An ocean nested regional climate model using POP and ROMS

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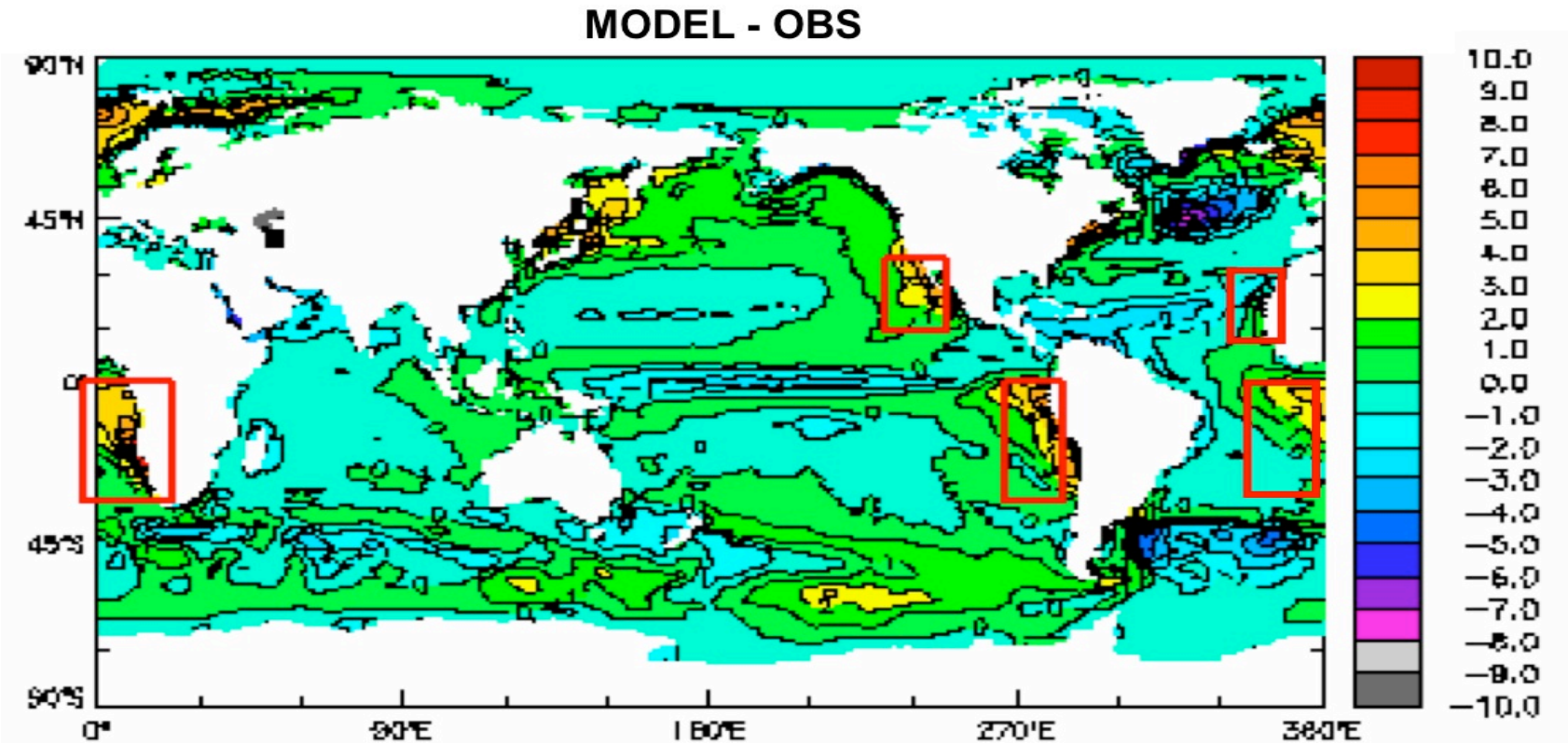
Outline

- Motivation - what's the problem?
- Definition - what is nesting?
- The nested ROMS ocean model
- Nested Regional Climate Model

CCSM2 SST Bias



- Regional **hot spots** along continental margins
- Large & Danabasoglu 2005

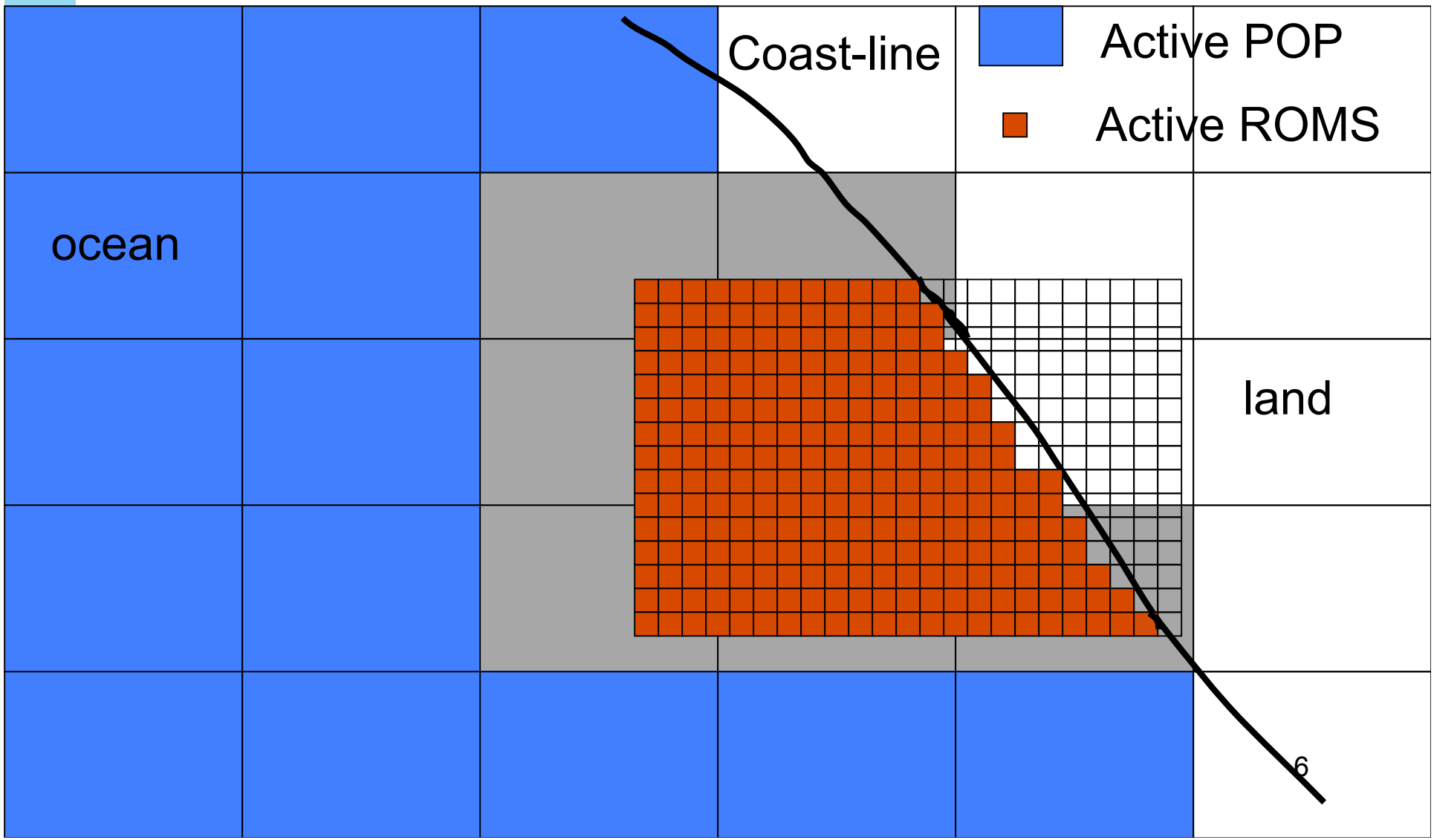
Why Nest Ocean Models?

- Need to represent regional scale processes and feedbacks
- Current OGCMs lack adequate spatial resolution (both vertical and horizontal)
- A high enough resolution OGCM domain is too expensive
- Utilize upscaling from a regional ocean model to improve the large scale circulation of an OGCM

What is Nesting?

- Local refinement via a family of nested grids
  - fixed high resolution local models embedded in larger coarse-grid global model
  - lateral boundary conditions provided by parent grid

Basic Nesting Case



What is Nesting (cont)?

- A recursive procedure for the temporal advancement of parent and child grids
  - Advance parent code by one parent (baroclinic) timestep
  - Interpolate lateral boundary conditions for child grid from parent grid
  - Advance child grid by one parent timestep in increments of the child grid timestep
  - Repeat

Nesting is not grid refinement

- Single grid with refined regions
- CFL condition requires implicit time stepping
- More common with finite element rather than finite difference/volume cores

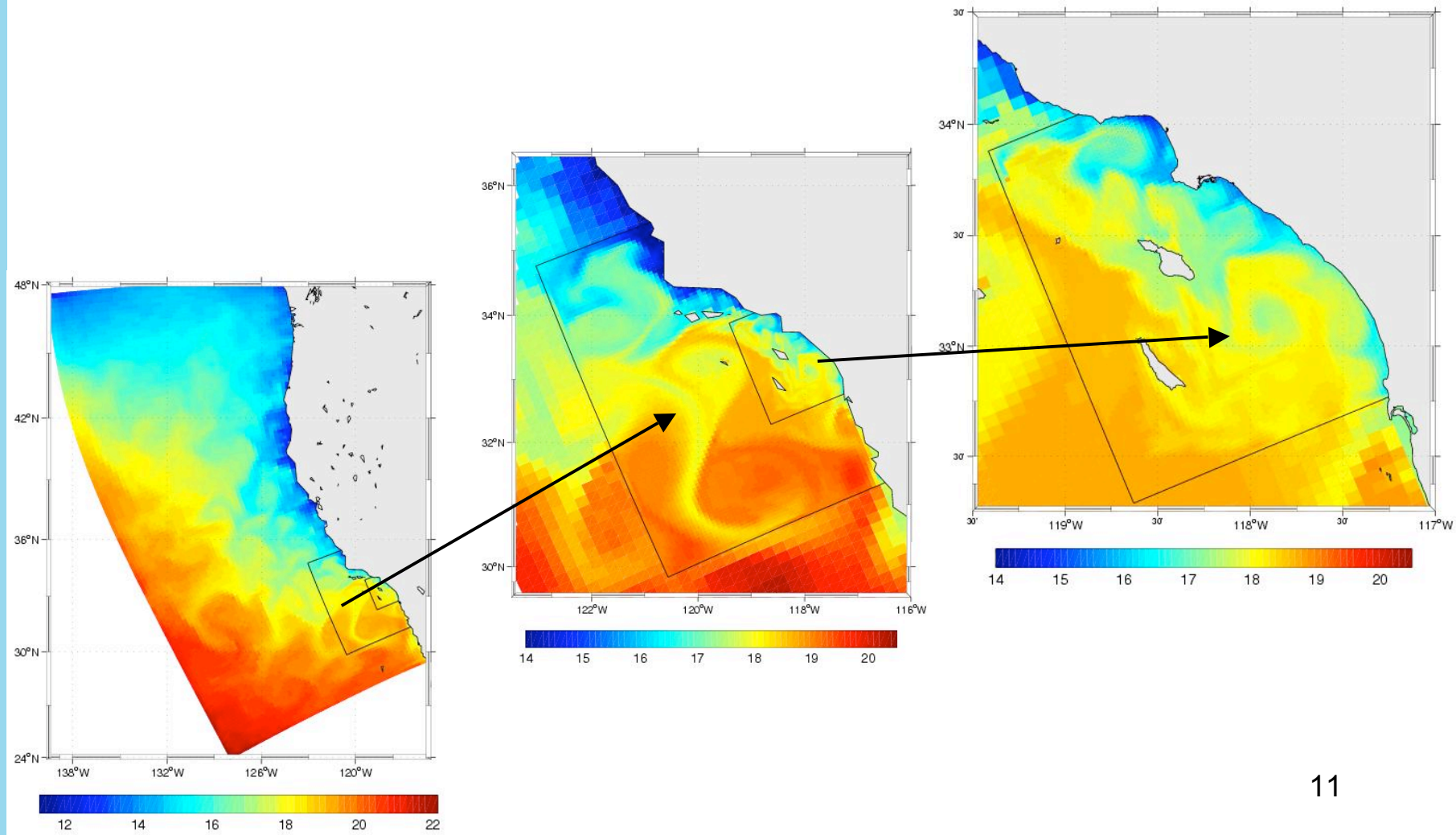
Regional Ocean Model System (ROMS)

- Split-explicit, free-surface, hydrostatic primitive equation ocean model
- Horizontal orthogonal curvilinear coordinates
- S-coordinates (stretched sigma), terrain-following vertical coordinates
- ESMF component version available

Nested ROMS

- Existing implementation communicates between nests through off line files
  - Weak coupling
  - Restricted to 1-way nesting only
- ESMF version in the works

SST from Nested ROMS



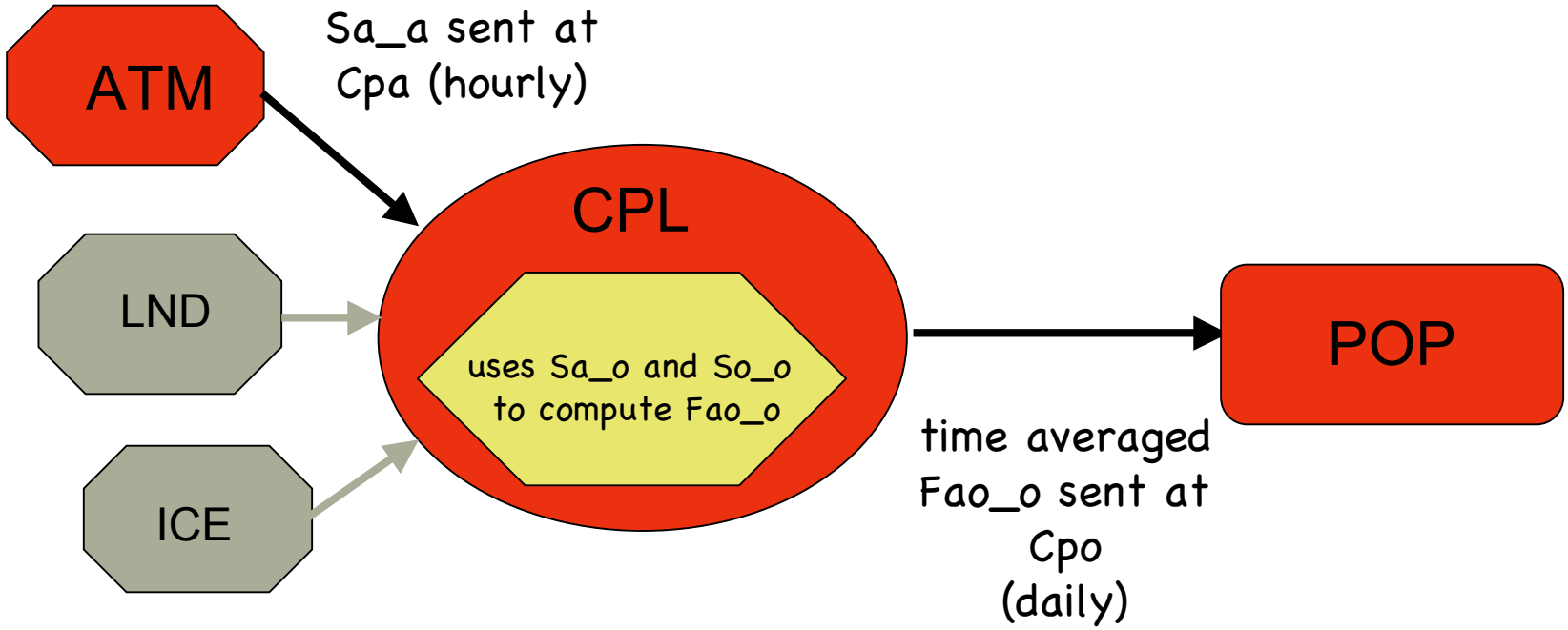
Comparison of Nested Solutions

- Similar features in parent grid
- Child grid
  - New instabilities
  - Longer filaments
  - Stronger upwelling
  - Intrusion of off shore warm water closer to shore
  - Narrower upwelling front

Stages for a Nested Regional Ocean Climate Model

1. 1-way nesting ROMS in POP and coupling to atmosphere
2. 2-way nesting ROMS in POP and coupling to atmosphere
3. ROMS coupled to nested WRF, POP coupled to CAM, 2-way nesting ROMS in POP

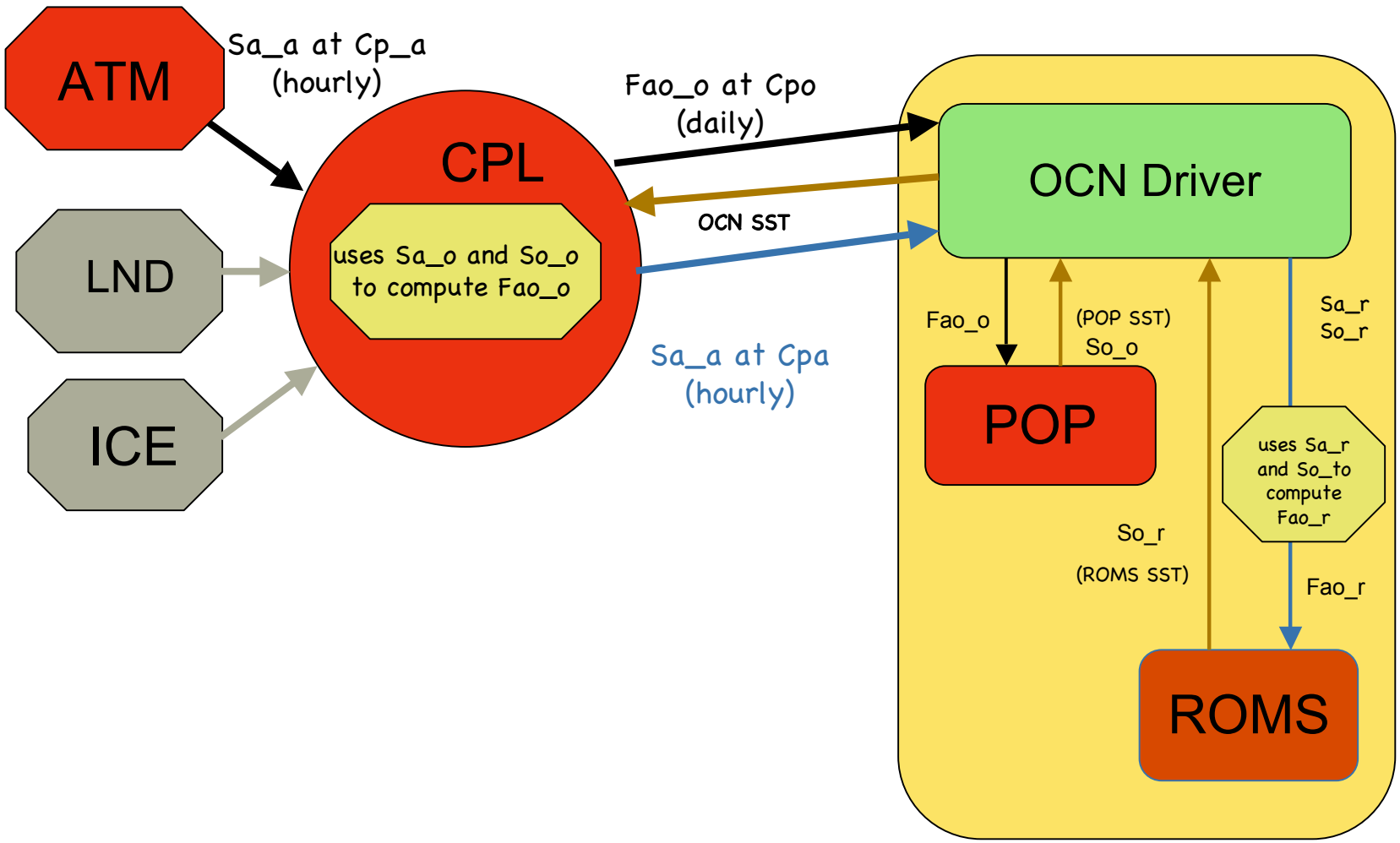
Current Data Flow : ATM->CPL->OCN



First Stage Tasks

- Replace POP with composite ocean having the option to default to the original POP only state
- Global to regional & regional to regional interpolation for communicating between ATM grid, POP grid, and multiple ROMS grids
- Subroutine-ization of ROMS code to control execution and import/export model forcing and state fields through calling arguments
- Ability to merge SST fields from multiple overlapping domains to feedback a composite SST to the coupler

New Data Flow : ATM->CPL->OCN



Stage 1

- Current Implementation uses CCSM2, which is based on MCT utilities
- ROMS interface changes based on ESMF component guidelines
- ROMS is an ESMF stand-alone component
- Composite ocean driver & merging code is designed to be swap-able with ESMF communication infrastructure

ESMF implementation of Stage 1 & 2

When CCSM4 adopts ESMF communication infrastructure;

- Plan to use exchange grid for conservative interpolation of surface fluxes
- Plan to use patch recovery techniques for
  - Vertical interpolation
  - Interpolation of lateral boundaries
  - Interpolation of vector quantities
- Plan to use ESMF_ArraySparseMatMul for interpolation

Challenges

- How do we quantify value added from nesting
- How do we conserve volume fluxes across the parent-child interface
- Difference in topography between parent and child grid can create inconsistencies
- How do we upscale the fine scale information without loss of all detail