Design and early results from a coupling of HYCOM and OLAM (The Ocean-Land-Atmosphere Model)

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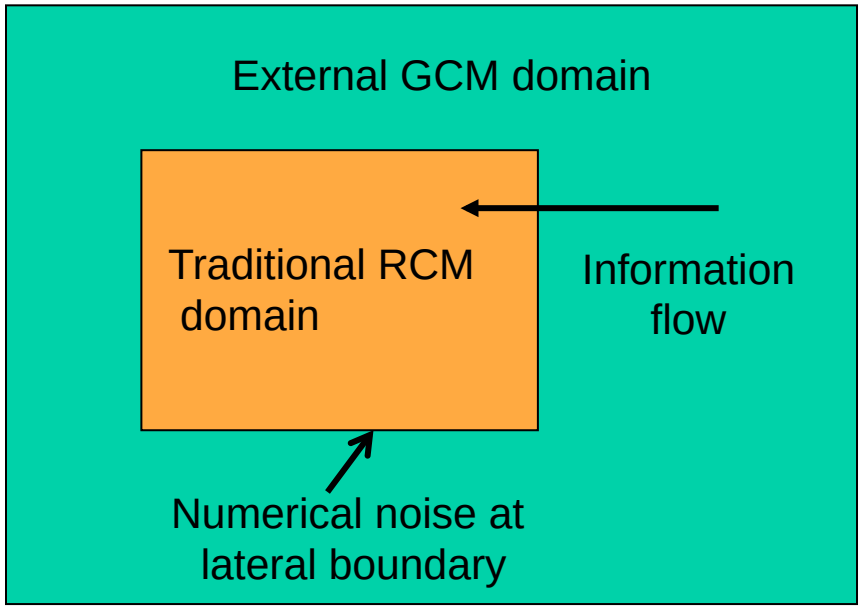
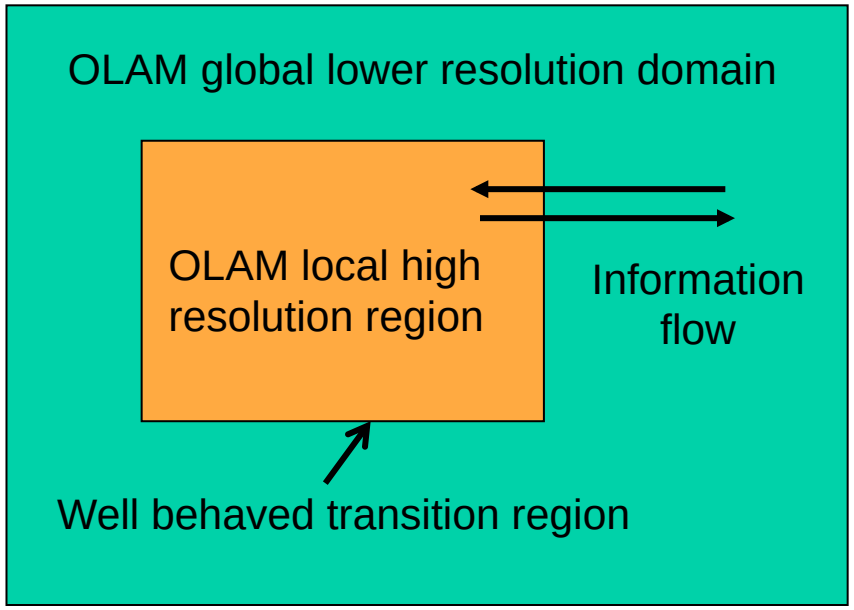
OLAM background

1. **OLAM is based partly on RAMS, a limited area atmospheric model specializing in mesoscale and cloud scale simulations.**

2. **The original motivation for OLAM was to provide a unified global-regional modeling framework in order to avoid the disadvantages of limited area models.**

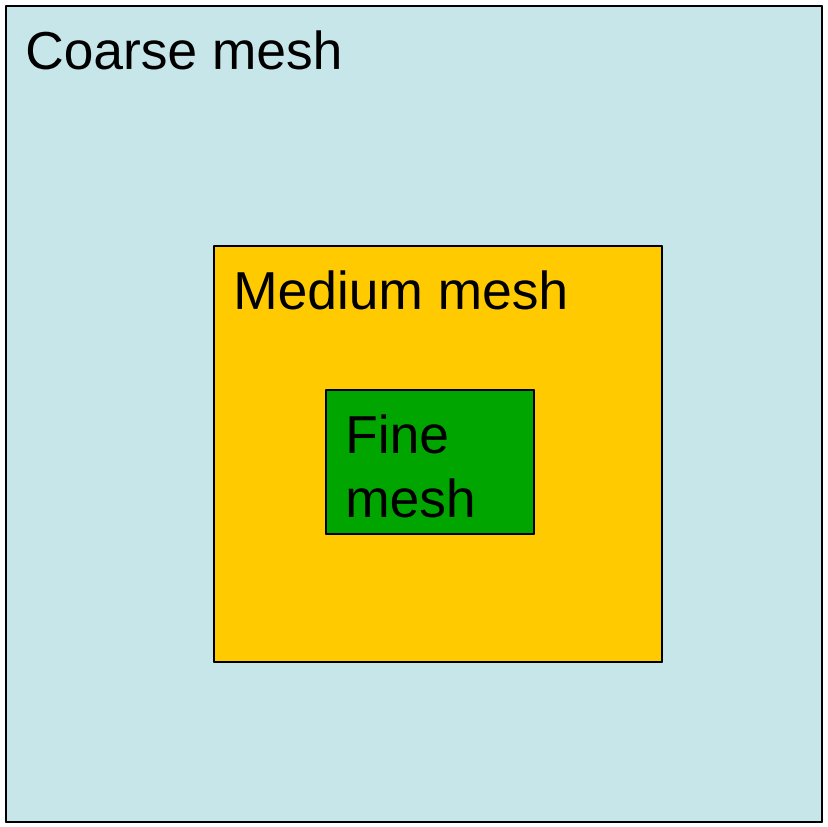




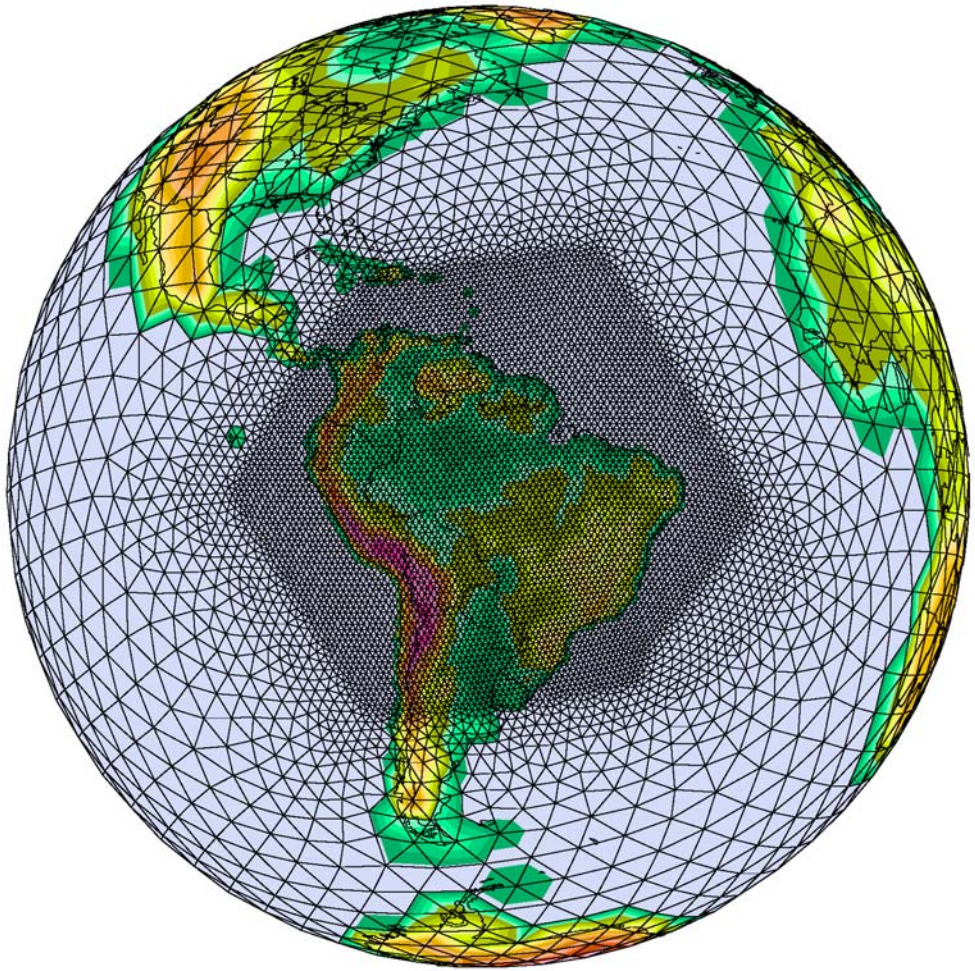
Many applications of regional and global numerical models require high resolution only in a limited area of a much larger model domain.

Local mesh refinement enables such model configurations with a minimal expenditure of computational resources.

Regional model (RAMS)

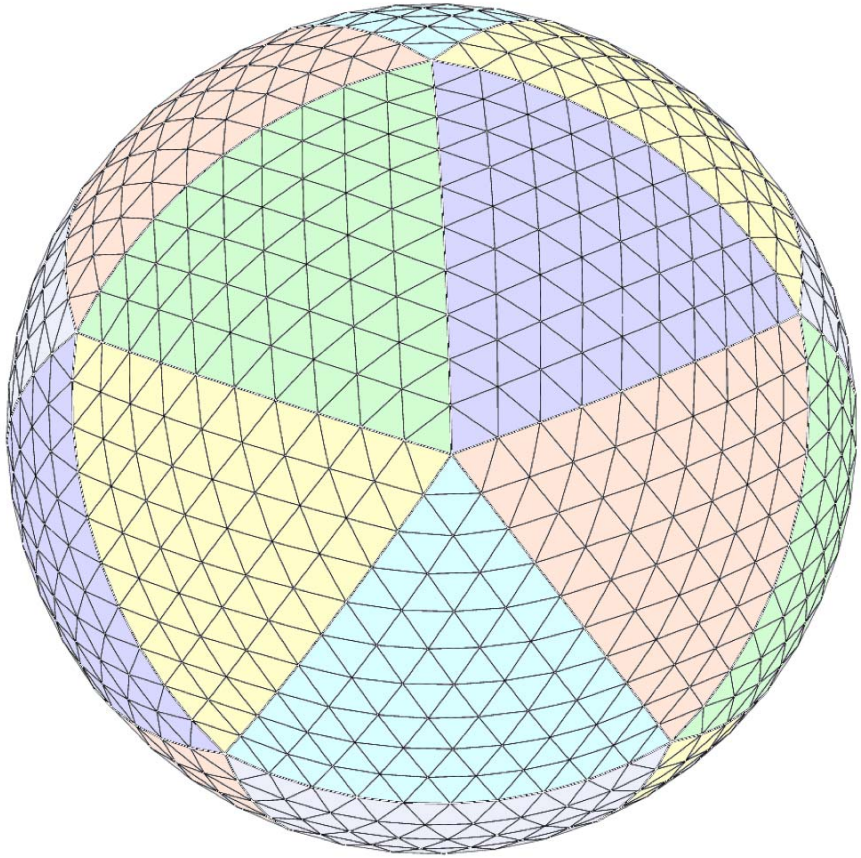


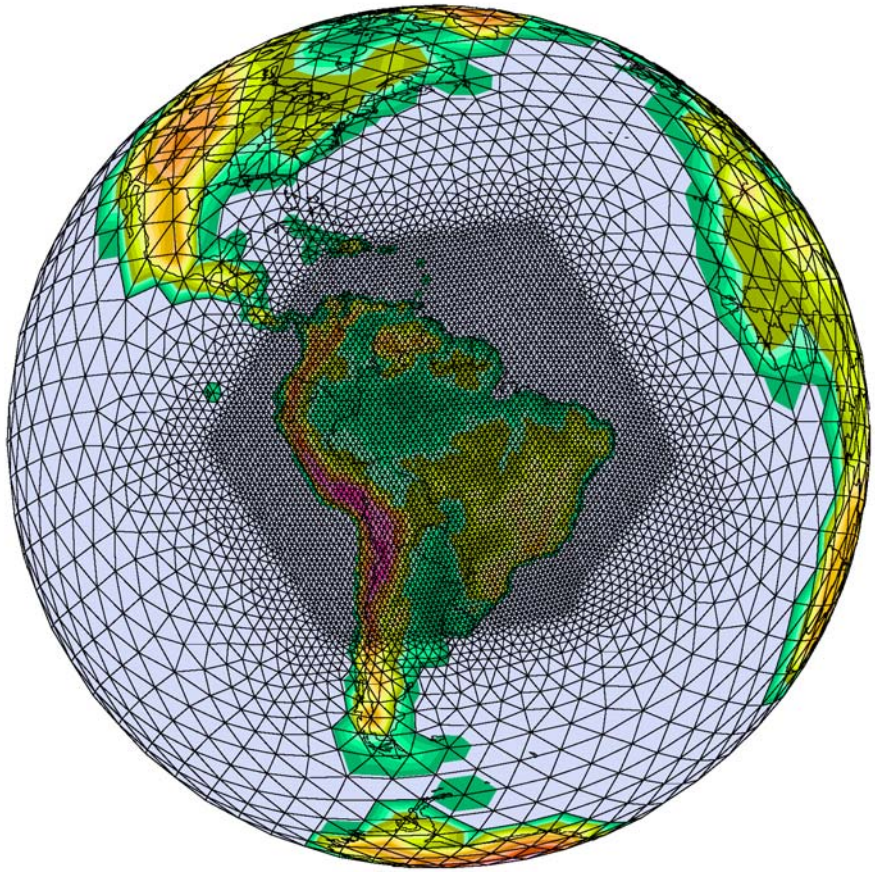
Global model (OLAM)



OLAM:

Triangular grid cells
No map projection
Seamless local mesh refinement

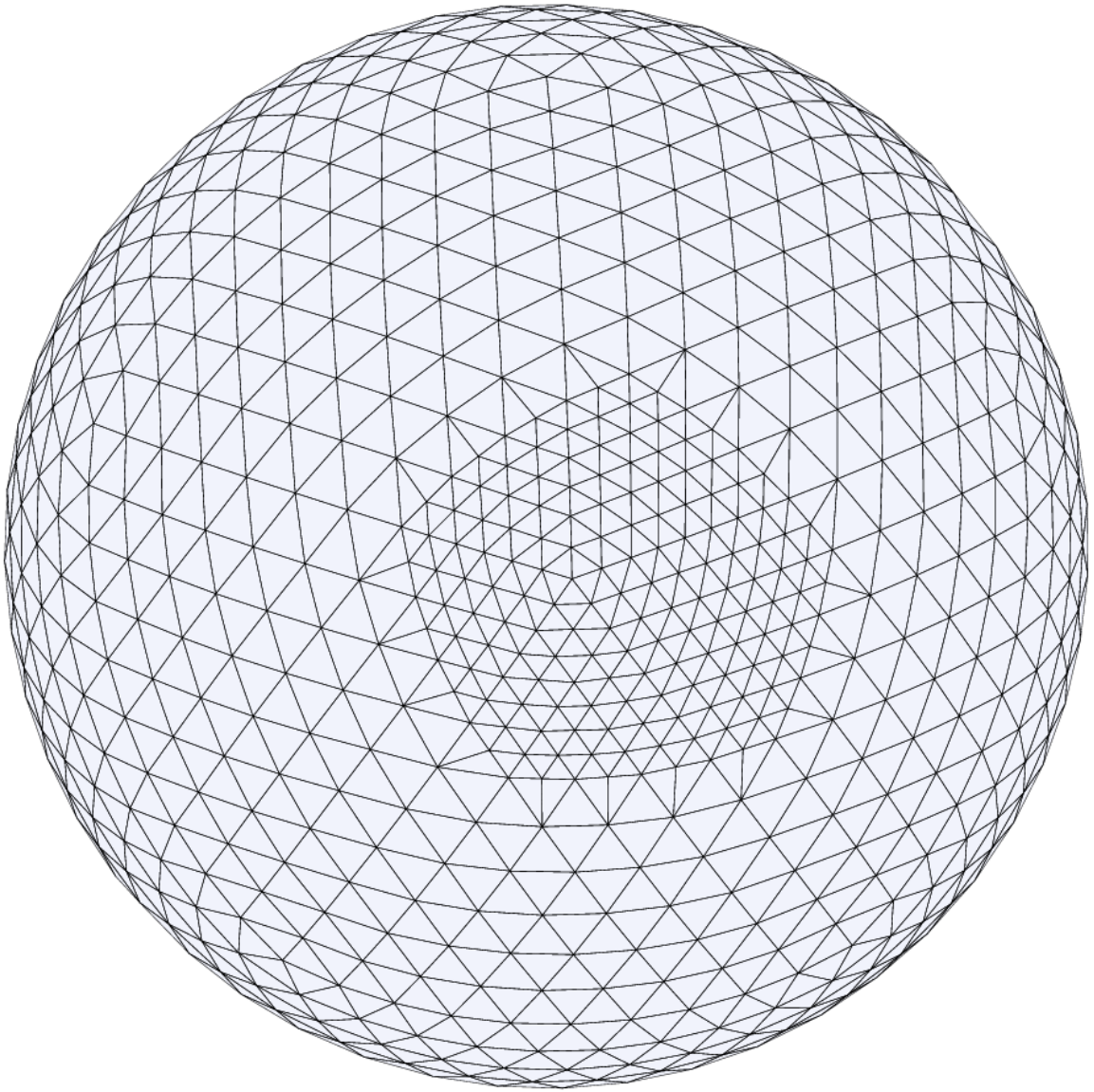




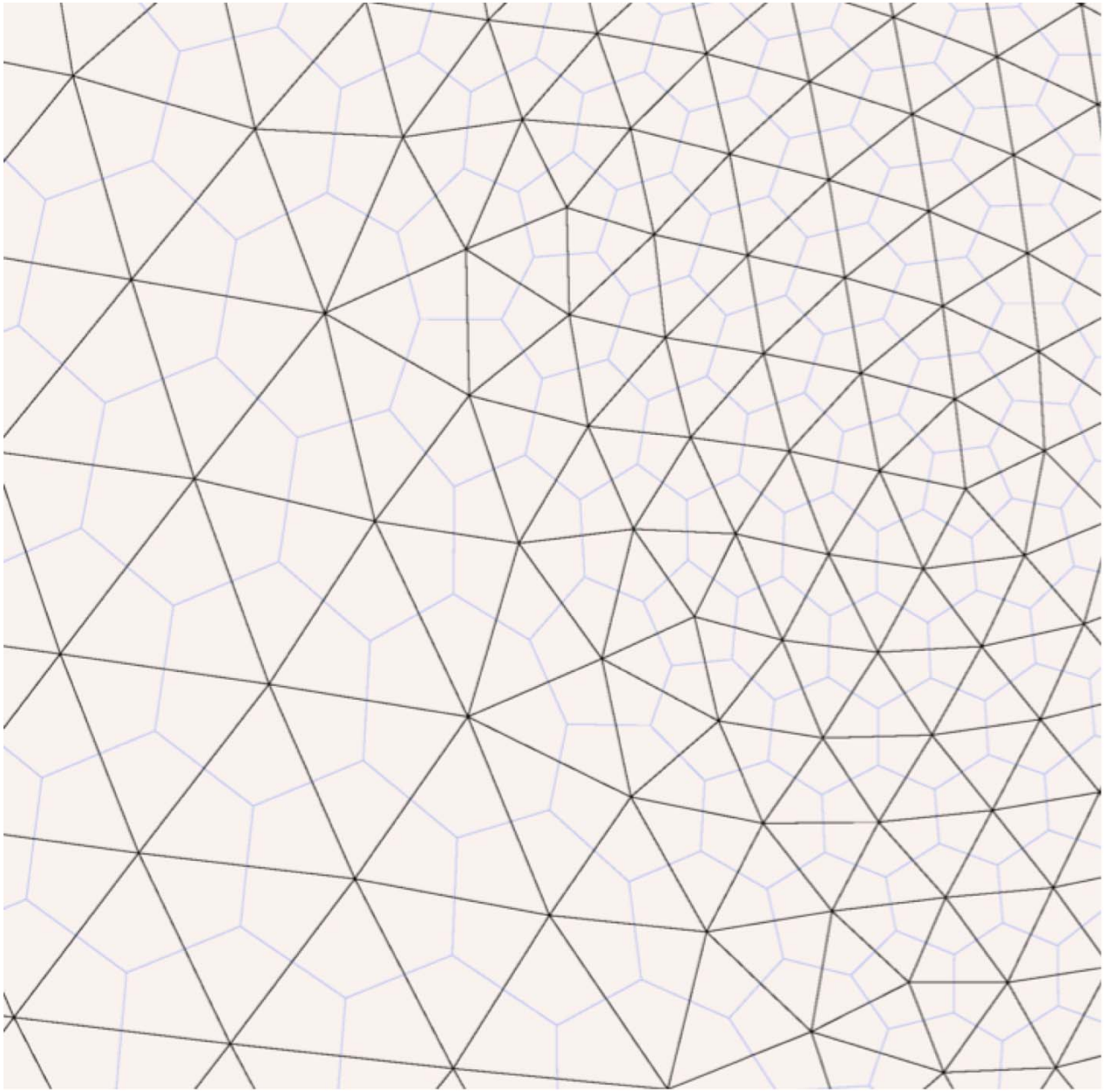
Triangular mesh offers quasi-uniform global coverage

It also allows local refinement with no overlapping of grid cells and no special nest communication

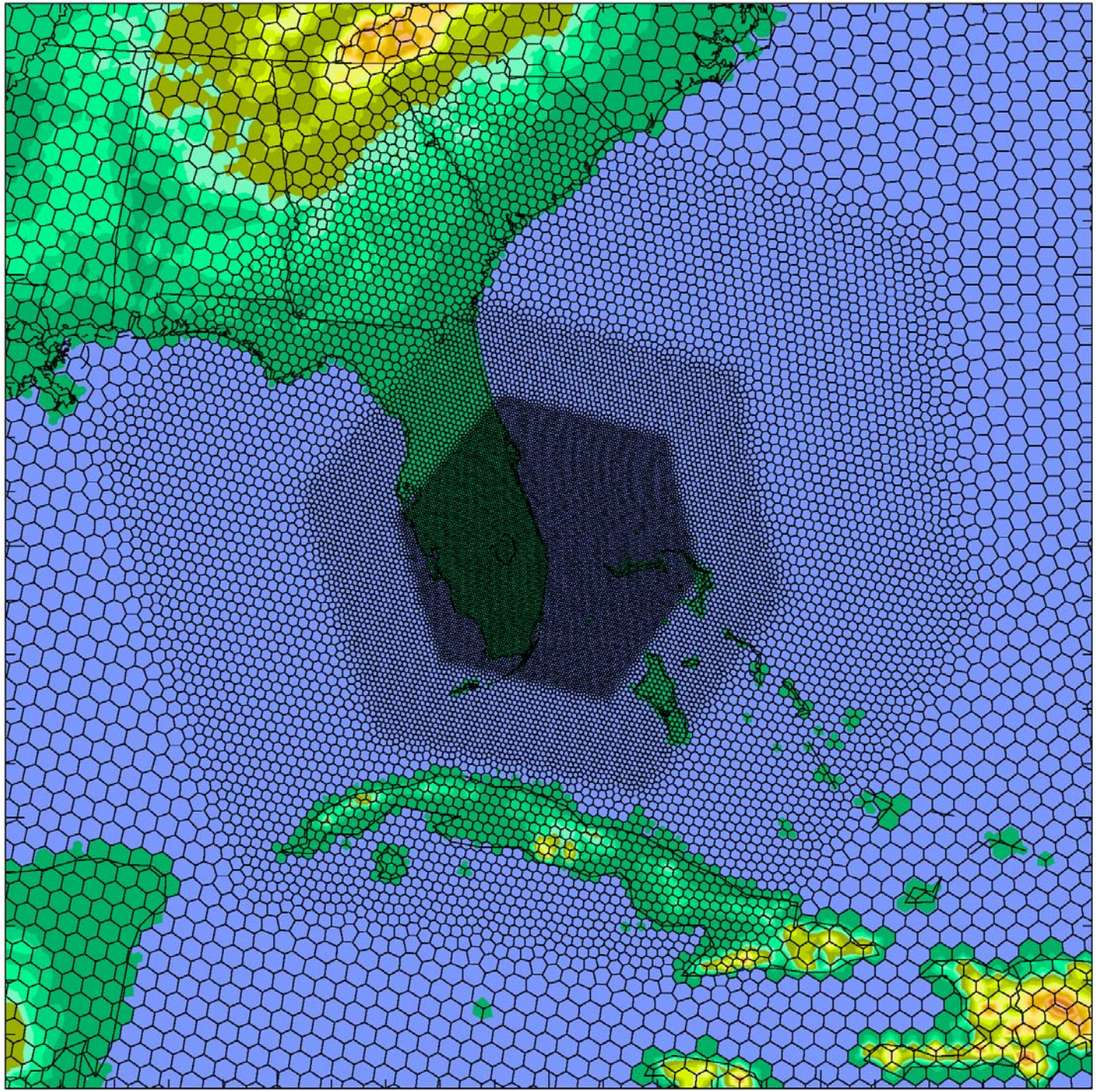
Each cell communicates directly with neighbors regardless of resolution

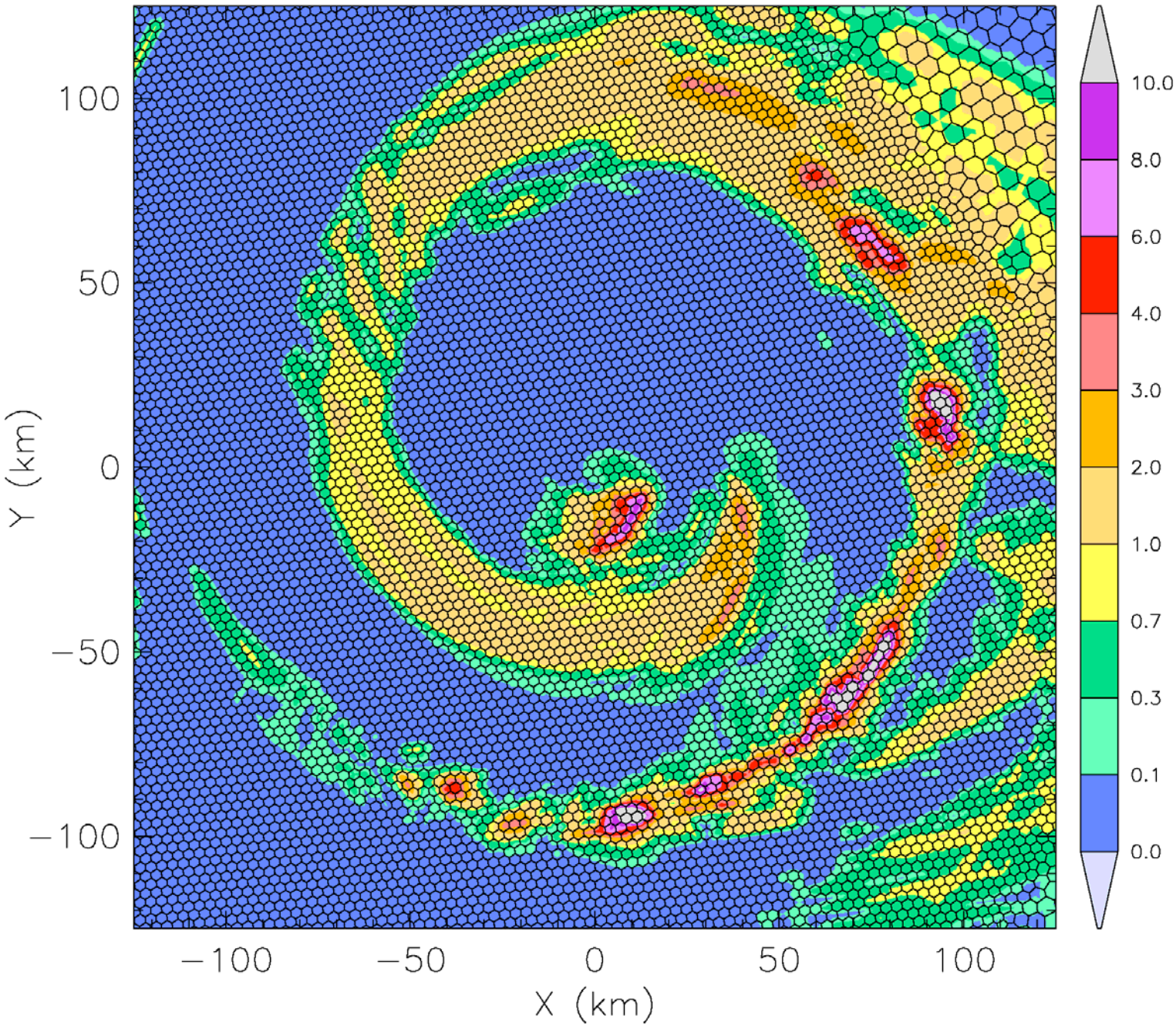


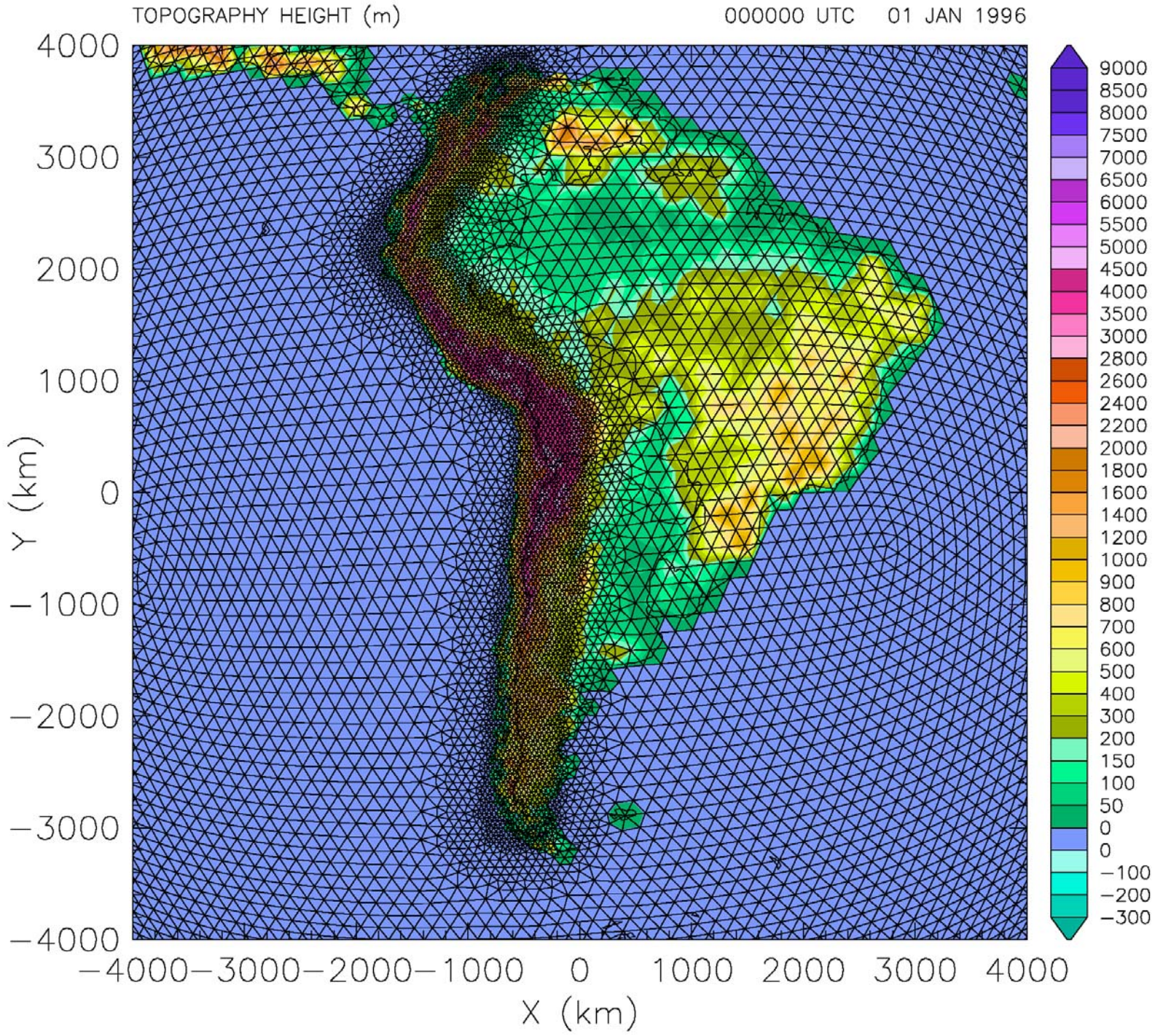
OLAM: Relationship between triangular and hexagonal cells (either choice uses Arakawa-C grid stagger)



OLAM:
Hexagonal grid cells




100
50
0
−50
−100
Y (km)
−100
−50
0
50
100
X (km)
10.0
8.0
6.0
4.0
3.0
2.0
1.0
0.7
0.3
0.1
0.0


TOPOGRAPHY HEIGHT (m)
000000 UTC 01 JAN 1996
4000
3000
2000
1000
0
−1000
−2000
−3000
−4000
Y (km)
−4000 −3000 −2000 −1000 0 1000 2000 3000 4000
X (km)
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
900
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700
600
500
400
300
200
150
100
50
0
0
−100
−200
−300

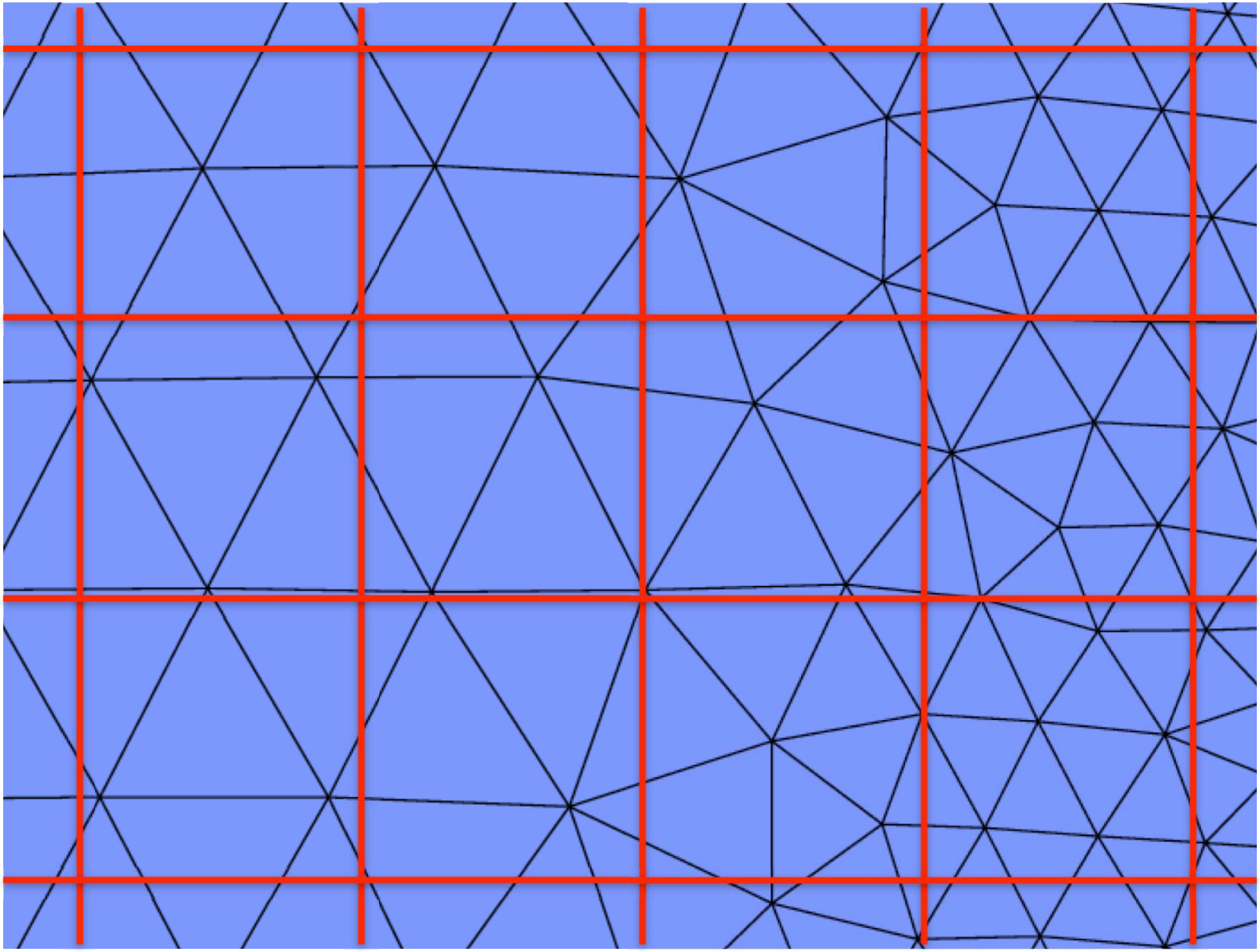
Coupler for OLAM and HYCOM - Two primary requirements:

1) Exchange fluxes of sensible heat, water vapor, momentum, precipitation (rain, snow, hail, etc.), other (CO_2).
2) Manage execution of both models so that they remain synchronized.

Software exists to couple different models (e.g., ESMF).

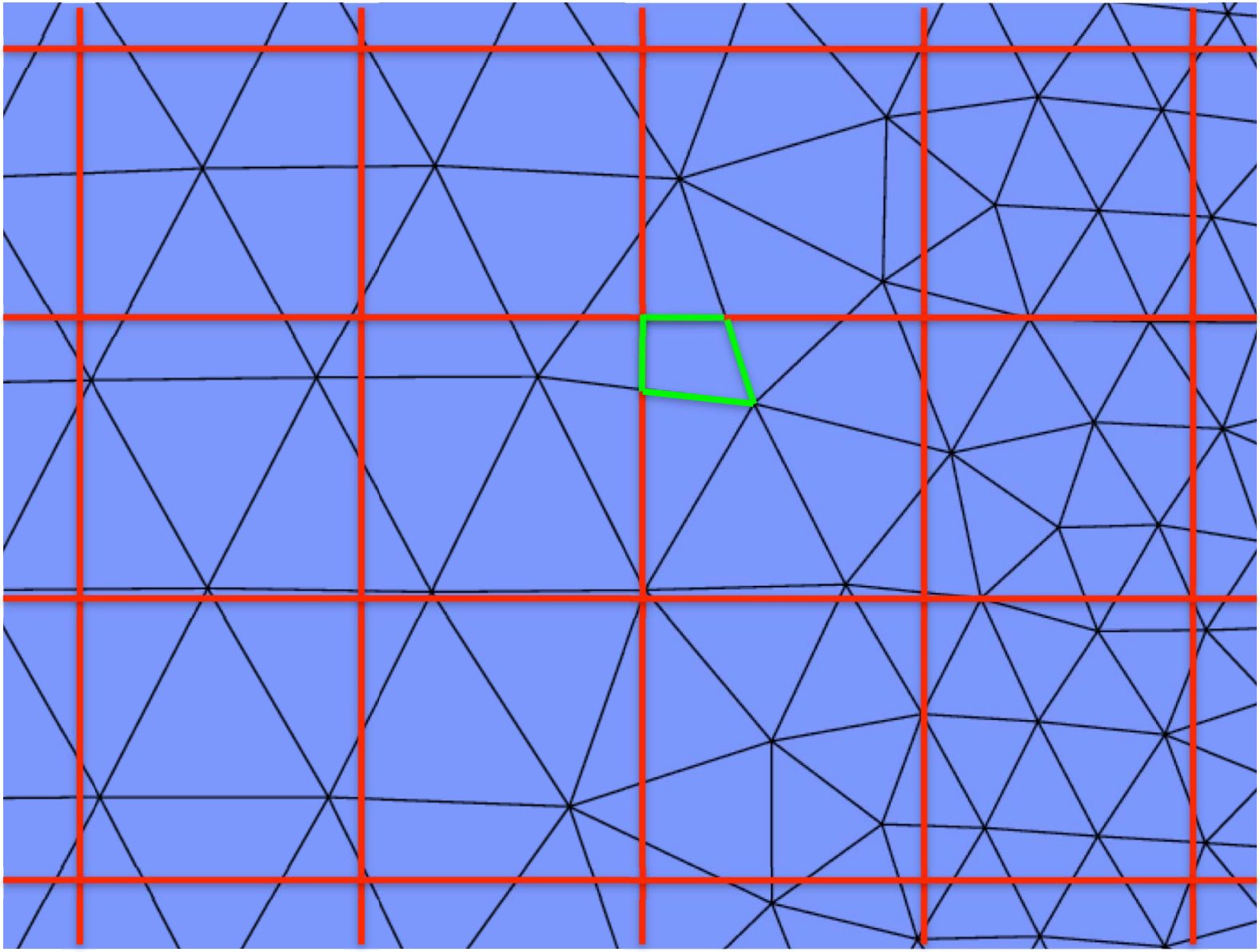
However, it is straightforward to write an efficient and fully conservative coupler.

Overlay of ATMOSPHERE and OCEAN meshes:



Overlay of ATMOSPHERE and OCEAN meshes:

FLUX CELLS



Flux cells are polygons that are constructed from overlay of atmosphere and ocean meshes.

Their size, shape, location, and connection to both meshes is determined during model initialization and all information is stored in lookup tables.

Atmosphere – Ocean fluxes:

Loop over all surface **flux cells**; for each cell:

Look up:

- Flux cell area
- Atmospheric cell index (i) and physical values
- Ocean cell index (i,j) and physical values

Evaluate:

- Surface turbulent fluxes
- Radiative fluxes

Apply:

- Turbulent fluxes (vapor, heat, momentum)
- Radiative fluxes
- Precipitation fluxes (rain, snow, hail, etc.)

Fluxes through each flux cell are weighted by area of that cell.

All flux transfers conserve mass, energy, and momentum.

Managing execution of both models: Synchronization

Method 1: Communicate solely by MPI

Method 2: Call one model as a set of subroutines from the other

A problem of particular interest:

What role do hurricanes play in projected climate change?

How are hurricane frequency, intensity, timing, and location impacted by projected climate change?

How would changes in hurricanes feed back on global climate?

(Hurricanes may cause net warming of tropical ocean.)