Fast passive microwave radiative transfer in precipitating clouds: Towards direct radiance assimilation

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Outline

- Introduction

- OPTRAN versus Eddington (gas absorption only)
  - Accuracy
  - Impact of thermal source terms

- Including Cloud liquid water/precipitation: First results
  - Biases GFS/AMSU under cloud-free and cloudy conditions
  - First results for precipitation

- Outlook

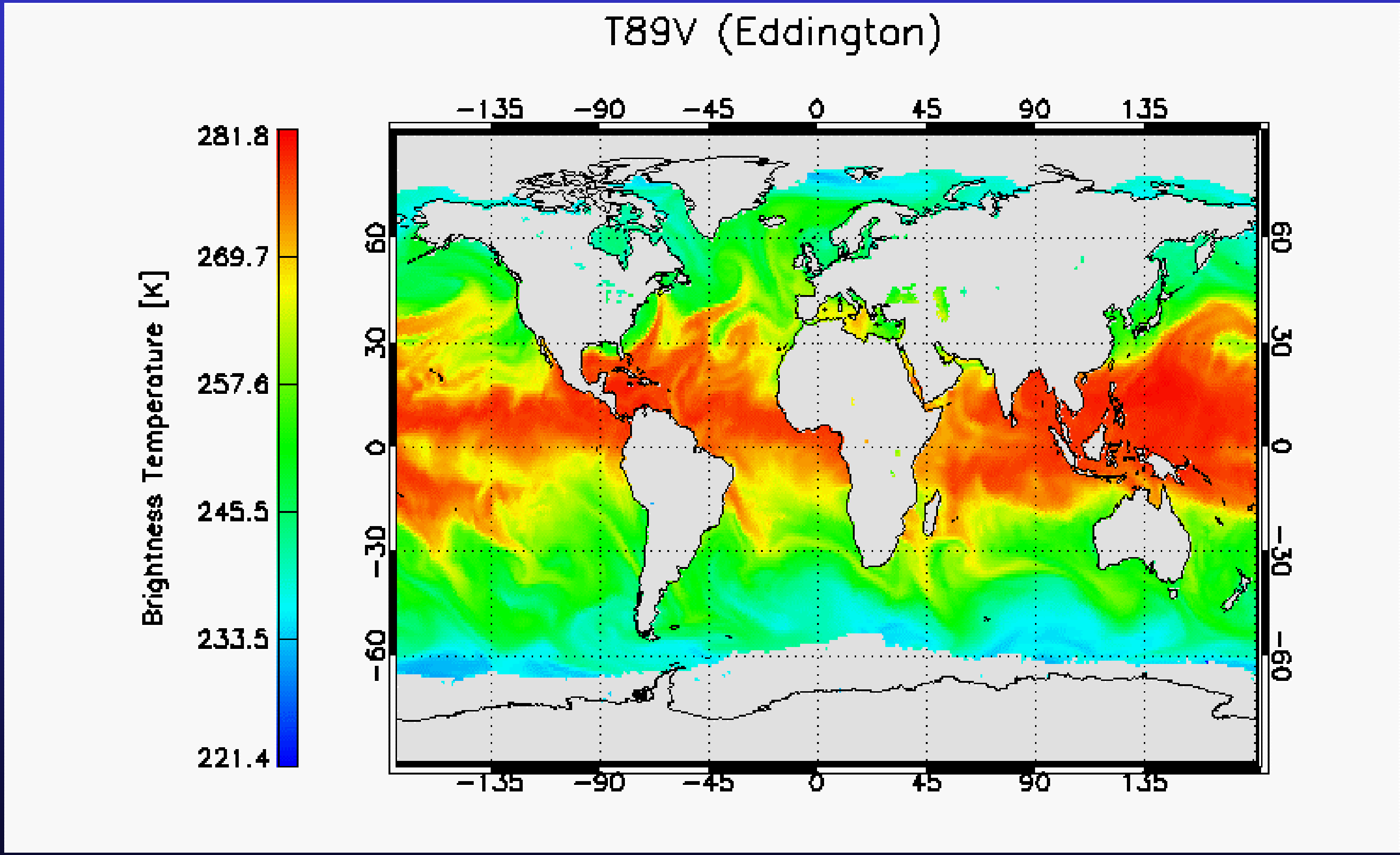
RT models for assimilation in NCEP GFS/GDAS under cloudy/precipitating conditions?

- Surface emissivity
- Scattering/emission by rain/frozen precipitation
- Emission by cloud liquid water
- Has to fit in current operational environment (interfaces etc.)
- Has to be fast

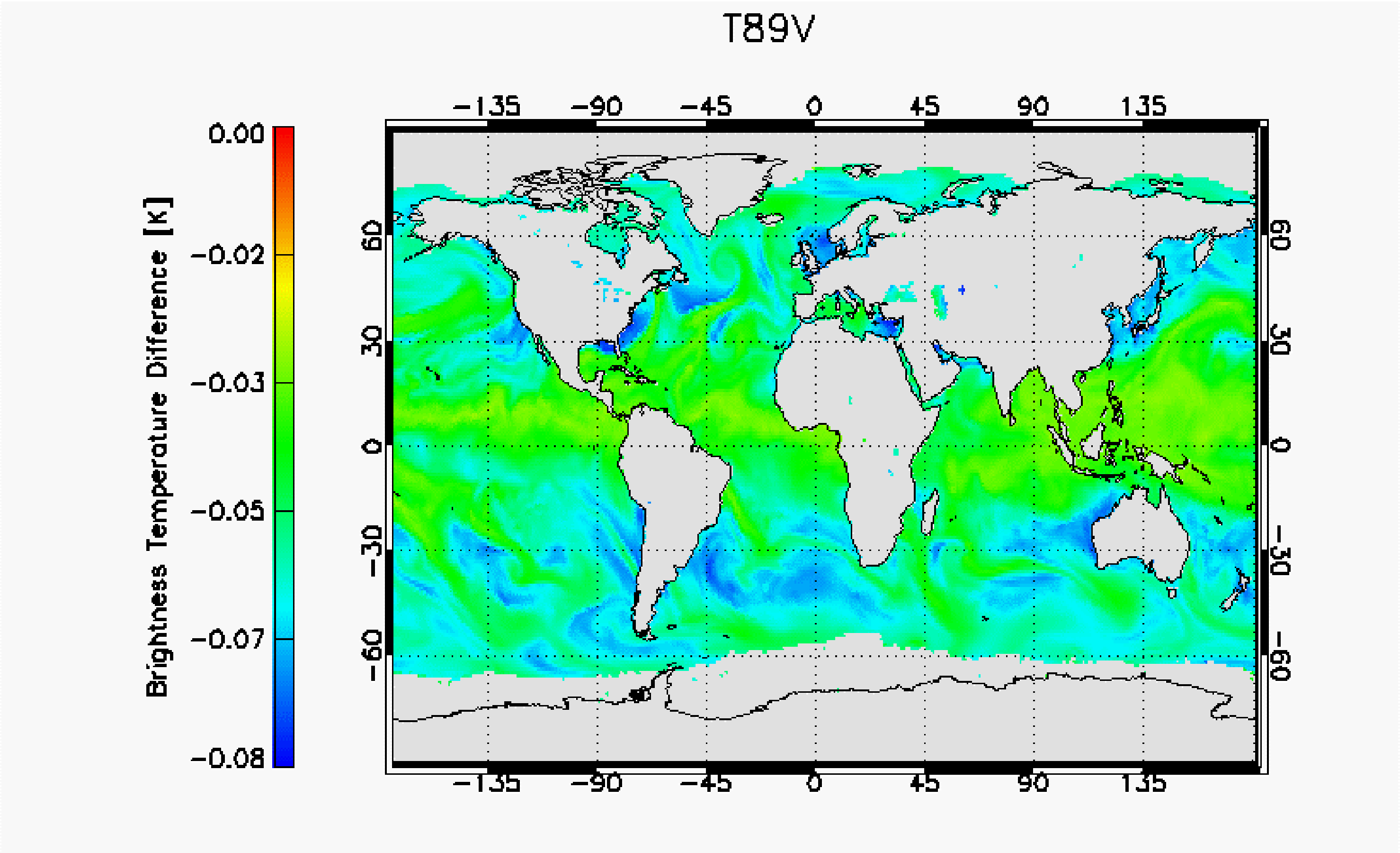
Current status

- Surface emissivity model (FASTEM-II) included in OPTRAN
- Eddington model (P. Bauer) included in OPTRAN
- Liquid water absorption included
- Scattering lookup tables for rain, snow, graupel, hail included
- Will present first comparison results with satellite data here

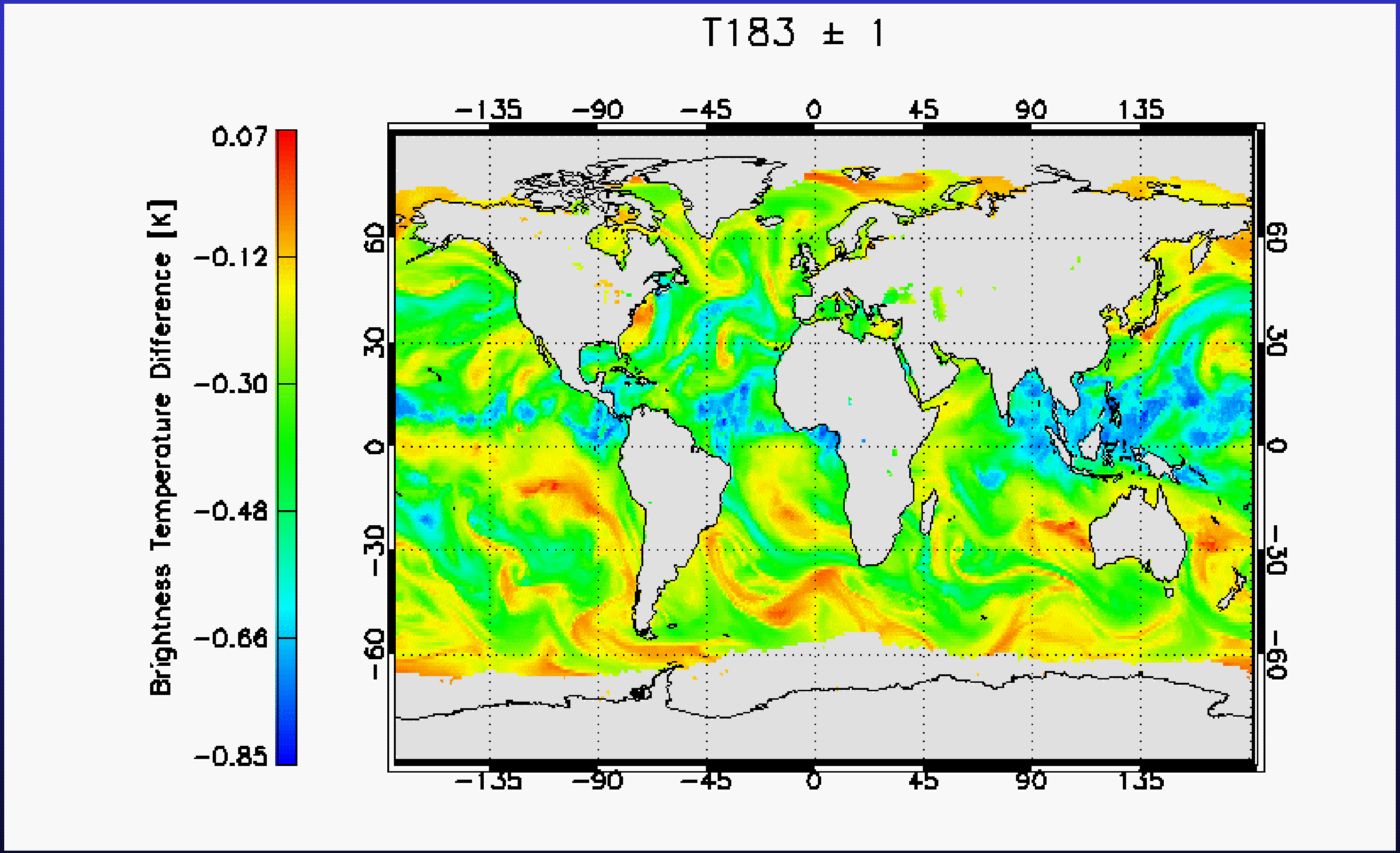
OPTRAN versus Eddington (gas absorption only)
(Sanity check for our implementation)



OPTRAN versus Eddington (gas absorption only) Difference 89 GHz



OPTRAN versus Eddington (gas absorption only) Difference 183±1 GHz (@ 53 zenith angle)

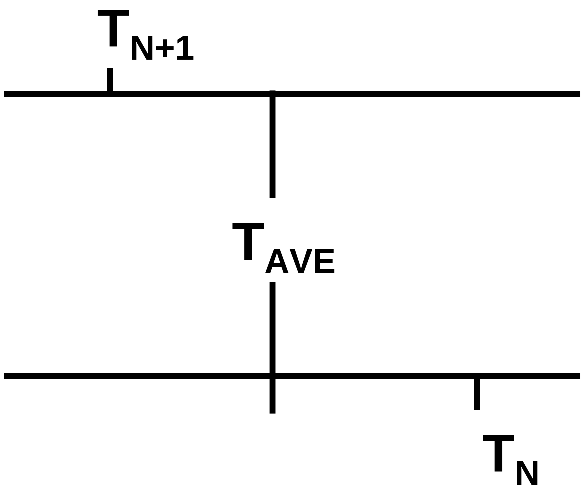


OPTRAN versus Eddington (gas absorption only)

Difference is due to treatment of thermal source term in radiative transfer:

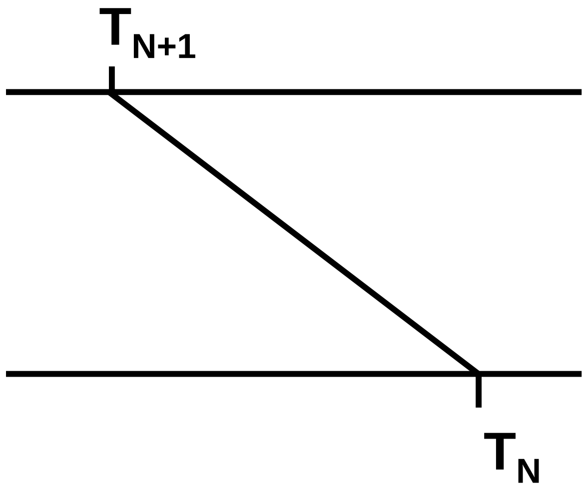
OPTRAN:

Assumes layer average temperature:

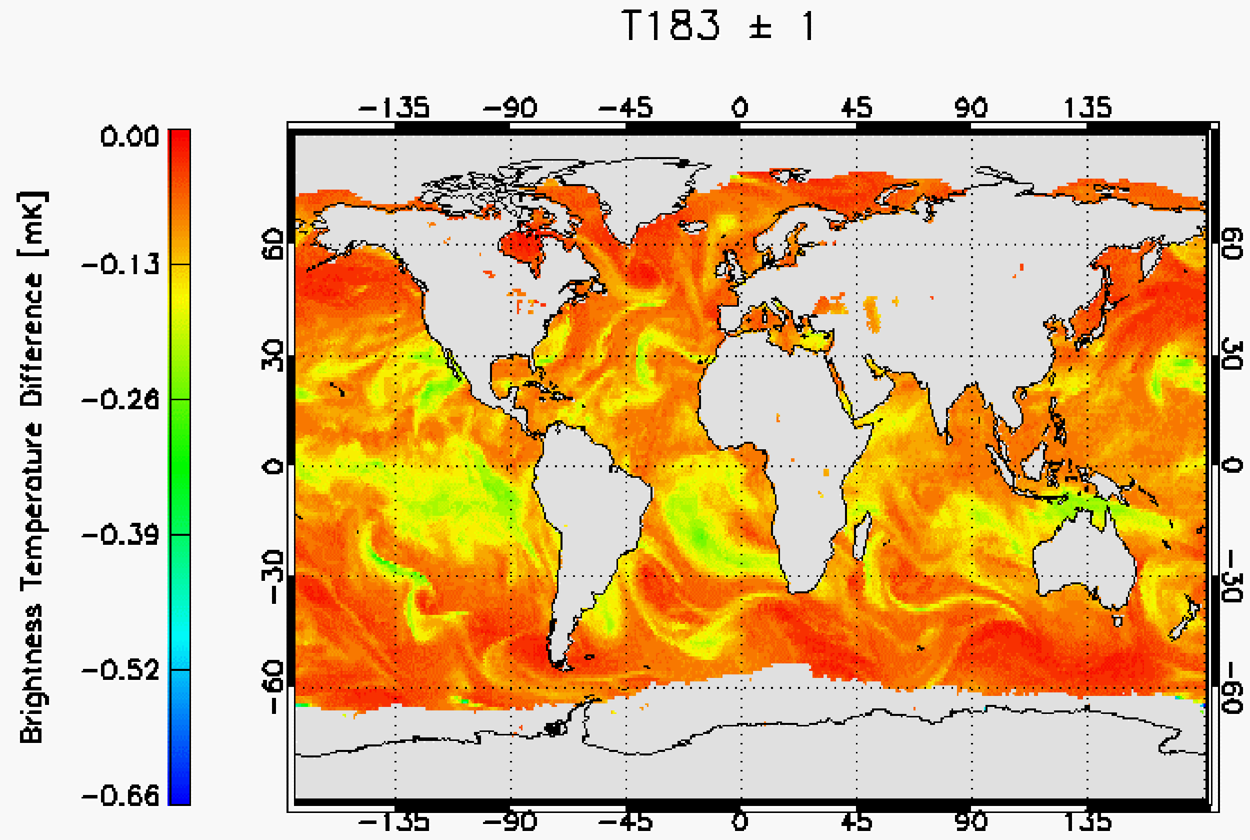


Eddington:

Assumes linear temperature change within layer:



OPTRAN versus Eddington (gas absorption only)
Same thermal source term



(Note: Units here is milli-Kelvin)

Differences in thermal source:

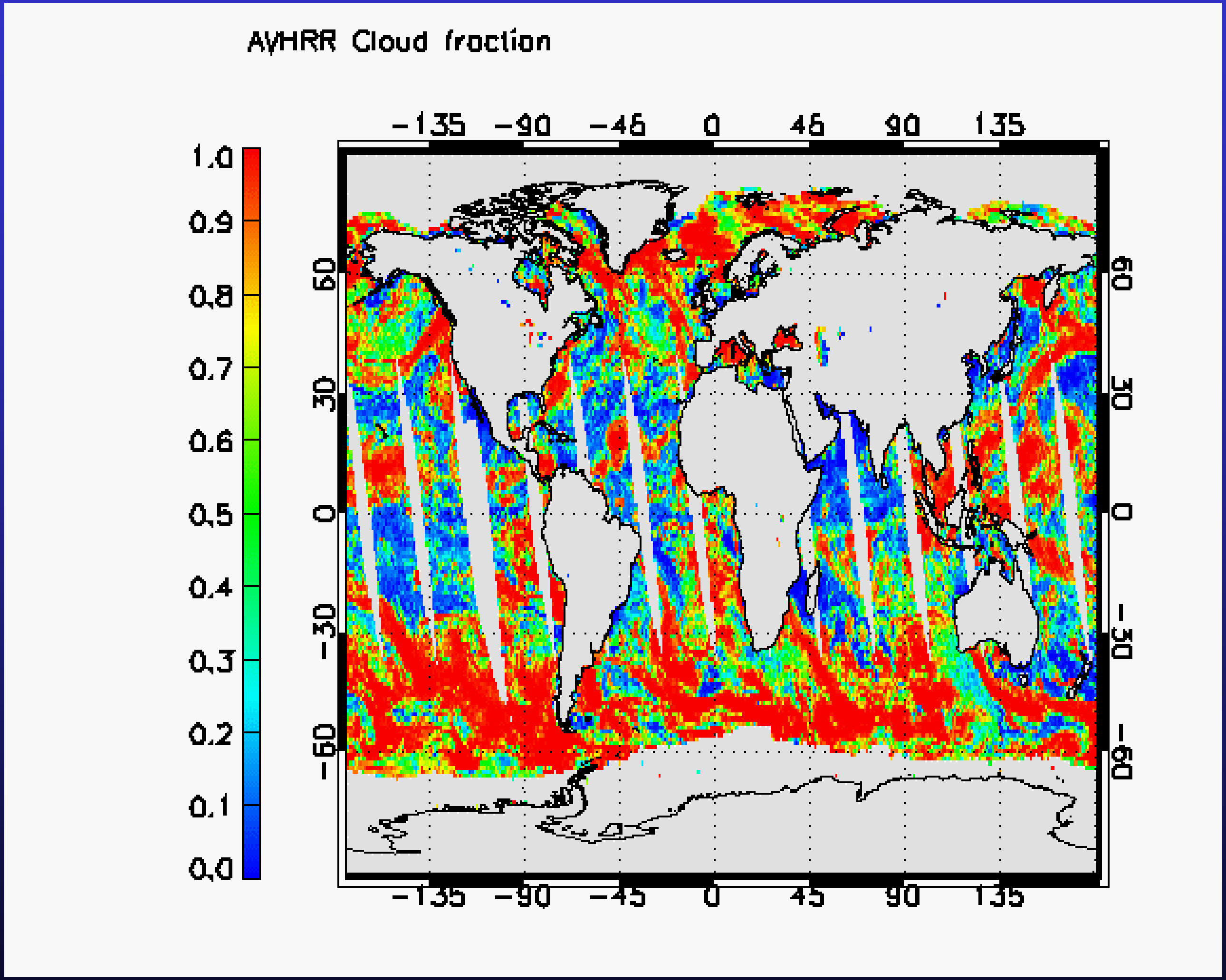
- Only important if the upper and lower level temperatures are significantly different AND if the layer is optically thick
- Differences depend on water vapor and/or temperature fields
- With increasing model vertical resolution difference approaches zero
- Both formulations of the thermal source have an analytical solution

Comparisons satellite/simulations including cloud liquid water

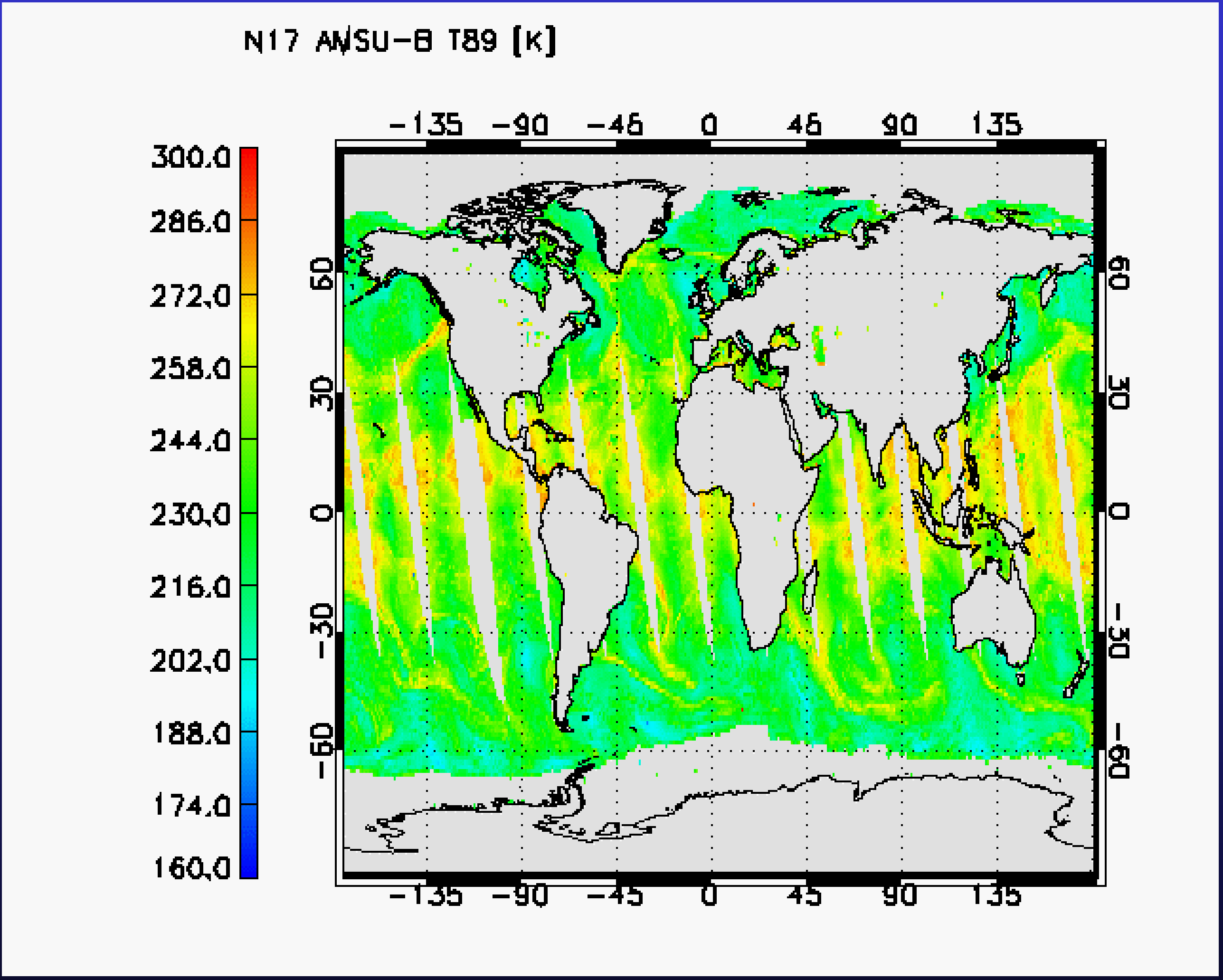
Screening strategy

- Stay within ±1.0 hours between GFS forecast and AMSU observation
- Use CLAVR-X (Heidinger, 2003) AVHRR gridded cloud product to find boxes that are at least 95% cloudy (or at maximum 5% cloudy for cloud-free)
- Compare AMSU-A/B window frequencies and AMSU-B 183 ±X GHz water vapor absorption channels

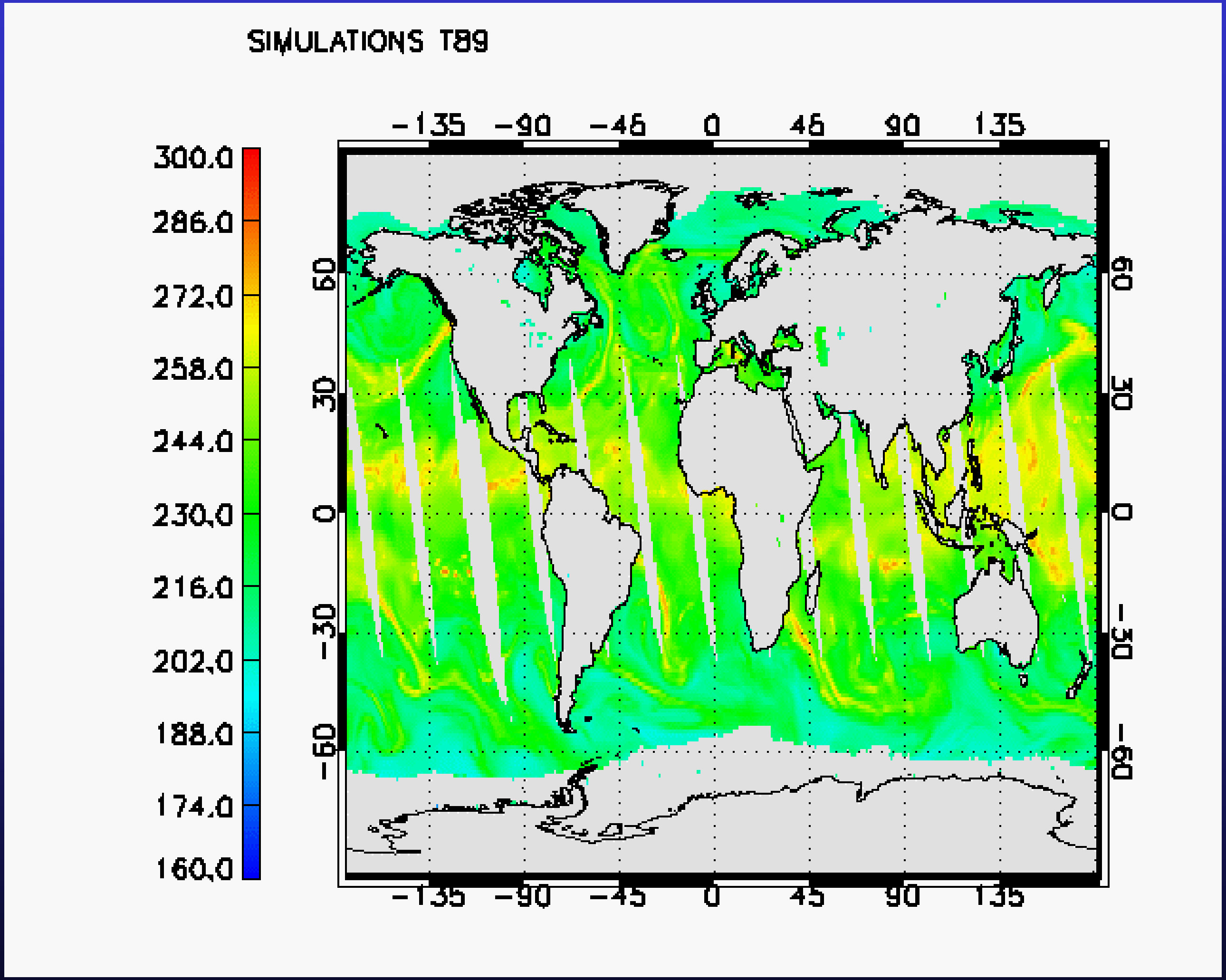
CLAVR-x (Heidinger, 2003) cloud coverage



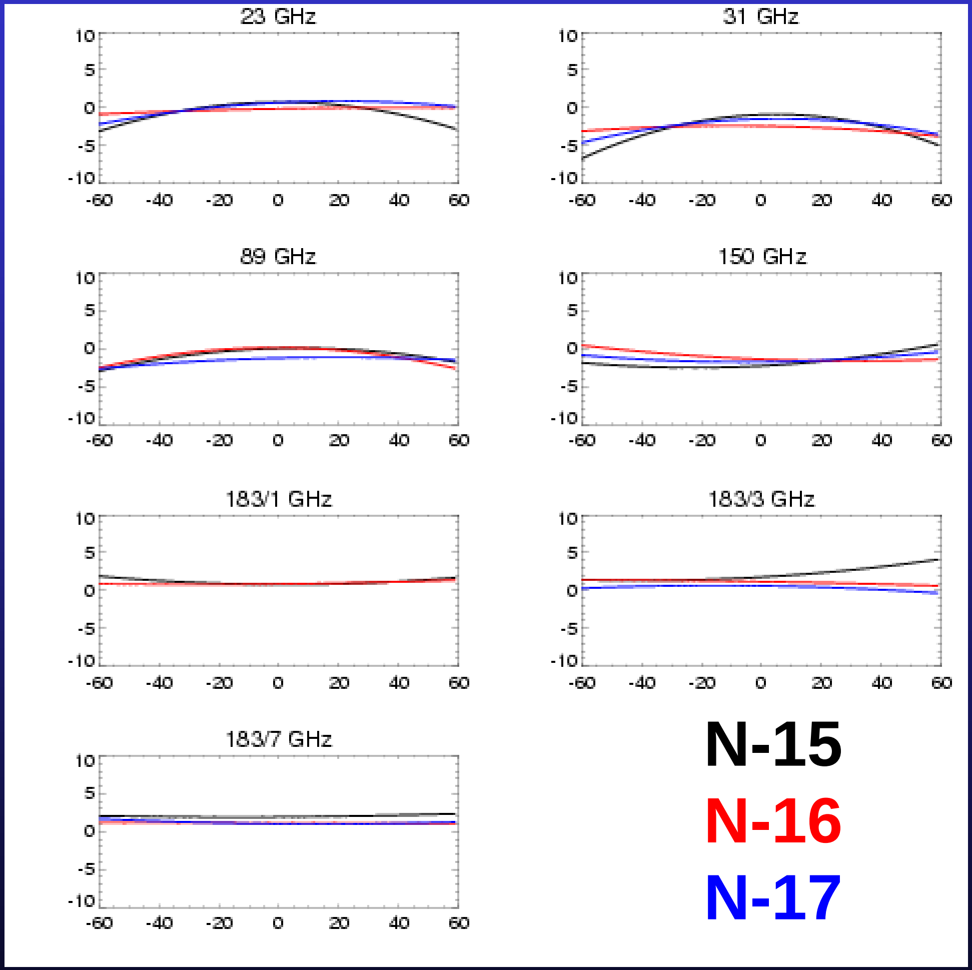
AMSU gridded product (Weng et al.)



Simulation (gas + cloud water)

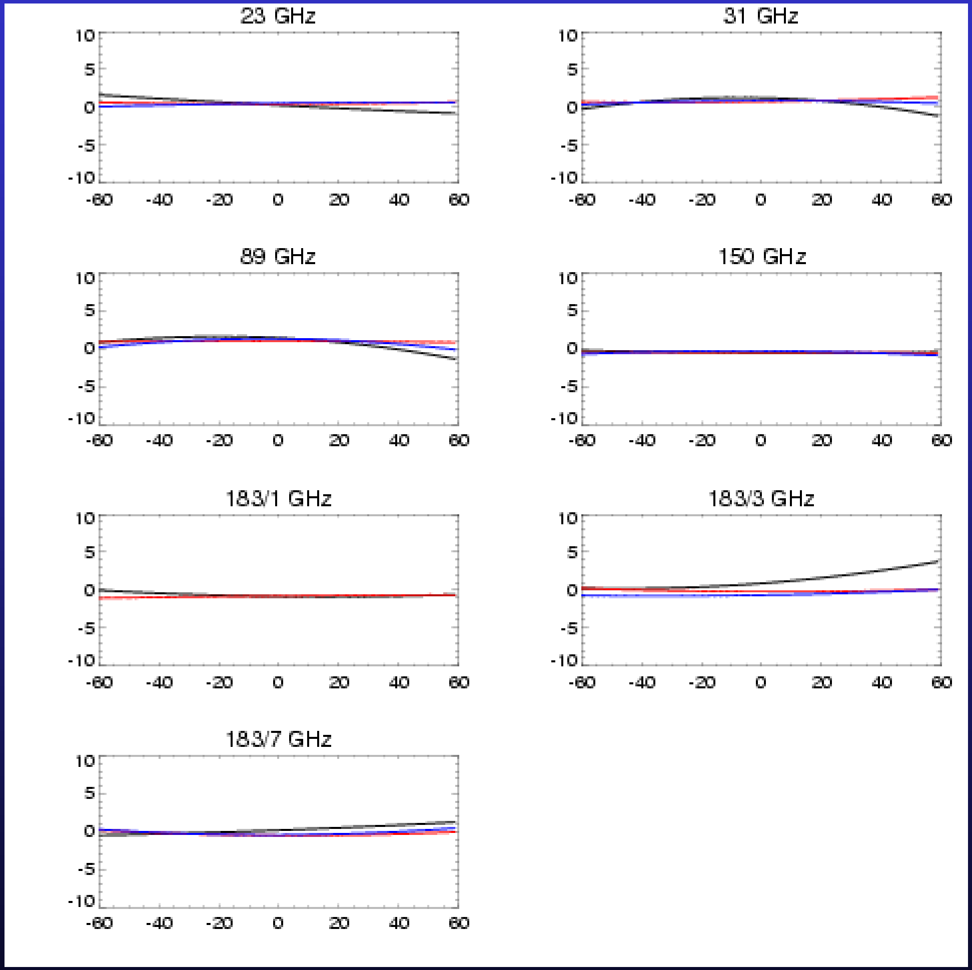


First assessment of AMSU-A/B versus GFS biases **cloud-free** (period: 16-19 Oct. 2003)



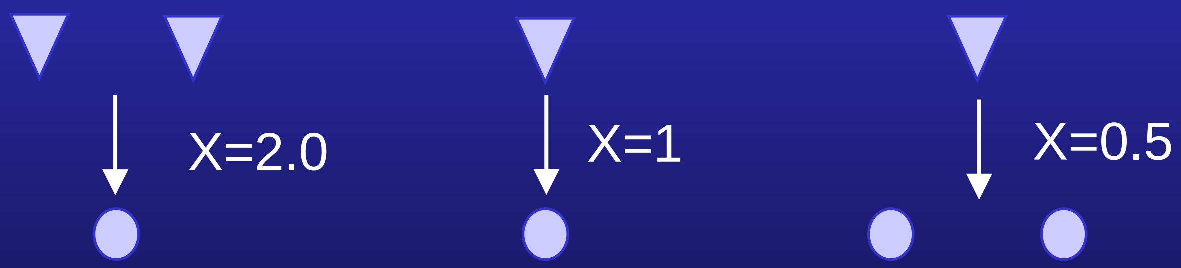
First assessment of AMSU-A/B versus GFS biases

cloudy (period: 16-19 Oct. 2003)



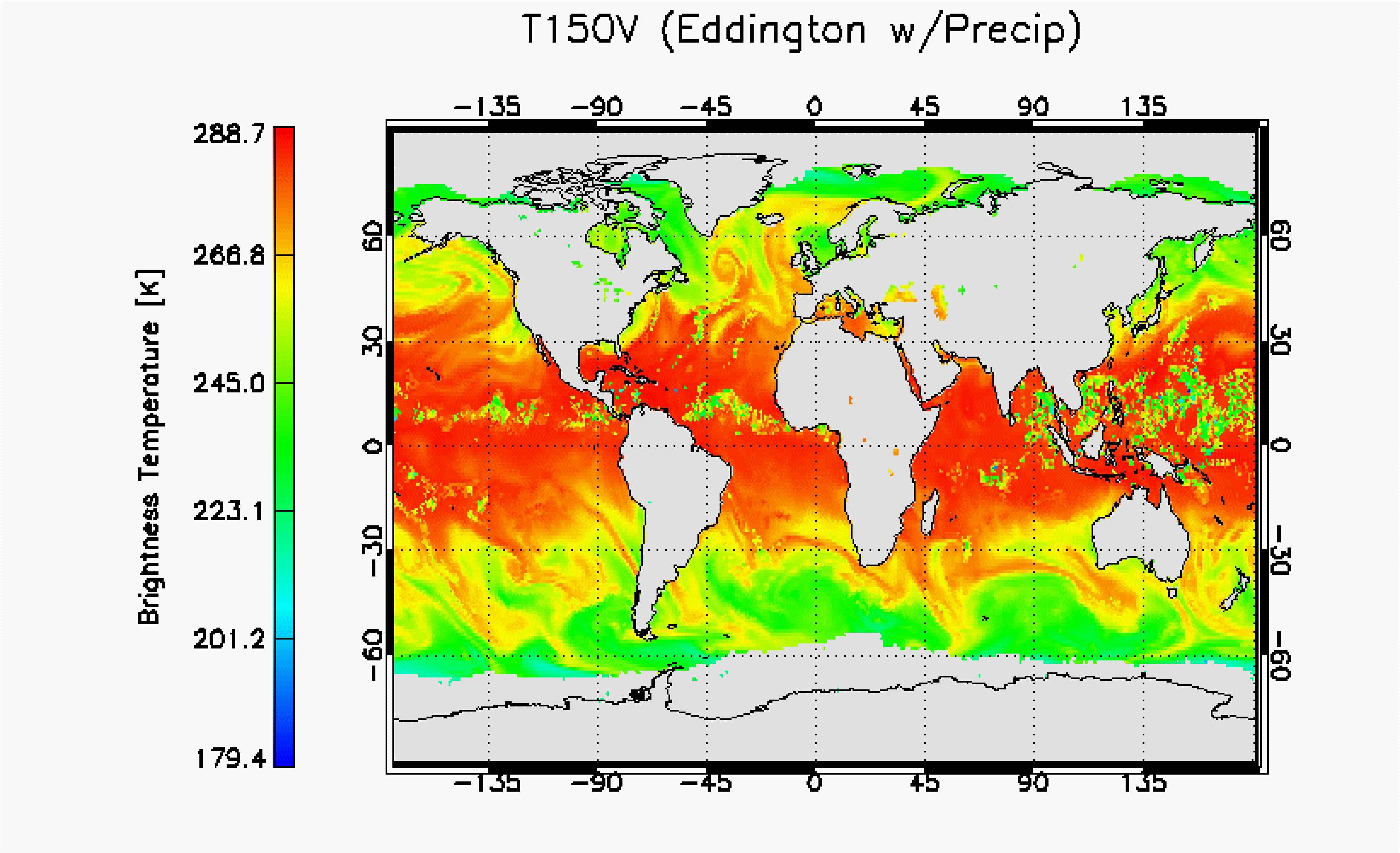
Precipitation microphysics, what to do with bulk ice?

- Both, frozen and liquid rain follow an exponential size distribution?
- Average ice particle diameter may differ from that of frozen precipitation at a given rain rate

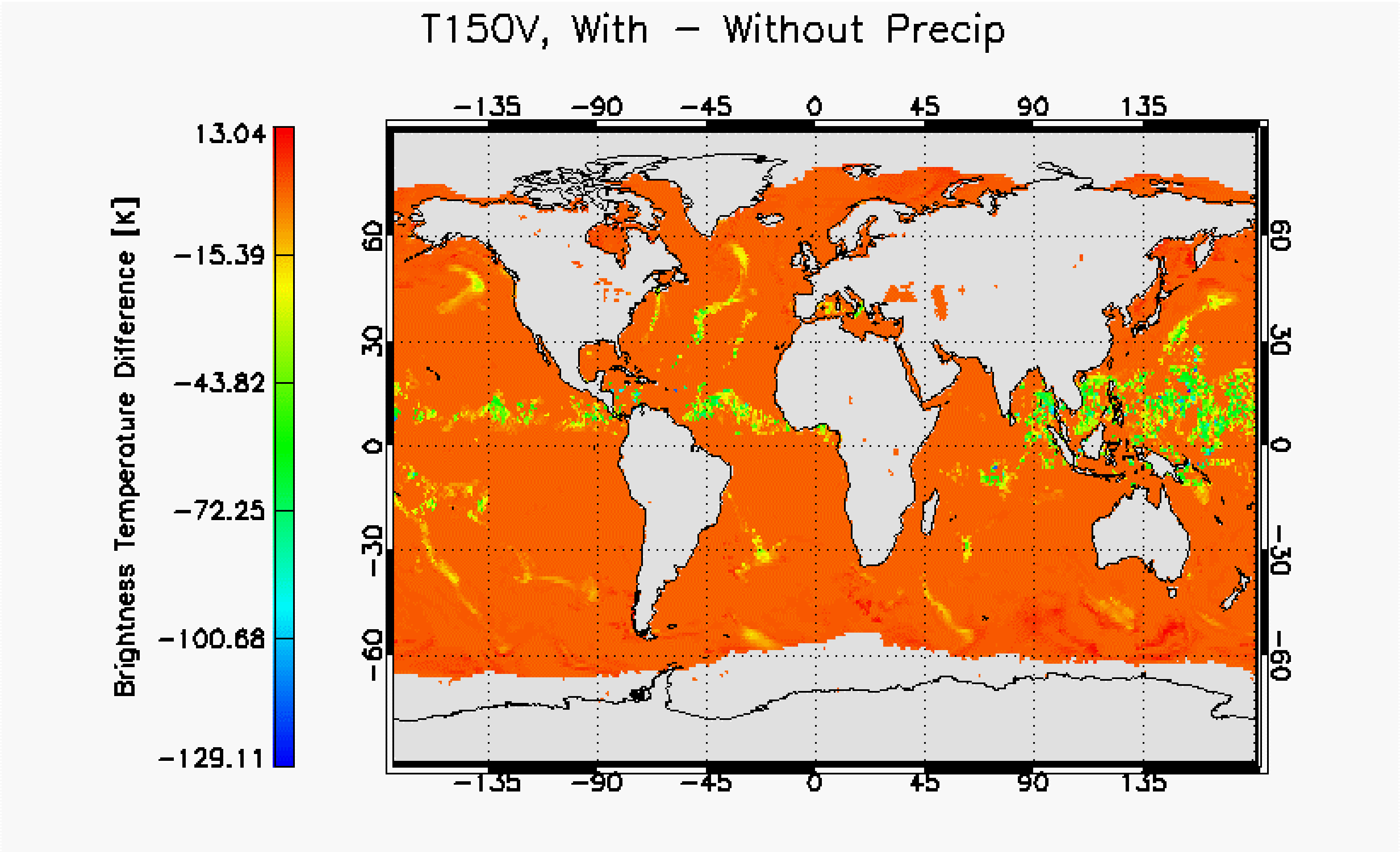


- Different ice densities may occur (snow, graupel, hail)

Simulation including precipitation



Difference with - without precipitation



Conclusions

- FASTEM surface emissivity model implemented in OPTRAN
- Eddington rt-model implemented in OPTRAN
- Eddington model agrees with OPTRAN in milli-Kelvin range if the same thermal source is used
- First comparisons with GFS 12 hour forecast fields

Future plans

- Monitor bias statistics over long time period

- Inclusion of other radiative transfer models in with other Radiative transfer models:
  - Weng and Liu polarized Eddington model (almost ready, in cooperation with F. Weng)
  - Successive order of scattering

- Precipitation assimilation:
  - Tangent linear, adjoint model
  - Include cloud diagnostics to generate precipitation rate
  - 1DVAR loop to optimize moisture profiles versus direct assimilation?

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