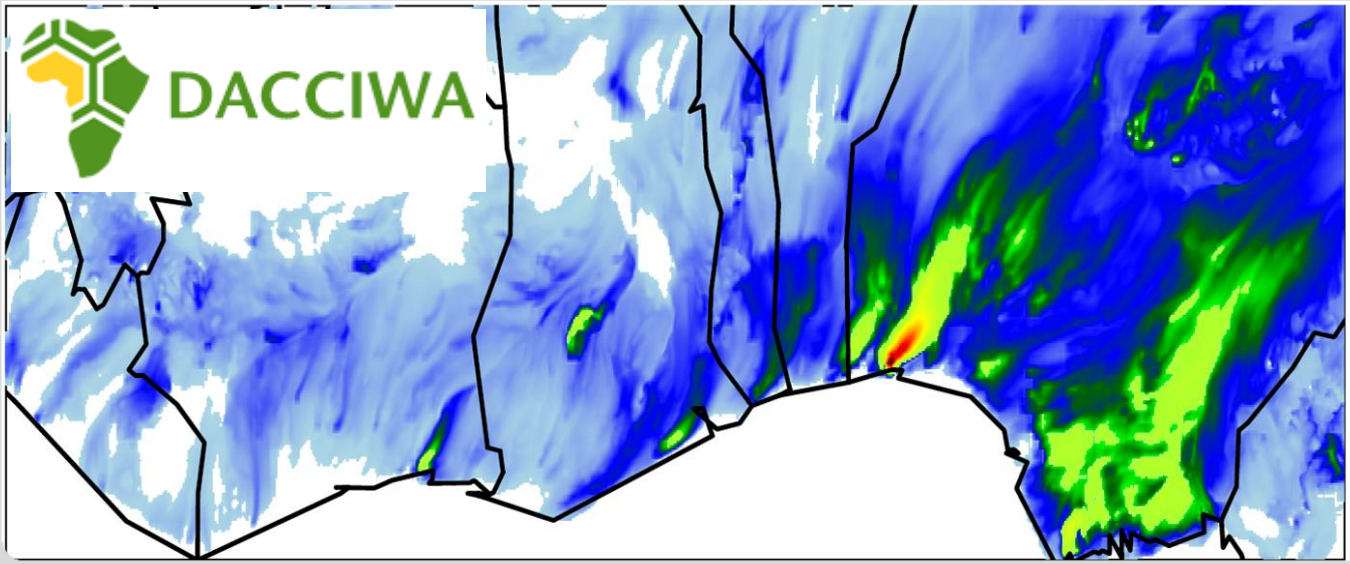
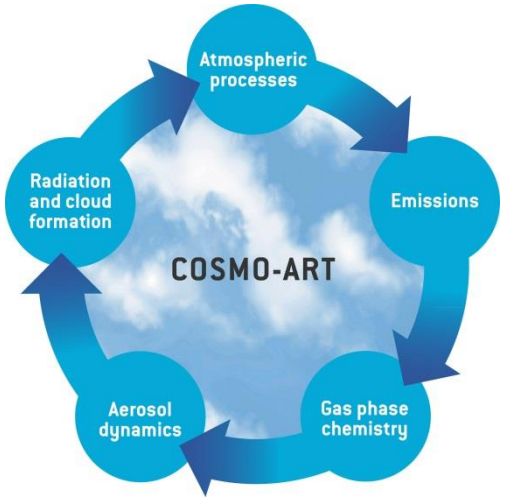
Karlsruhe Institute of Technology

Simulating aerosol-cloud interactions in southern West Africa with COSMO-ART in the framework of DACCIWA

Konrad Deetz and Bernhard Vogel

Institute of Meteorology and Climate Research – Aerosols, Trace Gases and Climate Processes





Our objectives within DACCIWA

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- **Atmospheric chemistry and aerosol-cloud interactions**
  - Impact of atmospheric composition on RF
  - Two-way coupling between aerosols and cloud droplets
  - Cloud microphysical and dynamical behavior across SWA

Atmospheric composition of SWA

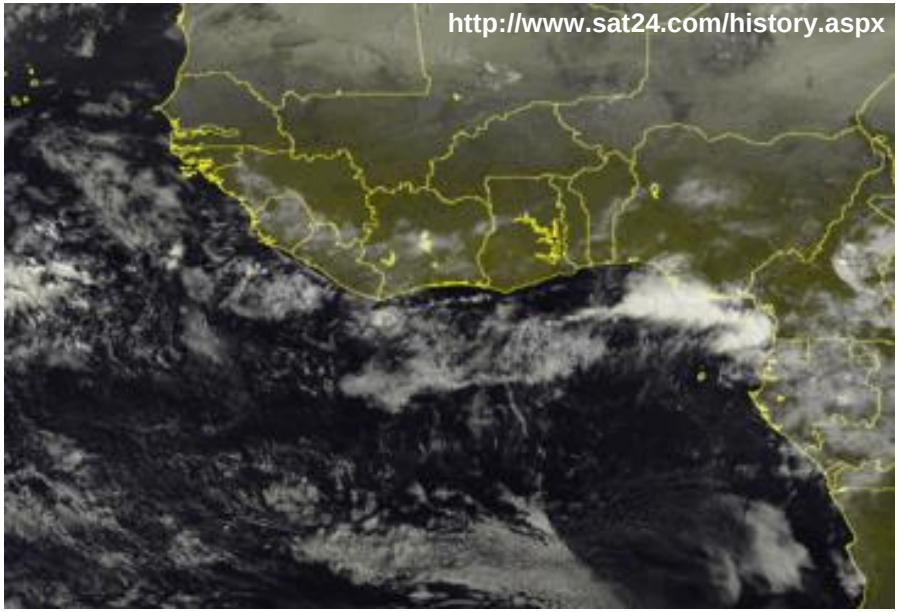
Atmospheric composition of SWA

- **Considered emissions:**
  - Sea salt
  - Dimethyl sulfide (DMS)
  - Mineral dust
  - Biogenic volatile organic compounds (BVOCs)
  - Vegetation fire emissions
  - Anthropogenic emissions
  - Flaring emissions

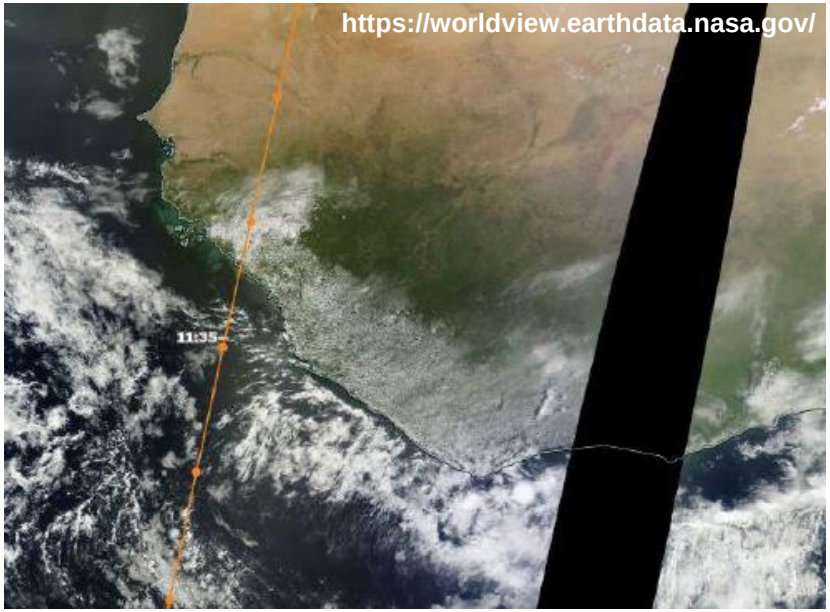
Case study on 7-8 June 2014

Case study on 7-8 June 2014

- **Observed cloud cover, 8 June 2014**



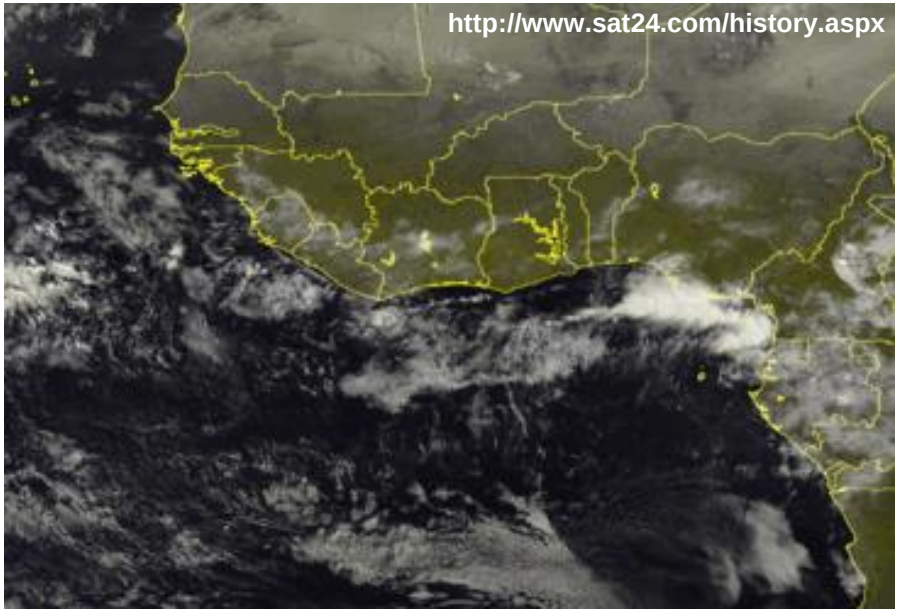
Eumetsat/Met Office MSG visible
9 UTC



MODIS Terra
approx. 12 UTC

Case study on 7-8 June 2014

- **Observed cloud cover, 8 June 2014**



Eumetsat/Met Office MSG visible
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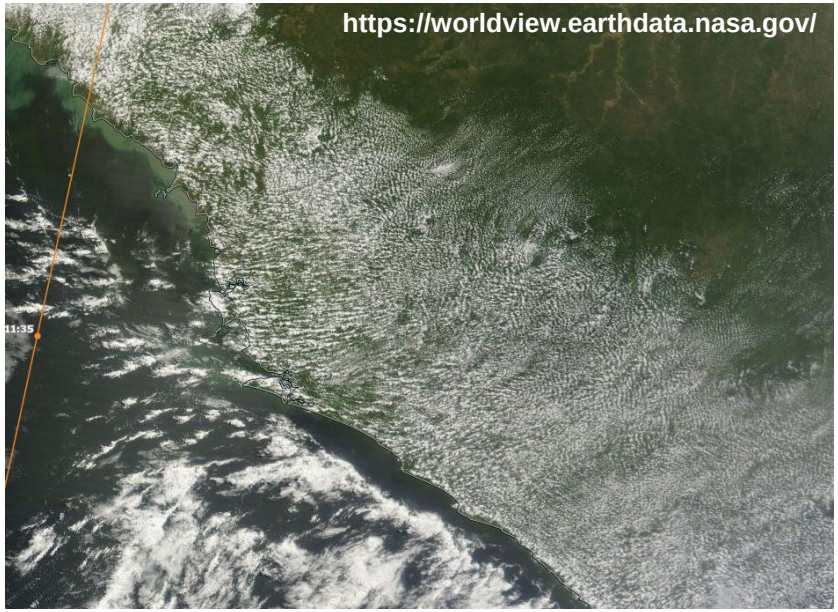
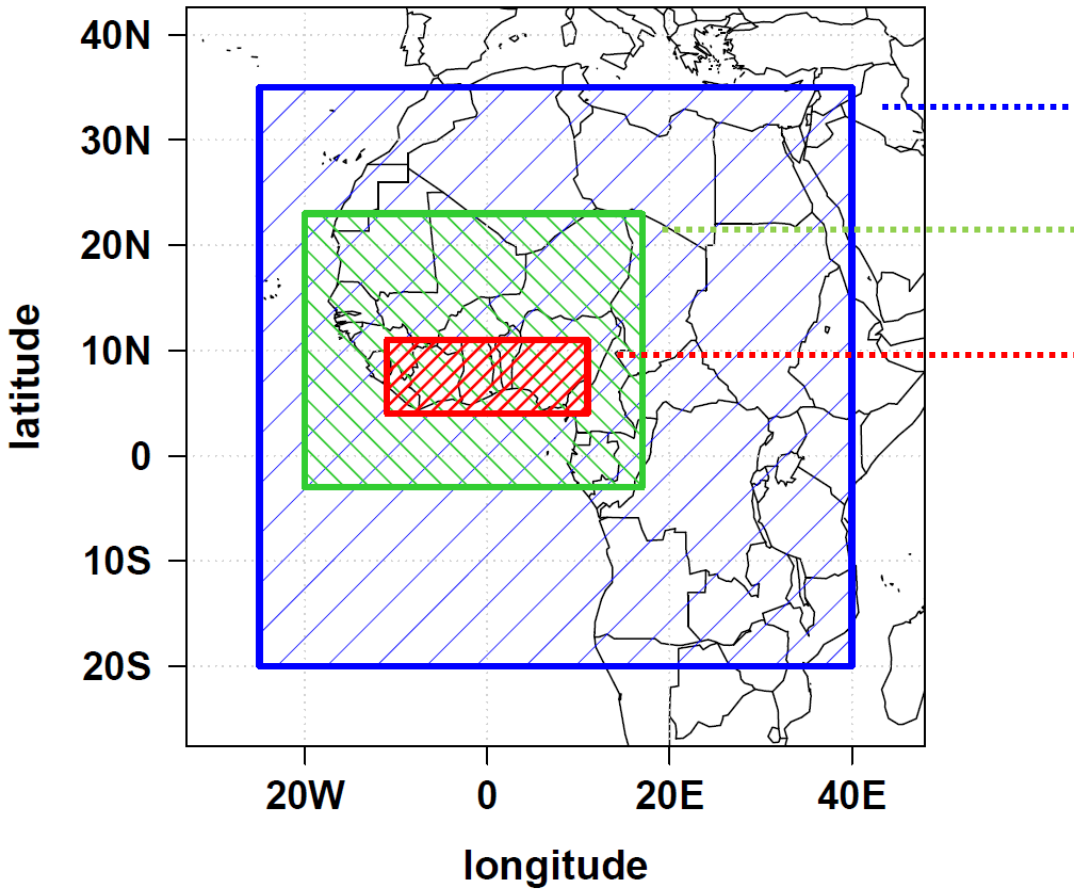


MODIS Terra
approx. 12 UTC

Case study on 7-8 June 2014

- **Simulation domains**



Continental (28km)

SWA (5km)

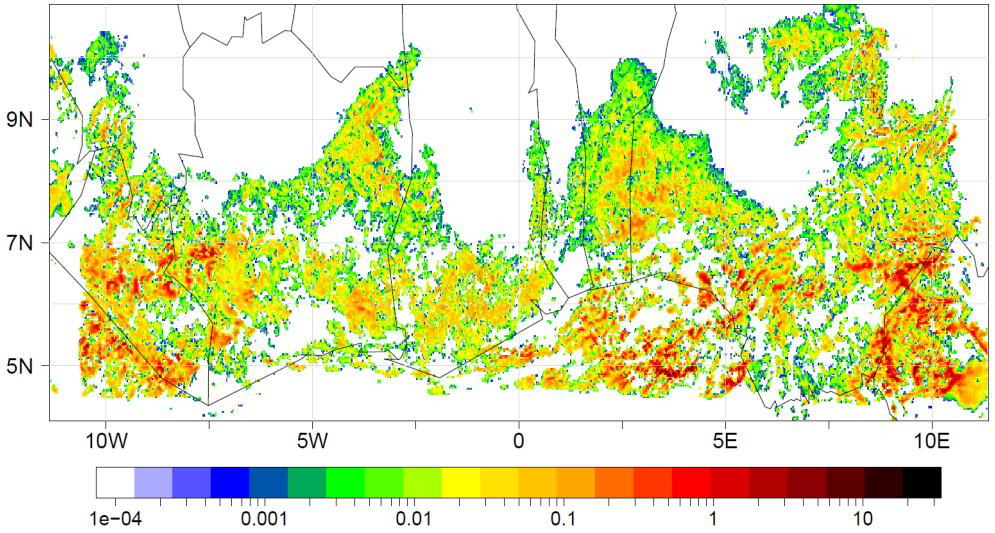
Regional (3km)

Case study on 7-8 June 2014

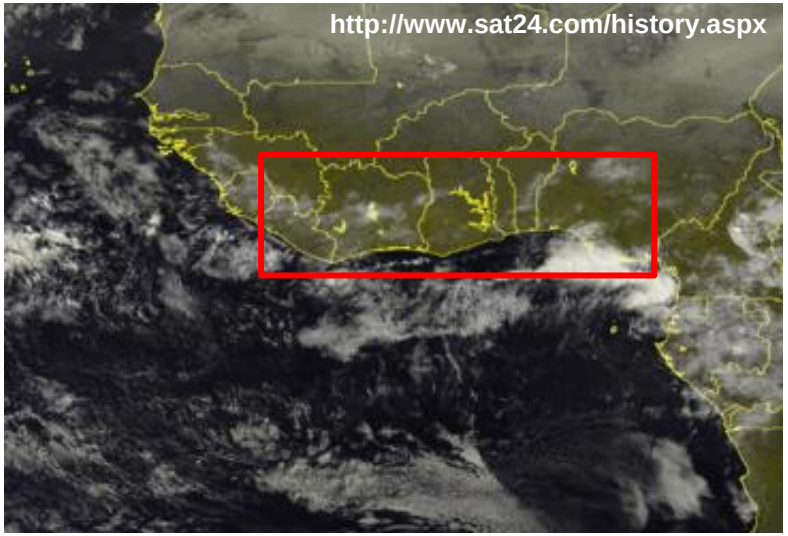
- **COSMO-ART simulation characteristics**
  - all simulations realized with two-moment microphysical scheme
  -  **ACI** – cloud interaction with prognostic aerosol
  -  **NO ACI** – no cloud interaction with prognostic aerosol (aerosol number distribution reduced by factor 0.01)

Case study on 7-8 June 2014

- **Vertical integrated specific cloud water (kg m^{-2}) and MSG cloud obs (8 June 2014, 9 UTC)**



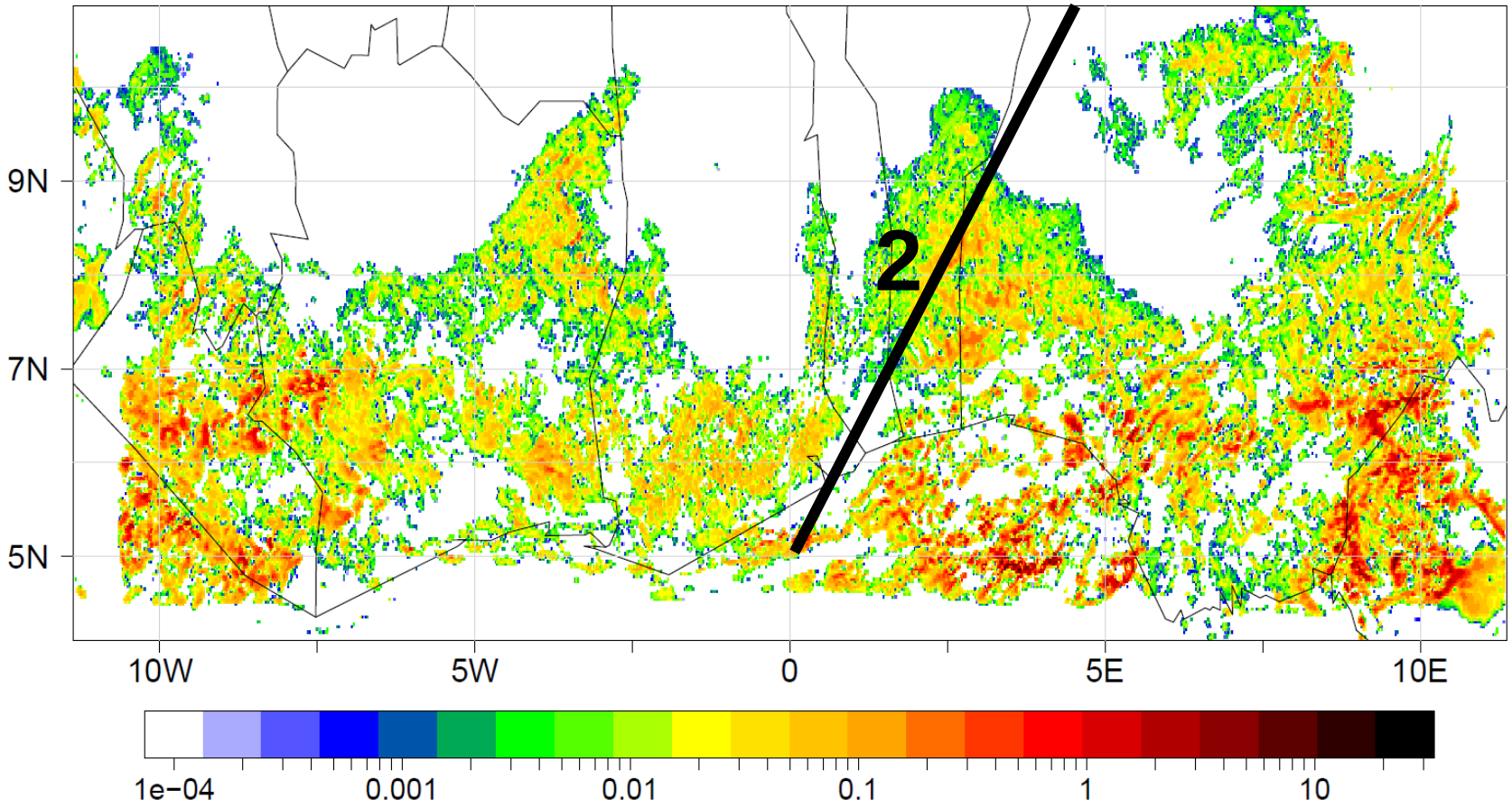
Cloud water ( )



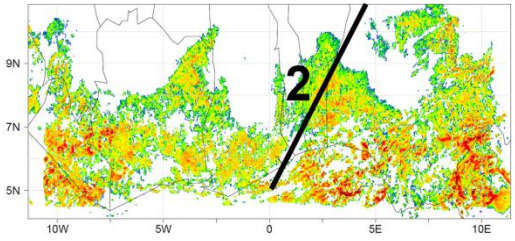
Eumetsat/Met Office MSG visible

Case study on 7-8 June 2014

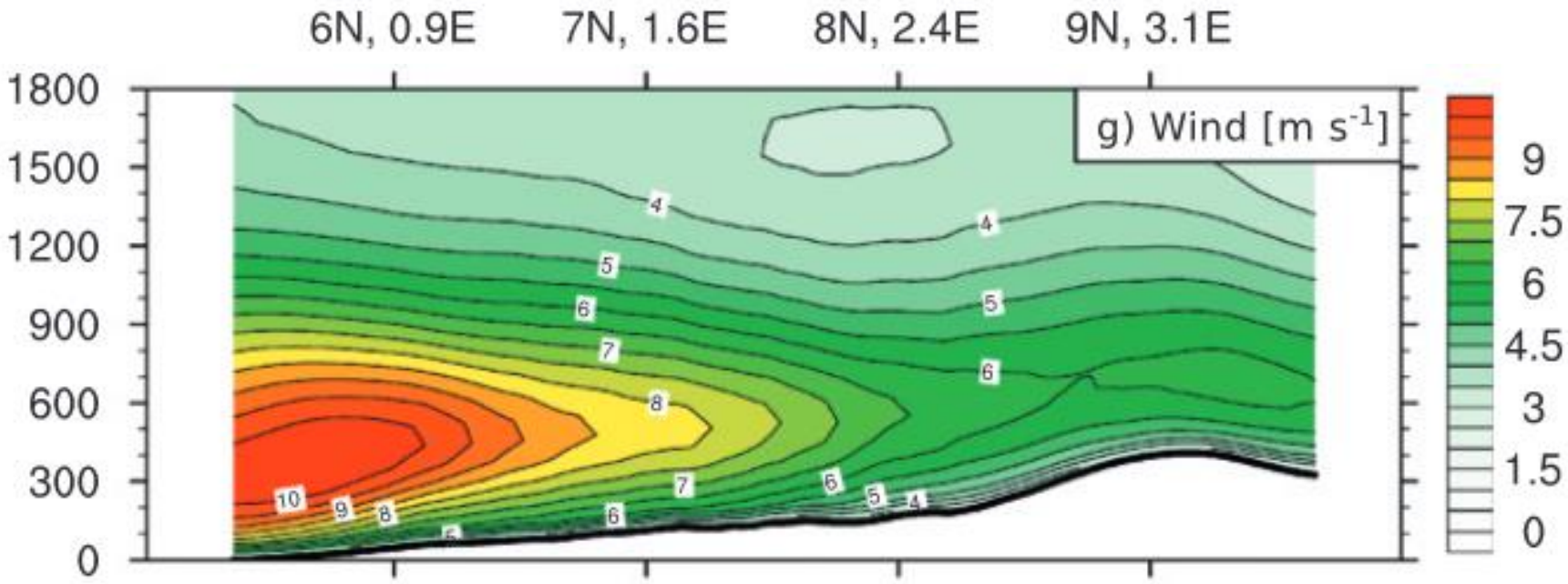
- **Study region**



Case study on 7-8 June 2014



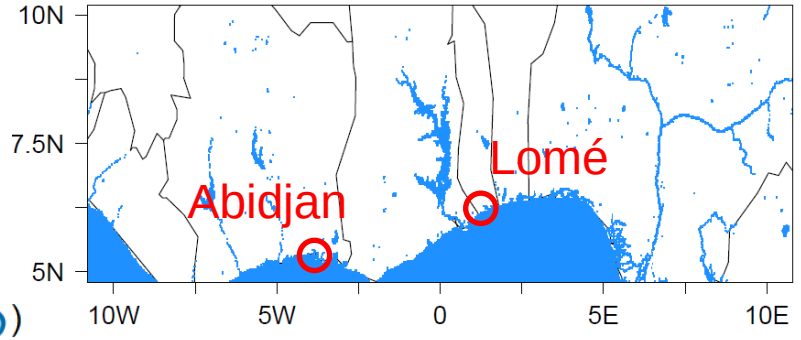
- **Cross section of wind speed (m s^{-1})**

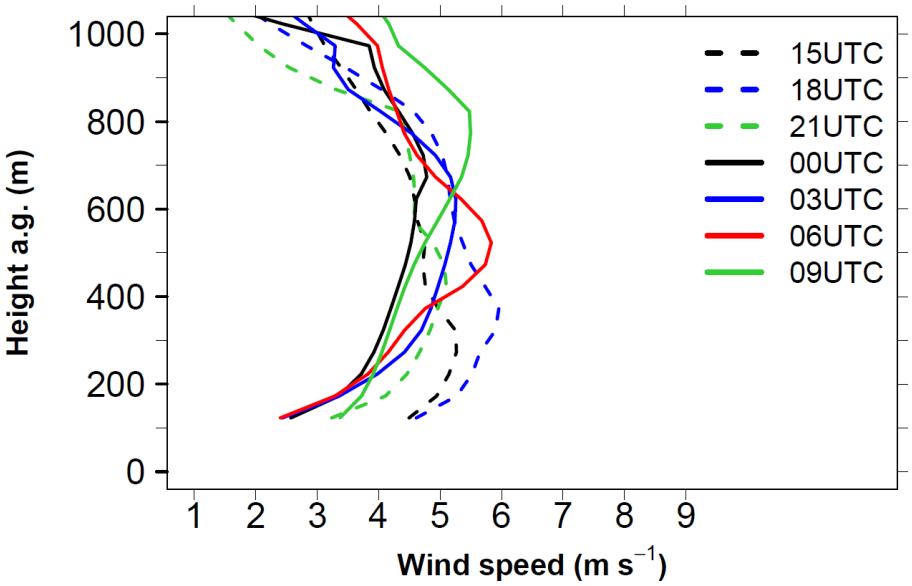


Schuster et al. (2013) - 55d model climatology (JAS 2006)
average from 18 to 6 UTC

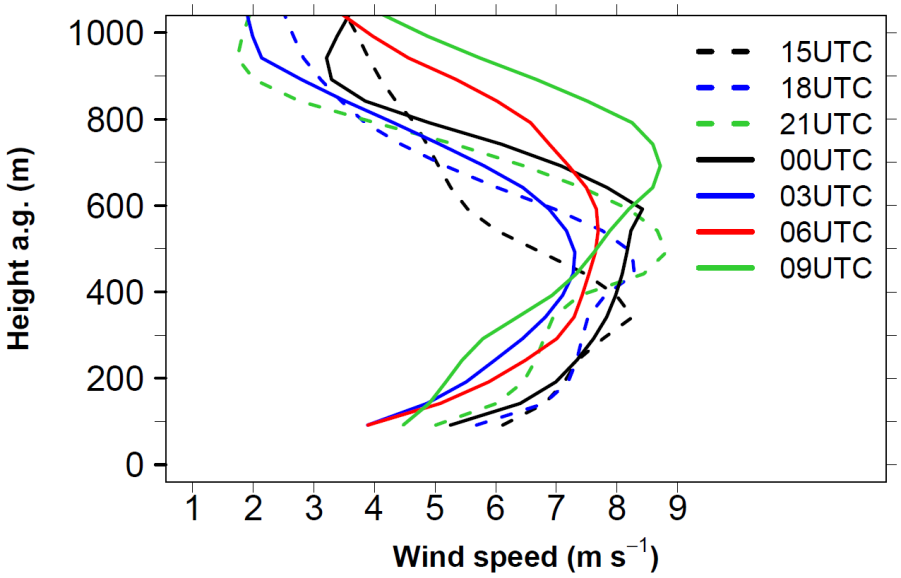
Case study on 7-8 June 2014

- **Simulated wind profile (m s^{-1})**
  (7 June 15 UTC – 8 June 9 UTC)



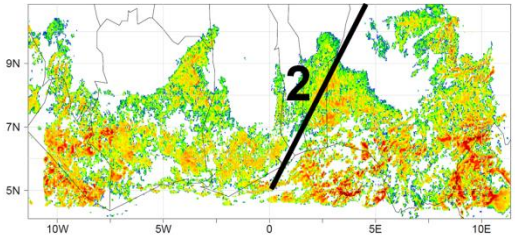


Abidjan (Ivory Coast)

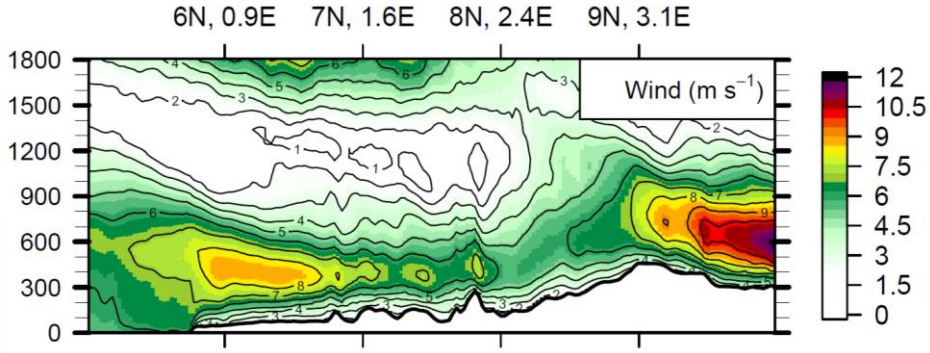


Lomé (Togo)

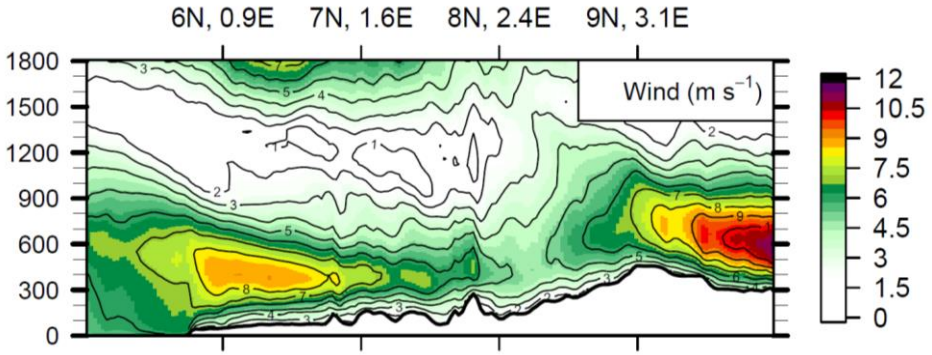
Case study on 7-8 June 2014



- **Cross section of wind speed (m s^{-1})**

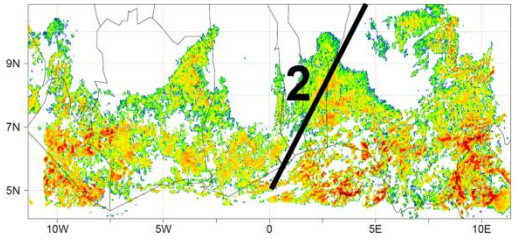


COSMO-ART ( ) - June 8, 2014
average from 0-6 and 18-23 UTC

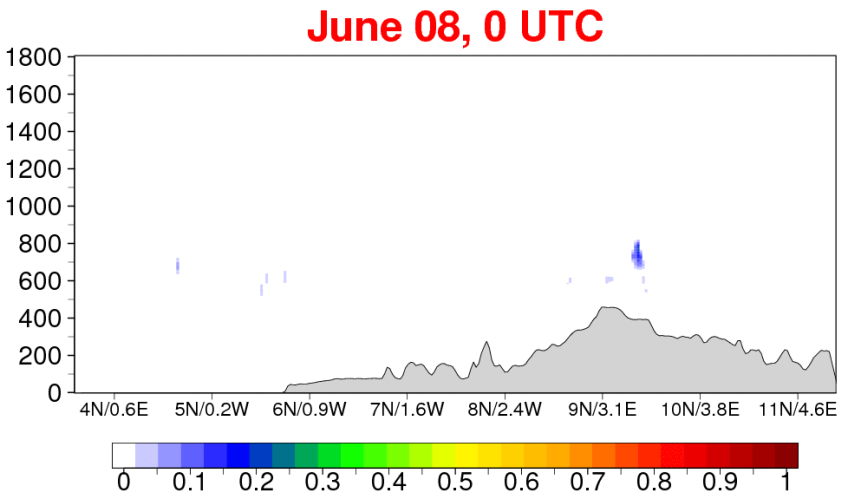


COSMO-ART ( ) - June 8, 2014
average from 0-6 and 18-23 UTC

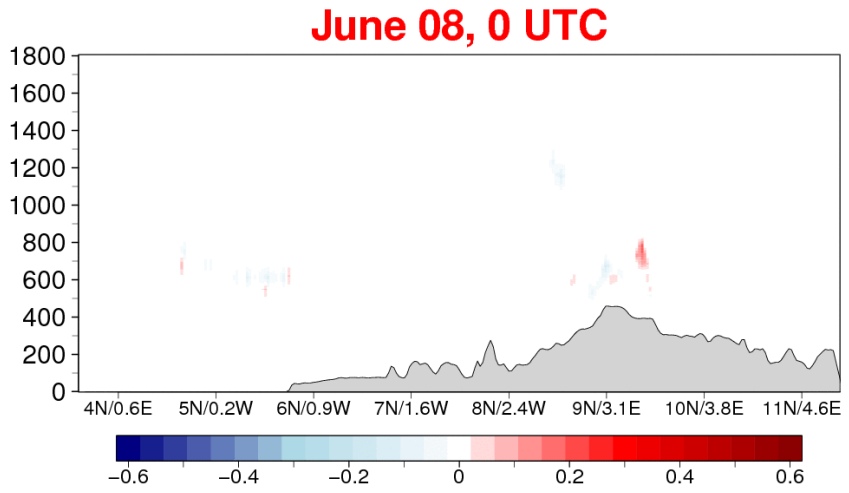
Case study on 7-8 June 2014



- **Cross section of specific cloud water (g kg^{-1})**

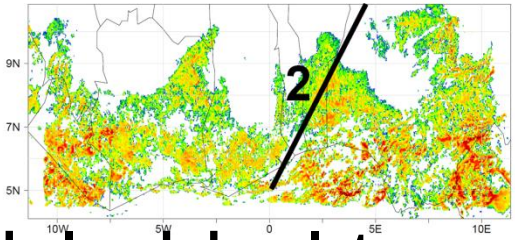


Cloud water ( )

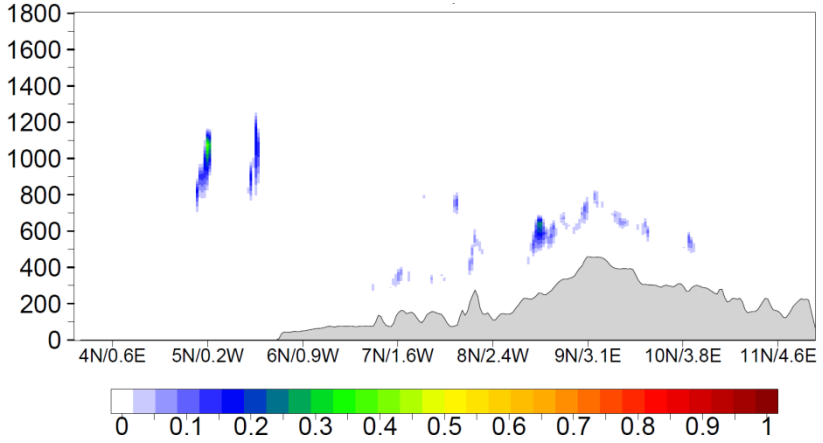


Cloud water (–)

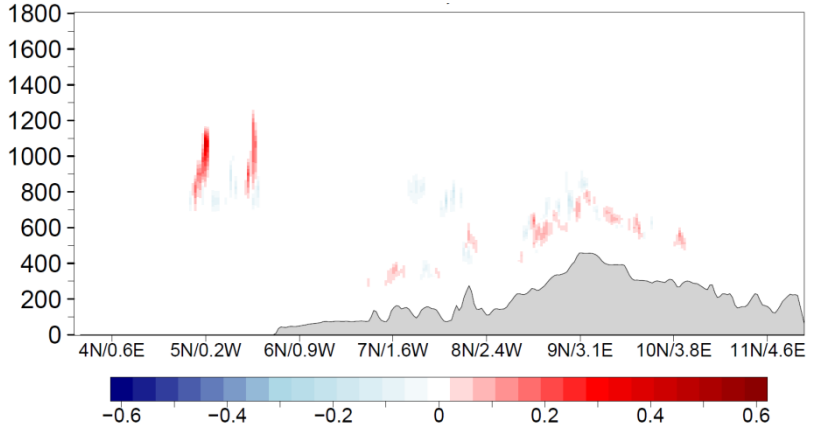
Case study on 7-8 June 2014



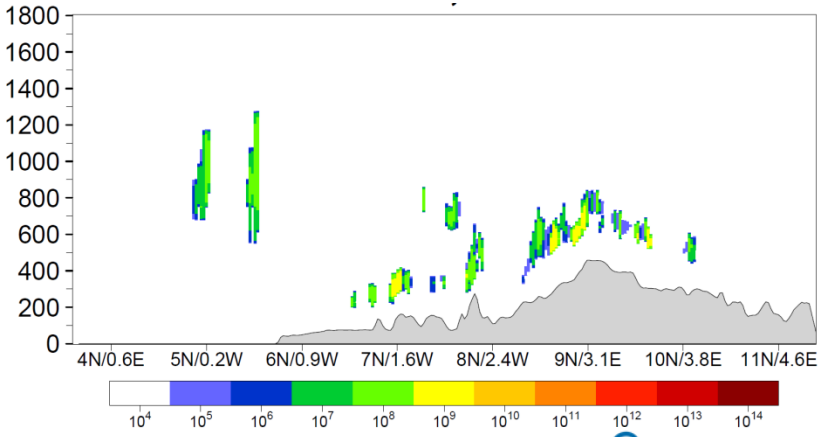
- **Cross section of specific cloud water (g kg^{-1}) and cloud droplet number (kg^{-1}) (8 June 2014, 7 UTC)**



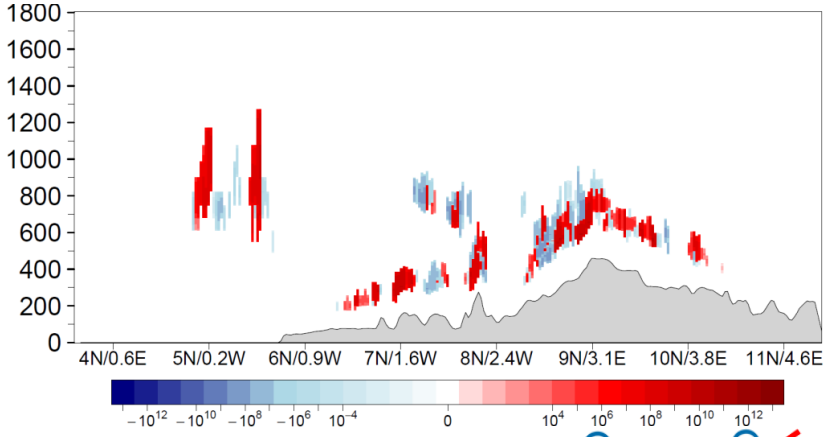
Cloud water ( )



Cloud water (–)



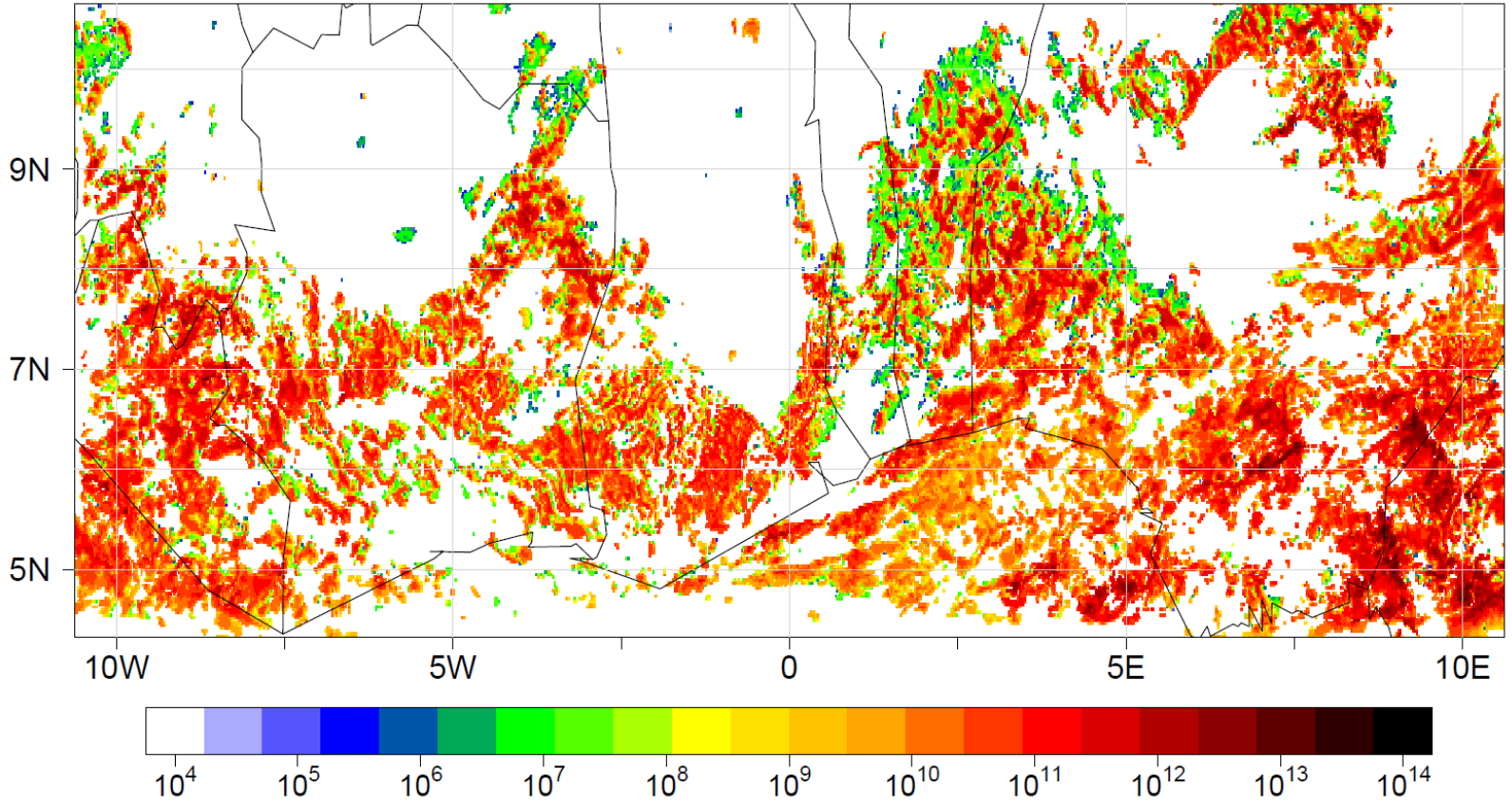
Cloud droplet number ( )



Cloud droplet number (–)

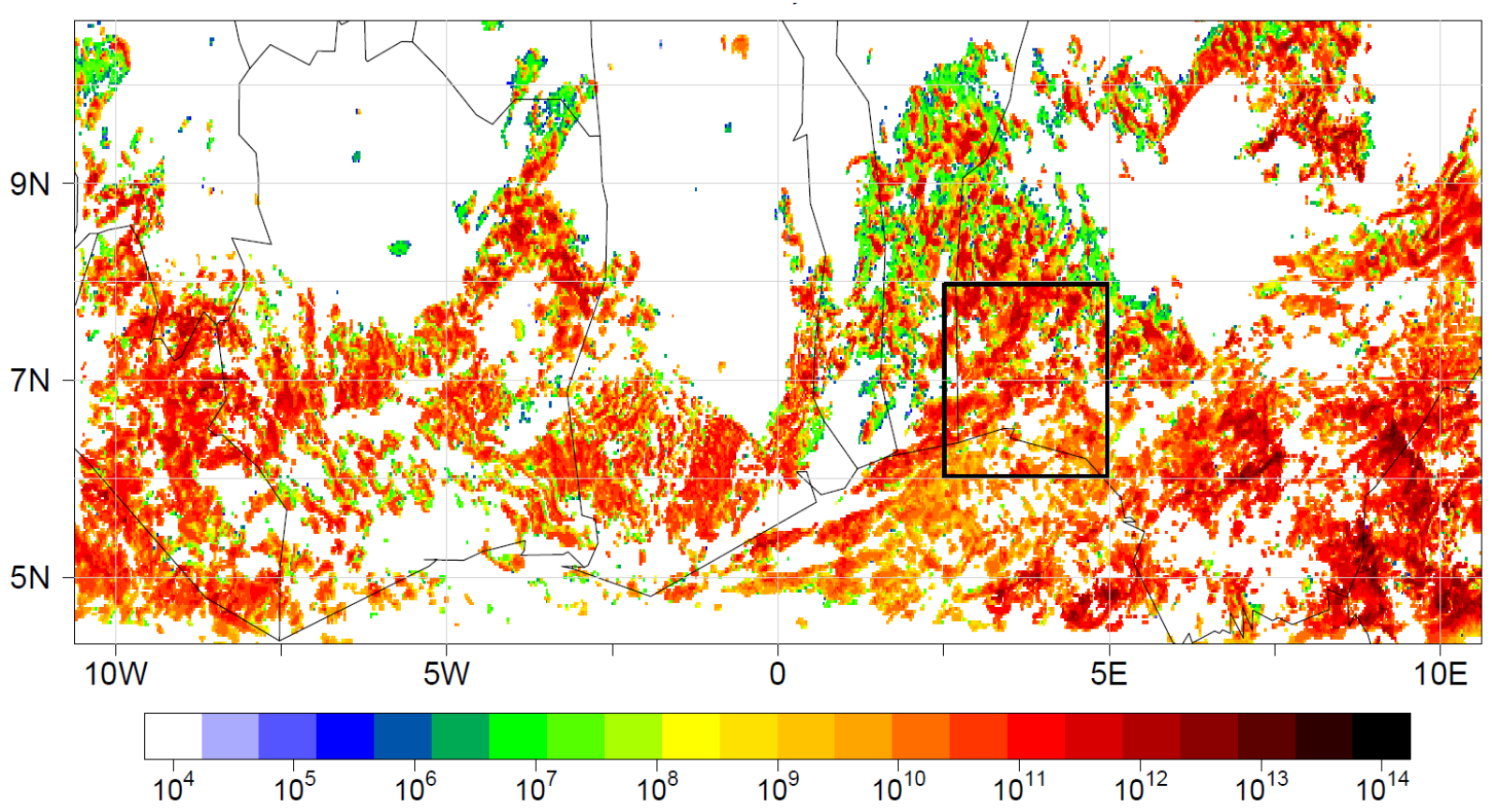
Case study on 7-8 June 2014

- **Vertical integrated specific cloud droplet number (m^{-2}) ( ) (8 June 2014, 7 UTC)**



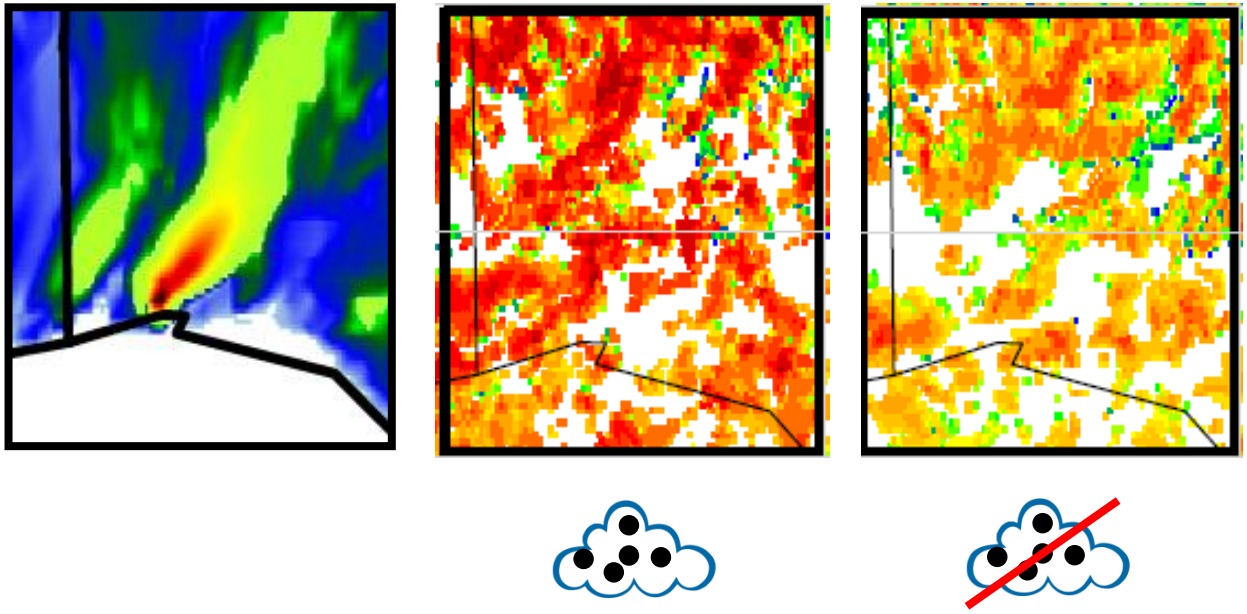
Case study on 7-8 June 2014

- **Vertical integrated specific cloud droplet number (m^{-2}) ( ) (8 June 2014, 7 UTC)**



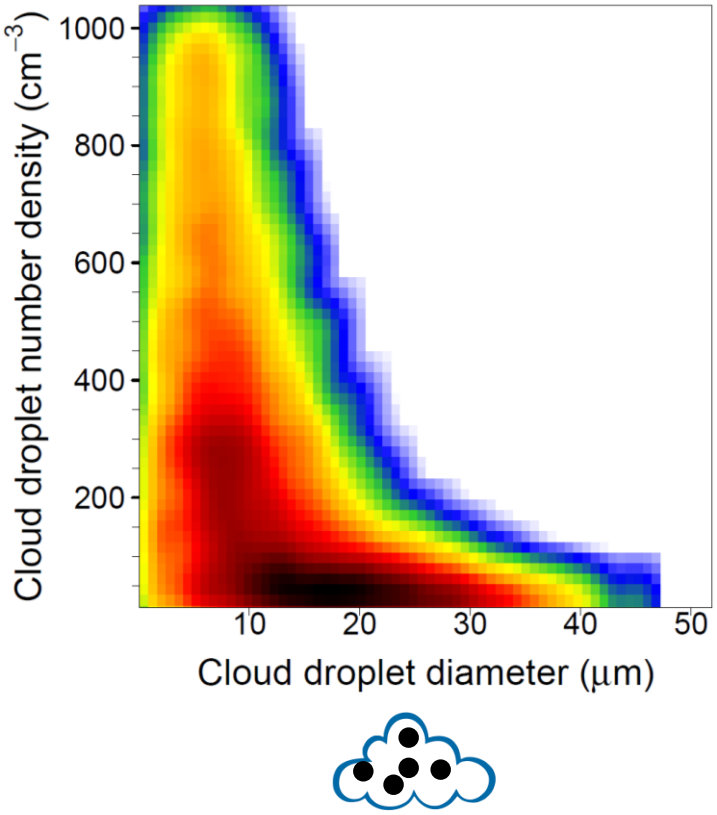
Case study on 7-8 June 2014

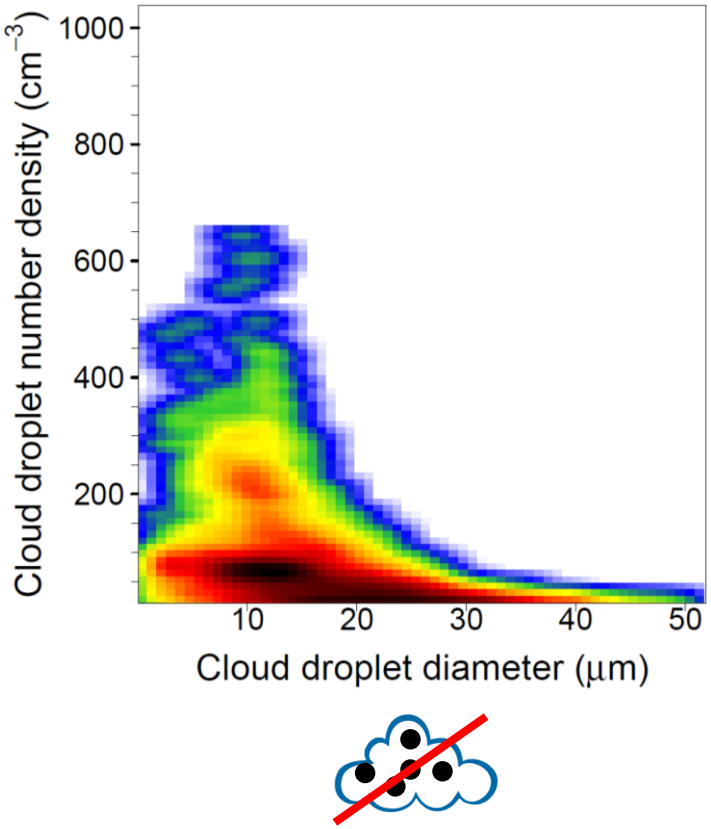
- **Vertical integrated specific cloud droplet number (m^{-2}) over greater Lagos area (8 June 2014, 7 UTC)**



Case study on 7-8 June 2014

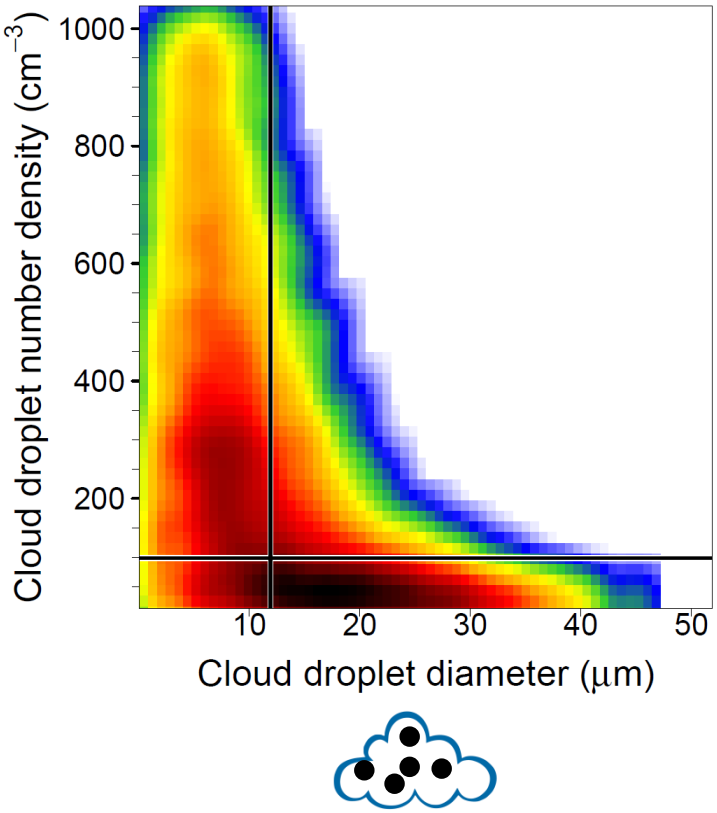
- **Cloud droplet number density depending on diameter over greater Lagos area (8 June 2014, 7 UTC)**

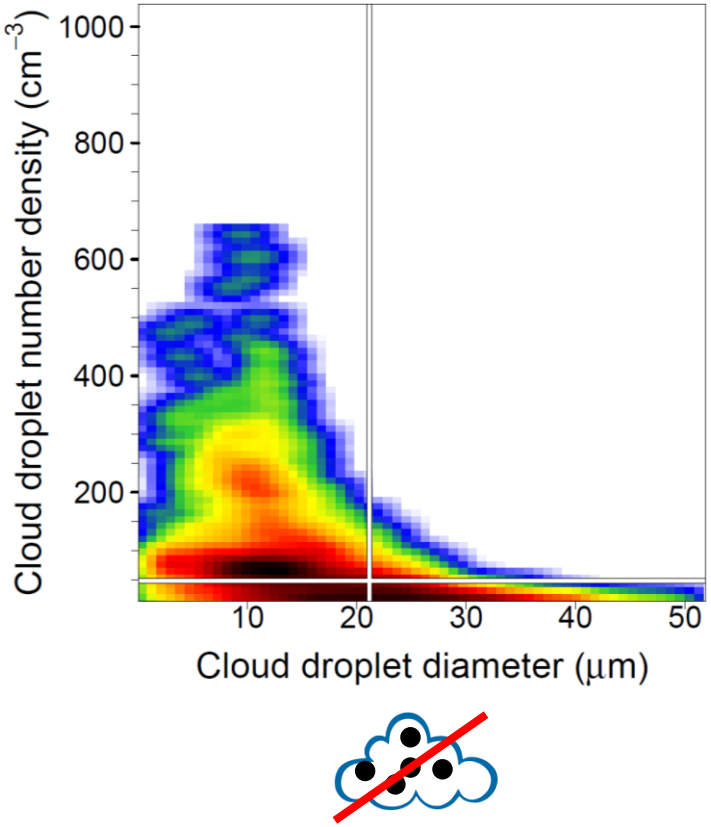




Case study on 7-8 June 2014

- **Cloud droplet number density depending on diameter over greater Lagos area (8 June 2014, 7 UTC) + median**





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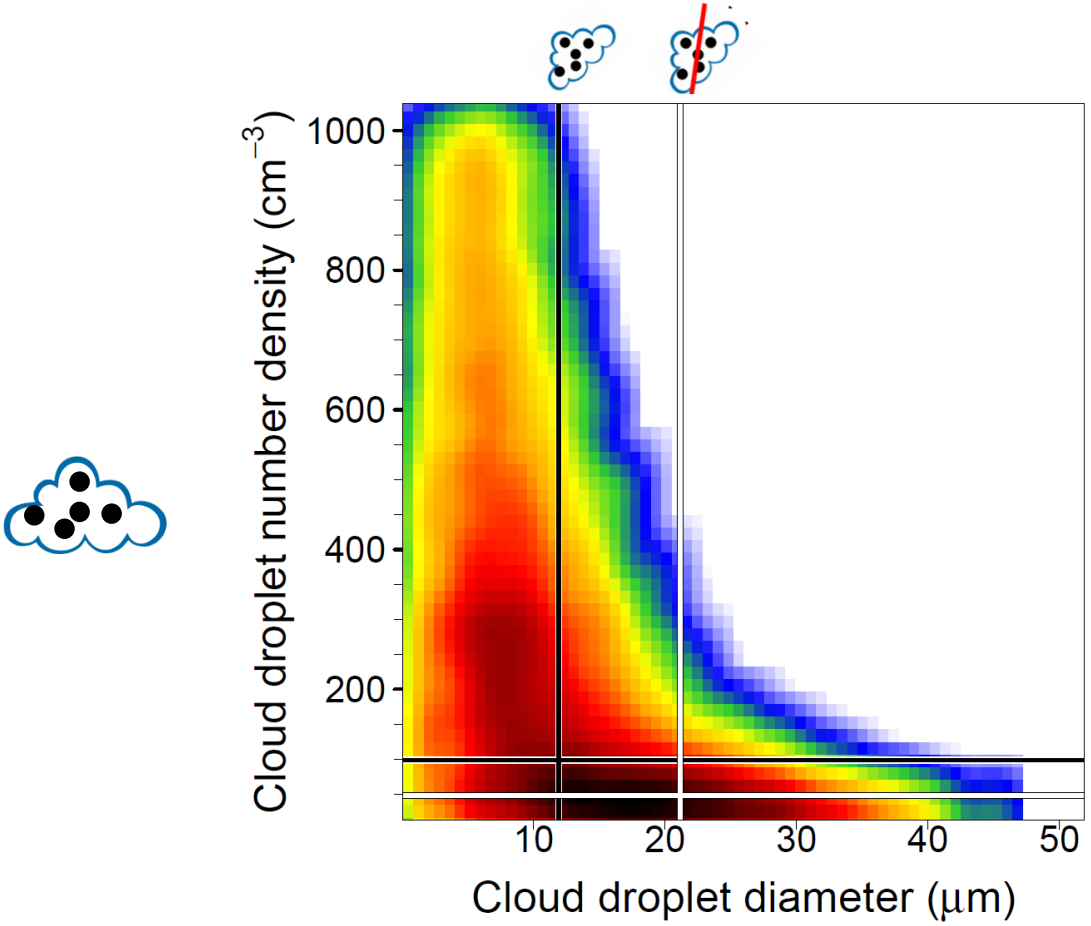
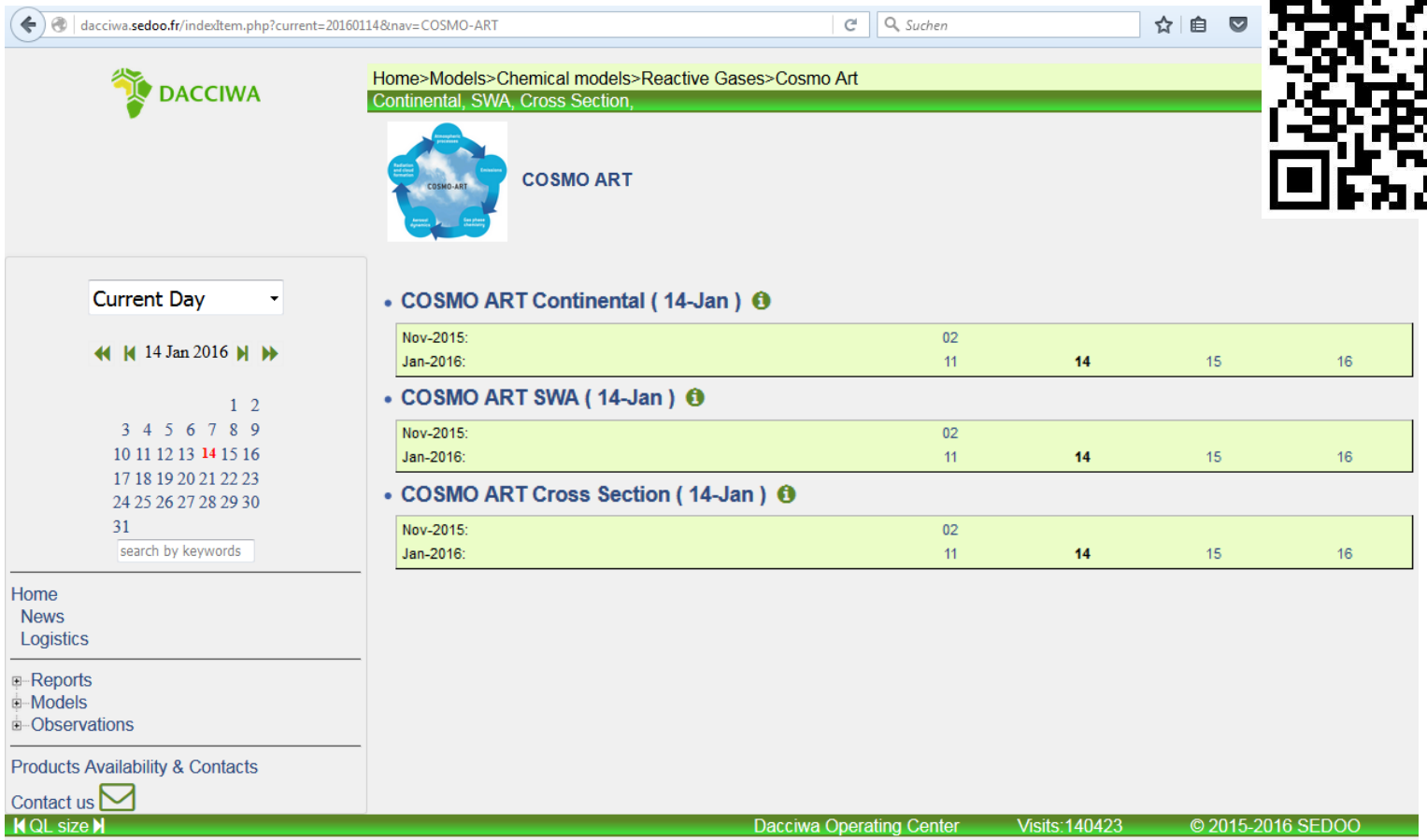


Pre-operational aerosol/chemistry forecasts

Pre-operational aerosol/chemistry forecasts

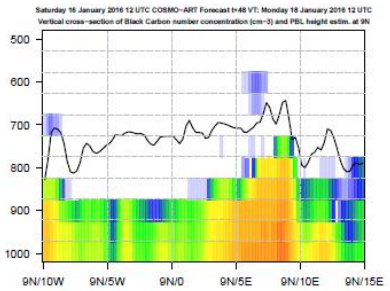
- **Visualization:**

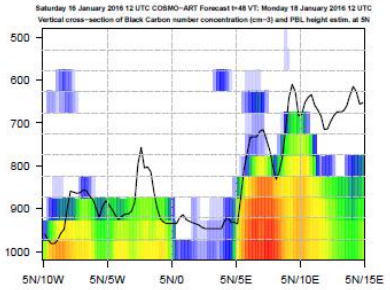
http://dacciwa.sedoo.fr → Chemical models → COSMO ART

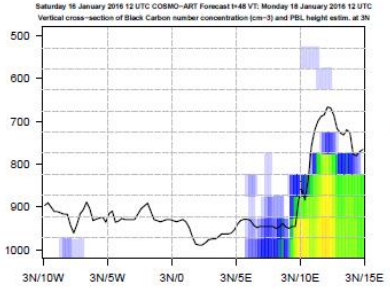


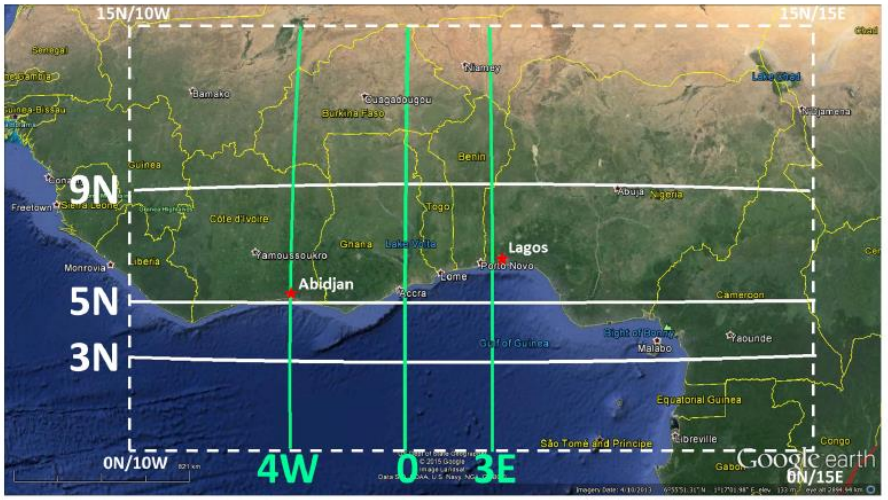
Pre-operational aerosol/chemistry forecasts

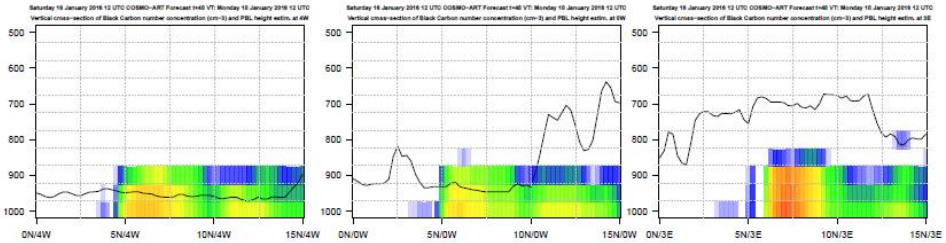
- **Forecast results from 16 January 2016**
  - **Cross sections: Black carbon number concentration (cm^{-3})**

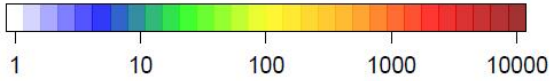










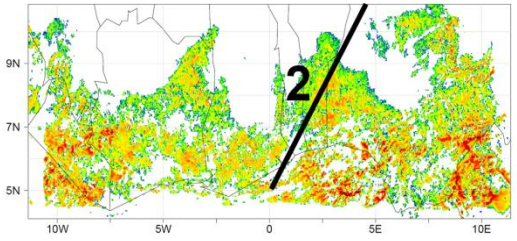


Conclusion and outlook

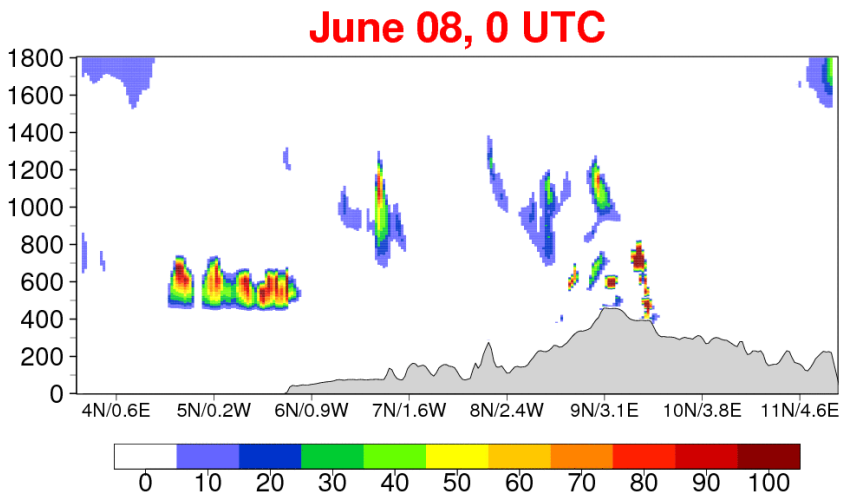
- COSMO-ART adapted to conditions of SWA
- Quantification of ACI within two-day case study
  - Considering aerosol/chemistry seems to have strong influence on SWA cloud formation
  - Cloud properties expecially changed in highly polluted areas
- Extended simulations (June 2015) in progress
- COSMO-ART forecast configuration tested and ready for operation

Appendix

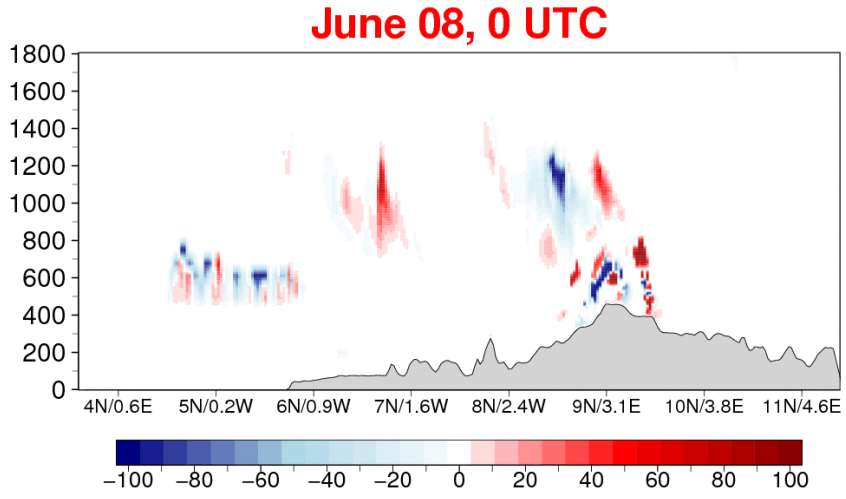
Case study on June 7-8, 2014



- **Cross section of cloud fraction (-)**

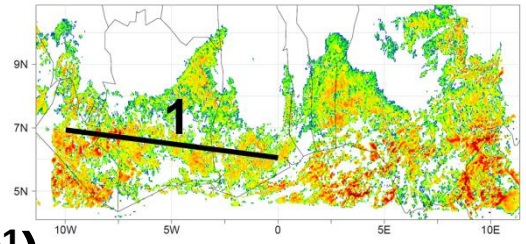


Cloud fraction ( )

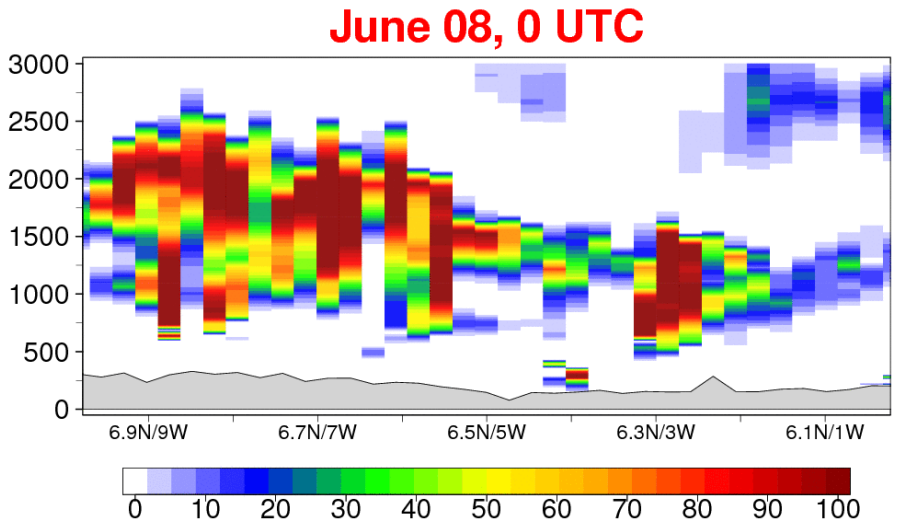


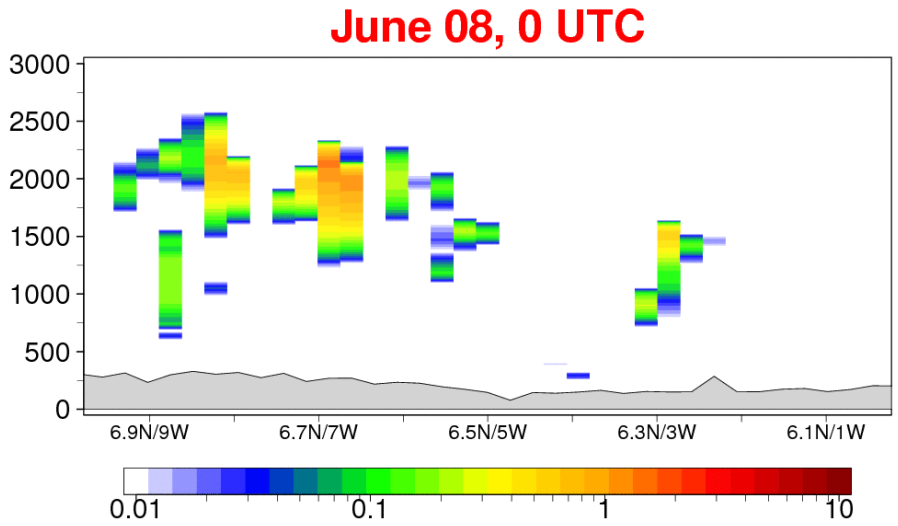
Cloud fraction (–)

Case study on June 7-8, 2014

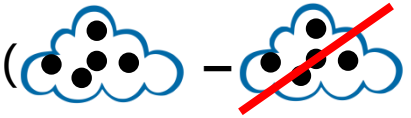


- Cloud fraction (-) and specific cloud water (g kg^{-1})



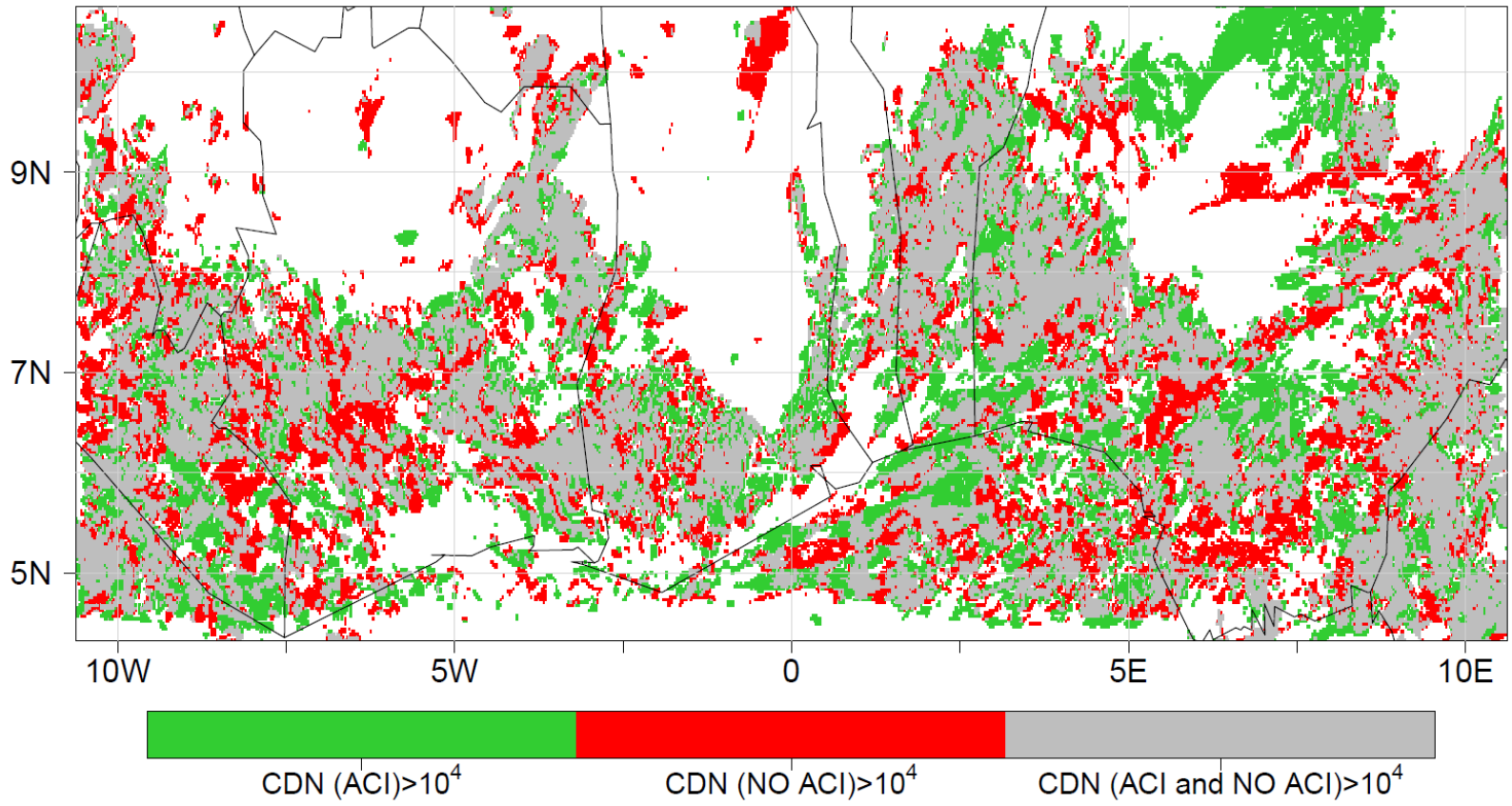


Cloud fraction ()

Cloud water ()

Case study on June 7-8, 2014

- **Vertical integrated specific cloud droplet number (CDN) > 10^4 m^{-2} (8 June 2014, 7 UTC)**



Pre-operational aerosol/chemistry forecasts

- **Model setup:**
  - Meteorology:

    - German Weather Service (DWD) ICON forecasts (R03B07)

  - Chemistry/aerosol:

    - Boundary: MOZART-4/GEOS-5

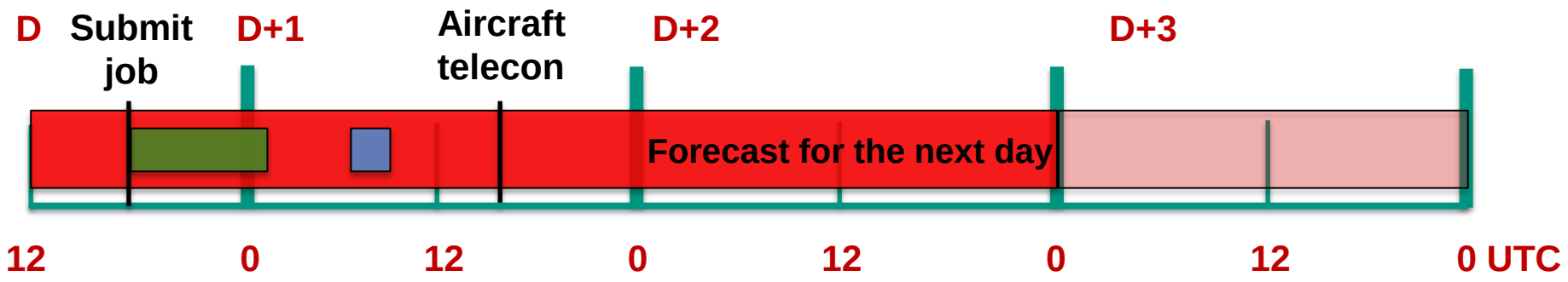
    - Initialization: previous COSMO-ART forecast

    - Anthropogenic emissions: EDGAR HTAP-V2 2010

    - Fire emissions: GFASv1.2 NRT

Pre-operational aerosol/chemistry forecasts

- **Simulation period: 57h**



Computing time

Postprocessing and provide

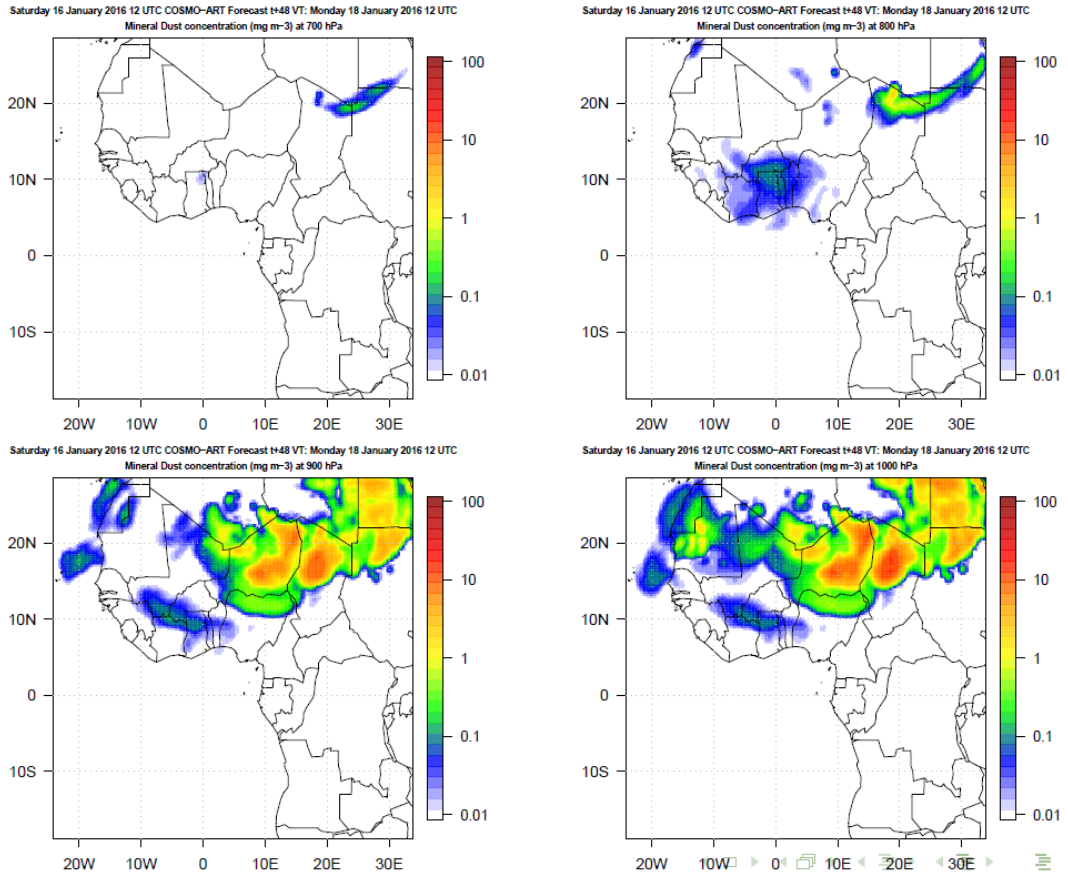
Forecast time

Pre-operational aerosol/chemistry forecasts

- **Postprocessing:**
  - Wind speed and direction, PBL height
  - Black carbon concentration (mass/number)
  - Mineral dust (mass/number)
  - Sea salt (mass/number)
  - Sulphate
  - Submicron particles (number)
  - Ozone
  - Carbon monoxide
  - NO_x
  - Sulphur dioxide
  - Isoprene

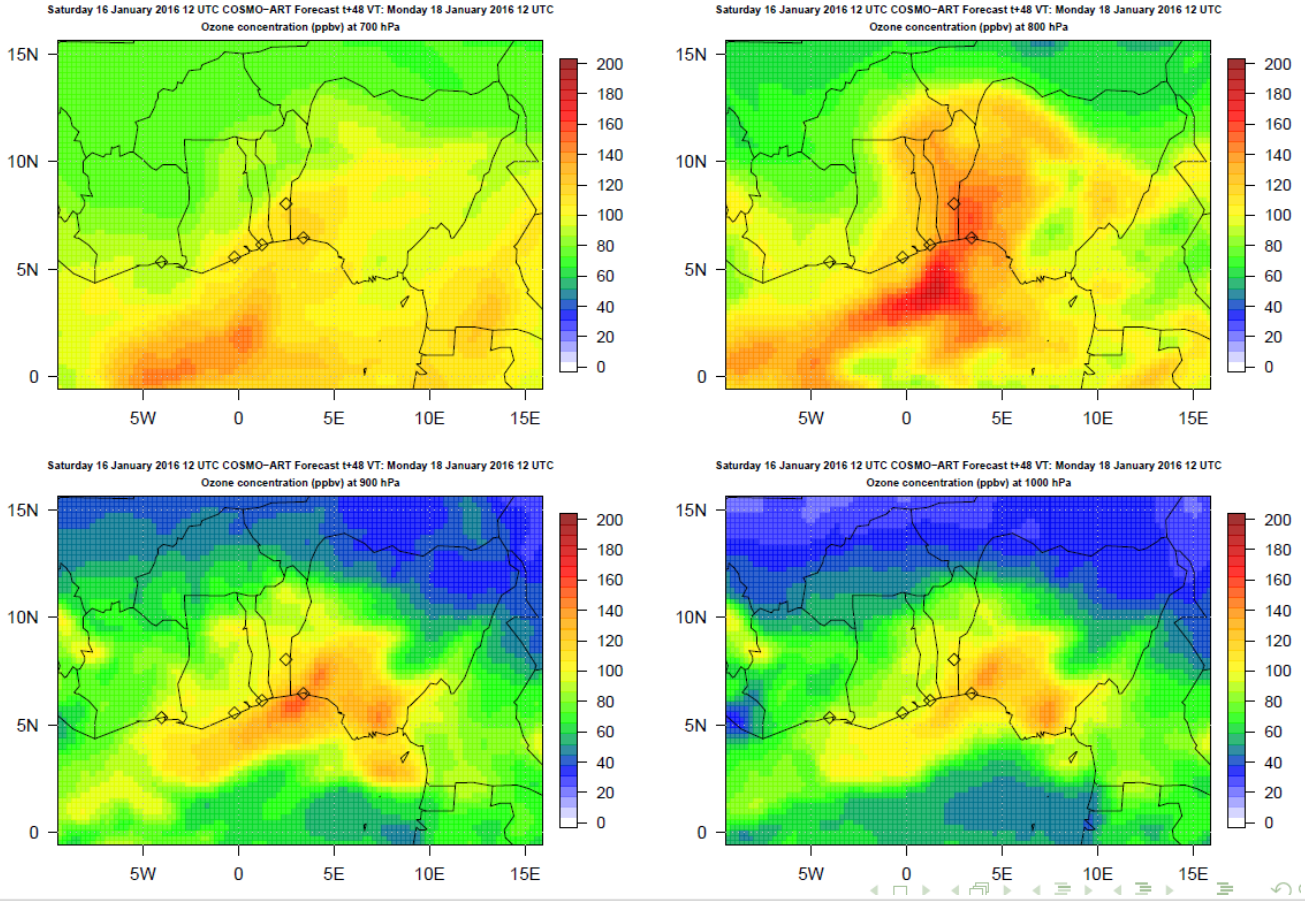
Pre-operational aerosol/chemistry forecasts

- **Forecast results from 16 January 2016**
  - **CONTINENTAL: Mineral dust concentration (mg m^{-3})**



Pre-operational aerosol/chemistry forecasts

- **Forecast results from 16 January 2016**
  - **SWA: Ozone volume mixing ratio (ppbv)**



Pre-operational aerosol/chemistry forecasts

- **Forecast results from 16 January 2016**
  - **Cross sections: Black carbon number concentration (cm^{-3})**