Reprocessing of Fundamental Climate Data Records From Microwave Sounders

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FIDelity and Uncertainty in Climate data records from Earth Observation (FIDUCEO) - What Is It About?

• **Need**: trustworthy information about climatic variability and change over decades
  • – rigorous science, including improving prediction
  • – decision making, e.g. putting the future in context
  • – climate services, meeting information needs
• **Problem**: proving the “trustworthy” part is hard. Often hasn’t been done well even for prominent, much-used data sets

• **FIDUCEO answer**: demonstrate “trustworthiness” across several FCDRs and CDRs and promote the methodologies across the EO-climate community
  • – methods, guidance and tools
## Fiduceo Aims: Uncertainty-quantified FCDR

<table>
<thead>
<tr>
<th>DATASET</th>
<th>NATURE</th>
<th>POSSIBLE USES</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVHRR FCDR</td>
<td>Harmonised infra-red radiances and best available reflectance radiances, 1982 - 2016</td>
<td>SST, LSWT, aerosol, LST, phenology, cloud properties, surface reflectance ...</td>
</tr>
<tr>
<td>HIRS FCDR</td>
<td>Harmonised infra-red radiances, 1982 - 2016</td>
<td>Atmospheric humidity, NWP re-analysis, stratospheric aerosol ...</td>
</tr>
<tr>
<td>MW Sounder FCDR</td>
<td>Harmonised μwave BTs for AMSU-B and equivalent channels, 1992 – 2016</td>
<td>Atmospheric humidity, NWP re-analysis ...</td>
</tr>
<tr>
<td>Meteosat VIS FCDR</td>
<td>Improved visible spectral response functions and radiance 1982 to 2016</td>
<td>Albedo, aerosol, NWP re-analysis, cloud, wind motion vectors ...</td>
</tr>
</tbody>
</table>

At all data set scales there is adequate quantification of error distributions to propagate uncertainty across all data transformations accounting for error correlation structures
Main Processing Chain for Microwave Humidity Sounders

- PRTs on internal target
- SSM/T 2
  - or
  - AMSU-B Level 1b
    - or
    - MHS Level 1b

Reference Radiance Temperature Computation

Gain (slope)

S

Raw instrument counts references

Linear assumption calculation

Linear assumption Earth view radiance

Antenna pattern and RFI correction

Non-linear coefficient correction

Manual scan bias correction

Temperature conversion (Planck or Rayleigh-Jeans)

Level 1c

$R_i = R_C + S(C_E - C_C)$
Earth View Radiance = cold space radiance + gain times count difference earth to cold space. Assumes linear gain, $S$

Antenna: Hewison and Saunders, 1996
RFI: Atkinson, 2001

John et al. J. Geophys Res. 118, p1
Analysis: Error Related to BB Temperatures

- Calibration target not thermally controlled, insulated from instrument
  - $\sigma = 1.2 \text{ mK}$
  - changes $< 0.1 \text{ mK/} \text{sec}$
  - gradients $< 100 \text{ mK/} ^\circ$
  - accuracy $< 100 \text{ mK}$

- No strong correlation between gain and temperature drifts

- Several days needed to reach stable conditions after data drop-out
Cross-Comparison: SSM/T2, AMSU-B, MHS, and HIRS

- Problem: observations at different local times
- Solutions:
  - opportunities for SNOs from orbit drift
  - small diurnal variations in subsidence zones
- Problem: Clouds affect infrared more than microwave
- Solution: Optimize cloud detection algorithms
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<th>NATURE</th>
<th>USE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Temperature CDRs</td>
<td>Ensemble SST and lake surface water temperature</td>
<td>Most of climate science model evaluation, re-analysis, derived/synthesis products ...</td>
</tr>
<tr>
<td>UTH CDR</td>
<td>From HIRS and MW, 1992 - 2016</td>
<td>Sensitive climate change metric, re-analysis ...</td>
</tr>
<tr>
<td>Albedo and aerosol CDRs</td>
<td>From M5 - 7, 1995 – 2006</td>
<td>Climate forcing and change, health ...</td>
</tr>
<tr>
<td>Aerosol CDR</td>
<td>2002 – 2012 aerosol for Europe and Africa from AVHRR</td>
<td>Climate forcing and change, health ...</td>
</tr>
</tbody>
</table>

Uncertainty information that (i) discriminates more and less certain data, (ii) is validated as being realistic in magnitude, (iii) is traceable back to the FCDR uncertainty information.
## FIDUCEO FCDR/CDR Improvements

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Typical FCDR</th>
<th>FIDUCEO</th>
<th>Typical CDR</th>
<th>FIDUCEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensemble spanning all forms of uncertainty</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>End-to-end traceability and propagation of uncertainty</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Satellite-series harmonisation at radiance level based on rigorous physics</td>
<td>Some examples (e.g. MW); Others seem ad-hoc</td>
<td>Yes</td>
<td>Some examples</td>
<td>Yes</td>
</tr>
<tr>
<td>Uncertainty estimates for every pixel</td>
<td>No, usually generic values at best</td>
<td>Yes</td>
<td>Some examples</td>
<td>Yes</td>
</tr>
<tr>
<td>Uncertainty components support uncertainty propagation in aggregated data</td>
<td>No</td>
<td>Yes</td>
<td>One known example</td>
<td>Yes</td>
</tr>
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