

Joint retrieval of aerosol and surface reflectance from **SEVIRI**


Yves GOVAERTS and Marta LUFFARELLI

RAYFERENCE

CEOS AC-AV 13, Paris, 29 June 2017

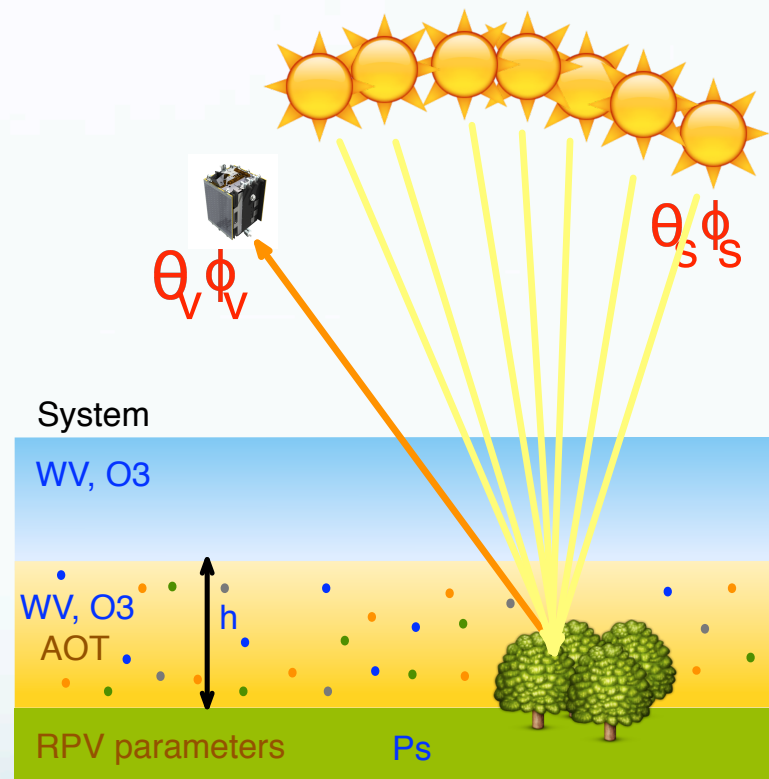
CISAR

The **C**ombined **I**nversion of **S**urface and **AeR**osols (CISAR) algorithm for the joint retrieval of aerosol properties and surface reflectance with a continuous variation of the state variables in the solution space

- Theory : Govaerts, Y. and Luffarelli, M.: Joint retrieval of surface reflectance and aerosol properties with **continuous variations** of the state variables in the solution space: Part 1: theoretical concept, Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-29, 2017
- MSG/SEVIRI data processing: ESA Aerosol_cci 

CISAR ALGORITHM

- The CISAR algorithm relies on the inversion of a coupled surface-atmosphere **radiative transfer model** (FASTRE) (no LUT).
- The retrieval is based on an **Optimal Estimation** (OE) approach following the method proposed by Govaerts et al. (2010).
- The OE approach seeks the best balance between the information derived from the observations and prior knowledge.
- **Retrieval uncertainty** is also estimated based on the OE theory.



CISAR ALGORITHM

- SEVIRI data are accumulated in time (5-days) to form a multi-angular and multi-spectral observation vector used to characterize the anisotropy of the surface reflectance and aerosol properties;
- Every 5-days period, CISAR retrieves the **surface reflectance** field in SEVIRI the bands VIS0.6, VIS0.8, NIR1.6;
- The fine and coarse mode **AOD** at $0.55\mu\text{m}$, the single scattering albedo and the phase function are derived with an hourly temporal resolution;
- Aerosol single scattering properties are **continuously** retrieved in the solution space (not just for a set of pre-defined aerosol classes, Govaerts and Luffarelli, 2017).

CISAR ALGORITHM

The inversion relies on

- SEVIRI observations;
- Prior information on:
 - Surface reflectance properties determined from the previous processed periods;
 - Regularization on the aerosol single scattering properties spectral variations;
 - Regularization on the AOD temporal variations.



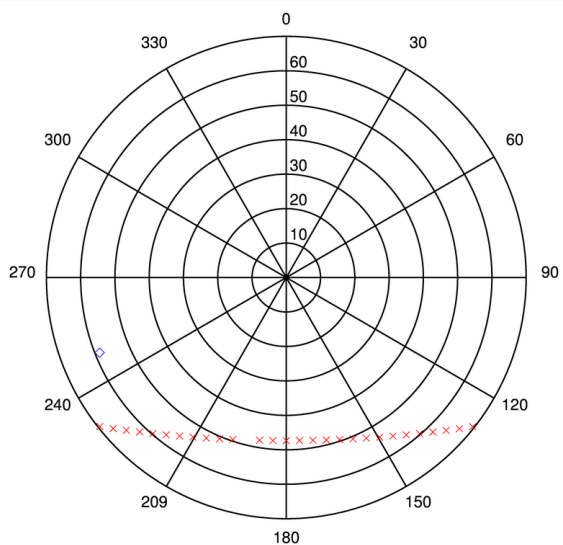
Aerosol_cci

SEVIRI HOURLY AEROSOL WITH CISAR

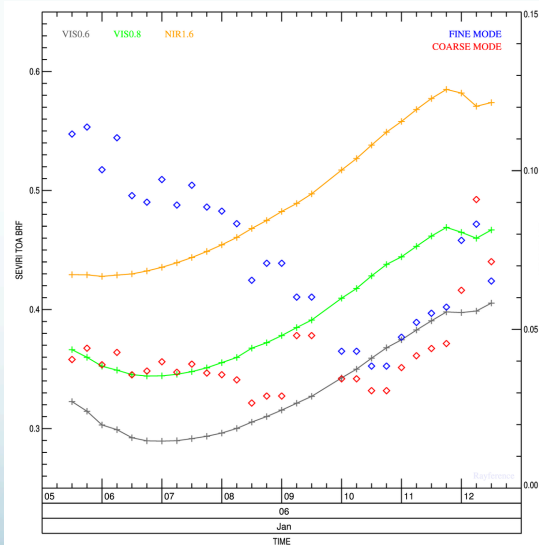
Daily variations of the Jacobians

Example over Solar Village on 06/01/2008

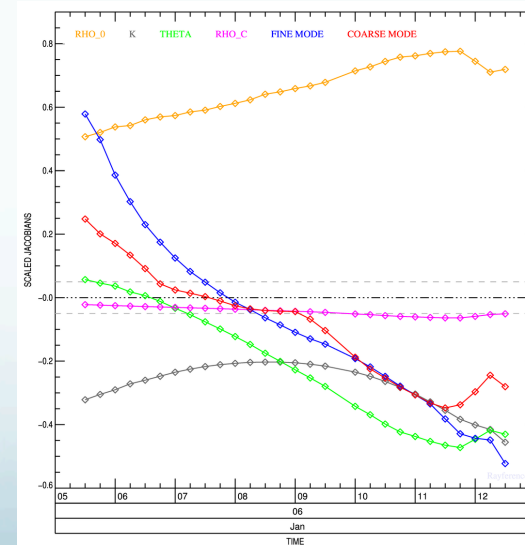
Geometry



Observations



Jacobians



CISAR ALGORITHM

A Quality Indicator is generated for each processed pixel and relies on:

1. The convergence of the algorithm to the solution;

2. The Entropy of the surface parameters;

$$H = -\frac{1}{2} \ln \left(\frac{\sigma_{posterior}}{\sigma_{prior}} \right)$$

3. The Entropy of the AOD;

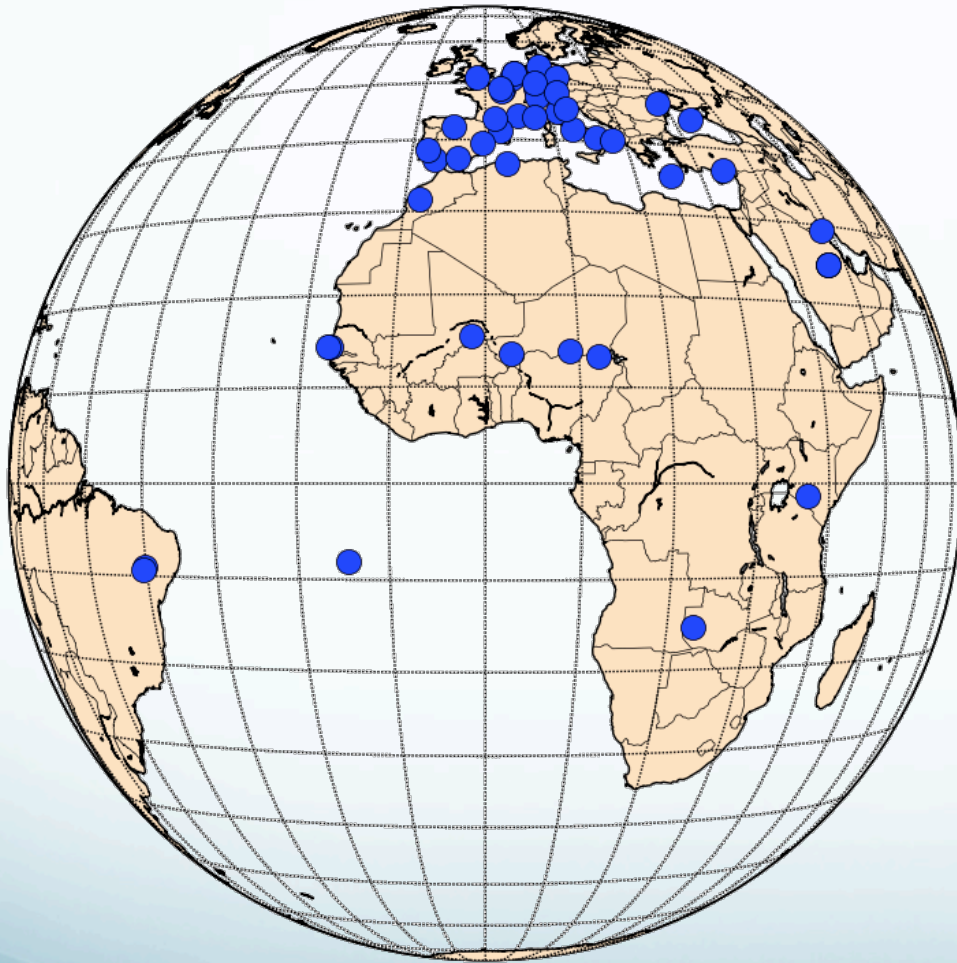
4. The magnitude of the observation cost function

$$Cost = \frac{|y_m - y_{obs}|}{\sigma_{obs}}$$

5. The magnitude of the Jacobians

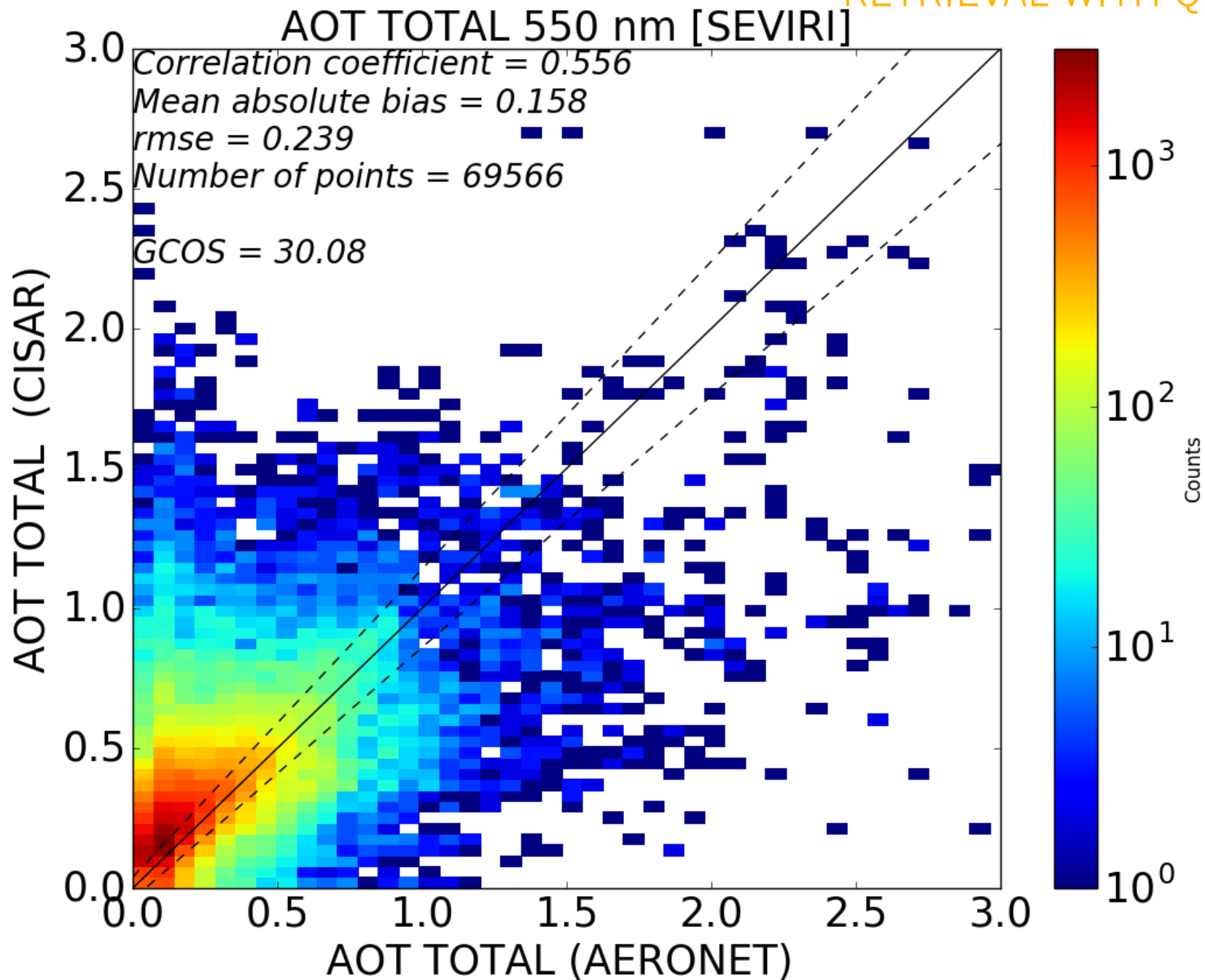
$$J = \frac{1}{\sigma_{obs}} \left| \frac{\partial y_m}{\partial x} \right|$$

COMPARISON WITH AERONET

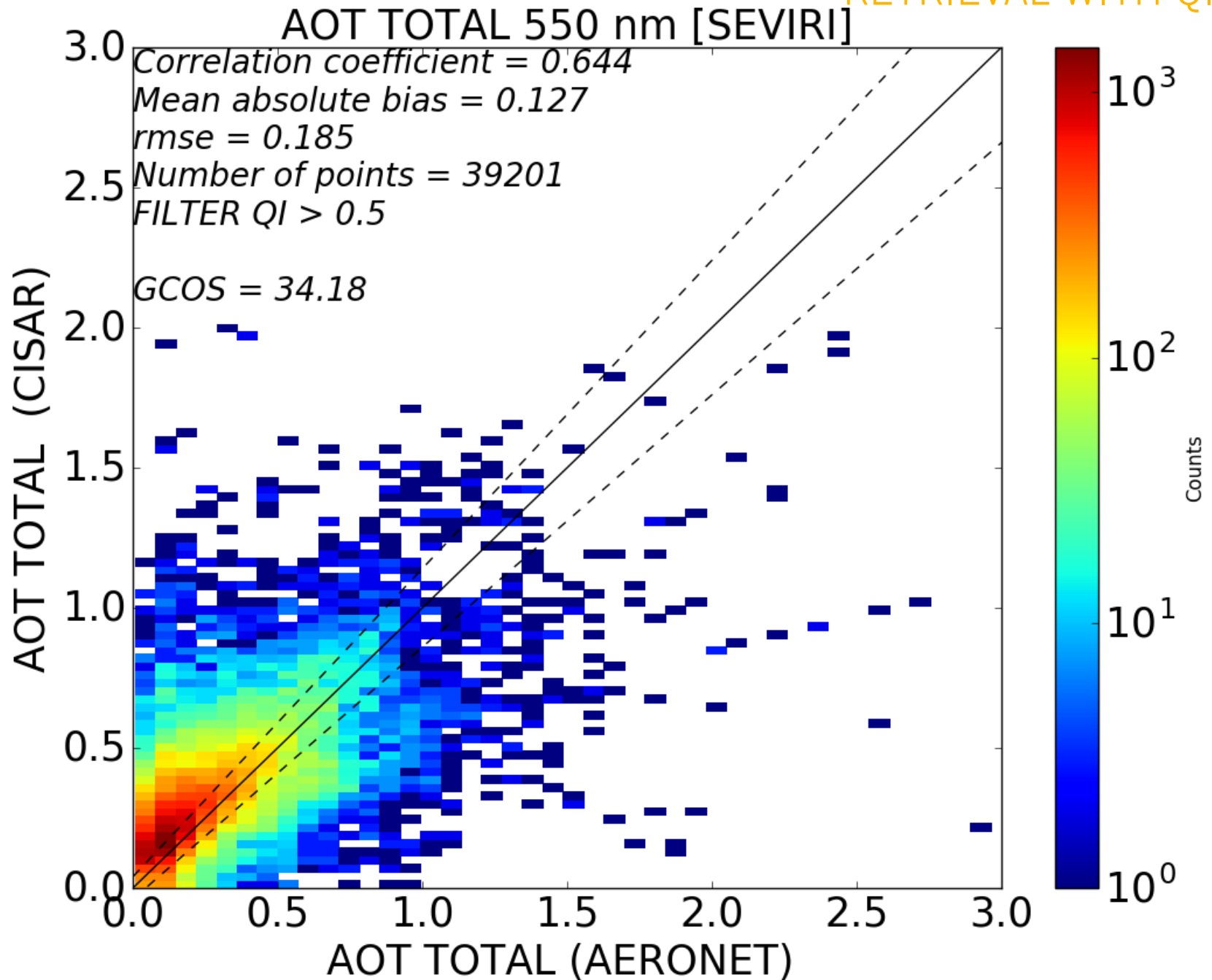


AERONET stations with observations all year long in 2008.

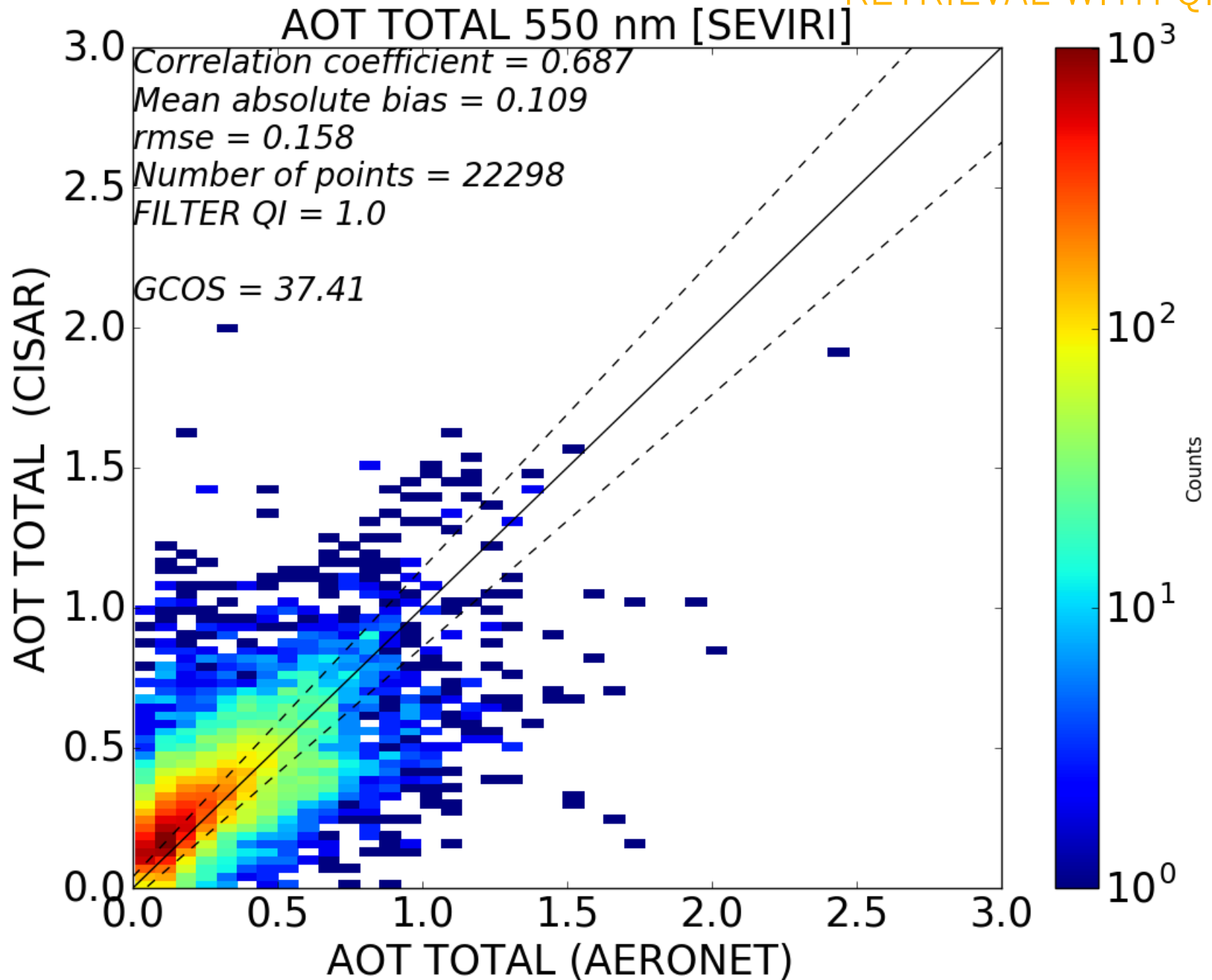
RETRIEVAL WITH $QI \geq 0.0$



RETRIEVAL WITH QI > 0.5



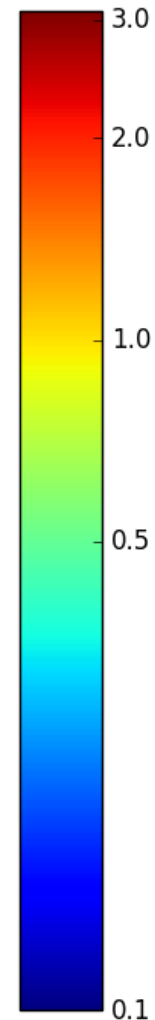
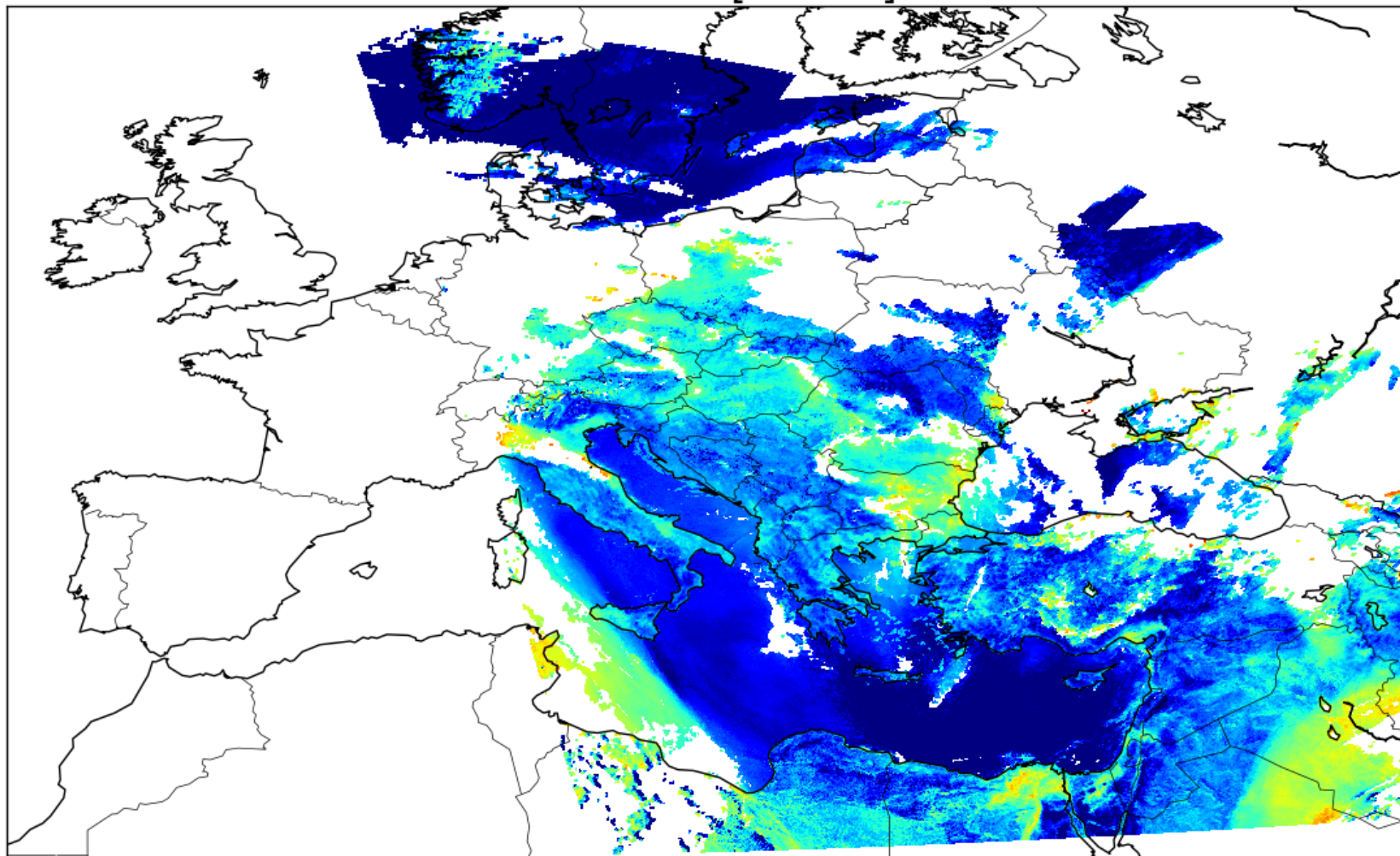
RETRIEVAL WITH QI = 1.0



Example of retrieval



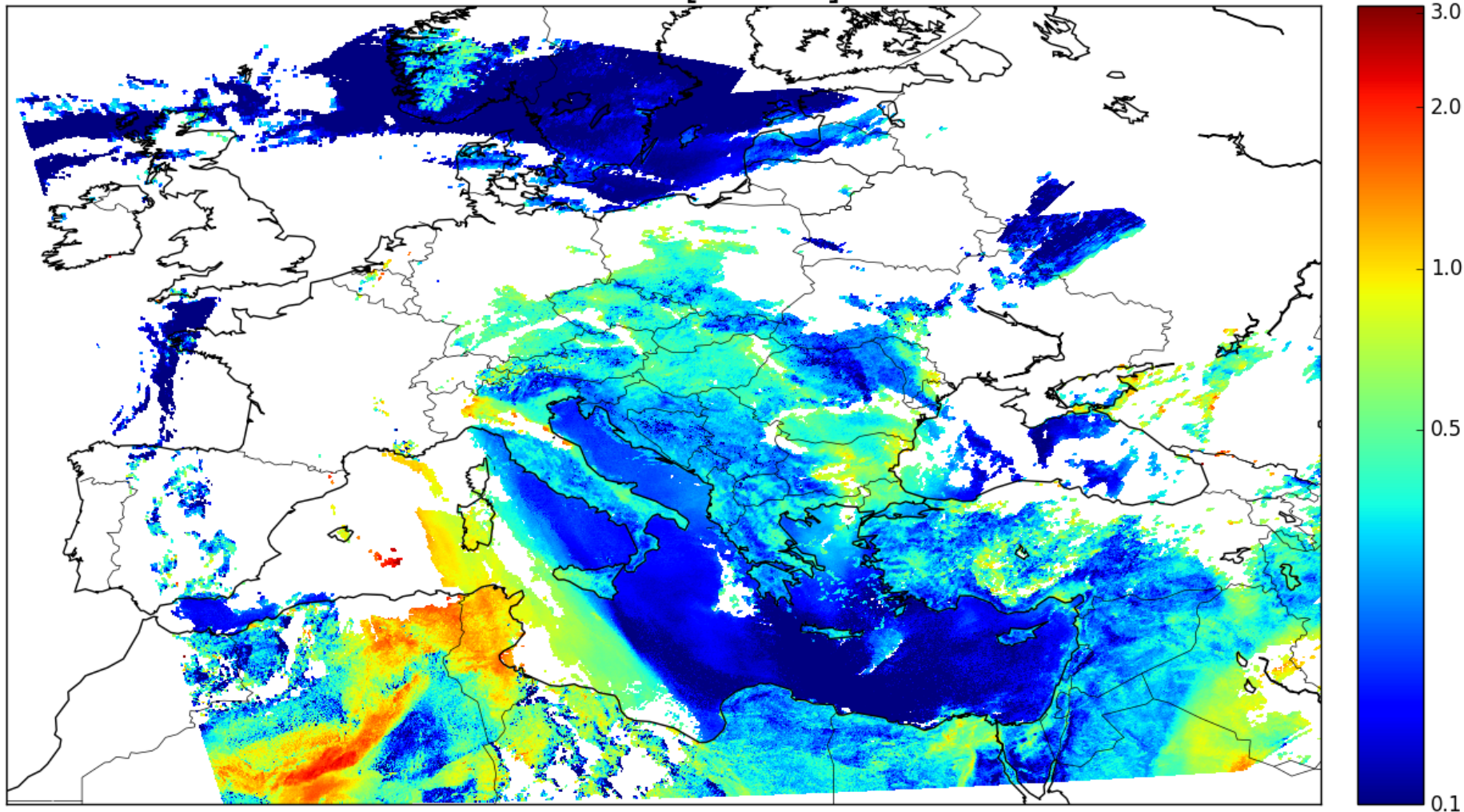
AOD550 [SEVIRI]



Example of retrieval



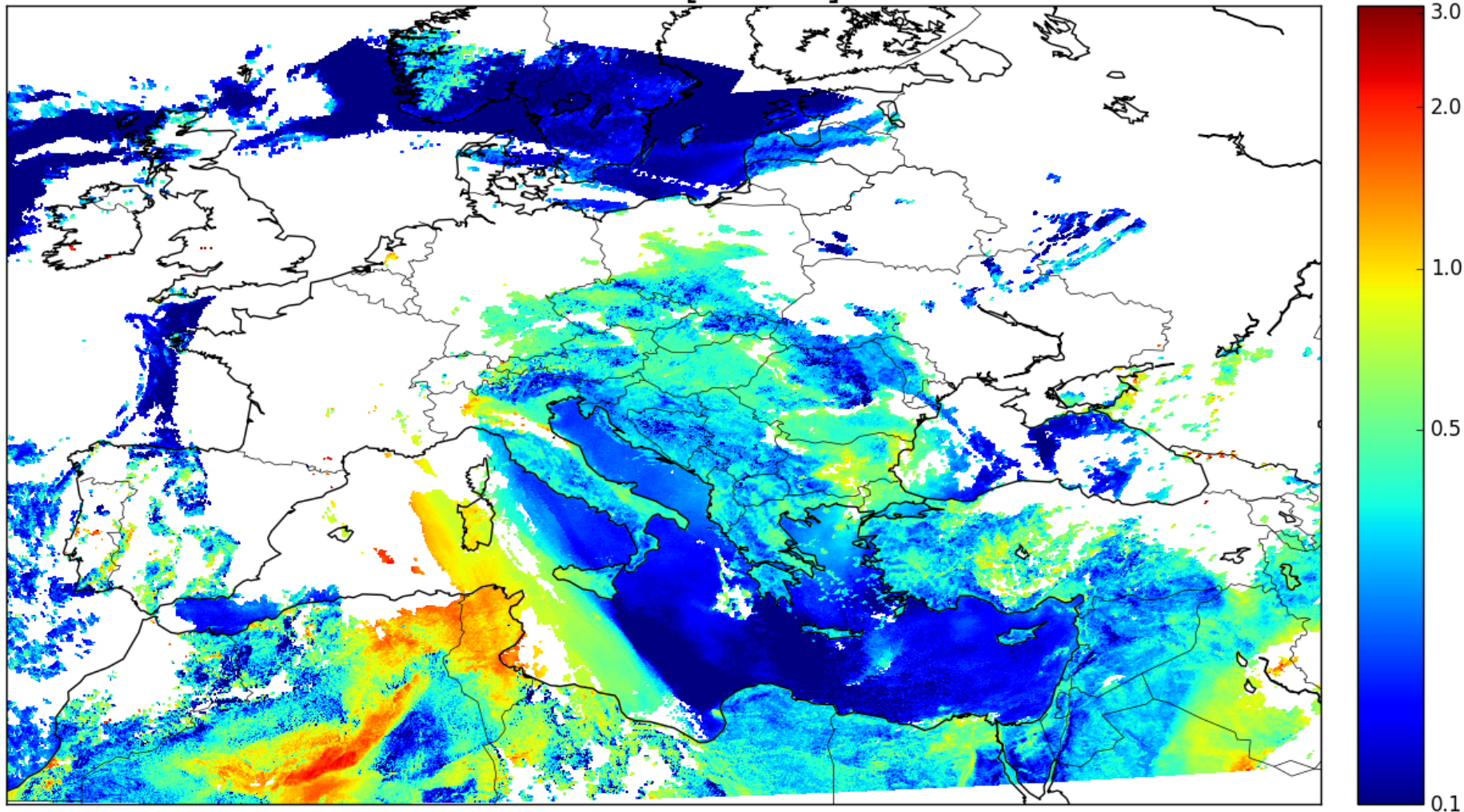
AOD550 [SEVIRI]



Example of retrieval



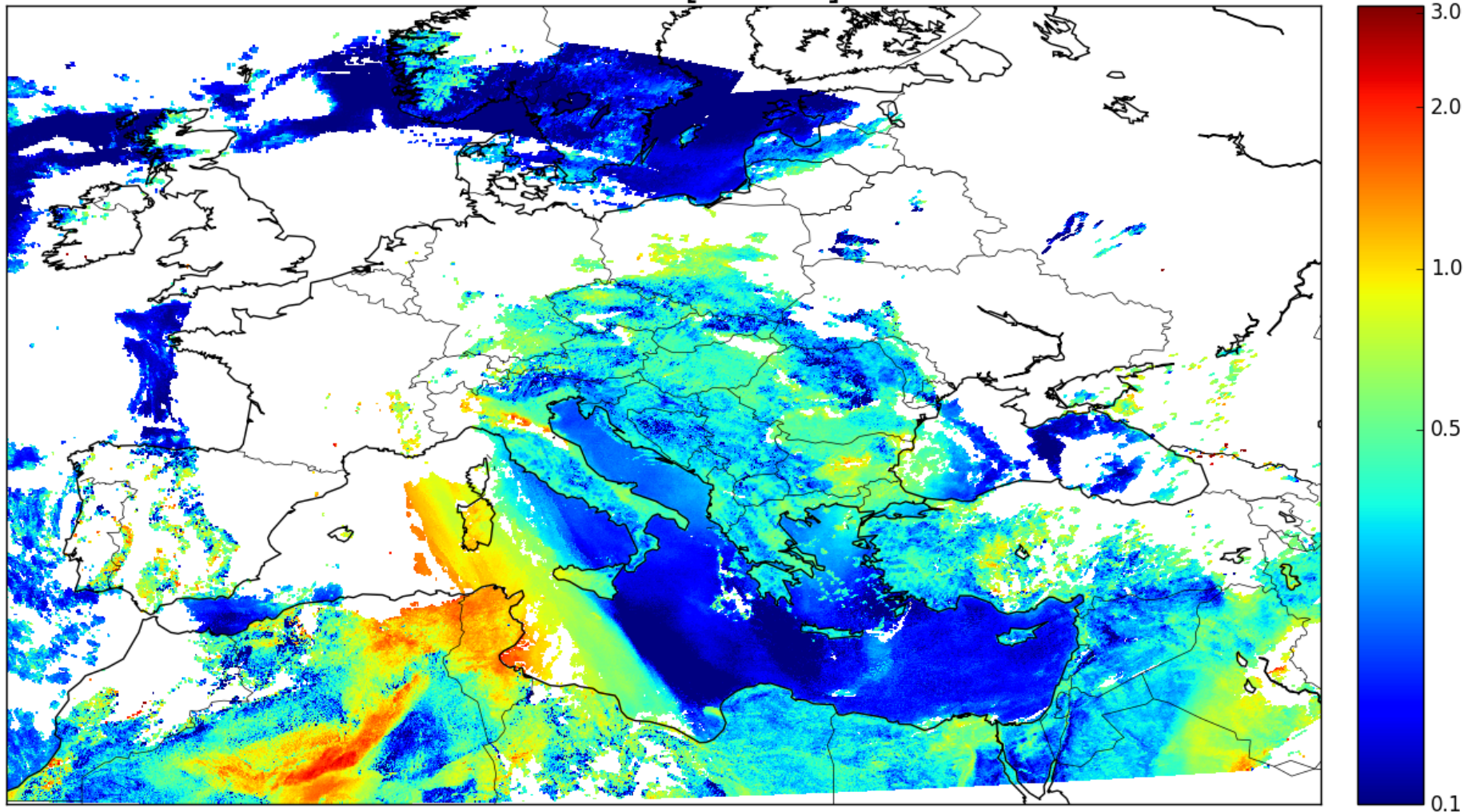
AOD550 [SEVIRI]



Example of retrieval



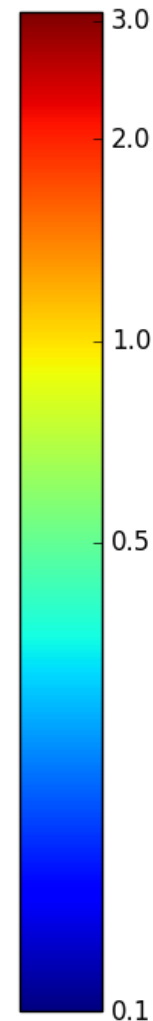
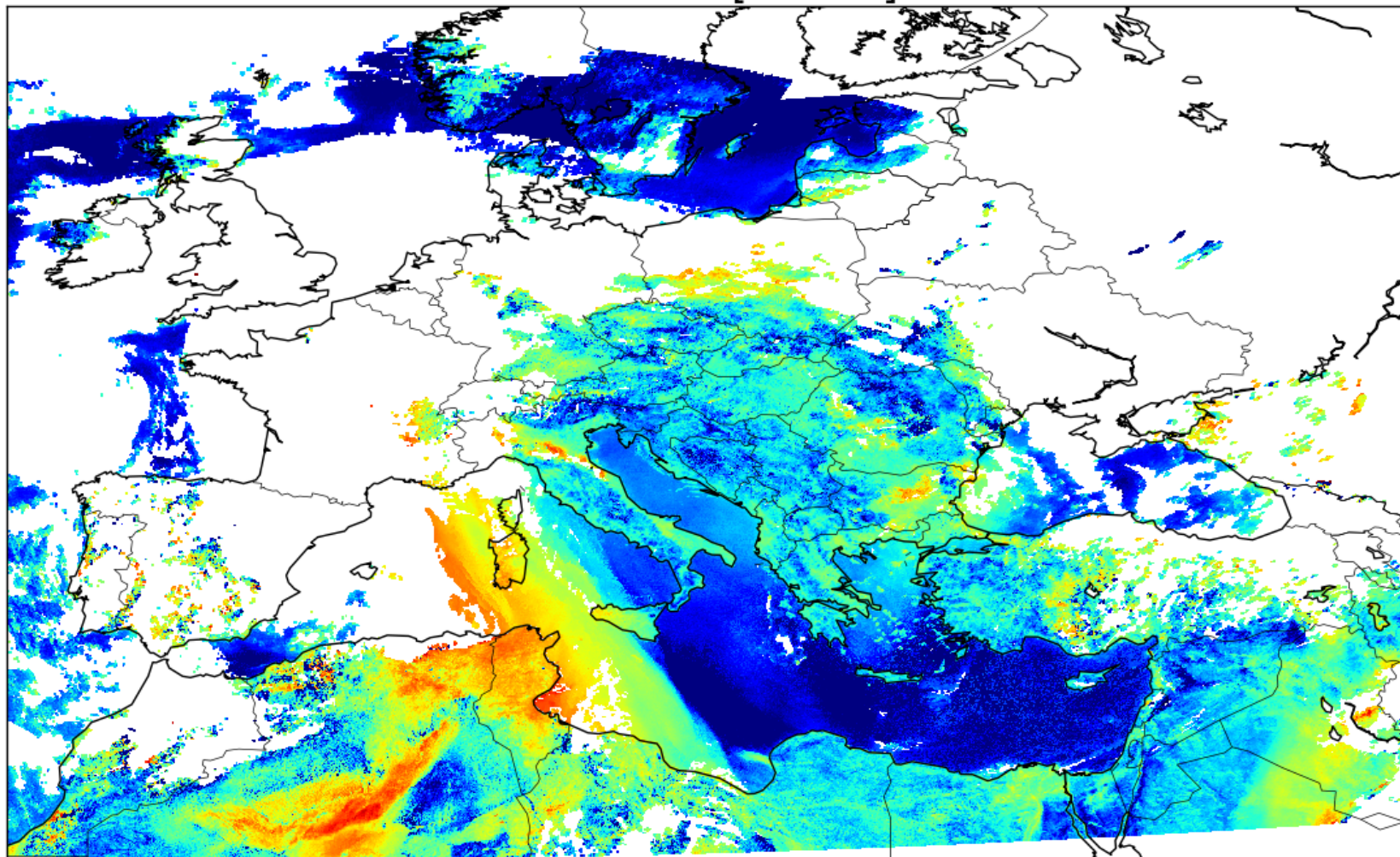
AOD550 [SEVIRI]



Example of retrieval



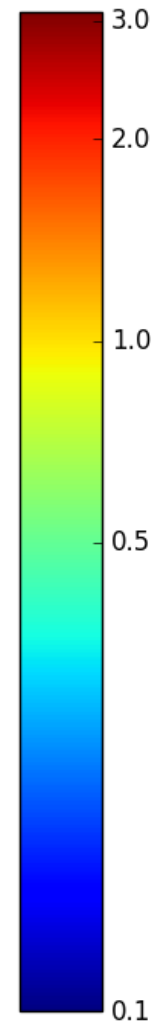
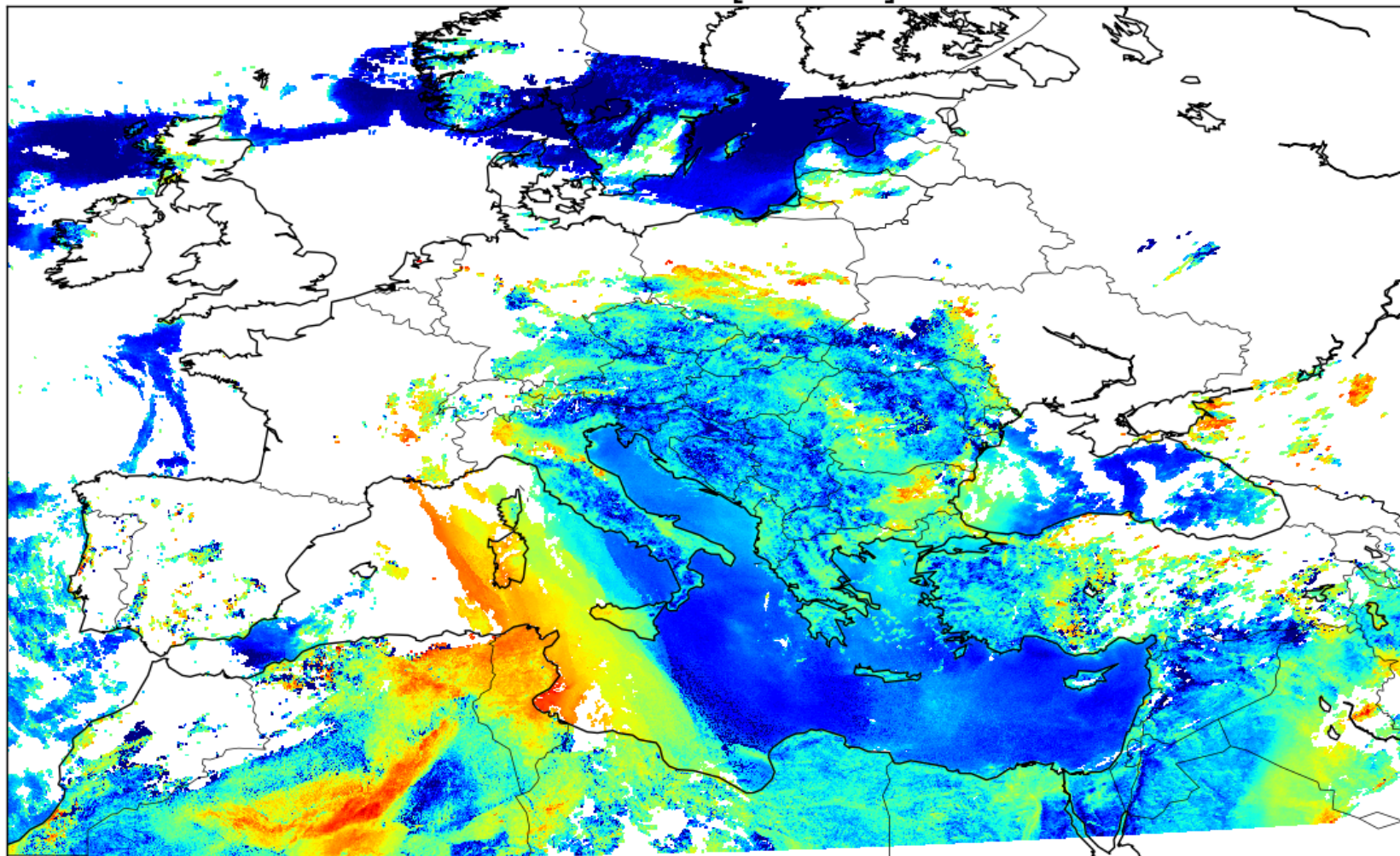
AOD550 [SEVIRI]



Example of retrieval



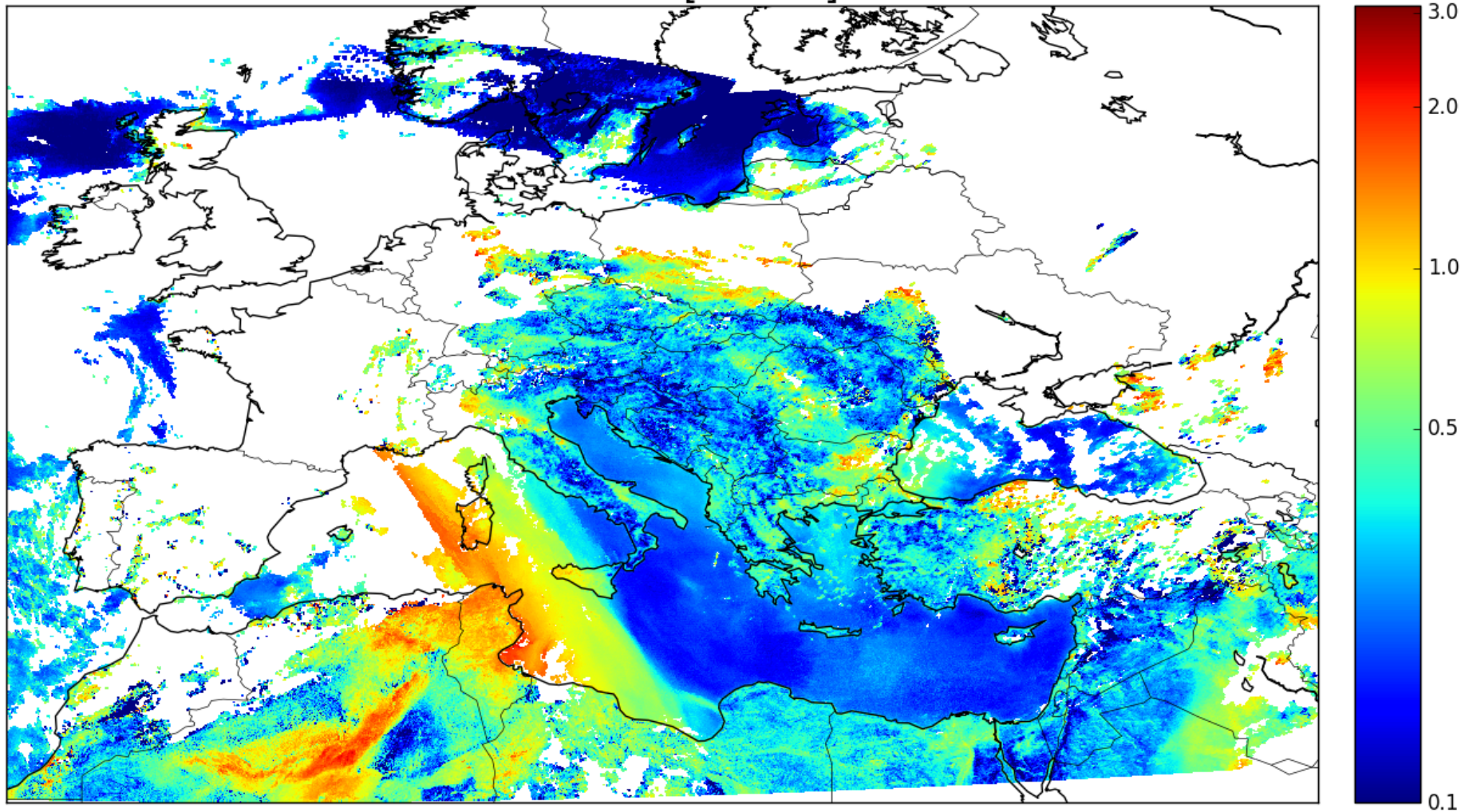
AOD550 [SEVIRI]



Example of retrieval



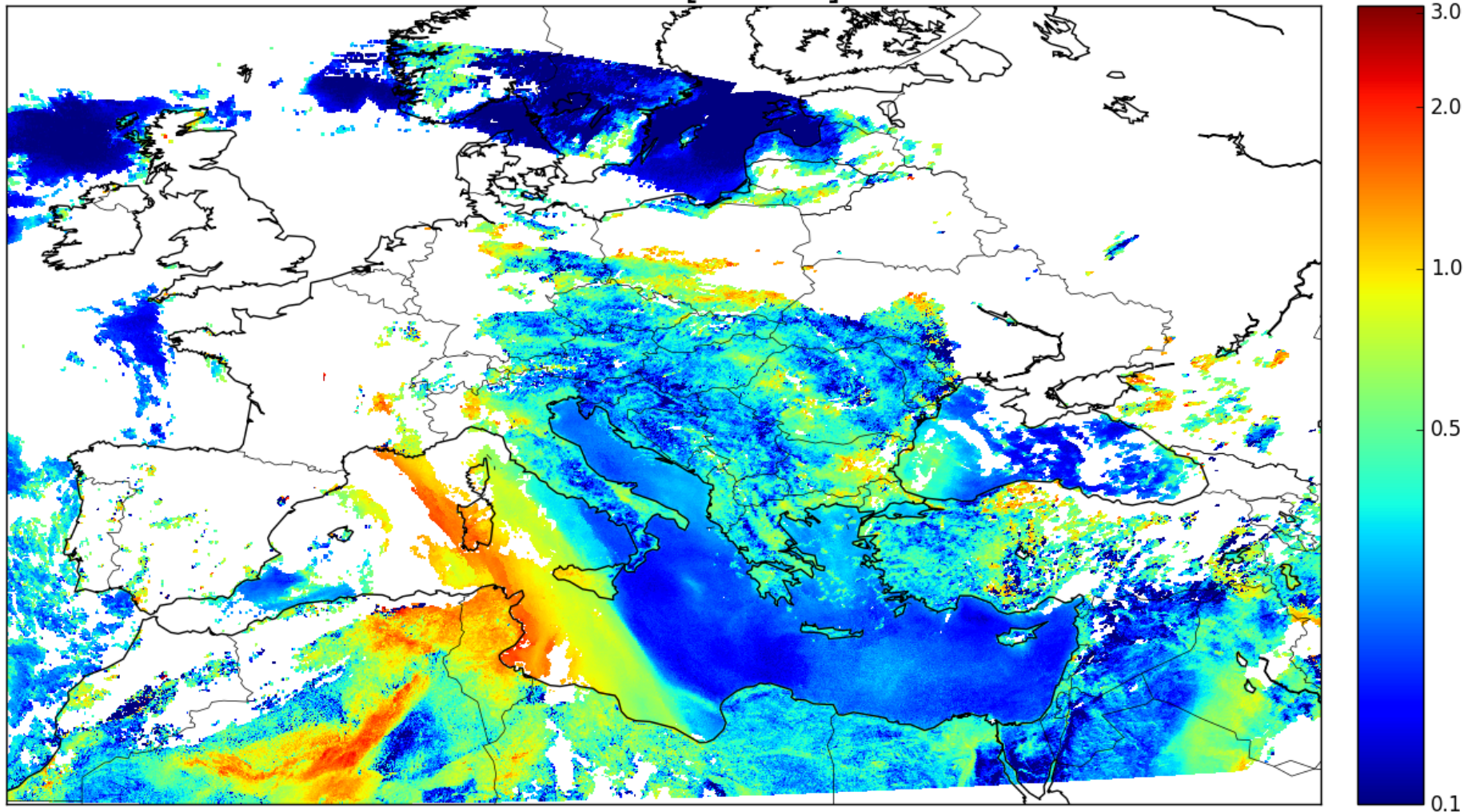
AOD550 [SEVIRI]



Example of retrieval



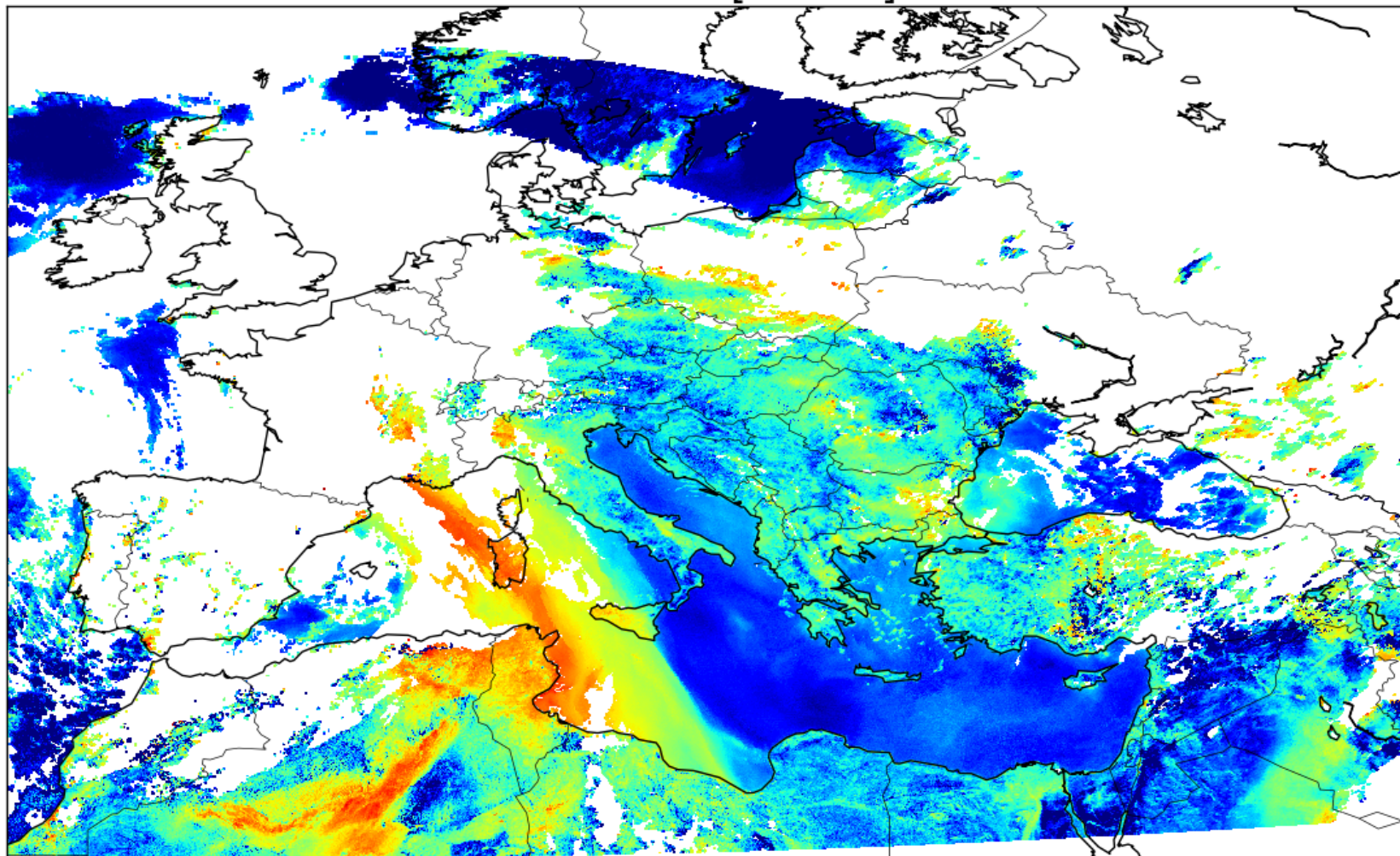
AOD550 [SEVIRI]



Example of retrieval



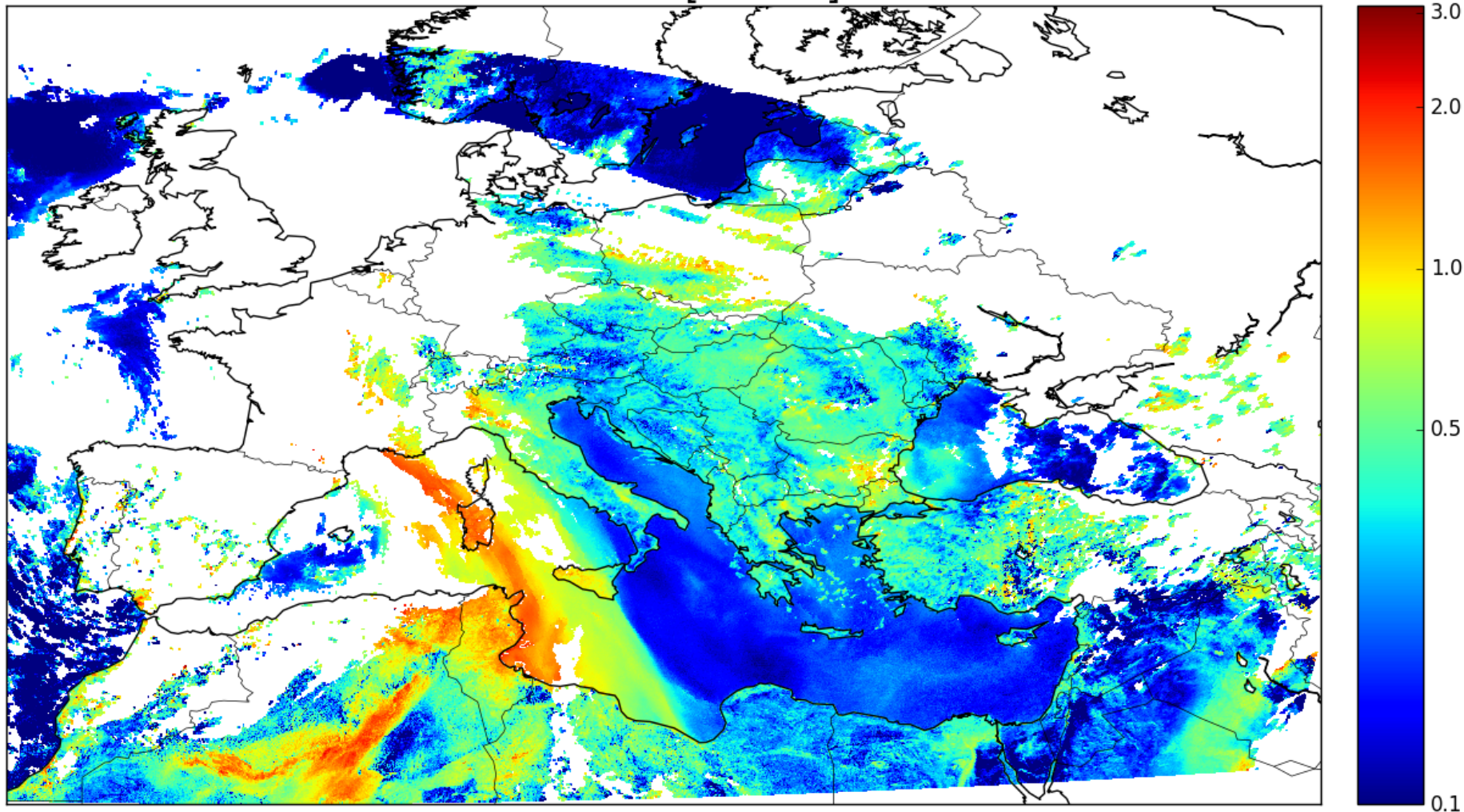
AOD550 [SEVIRI]



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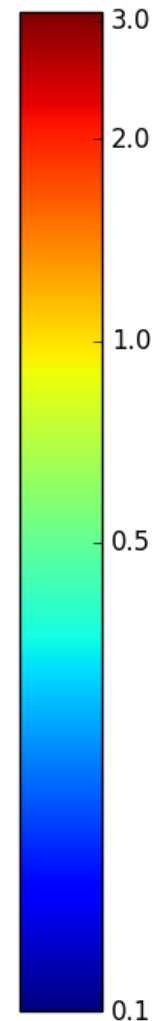
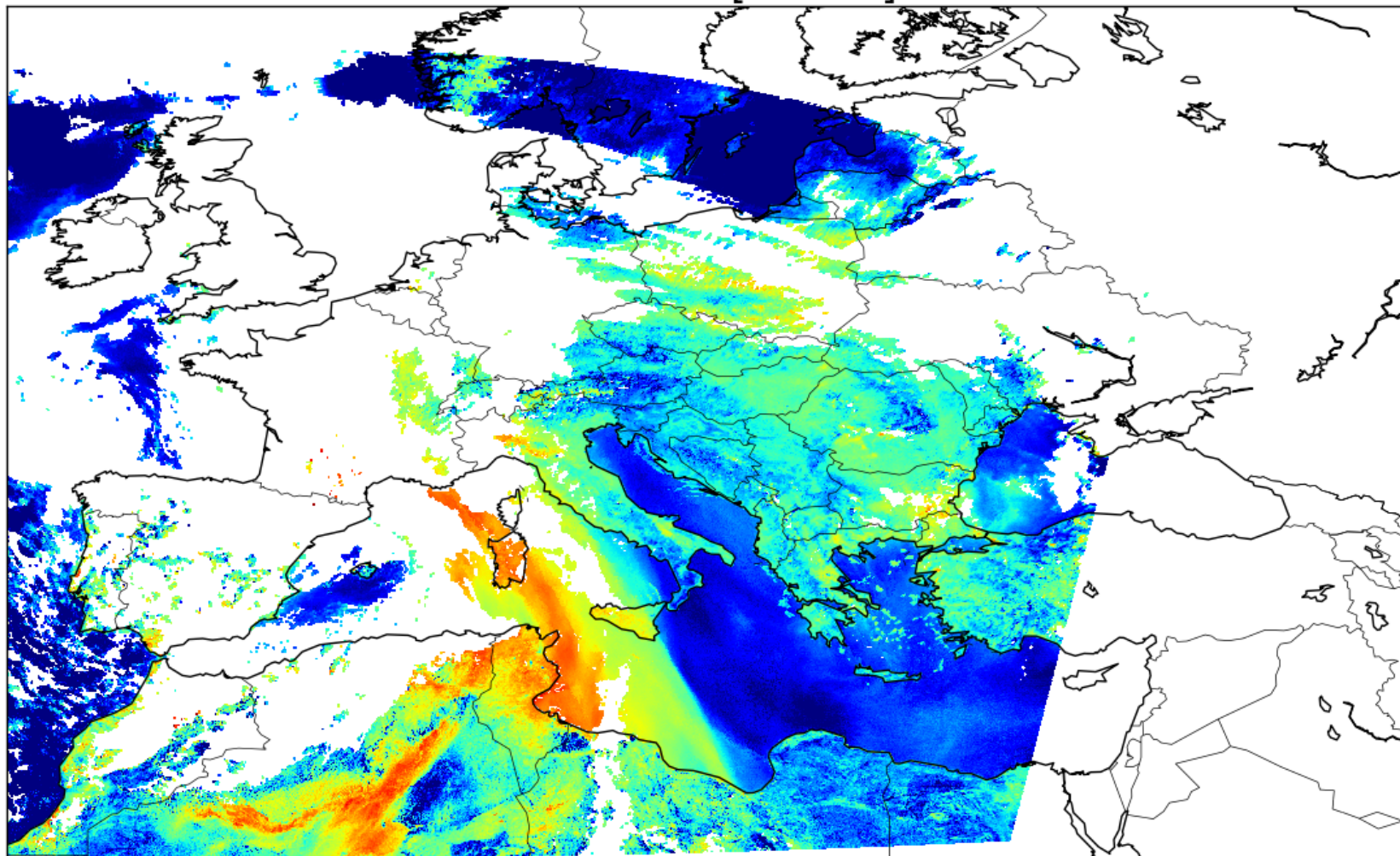
AOD550 [SEVIRI]



Example of retrieval



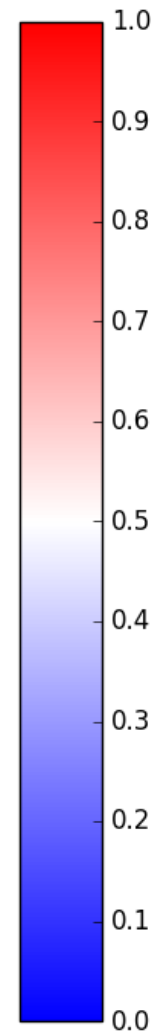
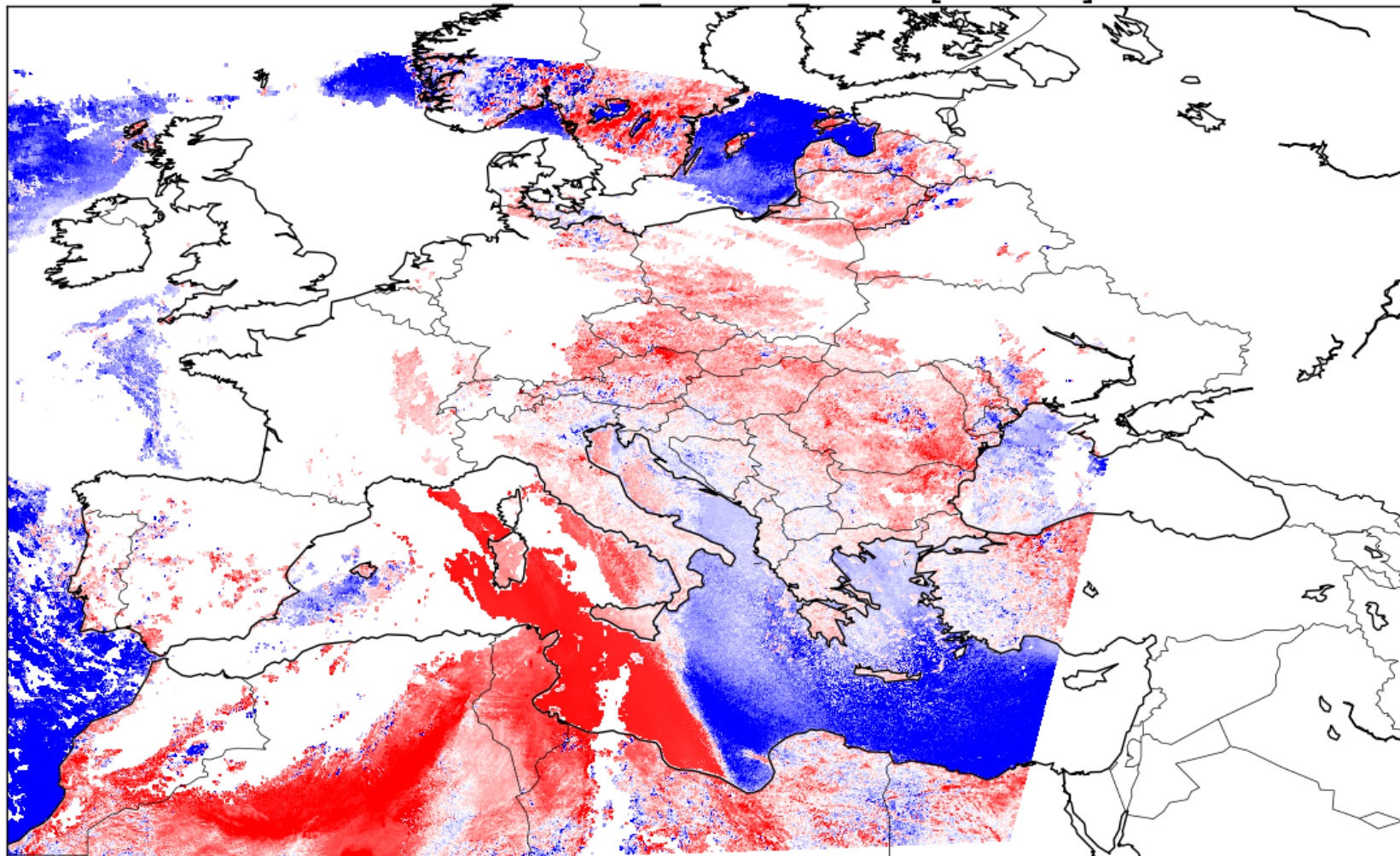
AOD550 [SEVIRI]



Example of retrieval



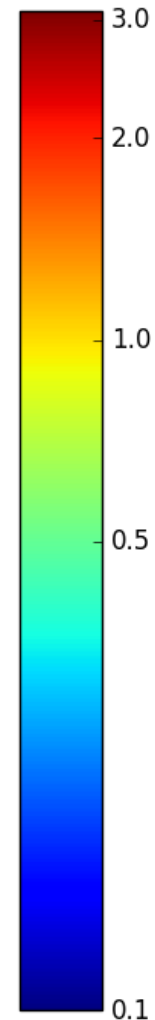
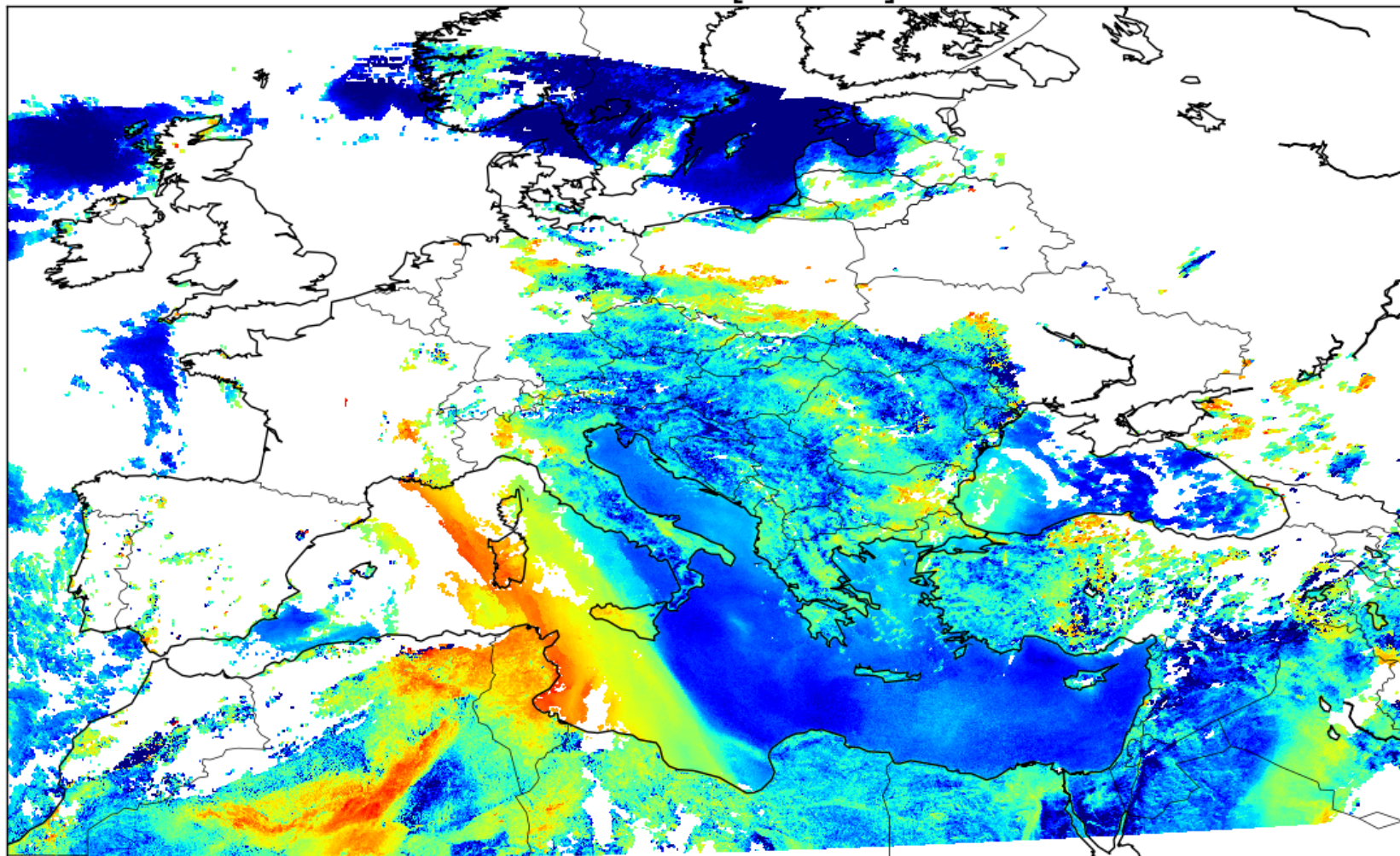
COARSE MODE RATIO 550 [SEVIRI]



Example of retrieval

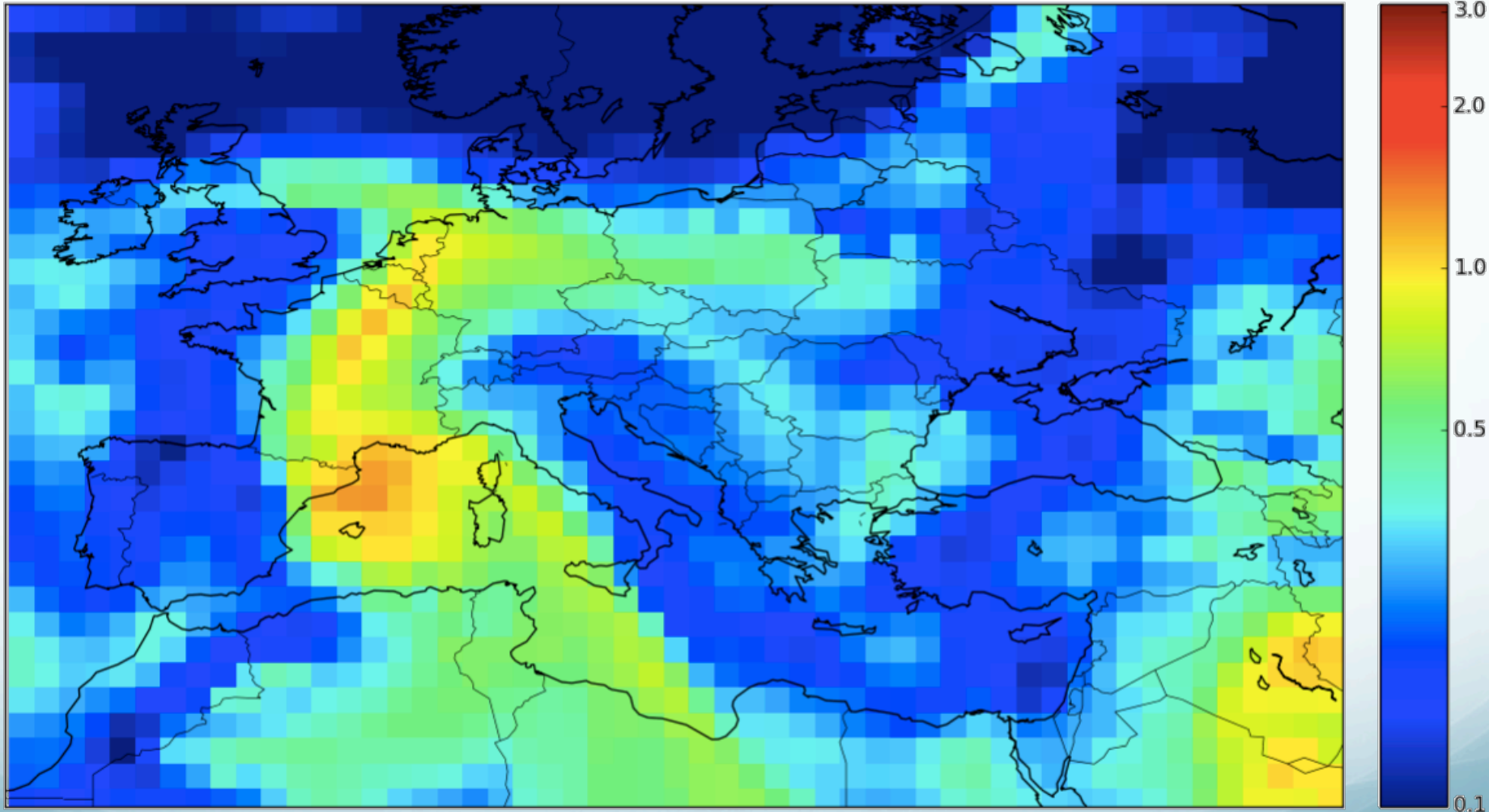


AOD550 [SEVIRI]



COMPARISON WITH CAMS

MACC AOD550

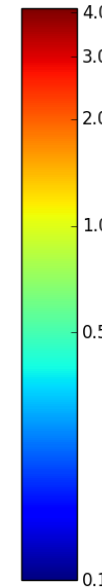
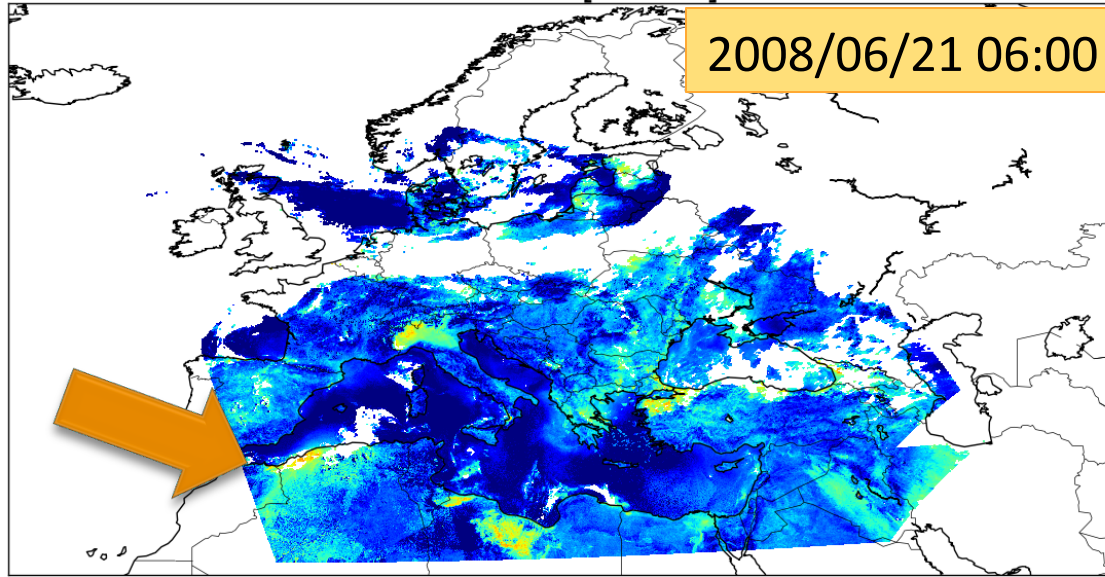


DATE: 2008/05/27 -- HOUR: 12

Storm event over Africa and Europe – June 2008

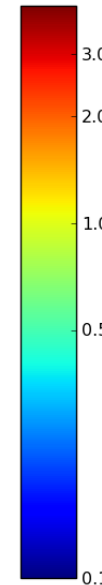
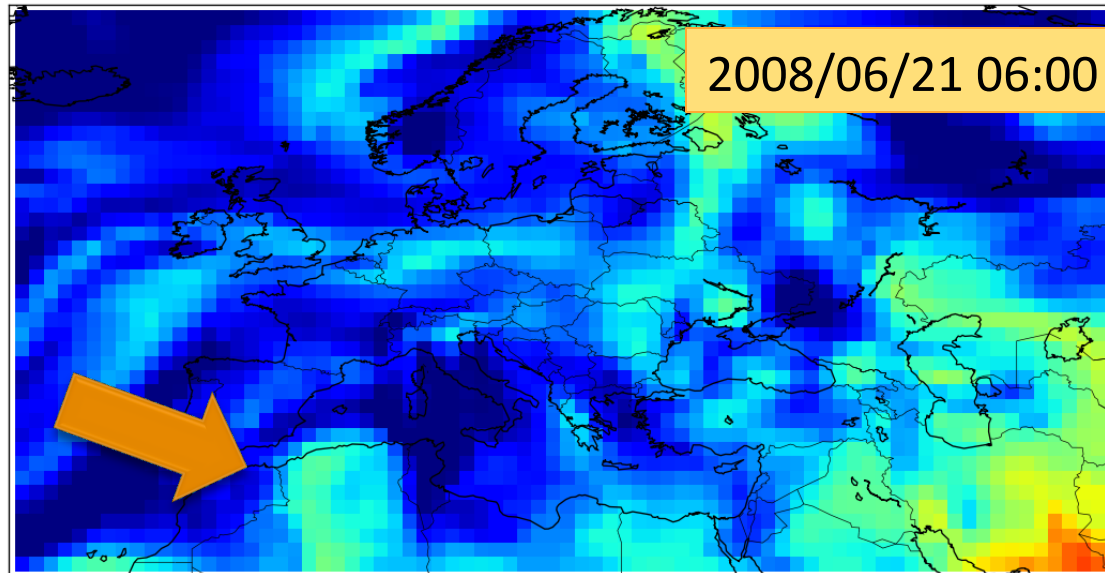


AOD550 [SEVIRI]



CISAR – SEVIRI
Spatial resolution:
~5 km
Temporal
resolution: 1 hour

MACC AOD550

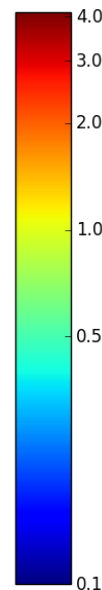
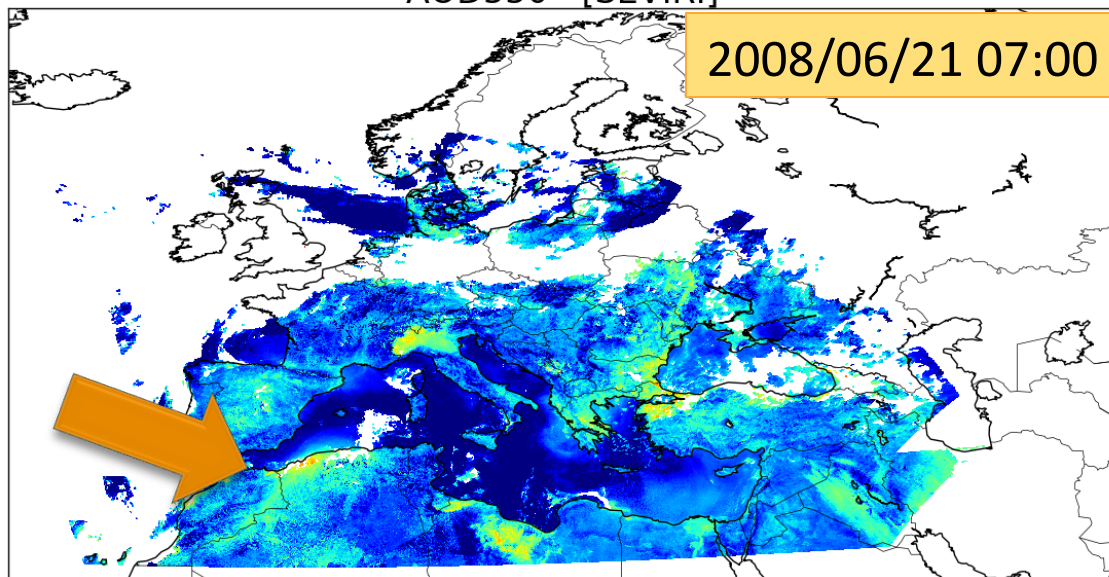


**MACC
REANALYSIS**
Spatial resolution:
~80 km
Temporal
resolution: 3 hour

Storm event over Africa and Europe – June 2008

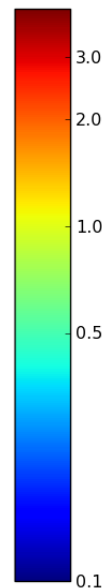
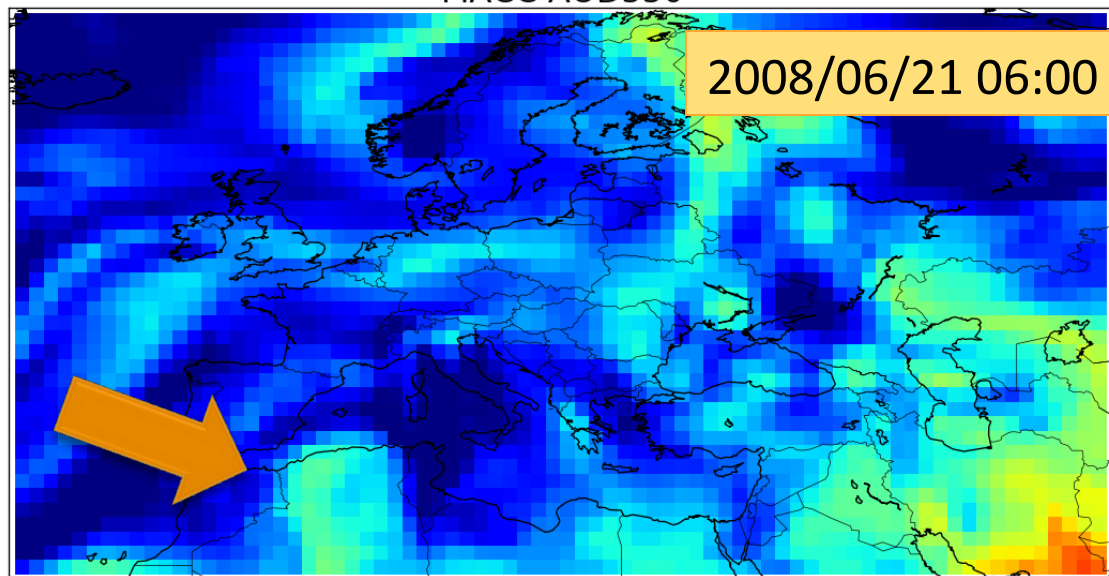


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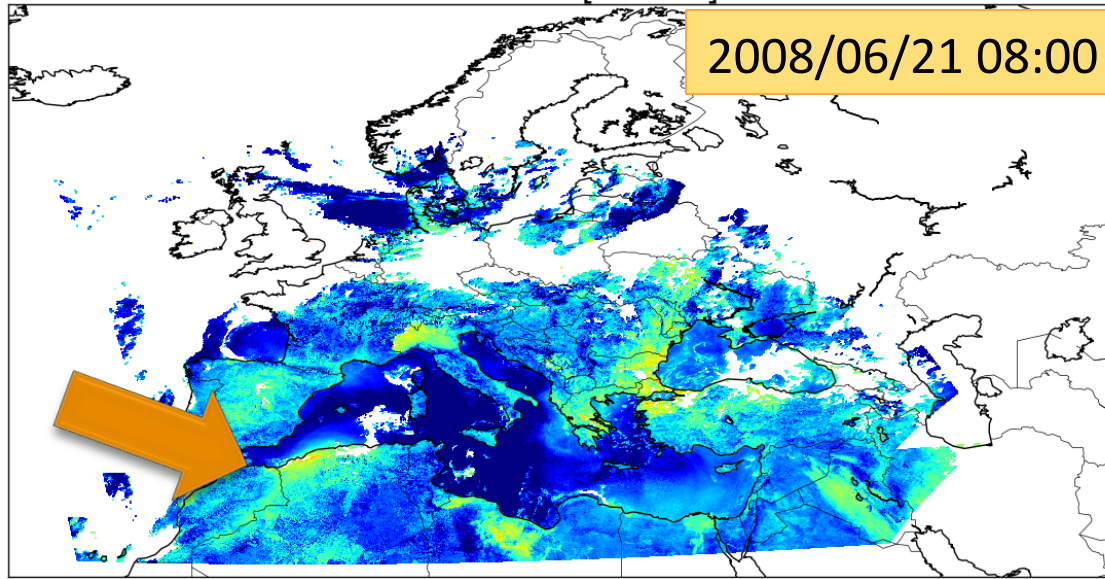


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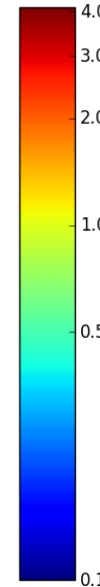
Storm event over Africa and Europe – June 2008



AOD550 [SEVIRI]

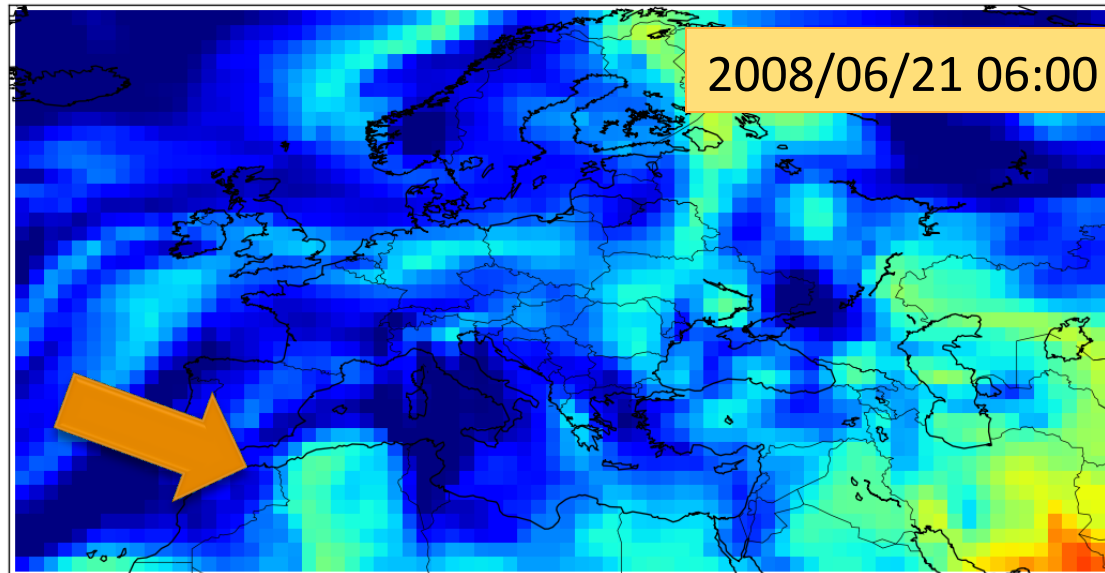


2008/06/21 08:00

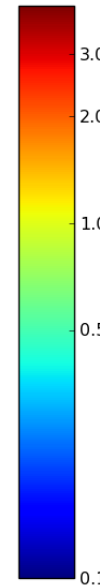


CISAR – SEVIRI
Spatial resolution:
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Temporal
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MACC AOD550



2008/06/21 06:00

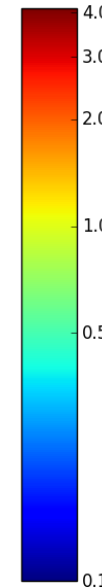
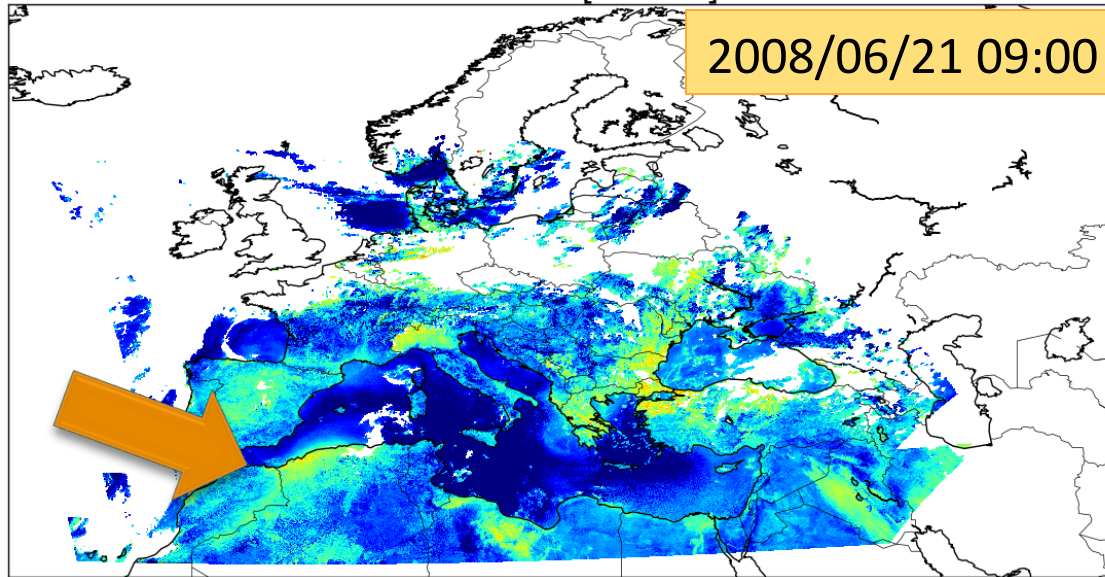


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Storm event over Africa and Europe – June 2008

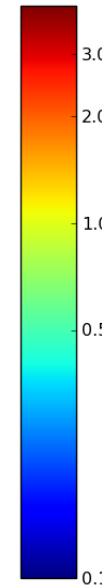
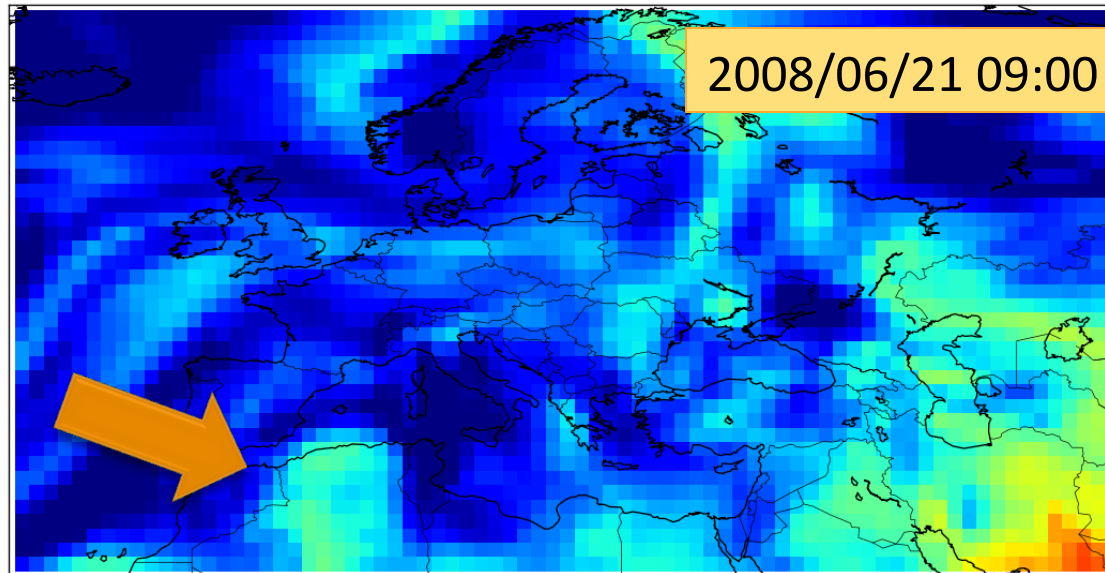


AOD550 [SEVIRI]



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MACC AOD550

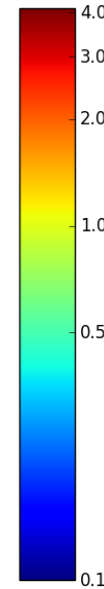
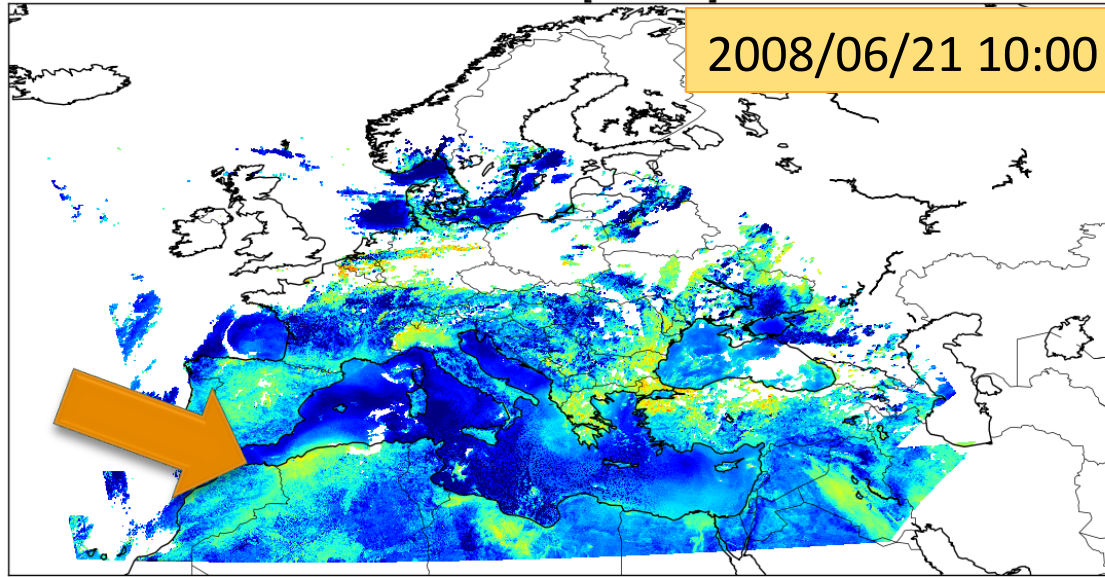


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Storm event over Africa and Europe – June 2008

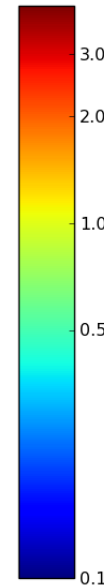
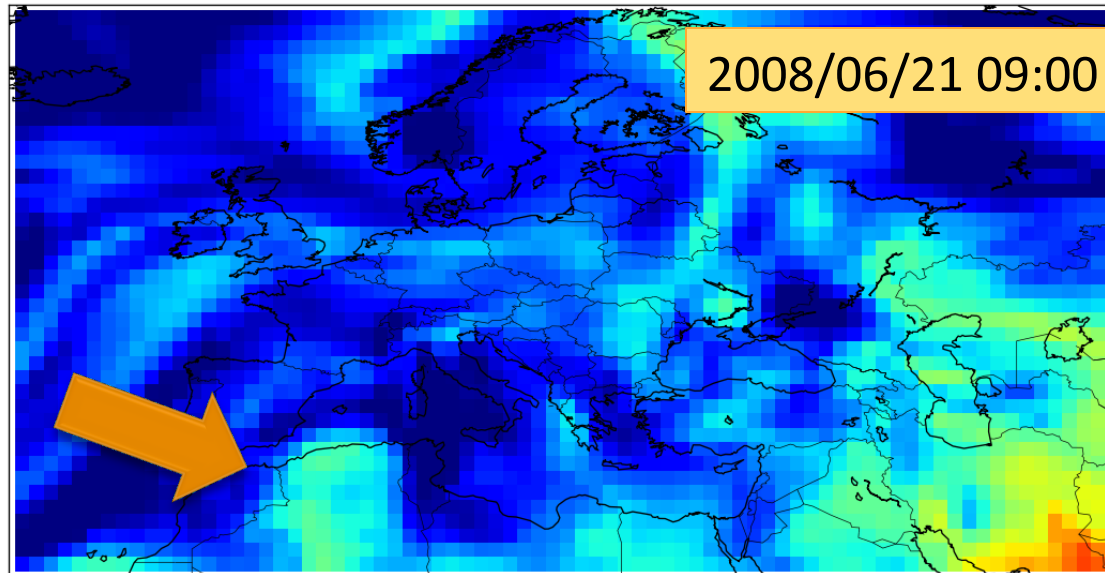


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MACC AOD550

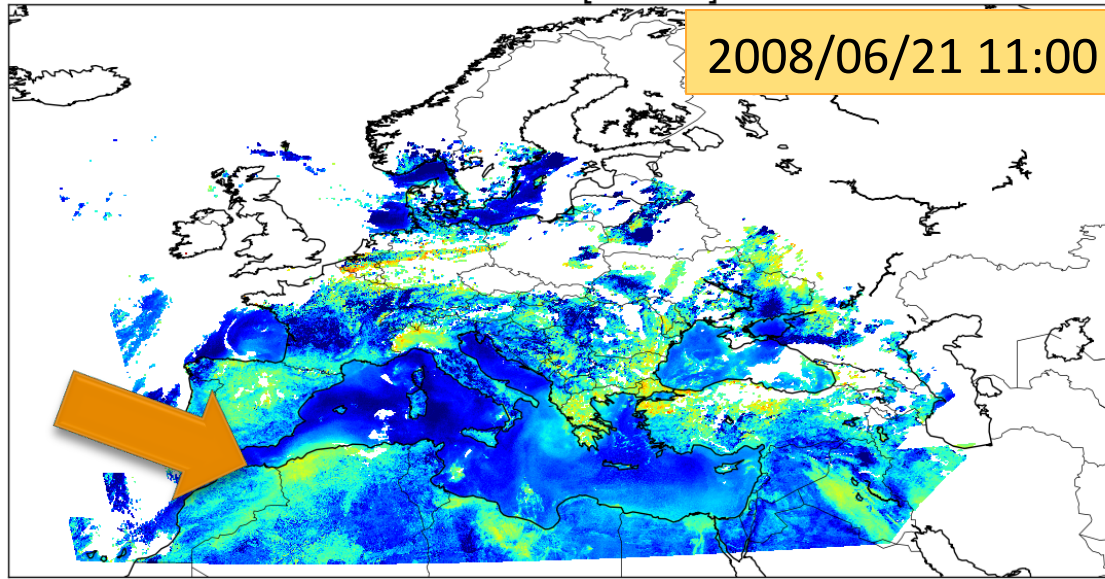


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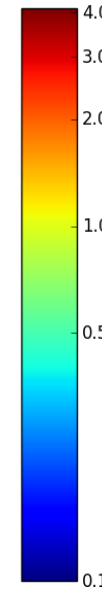
Storm event over Africa and Europe – June 2008



AOD550 [SEVIRI]

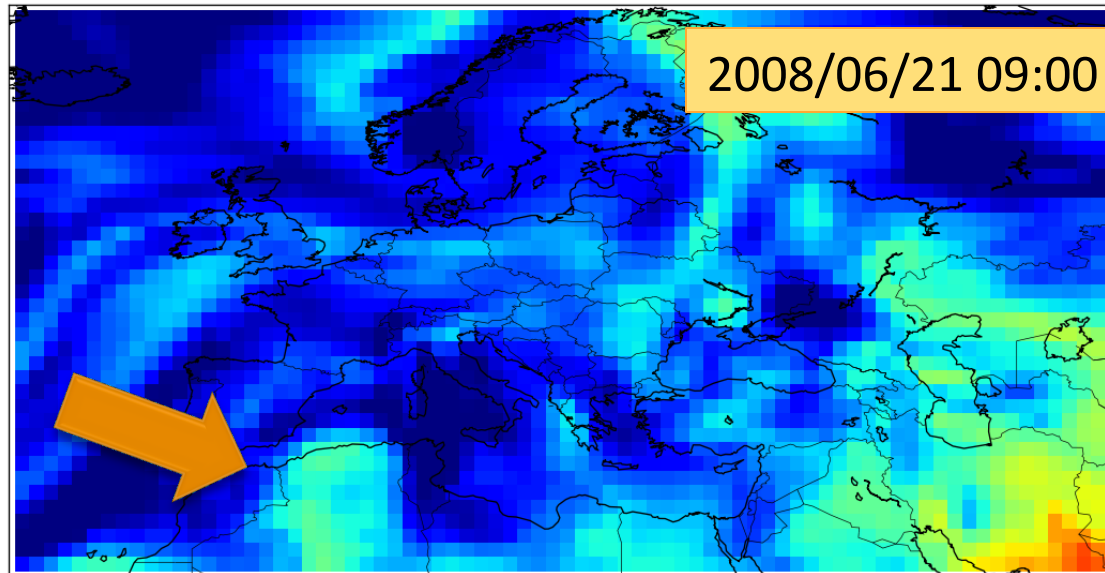


2008/06/21 11:00

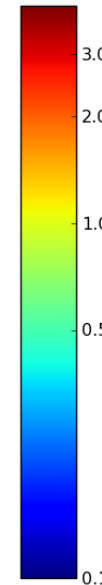


CISAR – SEVIRI
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MACC AOD550



2008/06/21 09:00

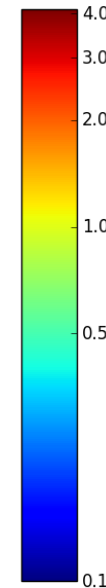
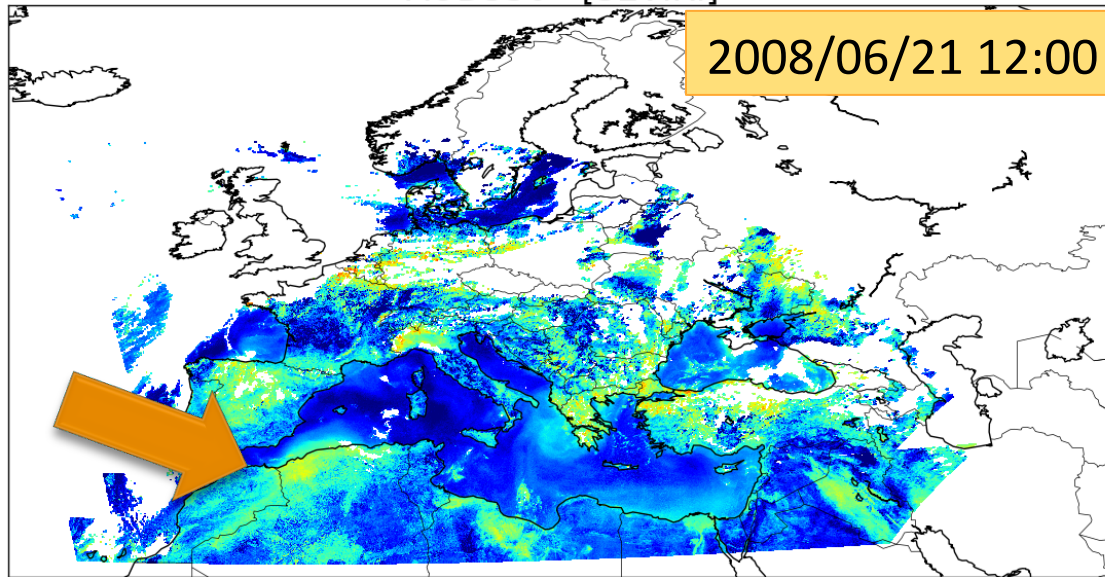


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Storm event over Africa and Europe – June 2008

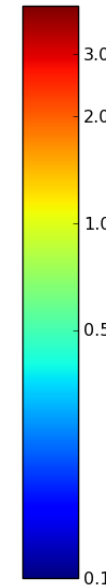
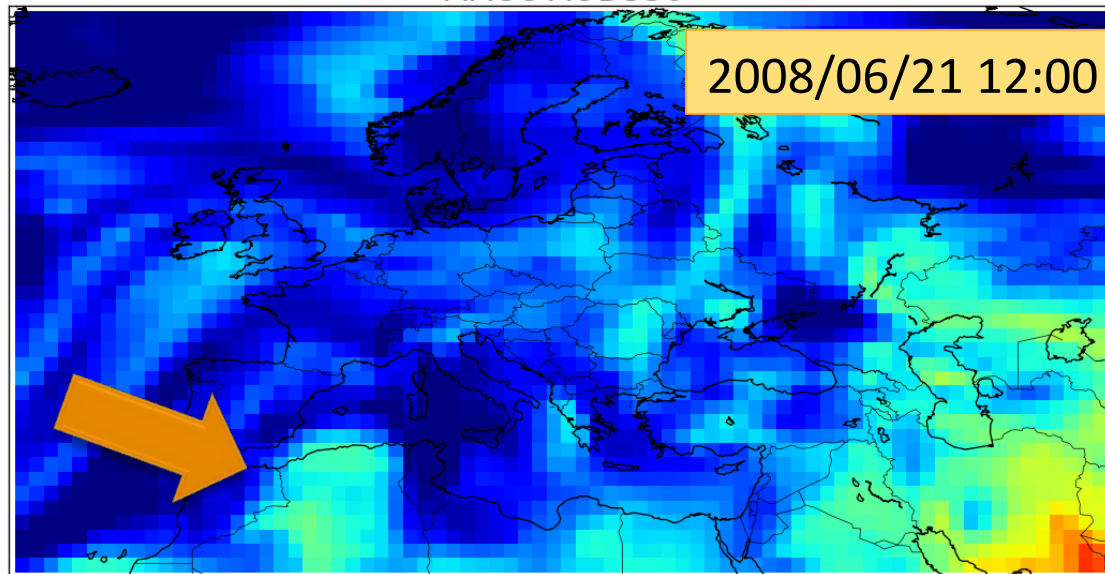


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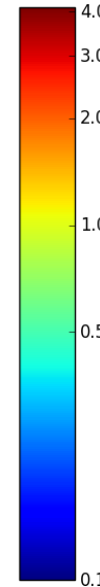
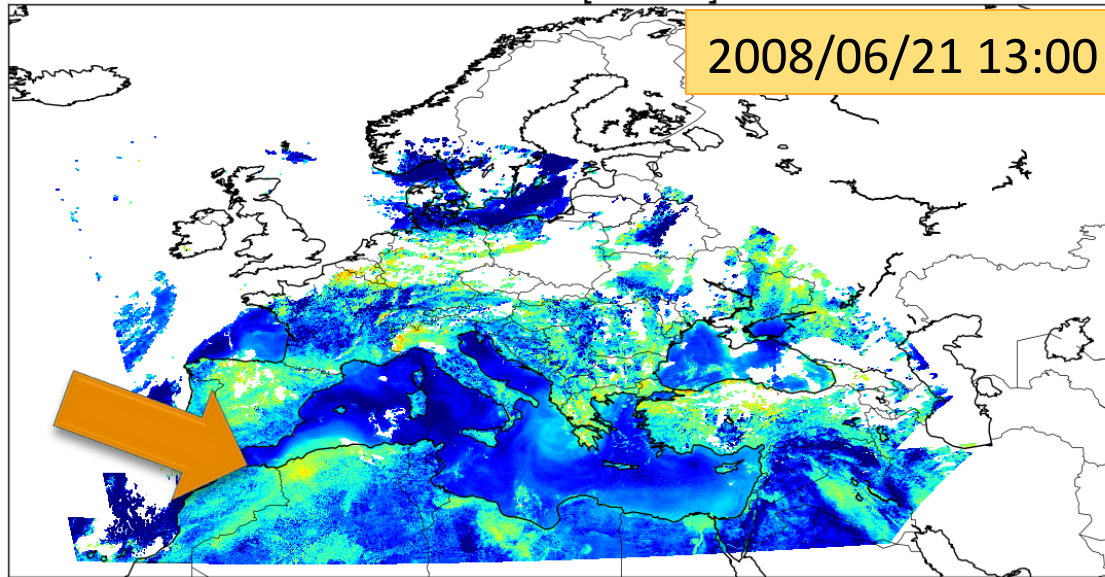


**MACC
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Storm event over Africa and Europe – June 2008

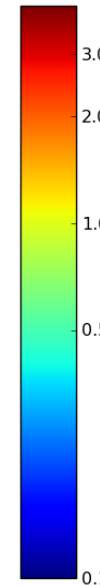
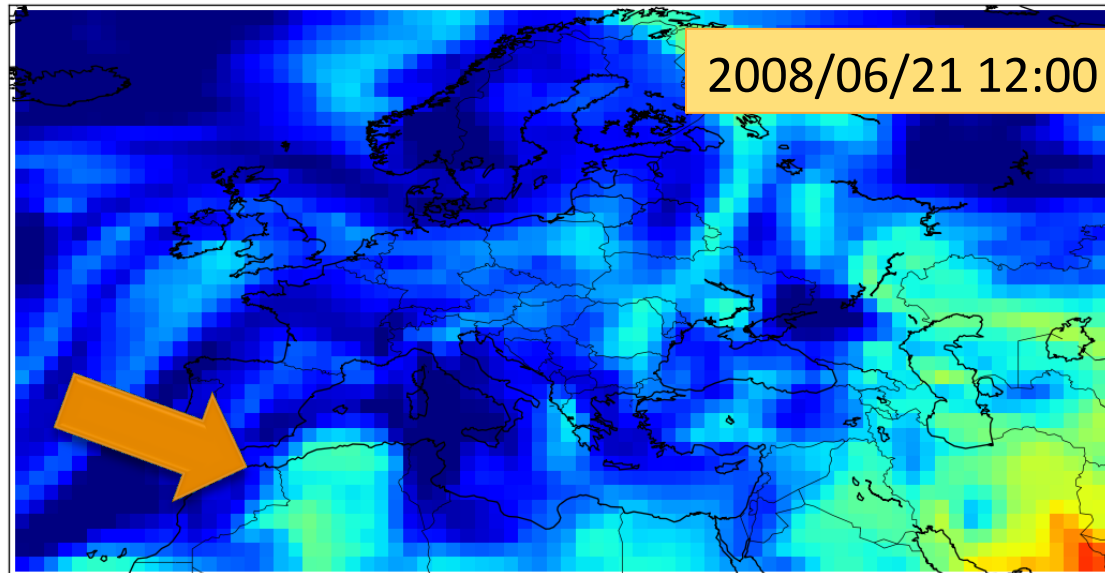


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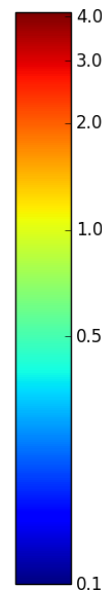
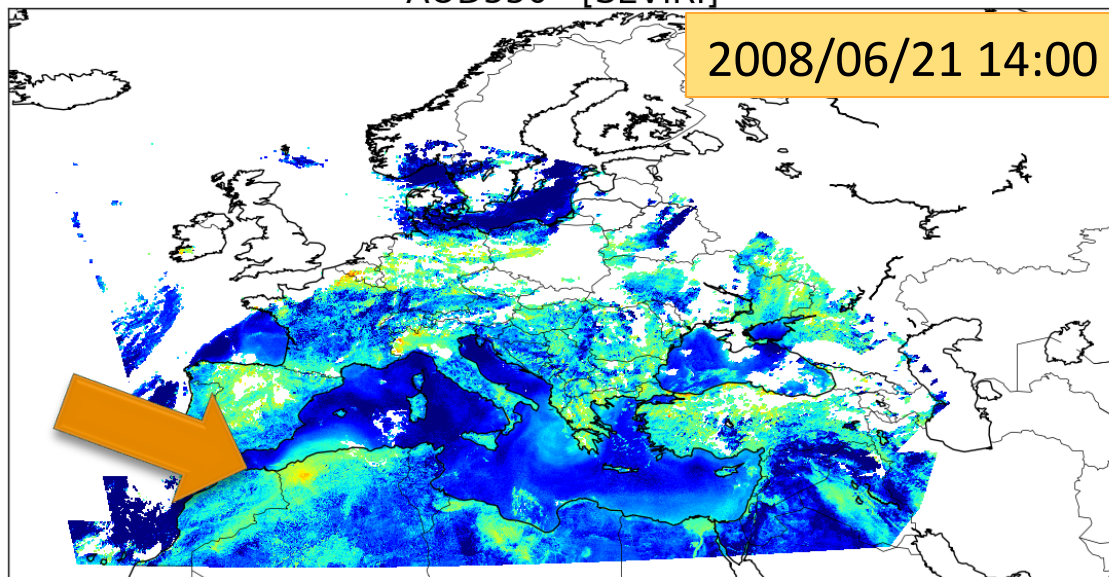


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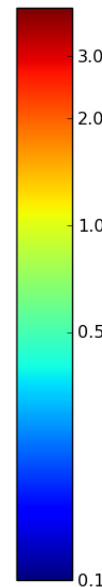
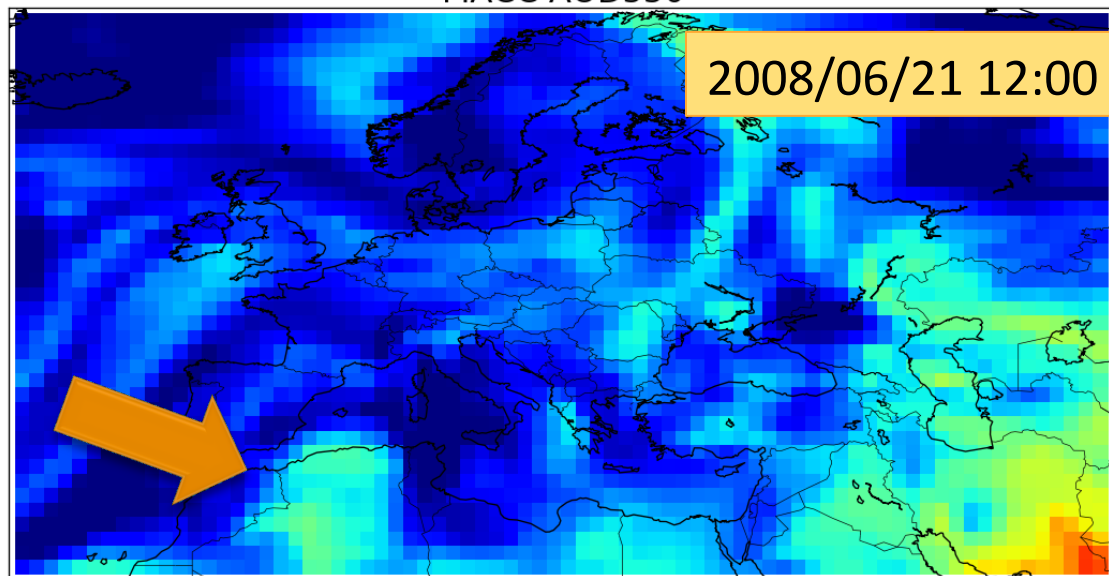


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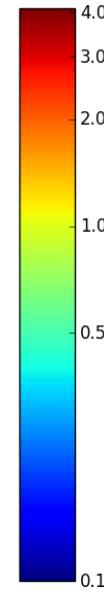
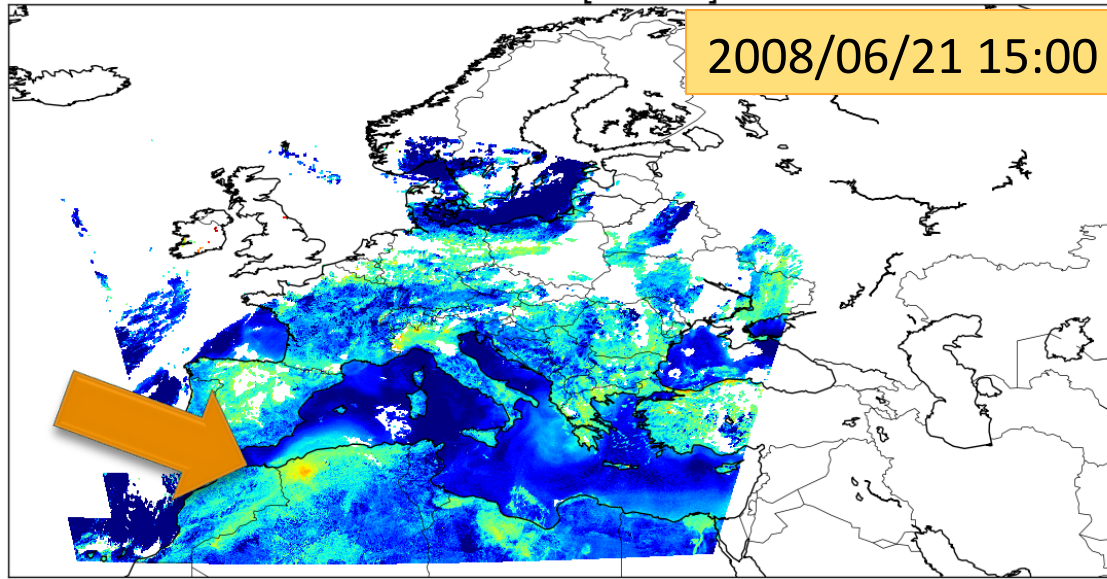


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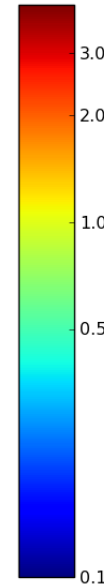
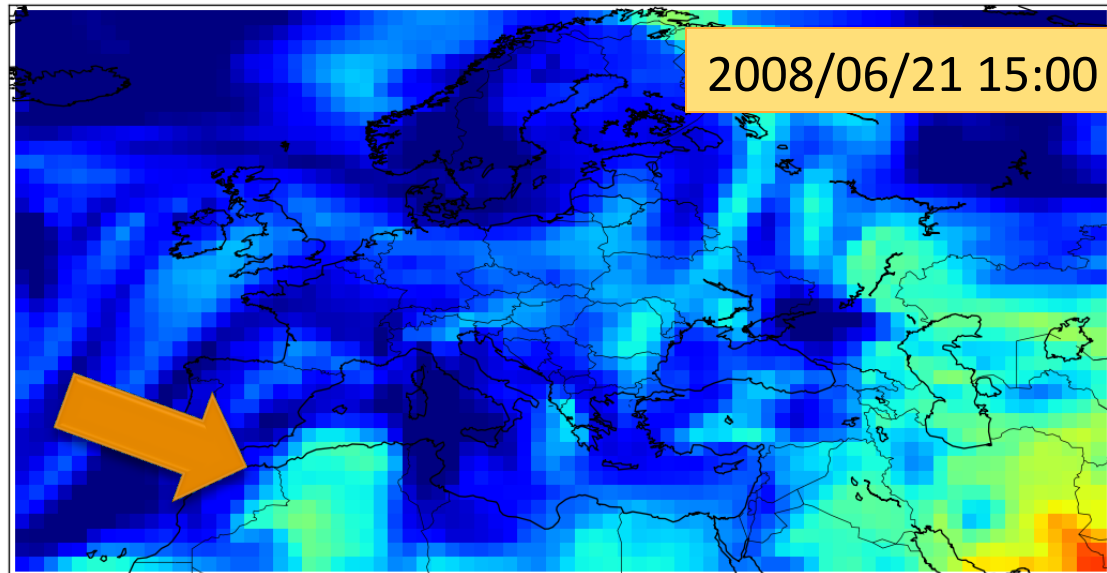


AOD550 [SEVIRI]



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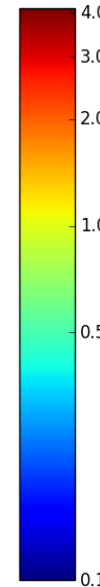
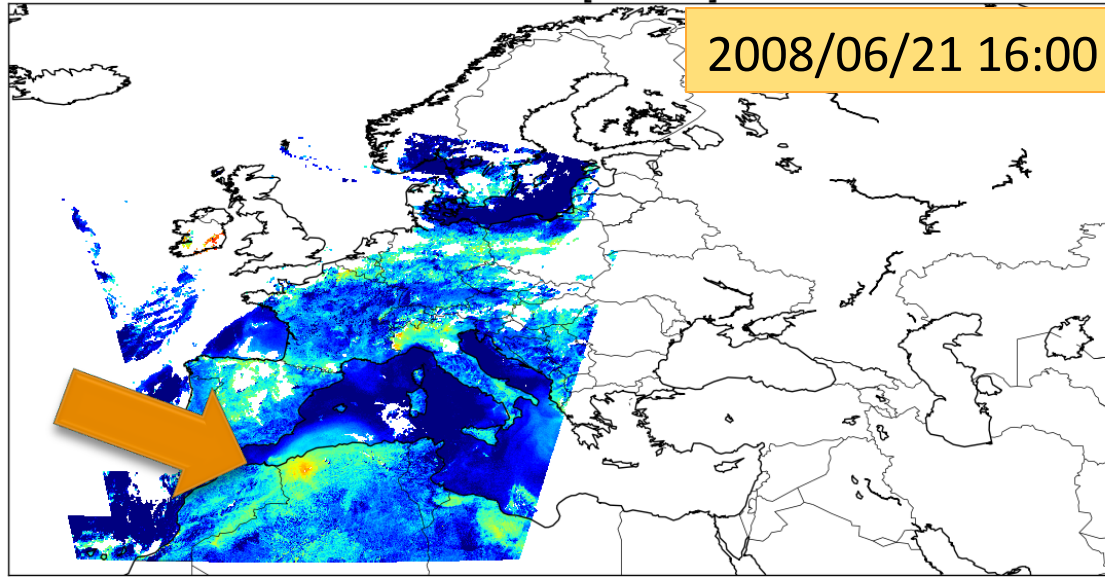


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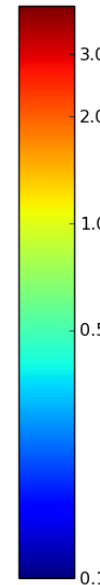
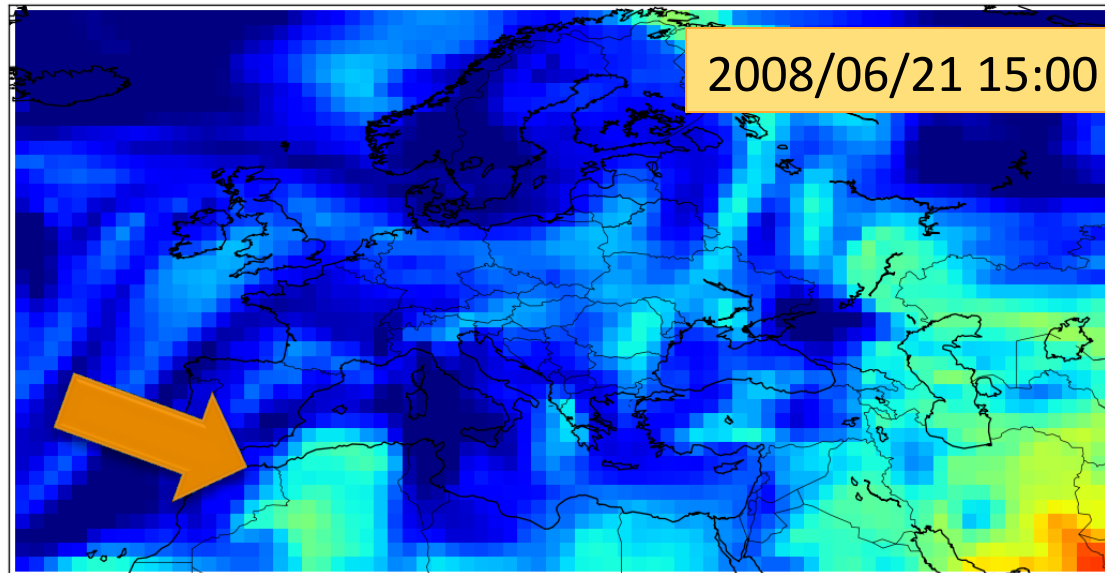


AOD550 [SEVIRI]



CISAR – SEVIRI
Spatial resolution:
~5 km
Temporal
resolution: 1 hour

MACC AOD550

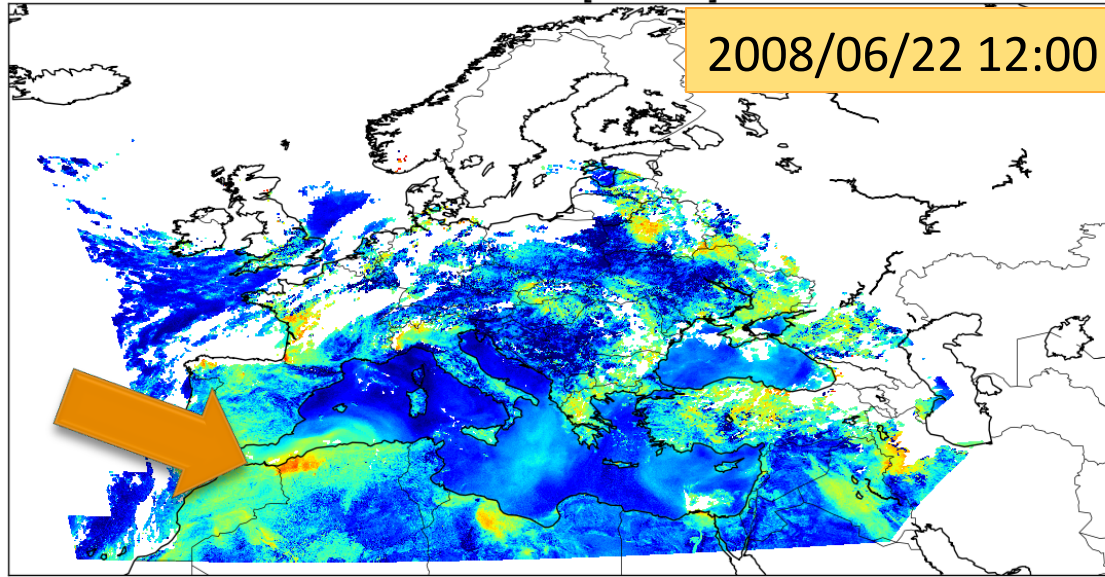


**MACC
REANALYSIS**
Spatial resolution:
~80 km
Temporal
resolution: 3 hour

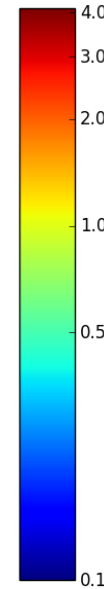
Storm event over Africa and Europe – June 2008



AOD550 [SEVIRI]

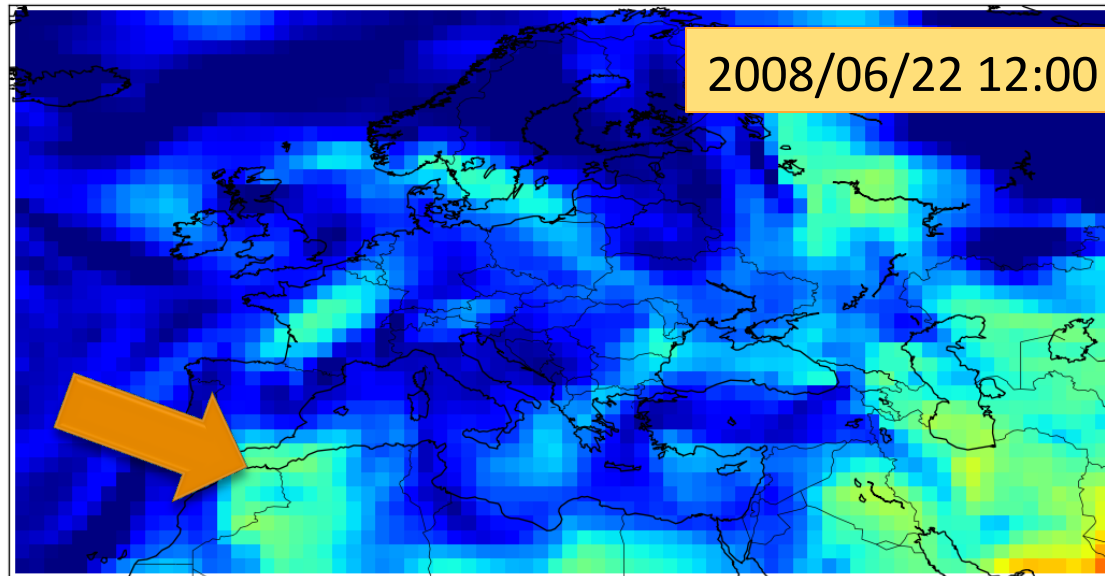


2008/06/22 12:00

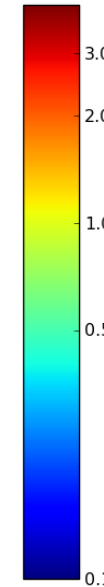


CISAR – SEVIRI
Spatial resolution:
~5 km
Temporal
resolution: 1 hour

MACC AOD550



2008/06/22 12:00

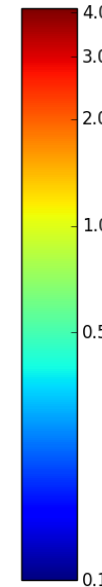
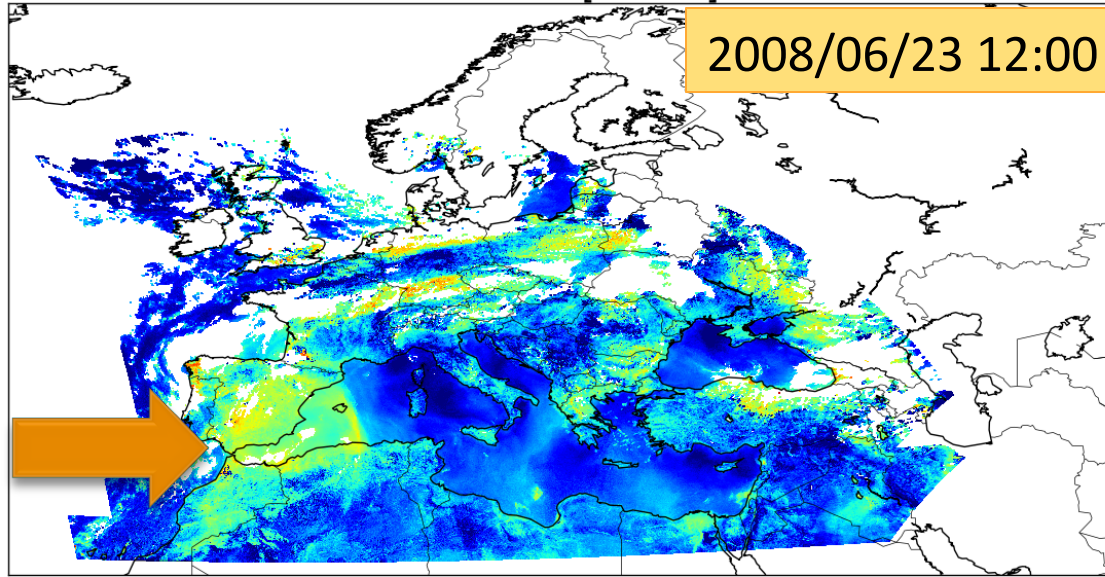


**MACC
REANALYSIS**
Spatial resolution:
~80 km
Temporal
resolution: 3 hour

Storm event over Africa and Europe – June 2008

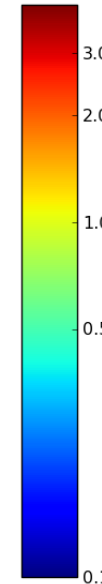
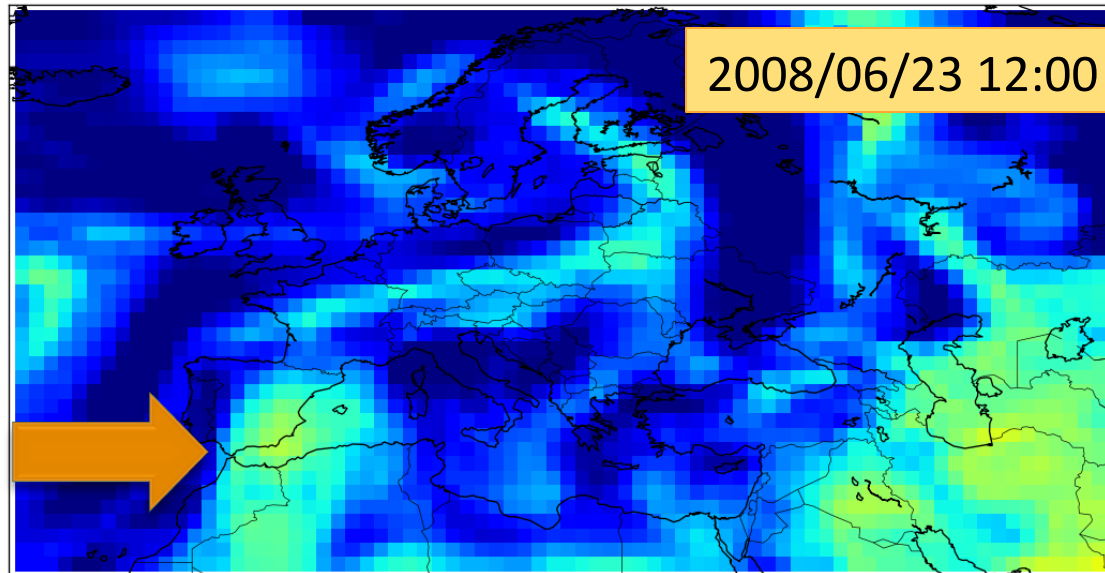


AOD550 [SEVIRI]



CISAR – SEVIRI
Spatial resolution:
~5 km
Temporal
resolution: 1 hour

MACC AOD550

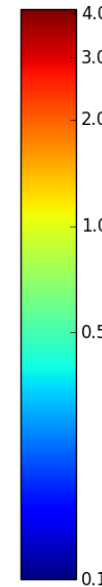
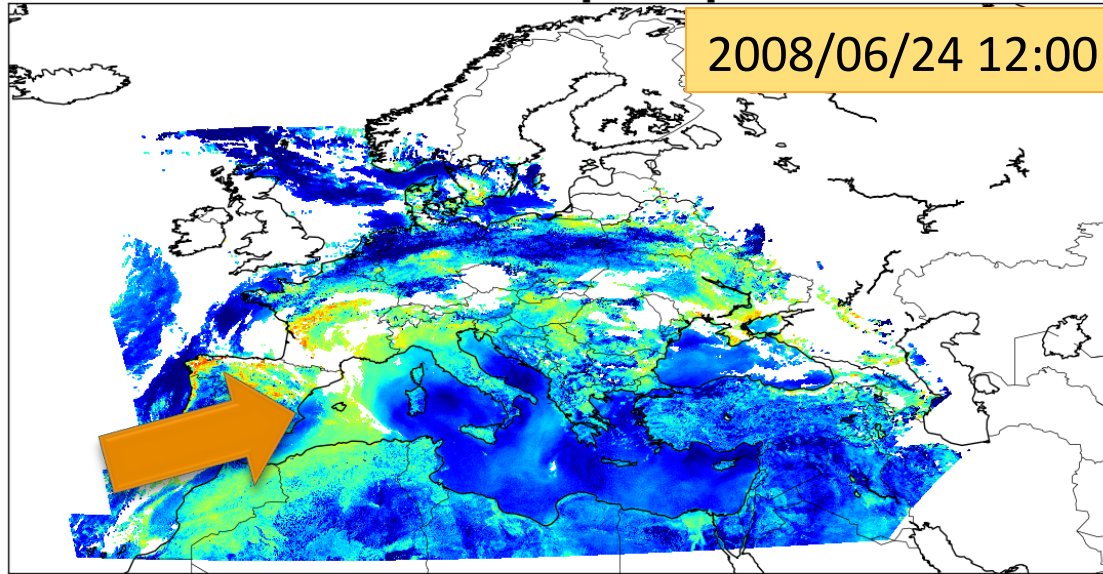


**MACC
REANALYSIS**
Spatial resolution:
~80 km
Temporal
resolution: 3 hour

Storm event over Africa and Europe – June 2008

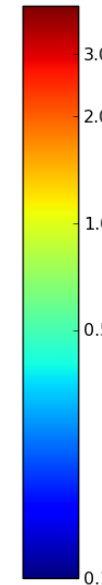
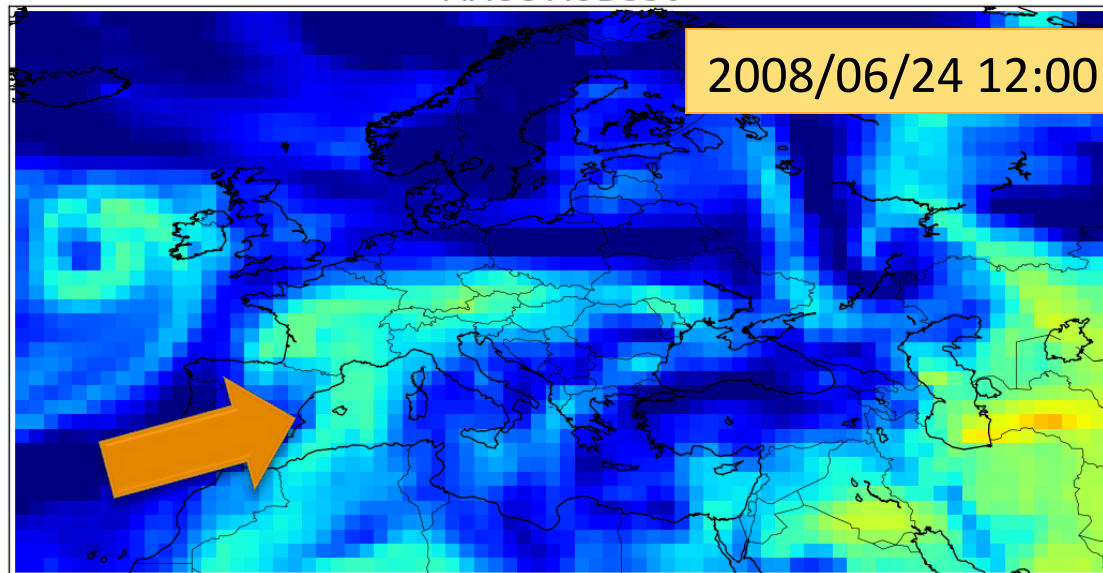


AOD550 [SEVIRI]



CISAR – SEVIRI
Spatial resolution:
~5 km
Temporal
resolution: 1 hour

MACC AOD550

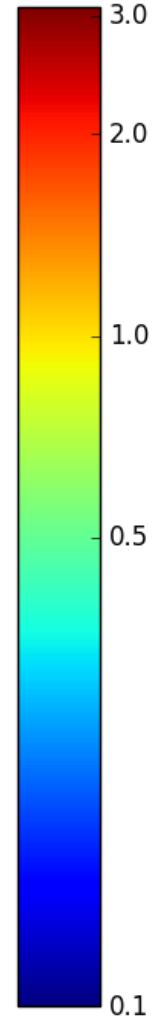
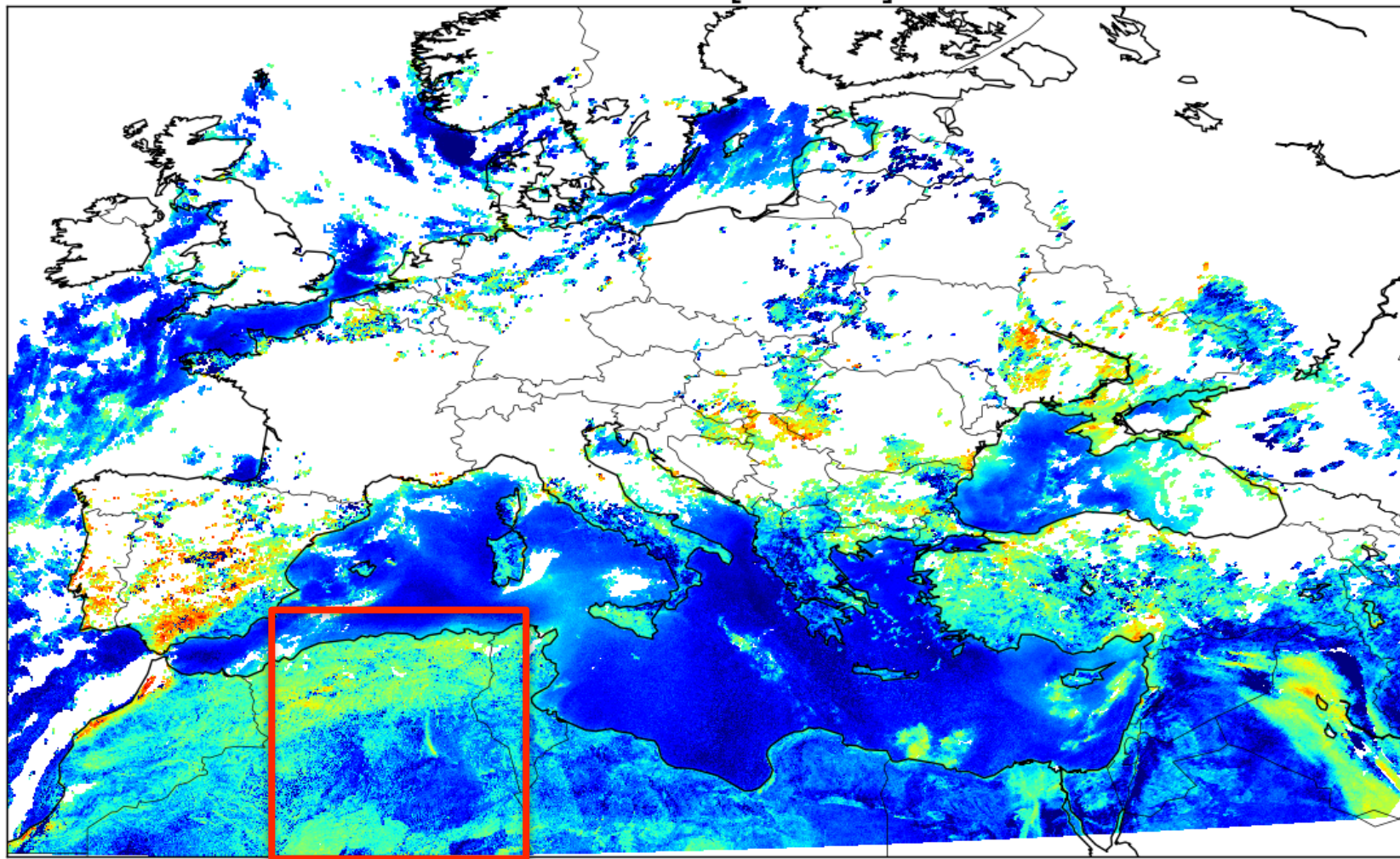


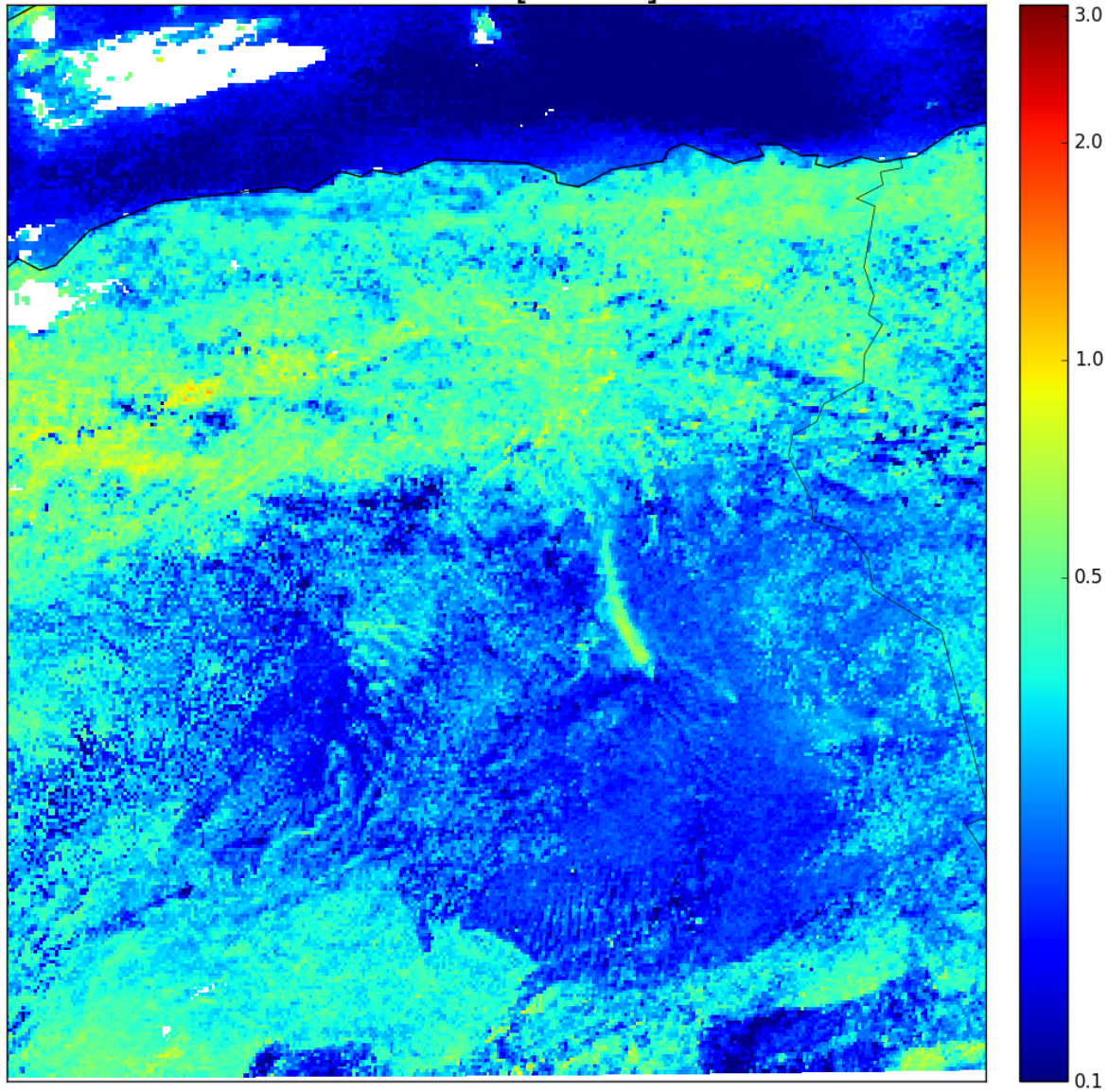
**MACC
REANALYSIS**
Spatial resolution:
~80 km
Temporal
resolution: 3 hour

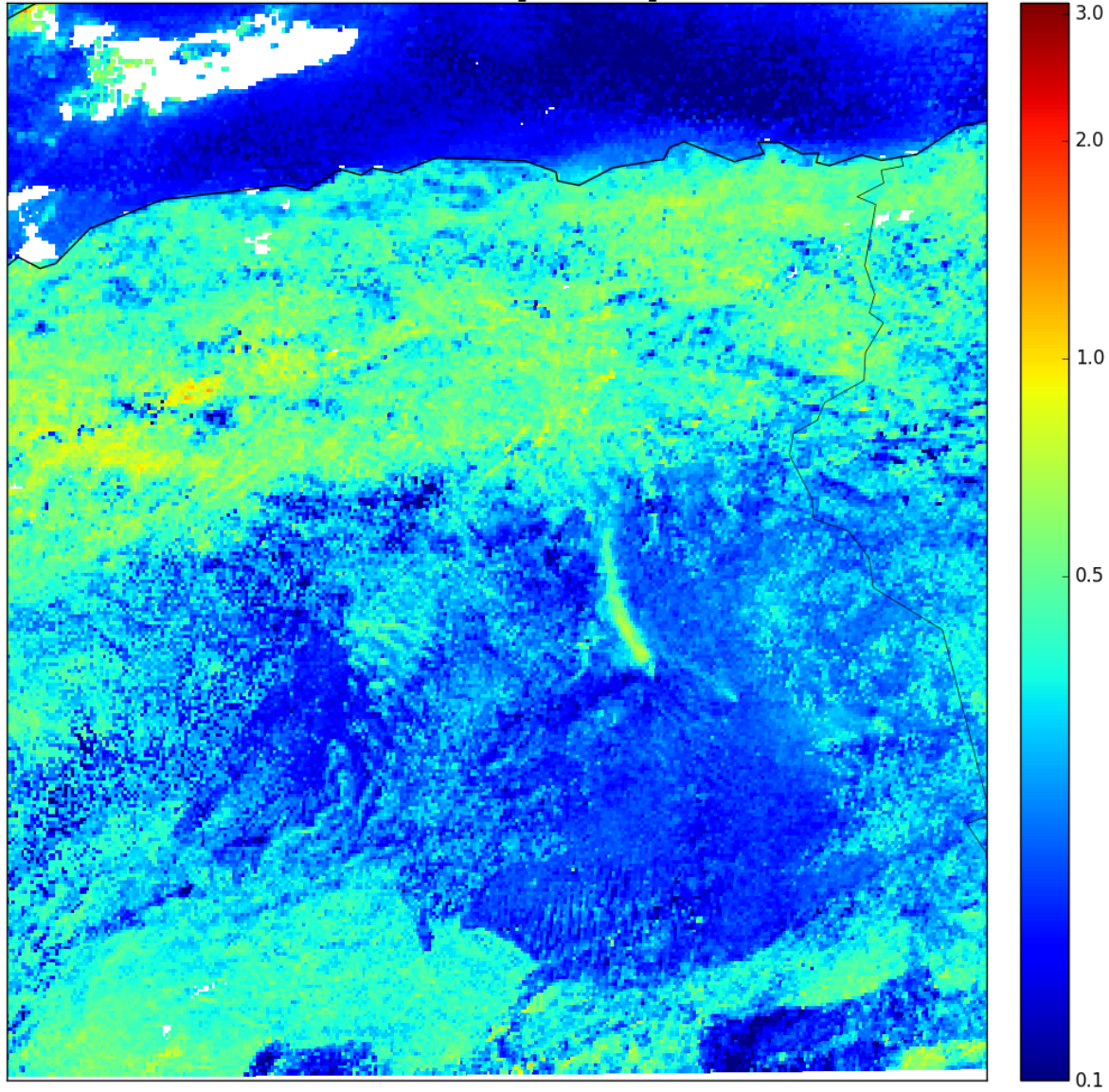
Example of retrieval

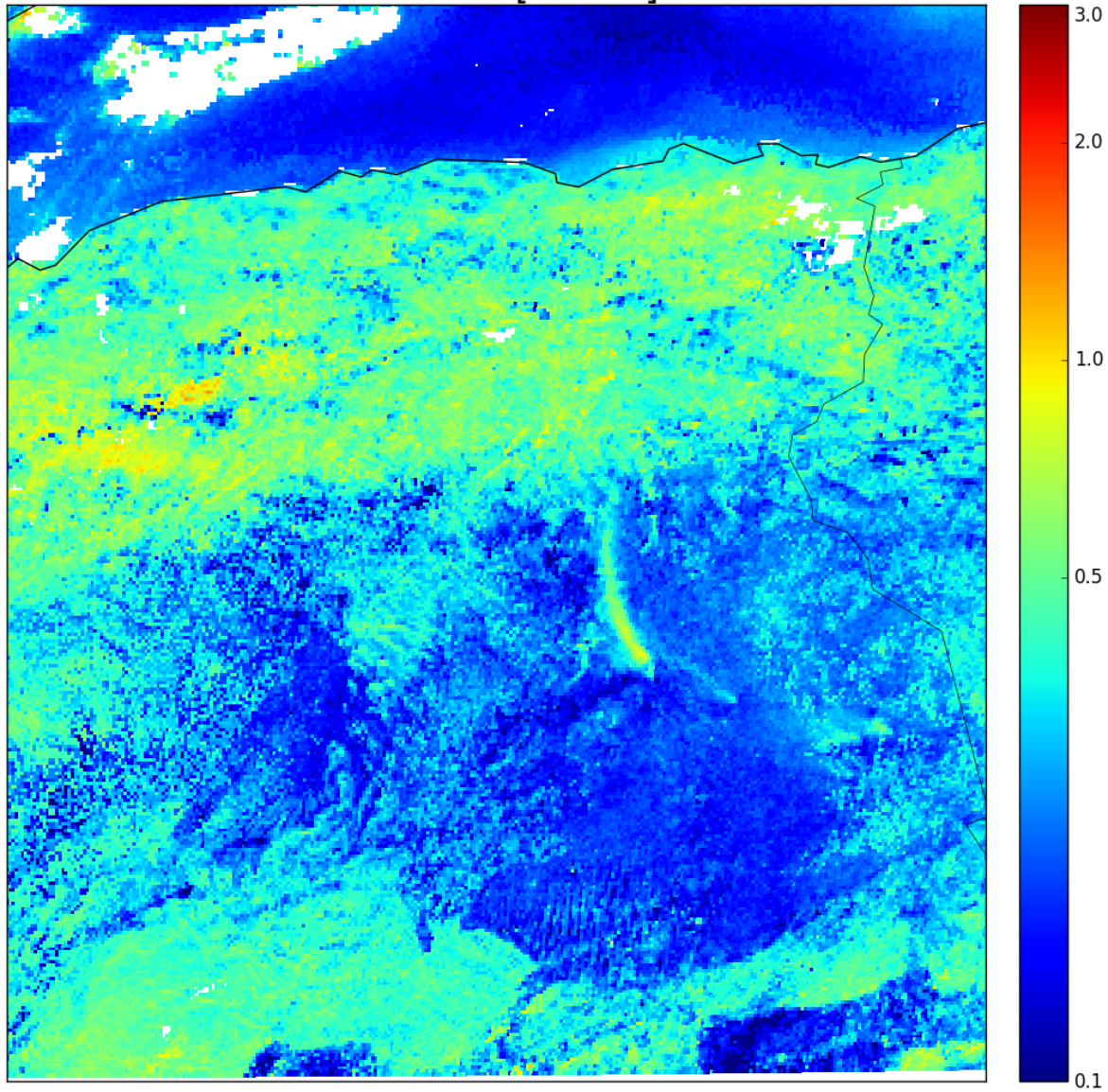


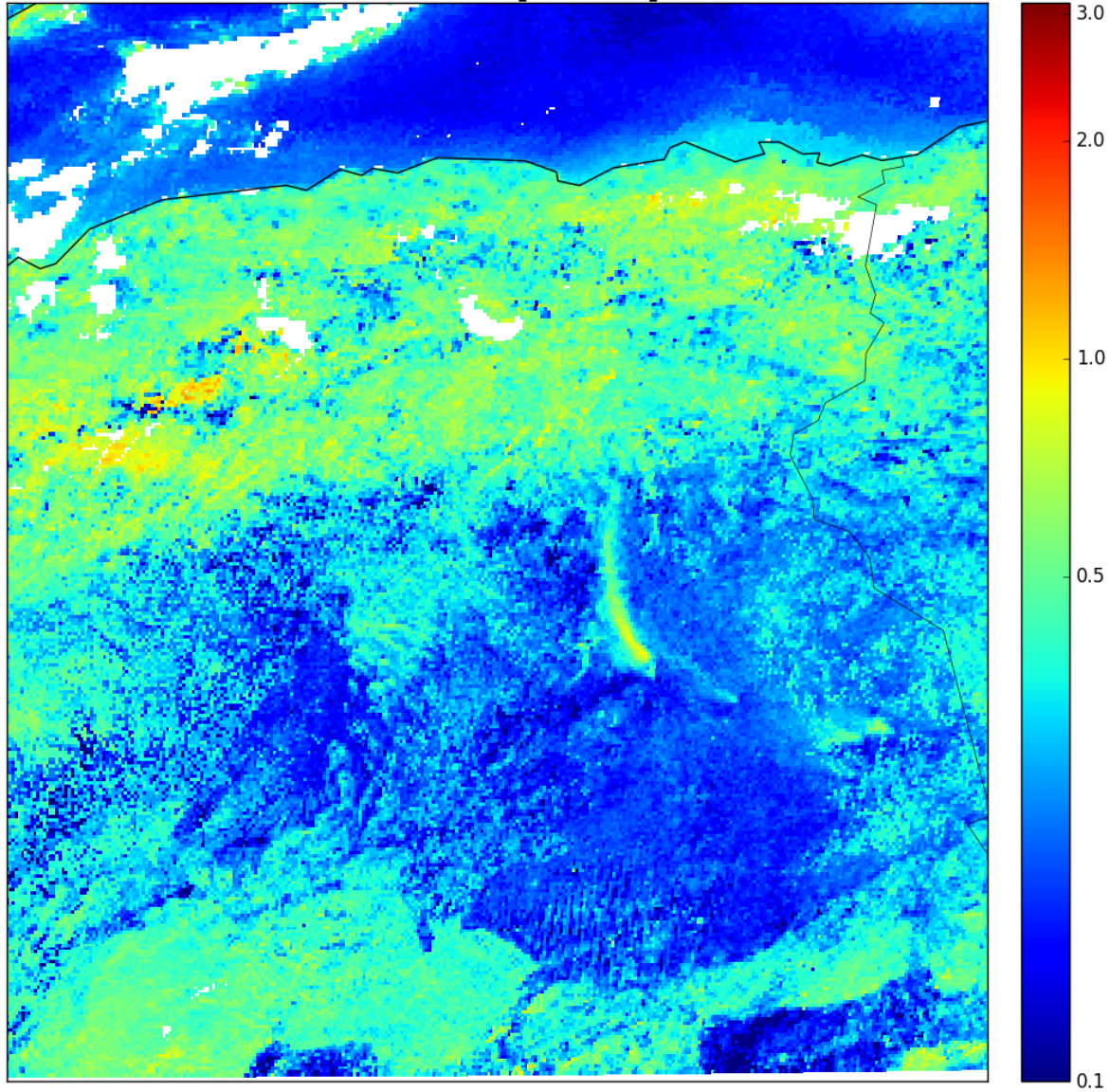
AOD550 [SEVIRI]

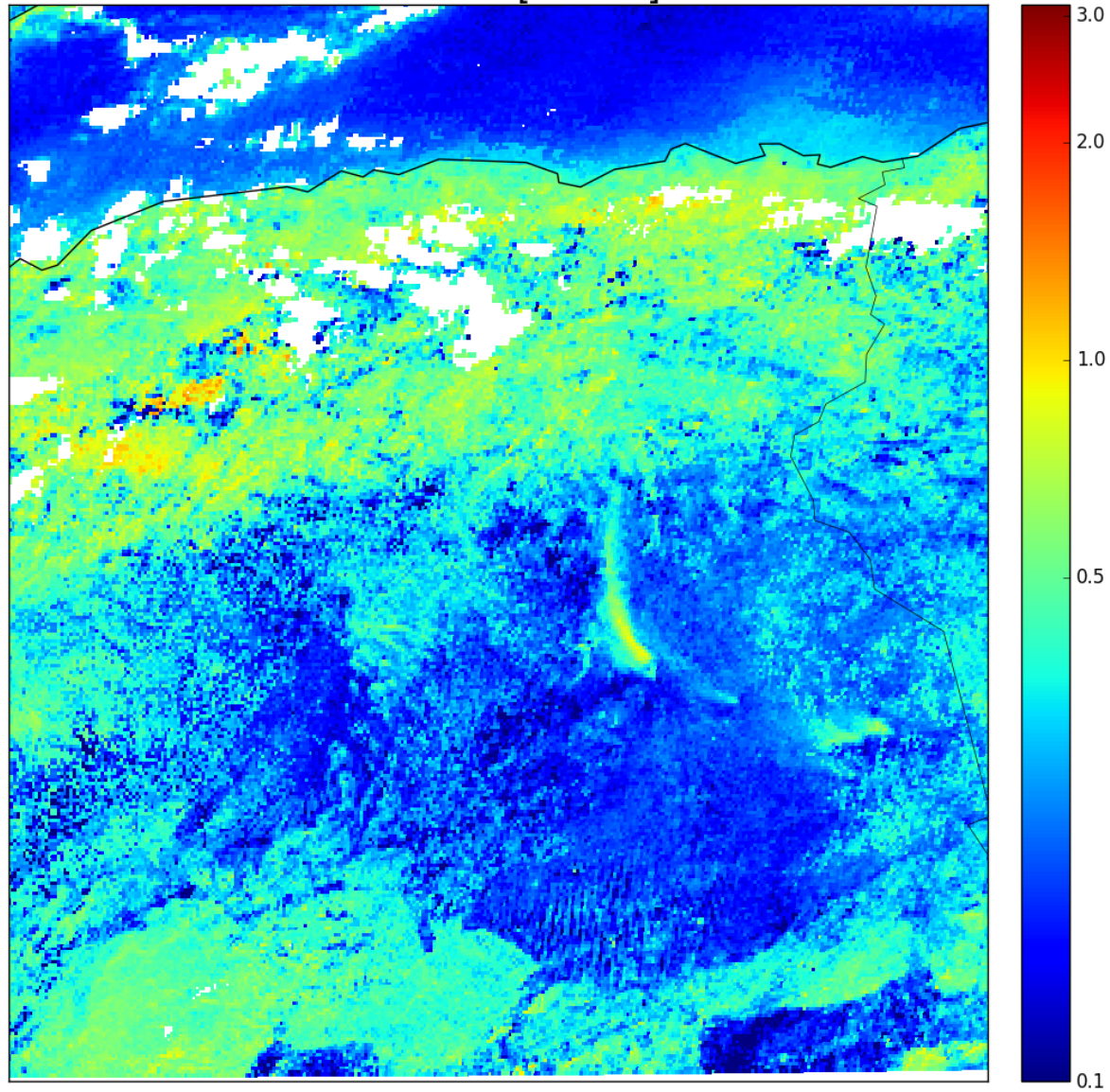


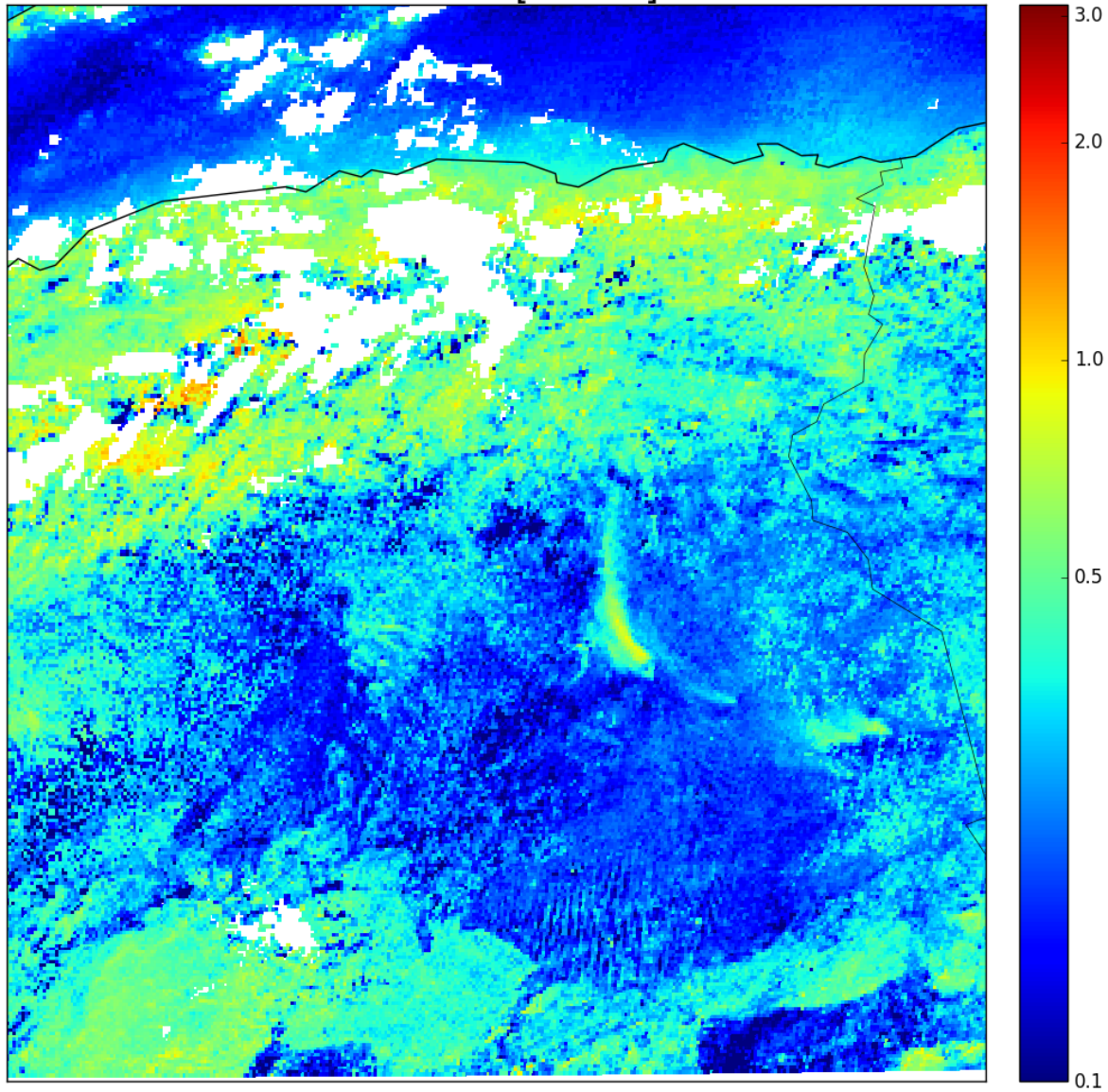


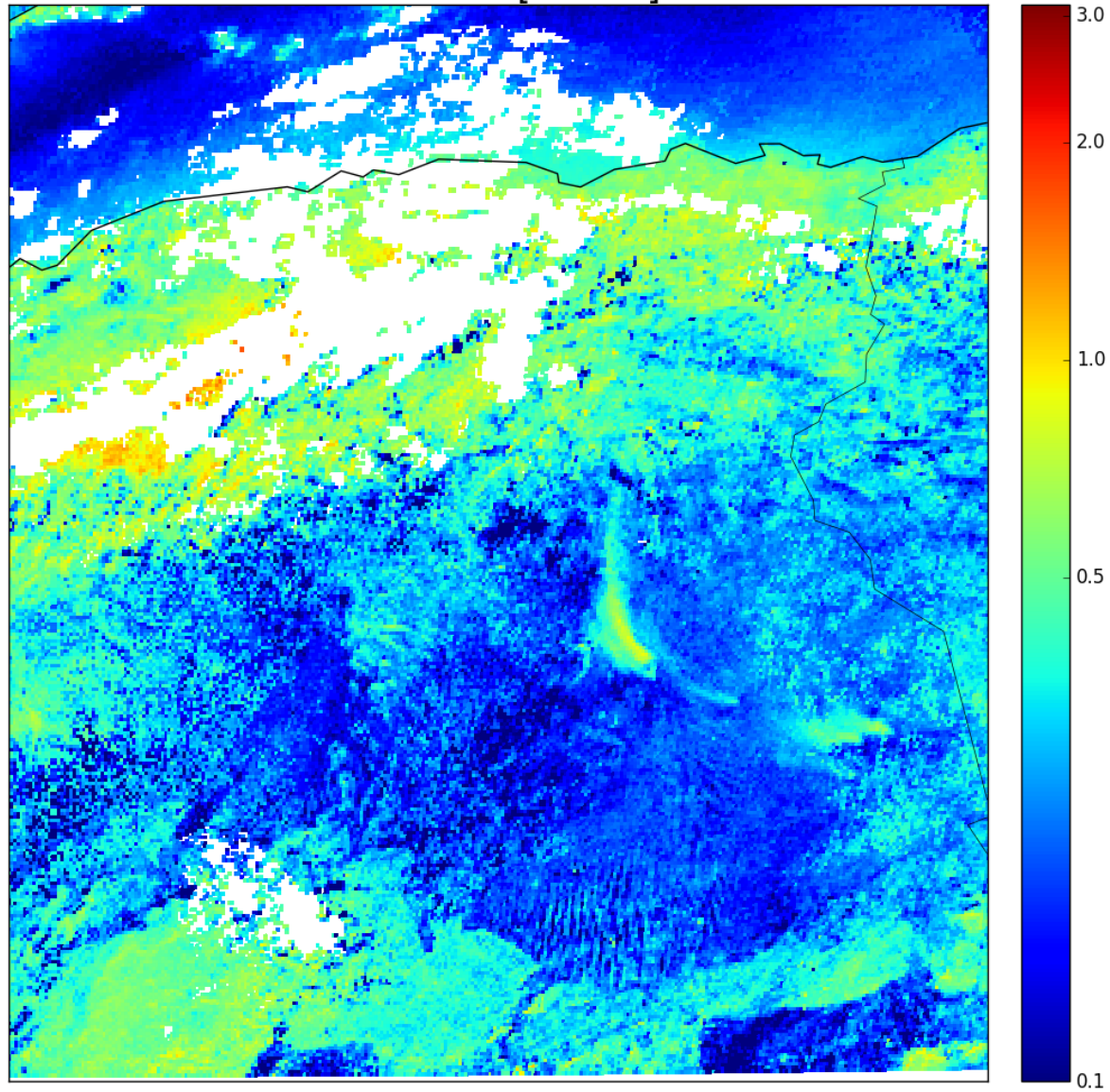


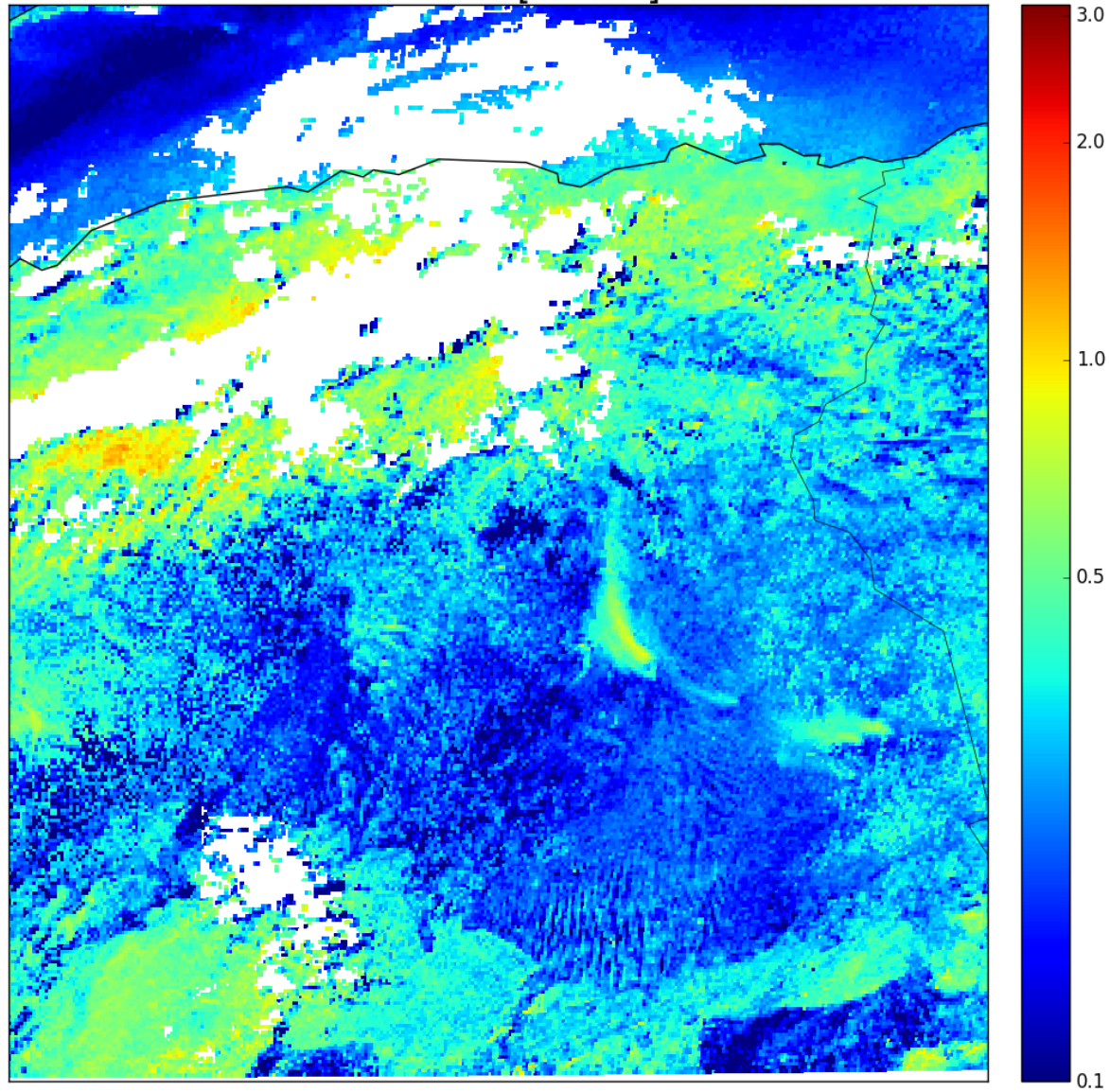


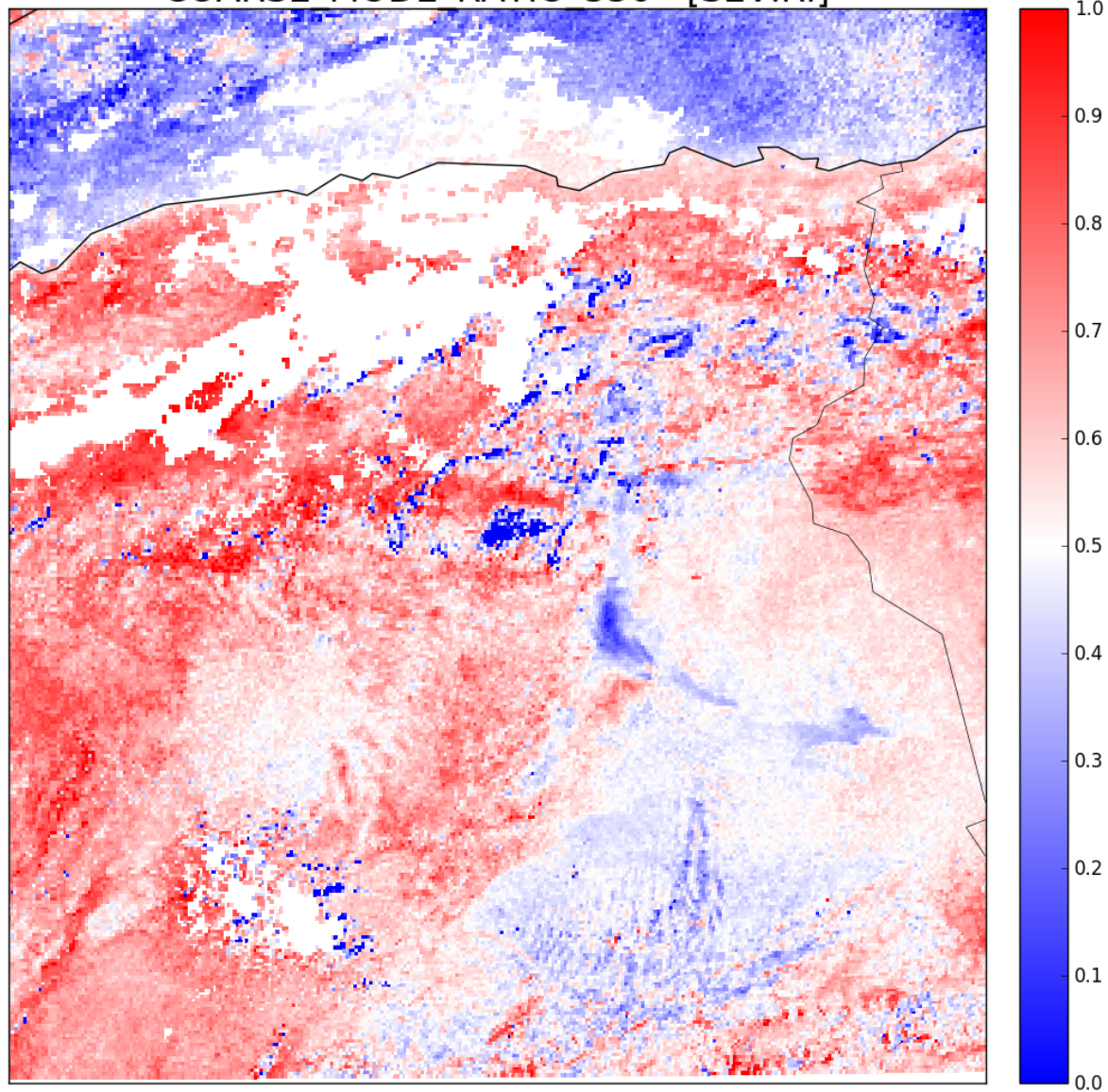


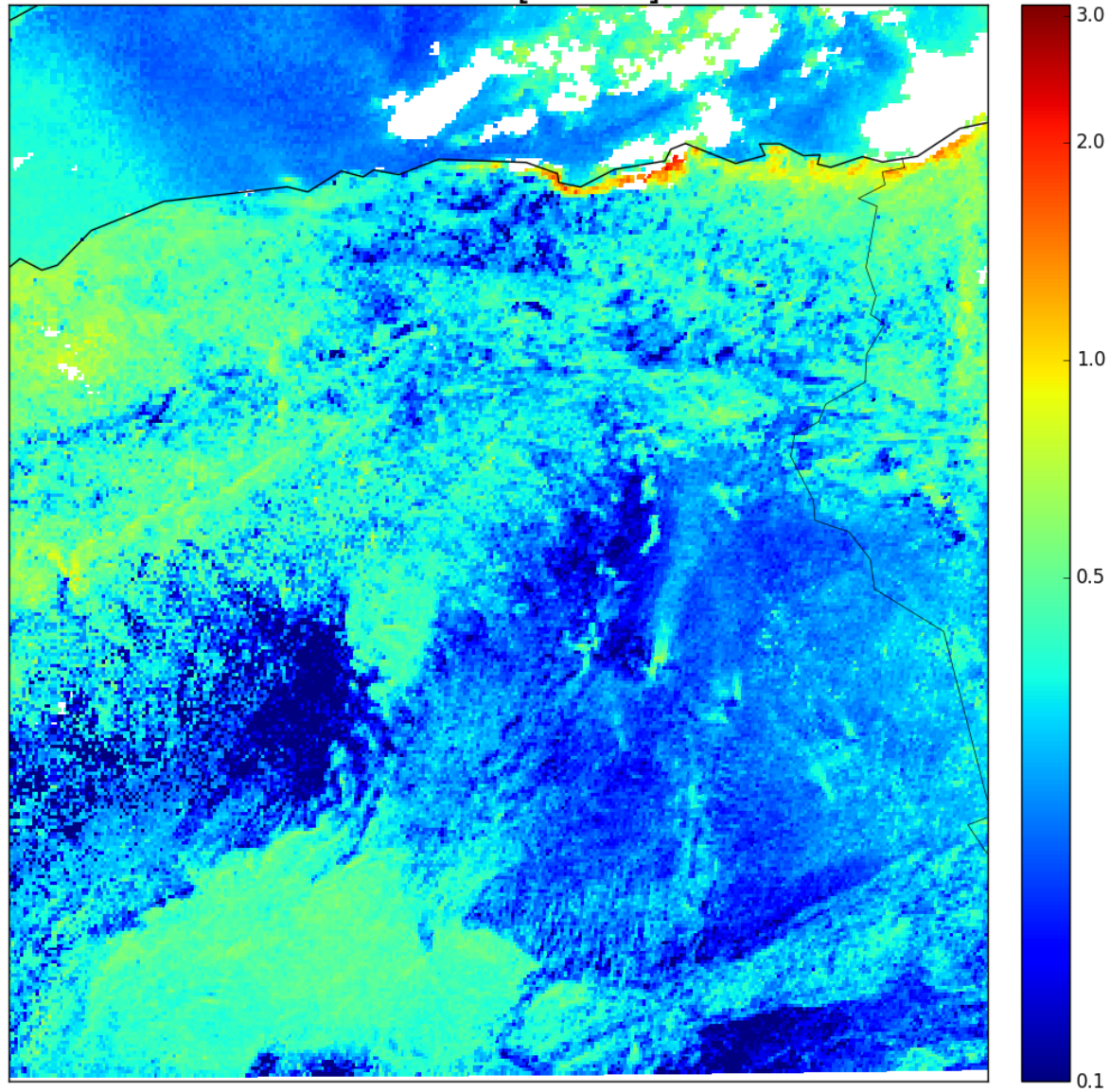


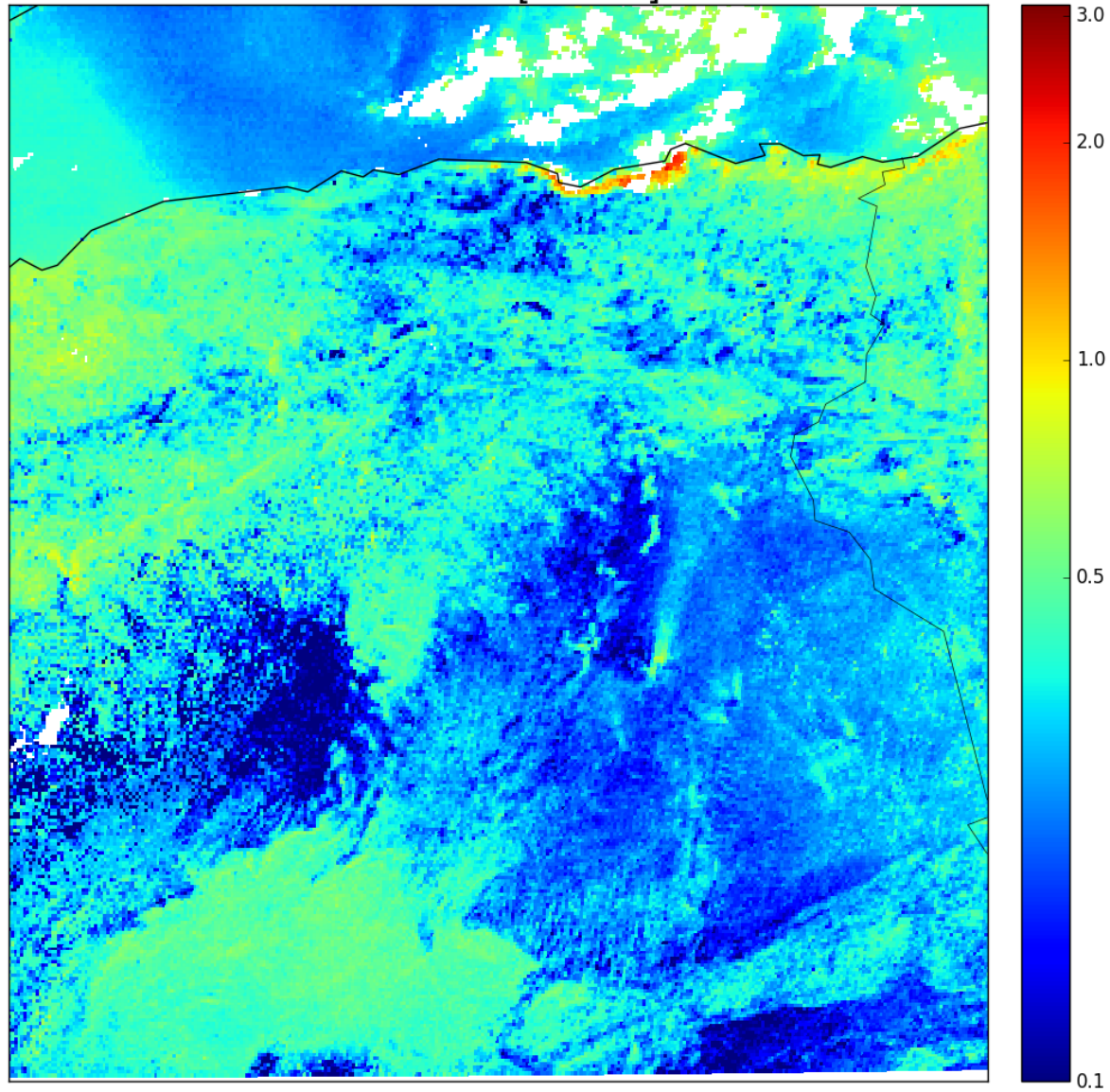


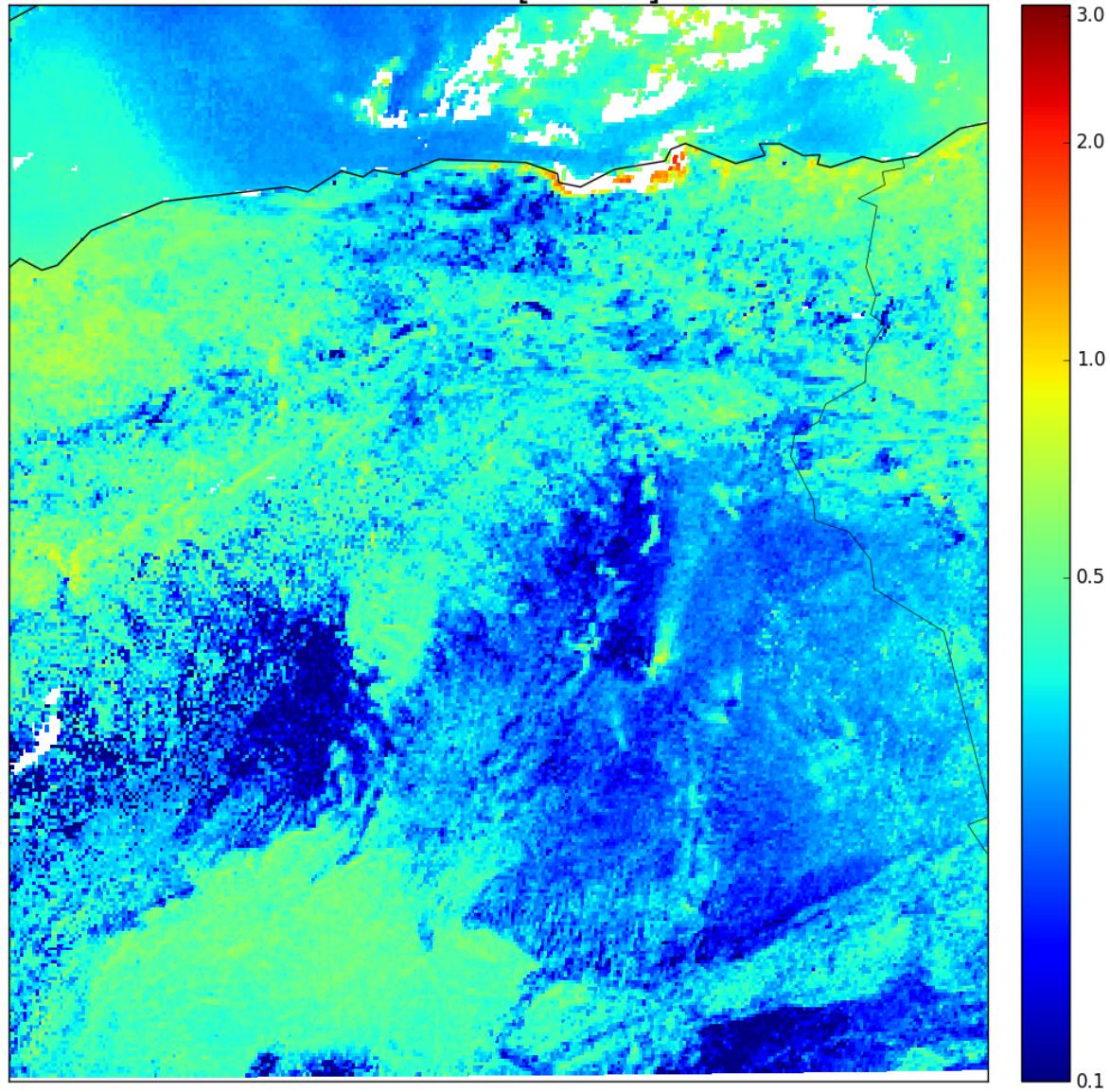


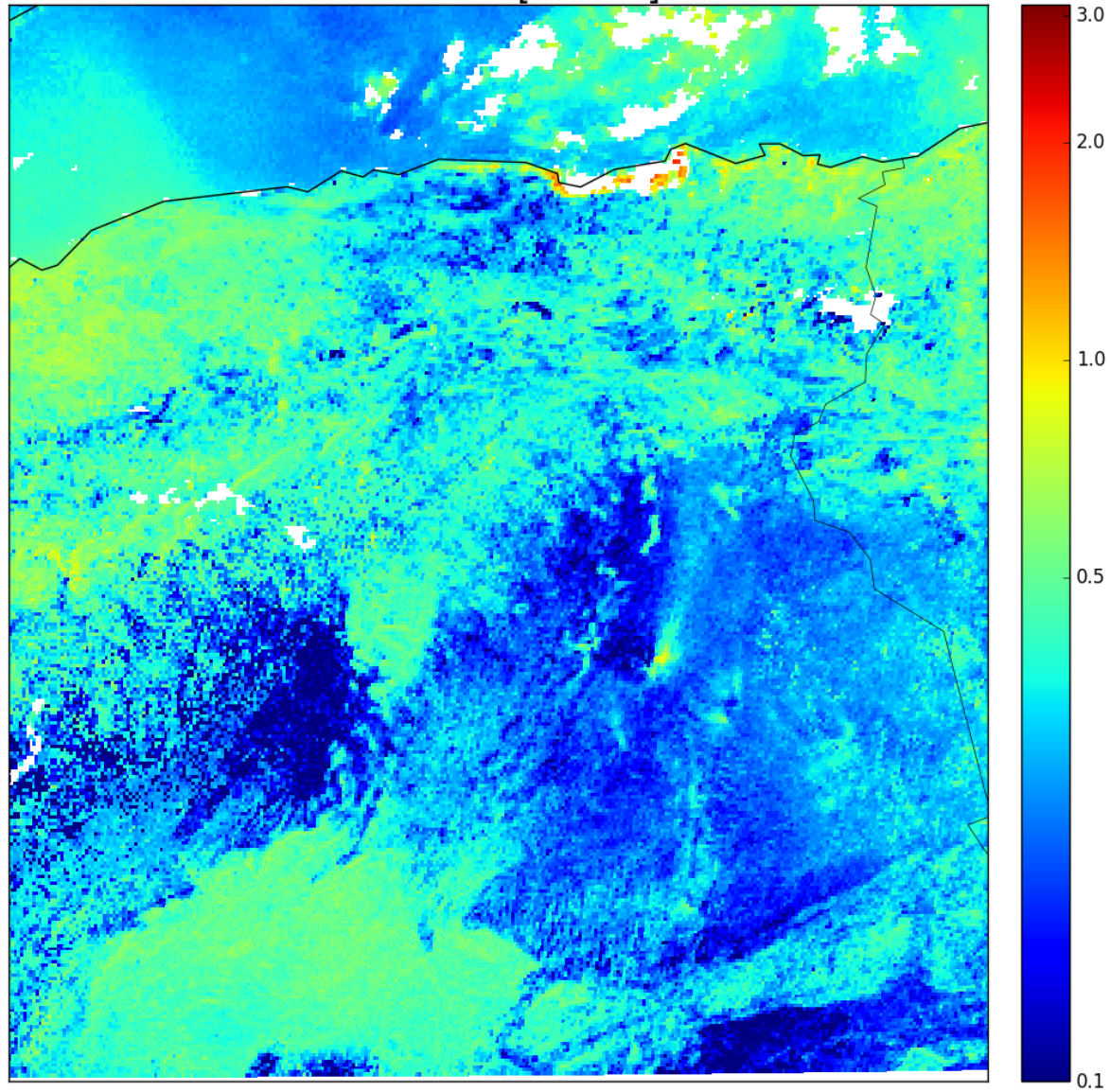


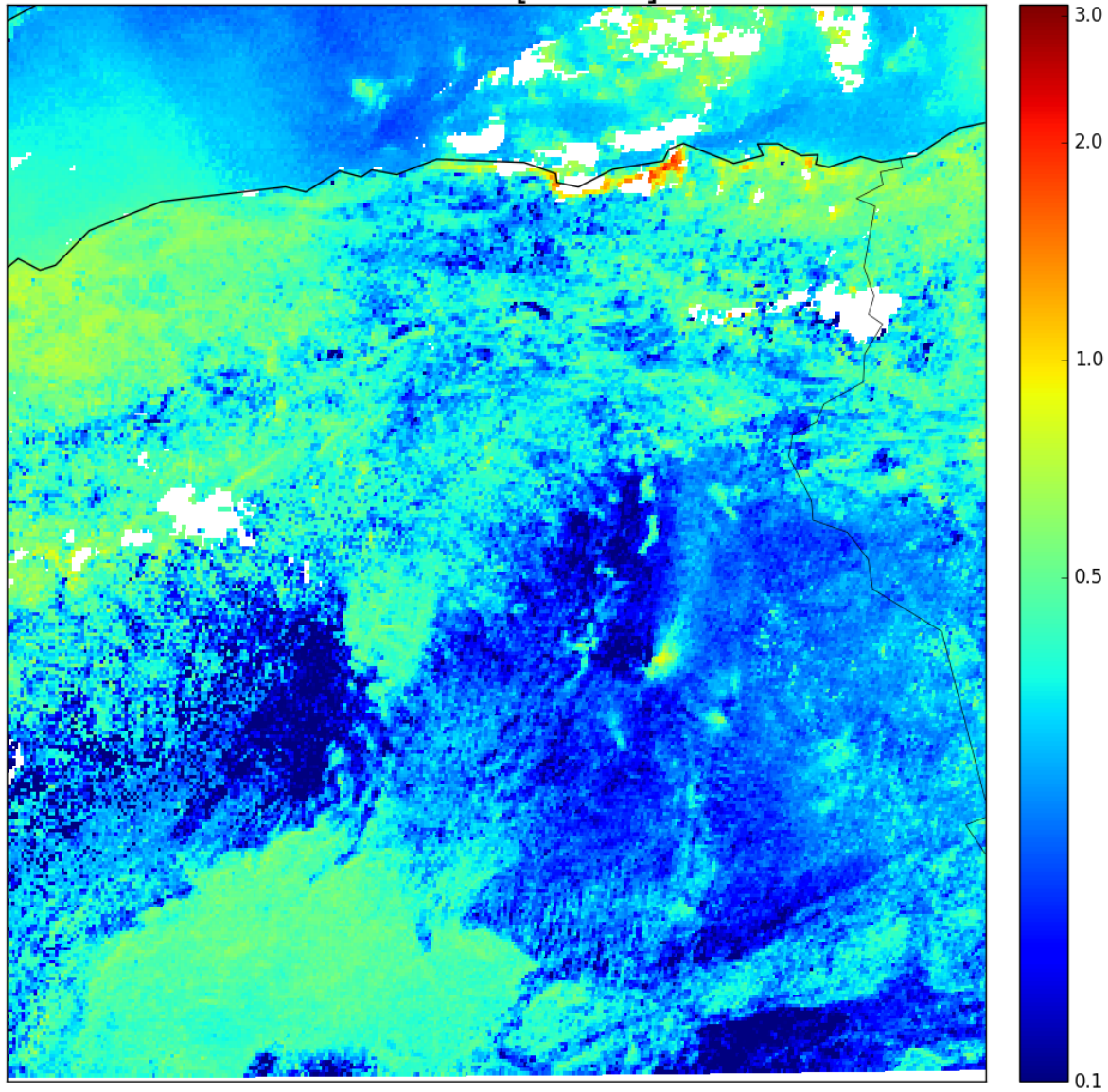


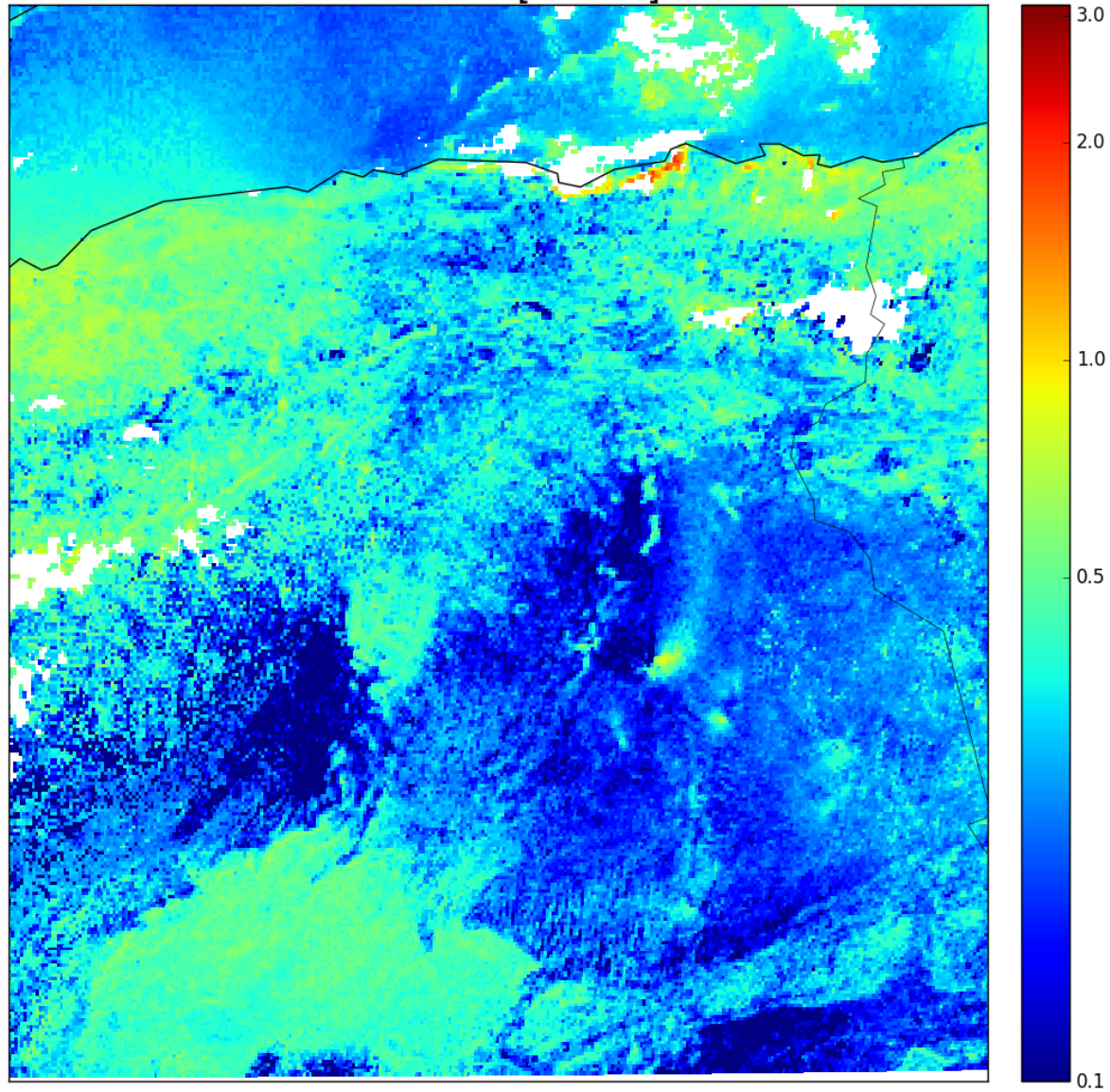


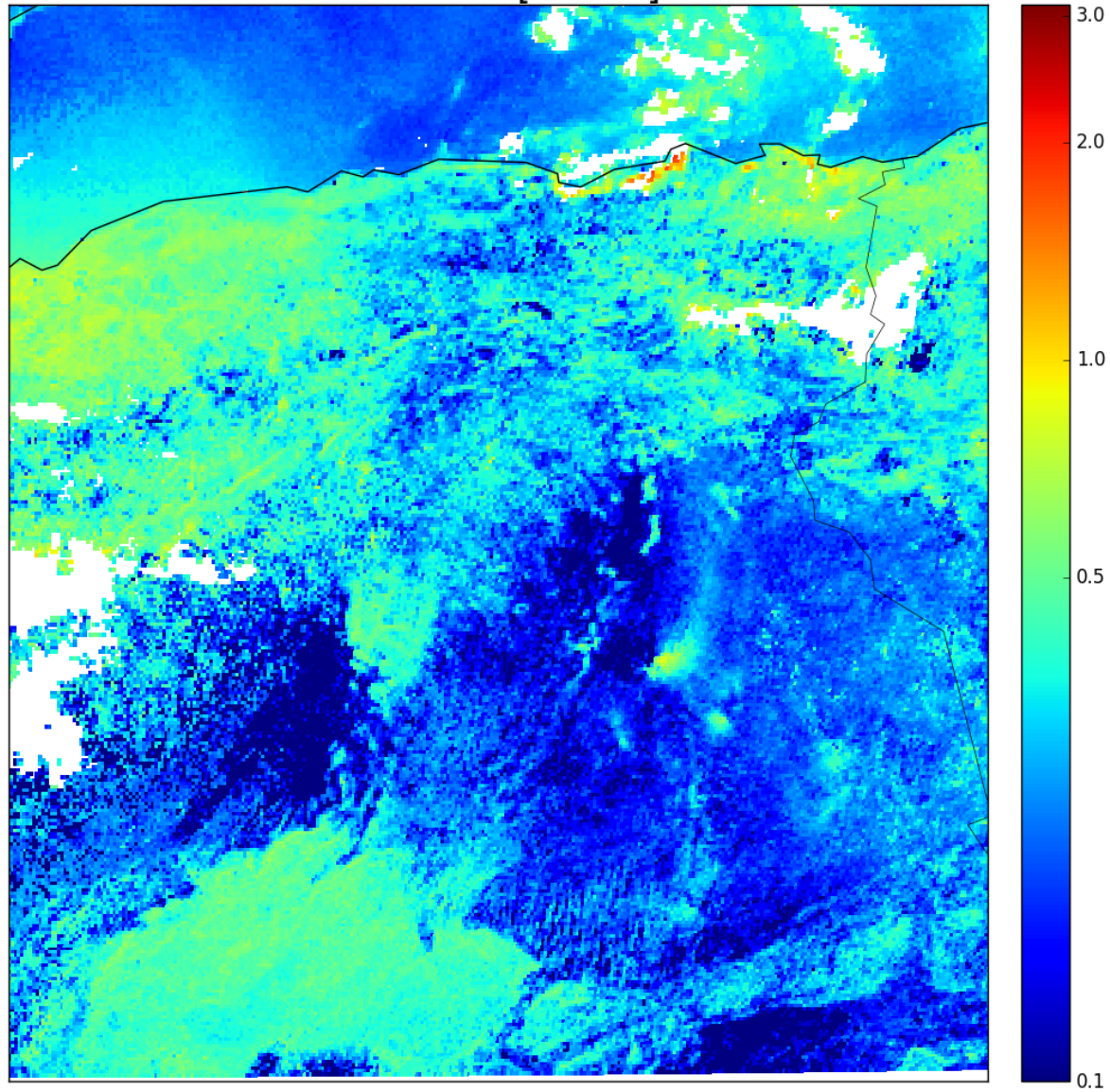


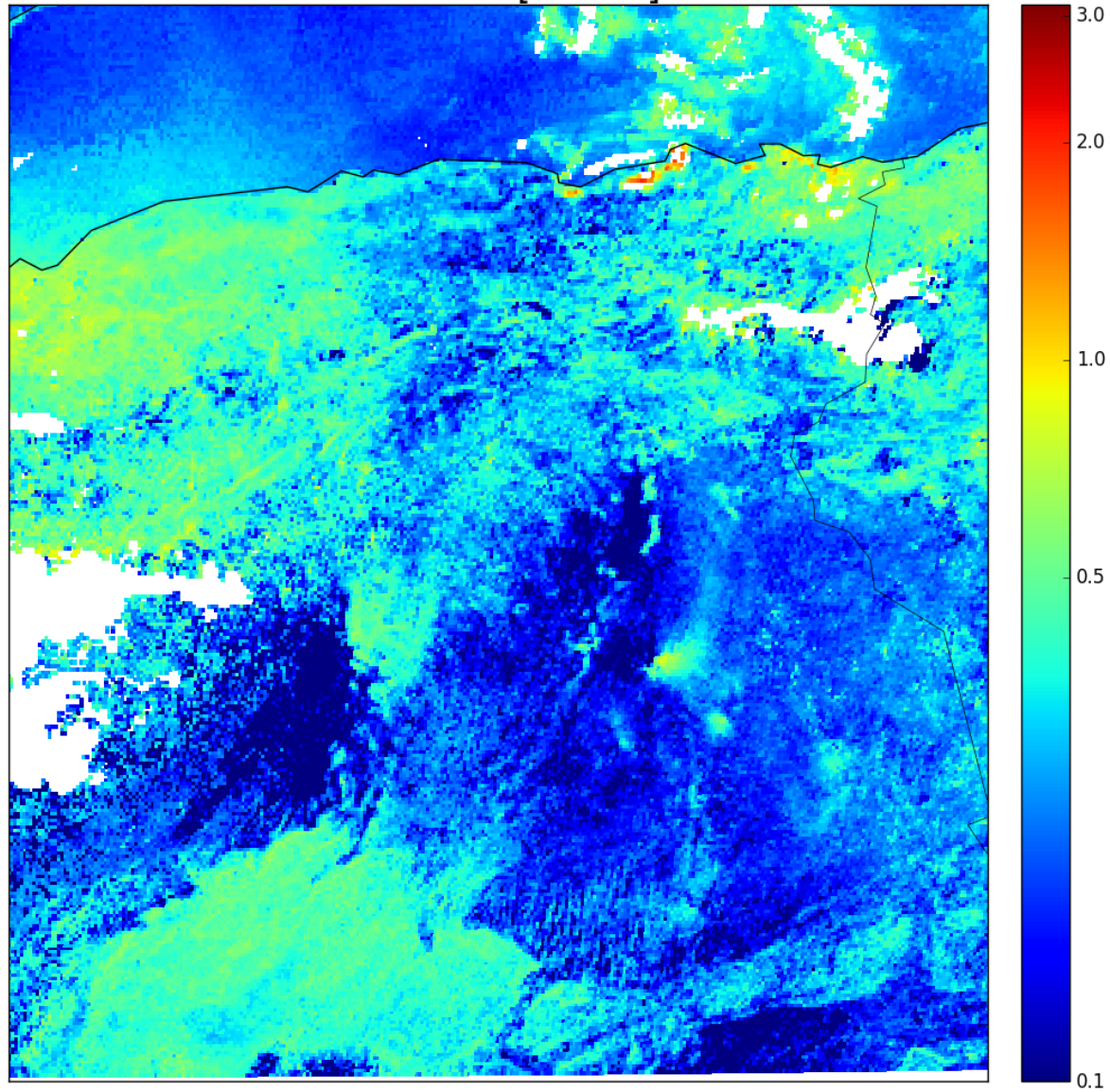


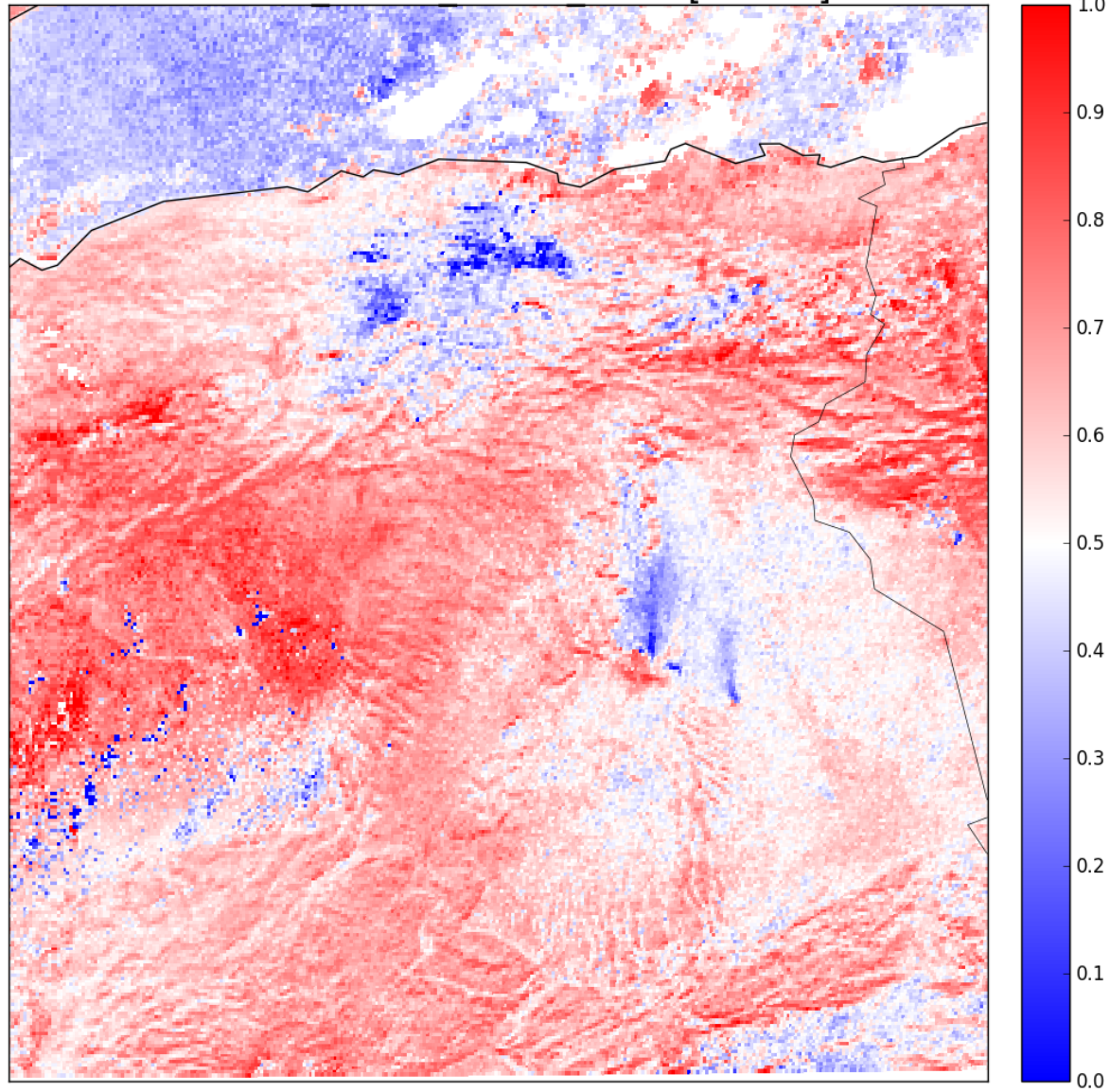


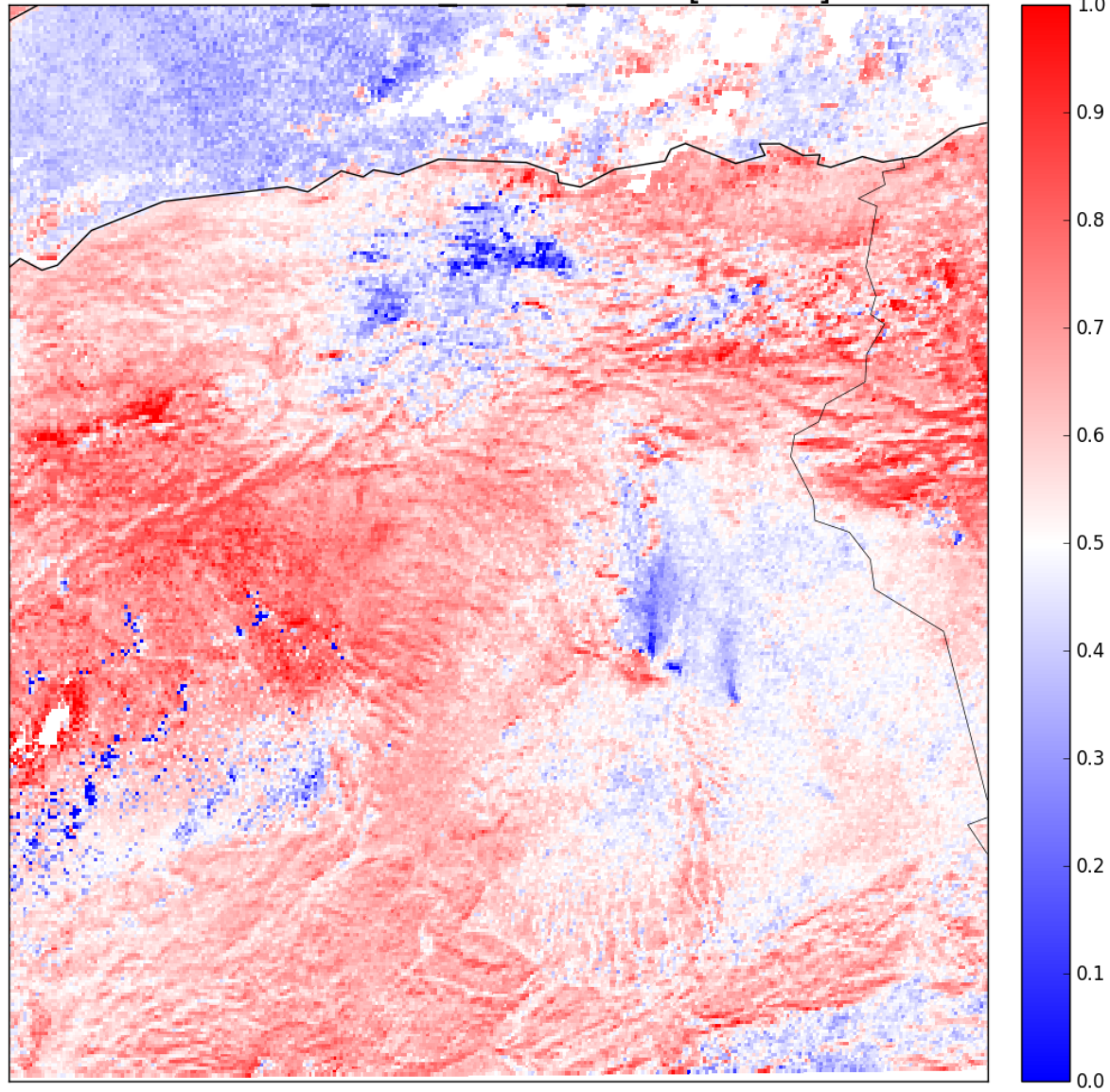


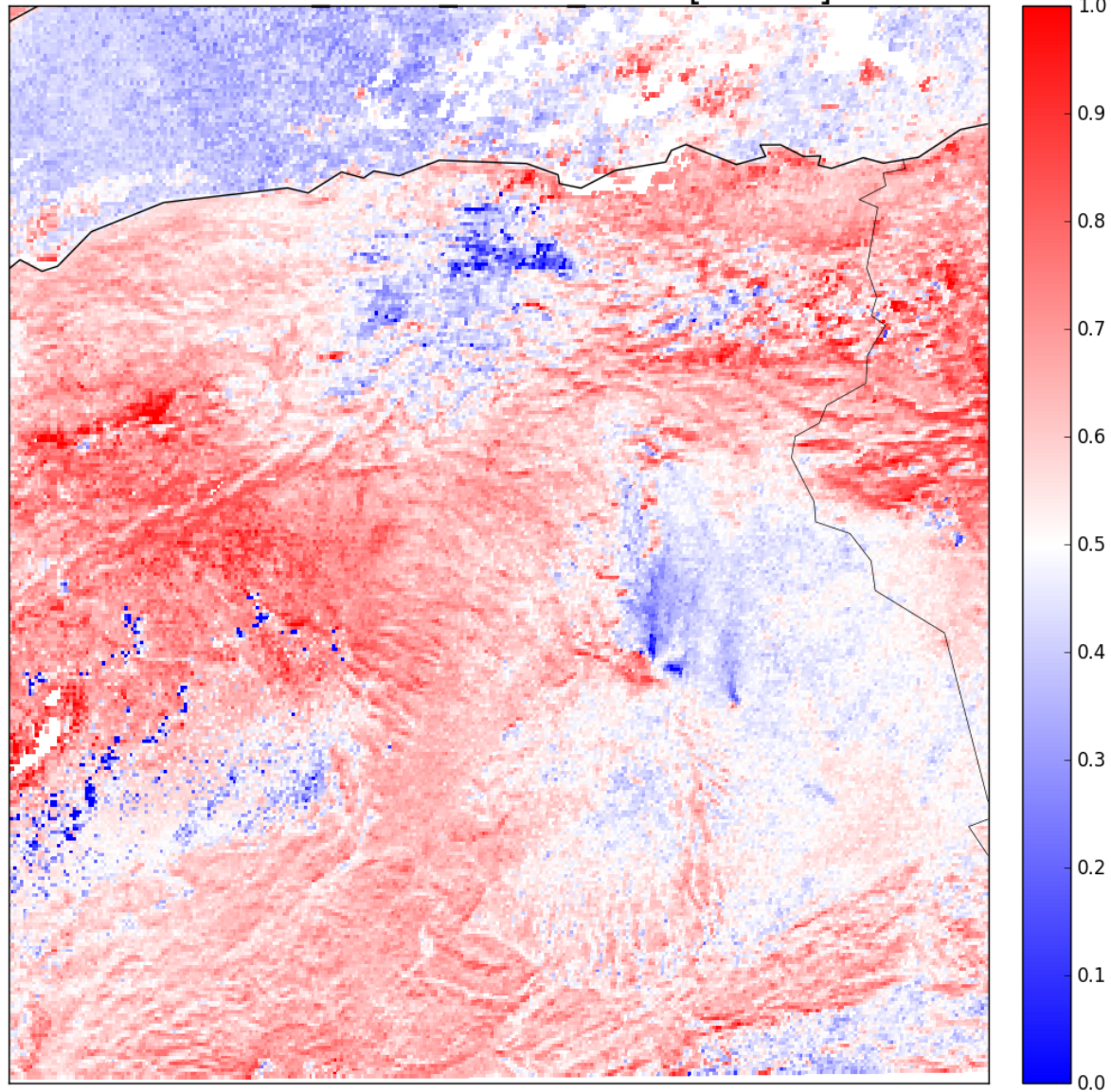


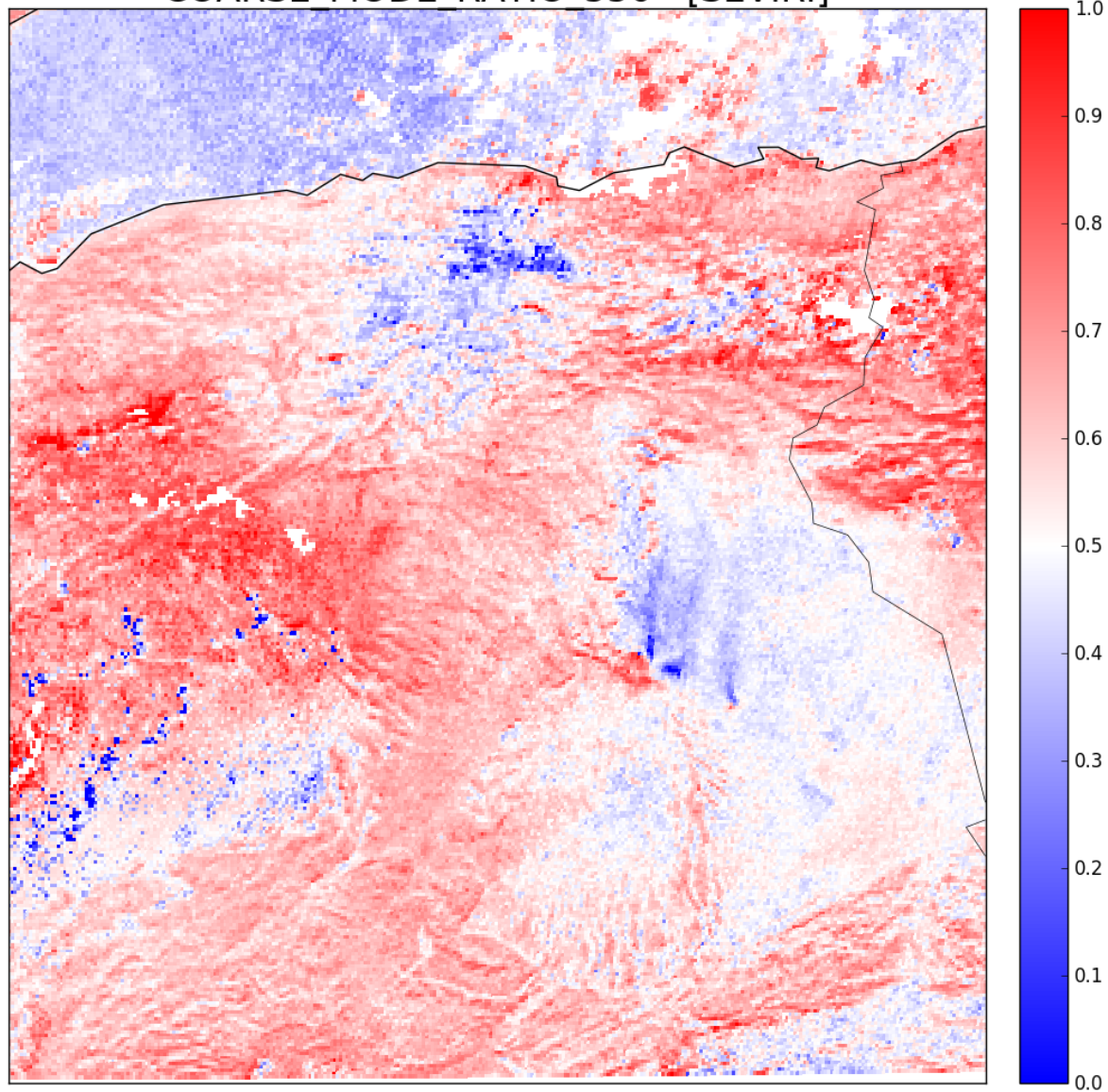


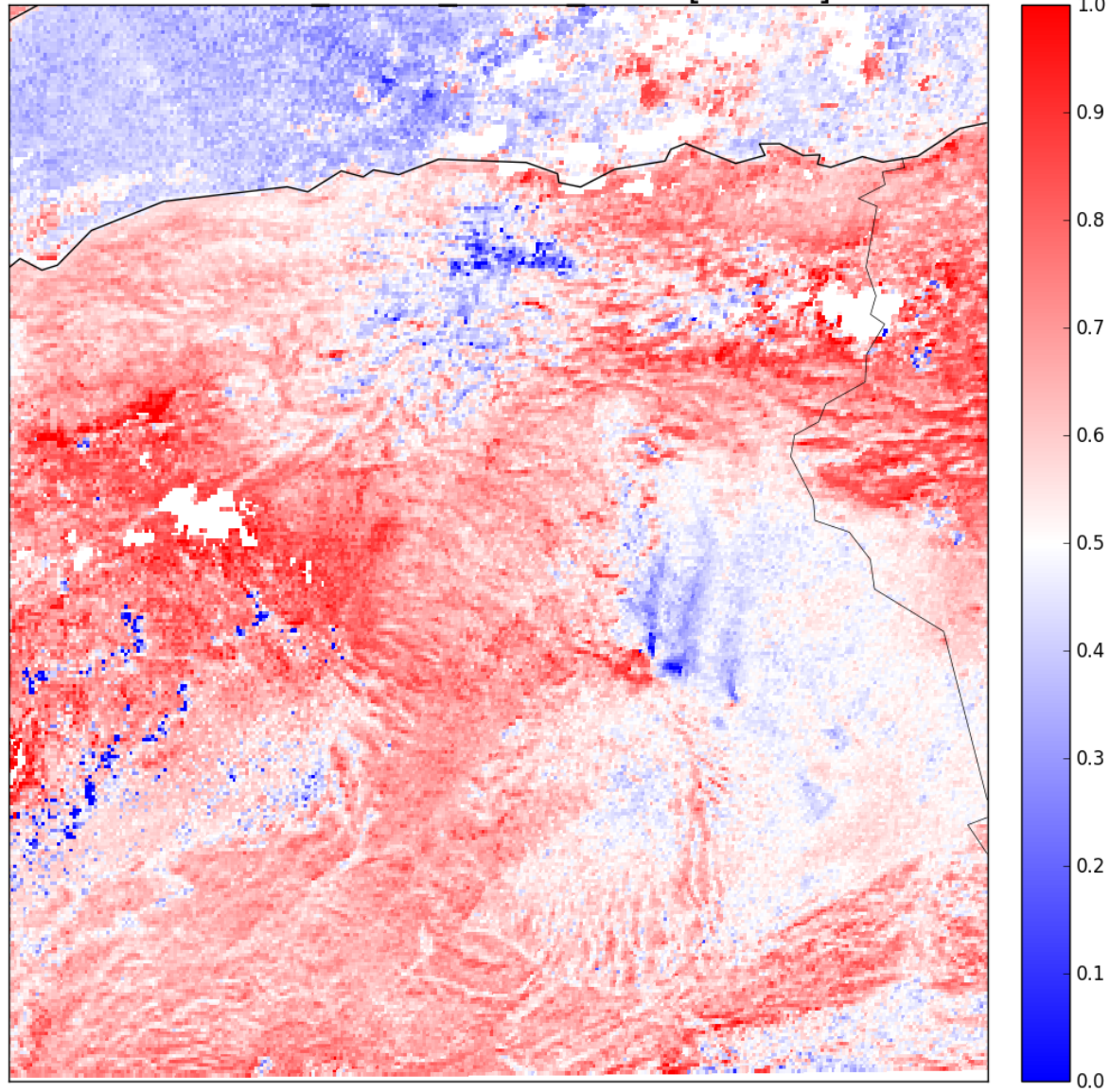


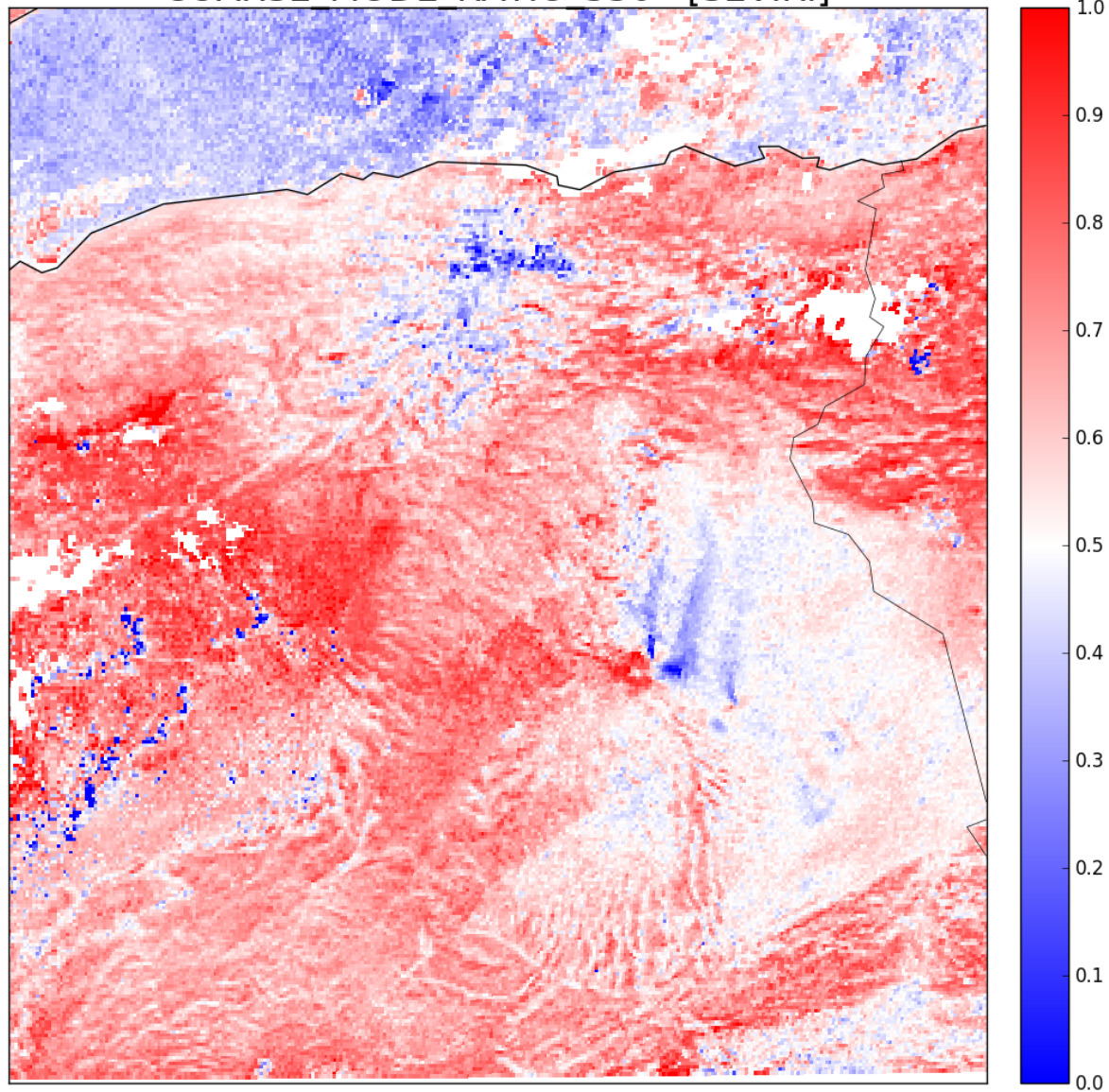


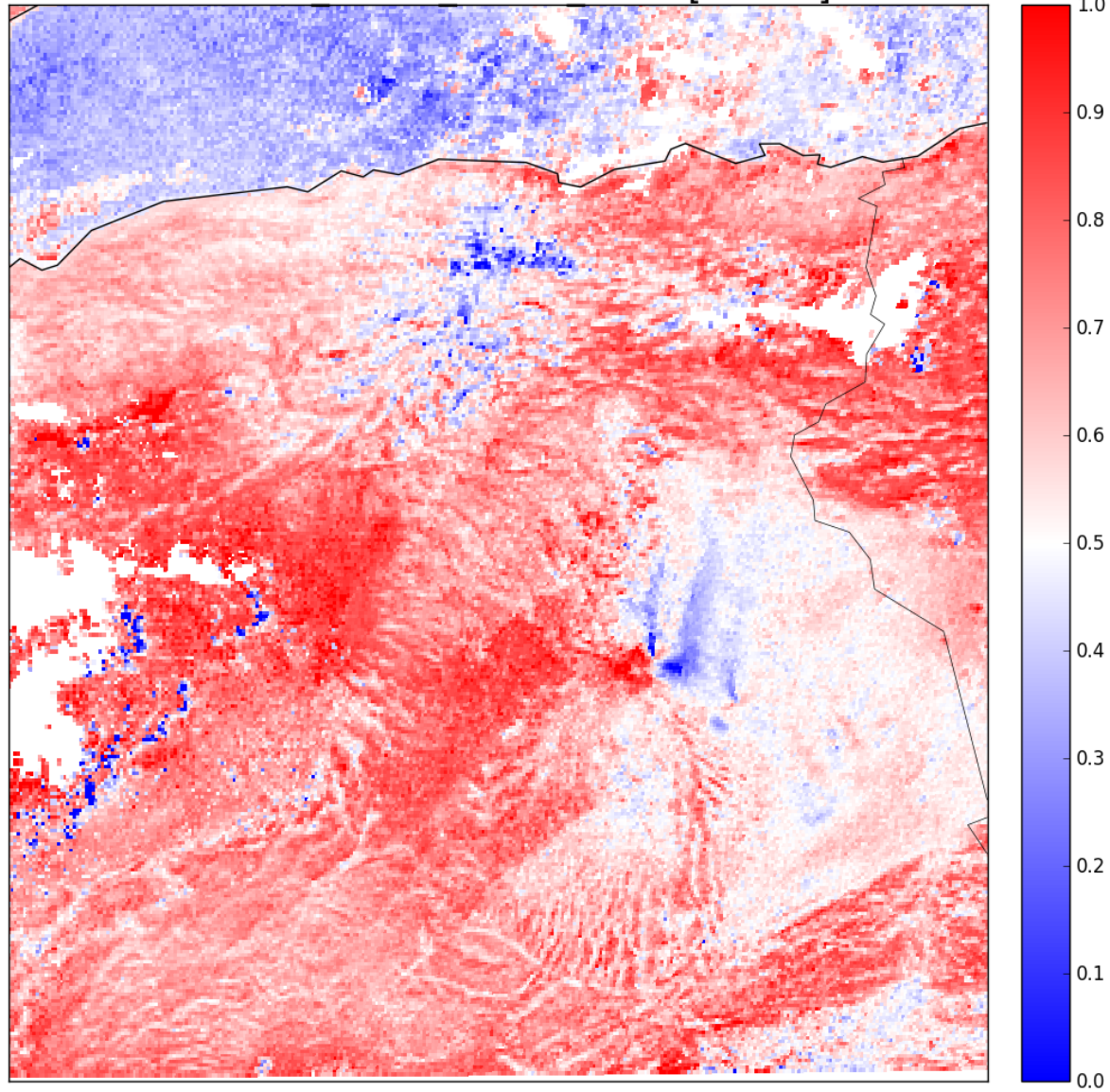


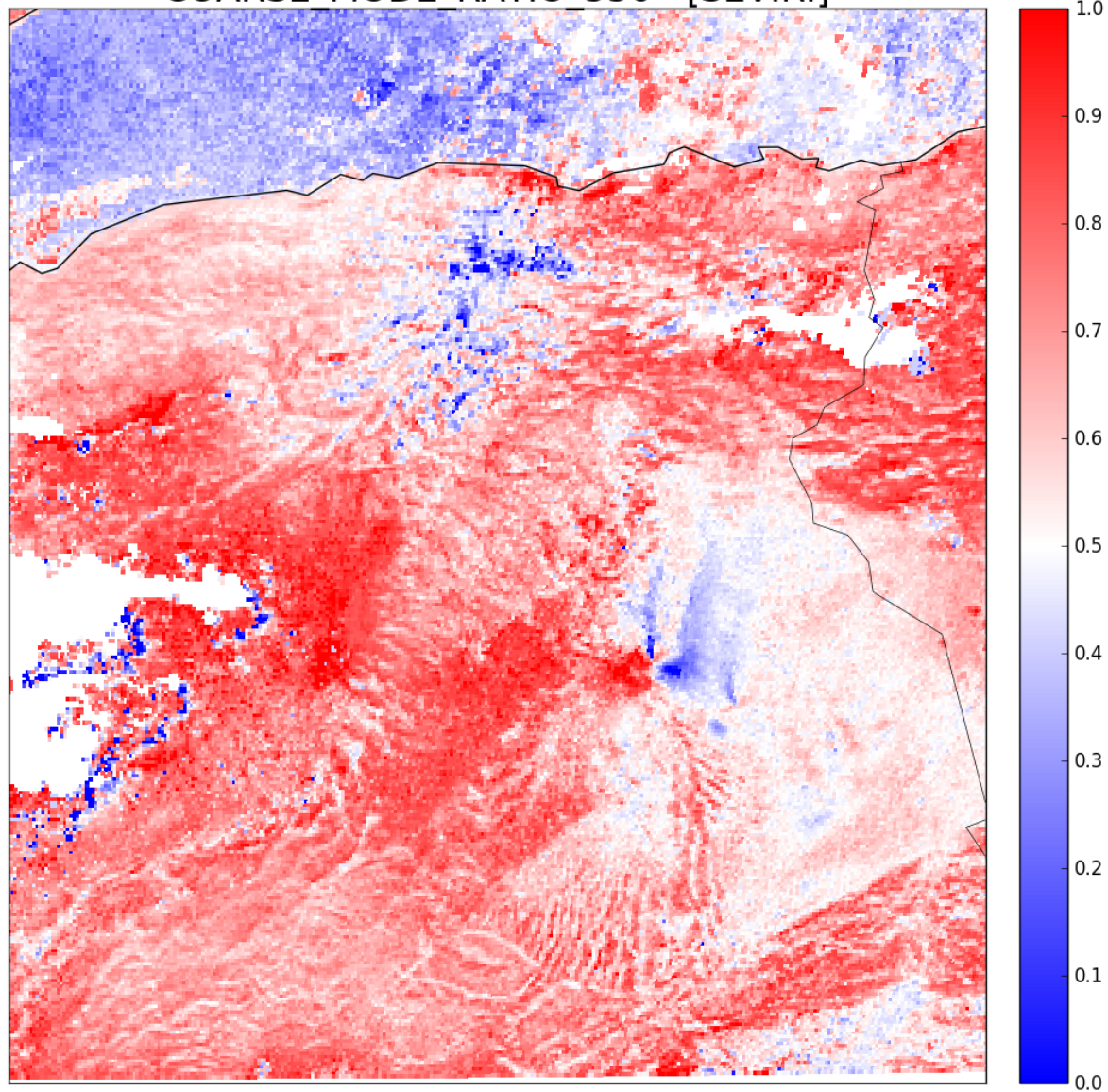




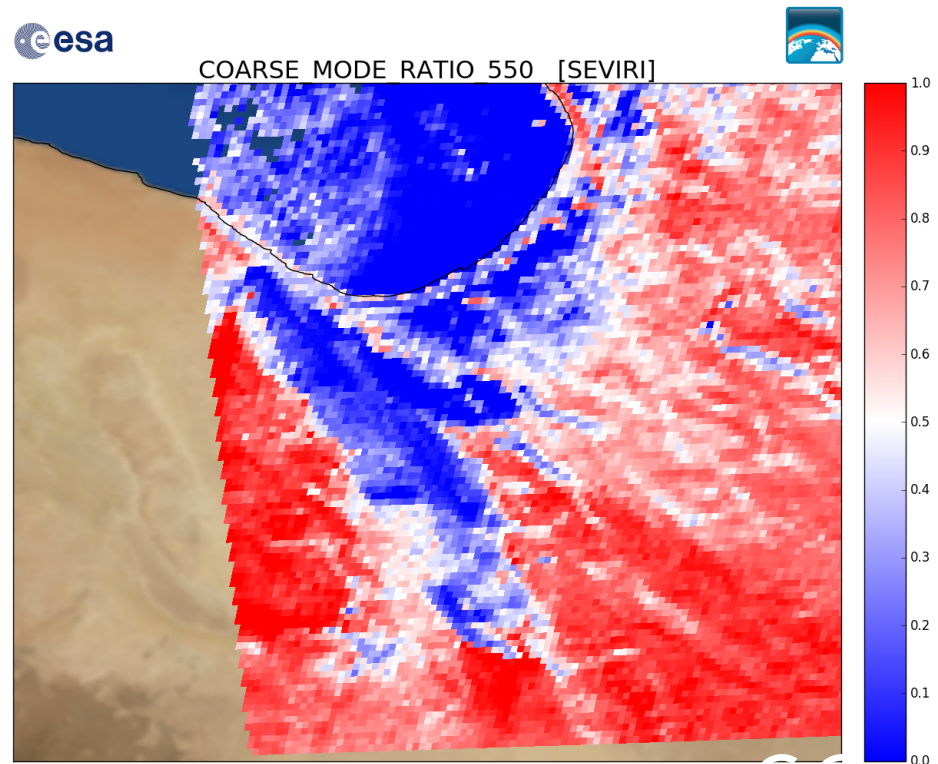
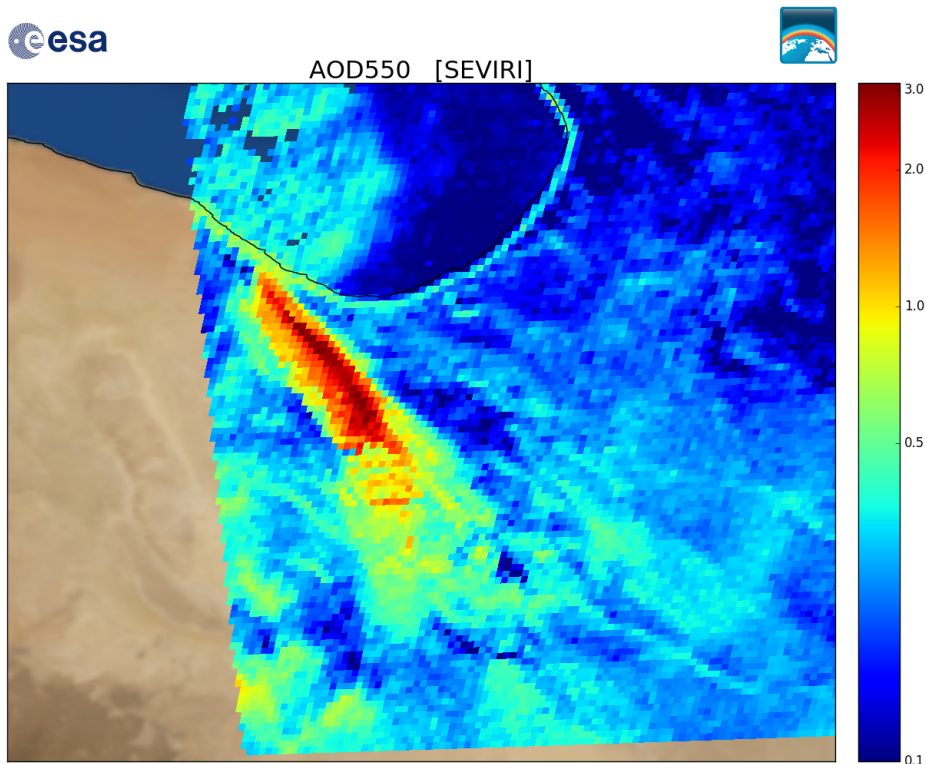




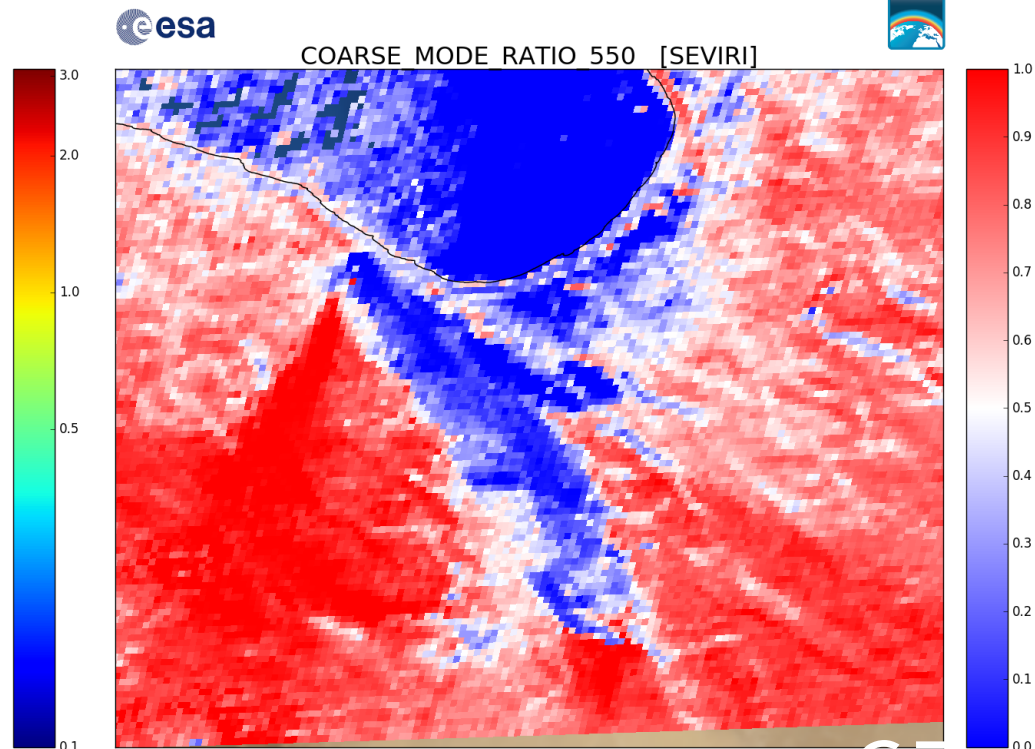
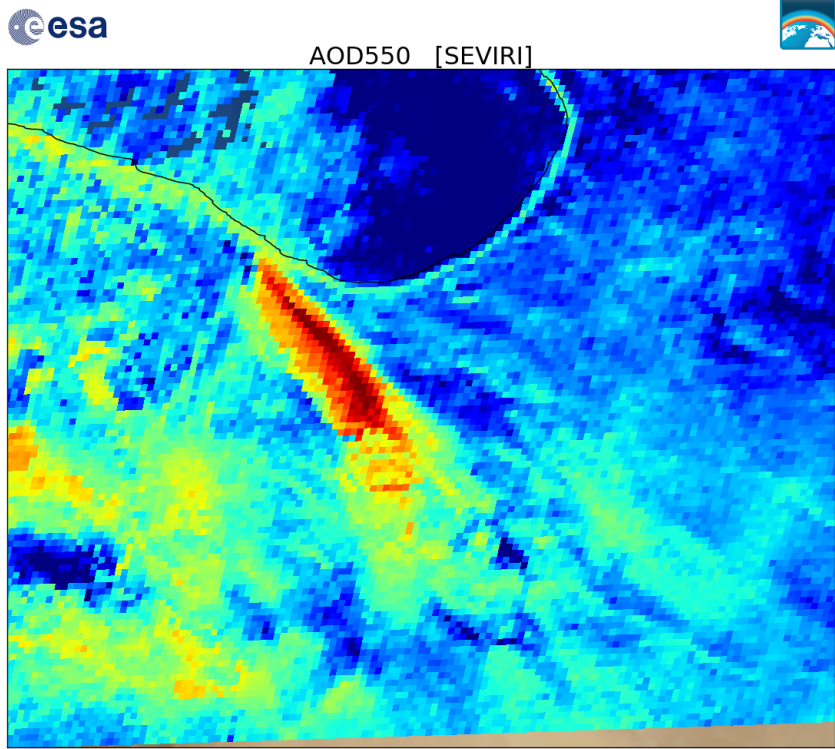




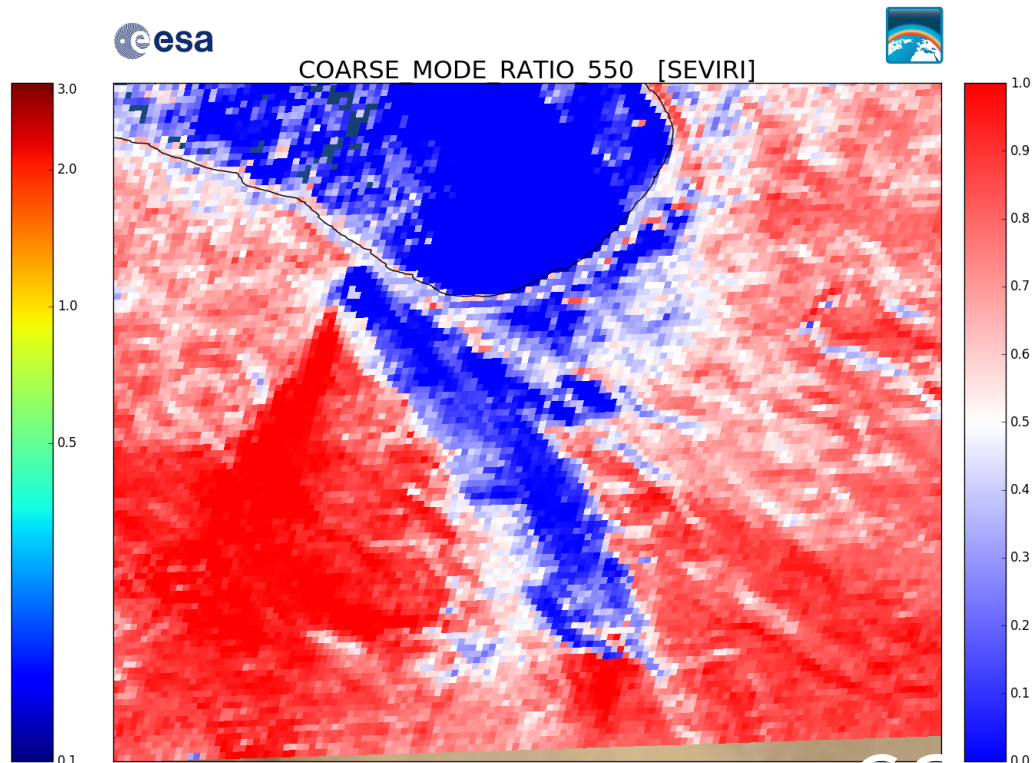
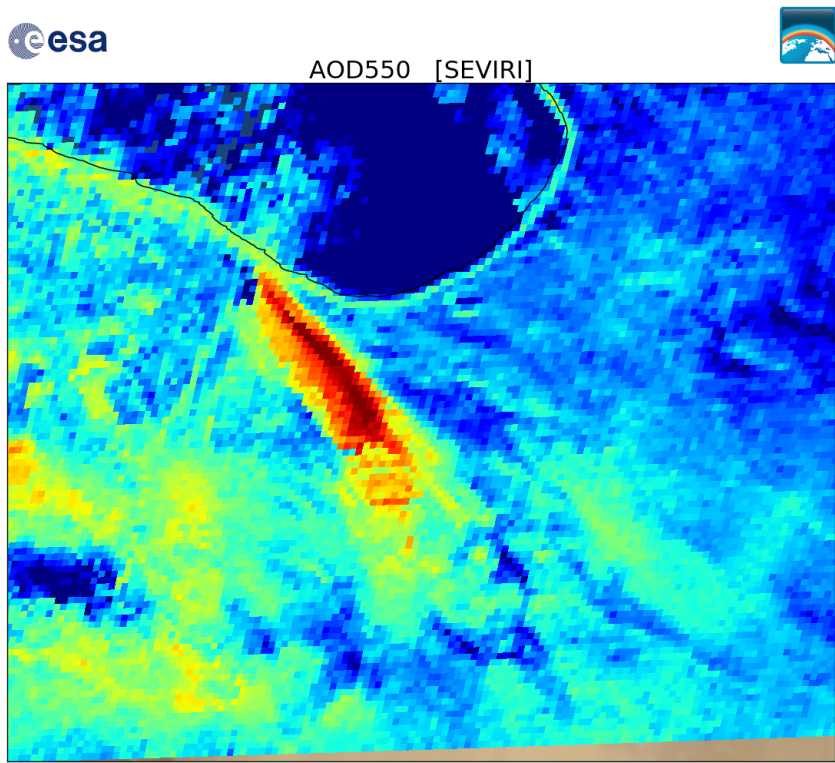
Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



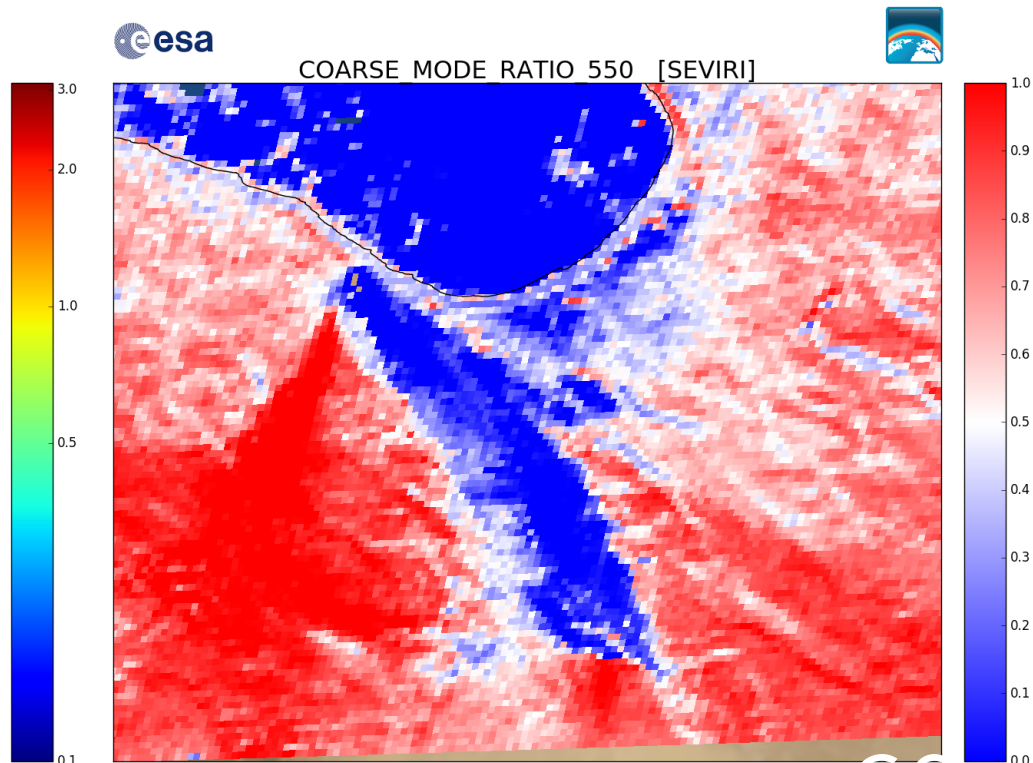
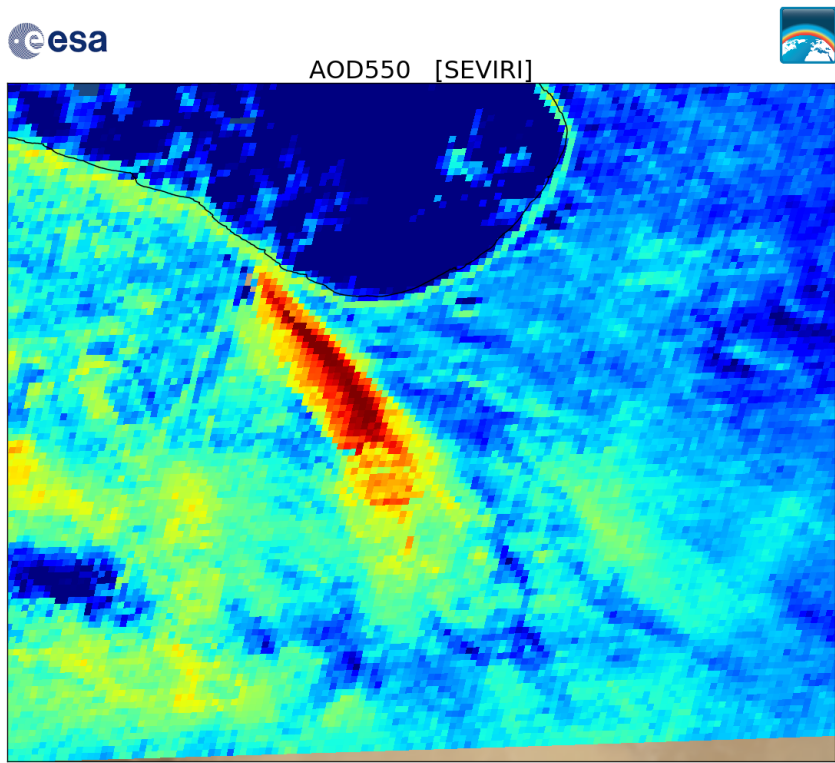
Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



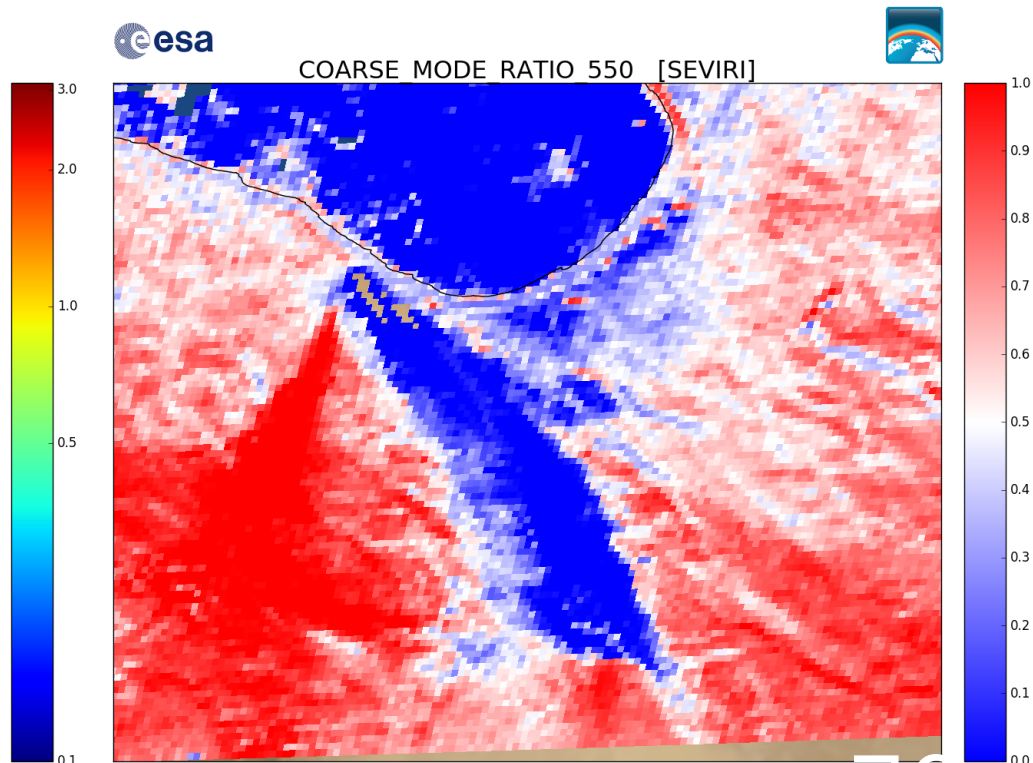
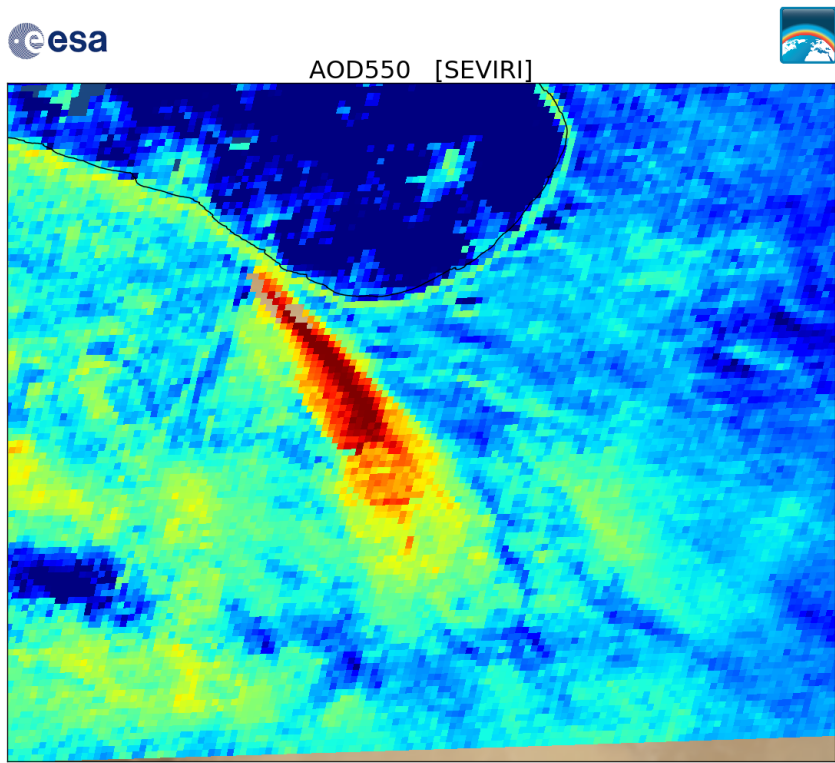
Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



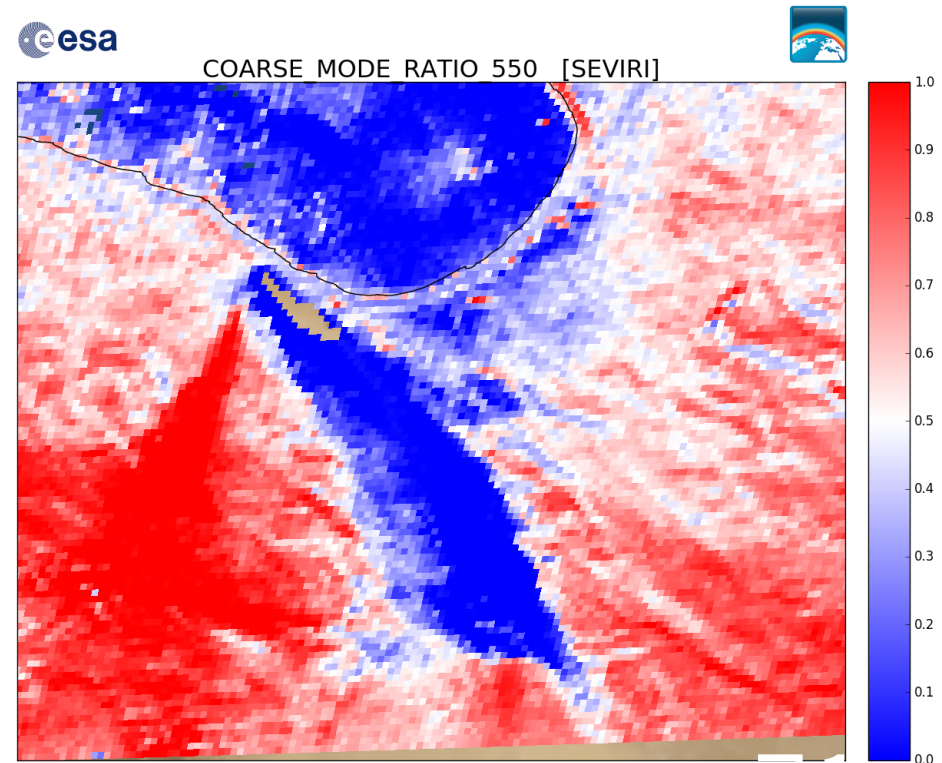
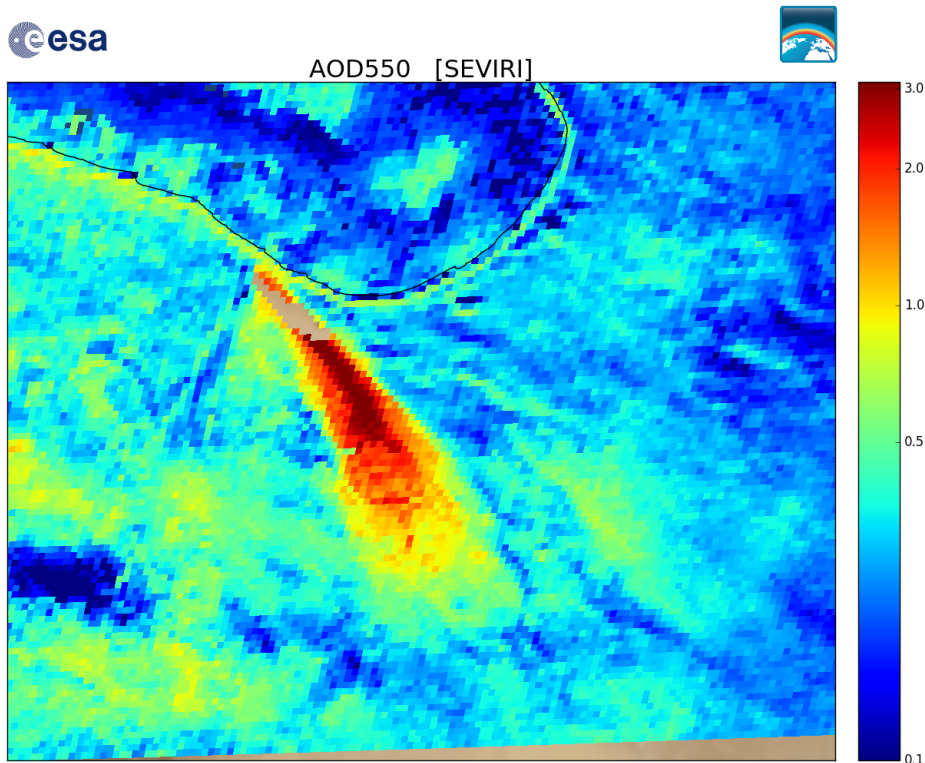
Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



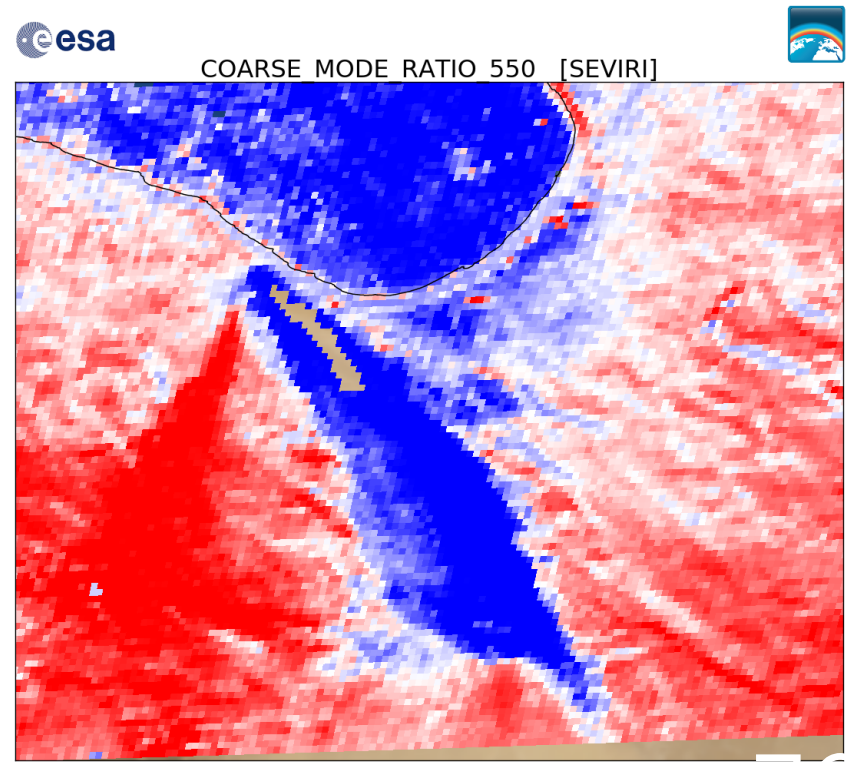
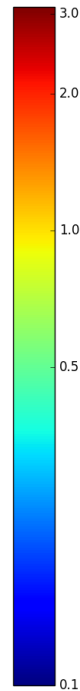
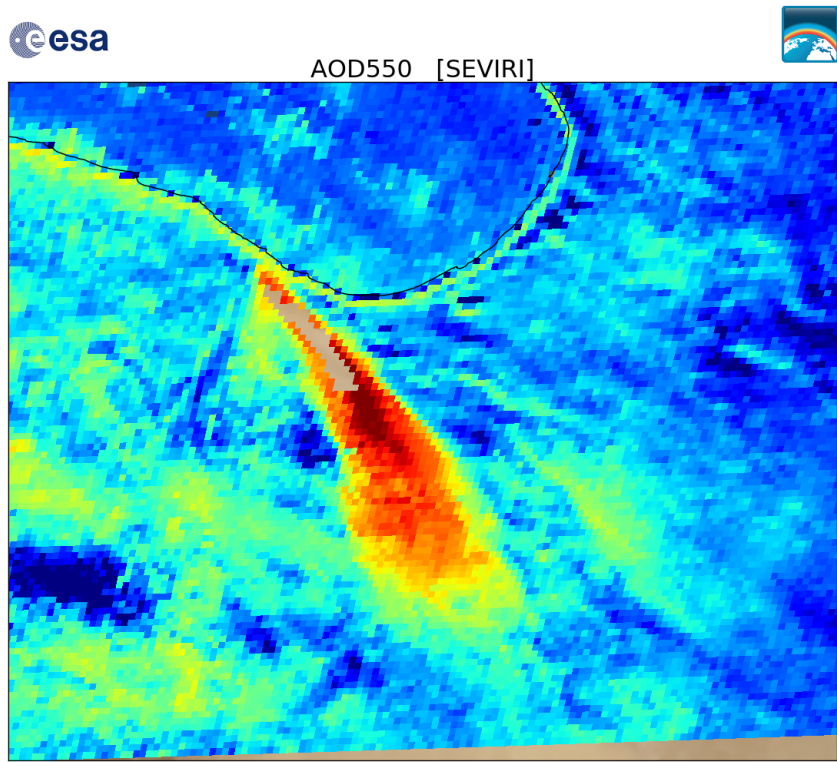
Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



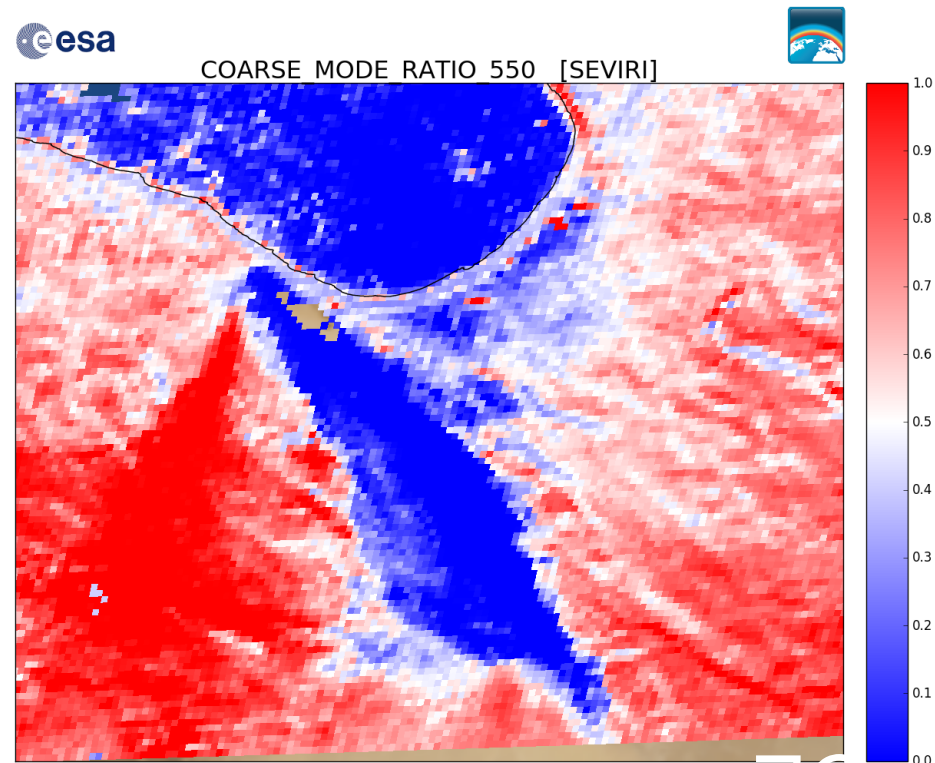
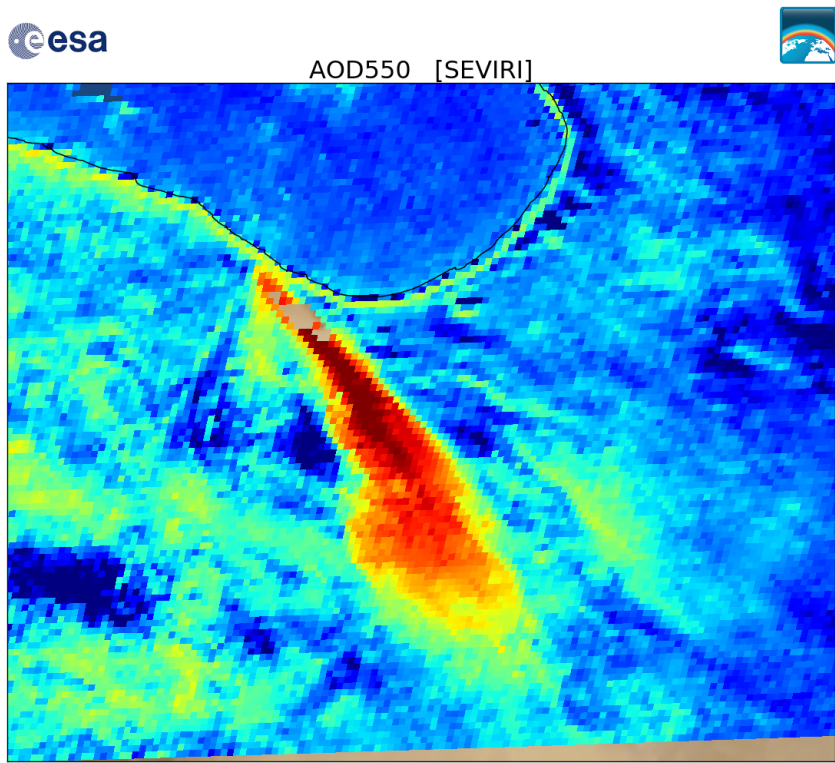
Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



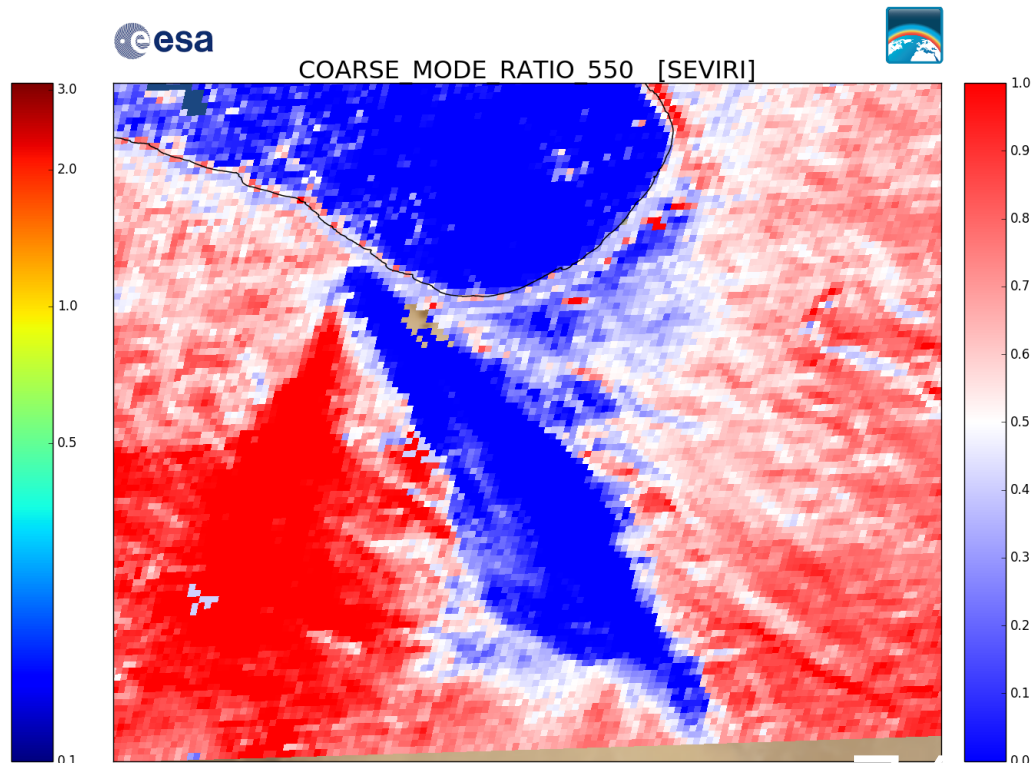
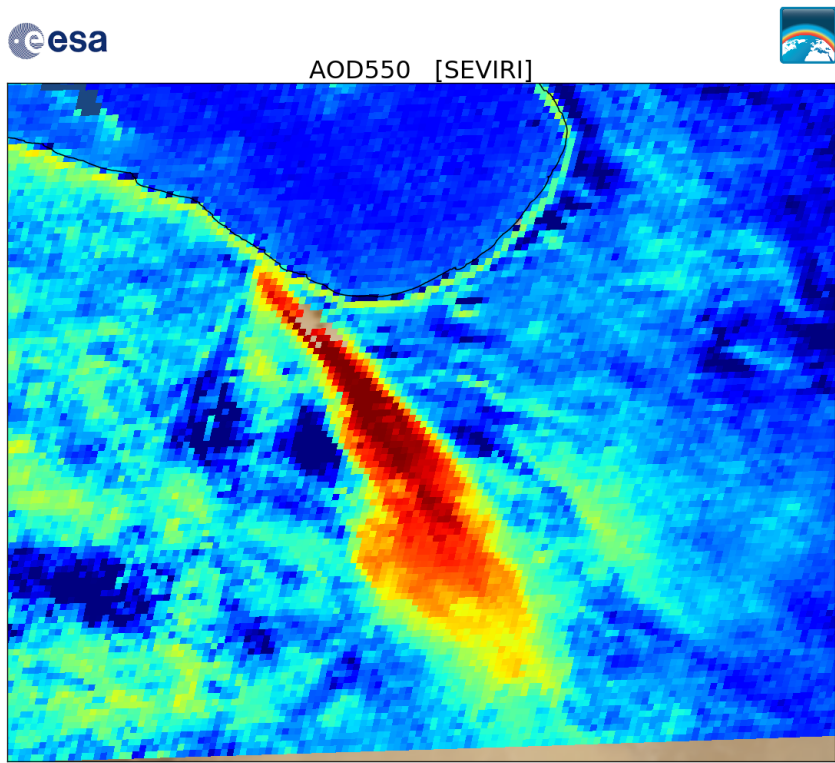
Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



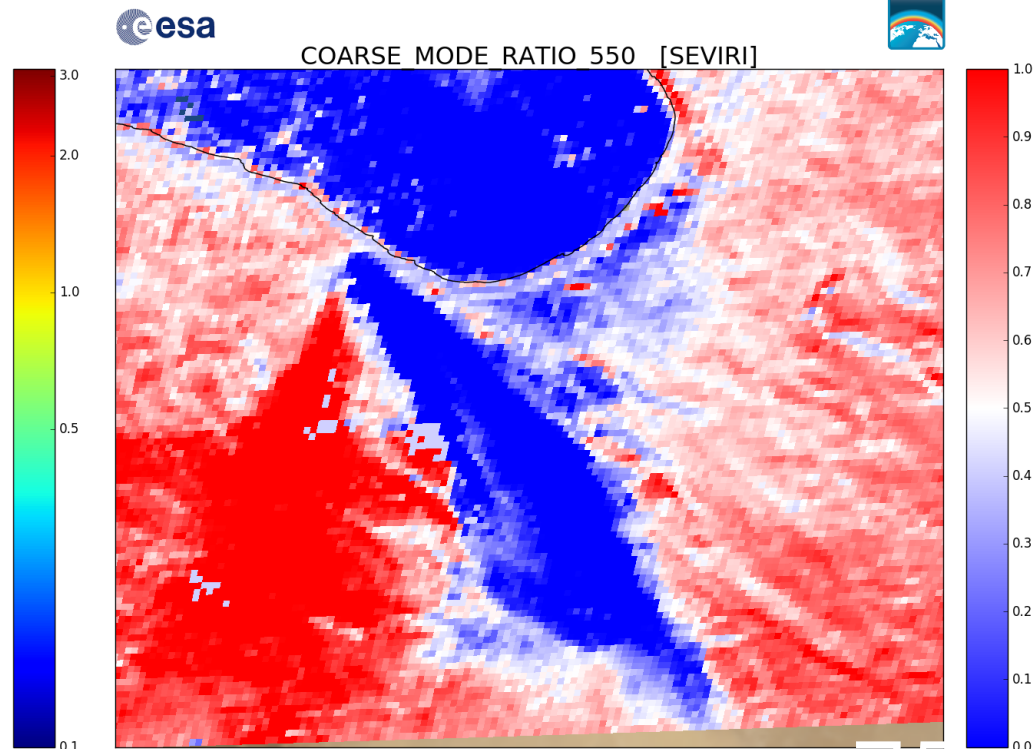
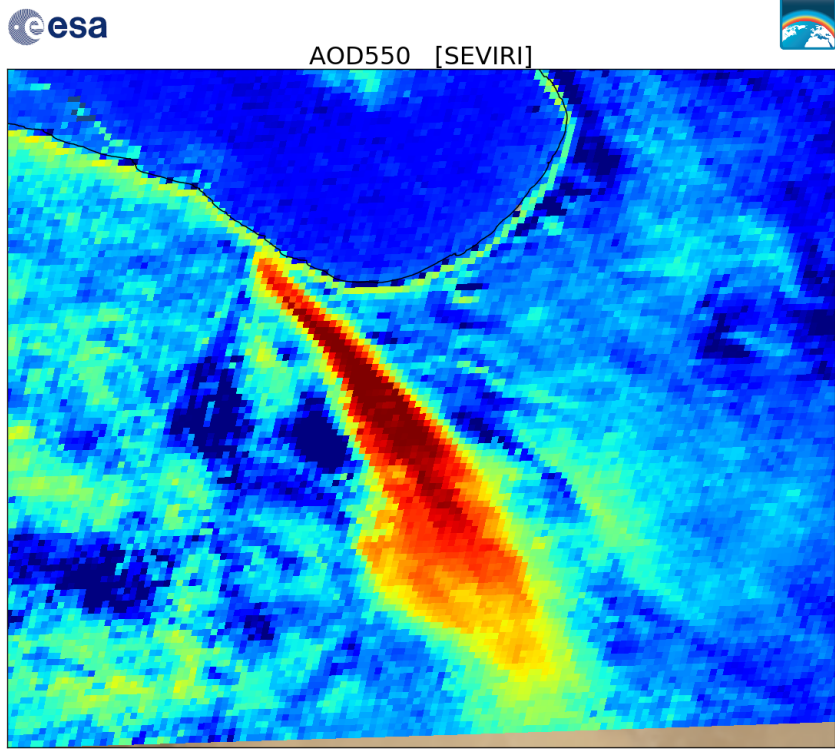
Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



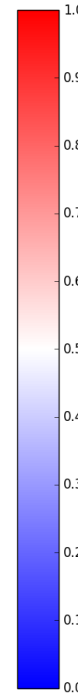
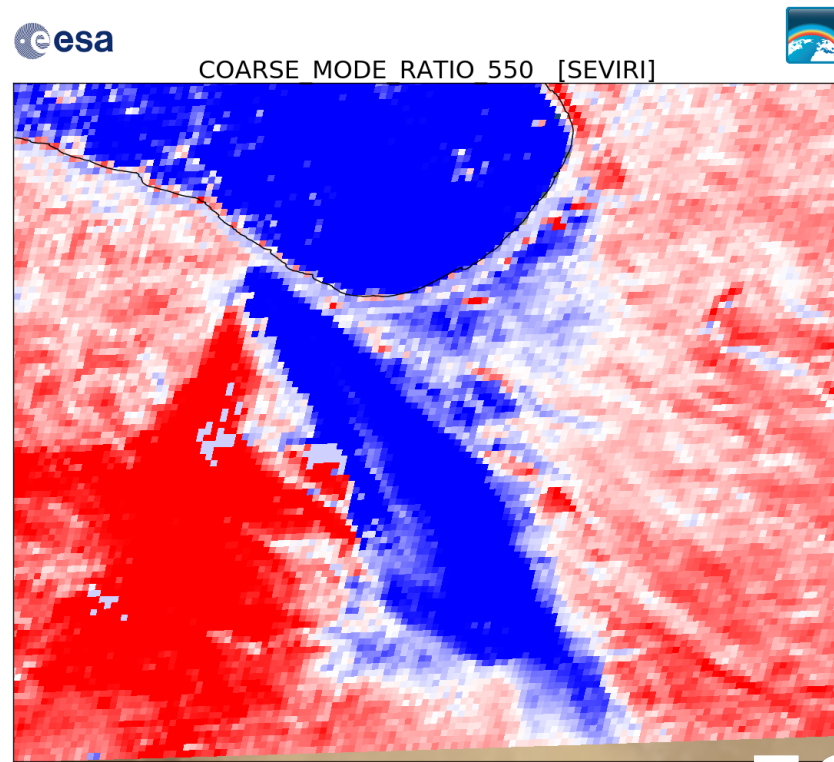
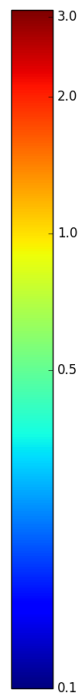
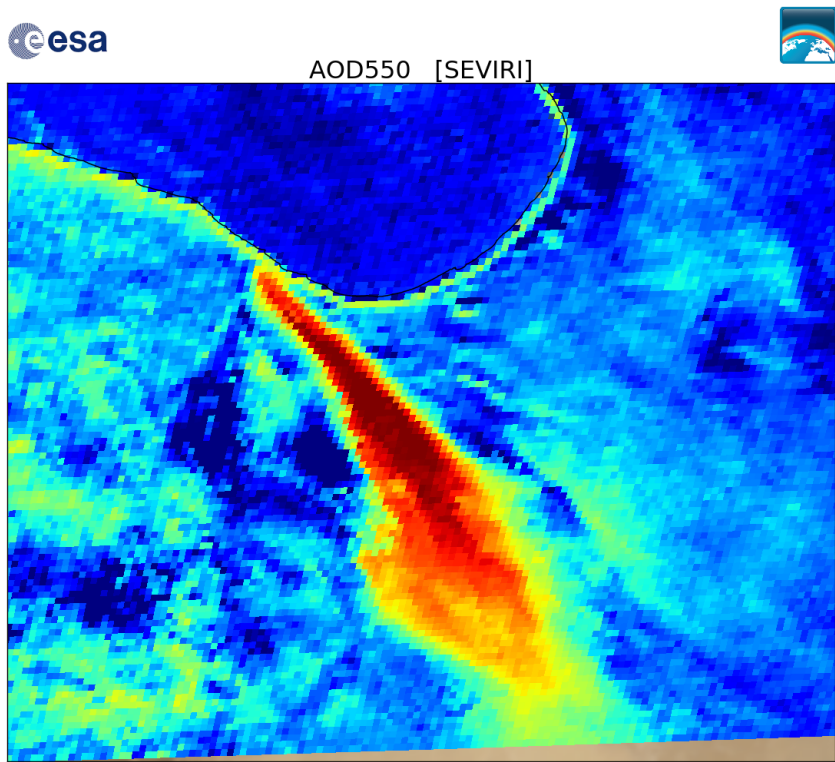
Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008

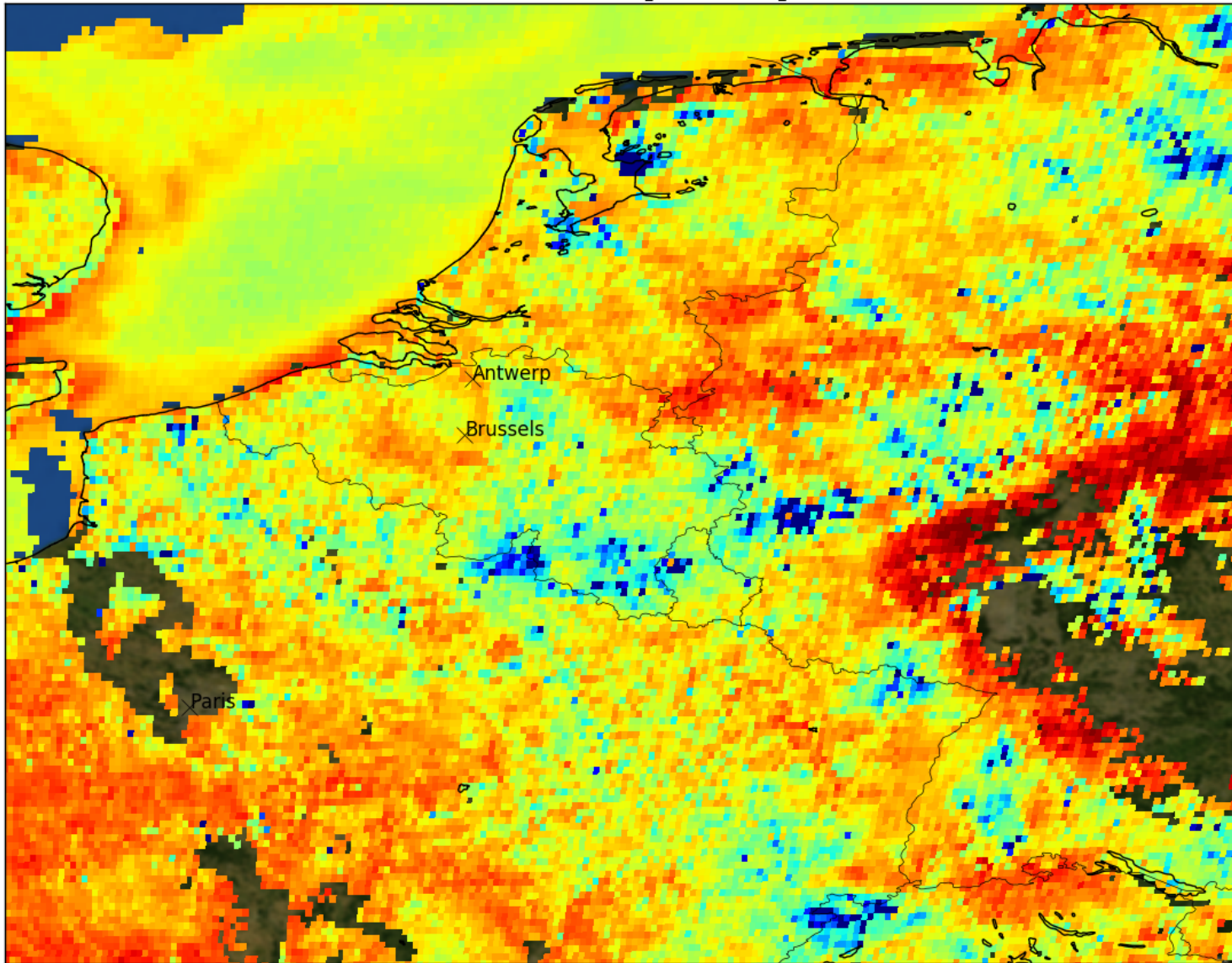


Fire on Tank 7 in Ras Lanuf (Libya) on 19th of August 2008



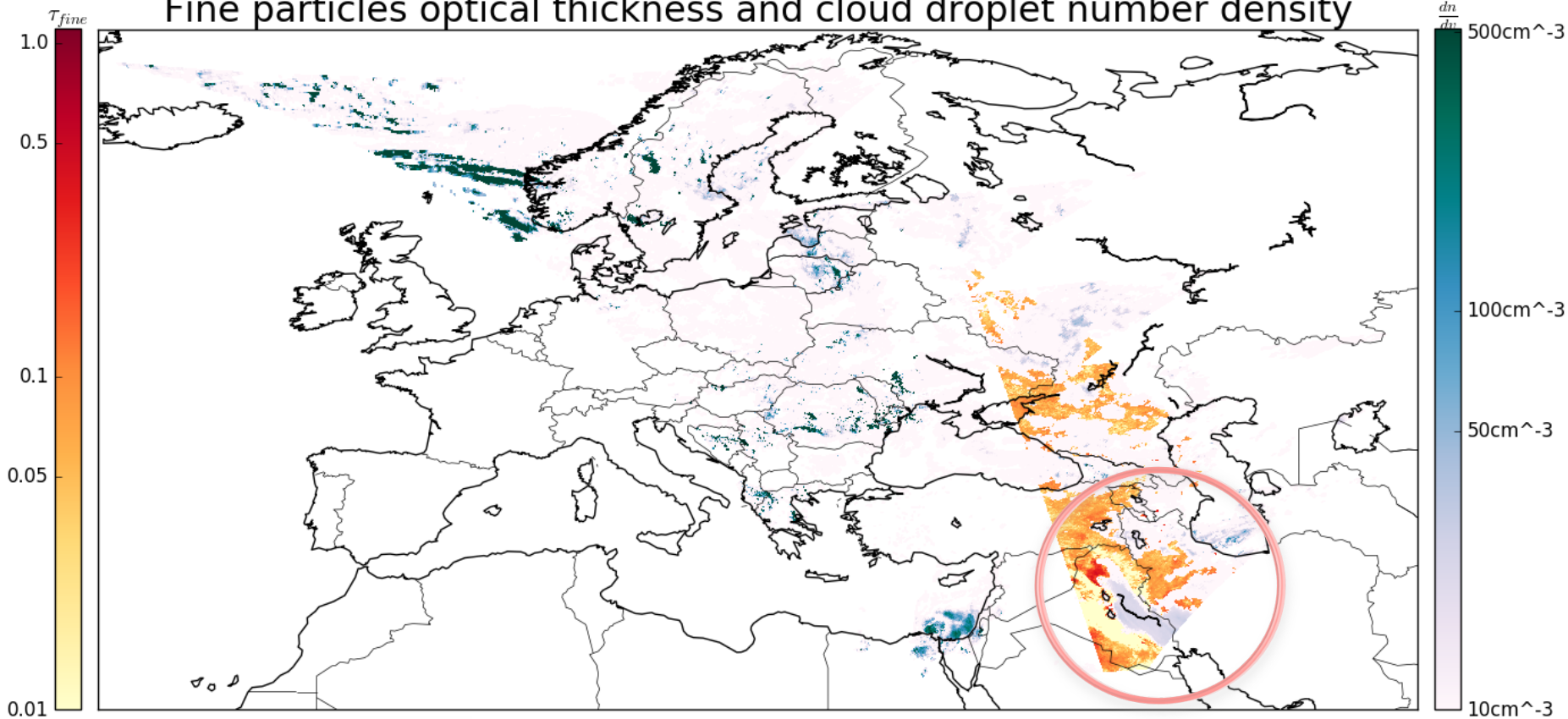


AOD550 [SEVIRI]



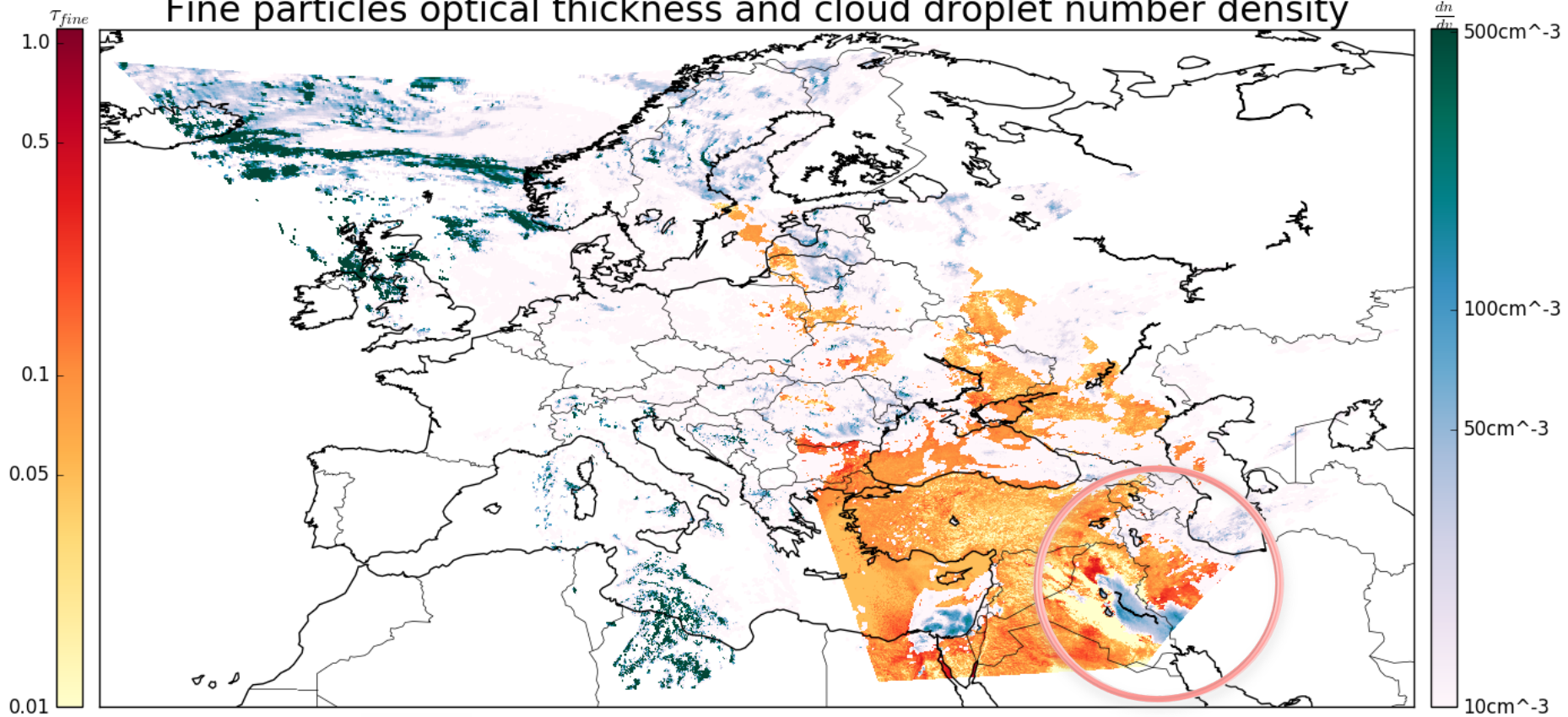
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



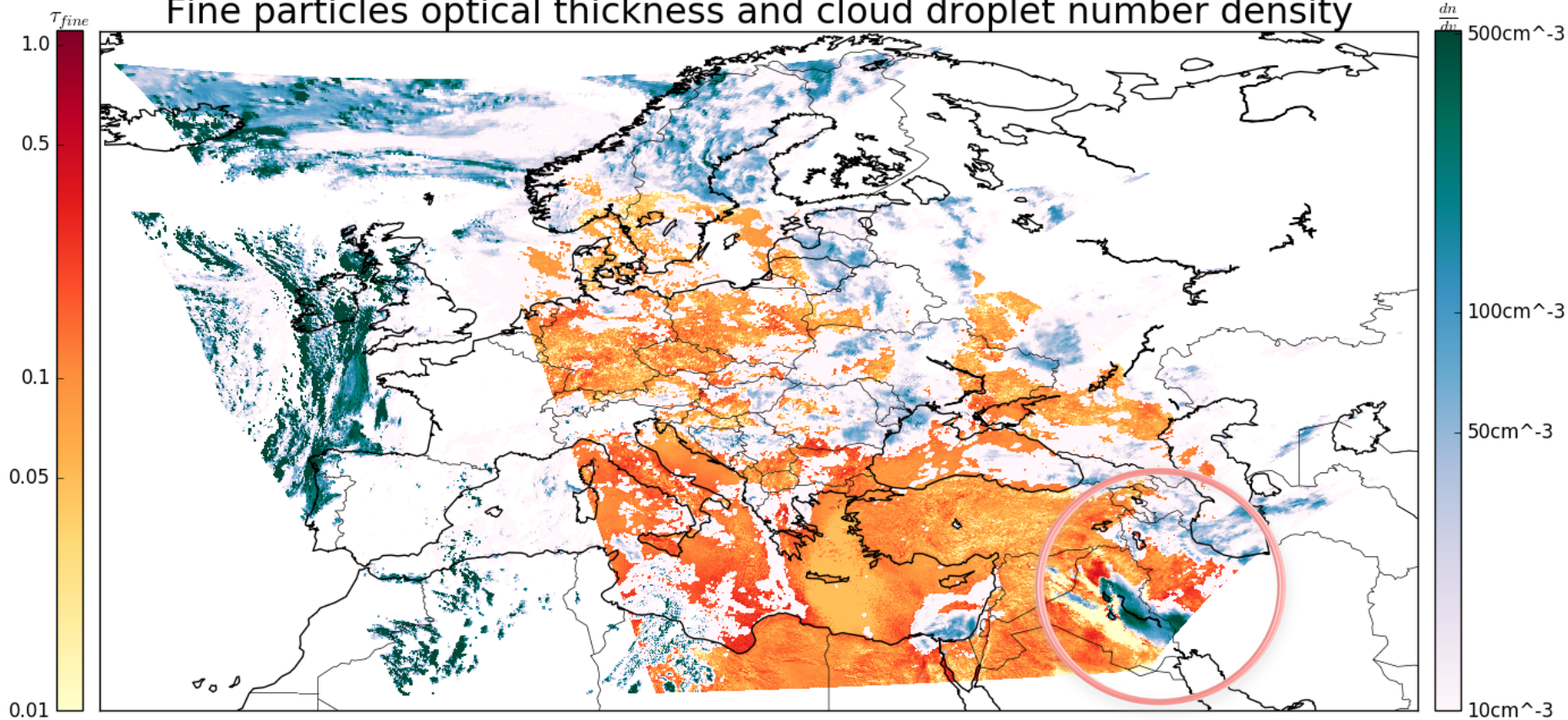
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



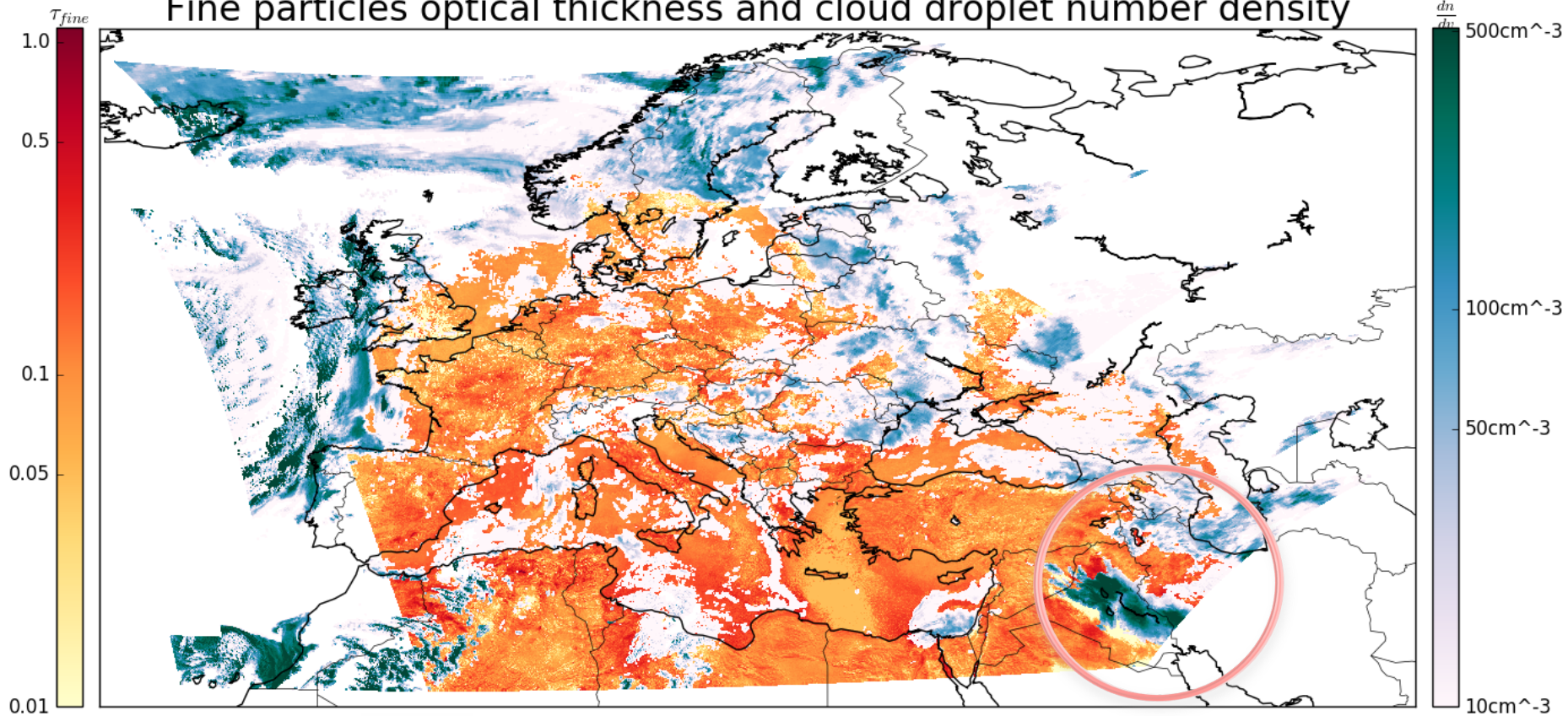
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



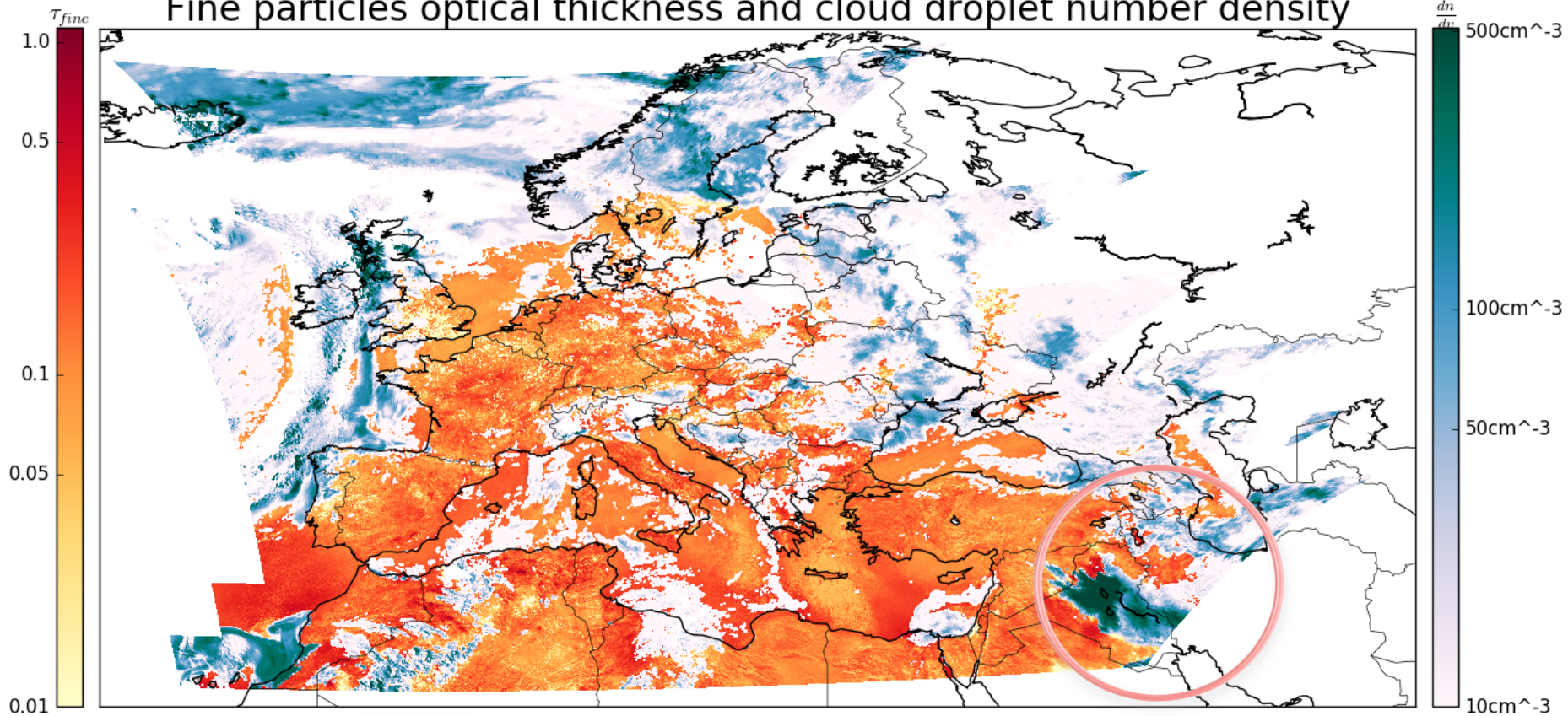
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



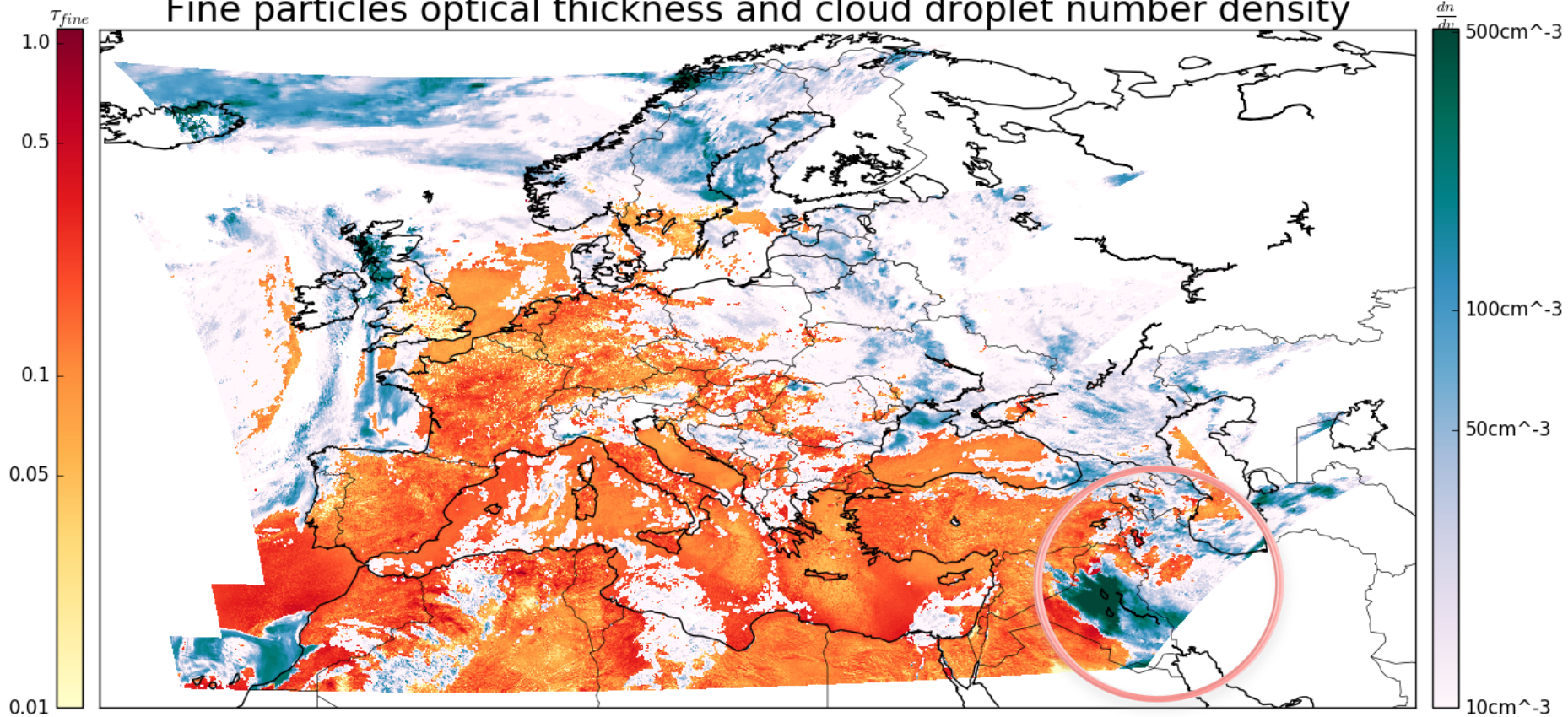
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



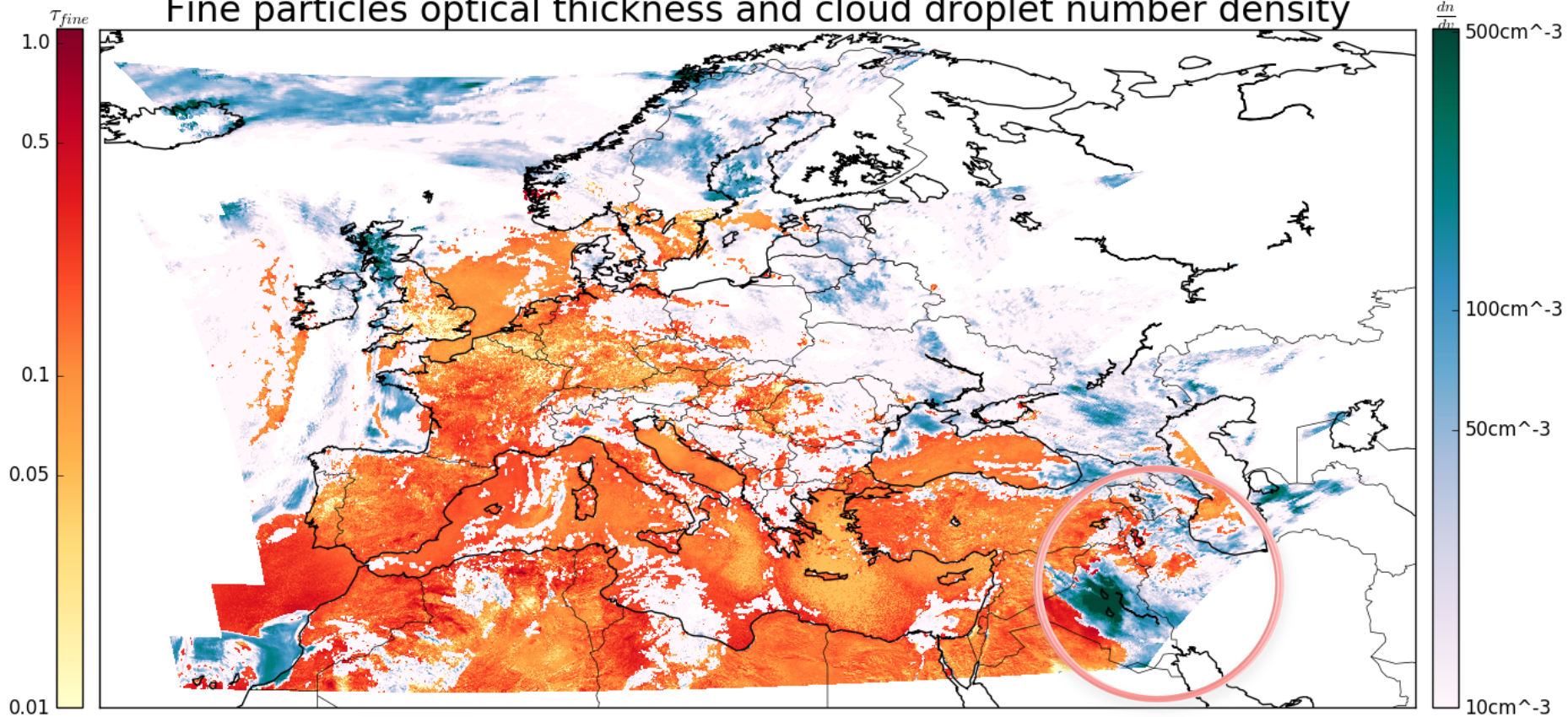
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



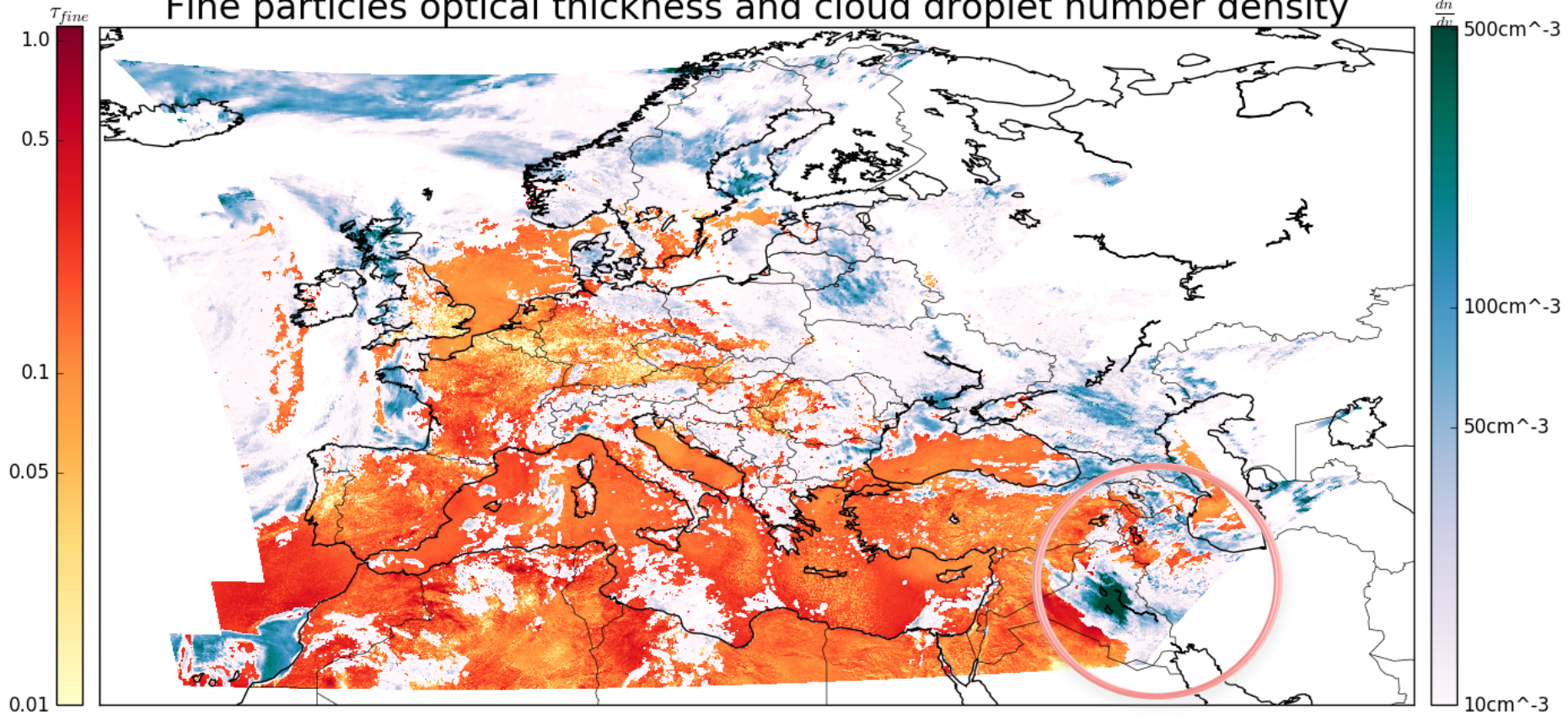
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



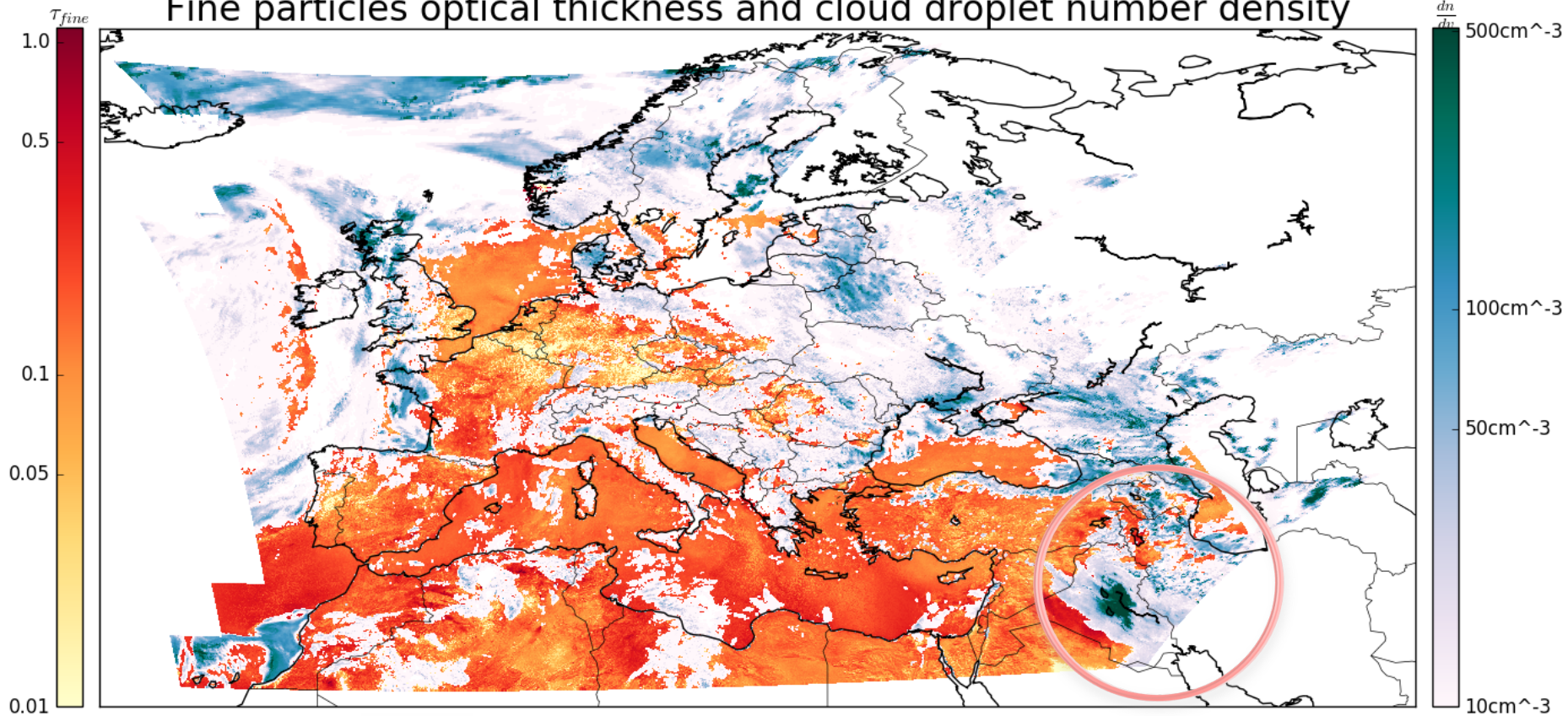
interaction

Fine particles optical thickness and cloud droplet number density



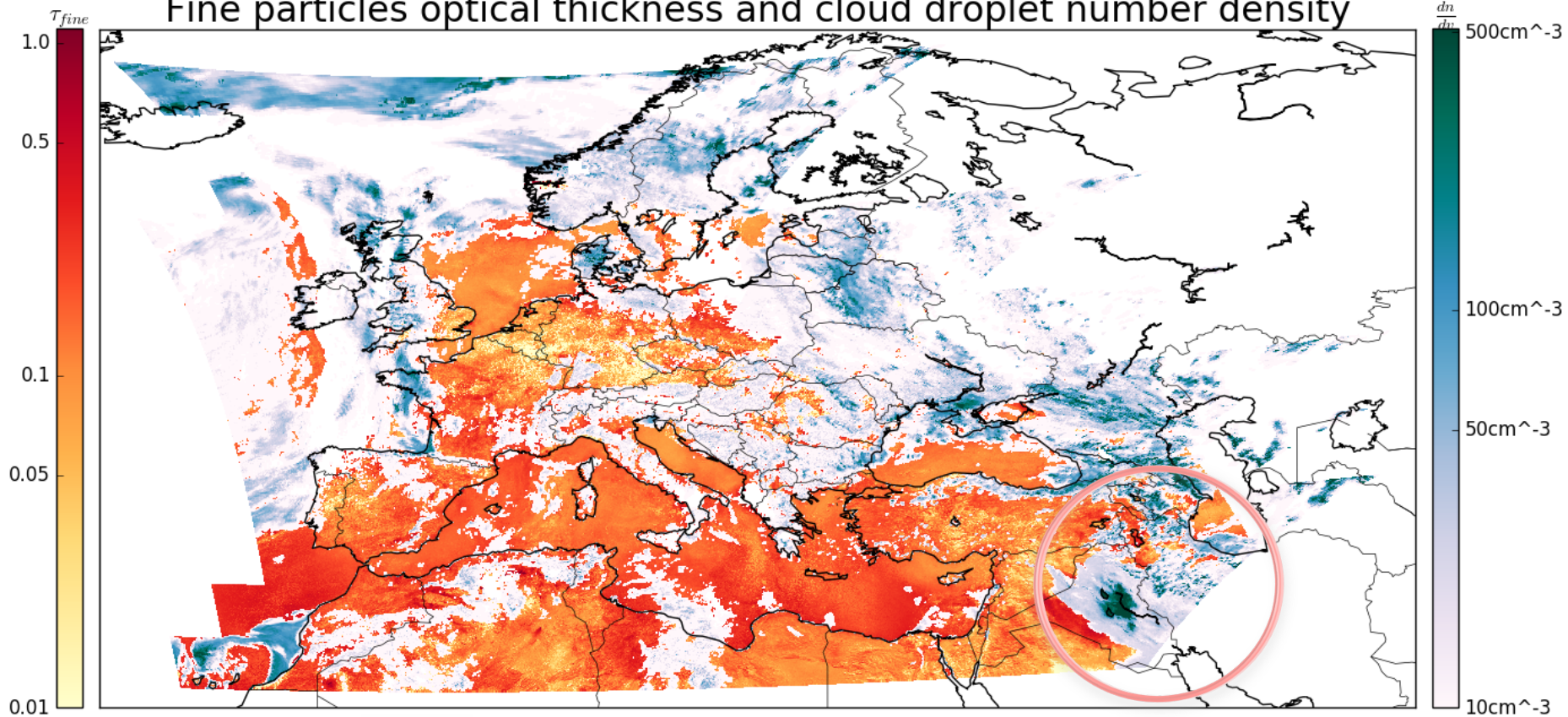
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



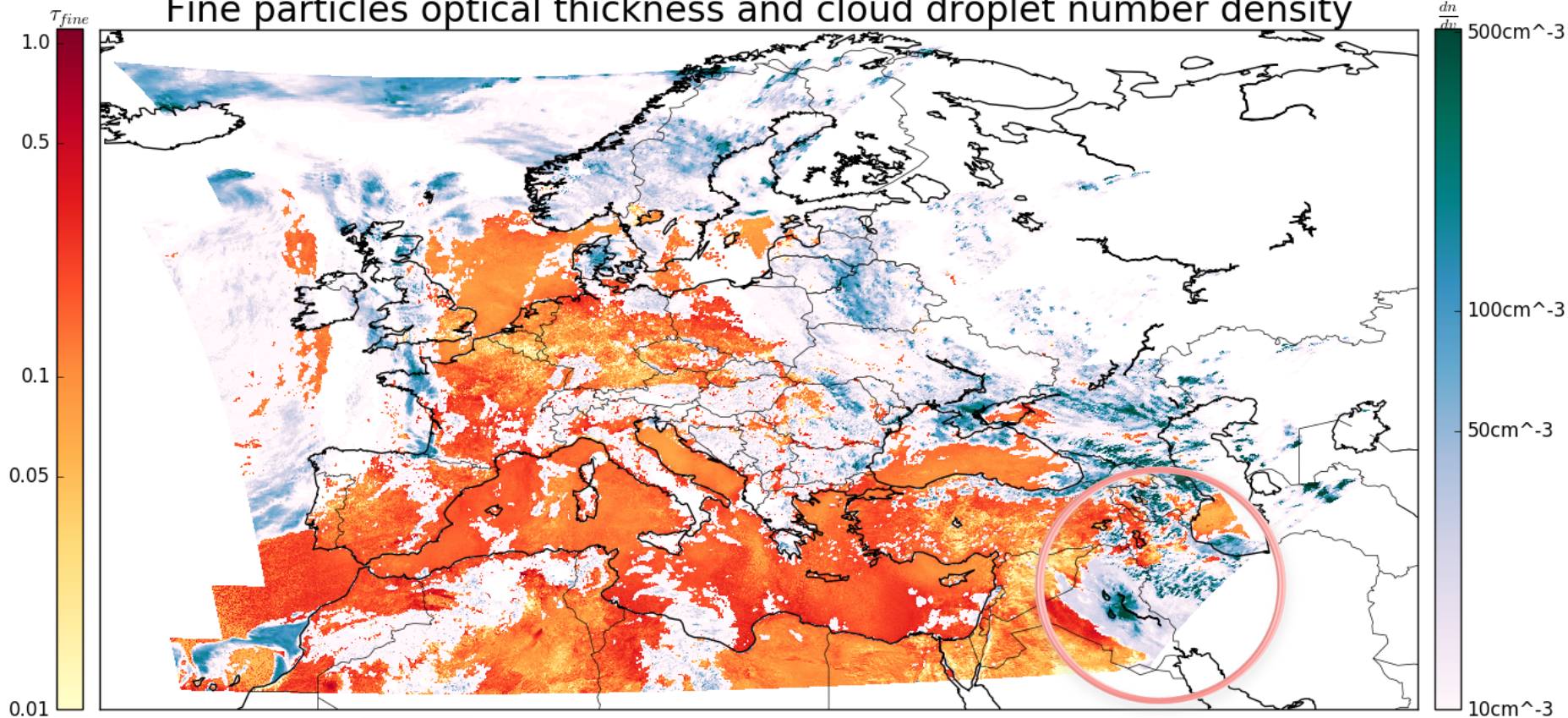
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



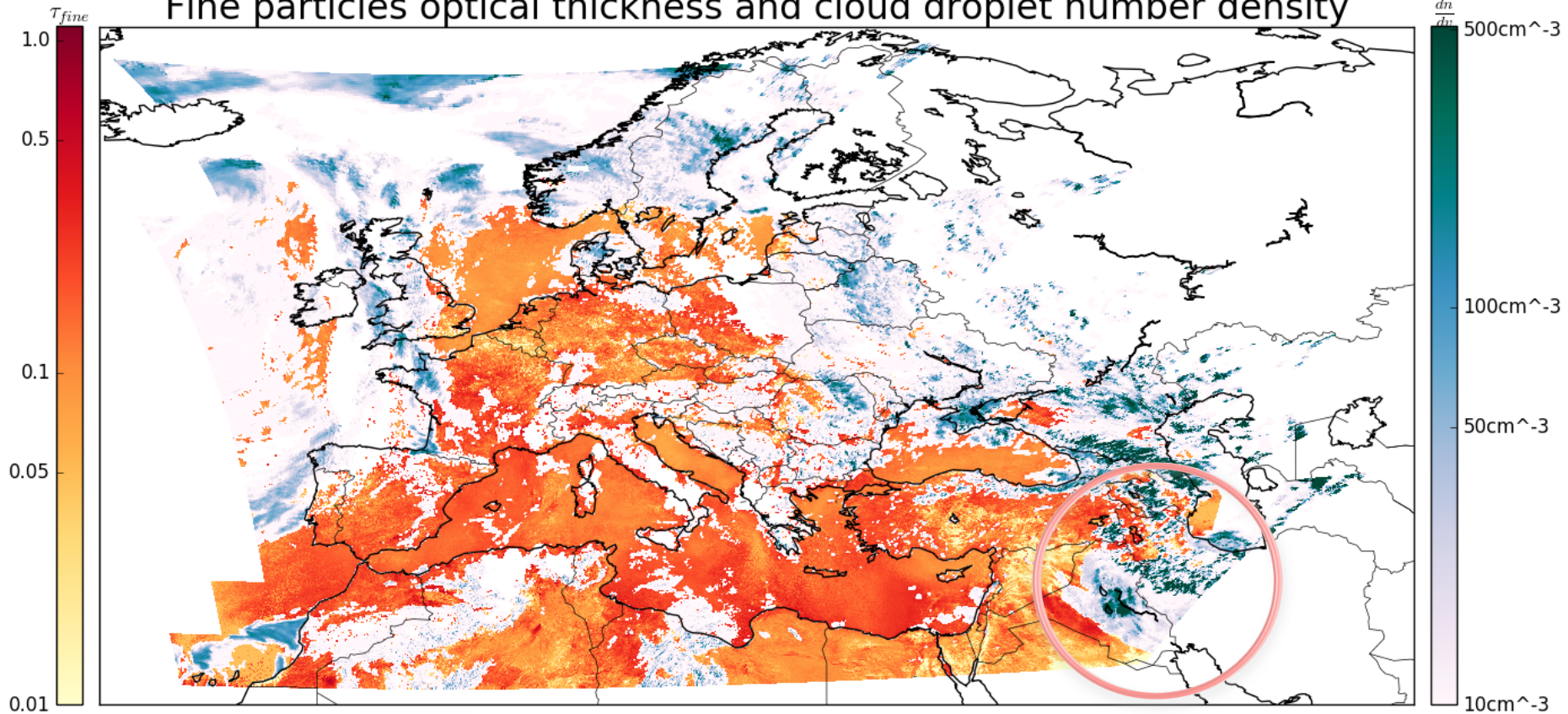
interaction

Fine particles optical thickness and cloud droplet number density



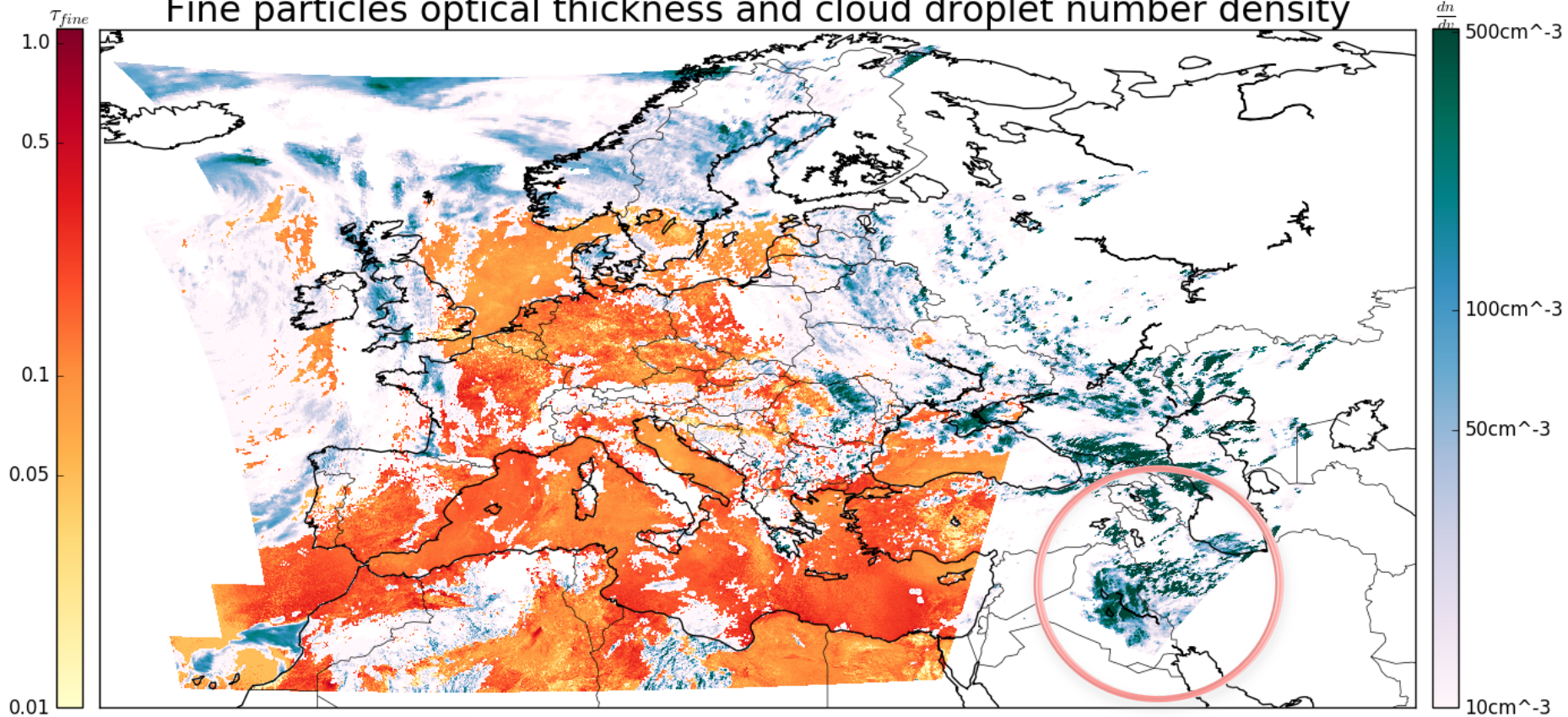
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



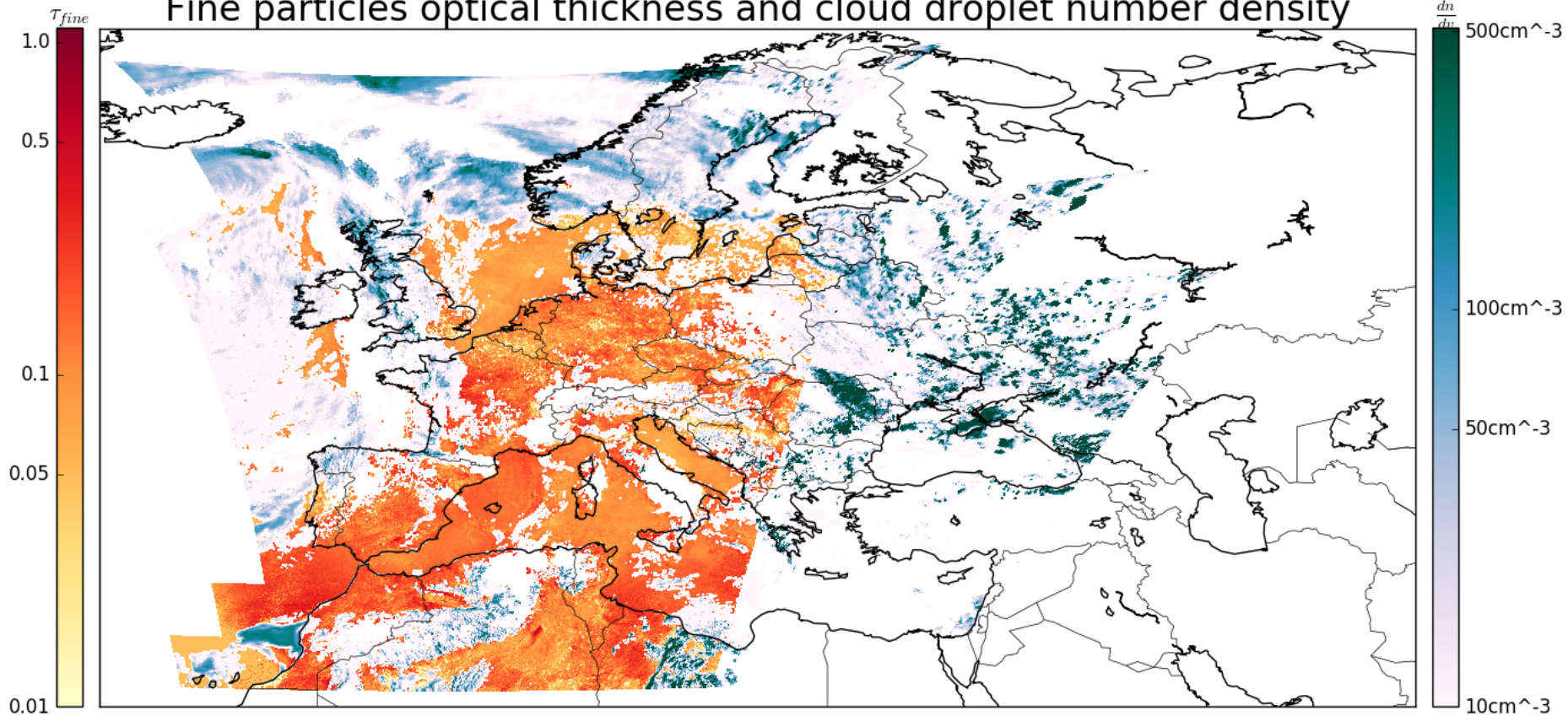
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



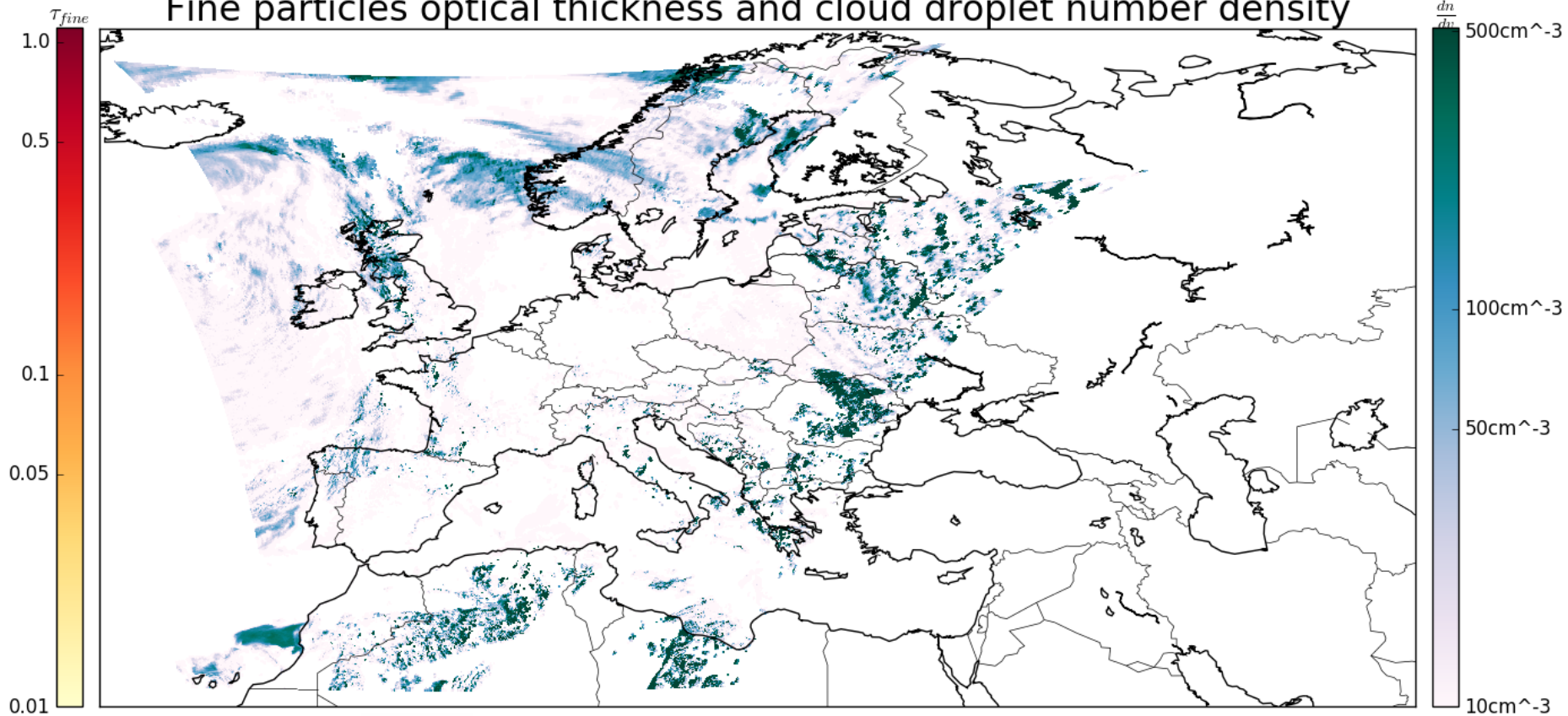
Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



Aerosol-cloud interaction

Fine particles optical thickness and cloud droplet number density



CONCLUSIONS

- The CISAR algorithm retrieves aerosol concentration and single scattering properties **continuously** over **any** type of surfaces;
- The accurate characterization of the surface BRF is essential for the retrieval of aerosol single scattering properties (phase function, ie, particle size);
- SEVIRI hourly AOD data have been generated in the framework of the **ESA** Aerosol_cci project;

CONCLUSIONS

- The algorithm is capable of discriminating fine and coarse mode aerosols and their daily evolution, even over bright surfaces;
- This information could be used to identify emission sources;
- There is a small overestimation with respect to AERONET at low AOD, the reason of which still needs to be analyzed;
- The algorithm is generic and has been (will be) applied on PROBA-V (S3);

CONCLUSIONS

- Future activities: new funding needed to:
 - Analyze the AOD daily cycle, e.g., South Africa (large differences are observed between products generated from morning or afternoon overpass polar satellites);
 - Perform quantitative comparisons with MACC and CAMS products;
 - Include the processing of clouds;
 - Process more data.

Additional information on CISAR
is available on our web page

www.rayference.eu

or

info@rayference.eu