Feasibility and sensitivity studies for CLARREO

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Outline

• Proposal to CLARREO SDT
• IR spectral signatures from satellite interferometer data
• Modelled ‘clear-sky’ IR variability from ERA Interim reanalyses
• All-sky sampling studies using SEVIRI data
• Future developments and activities
CLARREO SDT Proposal

• Imperial Team: H. Brindley, R. Bantges, C. Belotti, J. Harries, J. Murray, J. Russell

• IR Benchmarking
  – Natural variability in resolved IR spectrum
  – Satellite sampling / instrument characteristics

• Calibration-Validation
  – In-flight validation (simulations)
  – Far IR specific (TAFTS experience)
  – Ground to space calibration transfer

• Promotion of CLARREO within UK
### Spectral signatures from satellite data at Imperial

<table>
<thead>
<tr>
<th>Instrument</th>
<th>IRIS</th>
<th>IMG</th>
<th>AIRS</th>
<th>IASI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite</td>
<td>Nimbus 4</td>
<td>ADEOS</td>
<td>AQUA</td>
<td>METOP-A</td>
</tr>
<tr>
<td>Spectrometer type</td>
<td>FTS</td>
<td>FTS</td>
<td>grating spectrometer</td>
<td>FTS</td>
</tr>
<tr>
<td>Spectral coverage (cm(^{-1}))</td>
<td>400 – 1600 cm(^{-1}) continuous</td>
<td>715 – 3030 cm(^{-1}) 3 bands</td>
<td>650 – 2700 cm(^{-1}) 2378 bands</td>
<td>645 – 2760 cm(^{-1}) 3 bands</td>
</tr>
<tr>
<td>Spectral resolution</td>
<td>2.8 cm(^{-1})</td>
<td>0.1 cm(^{-1})</td>
<td>0.4–1.0 cm(^{-1})</td>
<td>0.5 cm(^{-1})</td>
</tr>
<tr>
<td>Footprint (nadir)</td>
<td>95 km diameter</td>
<td>8km x 8km</td>
<td>13 km diameter</td>
<td>12 km diameter</td>
</tr>
</tbody>
</table>
IRIS & IMG Clear Sky comparisons

(a) Brightness Temperature (K) vs. Wavenumber (cm⁻¹)

(b) Changes in Brightness Temperature (K) vs. Wavenumber (cm⁻¹)

(c) Changes in Brightness Temperature (K) vs. Wavenumber (cm⁻¹) for various gases
Cloud-free IASI / IMG (Central Pacific – AMJ)
Regional assessment of IR spectral variability

Figure 3. Geographic regions examined in this study. “WP” refers to western Pacific, “EP” to eastern Pacific, “AT” to Atlantic Ocean, “IN” to Indian Ocean, “AF” to Sahara Desert, “NP” to North Pacific, and “NA” to North Atlantic.

Iacono and Clough, JGR Vol.101, D23, 1996
IASI Satellite Configuration and Budgets

IASI Data: Level 1C ~ 900GB/month ~ 11TB/yr
Archiving data at Imperial from 2008 – onward
Infrastructure now in place
Regional variability (allsky top, clr lower)

Nadir only
Spectral resolution

IASI all sky differences iac_np

Brightness temp. (K)

-4 -2 0 2 4

1000 1500 2000 2500
Wavenumber (cm⁻¹)

2008: 42907
2009: 43461
2010: 43774

IASI (2.8cm⁻¹) all sky differences iac_np

Wavenumber (cm⁻¹)

1000 1500 2000 2500
Modelled ‘clear-sky’ variability from ERA Interim

- ERA Interim covers period 1989* onward
- Profiles of T, H₂O₉, O₃ from reanalyses
- CO₂, CH₄, N₂O from UKMO records (total column, 5 year global mean, interpolation)
- Surface emissivity constant at 0.99 globally
- Spectral radiances simulated at nadir using Oxford RFM (HITRAN 2008, MT CKD1.1)

* 1979 planned
RFM model runs

- monthly mean fields ('clear-sky' but using all profiles)
- 37 atmospheric levels (1000-1mb)
- spatially resolved 1.5°x1.5°
- 100-2500cm⁻¹, spectral resolution 0.5cm⁻¹
- ~29000 RT simulations per month
- Imperial College HPC (~7000 nodes)
ERA Interim –
temperature anomalies

Step change: 1998: SSU replaced by AMSU-A
IASI variability AMJ 2008/9/10

• Contrast IASI spectral variability with RFM/ERA simulated spectra
• Will be enhanced to compare “matched” IASI observations with 6-hourly ERA-I (and 3-hourly)
• Increased IASI data (entire years, 2008 - )
Observations vs modelled spectra

L:>800hPa, M:800-400hPa, H:<400hPa
35.4%
42.7%
32.6%

L: >800hPa, M: 800-400hPa, H: <400hPa
All-sky sampling studies using SEVIRI

- Investigate impact of sampling strategies using narrow-band spectral channels
- What is the effect of increased spectral resolution on previous results? (e.g. Doelling, Kirk-Davidoff)
- What is seen at different wavelengths?
- What degree of averaging is required to meet desired accuracy (i.e. do we need all wavelengths – e.g. different requirements may have different needs)?
SEVIRI narrow-band channels

A typical clear-sky spectrum of outgoing thermal energy.
Sampling strategy

- SEVIRI (METEOSAT-9) is used as “truth”
- virtual orbiter(s) are flown over the “true” field (true 90º polar orbits) -> “observations”
  - Orbital parameters from D. Doelling
- the 15min SEVIRI observations are averaged over 15º lat x 30º lon boxes
- the mean of obs over the box is compared to the “true” mean field (sampling error)
Sampling
Sampling SEVIRI 10.8μm (1 Satellite 0°) Saharan Desert / North Africa

Truth: 294.70K
“Observations”: 295.48K
Obs – Truth: 0.78K
Sampling SEVIRI 10.8μm (2 Satellites 0°,90°)
Saharan Desert / North Africa

Truth: 294.70K
“Observations”: 295.01K
Obs – Truth: 0.31K
Sampling SEVIRI 10.8μm (2 Satellites 0°,90°) Atlantic Ocean

Truth: 290.63K
“Observations”: 290.60K
Obs – Truth: -0.03K
Sampling – regional variation

IR_108, Mar-Aug, 2 orbiters

"observations" - "truth"
Sampling SEVIRI 12μm (2 Satellites 0°, 90°) Atlantic Ocean

Truth: 288.88K
“Observations”: 288.80K
Obs – Truth: 0.08K
Summary

- Investigating the regional variability in the spectrally resolved OLR from direct observations
- Assessing the ability of ERA-I with RFM to capture regional variability compared with the direct observations
- Sampling studies using geostationary data as “truth”
Future developments

• Scaled-back CLARREO mission impacts funding streams / research focus in the UK (statement)
• Spectral variability – full multi-year IASI comparisons
  – Compare with IRIS, IMG, TES, AIRS
• Simulated OLR using ERA-I
  – Regional “matched” (EOF analysis)
  – Extended to full years
  – Simulation of cloud fields
• Potential UK Met Office collaboration – use of COSP