A Direction of Global Climate Modeling and Prediction

In-Sik Kang

Seoul National University

Model development - physics : Daehyun Kim, Sung-Bin Park
- dynamics: Young-Min Yang
- CRM : Ildae Choi
Initialization : Yoo-Geun Ham, Eun-Jung Lee

Future direction

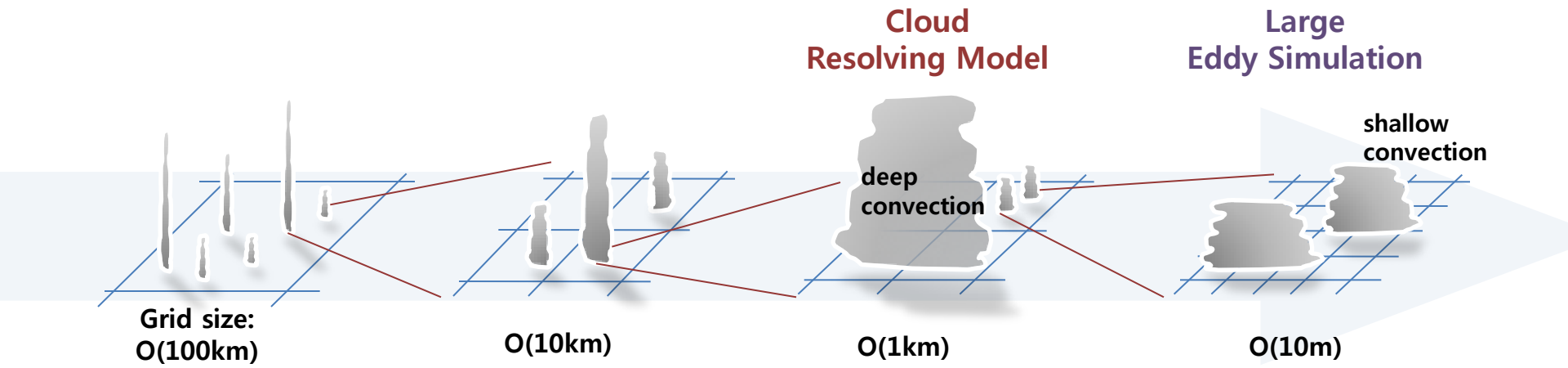
Low resolution coupled model
~ O(100km)

- **Model**
  - New concept of physics for high resolution model
- **Initialization**
  - Time-dependent ensemble Kalman filter

High resolution coupled model
~ O(10km)

Global Climate Modeling

- in view of resolution and turbulence



- Cumulus ensemble
- Equilibrium assumption

- Deep convection resolved
- Cloud microphysics

We are in intermediate state

✓ PDF based turbulence ensemble approach

✓ resolution dependent microphysics

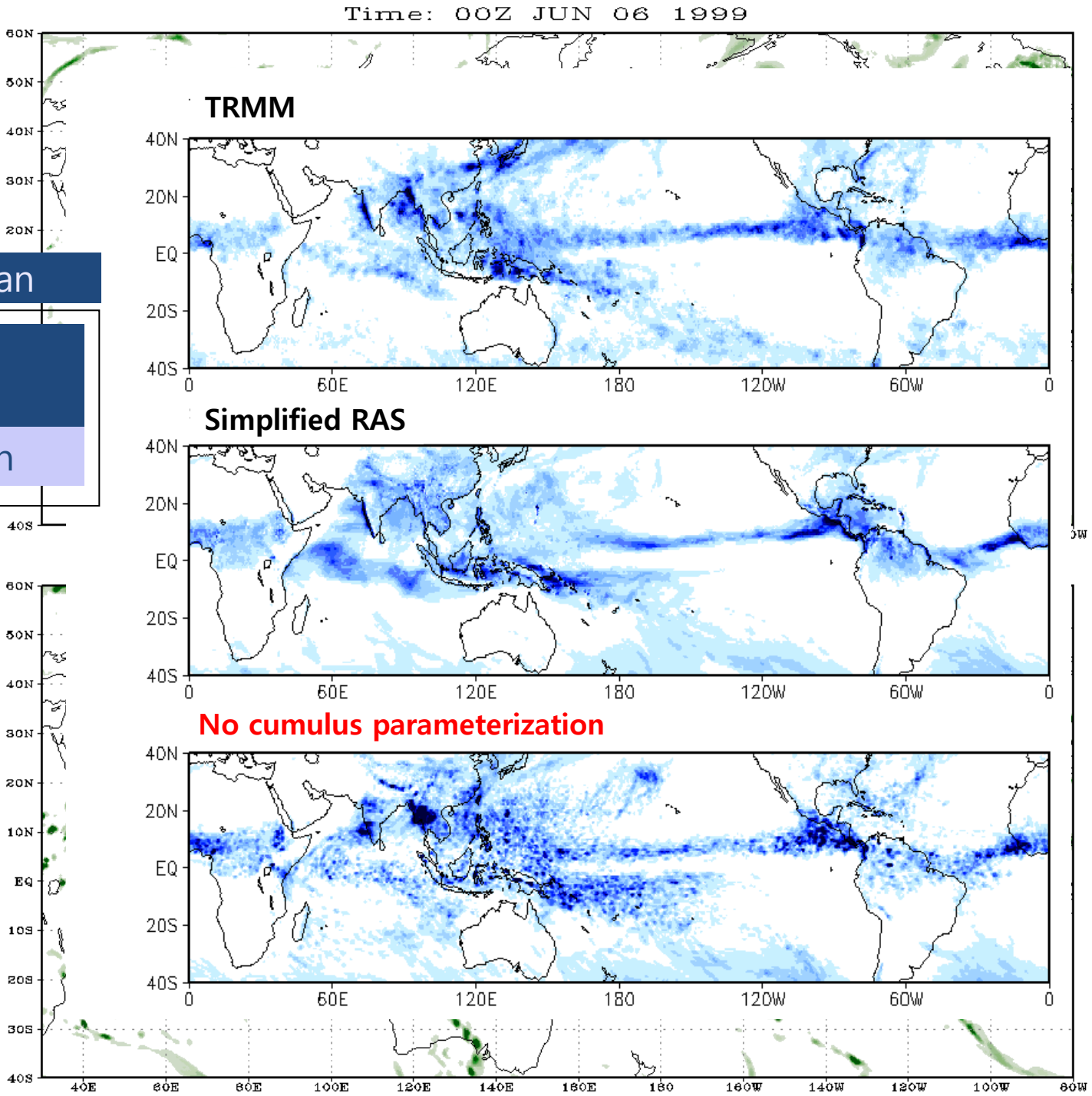
Simplified RAS

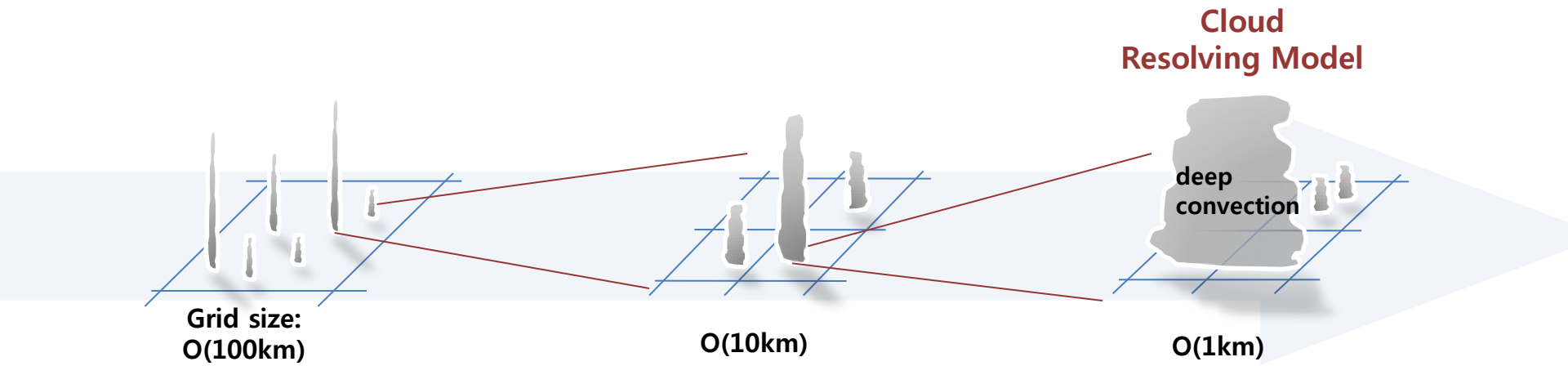
Monthly Mean

1999
June mean

precipitation

No cumulus parameterization



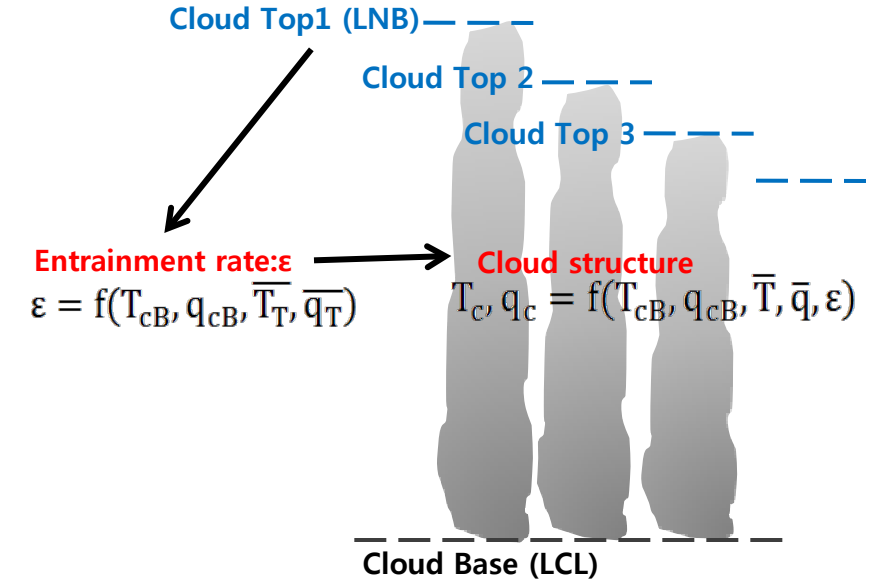


- Cumulus Ensemble
- Steady-state (equilibrium)
- Deterministic

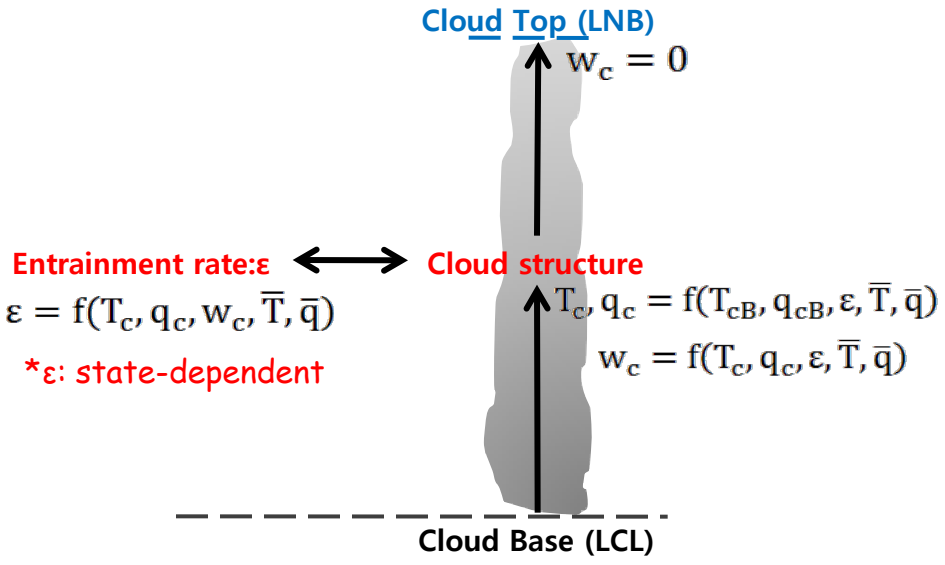
- Turbulence ensemble
- Prognostic
- Probabilistic

- Cloud resolving

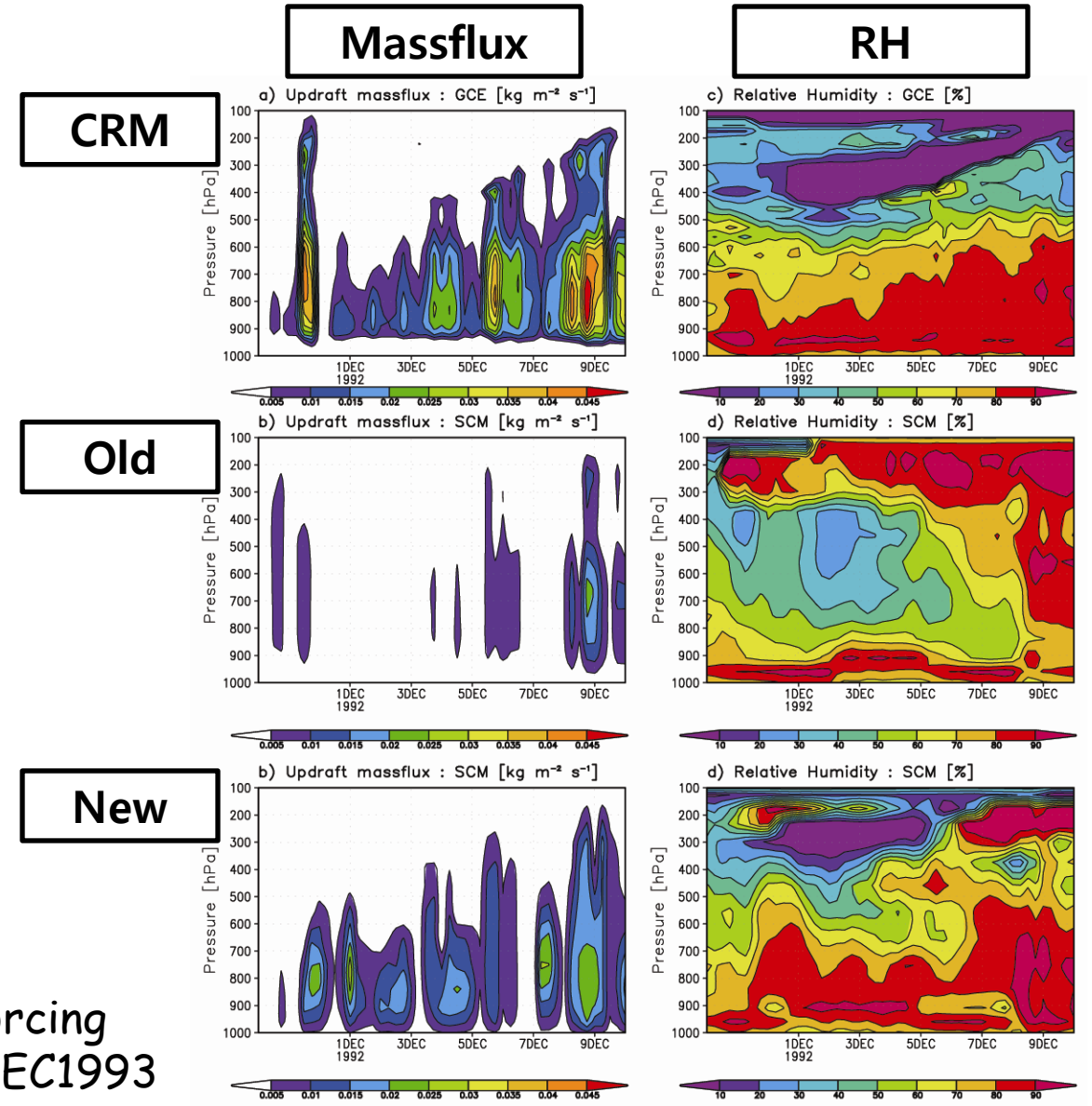
A-S type cumulus parameterization



Turbulence based parameterization



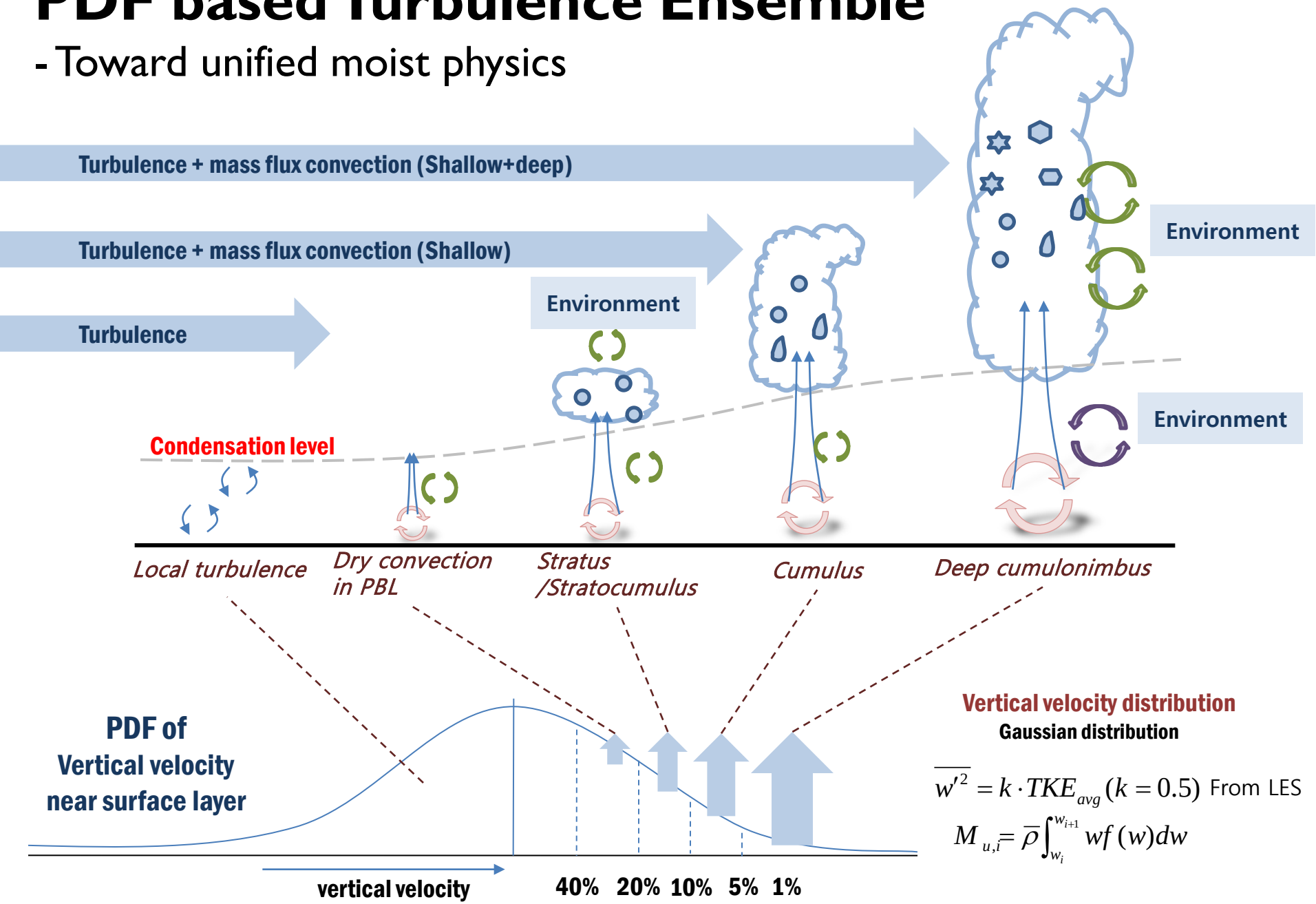
*similar approach: ECMWF, MPI, UKMO



SCM experiment
*TOGA-COARE forcing
*28NOV1992-10DEC1993

PDF based Turbulence Ensemble

- Toward unified moist physics



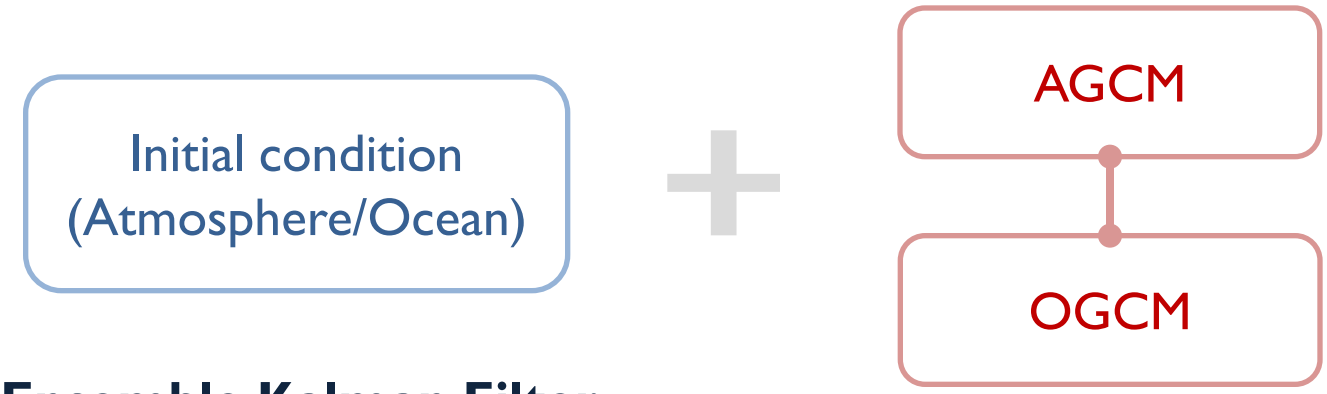
Cumulus ensemble

Low resolution ~O(100km)

PDF-based turbulence ensemble

High resolution ~O(10km)

Climate Prediction System



Ensemble Kalman Filter

(Current examined initialization method)

➢**Advantage of EnKF**

- Linear and adjoint model is not needed
- Nonlinear error evolution is allowed

➢**Model error (B) in EnKF**

- Magnitude of ensemble spread is assumed as model error (B)
- B is varying with time (Better representation of time-varying forecast error)

Hindcast experiments

Correlation skill of SST Start from May 1st ,19year hindcast experiments

EnKF

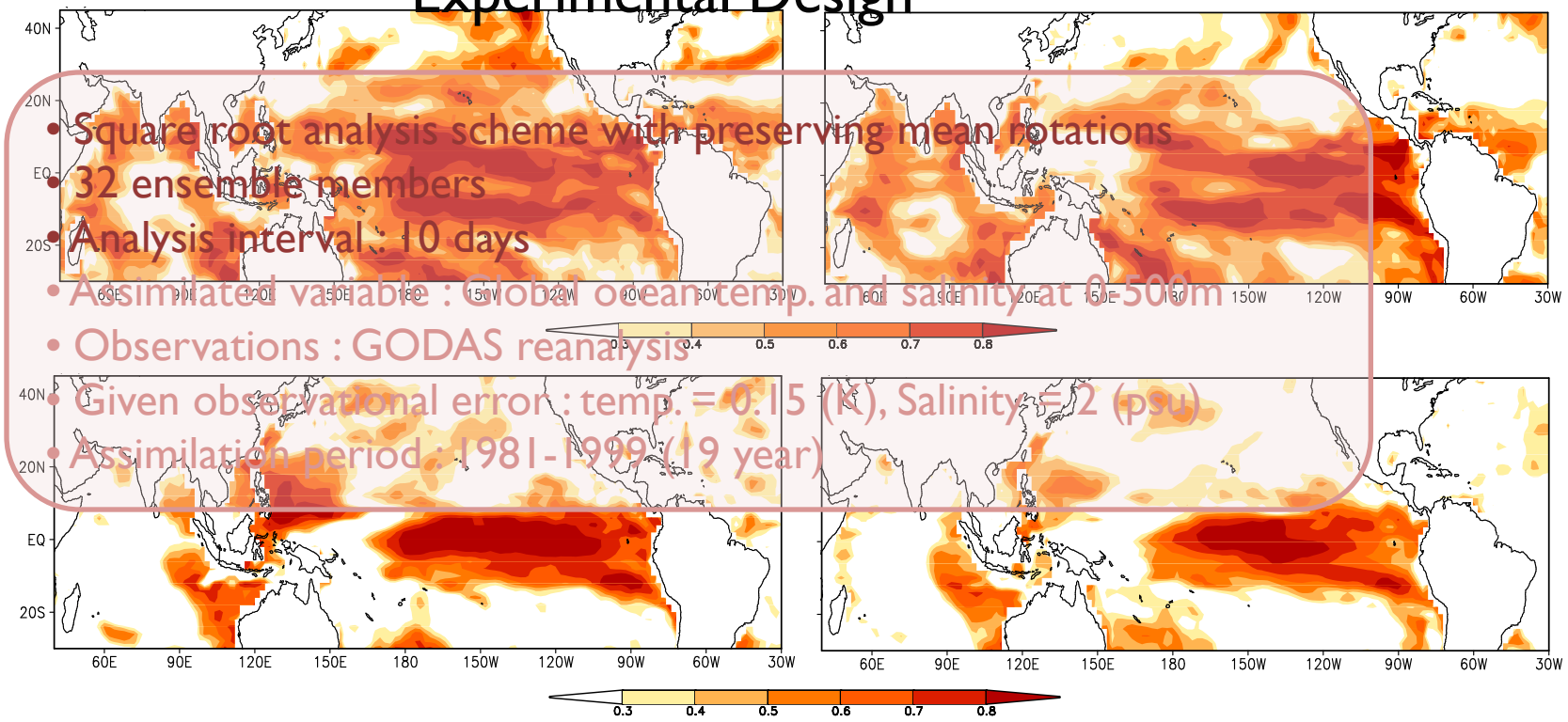
Nudging

Experimental Design

- Square root analysis scheme with preserving mean notations
- 32 ensemble members
- Analysis interval : 10 days
- Assimilated variable : Global ocean temp. and salinity at 0-500m
- Observations : GODAS reanalysis
- Given observational error : temp. = 0.15 (K), Salinity = 2 (psu)
- Assimilation period : 1981-1999 (19 year)

2-4 Lead month

5-7 Lead month



There is a positive impact, but need to be modified

Initialization methods for SNU Dynamical Prediction System

Ensemble Kalman Filter
(state-dependent : 3-dimensional approach)

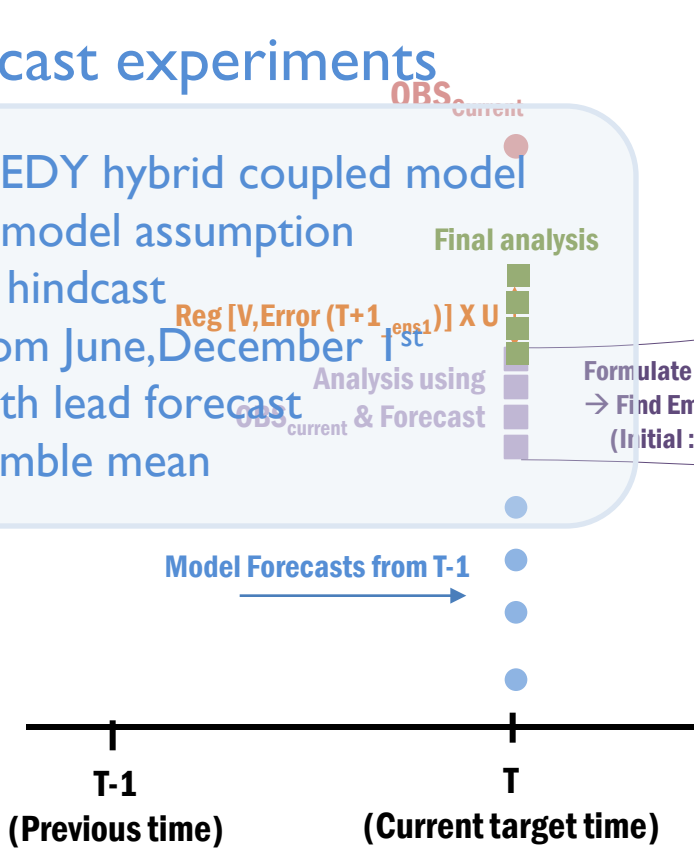
Time-dependent correction EnKF
(time-dependent : 4-dimensional approach)

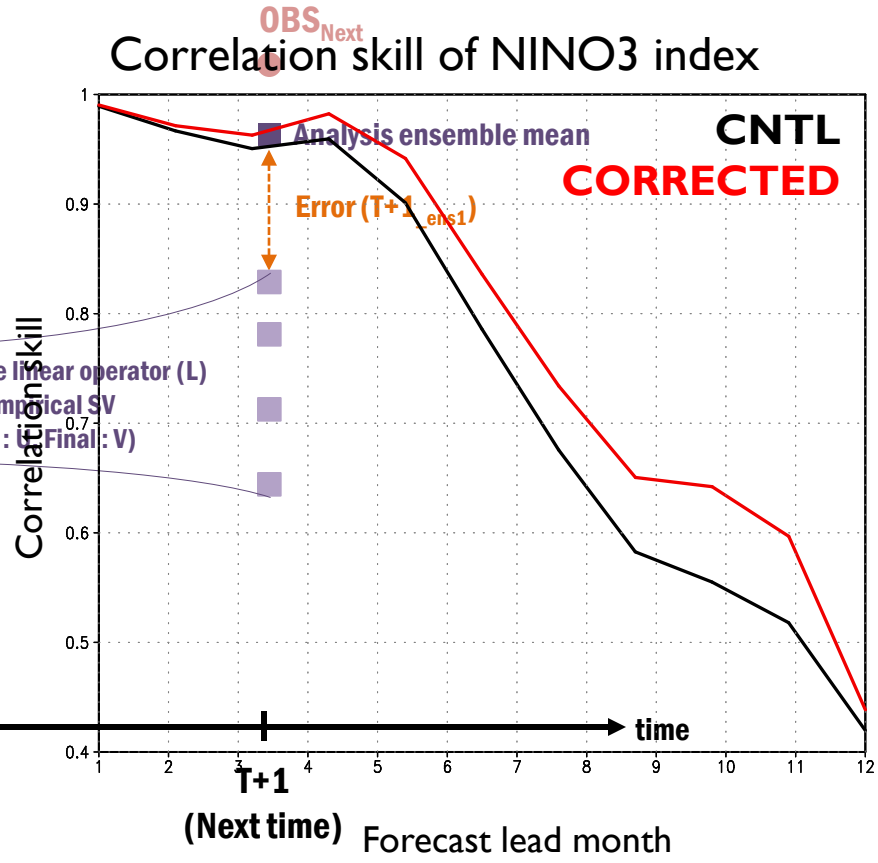
Time−dependent correction EnKF

Purpose of new scheme :
Correction to minimize forecast error at next time step

Forecast experiments

- CZ-SPEEDY hybrid coupled model
- Perfect model assumption
- 20 year hindcast
- Start from June,December 1st
- 12-month lead forecast
- 16 ensemble mean

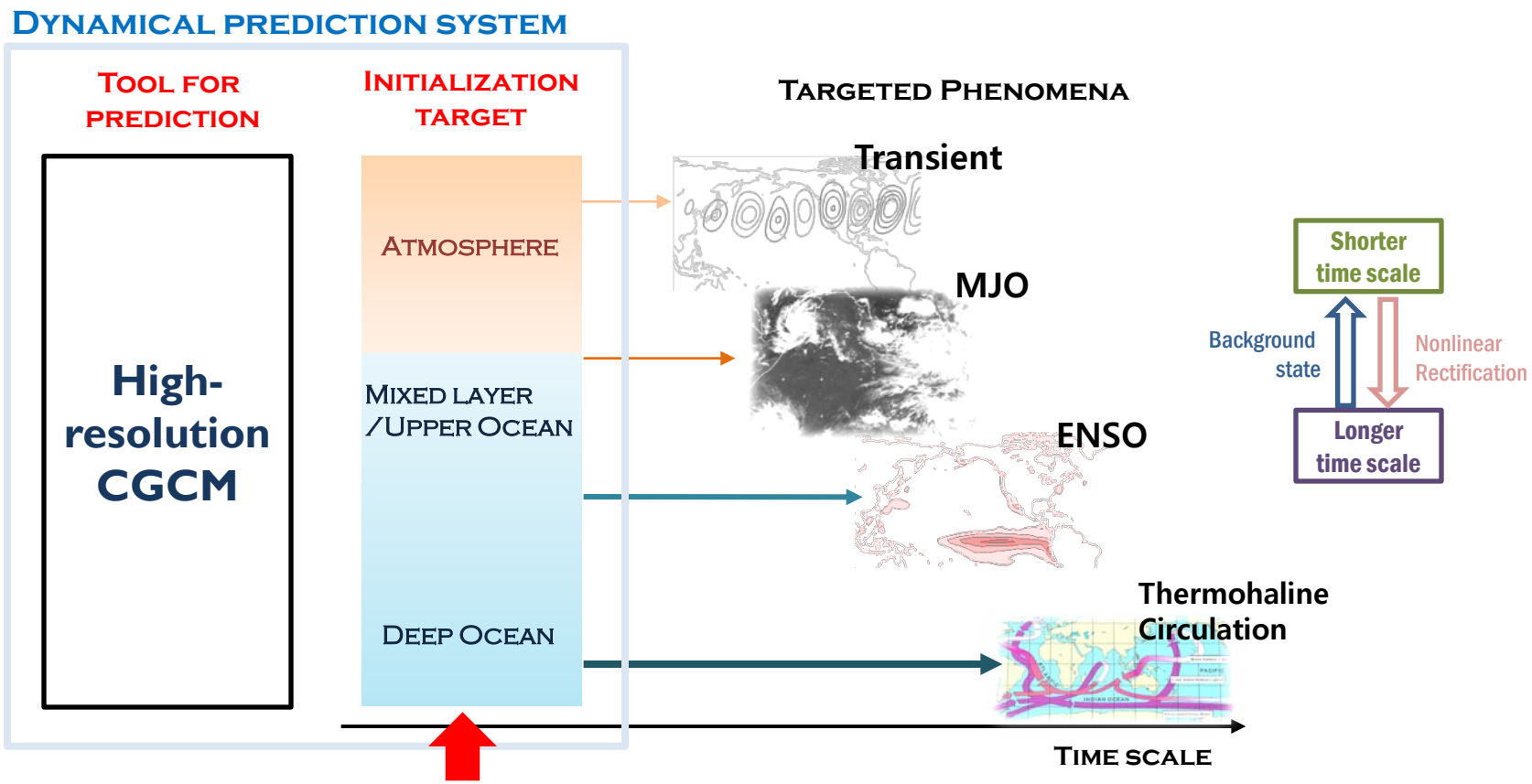




*During final OBS time, conventional EnKF is performed

Multi-scale prediction

- Toward seamless prediction



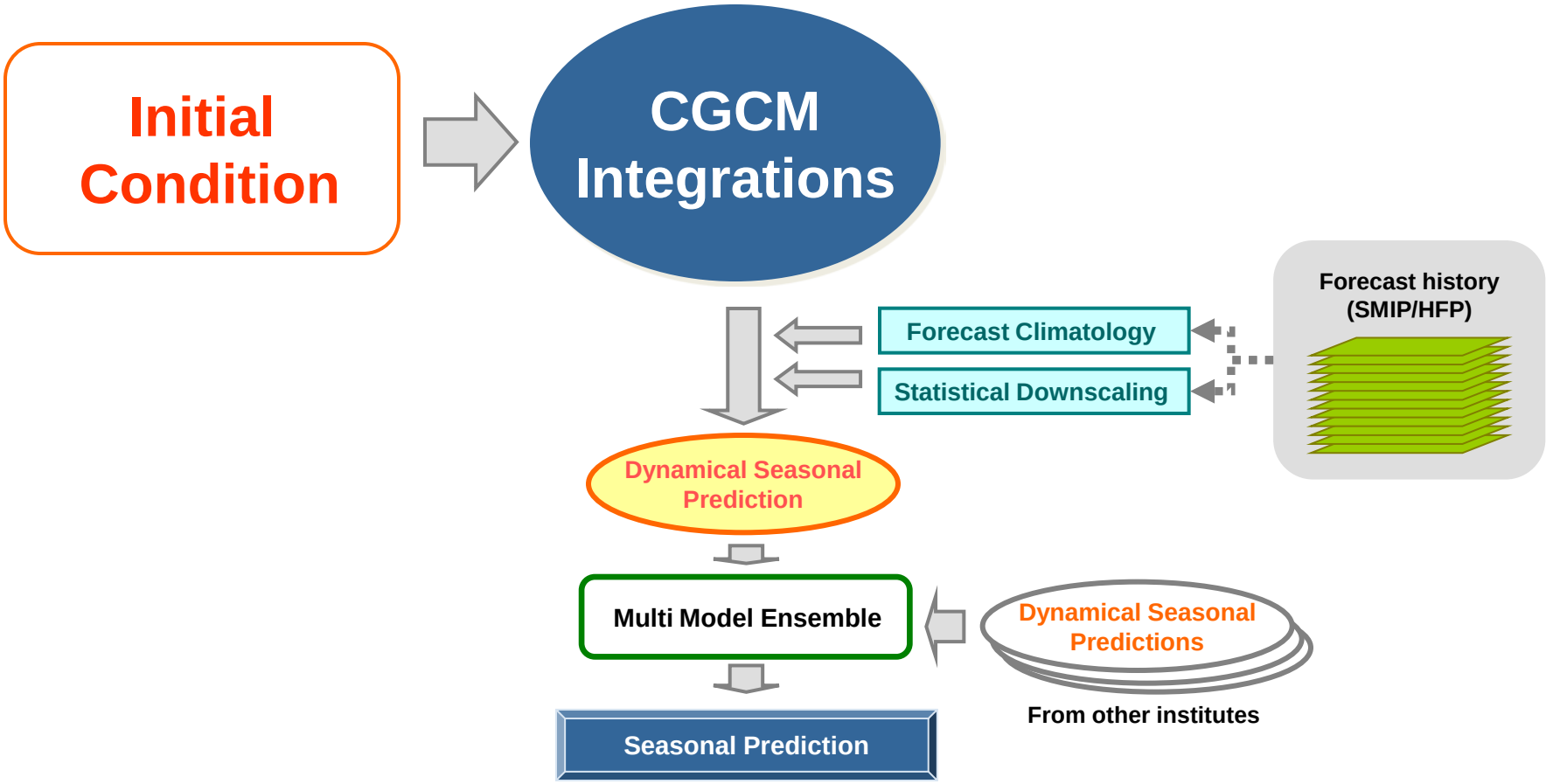
Memory/Tendency of various time-scale phenomena

Dynamical consistency between components in initial condition

e.g.) high-frequency/small-scale ↔ low-frequency/large-scale

Thank you!

Seasonal Prediction System

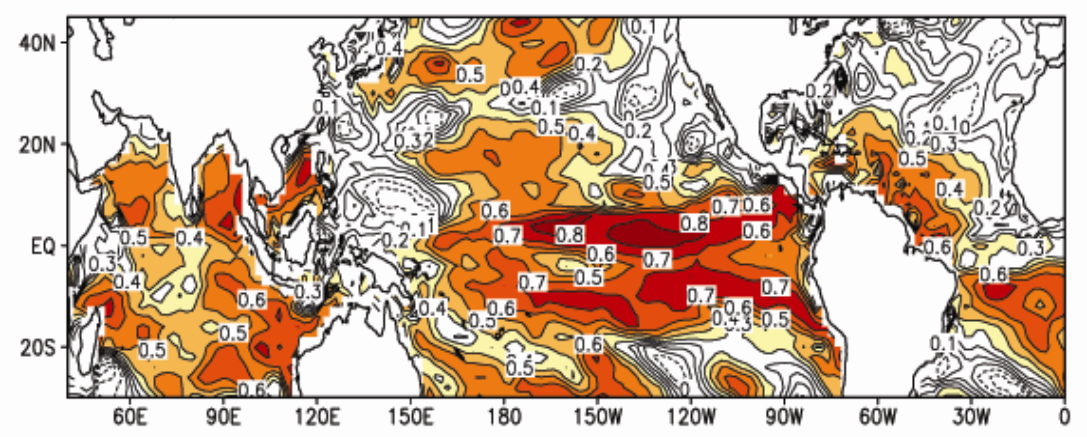


SNU Seasonal Prediction System

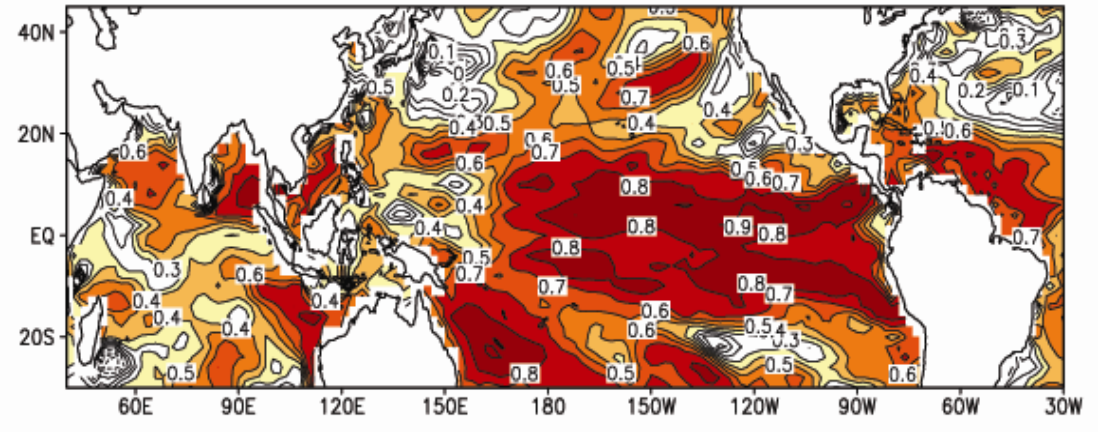
JJA SST correlation skill

Start from May 1st, 4 ensemble members

Old prediction system



New prediction system



Model Updates

CNTL + CMT + Diurnal coupling + Tokioka constraint + auto-conversion rate 3200s

Initialization Updates

SST + wind stress nudging with OGCM

⇩

3-dimensional temperature, salinity nudging