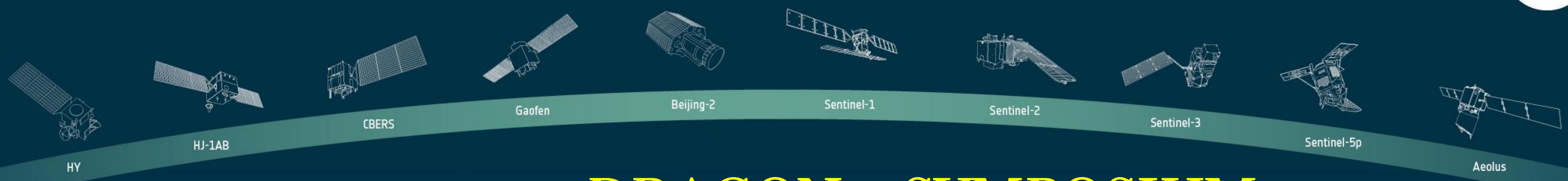

2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

[PROJECT ID. 59055]

[PROJECT TITLE : MONITORING EXTREME WEATHER AND CLIMATE EVENTS OVER CHINA AND EUROPE USING NEWLY DEVELOPED CHINESE AND EUROPEAN REMOTE SENSING DATA]

<11:00AM-12:30 PM, 17/OCT/2022, 1.1.1: CLIMATE CHANGE SESSION>

ID. 59055

PROJECT TITLE: MONITORING EXTREME WEATHER AND CLIMATE EVENTS OVER CHINA AND EUROPE USING NEWLY DEVELOPED CHINESE AND EUROPEAN REMOTE SENSING DATA

PRINCIPAL INVESTIGATORS: [PROF. FUXIANG HUANG]

CO-AUTHORS: [JINGNING LUO, SONG GAO, SONG LIU, RUIXIA LIU, ABHAY DEVASTHALE]

PRESENTED BY: [FUXIANG HUANG]

Project objectives:

Objective 1: Which weather and climate patterns drive extreme events?

Objective 2: What is the value of polar and geostationary satellites on monitoring extreme weather and climate events?

Objective 3: What is the value addition of satellite data to study co-variability of weather and climate patterns during extreme events?

Objective 4: To what extent is this co-variability simulated by the European Community Earth System model?

Objective 5: Interdisciplinary collaboration and young scientist training

EO Data Delivery

Data access (list all missions and issues if any). NB. in the tables please insert cumulative figures (since July 2020) for no. of scenes of high bit rate data (e.g. S1 100 scenes). If data delivery is low bit rate by ftp, insert "ftp"

ESA Third Party Missions	No. Scenes
1. NO_2	
2. CO	
3. CH_4	
4. HCHO	
5. Aerosol Index data	
6.	
Total:	
Issues:	

ESA Third Party Missions	No. Scenes
1.	
2.	
3.	
4.	
5.	
6.	
Total:	
Issues:	

Chinese EO data	No. Scenes
1. data from the visible to near-infrared , mid-infrared and far-infrared bands of the FY-4 AGRI (Advanced Geostationary Radiation Imager)	
2. surface PM 10 observing data	
3.	
4.	
5.	
6.	
Total:	
Issues:	

Dragon 5 Mid-term Results Reporting

Article

Satellite Monitoring of the Dust Storm over Northern China on 15 March 2021

Jingning Luo [1], Fuxiang Huang [1,*], Song Gao [2], Song Liu [3], Ruixia Liu [1] and Abhay Devasthale [4]

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2 National Meteorological Center, CMA, Beijing 100081, China; gaos@cma.gov.cn
3 Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China; liusong19@mails.ucas.ac.cn
4 Swedish Meteorological and Hydrological Institute (SMHI), SE-601 76 Norrköping, Sweden; abhay.devasthale@smhi.se
* Correspondence: huangfx@cma.cn; Tel.: +86-10-6840-9175

Abstract: Northern China was hit by a severe dust storm on 15 March 2021, covering a large area and bring devastating impact to a degree that was unprecedented in more than a decade. In the study, we carried out a day-and-night continuous monitoring to the path of the moving dust, using multi-spectral data from the Chinese FY-4A satellite combined with the Japanese Himawary-8 from visible to near-infrared, mid-infrared and far-infrared bands. We monitored the whole process of the dust weather from the occurrence, development, transportation and extinction. The HYSPLIT(Hybrid Single Particle Lagrangian Integrated Trajectory) backward tracking results showed the following two main sources of dust affecting Beijing during the north China dust storm: one is from western Mongolia; the other is from arid and semi-arid regions of northwest of China. Along with the dust storm, the upper air mass, mainly from Siberia, brought a significant decrease in temperature. The transport path of the dust shown by the HYSPLIT backward tracking is consistent with that revealed by the satellite monitoring. The dust weather, which originated in western Mongolia, developed into the "3.15 dust storm" in north China, lasting more than 40 h, with a transport distance of 3900 km, and caused severe decline in air quality in northern China, the Korean peninsula and other regions. It is the most severe dust weather in the past 20 years in east Asia.

Keywords: FY-4A satellite; Himawari-8 satellite; dust storm; satellite monitoring; HYSPLIT

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Citation: Luo, J.; Huang, F.; Gao, S.; Liu, S.; Liu, R.; Devasthale, A. Satellite Monitoring of the Dust Storm over Northern China on 15 March 2021. *Atmosphere* 2022, *13*, 157. https://doi.org/10.3390/atmos13020157

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1. Introduction

Sand and dust storms are severe environmental issues and air pollution events occurring in arid and semi-arid regions of the world [1,2]. In northeast Asia, deserts and sandy lands distributed in Mongolia and northwest China are the main sources of dust storms impacting the densely populated areas in China, Korea and Japan [3]. The dust storm occurred in northern China during 14–16 March 2021 (the "3.15" dust storm hereafter) significantly affected the air quality of north China and caused serious casualties and property losses in Mongolia. The great intensity, wide range of influence and long duration features of this dust storm are rare in the past decade, enabling it to become "the most serious dust storm in the past decade" and arousing widespread concern in the whole society. In Liang's paper, the authors analyzed the transport process of the mega dust storm by comprehensively analyzing various types of satellite remote sensing data and ground-based observations, combining with HYSPLIT backward trajectory tracking analysis technique [1]. In another research project, Filonchyk investigated the synoptic conditions using the ERA5 data from the European Center for Medium Range Weather Forecasts (ECMWF), and the research revealed the influence scope and distribution characteristics of particulate matter using combined data from ground-based observation network and satellite remote sensing data of the "3.15" dust storm [2].

atmosphere MDPI

Article

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1. Introduction

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On dust storm monitoring, satellite remote sensing has incomparable advantages over the ground-based station observation in terms of coverage [4,5]. Meanwhile, comparing with polar-orbit satellites, geostationary satellites have outstanding advantages in time continuity [6–8]. With the progress of satellite remote sensing technology in recent years, the new generation of geostationary environmental satellites can realize continuous and real-time monitoring of dust storm via the multi-channel observation data from visible light, short-wave infrared, medium-wave infrared and long-wave infrared [9,10]. As for the "3.15" dust storm, different kinds of polar-orbit satellite data provided helpful understanding of the event [1,2]. However, due to the limitation of polar-orbiting satellites, continuous monitoring of dust transport process cannot be realized. In this paper, we carried out a continuous and real-time remote sensing monitoring of the "3.15" dust storm using remote sensing data from the Chinese FY-4A satellite and Japanese Himawari-8 satellite.

Table 1. Key Technical Parameters of FY-4A AGRI and Himawari-8 AHI.

Channel	FY-4A AGRI		Himawari-8 AHI		Monitoring Ability
	Wave Length (μm)	Resolution (km)	Wave Length (μm)	Resolution (km)	
Visible light	0.470	1	0.470	1	Weak floating dust, aerosol and vegetation in the daytime
			0.510	1	Floating dust, aerosol and vegetation in the daytime
	0.650	0.5	0.639	0.5	Dust, low clouds and fog, vegetation in the daytime
	0.825	1	0.856	1	Dust and vegetation in the daytime
Near-infrared	1.375	2			Cloud phase
	1.610	2	1.61	2	Dust in the daytime, cloud phase
	2.250	2–4	2.25	2	Cloud density radius range
Short wave infrared	3.75	2	3.88	2	Dust, low clouds and fog during the day, at dawn and at dusk
	3.75	4			Dust, low clouds and fog during the day, at dawn and at dusk
Infrared	6.25	4	6.24	2	Water vapor in the upper troposphere
			6.94	2	Water vapor in the middle troposphere
	7.10	4	7.35	2	Water vapor in the lower troposphere
	8.50	4	8.59	2	Dust at night, at dawn and at dusk
	10.70	4	10.4	2	Dust in the daytime and at night
			11.2	2	Dust at night
	12.00	4	12.4	2	Dust in the daytime and at night
	13.50	4	13.3	2	Cloud top height

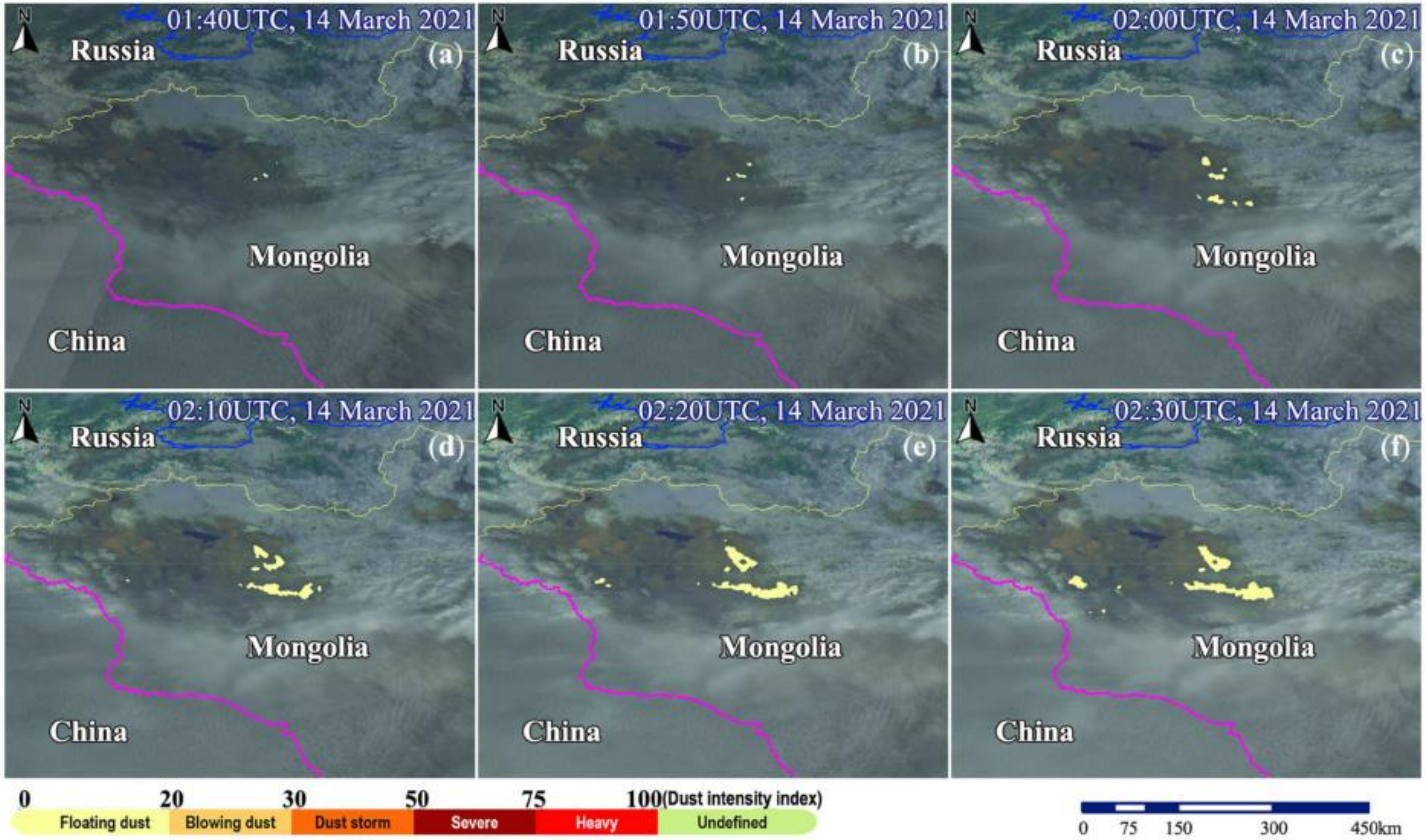


Figure 1. The initial stage of dust emission and development in Mongolia. (**a**–**f**) respectively correspond to dust distribution of every 10 minutes in the initial stage of dust emission.

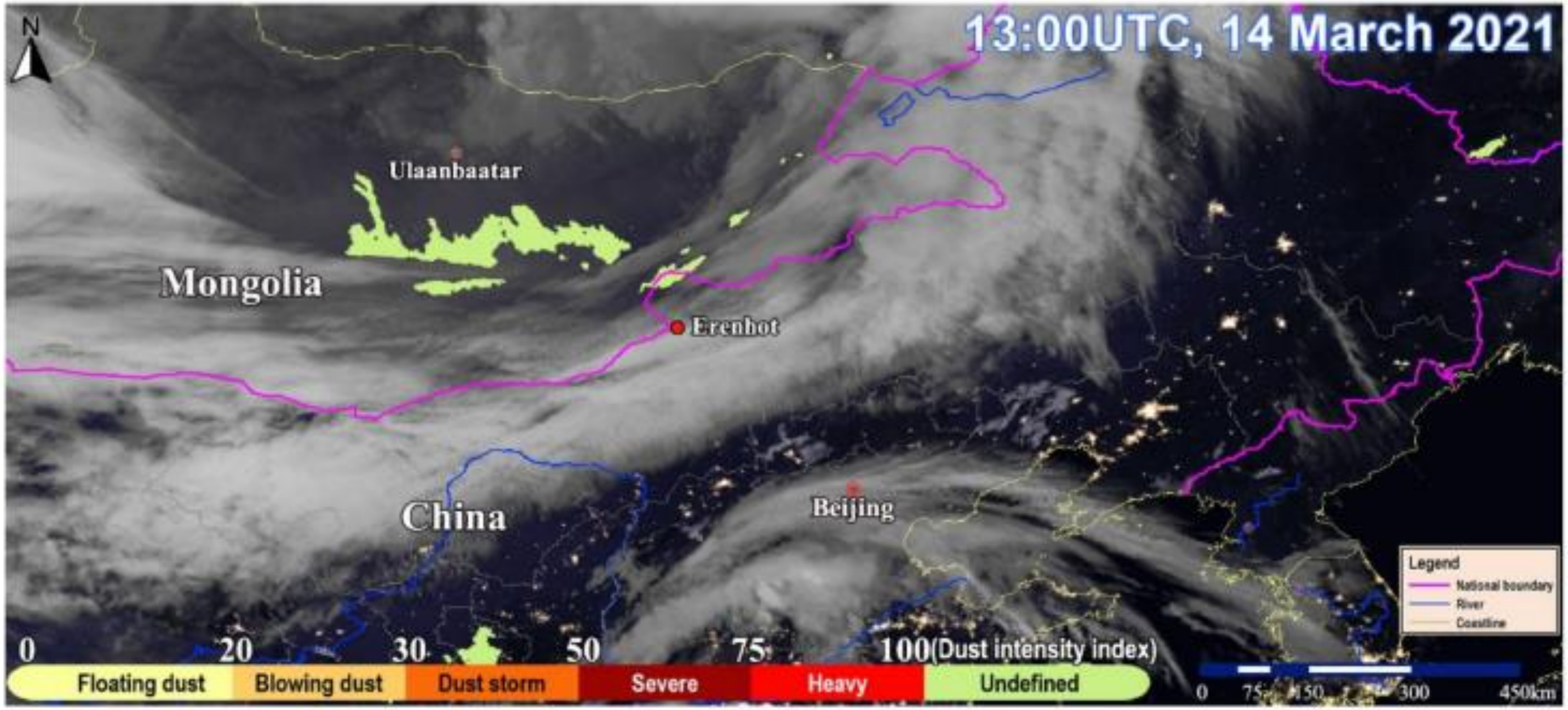


Figure 3. The dust transport crossed the China–Mongolia border from Erenhot, China at around 13:00, 14 March.

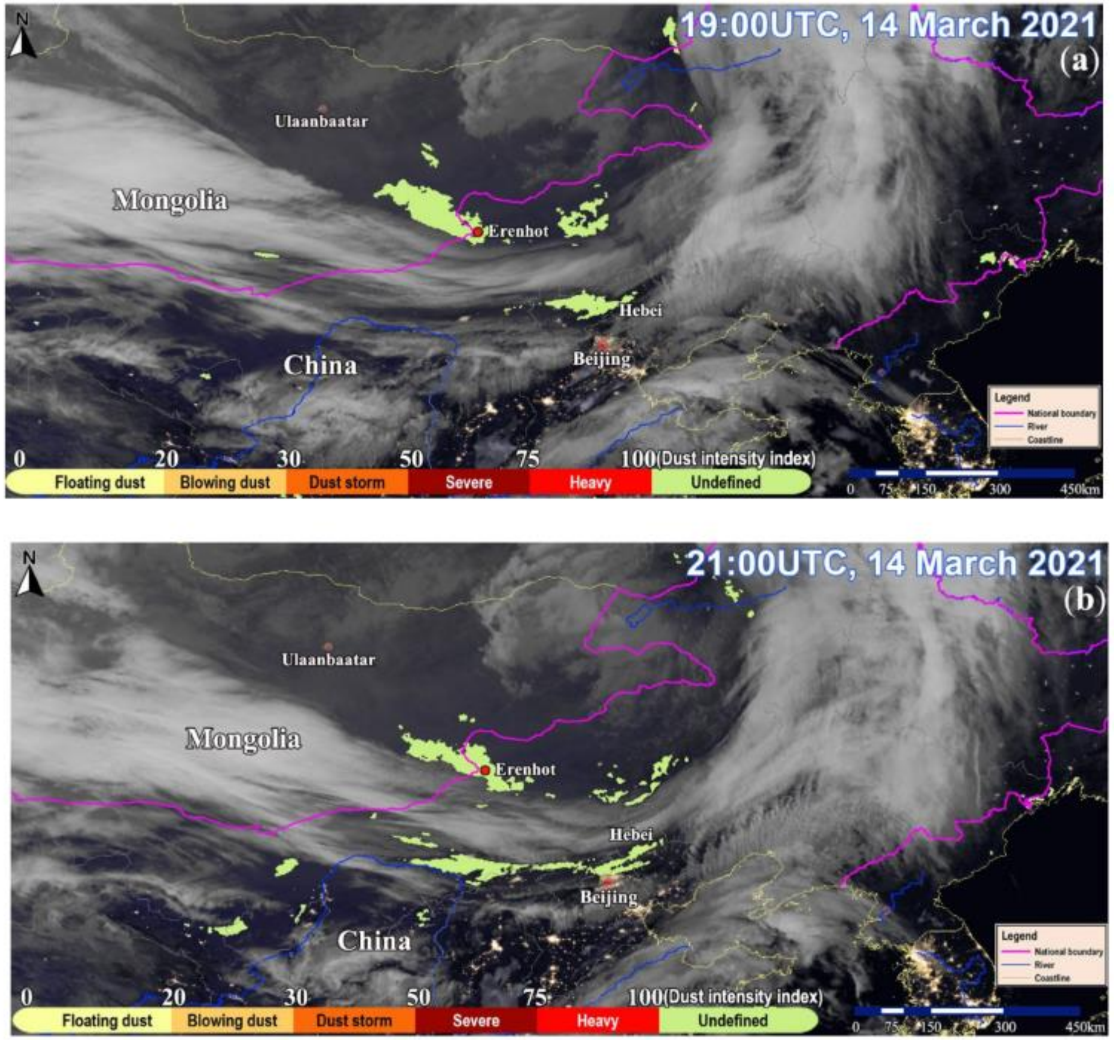


Figure 5. Dust air mass arrived in surrounding area of Beijing and formed dense floating dust. (**a**) and (**b**) correspond to the scenes at 19:00 and 21:00 (UTC) on 14 March 2021.

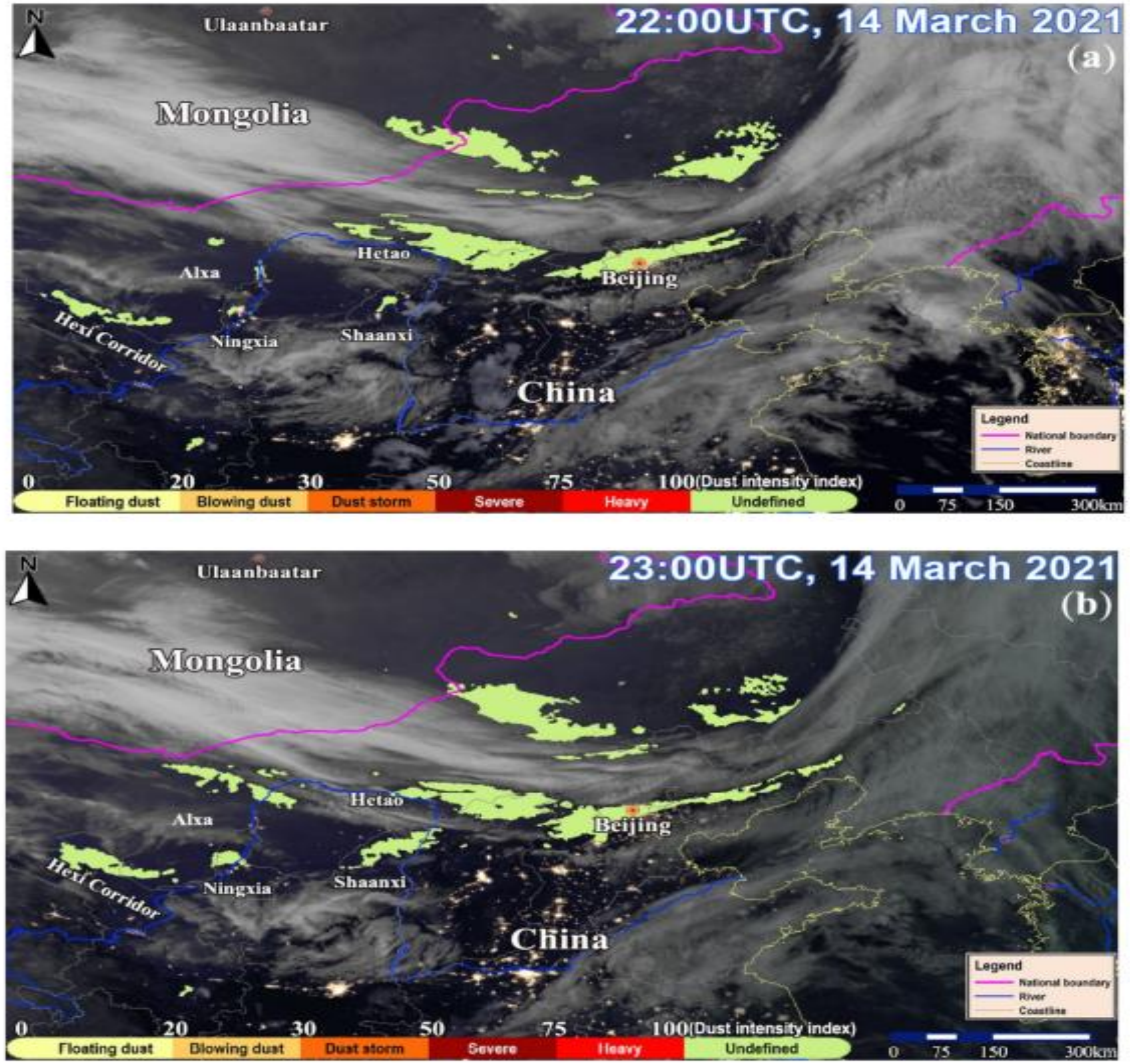
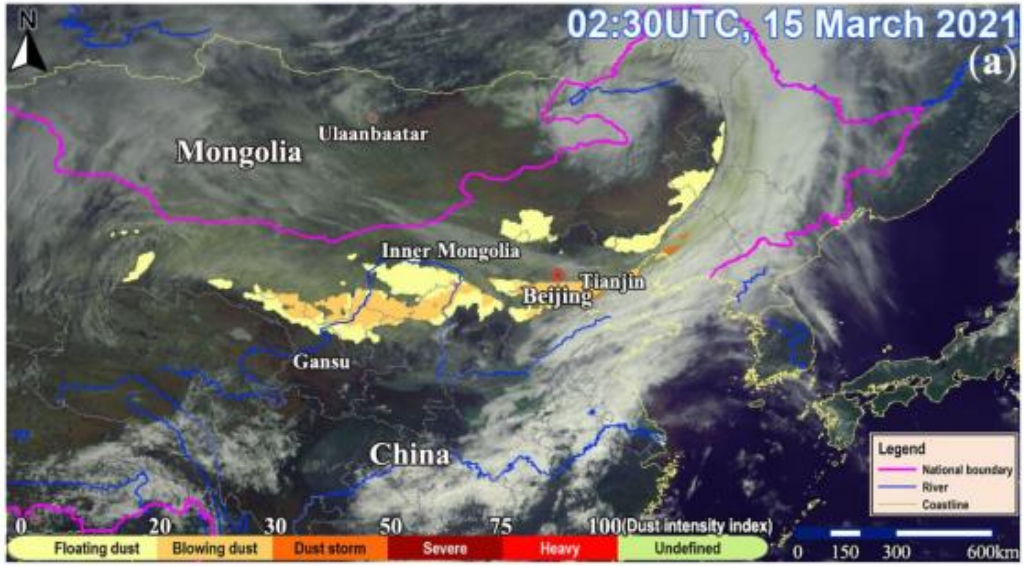
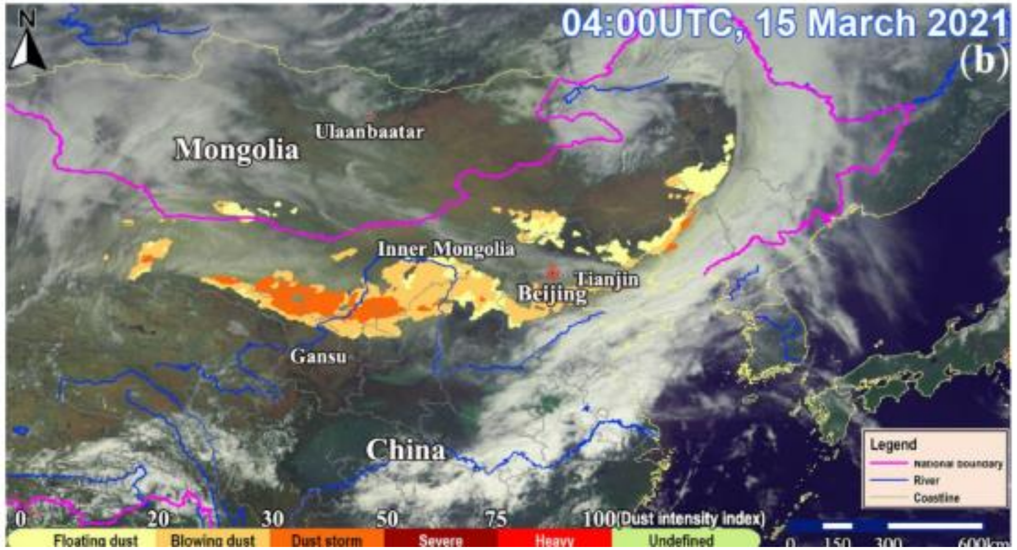


Figure 6. Dust emission and floating dust weather occurred in Hexi Corridor and moved eastward. (**a**) and (**b**) correspond to the scenes at 22:00 and 23:00 (UTC) on 14 March 2021.





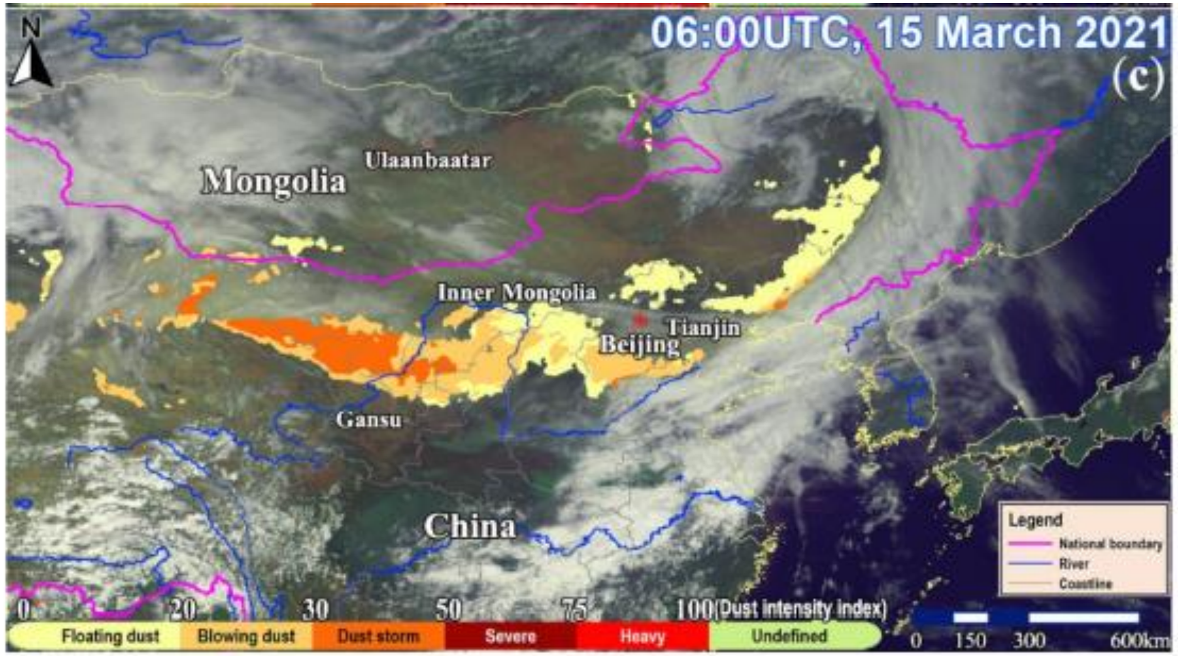


Figure 7. Dust distribution over north China and developed into dust storm at some part areas. (**a–c**) correspond to the scenes at 2:30, 4:00 and 6:00(UTC) on 15 March 2021 respectively, and the dust from western China developed into dust storm in the eastward transportation process.

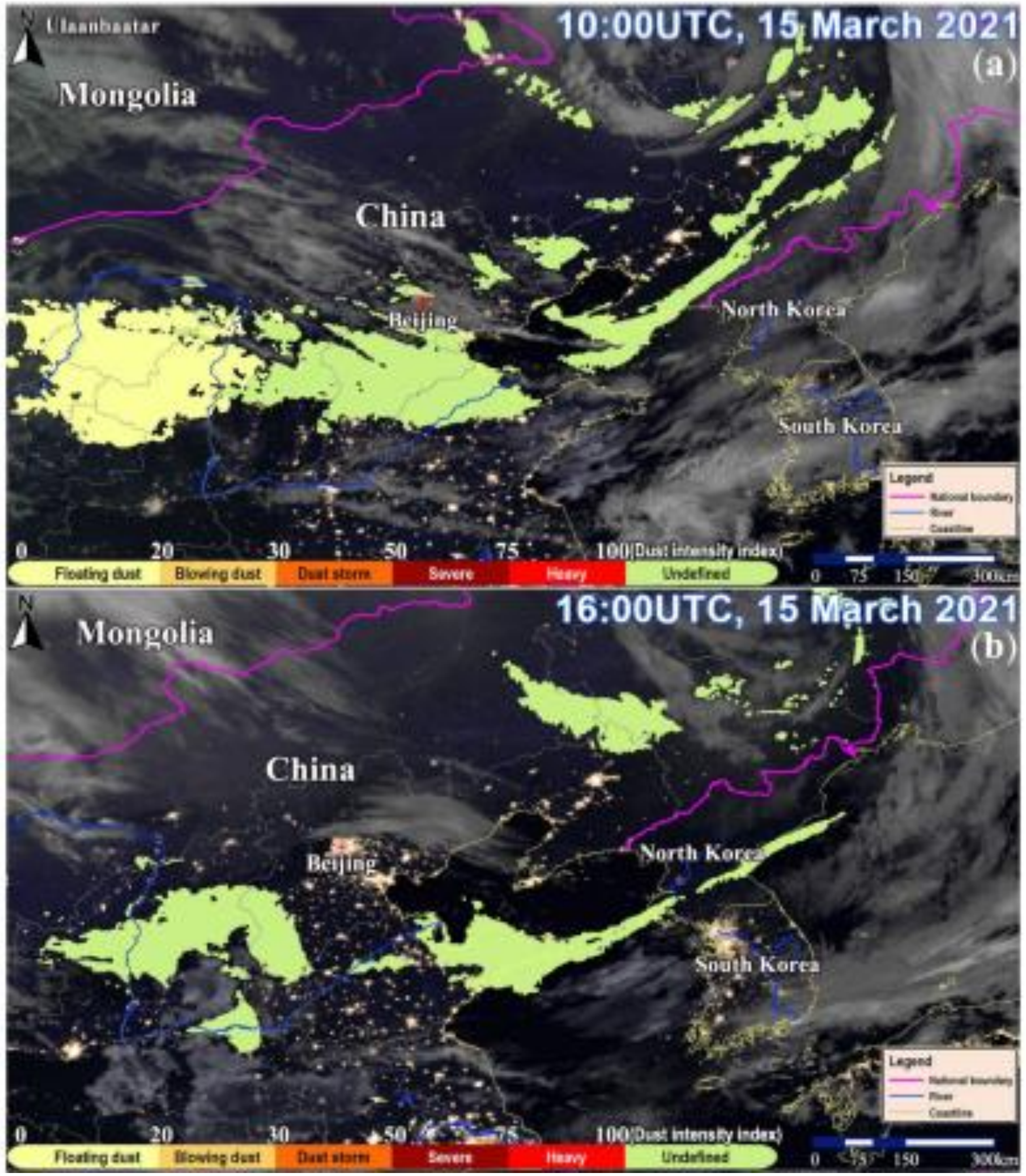


Figure 8. The dust storm gradually dissipated. (**a**–**c**) correspond to the scenes at 10:30, 16:00 and 19:00 on 15 March 2021 respectively, and the dust storm gradually dissipated in northeast China and adjacent areas.

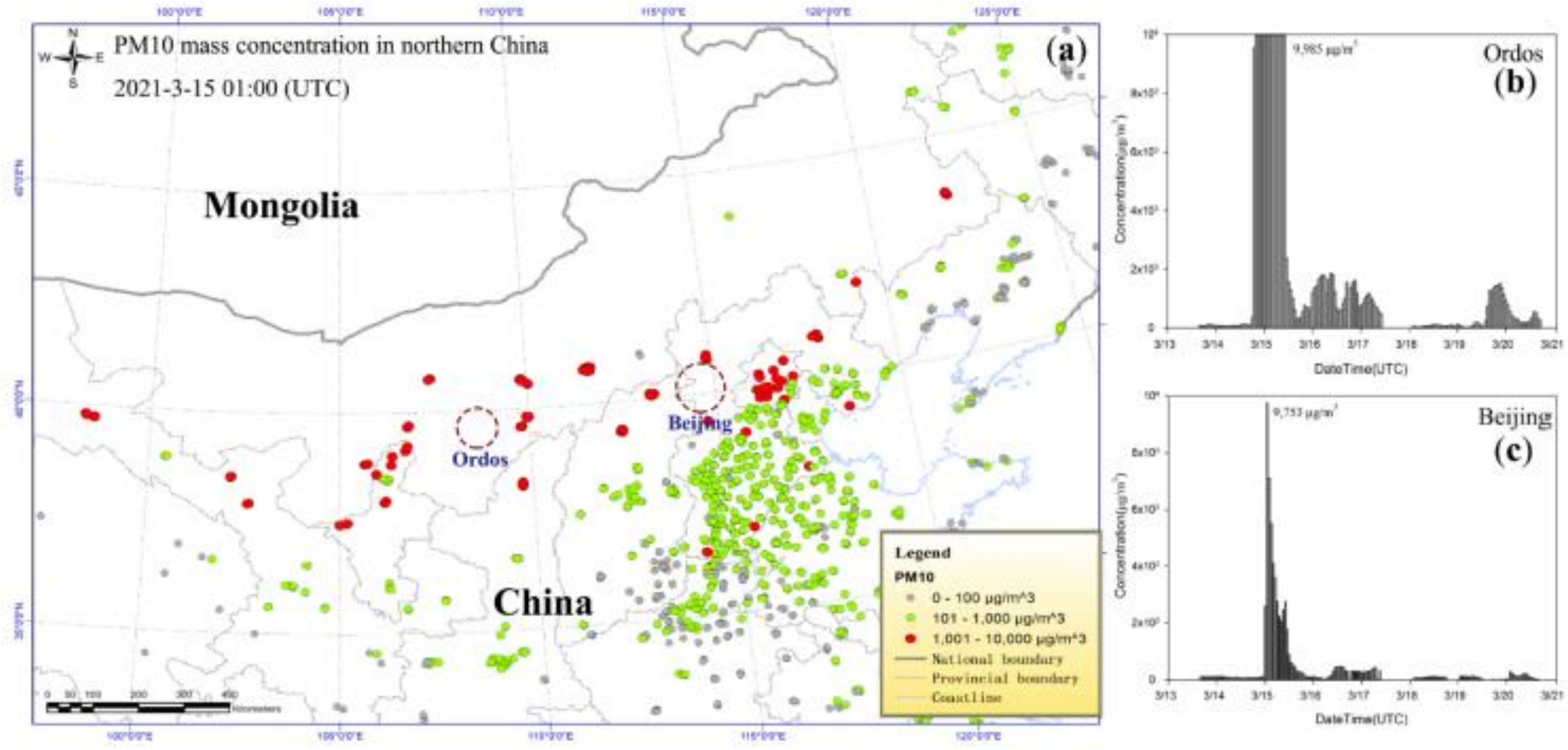


Figure 9. PM10 ground-based observation network (a) and variation of PM10 observation at Ordos (b) and Beijing (c).

Dragon 5 Mid-term Results Reporting

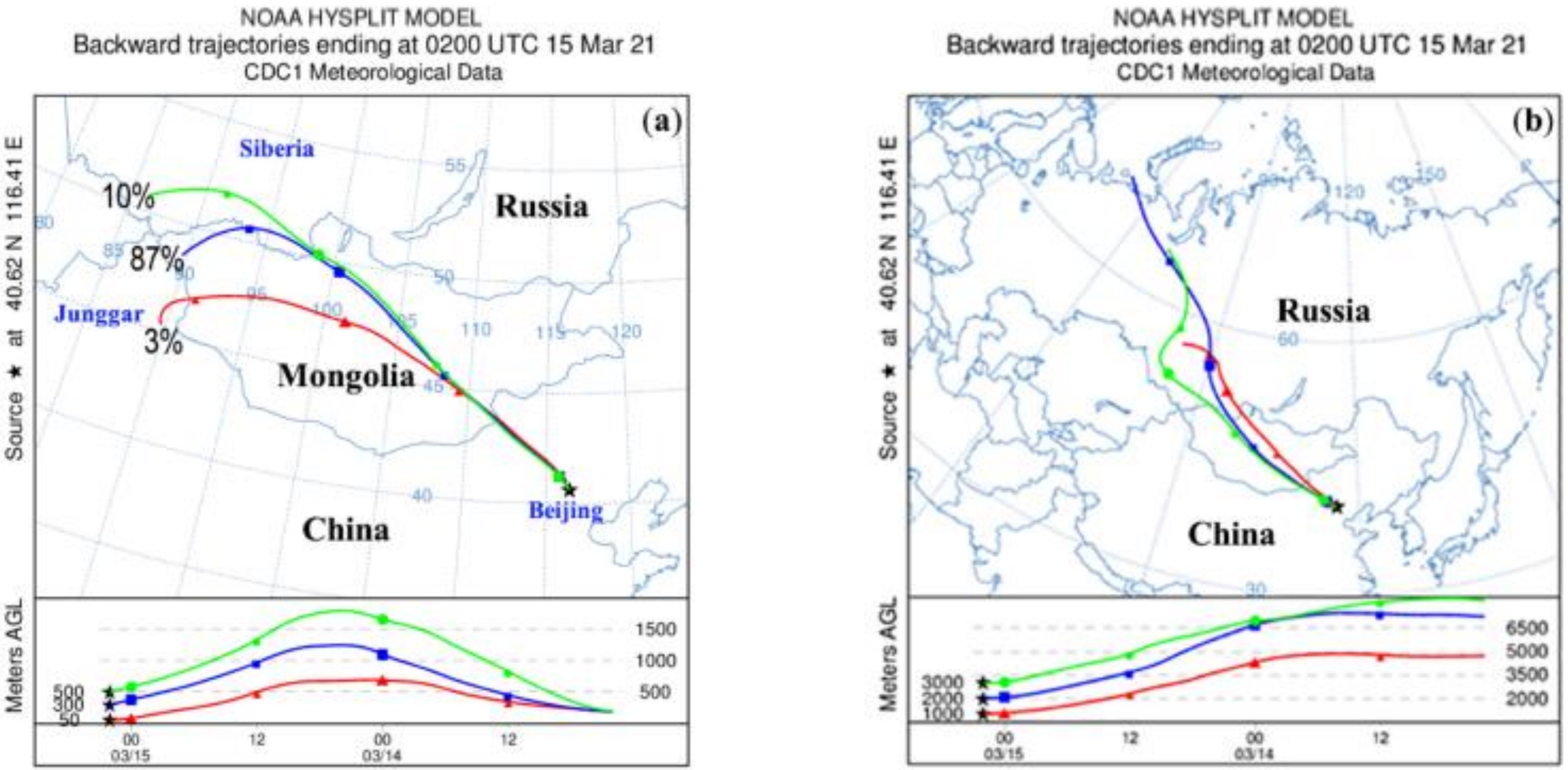


Figure 10. 48 h backward trajectory tracking results for location A. (**a**) and (**b**) correspond to the backward trajectory of air masses from the surface to 500 m and from 1000 m to 3000 m, respectively.

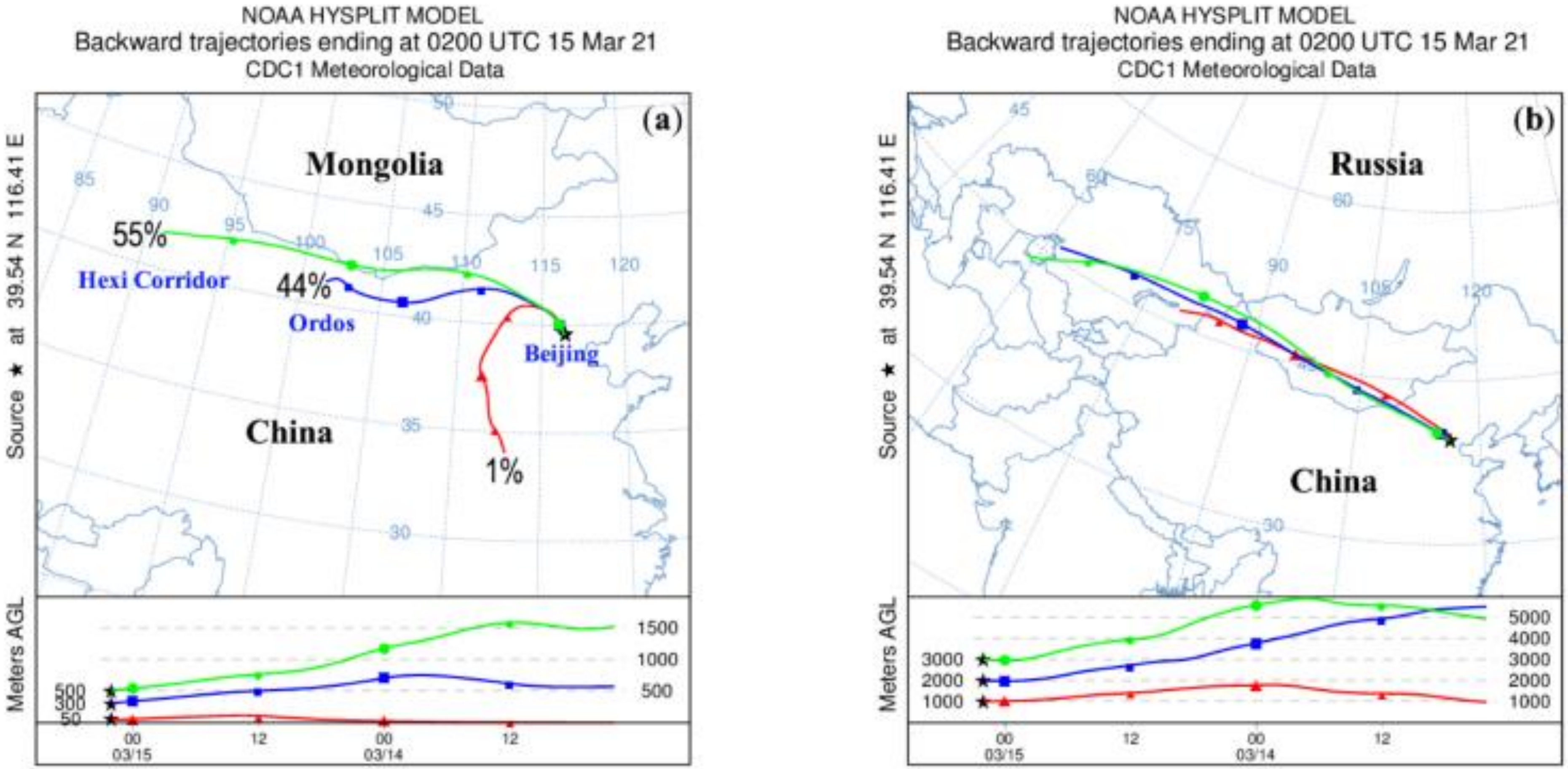


Figure 11. 48 h backward trajectory tracking results for location B. (a) and (b) correspond to the backward trajectory of air masses from the surface to 500 m and from 1000 m to 3000 m, respectively.

5. Conclusions

Influenced by the Mongolia cyclone, the dust weather originated in western Mongolia and developed into the "3.15 dust storm" in north China. The whole process of dust weather lasted for more than 40 h, with a transport distance of 3900 km, causing severe decrease in air quality in northern China, the Korean peninsula and other regions. In the paper, we carried out a day-and-night continuous satellite monitoring using combined data from visible light channel, near-infrared channel, mid infrared to thermal infrared channels and window area of the FY-4A AGRI and Himawari-8 AHI. The conclusions are as follows:

(1) Integrated use of observation data from different channels of geostationary satellites can realize a day-and-night continuous monitoring of dust transport process in large areas, providing important information for us to understand dust transport route, dust sources and affecting regions.

(2) Backward trajectory tracking analysis showed that there are two main sources of dust: one is from northwest Mongolia, and the other is from west China. In the process of dust transportation, the upper atmosphere mainly comes from Siberia region, which results in a remarkable temperature decline accompanied by the dust weather.

(3) Comparisons showed that the dust transporting route monitored by satellite is consistent with that of HYSPLIT analysis.

(4) Two aspects need to be solved by satellite monitoring, as follows: one is the dust intensity clarification during nighttime, the other is to eliminate effects of thick clouds such as the Mongolian cyclone on intracloud dust monitoring.

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Thank you for your attensions!