NOAA Unique CrIS ATMS Processing System (NUCAPS): Phase 3

Algorithm Readiness Review

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Review Agenda

Section	Time	Presenter
Introduction	9:00 – 9:10	Tom King
CDR Phase 3 Report	9:10 – 9:20	Tom King
Phase 3 Requirements	9:20 – 9:25	Tom King
Phase 3 Software Architecture	9:25 – 9:40	Tom King
Validation: Retrieval and OLR	9:40 – 10:20	Nick Nalli
Validation: ILS Evaluation	10:20 – 11:00	Antonia Gambacorta
Validation: System	11:00 – 11:25	Letitia Soulliard
Risk Summary	11:25 – 11:35	Tom King
Summary and Conclusions	11:35 – 11:40	Tom King

Review Outline

- Introduction
- CDR Phase 3 Report
- Phase 3 Requirements
- Phase 3 Software Architecture
- Validation
- Risk Summary
- Summary and Conclusions

Introduction

Presented by

Tom King

NUCAPS Objectives Phase 1

- Phase 1 Objectives:
  - » Apodize and subset the CrIS SDR's both spatially and spectrally to produce thinned radiance datasets for use by NWP and DOD centers within 3 three hours of observation (or 30 minutes of data receipt from IDPS) to NWS and DOD.
  - » SDR Validation Products: Global Grids, Matchups, and Binaries

NUCAPS Objectives
Phase 2

- Phase 2 Objectives:
  - » Provide CrIS/ATMS NOAA Unique products within three hours of observation (or 30 minutes of data receipt from IDPS) to NWS and DOD.
    - – Temperature, moisture, pressure profiles
    - – Cloud cleared radiances
    - – NOAA Unique trace gas products
    - – Principal components
    - – Science QC products for OSPO
  - » Provide NOAA Unique CrIS/ATMS Products with metadata to CLASS.
  - » EDR Validation Products: Global Grids, Matchups, and Binaries.

NUCAPS Objectives Phases 3 and 4

- Phase 3 Objectives:
  - Collocated CrIS/VIIRS-cloud datasets
  - CrIS OLR
  - ILS Shift
  - Retrieval updates (regression update, bug fixes)
  - Port from IBM to GNU Linux
  - Update to NUCAPS system preprocessor
- Phase 4 Objectives:
  - Full spectral CrIS implementation
  - Retrieval updates

Project Stakeholders – Development Team

- STAR - NUCAPS Integration Team (Walter Wolf- P.I., Thomas King, Letitia Soulliard, Haibing Sun, Kexin Zhang, Yunhui Zhao, Peter Keehn, and Larisa Koval,)
  - » Integrate algorithm code
  - » Develop documentation
  - » Work with data users and providers to obtain detailed product requirements
  - » Conduct tests and assist with validation

Project Stakeholders – Development Team

- STAR - NUCAPS Science team (Quanhua (Mark) Liu – Science Lead, Kexin Zhang, Changyi Tan, Flavio Sanchez, Nick Nalli, Antonia Gambacorta, Chris Barnet, Tony Reale, Bomin Sun, Mike Pettey)
  - » Develop and maintain the NUCAPS algorithms
  - » Conduct retrieval & OLR validation
  - » Assist with AWIPS implementation and Direct Broadcast (Barnet)

Project Stakeholders – Operations and Maintenance

- NDE (Geoff Goodrum, Peter MacHarrie, Dylan Powell)
  - » Develop the NDE system
  - » Integrate science algorithm packages received from STAR
  - » System test and deliver to OSPO
- OSPO (A.K. Sharma – NUCAPS PAL, Oleg Roytburd, Zhaohui Cheng, Donna McNamara)
  - » Run and maintain the NDE system on the operation side
  - » Distribute the data and products to users
  - » Conduct product quality monitoring (Cheng)

Project Stakeholders – Customers and Users

- U.S. Users:
  - » NCEP (John Deber, Andrew Collard, Dennis Keyser)
  - » GMAO (Will McCarty)
  - » AWIPS (Jim Heil)
  - » STAR (Mark Liu, Tony Reale)
  - » NCDC/CLASS (Phil Jones, Brian Merandi)
  - » AFWA/NRL (Ben Ruston)
- International Users:
  - » EUMETSAT (Simon Elliott)
    - – UK Met Office (Nigel Atkinson)
    - – ECMWF (Tony McNally)
    - – DWD (Reinhold Hess)
    - – Meteo-France (Lydie Lavanant)
    - – Plus other EUMETSAT members states
  - » CMC (Louis Garand)
  - » EC (Sylvain Heilliette)
  - » JMA (Hidehiko Murata)
  - » BOM (John Le Marshall)

Project Plan: Task and Schedules

- Tasks defined in the PSDI project plan:
  - » FY14_Polar_CrIS-ATMS_V2.0.ppt
  - » FY14_Polar_CrIS_OLR_V2.0.ppt

- Schedule (key milestones):
  - » Preliminary Design Review – May 9, 2007
  - » Critical Design Review – Sep. 29, 2008
  - » Test Readiness Review – Sep. 29, 2010
  - » Code Unit Test Review – Oct. 20, 2010
  - » Phase 1 Algorithm Readiness Review – Mar. 14, 2012
  - » NUCAPS Phase 1 Delivery – Mar. 19, 2012
  - » NUCAPS Phase 2 Delivery – Dec. 3, 2012
  - » Phase 2 Algorithm Readiness Review – Jan. 14, 2013
  - » SPSRB Briefing for Phase 1 – Jul. 17, 2013 (May 2013) (Jun. 2012) (Jan. 2012)

Project Plan: Task and Schedules

- Schedule (key milestones) continued:
  - » NUCAPS Phase 1 Operations Commence – Sep. 19, 2013 (Jun. 2013) (Jul. 2012) (Feb. 2012)
  - » SPSRB Briefing for Phase 2 – Sep. 18, 2013 (May. 2013) (Jun. 2012) (Jan. 2012)
  - » NUCAPS Phase 2 Operations Commence – Oct 2013 (Jun. 2013) (Jul. 2012) (Feb. 2012)
  - » NUCAPS Phase 3 Critical Design Review – Dec. 2, 2013 (Nov. 2013)
  - » NUCAPS Phase 3 DAP Delivery – May, 12, 2015
  - » NUCAPS Phase 3 Algorithm Readiness Review – Sep. 3, 2015
  - » SPSRB Phase 3 briefing – Sep./Oct. 2015
  - » NUCAPS Phase 3 Operations Commence – Oct./Nov. 2015

NUCAPS Phase 3 ARR Entry Criteria

- Phase 3 CDR Report (Review Item Disposition)
  - » PDR Risks and Actions
  - » CDR Risks and Actions
  - » TRR Risks and Actions
  - » Phase 1 ARR Risks and Actions
  - » Phase 2 ARR Risks and Actions
  - » Phase 3 CDR Risks and Actions
- Updated Phase 3 CDR
- Updated Requirements Allocation Document

NUCAPS Phase 3 ARR Entry Criteria

- Phase 3 Algorithm Readiness Review Document containing:
  - » Project schedule
  - » Requirements
  - » Software Architecture
  - » Unit Tests
  - » Risks and actions

- Phase 3 Delivered Algorithm Package (DAP)

NUCAPS Phase 3 ARR Exit Criteria

- Updated Phase 3 RID
- Updated Phase 3 ARR presentation package
- Updated Phase 3 RAD
- Updates to the Phase 3 DAP
  - » All code, test data, and SPSRB docs

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Phase 3 CDR Report

Presented by

Tom King

Phase 3 CDR Report

- The NUCAPS Phase Review Item Disposition (RID) spreadsheet (Shared on Google Docs)
- The RID covers the following:
  - Open PDR Risks and Actions at CDR
  - Open CDR Risks and Actions
  - Open TRR Risks and Actions
  - Phase 1 AAR Risks and Actions
  - Phase 2 AAR Risks and Actions
  - Phase 3 CDR Risks and Actions
- Risks closed in previous reviews are not shown here, but are located in the RID.
- Risks shown here that are marked as “closed” will be closed with the approval of this review.

PDR Risks and Actions

- **Risk #9:** Project metadata do not meet user requirements
- **Risk Assessment:** Medium
  - » Granule-level metadata have been created, but still needs to be reviewed by CLASS. That effort and the SA development haven't moved forward because of a lack of funding on the CLASS side. CLASS wants to begin archiving NUPs in Spring 2013. However, NUCAPS EDR capability needs to be delivered now for AWIPS to receive EDRs in January 2013. Therefore, CLASS will receive the EDRs and metadata in Spring 2013, but if they don't approve of the metadata, they will have to wait for the next NUCAPS DAP (version 3 to be delivered 09/25/2013) for any modifications.
- **Impact:** Medium
- **Likelihood:** Medium
- **Risk Mitigation:**
  - » Work with CLASS on the SA and making metadata available to them for approval.
  - » Work with Jay Morris at CLASS via the STAR CSWG to update and formalize the metadata methodology.
- **Status:** Closed

CDR Risks and Actions

- **Risk #30:** The current CrIS instrument's spectral resolution in the short-wave band is too low for retrieval of carbon products within requirements.
- **Risk Assessment:** Low
  - » New risk at CDR. The NPP CrIS will not be able to maintain continuity on this product.
  - » Even though the likelihood is high, we've assessed this issue as low because our one operational user (AWIPS) has not requested CO.
- **Impact:** Low
- **Likelihood:** High
- **Risk Mitigation:**
  - » J1 will have full spectral resolution and preparation for implementation is ongoing.
- **Status:** Open

TRR Risks and Actions

- **Risk #38:** NDE may have to deliver the system to operations without the completed documentation. SPSRB may or may not find this acceptable.
- **Risk Assessment:** High
  - » New risk added after TRR. This was a risk for the BUFR toolkit, but it also applies to this project as well.
- **Impact:** High
- **Likelihood:** Medium
- **Risk Mitigation:**
  - » NDE will work with STAR and OSPO PALs to complete the required sections of the SPSRB documents.
- **Status:** Closed

ARR Phase 1 Risks and Actions

- **Risk #39:** The review team would like to have a Software Code Review prior to operational implementation.
- **Risk Assessment:** Low
  - » The code was prepared and delivered to OSPO in June 2012, but OSPO could not review it because they had not received funding to make NPP operational. This is still true as of today.
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » After IASI code review, we cleaned up NUCAPS code on our side so it would meet operational requirements.
  - » We could do an SCR after delivery to NDE, once OSPO gets funding. Then, do a delta delivery.
- **Status:** Closed (SCR held on 2/20/2013)

ARR Phase 2 Risks and Actions

- **Risk #40:** NUCAPS ATBD is not finished.
- **Risk Assessment:** Low
  - » The risk should be low given that an ATBD does exist for AIRS and IASI, but it is not in a document following the SPSRB ATBD template.
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Complete the ATBD
- Status: Closed

ARR Phase 2 Risks and Actions

- **Risk #41:** NUCAPS EDR and CCR files will initially fail to be archived because CLASS does not currently have funding.
- **Risk Assessment:** High
  - » NUCAPS EDR and CCR files will initially fail to be archived because CLASS does not currently have funding.
- **Impact:** High
- **Likelihood:** High
- **Risk Mitigation:**
  - » Expedite work on the Submission Agreement as soon as CLASS has its funding to minimize the amount of data lost to the archive.
- **Status:** Closed

ARR Phase 2 Risks and Actions

- **Risk #42:** PAL and his team need to complete assigned sections of the SPSRB documents as they are already funded to do so.
- **Risk Assessment:** Low
  - » OSPO will not have completed documentation at the time of operational implementation.
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » NUCAPS team will deliver the DAP or at least the document part to OSPO so they can finish their sections.
- **Status:** Closed

ARR Phase 2 Risks and Actions

- **Risk #43:** PAL needs to identify the trace gas community users.
- **Risk Assessment:** Low
  - » This needs to be done prior to the operational briefing of the SPSRB to ensure operational approval for the project.
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » AK Sharma will work with Donna McNamara and others to identify who the trace gas users are for NUCAPS.
- **Status:** Closed (AK has identified Trace Gas users but users need to fill out DAR forms in order to get access. This is still pending.)

CDR Phase 3 Risks and Actions

- **Risk #45:** There are concerns about the CrIS granules having to wait for the VIIRS CM and CTH before they can be processed. NWP may not be getting data in a timely manner.
- **Risk Assessment:** Low
- **Impact:** Medium
- **Likelihood:** Low
- **Mitigation:**
  - » Evaluate and characterize the distribution of the delay to understand this risk and develop a solution. Andrew Collard indicated that a 10 minute wait for VIIRS would be the maximum acceptable additional delay to the current NUCAPS BUFR. Work with NDE to implement a timeout if VIIRS data fails to arrive.
- **Status:** Closed (see validation section)

CDR Phase 3 Review Report

- 9 Risks Total
  - » 1 PDR
  - » 1 CDR Phase 1
  - » 1 TRR Phase 1
  - » 1 ARR Phase 1
  - » 4 ARR Phase 2
  - » 1 CDR Phase 3
- 8 risks can be closed
- 1 risk remain open
  - » 1 CDR Phase 1

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Phase 3 Requirements

Presented by

Tom King

Requirements

- This section is broken into 2 parts
  - » NUCAPS Phases 1-3
  - » NUCAPS OLR requirements
- All requirements for Phases 1-3 are presented in this section, but we'll only cover new or updated requirements since Phase 3 CDR.
- The following color coding is used:
  - » Yellow - Basic requirements
  - » Green - New or updated requirements since Phase 3 CDR
  - » Gray - Removed requirements
- The revised Requirements Allocation Documents (RAD) are available (Shared on Google Docs)

NUCAPS Requirements – Basic Requirement 0.0

- **Requirement 0.0:** *The NUCAPS project shall adopt the standard practices of the STAR Enterprise Product Lifecycle (EPL), as established in the STAR EPL process assets v2.0, except as specified in requirement 0.1* (process)
- **Requirement 0.1:** The checklist items for the NUCAPS reviews shall be tailored. The tailored checklist items shall be established in the NUCAPS project file "NUCAPS Review Checklists v1r0.xls". (process).
- **Requirement 0.1.1:** The NUCAPS project file "NUCAPS Review Checklists v1r0.xls" shall be established and maintained under CM in the NUCAPS project artifact repository. (process)
- **Requirement 0.1.2:** The review artifacts specified in the file "NUCAPS Review Checklists v1r0.xls" shall be available to reviewers in advance of each review. (process)

NUCAPS Requirements – Basic Requirement 1.0

- **Requirement 1.0***: The NUCAPS shall generate CrIS thinned radiance products for NWP center users.* (product, functional)
- **Requirement 1.1**: *For NCEP, NUCAPS shall generate CrIS full spatial resolution granule files containing 399 CrIS channels.* (system, functional)
- **Requirement 1.1.1**: *The CrIS radiances for shall be apodized.* (product)
- **Requirement 1.1.1.1**: *The type of apodization shall be specified in the delivered system documentation.* (delivery, product)
- **Requirement 1.1.2**: *The NUCAPS shall develop the BUFR table for the CrIS radiances.* (system, functional)
- **Requirement 1.1.2.1**: *The CrIS radiance data for shall be represented as scaled radiances in the BUFR (instead of brightness temperatures).* (system, functional)

NUCAPS Requirements – Basic Requirement 1.0

- **Requirement 1.1.2.1.1**: *The BUFR radiance scaling shall allow for the storage of negative radiances.* (product)
- **Requirement 1.1.2.2**: *The radiance data shall be represented by 16 bit words in the BUFR format.* (system, functional)
- **Requirement 1.1.2.3**: *The NUCAPS shall supply the NDE System Development Team (SDT) with BUFR table as well as the frequency list.* (product, operational)
- **Requirement 1.1.2.4**: *The BUFR table shall contain a table 8 descriptor to allow users to differentiate between (a) CrIS radiances, (b) CrIS cloud-cleared radiances, and (c) CrIS principal component reconstructed radiances.* (product)
- **Requirement 1.1.2.5**: *The BUFR table shall use delayed replication for writing subsets of channels.* (product)
- **Requirement 1.1.2.6**: *The BUFR must contain the VIIRS derived cloud fraction and cloud height.* (performance)
- **Requirement 1.1.2.6.1**: *The VIIRS fields of view must be collocated to those of CrIS.* (performance)

NUCAPS Requirements – Basic Requirement 1.0

- **Requirement 1.1.2.7:** *The BUFR table shall contain the following variables. Variables with parentheses indicate dimensionality.* (product)

Satellite ID
ID of originating center
Satellite instrument
Satellite classification
Year
Month
Day
Hour
Minute
Second
Subsattellite Latitude
Subsattellite Longitude
Latitude
Longitude
Satellite Height
Satellite Zenith
Satellite Azimuth
Solar Zenith
Solar Azimuth

Orbit Number
Granule Number
Scan Line
CrIS FOR
CrIS FOV
Land Fraction
Land-Sea-Coast-Flag
Cloud Fraction
Cloud Height
CrIS Channels(1305)
CrIS Radiances(1305)
CrIS Quality Flag 1
CrIS Quality Flag 2(3)
CrIS Quality Flag 3(3)
CrIS Quality Flag 4(3)
CrIS Quality Flag 5
CrIS Quality Flag 6

NUCAPS Requirements – Basic Requirement 1.0

- **Requirement 1.1.3**: *The product for shall be available within three hours of observation.* (performance)

- **Requirement 1.1.4**: *The NUCAPS shall write CrIS radiance data for NCEP into netCDF4 format so they can be reformatted downstream into BUFR by the N4RT toolkit. Therefore, the contents of the BUFR table defined in section 1.1.2 are, at least, a subset of the netCDF4 output files.* (system, functional)

- **Requirement 1.1.4.1:** *The contents of the BUFR table defined in Requirement 1.1.2 are, at least, a subset of the netCDF4 output files. (system functional)*

- **Requirement 1.5:** *For EUMETSAT, NUCAPS shall generate CrIS full spatial resolution granule files containing all CrIS FOVs and FORs for all 1305 channels. All the other derived requirements for the NCEP product in section 1.1 also apply to this requirement.*

NUCAPS Requirements – Basic Requirement 1.0

- **Requirement 1.2 - Removed**: *For NRL and FNMOC, NUCAPS shall generate CrIS spatially thinned radiance granule files containing the warmest CrIS FOV per FOR for approximately 399 channels.* (system, functional)

  REMOVED: NRL and FNMOC will use the CrIS full channel set from the AirForce (email from Ben Ruston 5/19/2011)

- **Requirement 1.2.1 - Removed**: *The NUCAPS shall write CrIS thinned radiances for NRL and FNMOC into netCDF4 format so the NDE tailoring can convert it into BUFR format.* (system, functional)

- **Requirement 1.2.1.1 - Removed**: *In addition to the variables listed in 1.1.2.7, the BUFR table shall include "ascending and descending flag" variable.* (product)

- **Requirement 1.3:** *For GMAO, NUCAPS shall generate full spatial resolution CrIS radiance granule files for approximately 399 channels.* (system, functional)

- **Requirement 1.3.1:** *The NUCAPS shall write CrIS thinned radiances for GMAO into netCDF4 format so the NDE tailoring tool can convert it into BUFR format.* (system, functional)

NUCAPS Requirements – Basic Requirement 2.0

- **Requirement 1.4**: *The NUCAPS Integrated Product Team (IPT) shall perform validation and verification of CrIS thinned radiances.* (system, operational)

- **Requirement 1.4.1**: *The NUCAPS IPT shall verify that the thinned radiances in the output netCDF4 files are generated correctly and document this in the Validation and Verification Report (VVR).* (system, operational)

- **Requirement 1.5**: *For EUMETSAT, NUCAPS shall generate CrIS full spatial resolution granule files containing all CrIS FOVs and FORs for all 1305 channels. All the derived requirements for the NCEP product in section 1.1 also apply to this requirement.* (system, operational)

- **Requirement 1.6**: *The NUCAPS system shall have production rules and the capabilities to produce the CrIS BUFR without VIIRS CTH and CM if these 2 product are more than 10 minutes later than the target CrIS granule.* (system, operational)

  Note: Andrew Collard has indicated that NCEP does not want to wait more than 10 minutes for VIIRS data to arrive for the processing. In addition, Andrew has indicated that NCEP is willing to accept CrIS BUFR without the collocated VIIRS in these instances.

NUCAPS Requirements – Basic Requirement 2.0

- **Basic Requirement 2.0 - Removed**: *The NUCAPS shall generate granule files of Principal Components for NRL and FNMOC.* (product, functional)

  NRL and FNMOC will use the full 1305 channel set from the AirForce (email from Ben Ruston 5/19/2011)

- **Requirement 2.1 - Removed**: *The NUCAPS shall generate the eigenvector files that are needed to generate the principal components.* (product, functional)

- **Requirement 2.1.1 - Removed**: *The NUCAPS shall generate the global coverage input datasets used for generating eigenvector files.* (product, functional)

- **Requirement 2.1.2 - Removed**: *The NUCAPS shall supply NDE with the eigenvector files, to give to the customer, during delivery of the DAP.* (product, operational)

NUCAPS Requirements – Basic Requirement 2.0

- **Requirement 2.2 - Removed:** *The NUCAPS shall generate the Principal Component granule files for NRL and FNMOC from the CrIS warmest FOV per FOR.* (product, functional)
- **Requirement 2.2.1 - Removed:** *The NUCAPS shall write principal components into NetCDF4 format.* (system, functional)
- **Requirement 2.2.1 - Removed:** *The NUCAPS shall write principal components into NetCDF4 format.* (system, functional)
- **Requirement 2.2.2 - Removed:** *The NUCAPS IPT shall perform validation and verification of principal components products for NRL and FNMOC.* (system, functional)
- **Requirement 2.2.2.1 - Removed:** *The NUCAPS IPT shall verify that the principal components are being generated correctly and document these results in the VVR.* (system, operational)

NUCAPS Requirements – Basic Requirement 2.0

- **Requirement 2.3 - Removed:** *The NUCAPS shall generate the Principal Component granule files for NRL and FNMOC meeting the following temporal specifications.* (product, functional)

- **Requirement 2.4 - Removed**: *The NUCAPS shall generate the Principal Component files meeting the following spatial specifications:*
  - *Global coverage.*
  - *Horizontal resolution of* ≈50 km (Set of 9 CrIS FOV's collocated with ATMS FOR).

- **Requirement 2.5 - Removed**: *The NUCAPS shall generate approximately 85 principal components from the original 1305 CrIS channel set.*

NUCAPS Requirements – Basic Requirement 3.0

- **Basic Requirement 3.0:** *The NUCAPS shall generate trace gas profile products for U.S users.* (product, functional)

- **Requirement 3.1:** *The NUCAPS shall generate profiles of following trace gases for NRL and FNMOC, derived from a retrieval of CrIS/ATMS radiances:* (product, functional)

  Ozone
  Carbon Monoxide
  Carbon Dioxide
  Methane
  Volcanic Sulfur Dioxide Product
  Nitric Acid
  Nitrous Oxide

NUCAPS Requirements – Basic Requirement 3.0

- **Requirement 3.1.1**: *The NUCAPS trace gas profiles for NRL and FNMOC shall consist of at 100 levels.* (product, functional)

- **Requirement 3.1.2**: *The NUCAPS trace gas profiles for NRL and FNMOC shall meet performance specifications*. (product, functional)

- **Requirement 3.1.2.1**: *Trace gas profiles for FNMOC and NRL shall have the following accuracy*

  O3: 20%/5-km near tropopause

  O3: 10% total column

  CO: 40% mid-trop column (w/ 0.2 cm OPD SW band)

  CH4: 1% mid-trop column

  CO2: 1% mid-trop column

  HNO3: 50% mid-trop column. (product, performance)

- **Requirement 3.1.2.2**: *Trace gas profiles for FNMOC and NRL shall meet the following temporal specifications:*

  Timeliness of less than 3 hours after observation.

  Latency of no more the 15 minutes after granule data are available.

NUCAPS Requirements – Basic Requirement 3.0

- **Requirement 3.1.2.3**: *Trace gas profiles for FNMOC and NRL shall meet the following spatial specifications:*
  - *Global coverage.*
  - *Horizontal resolution of* ≈50 km (Set of 9 CrIS FOV's collocated with ATMS FOR).
- **Requirement 3.1.2.4**: *Trace gas profiles for FNMOC and NRL shall include the vertical weighting functions.*
- **Requirement 3.1.3**: *The NUCAPS shall produce the trace gas products in netCDF4 format for NRL and FNMOC.* (system, functional)
- **Requirement 3.2:** *The NUCAPS shall generate trace gas profile products for CLASS derived from CrIS/ATMS radiances.* (system, functional)
- **Requirement 3.2.1:** *The NUCAPS shall write the trace gas profile products for CLASS in netCDF4 format.* (system, functional)

NUCAPS Requirements – Basic Requirement 3.0

- **Requirement 3.2.2:** *The EDR product for CLASS shall contain the following trace gas profiles and surface and cloud properties calculated on each CrIS FOR:*

Time
Latitude
Longitude
View Angle
Satellite Height
Mean CO_2
Solar Zenith
Ascending/Descending Status
Topography
Land-Sea-Coast Flag
Surface Pressure
Skin Temperature
MIT Skin Temperature
First Guess Skin Temperature
Microwave Surface Class
Microwave Surface Emissivity
Number of Cloud Layers
Retrieval Quality Flag

Cloud Top Pressure
Cloud Top Fraction
Pressure (at 100 levels)
Effective Pressure (at 100 levels)
Temperature (at 100 levels)
MIT Temperature (at 100 levels)
First Guess Temperature (at 100 levels)
H_2O layer column density (at 100 levels)
H_2O mixing ratio (at 100 levels)
First Guess H_2O layer column density (at 100 levels)
First Guess H_2O mixing ratio (at 100 levels)
MIT H_2O layer column density (at 100 levels)
MIT H_2O mixing ratio (at 100 levels)
O_3 layer column density (at 100 levels)
O_3 mixing ratio (at 100 levels)
First Guess O_3 layer column density (at 100 levels)
First Guess O_3 mixing ratio (at 100 levels)
Liquid H_2O layer column density (at 100 levels)
Liquid H_2O mixing ratio (at 100 levels)

NUCAPS Requirements – Basic Requirement 3.0

Ice/liquid flag (at 100 levels)
CH_4 layer column density (at 100 levels)
CH_4 mixing ratio (at 100 levels)
CO_2 mixing ratio (at 100 levels)
HNO_3 layer column density (at 100 levels)
HNO_3 mixing ratio (at 100 levels)
N_2O layer column density (at 100 levels)
N_2O mixing ratio (at 100 levels)
SO_2 layer column density (at 100 levels)
SO_2 mixing ratio (at 100 levels)
Microwave emissivity
MIT microwave emissivity
Infrared emissivity
MIT infrared emissivity
Infrared surface emissivity
First Guess infrared surface emissivity
Infrared surface reflectance
Atmospheric Stability
Cloud infrared emissivity
Cloud reflectivity

NUCAPS Requirements – Basic Requirement 3.0

- **Requirement 3.2.3**: *The NUCAPS shall generate granule-level ISO-compliant metadata for CLASS.* (product, quality)

- **Requirement 3.2.4**: *The NUCAPS IPT shall create a Submission Agreement (SA) with CLASS. The SA shall include all information regarding the archival of EDR product granule files.* (product, quality)

- **Requirement 3.3**: *The NUCAPS shall generate trace gas profiles for GMAO, derived from CrIS/ATMS radiances.* (system, functional)

- **Requirement 3.3.1**: *The NUCAPS trace gas profiles for GMAO shall meet performance specifications.* (system, functional)

NUCAPS Requirements – Basic Requirement 3.0

- **Requirement 3.3.1.1**: *Trace gas profiles for GMAO shall have the following accuracy*
  - *O_3: 20%/5-km near tropopause*
  - *O_3: 10% total column*
  - *CO: 40% mid-trop column (w/ 0.2 cm OPD SW band)*
  - *CH_4: 1% mid-trop column*
  - *CO_2: 1% mid-trop column*
  - *HNO_3: 50% mid-trop column.* (product, performance)

- **Requirement 3.3.1.2**: *Trace gas profiles for GMAO shall meet the following temporal specifications:*
  - *Timeliness of less than 3 hours after observation.*
  - *Latency of no more the 15 minutes after granule data are available.*

- **Requirement 3.3.1.3**: *Trace gas profiles for GMAO shall meet the following spatial specifications:*
  - *Global coverage.*
  - *Horizontal resolution of* $\approx$50 km (Set of 9 CrIS FOV's collocated with ATMS FOR).

NUCAPS Requirements – Basic Requirement 3.0

- **Requirement 3.3.1.4**: *Trace gas profiles for GMAO shall include the vertical weighting functions.*
- **Requirement 3.4**: *The NUCAPS IPT shall perform tests to demonstrate that all trace gas profile products are being produced correctly and to user specification.* (system, operational)
- **Requirement 3.4.1**: *The results of the tests on the trace gas profile products shall be documented in the VVR.* (system, operational)
- **Requirement 3.5**: *The NUCAPS software shall perform a local angle correction to the CrIS radiances to generate retrievals.* (system, functional)
- **Requirement 3.6**: *The NUCAPS software will need to extract topography and land mask information from a Digital Elevation Model (DEM).* (system, functional)
- **Requirement 3.7**: *The NUCAPS software will need to resample the ATMS FOV to the resolution of the CrIS field of regard.*

NUCAPS Requirements – Basic Requirement 3.0

- **Requirement 3.8**: *The NUCAPS software will produce an SO_2 alert file if an SO_2 anomaly is detected by the retrieval preprocessing.*
- **Requirement 3.9:** *The NUCAPS software shall generate NOAA-Unique profiles for AWIPS derived from CrIS/ATMS radiances.*
- **Requirement 3.9.1:** *The NUCAPS shall write the retrieval products for AWIPS in netCDF4 format.*

NUCAPS Requirements – Basic Requirement 3.0

- **Requirement 3.9.2:** *The retrieval product for AWIPS shall contain the following variables.*

- *Note: This is a subset of the existing set of variables produced by the retrieval. It is our understanding that NDE will extract this subset of variables.*

CrIS FOR	Time
Latitude	Longitude
View Angle	Ascending/Descending Status
Topography	Surface Pressure
Skin Temperature	Quality Flag
Pressure (at 100 levels)	Effective Pressure (at 100 levels)
Temperature (Kelvin at 100 levels)	H2O (g/g at 100 levels)
O3 (ppb at 100 levels)	Liquid H2O (g/g at 100 levels)
Ice/Liquid Flag (at 100 levels)	SO2 (g/g at 100 levels)
Stability parameters	

NUCAPS Requirements – Basic Requirement 3.0

- **Requirement 3.10:** *The retrieval product shall use the following data as dynamic input.*
  - *One CrIS SDR granule file*
  - *One CrIS SDR geolocation granule file*
  - *Three ATMS TDR granule files adjacent to the CrIS target granule*
  - *Three ATMS TDR geolocation granule files adjacent to the CrIS target granule*
  - *Two GFS forecasts files whose forecast times surround that of the CrIS granule's middle observation time.*

Note: Surrounding ATMS granules are needed for both the ATMS/CrIS collocation (because of the scan misalignment) and the ATMS footprint resampling.

NUCAPS Requirements – Basic Requirement 4.0

- **Basic Requirement 4.0**: *The NUCAPS shall generate CrIS Cloud-clear Radiance (CCR) products for NWP centers and CLASS.* (product, operational)

- **Requirement 4.1**: *The NUCAPS shall generate CrIS CCR products for GMAO.* (system, operational)

- **Requirement 4.1.1**: *CCR products for GMAO shall have an accuracy of less then 1 Kelvin.* (system, functional)

- **Requirement 4.1.2**: *CCR products for GMAO shall meet the following temporal specifications. (system, functional):*

  Timeliness of less than 3 hours after observation.

  Latency of no more the 15 minutes after granule data are available.

NUCAPS Requirements – Basic Requirement 4.0

- **Requirement 4.1.3**: *CCR products for GMAO shall meet the following spatial specifications:*

  Global coverage.

  Horizontal resolution of ≈50 km (Set of 9 CrIS FOV's collocated with ATMS FOR).

- **Requirement 4.2**: *The NUCAPS shall generate CrIS CCR products for CLASS.* (system, operational)

- **Requirement 4.2.1**: *The NUCAPS shall write the CrIS CCR products for CLASS in netCDF4 format.* (system, functional)

- **Requirement 4.2.2**: *The product shall contain CrIS cloud-cleared radiances from all channels.* (product, quality)

- **Requirement 4.2.3**: *The NUCAPS shall generate for CLASS ISO-compliant granule-level metadata for the CCR product.* (product, quality)

NUCAPS Requirements – Basic Requirement 4.0

- **Requirement 4.2.4**: *The NUCAPS IPT shall create a Data Submission Agreement (DSA) with CLASS. The DSA shall include all information regarding the archival of CrIS CCR granule files.* (product, quality)

NUCAPS Requirements – Basic Requirement 5.0

- **Basic Requirement 5.0**: *The NUCAPS shall generate daily global products for system validation, maintenance, and development.* (product, operational)

- **Requirement 5.1**: *The NUCAPS shall generate matchup datasets between satellite measurements and other existing correlated instruments. These products are for STAR.* (system, operational)

- **Requirement 5.1.1**: *The NUCAPS shall generate daily matchups for CrIS and ATMS radiances.* (system, operational)

- **Requirement 5.1.1.1**: *The NUCAPS radiance matchups file shall be a direct access binary file.* (system, operational)

- **Requirement 5.1.1.1.1**: *The NUCAPS shall have code that can write radiance matchup files in direct access binary format.* (product, functional)

- **Requirement 5.1.1.2**: *The NUCAPS radiance matchups file shall be available one day after observation.* (system, operational)

NUCAPS Requirements – Basic Requirement 5.0

- **Requirement 5.1.2**: *The NUCAPS shall generate daily matchups for the CrIS/ATMS retrievals.* (system, operational)
- **Requirement 5.1.2.1**: *The NUCAPS daily matchups file shall be a direct access binary file.* (system, operational)
- **Requirement 5.1.2.1.1**: *The NUCAPS shall have code that can write the retrieval matchup files in direct access binary format.* (product, functional)
- **Requirement 5.1.2.2**: *The NUCAPS daily matchups file shall be available one day after observation.* (system, operational)
- **Requirement 5.2**: *The NUCAPS shall generate gridded products for STAR.* (system, operational)
- **Requirement 5.2.1**: *The NUCAPS shall generate daily Principal Component and reconstructed radiance gridded product files at 0.5X2.0 and 3.0X3.0 degree resolution for STAR.* (product, functional)

NUCAPS Requirements – Basic Requirement 5.0

- **Requirement 5.2.1.1**: *The NUCAPS principal component and reconstructed radiance gridded files shall be in direct access binary format.* (product, functional)

- **Requirement 5.2.1.1.1**: *The NUCAPS shall have code that can write principal component gridded files in direct access binary format.* (product, functional)

- **Requirement 5.2.1.2**: *The NUCAPS principal component and reconstructed radiance gridded files shall be available one day after observation.* (system, operational)

- **Requirement 5.2.1.3:** *The NUCAPS shall generate the eigenvector files that are needed to generate the principal components.*

- **Requirement 5.2.1.3.1:** *The NUCAPS shall generate the global coverage input datasets used for generating eigenvector files.*

- **Requirement 5.2.1.4:** *The NUCAPS shall generate the Principal Component files meeting the following spatial specifications:*

  Global coverage.

  Horizontal resolution of ≈50 km (Set of 9 CrIS FOV's collocated with ATMS FOR).

NUCAPS Requirements – Basic Requirement 5.0

- **Requirement 5.2.1.5:** *The NUCAPS shall generate approximately 85 principal components from the original 1305 CrIS channel set.*
- **Requirement 5.2.2**: *The NUCAPS shall generate daily CrIS/ATMS radiance gridded product files at 0.5X2.0 and 3.0X3.0 degree resolutions for STAR.* (product, functional)
- **Requirement 5.2.2.1**: *The NUCAPS CrIS/ATMS radiance gridded files shall be in direct access binary format.* (product, functional)
- **Requirement 5.2.2.1.1**: *The NUCAPS shall have code that can write radiance gridded files in direct access binary format.* (product, functional)
- **Requirement 5.2.2.2**: *The NUCAPS CrIS/ATMS radiance gridded files shall be available one day after observation.* (system, operational)
- **Requirement 5.2.3**: *The NUCAPS shall generate daily CrIS/ATMS EDR gridded product files at 0.5X2.0 and 3.0X3.0 degree resolutions for STAR.* (product, functional)

NUCAPS Requirements – Basic Requirement 5.0

- **Requirement 5.2.3.1**: *The CrIS/ATMS EDR gridded files shall be in direct access binary format.* (product, functional)

- **Requirement 5.2.3.1.1**: *The NUCAPS shall have code that can write the EDR gridded files in direct access binary format.* (product, functional)

- **Requirement 5.2.3.2**: *The NUCAPS CrIS/ATMS EDR gridded files shall be available one day after observation.* (system, operational)

- **Requirement 5.2.4**: *The NUCAPS shall generate daily CrIS CCR gridded product files at 0.5X2.0 and 3.0X3.0 degree resolution for STAR.* (product, functional)

- **Requirement 5.2.4.1**: *The NUCAPS daily CrIS CCR gridded files shall be in direct access binary format.* (product, functional)

- **Requirement 5.2.4.1.1**: *The NUCAPS shall have code that can write the CCR gridded files in direct access binary format.* (product, functional)

NUCAPS Requirements – Basic Requirement 5.0

- **Requirement 5.2.4.2**: *The NUCAPS daily CrIS CCR gridded files shall be available one day after observation.* (system, operational)

NUCAPS Requirements – Basic Requirement 6.0

- **Basic Requirement 6.0**: *The NUCAPS package shall be delivered to NDE for integration into the NDE Data Handling System (DHS). The following is required as part of this delivery.* (system, operational)

- **Requirement 6.1**: *NUCAPS shall be delivered in the form of a Delivered Algorithm Package (DAP) whose name and contents are defined in the NDE document entitled "Algorithm Delivery Standards, Integration, and Test V1.3". (system, delivery)*

- **Requirement 6.2**: *The NUCAPS shall be able to run on the NDE SADIE platform.* (system, functional)

- **Requirement 6.3**: *The NUCAPS unit driver scripts shall be able to read and handle the content from a Process Control File (PCF) passed to them from the NDE Product Generation Manager (PGM) for each run of the script.* (system, functional)

- **Requirement 6.4**: *The NUCAPS unit driver scripts shall each produce a Process Status File (PSF) after each run of the script in the format required by the NDE Data Handling System (DHS).* (system, functional)

NUCAPS Requirements – Basic Requirement 6.0

- **Requirement 6.5**: *The NUCAPS code shall adhere to the STAR/NDE coding and ESPC security standards.* (system, functional)

- **Requirement 6.6**: *The NUCAPS software shall be able to write all output product into CF-compliant netCDF4 format.* (system, functional)

- **Requirement 6.7:** *The NUCAPS IPT shall deliver an System Maintenance Manual. (product, operational). This is an SPSRB required document.*

- **Requirement 6.8:** *The NUCAPS IPT shall deliver a External Users Manual for NUCAPS products. (product, operational). This is an SPSRB required document.*

- **Requirement 6.9**: *Delivered code within the DAP must compile without errors or unexpected warnings using one or more of the following compilers:*

  xlC version 9.0 or greater (C/C++); gcc version 3.4.6 or greater (C/C++)

  xlf version 11.1 or greater (Fortran 77/90/95)

  java version 1.4.2 or greater. (system, functional)

NUCAPS Requirements – Basic Requirement 6.0

- **Requirement 6.10**: *Delivered Perl scripts must be compatible with version 5.8.2 or greater.* (system, functional)

- **Requirement 6.11:** *Delivered DAP must be compressed using gzip and follow the following naming convention:*

  Project-name_algorithm-identifier_Vnumber_date.tar.gz

- **Requirement 6.12:** *All NUCAPS output product files shall adhere to the naming convention specified in the NDE DAP Content Standards document.*

- **Requirement 6.13**: *Delivered code within the DAP must compile without errors using the Linux GNU Fortran and C/C++ compiler version 4.1.2 or greater* (system, functional)

NUCAPS Requirements – Basic Requirement 7.0

- **Basic Requirement 7.0**: *The delivered NUCAPS system shall be able to read and check NDE input data.*

- **Requirement 7.1**: *All NUCAPS software units shall be able to perform data range checks on the input HDF5 files provided by the NDE DHS.* (system, functional)

- **Requirement 7.2**: *The NUCAPS software shall be able to read the CrIS, ATMS and VIIRS HDF5 input data supplied by NDE.* (system, functional)

- **Requirement 7.2.1**: *The NUCAPS software shall be able to read the VIIRS Cloud Mask and Cloud Top Height produced by IDPS.* (system, functional)

- **Requirement 7.3**: *The NUCAPS software shall not process any instrument data if the input file ATMS or CrIS metadata indicates the platform is undergoing a maneuver. If the CrIS instrument is being calibrated, no data will be processed as well.*

NUCAPS Requirements – Basic Requirement 8.0

- **Basic Requirement 8.0:** *The NUCAPS software shall comply with OSPO coding standards identified in the OSPO security checklist.*

NUCAPS Requirements – Basic Requirement 9.0

- **Basic Requirement 9.0:** *The NUCAPS software shall produce data files for science quality monitoring of SDR and EDR data.*

- **Requirement 9.1:** *The NUCAPS software shall produce retrieval output statistics files from each retrieval run to monitor the CrIS EDR quality.*

- **Requirement 9.2:** *The NUCAPS software shall produce principal component score statistics files for each granule to monitor the CrIS SDR quality.*

Note: These files are produced in support of OSPO science quality monitoring efforts.

NUCAPS Requirements – Basic Requirement 10.0

- **Basic Requirement 10.0:** *The NUCAPS science team shall evaluate the need for an Instrument Line Shape (ILS) correction. If necessary, this correction will be implemented in the NUCAPS retrieval algorithm. If not, scientific justification must be provided for why it is not necessary.*

CrIS OLR
Project Requirements

- CrIS OLR Project requirements are present in this section.
- These were are shown in a separate section because these money to fund this portion of the project is separate from the regular NUCAPS funding.
- We will not cover these requirements as they were sent out for review on 9/30/2013.

Basic Requirement 0.0

- **CrIS-OLR-R 0.0:** *The CrIS OLR development project shall adopt the standard practices of the Satellite Product and Services Review Board (SPRB).*

  » **Driver:** *STAR Enterprise Product Lifecycle (EPL)*. The SPSRB process has been updated by incorporating aspects of the STAR EPL Process.

Basic Requirement 0.0

- **CrIS-OLR-R 0.1:** *The CrIS OLR development project practices shall be tailored from the SPSRB process.*

  » This requirement should be met by following the SPSRB process, as long as the tailoring does not introduce an incompatibility.

Basic Requirement 1.0

- **CrIS-OLR-R 1.0:** *The CrIS OLR package shall contains software to generate an Outgoing Longwave Radiation (OLR) product.*

- **Driver:** This basic requirement is traced to user needs as stated in SPSRB User Request #0907-0015 for NCEP/CPC.

Basic Requirement 1.0

- **CrIS-OLR-R 1.1:** *The OLR shall have horizontal resolution of each CrIS FOV.*
  - » User Request from NCEP/CPC.
- **CrIS-OLR-R 1.2:** *The OLR shall have a measurement accuracy < 0.2 W/m^2.*
  - » User Request from NCEP/CPC. Specifications are based on CERES OLR.
  - » Note: these specs are better than those assigned in the L1RD sup. V 2.9.

Basic Requirement 1.0

- **CrIS-OLR-R 1.3:** *The OLR shall have a measurement accuracy < 5 W/m^2*

  - » User Request from NCEP CPC. Specifications are based on CERES OLR.
  - » Note: these specs are better than those assigned in the L1RD sup. V 2.9.

- **CrIS-OLR-R 1.4:** *The OLR shall be produced within three hours of observation.*

  - » User Request from NCEP CPC. The data should reach the users prior to forecast cycles.

Basic Requirement 1.0

- **CrIS-OLR-R 1.5:** *The OLR product shall be written in netCDF4 format.*

User Request from NCEP CPC. Current QC monitoring tools operate on netCDF3 files.

Basic Requirement 1.0

- **CrIS-OLR-R 1.6:** *The CrIS OLR product shall be validated.*

- **CrIS-OLR-R 1.6.1:** *Routine data range checks in near real time to flag anomalous OLR values shall be performed.*

  - The OLR software will contain range checks to ensure that the OLR data will flag data outside of the range.

Basic Requirement 1.0

- **CrIS-OLR-R 1.6.2:** *The Matchup datasets between satellite measurements and other existing correlated instruments shall be generated.*

    The CrIS OLR product will be compared with that of the CERES and IASI OLR.

- **CrIS-OLR-R 1.6.3:** *Test OLR product files shall be sent to the customers in near real-time mode to ensure the product meets customer's needs and to allow them to test their product ingestion.*

    » Sample CrIS OLR product files will be made available to CPC on an ftp server for evaluation prior to delivery of the capability to operations. This will ensure that the product file meet user needs and expectations and facilitate user readiness.

Basic Requirement 1.0

- **CrIS-OLR-R 1.7:** *The CrIS OLR algorithm shall be implemented to generate the product to the required specifications.*

This is a requirement allocated to the code that generates OLR.

Basic Requirement 1.0

- **CrIS-OLR-R 1.7.1:** *The CrIS OLR code shall generate Outgoing Longwave Radiation from the CrIS SDR input.*
  - » This is allocated to the OLR code.
- **CrIS-OLR-R 1.7.2:***The CrIS OLR code shall use static regression coefficients to generate the OLR product.*
  - » This regression file will be generated by the science development team and will be read at run time by the OLR code.

Basic Requirement 1.0

- **CrIS-OLR-R 1.8:** *The CrIS OLR algorithm shall be implemented within NUCAPS system.*

- *See the NUCAPS RAD Version 1.4 for details about the NUCAPS requirements.*

- **CrIS-OLR-R 1.9:** *The CrIS OLR data files shall be archived at CLASS.*

Basic Requirement 1.0

- **CrIS-OLR-R 1.9.1:** *The CrIS Submission Agreement shall be developed and CrIS OLR netCDF4 granule files shall be added.*

- **CrIS-OLR-R 1.9.2:** *Metadata for the CrIS OLR netCDF files shall be generated for CLASS.*
  - » Metadata will be included at the header of the netCDF4 files.

Basic Requirement 2.0

- **CrIS-OLR-R 2.0:** *The CrIS OLR package shall have the QC monitoring capability.*

Driver: This basic requirement is traced to an OSPO need for QC monitoring.

Basic Requirement 2.0

- **CrIS-OLR-R 2.1:** *The CrIS OLR package output shall include overall quality control flags.*

  » Needed for distribution, archive, quality control and post-processing in the products files.

Basic Requirement 3.0

- **CrIS-OLR-R 3.0:** *A fully functional pre-operational package shall be created in the Development Environment at STAR.*

- **Driver:** This basic requirement is traced to a STAR need for a fully functional package ready for integration and system testing.

Basic Requirement 3.0

- **CrIS-OLR-R 3.1:** *The Development Environment shall use IBM P570 hardware.*
  - The orbit001b machine at STAR will be used.

- **CrIS-OLR-R 3.1.1:** *The Development Environment shall include a C/C++ compiler.*
  - » Needed for the C code. The orbit001b machine at STAR has this (IBM XL version 7.0 C/C++ compiler).
- **CrIS-OLR-R 3.1.2:***The Development Environment shall include Fortran compilers.*
  - » Needed for the Fortran 77 code and Fortran 90 code. The orbit001b machine at STAR has this (IBM version 10.01 Fortran 90 and 77 compilers).

Basic Requirement 3.0

- **CrIS-OLR-R 3.1.3:** *The Development Environment shall have 32 GB of memory.*

  » The orbit001b machine at STAR has this (16 CPUs with 2GB memory/CPU).

- **CrIS-OLR-R 3.1.4:** *The Development Environment shall have 3 TB of data storage.*

  - The orbit001b machine at STAR has this (5.5 TB SAN disk space).

Basic Requirement 3.0

- **CrIS-OLR-R 3.2:** *The Development Environment shall be capable of hosting unit tests.*

- **CrIS-OLR-R 3.2.1:** *The Development Environment shall have access to CrIS SDR data.*
  - » The orbit001b machine at STAR has access to these data through the STAR Collaborative Data Repository (SCDR). The NUCAPS system will preprocess the data used by the CrIS OLR package.

Basic Requirement 3.0

- **CrIS-OLR-R 3.3:** *The Development Environment shall host the CrIS OLR pre-operational package.*
  - » Complete test of the pre-operational code is expected before delivery to NDE.
- **CrIS-OLR-R 3.3.1:** *The CrIS OLR package will be integrated, run, and tested within NUCAPS.*
  - » The CrIS OLR development environment (orbit001b at STAR) will be the same machine as that used for NUCAPS. The updated version of NUCAPS will be delivered to NDE.

Basic Requirement 3.0

- **CrIS-OLR-R 3.4:** *The Development Environment shall use Linux hardware running RedHat 6 or the CENTOS equivalent.*
  - The orbit243l machine at STAR will be used.

- **CrIS-OLR-R 3.4.1:** *The Development Environment shall include GNU Fortran and C/C++ compilers version 4.1.2 or greater.*
  - » Needed for the Fortran 77 code and Fortran 90 code.

Basic Requirement 3.0

- **CrIS-OLR-R 3.4.2:** *The Development Environment shall have 2 GB of memory.*
  - » The orbit243l machine at STAR has this (4 CPUs with 2GB memory/CPU).
- **CrIS-OLR-R 3.4.3:** *The Development Environment shall have 3 TB of data storage.*
  - The orbit243l machine at STAR has this (4 TB SAN disk space).

Basic Requirement 4.0

- **CrIS-OLR-R 4.0:** *The CrIS OLR integrated pre-operational code shall be transitioned from the CrIS OLR Development Environment to the NDE Test Environment.*

  » **Driver:** NDE needs for a fully functional CrIS OLR package in its Test Environment.

Basic Requirement 4.0

- **CrIS-OLR-R 4.1:** *The integrated pre-operational package shall include all processing code and ancillary files needed to reproduce the unit test.*
  - » Specific items will be documented in the Code Test Review (CTR) package.

- **CrIS-OLR-R 4.2:** *The integrated pre-operational package shall include all input test data needed to reproduce the unit test.*
  - » Specific items will be documented in the Code Test Review (CTR) package.

Basic Requirement 4.0

- **CrIS-OLR-R 4.3:** *The integrated pre-operational package shall include all output data produced by the unit test.*
  - » Specific items will be documented in the Code Test Review (CTR) package.
- **CrIS-OLR-R 4.4:** *The integrated pre-operational CrIS OLR package shall be delivered to NDE within the NUCAPS Delivered Algorithm Package (DAP).*
  - » Code, test data, and documentation will be placed in a DAP whose contents are defined by the NDE DAP document: *Algorithm Delivery Standards, Integration, and Test V1.4*.

Basic Requirement 4.0

- **CrIS-OLR-R 4.4.1:** *The CrIS OLR algorithm theoretical basis shall be added to the NUCAPS Algorithm Theoretical Basis Document (ATBD) and delivered in an updated NUCAPS DAP.*
  - » The NUCAPS ATBD follows the SPSRB Version 2 document standards.
- **CrIS-OLR-R 4.4.2:** *The CrIS OLR software shall be documented within the NUCAPS System Maintenance Manual (SMM) and delivered in an updated NUCAPS DAP.*
  - » The NUCAPS SMM follows SPSRB Version 2 document standards.

Basic Requirement 4.0

- **CrIS-OLR-R 4.4.3:** *The CrIS OLR product user information shall be included in the NUCAPS External Users Manual (EUM) and delivered in an updated NUCAPS DAP.*
  - » The NUCAPS EUM follows SPSRB Version 2 document standards.

Basic Requirement 5.0

- **CrIS-OLR-R 5.0:** *The CrIS OLR software shall comply with OSPO Code Review Security check lists.*

  » **Driver:** OSPO need for compliance with code and security standards.

Basic Requirement 5.0

- **CrIS-OLR-R 5.1:** *The CrIS OLR software shall comply with OSPO data integrity check list.*
  - » OSPO data integrity check list is part of the OSPO Code Review Security check lists.
- **CrIS-OLR-R 5.2:** *The CrIS OLR software shall comply with OSPO development security check list.*
  - » OSPO development security check list is part of the OSPO Code Review Security check lists.

Basic Requirement 5.0

- **CrIS-OLR-R 5.3:** *The CrIS OLR software shall comply with OSPO code check list.*

  » OSPO code check list is part of the OSPO Code Review Security check lists.

CrIS OLR Project Requirements – Summary

- The CrIS OLR Package Requirements have been established.
- The Requirements have been documented in the Requirements Allocation Document (RAD).
- The Requirements are traceable to drivers (customer needs or expectations) and other requirements.

NUCAPS Requirements – Summary

- The NUCAPS Requirements have been established.
- The NUCAPS Requirements have been documented in the Requirements Allocation Documents (RAD).
- The NUCAPS Requirements are traceable to drivers (customer needs or expectations) and other requirements.

Review Outline

- Introduction
- CDR Phase 3 Report
- Phase 3 Requirements
- Phase 3 Software Architecture
- Validation
- Risk Summary
- Summary and Conclusions

NUCAPS Phase 3 Software Architecture

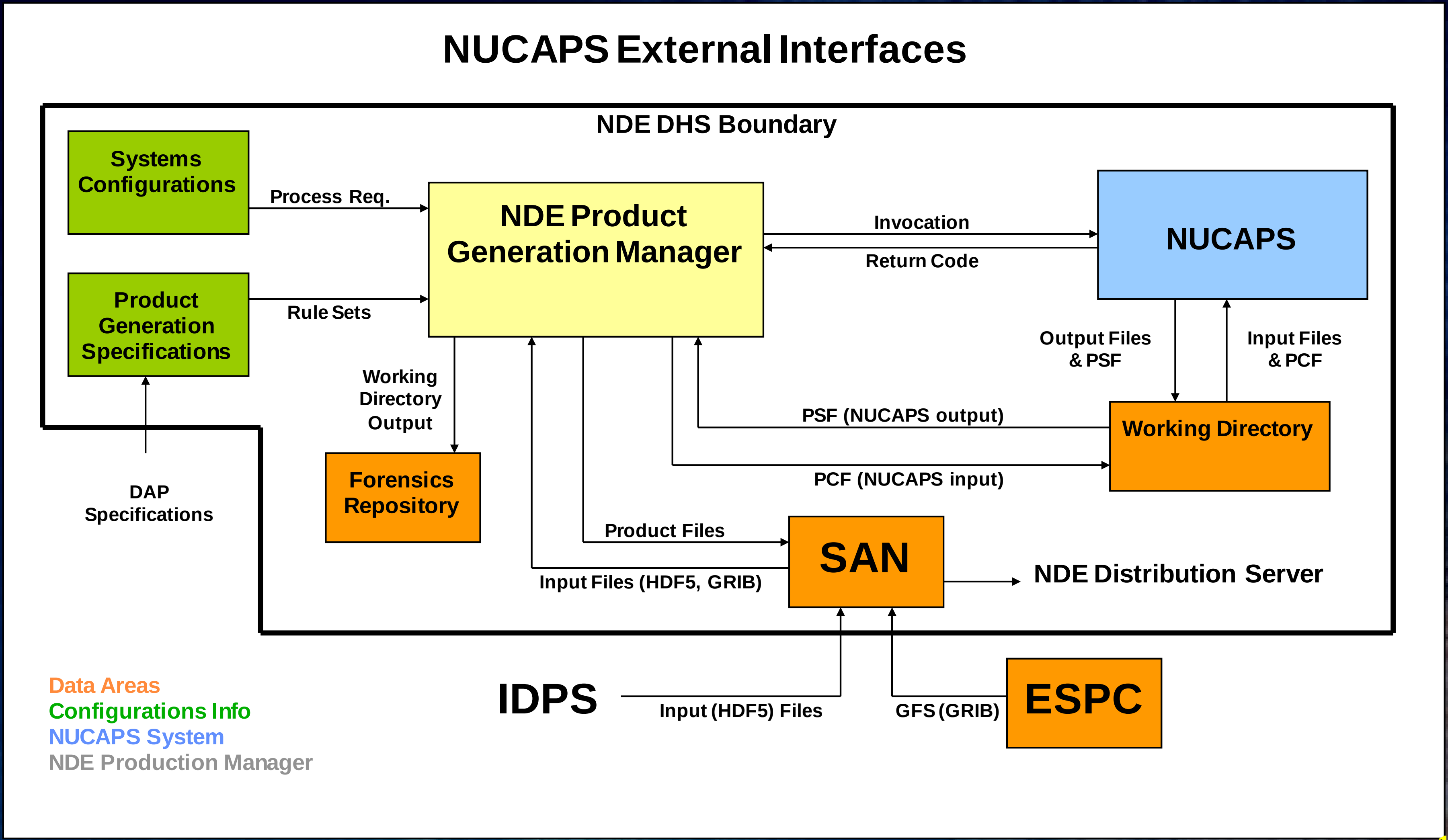
Presented by

Tom King

NUCAPS Phase 3 Software Architecture

- This section shows the architecture for the entire NUCAPS package (Phases 1-3). Modifications since CDR are show in green text. Only those will be discussed.
- The phase 3 delivery was a redelivery of the entire package as opposed to an incremental delivery (only updated components) because the phase 3 components are integrated into the existing software.
- The added phase 3 inputs are identified in the tables and the software flow diagrams.
- 3 Layers of design will be presented.
  - External Interfaces
  - System Layer
  - Unit Layer

NUCAPS Phase 3 External Interfaces



NUCAPS External Interfaces

- The following tables identifies the input files and output files for the entire NUCAPS package.

- The following new and modified items will be present in Phase 3:
  - » Inputs
    - – VIIRS CM + geo
    - – VIIRS CTH + geo
    - – 3 ATMS TDR geo (before we needed 3 ATMS TDRs, but only the 1 ATMS geo)
  - » Outputs
    - – NUCAPS OLR files (containing metadata in header)
    - – NUCAPS OLR global grids (for OSPO science quality monitoring efforts)
    - – CrIS SDR netCDF4 (updated to contain VIIRS cloud information for the BUFR generated downstream)
    - – NUCAPS EDR and CCR (updated for CF compliance)
    - – All global grid and match products are shut off except the EDR and OLR grids

NUCAPS Phase 3 External System Inputs

File	Input/ Output	Source	Description	State
CrIS SDR HDF5	Input	IDPS	CrIS granule files containing science data (radiances).	Dynamic
CrIS SDR Geo HDF5	Input	IDPS	CrIS granule files containing geolocation information for the science data.	Dynamic
ATMS TDR HDF5	Input	IDPS	ATMS granule files of ATMS antenna temperatures. 3 files are needed: the granule matching that of the CrIS granule and the 2 neighboring ATMS granules. The neighboring granules are needed for the FOV resampling.	Dynamic
ATMS TDR Geo HDF5	Input	IDPS	ATMS granule files containing geolocation information for the TDR. All 3 files are needed as above with the TDR files.	Dynamic
GFS Forecast	Input	NCEP	The GFS 6-hour forecast file in GRIB2 format	Dynamic
VIIRS Cloud Mask IP HDF5	Input	IDPS	VIIRS Intermediate Product (IP) Cloud Mask	Dynamic
VIIRS Cloud Top Height HDF5	Input	IDPS	VIIRS Cloud Top Height EDR	Dynamic
VIIRS Cloud Mask IP Geo HDF5	Input	IDPS	VIIRS Moderate Bands Ellipsoid Geolocation Data (Not Terrain Corrected) for Cloud Mask.	Dynamic
VIIRS Cloud Top Height Geo HDF5	Input	IDPS	VIIRS Cloud Aggregated Ellipsoid Geolocation Data (Not Terrain Corrected) for Cloud Top Height	Dynamic

NUCAPS Phase 3 External System Outputs (1)

File	Input/ Output	Source	Description	State
CrIS/ATMS + VIIRS Cloud (all CrIs FOVs 399 channels)	Output	NUCAPS	The CrIS/ATMS netCDF4 granule file for 399 channels on all CrIS FOVs for all FORs. This will also contain the collocated VIIRS cloud information. This file will be converted to BUFR outside of NUCAPS.	Dynamic
CrIS/ATMS + VIIRS Cloud (all CrIs FOVs 1305 channels)	Output	NUCAPS	The CrIS/ATMS netCDF4 granule file for 1305 channels on all CrIS FOVs for all FORs. This will also contain the collocated VIIRS cloud information. This file will be converted to BUFR outside of NUCAPS. It is also used for quality monitoring at OSPO.	Dynamic
NUCAPS EDR netCDF4	Output	NUCAPS	This is the netCDF4 granule output file containing the EDR product.	Dynamic
NUCAPS CCR netCDF4	Output	NUCAPS	This is the netCDF4 granule output file containing all the CCR product data.	Dynamic
NUCAPS EDR Monitoring	Output	NUCAPS	This is a small text file output from the NUCAPS retrieval that is to be made available to OSPO for EDR QC monitoring.	Dynamic
NUCAPS PCS Monitoring	Output	NUCAPS	This is a small text file output from the NUCAPS PCS processing that is to be made available to OSPO for SDR QC monitoring.	Dynamic
NUCAPS OLR	Output	NUCAPS	The CrIS OLR granule product file in netCDF4 with metadata.	Dynamic

NUCAPS Phase 3
External System Outputs (2)

File	Input/ Output	Source	Description	State
CrIS/ATMS 0.5X2 Global Grids	Output	NUCAPS	CrIS/ATMS daily global grids at 0.5X2 degree grid resolution.	Dynamic
CrIS/ATMS 3X3 Global Grids	Output	NUCAPS	CrIS/ATMSdaily global grids at 3X3 degree grid resolution.	Dynamic
CrIS 3X3 PCS Global Grids (3-band)	Output	NUCAPS	CrIS 3-band principal component daily global grids at 3X3 degree resolution.	Dynamic
CrIS 0.5X2 PCS Global Grids (1-band)	Output	NUCAPS	CrIS 1-band principal component daily global grids at 0.5X2 degree resolution.	Dynamic
CrIS 3X3 PCS Global Grids (1-band)	Output	NUCAPS	CrIS 1-band principal component daily global grids at 3X3 degree resolution.	Dynamic
CrIS/ATMS 0.5X2 EDR global grids	Output	NUCAPS	CrIS/ATMS EDRs on a daily global grid at 0.5X2 degree resolution.	Dynamic
CrIS CCR 0.5X2 global grids	Output	NUCAPS	Cloud-cleared CrIS radiances on a daily global grid at 0.5X2 degree resolution.	Dynamic
CrIS OLR 0.5X2 global grids	Output	NUCAPS	CrIS OLR daily global grid at 0.5X2 degree resolution.	Dynamic

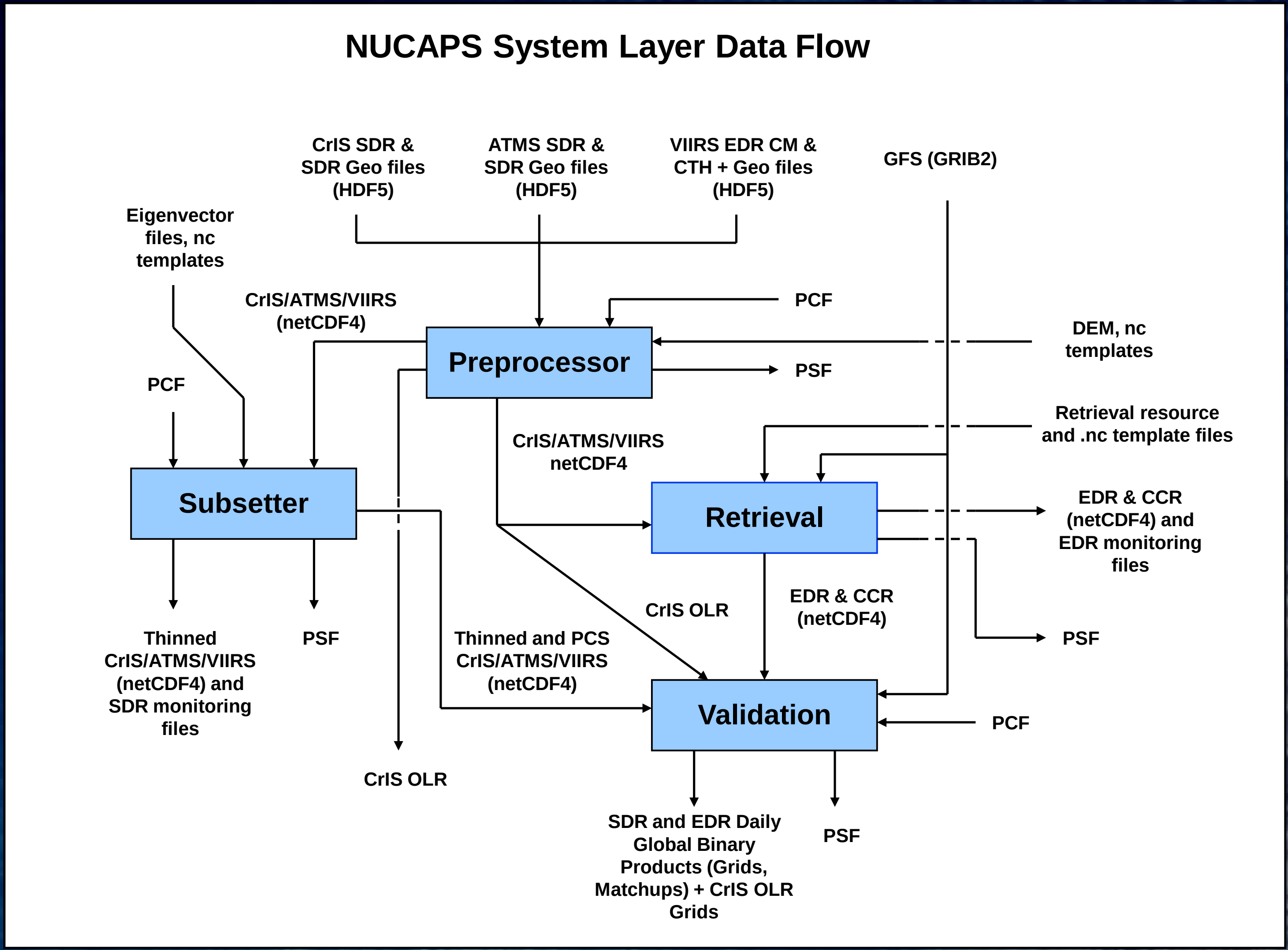
NUCAPS Phase 3 External System Outputs (3)

File	Input/ Output	Source	Description	State
GFS 0.5X2 global grids	Output	NUCAPS	A daily global coverage file of selected GFS forecast fields collocated to the same 0.5X2.0 degree grid as the CrIS/ATMS/VIIRS global grids.	Dynamic
CrIS 1-scan global binary	Output	NUCAPS	This file is a CrIS global binary used solely for off-line eigenvector generation at STAR	Dynamic
NUCAPS SDR matchups	Output	NUCAPS	This is a binary file containing all the NUCAPS SDR output matched to radiosonde locations.	Dynamic
NUCAPS SDR matchups list	Output	NUCAPS	This is a text file listing all the possible radiosonde matchup locations/times	Dynamic
NUCAPS EDR matchups	Output	NUCAPS	This is a binary file containing all the NUCAPS EDR output matched to radiosonde locations.	Dynamic
NUCAPS EDR matchups list	Output	NUCAPS	This is a text file listing all the possible radiosonde matchup locations/times	Dynamic

NUCAPS Phase 3 System-Layer Data Flow

- The next figure shows the NUCAPS Phase 3 “system layer” once it is configured within NDE.
- The text and figure elements labeled in blue also identify those components that are added to the Phase 1-2 configuration for Phase 3.

NUCAPS Phase 3 System-Layer Data Flow



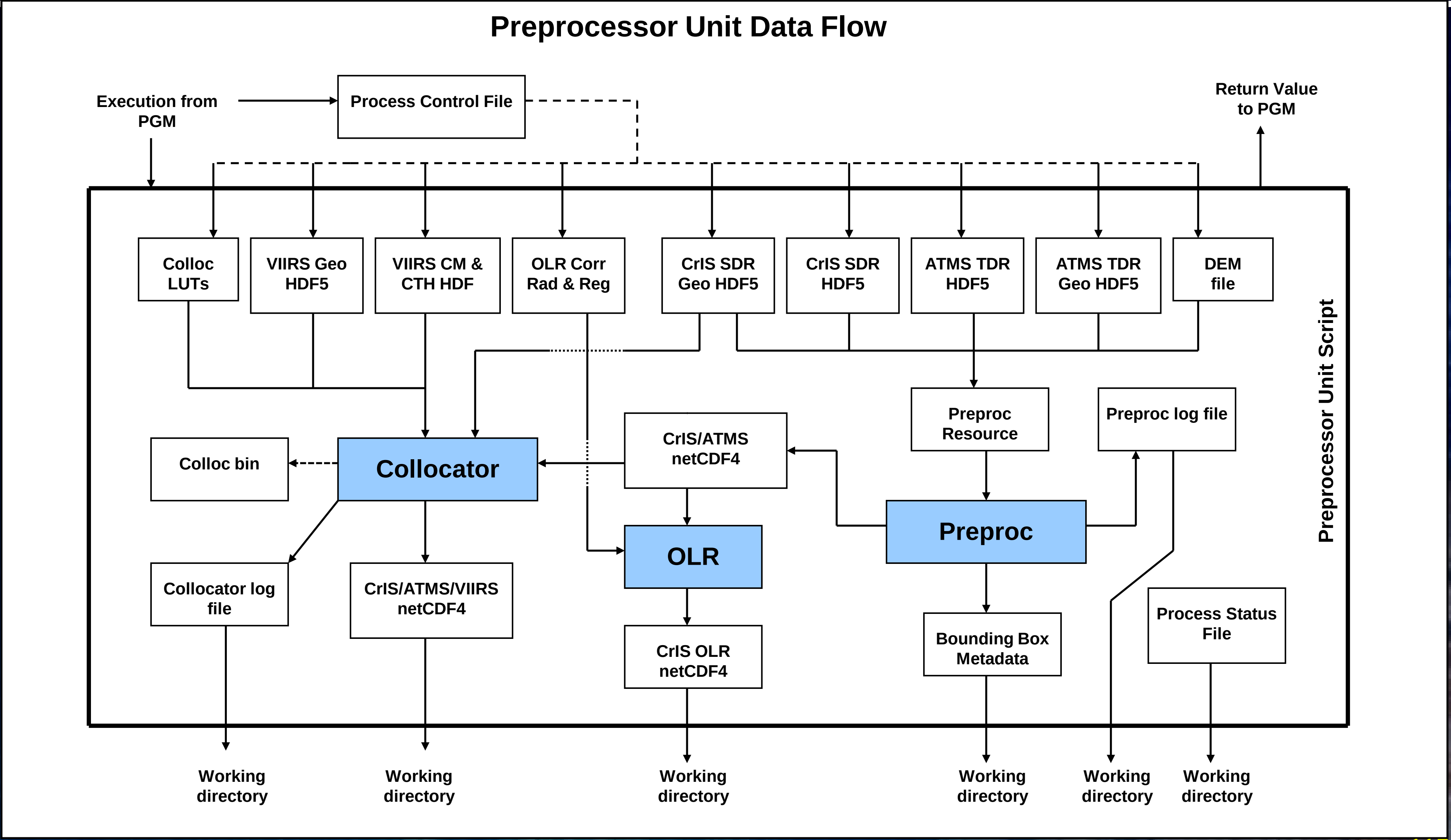
Preprocessor Unit

- Updates to the Preprocessor Unit code
  - » Preprocessor updates from Chris Barnet in IDL. Tish implemented these in Fortran.
    - – Completely changed the algorithm for matching CrIS and ATMS FOVs (due to scan misalignment between the 2 instruments).
      - Code now requires 3 ATMS geo files
    - – Bug in function for finding distance between 2 points (for matching CrIS and ATMS)
    - – Bug fixes and improvements in code that matches DEM variables to the CrIS and ATMS FOVs
    - – Bugs were fixed in the ATMS FOV resampling code
    - – Bug in atms_write_l2_binary.f90: We were using land fraction and percent land from CrIS center FOV to represent resampled ATMS footprint, but should have instead averaged over 9 CrIS FOVS
    - – Fixed incorrect indexing on time variable for ATMS.
    - – Speed up code by adjusting loops when resampling ATMS brightness temperatures
  - » VIIRS collocation added
    - – This is run inside a collocation sub-unit
  - » CrIS OLR added
  - » Ported to GNU
  - » VIIRS collocation can handle updated VIIRS CM and CTH EDRs (for IDPS 2.0 testing)
  - » NPP file name pattern hardcoding is removed so it can handle J1 testing

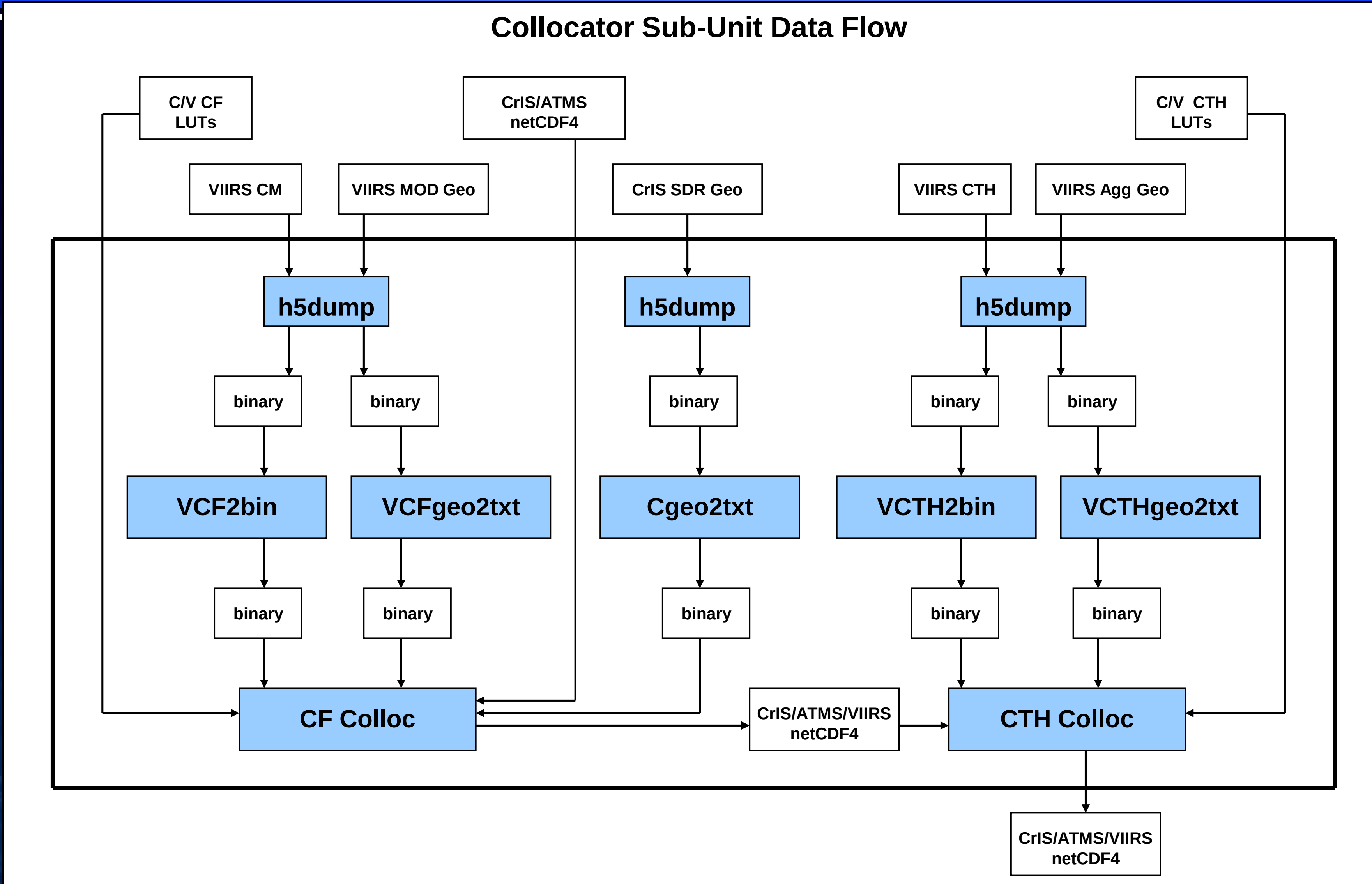
Preprocessor Unit

- The following figure and tables shows the Phase 3 Preprocessor unit data flows.
- The tables that follow identify the input, intermediate, and output files.

Preprocessor Unit



Collocator Sub-Unit



Preprocessor Unit Interfaces (1)

File	Input/ Output	Source	Description	State
PCF	Input	NDE	The Process Control File supplied by the NDE PGM.	Dynamic
CrIS SDR HDF5	Input	NDE	CrIS granule files containing science data (radiances).	Dynamic
CrIS SDR Geo HDF5	Input	NDE	CrIS granule files containing geolocation information for the science data.	Dynamic
ATMS TDR HDF5	Input	NDE	ATMS granule files of ATMS antenna temperatures at native ATMS resolution.	Dynamic
ATMS TDR Geo HDF5	Input	NDE	ATMS granule files containing geolocation information for the TDR.	Dynamic
VIIRS Cloud Mask IP HDF5	Input	IDPS	VIIRS Intermediate Product (IP) Cloud Mask	Dynamic
VIIRS Cloud Top Height HDF5	Input	IDPS	VIIRS Cloud Top Height EDR	Dynamic
VIIRS Cloud Mask IP Geo HDF5	Input	IDPS	VIIRS Moderate Bands Ellipsoid Geolocation Data (Not Terrain Corrected) for Cloud Mask.	Dynamic
VIIRS Cloud Top Height Geo HDF5	Input	IDPS	VIIRS Cloud Aggregated Ellipsoid Geolocation Data (Not Terrain Corrected) for Cloud Top Height	Dynamic
DEM binary	Input	NUCAPS	Digital Elevation Model file containing surface elevation and land-sea-coast coverage for the globe at 1km.	Static
CrIS/ATMS/VIIRS CDL template	Input	NUCAPS	The netCDF4 CDL template used to create the output file.	Static

Preprocessor Unit Interfaces (2)

File	Input/ Output	Source	Description	State
CrIS wt files (750m)	Input	NUCAPS	The CrIS weighting function coefficients which determine how averaging to be performed on the 750 m VIIRS data collocated to CrIS	Static
CrIS wt files (6km)	Input	NUCAPS	The CrIS weighting function coefficients which determine how averaging to be performed on the 6 km VIIRS data collocated to CrIS	Static
CrIS Corr Rad	Input	NUCAPS	The CrIS OLR input radiation correction coefficient file.	Static
CrIS Pseudo Chan	Input	NUCAPS	The CrIS OLR input pseudo 20 channel parameter file.	Static
CrIS OLR Regression	Input	NUCAPS	The CrIS OLR regression coefficient file.	Static
Collocator Resource	Intermediate	NUCAPS	This is the resource text file containing the input file names and input parameters for the collocator program.	Dynamic
Combiner Resource	Intermediate	NUCAPS	This is the resource text file containing the input file names and input parameters for the combiner program.	Dynamic
CrIS/ATMS/VIIRS netCDF4	Output	NUCAPS	The output spatially and temporally collocated CrIS, ATMS, and VIIRS data. The CrIS and ATMS data file consist of radiances and the VIIRS data will consist of the cloud fraction and height averaged onto the CrIS FOVs. CrIS radiances have also been apodized and corrected for local angle viewing. The surface information has been added in from the DEM as well.	Dynamic

Preprocessor Unit Interfaces (2)

File	Input/ Output	Source	Description	State
Bounding Box metadata	Output	NUCAPS	This is a small text file containing NUCAPS internal metadata about the bounding box of the granule and ascending/descending status. This file is required as input to the Retrieval Unit.	Dynamic
NUCAPS OLR	Output	NUCAPS	The CrIS OLR granule product file in netCDF4 with metadata.	Dynamic
Collocator Run log	Output	NUCAPS	This is the run log containing the standard output and return status of Collocator sub-unit.	Dynamic
Combiner Run log	Output	NUCAPS	This is the run log containing the standard output and return status of Combiner sub-unit.	Dynamic
PSF	Output	NUCAPS	This is the Process Status File which is the formatted output status for the entire Preprocessor unit	Dynamic

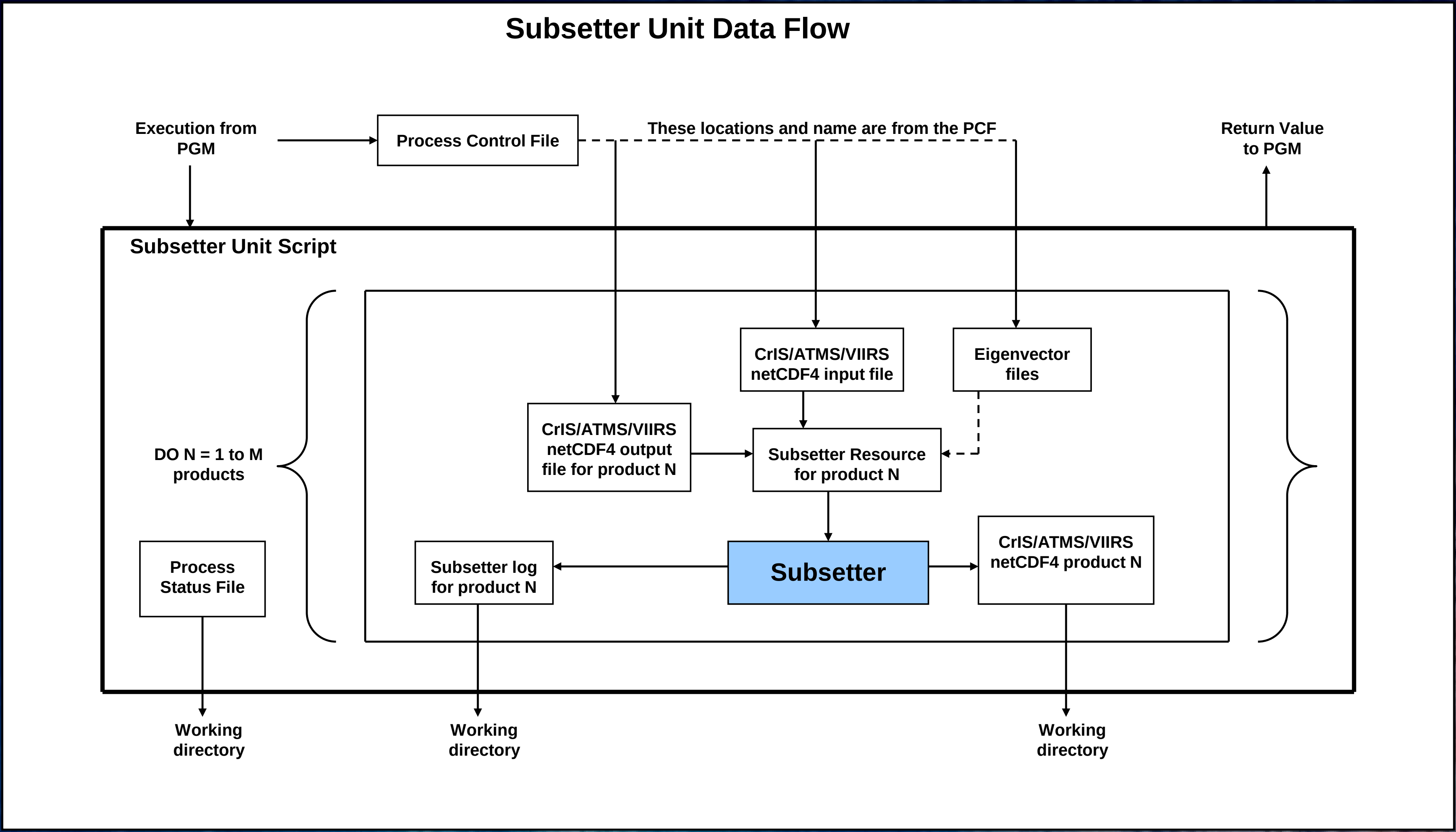
Subsetter Unit

- Updates:
  - » No design changes
  - » Ported to GNU
  - » 399 subset now contains VIIRS cloud info due to upstream changes in the Preproc Unit

- The following figure and tables shows the Phase 3 Subsetter unit data flows.

- The tables identify the input, intermediate, and output files.

Subsetter Unit



Subsetter Unit Interfaces (1)

File	Input/ Output	Source	Description	State
PCF	Input	NDE	The Process Control File supplied by the NDE PGM.	Dynamic
CrIS/ATMS/VIIRS netCDF4	Input	NUCAPS (Preprocessor unit)	The full spectral and spatial resolution netCDF4 files of spatially and temporally collocated CrIS, ATMS, and VIIRS granule files. CrIS radiances have been apodized and corrected for local angle viewing.	Dynamic
Full-band eigenvector File	Input	STAR	The full-band (for 1305 channels) eigenvector file used to generate the principal components.	Static
Band-1 eigenvector file	Input	STAR	The band-1 eigenvector file used to generate the principal components.	Static
Band-2 eigenvector file	Input	STAR	The band-2 eigenvector file used to generate the principal components.	Static
Band-3 eigenvector file	Input	STAR	The band-3 eigenvector file used to generate the principal components.	Static
CrIS/VIIRS template, all FOVs 399 channels	Input	STAR	The thinned radiance netCDF4 template used to make all FOVs on all FORs, 399 channel file.	Static
CrIS/VIIRS template, center FOVs 399 channels	Input	STAR	The thinned radiance netCDF4 template used to make center FOVs on all FORs, 399 channel file.	Static

Subsetter Unit Interfaces (2)

File	Input/ Output	Source	Description	State
PCS CrIS/VIIRS template 1-scan	Input	STAR	This is a thinned radiance netCDF4 template file for generating subsets with full resolution CrIS data on only 1 scans per granule.	Static
PCS CrIS/VIIRS template (3-band) All FOVs	Input	STAR	The principal component netCDF4 template file used to make the 3-band, 300 PCS file, for all FOVs.	Static
PCS CrIS/VIIRS template (1-band) All FOVs	Input	STAR	The principal component netCDF4 template file used to make the 3-band, 100 PCS file, for all FOVs.	Static
PCS CrIS/VIIRS template (3-band) Center FOV	Input	STAR	The principal component netCDF4 template file used to make the 3-band, 300 PCS file, for the center FOV.	Static
PCS CrIS/VIIRS template (1-band) Center FOV	Input	STAR	The principal component netCDF4 template file used to make the 3-band, 100 PCS file, for the center FOV.	Static
CrIS/ATMS/VIIRS all FOVs 399 resource	Intermediate	NUCAPS	This is the resource file needed to generate the CrIS/ATMS/VIIRS all FOVs 399 channel file.	Dynamic
CrIS/ATMS/VIIRS center FOV 399 resource	Intermediate	NUCAPS	This is the resource file needed to generate the CrIS/ATMS/VIIRS center FOV 399 channel file.	Dynamic

Subsetter Unit Interface (3)

File	Input/ Output	Source	Description	State
CrIS/ATMS/VIIRS 1-scan resource	Intermediate	NUCAPS	This is the resource file needed to generate the CrIS/ATMS/VIIRS 1-scan file.	Dynamic
PCS CrIS/ATMS/VIIRS 3-band resource (All FOVs)	Intermediate	NUCAPS	This is the resource file needed to generate the PCS CrIS/ATMS/VIIRS 3-band file (for all FOVs).	Dynamic
PCS CrIS/ATMS/VIIRS 1-band resource (All FOVs)	Intermediate	NUCAPS	This is the resource file needed to generate the PCS CrIS/ATMS/VIIRS 1-band file (for all FOVs).	Dynamic
PCS CrIS/ATMS/VIIRS 3-band resource (Center FOV)	Intermediate	NUCAPS	This is the resource file needed to generate the PCS CrIS/ATMS/VIIRS 3-band file (for the center FOV).	Dynamic
PCS CrIS/ATMS/VIIRS 1-band resource (Center FOV)	Intermediate	NUCAPS	This is the resource file needed to generate the PCS CrIS/ATMS/VIIRS 1-band file (for the center FOV).	Dynamic
CrIS/ATMS/VIIRS all FOVs 399 run log	Output	NUCAPS	This is the run log for the CrIS/ATMS/VIIRS all FOVs 399 channel file.	Dynamic
CrIS/ATMS/VIIRS center FOV 399 run log	Output	NUCAPS	This is the run log for the CrIS/ATMS/VIIRS center FOV 399 channel file.	Dynamic
CrIS/ATMS/VIIRS 1-scan run log	Output	NUCAPS	This is the run log for the CrIS/ATMS/VIIRS 1-scan run log file.	Dynamic
PCS CrIS/ATMS/VIIRS 3-band run log (all FOVs)	Output	NUCAPS	This is the run log for the CrIS/ATMS/VIIRS 3-band file (all FOVs).	Dynamic

Subsetter Unit Interface (4)

File	Input/ Output	Source	Description	State
PCS CrIS/ATMS/VIIRS 1-band run log (all FOVs)	Output	NUCAPS	This is the run log for the CrIS/ATMS/VIIRS 1-band file (all FOVs).	Dynamic
PCS CrIS/ATMS/VIIRS 3-band run log (center FOVs)	Output	NUCAPS	This is the run log for the CrIS/ATMS/VIIRS 3-band file (center FOVs).	Dynamic
PCS CrIS/ATMS/VIIRS 1-band run log (center FOVs)	Output	NUCAPS	This is the run log for the CrIS/ATMS/VIIRS 1-band file (center FOVs).	Dynamic
CrIS/ATMS/VIIRS, all FOVs 399	Output	NUCAPS	The CrIS/ATMS/VIIRS netCDF4 granule file for 399 channels on all CrIS FOVs for all FORs. This is will be converted to BUFR outside of NUCAPS	Dynamic
CrIS/ATMS/VIIRS, center FOV 399	Output	NUCAPS	The CrIS/ATMS/VIIRS netCDF4 granule file for 399 channels on the center CrIS FOV for all FORs. This file is used as input to the 05.X2.0 degree global grids.	Dynamic
CrIS/ATMS/VIIRS 1-scan product	Output	NUCAPS	The CrIS/ATMS/VIIRS netCDF4 granule file with only 1 full resolution scans of CrIS FOVs for all 1305 channels. This file is used in the validation unit to generate a thinned coverage daily global file.	Dynamic
PCS CrIS/ATMS/VIIRS 3-band (all FOVs)	Output	NUCAPS	The CrIS PCS full spatial resolution netCDF4 granule file for 3-bands of 300 PCS (all FOVs)	Dynamic
PCS CrIS/ATMS/VIIRS 1-band (all (FOVs)	Output	NUCAPS	The CrIS PCS full spatial resolution netCDF4 granule file for 1-band of 100 PCS (all FOVs)	Dynamic

Subsetter Unit Interfaces (5)

File	Input/ Output	Source	Description	State
PCS CrIS/ATMS/VIIRS 3-band (center FOVs)	Output	NUCAPS	The CrIS PCS full spatial resolution netCDF4 granule file for 3-bands of 300 PCS (center FOVs)	Dynamic
PCS CrIS/ATMS/VIIRS 1-band (center (FOVs)	Output	NUCAPS	The CrIS PCS full spatial resolution netCDF4 granule file for 1-band of 100 PCS (center FOVs)	Dynamic
PCS SDR monitoring file	Output	NUCAPS	This is the PC Score statistics monitoring file which is used for SDR monitoring by OSPO	Dynamic
PSF	Output	NUCAPS	This is the Process Status File containing the formatted status output for the entire Subsetter unit	Dynamic

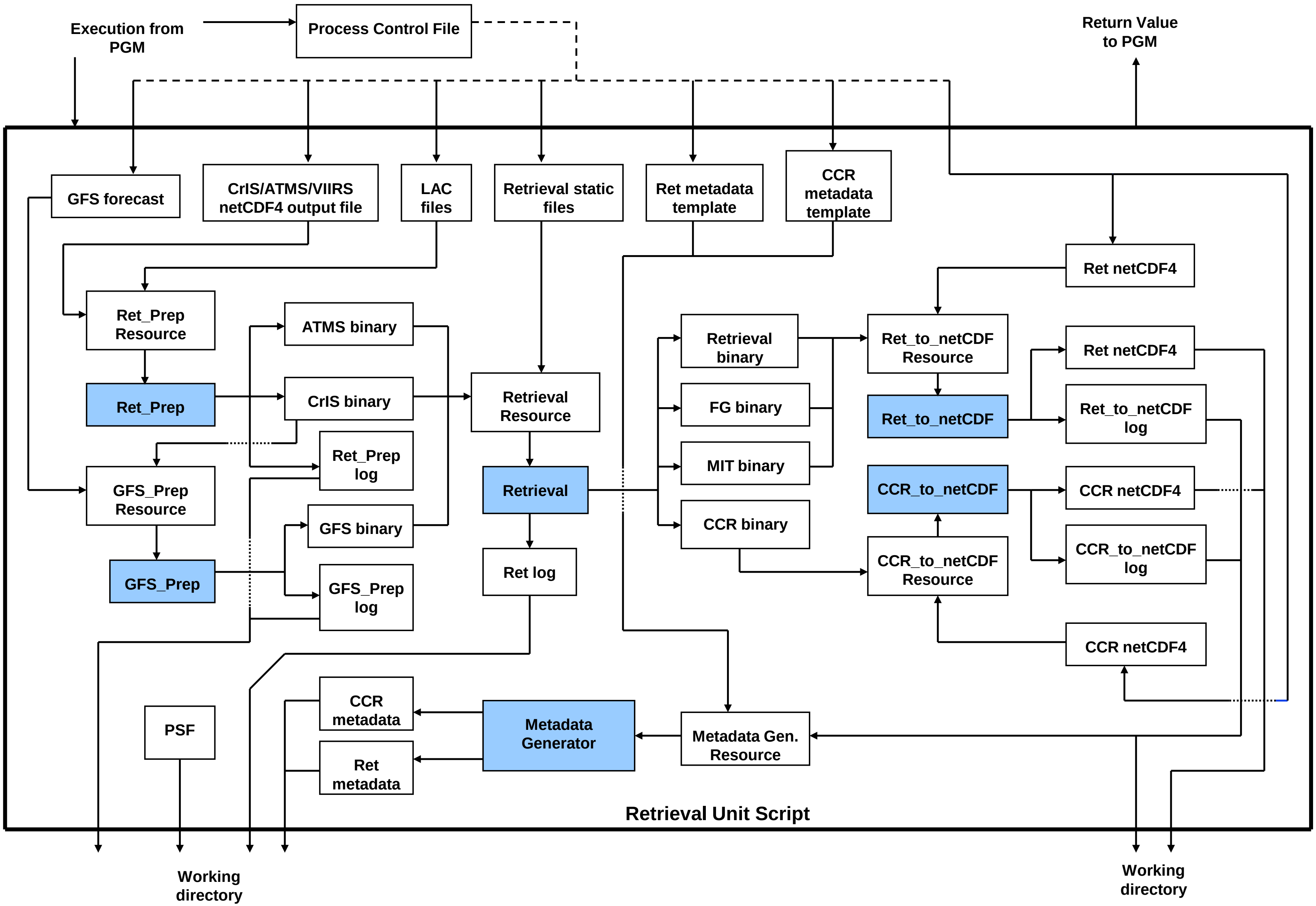
Retrieval Unit

- Updates:
  - » No design changes
  - » Ported to GNU, namelist updates, several bug fixes
  - » New retrieval regression
  - » Merging of retrieval codes and implementation of backwards compatibility for AIRS/IASI/CrIS

- The following figure and tables shows the Retrieval unit data flows.

- The tables identify the input, intermediate, and output files.

Retrieval Unit Data Flow



Retrieval Unit Interfaces (1)

File	Input/ Output	Source	Description	State
PCF	Input	NDE	The Process Control File supplied by the NDE PGM.	Dynamic
CrIS/ATMS/VIIRS netCDF4	Input	NUCAPS (Preprocessor unit)	The spatially and temporally collocated CrIS, ATMS, and VIIRS granule data files. CrIS radiances have been apodized and corrected for local angle viewing.	Dynamic
GFS Forecast	Input	NCEP	The GFS 6-hour forecast file in GRIB format	Dynamic
NUCAPS Bounding Box	Input	NUCAPS (Preprocessor Unit)	This is an internal metadata file for NUCAPS. It is produced by the Preprocessor Unit and contains the bounding box and ascending/descending status.	Dynamic
NUCAPS EDR template	Input	STAR	This is the netCDF4 template file needed to create the EDR output file.	Static
CrIS CCR template	Input	STAR	This is the netCDF4 template file needed to create the CCR output file.	Static
CrIS AR CCR template	Input	STAR	This is the netCDF4 template file needed to create the CCR output file specifically for the CLASS (“AR” = Archive).	Static

Retrieval Unit Interfaces (2)

File	Input/ Output	Source	Description	State
Cloud namelist	Input	STAR	Cloud files name list	Static
IO namelist	Input	STAR	Input/Output name list	Static
Microwave namelist	Input	STAR	Microwave file name list	Static
Ozone namelist	Input	STAR	Ozone file name list	Static
Pro namelist	Input	STAR	Profile file name list	Static
Temp namelist	Input	STAR	Temperature file name list	Static
Water namelist	Input	STAR	Water vapor file name list	Static
CC_DAY_FILENAME			This is the name and location (if not in the local working directory) of the clear flag day time file needed by the retrieval.	Static
CC_NIGHT_FILENAME	Input	STAR	This is the name and location (if not in the local working directory) of the clear flag night time file needed by the retrieval.	Static
OLRCOEFFILE	Input	STAR	This is contains the rapid transmittance coefficients to compute outgoing longwave radiation.	Static
TUNINGCOEFFILE	Input	STAR	The tuning coefficient file.	Static
TUNINGMASKFILE	Input	STAR	The tuning mask file.	Static
RTAERRFILE	Input	STAR	The error coefficient file for the radiative transfer model.	Static
MWNOISEFILE	Input	STAR	This is microwave noise file.	Static
TC_AMSU	Input	STAR	This is the ATMS transmittance coefficient file.	Static
TC_AIRS	Input	STAR	This is the post-flight CrIS RTA coefficient file.	Static

Retrieval Unit Interfaces (3)

File	Input/ Output	Source	Description	State
IRNOISEFILE	Input	STAR	This is post-flight CrIS RTA coefficients file.	Static
SOLARFILE	Input	STAR	This is the CrIS solar irradiance file for the radiance calculation.	Static
NOAAEIGFILE	Input	STAR	This is the NOAA IR regression radiance eigenvector file.	Static
NOAAFRQFILE	Input	STAR	This is the NOAA IR regression frequency file.	Static
NOAAANGFILE	Input	STAR	This is the NOAA angle depended regression coefficient file.	Static
NOAAREGFILE	Input	STAR	This is the NOAA IR regression coefficient file.	Static
CLDAVGFILE	Input	STAR	This is the cloud averaging table.	Static
L2ERROR_IN	Input	STAR	This is a file containing the ensemble error estimate of climatology.	Static
MASUDAFILE	Input	STAR	This is coefficients file for the Masuda surface emissivity model for ocean.	Static
MWCOVFILE	Input	STAR	This is a microwave retrieval covariance file.	Static
ECOFFILE	Input	STAR	This is a microwave retrieval error covariance file.	Static
HSBWEIGHTFILE	Input	STAR	This is a microwave weighting file.	Static
UARSCLIMFILE	Input	STAR	This is the UARS climatology file for upper atmosphere.	Static
NCEPCLIMFILE	Input	STAR	This is the NCEP climatology file for Temperature and water vapor.	Static

Retrieval Unit Interfaces (4)

File	Input/ Output	Source	Description	State
CrIS ret binary	Intermediate	NUCAPS	The CrIS retrieval input format binary file.	Dynamic
ATMS ret binary	Intermediate	NUCAPS	The ATMS retrieval input format binary.	Dynamic
GFS ret binary	Intermediate	NUCAPS	The GFS retrieval input format binary.	Dynamic
Retrieval binary	Intermediate	NUCAPS	The retrieval output binary.	Dynamic
FG binary	Intermediate	NUCAPS	The first guess output binary.	Dynamic
MIT binary	Intermediate	NUCAPS	The MIT retrieval output binary.	Dynamic
CCR binary	Intermediate	NUCAPS	The CCR output binary.	Dynamic
TRU binary	Intermediate	NUCAPS	The TRU (Truth file) output binary.	Dynamic
F61 binary	Intermediate	NUCAPS	The f61 output binary.	Dynamic
F69 binary	Intermediate	NUCAPS	The f69 output binary.	Dynamic
F70binary	Intermediate	NUCAPS	The f75 diagnostic output binary.	Dynamic
F95 binary	Intermediate	NUCAPS	The f95 diagnostic output binary.	Dynamic
BIN binary	Intermediate	NUCAPS	The BIN diagnostic output binary.	Dynamic
Ret_Prep resource	Intermediate	NUCAPS	The Ret_Prep resource file required to reformat the satellite data into the retrieval input format.	Dynamic

Retrieval Unit Interfaces (5)

File	Input/ Output	Source	Description	State
GFS_Prep resource	Intermediate	NUCAPS	The GFS_Prep resource file required to reformat the GFS surface pressure data into the retrieval input format.	Dynamic
Retrieval resource	Intermediate	NUCAPS	The resource file required to run the retrieval.	Dynamic
Ret_to_netCDF resource	Intermediate	NUCAPS	The resource file required to reformat the retrieval, FG, and MIT output into netCDF4.	Dynamic
CCR_to_netCDF resource	Intermediate	NUCAPS	The resource file required to reformat the CCR output into netCDF4 format.	Dynamic
Ret_Prep run log	Output	NUCAPS	The Ret_Prep run log file.	Dynamic
GFS_Prep run log	Output	NUCAPS	The GFS_Prep run log file.	Dynamic
NUCAPS Retrieval run log	Output	NUCAPS	The Retrieval run log file.	Dynamic
Ret_to_netCDF run log	Output	NUCAPS	The Ret_to_netCDF run log file.	Dynamic
CCR_to_netCDF run log	Output	NUCAPS	The CCR_to_netCDF run log file.	Dynamic
NUCAPS EDR netCDF4	Output	NUCAPS	This is the netCDF4 granule output file containing the EDR.	Dynamic

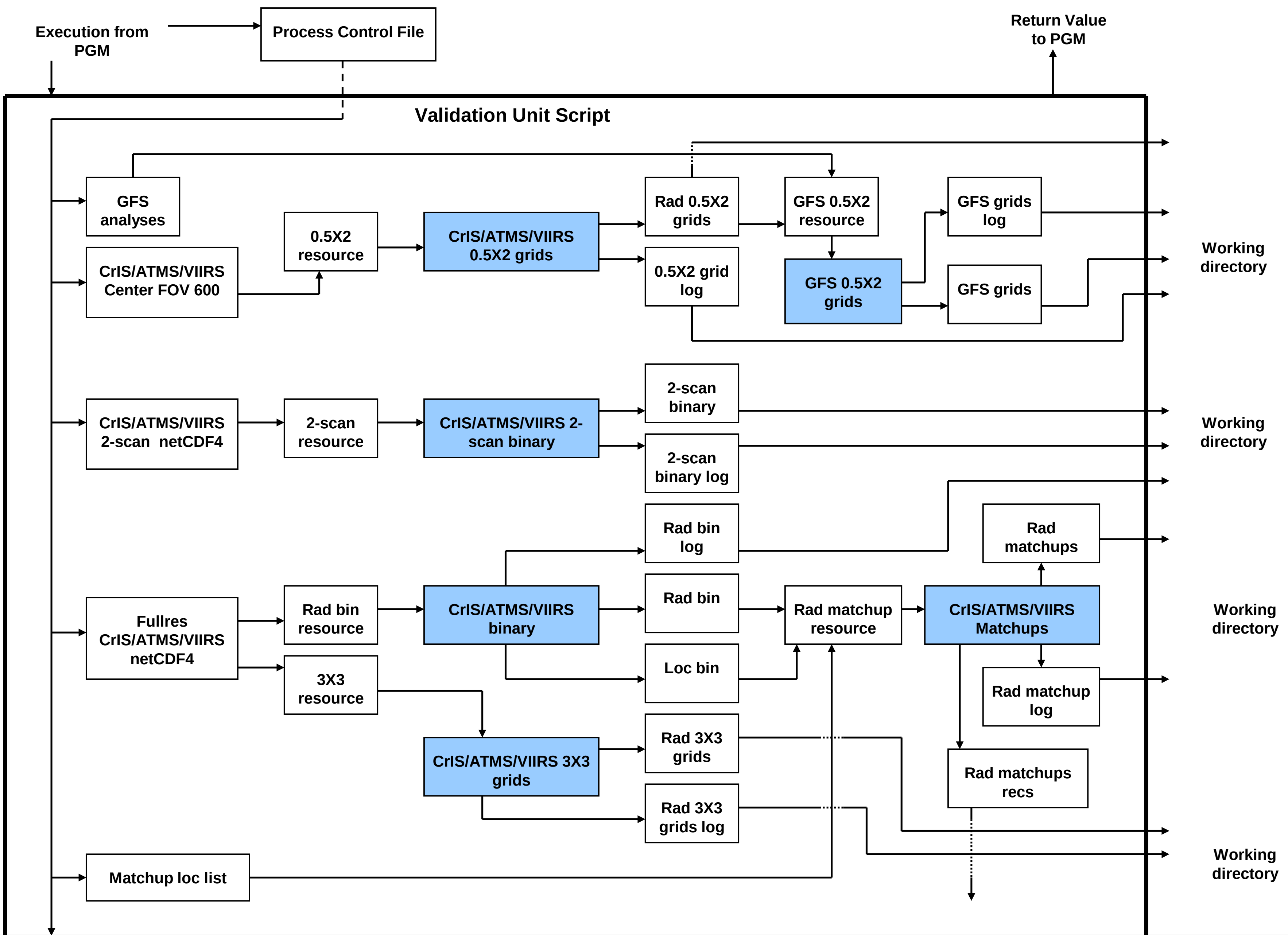
Retrieval Unit Interfaces (6)

File	Input/ Output	Source	Description	State
CrIS CCR netCDF4	Output	NUCAPS	This is the netCDF4 granule output file containing all the CCR product data.	Dynamic
NUCAPS EDR monitoring file	Output	NUCAPS	This is the retrieval.out EDR statistics monitoring file for OSPO.	Dynamic
Retrieval log	Output	NUCAPS	This is the run log containing the standard output and return status of retrieval sub-unit processes.	Dynamic
PSF	Output	NUCAPS	This is the Process Status File containing the formatted status output for the entire Retrieval unit	Dynamic

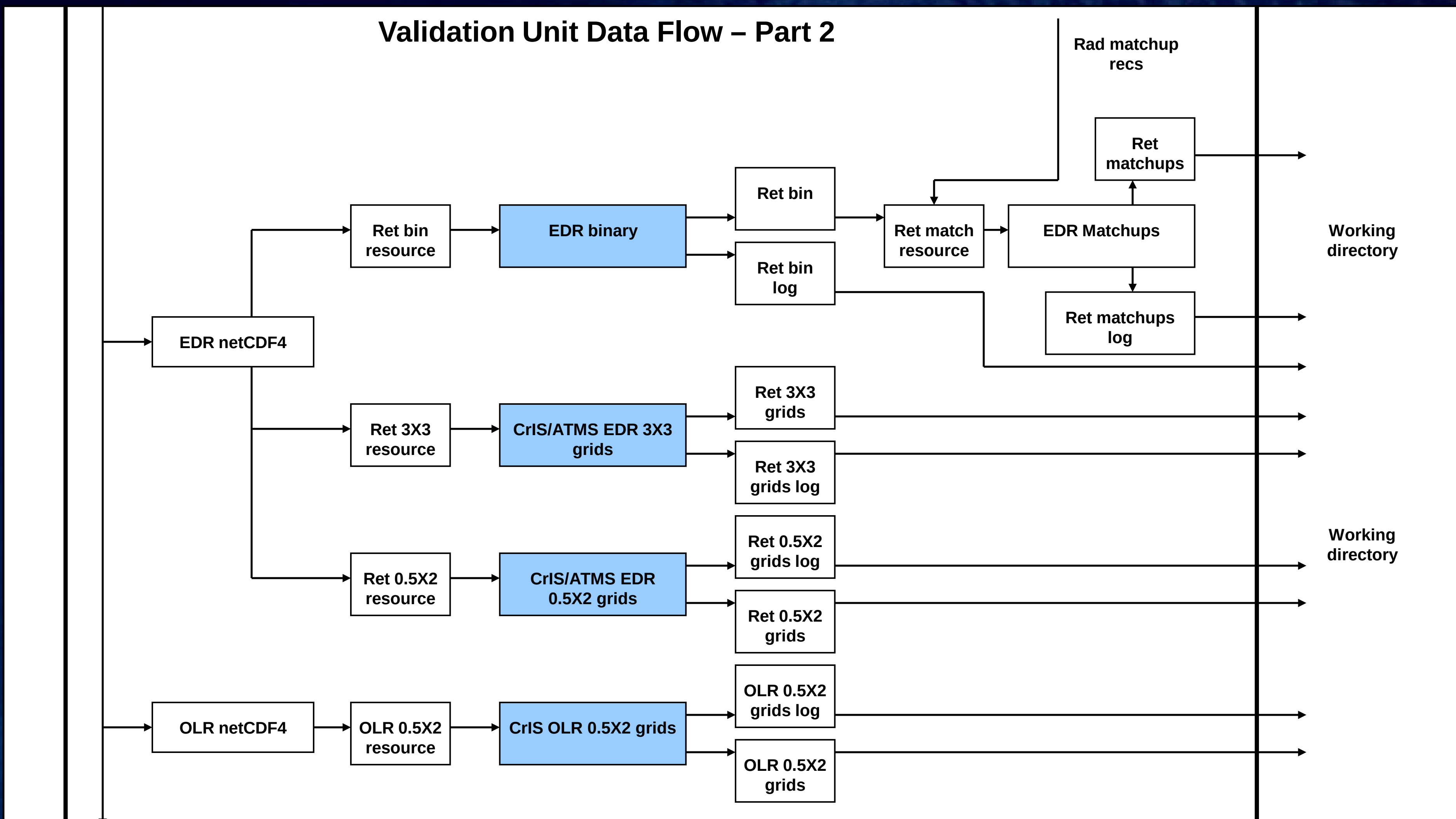
Validation Unit

- Noteworthy items:
  - » Addition of OLR Grid generation
  - » Ported to GNU and some bug fixes found during port
  - » Turned off all validation products except OLR and EDR daily global grids.
- The following figure and tables shows the Phase 3 Validation unit data flows. All new items are identified in blue
- The tables identify the input, intermediate, and output files.

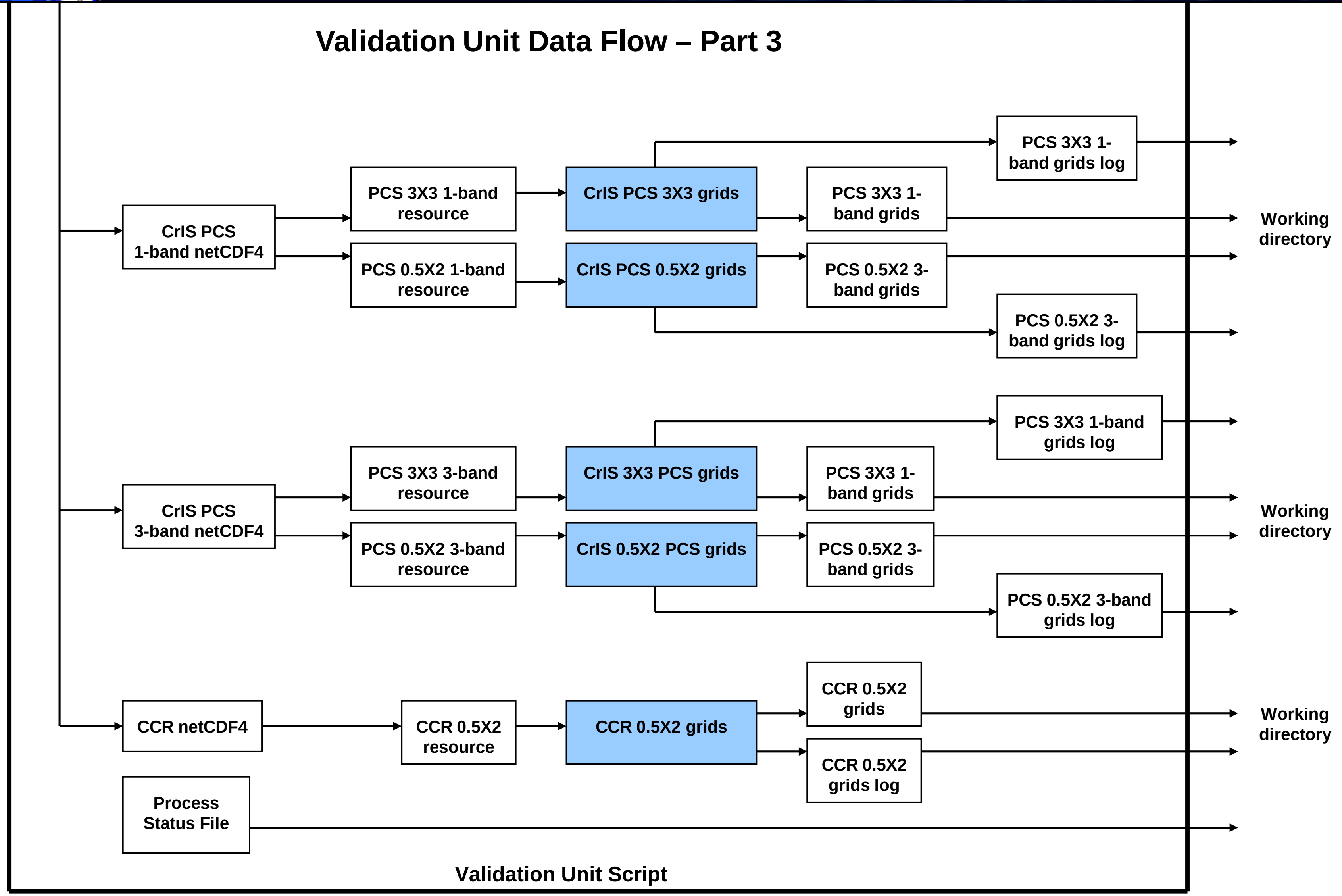
Validation Unit Data Flow – Part 1



Validation Unit (2)



Validation Unit (3)



Validation Unit Interfaces (1)

File	Input/ Output	Source	Description	State
PCF	Input	NDE	The Process Control File supplied by the NDE PGM.	Dynamic
CrIS/ATMS/VIIRS netCDF4	Input	NUCAPS (Preprocessor)	The spatially and temporally collocated CrIS, ATMS, and VIIRS granule data files (all CrIS FOVs and channels) CrIS radiances have been apodized.	Dynamic
Thinned CrIS/ATMS/VIIRS netCDF4 file for a center FOV, 399 channels	Input	NUCAPS (Subsetter)	The CrIS/ATMS/VIIRS netCDF4 files for the center FOV.	Dynamic
Thinned CrIS/ATMS/VIIRS netCDF4 1-scan file.	Input	NUCAPS (Subsetter)	The CrIS/ATMS/VIIRS netCDF4 files containing only 1 scans of CrIS FOVs per granule.	Dynamic
PCS CrIS/ATMS/VIIRS 1-band (all (FOVs)	Input	NUCAPS (Subsetter)	The CrIS PCS full spatial resolution netCDF4 granule file for 1-band of 100 PCS (all FOVs)	Dynamic
PCS CrIS/ATMS/VIIRS 3-band (center FOVs)	Input	NUCAPS (Subsetter)	The CrIS PCS full spatial resolution netCDF4 granule file for 3-bands of 300 PCS (center FOVs)	Dynamic
PCS CrIS/ATMS/VIIRS 1-band (center (FOVs)	Input	NUCAPS (Subsetter)	The CrIS PCS full spatial resolution netCDF4 granule file for 1-band of 100 PCS (center FOVs)	Dynamic
EDR netCDF4	Input	NUCAPS (Retrieval)	This is the netCDF4 granule file containing the EDR product.	Dynamic
CrIS CCR netCDF4	Input	NUCAPS (Retrieval)	This is the netCDF4 granule file containing all the CCR product data.	Dynamic
GFS analyses	Input	NCEP	These are the GFS analysis files generated at 00, 06, 12, and 18Z.	Dynamic

Validation Unit Interfaces (2)

File	Input/ Output	Source	Description	State
Matchup loc list	Input	NUCAPS	This is a static ASCII text file containing a list of in-situ measurement locations and observations times. These are mostly radiosonde observations, but could include aircraft or dropsondes as well.	Static
NUCAPS OLR	Input	NUCAPS	The CrIS OLR granule product file in netCDF4 with metadata.	Dynamic
Rad bin	Intermediate	NUCAPS	The CrIS/ATMS/VIIRS global binary used as the input to the CrIS/ATMS/VIIRS matchups.	Dynamic
Ret bin	Intermediate	NUCAPS	The EDR global binary used as the input to the EDR matchups.	Dynamic
Rad matchups recs	Intermediate	NUCAPS	The matchup direct access record list produced by the CrIS/ATMS/VIIRS matchups and used by the NUCAPS EDR matchups.	Dynamic
CrIS/ATMS/VIIRS 0.5X2 grids resource	Intermediate	NUCAPS	The resource file required to generate the CrIS/ATMS/VIIRS 0.5X2 grids.	Dynamic
CrIS/ATMS/VIIRS 3X3 grids resource	Intermediate	NUCAPS	The resource file required to generate the CrIS/ATMS/VIIRS 3X3 grids	Dynamic
1-scan resource	Intermediate	NUCAPS	The resource file required to generate the CrIS/ATMS/VIIRS 1-scan binary.	Dynamic

Validation Unit Interfaces (3)

File	Input/ Output	Source	Description	State
CrIS/ATMS/VIIRS binary resource	Intermediate	NUCAPS	The resource file required to generate the CrIS/ATMS/VIIRS global binary which is needed for the matchups.	Dynamic
GFS forecast grids resource	Intermediate	NUCAPS	The resource file required to generate the 0.5X2 GFS global grids.	Dynamic
Rad matchup resource	Intermediate	NUCAPS	The resource file required to generate the CrIS/ATMS/VIIRS matchups.	Dynamic
Ret bin resource	Intermediate	NUCAPS	The resource file required to generate the EDR global binary which is needed for the retrieval matchups.	Dynamic
Ret match resource	Intermediate	NUCAPS	The resource file required to generate the EDR matchups.	Dynamic
Ret 0.5X2 resource	Intermediate	NUCAPS	The resource file required to generate the NUCAPS EDR 0.5X2 grids	Dynamic
PCS 3X3 1-band resource	Intermediate	NUCAPS	The resource file required to generate the 1-band PCS CrIS/ATMS/VIIRS 3X3 grids.	Dynamic
PCS 0.5X2 1-band resource	Intermediate	NUCAPS	The resource file required to generate the 1-band PCS CrIS/ATMS/VIIRS 0.5X2 grids.	Dynamic

Validation Unit Interfaces (4)

File	Input/ Output	Source	Description	State
PCS 0.5X2 3-band resource	Intermediate	NUCAPS	The resource file required to generate the 3-band PCS CrIS/ATMS/VIIRS 0.5X2 grids.	Dynamic
CCR 0.5X2 resource	Intermediate	NUCAPS	The resource file required to generate the CCR 0.5X2 grids.	Dynamic
CrIS/ATMS/VIIRS 0.5X2 grids run log	Output	NUCAPS	The run log generated by the running of the CrIS/ATMS/VIIRS 0.5X2 grids program.	Dynamic
CrIS/ATMS/VIIRS 3X3 grids run log	Output	NUCAPS	The run log generated by the running of the CrIS/ATMS/VIIRS 3X3 grids program.	Dynamic
1-scan run log	Output	NUCAPS	The run log generated by the running of the CrIS/ATMS/VIIRS 1-scan binary program.	Dynamic
CrIS/ATMS/VIIRS binary resource	Output	NUCAPS	The run log generated by the running of the CrIS/ATMS/VIIRS global binary program.	Dynamic
GFS forecast grids run log	Output	NUCAPS	The run log generated by the running of the GFS 0.5X2 grids program.	Dynamic

Validation Unit Interfaces (5)

File	Input/ Output	Source	Description	State
Rad matchup run log	Output	NUCAPS	The run log generated by the running of the CrIS/ATMS/VIIRS radiance matchups program.	Dynamic
Ret bin run log	Output	NUCAPS	The run log generated by the running of the EDR binary program.	Dynamic
Ret match run log	Output	NUCAPS	The run log generated by the running of the EDR matchups program.	Dynamic
Ret 0.5X2 run log	Output	NUCAPS	The run log generated by the running of the EDR 0.5X2 grids program.	Dynamic
PCS 3X3 1-band run log	Output	NUCAPS	The run log generated by the running of the 1-band PCS CrIS/ATMS/VIIRS 3X3 grids program.	Dynamic
PCS 0.5X2 1-band run log	Output	NUCAPS	The run log generated by the running of the 1-band PCS CrIS/ATMS/VIIRS 0.5X2 grids program.	Dynamic
PCS 0.5X2 3-band run log	Output	NUCAPS	The run log generated by the running of the 3-band PCS CrIS/ATMS/VIIRS 0.5X2 grids program.	Dynamic

Validation Unit Interfaces (6)

File	Input/ Output	Source	Description	State
CCR 0.5X2 run log	Output	NUCAPS	The run log generated by the running of the CCR 0.5X2 grids program.	Dynamic
OLR 0.5X2 run log	Output	NUCAPS	The run log generated by the running of the CrIS OLR 0.5X2 grids program.	Dynamic
CrIS/ATMS/VIIRS 0.5X2 Global Grids	Output	NUCAPS	CrIS/ATMS/VIIRS daily global grids at 0.5X2 degree grid resolution.	Dynamic
CrIS/ATMS/VIIRS 3X3 Global Grids	Output	NUCAPS	CrIS/ATMS/VIIRS daily global grids at 3X3 degree grid resolution.	Dynamic
CrIS 0.5X2.0 PCS Global Grids (3-band)	Output	NUCAPS	CrIS 3-band principal component daily global grids at 0.5X2 degree resolution.	Dynamic
CrIS 0.5X2 PCS Global Grids (1-band)	Output	NUCAPS	CrIS 1-band principal component daily global grids at 0.5X2 degree resolution.	Dynamic
CrIS 3X3 PCS Global Grids (1-band)	Output	NUCAPS	CrIS 1-band principal component daily global grids at 3X3 degree resolution.	Dynamic
CrIS/ATMS 0.5X2 EDR global grids	Output	NUCAPS	CrIS/ATMS EDRs on a daily global grid at 0.5X2 degree resolution.	Dynamic
CrIS CCR 0.5X2 global grids	Output	NUCAPS	Cloud-cleared CrIS radiances on a daily global grid at 0.5X2 degree resolution.	Dynamic
CrIS OLR 0.5X2 global grids	Output	NUCAPS	CrIS OLR on a daily global grid at 0.5X2 degree resolution.	Dynamic

Validation Unit Interfaces (7)

File	Input/ Output	Source	Description	State
GFS forecast global grids	Output	NUCAPS	A daily global coverage file of selected GFS forecast fields collocated to the same 0.5X2.0 degree grid as the CrIS/ATMS/VIIRS global grids.	Dynamic
CrIS 1-scan global coverage binary	Output	NUCAPS	This file is a CrIS global binary used solely for off-line eigenvector generation at STAR	Dynamic
NUCAPS SDR matchups	Output	NUCAPS	This is a file with matches between CrIS/ATMS/VIIRS FORs and radiosonde (or other instrument) locations.	Dynamic
NUCAPS EDR matchups	Output	NUCAPS	This is NUCAPS EDR output matched to radiosonde locations.	Dynamic
Run log	Output	NUCAPS	This is the run log containing the standard output and return status of Validation unit sub-unit processes.	Dynamic
PSF	Output	NUCAPS	This is the Process Status File containing the formatted status output for the entire Validation unit	Dynamic

Updates to PCF Files

- NUCAPS_Preproc.pl.PCF
  - » Satellite ID
  - » VIIRS CM
  - » VIIRS CTH
  - » VIIRS Moderate Bands Ellipsoid Geolocation Data (Not Terrain Corrected)
  - » VIIRS Cloud Aggregated Ellipsoid Geolocation Data (Not Terrain Corrected)
  - » VIIRS file count
  - » VIIRS netCDF template file
  - » CrIS FOV 750 m weighting function file
  - » CrIS FOV 6 km weighting function file
  - » CrIS OLR input radiation correction coefficient file
  - » CrIS OLR regression coefficient file
  - » Flag to turn on or off the VIIRS/CrIS collocation
  - » Flag to turn on or off the OLR

Updates to PCF Files

- NUCAPS_Subset.pl.PCF has some updates
  - Satellite ID
- NUCAPS_Retrieval.pl.PCF has some updates
  - Satellite ID
- NUCAPS_Validation.pl.PCF has some updates
  - Satellite ID
  - CrIS OLR input files for the 0.5X2.0 grids
  - Flags setting all products OFF except EDR and OLR grids

Updates to PSF Files

- NUCAPS_Preproc.pl.PSF
  - » NUCAPS OLR netCDF4
- NUCAPS_Validation.pl.PSF
  - » NUCAPS OLR 0.5X2.0 Global Grid
  - » Removal off all the validation products that are not the OLR and EDR grids

NUCAPS Phase 3 Software Architecture Summary

- NUCAPS Phase 3 delivery is a redelivery of the entire code package (all 4 original software units).
- Updates were made to the following:
  - » The Preprocessor, Retrieval, and Validation Units (driver scripts and Fortran code)
  - » Updates to PCF and PSF files for all units
  - » Updates to production rules to both units
  - » Updates to the SMM and EUM
- The subsetter unit did not need to change to handle processing the CrIS thinned radiances.
- BUFR Toolkit did not need to change to produce the CrIS BUFR with the VIIRS cloud information.

Review Outline

- Introduction
- CDR Phase 3 Report
- Phase 3 Requirements
- Phase 3 Software Architecture
- Validation
- Risk Summary
- Summary and Conclusions

NUCAPS (v1.5) Phase 3 Delivery Verification and Validation

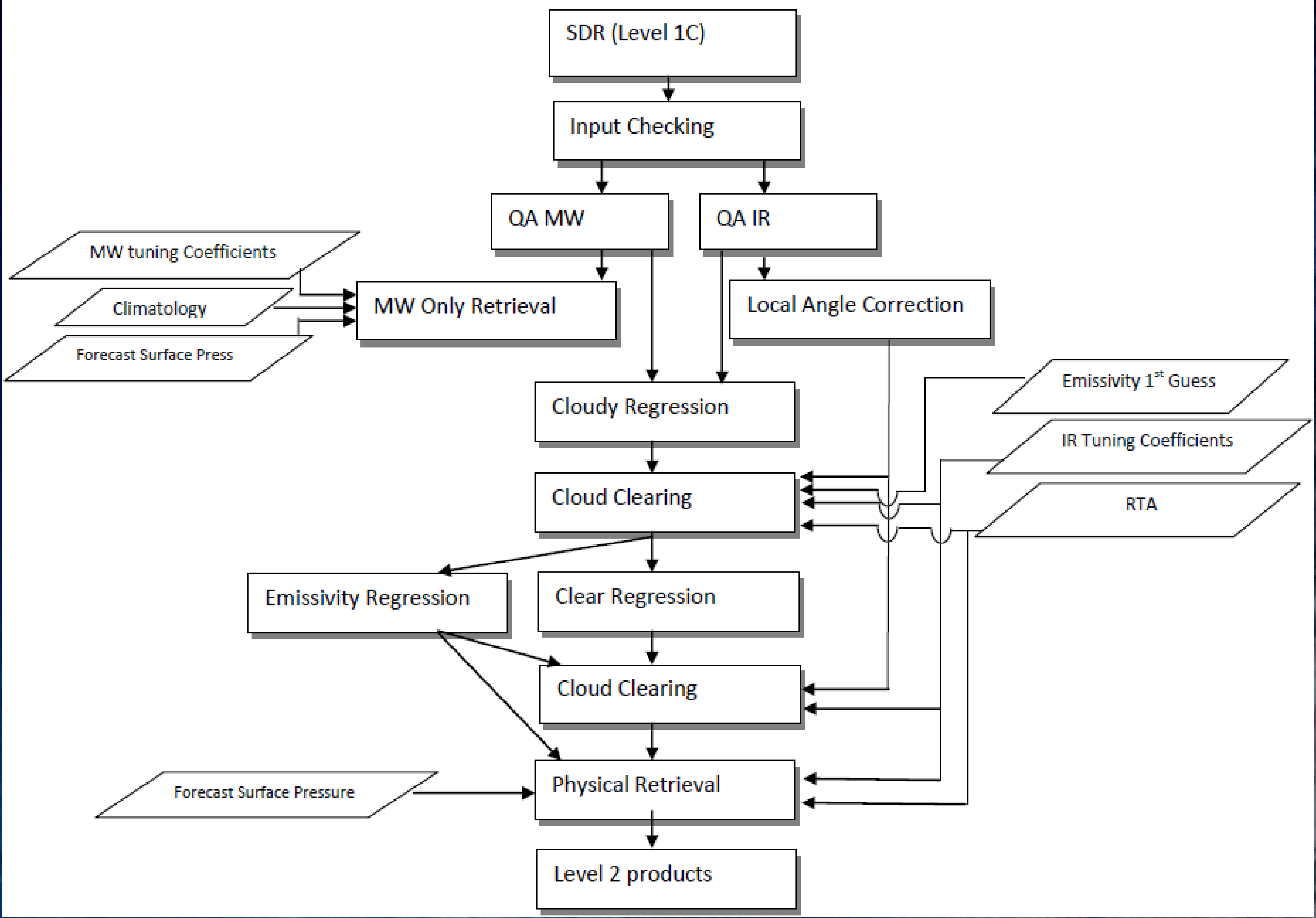
Quanhua (Mark) Liu, Chris Barnet, Antonia Gambacorta, Nick Nalli, Changyi Tan, Kexin Zhang, Flavio Iturbide-Sanchez, Mike Wilson, Bomin Sun, and Tony Reale

Presented by
Nick Nalli

Outline

- NUCAPS Retrieval System
- Updates, Versioning
- Validation Methodology
- Verification
- Validation
- Outgoing Longwave Radiation (OLR)
- Infrared Ozone Profile

NUCAPS Retrieval System Flowchart



Early NUCAPS Development and Updates

Date in ClearCase	Version	Impact/Notes:
Sept. 12, 2013	v1.0	Original NUCAPS (currently in operations). This was built on top of IASI-OPS (circa November 2011) by Antonia Gambacorta
Efforts to Unite Present-Day IASI (4/16/2013) and NUCAPS into One System using Two Different Approaches		
March 18, 2014	v1.1	Antonia Gambacorta's merge: Begin with NUCAPS v1.0 and upgrade November 2011 IASI to 4/16/2013 IASI.
April 2, 2014	v1.0.1	Mike Wilson's merge: Begin with 4/16/2013 IASI and rebuild NUCAPS.
Compare v1.1 and v1.0.1 to get rid of bugs **Successful Merge**		
April 17, 2014	v1.2	Backwards Compatible with NUCAPS (v1.0) and Present-Day IASI (4/16/2013)

NUCAPS Updates After Algorithm Merge

Date in ClearCase	Version	Impact/Notes:
Fixes to Code		
June 2, 2014	v1.3	Suggestions from Antonia Gambacorta: • Max solar zenith angle = 90 • Change math in surface.F to match variable names • Make background cosmic radiation dynamic with granule name instead of static • Check relative humidity above surface only
June 18, 2014	v1.4	Suggestions from Chris Barnet: • Change mean water calculation in simstat.F • Fixed initialization in simstat.F (num80=0) • Minor changes to ret_driver.F • Minor formatting changes

Upgrades for GNU Compiler Compatibility

Date in ClearCase	Version	Impact/Notes:
GNU Fortran Fixes		
July 23, 2014	v1.4.1	Fixes by Mike Wilson: • Moved certain variables from local variables to global (common block), since their values needed to be saved between profiles • Fixed variables that were not initialized, partially initialized, or not properly cleared before the next profile
July 25, 2014	v1.4.2	• Minor change by Changyi Tan for ecovi variable (to clean up initialization) • Minor upgrade to simstat.F by Chris Barnet (unrelated to gnu issues)

Most Recent Versions

Date in ClearCase	Versio n	Impact/Notes:
Stage-1 Validated Maturity		
Sep 3, 2014	v1.4.2	Stage-1 Validated Maturity achieved
Preprocessor		
Sep 23, 2014	v1.4.3	IDL Preprocessor rewritten and delivered in Fortran by Tish Soulliard
Current Version		
June 22, 2015	v1.5	• Updated Regression Coefficients by Kexin Zhang • Minor Formatting Fixes by Changyi Tan

Pending or Expected Near-Future Changes to NUCAPS

Item	Impact/Notes:
CrIMSS Precipitation Algorithm	• Based on work from Ralph Ferraro et al. • Ported to NUCAPS experimentally by Mike Wilson and Flavio Iturbide-Sanchez
Recent Updates by Antonia Gambacorta: • Code fixes: proft.F, comp_rad.F, load_tuning.F • Look-up table changes: – New ATMS noise file – New ATMS tuning file • Updated namelist to not use channel 16 when calculating MW-only temperatures	• Initial tests by Mark Liu's group showed that the tuning file improved the MW-only product, but dropped yields in the combined MW+IR product. • Need guidance on which changes should be pushed into the DAP, and which changes need more work before delivery.
Updated Regression from Kexin Zhang	Fixes issue in ECMWF water vapor units.

Validation Methodology Hierarchy

(e.g., *Nalli et al., JGR Special Section,* 2013)

1. **Numerical Model (e.g., ECMWF, NCEP/GFS) Global *Comparisons***
   - » Large, truly global samples acquired from Focus Days
   - » Useful for early sanity checks, bias tuning and regression
   - » However, not independent truth data

2. **Satellite EDR (e.g., AIRS, ATOVS, COSMIC) *Intercomparisons***
   - » Global samples acquired from Focus Days (e.g., AIRS)
   - » Consistency checks; merits of different retrieval algorithms
   - » However, IR sounders have similar error characteristics; must take rigorous account of averaging kernels of both systems (e.g., *Rodgers and Connor,* 2003)

3. **Conventional RAOB Matchup *Assessments***
   - » WMO/GTS operational sondes launched ~2/day for NWP
   - » Useful for representation of global zones and long-term monitoring
   - » Large statistical samples acquired after a couple months' accumulation (e.g., *Divakarla et al.,* 2006)
   - » **NOAA Products Validation System (NPROVS)** (*Reale et al.,* 2012)
   - » Limitations:
     - – Skewed distribution toward NH-continental sites
     - – Mismatch errors, potentially systematic at individual sites
     - – Non-uniform, less-accurate and poorly characterized radiosondes
     - – RAOBs assimilated , by definition, into numerical models

4. **Dedicated/Reference RAOB Matchup *Assessments***
   - » *Dedicated* for the purpose of satellite validation
     - – Known measurement uncertainty and optimal accuracy
     - – Minimal mismatch errors
     - – Atmospheric state "best estimates" or "merged soundings"
   - » Reference sondes: CFH, **GRUAN** corrected RS92/RS41
     - – Traceable measurement
     - – Uncertainty estimates
   - » Limitation: Small sample sizes and geographic coverage
   - » E.g., **ARM sites** (e.g., *Tobin et al.,* 2006), BCCSO, PMRF, AEROSE

5. **Intensive Field Campaign *Dissections***
   - » Include dedicated RAOBs, some *not* assimilated into NWP models
   - » Include ancillary datasets (e.g., ozonesondes, lidar, M-AERI, MWR, sunphotometer, etc.)
   - » Ideally include funded aircraft campaign using IR sounder (e.g., NAST-I, S-HIS)
   - » Detailed performance specification; state specification; SDR cal/val; EDR "dissections"
   - » E.g., **AEROSE**, **CalWater/ACAPEX**, **SNAP**, JAIVEX, WAVES, AWEX-G, EAQUATE

Assessment Methodology: Statistical Metrics

- Level 1 AVTP and AVMP accuracy requirements are defined over **coarse layers**, roughly 1–5 km for tropospheric AVTP and 2 km for AVMP (Table, Slide 6).
- We have recently introduced rigorous **zonal/land/sea surface area weighting** capabilities to these schemes for dedicated/reference RAOB samples

AVTP

$$\mathrm{RMS}(\Delta T_{\mathcal{L}}) = \sqrt{\frac{1}{n_j}\sum_{j=1}^{n_j}(\Delta T_{\mathcal{L},j})^2} \qquad \mathrm{BIAS}(\Delta T_{\mathcal{L}}) \equiv \overline{\Delta T}_{\mathcal{L}} = \frac{1}{n_j}\sum_{j=1}^{n_j}\Delta T_{\mathcal{L},j}$$

$$\mathrm{STD}(\Delta T_{\mathcal{L}}) \equiv \sigma(\Delta T_{\mathcal{L}}) = \sqrt{[\mathrm{RMS}(\Delta T_{\mathcal{L}})]^2 - [\mathrm{BIAS}(\Delta T_{\mathcal{L}})]^2}$$

AVMP and O_3

– W2 weighting was used in determining Level 1 Requirements

– To allow compatible STD calculation, W2 weighting should be consistently used for both RMS and BIAS

$$\Delta q_{\mathcal{L},j} \equiv \frac{\hat{q}_{\mathcal{L},j} - q_{\mathcal{L},j}}{q_{\mathcal{L},j}} \qquad \mathrm{RMS}(\Delta q_{\mathcal{L}}) = \sqrt{\frac{\sum_{j=1}^{n_j} W_{\mathcal{L},j}(\Delta q_{\mathcal{L},j})^2}{\sum_{j=1}^{n_j} W_{\mathcal{L},j}}},$$

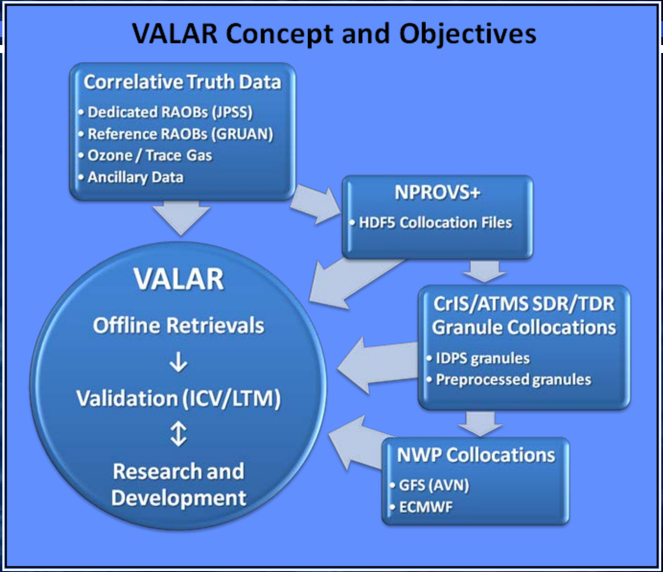
water vapor weighting factor, $W_{\mathcal{L},j}$,

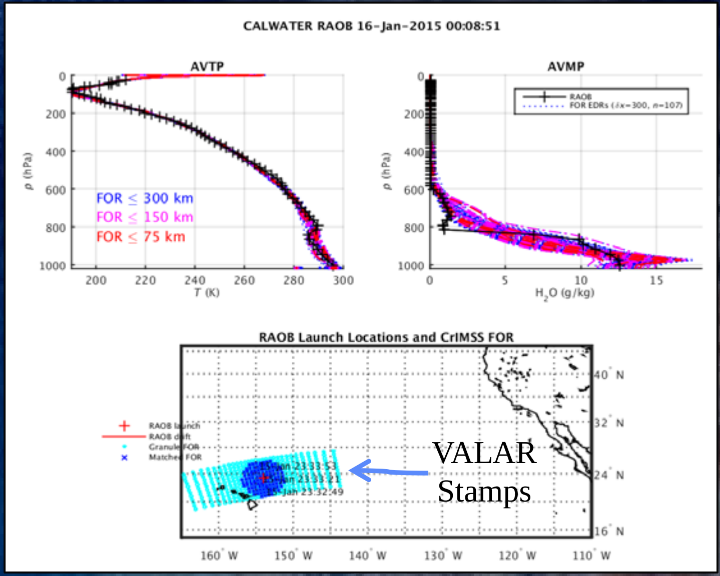
$$\mathrm{BIAS}(\Delta q_{\mathcal{L}}) = \frac{\sum_{j=1}^{n_j} W_{\mathcal{L},j}\,\Delta q_{\mathcal{L},j}}{\sum_{j=1}^{n_j} W_{\mathcal{L},j}}, \qquad W_{\mathcal{L},j} = \begin{cases} 1 & , \mathrm{W}^0 \\ q_{\mathcal{L},j} & , \mathrm{W}^1 \\ (q_{\mathcal{L},j})^2 & , \mathrm{W}^2 \end{cases}$$

$$\mathrm{STD}(\Delta q_{\mathcal{L}}) = \sqrt{[\mathrm{RMS}(\Delta q_{\mathcal{L}})]^2 - [\mathrm{BIAS}(\Delta q_{\mathcal{L}})]^2}$$

JPSS SNPP Validation Datasets and Tools

- **STAR Validation Archive (VALAR)** (*Nalli et al.*, 2014)
  - Low-level research data archive designed to meet needs of Cal/Val Plan
  - Dedicated/reference and intensive campaign RAOBs
  - SDR/TDR granule-based collocations ("stamps") within 500 km radius acquired off SCDR (past 90 days) or CLASS (older than 90 days)
  - Trace Gas EDR validation
  - Offline retrievals / retrospective reprocessing
  - MATLAB and IDL statistical codes and visualization software tools for monitoring
  - Rigorous coarse-layer (1-km, 2-km) product performance measures based on statistical metrics corresponding to Level 1 Requirements detailed in *Nalli et al.* (2013)
- **NOAA Products Validation System (NPROVS)** (*Reale et al.*, 2012)
  - Conventional RAOBs (NPROVS+ dedicated/reference), "single closest FOR" collocations
  - HDF5-formatted Collocation Files facilitates GRUAN RAOB matchups within VALAR
  - NRT monitoring capability
  - Satellite EDR intercomparison capability
  - Java based graphical user interface tools for monitoring
    - Profile Display (PDISP)
    - NPROVS Archive Summary (NARCS)

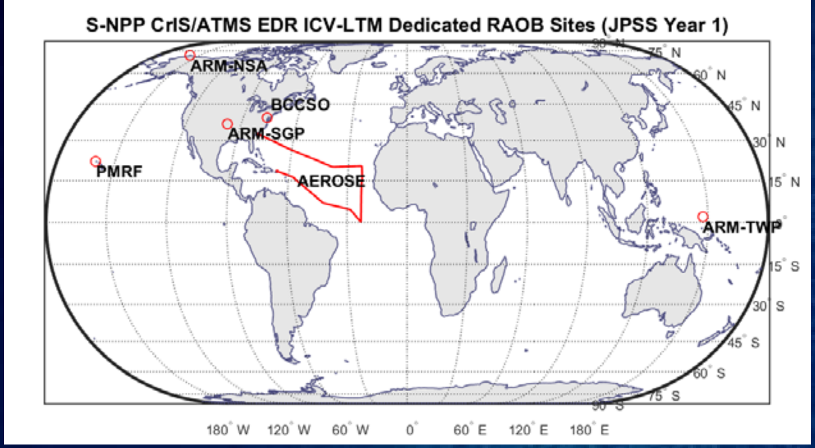


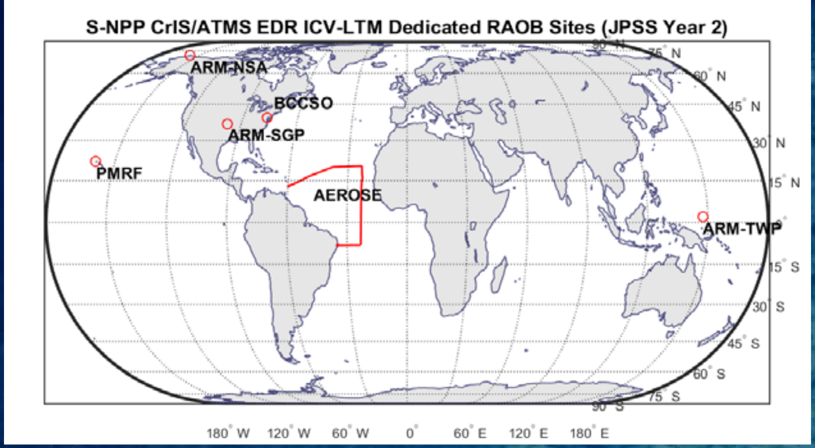


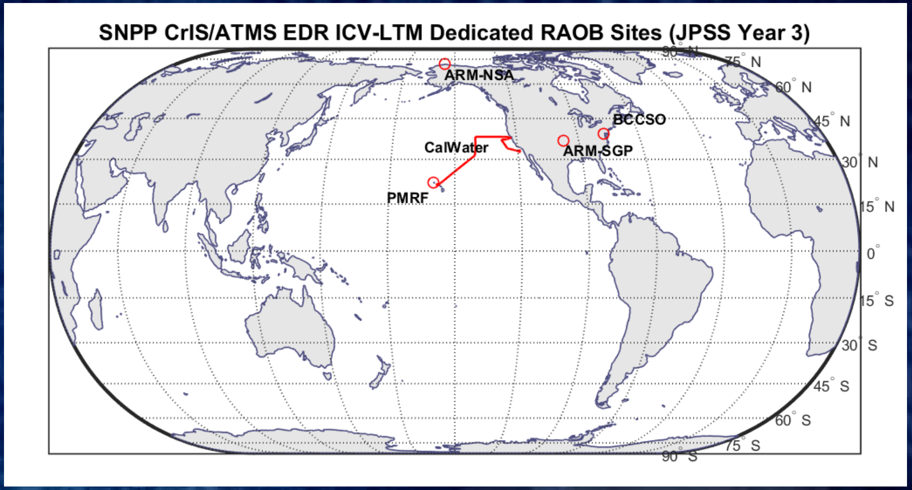
VALAR/NPROVS+ Dedicated and Reference RAOB Sites

JPSS SNPP Dedicated Year 3 (2014-2015)

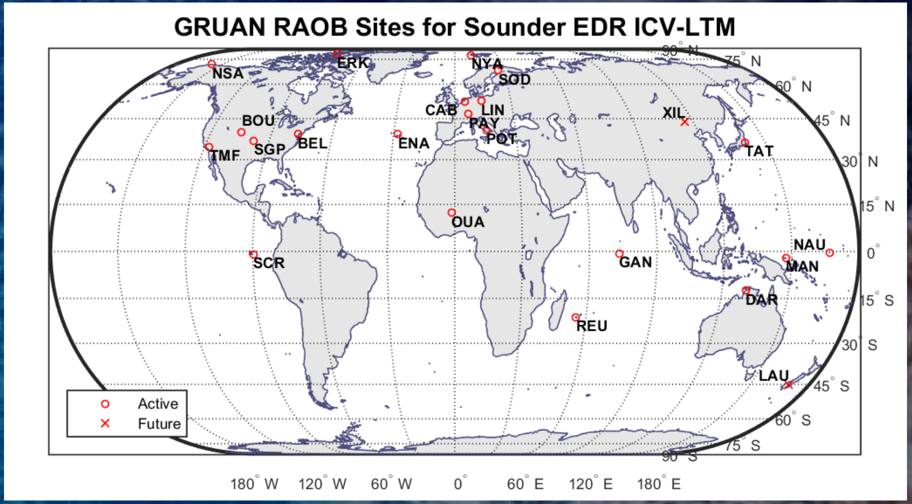
JPSS SNPP Dedicated Years 1 and 2 (2012-2014)



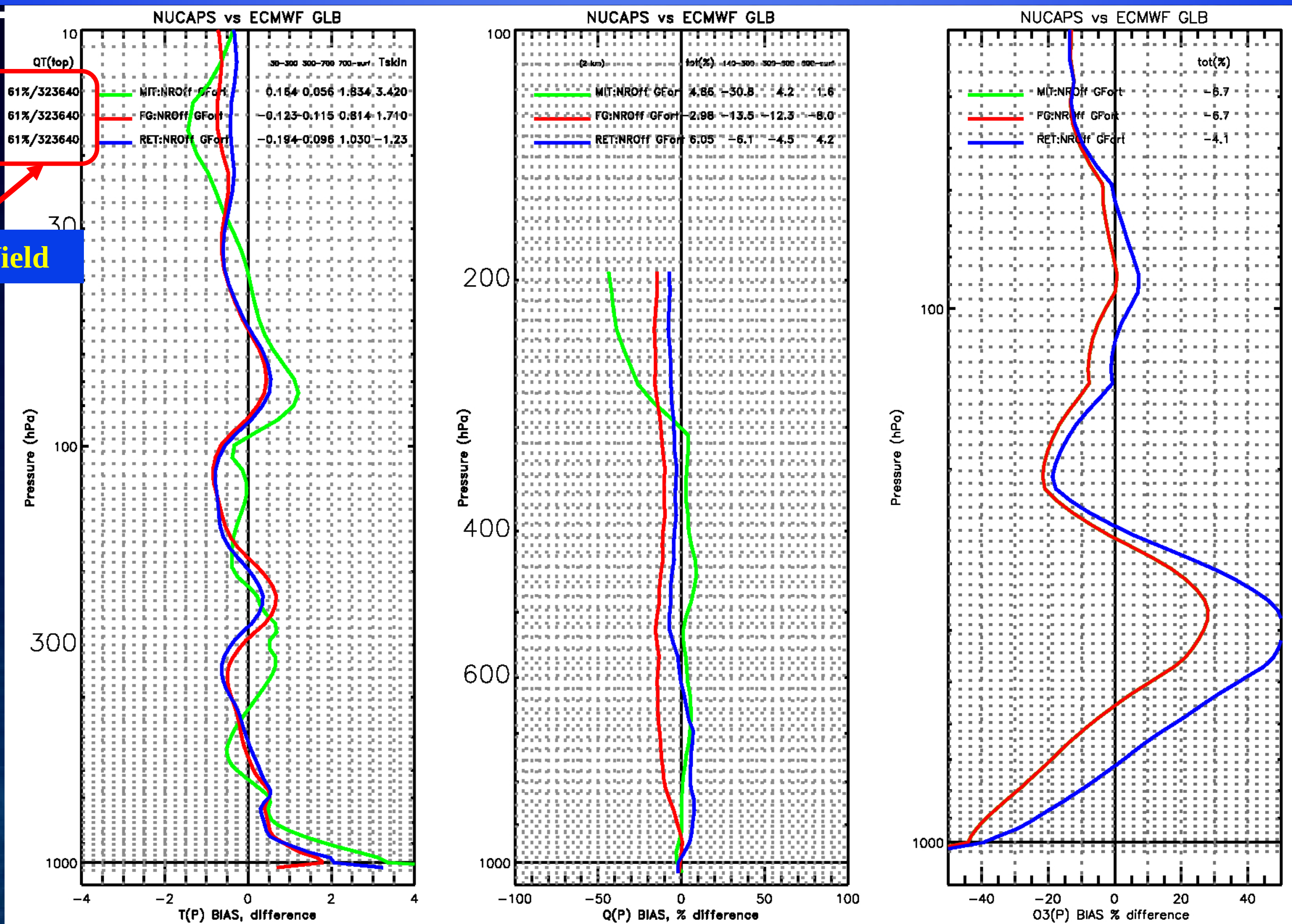




GRUAN Reference Sites

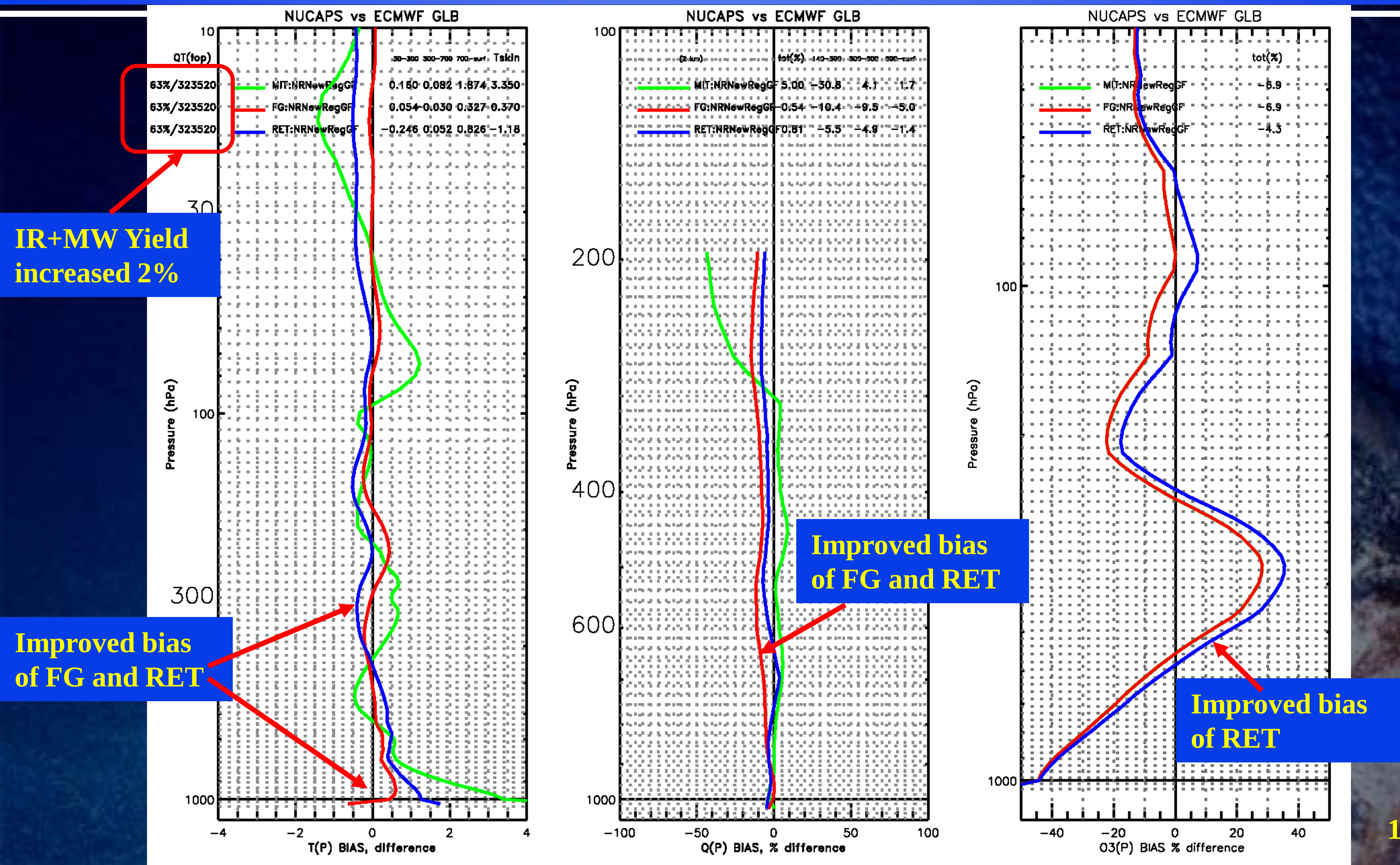


NUCAPS Offline Updated IR Regression Coef vs ECMWF
Global Bias (17 Feb 2015 Focus Day)

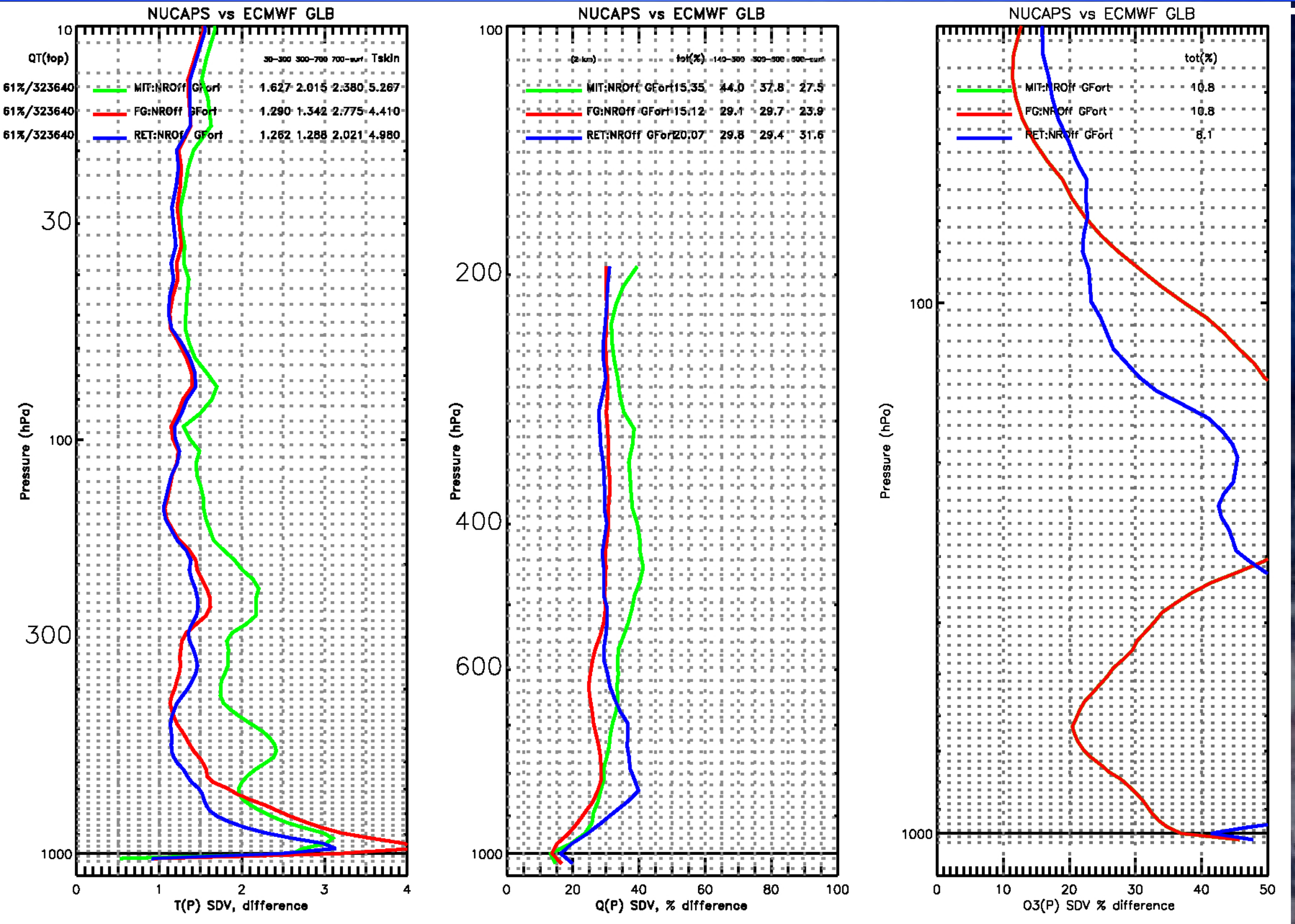


IR+MW Yield

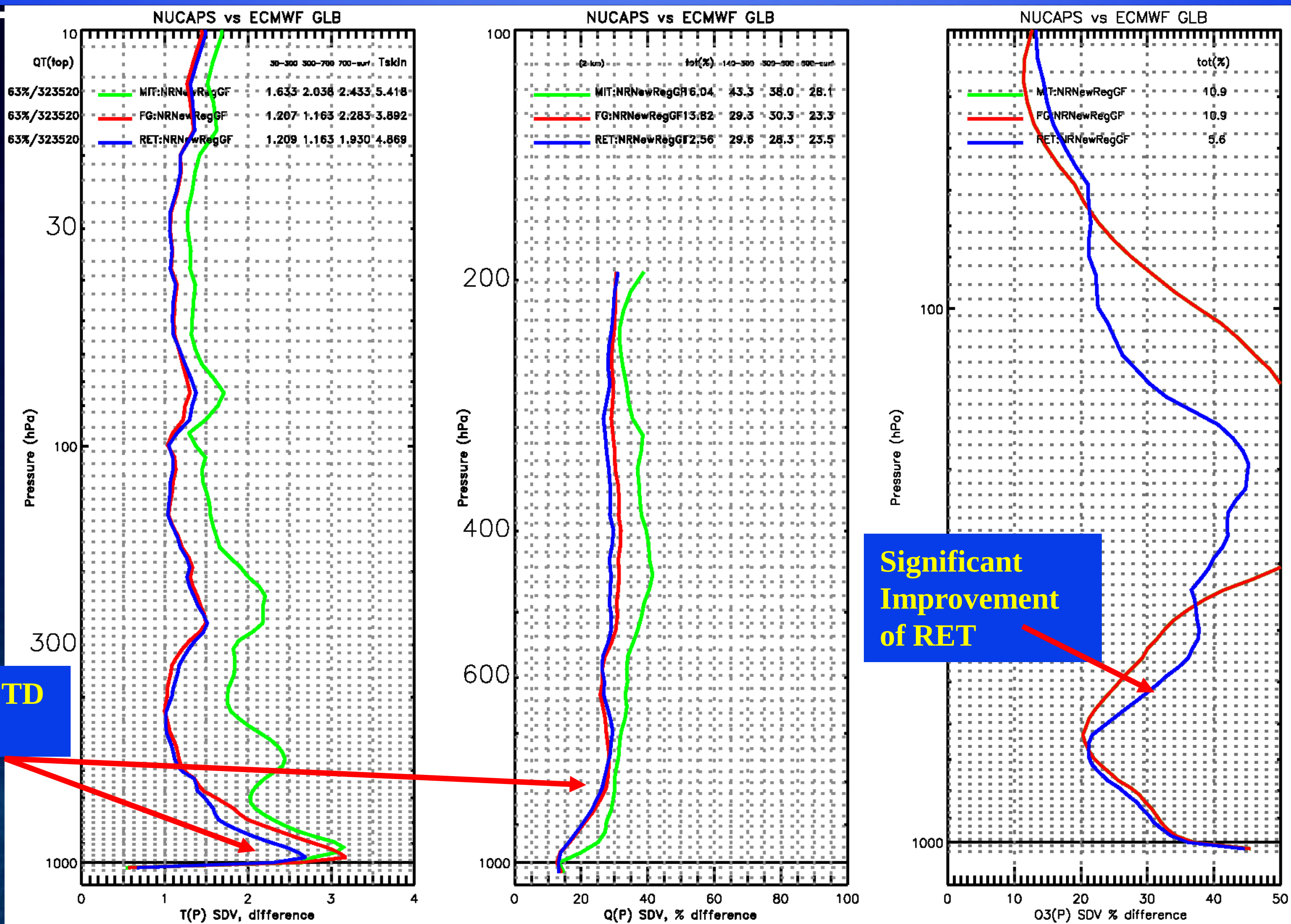
NUCAPS Offline New IR Regression Coef vs ECMWF Global Bias (17 Feb 2015 Focus Day)



NUCAPS (Nom. Res.) Offline Old IR Regression Coef vs ECMWF
Global STD (17 Feb 2015 Focus Day)



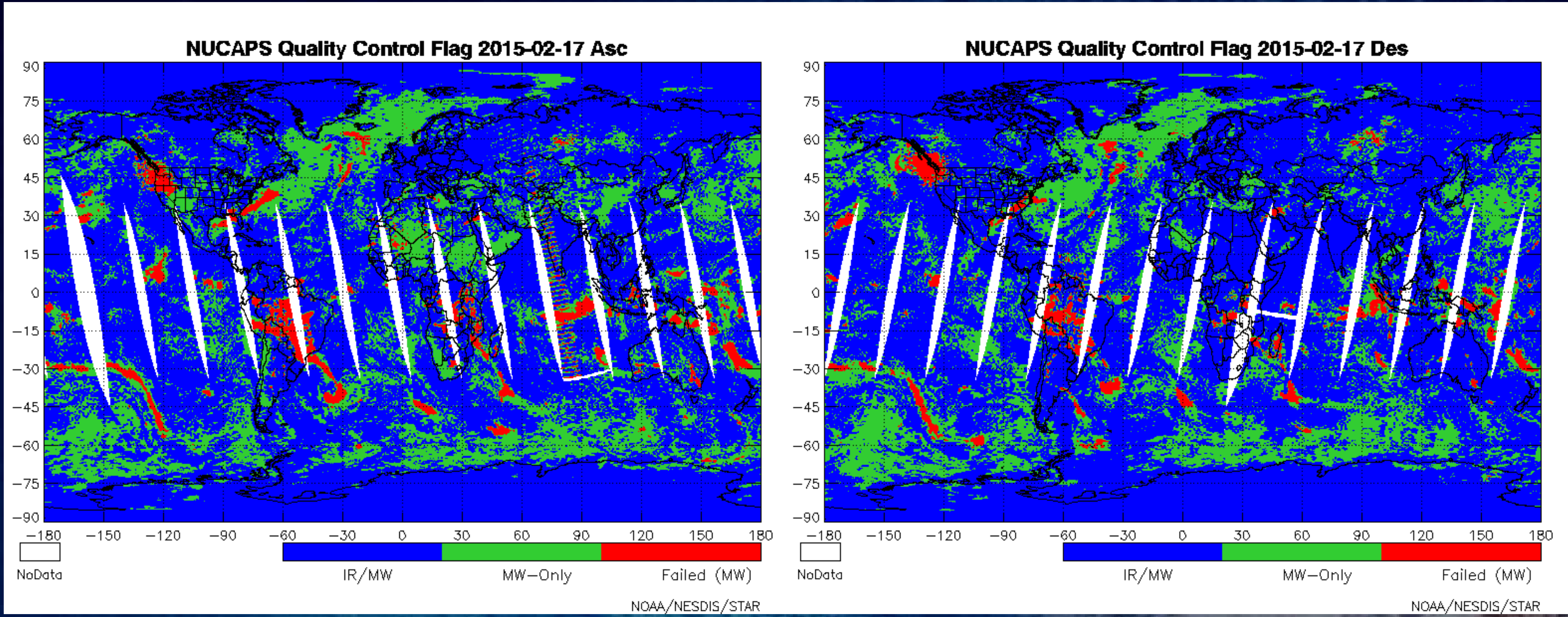
NUCAPS (Nom. Res.) Offline New IR Regression Coef vs ECMWF
Global STD (17 Feb 2015 Focus Day)



Reduced STD in RET

Significant Improvement of RET

NUCAPS Quality Flag



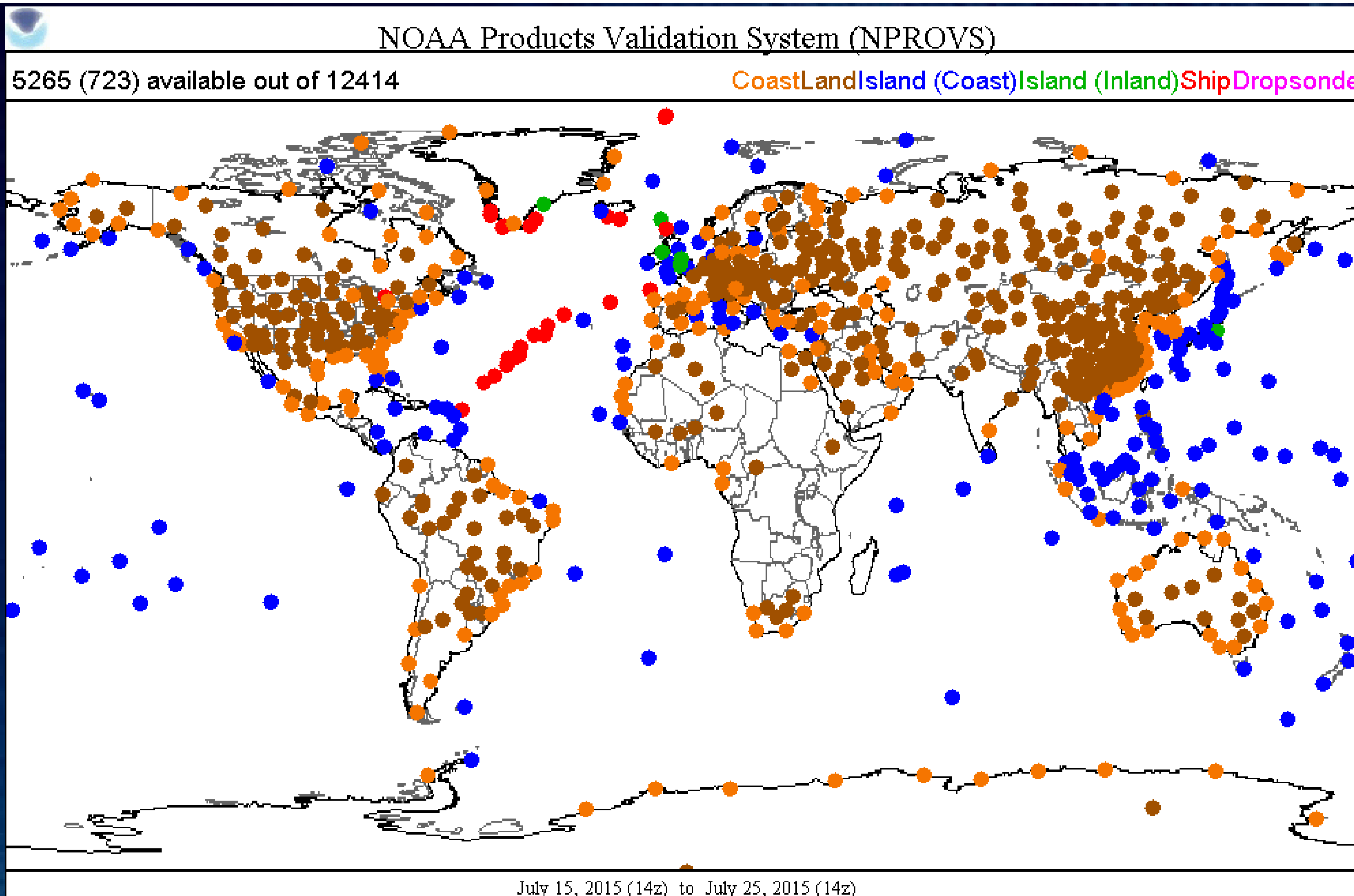
Summary of Retrieval QC Flags (17 Feb 2015 Focus Day)

NUCAPS Nominal Spectral Resolution (GFortran): Old IR Regression Coefficients						
Bit5(2^4=16)	Bit4(2^3=8)	Bit1(2^0=1)	Summary of Retrieval Quality Control Flags			
Regression	MW-only	IR + MW	QC Category	All Data	Ascending	Descending
0=Accepted	0=Accepted	0=Accepted	QC=0 (%)	61.669	60.015	63.281
0=Accepted	0=Accepted	1=Rejected	QC=1 (%)	35.142	36.484	33.834
0=Accepted	1=Rejected	1=Rejected	QC=9 (%)	3.189	3.501	2.885
1=Rejected	0=Passed	1=Rejected	QC=17 (%)	0	0	0
1=Rejected	1=Rejected	1=Rejected	QC=25 (%)	0	0	0
			IR+MW Accepted	61.669	60.015	63.281
			MW-Only Accepted	96.811	96.499	97.115
			Regression Accepted	100	100	100
			All Rejected	0	0	0
			Total	100	100	100

NUCAPS Nominal Spectral Resolution (GFortran): New IR Regression Coefficients						
Bit5(2^4=16)	Bit4(2^3=8)	Bit1(2^0=1)	Summary of Retrieval Quality Control Flags			
Regression	MW-only	IR + MW	QC Category	All Data	Ascending	Descending
0=Accepted	0=Accepted	0=Accepted	QC=0 (%)	63.468	62.465	64.447
0=Accepted	0=Accepted	1=Rejected	QC=1 (%)	33.478	34.305	32.671
0=Accepted	1=Rejected	1=Rejected	QC=9 (%)	3.054	3.23	2.882
1=Rejected	0=Passed	1=Rejected	QC=17 (%)	0	0	0
1=Rejected	1=Rejected	1=Rejected	QC=25 (%)	0	0	0
			IR+MW Accepted	63.468	62.465	64.447
			MW-Only Accepted	96.946	96.77	97.118
			Regression Accepted	100	100	100
			All Rejected	0	0	0
			Total	100	100	100

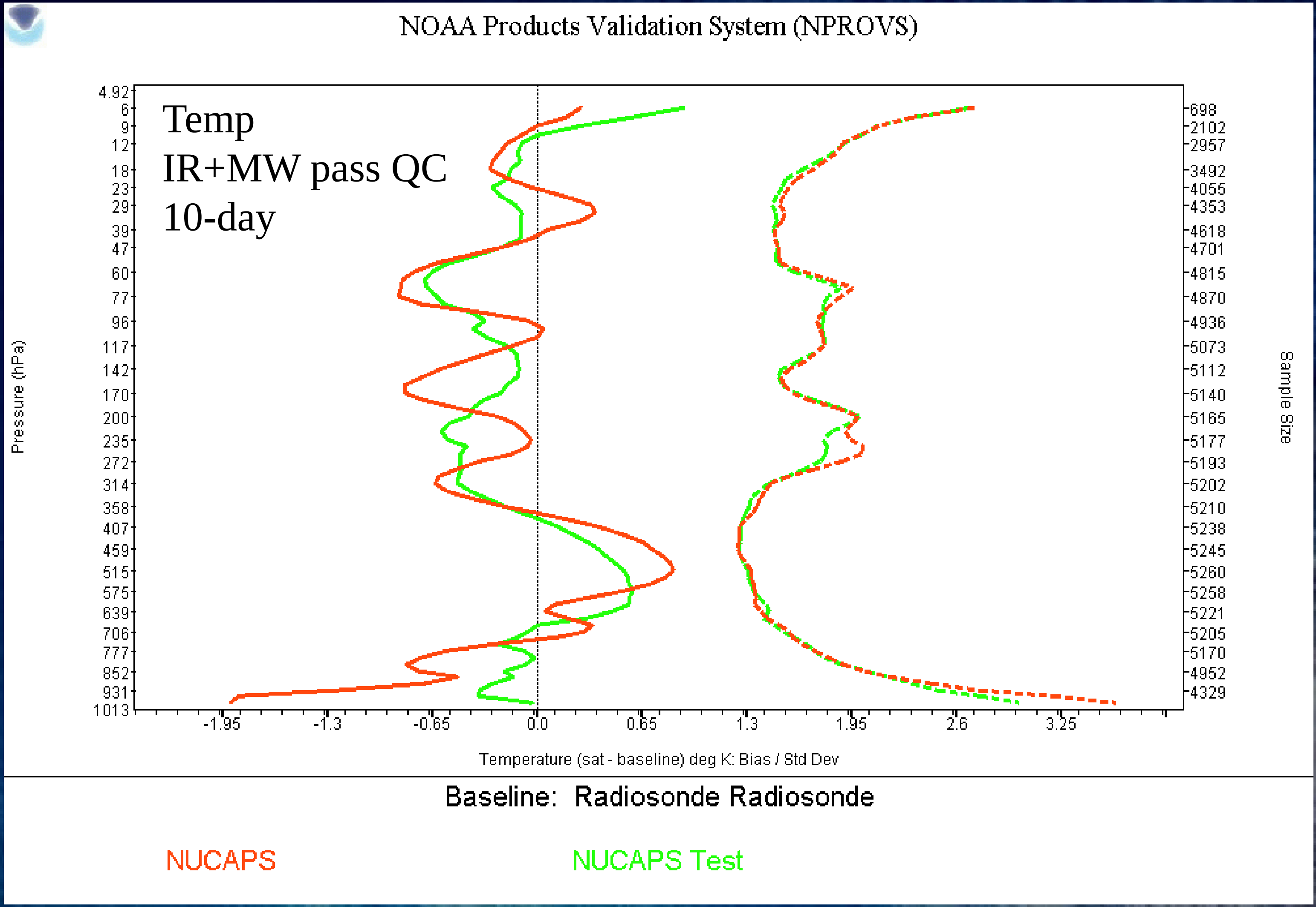
- IR/MW Yield increased about 2%
- MW-only Yield decreased about 2%
- IR/MW Yield is larger at Night (Des)

NUCAPS in NPROVS



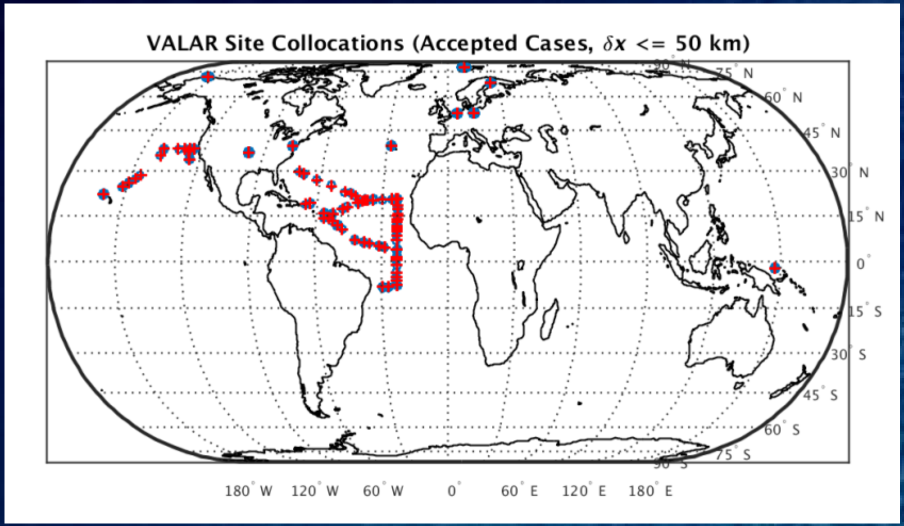
10-day sample collocated with NUCAPS IR+MW pass QC including newly deployed NUCAPS parallel (test) system

NUCAPS in NPROVS

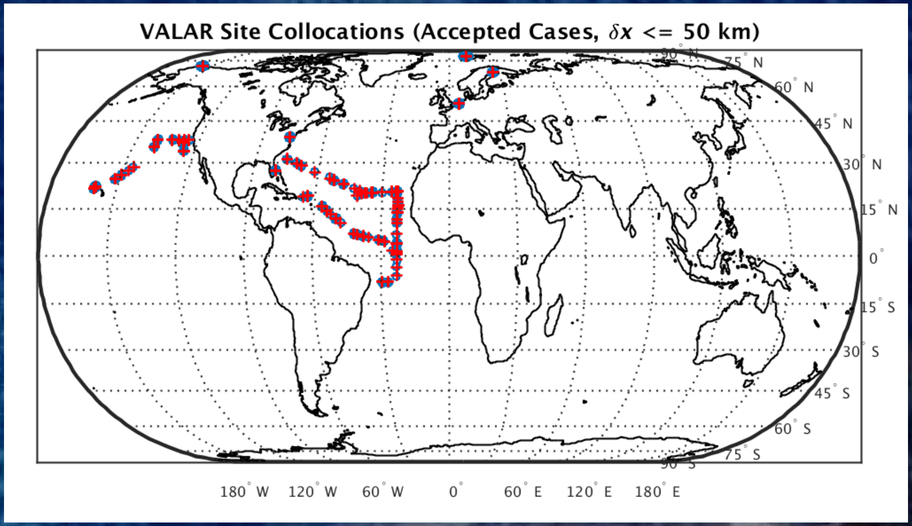


VALAR Dedicated/Reference RAOB Collocations
50 km radius

NUCAPS OPS-EDR Sample

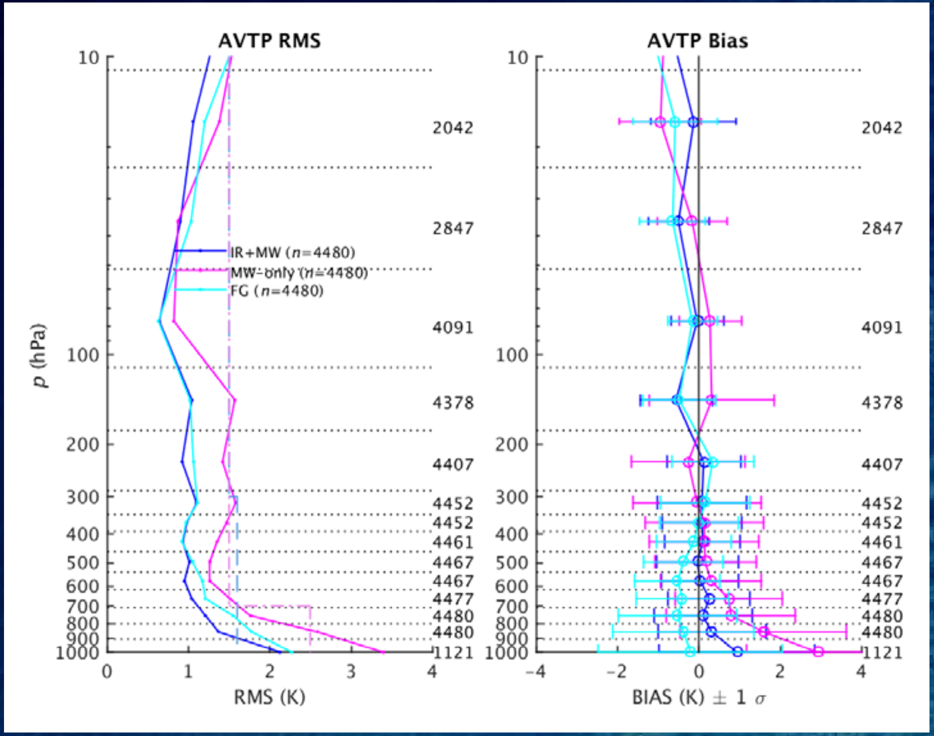


NUCAPS Offline (v1.5) Prelim Sample

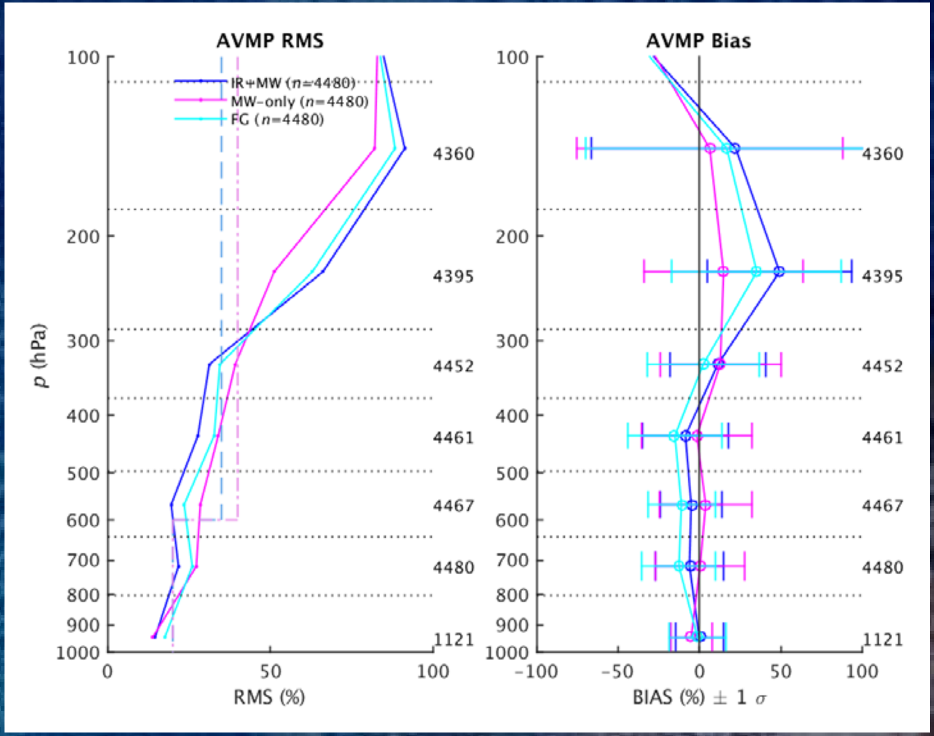


NUCAPS OPS-EDR
VALAR Dedicated/Reference RAOB Sample

AVTP

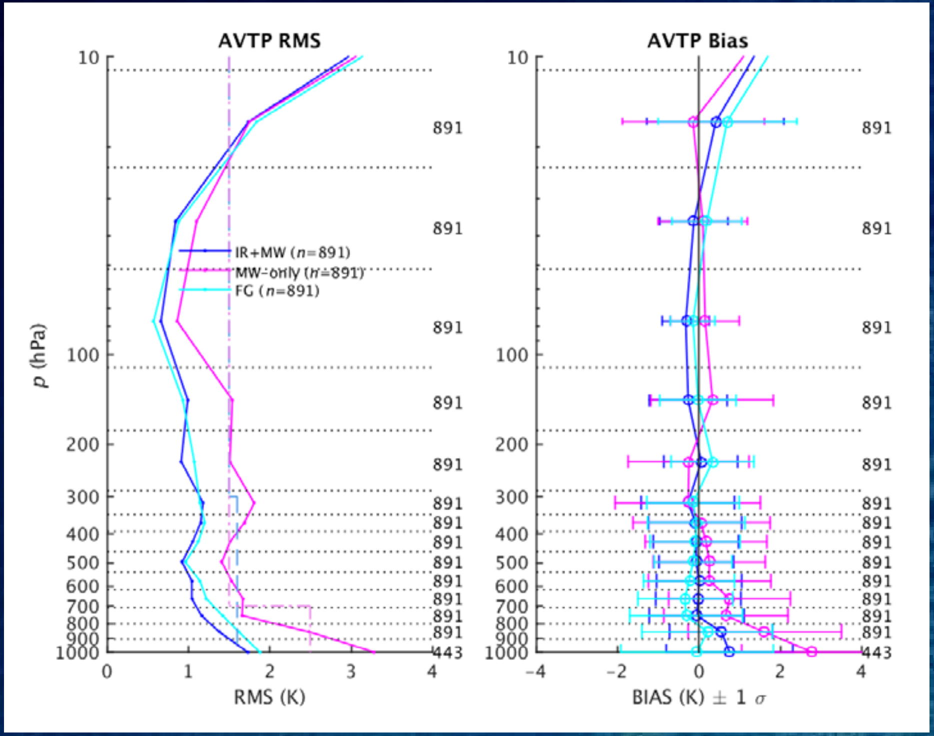


AVMP

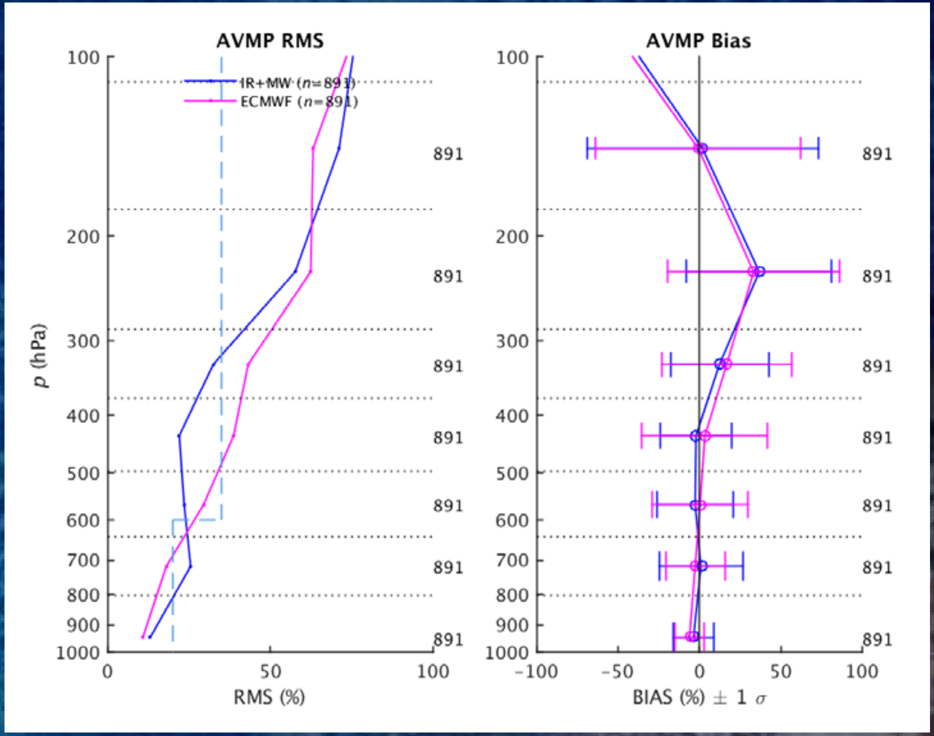


NUCAPS Offline (v1.5) EDR
VALAR Dedicated/Reference RAOB Prelim Sample

AVTP



AVMP



Outgoing Longwave Radiation Requirements

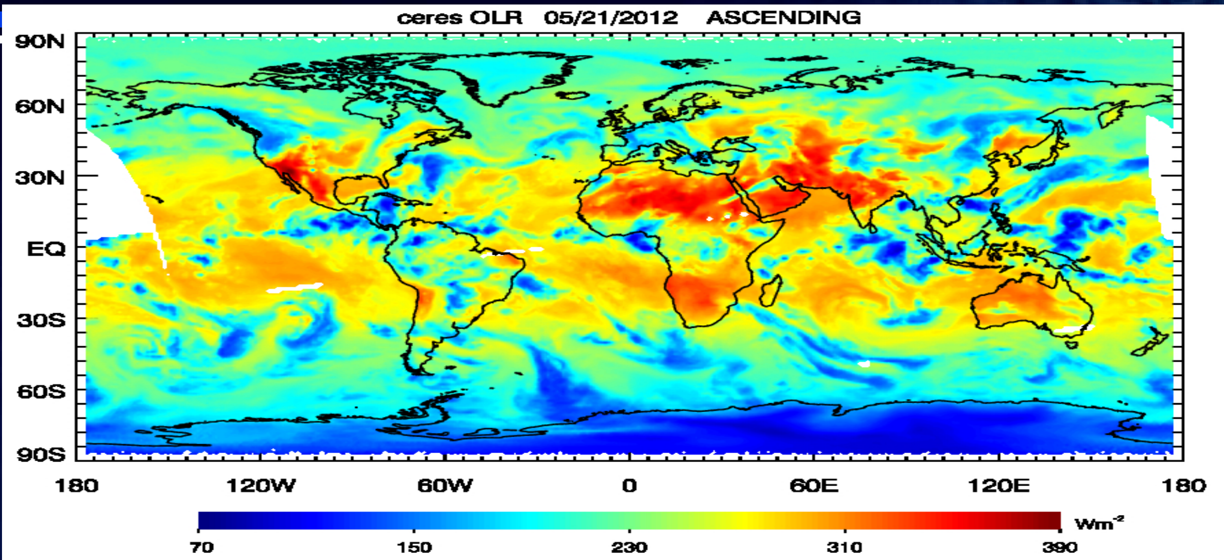
OLR is the instantaneous radiative energy emitted by the Earth-atmosphere system at the Top of the Atmosphere (TOA) to space into a hemisphere. Requirements are given in the following table (JPSS L1RD v2.9, June 27, 2013)

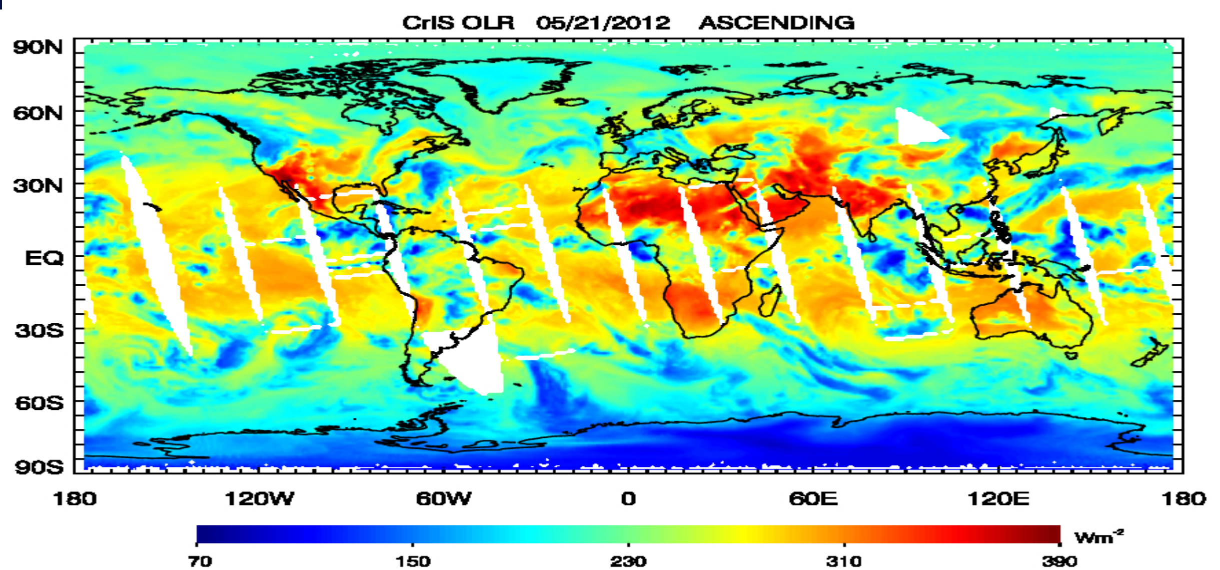
Table 5.4.2 - Outgoing Longwave Radiation (CrIS)

EDR Attribute	Threshold	Objective
OLR Applicable Conditions: 1. Daytime and nighttime, rergardless of sky conditions.		
a. Horizontal Cell Size	25 km at Nadir	10 km at Nadir
b. Mapping Uncertainty, 3 Sigma	5 km at Nadir	2 km at Nadir
c. Measurement Range	0 to 500 W/m^2	0 to 500 W/m^2
d. Measurement Precision	12 W/m^2	6 W/m^2
e. Measurement Accuracy	5 W/m^2	3 W/m^2
f. Refresh	At least 90% coverage of the globe every 12 hours (monthly average) (once/daytime; once/nighttime)	< 12 hrs.
		v2.8, 5/3/13

Notes:
1. OLR is now an infrared product produced from CrIS, rather than CERES data.

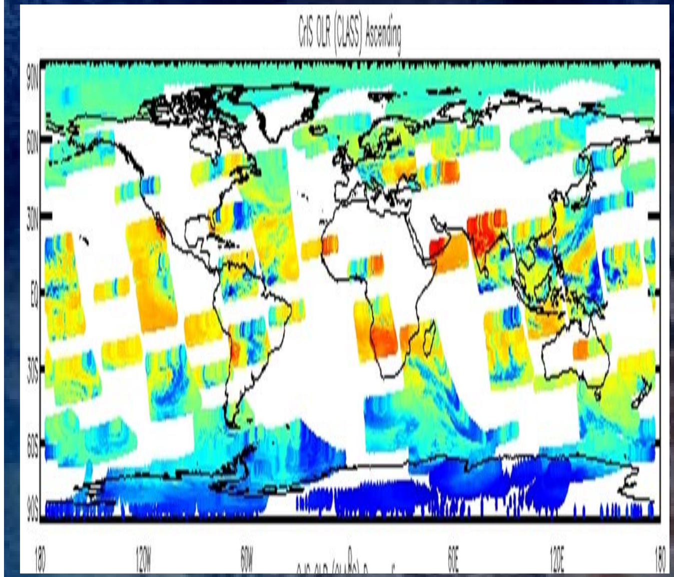
SNPP CrIS OLR versus CERES OLR, 21 May 2012



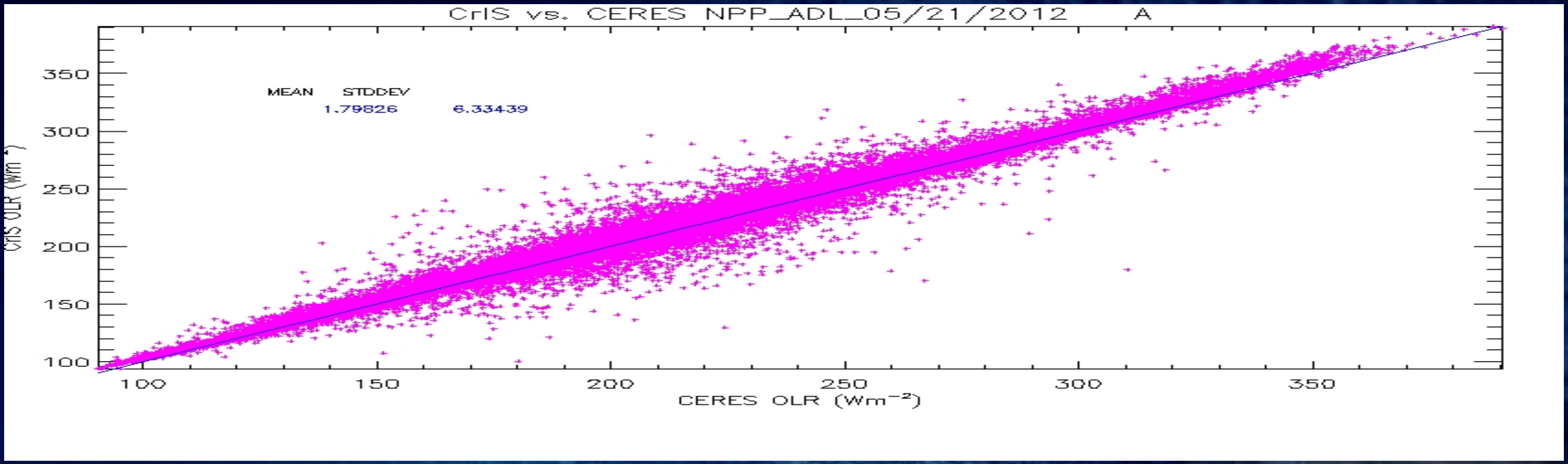


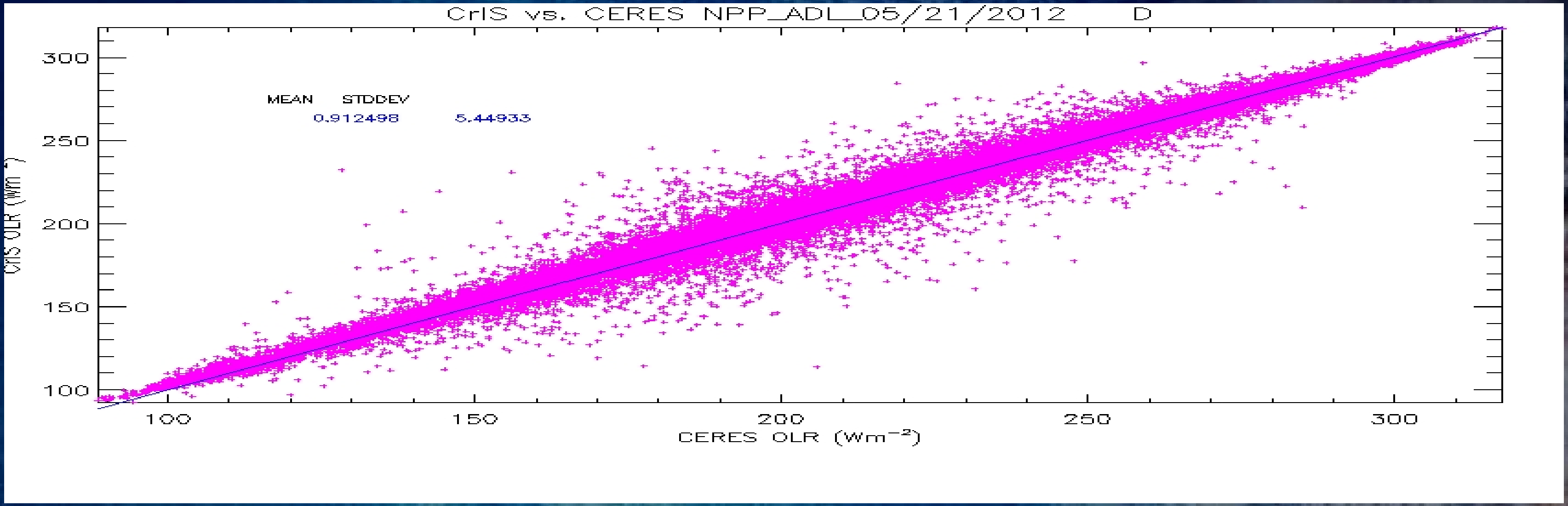
CERES S-NPP FM5 online
Available from
January 27 to May 31, 2012.

CrIS SDR has quality before June 2012 (see figure below)
STAR AIT team re-process CrIS SDR data using current calibration method.

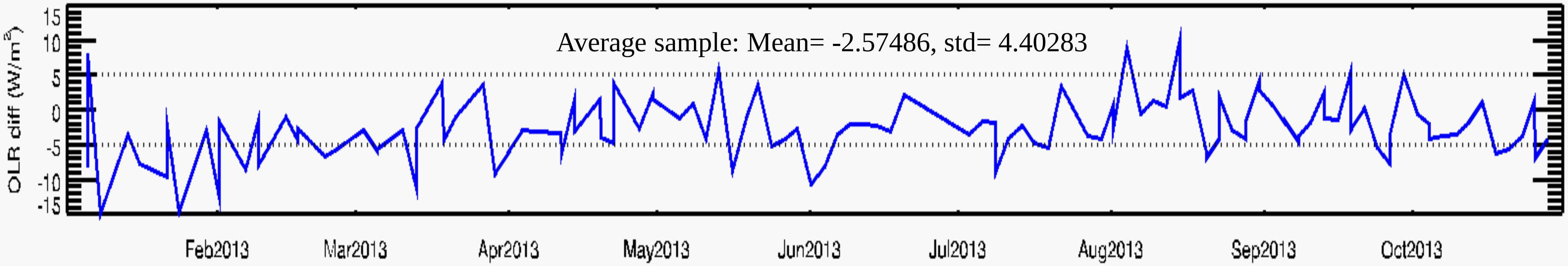


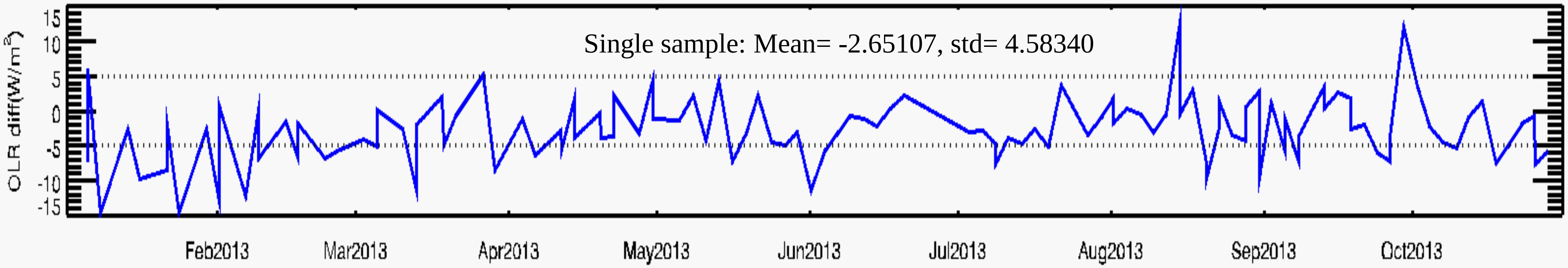
CrIS retrieved OLR versus CERES NPP OLR global





CrIS versus CERES Aqua OLR over SNOs





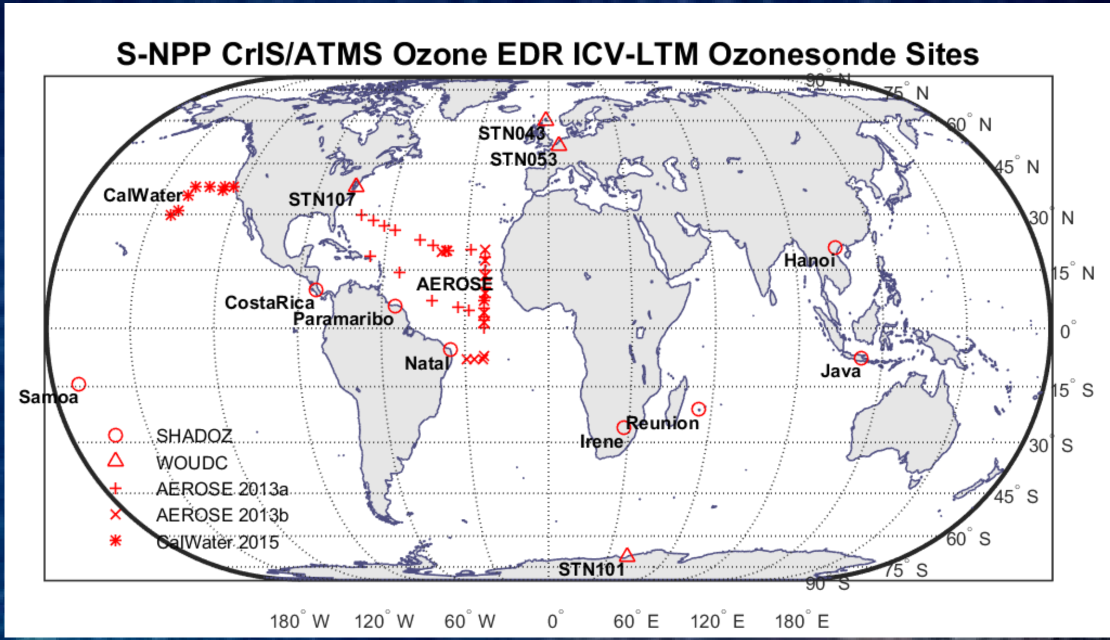
Infrared Ozone Profile Requirements

L1RD
p. 48

Attribute	Threshold	Objective
Surface to TOA	Report on RT grid used within retrieval (100 layers). Each layer reports the layer column density.	report on 100 layers used within retrieval
Horizontal Cell Size	50 km at nadir	15 km at nadir
Mapping Uncertainty	10 km	5 km
Measurement Precision (STD) 4 – 260 hPa (6 statistic layer) 260 – surface (1 statistic layer)	 20% 20%	 10% 10%
Measurement Accuracy (BIAS) 4 – 260 hPa (6 statistic layer) 260 – surface (1 statistic layer)	 10% 10%	
Measurement Uncertainty (RMS) 4 – 260 hPa (6 statistic layer) 260 – surface (1 statistic layer)	 25% 25%	 15% 15%
Refresh	At least 90% coverage of the globe every 16 days (monthly average, both day and night)	NS

NUCAPS Trace Gas Validation *In Situ* Truth Datasets

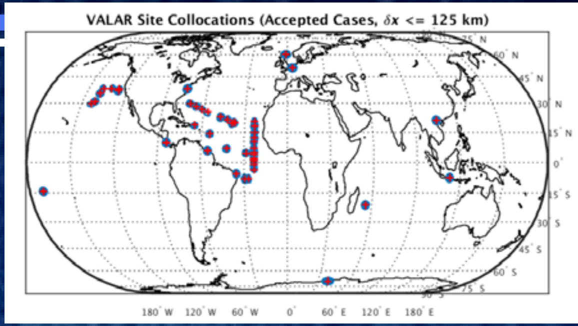
- **Collocated ozonesondes** for **O_3 (ozone) profile EDR**
  - » **Dedicated Ozonesondes**
    - – **NOAA AEROSE** (*Nalli et al.* 2011)
    - – **CalWater/ACAPEX 2015**
  - » **Sites of Opportunity**
    - – **SHADOZ**
      - Costa Rica
      - Hanoi
      - Irene
      - Java
      - Natal
      - Paramaribo
      - Reunion
      - American Samoa
    - – **WOUDC**
      - STN043
      - STN053
      - STN107
      - STN101



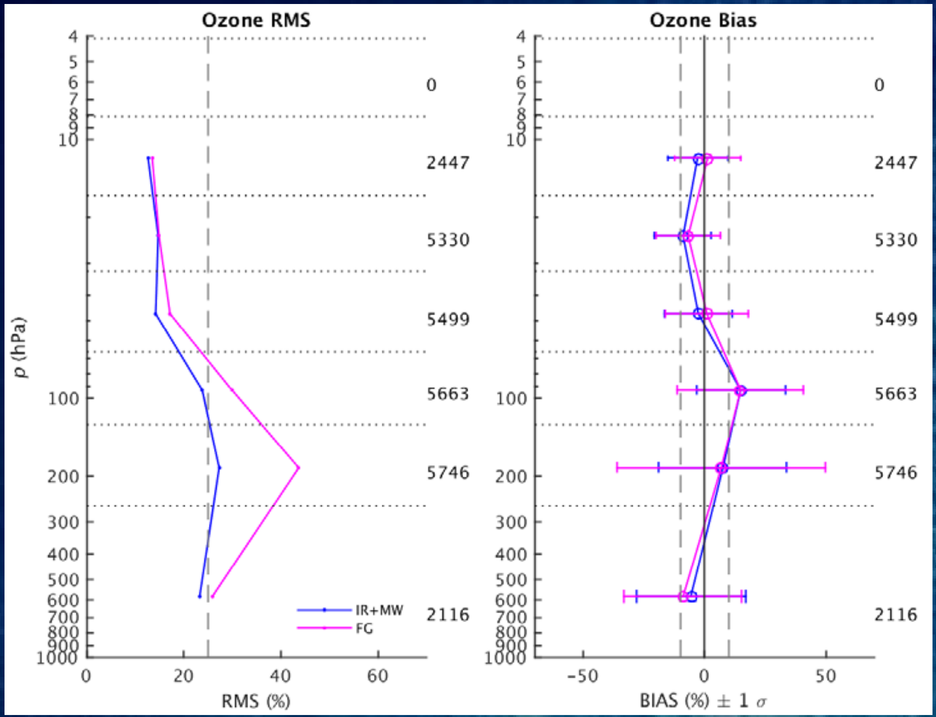
- Data suitable for carbon product CO, CO_2, CH_4 are currently being identified
  - » MOZAIC aircraft (CO)
  - » NOAA ESRL flask data (CO)
  - » Satellite data (MLS, OCO-2, etc.)
  - » Additional data currently being sought

Stage-2 Infrared Ozone Profile Validation
NUCAPS Offline (v1.5) EDR versus Global Ozonesondes

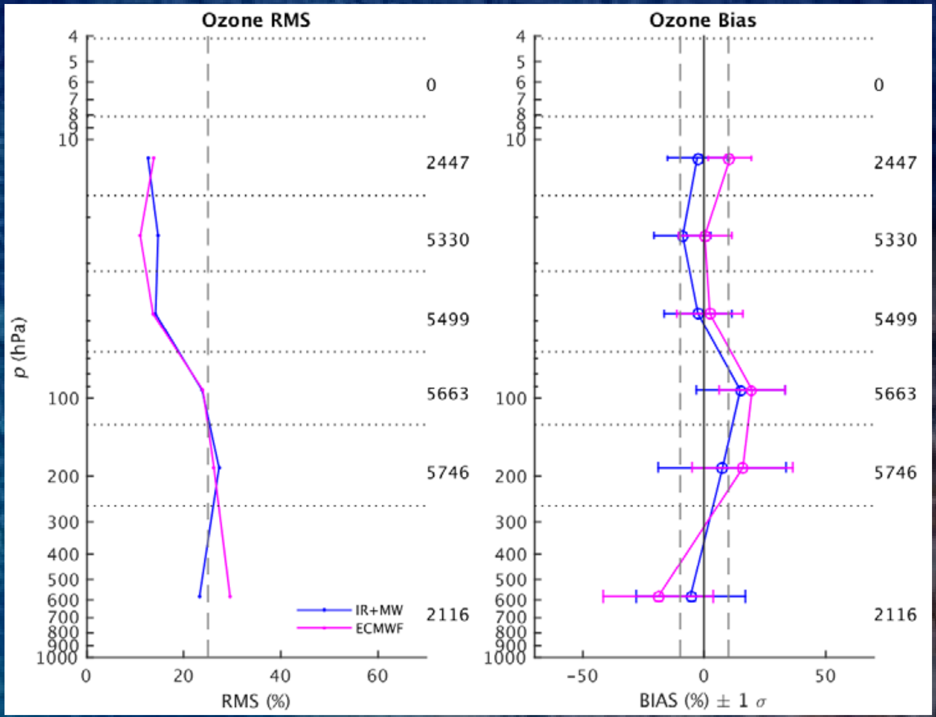
VALAR Dedicated, SHADOZ and WOUDC Ozonesonde Sample



Retrieval and ***A Priori* First Guess**



Retrieval and **ECMWF**



Summary

- The delivery is under version control (ClearCase)
- Impact of algorithm upgrades on AVTP and AVMP have been verified versus global Focus Day ECMWF
  - » NUCAPS v1.5 significantly improved the retrieval accuracy for AVTP, AVMP, and infrared ozone
  - » Validation of v1.5 versus global Dedicated/Reference RAOB collocations currently work in progress
- OLR meets the objective requirements
- Infrared Ozone Profile EDR meets L1RD specification requirements for Stage-2 Validated maturity

Scene in-homogeneities effects on interferometer-based radiance measurements and their impact on retrievals

Antonia Gambacorta
Science and technology Corporation
NUCAPS Phase 3 Algorithm Readiness Review
2015-09-03

Definition of the problem

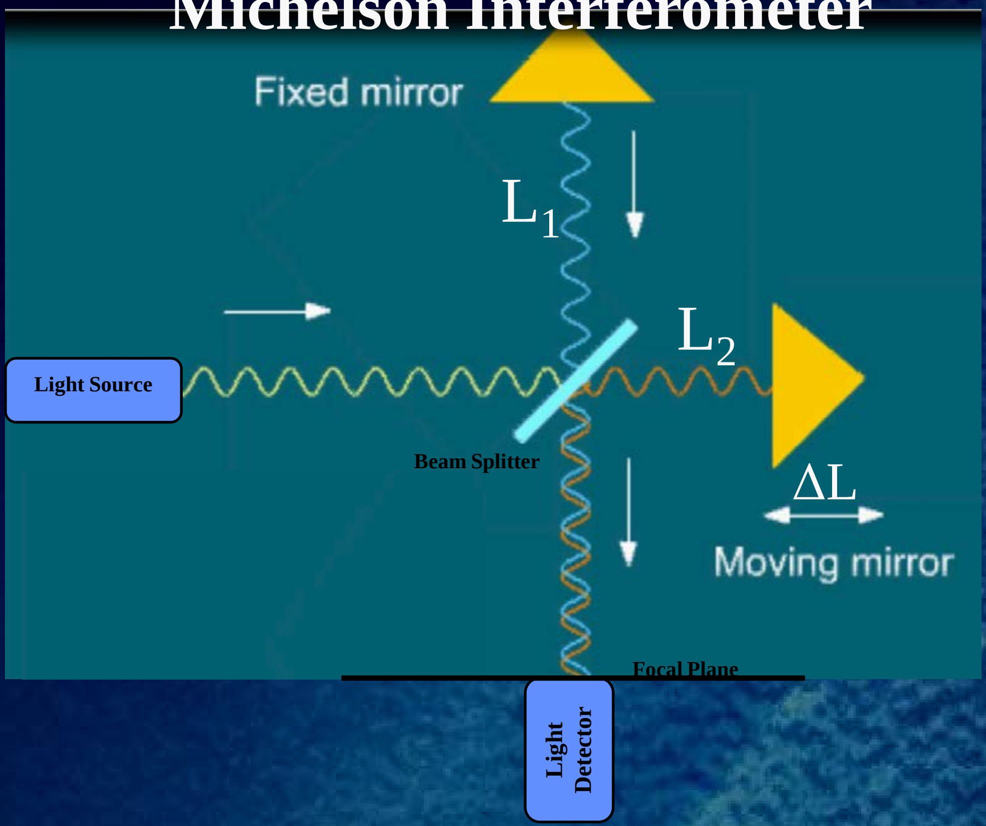
- **The precise knowledge of the Instrument Line Shape (ILS) of an interferometer is critical for any application of the radiance measurement: any error in the parameterization of the ILS will introduce a radiance error *δR* in the measured radiance spectrum.**

- **Scene in-homogeneities (clouds, surface in-homogeneities over the field of view) are responsible for an overall distortion of the theoretical FOV ILS, which is mainly a peak frequency shift effect, *δv*, hence the definition of *ILS shift*.**

- ***1) What is the magnitude of the radiance error introduced by the ILS distortion?***
- ***2) What is the impact on the retrieval performance?***

Basic Concept of Interferometry

Michelson Interferometer



The detector measures the variation of intensity as the mirror is displaced:

$$G(x) = g(\nu)[1 + \cos(2\pi\nu \cdot x)]$$

g(ν) = Input radiant power at frequency ν

x = Path Difference = 2(L1-L2)

Constructive Interference: x = nλ

Destructive Interference: x = (2n+1) λ/2

Polychromatic source:

$$G(x) = \int_0^\infty g(\nu)[1 + \cos(2\pi\nu \cdot x)]d\nu$$

Interferogram = oscillating part of G(x)

$$I(x) = \int_0^\infty g(\nu)\cos(2\pi\nu \cdot x)d\nu$$

The spectrum of the Source is Given by the Fourier Transform of the Interferogram

In practice the first term is lost due to AC coupling of the detectors.
Interferogram = oscillating part of G(x)

$$I(x) = KYH\int_0^{\infty} g(\nu)\cos(2\pi\nu\cdot x)\,d\nu$$

(cm^2 sr) (Volts/Watts) (Watts/cm^2 /sr/cm^{-1}) cm^{-1}= Volts

- H → Detector response (Volts/Watts)
- Y → Optical acceptance (cm^2 sr)
- K → Amplifier gain or optical losses

$$I(x) = C\int_{-\infty}^{\infty} g'(\nu)\cos(2\pi\nu x)\,d\nu = C\int_{-\infty}^{\infty} g'(\nu)\exp(j2\pi\nu x)\,d\nu$$

$$g'(\nu) = \begin{cases} \frac{g(\nu)}{2} & for\,\nu \geq 0 \\ \frac{g(\nu)}{2} & for\,\nu < 0 \end{cases}$$

I(x) is the Fourier transform of the source, g(ν).
The spectrum of the source is given back by the Inverse Fourier transform of I(x):

$$g(\nu) = \mathrm{F}^{-1}[I(x)] = \frac{2}{C}\int_{-\infty}^{+\infty} I(x)\exp(j2\pi\nu x)\,dx$$

Can't measure x over [-∞, ∞]
The interferogram is truncated at L_{max}

Truncation of the Interferogram

The measurement limit is a truncation of the interferogram between $\pm L_{max}$:

$$g_{meas}(\nu) = \frac{2}{C}\int_{-\infty}^{+\infty} A(x)I(x)\exp(j2\pi\nu x)dx$$

$$A(x) = \begin{cases} 1; |x| \le L_{\max} \\ 0; |x| > L_{\max} \end{cases}$$

$$g_{meas}(\nu) = \frac{2}{C}\mathrm{F}[A(x)I(x)] = \frac{2}{C}\mathrm{F}[A(x)]\otimes \mathrm{F}[I(x)] = \mathrm{ILS}\otimes \mathrm{g}(\nu)$$

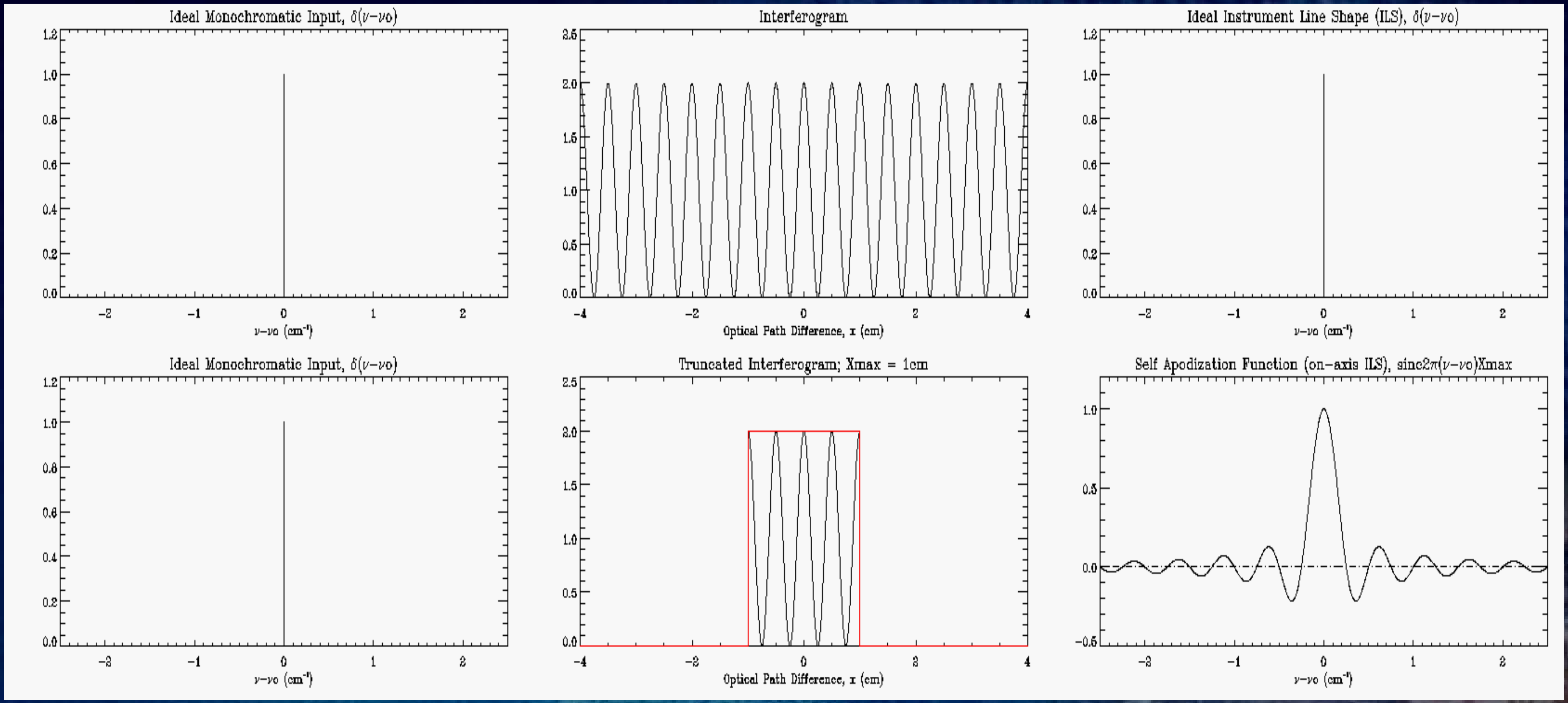
The instrument effect is a loss in accuracy where the original spectrum is “broaden” by the convolution with the instrument line shape function:

$$g_{meas}(\nu) = \int_{-\infty}^{+\infty} ILS(\nu-\nu')g(\nu')d\nu'$$

In the case of the box car function, A(x):

$$ILS = \mathrm{F}[A(x)] = 2L_{\max}\frac{\sin(2\pi\nu L_{\max})}{2\pi\nu L_{\max}} = 2L_{\max}\,\mathrm{sinc}(2\pi\nu L_{\max})$$

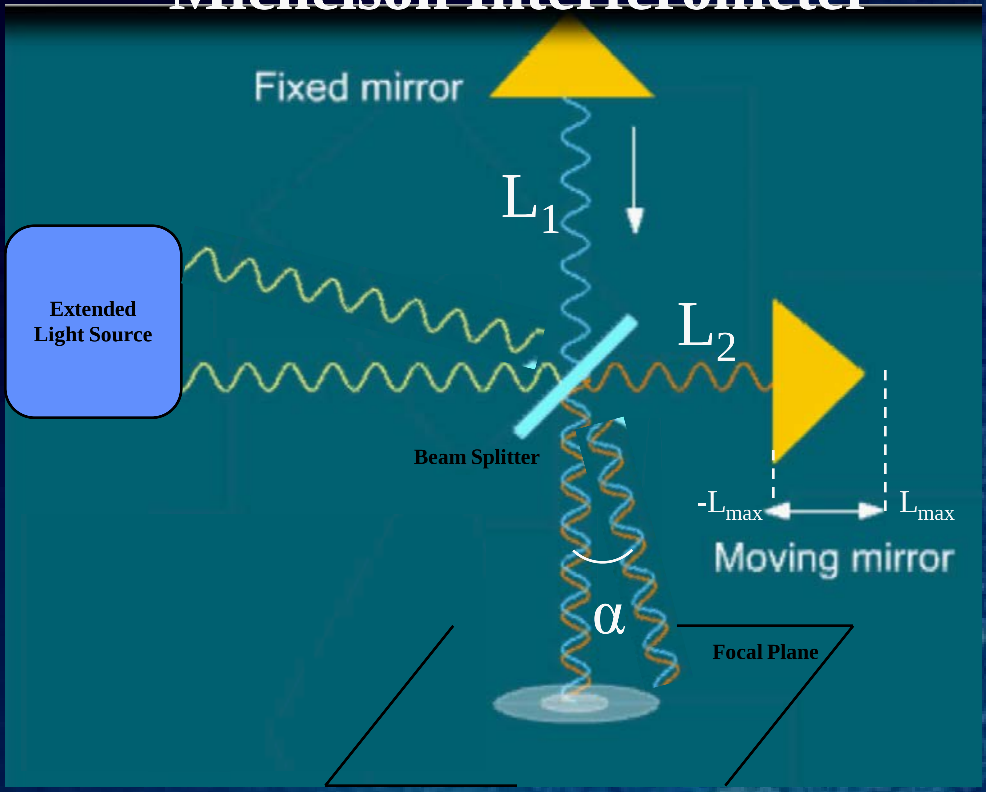
Truncation of the Interferogram & Resulting Instrument Line Shape



The Instrument Line Shape resulting from the box-car truncation is a sinc function with pronounced side lobe effects.

Basic Concept of Interferometry

Michelson Interferometer



A natural source of light has off-axis propagating beams which will intercept the focal plane at different angles, α.

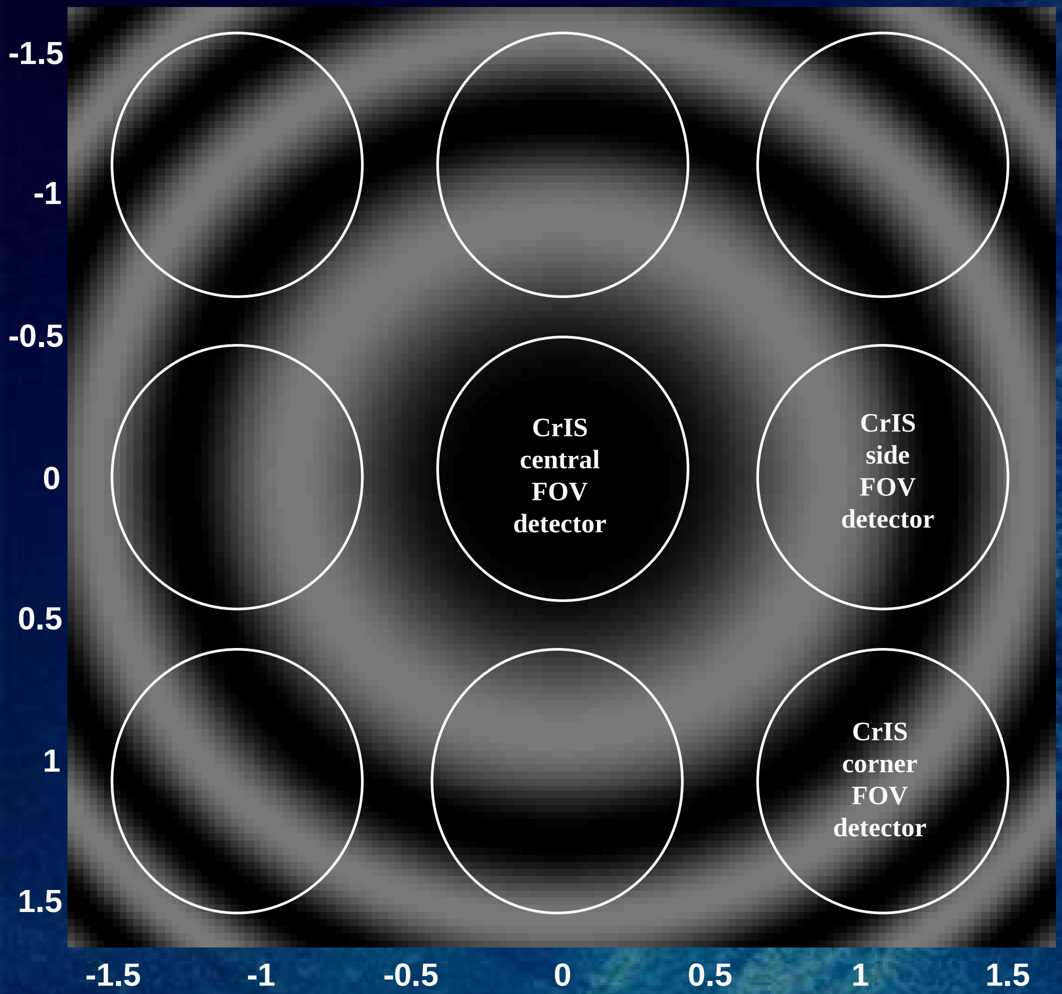
Off-axis optical path difference:
$X_{off\text{-}axis} = X_{on\text{-}axis}\cos\alpha$

The off-axis measurement on the screen is a α-dependent interference pattern consisting of a bright center and alternating dark and bright fringes given by:

$$G(x) = g(\nu)[1 + \cos(2\pi\nu \cdot x\cos\alpha)]$$

Self Apodization Effect & CrIS FOV Geometry

Focal Plane

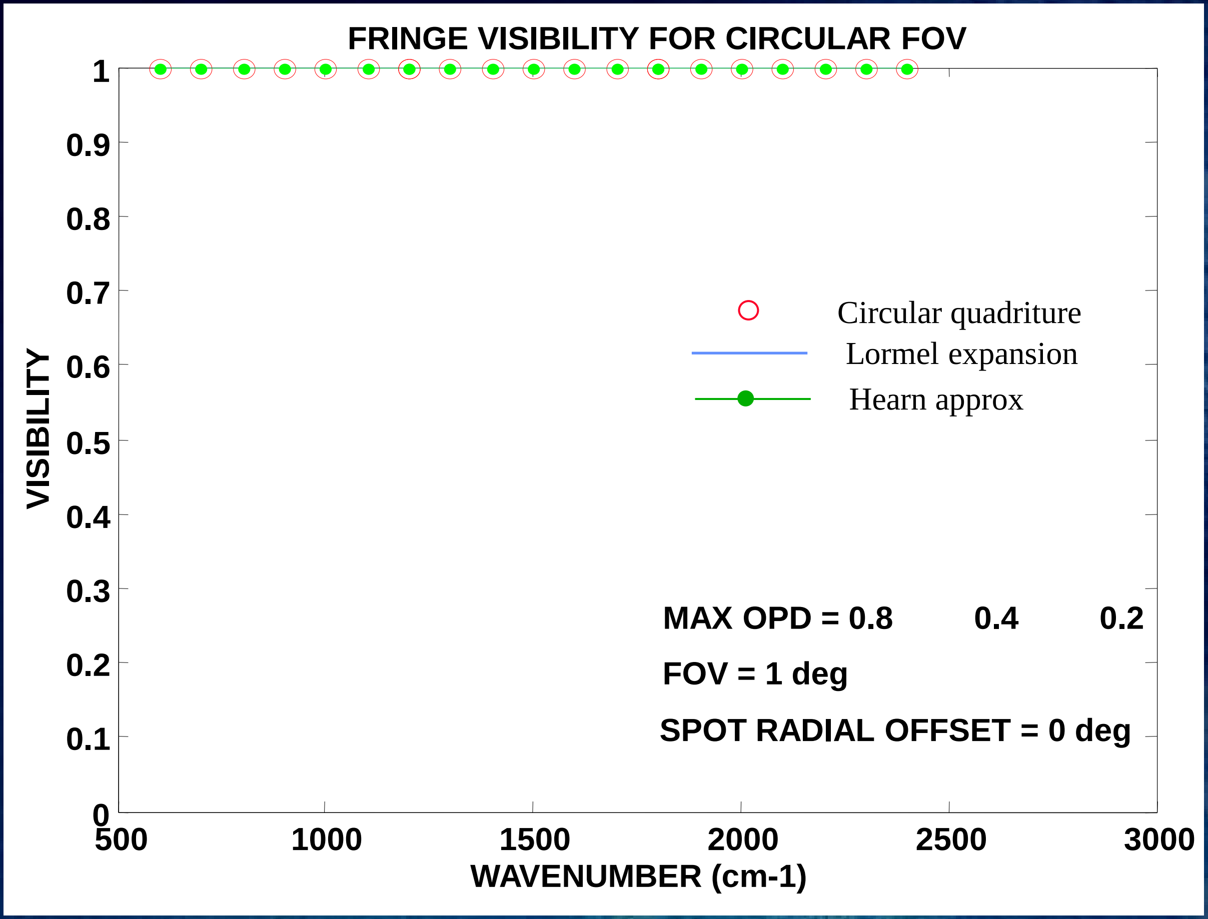


What the detector measures is the integration over the solid angle subtended by the detector at the exit pupil:

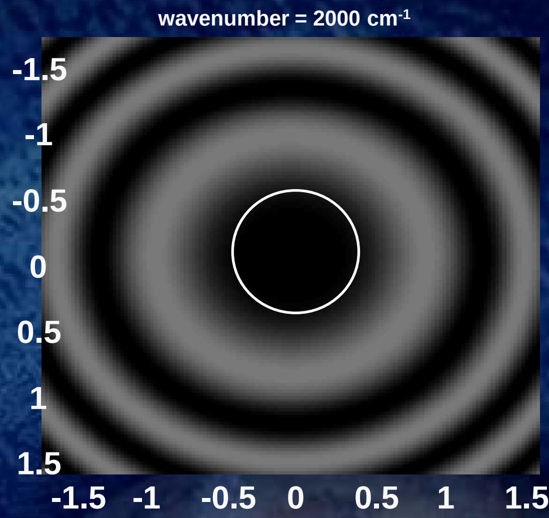
$$G(x) = \int_0^{\Omega_{max}} G(x,\Omega)\,d\Omega$$

If the detector FOV falls beyond the central bright spot, it will integrate over bright and dark fringes, hence a signal loss corresponding to a reduction in signal to noise ratio ("Self Apodization Effect")

Visibility for CrIS Central FOV



Picture courtesy of D. Mooney

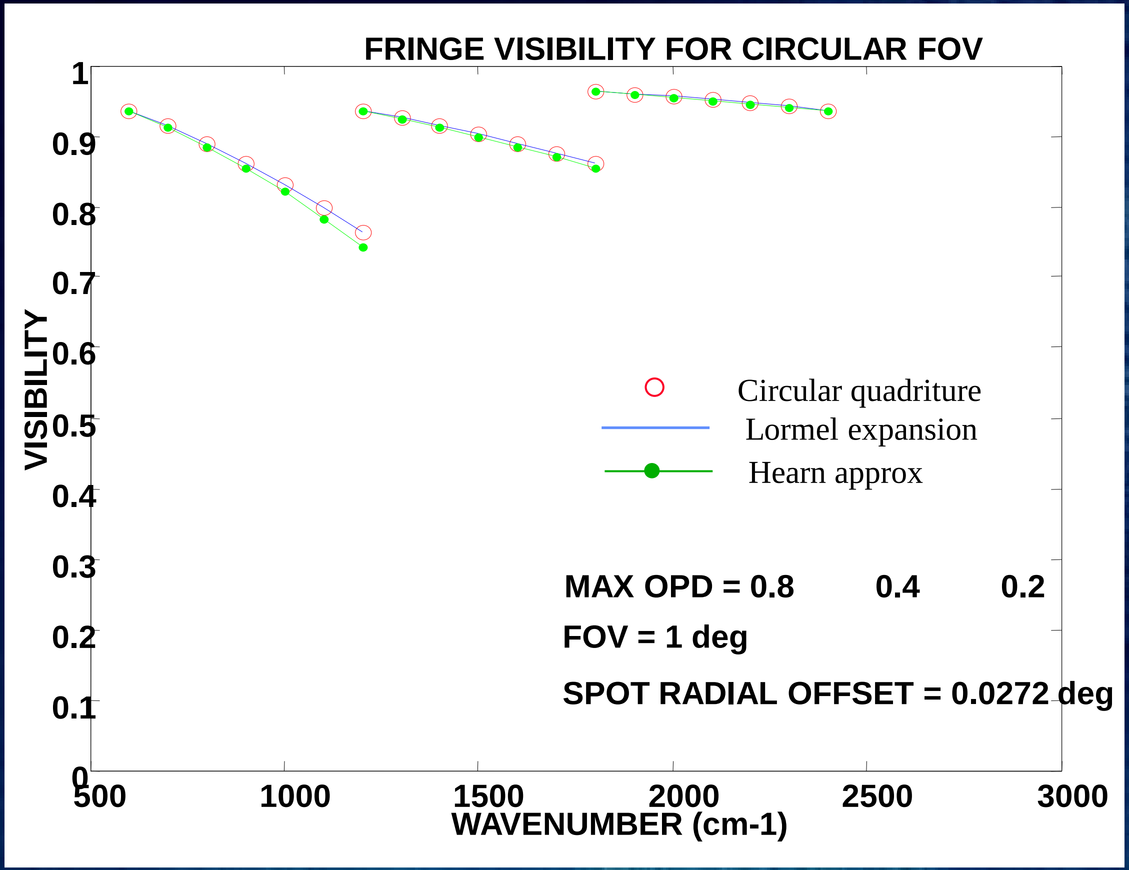


Define visibility V(x):

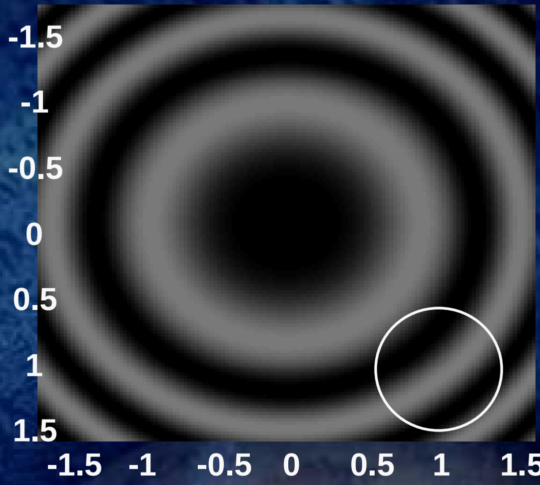
$$V(X) = \frac{G_{max}(x) - G_{min}(x)}{G_{max}(x) + G_{min}(x)}$$

The central detector falls inside the central bright spot. There is no loss in signal, V(x) =1

Visibility for CrIS Corner FOV



Picture courtesy of D. Mooney

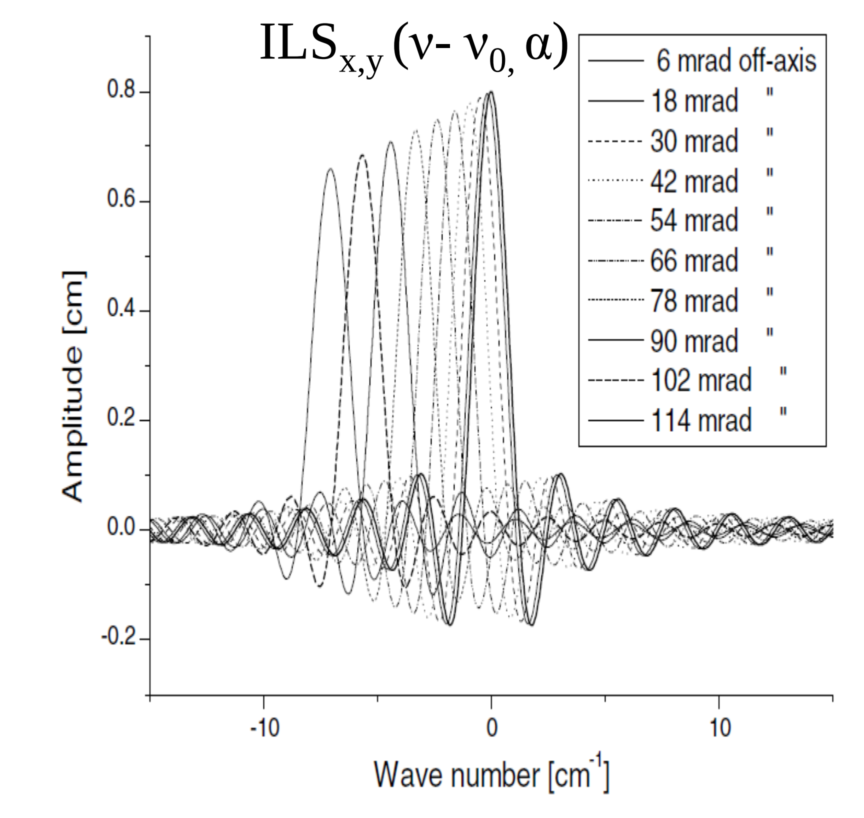


Define visibility V(x):

$$V(X) = \frac{G_{max}(x) - G_{min}(x)}{G_{max}(x) + G_{min}(x)}$$

The corner detector falls outside the central bright spot. There is a loss in signal, V(x) <1.

Off-Axis ILS



The off-axis ILS is shifted, asymmetric and attenuated. The frequency shift of the peak is the dominating effect and is related to the angular offset of the light beam as:

$$\frac{\delta\upsilon}{\upsilon} \sim \alpha\delta\alpha$$

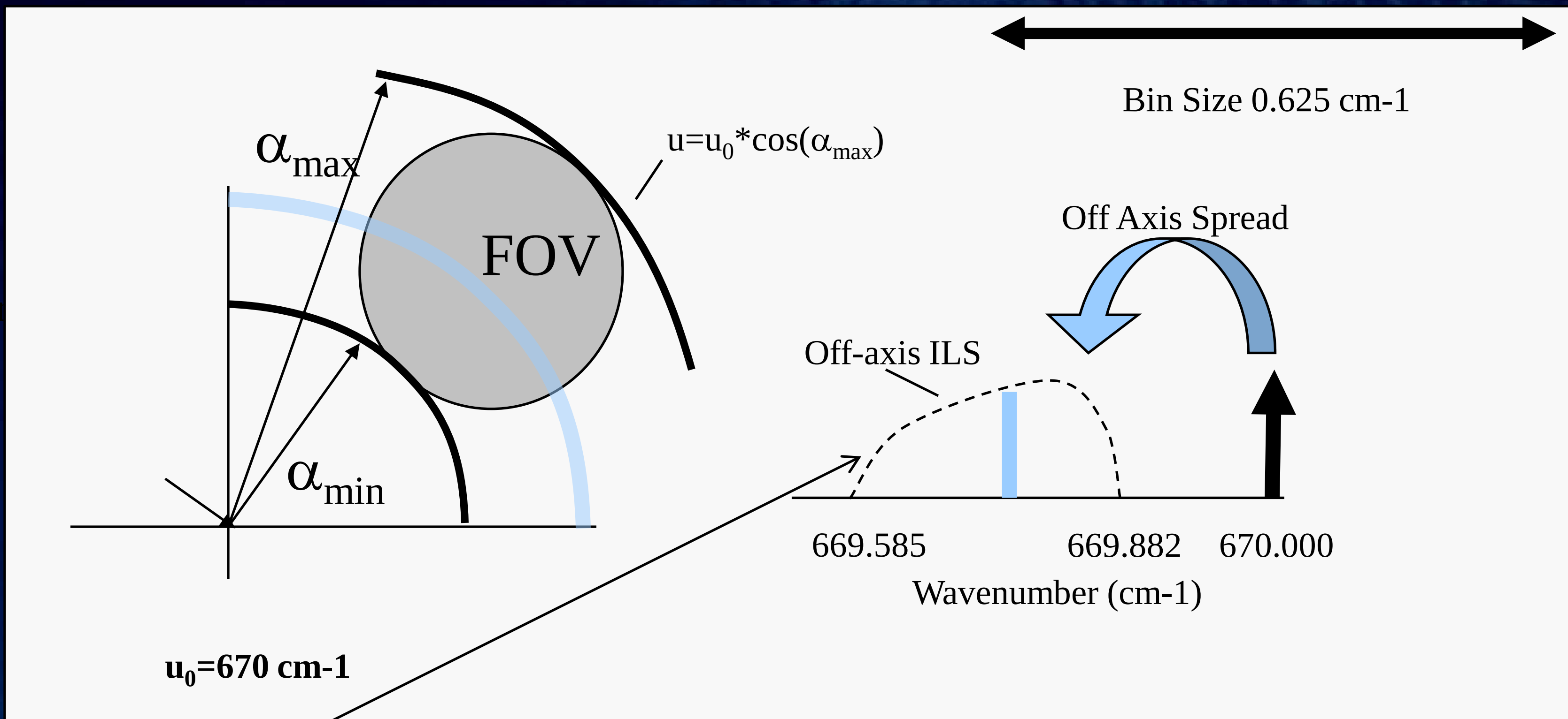
Homogeneous source (and monochromatic):

$$\mathrm{ILS}^{\alpha}{}_{x,y}(\nu - \nu_0) = \mathrm{ILS}^{\alpha}{}_{x',y'}(\nu - \nu_0)$$

We can express the resulting output spectrum at each frequency as:

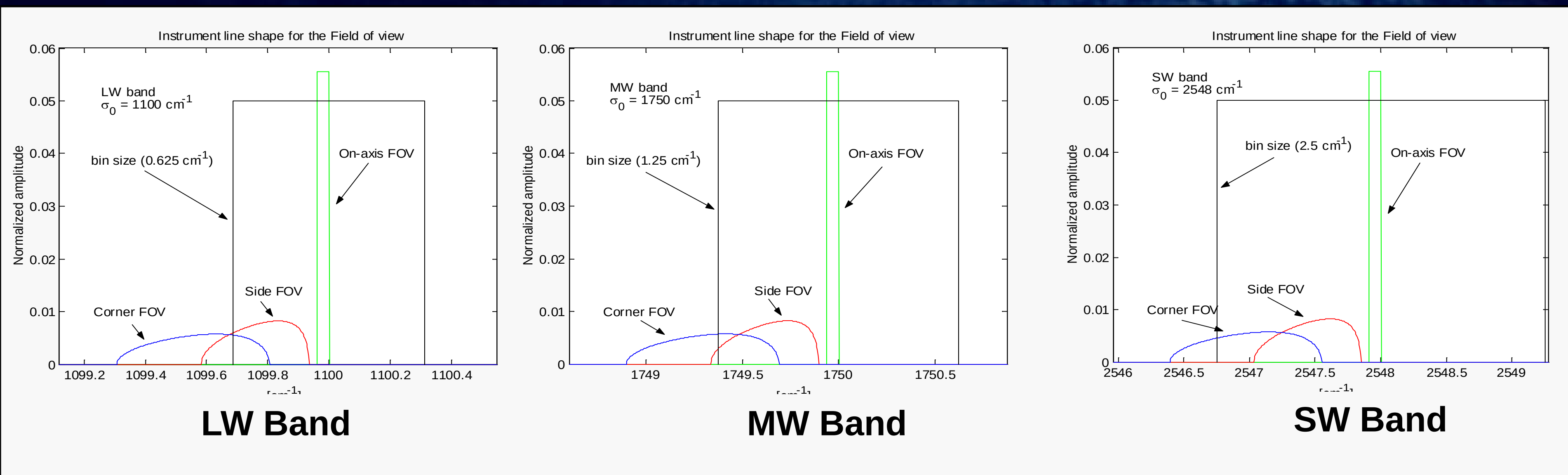
$$g_{meas}(\nu) = \sum_{FOV} ILS_{x,y}(\nu - \nu_0) \otimes g(\nu_0)$$

Smear & Shift Effect in an OFF-Axis FOV ILS



$$\mathrm{ILS}_{\mathrm{FOV}}(v - v_0) = \sum_{FOV} ILS_{x,y}(v - v_0)$$

Smear & Shift Effect of Each FOV ILS in the 3 Bands (one example for each band)



Picture courtesy of D. Mooney

- Shifts of the ILS by half a bin width are typical for corner FOVs

Self Apodization Matrix

Polychromatic, homogeneous source:

$$g_{meas}(v) = \sum_{FOV} ILS_{x,y}(v - v_0) \otimes g(v_0) + \sum_{FOV} ILS_{x,y}(v - v_1) \otimes g(v_1) + \ldots + \sum_{FOV} ILS_{x,y}(v - v_n) \otimes g(v_n)$$

$$g_{meas}(v) = \mathrm{ILS}_{FOV}(v - v_0) \otimes g(v_0) + \mathrm{ILS}_{FOV}(v - v_1) \otimes g(v_1) + \ldots$$

In matrix form ("Self Apodization Matrix"):

$$\begin{bmatrix} g_{meas}(v_0) \\ g_{meas}(v_1) \\ \ldots \\ \ldots \\ \ldots \\ g_{meas}(v_n) \end{bmatrix} = \begin{bmatrix} \mathrm{ILS}_{FOV}(v_0 - v_0) & \mathrm{ILS}_{FOV}(v_0 - v_1) & \ldots & \mathrm{ILS}_{FOV}(v_0 - v_n) \\ \mathrm{ILS}_{FOV}(v_1 - v_0) & \mathrm{ILS}_{FOV}(v_1 - v_1) & \ldots & \mathrm{ILS}_{FOV}(v_1 - v_n) \\ & \ldots & & \\ & \ldots & & \\ \mathrm{ILS}_{FOV}(v_n - v_0) & \mathrm{ILS}_{FOV}(v_n - v_1) & \ldots & \mathrm{ILS}_{FOV}(v_n - v_n) \end{bmatrix} \begin{bmatrix} g_{\alpha=0}(v_0) \\ g_{\alpha=0}(v_1) \\ \ldots \\ \ldots \\ g_{\alpha=0}(v_n) \end{bmatrix}$$

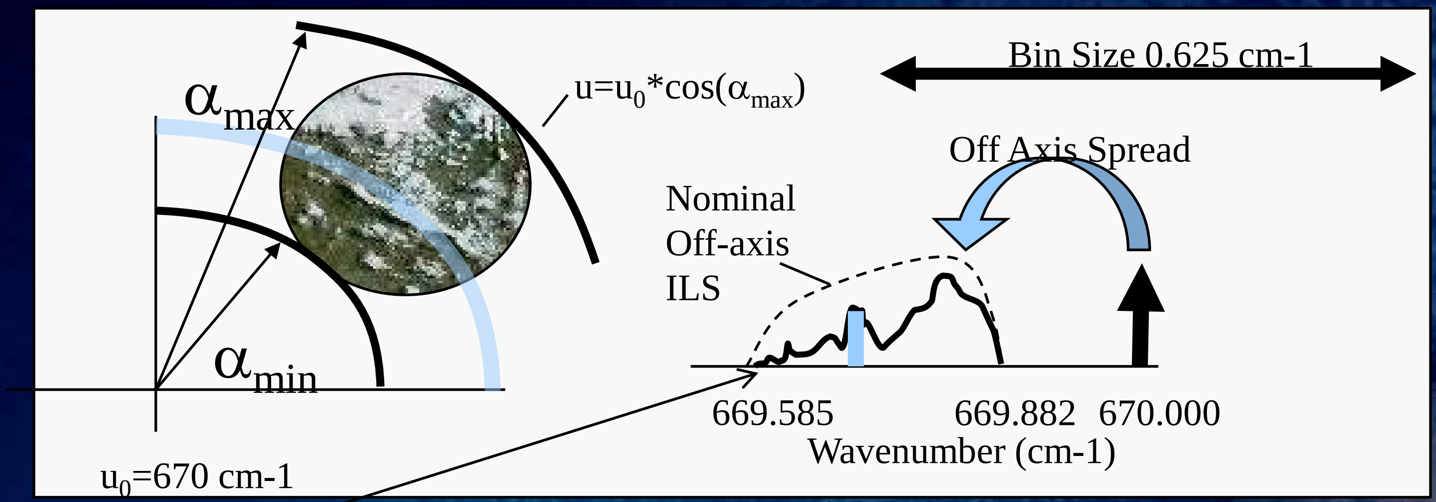
IMPORTANT: The inversion of the self apodization matrix allows for off-axis correction and removes the self-apodization effect of the 9 FOVs.

The self apodization removal requires accurate knowledge of each ILS_{FOV} ("Nominal ILS)"

FOV ILS Distortion in Presence of Scene Inhomogeneities

In-homogeneous scene:

$$\mathrm{ILS}^{\alpha}{}_{x,y}(v-v_0) \neq \mathrm{ILS}^{\alpha}{}_{x',y'}(v-v_0)$$



$$\mathrm{ILS}_{\mathrm{FOV}}(v-v_0) = \sum_{FOV} ILS_{x,y}(v-v_0)$$

- Scene in-homogeneities (clouds, surface variability, et.) are responsible for an *angular* shift of the radiometric center of the FOV (towards the location in the FOV where the warmer scenes are distributed) and an associated distortion of the nominal FOV ILS. This introduces an error in the nominal self apodization matrix which mainly consists in a spectral shift of the FOV ILS peak frequency.
- This error is propagated through the off-axis correction (inversion of the self apodization matrix) introducing an error in the measured radiance spectrum.

Why is it important to assess the magnitude of the radiance error introduced by the ILS distortion?

- Scene in-homogeneities (clouds, surface variability, et.) are responsible for an *angular* shift of the radiometric center of the FOV (towards the location in the FOV where the warmer scenes are distributed) and an associated distortion of the nominal FOV ILS. This introduces an error in the nominal self apodization matrix which mainly consists in a spectral shift of the FOV ILS peak frequency.
- This error is propagated through the off-axis correction (inversion of the self apodization matrix) introducing an error in the radiance spectrum.

- Assessing the magnitude of the radiance error introduced by the ILS distortion is important for remote sensing applications.
- Example: Forcings/Feedbacks studies
    - CO2 growth rate is 2 ppm/year and introduces a forcing of 0.06K/year at 2388 cm^{-1}
    - AIRS stability < 0.01K/year (radiometric and frequency)allows CO2trends/variability to <0.5 ppm.
    - CrIS frequency errors of 1 ppm = 0.015K at 2388 cm^{-1}
    - Need frequency errors on CrIS <1 ppm to reach AIRS stability and measure 0.5 ppm CO2 forcing.
- Example: retrieval of atmospheric variables
    - Any radiance error δR will propagate through the retrieval scheme and introduce a retrieval error δX

- **What's the magnitude of the radiance error introduced by the ILS distortion?**
- **What is the impact on the NUCAPS retrievals?**

What's the magnitude of the radiance error introduced by the ILS distortion due to scene inhomogeneities?

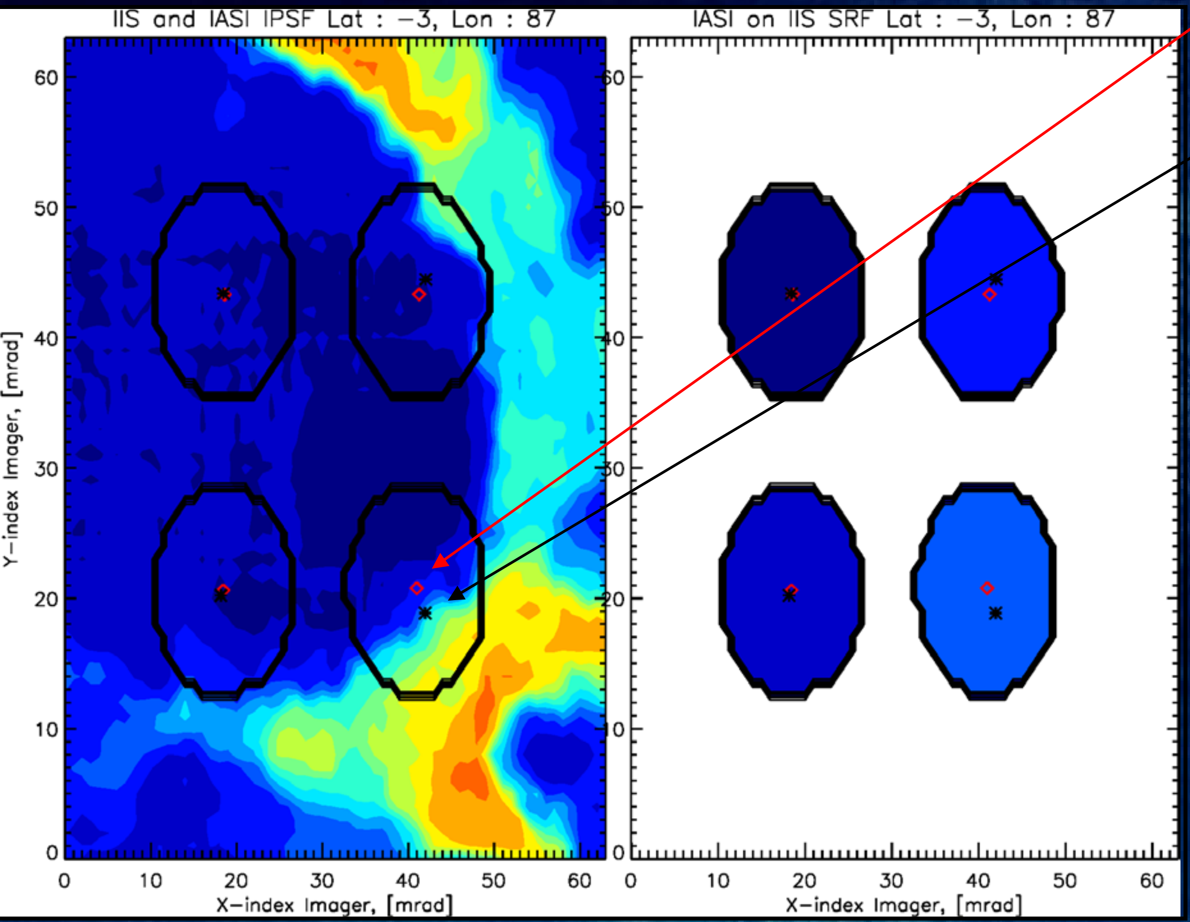
Two possible approaches:

1) By simulation: we use a sub-pixel imager to identify the scene in-homogeneity types present in the pixel; we parameterize the microphysical radiative properties of the scene in-homogeneities and correct the self apodization matrix. Compute corrected radiances and calculate δR. Computationally intense, need a correct parameterization of radiative properties of all possible scene in-homogeneities.

1) By measuring it: we use a sub-pixel imager to measure the actual angular shift $\delta\alpha$ of the FOV radiometric centroid. Determine the corresponding spectral shift $\delta\nu$ of the FOV ILS.
Re-sample the measured radiance spectrum via Fourier inversion and zero-filling technique and re-compute the corrected radiance spectrum. Compute δR. Computationally intense but easier (see next slide).
   - Need an accurately collocated sub-pixel imager.
   - The onboard imager VIIRS is not perfectly collocated to CrIS to ensure the level of accuracy required to compute the angular radiometric offset.
   - We run an experiment using the IASI (2x2 FOV geometry) and the associated Integrated Imaging Subsystem (IIS) instrument. The IIS lays on the same focal plane of IASI and offers a highly accurate collocation.
   - We will leverage on the lessons learned from IASI+IIS to make appropriate conclusions on the ILS shift problem for the CrIS instrument (same instrument concept, different geometry).

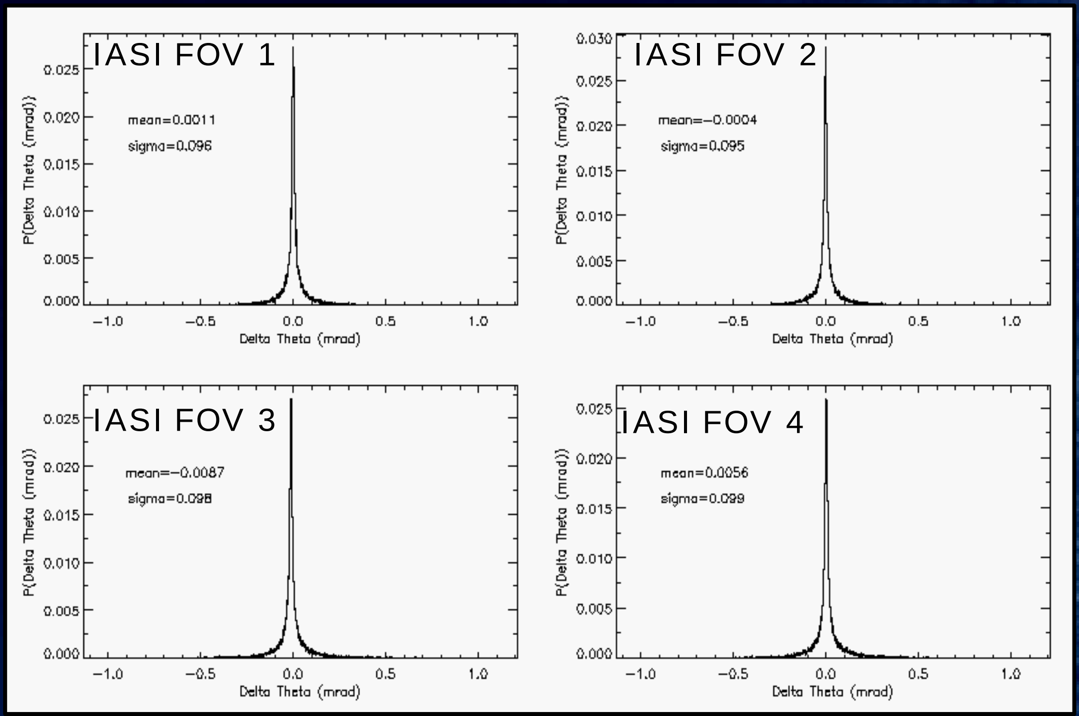
IASI Nominal Geometric Centroids (◊) versus *Radiometric* Centroids (*) :

IIS Imager (64x64 pixels) and IASI FOVs (black contour)



- Nominal Geometric Centroids obtained from the IASI Instrument Point Source Function (IPSF)
- Radiometric Centroids obtained from integrating the IIS subpixel measurements (IIS LW frequency)
- Spatial inhomogeneities introduce a shift δα between the geometric and radiometric centroids .
- The higher the spatial inhomogeneity, the largest the radiometric centroid shift, δα.
- IASI's detector (right panel) does not know anything about the sub-pixel in-homogeneities. The off-axis correction assumes uniform scenes and uses the nominal FOV ILS.
- The radiometric angular offset δα corresponds to a spectral shift δν in the FOV ILS introducing an error δR that we want to quantify.

IASI ILS frequency shift computation in presence of non uniform scenes



The ILS distortion due to the presence of scence inhomogeneities is mainly a frequency shift effect,$\delta\nu$. Its relationship with the angular offset,$\delta\alpha$, between the geometric and radiometric centers of the FOV is :

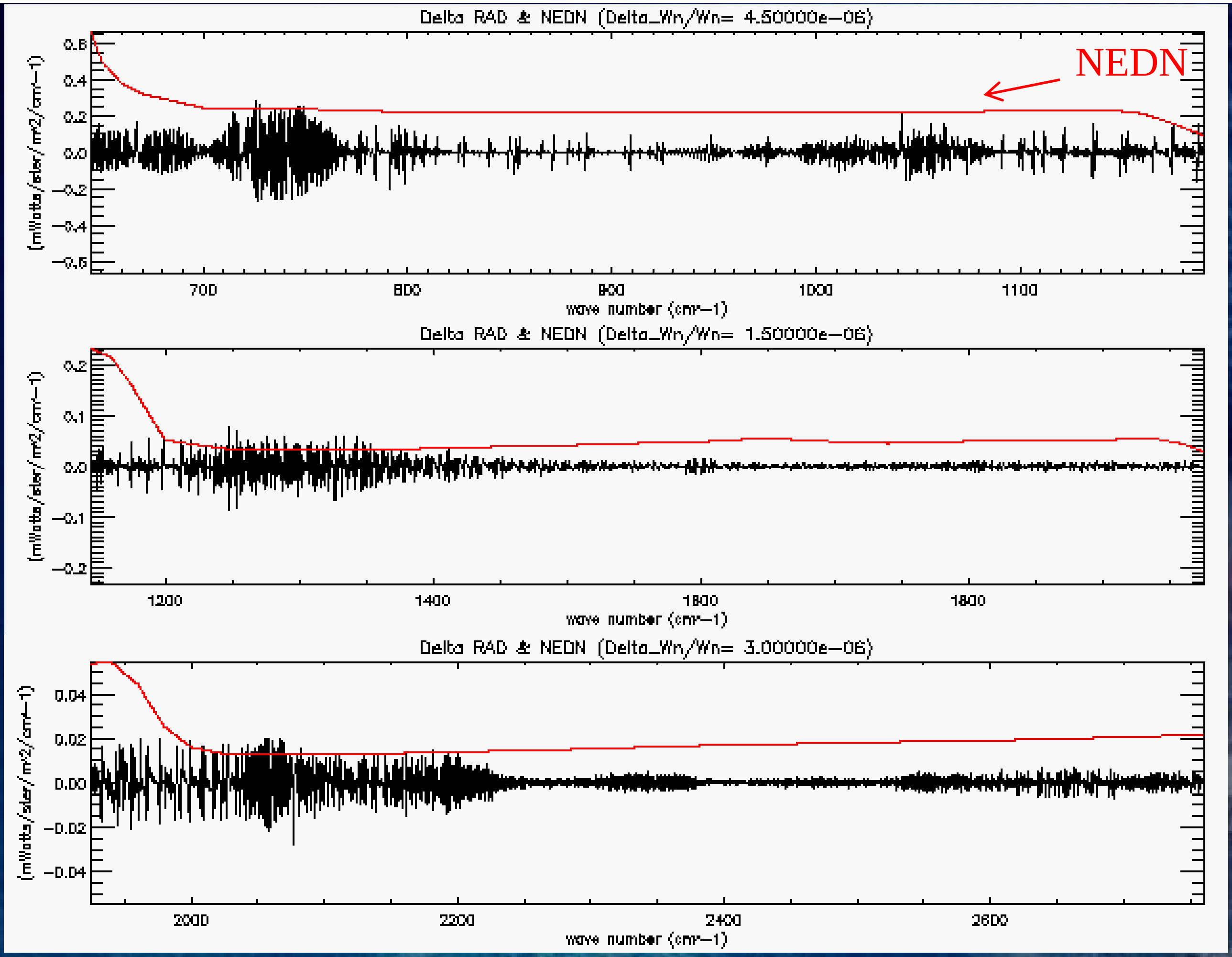
$$\frac{\delta\nu}{\nu} \sim \alpha_0 \delta\alpha$$

<u>Lessons learned from IASI + IIS:</u>

- Global $\delta\alpha$ distribution results:
  - **mean = 0.001mrad;**
  - **1 sigma = 0.1 mrad;**
- Spectral shift:
  - **$\delta\nu/\nu$ =1.5 ppm (for $\delta\alpha$ = 1 sigma)**
- Radiance error lower than NEDN across the three bands, hence is negligible (next slide).

Ref: Gambacorta et al.; Proceedings of 2nd IASI International Meeting, Sevrier, France, 2010.

IASI radiance error induce by ILS shift



Band 1
3 sigma shift error

Band 2
1 sigma shift error

Band 3
2 sigma shift error

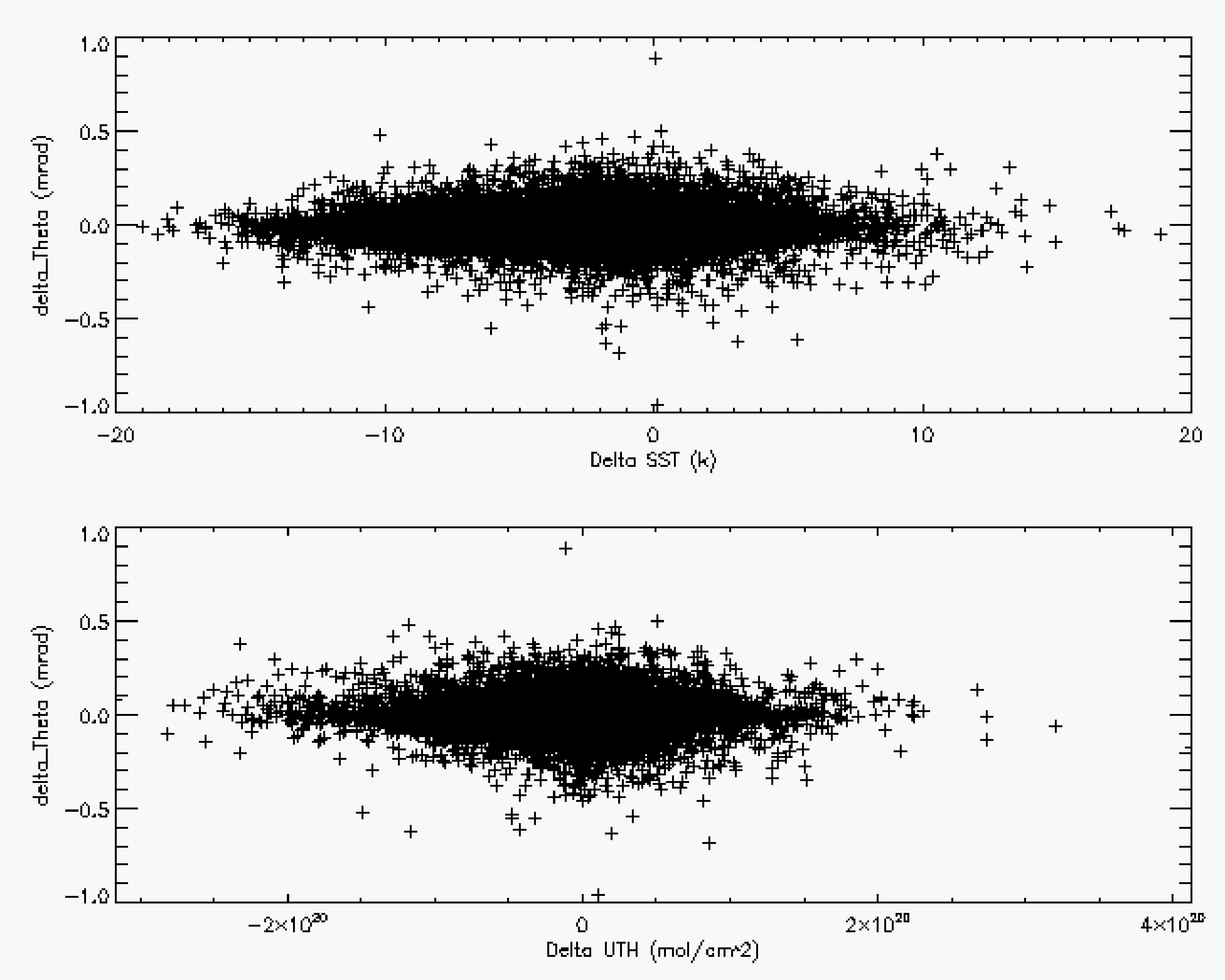
- **Radiance error lower than NEDN across the three bands, hence is negligible.**

IASI Radiance Error Assessment

• The radiance error of the IASI spectra introduced by the ILS shift is generally negligible wrt the IASI instrument noise.
• Only 5% of the full day ensemble is seen to undergo an angular shift of ~1 sigma or higher.

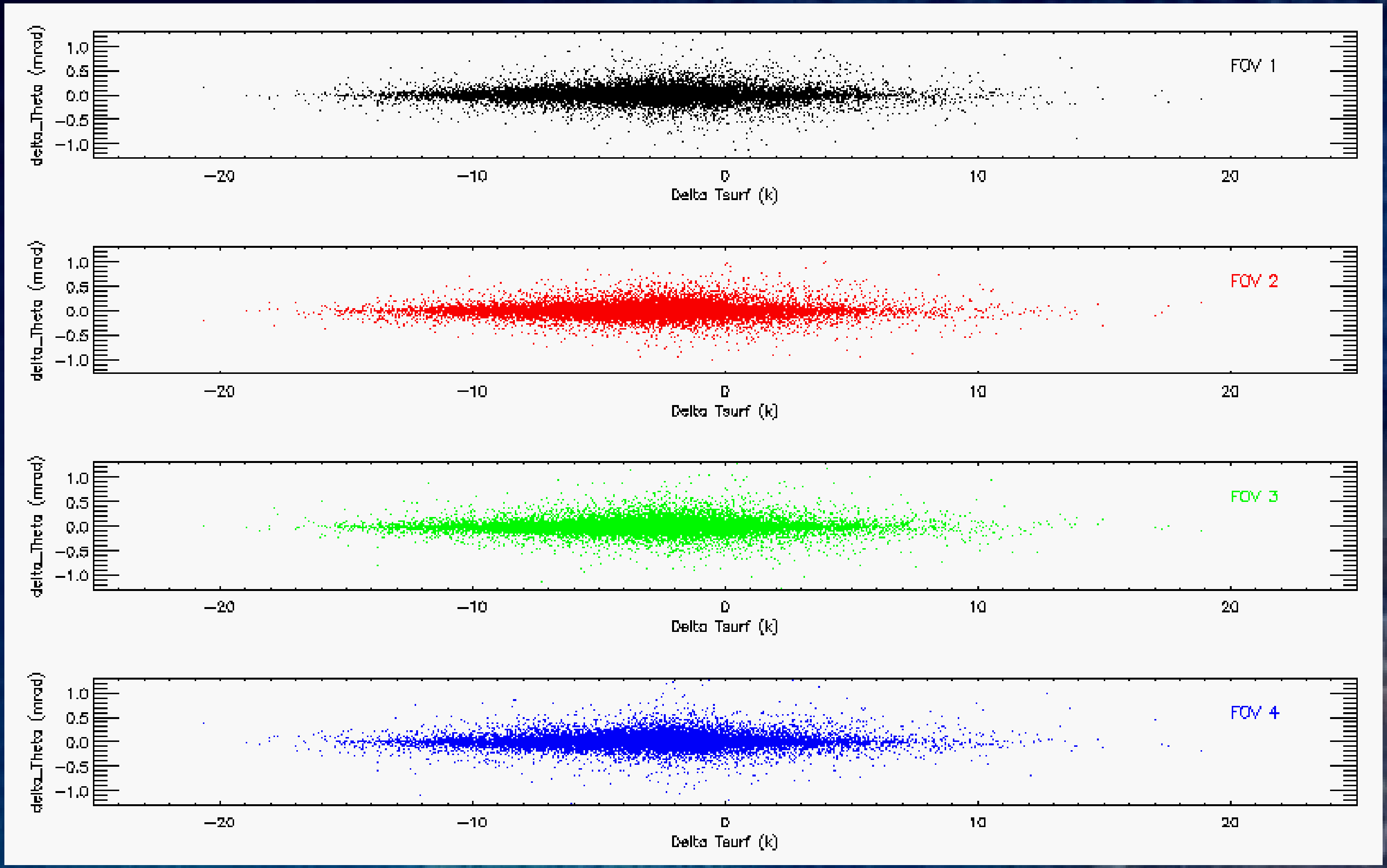
• Next slide: we investigate the effect of the ILS shift on the retrieval performance

4 FOV MEAN Centroid Shift vs SST & UTH bias (Oct 19 2007)



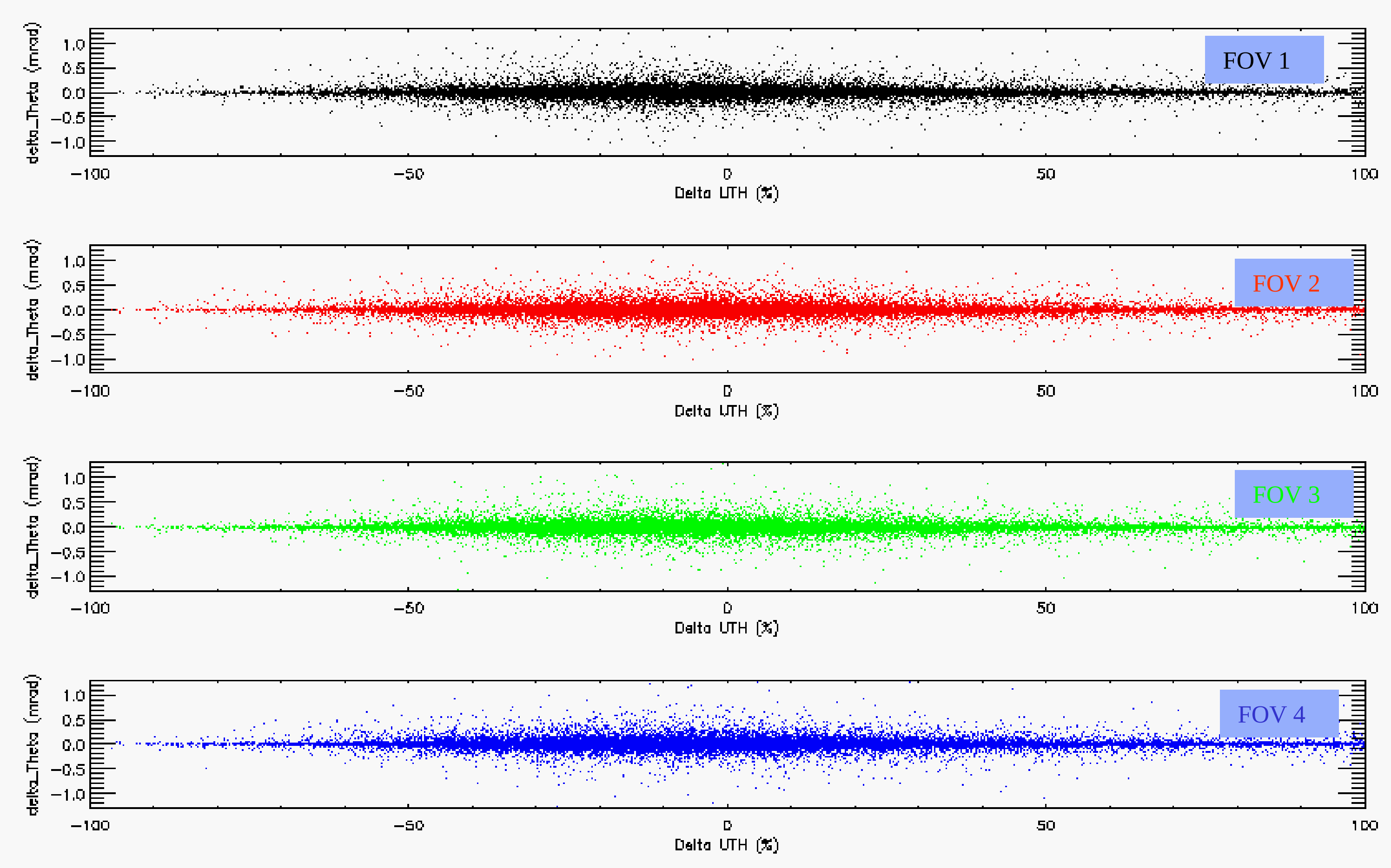
No significant correlation is seen to stand out between the averaged radiometric angular shift and the retrieved SST or UTH bias

Centroid Shift vs Tsurf bias (ret- ecmwf) (Oct 19 2007)



No significant correlation is seen to stand out between each FOV radiometric angular shift and the retrieved SST bias

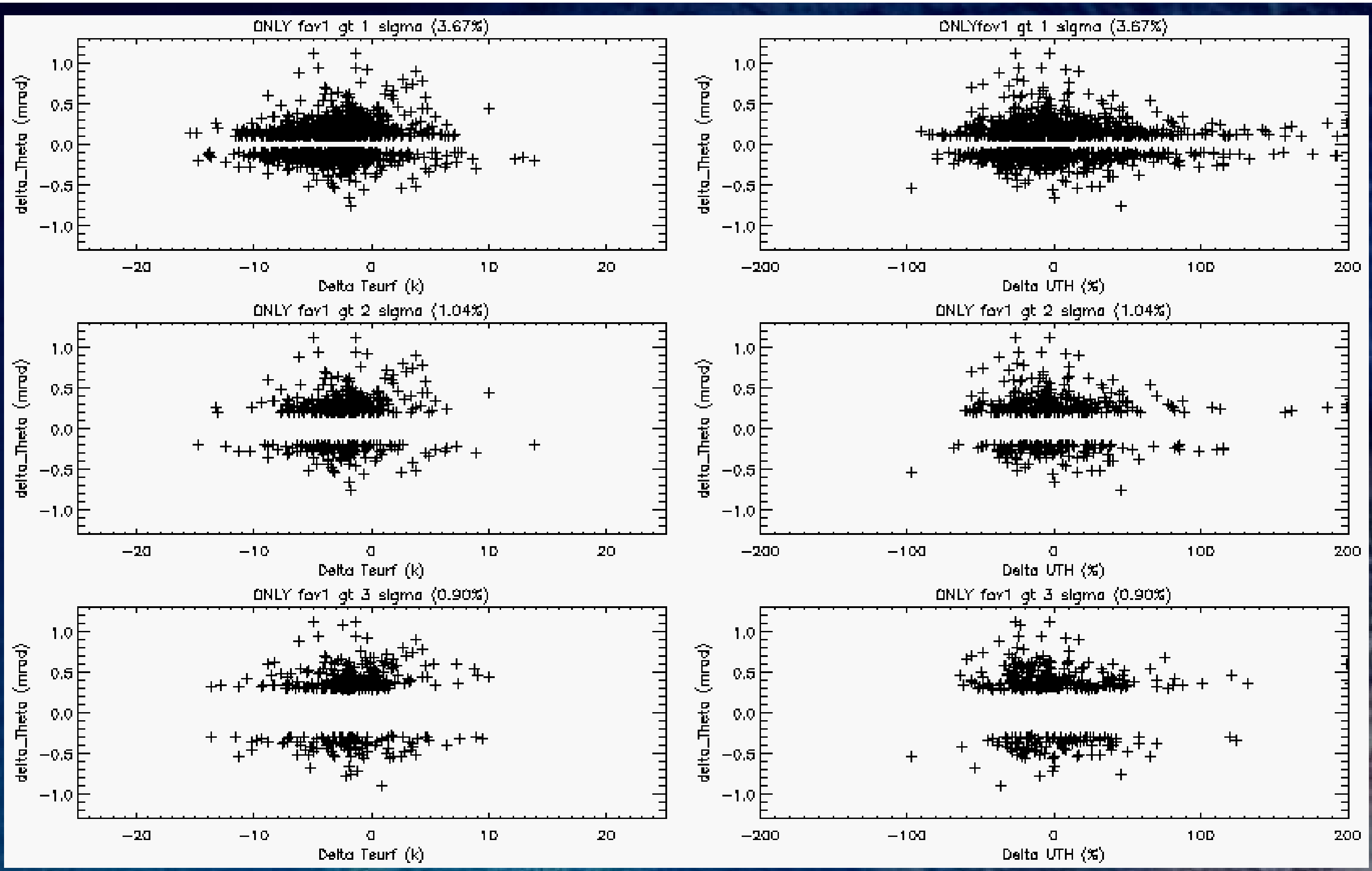
Centroid Shift vs UTH bias (ret- ecmwf) (Oct 19 2007)



No significant correlation is seen to stand out between each FOV radiometric angular shift and the retrieved UTH bias

Examples of cases that are likely to pass Radiance Cloud Clearing QAs (high cloud contrast)

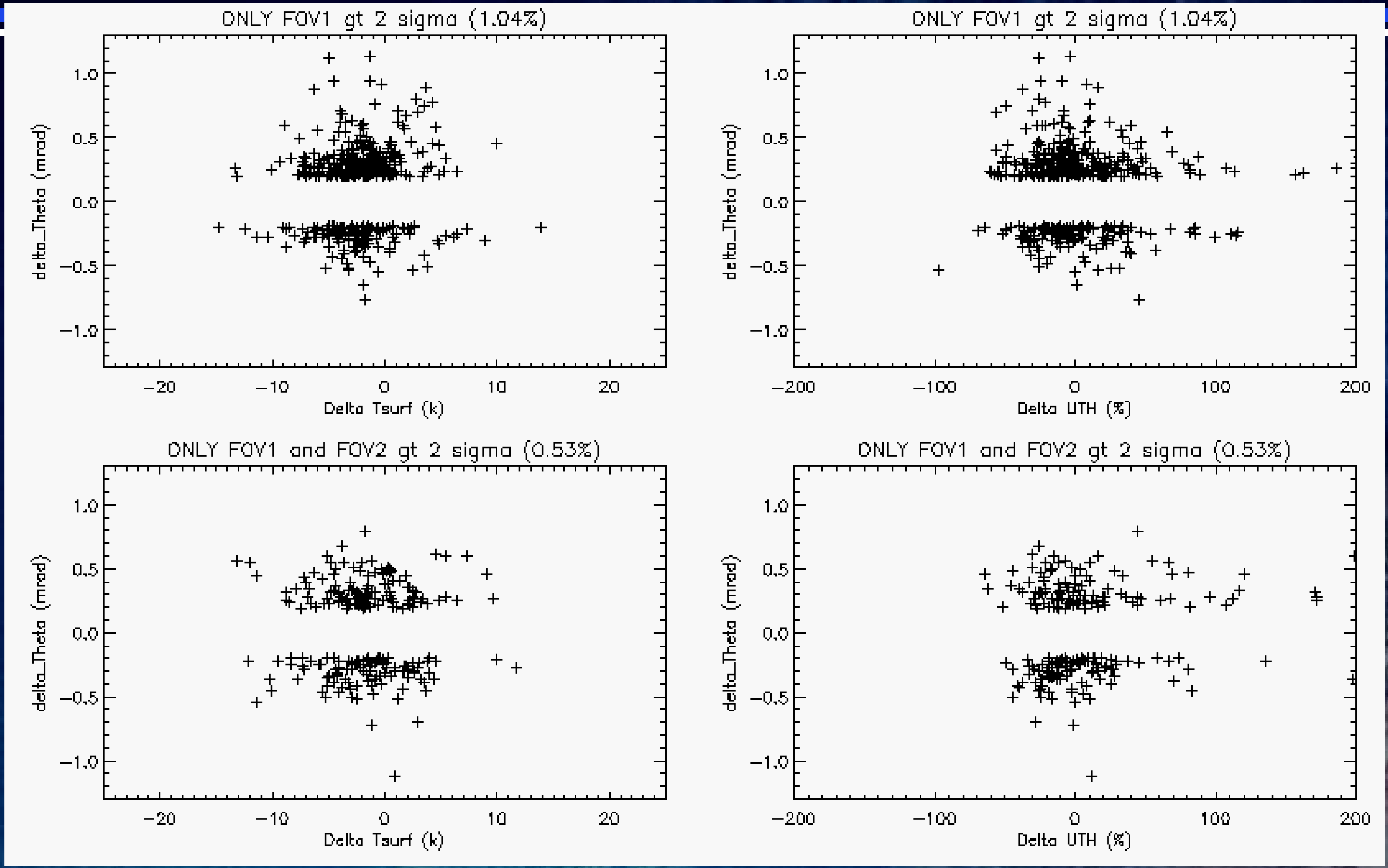
1) ONLY FOV 1 has dα gt 1, all others lt 1 sigma
2) ONLY FOV 1 has dα gt 2, all others lt 1 sigma
3) ONLY FOV 1 has dα gt 3, all others lt 3 sigma



No significant correlation is seen to stand out between the radiometric angular shift and the retrieved SST or UTH bias

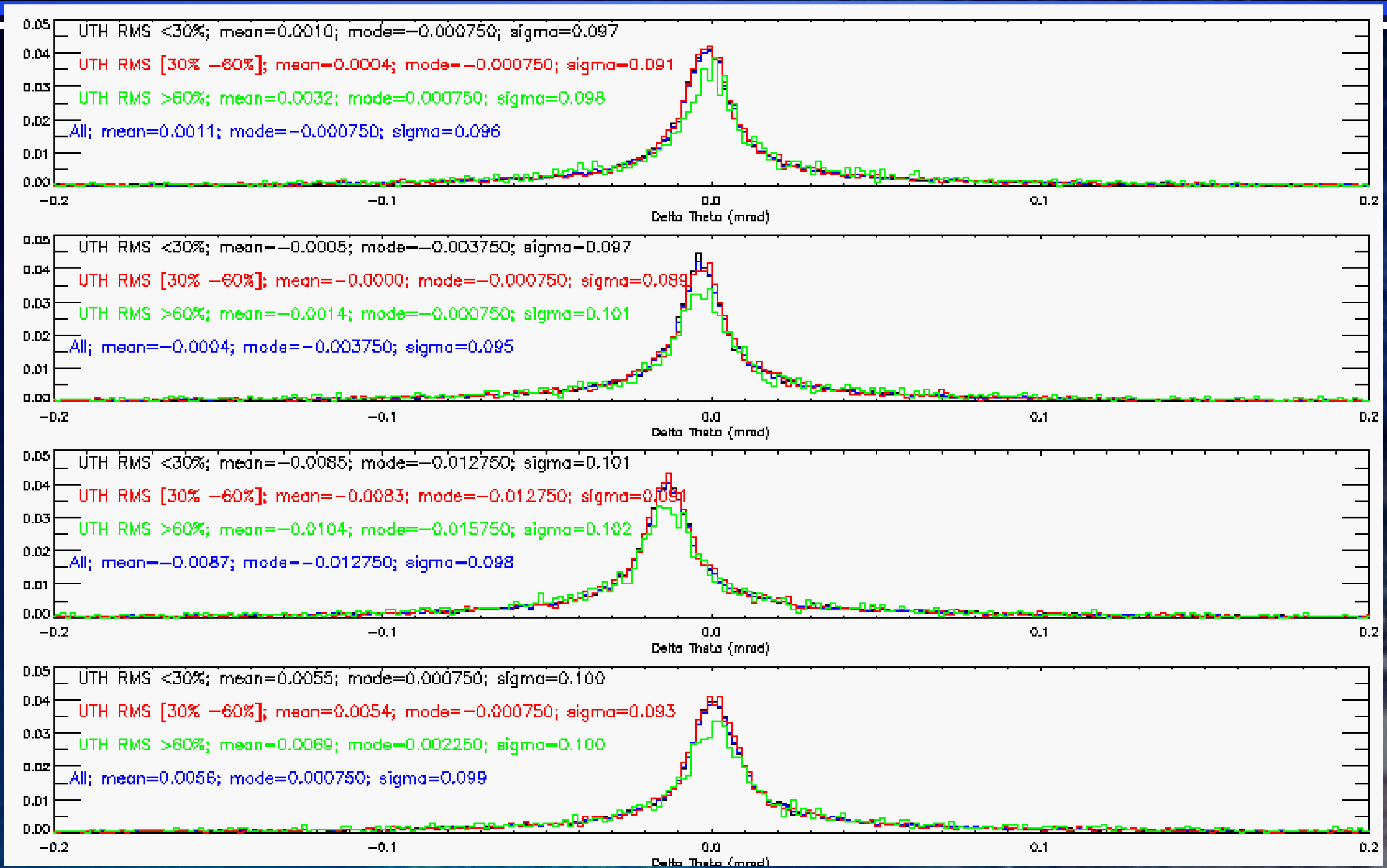
Examples of cases that are likely to pass Radiance Cloud Clearing QAs (high cloud contrast)

1) ONLY FOV 1 dθ gt 2, all others lt 1 sigma
2) ONLY FOV1 and FOV2 gt 2 sigma, all others lt 1 sigma



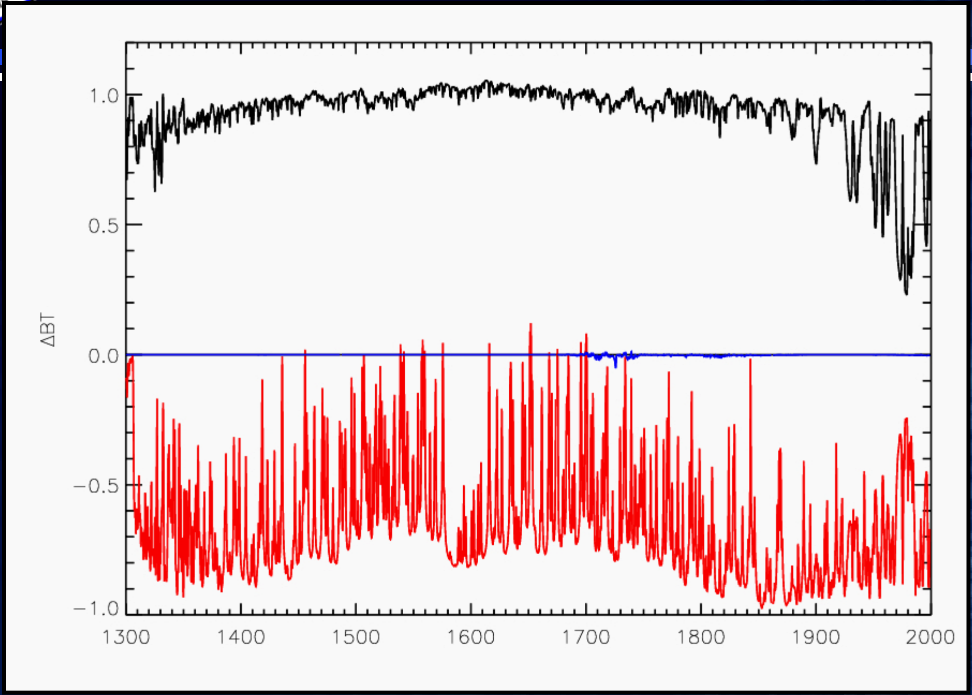
No significant correlation is seen to stand out between the radiometric angular shift and the retrieved SST or UTH bias.

Centroid Distribution Conditioned by UTH statistics



No significant correlation is seen to stand out between the radiometric angular shift and the retrieved UTH rms

Comparison with the Sensitivity to Temperature and Water Vapor Perturbations in 6.7 μm Band



1K temperature perturbation

10% water perturbation

10% ozone perturbation

•The retrieval uncertainty is dominated by bigger sources of error than the measured ils shift induced radiance error.

•The main assumption of the cloud clearing algorithm is that besides clouds, everything in the FOR scene is homogeneous. This is a much broader assumption than the ILS shift radiance error;

• Example: water vapor in the FOR can vary up to 10% and more. The radiance error introduced by this assumption can go up to 1K.

Radiance Error Assessment & Impact on the Retrieval Accuracy: Lessons Learned from IASI

- The analysis above indicates that the IASI radiance error induced by the ILS shift in presence of clouds is negligible:
  - Only 5% of the full day ensemble is seen to undergo an angular shift of ~1 sigma or higher.
  - The radiance error is by far smaller than the instrument noise for radiometric center offset values up to 3 sigma (band 1), 2 sigma (band 3) and 1 sigma (band2) of the overall offsets distributions.
  - In retrieval space, there does not appear to exist any correlation among angular offsets and retrieval biases of SST, UTH, CH4, etc (not shown) wrt ECMWF or climatology. This is possibly due to:
    - the presence of other factors dominating the uncertainty in the retrievals
    - no preferential distribution in angular offsets across the 4 FOVs (all 4 are centered around zero angular offset) such that the effect is likely to be averaged to zero during cloud clearing.
  - Angular offsets can still be monitored in order to build an ad hoc rejection flag (under study).

Lessons Learned from IASI and Considerations on the ILS Shift Effect on CrIS

•CrIS has lower instrument noise than IASI (the lower the max optical path, the lower the fringe effect, the higher the signal to noise), but a lower spectral resolution (the lower the max optical path, the lower the spectral resolution) which makes it less sensitive to the spectral shift.

• CrIS central FOV falls in within the central bright spot at all frequencies. Self apodization is more severe in IASI which makes it more sensitive to the ILS shift than CrIS.

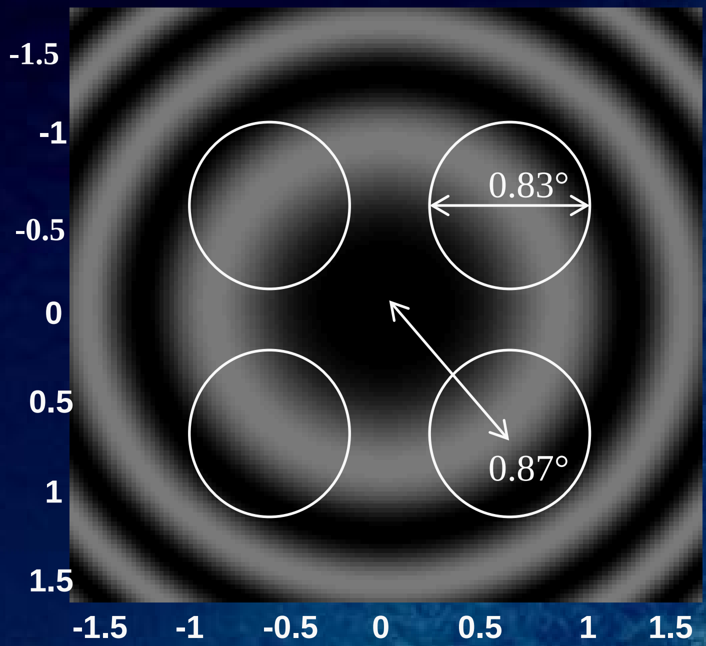
• IASI is a 9:am/9:30pm equatorial crossing orbit; CrIS is a 1:30am/1:30pm equatorial crossing orbit. The climatology of clouds observed is quite different. 1:30pm is the onset of convection leading to overcast scenes, normally rejected by any retrieval or assimilation scheme. 9:30pm is likely the time for convective cloud detrainment leading to the formation of cirrus anvils. Broken cloud scenes, which are likely to introduce significant scene in-homogeneities, can likely pass the retrival rejection criteria.

• Based on the above consideration we can estimate the effect of the ILS shift to be less important for CrIS than for IASI.

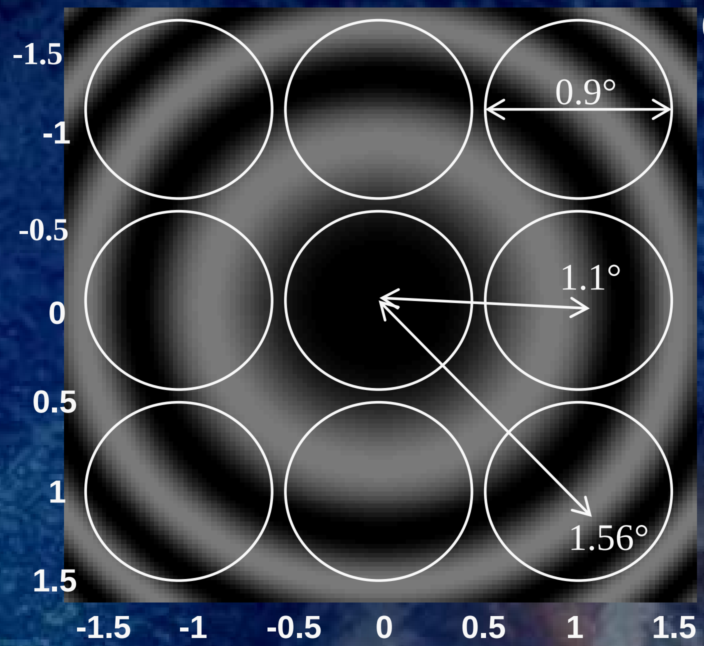
•The only remaining issue to be investigated though, is CrIS's acquisition geometry. See next slide.

IASI vs CrIS FOV geometry

IASI



CrIS



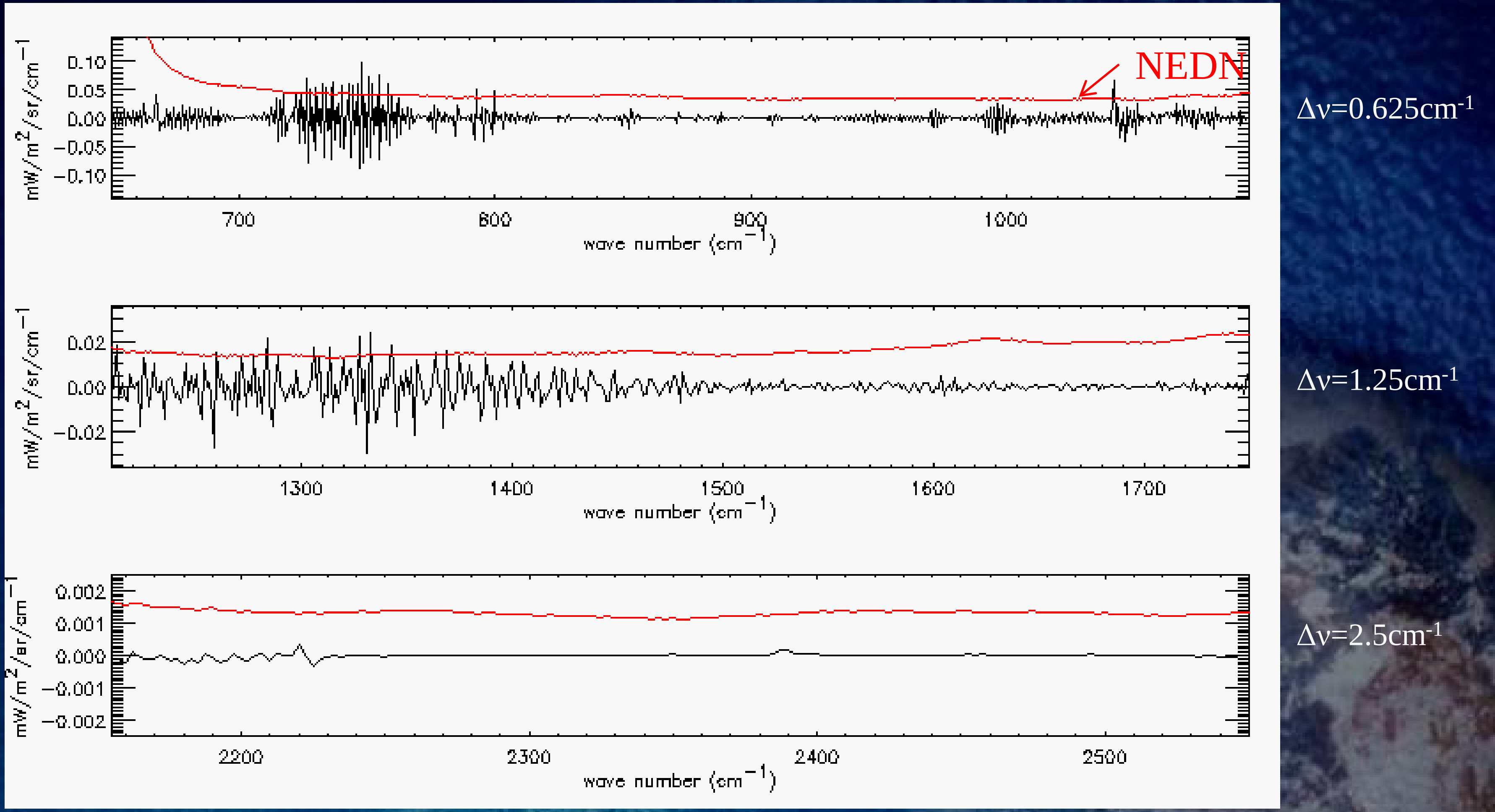
• Applying IASI's δα results to CrIS (assuming sub-pixel heterogeneity and instrument characteristics are close enough between the two instruments):

- CrIS Side Cube (α=1.1°=0.019rad): δν/ν ~ αδα = **1.91e-6**
- CrIS Corner Cube (α=1.56°=0.027rad): δν/ν ~ αδα = **2.72e-6**

< 3ppm
(spectral calibration requirement)

CrIS un-apodized radiance error induced by 1 sigma ILS shift - *Side cube* –

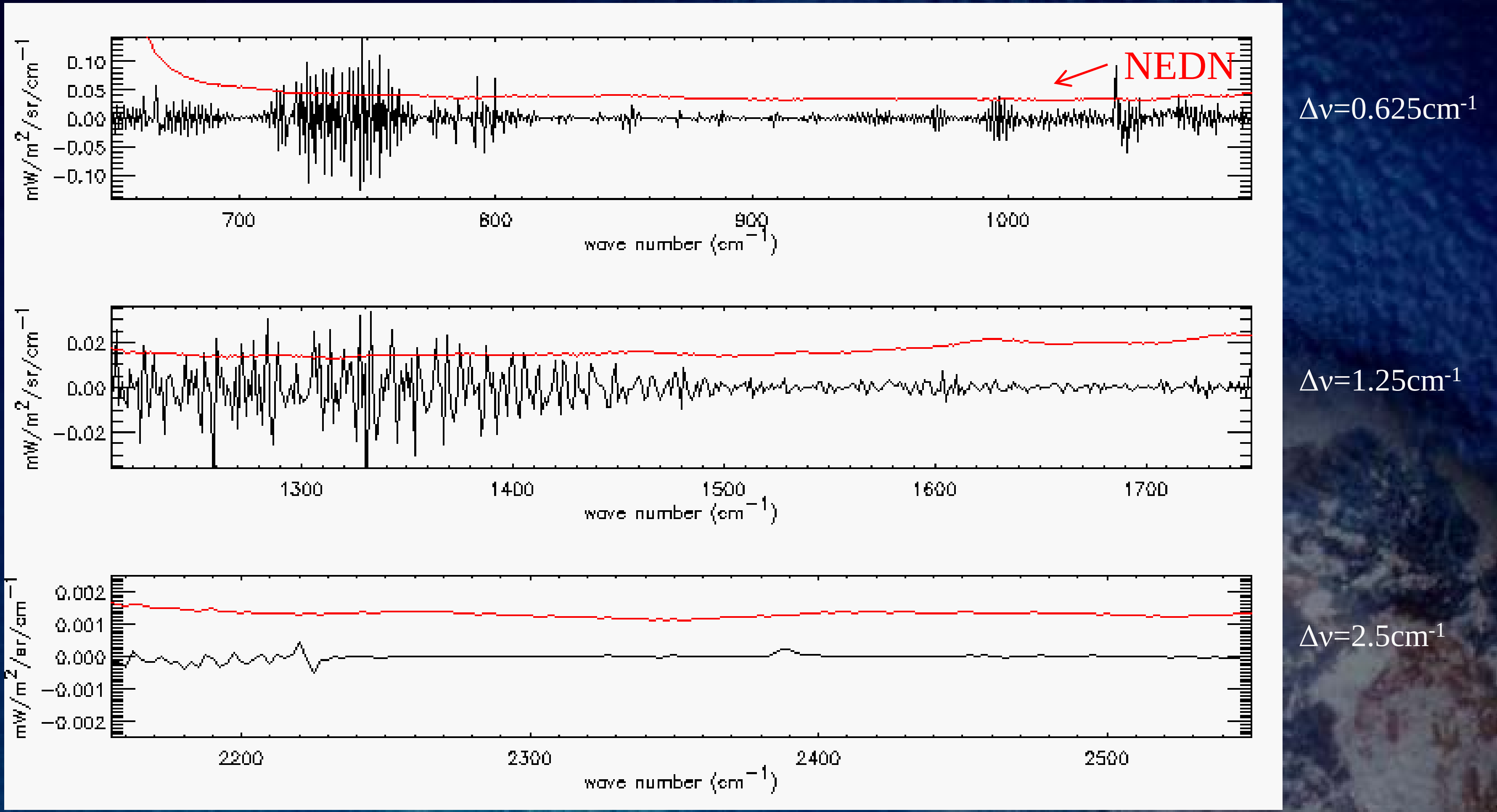
Nyquist sampling: 0.625cm^{-1} (LW); 1.25cm^{-1} (MW); 2.5cm^{-1} (SW)



- Radiance error lower than NEDN across the three bands, hence is negligible.

CrIS un-apodized radiance error induced by 1 sigma ILS shift - *Corner cube* –

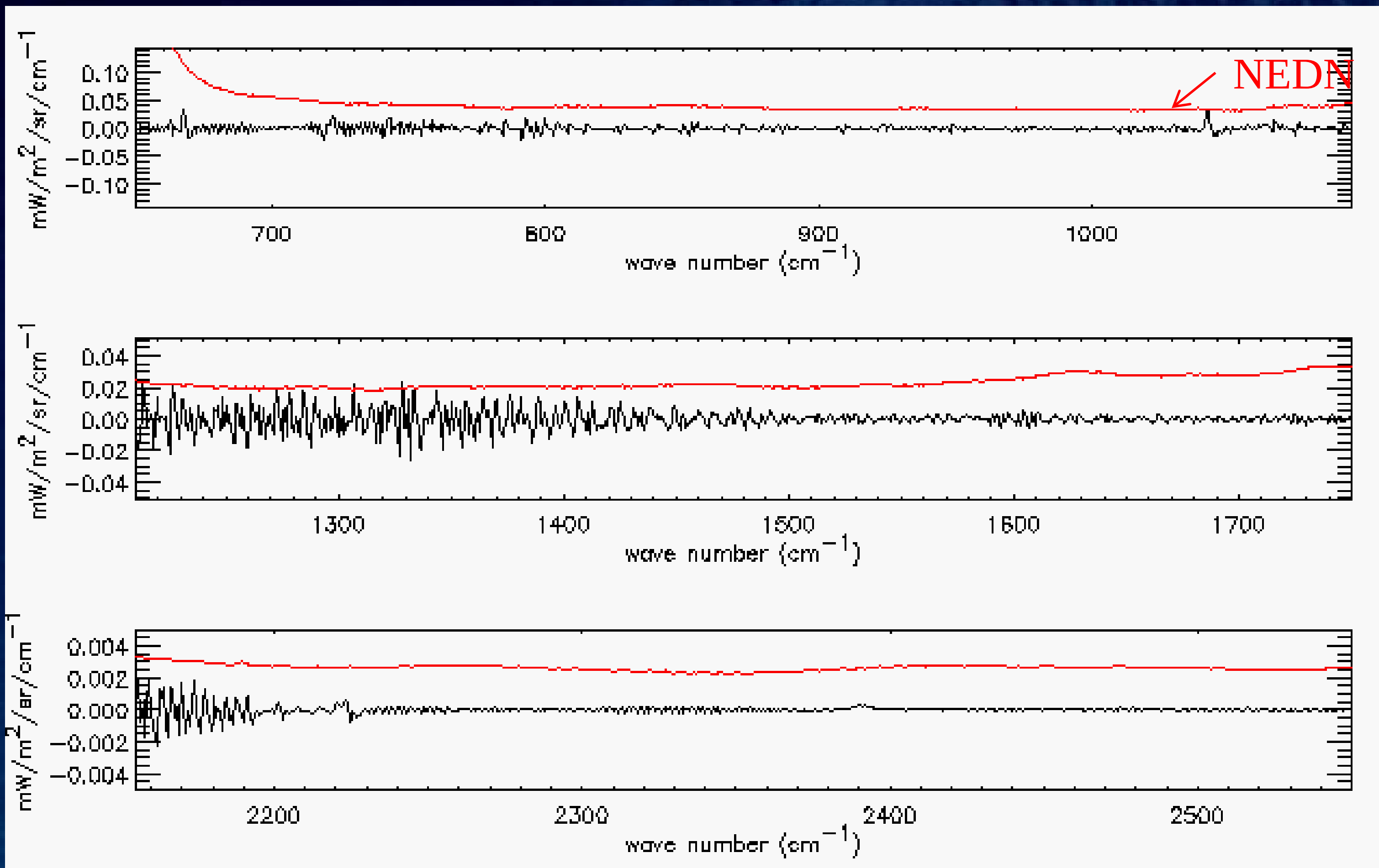
Nyquist sampling: 0.625cm^{-1} (LW); 1.25cm^{-1} (MW); 2.5cm^{-1} (SW)



- **Radiance error lower than NEDN across the three bands, hence is negligible.**

CrIS apodized radiance error induced by 1 sigma ILS shift - *Side cube –*

Nyquist sampling: 0.625cm^{-1} (LW); 0.625cm^{-1} (MW); 0.625cm^{-1} (SW)



Δν=0.625cm^{-1}

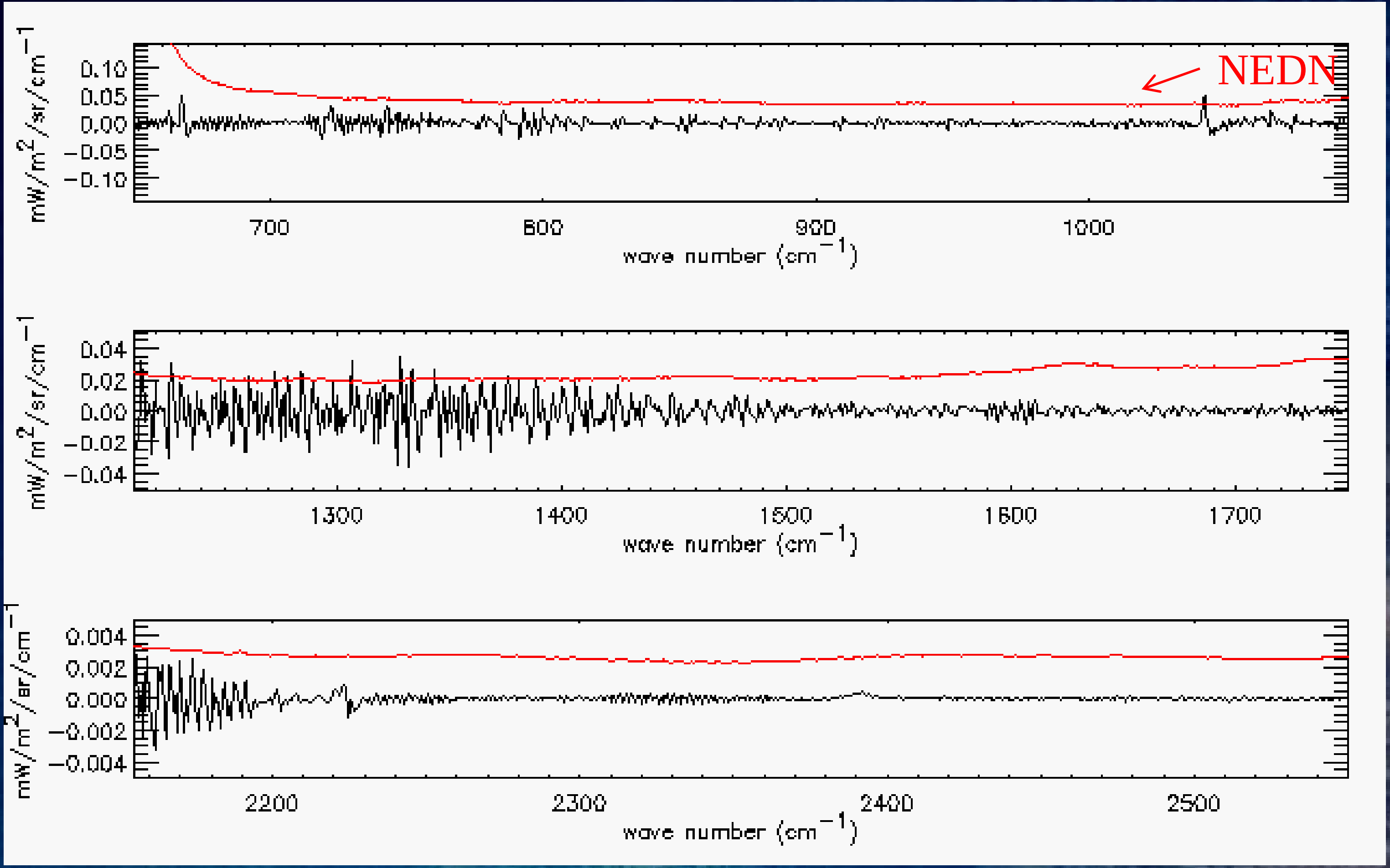
Δν=0.625cm^{-1}

Δν=0.625cm^{-1}

- Radiance error lower than NEDN across the three bands, hence is negligible.

CrIS apodized radiance error induced by 1 sigma ILS shift - *Corner cube –*

Nyquist sampling: 0.625cm^{-1} (LW); 0.625cm^{-1} (MW); 0.625cm^{-1} (SW)



Δν=0.625cm^{-1}

Δν=0.625cm^{-1}

Δν=0.625cm^{-1}

•Radiance error lower than NEDN across the three bands, hence is negligible.

Radiance based applications

Example: Forcings/Feedbacks studies

- CO2 growth rate is 2 ppm/year and introduces a forcing of 0.06K/year at 2388 cm^{-1}
- AIRS stability < 0.01K/year (radiometric and frequency)allows CO2trends/variability to <0.5 ppm.
- CrIS frequency errors of 1 ppm = 0.015K at 2388 cm^{-1}
- Need frequency errors on CrIS <1 ppm to reach AIRS stability and measure 0.5 ppm CO2 forcing.

Ways to still correct for the problem

- Measure the radiance error and flag these cases out or correct for the problem
  - Need a precise sub-pixel measurement of the radiometric displacement for each frequency.
  - Corrections can be computationally compelling
- Via SVD, reconstruct the radiances removing the eigenvector carrying the ILS shift error
  - Need to identify the correct eigenvector
  - Need to ensure not tossing out important information
- Only use the central FOV (which is not affected by the problem)
  - Penalizes spatial resolution

Conclusions

- The error introduced by the ILS distortion falls below the instrument noise both in low and high resolution.

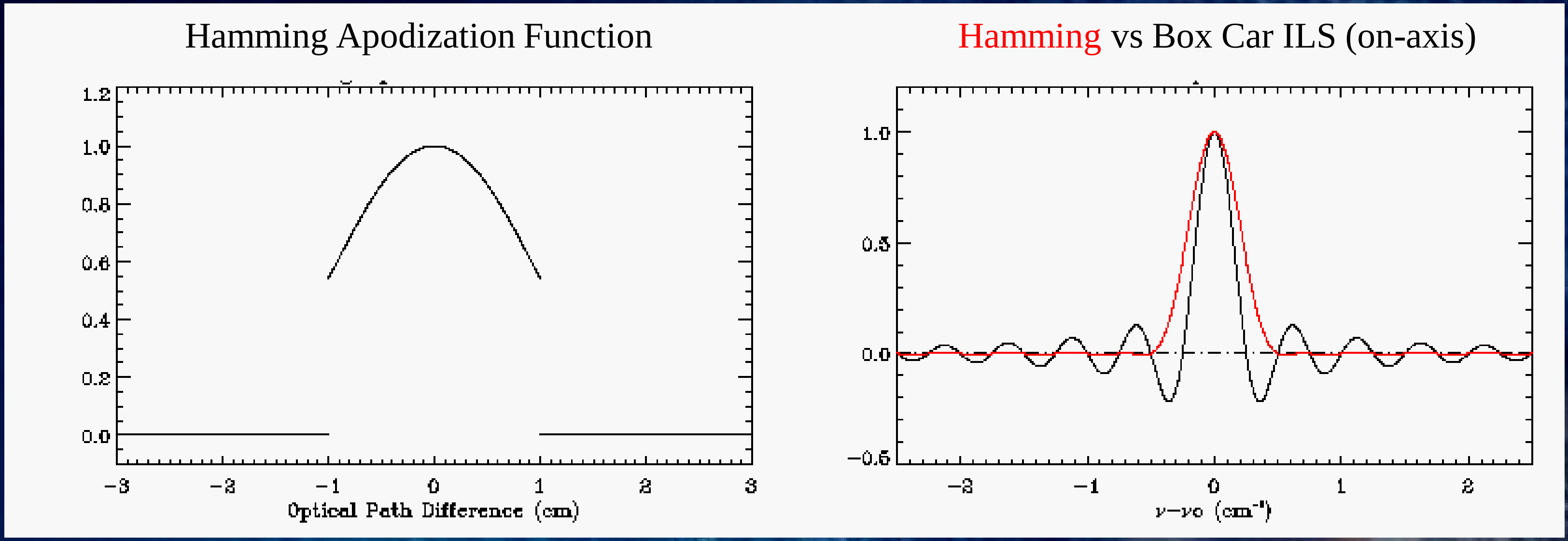
- The error is significantly smaller compared to other sources of error present during the retrieval process, hence is negligible for retrieval applications.

- The problem can become important for radiance-based applications.

- Ways to correct for the problem if necessary:
    - Measure the radiometric displacement and flag these cases out or correct for the problem
        - Need a precise sub-pixel measurement of the radiometric displacement for each frequency.
        - Corrections can be computationally compelling
    - Via SVD, reconstruct the radiances removing the eigenvector carrying the ILS shift error
        - Need to identify the correct eigenvector
        - Need to ensure not tossing out important information
    - Only use CrIS central FOV which is not affected by the problem
        - Penalizes spatial resolution

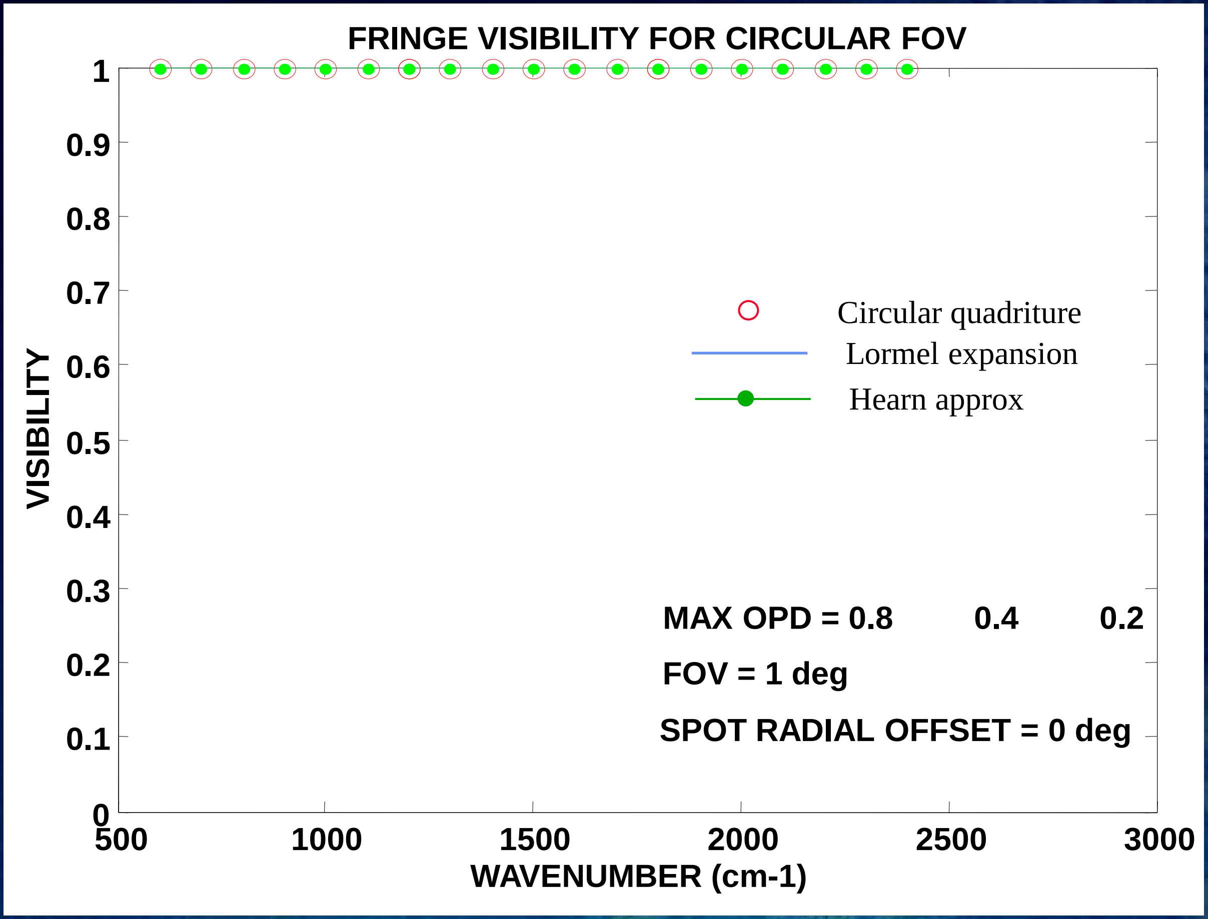
BACK UP

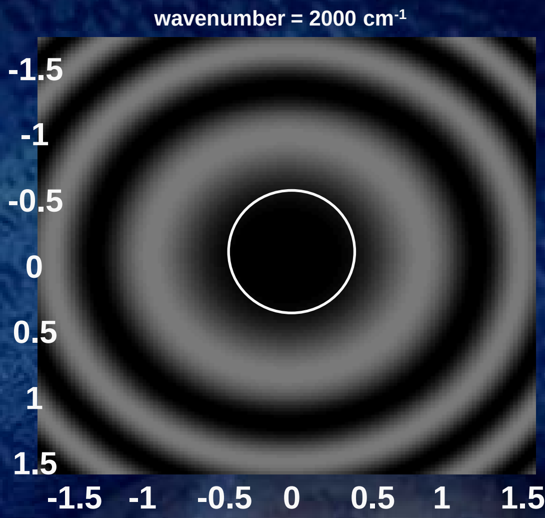
Hamming Apodization Function (on-axis monochromatic input)



The Instrument Line Shape resulting from the Hamming truncation function is a more smoothed function that gets rid of side lobe effects with the penalty of lower spectral resolution and correlated adjacent channels.

Visibility for CrIS Central FOV





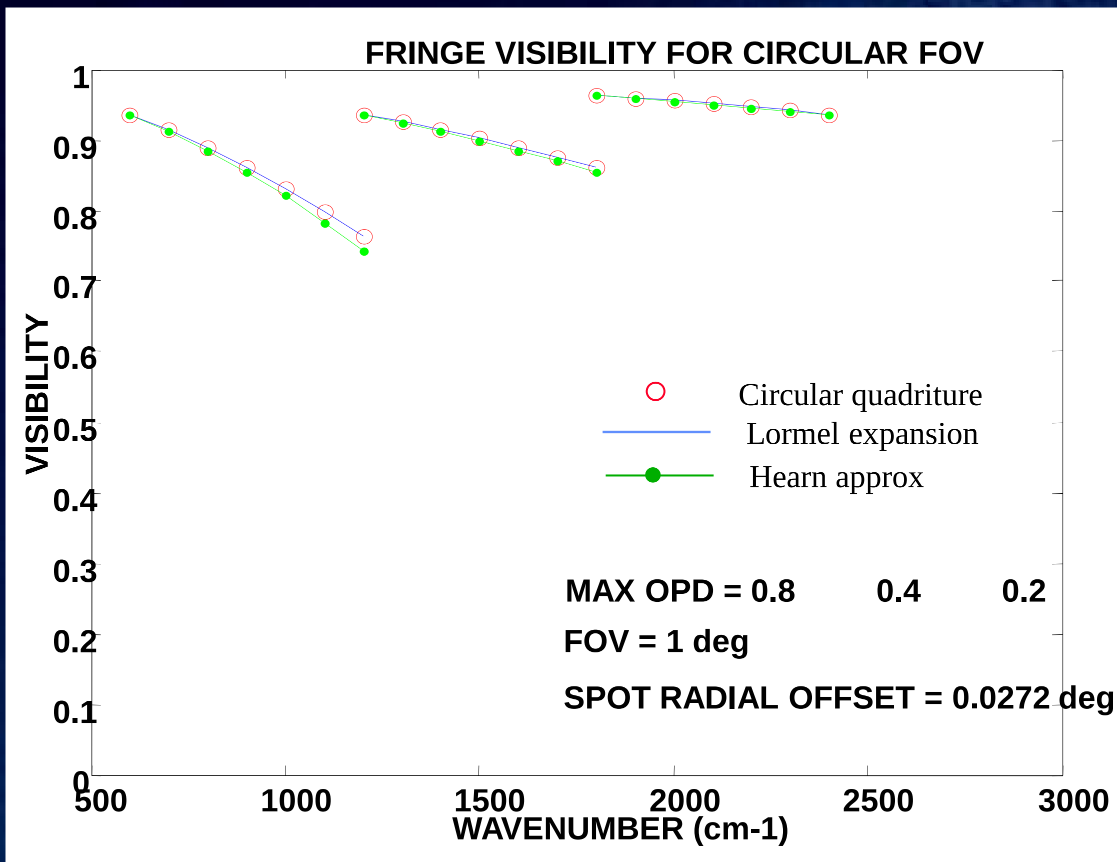
Picture courtesy of D. Mooney

Define visibility V(x):

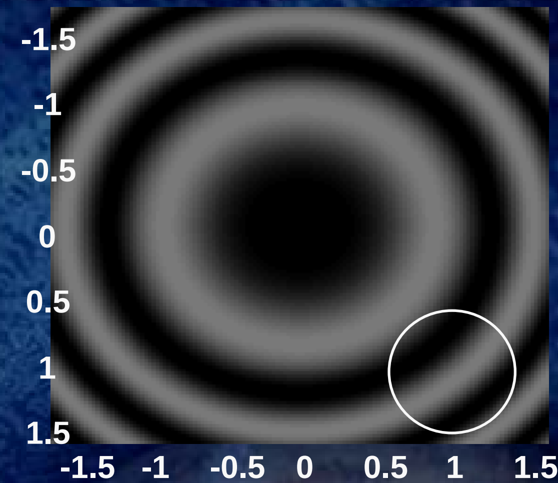
$$V(X) = \frac{G_{max}(x) - G_{min}(x)}{G_{max}(x) + G_{min}(x)}$$

The central detector falls inside the central bright spot. There is no loss in signal, V(x) =1

Visibility for CrIS Corner FOV



Picture courtesy of D. Mooney



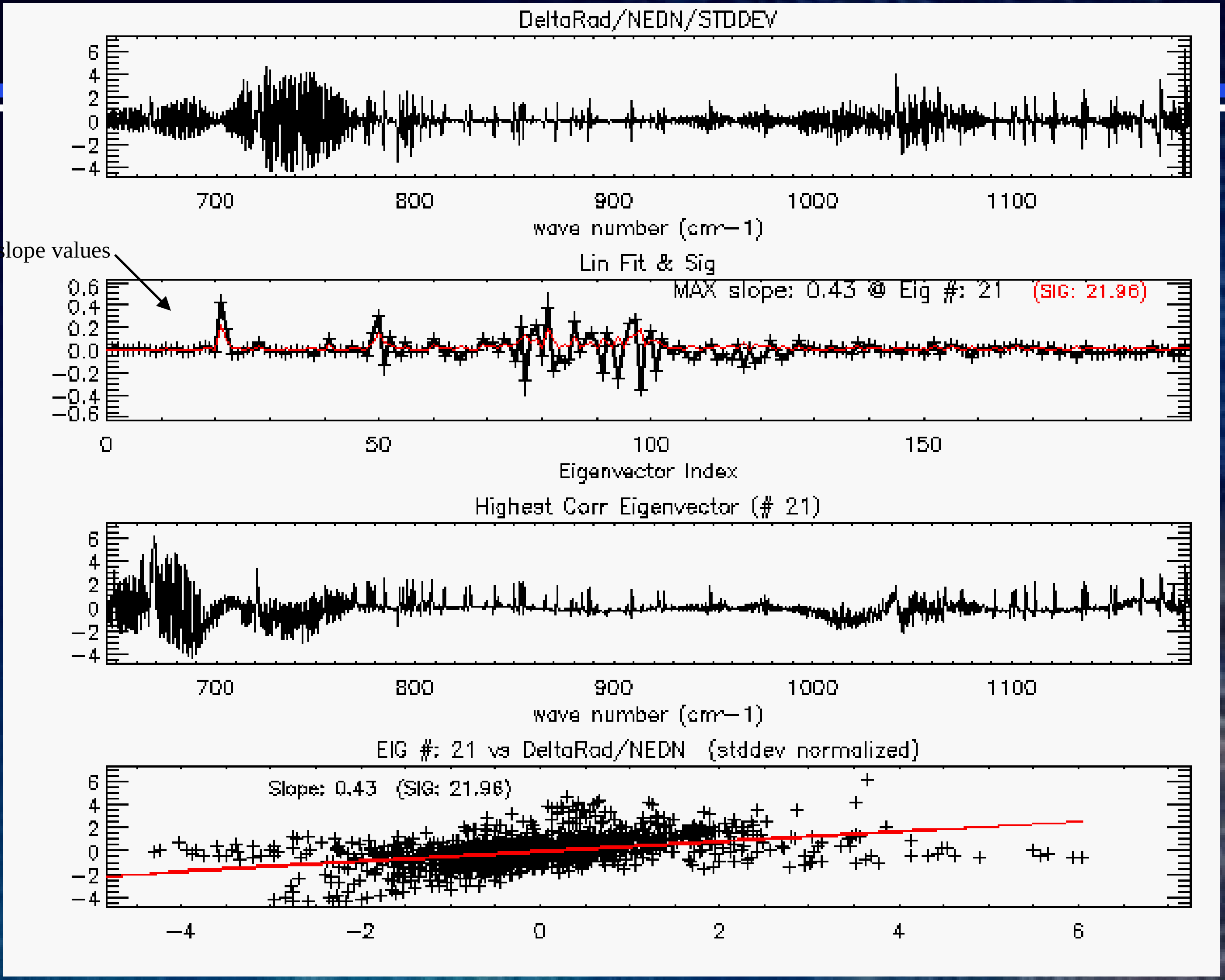
Define visibility V(x):

$$V(X) = \frac{G_{\max}(x) - G_{\min}(x)}{G_{\max}(x) + G_{\min}(x)}$$

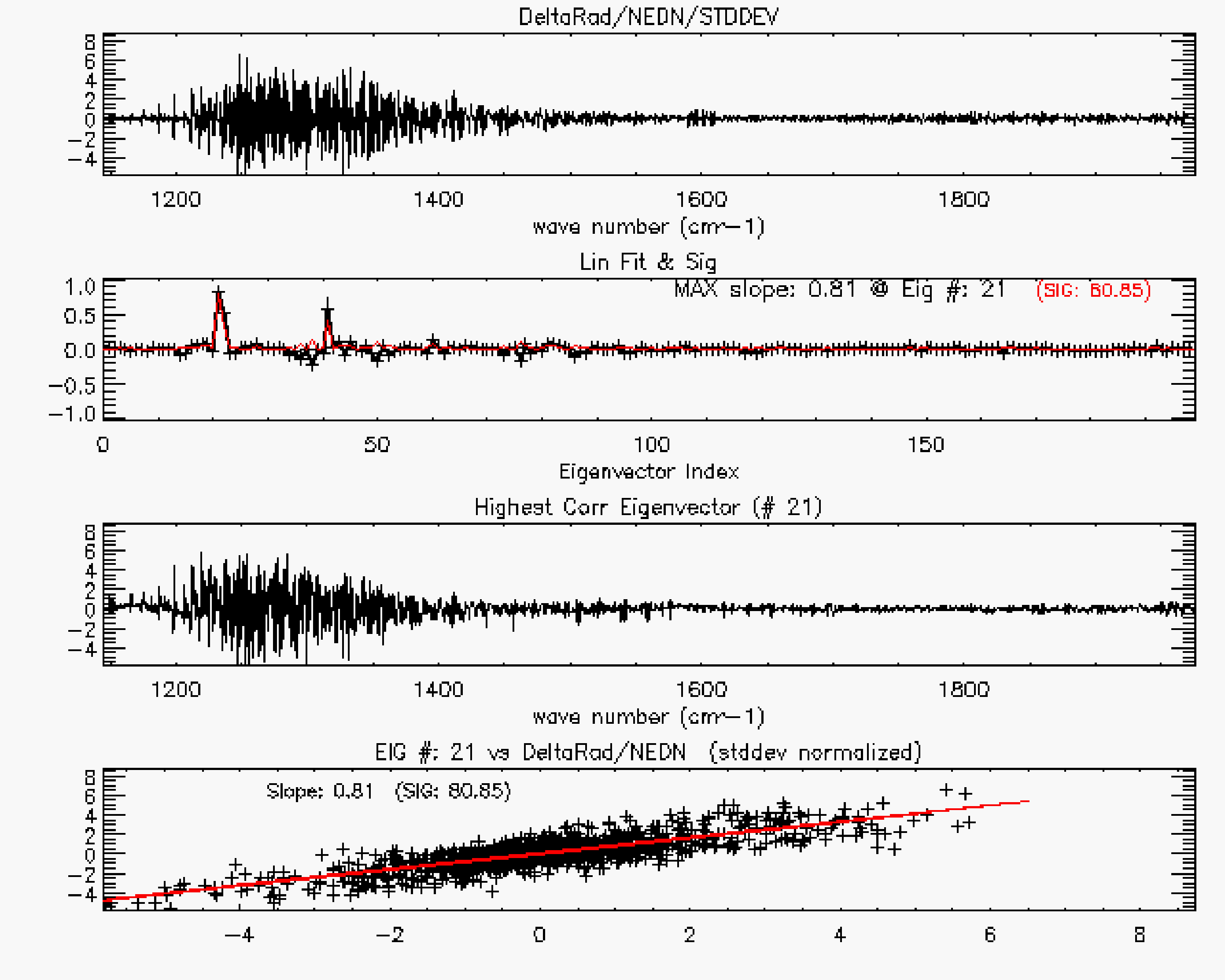
The corner detector falls outside the central bright spot. There is a loss in signal, V(x) <1.

Band 1, Gran # 393

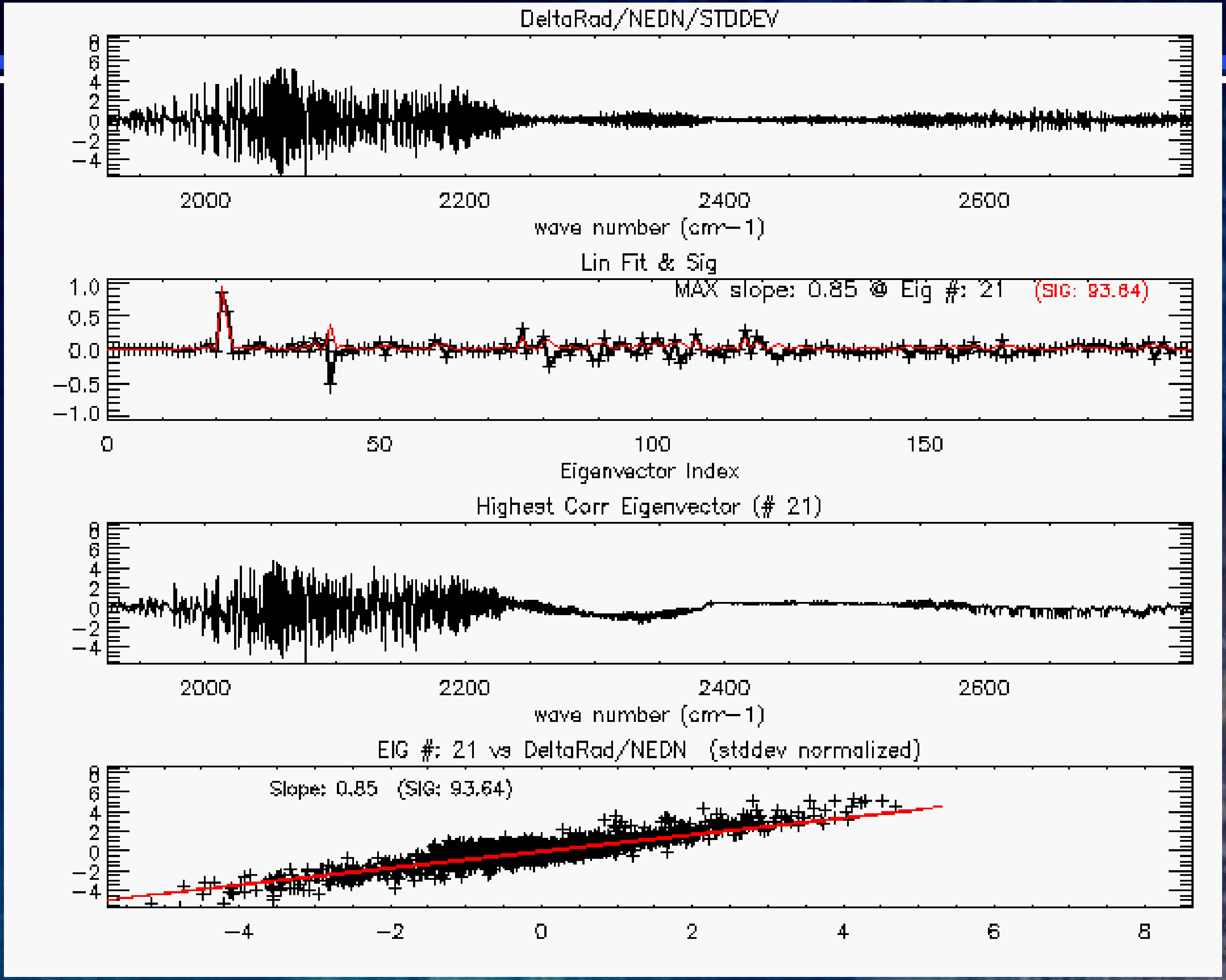
Each black point is a slope values



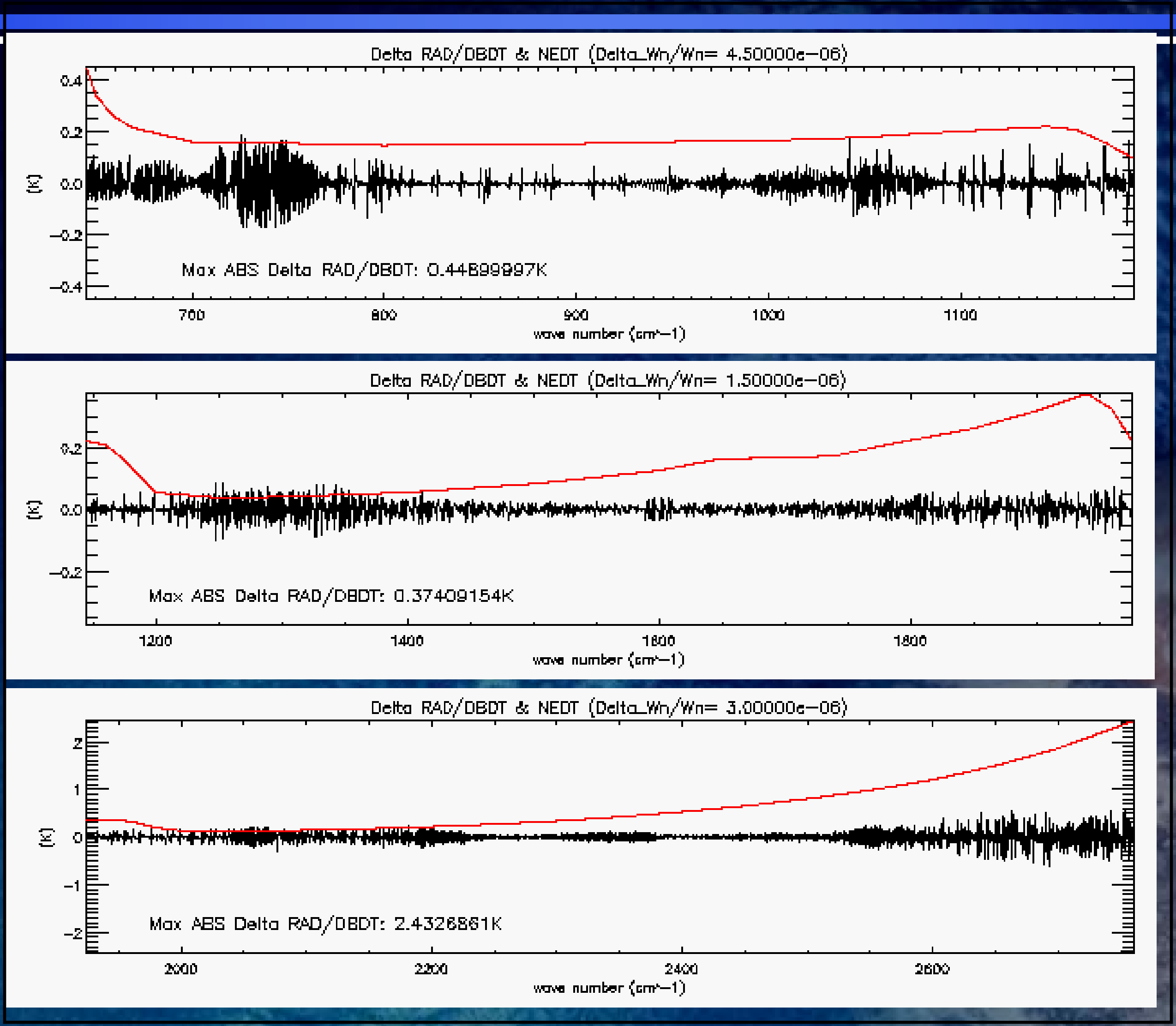
Band 2, Gran # 393



Band 3, Gran # 393

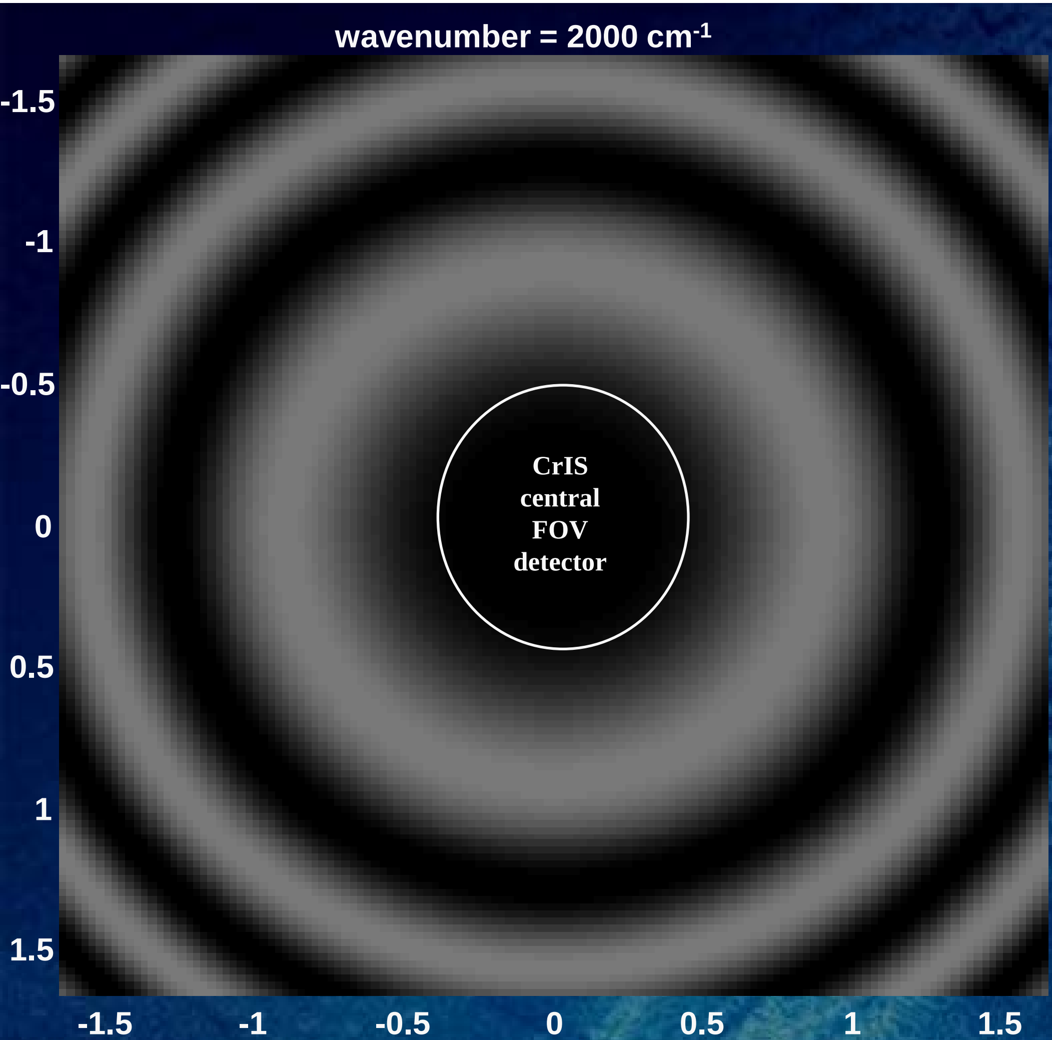


Band 1, 2, and 3 BT error summary



Self Apodization Effect & CrIS FOV geometry

$$\frac{\nu}{\Delta\nu} = 2x_{max}\nu$$



What the detector measures is the integration over the solid angle subtended by the detector at the exit pupil:

$$G(x) = \frac{g(\nu)}{\Omega_{max}} \int_0^{\Omega_{max}} [1 + \cos 2\pi\nu x(1 - \frac{\Omega'}{2\pi})] d\Omega'$$

$$ILS(\nu) = \mathrm{F}[\mathrm{G(x)}] \propto \mathrm{sinc}(2\pi\nu x_{max})$$

Spectral Resolution: (RSR): $\Delta\nu = \dfrac{1}{2x_{max}}$

Visibility: $V(X) = \dfrac{G_{max}(x) - G_{min}(x)}{G_{max}(x) + G_{min}(x)}$

Spectral Resolution – Visibility Trade off

X ↑ SR ↑ V ↓

Validation: System

Presented by

Letitia Soulliard

NUCAPS CF Compliance

- NUCAPS EDR, CCR, and OLR netCDF4 output files were run through a CF compliance checker (http://puma.nerc.ac.uk/cgi-bin/cf-checker.pl).
- The following slides shows the results of the tool. Note that all files ran successfully through the checker without errors.

CF Compliance

File name: NUCAPS-EDR_v1r0_npp_s201508072359449_e201508070000147_c201508081747310.nc

Output of CF-Checker follows...

CHECKING NetCDF FILE: /tmp/4583.nc
=====================
Using CF Checker Version 2.0.6
Checking against CF Version CF-1.5
Using Standard Name Table Version 29 (2015-07-08T09:43:36Z)
Using Area Type Table Version 3 (8 July 2015)
…
ERRORS detected: 0
WARNINGS given: 0
INFORMATION messages: 7

CF Compliance

File name: NUCAPS-CCR-AR_v1r0_npp_s201508072359449_e201508070000147_c201508081747310.nc

Output of CF-Checker follows...

CHECKING NetCDF FILE: /tmp/4583.nc

=====================

Using CF Checker Version 2.0.6

Checking against CF Version CF-1.5

Using Standard Name Table Version 29 (2015-07-08T09:43:36Z)

Using Area Type Table Version 3 (8 July 2015)

…

ERRORS detected: 0

WARNINGS given: 0

INFORMATION messages: 4

CF Compliance

File name: NUCAPS-OLR_v1r0_npp_s201508072359449_e201508080000147_c201508081349550.nc

Output of CF-Checker follows...

CHECKING NetCDF FILE: /tmp/4583.nc

=====================

Using CF Checker Version 2.0.6

Checking against CF Version CF-1.5

Using Standard Name Table Version 29 (2015-07-08T09:43:36Z)

Using Area Type Table Version 3 (8 July 2015)

…

ERRORS detected: 0

WARNINGS given: 0

INFORMATION messages: 0

Script Updates for J1

- Output file name definitions use satellite ID instead of hardcoded NPP.

See lines 452-455 in NUCAPS_Retrieval.pl

```
$NUCAPS_CCR_AR_PRODUCT = "NUCAPS-CCR-AR_v1r0_${SATELLITE_ID}_s${job_coverage_start}_e${job_coverage_end}_c${CreationTime}0.nc";
$NUCAPS_L2_PRODUCT = "NUCAPS-EDR_v1r0_${SATELLITE_ID}_s${job_coverage_start}_e${job_coverage_end}_c${CreationTime}0.nc";
$NUCAPS_AWIPS_PRODUCT = "NUCAPS-EDR-AWIPS_v1r0_${SATELLITE_ID}_s${job_coverage_start}_e${job_coverage_end}_c${CreationTime}0.nc";
$NUCAPS_EDR_MONITORING_PRODUCT = "NUCAPS-EDR-
MONITORING_v1r0_${SATELLITE_ID}_s${job_coverage_start}_e${job_coverage_end}_c${CreationTime}0.txt";
```

Script Updates for J1

- Input VIIRS CM files are read differently depending upon whether they are IP or EDR (from IDPS 2.0) files.

See lines 1069-1095 in NUCAPS_Preproc.pl

```
if ( $CF_file =~ /IICMO/ ) {

  $rc[0] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/QF1_VIIRSCMIP -b BE -o $QF1_file $CF_file >> $H5junk");
  $rc[1] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/QF2_VIIRSCMIP -b BE -o $QF2_file $CF_file >> $H5junk");
  $rc[2] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/QF3_VIIRSCMIP -b BE -o $QF3_file $CF_file >> $H5junk");
  $rc[3] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/QF4_VIIRSCMIP -b BE -o $QF4_file $CF_file >> $H5junk");
  $rc[4] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/QF5_VIIRSCMIP -b BE -o $QF5_file $CF_file >> $H5junk");
  $rc[5] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/QF6_VIIRSCMIP -b BE -o $QF6_file $CF_file >> $H5junk");
  $rc[6] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/GranuleAllOcean -b BE -o $GAO_file $CF_file >> $H5junk");
  $rc[7] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/GranuleNoOcean -b BE -o $GNO_file $CF_file >> $H5junk");
  $rc[8] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/ScanAllOcean -b BE -o $SAO_file $CF_file >> $H5junk");
  $rc[9] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-IP_All/ScanNoOcean -b BE -o $SNO_file $CF_file >> $H5junk");

} else {

  $rc[0] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/QF1_VIIRSCMEDR -b BE -o $QF1_file $CF_file >> $H5junk");
  $rc[1] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/QF2_VIIRSCMEDR -b BE -o $QF2_file $CF_file >> $H5junk");
  $rc[2] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/QF3_VIIRSCMEDR -b BE -o $QF3_file $CF_file >> $H5junk");
  $rc[3] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/QF4_VIIRSCMEDR -b BE -o $QF4_file $CF_file >> $H5junk");
  $rc[4] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/QF5_VIIRSCMEDR -b BE -o $QF5_file $CF_file >> $H5junk");
  $rc[5] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/QF6_VIIRSCMEDR -b BE -o $QF6_file $CF_file >> $H5junk");
  $rc[6] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/GranuleAllOcean -b BE -o $GAO_file $CF_file >> $H5junk");
  $rc[7] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/GranuleNoOcean -b BE -o $GNO_file $CF_file >> $H5junk");
  $rc[8] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/ScanAllOcean -b BE -o $SAO_file $CF_file >> $H5junk");
  $rc[9] = system("$H5DUMP_LOC -d /All_Data/VIIRS-CM-EDR_All/ScanNoOcean -b BE -o $SNO_file $CF_file >> $H5junk");

}
```

VIIRS Clouds in CrIS BUFR

- CrIS SDR BUFR files were dumped and compared to dumps of the (input) CrIS netCDF4 files
- The results demonstrate that the VIIRS cloud faction and cloud top height are being successfully encoded into the BUFR files.
- Jim Jung and Andrew Collard at EMC have also verified the content and in the coming months will be verifying the impact of the cloud information.

VIIRS Cloud Fraction and Cloud Height in BUFR and NetCDF files

- The VIIRS cloud fraction (unit: %) and cloud height (unit: meter) fields in the dump of NUCAPS BUFR file

005040	ORBN	17048.0	NUMERIC	Orbit number
010001	HOLS	0.0	M	Height of land surface
007002	HMSL	833280.0	M	Height or altitude
021166	ALFR	0.00	NUMERIC	Land fraction
008012	LSQL	1.0	CODE TABLE	Land/Sea qualifier
020010	TOCC	99.0	%	Cloud cover (total)
020014	HOCT	7980.0	M	Height of top of cloud
002165	RDTF	2048.0	FLAG TABLE(4)	Radiance type flags

- The VIIRS cloud fraction and cloud height (unit: km) fields in the dump of the input NUCAPS NetCDF file

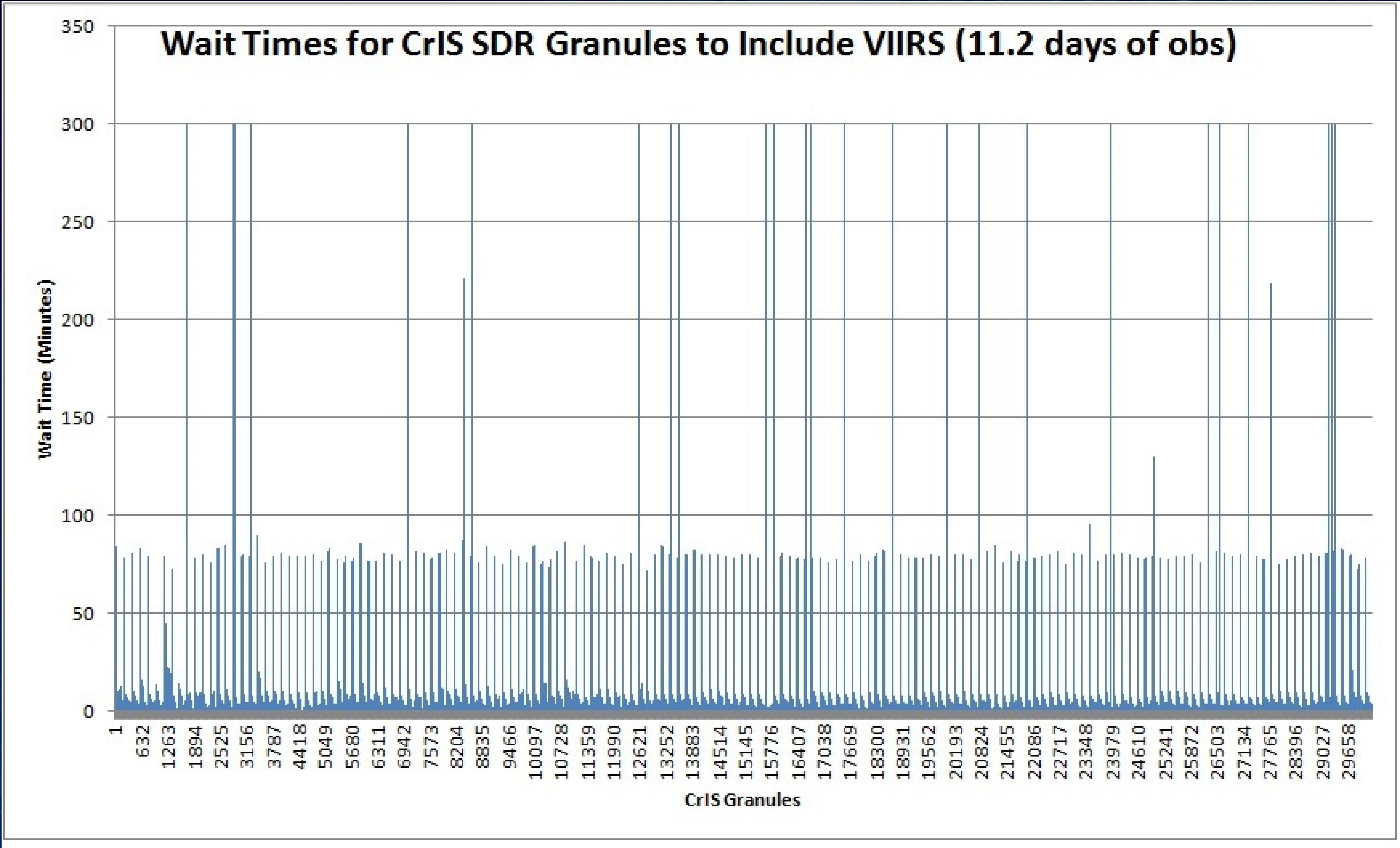
```
Cloud_Fraction =
0.9939501, 0.8305168, 0.9427425, 0.9996753, 0.978126, 0.9193422, 0.9988972,
  0.9987882, 0.9998063,
0.9977902, 0.986074, 0.9411805, 1, 0.9739865, 0.9361033, 0.9450675,
  0.9495209, 0.8961471,
```

```
Cloud_Height =
7.978416, 6.327145, 5.398026, 7.496365, 7.261185, 6.4313, 8.161325,
  7.623126, 6.658346,
6.963827, 6.591526, 5.405759, 7.622401, 6.437095, 3.98311, 6.621141,
  3.939479, 4.23858,
```

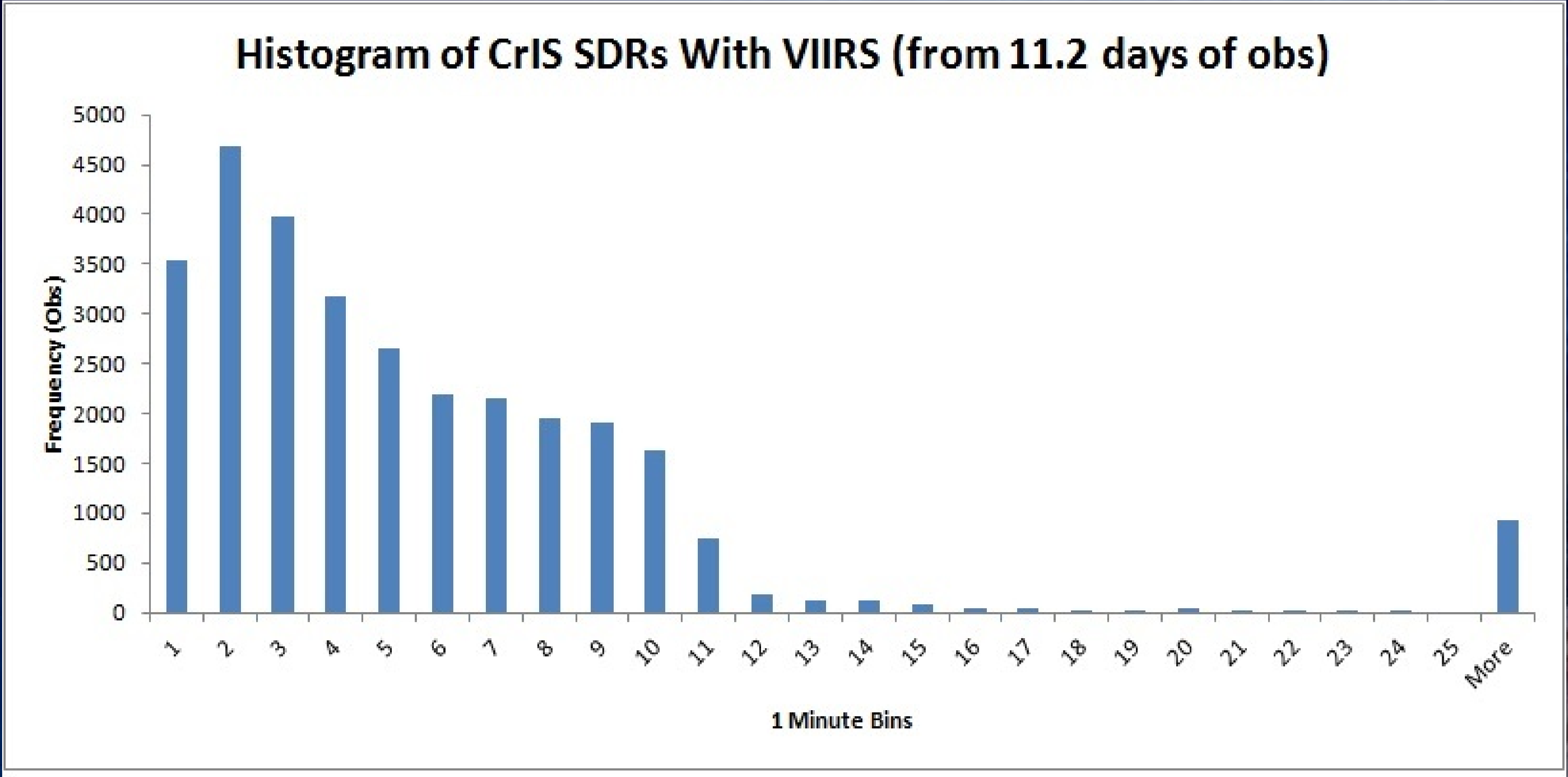
NDE VIIRS Latency

- Dylan Powell provided us with 11.2 days (30,247 obs) of NUCAPS granule wait time data run at OSPO.
- The wait times start when a CrIS SDR GEO file arrives and ends when all the required AMTS, VIIRS CM and CTH data are available for processing.
- The following plots show, in different ways, the distribution these wait times. The following results are worth noting:
  - » Average wait time is 7.1 minutes
  - » Over 92% of the granules are ready within 10 minutes
  - » After 25 minutes only 3% of the data files are not ready

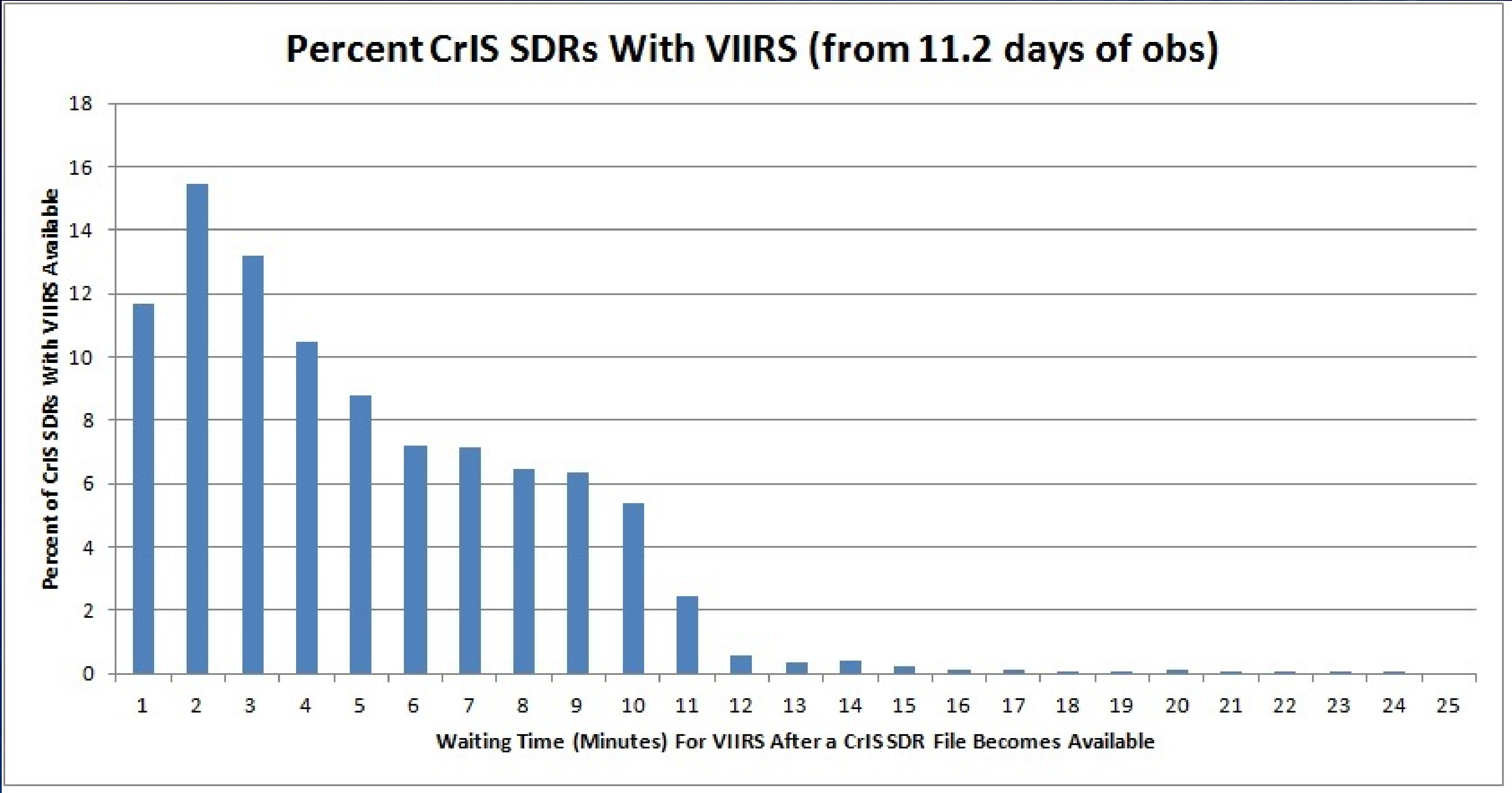
NDE System VIIRS Latency



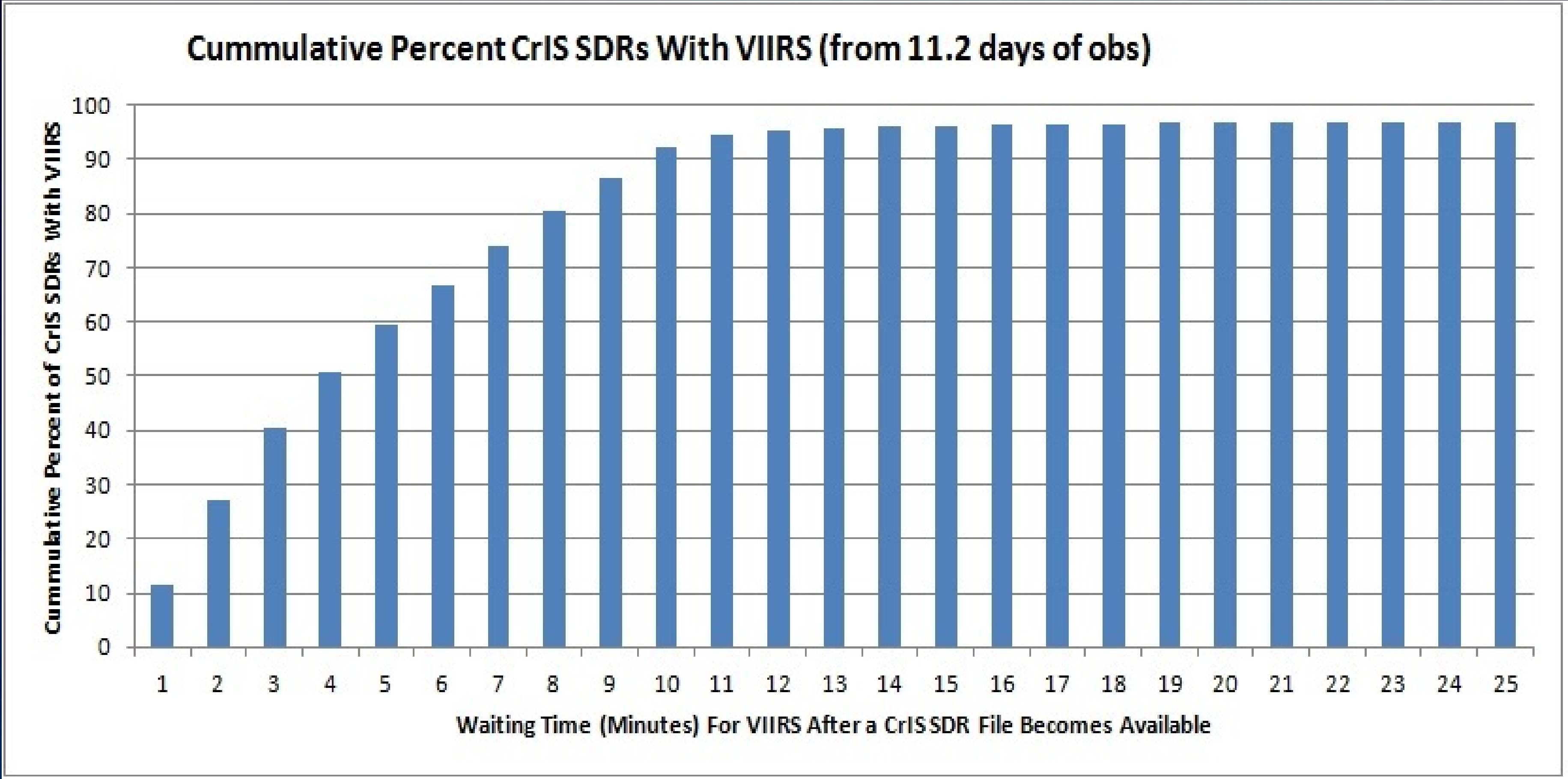
NDE VIIRS Latency



NDE VIIRS Latency



NDE VIIRS Latency



NDE VIIRS Latency

- Based on these results and a meeting with EMC (Andrew Collard, John Derber, Dennis Keyser, and Jim Jung), we recommend NDE implement a 10 minute wait for VIIRS CM and CTH data.
- After that 10 minute threshold, the CrIS data will be processed, but will be done so without VIIRS.

DAP Checklist

- The initial preliminary Phase 3 NUCAPS DAP package was delivered on 5/4/2015 and was updated 5 times since the initial delivery. The latest version is: NUCAPS_v3-0_20150902.tar.gz.
- It was delivered to NDE and tested. It is located on SADIE at: /utilraid/data/users/tking/NUCAPS/DAP_20150504/
- Dylan Powell is currently testing NUCAPS_v3-0_20150831.tar.gz on NDE PE2.
- NUCAPS_v3-0_20150902.tar.gz has a correction to make the OLR netCDF4 files CF-compliant.

DAP Checklist

File	Contents	Description
DOCS	Delivery_Memo NUCAPS_ATBD_20130821.pdf NUCAPS_EUM_V4.0.docx NUCAPS_PCF-PSF_Definition.docx NUCAPS_Production_Rules.docx NUCAPS_SMM_V4.0.docx README	This is all the SPSRB documentation for OSPO and the required NDE DAP documents.
SOURCE	code gfs_preprocessor retrieval	These 3 directories contain all Fortran source code for the retrieval, GFS preprocessor, and system code.
CrISOPS	CDLFILES Common_Bin DEM forecast_times matchups olr pc_coeffs resample retrieval scripts viirs_colocation	These directories contain all system scripts and static data files.
TEST	Granule_2011059_2011357 Validation_restart	These directories contain test data for all 4 units run on SADIE.

Validation Summary

- NUCAPS Phase 3 validation has demonstrated that the following are ready for implementation.
  - » Retrieval (T, q, O3)
  - » OLR
  - » ILS impact is negligible
  - » CrIS/VIIRS BUFR contents and timeliness

- DAP Checklist has verified that the DAP contents are complete and compliant with DAP standards.

Review Outline

- Introduction
- CDR Phase 3 Report
- Phase 3 Requirements
- Phase 3 Software Architecture
- Validation
- Risk Summary
- Summary and Conclusions

Risk Summary

Presented by

Tom King

Open Risks and Actions

- **Risk #30:** The current CrIS instrument's spectral resolution in the short-wave band is too low for retrieval of carbon monoxide within requirements.
  - **Risk Mitigation:**
  - JPSS Project Office has been investigating bringing down full resolution data in the CrIS RDR, but there is not yet a plan to put it into the SDR.
  - NUCAPS science development team will continue to work with the Project Office to have these data available in the SDR.
- **Status:** Open

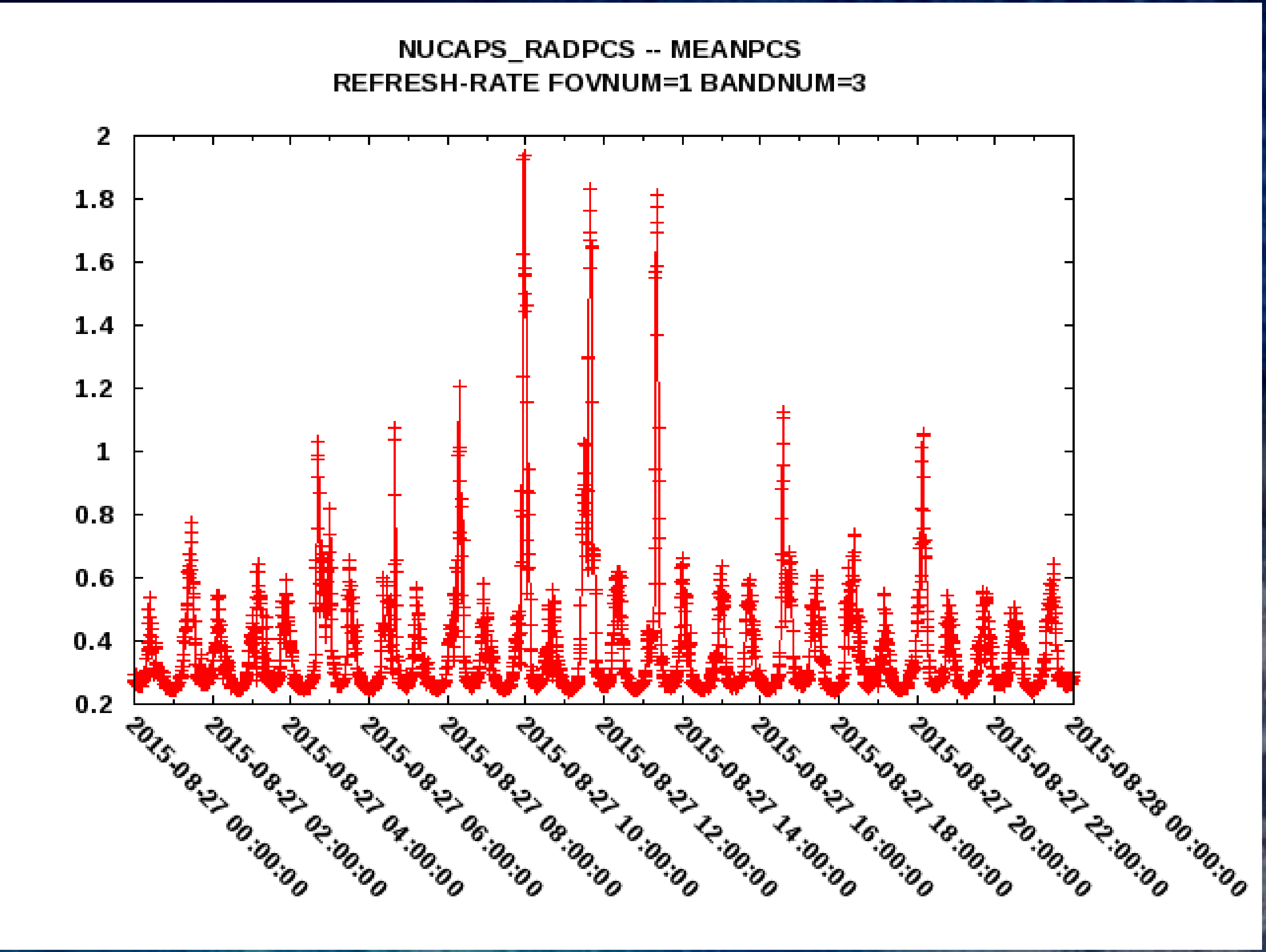
New Risks and Actions

- **Risk #46:** NUCAPS band 3 eigenvectors used for the principal component reconstruction have likely degraded and will need to be regenerated. The reconstructions scores are used for NUCAPS SDR product monitoring the OSPO Product Monitoring System.
- **Risk Assessment:** Low
  - » OSPO will have a degraded product monitoring capability.
- **Impact:** Low
- **Likelihood:** High
- **Risk Mitigation:**
  - » The NUCAPS science team will need to generate new eigenvector files. This work will also need to be done for the full-spectral data.
- **Status:** Open

New Risks and Actions

- **Risk #47:** The NUCAPS CCR netCDF4 files need to be modified to include the QC that is now output in the retrieval binary file. This is required for user convenience. It will make the file slightly larger. It needs to be done within the next 4 months to accommodate reprocessing efforts. In addition, changes are needed to add the precipitation flag and the ATMS tuning.
- **Risk Assessment:** Low
  - » This is needed to support AWIPS and Direct Broadcast users.
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » To mitigate this issue, the development team will make the changes offline and then show Chris exactly what the changes are to the output file. Chris can implement this in his reprocessing in the near term so he doesn't have to reprocess later. This can go into operations in the next delivery (whenever that is), but it won't have to be done within the next 4 months. The development team will hold meets in September to coordinate updates for the precipitation flag and the tuning.
- **Status:** Open

New Risks and Actions: Risk #46 Continued



Review Items Summary

- 2 risks remain open
  - » 1 low (CDR Phase 1)
  - » 1 low (CDR Phase 3)

Review Outline

- Introduction
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Summary and Conclusions

Presented by

Tom King

Review Objectives Have Been Addressed

- The following have been reviewed
  - » Schedule
  - » Risks and Actions
  - » Updated Requirement Allocation
  - » Software Architecture Updates
  - » Product, System, DAP Validation

Next Steps for NUCAPS

- Update project materials and post them for the review team.
- Assist OSPO and NDE with transition, validation, and maintenance
- Continue work on NUCAPS Phase 4 (full-res CrIS)
- Continue to assist all validation efforts at STAR

Open Discussion

- The review is now open for free discussion