



NASA Langley Research Center

NASA Langley Atmospheric Sciences Data Center

CERES FM5 on NPP

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ASDC

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ASDC Functions

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- Ingest
 - Receive/Order all input data from external sources
 - Accept and Ingest Results of CERES Production
- Archive
 - Store and protect CERES inputs and data products
- Distribution
 - External Customers
 - Data Products through LaTIS Order Tool
 - Internal Customers
 - Data needed for Production Requests
 - Data for Science Team to use in Cal/Val, analysis, testing
- Production
 - Create Data Products as requested by CERES PI
 - Initial Processing
 - Re-processing (target is 10x)
- Reporting
 - DMT and Science Team Meetings
 - Failed ingests or production problems
 - Statistics (but not identity) about Data Product orders

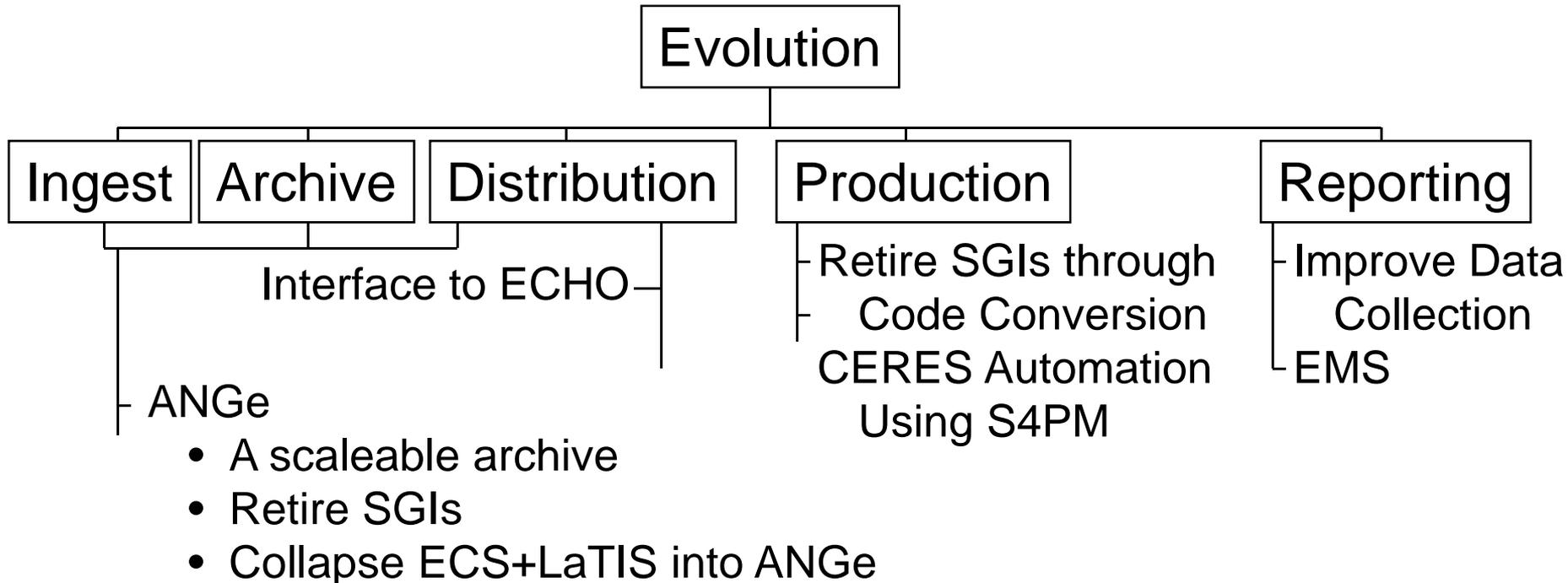


ASDC is Evolving

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- Objectives

- Reduce cost of data stewardship without compromising data quality
 - System maintenance
 - Ancient production management code
 - Reduce labor cost of operations
- Improve throughput in reprocessing
 - Leverage modern processors and storage systems
- Improve accessibility and integration with EOS-DIS holdings





Climate Data Records Constraints

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- Climate Data Records
 - 40 year time series of internally consistent data
 - Climate data requires high accuracy on decade time scales
 - Avoid introducing artifacts due to changes in processing environment
 - Re-process entire set in 2 years to or not useful to leading edge work
- CERES Product Naming Describes Maturity of Data Product
 - ValRx - Internal use to verify production accuracy
 - Beta - Initial public release for evaluation by potential users
 - Edition - Publication quality, public release
 - Data Quality Summary to describe characteristics for users
 - Algorithms remain unchanged during the processing of an Edition
 - Perpetually available for review of published scientific papers
- Large volume of data increases stability of calibration
 - Improves understanding of errors in measurement
 - Calibration using 5-year basis is far better than 3-month



CERES Science Data Operations

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- Monitor Instrument Health from initial data products
- Produce Climate Data Records
 - Code Development and Analysis
 - Ingest and Archive Inputs at ASDC
 - Production, Archive and Distribution at ASDC
 - Beta, Edition designations
 - Edition 1 version
 - Re-processing for subsequent editions
- Calibration/Validation of Data Products
 - Intercalibration of Data Products with other instruments
 - Remote Sensing
 - Ground-based systems
 - Instrument Gain and Spectral Response Function



CERES/NPP External Inputs

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Parameter	Parameter Name	Freq	CERES Source	Proposed FM5 Source	Comments
L0	Pre-L0 packet slugs	12/hr	Terra,Aqua supplies L0 data product	FM5 Instrument	660sec HDF-5 Make FM-5 L0 @LaRC
Attitude	Attitude	1/hr	GSFC Flight Dyn Facility	NPP	Hist: Missing data
Ephemeris	Ephemeris	1/hr	GSFC Flight Dyn Facility	NPP	Hist: Missing data
APD	Aerosol (Coln) Optical thickness, type/size	1/day	MODIS	NPP-VIIRS	Day and night-EDR
OPD	Ozone Profile	1/day	NCEP SMOBA	NPP	Day and night
MWH	Microwave Humidity	6/day	GEOS (GMAO)	NCEP	Probably not needed
GAP	3-D Met Data	4/day	GMAO	GMAO	ECMWF Monthly delivery
GAP	Land Surface Temp	4/day	GMAO	GMAO	
GAP	Sea Surface Temp	1/day	GMAO	GMAO	
CID	Cloud Imager Data	1/day	VIRS, MODIS	VIIRS from SDS	Subsampling, selected channels, GSFC algorithms
SURFMAP(DEM)	Surface Digital Elevation	1 time		NPP standard	
SURFMAP(SNOW)	Snow Map	1/wk	NCEP/NESDIS	NPP standard	
SURFMAP(ICE)	Ice Map	1/wk	NCEP/NESDIS	NPP standard	



CERES Algorithms

- Organized into Working Groups
 - Instrument
 - ERBE-like
 - SARB
 - Clouds
 - Inversion
 - TISA
 - MOA
- Each has several types of code
 - Production Code
 - Analysis
 - Calibration/Validation



Division of Processing Responsibilities

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- SCF Provides Code Development, Testing, Cal/Val and Analysis Capabilities
 - SGI 3800
 - Mac G5 cluster using Sun Grid-Engine
- ASDC Produces/Distributes Data Products
 - Processing environment compatible with SCF
 - Minimize work required once delivered to ASDC
 - Ensure data products are consistent with Science Requirements
 - Codes delivered by Instrument Team
 - Sample Data and Production Manual for testing
 - Promotion after testing by SSI&T
 - ASDC ANGe to modernize ingest, archive and distribution
 - ASDC Production Automation
 - Based on GSFC's SP4M tool
 - MISR, Flashflux running
 - CERES in design: ETA Winter, 2008



SCF Functions

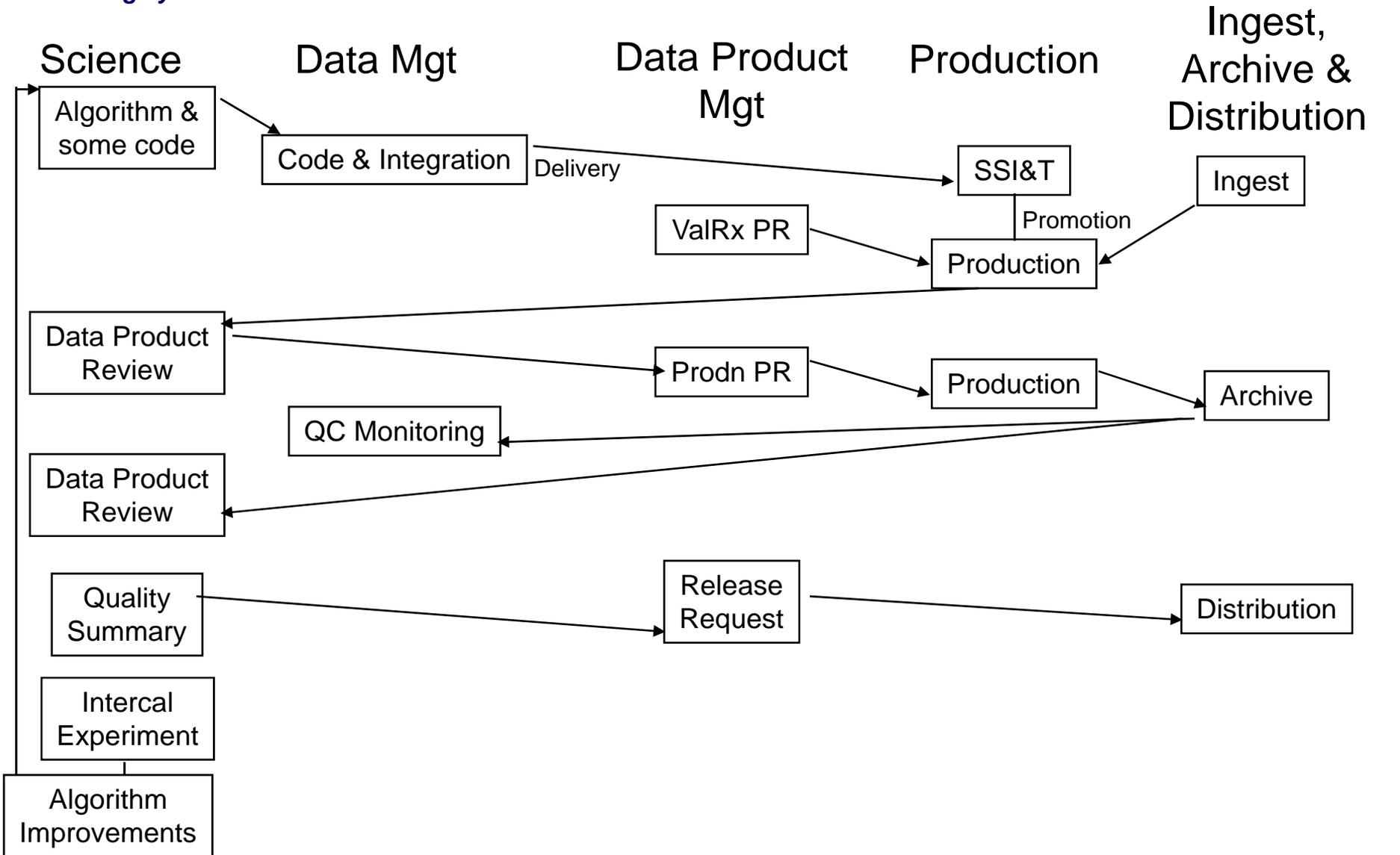
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- Support Science Team
 - Algorithm and code development and testing
 - Validation and inter-calibration analysis
 - Analysis of scientific data
 - Research and Analysis Projects related to Radiation Science, Climate and Clouds
 - Production Computing environment
 - Complement to the ASDC
- Types of Operations
 - Code Development and evaluation
 - Short or proof runs of data products (non-public)
 - Experimental data products
 - Comparison of validation or inter-calibration data sets



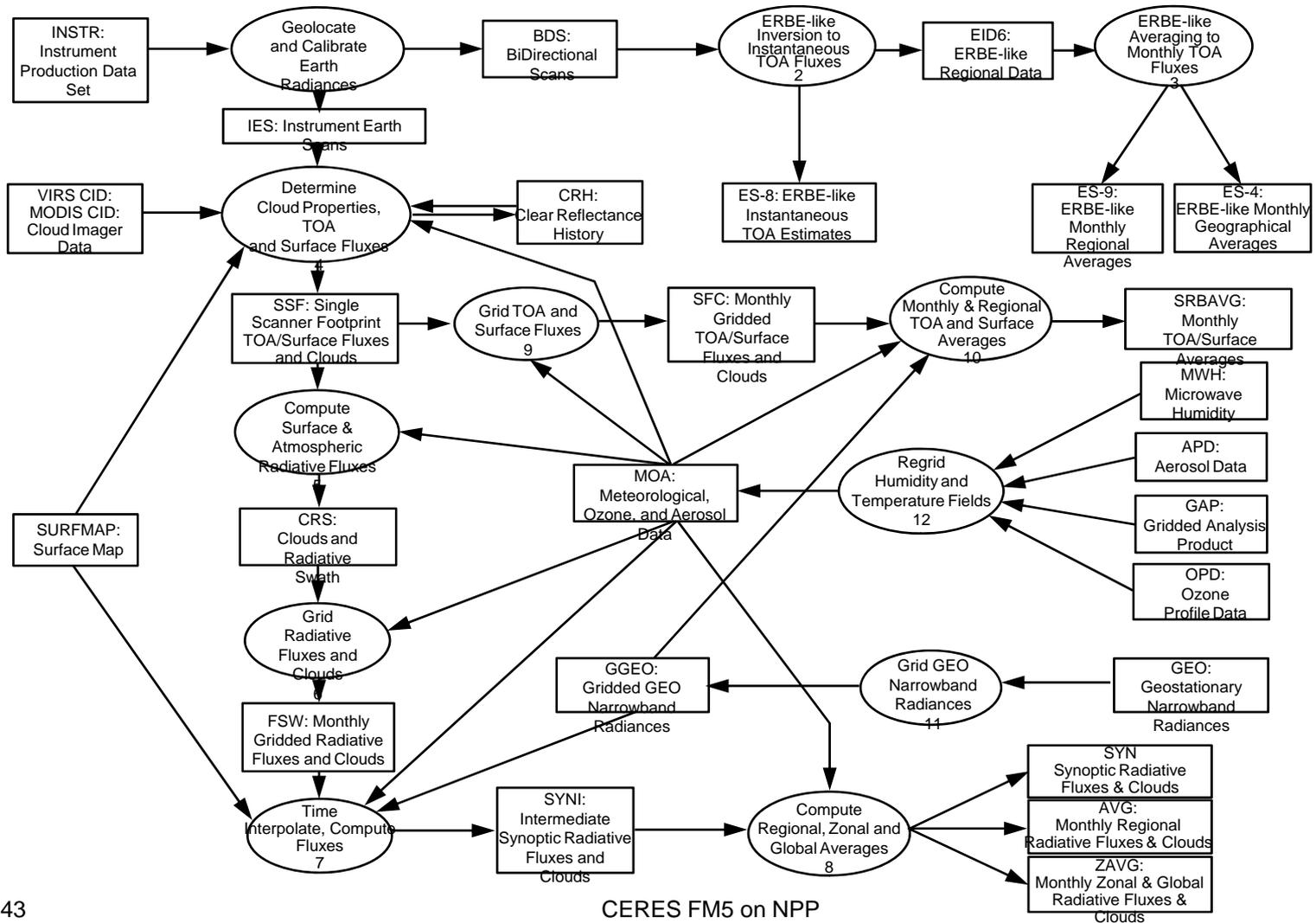
CERES Data Processes

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CERES Climate Data Record Production





State of CERES Production Codes

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Subsystem	LOC	Stage A Conversion (SGI3800, MacG5, LINUX 970, cluster)	Stage B Conversion (Intel using Mac, LINUX)	NPP Code Change %	NPP Mods
cereslib	159,077	Complete		5	numerous
Instrument	110,731	Complete; not 970	Need ADA compiler	22 (toolkit)	FM5 L0 & gains &SRF NPP att/ephem, toolkit
ERBE-like	53,764	WIP			Static snow map
SARB	56,055	WIP		5	Input format
Inversion	22,321	WIP		24	ADM Models
Clouds	259,841	WIP		24	VIIRS inputs, Cloud property rad xfr for new spectral ch,
GGEO	39,865	WIP		24	Like clouds
Synoptic SARB	5,820	Running on Magneto		5	Input format
TISA-Gridding	31,173	WIP			
TISA-Averaging	81,439	WIP			
MOA	10,287	Running on Magneto		6	NCEP 4d Assim, 3/6hr forecast
Prep Work		Cluster, SAN, define scientifically identical for each SS	Development Platform, Compiler Selection, Toolkit		Input data formats



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CERES Aqua/Terra Data Products

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.



Launch, Early Orbit & Activation

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- ASDC
 - Ready to process 1 year before launch
 - Support initial testing of C/V, ValRx data products
 - Algorithm and code adjustments as data is examined
 - Access to data by Science Team
 - Support Production of Beta, Edition data products
 - Accept code changes
 - Reprocessing of data
 - Public Release approval by CERES Science Team
 - Add FM-5 data products to CERES Climate Data Repository
 - ANGe ordering tools
 - ECHO, if ESDIS so desires



CERES Cal/Val's all Data Products

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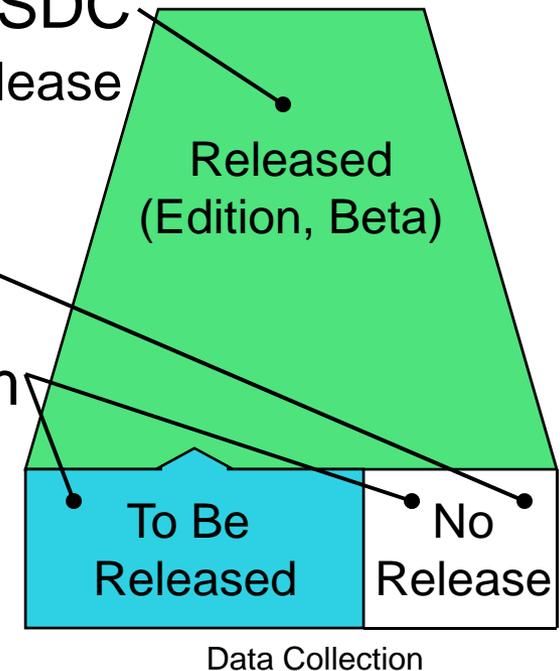
- Each data product is validated before it is released to the public
 - Comparison against other data sources
- Calibration of Instrument
 - Start with ACCURATE characterization on ground
 - Intercalibration with Aqua, Terra, GERB
 - Intercalibration with available Ground Stations
 - 3-month, 6-month instrument analysis
 - 5-year instrument analysis



Data Distribution External to LaRC

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- Primary Access Control by LaRC Center Firewall
- Controls based on Relationship to Instrument Teams
 - Released Data Products Published by ASDC
 - Data Quality Summary required for Public Release
 - Ordered via standard EOS/LaRC tools
 - Collaborate with non-local Scientists
 - Data derived from data products
 - Collaborate with non-local Science Team
 - Unreleased data products for cal/val
 - CALIPSO data to CNES partners
- ASDC Distribution via many tools
- SCF Distribution via ftp or http at scientists request
 - Web/ftp server farm
 - Permit public to run codes of interest on cave website





CERES on NPP

Phase 2 Kickoff for Ground Systems

Backup Data



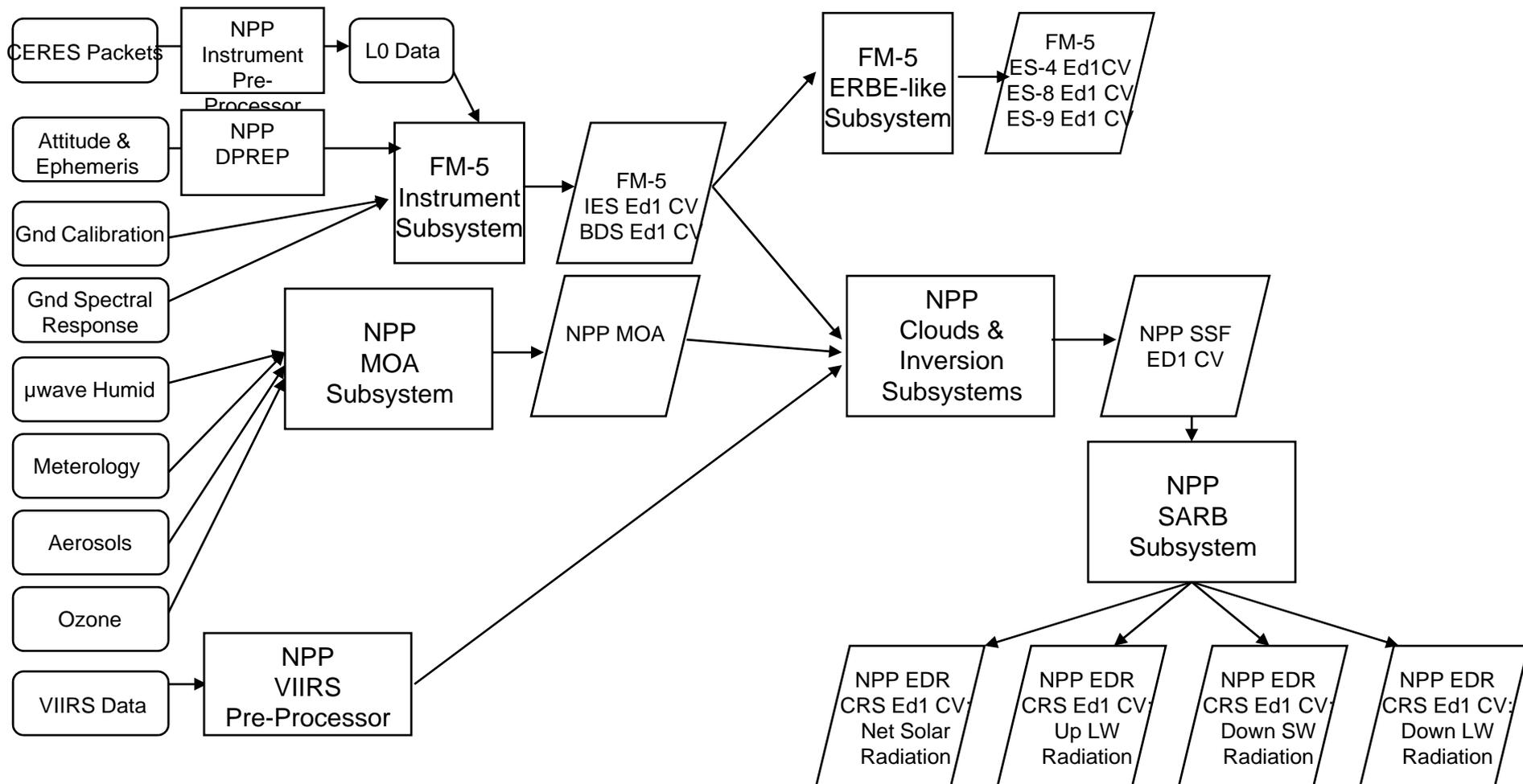
FM-5 Work at ASDC

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- Hardware
 - Processing for cal/val, initial production, re-processing
 - Storage for inputs, data products
- Ingest
 - Workflows for any new/mod inputs
- Distribution
 - Minor work for ordering
 - Resolve ECHO inclusion
 - Pipeline to CLASS
- Production
 - Same model as Terra, Aqua
 - New PGE's
- Reporting
 - Need to determine statistics/metrics required by SDS



NPP FM-5 EDR & Calibration Processing





CERES ICD

- Ingest Inputs
 - Prefer subscription/push model
 - Inputs are stored for use in later re-processing
- Deliver Data Products
 - Plan for Delivery to Public
 - Need permanent public archive to provide long time series Climate-quality Data Record
 - Archive data products for trend analysis, cal/val



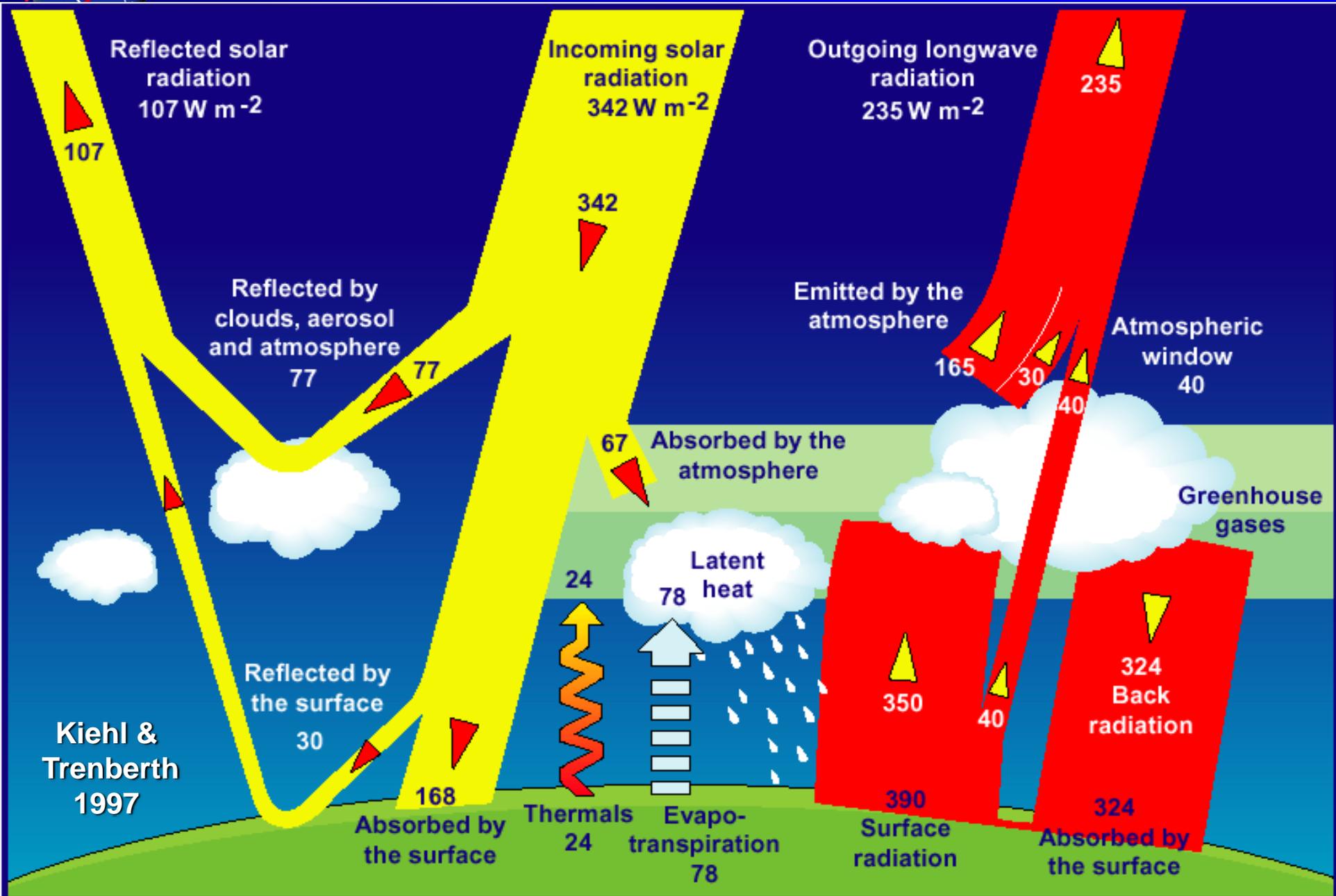
Discovery Needs Data Fusion

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- Permit focus on climate physics vs. instrument output
 - High quality measurements
 - Description of calibration quality, errors
- Integrate multiple sources into consistent data sets
 - 8-Dimensional sampling problem
 - Use all critical data, regardless of source or location needed to unscramble the physics
 - Must understand the errors in all the inputs and measurements and error propagation through calculations
 - Use for both computation and visualization



Climate System Energy Balance:



CERES: Integrated Data for Radiation/Cloud/Aerosol

- 2 to 10 times ERBE accuracy: moving from 5 W/m^2 toward 1 W/m^2
- TOA, surface and atmosphere fluxes
- A radiative 4-D assimilation: integration of surface/cloud/aerosol/atmosphere constrained to TOA flux

Input Data

CERES Crosstrack Broadband
CERES Hemispheric Scan ADMs
MODIS Cloud/Aerosol/Snow&Ice
Microwave Sea-Ice
MATCH Aerosol Assimilation
GEOS 4-D Assimilation Weather
(fixed climate assimilation system)
Geostationary 3-hourly Cloud
Consistent Intercalibration

Output Data

ERBE-Like TOA Fluxes (20km fov, 2.5 deg grid)

CERES Instantaneous TOA/Sfc/Atmosphere Flux
- 20km field of view (SSF, CRS products)
- 1 degree grid (SFC, FSW products)
- Fluxes, cloud & aerosol properties

CERES Time Averaged TOA/Sfc/Atmosphere
- 3-hourly, daily, monthly
- 1 degree grid (SRBAVG,AVG, ZAVG products)
- Fluxes, cloud and aerosol properties



What does it take to do climate data product fusion at this complexity and accuracy?

- **A divide and conquer working group structure**
 - *Algorithm working groups and chairs: instrument cloud, anisotropy, surface flux, surface & atmos fluxes, time interpolation & spatial averaging*
 - *Data Management working group*
 - *Atmospheric Sciences Data Center for production archive and distribution*
- **A ton of algorithm, validation, qc, exception handling**
 - *600,000 lines of executable production code*
 - *1 million lines of offline validation/qc code*
 - *2,000 Gbytes of input data per month of CERES processing*



8-Dimensional Sampling Problem

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- wavelength
- latitude
- longitude
- height
- time
- viewing zenith angle
- viewing azimuth angle
- solar zenith angle



Radiation and Climate Sciences Needs

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- Support Scientific Processes
 - Remote Sensing data production
 - Develop and maintain code
 - Produce and make available data products from sensor inputs
 - Support field campaign, flight experiments and in situ measurements
 - Calibration and Validation of instruments, algorithms and data products
 - Collaboration with other Scientists in Investigations
 - Produce data products
- Provide access to Data
 - Minimize the time delays and effort due to staging
 - Standard directory architecture allows software to run on any machine
 - Metadata to locate appropriate data sets and their coverage
 - Analysis of phenomena using all available measurements
 - Support scientist's code development
- Interoperability with non-local Earth Sciences Community
- User Services
 - Assist Users in applying the tools and resolving IT problems



Overview of CERES Data

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- Produce Climate Quality Data Records
 - Long time series with low signal amplitude
 - Stability and Calibration/Validation
- Development of Codes for Data Product Production
 - Initial production
 - Long production runs with same codes
 - Regular Re-processing to incorporate improvements
- Support for Calibration/Validation of each Data Product
 - Evaluate for Release
 - Evaluation of Algorithms/Codes/Data Products
 - Intercalibrate with other instrument measurements
- Production of Data Products
- Release of Data Products



SCF Capabilities

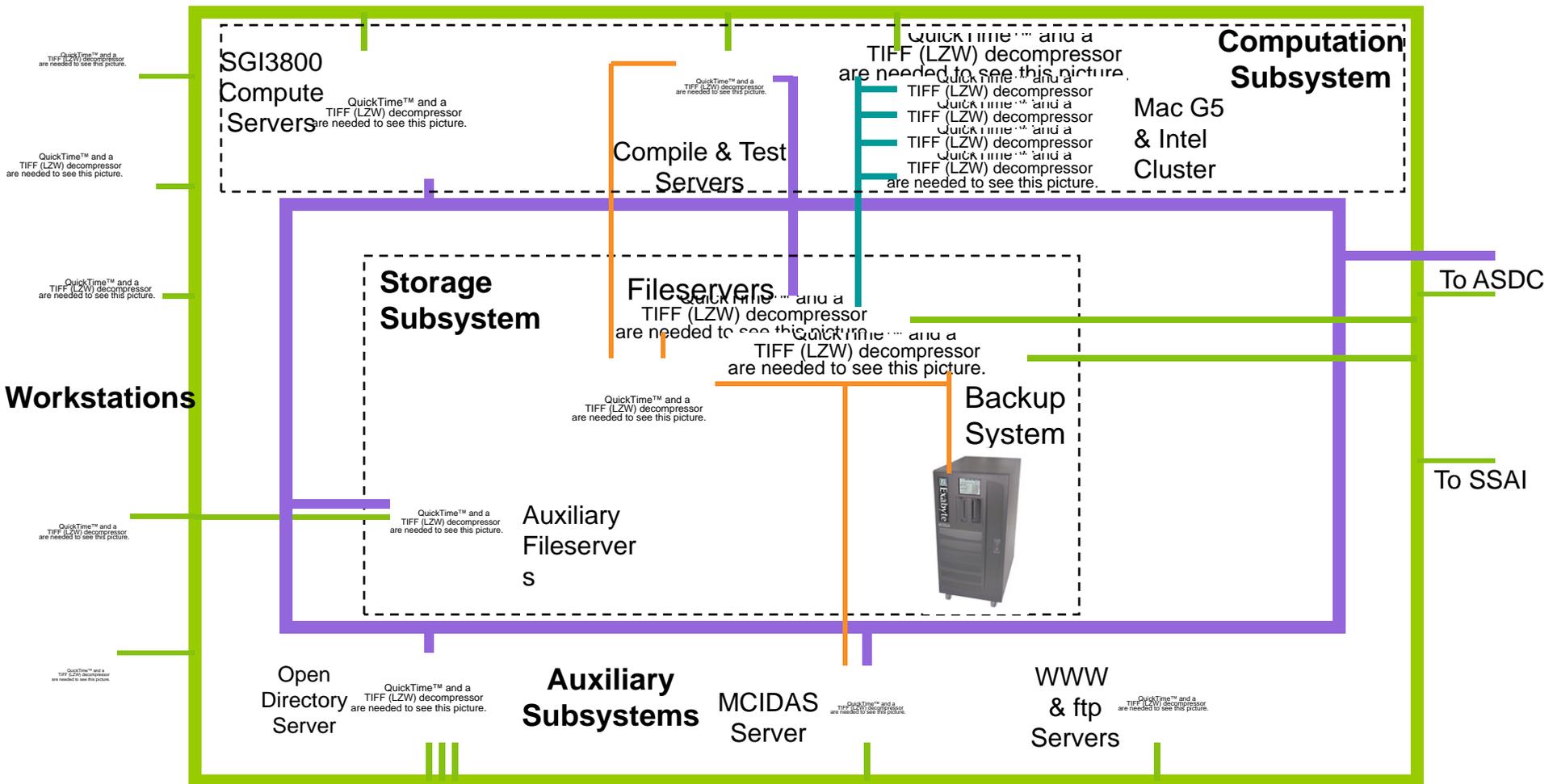
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- Computation
- Storage
- Communications
- Authentication, file ownership, permissions management
- Printing
- Backup
- Web Services
- Exchange of data with external partners
- Security Services
 - Log collection and analysis
- User Services
- User Workstations



CERES SCF Simplified Architecture

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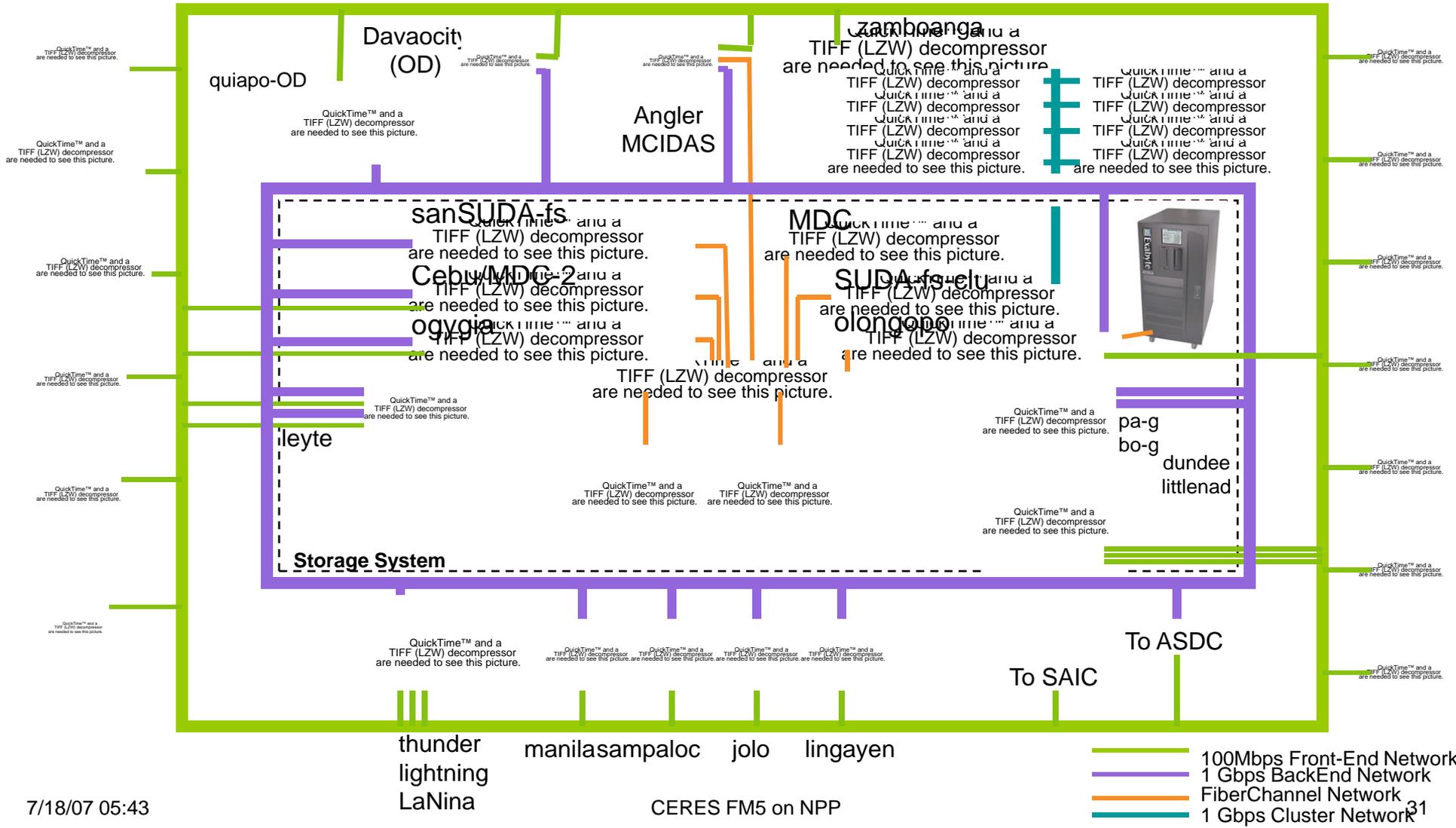


- 100Mbps Front-End Network
- 1 Gbps BackEnd Network
- FiberChannel Network
- 1 Gbps Cluster Network



CERES SCF Target Architecture

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SCF Component Status

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Component	Current Status	Dec 2007	Comments
SAN	120TB	200TB	Add 100TB annually
Backup/Archive	To Tape (120TB)	To Tape (200TB)	Split Archive & Revolving BU
Compile Server	G5:1x1p, 1x4p Intel:1x4p	G5:1x1p, 2x2p, In:1x4p	Start Assessing Intel processor
Cluster/SGE	G5: 50 nodes	G5: 50 nodes Intel: 4 nodes	Start Assess Intel queuing issues
SGI3800	Kill Local Disks (Jul)	Operational	Maint ends 4/8
WebServers	Redundant, Load Balanced Servers		Data from User File Servers
Compilers	GCC, xlf, SGI, NAG	GCC, xlf, SGI, NAG	GCC, xlf, SGI, NAG
Comms	FEN-100Mbps BEN-1GigE	FEN-100Mbps BEN-10GigE	FEN=> users BEN=> data xfr ASDC-FiberChannel



CERES SCF Cluster Concept of Ops

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- User develops and tests code on individual workstation
- User does final testing and interactive production on manila, corregidor, (+2)
- To perform larger test, use zamboanga (G5 cluster)
 - Is it a short, simple run with data already staged?
 - Prepare job request file and put in scheduler in-box
 - Is it a complex or production-like run?
 - Is this SS already configured for S4PM
 - Prepare an S4PM job request (looks like a PR)
 - If not, work with Scott Zentz to create S4PM infrastructure
- Production Runs (NEWS, AVX)
 - Standing PRs using S4PM to test for data availability and then run jobs in proper order



Local Data Access

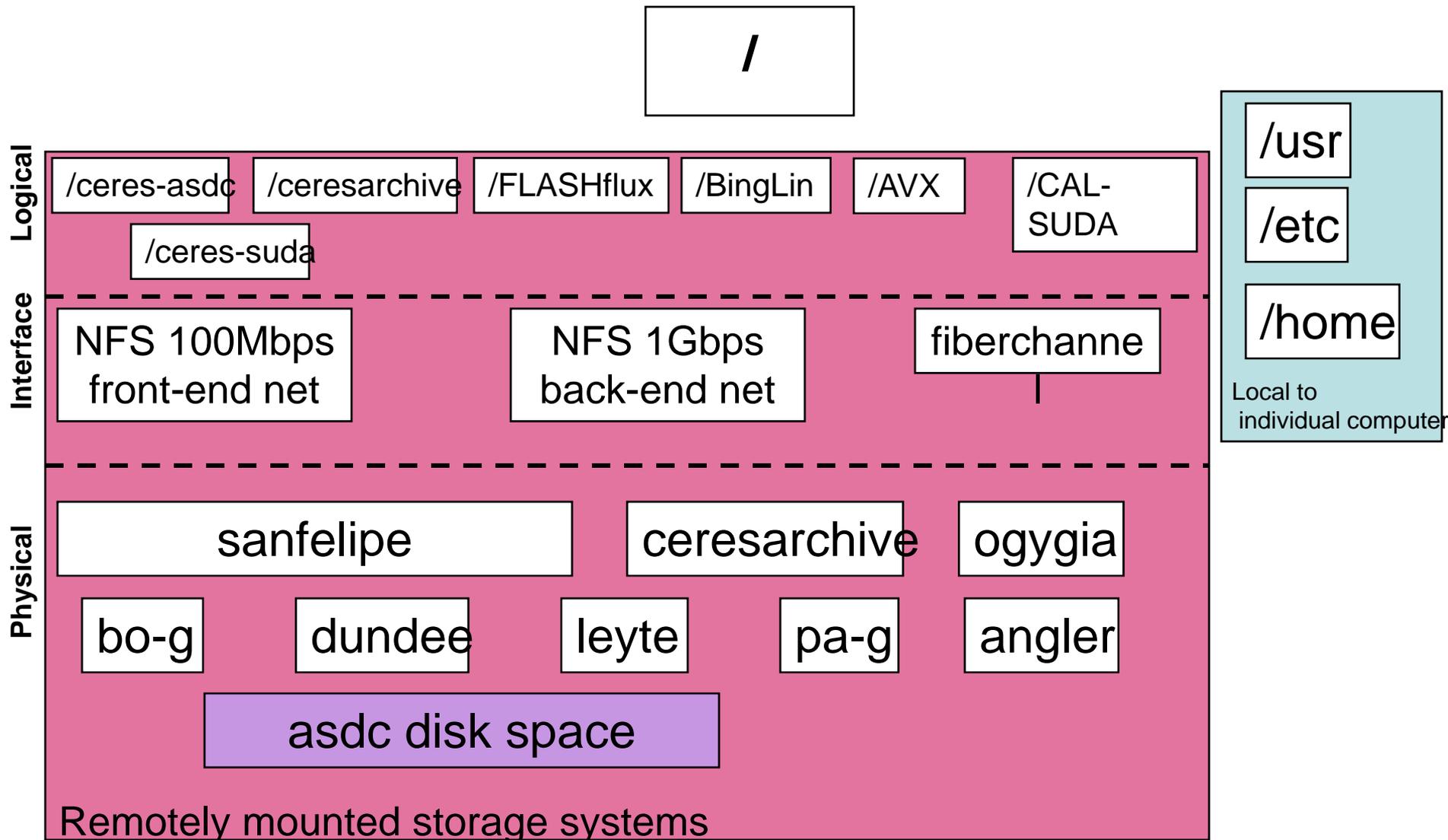
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- **Objective: Data access without staging**
 - Enhances scientific processes of discovery and analysis
 - Data fusion helps transform processes from instrument measurements to analysis of phenomena
 - Need long time-series to understand climate processes
 - CERES, CALIPSO, MODIS, Cloudsat, AMSR, GMAO, Match aerosols, NCEP, ISCCP, ERBE
- **Implement multi-tiered processing capability**
 - Integration of workstations into high capacity computation and large volume data-access environments
 - Run code for small, exploratory data analysis on workstation
 - Migrate code without significant change to high-capacity cluster or multi-processor environment
 - When need large-scale processing or improved data I/O



Logical File Architecture

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Communications Upgrades

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- Upgrade back-end network to 10Gbps
 - Expand reach to upstairs computer room
 - Coordinate acquisition, interoperability and schedule with ASDC
- Foreign-national firewall
 - Isolate SD assets from remainder of LaRCNet
 - Needs coordination with LaRC OCIO



IT Security

- Confidentiality
 - Limited ITAR data - Instrument commands
- Integrity
 - Ensure data persists without unauthorized change
- Availability
 - Ensure systems and data can be used by scientists
- Issues
 - Certification and Authorization Process in Progress
 - System Security
 - Personnel Security
 - Collaboration with non-US citizens



Translating Algorithms into Tools

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- 12 Subsystems each with multiple PGEs
 - Described by ATBDs
- Subsystem Working Groups
 - Collaboration between Scientists & Data Management staff
 - Develop production codes
 - Analyze resulting production runs for validity & release
 - Identify opportunities for cal/val
 - Evaluate cal/val results to improve algorithms/codes
 - Document science/codes, cal/val efforts, data product quality
 - Evaluate changes to input data for impact on related products



Code Development Model

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- Apply principles of software engineering without inhibiting scientific research
 - Code supports the scientific investigation, not end product
 - Validation troubleshoots the entire process
 - Ensure code implements the scientists algorithm
 - Data Quality Summary qualifies inputs, limitations, errors
 - Long term support of the code
- Migrate from single-platform to multi-platform model
 - 40-year record requires platform-independent data products
 - CDC to SGI to Mac/SGI/IBM/Sun
 - Big-endian to to big/little endian to endian-independent
 - Code Conversion in progress to achieve multi-platform capability
- Code Development Tools
 - Software engineering tools: CVS
 - Code Development
 - Compilers, debuggers, execution analysis in UNIX and Windows
 - IDL, F90, F95, MPI, Ada, C, C++, Perl, MATLAB
 - Satellite Toolkit, HDF4/5, netCDF, cereslib, CALIPSO Framework, viewHDF



SCF Feeds into ASDC

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- Code Delivery Process imposes producibility on Codes
 - Permits scientists max flexibility in implementing algorithms
 - Forces sufficient conformity to deliver for production
- Completing a migration to data-centric model
- Leverage Heterogeneous computing environment
 - Improve performance for fixed funding level
- Web-based publishing and distribution
 - Metadata catalog in progress for local data sets
- Consultation and Support
 - Common System Admin
 - Compiler expertise
 - Code migration support



CERES Code Conversion

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- Based on running on a single processor
 - Multi-processing issues handled by cluster effort
- Code Clean-up
 - Lessons Learned from Donaldson experience
 - Coding practices (common block, data, mixed-mode arithmetic)
 - Documentation and CM to track what is certified
 - Re-examine granularization of data to be processed
 - Eventually address bit-ordering to permit use of Intel processors
- Code Certification
 - Develop code certification process for each SS
 - Automate code certification testing
 - Use for all code changes as part of delivery
 - CM of code versions, not just data product versions



CERES/NPP VIIRS Channels

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Channel	λ_c (nm)	$\Delta\lambda$ (nm)	Wavelength Type	Radiance Type	Spatial Resolution Type	Focal Plane Assembly	File Size (GB)	Daily Quantity	Total GB Daily
M5	672	20	VIS	Reflective	Moderate	VISNIR			
M7	865	39	NIR	Reflective	Moderate	VISNIR			
M9	1378	15	SWIR	Reflective	Moderate	SMWIR			
M10	1610	60	SWIR	Reflective	Moderate	SMWIR			
M11	2250	50	SWIR	Reflective	Moderate	SMWIR			
M12	3700	180	MWIR	Reflective	Moderate	SMWIR			
M13	4050	155	MWIR	Emissive	Moderate	SMWIR			
M14	8550	300	LWIR	Emissive	Moderate	LWIR			
M15	10763	1000	LWIR	Emissive	Moderate	LWIR			
M16	12013	950	LWIR	Emissive	Moderate	LWIR			



CERES PGE Status - 1

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Table 1: PGE Current Events Status Table

Subsystem ID	PGE ID	Current PGE Production Status ¹	Scripts NOMAD compliant ? (Y/N)	Scripts EXIT CODE compliant ? (Y/N)	Prod. Platform (W, M, M*) ²	Test Plan in Word? (Y, N, or Review)	Op Man In Excel? (Y, N, or Review)	Comments	
Instrument - 1	CER1.0P1	Developing	Y	Y	Planning W, M ¹	Y	Review	With upcoming delivery	
	CER1.1P1	Active	Y	Y	W	Y	Review	With upcoming delivery	
	CER1.1P2	Disabled	N/A	N/A	N/A	Y	Review	? -Activated w/ nxt delivery	
	CER1.1P3	Active	Y	Y	W	Y	Review	With upcoming delivery	
	CER1.1P4	Disabled	N/A	N/A	N/A	Y	Review	? -Activated w/ nxt delivery	
	CER1.1P5	Active	Y	Y	W	Y	Review	With upcoming delivery	
	CER1.1P6	Disabled	N/A	N/A	N/A	Y	Review	? -Activated w/ nxt delivery	
	CER1.2P1	Active	Y	Y	W	Y	Review	With upcoming delivery	
	CER1.3P1	Active	Y	Y	W	Y	Review	With upcoming delivery	
	CER1.3P2	Active	Y	Y	W	Y	Review	With upcoming delivery	
	CER1.3P3	Active	Y	Y	W	Y	Review	With upcoming delivery	
	ERBE-like - 2	CER2.1P1	Active	Y	N	W	Y	N	
		CER2.2P1	Active	N	Y	W	Y	N	
		CER2.3P1	Active	N	Y	W	Y	N	
CER2.3P2		Active	N	Y	W	Y	N		
CER2.4P1		Active	N	Y	W	Y	N		
ERBE-like - 3	CER3.1P1	Active	N	Y	W	Y	N		
	CER3.2P1	Active	N	Y	W	Y	N		
	CER3.2P2	Disabled	N/A	N/A	N/A	N/A	N/A		
Clouds	CER4.1-4.0P1	Active	Y	Y	W	Y	N		
4.1-4	CER4.1-4.1P1	Disabled	N/A	Y	W	N/A	N/A	PCF script email / eos + operations and Sunny	
	CER4.1-4.1P2	Active	N	Y	W	Y	N		
	CER4.1-4.1P3	Active	N	Y	W	Y	N		
	CER4.1-4.1P4	Active	Y	Y	W	Y	N	PCF to eos operations	
	CER4.1-4.1P5	Active	Y	Y	W	Y	N	PCF to eos operations	
	CER4.1-4.1P6	Delivered	Y	Y	W	Y	N		
	CER4.1-4.2P1	Active	Y	Y	W	Y	N		
	CER4.1-4.2P2	Active	Y	Y	W	Y	N		
	CER4.1-4.2P3	Active	Y	Y	W	Y	N		
	CER4.1-4.2P4	Delivered	Y	Y	W	Y	N		



CERES PGE Status - 2

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QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.



CERES PGE Status - 3

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	CER9.1P1	Active	Y	Y	W	Y	N	
	CER9.2P1	Active	Y	Y	W	Y	N	
	CER9.3P1	Active	Y	Y	W	Y	N	
	CER9.4P1	Active	Y	Y	W	Y	N	
TISA Avg - 10	CER10.0P1	Developing	Y	Y	Planning W, M ¹	Y	N	
	CER10.0P2	Developing	Y	Y	Planning W, M ¹	Y	N	
	CER10.0P3	Developing	Y	Y	Planning W, M ¹	Y	N	New PGE for plots
	CER10.1P1	Disabled	Y	Y	W	N/A	N/A	Replace with CER10.0P2
	CER10.1P2	Disabled	Y	Y	W	N/A	N/A	Replace with CER10.0P1
	CER10.2P1	Deleted	Y	Y	W	N/A	N/A	
	CER10.3P1	Deleted	Y	Y	W	N/A	N/A	
	CER10.1P3	Disabled	Y	Y	W	N/A	N/A	
	CER10.1P4	Active	Y	Y	W	N/A	N/A	Replace with CER10.0P2 for Terra
	CER10.1P5	Active	Y	Y	W	N/A	N/A	Replace with CER10.0P1 for Terra
GCEO - 11	CER11.1P1	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.1P2	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.1P3	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.1P4	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.1P5	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.1P6	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.1P7	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.1P8	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.1P10	Active	Y	Y	W	Y	N	
	CER11.2P1	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.2P2	Active	Y	Y	W	Y	N	
	CER11.3P1	Disabled	N/A	N/A	N/A	N/A	N/A	
	CER11.4P1	Active	Y	Y	W	Y	N	
	CER11.5P1	Deleted	N/A	N/A	N/A	N/A	N/A	
	CER11.6P1	Active	Y	Y	W	Y	N	
	CER11.7P1	Developing	Y	Y	Planning W, M ¹	Y	N	
Regrid MOA -12	CER12.1P1	Active	N	Y	W, M	Y	N	