EarthCARE Modeling Workshop 2022
– Wrap-up of DAY3 –

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H. Kawai (MRI), M. Zhao (GFDL), A. Gettelman (NCAR), C. Golaz (LLNL),
and J Mülmenstädt (PNNL)

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- Workshop Goals
- Day3 Wrap-up
- Scientific Questions and Open Discussions

Workshop Goals (Day1–Day3)

- **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.

- **Analysis:**
  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.

- **Field campaigns:**
  Solidifying ECARE outcomes w/ field measurements for observations and modeling collaborations.

- **Discussions on sciences connected to NASA/AOS (or ACCP), which is planned for launch around 2030, including possible collaborations with EarthCARE.**

Day3 Agenda

- **Kentaroh Suzuki (AORI/The University of Tokyo)**
  Use of satellite observations for constraining aerosol-cloud-precipitation processes in climate models

Science Questions:

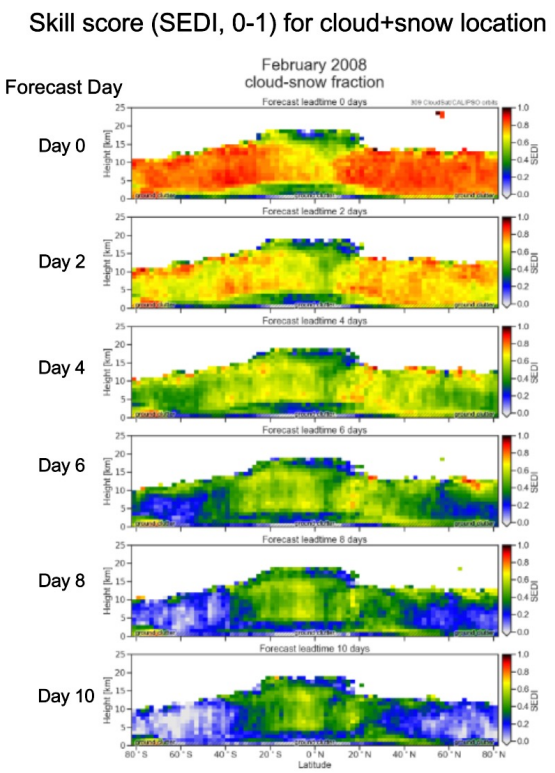
– How can process signatures of aerosol-cloud-precipitation interaction be identified in satellite observations?
– What combination of observables? How to combine them?
– How can they serve as metrics/diagnostics for process "fingerprint"?
– How useful are these metrics/diagnostics to evaluate/constrain global models?
– How do the process signatures link to macroscopic/large-scale impacts on climate?
– How can new capabilities of EarthCARE advance model diagnostics/constraints in terms of these questions?

– MODIS-CloudSat combined PDF diagram (CFODD)
– linkage of the process realism to climate forcing
– Dynamics-microphysics coupling from satellite? – Yes: Land / Ocean difference
– ACI in a GCRM; how realistic

Day3 Agenda

- **Richard Forbes (ECMWF)**
  Improving global weather prediction: the role of spaceborne radar and lidar

  – Global NWP models – where are we heading?
  – 10 DYAMOND models; There is still much uncertainty in the global characteristics of forecast models
  – Operational ECMWF global IFS 9km
  – beyond 10 days; extending the forecast range
  – microphysical param increasing in complexity
  – multi-moment microphysical parameterization
  – stochastic perturbation of total tendencies (SPPT)
  – source of uncertainty in parameterization (SPP)
  – Challenge: to use Doppler to constrain vertical velocity at storm-scale



oving global weather prediction

Shannon Mason

Day3 Agenda

- **Hideaki Kawai (MRI)**
  Examples of possible evaluation of GCMs using cloud radar and lidar satellite data

  – cloud-top height of mid-latitude low clouds
  – frequency of marine fog occurrence – CALIPSO seem well capture the fog
  – various improvements in cloud processes MRI model
  – SLF is improved by using CALIPSO data, contributes to well representation of SO radiation
  – improving ice fall velocity

- **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

  – Atmospheric river, GFDL 50 km highreso simulation
  – Storm detection, Mesoscale convective systems
  – % of annual precipitation from AR, TS, and MCS days
  – % of extreme precipitation days also well captured
  – precipitation intensity averaged from all AR, TS, and MCS days

Day3 Agenda

- **Andrew Gettelman (NCAR/CESM)**
  Confronting global models with observations of clouds and precipitation

  – What are major issues for cloud and precipitation
  – How can EarthCARE help?
  – Model-Data fusion
  – New method; machine learning
  – WRF (4km) and 3km simulation with MG3 against PRISM observation
  – Major issues
    – cloud phase
    – size distribution
    – dynamics-microphysics coupling (vertical structure)
    – aerosol activation (ACI)
    – precipitation formation (frequency & intensity)
  – SOCRATES in-situ flight over SO: CAM6 too little ice, high climate sensitivity
  – dynamics
  – precipitation frequency: machine learning can help to reduce precipitation bias
    – to constrain microphysical relationship between Re and precipitation.

Day3 Agenda

- **Chris Golaz (LLNL/E3SM)**
  Learning from models that won't

  – E3SMv2: lower ECS and smaller ERFaci, improved against v1, but historical temperature record
  – single forcing ensemble to separate the model uncertainties
  – GHG, Aerosols, Everything else (other)
  – Models should understand both GHG positive forcing and negative aerosol forcing

- **Johannes Mülmenstädt (PNNL)**
  What model resolution is required to parameterize clouds, and how can observations tell us when we're there?

  – *All models are wrong, but some are useful*
  – negative LWP response to increased Nd from AMSR
  – process fingerprints in Nd-LWP: dLWP/dt via entrainment and precipitation
  – effects of turbulence on cloud adjustment
  – Nd-LWP funny relation in CMIP6; why?

Summary and Next Steps

► Advances in Observations

– new variables in ECARE (e.g., doppler velocity, lidar ratio)
  – vertical motion, ice particle types, aerosol types (Day 1: H. Okamoto)
– improved detection sensitivity, better detection of optically thin clouds
– collocated information on CF, height, and radiation (Day 2: J.-L. Dufresne)

► Advances in Modeling and Evaluation

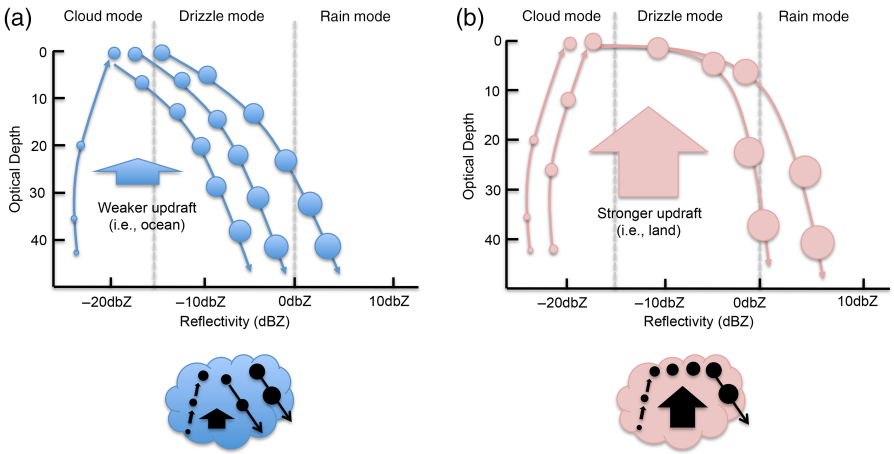
– assumption of precipitation fraction and CFAD (Day1: T. Hashino)
– ECARE in COSP (UV lidar?)
– single forcing ensemble to separate the model uncertainties (Day 3: C. Golaz)
– Nd-LWP relation: subgrid representation; resolution (Day 3: J. Mülmenstädt)
– machine-learning approach to reduce precipitation bias (Day 3: A. Gettelman)

► Obs-Model Synergies

– Geophysical Variable Maps (Day2: G. Feingold)
– resolution gaps, scale-aware/definition-aware comparison
– process-oriented diagnostics; emergent constraint (Day 3: K. Suzuki)
– radar and lidar synergy to evaluate models (Day 3: R. Forbes, H. Kawai)
– subgrid heterogeneity, vertical overlap
– how to constrain future extreme precipitation change using models and present-day satellite record? (Day 3: M. Zhao)

EarthCARE Workshop Day3: Questions

- How can we improve model biases by ECARE data and instrument simulator?
- How to use Doppler velocity of the ECARE in GCMs?
  - Dynamics-microphysics coupling from satellite?
    - Yes: Land / Ocean difference



- How can process signatures of aerosol-cloud-precipitation interaction be identified in satellite observations?
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Discussion and Comments

- **Need to discuss about including EarthCARE function to the simulator with relevant researchers**

- **Importance of impact on weather prediction (along with climate impact)**