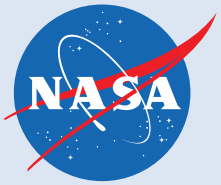


A common representation of vertical information content in retrievals from different sounding instruments

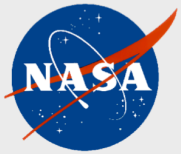
Eric Fetzer and Evan Manning

Jet Propulsion Laboratory, California Institute of Technology

NASA Sounder Science Team Meeting

Greenbelt, MD

October 4, 2018



National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Status Update

AIRS and CrIMSS Vertical Resolution, Averaging Kernels, Error Covariances, etc.

Eric Fetzer, Bill Irion and Evan Manning

Jet Propulsion Laboratory,
California Institute of Technology

Sounder Discipline Telecon
Monday, March 27, 2017

Two General Goals

1. **Seamlessly merge Level 2 data from *multiple sounding instruments* through:**
   - **Common formats, readers, variable names, etc.**
   - **Consistent representation of information content.**

2. **Ensure reproducibility from original data sources, conveying:**
   - **Different instrument error characteristics.**
   - **Dissimilar algorithms.**
   - **Different vertical information content.**

Currently Five Hyperspectral Infrared Instruments in LEO

Even more microwave and HIRS instruments

Infrared Instrument	AIRS	IASI	CrIS	IASI	CrIS
Start Date	31 Aug 2002	19 Oct 2006	28 Oct 2011	17 Sep 2012	18 Nov 2014
Agency	NASA	EUMETSAT	NOAA	EUMETSAT	NOAA
Satellite	Aqua	MetOp-A	S-NPP	MetOp-B	NOAA-20
Equator crossing time	1:30 PM	9:30 PM	1:30 PM	9:30 PM	1:30 PM
Orbit Period	98 minutes	101 minutes	101 min	101 minutes	101 min
Orbit altitude	700 km	800+ km	800+ km	800+ km	800+ km

Status of Activities

- ***Ready*: we will be implementing this**
  - **Send Evan and me an email if you have *minor* suggestions.**

- ***Open*: We are still working the details.**

Ready
At A Minimum…

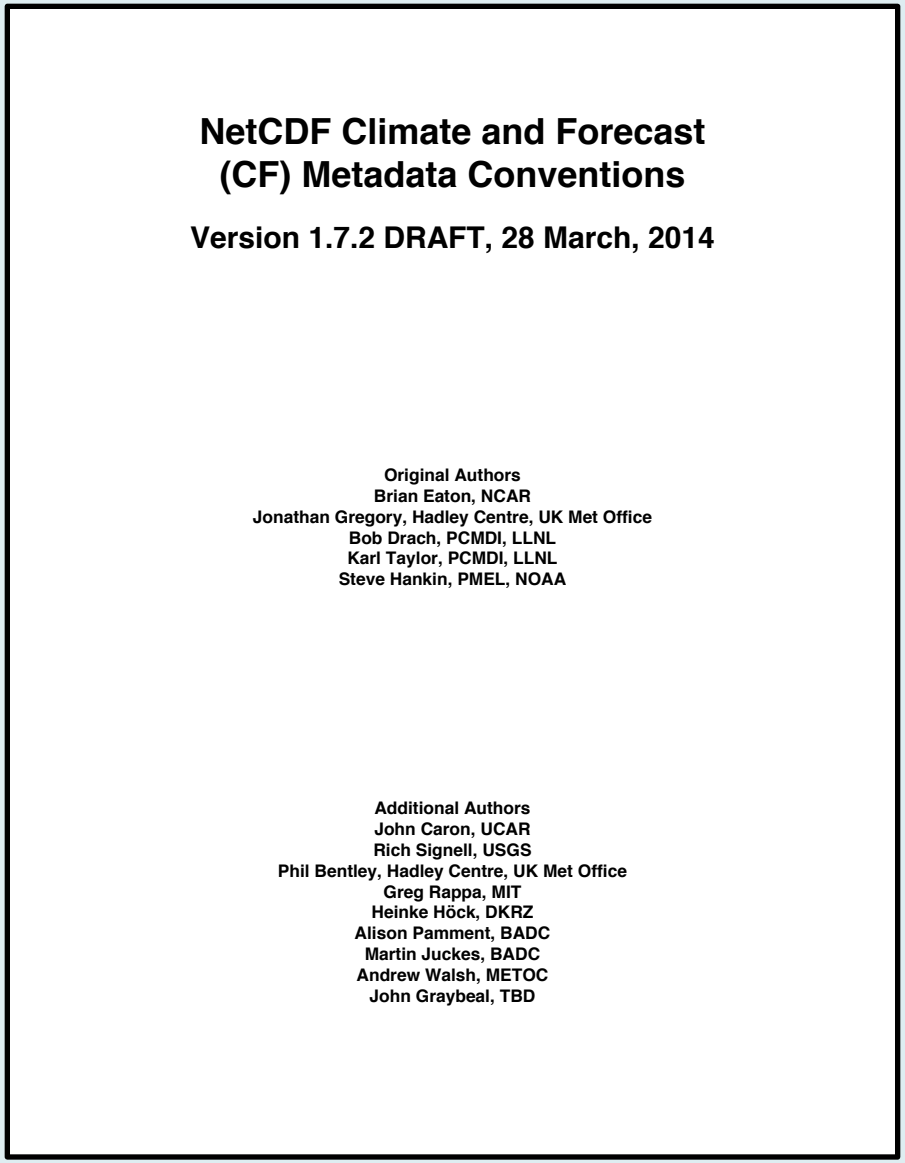
- **A common vertical profile for any and all products**
  - **100 pressure levels**
- **CF convention.**
- **SI units.**
- **NetCDF4 / HDF5 data format.**
- **Consistent variable names for identical quantities**
  - **E. g. temperature from AIRS/AMSU or CrIS/ATMS called air_temperature.**

Ready

CF naming convention

See

http://cfconventions.org



NetCDF Climate and Forecast (CF) Metadata Conventions

Version 1.7.2 DRAFT, 28 March, 2014

Original Authors
Brian Eaton, NCAR
Jonathan Gregory, Hadley Centre, UK Met Office
Bob Drach, PCMDI, LLNL
Karl Taylor, PCMDI, LLNL
Steve Hankin, PMEL, NOAA

Additional Authors
John Caron, UCAR
Rich Signell, USGS
Phil Bentley, Hadley Centre, UK Met Office
Greg Rappa, MIT
Heinke Höck, DKRZ
Alison Pamment, BADC
Martin Juckes, BADC
Andrew Walsh, METOC
John Graybeal, TBD

Vertical Coordinates

- ***Ready*** **Report on AIRS support levels: …904.866, 931.524, 958.591, 986.067, 1013.95, 1042.23, 1070.92, 1100.0 hPa.**

- ***Open?*** **A *'coarse resolution coordinate system'* applicable across sensors, like:**
  - **AIRS Standard: 1100, 1000, 925, 850, 700, 600, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 15, 10, 7, 5, 3, 2, 1.5, 1, 0.5, 0.2, 0.1 hPa?**

Ready

Gases and Their Units

- **SI units, following the CF convention.**

- **Water vapor will be in mass mixing ratio (kg / kg dry air), the climate modelling standard**
  - **Not specific humidity (kg / kg moist air).**
  - **Converting upper trop water vapor to mole fraction will require multiplication by a constant.**

- **Other gases will be in mole fraction, the composition community standard**
  - **Not volume mixing ratio (molecules / molecule of moist air).**

- **Total ozone will be proportional to Dobson Units, but not in DU.**

Mostly Ready L2 vertical resolution basic concept -- WV example (Evan, 3/2017)

For WV in L2 we'll have MMR on 100 levels: "h2o_mmr"

- **Plus QC {0, 1, 2} on 100 levels**
- **Plus error estimates on 100 levels**
  - **Unless there's a good way to do this at reduced resolution***
- **Nothing on "customary" levels like 850 hPa -- users can interpolate**
- **Nothing on layers -- users can resample/integrate**
  - **We will have column density on 100 layers, renamed as "mol_lay" and tucked in a separate mol_lay subgroup for use in forward models**
- **Also trapezoid info in separate "ave_kern" (TBD) subgroup**
  - **Like AIRS L2: ave_kern, boundary info, maybe retrieved values**
  - **No verticality or effective pressure -- these are easily derivable**

AIRS V6 Temperature Averaging Kernels on Trapezoids

Name	Type	Extra Dimensions	Explanation
Temp_ave_kern	32-bit floating-point	TempFunc (= 23) x TempFunc (= 23)	Averaging kernel for temperature retrieval.
Temp_verticalty	32-bit floating-point	TempFunc (= 23)	Sum of the rows of Temp_ave_kern.
Temp_dof	32-bit floating-point	None	Measure of the amount of information in temperature profile retrieval (deg of freedom).

Mostly Ready L3 vertical resolution basic concept -- WV example (Evan, 3/17)

For WV in L3 we'll have MMR on 100 levels

- **Straightforward gridding of Q0+Q1 L2**
  - **Gridding on a constant pressure grid in the face of variable surface pressure raises subtle issues, for another day**
- **Plus gridded error estimates on 100 levels**
  - **Unless there's a good way to do this at reduced resolution**
- **Nothing on "customary" levels like 850 hPa -- users can interpolate**
- **Nothing on layers -- users can resample/integrate**
  - **Not even column density**
- **No averaging kernels or other trapezoid info**

Open Organizing Variables

- **The GES DISC (Goddard DAAC) will support *variable* subsetting services**

⇒ **Organizing data into "menu" items by science AND technical themes. Some candidates:**

  - **Moist thermodynamics: Temperature, water vapor and clouds.**
  - **Composition: ozone, carbon monoxide.**
  - **Surface properties: SST, LST, emissivity.**
  - **Diagnostic variables: First guess, intermediate output, etc.**
  - **Custom orders: User chooses.**
  - **etc.…**

- **Aggregating is still a challenge**
  - **Data granules are arbitrary, but engrained.**
  - **Want one day of Level 2 temperature? You get 240 files…**
    - **Moore's Law means ~100 x cheaper technology than ca. 2000 when data granules were implemented.**

Wide Open

Preserving information from dissimilar instruments and algorithms, including:

- Infrared/microwave, infrared-only, microwave-only
- Different vertical representations
  - Sigma versus pressure levels
  - Different trapezoids for different quantities.
- Different quality flagging for different quantities.
- Different algorithms.
- Different information content
  - Example: IASI spectra (and L2) contain more information than AIRS spectra

This should all be conveyed in archived products!

Next Steps: *My Fall 2018 Project*

- **Look into a *common* information content format.**
- **Report on this at a Sounder telecon and/or the Spring 2019 AIRS Science Team Meeting.**
- **Any common information content format will be more complicated than AIRS standard products.**
- **How do we perform cross-sensor comparisons (as in Rodgers and Connor, 2003)?**