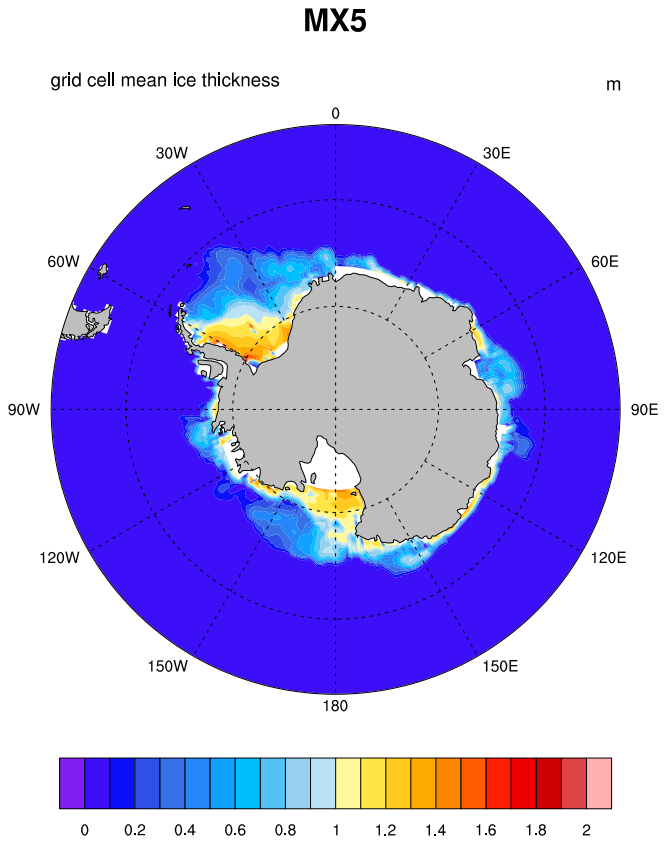
Interactions need to be updated with new additions.

- Three-way coupled atmosphere-ocean-ice system with GSM (T126),MOM5 and CICE (0.5 degree, 0.25 deg tropics)
- Running 15 days, not yet delivered. Delivery waiting on: 1) improved cold start capability, 2) full restart capability (GSM version needs to be updated for restart).



Status: UGCS Seasonal 0.2 Milestone





Next Steps

- Currently use CFS initial states
- Initialization with snow depth and snowfall on sea ice
- Salinity coupling: Mushy-layer physics simulates salt profile in sea ice
- Heat, fresh water, salt coupling to MOM

Getting and Running Coupled NEMS Code

- Coupled NEMS code can be checked out of the NEMS repository:

```
# $ svn co -r <revision> \
  https://svnemc.ncep.noaa.gov/projects/nems/apps/UGCS-Seasonal/trunk \
  UGCS-Seasonal
```

- Code can be checked out onto Yellowstone as well as EMC computers.
- Instructions for building and running are on the Coupled NEMS website: http://cog-esgf.esrl.noaa.gov/projects/couplednems/ugcs-seasonal

Sample NEMS Configure File (nems.configure)

```
##################################
# NEMS Run Time Configuration File  #
##################################
# EARTH #
EARTH_component_list: MED ATM OCN ICE

# MED #
med_model:                nems
med_petlist_bounds:       60 65

#ATM#
atm_model:                gsm
atm_petlist_bounds:       0 31

# OCN #
ocn_model:                mom5
ocn_petlist_bounds:       32 55

# ICE #
ice_model:                cice
ice_petlist_bounds:       56 59
```

Processor layout

```
# Run Sequence #

runSeq::
@7200.0
  MED MedPhase_slow
  MED -> OCN :remapMethod=redist
  OCN
  @3600.0
   MED MedPhase_fast_before
   MED -> ATM :remapMethod=redist
   MED -> ICE :remapMethod=redist
   ATM
   ICE
   ATM -> MED :remapMethod=redist
   ICE -> MED :remapMethod=redist
   MED MedPhase_fast_after
  @
  OCN -> MED :remapMethod=redist
 @
::
```

Colors show actions performed by:

- Connectors (->)
- Mediator (MED)
- Models

(@) indicates coupling interval

Mediator Run Phases

Advance_slow

Runs before OCN and prepares its import State

- Average accumulated ATM and ICE fields in FBaccumAtm, FBaccumIce, and FBaccumAtmOcn
- Regrid averaged fields to OCN grid
  - FBaccumATM → FBAtm_o
  - FBaccumICE → FBIce_o
- Copies fields in FBAtm_o, FBIce_o, FBaccumAtmOcn to FBforOcn
- Custom merges:
  - Precip, heat flux, LW flux scaled using ice fraction
  - Momentum fluxes and SW flux merged from ATM and ICE
- Reset accumulator FieldBundles
- Copy FBforOcn into NState_OcnExp

Mediator Run Phases

Advance_fast_before

Runs before ATM and ICE and prepares their import States

- Copies data from ATM, ICE, OCN import States into FieldBundles: FBAtm_a, FBOcn_o, FBIce_i
- Regrid:
  - FBAtm_a → FBAtm_i (ATM fields on ICE grid)
  - FBOcn_o → FBAtm_i (OCN fields on ICE grid)
  - FBOcn_o → FBOcn_a (OCN fields on ATM grid)
  - FBAtmOcn_o → FBAtmOcn_a (ATM/OCN flux fields on ATM grid)
  - FBIce_i → FBIce_a (ICE fields on ATM grid)
- Copy regridded fields to FBforAtm and FBforIce
- Determine OCN, ICE, and LND masks; determine OCN/ICE fractions
- Merge OCN+ICE fields to ATM (e.g., surface temp, heat & momentum fluxes)
- Copy FieldBundles to States for export from Mediator
  - FBforATM → NState_AtmExp
  - FBforICE → NState_IceExp

Mediator Run Phases

Advance_fast_after

Runs after ATM and ICE and accumulates fields for the OCN

- Regrid FBAtm_a → FBAtm_o (ATM fields on OCN grid)
- Compute ATM/OCN fluxes; store in FBAtmOcn_o
- Accumulate ATM, ICE and ATM/OCN fluxes
  - NState_AtmImp accumulated into FBaccumATM
  - NState_IceImp accumulated into FBaccumICE
  - FBAtmOcn_o accumulated into FBaccumAtmOcn
- Accumulation counters incremented