Preparation for the Distribution of IASI Radiances to NCEP and GMAO

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Outline

- Overview
- Background
- IASI Simulations
- IASI Subsetting and Distribution
- PCA using IASI Data
- Summary
Overview

• Provide calibrated and navigated IASI radiances, reconstructed radiances, principal components, and cloud cleared radiances to NCEP, GMAO, AFWA, and NRL for assimilation within three hours of observation.
Background

- IASI subsetting and distribution system is based off the AIRS processing and distribution system.

- AIRS Near Real-Time System has been operational for three and a half years.
AIRS Near Real-Time System

- Distributes over 95% of the near real-time AIRS data to the NWP centers within three hours of observation.

- Subset AIRS datasets and distribute in BUFR format.

- The AIRS data are used operationally at NCEP, ECMWF and the Met Office.
Preparation for IASI: Simulation System
Purpose of the Simulation System

- 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.
• The IASI simulation system emulates the instrumental and orbital characteristics of the IASI instrument on MetOp-1 platform and produces 1.3 million spectra/day.

• The microwave brightness temperature at the IASI observation point are also simulated.
Simulation System Characteristics

- Orbit simulation
  » MetOp 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 the IASI Level 1C data in the current EUMETSAT format.

• Simulated IASI granule data is produced every 176 seconds.

• AMSU and MHS data in the current OSDPD Level 1B format.
IASI Level 1C Files

- The subsetting system produces files that are in BUFR format.

- Format was created by Simon Elliot at EUMETSAT.

- Collaboration between NWP centers and EUMETSAT for agreement upon one IASI L1C BUFR format.
Preparation for IASI: Subsetting and Distribution
Incoming Data for IASI Operations

- IASI Level 1C Granule Data (EUMETSAT)
- AVHRR Level 1B Orbital Data (NOAA)
- AMSU and MHS Level 1B Orbital Data (NOAA)
IASI Level 1C Data

- Binary files (~60 MB/granule)
- Granules 176 seconds in length (491 granules/day)
- 22 scans per granule (1 scan/data record)
- 120 IASI FOVs per scan
- 4 IASI FOVs within an AMSU FOV (IASI FOR)
  » 8700 IR channels with two guard bands around the standard 8461 channel set
  » Scan geometry
  » QC flags
  » IASI image on the IASI FOR
- → Total of 29 GB/day …..this is why we subset!
The IASI Field of Regard

Dimensions at nadir

IASI FOV

AMSU FOV

All 4 IASI FOVs are sampled simultaneously for all 8461 channels.

12 km

17.5 km
AVHRR Level 1B Data

- Global 1 km level 1B from OSDPD
  - Orbital files
  - 2048 FOVs per scan
  - 5 channels of radiances (IR and visible)
    - 6 frequencies, 5 transmitted channels
  - Scan geometry
  - CLAVR cloud mask
  - File size ~58 MB/orbit
Overall System Design

EUMETSAT Simulation System

EPSC

IASI L1C

AMSU/MHS L1B

AVHRR L1B

EUMETSAT L2

L1B proc.

L1B proc.

AVHRR proc.

netCDF

netCDF

netCDF

BUFR

BUFR

Matchup Locs

Matchups

Global Binaries

Global Grids

Monitoring

DDS
Subsetter Model For IASI Level 1C Products

Scheduler

Granule Staging

OPUS

Granule level processing

CDL template

ncgen

netCDF to BUFR

Check BUFR

DDS

STAR

binaries

Monitoring

netCDF to pre-L2

binary

netCDF

Subset

IASI Subsetter (exe)

netCDF to netCDF

IASI 1C & ancillary files

L2 Proc.
Subsetting For IASI/AVHRR
NOAA Unique Processing

Scheduler
Granule
Staging

OPUS
Granule
Level processing

Collocation

Clear/Cloudy netCDF
AVHRR
Statistics

Match binary
AVHRR L1B

IASI L1C

Subsetter (exe)
netCDF
tonetCDF to BUFR

BUFR

DDS
The Subsetting Concept

- **Spectral Subsets**
  - Chosen using information content studies.
  - Extract a set of channels of the original 8461 set.
  - Collapse the 8461 channels into a set of principal components.

- **Spatial Subsets**
  - Select specified FOVs from the granule.
A Spatial Subset Example

IASI Field of Regard

IASI FOV
Output File Formats

- **BUFR**
  - The standard format for NWP centers.
  - The IASI BUFR file format was developed by working closely with EUMETSAT and other NWP centers.
  - Simulated near real time BUFR files are currently available to the following NWP centers for evaluation:
    - EUMETSAT, NCEP, GMAO, UK-Met, ECMWF, Meteo-France, CMC (Canada), JMA (Japan)

- **netCDF**
  - Intermediate internal format that may be distributed to users.

- **Binary**
  - An internal final format for validation and monitoring.
  - Format is compact and I/O is simple.
  - No toolkits or APIs are necessary, just a reader and a writer are required.
## Proposed Products

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Channels</th>
<th>Data Type</th>
<th>IASI FORs/granule</th>
<th>Subset scheme per scan line</th>
<th>IASI FOV #</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>IASI</td>
<td>*616</td>
<td>RAD</td>
<td>330</td>
<td>Every other AMSU FOV</td>
<td>1</td>
<td>BUFR netCDF</td>
</tr>
<tr>
<td>IASI</td>
<td>*616</td>
<td>RAD</td>
<td>330</td>
<td>Every other AMSU FOV</td>
<td>1,2,3,4</td>
<td>BUFR netCDF</td>
</tr>
<tr>
<td>IASI</td>
<td>8461</td>
<td>RAD</td>
<td>660</td>
<td>All FOVs</td>
<td>1,2,3,4</td>
<td>BUFR netCDF</td>
</tr>
<tr>
<td>IASI</td>
<td>*616</td>
<td>RR</td>
<td>330</td>
<td>Every other AMSU FOV</td>
<td>1</td>
<td>BUFR netCDF</td>
</tr>
<tr>
<td>IASI</td>
<td>200</td>
<td>PCS</td>
<td>330</td>
<td>Every other AMSU FOV</td>
<td>1</td>
<td>BUFR netCDF</td>
</tr>
<tr>
<td>IASI (AVHRR)</td>
<td>*616</td>
<td>RAD (warmest or clearest)</td>
<td>330</td>
<td>Warmest or clearest IASI FOV based on AVHRR</td>
<td>1</td>
<td>BUFR netCDF</td>
</tr>
<tr>
<td>AVHRR</td>
<td>5</td>
<td>RAD</td>
<td>660</td>
<td>All FOVs</td>
<td>1,2,3,4</td>
<td>BUFR netCDF</td>
</tr>
</tbody>
</table>

PCS - Principal Components; RAD - Radiance; RR - Reconstructed Radiance; FOR - Field of Regard

* 616 channel set determined through a NOAA/ECMWF collaborative effort.
Distribution

- The Simulated BUFR data is available on the AIRS data server (nanuk.eosdis.nasa.gov).
- The OSDPD DDS server will be the staging location for product distribution.
- OSDPD will handle the distribution of the near real-time IASI BUFR files.
Current Distribution List

- **NCEP**
  - Subset level IASI 1C radiances (BUFR)
  - Subset IASI principal components (BUFR)
  - Subset IASI reconstructed radiances (BUFR)
  - Clearest/Warmest IASI FOVs from each field of regard (BUFR)

- **GMAO**
  - Subset IASI level 1C radiances (BUFR)
  - Subset IASI principal components (BUFR)
  - Subset IASI reconstructed radiances (BUFR)
  - Clearest/Warmest IASI FOVs from each field of regard (BUFR)
Current Distribution List (cont)

- **AFWA**
  - A requested products list has been received and a distribution agreement is in progress.

- **NRL**
  - Product list is yet to be determined

- **CLASS**
  - All Level 1C IASI data from EUMETSAT (plus metadata)
  - 3 deg latitude x 3 deg longitude global grids
Principal Component Analysis Using Simulated IASI Data
The use of PCA in processing IASI data

- Simulated IASI data training set
  For each granule we use:
  * 2 scan lines
  * 4 IASI FOV
  * 8461 channels

- Computed Eigenvectors for all 8461 channels

- For easy computation, divided the 8461 channels into three bands:
  » band 1: 2261 channels 645cm\(^{-1}\) ~ 1210cm\(^{-1}\)
  » band 2: 3160 channels 1210.25cm\(^{-1}\) ~ 2000cm\(^{-1}\)
  » band 3: 3040 channels 2000.25cm\(^{-1}\) ~ 2760cm\(^{-1}\)
The use of PCA in processing IASI data

- The algorithm to generate and apply IASI eigenvectors is same as AIRS.
- Computed 200 principal components for each band.
- Reconstruct the radiances by using principal components.
- Compute the reconstruction scores.
IASI BT and Reconstruct BT
IASI BT - Reconstruct BT
IASI Reconstruction Scores for Band 1 and Band 2
IASI Reconstruction Scores for Band 3
PCA for All Bands with Noise

IASI Observed BT (844 cm⁻¹) March 31, 2006

IASI Reconstructed BT (844 cm⁻¹) March 31, 2006
IASI Simulate BT - IASI Simulate Reconstructed BT

IASI Obs–Rec BT (844 cm⁻¹) March 31, 2006

Ascending
PC Scores for 3-Band and Full-Band
IASI Reconstruction Scores and Noise
PCA Usage

- Will create post launch eigenvector set for IASI data from whatever period of time to produce a stable eigenvector set.

- 3 Bands – Monitoring

- All Channels – Monitoring and Distribution
Cloud Clear Radiances

- Producing cloud cleared radiances in near real-time using the AIRS-heritage algorithm.
- Use cloud masked AVHRR radiances, convolved to the IASI FOVs, to QA the IASI cloud cleared radiances.
- Put cloud cleared radiances in BUFR format for distribution.
A simulation system is currently running continuously simulating IASI/AMSU/MHS data. This allows STAR to constantly test the ongoing system development.

These data are being used to produce several spectral and spatial subset products of level 1C IASI data.

These data are available on the AIRS data server in BUFR format (since 10/25/2005).

After launch, these products will be distributed operationally to the NCEP, GMAO, and DOD centers.
Future Work

- Will use our experience with AIRS/AMSU and IASI/AMSU to build a simulation and distribution system for CrIS/ATMS.