### Radiation, Cloud Water Content and Precipitation Evaluation of CMIP3 and CMIP5 20th Century Simulations: Implications for Neglecting Precipitating/Convective Cloud Hydrometeors on Radiation.

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# Evaluation of Cloud ice in CMIP3 and CMIP5 GCMs and Contemporary Analyses



So far, in the 16 CMIP5 models, four models **partially** consider the interaction of precipitating and/or convective core hydrometeors with radiation in their models.

➔ discriminating observed "cloud only" IWC data is needed for meaningful modeldata comparison for <u>cloud ice only</u> for most CMIP5 models.

(Li and Waliser et al., 2012a, in review)

# **Observed Ice** Water Content Data Used:

- **1. CWC** CloudSat Radar Only (Standard CloudSat product)
- 2. DARDAR CloudSat Radar +CALIPSO Lidar combined products (Delanoe et al., 2010)].
- **3. 2CICE** CloudSat Radar +CALIPSO Lidar combined products (Deng, 2011)

# **Observed Liquid** Water Content Data Used:

- 1. CloudSat LWP (900 ~100 hPa)
- 2. AMSRE
- 3. MODIS

# **Observed Cloud Ice/Liquid Water Content**

# Methods to estimate observed cloud ice water content (CIWC) and cloud liquid water content (CLWC) from CloudSat and/or Calipso:

• FLAG method - Methods used to filter out cloud hydrometers using flags with convective & precipitation cases & column information to get ballpark estimates of CIWCL & CLWC for use in IPCC model evaluation ((Li et al., 2008; Waliser et al., 2009)



Filtering out convective clouds and precipitating cases we can get as a *preliminary* estimate of ice in clouds (albeit this has shortcomings)

(Waliser et al, 2009; Li et al., 2008)



(Chen et al., 2011)

## Observed Cloud Water Content (WIP) for Model-Data Evaluation



# Observed Ice Water Content (IWC) for Model-Data Evaluation



IPCC CMIP5 Model Uncertainties: "Cloud Ice water Path- IWP"



### CMIP3

### CMIP5

80 100

(a) CMIP5 Model Mean Bias No GISS (c) CMIP5 Model Mean Bias No GISS/Inmcm4



# Bias of CMIP5 Ensemble Mean CLWP vs Obs. Cloud Only LWP



### **Bias of CMIP Ensemble Mean CIWP vs Obs. Total IWP**



# Bias of CMIP Ensemble Mean CLWP vs Obs. Total AMSRE



Significant underestimate CIWC & CLWC are identified in CMIP3 and CMIP5 in particular over convection active regions against observed **TOTAL** Cloud Ice & Liquid estimates.

### CMIP downward shortwave at the surface (RSDS) Bias



(Li, Waliser and Stephens et al., 2012c, in preparation)

### **CMIP Reflected SW at TOA Bias**



(W m<sup>-2</sup>)

# CMIP 3 & CMIP5 OLR Bias



#### Note that the cloud top height are overestimate in CMIP5

NET RADIATIVE EFFECTS: NO SNOW-RADIATION -

CONTROL(WITH)

CloudSat offline (Waliser et al., 2010)

6ÓE

120E

120W

180



6ÓE

120E

180

12**0**W

15

9

6

3

-2 -5

> 15 9 6

3

-2

#### "DIRECT" IMPACT ON RADIATIVE HEATING PROFILES



### Summary and Current/Future Works Researches for Cloud-Convection-Precipitation-Dynamics



1. Characterizations of GCM Cloud Ice/Liquid Model Biases 2007

2009

2010

2011

2012

- 2. Led to the need & capabilities to discriminate between large-particle/falling precipitation vs small-particle/suspended cloud ice (or liquid) in the observations to have viable & relevant estimates for models.
- 3. Identify potential for Earth Radiation Budget & circulation biases due to ignoring largeparticle/precipitation in GCM radiation calculations.
- 4. Characterizing and reducing GCM radiation biases in weather/climate models associated with ignoring precipitation impacts on radiation.
- radiation.
  5. Cloud-Precipitation-Latent-Radiation-Dynamics interactions.
- 6. ....
- 7. .....CMIP6





# Thanks