

THE **GLAM*** AIRBORNE CAMPAIGN ACROSS THE MEDITERRANEAN BASIN



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***GLAM** = **G**radient in **L**ongitude of **A**tmospheric constituents above the
Mediterranean basin

Acknowledgement

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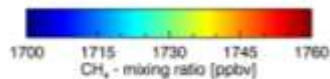
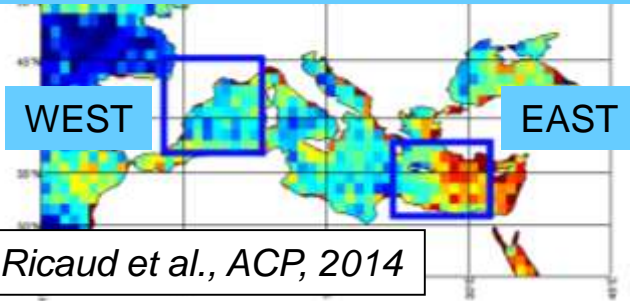
- Ricaud, P., et al., Bull. Am. Met. Soc., 99, 361-380, 2018.

Context

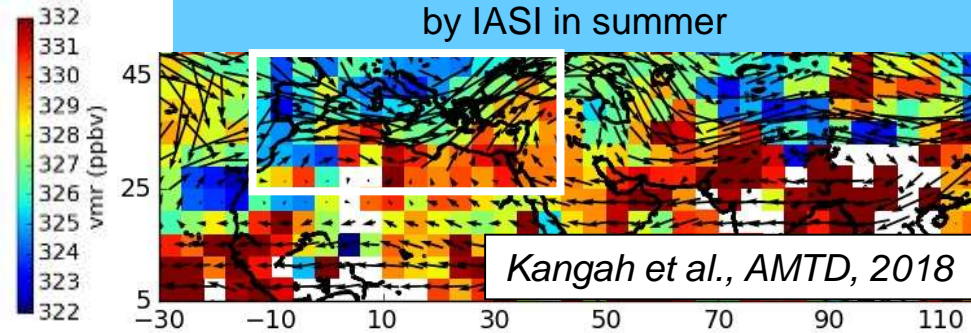
- The Mediterranean is located in a transitional zone between subtropical and mid-latitudes regimes, highly sensitive to climate change
- Global or regional model simulations show a pronounced decrease in precipitation (2000-2100), especially in the warm season
- In terms of anthropogenic pollution sources, the Mediterranean is at the confluence of three continents (Europe, Africa and Asia) and the impact of these distinct continental sources as the industrial and densely populated coastal areas or the forest fires is still not fully understood, especially on the ozone (O_3) and carbon monoxide (CO) budgets in which methane (CH_4) interplays through complex reactions with nitrogen oxides (NOx)
- Polluted air masses may originate from Asia, Africa and North America
- CHARMEX/MISTRAL
- WP5: Variability & Trends

Motivations

Tropospheric CH₄ spaceborne measurements by AIRS in summer



Tropospheric N₂O spaceborne measurements by IASI in summer



Impact of the Asian Monsoon Anticyclone on the Eastern Mediterranean Basin in the UT in summer



East-West gradients observed and modelled over the Mediterranean Basin (MB) in summer in GHGs, as methane (CH₄) and nitrous oxide (N₂O)

Impact of the Asian pollutants/GHGs on the Eastern MB via the Asian Monsoon and its associated Anticyclone

Objectives

- IMPACT of the ASIAN MONSOON ANTICYCLONE on the EASTERN MB
- Summertime airborne campaign
- East-West Gradient in the mid-to-upper Troposphere
- Vertical Profiling
- Pollutants/aerosols/GHG

The GLAM Campaign

Falcon 20



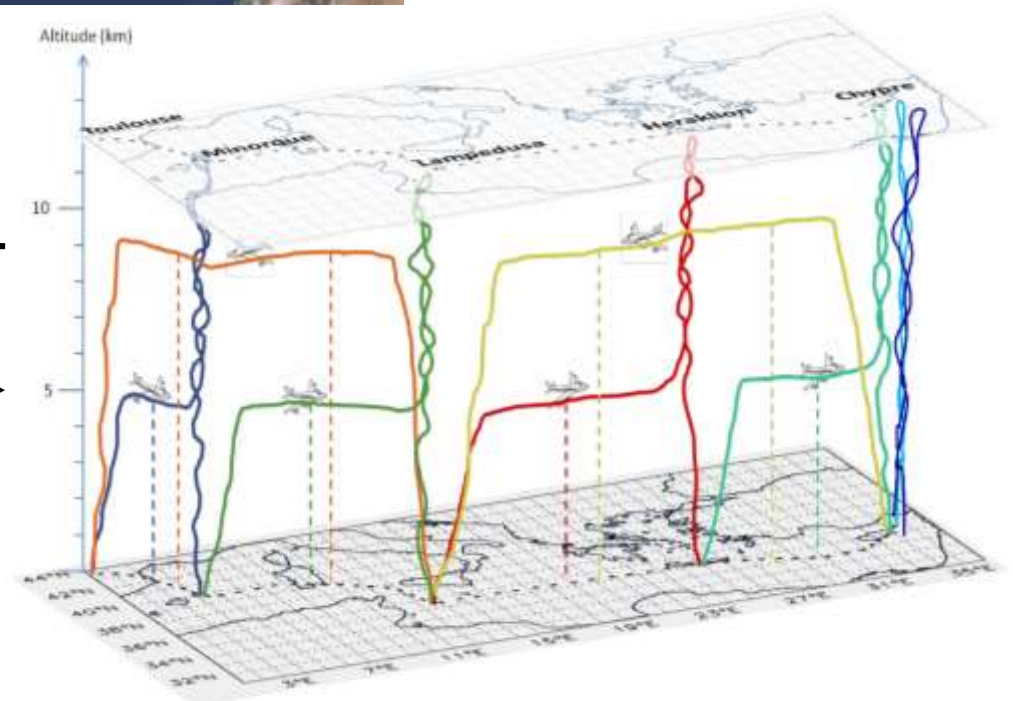
D3 - Flights 5 and 6
at 300, 5000 and 9000 m

GLAM : 6 - 10 AUGUST 2014

6 Aug - D1 - at 5000 m Flight 1 and Flight 2 from TOULOUSE to LAMPEDUSA via Menorca
 7 Aug - D2 - at 5000 m Flight 3 and Flight 4 from LAMPEDUSA to LARNACA via HERAKLION
 8 Aug - D3 - at 300, 5000 and 9000 m Flight 5 and Flight 6 south of Cyprus
 9 Aug - D4 - Day off
 10 Aug - D5 - at 9000 m Flight 7 and Flight 8 from LARNACA to TOULOUSE via Lampedusa

9 km ←

5 km →



Measured Parameters

F-20

H₂O, O₃, aerosol concentration & size distribution (0.2-3 μm), temperature, upward/ downward SW and LW radiations

SPIRIT

CO, CH₄, N₂O, CO₂

SPIRIT

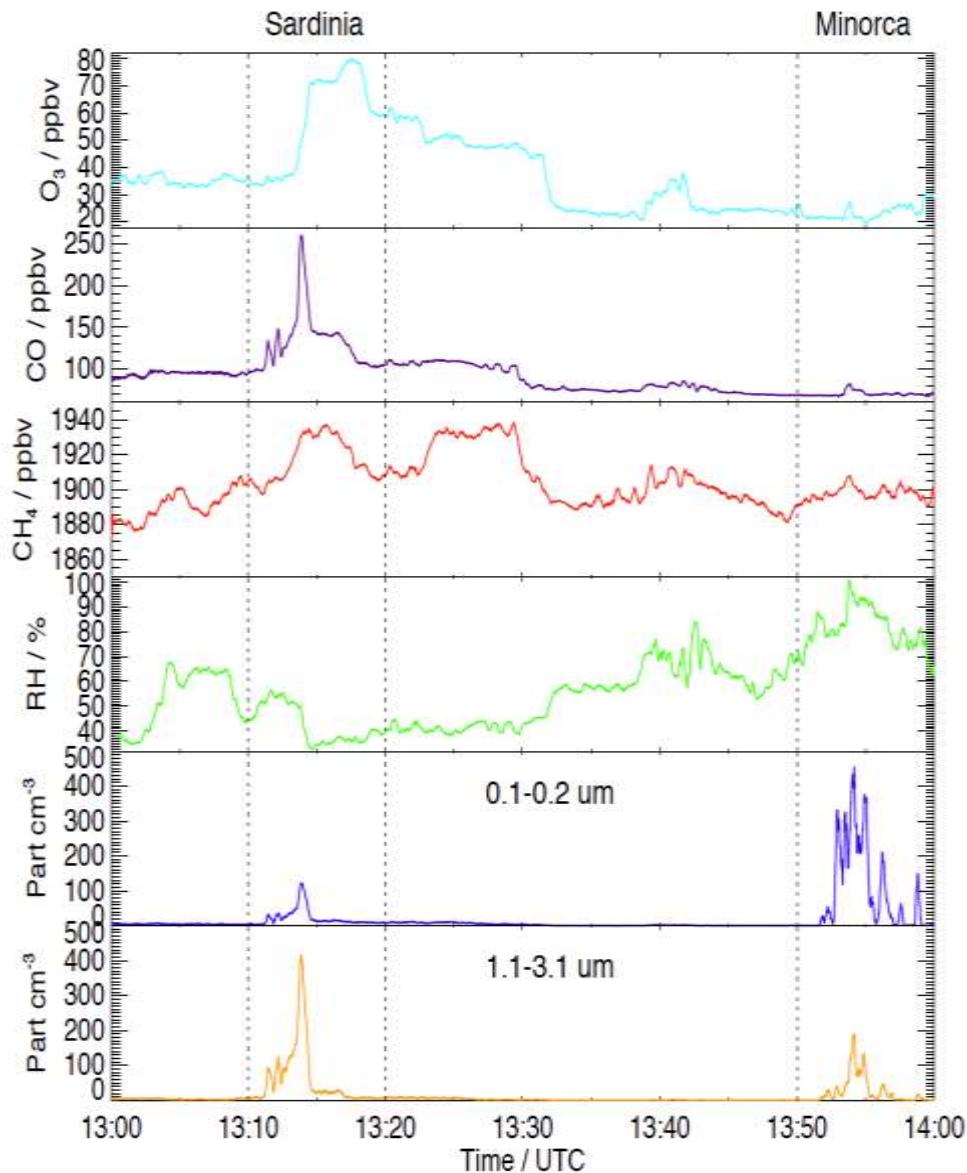


Other Data sets

- CAMS / Chemical Forecast and Analyses
- ARPEGE / Meteorological Forecast
- MOCAGE / chemical compounds and aerosols
- ALADIN-Climat / aerosols
- Spaceborne observations / O₃ and aerosols
- Back-trajectories from HYSPLIT and FLEXPART

- Surface stations / Chemical compounds and aerosols
 - Lampedusa, Italy
 - Heraklion, Greece
 - Cyprus

In-situ Measurements on 10 Aug. at 9 km



Thin black layer

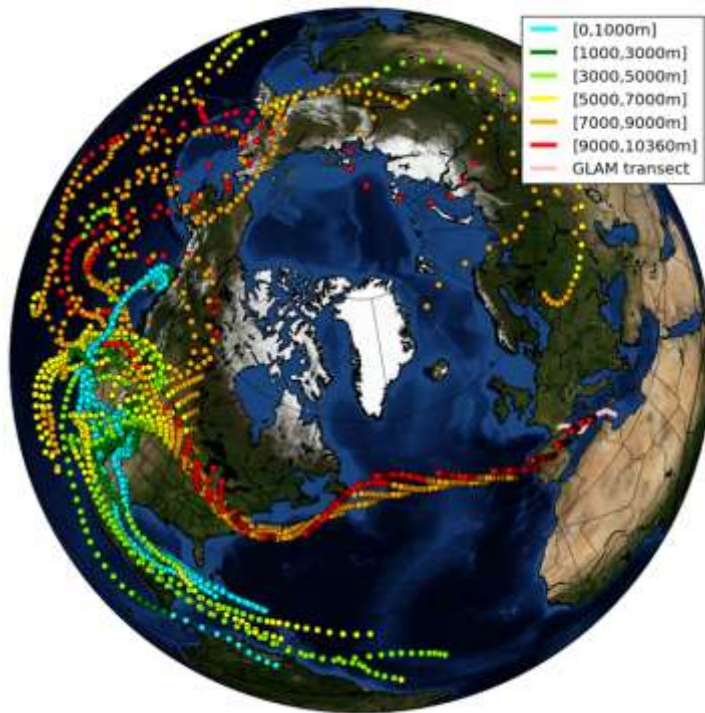
On 10 Aug. 2014, 2 aerosol anomalies are detected at 9 km:

At 13h13 UT, above Sardinia, a coarse size of particles is associated with a CO maximum, an O_3 and a CH_4 shift and a weak RH.

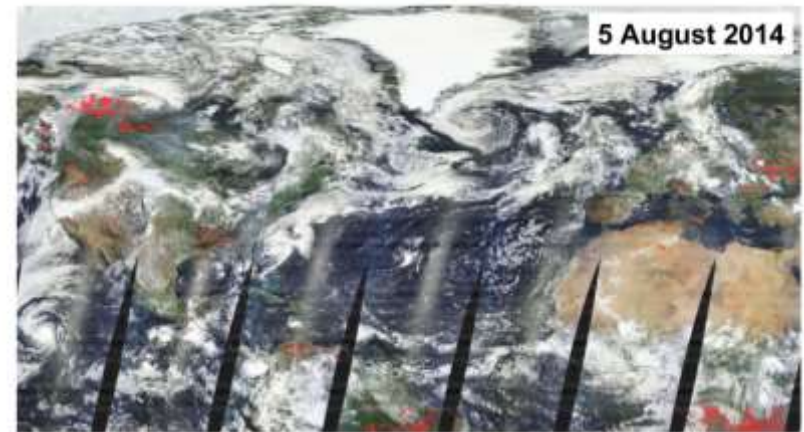
At 13h55 UT, nearby Minorca, a fine size of particles is associated with high RH and no O_3 , CH_4 and CO change.

Northern American Fires

20-day back trajectories
from Sardinia on 10
August at 13h13 UT



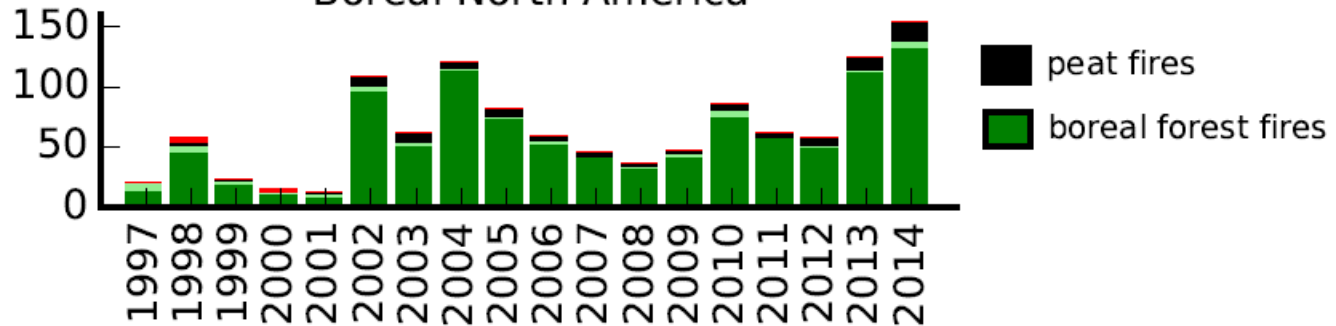
MODIS Fires on 5 August



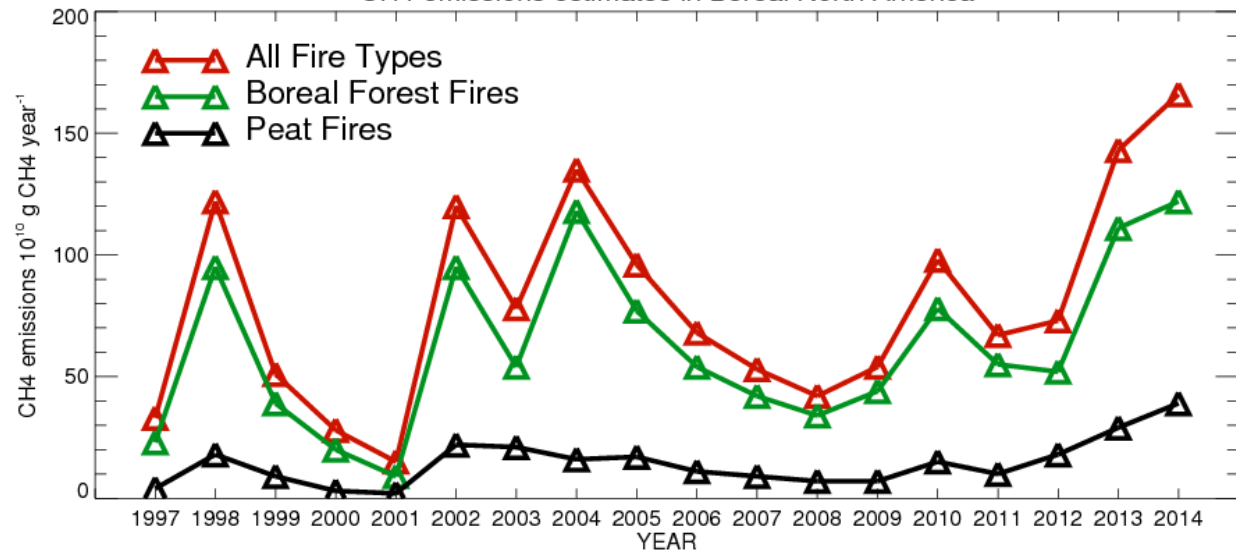
Air parcels flew over Northern Territories end of July in the lowermost troposphere and were uplifted over the Atlantic Ocean on 6 August up to the upper troposphere although pyroconvection to the middle troposphere cannot be ruled out.

Boreal North America

Annual Fire C Emissions (Tg C year⁻¹)
Boreal North America



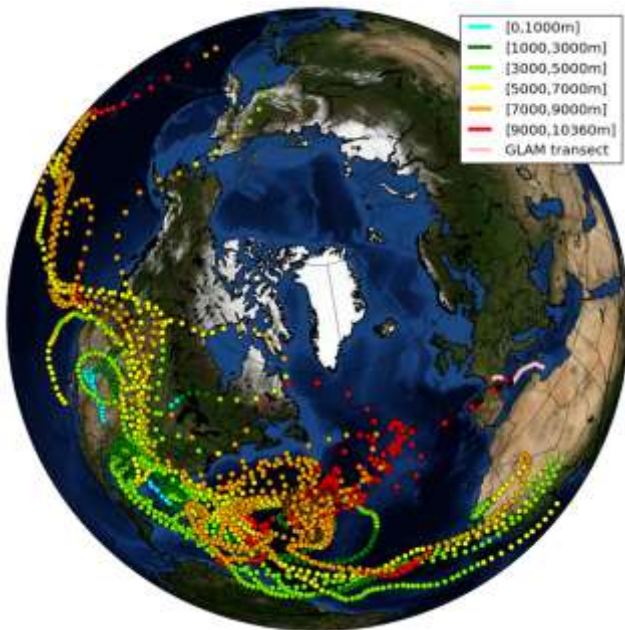
CH₄ emissions estimates in Boreal North America



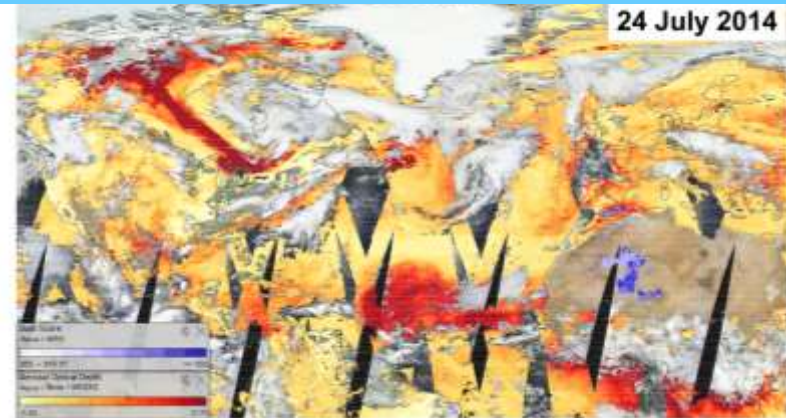
From the GFED inventory, the Boreal North America region, in terms of annual fire carbon and CH₄ emissions, the year 2014 was the most intense over the period 1997-2014.

Saharan Dust

20-day back trajectories from Minorca on 10 August at 13h55 UT

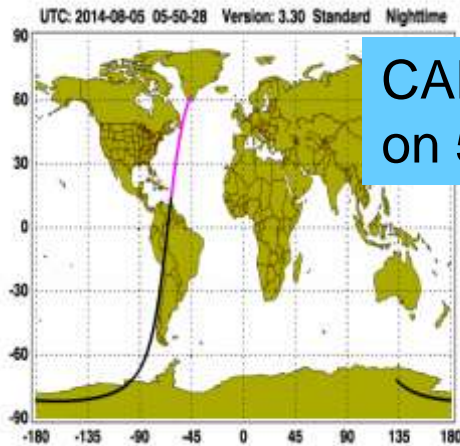


AIRS Dust & MODIS AOD on 24 July

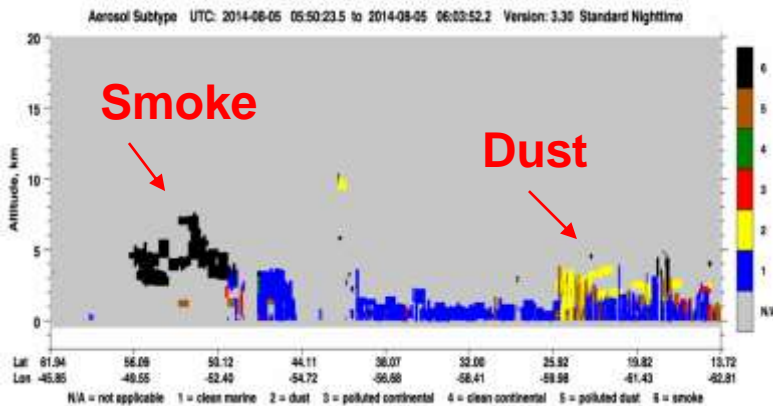


Saharan dust outbursts from Africa were measured propagating in the tropics towards the Caribbean Sea. The air parcels originated from Minorca were originated from Africa then Florida before being uplifted to the upper troposphere over the Atlantic Ocean by a Warm Conveyor Belt.

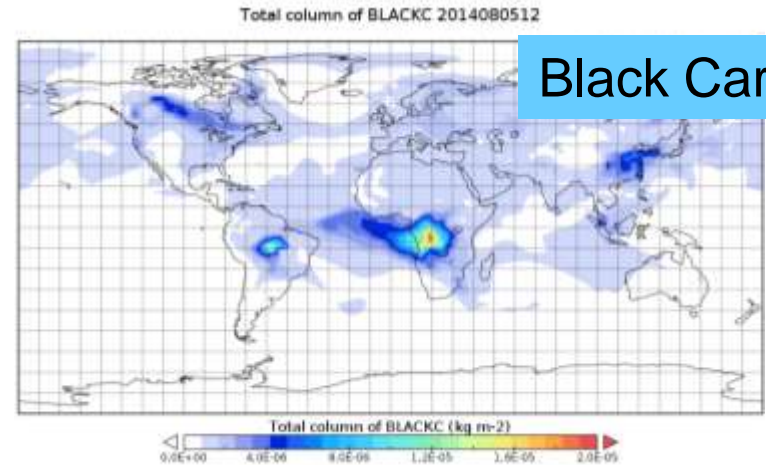
Global-scale Modelling and Observations



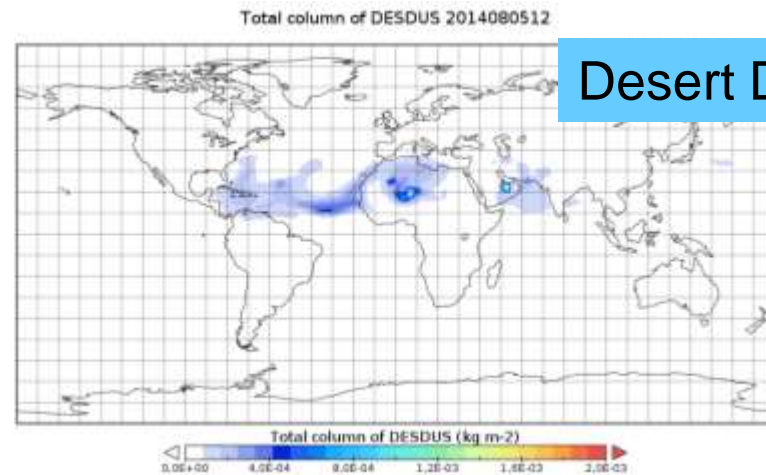
CALIOP/CALIPSO
on 5 August



MOCAGE CTM on 5 August



Black Carbon

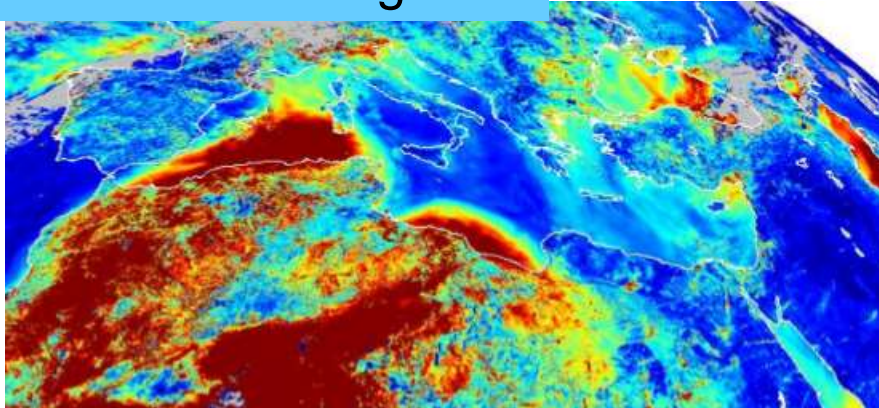


Desert Dust

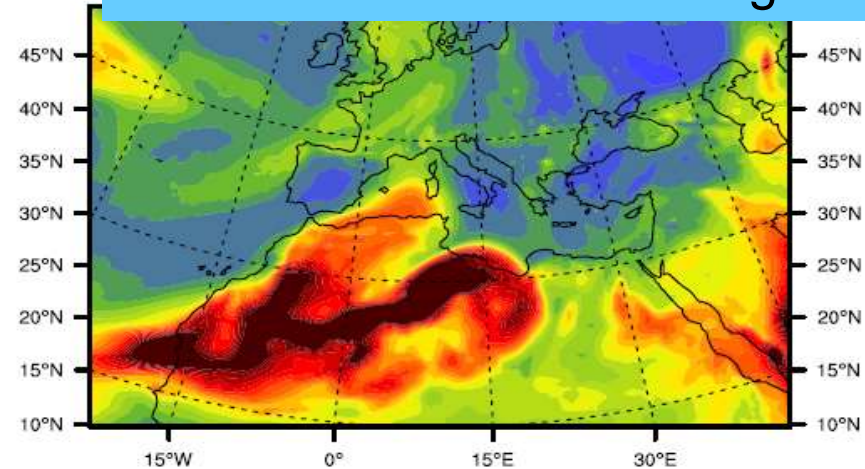
On several occasions prior and during the GLAM campaign, CALIOP/CALIPSO has sampled smoke over Northern Atlantic and dust away from Florida, as on 5 August 2014, consistently with MOCAGE.

Modelling and Observations on 10 August

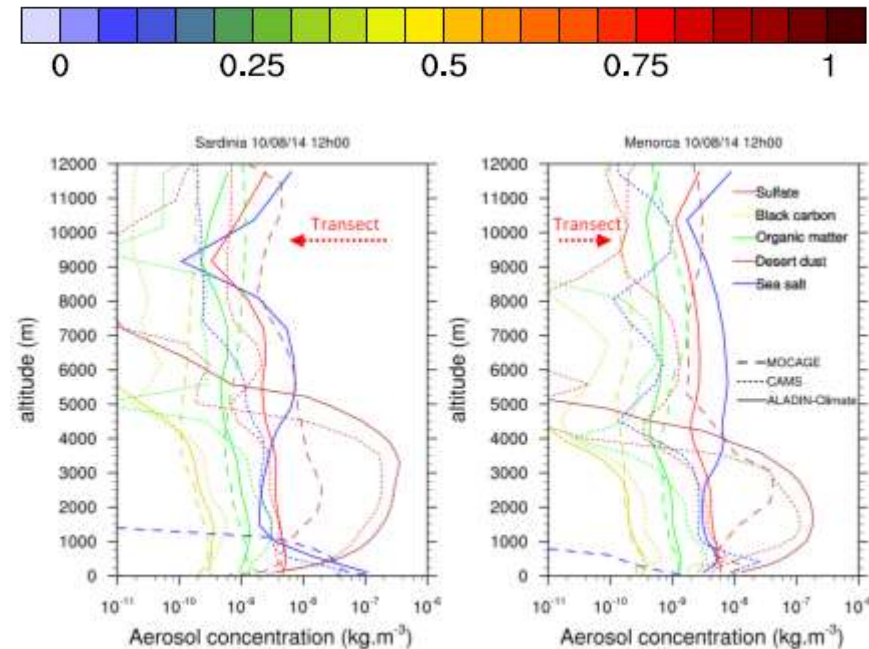
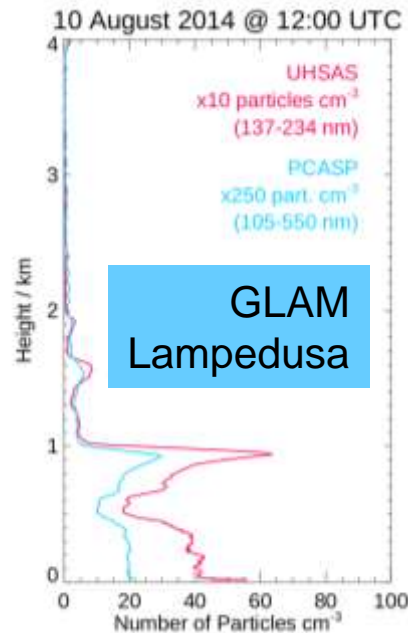
SEVIRI on 10 August



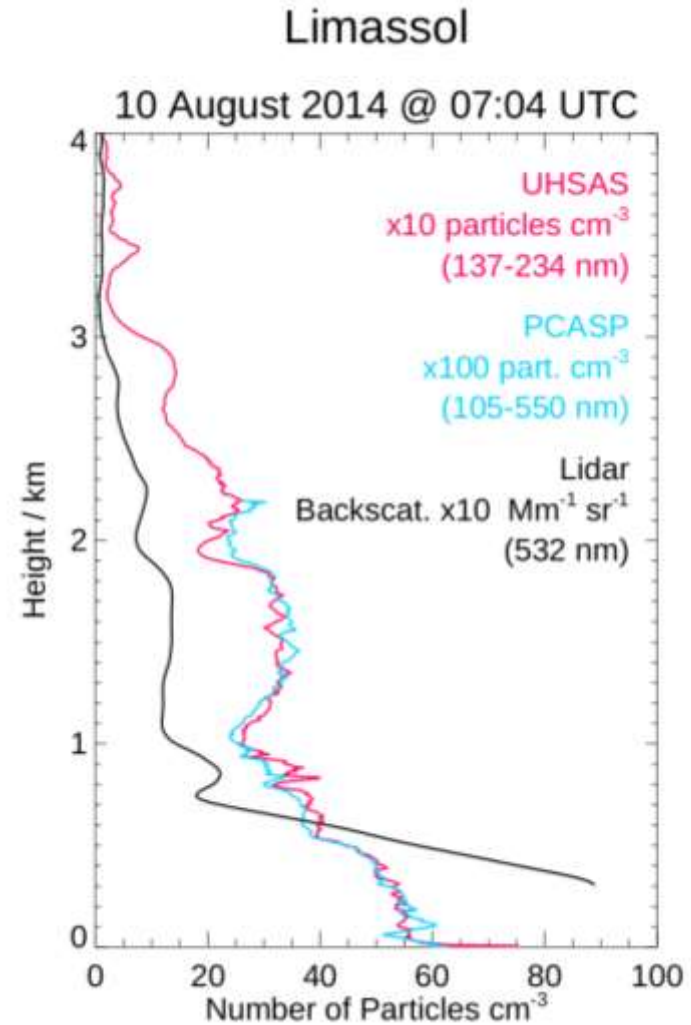
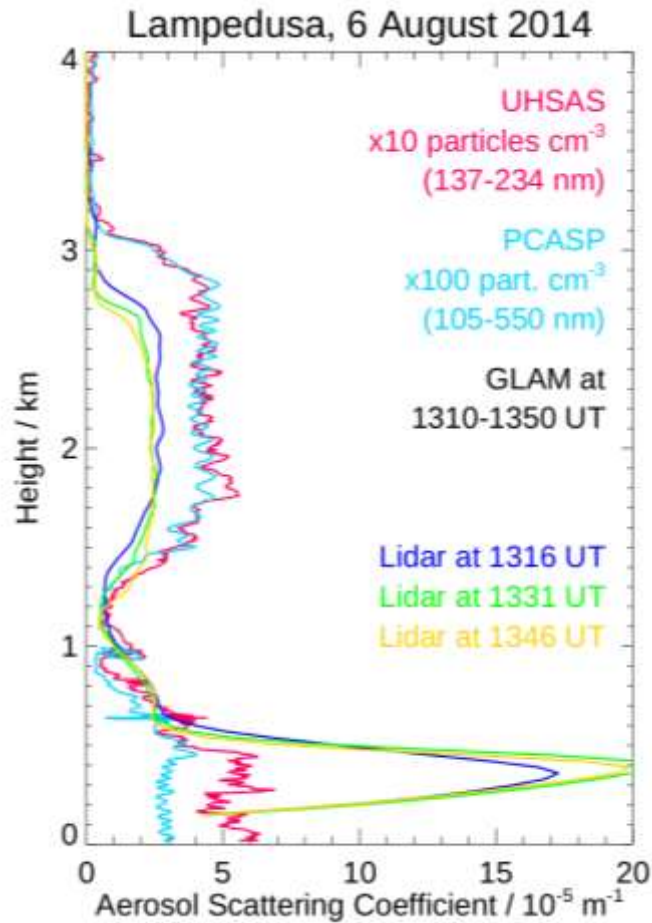
ALADIN-CLIMAT on 10 August



The Saharan dust outburst detected by SEVIRI propagating from Africa to the Mediterranean Basin on 10 August is mainly concentrated below 5 km



Aerosol Profiles

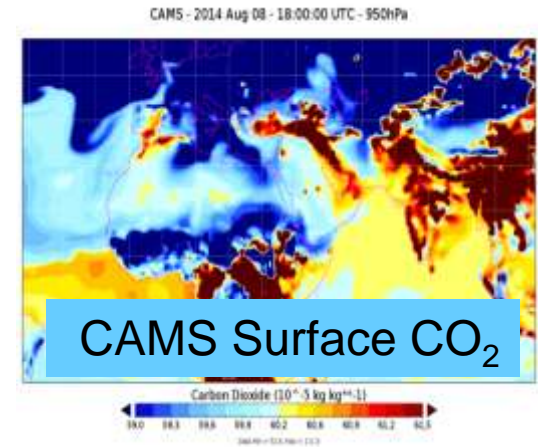
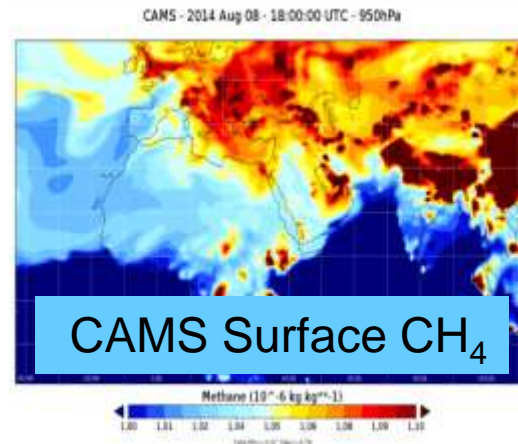
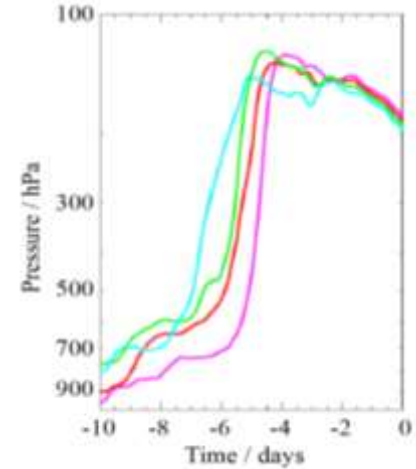
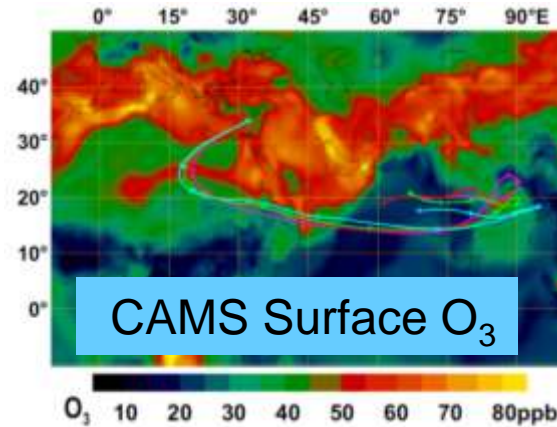
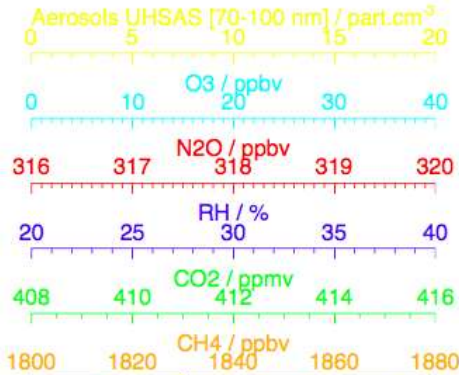


GLAM and surface Lidar aerosol profiles are consistent

Asian Monsoon Anticyclone & Arabian Sea Impact on the Eastern MB

Larnaca, 8 August 2014, 12:00 UTC

29 July 2014



Impact of the Maritime Boundary Layer of the Arabian Sea to the Eastern Med UT via the Asian Monsoon Anticyclone: low O₃, CO and CH₄, high H₂O and CO₂

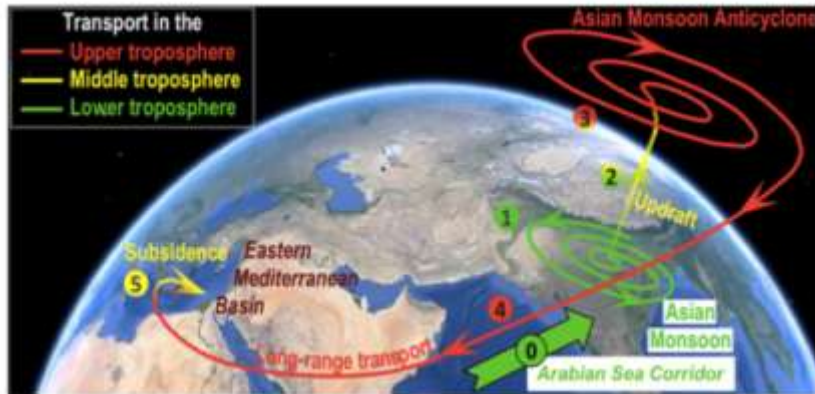
Synthesis



- The GLAM airborne campaign
 - Intercontinental transport
 - East-West Variability
 - Surface stations

- Proposed new airborne campaigns focussed on the link between the Eastern Mediterranean and the Arabian Sea

COSAC: Continental and Oceanic Sources of pollutants, greenhouse gases and aerosols in the Arabian sea Corridor



4-yr project submitted to the French ANR
600 k€ budget
Source, Transport & Ageing
Pollutants, GHGs and Aerosols
Airborne campaign

Falcon 20

August 2020

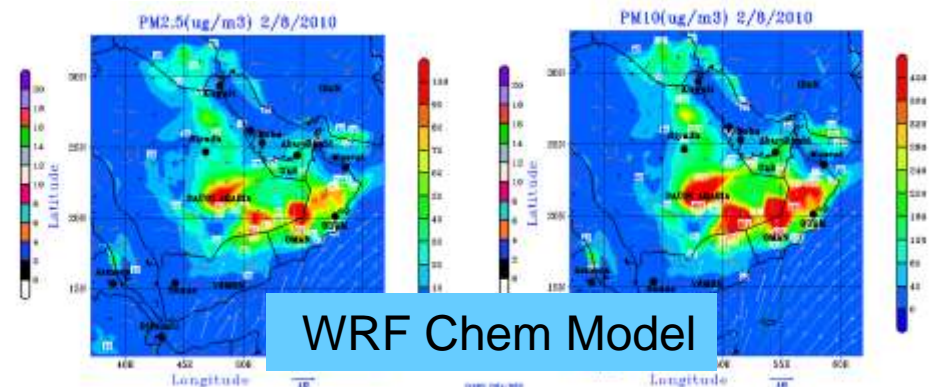
Toulouse (France) to Duqm (Oman)

Instruments SPECIES and SPIRIT

Aerosol Lidar

Surface measurements in Oman and in
Cyprus

Modelling & Satellite



Planetary Boundary Layer in Oman and the
Arabian Sea

Upper Troposphere in Cyprus

O₃, CO, NO₂, NO_x, HNO₃, NH₃, H₂CO, OCS

CO₂, CH₄, H₂O and N₂O

Aerosols (radius < 20 μm)

COSAC Collaborations

- France
 - CRNM
 - LA
 - LSCE
 - LPC2E
 - SAFIRE
- Oman
 - Sultan Qaboos University
 - Directorate General of Meteorology
- Germany/MPI
- Cyprus/The Cyprus Institute
- Israel/Univ. Jerusalem
- Japan/Chiba Univ.
- India/BIT
- ECMWF/CAMS