4th Workshop of the International Precipitation Working Group

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Research Working Group

2008 recommendations, statements, action items

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Research Related Recommendations from Steamboat Springs Snowfall Workshop

- **Recommendation 1:** Encourage the generation of **community CRM/NWP model profile databases** that represent natural variability. A parallel effort for databases from observations or combined model simulations and observations is also encouraged.

- **Recommendation 2: Use "modeling chains" as a basic research tool to develop an understanding of the relationship between snowfall and radiative transfer**. A modeling chain begins with a detailed cloud resolving model (CRM) employing a physically robust microphysical model of the ice process, relying on known physical principles and on as few assumptions as feasible. The second component of the "modeling chain" is the representation of the complex optical properties of the ice hydrometeors, employing as few "simplifying " assumptions as possible. The final component of the "modeling chain" is formation of a robust radiative transfer model through the complex ice fields, also with a minimal set of assumptions. Although the complex models employed in such a "modeling chain" may be impractical for real-time retrieval or assimilation, it can provide a basis for making simplifying assumptions that enable retrieval and parameterized microphysical calculations.

- **Recommendation 3(see rec. 1): Recognize "Data Assimilation" as a necessary component of snow analysis from space-based measurements.** It was recognized by virtually all of the working groups that a full direct measurement of snowfall by any single space-borne measurement alone is most likely an unattainable goal. Nearly all working groups arrived at the conclusion that space-time distribution of snowfall can be potentially diagnosed most accurately by combining all space based observations with surface based observations over space and time in a physically consistent manner through cloud resolving

data assimilation. Although the assimilated analyses could be used as a starting platform for prediction, the emphasis here is strictly on providing a space-time analysis of snowfall from a diverse system of observation tools using a physically robust cloud resolving model as the space-time interpolator and as a tool to build in realistic variability into the analysis resulting by the modulation by small scale features such as topography.

- **Recommendation 4:** Community efforts led by the International TOVS Working Group (ITWG) have successfully led to the emissivity databases and inventories. **Continuing community efforts to study and development of high-latitude surface emissivity products** (10-200 GHz) including error estimates are strongly recommended.

- **Recommendation 5:** The use of **combined active and passive satellite data** for snowfall detection/retrieval should be further encouraged. Active space-borne instruments need to have a low detectability threshold (smaller than roughly 5 dBZ) to detect light rainfall and snowfall. CloudSat as well as the planned missions ACE and EarthCare will provide space-borne cloud radars. In particular, the combined use of CloudSat with AMSR-E and/or AMSU is encouraged.

- **Recommendation 6: Future space borne measurement platforms must have high sensitivity and be able to detect reflectivity down to within 100-200 m of the surface and with a sensitivity of -20 to -30 dBz.** Snowfall occurs primarily from shallow stratiform , orographic or clouds of a CBL producing light snow over long periods. Moreover the low-level snowfall is divided often between blowing and falling snow. Active sensors designed to detect this process must be able to detect reflectivity in the lowest 500m^{-1} km of the atmosphere with high sensitivity of -20 dBz or better

New Business / Research Questions:

1. What is the status and direction for light rain / snowfall retrieval? [HF PMW, 94 GHz+ Radar]

2. How can physically based, multi-spectral / multi-sensor remote sensing be further developed and advanced? [ill posed retrievals: surface emissivity, 3-D CRM+3-D RTM, time dependence from model and feature tracking/morphing, improved beamfilling issues: synergize with other observations such as VIS, IR, forecast/nowcast models, improved microphysical information, spectral bin microphysics in CRMs – providing improved info on PSD, shape, spatial / temporal variability]

3. What is the status of CRM, merged models, and data assimilation (e.g., GSMap, others)
[CRMS: improved microphysics, better resolution, improved physical schemes, etc., global coverage][Recommend expanded use of simulator/CRMs, particularly in field campaigns to validate model results → improving global retrievals. **Education recommendation:** CRM inventory, status, physical

assumptions, how are they being used currently, limitations, been validated?, etc. Recommend CRM intercomparison and/or work with GEWEX for selected cases/field campaigns. Data assimilation provides a framework for incorporating diverse observations (model/physical) and forms a basis for error characterization—4DVar, CRM->ensemble forecasting (ensemble kalman filter), Data assimilation application to specific parameter estimation.]
Education recommendation: status/inventory of data assimilation methods for use in precipitation remote sensing/inference/forecasting.

4. What is the status of PMW forward modeling in scattering atmospheres?
[1. emissivity + 2. scattering → major issues, keep going. Land surface emissivity: sea ice/snow cover, vegetation, temperature, soil moisture, etc. HF over ocean emissivity, wind speed dependence. Emissivity variance WRT temperature/salinity. Scattering: improved particle microphysics/optical properties]

5. How can ground based methods (radar, gauges, etc.) be used to complement space-based retrievals? (i.e., the "research" role of GV)
[integration / linking between communities to solve common problems,

recommend stronger interface with existing ground communities. Specific examples? e.g., CRM intercomparison within GV framework. Improve temporal information and incorporate into retrievals. Use ground based obs. to improve surface / vertical profile information where available. Recommend surface obs. communities make data available to remote sensing community for use in retrieval schemes.]

6. What's the status of space-based radar techniques, and how can they be improved/used to improve upon existing precipitation remote sensing methods? (TRMM, GPM, CloudSat, EarthCare, FY4 ~ 2014)
[data availability for new satellite data: FY3A, other new satellite obs., agreement with China → how can IPWG help facilitate data sharing? Recommend open data policy (all data types) for existing and future satellite missions: e.g., SSMI/S, FY3A, etc. Invite military to come to IPWG.
See previous comments for improvement ideas]

7. Geostationary Microwave platforms – research status?
[Recommend summary/white paper for GeoMW to educate the community on the benefits and disadvantages.]

8. Which non-precip specific future missions can be leveraged to provide precipitation information (e.g., SMOS, ACE, Aquarius, etc.)
[Current: CloudSat, MODIS, Grace, GPS, Wind Scatterometers, Humidity Sounders; SMOS, ACE, Aquarius, EarthCARE] Other research methods related to precipitation: lightning, aerosol, hydrology, etc. [life cycle information, time dependence of specific events, other missions?]

New/Continued Recommendations

(reorganize in terms of priority, who are the recommendations to? Keep workshops in mind)

1. Recommend that algorithm developers be aware that significant progress has been made in merged algorithm/modelling activities and thus encourage that architectures be designed to allow models to be used effectively.

1a. Generate merged data for public use

1b. Statement supporting generalized satellite simulator development, incorporating real and modeled data.

1c. Need for a consideration of temporal character of algorithm/product requirements, modeled physical relationships, and observations.

2. Recommend future satellite orbits to allow synergies between other satellites, e.g.. A-train, Modis/CloudSat

2a. Tradeoffs: Cost, design, scientific requirements

2b. multiple nadir looking radars

2c. synergize radar platforms with PMW HF platforms (e.g., ACE + AMSR3) to improve physical information in wider swath.

3. Recommend that space agencies continue to support and encourage the use of high frequency (100+ GHz) channels in order to retrieve light/frozen precipitation over both land and ocean (Aonashi/AMSR3).

4. Recommend support for novel research efforts aimed at incorporating model products/processes into satellite remote sensing of precipitation

4a. Encouragement of R&D efforts, e.g., PMW algorithms over land; next-generation ideas, satellite simulator

4b. Physical retrievals and associated improvements

4c. Neural network, non-physical/statistical methods using model products as virtual measurements

4d. Research into how to merge differences in disparate observation platforms (e.g., constellation observations), how to combine / weight measurements from different platforms (e.g., merge AMSUB + TMI rain estimates). E.g., a "level 3 product". Related to intercalibration (refer to merge with previous comments)

5. Does IPWG need to continue recommending snowfall workshop type activities? Does more need to be done? What elements are lacking for snowfall detection/measurement of relevance to larger community?

[yes. Other workshops for other topics? CRM/Algorithm development workshop – invite cloud modeling community, coordinate with GEWEX.]

6. (dead) Recommendation for GEO microwave pending on broader education of IPWG community with respect to feasibility for precipitation retrieval. (can't recommend an actual mission)

7. Recommend that developers of passive microwave algorithms pay attention to low precipitation rates -- give some kind of guidance as to the confidence in estimates below their unambiguous detectability threshold.

7a. Make use of space-based radar observations to improve PMW detection/measurement

7b. Use models to improve information content / separate signal from noise

7c. Use satellite simulator to determine optimal observation / retrieval scheme

7d. Community efforts led by the International TOVS Working Group (ITWG) have successfully led to the emissivity databases and inventories. **Continuing community efforts to study and development of high-latitude surface emissivity products** (10-200 GHz) including error estimates are strongly recommended.

8. Recommend improved data delivery coordination/sharing between international agencies, (merge in data sharing comments)

8a. Recommend additional and/or shared ground stations to reduce data loss for satellites with limited existing receiving stations → specific recommendation to CGMS.

9. Recommend that people in research group actually start doing some instead of recommending too much stuff.

- 10. Radar from space observations: **Recommendation 6: Future space borne measurement platforms must have high sensitivity and be able to detect reflectivity down to within 100-200 m of the surface and with a sensitivity of -20 to -30 dBz.** Snowfall occurs primarily from shallow stratiform , orographic or clouds of a CBL producing light snow over long periods. Moreover the low-level snowfall is divided often between blowing and falling snow. Active sensors designed to detect this process

must be able to detect reflectivity in the lowest 500m^{-1} km of the atmosphere with high sensitivity of -20 dBz or better (Doppler/LDR for melting layer detection)

- Recommendation for radar on operational missions (*poes)? Would it be useful for precipitation research?

New/Continued Statements

1. IPWG supports scientifically relevant channel selection, and we encourage band preservation/protection.

1a. Engineering solutions required to detect and reduce radio interference effects (more of a recommendation)

2. Continue support for upcoming missions with high frequency PMW channels, relevant to light precipitation: ACE/AMSR3, FY4, SSMI/S

2a. Use high frequency radar for snowfall / light rain / shallow precip detection

(e.g., 94 GHz)

New Action Items

[any statements we need to make to CGMS→WMO? Priority recommendations/statements → action items]

[make specific action items to address above recommendations]

1. Formation of “web committee” to review, revise, update web-based IPWG-community related data products/models/links, etc.

2. Formation of a WG (move from recommendations).