Earth System Research Laboratory

Global Monitoring Annual Conference

Integrated Climate Observing and Monitoring:

A New Paradigm

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Traditional and Historic NOAA Practice

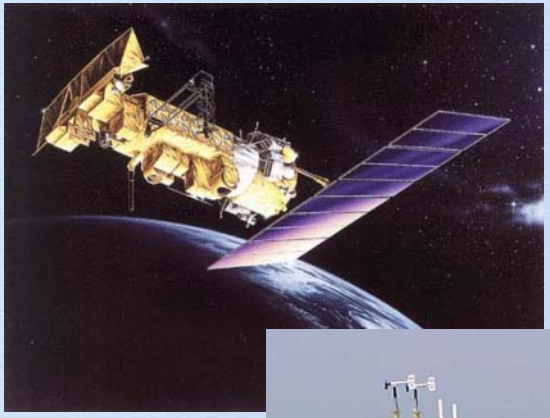
- Observing system justified on the basis of a requirement, but focused on a single observing method, e.g.,
  - Satellite platform
    - Geostationary
    - Low earth orbiting
  - In situ observations
    - Mobile
    - Fixed
  - Monitoring
    - Entirely separate activity

New Paradigm for NOAA

- Consider multiple observing systems for specific Essential Climate Variables (ECVs)
  - For example – Sea Level:
    - Tide gauges
    - Altimetry
    - Sub-surface ocean temperature
    - Glacier
    - Ice sheets

Characteristics of "Climate" Observing Systems

- Science-based
- Operations and maintenance are a high priority
- Measure 1 or more variables using a single approach
- Calibration is a high priority



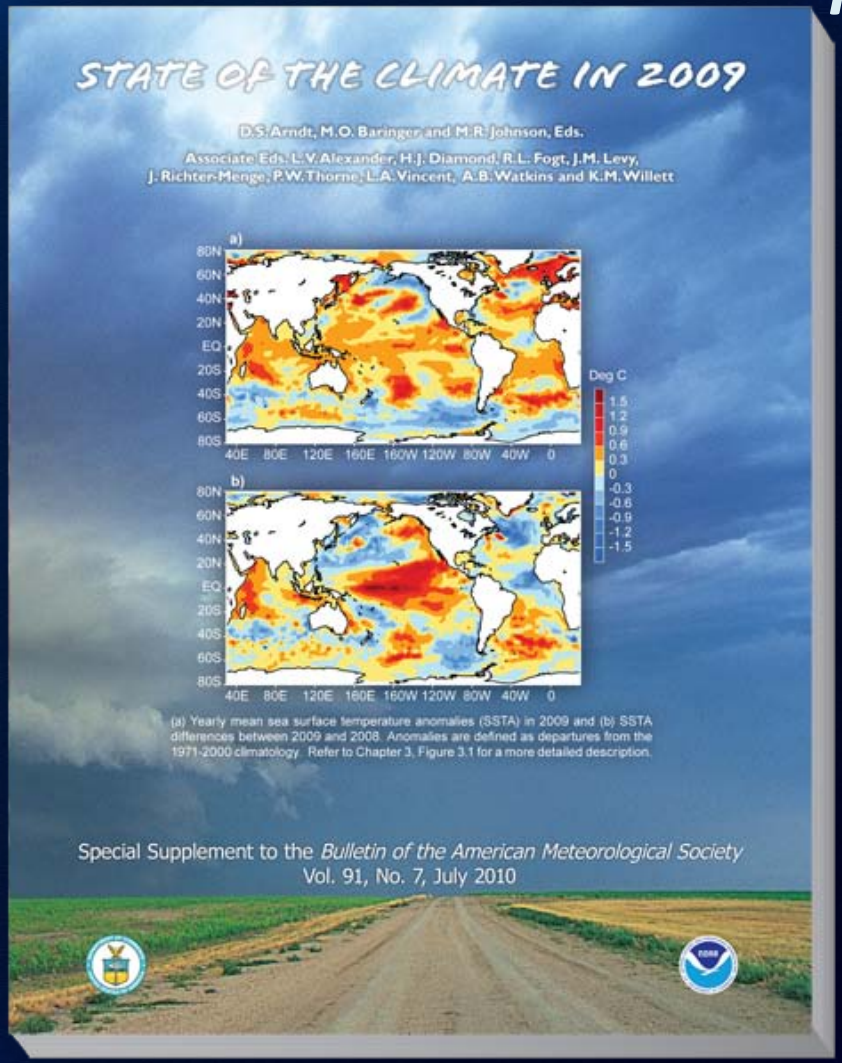
Characteristics of Integrated "Climate" Observing System

- All of the previous slide
- Measure a single or multiple variables using multiple approaches
  - Independent observing methods for the same variable

Characteristics of "End to End" Climate Monitoring

- Transformation of observations into a time series with known uncertainties related to time-dependent and random errors
  - Requires peer-reviewed, science based processing
  - Transparency and reproducibility
  - Expert analysis and interpretation
  - Open reviews
  - Public availability of all steps (barring classified information)
- Independent science teams to transform time series into homogeneous climate time series with known structural errors
- Communications – unmet need

BAMS *State of the Climate in 2009: A mean to assess current paradigm*

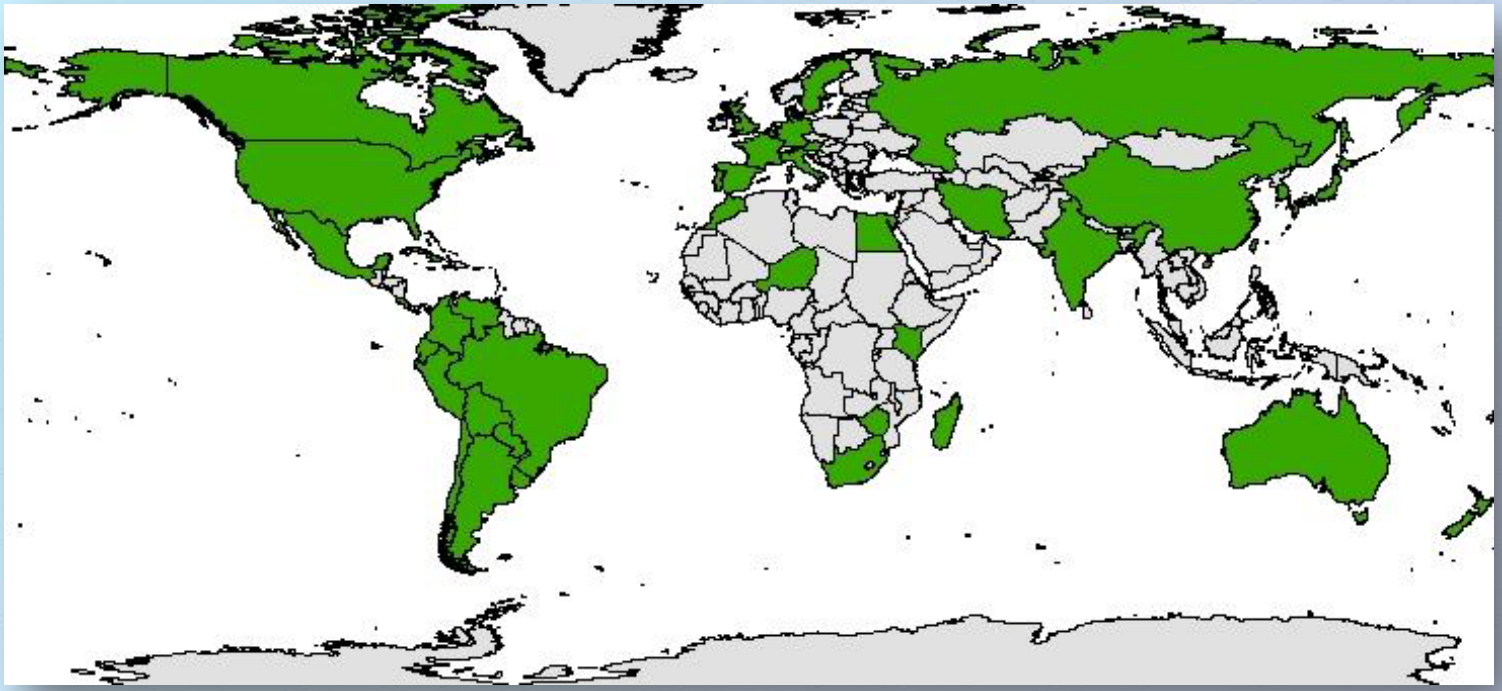


back cover

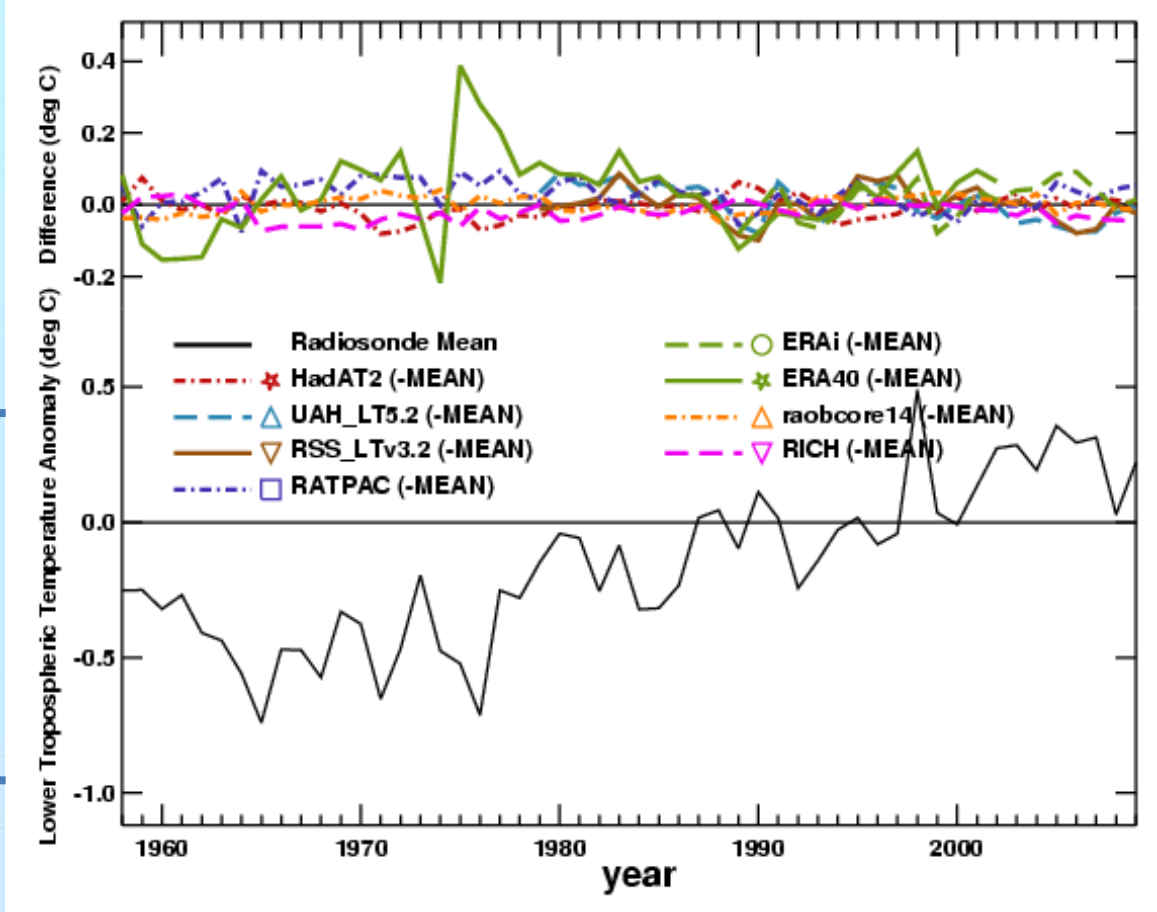
front cover

BAMS *State of the Climate* Report

- 302 authors from 168 institutions in 47 nations
- Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Canada, Chile, China, Colombia, Comoros, Costa Rica, Cuba, Denmark, Ecuador, Egypt, France, Germany, India, Iran, Italy, Jamaica, Japan, Kenya, Madagascar, Mauritius, Mexico, Morocco, New Zealand, Niger, Paraguay, Peru, Portugal, Russia, Seychelles, Solomon Islands, South Africa, South Korea, Spain, Sweden, Taiwan, United Kingdom, United States, Uruguay, Venezuela, Zimbabwe



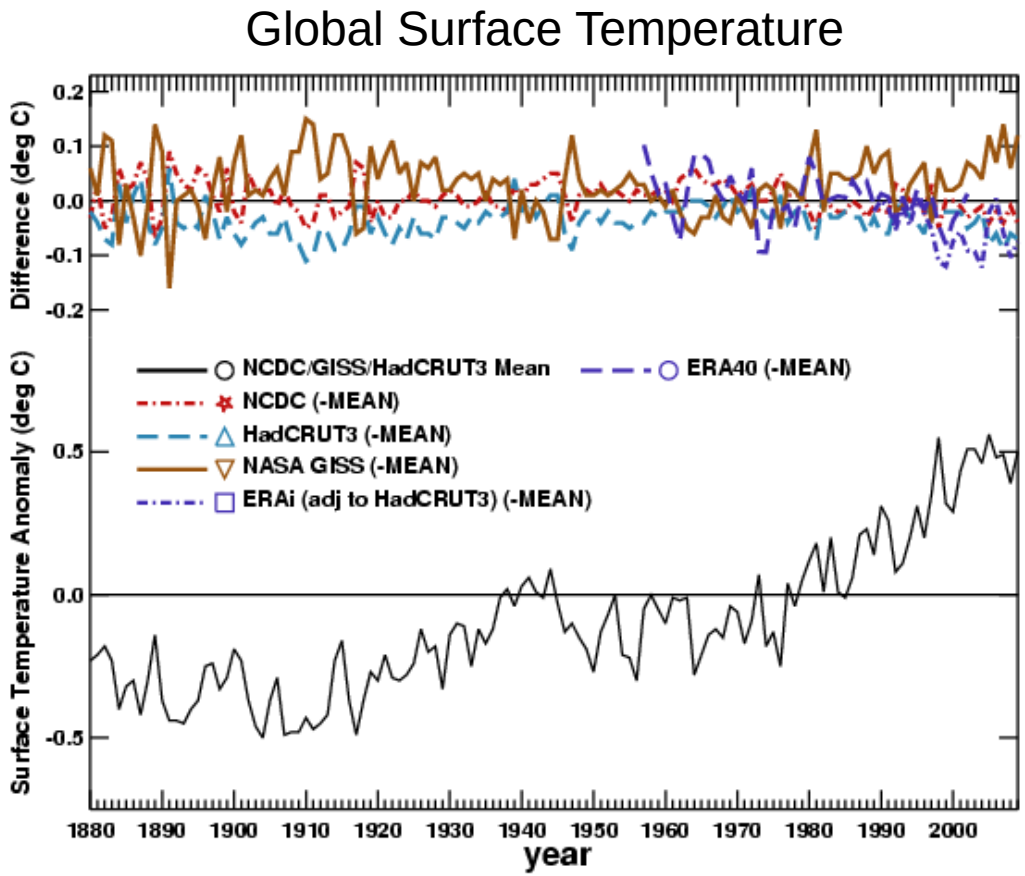
Essential Climate Variable:
Tropospheric Temperature



Baseline: mean of balloon-borne global in-situ datasets

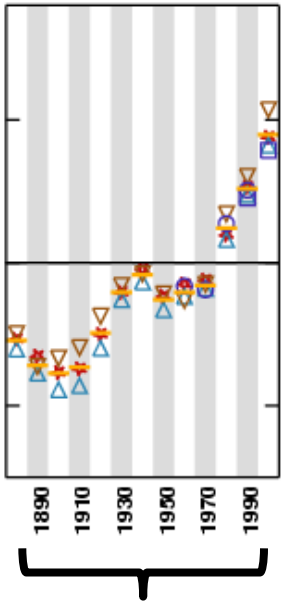
OBSERVING
Satellite-borne (MSU, from multiple sources)
Balloon-borne (RATPAC)
Reanalysis Data

Independent Science Teams Analyzing the Same Essential Climate Variable



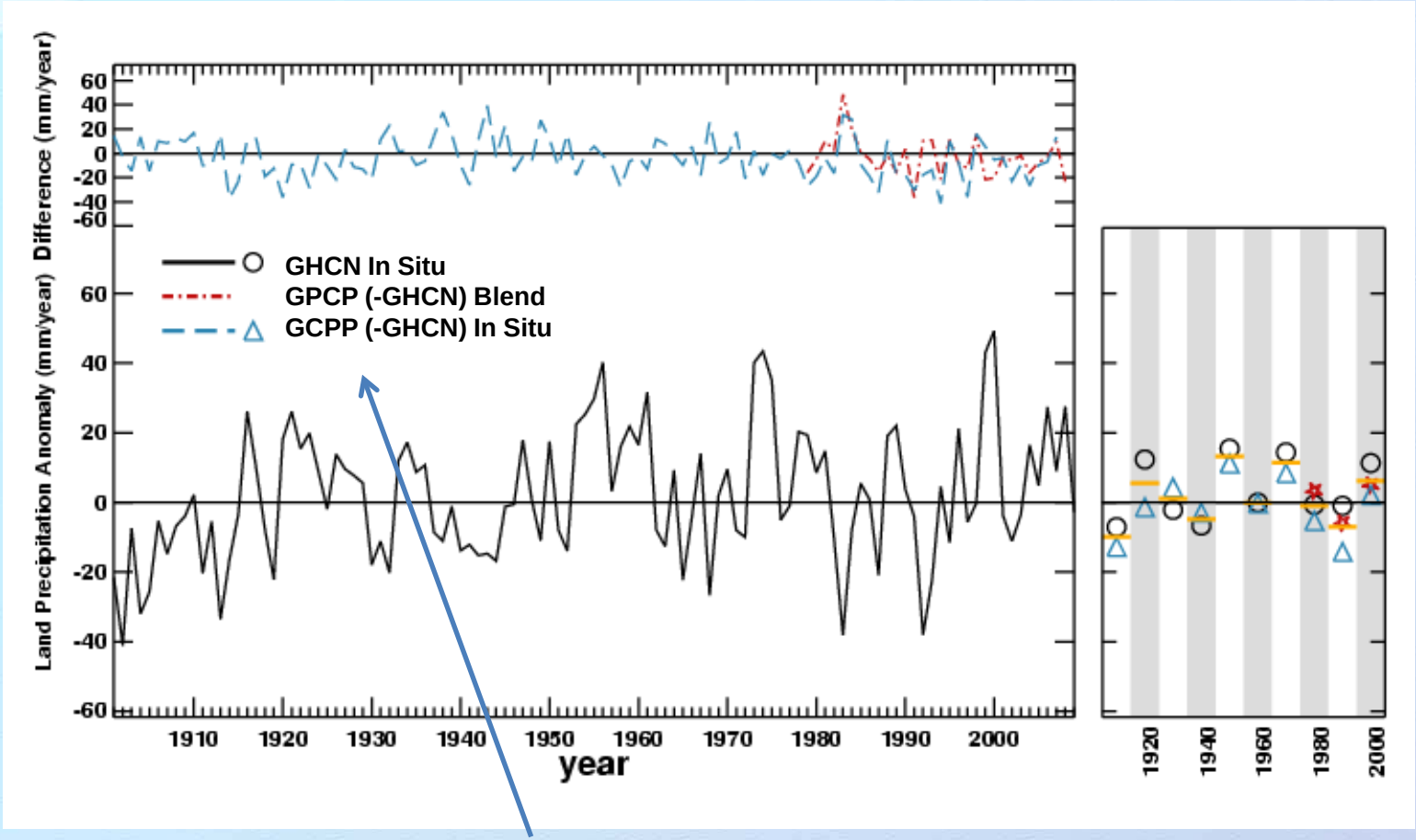
Annual intercomparison of anomalies from each data set. Establish how the different data sets perform vs. each other.

Baseline: mean of three major global in-situ datasets



Decadal-average anomalies of these datasets

Essential Climate Variable: Global Precipitation



Precipitation data sets contain varying composition of satellite-derived and in-situ observed precipitation.

State of the Climate – Essential Climate Variables

Domain	Essential Climate Variable	2007	2008	2009
Atmospheric Surface	Air temperature	Y	Y	Y
Atmospheric Surface	Precipitation	Y	Y	Y
Atmospheric Surface	Air pressure	N	Y	Y
Atmospheric Surface	Surface radiation budget	N	N	N
Atmospheric Surface	Wind speed and direction	P	P	P
Atmospheric Surface	Water vapor	N	N	N
Atmos Upper Air	Earth radiation budget (including solar irradiance)	P	Y	Y
Atmos Upper Air	Upper-air temperature (including MSU radiances)	Y	Y	Y
Atmos Upper Air	Wind speed and direction	N	N	N
Atmos Upper Air	Water vapor	N	Y	Y
Atmos Upper Air	Cloud properties	P	Y	Y
Atmos Composition	Carbon dioxide	Y	Y	Y
Atmos Composition	Methane	Y	Y	Y
Atmos Composition	Ozone	Y	Y	Y
Atmos Composition	[Other long-lived greenhouse gases]:	N	N	P
Atmos Composition	Nitrous oxide	Y	Y	Y
Atmos Composition	Chlorofluorocarbons	Y	Y	Y
Atmos Composition	Hydrochlorofluorocarbons	Y	Y	Y
Atmos Composition	Hydrofluorocarbons	Y	Y	Y
Atmos Composition	Sulphur hexaflurorides	Y	Y	Y
Atmos Composition	Perfluorocarbons	N	N	N
Atmos Composition	Aerosol properties.	Y	Y	y

Domain	Essential Climate Variable	2007	2008	2009
Ocean surface	Sea surface temperature	Y	Y	Y
Ocean surface	Sea surface salinity	Y	Y	Y
Ocean surface	Sea level	Y	Y	Y
Ocean surface	Sea state	N	N	N
Ocean surface	Sea ice	Y	Y	Y
Ocean surface	Current	Y	Y	Y
Ocean surface	Ocean color (for biological activity)	Y	Y	Y
Ocean surface	Carbon dioxide partial pressure	P	P	P
Ocean subsurface	Temperature	Y	Y	Y
Ocean subsurface	Salinity	N	N	N
Ocean subsurface	Current	P	P	P
Ocean subsurface	Nutrients	N	N	N
Ocean subsurface	Carbon	Y	P	P
Ocean subsurface	Ocean tracers	N	N	N
Ocean subsurface	Phytoplankton	N	N	N
Terestrial	Soil moisture and wetness	P	P	P
Terestrial	Surface ground temperature	N	N	N
Terestrial	Subsurface temperature and moisture	N	N	N
Terestrial	Snow and ice cover	Y	Y	Y
Terrestrial	Permafrost & Seasonally Frozen Ground	P	P	P
Terestrial	Glaciers and ice sheets	Y	P	P
Add'l Terrestrial	River discharge		P	P
Add'l Terrestrial	Water use		N	N
Add'l Terrestrial	Ground water		N	N
Add'l Terrestrial	Lake levels		N	P
Add'l Terrestrial	Albedo		N	N
Add'l Terrestrial	Land cover (including vegetation type)		P	N
Add'l Terrestrial	Fraction of absorbed photosynthetically active radiation (fAPAR)		Y	Y
Add'l Terrestrial	Leaf area index (LAI)		N	N
Add'l Terrestrial	Biomass		N	P
Add'l Terrestrial	Fire disturbance		N	P

Essential Climate Variables (ECVs):
Atmospheric Surface

ECV	2009	Variable	Source		
Air temperature	Y	Sfc Temp	GHCN	ERSST	
		Sfc Temp	HadCrut		
		Sfc Temp	GISS	HadCRUT3	NCDC
Precipitation	Y	Precipitation	RSS	GHCN	
		Precip Anomalies	GHCN	GPCC	GPCP
		Precip (Ocean <60lat))	RSS	GPCP	CMAP
		Precip (Ocean <60lat))	RSS		
Air pressure	Y	MSLP	Had	NCEP/NCAR	
Surface radiation budget	N				
Wind speed and direction	P	Wind Speed	AMSR-E		
		Wind Speed	AMSR-E	SSM/I	
		Wind Speed	AMSR-E	SSM/I	

KEY

Satellite-based	In-situ	Ground-Based Remote Sensing	Reanalysis

Essential Climate Variables (ECVs):
Atmospheric Upper-Air

ECV	'09	Variable	Source					
Earth rad'n budget	Y	TOA ERB	CERES					
Upper-air temperature	Y	Lower Strat	RSS-MSU					
		Lower Strat	HadAt2	RATPAC	RICH	UAH	RSS	ERAi
		Lower Strat	ERAi	ERA-40				
		Lower Trop	ERAi					
		Lower Trop	HadAt2	RATPAC	RICH	UAH	RSS	ERAi
		Lower Trop	ERAi	ERA-40				
Wind speed & direction	N							
Water vapor	Y	Total Column WV	SSM/I	GPS				
		Total Column WV	GPS	SSM/I	COSMIC			
		Total Column WV	SSM/I	AMSR-E				
Cloud properties	Y	Cloudiness	PATMOS-x					
		Cloud anomaly	PATMOS-x					
		Cloud anomaly	ISCCP	MODIS	MISR	PATMOS-x	Sfc Obs	

KEY

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Essential Climate Variables (ECVs): Atmospheric Composition

ECV	'09	Variable	Source		
Carbon dioxide	Y	monthly CO_2	ESRL observatories		
Methane	Y				
Ozone	Y	Ozone	GOME-2		
		Ozone	GOME-1	GOME-2	
		Ozone	GOME-	spectrometer	
		Upr Strat O_3	lidar	micro spect.	SBUV SAGE HALOE
Other long-lived GHGs	P				
Nitrous oxide	Y		ESRL observatories		
Chlorofluorocarbons	Y		ESRL observatories		
Hydrochlorofluorocarbons	Y		ESRL observatories		
Hydrofluorocarbons	Y		ESRL observatories		
Sulphur hexaflurorides	Y				
Perfluorocarbons	N				
Aerosol properties.	y				

KEY

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Essential Climate Variables (ECVs):
Ocean Surface

ECV	'09	Variable	Source	
Sea surface temperature	Y	SST	OISST	
		SST	OISST	
		SST	ERSST v3b	
Sea surface salinity	Y	Salinity	Argo	
Sea level	Y	SSH	SSALto / Duacs	UHawaii gauge
		Global MSL	TOPEX/Poseidion	Jason
		Global MSL	Argo	GRACE
		Sea level Variability	Tide gauges	
Sea state	N			
Sea ice	Y	Sea Ice Extent	NSIDC	
Current	Y	Zonal anomalies	OSCAR	
		Zonal anomalies	OSCAR	
Ocean color	Y	Chlorophyll	SeaWIFS	
			SeaWIFS	
CO2 partial pressure	P	Air-sea flux	Park et al	

KEY

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Essential Climate Variables (ECVs):
Ocean Sub-Surface

ECV	'09	Variable	Source		
Temperature	Y	Upper OHCA	Hadley	NODC	PMEL
		Upper OHCA	various XBT		
Salinity	N				
Current	P	MOC Components	MOCHA	UK-NERC	
Nutrients	N				
Carbon	P	dissolved inorganic CO_2	CLIVAR		
Ocean tracers	N				
Phytoplankton	N				

KEY

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Essential Climate Variables (ECVs): Terrestrial

ECV	'09	Variable	Source
Soil moisture and wetness	P		
Surface ground temperature	N		
Subsurface temperature and moisture	N		
Snow and ice cover	Y	Snow Cover Extent	GOES
Permafrost	P		
Glaciers and ice sheets	P	Glacier mass	observations
River discharge	P	River Discharge	Gauge data
Water use	N		
Ground water	N		
Lake levels	Y	Lake Levels	JASON
Albedo	N		
Land cover (including veg. type)	N		
Fraction of absorbed photosynthetically active rad'n	Y	fAPAR	SeaWIFS
Leaf area index (LAI)	N		
Biomass	P	Biomass Burning	GEMS/MACC
Fire disturbance	P	Biomass Burning (proxy)	GEMS/MACC

KEY

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Conclusions

- NOAA would do well to use a new paradigm in its strategy for observing and monitoring initiatives
- Integrated "Climate" Observing
  - Multiple platform long-term monitoring requests
  - End-to-end observing and monitoring
  - Communication