HWRF / HMON COUPLING

- AM = HWRF or HMON
- OM = POM or HYCOM
- WM = WW3
- C = Coupler: sea surface to sea surface grid-to-grid interpolation; controls; diagnostics
  (all separate executables)
- each Component (AM, OM, WM) executable can be run either in the coupled system or standalone
The Coupled System

- AM: HWRF or HMON
  - SST
  - surface winds, HWRF moving domain
- OM: POM or HYCOM
  - SST
  - surface fluxes
- WM: WW3
  - surface winds, HWRF moving domain

Grid-to-grid interpolation / extrapolation

(+ additional WM↔AM and WM↔OM communications)
- Fine resolution moving domain grid is considered a section of fine resolution stationary grid in parent domain.
- Initialization of interpolation: for course resolution grid and fine resolution grid in parent domain.
**RUN-TIME DATA FLOW**

**OM**
- Hand-shaking; exchange of grids, sea/land masks
- **Time loop**
  - Time step: $\Delta t_0$
  - Coupling time step: $\Delta t_c = n_0 \Delta t_0$

get initial surf. fluxes

send SST

- Do time step

receive surf. fluxes if/where available;
update surf. fluxes (for next time step)

**Coupler Interpolation**
- Initialization
  - ("interpolation weights")

**AM**
- Hand-shaking; exchange of grids, sea/land masks
- **Time loop**
  - Time step: $\Delta t_A$
  - Coupling time step: $\Delta t_c = n_A \Delta t_A$

receive SST if/where available; update SST

- Do time step
  - Accumulate surf. fluxes

send accumulated surf. fluxes
Data interpolation

- Interpolation: bilinear in elementary grid cells, sea points to sea points only

- Data not supplied by interpolation, due to domain and sea-land mask inconsistencies, are provided by:
  - background (e.g. GFS) data
  - extrapolation on domain’s sea-point-connected component, for a specified number of grid steps, with (AM SST) or without (OM surface fluxes) relaxation to background data
Parallelized interpolation

Domain to interpolate from
(fields broadcast)

Domain to interpolate to
(fields tiled)
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**Interpolation initialization**: for each domain 2 gridpoint $p_{ij}$ find domain 1 elementary grid cell $C_{k1}$ such that $p_{ij}$ lies inside $C_{k1}$

**Data**:
- the domains are not necessarily quadrilateral
- elementary grid cells $C_{kl}$ are quadrilateral but not necessarily the elementary cell $(k,l), (k+1,l), (k+1,l+1), (k,l+1)$ in terms of indexing
- gridpoints are represented by their latitudes/longitudes (or other common coordinates); grids are general (not latitudinal/longitudinal)

**Methods**:  
- **direct search**: $\sim N^4$ operations: inefficient. Cannot be pre-computed once and forever, as each forecast uses its own domains
- **current method**: $\sim N^3$ operations. Algorithm: go along a “continuous” path on grid 2; check if the current segment of the path crosses domain 1 boundary an odd number of times, thus determining if the current domain 2 gridpoint lies inside domain 1; if it does, search for the grid 1 cell using the one found for the previous domain 2 gridpoint as a 1st guess and if necessary continuing the search in expanding rectangles
- Implication for the case of AM moving nested grid: initialization performed for a “total” grid covering the entire static domain and including all possible positions of the moving grid as sub-grids. Alternative: dynamic (run-time) initialization
EFFICIENCY

$T$ – WCT of Coupled System; $T_i$ – WCT of Component, $N$ – number of components

Optimal communication setup definition: for given $T_1$, $T_2$, $T_C$
$T$ is a minimum (neither Component waits for the other Component). If $T_C=0$ (ideal case) then $T=\max(T_1,T_2)$.

For optimal communication setup (exists for $N=2$):

$$T=\max(\min(T_1,T_2)+T_C,\max(T_1,T_2))$$

i. e. if $T_1\geq T_2$ then

$$T=\max(T_2+T_C,T_1)$$

with $N > 2$ the optimal communication setup may or may not exist