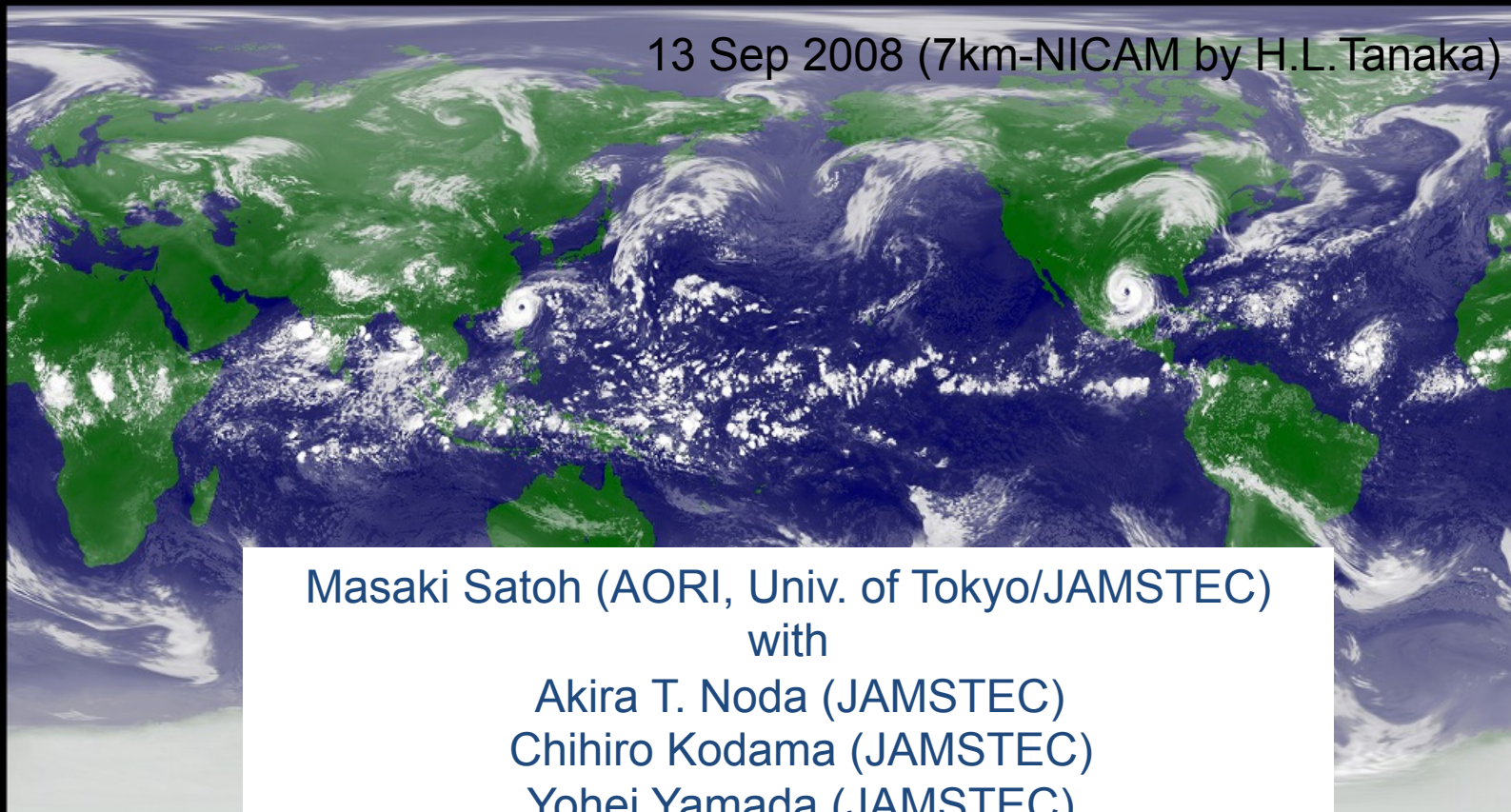




# Cloud responses simulated by NICAM

13 Sep 2008 (7km-NICAM by H.L.Tanaka)



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with

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CMMAP 13th Team Meeting, August 7 - 9, 2012

Hilton, Fort Collins, USA [Group web page http://nicam.jp](http://nicam.jp)

# NICAM cloud changes

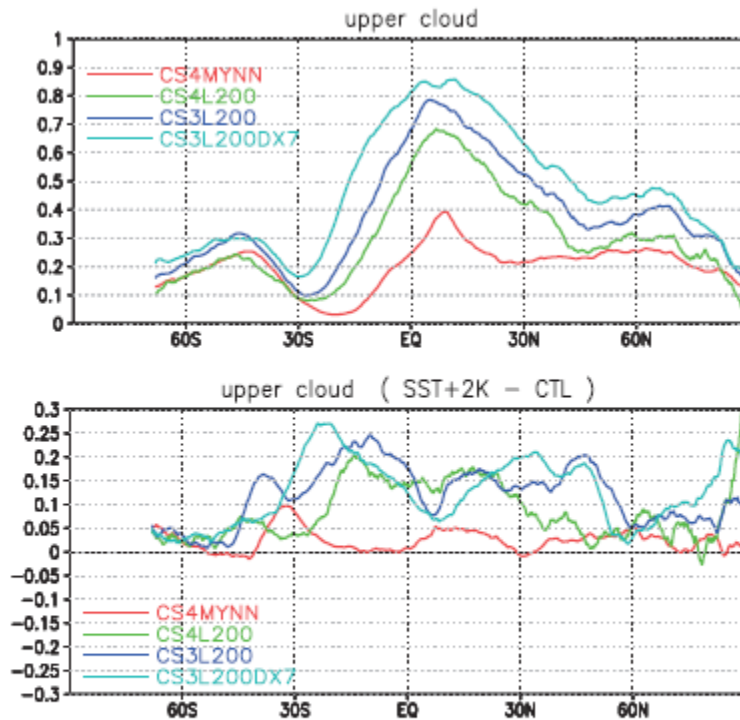


FIG. 2. Latitudinal distribution of ISCCP upper-cloud fraction for (top) the control experiments, CTL, and (bottom) the differences between the results of the control experiments and the +2K experiments (SST+2K - CTL).

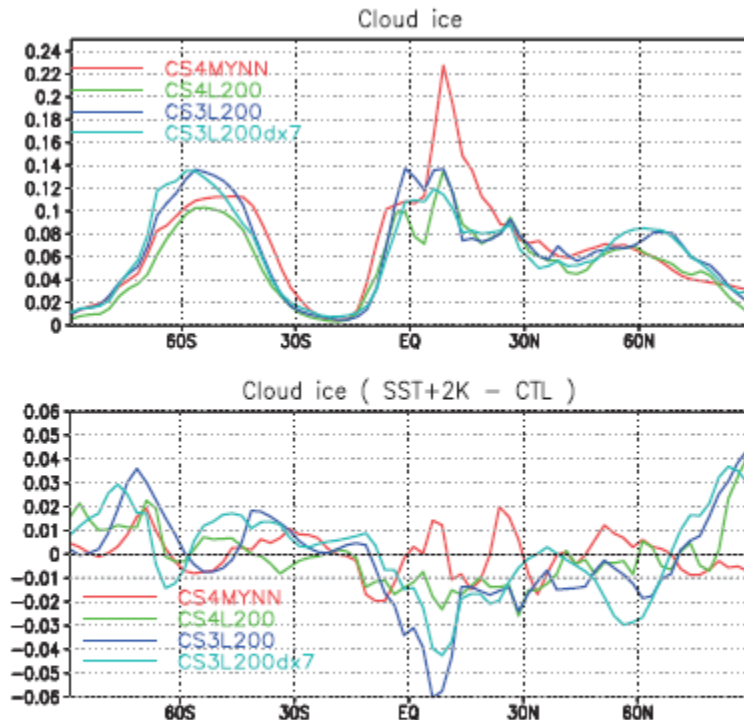


FIG. 3. Latitudinal distribution of (top) the IWP and (bottom) the difference between the results of the control experiments and the +2K experiments ( $\text{kg m}^{-2}$ ).

Sato et al. (2012, JCLI)

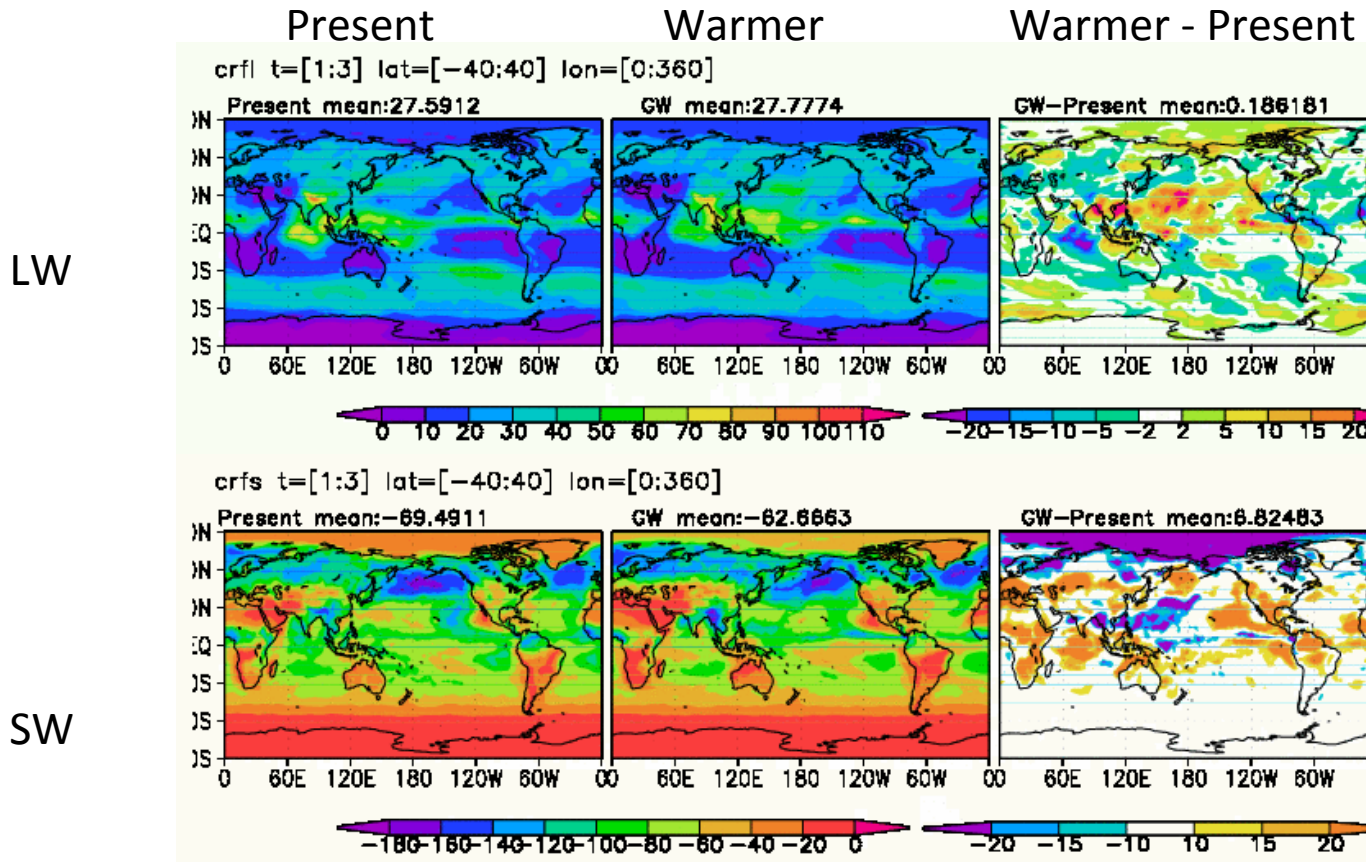
# Characteristics of cloud changes

- Tropics
  - IWP decrease, or marginal (PBL=MYNN2)
  - Cloud fraction increase
    - IWP and cloud fraction show an opposite response
- Extra-tropics
  - IWP increase
  - Cloud fraction increase

# Experiments

- NICAM.05
  - Simple CP (Grabowski 1998); PBL: MY2
  - APE, CTL vs SST+2K
    - Tomita et al.(2005), Miura et al.(2005)
- NICAM.07
  - G98; MY2-Smith & MYNN2
  - Perpetual July, CFMIP-I exp.
    - Iga et al.(2007,GRL), Iga et al. (2011,JCLI)
    - Collins and Satoh (2008,FIAS), Satoh et al.(2012,JCLI)
- NICAM.08
  - G98; MYNN2 Oouchi et al. (2009ab); Yamada et al.(2010)
  - Realistic exp. 2004JJA (CTL) vs ~2100JJA (GW)
- NICAM.09
  - NSW6 (Tomita et al. 2008); MYNN2
  - APE: Qobs vs SST+4K
  - Realistic exp. 2004JJA (CTL) vs ~2100JJA (GW)

# Change in cloud radiative forcing



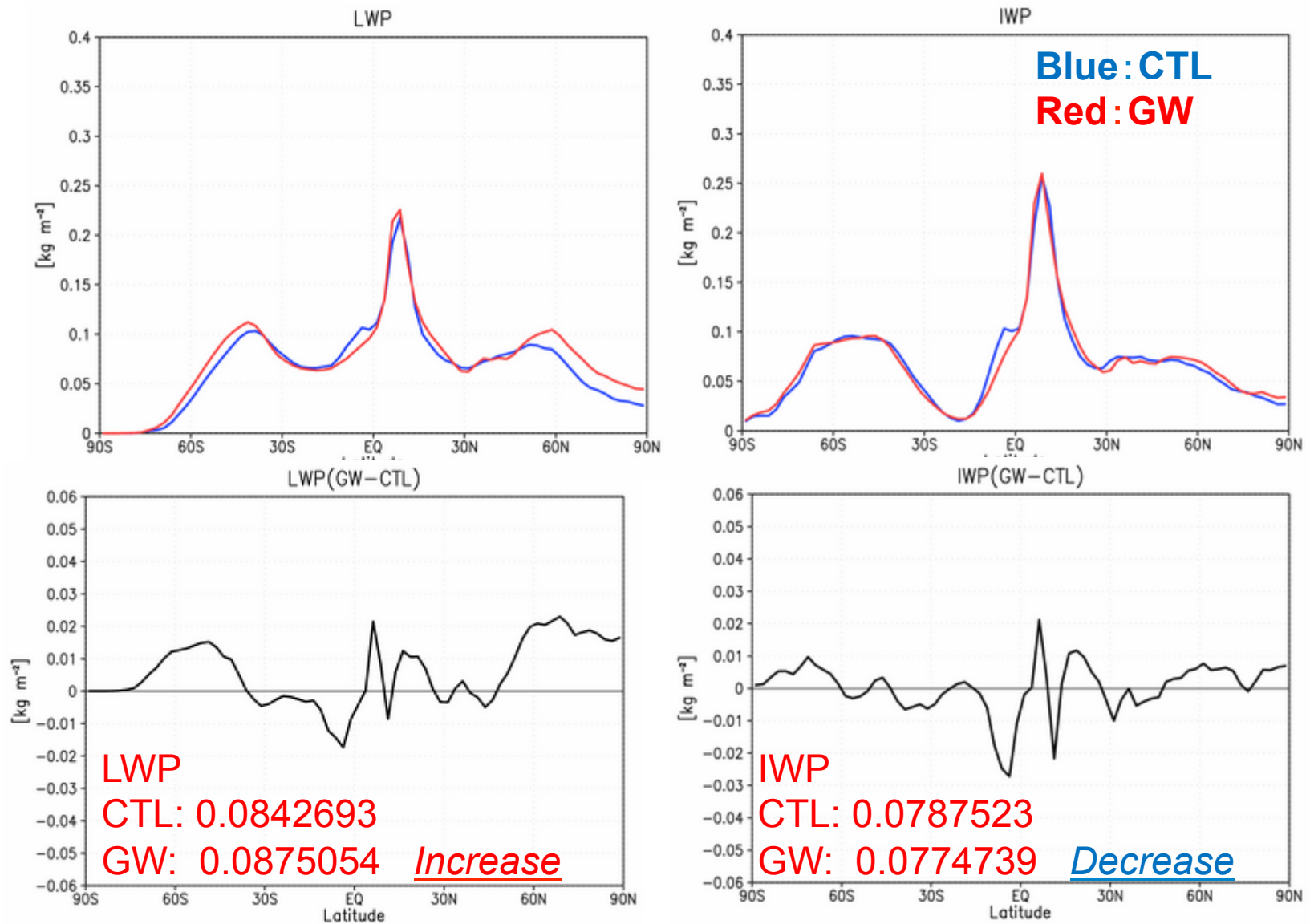
LW: Increase  
in West. Pacific  
SW: decrease

	NET CRF (W/m <sup>2</sup> )	LW CRF (W/m <sup>2</sup> )	SW CRF (W/m <sup>2</sup> )	High cloud (%)
Present	41.9	-27.6	69.5	19.0
Warmer	34.9	-27.8	62.7	21.4
<b>Change</b>	<b>-7.0</b>	<b>-0.2</b>	<b>-6.8</b>	<b>+2.4</b>

40S-40N



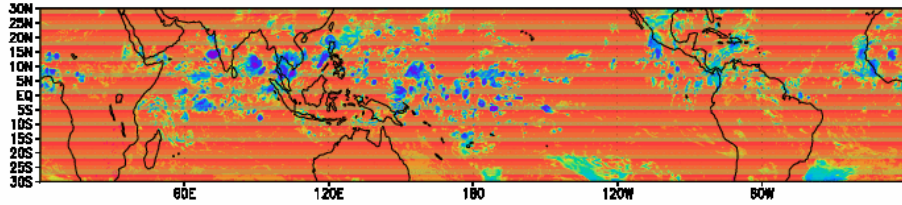
# Zonal mean LWP and IWP



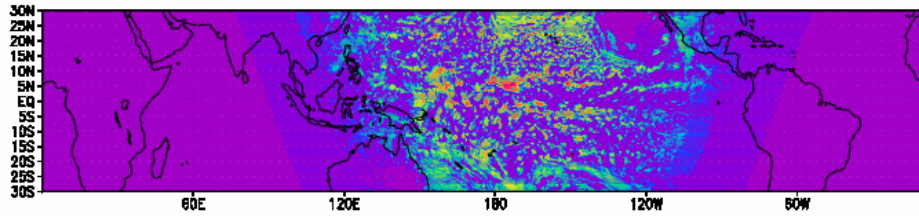
- Cloud clusters
- Tropical cyclones
- Storm tracks

# Example of high cloud

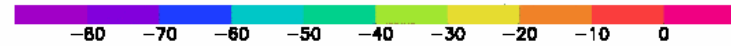
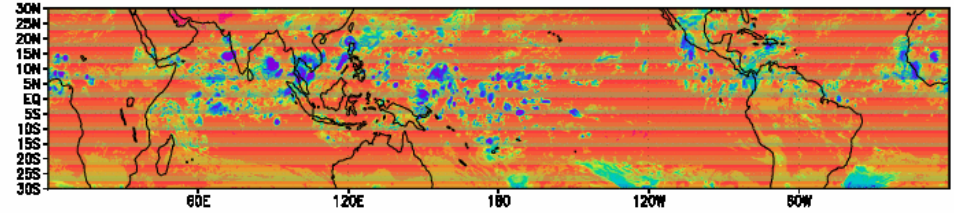
LW CRF



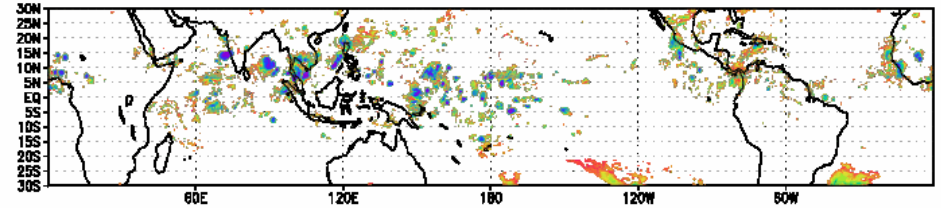
SW CRF



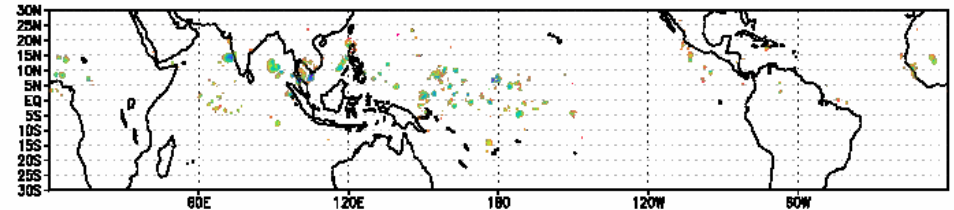
Tbb



tbb < -38



tbb < -65





# Probability density map

High clouds

Decrease in west. Pacific

Increase in Mid-, East. Pacific

$$\int P(x,y)dx dy = 1 \text{ for each category}$$

※個々のカテゴリの頻度は半径が小さいほど多い

Present

Warmer-Present

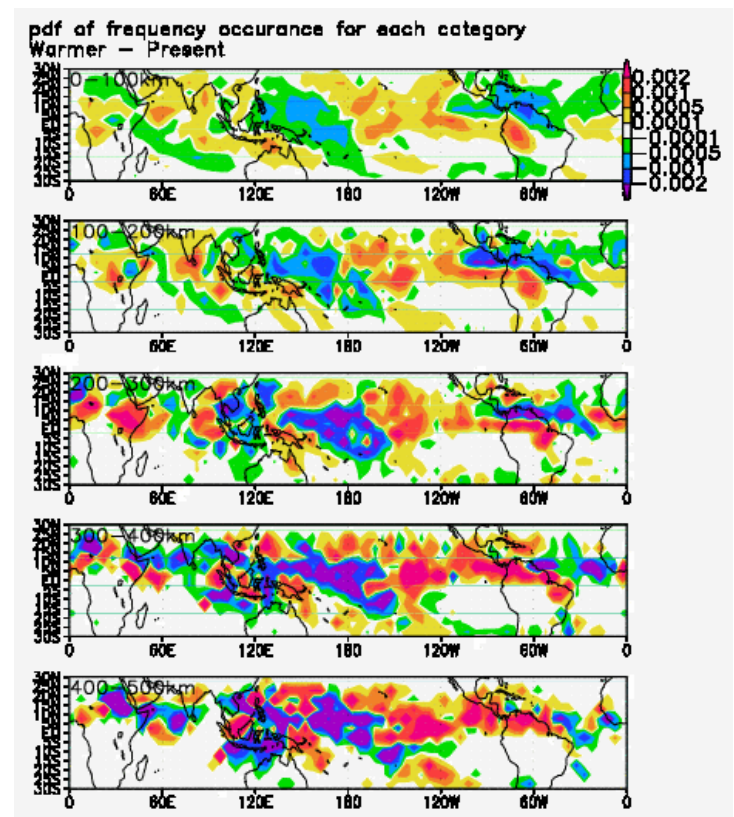
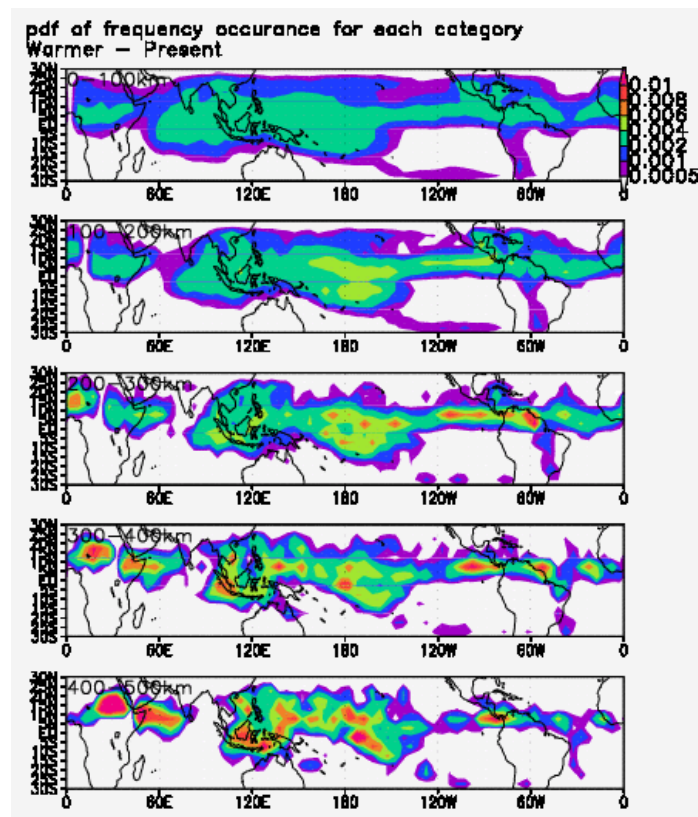
0-100km

100-200km

200-300km

300-400km

400-500km



# Cloud area analysis

## Changes of high cloud and cloud radiative forcing

Decrease in larger clouds: less organization

Smaller clouds (0-50km): increase

LW CRF → more negative

SW CRF → less positive

Mid-scale clouds(50-200km): decrease

LW CRF → less negative

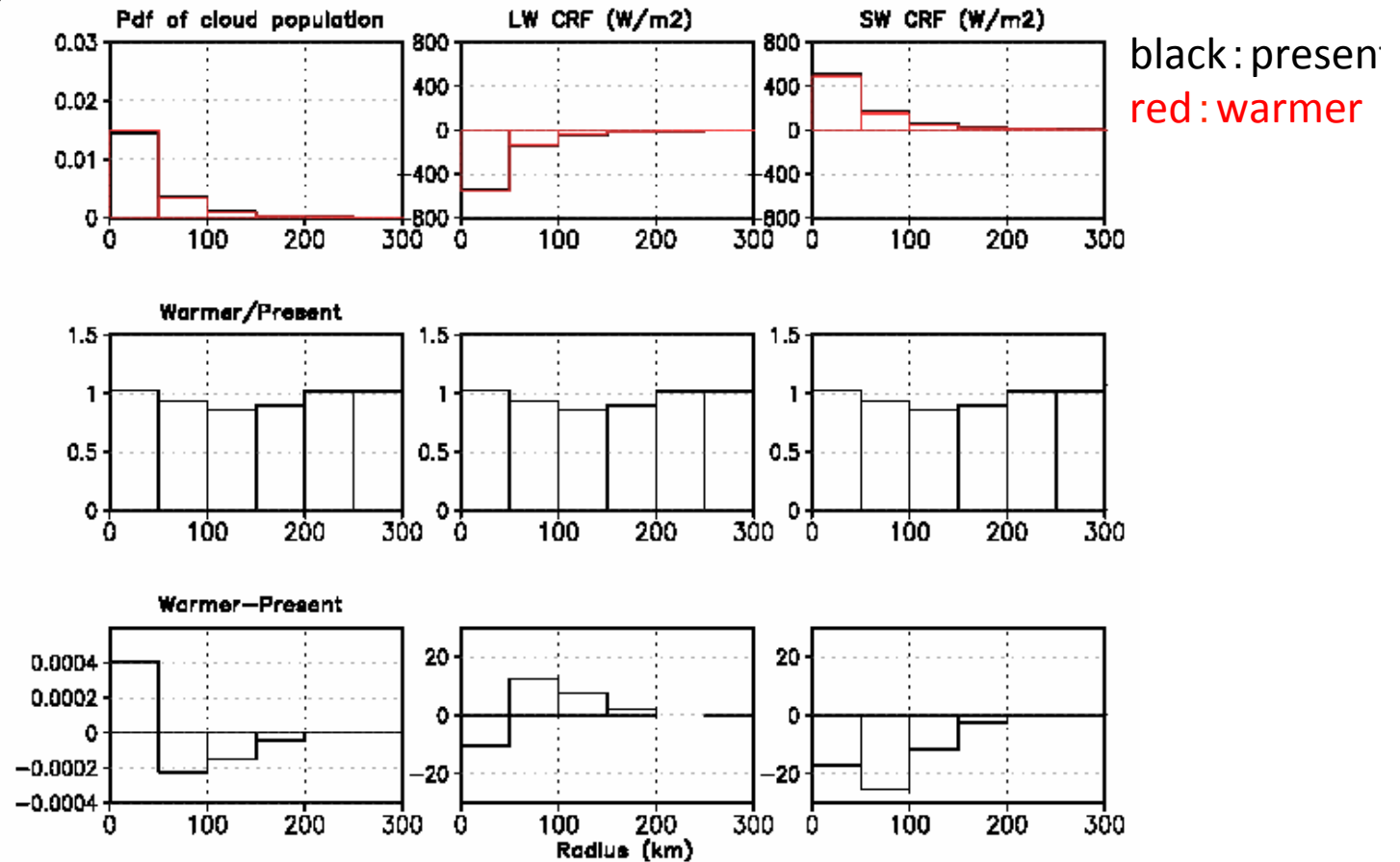
SW CRF → less positive

Data : JJA (Yamada et al. 2010)

30N-30S

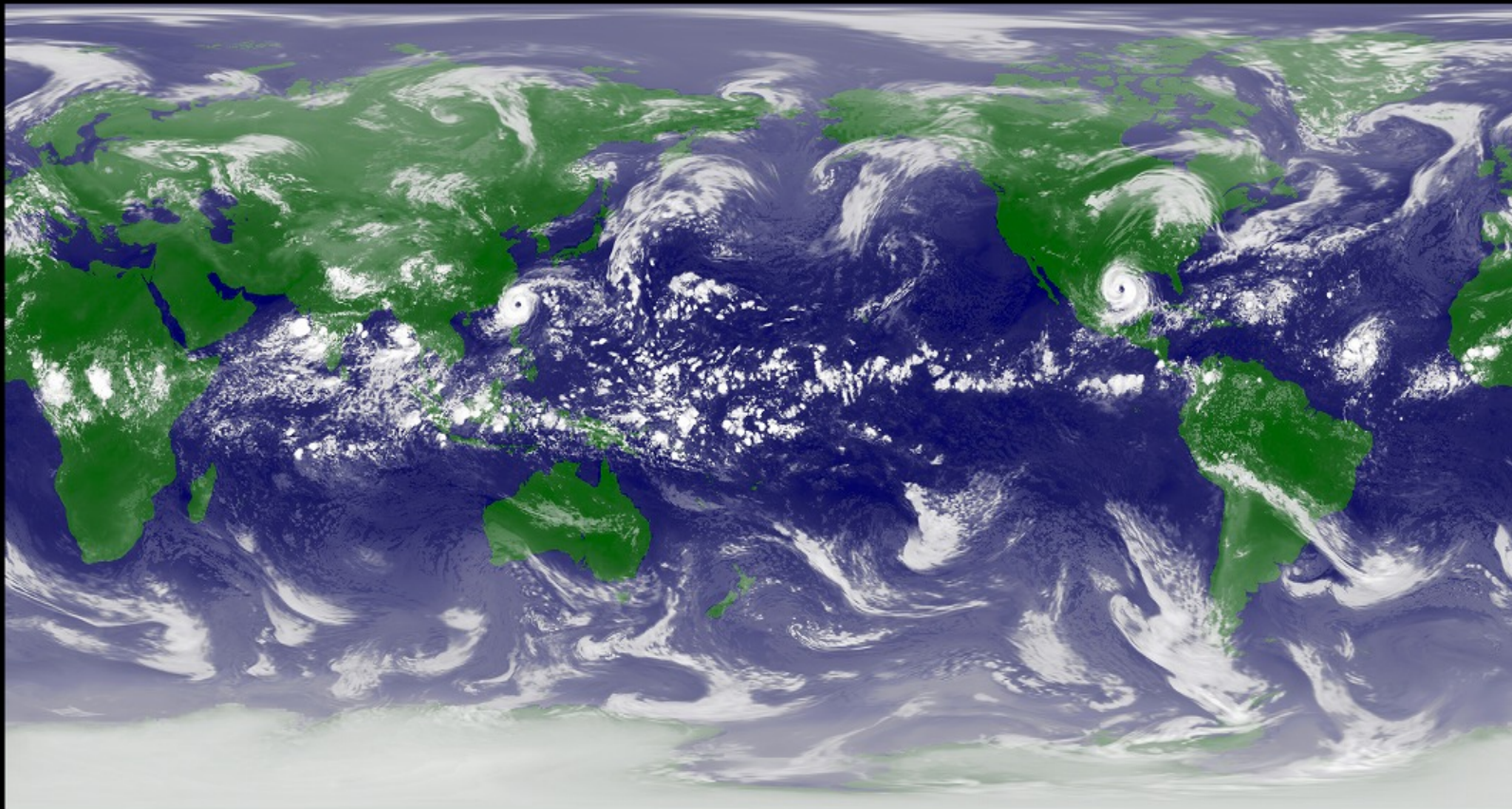
High cloud : Tbb < -38deg

Positive when cooling



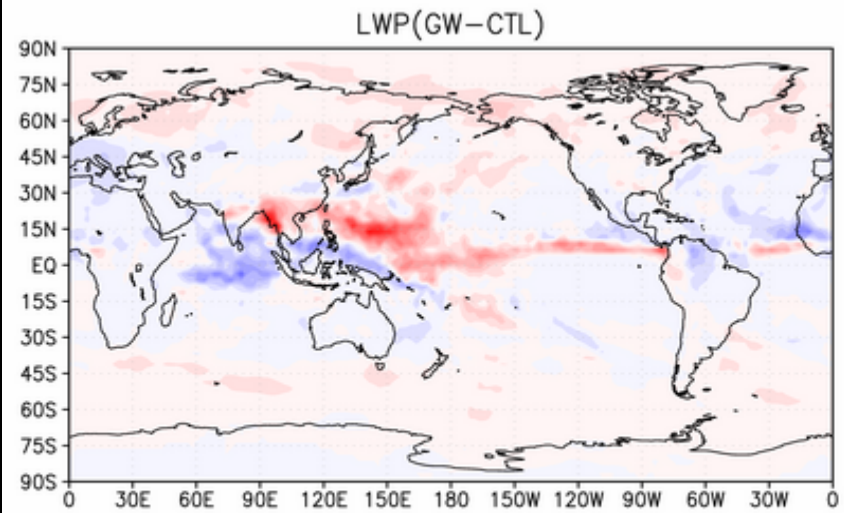
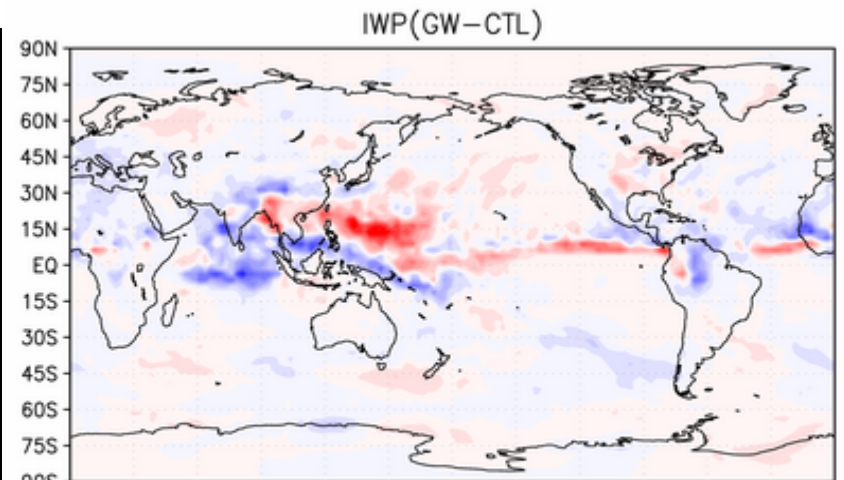
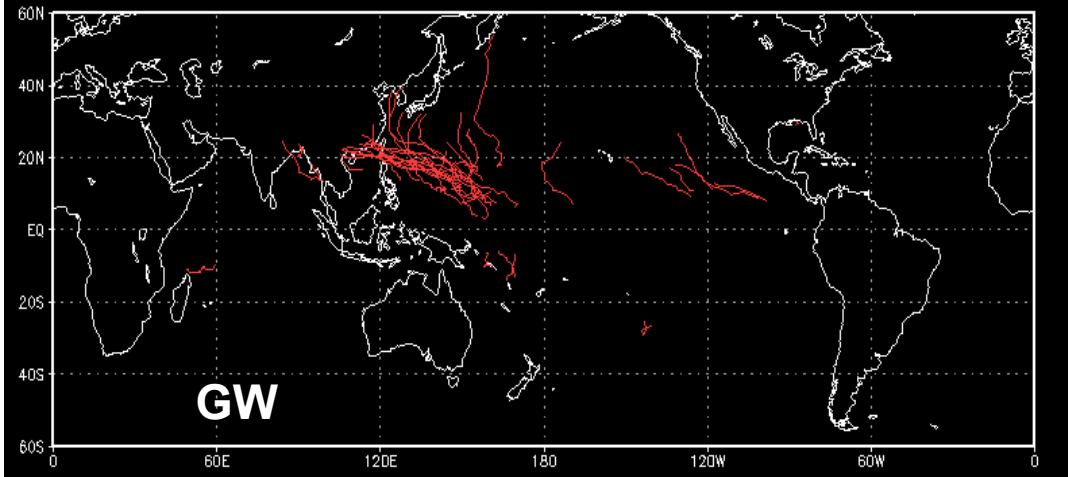
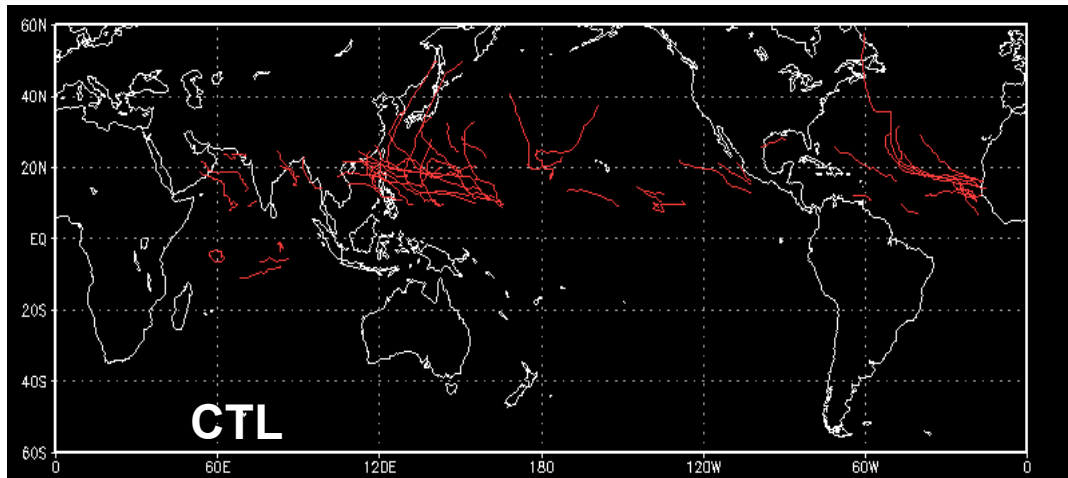
NICAM glevel-10

2008091300 Z





# Changes in TC tracks and clouds



# TC frequency

NI: North Indian Sea; SI: South Indian Sea

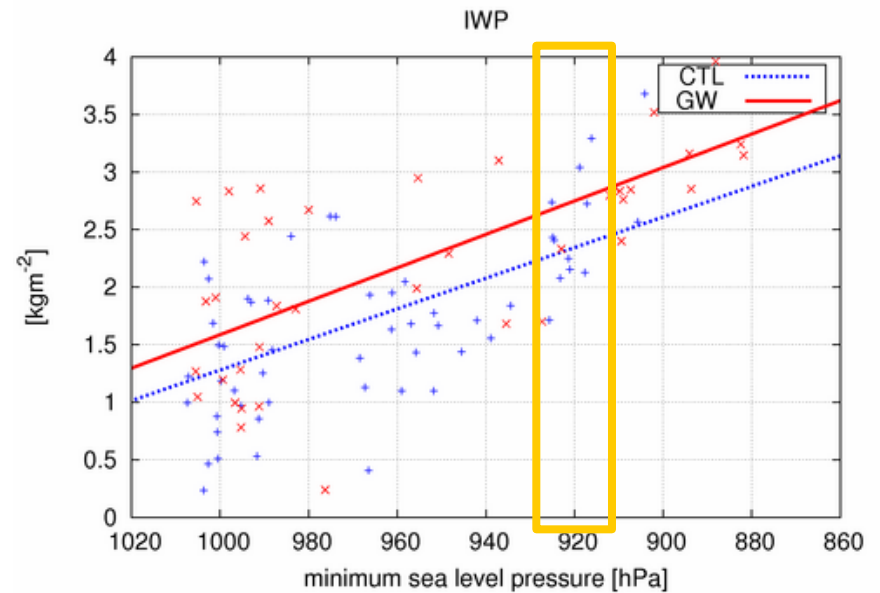
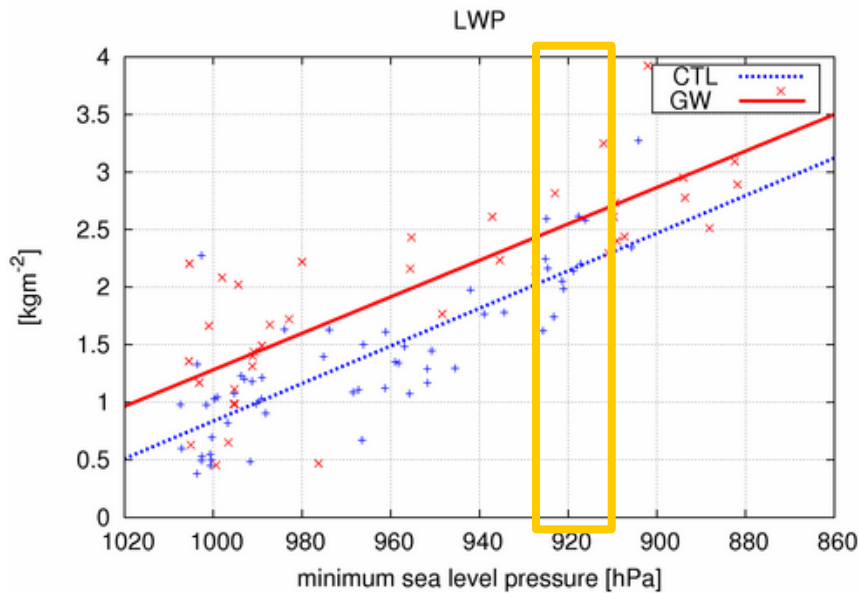
NWP: North West. Pacific; NEP: North East. Pacific

SP: South Pacific

NA: North Atlantic; SA: South Atlantic

	NI	NWP	--	NEP	NA	SI	SP	SA	GL
OBS	1	20	2	11	14	1	0	0	47
CTL	8	21	8	9	15	4	0	0	57
GW	4	24	4	6	1	1	4	0	40

# TC intensities and LWP, IWP



IWP & LWP:  $\text{GW} > \text{CTL}$ , especially for  $\text{SLP} > 920 \text{hPa}$

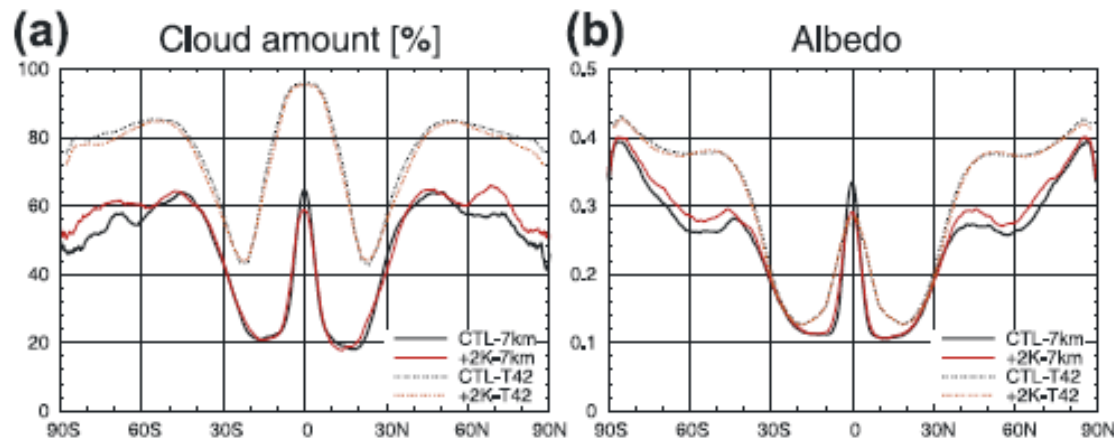
Number of TCs CTL=57, GW=40

Average in the circle with  $R=500 \text{km}$  from the TC Center at the strongest stage



# Miura et al. [2005]

- Cloud feedback by NICAM-APE
  - In high-latitude, cloud increases at SST+2K
    - SW ↓ decrease→negative feedback (T42 GCM positive)
  - implies importance of smaller scale clouds not represented by coarse GCMs

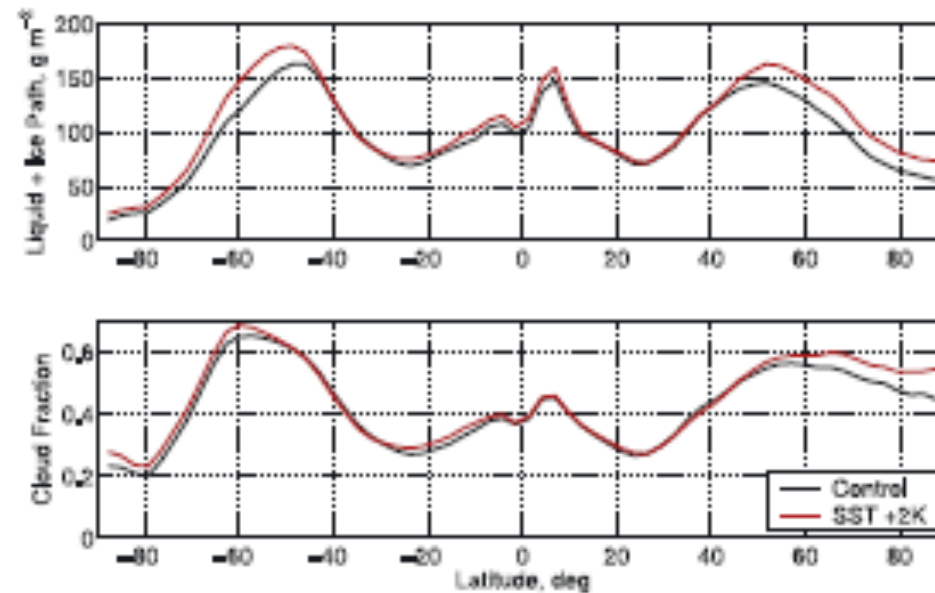


**Table 1b.** Differences in  $A_c$ ,  $Q$ , and  $F$  in +2K from those in CTL for the 7 km run in NICAM and for the T42 run in CCSR/NIES/FRCGC AGCM

	$dA_c$	$dQ$	$dF$
NICAM 7km	0.96	-1.82	2.68
AGCM T42	-1.46	0.59	4.17

Changes in  
 $dA_c$ : cloud fraction  
 $dQ$ : downward SW  
 $dF$ : OLR

# Negative feedback in high-latitudes



**Figure 5.** The annual zonal-mean changes in (top) liquid + ice path,  $\text{g m}^{-2}$  and (bottom) column-integrated cloud fraction for the control (black) and +2 K (red) runs.

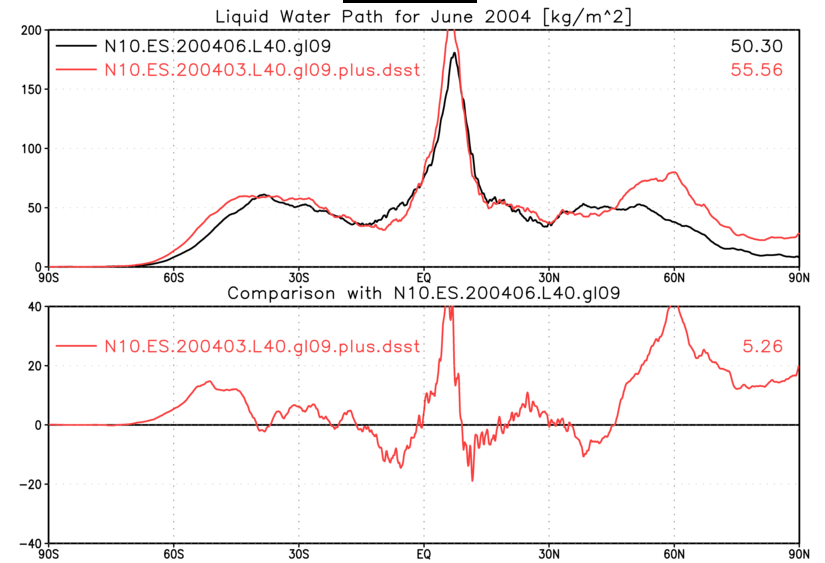
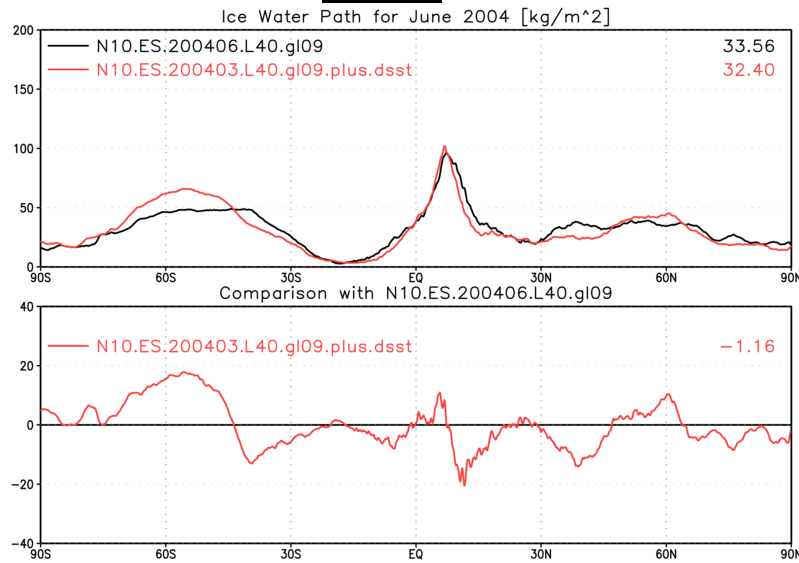
MMF: Wyant et al.(2005,GRL)

# Zonal-mean IWP & LWP (ctl-200406 vs. gw-200403)

IWP

LWP

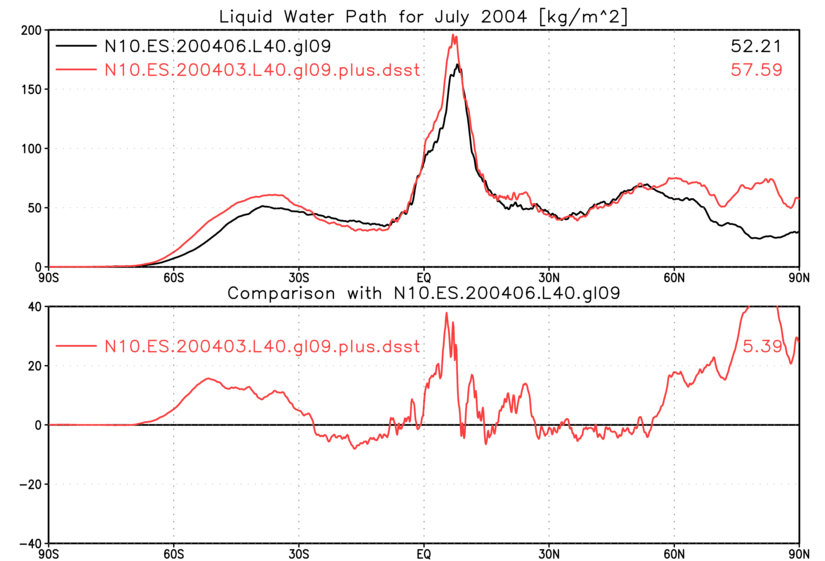
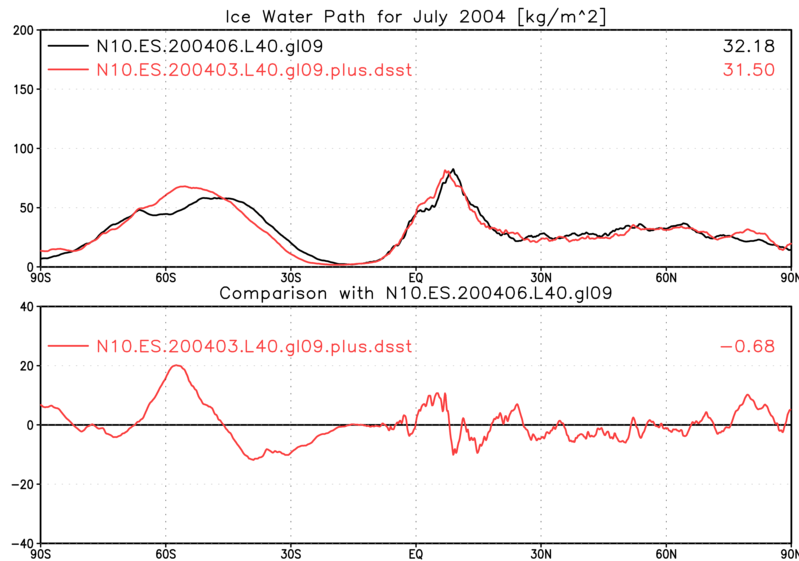
June



file : /cwork5/kodama/nicam\_analysis/gs/template/precip.gs  
N10.ES.200406.L40.gi09: 00Z15JUN2004-00Z15JUN2004  
N10.ES.200403.L40.gi09.plus.dsst: 00Z15JUN2004-00Z15JUN2004

file : /cwork5/kodama/nicam\_analysis/gs/template/precip.gs  
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July



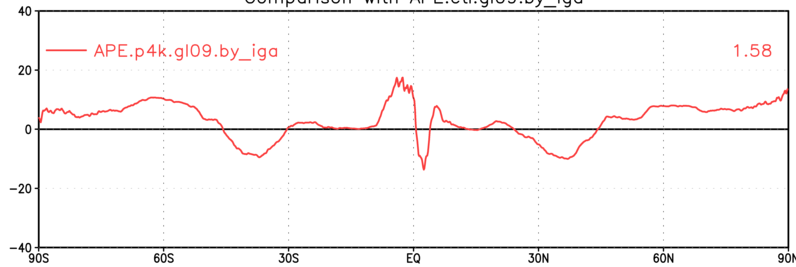
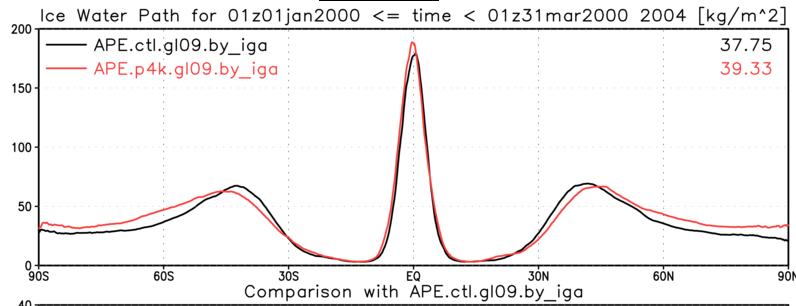
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# Zonal-mean IWP & LWP (APE)

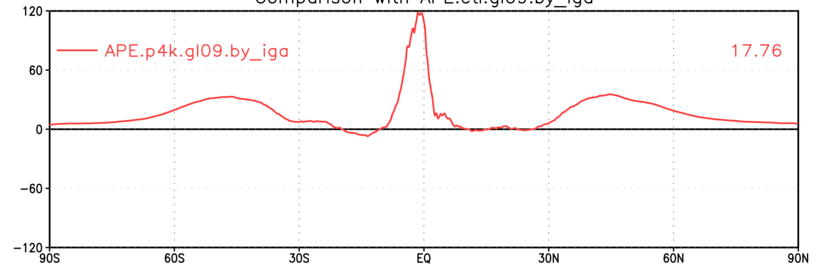
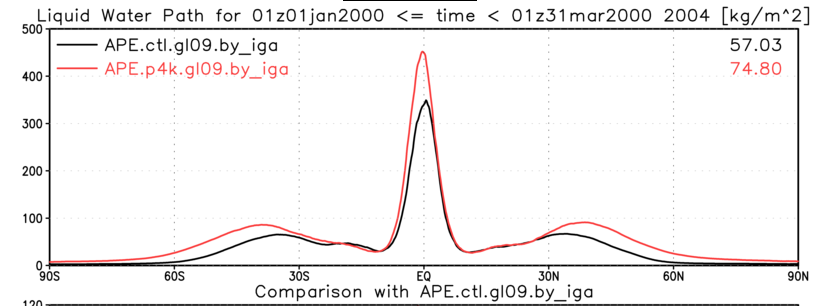
1-90dy

## IWP



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 APE.p4k.gl09.by\_iga: 01Z01JAN2000-00Z31MAR2000

## LWP



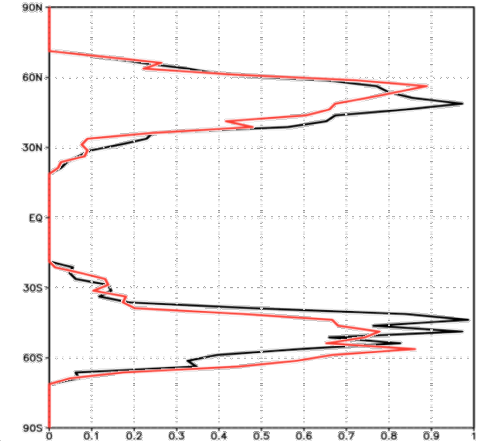
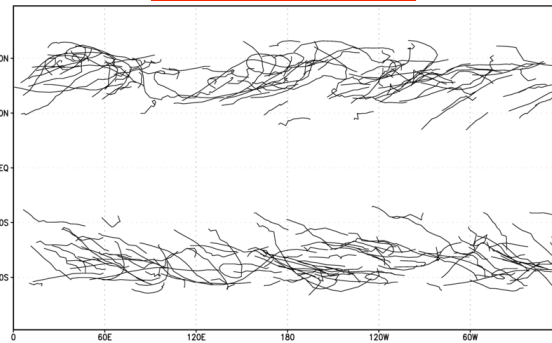
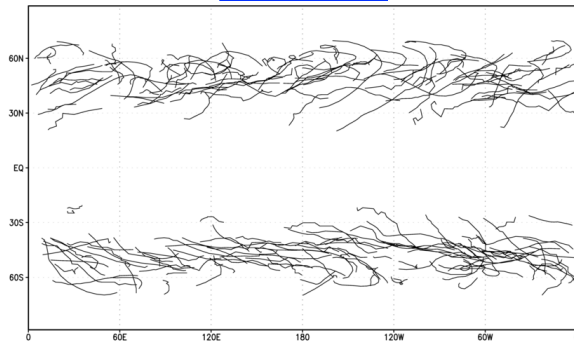
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 APE.ctl.gl09.by\_iga: 01Z01JAN2000-00Z31MAR2000  
 APE.p4k.gl09.by\_iga: 01Z01JAN2000-00Z31MAR2000

# Cloud changes of extra-tropical cyclones: NICAM APE exp.

QObs

QObs+4K

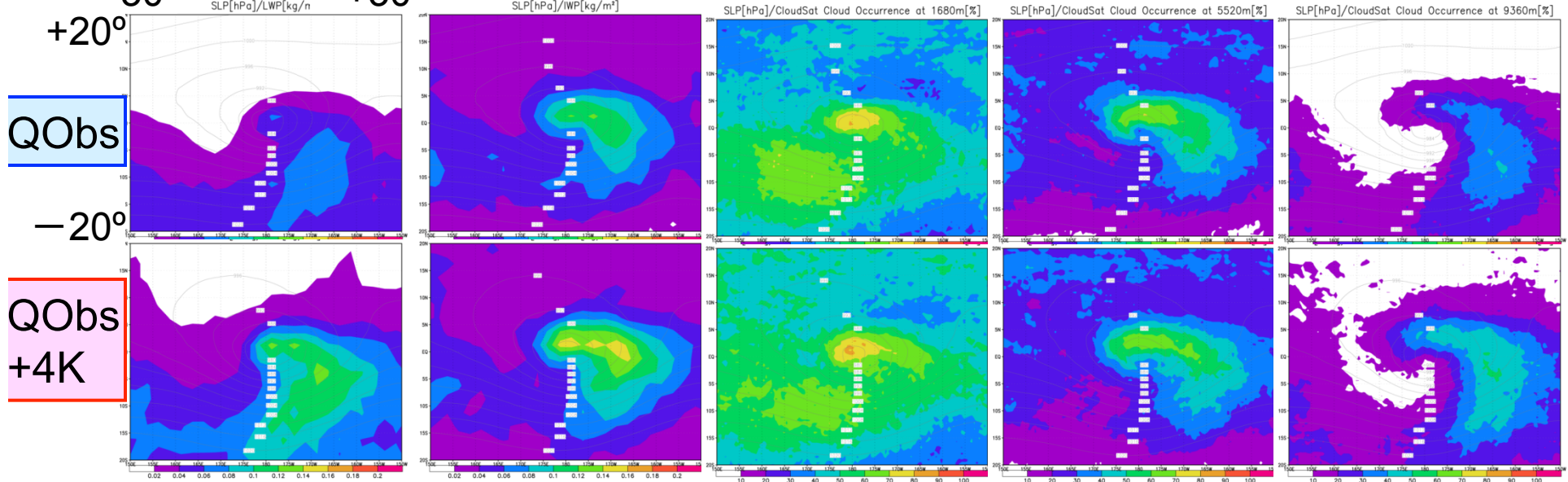
QObs QObs+4K



polar ↑  
-30°

+30°

↓ LWP, IWP, Cloud(1680,5520,9360m)



# Summary and next issues

- Identify CRF-contributions of cloud systems (e.g. TCs, stormtracks)
- Cloud microphysics dependence
  - Use of idealized framework (e.g. KiD)
- Satellite evaluations (see poster)