Coupled model development on an icosahedral grid at NOAA/ESRL

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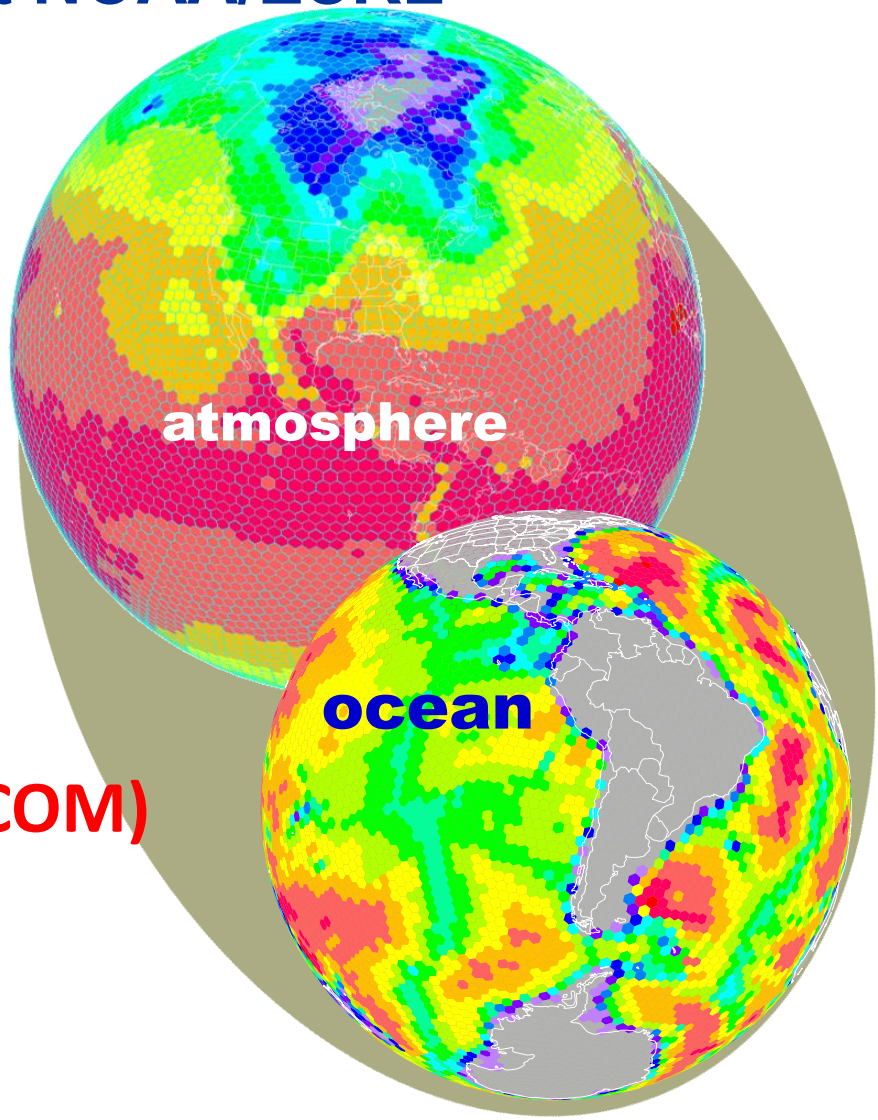
Coupled Atmospheric-Ocean Modeling on an Icosahedral Grid at NOAA/ESRL

Flow-following* finite volume Icosahedral Model (FIM)

Icosahedral Ocean Model (iHYCOM)



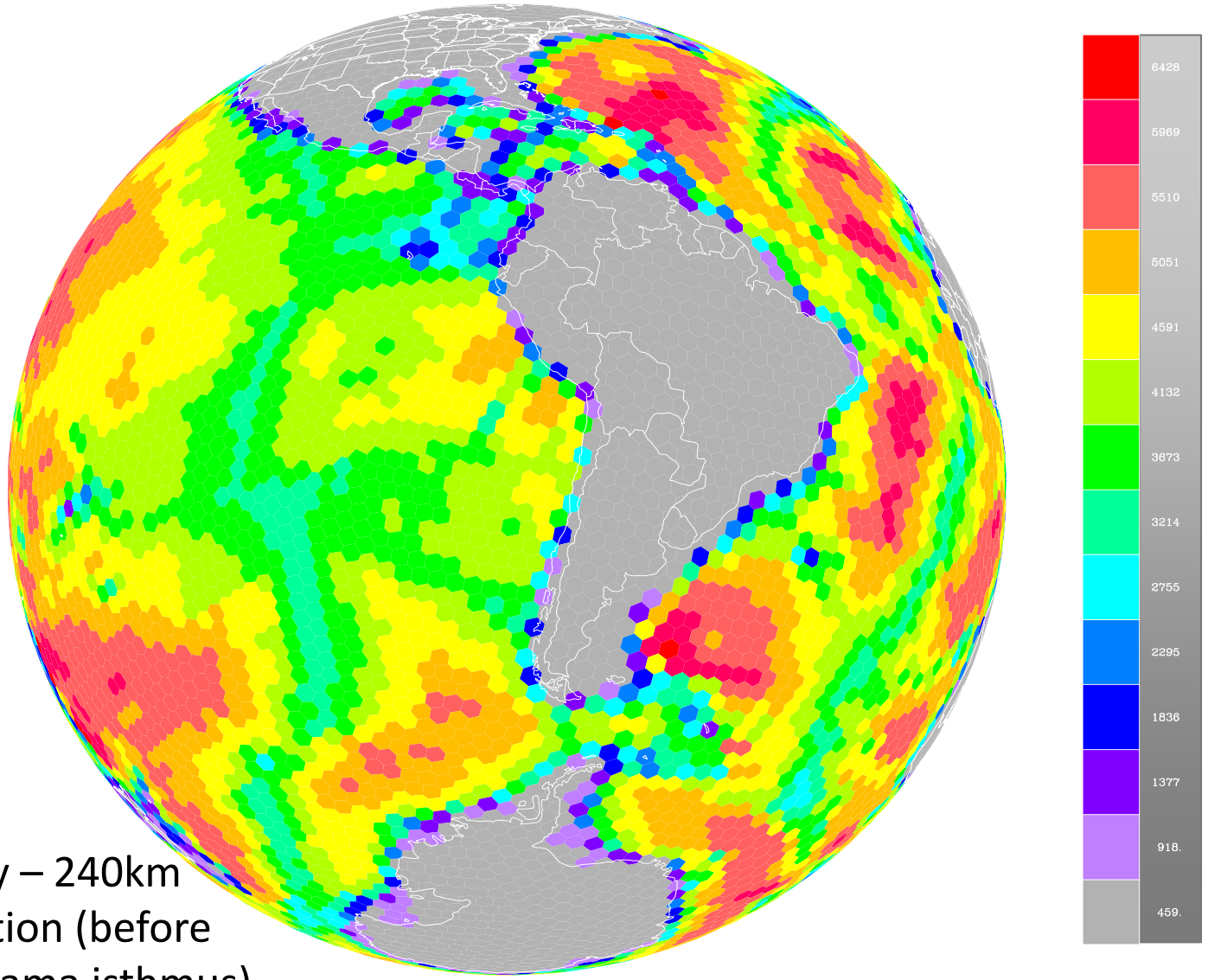
* flow-following = vertically quasi-Lagrangian

Coupled Climate Model at NOAA/ESRL

– **FIM atmospheric model**
  - Flow-following, finite volume, quasi-Lagrangian vertical coordinate, hydrostatic dynamics
  - On the icosahedral horizontal grid
  - Developed at NOAA/ESRL in collaboration with NCEP: GFS column physics
  - Running operationally with comparable scores to NCEP GFS **(http://fim.noaa.gov)**

– **iHYCOM ocean model**
  - HYCOM ocean model rewritten for icosahedral grid
  - Sharing multiprocessor environment developed for FIM
  - No need for flux coupler at the air-sea surface

HYCOM on icosahedral grid: **iHYCOM**



Bathymetry – 240km grid resolution (before closing Panama isthmus)

iHYCOM basics

- icosahedral horizontal mesh (same as in FIM)
- Arakawa A grid (same as FIM)
- leapfrog time stepping (different from FIM)
- 26 vertical hybrid layers as in HYCOM
  - constant z layers near the surface
  - isopycnic layers in the interior
- full complement of surface forcing
  - wind, heat, freshwater
- Prognostic variables: dp,T,S,u,v
- No barotropic/clinic mode splitting, but different time steps
  - short time step for momentum, continuity equation
  - long time step for T/S transport, grid maintenance

Coupled Climate Model at NOAA/ESRL

- Common icosahedral grid structure for both atmosphere and ocean - no coupler needed
- 5-year tests at 60km resolution with reasonably low global drift
- Very scalable, can be run at resolutions down to 10-15km
- Next step: explore, and attempt to reduce, regional biases in SST etc.
- Then: perform hindcasts, participate in NMME, conduct ESPC-related experiments for blocking, MJOs, and tropical cyclones with other global models

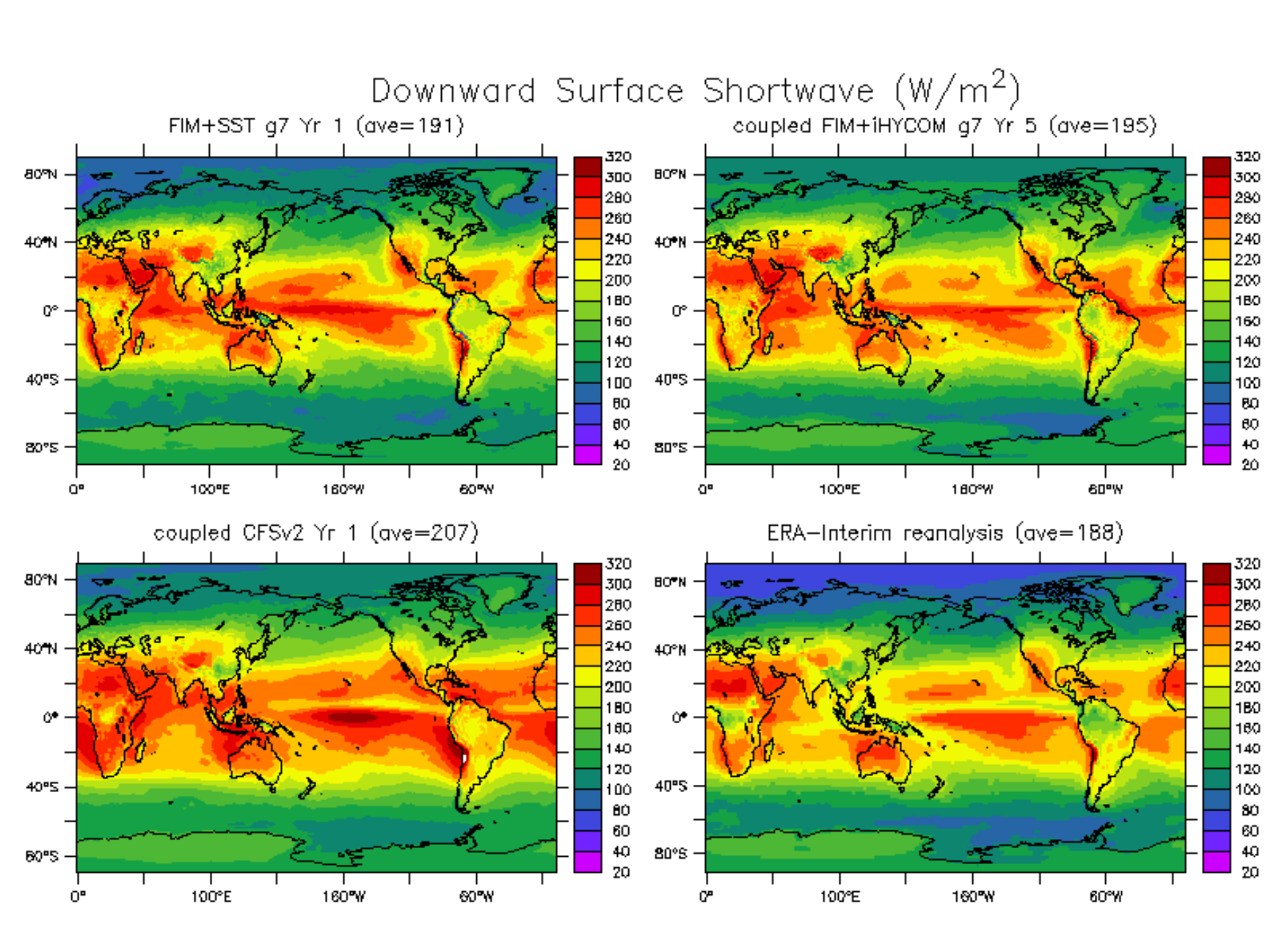
No need for flux coupler

- Grid nesting is common in weather modeling, but grid discontinuities are usually kept away from the region of interest

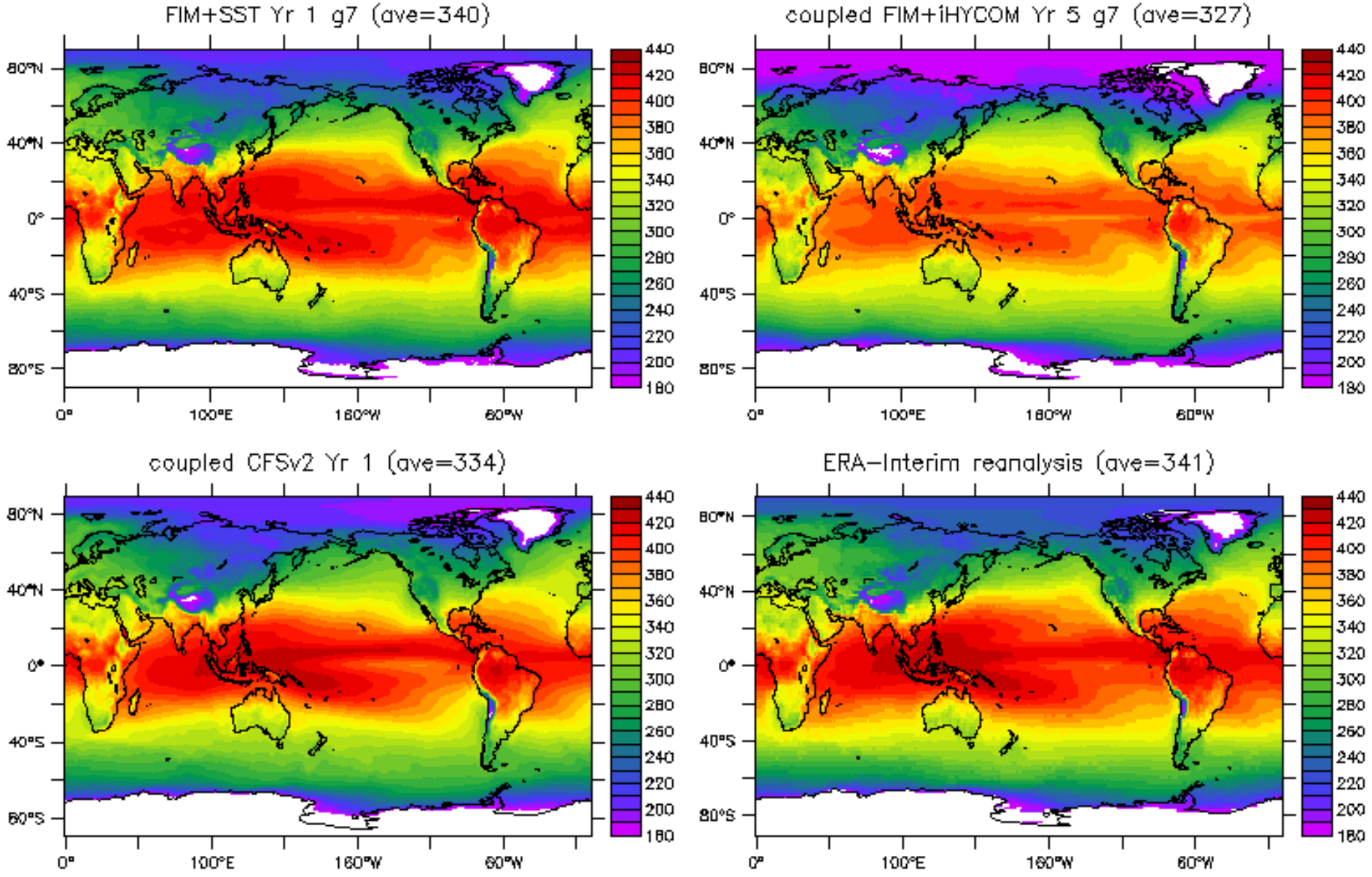
- To avoid joining disparate grids at the ocean-atmosphere interface, arguably the region of most interest in coupled modeling, the two models share the same horizontal grid

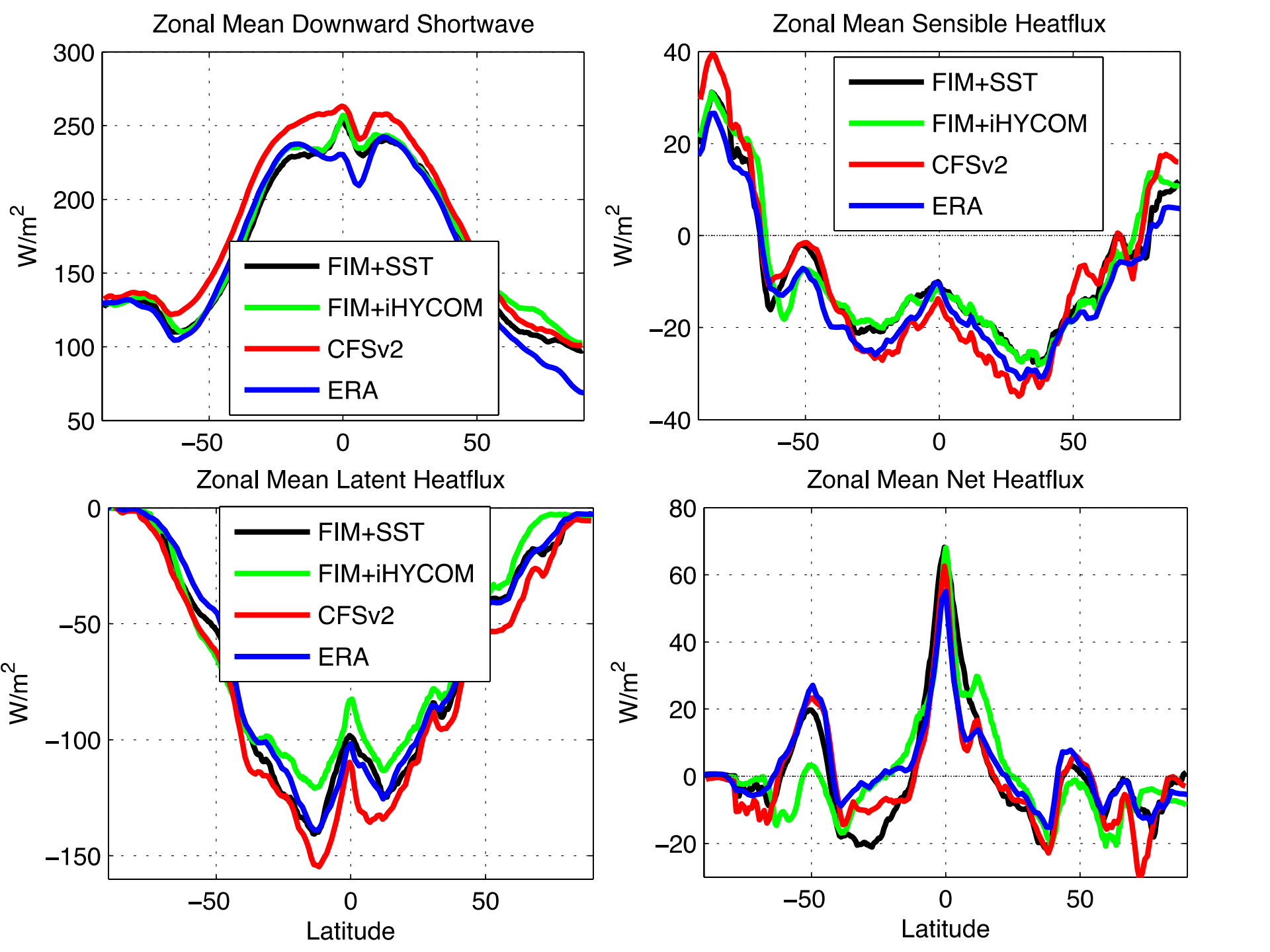
Current status of FIM/iHYCOM coupling

- A team of ~~two~~-scientists
  1.3
- Fully two-way coupling of FIM and iHYCOM
- Only a simplified thermodynamic sea ice model

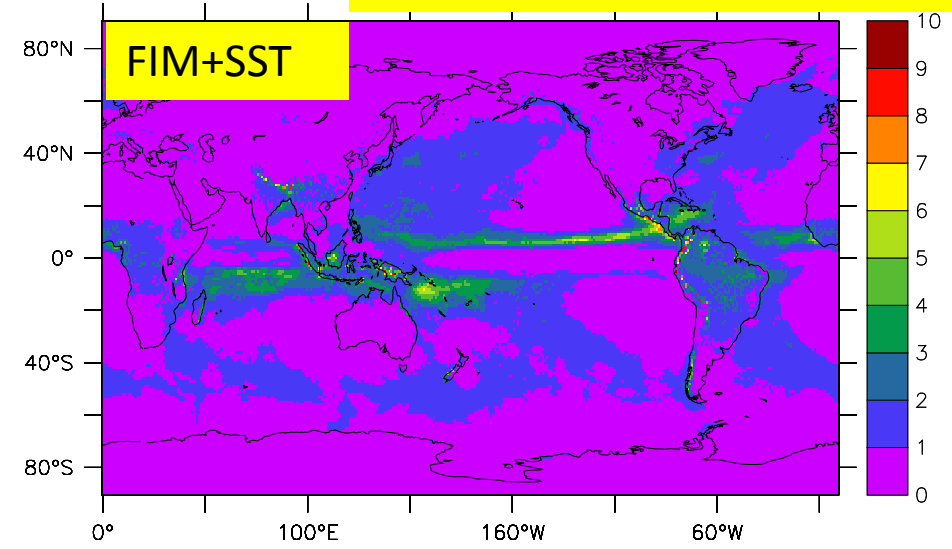

Downward Surface Shortwave (W/m2)
FIM+SST g7 Yr 1 (ave=191)
coupled FIM+iHYCOM g7 Yr 5 (ave=195)
coupled CFSv2 Yr 1 (ave=207)
ERA-Interim reanalysis (ave=188)
80°N
40°N
0°
40°S
80°S
0°
100°E
160°W
60°W
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20

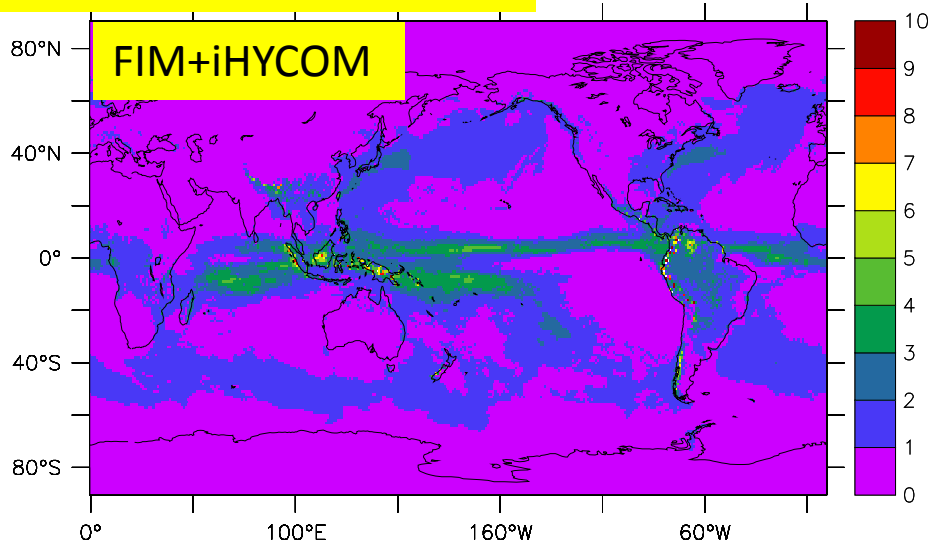
Downward Surface Longwave (W/m^2)

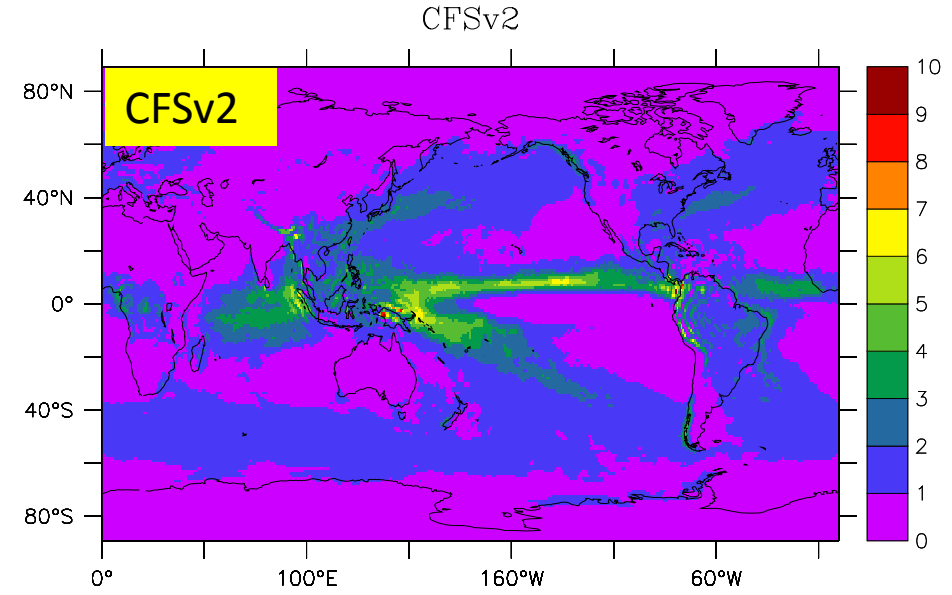


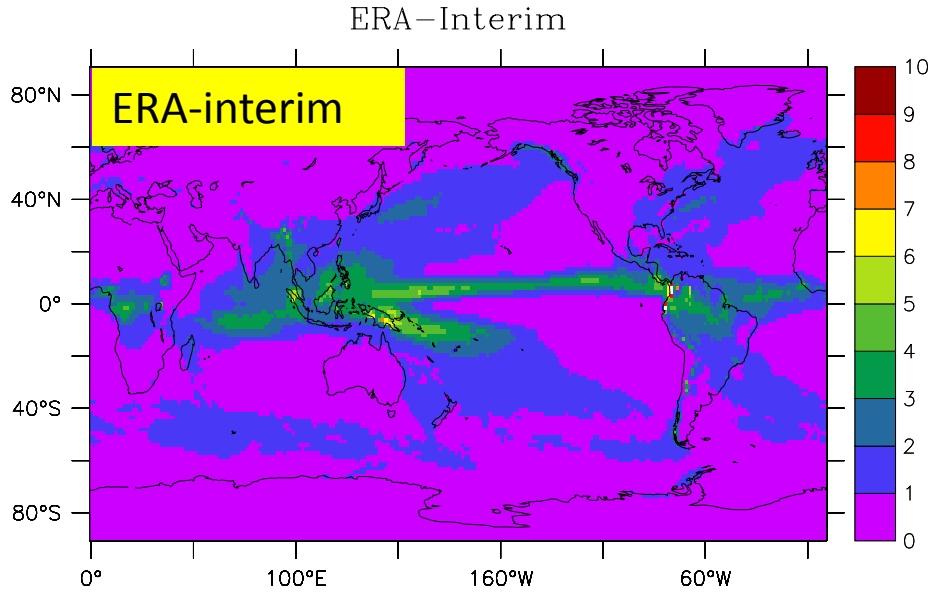

Zonal Mean Downward Shortwave
W/m2
300
250
200
150
100
50
−50
0
50
FIM+SST
FIM+iHYCOM
CFSv2
ERA
Zonal Mean Sensible Heatflux
W/m2
40
20
0
−20
−40
−50
0
50
FIM+SST
FIM+iHYCOM
CFSv2
ERA
Zonal Mean Latent Heatflux
W/m2
0
−50
−100
−150
−50
0
50
Latitude
FIM+SST
FIM+iHYCOM
CFSv2
ERA
Zonal Mean Net Heatflux
W/m2
80
60
40
20
0
−20
−50
0
50
Latitude

Precipitation (m/year)









CFSv2 has more realistic precipitation patterns than FIM

Conclusions

- Coupled FIM/iHYCOM model has the advantage of no grid discontinuity at the air-sea surface, and no need for complicated flux coupler
- The mathematical similarity of the two models allows them to share dycore components and software engineering innovations
- FIM/iHYCOM will be a member of NMME (National Multi-Model Ensemble) & ESPC (Earth System Prediction Capacity)
- There are still large local SST biases, which are mainly due to biases in surface heat fluxes
- Climate drifts in multi-year coupled runs reveal the need to re-tune the column physics parameterizations in FIM which presently are optimized for weather forecast
- Precipitation patterns from CFSv2 are more realistic than from FIM/iHYCOM. This may be related to different cloud schemes used in two models