Intra-seasonal to Inter-annual Forecasting at the NASA Global Modeling and Assimilation Office

S. Schubert, M. Rienecker and M. Suarez

CTB National MME Planning Meeting

Johns Hopkins University Applied Physics Lab

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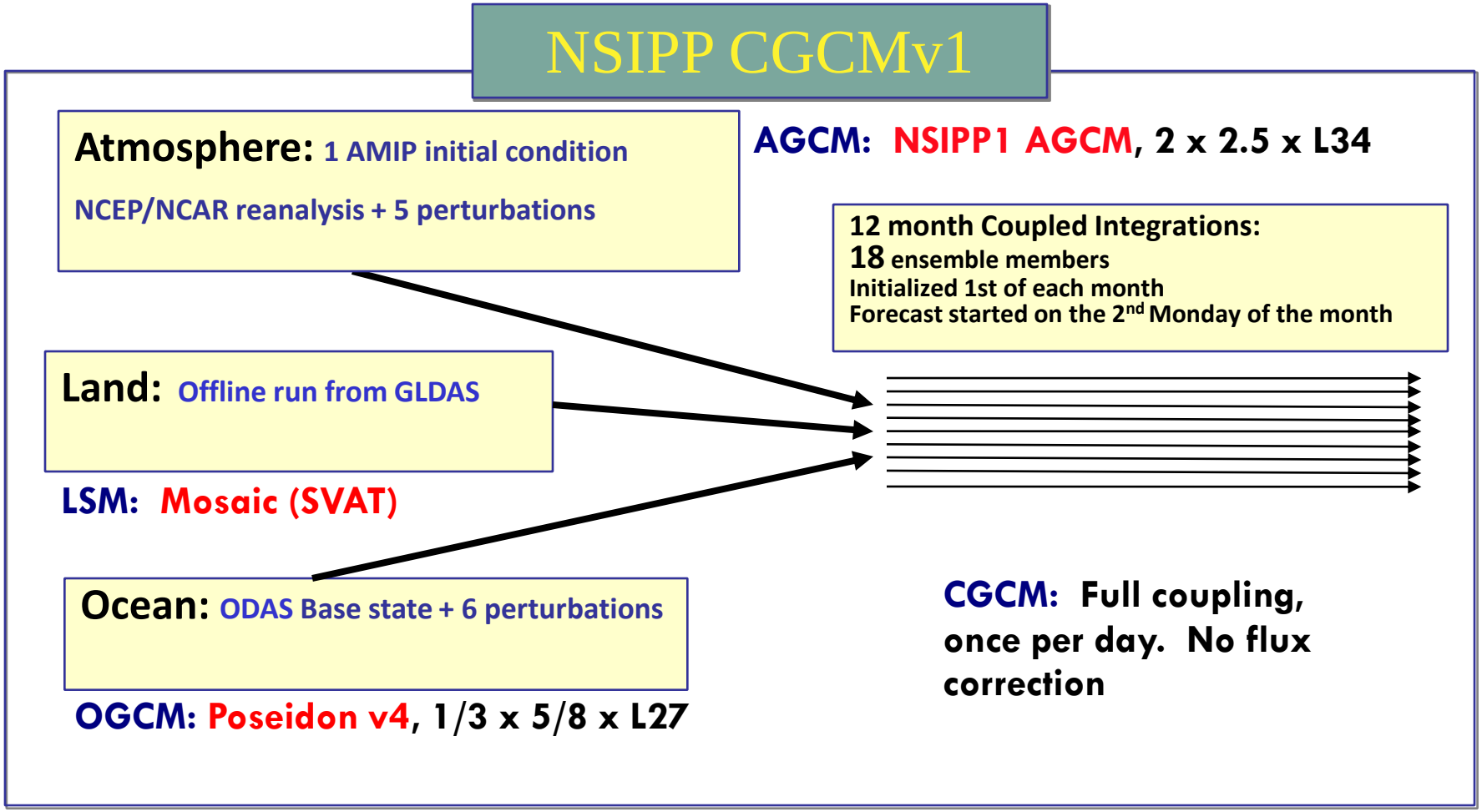
Current Activities

- Routine 12 month forecasts every month: tier 1 (CGCMv1) and tier 2 (forced with IRI SST)
  - hindcast suite 1993-2002, forecasting since 2003
  - contribute forecasts to various national and international multi-model predictions
- Currently transitioning to GEOS-5
  - initial focus on decadal predictions (CMIP-5)
  - For ISI we anticipate 30-year hindcast suite beginning 1982
- Existing CTB proposal (with EMC) focused on strategies for initializing MJO/subseasonal variability

The current GMAO Seasonal Forecast System

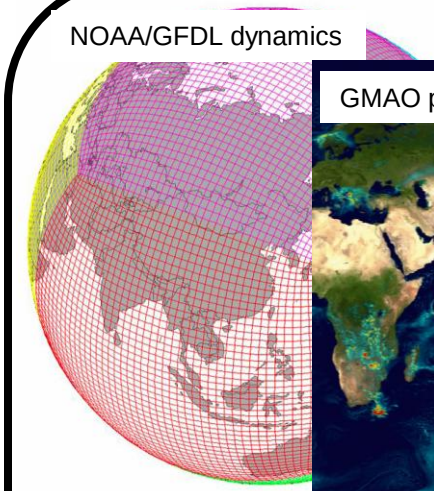


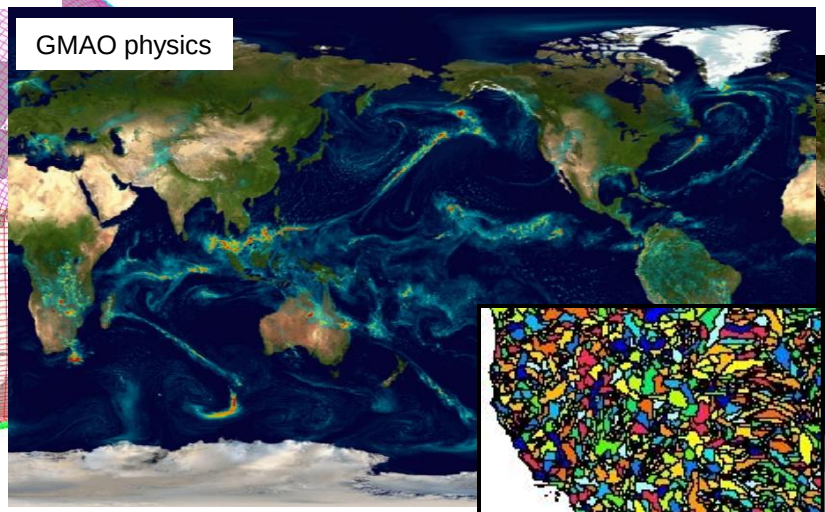
ODAS: (Offline run with surface forcing from NCEP2, relaxation to Reynolds SST and Levitus SSS, Assimilation of Temperature profiles, Salinity profiles from Argo) Univariate Optimal Interpolation for T and S

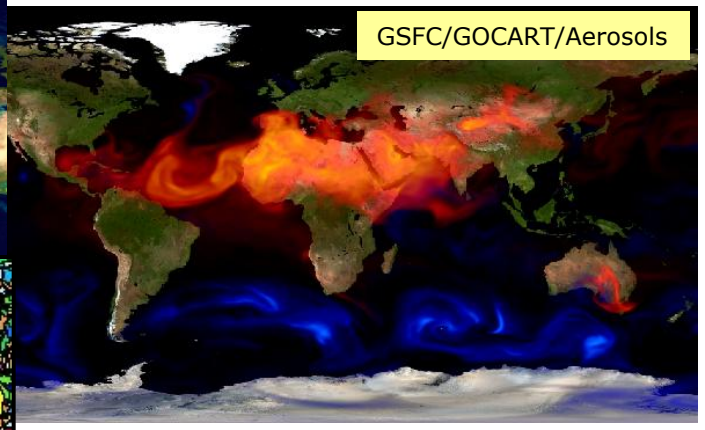
AMIP: AGCM run with observed SSTs (Reynolds)

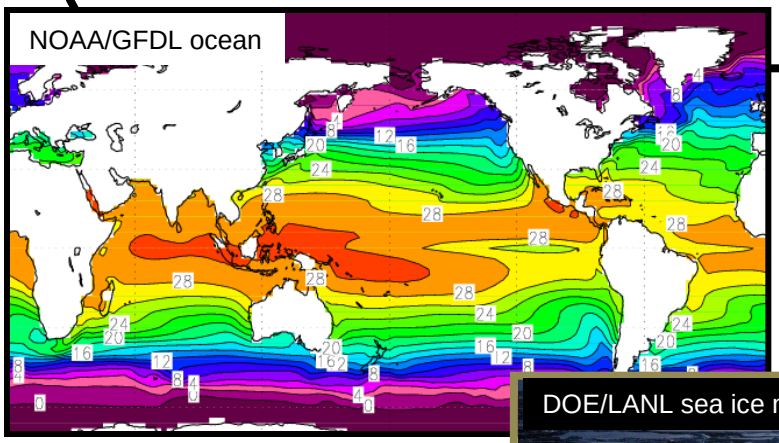
GLDAS: Global Land Data Assimilation System surface forcing for offline LSM run

GEOS-5 AOGCM for seasonal forecasts









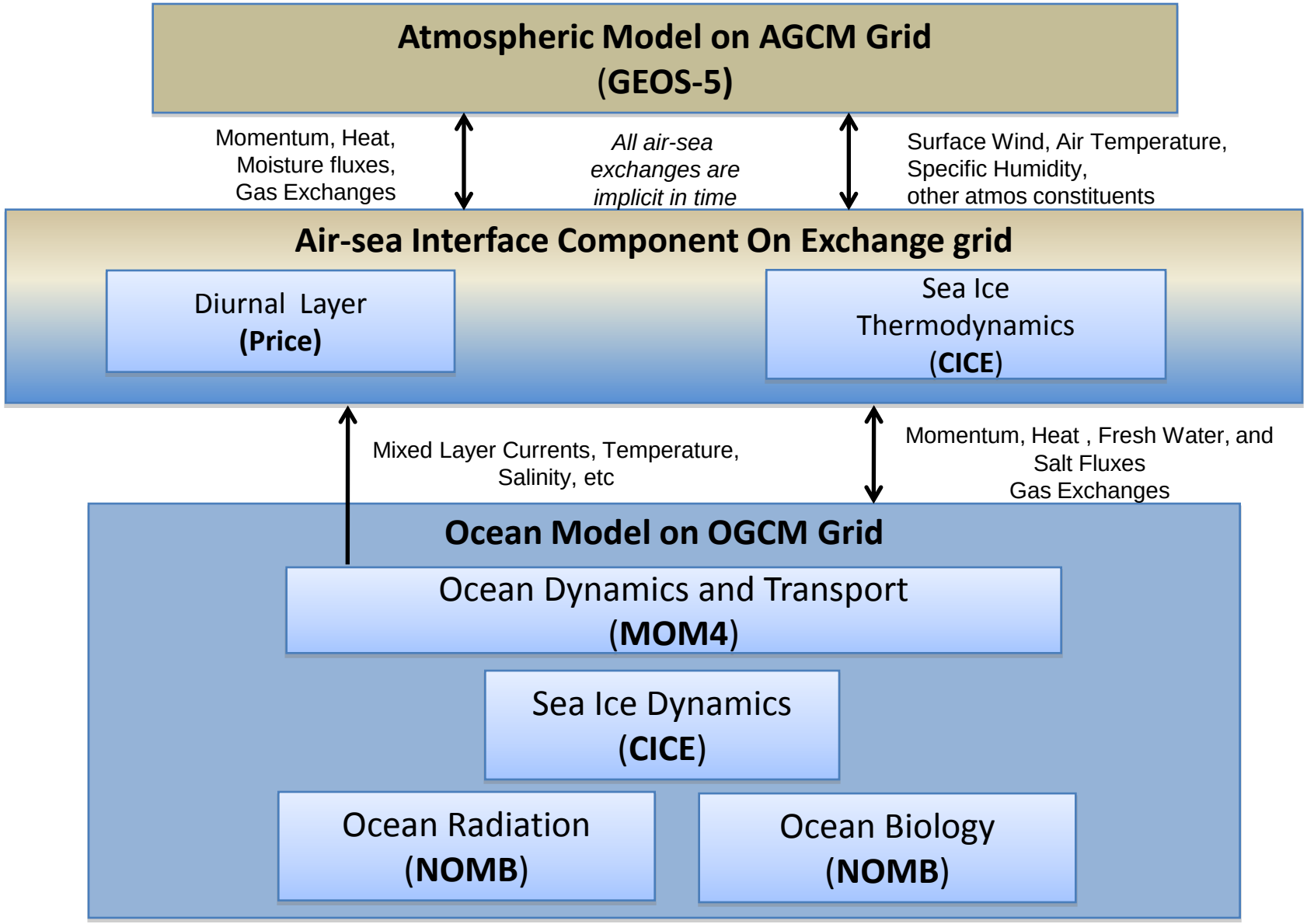
GEOS-5 AGCM for ISI Prediction

- Finite volume dynamical core (Lin, 2004)
  - 1°x1.25°x44 layers
- Convection: Relaxed Arakawa-Schubert (Moorthi and Suarez, 1992)
  - Modified after Sud and Walker (1999) to compute rainout from updraft
  - Stochastic Tokioka (1988) trigger
- Prognostic Cloud/Microphysics: Bacmeister et al. (2006)
- Boundary Layer: Lock (2000) and Louis (1982)
  - Use larger of K values from the two schemes
  - Lock scheme suppressed in presence of wind shear
  - Louis turbulent length scale from (diagnosed from K profile) PBL depth
- Radiation: Shortwave – Chou and Suarez (1999), Longwave – Chou et al. (2001)
- Surface Layer: Monin-Obukov of Helfand and Schubert (1995)
- Gravity Wave Drag Scheme based on McFarlane (1987) and Garcia and Boville (1994)
- Interactive Aerosol from GOCART model
- Chemistry
  - GHGs, ozone: relaxation to time evolving specified zonal means consistent with IPCC

The GEOS-5 OGCM for ISI Prediction

- MOM4
  - Version 4.1 patch 1
  - ½°x½°x40 levels (1/4° equatorial refinement), tri-polar grid
  - B-grid, Z-coordinate (geopotential option)
  - KPP vertical mixing
  - Laplacian horizontal diffusion and friction
- Diurnal skin layer (Price)
- Sea ice: CICE (Los Alamos National Laboratory)

GEOS-5 AOGCM Coupling Configuration

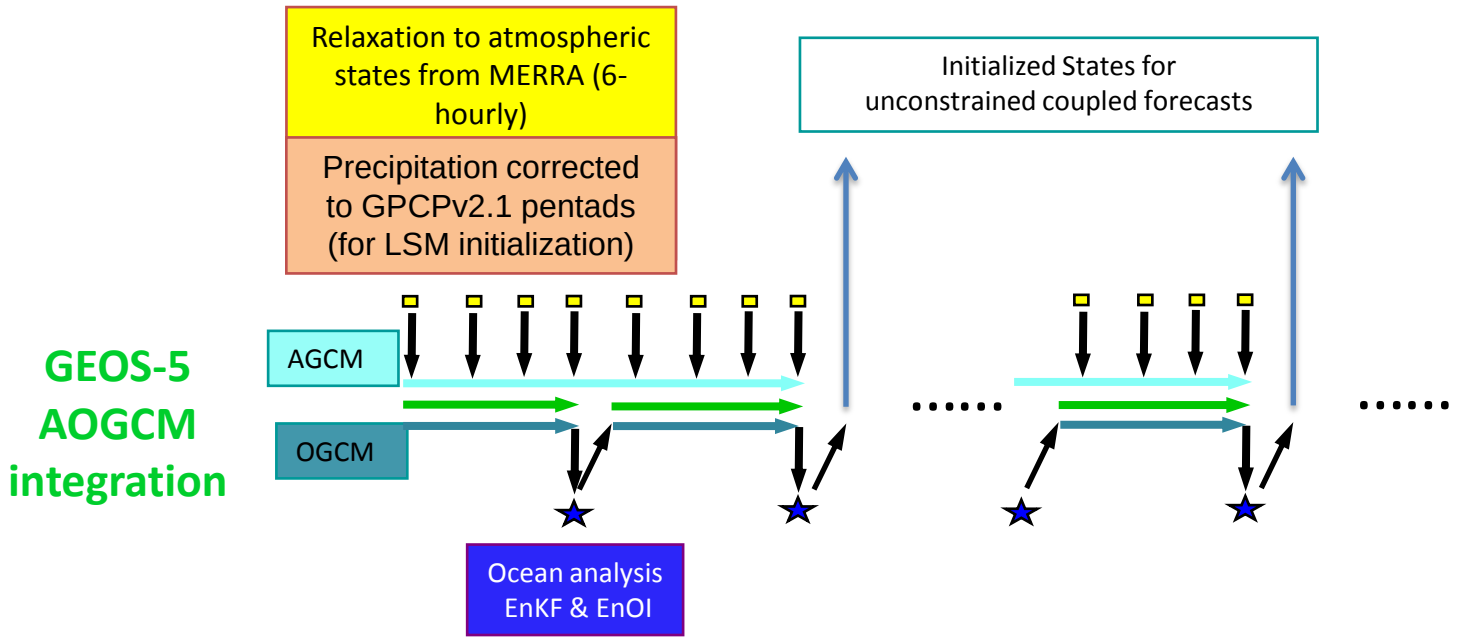


GEOS ODAS-2

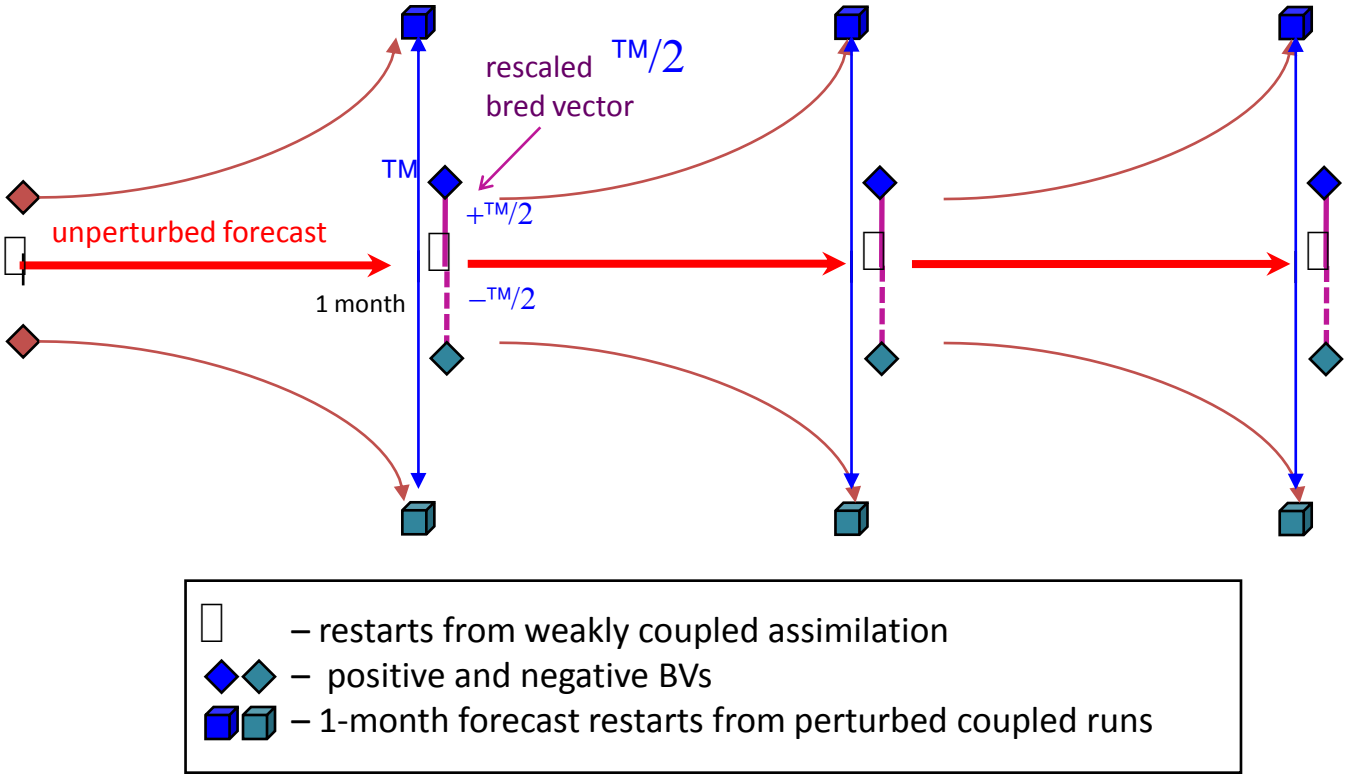
- ODAS-2 can be run as an Ensemble Kalman Filter (EnKF) with state-dependent multivariate background error covariances or as an Ensemble OI (EnOI) with static multivariate background error covariances
  - EnKF: 20 member ensemble
  - EnOI: Static ensemble of 20 EOFs from time series of differences in 20-member ensemble AOGCM simulation

- T and S profiles (Buoys, XBTs, CTDs, Argo) and Reynolds SST are assimilated daily.
- XBT temperature profiles have been corrected according to Levitus et al. (2009).
- For XBTs and Buoys, synthetic salinity profiles are generated from Levitus & Boyer S(T)
- Climatological SSS is assimilated to compensate for errors in fresh water input from precipitation and river runoff.
- Sea Level Anomalies are from AVISO.
- Analysis is also constrained by Levitus & Boyer climatological temperature and salinity – correction made to first guess fields before assimilation of other real-time data – univariate.
- Multivariate covariances correct T and S, not currents.

GEOS-5 Coupled analysis cycle for Initialization of ISI Predictions



Two-sided breeding in a coupled system



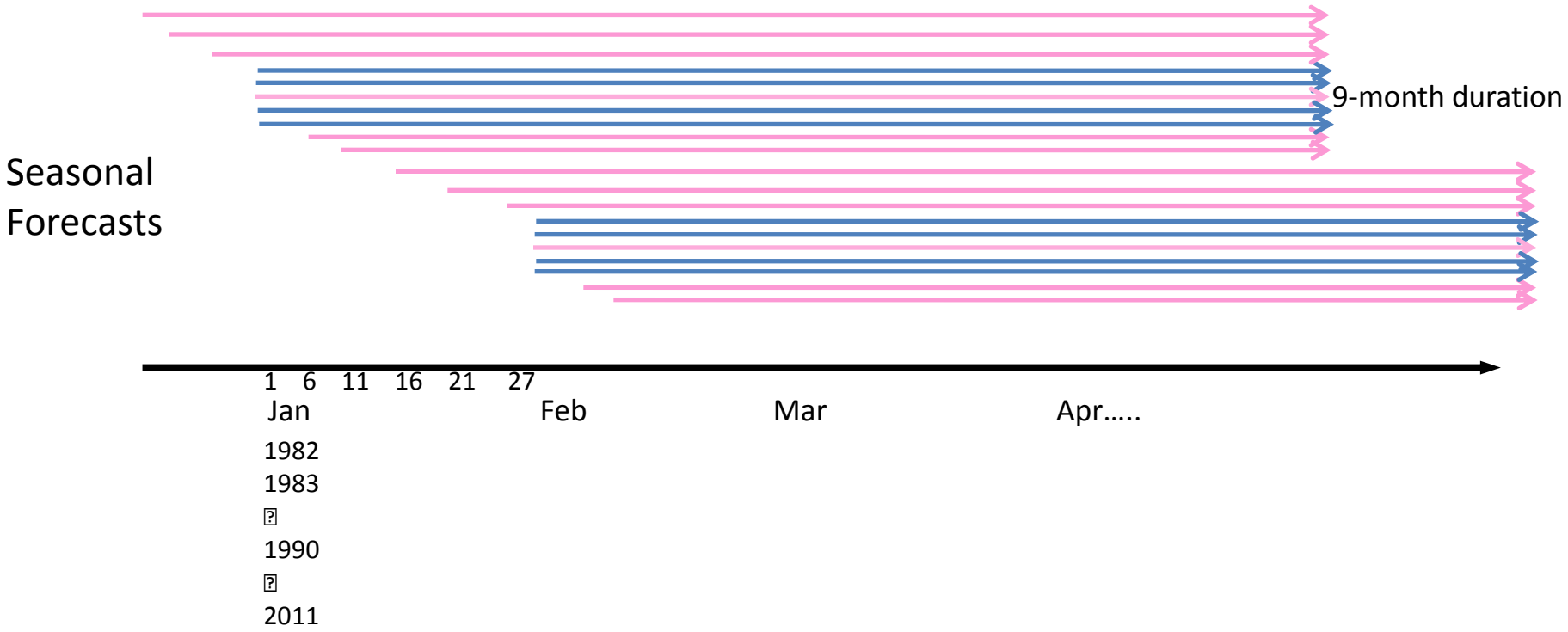
• **Bred vectors** : 0.5* difference between the coupled forecast with positive perturbation and the coupled forecast with negative perturbation (accounts for model drift).

• Coupled breeding cycle needs to choose physically meaningful breeding parameters in order to choose the type of instability

For seasonal prediction: BV_SST=0.1°C in Niño3 region and rescaled every month

Courtesy: Shu-Chih Yang

Seasonal Forecast strategy with GEOS-5



Seasonal ensembles:
1st of month: Bred Vector perturbations (1-month rescaling) and/or coupled EnKF perturbations
Later initialization to subsample subseasonal evolution in initial conditions

Forecast anomalies calculated relative to ensemble climatological drift for each start date

Possible Contributions to National MME

-Carry out suite of hindcasts with GEOS-5 as necessary to allow initial assessment of skill for possible inclusion in MME

-Make GEOS-5 coupled model available for running on a future MME computing platform

-Develop GEOS-5 hybrid model (with NCEP physics), initial work already completed (has been on hold for 2 years), would need additional resources at GMAO and NCEP to update and test

Tentative Timelines

Ocean assimilations (2 streams):

EnOI: 2011 completed at the end of April

EnKF: 2011 completed at end of May

1-month forecasts for Bred Vector generation: end of May

6-month forecasts (10-member ensemble) for January and July: end of June