Investigating the impact of the IASI ILS shift in presence of non uniform scenes

Antonia Gambacorta (1) Chris Barnet (2)
Eric Maddy (1) Walter Wolf (2)

(1) NOAA/NESDIS/STAR/DELL
(2) NOAA/NESDIS/STAR
Introduction

• The precise knowledge of the Instrument Line Shape (ILS) is critical for measurements with a hyper spectral sounder: any error $\delta \nu$ in the knowledge of the ILS centroid will introduce an error $\delta R$ on the radiance spectrum.

• Non-uniformly illuminated scenes are responsible of a distortion of the theoretical ILS, which is mainly a frequency shift effect, $\delta \nu$, of the ILS centroid.

• 1) What is the magnitude of the radiance error introduced by the ILS shift?
• 2) What is its impact on the retrievals?
Nominal Geometric Centroids (∆) versus Radiometric Centroids (*) :

- Nominal Geometric Centroids obtained from the IASI Instrument Point Source Function (IPSF)
- Radiometric Centroids obtained from the IIS measurement and the IASI IPSF
- Spatial inhomogeneities introduce a shift between the geometric and radiometric centroids
- The higher the spatial inhomogeneity, the largest the radiometric centroid shift

IIS Imager (64x64 pixels) and IASI FOVs (black contour)
In general a non uniform light source introduces a distortion in the pixel ILS. The frequency shift $\delta v$ of the peak is the dominant effect.

This frequency shift is a source of error in the radiance spectrum that we try to quantify (next slides).
Centroid shift ($\delta \theta$) distributions (units in mrad) (mid lat ocean night cases, clear & cloudy, October 19th, 2007)

\[
\frac{\delta V}{V} \sim \langle \theta_{fov} \rangle \delta \theta = \begin{cases} 
1.5\times10^{-6} & (\delta \theta = 1\sigma \sim 0.1\text{mrad}) \\
3.0\times10^{-6} & (\delta \theta = 2\sigma \sim 0.2\text{mrad}) \\
4.5\times10^{-6} & (\delta \theta = 3\sigma \sim 0.3\text{mrad})
\end{cases}
\]
Radiance Error - BAND 1 (Gran # 393)

\[ d\theta = 1 \text{ sigma} (0.1 \text{ mrad}): \frac{dv}{v} \approx 1.5 \times 10^{-6} \]

\[
\text{Radiance error} \ll \text{Instrument noise}
\]
Radiance Error - BAND 1 (Gran # 393)

\[ d\theta = 2 \text{ sigma} \ (0.2 \text{ mrad}) : \frac{dv}{v} \sim 3 \times 10^{-6} \]

Radiance error \( \ll \) Instrument noise
Radiance Error - BAND 1 (Gran # 393)

\(d\theta = 3 \text{ sigma} \) (0.3mrad): \(dv/v \sim 4.5 \times 10^{-6}\)

The radiance error becomes comparable to the instrument noise.
Radiance Error - BAND 2 (Gran # 393)

\( d\theta = 1 \sigma \) (0.1mrad): \( dv/v \sim 1.5 \times 10^{-6} \)

the radiance error becomes comparable to the instrument noise
Radiance Error - BAND 3 (Gran # 393)

\[ d\theta = 2 \sigma (0.1 \text{mrad}) : dv/v \sim 3 \times 10^{-6} \]

the radiance error becomes comparable to the instrument noise
Part I first conclusions:
The radiance error introduced by the ILS shift is generally negligible wrt the instrument error. Only 5% of the full day ensemble is seen to undergo a shift ~ 1 sigma or higher.

Part II (next slides):
Impact of the ILS shift on level 2 products
No significant correlation is seen to stand out.
No significant correlation is seen to stand out
Centroid Shift vs UTH bias (ret-ecmwf) (ocean night mid lat Oct 19 2007)

No significant correlation is seen to stand out
Examples of cases that are likely to pass Radiance Cloud Clearing QAs (high cloud contrast)

1) ONLY FOV 1 has $d\theta > 1$, all others $< 1$ sigma
2) ONLY FOV 1 has $d\theta > 2$, all others $< 1$ sigma
3) ONLY FOV 1 has $d\theta > 3$, all others $< 3$ sigma

No significant correlation is seen to stand out
Examples of cases that are likely to pass Radiance Cloud Clearing QAs (high cloud contrast)

\[
\begin{align*}
1) & \text{ ONLY FOV 1 } \theta > 2, \text{ all others } \leq 1 \text{ sigma} \\
2) & \text{ ONLY FOV1 and FOV2 } \theta > 2 \text{ sigma, all others } \leq 1 \text{ sigma}
\end{align*}
\]

No significant correlation is seen to stand out
Centroids distribution conditioned by UTH statistics

No significant correlation is seen to stand out
Comparison with the sensitivity to temperature and water Vapor perturbations in 6.7 µm Band

• The retrieval uncertainty appears to be dominated by other sources of 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 unperturbed ILS one; i.e. water vapor in the FOR can vary up to 10% and more.
Final conclusions

The analysis above indicates that the radiance error induced by the ILS shift in presence of clouds is negligible:

- 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 (band 2) 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 off line in order to build an ad hoc rejection flag (under study).
BACK UP SLIDES
Each black point is a slope value.
Band 2, Gran # 393

DeltaRad/NEDN/STDDEV

wave number (cm⁻¹)

Lin Fit & Sig

MAX slope: 0.81 @ Eig #: 21 (SIG: 80.85)

Eigenvector Index

Highest Corr Eigenvector (# 21)

EIG #: 21 vs DeltaRad/NEDN (stddev normalized)

Slope: 0.81 (SIG: 80.85)