MERRByS TDS-1 Products and Tools for Ocean Winds

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NOC, Southampton

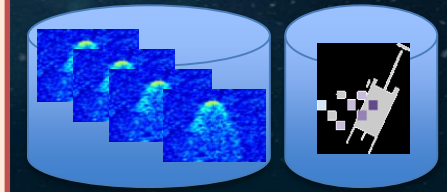
Ack: SSTL, NOC, ESA, Surrey, Newcastle, CEOI, UKSA, InnovateUK, CYGNSS

MERRByS System

Onboard TDS-1

L0 - Raw sampled data
- Data: ~2 minutes = 1GB

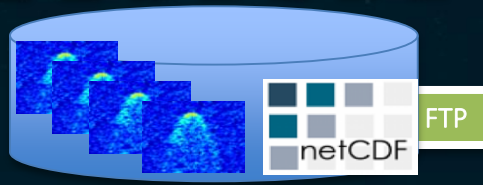
L1a - Onboard-processed DDMs
- 4 channels: 10,240 GPS correlators
- **Reduced data rate => continuous operation**



On Ground

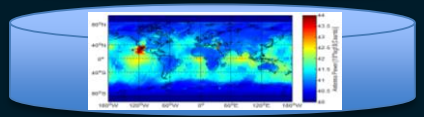
L0 Research / Experiments

L1b – Onboard-processed DDMs
- **with synchronised metadata, radiometric calibration, direct signals**



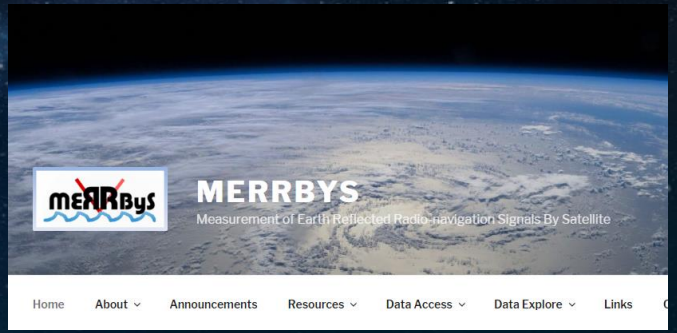
L2 - Wind speed tracks

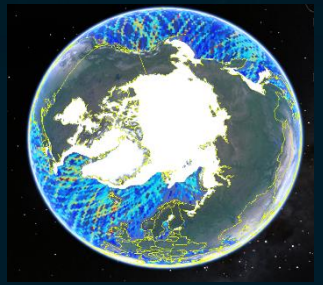
L3 - Wind map products



Data Sharing

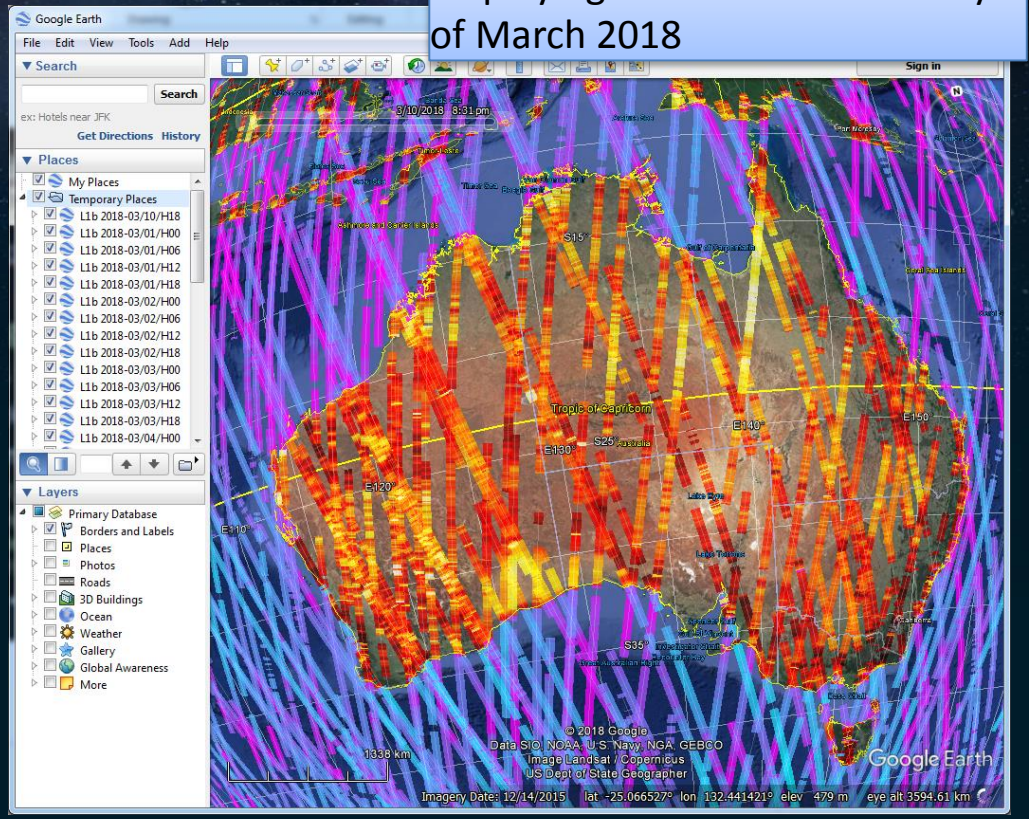
- MERRByS provides free access to TDS-1 data:
  - Level 1b DDMs
  - Level 2 Ocean Wind Speed
- Allowing access to researchers to help find applications in data, learn lessons
  - Creative Commons Licence – attribution and non-commercial
- Standard User
  - Apply for account password, as before
  - 1 month latency
- Fast Data Users
  - Apply for account password – select fast data user
    - Additional interaction with SSTL & NOC – support and feedback
  - Providing pilot data service – demo of data release within 1-2 days of measurement
- Best efforts basis – no guarantees!





Level 1b – Onboard DDMs

- Data Access:
  - FTP server
  - NetCDF Format
  - Full metadata
    - Direct signals
    - Blackbody calibration
    - DDMs
- Catalogue
  - Google Earth KMZ
  - Detailed 6 hour tracks in FTP '_Catalogue' folder
  - Monthly summary maps on www site



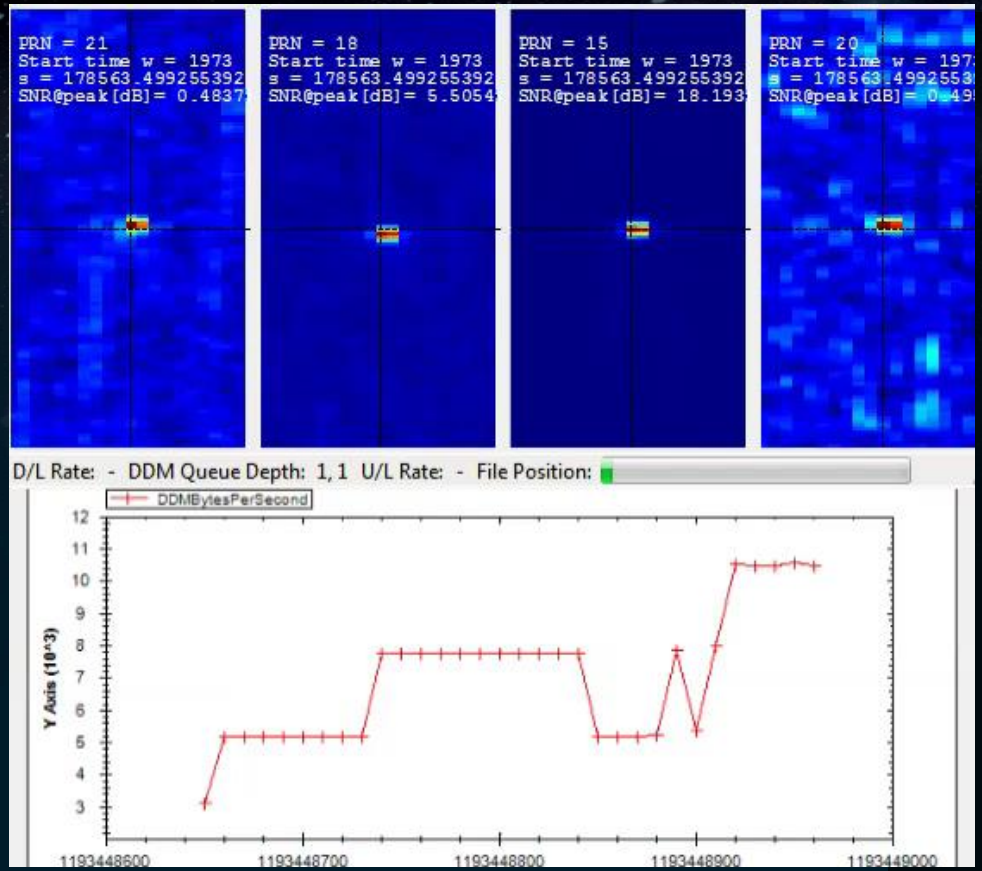
Level 1b – Change of operation Feb 2018

- Mission extension
  - TDS-1 had timeshare of 8 payloads. SGR-ReSI was 2/8 days
  - Since Sept 2017, trying the SGR-ReSI operating 100%. Trial Feb. 2018
- Streamlined operations required us to revisit the data budget
- Onboard DDM Selection:
  - Only downlink a DDM if antenna gain > 0dBi
    - This was the filtering used in the L2 wind speed, so moved filter into orbit
- Onboard DDM Compression

	L1a (as downlinked to ground)	L1b (as provided to users)
Original	• 32 bits per pixel	• Normalised to 16 bits
Compressed DDM	• Quantised DDM pixels to round away some least significant bits • Variable rate 8/16/24/32 bits depending on pixel power	• Normalised to 16 bits (the same)

- Should not be noticeable to the user: L1b Version 0.71
- Achieves compression ratio factor 6. Total 500 MB per 24 hours

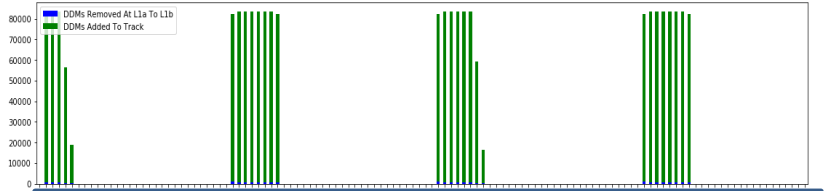
DDM Variable Rate Compression



- Onboard DDM Selection:
  - Only downlink a DDM if antenna gain > 0dBi
- Onboard DDM Compression
  - Background downloaded at 8 bits per pixel
  - If needed 16/24/32 bits are output to prevent overflow/limiting
  - Variable Rate Coding

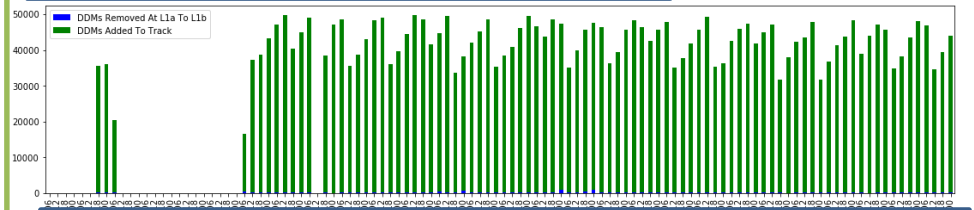
Move to Continuous Operations

Number of DDMs 2/8 days

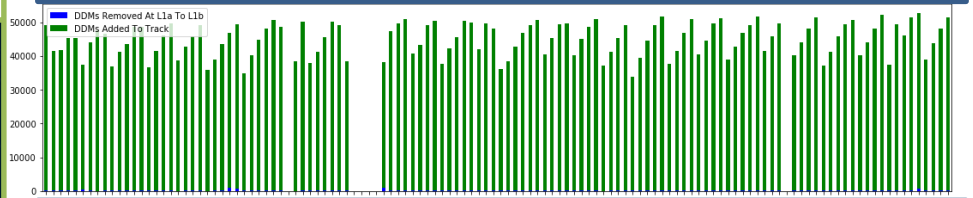


June 2017

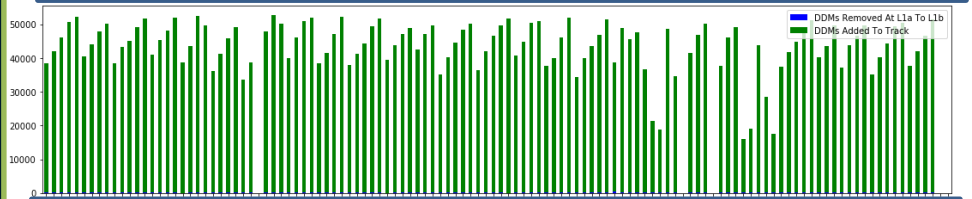
Number of DDMs 7/7 days



Feb. 2018



March 2018



April 2018

Continuous operations are resulting in 4x coverage

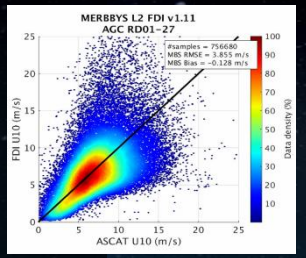
In May 2018 a satellite issue has paused the service but it is now resuming

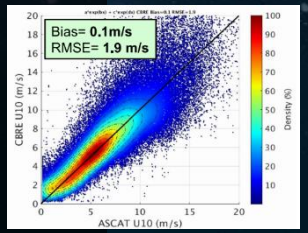
Calibration

- Physical observable is of surface reflectivity. The measurement system is subject to system and receiver errors.
- L1b metadata contains information to allow correction for:
  - Transmitter power & Transmitter antenna pattern
    - Onboard measurement of direct signals (under refinement)
  - Reflection geometry (surface area / incidence angle) & Path losses
  - Receiver gain and noise figure
    - Blackbody and external reference measurements
  - Receiver antenna pattern & Platform attitude
    - Believe dominant error source and with some seasonal variation
    - (Under refinement on TDS-1, but easier to solve for future satellites)
- Calibration approach is to provide the needed data which is then applied in Level 2
  - Most flexible approach
  - Suitable for our whole DDM processing (parameters change over the scattering zone)
  - But needs high-level of system knowledge in L2 algorithm

Level 2 – Ocean Wind Speed

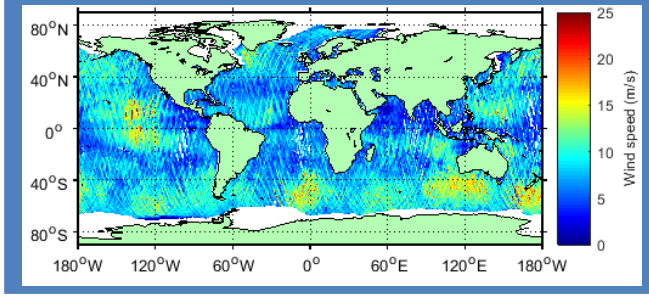
- Two types available on MERRByS:
  - FDI v1.11 (Fast Delivery Inversion)
    - An initial attempt within 6 months of launch – from 2015
    - To empirically retrieve wind speed - from SNR
    - First order correction - for antenna pattern, but none of the other error sources
  - CBRE v0.5 (Calibrated Bistatic Radar Equation)
    - Uses additional Receiver and Transmitter corrections [see Giuseppe Foti Talk later]
      - Now being deployed onto the MERRByS system. Re-process all data
    - Current Status:
      - Deployment is work in progress
      - Coverage sparse, but issue with data flag is understood and being resolved
      - Sea ice filter 55 degree latitude



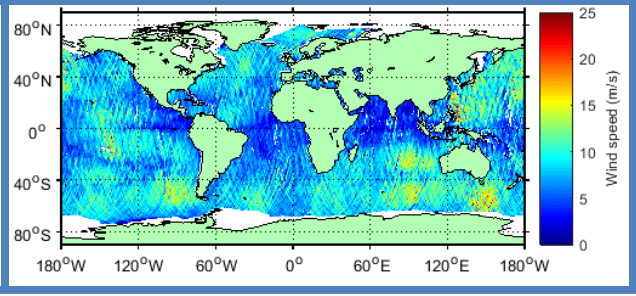


L2 FDI wind speed

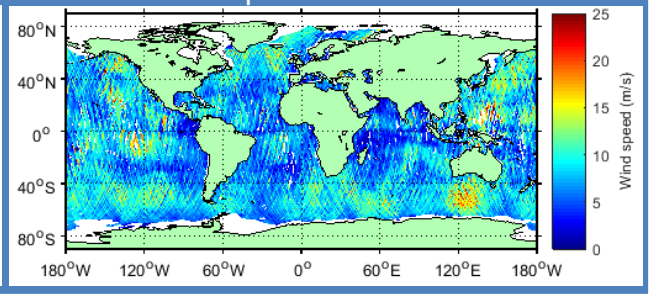
Feb 2018



March 2018

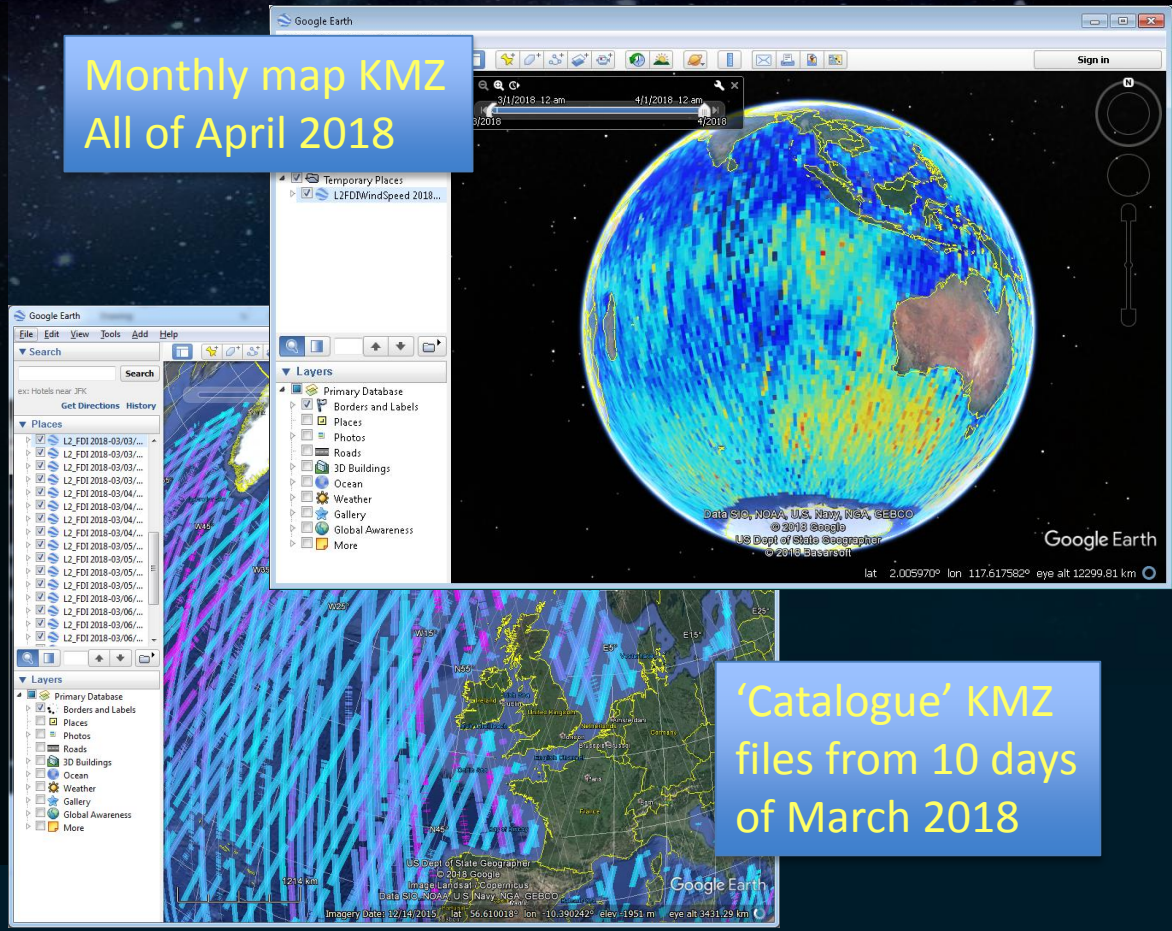


April 2018

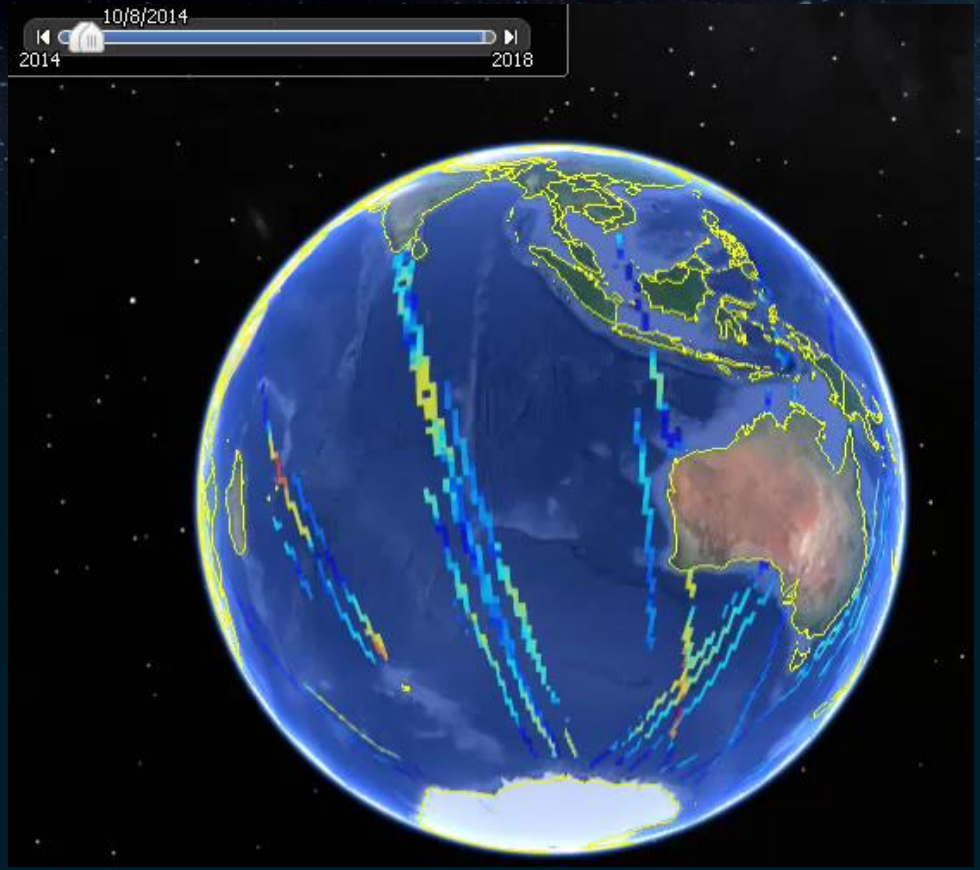


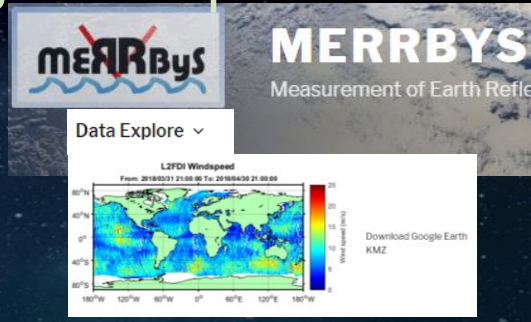
Level 2 – Wind Speed

- Data Access:
  - FTP server
  - NetCDF Format
  - Metadata
    - Low-level quality flags
- Catalogue
  - Google Earth KMZ
  - Monthly summary maps on www site
  - Detailed 6 hour tracks in FTP '_Catalogue' folder



L2 FDI Wind Monthly Average Maps





L2 Monthly Wind Google Earth Overlay

- Commissioning
- 3 year Mission 2/8 days
- Retirement ‘on ice’
- Mission extension 7/7 days

See:

MERRByS website

“Data Explore”

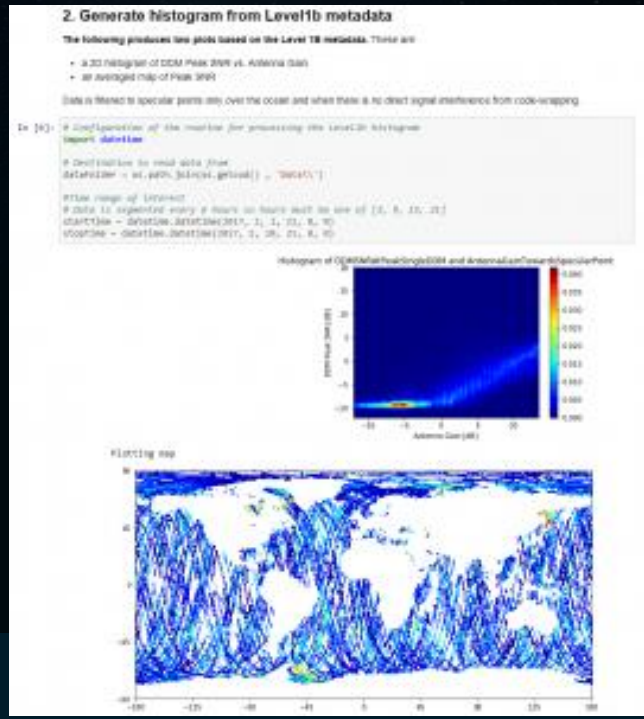
“TDS-1 Operations Timeline”

MERRByS and Google Groups

- Website www.merrbys.co.uk
  - Announcements
  - Documentation:
    - inc. Mission Description, Product Manual V4
  - Registration
  - Links to data (FTP)
  - Example code for reading the data
    - GitHub
  - Operations Timeline
  - Data Explore
    - Availability over last 24 hours
    - Monthly Availability
    - Monthly Wind Speed Maps
  - User Forum

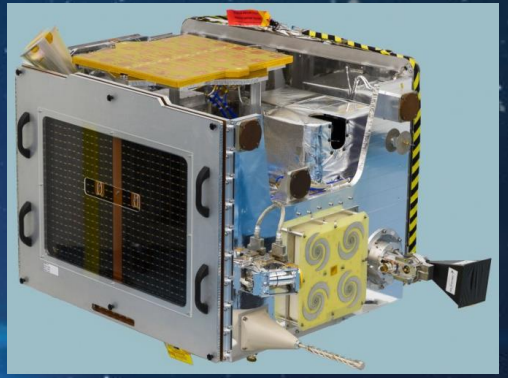
Example tools

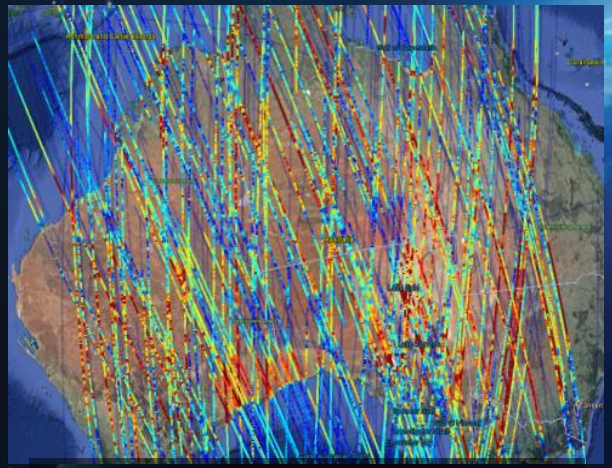
- In 2017 - transitioned to commonly used data structures
  - NetCDF Data Format
  - Each file: 6 hours of observations centred UTC: 0000, 0600, 1200, 1800
- Example Tools – Free on GitHub
  - Matlab
  - Python / Jupyter
- Examples:
  - Download Data
  - Explore L1b (a 2D histogram example)
  - Display L2 wind speed (FDI & CBRE)
  - Search for measurements



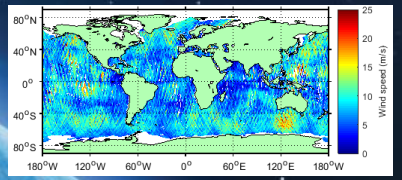
- Please use the MERRBySS data and let us know your feedback….

Thank you…





L1b power showing surface properties: Moisture, Roughness over Australia



Future applications? Using the DDM projected on to the Earth's surface