Algorithm Inventory - CMORPH

1. Description/Theory

Reference: Joyce, R. J., J. E. Janowiak, P. A. Arkin, and P. Xie, 2004: CMORPH: A method that produces global precipitation estimates from passive microwave and infrared data at high spatial and temporal resolution.. J. Hydromet., 5, 487-503.

CMORPH (CPC MORPHing technique) produces global precipitation analyses at very high spatial and temporal resolution. This technique uses precipitation estimates that have been derived from low orbiter satellite passive microwave (PMW) observations exclusively, and whose features are transported via spatial propagation information that is obtained entirely from geostationary satellite IR data. In effect, IR data are used as a means to transport the microwave-derived precipitation features during periods when microwave data are not available at a location. Propagation vector matrices are produced by computing spatial lag correlations on successive images of geostationary satellite IR which are then used to propagate the microwave derived precipitation estimates. This process governs the movement of the precipitation features only. At a given location, the shape and intensity of the precipitation features in the intervening half hour periods between microwave scans are determined by performing a time-weighting interpolation between microwave-derived features that have been propagated forward in time from the previous microwave observation and those that have been propagated backward in time from the following microwave scan. We refer to this latter step as "morphing" of the features.

2. Strengths and Weaknesses

Strengths:

Inaccuracies of the use of IR data for rainfall estimation are eliminated through the sole use of passive microwave retrievals for rainfall derivation.

Both forward and backward in time spatial propagation of PMW rainfall extends the use of relatively accurate, however, instantaneous PMW estimation into spatially and temporally complete precipitation analyses.

CMORPH adequately propagates rainfall that moves relatively in sync with associated high elevation cloud cover.

Weaknesses:

Rainfall that develops, matures, and decays (i.e. especially warm season afternoon convective complexes over land) between all available satellite PMW swaths will obviously not be detected by the PMW estimated rainfall used as input into CMORPH.

Rainfall that does not move in sync with associated high elevation cloud cover will not benefit from the IR derived propagation of CMORPH. An example of this would be the common horizontal wind shear found in South America resulting from a persistent upper level anticyclone, west of the continent, equator-ward pushing cirrus that emanating from rainfall complexes often propagating southward.

3. Algorithm Inputs

A. Satellite Data

1. Geostationary:

The CPC operationally extracts geostationary satellite IR brightness temperature (T_b) information (Janowiak et al., 2001) through the Man-computer Interactive Data Access System archive available from NOAA/NESDIS/OSDPD/SSD. CPC maps each satellite IR image to a rectilinear grid at 0.03635 degrees of latitude and longitude resolution (~ 4 km at the equator), parallax corrects for geometric mis-navigation of high cloud, calibrates IR from all sensors to the GOES East 10.7 micron channel, and corrects for cold limb effect of IR retrieval at large zenith angles (Joyce et al., 2001). Available at CPC, 2.5 hour latency.

Janowiak, J. E. , R. J. Joyce, and Y. Yarosh, 2001: A real-time global half-hourly pixel-resolution IR dataset and its applications. *Bull. Amer. Meteor. Soc.*, **82**, 205-217.

Joyce, R. J., J. E. Janowiak, and G. J. Huffman, 2001: Latitudinally and seasonally dependent zenith-angle corrections for geostationary satellite IR brightness temperatures. *J. Appl. Meteor.*, **40**, 689-703.

A. GOES-12 East (half hourly - 10.7 micron, 15-30 minute delay)
B. GOES-10 West (half hourly - 10.7 micron, 15-30 minute delay)
C. GOES-9 GMS (half hourly - 10.7 micron, 15-30 minute delay)
D. METEOSAT-7 (half hourly - 11.5 micron, 15-30 minute delay)
E. METEOSAT-5 (half hourly - 11.5 micron, 15-30 minute delay)

2. Low Earth Orbit

A. TRMM TMI rainfall (2A-12 GPROF algorithm, available on NOAA/NESDIS gp10.ssd.nesdis.noaa.gov, ~1.5 hour latency)
B. AQUA AMSR-E rainfall (NESDIS algorithm, version 6, ~3 hour latency)
C. DMSP-13,14,15 SSMI rainfall (*primary*: GPROF V-6 algorithm, available on NOAA/NESDIS ftp.orbit.nesdis.noaa.gov, ~1.5 hour latency, *backup*: EDR FNMOC algorithm, available on NOAA/NESDIS gp10.ssd.nesdis.noaa.gov, ~1.5 hour latency)
D. NOAA-15,16,17 AMSU-B rainfall, current NESDIS algorithm, available on NOAA/NESDIS gp10.ssd.nesdis.noaa.gov, ~2.5 hour latency)

B. Ancillary Data

1. Model Data

none

2. In Situ

none .

3. Other (i.e. topography data base)

none

4. Processing (i.e. Level 2 processing ingests Level 1 products as input)

A. Product Development Level 1

1. Develop 30 minute, 8-km matrices of all PMW sensor combined rainfall, calibrated to TRMM TMI 2A-12.

   A. Map all PMW rainfall into rectilinear 0.0727 lat/lon resolution (8-km at equator), 30 min arrays for each sensor-type/algorithm
   B. Calibrate each sensor-type/algorithm rainfall to TMI 2A-12 using frequency matching, heaviest to lightest rain rates, separate for 10 degree latitude bands, and surface type.
   C. Combine sensor-type rainfall for each 30 minute, 8-km map. Order of sensor-type/algorithm preference in overlap reagions [1. TMI, 2. AMSR-E, 3. SSMI (GPROF primary, EDR backup), 4. AMSU-B]

2. Develop 30 minute, 2.5 degree lat/lon PMW rainfall propagation vector matrices.

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   A. Average 4 km 30 minute CPC merged IR to 8 km matrices.
   B. Create 2.5 degree lat/lon cloud system advection vector arrays from spatial lag correlation of successive 30 minute merged IR
   C. Produce PMW rainfall propagation vector matrices by tuning cloud system advection vectors to spatially/temporally matched radar rainfall propagation.

B. Product Development Level 2

1. Propagate and morph PMW precipitation.

A. Spatially propagate, forward in time, 8-km combined PMW rainfall (A.1) from “past” orbits using rainfall propagation matrices (A.2).
B. In a separate processing, spatially propagate, backward in time, 8-km combined PMW rainfall (A.1) from “future” orbits using rainfall propagation matrices (A.2).

C. Morph rainfall by inversely weighting both forward and backward propagated rainfall by the respective temporal distance from observed PMW precipitation.

5. Output Products

A. 30 minute 0.0727 lat/lon (8-km at equator) CMORPH

1. Temporal/Spatial resolution: 30 minute, 0.0727 lat/lon

2. Spatial Coverage: global, 60N-60S

3. Dedicated Product Web Page Location:

http://www.cpc.ncep.noaa.gov/products/janowiak/MW-precip_index.html

4. Processing Specifics
- **A. Latency:** 19 hours
- **B. Update Frequency:** 1 hour

5. Operational Availability of Product
- **A. Source:** ftpprd.ncep.noaa.gov, /pub/precip/global_CMORPH/30min_8km
- **B. Latency:** variable: 20 hours for 23 UTC, 44 hours for 00 UTC
- **C. Update Frequency:** daily
- **D. Available Record Length:** most recent 4 days

6. Historical Availability of Product
- **A. Source:** CPC tape archive
- **B. Update Frequency:** monthly
- **C. Available Record Length:** December 2002 thru August 2005

B. 3 hourly 0.25 degree lat/lon CMORPH

1. Temporal/Spatial resolution: 3 hourly 0.25 degree lat/lon

2. Spatial Coverage: global, 60N-60S

3. Dedicated Product Web Page Location:

http://www.cpc.ncep.noaa.gov/products/janowiak/MW-precip_index.html

4. Processing Specifics

- **A. Latency:** variable: 20 hours for 21-24 UTC, 44 hours for 00-03 UTC
- **B. Update Frequency:** daily

5. Operational Availability of Product

- **A. Source:** ftpprd.ncep.noaa.gov, /pub/precip/global_CMORPH/3-hourly_025deg
- **B. Latency:** variable: 20 hours for 23 UTC, 44 hours for 00 UTC
- **C. Update Frequency:** daily
- **D. Available Record Length:** entire archive [Dec. 2002 – present]

6. Historical Availability of Product (same as 5 above)

6. Planned Modifications/Improvements

Improve NOAA AMSU-B rainfall normalization to TRMM TMI-2A12. Currently work involves a limb dependent beam position correction and improvements in oceanic regions where conical scanner TMI, AMSR-E, and SSMI depict 2-3 times the spatial coverage of rainfall relative to AMSU-B.

Improve upon a modified version of CMORPH (CMORPH-IR) in which IR derived rainfall estimates are substituted for CMORPH derived from PMW scans that are too far from original swath time.

7. Capability of Producing Retrospective Data

One aspect of CMORPH retrospective processing is tied the availability of high resolution IR Since this is what rainfall propagation vectors used are generated from. Merged CPC high resolution IR is available from February 2000 thru April 2002, then a May 2002 thru October 2002 gap, then November 2002 thru present. Work on filling the May 2002 – October 2002 gap is in progress. There are plans to process November 1998-1999 from archived area files.

Another ingredient for CMORPH retrospective processing is orbit file PMW rainfall availablilty. The orbit file format is a requirement since high resolution mapping of the PMW rainfall is essential for finite propagation purposes. PMW orbit files already archived at CPC, however, not processed into CMORPH include the July – November 2002 period. Currently data mining is ongoing for PMW orbit files prior to the July 2002 period.

8. Contact Personnel:

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9. Additional Comments

none