HY HJ-1AB CBERS Gaofen Beijing-2 Sentinel-1 Sentinel-2 Sentinel-3 Sentinel-5p Aeolus

2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

[PROJECT ID. 59013]

EMPAC

(Exploitation of satellite remote sensing to improve our understanding of the Mechanisms and Processes affecting Air quality in China)

18 OCTOBER 2022, 8:30AM - 10:00AM CEST

ID. 59013

PROJECT TITLE: EMPAC

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CO-AUTHORS: Sarah Safieddinne (LATMOS), Yong Xue (Univ. Derby), Costas Varotsos (Univ. Athens), Gerrit de Leeuw (KNMI), Yan Yin (NUIST), XingYing Zhang (NSMC), Kai Qin (CUMT), Zhengqiang Li (AIR-CAS), Jianping Guo (CAMS)

PRESENTED BY: Ronald van der A

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. OMI	
2. HIMAWARI	
3. MODIS (TERRA&AQUA)	
4. METOP	
5.	
6.	
Total:	
Issues:	

ESA Missions	No. Scenes
1. Sentinel 3 SLTSR	
2. Sentinel-5P TROPOMI	
3. Sentinel 5	
4. AEOLUS	
5.	
6.	
Total:	
Issues:	

Chinese EO data	No. Scenes
1. FY-3C MERSI	
2. FY-3A/B/C TOU	
3.	
4.	
5.	
6.	
Total:	
Issues:	

Project's objectives:

- Exploitation of satellite remote sensing to improve our understanding of the Mechanisms and Processes affecting Air quality in China

Results after 2 years of activity:

- CO changes due to COVID regulations
- Mechanisms for changes in O_3 concentration in a subtropical coniferous forest
- Trace gas removal in ice particles and solid particles
- NOx emissions derived from TROPOMI (S5p)
- Meteorological and anthropogenic induced changes in the AOD

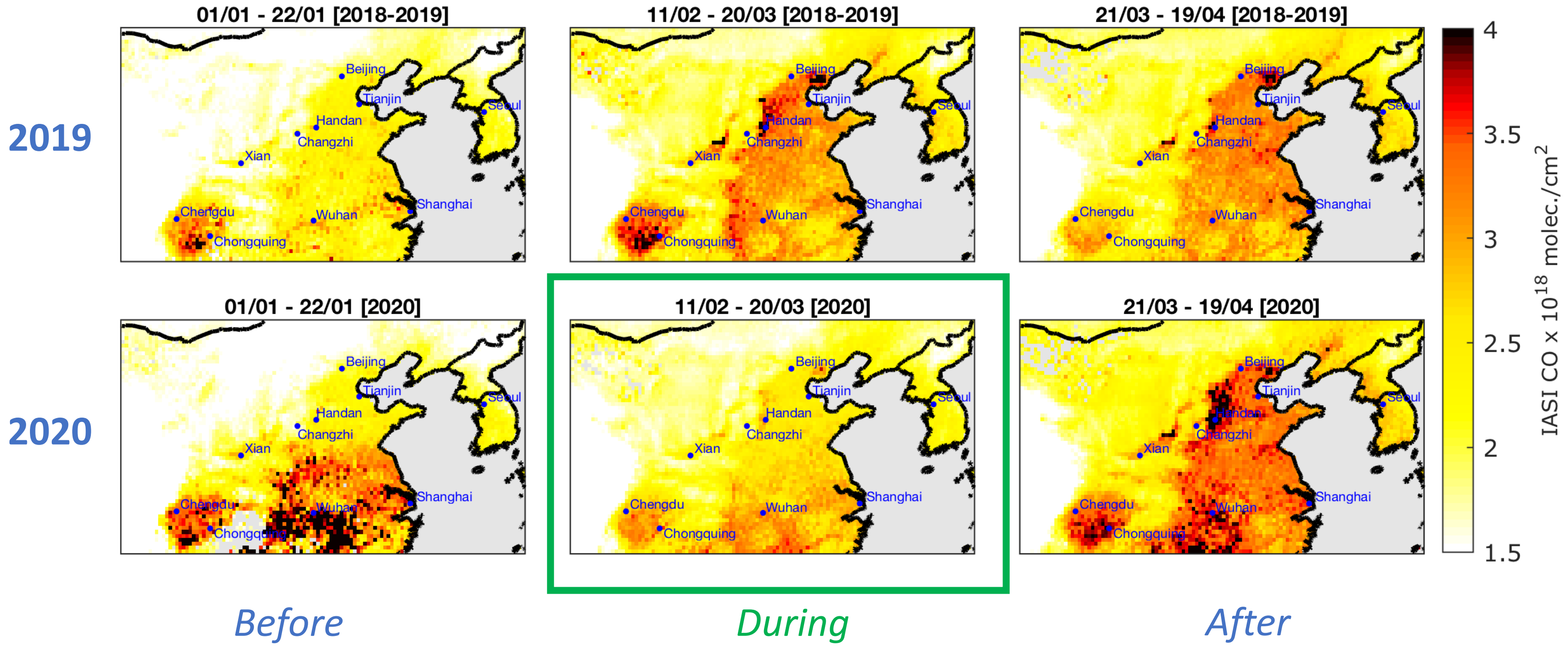
Young scientist results:

- Drone observations of NO2 in the boundary layer.
- Ship emissions on inland rivers
- Arctic lightning NOx

Anthropogenic air pollution reduction during 2020 lockdown

IASI remote sensing observations

Carbon monoxide - China



https://iasi-ft.eu/covid-19/europe-air-pollution/

Relationships/mechanisms between O_3 and its influencing factors

- **Empirical model of O_3 concentration in a subtropical coniferous forest**

$$e^{-0.1k_3O_3tm}\times\cos(Z) = A_1PAR + A_2e^{-a_1ISOm}\times\cos(Z) + A_3\,e^{-kWm}\times\cos(Z) + A_4\,e^{-S/Q} + A_0$$

- **The ratio of diffuse and global radiation (S/Q) is an important indicator of interaction between solar radiation and atmospheric composition**.
- The atmospheric substances (**GLPs** controlling **S/Q**) determine the turning points for O_3, BVOCs, particles, and also for meteorological factors, air temperature (T), relative humidity (RH), water vapor (E).
- Solar radiation (PAR) is a vital energy source **controlling the changes of atmospheric constituents and atmospheric states**

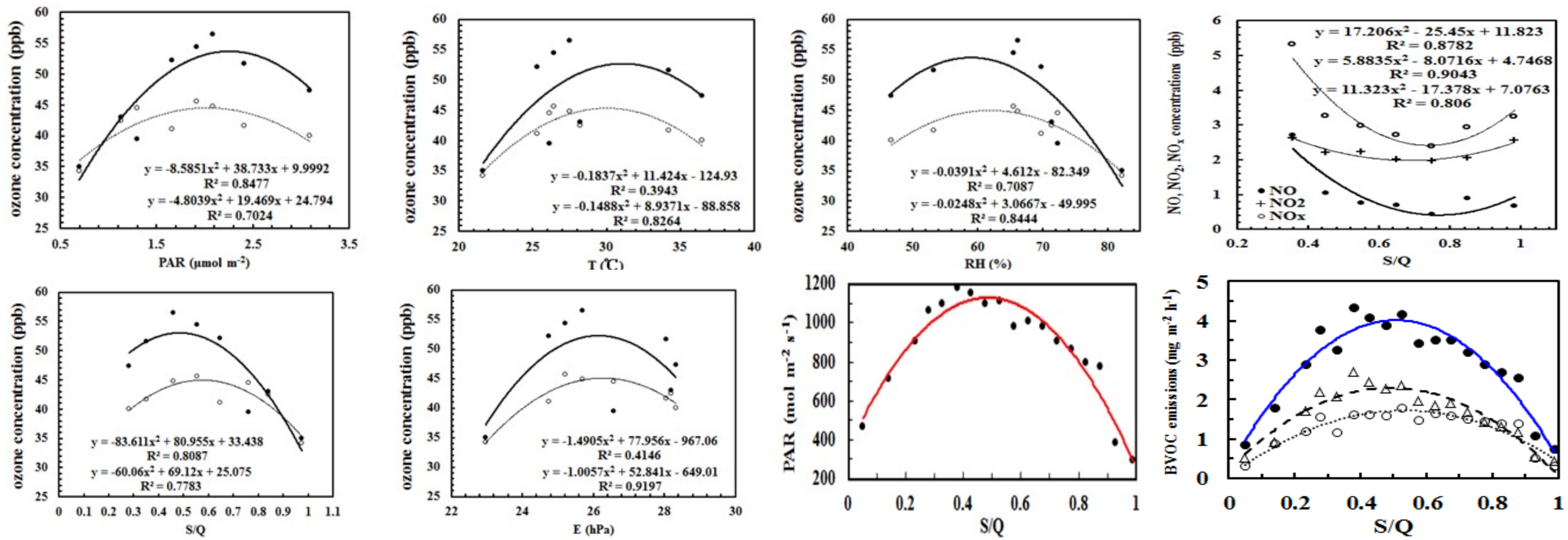


Fig. The relationships between O_3 concentration and its influencing factors (left), as well as between PAR and S/Q (middle), NO, NO_2, NOx and S/Q (up right), and BVOC emissions and S/Q (bottom right).

S, Q: diffuse and global radiation. (Bai, 2021, Atmosphere; Bai, 2021, Ecology and Environmental Sciences)

On the tropospheric gases removal due to their diffusion in ice particles

Costas VAROTSOS* and Yong XUE**

*Department of Environmental Physics and Meteorology, National and Kapodistrian University of Athens, Athens 15784 Greece

**School of Environment Science and Spatial Informatics, University of Mining and Technology, Xuzhou, Jiangsu 221116, PR China

When in a solid a single diffusion mechanism is operative, the diffusion coefficient, D, is often found to obey an Arrhenius type behaviour, i.e $D = D_o \exp[-E/(k_B T)]$

Summary of rate parameters for the diffusion coefficients of selected compounds in ice.

	E(kcal/mol)	D_o (cm²/s)	D(180 K) (cm²/s)	T(K) Ref.
HCl	15.3±1.0	$1.5\times10^{7\pm0.2}$	4.83×10^{-12}	169.0–194.9; Livingston et al., 2001
HCOOH	21.8±0.9	$8\times10^{14\pm0.1}$	2.42×10^{-12}	175.1-194.9; Livingston et al., 2002
CH_3COOH	17.0±0.7	$1.0\times10^{10\pm0.1}$	2.08×10^{-11}	169.9–194.9; Livingston et al., 2002
	13.14±3.0	$0.813\times10^{6\pm3.2}$	8.6×10^{-11}	198–213; Nehme, 2006
CH_3OH	15.2±0.7	$2.4\times10^{7\pm0.3}$	7.8×10^{-12}	169.4-185.4; Livingston et al.,2002

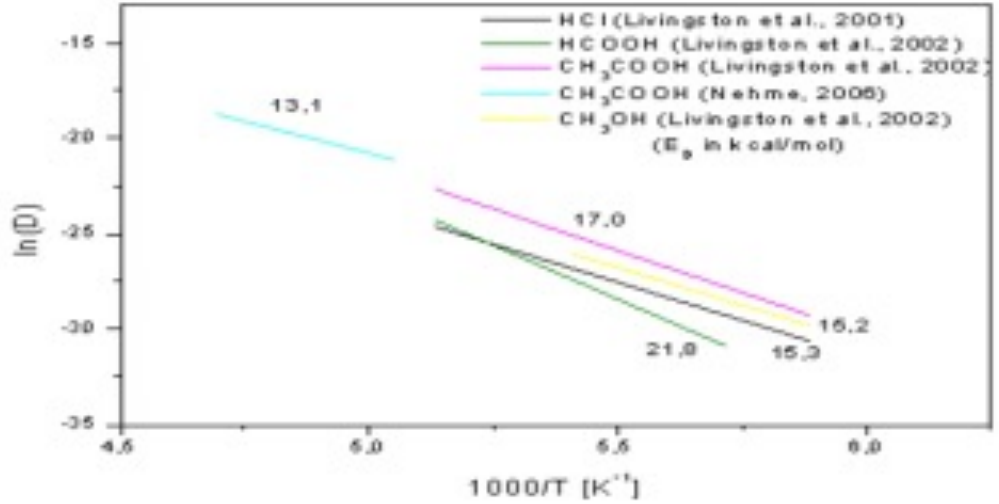


Fig. 1. Arrhenius plots for temperature dependent diffusion coefficients for various species in ice as obtained by the LRD depth-profiling technique (Livingston et al., 2001, 2002) and chemical titration (Nehme, 2006). The figures on the individual lines are activation energies (in kcal/mol) as derived by the authors.

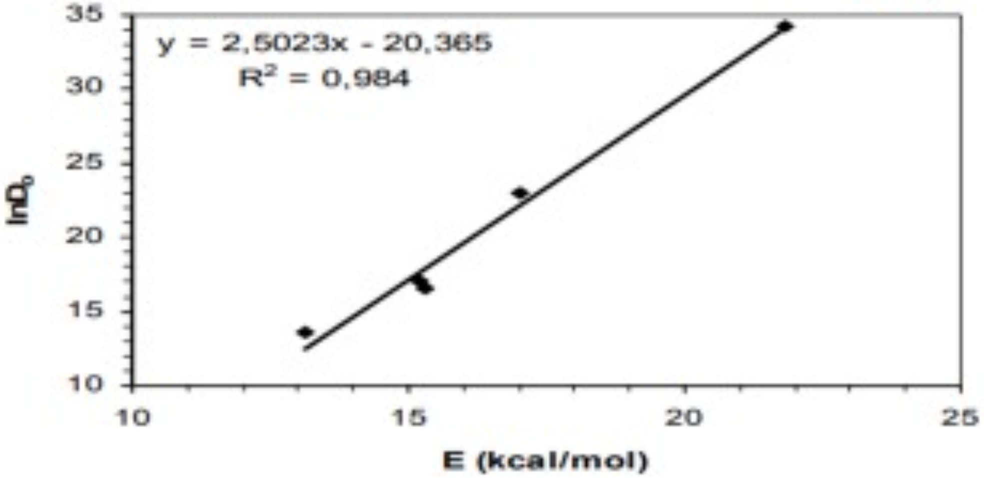


Fig. 2. Relationship between the pre-exponential factor D_o of the diffusion coefficient and the activation energy E.

CONCLUSIONS

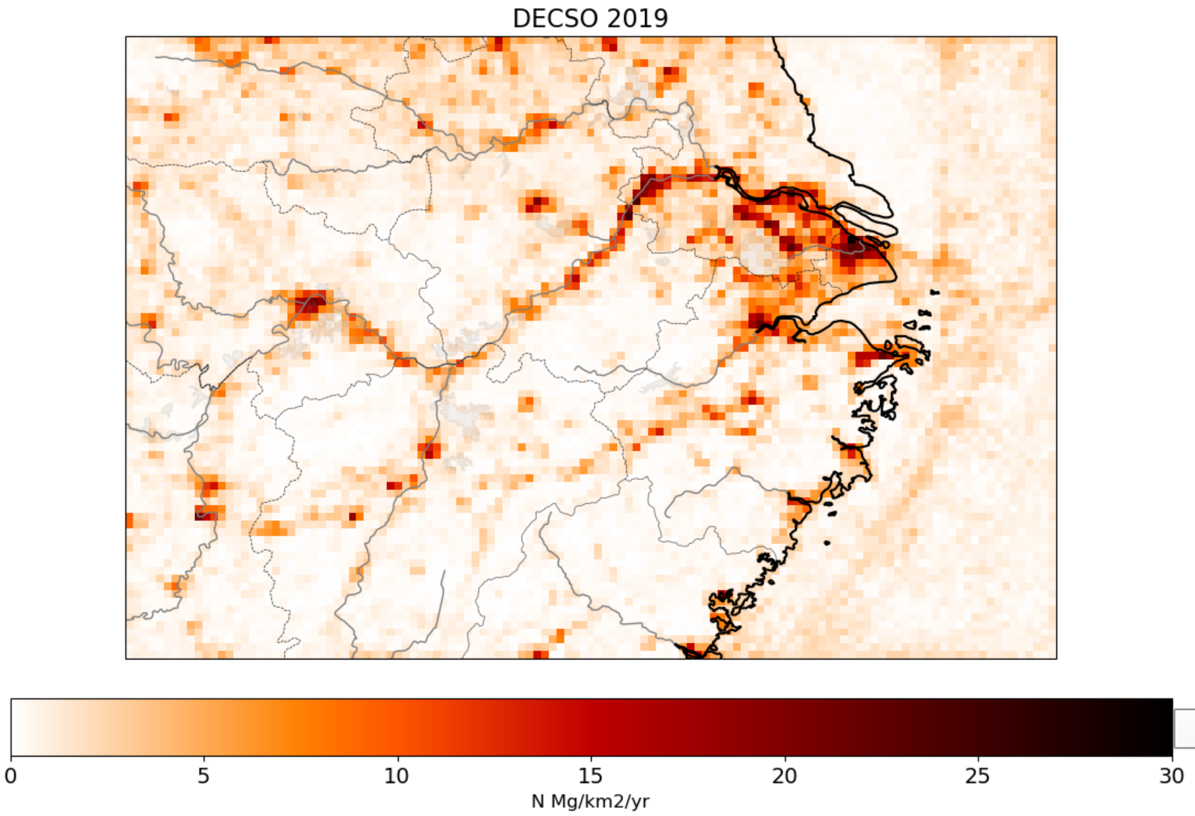
From Figures 1 an2 it is argued that the diffusion in ice of these compounds is governed by a vacancy – mediated mechanism, i.e., H2O vacancies are required to diffuse to lattice sites adjacent to these compounds prior to the diffusion of the corresponding molecule into the vacancy sites. In addition, we show that the diffusion coefficients of these compounds exhibit a specific interconnection, i.e., a linear relationship holds between the logarithm of the pre-exponential factor, *Do*, and the activation energy *E*. Based on this conclusion we also calculated the tropospheric O3 removal due to its diffusion in solid particles (e.g., dust and black carbon particles or in cirrus clouds).

NOx emissions using TROPOMI

DECSO version 6.1 using superobservations based on the TROPOMI NO2 retrieval v.2 (PAL data set) and the latest version of CHIMERE (version 2020r3).

Spatial resolution: 10 km

Temporal resolution: daily

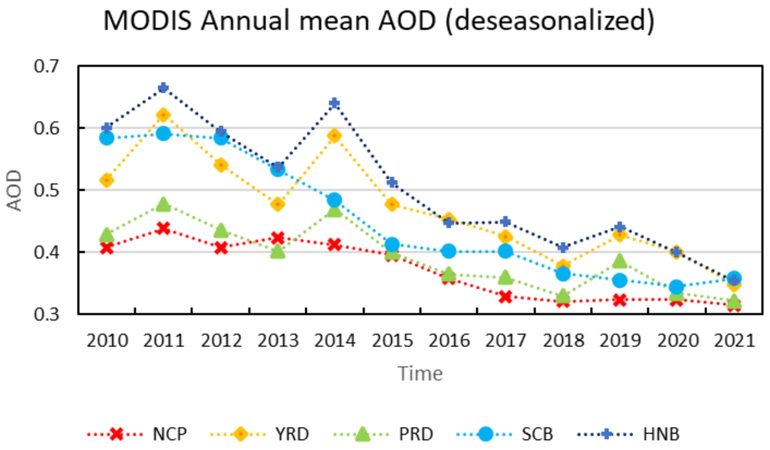


For ship emissions from the Yangtze river: see poster (ID 163) of Xiumei Zhang

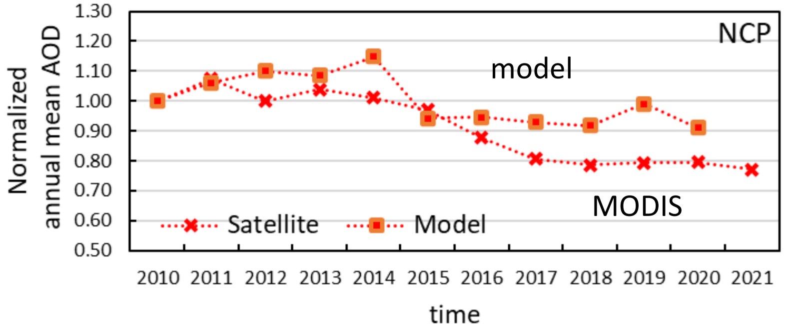
Meteorological and anthropogenic induced changes in the AOD over China

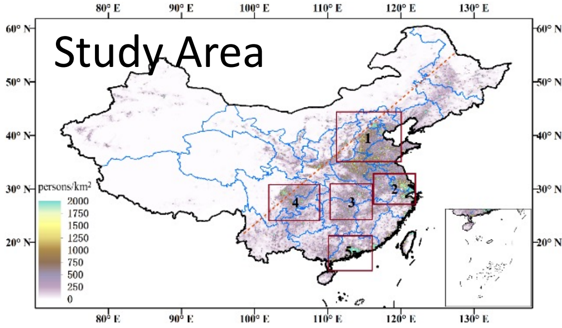
Gerrit de Leeuw, Hanqing Kang, Cheng Fan, Zhengqiang Li, Chenwei Fang, Ying Zhang

Satellite data show the **decline of AOD** over China during the last decade. Time series over **5 selected study areas** (see map) also the **flattening** after 2018 (de Leeuw et al. ,2018)

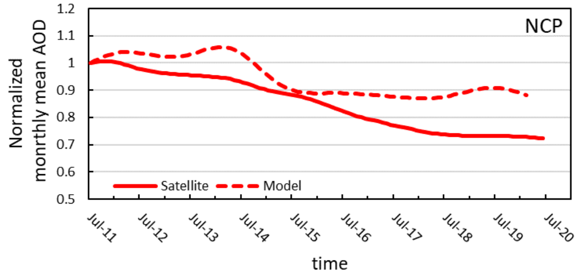


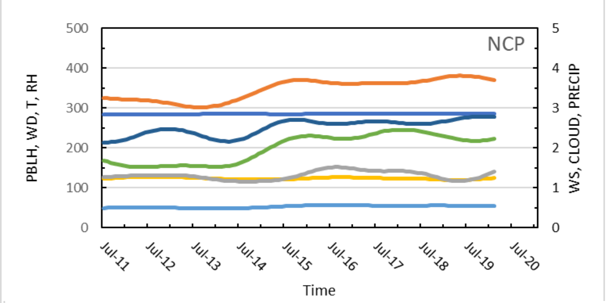
To **discriminate between anthropogenic contributions** (emission reduction policies and clean air actions) and natural influences, the satellite data were compared with **model simulations** using the Community Earth System Model (CESM). In these simulations, the runs were made with **actual meteorological data** while **emissions were fixed** to those in 2010. Hence, modeled AOD variations are due to **meteorological influences**, the difference between observed and modeled variations are due to **anthropogenic influences** (Kang et al, 2019).

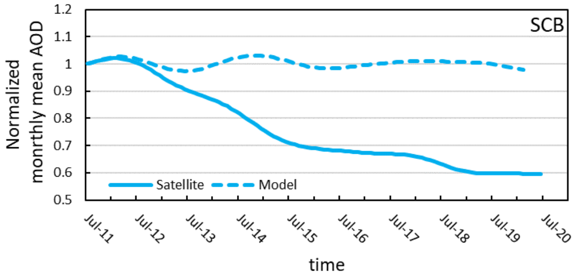


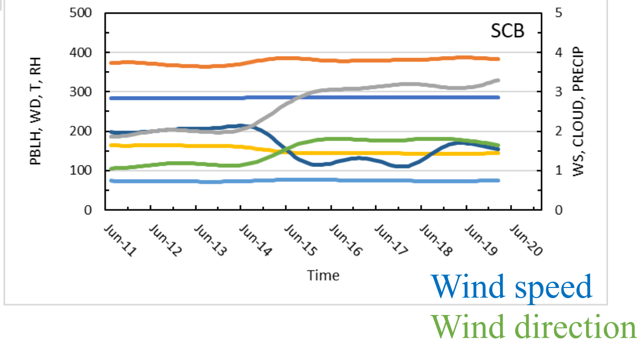


Results: after **normalization** and application of a **low-pass filter** to remove short-term fluctuations such as seasonal influences, the **meteorological and anthropogenic influences have been determined**. Results over NCP and SCB are shown as examples, together with meteorological data.









Conclusions:

- Strong differences between the five regions
- Substantial changes in meteorological contributions around 2014/2015, with remarkable changes in both wind speed and wind direction
- Complete results in de Leeuw et al. (2022), submitted

References:

de Leeuw et al. (2018) https://doi.org/10.1016/j.apr.2022.101359.
Kang et al. (2019) https://doi.org/10.1016/j.atmosres.2018.09.012

Young scientists

Europe

- Mirjam den Hoed (KNMI). Travelling to China is currently complicated, therefore no new campaign has been joined. She is currently analysing data from an earlier (pre-covid) campaign, which she participated.

China

- Xin Zhang (NUIST): he has stayed at KNMI from October 2021 – September 2022 to use TROPOMI observations to study Arctic source, in particular lightning.
- Xiumei Zhang (NUIST): she is currently visiting KNMI for one year, to study ship emissions in the Yangtze River Delta and in the Rotterdam region using AIS and satellite data

Chinese Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
Xin Zhang	NUIST, Nanjing	Lightning NO_2 in the Arctic	Poster ID 165
Xiumei Zhang	NUIST, Nanjing	The Impact Of Inland Ship Emissions On Air Quality	Poster ID 163

European Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
Mirjam den Hoed	KNMI, The Netherlands	Measurement Of Vertical In-situ Nitrogen Dioxide Profiles Near Nanjing Using a Quadcopter	Poster ID 188

Unique drone measurements of NO_2

KNMI has developed a lightweight, accurate NO_2-sensor that was deployed on a quadcopter near Nanjing to measure vertical in-situ nitrogen dioxide profiles.

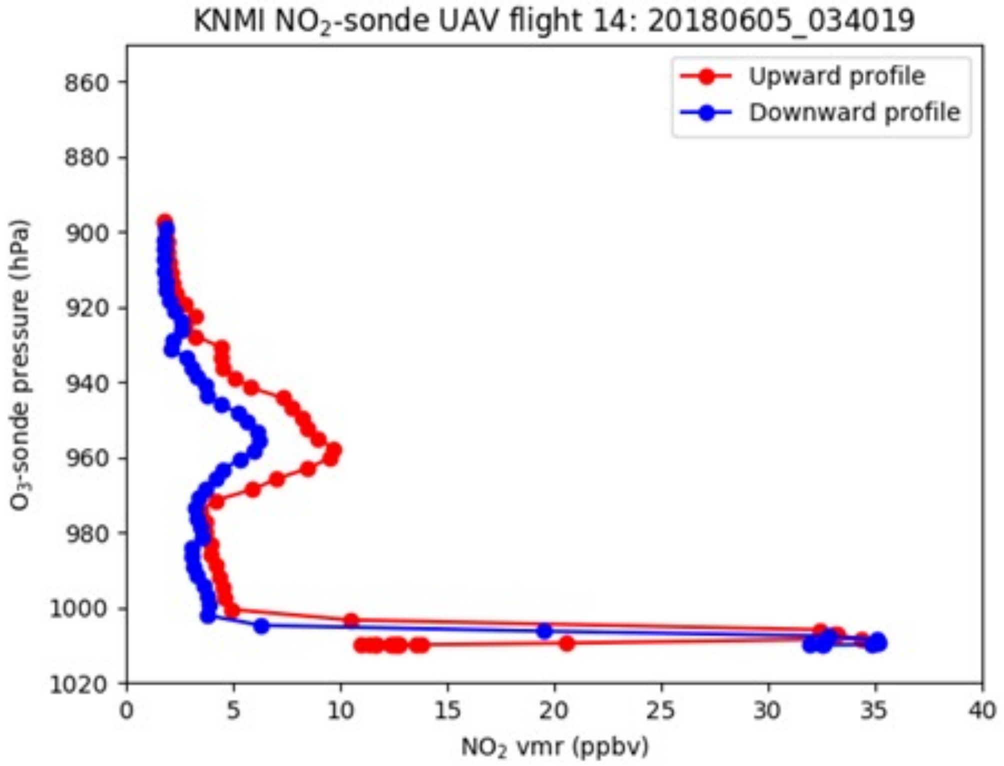
Summary of KNMI NO2-sonde activities:

- 1-14 June 2018
- 13 days of measurements
- 6 flights / day
    - morning: 8 AM; afternoon: 12 & 4 PM;
      evening: 8 PM and night: 12 & 4 AM
- ~ 50 NO_2 vertical profiles within PBL (900-1300m)
- 2 side-by-side inter comparisons
  with NO_2 monitor at NUIST
- Ancillary bicycle and ground measurements

Authors: Mirjam M. Y. den Hoed, Ronald van der A, Gerrit de Leeuw, Hanqing Kang

Results: measurements clearly demonstrate the diurnal cycle of NO_2

Example of elevated NO_2 concentrations close to the surface during the night and early morning:



Example of a flat NO_2 vertical profile shape with lower concentrations due to mixing of the PBL from sunrise onward: