1. Climate monitoring principles – note implications for satellite-derived precipitation measurements.

2. Operational climate applications of precipitation data/role of satellite-derived estimates

The following cover primarily applications related to seasonal-to-interannual climate variability, although issues associated with longer time scales and anthropogenic climate change are mentioned. The main operational activities can be separated into monitoring, initialization of prediction systems, and forecast verification.

Climate monitoring is the approximate equivalent of nowcasting on the weather time scale. It is the set of activities that provides knowledge of the current state of the climate system in the context of its historical behavior. Precipitation is among the most crucial parameters for such monitoring, due to its central role in the effect of climate on human society. The products required for operational use include global and regional, with temporal resolution from monthly down to daily or finer. Global products, covering all latitudes with resolution of monthly or better and 2.5˚ latitude/longitude or finer, are required to track the precipitation variability associated with the El Niño/Southern Oscillation (ENSO) and other principal modes of large-scale climate variability. The monitoring of regional variations in water availability, including droughts and floods, requires finer time and space resolution, daily and 10 km, in order to resolve important features. The diagnostic studies required to understand such variability, which are critically linked to operational monitoring, require hourly resolution for regional products. The monitoring of longer time scale variability, including global change, has less stringent requirements for spatial and temporal resolution. All climate monitoring efforts require precipitation datasets with long duration and a lack of artifacts in the temporal record. These requirements present significant challenges to the incorporation of satellite-derived precipitation estimates.

Climate prediction methods include both statistical and dynamical models of varying complexity. In many cases, these models require initialization by historical data, including precipitation. In some cases, climate prediction models must be "spun up" over a period of months or years to achieve a balanced initial state. One example is the initialization of soil moisture used as a part of the prediction of US surface temperature. While the required data for the current operation are obtained from station observations, extension of this methodology to other parts of the world, required to permit improved global forecasts, will require the use of estimates from satellite observations. At present, precipitation initialization is not needed for dynamic models, but investigation of the possibility that it may improve predictions of seasonal-to-interannual variability from coupled ocean-atmosphere models as well as forecasts of weekly-to-seasonal variability from atmospheric models is underway.

Climate forecasts, once issued, must be verified. Since precipitation is one of the most crucial parameters in any climate forecast, its verification is critical. While gauge-based datasets provide useful information in many cases, the use of satellite-derived estimates, and combinations of various sources of information, is necessary to capture the full character of forecast skill. This requirement has two components: the verification of model predictions, and the verification of publicly available forecasts. The latter requirement is generally less stringent, often satisfied by gauge observations alone. However, the success of the various prediction models used in the forecast process requires spatially complete, often global, datasets of precipitation. Here as well, the requirements for forecast verification will generally be met by datasets that satisfy the requirements for climate monitoring.

3. Operation climate precipitation estimation algorithms and products

This first table contains algorithms are merged products based on many inputs, including satellite-derived estimates from geostationary and low earth orbit IR, SSM/I and AMSU B. In general, they all incorporate gauge observations in some fashion. Note that the GPCP daily product uses gauges only in the sense that its monthly totals are constrained to agree with the GPCP monthly values, in which gauge observations are used as input over land. The second table contains algorithms that are based only on satellite observations.

Algorithm	Application	Update frequency	Latency	Space/time scales	Accuracy	Areal/temporal coverage
GPCP monthly	Monitoring, verification, research	Monthly	3 months	2.5˚/monthly		Global/Jan 1979 – present
GPCP pentad	Monitoring, verification, research	Seasonal	3 months	2.5˚/5-day		Global/Jan 1979 – present
GPCP daily	Monitoring, research	Monthly	3 months	1˚/daily		Global – 50˚N-50˚S/November 1997 - present
African	Monitoring	Daily	6 hours	10 km/daily		Africa/April 2000(?) – present
South Asian	Monitoring	Daily	6 hours	10 km/daily		South Asia/April 2001 - present
CAMS/OPI	Monitoring	Monthly	6 hours	2.5˚/daily		Global/January 1979 - present

Algorithm	Input data	Application	Update frequency	Latency	Space/time scales	Accuracy	Areal/temporal coverage
Goddard 3-hourly	IR and microwave (SSM/I, TRMM)	Monitoring	3 hours	6 hours	0.25˚/3-hourly		Global – 50˚N-50˚S/January 2002 – present
GPI	IR	Baseline, input to merged algorithms	30 minutes	15 minutes	Various		Global – 40˚N-40˚S/January 1986 – present
NESDIS/FNMOC Scattering index (Ferraro)	SSM/I	Baseline, input to merged algorithms, monitoring, research	Daily	6 hours	0.25˚/daily 1.0˚/pentad, monthly 2.5˚/pentad, monthly		Global/July 1987 – present
NESDIS High Frequency (Weng and Ferraro)	AMSU	Baseline, input to merged algorithms, monitoring, research	Daily	4 hours	0.25˚/daily 1.0˚/pentad, monthly 2.5˚/pentad, monthly		January 1999 - present
Goddard Profiling Algorithm (GPROF)	TMI, AMSR	Monitoring, research	Daily	4 hours	0.25˚/daily 1.0˚/pentad, monthly 2.5˚/pentad, monthly		November 1997 - present
Wilheit/Chang	SSM/I, TRMM(?)	Baseline, input to merged algorithms, research	Monthly	3 months	2.5˚/monthly		Global ocean/July 1979 – present
TOVS	TOVS/HIRS	Input to merged algorithms, research	Daily	1 month(?)	1˚/daily		Global/January 1979 - present
OPI	AVHRR	Input to merged algorithms	Daily	1 day	2.5˚/daily		Global/January 1979 - present