Prediction skill of Asian Dust Generation in hindcast data of Asian Dust Seasonal Forecasting Model (GloSea5-ADAM)

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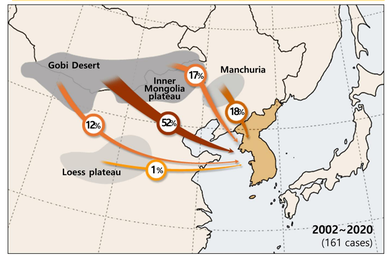
Introduction

- Asian dust in South Korea is mainly affected by Spring, and the main source regions of Asian dust the Gobi Desert, the Inner Mongolia plateau, and Manchuria.
- To forecast Asian dust for the Spring of South Korea, the Korea Meteorological Administration (KMA) has operated GloSea5-ADAM, the Asian dust seasonal forecasting model.
- This study investigated the prediction skill of the Asian dust seasonal forecasting model (GloSea5-ADAM) on the Asian dust and meteorological variables (10 m wind speed, 1.5 m air temperature, and relative humidity) related to the dust generation for the period of 1991~2016.
- Additionally, we evaluated the prediction skill of those variables depending on the combination of the initial dates in the sub-seasonal scale for the dust source region affecting South Korea.

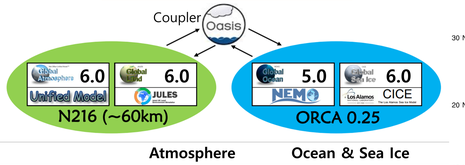
Asian dust source regions and transport route affecting South Korea



GloSea5-ADAM

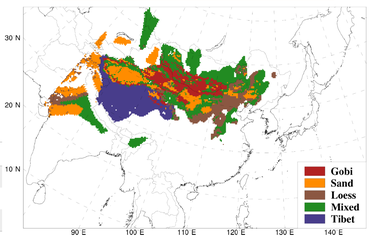
- GloSea5-ADAM was developed by incorporating soil type in the Asian dust source region and the dust generation algorithm of the Asian Dust and Aerosol Model (ADAM) into the Global Seasonal Forecasting System version 5 (GloSea5) (Park et al., 2010; Ryoo et al., 2020).
- GloSea5 is the 5th version of the UK Met Office ensemble prediction system for monthly to seasonal forecasts operated by KMA and is a fully coupled model (Atmosphere-Land-Ocean-Sea Ice).
- Soil types of source region in ADAM3 are divided into 5 types (Gobi, Sand, Loess, Mixed and Tibet).

Information of GloSea5



	Atmosphere	Ocean & Sea Ice
Model version	UM8.6, JULES4.7	NEMO3.4, CICE4.1
Horizontal resolution	N216(0.83°x0.56°)	ORCA tri-polar grid at 0.25°
Vertical resolution	85 levels (~85km)	75 levels

Soil type in GloSea5-ADAM



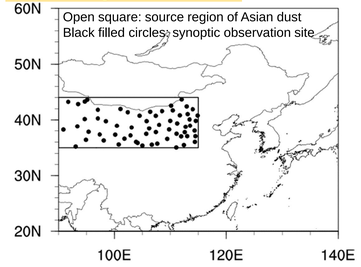
- Dust generation algorithm in GloSea5-ADAM

$$H_{ADAM3} = \sum_{i=1}^{n} (1 - f_i R_i) \times \alpha \times u_*^4 \quad if\ U_{10} \geq U_{10t}\ and\ RH_{1.5} \leq RH_{1.5t}$$

U_{10}: 10 m wind speed
U_{10t}: Threshold for U_{10}
$RH_{1.5}$: 1.5 m relative humidity
$RH_{1.5t}$: Threshold for $RH_{1.5}$

Study area & data

Analysis area



Hindcast and observation data

Hindcast of GloSea6-ADAM	
Term	1991 ~ 2016 (26yr)
Initial time	00UTC on 1st , 9th , 17th , 25th
Forecast time	Forecast time : 255days
Ensemble member	3 members
Variables	10 m wind speed, 1.5 m air temperature & relative humidity, PM_{10} concentration
Observation	
Meteorological data	ECMWF ERA5
Asian dust	Synoptic observation (#6-9, 30-35, 98)

Evaluation criteria

- The Asian dust and meteorological variables from GloSea5-ADAM were compared to that from Synoptic observation and ECMWF ERA5, respectively.
- The mean bias error (MBE), root-mean-square error (RMSE), and anomaly correlation coefficient (ACC) were used as evaluation criteria.

$$MBE = \frac{1}{n}\sum_{i=1}^{n}(F_i - O_i)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(F_i - O_i)^2}$$

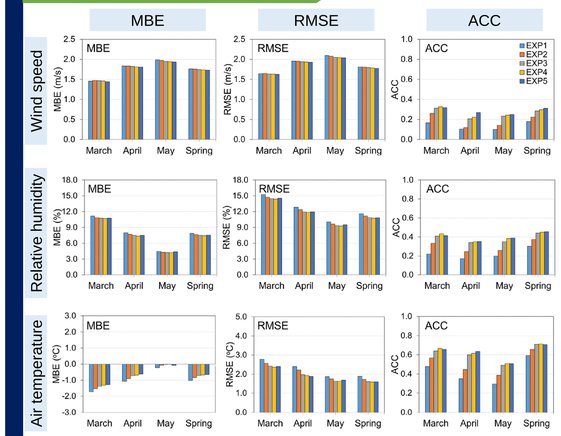
$$ACC = \frac{\frac{1}{n}\sum_{i=1}^{n}(F_i - \bar{F}) \times (O_i - \bar{O})}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(F_i - \bar{F})^2} \times \sqrt{\frac{1}{n}\sum_{i=1}^{n}(O_i - \bar{O})^2}}$$

Experimental designs

	Initial date for		
	March	April	May
EXP1	02/01, 02/09, 02/17	03/01, 03/09, 03/17	04/01, 04/09, 04/17
EXP2	02/09, 02/17, 02/25	03/09, 03/17, 03/25	04/09, 04/17, 04/25
EXP3	02/17, 02/25, 03/01	03/17, 03/25, 04/01	04/17, 04/25, 05/01
EXP4	02/25, 03/01	03/25, 04/01	04/25, 05/01
EXP5	03/01	04/01	05/01

Result & Summary

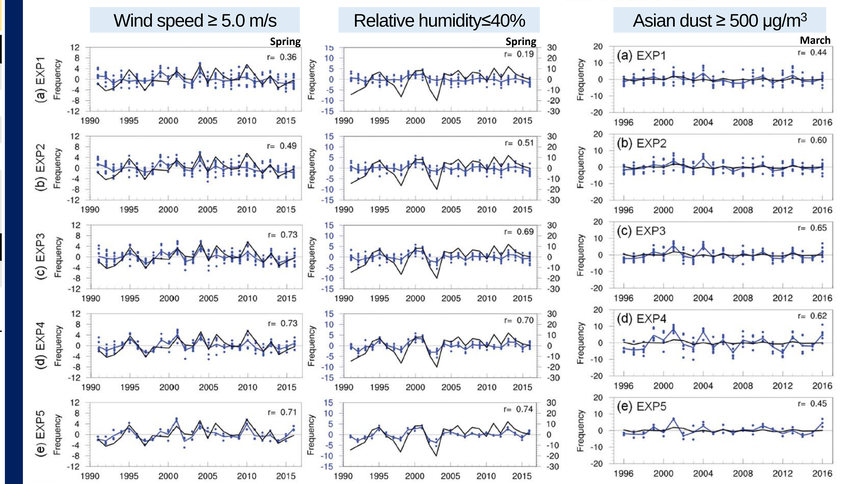
Evaluation of meteorological variables



- For all variables, the use of the initial dates closest to the prediction month (EXP1→EXP3) led to the best performances based on MBE, RMSE, and ACC.
- The performances could be improved by adjusting the number of ensembles considering the combination of the initial date (EXP3~EXP5).

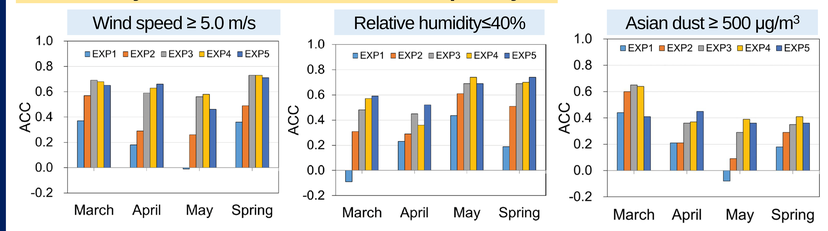
Frequency anomalies

Blue filled circles: GloSea5 ensemble members
Blue line: GloSea5 ensemble mean
Black line: ERA5 mean



- The good performances showed when the use of the initial dates closest to the prediction month (EXP1→EXP3) based on ACC of frequency. The difference in the correlation coefficient by the number of initial date (EXP3~EXP5) was similar.
- The best performance of Asian dust generation with an correlation of 0.65 in the occurrence frequency of Asian dust in March when using the closest initial dates for initial conditions.

Anomaly correlation coefficient of frequency



- In case of Asian dust, ACC in Spring was as high as 0.4 when using the closest two initial dates (EXP4).
- The Asian dust and meteorological variables in the source region showed high ACC in the prediction scale within one month.

Reference

- Park, S.-U., A. Choe, E.-H. Lee, M.-S. Park, and X. Song, 2010: The Asian dust aerosol model 2 (ADAM2) with the use of normalized difference vegetation index (NDVI) obtained from the Spot4/vegetation data. Theor. Appl. Climatol., 101, 191-208, doi:10.1007/s00704-009-0244-4.
- Ryoo, S.-B., Y.-K. Lim, and Y.-S. Park, 2020: Seasonal Asian Dust Forecasting Using GloSea5-ADAM. Atmosphere, 11, 526, doi:10.3390/atmos11050526.

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