Data assimilation and Potential Predictability
(GOAPP Research in UNBC)

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March, 12, 2009

Ocean Data Assimilation (Ziwang Deng, Youmin Tang)

- Argo data + TAO/TRITON + XBT +CTD
- Localized EnKF and Ensemble Kalman Smooth

Potential Predictability – (Xiaoqin Yan, and Youmin Tang)

- **Information-based measure of potential predictability**
- **Multiple model ensemble**
- **Preliminary results**
- **Summary**

A theoretical framework of Predictability study

- ☐ A measure of uncertainty of random variables: Entropy.

- ☐ The potential predictability of a system may be assessed in terms of differences between two entropies, climatological entropy and predictive entropy. Such differences can be expressed by (Schneider and Griffies 1999; Kleeman 2002; DelSole 2004)

- ☐ Relative entropy $$R = \int p(x) \log \frac{p(x)}{q(x)} dx$$

R measures the decrease of uncertainty due to prediction, i.e.,
additional information provided by prediction beyond climatological prediction.

A large R indicates that more useful information is being supplied by a prediction, which makes it more reliable. The average of R over all predictions is defined as *Mutual information* (MI)

Potential correlation skill

$$MI = -\frac{1}{2}\log(1 - r^2)$$

$$r = \sqrt{1 - e^{-2*MI}}$$
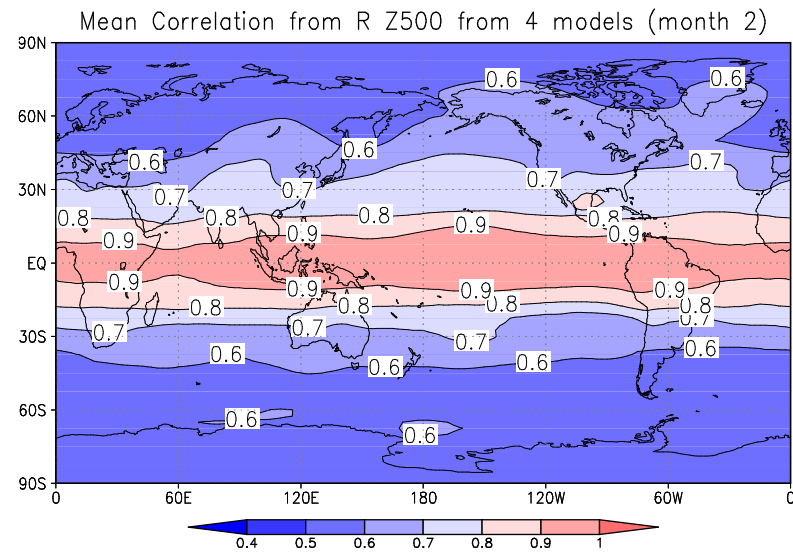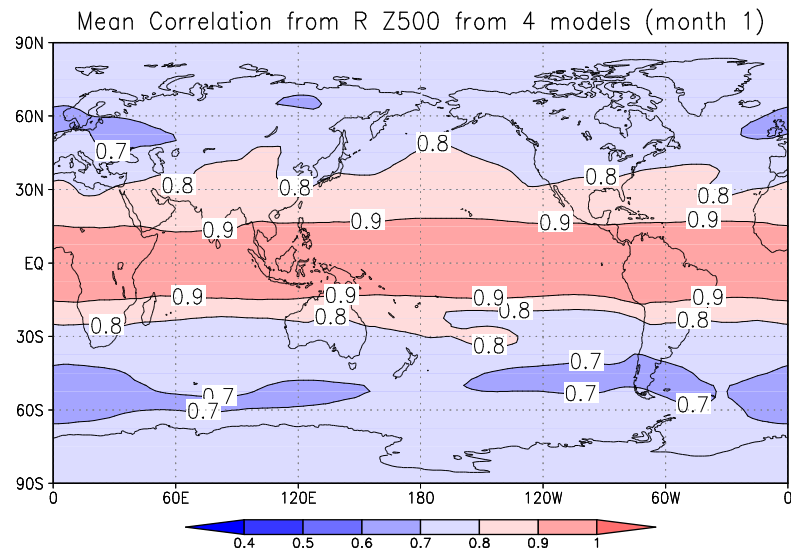
Multiple Models (HFP2)

http://www.cccma.ec.gc.ca/data/hfp2/hfp2.shtml

GEM, AGCM2, AGCM3, SEF

The Integrations are initialized from the NCEP/NCAR reanalysis lagged at 12-hour intervals prior the forecast period. The global sea surface temperature anomaly from AMIP for the month prior the forecast period is persisted during the 4-month forecast period.

The period: 1969 – 2002. Ensemble size of each model is 10.

Potential correlation skill of 500 mph, estimated from multiple model ensemble
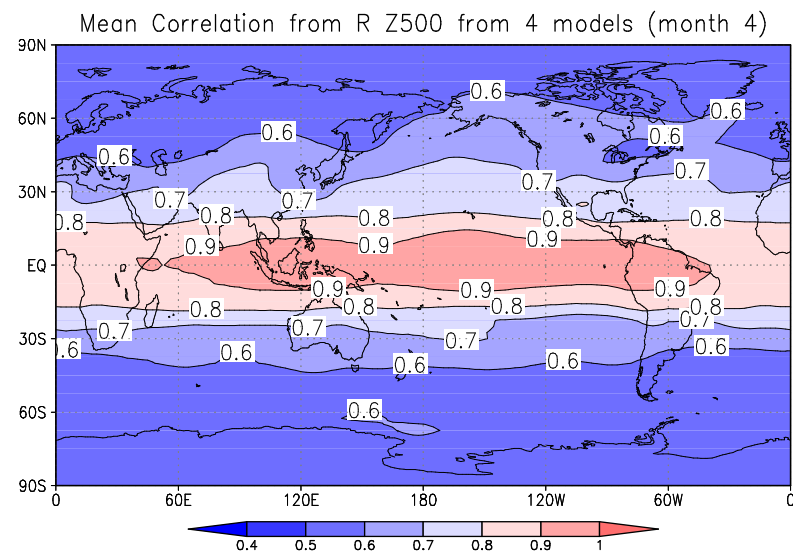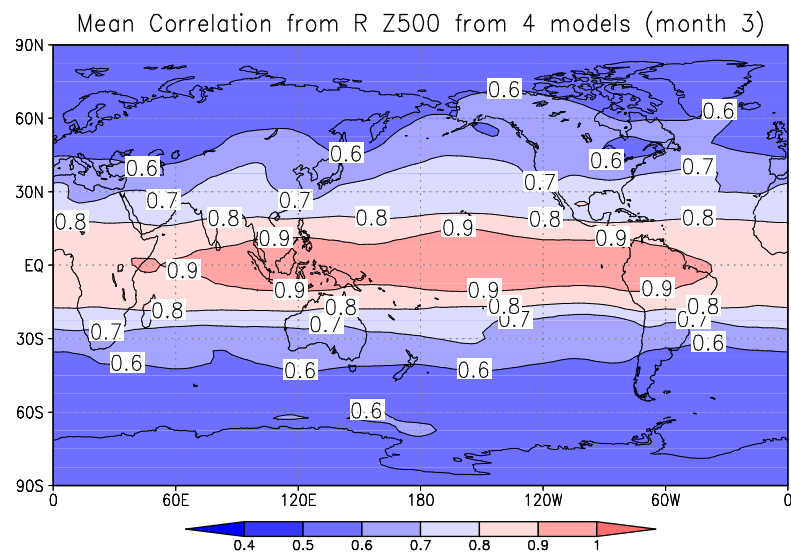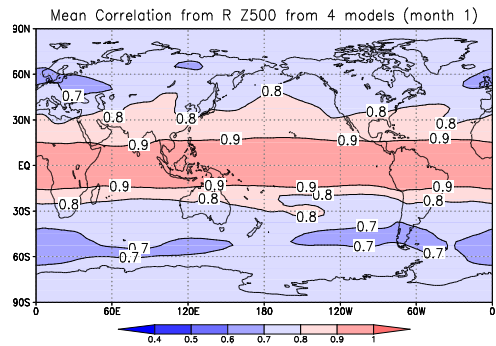
Actual correlation skill of 500 mph of ensemble mean by multiple models, against NCEP reanalysis counterpart values.
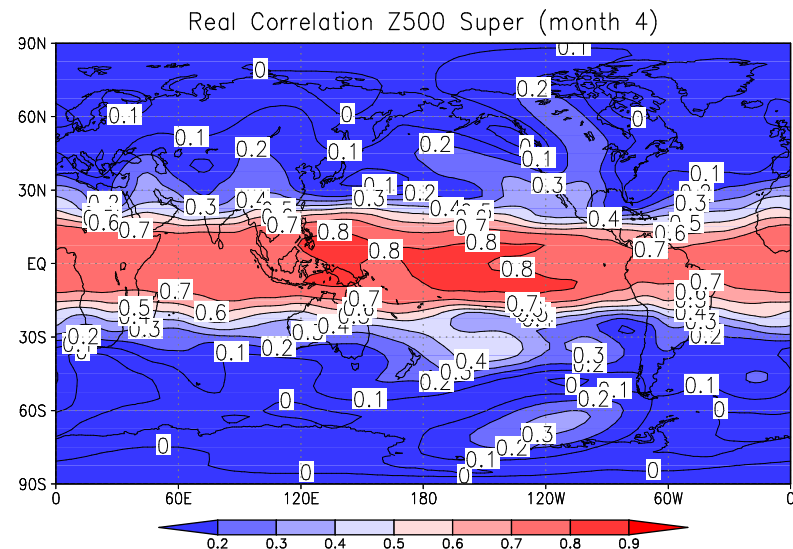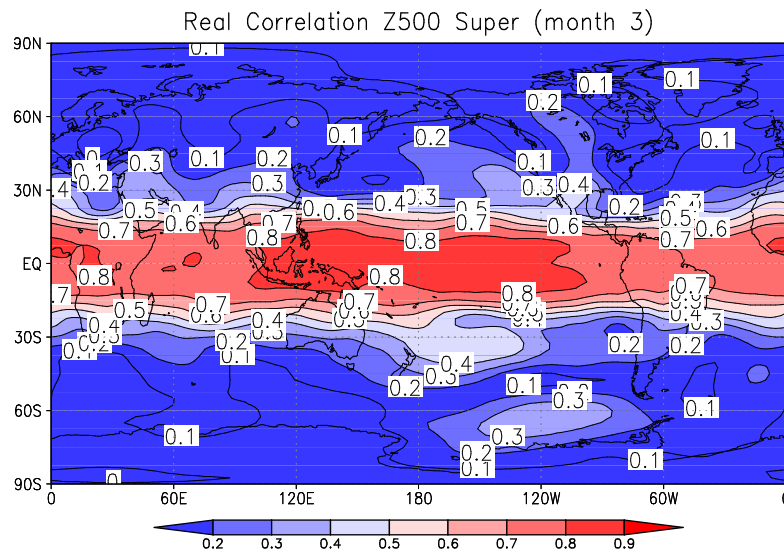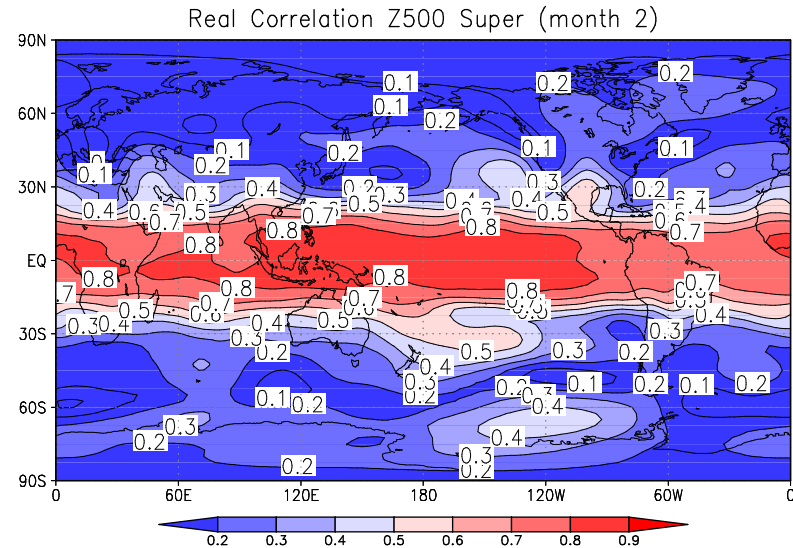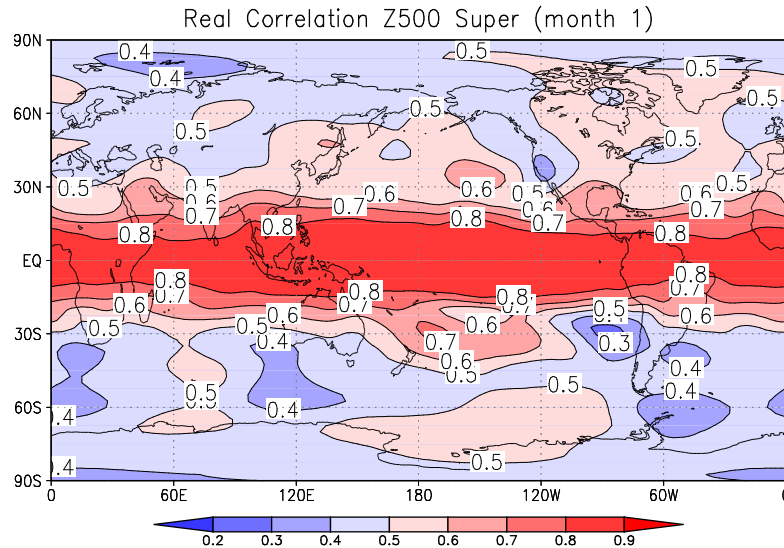
Potential skill

Real skill
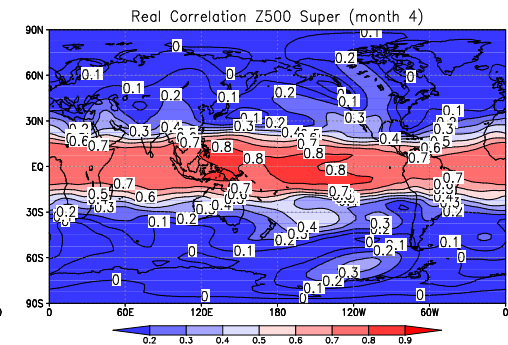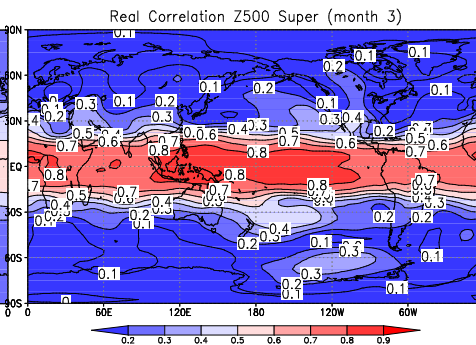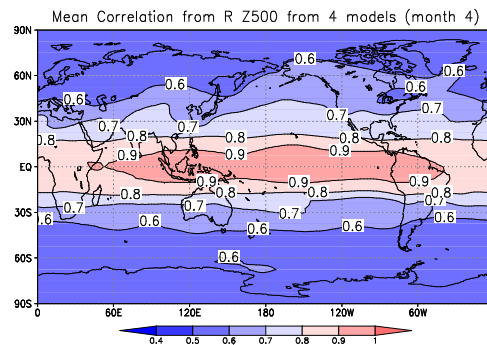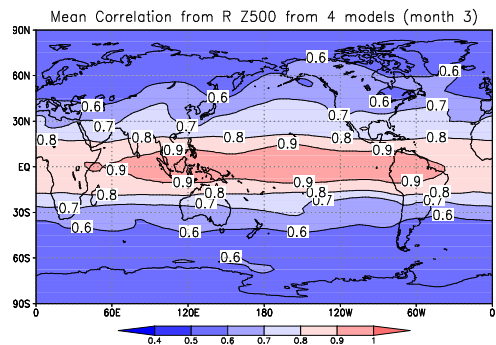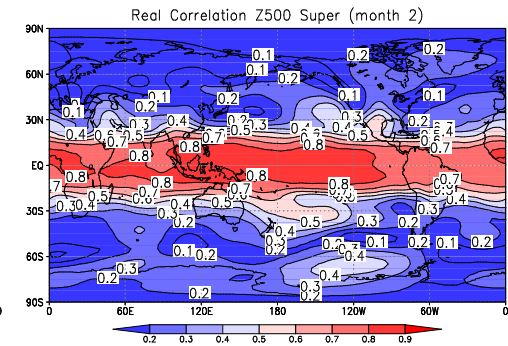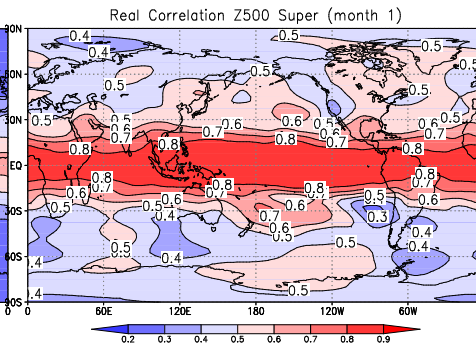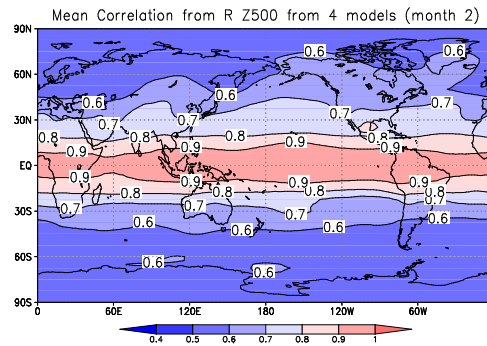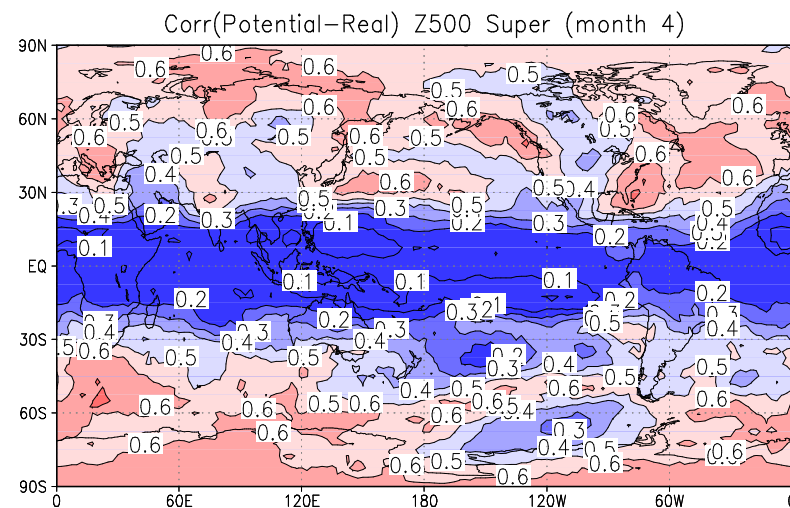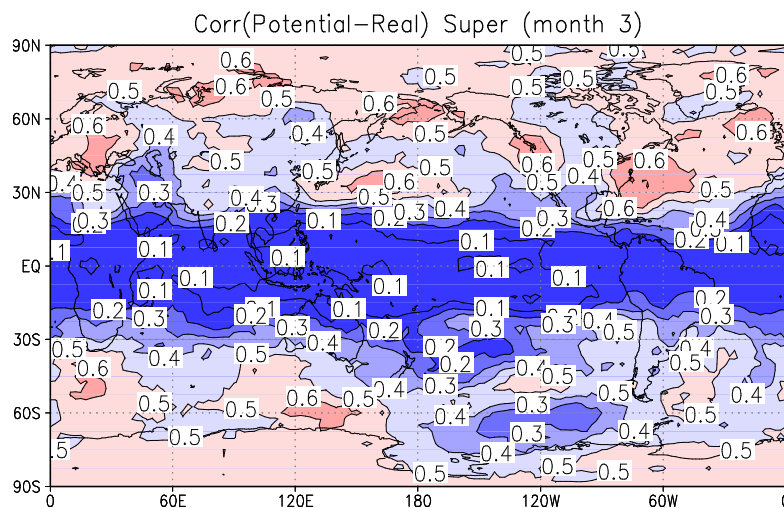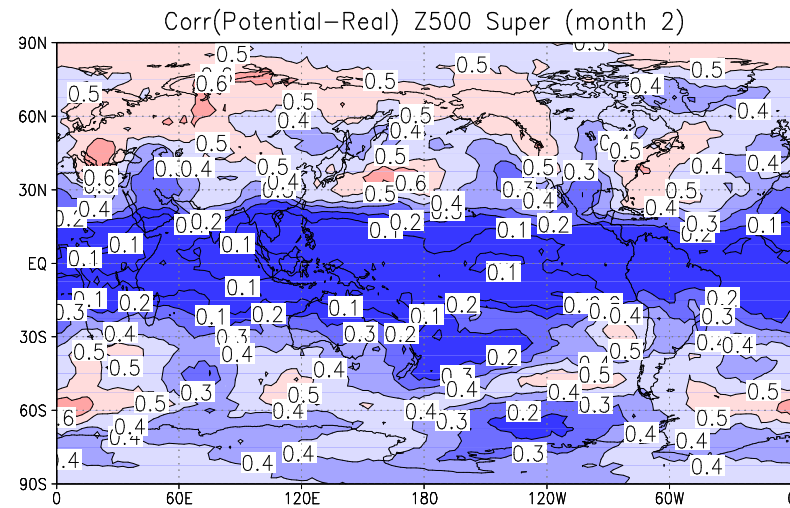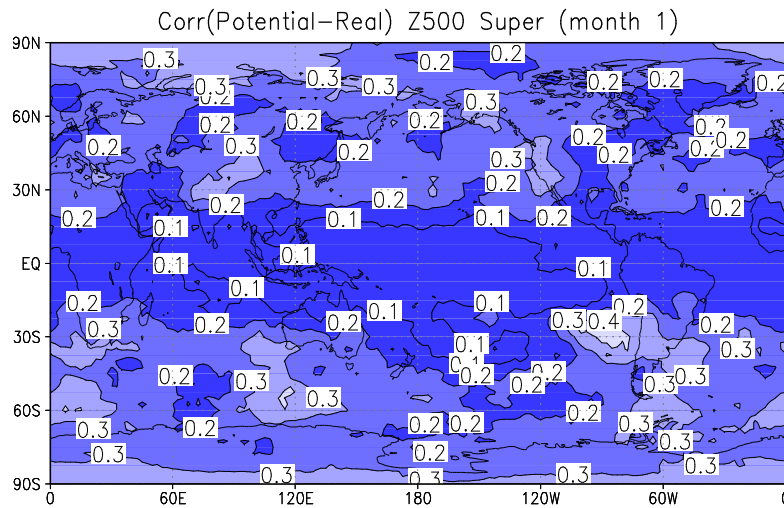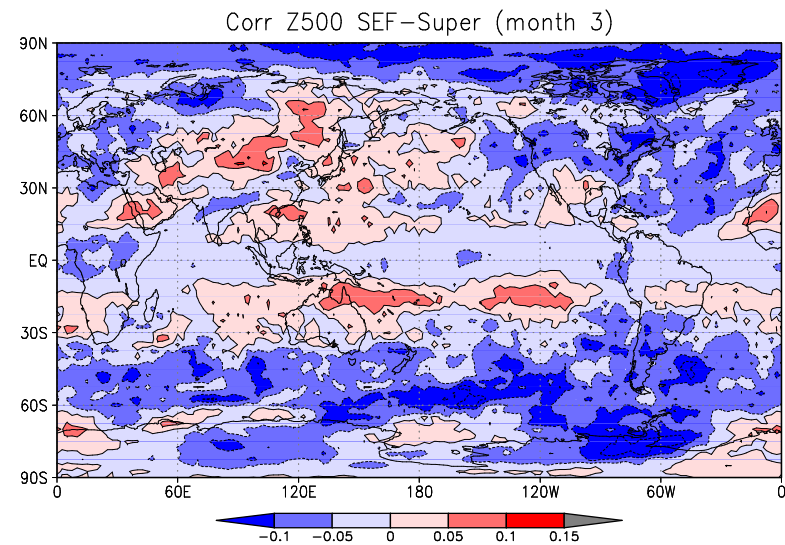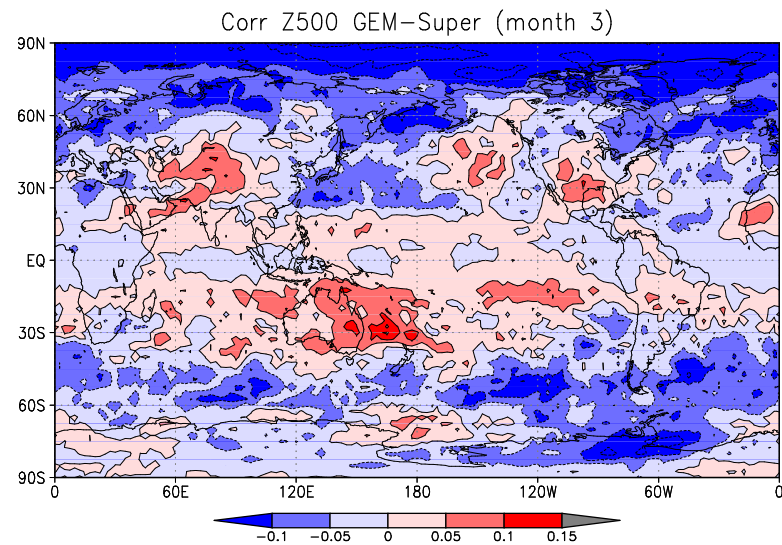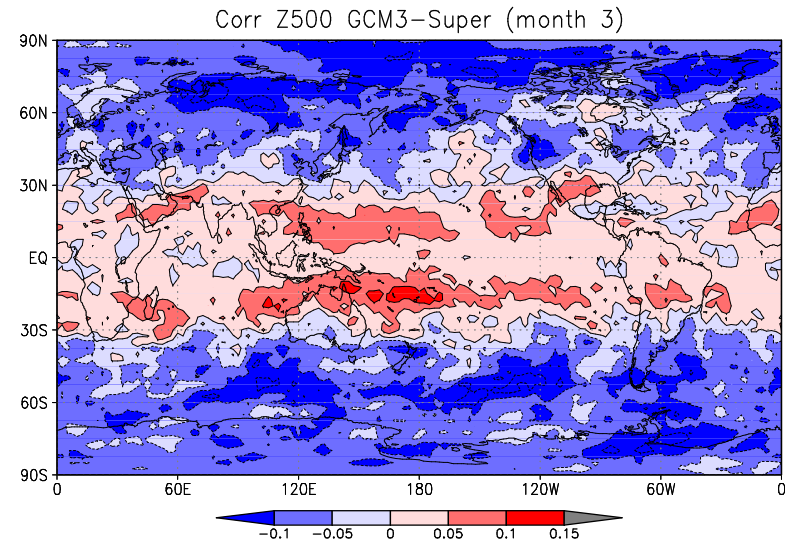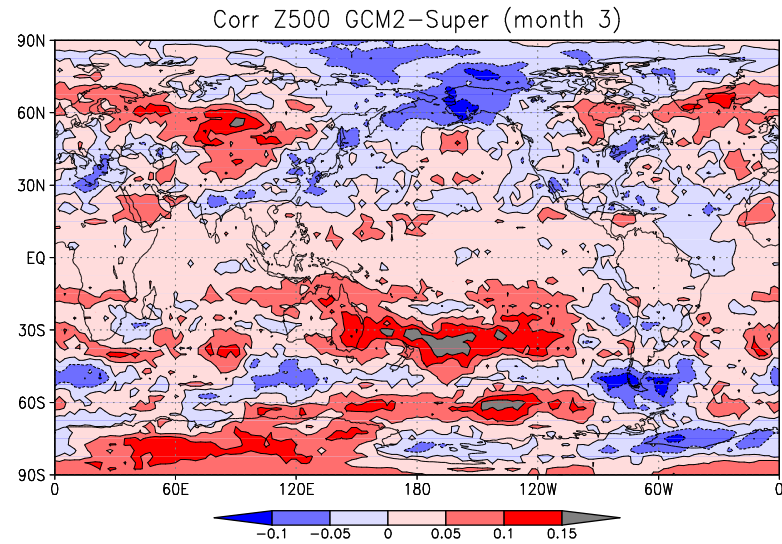
Difference between potential predictability and real predictability

Corr(Potential−Real) Z500 Super (month 1)
Corr(Potential−Real) Z500 Super (month 2)
Corr(Potential−Real) Super (month 3)
Corr(Potential−Real) Z500 Super (month 4)

The difference of potential predictability between multiple model's ensemble and individual model's ensemble . (lead time = 3 months)
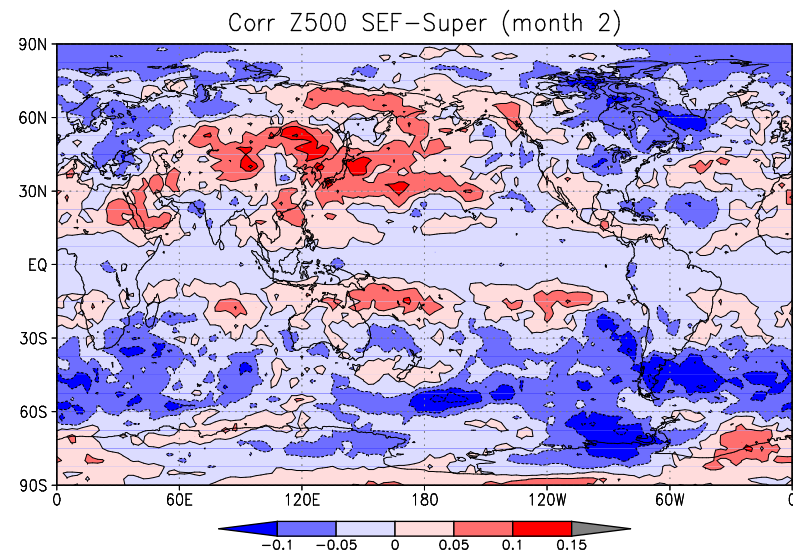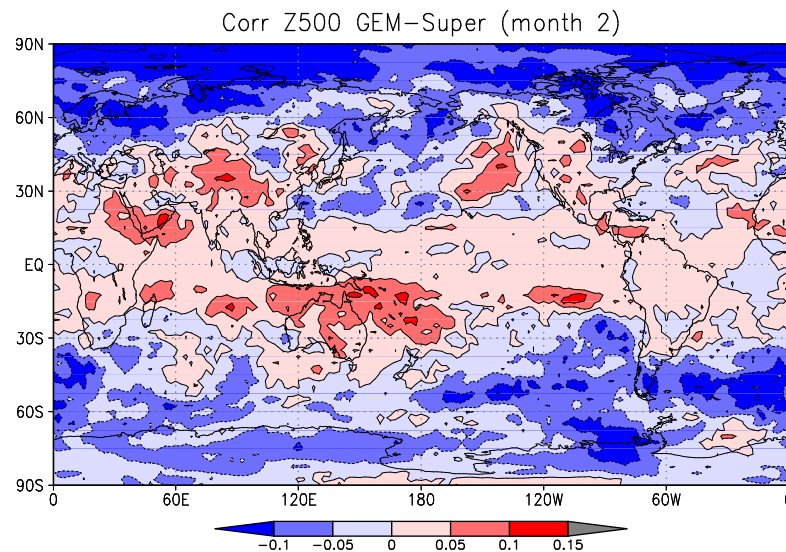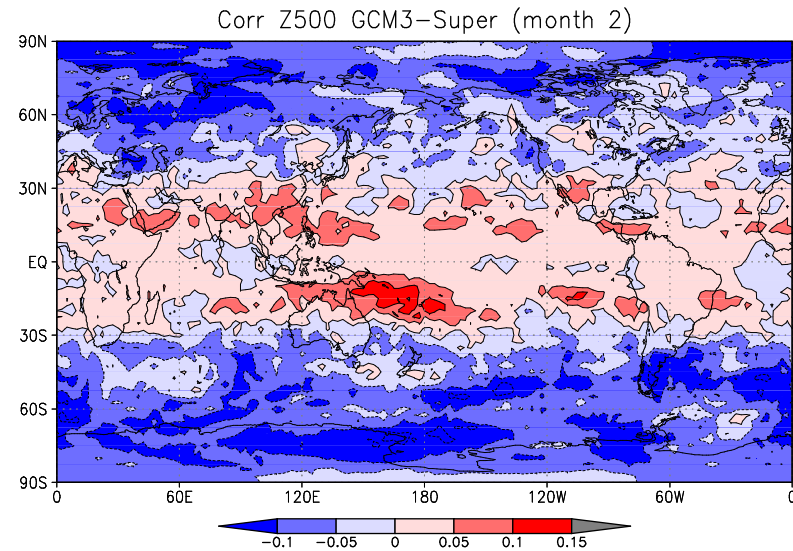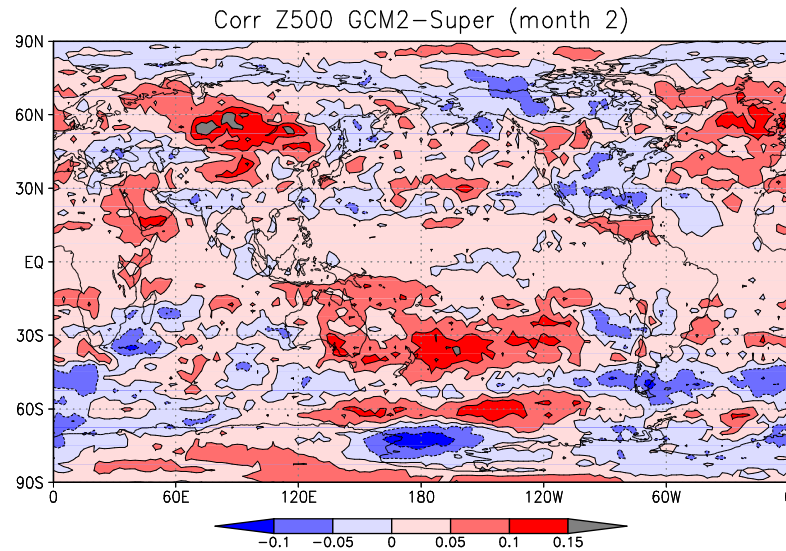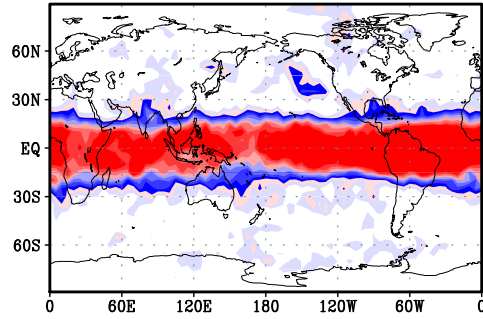
The difference of potential predictability between multiple model's ensemble and individual model's ensemble (lead time = 3 months)
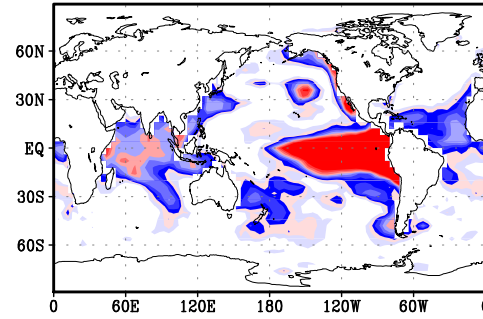
The difference of potential predictability between multiple model's ensemble and individual model's ensemble (lead time = 4 months)
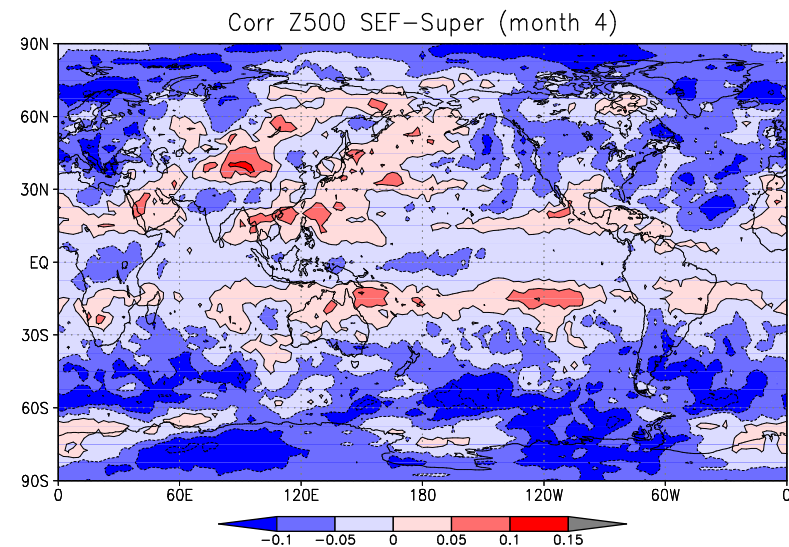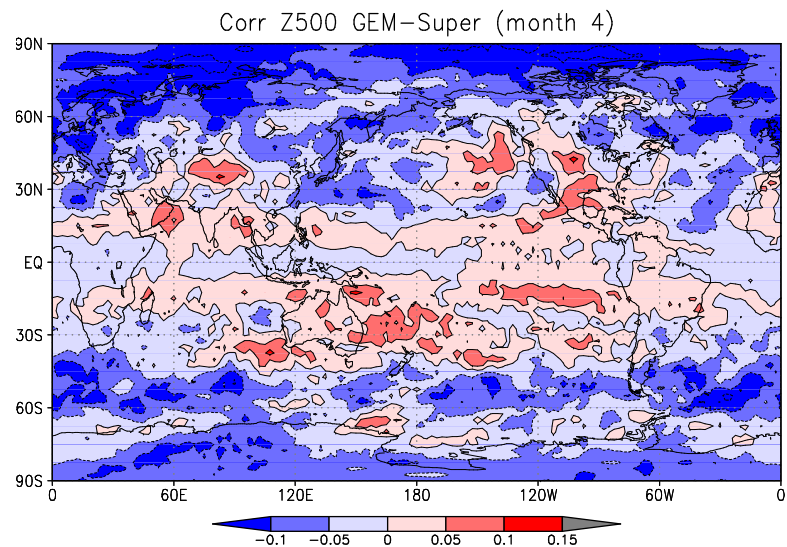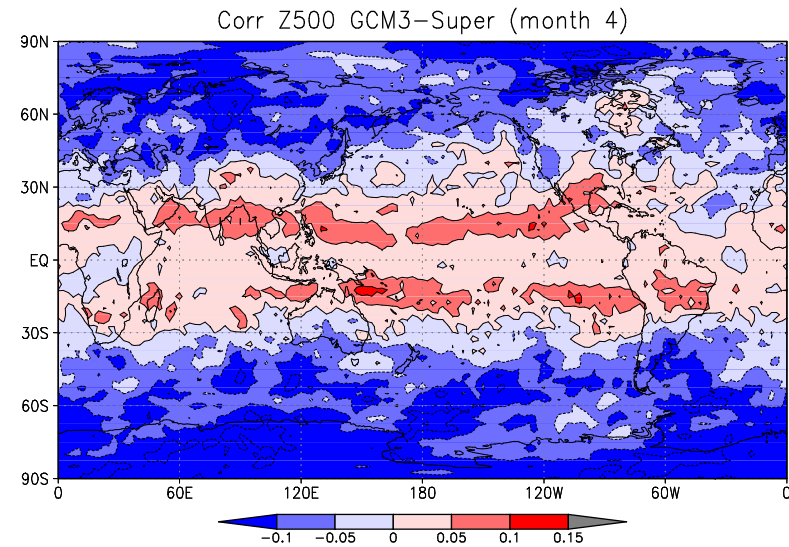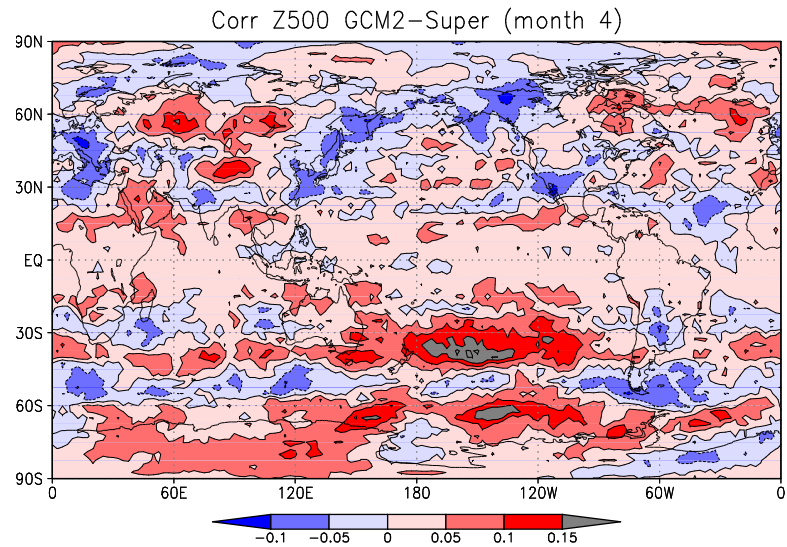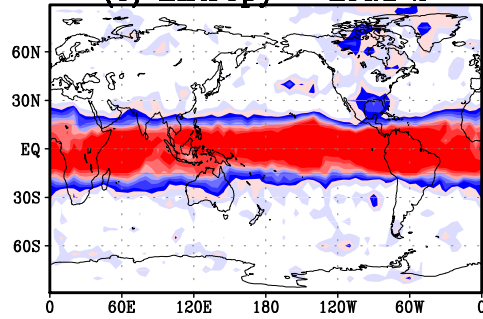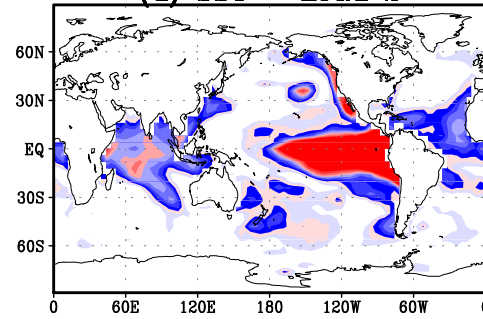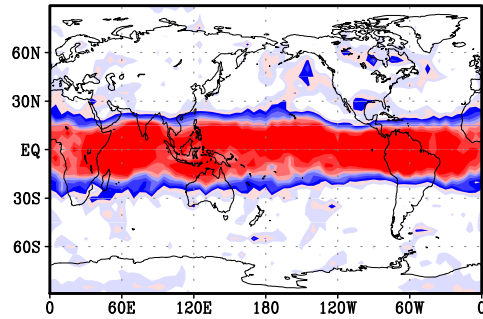
(a) Entropy – Lead 1   (b) SST – Lead 1
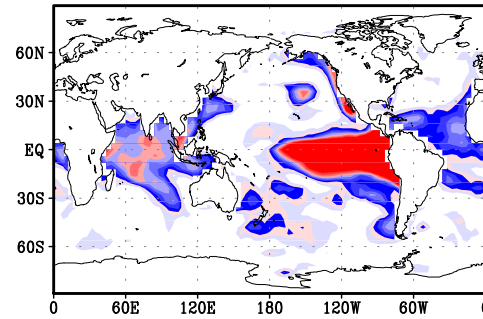
(c) Entropy – Lead 2   (d) SST – Lead 2

(e) Entropy – Lead 3   (f) SST – Lead 3

(g) Entropy – Lead 4   (h) SST – Lead 4

0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

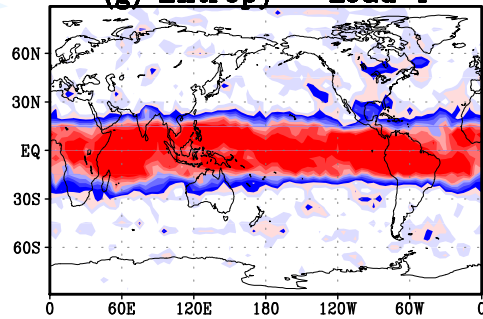(a) Entropy – Lead 1   (b) SST – Lead 1

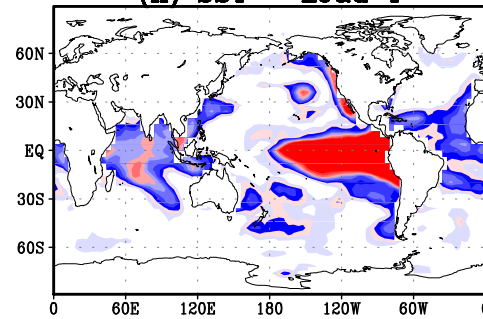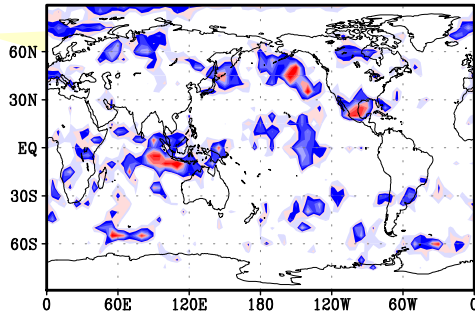(c) Entropy – Lead 2   (d) SST – Lead 2
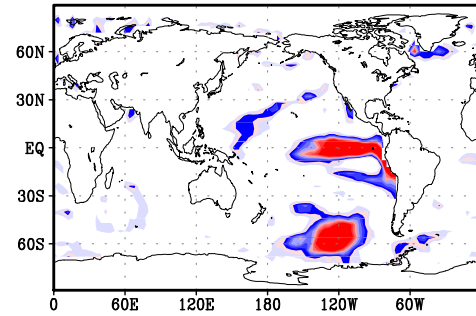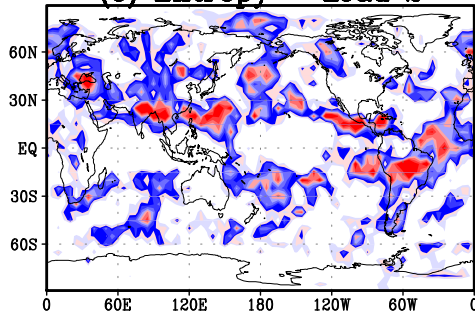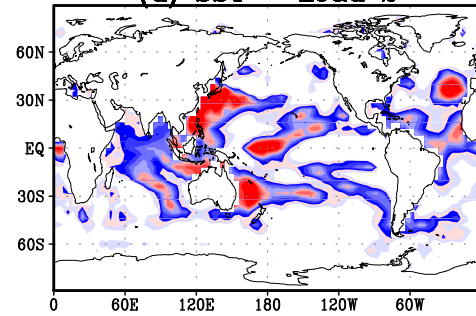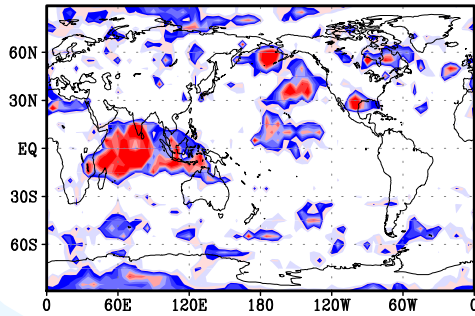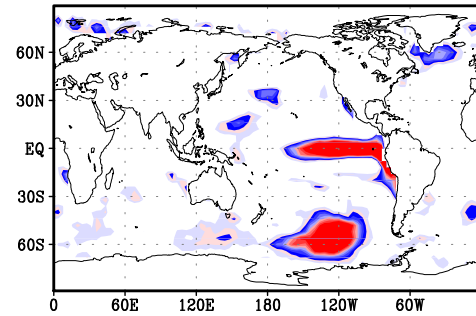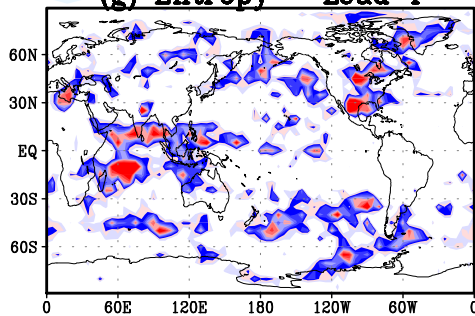
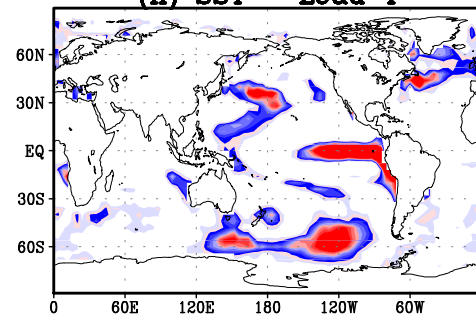(e) Entropy – Lead 3   (f) SST – Lead 3

(g) Entropy – Lead 4   (h) SST – Lead 4

0.1   0.2   0.3   0.4   0.5   0.6   0.7   0.8   0.9   1

Conclusion and Future work

- The potential predictability, measured by mutual information, is much larger than real skill in middle-high latitudes, suggesting a large room of improvement for seasonal climate predictions in these regions.

- The potential predictability of the tropical regions is mainly contributed by the tropical SST signals, especially by the eastern equatorial Pacific SST (ENSO).

- Future work: i) the source of potential predictability in middle-high latitudes;
  ii) the most predictable patterns.