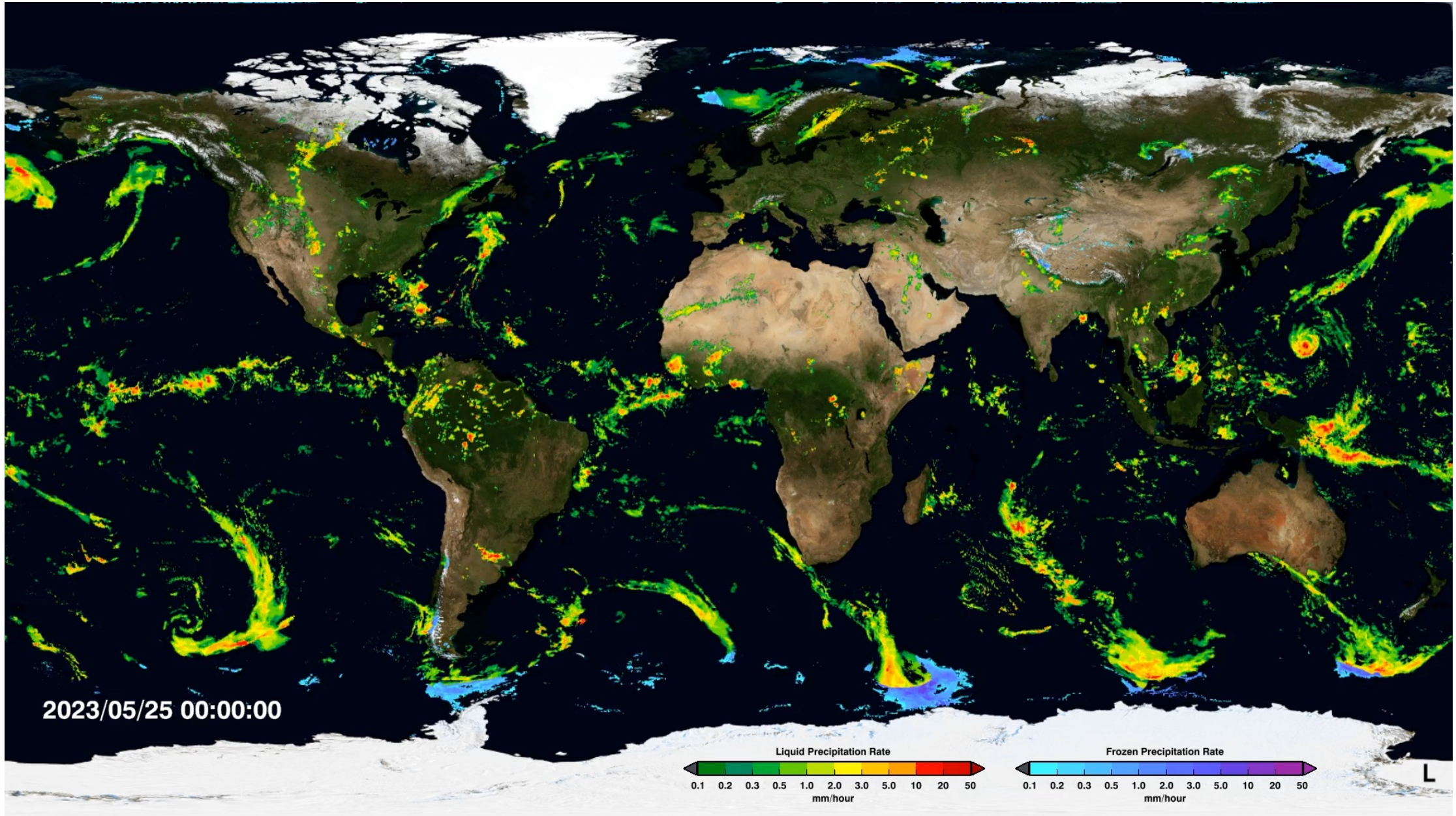
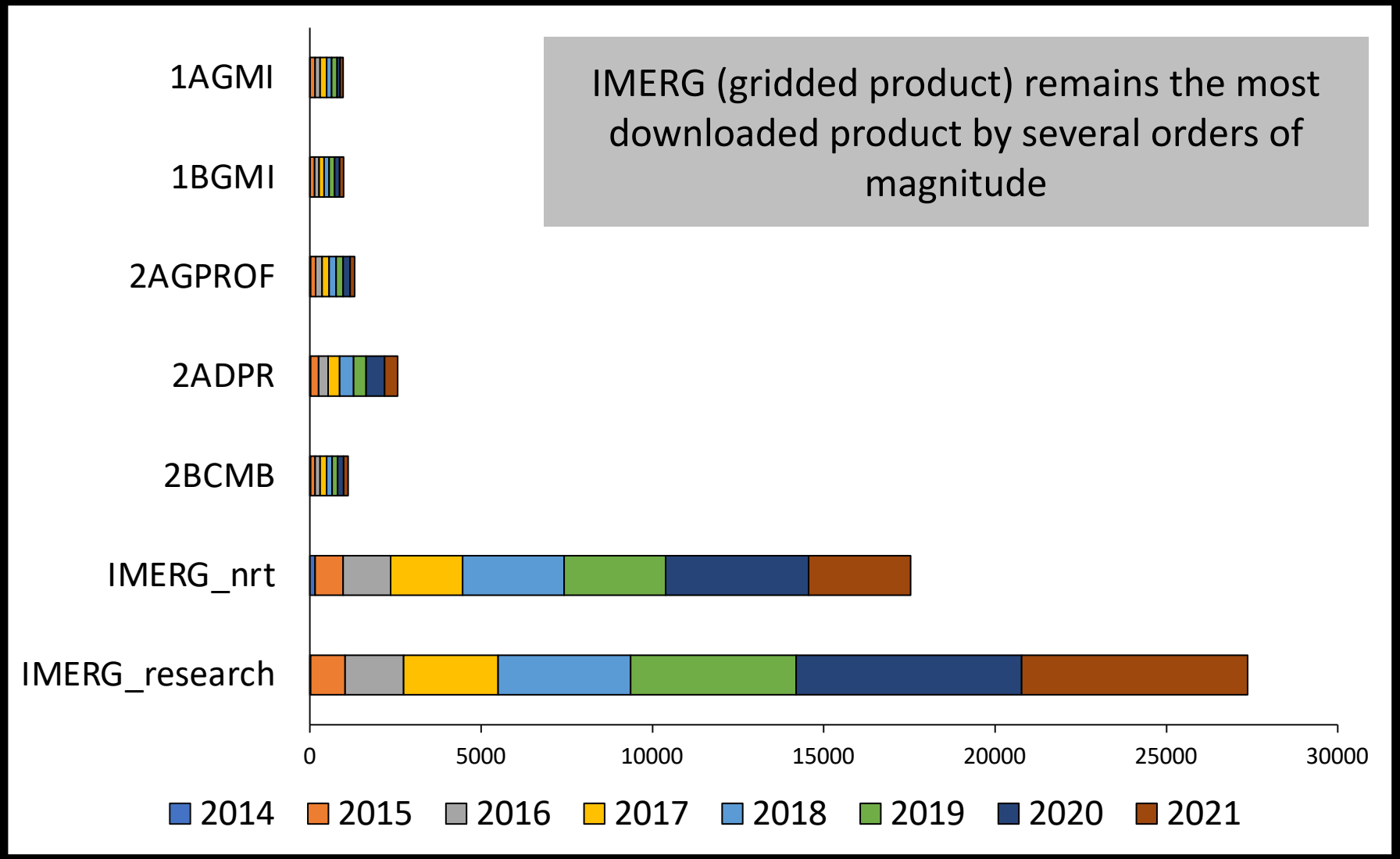
The Future of Global Precipitation Mapping

Sarah Ringerud NASA GSFC

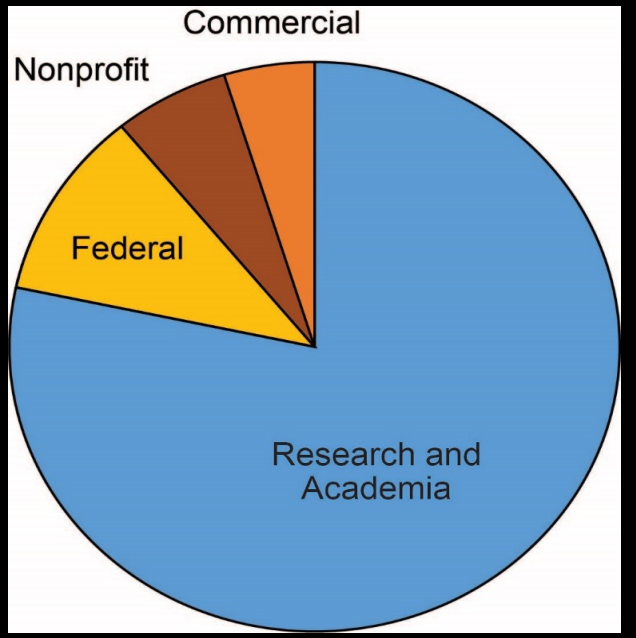
Ian Adams, Mircea Grecu, George Huffman, Chris Kidd, Rachael Kroodsma, Lisa Milani, Jeff Piepmeier, Andrea Portier


2023/05/25 00:00:00
Liquid Precipitation Rate
0.1 0.2 0.3 0.5 1.0 2.0 3.0 5.0 10 20 50
mm/hour
Frozen Precipitation Rate
0.1 0.2 0.3 0.5 1.0 2.0 3.0 5.0 10 20 50
mm/hour
L

Community Synthesis



GPM Data Products by Distinct Users



GPM End Users by Sector

Courtesy Andrea Portier

GPM Applications

Connecting Observations to Decision-making

NWP; TC monitoring; S2S & climate modeling

Landslide nowcasting; Flood estimation; Reinsurance; Situational awareness

Track precipitation anomalies for vector and water borne diseases

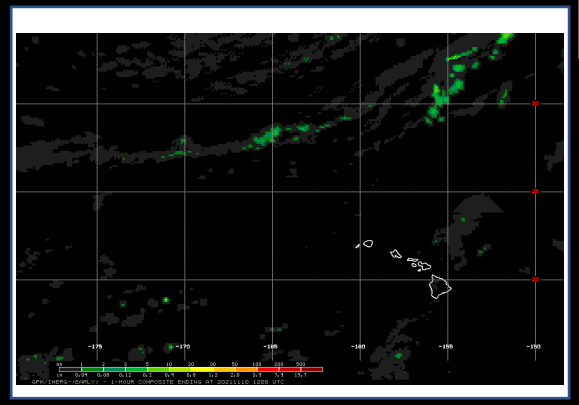
Assess freshwater inputs for hydropower generation

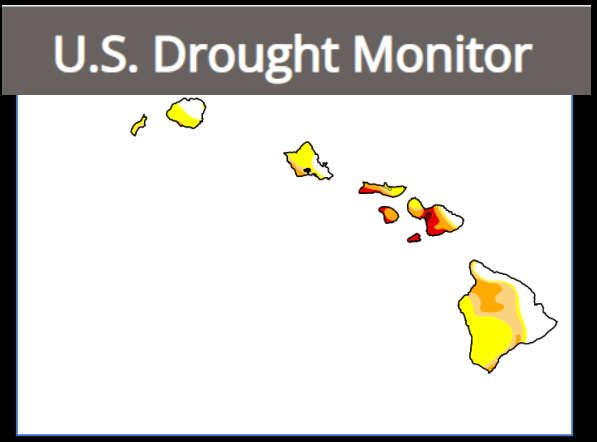
Monitor changes in precipitation associated with animal migration

Assess freshwater inputs to quantify water fluxes

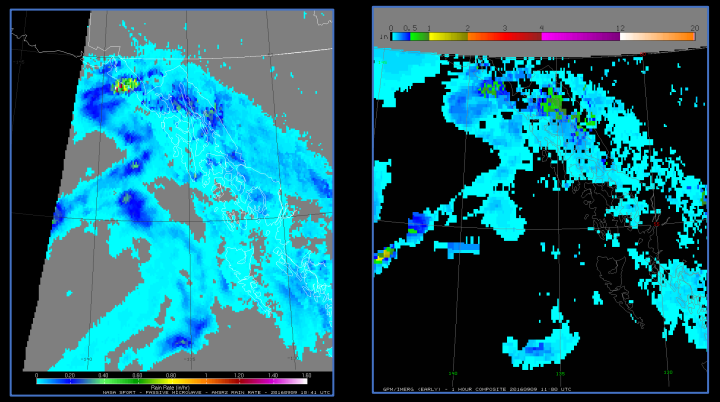
Use Cases

Hawaii US Drought Monitor Report: using IMERG accumulations

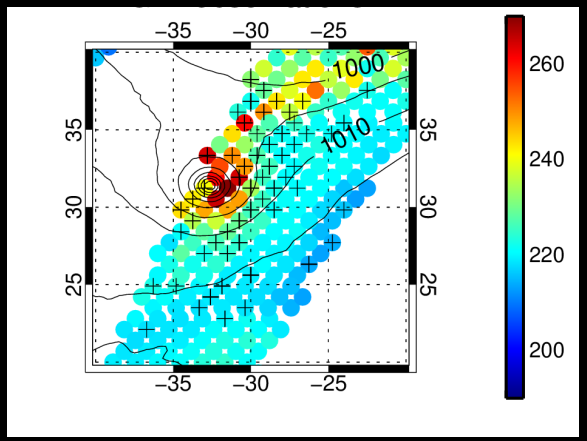




Atmospheric river/ extremes nowcasting and forecasting: using L2 rain rate and 1-hr accumulation of IMERG, NASA SPoRT/ NWS WFOs



Assimilation of GMI Tb in NWP for initializing model runs at ECMWF

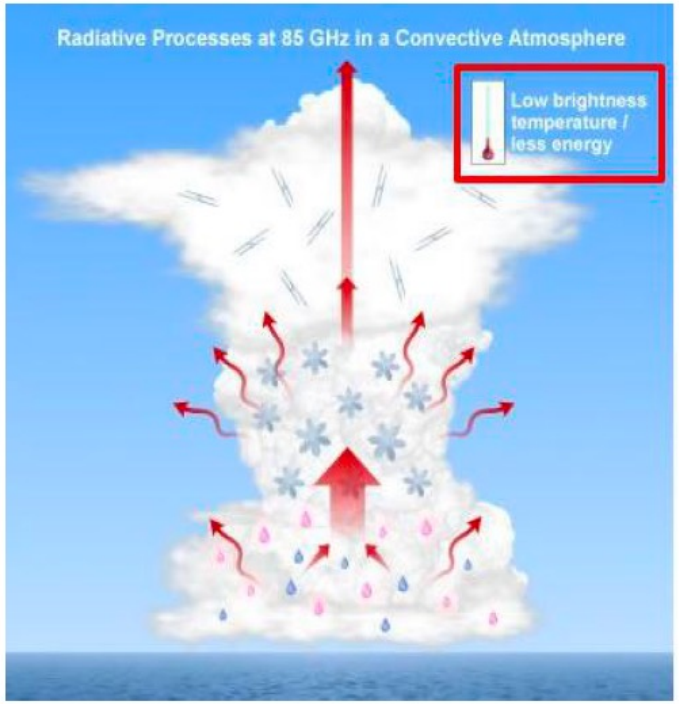


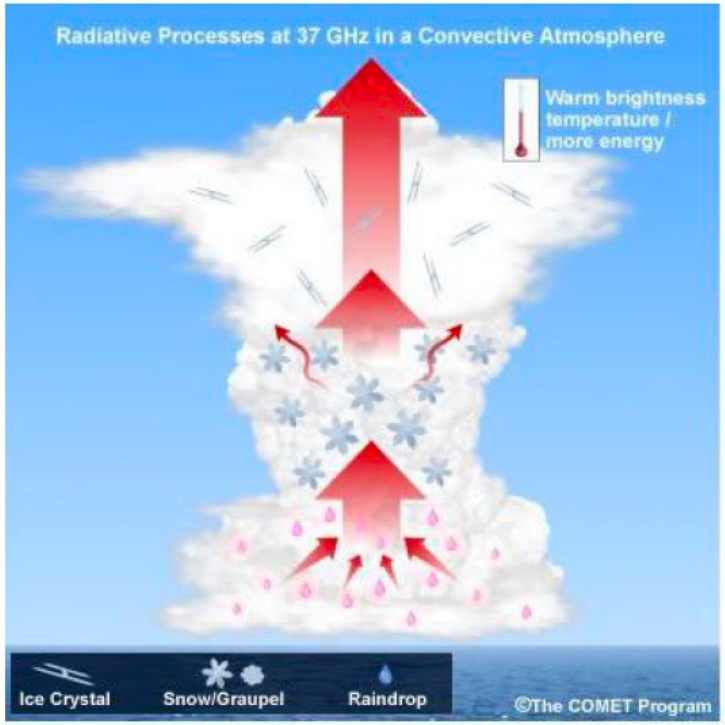
Courtesy Andrea Portier

Lower Frequency Window Channels

85-91-GHz images → primary signature is lowered T_b caused by ice scattering and cloud and rain droplets within deep convection and precipitating anvil clouds

36-37-GHz images → primary signature is elevated Tb because of minor emission from liquid hydrometeors near or below the freezing level





UN WMO Typhoon Committee

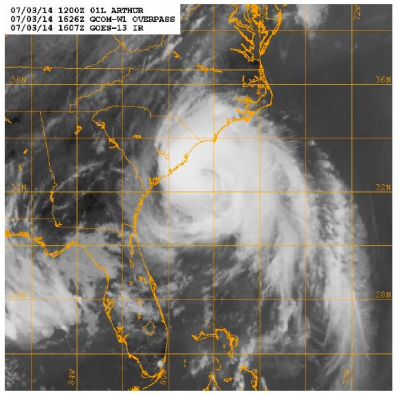
36-37GHZ Imagery Interpretation

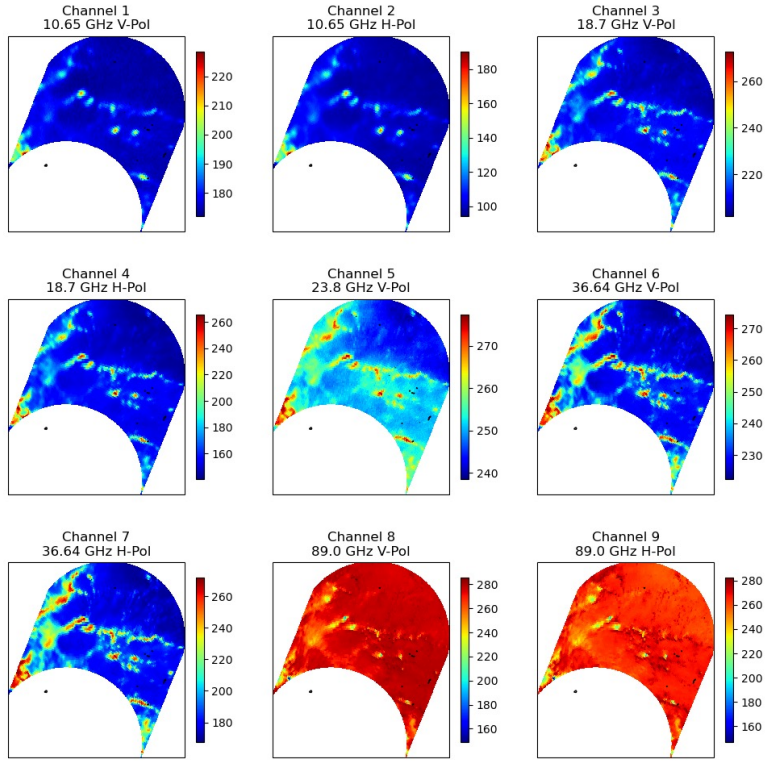
Precipitating clouds and land-surface appear warm against a relatively cold ocean background

Cold features: sea surface only

Imagery highlights low-level cloud features and storm structure

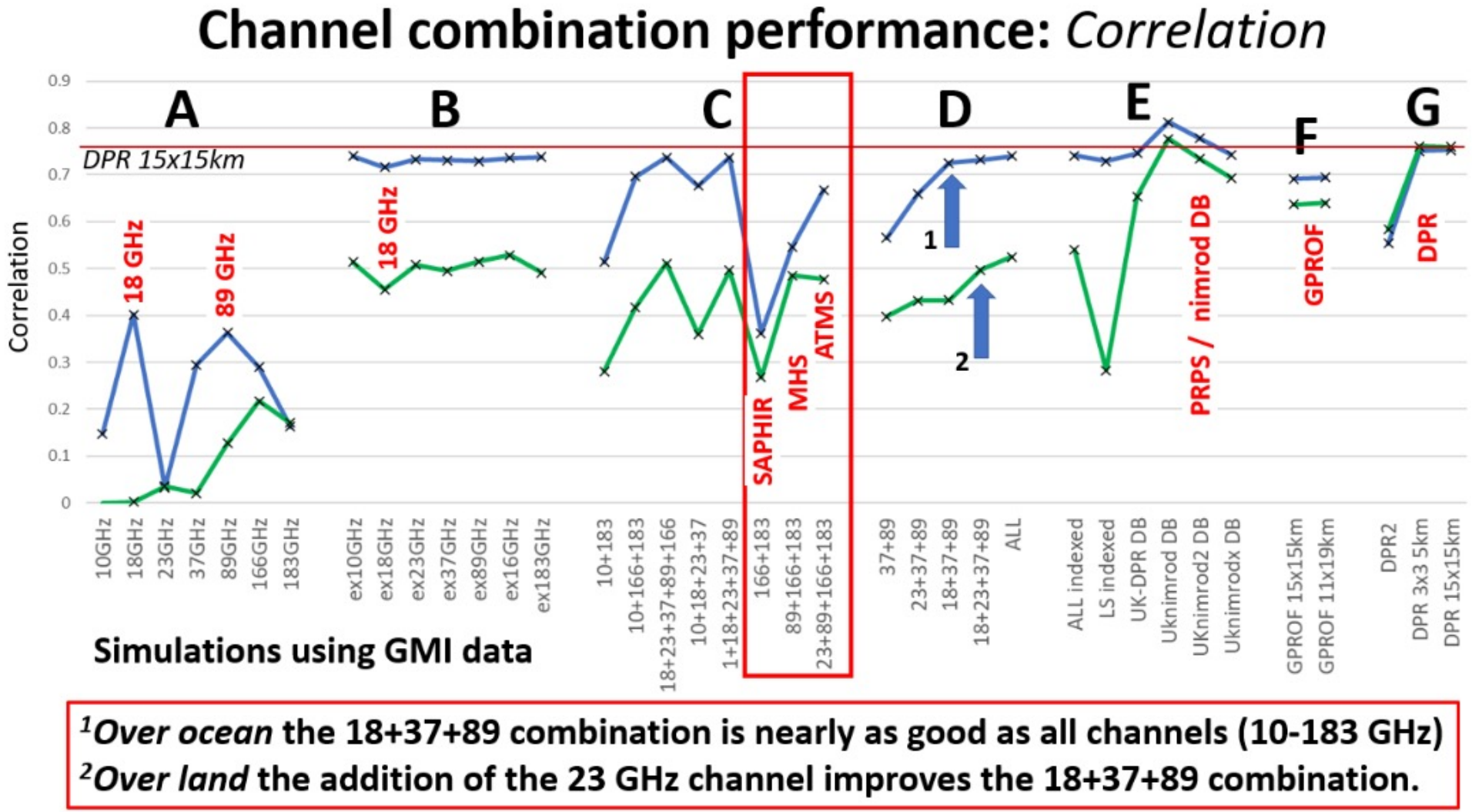
Imagery identifies cirrus-covered eyes and gives a 'true' low-level center instead of a mid/upper-level center (as in 85-91 GHz imagery





Kwaj – Mircea Grecu

Channel Selection

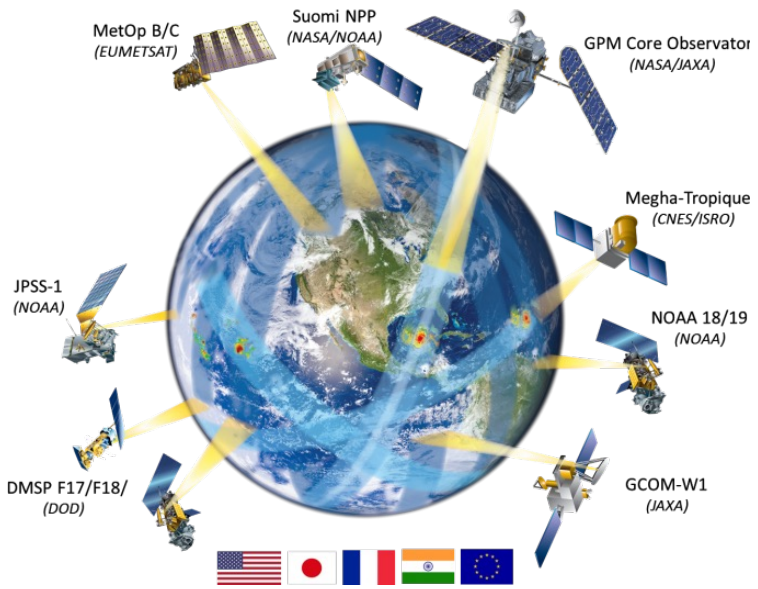


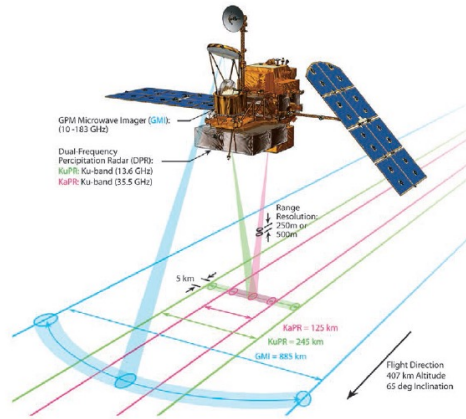
[1]*Over ocean* the 18+37+89 combination is nearly as good as all channels (10-183 GHz)
[2]*Over land* the addition of the 23 GHz channel improves the 18+37+89 combination.

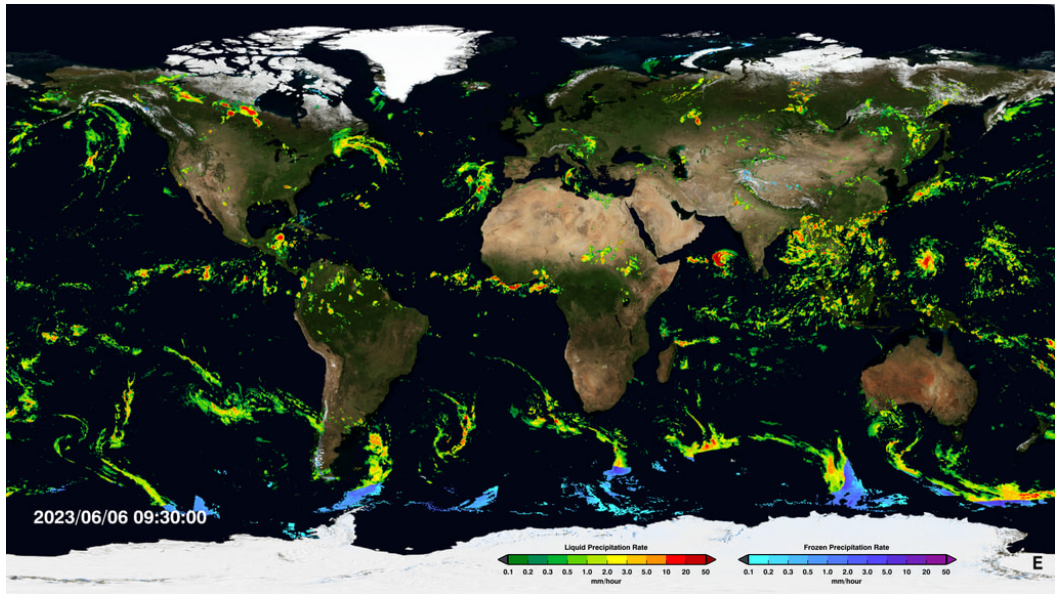
Chris Kidd poster

Global Mapping

- Excellent process-focused missions on horizon (AOS, INCUS, TROPICS)
  - Advance precipitation science
  - Understand processes/properties
- Mapping – separate issue
  - GPM: constellation + high quality calibrator
  - Climate data record
  - Machine learning techniques require long-term, high-quality sampling
- Over Ocean – 18, 37, 89 key frequencies for more direct observation
  - Over land: improves light precipitation retrievals, determining snow cover, soil moisture connections
  - Desired by decision makers with higher temporal sampling







The Post-GPM Era

- Industry moving to smaller, higher frequency instruments
  - Indirect
    - Depends on ice-precip relationships – can't assume constant
    - Need to keep calibrating these
- Conical scanners – big antennas, poor sampling at desired frequencies, expensive
  - Gaps between FOVs
- Machine learning, data assimilation schemes need data!
- Can we make something smaller, cheaper, better?
  - Demonstrate technology – hope taken up by operational agencies & private industry

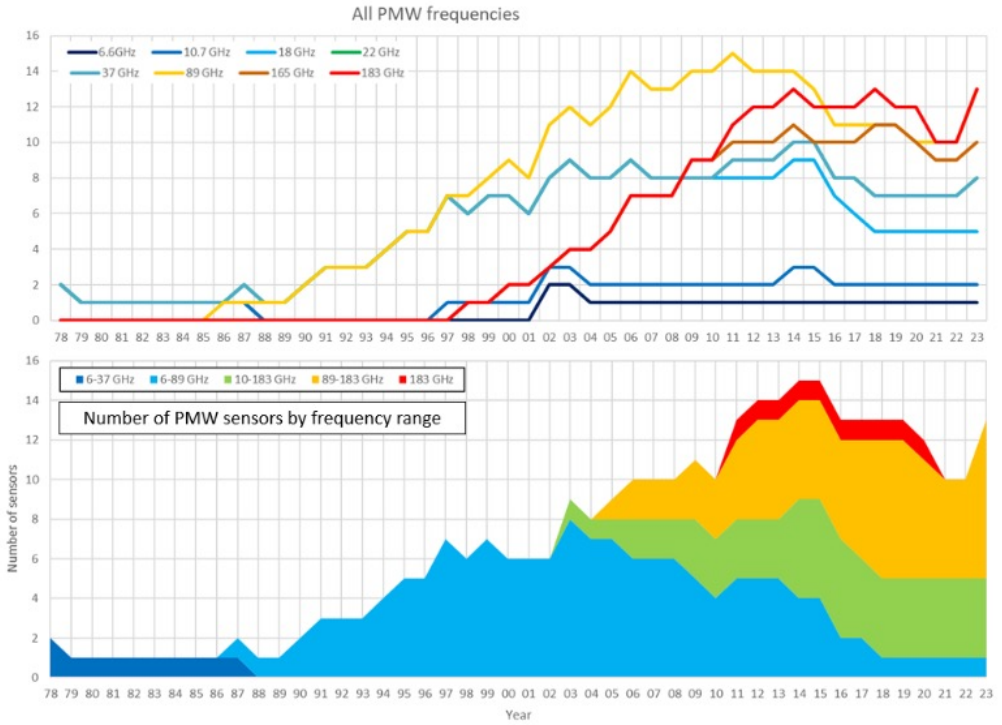
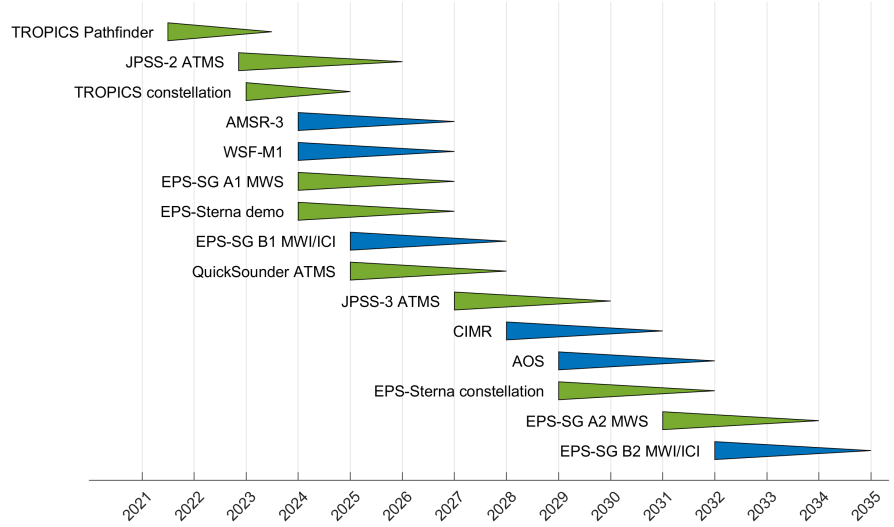


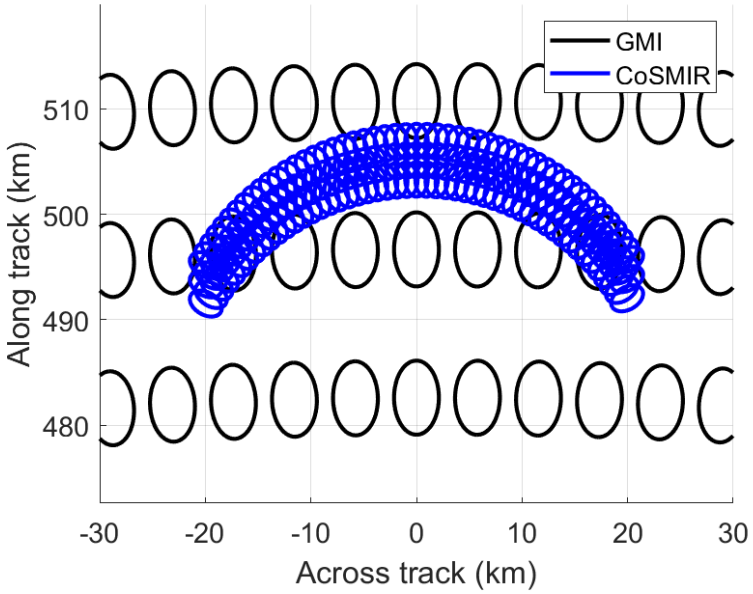
Figure 6: Number of passive microwave sensors by frequency (top) and by range of frequencies (bottom).



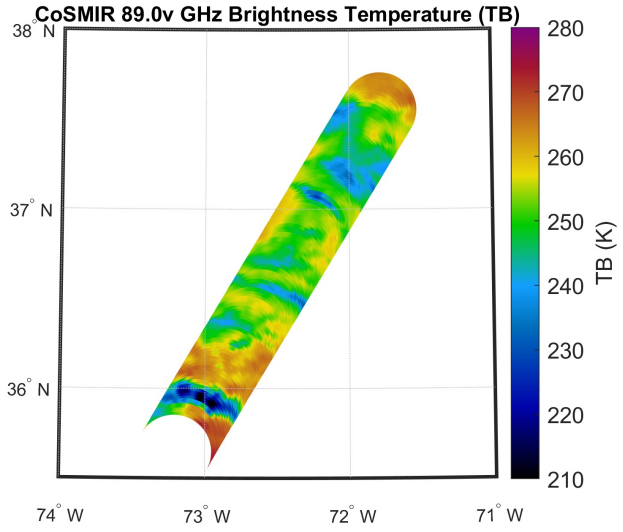
Chris Kidd, Rachael Kroodsma

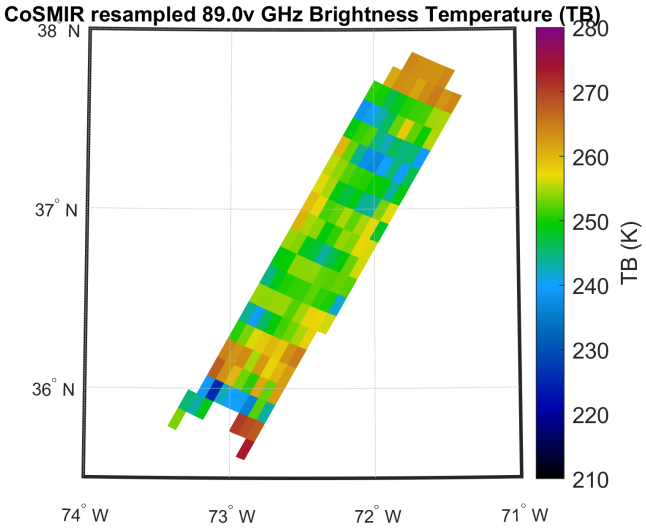
Paths Forward

- **Nyquist sampling**
  - Signal can be reconstructed from samples if waveform is sampled at intervals half the beamwidth
  - Reconstruct with ML
  - Enables resolution enhancement and mitigation of beam-filling, under-sampling issues
- **Deployable Reflectors**
  - Deployable mesh antenna
  - Small stowed antenna minimizes launch cost
  - Small-sat or cubesat



CoSMIR has a smaller footprint (2.1x3.3 km compared with GMI 4x7 km) but is able to sample at Nyquist in both across-track and along-track (and several times Nyquist in the across-track direction).





Rachael Kroodsma, Mircea Grecu

Key Takeaways

- Global mapping of precipitation is crucial for a multitude of applications from real-time decision making to the climate data record
  - 18, 37, 89 GHz are highly desirable here
- As community moves to smaller, higher frequency radiometers lose important direct precipitation information and calibration capabilities
  - Emerging ML focus – need high volume, high quality data
- Emerging technologies enabling Nyquist sampling and deployable reflectors can make 18, 37, 89 GHz small-sat technology smaller, cheaper, better
- A technology demonstration could encourage private industry, operational agencies to take up these frequencies long term