# EOS MLS software

# Instrument Data Processing

[*http://mls.jpl.nasa.gov/*]


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# Overview

- Background
  - ⇨ Mission
  - ⇨ Instrument
  - ⇨ Science objective
- Software and its division into levels:
  - ⇨ Level 1 outputs radiances
  - ⇨ Level 2 outputs atmospheric molecular abundances
  - ⇨ Level 3 outputs daily and monthly maps and means
- Data flow between levels
  - ⇨ HDF4 and HDF-EOS1
  - ⇨ Products of Levels 2 and 3 to be archived
  - ⇨ Metadata
- Future plans–HDF5 and HDF-EOS5

# Background

**The mission** What is EOS MLS?

- Measure atmospheric temperature, water, ozone and significant molecules from $\sim 5 - 80\text{km}$
- Joint project: JPL (US) and Edinburgh University (UK)
- Greatly enhanced follow-on to UARS MLS experiment
  - ⇨ Looks and scans limb forward instead of sideways
  - ⇨ More sensitive instruments and more precise measurements
  - ⇨ More radiometers and more atmospheric molecules
  - ⇨ Greater spectral bandwidth and lower altitudes
- Currently scheduled for launch in July 2003 on AURA spacecraft

**The instrument** What instruments is it made up of?

- Four GHz (118, 190, 240, 640) and one THz (2.5) radiometers
- 1.6m primary antenna for the GHz instruments
- 35 spectrometers of four different types, simultaneously observing emission from $\sim 10$ different molecules

# What are its objectives?

- Determine if stratospheric ozone is recovering
  - ⇨ Influence of human activities
  - ⇨ Arctic vulnerability
  - ⇨ Stratospheric chemistry producing or destroying ozone
- Improve understanding of climate variability
  - ⇨ Global warming
  - ⇨ Verify, constrain, or eliminate key climate models
  - ⇨ Distinguish local events (fires, volcanos) from widespread trends
- Pollution in the upper troposphere

# Level 1 data processing

**Purpose** Convert unprocessed instrument data into calibrated radiances

- ❑ Accepts Level 0 and AURA spacecraft auxiliary data
  - ⇨ Level 0 includes all instrument telemetry
  - ⇨ SDP Toolkit expects ephemeris and attitude data to be binary and therefore platform-specific–we would prefer HDF or HDF-EOS
- ❑ Outputs (All HDF4 SD)
  - ⇨ Two radiance files to stay below 2GB limit imposed by HDF4
  - ⇨ One engineering file
  - ⇨ One orbit and attitude file
  - ⇨ May merge radiance files with move to HDF5

# Level 2 data processing

**Purpose** Convert calibrated radiances into atmospheric abundances

- ❑ Accepts Level 1, AURA spacecraft auxiliary data, and operational meteorology data
  - ⇨ Meteorology–from NCEP and DAO–are expected to be HDF-EOS
- ❑ Outputs of two types
- ❑ L2GP
  - ⇨ HDF-EOS swath
  - ⇨ The standard product
  - ⇨ 1 molecule, 1 day in 1 file for most products
  - ⇨ Some may have multiple resolutions and/or include column amounts
- ❑ L2AUX
  - ⇨ HDF4 SD
  - ⇨ Format similar to Level 1 radiances
  - ⇨ Diagnostic

# Level 2 data processing (continued)

**Products** More about our use of HDF-EOS swaths

- ❑ Geolocation coordinates: time, latitude, longitude, and pressure
- ❑ Adhere to AURA guidelines found at
  - ⇨ Files created using HDF-EOS5 (Not yet); using Swath data type
  - ⇨ Structure names chosen from valids list
  - ⇨ Altitudes by way of a pressure grid
  - ⇨ Data fields ordered so that pressures increment fastest
  - ⇨ Data fields stored in specified units
  - ⇨ HDF Fill and missing values both take value of Missing Value data field attribute
- ❑ (See talk by Cheryl Craig (NCAR) February 27 3:30 pm)
- ❑ Column amounts also stored as swaths; may use pressure coordinate to store tropopause pressure
- ❑ Quality, precision, and possibly other data stored in file with product data

# Level 3 data processing

**Purpose** Map atmospheric abundances, calculate means

- Accepts Level 2 products

**Outputs** Produced by two separate PGEs

Daily program

- Processes standard Level 2 products
- Produces daily maps

Monthly program

- Processes standard, diagnostic and noisy Level 2 products
- Produces monthly maps
- Produces daily and monthly zonal means

# Level 3 data processing (continued)

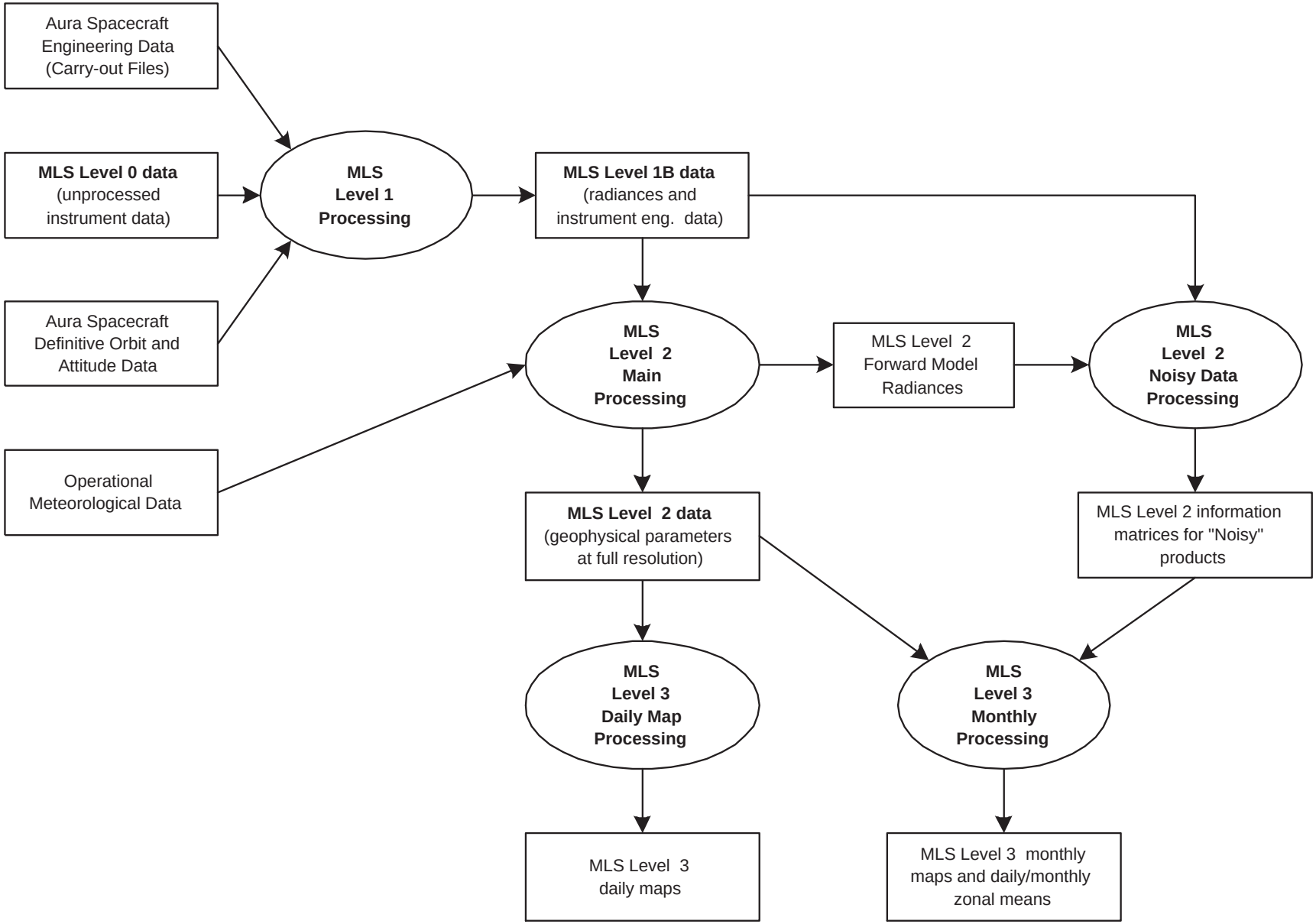
**Product** Map data

- Daily and monthly
- HDF-EOS grid: both latitudes and longitudes
- longitudes range from $-180$ to $179deg$ every $4deg$
- latitudes range from $\pm 82deg$ every $2deg$
- Diurnally-varying daily products split into three modes–ascending, descending, and combined; not all products

**Product** Zonal mean data

- Daily and monthly
- Latitudes only, at Level 2 spacing
- Both daily and monthly split into three modes
- Use HDF-EOS Swath with no longitude data, unless new HDF-EOS Zonal Mean data type defined

# Data flow


Aura Spacecraft Engineering Data (Carry-out Files)
MLS Level 0 data (unprocessed instrument data)
Aura Spacecraft Definitive Orbit and Attitude Data
Operational Meteorological Data
MLS Level 1 Processing
MLS Level 1B data (radiances and instrument eng. data)
MLS Level 2 Main Processing
MLS Level 2 Forward Model Radiances
MLS Level 2 Noisy Data Processing
MLS Level 2 data (geophysical parameters at full resolution)
MLS Level 2 information matrices for "Noisy" products
MLS Level 3 Daily Map Processing
MLS Level 3 Monthly Processing
MLS Level 3 daily maps
MLS Level 3 monthly maps and daily/monthly zonal means

# Data flow

**Native Binary** Bad stuff (mostly successful in not using it)

- Platform-dependent; HDF and HDF-EOS are platform-independent
- Currently forced to use with ephemeris and attitude data

**HDF4** Good stuff (but we try to avoid it where we can)

- Forced to use it sometimes
- Will be moving to HDF5

**HDF-EOS** Very good stuff (try to make it the only one our users need)

- Standard geolocations for placing data

**Metadata** Necessary to enable users to order Level 1, 2, and 3 products

- Archived at DAAC
- Describe data product's species, date, goodness, etc.
- Combines static data (attribute names) with dynamic (their values)
- Assume our users will order our data by product/day

# Future plans

**HDF5 and HDF-EOS5** Welcome or eagerly-awaited changes

- Finally some Linux support
- Awaiting IDL support

**Other new features** Further steps we might take

- We are open to good ideas

**Challenges** No guarantees–hard work ahead

- How to store diagnostics (point, grid, swath, SD?)
- How to make our data products easier to use?
- What standard names, units, axes can we adhere to or force others to adhere to?
- Zonal mean data don't fit neatly into any existing HDF-EOS structure