Retrieval of Atmospheric Microwave Radiometer Observations

Jian Xu¹, Franz Schreier², Mareike Kenntner², Andreas Fix², and Thomas Trautmann¹

¹DLR — German Aerospace Center, Remote Sensing Technology Institute, Oberpfaffenhofen, GERMANY
²DLR — German Aerospace Center, Institute for Atmospheric Physics, Oberpfaffenhofen, GERMANY

MTP Overview

MTP (Microwave Temperature Profiler)
- Passively measure thermal emission from oxygen molecules
- Operational since many decades
- Focus on the upper troposphere and lower stratosphere
- Scan from near zenith to near nadir in the flight direction
- Recently on DLR’s Falcon and HALO aircrafts

Weighting Function

Quantitative measure that describes how different altitude regimes contribute to the measured signal

Retrieval Test: MTP Configuration

- Grande atmospheres
  - Inequidistant altitude grid
    - denser when near aircraft
    - coarser
  - Different a priori information

Retrieval Test: TELIS Configuration

- Based on TELIS data
  - synthetic DLR-THz data
  - real SRON-GHz data
  - Equidistant altitude grid
  - Different a priori information

Outlook

- Reliability test using MTP data with actual instrument input
- Sensitivity study with respect to instrument parameters
- Underdetermined inverse problem
- A priori information critical

Oxygen Diagnostics

- O₂ emission around 55–60 GHz
- Covering MTP frequencies (56.363 GHz, 57.612 GHz, 58.363 GHz)

Dedicated Retrieval Code

TIRAMISU (Temperature InverSion Algorithm for Microwave SoUnding)
- Line-by-line calculation based on GARLIC
- Regularized nonlinear least squares fitting
- Temperature derivatives by automatic differentiation
- Adaptive regularization methods

<table>
<thead>
<tr>
<th>Regularization Method</th>
<th>Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tikhonov regularization</td>
<td>x₀ (a priori)</td>
</tr>
<tr>
<td>Iteratively regularized Gauss–Newton</td>
<td>x₁ (a priori)</td>
</tr>
<tr>
<td>Regularizing Levenberg–Marquardt</td>
<td>x_{n-1} (previous iterate)</td>
</tr>
</tbody>
</table>