

The Current Status of the AIRS V7 Retrieval Product Testing

Qing Yue¹

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Summary of JPL AIRS V7 Testing Analyses

- Using the sounding system data product testing framework developed at JPL, the AIRS team has tested various versions of algorithms, which helps to further improve the retrieval, especially IR-only.
- The latest versions that have been tested: V6.52IR only, V6.46IR+MW.
 - *Improved SCCNN* (Adam's talk):
 - removing the biased ECMWF in the training data (V6.46)
 - increased training dataset to deal with interannual variability (V6.50)
 - projected principle component method to reduce SCC errors near sfc (V6.51IR)
 - *Modified QC methodology (V6.52 and V6.53)*:
 - QC in PBL over land now relies more on near surface layers
 - Tighter QC thresholds for mid and low atmosphere over land and mid atmosphere over frozen surfaces
 - *IR-only surface classes*:
 - GFS snow cover and snow water equivalent data used to distinguish non-frozen and frozen surfaces (since V6.46).
 - *Algorithm: Changed channel sets, internal covariance matrix methodology, O₃*: (preV6.4)

AIRS V7 Goals

Met
Partially met or uncertain
Unmet

1. Goal zero: good general quality
2. Remove day-night performance difference
3. Better IR-only algorithm than V6IR-only: surface classes, SCCNN, channels,...
4. Better IR only products than V6 IR+MW
5. Better ozone
6. Improved stratosphere and polar
7. Unified retrieval algorithm for both AIRS and CrIS
8. Improved L1B (not included in L2 retrieval)
9. Improved file format: NetCDF4
10. Better PBL over land (cold season): IR+MW, IR-only ->temporal and regional
11. More accurate characterization of errors within our v6 formalism:
 - a. More accurate error estimates
 - b. Better flagging of bad cases with Q0, Q1, Q2

Examples of JPL AIRS V7 Testing Analyses

- Comparisons with collocated reanalysis data:
 - General quality check: Spatial distribution of yield, retrieval bias, sampling bias. **Stage-0**
 - Causes of data quality issues: multiple variable analysis, cross-correlations. **Stage-1A**
- Total precipitable water vapor comparison with other microwave sensors. **Stage-0**
- Comparisons with collocated radiosonde measurements on water vapor and temperature vertical profiles (Sun's talk): **Stage-1A**
 - Collocated NN, ECMWF, and AIRS L2 retrievals: mean bias and RMS
 - Europe (especially in winter), MAGIC sondes
- Surface classes comparisons with data from National Snow and Ice Center: **Stage-2**
- O₃ information content analysis, and L2 total column ozone and ozone profiles (Evan's talk): compared with ozone sonde at Dumont d'Urville Stage: **Stage-1B**
- Near surface T and Q compared to MesoNet and ICOADS **Stage-1B**
- L1B radiance (Tom's talk).
- Cloud cleared radiance product (MODIS, RTM: Chris's Talk) **Stage-2**
- Drift of the biases using PREPQC sondes **Stage-2**

Improved IR-only algorithm including the IR-only surface classes since V6.46

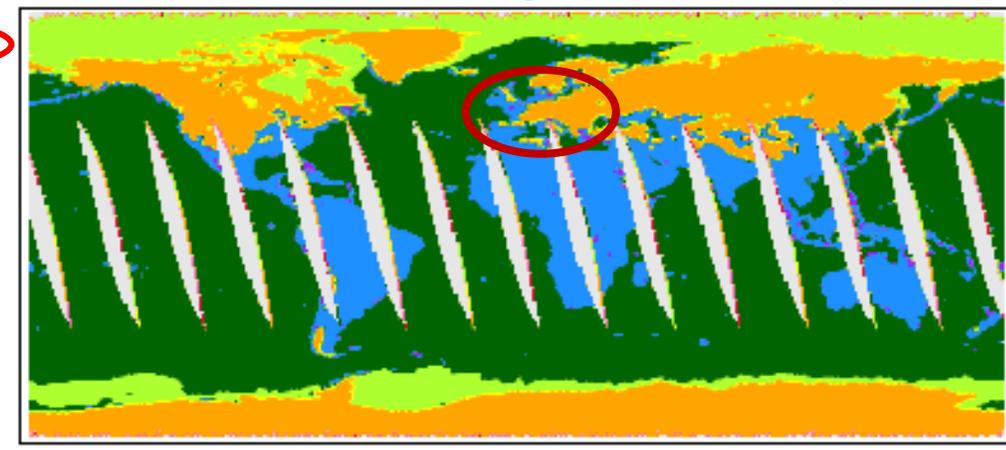
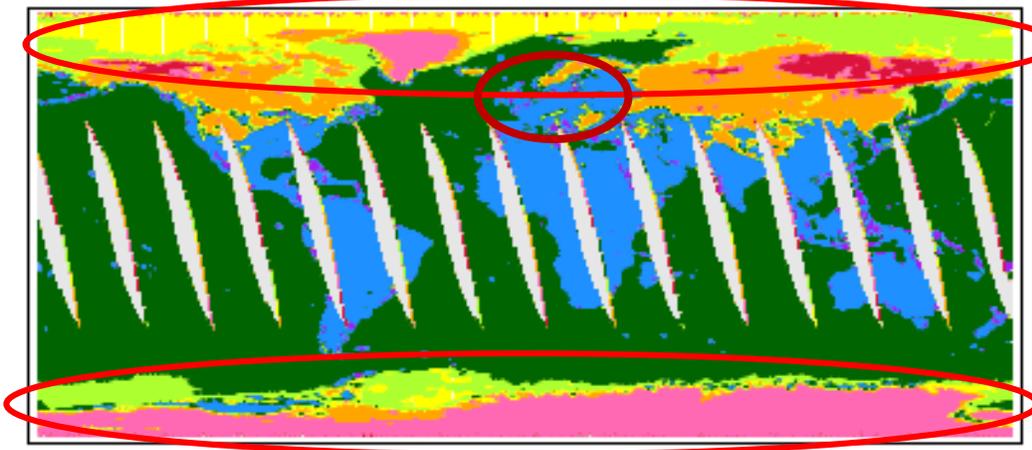
Reference data (Daily):

- Northern Hemisphere: National Ice Center's Interactive Multisensor Snow and Ice Mapping System (IMS) NH Snow and Ice Analysis at 24-km resolution (Daily)
 - Sensors and instruments used:
https://nsidc.org/data/docs/noaa/g02156_ims_snow_ice_analysis/#sensor-table
- Antarctic Area: NOAA Antarctic Sea Ice Extent Data (Daily).
 - SMMR, SSM/I, SSMIS

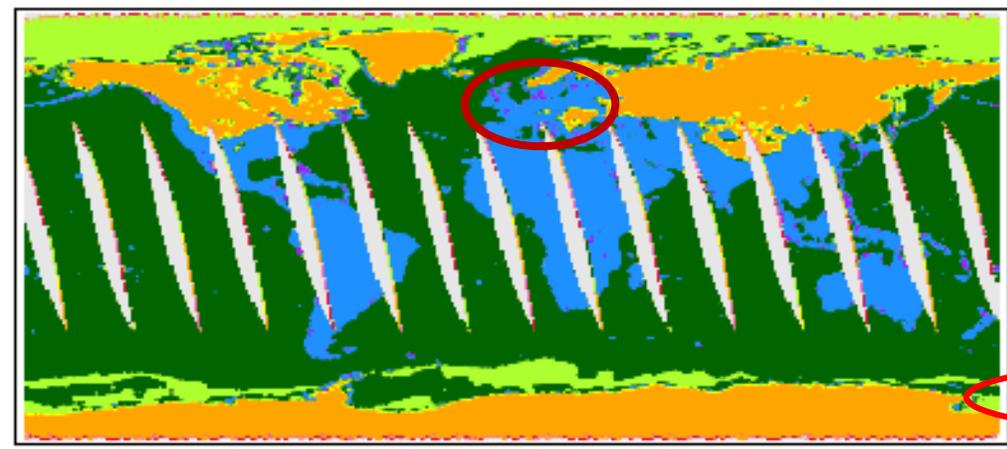
Ascending:

Asc: AIRS V6.46 SurfClass 2015.01.02

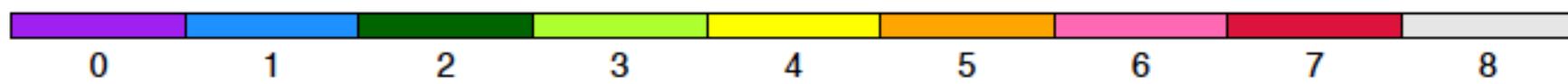
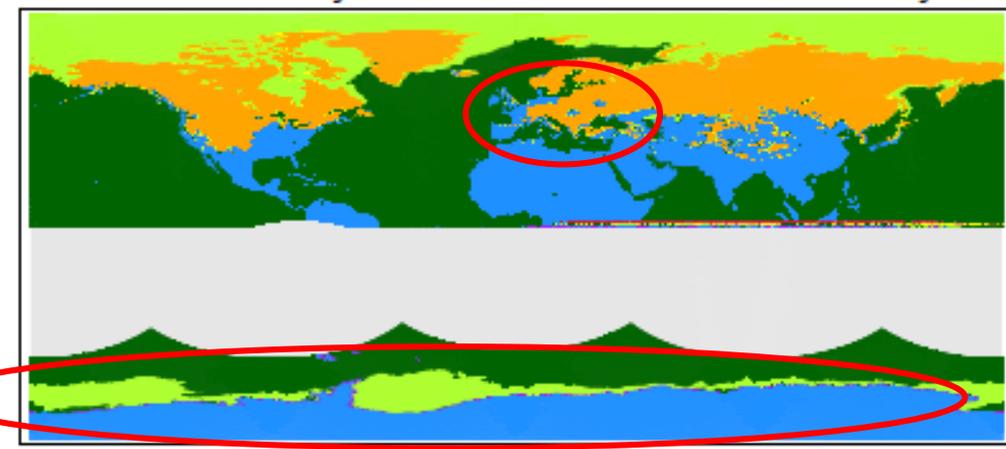
Asc: AIRS V6.46 IR-only SurfClass 2015.01.02



Asc: AIRS V6 IR SurfClass 2015.01.02



NSIC IMS Daily NH&SH Snow and Ice Analysis



IR+MW: 0=coast 1=land 2=ocean 3=new snow 4=old snow 5=high-freq-scat snow 6=glacier/snow (very low scat) 7=snow (lower-freq scat)

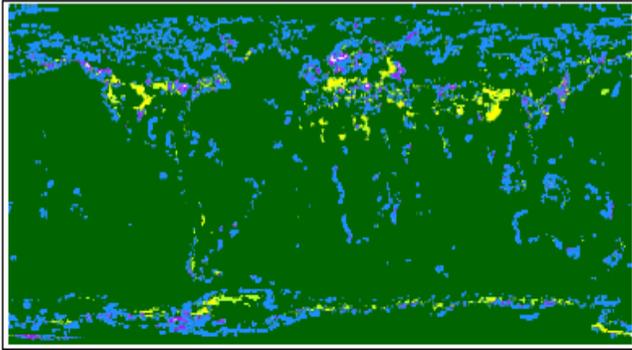
IR: 0=coast 1=land 2=ocean 3=sea ice 5=frozen land

NSIC IMS: 1=land 2=ocean 3=sea ice 5=snow 8=missing data

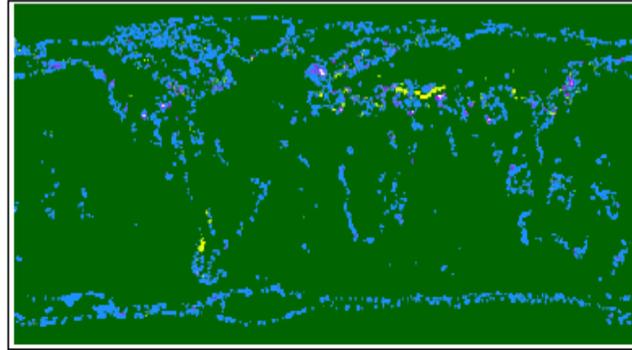
Note: NOAA SH sea ice extent data does not identify snow/ice over land

Summary on AIRS Surface Classes

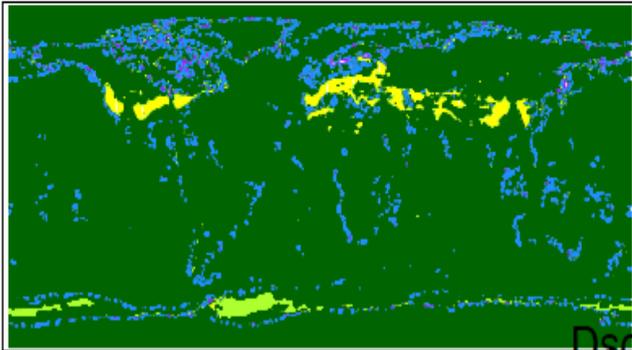
D-A: AIRS V6.46 SurfClass 2015.01.02



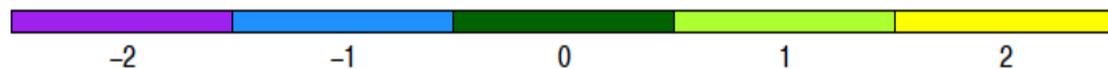
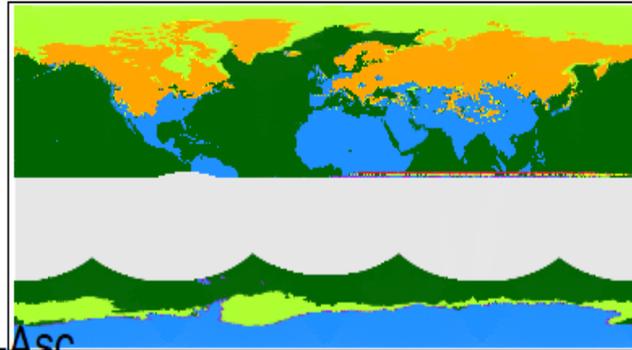
D-A: AIRS V6.46 IR-only SurfClass 2015.01.02



D-A: AIRS V6 IR SurfClass 2015.01.02



NSIC IMS Daily NH&SH Snow and Ice Analysis



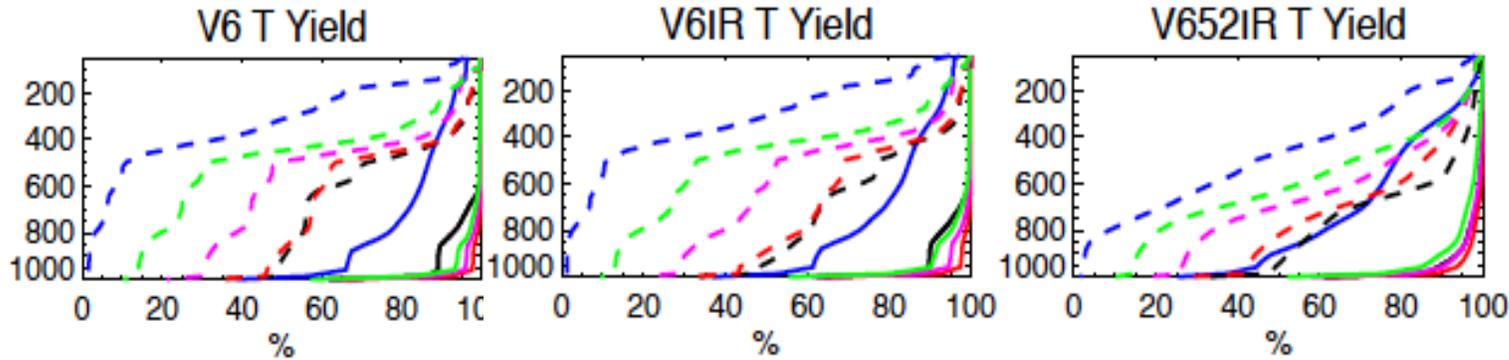
- V6.46 IR-only surface is very similar to the NSIC snow and ice extent. Small differences probably due to resolution differences.
- **V6.46 IR+MW shows non-frozen land over Europe, where NSIC data shows snow.**
- More frozen land in the high-mountain regions in V6.46 IR-only than V6.46 IR+MW.
- The Antarctic region sea ice anomaly in the V6 IR-only products is removed in the new versions.
- The day-night difference in the IR-only algorithm is largely removed in the new versions.

Difference between descending and ascending surface classes in AIRS products. Lower right shows NSIC snow and ice data with the vertical color bar same as previous figures.

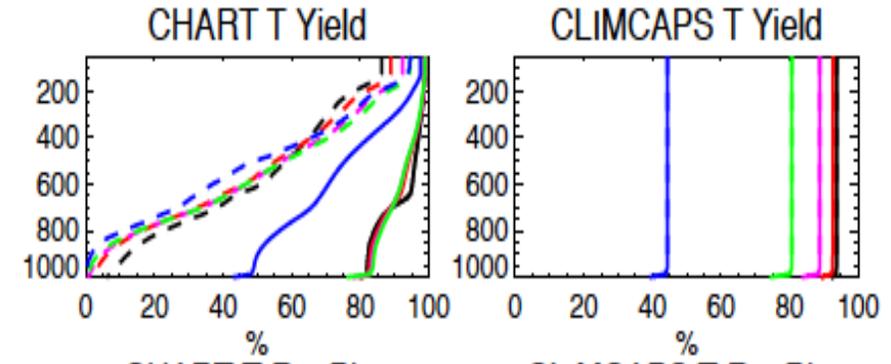
AIRS and CrIMS Temperature Profile Retrieval Yield

01/2015

Over Ocean:

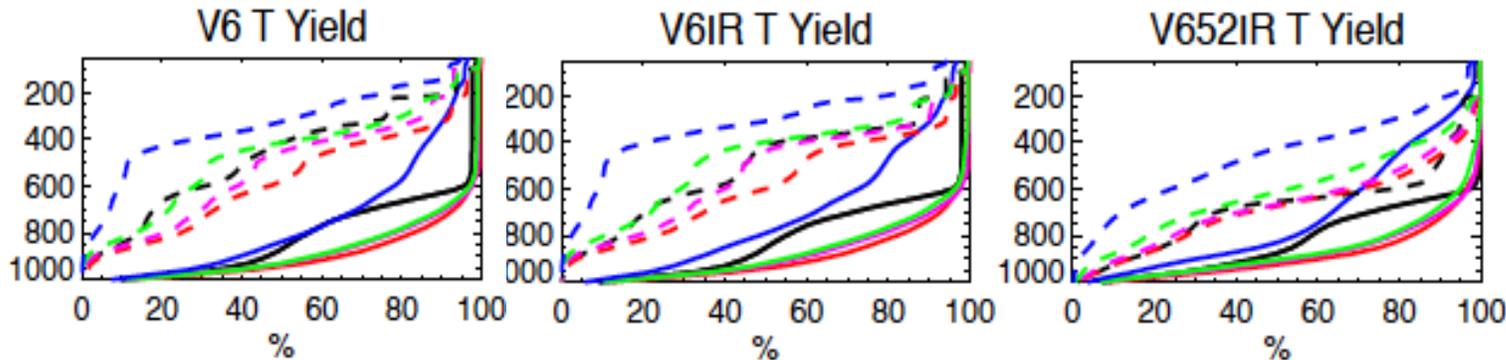


Over Ocean:

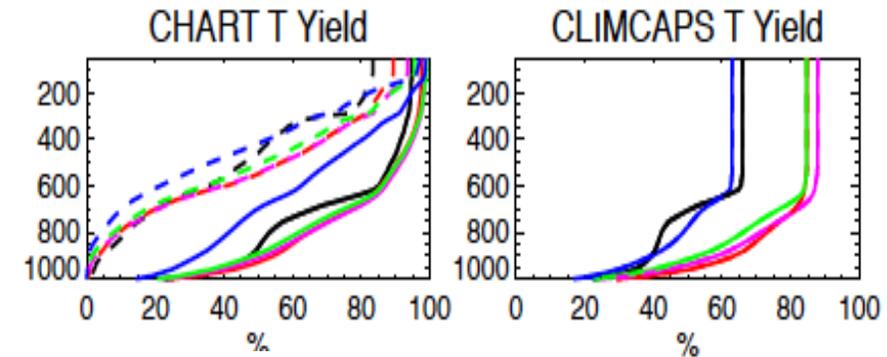


Grouped based on CHARTS cloud

Over Land:



Over Land:

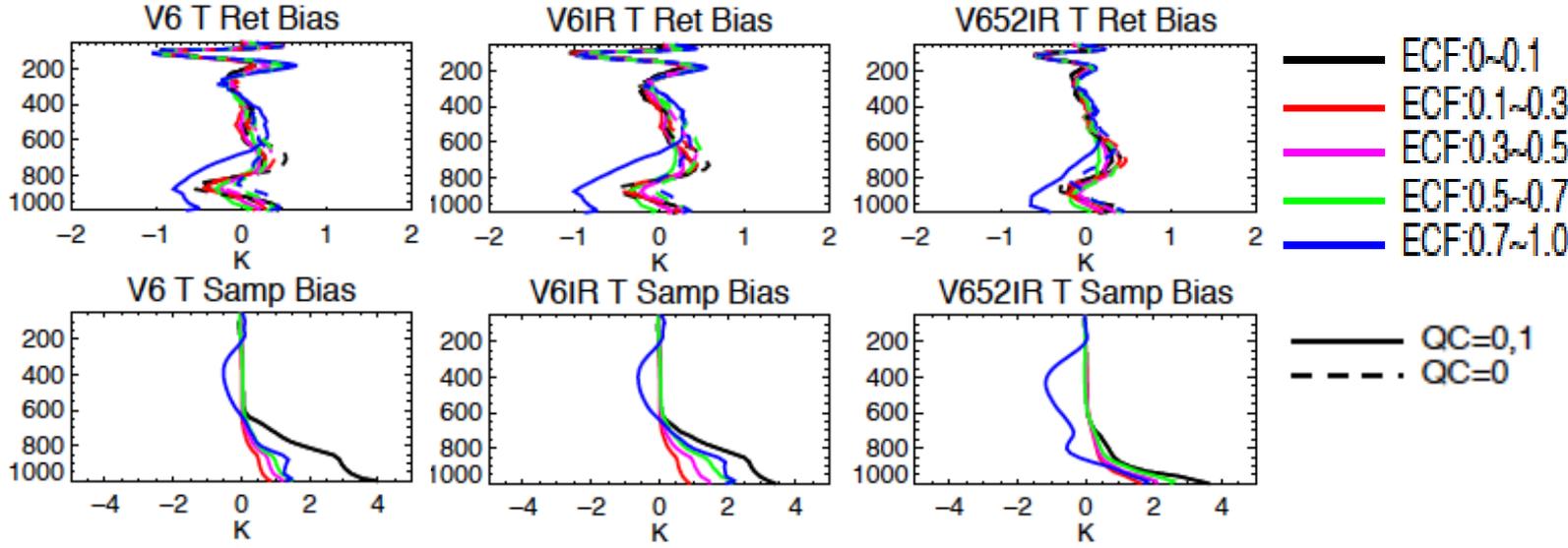


- Increase V7IR QC over high lat frozen surface land than IR+MW
- Decreased V7IR QC over ocean
- Different QC in CHARTS and CLIMCAPS

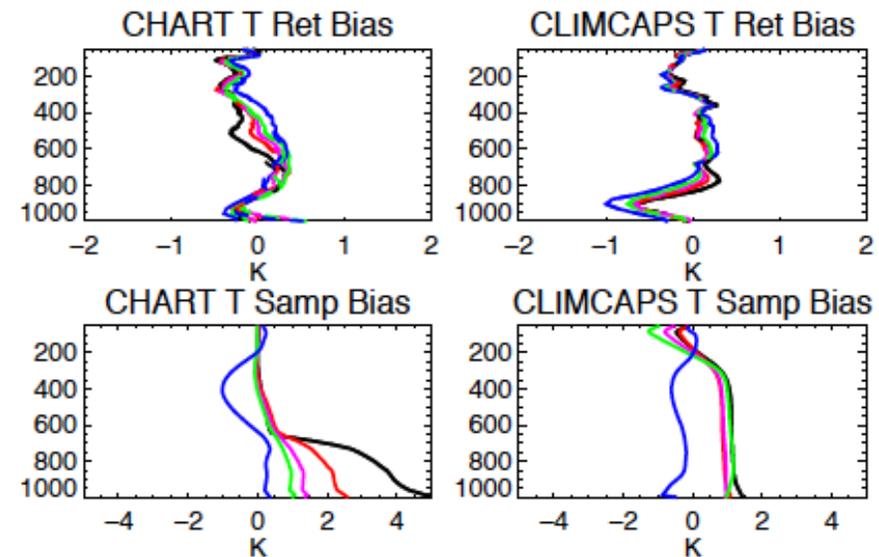


AIRS and CrIMS Temperature Profile Retrieval: Differences with ECMWF

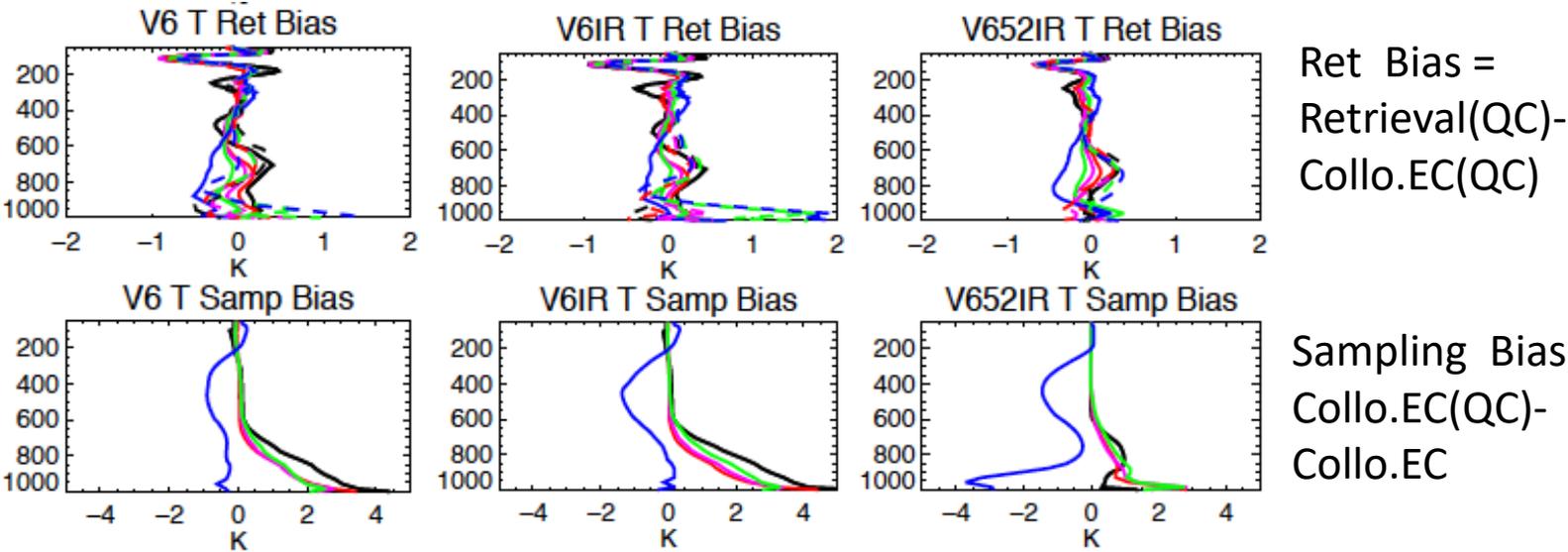
Over Ocean:



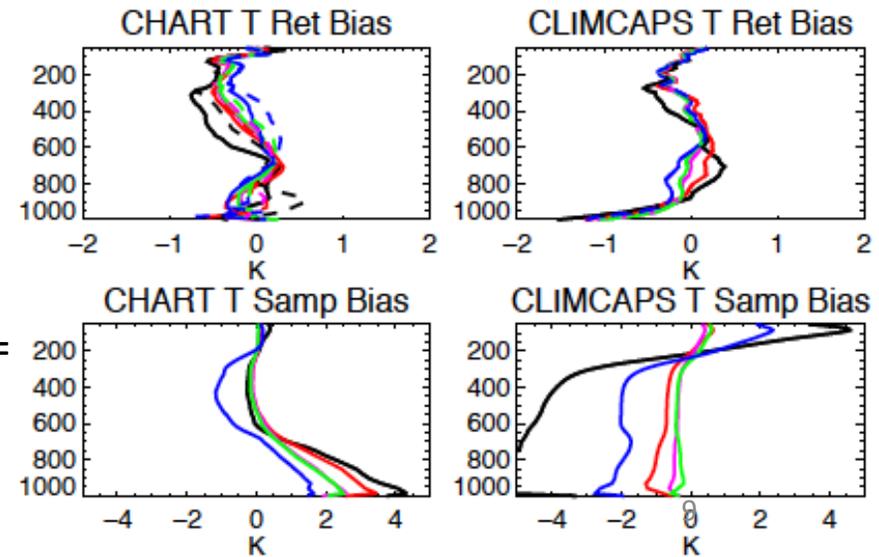
Over Ocean:



Over Land: V652IR: Smaller ret bias; larger sampling bias for overcast

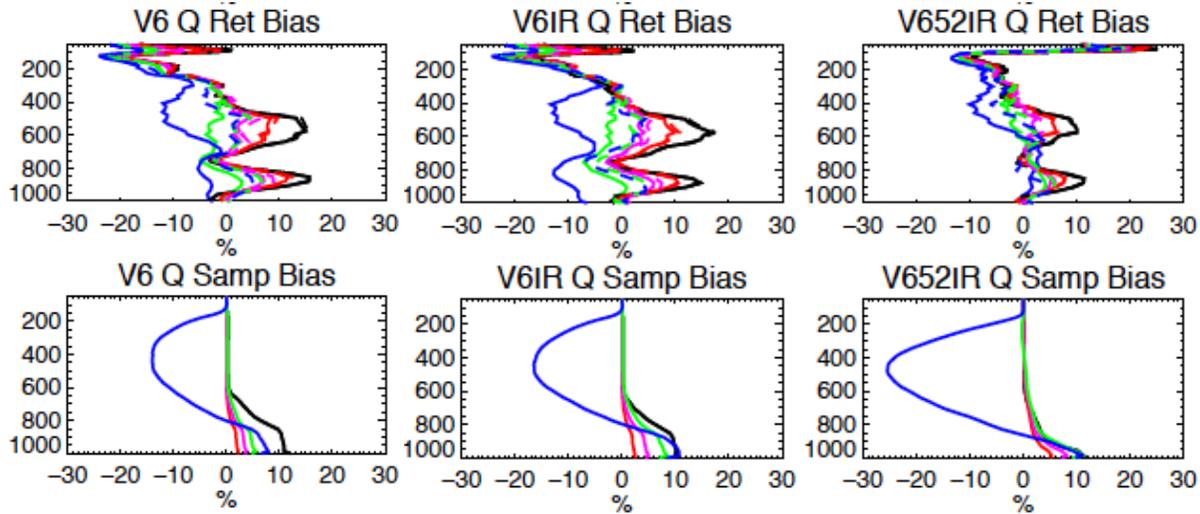


Over Land:

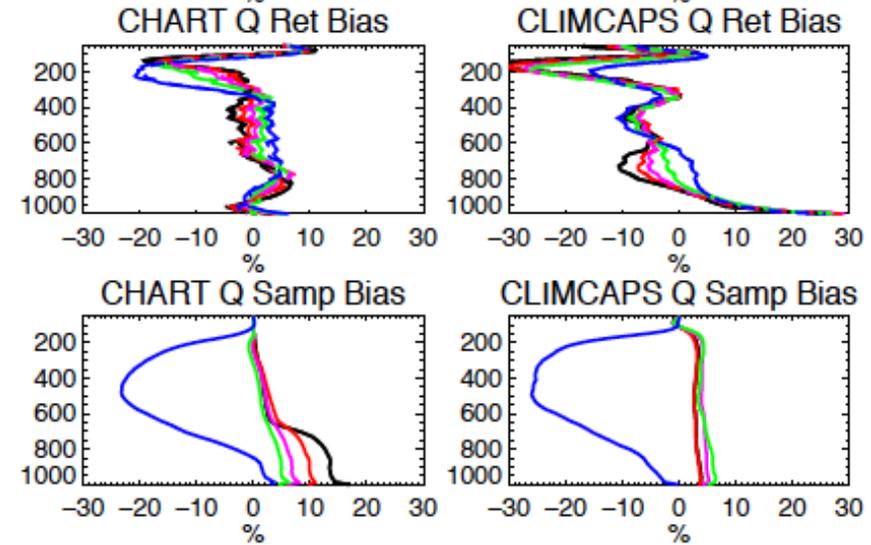


AIRS and CrIMS Humidity Profile Retrieval: Differences with ECMWF

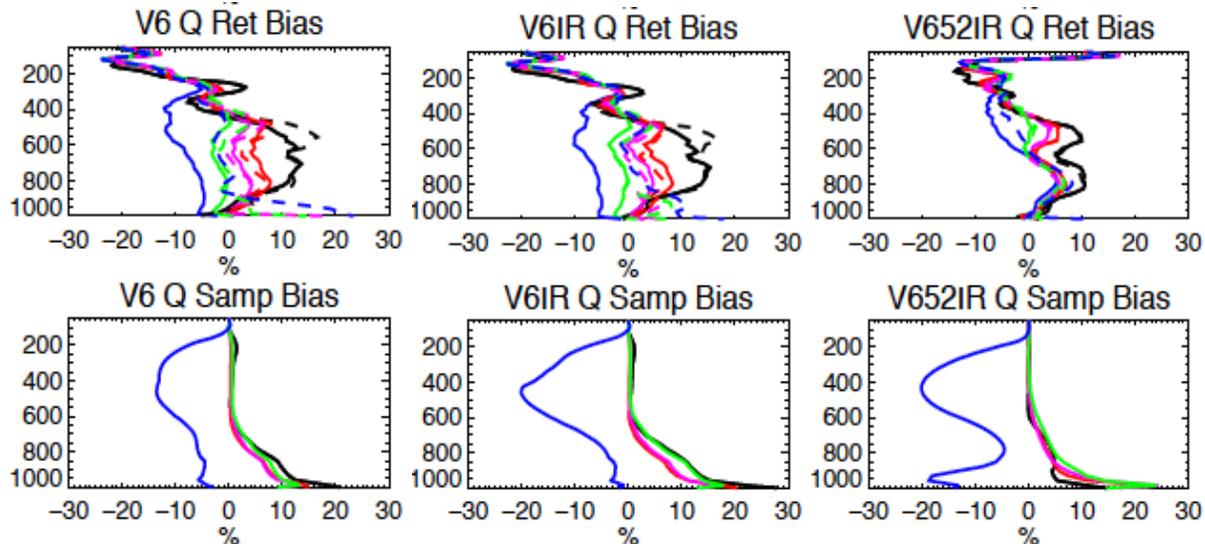
Over Ocean:



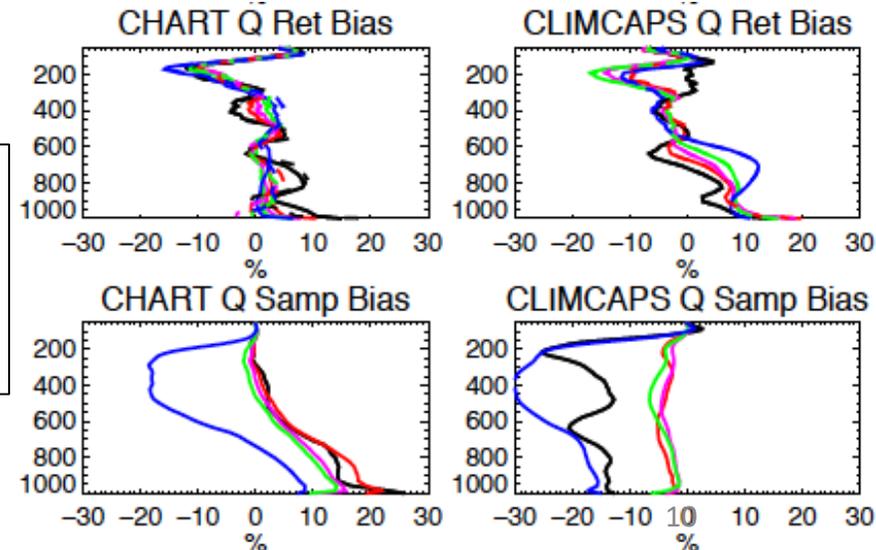
Over Ocean:



Over Land: V652IR: Smaller ret bias; larger sampling bias for overcast

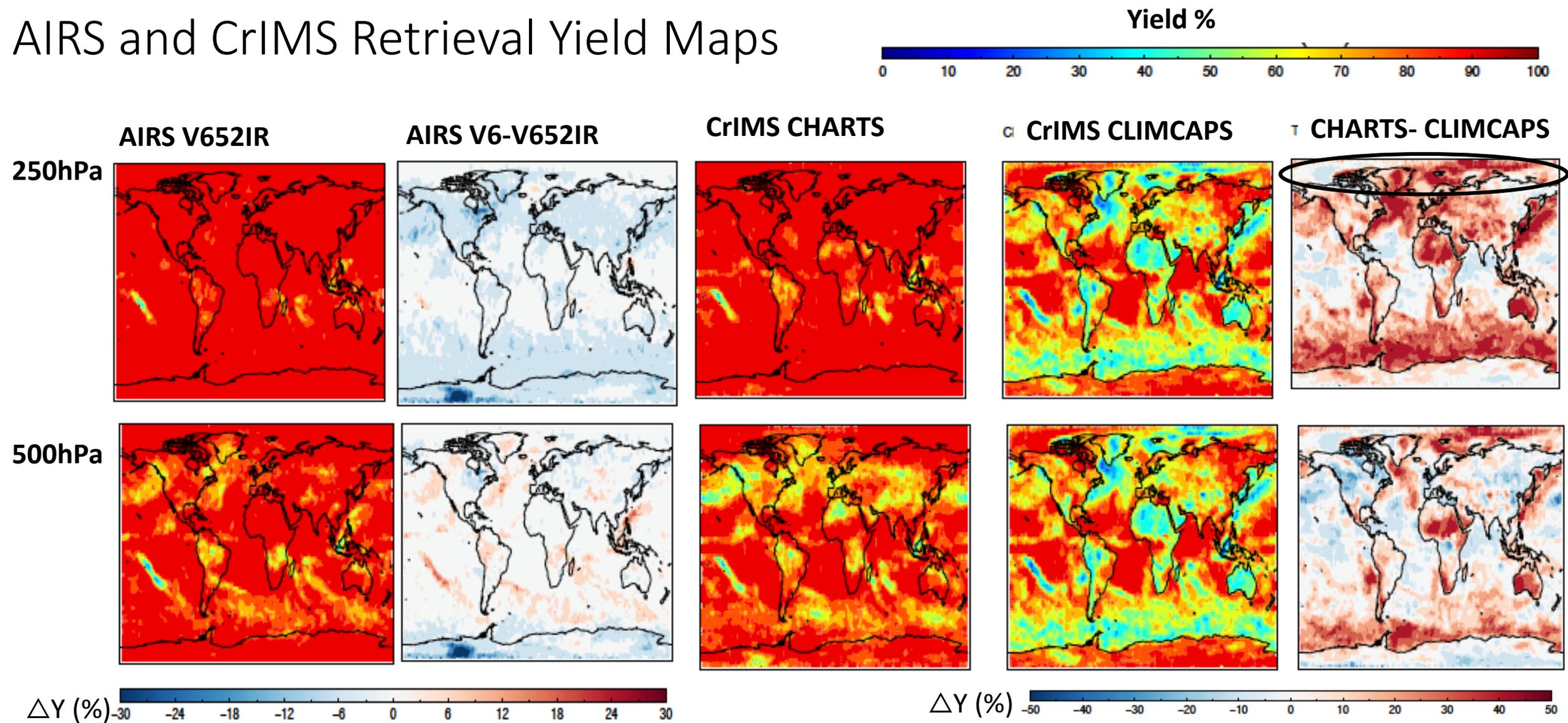


Over Land:



- Global mean point of view
- Spatial distributions

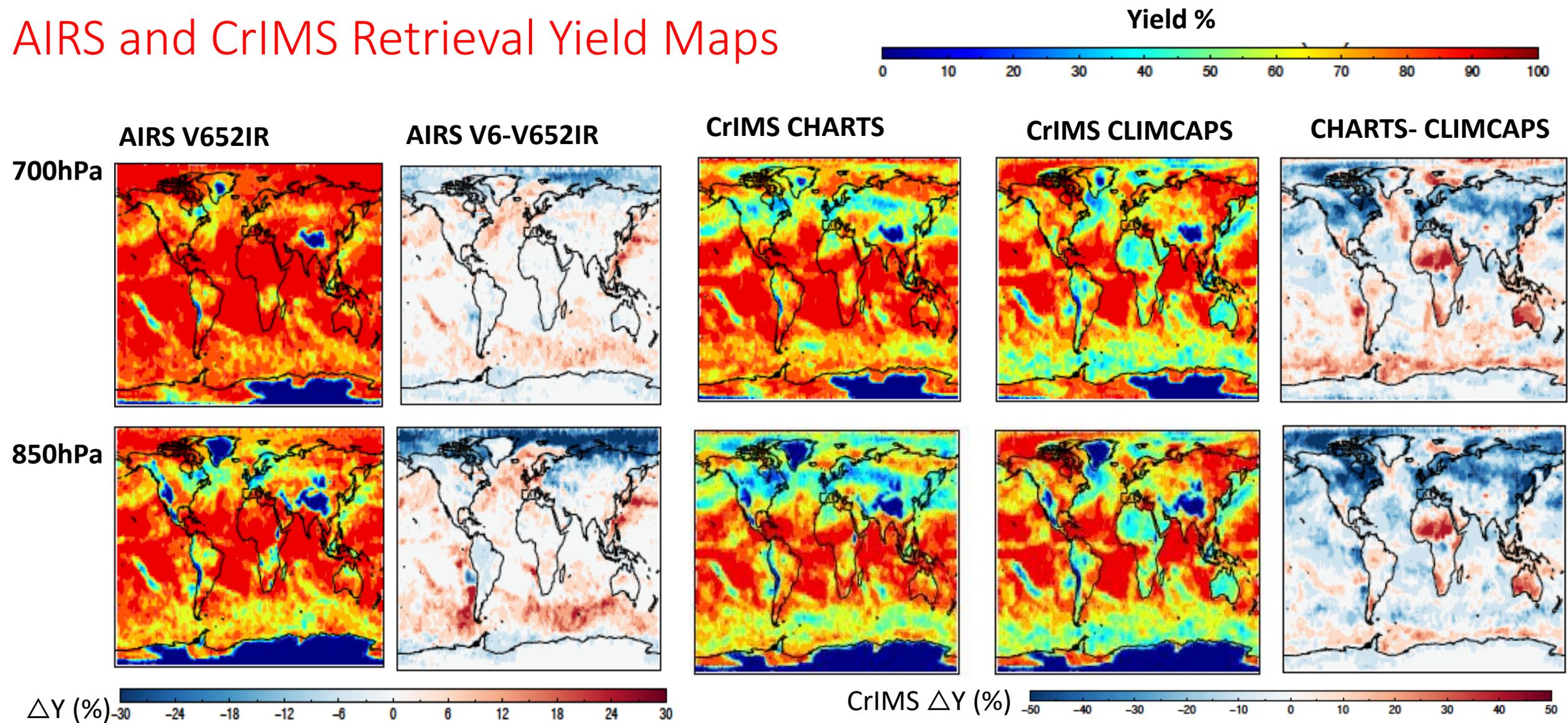
AIRS and CrIMS Retrieval Yield Maps



AIRS: V652IR higher 250hPa yield; lower yield in very cloudy region over ocean; higher yield over polar regions.

CrIMS: CHARTS higher yield at 250hPa except over tropical ocean and polar; CHARTS lower yield at 500 hPa over land except deserts (seems to relate to surface class).

AIRS and CrIMS Retrieval Yield Maps

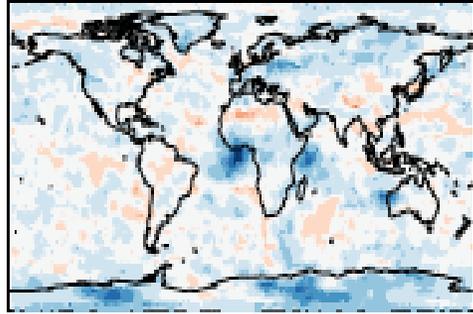


AIRS: V652 higher yield in polar region \rightarrow larger retrieval bias; lower yield over ocean

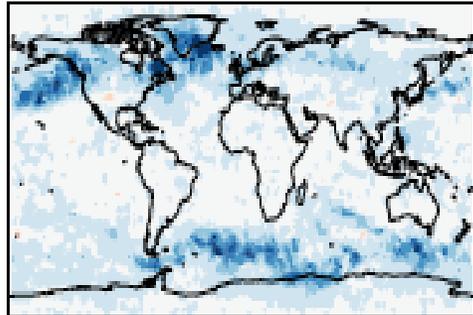
CrIMS: CHARTS higher yield in S. Ocean and desert, but lower yield over mid-high lat land

AIRS and CrIMS 500 hPa Bias With Collocated ECMWF: T

AIRS V6.52IR

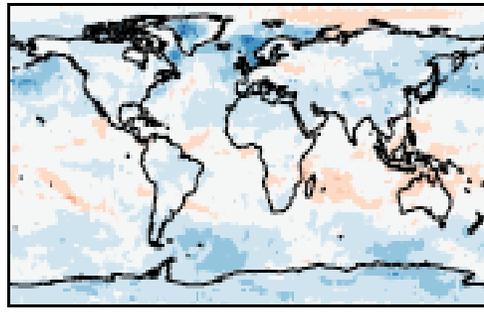


V652IR T Sampling Bias

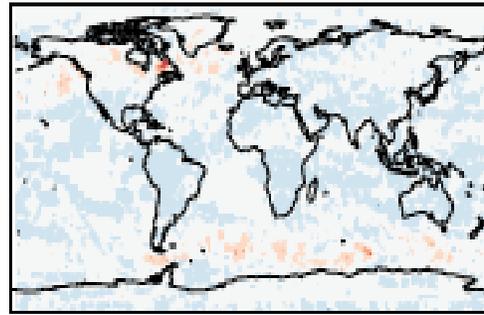


V652IR: Smaller warm ret bias in cloudy region;
 smaller cold ret bias in high lat region
 Cold sampling bias from storm track regions

T AIRS V6-V6.52IR



T Sampling: V6-V652IR



Ret Bias =
 Retrieval(QC)-
 Collo.EC(QC)

Sampling Bias =
 Collo.EC(QC)-
 Collo.EC

CrIMS CHARTS

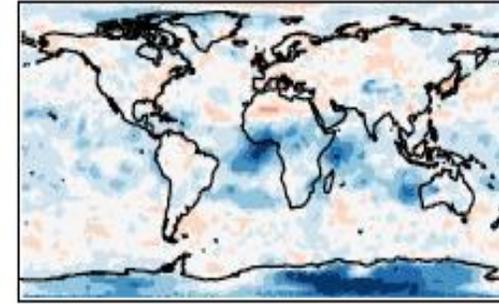
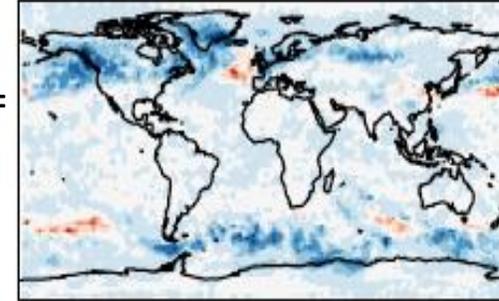
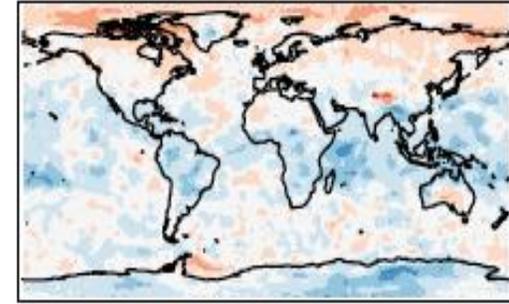


CHART T Sampling bias



CLIMCAPS

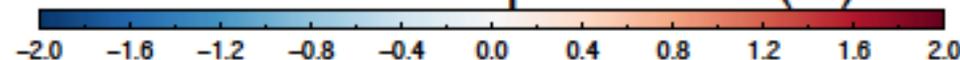


CLIMCAPS T Sampling Bias

CLIMCAPS produces warmer pole temperature than
 CHARTS

Differences between reanalyses? NN trained using
 ECMWF ---MERRA as initial guess

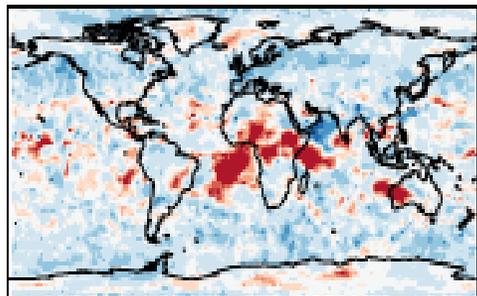
500hPa Temperature (K)



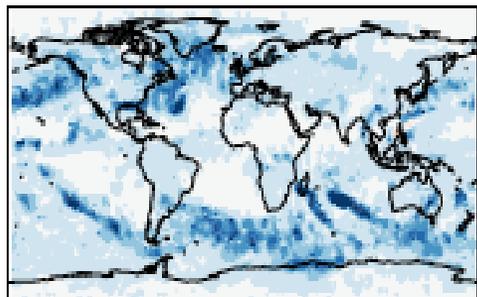
AIRS and CrIMS 500 hPa Bias With Collocated ECMWF: SH

AIRS V6.52IR

V652IR Q Ret Bias

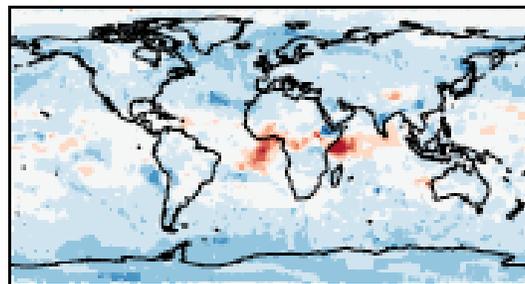


V652IR Q Sampling Bias

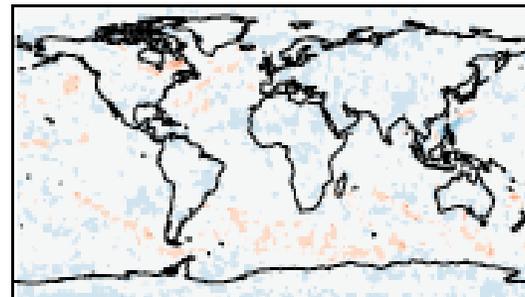


AIRS V6-V6.52IR

Q Ret: V6-V652IR



Q Sampling: V6-V652IR



CrIMS CHARTS

CHART Q Ret Bias

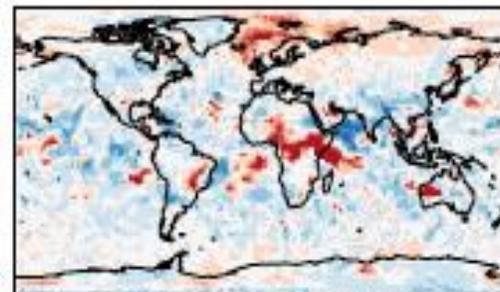
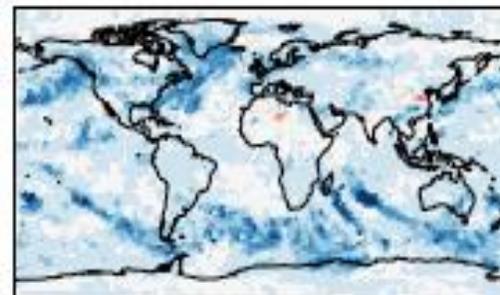
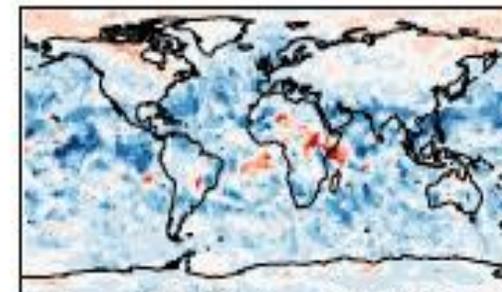


CHART Q Sampling Bias

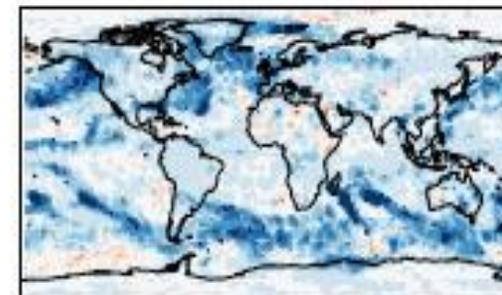


CLIMCAPS

CLIMCAPS Q Ret Bias



CLIMCAPS Q Sampling Bias

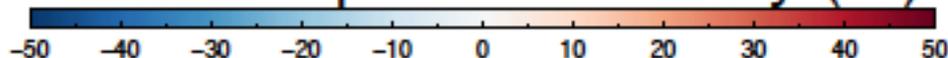


V652IR: smaller dry bias overall except in the wet bias region, where a smaller wet ret bias is seen

CLIMCAPS produces dryer atmosphere except over arctic than ECMWF.

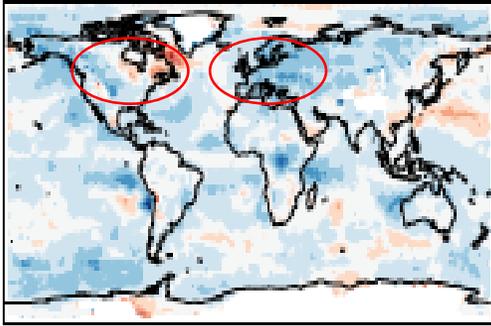
Differences between reanalyses? NN trained using ECMWF ---MERRA as initial guess

500hPa Specific Humidity (%)

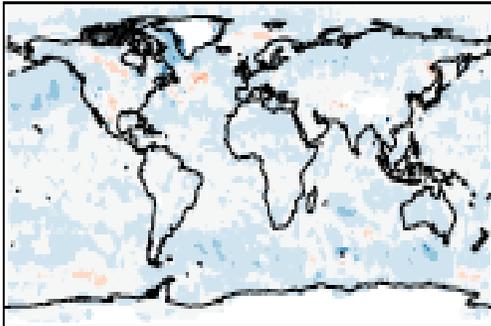


AIRS and CrIMS 850 hPa Bias With Collocated ECMWF: T

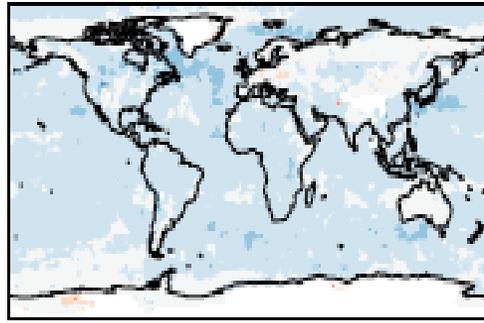
AIRS V6.52IR



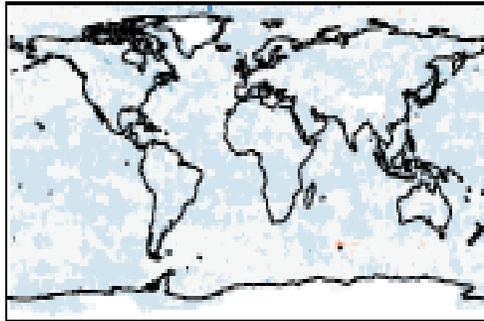
V652IR T Sampling Bias



T AIRS V6-V6.52IR



T Sampling: V6-V652IR



V652IR: cold bias in PBL over Europe in cold season
Pattern over N. America in all versions

CrIMS CHARTS

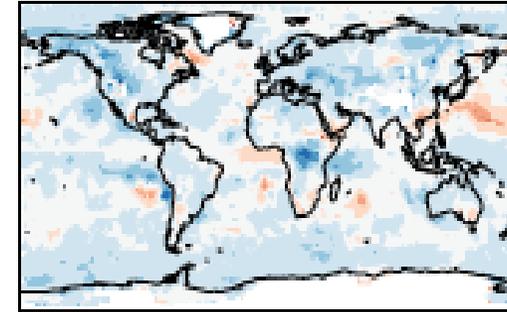
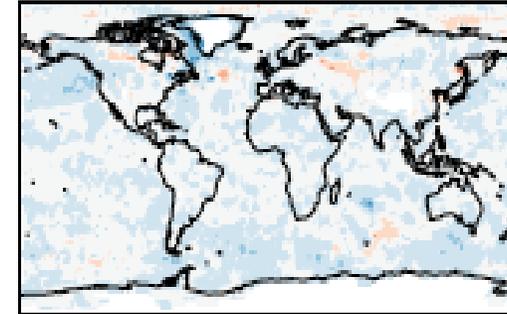
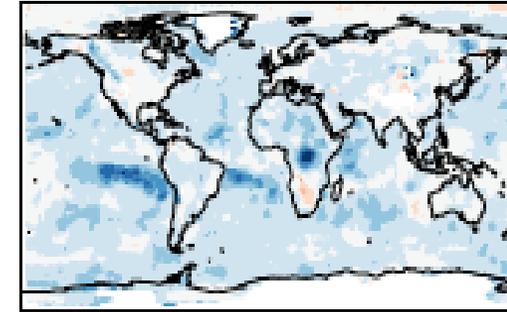


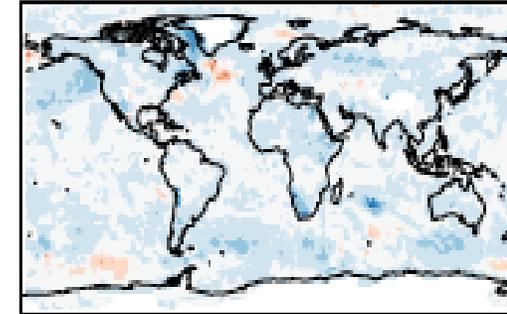
CHART T Sampling bias



CLIMCAPS



CLIMCAPS T Sampling Bias

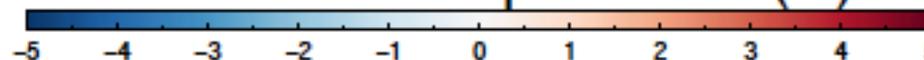


Ret Bias =
Retrieval(QC)-
Collo.EC(QC)

Sampling Bias =
Collo.EC(QC)-
Collo.EC

CLIMCAPS colder than ECMWF everywhere.
Differences between reanalyses?

850 hPa Temperature (K)



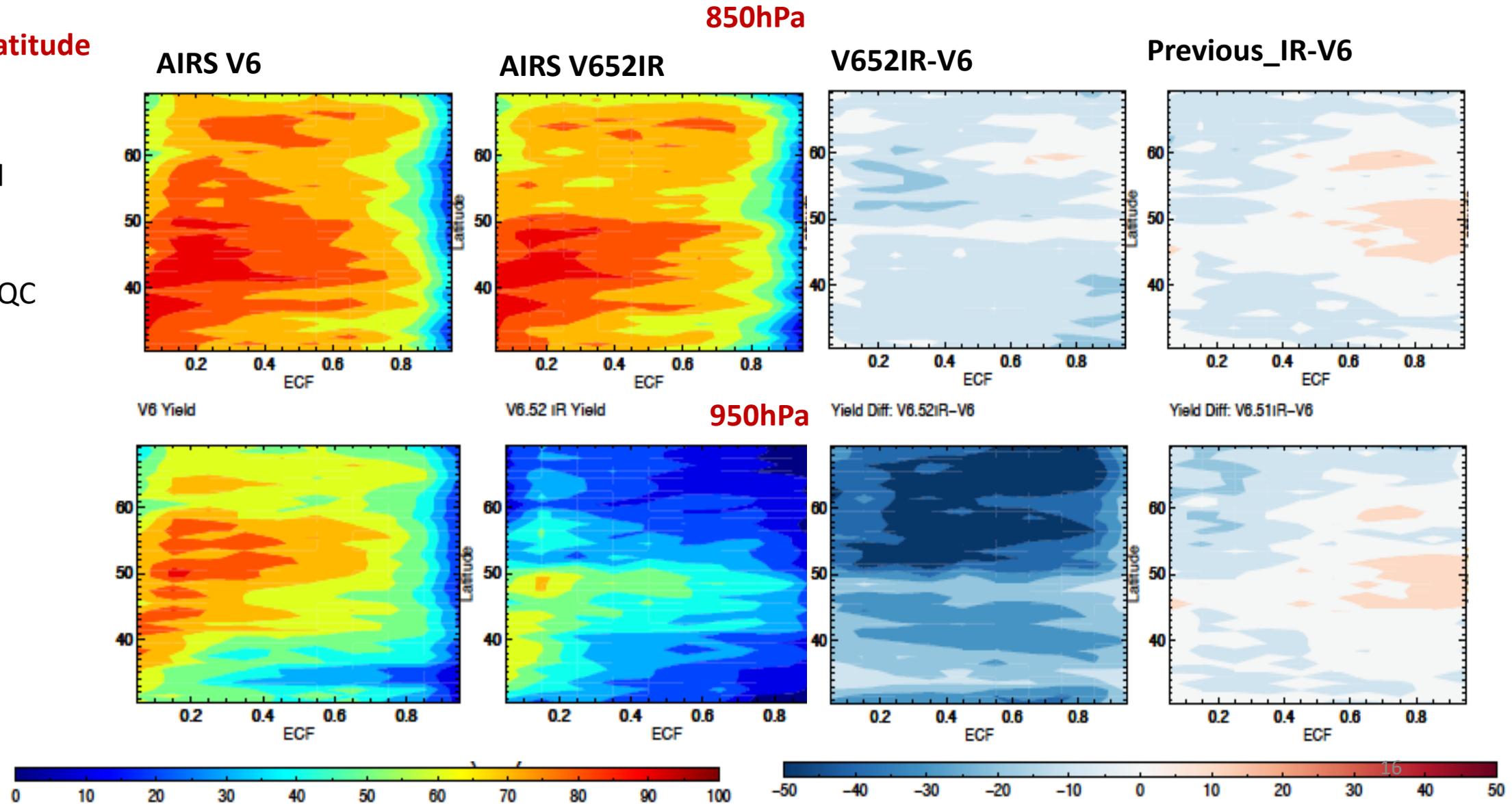
Now Take a Closer Look on AIRS: Over Ocean Improvements Even in the DC.

MAGIC comparison shows within PBL new IR-only comparable with V6IR+MW

Challenge is PBL over mid-high lat land in cold season, especially for IR-only

Europe: ECF-Latitude

- Improving SCCNN and physical retrieval
- Improving QC



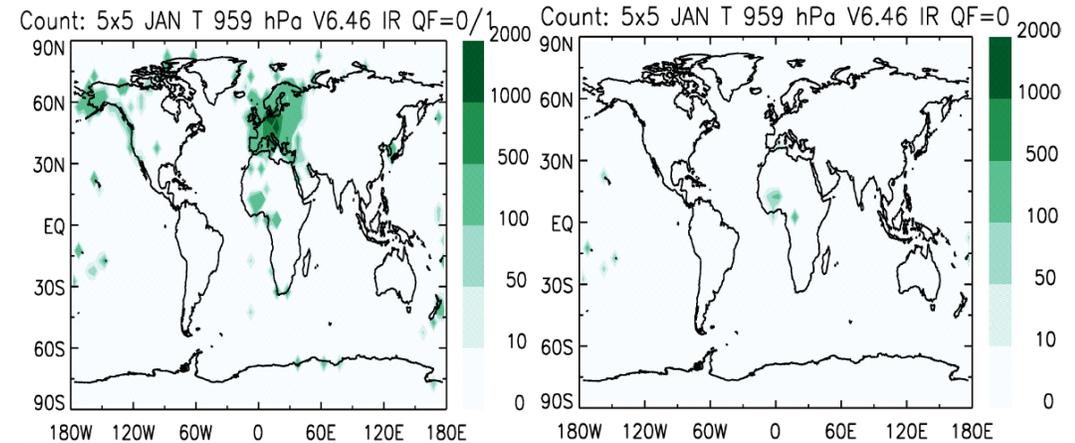
Europe 01/2015 Temperature Retrieval and NN Diff. With ECMWF

1. 500hPa, final retrieval improved upon NN over all ECF, new IR-only better than old (IR+MW) (not shown).
2. 700hPa, final retrieval improved upon NN when $ECF < 0.7$
3. Within PBL: final retrieval improved upon NN when $ECF < 0.3$ with a regional dependence. Overall larger cold bias.
4. Sun Wong: cloud, surface temperature

Sample Counts in Each 5°×5° Grid Cell at 959 hPa

V6.46 IR-Only QF = 0 or 1

Same as left but QF = 0

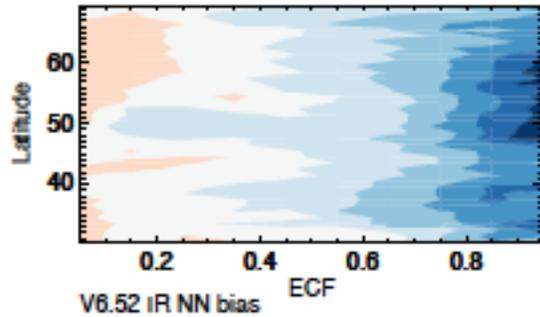
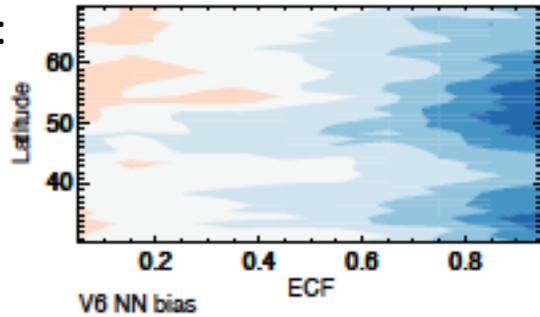


AIRS V6

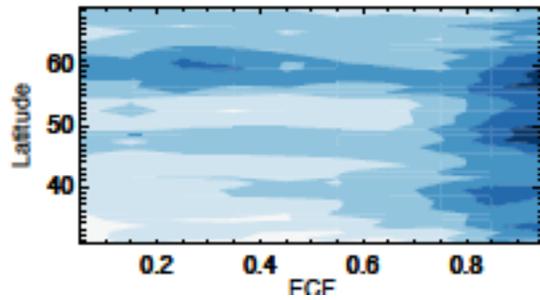
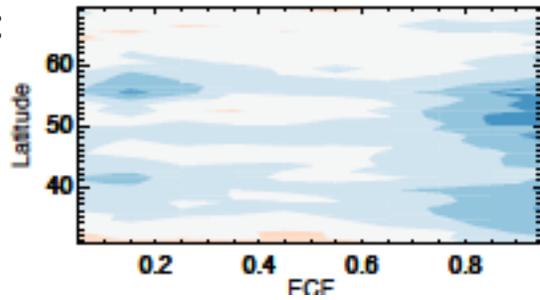
700 hPa

AIRS V6.52IR

Ret:



NN:

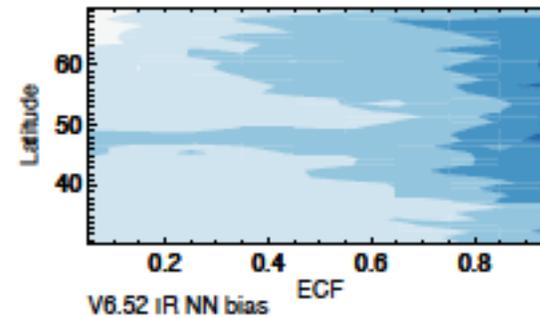
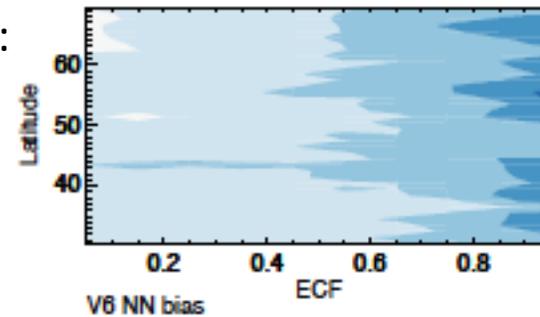


V6 Ret bias

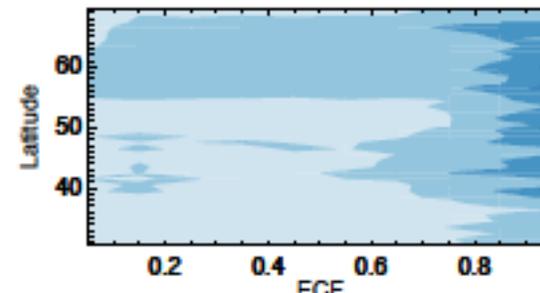
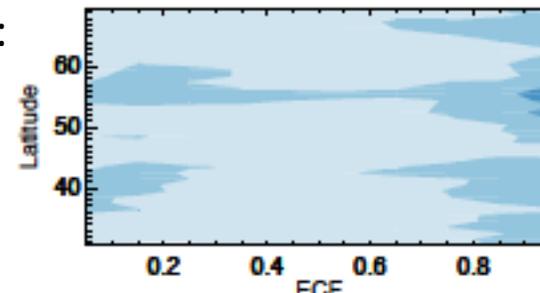
850hPa

V6.52 IR Ret bias

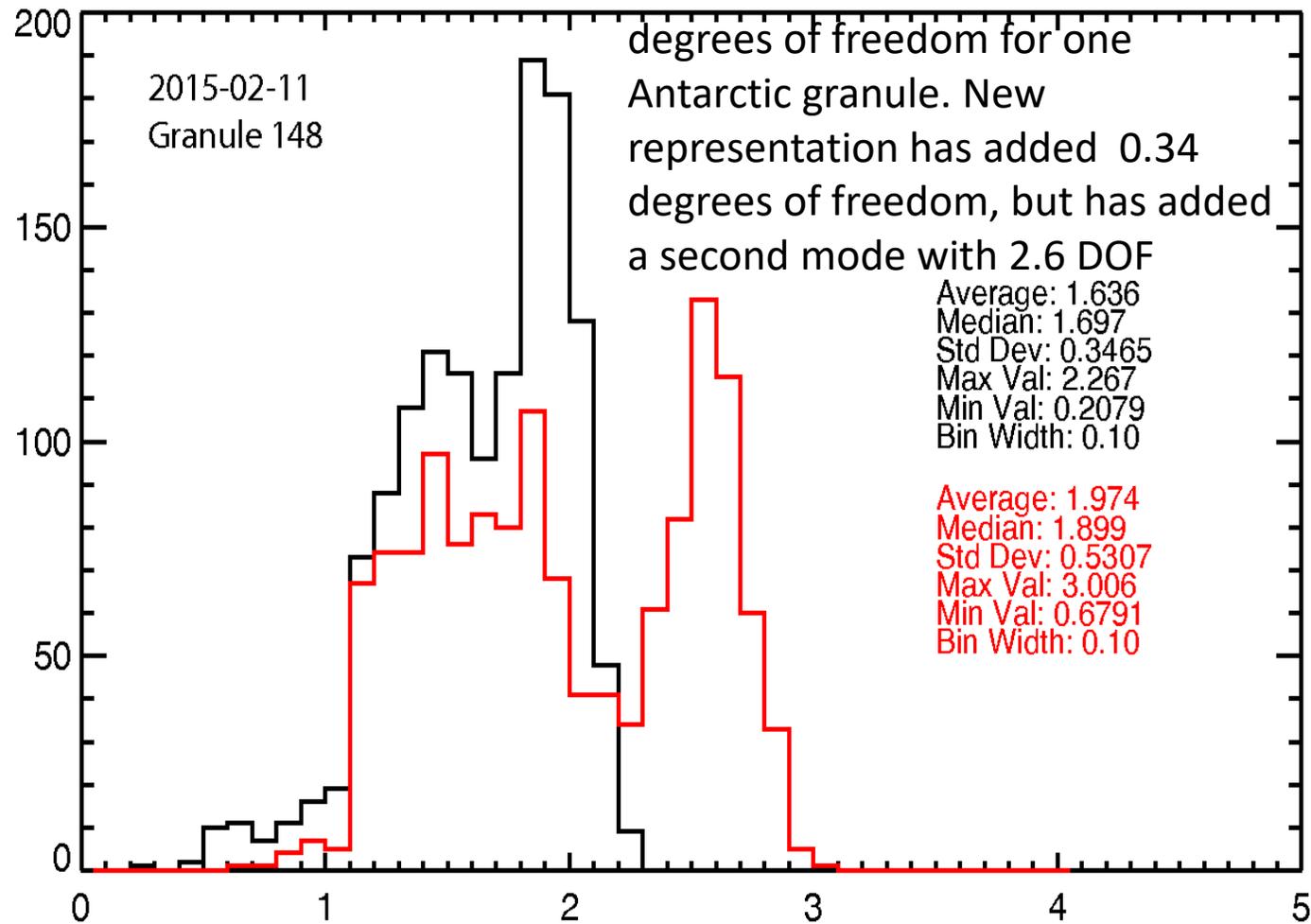
Ret:



NN:

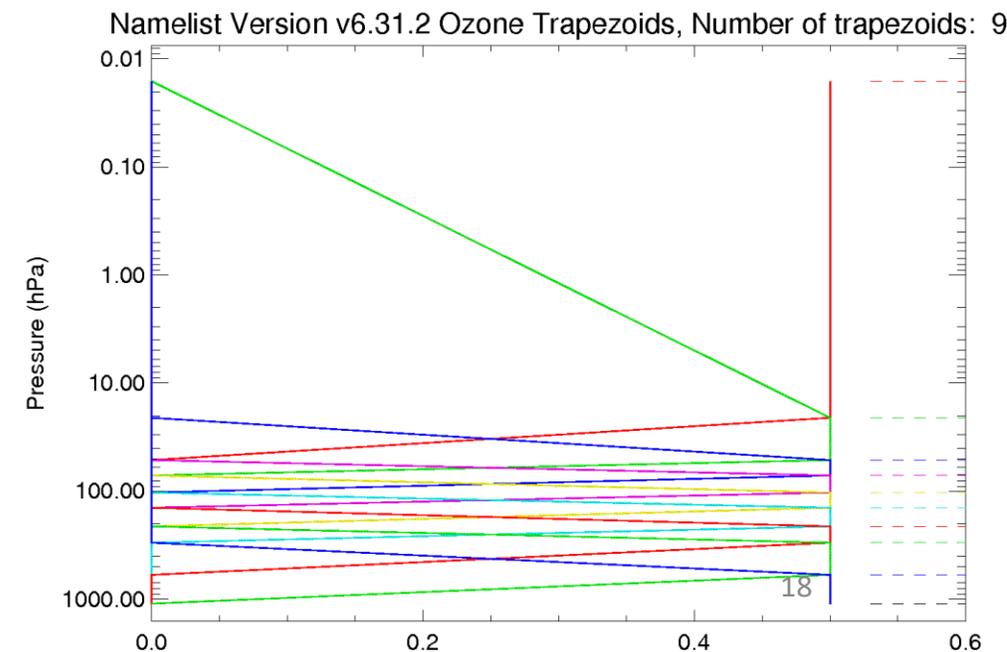
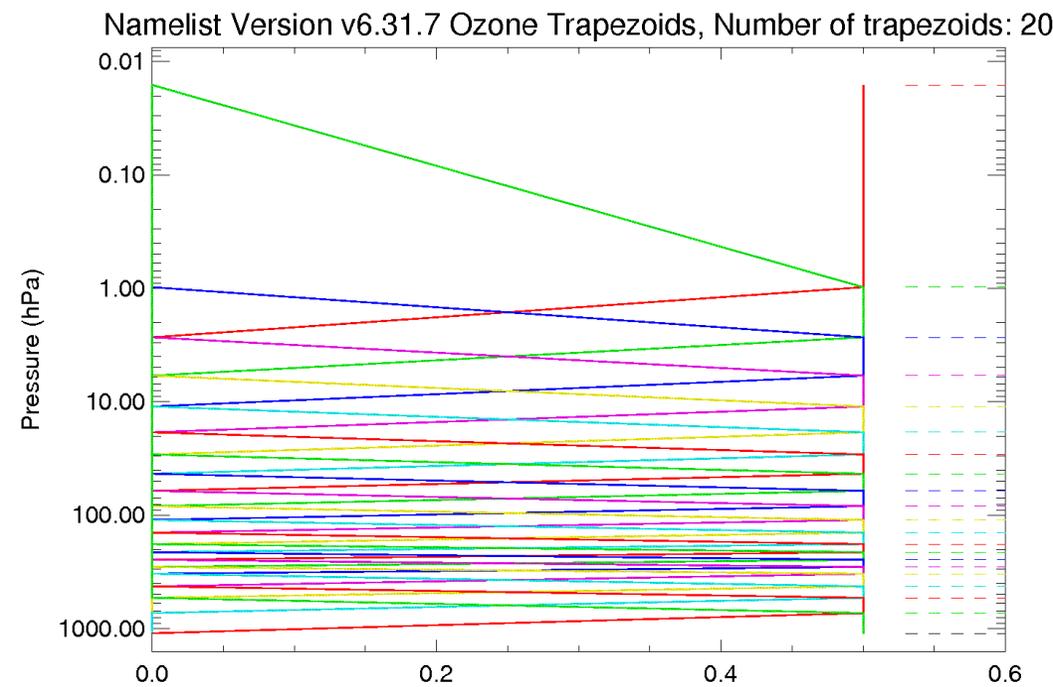


1. Improved ozone information content due to increased trapezoid, which improved ozone profiles in mid-stratosphere
2. Total ozone retrieval in the polar area does not stick with first guess, instead, it is a blend of first guess and AIRS sensitivity.



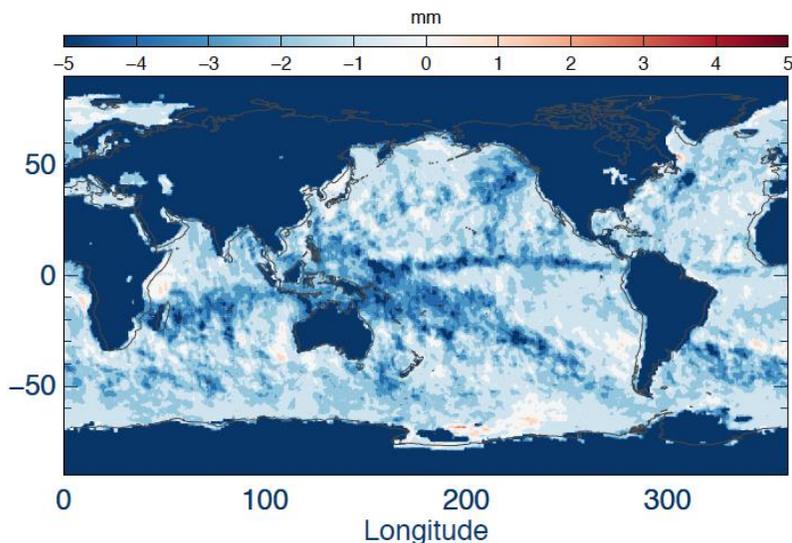
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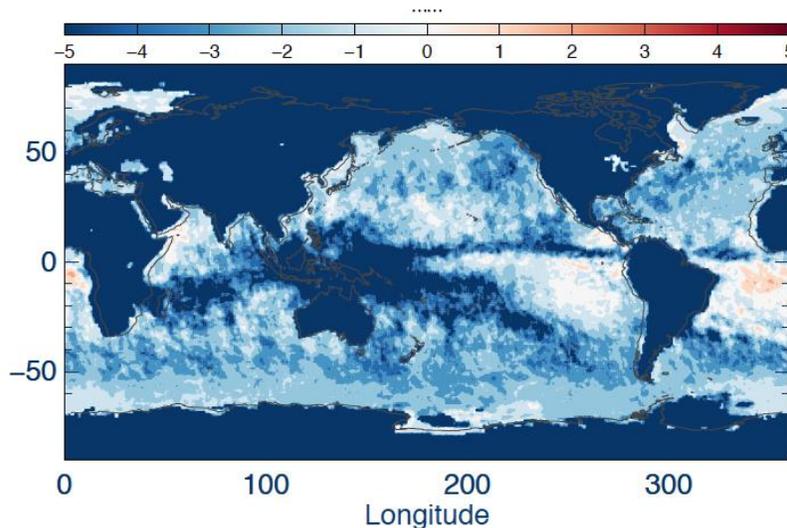


1. Day-night performance difference is gone.

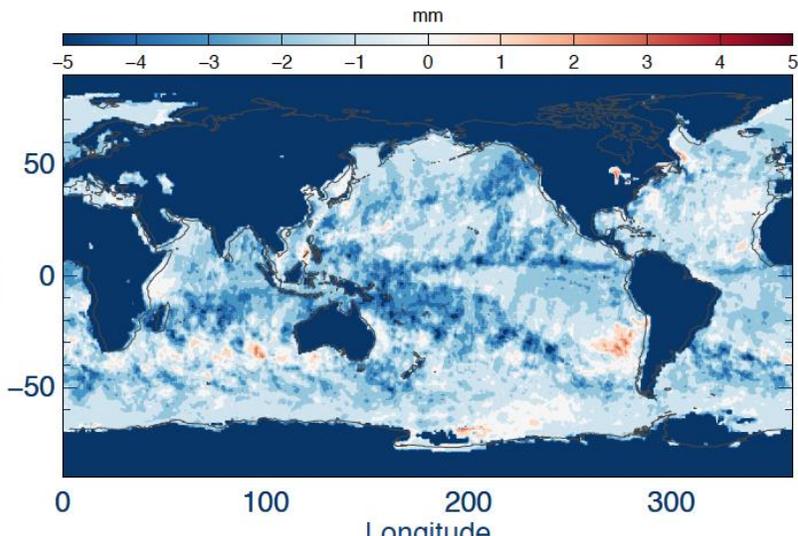
Asc: V6.46 IR+MW minus AMSR2



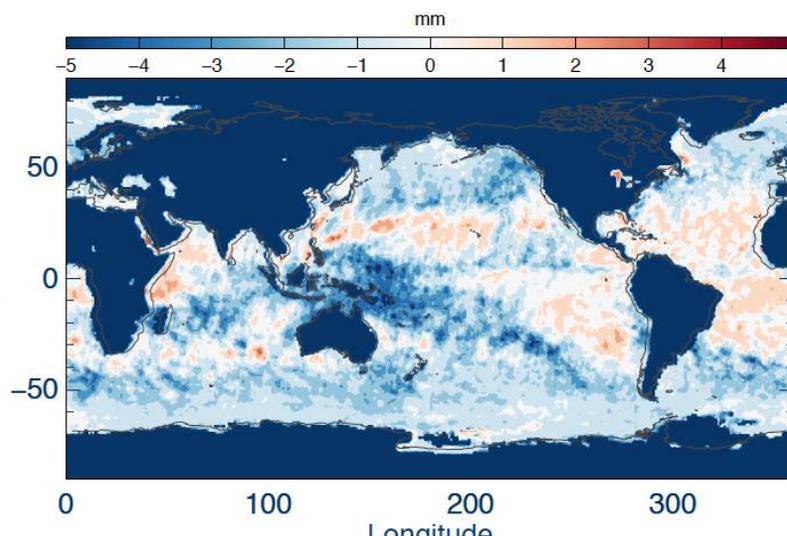
Asc: V6 IR+MW minus AMSR2



Dsc: V6.46 IR+MW minus AMSR2



Dsc: V6 IR+MW minus AMSR2



2015 January
TPW V6.46
IR+MW: dry bias
in deep convective
area improved,
nighttime wet bias
in the subtropical
low cloud region
decreases or
changes to small dry
bias.

Examples of new Reference Data on Temperature and Humidity in Different Climate Regimes

Testing retrievals in different climate regimes using the collocation and analysis tools already developed with reference data independent of reanalyses.

Campaign	Location	Time	Climate Regimes
HS3 (Hurricane and Severe Storm Sentinel)	Lat: 10 ~ 50 Lon: -160 ~ -19	Aug and Sep from 2011 to 2014	Midlat and Tropic ocean, severe storm
SHOUT (Sensing Hazards with Operational Unmanned Technology)	Lat: 10 ~ 50 Lon: -160 ~ -19	Aug-Sep, 2015 Feb, 2016 Aug-Oct, 2016	Midlat and Tropic ocean, severe storm
WISPAR (the Winter Storms and Pacific Atmospheric Rivers)	Lat: 0 ~ 90 Lon: -170 ~ -120	Feb-March, 2011	Atmospheric Rivers, Arctic environment
VOCALS (VAMOS Ocean-Cloud-Atmosphere-Land Study)	Lat: -30 ~ -15 Lon: -90 ~ -70	Oct-Nov, 2008	Southeastern Pacific low cloud region
SOCRATES (Southern Ocean Clouds Radiation Aerosol Transport Experimental Study)	Lat: -70 ~ -30 Lon: 130 ~ 180	Jan-Feb, 2018	Southern Ocean

Additional testing analyses:

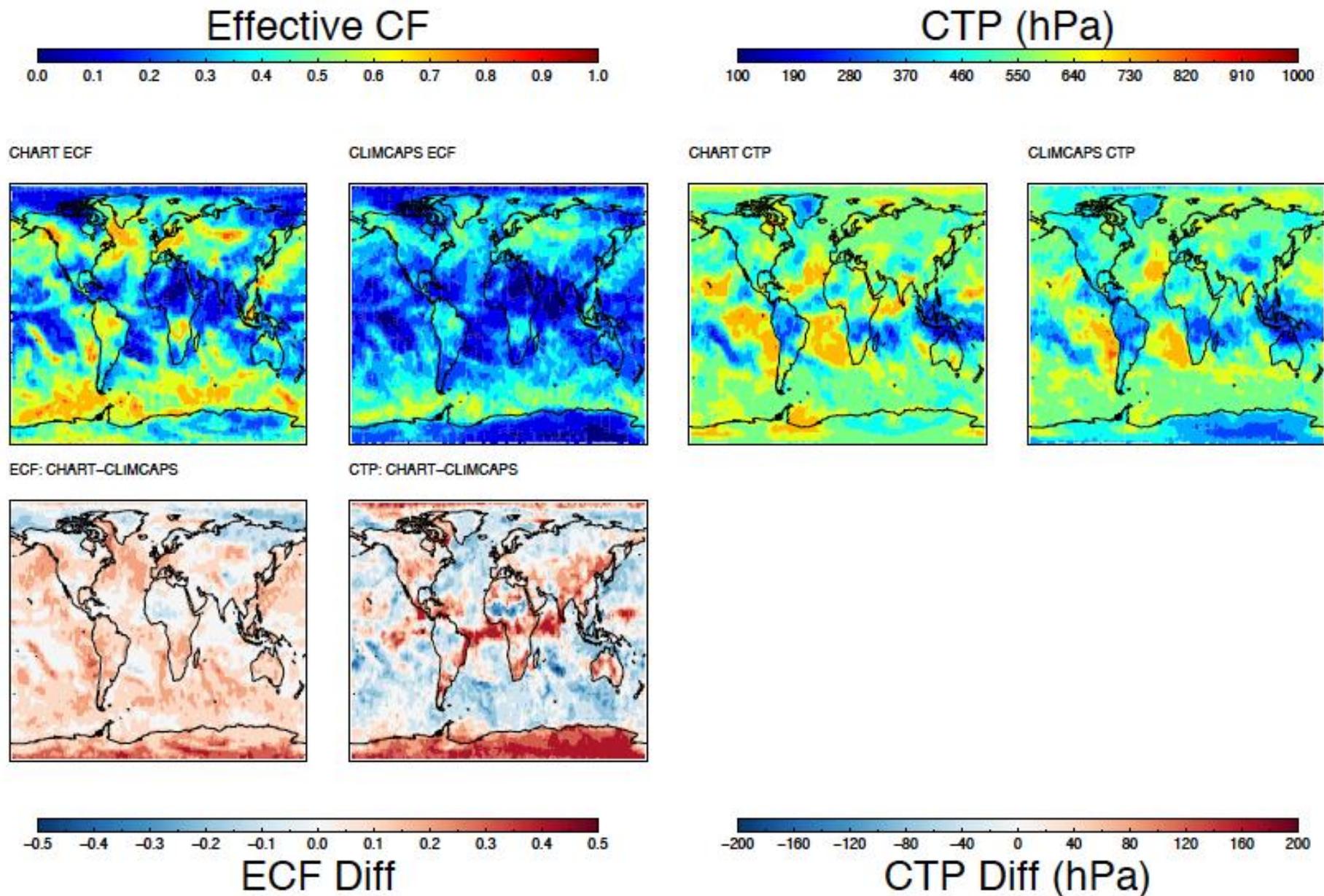
- Information content analysis: initial guess and spectral sensitivity; vertical resolution; ...
- Climate quality: continuity, anomaly time series, run test data runs for focus days throughout the AIRS and CrIMS mission?
- More trace gases: Vivienne et al.

AIRS V7 Goals

Met
Partially met or uncertain
Unmet

1. Goal zero: good general quality
2. Remove day-night performance difference
3. Better IR-only algorithm than V6IR-only: surface classes, SCCNN, channels,...
4. Better IR only products than V6 IR+MW
5. Better ozone
6. Improved stratosphere and polar
7. Unified retrieval algorithm for both AIRS and CrIS
8. Improved L1B (not included in L2 retrieval)
9. Improved file format: NetCDF4
10. Better PBL over land (cold season): IR+MW, IR-only ->temporal and regional
11. More accurate characterization of errors within our v6 formalism:
 - a. More accurate error estimates
 - b. Better flagging of bad cases with Q0, Q1, Q2

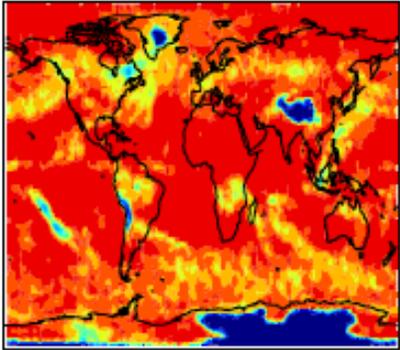
CHARTS and CLIMCAPS Cloud Difference



AIRS and CrIMS 700 hPa Temperature Retrieval Yield, Retrieval Bias, and Sampling Bias Against Collocated ECMWF

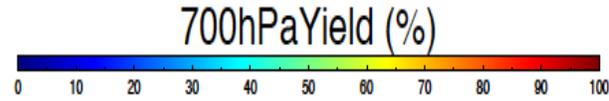
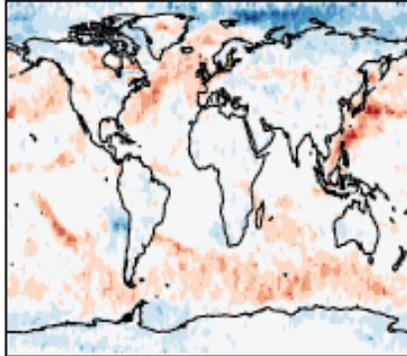
AIRS V652 IR

V652IR T Yield



AIRS V6-V6.52IR

T Yield Diff: V6-V652IR



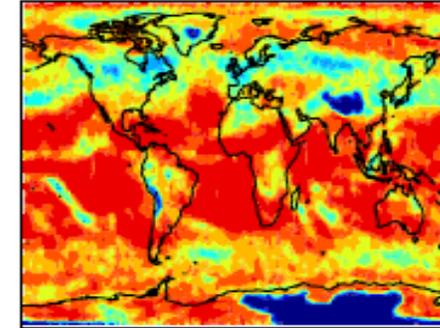
700hPaYield Diff (%)

V652IR: smaller yield in very cloudy; larger high lat yield

CHARTS different from AIRS

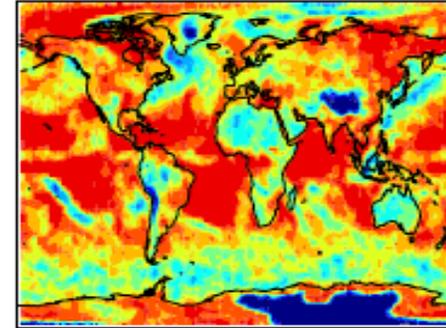
CrIMS CHARTS

CHART T Yield



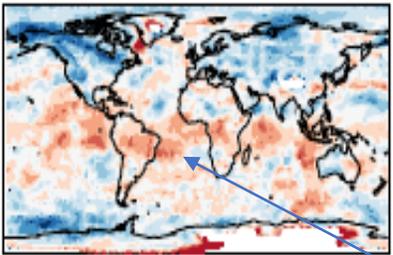
CrIMS CLIMCAPS

CLIMCAPS T Yield



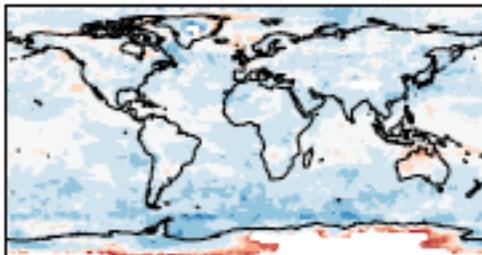
AIRS V652IR

V652IR T Ret Bias

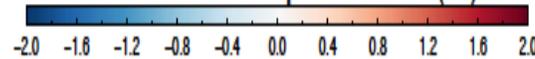


AIRS V6-V6.52IR

T Ret: V6-V652IR



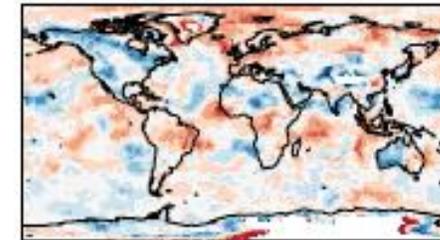
700hPa Temperature (K)



V652IR: cold bias over mid-high lat land

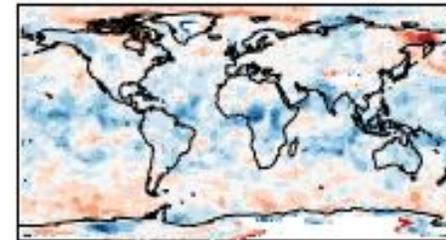
CrIMS CHARTS

CHART T Ret Bias

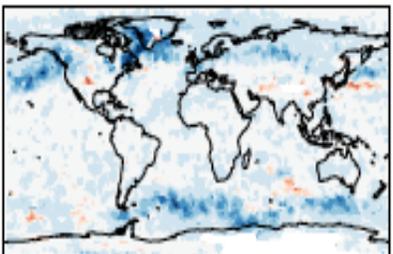


CrIMS CLIMCAPS

CLIMCAPS T Ret Bias



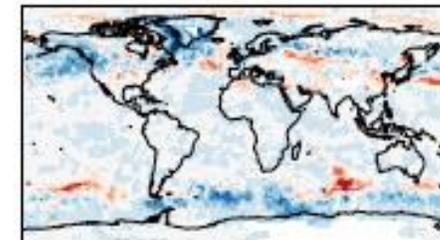
V652IR T Sampling Bias



Possibly Related to ECMWF PBL height too low issue

CLIMCAPS produces colder 700hPa T than CHARTS except in N. Am. and Sahara, s. ocean. Discontinuity lines?

CHART T Sampling bias



CLIMCAPS T Sampling Bias

