Global dust altitude seasonal climatology based on CALIPSO observations

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The importance of dust aerosols altitude

- Dust aerosols influence many environmental processes (earth’s radiative budget, hydrological cycle, ocean biogeochemistry, atmosphere’s oxidizing capacity and air quality).
- Knowledge of their altitude (in addition to their optical depth) is required to quantify their impact on the abovementioned processes.
- This parameter is not easily measurable except from lidars and more recently from passive infrared remote sensors (AIRS or IASI).
CALIPSO and CALIOP

- The CALIPSO satellite was launched in April 2006 (observations after 13 June 2006) and it is part of the A-Train constellation. CALIPSO comprises three instruments, the Cloud-Aerosol LIdar with Orthogonal Polarization (CALIOP), the Imaging Infrared Radiometer (IIR), and the Wide Field Camera (WFC). Its repetition cycle is 16 days.

- CALIOP is a two-wavelength polarization sensitive lidar. At 532 nm, it has horizontal and vertical resolutions of 333 m and 30 m, respectively, while its beam diameter is ~70 m at the earth’s surface.

- The depolarization (532 nm) allows to discriminate between dust and other types of aerosols, which generally do not depolarize light.

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CALIPSO data

- The L2 – 5 km aerosol layer product (version 3.01) is used here to calculate the seasonal climatology (daytime and night time data) during the last 5 years (June 2006 – May 2011).

- Two classes of aerosols are used from the L2 product: “dust” and “polluted dust”. It is known that the polluted dust class may also contain smoke or polluted continental aerosols, so results on the regions possibly contaminated by these aerosols are treated with caution and generally avoided.

- Correction of the eventual overlap of the dust layers, due to possible layer detection algorithm weaknesses.
Seasonal localization of dust aerosols

- Detection of dust source regions and their activation season from CALIPSO, which is coherent with present knowledge.

- The dust zone (N. Africa – Arabian peninsula – C. Asia) is continuous with maxima during spring – summer.

- Need of the “polluted dust” class in order to fulfill the analysis of sources and transport.
Vertical distribution of dust aerosols

Warning: also, smoke aerosols in the upper layers
Dust transport above the Atlantic at 15°N

- Dust is more elevated in summer than in winter.
- Dust altitude decreases with longitude, mostly after -40°E (especially in summer).
- Elevated layers during spring (~3 km) and summer (~3.5 km), while in contact with surface over the Caribbean Sea.
- Absence of dust above ~6 km.
Dust export from Asia during spring

- Export from Taklamakan desert up to 10 km with maximum at ~6 km.
- Transport eastward mostly near the earth’s surface, although between 30-40°N also in the upper troposphere.
- Deposition of the low levels dust up to Japan (~140°E), afterwards transport in the mid troposphere (~ 5 km) above Pacific (30-60°N).
Mean altitude

- **Sahara + Arabian peninsula:** ~1.5 km in winter and ~3 km in summer. Regional minimum above Egypt in summer.
- **Taklamakan + Gobi deserts:** >4.5 km in spring.
- **Tropical Atlantic ocean:** ~1.5 km in winter – spring and >2.5 km in summer.
- **Indian ocean:** ~1 km in winter and ~3 km in summer.
- **Australia:** ~2 km in autumn/winter.
Mean geometrical thickness

- **Sahara + Arabian peninsula:** ~1 km in winter and >2.5 km in summer.
- **Taklamakan + Gobi deserts:** ~1 km in spring.
- **Tropical Atlantic ocean:** ~1 km in winter and >1.5 km in summer.
- **Indian ocean:** ~1 km in winter and ~2 km in summer.
- **Australia:** >1.5 km in autumn/winter.
- **Strong contrast land – sea, with finer layers above sea.**
Variability

Generally the standard deviation is:
- 1-1.5 km for the altitude, except from the spring dust transport from C. Asia (>2 km).
- 0.7-1.2 km for the thickness, except above Sahara + Middle East (>1.5 km).

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Difference between [Night] and [Day+Night] data

Night data have better signal to noise ratio. Difference is smaller than
- 200 m for the altitude, except during the Asian spring transport (~400 m).
- 100 m for the thickness.

These differences are minor in front of the standard deviations.

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The export of dust from its main sources can be explained by the wind direction.

The geometrical thickness of the dust layer can be overall explained by the vertical wind velocity, with regions like southwest Arabian Peninsula and south Sahara, which present strong convection essentially during summer to display thicker dust layers.

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Conclusions

- The **global seasonal climatology** of dust aerosols mean altitude and geometrical thickness is presented by using 5 years of CALIPSO observations with 1° resolution.
- Results show that both dust mean altitude and geometrical thickness present an obvious **seasonal dependence** with lower values during winter and higher values during summer.
- There is a **land-sea contrast**, especially for the geometrical thickness, with higher values above continents.
- For the dust zone the **altitude** is \(\sim 2\) km during winter, while it reaches \(\sim 3\) km during summer; the dust **geometrical thickness** goes from about 1-1.5 km during winter to its maximum of \(\sim 3\) km during summer.
- Above the **desert regions of central Asia**, altitudes over \(5.5\) km are observed during spring, with the subsequent long-range transport at \(\sim 4.5\) km towards North America.
Thanks!

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