CFSv2 Sea Ice

Xingren Wu[*] and Robert Grumbine
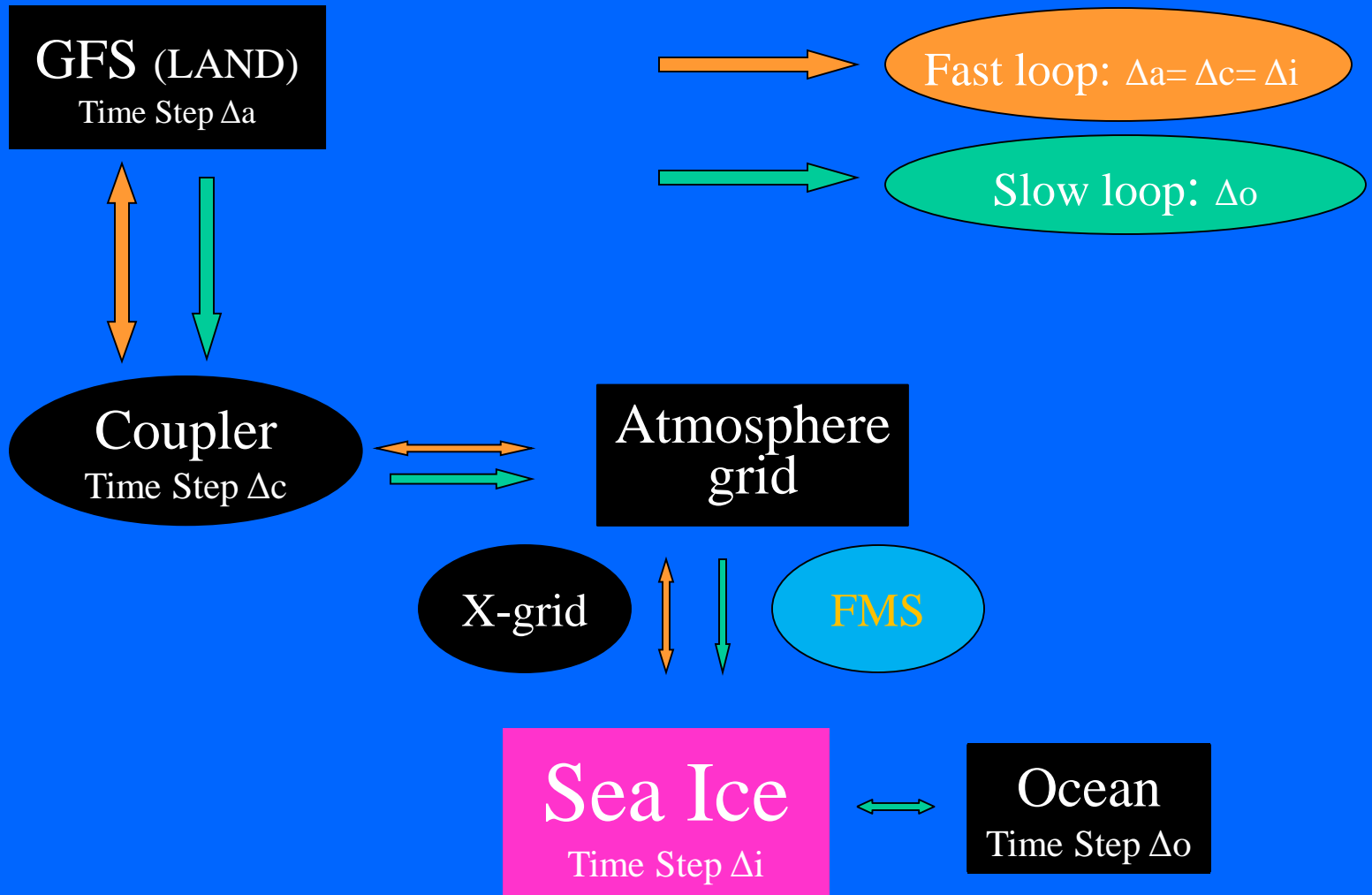### EMC/NCEP/NWS/NOAA
* IMSG

CFSv2 Sea Ice - GFDL Sea Ice Simulator:

- **Hunke and Dukowicz (1997) elastic-viscous-plastic (EVP) ice dynamics model**
  - ➢ **Improved numerical method for Hibler's viscous-plastic (VP) model**

- **Winton (2000) 3-layer thermodynamic model plus ice thickness distribution**
  - ➢ **2-layer of sea ice and 1-layer of snow**
 - ➢ **5 categories of sea ice**

Hunke E.C., Dukowicz J.K. (1997). An elastic-viscous-plastic model for sea ice dynamics. *Journal of Physical Oceanography*, 27, 1849-1867.

Winton M. (2000). A reformulated three-layer sea ice model, *J. of Atmospheric and Oceanic Technology*, 17, 525-531.

Sea Ice - one component of CFSv2

GFS (LAND)
Time Step Δa

Fast loop: $\Delta a = \Delta c = \Delta i$

Slow loop: Δo

Coupler
Time Step Δc

Atmosphere grid

X-grid

FMS

Sea Ice
Time Step Δi

Ocean
Time Step Δo
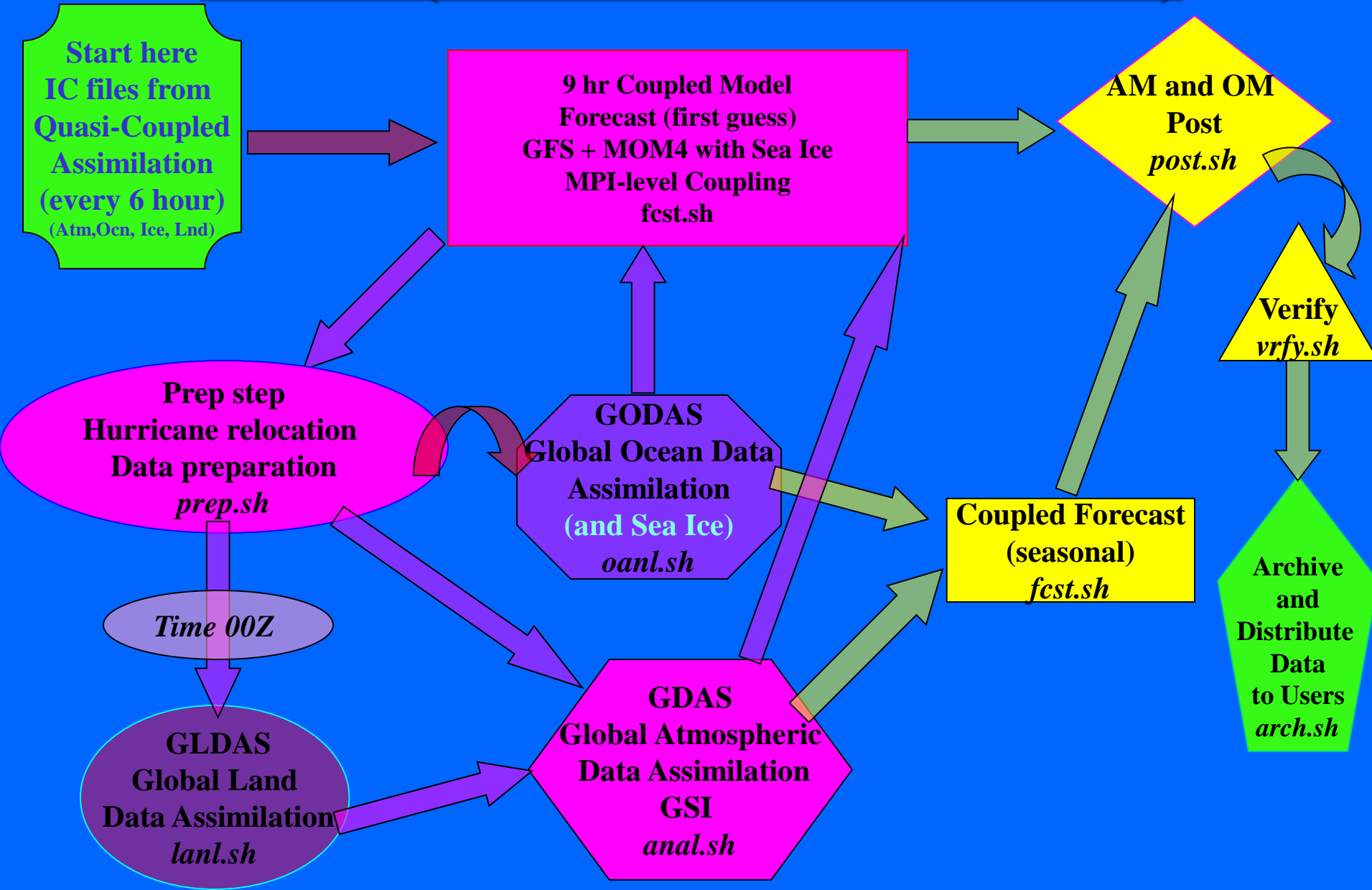
MOM4/SIS: MOM4P0d   August 2004

Tripolar grid of Murray (1996) over the Arctic for the sea ice model (the same as that for the ocean model)
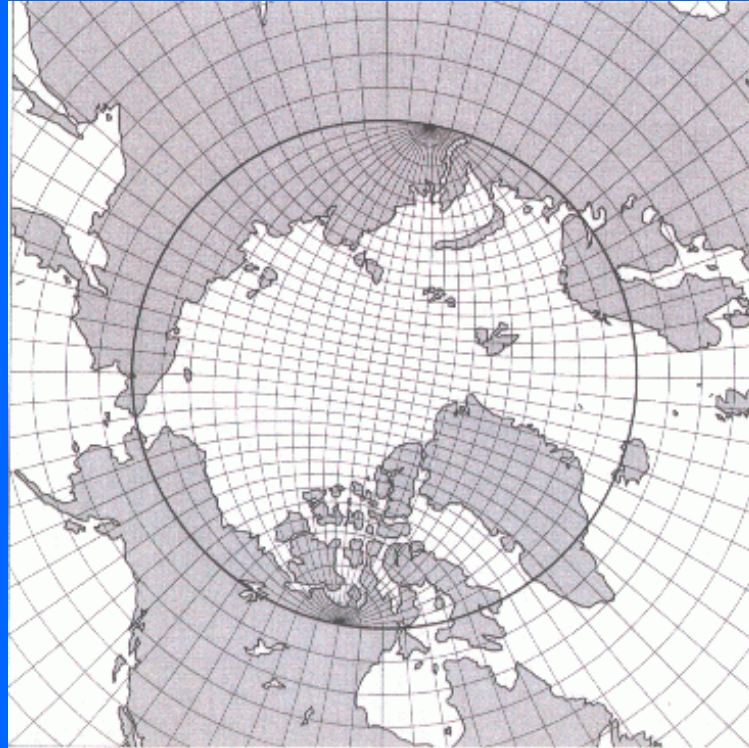
This avoids a singularity at the North Pole

Murray R (1996). Explicit generation of orthogonal grids for ocean models, J.Comp.Phys., 126, 251-273.)

CFSv2 (Assimilation and Forecast)

Start here
IC files from
Quasi-Coupled
Assimilation
(every 6 hour)
(Atm,Ocn, Ice, Lnd)

9 hr Coupled Model
Forecast (first guess)
GFS + MOM4 with Sea Ice
MPI-level Coupling
fcst.sh

AM and OM
Post
post.sh

Verify
vrfy.sh

Prep step
Hurricane relocation
Data preparation
prep.sh

GODAS
Global Ocean Data
Assimilation
(and Sea Ice)
oanl.sh

Coupled Forecast
(seasonal)
fcst.sh

Archive
and
Distribute
Data
to Users
arch.sh

Time 00Z

GDAS
Global Atmospheric
Data Assimilation
GSI
anal.sh

GLDAS
Global Land
Data Assimilation
lanl.sh

Courtesy: Shrinivas Moorthi (EMC/NCEP)

Sea Ice Data "Assimilation" (Nudging)

- **In CFSR/CFSv2 we assimilated sea ice concentration by nudging the sea ice concentration towards the observed value:**
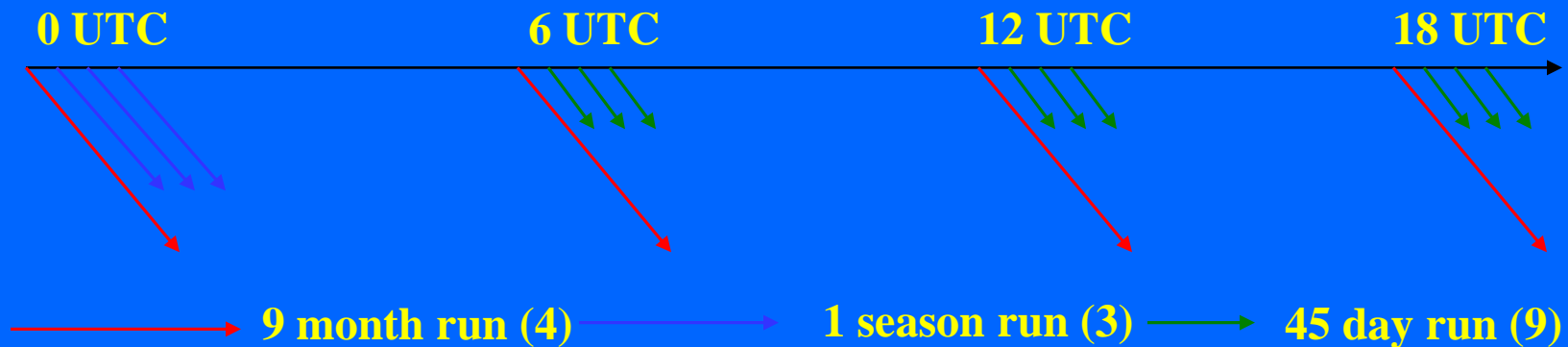
$$fi\_A = fi\_F + k*(fi\_O - fi\_F)$$

- **The nudging coefficient k was set to 1. Therefore, the CFSR/CFSv2 final product was in fact the observed sea ice concentration.**

Operational Configuration for CFSv2 Forecast

There are a total of 16 members runs every day

- ✓ **4 runs go out to 9 months**
- ✓ **3 runs go out to 1 season**
- ✓ **9 runs go out to 45 days**

CFSv2 data ➔ http://cfs.ncep.noaa.gov

0 UTC   6 UTC   12 UTC   18 UTC

9 month run (4) ——— 1 season run (3) ——— 45 day run (9)

CFS reanalysis (CFSR) and reforecast

- ✓ **A new Reanalysis of the atmosphere, ocean, sea ice and land over the 32-year period (1979-2010) had been done, which was used to provide consistent initial conditions for CFS reforecats.**

- ✓ **A complete Reforecast of the CFS over the 29-year period (1982-2010) had been done, which was used to provide stable calibration and skill estimates of the new system, for operational seasonal prediction at NCEP (CFSv2)**
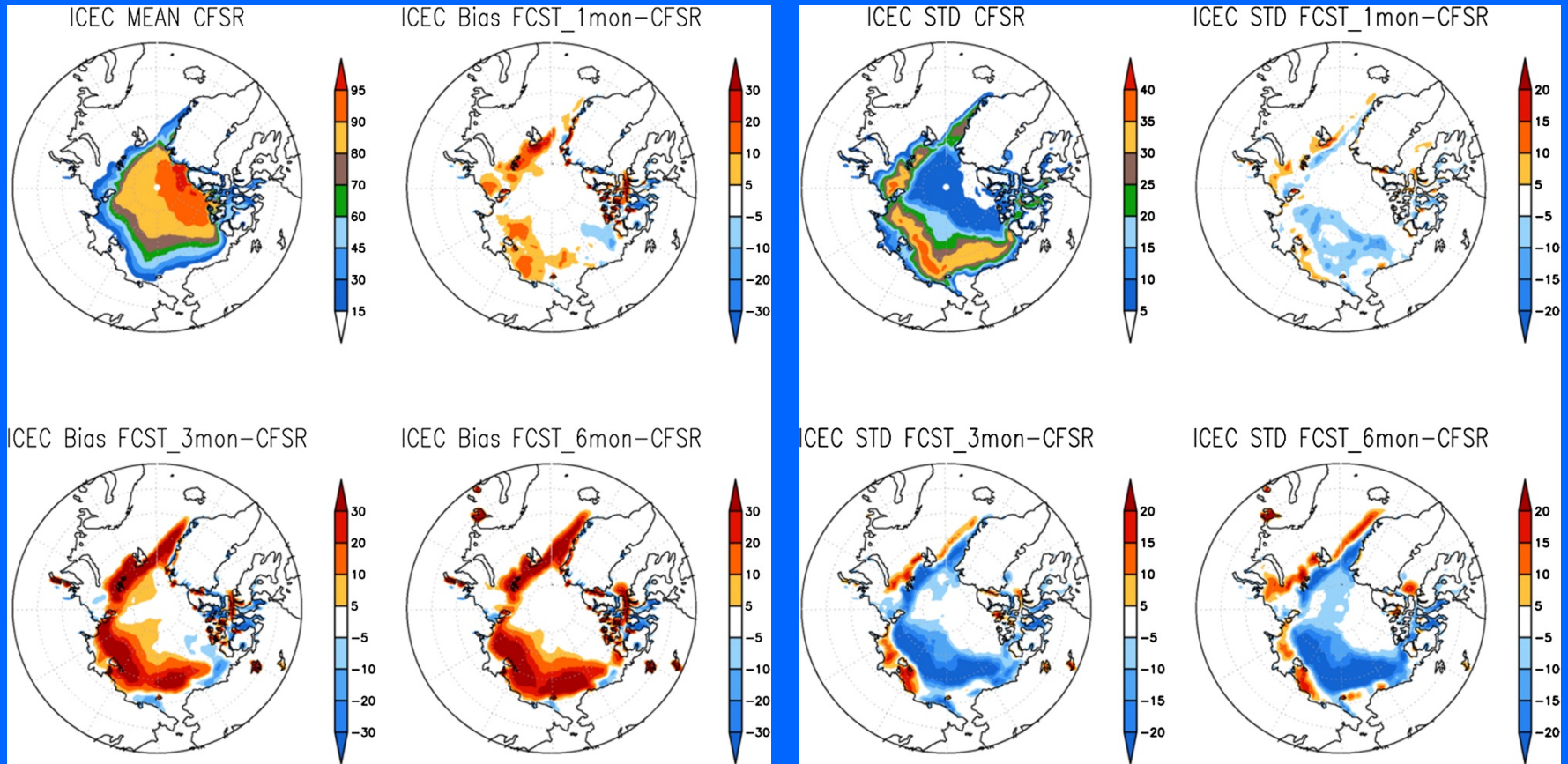
CFS Reanalysis and Reforecast data:
http://nomads.ncdc.noaa.gov/data.php?name=access#cfs
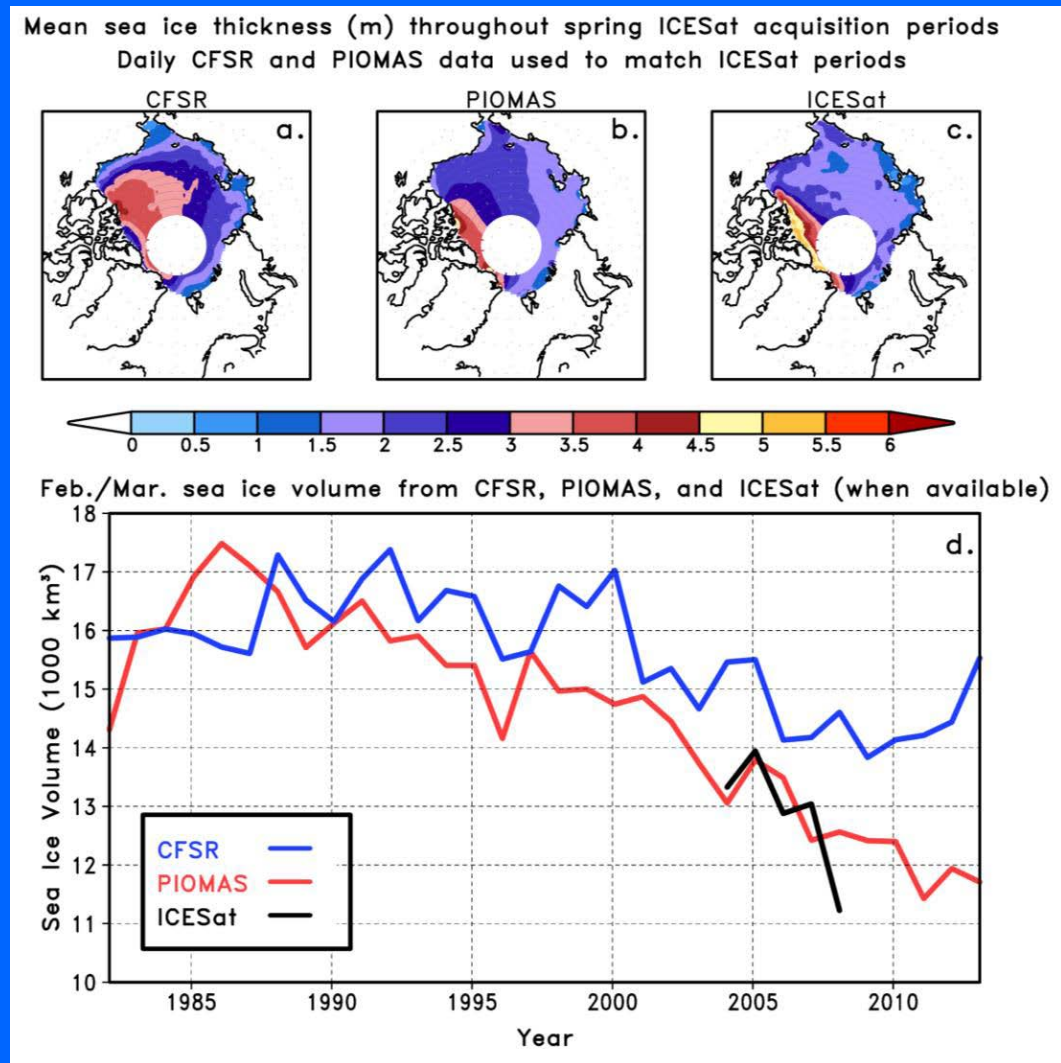
Evaluation/Performance/Community model

- Operational CFSv2 – available to the public
  - ✓ Data (CFSR - Jan 1979 to Mar 2011; CFSv2 – from Apr 2011)
  - ✓ Model
- CPC has been using the data for Climate Forecast

- CPC has been using the model
- COLA has been using the model
- IITM has been using the model
- …

- EMC used the model with revised sea ice IC participating in SIO for September
- CPC used the data with bias correction participating in SIO

CFSR SIC (Sept), and the bias and SD from the prediction (1982-2009)

Sea Ice thickness (spring) from CFSR vs PIOMAS and ICESat

Mean sea ice thickness (m) throughout spring ICESat acquisition periods
Daily CFSR and PIOMAS data used to match ICESat periods

Future development

- NGGPS development – NEMS coupling atmosphere/land/ocean/sea ice/wave/aerosol/…

- Data assimilation providing ICs for NGGPS/UGCS
  - For sea ice - assimilating sea ice concentration and thickness using Local Ensemble Transform Kalman Filter (LETKF)

- For CFSv3 more than one sea ice model may be tested - CICE/SIS2/KISS/…
  - GFDL has provided SIS2 (and MOM6) to EMC

Questions for coupling

- **Grids:**
  - **Should ice and ocean be on the same grid?**
- **Masks:**
  - **Should land and sea grids "tile" each other?**
- **Coupling fields:**
  - **Where will the surface fluxes be calculated?**
- **Cold start:**
  - **How to initialize the coupled model?**
- **Restart:**
  - **Are coupling fields needed for initialization?**
- **Climatology fields:**
  - **Are they needed (such as runoff)?**

Thank you!

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CFSv2 data:
http://cfs.ncep.noaa.gov

CFS Reanalysis data:
http://nomads.ncdc.noaa.gov/data.php?name=access#cfs