HWRF Coupling

2015: AM=HWRF, OM=POM, C=Coupler

+ capability for OM=HYCOM

+ capability for WM=WaveWatch 3 (1-way)

EMC, HWRF team, D. Sheinin

2016: AM=HWRF, OM=POM, WM=WW3 (1-way)**, C**

+ capability for OM=HYCOM

+ capability for full AM/OM/WM coupling

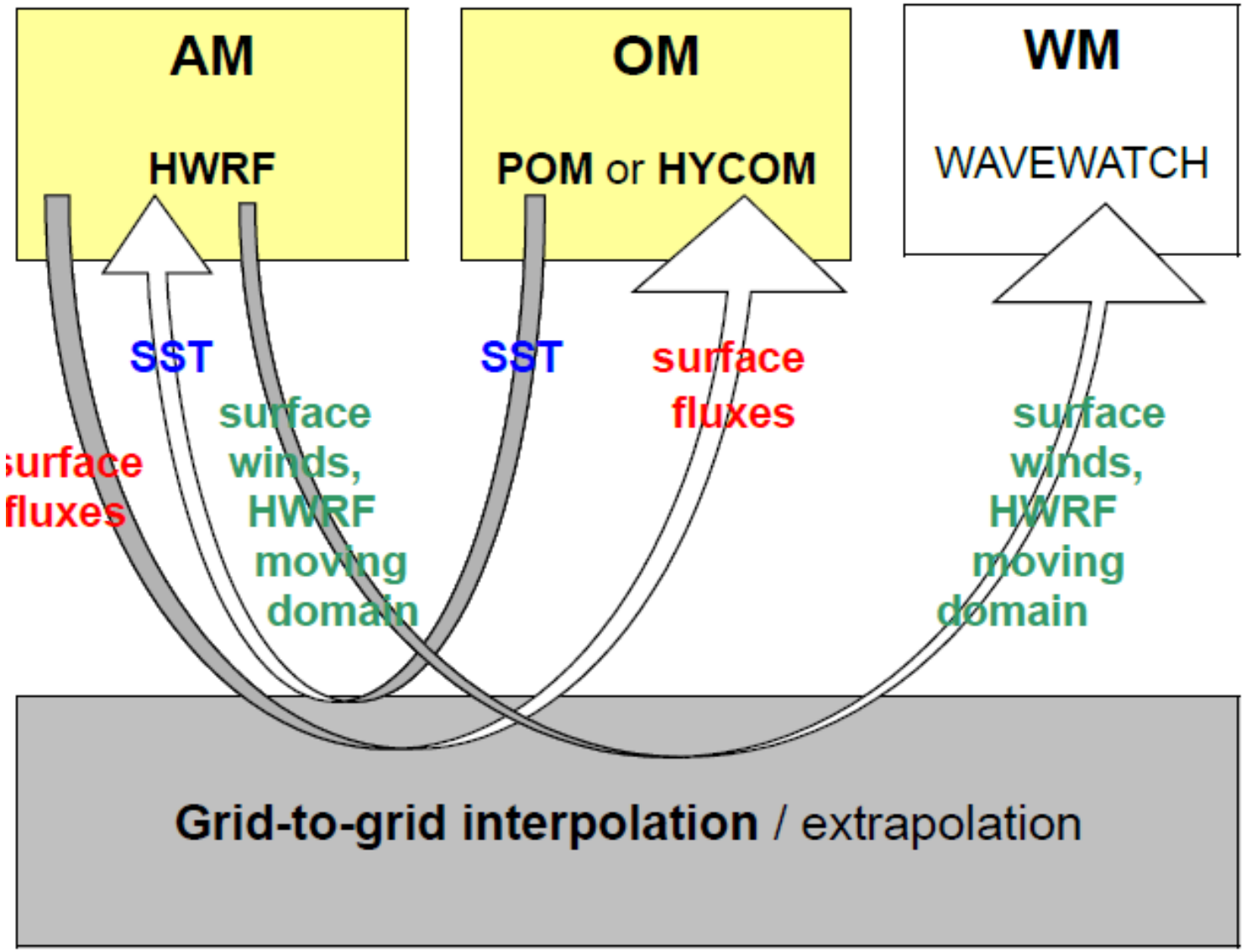
EMC, HWRF team, URI, D. Sheinin, Bin Liu

HWRF / Ocean / Waves Coupling

2015 (2016): **AM↔OM** + AM→WM ($\mathbf{V}_{surf}$)

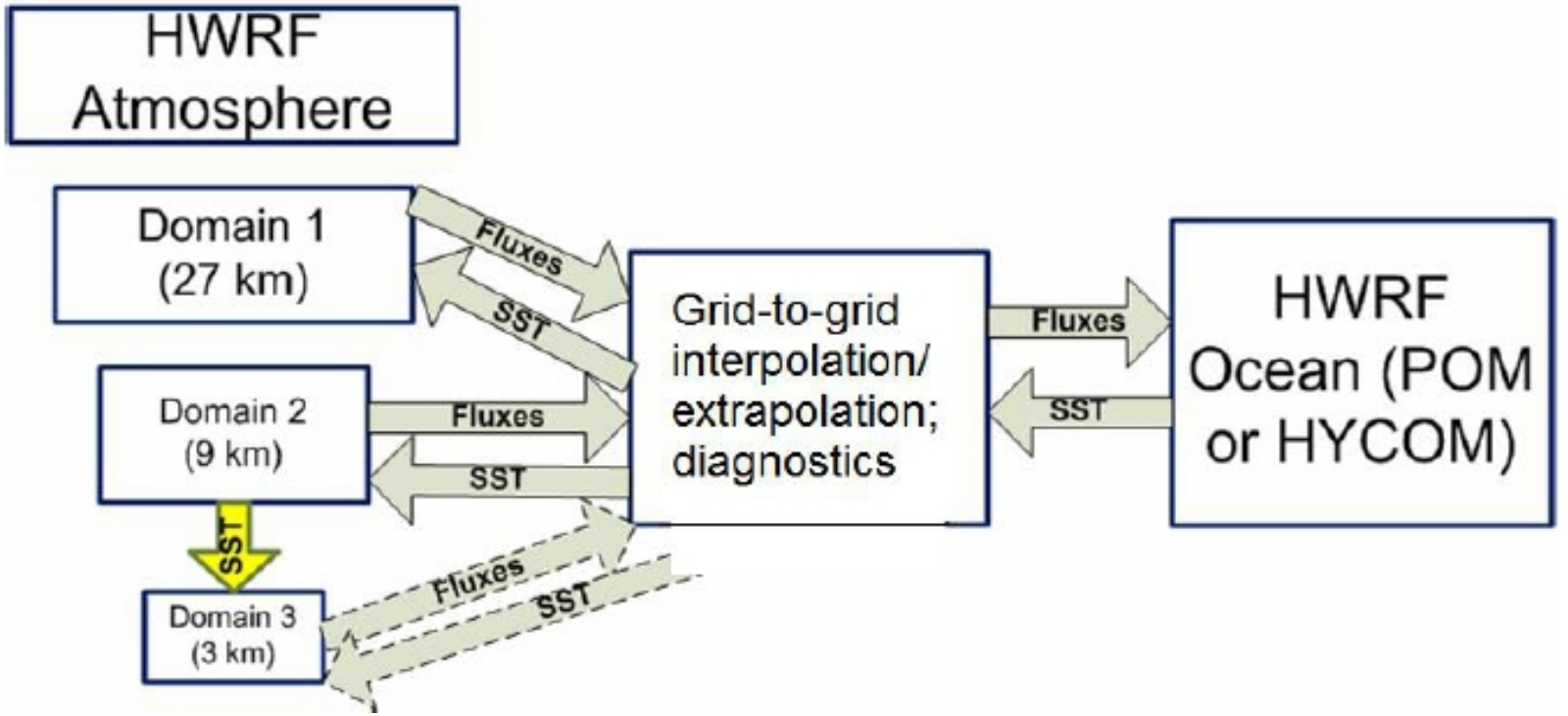
– Surface grid data communications:
  - AM: 3 HWRF nested domains
  - AM→OM: heat/momentum fluxes (time averaged)
  - OM→AM: SST (instantaneous)
– Surface grid data interpolation (sea to sea)

The Coupled System

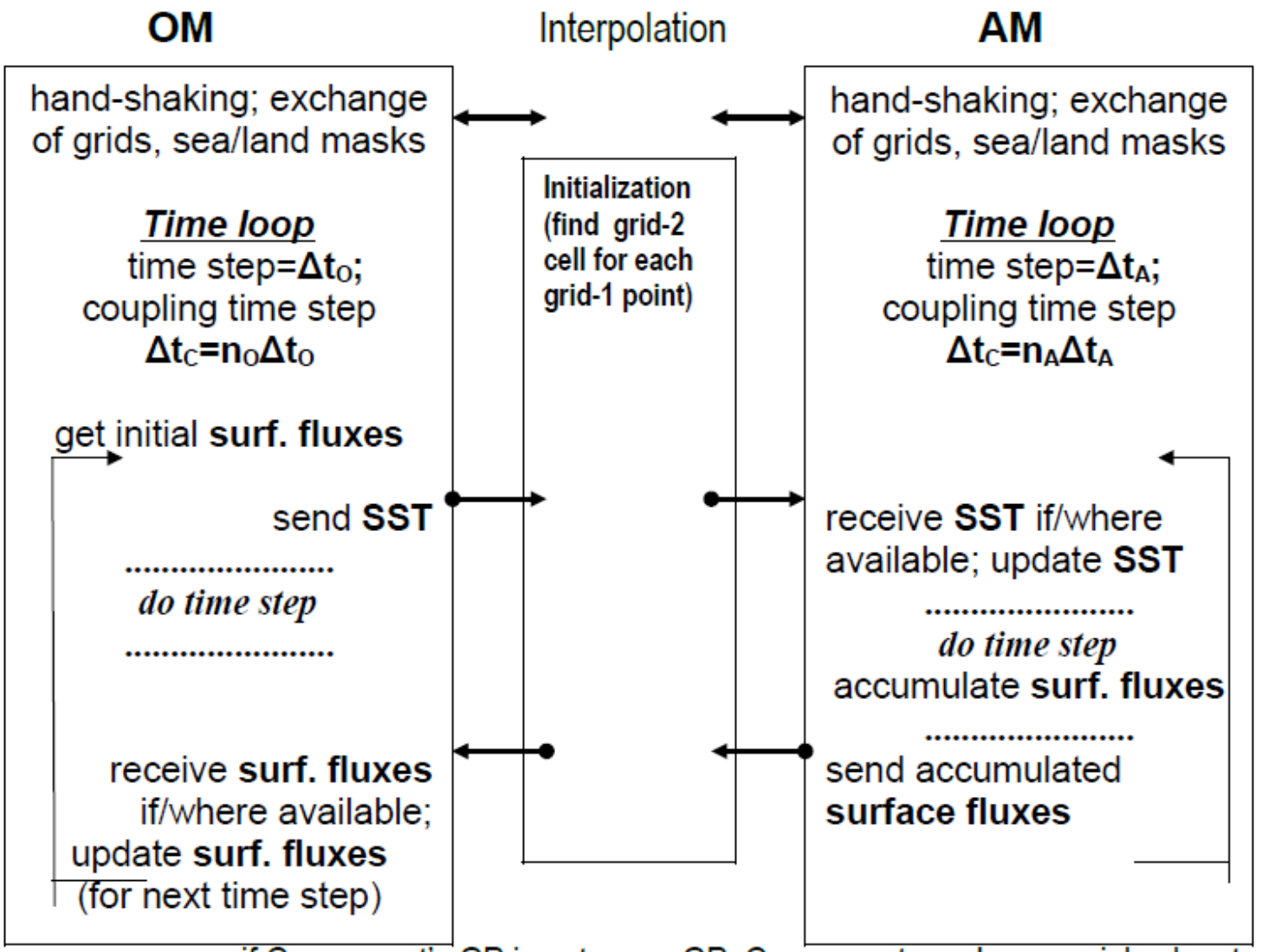


(additional communications developed)

Data flow in operational (2015) **coupled HWRF**



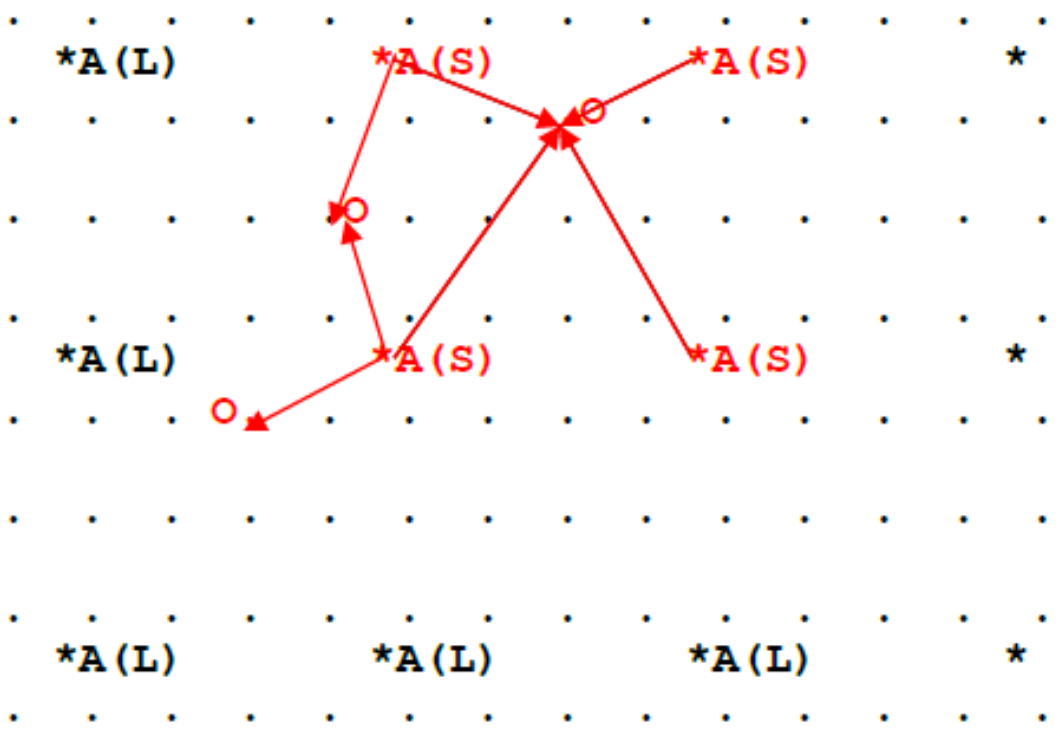
RUN-TIME COMMUNICATIONS



- if Component's GP is not a sea GP, Component sends a special value, to be discarded by interpolation procedure
- if no data is obtained at a GP by interpolation procedure, background data is used
- each Component can be run either in the coupled system or standalone, with the same code/executable (if there is nothing to communicate with, Component works standalone)

Data interpolation

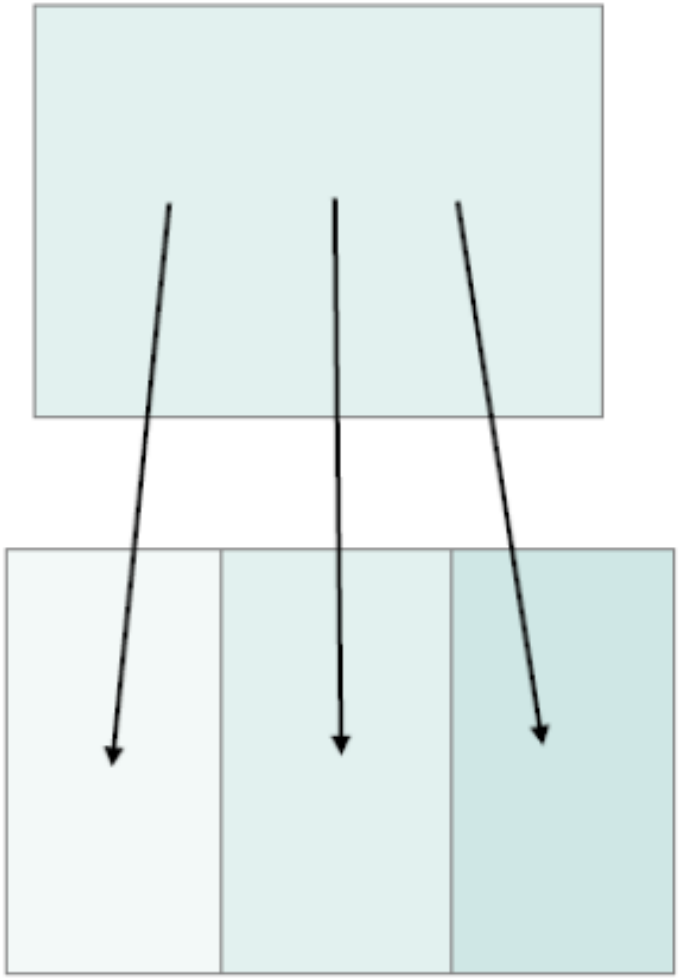
• Interpolation: bilinear in elementary grid cells, sea points to sea points only



• 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)

Interpolation initialization: for each domain 2 gridpoint p_{ij} find domain 1 elementary grid cell c_{kl} such that p_{ij} lies inside c_{kl}

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: **~N^4** operations: inefficient. Cannot be pre-computed once and forever, as each forecast uses its own domains
- **current method:** **~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; $\mathbf{T_i}$ – WCT of Component

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 $T=\max(T_1,T_2)$.

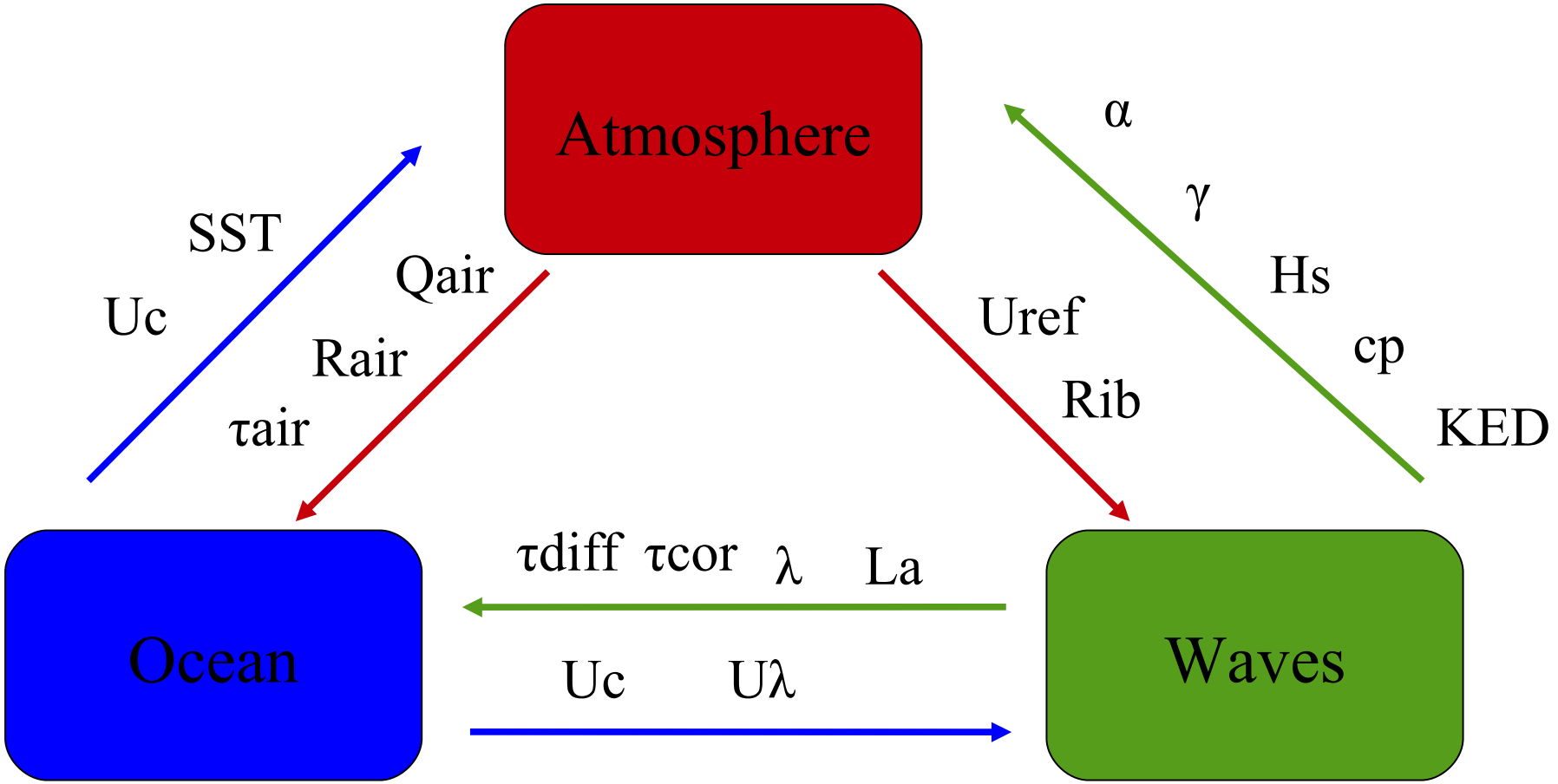
For optimal communication setup:

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

I. e. **if $T_1 \geq T_2$ then**

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

On Jet, $T_c \approx 30$ s. per model forecast day (18/6/2 km res)



FULL AM/OM/WM COUPLING

– **air-sea fluxes** depend on **sea surface state** and **WBL**
– **wave model** is forced by **wind**, includes **surface/depth currents**
– **ocean model** forced by **heat flux**, **wind stress** modified by **growing or decaying wave fields and Coriolis-Stokes effect.** Turbulent mixing is modified by Stokes drift (**Langmiur turbulence**)