



# Development of the IASI Operational Processing and Distribution System

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# Outline

- Goals
- AQUA Processing
- IASI Simulations
- IASI Subsetting and Distribution



# Goals

- Provide calibrated and navigated IASI radiances, reconstructed radiances, and principal components to NCEP and GMAO for assimilation within three hours of observation.
- Create simulated IASI data to test system ingestion, NOAA product generation, and to produce IASI BUFR files for the NWP community.
- Use the AIRS/AQUA processing and distribution system as a basis for the IASI subsetting and distribution system.



# AQUA Processing



# Instruments on AQUA Satellite

- Atmospheric Infrared Sounder (AIRS) – Grating Spectrometer with 2378 channels that has spectral coverage from 650-2700  $\text{cm}^{-1}$  (3.7 to 15.4  $\mu\text{m}$ ).
- Advance Microwave Sounding Unit (AMSU) – Microwave sounder with 15 channels in the spectral range of 23 to 89 GHz.
- Humidity Sounder for Brazil (HSB) – Microwave sounder with 4 channels in the spectral range of 150 to 187 GHz.
- Moderate Resolution Imaging Spectroradiometer (MODIS) – 36 spectral bands ranging from 0.4 – 14.4  $\mu\text{m}$ .



# Instruments on MetOp1 Satellite

- Infrared Atmospheric Sounding Interferometer (IASI) – Fourier Transform Spectrometer with 8461 channels that has spectral coverage from 645-2760  $\text{cm}^{-1}$ .
- Advance Microwave Sounding Unit (AMSU) – Microwave sounder with 15 channels in the spectral range of 23 to 89 GHz.
- Microwave Humidity Sounder (MHS) – Microwave sounder with 5 channels in the spectral range of 89 to 190 GHz.
- Advanced Very High Resolution Radiometer (AVHRR) – 6 spectral bands ranging from 0.58 – 12.5  $\mu\text{m}$ .



# AQUA - MetOp1 Comparison

- AIRS
- AMSU
- HSB
- MODIS
- Granule Processing
- IASI
- AMSU
- MHS
- AVHRR
- Granule Processing



# Granule Processing

- AIRS Processing starts at Level 0
- AIRS Granules contain 6 minutes of data
- 240 Granules per day
- 35 GB per day
  - » 9 FOV
  - » 2378 channels
  - » 4 bytes/word
- IASI Processing starts at Level 1C
- IASI Granules contain ~3 minutes of data
- 491 Granules per day
- 30 GB per day
  - » 4 FOV
  - » 8461 channels
  - » 2 bytes/word

# Two Years Before AQUA Launch



- Started working on a AIRS/AMSU/HSB simulation system – data were output into the “official” Level 1B format.
- Worked with NWP centers on creating a AIRS/AMSU/HSB BUFR format.
- Created Level 1B readers and subsetter.



# One Year Before Launch

- Had a fully operational AIRS/AMSU/HSB simulation system – data were produced every 6 minutes.
- The Level 1B data were subset and put in the initial BUFR format.
- BUFR files were placed on the local NOAA server for pick up.



# Conversion to Real Data

- Delivered the simulated data in BUFR format to the NWP centers through CEMSCS.
  - » Gave time to create the file name convention.
- Conversion from simulated to real AIRS/AMSU/HSB data was implemented without any problems on October 9, 2002.
  - » Added data quality flags three weeks later.



# AQUA Products

- Distributing in near-real time 9 separate BUFR files containing AIRS/AMSU/HSB data.
- Test BUFR files containing alternate products.
- On average, over 95% of the data is distributed to NWP centers within 3 hours of observation.



# NWP Customers

- NCEP
- GMAO (DAO)
- CMC (Canada)
- JMA (Japan)
- FNMOC (US Navy)
- BMRC (Australia)
- UK-Met Office
- ECMWF
- Meteo-France
- DWD (Germany)
- CPC



# IASI Simulations

# Characteristics of Simulation System



- The IASI simulation observation system is based off the AIRS/AMSU/HSB simulation system.
- The IASI simulation observation system emulates the instrumental and orbital characteristics of the IASI instrument on the MetOp platform and produces 1.3 million spectra/day.
- The microwave brightness temperature at the IASI observation point are also simulated at the same time.

# Purpose of the Simulation System



- To provide the NWP community with test data to prepare for ingestion as well as to work out any issues regarding format and content.
- To provide a robust data distribution environment for development and testing of the IASI data sub-setting system.
- Allow for a smooth transition of the IASI data processing system from the development environment to the operational environment, during both the integration and test phases of the transition.

# Simulation System



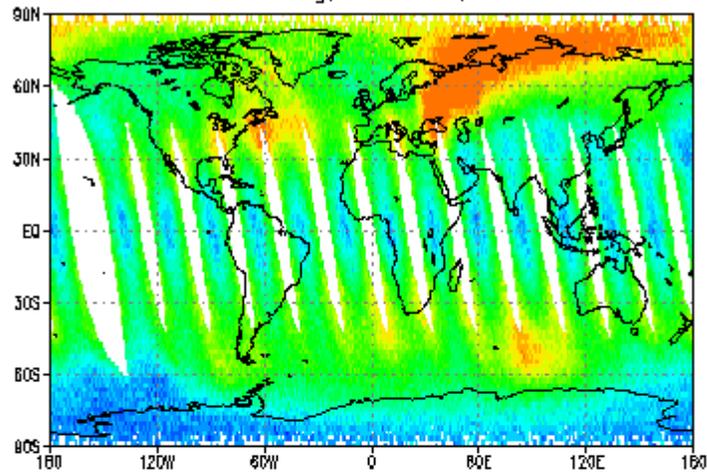
- Orbit simulation
  - » MetOp1 ephemeris data.
- Field of View simulation
  - » all sensor pointing and FOV geo-location.
- Surface properties simulation
  - » the surface radiative properties.
- Atmosphere simulation
  - » atmospheric profiles.
- Forward model (radiative transfer model)
  - » simulated observation radiance/brightness temperatures.



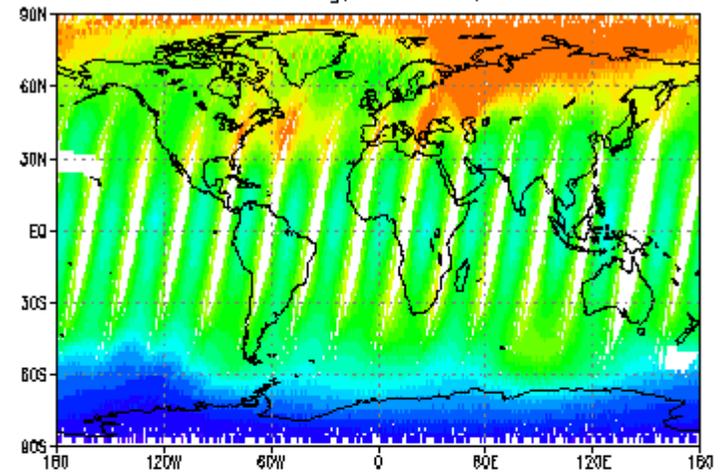
# Simulation Output

- The output of the simulation system is in the IASI Level 1C EUMETSAT EPS format.
- AMSU and MHS data in the current OSDPD Level 1B format.
- Enables the creation and testing of the post-launch Level 1B/1C readers and subsetter prior to launch.

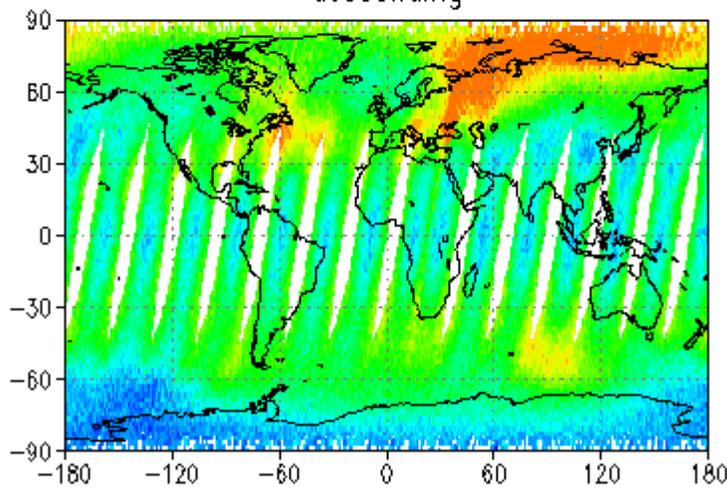
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ascending, MAR 27, 2005



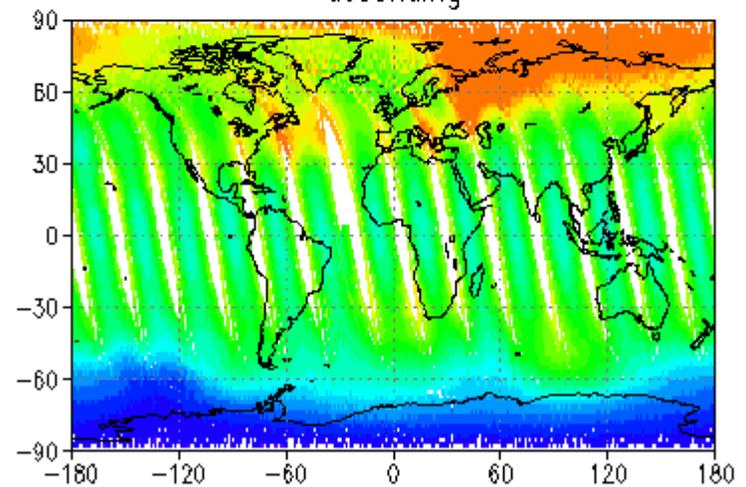
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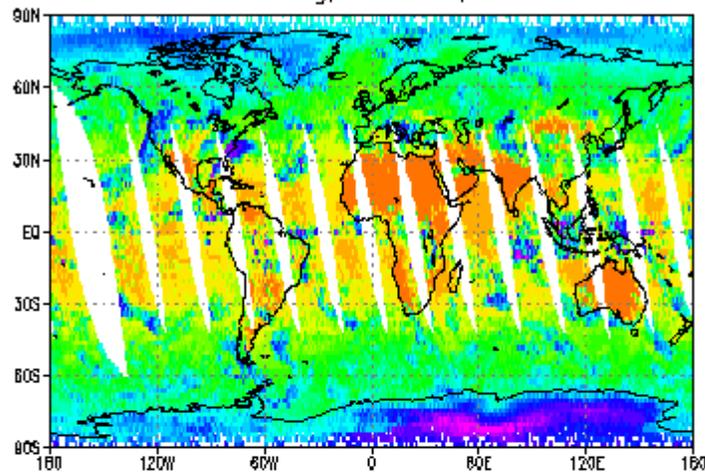
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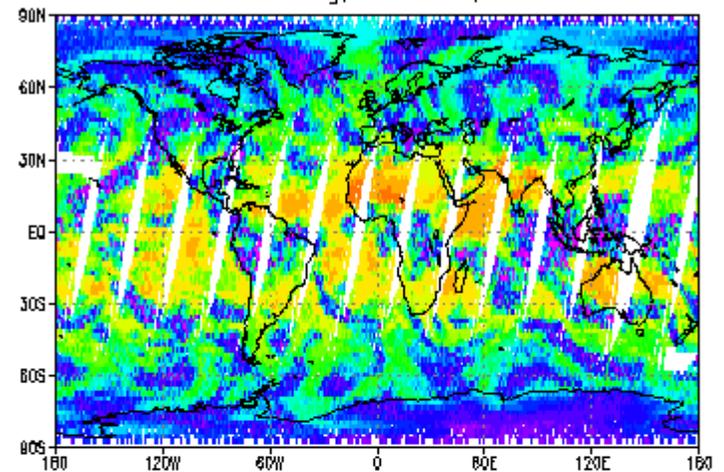
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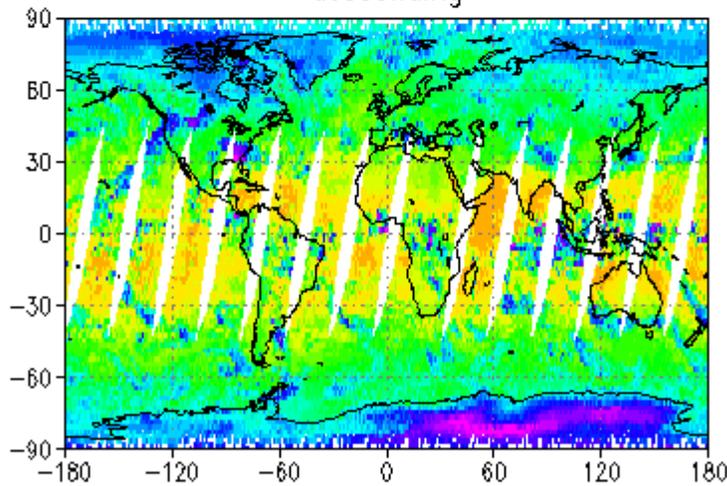
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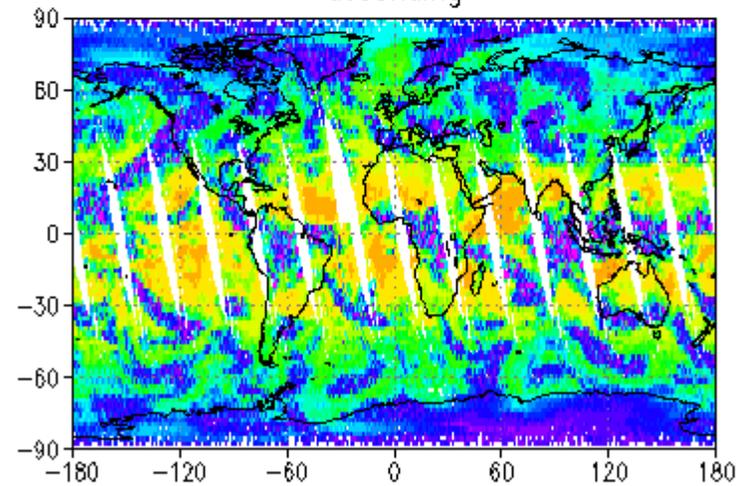
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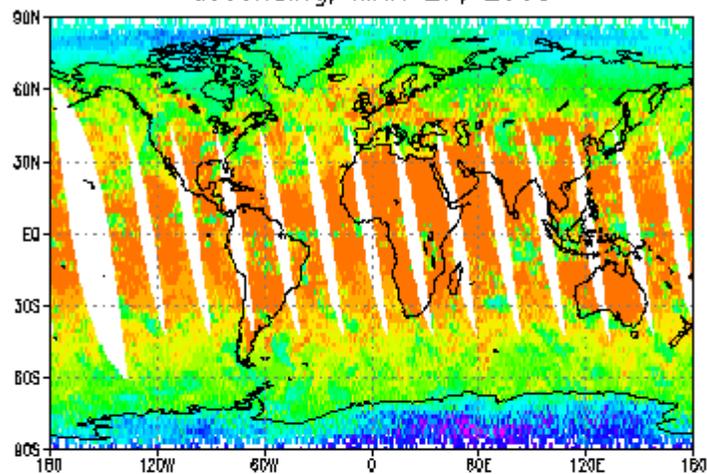
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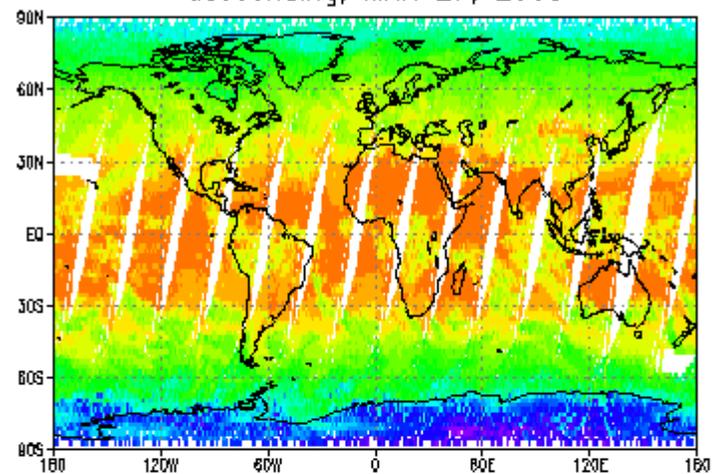
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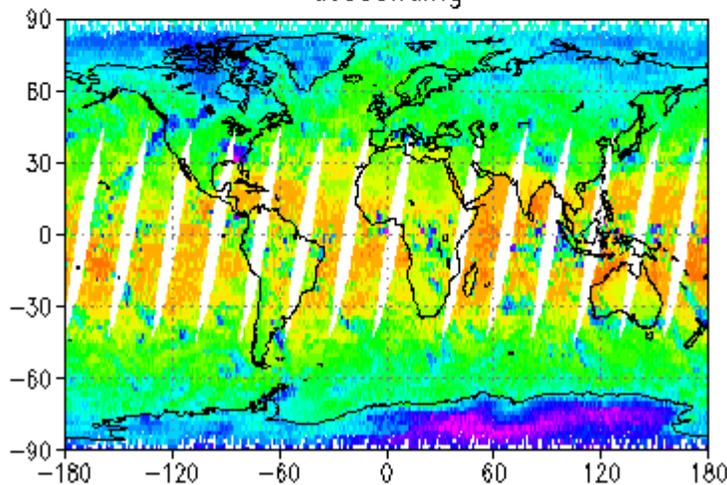
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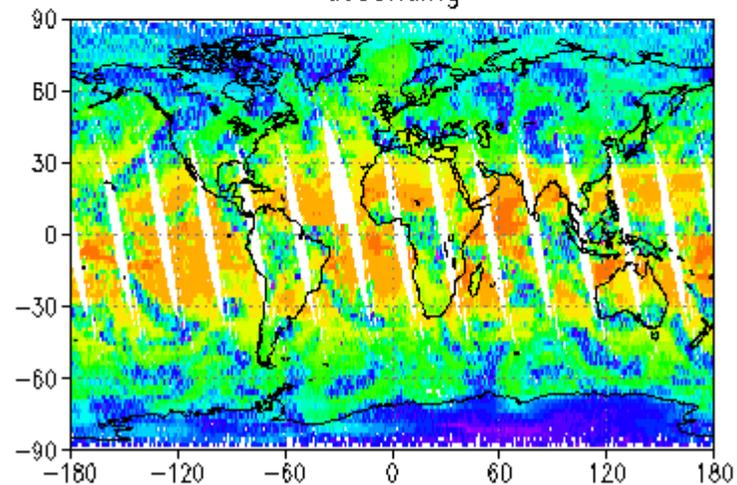
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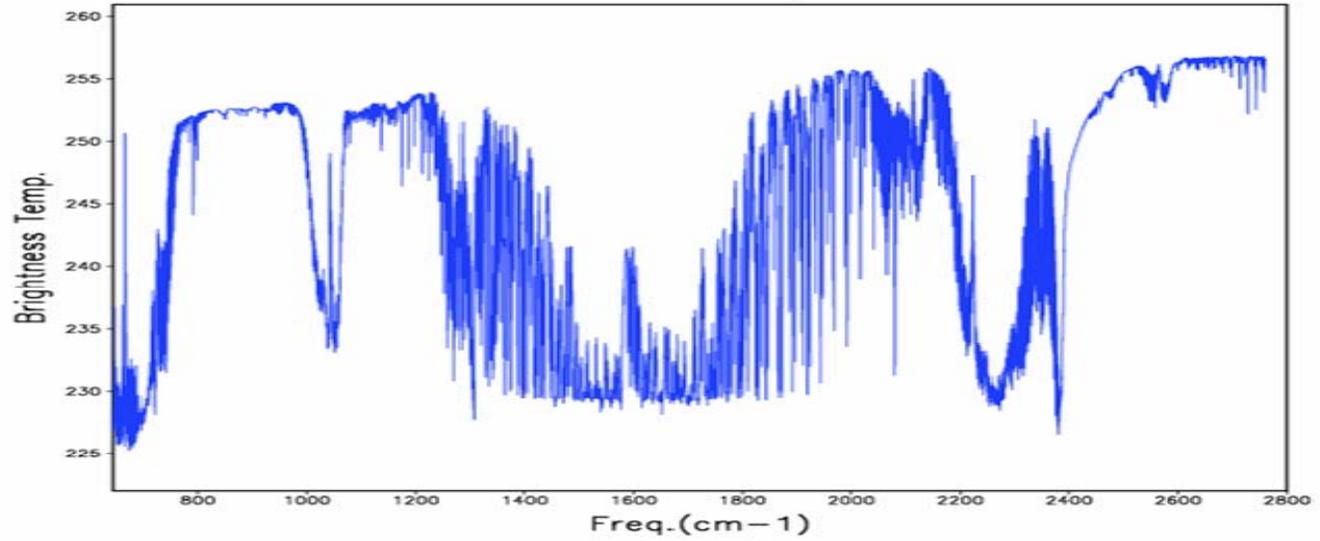
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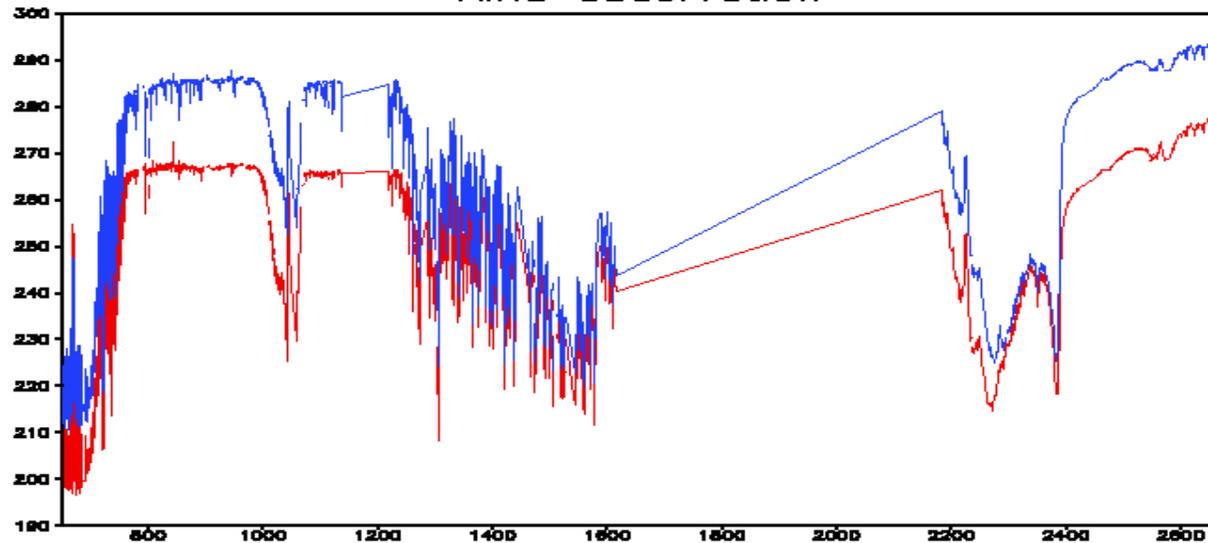
ascending



### Simulated IASI Spectrum



### AIRS Observation





# IASI Subsetting and Distribution

# Incoming Data for IASI Subsetting



- IASI Level 1C
  - » For subset products
- IASI Level 2
  - » For subset products
  - » For validation
- AVHRR Level 1B and Level 2
  - » For clear/cloudy AVHRR radiances/reflectances on the IASI footprints
- AMSU and MHS Level 1B



# IASI Level 1C Data

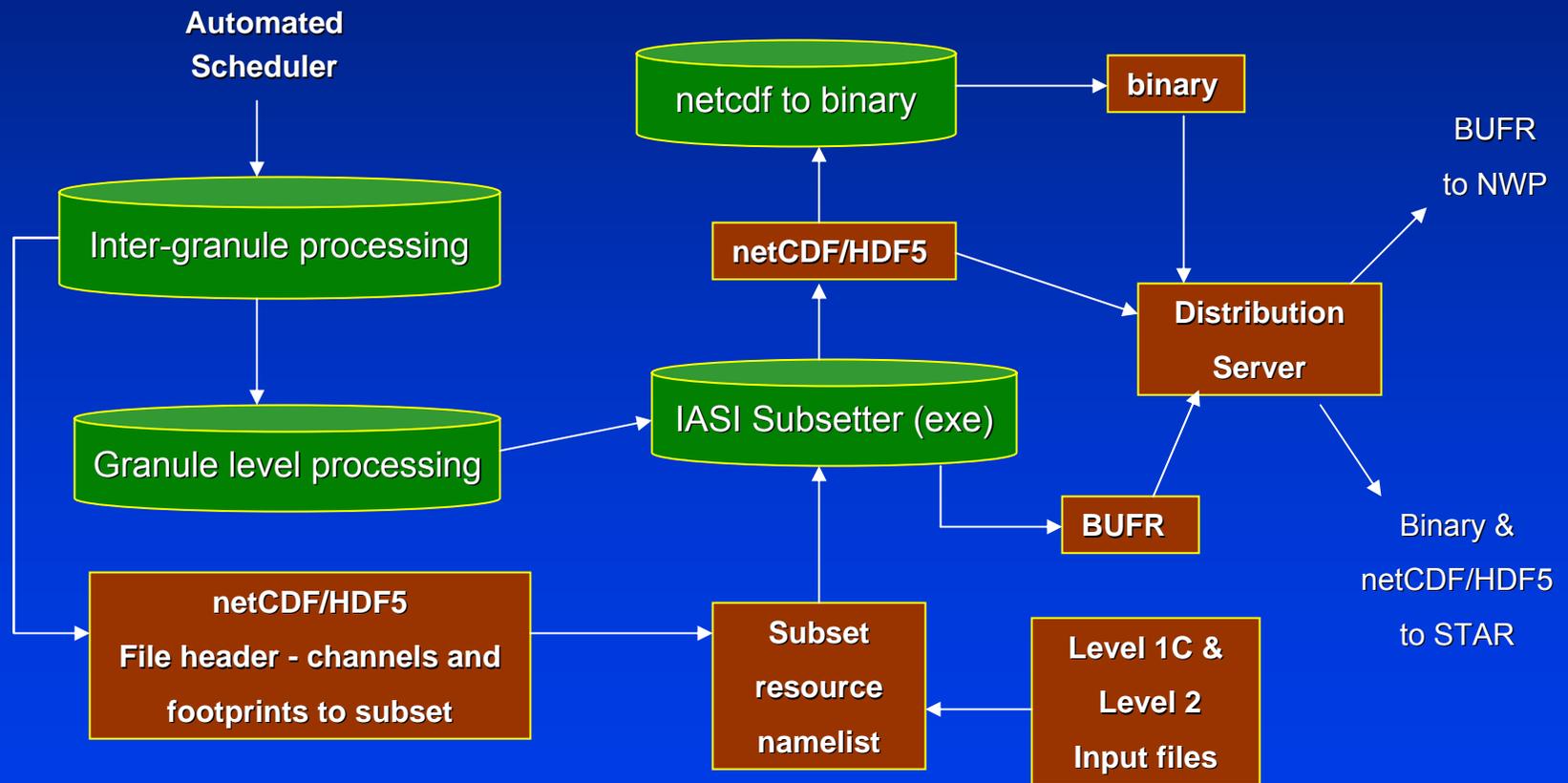
- Binary format files (60.2 MB/granule)
- Whole ~3-minute granules (491 granules/day)
- 22 Scans per granule (1 scan is a single Measurement Data Record)
- 30 AMSU FOR (Fields Of Regard) per scan
- Each FOR is a 2 X 2 matrix of IASI FOVs (Fields Of View)
- 4 IASI FOVs per FOR
  - » 8461 IR channels of radiance/FOV
  - » Sub-FOR image (64X64)
  - » QC flags
  - » Scan geometry
- → Total of 29 GB/day .....this is why we subset!



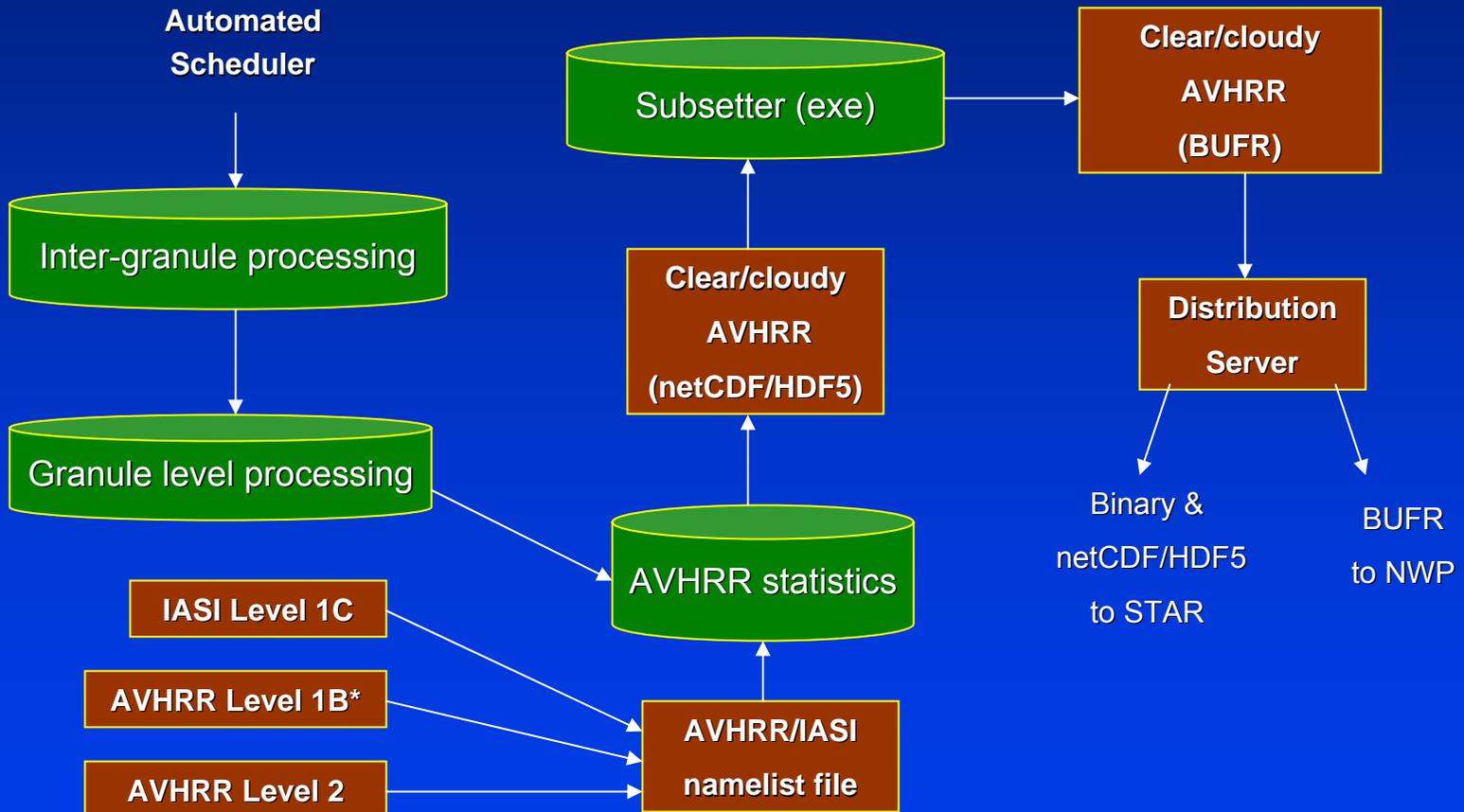
# System Hardware for MetOp1

- IBM Power 5
  - » 16 CPUs
  - » 2 GB memory/CPU (P5-570s)
  - » 8 GB of swap space
  - » 3 TB disk space
- 3 of these systems in total:
  - » Operational machine
  - » Backup operational machine
  - » Development (test) machine

# Subsetter Model For IASI Level 1C Products



# Subsetting For AVHRR Distribution

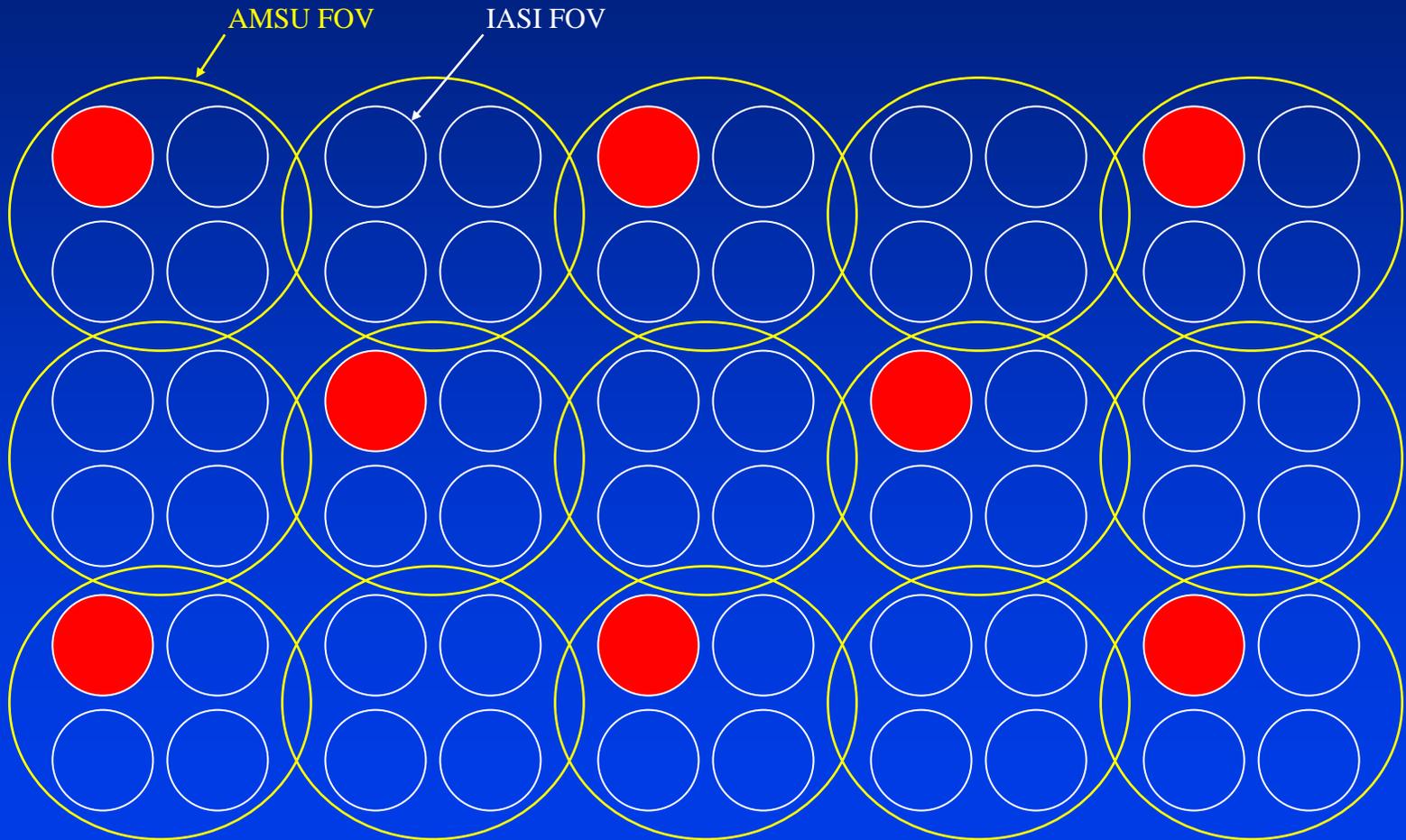




# Subset Schemes

- Spectral Subsets (chosen for information content)
  - » Extract ~500 channels of the original 8461 set.
  - » Collapse the 8461 channel set into ~85 principal components.
- Spatial Subsets (chosen to scale to AIRS products)
  - » 1/8 of the original full spatial set (1 FOV/every other FOR).
    - 1<sup>st</sup> FOV in the FOR
    - clearest FOV in the FOR
  - » 1/2 of the original full spatial set (4 FOVs/every other FOR).

# A Spatial Subset Example





# Ideas For Subset Products

Instrument	Channels	Data	FOR/granule	Sample scheme per scan line	IASI FOV #	Format
IASI	~500	RAD	330	EOF – odd or even numbered	1	BUFR
IASI	~500	RAD	330	EOF - odd numbered	1,2,3,4	BUFR
IASI	~500	RR from the PCS	330	EOF – odd or even numbered	1	BUFR
Daily IASI	~85	PCS	330	EOF - odd numbered	1	BUFR
IASI	~500	CCR (from the retrieval)	330	EOF - odd or even numbered	1	BUFR
IASI	~500	Cloud cleared PCS RR (from the retrieval)	330	EOF - odd or even numbered	1	BUFR
AVHRR	6	Mean Clear & Cloudy RAD on IASI FOVs	330	EOF – odd or even numbered	1	BUFR

EOF – Every Other FOR; PCS Principal Components; RAD Radiance; RR Reconstructed Radiance; CCR Cloud Cleared Radiances



# Output File Formats

- BUFR
  - » The standard for NWP centers.
  - » Currently working with EUMETSAT and the NWP centers to create this format for IASI.
- netCDF/HDF5
  - » Intermediate internal format where data dimensions can be easily extracted for use in allocation before the actual reading of the file.
- Binary
  - » An internal final format for ORA use.
  - » Format is compact and I/O is simple.
  - » No toolkits or APIs are necessary, just a reader and a writer are required.



# Summary

- Near Real-Time AQUA (AIRS/AMSU/HSB) System is in place and is the baseline for building the IASI Simulation and Distribution System – and future systems as well.
- The MetOp1 simulator and subsetters are running on a development machine. Simulated IASI data in BUFR format will soon be placed on the [nanuk.eosdis.nasa.gov](http://nanuk.eosdis.nasa.gov) data server.
- Simulated IASI BUFR files will be sent through the CEMSCS server prior to the availability of the real IASI data.
- The actual subset IASI data will be made available to NCEP and GMAO after launch.