Comparison of the Optimal Cloud Analysis Product (OCA) and the GOES-R ABI Cloud Height Algorithm (ACHA) Cloud Top Pressures for AMVs

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Motivation

- AMV generation is increasingly reliant on cloud top pressure (CTP) generated from separate cloud retrieval algorithms.
- Groups such as the International Cloud Working Group (ICWG) compare cloud products (pixel level) but don’t focus on the subset of pixels that are used as AMV tracers.
- Beyond product performance, the potential use of diagnostic parameters like the cloud pressure uncertainty are important to investigate for usage of cloud pressures by AMV algorithms.

Goals

- Develop an analysis to allow for a study of the impact of CTP performance for the AMV applications.
- Use ACHA (NOAA) and OCA (EUMETSAT) as the first products to test out analysis concepts.
- Extend this analysis to other pixel level cloud algorithms and link to the CTP analysis being done in the ICWG.

The Process

- Download October 2015 (hourly) Meteosat-10 OCA from the Eumetsat archive in GRIB2 format.
- Convert OCA GRIB2 files into HDF4.
- Run matching hourly ACHA analysis and read in OCA fields into auxiliary variables to create one level2 HDF4 file.
- Run hourly AMVs using the above level2 HDF4 file for cloud information, and the GOES-R tracking framework.
  - Run once for ACHA CTP.
  - Run once for OCA CTP.
- Conduct collocations with NASA CALIPSO/CALIOP Cloud Layer Product.

Cloud Variables Read from Level2 Files for AMV Production
ACHA AMVs

Cloud Analysis Algorithm	Variable
ACHA	Cloud Mask
ACHA	Cloud Top Pressure
ACHA	Cloud Height Quality Flags
ACHA	Cloud Top Temperature
ACHA	Cloud Top Height
ACHA	Cloud Phase
ACHA	Cloud Type
ACHA	Inversion Flag
ACHA	Cloud Top Pressure Error
ACHA	Cloud Top Temperature Error
ACHA	Cost

Cloud Variables Read from Level2 File for AMV Production

OCA AMVs

Cloud Analysis Algorithm	**Variable**
ACHA	Cloud Mask
OCA	**Cloud Top Pressure – Layer 1**
ACHA	Cloud Height Quality Flags
ACHA	Cloud Top Temperature
ACHA	Cloud Top Height
OCA	**Cloud Phase**
ACHA	Cloud Type
ACHA	Inversion Flag
OCA	**Cloud Top Pressure Error – Layer 1**
ACHA	Cloud Top Temperature Error
OCA	**Cost**

DIRECT COMPARISONS OF ACHA & OCA AT THE PIXEL LEVEL

Review of OCA and ACHA

Similarities:

1. Optimal Estimation Algorithms.
2. Use fast radiative transfer models fed with copious amounts of NWP ancillary data.
3. Treat multi-layer clouds.
4. Generate a cost values that can indicate failures of the retrievals.

Differences:

OCA

- Input = [0.6, 0.8, 1.6, 3.9, 6.2, 7.3, 8.7, 9.7, 10.8, 12, 13.4 μm] + cloud mask
- O.E. Output = [COT, CTP, CRE, Phase, COT*,CTP*]
- CTP uncertainty generated directly from O.E. matrices
- Includes a solar component so that COT and CRE not limited by the IR sensitivity.

ACHA

- Input = [6.2, 10.8, 13.4 μm]** + cloud mask + cloud phase + multi-layer flag.
- O. E. Output = [CTT, CEMS, β, CTT*]
- Derived Output = [CTP, CTH, COT, CRE, CTP*, CTH*]
- COT and CRE are derived solely for IR obs. so COT saturates above 4.
- CTP uncertainty generated from O.E. CTT errors and factors based on lapse rates.
- ACHA feeds into DCOMP - a solar reflectance O.E. algorithm for daytime COT and CRE.

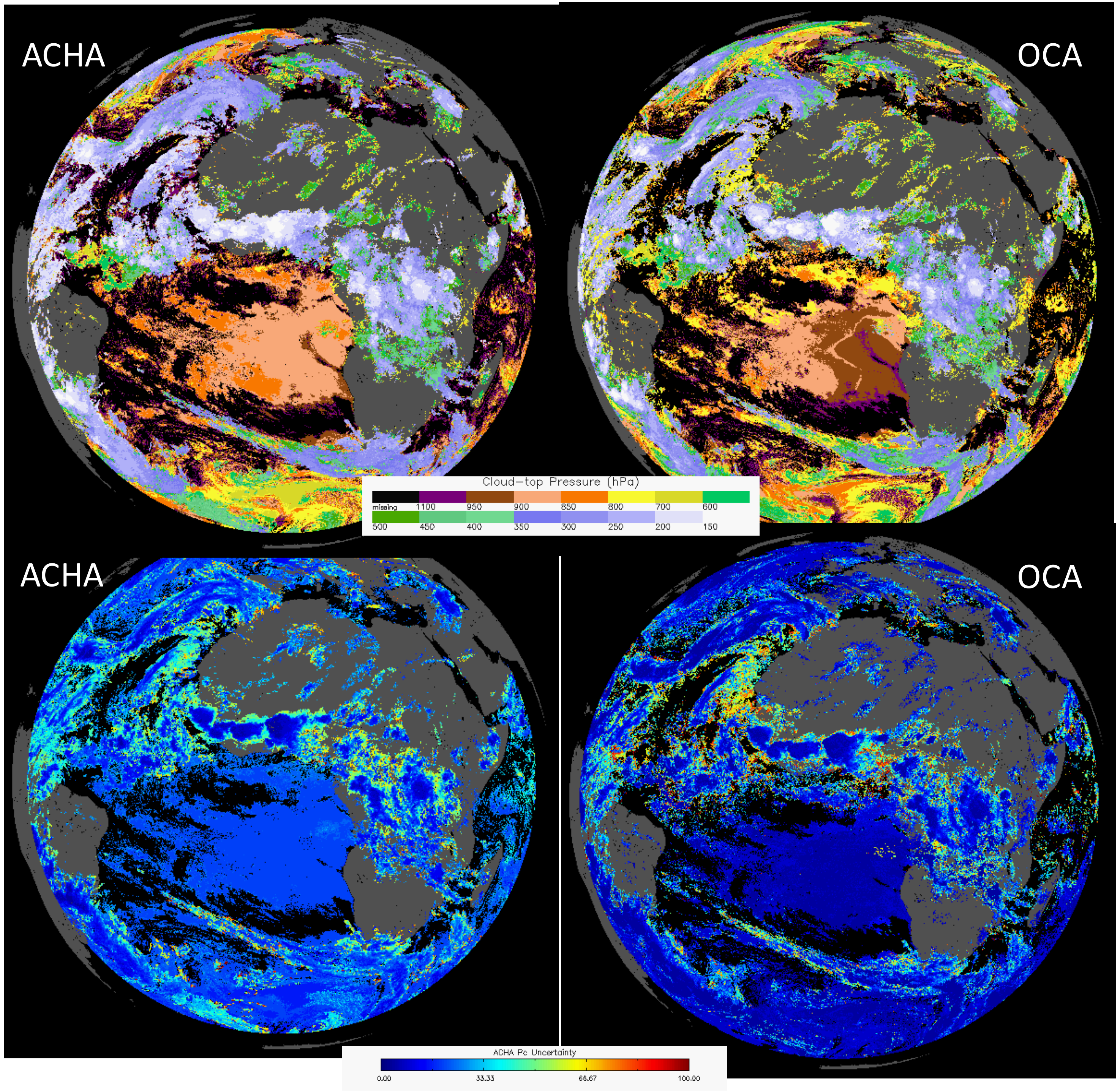
COT*, CTP*, CTH* = value of lower cloud when a multilayer retrieval is done

** ACHA input is always 2 or 3 channels which can include 6.2, 8.5, 11, 12 or 13.3 μm

SEVIRI EXAMPLES

- ACHA and OCA data from October 2015 acquired.
- Examples shown on the right. CTP on top and CTP uncertainties on bottom.
- AMV data generated from 15 minute triplets centered on the hour.

October 11, 2015

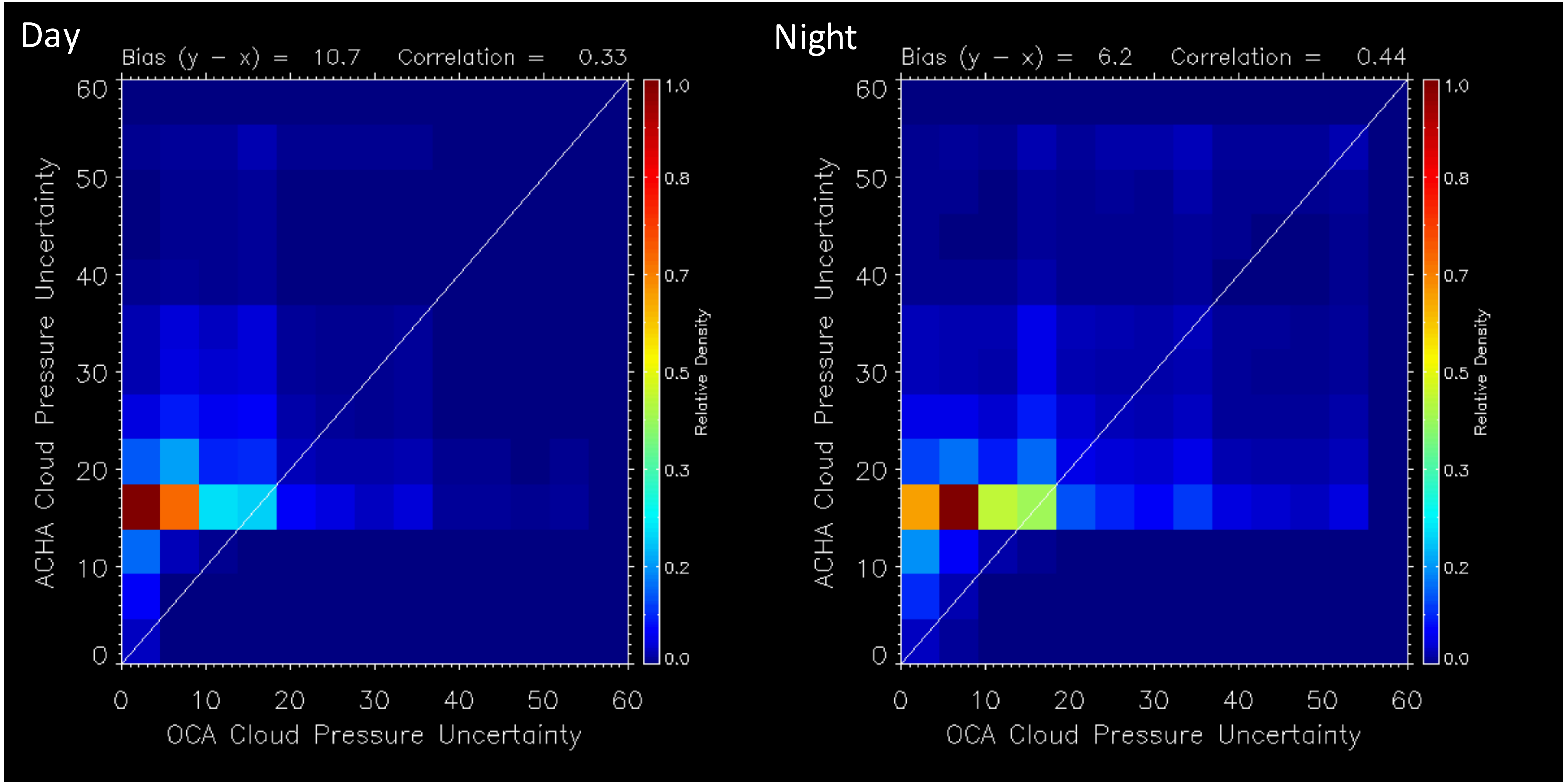


CTP Uncertainty Comparison

Summary

- Correlation is greater at night than day.
- ACHA is very correlated with cloud emissivity (day and night).
- OCA is also correlated with cloud emissivity at night but not at day.
- Uncertainties should vary. OCA uses more channels and all channels can contribute.
- How can this be "standardized" for AMV use?

Scatterplot of ACHA (y-axis) and OCA (x-axis) CTP pressure uncertainties for MSG SEVIRI data on October 11, 2015. Data is all data and not limited to AMV targets.



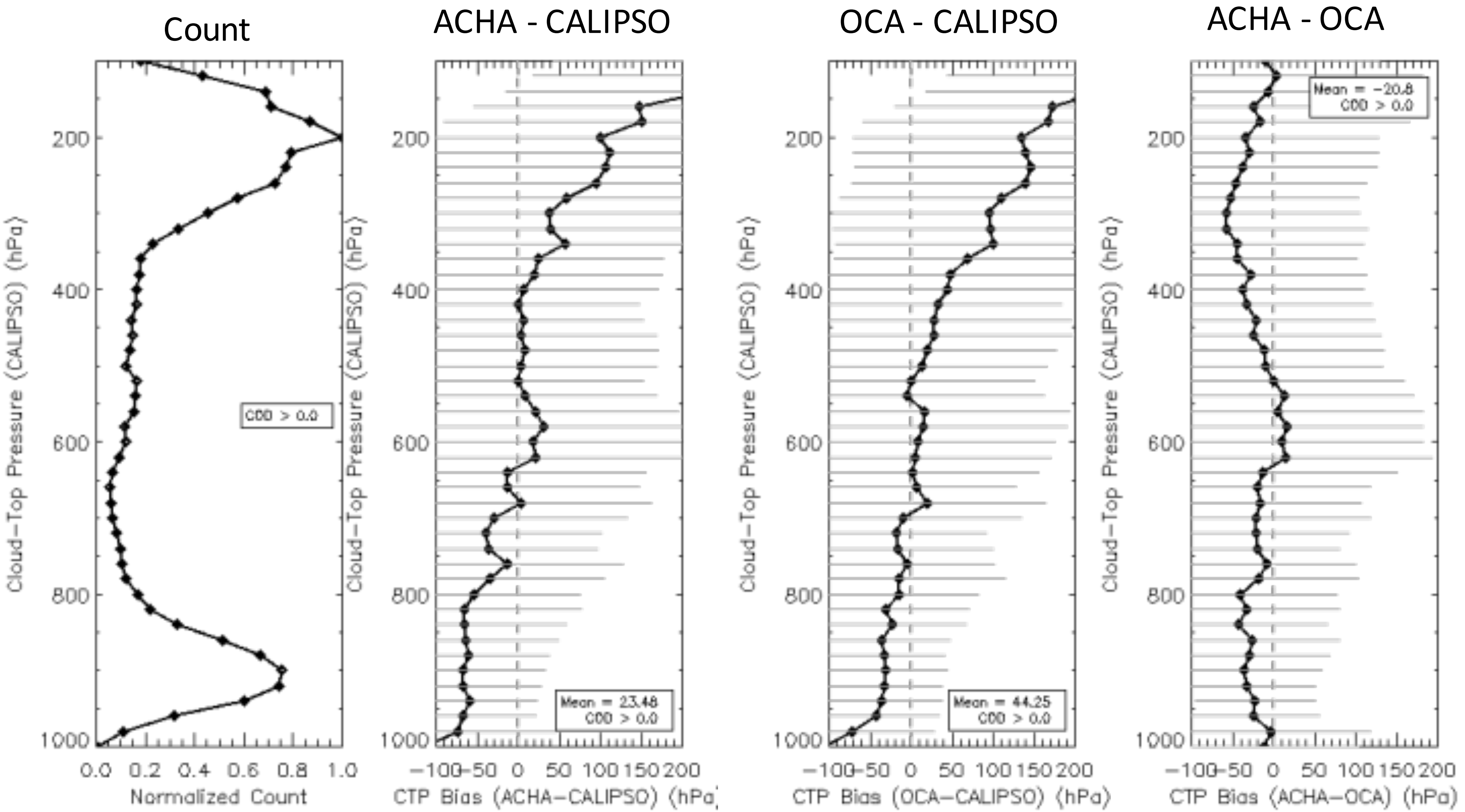
CALIPSO COMPARISONS

CALIPSO COMPARISONS

Summary

- OCA and ACHA comparisons to CALIPSO are very similar
- Both are lower at high altitudes and higher at low altitudes.
- ACHA is higher than OCA at most levels.

No Optical Depth or Phase Matching



Count

ACHA - CALIPSO

OCA - CALIPSO

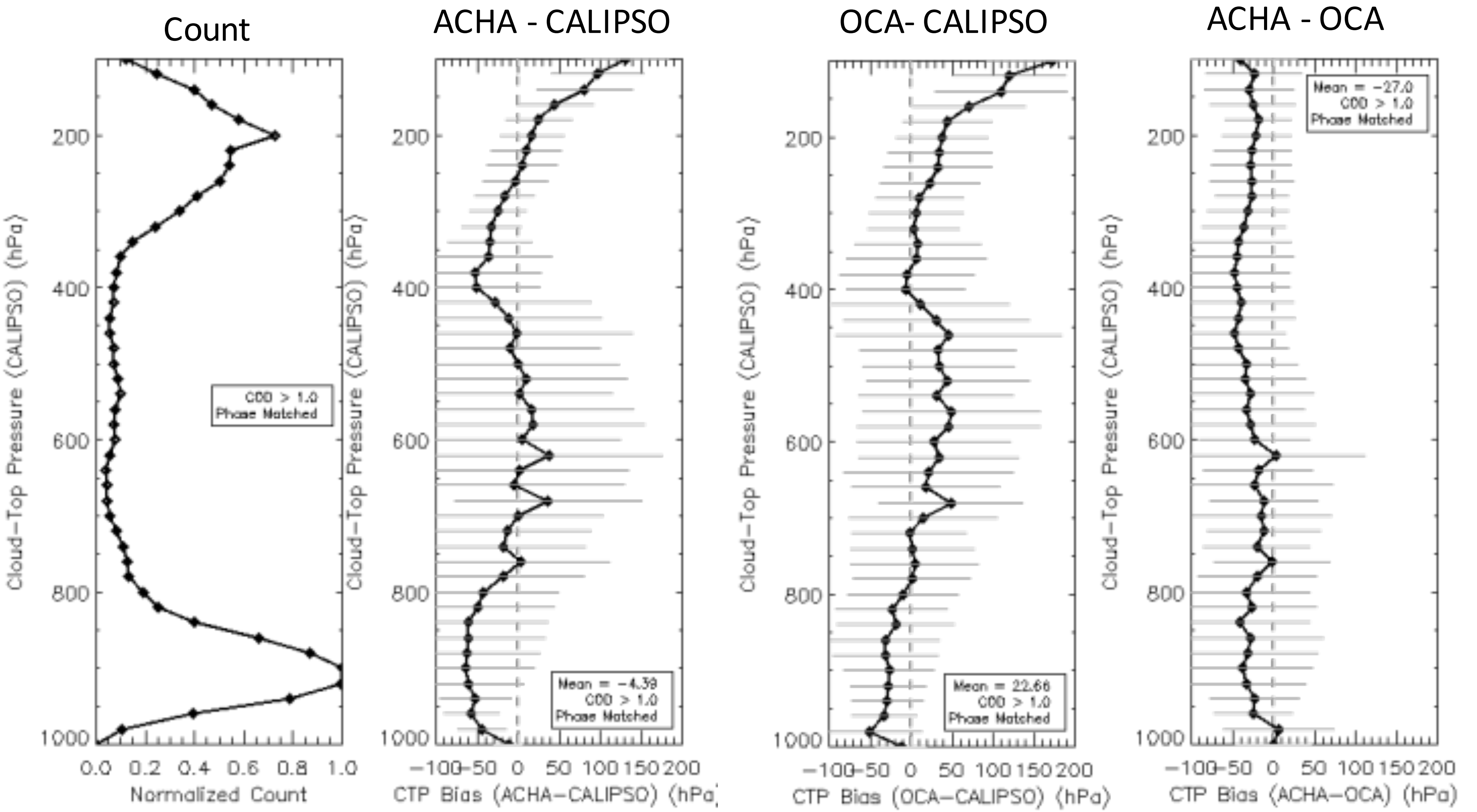
ACHA - OCA

CALIPSO COMPARISONS

Summary

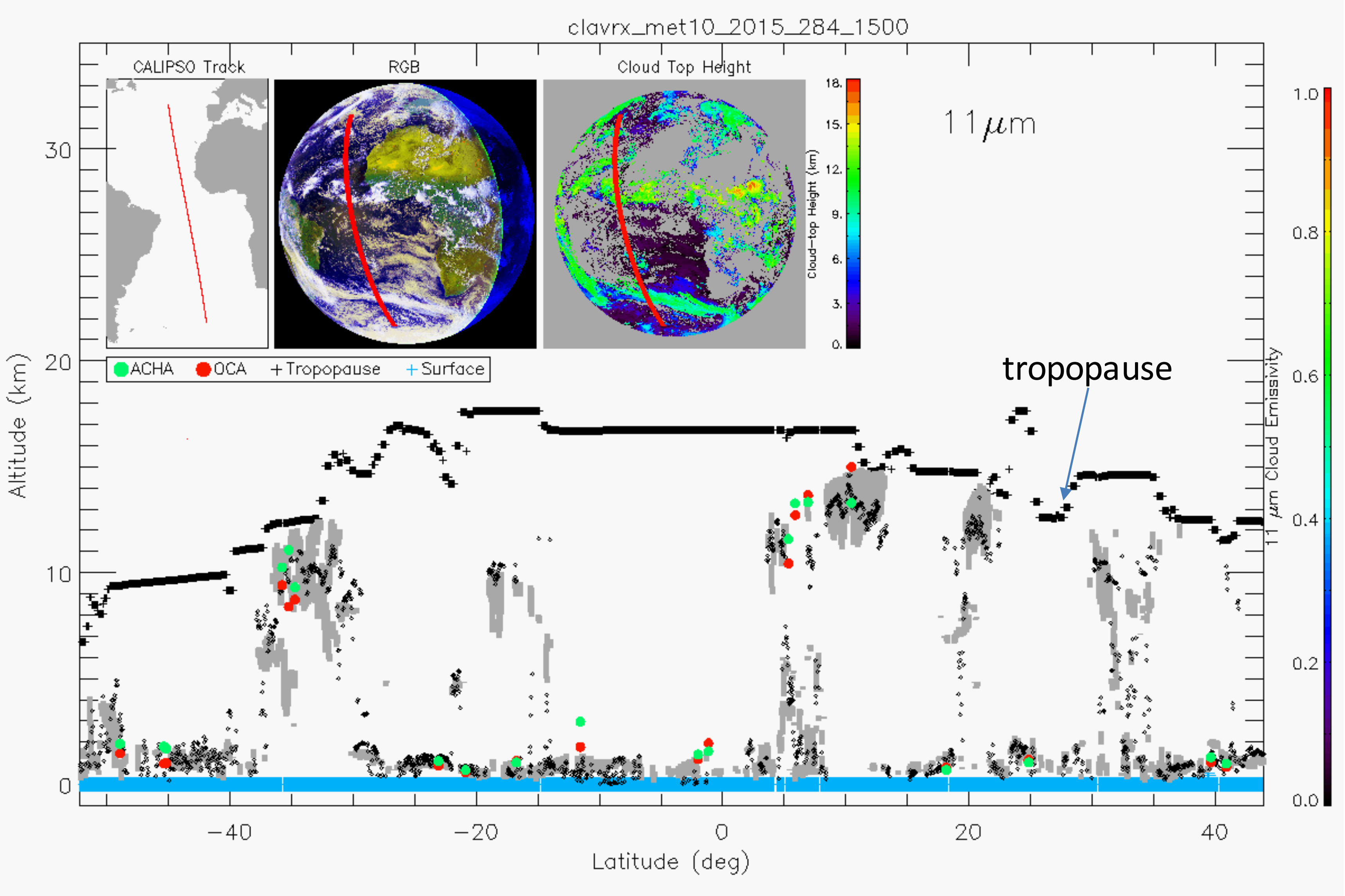
- Filtering shifts distribution towards lower levels.
- Filter narrows spread at high levels.
- Not much impact on bias.
- Phase matching is more effective than COD filter.

Optical Depth > 1 and Phase Matched



AMV Heights Overlaid on CALIPSO/CALIOP

- Grey regions are the CALIPSO CALIOP cloud layers
- Small black points are the raw ACHA retrievals
- Green points are ACHA AMV heights
- Red points are OCA AMV heights.
- AMV height assignment process can result in heights that differ from pixel level ACHA or OCA



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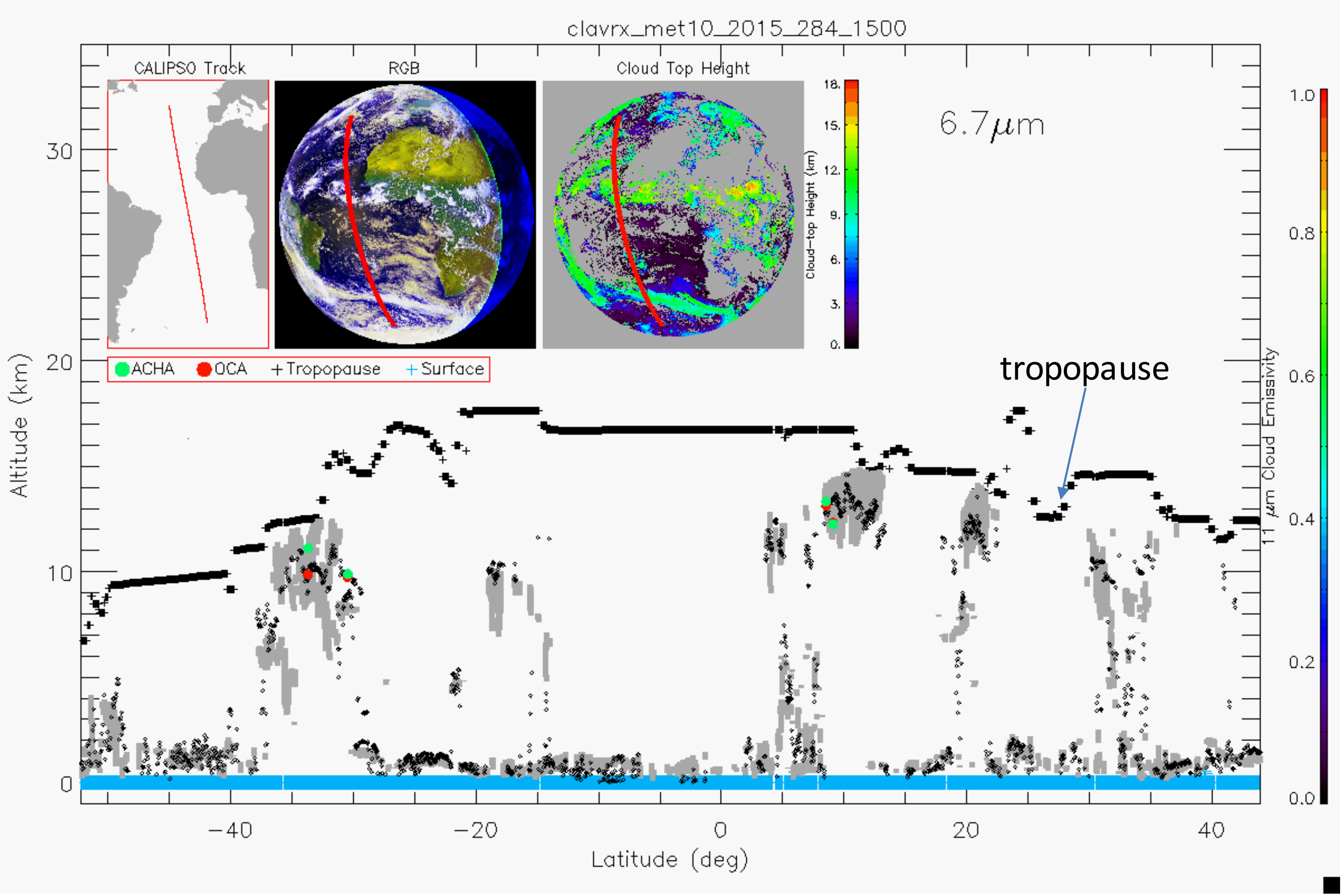
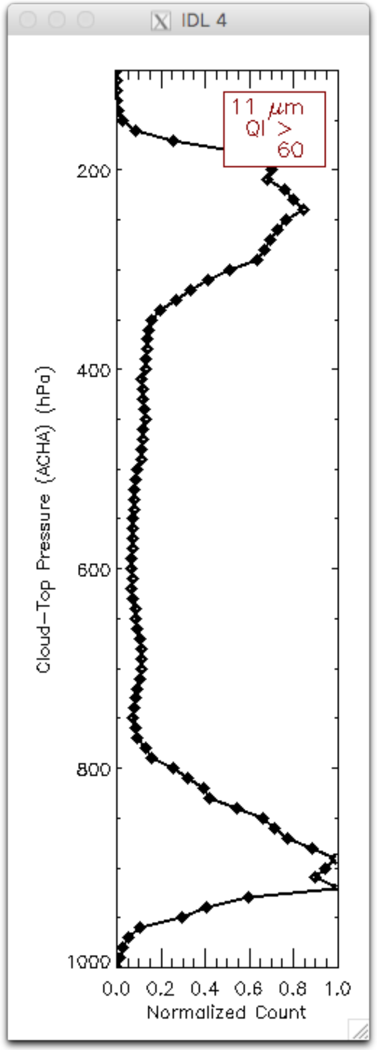


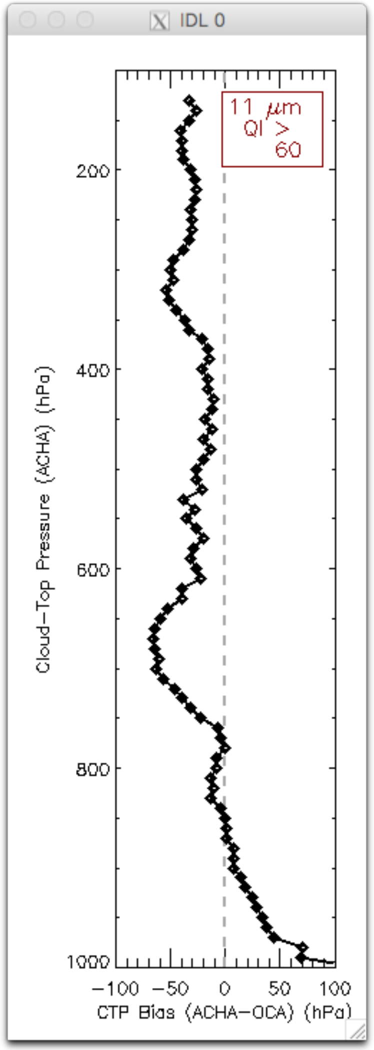
GOES-R AMV CLOUD PRESSURES

AMV CTP Differences (11 μm)

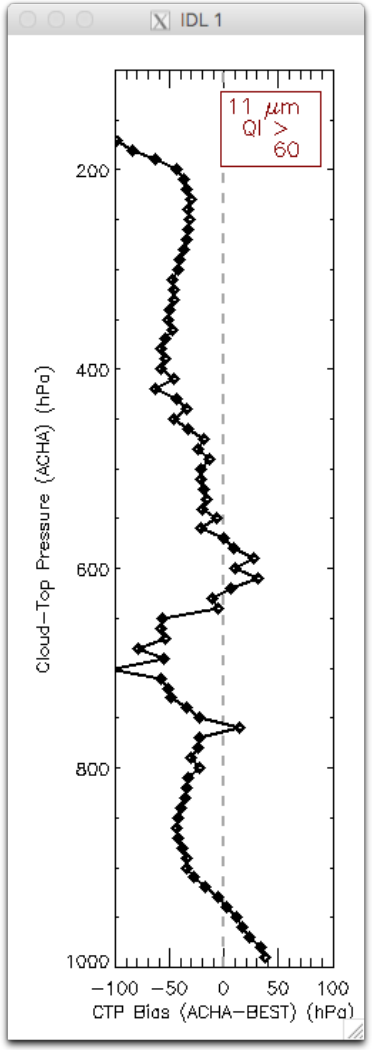
Count



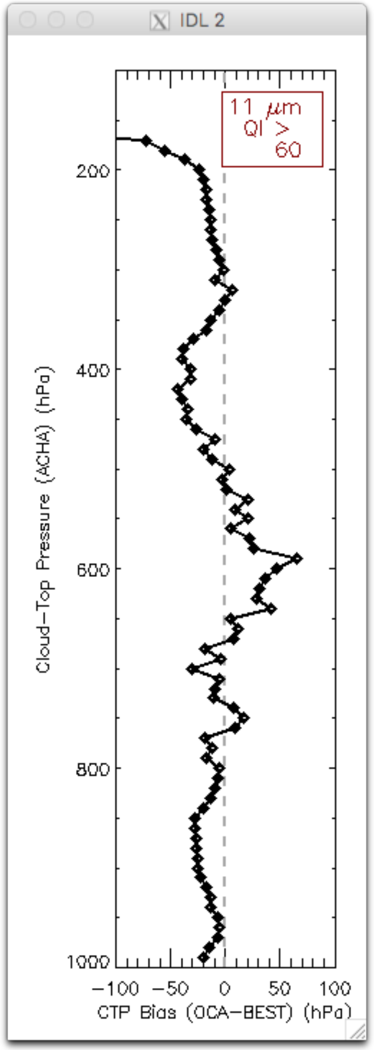
ACHA - OCA



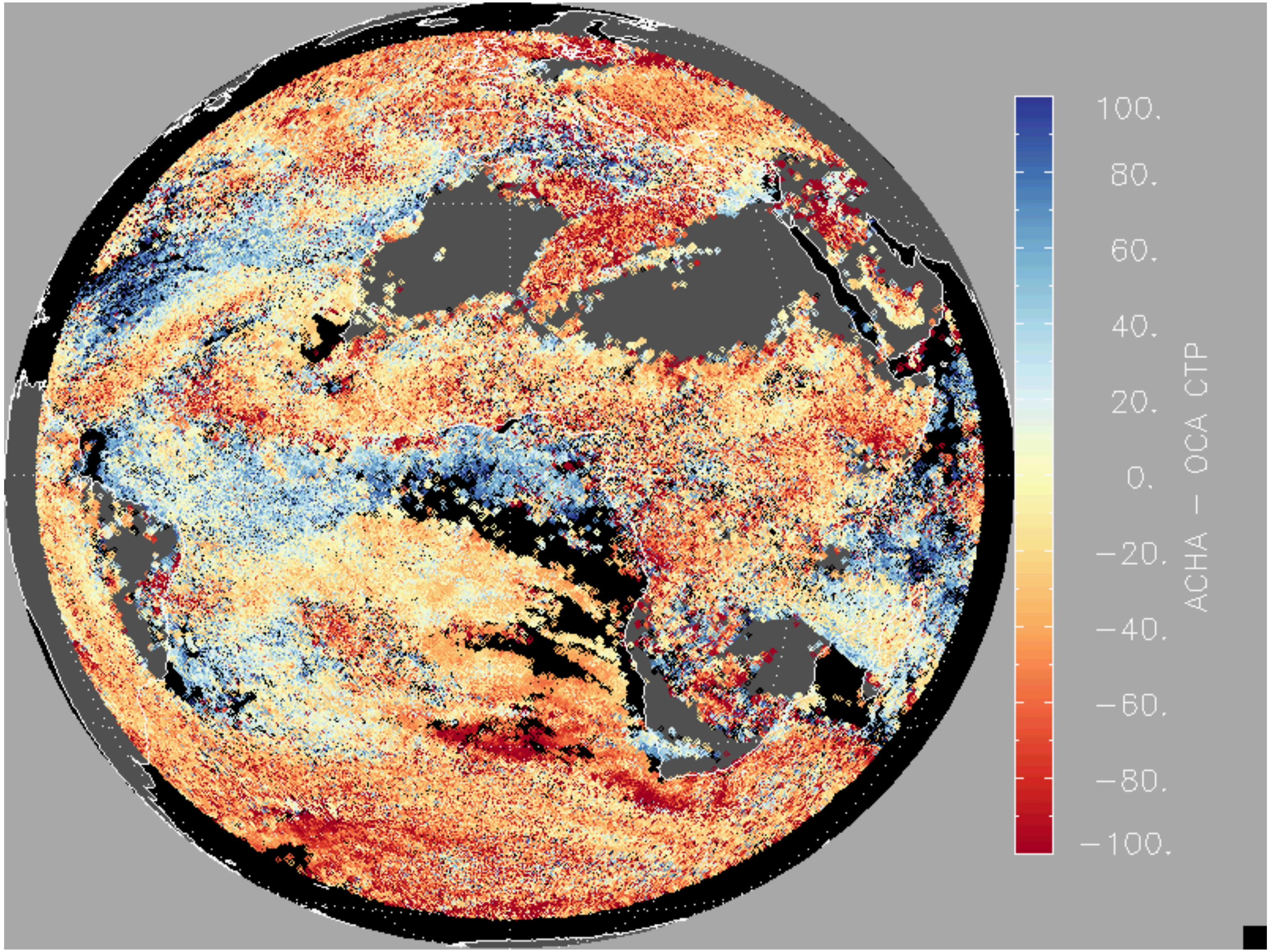
ACHA - BFIT



OCA - BFIT



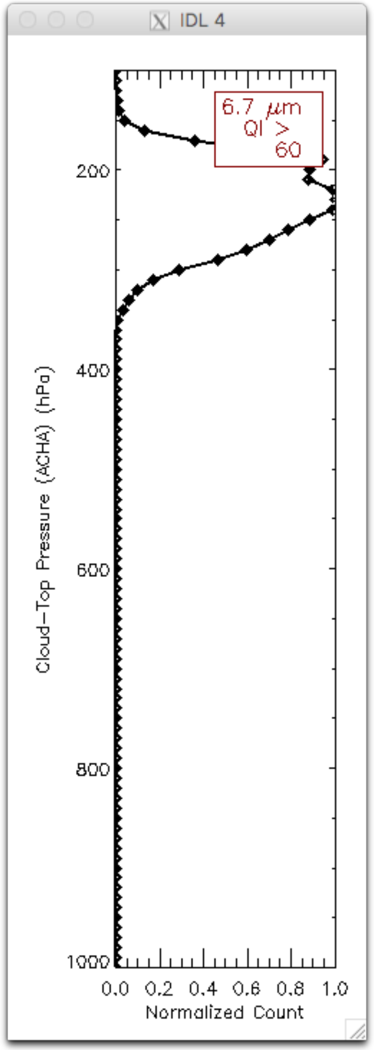
AMV CTP Differences (11 μm)



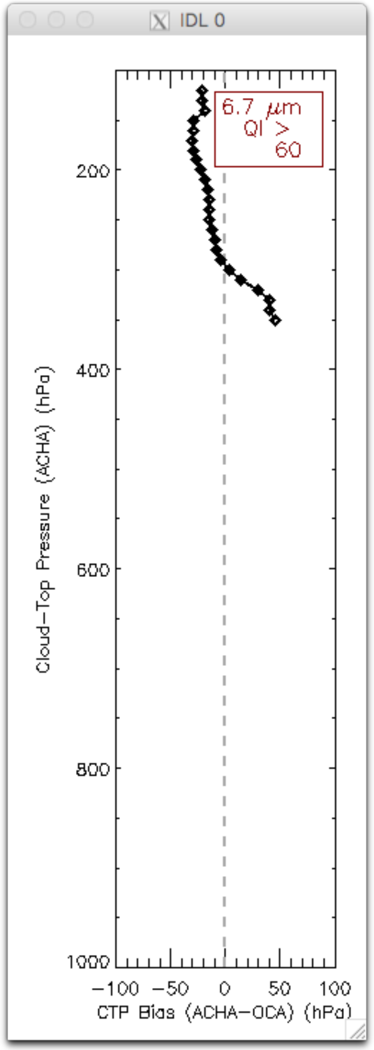
October 11, 2015

AMV CTP Differences (6.7 μm)

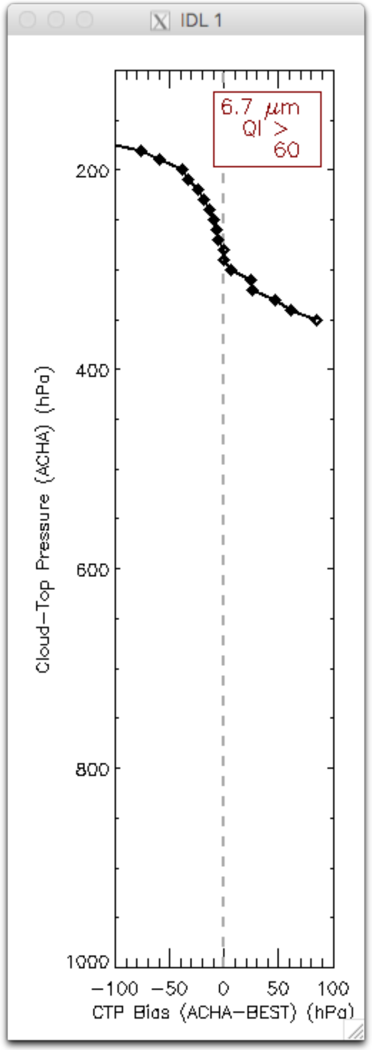
Count



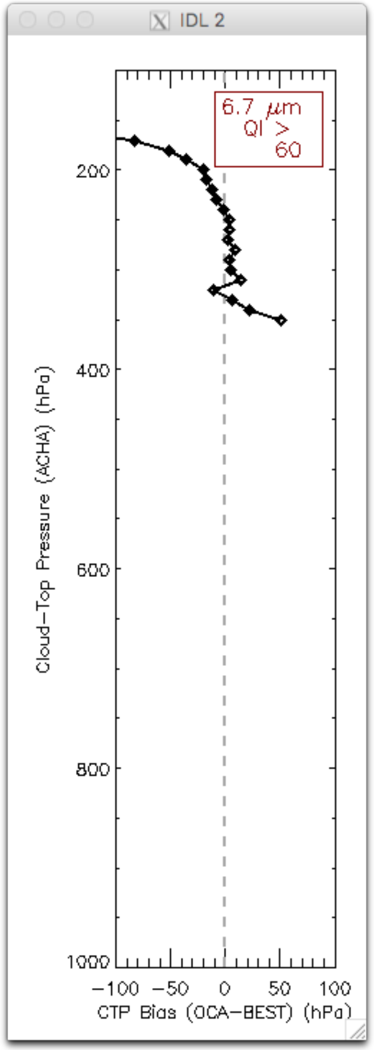
ACHA - OCA



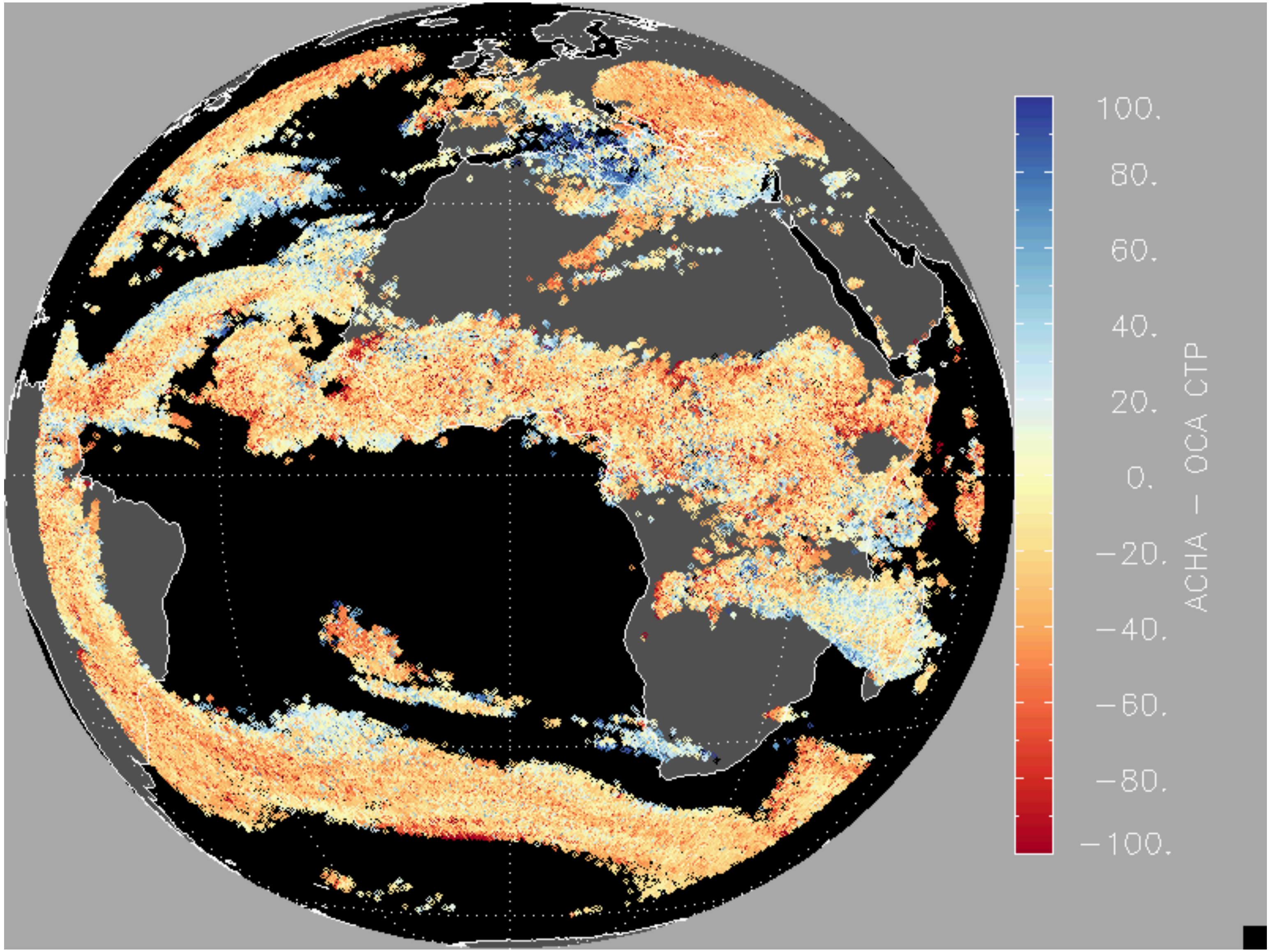
ACHA - BFIT



OCA - BFIT



AMV CTP Differences (6.7 μm)



October 11, 2015

Conclusions

- An initial analysis package has been developed to facilitate progress in improving cloud height products for AMV applications.
- OCA and ACHA are used as examples, but this can be expanded to any pixel level CTP product.
- Preliminary findings are:
  - OCA and ACHA are similar, but do have systematic differences that warrant study.
  - CTP uncertainties show correlation but their use in AMV quality screening is not obvious.

Questions

- Does the standard performance comparison between OCA and ACHA predict the AMV performance?
- Since both OCA and ACHA are O.E. algorithms, do their uncertainties agree?
- Does the AMV community want standard cloud product uncertainty metrics?

Backup Material

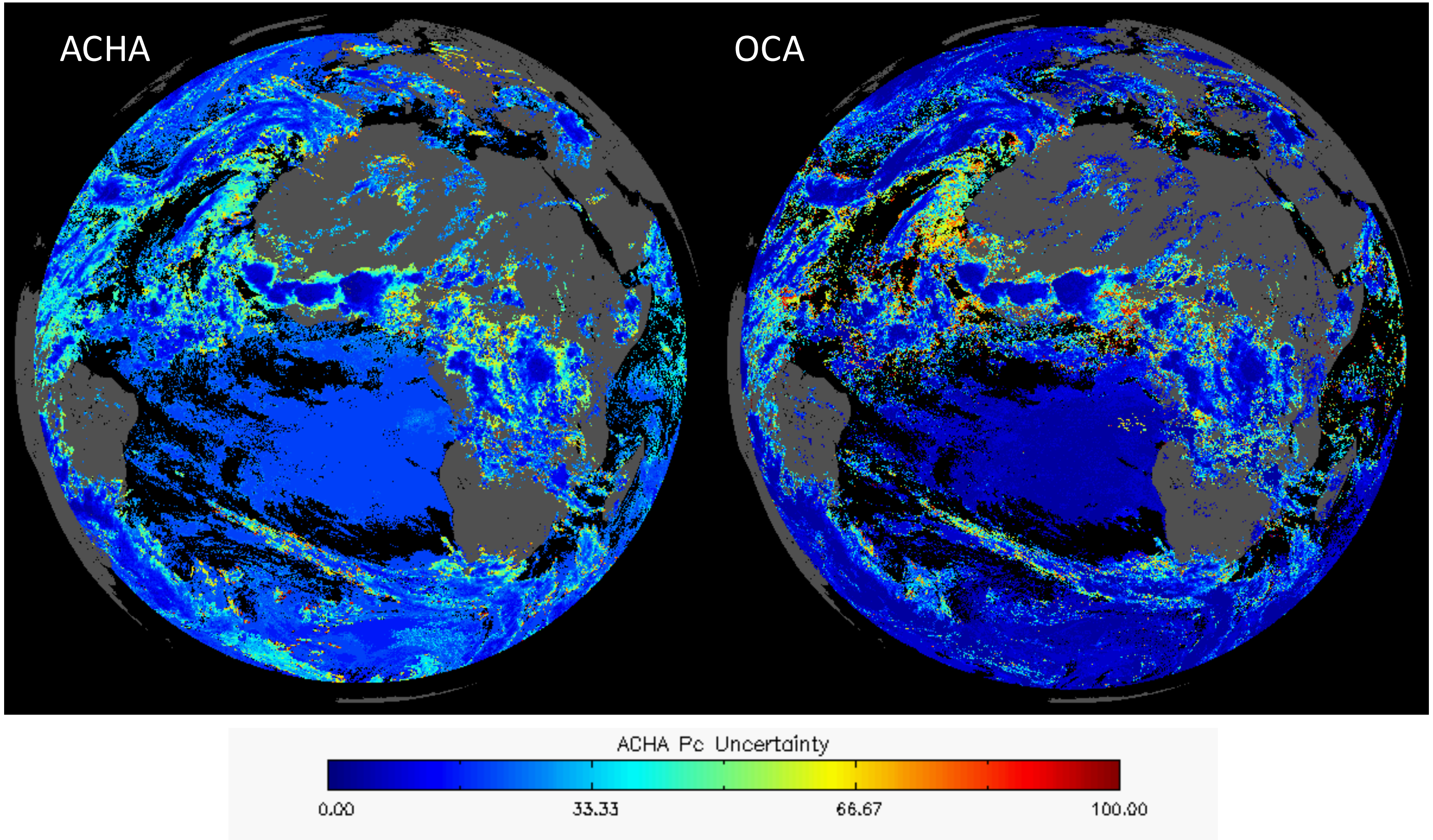
THANK YOU

Cloud Pressure Uncertainty

Summary

- Both ACHA and OCA make CTP uncertainties.
- ACHA uncertainties are the same day and night.
- OCA has lower uncertainties during the day..
- ACHA and OCA nighttime CTP uncertainties are correlated with cloud emissivity (from ACHA).
- The ICWG is expanded its inter-comparisons to include CTP uncertainty.

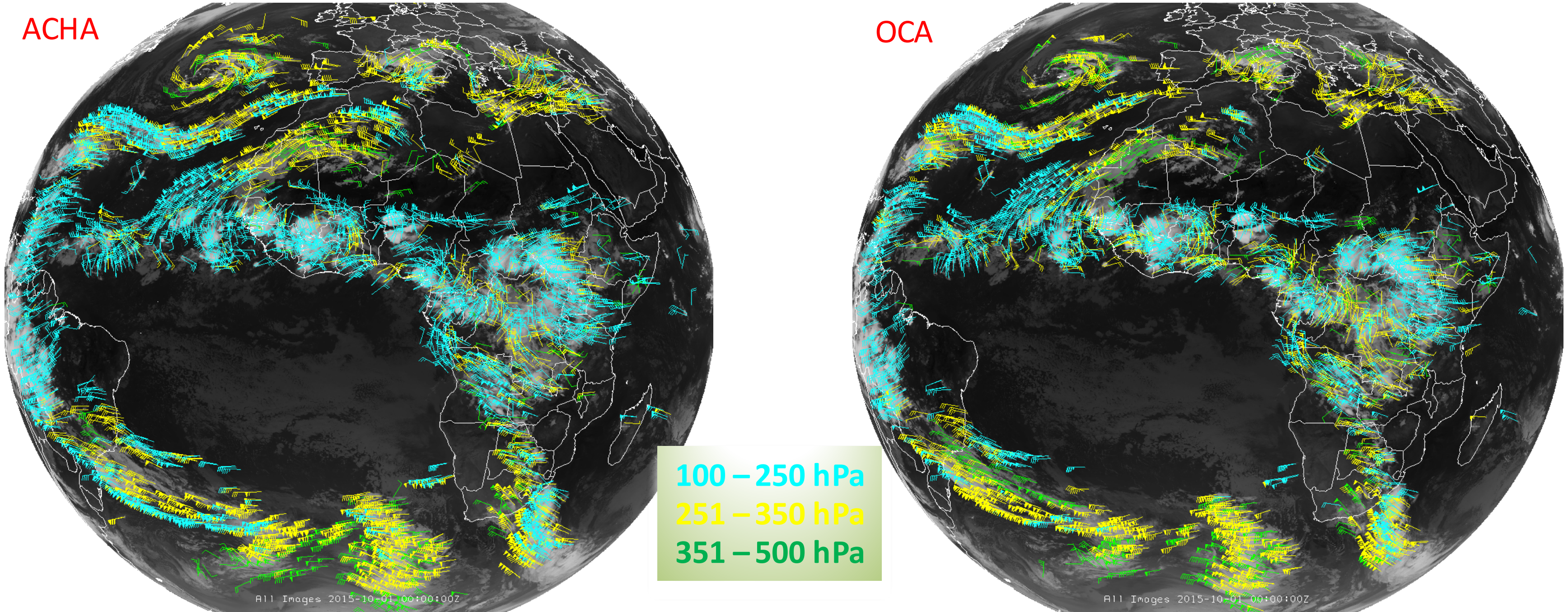
October 11, 2015 03:00 UTC



GOES-R AMV Analysis

- Steve Wanzong ….

OCA and ACHA heights run through the GOES-R winds algorithm



OCA DESCRIPTION IN MORE DETAIL

EUMETSAT Optimal Cloud Analysis: 1. Optimal Estimation

1. Define State: x = [COT, CRE, CTP, (phase), Tskin]
2. Define Measurements: y = [0.6, 0.8, 1.6, 3.9, 6.3, 7.2, 8.7, 9.6, 10.8, 12.0, 13.4]
3. Have a fast forward model $y(x)$ (and gradient model)
4. Find state x that maximises $P(x|y)$:

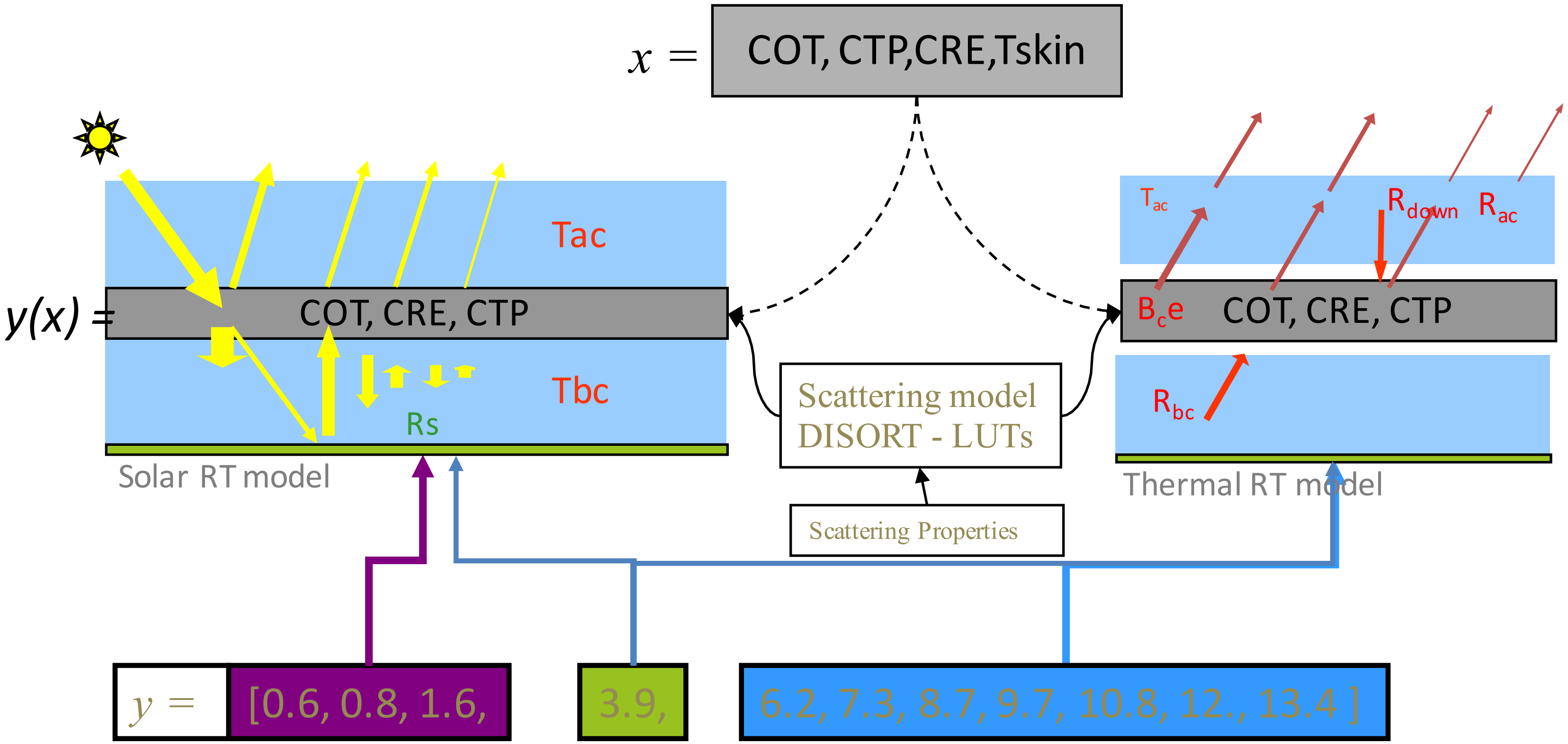
Radiance information Prior information

$$\boxed{P(x\,|\,y) = \exp^{(y_m \;\; y(x))S_y{}^{1}(y_m \;\; y(x))^T} . \exp^{(x \;\; x_b)S_x{}^{1}(x \;\; x_b)^T}}$$

Minimise* w.r.t. x: $\boxed{J = (y_m \;\; y(x))S_y{}^{1}(y_m \;\; y(x))^T + (x \;\; x_b)S_x{}^{1}(x \;\; x_b)^T}$

* Levenburg Marquardt

EUMETSAT Optimal Cloud Analysis: 2. y(x) Fast Forward Model



$x =$ COT, CTP,CRE,Tskin

$y(x) =$

Tac

COT, CRE, CTP

Tbc

Rs

Solar RT model

Scattering model
DISORT - LUTs

Scattering Properties

T_{ac}

R_{down} R_{ac}

$B_c e$ COT, CRE, CTP

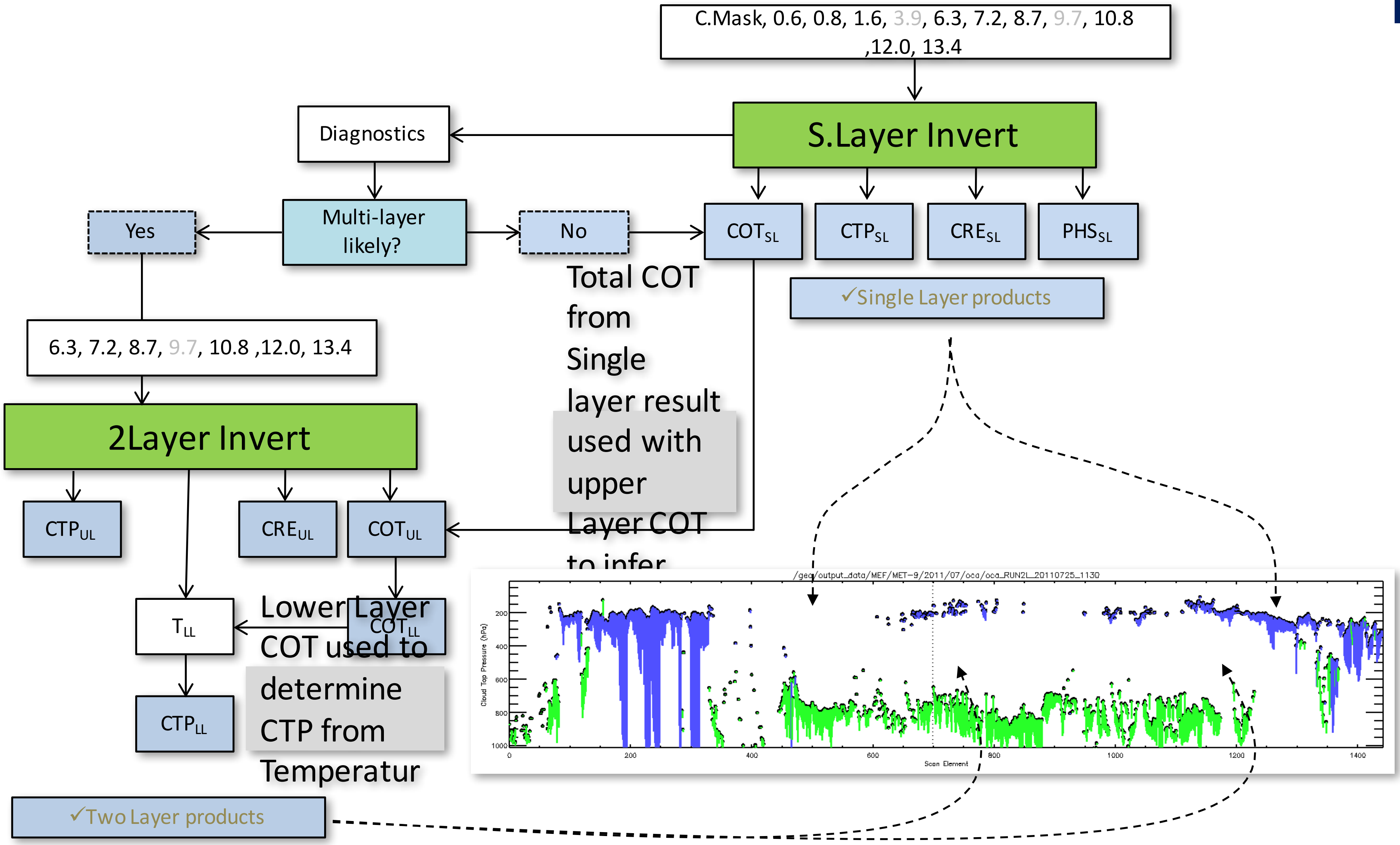
R_{bc}

Thermal RT model

$y =$ [0.6, 0.8, 1.6, 3.9, 6.2, 7.3, 8.7, 9.7, 10.8, 12., 13.4]

Cloud-free atmospheric Radiances and Transmittances from RTTOV-11 using ECMWF f/c

EUMETSAT Optimal Cloud Analysis: 3. Single/Multi-layer Strategy

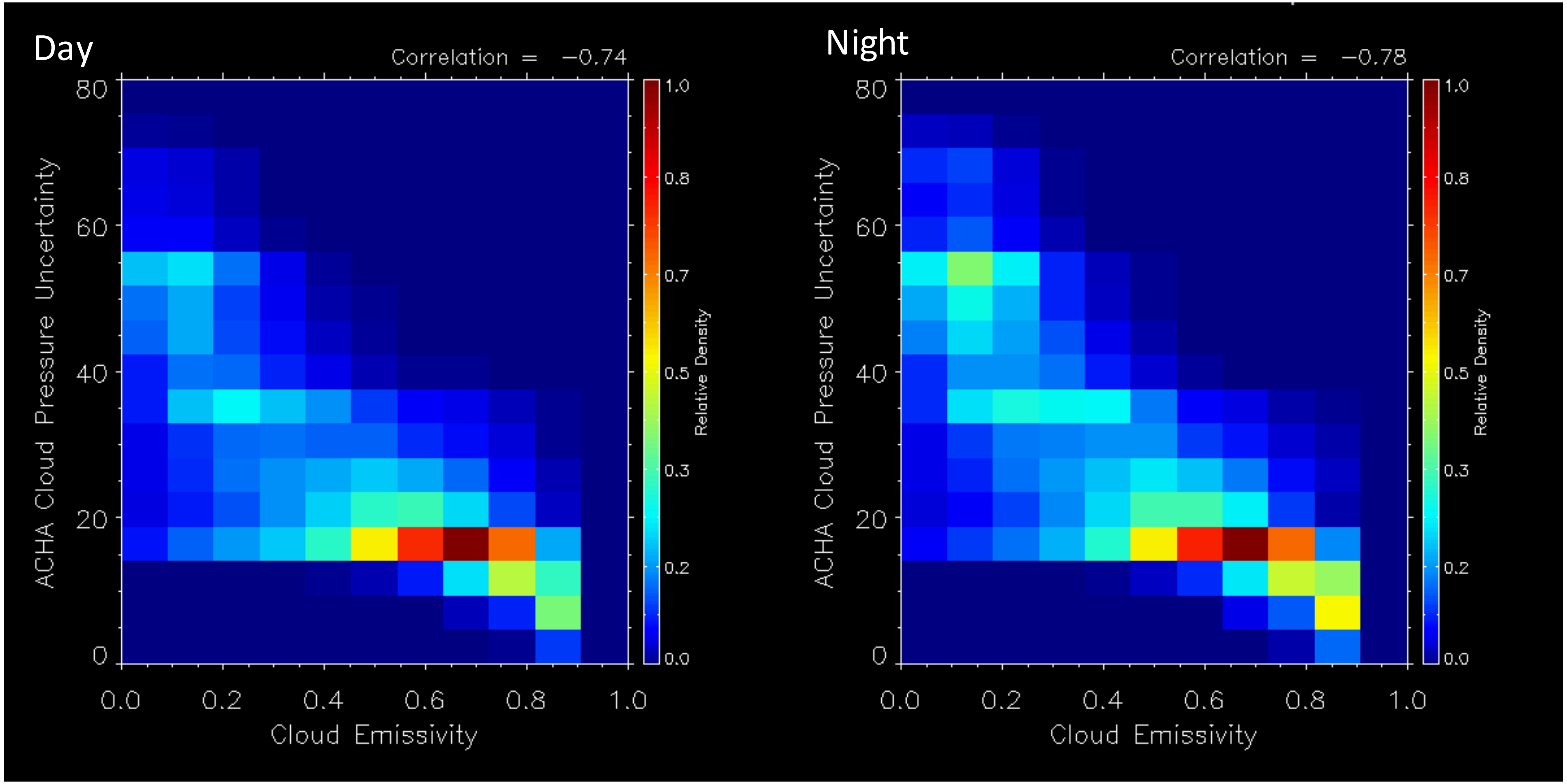


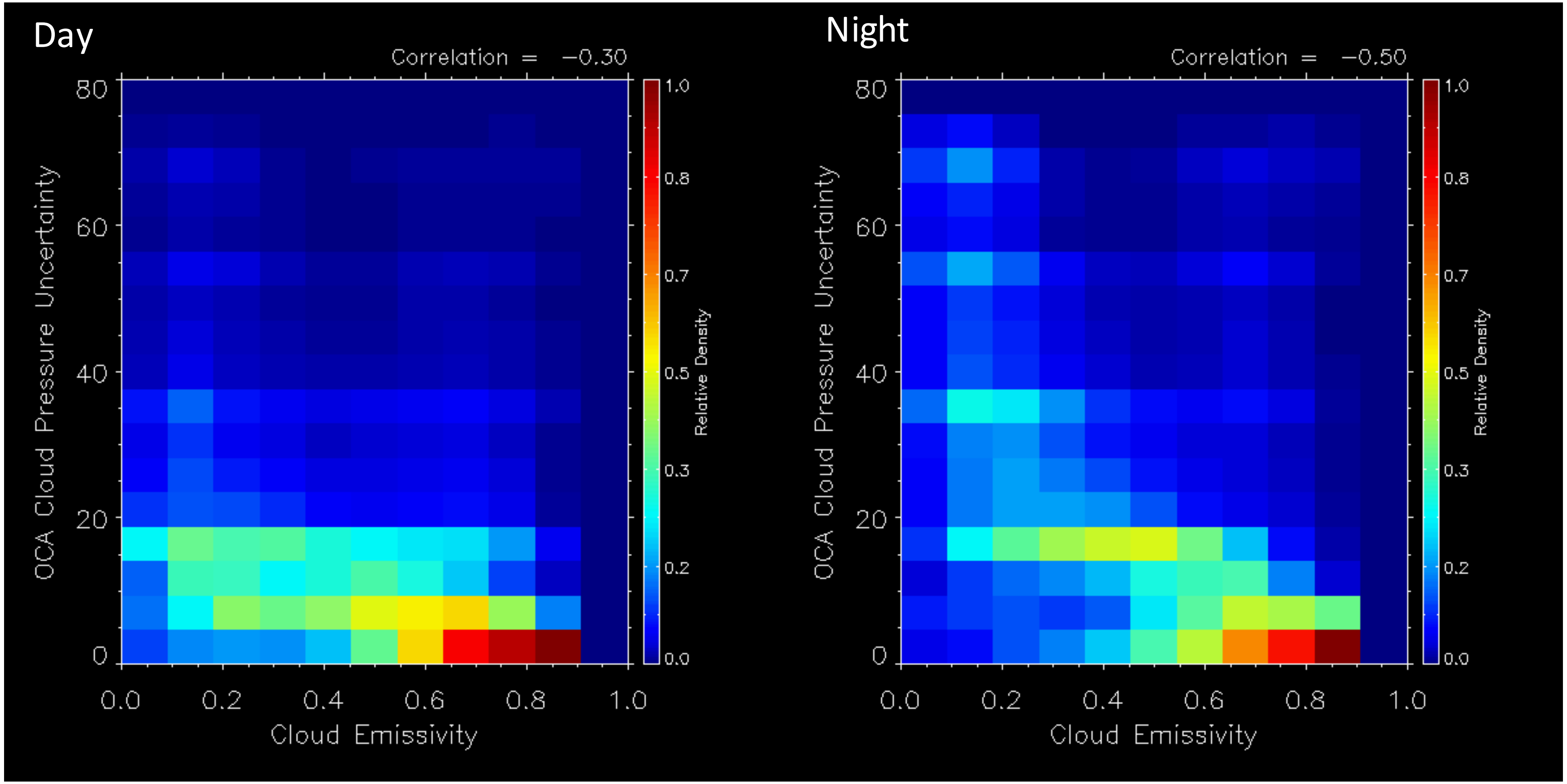
Total COT from Single layer result used with upper Layer COT to infer

Lower Layer COT used to determine CTP from Temperatur

AWG Cloud Height Algorithm (ACHA)

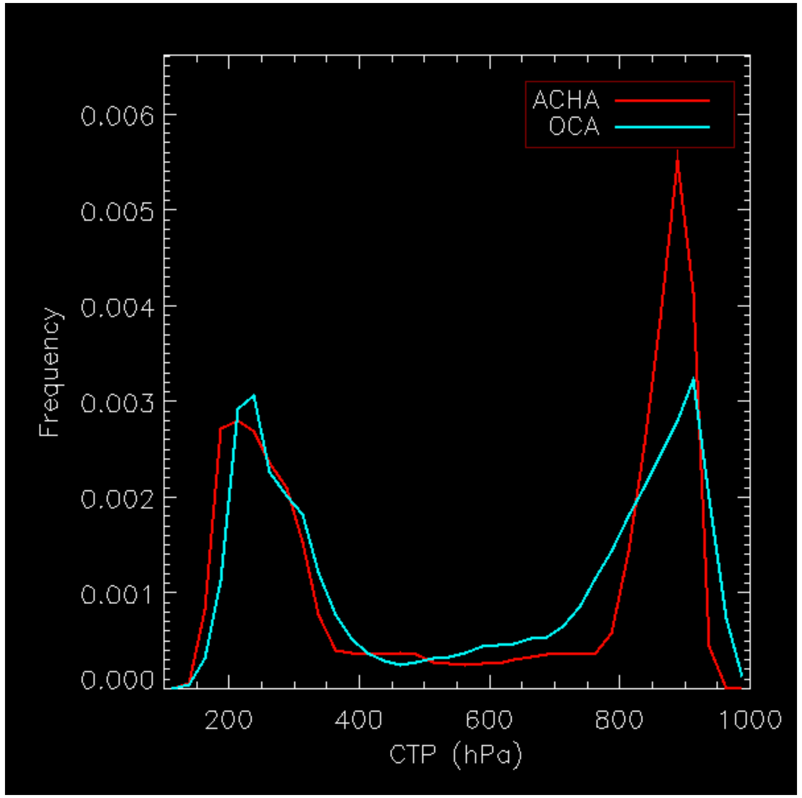
- Developed first as part of GOES-R Algorithm Working Group (AWG).
- Also an Optimal Estimation (OE) but IR-only
- Support multiple modes – each mode is a channel combination (e.g. mode 8 = 11, 12,13.3 μm). Supports many sensors – AVHRR, MODIS, GOES-IP, GOES-R, SEVIRI, MTSAT, COMS, VIIRS, AHI
- Fundamental output is Cloud Temperature, emissivity and 11/12 β (i.e. an IR Angstrom exponent related to microphysics). This makes the Kernel matrix an easy calculation.
- Cloud Height, Pressure, optical depth and particle size are derived from fundamental outputs.
- Requires no LUTS. Ping Yang's IR microphysical library used to make regressions for relating emissivity variations.
- Multi-layer clouds are modelled by assuming the surface is the lower cloud. Only lower cloud temperature is retrieved.

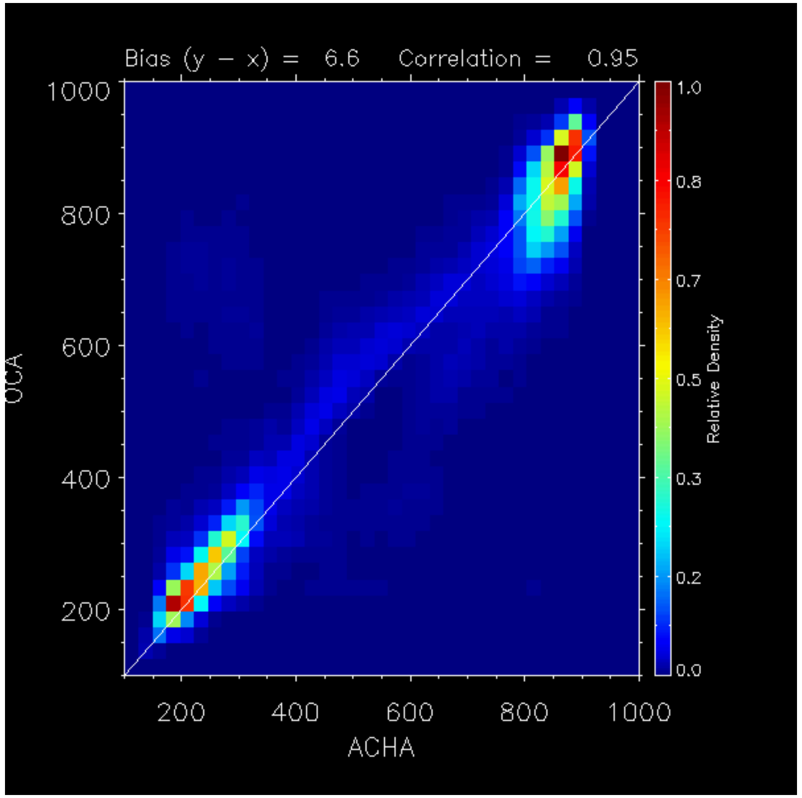

Day
Correlation = −0.74
Night
Correlation = −0.78
ACHA Cloud Pressure Uncertainty
0
20
40
60
80
Cloud Emissivity
0.0
0.2
0.4
0.6
0.8
1.0
Relative Density
0.0
0.2
0.3
0.5
0.7
0.8
1.0


Day
Correlation = −0.30
OCA Cloud Pressure Uncertainty
80
60
40
20
0
0.0
0.2
0.4
0.6
0.8
1.0
Cloud Emissivity
Relative Density
1.0
0.8
0.7
0.5
0.3
0.2
0.0
Night
Correlation = −0.50
OCA Cloud Pressure Uncertainty
Cloud Emissivity
Relative Density

Comparison of Heights Used for Winds

- Steve Wanzong modified CLAVR-x to read OCA Level-2 files from SEVIRI and to ingest OCA and ACHA into CLAVR-x Level-2 output.
- GOES-R Winds algorithm applied to these heights.
- Height comparison below is only for the final heights of the wind vectors after the filtering and data rejection of the GOES-R Winds Logic.
- These are the 10.8 μm Wind Vectors. Complete analysis shown at IWWG.

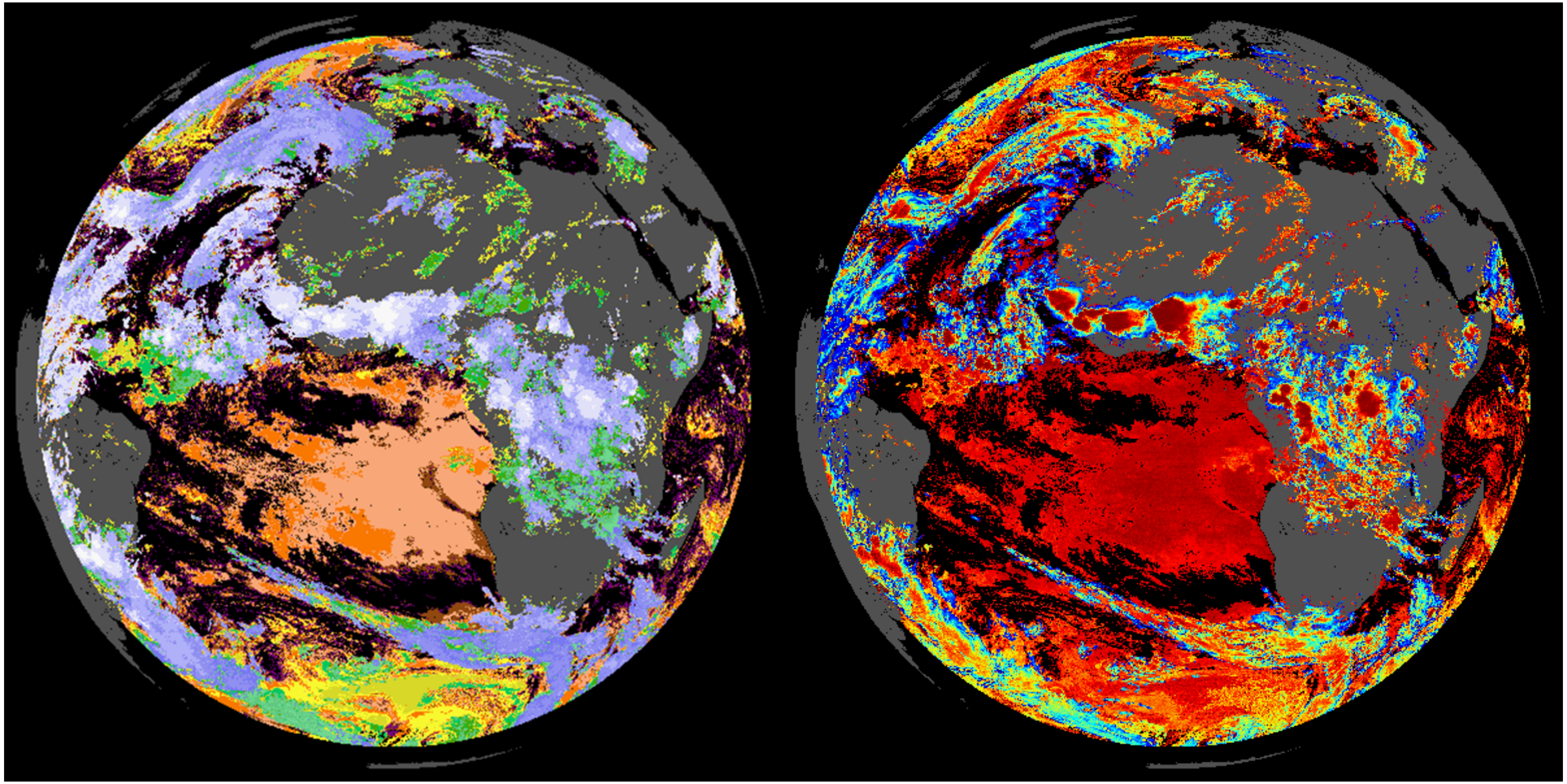




October 12, 2015 – All time periods

OCA = Eumetsat Height, ACHA = NOAA Height

Cloud Emissivity



Cloud Emissivity