ECMWF IFS with Super-Parameterization: Preliminary Results

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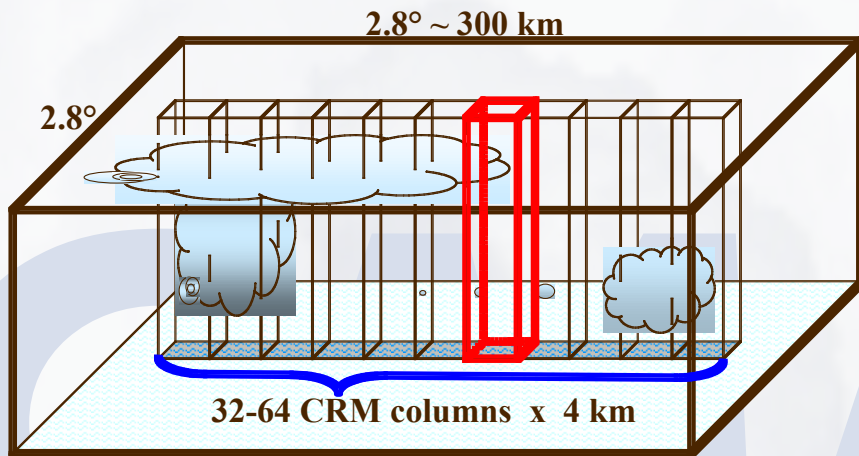
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Glenn Carver
Filip Vana

Tim Palmer
Aneesh Subramanian

Superparametrization (SP)

2.8° ~ 300 km

2.8°

32-64 CRM columns x 4 km

$$\frac{\partial \overline{s}}{\partial t} = -\overline{\nabla s V} - \frac{\partial \overline{s}\,\overline{\omega}}{\partial p} + Q_1$$
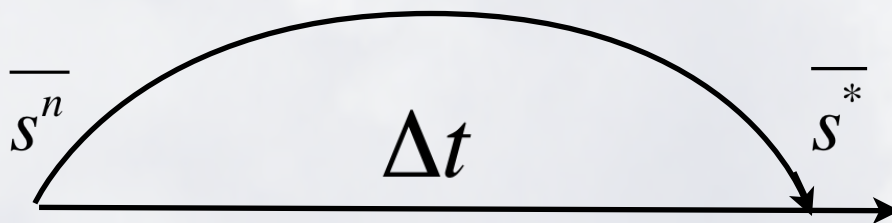
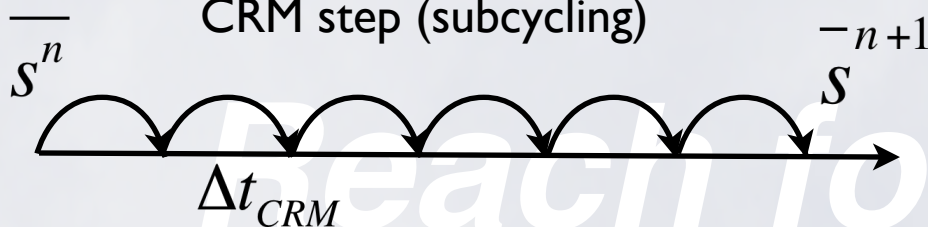GCM Resolved   Column-Physics (parameterizations)

CRM Forcing:

$$-\overline{\nabla s V} - \frac{\partial \overline{s}\,\overline{\omega}}{\partial p} = \frac{\overline{s}^* - \overline{s}^n}{\Delta t}$$

Dynamics Step:

$\overline{s}^n$ Δt $\overline{s}^*$

CRM Tendency:

$$Q_1 = \frac{\overline{s}^{n+1} - \overline{s}^*}{\Delta t}$$

CRM step (subcycling)

$\overline{s}^n$ $\overline{s}^{n+1}$

Δt_{CRM}

IFS – Integrated Forecast System

- **Atmospheric model and data assimilation system (4D-Var)**

- **Developed and maintained by the European Centre for Medium-Range Weather Forecasts (ECMWF);**

- **Global model; runs every twelve hours;**

- **Up to 15-day forecasts;**

- **Deterministic forecasts (resolution of 16 km, 137 levels)**

- **51-member ensemble forecasts (32 and 64 km, 91 levels);**

- **Used to create reanalysis products like ERA-40 and ERA-I;**

- **Monthly and seasonal forecasts with coupled system;**

- **Current operational cycle (version) - 41R3**

SP-IFS – Super-parametized IFS: History:

- **First implemented in OpenIFS, which is a free running IFS(cycle 38R1), but without data assimilation system;**

- **First experiments have been performed using T42 L91 resolution (~2.8° x 2.8°);**

- **SP: 32 x 74; Δx=4 km; IFS' cumulus and all cloud parameterizations are switched off;**

- **Preliminary results of T42 were interesting to warrant further tests with T159 (~1.125° x 1.125°) using ECMWF's supercomputer;**

- **Fall 2014: SP is implemented in IFS Single-Column Model CY40R1 and in IFS CY40R3;**

- **SP can be chosen as an option when setting the IFS run using prepIFS system;**

- **Currently, implemented in latest operational CY41R3.**

JJA Precipitation
T159

GPCP (OBS)
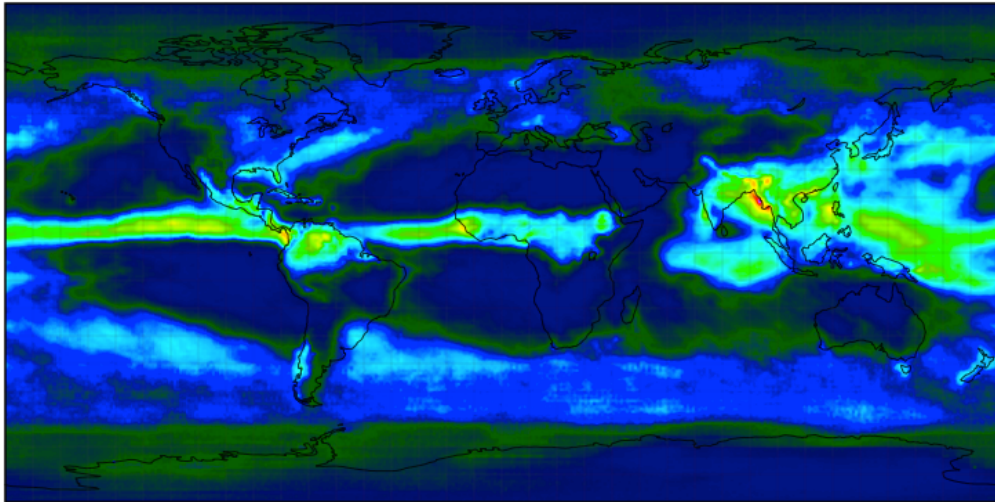
SP-IFS
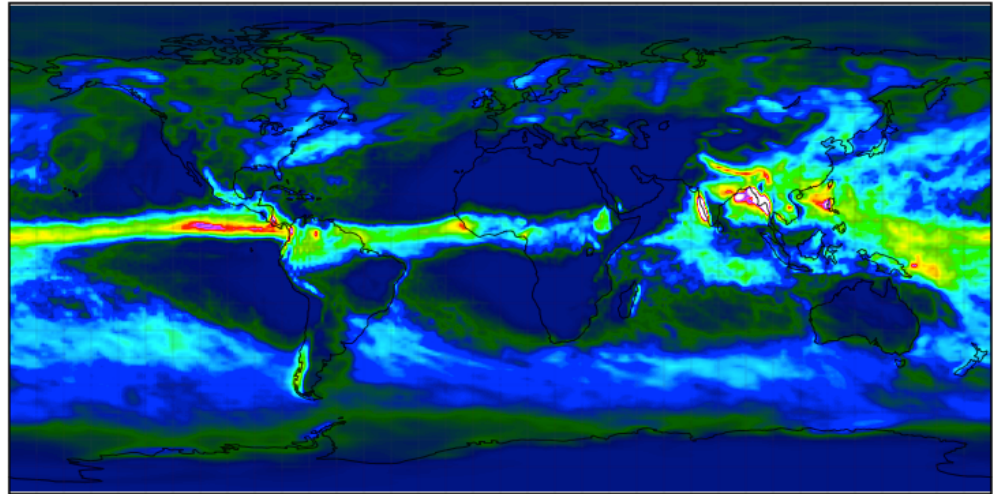
IFS
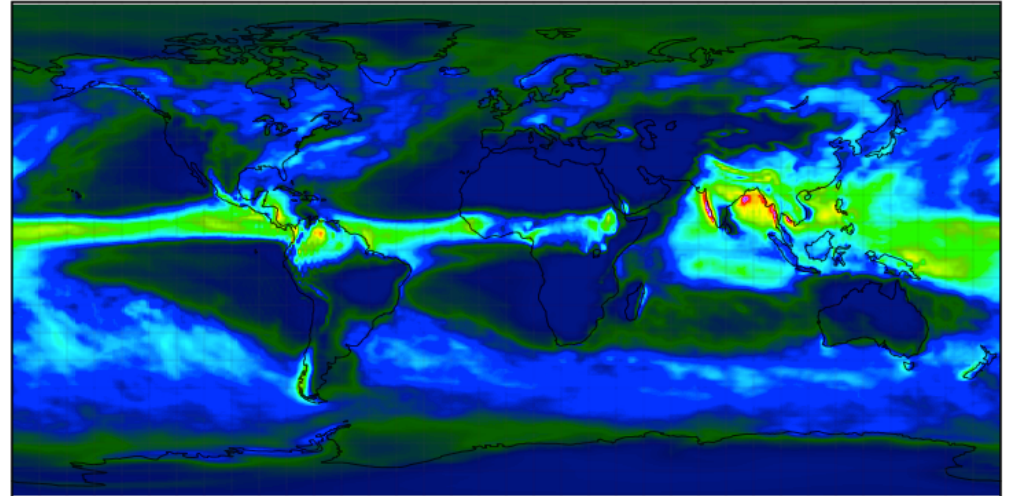
Mean climatology of SP-IFS doesn't look bad for a model which hasn't been properly tuned.

0.000   3.000   6.000   9.000   12.000   15.000   18.000
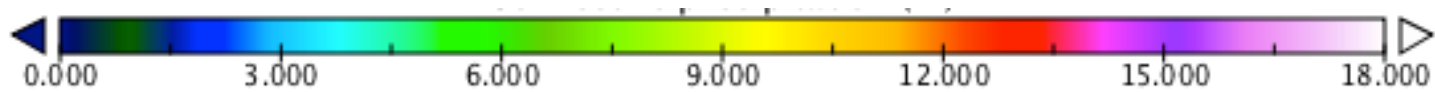
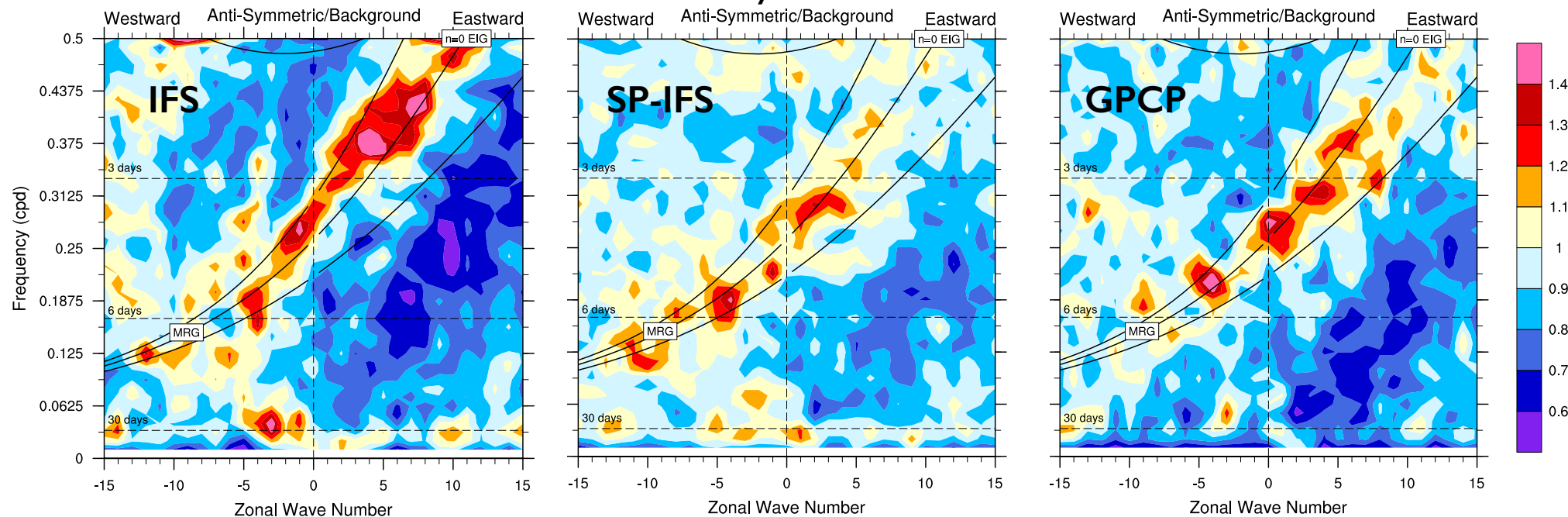Frequency Spectrum (Subseasonal): Precipitation in Tropics (15°S-15°N)
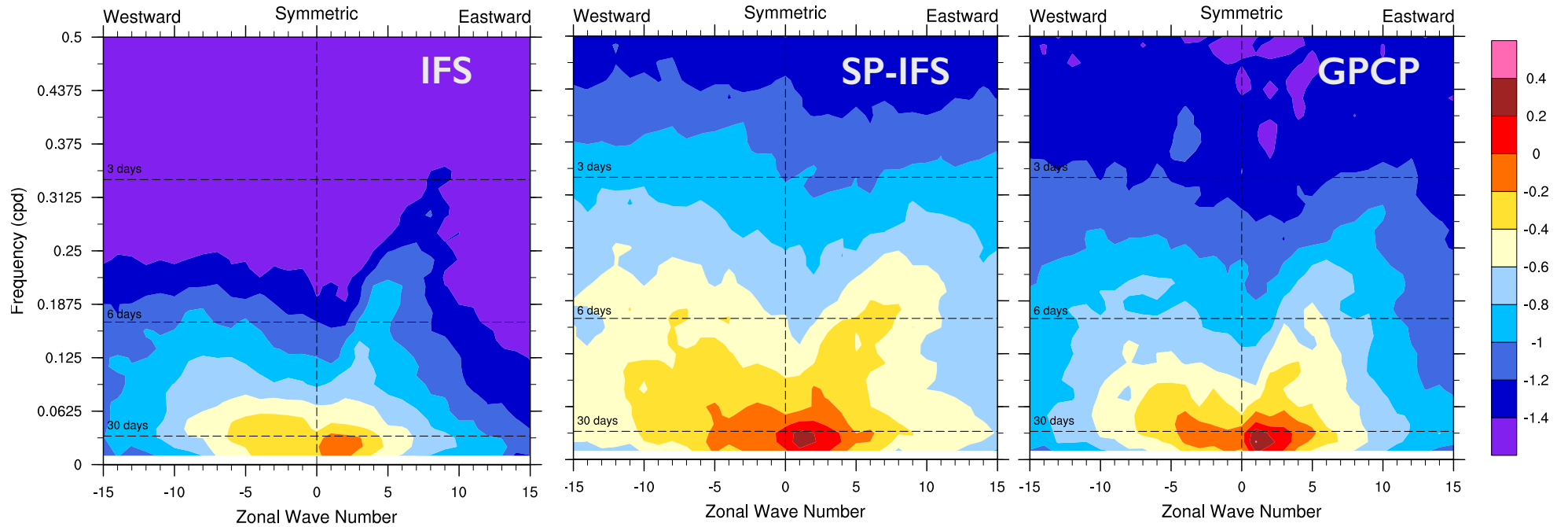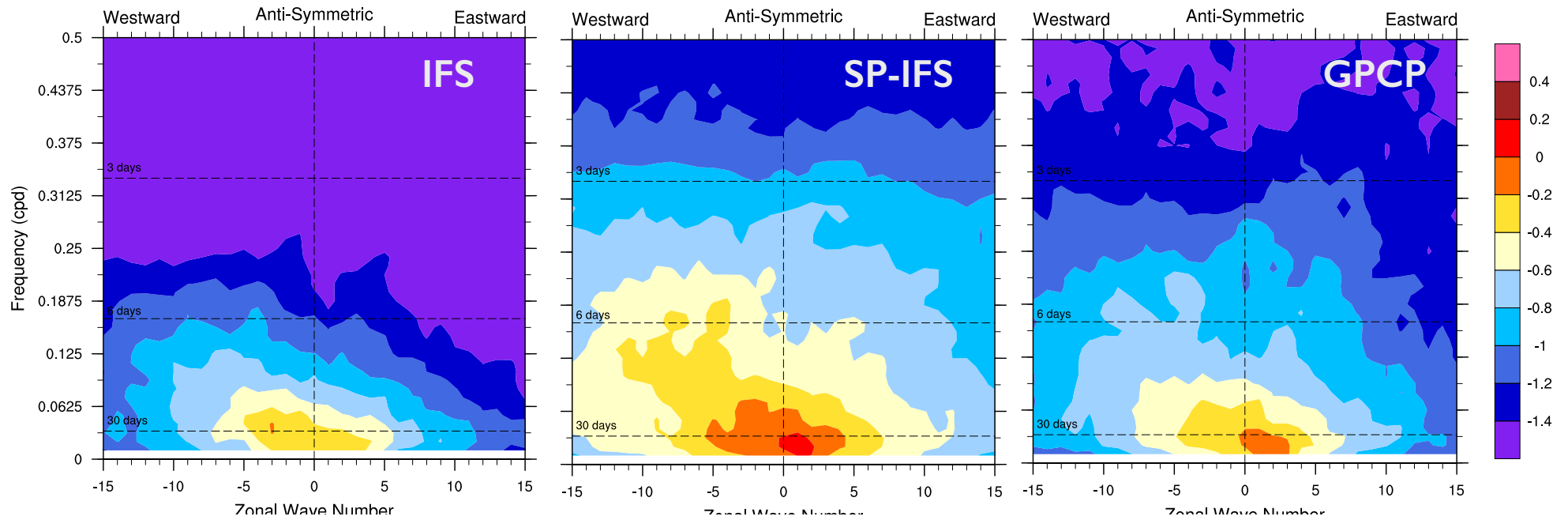
Frequency Spectrum (S/N): Precipitation in Tropics (15°S-15°N)
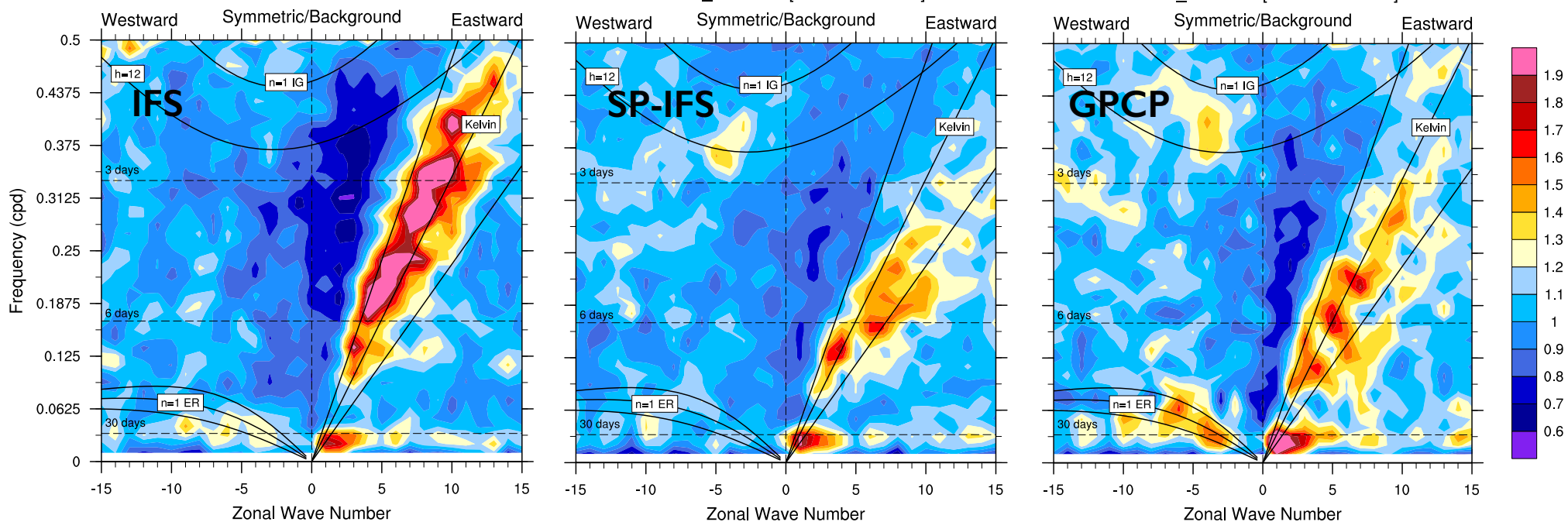
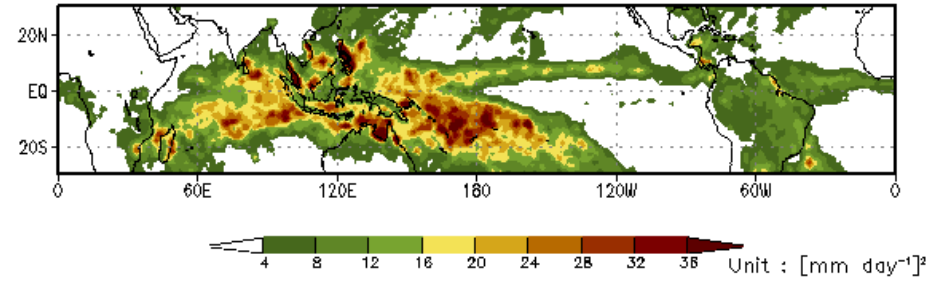# Variance: 20-100 day filtered precipitation

## Summer (May-Oct)   Winter (Nov-Apr)

(b) 20-100 day variance, PRCP, TRMM, Summer
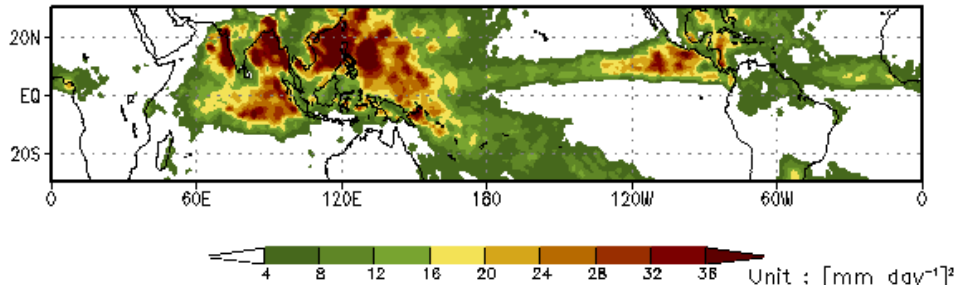
TRMM

(b) 20-100 day variance, PRCP, TRMM, Winter

Unit : [mm day⁻¹]²

(b) 20-100 day variance, PRCP, CTRL, Summer(May-Oct)

IFS
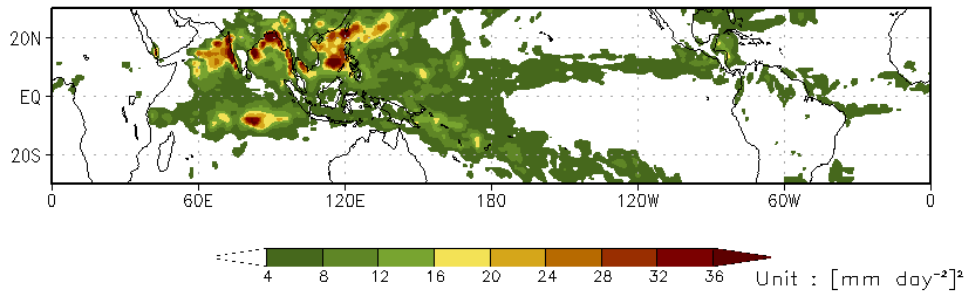
(b) 20-100 day variance, PRCP, CTRL, Winter(Nov-Apr)

Unit : [mm day⁻²]²
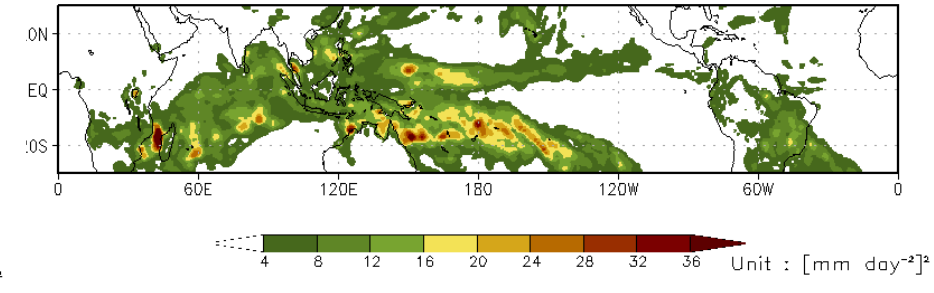
(b) 20-100 day variance, PRCP, SP32, Summer(May-Oct)
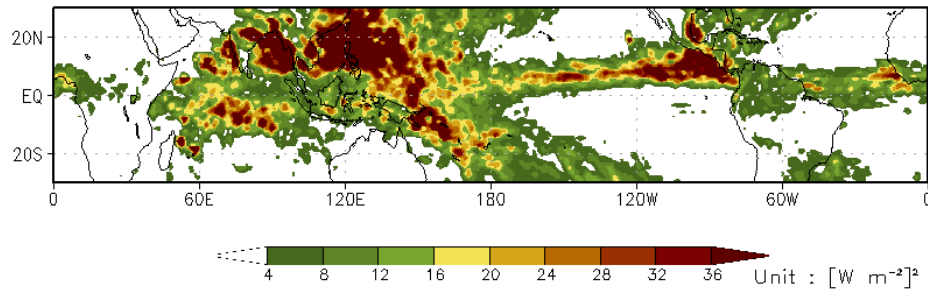
SP-IFS

(b) 20-100 day variance, PRCP, SP32, Winter(Nov-Apr)

Unit : [W m⁻²]²
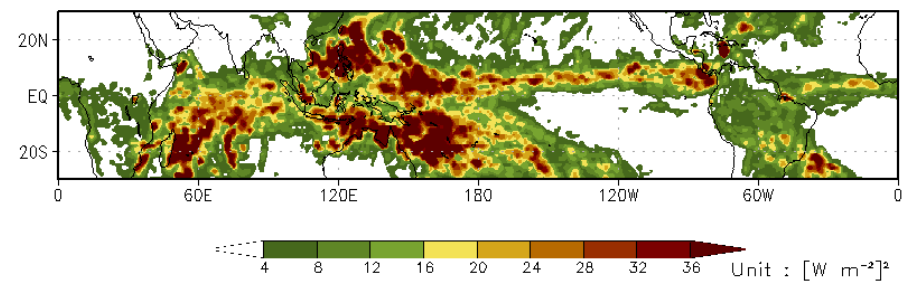
Variance: 20-100 day filtered U850

Summer (May-Oct)

Winter (Nov-Apr)
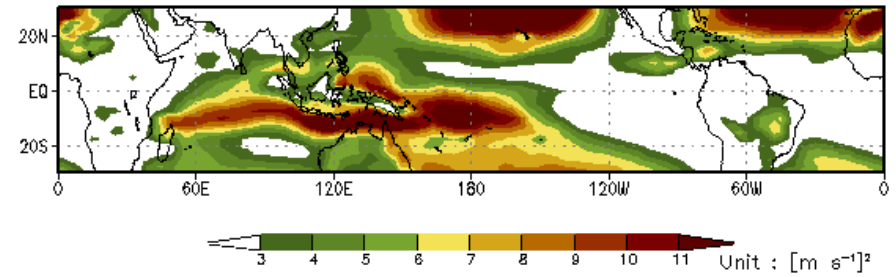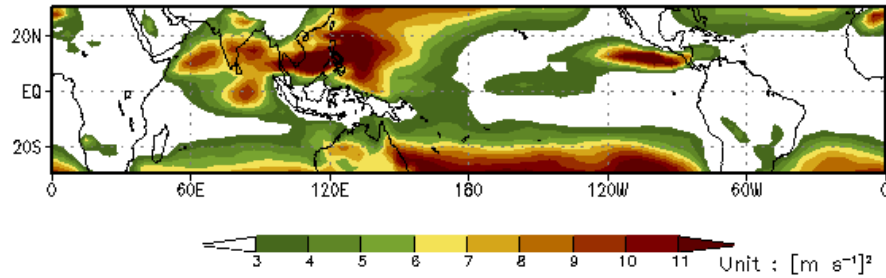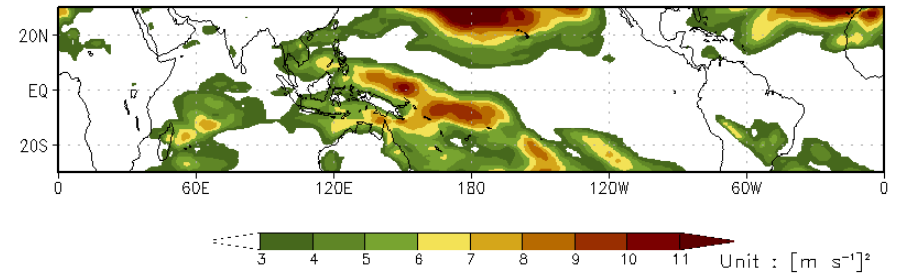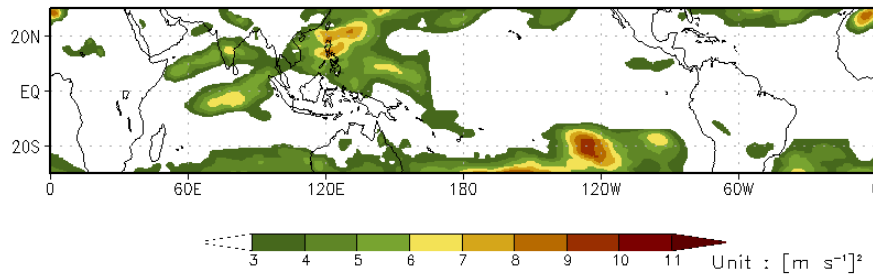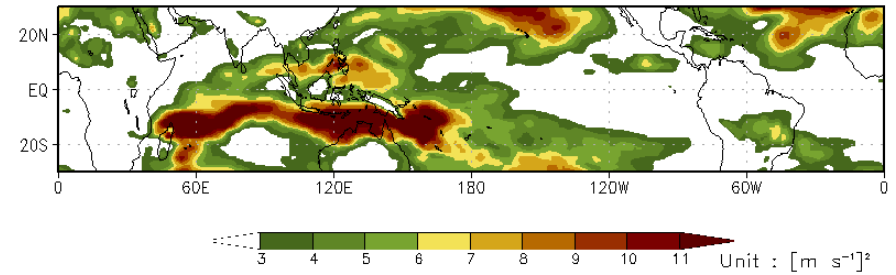
MJO eastward propagation

Lag correlation (U850, Winter)

ERA40

Reference domain:
1.25S-16.25N, 68E-96E

* US CLIVAR MJO Diagnostic metrics

IFS

SP-IFS

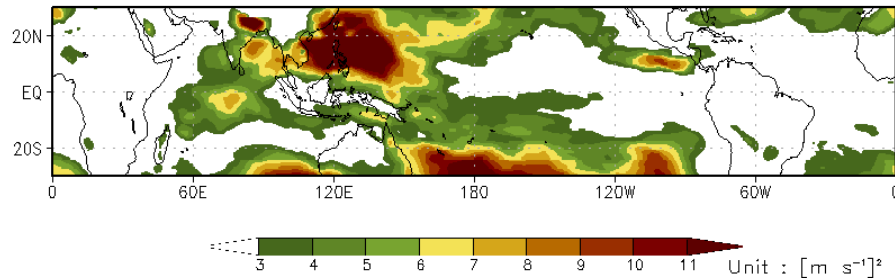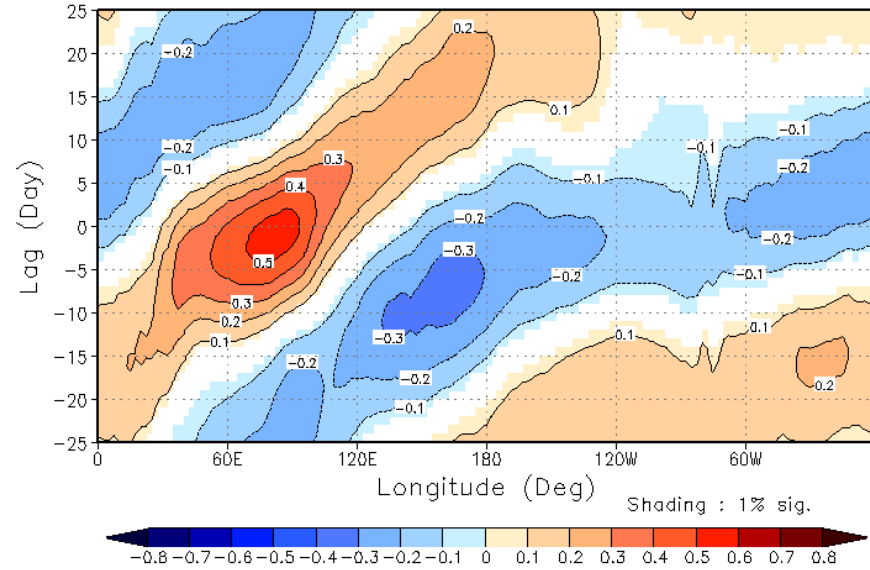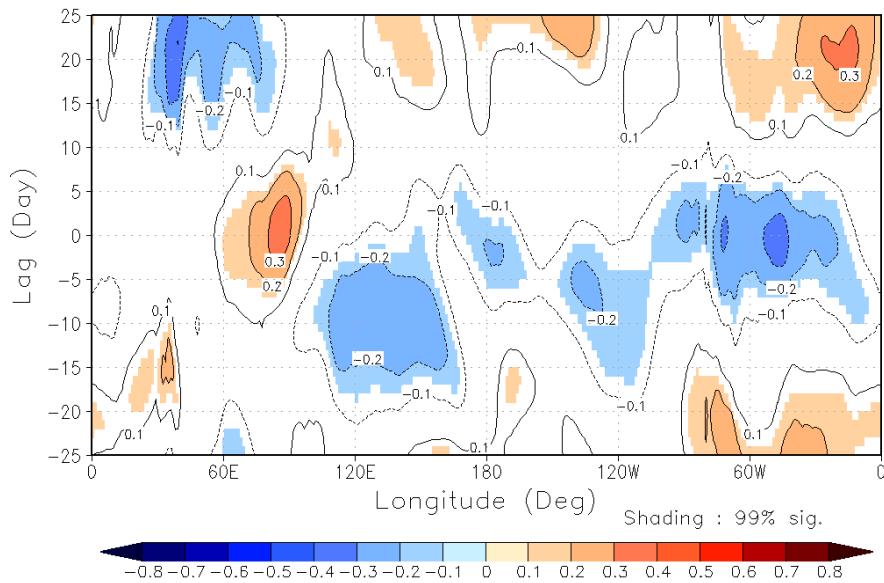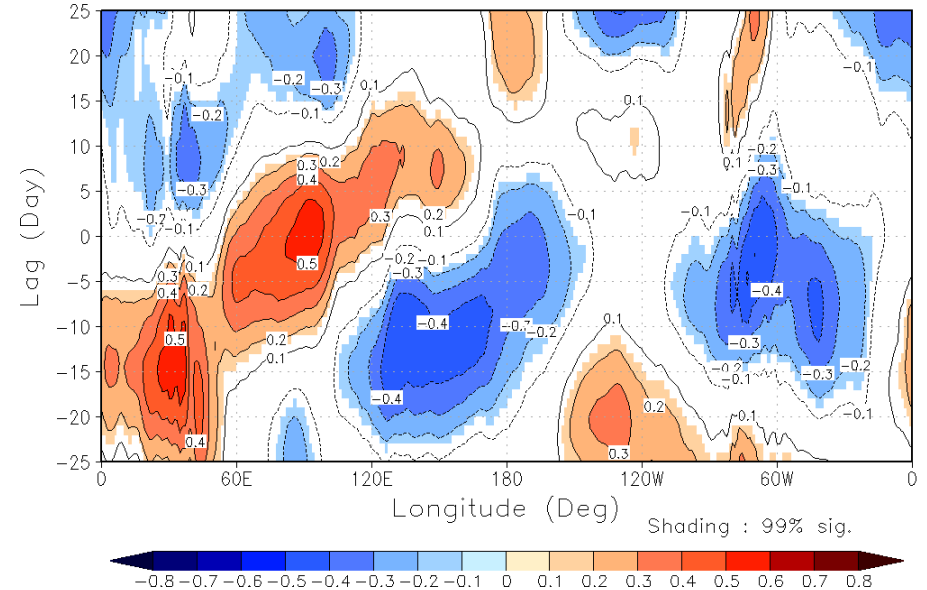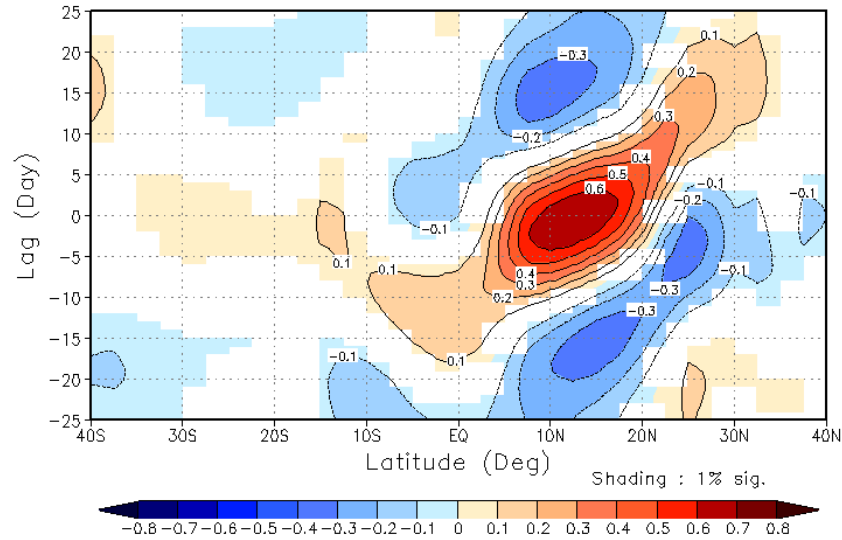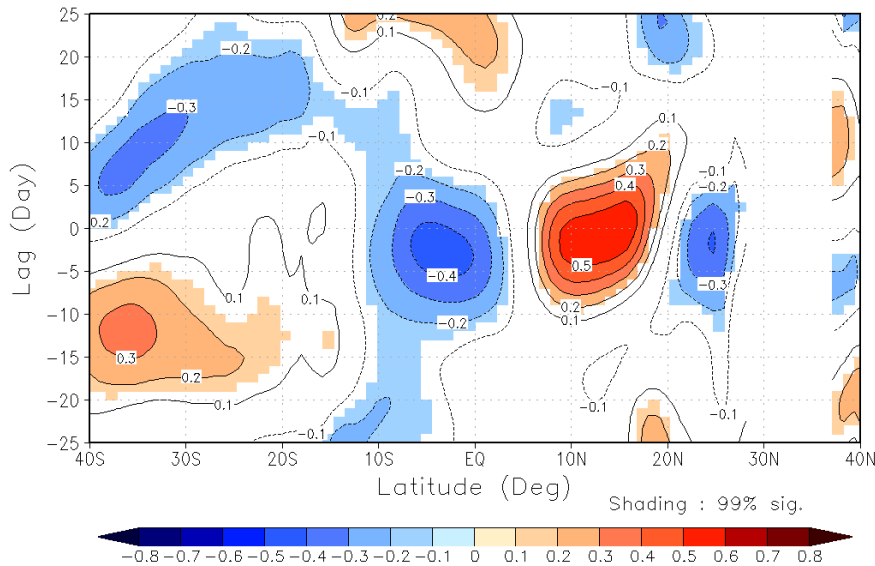# Summer ISO northward propagation

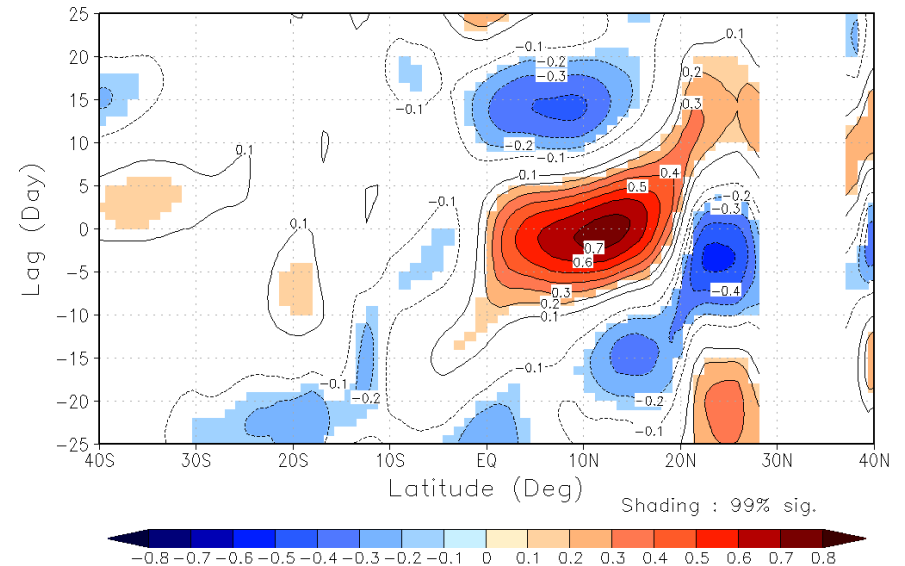## Lag correlation (U850, Summer)

ERA40

Reference domain:
3.75N-21.25N, 68E-96E

IFS

SP-IFS

Lada.
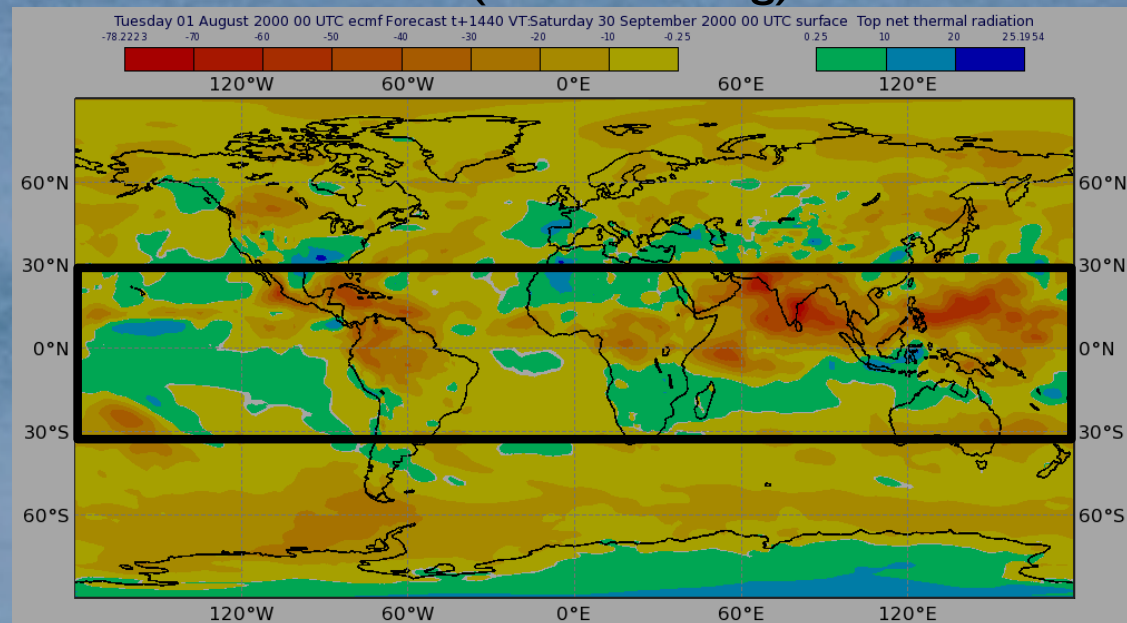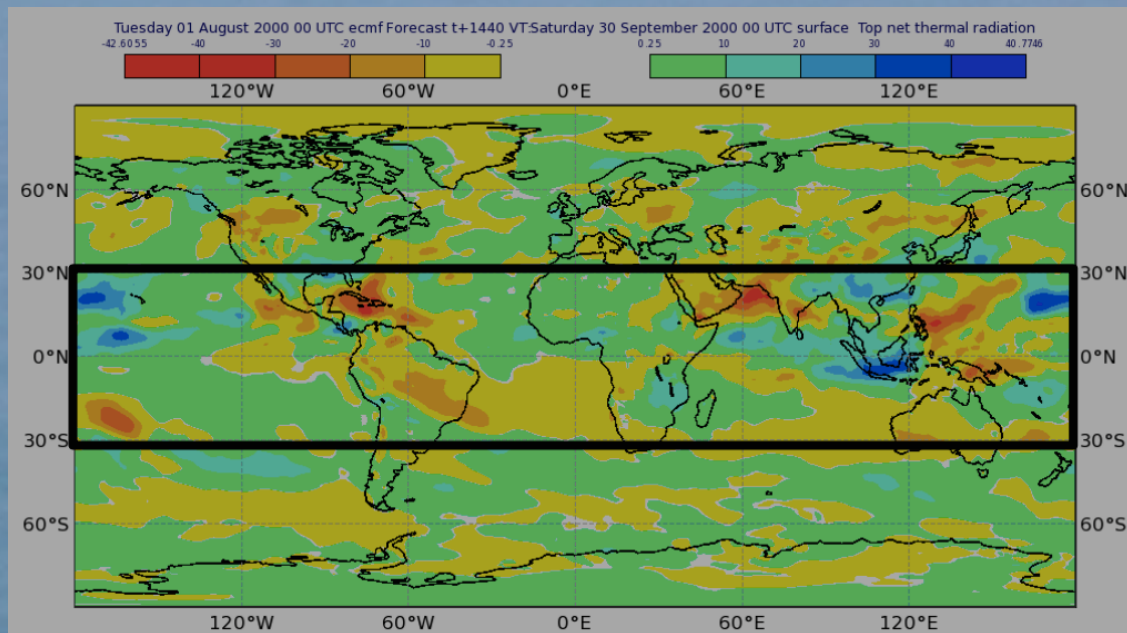
Tuning.

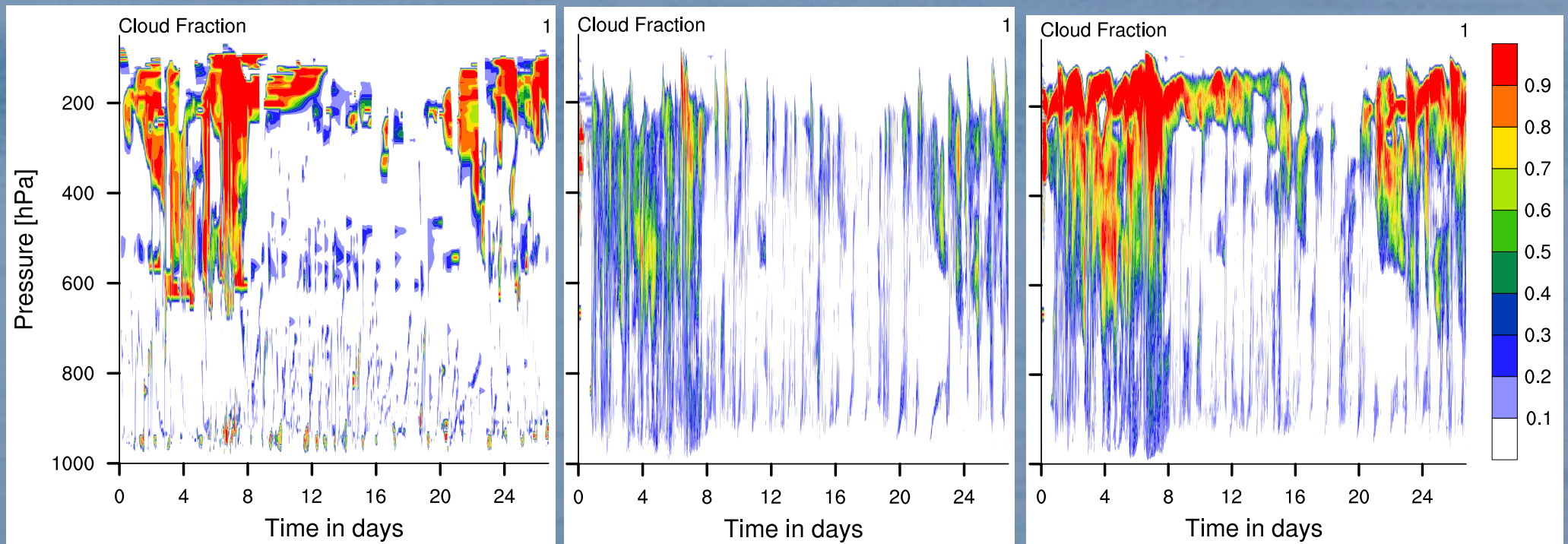# Bias in OLR in SP-IFS CY40R1 forecast

SP-IFS (before tuning)

IFS

Tuning for cloud fraction using SCM IFS
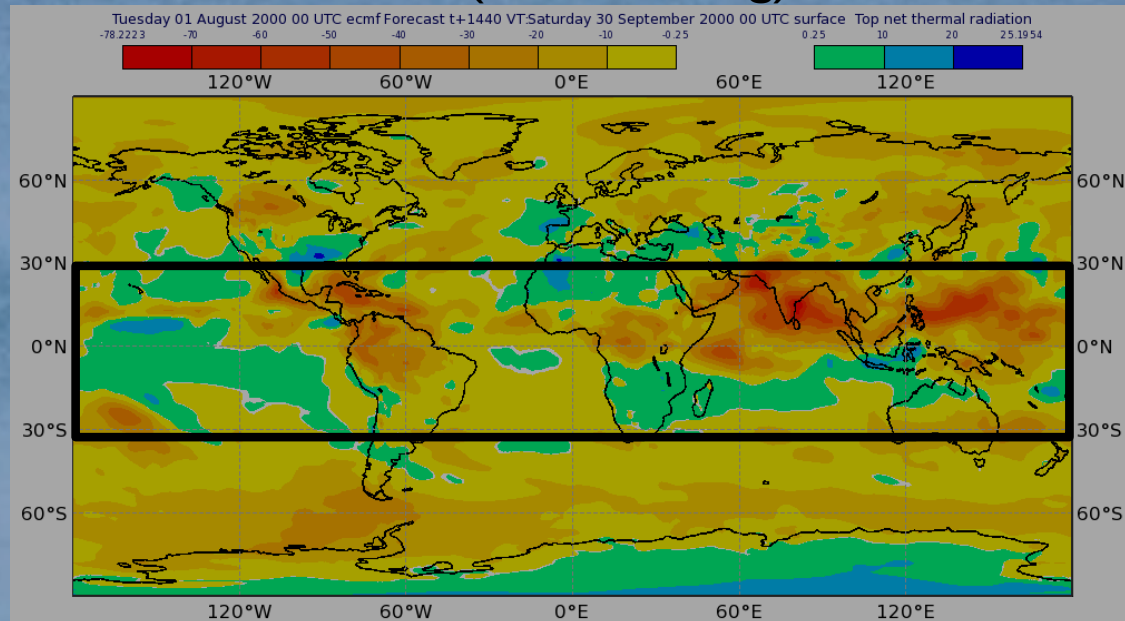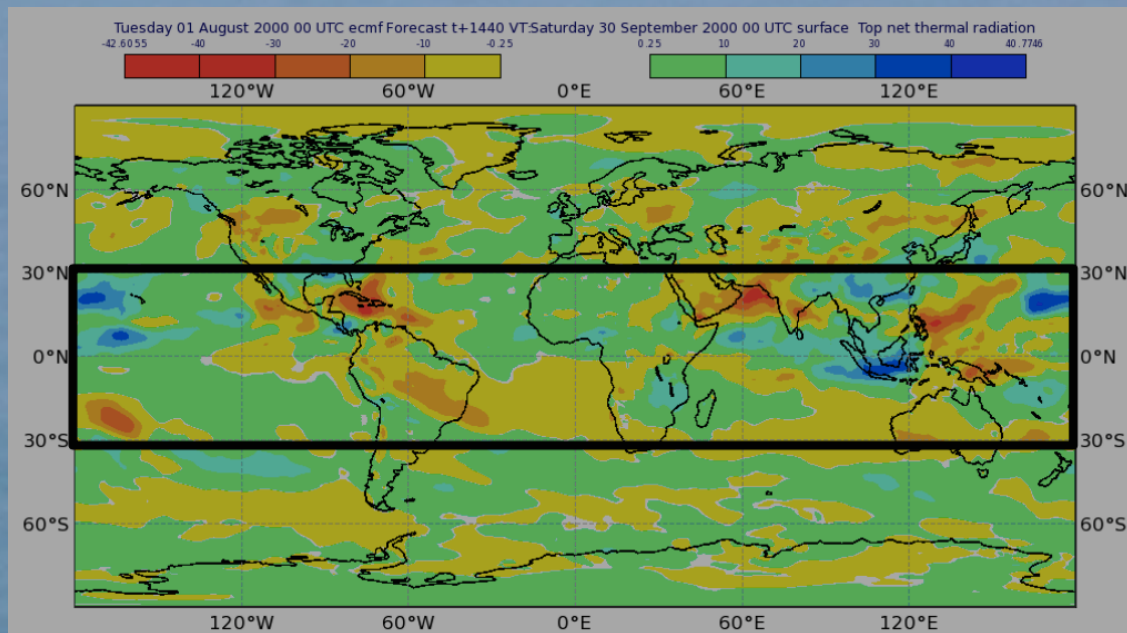## (TWP ICE case)

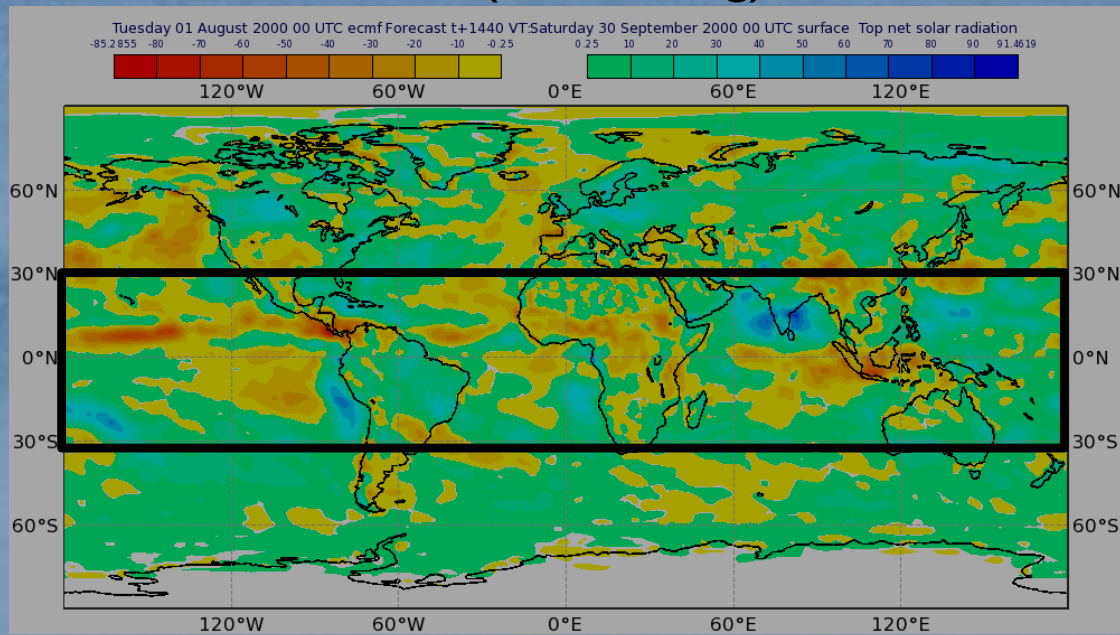# Bias in OLR in SP-IFS CY40R1 forecast

SP-IFS (before tuning)

IFS

Bias in OLR in SP-IFS CY40R1 forecast

SP-IFS (after tuning)

Tuesday 01 August 2000 00 UTC ecmf Forecast t+1440 VT:Saturday 30 September 2000 00 UTC surface Top net solar radiation

IFS

Tuesday 01 August 2000 00 UTC ecmf Forecast t+1440 VT:Saturday 30 September 2000 00 UTC surface Top net thermal radiation
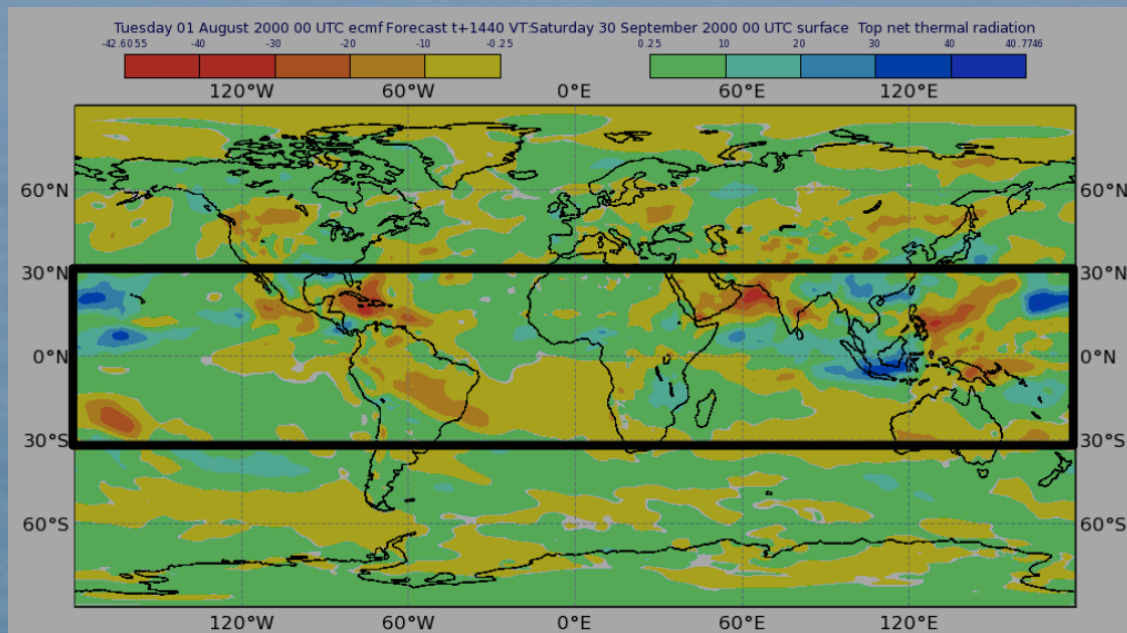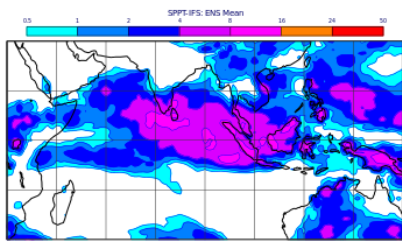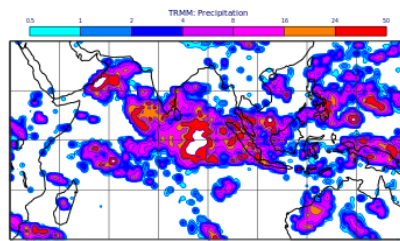
Ensemble forecasts with SP-IFS
Tim Palmer and Aneesh Subramanian

Forecast Error and Spread in Precipitation:
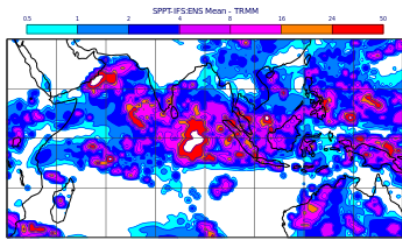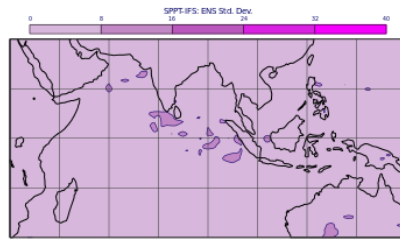
SPPT IFS
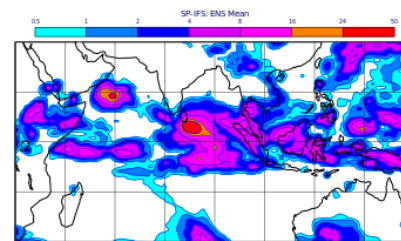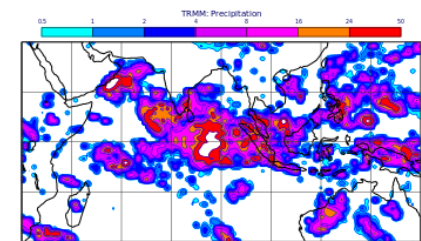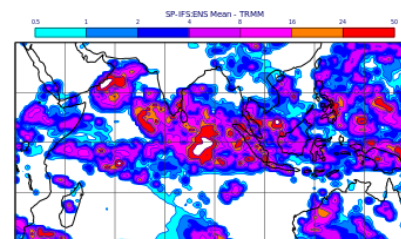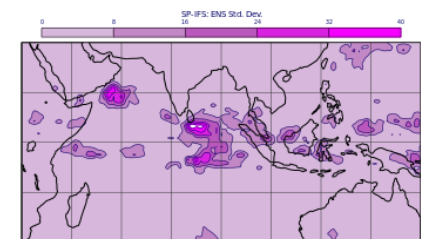
SSP IFS

(Initial date: Oct 21, 2011) + 240h

Error in Precipitation is of same order of magnitude, but spread is greater in SSP IFS
Hence, SSP IFS is a more reliable forecase ensemble for precipitation in this case.

Reach for the sky.

Outlook

- **The management seem very impressed by the SP-IFS capability.**

- **Both Heads of Research and Forecast Departments are very supportive to further explore possibilities of IFS with SP option.**

- **The SP code will continue to be supported in future IFS cycles as auxiliary option.**

- **Full access to the ECMWF supercomputing resources is given.**

- **Near-term plans:**

  - **Climate runs (AMIP style)**

  - **Monthly and seasonal forecasts**

  - **A paper to document the model**