Laboratory of Atmospheric Physics,
Aristotle University of Thessaloniki

Active and passive remote sensing activities at Thessaloniki, Greece

Dimitris Balis

Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki, Greece

With contributions from

A. Bais, M. Koukouli, A. Garane, I. Fountoulakis, K. Fragkos,

I. Zyrichidou, T. Drosoglou, N. Siomos

To be presented…..

- A very brief introduction to the infrastructure of the Laboratory of Atmospheric Physics of the Aristotle University of Thessaloniki. Greece
- Long-term ground based remote sensing at Thessaloniki
  - Total Ozone and Ozone profiles (Brewer)
  - Aerosols (Lidar and sunphotometers)
  - Trace gases (MAX-DOAS-Phaethon)
- Satellite remote sensing activities
  - Validation of Ozone, SO_2, NO_2
  - Long-term variability studies
  - Emission estimates

LAP/AUTH Ground-Based Monitoring

Single Brewer spectrophotometer (1982-)

Double Brewer spectrophotometer (1993-)

Aerosol Lidar (2000-)

CIMEL sunphotometer (2003-)

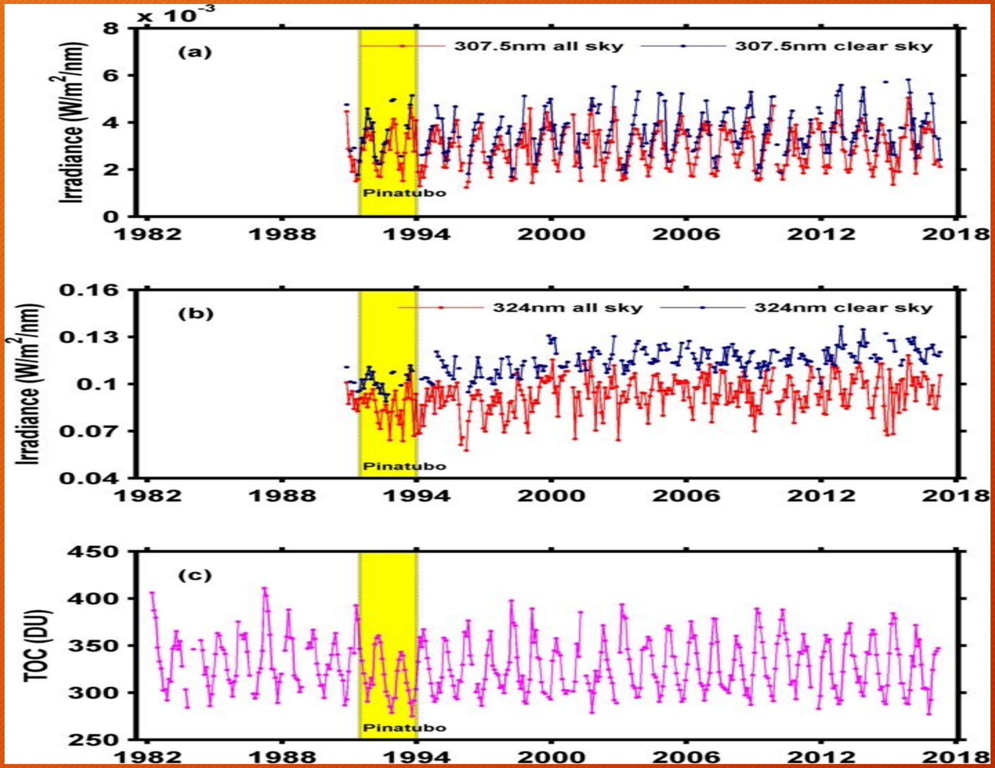
MAX-DOAS spectrophotometers (2011-)

A NILU-UV network (2004-)

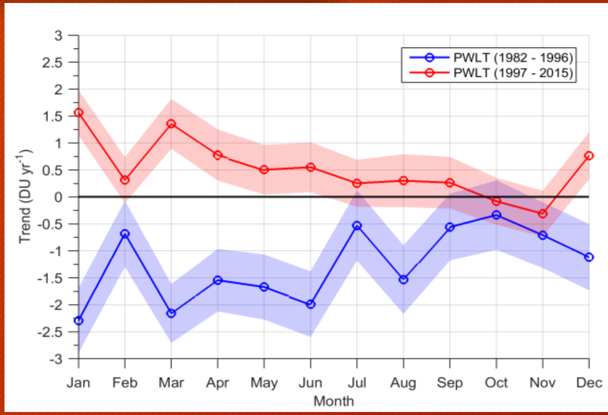
Broadband pyranometers (UV-B, UV-A, Total)

Long term monitoring of ozone at Thessaloniki

Monthly mean spectral UV and TOC from the record of Brewer B005



Fragkos et al., TAC, 2016

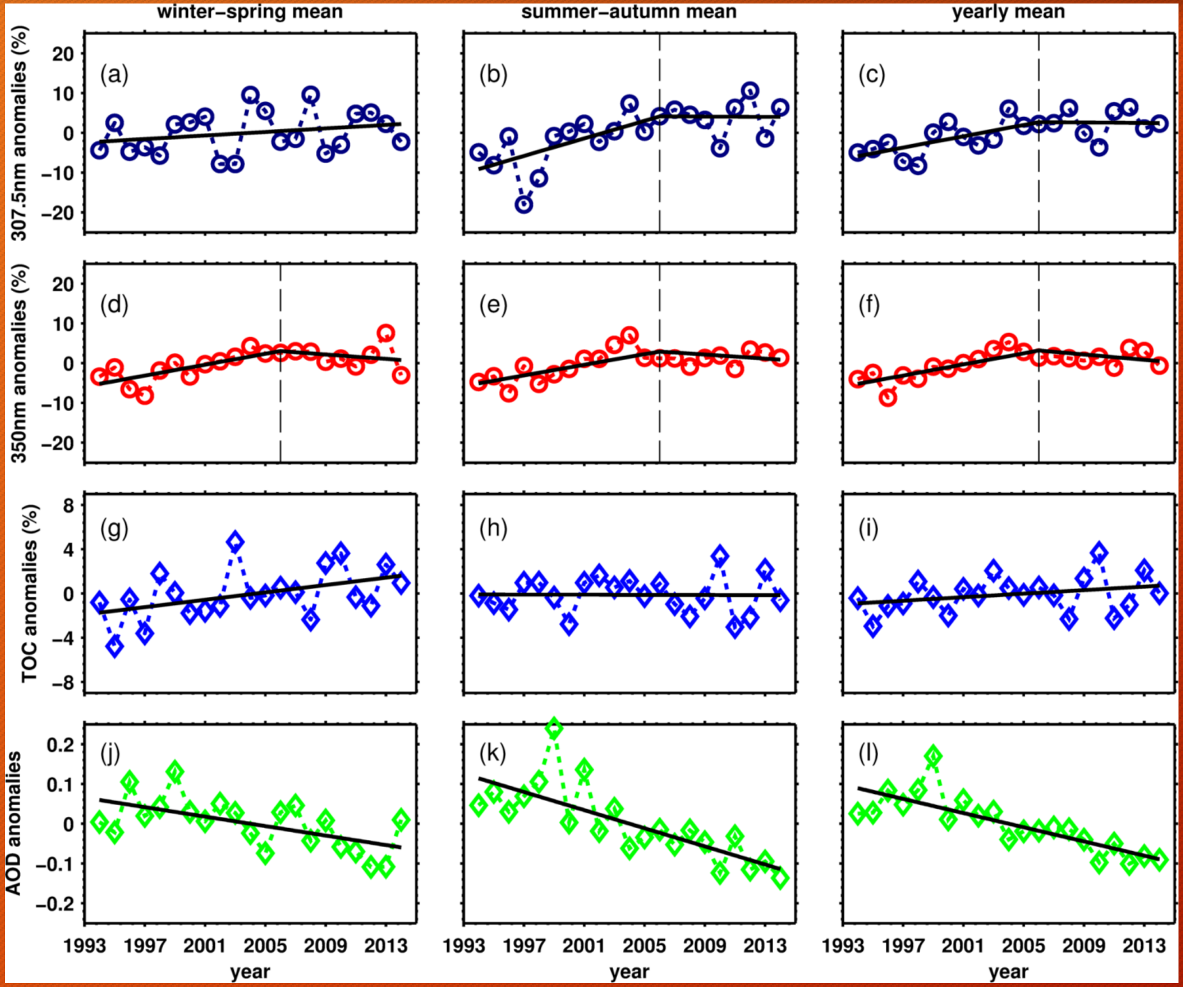


TOC trend (DU/year)	
Period	PWLT
1982-1996	-1.26±0.18*
1997-2014	0.52±0.13*

* Statistical significant at the 95%

The first commercial Brewer spectrophotometer operates in LAP since March 1982

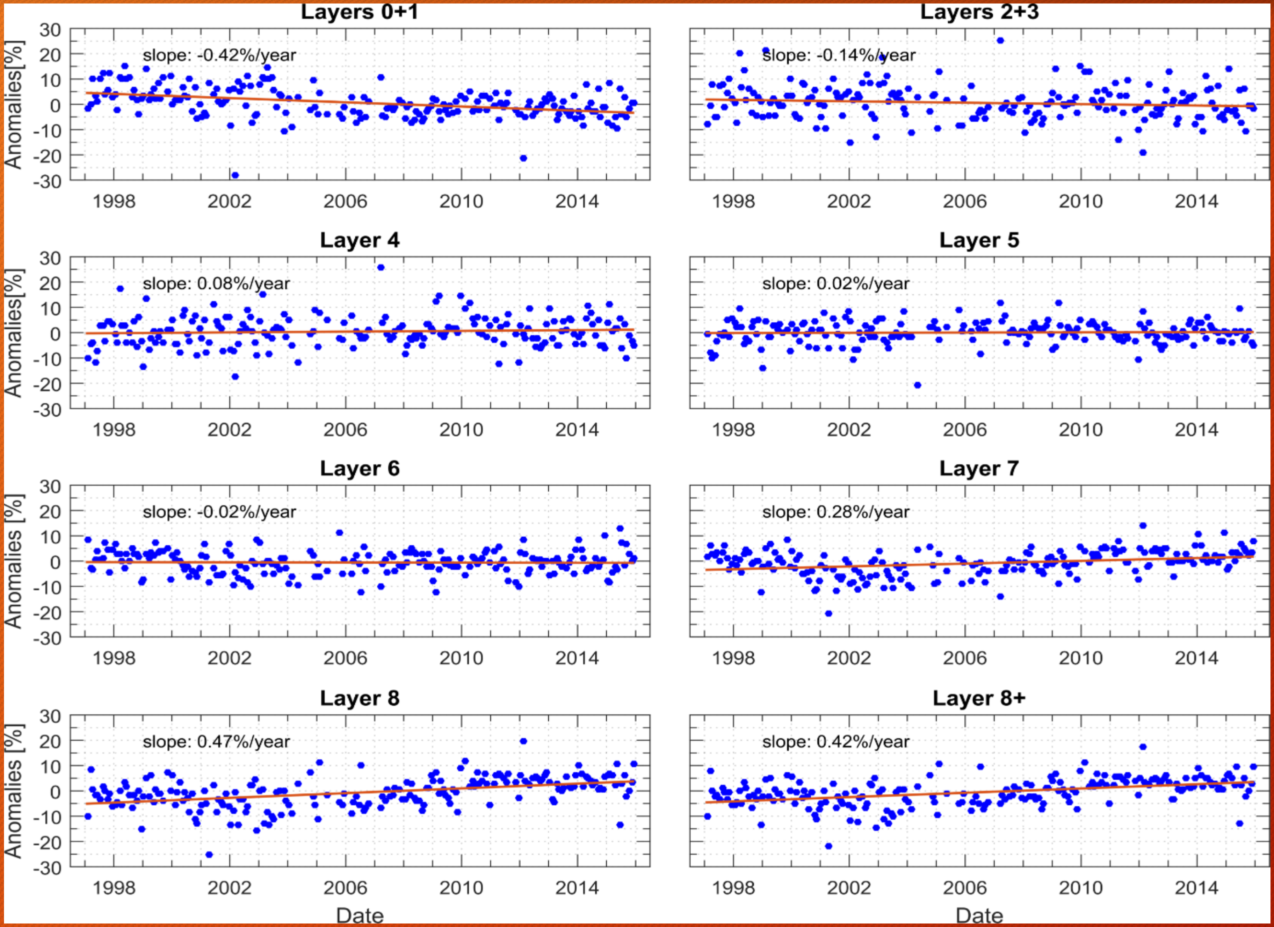
Trends of spectral UV irradiance, TOC and 320nm AOD in the post-Pinatubo period



A piece-wise trend consisting of two linear trends has been drawn when a statistically significant turning point has been detected; otherwise a linear trend for the entire period has been drawn.

Fountoulakis et al., ACP, 2016.

Ozone profile trends based on Umkehr observations

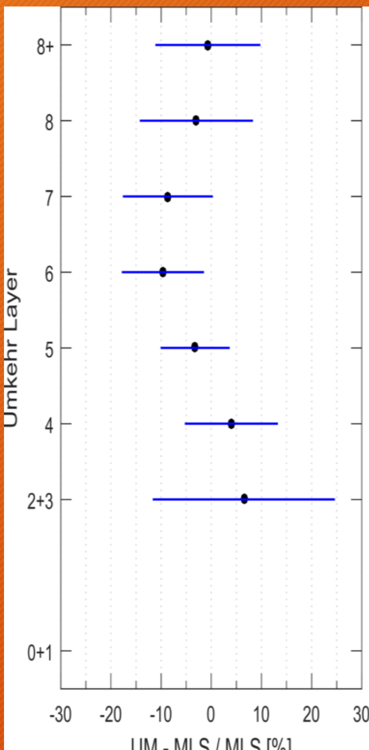


Layer	Layer Boundary (km)	Pressure limits (hPa)
0	0 - 5	1013 - 506.5
1	5 - 10	506.5 - 253.25
2	10 - 15	253.25 - 126.63
3	15 - 20	126.63 - 63.31
4	20 - 25	63.31 - 31.66
5	25 - 30	31.66 - 15.83
6	30 - 35	15.83 - 7.91
7	35 - 40	7.91 - 3.96
8	40 - 45	3.96 - 1.98
9	45 - 50	1.98 - 0.99
10	50 - 55	0.99 - 0.49
11	55 - 60	0.49 - 0.25
12	60 - 65	0.25 - 0.12
13	65 - 70	0.12 - 0.06
14	75 - 80	0.06 - 0.03
15	80 - top of the atmosphere	0.03 - 0

Trends are significant in layers 7, 8 and 8+, Fragkos et al. in preparation, 2017.

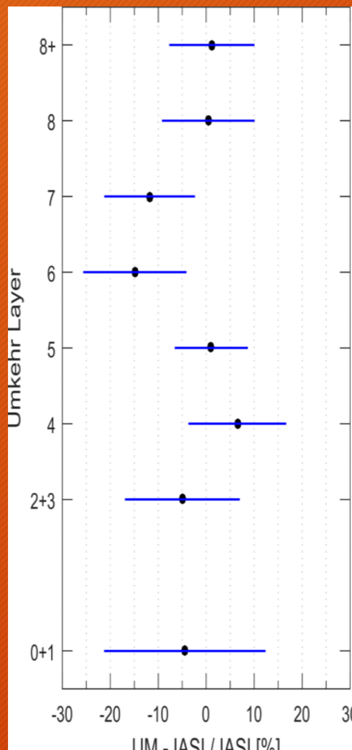
Umkehr - Satellite comparisons of O_3 profiles

Umkehr - MLS



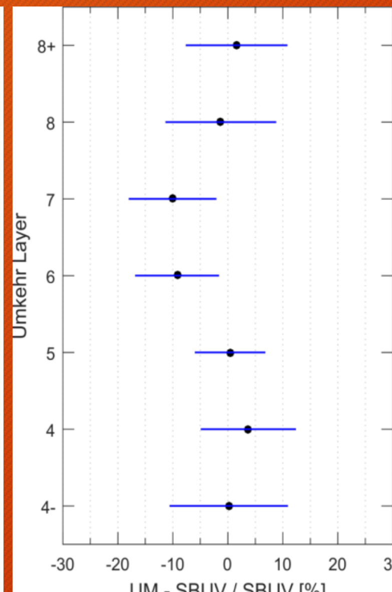
2004-2015

Umkehr - IASI

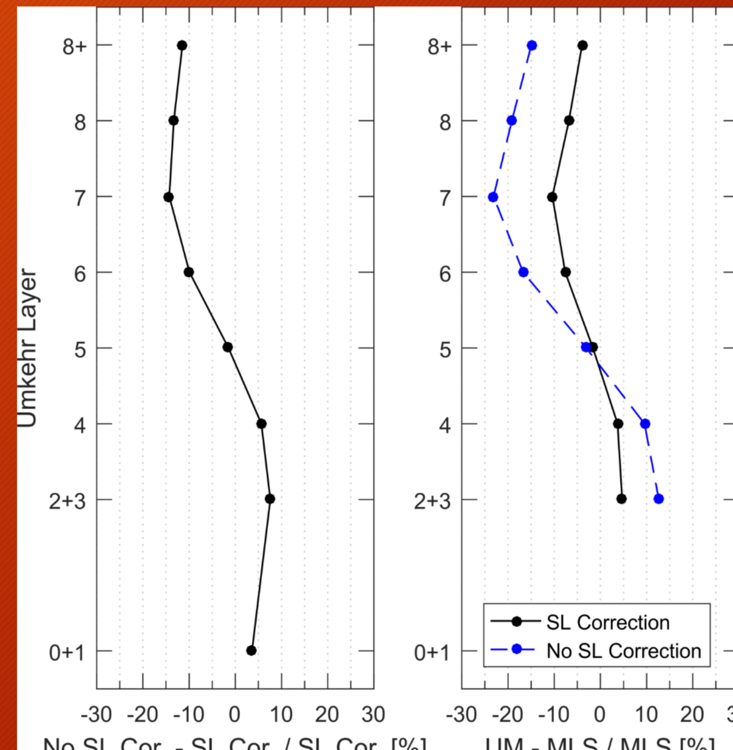


2007-2015

Umkehr - SBUV



1997-2015



Stray light effect: B005 Slit Function measured by He-Ne laser at 325 nm

Long term monitoring of aerosols at Thessaloniki

EARLINET

Profiling of aerosols and clouds

Member of EARLINET since 2000

Multiwavelength Raman Lidar (3b+2a+1d)

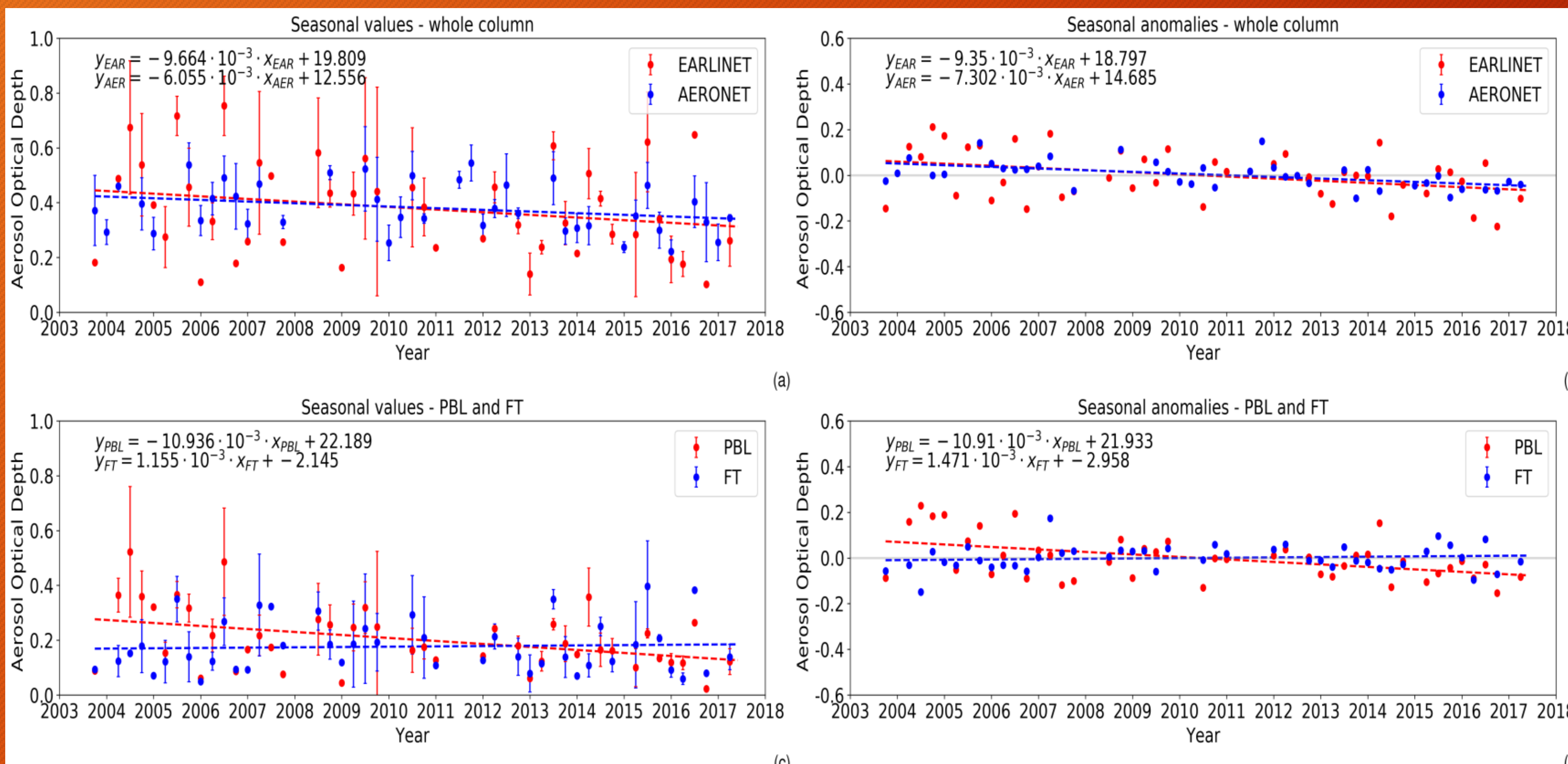
Climatological measurements

Special events (dust, fires)

CALIPSO validation

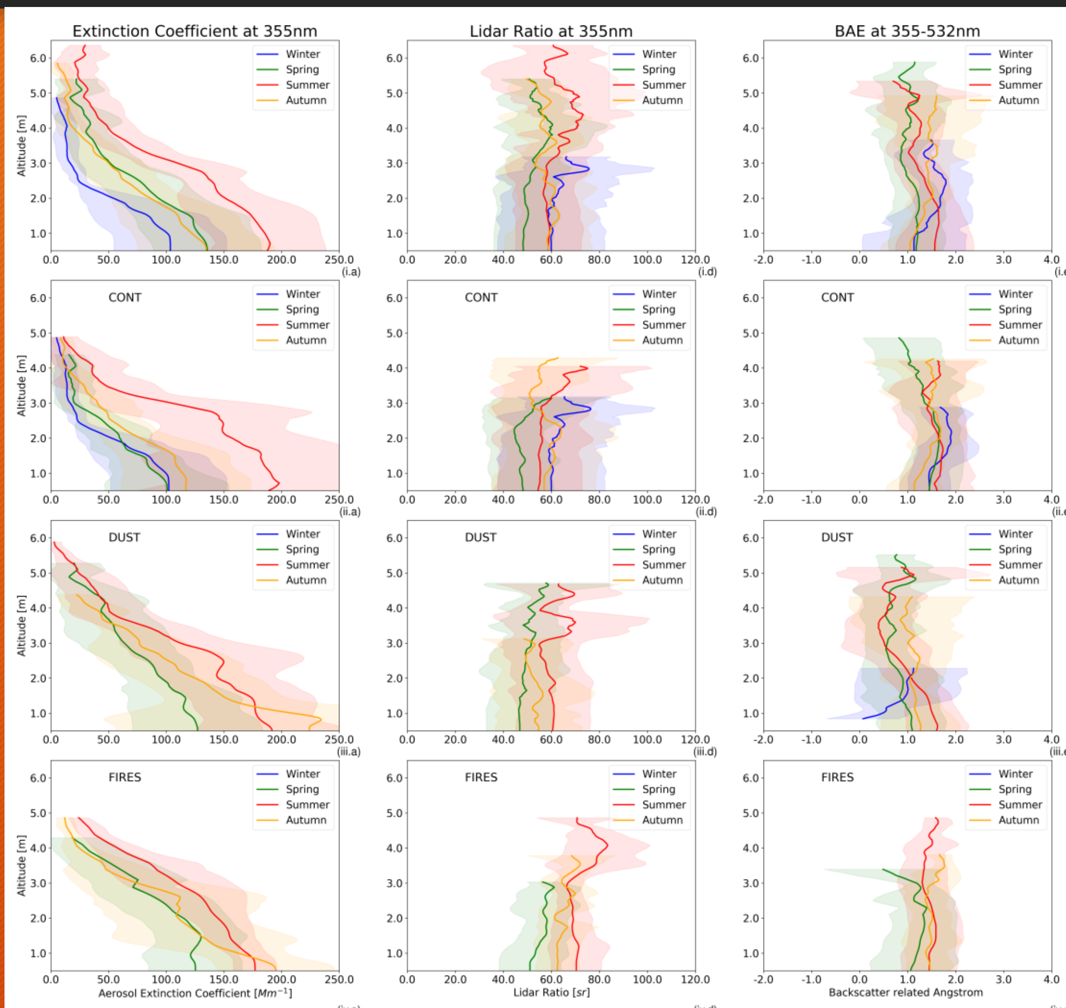
Validation of volcanic ash products from passive sensors

Consistency of EARLINET and AERONET trends



N. Siomos et al., submitted to ACP, 2017

Aerosol typing from lidar

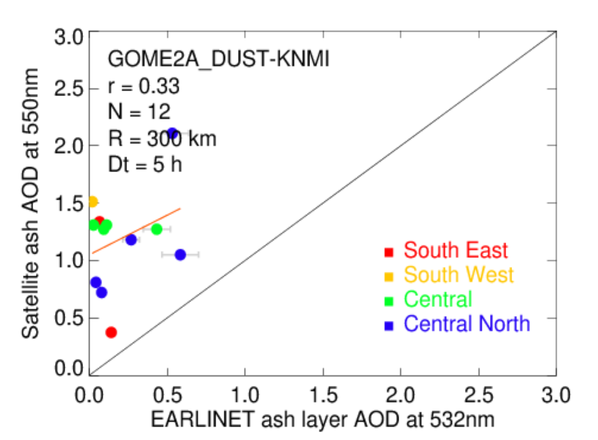


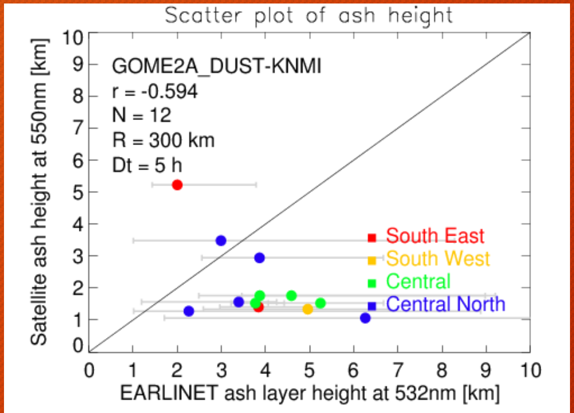
Climatological profiles for intensive and extensive properties of aerosol for:

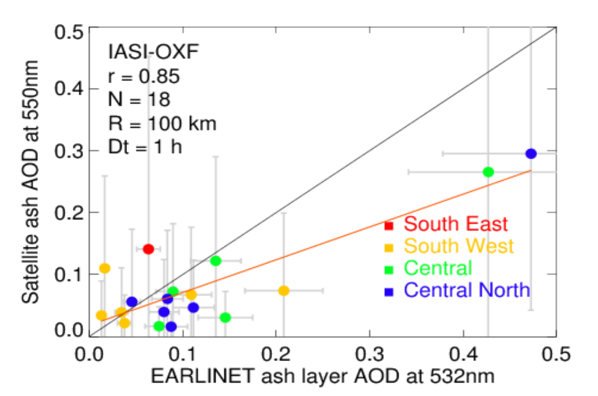
Continental aerosols
Desert dust
Biomass burning aerosols

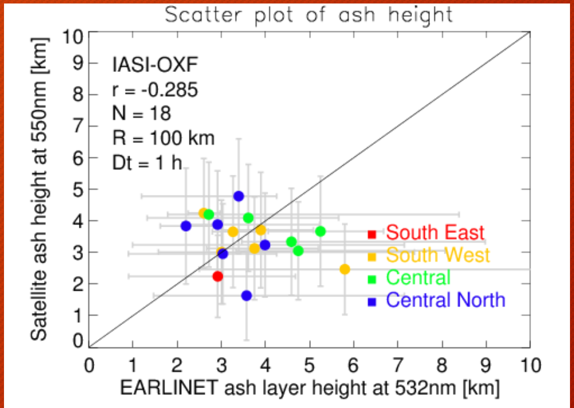
Typical for mixtures observed in SE Mediterranean

Validation of volcanic ash products using EARLINET data









Validation of ash optical depth and layer height retrieved from passive satellite sensors using EARLINET and airborne lidar data: The case of the Eyjafjallajökull eruption

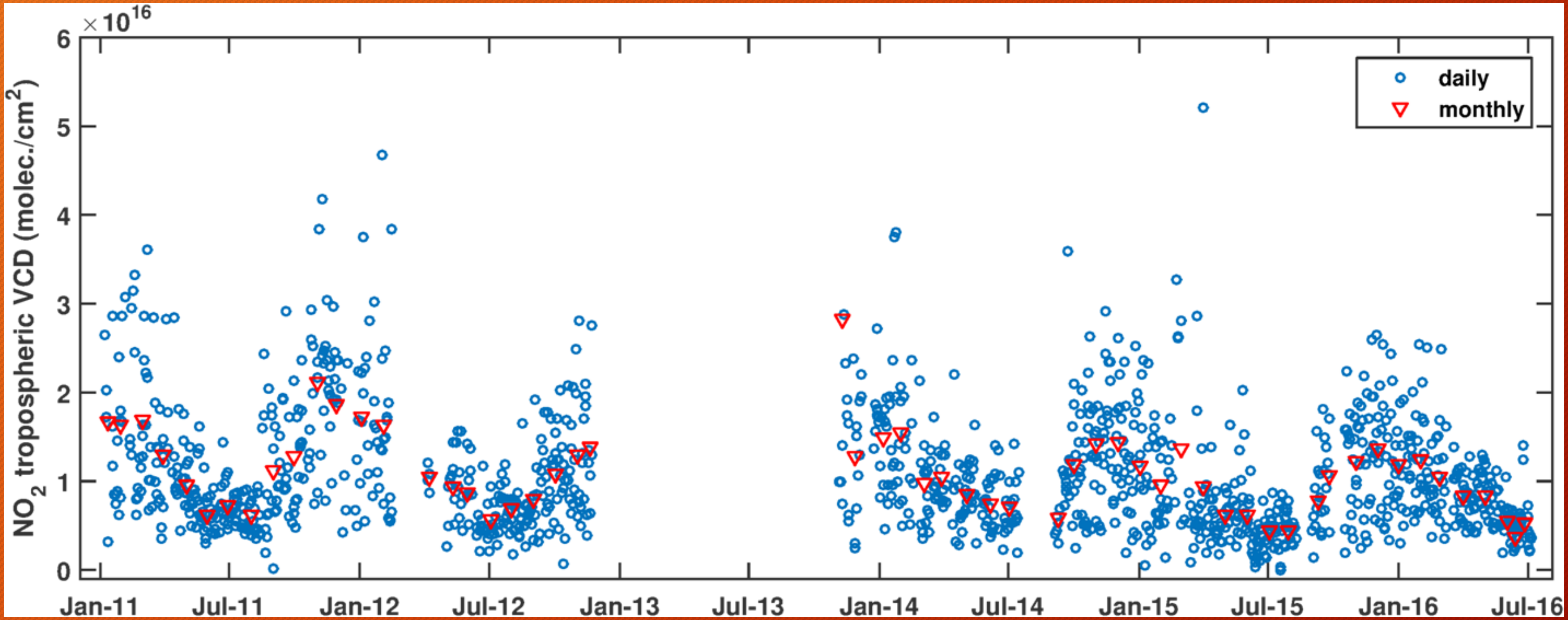
Balis et al., ACP, 2016

Long term monitoring of trace gases and aerosols at Thessaloniki using MAX-DOAS

The MAX-DOAS instrument at LAP-AUTH (Phaethon)

- 2048 pixel CCD detector – spectrally resolved measurements
- Thermo-Electric Cooling (set to 5°C) - high stability and noise minimization
- Spectral range: 300-450 nm
- spectral resolution: 0.34-0.42 nm
- direct sun and sky radiance measurements
- 2-axis tracker: observations at several elevation and azimuth viewing angles
- target products:
  - total/tropospheric columns and vertical profiles of trace gases; NO_2, O_3, HCHO, O_4
  - aerosol extinction profiles and optical depth

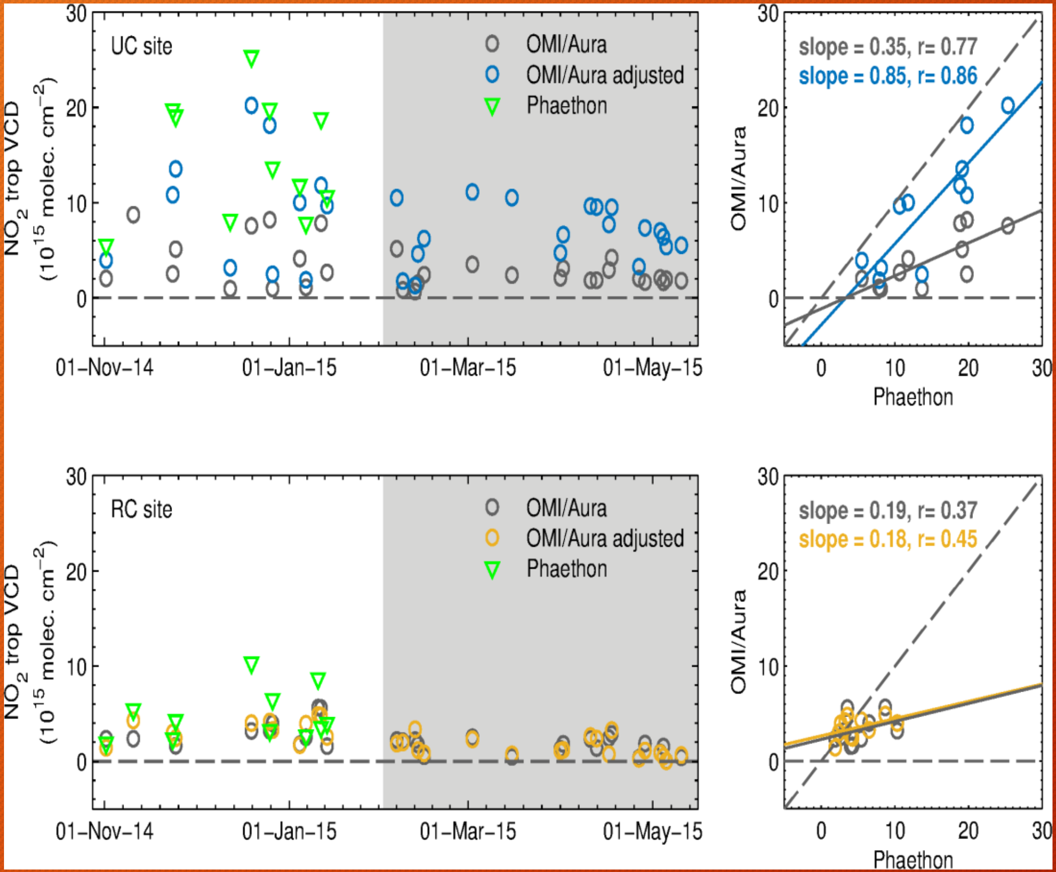
Tropospheric NO_2 at Thessaloniki

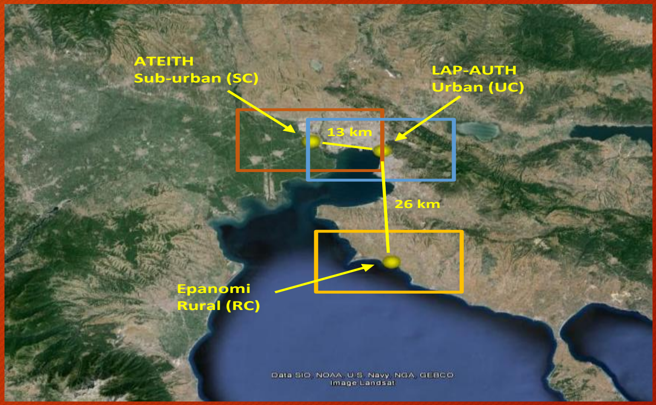


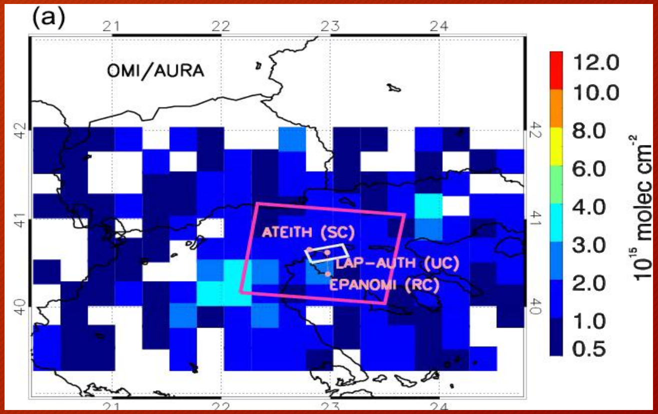
The instrument was developed at AUTH with the support of ESA, GSRT and BIRA

Drosoglou, T., et al., ACP, 2017.

Comparisons with satellite with the aid of an air quality model

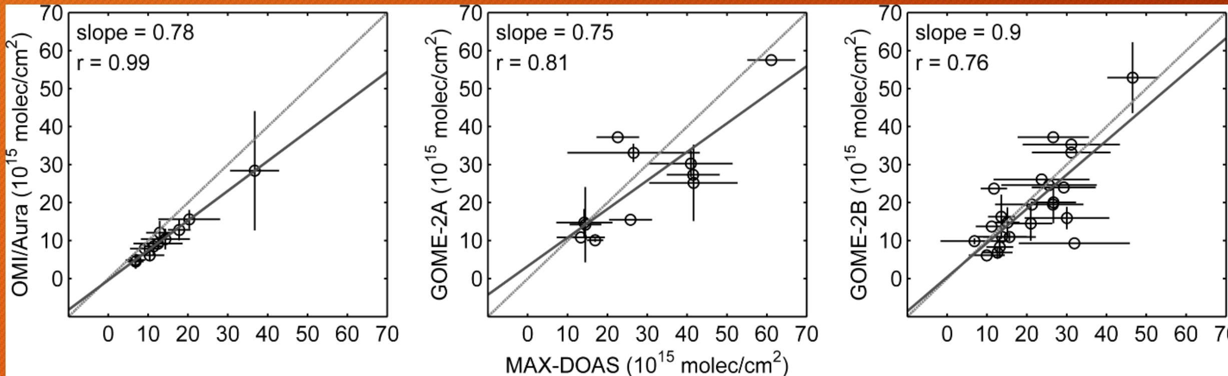




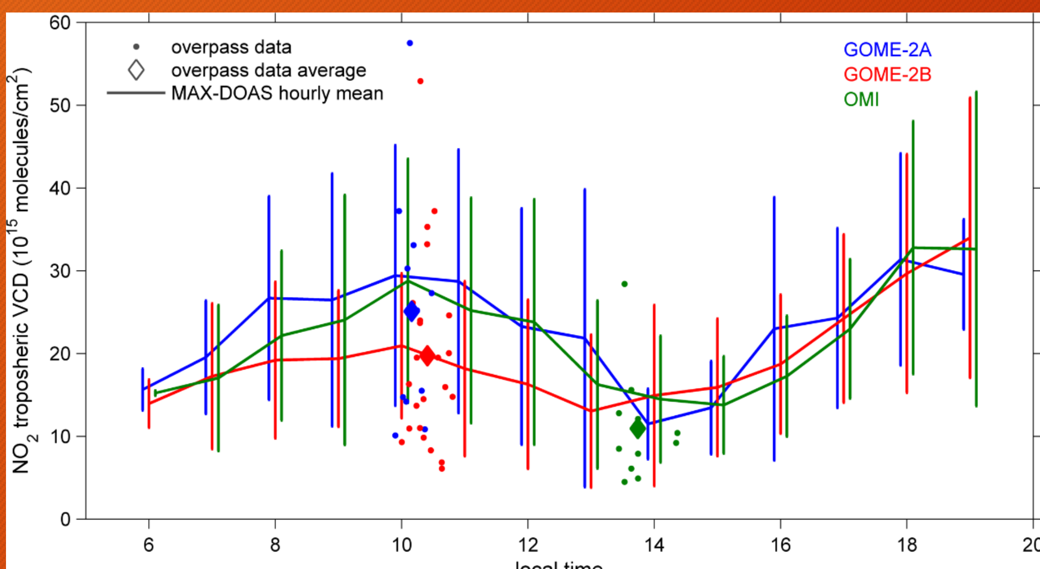


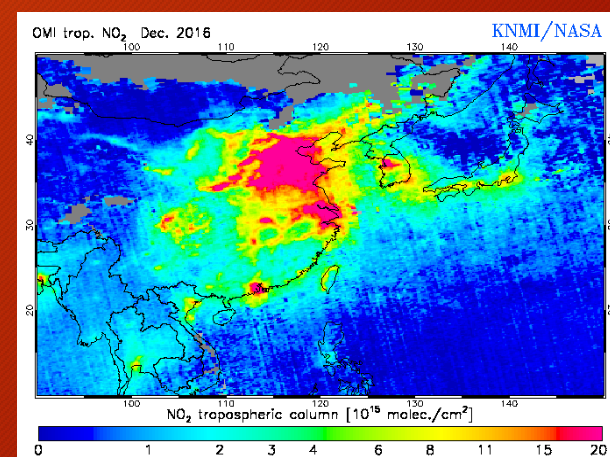
Drosoglou, T., et al., ACP, 2017.

Ghuangzhou – China (MarcoPolo) (2015-2016)



- OMI NO_2 product: DOMINO v2.0
- GOME-2A, GOME-2B products: TM4NO2A version 2.3



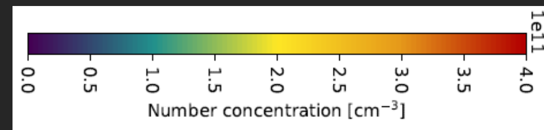


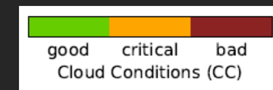
Drosoglou et al., AMT, 2017

Overview

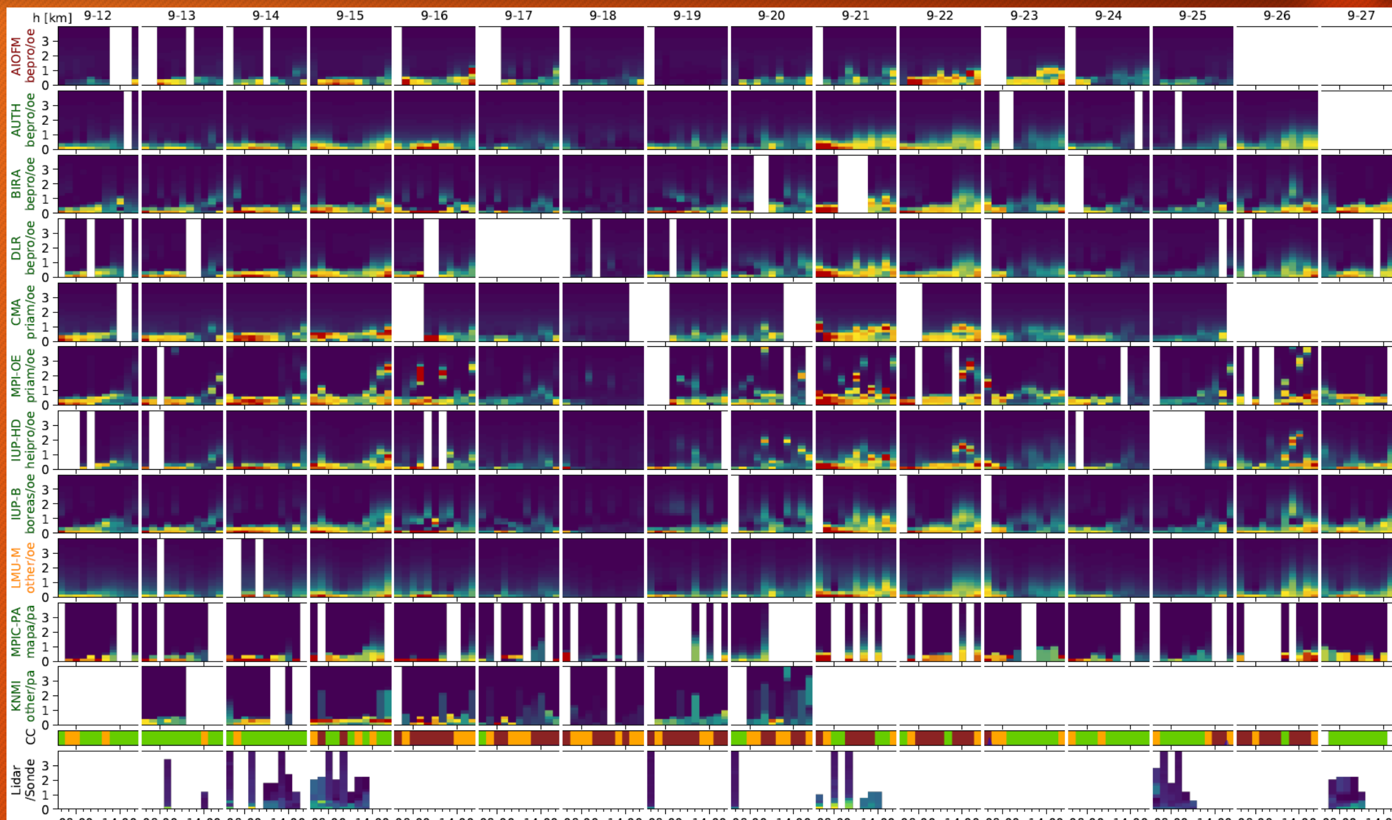
NO_2 - UV

Monday





Sat Mon Sat Mon



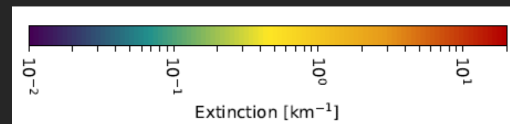
Jan-Lukas Tirpitz (1), Udo Frieß (1), Francois Hendrick (2) and the CINDI-2 Profiling Task Team

Cabauw Intercomparison of Nitrogen Dioxide Measuring Instruments 2 September 2016

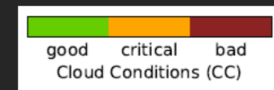
Overview

Aerosol - 360 nm

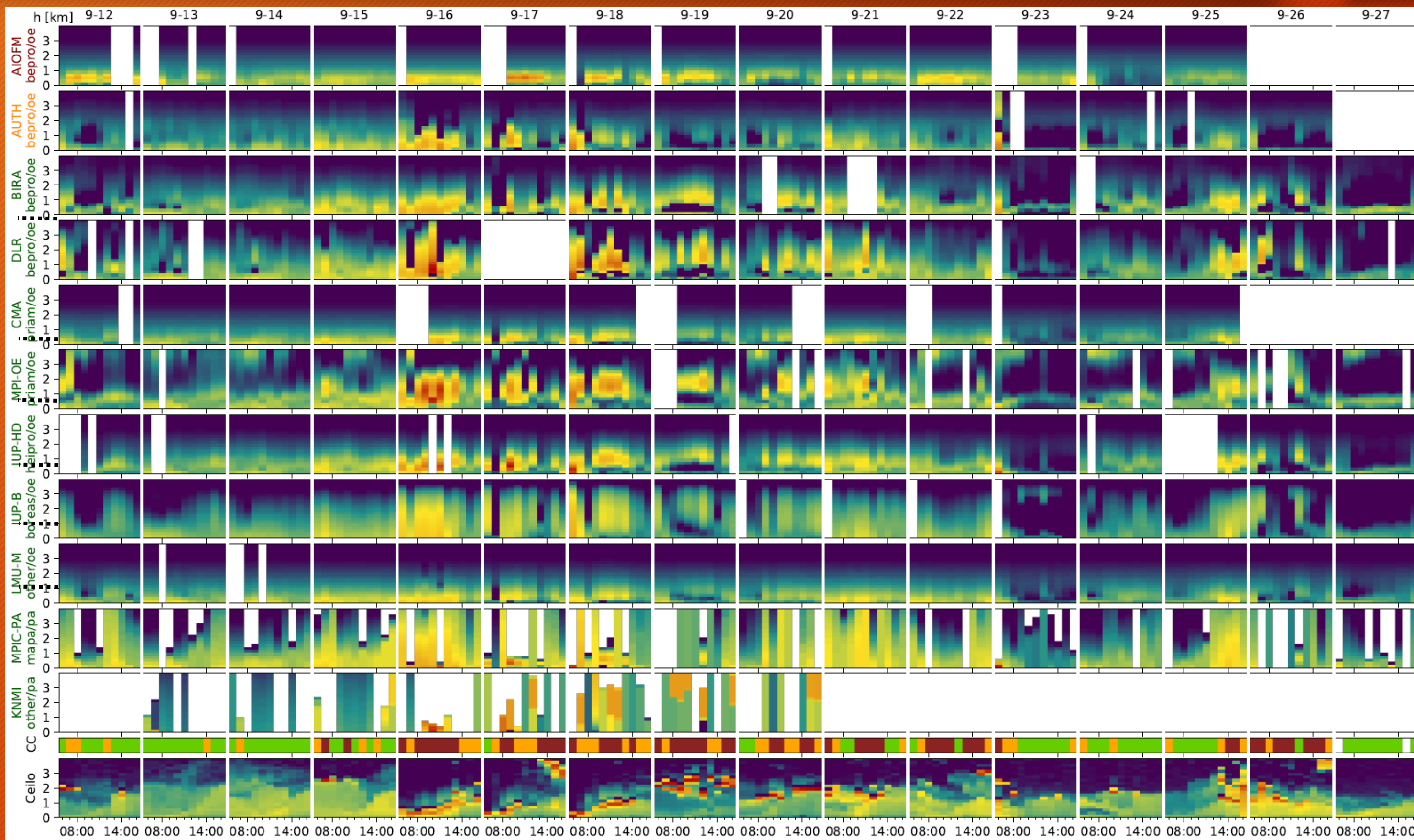
Monday



Sat Mon



Sat Mon



Jan-Lukas Tirpitz (1), Udo Frieß (1), Francois Hendrick (2) and the CINDI-2 Profiling Task Team

Cabauw Intercomparison of Nitrogen Dioxide Measuring Instruments 2 September 2016

Validation of satellite products for the atmospheric composition

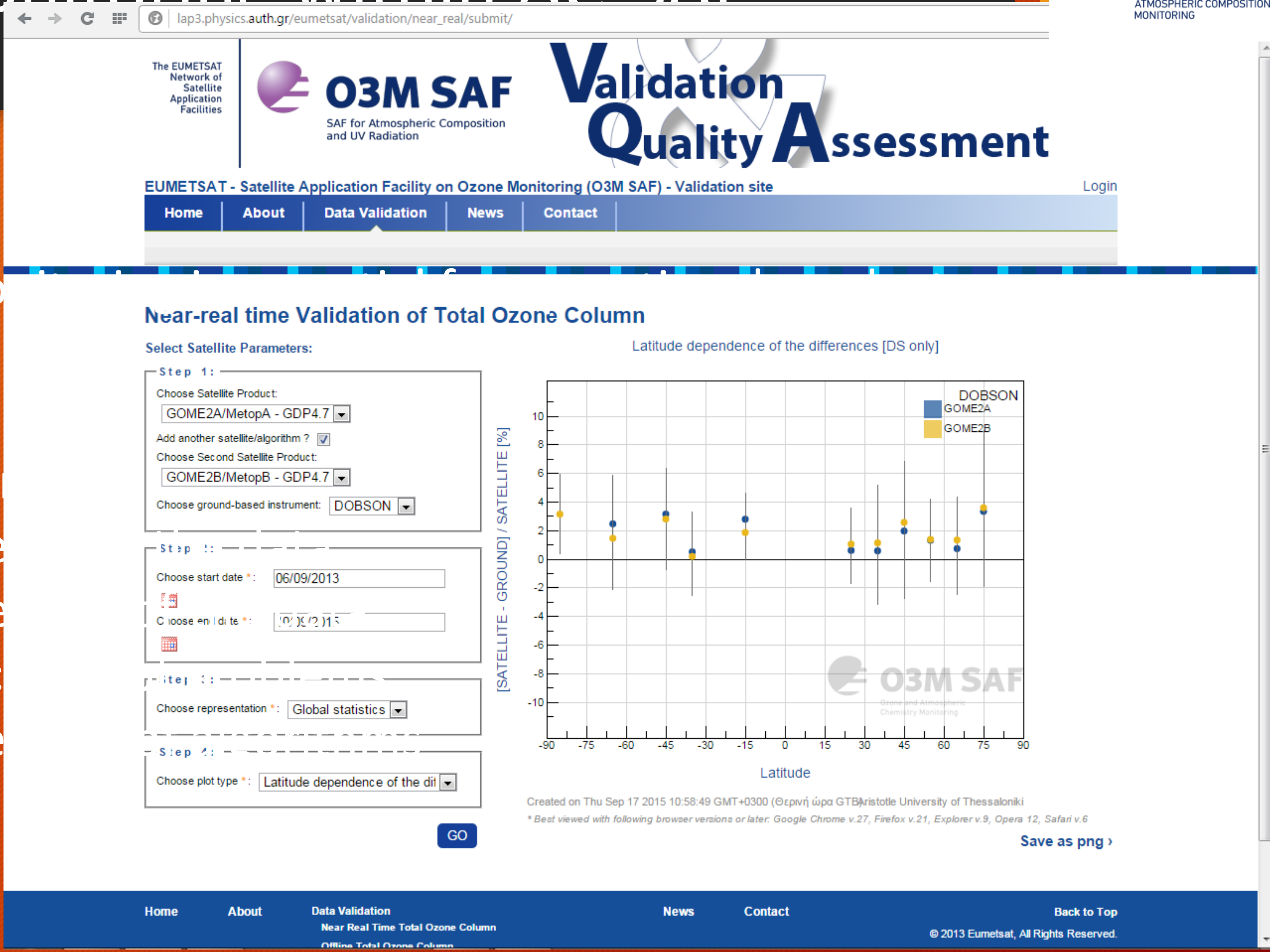
Validation of satellite products - EUMETSAT

EUMETSAT AC SAF ATMOSPHERIC COMPOSITION MONITORING

- Validation and near-to-real time Quality monitoring is an inherent part of the O3M-SAF (March 2017 -> **AC-SAF)**
- Supports MetOp satellites, GOME-2 and IASI instruments and a large number of operational products
- http://lap3.physics.auth.gr/eumetsat
- http://cdop.aeronomie.be

QA monitoring within AC-SAF

EUMETSAT
AC SAF
ATMOSPHERIC COMPOSITION MONITORING

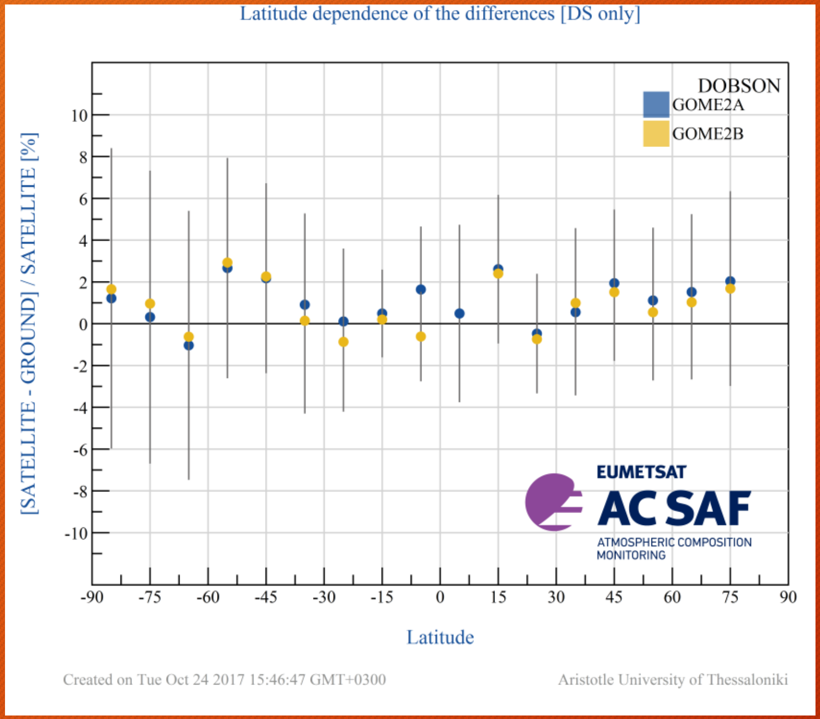


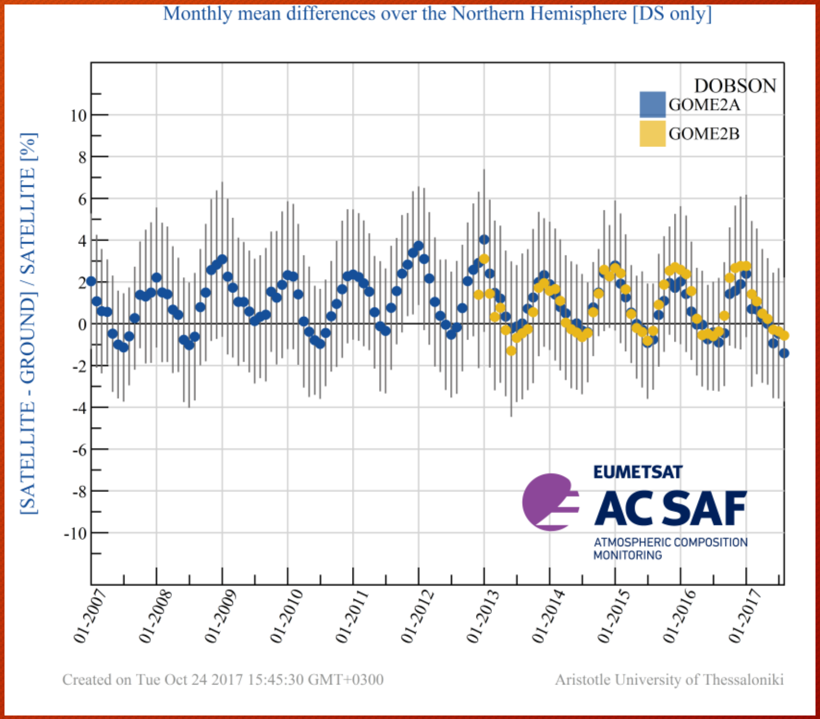
Quality Mo

Benefits fo

- Consiste
- Homoge
- Identific
- Improve

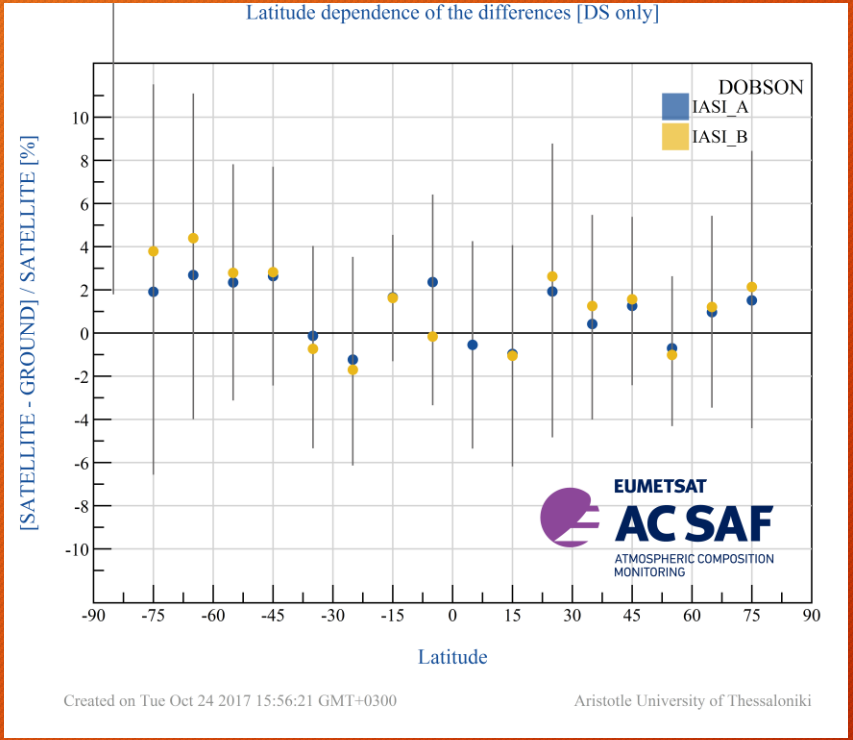
GOME-2 GDP4.8 total ozone validation

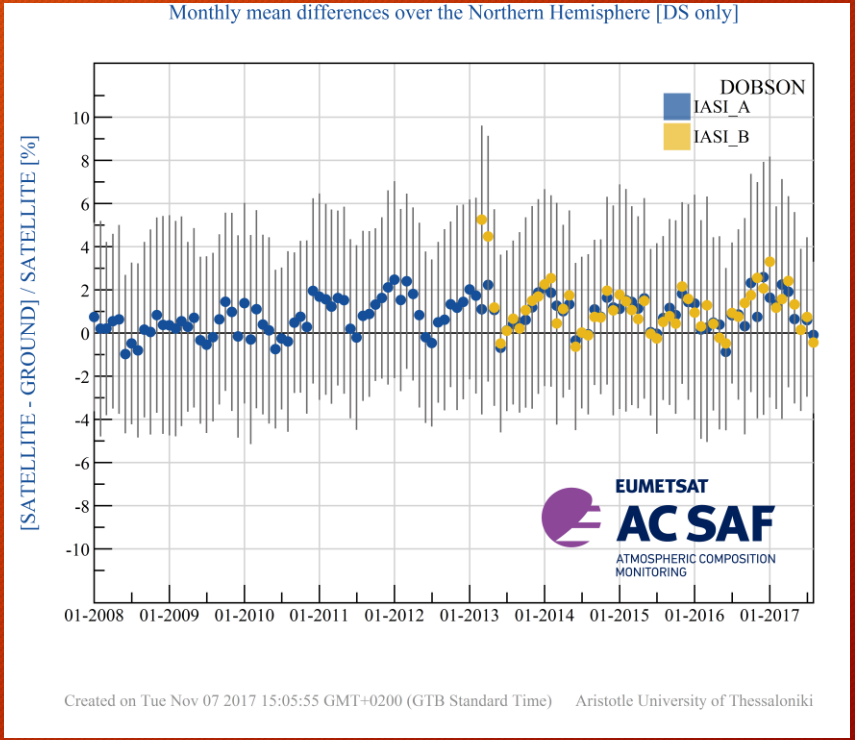




From http://lap3.physics.auth.gr/eumetsat

IASI-FORLI total ozone validation (AC-SAF)

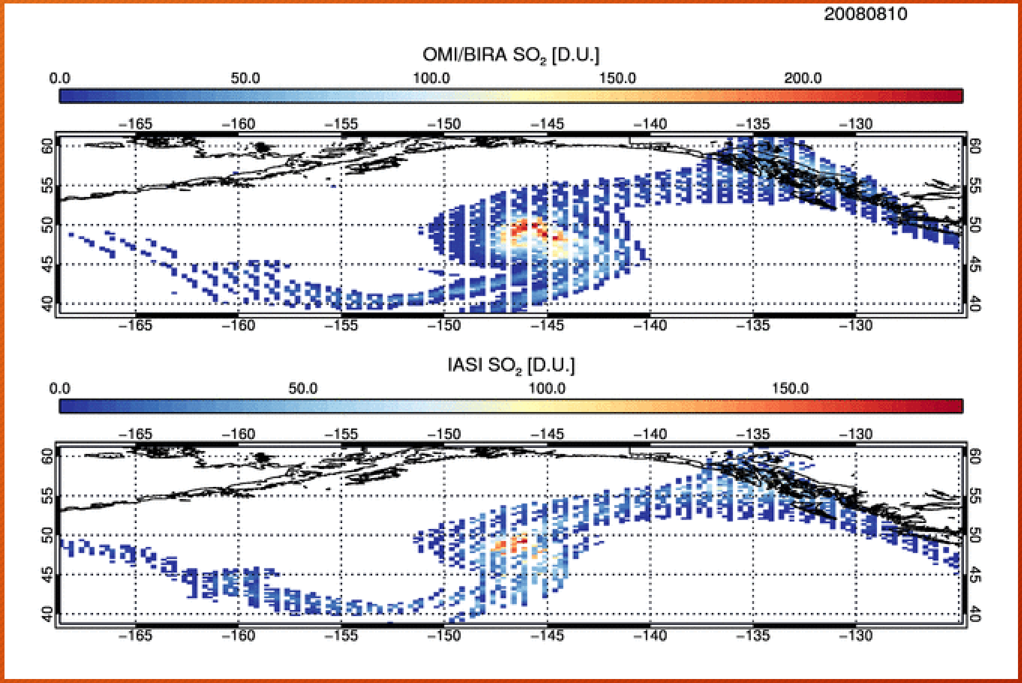


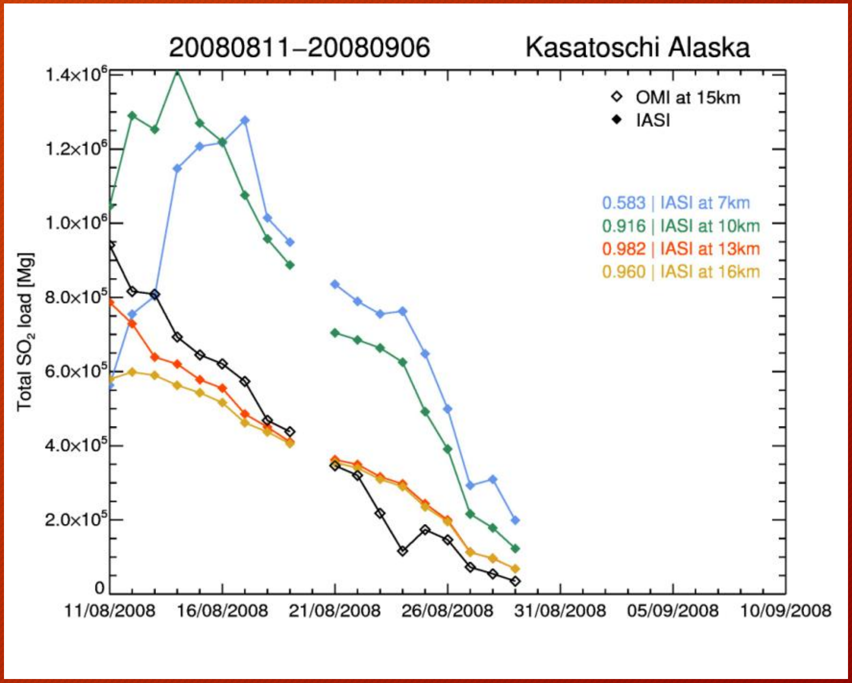


Validation of volcanic SO_2 (AC-SAF)

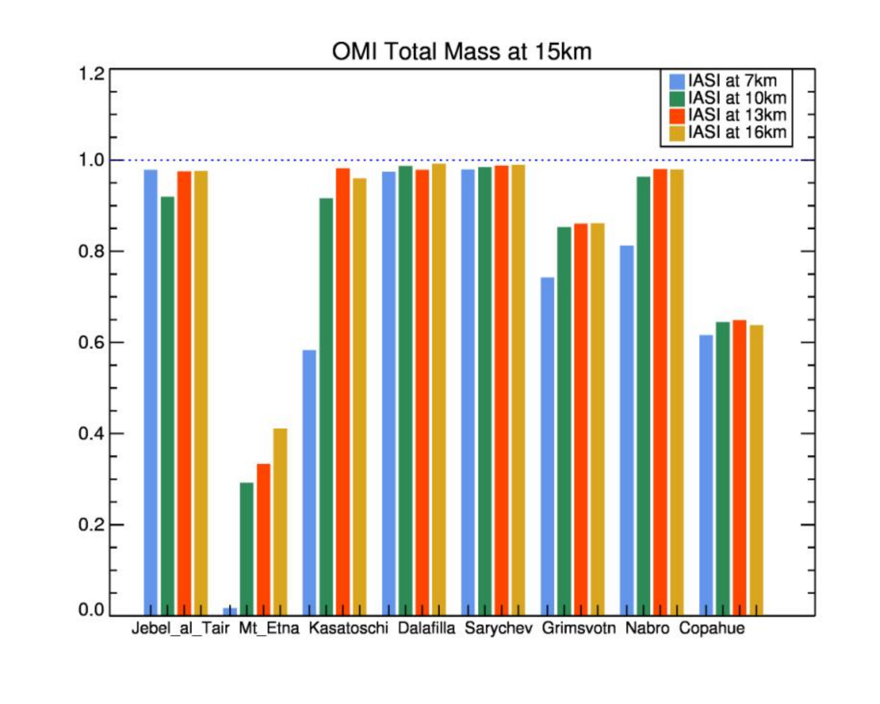
EUMETSAT AC SAF ATMOSPHERIC COMPOSITION MONITORING

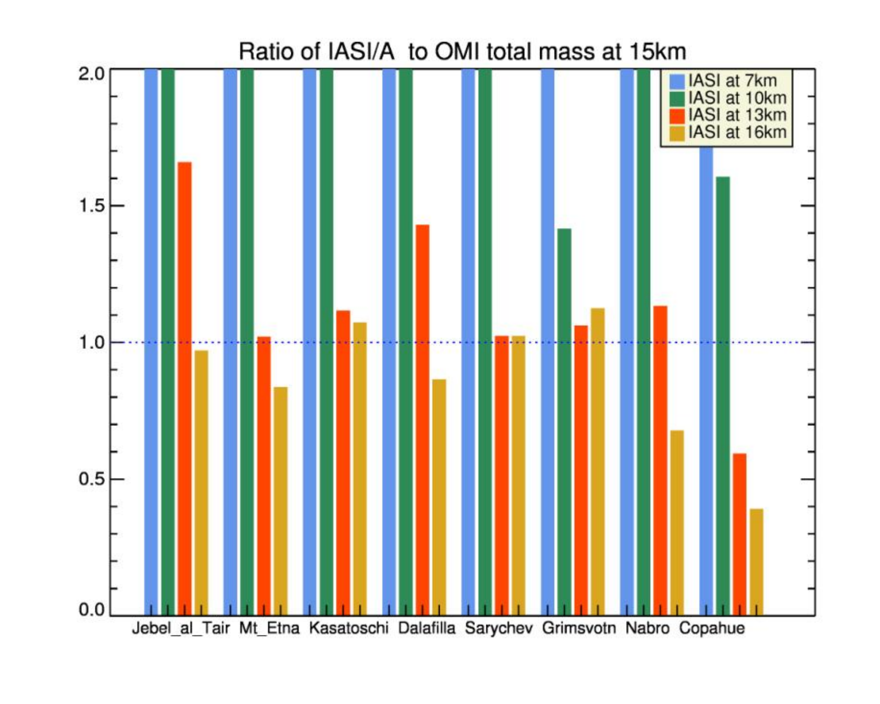
Kasatochi 2008 eruption, Alaska





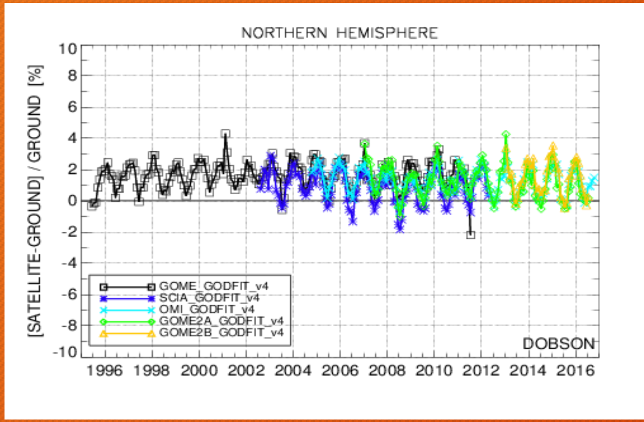
Validation of volcanic SO_2 (AC-SAF)

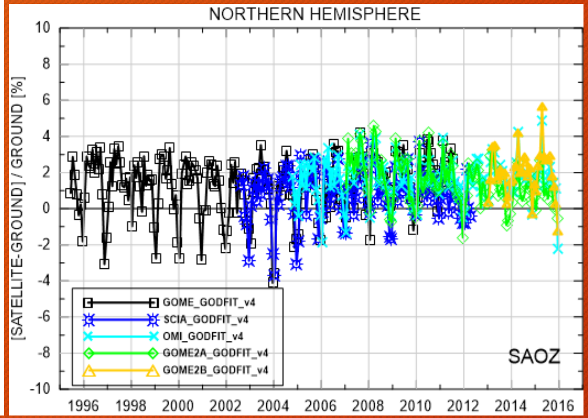


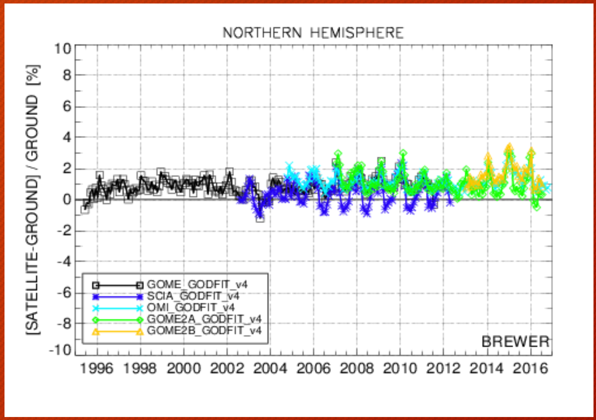


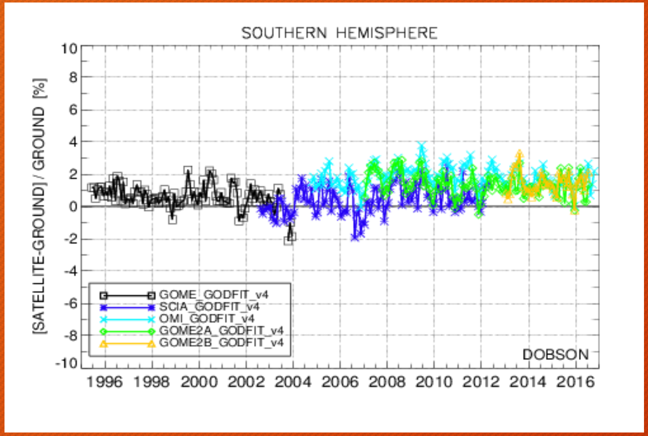
Correlation coefficient

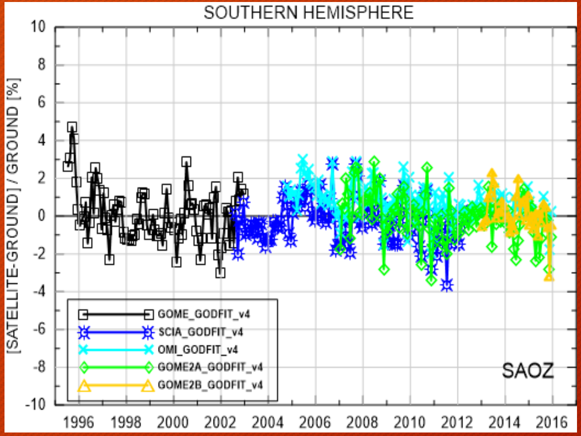
Validation activities within ESA's Ozone CCI GODFIT v4. level-2





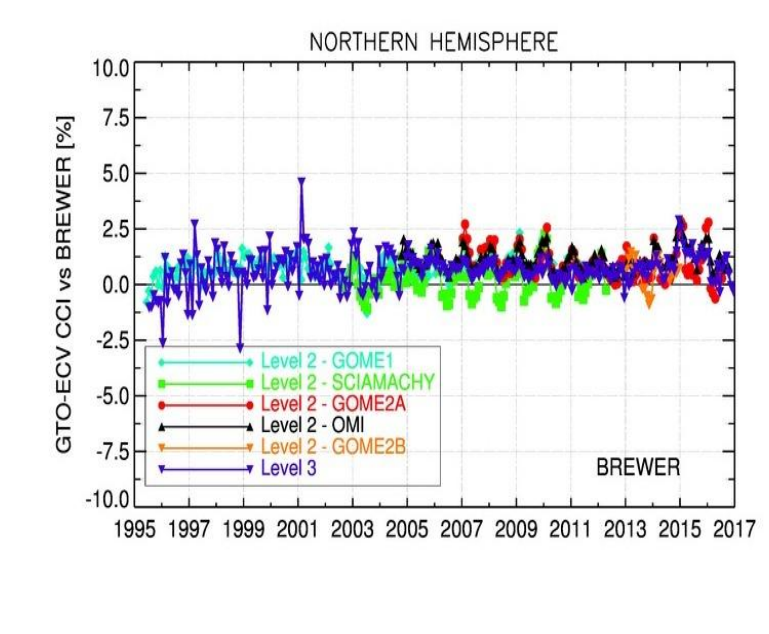


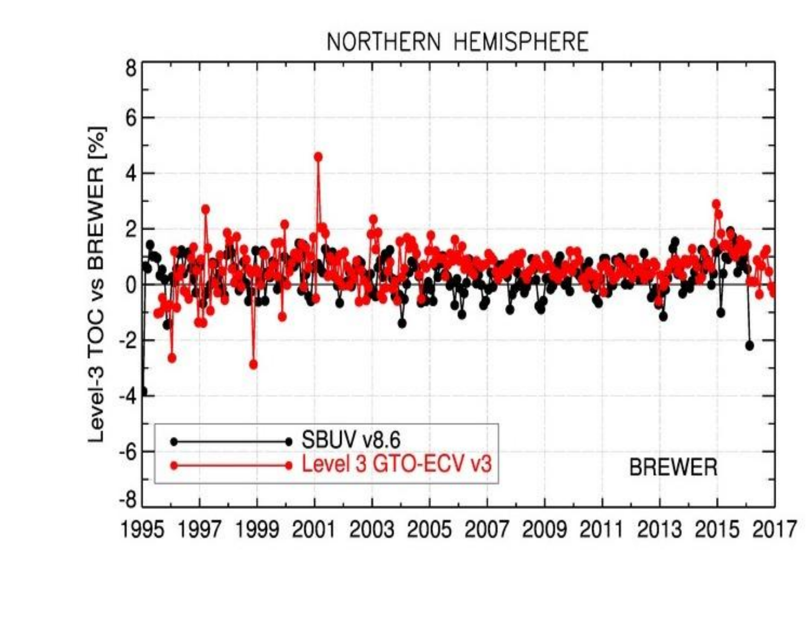




Garane et al., AMTD, 2017

GTO-ECV level-3 validation





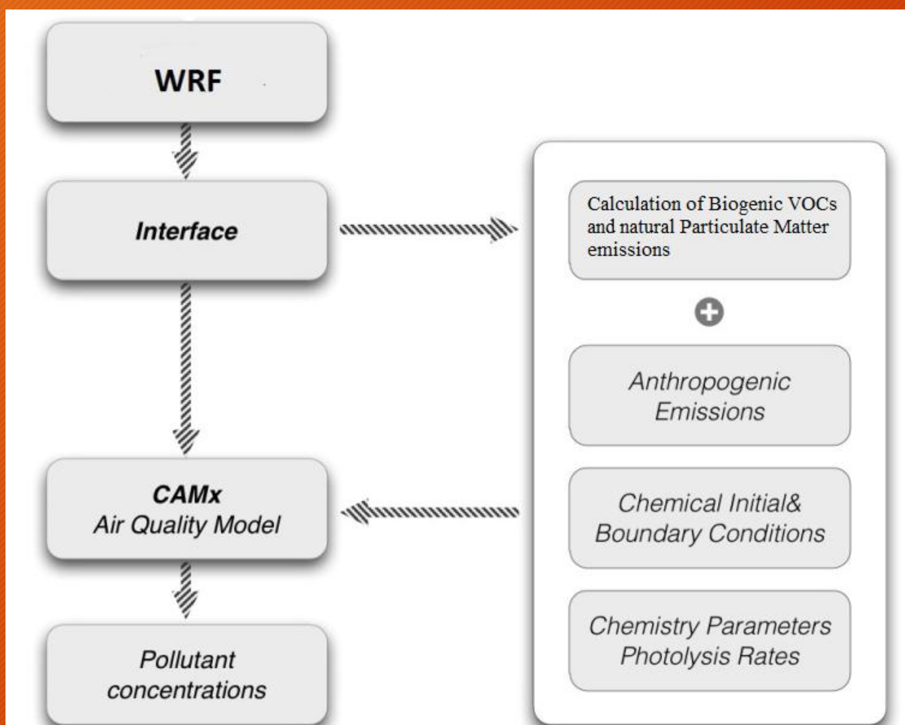
Garane et al., AMTD, 2017

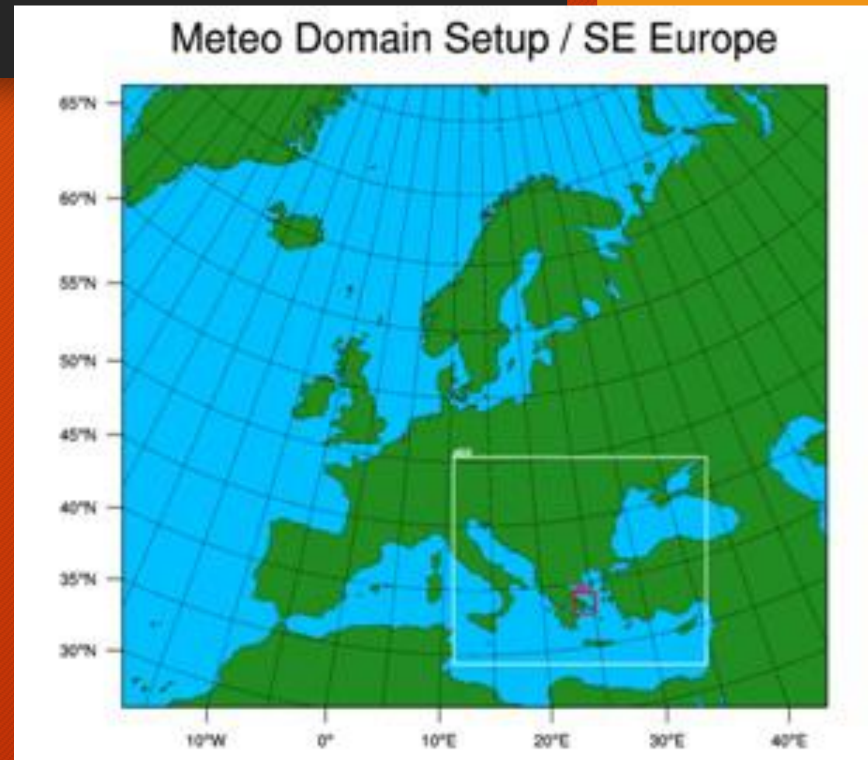
Overview of air quality studies using satellite data

LAP/AUTH Air Quality Modelling

Europe (30km)
Eastern Mediterranean (10km)
Athens – Thessaloniki (2 km)

The WRF (3.2.1) - CAMx (5.3) system runs operationally to issue 72-hours forecasts of O_3, NO_2, NO, CO, SO_2, PM2.5 and PM10 up to about 10 km a.g.l.





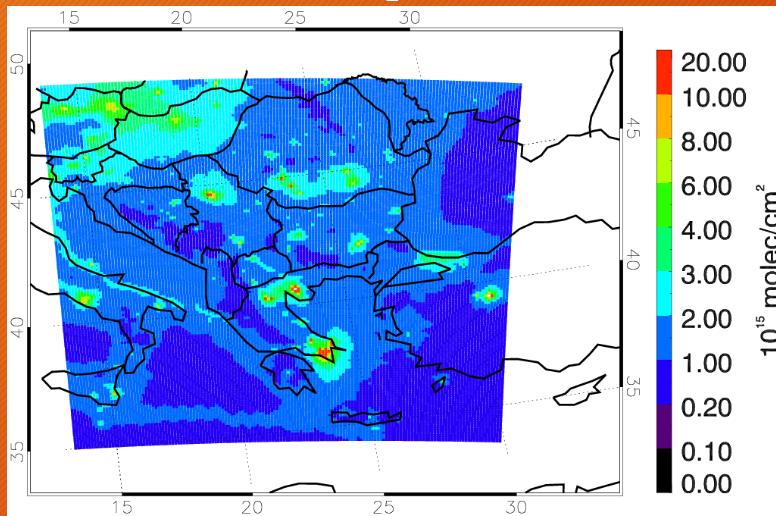
macc Monitoring atmospheric composition & climate

Myair Pasodoble

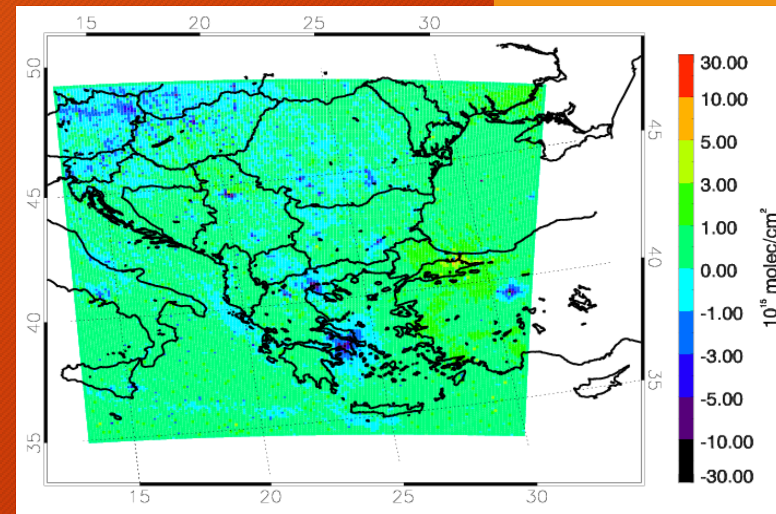
ANNUAL (04/2009-03/2010) DISTRIBUTIONS

NO_2 concentration in 10^{15} molecules/cm^2

CAMx simulated tropospheric NO_2 columns



OMI/Aura minus CAMx tropospheric NO_2 columns

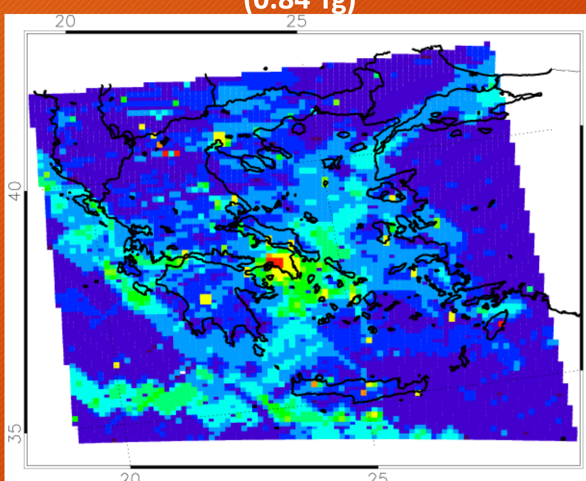


INVERSE MODELLING

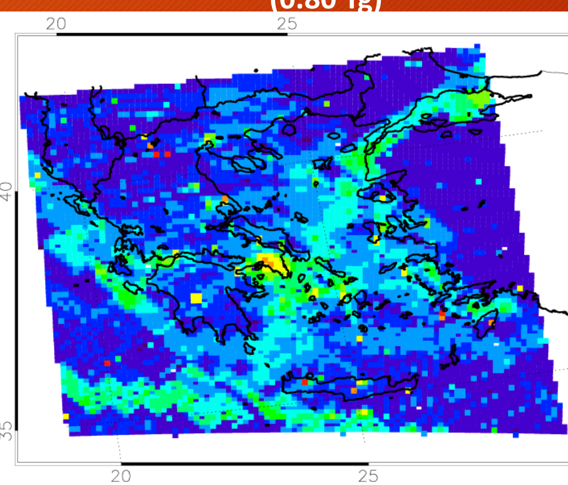
Mass balance approach
(Martin et al., 2003)

NOx emissions in 10^3 kg

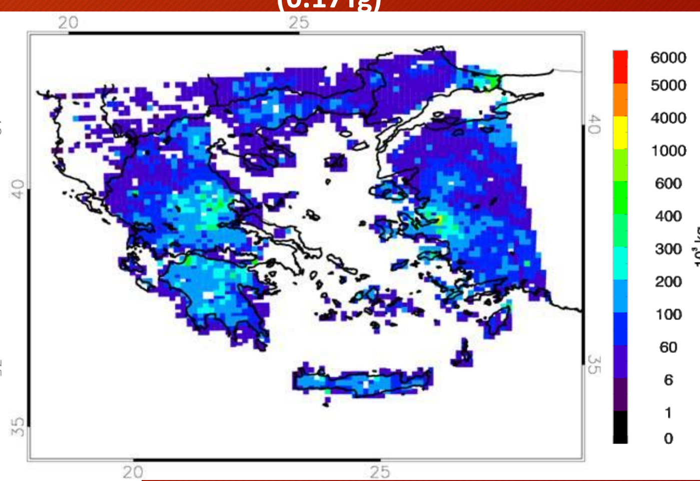
Fossil fuel a priori emissions
(0.84 Tg)



Fossil fuel a posteriori emissions
(0.80 Tg)



Soil a posteriori emissions
(0.17Tg)

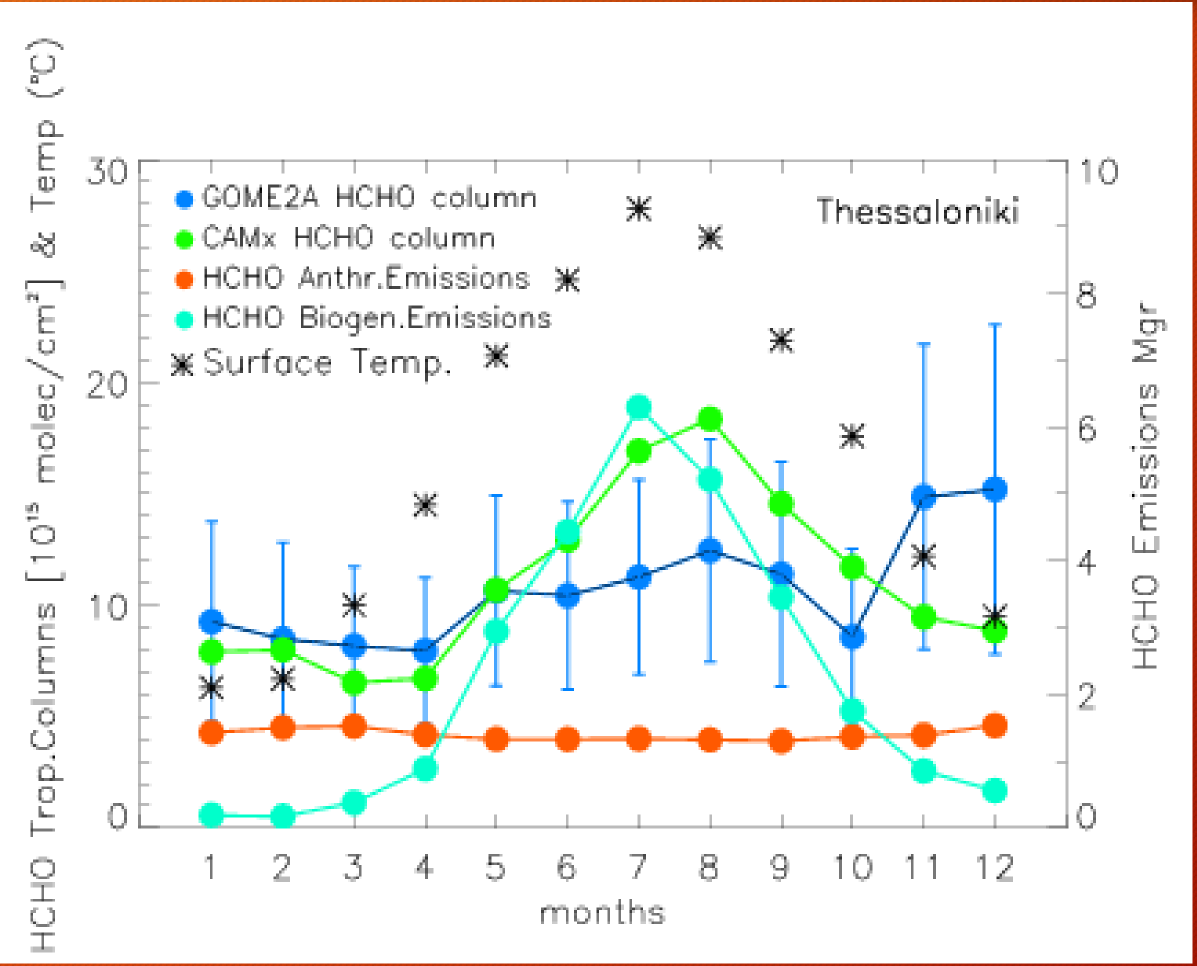


LAP/Auth Satellite Data Team – HCHO

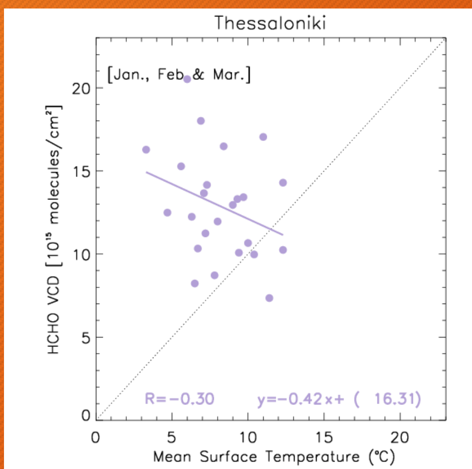
Satellite HCHO observations have been analyzed in order to update existing HCHO emission inventories over Europe in view of the changes in heating preferences in Southern European countries which were mostly affected by the economic recession of recent years.

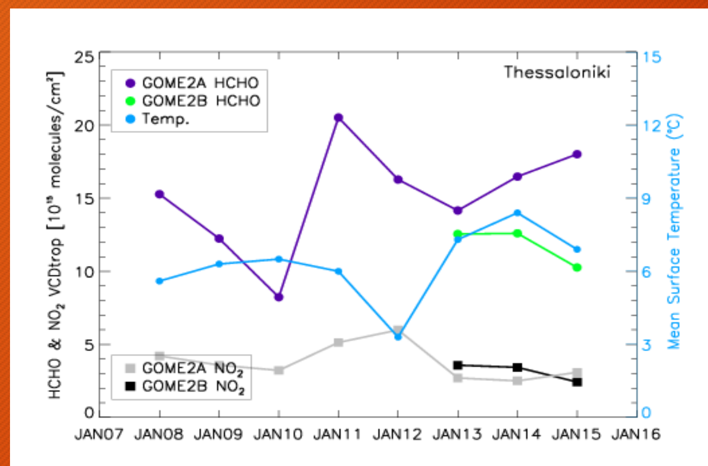
Zyrichidou I., Balis D., Liora N., et al., **Investigating the impact of the economic recession over Mediterranean urban regions on satellite-based formaldehyde columns; comparison with chemistry transport model results,** Proceedings of the 13th International Conference on Meteorology, Climatology and Atmospheric Physics, 19-21 September, Thessaloniki, Greece, 2016.

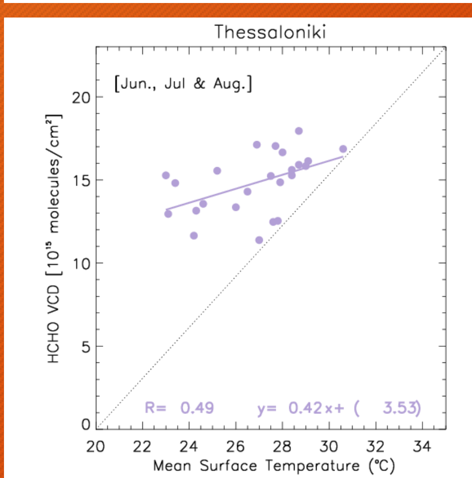
Evaluating CAMx HCHO emissions using GOME2A observations - 2009



The possible effect of increased wood sales in HCHO

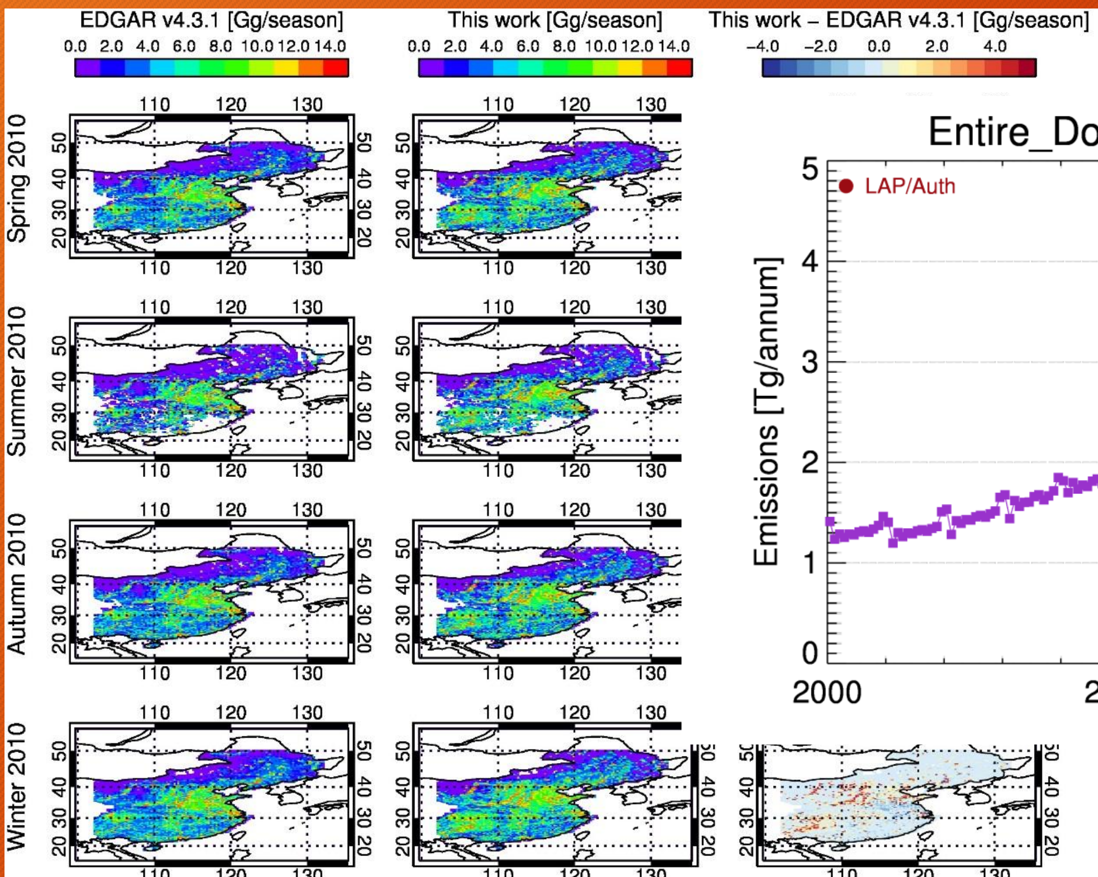


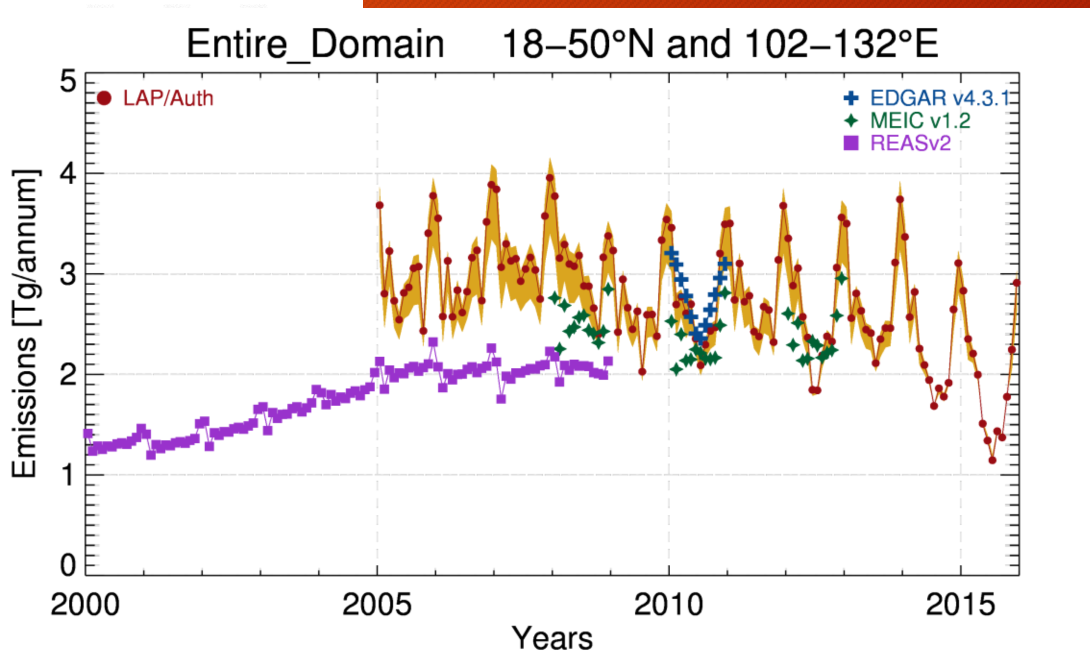




Increase of the retail sales of wood by almost 700%) since the beginning of the economic recession

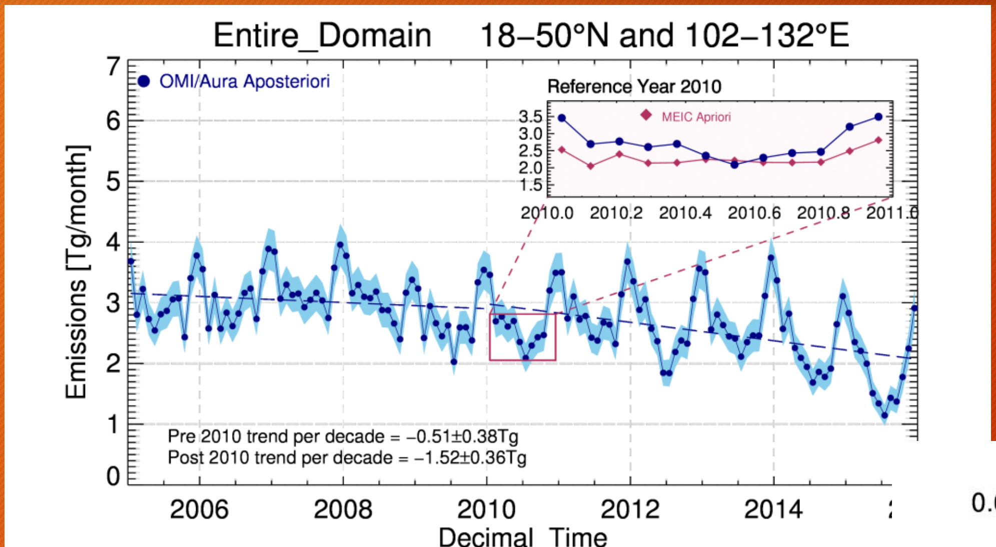
LAP/Auth Satellite Data Team – SO_2 emissions over China

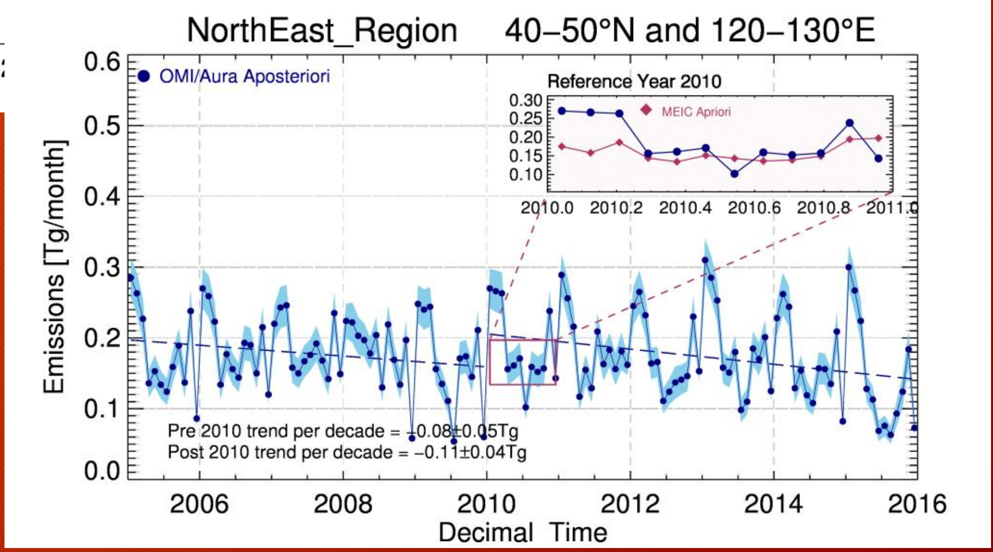




Koukouli et al., AMTD, 2017

LAP/Auth Satellite Data Team – SO_2 emissions over China





Koukouli et al., AMTD, 2017

Vielen Dank für Ihre Aufmerksamkeit
Thank you for your attention