General remarks: Introduction to model-satellite collaborations

Satoh Masaki

Atmosphere and Ocean Research Institute, University of Tokyo EarthCARE Modeling Workshop Dates: 16(Wed)-18(Fri), Feb. 2022; online meeting Time: 13-16 UTC https://cesd.aori.u-tokyo.ac.jp/ECARE2022/

Quick introduction to ECARE-Modeling WS Feb. 7, 2022

EarthCARE launch: September 2023

□Start considering the use of EathCARE data for model collaborations

□We will hold a follow-up workshop around one year from now (~Feb. 2023)

□What's unique about EarthCARE (among others)

- Doppler cloud radar (CPR): vertical motion of cloud particles
- High spectral resolution lidar (HSRL): details of cloud microphysics

□Topics for model and ECARE collaborations:

- Models: GCMs, GSRMs, RCMs,...
- Simulators: COSP; J-Sim, ECSIM, ...
- Metrics or methodology of validations: CFADs, Joint PDFs, categorization based on cloud types (ISCCP matrix), cloud objects, ...
- Process understanding
- Synergy with GV, other observations

Requests for speakers

Main theme: How can models and ECARE collaborate? Specifically

- How to evaluate/improve models by ECARE data?
- What are the major issues/biases of models in representations of cloud, convection, precipitation and aerosols?
- Process understanding: cloud, precipitation, convection, radiation and their coupling.
- New research areas/subjects arising from ECARE.

Main topics https://cesd.aori.u-tokyo.ac.jp/ECARE2022/

- Evaluation/improvement of cloud/convection/aerosol processes of models through ECARE observations.
- Key questions/issues arising from Global Storm Resolving Models: Lessons from DYAMOND and new initiatives.
- Key questions/issues arising from GCMs or climate modeling: Uncertainties of GCMs related to clouds/convection. Lessons from past COSP analysis on CMIP models and new initiatives.
- <u>Analysis:</u>

Talks on topical analysis studies will be encouraged, including new research initiatives using Doppler cloud radar: e.g. global view of vertical motions/mass flux.

- Satellite simulators: Overview of existing satellite simulators and tasks for analysis of ECARE using simulators
- Assimilation:

Assimilation is a significant part of the satellite-modeling collaboration. In this workshop, overviews of assimilation activities related to ECARE will be introduced. Technical details will be discussed in a separate assimilation meeting in the future. New ideas of assimilation, such as parameter estimation, might be covered.

- Introduction to forthcoming field campaigns in support of ECARE and modeling collaborations.
- Discussions on sciences connected to NASA/AOS (or ACCP), which is planned for launch around 2030, including possible collaborations with EarthCARE.

DAY1: 16 Feb. (Wed), 2022

Start: 13:00 UTC Chair: Hajime Okamoto; Rapporter: Woosub Roh

Introduction:

•Masaki Satoh (AORI/The University of Tokyo) "General remarks: introduction to model-satellite collaborations": <u>Quick Introduction of WS</u>

- •Hajime Okamoto (RIAM/CIRAP, Kyushu University) "Development of algorithms and expected products for EarthCARE mission"
- •Takuji Kubota (JAXA) "EarthCARE Overview"
- •Tobias Wehr (ESA) "EarthCARE ESA product"

Simulators:

Tempei Hashino (Kouchi Tech. Univ.) "Overview of Joint Simulator and application to GCM"
Alejandro Bodas-Salcedo (Met Office) "COSP contributions to CMIP5&6"

Assimilations:

Mark Fielding (ECMWF) "Using EarthCARE assimilation as a route to model evaluation"
Zhiquan Liu (NCAR) "Assimilation of all-sky data from geostationary imagers with the Model for Prediction Across Scales"

Wrap-up of DAY1: ~15:30 UTC •Rapporter: Woosub Roh (AORI, The University of Tokyo)

DAY2: 17 Feb. (Thu), 2022

Start: 13:00 UTC Chair: Masaki Satoh; Rapporter: Tatsuya Seiki

Global Storm-Resolving Models and DYAMOND w GV:

•Bjorn Stevens (MPI-M) "EarthCare and the challenge of simulating the coupled climate of the tropics using global storm-resolving models"

•Silke Gross (DLR, Oberpfaffenhofen) "EarthCARE-like payload on HALO – lessons learned and plans for future validation"

•Roh Woosub (AORI, The University of Tokyo) "An evaluation of NICAM using a ground-based 94 GHz Doppler radar over Tokyo"

•Ann Kristin Naumann (MPI, Hamburg) "Microphysical uncertainties in ICON"

•Jean-Louis Dufresne (IPSL, Paris) "The importance of optically thin low-level clouds and of considering small scale heterogeneity in cloud properties"

Process analysis/modeling:

•Hiro Masunaga (Nagoya U) "Cloud-radiation interactions in the real atmosphere: A-Train, EarthCARE, and beyond"

•Graham Feingold (NOAA) "Anticipated new insights into warm clouds from the EarthCARE mission"

•Toshihisa Matsui (NASA/Goddard) "Dynamics and Microphysics of Cumulus Thermals within Simulations of Aerosol-Deep Convection Interactions" (about thermal bubble statistics of dynamics and microphysics from LES)

Wrap-up of DAY2: ~15:00 UTC

•Rapporter: Tatsuya Seiki (JAMSTEC)

DAY3: 18 Feb. (Fri), 2022

Start: 13:00 UTC Chair: Kentaroh Suzuki; Rapporter: Takuro Michibata

General Circulation Models:

- •Kentaroh Suzuki (AORI/The University of Tokyo) "Use of satellite observations for constraining aerosol-cloudprecipitation processes in climate models"
- •Richard Forbes (ECMWF) "Improving global weather prediction: the role of spaceborne radar and lidar"
- •Takuro Michibata (Okayama University) "Evaluation of cloud micro- and macrophysical properties in the MIROC6 with A-Train observations and COSP simulator"
- Hideaki Kawai (MRI) "Examples of possible evaluation of GCMs using cloud radar and lidar satellite data"
 Ming Zhao (GFDL) A study of atmospheric river (AR), tropical storm (TS), and mesoscale convective system (MCS) associated precipitation and extreme precipitation in present and warmer climates"
- Andrew Gettelman (NCAR/CESM) "Confronting global models with observations of clouds and precipitation"
 Chris Golaz (LLNL/E3SM) "Learning from models that won't"
- •Johannes Mülmenstädt (PNNL) "What model resolution is required to parameterize clouds, and how can observations tell us when we're there?"

Wrap-up of DAY3: ~15:00 UTC

•Rapporter: Takuro Michibata (Okayama University)

Contents

- Model activities toward EarthCARE in Japan
- Model Evaluations, metrics
- Sensitivity to cloud microphysics parameters
- Global view of atmospheric vertical motions as a new direction of science

Model evaluations

- Models: GCMs, GSRMs, RCMs,…
- Simulators: COSP; J-Sim, ECSIM, …
- Metrics or methodology of validations: ISCCP matrix, CFADs, Joint PDFs, categorization based on cloud types, …
- Synergy with GV, other observations for modeling
- Process understanding using models
- Assimilations, Not so focused on aerosols

Model activities toward EarthCARE in Japan NICAM + Joinst Simulator for Satellite Sensors



Illingworth et al. (2015, BAMS): Global simulation by the 3.5-km-gridded NICAM model: (top) simulated visible radiances, TOA upward longwave flux (W m–2), and 94-GHz CPR signal (dBZ) on 18 Jun 2008. (bottom) Regional segments of observed and simulated brightness temperature at 10.8 μ m (K) with a Tropical Cyclone Fengsheng and height-distant cross sections for CPR (dBZ) and lidar (log10 of 1 m⁻¹ sr⁻¹) signals along the CloudSat orbit (white line) on 18 Jun 2008. The observed brightness temperature was taken from Himawari.



Satoh, M., Roh, W., Hashino, T. (2016)

Evaluations of clouds and precipitations in NICAM using the Joint Simulator for Satellite Sensors. CGER's Supercomputer Monograph Report. Vol. 22, 110 pp, ISSN 1341-4356, CGER-I127-2016.



Model Evaluation by satellite observation Traditional ISCCP evaluation



90S ·

120E

10 20 30 40 50 60 70 80 90

00 25 50 75 100

25 50 75 100

10 20 30 40 50 60 70 80 90

NICAM with COSP Kodama et al. (2012, JGRA)

Evaluation and improvement

NICAM with COSP Kodama et al. (2012, JGRA)



Evaluation and improvement

T3TEF: Tropical Rainfall Measuring Mission (TRMM) Triple-Sensor Three-Step Evaluation Framework (Matsui et al. 2009, JTECH, DOI:10.1175/2008JTECHA1168.1)







Cumulative probability distributions of polarizationcorrected TMI brightness temperature at 85 GHz (PCT_{b85}; circles, shallow; squares, congestus; diamonds, midcold; and triangles, deep)

Evaluation and improvement Evaluation of NICAM by T3TEF Now used as "Roh scheme" in NICAM







190



330







10

16

Evaluation and improvement of ground observation ULTIMATE: ULTra-slte for Measuring Atmosphere of Tokyo metropolitan Environment



Global Storm Resolving Models, status DYAMOND: DYnamics of the Atmospheric general circulation Modeled On Nonhydrostatic Domains

- The first inter-comparison of global storm resolving models (less than 5 km).
- DYAMOND summer simulations: 40 days integration: 1 August 20 September 2016 Atmosphere-only, AO-coupled model
- DKRZ and ESiWACE provide support and space of data storage <u>https://www.esiwace.eu/services/dyamond</u>
- DYAMOND winter simulations: 40 days integration: 20 January 1 March 2020 Atmosphere-only, AO-coupled model, coordination with EUREC4A
- DYAMOND-Next under consideration: e.g. 30 years AO-coupled model experiments Coordination with Digital Earths





- DYAMOND summary paper: Stevens et al.(2019, PEPS)
- DYAMOND Special edition: J. Meteor. Soc. Japan



(Judt et al. 2021, JMSJ)

Robustness and Uncertainties of the DYAMOND results

- All models look good cloud distribution compared to Himawari, OLR, and precipitation.
- Meso-scale structure captured globally (Arnold et al. 2020)
- However, a lot of variability exists for vertical structure of clouds.
- Tropical cyclones statistics are within similar range, but very different structure (Judt et al. 2021)
- Cloud evaluations using various observations are on-going (Roh and Satoh, 2021)

OLR on 11 August 2016



Roh, W., Satoh, M., Hohenegger, C. (2021, JMSJ)

Net Shortwave Outgoing Radiation on 11 August 2016

NICAM

(aviam.inc

ICON

FV3

SAM

- The domain averaged OLR is relatively similar across the models
- The NSR shows large differences among the models.
- Vertical profiles of hydrometeors
 are divergent.



NICAM sensitivity to cloud microphysics parameters

- Parameters evaluated by satellite observation are not necessarily best in performance.
- Compensation of errors?
- Missing processes?

Intermediate characteristics b/w MIP & MJO would be preferable.

- Retuning of the terminal velocity of snow and rain & Dropped cld. ice
- Introduction of qv, qc, qi diffusion in the vicinity of convection
- Introduction of "Leonard term" (= Additional turbulent flux) for qv, qc, qi



Two standard settings of NICAM NSW6 : MIP (Roh scheme) & MJO (Miura scheme)

Courtesy of Daisuke Takasuka (JAMSTEC)





Global view of atmospheric vertical motions



high latitudes

equator



Summary

EarthCARE launch: September 2023

Start considering the use of EathCARE data for model collaborations

We will hold a follow-up workshop around one year from now (~Feb. 2023)

- Model activities toward EarthCARE in Japan
 - L1, assimilations
 - Similar activity is being considered for post-GPM (2028-)
- Model Evaluations and improvements
 - Methodology, metrics
 - To consider use of CPR Doppler velocity data
- Model sensitivity to cloud microphysics
 - GSRMs sensitive to cloud microphysics parameters/schemes
 - How cloud microphysics affect circulations and climate sensitivity
 - Also, sensitivity of GCMs to convective parameterization
- Global view of atmospheric vertical motions as a new direction of science
 - Synthetic studies using various observations, high-resolution models, and theoretical studies