Global Coupled Atmosphere/Ocean Model for Climate and Seasonal Forecast Applications

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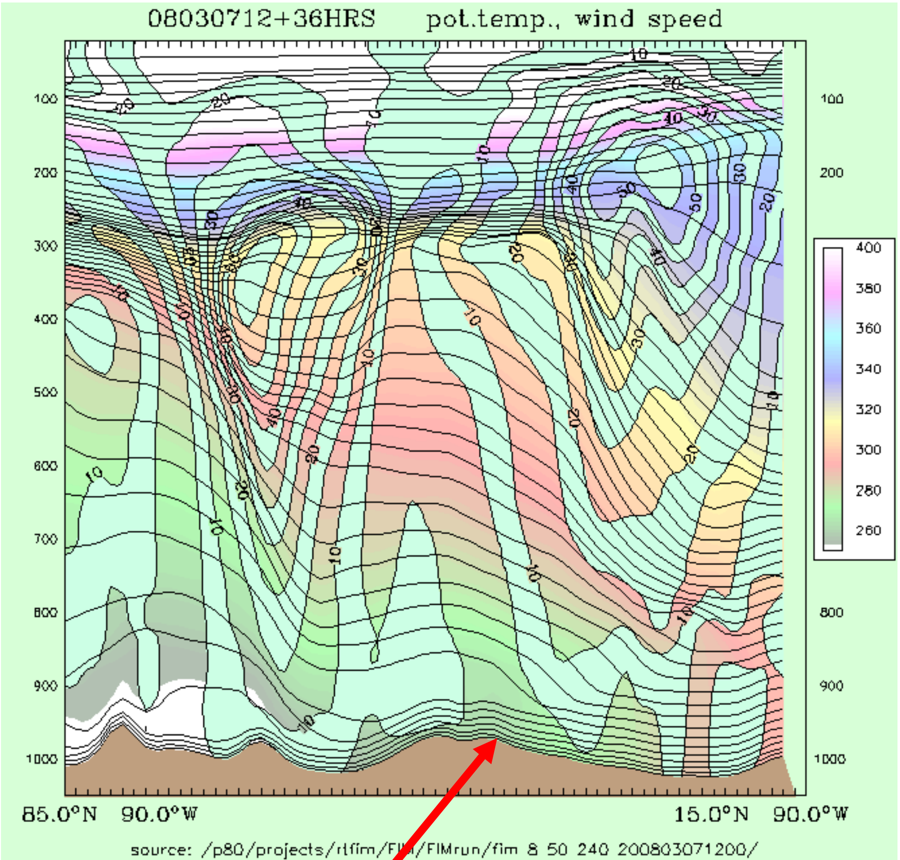
Coupled Atm/Ocean Model at NOAA/ESRL

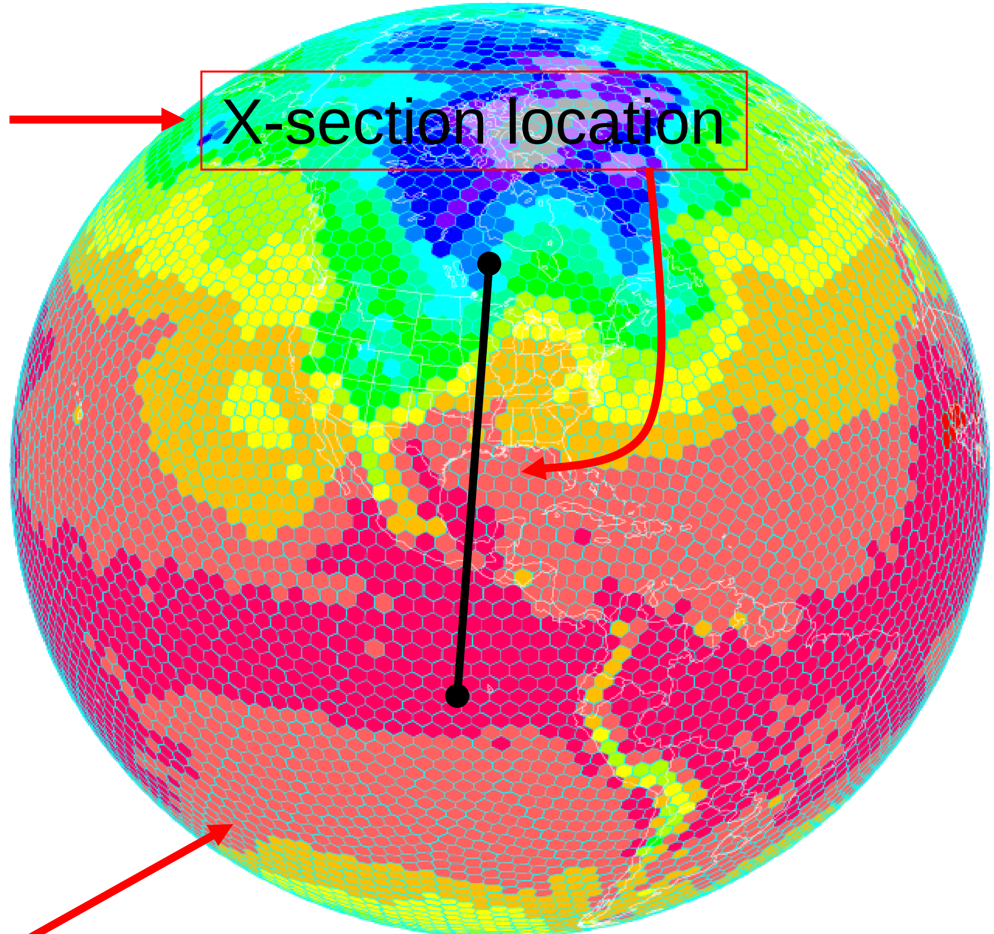
- **FIM atmospheric model** - **http://fim.noaa.gov**
  - Flow-following (isentropic-sigma quasi-Lagrangian vertical coord), finite-volume, hydrostatic dynamics
  - On icosahedral horizontal grid
  - Developed at NOAA/ESRL in collaboration with NCEP: GFS column physics
  - Multi-year real-time and retrospective testing
  - Comparable/slightly better scores compared to NCEP GFS
- **iHYCOM ocean model**
  - HYCOM ocean model rewritten for icosahedral grid
  - Sharing multiprocessor environment devel. for FIM

No need for flux coupler with common grids for atmos/ocean in FIM/iHYCOM

- 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





Temperature at lowest level

Flow-following- finite volume

Icosahedral

Model FIM

FIM numerical model

- Horizontal grid
  - Icosahedral, Arakawa A grid – 60km/30km/15km/10km
- Vertical grid
  - Staggered Lorenz grid, ptop = 0.5 hPa, θtop ~2200K
  - Generalized vertical coordinate
    - Hybrid θ-σ option (64L, 38L, 21L options currently)
    - GFS σ-p option (64 levels)
- Numerics
  - Adams-Bashforth 3rd order time differencing
  - Flux-corrected transport, rigorously conservative
- Physics
  - GFS physics suite (May 2011 version, May 2013 McICA radiation)
- Coupled model extensions
  - Chem – WRF-chem/GOCART
  - Ocean – icosahedral HYCOM

Present Physics in FIM

GFS physics

- Immediate goal for FIM is to contribute dynamic-core diversity to NCEP Global Ensemble Forecast System
- Use of GFS physics allows evaluation of differences between global spectral model and FIM dynamic core.

Application of GFS physics to FIM

- No changes needed to physics for hybrid θ-σ application with one exception: mod to avoid negative mass flux in deep/shallow cu, no change to GFS performance
- Applied every 180s (multiple explicit time-steps in FIM)

Current retrospective experiments for medium-range and seasonal forecasts with Grell-Freitas replacing GFS deep/shallow cumulus

GFS Physics:

May 2011 physics including the Han/Pan deep/shallow cu but with the McICA radiation option

isol = 1 ! use varying solar const with 11-yr cycle
ico2 = 2 ! use obs co2 monthly data with 2-d variation
iaer = 11 ! opac climatology, with volcanic forcing
iems = 1 ! use varying sfc emiss, based on sfc type
iovr_lw=1 ! max-random overlap clouds
iovr_sw=1 ! max-random overlap clouds
isubc_lw=2 ! use McICA with random seed
isubc_sw=2 ! use McICA with random seed

Seasonal Experiments

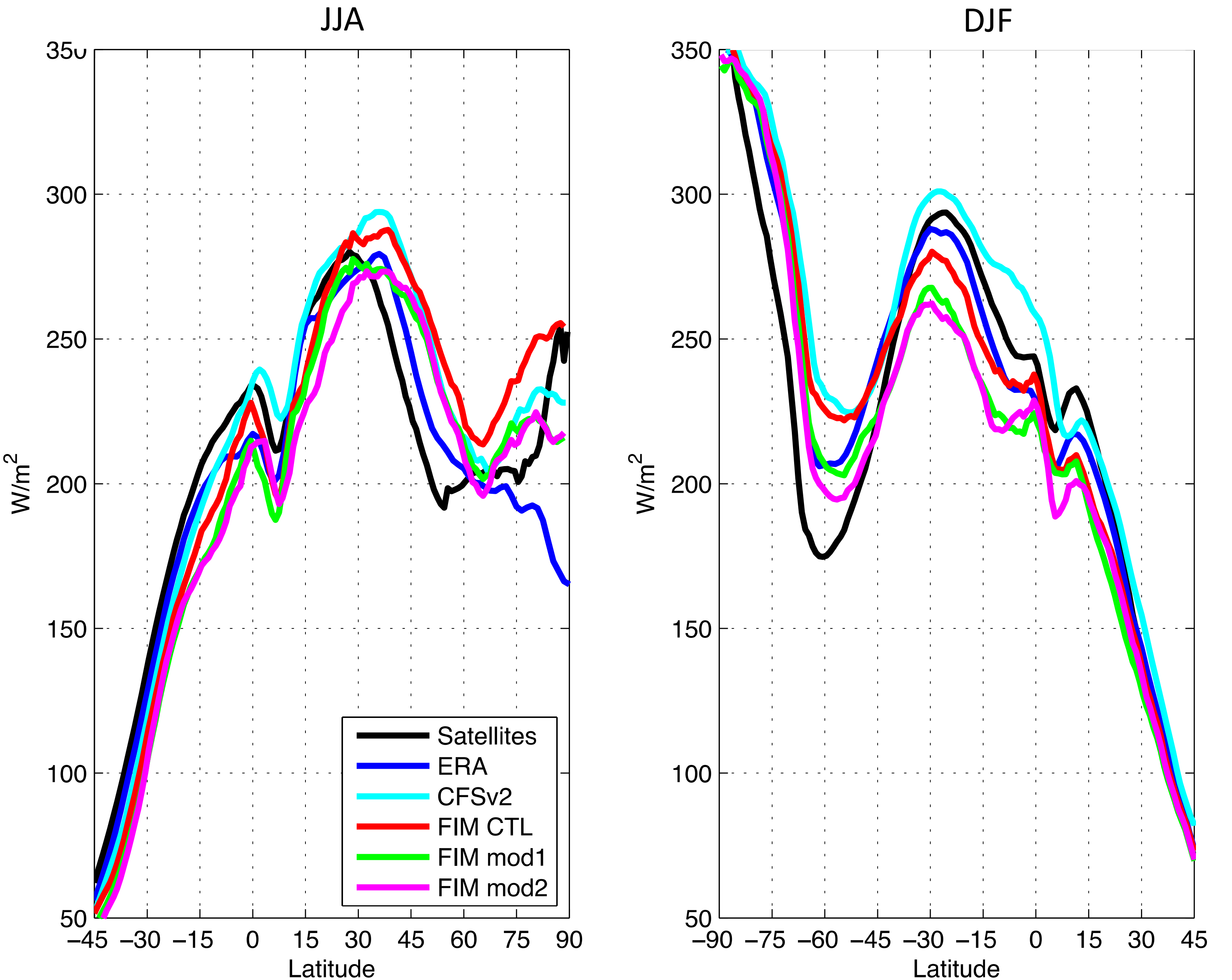
✧ Uncoupled atmospheric model with observed SST, ice temperature & coverage → near zero global heat & freshwater flux at surface

✧ Uncoupled ocean model with atmospheric forcings, like Common Ocean-ice Reference Experiments (CORE) → near zero local SST drift

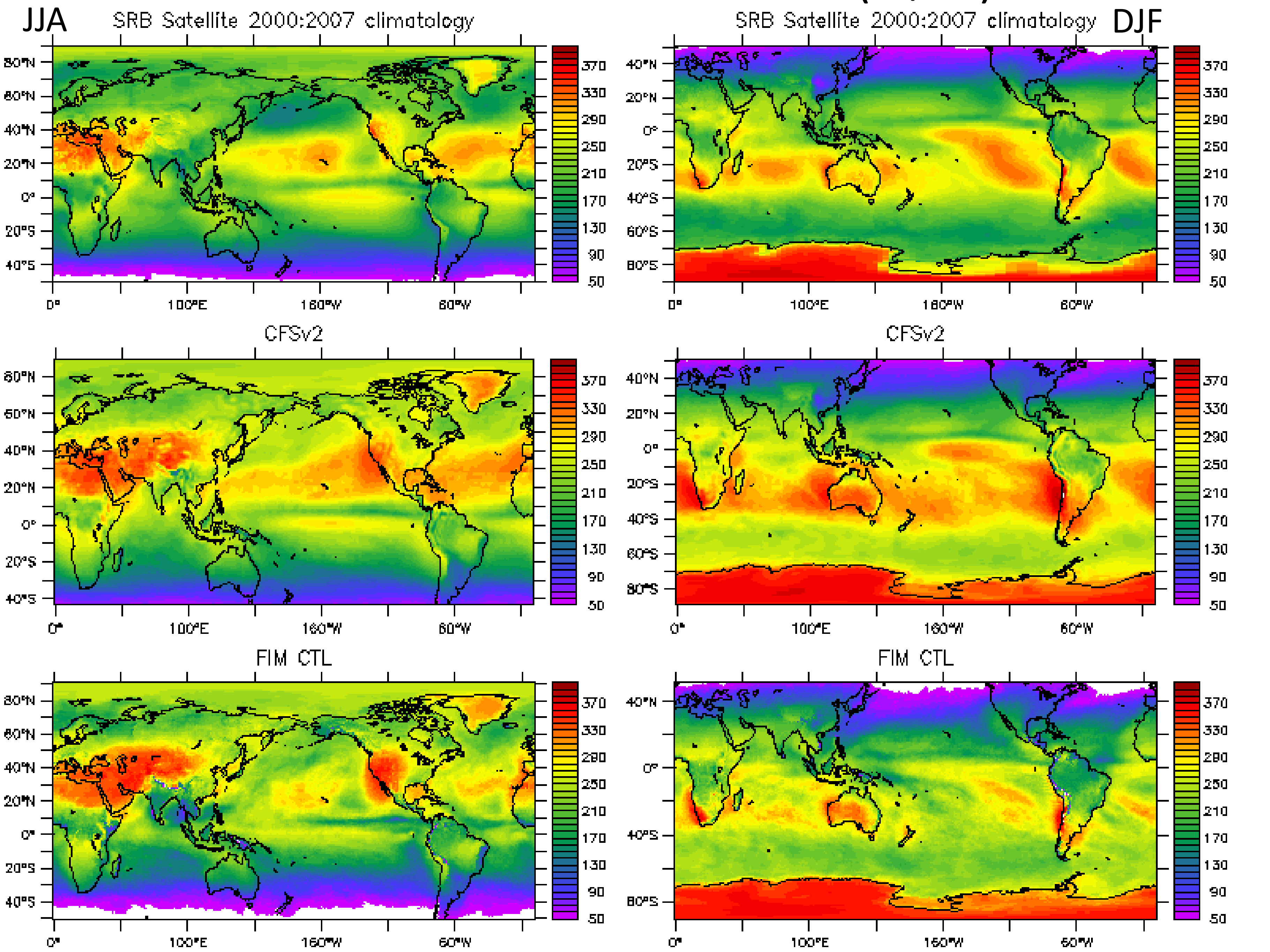
- **FIM CTL:** a control run at 60km mesh size, 64 layers
- **FIM mod1:** using the cloud fraction calculation in WRF, a modified version of Xu & Randall (1996)
- **FIM mod2:** using the GF (Grell & Freitas 2013, ACPD) convection scheme instead of Han-Pan scheme

(all using monthly observed SST, ice temperature and ice coverage data)

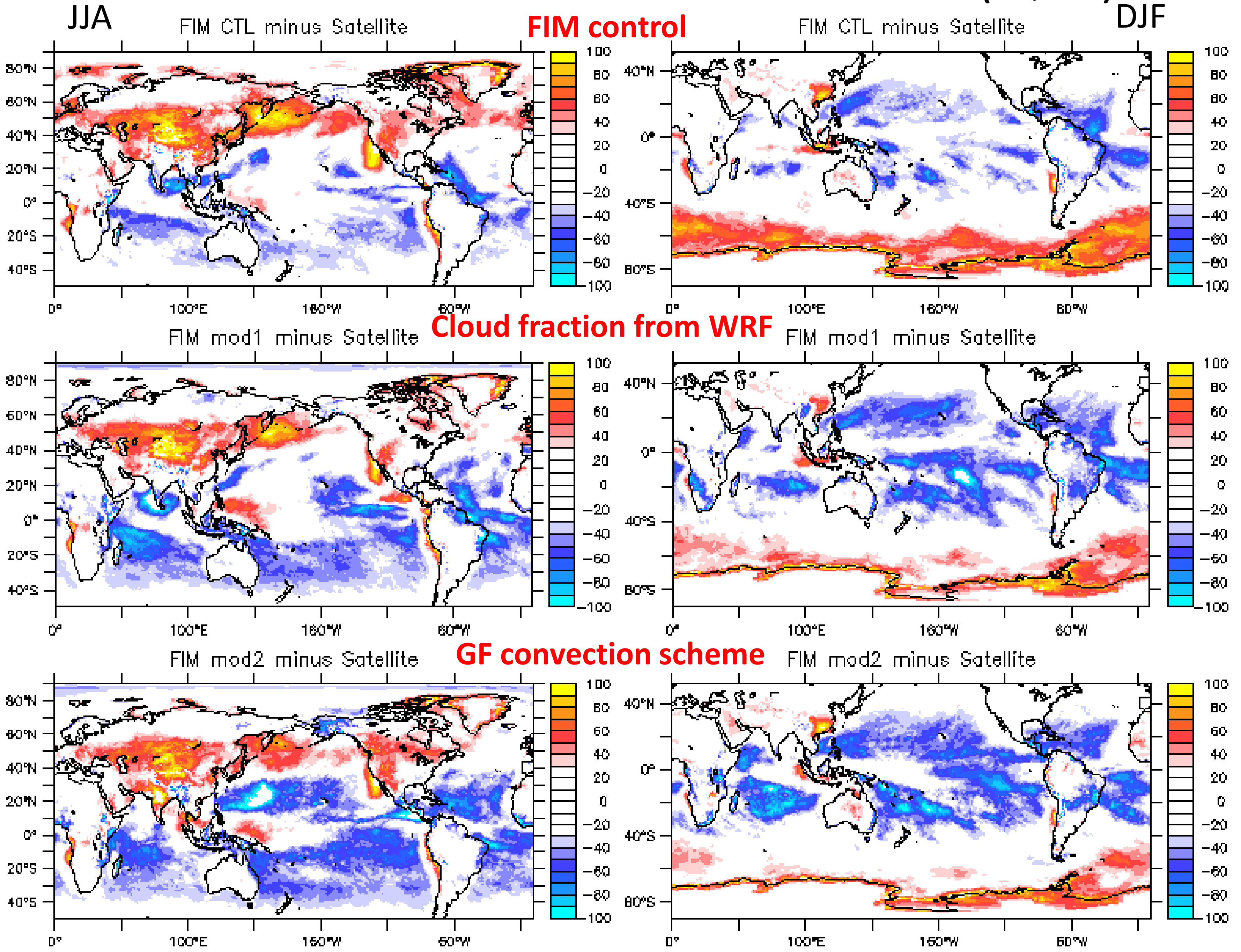
Zonal Mean Surface Downward Shortwave



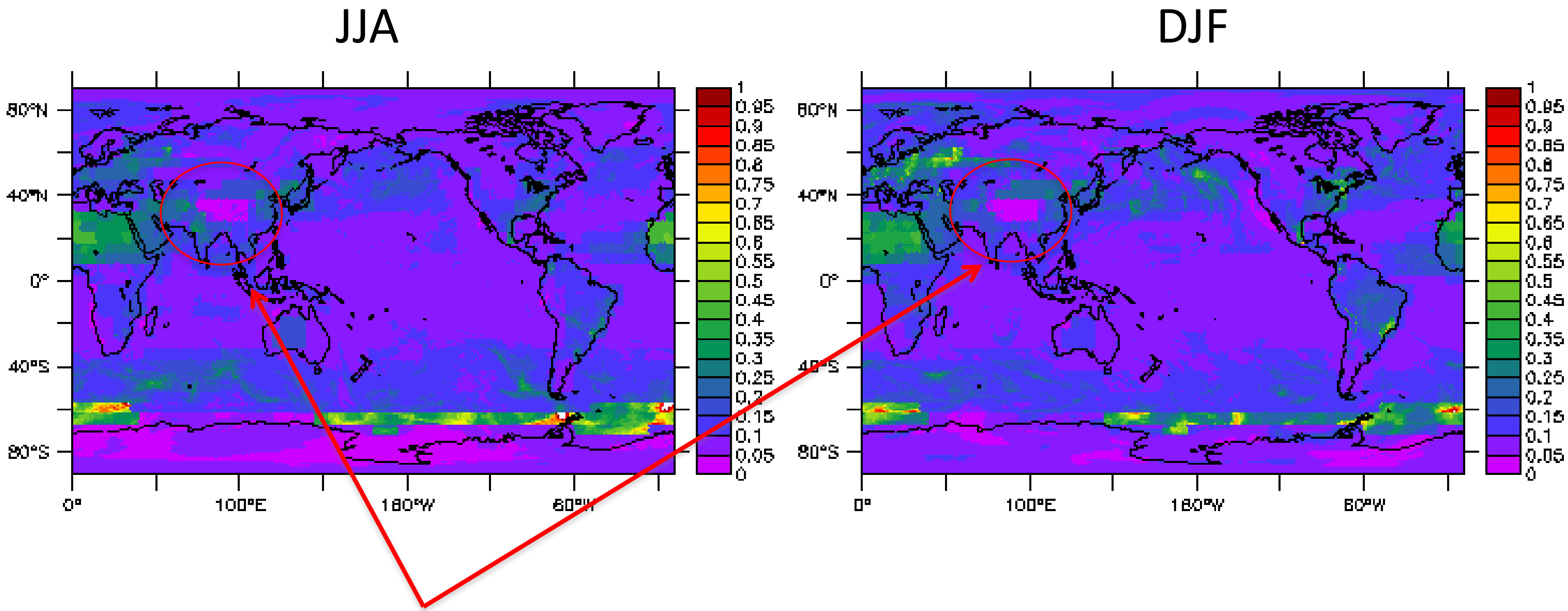
Downward Surface Shortwave (W/m^2)



Biases in Downward Surface Shortwave (W/m²)



Aerosol Optical Depth



Aerosol Optical Depth Too Low?

Summary

- Coupled FIM/iHYCOM model has the advantage of avoiding grid discontinuity at the air-sea surface, hence no need for interpolating flux coupler
- The mathematical similarity of the two models allows them to share dycore components and software engineering innovations
- FIM/iHYCOM is being developed to participate in NMME (National Multi-Model Ensemble). Also for ESPC (Earth System Prediction Capacity) applications
- There are still large regional biases in surface shortwave fluxes, most likely due to biases in cloud coverage
- Remaining climate drift in multi-year coupled runs reveals the need to further revise the column physics parameterizations in FIM/GFS/CFS via coordination between ESRL, EMC, and MAPP Process Teams