

# Precipitation Virtual Constellation (P-VC)

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WGCV-38

College Park, MD USA

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**Background:** The CEOS Precipitation Virtual Constellation was established in 2007 with the participation of seven CEOS members as one of the four prototype CEOS Constellations.

**Purpose:** Its primary role is to establish an international framework to guide, facilitate, and coordinate the continued advancement of multi-satellite global precipitation missions.

1. To provide a framework for implementation and monitoring of GEO task AR-06-10 (subsequently merged into DA-07-03, AR-09-02, IN-01-C2).

*Advocate and facilitate the timely implementation of the Global Precipitation Measurement (GPM) mission and encourage more nations to contribute to the GPM constellation*

2. To sustain and enhance an accurate and timely global precipitation data record including a Fundamental Climate Data Record essential for understanding the integrated weather/climate/ecological system, managing freshwater resources, and monitoring and predicting high-impact natural hazard events.

*This data record should be fit for the purpose specified by GCOS for the monitoring of Precipitation as an essential climate variable (ECV)*



## CEOS P-VC is unique in having:

1. An existing constellation of precipitation sensors using TRMM as a reference for providing multiple merged multi-satellite global precipitation products for research and applications,
2. An international constellation satellite mission launched in February 2014, the Global Precipitation Measurement (GPM) mission is a realization of the CEOS PC which includes other existing and planned missions capable of observing precipitation like the S-NPP, Megha-Tropiques, GCOM-W1, MetOp-B, and recently launched DMSP F19 satellites.



- The implementation of CEOS P-VC is in four phases

year	2007	2008	2009	2010	2011	2012-2013	2014	2015	2016	2017	2018	2019	2020
phase	study phase	GPM preparatory phase					GPM phase					post -GPM phase	
							<div style="border: 1px solid black; border-style: dashed; padding: 10px; width: fit-content; margin: auto;">GPM</div>						

# P-VC Phase Descriptions



## ✓ Study Phase (2007)

- Startup activities and survey existing P-VC member multi-satellite products: NASA TRMM 3B42, JAXA GSMaP, NOAA CMORPH/QMORPH, NRL-Blend SRE, EUMETSAT MPE

## ✓ GPM preparatory phase (2008-2013)

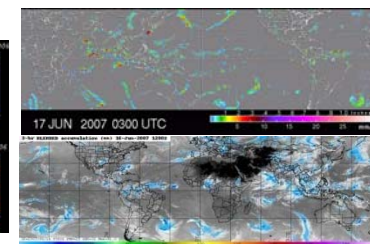
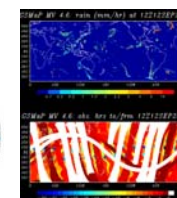
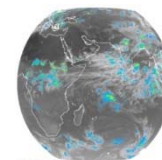
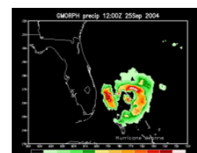
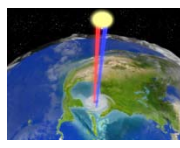
- Comparison of different methods of inter-calibration for generating uniform precipitation estimates from diverse types of precipitation sensors
- Evaluation of different multi-sensor precipitation products
- The prototyping of uses of merged data products from multiple sensors as well as evaluation of tools to support such use

## • GPM phase (2014-2018)

- Launch and operation of GPM, the first constellation-focused mission that will improve precipitation estimates through extensive intercalibration and the use of a reference standard

## • Post-GPM phase (after 2018)

- Beyond timeframe of GEOSS 10-Year Implementation Plan
- Lessons learned from GPM and other P-VC activities will serve to guide the planning and further evolution of CEOS P-VC





- **Reminder of 3-year outcomes**

- P-VC Data Portal
  - WA-01-C1\_3 Phase 1 – “link only” interface
  - WA-01-C1\_4 Phase 2 – “query/results/order based” interface
- Precipitation ECV support – Response to GCOS Action A-8 - Ensure continuity of satellite precipitation products (Deliverables #1, #2, #3, #4, #5 )
- Deployment of GPM phase constellation satellites and maintaining continuity with TRMM
- Advocacy of post-GPM phase P-VC



- **Accomplishments**

- P-VC Data Portal

- Phase 1 of P-VC Data Portal completed (WA-01-C1\_3)
    - Phase 2 of P-VC Data Portal implementation underway (WA-01-C1\_4)
      - Data Portal Phase 2 study (function and architecture) completed and submitted to P-VC agencies

- Precipitation ECV support – Response to GCOS Action A8

- GCOM-W1/AMSR2 L2 data publicly available (Deliverable #1)
    - GCOM-W1/AMSR2 and TMI/AMSR-E intercalibration update (Deliverable #3)
    - Megha-Tropiques/SAPHIR L2 data publicly available (Deliverable #1)
    - CEOS P-VC Microwave Imager Availability White Paper Update completed (Deliverable #1)
    - X-Cal WG meetings at CNES Toulouse Space Center (France), CSU (USA), and College Park as well as weekly videocons (Deliverables #2, #3, #4, and #5)
    - GPM Precipitation Processing System processing L1, L2, and L3 data products and publicly available (Deliverables #2, #3, #4, and #5)





- **Accomplishments (cont.)**

- 6th GPM Ground Validation Workshop (hosted by CNR) held November 4-8, 2013 (Italy) (Deliverables #2, #3, #4)
- Deployment of GPM phase constellation satellites and maintaining continuity with TRMM
  - GPM Core Observatory launched and commissioned with all standard products publicly available at <http://pmm.nasa.gov/data-access>
  - TRMM extended through 3Q2017 based on 2013 NASA Senior Review but out of fuel and slowly descending
- Advocacy of post-GPM phase P-VC
  - CEOS P-VC Microwave Imager Availability White Paper Updated
  - GPM FO meetings held on sidelines of 2013 and 2014 PMM Science Team meetings as well as Integrated Global Precipitation and Clouds mission concept workshop at NASA GSFC
- Planning for 5th P-VC Workshop
  - November 2014, Tsukuba, Japan (on sidelines of 7th IPWG Workshop)



# Cal/Val and the CEOS P-VC



- Advancement of Cal/Val is essential to meeting the goals of the CEOS P-VC and realizing the multi-satellite precipitation measuring systems of the future
- Passive microwave radiometer calibration (e.g. GMI, TMI, AMSR-2, ATMS, SAPHIR, MHS, etc.)
- Passive microwave radiometer inter-satellite calibration (X-Cal WG)
- Space based precipitation radar calibration (e.g. GPM DPR)
- Ground Validation System (GVS) critical component of GPM system
  - Pre-launch retrieval algorithm development
  - Post-launch product validation
  - Major functions/development items: validation network (national, international), field campaigns (DOE, NOAA, international partners), Ku/Ka band Dual-frequency, Dual-polarized, Doppler Radar (D3R)
  - <http://pmm.nasa.gov/science/ground-validation>



## ○ X-Calibration Working Group (X-Cal WG)

- International working group (in coordination with WMO CGMS/GSICS) to develop a consensus reference standard for cross-calibration of microwave radiometers to produce uniform global precipitation products within a consistent framework.
- Fifteen WG meetings held since 2007
- 15<sup>th</sup> WG meeting, July 10-11, 2014, College Park, MD USA
- NASA, JAXA, CNES, ISRO, INPE, CONAE, NOAA, NRL, EUMETSAT, JMA, UKMET, Universities from the U.S. and Asia participate (WGCV/MSSG invited since January 2008)
- Discovered/Fixed Problem in TMI (*ca.* 2K p-p), implemented fix in V7 algorithm
- Implementation of L1C intercalibration processing (conical imagers and sounders) including calibration constants for pre-launch PPS
- Instrument liaisons for 9 contemporary passive microwave instruments
- <http://www.gpm-x-cal.info/>



## ○ Invitation for WGCV/MSSG to participate in X-Cal WG reiterated

- Consider the upcoming X-Cal WG meeting to be held in January/February 2015 in Orlando, FL USA or the 7<sup>th</sup> GPM International Ground Validation Workshop to be held on May 11-14, 2015 in Seoul, Korea
- We also welcome dialog with the P-VC on other aspects of our activities and potential WGCV/MSSG interests/support



- **CEOS P-VC Co-Leads – Steve Neeck, [steven.neeck@nasa.gov](mailto:steven.neeck@nasa.gov), Riko Oki, [oki.riko@jaxa.jp](mailto:oki.riko@jaxa.jp)**
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- **Erich Stocker – Data Systems and P-VC Data Portal Co-lead, [erich.f.stocker@nasa.gov](mailto:erich.f.stocker@nasa.gov)**



Committee on Earth Observation Satellites

WGCV-38

College Park, MD USA

October 1, 2014



# Backup

# Response to GCOS Action A8 - *Ensure continuity of satellite precipitation products*



## ○ Deliverables

1. Sustainment and enhancement of constellation of satellites carrying microwave radiometers (both imagers and sounders) and moderate inclination satellite carrying microwave imager and precipitation radar.
2. Well characterized and stable Level 1B calibrated, geolocated brightness temperature ( $T_b$ ) products from each PC radiometer.
3. Inter-calibrated brightness temperature ( $T_c$ ) products by applying the GPM core observatory reference standard.
4. Precipitation retrievals using physically based a-priori database constructed from combined radiometer/radar measurement.
5. Global monthly PDF of precipitation intensity based on the above.



- **Lead Agencies:**
  - Japan – JAXA: Riko Oki, [oki.riko@jaxa.jp](mailto:oki.riko@jaxa.jp) & USA – NASA: Steven Neeck, [steven.neeck@nasa.gov](mailto:steven.neeck@nasa.gov)
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# Participation (cont.)



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# U.S. P-VC Co-Lead Team



- **Steven Neeck/NASA HQ**
- **Ramesh Kakar/NASA HQ**
- **Gail Jackson/NASA GSFC**
- **Erich Stocker/NASA GSFC (SEO POC, Data Systems)**
- **Scott Braun/NASA GSFC (Visualization POC)**
- **Xiaopeng Hu/NASA GSFC (P-VC Data Portal)**
- **Chris Kidd/NASA GSFC/University of Maryland**
- **Bob Adler/ University of Maryland Baltimore County**
- **Ralph Ferraro/NOAA**
- **Joe Turk/JPL**
- **Ian Adams/NRL**
- **Chris Kummerow/Colorado State University**

# Japan P-VC Co-Lead Team



- **Riko Oki, JAXA**
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- **Toshiaki Takeshima, JAXA**
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- **Yoshiyuki Chihara, Ministry of Education, Culture, Sports, Science and Technology**

# P-VC Approach

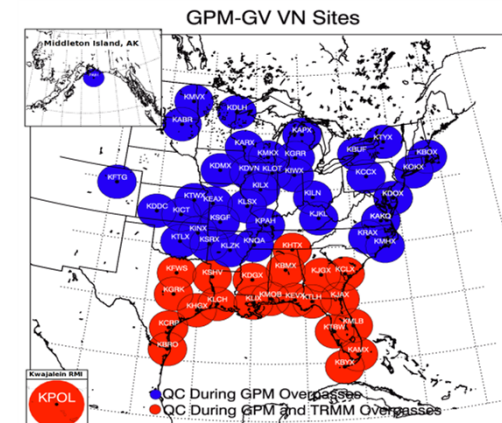
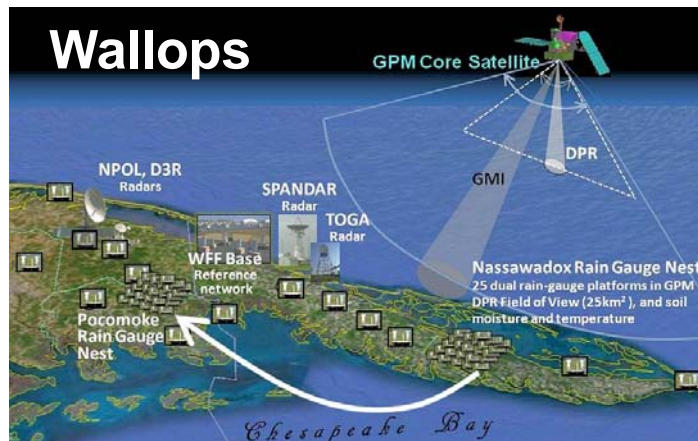


- **Develop a consistent framework to produce inter-calibrated precipitation sensor measurements and retrieval products**
- **Identify key points of agreement for space agency co-operation in order to meet the needs of both the data producer and user communities**
- **Results-focused, identifying what steps are necessary by space agencies (and other groups responsible for product generation, in-situ observations etc) to develop the constellation data sets and information services. CEOS PC should also encourage the development and evaluation of precipitation products produced from the constellation data. This should include inter-comparisons and validation against high quality ground data.**
- **Recognize the Constellation member's national plans for implementing their respective Earth observing programs (e.g. the U.S. Decadal Survey).**
- **Have strong collaboration with the CEOS Working Group on Calibration and Validation (WGCV) and the CEOS Working Group on Information Systems and Services (WGISS)**

# Precipitation Ground Validation



1. **Direct validation** (Satellite retrievals compared to ground observations)
2. **Physical validation** (Understanding remote sensing principles)
3. **Integrated hydrological validation** (Linking to societal benefits)

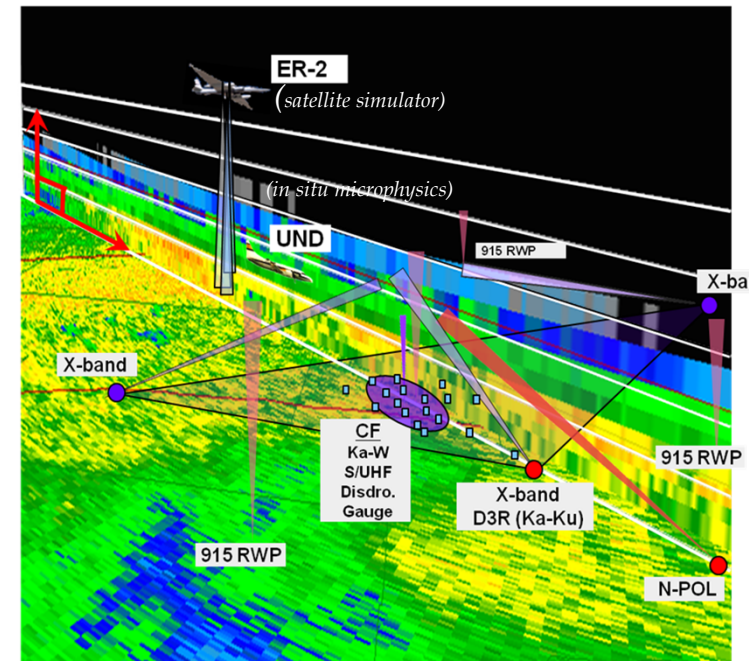




# Ground Validation Status



- Completed six campaigns for **physical validation**:
  - 2 major GPM field campaigns: MC3E (Apr-Jun 2011) & GCPEX (Jan-Feb 2012)
  - 2 leveraged partner campaigns: C3VP (Jan 2007) & LPVEx (Sep-Oct 2010).
  - Contributions to 2 partner efforts: Pre-CHUVA (Mar 2010) & HyMeX (Sep-Oct 2012).
- **Integrated hydrological validation** campaigns:
  - Iowa Flood Study (IFloodS) May-June 2013
  - Integrated Precipitation and Hydrology Experiment (IPHEX): May-June 2014
- **Direct validation**:
  - GV Research Facility at Wallops Island, USA.
  - Operational Validation Network (VN) providing radar and satellite overpass data over CONUS.
  - Automated NMQ rain rate data stream for L2/L3 product validation in testing phase.
- **International collaborations**:
  - GPM GV instruments at 3 Canadian WMO Solid Precipitation Inter-comparison Exp. (SPICE) sites.
  - Finnish Meteorological Institute operates GV instruments in northern Finland (~70N).
  - Agreement with S. Korea on GV data exchange.
  - Collaboration with EUMETSAT H-SAF.



# A Global View of Precipitation with a Global Team

