CLIMATE DATA RECORDS (CDRS)
HISTORY, STATUS, & FUTURE

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THE BASIS FOR THE NOAA CLIMATE DATA RECORD (CDR) PROGRAM WAS THE RECOGNITION THAT MOST ESSENTIAL CLIMATE VARIABLES SHARE COMMON SCIENCE STEPS
DEFINING A CDR AND START OF CDR PROGRAM

- Climate Data Record (CDR): A Climate Data Record is a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change [NRC, 2005].

- CDR definition still requires a ‘fit for purpose’ definition. Adopt the Global Climate Observing System (GCOS) Essential Climate Variable (ECV/CDR) requirements.

- NOAA CDR Program is operational, so we also need a metric for assessing the ‘maturity’ of research CDRs to identify characteristics of process maturity => a CRD Maturity Matrix

- Funding resulted from NPOESS Nunn-McCurdy Certification in 2006
## GCOS ECV CDR REQUIREMENTS FOR EARTH RADIATION BUDGET

<table>
<thead>
<tr>
<th>ECV</th>
<th>Product</th>
<th>Frequency</th>
<th>Resolution</th>
<th>Required measurement uncertainty</th>
<th>Stability (per decade)</th>
<th>Standards/references</th>
<th>Entity (see Part II, section 2.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth radiation budget</td>
<td>Top-of-atmosphere ERB long-wave (reflecting)</td>
<td>Monthly (resolving diurnal cycle)</td>
<td>100 km/NA</td>
<td>Requirements on global mean: 1 W/m²</td>
<td>0.2 W/m²/decade</td>
<td>NOAA Tech. Rep. NESDIS 134</td>
<td>WGClimate</td>
</tr>
<tr>
<td></td>
<td>Top-of-atmosphere ERB short-wave (reflected)</td>
<td>Monthly (resolving diurnal cycle)</td>
<td>100 km/NA</td>
<td>Requirements on global mean: 1.0 W/m²</td>
<td>0.3 W/m²/decade</td>
<td>NOAA Tech. Rep. NESDIS 134</td>
<td>WGClimate</td>
</tr>
<tr>
<td>Total solar irradiance</td>
<td>Daily</td>
<td>NA/NA</td>
<td>0.035%</td>
<td>0.01%/decade</td>
<td></td>
<td></td>
<td>WGClimate</td>
</tr>
<tr>
<td>Solar spectral irradiance</td>
<td>Daily</td>
<td>Spectral resolution: 1 nm &lt; 290 nm 2 nm (290–1 000 nm) 5 nm (1 000–1 600 nm) 10 nm (1 600–3 200 nm) 20 nm (3 200–6 400 nm) 40 nm (6 400–10 020) 20 000 nm (spacing up to 160 000 nm)</td>
<td>0.3% (200–2400 nm)</td>
<td>1.0% (200–2 400 nm/decade)</td>
<td></td>
<td></td>
<td>WIGOS</td>
</tr>
</tbody>
</table>
NPOESS NUNN-MCCURDY CERTIFICATION
AN OPPORTUNITY FROM ‘DESCOPING’ CLIMATE SENSORS

• NPOESS (now JPSS) was to include climate sensors transitioned from NASA including Solar Irradiance (TIM, SIM), Earth Radiation (CERES, ERBE), and Aerosols (APS)

• OMB and OSTP asked NOAA and NASA to develop a recovery plan for these sensors
  • NOAA Climate Sensor program – funded CERES-5, CERES-6, TSIS-1
  • No NOAA APS since failure of GLORY mission (only research APS did not fly)
  • Continuing JPSS budget overruns caused climate sensors to be transferred back to NASA
  • NOAA CDR Program funded to process data operationally including the full suite of climate sensors and JPSS sensors
ORIGIN OF MATURITY MATRIX – INFORMATION PRESERVATION

<table>
<thead>
<tr>
<th>Sensor Use</th>
<th>Documentation</th>
<th>Metadata &amp; QA</th>
<th>Algorithm stability</th>
<th>Validation</th>
<th>Public Release</th>
<th>Science &amp; Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>How long and widely used is this type of sensor?</td>
<td>Is the Operational Algorithm Description full, complete, and peer reviewed?</td>
<td>How full and complete are the metadata and quality assessment?</td>
<td>Are algorithms under configuration management and how mature?</td>
<td>How complete is the validation?</td>
<td>Are the data, algorithms and software open and available to the Public?</td>
<td>How extensive is the peer reviewed literature and how varied are the applications?</td>
</tr>
</tbody>
</table>
### Quantifying the CDR Maturity Matrix

#### Maturation Stages:

1. **Initial CDR**
   - Research Mission with limited period of record
   - Minimal changes expected
   - Algorithm unstable
   - Metadata & QA: small, simple data set
   - Validation: limited data available for use
   - Public Release: limited

2. **Experimental CDR**
   - Research Mission with sufficient period of record
   - Moderate changes expected
   - Algorithm mature
   - Metadata & QA: moderate data set
   - Validation: data available for use
   - Public Release: limited

3. **Provisional CDR**
   - Research Mission with sufficient period of record
   - Moderate changes expected
   - Algorithm mature
   - Metadata & QA: moderate data set
   - Validation: data available for use
   - Public Release: limited

4. **Validated CDR**
   - Research Mission with sufficient period of record
   - Moderate changes expected
   - Algorithm mature
   - Metadata & QA: moderate data set
   - Validation: data available for use
   - Public Release: limited

5. **Sustained CDR**
   - Research Mission with sufficient period of record
   - Moderate changes expected
   - Algorithm mature
   - Metadata & QA: moderate data set
   - Validation: data available for use
   - Public Release: limited

6. **Benchmark CDR**
   - Research Mission with sufficient period of record
   - Moderate changes expected
   - Algorithm mature
   - Metadata & QA: moderate data set
   - Validation: data available for use
   - Public Release: limited

#### Criteria for Maturation:

- **Research:**
  - Initial CDR: Data and base data sets created
  - Experimental CDR: Significant changes likely
  - Provisional CDR: Moderate changes likely
  - Validated CDR: Moderate changes likely
  - Sustained CDR: Moderate changes likely
  - Benchmark CDR: Moderate changes likely

- **Operations:**
  - Initial Capability: Unavailable
  - Full Operations Capability: Unavailable

- **Science & Applications:**
  - Not applicable

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[https://doi.org/10.1175/BAMS-D-15-00015.1](https://doi.org/10.1175/BAMS-D-15-00015.1)
CDR RESEARCH TO OPERATIONS – AN INTEGRATED TEAM APPROACH LINKING CODE WITH DOCUMENTATION WITH DATA

- **Code** – all code contains errors. Review, version control, security review, and public access improve code quality and security.

- **Documents** – assure that others can best benefit from your work.

- **Data** – NOAA NCEI is the NARA Agency records center for oceans and atmospheres. Official archive means your records are preserved long term.
GROWTH AND STATUS OF CDR PROGRAM

- 41 CDRs at initial operating capability as of October 2017
- International Satellite Cloud Climatology Project is a Final operating capability pathfinder
- CDRs remain as 1 of only 3 NCEI metrics in Commerce budget blue book 2018-2023

Operational CDR quantity limit based on “work-in-progress”

- PI R20 “work-in-progress”, from Grant Competition
- 20+ more individual CDRs in the work “Pipeline”
- Sustainment cost also limits operational CDR carrying capacity
INTERNATIONAL COOPERATION ON CDRS
WGCLIMATE AND ECV ARCHITECTURE

• Working Group on Climate is joint CEOS/CGMS
• Works with WMO & GCOS to assess ECVs and advise space agencies on climate observations
EUROPEAN EFFORTS TO GENERATE CDRS

HTTPS://DOI.ORG/10.1175/BAMS-D-16-0074.1

• Improves on many of the NOAA CDR Program Efforts
• Found System Maturity Matrix applies to in situ and re-analysis data sets as well as satellite data
• Propose an Application Performance Matrix to assess CDR fitness for purpose

![Application Performance Matrix]

<table>
<thead>
<tr>
<th>Software Readiness</th>
<th>Metadata</th>
<th>User Documentation</th>
<th>Uncertainty Characterisation</th>
<th>Public access, feedback, and update</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coding Standards</td>
<td>Standards</td>
<td>Formal description of scientific methodology</td>
<td>Standards</td>
<td>Public Access/Archive</td>
<td>Research</td>
</tr>
<tr>
<td>Software Documentation</td>
<td>Collection level</td>
<td>Formal validation report</td>
<td>Validation</td>
<td>Version</td>
<td>Decision support system</td>
</tr>
<tr>
<td>Numerical Reproducibility and portability</td>
<td>File level</td>
<td>Formal product user guide</td>
<td>Uncertainty quantification</td>
<td>User feedback mechanism</td>
<td></td>
</tr>
<tr>
<td>Security</td>
<td></td>
<td>Formal description of operations concept</td>
<td>Automated quality monitoring</td>
<td>Updates to record</td>
<td></td>
</tr>
</tbody>
</table>

Legend

1 2 3 4 5 6
ECV ARCHITECTURE IS BEING REALIZED IN THE EU COPERNICUS CLIMATE CHANGE SERVICE (C3S)

• C3S is funded (~30 M€/yr.) by DG GROW (not science or environment) and will be evaluated on providing positive economic impact

• C3S is led by ECMWF, is 100% operational, and has adopted/adapted many of the CDR Program approaches for its Climate Data Store (QA4ECV)

• Initial EC funding is 5yr. +5yr. ECMWF reanalysis and seasonal forecasts are routine. All products and data are open as part of EU Copernicus and Sentinel programs
SHOULD AN ECV MATURITY ASSESSMENT BE MANDATORY FOR USE IN POLICY?

- Consider ‘Global Surface Temperature’
  - There is no ‘Global Surface Temperature’ ECV; there is Sea Surface Temperature and Near-Surface Air Temperature
  - What is the CDR maturity and application performance maturity of these ECVs? Begin with the ECV/CDR requirements

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<tr>
<td>Sea-surface temperature</td>
<td>Sea-surface temperature</td>
<td>Hourly to weekly</td>
<td>1–100 km</td>
<td>0.1 K over 100-km scales</td>
<td>&lt; 0.03 K over 100-km scales</td>
<td>WGClimax</td>
<td>JCOMM</td>
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<tr>
<td>Temperature (surface)</td>
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<tr>
<td>ERSST-V4</td>
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<tr>
<td>GHCN-M V4alpha</td>
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</tr>
</tbody>
</table>

**CDR MATURITY ASSESSMENT OF KARL ET AL., 2015**

<table>
<thead>
<tr>
<th>SOFTWARE READINESS</th>
<th>METADATA</th>
<th>USER DOCUMENTATION</th>
<th>UNCERTAINTY CHARACTERISATION</th>
<th>PUBLIC ACCESS, FEEDBACK, UPDATE</th>
<th>USAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
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<td>1</td>
</tr>
</tbody>
</table>
THE GLOBAL SURFACE TEMPERATURE ‘HIATUS’
ASSESSING CDR MATURITY AND APPLICATION PERFORMANCE

• Consider Karl et al. ‘Possible artifacts of data biases in the recent global surface warming hiatus’ (K15 - doi:10.1126/science.aaa5632) - “Indeed, according to our new analysis, the IPCC’s (1) statement of 2 years ago—that the global surface temperature “has shown a much smaller increasing linear trend over the past 15 years than over the past 30 to 60 years”—is no longer valid”
  • Criticized by Fyfe et al. (doi:10.1038/nclimate2938)— Slowdown still exists in K15 ‘new’ data set; Decadal oscillation is perhaps ocean variability (see NAS doi:10.17226/23552)
  • Criticized by Bates (2017 https://judithcurry.com/2017/02/04/climate-scientists-versus-climate-data/) for misidentification of data sets, lack of archive, etc. Result not traceable.
  • Re-examination of K15 data sets, conclusions, and NOAA press release (here and in DOC 2018 Scientific Assessment Committee)
K15 CONCLUSION VERSUS K15 DATA

• K15 “Indeed, according to our new analysis, the IPCC’s (1) statement of 2 years ago—that the global surface temperature “has shown a much smaller increasing linear trend over the past 15 years than over the past 30 to 60 years”—is no longer valid”

• Real conclusion from K15 Figure 1 - The 90% confidence intervals of the “Hiatus” old and new analysis include both base period results (i.e., they are not different) and the confidence intervals for both of these results include zero temperature trend (i.e., they are both positive but neither can be distinguished from zero).

• Bias (i.e., systematic) errors are not included in any of the K15 analysis. New SST analysis (ERSST V5) makes different bias corrections (ship air temperature transfer standard did not exist for K15 2011-2014 time period) and gets another different, but statistically overlapping, result.
NOAA K15 PRESS RELEASE VERSUS DATA

• K15 –
  • “Even starting a trend calculation with 1998, the extremely warm El Niño year that is often used as the beginning of the “hiatus,” our global temperature trend (1998–2014) is 0.106°C decade⁻¹.”

• Actual Data –
  • 1998 is actually neutral (El Niño & La Niña), 1999 & 2000 are cold La Niña
  • 2000-2014 is not “included in IPCC, 2013”
  • Confidence limits again overlap
  • Confidence limits disappear in press release and are replaced by a single value
CONCLUSIONS

• I’m proud to have helped establish the NOAA CDR Program and to ensure the continuity of Solar Irradiance and Earth Radiation observations.

• The CDR Program has helped to define nomenclature and metrics that are ensuring the long-term preservation and access to climate data and information.

• CDR metrics have been adapted and implemented by the international community.

• The EU Copernicus Climate Change Service is an ambitious, operational program that seeks to demonstrate the economic value of climate change products and services now.

• Independent CDR maturity assessment should be mandatory and required for any data set used to help set policy.
THANKS

ESPECIALLY TO ALL WHO HELPED ESTABLISH AND RUN THE NOAA CDR PROGRAM