



FY-USERCON 2021

1-5 November 2021
Beijing, China



Use of FORMOSAT-7/COSMIC-2 Radio Occultation data in diagnosing volcanic eruption and other meteorological applications

CHAN Ying-wa and So Chi-kuen

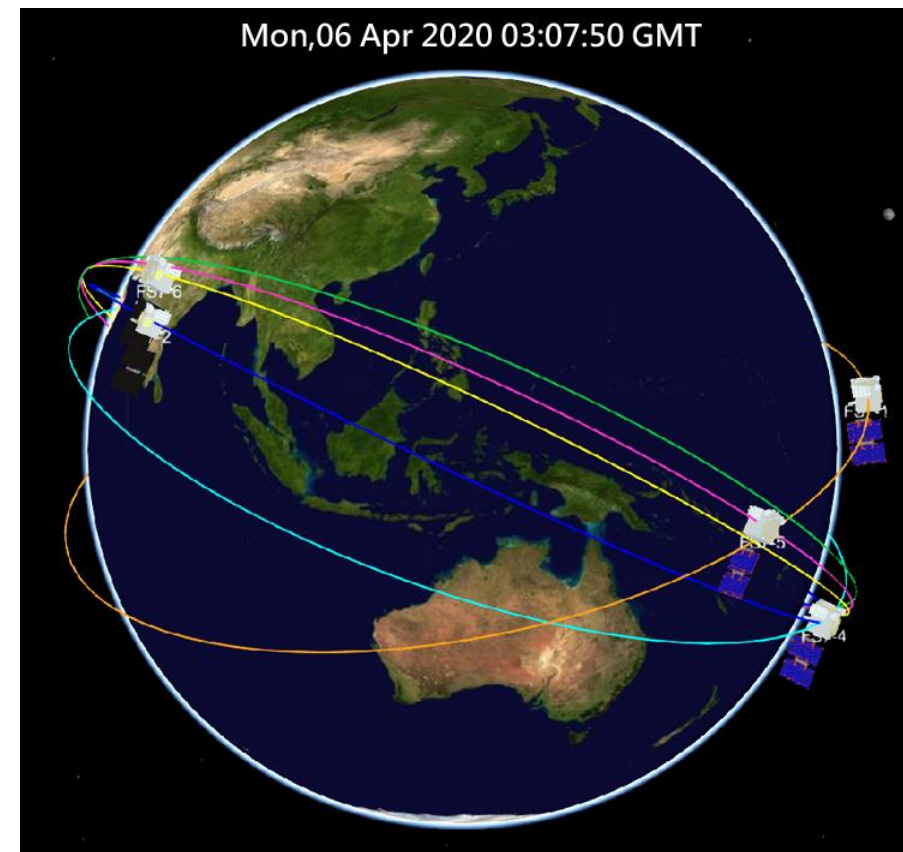
Hong Kong Observatory



Applications of FORMOSAT-7/COSMIC-2 (FS7/CS2)

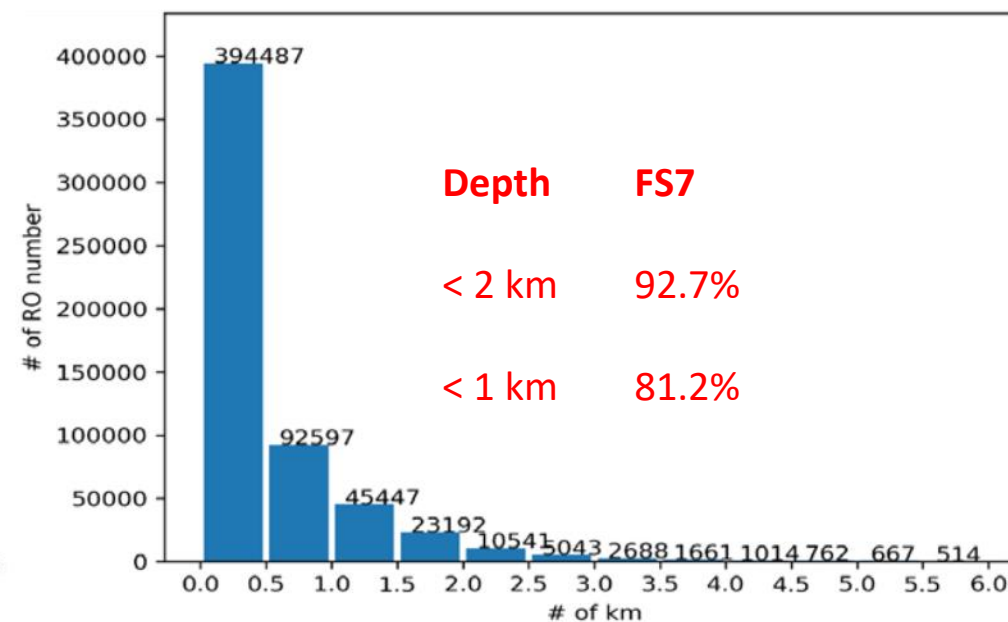
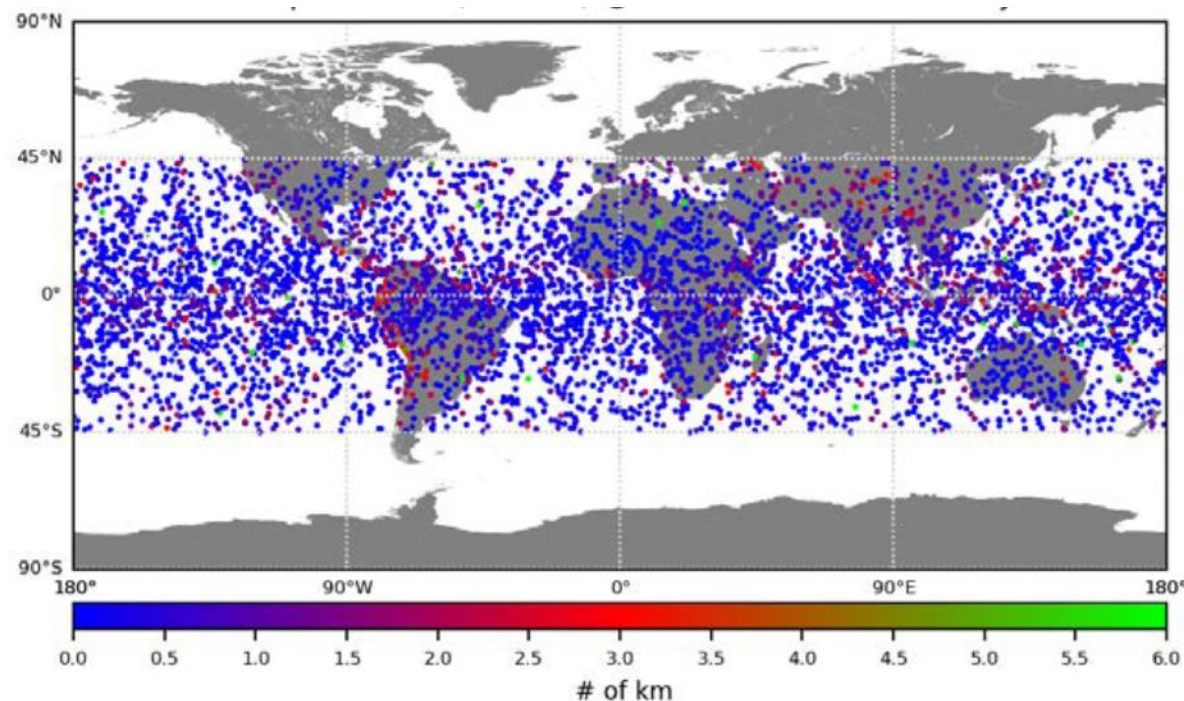
Constellation

- It comprises of 6 satellites flying at 6 different orbital planes at altitude of 550 km and orbit inclination angle of 24 degrees. All 6 satellites orbit the earth with a period of about 97 minutes.
- The 6 satellites were launched in June 2019 and RO data made available on the Internet since 1 October 2019.





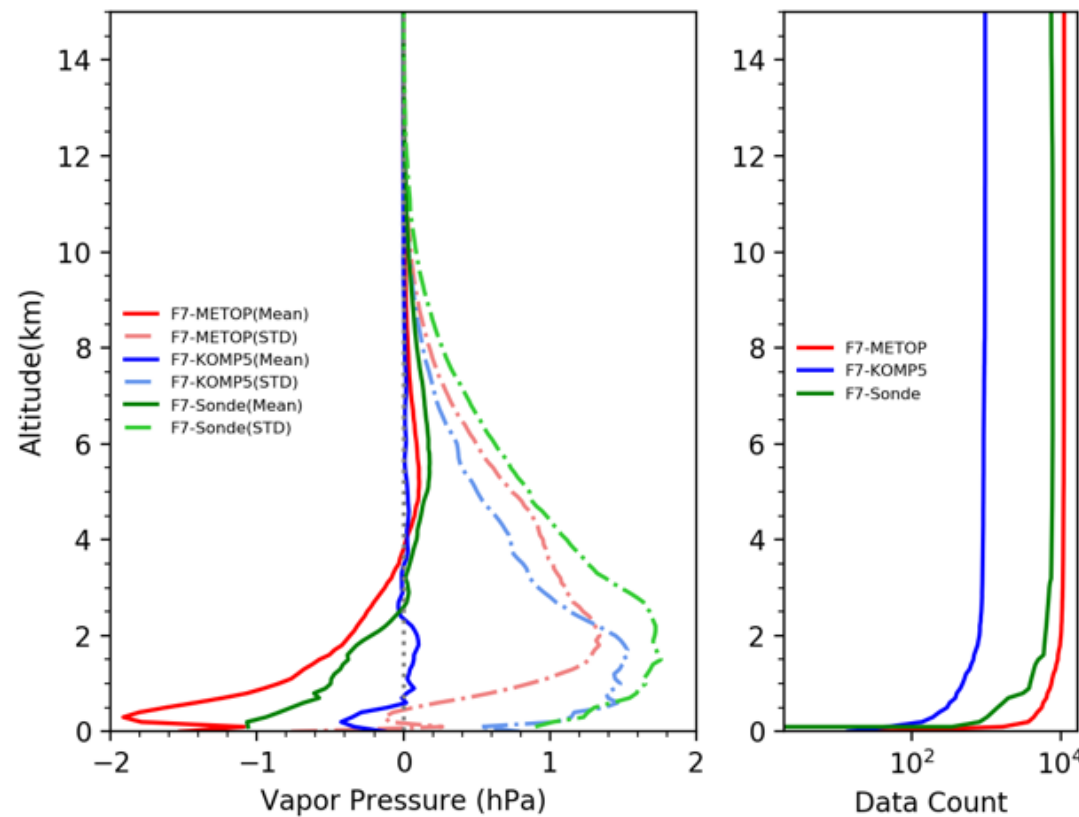
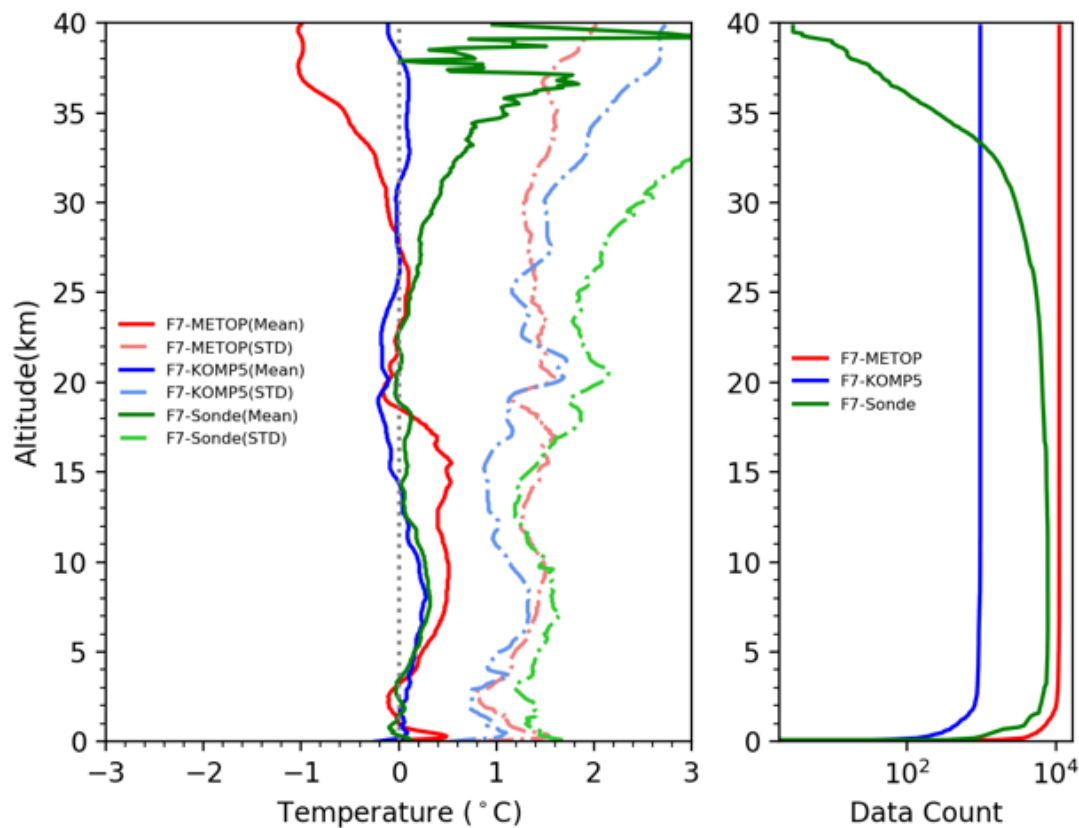
- Each FS7/CS2 satellite is equipped with a RO receiver which receives the GNSS signals from GPS signals from the United States and GLONASS signals from Russia



- RO profiles are generated by processing the magnitude of refraction for the GNSS and GLONASS signals as the refraction depends on the temperature and water vapor concentration in the atmosphere. The 6 FS7/CS2 satellites collect 4,000 to 5000 RO profiles daily between around ± 45 degree latitude.



Comparison with Metop and KOMPSAT-5 satellites as well as radiosondes



Bias – solid line
a positive temperature bias

RMSE – dashed line
a negative moisture bias

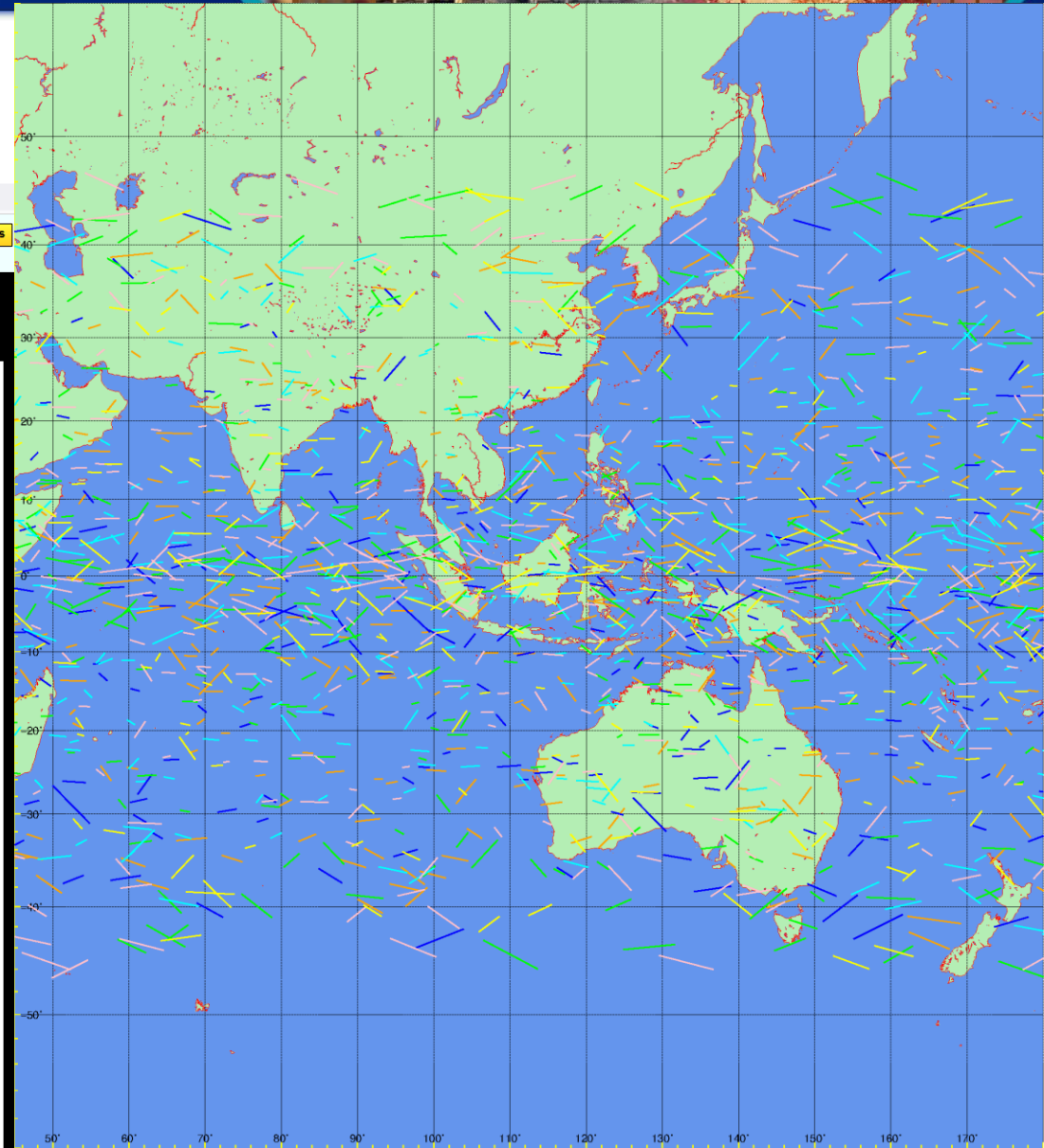
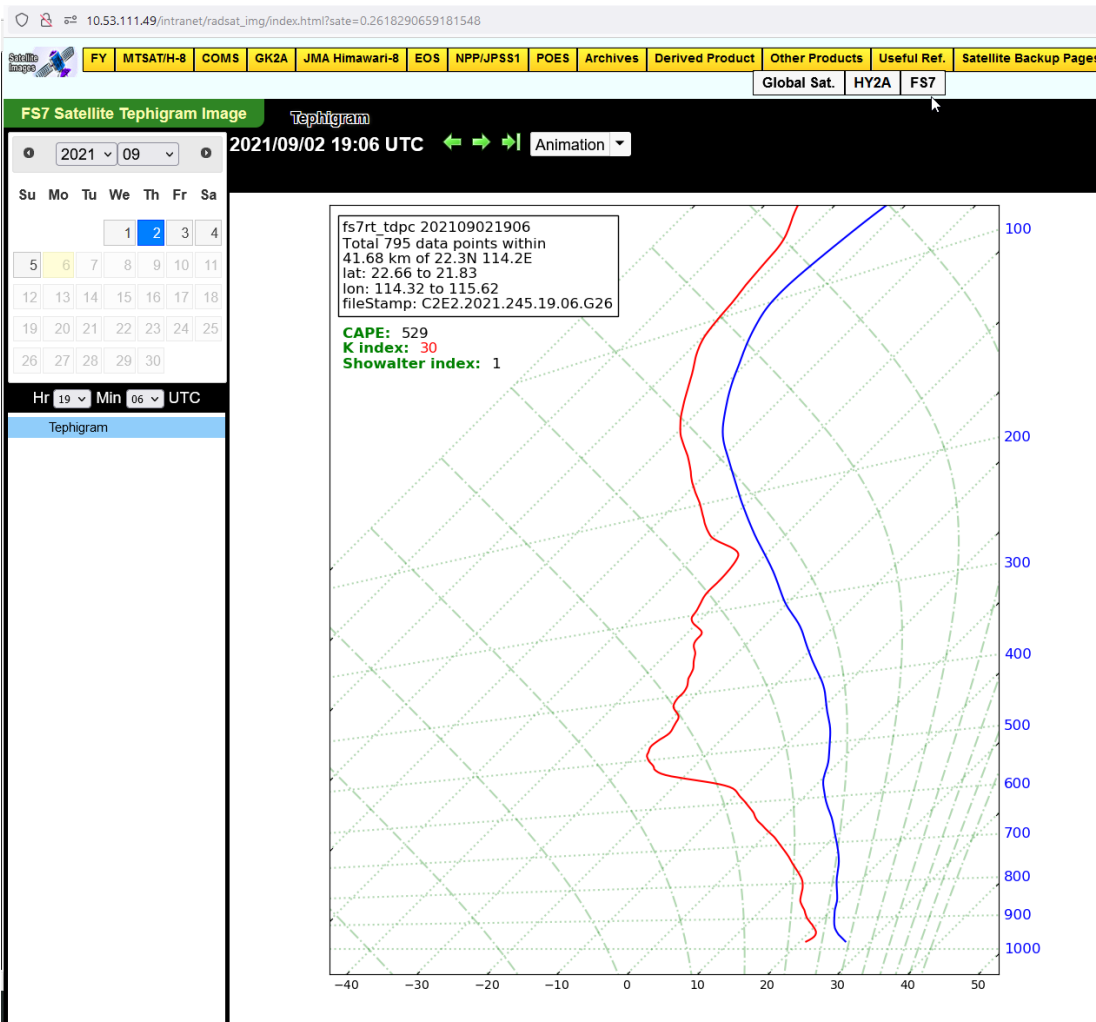


Performance

The verifications against multiple soundings (dropsondes and radiosondes) show consistent characteristics with a positive temperature bias of 0.5K and a negative moisture bias of 2 hPa in the troposphere.



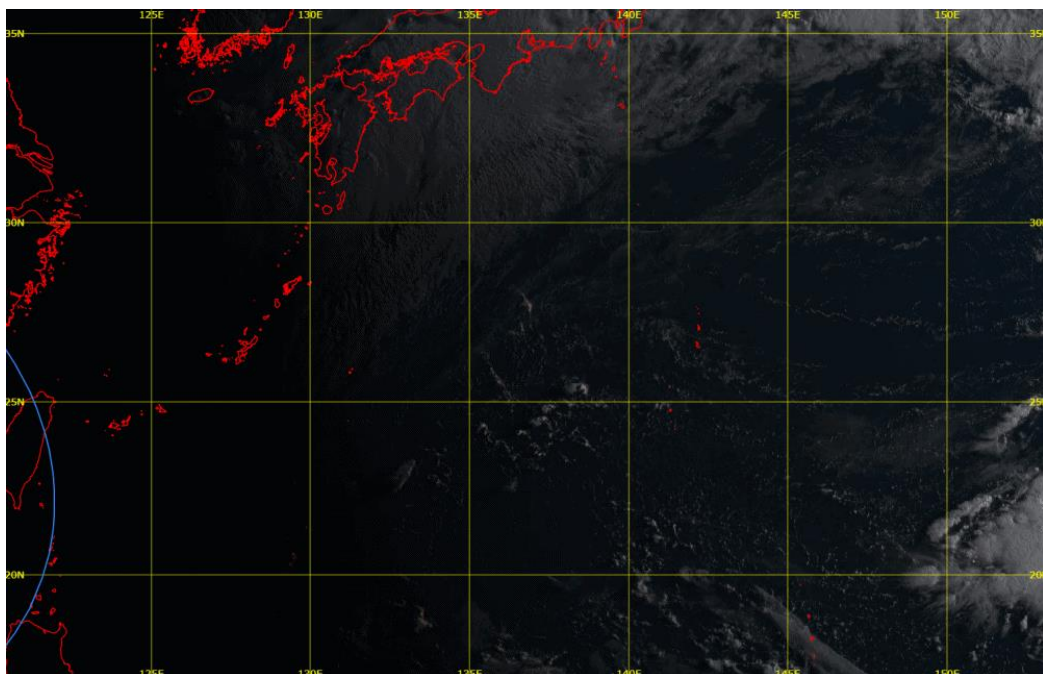
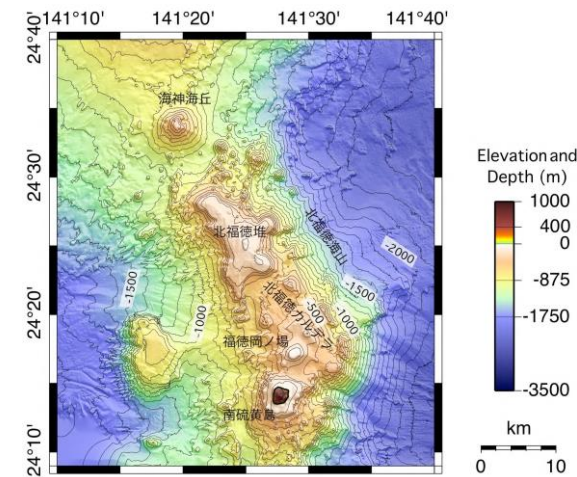
FS7/CS2 RO profiles on the HKO Intranet



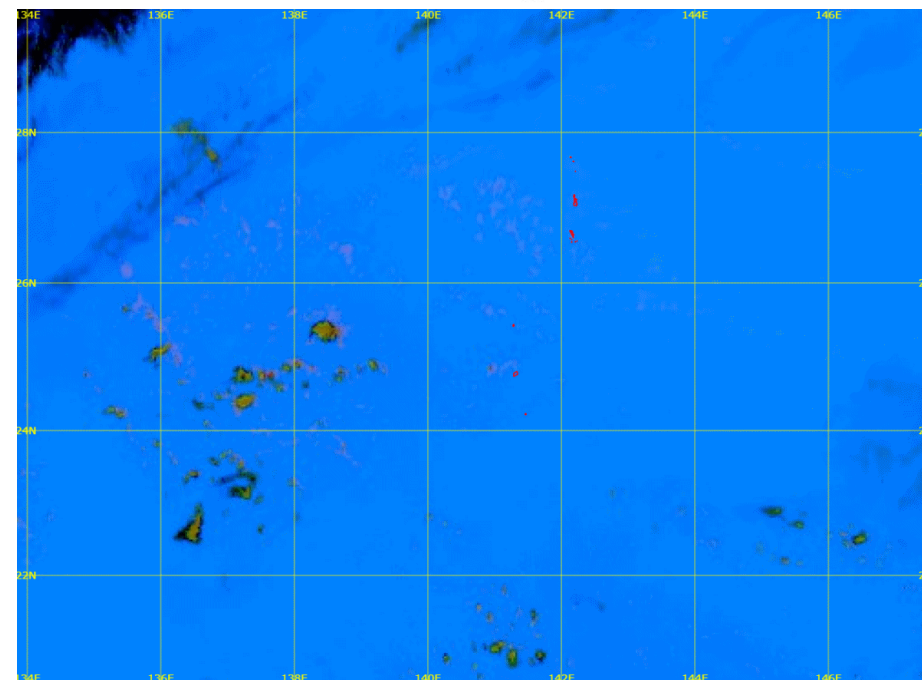


Fukutoku-Okanoba Volcanic Eruption

Started on 12 Aug 2021



H8 TC 2021/08/12 21:00 UTC



H8 Dust 2021/08/12 20:30 UTC



Monitoring of Fukutoku-Okanoba Volcanic Eruption

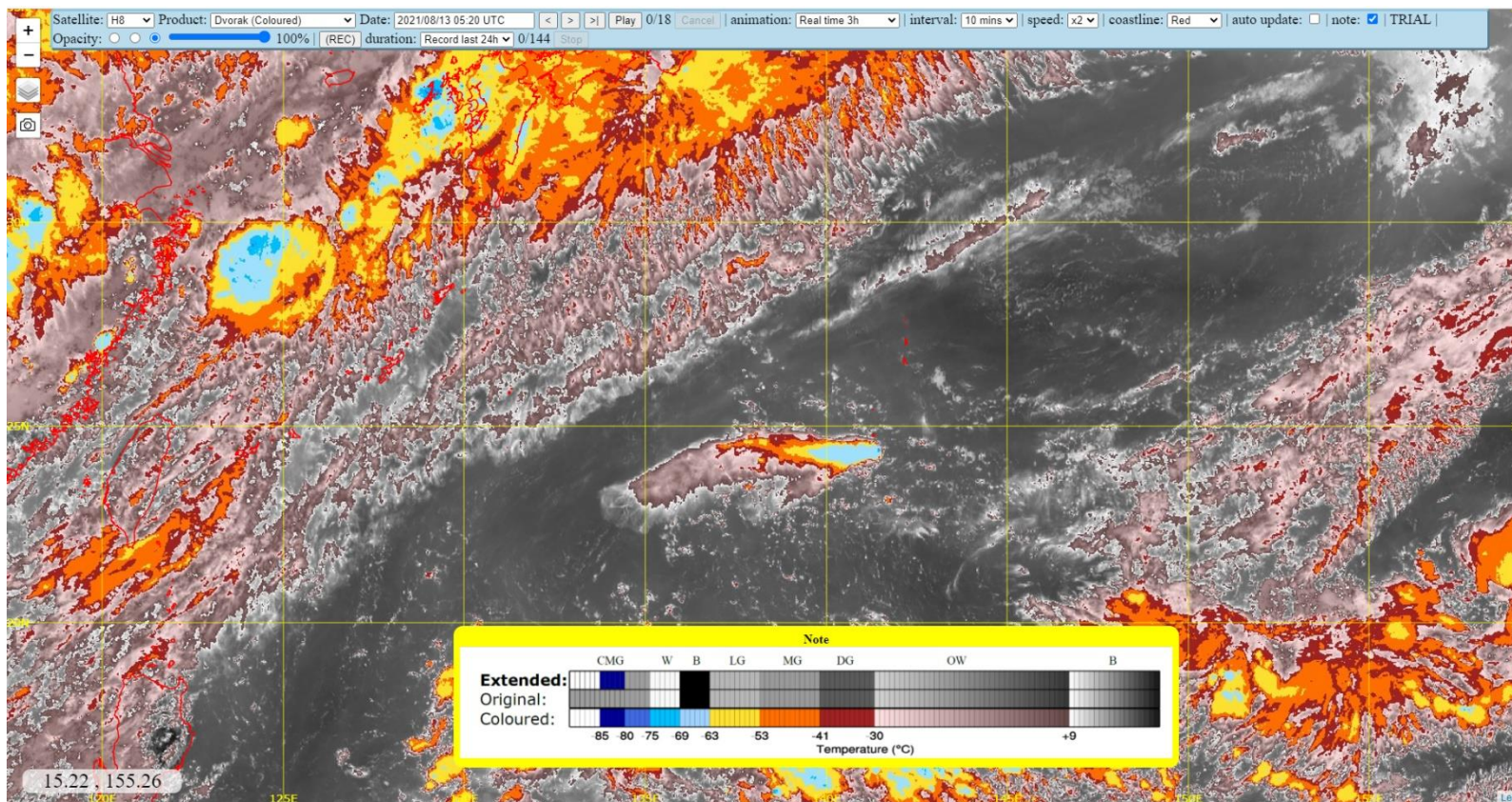
- Plume Height
- Composition of Volcanic Plume

Estimated plume height of
around **16 km** based on
Japan Coast Guard flight
observation





Himawari-8 Colour D'vorak Image to estimate plume height



$$H = (T_o - T) / L$$

where

H: Plume height (km)

T_o : Sea-level Temp. $\sim 300\text{K}$

T: Temp. (198K or $-75\text{ }^\circ\text{C}$)

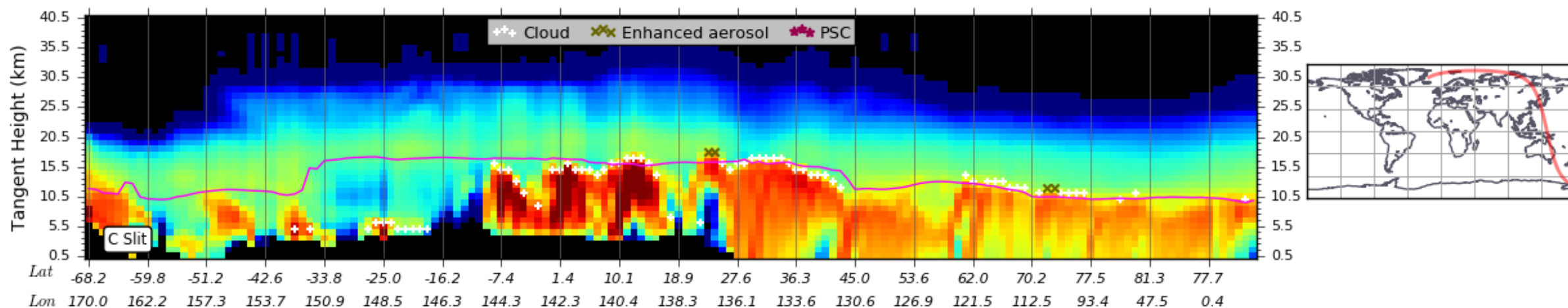
L: Lapse rate (6.5K/km)

$H \sim 15.7\text{ km}$



Analysis aerosol top

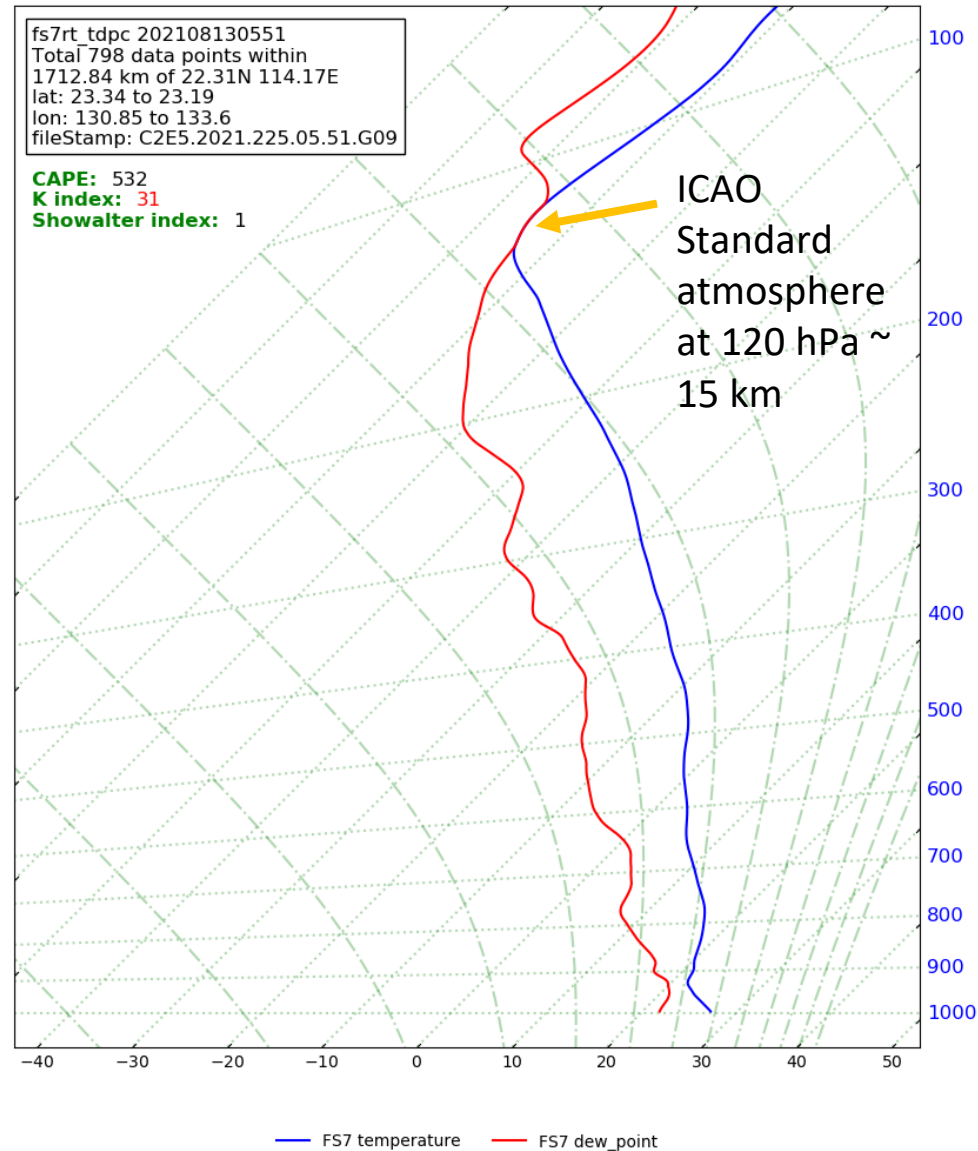
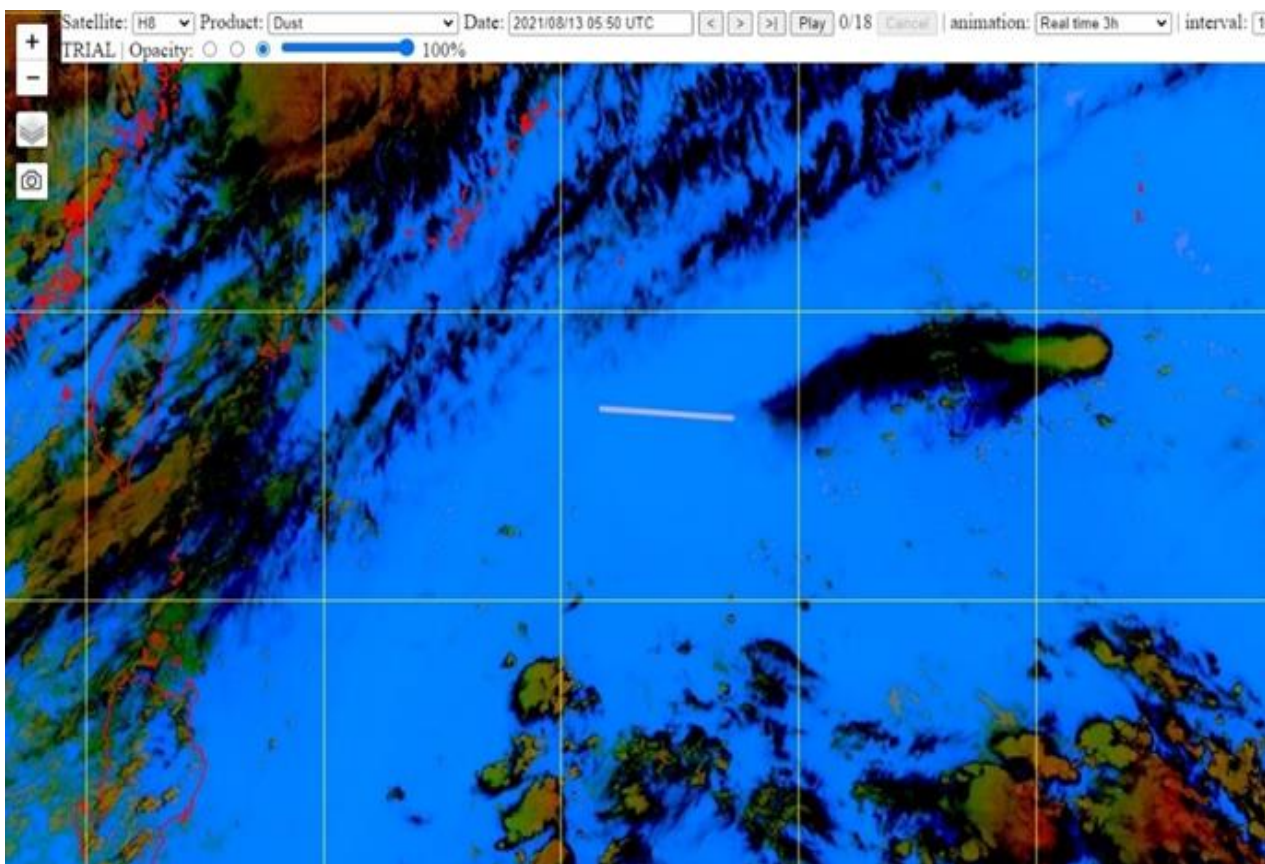
Aerosol Extinction Values retrieved at 997 nm



Ozone Mapping Profiler Suite (OMPS) Limb Profiler (LP) aerosol plots:

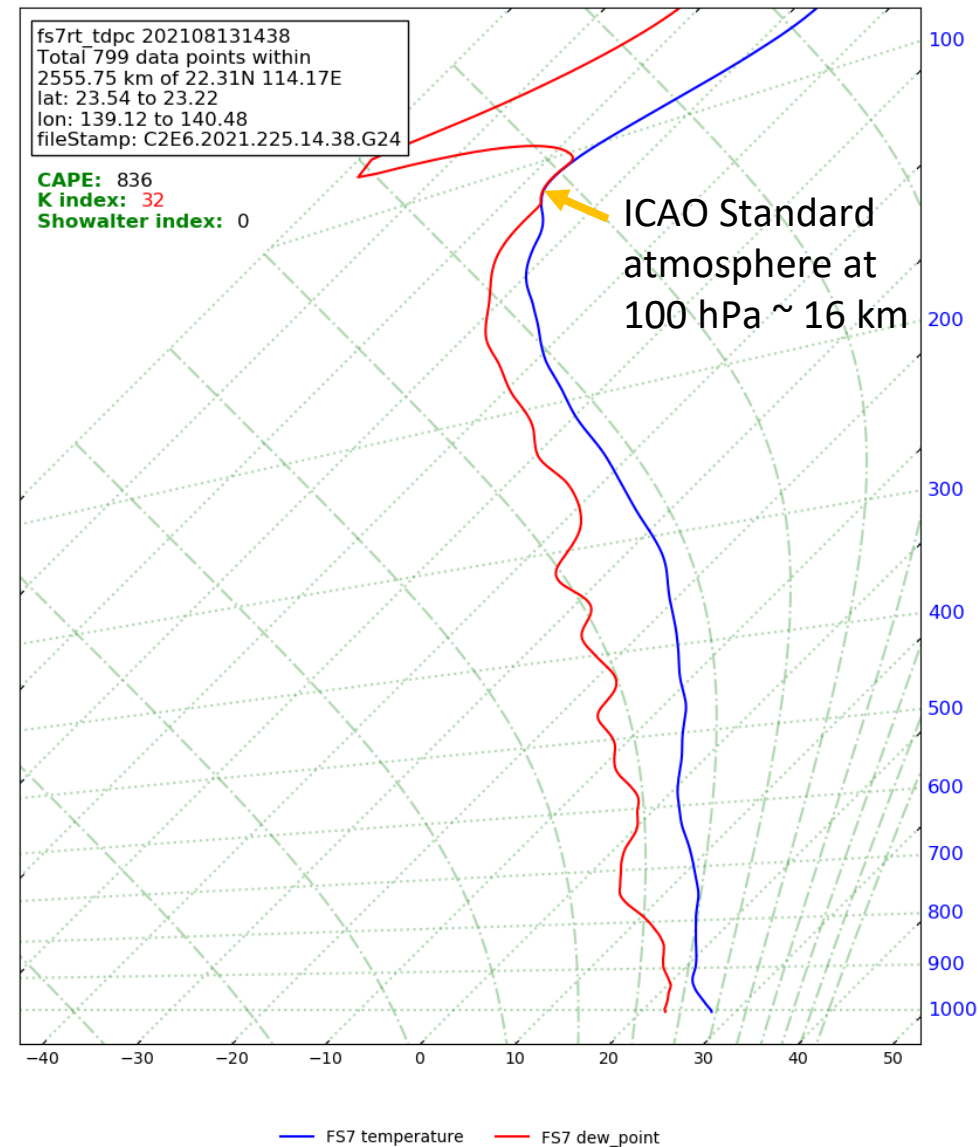
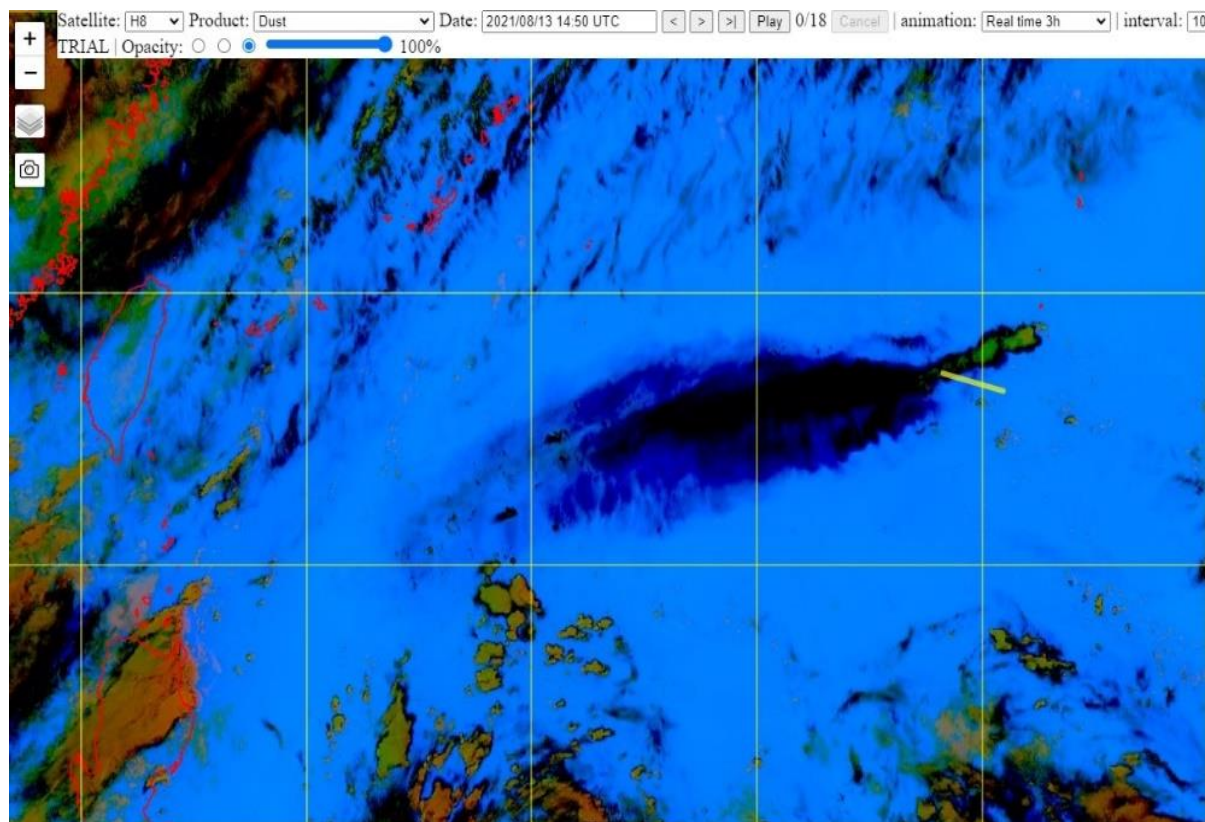


Analysis plume height using FS7/CS2 RO Data



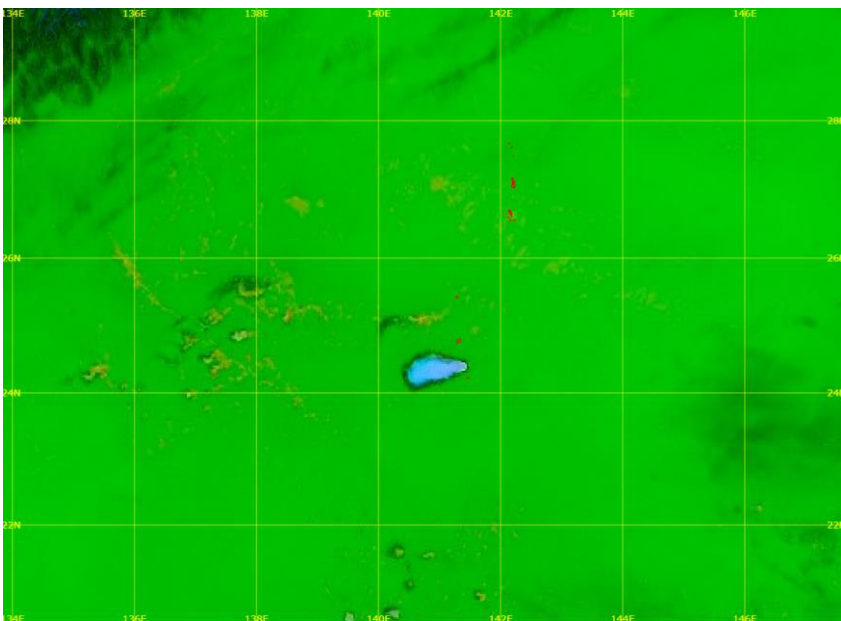


Analysis plume height using FS7/CS2 RO Data

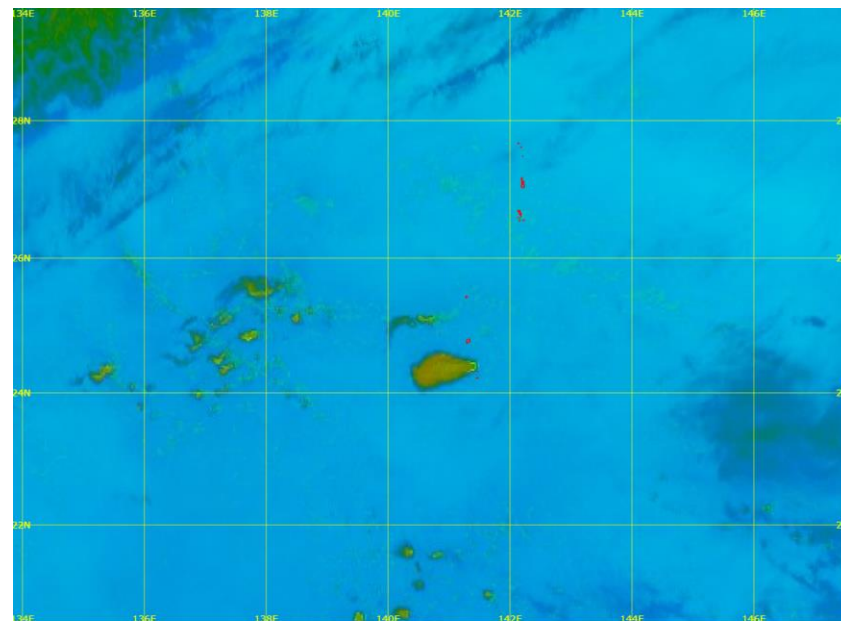




Himawari-8 Ash and SO₂ RGB Images



H8 Ash 2021/08/12 22:10 UTC



H8 SO₂ 2021/08/12 22:10 UTC

24-Hours Ash Microphysics Interpretation of Colours

Colour	Interpretation
	Cold, thick, high-level clouds
	Thin Cirrus clouds Contrails
	Volcanic SO ₂ clouds
	Volcanic Ash clouds

Colour interpretation and RGB values for SO₂ RGB imagery

Color	Interpretation	RGB Value	HTML
	Upper level SO ₂	240,45,0	#F02D00
	Lower level SO ₂	140,240,0	#8CF000
	Lower-upper level SO ₂	220,255,0	#DCFF00
	Thick clouds	150,120,0	#967800
	Thin high level clouds	5,2,20	#050214
	Low level clouds	5,200,90	#05C85A

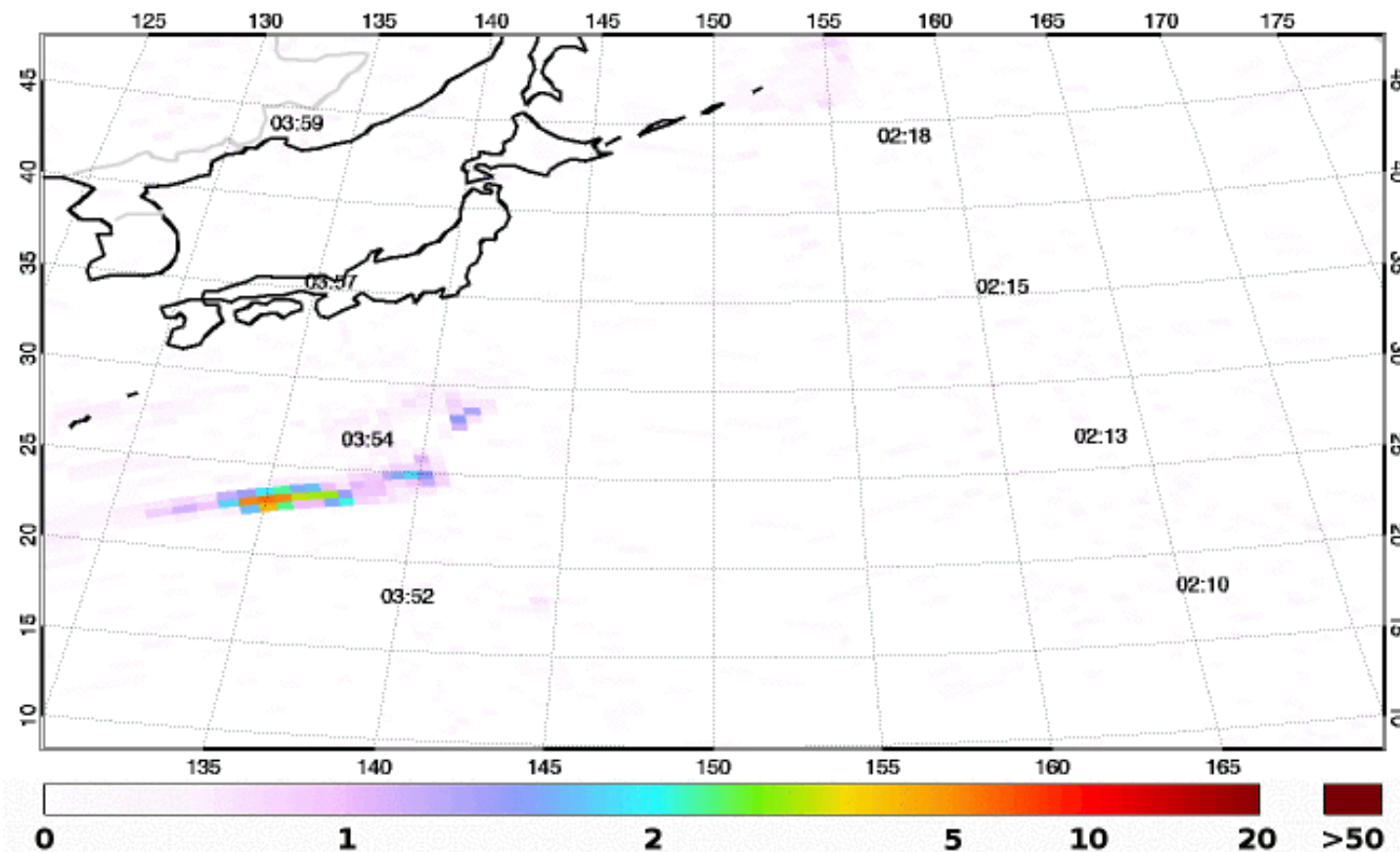


SO₂ emission

SO₂ vertical column [DU]

14 August 2021

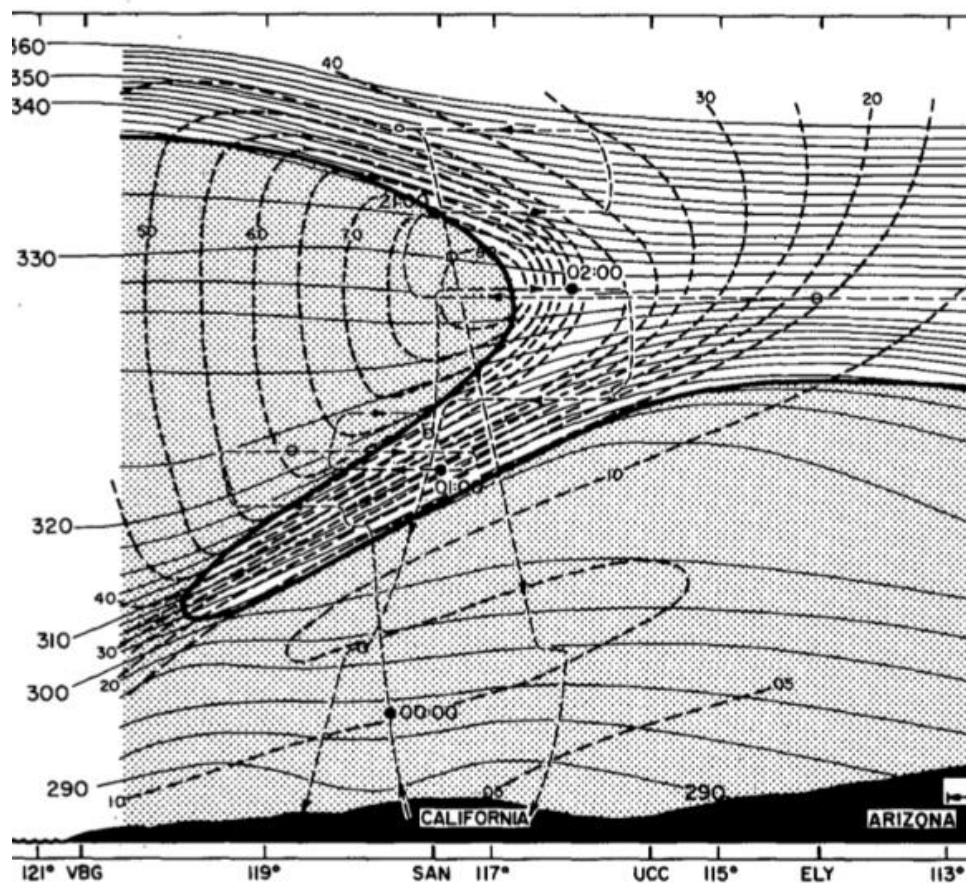
OMPS – NASA/GINA/FMI/BIRA-IASB



Ozone Mapping and Profiler Suite (OMPS); Geographic Information Network of Alaska (GINA)
Finnish Meteorological Institute (FMI); Royal Belgian Institute for Space Aeronomy (BIRA-IASB)



Stratospheric Intrusion



- Tropopause folding
- Moisture gradient
- Jet stream
- Turbulence



Tracers: i) Ozone; ii) Potential Vorticity iii) RO profiles

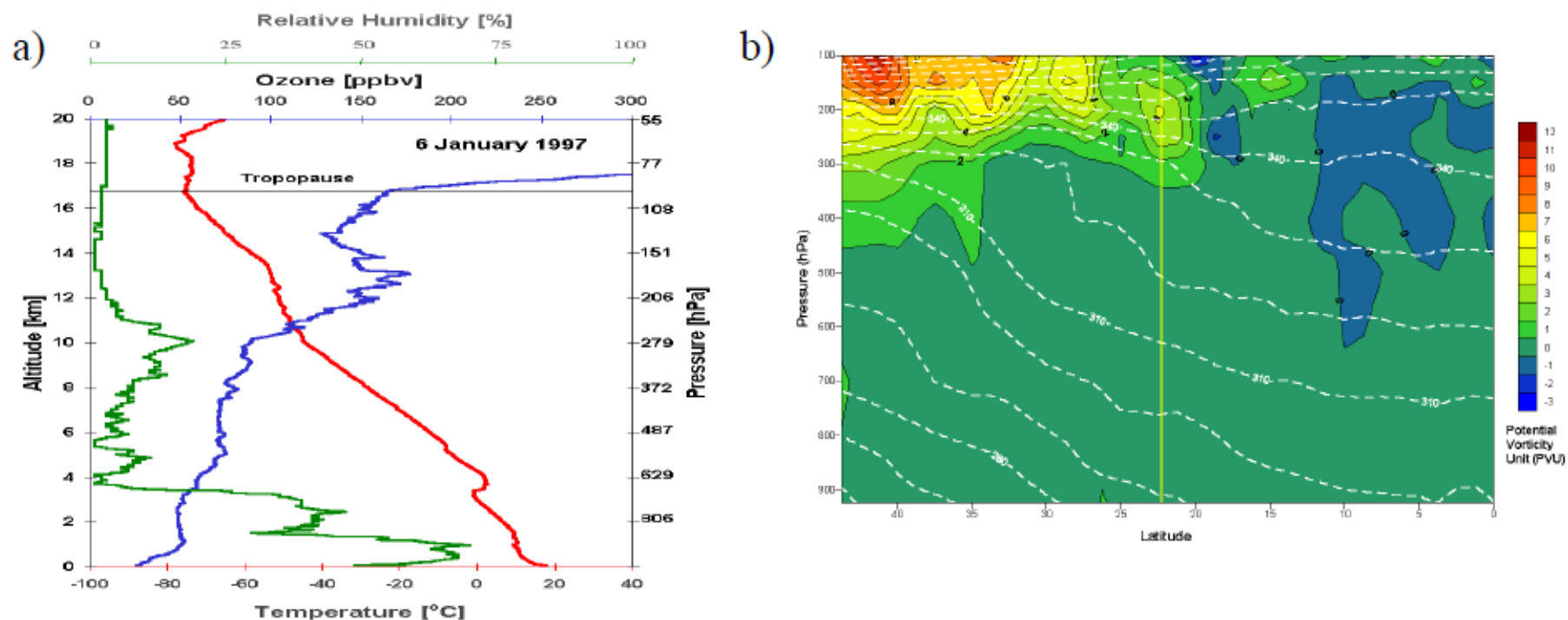
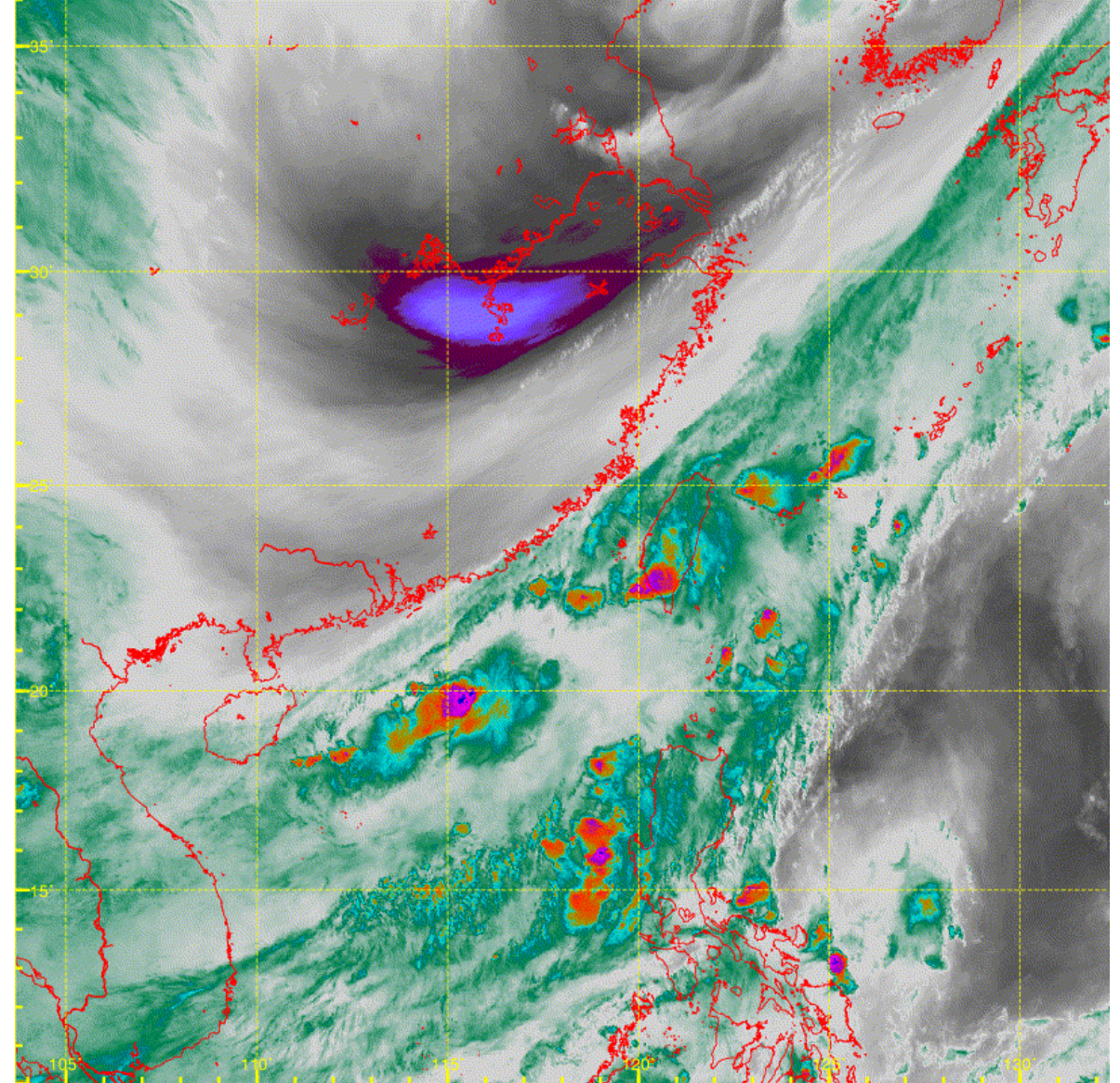


Fig. 3. Ozone profile on 6 January 1997 is shown in a) with the ozone profile marked in blue, temperature in red and relative humidity in green. Meridional cross section of potential vorticity along 113.75 °E at 0000 UTC is shown in b) with black lines the potential vorticity in PV units, dashed white lines potential temperature in °K, and vertical yellow line Hong Kong's latitude.

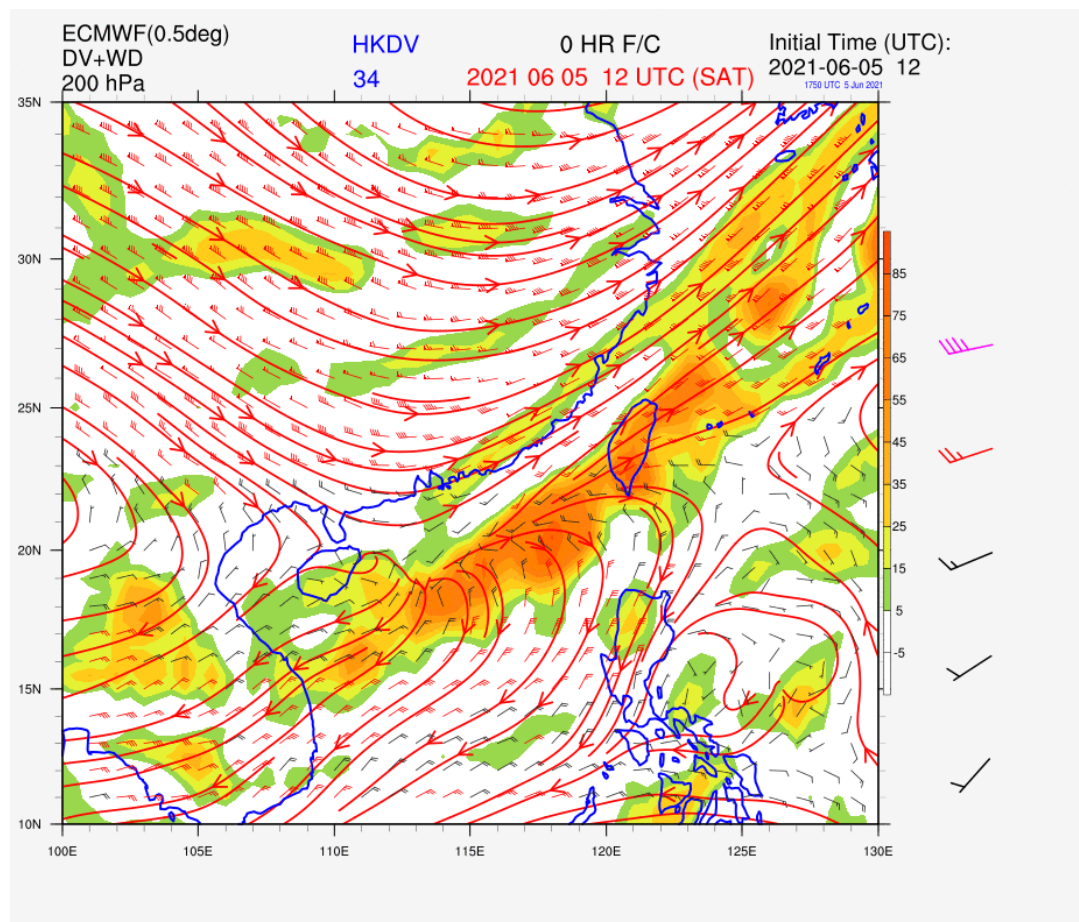


Stratospheric intrusion on 6-7 June 2021

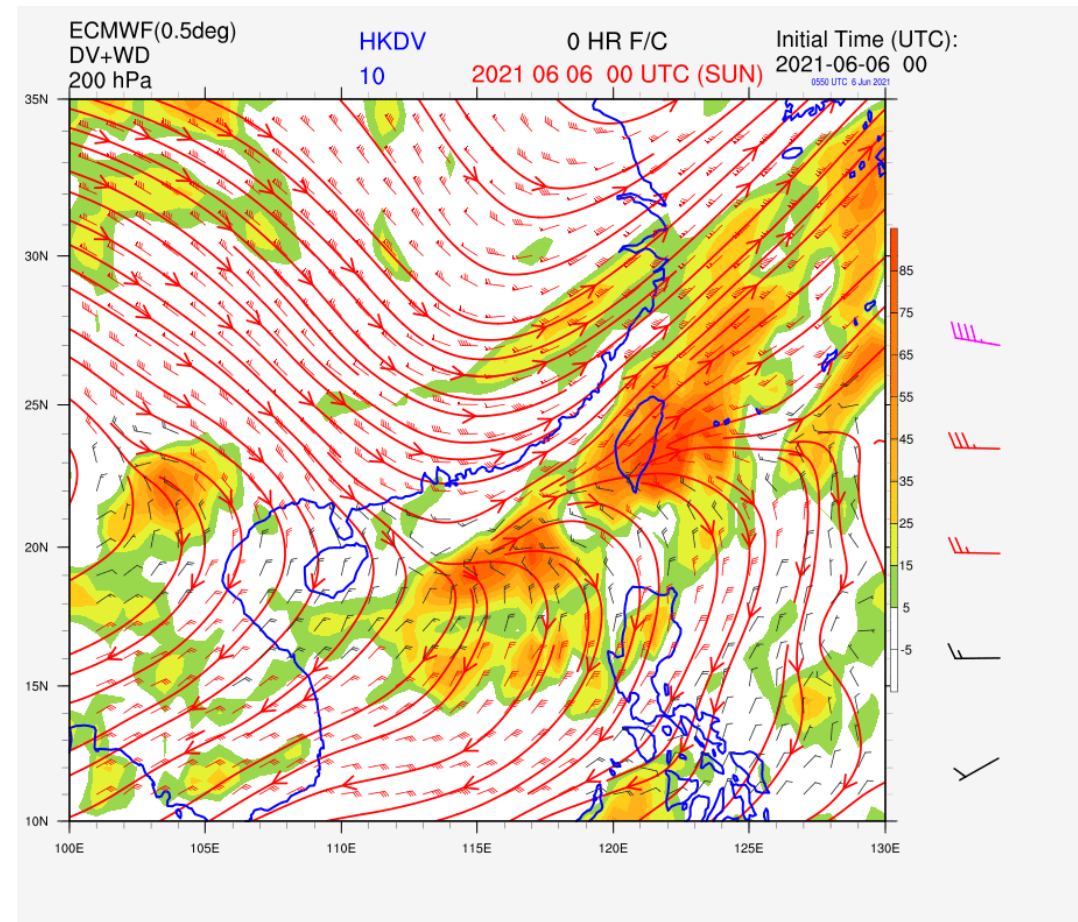




Stratospheric intrusion on 6-7 June 2021



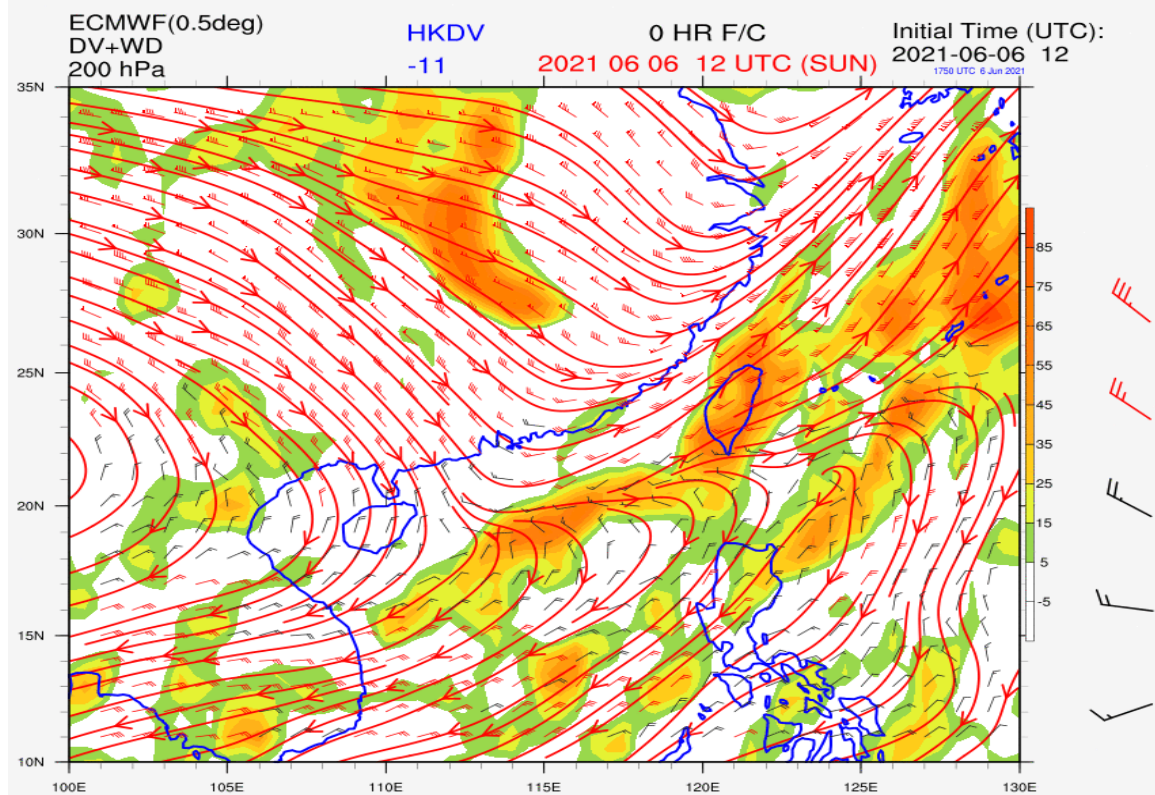
200 hPa flow at 12 UTC on 5 June 2021



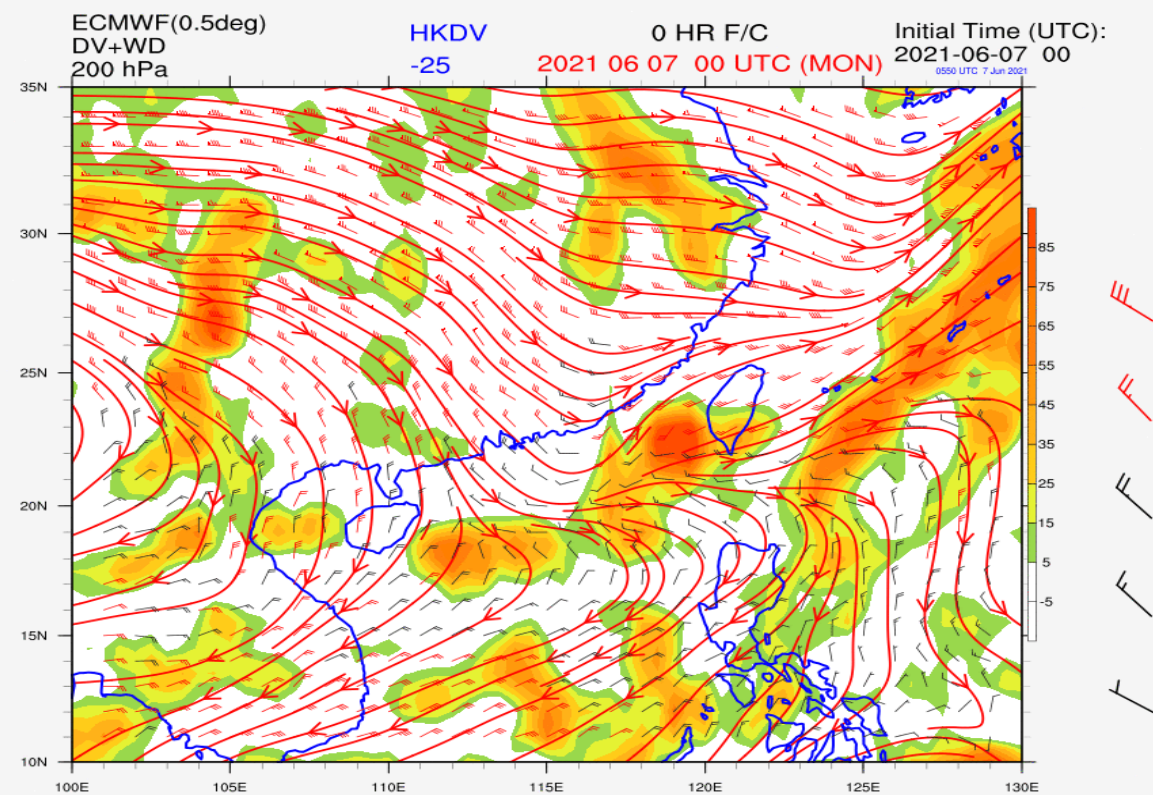
200 hPa flow at 00 UTC on 6 June 2021



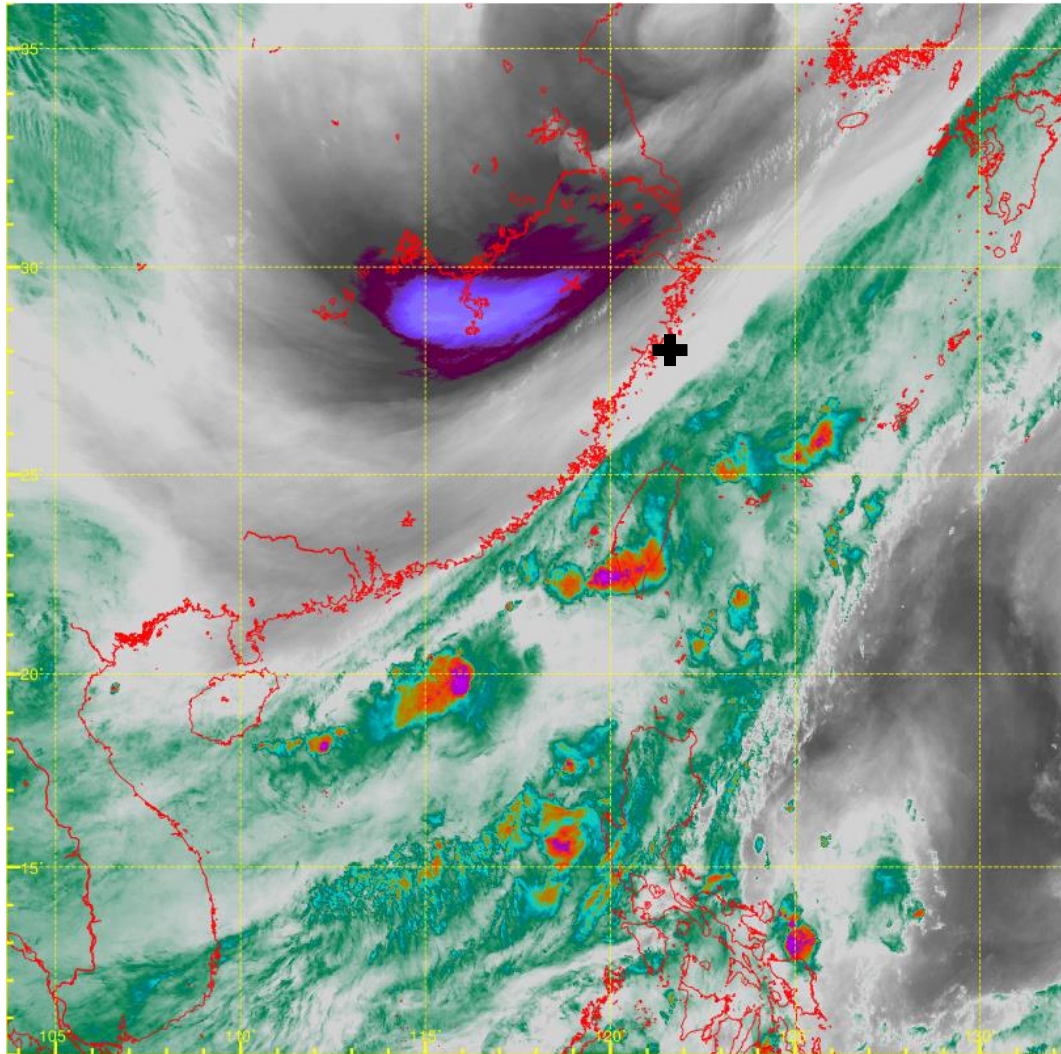
Stratospheric intrusion on 6-7 June 2021



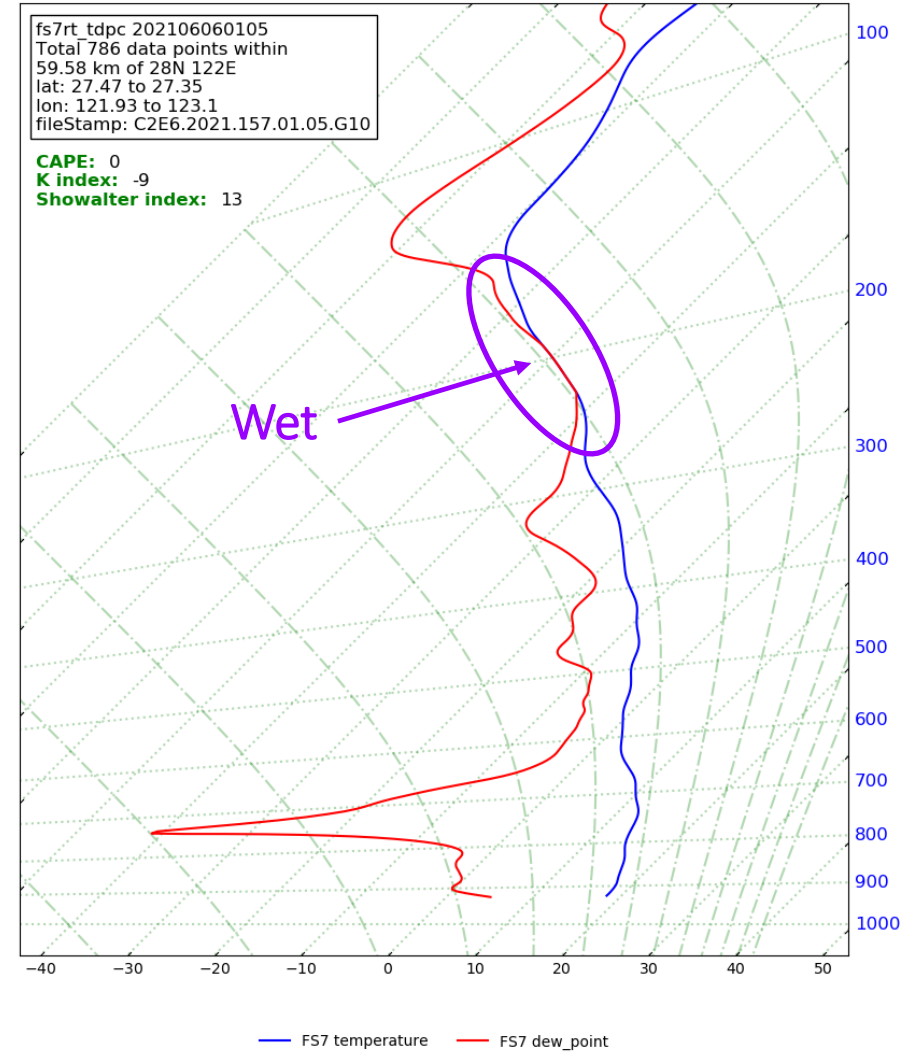
200 hPa flow at 12 UTC on 6 June 2021



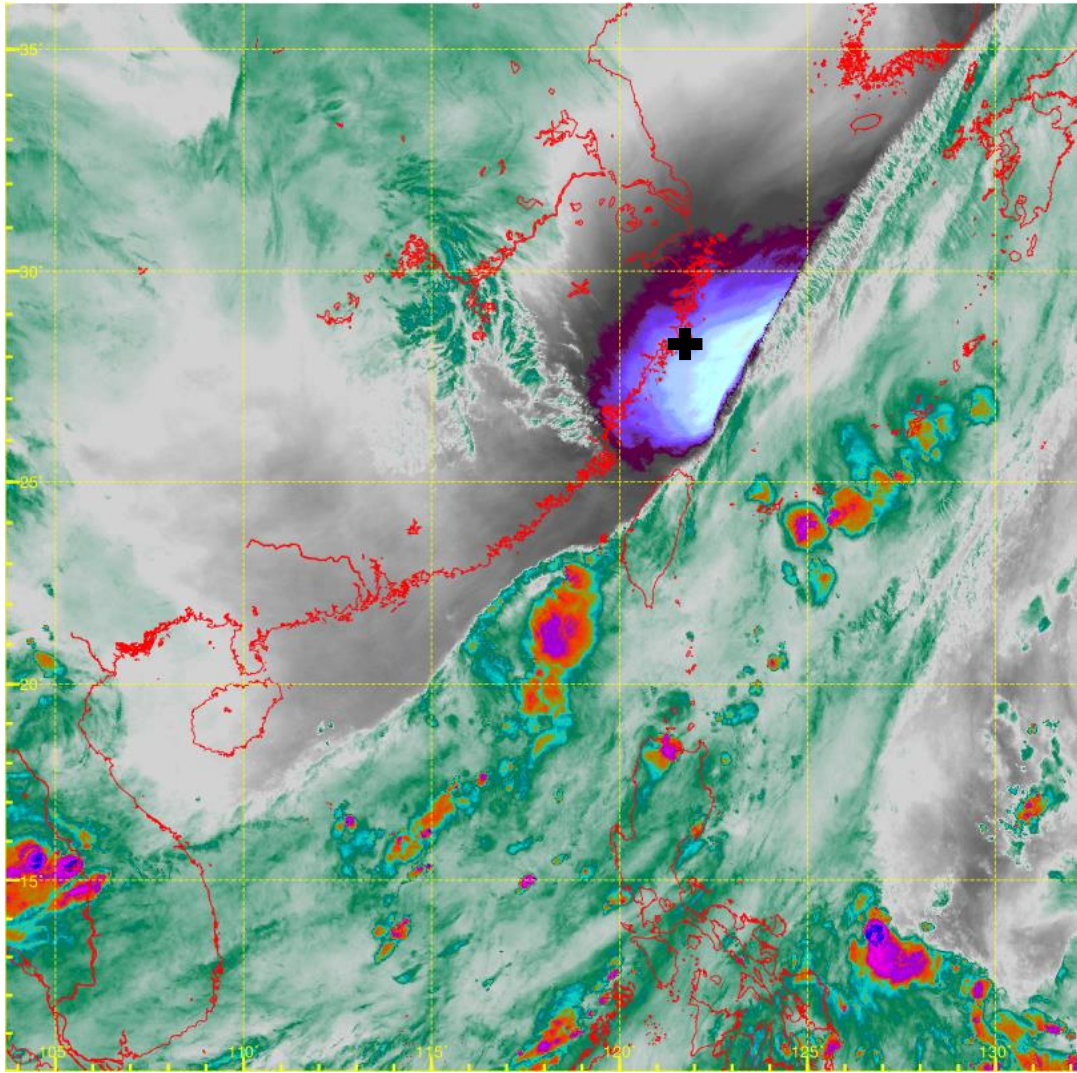
200 hPa flow at 00 UTC on 7 June 2021



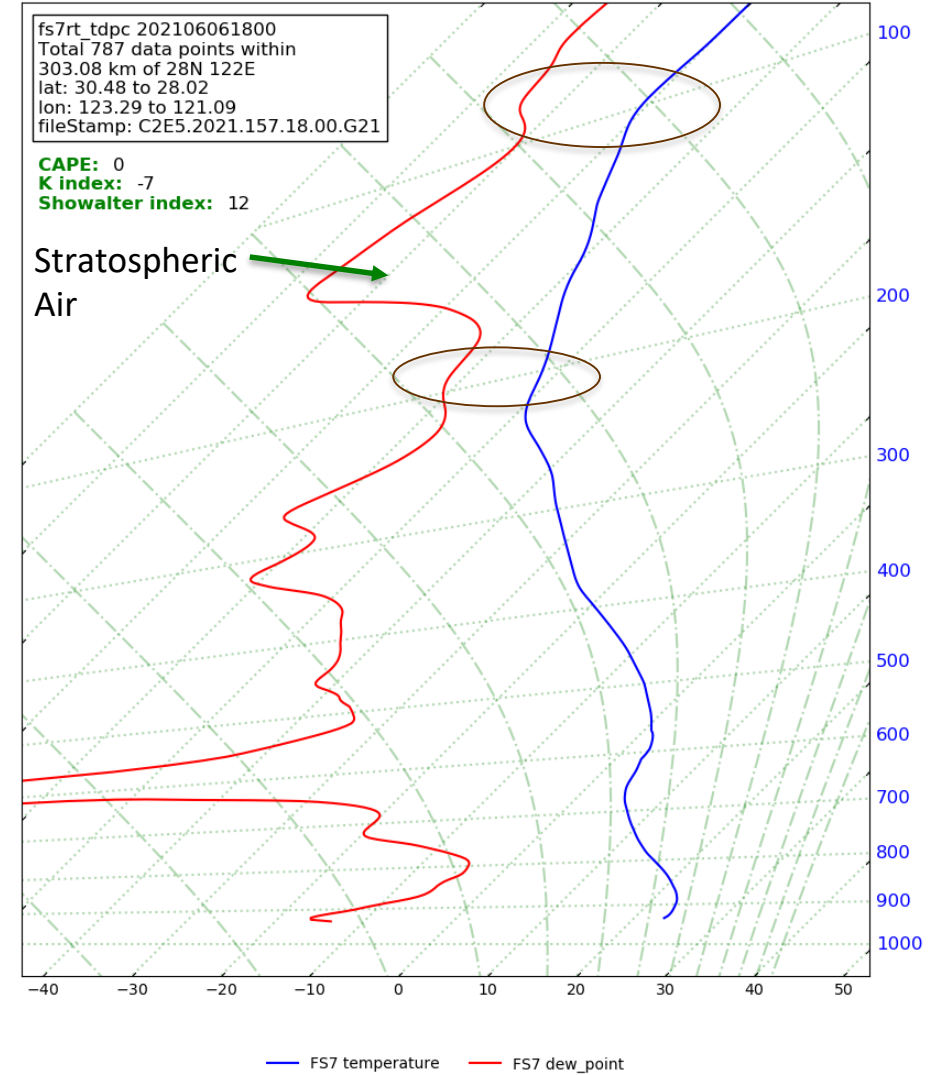
H-8 Water Vapour imagery at 01:00 UTC on 6 June 2021



RO profile near 28°N, 122°E at 01:05 UTC on 6 June 2021



H-8 Water Vapour imagery at 18:00 UTC on 6 June 2021



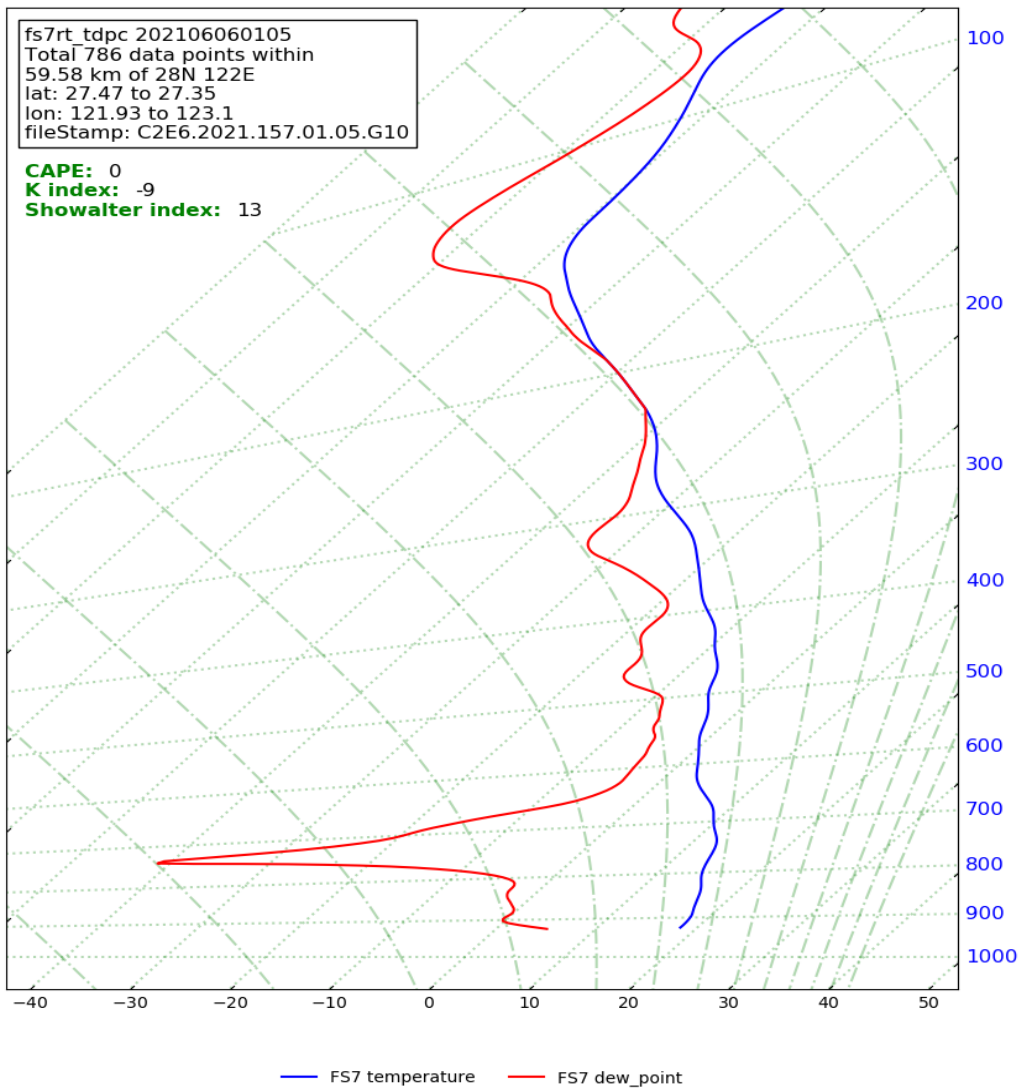
RO profile near 28°N, 122°E at 18:00 UTC on 6 June 2021



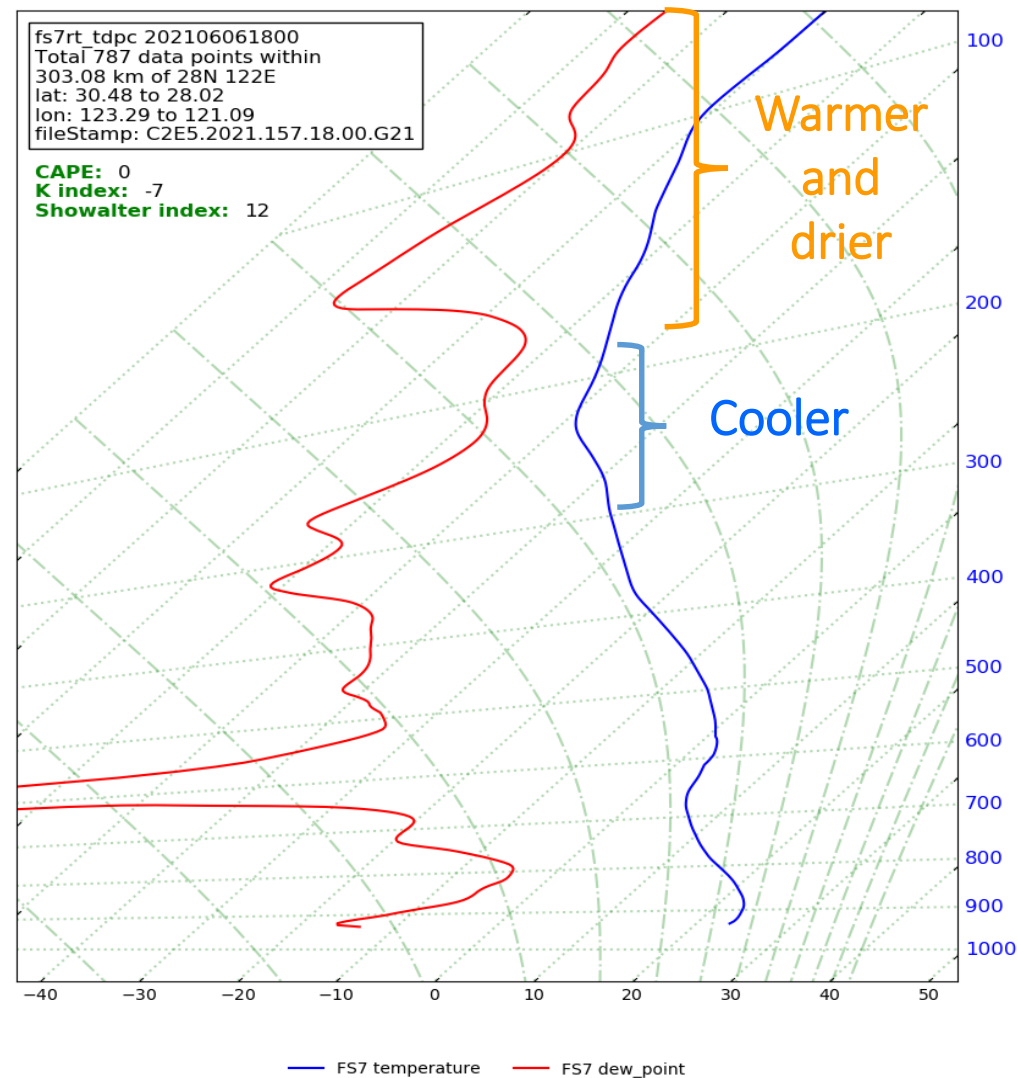
2021/06/06 01:05

2021/06/06 18:00

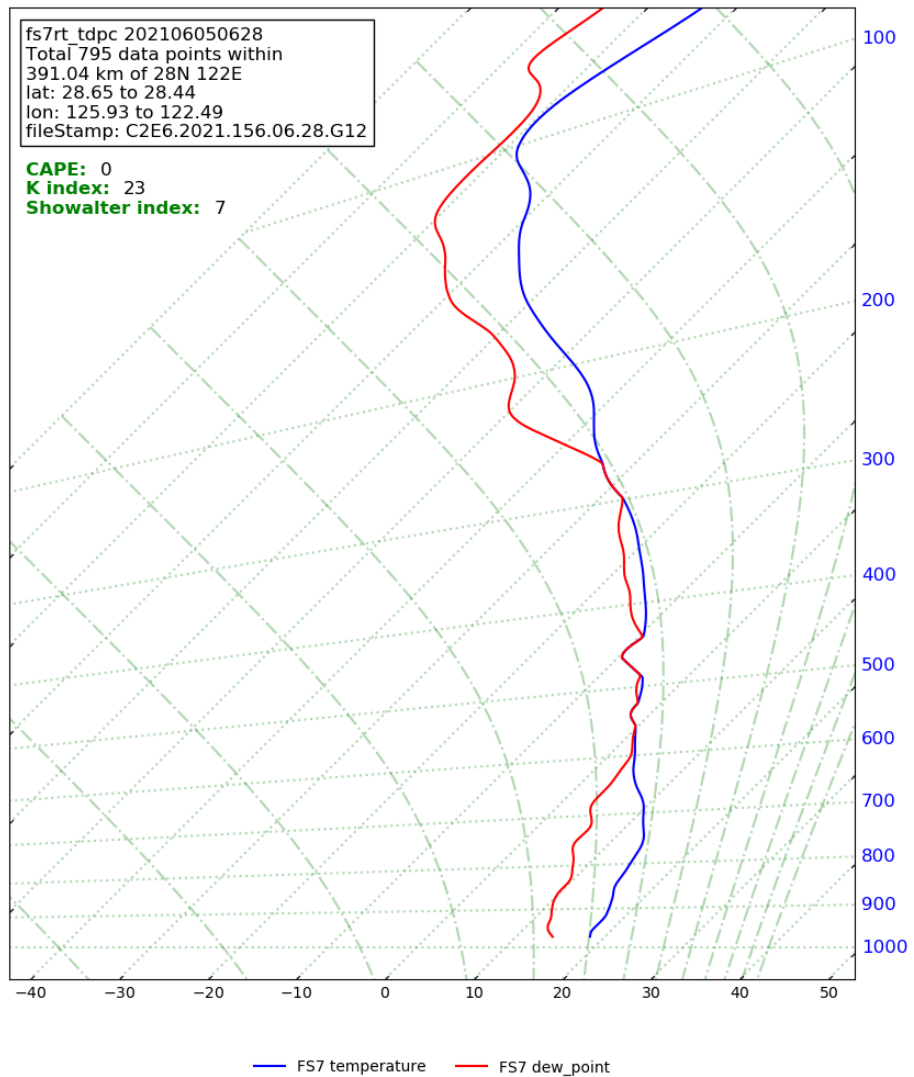
Pressure	Temp	Pressure	Temp	Difference [T(18:00) – T(01:05)]
299.3	-29.5	299.6	-34.7	-5.2
286.9	-32.0	287.0	-36.7	-4.7
278.9	-33.5	278.9	-37.9	-4.4
269.2	-35.1	268.9	-39.6	-4.5
259.7	-36.5	259.3	-41.5	-5.0
248.7	-38.1	248.0	-43.9	-5.8
239.9	-39.7	239.0	-46.0	-6.3
229.6	-41.9	228.4	-48.3	-6.4
219.6	-44.4	218.3	-49.9	-5.5
208.4	-47.4	206.9	-51.1	-3.7
199.2	-50.1	197.6	-52.3	-2.2
188.8	-53.3	187.2	-53.8	-0.5
178.8	-56.4	177.3	-55.5	0.9
169.2	-59.1	167.8	-57.2	1.9
158.7	-62.1	157.6	-58.9	3.2
149.9	-64.7	149.0	-60.1	4.6
139.3	-67.7	138.7	-62.0	5.7
129.2	-69.5	128.9	-64.4	5.1
119.9	-69.8	119.8	-66.3	3.5
109.4	-70.5	109.4	-68.6	1.9
99.7	-72.1	99.8	-70.7	1.4
89.3	-74.7	89.5	-70.2	4.5
79.9	-74.2	80.3	-69.9	4.3
69.8	-72.3	70.3	-69.5	2.8
59.5	-66.3	60.1	-65.4	0.9
49.8	-62.1	50.7	-61.3	0.8



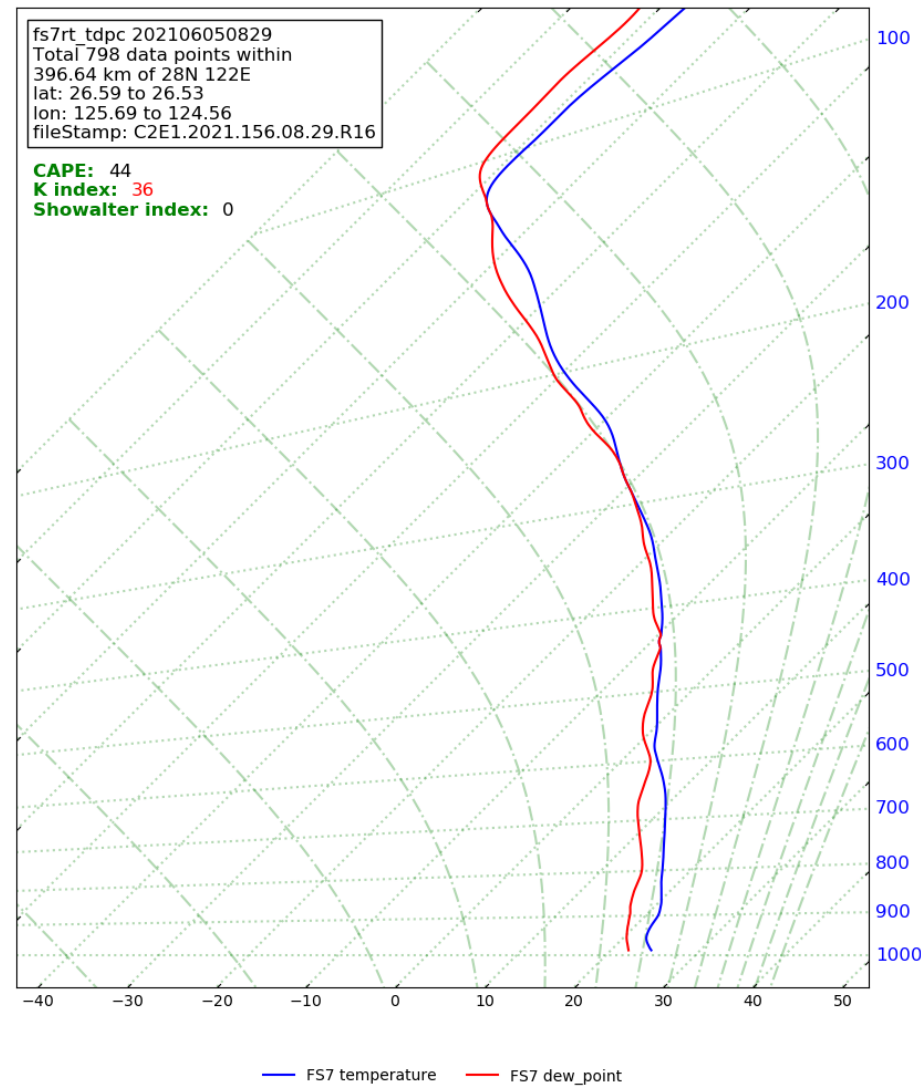
RO profile near 28°N, 122°E at 01:05 UTC on 6 June 2021



RO profile near 28°N, 122°E at 18:00 UTC on 6 June 2021



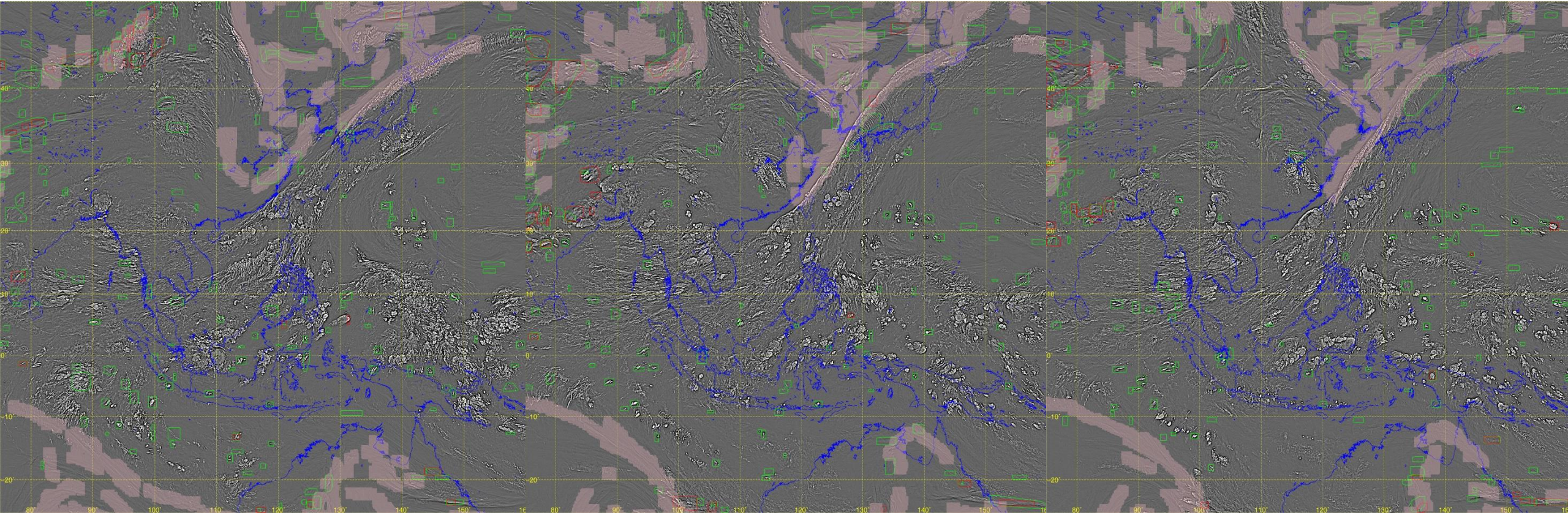
RO profile near 28°N, 122°E at 06:28 UTC on 5 June 2021



RO profile near 28°N, 122°E at 08:29 UTC on 5 June 2021



Turbulence-prone areas

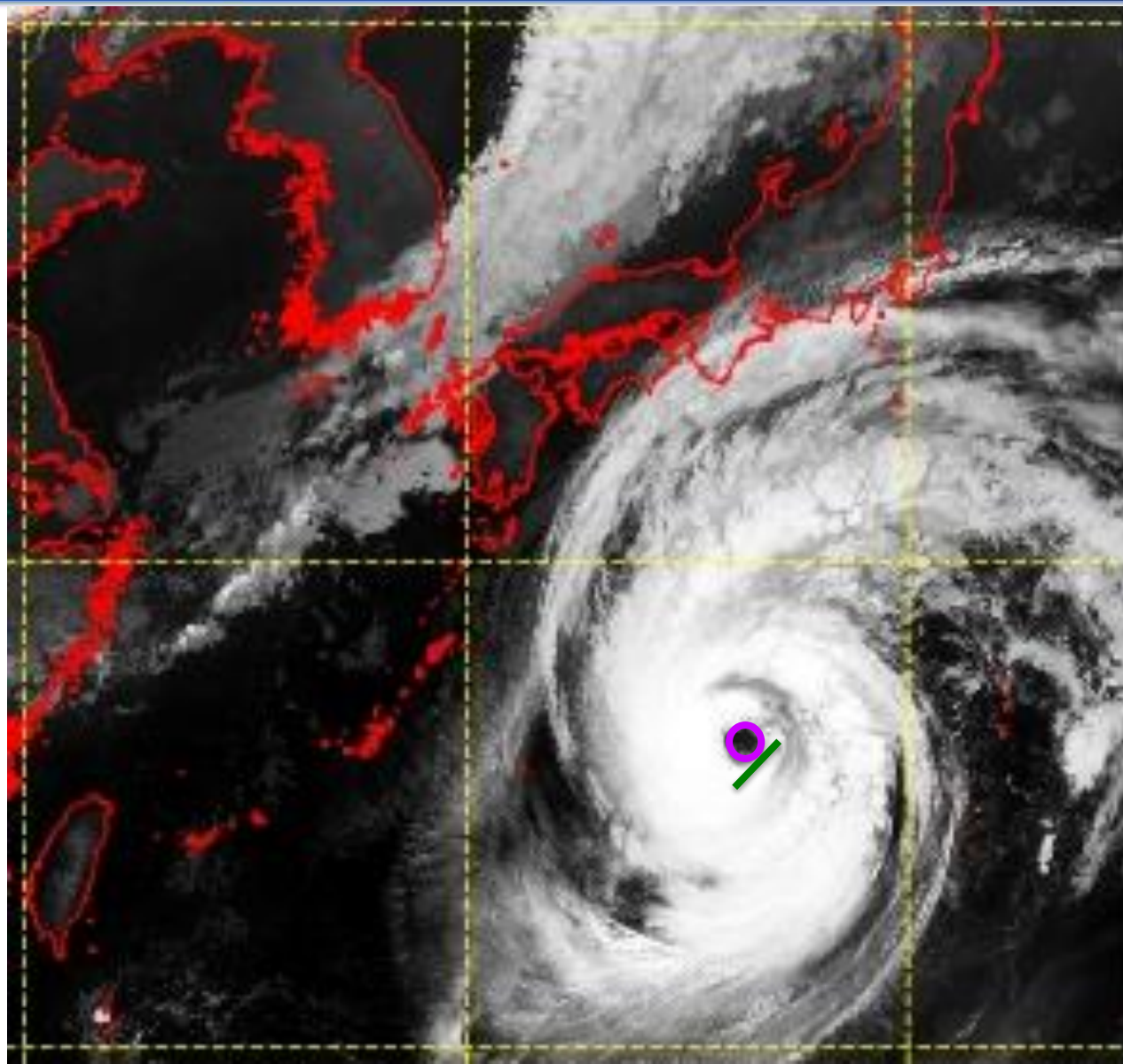


01:00 UTC

15:10 UTC

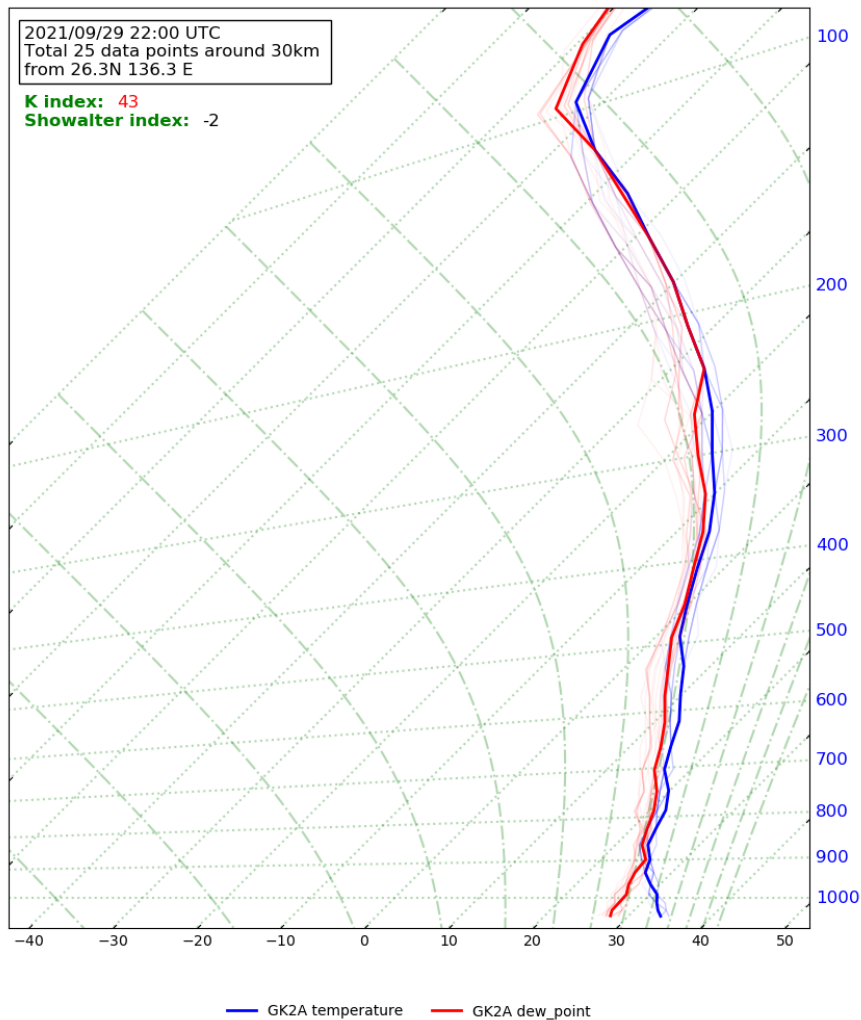
18:10 UTC

H-8 high-pass filtered WV imagery on 6 June 2021

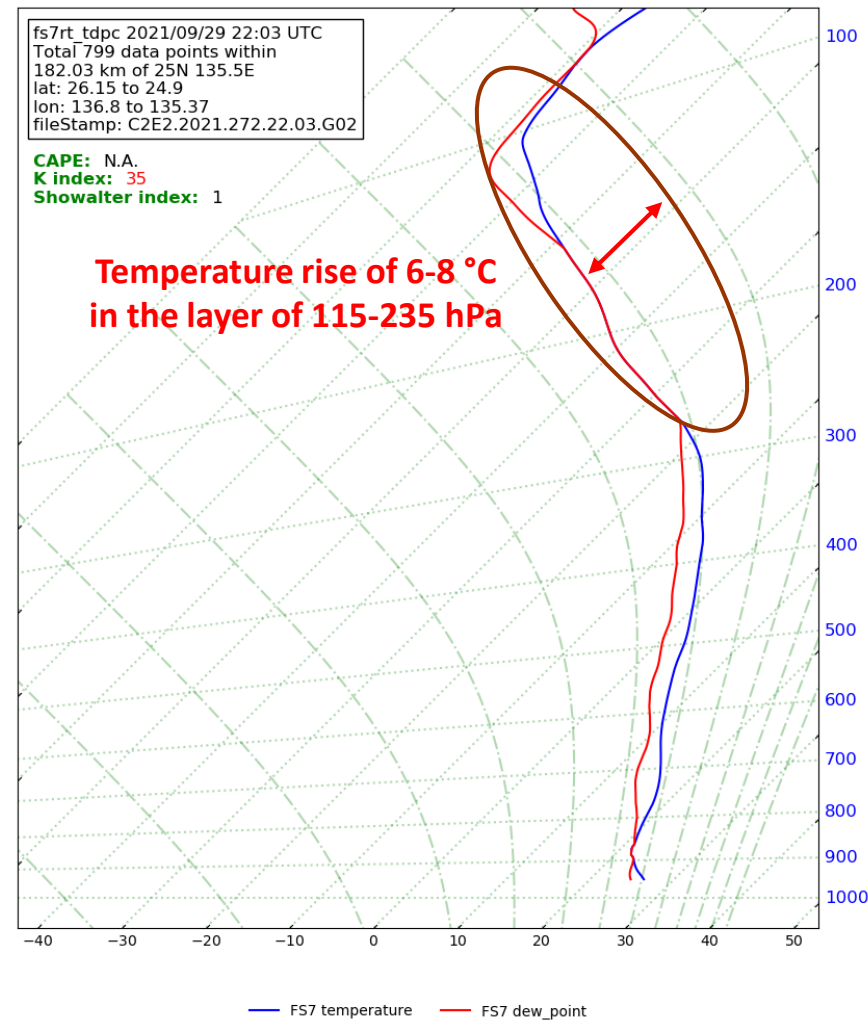


Identify Warm Core Structure of Mature Tropical Cyclone

H-8 IR image at
22:00 UTC on 29 September 2021
(Severe Typhoon Mindulle)



GK2A profile near 26.3°N, 136.3°E
at 22:00 UTC on 29 September 2021



RO profile in the region of 24.9-26.15°N, 135.37-136.8°E
at ~22:03 UTC on 29 September 2021



CONCLUSION

- FS7/CS2 RO profiles are useful in diagnosing various meteorological processes;
- Potential use of FS7/CS2 RO profiles in NWP to be explored.



FY-USERCON 2021

1-5 November 2021
Beijing, China



THANK YOU