RTTOV C++ Interface and Preliminary Comparison with CRTM for cloudy radiance simulation using MPAS-JEDI

Zhiquan (Jake) Liu

Prediction, Assimilation & Risk Communication (PARC) Section
Mesoscale and Microscale Meteorology (MMM) Laboratory, NCAR

JEDI Meeting, September 24, 2020

Project Background

- **PANDA-C** (Prediction AND Assimilation for Cloud) project
  - NCAR/MMM + JCSDA, funded by USAF, started from 2018

- Aim at building a NWP-based system for improving **Cloud Analysis and Forecasting** at USAF.

- **Cloudy radiance data assimilation** using CRTM and RTTOV is an important part of the project
  - RTTOV is currently used in AF's operation with their use of UM's DA system

Status of UFO's CRTM/RTTOV interface (back in May 2020)

- Work presented here has been done back to April/May, when
  - PANDA-C team can do cloudy radiance DA with cloudy CRTM interface in UFO and MPAS-JEDI specific development (e.g., hydrometeor analysis variables).
  - UFO has a preliminary **RTTOV Fortran interface**, but no capability for cloudy radiance simulation/assimilation, which is required by our PANDA-C project.

- Decided to implement a **RTTOV C++ interface** with cloudy radiance capability
  - C++ API is recommended by the RTTOV team,
  - Also seems to be easier to work with (e.g., likely shorter interface code)

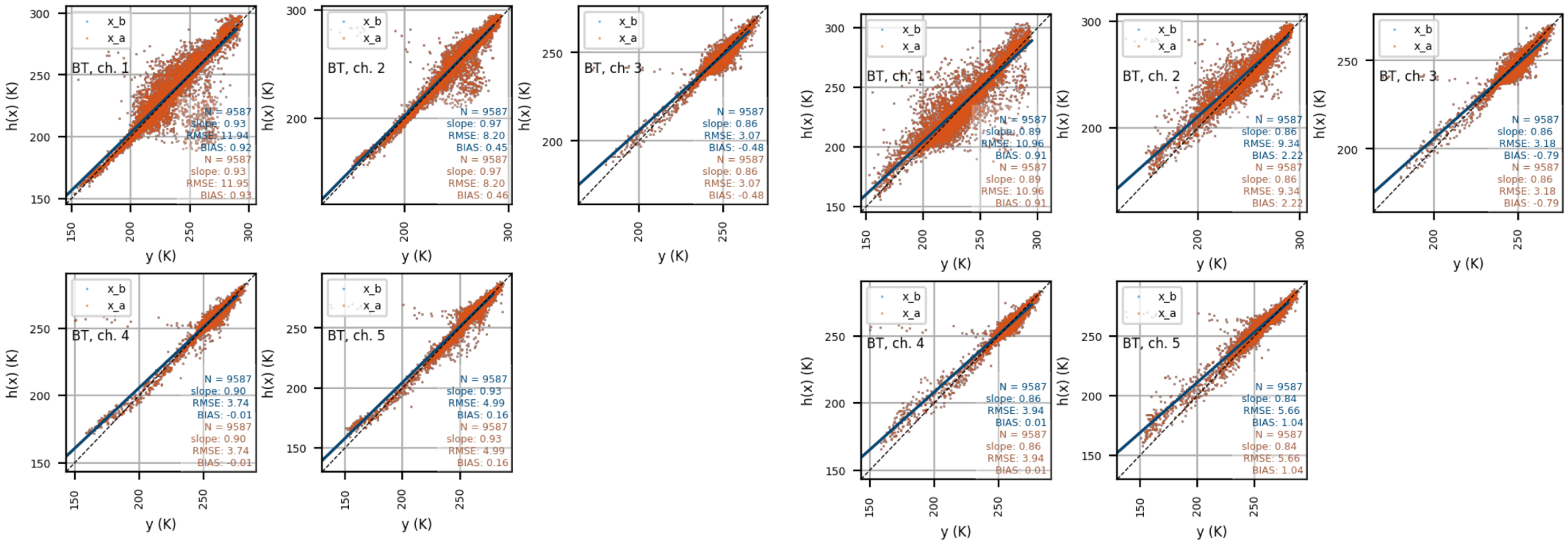
Status of RTTOV C++ interface development

- Allow forward simulation
- Can simulate cloudy radiance from different type of sensors, including infrared and microwave, also visible and near infrared channels.
- Tested cloudy radiance simulations for all channels of ABI, AHI, AMSU-A, and MHS with MPAS-JEDI, mostly at 120-km resolution

CRTM, noaa18-mhs

RTTOV, noaa18-mhs

Valid at 2018041500



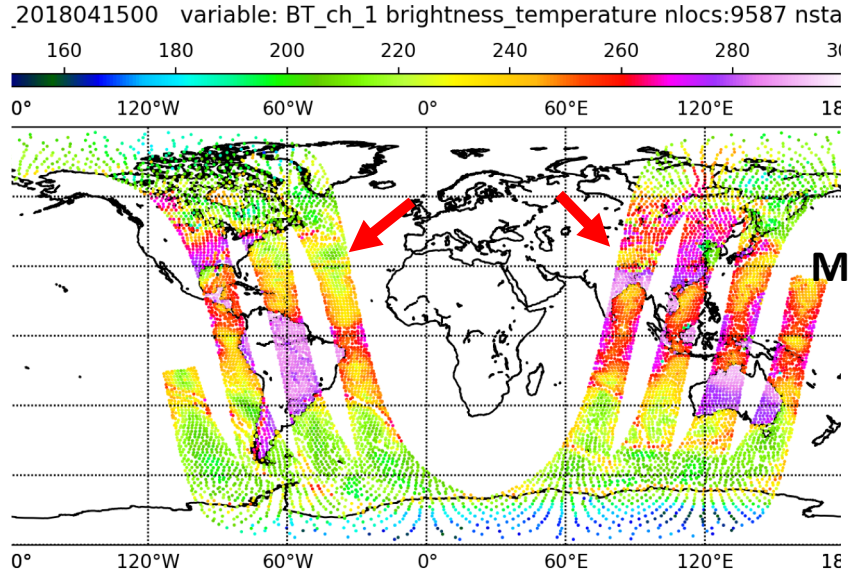
Model input is a MPAS 6-h FC at 120-km resolution with WSM6 microphysics scheme

Overall comparable, RTTOV has smaller OMB for channel 1, but larger OMB for channel 2-5

CRTM uses all 5 hydrometeors (liquid water, ice, rain, snow, graupel),

But RTTOV does not use graupel.

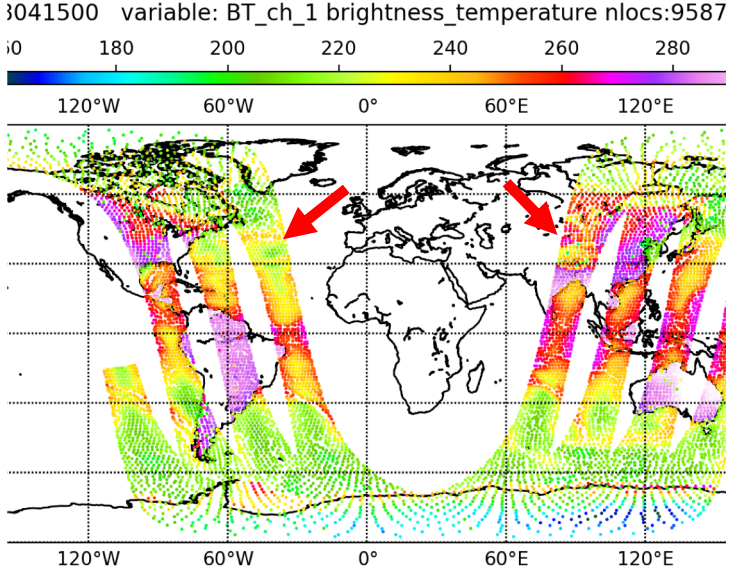
Valid at 2018041500



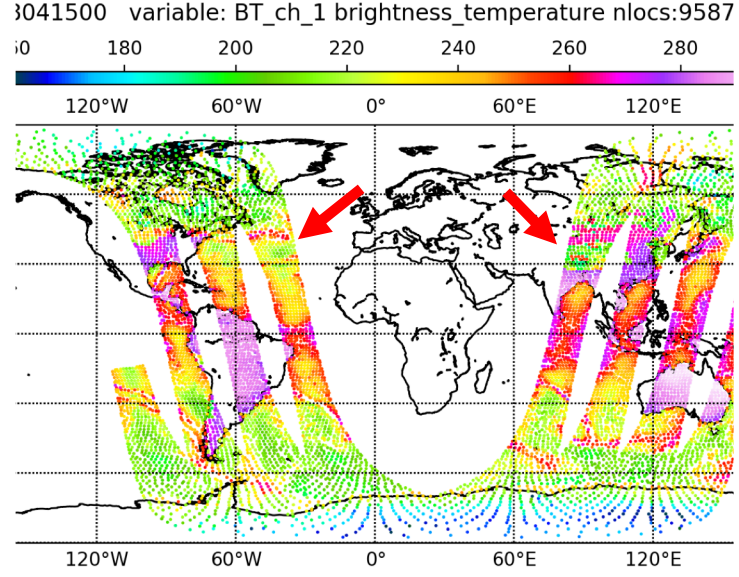
MHS ch1

Obs

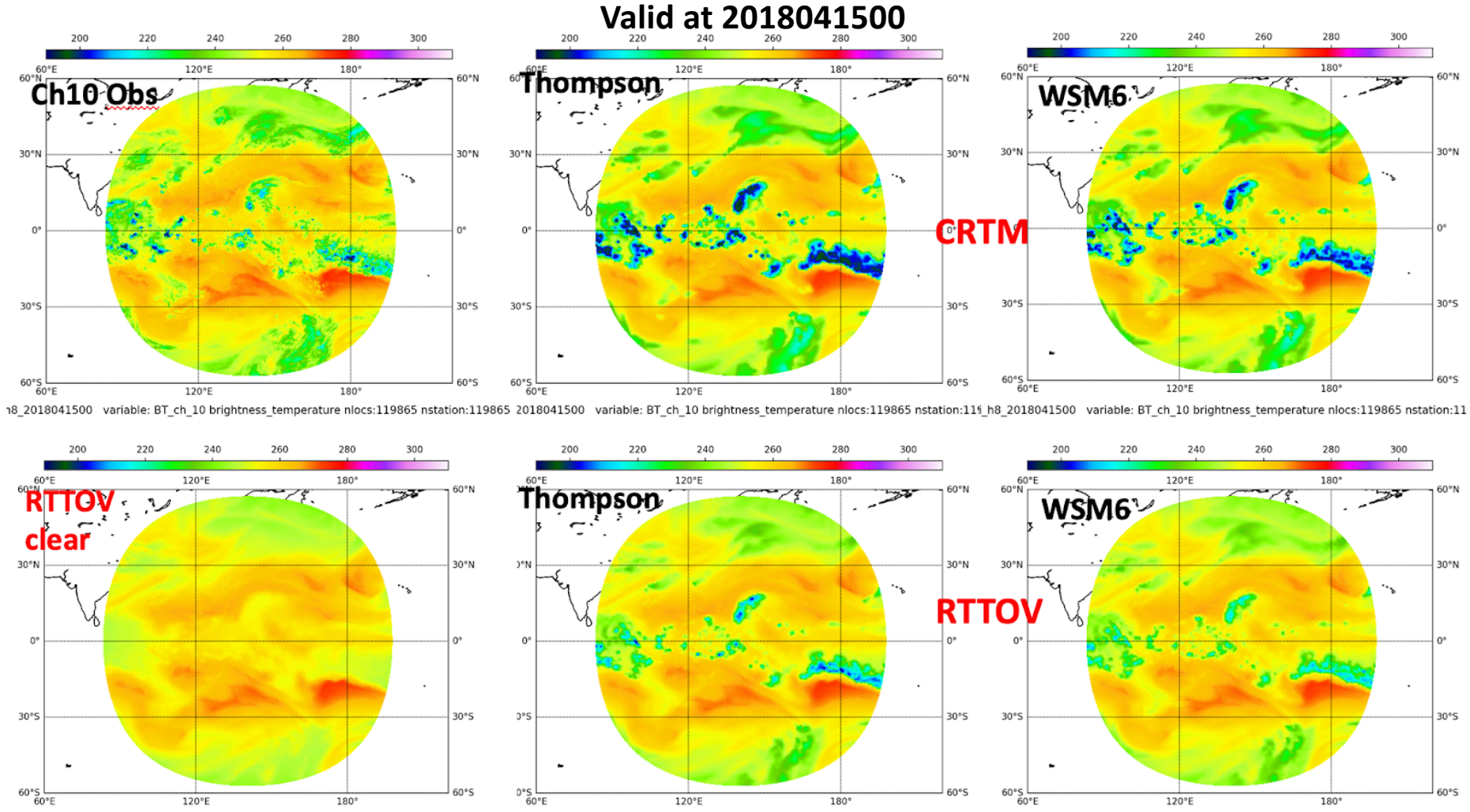
RTTOV simulation

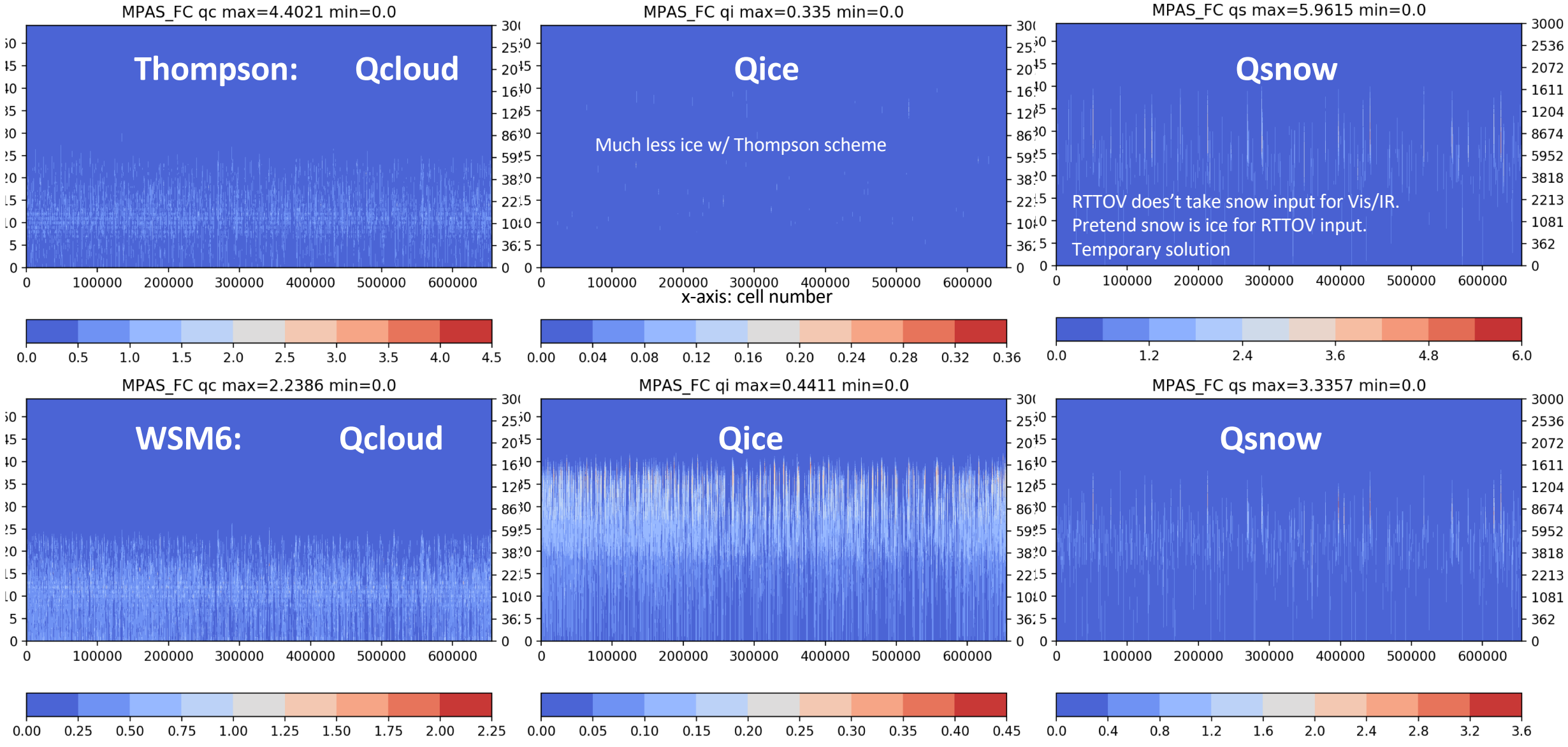


CRTM simulation

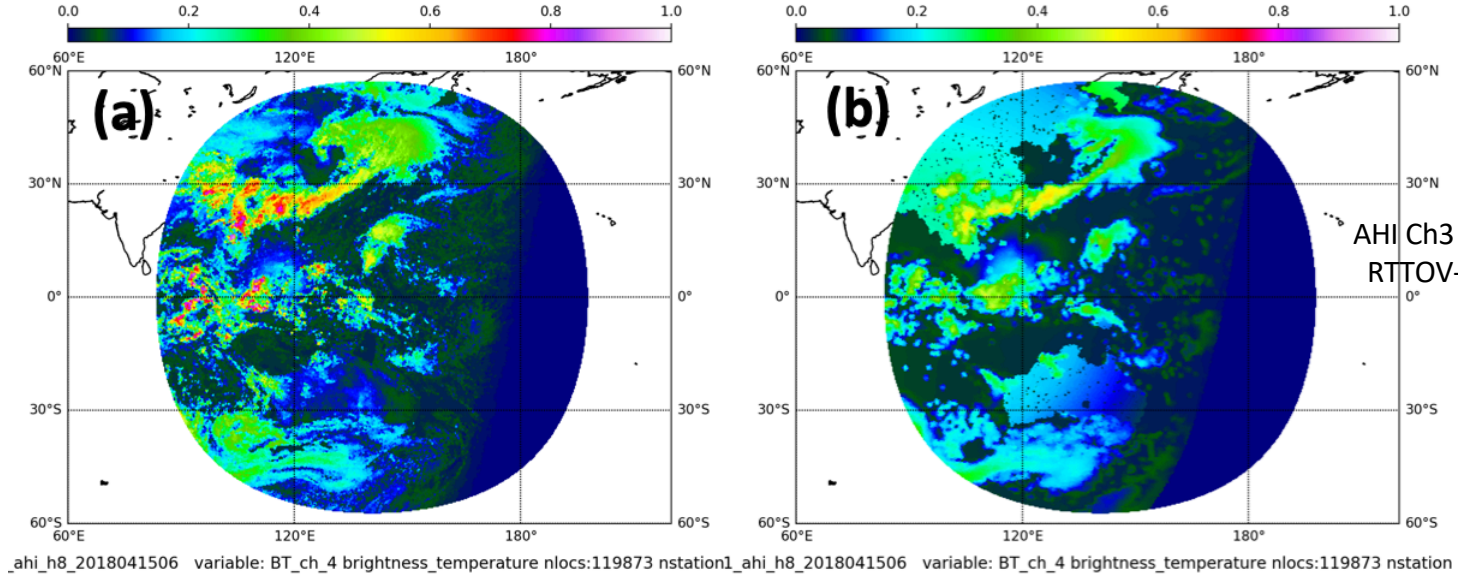


CRTM vs. RTTOV for AHI Ch10, low-level WV channel




MPAS_FC qc max=4.4021 min=0.0
Thompson: Qcloud
MPAS_FC qi max=0.335 min=0.0
Qice
Much less ice w/ Thompson scheme
MPAS_FC qs max=5.9615 min=0.0
Qsnow
RTTOV does't take snow input for Vis/IR.
Pretend snow is ice for RTTOV input.
Temporary solution
x-axis: cell number
MPAS_FC qc max=2.2386 min=0.0
WSM6: Qcloud
MPAS_FC qi max=0.4411 min=0.0
Qice
MPAS_FC qs max=3.3357 min=0.0
Qsnow

AHI Ch3 Obs Reflectance 0.64 um (red channel)

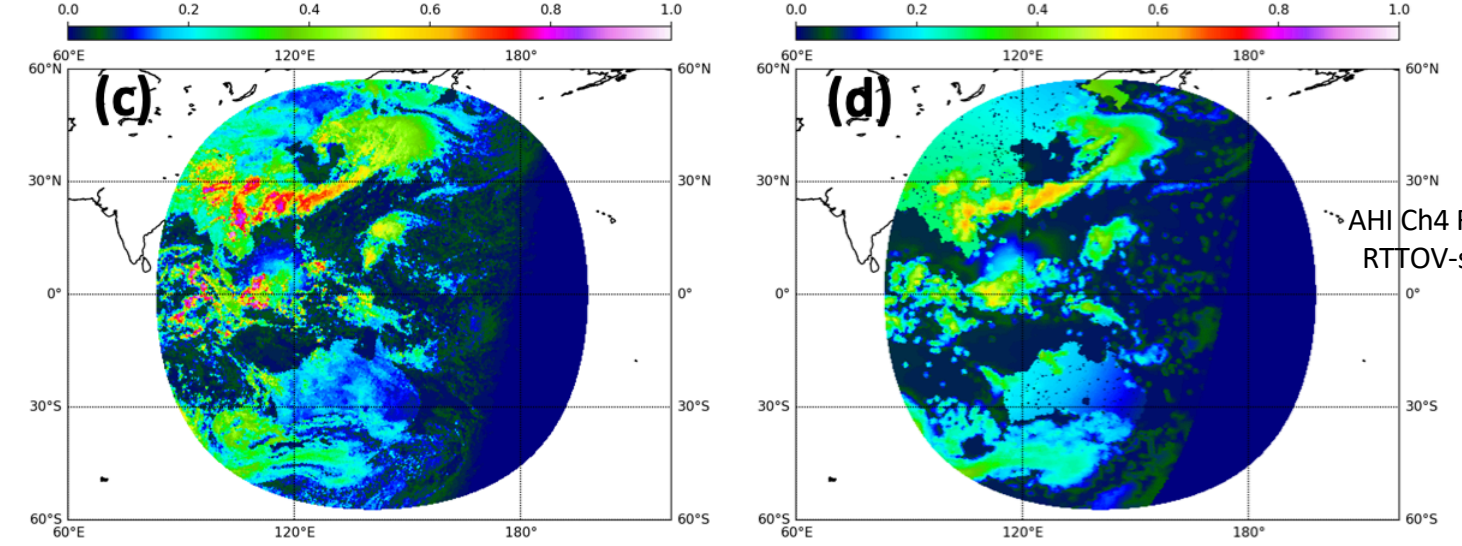


AHI Ch3 Reflectance RTTOV-simulated

Valid at 2018041506

_ahi_h8_2018041506 variable: BT_ch_4 brightness_temperature nlocs:119873 nstation1_ahi_h8_2018041506 variable: BT_ch_4 brightness_temperature nlocs:119873 nstation

AHI Ch4 Obs Reflectance 0.86 um (veggie channel)



AHI Ch4 Reflectance RTTOV-simulated

Summary

- RTTOV C++ interface works reasonably well for cloudy radiance simulation of different bands.
- RTTOV's and CRTM's cloudy radiance simulation overall comparable for MW, but larger difference for IR.
- Need to better understand different treatment of ice phase hydrometeors between CRTM and RTTOV, especially for IR/Vis
- Need some caution when using different microphysics schemes

Plan

- Update interface code with the latest repository
- Develop tangent linear and adjoint interface for data assimilation purpose
- Gradually merge code

MPAS-JEDI month-long cycling experiments at 30km mesh

20-member pure 3DEnVar

Clr: forecasts from MPAS-JEDI ICs
conventional obs
+ clear-sky AMSU-A (with CRTM)

CldMHS: forecasts from MPAS-JEDI ICs
conventional obs
+ clear-sky AMSU-A
+ all-sky MHS (with CRTM)

CSGFS: forecasts from GFS ICs

CSEC: forecasts from ECMWF ICs

500 hPa Geopotential height ACC scores