WMO SCOPE-Nowcasting using new-generation satellite data: Progress and Perspectives

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WMO Space Programme

8th Asia-Oceania Meteorological Satellite Users' Conference
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New-Generation Meteorological Satellites

Geostationary orbit:

Satellite	Operator	Launch date	Longitude	Imager	Number of spectral channels	Spatial resolution	Temporal resolution (full disk)	Sounder / Lightning Mapper
Himawari-8	JMA	7 Dec 2014	140E	AHI	16	0.5-2km	10min	- / -
Electro-L N2	ROSHYDRO-MET	11 Dec 2015	78E	MSU-GS	10	1-4km	15min	- / -
INSAT-3DR	ISRO	8 Sep 2016	74E	IMAGER	6	1-8km	30min	S / -
Himawari-9	JMA	2 Nov 2016	140E	AHI	16	0.5-2km	10min	- / -
GOES-16	NOAA	19 Nov 2016	89.5W (final TBD)	ABI	16	0.5-2km	15min	- / L
FY-4A	CMA	10 Dec 2016	86.5E	AGRI	14	1-4km	15min	S / L
Geo-KOMPSAT-2A	KMA	2018	128.2E	AMI	16	0.5-2km	10min	- / -
GOES-S	NOAA	2018	75W	ABI	16	0.5-2km	15min	- / L
FY-4B	CMA	2018	105E	AGRI	14	0.5-4km	15min	S / L
MTG-I/S	EUMETSAT	2020-22	0°	FCI	16	0.5-2km	10min	S / L
…								

Low-Earth orbit:

Satellite	Operator	Launch date	Orbit	Payload
JPSS-1	NOAA	2017	13:30 asc	ATMS, CrIS, CERES, OMPS-nadir, VIIRS, SEM (EPS, HES, SSJ5)
FY-3E	CMA	2018	06:00 desc	HIRAS, ERM-2, GNOS, MERSI-2, MWHS-2, MWTS-3, OMS (limb, nadir), SIM-2, WindRAD, SES (IPM, SEM, X-EUV)
EPS-SG	EUMETSAT	2021-2022	09:30 desc	MetImage, 3MI, IASI-NG, MWS, MWI, S-5, ICI, RO

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Status: Sep 2017; Source: [OSCAR/Space]

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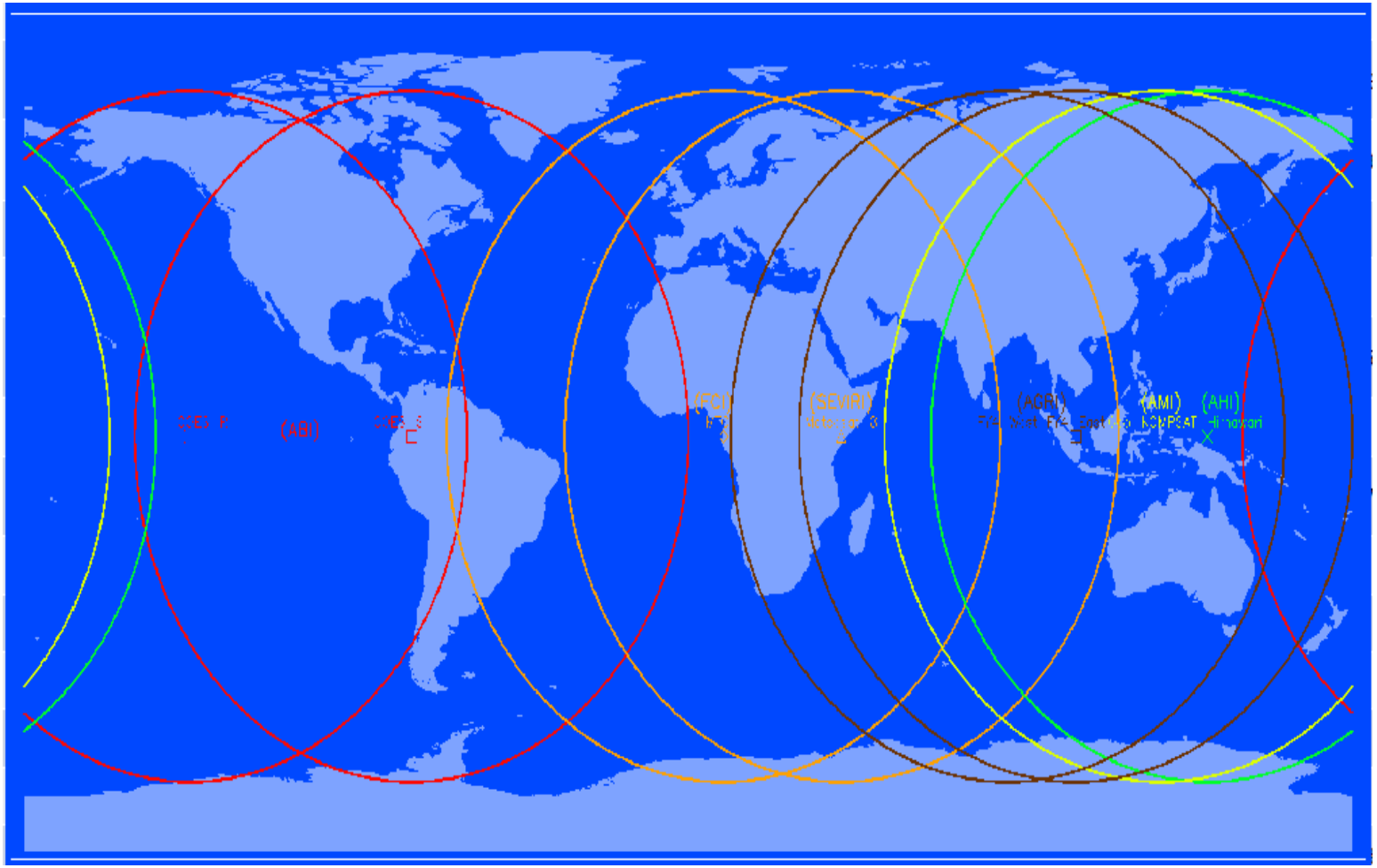
Overlap in Footprint ….



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… in Spectral Coverage ….

Central Wavelength [µm]	H-8 AHI	GOES-R ABI	FY-4A AGRI	GEO-KOMPSAT-2A AMI	MTG-I1 FCI
0.44 - 0.47	•	•	•	•	•
0.51	•			•	•
0.64 - 0.65	•	•	•	•	•
0.83 - 0.86	•	•	•	•	•
0.91					•
1.4		•	•	•	•
1.6	•	•	•	•	•
2.3	•	•	•		•
3.8 - 3.9	•	•	•	•	•
6.2 – 6.3	•	•	•	•	•
7.0 – 7.1	•	•	•	•	
7.3 - 7.4	•	•		•	•
8.5 - 8.7	•	•	•	•	•
9.6 - 9.7	•	•		•	•
10.3 - 10.7	•	•	•	•	•
11.0 - 11.2	•	•	•	•	
12.3	•	•		•	•
13.3 - 13.5	•	•	•	•	•

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… in Level 2 Products

Level 2 Product Category	Himawari AHI	GOES-R ABI	FY-4A AGRI	GEO-KOMPSAT-2A AMI	MTG-I1 FCI
Clear Sky / Cloud Mask and Radiances	•	•	•	•	•
Atmospheric Motion Vectors	•	•	•	•	•
Cloud Type and Microphysical Information	•	•	•		•
Cloud Top Height / Pressure /Temperature	•	•	•	•	•
Stability Indices		•			•
Aerosol Information, e.g. Optical Depth	•	•	•	•	•
Rainfall Rate / QPE		•	•	•	•
Solar Radiation (upward/downward)		•	•		•
Longwave Radiation (upward/downward)		•	•		•
Surface Properties (e.g. temperature, emissivity, albedo)		•	•	•	•
Fire Detection / Fire Radiative Power /Burnt Area		•	•	•	•
Volcanic Ash information (detection, height, mass loading)	•	•			•

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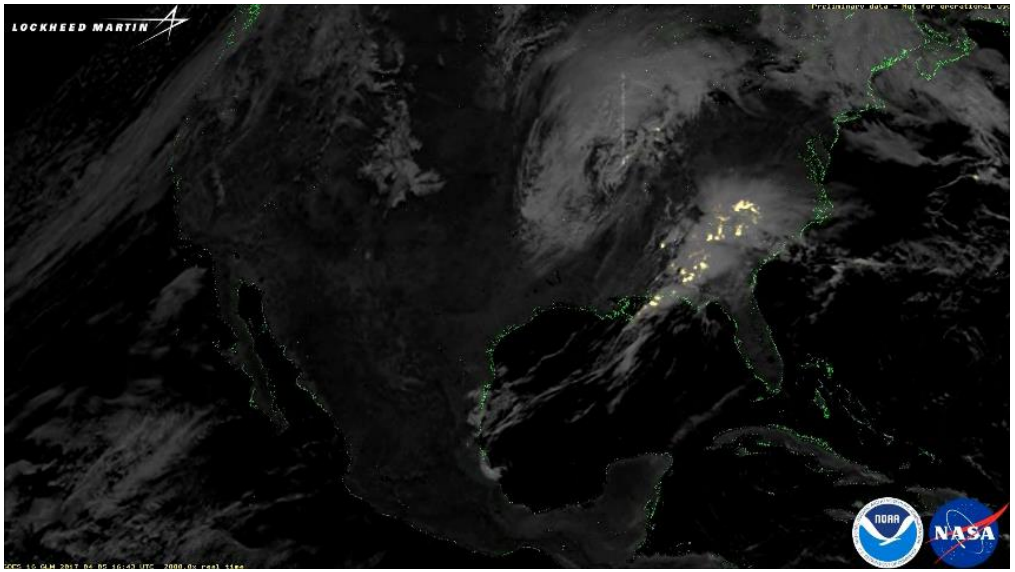
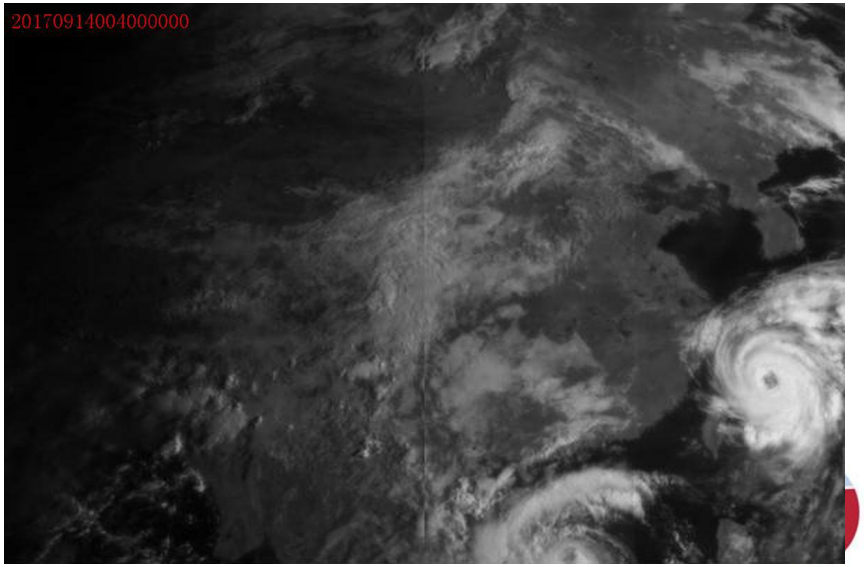
Using next-generation GEO imagers and lightning mappers



GOES-16 ABI and GLM

CMA FY-4A AGRI and LMI



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Motivation

Overlap in coverage, channels, products

- offers opportunities for combined use and capacity building

but

- poses challenges for users in the area of data reception, data interpretation, and potential data redundancy

The WMO SCOPE-Nowcasting initiative addresses some of these challenges for nowcasting applications

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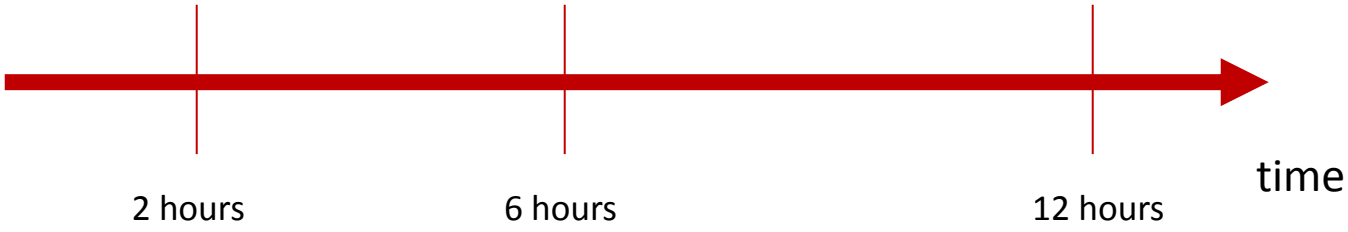
What is Nowcasting?

Various definitions exist:

0-2 hours or 0-6 hours;
usually 6-12 hours is called "Very Short Range Forecasting"



Nowcasting ……. Nowcasting … Very Short Range Forecasting

From WMO website:

- Nowcasting comprises the detailed description of the current weather along with forecasts obtained by extrapolation for a period of 0 to 6 hours ahead.
- In this time range it is possible to forecast small features such as individual storms with reasonable accuracy.

WMO SCOPE-Nowcasting

*SCOPE : Sustained Coordinated Processing of Environmental Satellite Data

Objectives

- Simplify access and use of satellite data for nowcasting in smaller or developing nations, with limited expertise and infrastructure
- Gain efficiencies for more advanced nations through combining resources, expertise

Pilot Projects

a. Using satellite data from multiple sources (>1 provider)

b. Demonstrating value of consistent, accessible, well-documented satellite-based products

c. Pilot phase → sustained operation

Users

- Severe weather forecasting demonstration projects (SWFDP)
- Aviation meteorology and Volcanic Ash Advisory Centres (VAAC), ICAO
- Sand and Dust Storm Warning Centres (SDS-WAS)

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First Four Pilot Projects (2013-)

Category	Product	Region	Provider	User	Gaps
Basic nowcasting	**Imagery (VIS/IR, RGB composites), basic products**	WMO Region II (Asia) and Region V (SW Pacific)	JMA, CMA, KMA	NMHSs in Region II and V	No standard products available; products limited
Advanced nowcasting	**Volcanic Ash Products**	Global	CMA, JMA, KMA, EUMETSAT, NOAA	NMHSs, VAACs	No standard products available; products limited
Advanced nowcasting	**Blended satellite global precipitation product (GEO+LEO)**	Global coverage	Hydro Estimator, NASA TRMM (3B42), NOAA (real-time MW)	Civil authorities, NMHSs, Flash flood guidance systems, general users	Rapid, facilitated access to quantitative precipitation estimates
Real-Time Atmospheric Composition products	**Dust Monitoring and Prediction Products**	WMO Region II (Asia) and V (South-West Pacific)	CMA, JMA, KMA	SDS-WDCs, NMSs (to issue results and warnings) in RA II and RA V	Regional diversity of aerosol-related products not harmonized

Pilot Project 1: Basic VIS/IR imagery and RGBs for Asia-Pacific

Objective

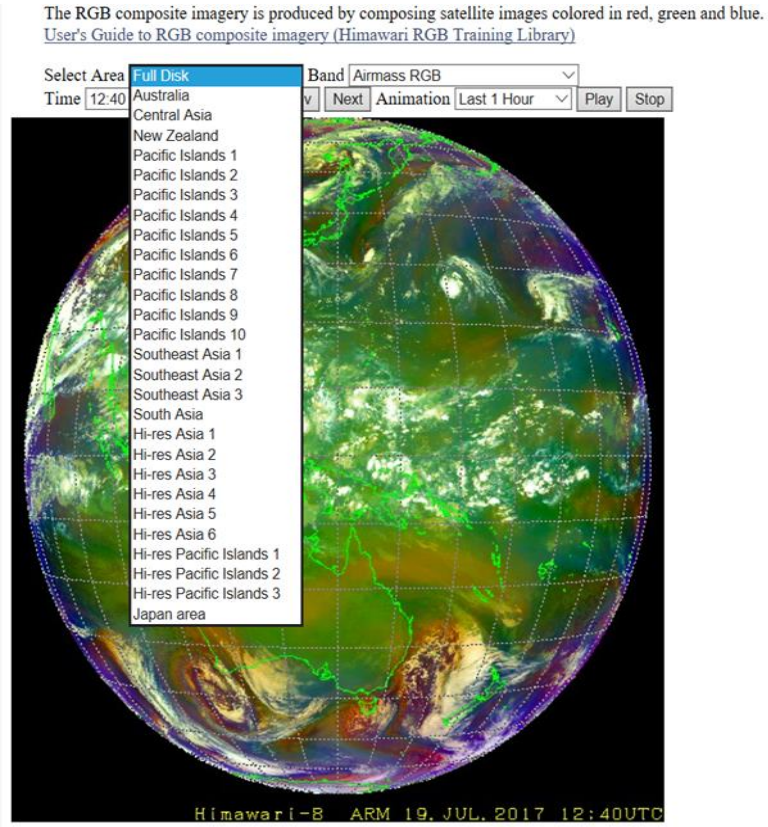
- **Consistent low-volume imagery and products available to NMHSs in Asia-Pacific Region, based on GEO imagery (Himawari-8, FY-4A, GK-2A)**

Achievements

- Apply WMO standard RGB recipes
  - RGB Expert Workshop 7-9 Nov 2017 hosted by JMA, WMO and EUMETSAT
- JMA disseminate RGB products as part of the Himawari-8 product suite
- JMA provide RGB products and Heavy Rainfall Potential product to support SWFDP in RA II and RA V
- Coordinated capacity building in RA II and RA V by JMA and VLab training centres hosted by BOM Australia, CMA, KMA

Next steps

- CMA and KMA planning RGBs for their next-generation GEO imagery
- BOM Australia to investigate possibility of hosting datasets for nowcasting in RA II/V (e.g., for small-island states)



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Pilot Project 2: Satellite-derived volcanic ash information for aviation

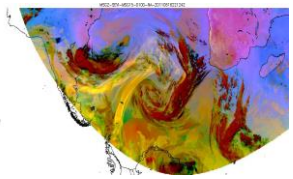
Objective

A globally-consistent volcanic ash product (from GEO and LEO):

- Clear need expressed by ICAO for a consistent product to be made available globally
- A number of centres have made recent advances in developing satellite-based volcanic ash products; these could form the basis of a standard

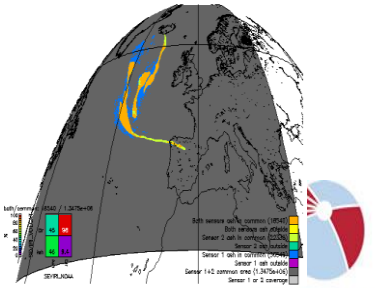
Achievements

- Satellite-based volcanic ash retrieval algorithm inter-comparison
  - Algorithm Contributions (Total: 27 (22))
  - 2015 meeting generated 22 recommendations for improving satellite-based volcanic ash detection and quantification
  - Proposed actions to conclude activity (8-12 month effort)



Next steps

- Preparations underway to update and finalize inter-comparison in autumn 2018; strong community interest (providers, VAACs, ICAO)



Pilot Project 3: Satellite-derived precipitation information

Objective

(Quasi)Global rainfall nowcasting accumulation with low latency for Severe Rainfall Risk Reduction, with rapid and easy access

Achievements

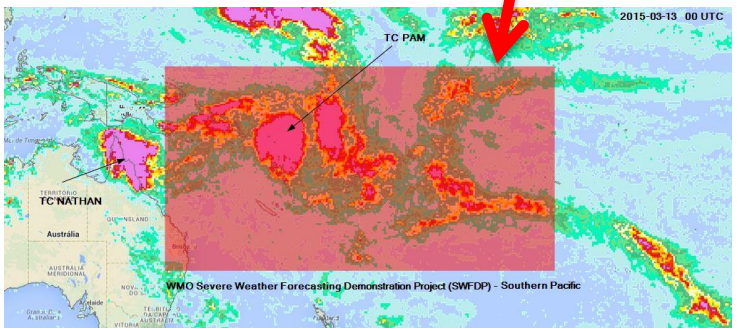
Satellite-based quasi-global low-latency precipitation products (60° N-60° S) for

- Nowcasting precipitation rate: 1h accumulation, 1-3h lead time using NOAA Global HydroEstimator (IR+NWP) and INPE Brazil short-term forecast software (ForTrACC) → less accurate, low latency
- Accumulated precipitation over past 24/48/72h, ~4 hours latency using blended (GEO+LEO) precipitation product (NASA IMERG early product)
- INPE Brazil integrates those products on a GIS web-based platform (SIGMA, http://sigma.cptec.inpe.br/scope/), running as a prototype
- Regions of interest based on WMO SWFDP regions, other layers can be added

Next steps

- Transition prototype into operational environment (software free and open)
- Establish validation procedure using IPWG sites, to allow users to assess uncertainty of the products through the SIGMA platform
- Reduce latency

SWFDDP South-West Pacific Region of Interest



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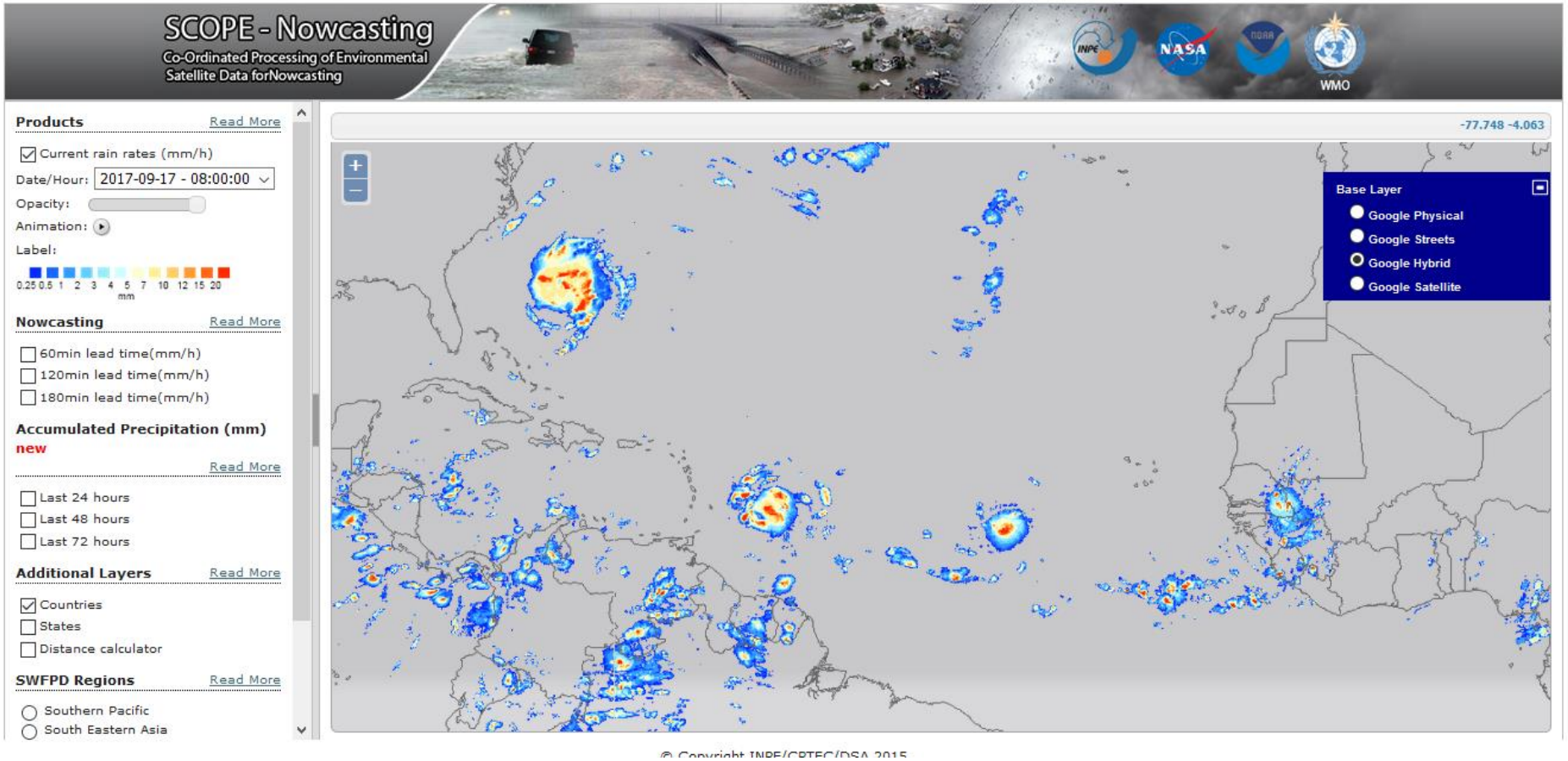
Pilot Project 3: Satellite-derived precipitation information



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Pilot Project 4: Sand and Dust Monitoring in East Asia

Objective

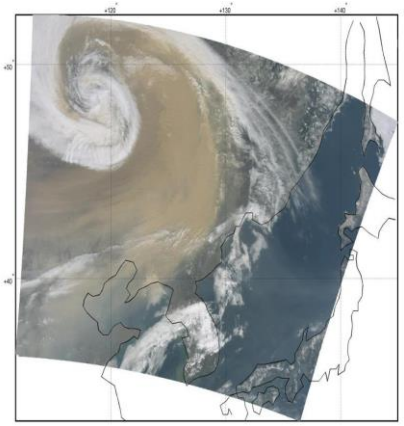
- Regionally consistent Aeolian dust products based on a common algorithm, mainly based on GEO imagery (Himawari-8, FY-4A, GK-2A)
- Rationalize regional diversity of aerosol-related products that are mostly not harmonized, and not always sustained.

Achievements

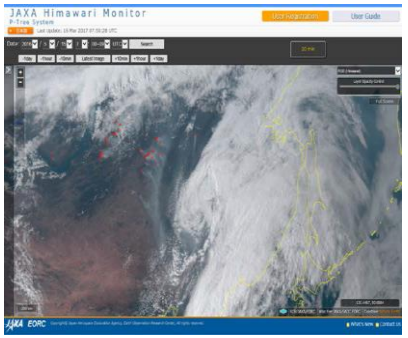
- CMA, JMA and KMA are testing and validating present and next-generation dust products against case studies
- Sharing of in-situ datasets among CMA, JMA and KMA
- Joint presentation of results at user conferences (AOMSUC)
- Contact with Asian node of Sand and Dust Storm Warning Centre (SDS-WAS) hosted by CMA Beijing

Next steps

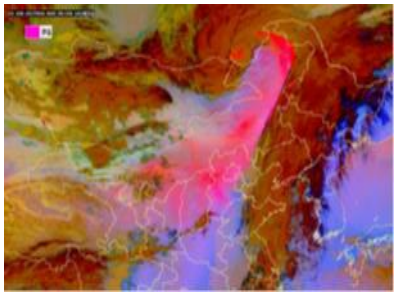
- Further liaision with SDS-WAS Beijing to achieve availability of satellite-based products on SDS-WAS portal
- Use of satellite-based products in data assimilation
- Inter-comparison of products from JMA, CMA, KMA to include JAXA
- Further comparison of COMS, FY-4A, H-8 products with AERONET, possibly through AEROSAT community
- Report to AOMSUC

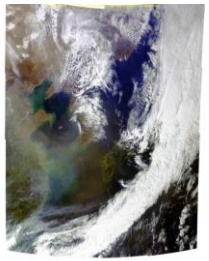


FY-3 dust products (CMA)



Himawari-8 Wild Fire Product (JMA)





Dust detection of COMS (KM

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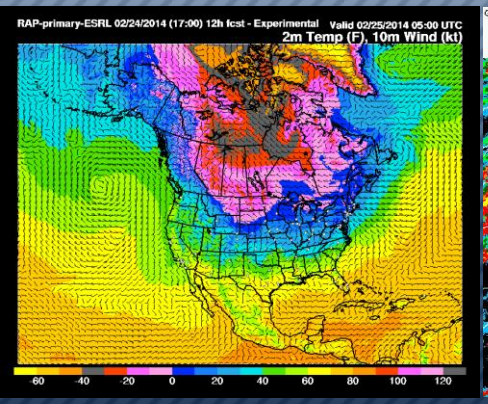
Proposals for new pilot activities

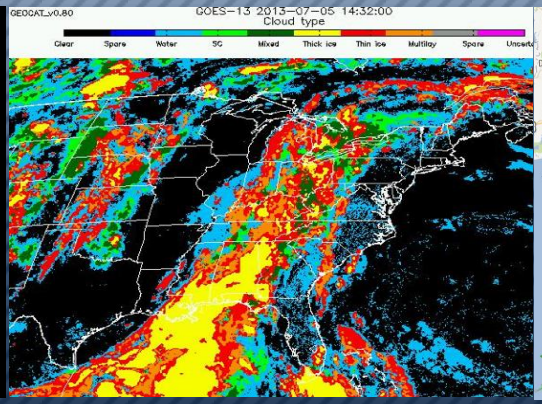
(SCOPE-Nowcasting executive panel meeting, 18-20 Sep 2017)

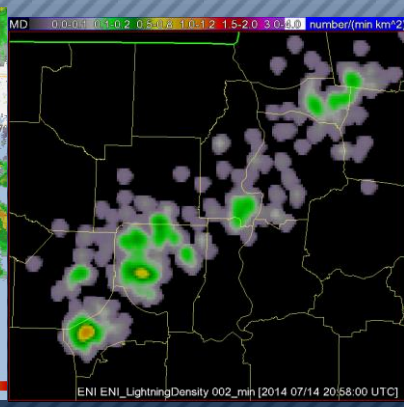
Category	Activity	Region	Provider	User
Nowcasting in a Big Data world	**Multi-sensor feature-based nowcasting of convective development**	Demonstration studies in area of interest (1 or more per agency)	Lead: NOAA, AuBOM Contributors: CMA, KMA, JMA, SIMEPAR, EUMETSAT (TBC)	NMHS
Advanced nowcasting	**Atmospheric structure with focus on water vapour using vertical weighting functions, low-level water vapour bands (TBC)**	TBD	EUMETSAT (TBC), CMA	TBD
Advanced nowcasting	**Incorporating satellite-based MW observations about column-condensed water into nowcasting applications**	Global tropics	Lead: NASA JPL; Contributors: OMP, U Castilla la Mancha, IMD, NOAA, CMA	NHMS, Commercial aviation weather departments

Transforming "Big Data" to Information

GB of data → KB of information

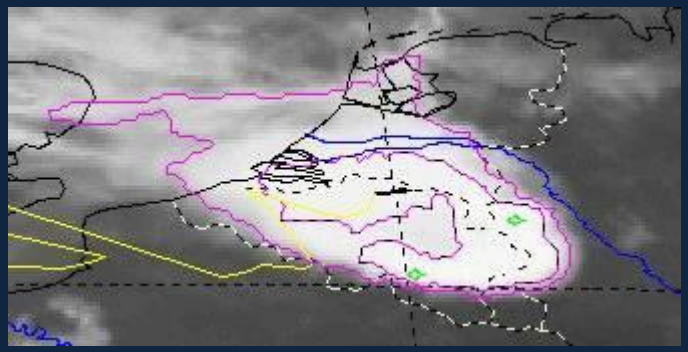


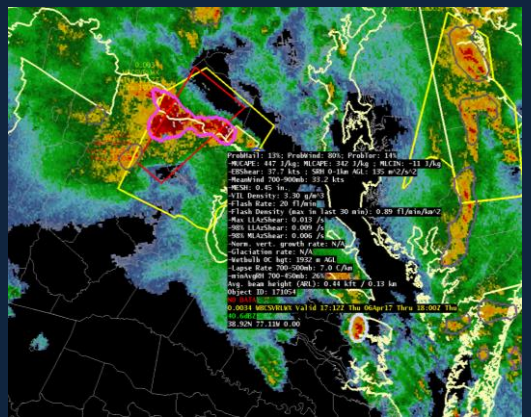




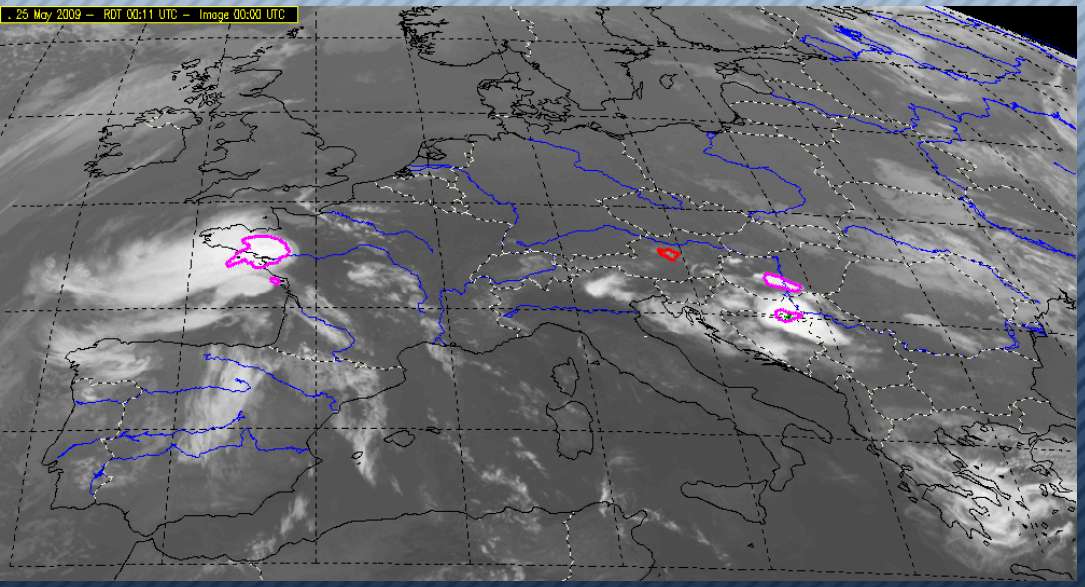
High-resolution NWP Data | **Satellite Derived Fields** | **Radar (if available)** | **Lightning**

e.g. Probability a thunderstorm will produce hazardous weather minutes in the future (60-90 minutes)



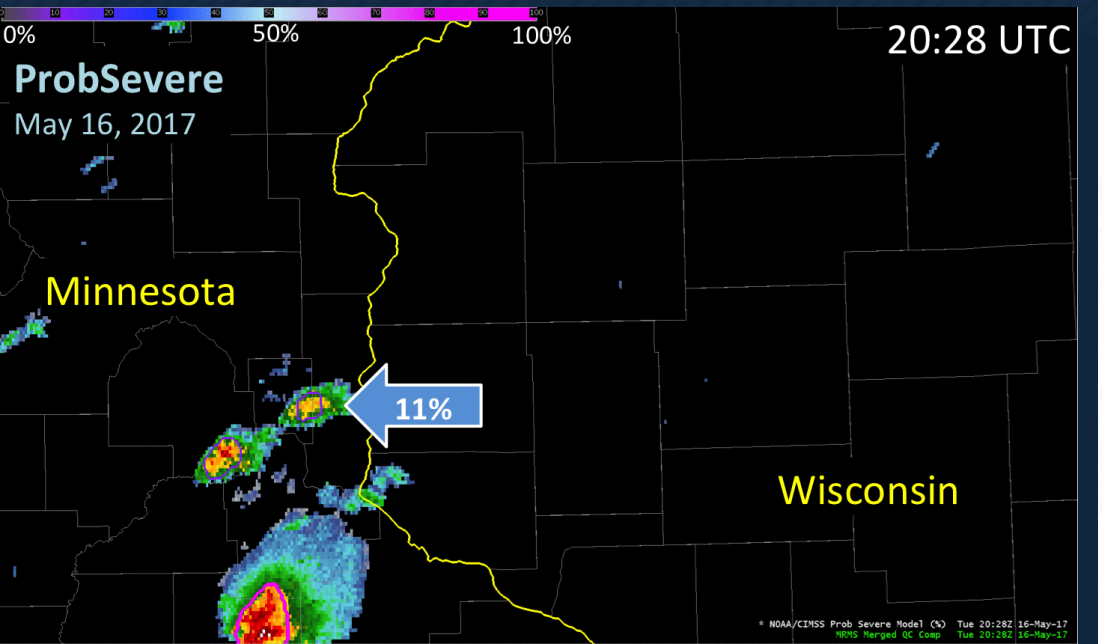


EUMETSAT NWC SAF RDT

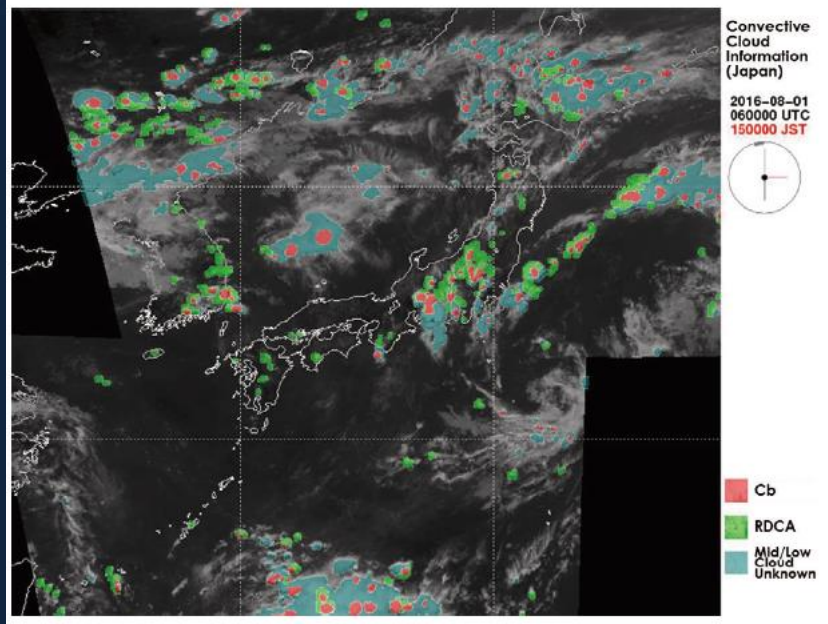


A sampling of the different approaches and product definitions

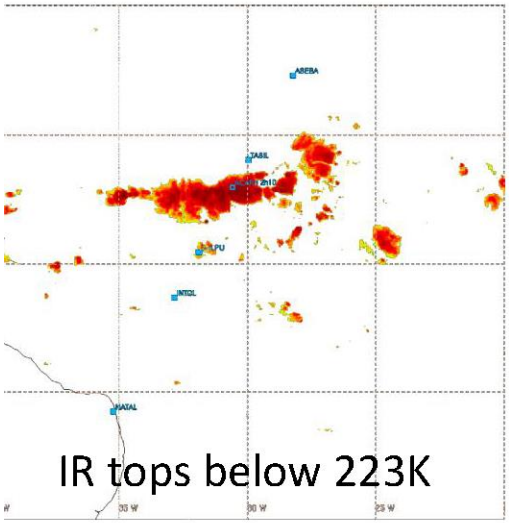
NOAA ProbSevere



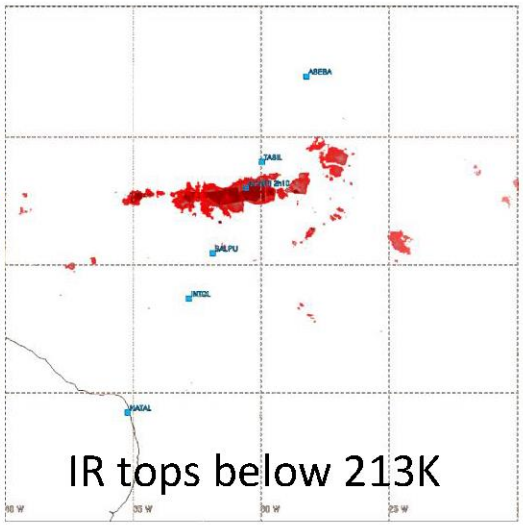
JMA RDCA



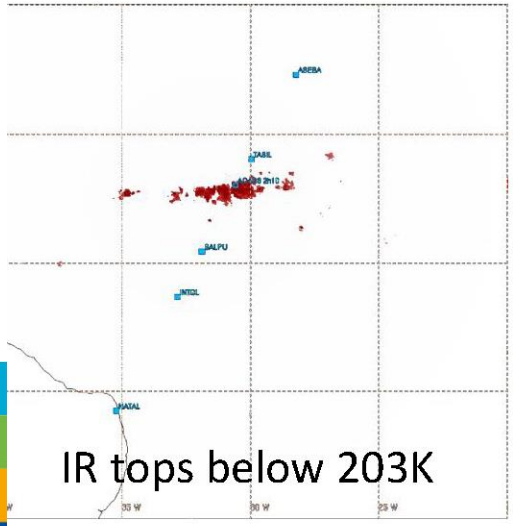
How could microwave information help? AF 447: Detection of convective cores



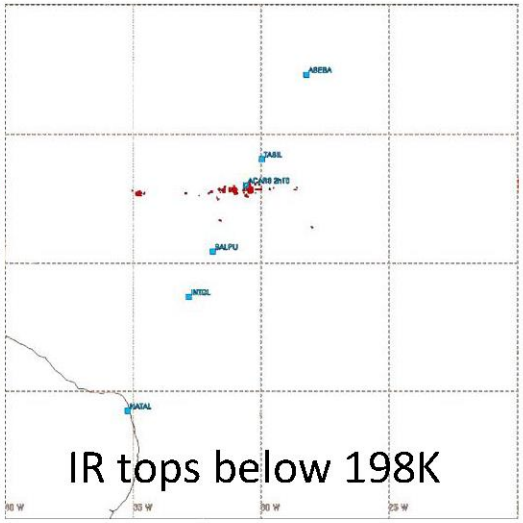
IR tops below 223K



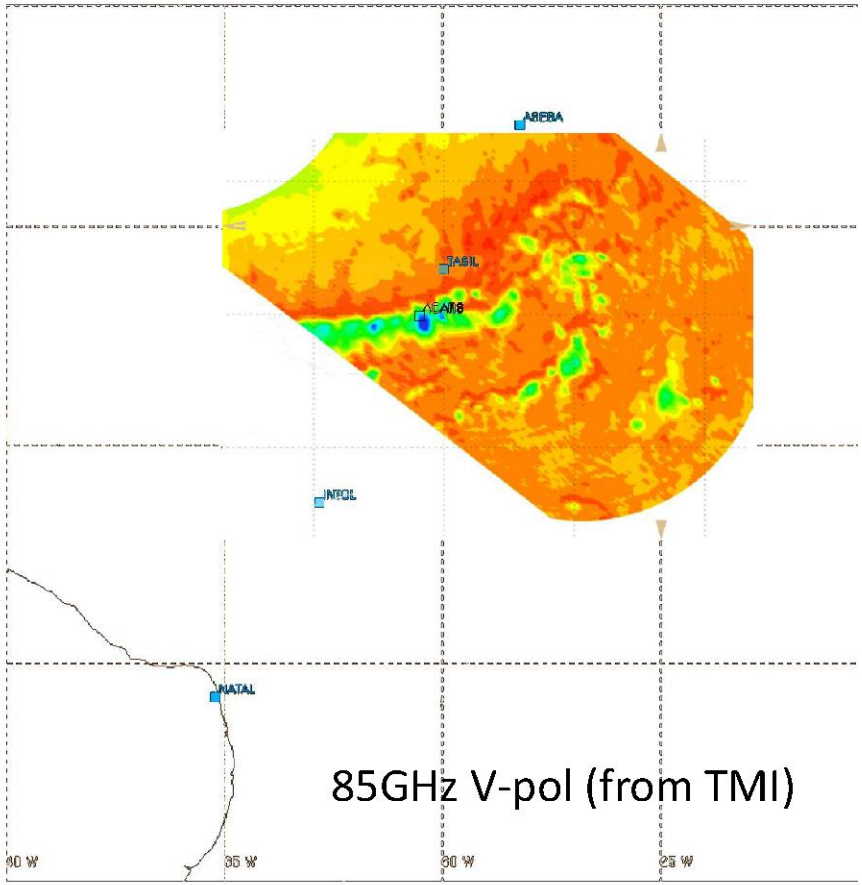
IR tops below 213K



IR tops below 203K



IR tops below 198K



85GHz V-pol (from TMI)

@ 02:30 Z

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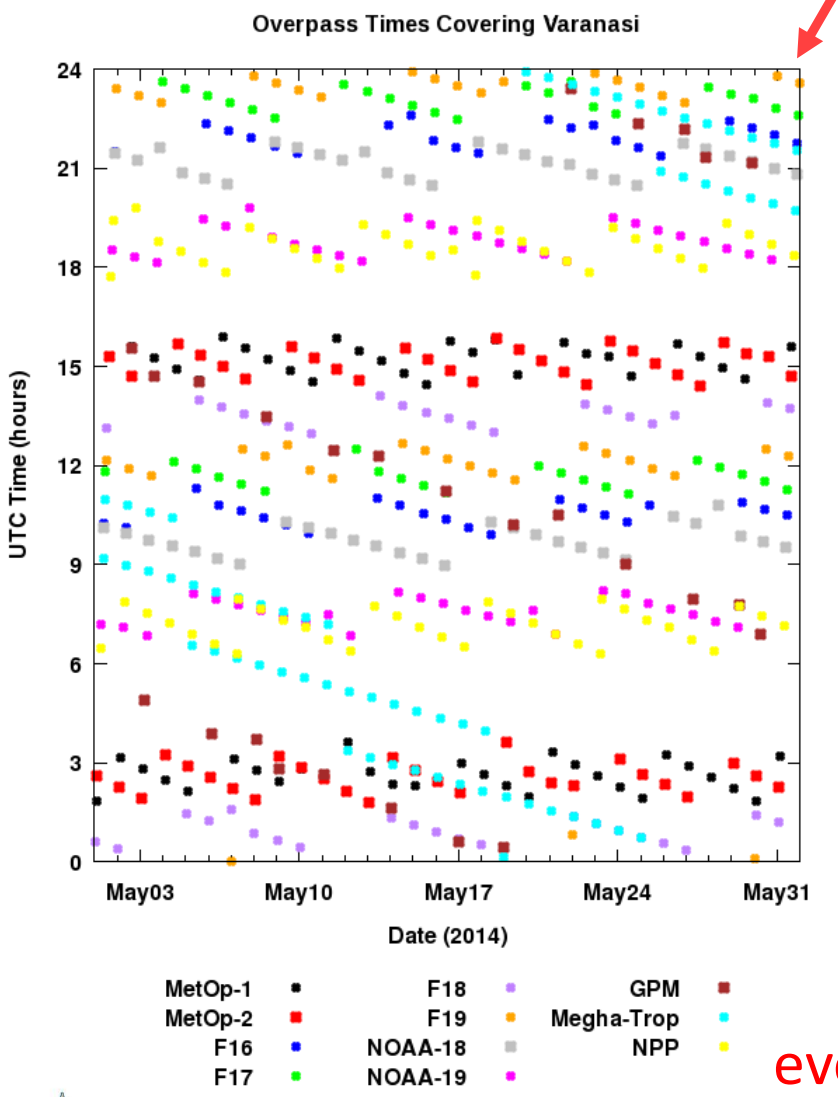
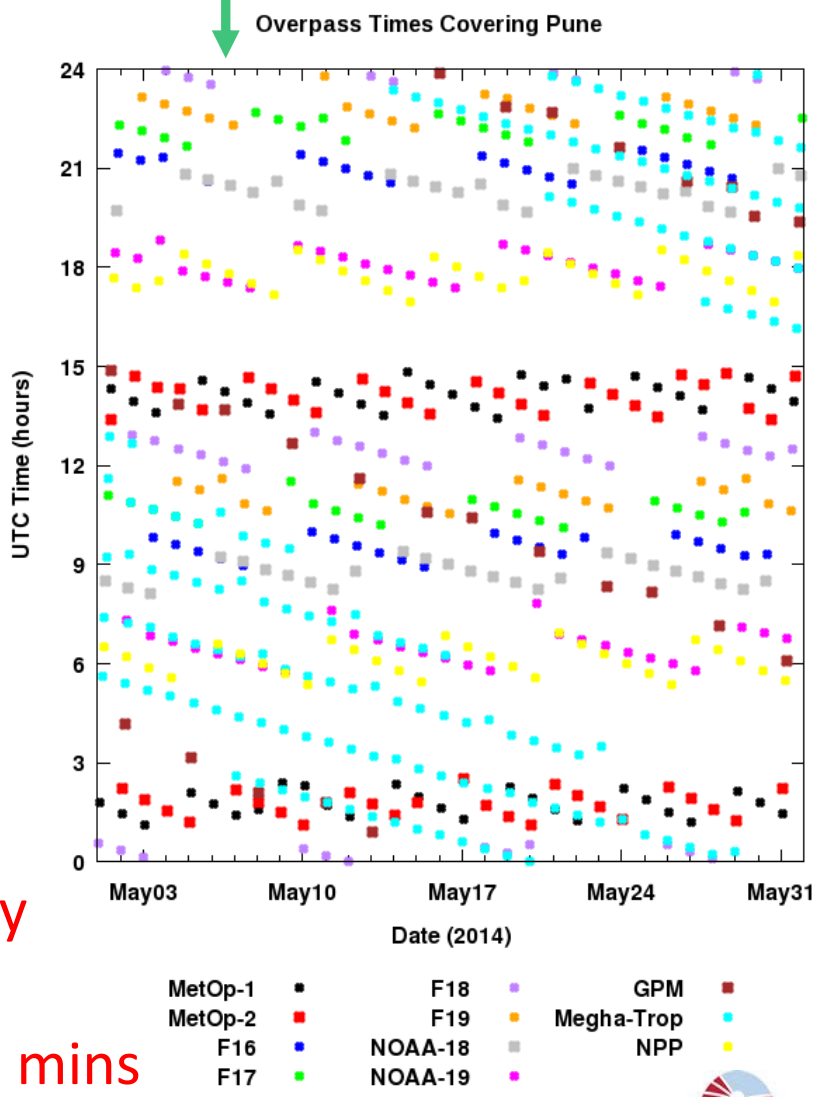
Temporal sampling of today's microwave constellation
1 month of passes over Varanasi (left) and Pune (right)





18 /day
so
every ~ 80 mins
(on average)

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Concluding remarks

- WMO SCOPE-Nowcasting Pilot activities have been successful in many ways

- Some “Pilots” await transitioning into operations
- New Pilots about to start

- Some expected benefits of SCOPE-Nowcasting have been realized:
  1. Improved access to satellite data by WMO member states
  2. Improved confidence in products generated through SCOPE-Nowcasting
  3. Reduced operating costs associated with technological change and software upgrades
  4. Reduced training overheads
  5. Improved cooperation between NMHSs through access to shared products
  6. Strong connections between scientists across agencies as a foundation for increased collaboration

- User community involvement and feedback critical to further success

- Proposals for new Pilots can be made to WMO Secretariat or the SCOPE-Nowcasting Executive Panel

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

Thank you
Merci

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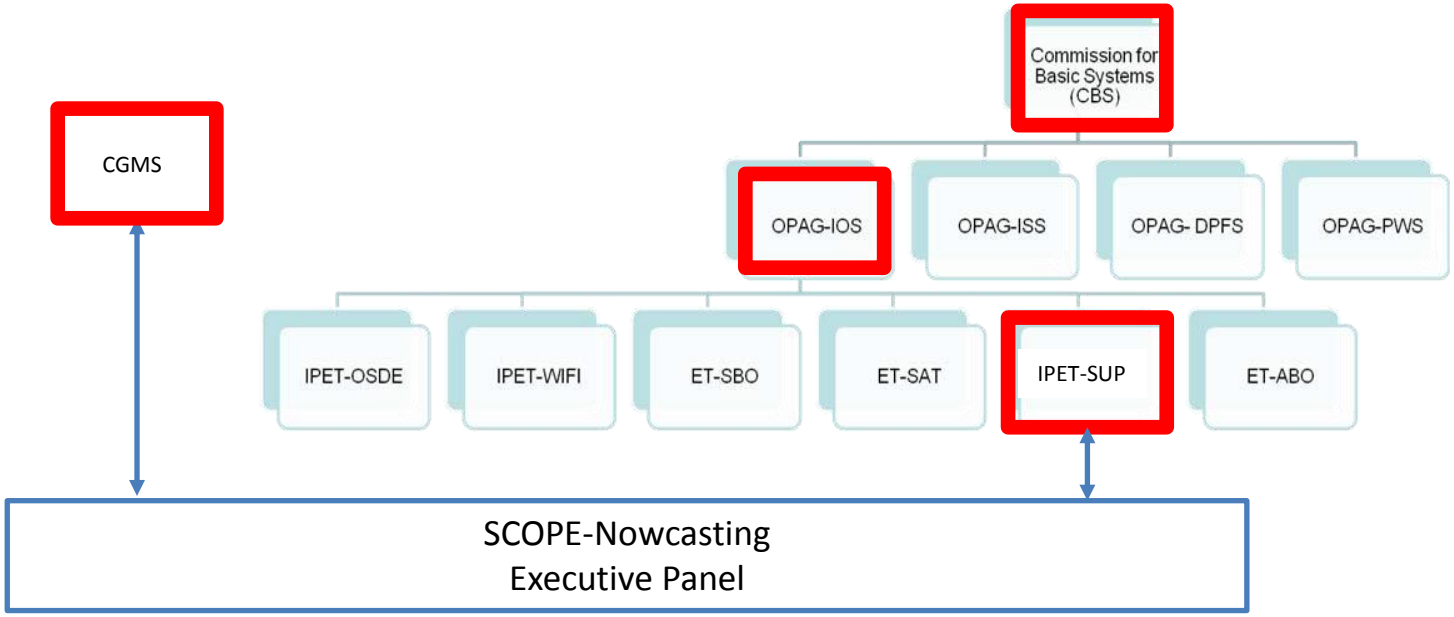
SCOPE-Nowcasting reporting to WMO and Satellite Operators (CGMS)



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Nowcasting Application Areas

- Convective Storms
- Mesoscale features associated with tropical cyclones
- Local precipitation events
- Sand and dust storms
- Winter weather
- Wild Fires
- Contaminated areas
  (incl. volcanic eruptions)

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SCOPE-Nowcasting Pilot Project Criteria

- Use of multi-satellite data
- Dataset formats can be read by standard tools
- Concise product documentation
- Open and easy access
- Available in near-real time (<6h)
- Availability of training information
- An official commitment from all agencies involved in the project