

The role of convective triggering in an AGCM

Tsuneaki Suzuki, Seita Emori, Teruyuki Nishimura,
and Shinji Matsumura

Frontier Research System for Global Change

Role of convective trigger

- Initialize (cumulus) convection
 - Determine the timing to occur convection
- Control instability of upper atmosphere
 - Affect condensation processes and precipitation
- Change the boundary layer condition
 - Moisten boundary layer

How to understand effect of triggering

1. Investigate the behavior of convection by using super-fine resolution model ($\Delta x \sim 100\text{m}$).
 - Environment of simulation is limited and global simulation cannot be performed.
2. Introduce conceptual triggering model into GCM's (or mesoscale-model's) convection parameterization.
 - The model expresses triggering process only qualitatively.

In this study, we are interested in role of convective triggering in global atmospheric phenomena.

Parameterization of convective trigger

- Fine resolution model ($1 \text{ km} < \Delta x < 10 \text{ km}$)
 - When parameterizing (cumulus) convection, we face the triggering process in the first place.
 - ∴ *In order to resolve the buoyant parcel which induces convection, horizontal resolution should be finer than several hundred meters.*
- General circulation model (GCM)
 - Convective parameterization for GCM represent the effect of several cumulus statistically.
 - Better parameterization should include statistical triggering effect.
 - ∴ *Each cumulus depends on convective triggering.*

Trigger function in this study

- Check the virtual potential temperature of source parcel at LCL (instead of LFC) by comparing it with environmental virtual potential temperature (Hong and Pan, 1998).

$$\theta_{src} + \delta\theta \Rightarrow \theta_{env}$$

$\delta\theta$: perturbation of virtual potential temperature

• Definition of source layer

- Source layer has largest moist static energy between surface and 400 hPa above the surface

Mechanisms perturbing virtual potential temperature

- **Surface inhomogeneities**

(constant value)

- Turbulence-induced buoyancy

$$\Delta\theta_{cbt} = b \frac{\overline{(w\theta)'}_0}{w_s}$$

- **Convergence (divergence) in source layer**

$$\Delta\theta = \theta_0 \left[1 + c_4 x \left(\frac{\partial \theta}{\partial p} \right)^{1/3} \right]$$

- Updraft at the head of gust front

$$\Delta\theta_{gst} = a \left[\frac{\partial W_g}{\partial Z_h} \right]^{1/2}$$

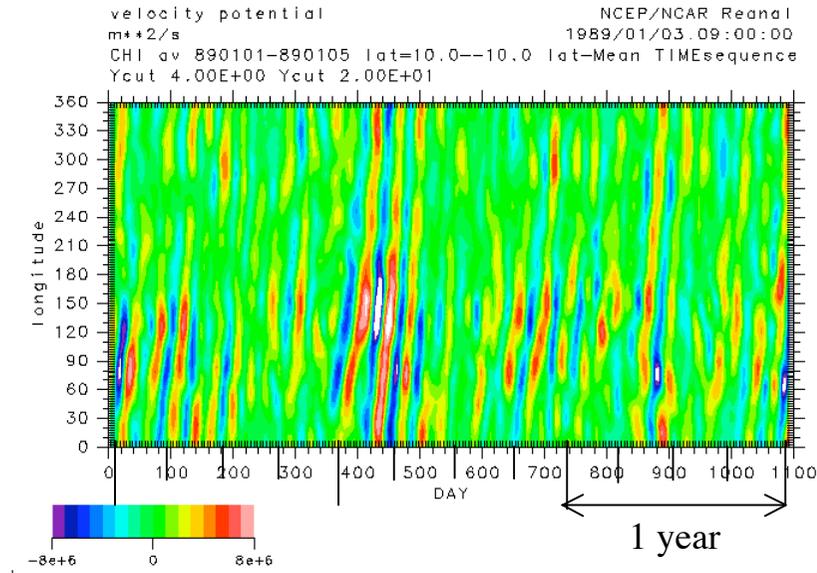
The sub-grid feature of gust front is prognosed according to the model of Qian et al. (1998)

Convective triggering in GCM

- Simulation was performed by CCSR/NIES AGCM with the resolution of T106L20
 - The triggering function was implemented into prognostic Arakawa–Schubert scheme.
 - Large scale condensation is described by Le-Treut and Li scheme.

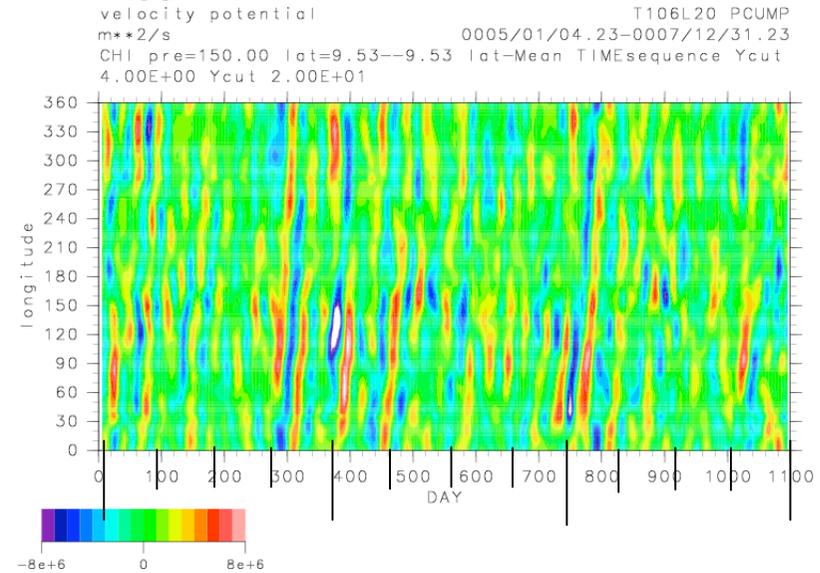
Time-longitude diagrams of filtered velocity potential at 150 hPa

Observation

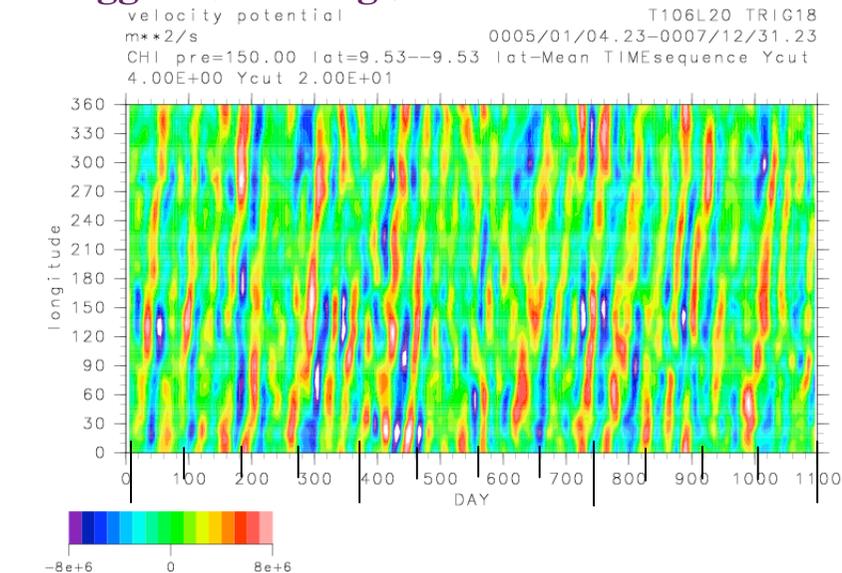


No trigger

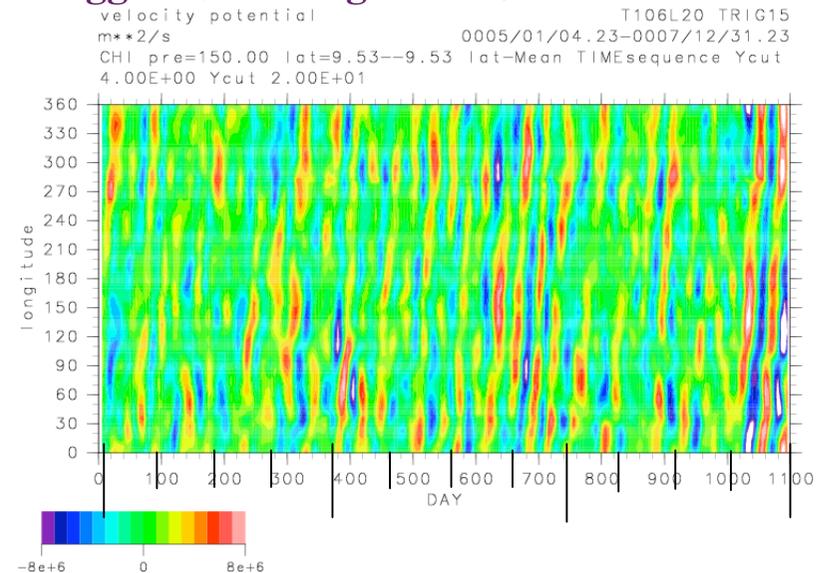
(10°N-10°S)



Trigger (inhomog.)



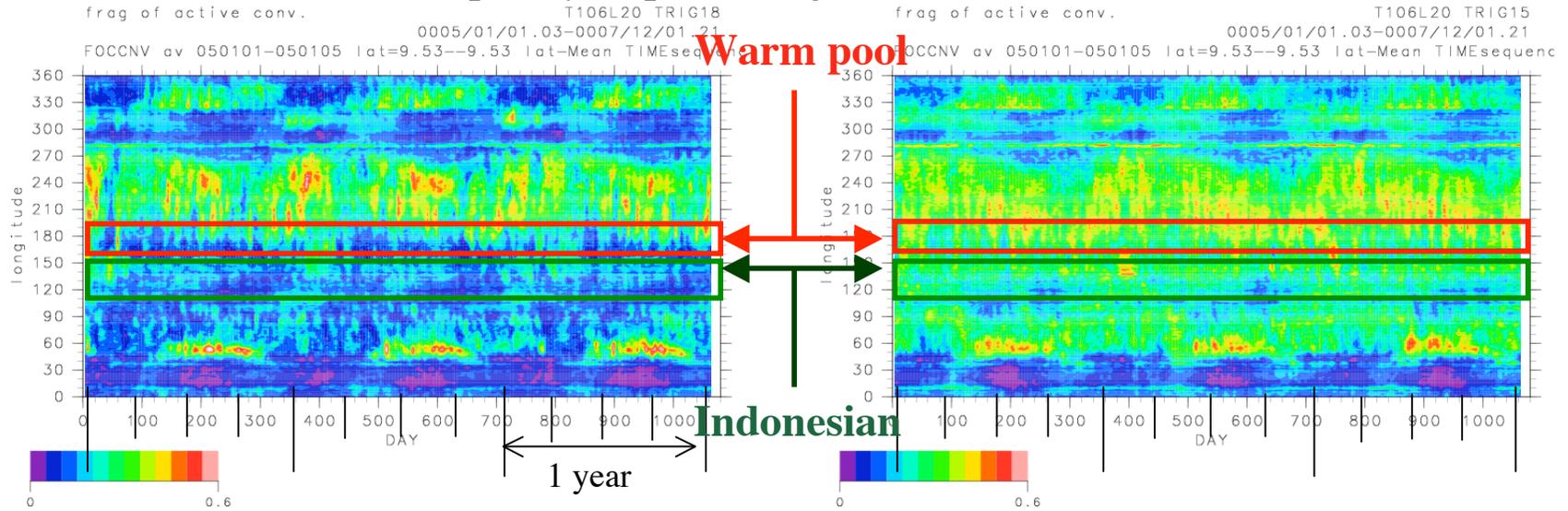
Trigger (inhomog.+conv.)



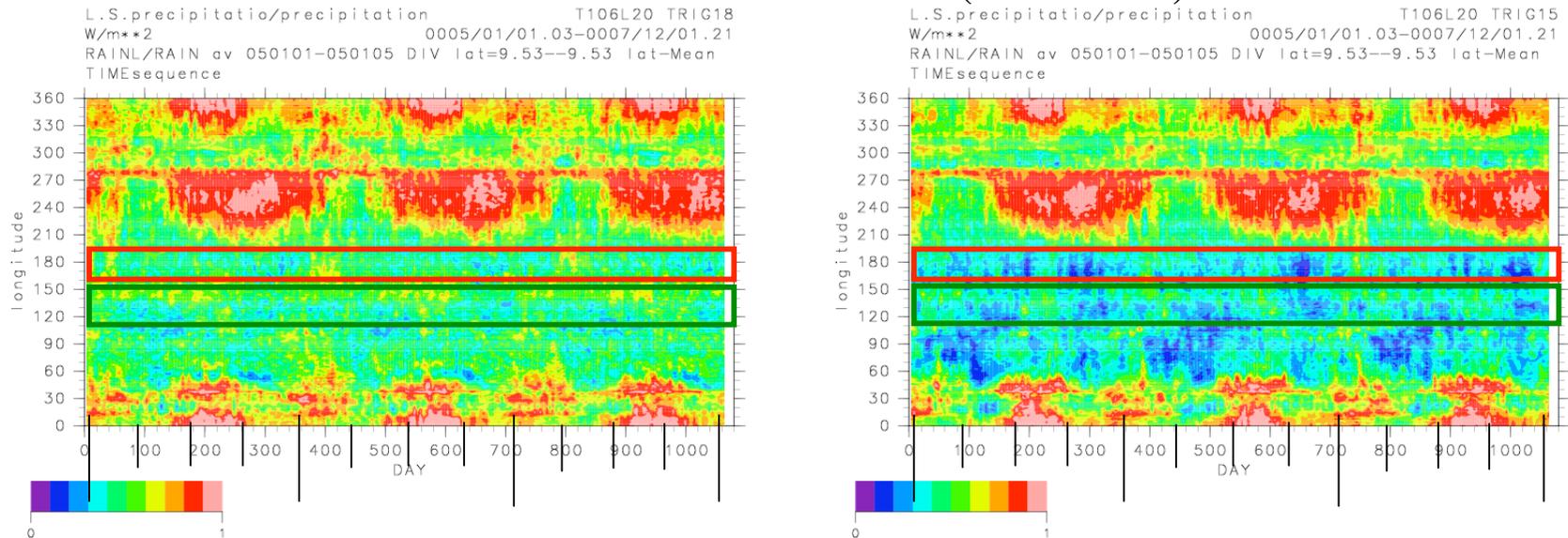
Trigger (inhomog.)

Trigger (inhomog.+conv.)

Frequency of permitting convection (10°N–10°S)



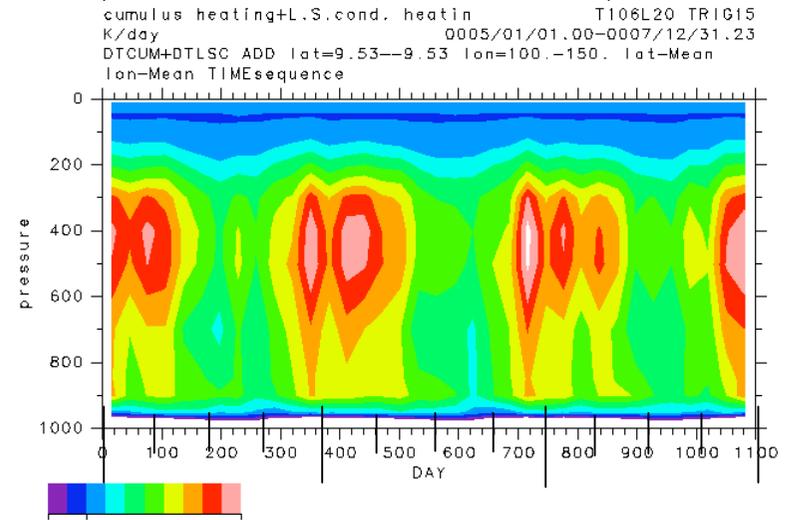
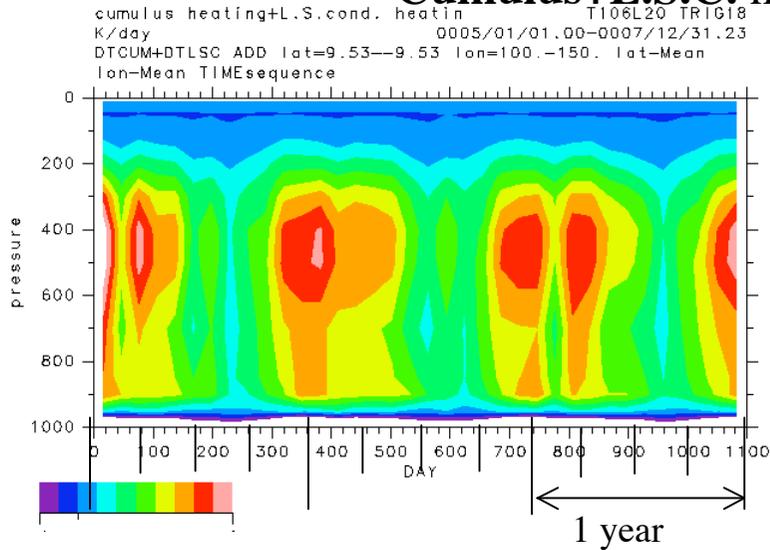
L.S.C. rain / total rain (10°N–10°S)



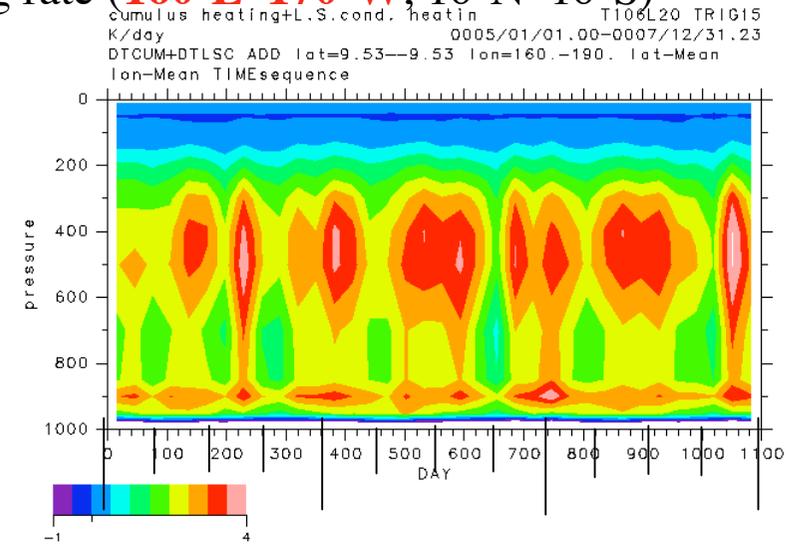
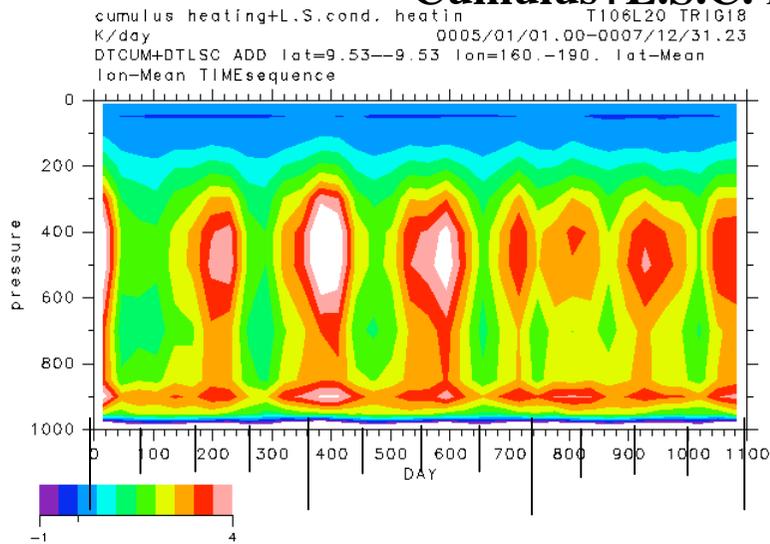
Trigger (inhomog.)

Trigger (inhomog.+conv.)

Cumulus+L.S.C. heating rate (100°E–150°E, 10°N–10°S)



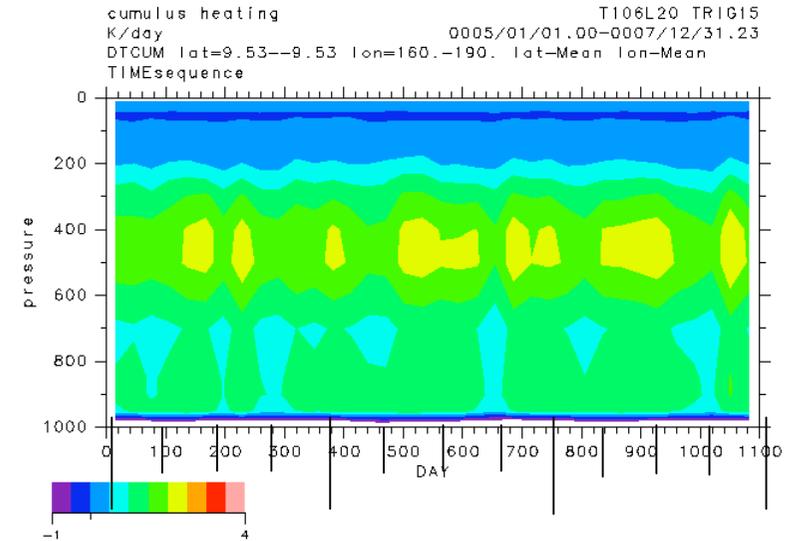
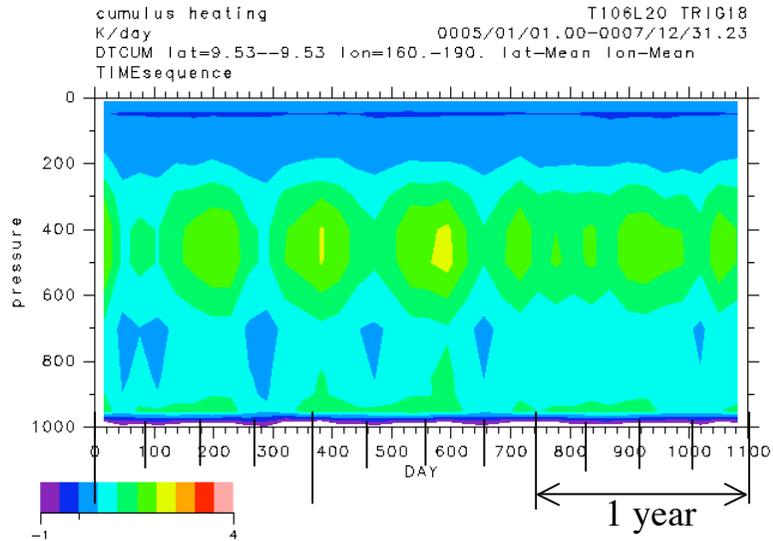
Cumulus+L.S.C. heating rate (160°E–170°W, 10°N–10°S)



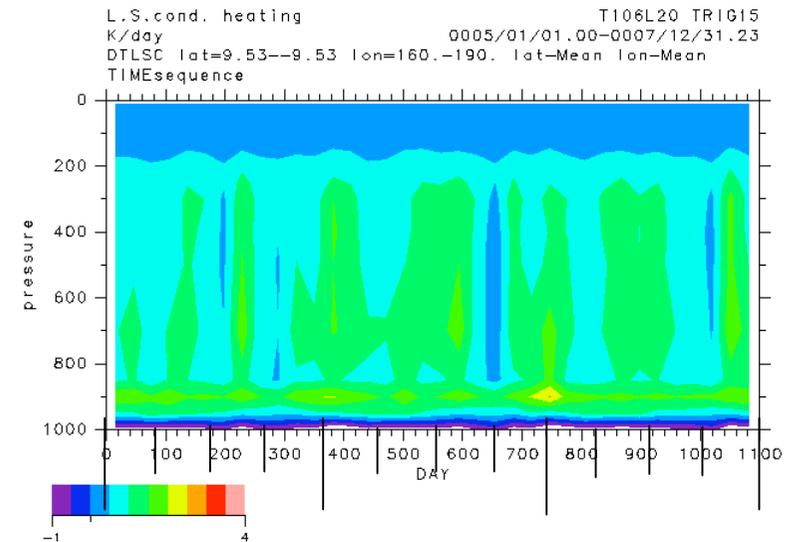
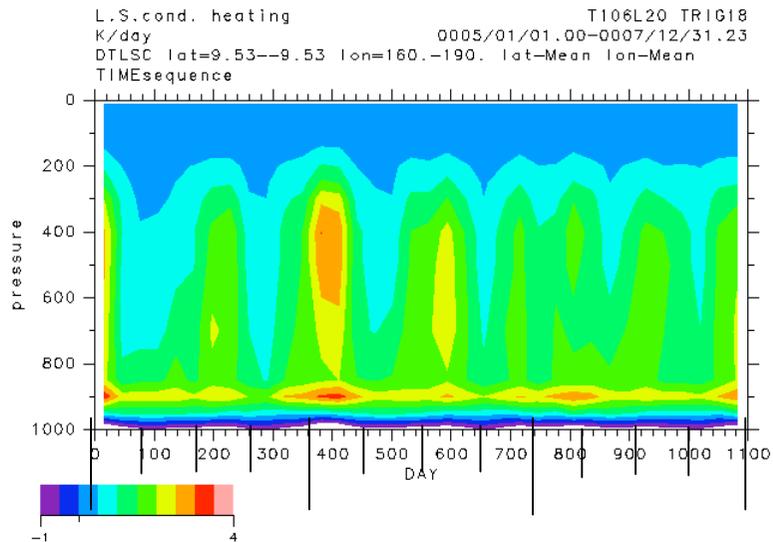
Trigger (inhomog.)

Trigger (inhomog.+conv.)

Cumulus heating rate (160°E–170°W, 10°N–10°S)



L.S.C. heating rate (160°E–170°W, 10°N–10°S)



Summary and toward the future

- To simulate atmospheric phenomena more realistically in GCM, we should introduce appropriate triggering processes.
- Current triggering model is very conceptual.
We need more realistic triggering parameterization.
- Better triggering parameterizations
 - have the dependence of model resolution,
 - change the strength of triggering by region and time according to obvious physical mechanisms ,
 - include less tuning parameters.
- We should investigate convective triggering using super-fine-resolution model under various conditions.