A severe dust event over the Mongolian Gobi in 3-5 March, 2016

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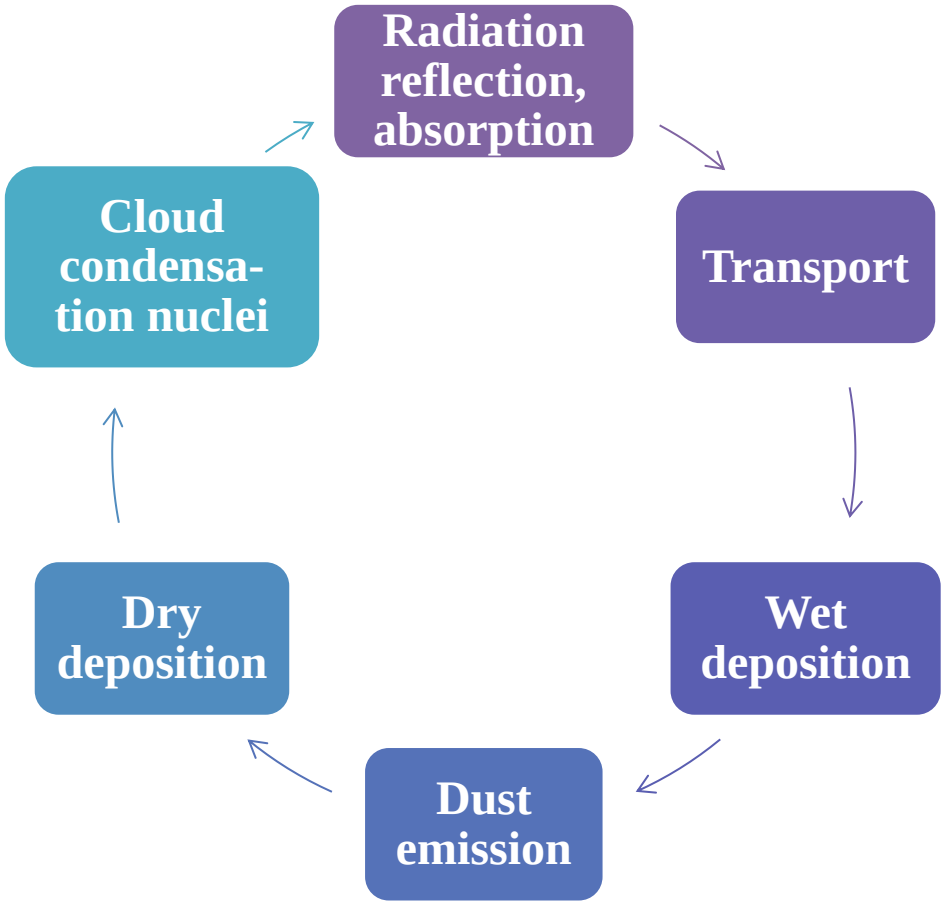
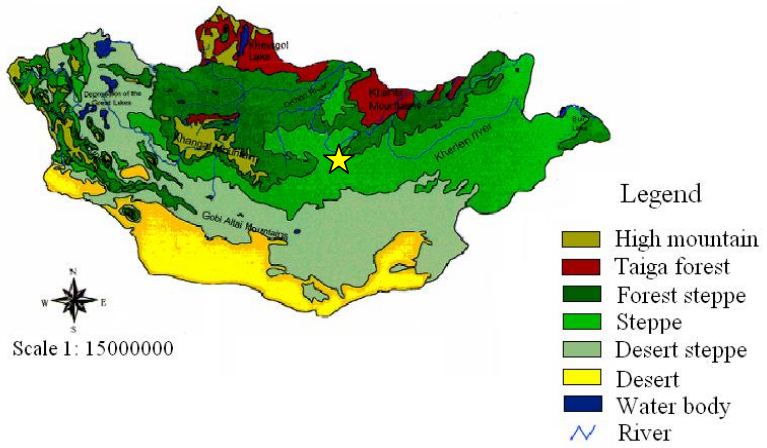
- Conclusions

Introduction: Dust cycle (Shao, 2008)



- Dust emission is a key component of the global mineral-dust cycle.
- Dust cycle includes emission, transport and deposition of dust, and the atmospheric processes such as condensation nuclei for cloud formation and radiation reflection and absorption.
- The estimated global dust emission is 2000 Mt yr^{-1}.
- Aerosols have a net effect of global cooling.

Introduction of dust storms in Mongolia



- Natural zones
- 34.6% of territory is the dry land areas, of which 28.4% -Desert steppe (Gobi) & 6.2% -the Desert.

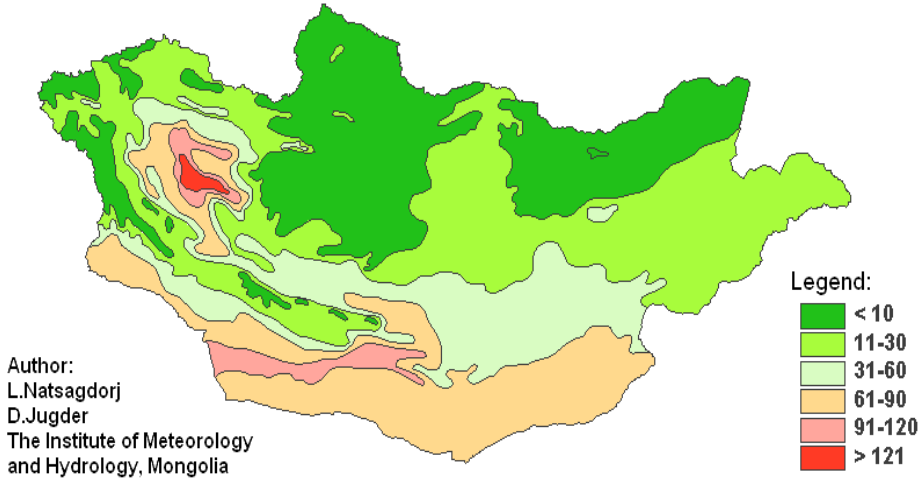
❖DSSs frequently occur in the Gobi Desert in spring due to strong winds, scarce vegetation, and dry soil conditions.

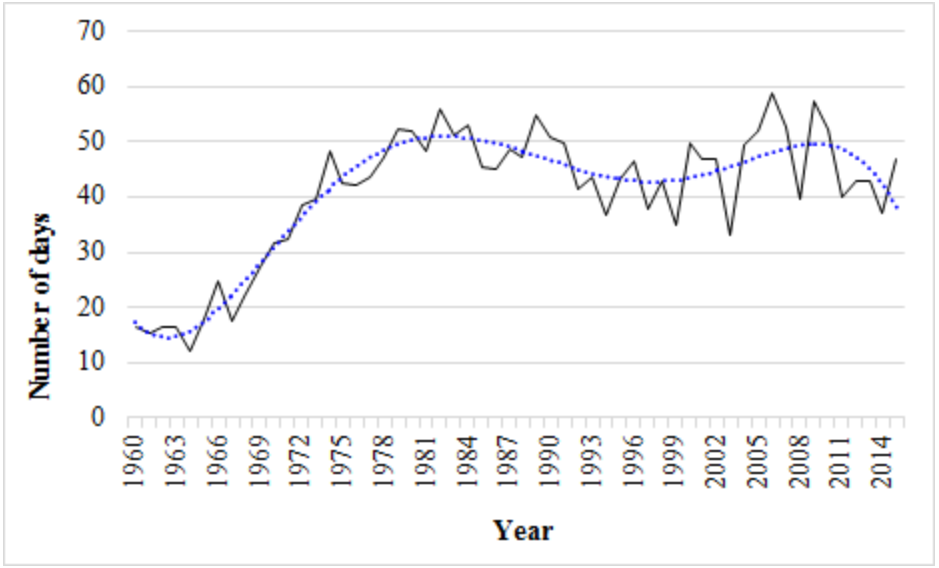
❖DSSs are natural disaster phenomena that can have negative and direct consequences, including loss of life, delays to aviation, interruptions to rail and vehicular transport, and reductions in pasture for livestock. DSSs have long-term effects regarding soil erosion, sand movement, and desertification processes (Natsagdorj et al., 2003).

❖The dust source area of Northeast Asia (target area: 35–45°N, 100–115°E) has significant influence on the level of Asian dust in Japan (Kimura, 2012a, 2012b; Kimura and Moriyama, 2014).

Distributions and trend of dust storms in Mongolia

Number of dusty days /32 stations, 1960-2015/.





- Distributions of dust storms using number of dusty days (1960 -1999).
- Dust events have increased in the arid and semi-arid regions of Mongolia and China during last decade (Shinoda et al, 2011)

Expected Warning criteria for wind & dust event

- Warning criteria for wind & dust/sandstorm events
  (The Mongolian Government's 286th Resolution, 2015, Annex 5.2: A list of meteorological hazardous phenomena)

Phenomenon	Intensity for weather warning	Intensity for severe weather warning
Strong wind	Wind speed ≥ 18 m s^{-1} (Gale ≥ 24 m s^{-1})	Very strong wind ≥ 24 m/s in the steppe, ≥28 m/s in the Gobi with gale 34 m/s
Dust storm	Visibility ≤ 1000 m Duration ≥ 3 h	

- Intensity classifications of dust and sandstorm events using visibility criterion (Manual, 2014, Volume 14, Part 212, p.93-94).

Type of dust/sand storm	Visibility, m
Severe dust storm	≤ 50
Regular dust storm	51-1000
Slight dust storm	> 1000

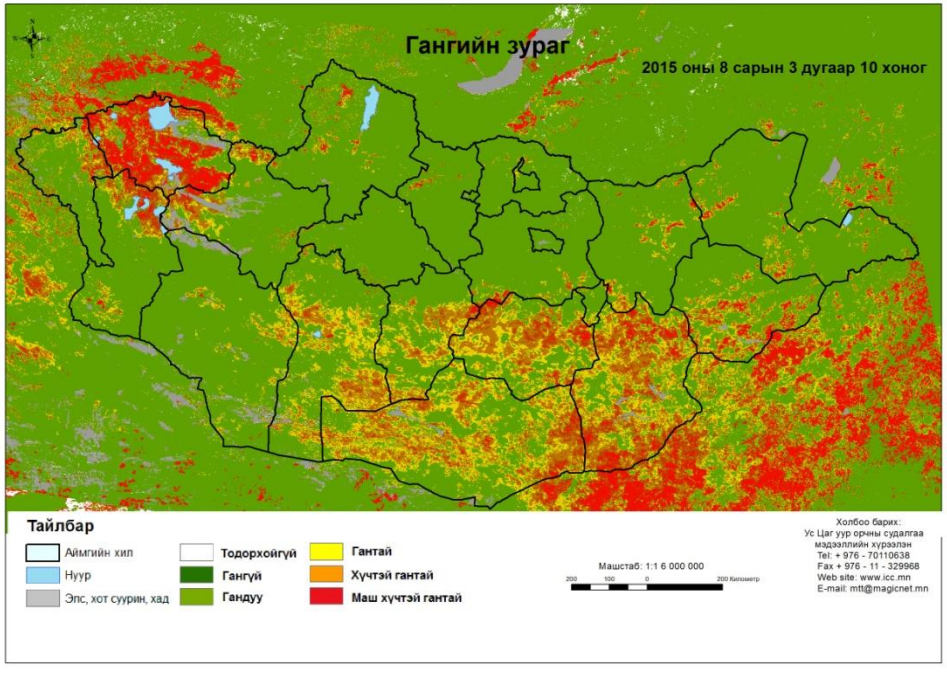
Characteristics of the severe dust event over the Mongolian Gobi in 3-5 March, 2016

Severe dust storms

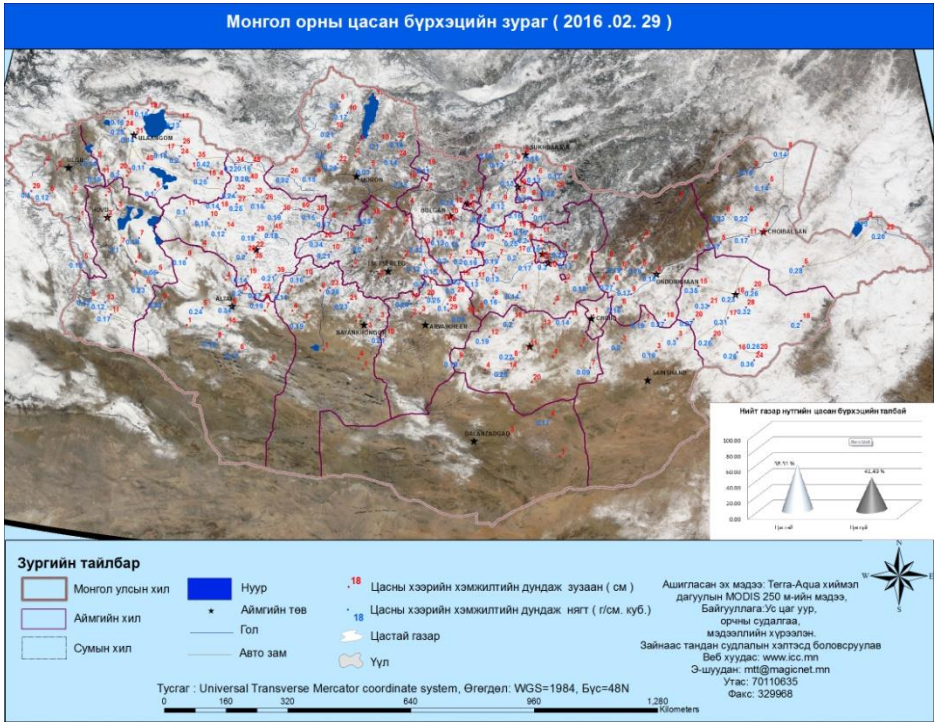
- Severe dust storms refers to one of the dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life.
- The NAMEM observing and forecast system helps reduce disaster risks by providing information for early warnings.
- **Alerts & Warnings** for severe weather delivered by Radio, TVs, real-time web displays, hand-phones etc.

Land surface condition: vegetation & snow

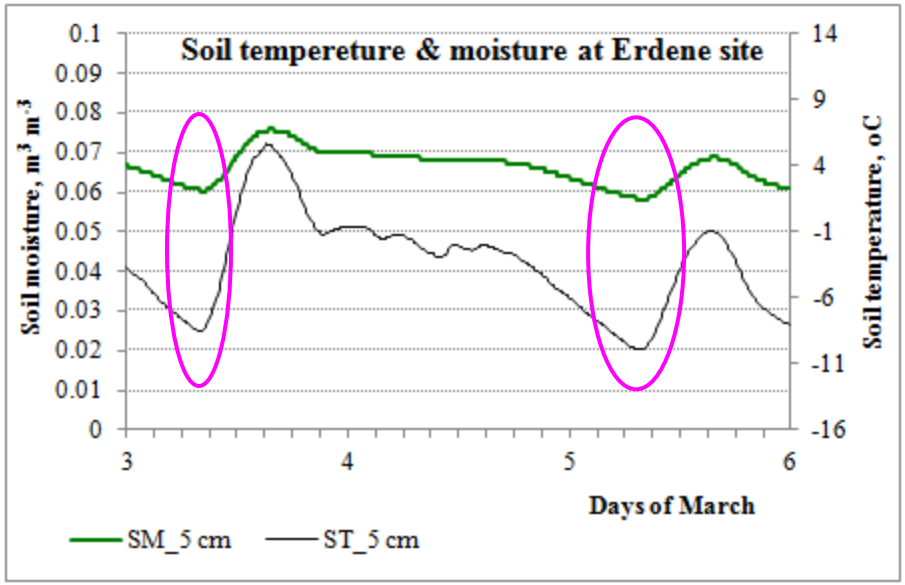
- Summer drought in the end of Aug.2015
- Red/yellow colors show drought.
- Vegetation was less.

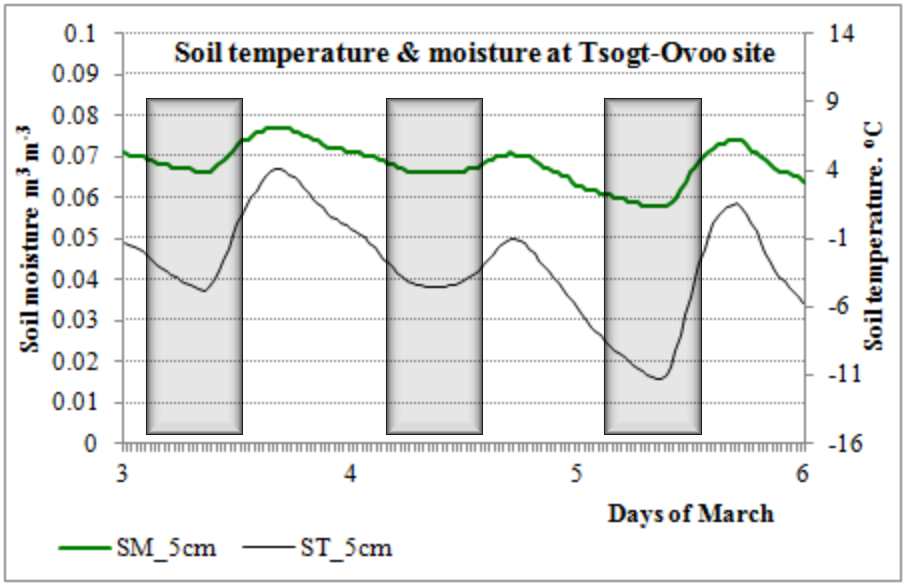


- Winter snow in the end of Feb.2016
- There is no snow cover over the Gobi Desert area
- Soil moisture was less.



Land surface condition:
Soil moisture at 2 sites in the Gobi Deserts

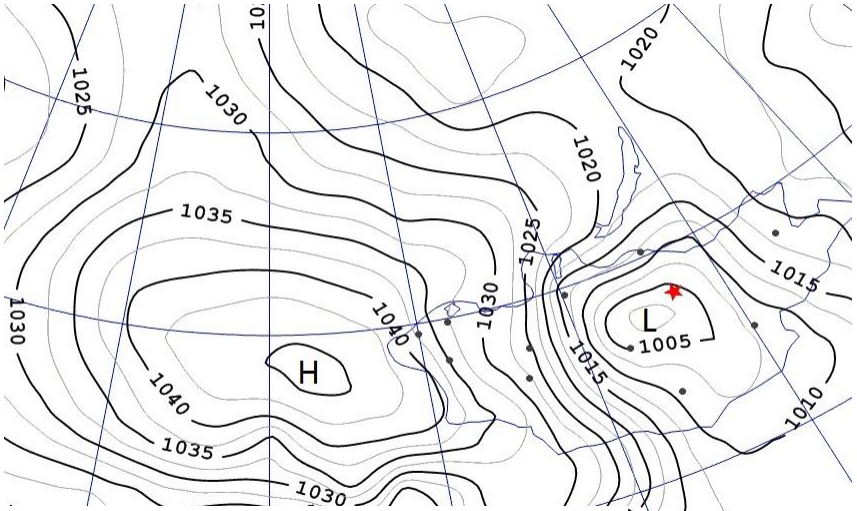




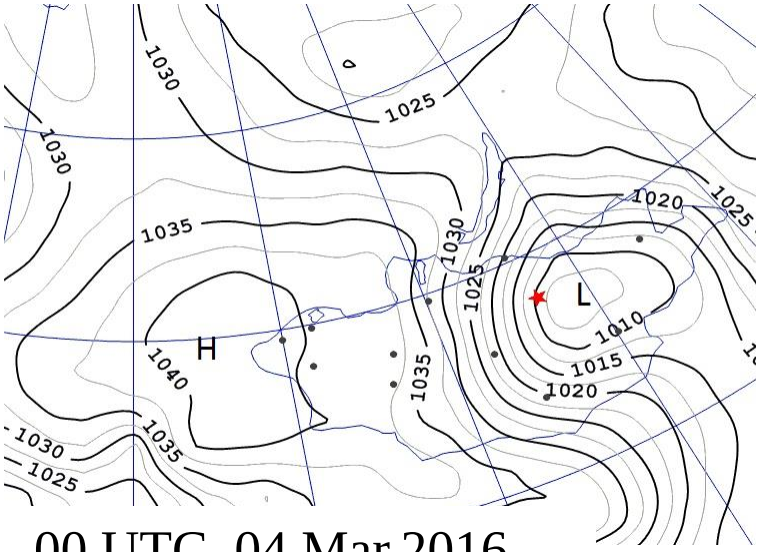
- SM at 5 cm depth was 6.0% and 6.6% at Erdene and Tsogt-Ovoo sites, respectively, during the dust event.
- SM less than 6.0-6.6 are critical values of soil moisture for dust emission (Nickling, 1978, Kimura et at al., 2009, Abulaiti and Kimura, 2011, Jugder, 2015)

Weather condition at the surface

ECMWF model results, surface pressure at initial time (+00h)

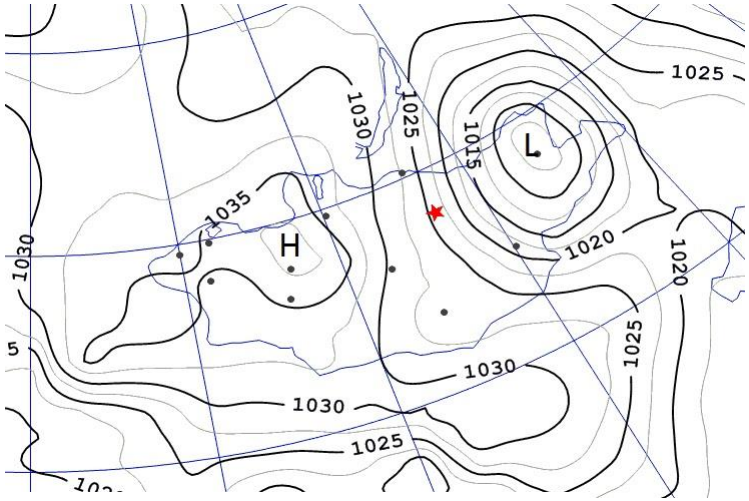


12 UTC, 03 Mar.2016



00 UTC, 04 Mar.2016

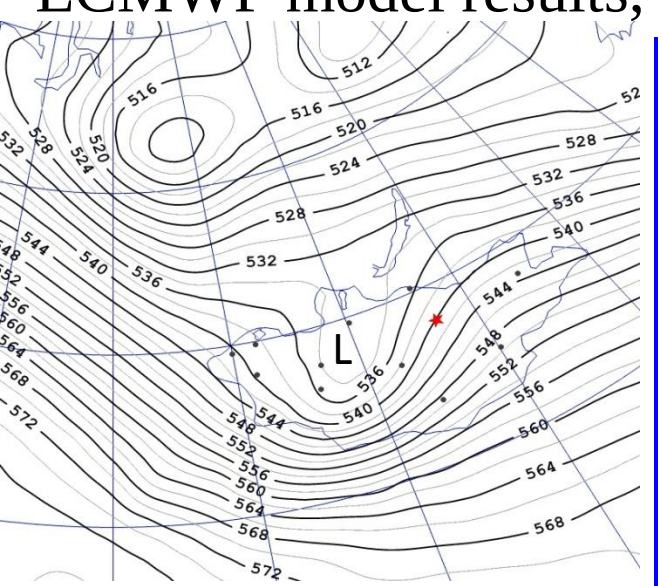
- A cyclone formed over the lee side of the Khangai and Khuvusgul Mountains and generated the strong dust event.

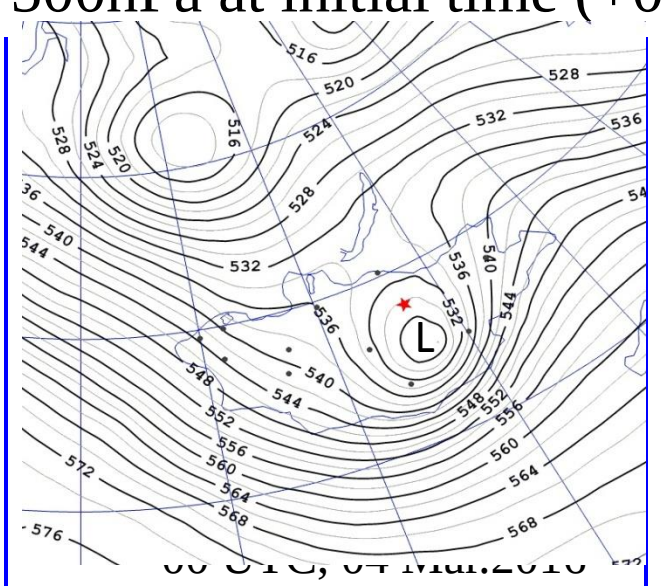


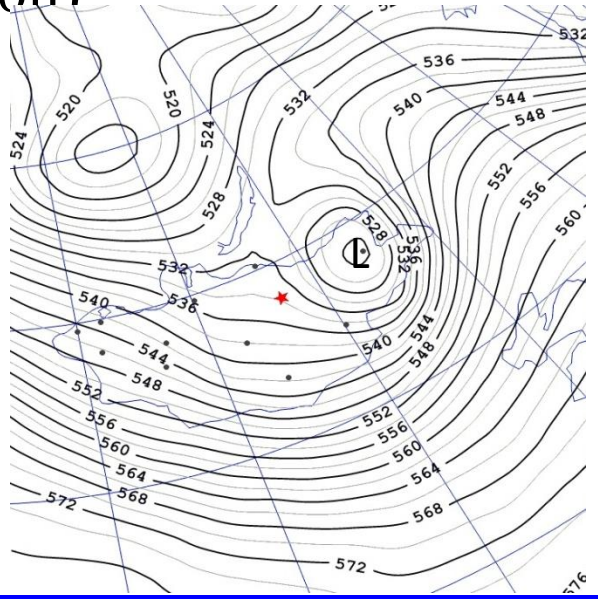
12 UTC, 04 Mar.2016

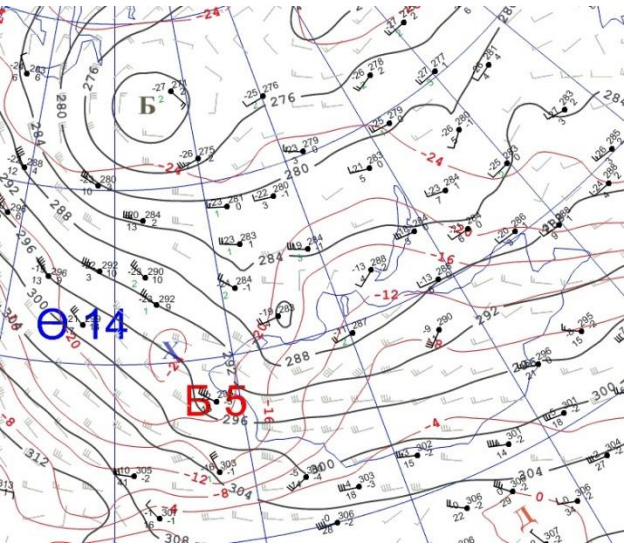
Weather condition: 500hPa &700 hPa

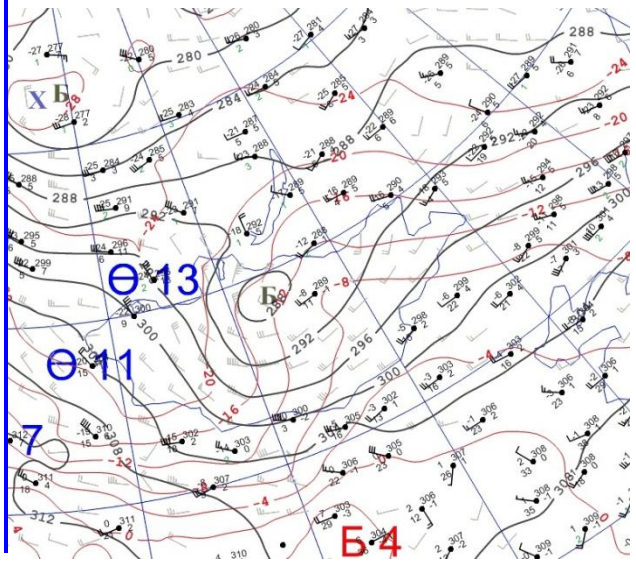
ECMWF model results, 500hPa at initial time (+00h)

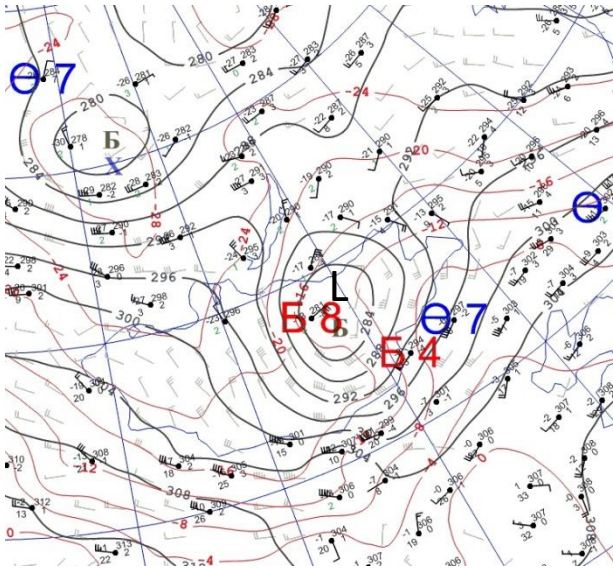






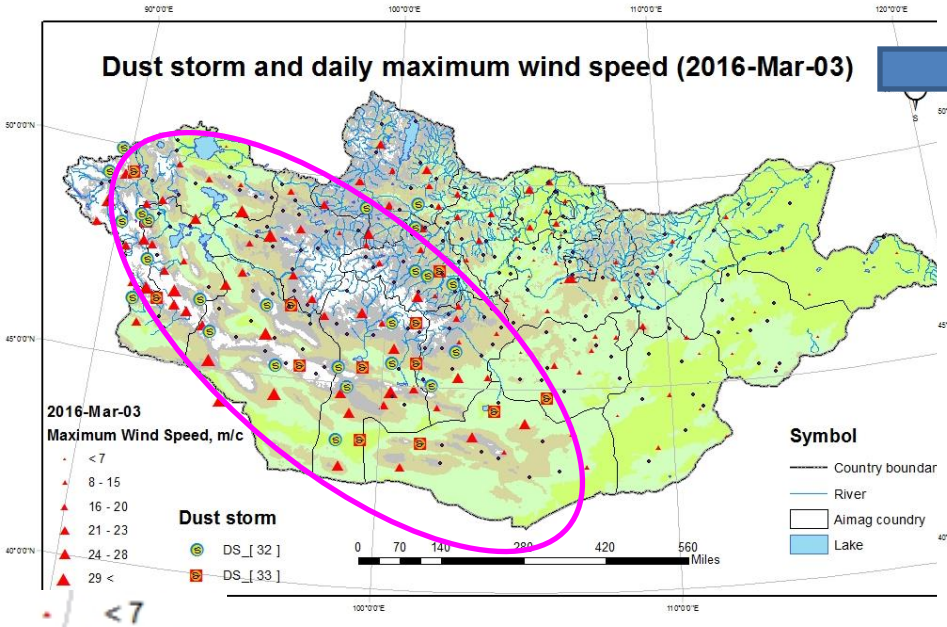


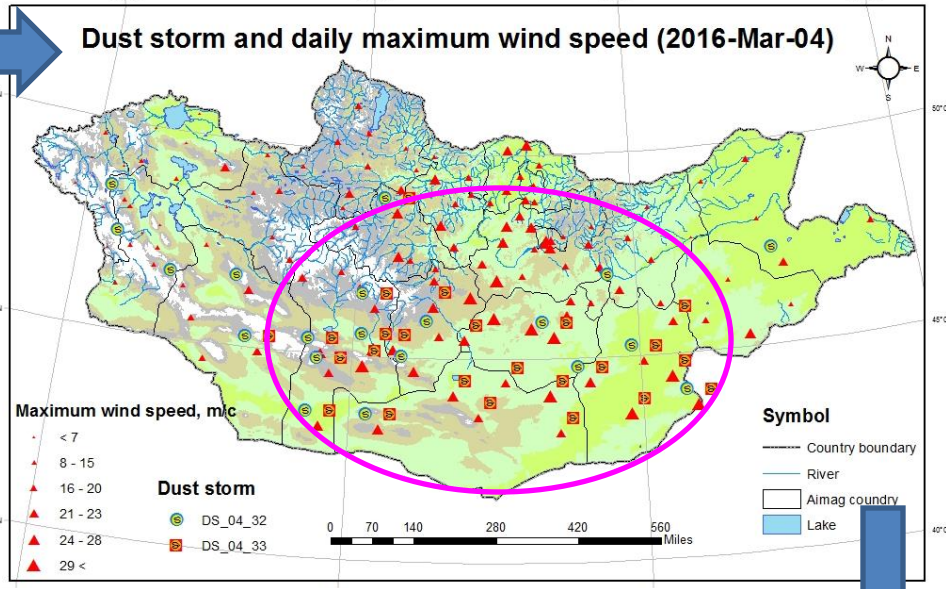


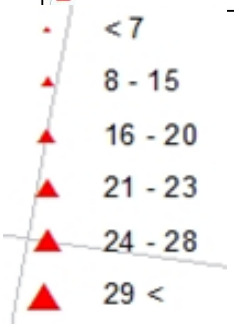


Observations of 700 hPa, 00UTC and 12 UTC, 03 Mar.2016, 00UTC, 04 Mar. 2016

Max. wind speeds and dust storms and over Mongolia in 3-5 March 2016



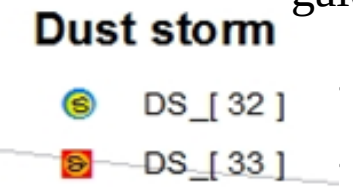




Warning level:

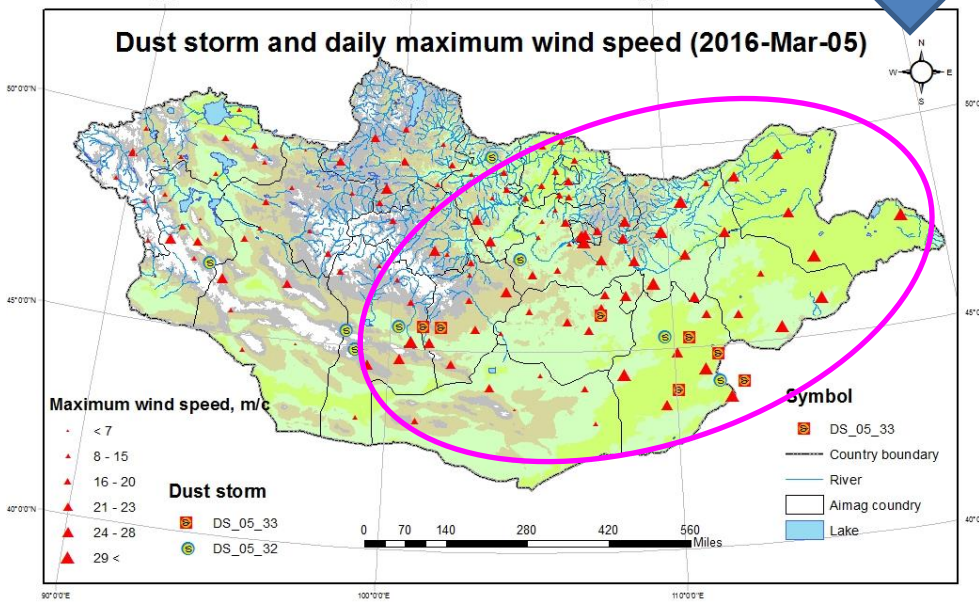
Strong wind ≥18 m/s with gale 24 m/s

Very strong wind ≥ 24 m/s in the steppe, ≥28 m/s in the Gobi with gale 34 m/s

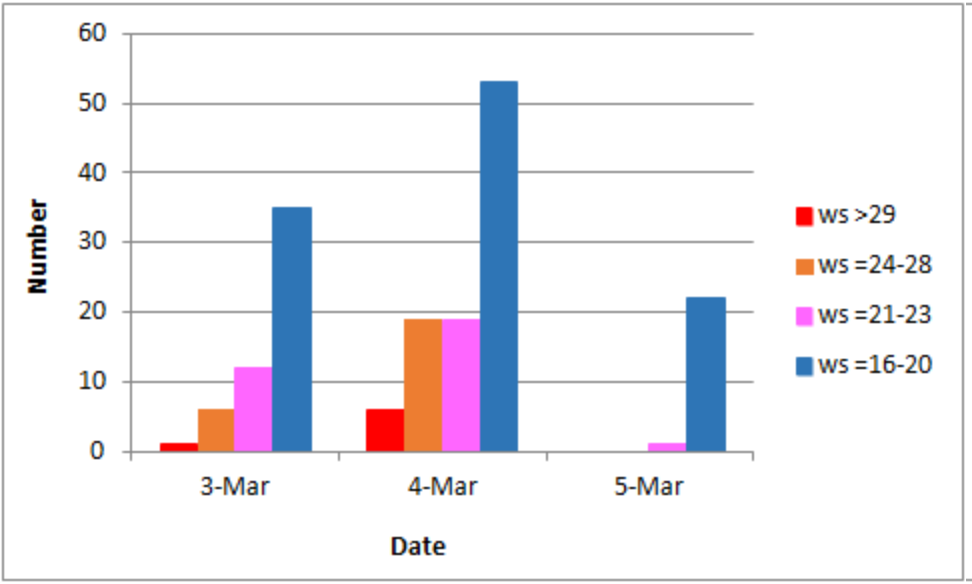


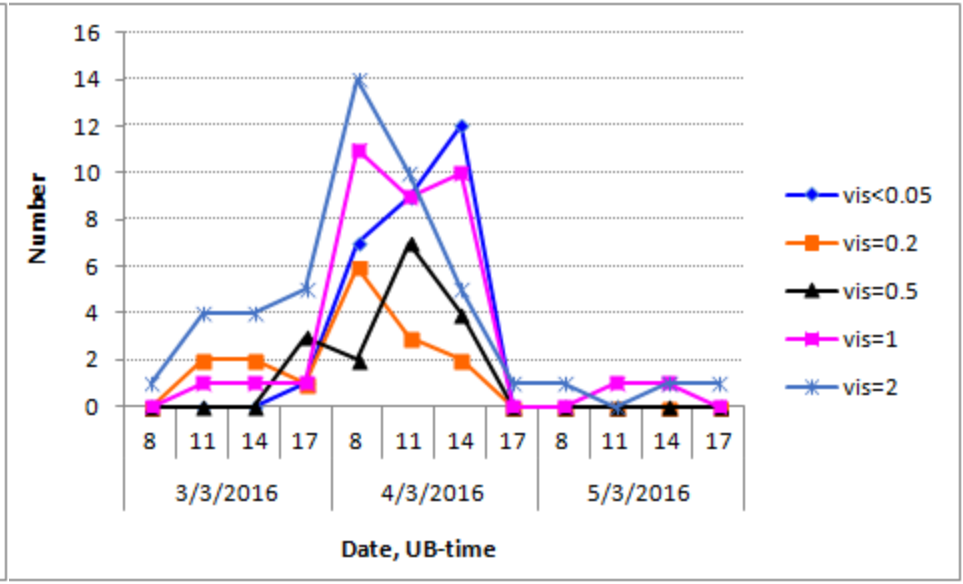
Slight and moderate DSS

Severe dust storms



Number of stations, at which wind speeds≥16 m/s and visibilities ≤ 2 km.

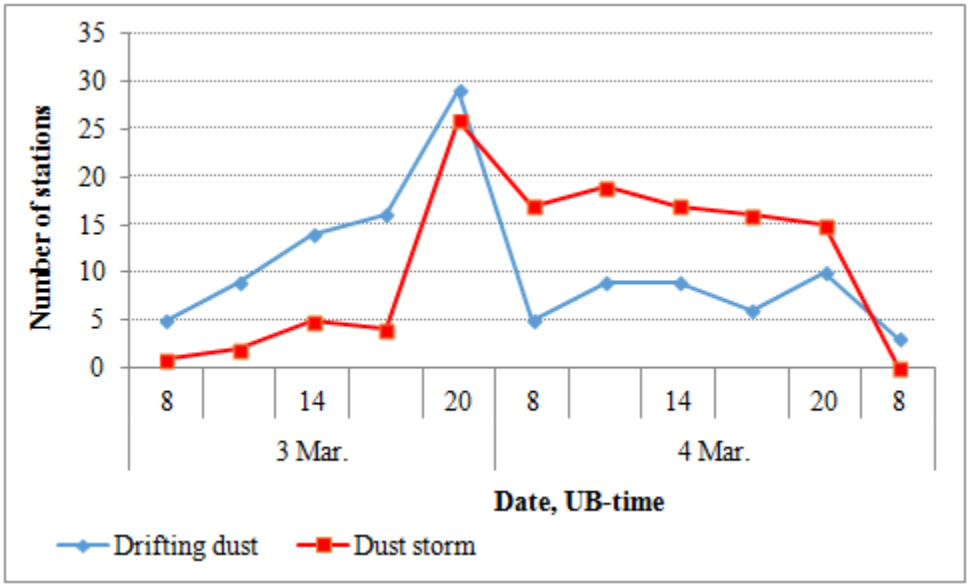




- Max. wind speed was more than 28 m/s at 6 stations, 21-28 m/s at 38 stations & 16-20 m/s at 66 stations on 4 March.
- Visibility was less than 50 m at 7-12 stations, 200-500 m at 10 stations on 4 March due to dust storms and snowstorms.

Number of stations observed severe dust storms

- According to the Manual on Codes, WMO No. 306 (1995), code figures 30–35 shall be used only when dust or sandstorms occur at the time of observation at fixed surface stations:
- 30 to 32 — Slight or moderate DSS.
- 33 to 35 — Severe DSS (WMO No. 306, Code Table 4677).

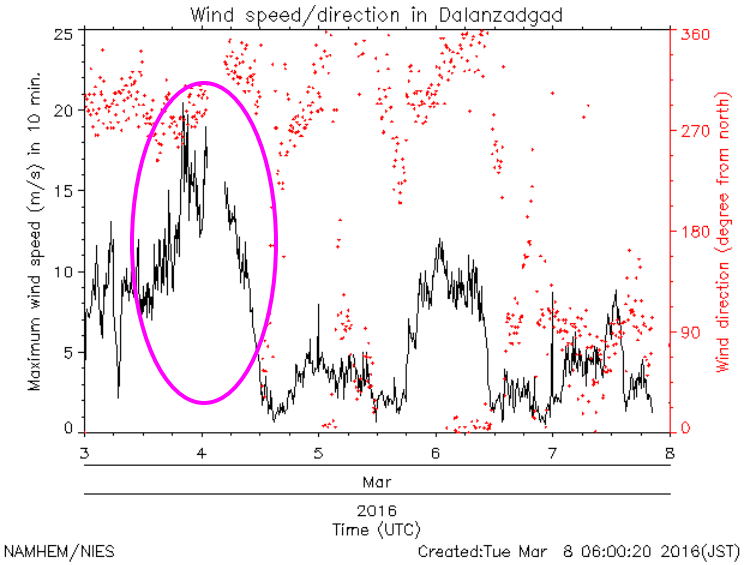


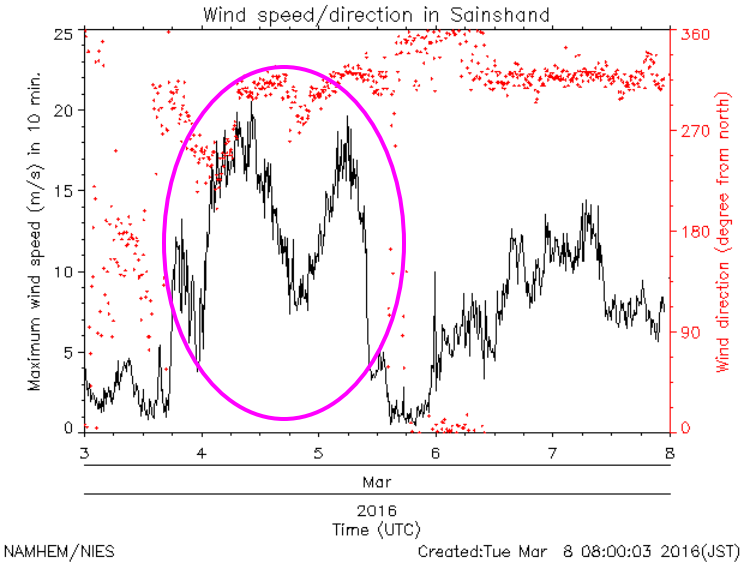
Number of stations with dust storms coded by 33-35 was 15-25 from 20:00 o'clock 3 Mar. to 20:00 o'clock 4 Mar.

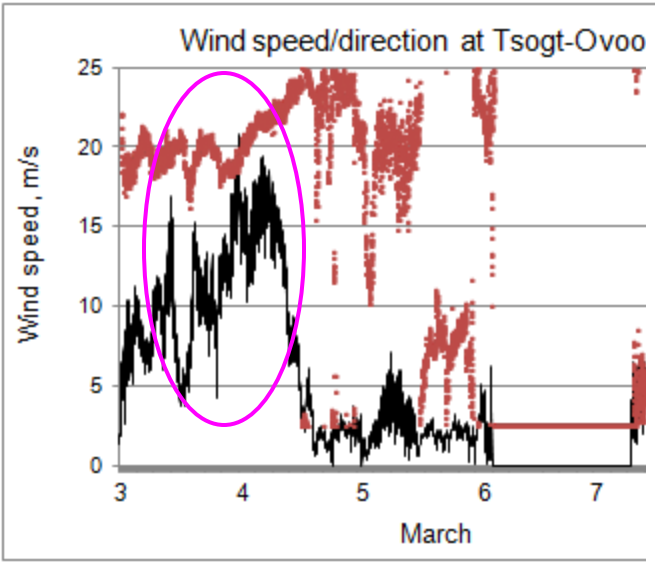
Observed wind speed, PM_{10} and Visibility

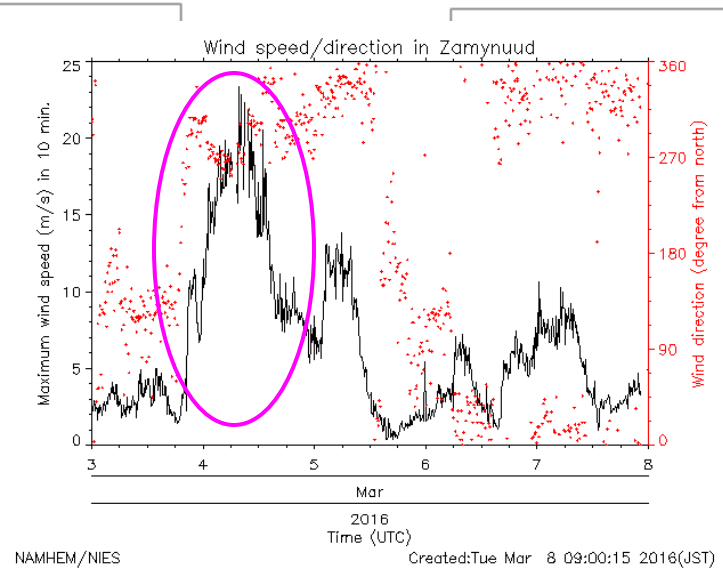
Site name	Maximum wind speed averaged by 10 min, m/s	PM10, µg/m3	Measured minimum visibility, km
Dalanzadgad	20.4	1682	Ins.failure
Tsogt-Ovoo	20.8	1268	Ins.failure
Sainshand	20.6	350	0.6 (< 1 km during 3 hours)
Zamyn-Uud	23.3	1789	0.3 (< 1 km during 8 hours)
Erdene	24.5	---	----

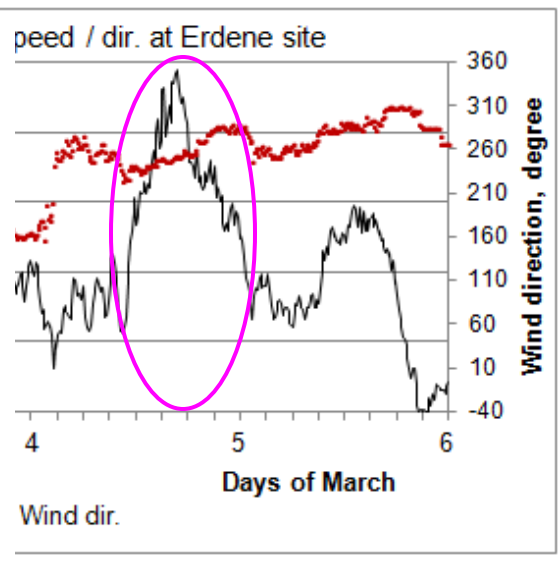
Measured Max. wind at Dalanzadgad, Sainshand, ZamynUud and Erdene sites



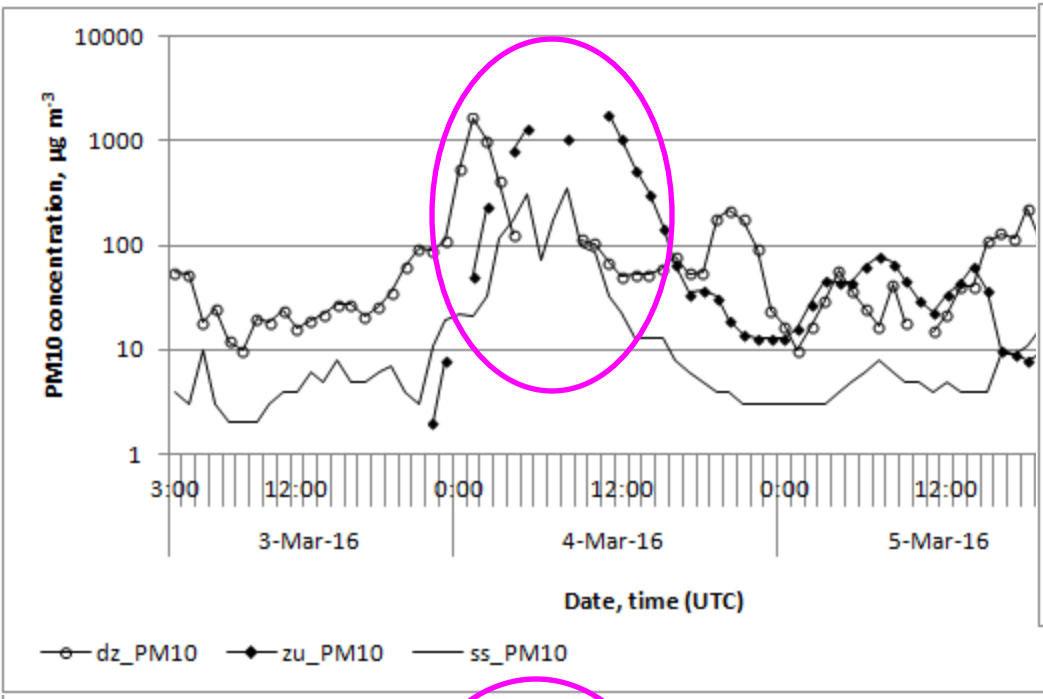


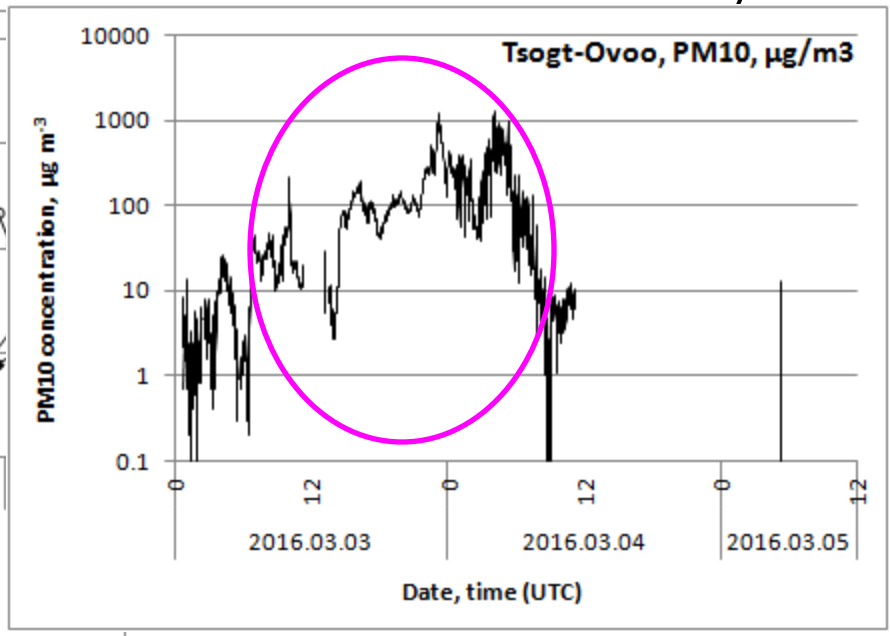


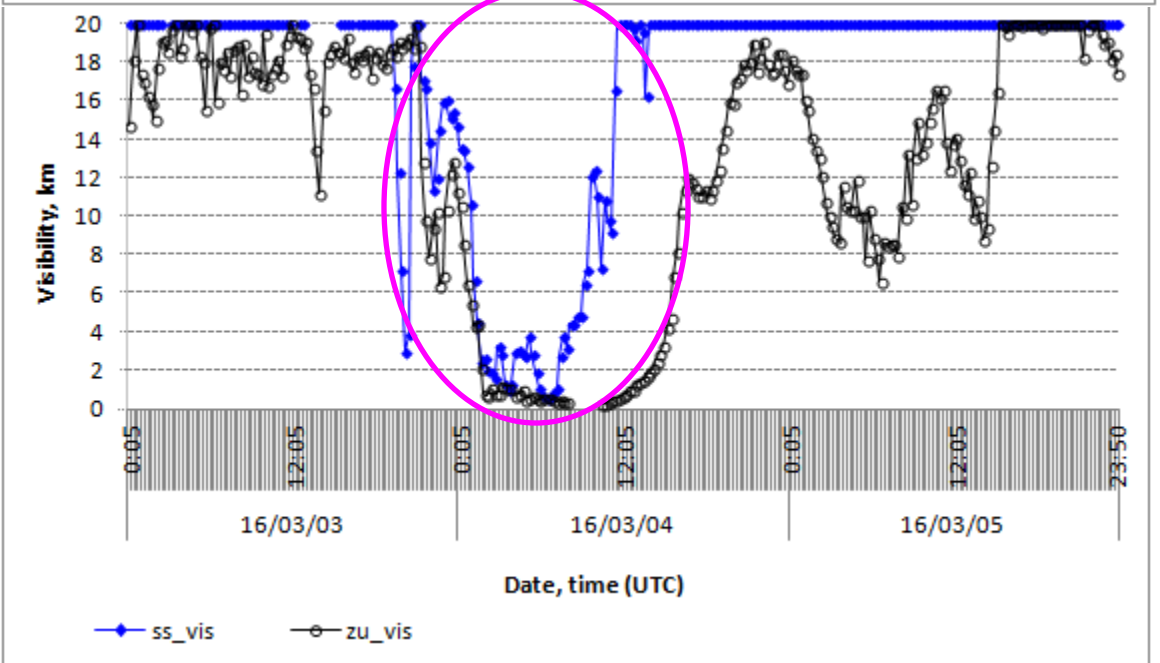




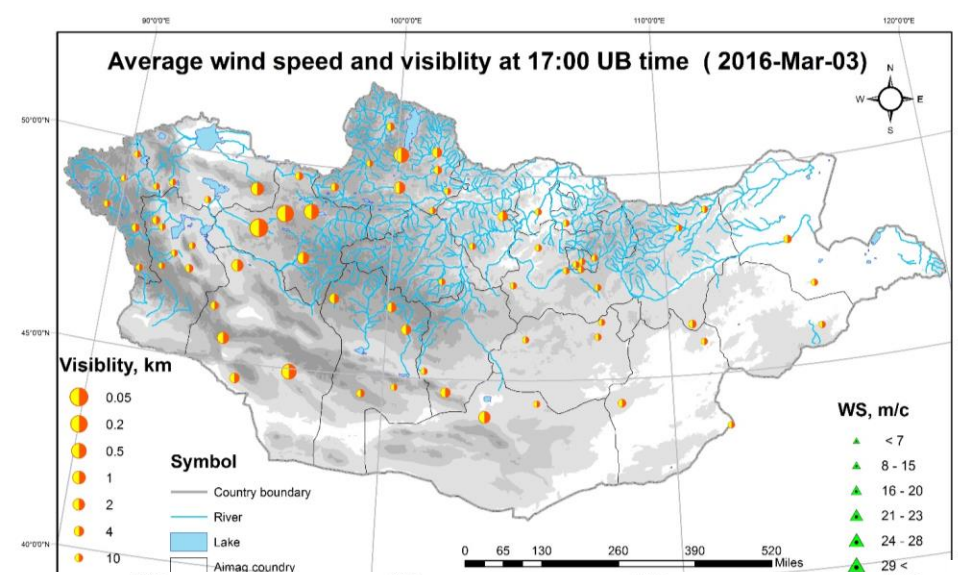
Measured dust concentration and visibility

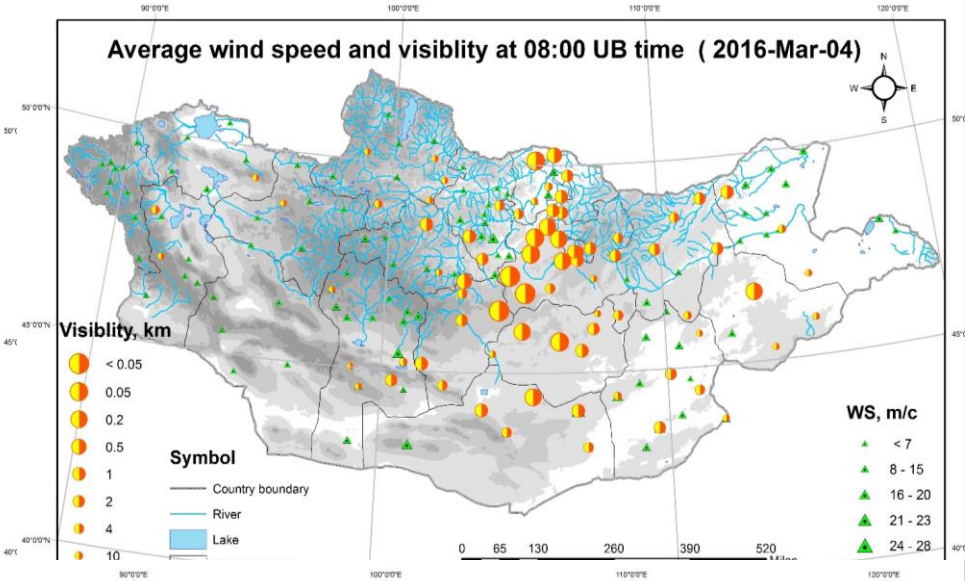


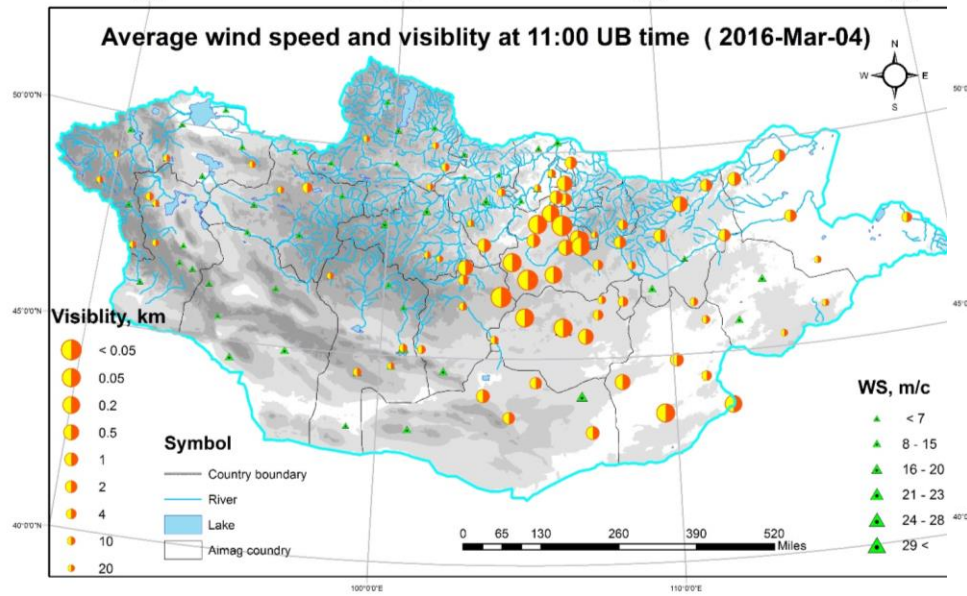


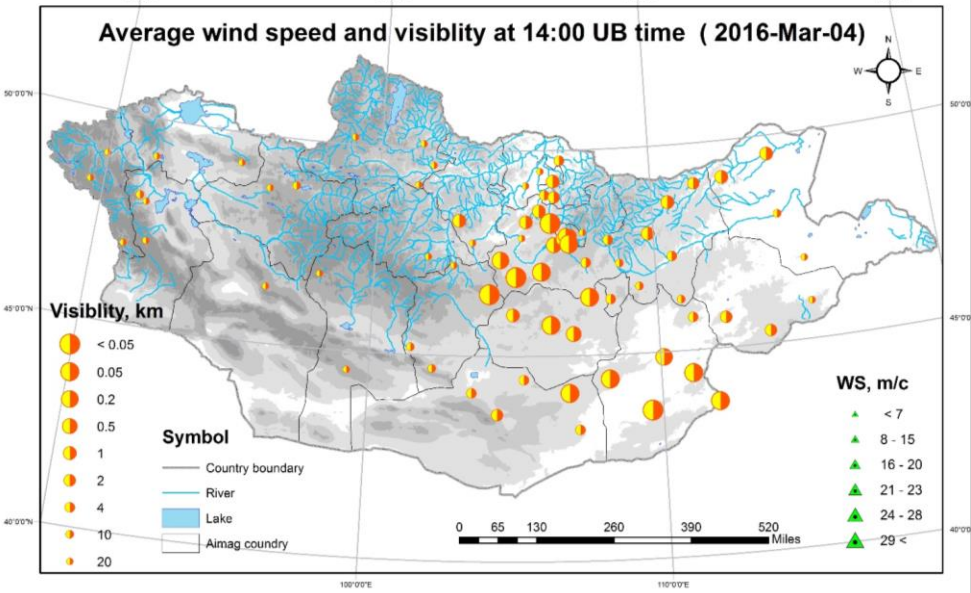


Visibility coded by 90-98 over Mongolia in 3-5 Mar.



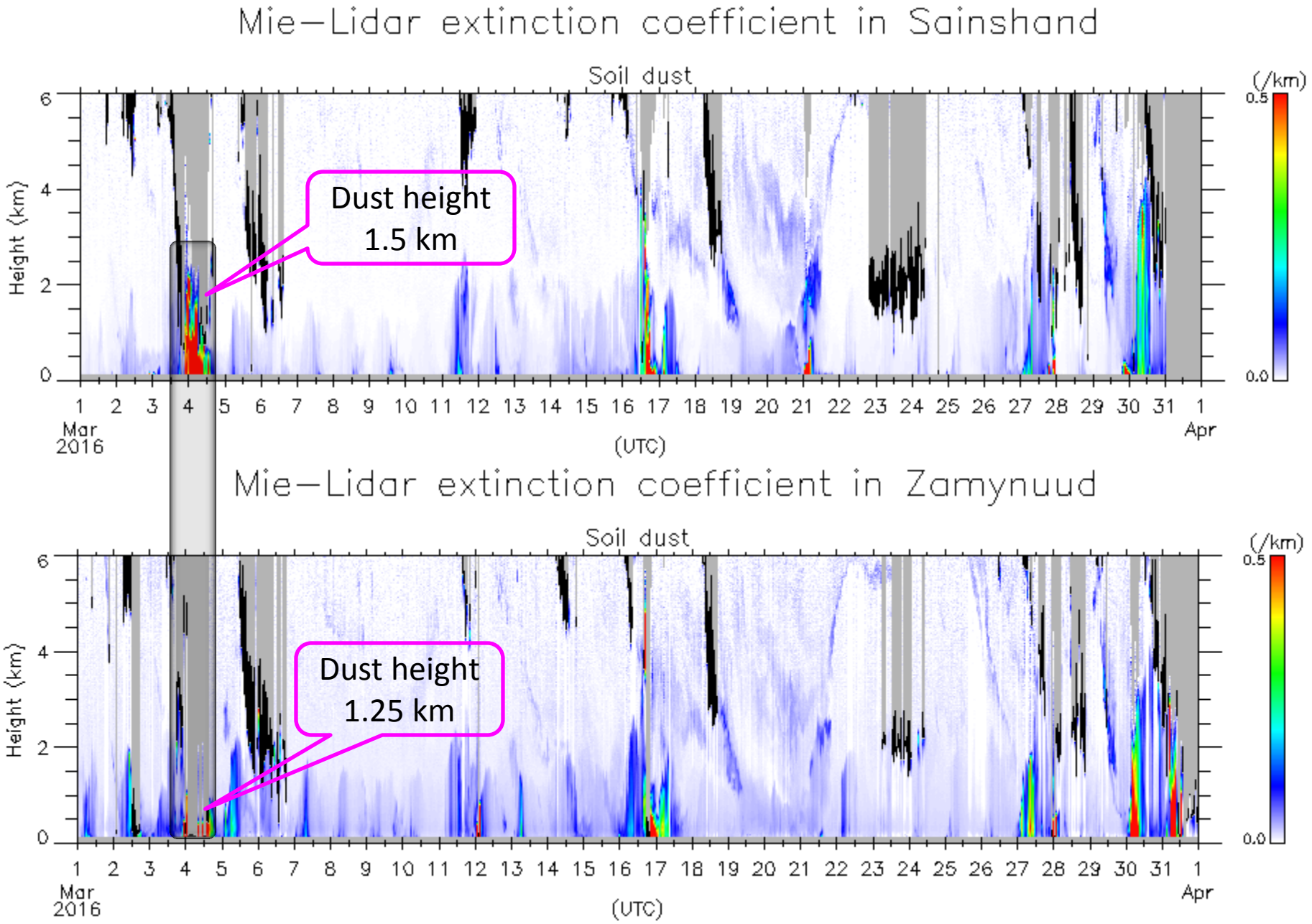




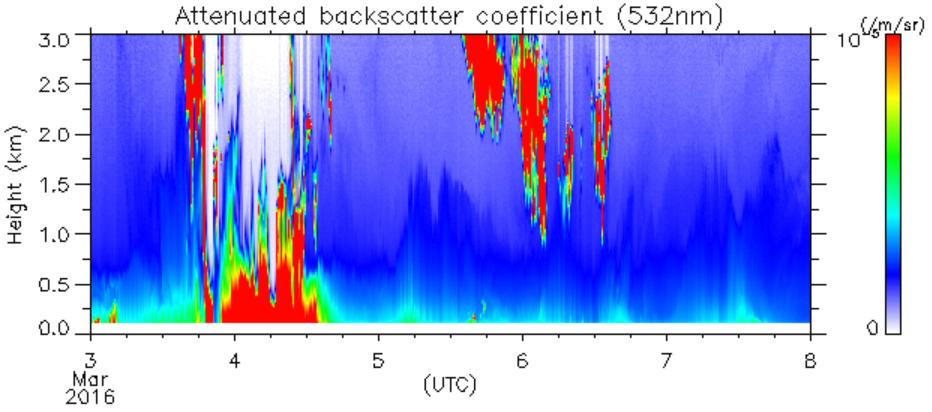


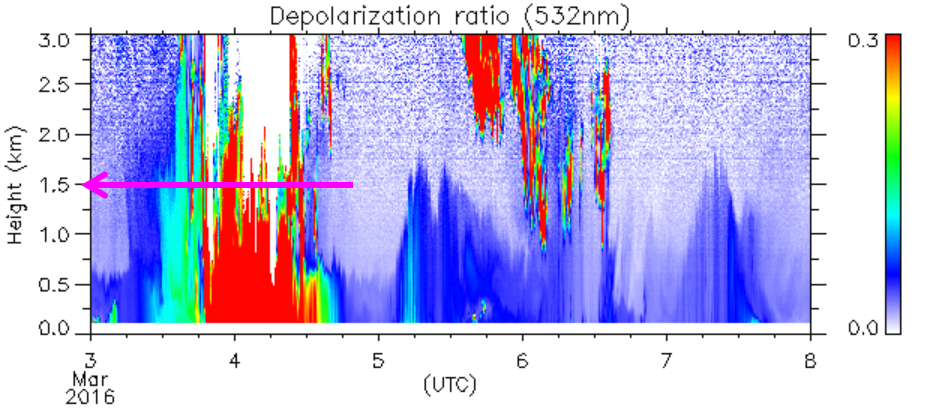
- Visibility dropped to less than 50 m.

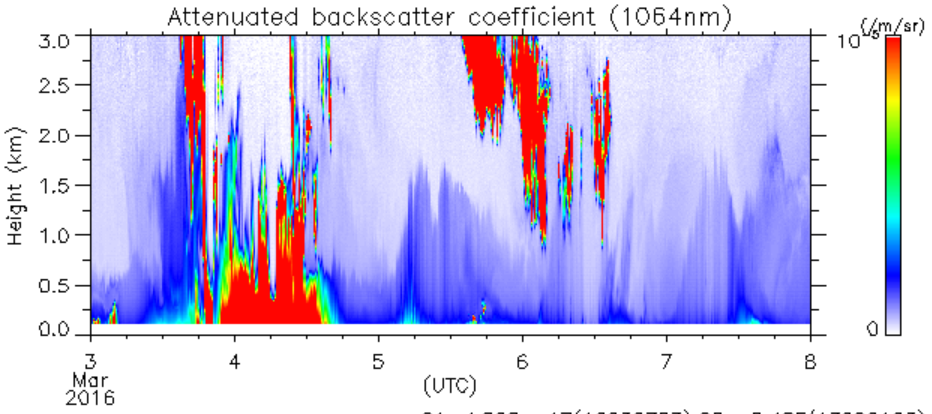
Mie-Lidar extinction coefficient



Lidar Observation in Sainshand







NAMHEM/NIES

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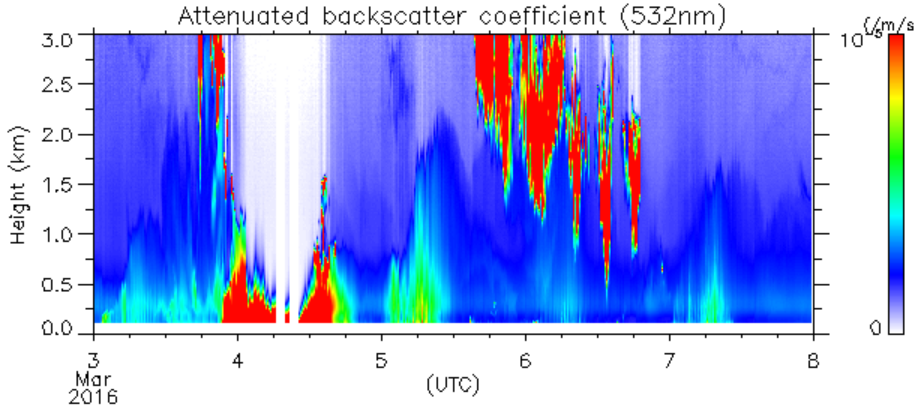
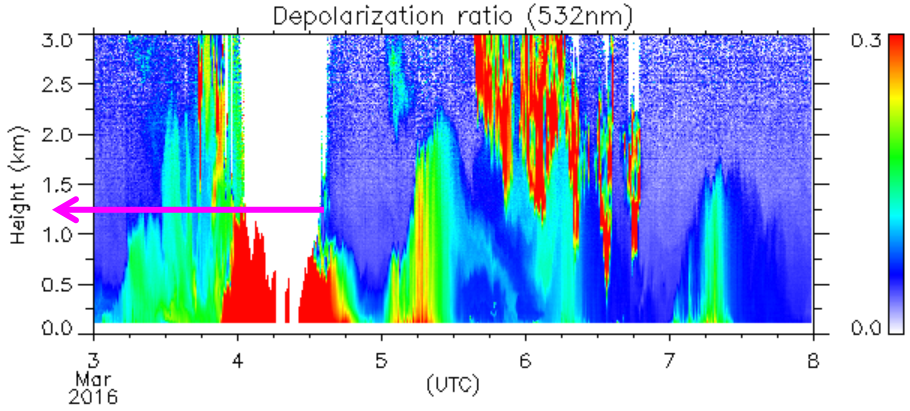
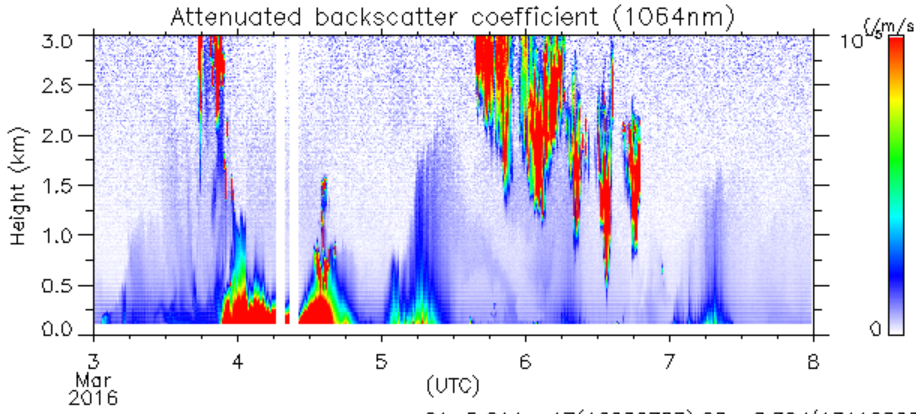
Created: Tue Mar 8 09:00:05 2016JST

Lidar Observation in Zamynuud







NAMHEM/NIES

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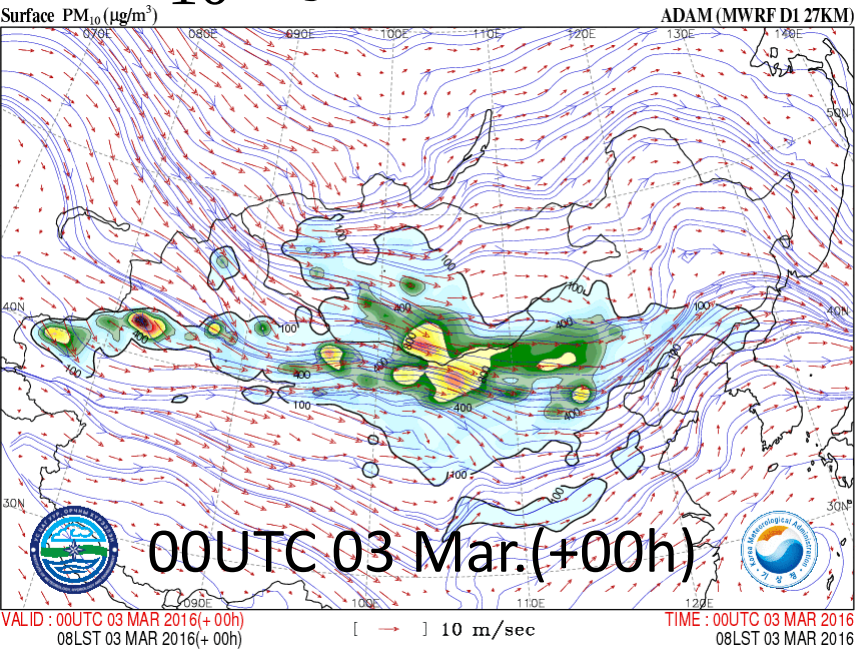
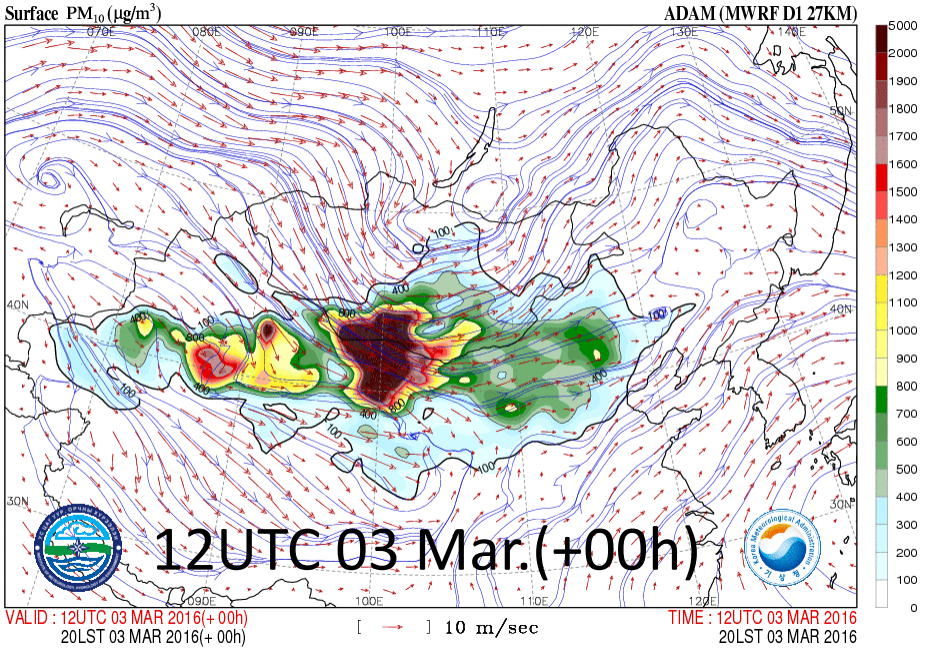
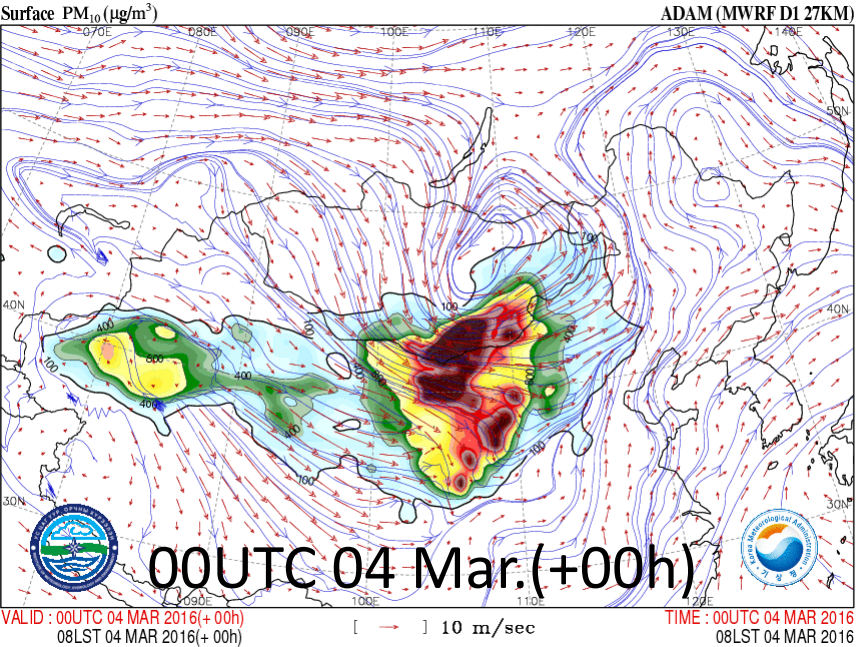
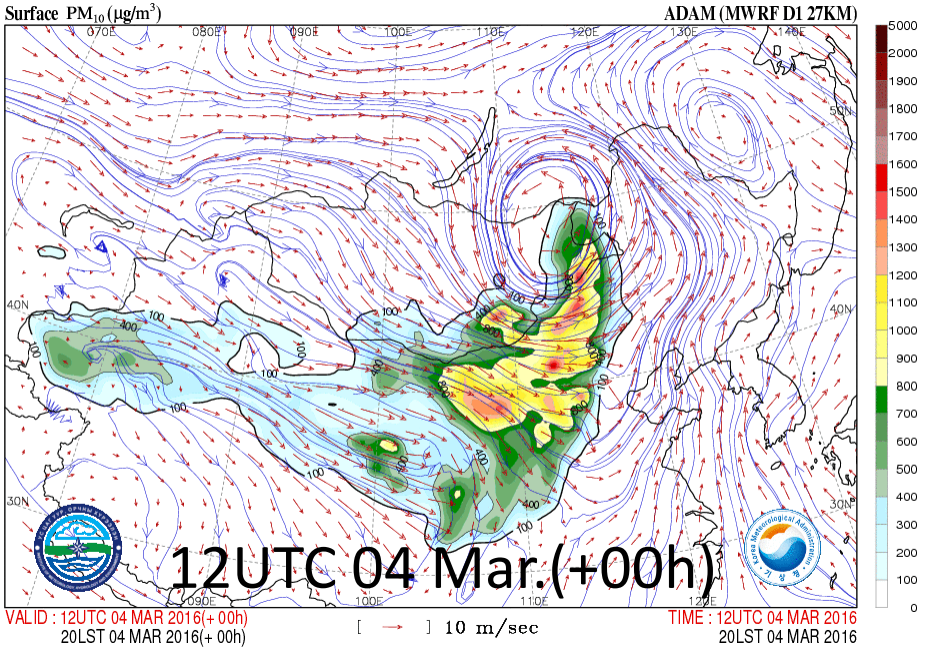
Created: Tue Mar 8 09:00:12 2016JS

PM_{10} by the MGL-ADAM model at initial times





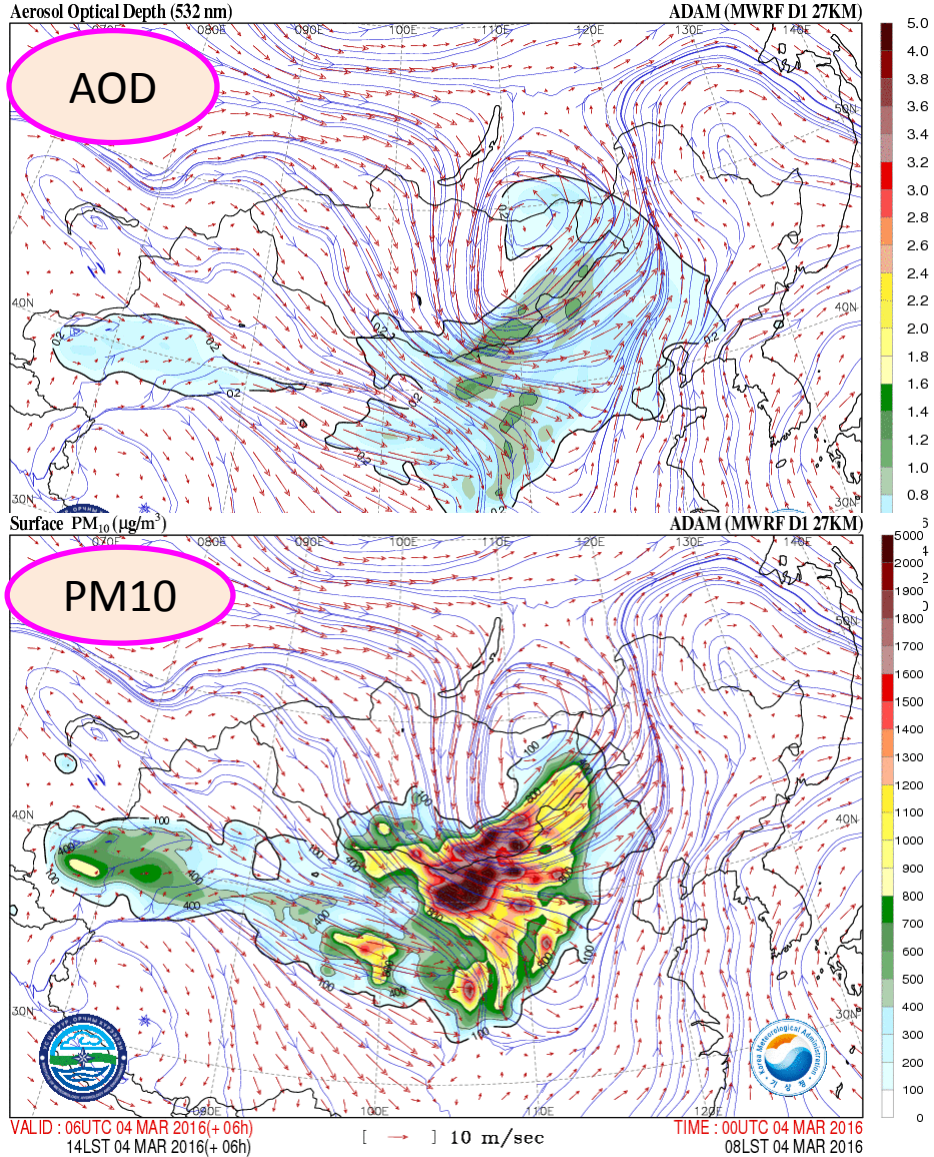




MGL-ADAM model result:

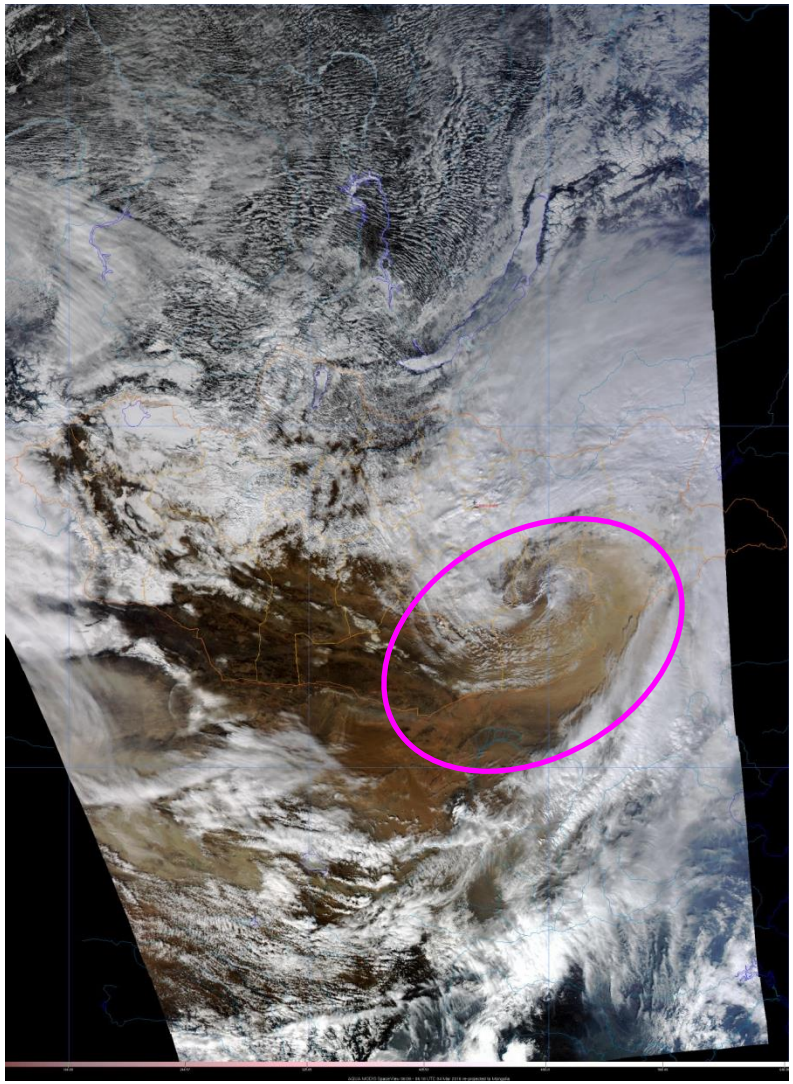
valid at

14 LST, 04 Mar. 2016(+06h)

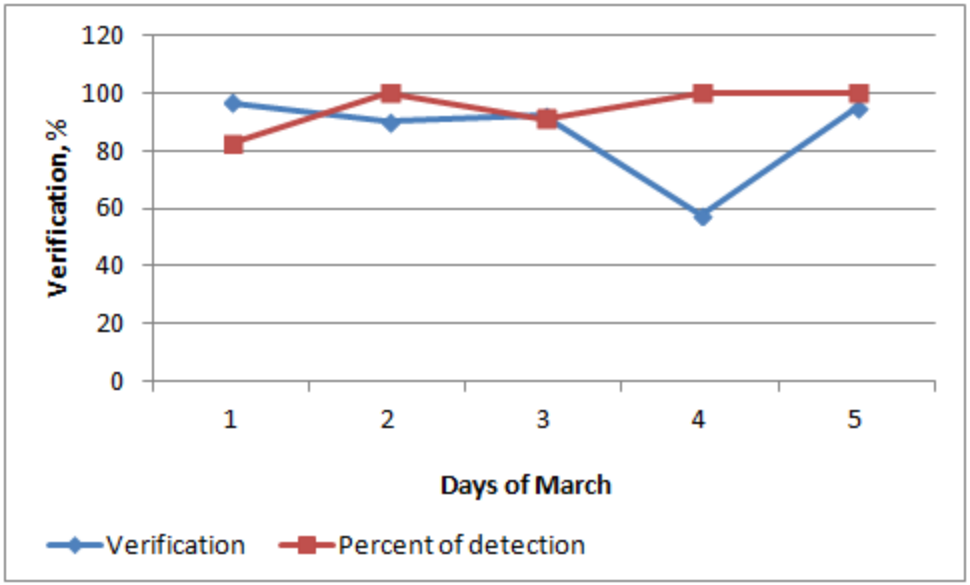


Satellite image by MODIS, Aqua/Terra

at 14:08 LST, 04 Mar. 2016

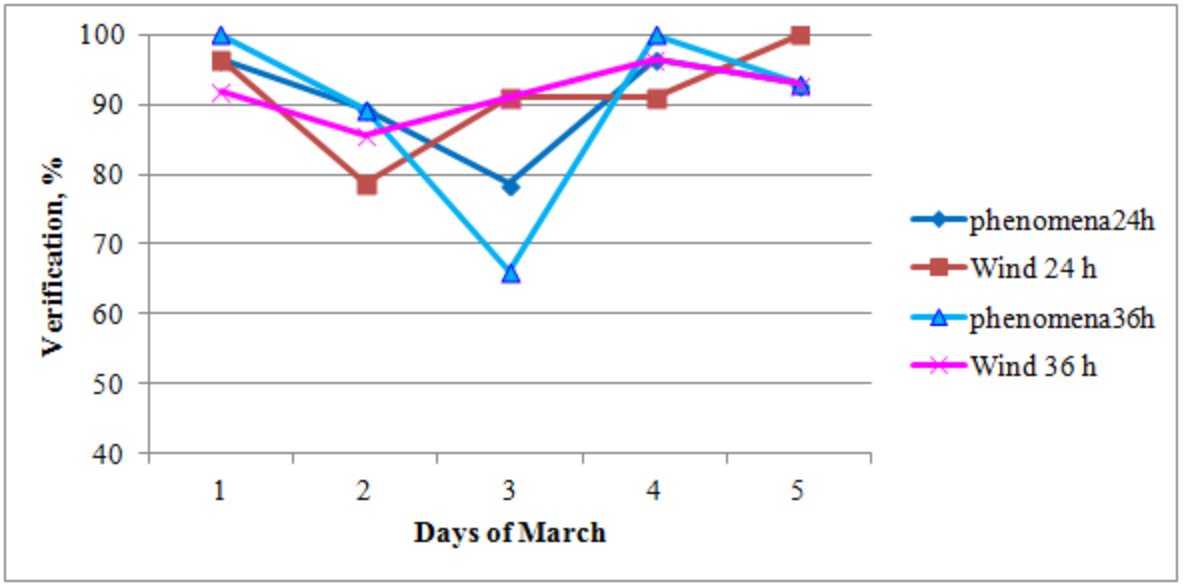


Warning forecast validation



- **Alerts & Warnings:** Custom alerts for severe weather delivered by way of email, real-time web displays or other electronic means.
- Verification for weather warning was 90-96%, but 57% in 4 March (overestimated spatial distribution).
- Verification for severe weather warning 87-92%.
- POD were 82-100% for both WW and SWW.

Daily forecast validation (by 28 stations)



- Wind forecast verification was 79-86% in the starting day of the dust event and 91.0-96.4% during dust storm days.
- Forecast verification of the dust storm and snow storm was lower in 3 March as 78.6% and 66.1%.

The severe storm impacts

Consequences	Number	
Missing herders	44	
Weather-bound automobiles / people	17 / 88	
Motorbikes	3	

- Severe dust storm and snowstorm caused serious social trouble, fortunately there was no loss of human life.

Conclusions

- The dust event observed in 3-4 March was the strongest storm in Mongolia in spring of 2016.
- The lee cyclone formed on the leeward (downwind) side of the Khangai, Khuvusgul mountain barriers and developed as upper-level cyclone.
- This lee cyclone produced major windstorms and dust storms downstream of the mountain barrier.
- The dust storm covers the Gobi Desert areas in the southern part of the country, while snowstorm covers the northern part.

Conclusions

- The dust event was specific because it was the strongest dust storm in this year of 2016.
- Measured max. wind was 32 m/s during the dust event. Lowest visibility was less than 50 m.
- Temporal forecasts were good but spatial forecasts had some mistakes.
- There was no loss of human life.

Thank you for your attention