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

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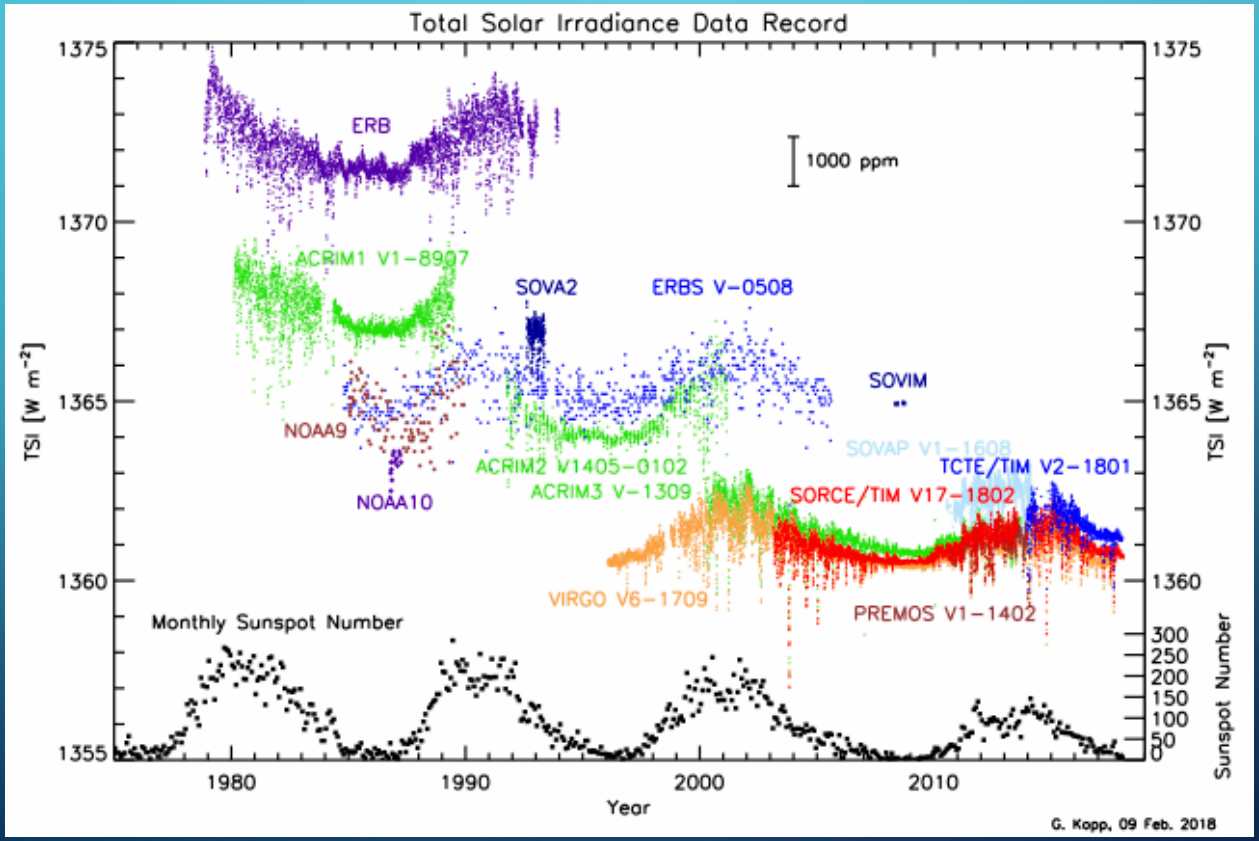
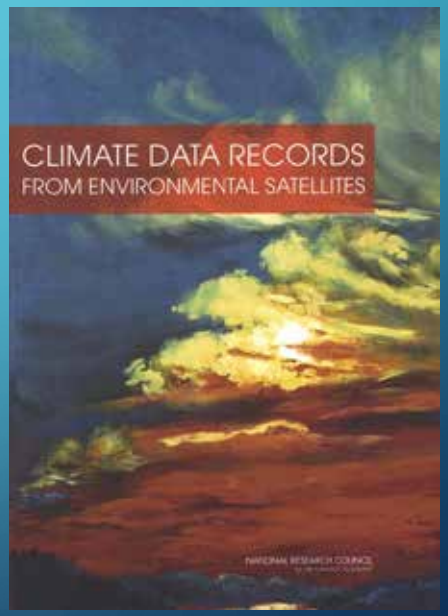
THE BASIS FOR THE NOAA CLIMATE DATA RECORD (CDR) PROGRAM WAS THE RECOGNITION THAT MOST ESSENTIAL CLIMATE VARIABLES SHARE COMMON SCIENCE STEPS



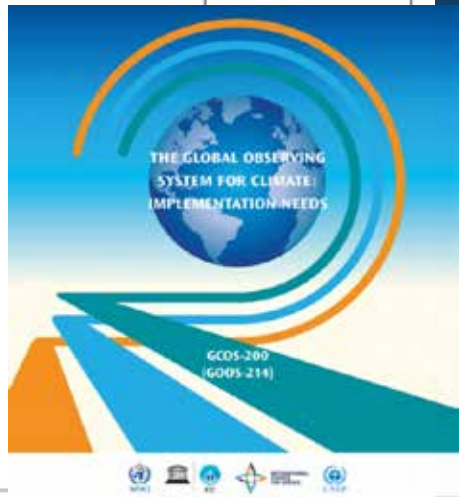
DEFINING A CDR AND START OF CDR PROGRAM

- 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

Atmospheric ECV product requirements								
ECV	Product	Frequency	Resolution	Required measurement uncertainty	Stability (per decade)	Standards/ references	Entity (see Part II, section 2.2)[94]	
							Satellite	In situ
Earth radiation budget	Top-of-atmosphere ERB long-wave	Monthly (resolving diurnal cycle)	100 km/NA	Requirements on global mean: 1 W/m^2	0.2 W/m^2/decade	NOAA Tech. Rep. NESDIS 134	WGClimate	
	Top-of-atmosphere ERB short-wave (reflected)	Monthly (resolving diurnal cycle)	100 km/NA	Requirements on global mean: 1.0 W/m^2	0.3W/m^2/decade	NOAA Tech. Rep. NESDIS 134	WGClimate	
	Total solar irradiance	Daily	NA/NA	0.035%	0.01%/decade		WGClimate	
	Solar spectral irradiance	Daily	Spectral resolution: 1 nm < 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)	0.3% (200–2400 nm)	1%(200–2 400 nm/ decade		WGClimate	WIGOS



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

Where can products easily be found?

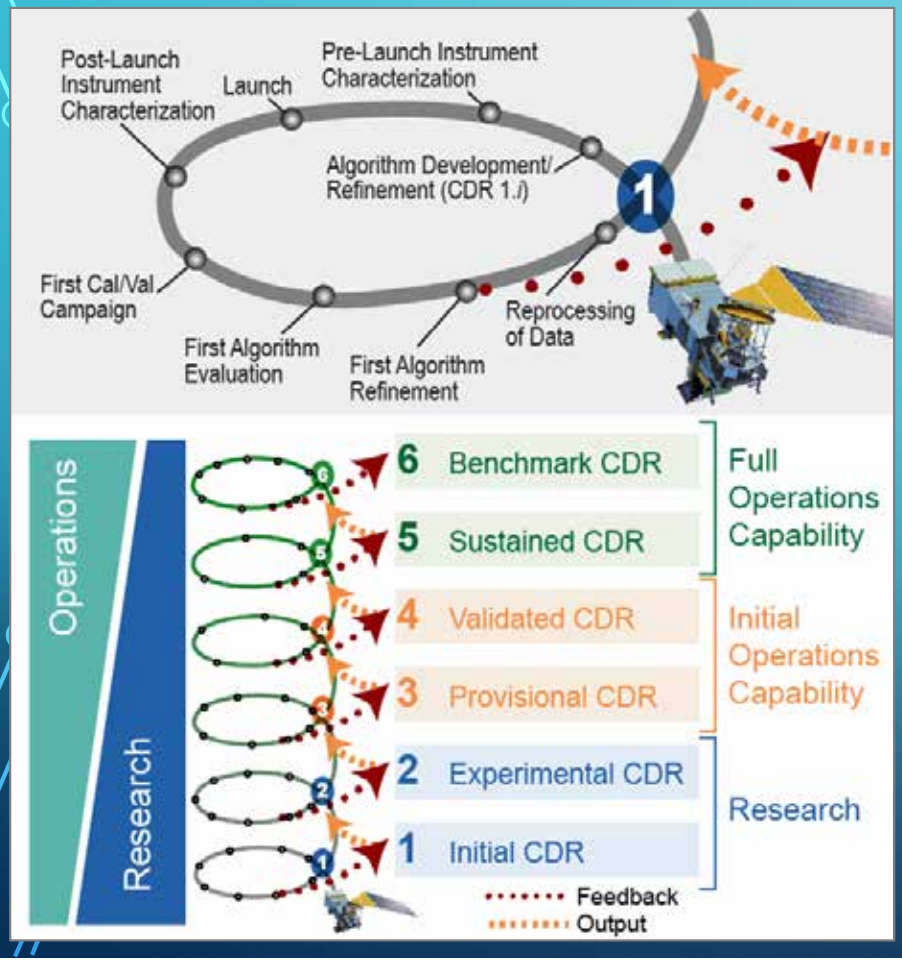
What original observations were used in the product?

What methods were used to create the product?

How do we ensure authenticity of the product?

Sensor Use	Documentation	Metadata & QA	Algorithm stability	Validation	Public Release	Science & Applications
How long and widely used is this type of sensor?	Is the Operational Algorithm Description full, complete, and peer reviewed?	How full and complete are the metadata and quality assessment?	Are algorithms under configuration management and how mature?	How complete is the validation?	Are the data, algorithms and software open and available to the Public?	How extensive is the peer reviewed literature and how varied are the applications?

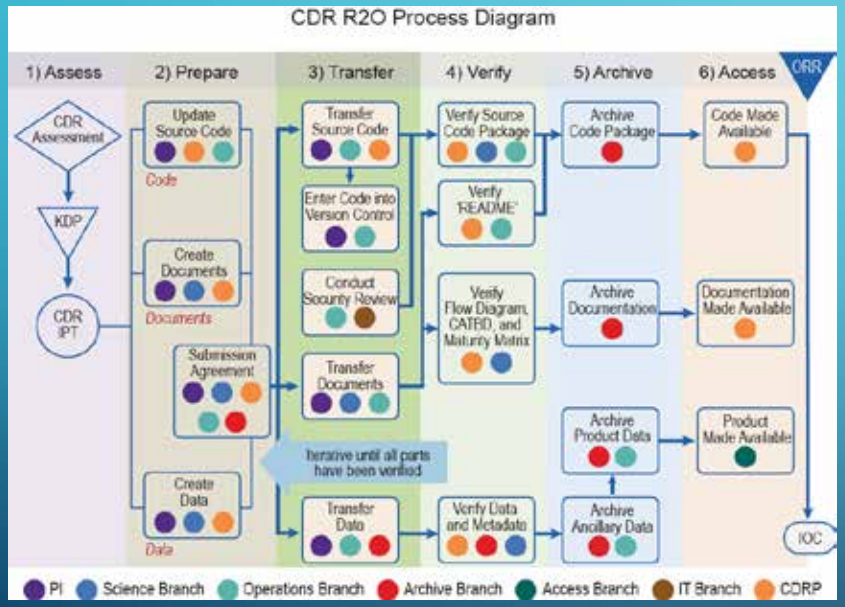
QUANTIFYING THE CDR MATURITY MATRIX



Maturity	Sensor Use	Algorithm stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications
1	Research Mission with limited period of record	Significant changes likely	Incomplete	Draft Operational Algorithm Description (OAD)	Minimal	Limited data availability to develop familiarity	Little or none
2	Research Mission with limited period of record	Some changes expected	Research grade (extensive)	OAD Version 1+	Uncertainty estimated for select locations/times	Data available but of unknown accuracy; caveats required for use.	Limited or ongoing
3	Research Mission with sufficient period of record	Minimal changes expected	Research grade (extensive); Meets international standards	Peer-reviewed OAD and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
4	Operational Mission with sufficient period of record	Minimal changes expected	Stable, Allows provenance tracking and reproducibility; Meets international standards	Public Operational Algorithm Description (OAD); Peer-reviewed product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data archived and available but of unknown accuracy; caveats required for use.	Operationally used in applications and assessments demonstrating positive value.
5	All relevant research and operational missions; unified and coherent record demonstrated across different sensors	Stable and reproducible	Stable, Allows provenance tracking and reproducibility; Meets international standards	Public OAD and Validation Plan; Peer-reviewed product and validation articles	Consistent uncertainties estimated over most environmental conditions by multiple investigators	Multi-mission record is archived and publicly available with associated uncertainty estimate	Used in published applications and assessments by different investigators
6	All relevant research and operational missions; unified and coherent record over complete series; record is considered scientifically irrefutable following extensive scrutiny	Stable and reproducible; homogeneous and published error budget	Stable, Allows provenance tracking and reproducibility; Meets international standards	Product, algorithm, validation, processing and metadata described in peer-reviewed literature	Observation strategy designed to reveal systematic errors through independent cross-checks, open inspection, and continuous interrogation	Multi-mission record is publicly available from Long-Term archive	Used in multiple published applications and assessments by different investigators
Comments for Maturity rating Avg rating = 3.9	POR 1854 to present ship and buoy data consists of (ICOADS2.4 + marine obs after 2006) NOTE: pseudo calibration uses average statistical adjustment factors not instrumental Historical data has large uncertainty	Code documented throughout Multiple papers published Source code is packaged and deployable	FGDC compliant User Manual available	Algorithm techniques published in multiple papers Internal wiki page with overview, flow chart, white papers, and code descriptions Source code is packaged and deployable	comparisons made with equivalent products e.g., HadSST and GSST comparisons with simulations (e.g., GFDL CM2.1 but need others) comparisons among previous versions	Data archived and available on ftp server Product updated monthly	Well published and referenced research Most recent version will need a paper after testing MetOffice adjustment factors and new ICOADS release

https://doi.org/10.1175/BAMS-D-15-00015.1

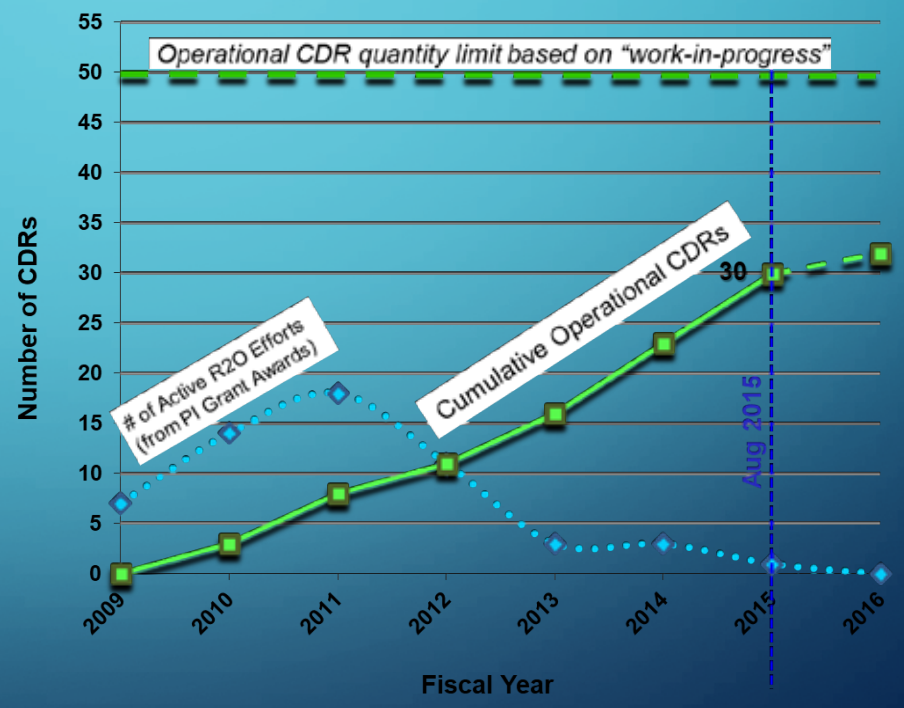
CDR RESEARCH TO OPERATIONS – AN INTEGRATED TEAM APPROACH LINKING CODE WITH DOCUMENTATION WITH DATA



- 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

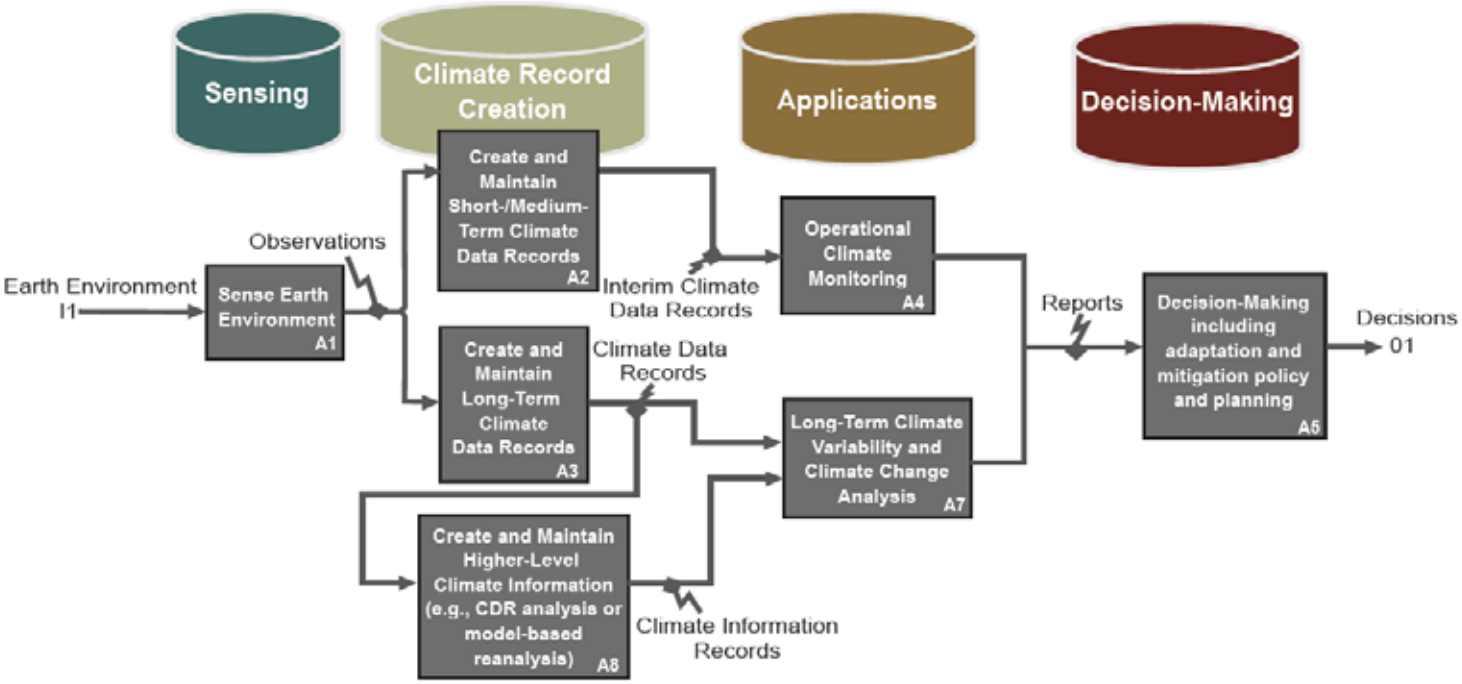
- 41 CDRs at initial operating capability as of October 2017
- International Satellite Cloud Climatology Project is a Final operating capability pathfinder
- CDRs remain as 1 of only 3 NCEI metrics in Commerce budget blue book 2018-2023

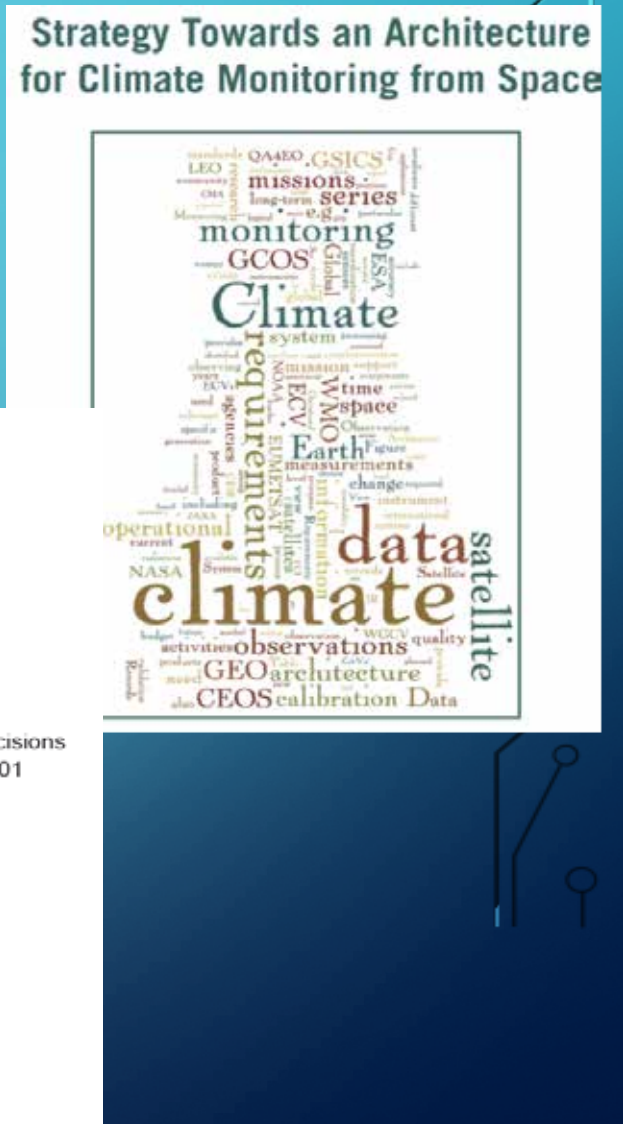


- PI R2O "work-in progress", from Grant Competition
- 20+ more individual CDRs in the work "Pipeline"
- Sustainment cost also limits operational CDR carrying capacity

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

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

ECV	Products	Frequency	Resolution	Required measurement uncertainty	Stability (per decade unless otherwise specified)	Standards/ References	Entity (see Part II, section 2.2)[100]	
							Satellite	In situ
Sea-surface temperature	Sea-surface temperature	Hourly to weekly	1–100 km	0.1 K over 100-km scales	< 0.03 K over 100-km scales		WGClimate	JCOMM
Temperature (surface)		Hourly	Site	0.1 K	0.02 K/decade	P. Jones		WIGOS
		Daily Tx/Tn		0.1 K				WIGOS

CDR MATURITY ASSESSMENT OF KARL ET AL., 2015	SOFTWARE READINESS	METADATA	USER DOCUMENTATION	UNCERTAINTY CHARACTERISATION	PUBLIC ACCESS, FEEDBACK, UPDATE	USAGE
ERSST-V4	2	3	4	3	3	4
GHCN-M V4alpha	1	1	1	1	1	4

THE GLOBAL SURFACE TEMPERATURE 'HIATUS' ASSESSING CDR MATURITY AND APPLICATION PERFORMANCE

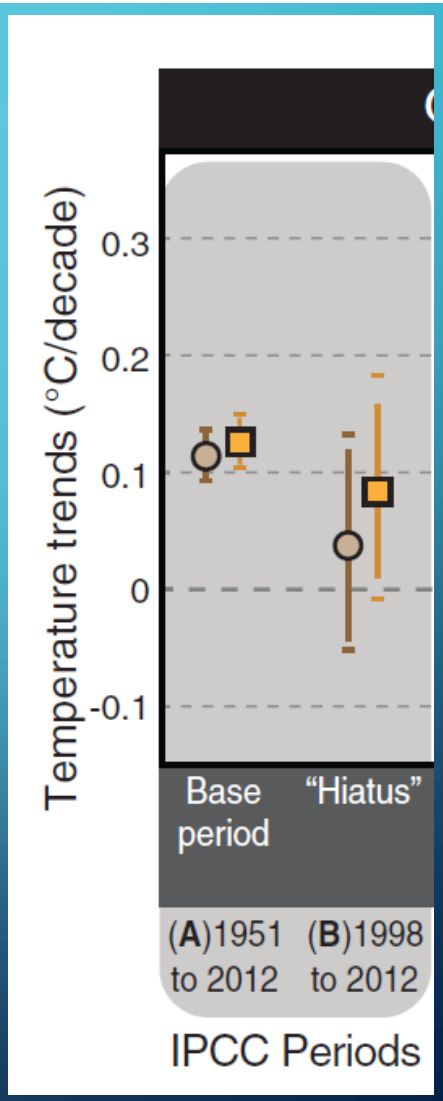
- Consider Karl et al. 'Possible artifacts of data biases in the

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.

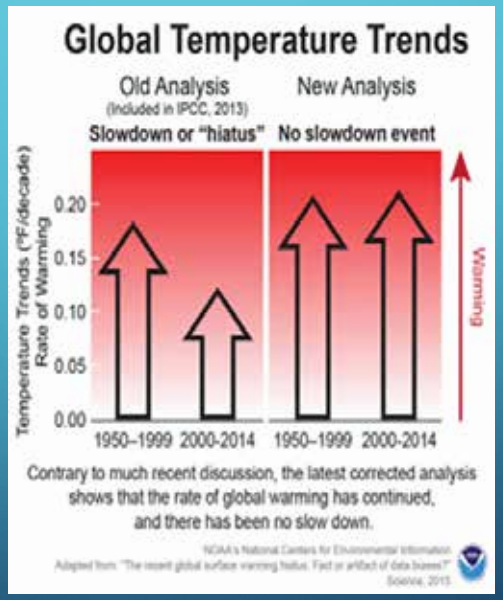


Circle = Old analysis
Square=New analysis
NOTE – 90% Random Error Confidence Limits

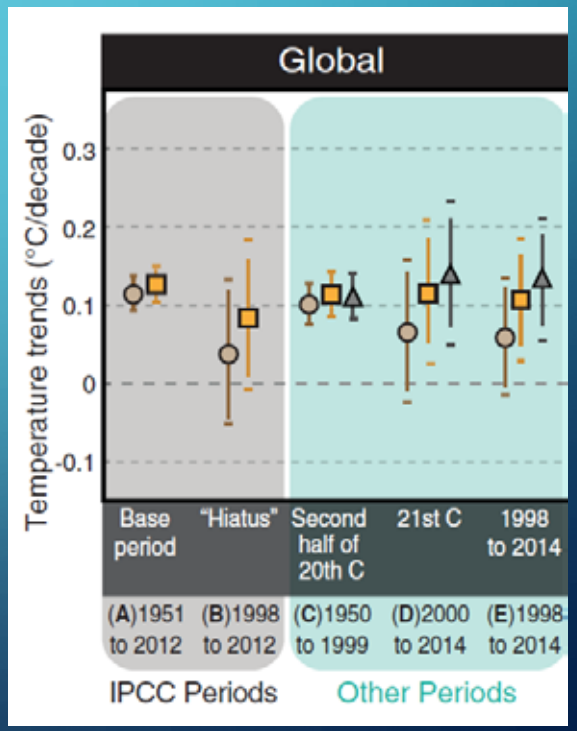
NOAA K15 PRESS RELEASE VERSUS DATA

- 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

Press Release



Data from K15



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