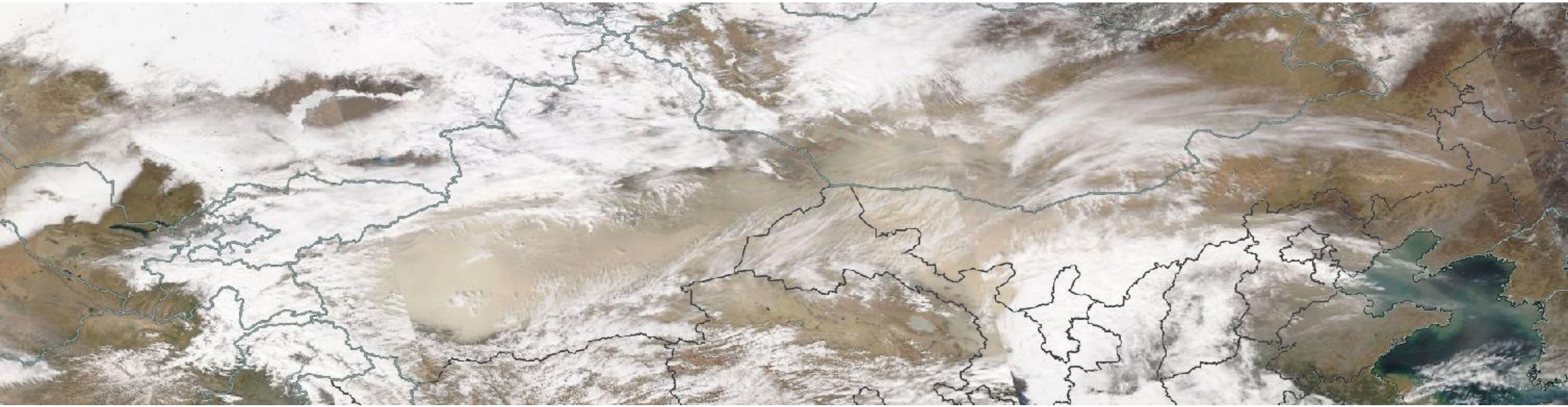
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Aeolian dust sources, transport and deposition over the Chinese Loess Plateau during 1999-2019: A study using the FLEXDUST and FLEXPART models.

Examining the linkage between the East Asian winter monsoon and deposition over the Chinese Loess Plateau on an interannual scale.

Ove Haugvaldstad, Hui Tang, Anu Kaakinen & Frode Stordal



Credit: Nasa Worldview

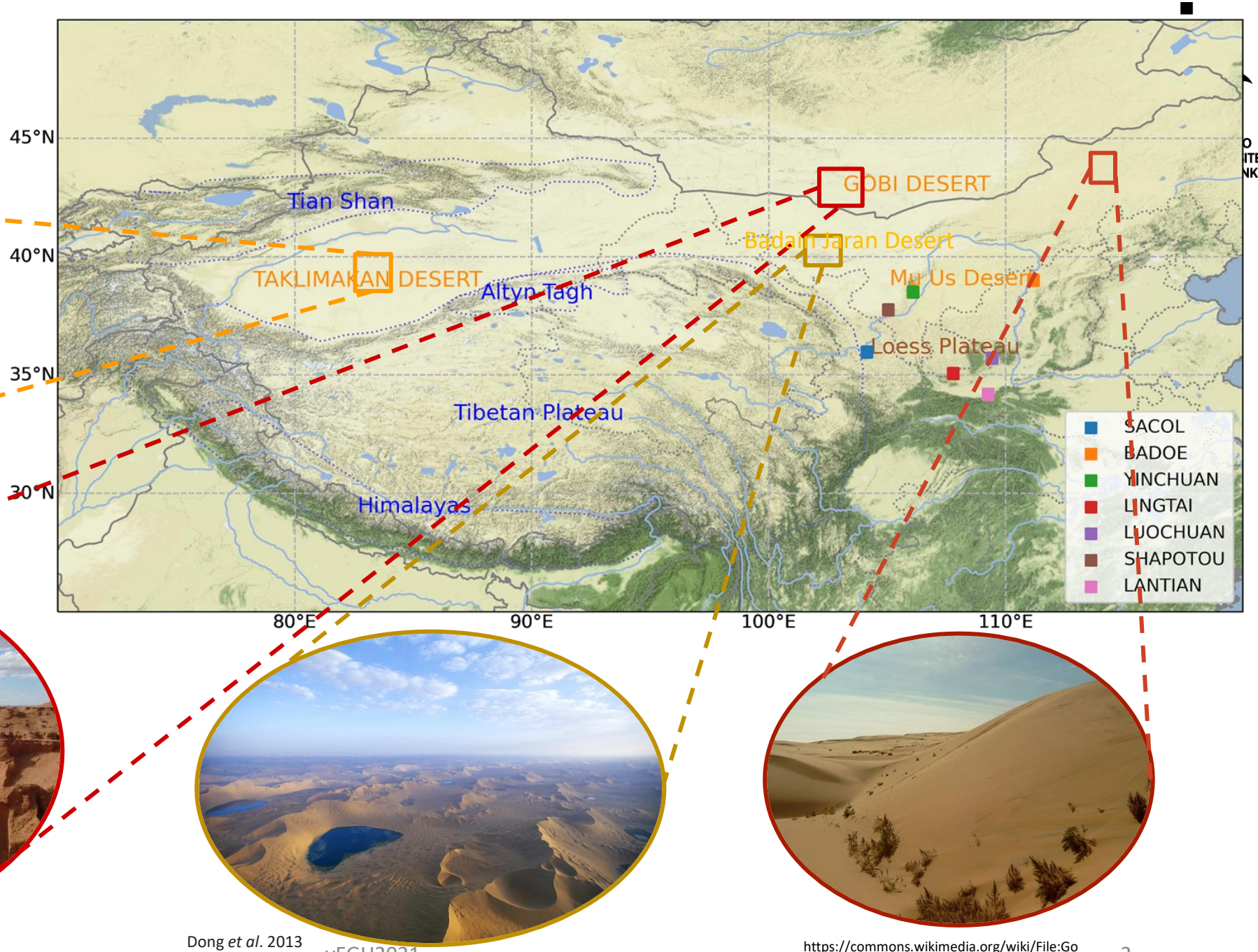
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By Pravit - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=3575981



Photo: Alice Anderson



Dong *et al*. 2013

https://commons.wikimedia.org/wiki/File:Gobi_Desert.jpg#/media/File:Gobi_Desert.jpg

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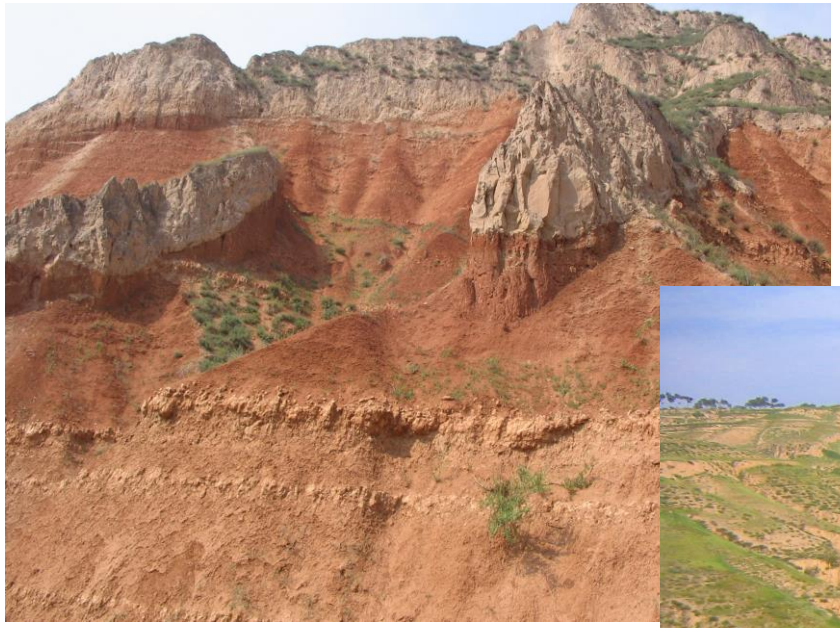


Photo: Anu Kaakinen



Photo: Mikael Fortelius



Photo: Thomas Stevens

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The East Asian winter monsoon has a major impact on East Asian winter climate.

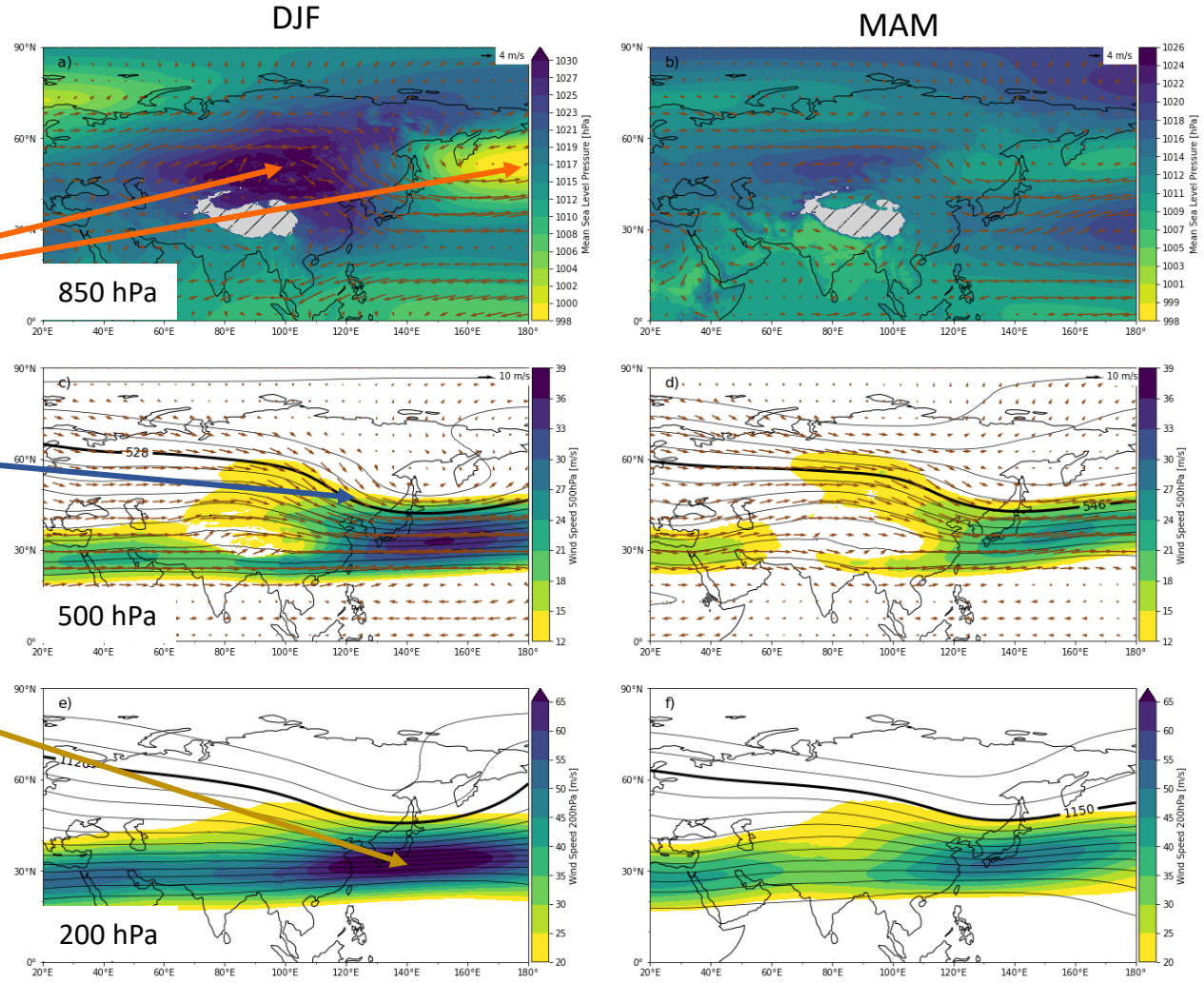
The primary driver of the EAWM the land sea contrast.

The three major of EAWM components:

1. The Siberian High-, Aleutian Low-pressure systems
2. The East Asian trough
3. East Asian jet

Strong north westerlies to the east of the Siberian High.

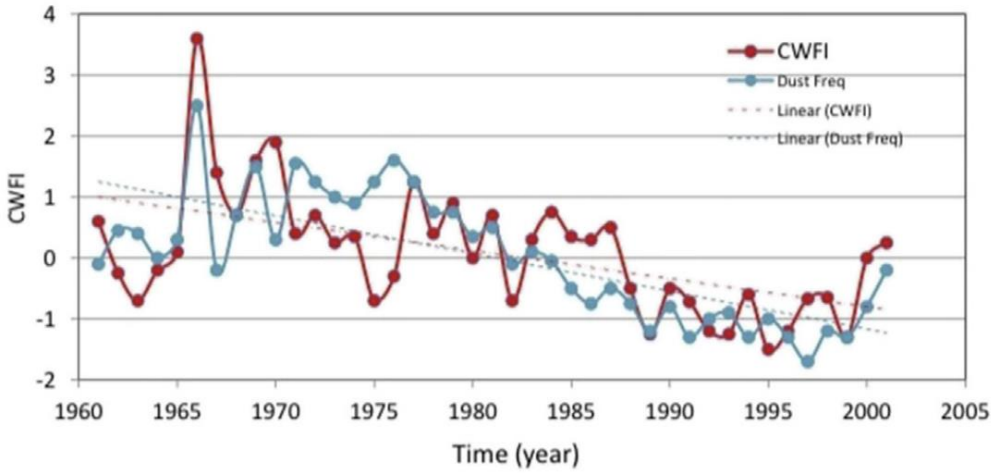
ERA 5 climatology 1999-2019



EAWM strength is assumed to be linked Loess deposition rate and grain size changes.



Photo: Anu Kaakinen



(Wyrwoll et al 2016)

- Dust emissions primarily occur in spring -> hence might be **not representative** of winter synoptic conditions (Roe 2009).

- Wyrwoll et al 2016 established a link between EAWM strength (cold wave frequency) and dust frequency.

However, Dust Frequency is not deposition!

- **Is the accumulation (deposition) rate really linked to the winter monsoon circulation? Why?**

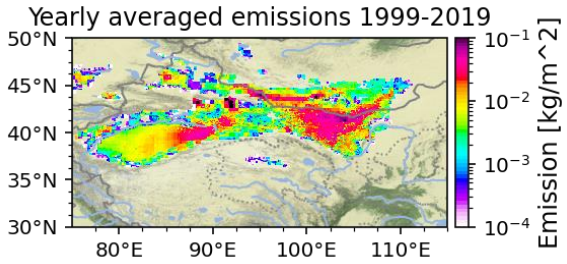
- **Is the particle size a better index of the winter monsoon? Why?**

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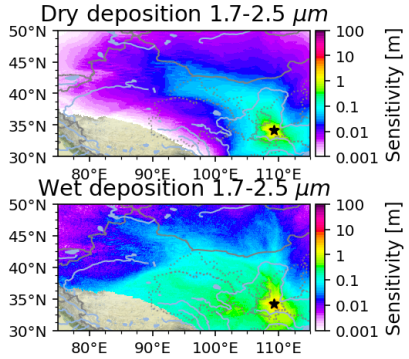
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Modelling workflow

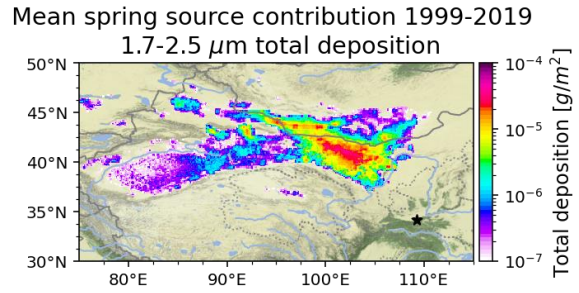
Dust emissions



Dust transport and deposition



Receptor quantities



FLEXDUST

- 3 hourly, 0.1x0.1 degree emissions flux
- Assumed size distribution < 20µm

ERA5

Zwaaftink et al. 2016

Done in post processing

Dust emission field match with corresponding emission sensitivity.

FLEXPART

- Sampled every 900 s, output every 3h, 0.1x0.1 degree.
- Dry and Wet deposition runs are sperate.
- New 5 day backward trajectories started every 3 hours
- Two particle size bins “Fine Silt” 1.7 – 2.5µm , “Coarse silt” 15-20µm

Emission sensitivity

ERA5

Pisso et al. 2019

=

Dry deposition

Wet deposition

- Map of source contribution

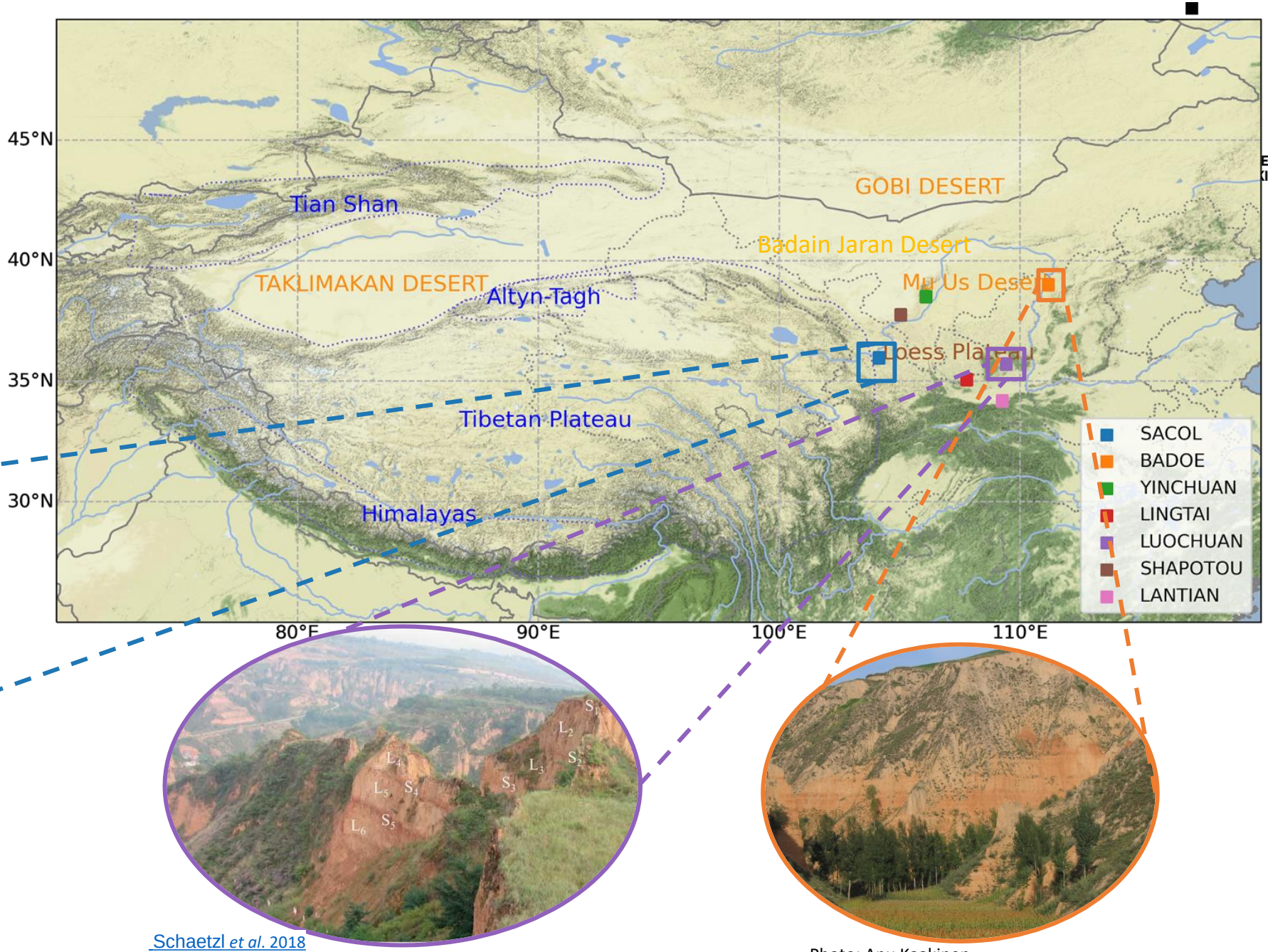
FLEXPART

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Receptor locations



Zhang et al. 2013



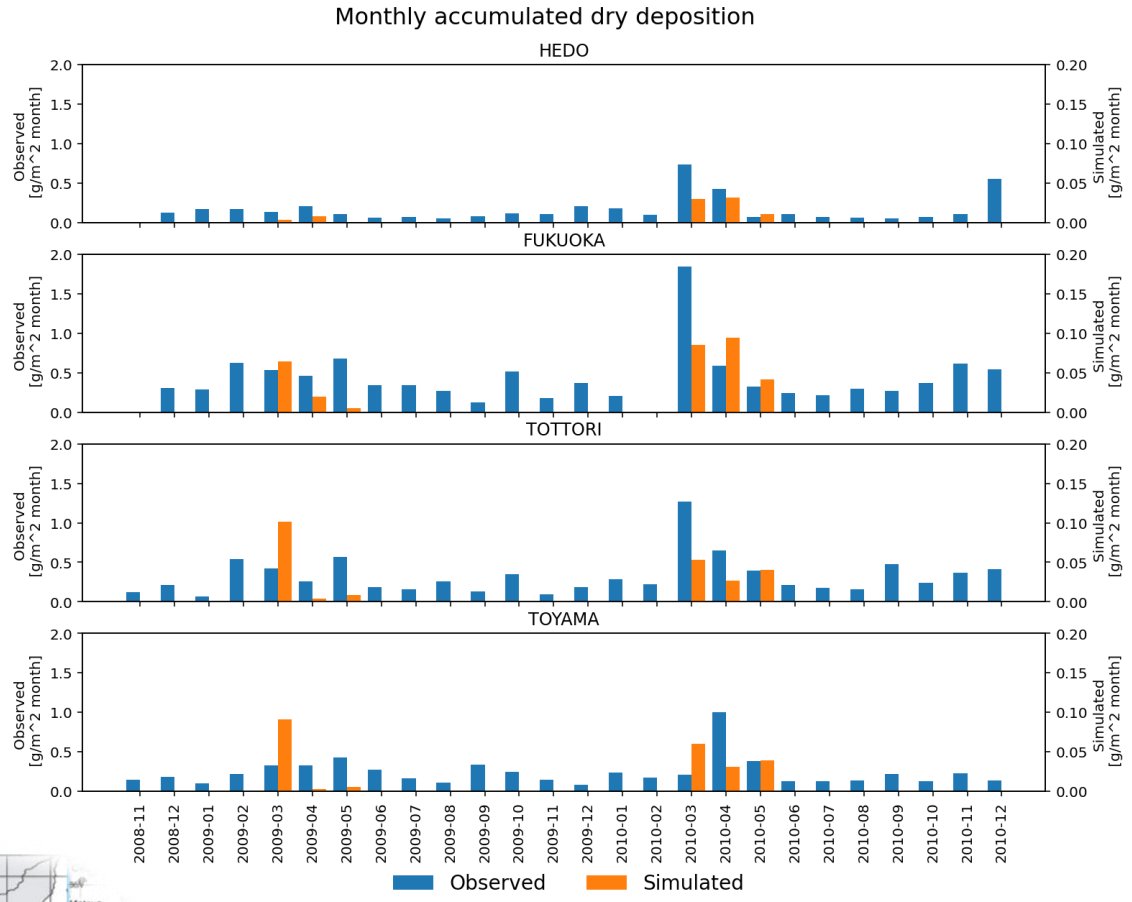
Schaetzl *et al.* 2018

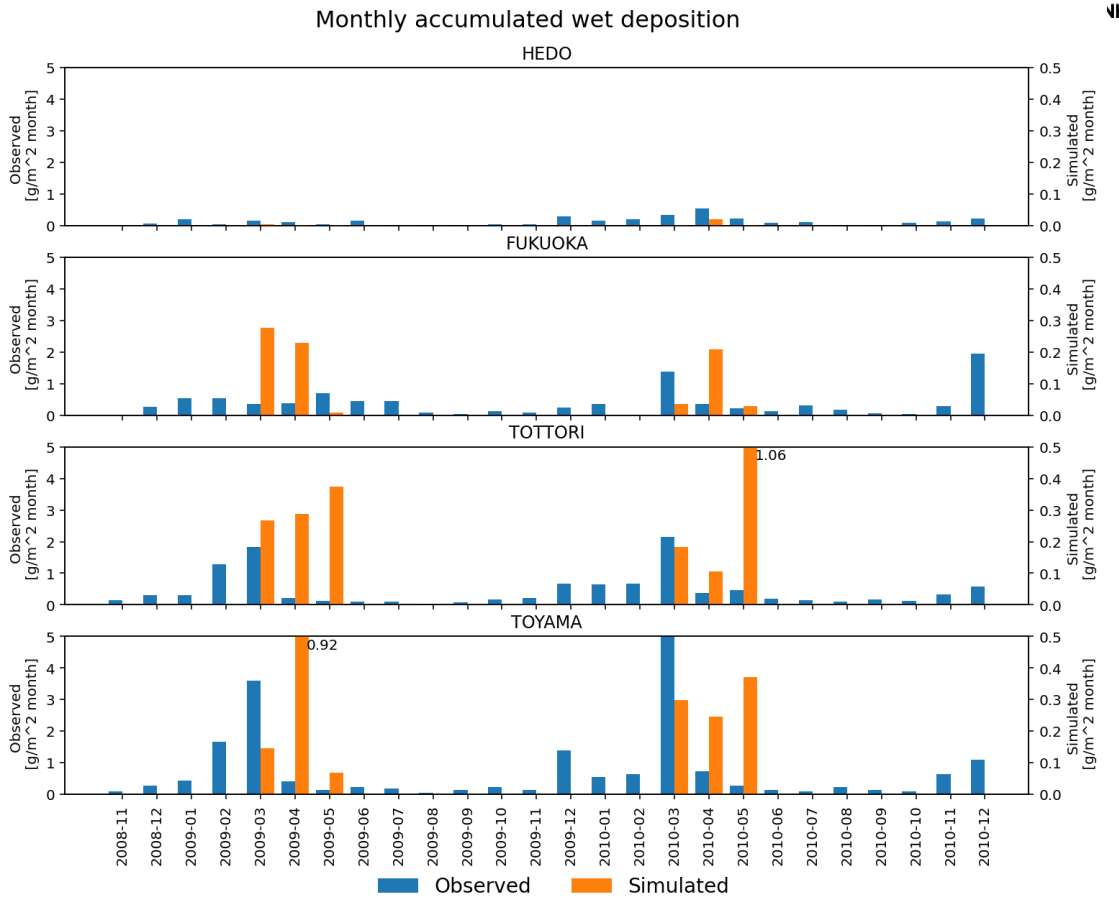
Photo: Anu Kaakinen

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FLEXPART reproduce spatial and interannual variation in observation







Observational deposition dataset : Osada et al. 2014 https://doi.org/10.5194/acp-14-1107-2014

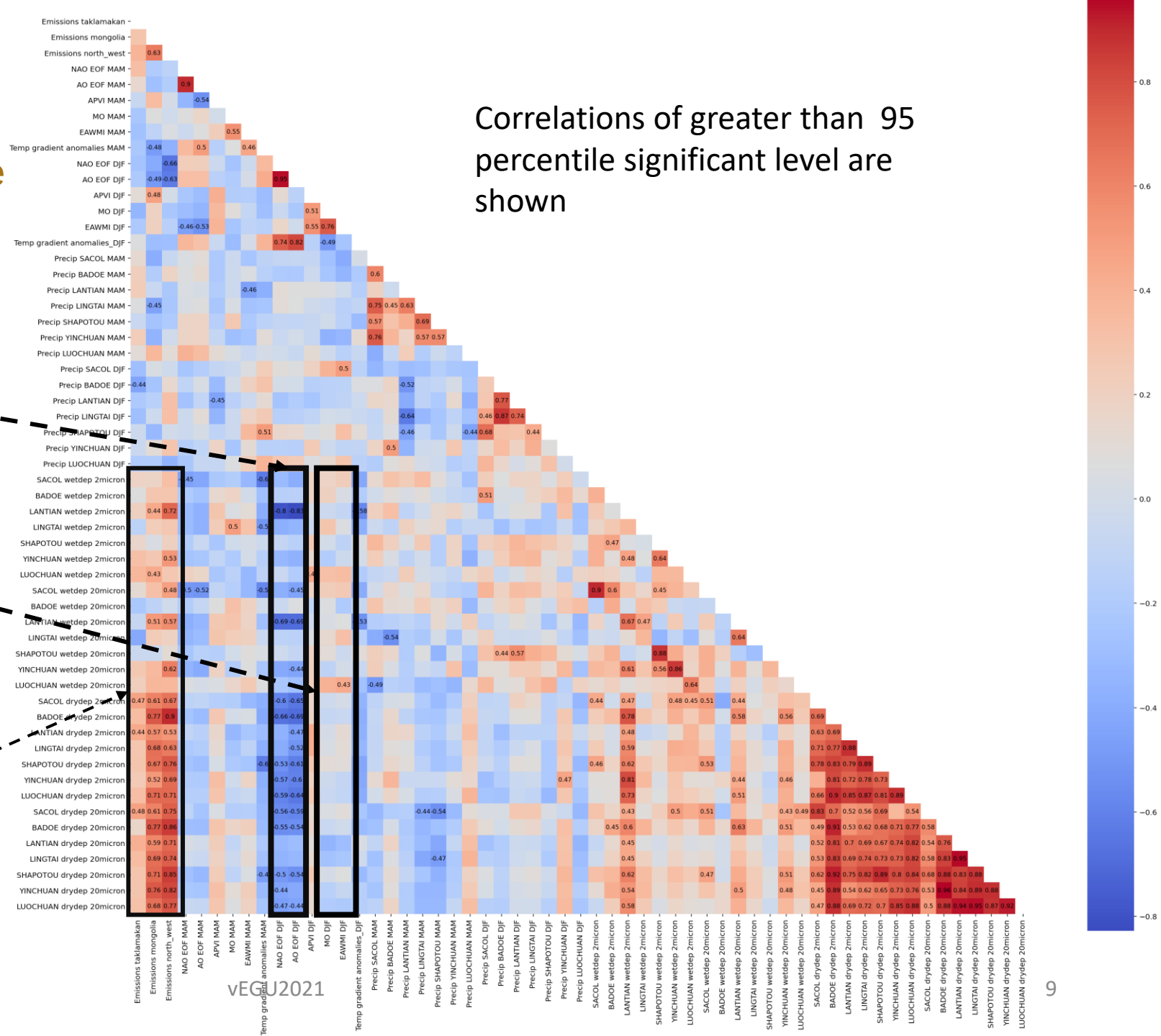
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Inter annual correlations among deposition at each site and local and large-scale climate indices

Dust deposition show strong correlation with winter AO, NAO.

… but spring dust deposition not related to winter monsoon.

No correlation between dust emissions and wet deposition, suggest that wet deposition is primarily due to single events.



Correlations of greater than 95 percentile significant level are shown

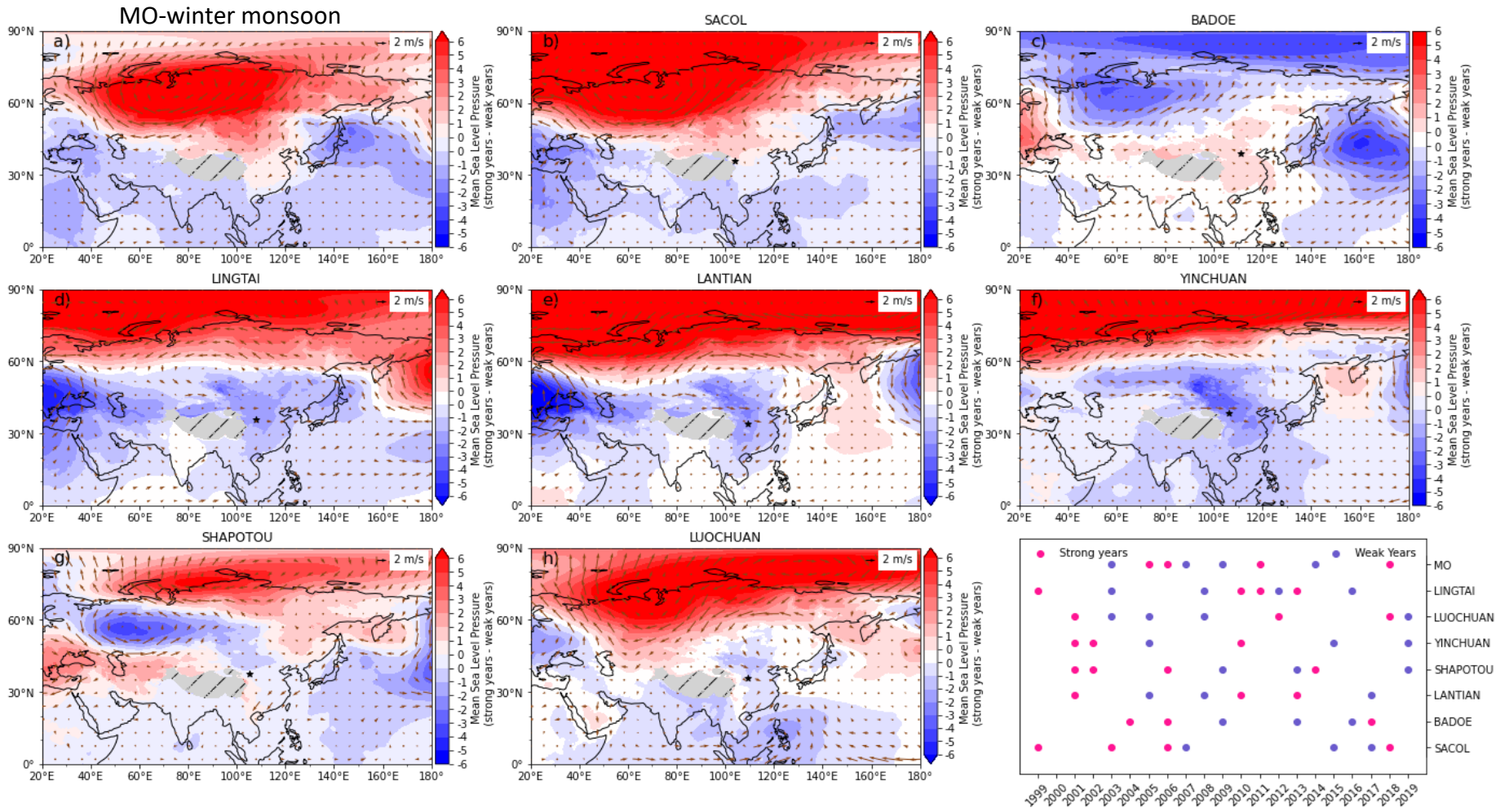
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Negative AO circulation anomalies generally correpsond to high deposition years

Prominent negative AO pattern MSLP anomaly pattern for most sites except Badoe, which seems to be more influenced by the pressure changes over the ocean.

DJF 850 hPa winds and MSLP composite of total depostion fine silt



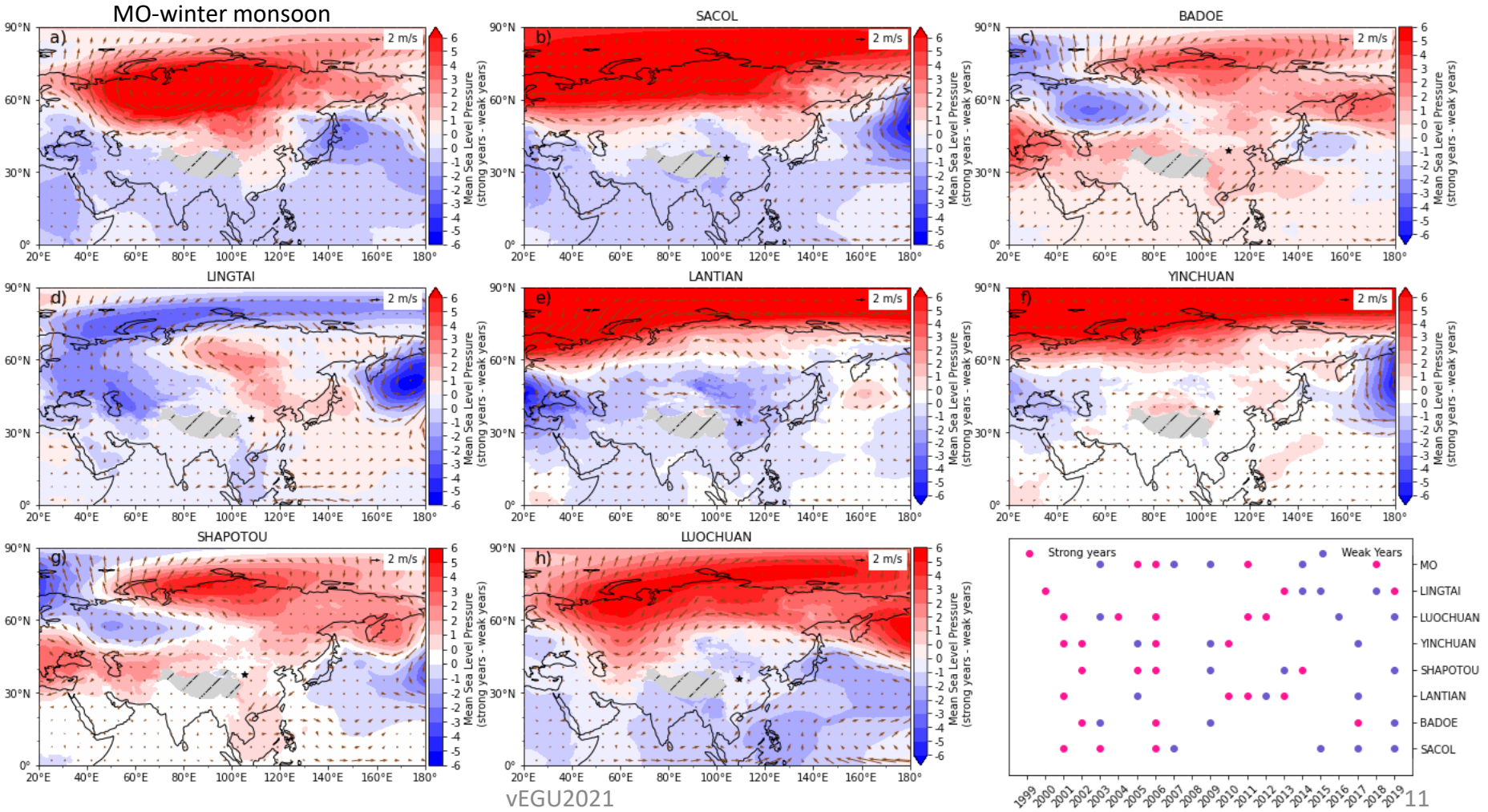
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Most sites does not show different circulation composite between coarse and fine particles.

Badoe and Lingtai are exceptions.

DJF 850 hPa winds and MSLP composite total depostion coarse silt

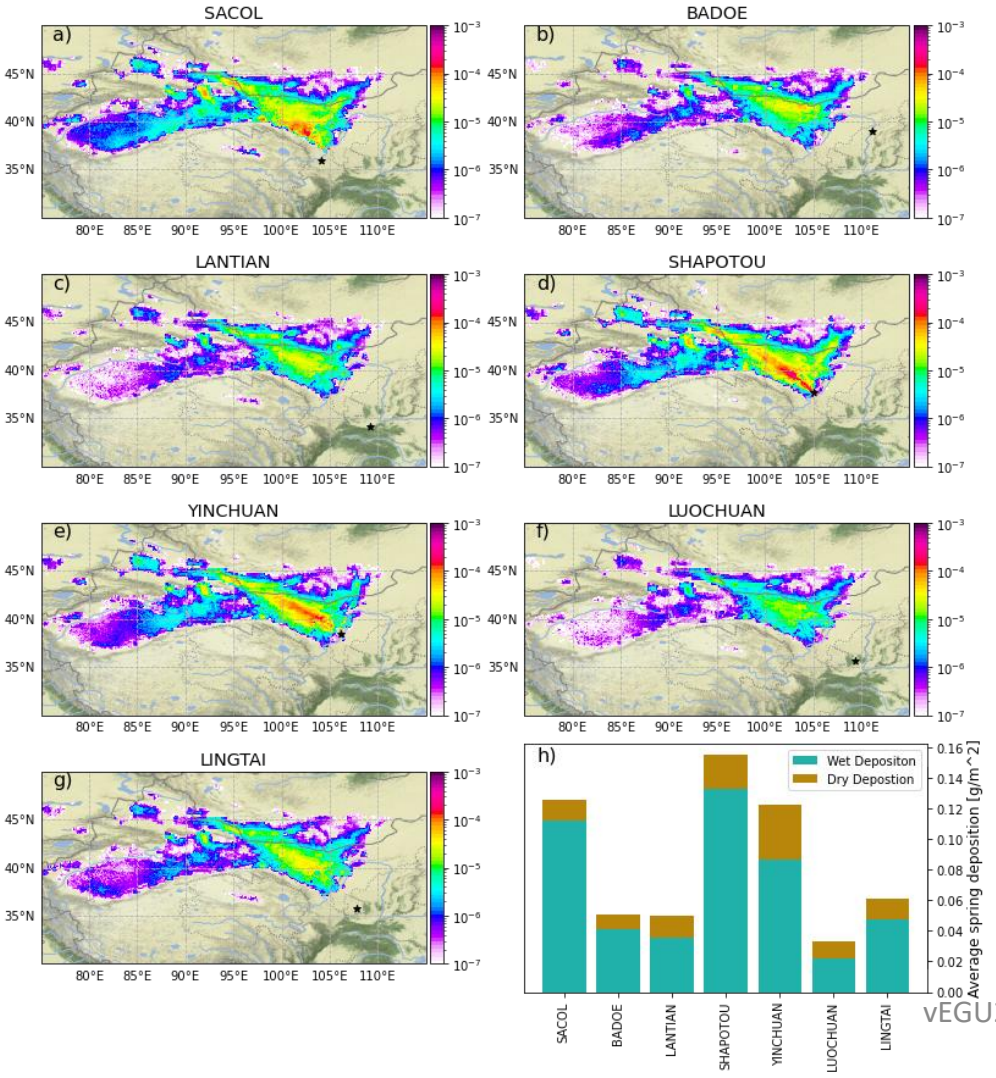


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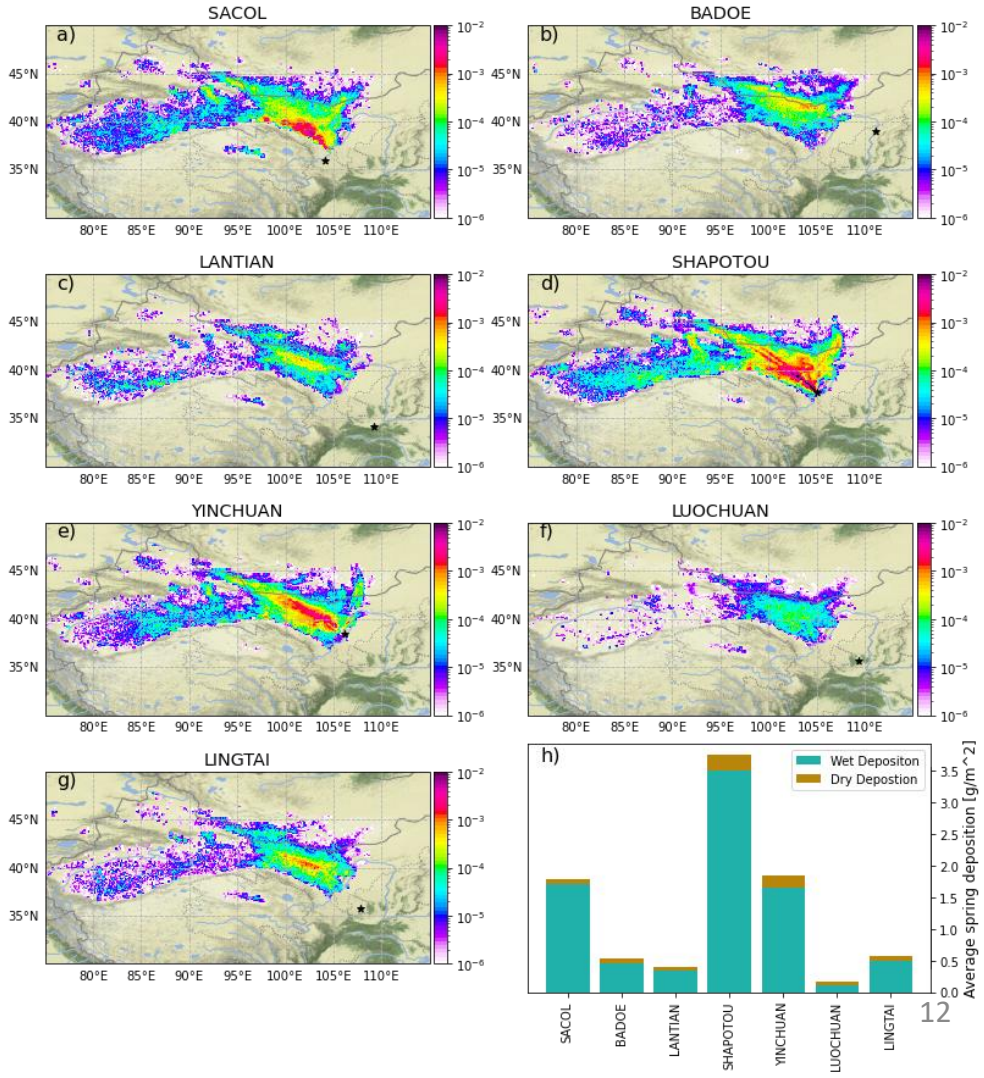
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Mongolia and Northwest CLP have the largest contribution to total deposition for all the loess sites

Total deposition Fine silt



Total deposition Coarse silt



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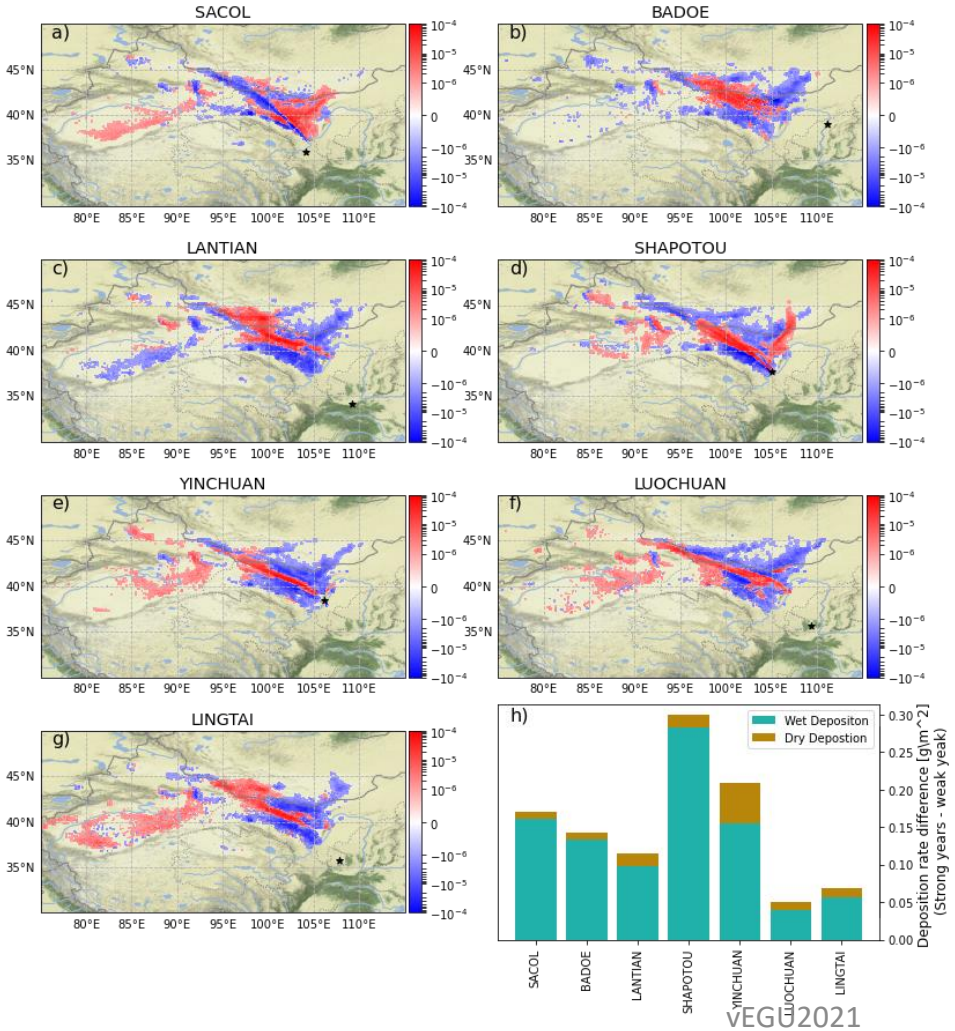
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Strong deposition years have a more concentrated source contribution.

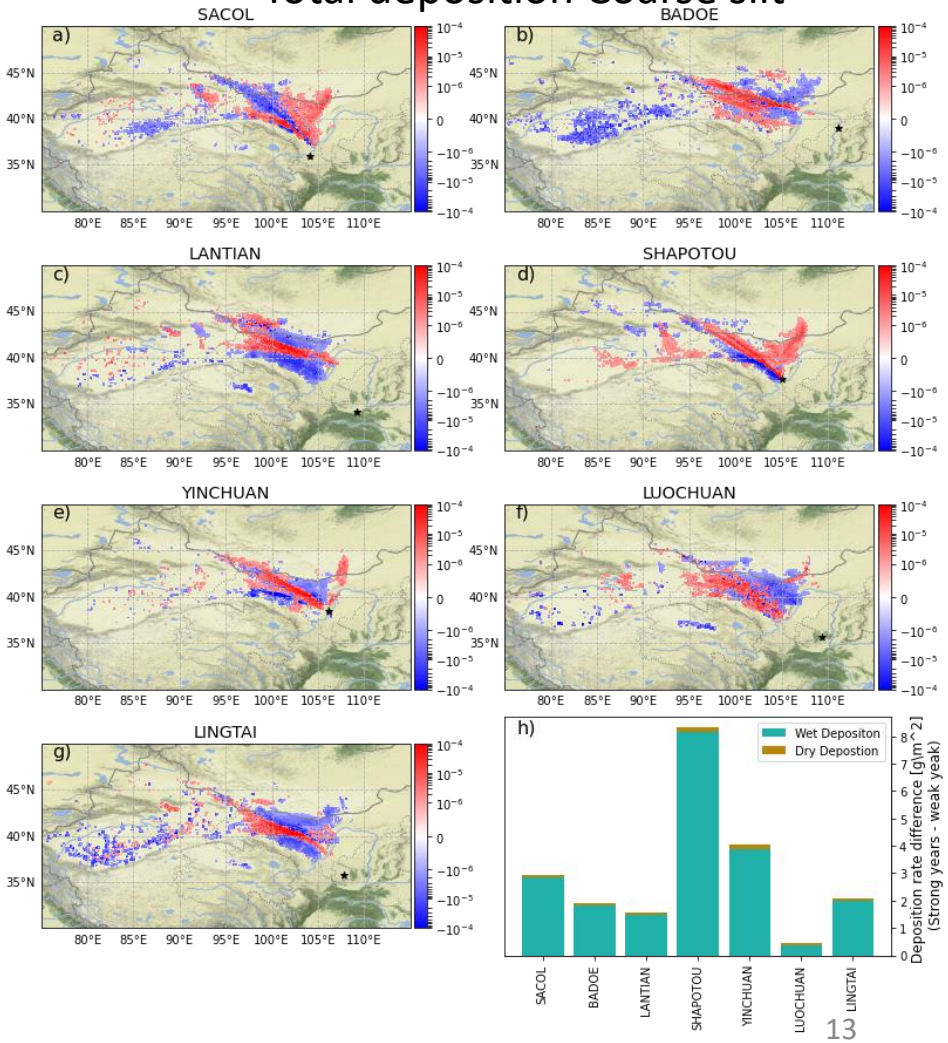
Concentrated source contribution in strong deposition years, suggest large contribution from single dust events.

Normalized source contribution strong – weak deposition years.

Total deposition Fine silt



Total deposition Coarse silt



Conclusion

- FLEXPART/FLEXDUST can reasonably reproduce the spatial and interannual variation in dust deposition when compared with observation.
- The 7 Loess sites show spatial difference in their source contribution, western sites have a stronger contribution from Taklamakan.
- Strong deposition year have a more concentrated source contribution, compared to weak deposition years. Suggesting large contribution from single dust events.
- The spring dust deposition at all the 7 site correlates well with the winter AO/NAO, but not winter monsoon indices.
- The possible mechanisms linking negative winter AO and dust deposition: negative AO favours intense cold surges intruding into East Asia [Yang et al. 2020] , which can be further amplified due to increased snow and cloud cover over central Siberia during negative AO winters [Liu et al. 2018].
- Further research remains to pinpoint the exact mechanisms linking winter AO to dust deposition over the CLP.

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