The CFMIP meeting, 9 Jun. 2015

Changes in Marine Fog in a Future Climate

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Purposes

- Changes in marine fog
- What controls the changes?
- Impact of Changes in Marine Fog on Cloud Feedback

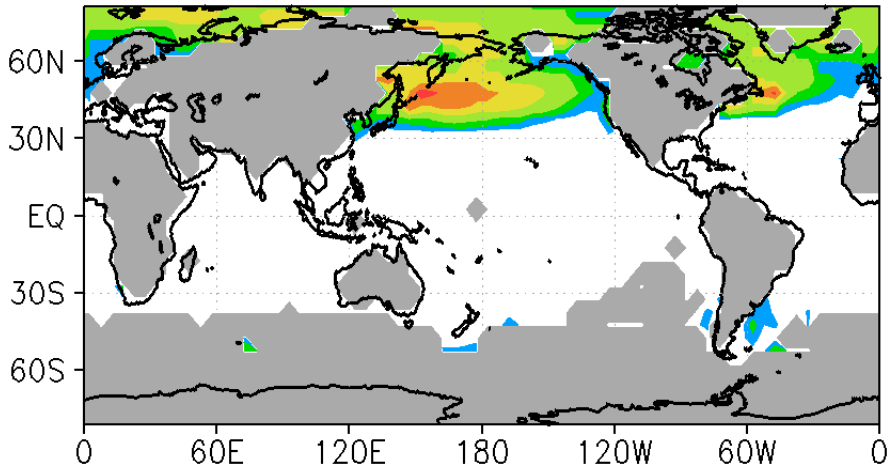
Used Data

- AMIP, AMIP+4K and AMIP_future runs using MRI-CGCM3
  - The 31 years average (1979−2009)
  - Model level data (L48)
  - Monthly & Daily Data
- CMIP5 multi model data
  - Sea Level Pressure

Frequency of occurrence of fog (July)

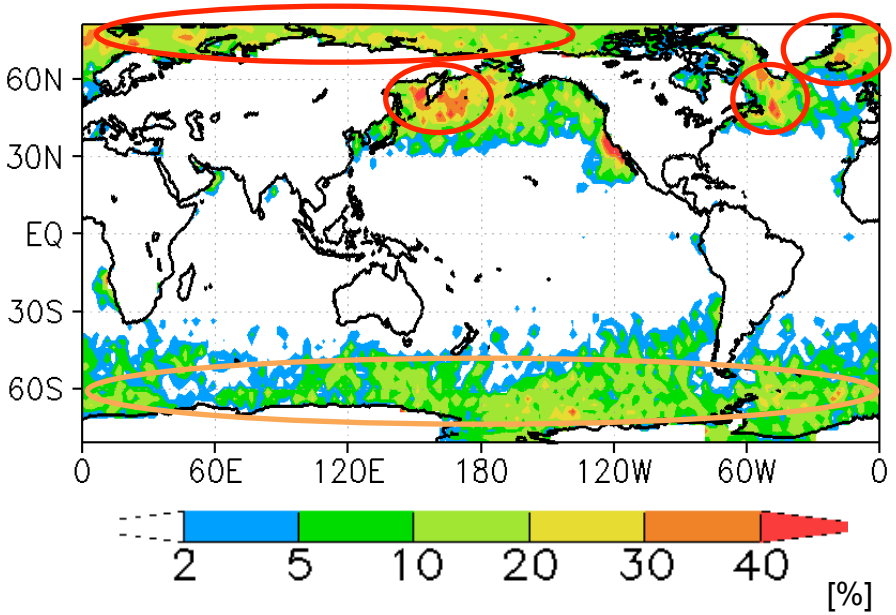
Ship Obs. Climatology

(EECRA)

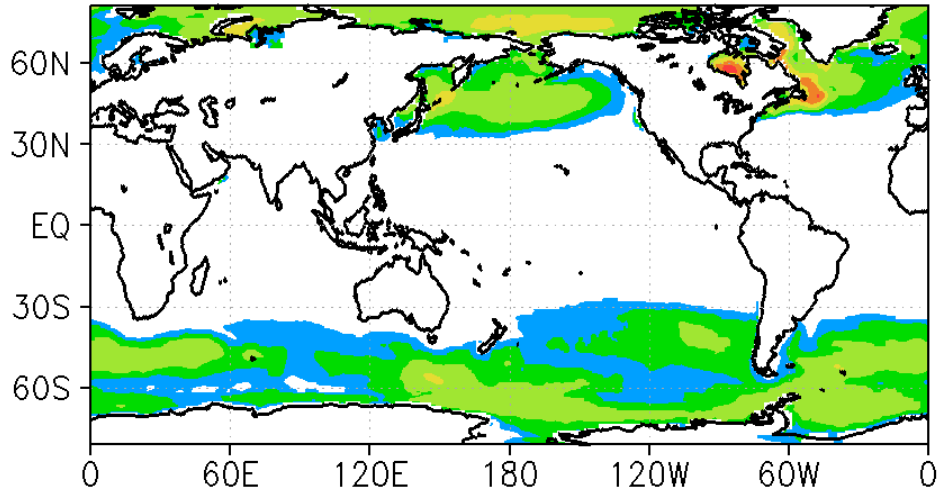


KU CALIPSO Cloud Mask 0-240m

(2007-2009)



MRI-CGCM3 (Cloud Fraction at z=1)



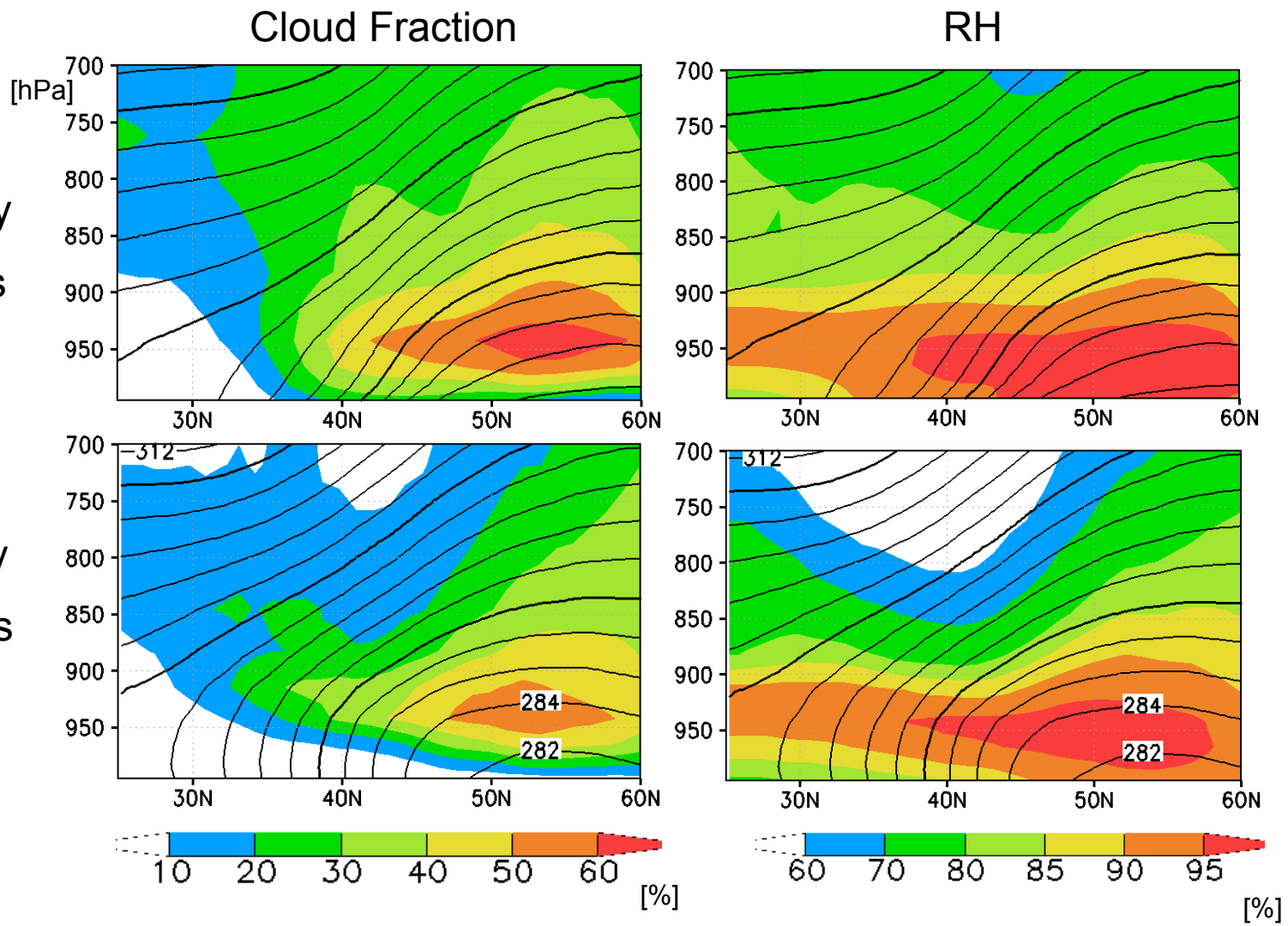
* Around Kamchatka Peninsula
* Near Newfoundland
* North of Iceland
* Arctic Ocean along Eurasia
* Southern Ocean

MRI-CGCM3 seems to represent fog relatively well.

(cf. Teixeira (1999), Kawai et al. (2015))

Vertical Structure of Clouds in the model

North Pacific (July, average: 170E-170W)



Shade : Cloud Fraction or RH

Contour : Potential Temperature

based on Daily Data

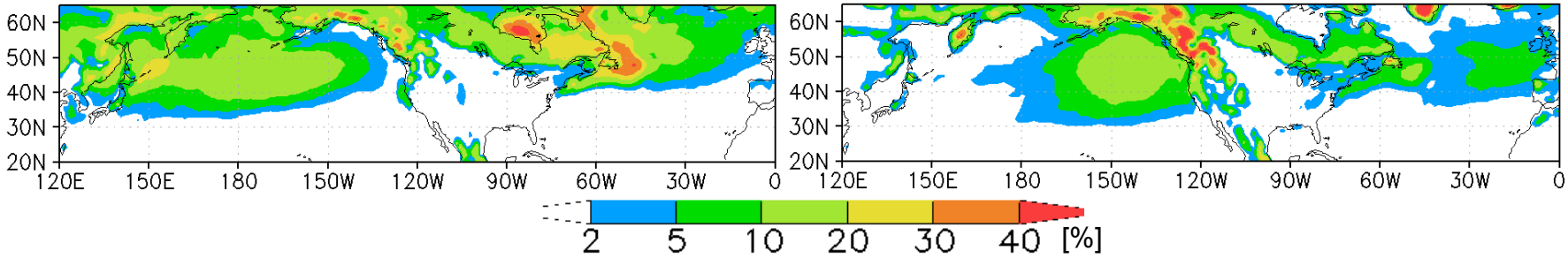
Future Change in Marine Fog

Cloud Fraction at z=1

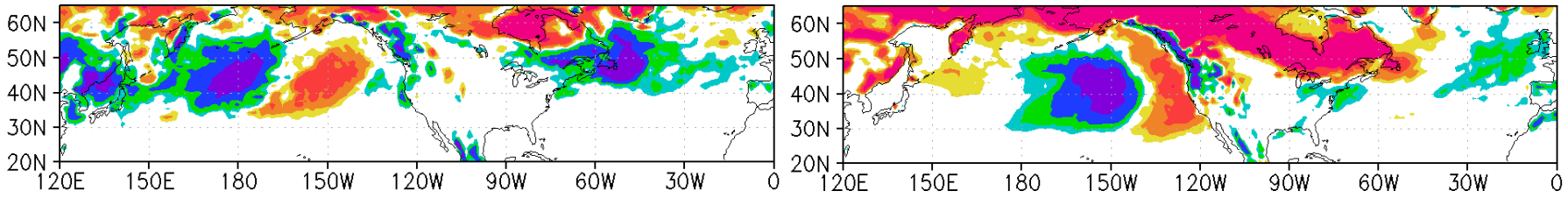
July

January

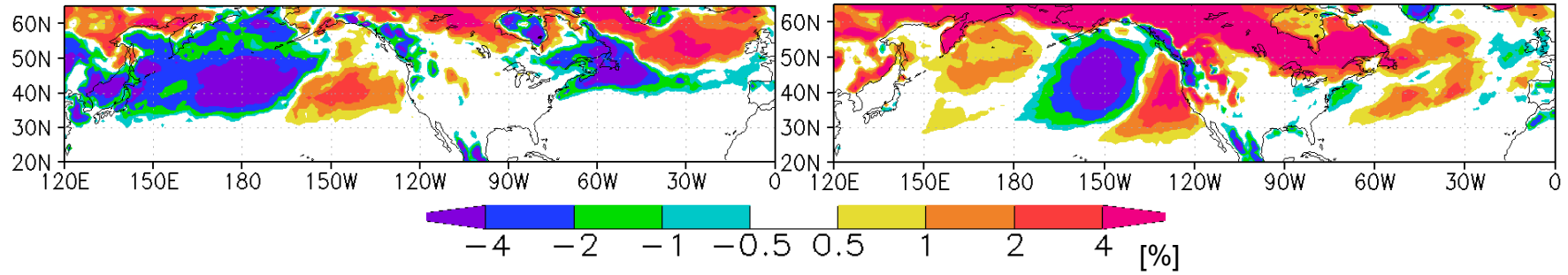
AMIP



AMIP+4K – AMIP



AMIP_future – AMIP



Decrease: Central N. Pac., Western N. Atl.

Eastern N. Pac: A pair of increase and decrease

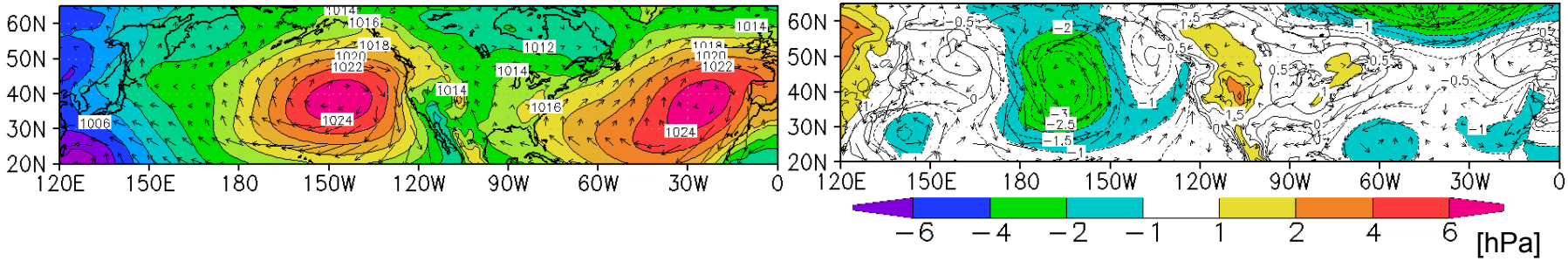
Changes in Meteorological Fields

July

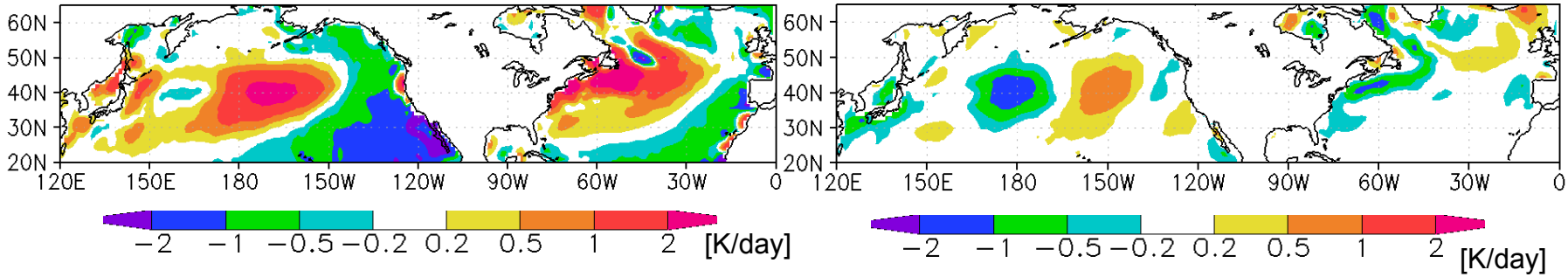
AMIP

AMIP+4K – AMIP

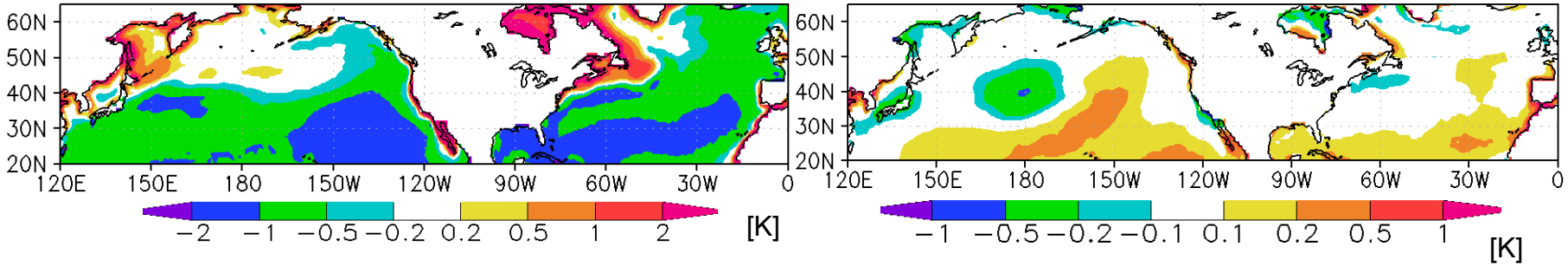
Sea Level Press. & 10m Wind



Surface Temperature advection



2mT - SST



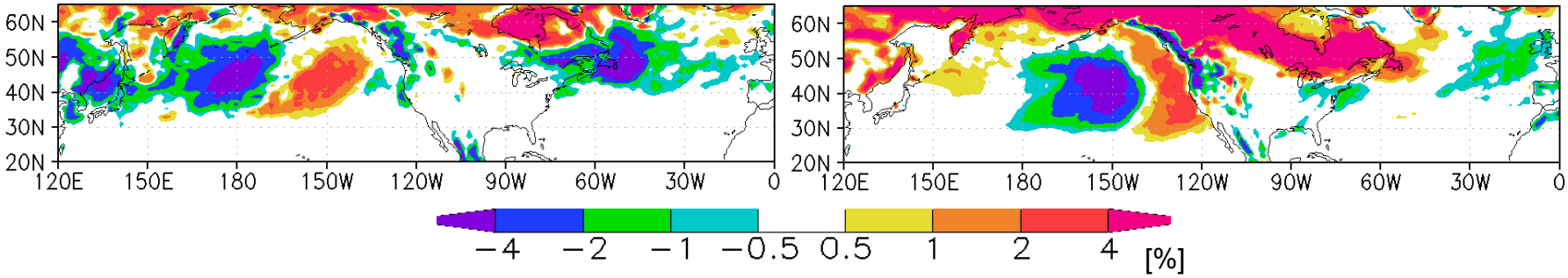
Future Change in Marine Fog & Met. Fields

AMIP+4K – AMIP

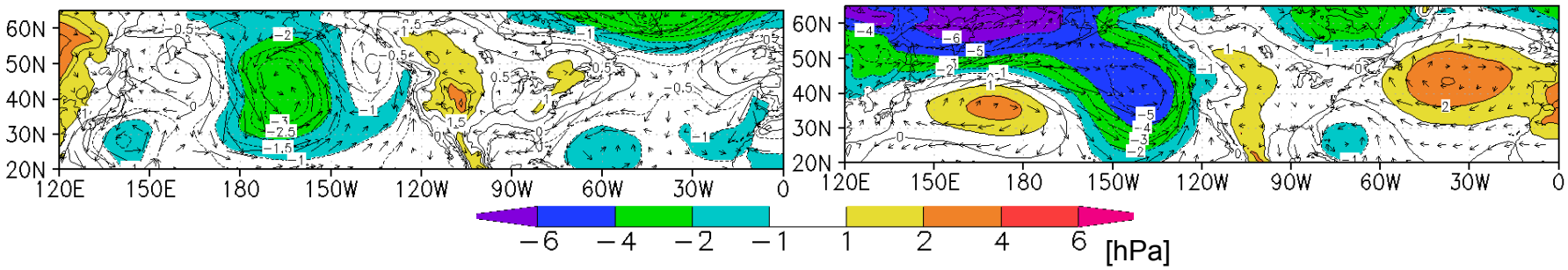
July

January

Cloud Fraction at z=1



Sea Level Press. & 10m Wind



Weakened N. Pac high pressure system
Weakened low pressure area over N. American Cnt.

Decrease: Central N. Pac., Western N. Atl.
Increase: Eastern N. Pac.

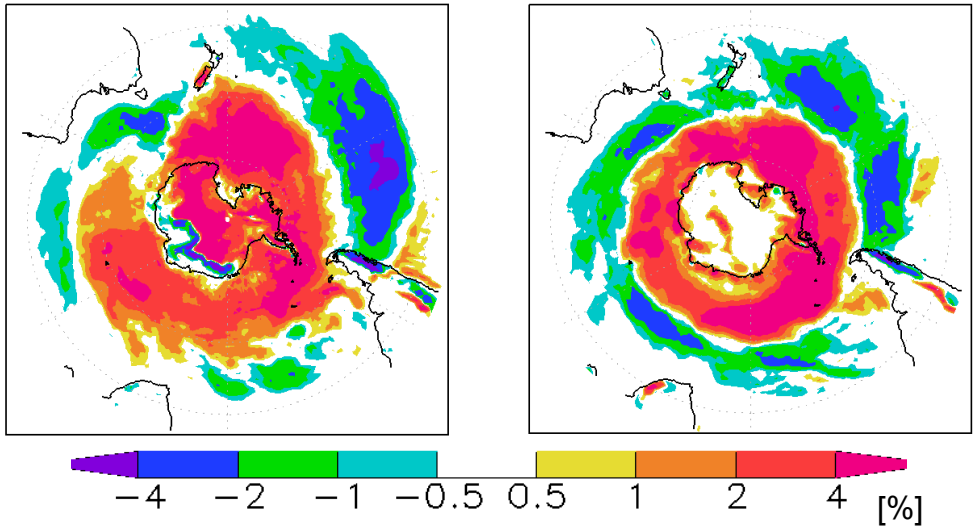
Future Change in Marine Fog & Met. Fields

AMIP+4K – AMIP

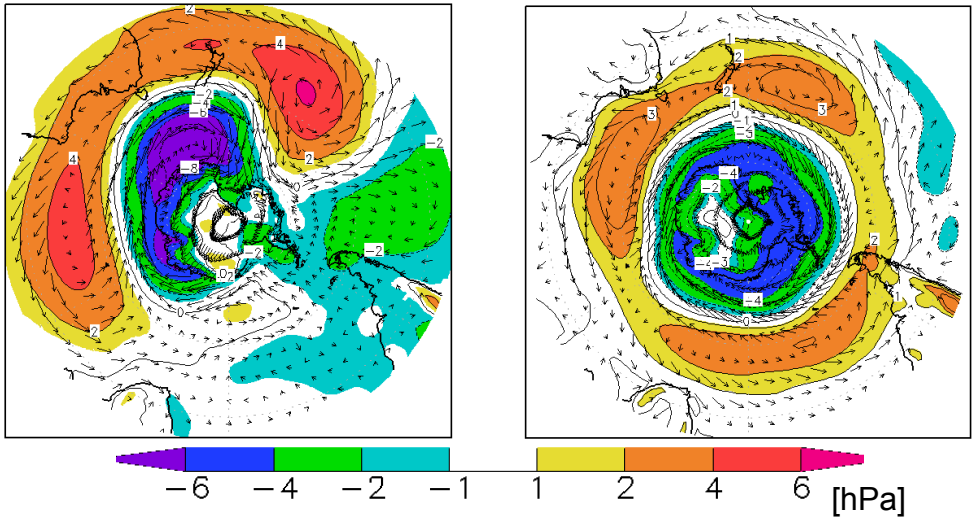
July

January

Cloud Fraction
at z=1



Sea Level Press.
& 10m Wind



Non-Zonal
Change

Zonal
Change

Changes in Meteorological Fields – CMIP5 models –

Sea Level Pressure

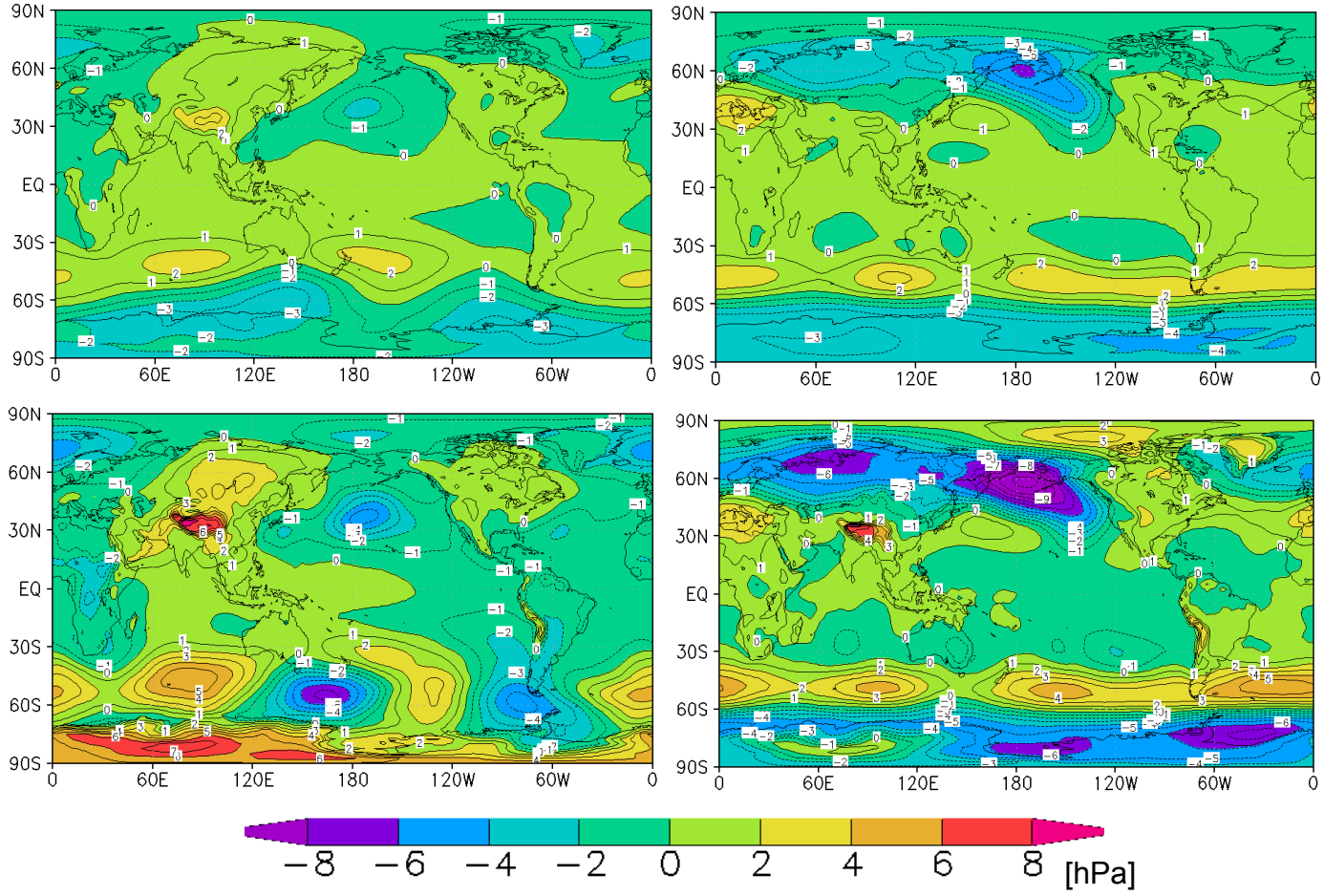
AMIP+4K – AMIP

July

January

CMIP5
10 models
Ensem. Mean

MRI-CGCM3



Changes in SLP for CMIP5 models show common characteristics.

Impact of Change in Marine Fog on Cloud Feedback

Contribution of clouds, for example, between 960hPa and the surface, to cloud feedback for short wave radiation is roughly estimated as follows:

CRE due to clouds between 960hPa & Surface for SW

≈ SWup(all sky, at 960hPa) – SWup(clear sky, at 960hPa)
– (SWup(all sky, at surface) – SWup(clear sky, at surface))

SWup : upward short wave radiative flux

Downward : positive

cf. CRE at the top for SW =
SWup(all sky, at z_{top}) – SWup(clear sky, at z_{top})

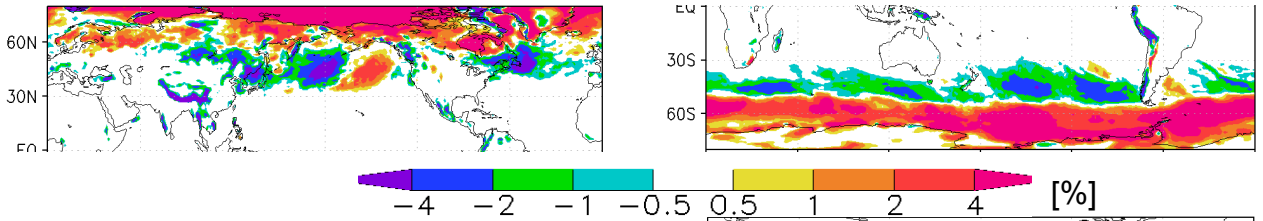
Impact of Change in Marine Fog on Cloud Feedback

AMIP+4K – AMIP

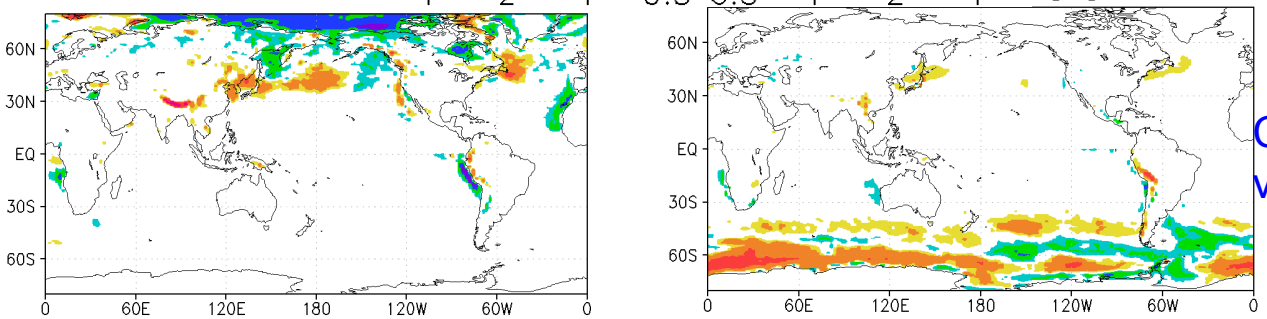
July

January

Cloud Fraction at z=1

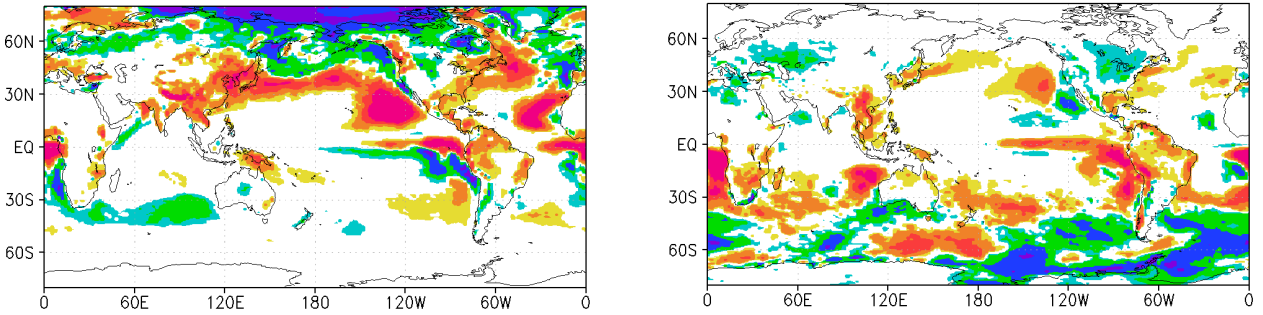


CRE_SWup 960hPa - Surf

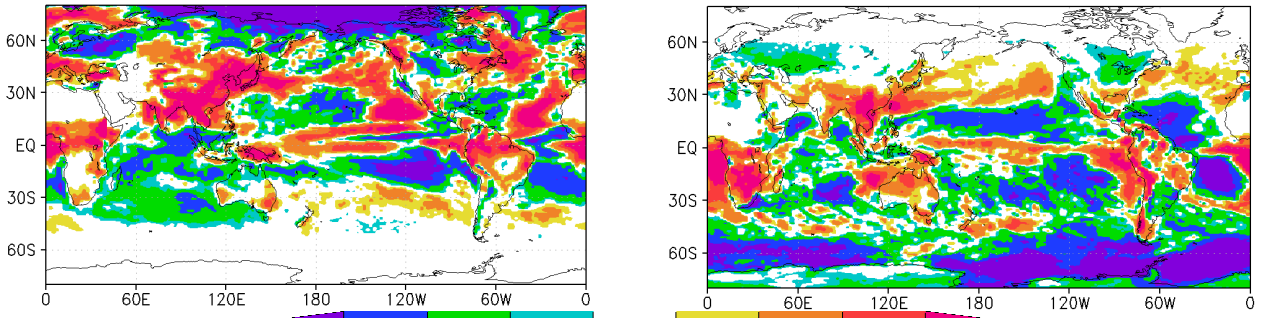


Contribution very small

CRE_SWup 900hPa - Surf



CRE_SWup 700hPa - Surf

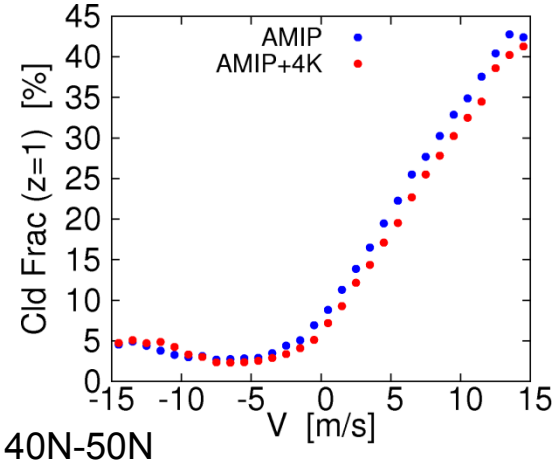


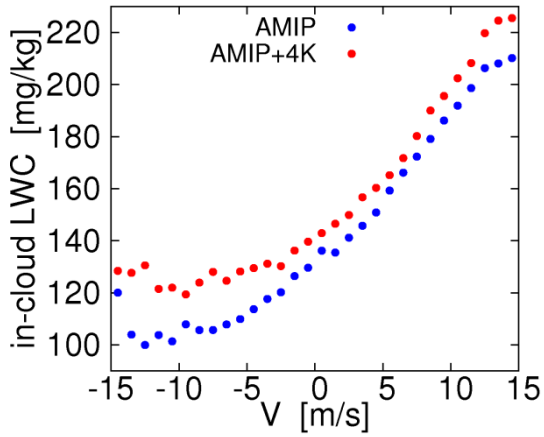
Wind – Cloud relationship

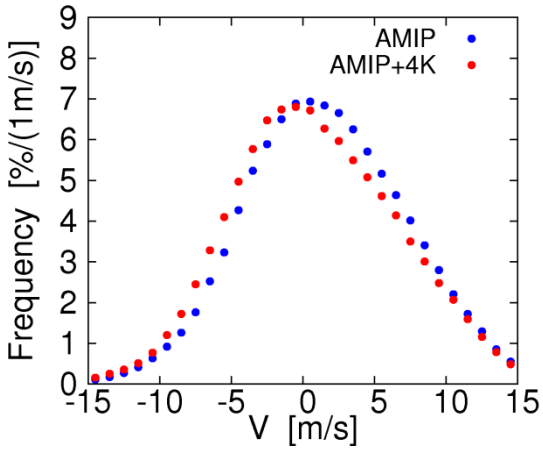
based on Daily Data

North Pacific (Jul.)

160E-200E, 40N-50N

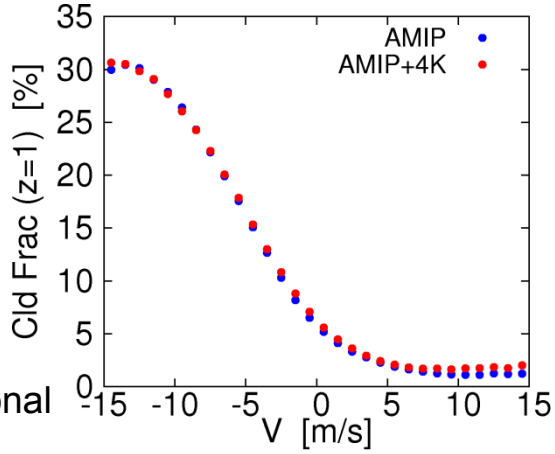


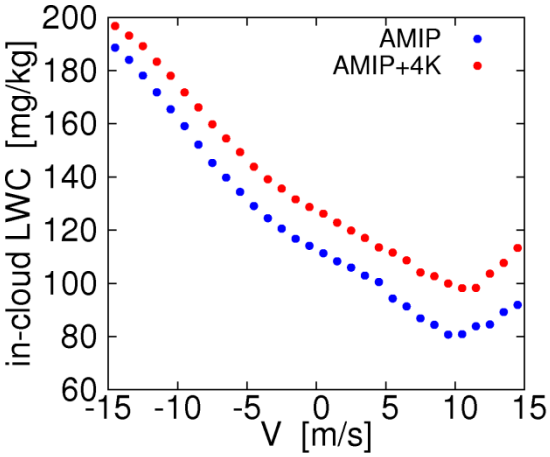


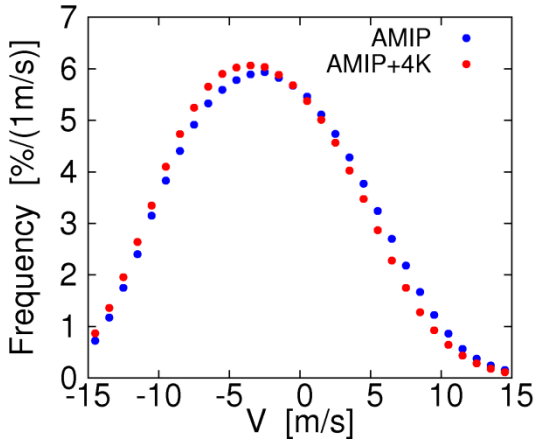


Southern Ocean (Jan.)

60S-45S, Zonal







clear correlations : between V & cloud fraction between V & in-cloud LWC

in-cloud LWC is increased in AMIP+4K.

⬅ increased q_{sat}

Summary

- Changes in marine fog

  (NH)
  - July: Decrease in Central N. Pac., Western N. Atl.
    Increase in Eastern N. Pac.
  - Jan: A pair of increase and decrease in Eastern N. Pac.

- Changes in marine fog correspond to changes in sea level pressure patterns

  (NH)
  - July: Weakened N. Pac high pressure system.
  - Jan: Deepened Aleutian low pressure system near Alaska.

- Changes in SLP for CMIP5 models show common characteristics.

- Impact of Change in Marine Fog on Cloud Feedback is (not ignorable but) not significant.

- In-cloud LWC is increased in the future climate.

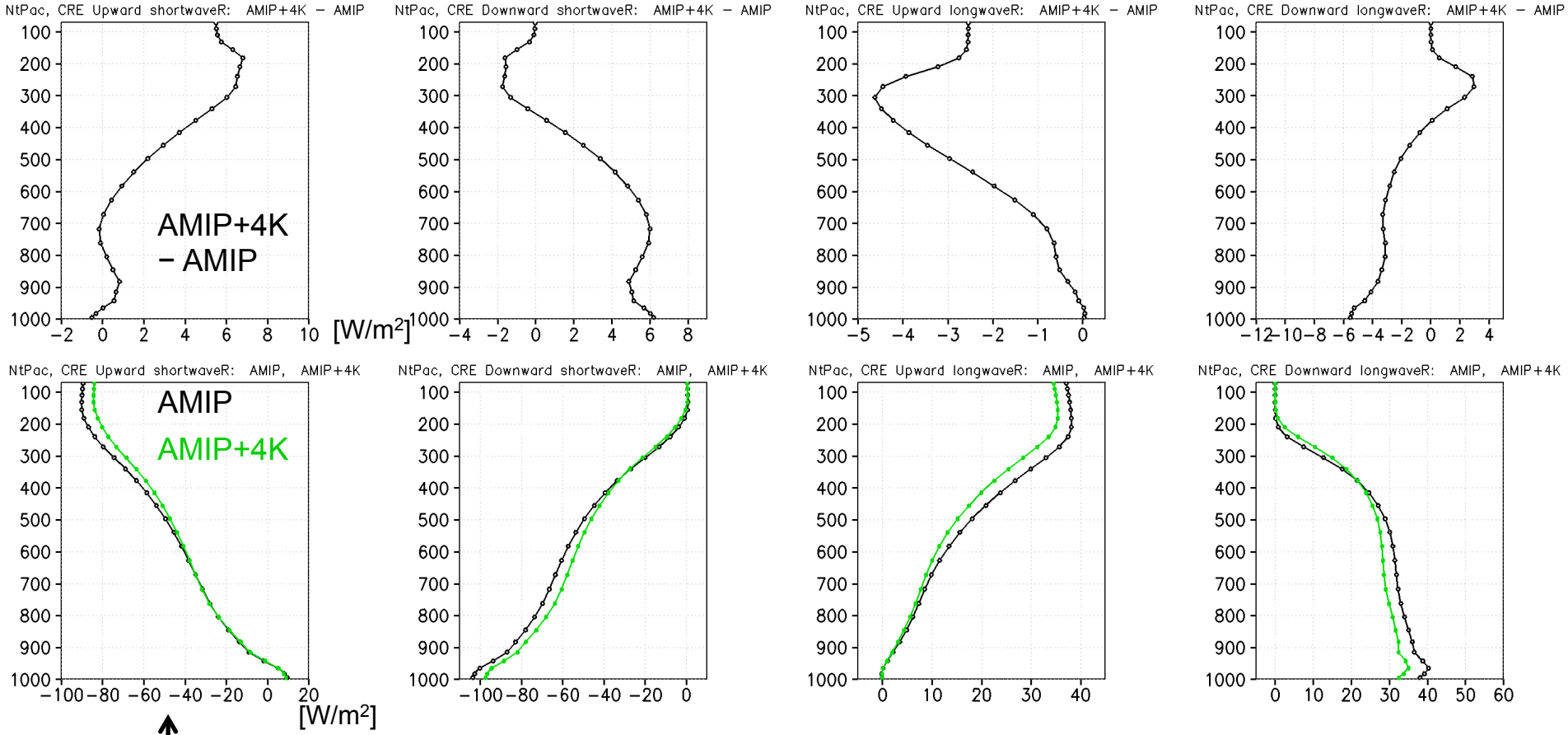
Backup Slides

SWup

SWdown

LWup

LWdown

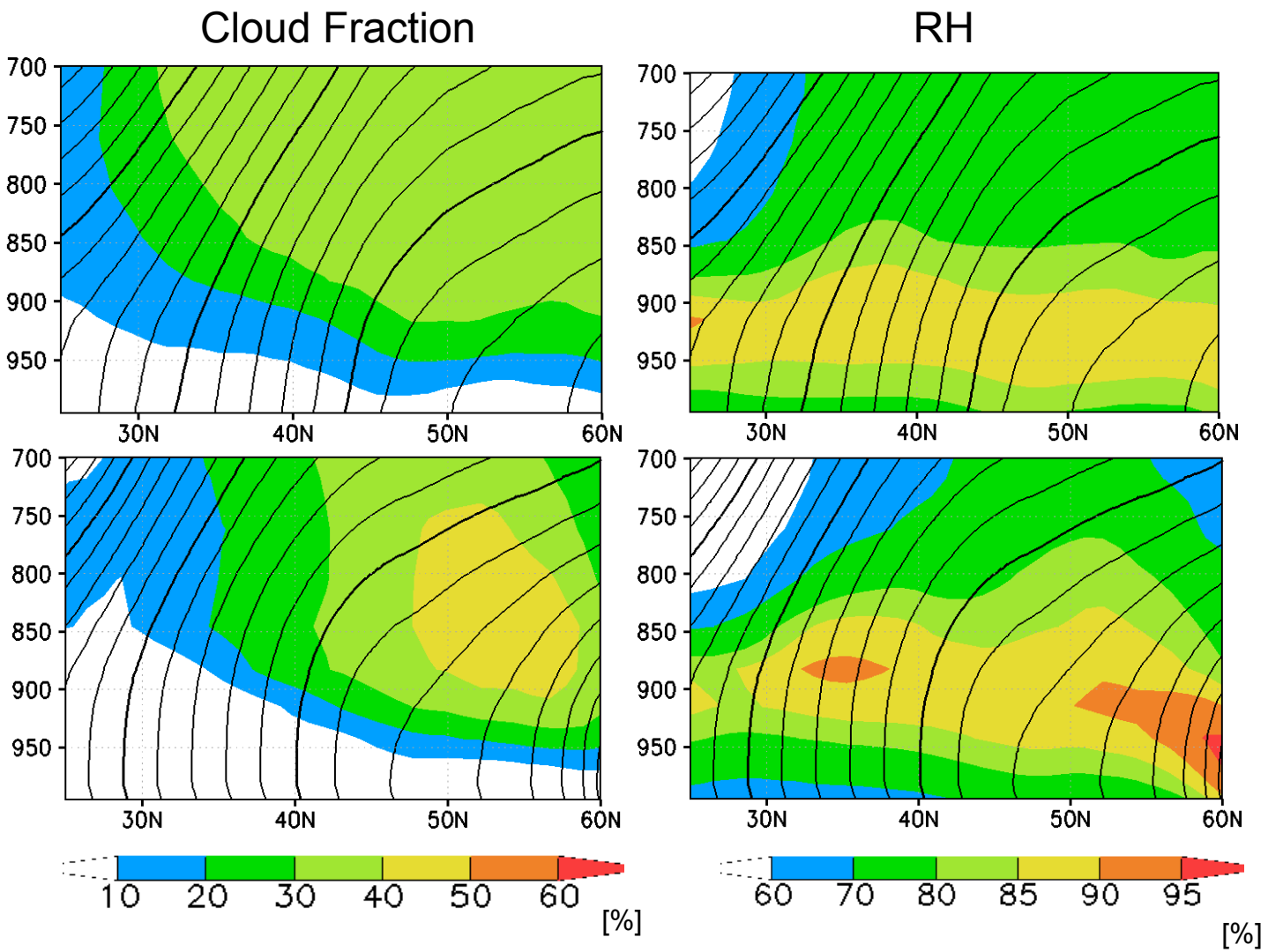


SWup(all sky, z) – SWup(clear sky, z)

Downward : positive

Vertical Structure of Clouds in the model

North Pacific (January, average: 170E-170W)



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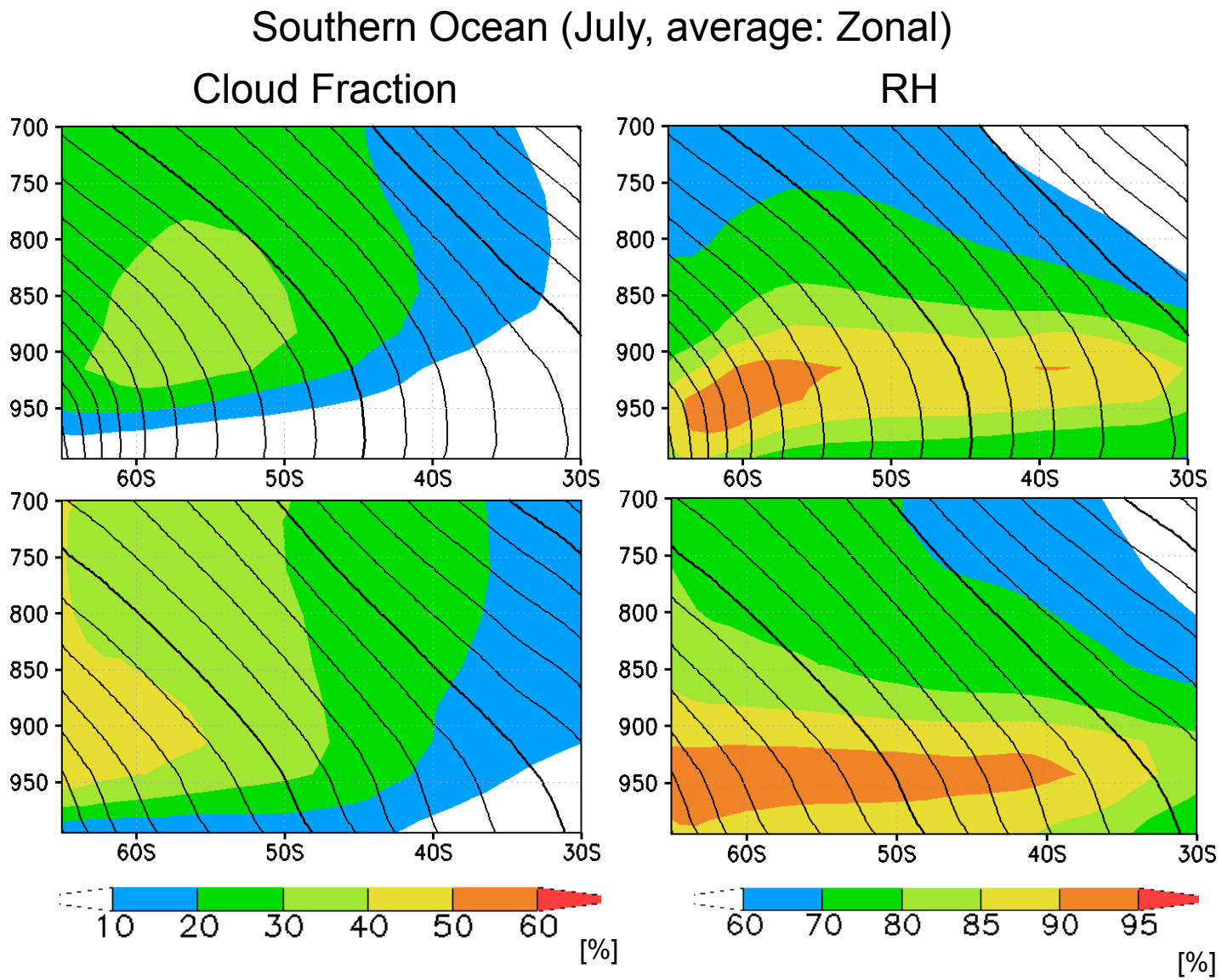
Contour : Potential Temperature

based on Daily Data

Vertical Structure of Clouds in the model



Shade : Cloud Fraction or RH

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