PROCESSING THE ROMEX DATA SET USING CDAAC

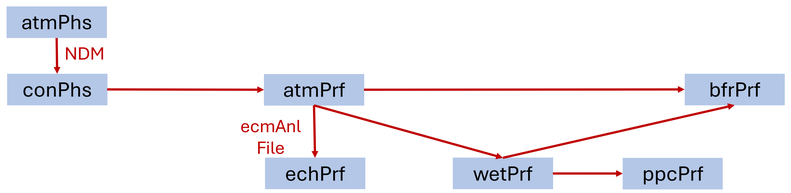
V.PETRONI, T. VANHOVE, H. VEITEL

COSMIC Program, University Corporation for Atmospheric Research (UCAR), Boulder, CO, USA

Abstract

The Radio Occultation Modeling EXperiment (ROMEX) is a collaboration between organizations around the globe to better understand the impact of increasing radio occultation (RO) profiles on research and weather/climate prediction. UCAR's COSMIC Data Analysis and Archive Center (CDAAC) team is involved in the processing of the excess phase files provided by the many missions involved to produce neutral atmospheric products for analysis. The data were received via EUMETSAT in various different formats and in some cases with unfamiliar features. Therefore, various preprocessing algorithms were developed to address formatting, missing variables, and navigation bit application for the Sentinel-6A, Spire, MetOp, FengYun-3, and Tianmu missions. This poster will detail specific needs that the pre-processing algorithms met for each mission. We also address the data verification process with the use of bending angle statistics.

(2) CDAAC Processing Pipeline



(4) Special Case: Spire and Tianmu

- The Sentinel and Tianmu missions both had different receiver formats than other missions, which required some adjustments before the data could be put through CDAAC. These receiver differences affected specifically the GLONASS data from these missions. Both data sets were received in atmPhs format, which made it easier for us to make adjustments.

Spire

- The Spire GLONASS data bits must be applied at a different frequency than those of other GNSS.
- The pre-processing steps required identifying GLONASS data and applying bits differently to acquire a smooth conPhs file which could then be processed by CDAAC .
- The occfreq1 and occfreq2 attributes were added to the data.

Tianmu

- The Tianmu mission tracks the BeiDou GNSS system, but we did not have the necessary bits to apply.
- The 2 quadrant phase connection method was used to create the conPhs files.
- The data was also missing some attributes which CDAAC uses in it's processing, such as occfreq1 occfreq2, startTime and stopTime. These were added in the pre-processing step.

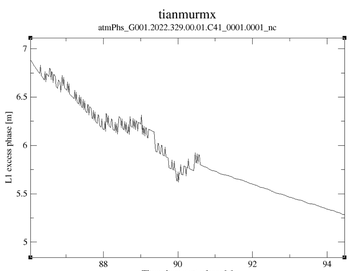


Figure 1: Excess phase of one Tianmu atmPrf, where the navigation bits are shown. Image by Doug Hunt.

(1) CDAAC Processing

- The ROMEX data was received in connected phase or atmospheric phase format (conPhs or atmPhs).
  - Note: atmPhs data required an extra step to apply the Navigation Data Modulations (NDM) before it could be processed.
- The conPhs data then gets converted to dry pressure and temperature data, which we call an atmospheric profile (atmPrf). The quality control is applied after this step, and bad atmPrf files are flagged.
- ecmAnl is the ECMWF Analysis, which is used to create the ECMWF ERA5 Analysis profile (echPrf).
- An analysis of the atmPrf is preformed and yields an echPrf, which can be used for comparisons.
- A wetPrf is created out of the atmPrf and ecmPrf, which includes moisture information.
- A tall ppcPrf is created, which is a profile to profile comparison.
- The data then gets translated and encoded into BUFR format, which produces a bfrPrf.

conPhs	Connected Phase
atmPhs	Atmospheric Phase
atmPrf	Atmospheric Profile
echPrf	ECMWF ERA5 Analysis
wetPrf	Wet atmospheric profile
bfrPrf	BUFR Profile
ppcPrf	Profile to profile comparison
ecmAnl	ECMWF analysis
NDM	Navigation Data Modulation

(5) Special Case: FengYun-3

- The FengYun-3 data was received in the atmPhs format and required bits be applied to create a conPhs format. Additionally the atmPhs had a few features which were unsupported by CDAAC and some variable adjustments had to be made so that CDAAC could read and process this data.
  - The L1 and L2 frequencies in the FengYun-3 data were not recognizable by CDAAC. These were adjusted during the preprocessing step.
  - Certain variables which CDAAC uses to process data were missing from the FengYun-3 data. Variables such as occultation height, or occultation start time and stop time were added or renamed to allow proper processing.
  - FengYun-3 is also open / closed loop processing, and the open loop phase model and L2CA open loop phase model variables needed to be filled in so CDAAC could tell when open / closed loop data begins.
  - We used the 2 quadrant phase connection method due to time tag errors in the data.

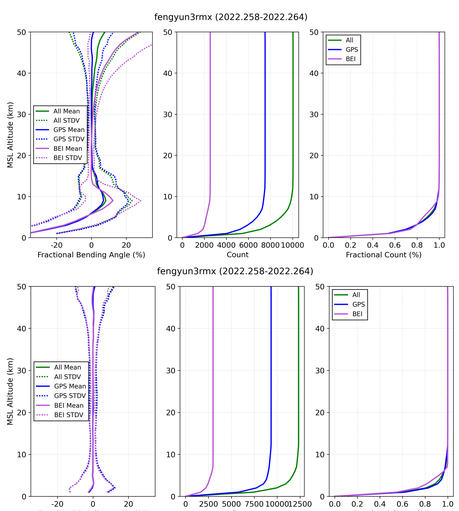


Figure 2: Bending angle bias plots of the first attempt at processing the FengYun-3 mission vs the final processing of the FengYun-3 mission. The image on the top shows very clear features caused by the formatting issues which CDAAC could not recognize.

(3) Special Case: MetOp and Sentinel-6

- The MetOp missions and Sentinel-6 mission data came in a similar format. A pre-processing method was used to format the conPhs / atmPhs data into CDAAC readable files for these three missions.

MetOp

- The Sentinel-6 pre-processing was used as a base for the MetOp pre-processing.
- Adjustments were made for MetOps close loop / open loop processing.
- Additionally, the MetOp data was in atmPhs format, which required bits to be applied to convert it into conPhs format.

Sentinel-6

- The Sentinel-6 data files had a lot of extra information which CDAAC would not be able to read through.
- A pre-processing method was developed to take these files and remove the information which was not needed, as well as format the variables into a CDAAC readable conPhs file.

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(5) Data Validation Process

- With so many different formats of data and previously unknown missions, we needed a way to verify that CDAAC was producing accurate results.
  - The Bending angle comparisons to the echPrf were the first clue we had in order to verify the data accuracy.
  - Based on initial bending angle bias plots, we could find the problem areas of missions which were not processed correctly, and have a clue on what needs to be done to fix them.
  - With some missions, we needed to verify that the BUFR files we made were encoded correctly. These were hand checked for accuracy.

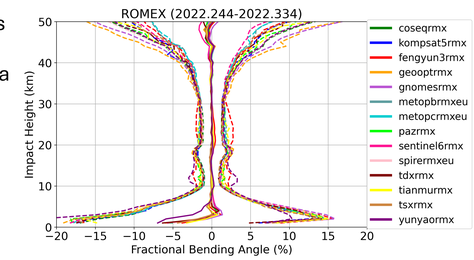

Figure 3: Bending angle bias as compared to the echPrf plot for all ROMEX missions for the entire ROMEX time period, used as a final verification that the data was accurate.

Figure 4: Bending angle bias plot with all ROMEX mission data combined.