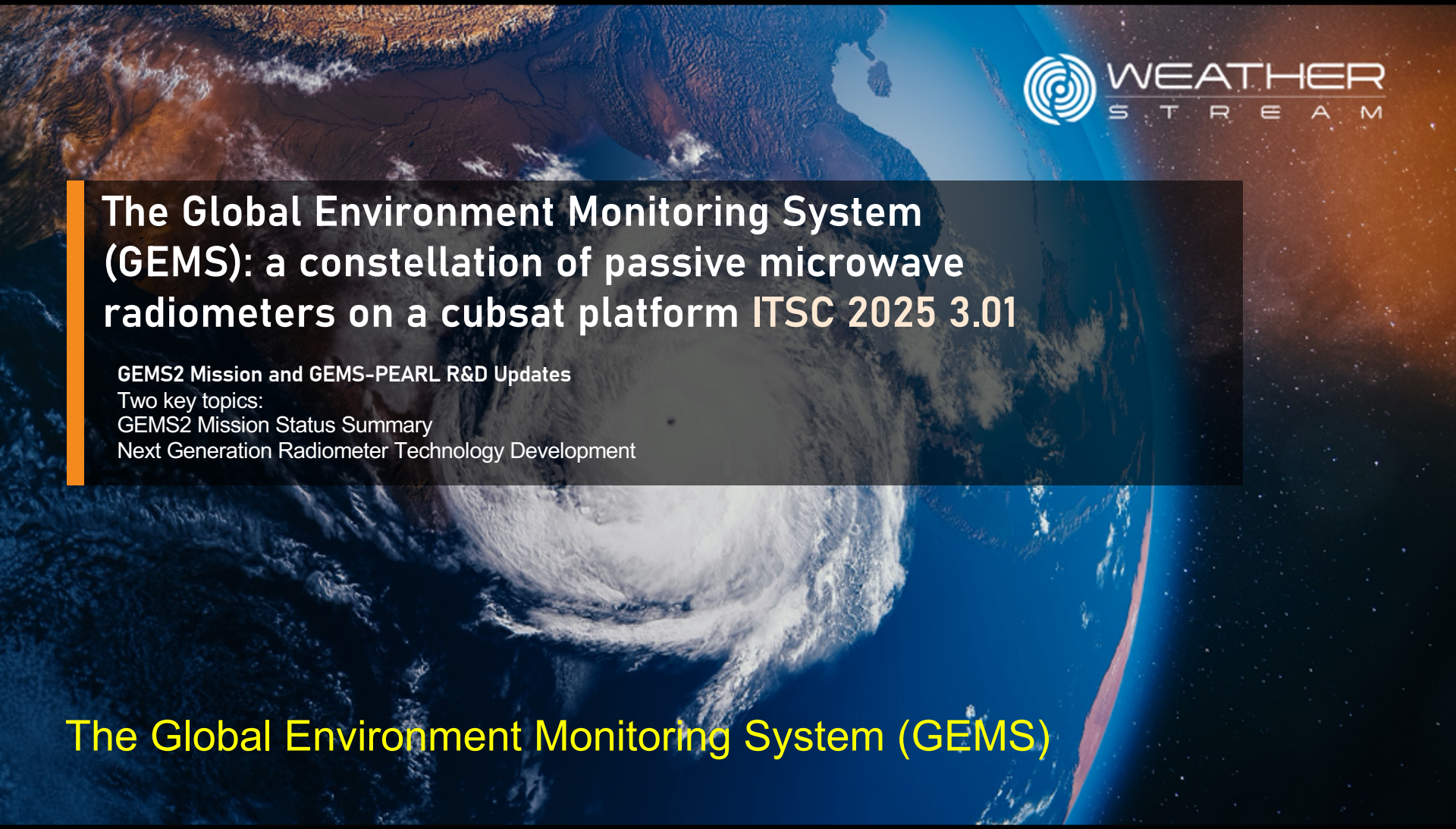
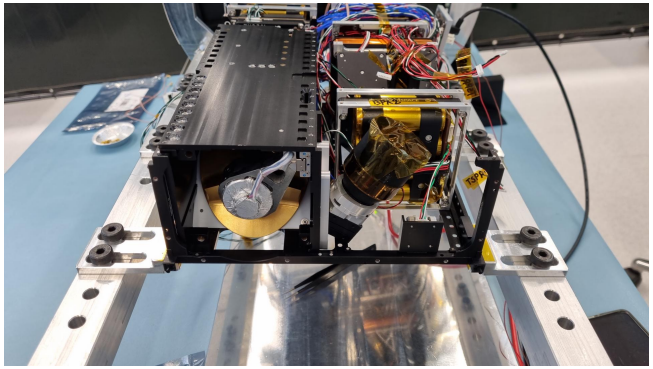


The Global Environment Monitoring System (GEMS): a constellation of passive microwave radiometers on a cubsat platform ITSC 2025 3.01

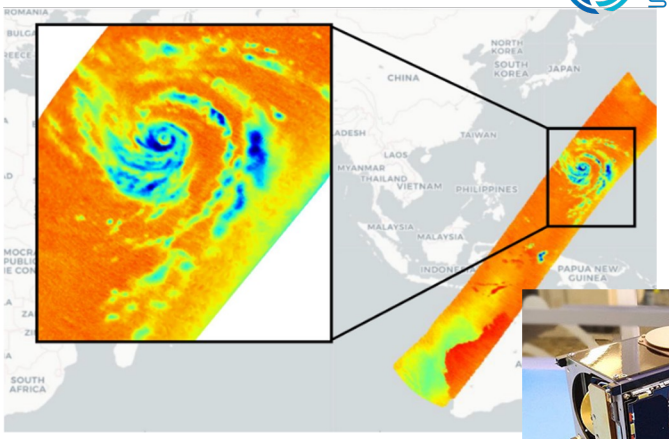
GEMS2 Mission and GEMS-PEARL R&D Updates
Two key topics:
GEMS2 Mission Status Summary
Next Generation Radiometer Technology Development

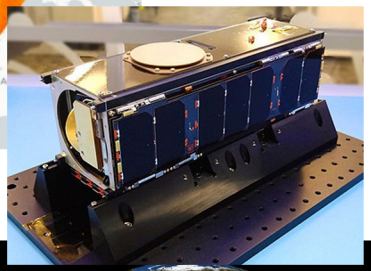
The Global Environment Monitoring System (GEMS)

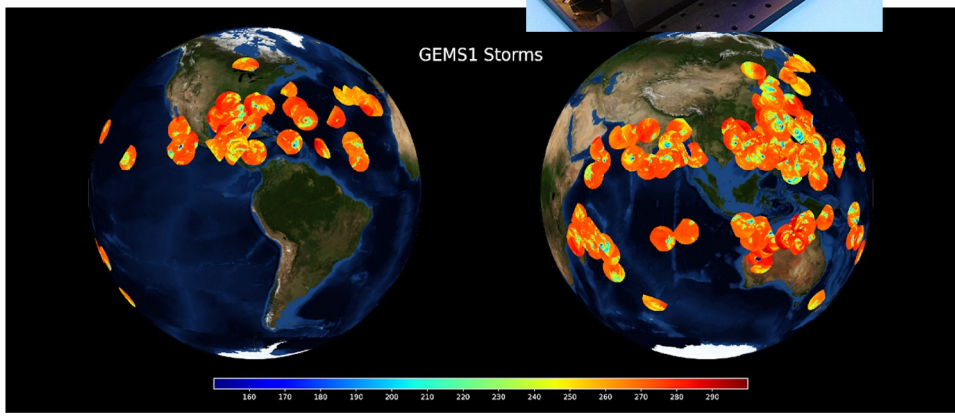
- GEMS2 Mission Status



GEMS2-Amethyst 6U Cube Satellite in final Assembly, Integration, and Testing May 2025







3 GEMS2 payloads in production, 2 flight, 1 one ETU/spare

2 launches planned Oct 2025 and June 26 on Transporter rideshares

End to end ground system in late stages of testing and validation

L1a/L1b pseudo data available
L2 processing in refinement / validation

The Global Environment Monitoring System (GEMS)

• GEMS2 Payload Specifications

Scanning Technique: Cross-track and Along-track Nyquist spatial sampling at 16 km SSP. Swath ~1800-2200 km altitude dependent. Scan rate ~1 Hz

Resolution: 16 km nadir resolution for channels 104-125 GHz, 12 km nadir resolution for channels 155-185 GHz

Near-global coverage twice/day

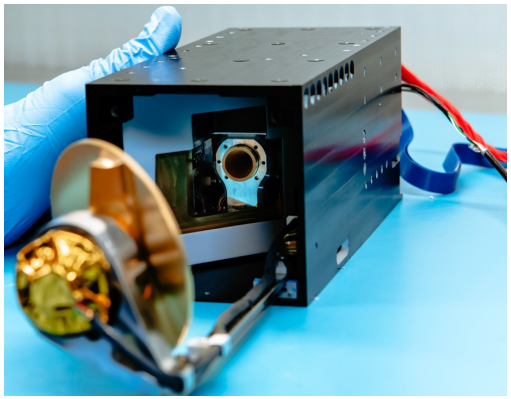
Satellite: 6U CubeSat ~12 kg mass

Mission Life: 3-5 years nominal

Payload Mass: 3 kg

Power: 15 W

Data Rate: 300 kbps



The Global Environment Monitoring System (GEMS)

• GEMS2 Payload Specifications

IF Passbands			RF Passbands			
IF Lower (MHz)	IF Upper (MHz)	IF Bandwidth (MHz)	LSB Lower (GHz)	LSB Upper (GHz)	USB Lower (GHz)	USB Upper (GHz)
118GHz Band						
6300	14000	7700	104.7503	112.4503	N/A	N/A
3700	6300	2600	112.4503	115.0503	122.4503	125.0503
2500	3700	1200	115.0503	116.2503	121.2503	122.4503
1700	2500	800	116.2503	117.0503	120.4503	121.2503
1300	1700	400	117.0503	117.4503	120.0503	120.4503
900	1300	400	117.4503	117.8503	119.6503	120.0503
500	900	400	117.8503	118.2503	119.2503	119.6503
300	500	200	118.2503	118.4503	119.0503	119.2503
150	250	100	118.5003	118.6003	118.9003	119.0003
75	125	50	118.6253	118.6753	118.8253	118.8753
37.5	62.5	25	118.6878	118.7128	118.7878	118.8128
18.75	31.25	12.5	118.71905	118.73155	118.76905	118.78155
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2.25	3.75	1.5	118.74655	118.74805	118.75255	118.75405
IF Passbands			RF Passbands			
IF Lower (MHz)	IF Upper (MHz)	IF Bandwidth (MHz)	LSB Lower (GHz)	LSB Upper (GHz)	USB Lower (GHz)	USB Upper (GHz)
183GHz Band						
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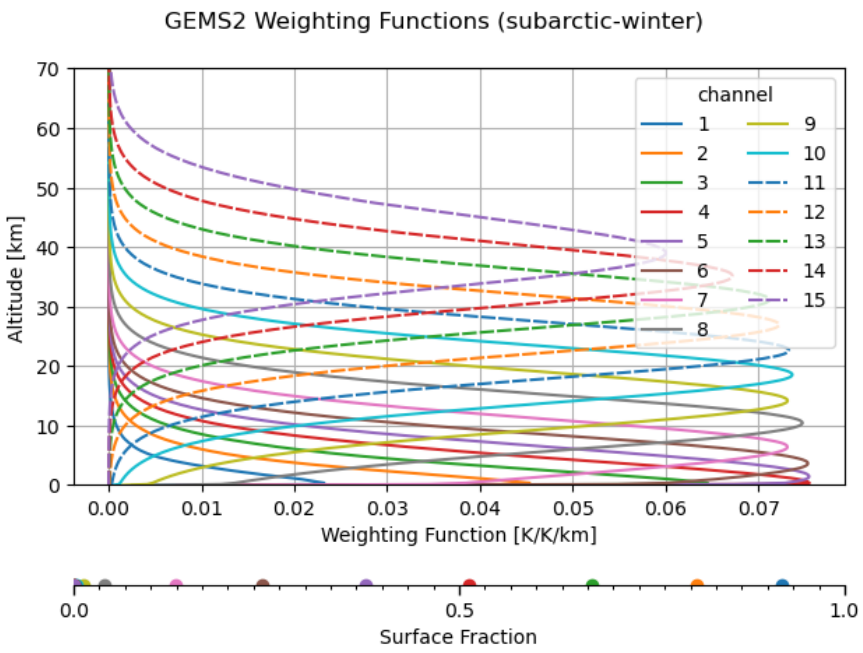
10000	18000	8000	165.3100	173.3100	N/A	N/A
5250	9750	4500	173.5600	178.0600	N/A	N/A
4200	5200	1000	178.1100	179.1100	N/A	N/A
3200	4200	1000	179.1100	180.1100	N/A	N/A
2100	3100	1000	180.2100	181.2100	N/A	N/A
1000	2000	1000	181.3100	182.3100	184.3100	185.3100
450	950	500	182.3600	182.8600	183.7600	184.2600
150	450	300	182.8600	183.1600	183.4600	183.7600

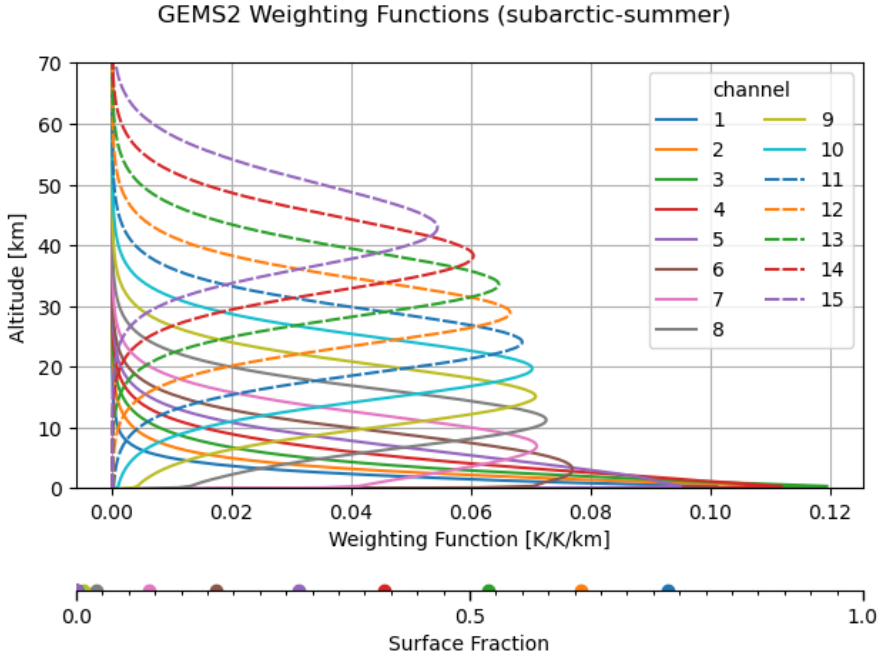
Channel Number	ΔT_{RMS}	$\Delta T_{RMS,sos}$
1	0.268 K	0.217 K
2	0.303 K	0.269 K
3	0.321 K	0.426 K
4	0.414 K	0.570 K
5	0.513 K	0.574 K
6	0.493 K	0.515 K
7	0.544 K	0.684 K
8	0.832 K	0.911 K
9	1.269 K	1.074 K
10	1.641 K	1.514 K
11	2.201 K	2.018 K
12	2.686 K	3.046 K
13	4.929 K	4.400 K
14	4.453 K	5.731 K
15	8.809 K	9.033 K
16	1.445 K	1.364 K
17	1.075 K	0.982 K
18	1.464 K	1.281 K
19	2.591 K	2.139 K
20	2.099 K	1.839 K
21	1.984 K	1.539 K
22	1.827 K	1.476 K
23	1.848 K	1.686 K
24	2.445 K	1.880 K

The Global Environment Monitoring System (GEMS)

• GEMS2 Payload Specifications

118.75 GHz Channel Weighting Functions

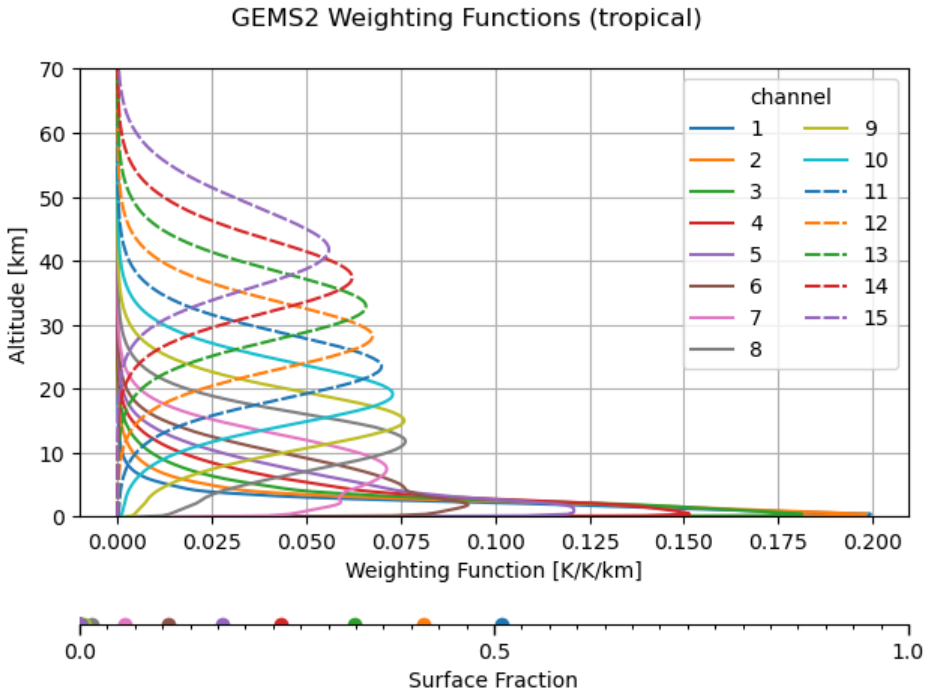




The Global Environment Monitoring System (GEMS)

• GEMS2 Payload Specifications

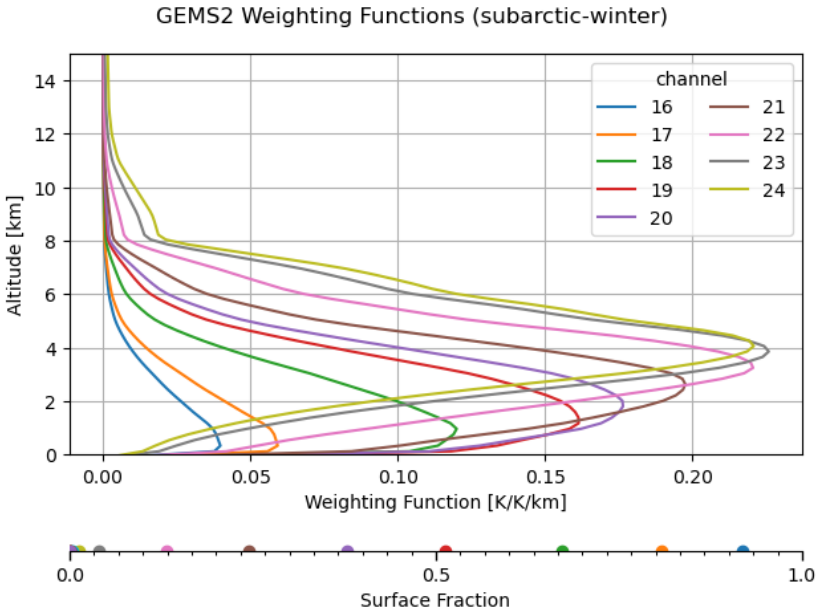
118.75 GHz Channel Weighting Functions

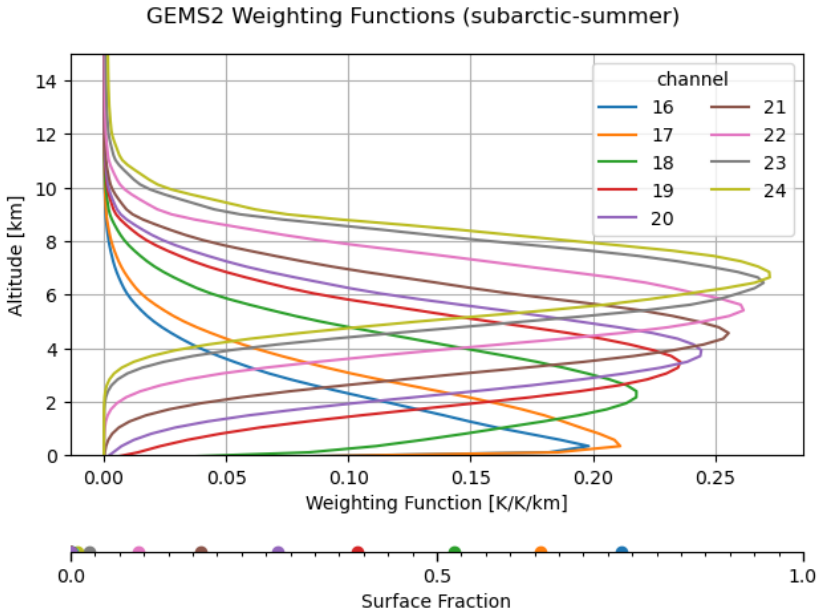


The Global Environment Monitoring System (GEMS)

GEMS2 Payload Specifications

183 GHz Channel Weighting Functions

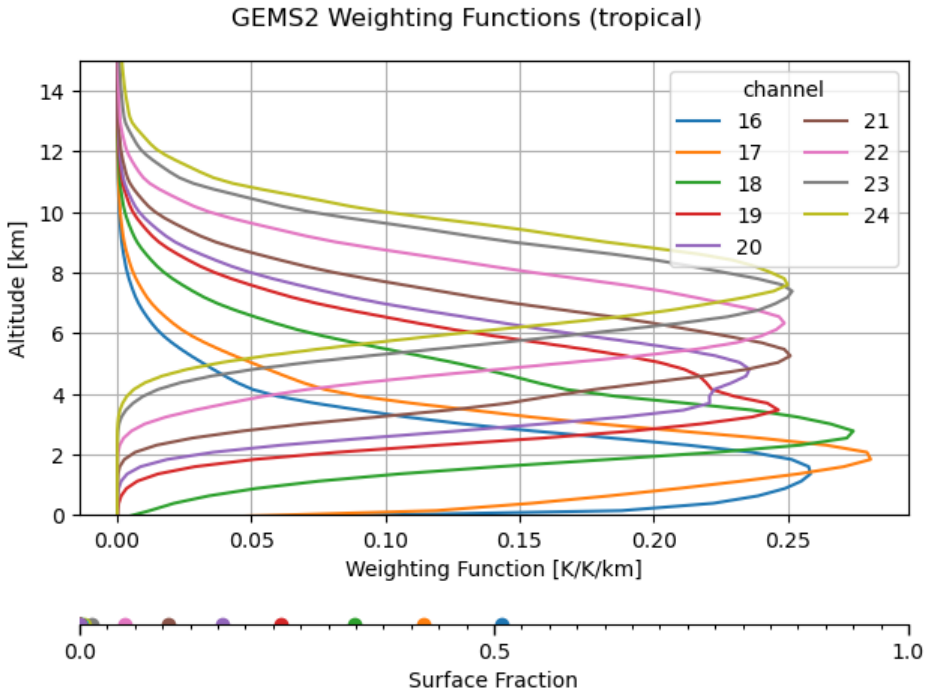




The Global Environment Monitoring System (GEMS)

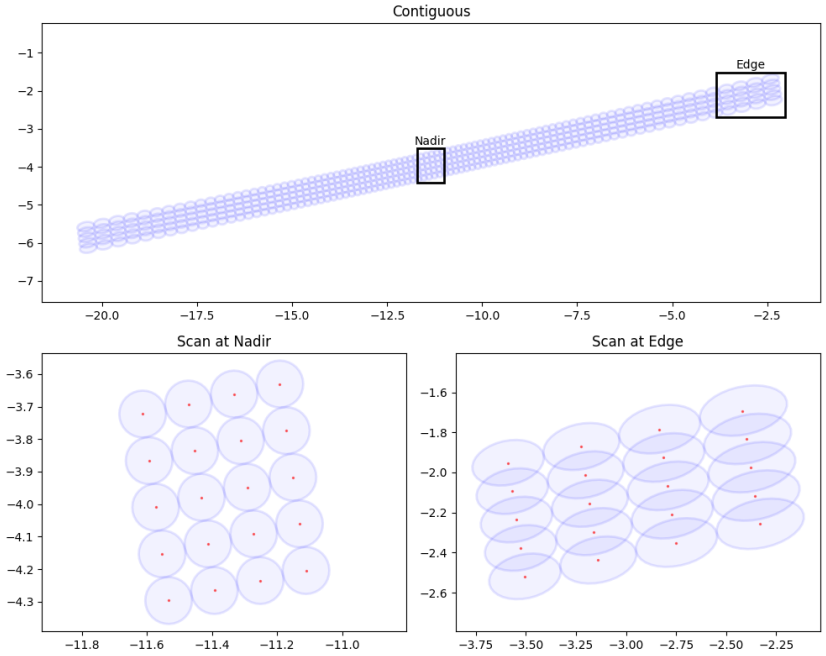
• GEMS2 Payload Specifications

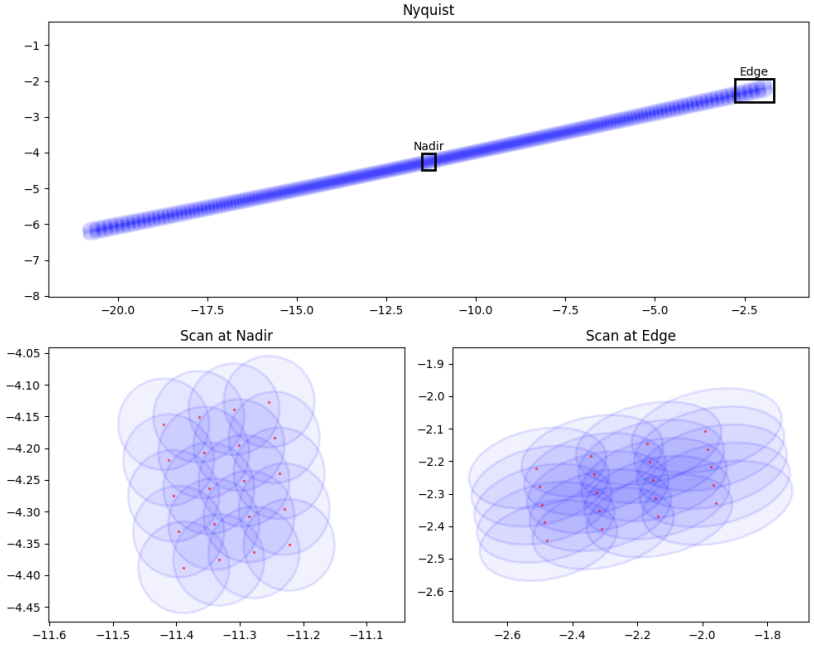
183 GHz Channel Weighting Functions



The Global Environment Monitoring System (GEMS)

- GEMS2 Nyquist Spatial Sampling Regime





The Global Environment Monitoring System (GEMS)

Ground Segment Overview

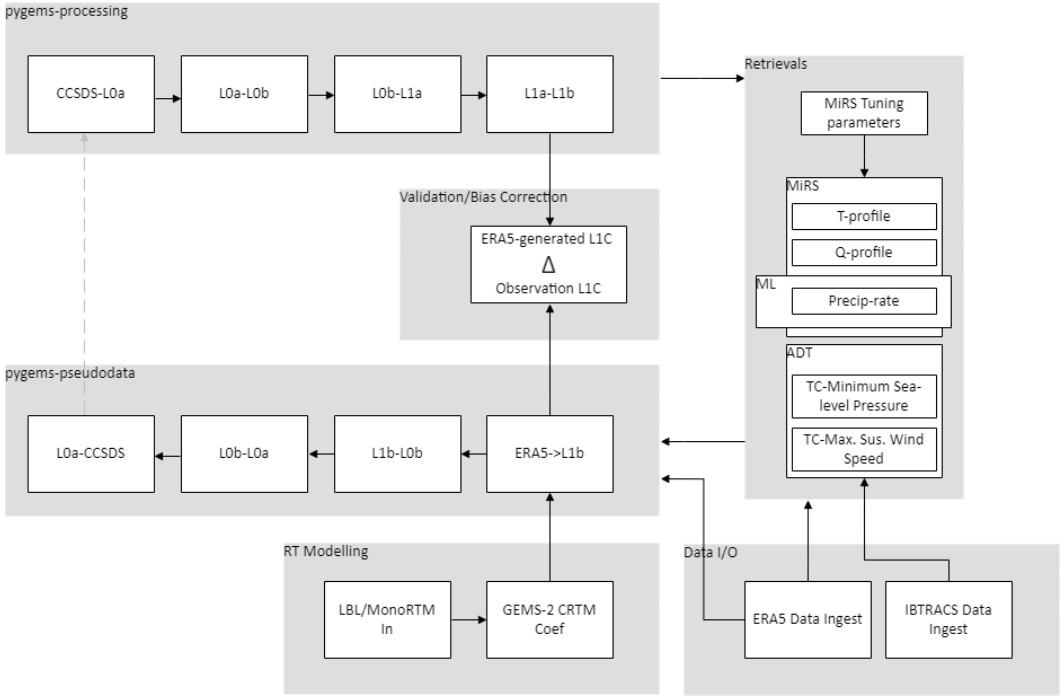
Modular design enabling rapid development and deployment of processing segments

pygems: internally-developed python package handling all facets of data processing.
GEMS-1 heritage, developed significantly since

pygems-processing: forward processing of space packet to L1b data

pygems-pseudodata: 'reverse' processing from ERA5/NWP analysis to L1b to space packet data

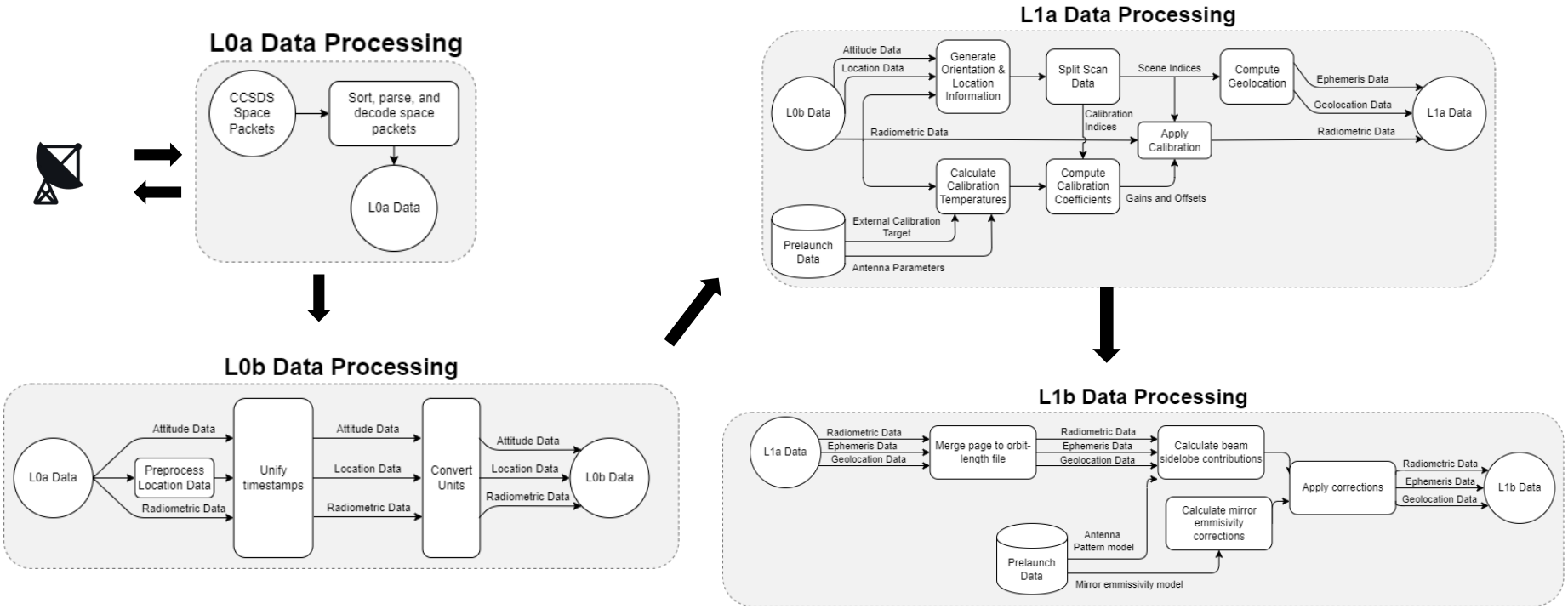
- CRTM for radiative transfer
- pre-defined TLEs
- Using same tools/functions as pygems-processing



The Global Environment Monitoring System (GEMS)

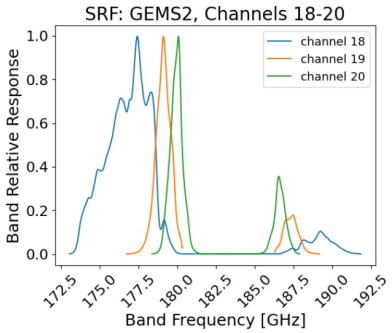
GEMS2 Data Systems Infrastructure

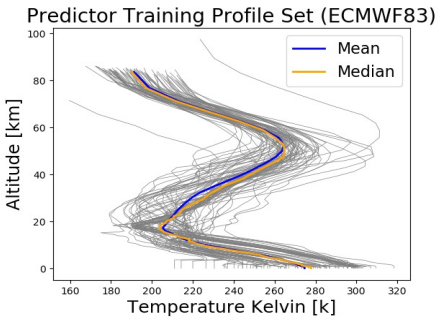
AWS-hosted, automated ground processing environment.

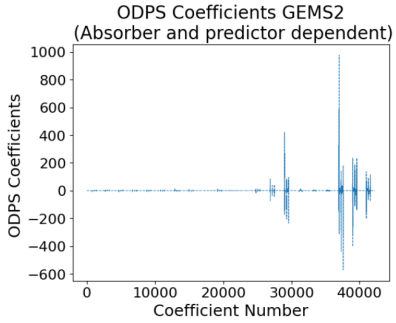


The Global Environment Monitoring System (GEMS)

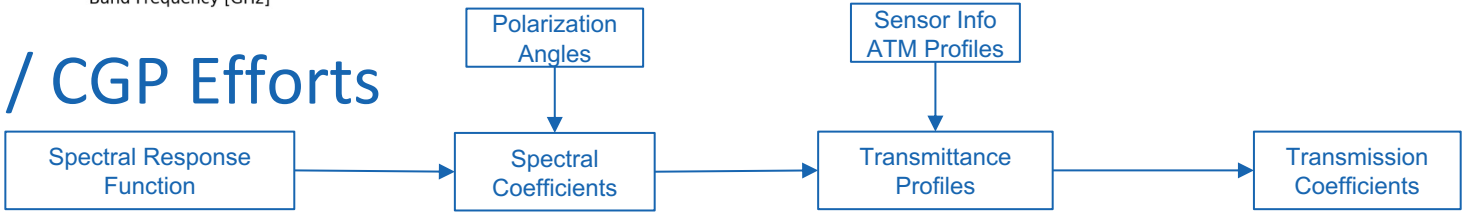
- JCSDA JEDI CRTM/CGP Package Contributions







CRTM / CGP Efforts

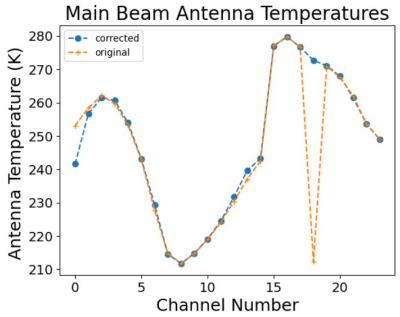


pygems-pseudodata uses CRTM modules and coefficients to generate synthetic observations for GEMS2.

Using the Coefficient Generation Package (CGP) we can generate transmission coefficients which can be used with CRTM.

Corrected previous spectral response functions to get a more accurate representation of transmission coefficients for GEMS2.

Working closely with JCSDA to release back to the community.



Next Generation Microwave Radiometer Capabilities

New architecture in development which solves many long-standing challenges with radiometer calibration stability, interference resistance, bias correction, and long-term calibration traceability

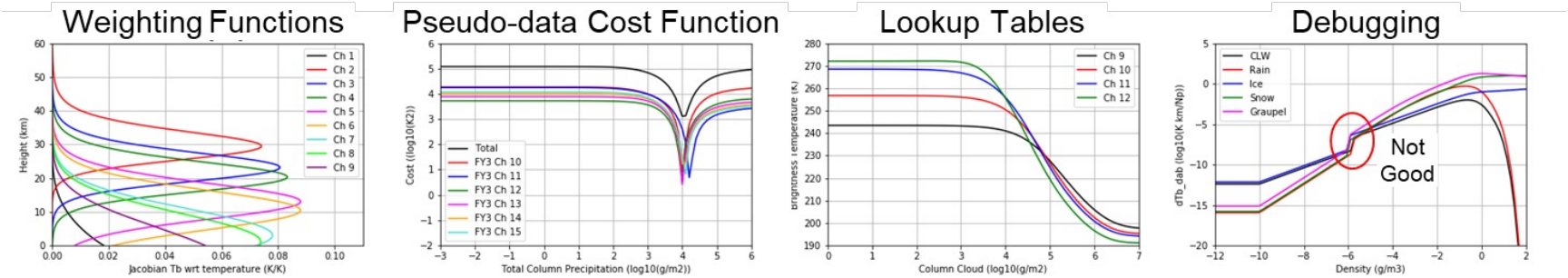
NOAA/NASA NEON SMBA Phase A studied multiple new challenging requirements: > Hyperspectral radiometry for window and sounding bands > Radio Frequency Interference Detection > New bands (ATMS+118, 229 GHz) > Expanded bandwidths for imaging and sounding bands > Nyquist spatial sampling for some bands	NASA AOS Phase A: Ice cloud imaging millimeter and submillimeter wave radiometer > 118, 183, 325, and 680 GHz bands > Dual polarization for all bands > 58 channels (29 for each polarization)
Internally-developed GEMS3 sounder: > Currently TRL5, following planned GEMS2 launches > Cover 50-58, 89, 118, and 183 GHz bands – currently at TRL5	Weather Stream's GEMS-PEARL program funded by SDA, SSC, and IRAD: > Developing modular, low-cost passive microwave polarimetric imagers > Deployable antenna innovation > Building on WindSat, WSF-M, COWVR heritage > C+X band configuration, K/Ka band configuration, Ka/W band configuration > Future expansion to P, L, S band imagery

- SPECTRUM Software Development with ONR

SPECTral Radiative transfer Unified Model (SPECTRUM)

- Current Phase II SBIR effort to develop radiative transfer software suite for targeted remote sensing product development to support US Navy remote sensing needs
- Build a test bench which makes it easy to apply multiple RT models to study a sensor design or target observation

Type	Group	Description
Atmosphere	Spectra	Absorption spectra for atmosphere
Land Surface	Spectra	Absorption and scattering spectra for various land types
Surface Water	Spectra	Absorption/scattering spectra ocean, freshwater, sea ice
Atmosphere	Profiles	Standard temperature, humidity, and pressure profiles
Trace Gases	Spectra	Absorption spectra for atmospheric trace gases
Hydrometeors	Profiles	Cloud liquid water, ice, hail, snow, precipitation
Ionosphere	Profiles	Vertical profiles of ion concentrations and species
Ozone	Profiles	Observed vertical profiles of ozone concentration
Water vapor	Profiles	Observed vertical profiles of water vapor



- Thank you

SUMMARY:

WxS GEMS Technology is

1. Similar performance to AMSU/ATMS
2. Much lighter weight & smaller volume
3. Significantly cheaper, affordable
4. Flexible Deployment
5. Constellation to achieve coupled temporal/spatial sampling for sever wx
6. GEMS-2 data available

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Questions Welcomed!

POC: Michael Hurowitz, Weather Stream (WxS) mhurowitz@weatherstream.com

The Global Environment Monitoring System (GEMS)