Overview

- **Variability** : “What” do we want predict
- **Predictability** : What is “to predict”
- **Methods** : “How” do we predict
- **Verification** : How to make a “good” prediction
- **Operation** : In reality?

Seasonal Prediction (0)
: Climate Variability

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APEC Climate Center

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Tell us your “weather” during a season

1. What happens?
2. Irregularity?

3. What weather type do you like?

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Tell us your “Climate”

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What climate phenomena are you familiar with?

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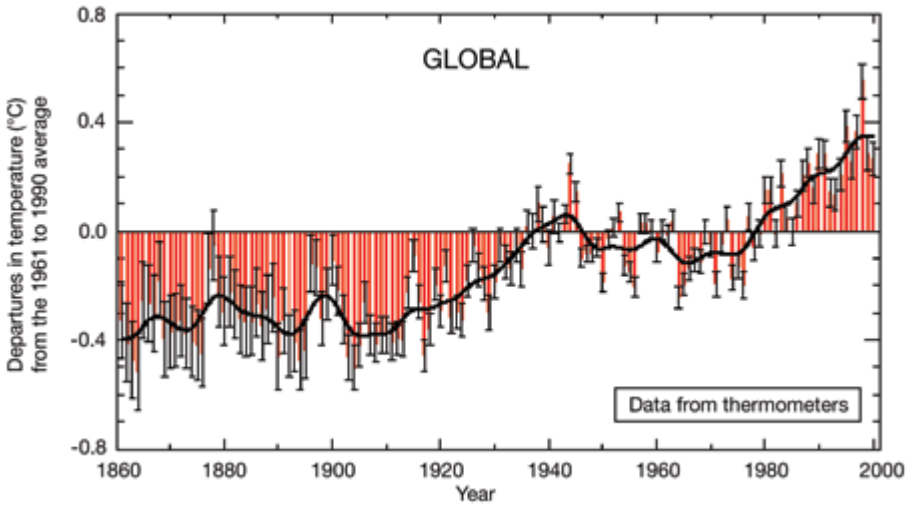
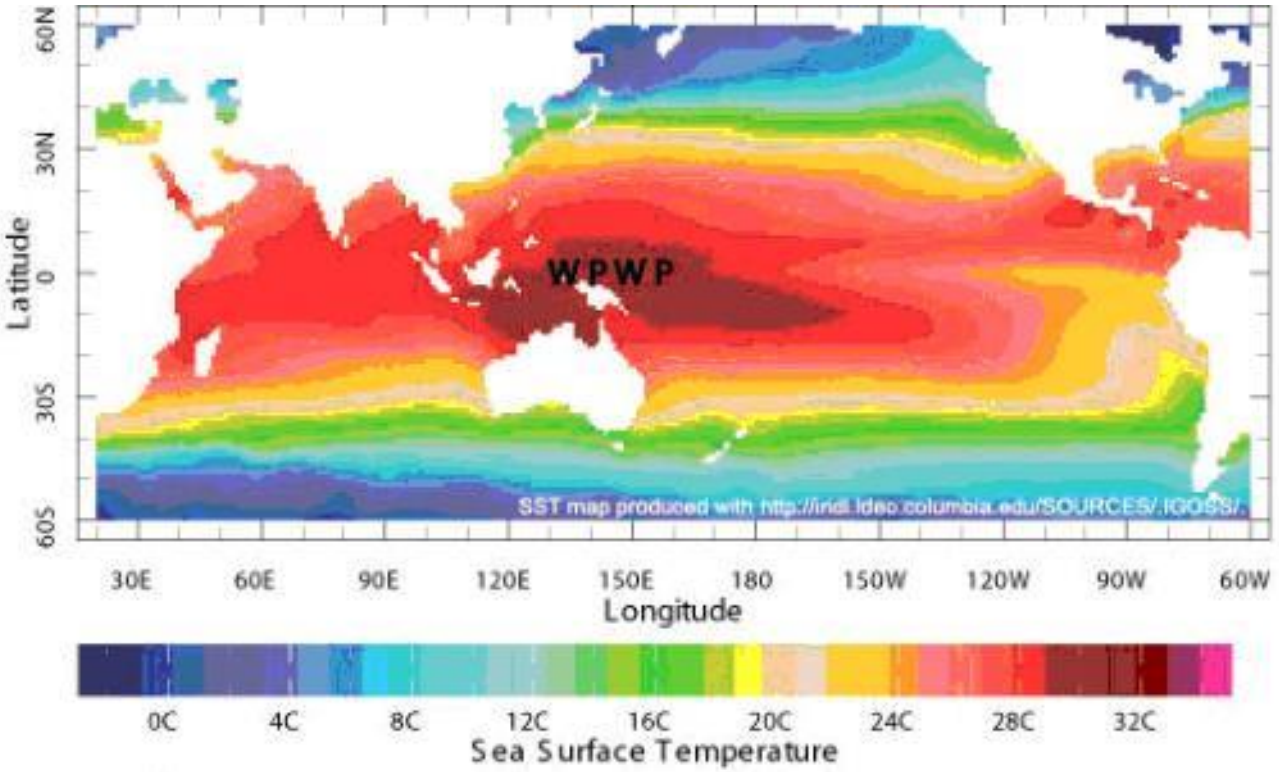
Climate Change

- Changes in our expectation



Warm pool

- Climate Engine : remember “mean” feature



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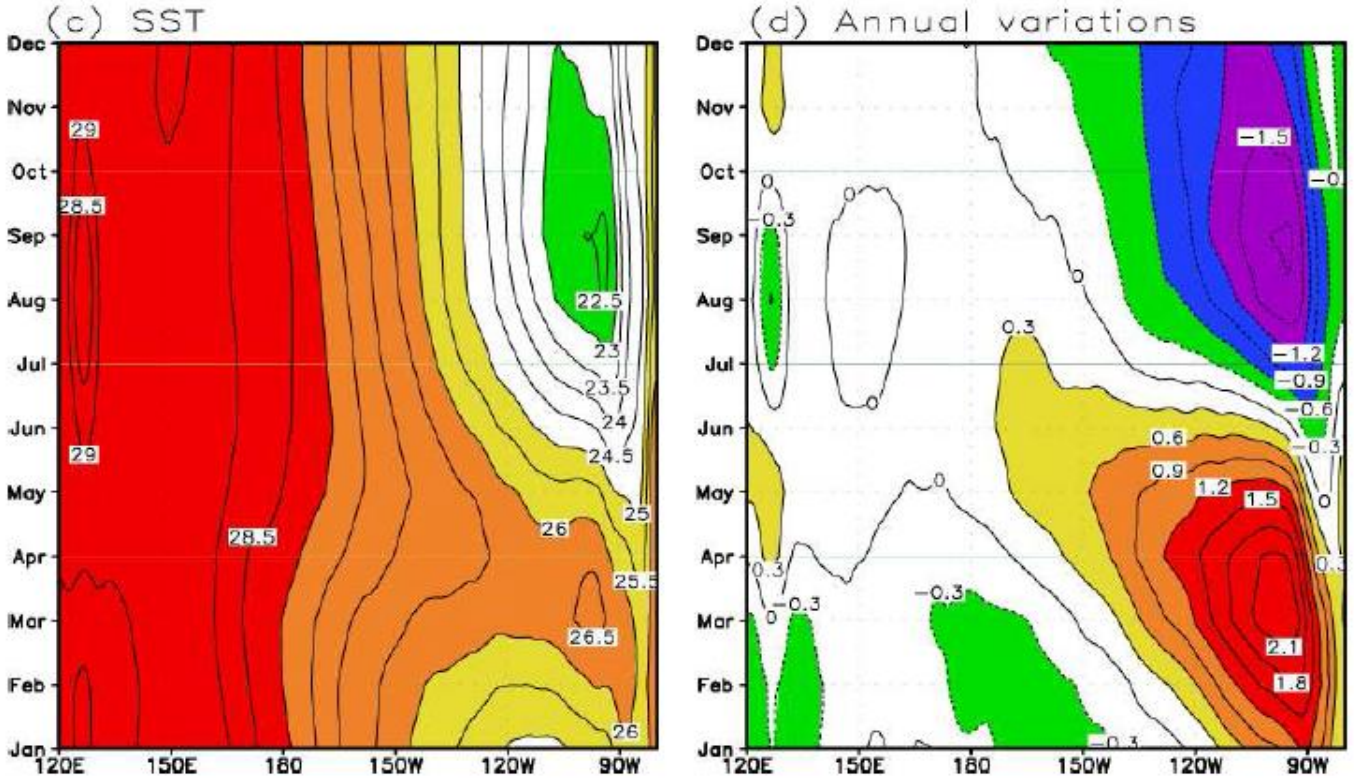
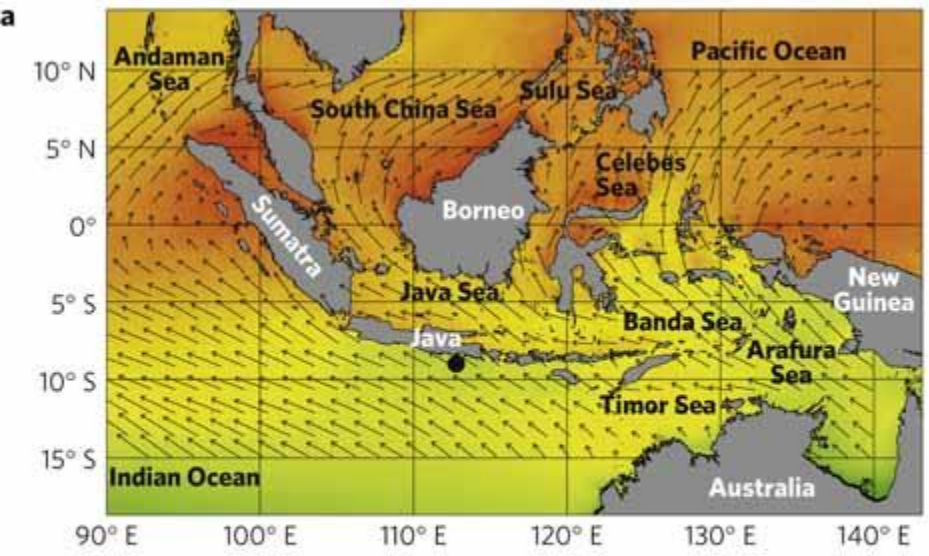
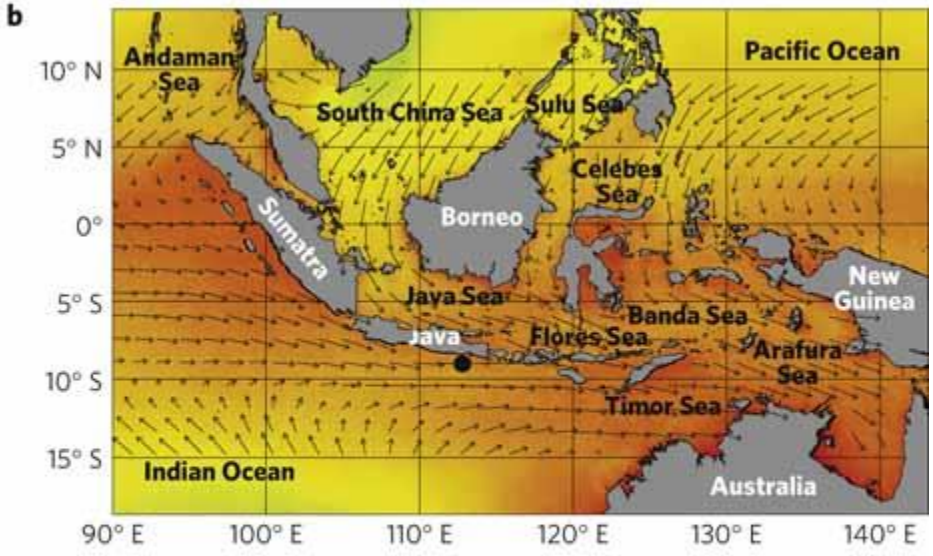
Seasonal cycle

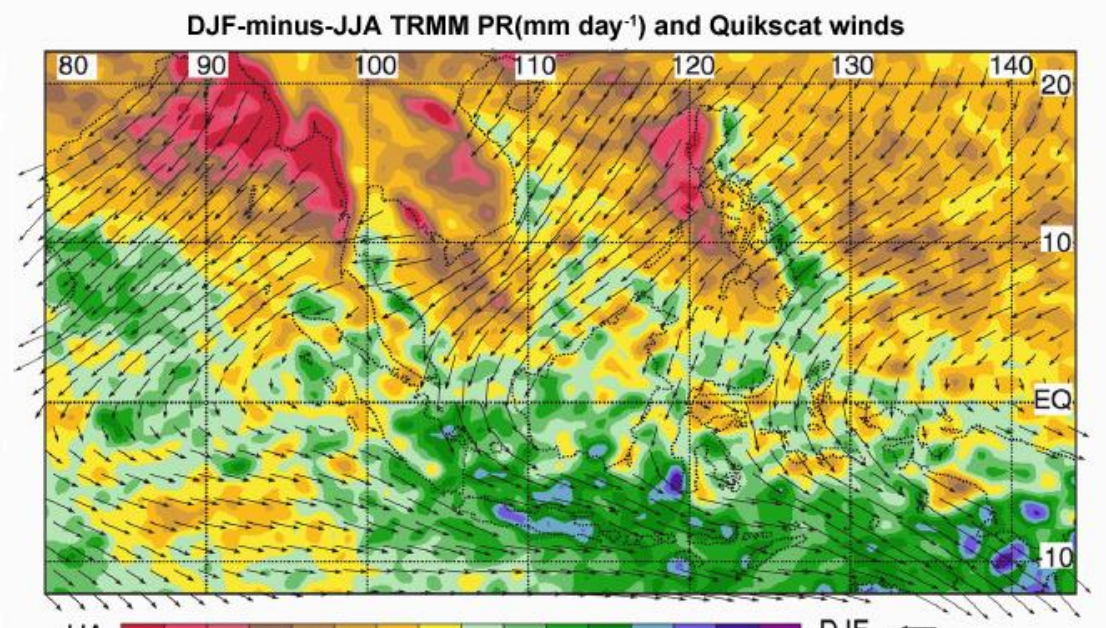


Monsoon



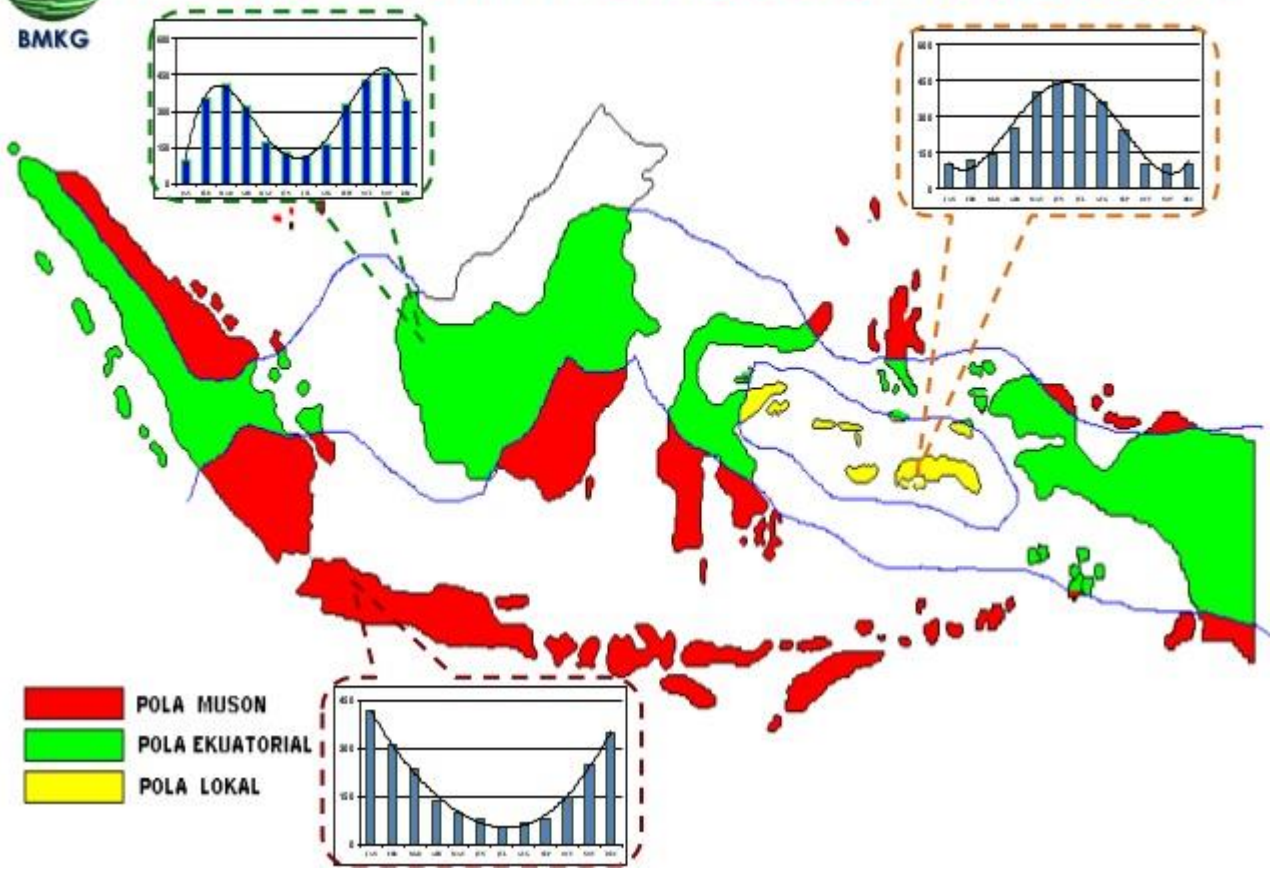


Mohtadi et al. (2011)



POLA UMUM TYPE HUJAN DI INDONESIA

BMKG



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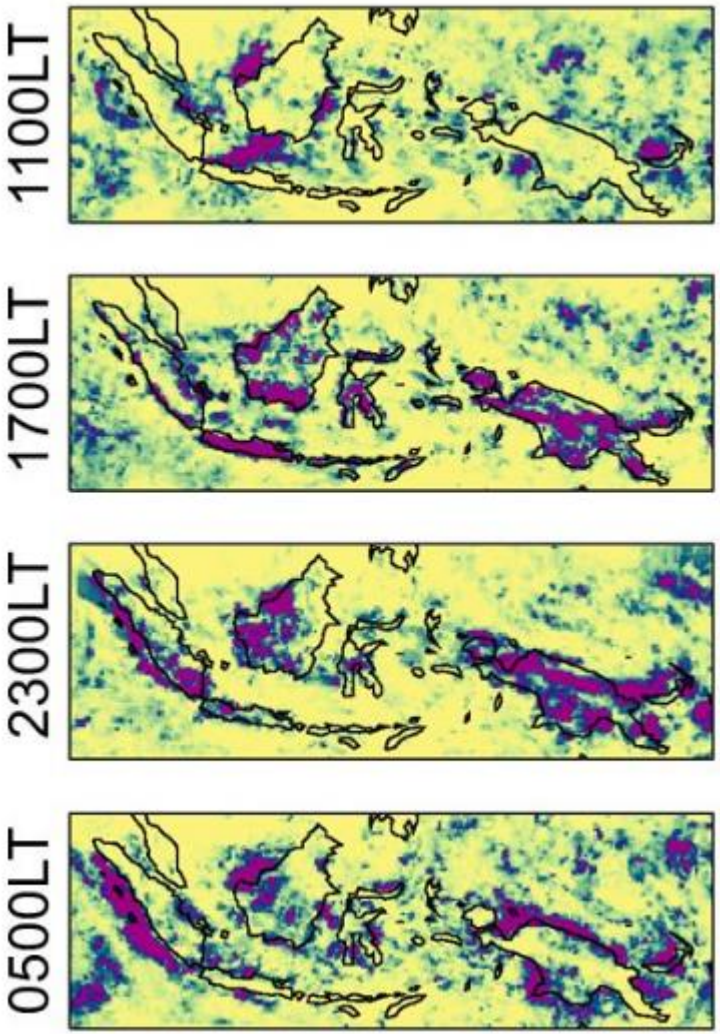
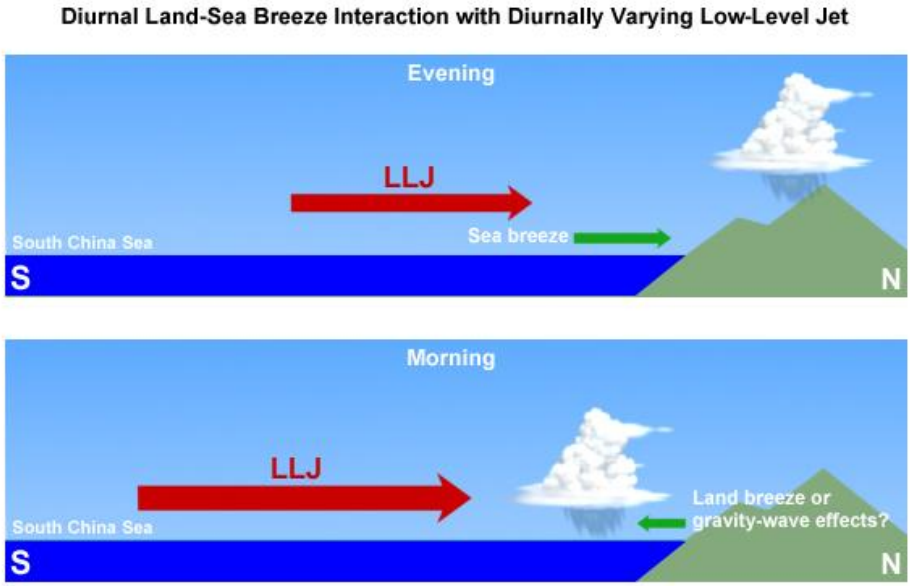
Diurnal cycle



From Jane Strachan

Land-sea breeze

Mountain-Valley circulation



From R. Johnson

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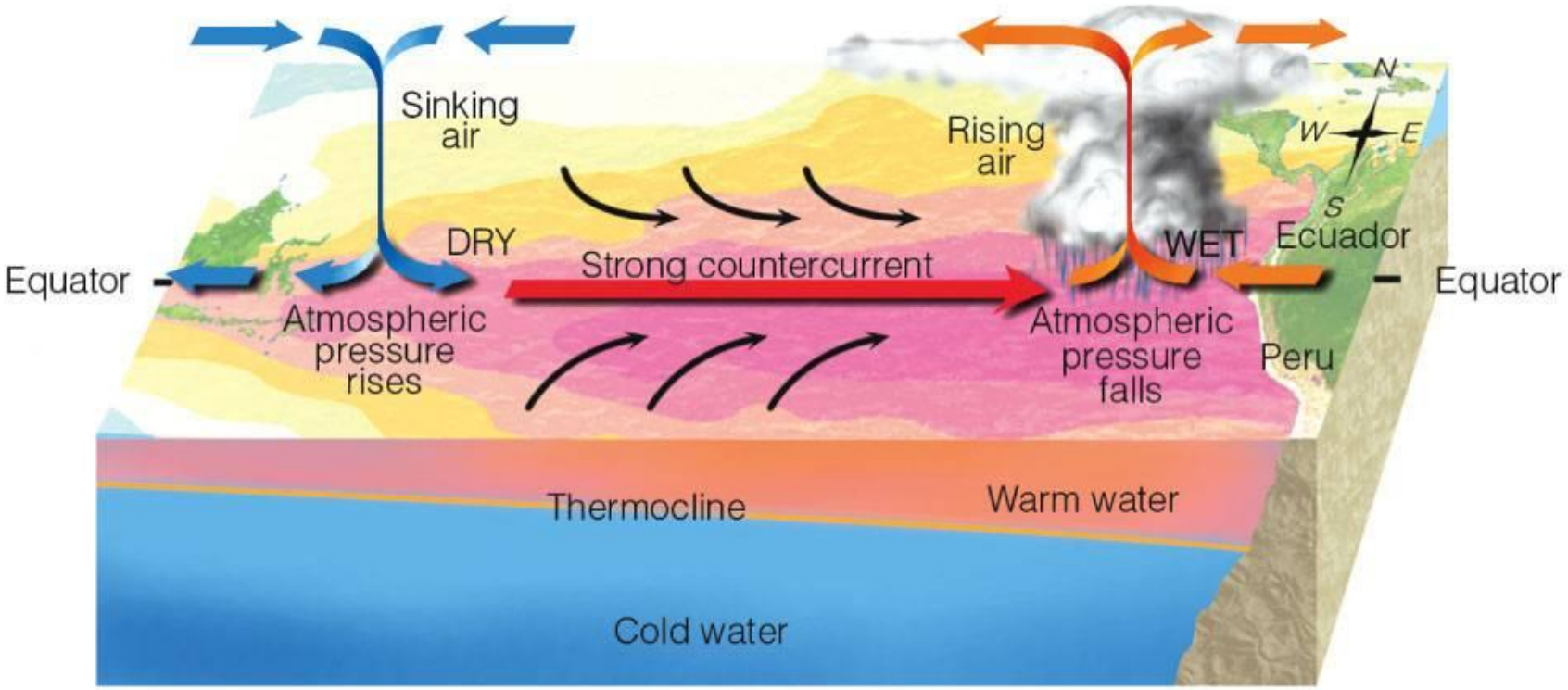
El Nino, ENSO

- A Big Ocean Swing



(b) El Niño Conditions

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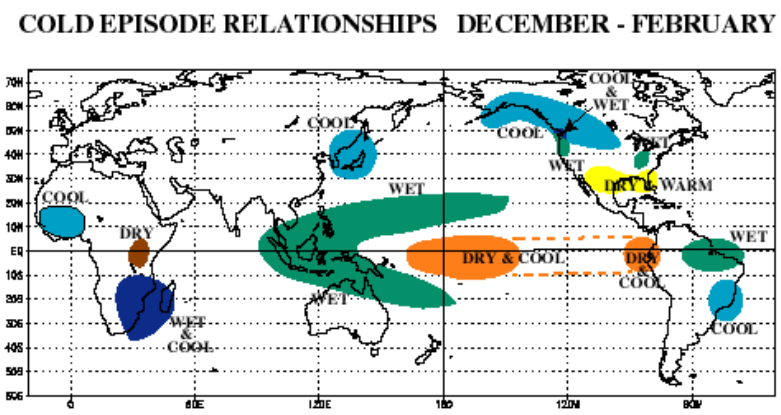
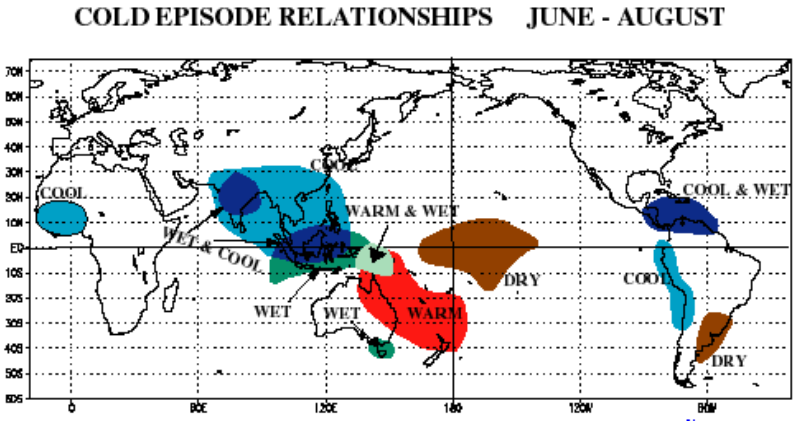
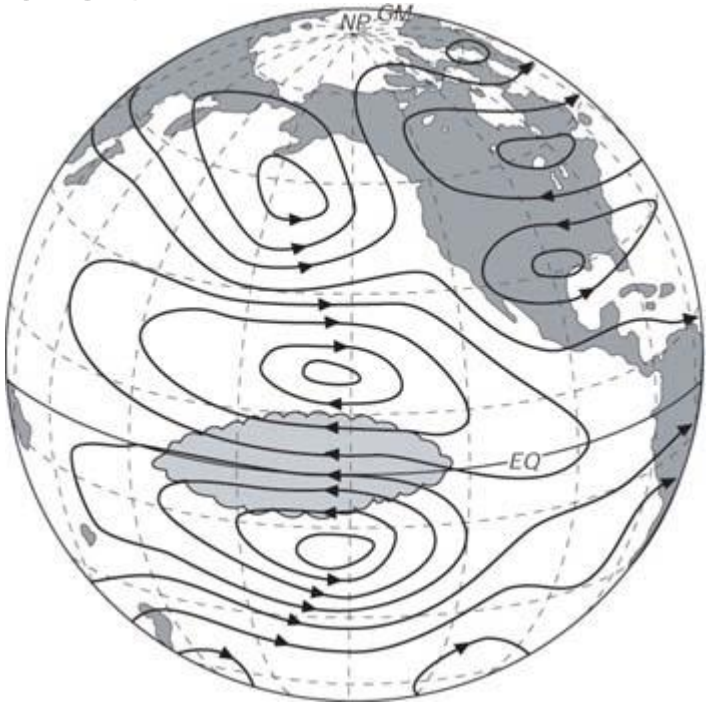
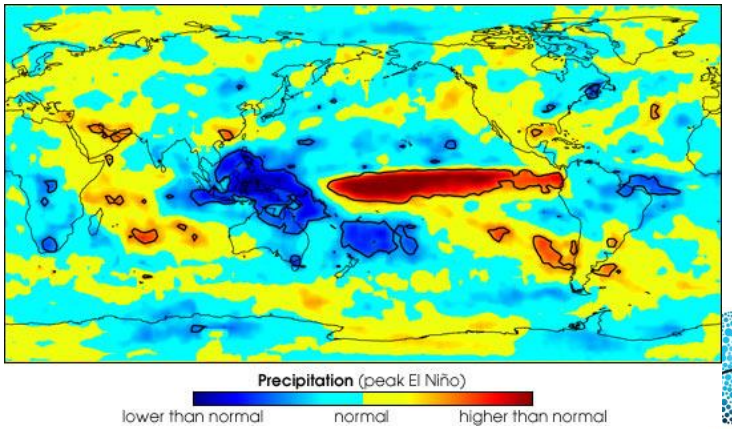
ENSO impact









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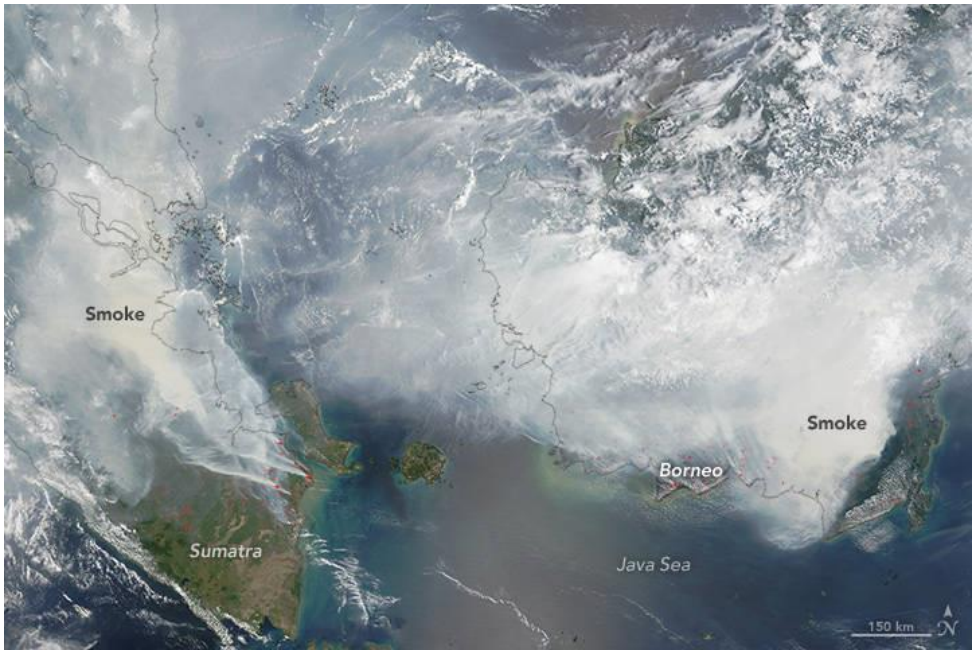
What happened during this El Nino?



INDONESIA[11]

six to eight weeks

delay in seasonal rains

TIMOR-LESTE[3]

up to 50%

of Timor-Leste could be food and water insecure by the second quarter of 2016

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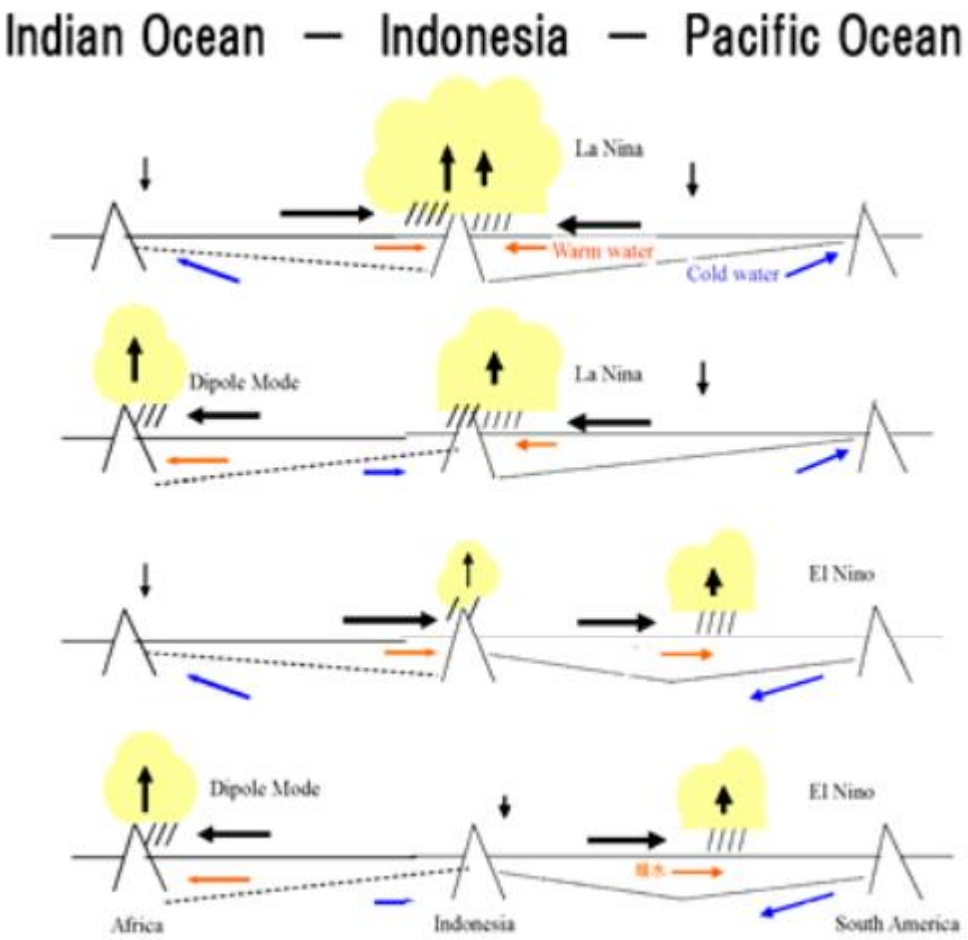
Don’t forget Indian Ocean



Two modes

1. IO Dipole (SO)
2. IO Basin mode (AM)

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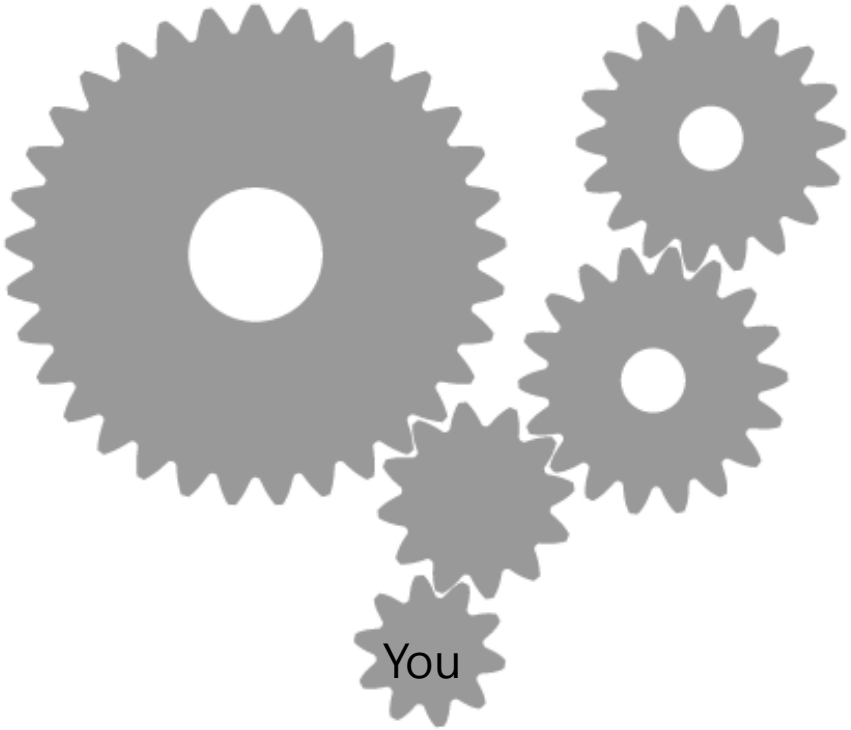
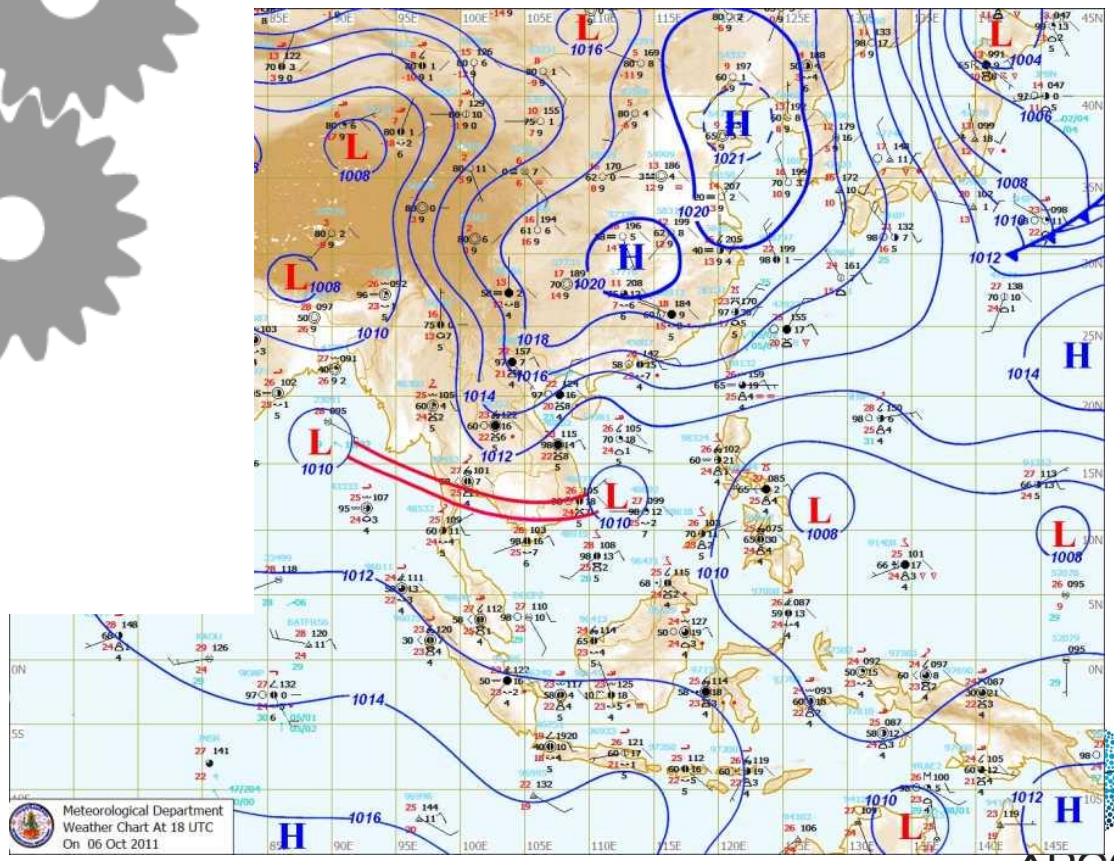
How they change weather?





Maritime continent

- World Climate Engine : The most influential region in the world
- VERY COMPLEX (Geography, Phenomena, Scale Interactions)
- Not well understood and therefore not well modelled

- HOW TO PREDICT?

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Seasonal Prediction (1)
: Introduction/Predictability

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Overview

- Predictability
- Methods
- Verification + Downscaling
- Operation

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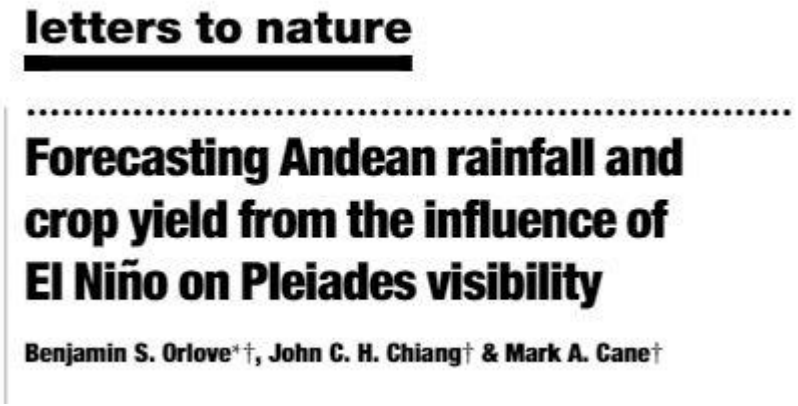
Seasonal prediction

- **Target : seasonal weather statistics with a few months lead time**
  - **Mostly, seasonal or monthly mean Temp. or Prec.**

- **Why we do this? : for planning (serious)**



letters to nature

Forecasting Andean rainfall and crop yield from the influence of El Niño on Pleiades visibility

Benjamin S. Orlove*†, John C. H. Chiang† & Mark A. Cane†

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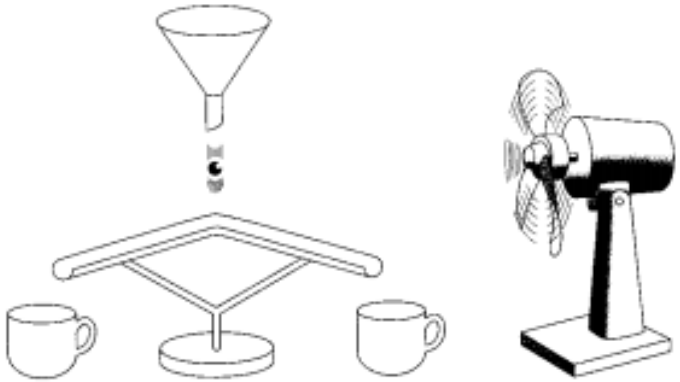
History of Short-term (Seasonal) Climate Prediction

- 1960's : Hypothesis proposed
- 1980's : ENSO prediction + Atm. LFV. (PNA..)
- 1990's : (Experimental) Dyn. Seasonal Fcst.
- 2000's : International collaboration (MIPs)
- 2010's : Operation (GFCS, RCOFs/WMO)



T. Palmer (1998)

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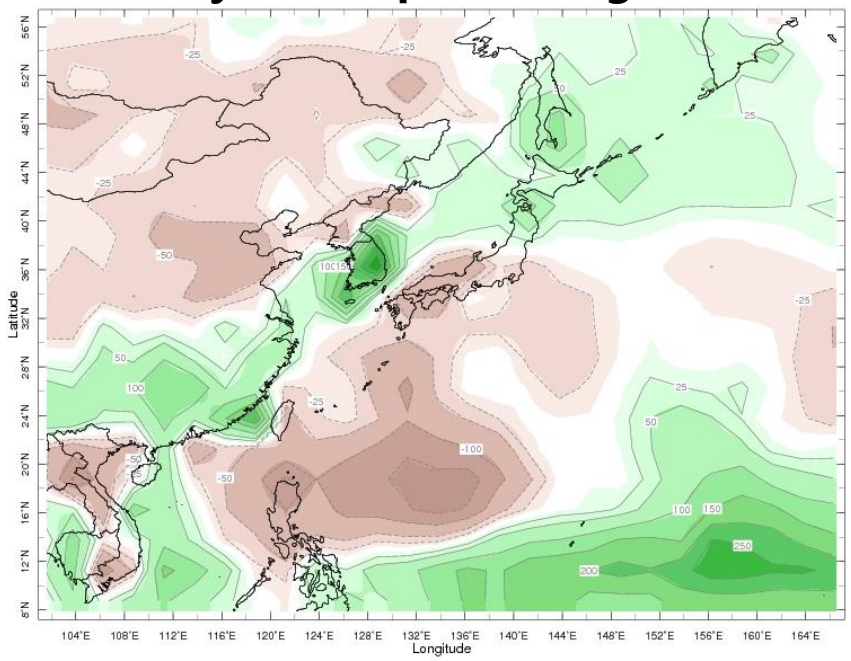
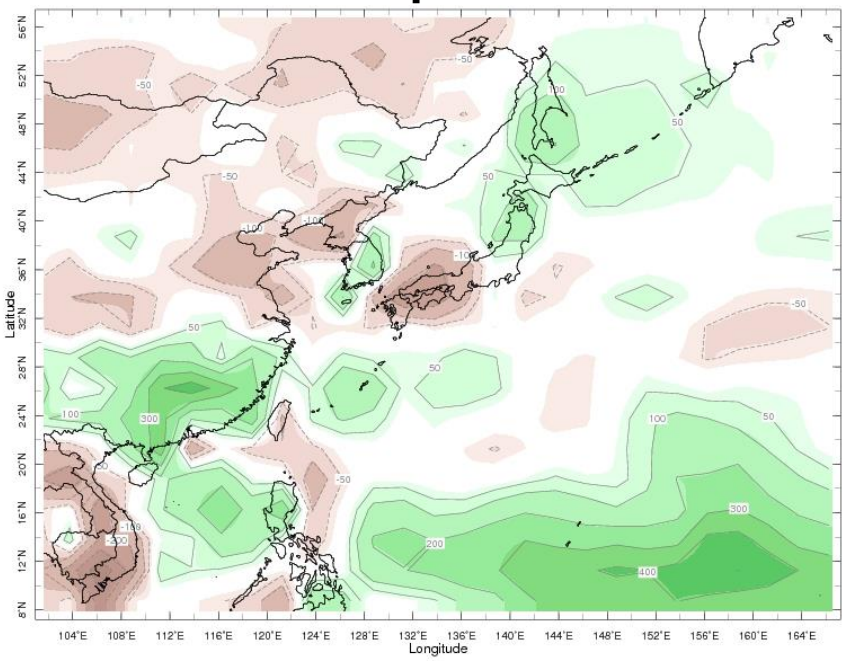
2002 summer rainfall

Monthly mean prec. (Aug)



Aug 2002

Summer mean prec.



Jun-Aug 2002

Typhoon “RUSA” passed at 8/31 (1000mm a day)

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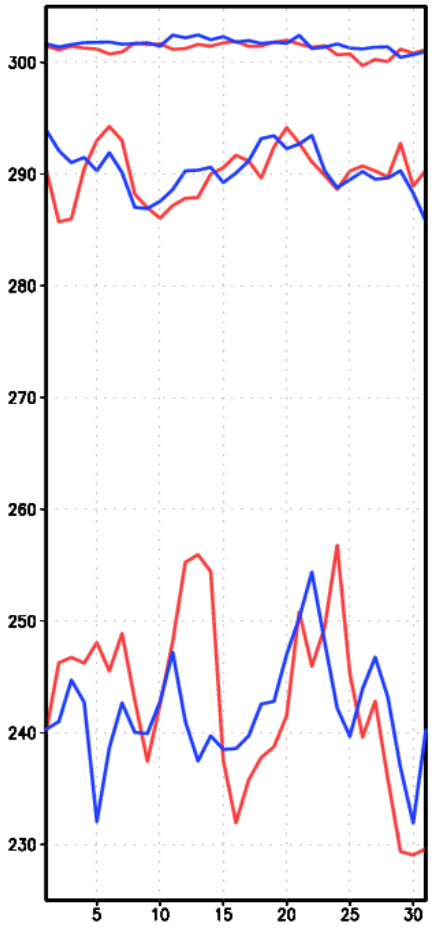
Begin with Questions

How is the seasonal mean determined?



What causes change (variability) of the mean?

- **By chance?**

- **By "something"?**

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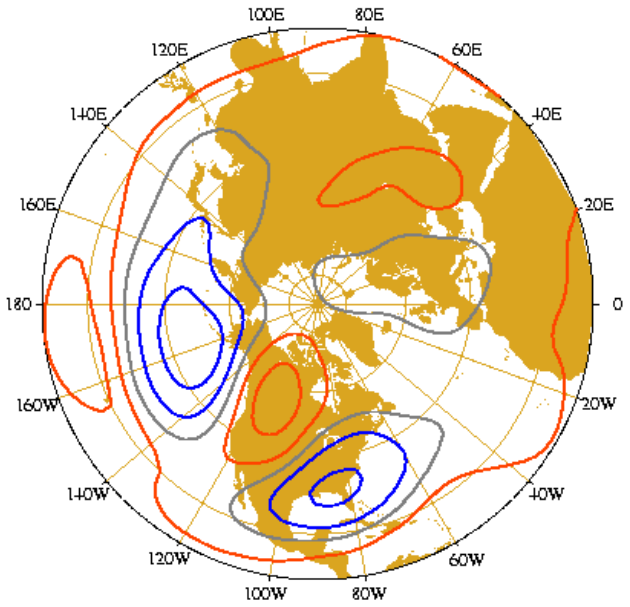
PNA debates



1. Forced by El Nino

2. Atmospheric internal variability (random)

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Two scales

- Fast and small scale processes
  - Weather, Tropical cyclone
- Slow and large processes
  - Climate, ITCZ, ENSO

- Slow process consist of Fast processes but if it has its own slow dynamics, it can control Fast processes

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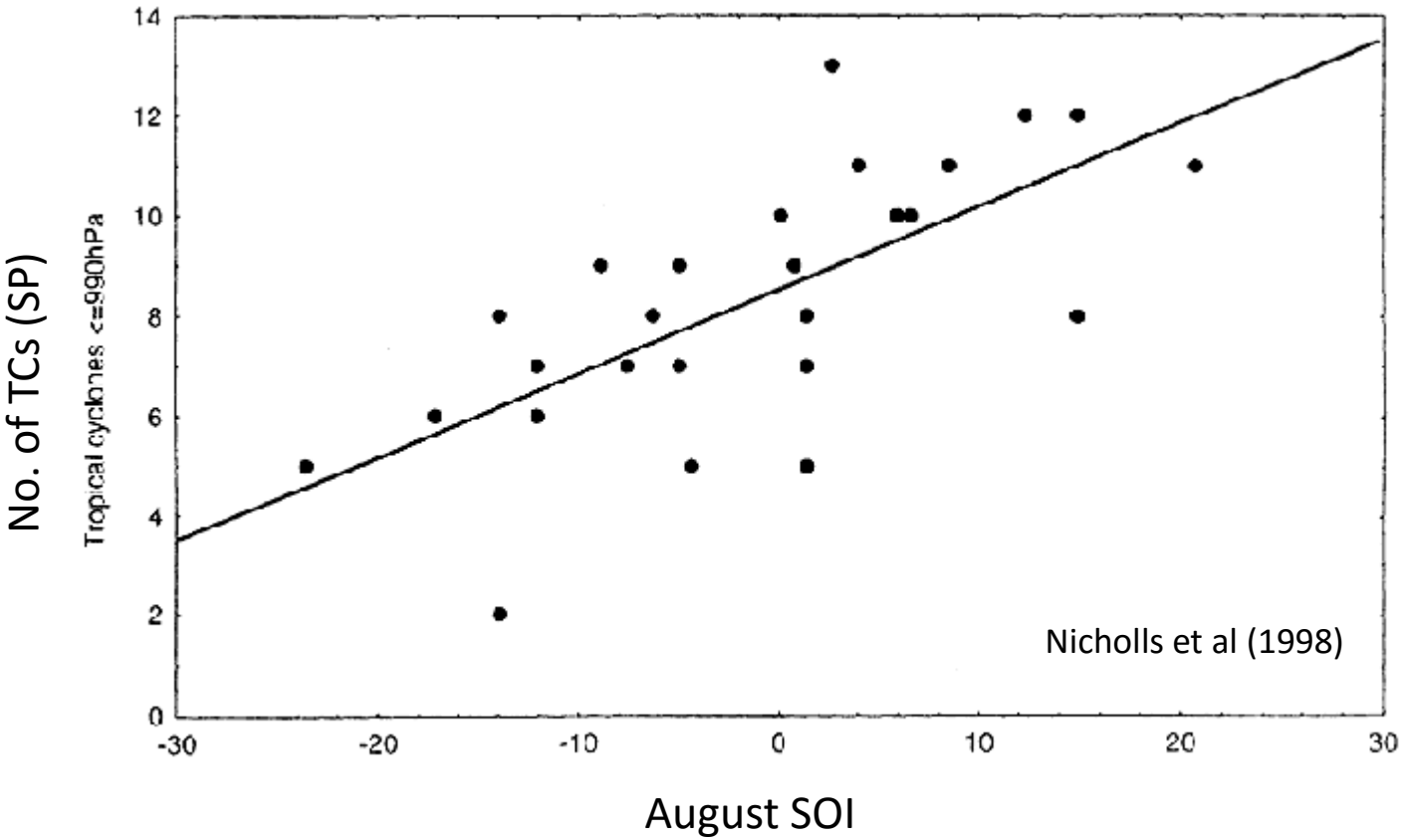
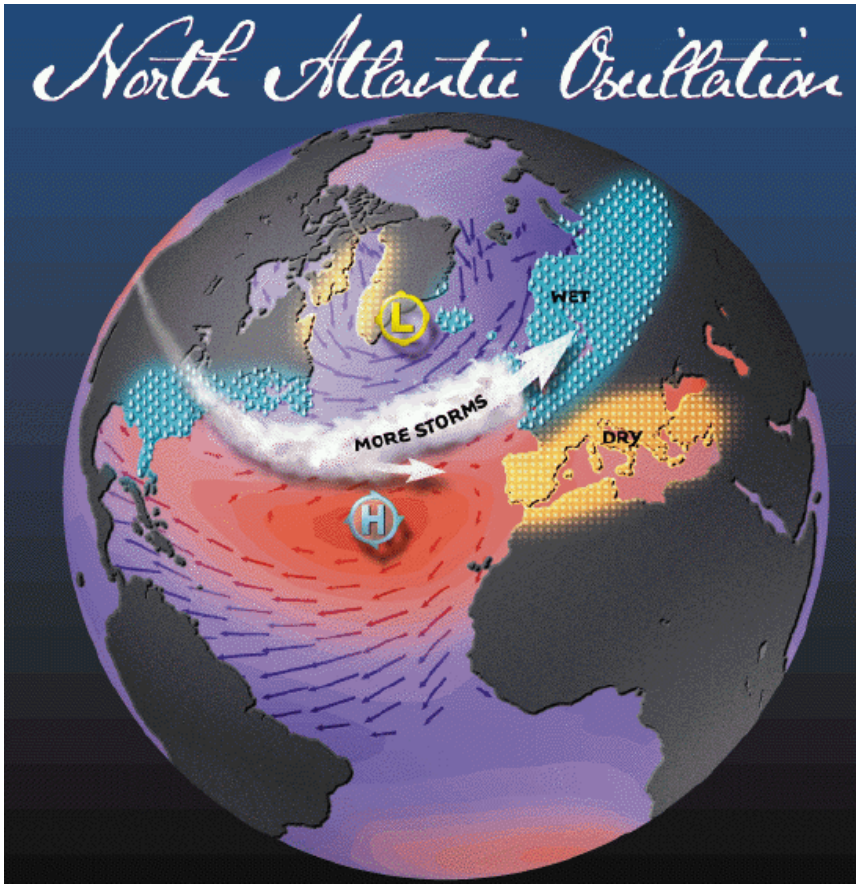
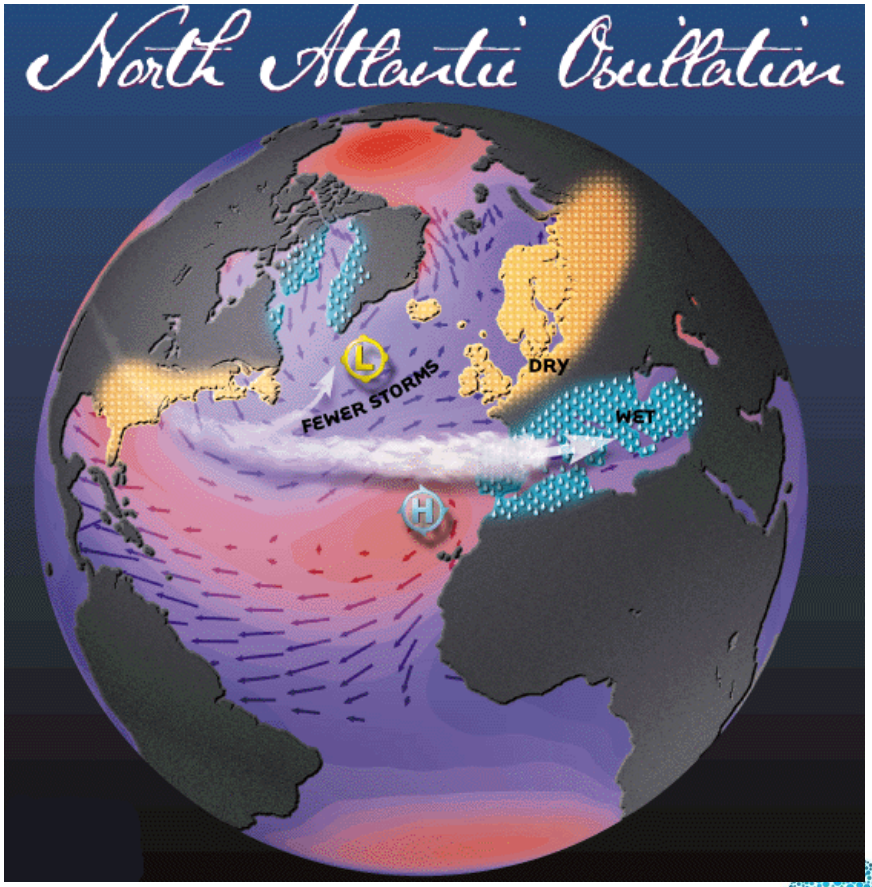
Two scales


No. of TCs (SP)
Tropical cyclones <=990hPa
14
12
10
8
6
4
2
0
-30
-20
-10
0
10
20
30
August SOI
Nicholls et al (1998)

NAO(north Atlantic oscillation)

NAO changes passage of storms (weather system)





http://www.ldeo.columbia.edu/res/pi/NAO/

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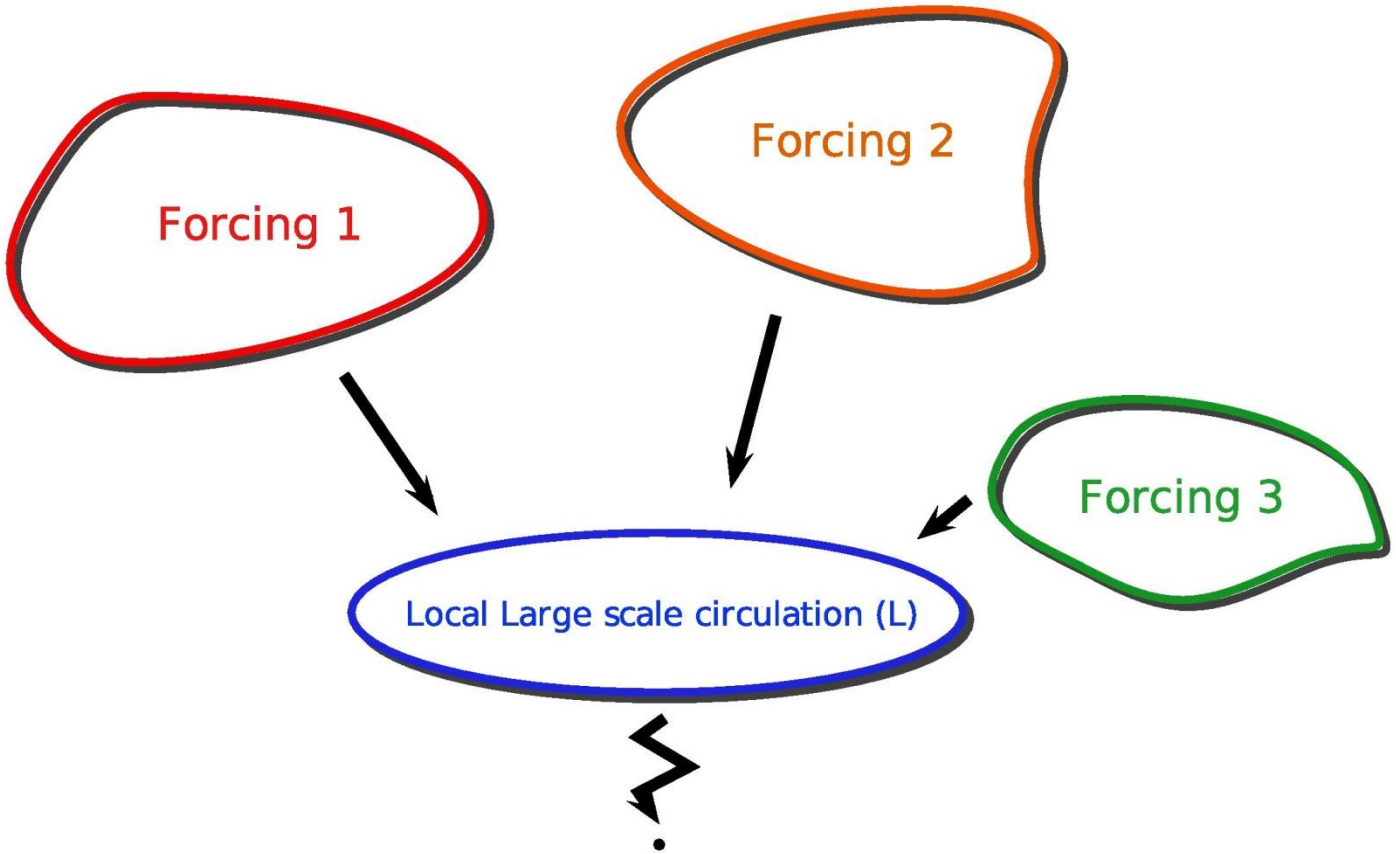
Local large scale circulation



Local weather statistics (Korean summer rainfall)

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Local large scale circulation

- Local climate (i.e. seasonal mean) is defined by how weather behaved during a season (statistics)
- Therefore, understanding weather behavior is the first step of seasonal forecast (often ignored..)
- In many cases, local large scale pattern that directly affect local weather is visible in seasonal time scale
  - Question is whether we can predict that large scale pattern directly or via teleconnection

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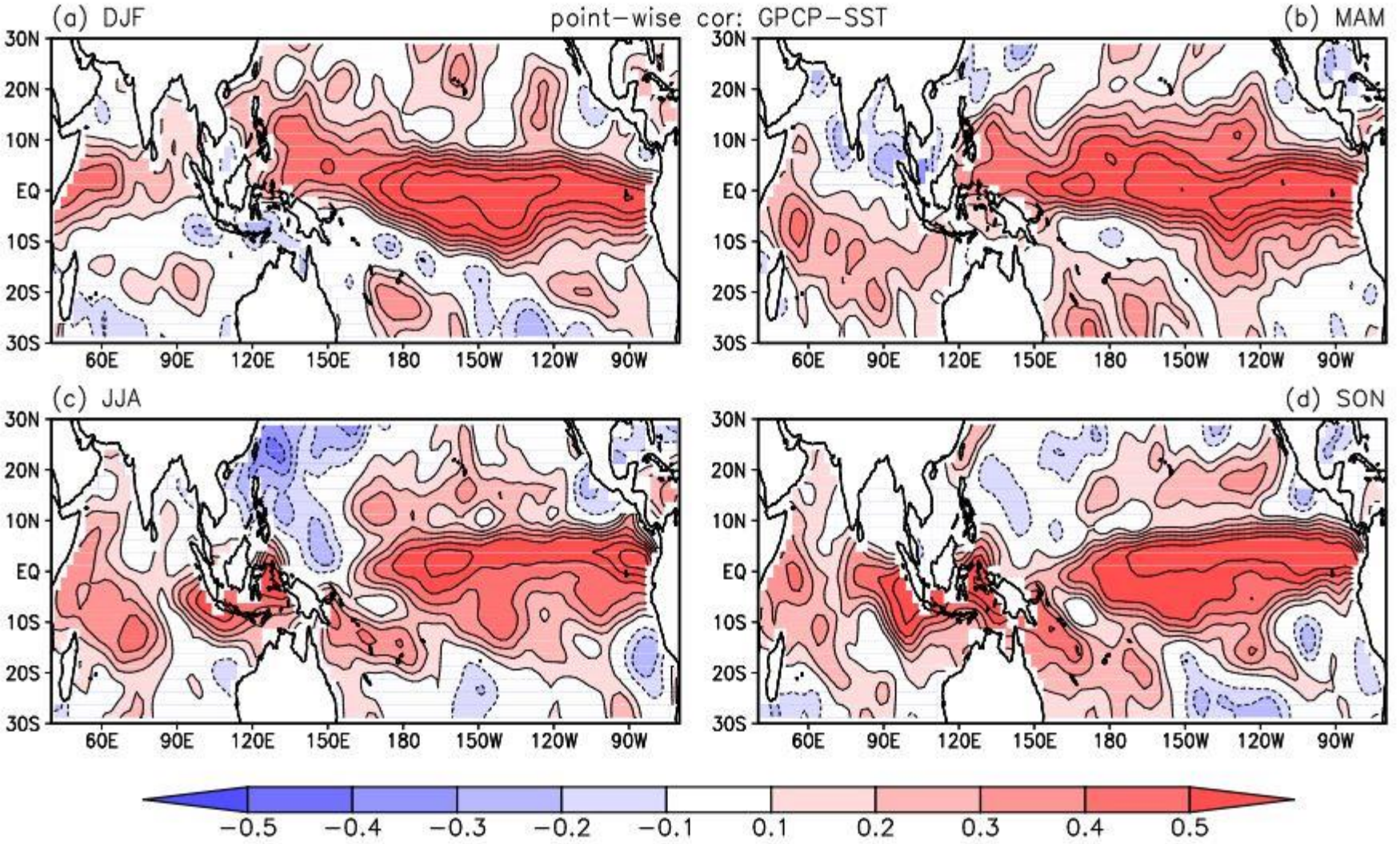
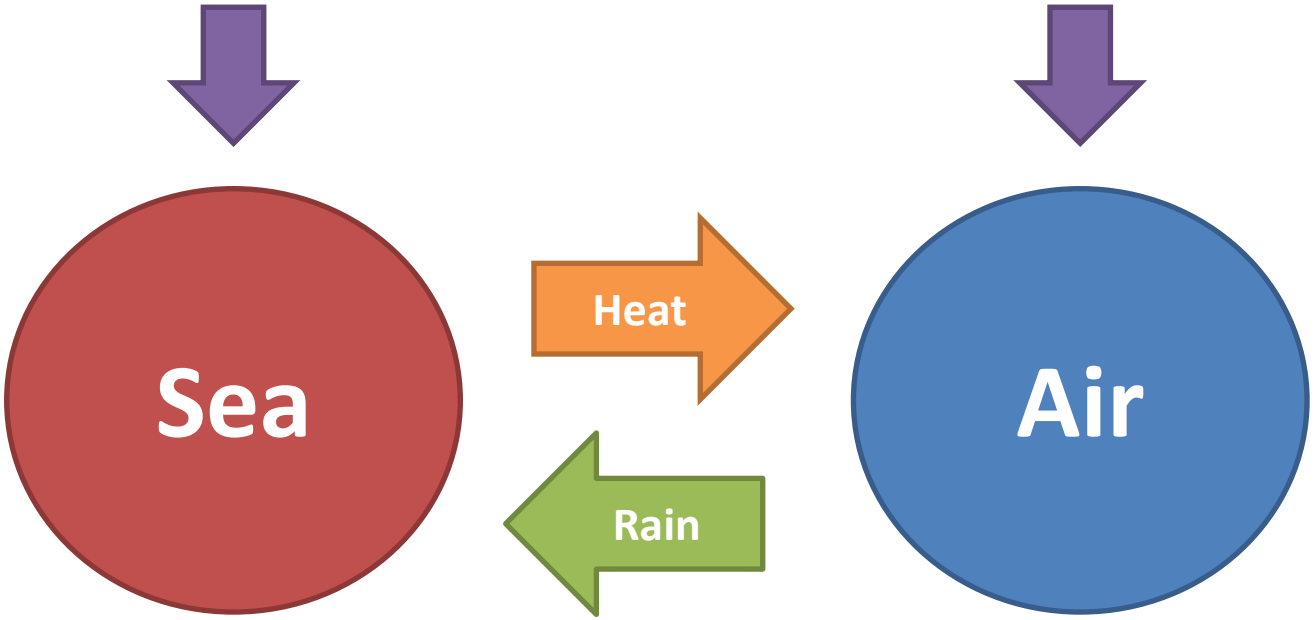
Do not miss : air-sea interaction



Feedbacks



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LARGE SCALE PATTERN ASSOCIATED WITH RAINFALL

Local large circulation and Teleconnection

One Point Correlation map with seasonal mean local rainfall(APRODITE or CRU data) with other variables

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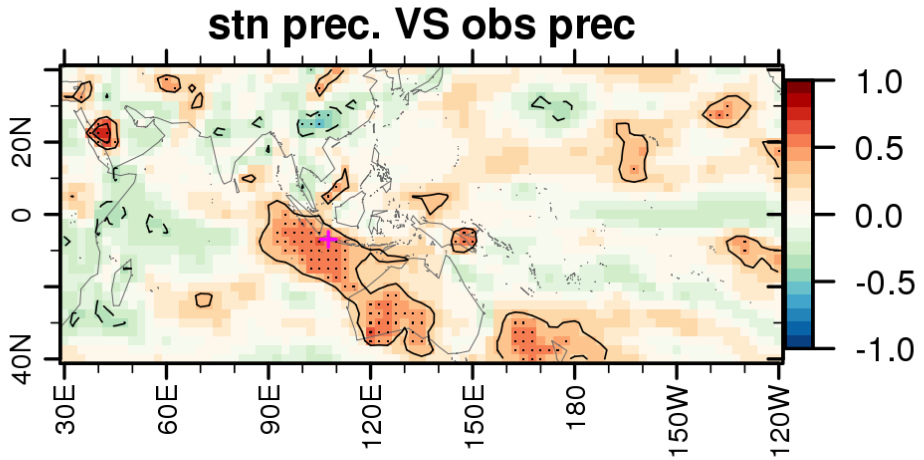

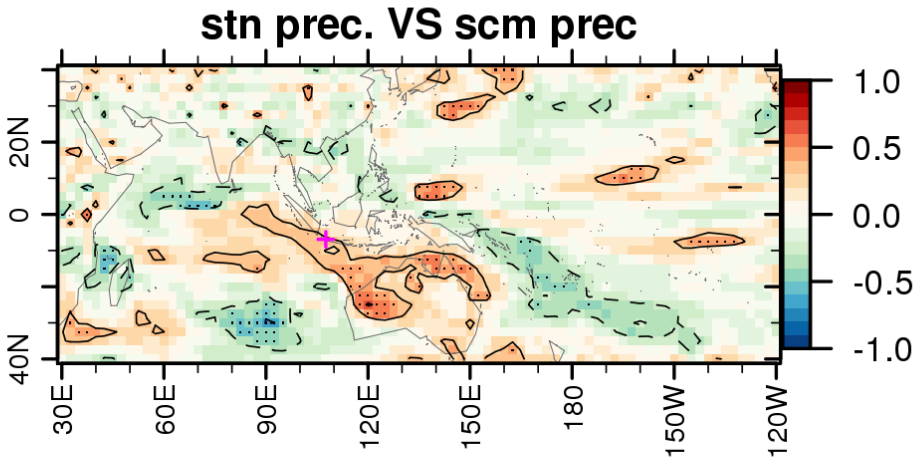

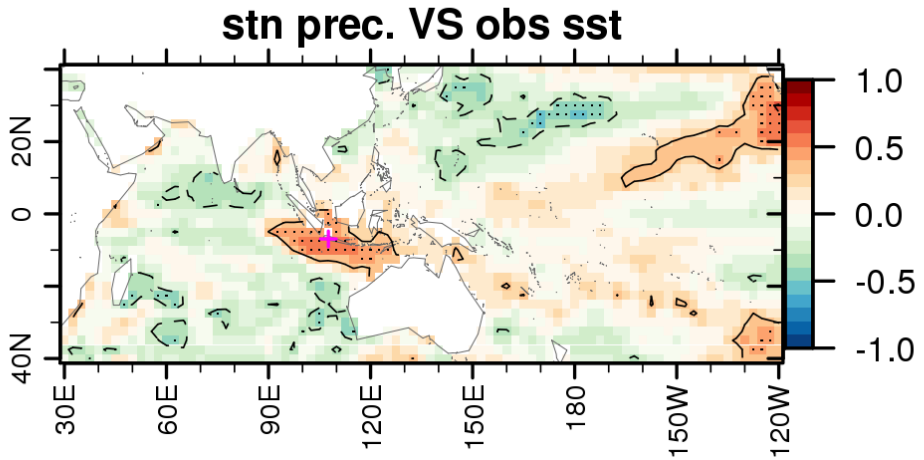

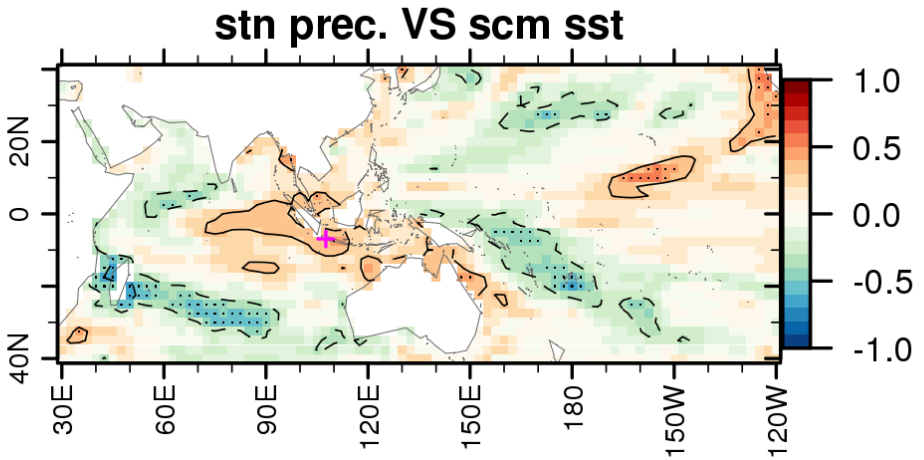

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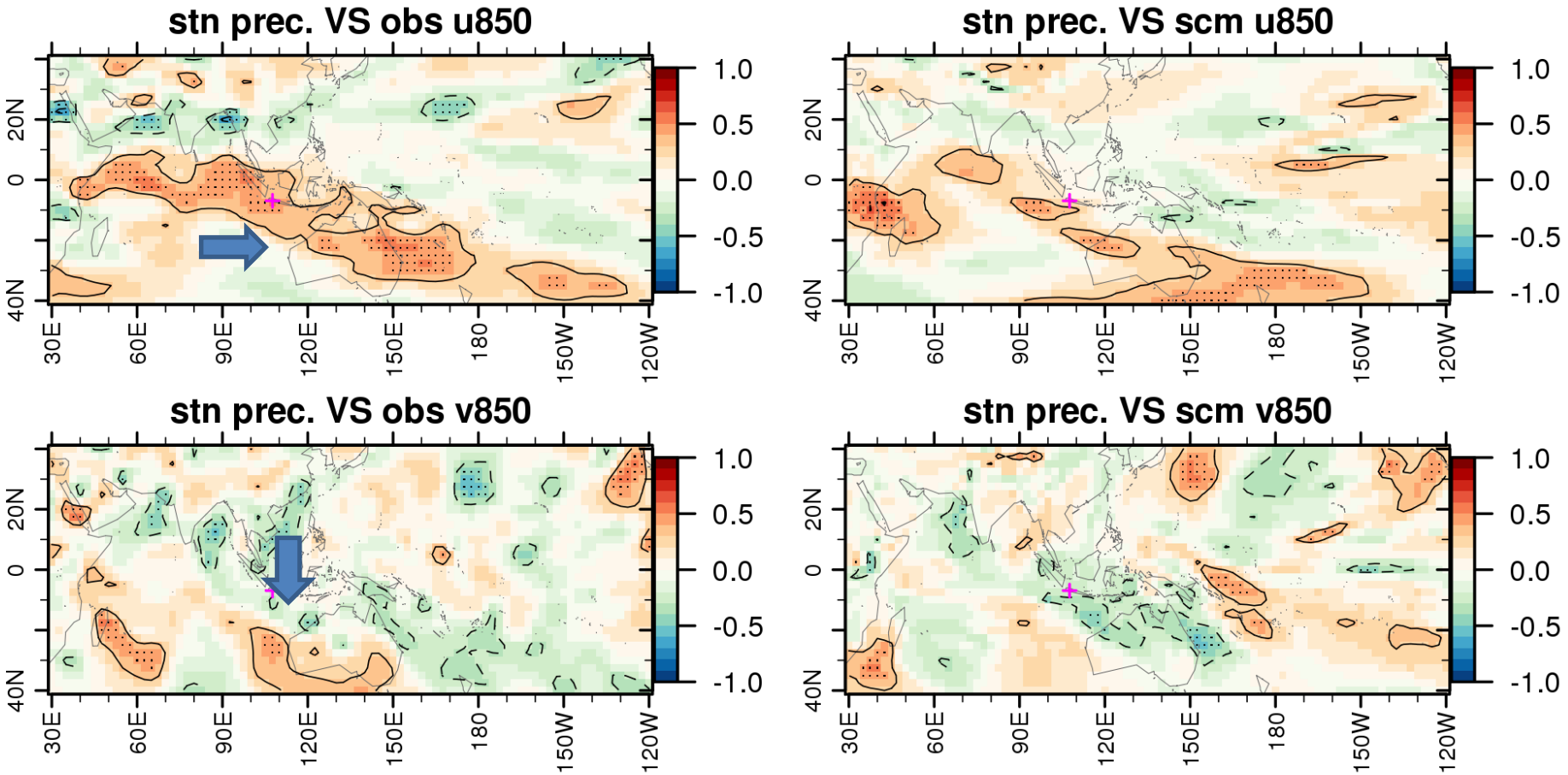

Weakening of Mean monsoon flow (southwesterly)
-> Increase SST + Rainfall

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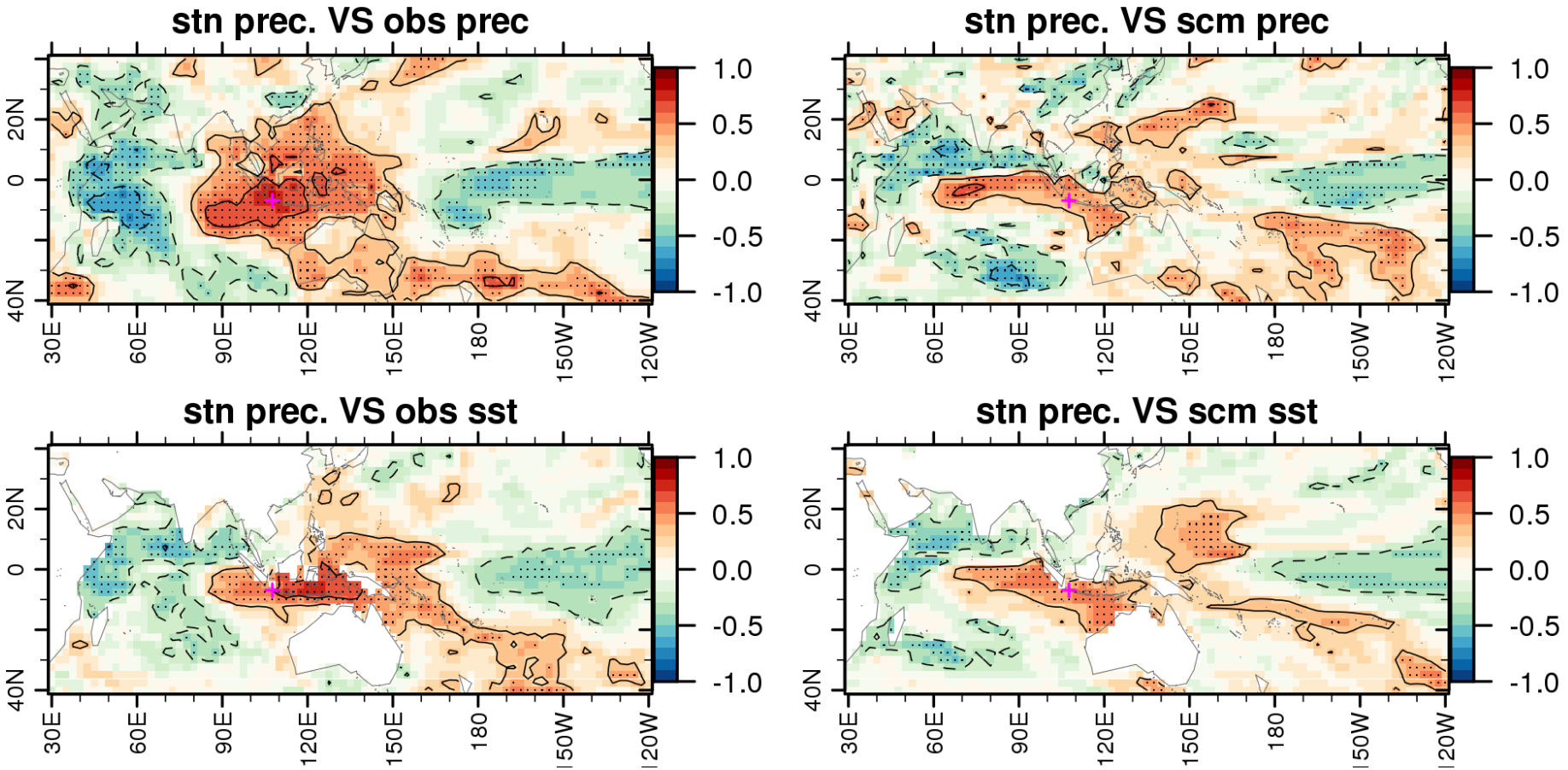

La Nina (and IOD) signature

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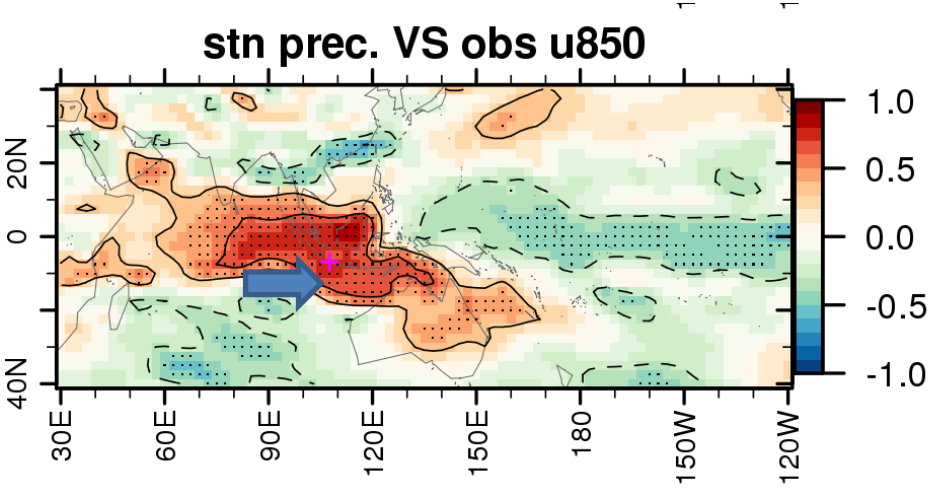

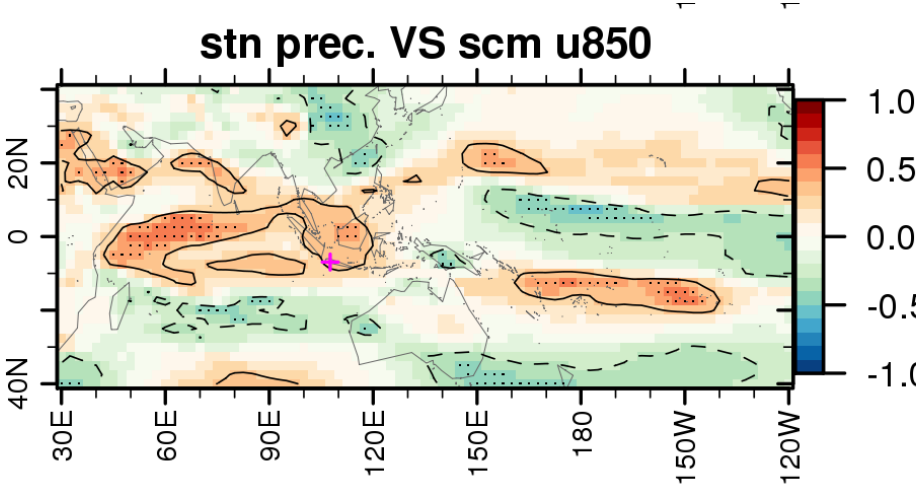

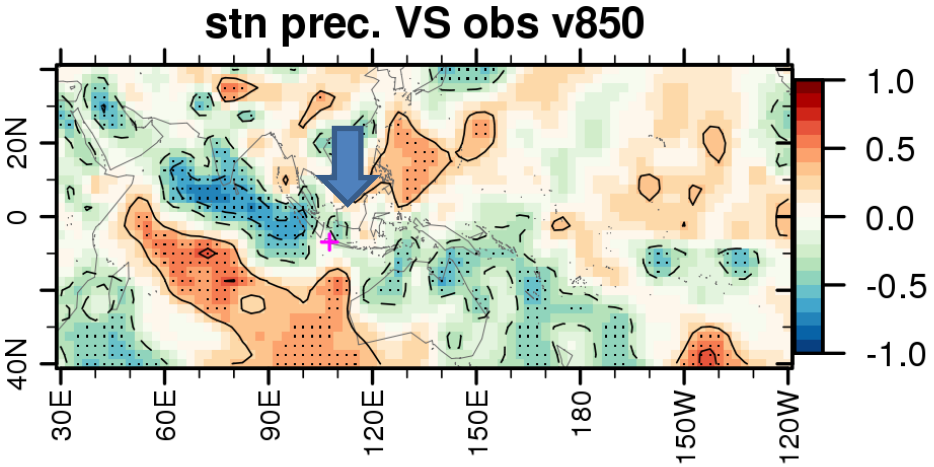

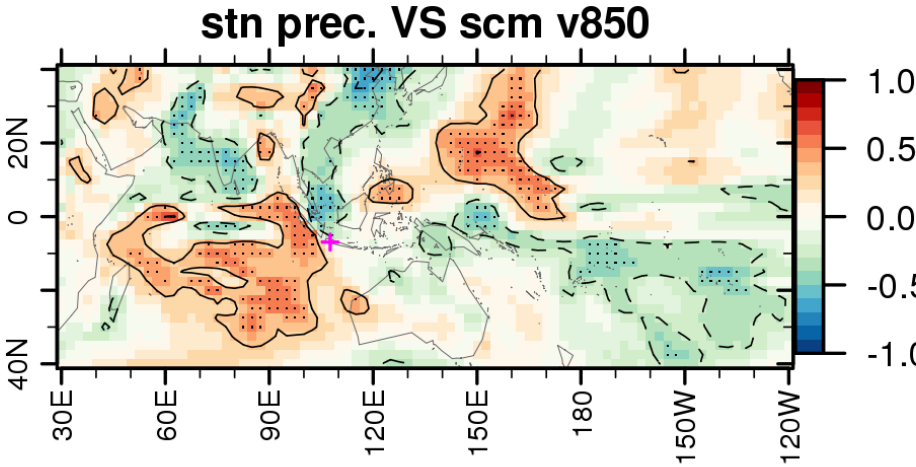

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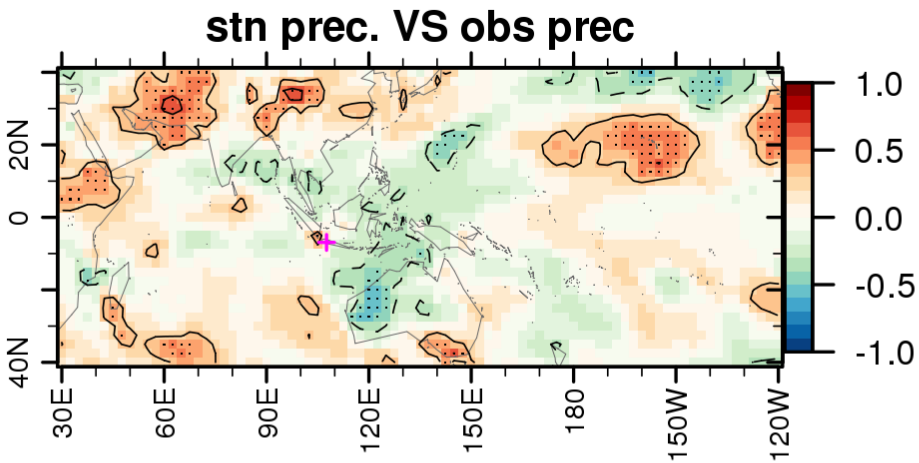

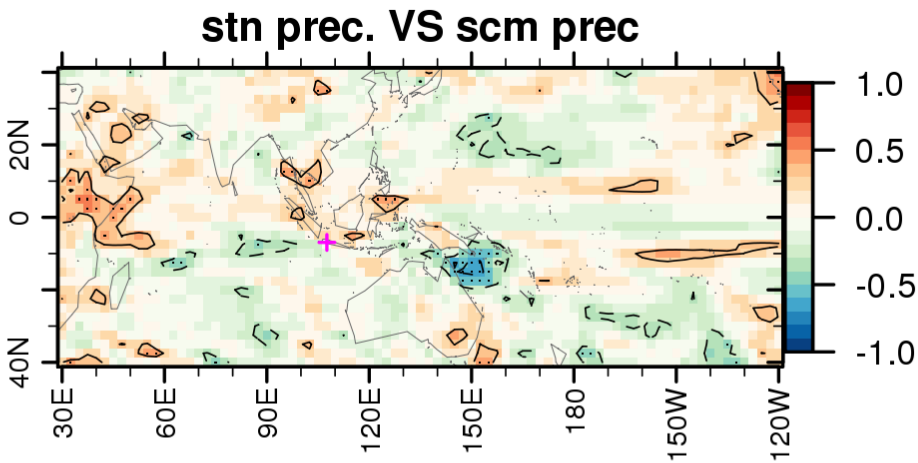

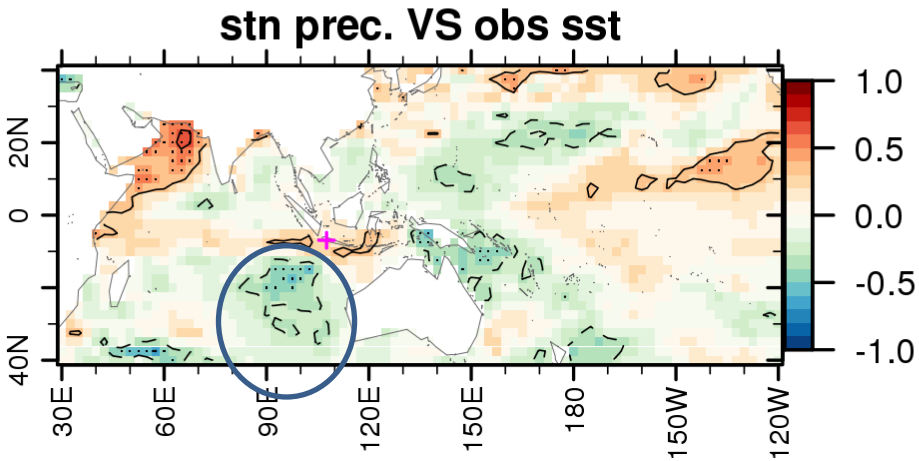

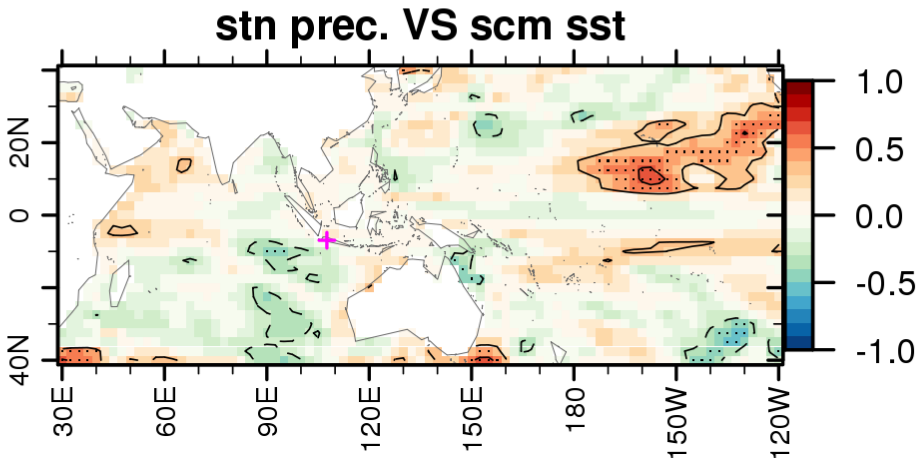

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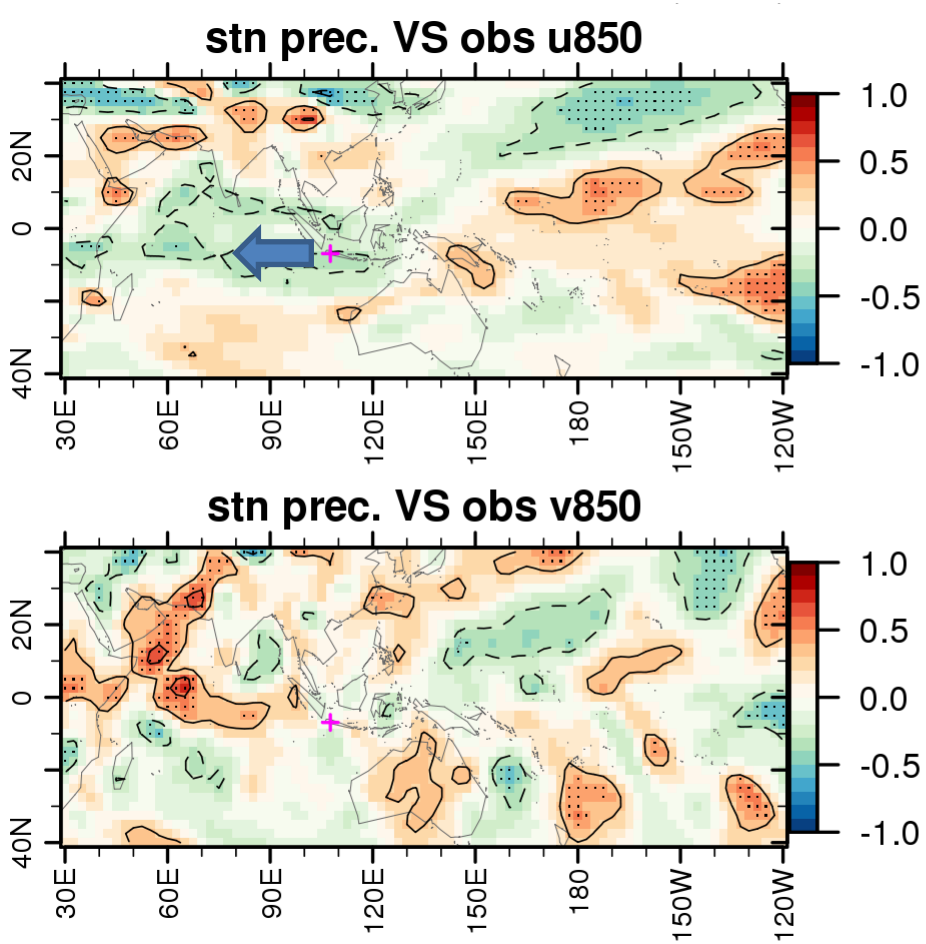

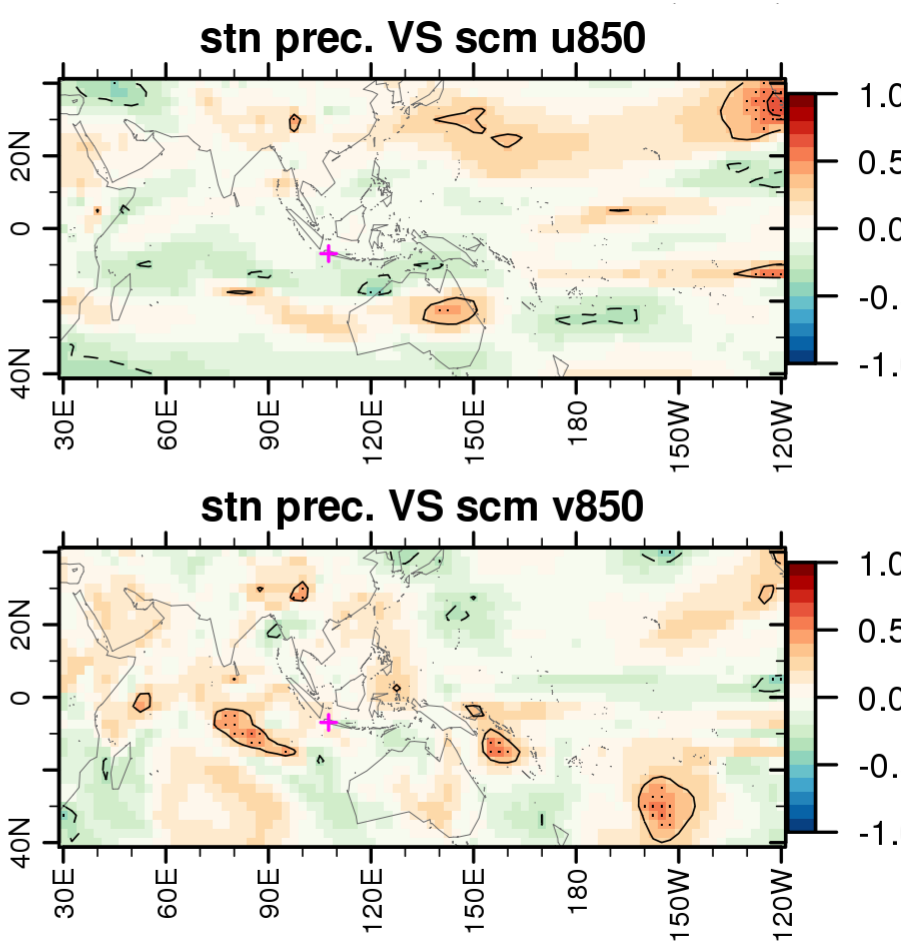

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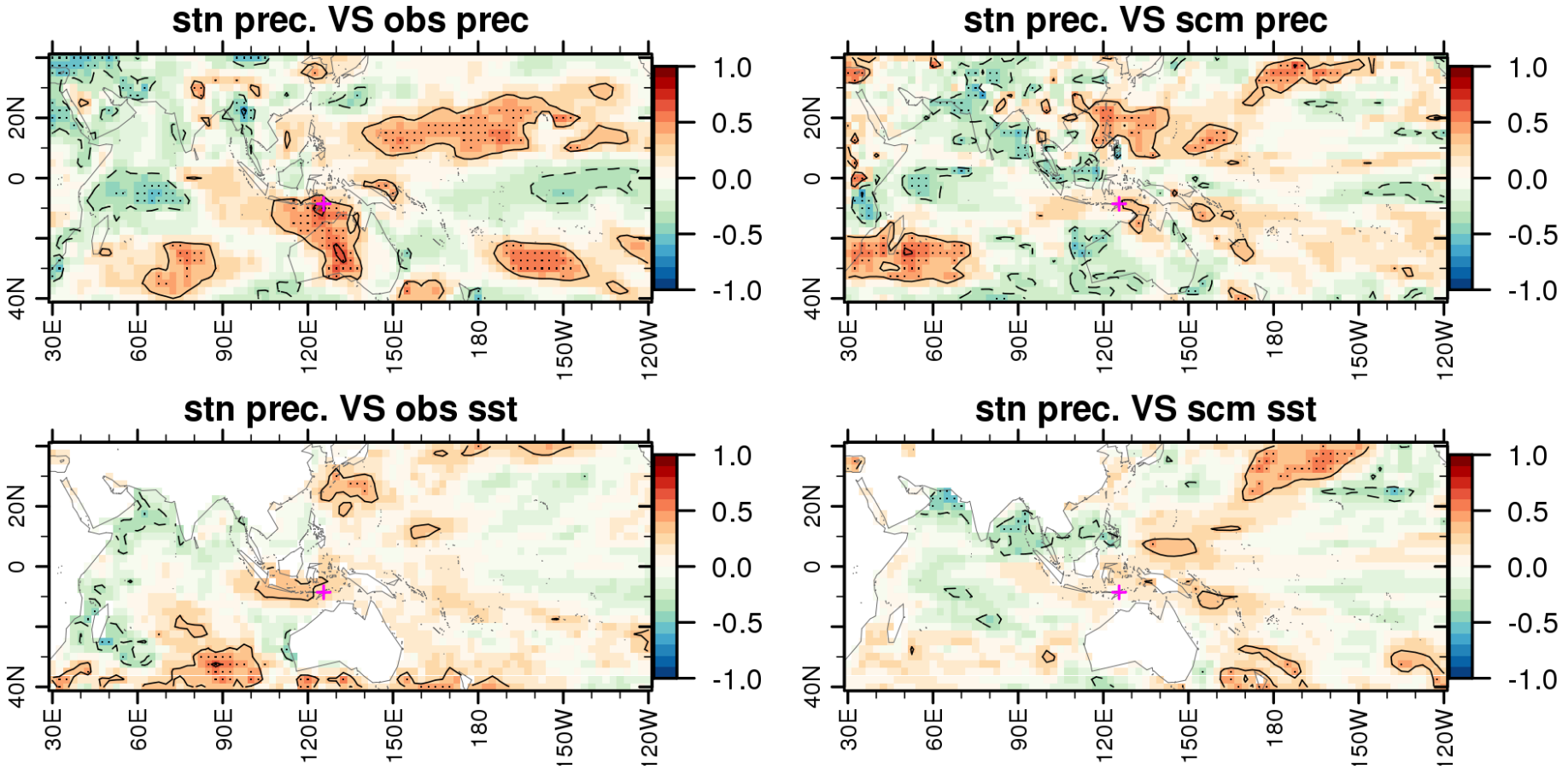

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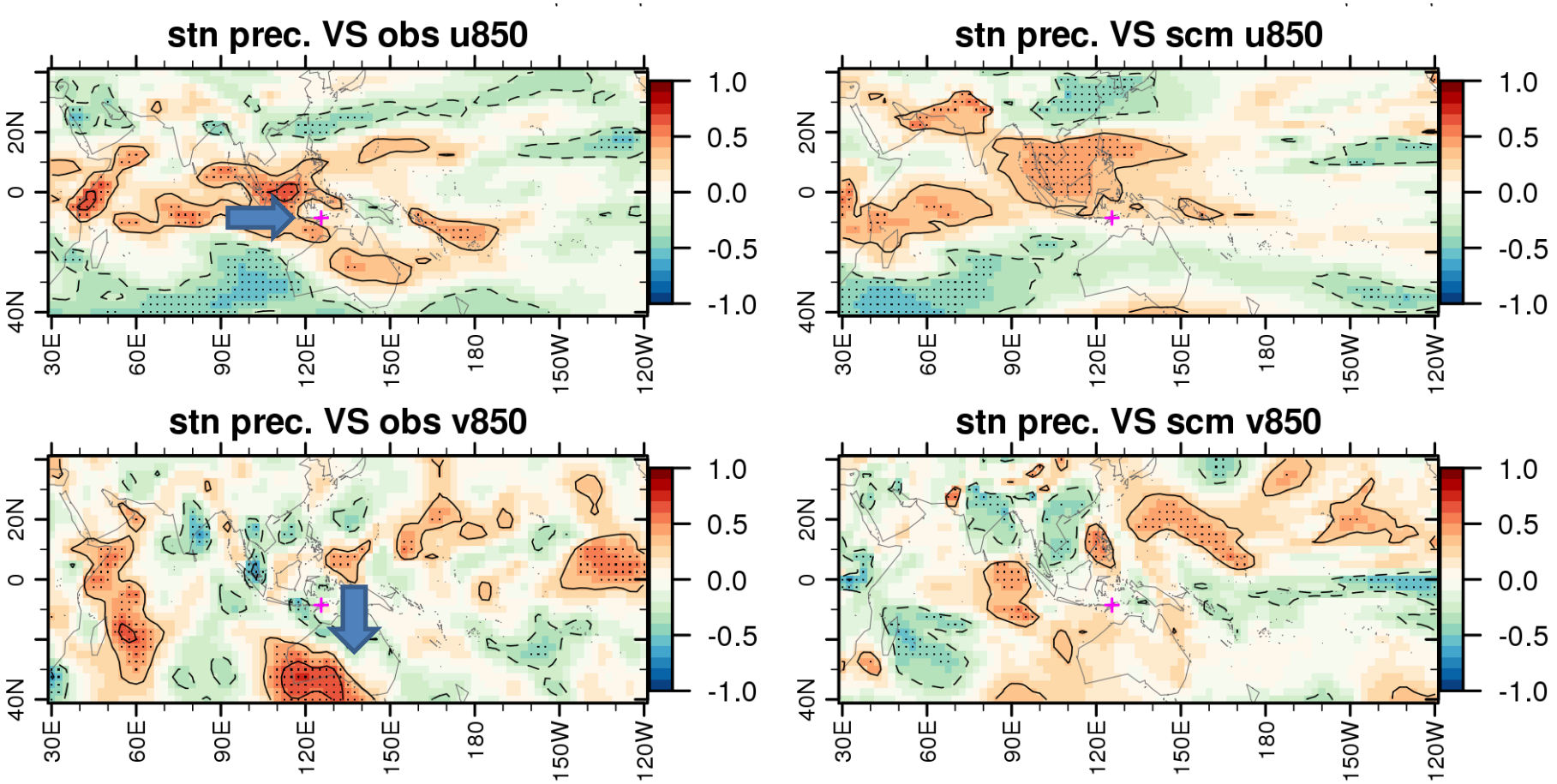

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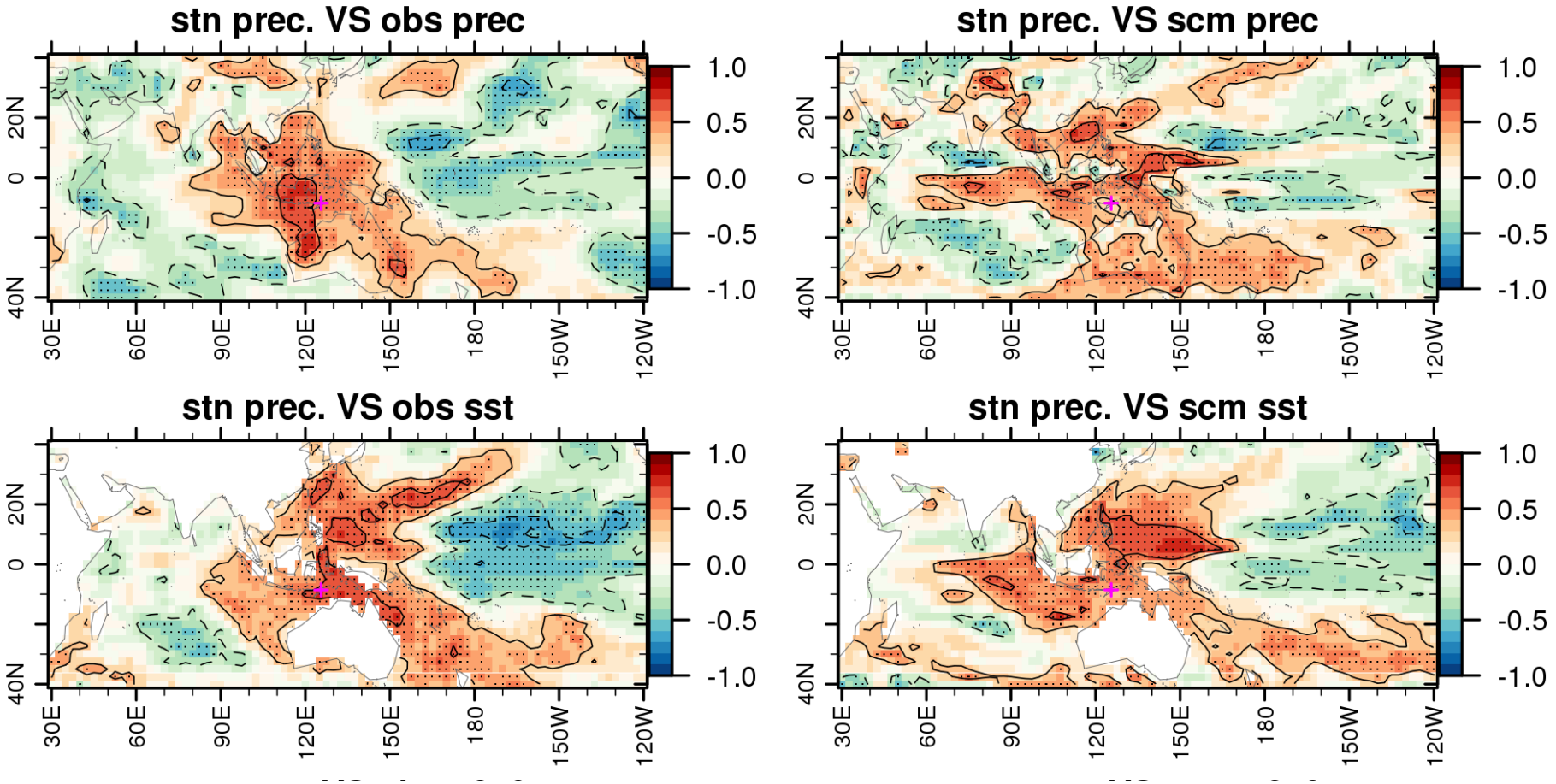

Similar to Jakarta too! (La Nina but not clear with IOD)

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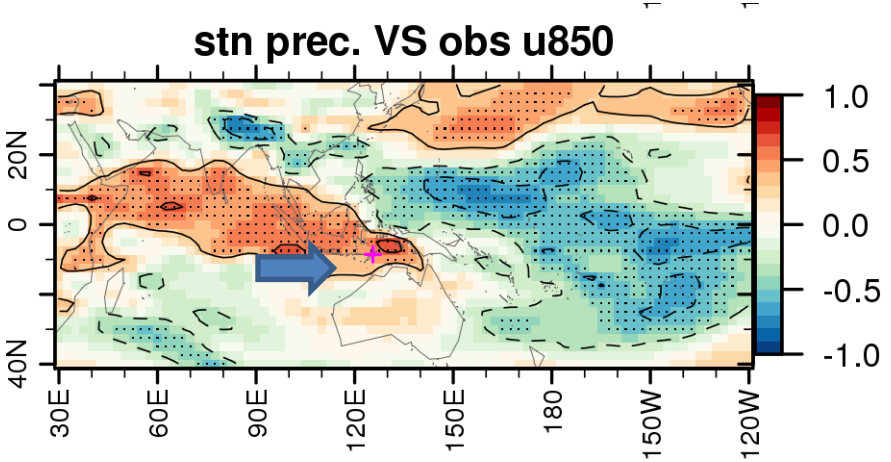

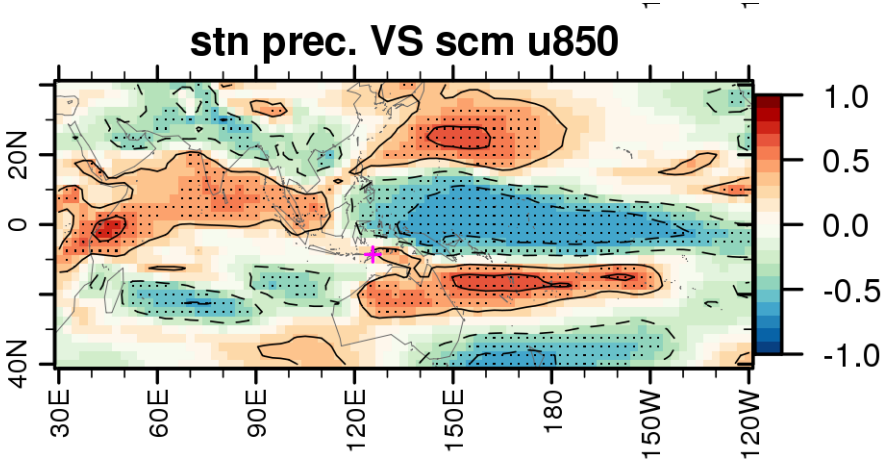

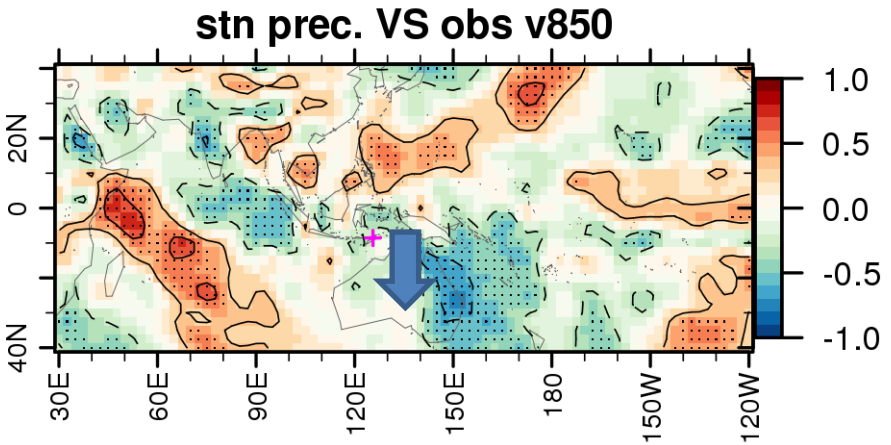

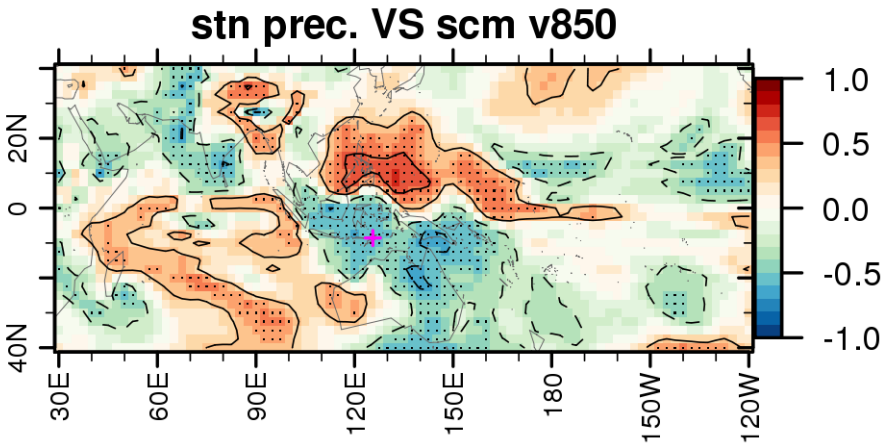

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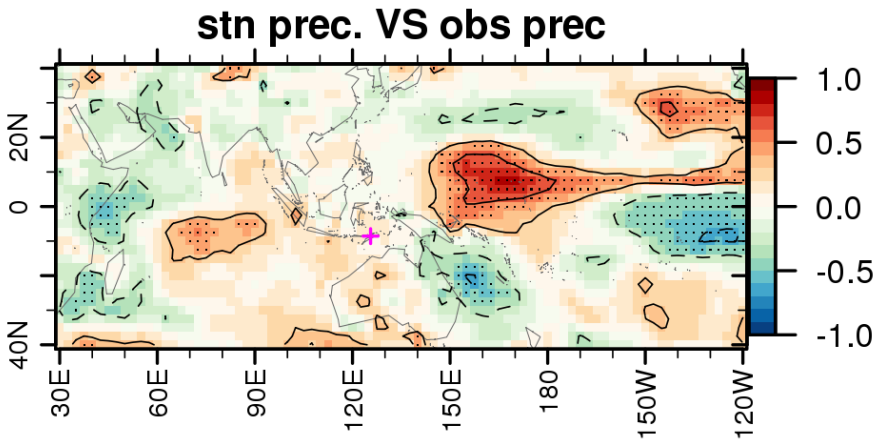

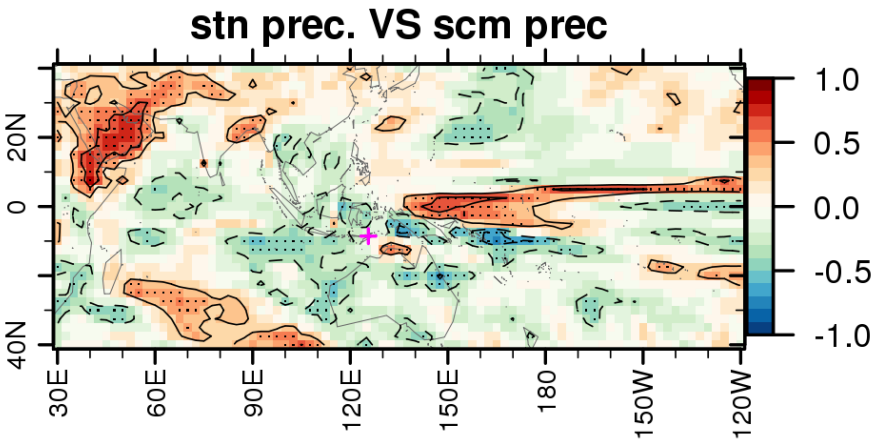

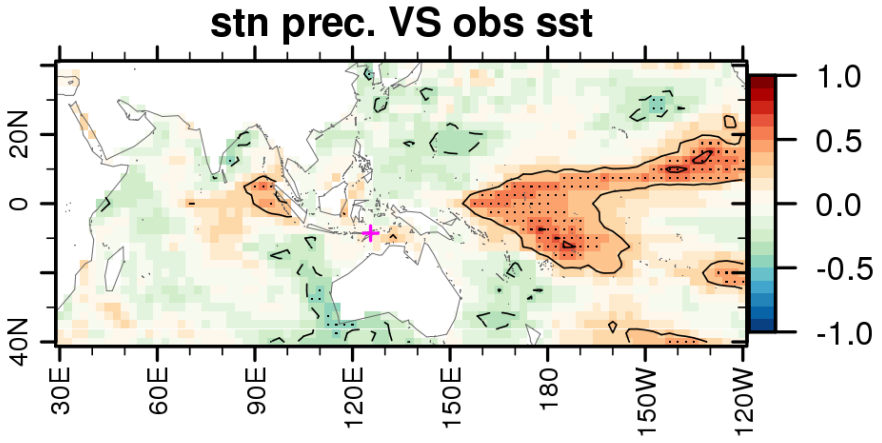

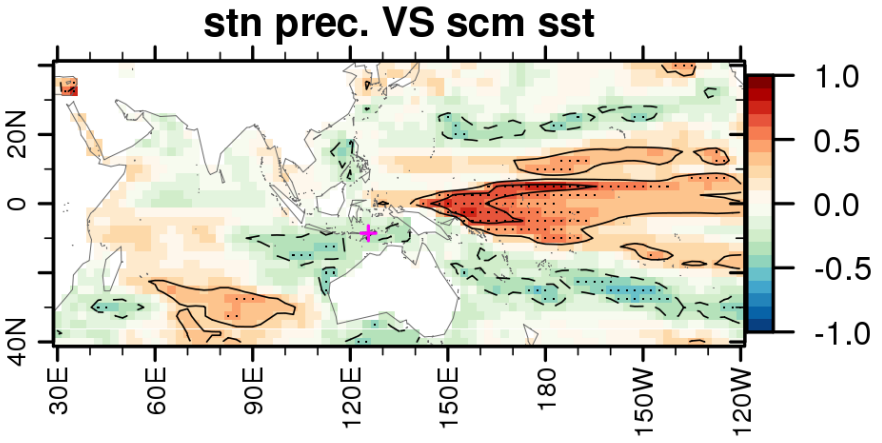

Similar to Jakarta too!! (Difficult but Some interesting signal at equatorial Pacific, El Nino Modoki?)

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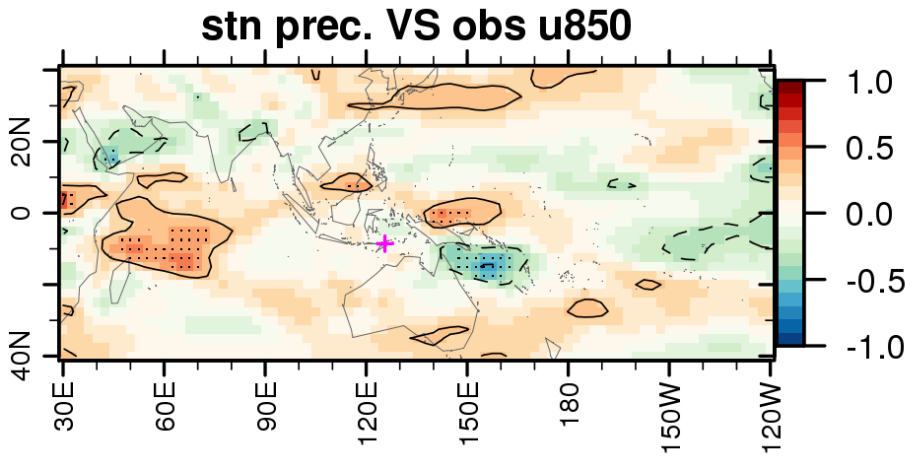

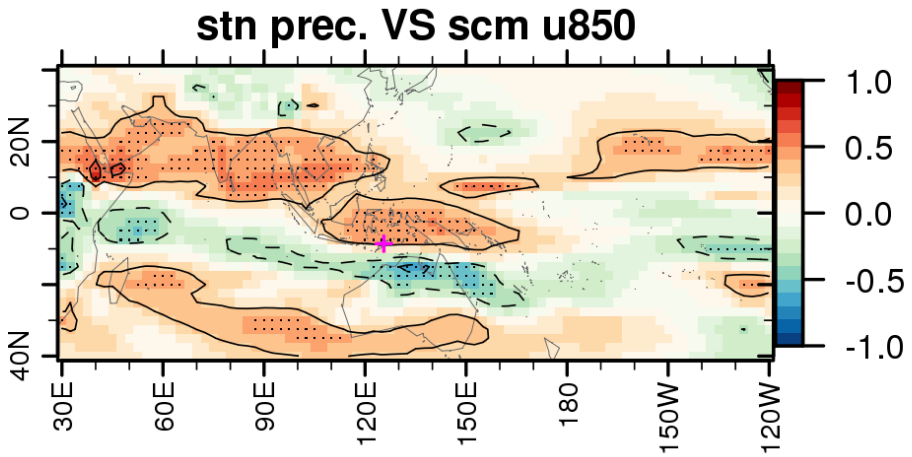

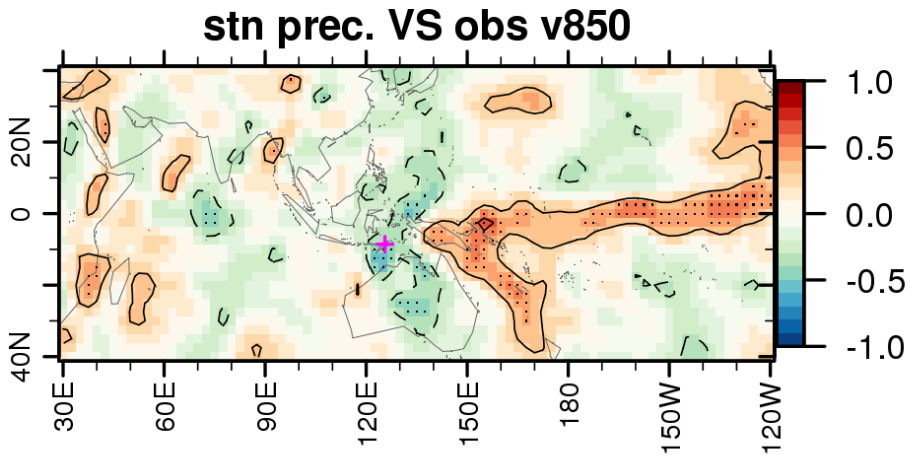

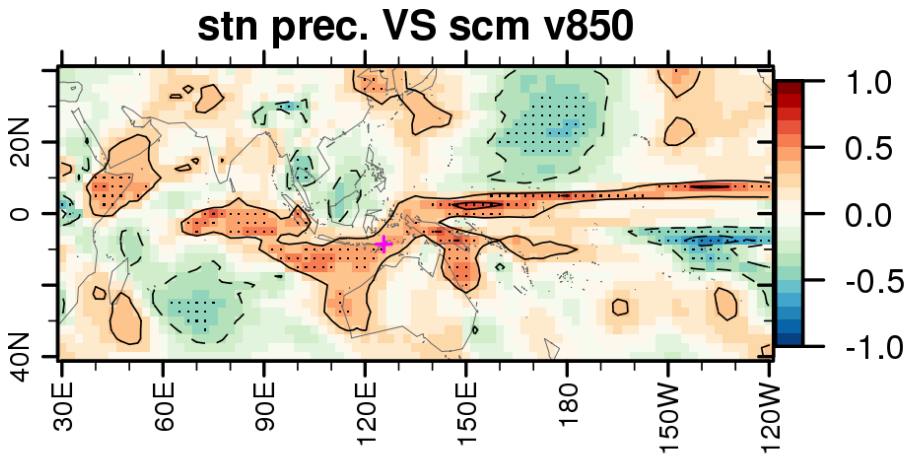

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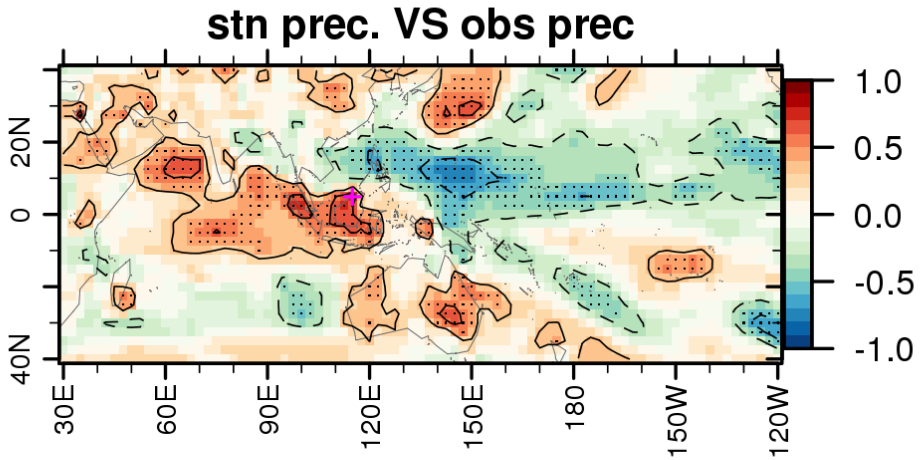

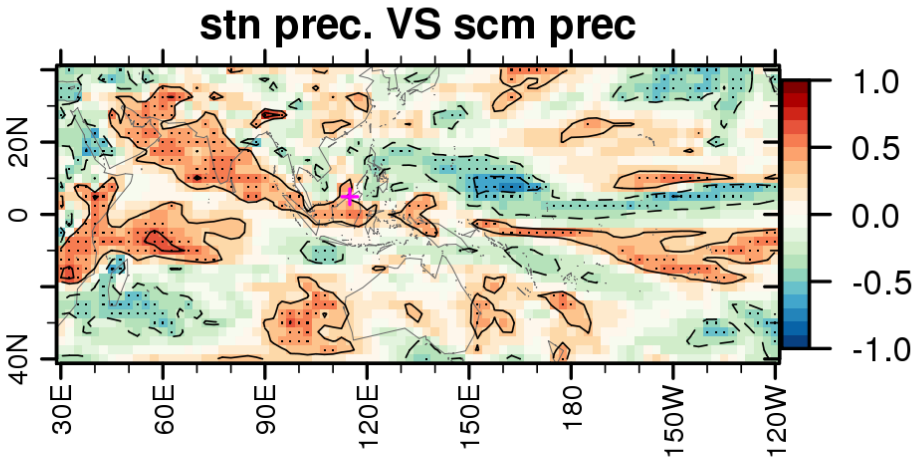

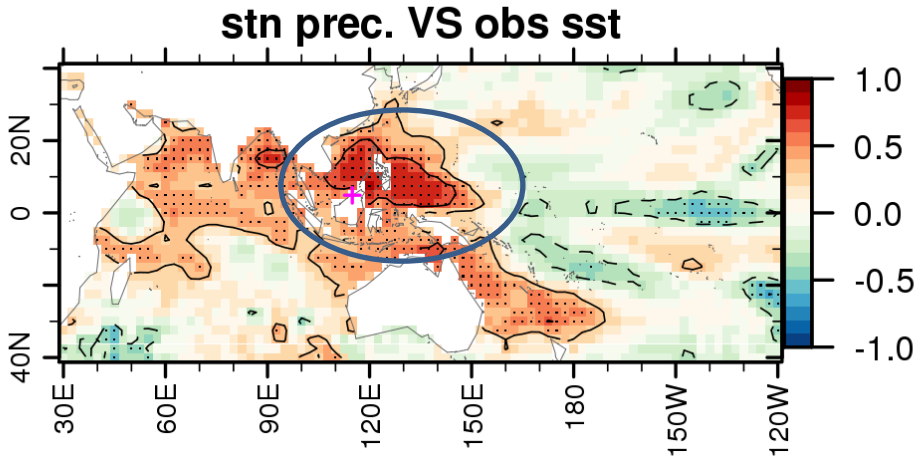

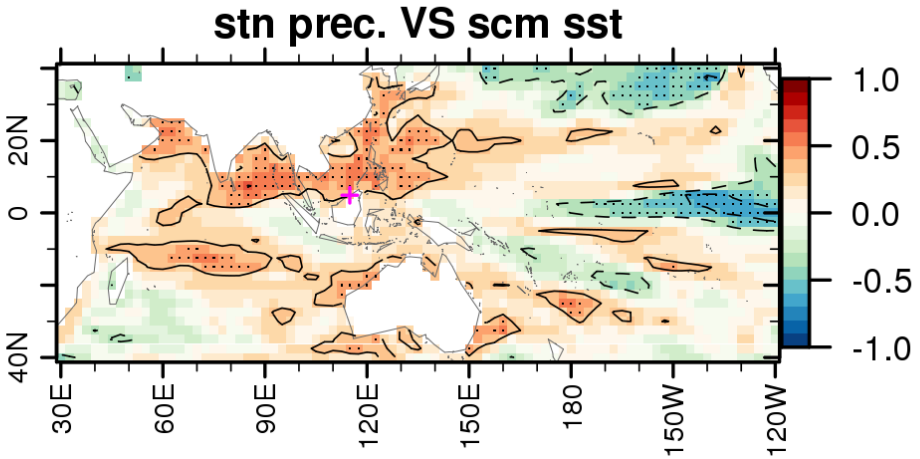

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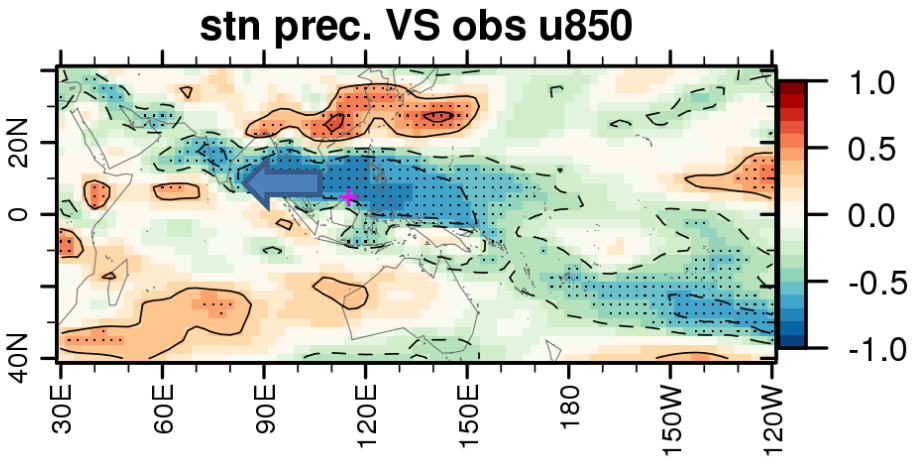

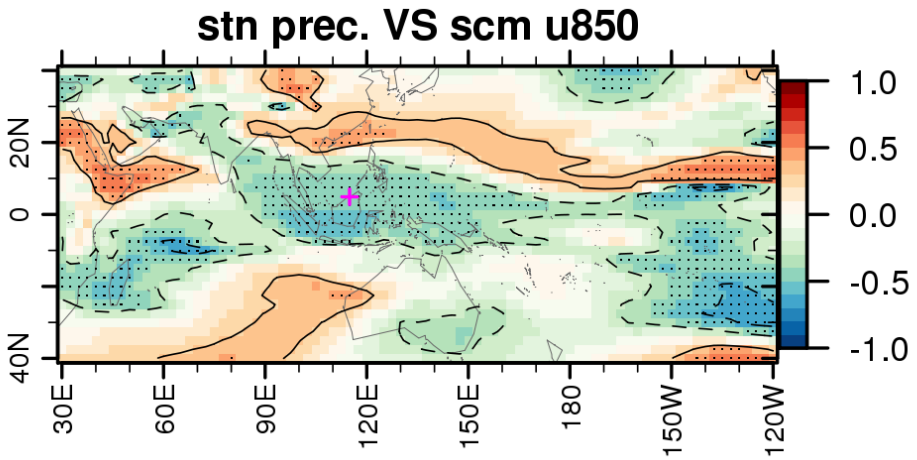

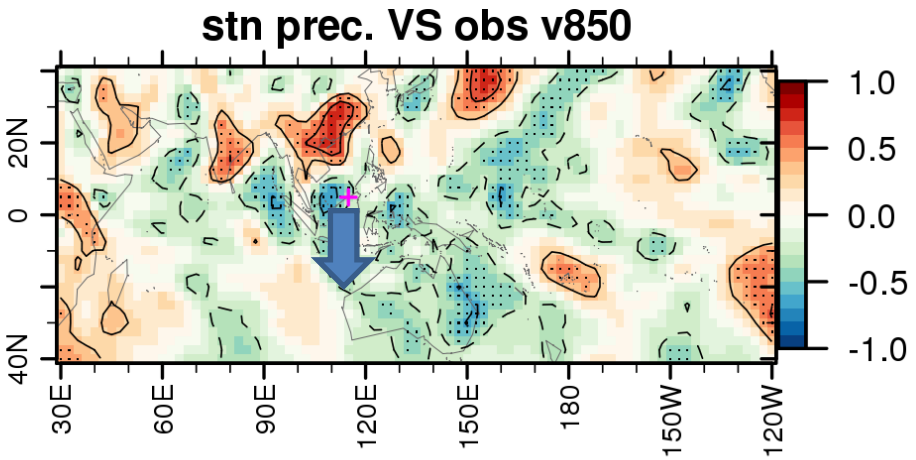

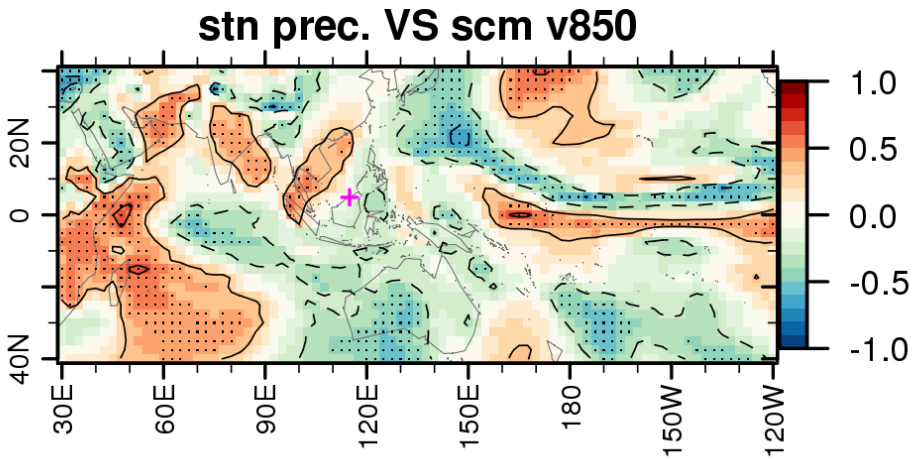

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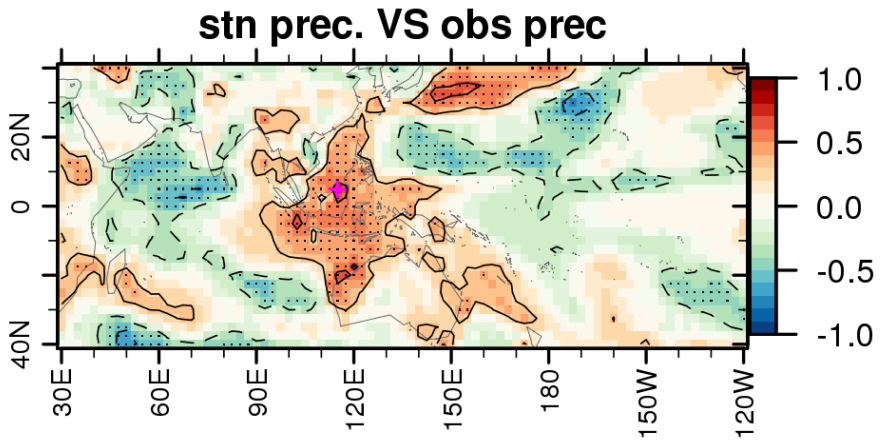

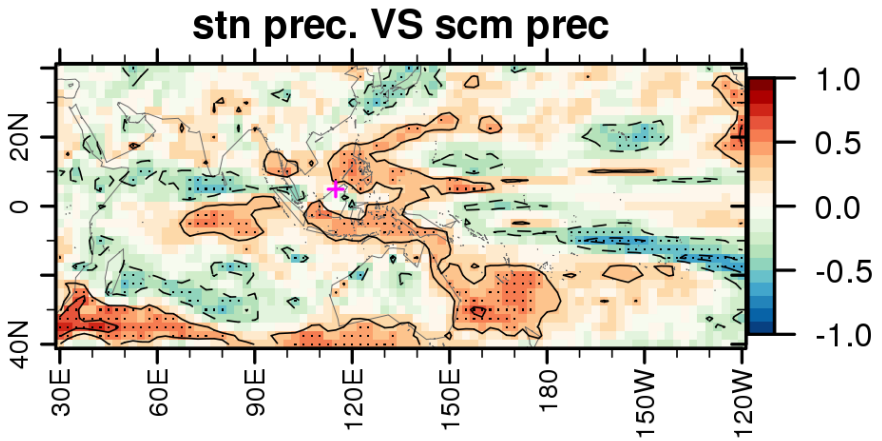

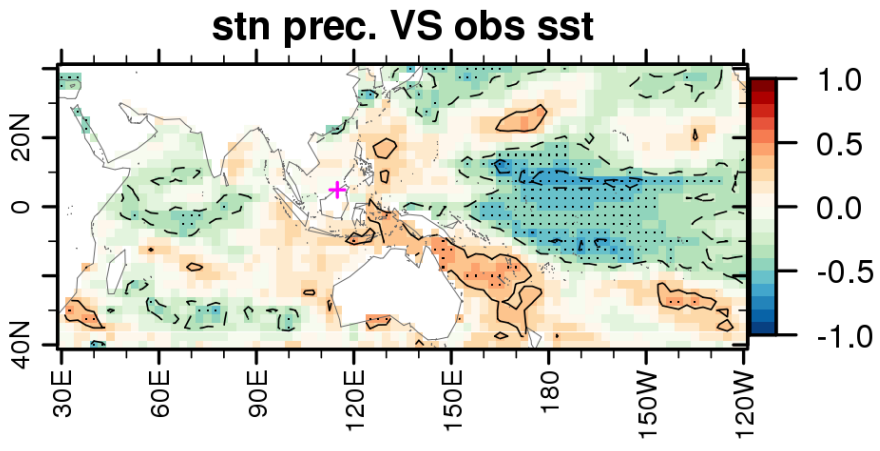

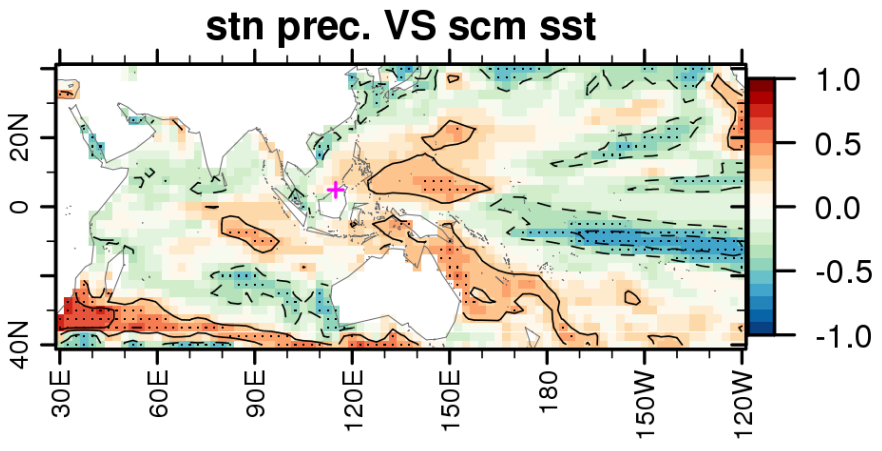

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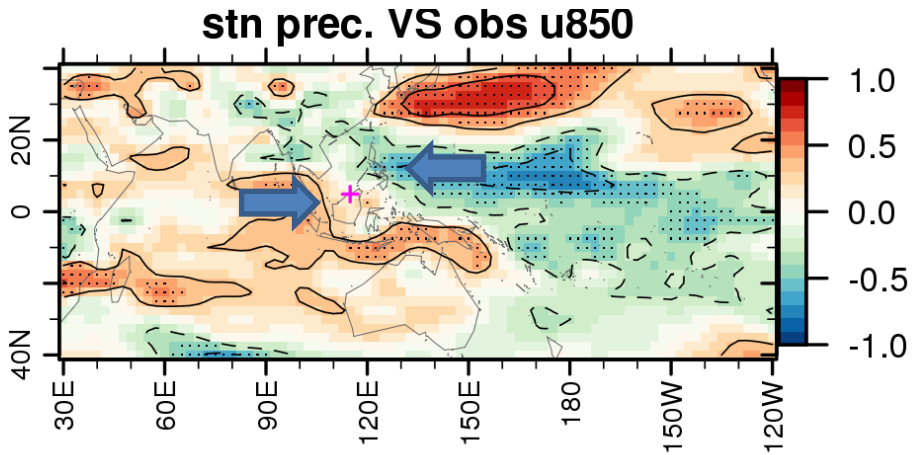

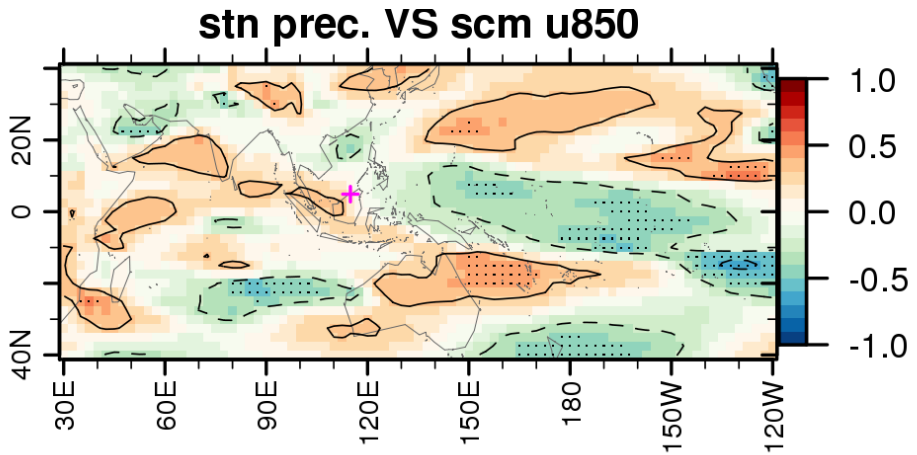

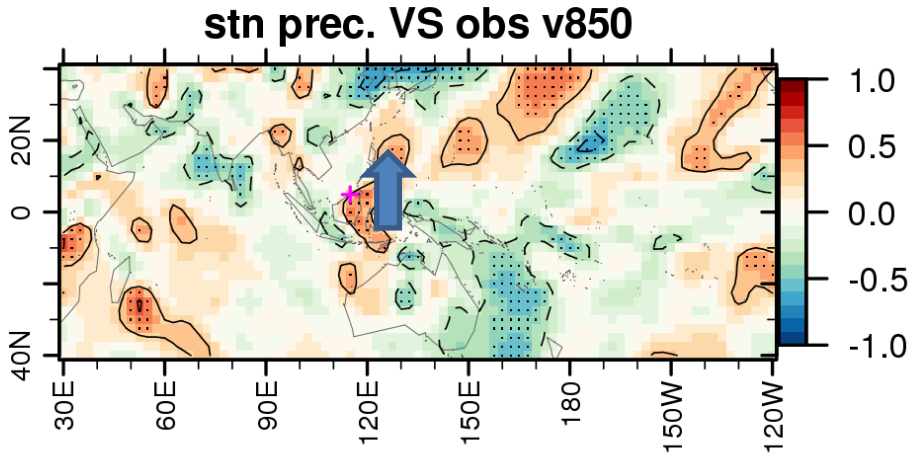

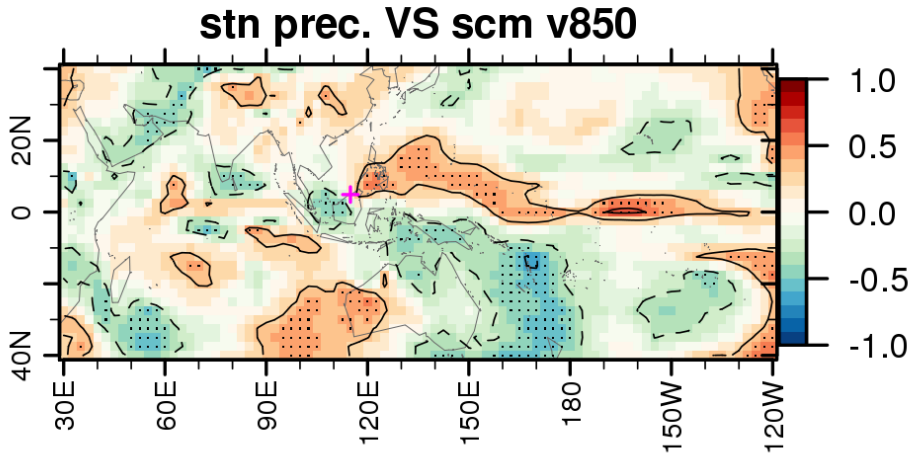

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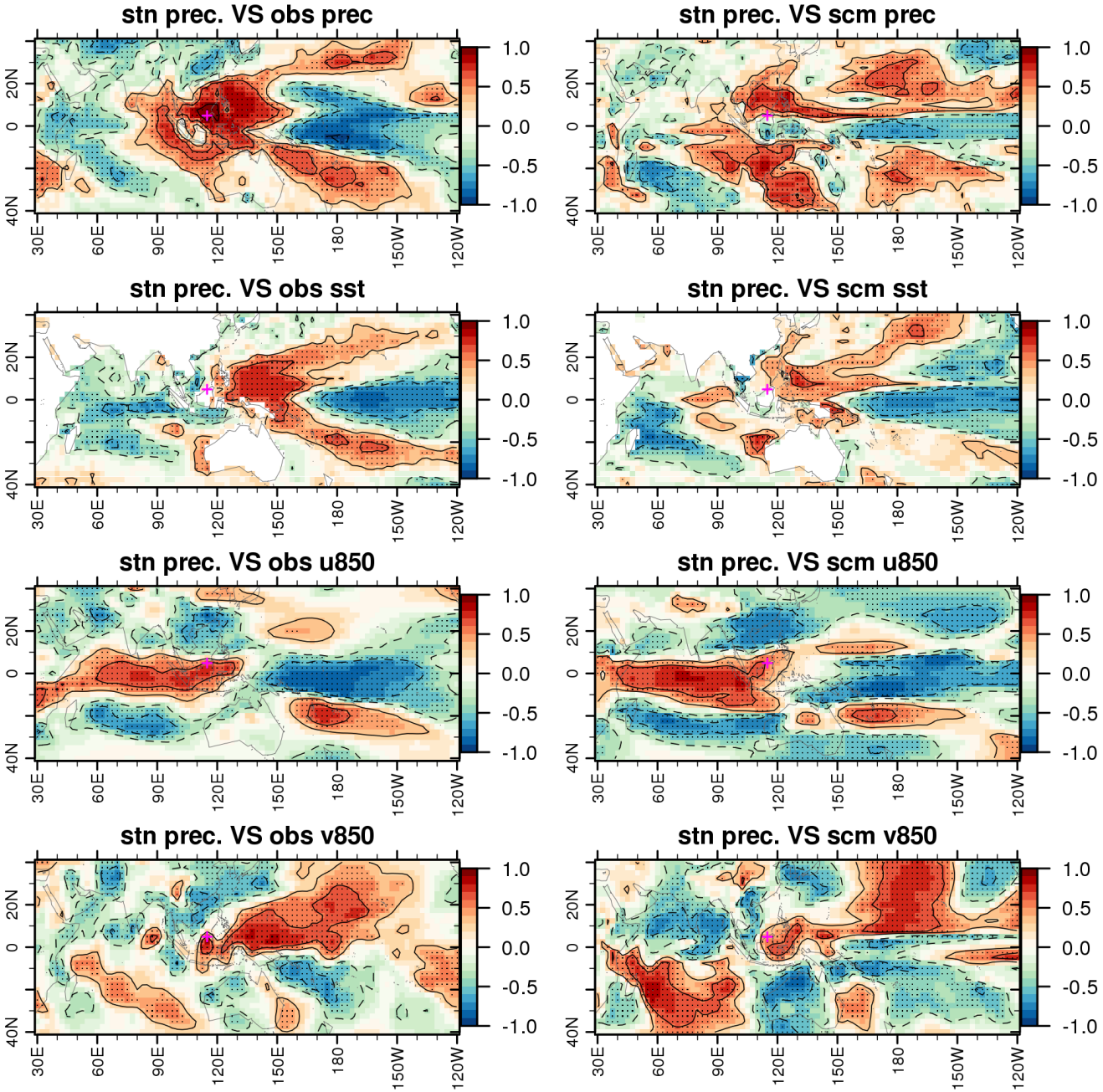

La Nina!

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Predictability

- More structured pattern : higher potential
- But actual predictability depends on model's ability to predict the pattern

  – How do we predict?

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Seasonal Prediction (2) : Methods

Jin Ho Yoo
APEC Climate Center

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Methods

- Statistical (Empirical)
  - Use observed relationship of climate system to predict future
  - Linear
- Dynamical
  - Based on “physical law” of climate system and expect to mimic “the memory”
  - Nonlinear

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Which one is better?

Statistical

- Simple and cheap
- Based on data
- Data is real thing but do we have enough?

Dynamical

- Complex and expensive
- Based on Law
- Is our understanding accurate?

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Statistical forecasting

- (0) Climatology $x(t+1) = \bar{x}$
  - Baseline of seasonal forecasting
  - “Nothing particular, Sir.”
  - Deterministic forecast
    - Rainfall amount will be similar to 30year average
  - Probabilistic forecast
    - Near normal ?
    - I don’t know? (33%:33%:33%)

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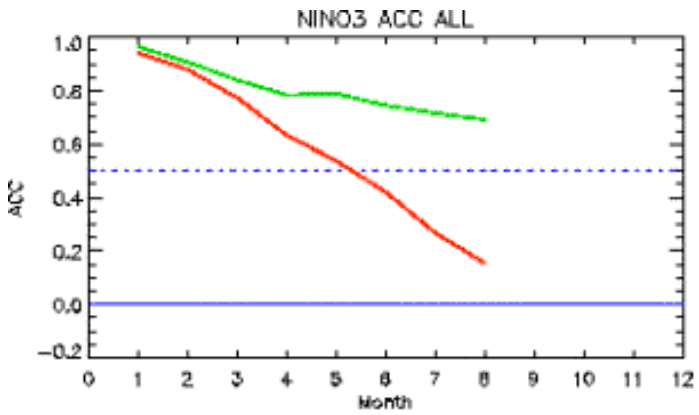
Statistical forecasting

- (1) Persistence $x'(t+1) = x'(t)$
  - Assume that future will be same as it is now
  - ANOMALY !
  - Often Close to people's expectation
  - Effective when the autocorrelation is large
    - Often used for ENSO forecast (Nino3.4)



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Statistical forecasting

- (2) Regression $x'(t+1) = ay(t) + b$
  - The most popular method and many variations
  - x : predictand (e.g. rainfall at a station)
  - y : predictor (e.g. NINO3.4 SST)

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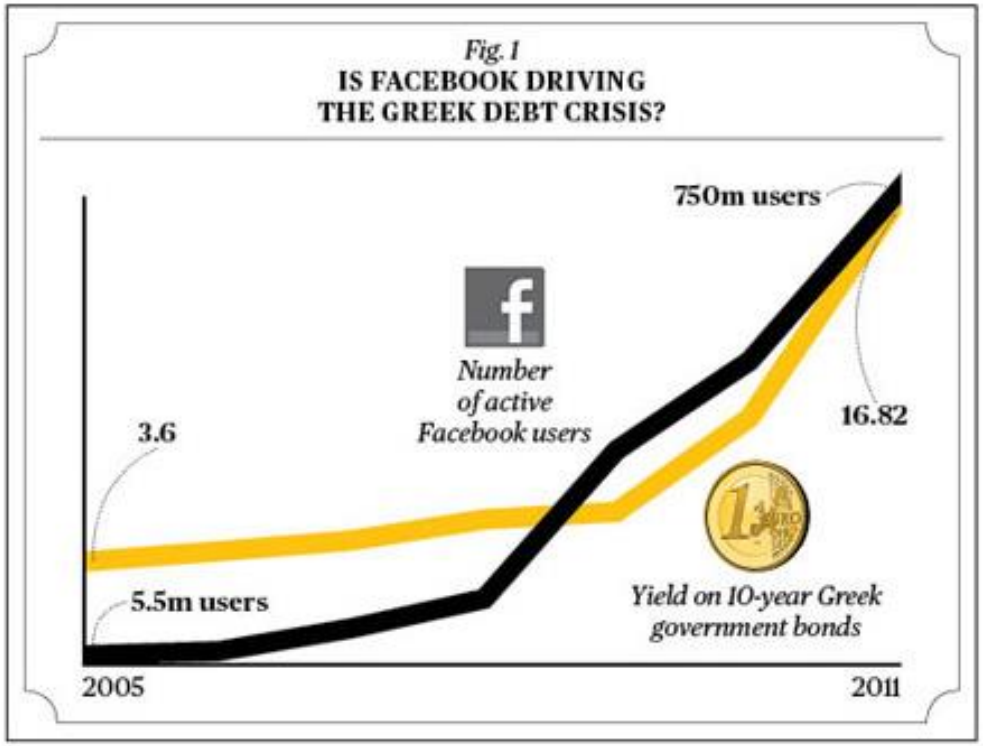
Predict yield of Greek bonds with Facebook users

- Is it appropriate?



From *business week*

If yes, why?

If not, why?

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Regression based forecast

- Question #1 $x'(t+1) = ay(t) + b$
  - How to define predictor (y)?
  - By definition, predictor should cause some changes in variation of predictand

  - Predictand : my mood in the morning
  - Predictor?

Regression based forecast

- Question #2 $x'(t+1) = ay(t) + b$
  - How to define a and b?
  - your choice. Linear, nonlinear, single, multi….
    - Complex one is not necessarily better.
  - Predictand : my mood in the morning
  - Predictor :
  - a , b?

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Regression based forecast

- Question #1 : Predictor selection
  - Should be based on Physical relationship between predictors and predictands
  - Predictor cannot be tiny signal in the seasonal forecast
  - Keep “doubt” on the possibility of selection by chance
  - Selected predictor should be validated with separate data

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Regression based forecast

- Question #2 : appropriate Function

$$x'(t+1) = ay(t) + b$$

$$x'(t+1) = a_1 y_1(t) + a_2 y_2(t) b$$

$$x_1'(t+1) + x_2'(t+1) = a_1 y_1(t) + a_2 y_2(t) b$$

- One to One : often not very satisfactory, limited cases
- One to Multi : easy to overfit (lie)
- Multi to Multi : looks nice but often produce nothing practical

- If they gives similar result, the simpler is the better

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Cross-validation

- Climate data record is short (~3-40years)
  - EX) We have only a few El Nino events.
  - It's better to consider as many event as possible
  - Then, how to verify? (How to estimate skill of developed method?) for new cases?

  - Devide data into Training and Validation period

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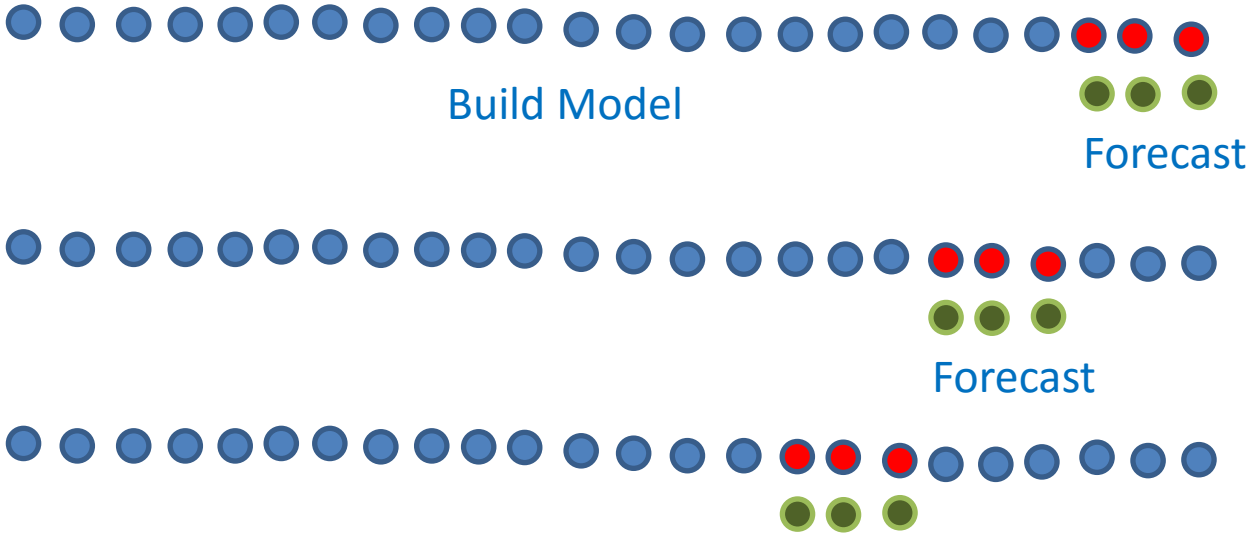
Cross-validation



- Exact value of model parameters can change
- NEVER use “omitted” data in ANY CASE of model development

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The most important thing

- Physical understanding of;

1. What weather event/system consists of your seasonal climate (LOCAL, predictand)

2. What external (slow varying factor) controls the weather system (GLOBAL, predictor)

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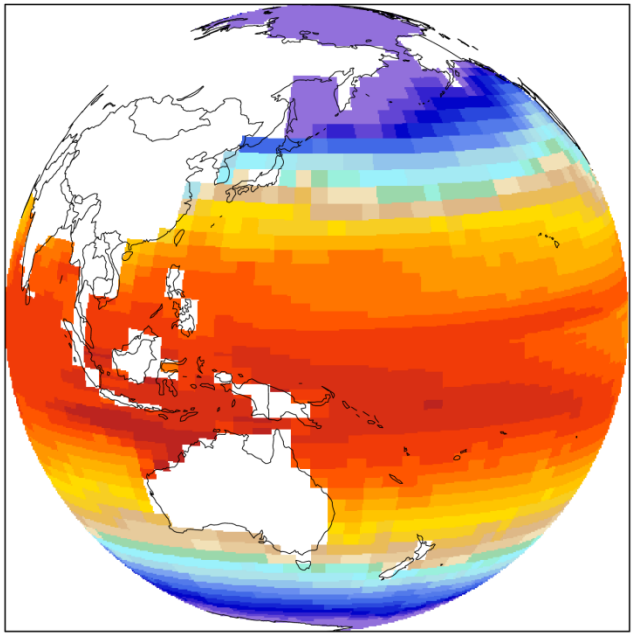
Dynamical forecast

- Use GCM : Global Climate Model
  - It used to be called “General Circulation Model”



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Dynamical forecast

- Governing Equations
  - Written as computer program code (NWP)

$$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u}\cdot\nabla)\mathbf{u} = \nabla\Phi - 2\Omega\times\mathbf{u} - \frac{1}{\rho}\nabla p + \mathscr{F}$$

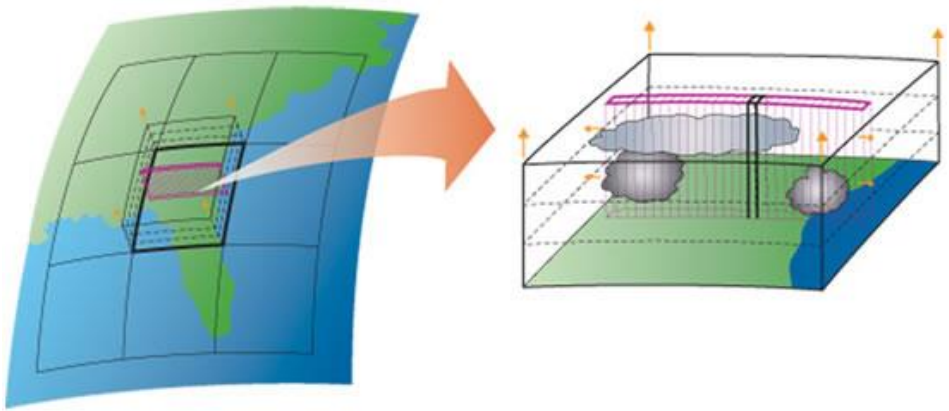
$$\frac{\partial \rho}{\partial t} + \vec{\nabla}(\rho\vec{u}) = 0 \quad \Leftrightarrow \quad \frac{D\rho}{Dt} = -\rho\nabla\cdot\mathbf{u}$$

$$\frac{\partial \theta}{\partial t} + \vec{u}\cdot\vec{\nabla}\theta = l$$

```
//Belehradek functions:
//
//     DTstage(T+9.11)^-2.05
//
    MinTime=pow(T[j]+9.11, -2.05);//Minimum time to advance to stage (in days)
    for(k=0;k<numLifeStage;k++)
    {
        MaxRate[k]=MinTime*DTstage[k];
        MaxRate[k]=MaxRate[k]*ToSecs;//Convert to seconds
        MaxRate[k]=1.0/MaxRate[k];//Convert to rate
    }


//Parameters for Ivlev functions controlling food dependence
//
//    R=a(1-exp(-b*(food-c)))--development rate (days^-1)
//
// But, idea is that temp sets max growth rate, and food tells us how close
// we get to the max.  In this sense, a=1 (Campbell figured an absolute
// rate, we're essentially normalizing his rates by rate at 4oC.
//
//b=[ones(1,6)*params.bnaup,ones(1,6)*params.bcop];

    for(k=0;k<6;k++)
        Rfood[k]=(1.-exp(-(F[j]-c)*params.bnaup));
    for(k=6;k<12;k++)
        Rfood[k]=(1.-exp(-(F[j]-c)*params.bcop));

//Multiply Rfood by MaxRate to get the actual rate.
    for(k=0;k<12;k++)
        R[k]=MaxRate[k]*Rfood[k];

    R[12]=0.;//adults don't molt


//M[k]=mortality rate for stage k at node j
//
    gammaT=gamma0*(1.-gamma0)*pow(T[j]/Tc,z);
    //gammaT=0.1; //Overrride temp dependent mortality
```

Numerical modeling

- Issue
  - Digitization (physical variable is continuous, but computer needs digitization”
    - Resolution, subgrid-scale parameterization



  - Unknown processes, tunable parameters
  - Initialization (for forecasting)

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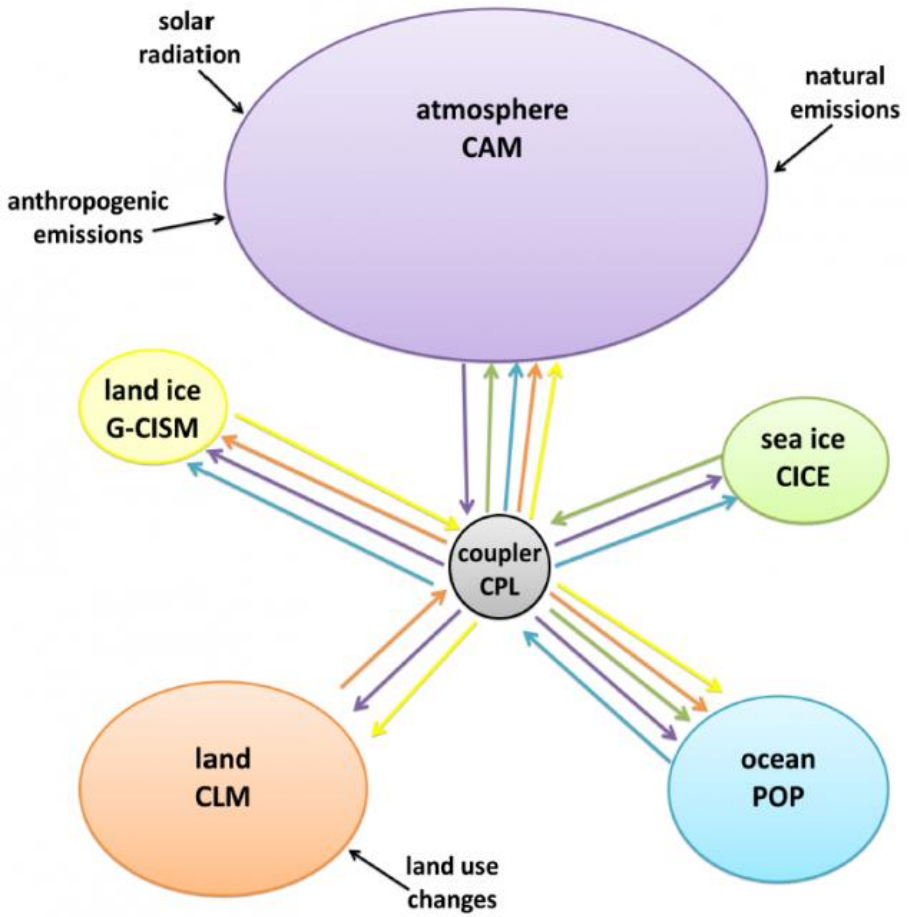
GCMs

- Coupled GCM
  - Atmosphere
  - Ocean
  - Sea-Ice
  - Land surface
  - Chemistry
  - Biosphere



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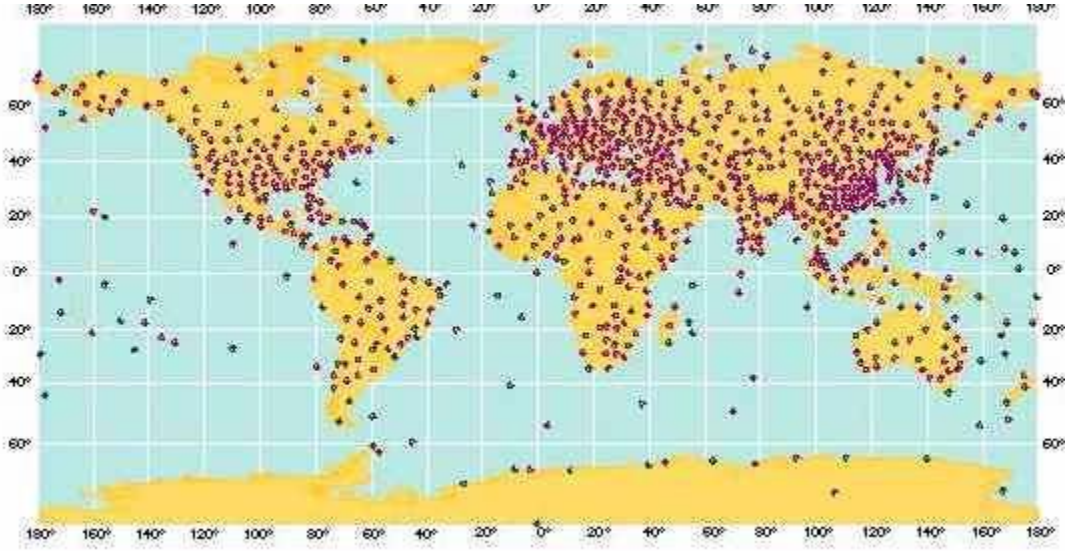
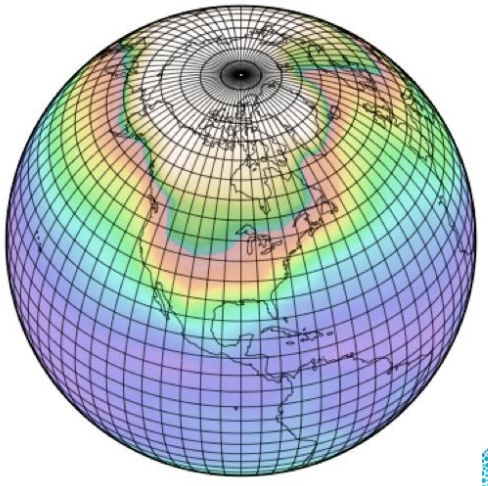
Initialization

Estimating Current status of climate system

- Preparing the beginning climate state of GCM with available observation
  - Balance between Wrong GCM vs Wrong OBS.
  - Balance between components (Atm, Ocn)





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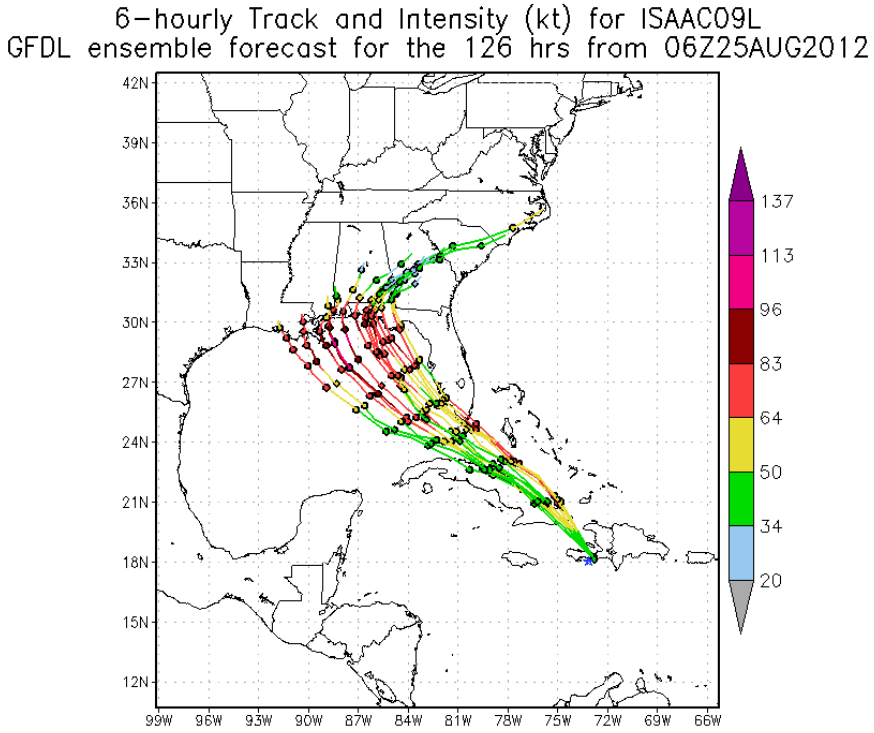
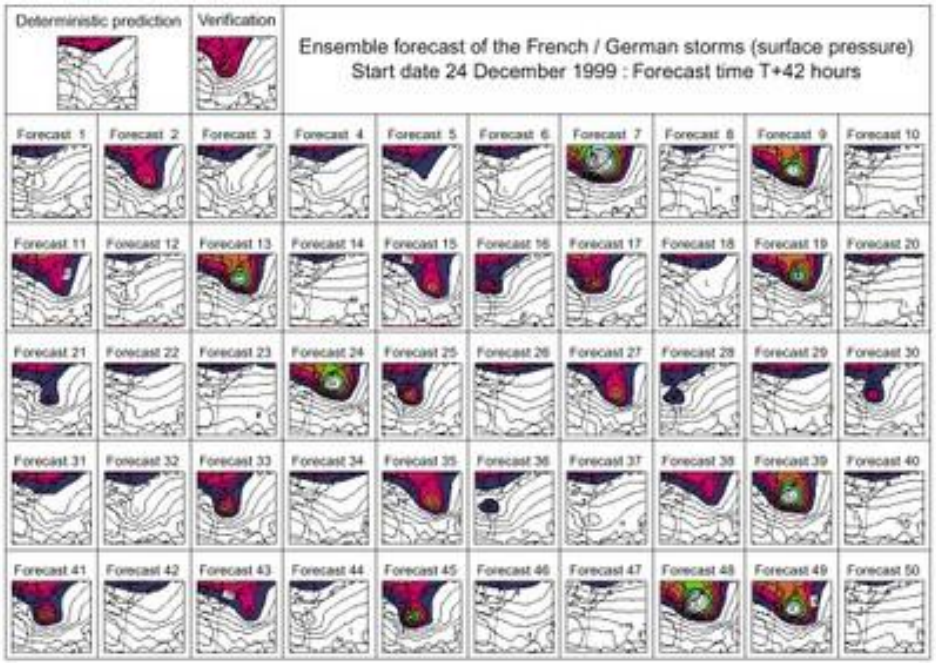
Ensemble Forecasting

- Run many times
  - Starts from slightly different initial conditions





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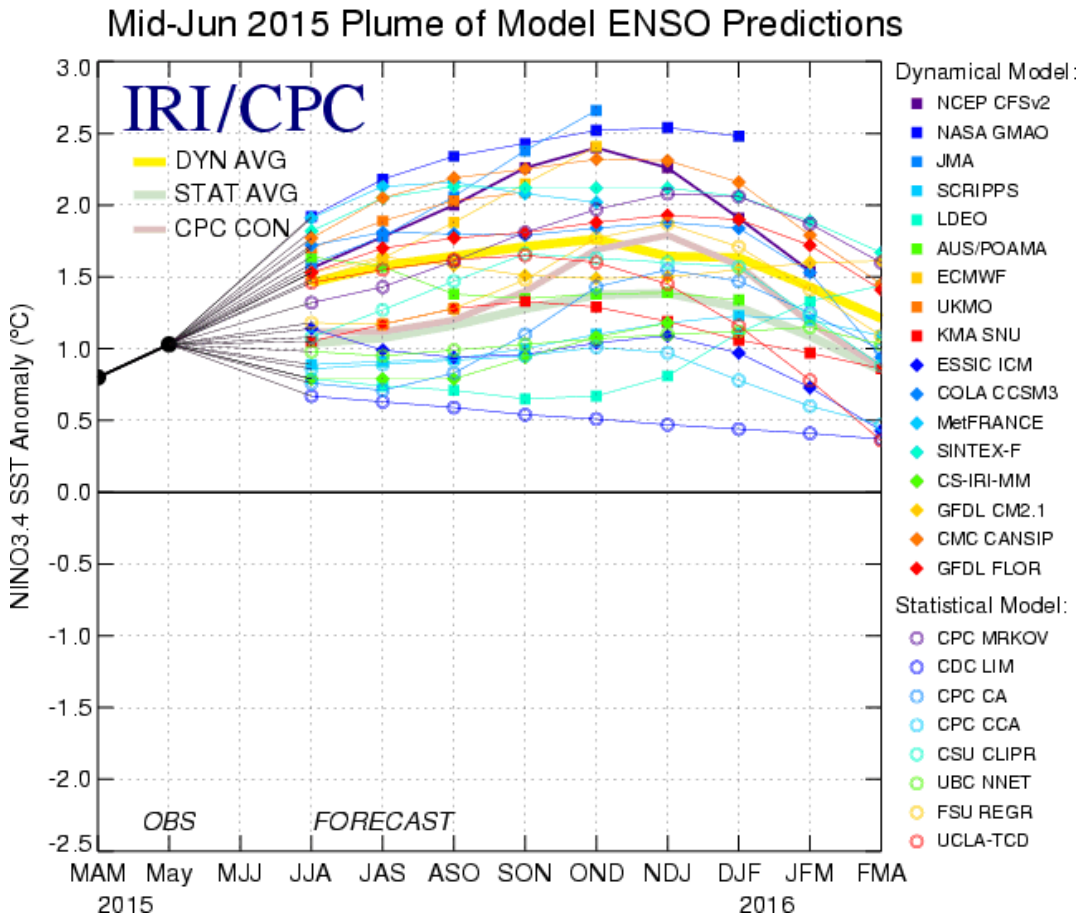
Multi Model Ensemble Forecasting

- Run with many models



Which one??

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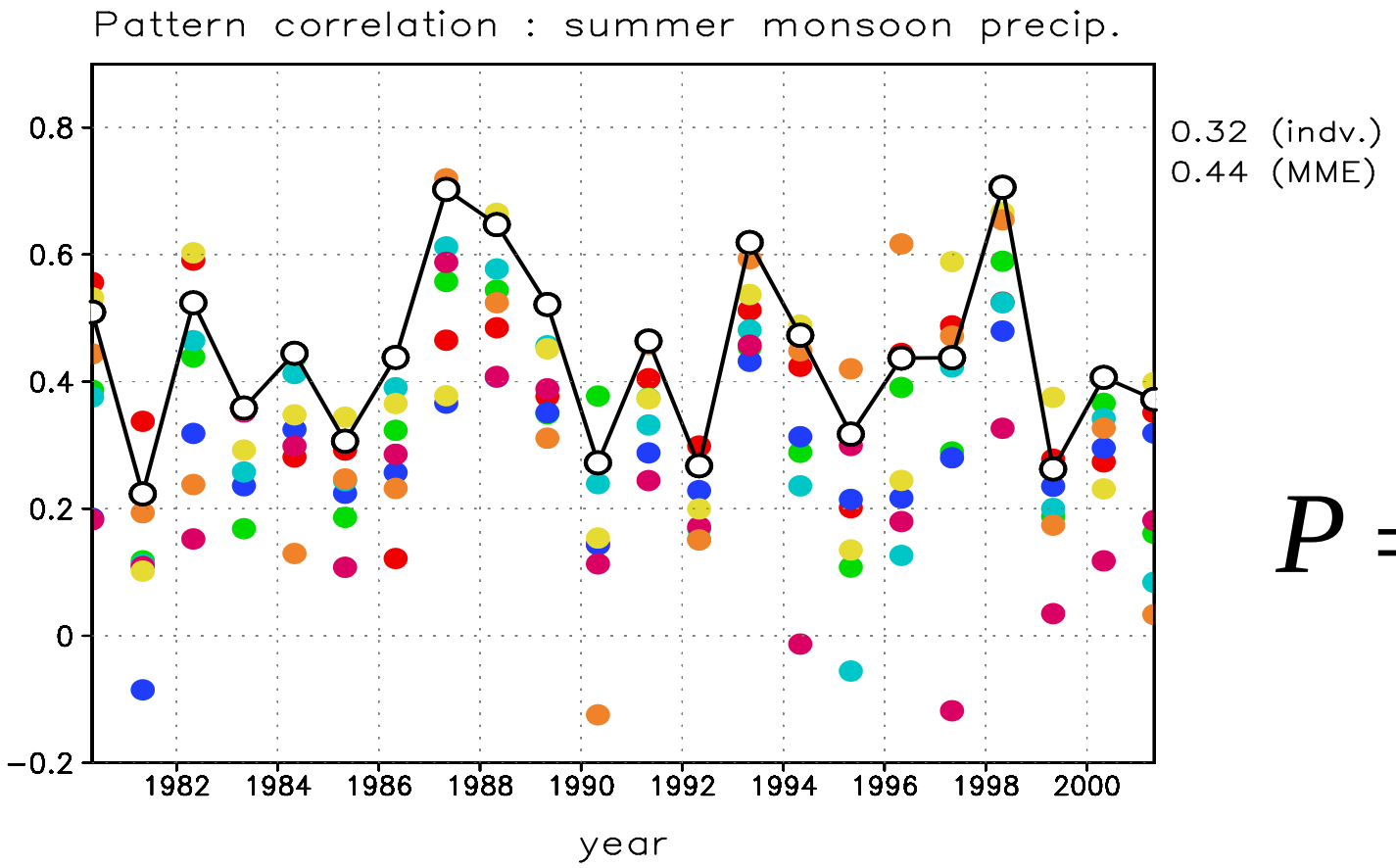
Use all!



$$P = \sum_i a_i F_i$$

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Predictability of Multi Model Ensemble

Correlation skill of a single model

$$R_i = \frac{\overline{xy_i}}{\sqrt{V(x)V(y_i)}}$$

Correlation skill of MME

$$\langle y \rangle = 1/M \sum_{i=1}^{M} y_i$$

$$R_{MM} = \frac{\overline{x\langle y \rangle}}{\sqrt{V(x)V(\langle y \rangle)}} = \frac{1}{M}\sum_{i=1}^{M}\left(R_i \sqrt{\frac{V(y_i)}{V(\langle y \rangle)}} \right) = \langle R \rangle \sqrt{\frac{\langle V(y) \rangle}{V(\langle y \rangle)}}$$

$$\langle R \rangle = \frac{1}{M}\sum_i R_i$$

$$V(\langle y \rangle) = \langle V_{Single} \rangle - \frac{M-1}{M}\langle V(y_n) \rangle - \frac{M-1}{M}\langle (V(e) - C(e)) \rangle$$

$$R_{MM} = \frac{\langle R \rangle}{\sqrt{V(\langle y \rangle)}} = \frac{\langle R \rangle}{\sqrt{\langle r \rangle}}$$

$$\langle r \rangle = \frac{1}{M^2}\sum_i \sum_j \frac{\overline{y_i y_j}}{V}$$

$$E_{MM} = \langle V_{Single} \rangle (1 + \langle r \rangle - 2\langle R \rangle)$$

$$Observation : x = x_s + x_n$$

$$Forecast : y = y_s + y_n = x_s + e + y_n$$

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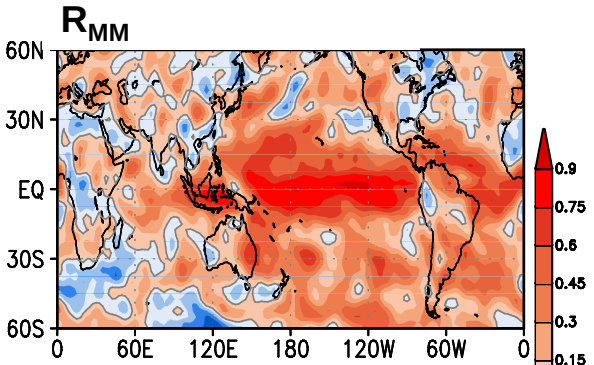
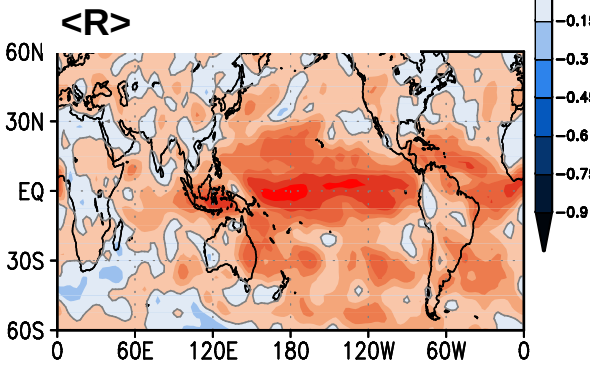
Temporal correlation skill (SUMMER MEAN PRCP)

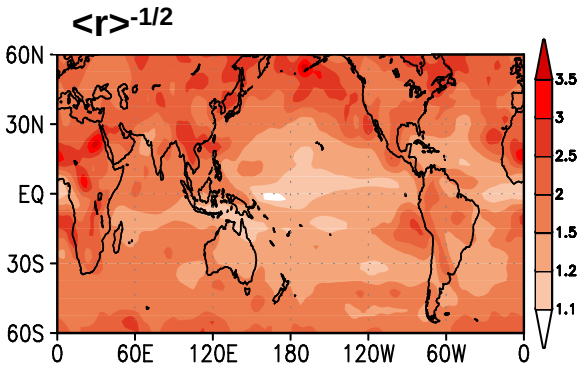
Multi-model ensemble correlation skill



Mean correlation skill of individual models

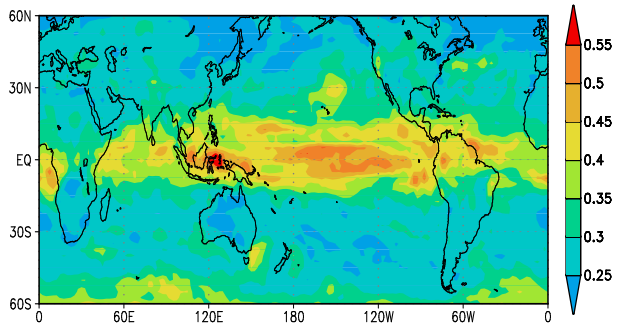


Inflation factor of correlation skill by multi-model ensemble



$$V(\langle y \rangle) = V_{Single} - \frac{M-1}{M}\langle V(y_n)\rangle - \frac{M-1}{M}\langle (V(e) - C(e))\rangle$$

Contribution of systematic error (conditional) cancellation



$$R_{MM} = \frac{\langle R \rangle}{\sqrt{V(\langle y \rangle)}} = \frac{\langle R \rangle}{\sqrt{\langle r \rangle}}$$

Independent and good models : Best forecast result (on average)

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Beauty of Democracy

- Independent and Rational individuals :
  - Best decision for society (in a long run)

Seasonal Prediction (3)
: Evaluation and Downscaling

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Which one?

- Evaluation of forecast : verification

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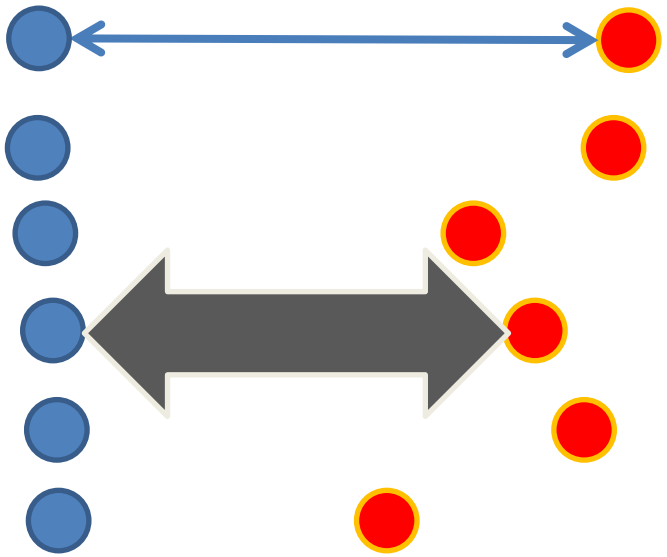
Verification

- Evaluation : measure of closeness



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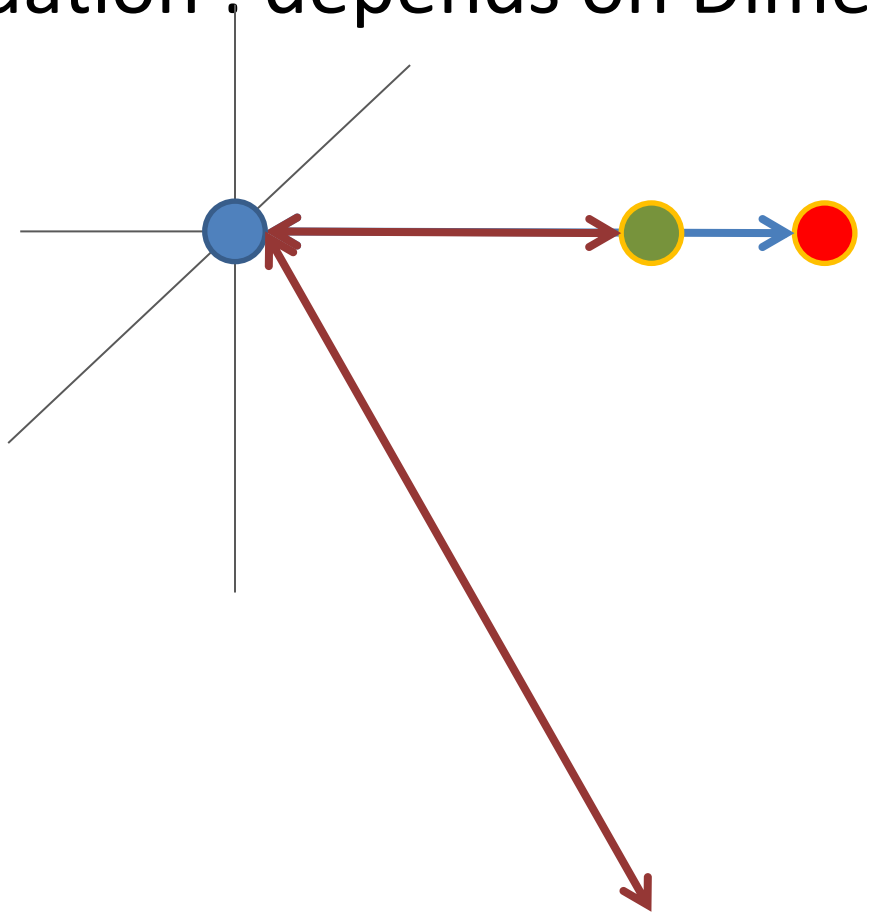
Verification

- Evaluation : depends on Dimension/Viewpoint



Deterministic forecast

- Various measures
  - MSE (Mean Square Error), RMSE (Root MSE)
    - $MSE = \frac{1}{N}\sum_i (F_i - O_i)^2$
  - ACC(Anomaly correlation, Pattern), TCC (Temporal correlation)
  - MSSS (Mean Squere Skill Score)
    - Conventional form of skill score
    - $1 - \frac{E}{E_c}$, E : error/penalty, Ec : error of reference forecast

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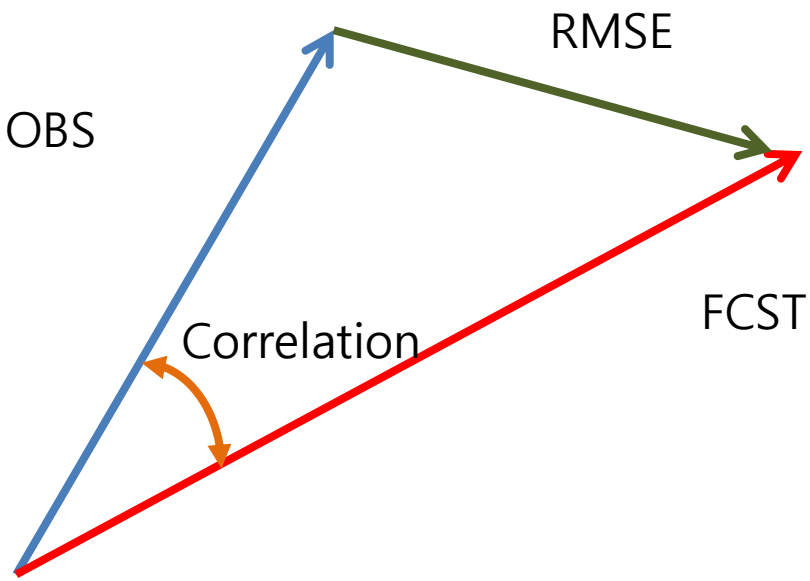
Verification

- Evaluation : depends on Dimension/Viewpoint



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Probabilistic forecast

- Brier score (Brier Skill Score)
  - MSE of prob. forecast
    - $BS = \frac{1}{N}\sum_i (F_i - O_i)^2$, F=1/0, O=1/0
    - BSS (Brier skill score)
      - $1 - \frac{BS}{BS_c}$,
      - E : error/penaly, Ec : error of reference forecast

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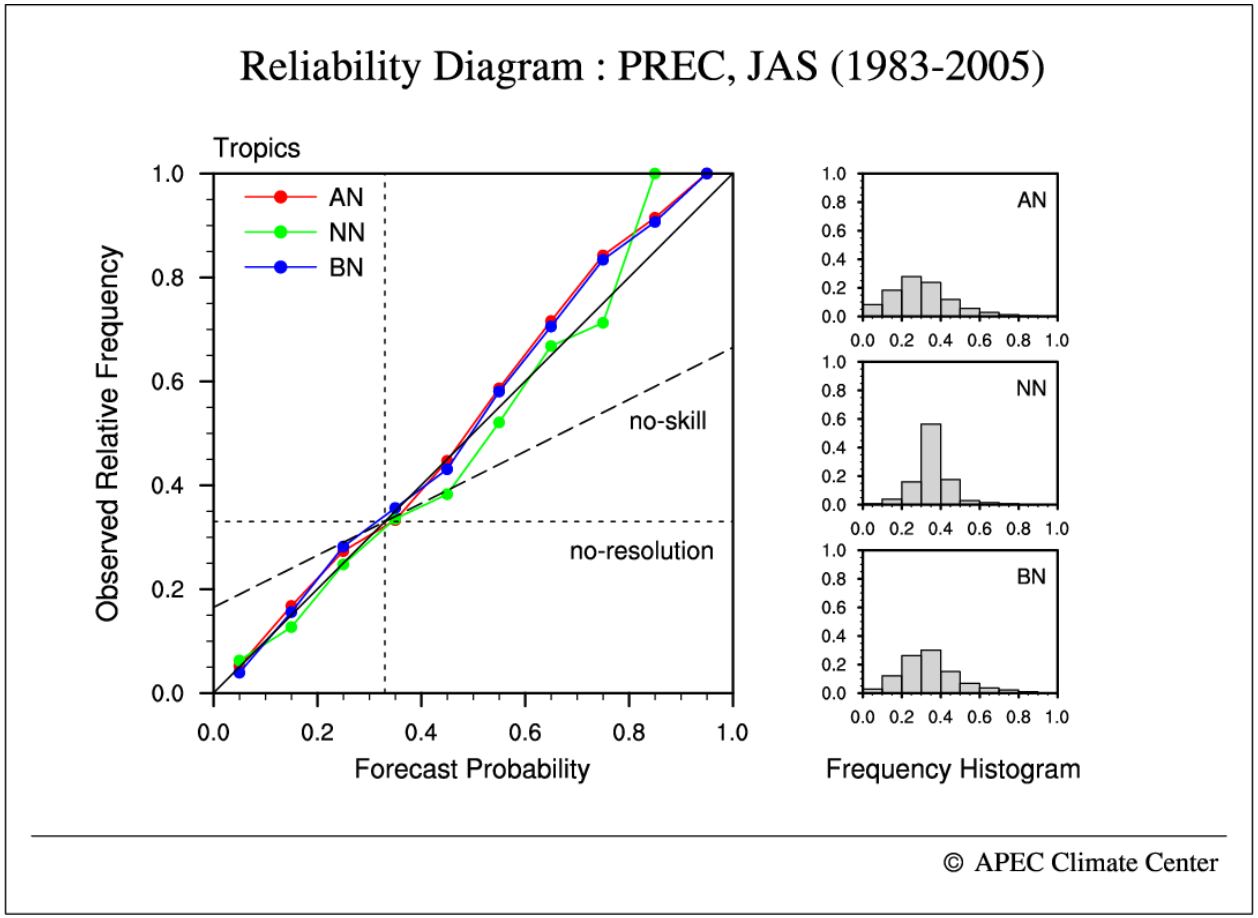
Probabilistic forecast (Categorical)

- Reliability curve



Probabilistic forecast (Categorical)

- ROC (Relative Operating Characteristics)

F \ O	Yes	No
Yes	Hit (H)	False Alarm (F)
No	Miss (M)	Correct Rejection (C)

  - *HR (Hit rate) = H/(H+M)*
  - *FAR (False Alarm rate) = F/(F+C)*
    - *Good forecast : HR↑, FAR ↑*

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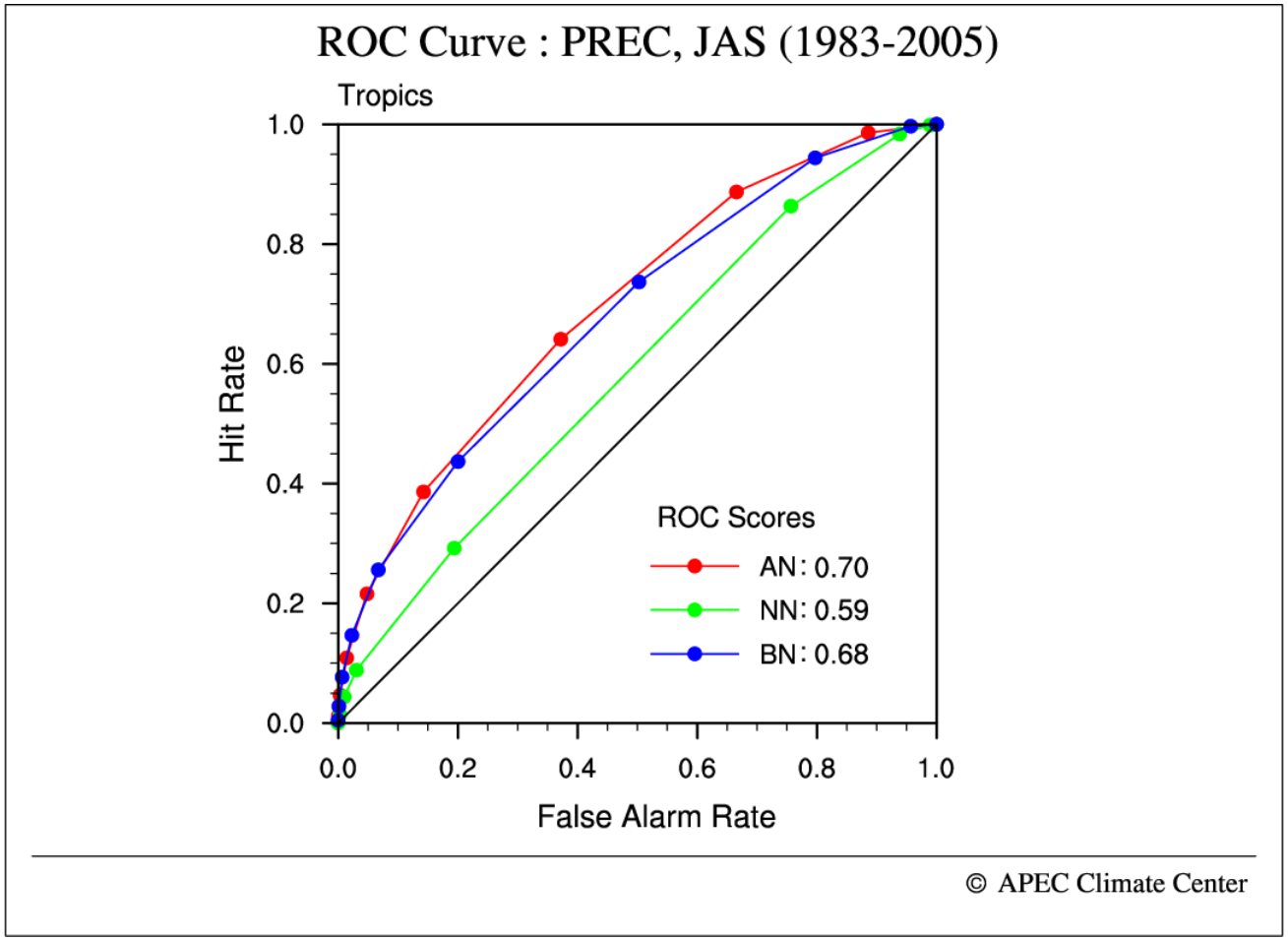
Probabilistic forecast (Categorical)

- ROC (Relative Operating Characteristics)



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Probabilistic forecast (Categorical)

- HSS (Heidke Skill Score)

F \ O	Yes	No
Yes	Hit (H)	False Alarm (F)
No	Miss (M)	Correct Rejection (C)

- *HSS = (score – score by chance)*
  /(perfect score – score by chance)

$$\{(h+c)/n - [(h+f)(h+m)+(f+c)(m+c)]/n^2\}$$
$$/\{1 - [(h+f)(h+m)+(f+c)(m+c)]/n^2\}$$

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Forecast economic value

$$V = \frac{E_{cli} - E_{fore}}{E_{cli} - E_{per}}$$

		Observation (real event)	
		Yes	No
Forecast (action)	Yes	Hit (h) Cost	False alarm (f) Cost
	No	Miss (m) Loss	Correct rejection (c) 0

V=1 : perfect forecast

V=0 : climatological forecast

$$E_{fore} = (h + f)C + mL$$

E_{fore} : Expected expense of forecast

E_{per} : Expected expense of perfect forecast

E_{cli} : Expected expense of climatological forecast

- When the forecast is perfect, f = m = 0. and h=ō. Then, $E_{per} = hC = \bar{o}C$
- When the forecast is climatology. The only one kind of action will be kept.

If Yes : E=(h+f)C=C, otherwise E=mL=ōL. If decision maker is rational, he/she will choose action of low expense. Thus, $E_{cli} = \min(C, \bar{o}L)$

$$V = \frac{\min(\frac{C}{L}, \bar{o}) - (h + f)\frac{C}{L} - m}{\min(\frac{C}{L}, \bar{o}) - \frac{C}{L}\bar{o}}$$

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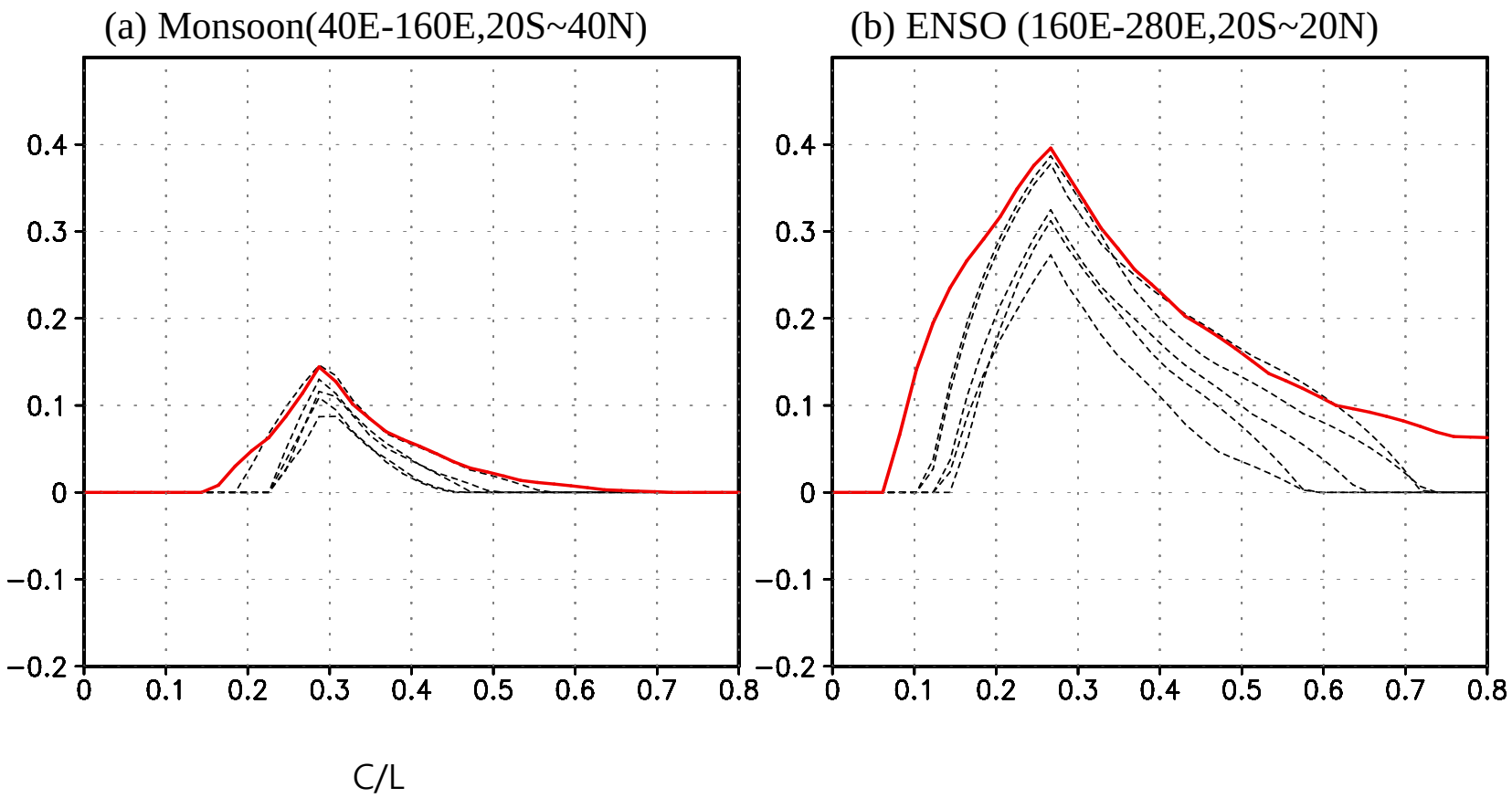
Value of Probabilistic forecast (Above normal) : GCMs



Forecast verification

- There are numerous ways
- Can be chosen by “what” do you want to see
- If not clear, use popular one.
- Difficulties in “translating” meteorological skill score into Public wording.

- Let’s see some results!

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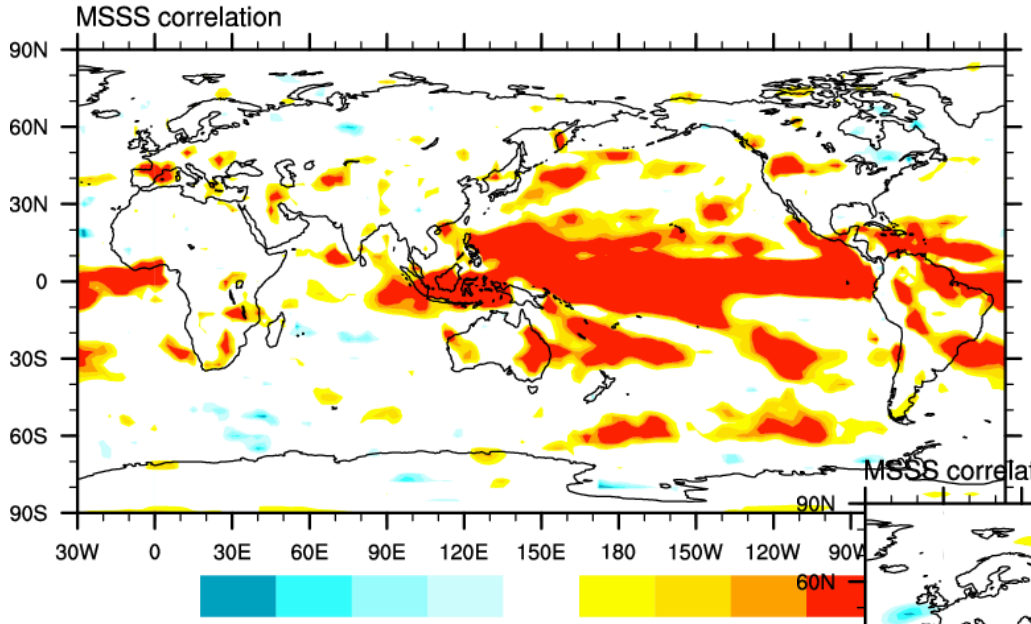
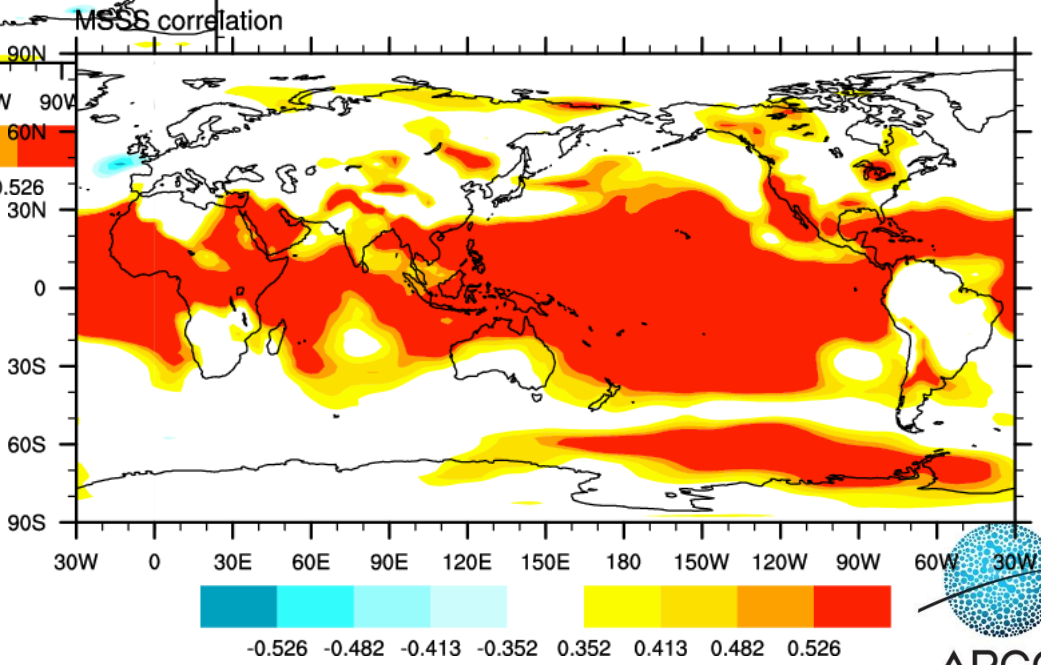
APCC MME (TCC)



Rainfall (JJA)



SLP (JJA)

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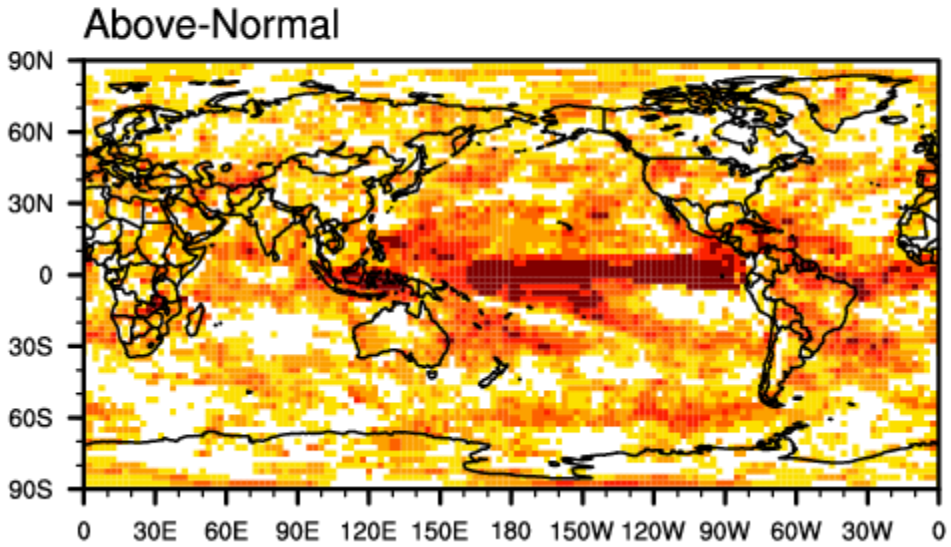
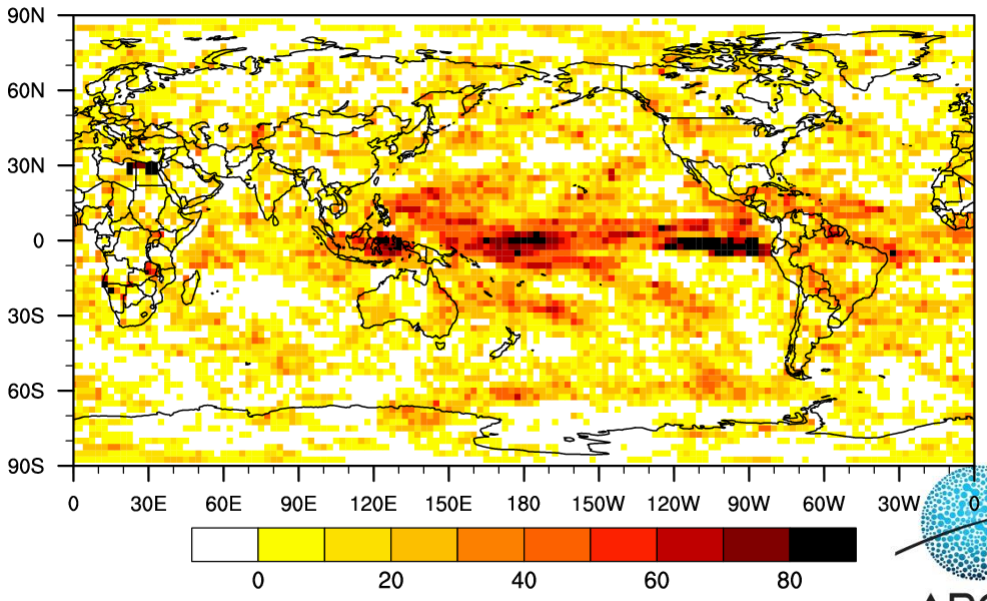
ROC Score : PREC, JJA (1983-2005)



Heidke Skill Score : PREC, JJA (1983-2005)



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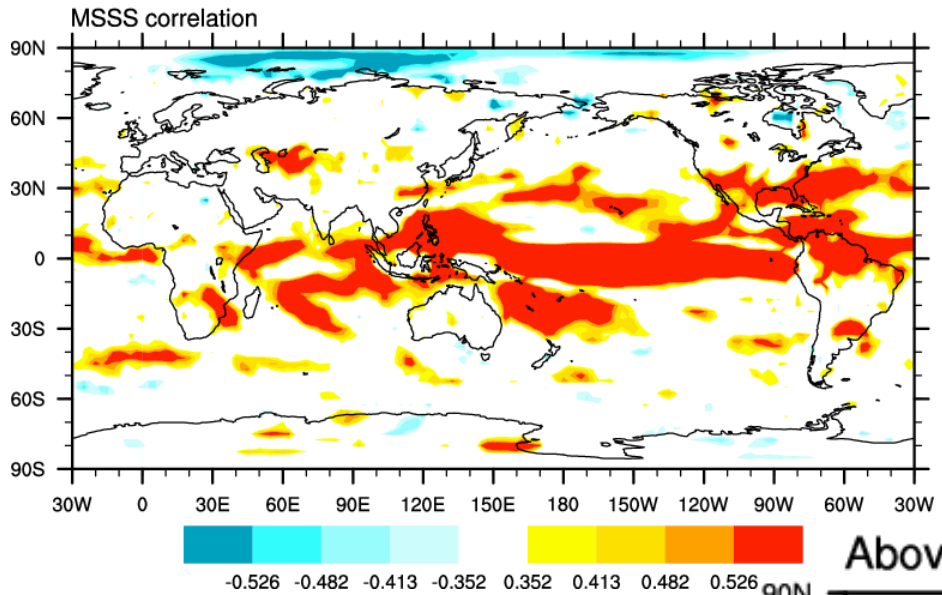
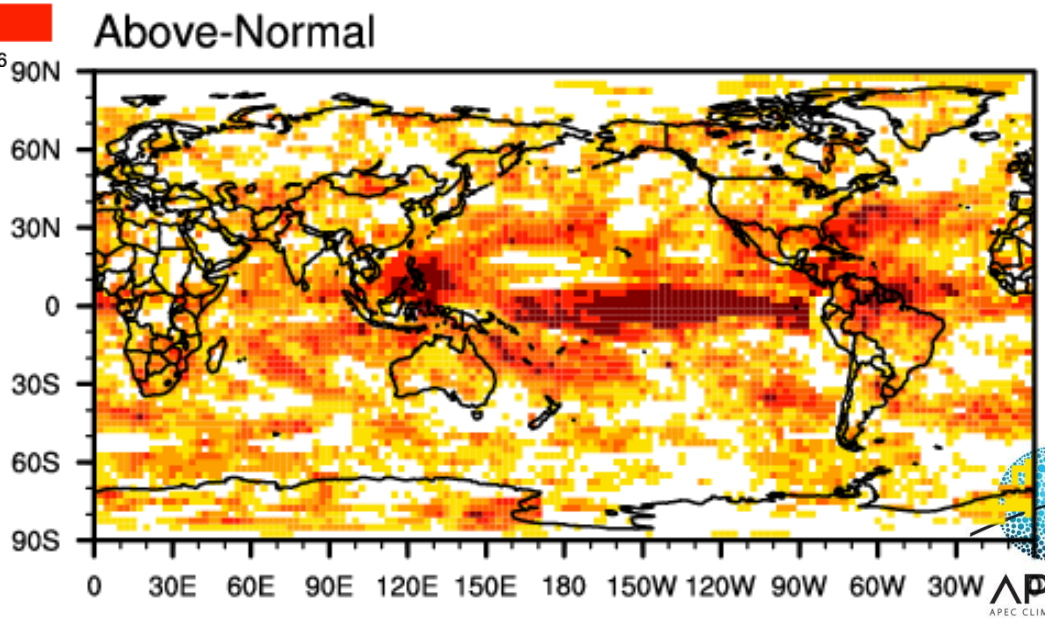
DJF season



Rainfall (JJA)

ROC score
Rainfall (DJF)



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R = 0.5, how good it is?

- Explaining 25% variance (R^2)
- A single verification score cannot tell everything.
- Multi aspect evaluation is necessary
- User oriented verification would be useful

- “this man can run fast, how good he is?”

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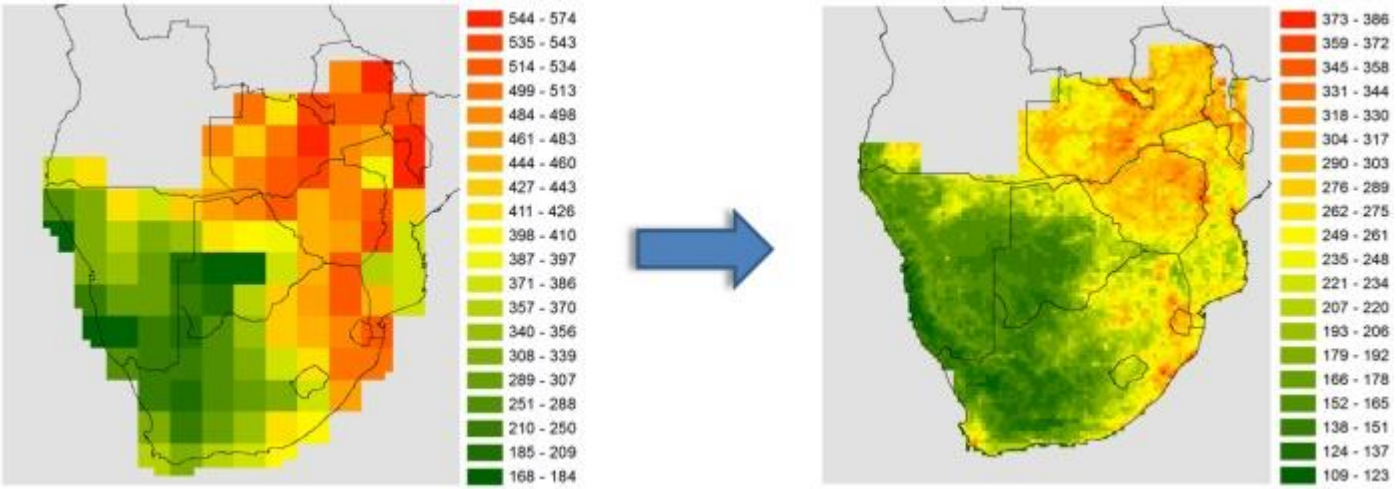
Downscaling



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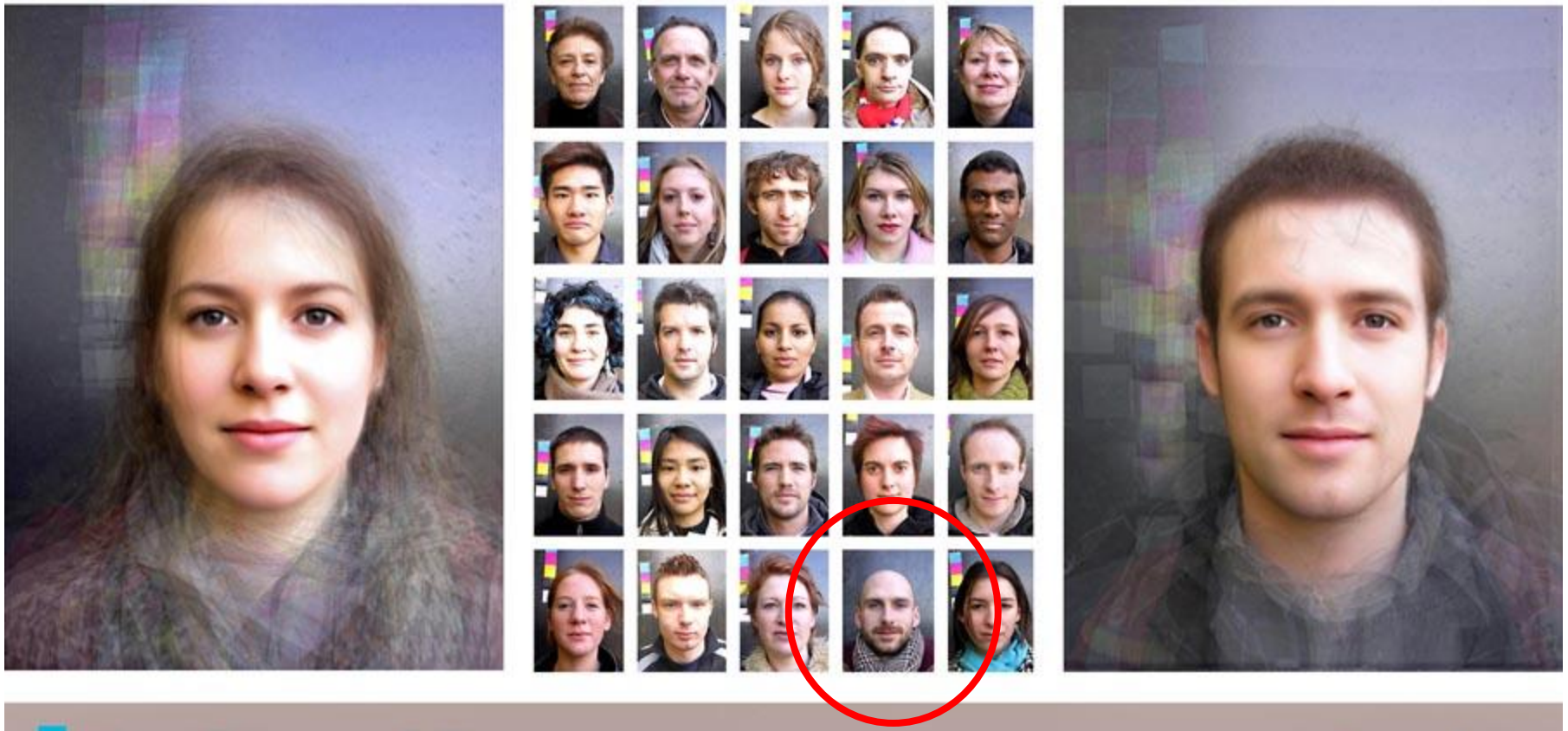
Average face



Average face

We need additional information to downscale

- How to draw the information of a particular “point” from averaged(large scale) value
  - Resolve the process determining point value
  - Find a relationship between the point and large scale

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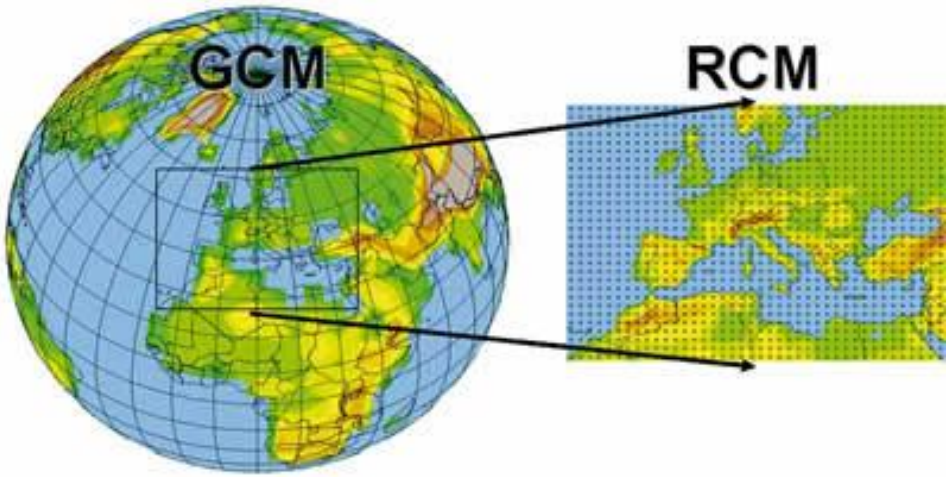
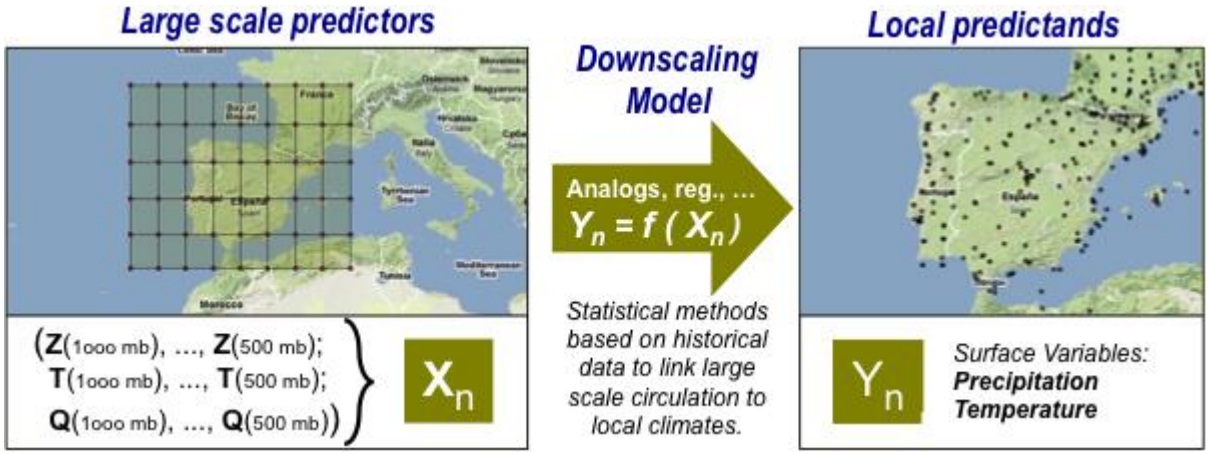
HOW?

Dynamical



Statistical



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What if the Large scale information is not very correct?

- Statistical downscaling can be understood as
  - A statistical forecast based on “forecast” field
- Dynamical downscaling is mostly useful
  - only if the problem is associated with resolving topography (or other complexity of land surface)

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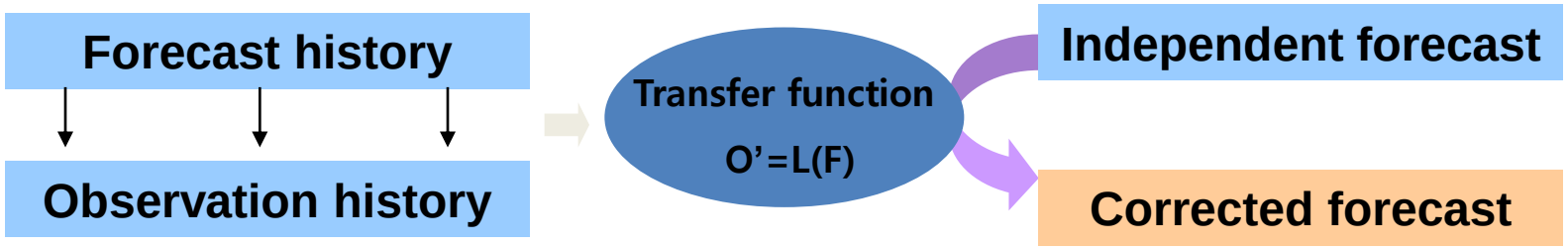
Statstical downscaling : CLIK



There are many approaches in post-process, All of them share similar assumption. :
Statistics between forecast and observation is stationary

If statistics is not stationary, post-process will not work in independent forecast

Thus, statistical stability is a rule of thumb in the statistical post-process (avoiding overfitting)

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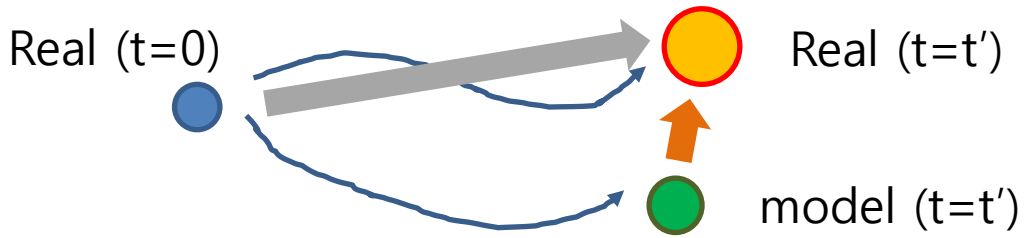
Approach

- **Statistical forecasting based on past forecast**

$y(s,t)$: observation
$x(s,t)$: forecast

$$y'(t) = f(x(t), \alpha), \alpha = g(x(1:t-1), y(1:t-1))$$



- **The most common way : Regression**

$$\sum_j b_j y_j = \sum_i a_i x_i + \epsilon$$

- If i & j = 1 : Linear regression
- i > 1, j = 1 : Multiple regression
- i & j > 1 : CCA, SVD, etc

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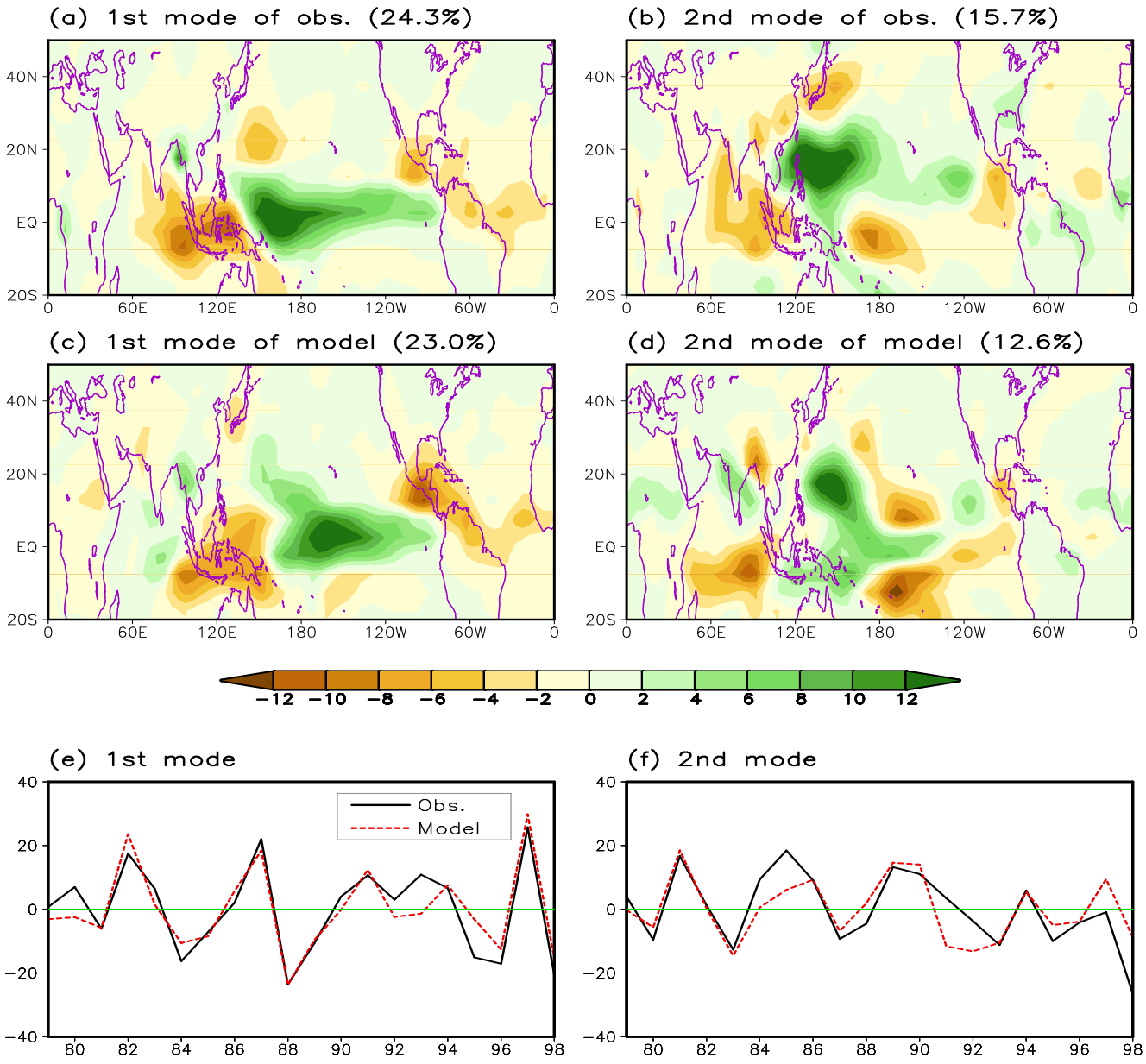
EOF of Summer Mean Precipitation



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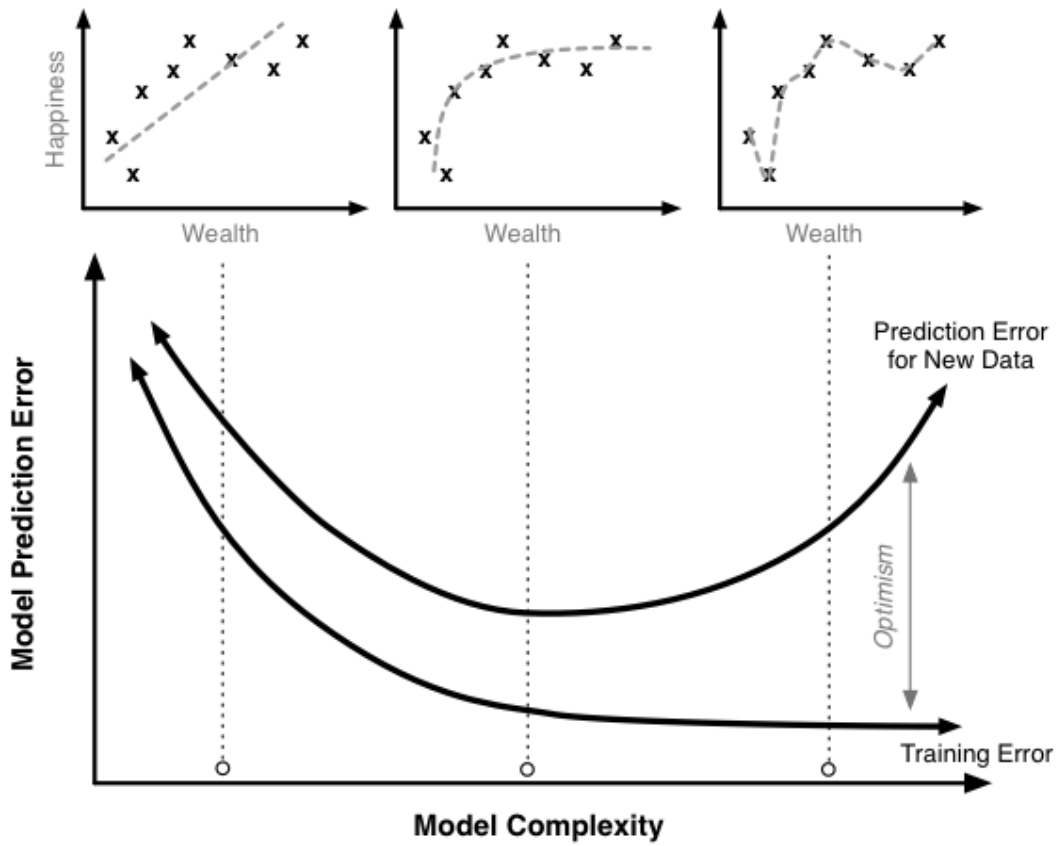
Weakness : overfitting

- **Consider potential predictability**



from Scott Fortmann-Roe 2012

If model output is fitted to the unpredictable noise : Overfitting.

What if we remove “noise” in the observation?

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The most important thing

- Physical understanding of;

1. What weather event/system consists of your seasonal climate (LOCAL, predictand)
2. What external (slow varying factor) controls the weather system (GLOBAL, predictor)

And, whether model is able to predict 1 or 2

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Clik
Climate Information Toolkit

CLIK

http://clik.apcc21.org

CLIK : online prediction tool

- For those who wants to play with model data
- To allow user manipulation of multi model prediction in producing his/her own forecast
- To provide statistical downscaling capability using multi model prediction

  – Prediction : Diff. combinations
  – Downscaling : model to station matching

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Downscaling in CLIK

- Use "observed" large scale pattern (X) associated with climate variability at stations
- X needs to be predicted by GCMs to some degree
  - X becomes predictor (user selected area)

- CLIK does not provide any prior information for selection of predictor (to avoid overfitting)
  - Basic knowledge on Local large scale circulation and associated global teleconnection is necessary

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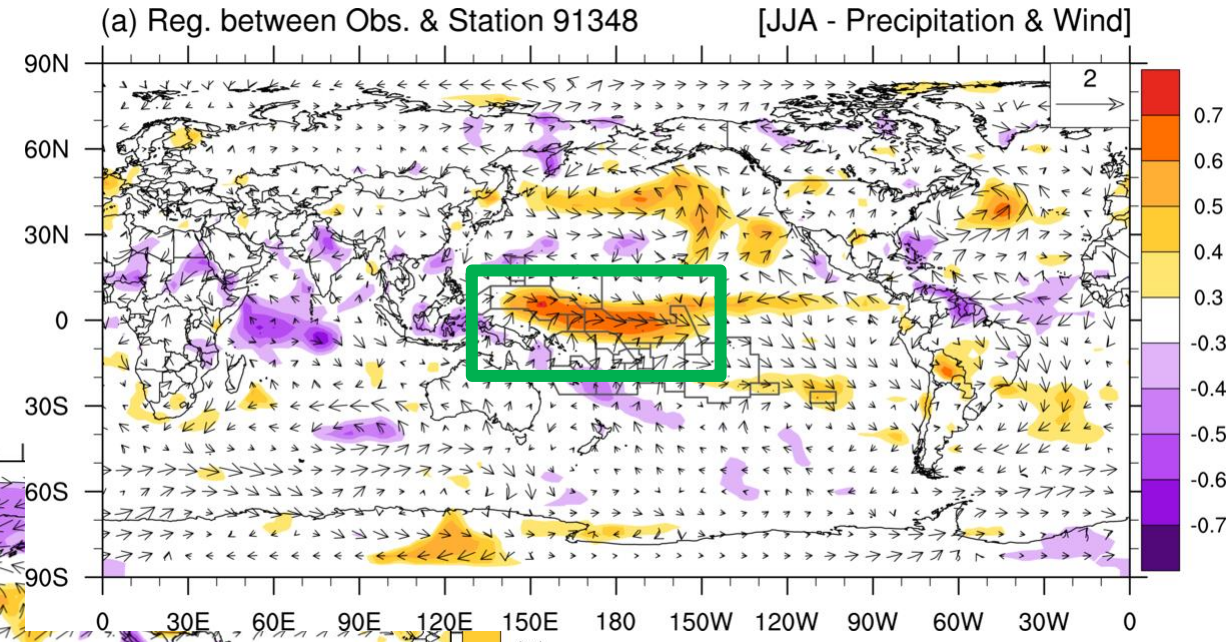
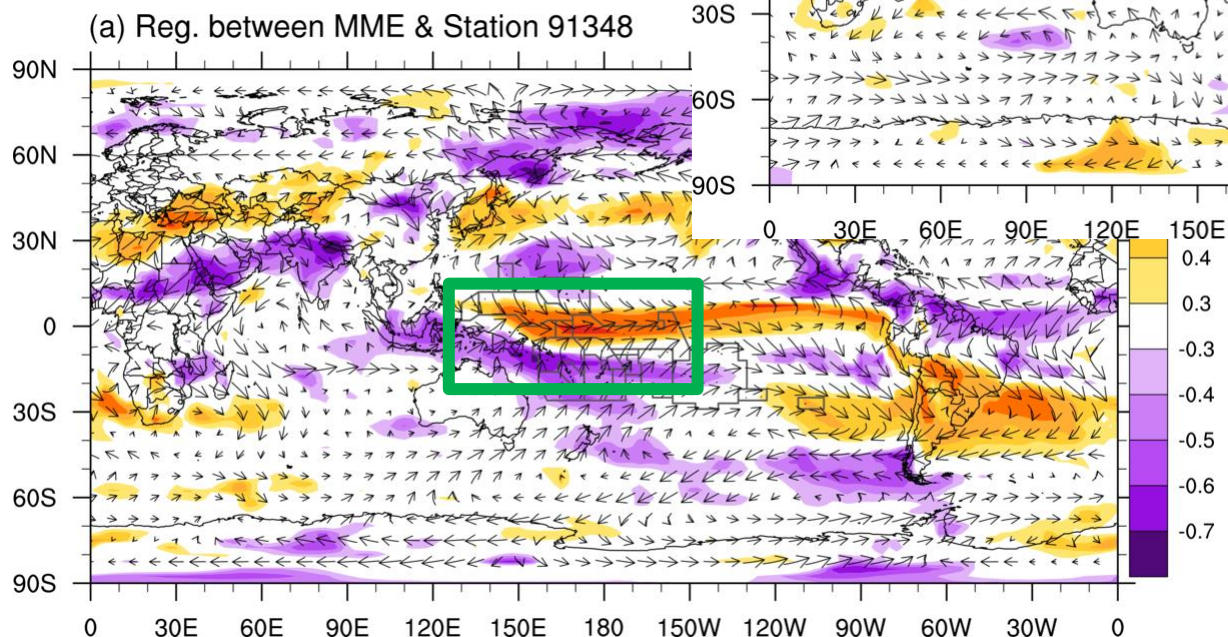
Predictor selection

Meaningful pattern? (hopeful)
: significance score

Station data





Consistency between obs. and GCMs (good)
: pattern score

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The most important thing you need is,

Patience

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Seasonal Prediction (4)
: Operation and discussion

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What we do?

- Collecting data and information
- Combine them
- Make a draft (preliminary decision)
- Consultation (discussion)
- Issue!

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Current observation (monitoring)

- ENSO
  - WMO El Nino Update
- IOD
- ISO
  - CPC MJO page, APCC BSISO page

Why we monitor (analyze) current climate state?

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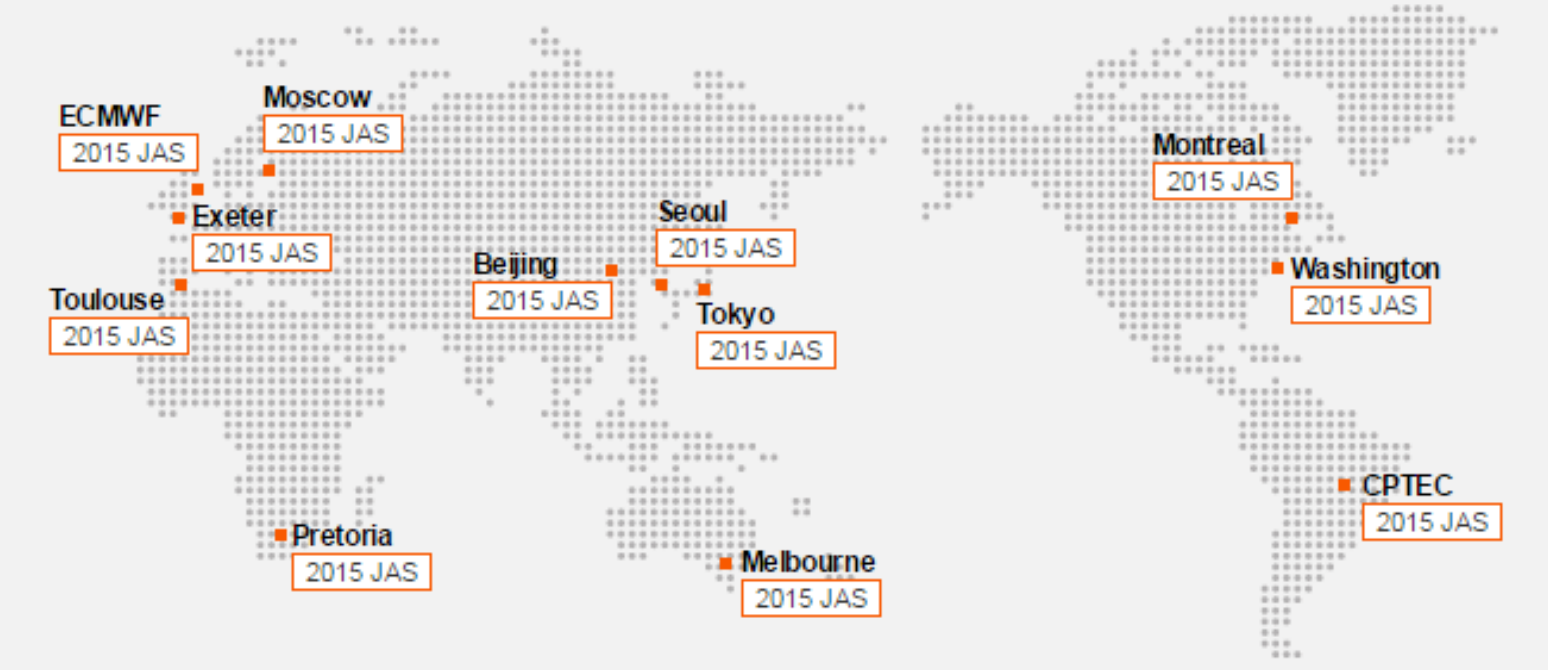
Global forecast Information

- Dynamical Seasonal Prediction
  - GPCs, WMO LC_LRF, APCC, IRI, NMME



www.wmolc.org : only open to WMO members

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Monitoring & Forecast information

- More maps are not always helpful unless they are DIGESTED properly
- It is known that Multi Model Ensemble tends to produce better forecast than a single model but it can loose regional details (maybe because of this, general skill is high)
- At best, all the information is merely explain large scale feature

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Combining information

- If you can trust one thing, that is enough
- If you have different information with similar reliability, trust both
  - Are they Independent?
- If you can distinguish good and better information (but they are different), combine them with weight
- If you don't have any idea on the reliability, treat them similarly (they are all 'state-of-art' information)

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Cautions

- How reliable our evaluation is?
- Even if you trust them, they can be wrong.
  - One reason to issue “probabilistic forecast”

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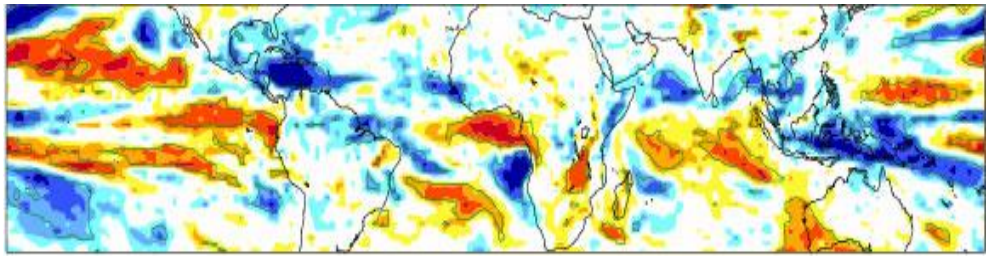
2006 JJA mean Rainfall forecast

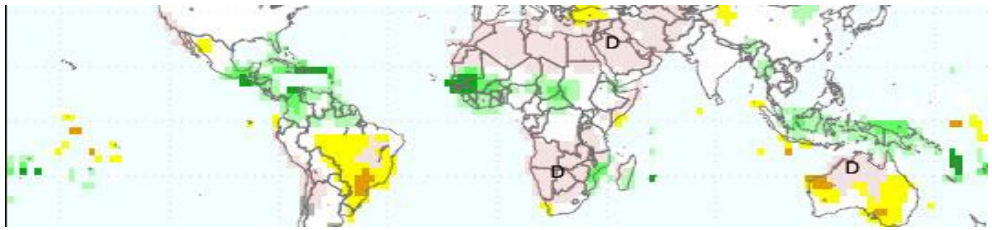
Warm colors : dry

Cool colors : wet

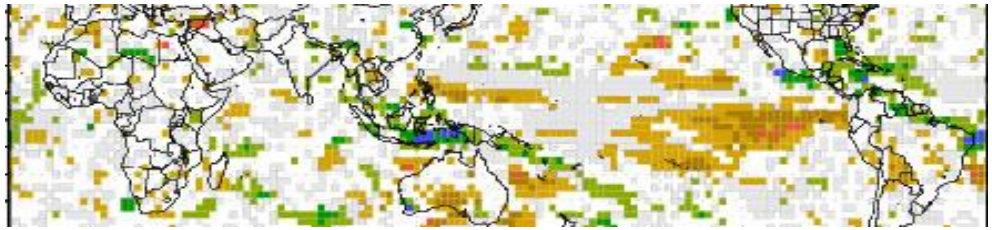
ECMWF



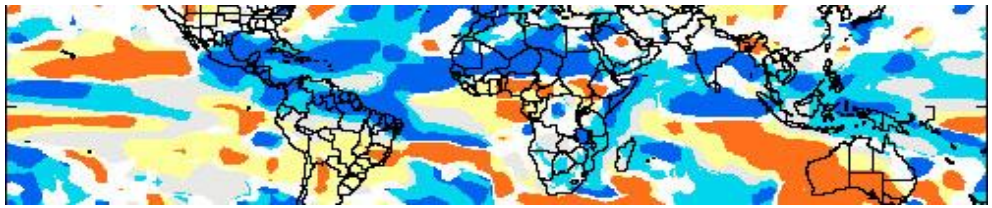
IRI

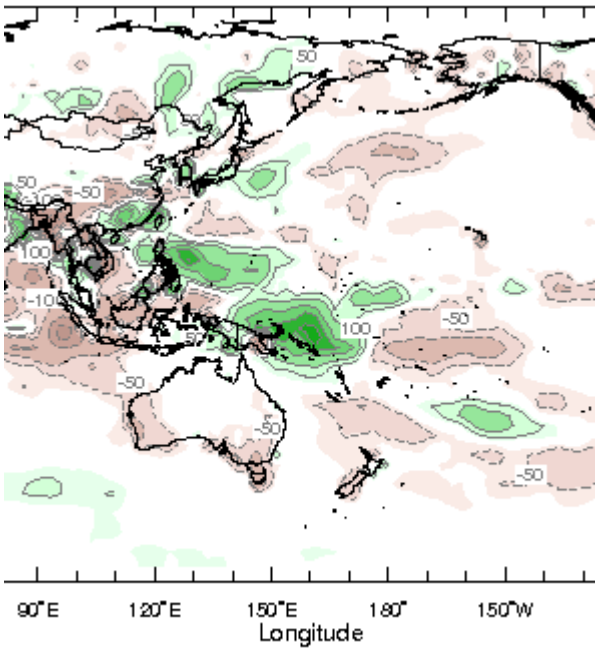


JMA



UKMO





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A few more…

- Subseasonal information (MJO…)
- A new type of El Nino (El Nino Modoki)
- Way forward

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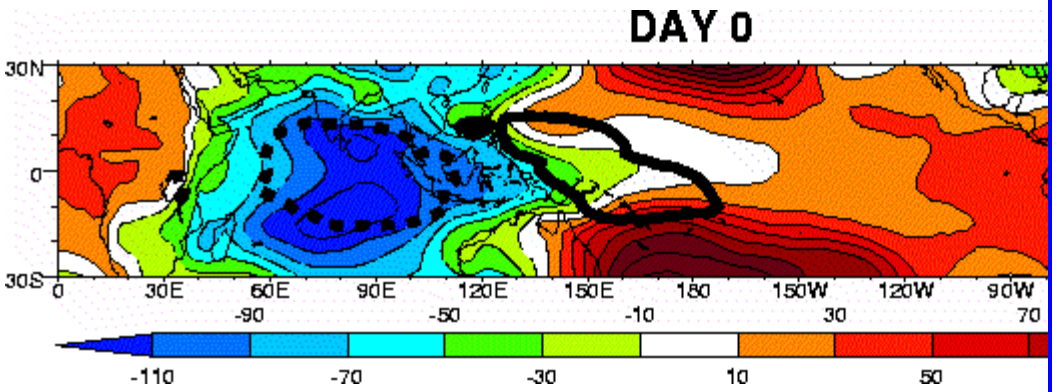
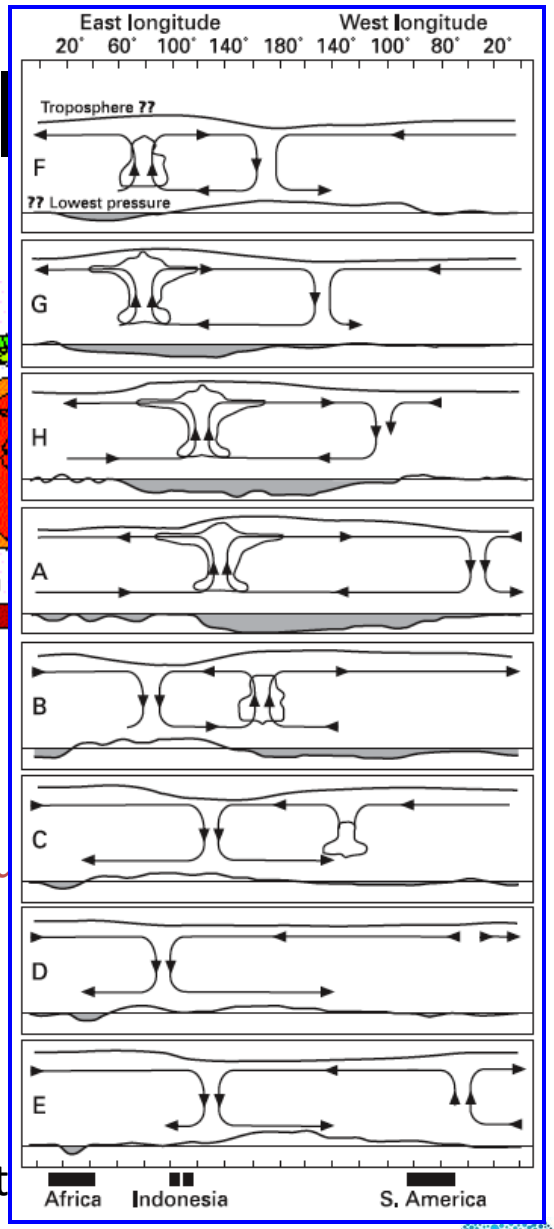
Madden-Julian Oscill





Madden & Julian (1971) : 40-50day oscillation (30-60days ISO)

Eastward moving large scale convective anomaly along the equ
baroclinic structure

(precipitation anomaly is predominant in Indo-Pacific sector)

It can be a predictability source of extended range forecast in t

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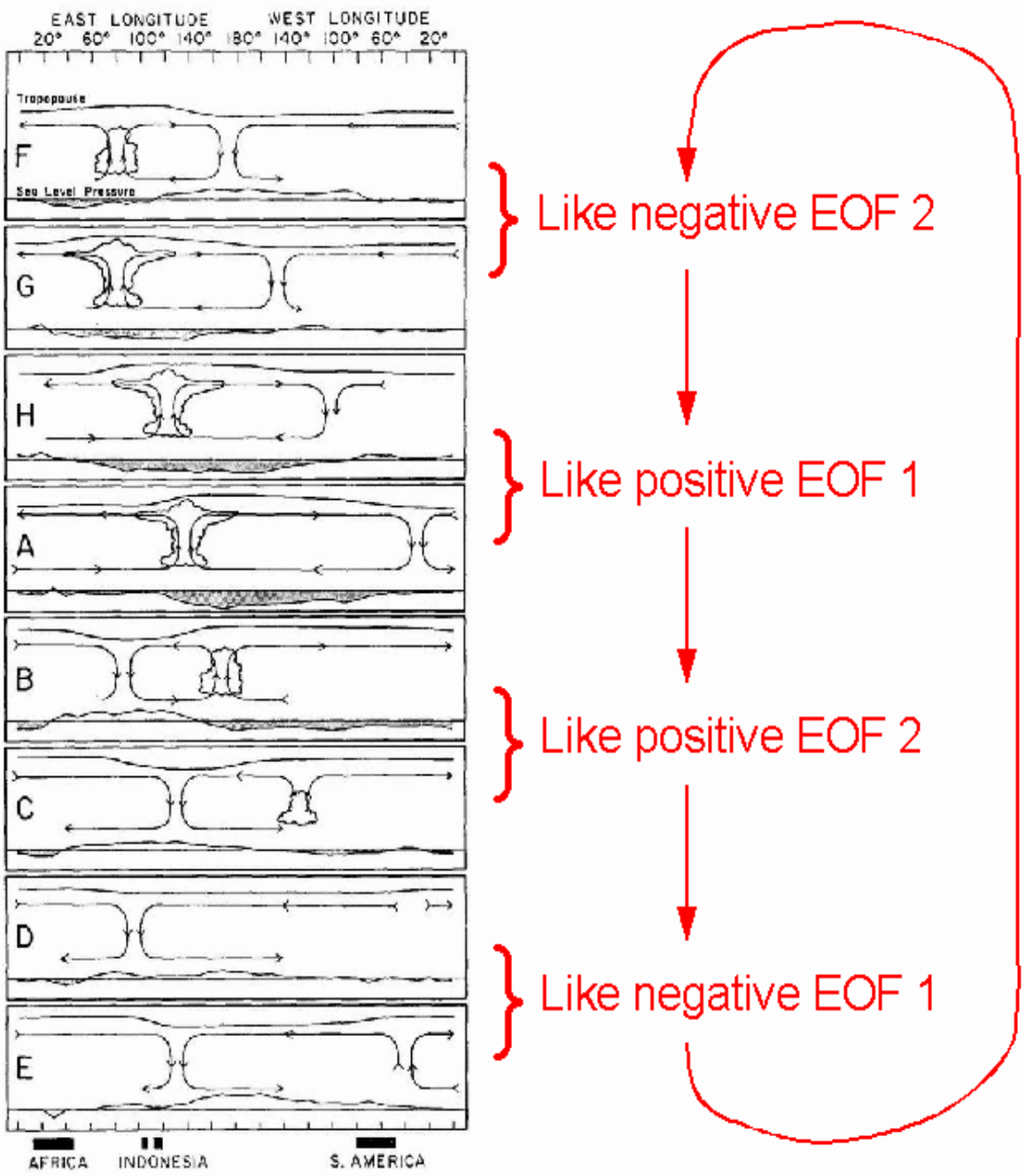
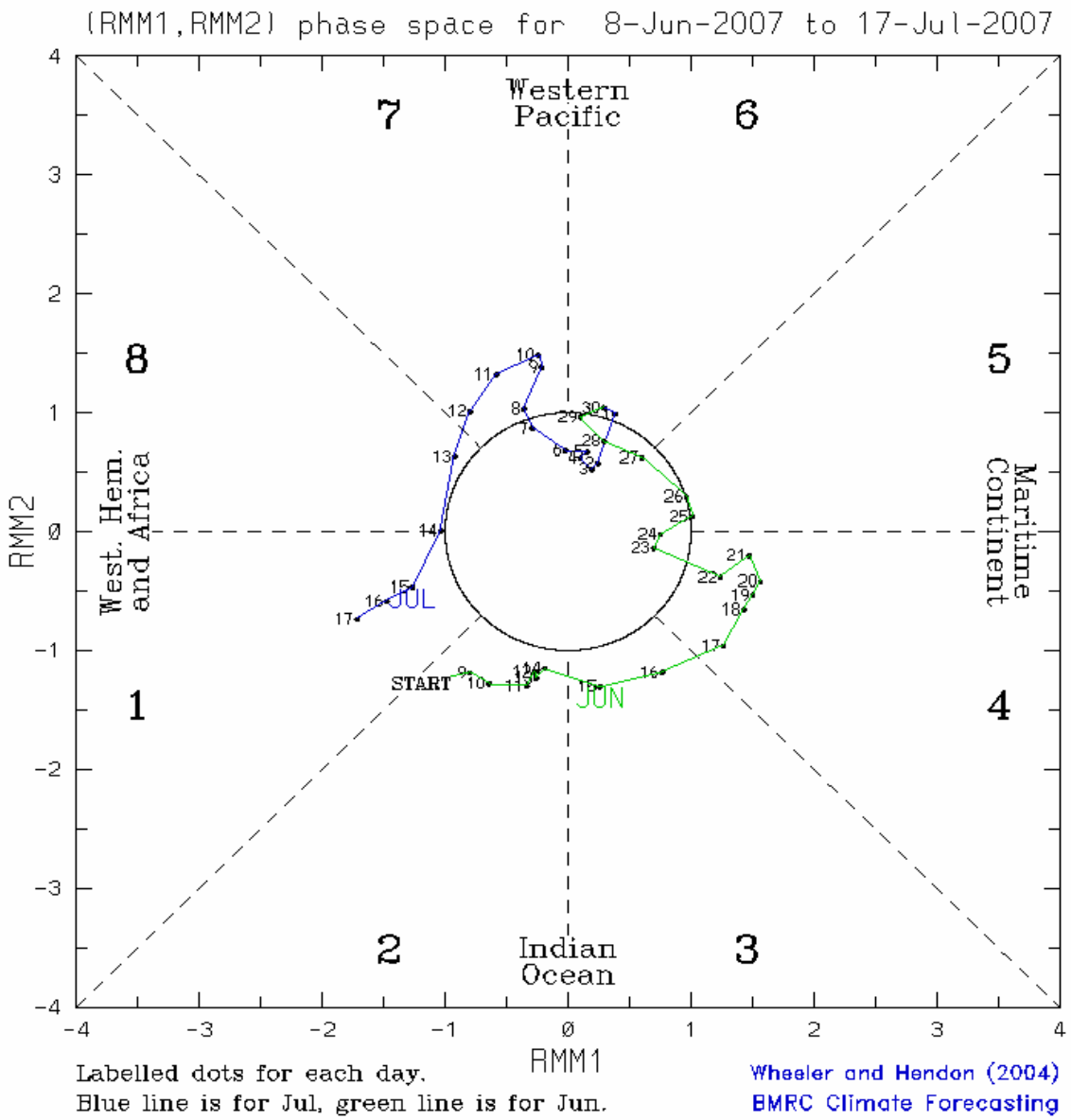
Madden and Julian (1972)





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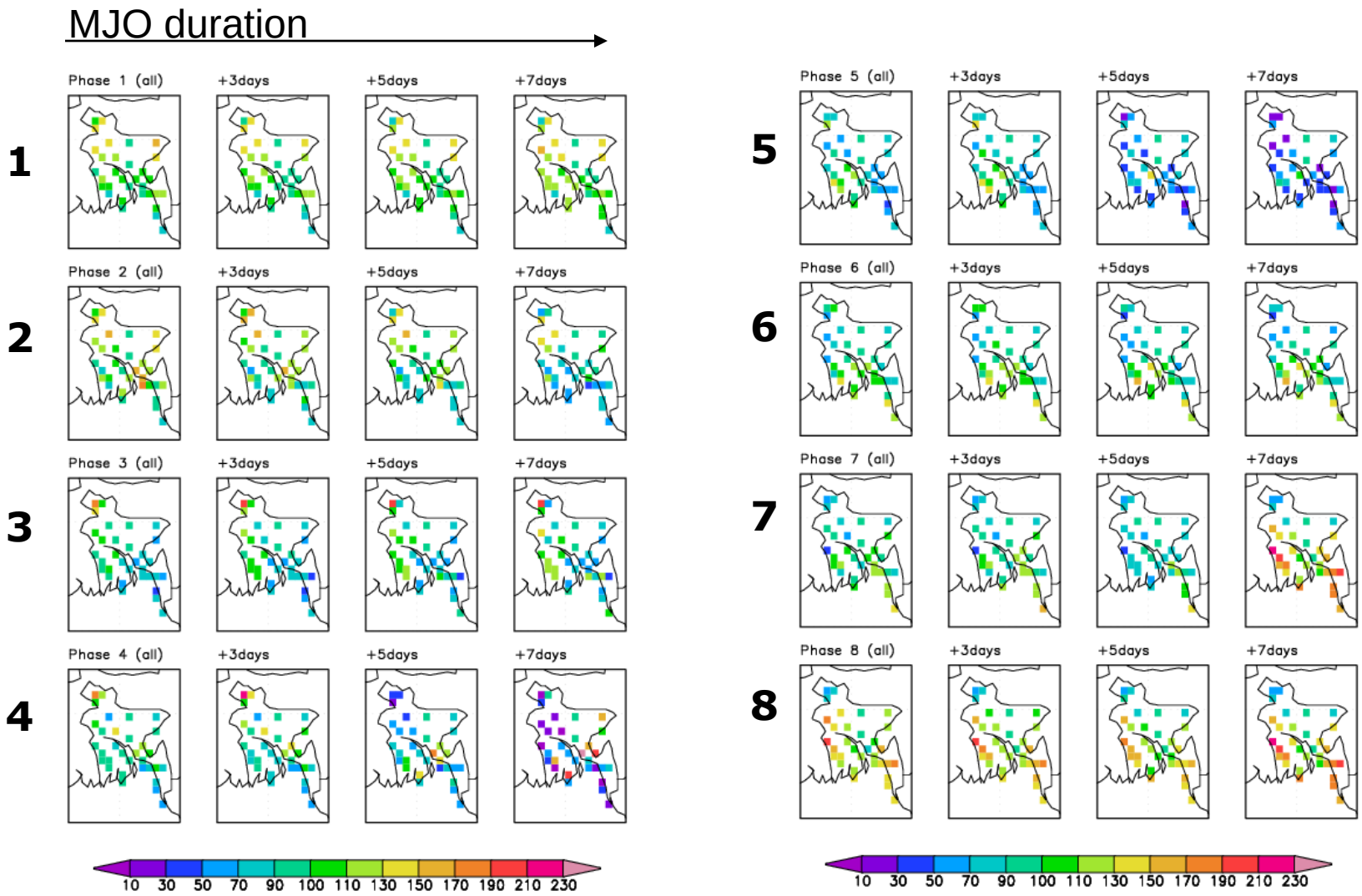
MJO and Bangladesh rainfall (% of climatology)



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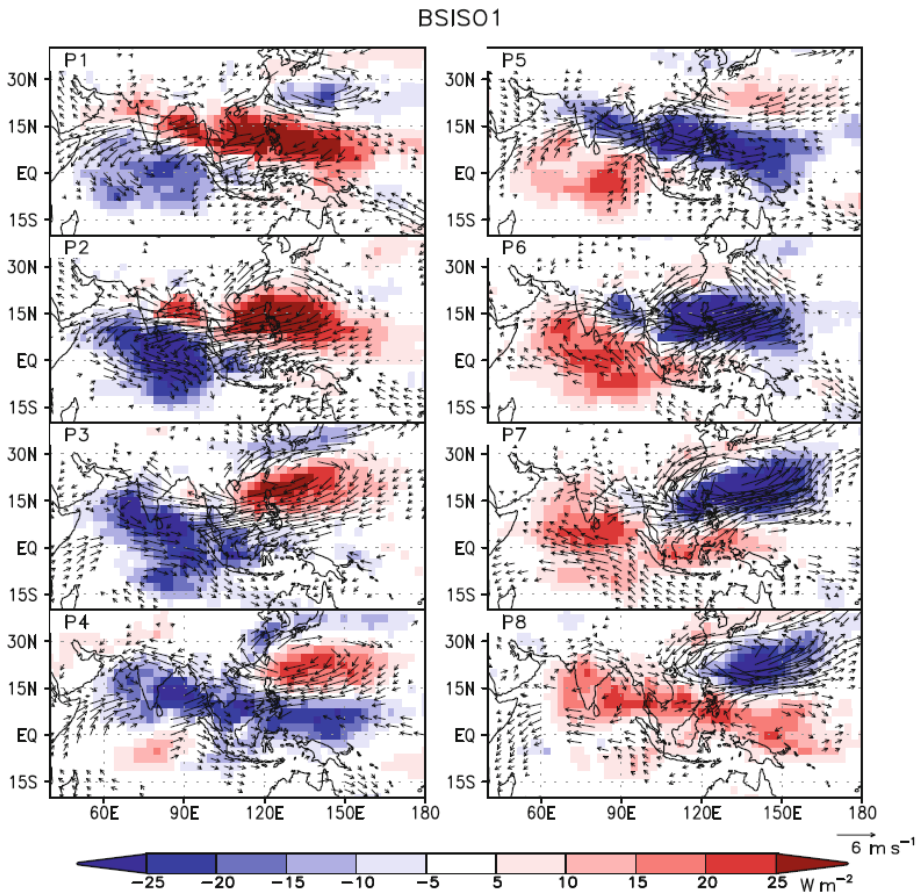
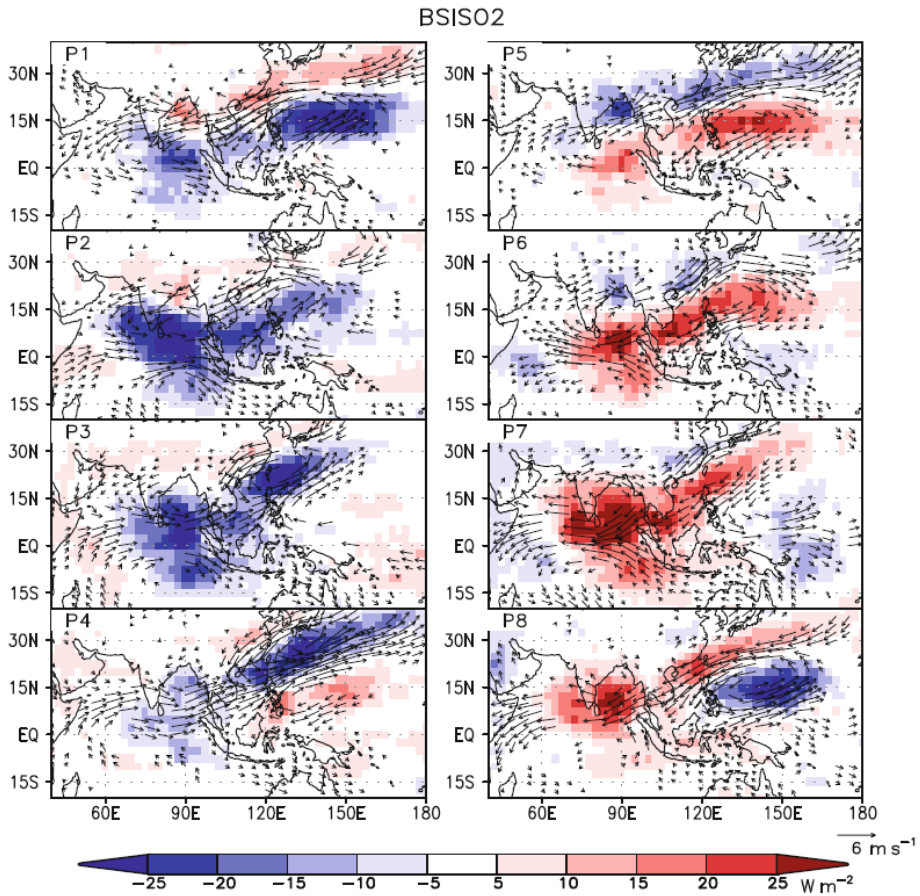
BSISO (Boreal Summer ISO)

The canonical northward propagating component



The AMS pre-monsoon and onset component



Lee, J.-Y., B. Wang, M. C. Wheeler, X. Fu, D.E. Waliser, and I.-S. Kang, 2013: Real-time multivariate indices for the boreal summer intraseasonal oscillation over the Asian summer monsoon region. Clim. Dyn., 40, 493-509.

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BSISO forecast (May-Oct)

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Forecasts

Welcome to the Boreal Summer Intraseasonal Oscillation (BSISO) forecast website. The BSISO forecast activity has been initiated in 2013 with the goal of improving our ability to understand and forecast the BSISO based on numerical models in cooperation with the CAS/WCRP Working Group on Numerical Experimentation (WGNE) Madden Julian Oscillation (MJO) Task Force, and hosted at the APEC Climate Center (APCC). This website will be updated as additional models become available and verification statistics and various ways of displaying forecast information generated. Below are links to the BSISO monitoring website and the MJO moel forecasts

BSISO Realtime Monitoring
Operational Realtime Dynamical Model MJO Forecasts

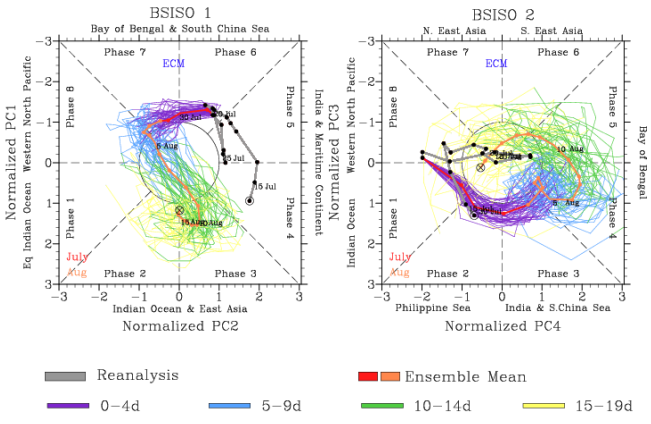
Dynamical Model BSISO Forecasts

A key for the label headings in the figure box is provided below.

Note: Move cursor over product name to display. Click for additional information.

Phase Plots of BSISO Index Forecasts			
BOM	CFS	GFS	UKM
ECM			

BSISO Forecast for 28July2014–16Aug2014

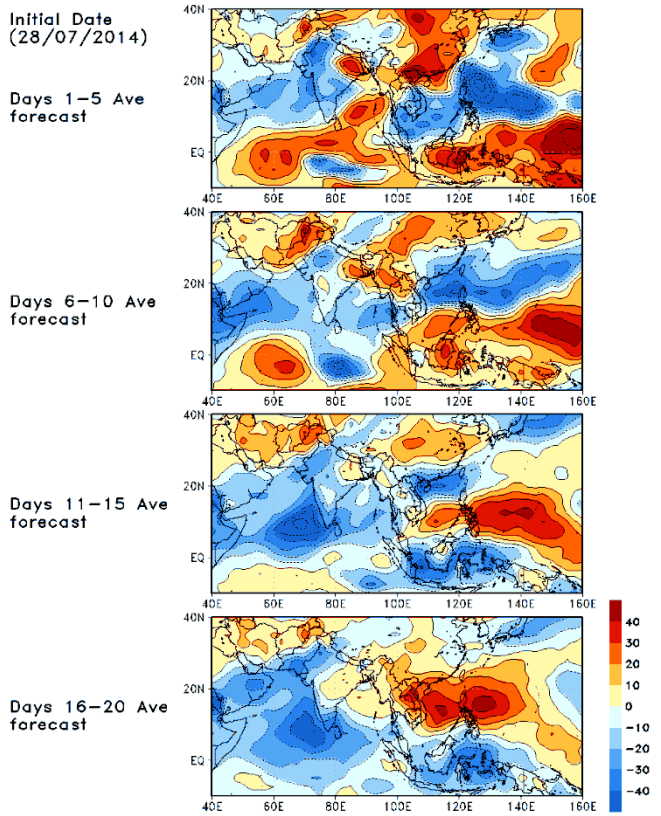


Spatial OLR Anomalies

A key for the label headings in the figure box is provided below.

Note: Move cursor over product name to display. Click for additional information.

Phase Plots of BSISO Index Forecasts			
BOM	CFS	GFS	UKM
ECM			



S2S project

Subseasonal to seasonal (15-60days)

Objectives

1.To improve forecast skill and understanding on the subseasonal to seasonal timescale with special emphasis on high-impact weather events

2.To promote the initiative's uptake by operational centres and exploitation by the applications community

3.To capitalize on the expertise of the weather and climate research communities to address issues of importance to the Global Framework for Climate Services

http://s2sprediction.net

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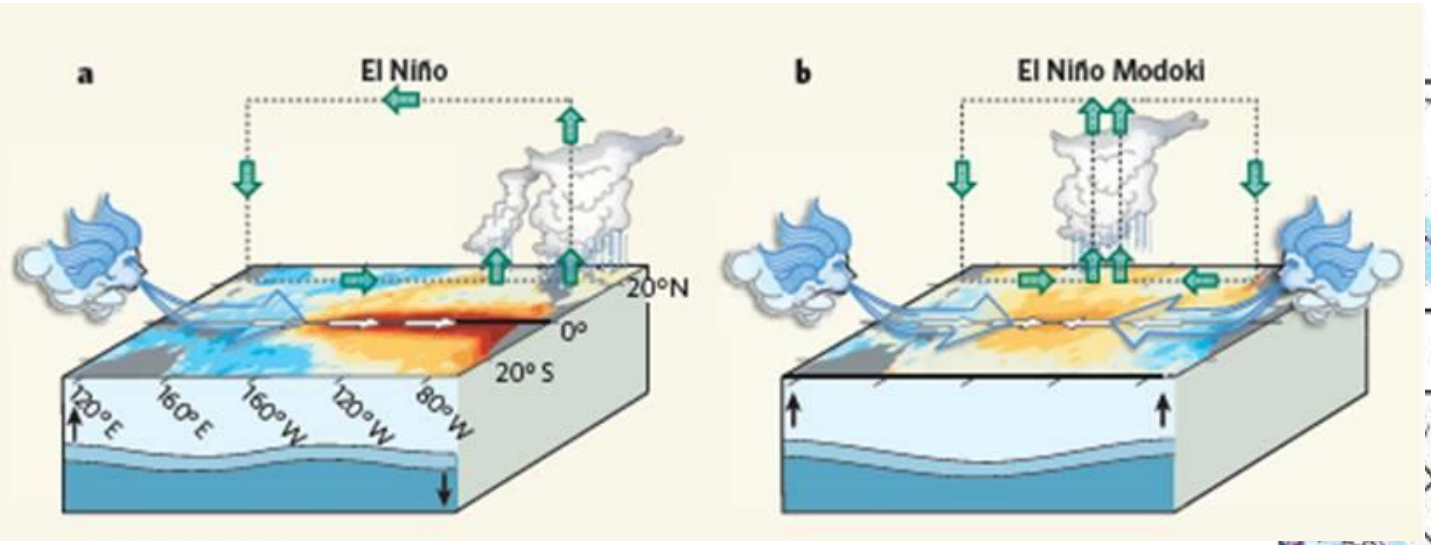
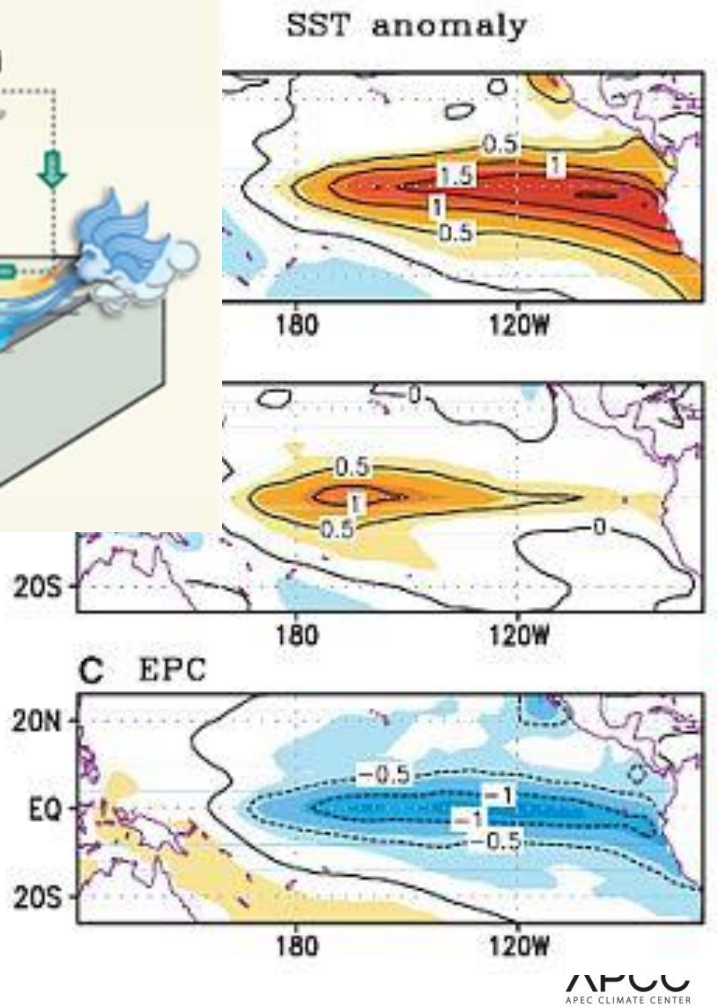
New type of El Nino

El Nino Modoki (Central Pacific El Nino)





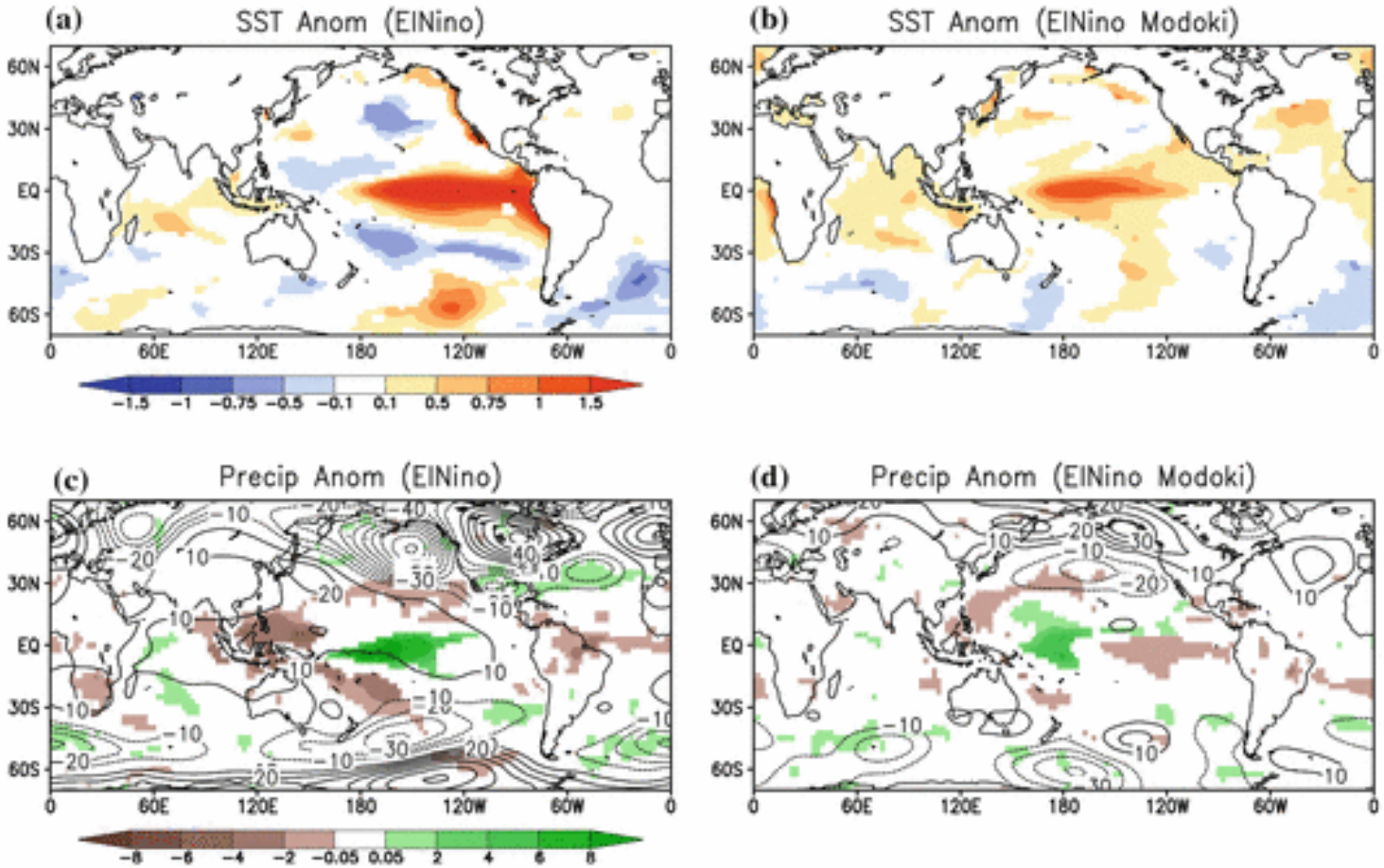


Fig. 2 **a** Composite observed significant SST (°C) anomalies during El Niño years. **b** Same as **a** but for El Niño Modoki years. **c** Composite observed significant precipitation (mm/day; *shaded*) anomalies and 500 hPa Geopotential Height (m; *contours*) anomalies during El Niño Years. **d** Same as **c** but for El Niño Modoki years. All the *shaded* values are significant at 90% using *t* test

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So, what are you going to do with CLIK

- Hope you were able to find suitable predictors for your locations
  - Yes : produce forecast
  - No : try more! (It is important to understand the large scale circulation that affects local weather)

- Once you've got a forecast, you need to combine them with other informations.
  - It's an area of "art" at this moment

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Suggestions?
Questions?

Thanks

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How to deal with many “hopeful” results?

- Combine (average) them
- Pick up one (a few) with highest corr.

- Automatic? : In the future..

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