PAUL SCHERRER INSTITUT

LABOR FÜR ATMOSPHÄREN-CHEMIE

Preliminary Results of MM5/CAMx Simulations for Winter and Summer 2006 in Switzerland

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Aerosol Measurements / Modeling

Winter (January 2006)

Summer (June 2006)

Summer vs.Winter

Conclusions / Outlook

Aerosol Measurements 2006

January	: Zurich (urban)
February	: Reiden (rural, motorway)
June	: Payerne (rural)

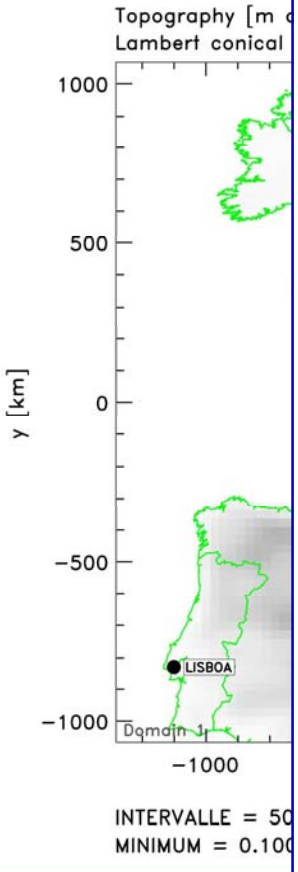
Aerosol Mass Spectrometer (AMS)	: nitrate, sulfate, ammonium, organics
^{14}C analysis	: fossil C, nonfossil C
Aethalometer	: black carbon (BC)
NABEL network	: PM10, PM2.5

Modeling

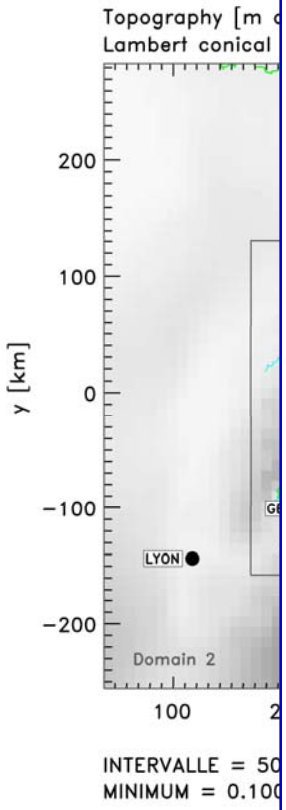
simulation periods	1-31 Jan. 2006 1-30 June 2006
models	MM5/CAMx
domains	27, 9, 3 km
vertical resolution	31/14 layers
gas-phase mechanism	CBM-IV
aerosol modules	ISORROPIA, RADM-AQ SOAP
particle size	PM2.5

Model Domains for Switzerland

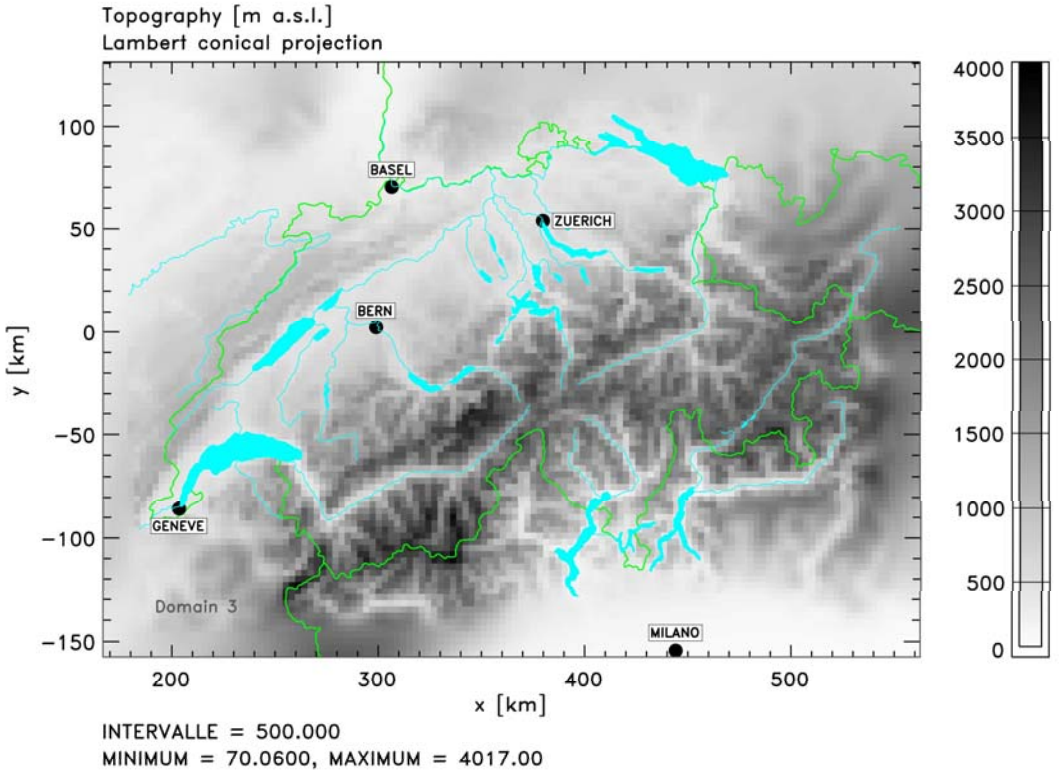
Domain 1, 27 km



Domain 2, 9 km



Domain 3, 3 km



Winter

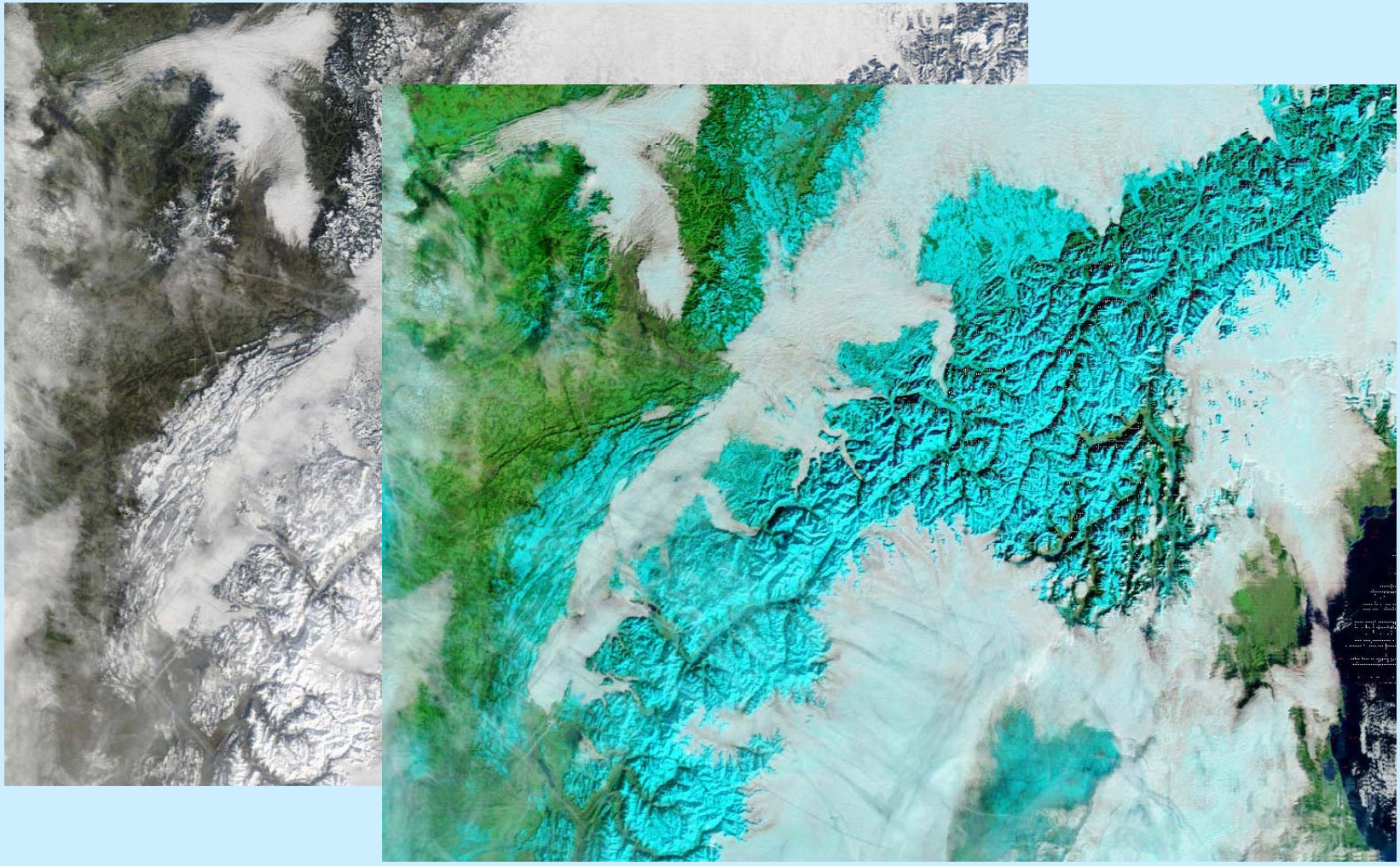
(January 2006)

Fog Layer Observed from Pilatus (Central Switzerland)

Courtesy Peter Bucher @ Umwelt+Energie, Luzern

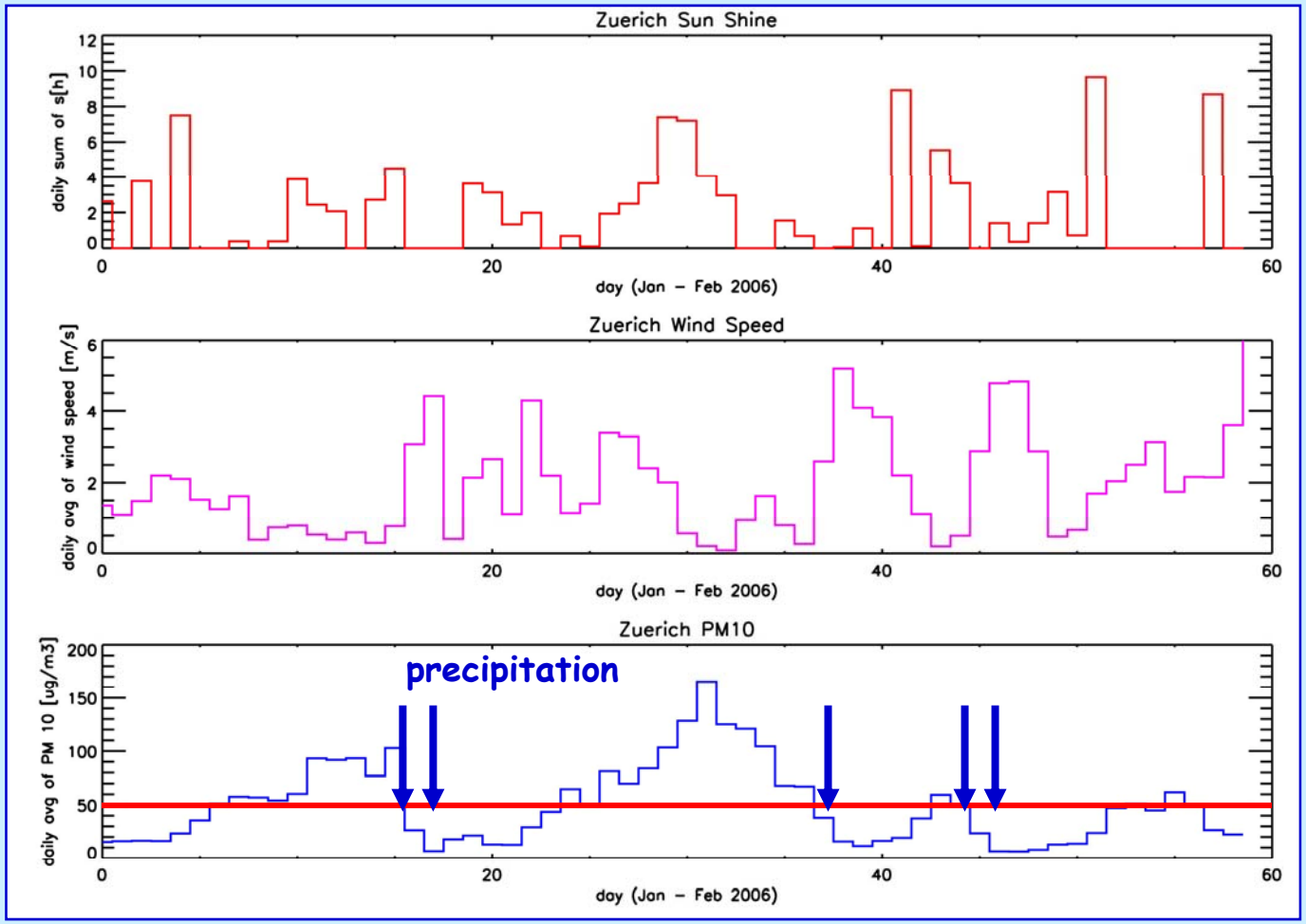
Image Taken by MODIS on NASA's Satellite Terra

January 8, 2006



http://rapidfire.sci.gsfc.nasa.gov/realtime/

Daily Values of Sun Shine, Wind Speed and PM10 at Zurich. Jan - Feb 2006

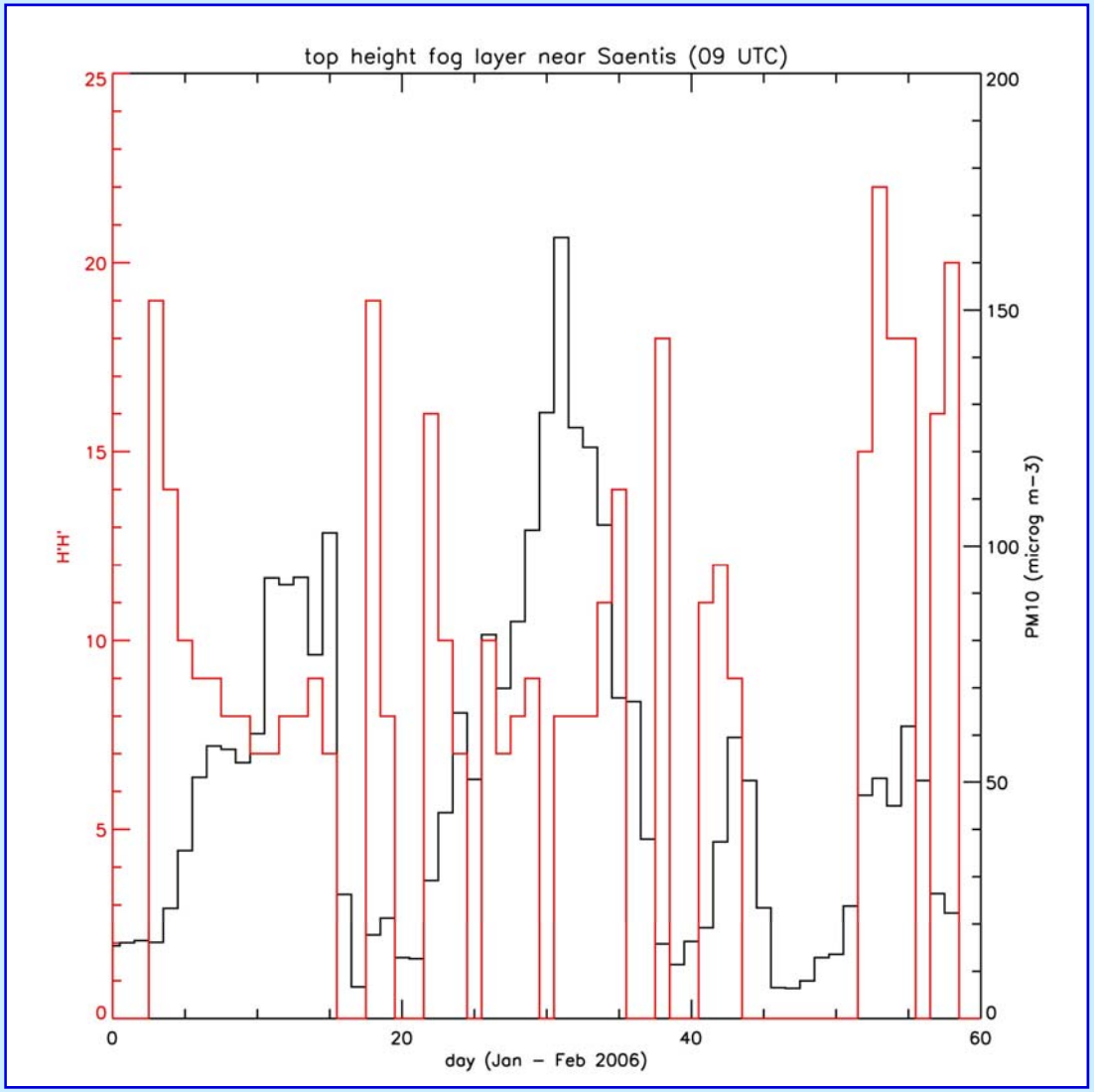


50 ug m^{-3} .
24 h average, must not be exceeded more than once a year

Alpine Weather Statistics ("Alpenwetterstatistik")

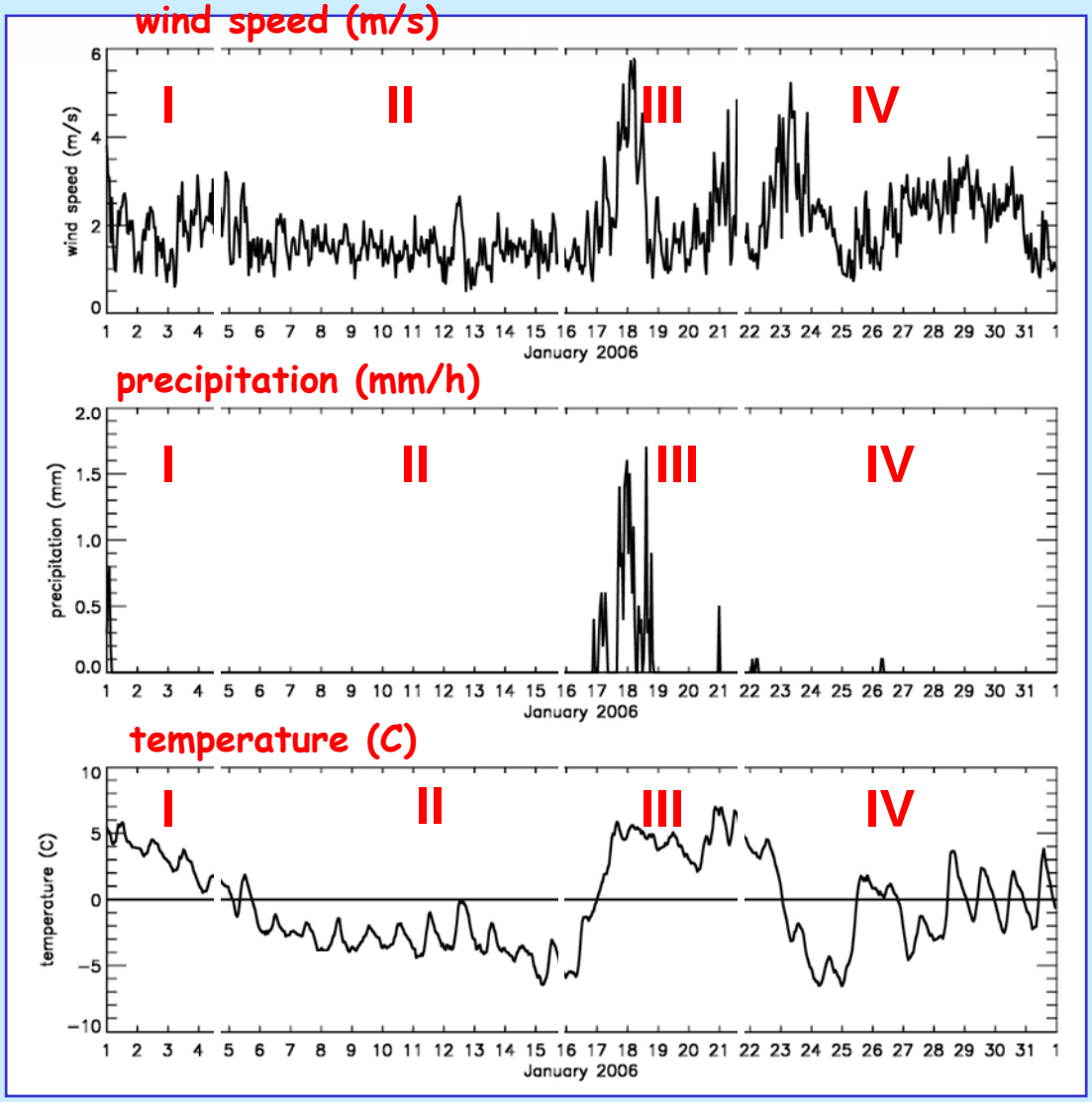
Weather Index H'H': Fog Layer Top Height over the Swiss Plateau

top height (hm)



Meteorological parameters

(Zurich, January 2006)



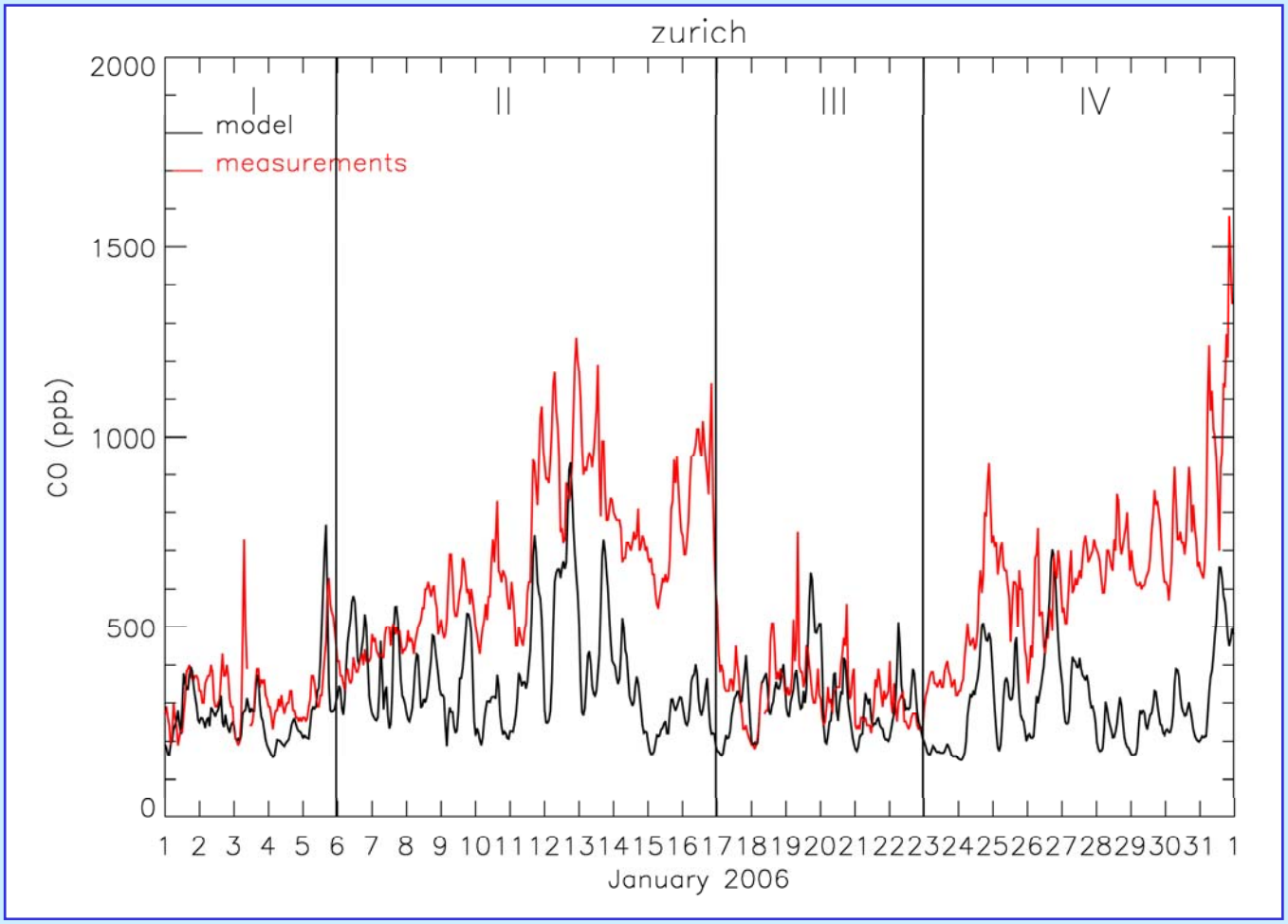
I *1- 6 January*
T > 0 °C
no precipitation
moderate wind speed

II *6-17 January*
T < 0 °C
no precipitation
low wind speed

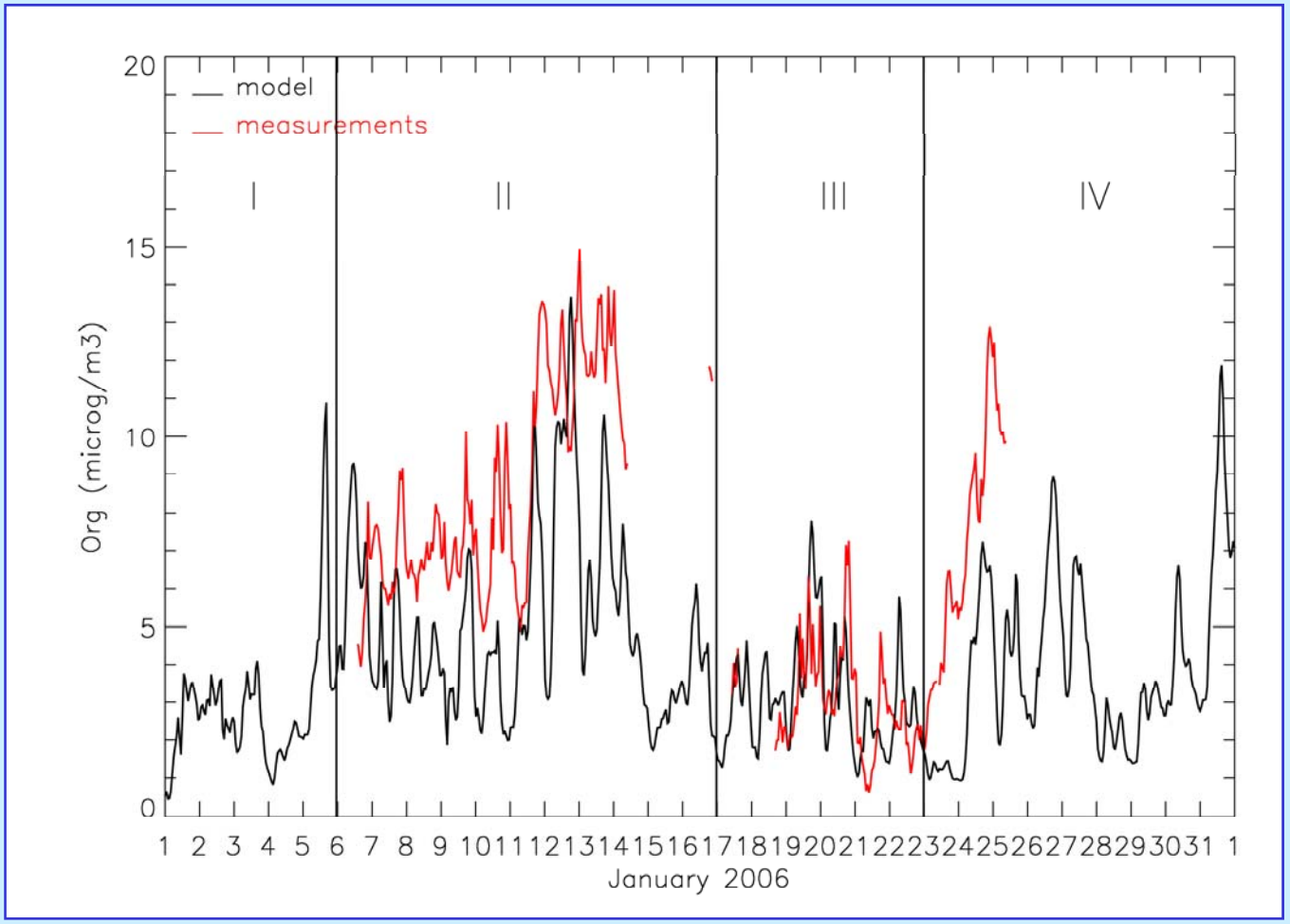
III *17-23 January*
T > 0 °C
precipitation
high wind speed

IV *23-31 January*
mixed conditions

CO at Zurich, January 2006

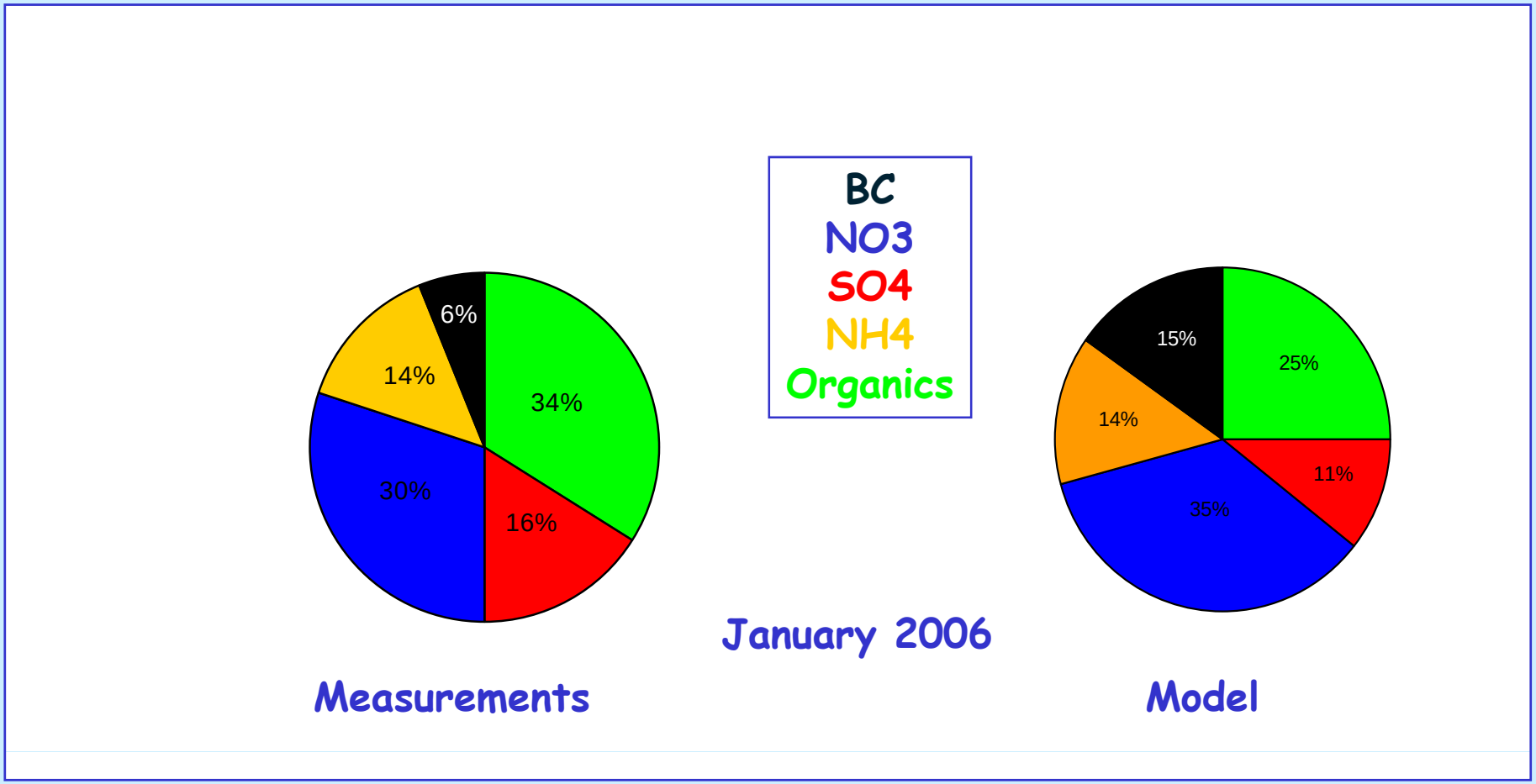


Organic aerosols at Zurich, January 2006



41% of OC from wood burning ***(Szidat et al. JGR, 2006)***

Average aerosol composition in Zurich

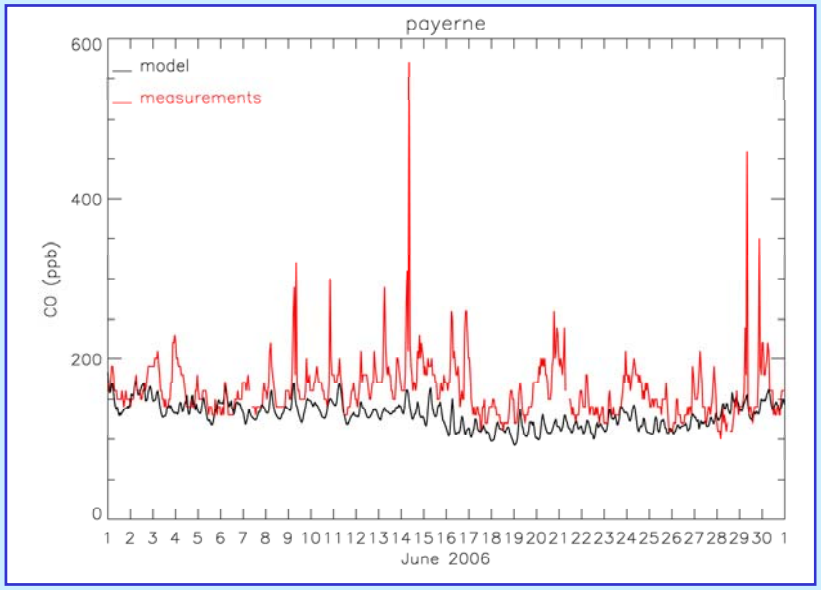


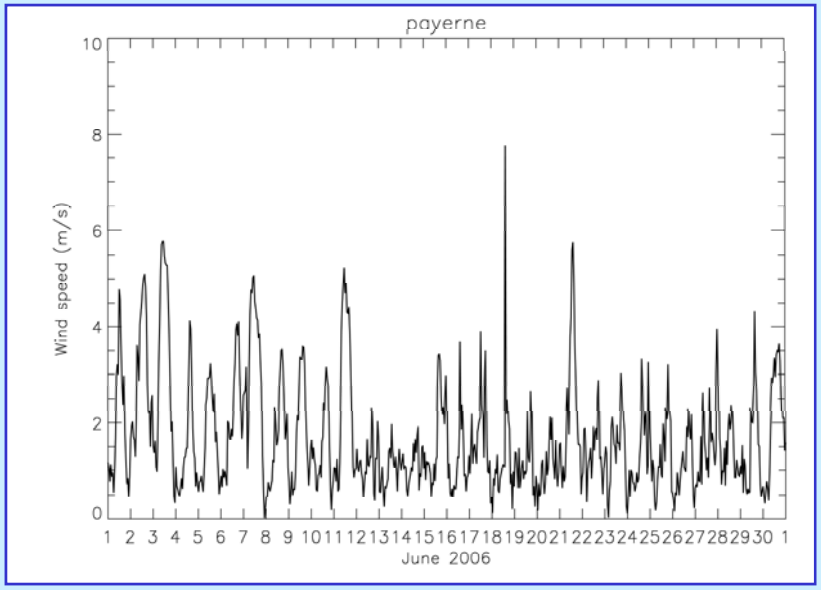
Main components: nitrate and organic aerosols

Summer

(June 2006)

CO and wind speed at Payerne, June 2006



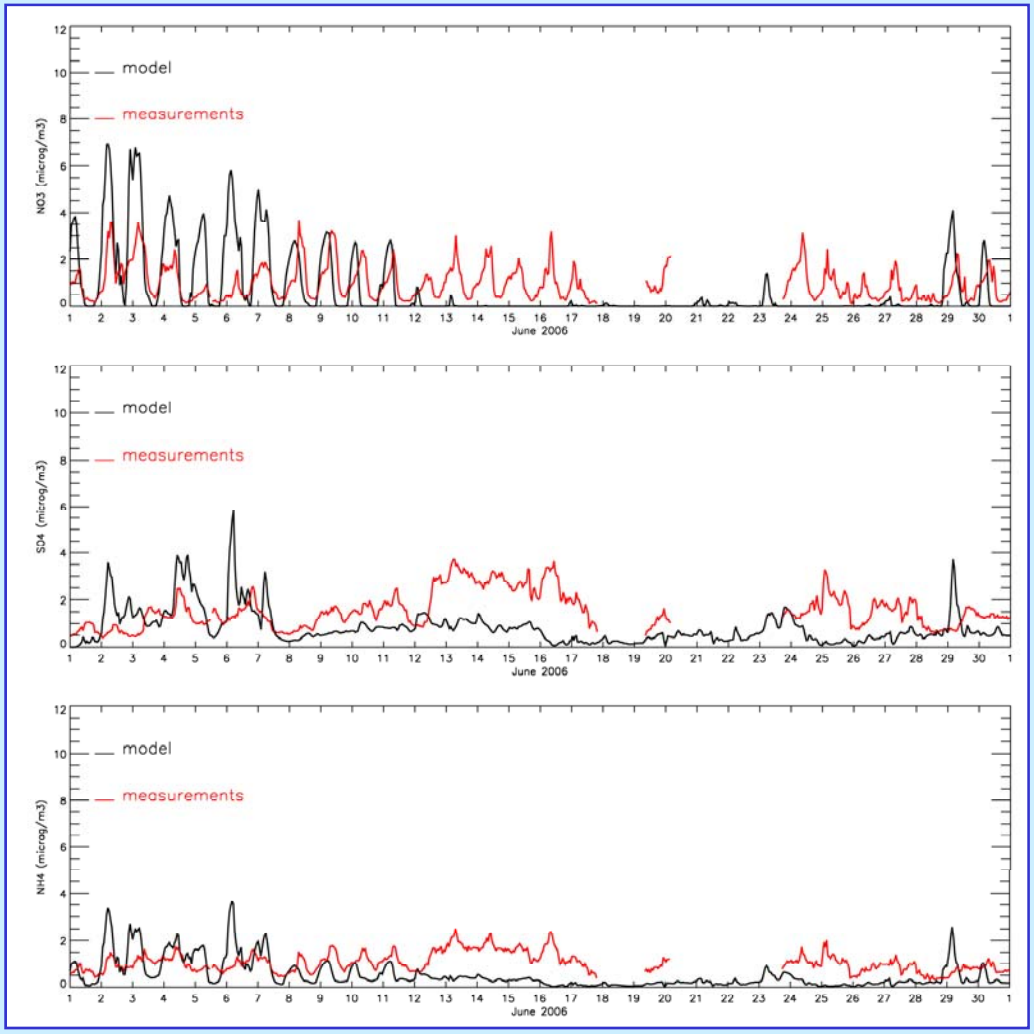


Inorganic aerosols at Payerne, June 2006

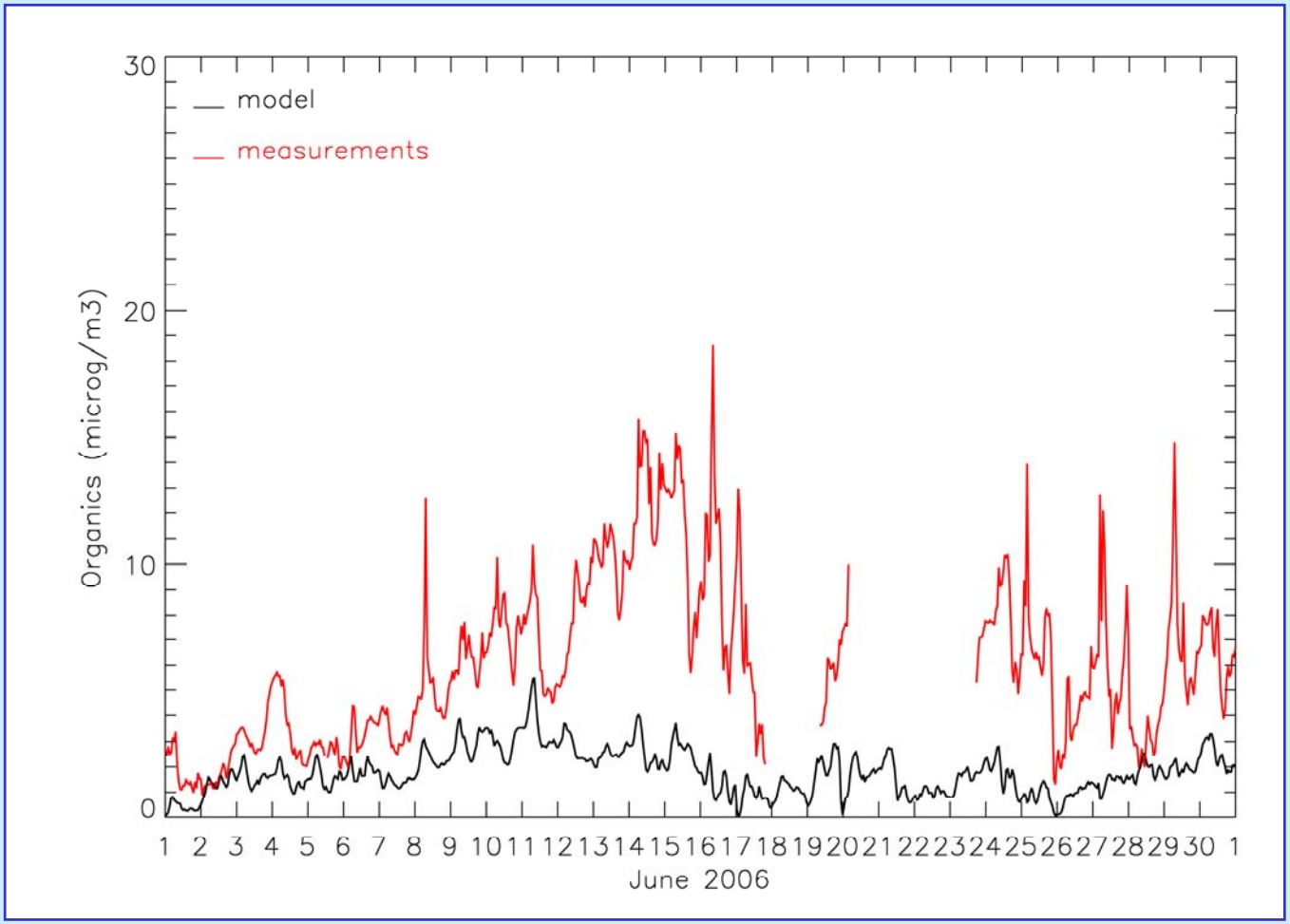
NO3

SO4

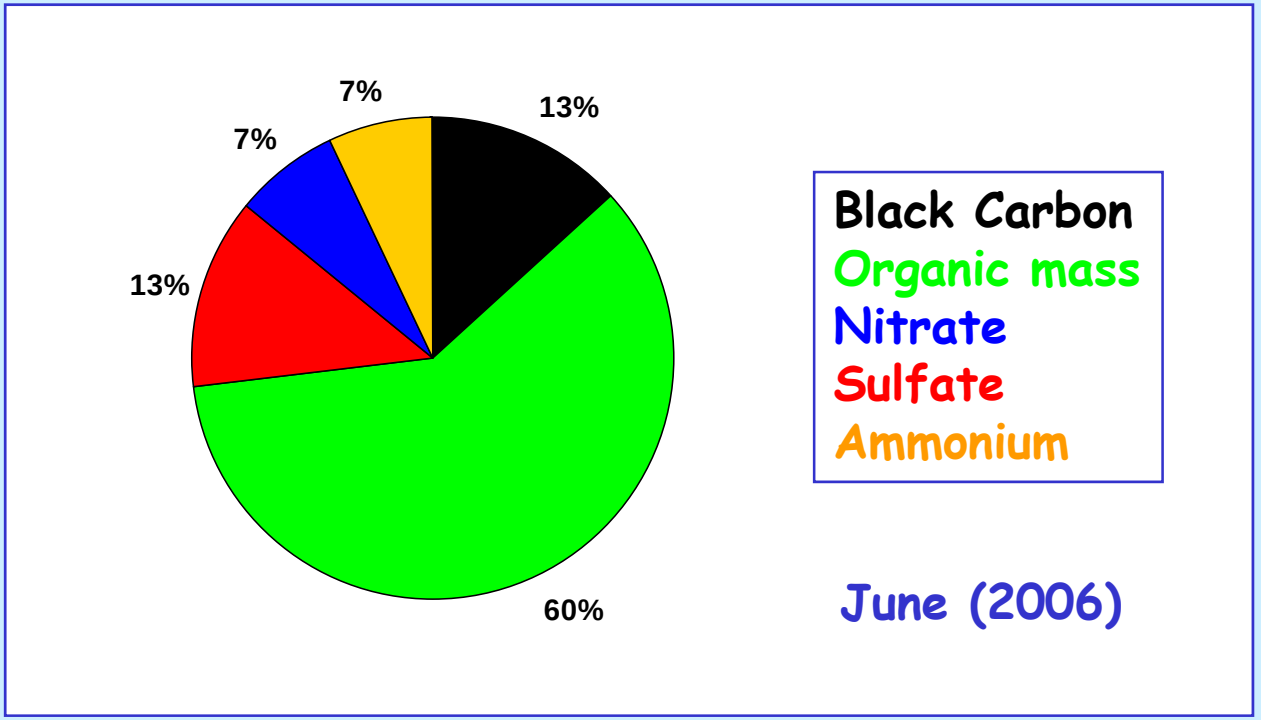
NH4



Organic aerosols at Payerne, June 2006



Average aerosol composition measured in Payerne

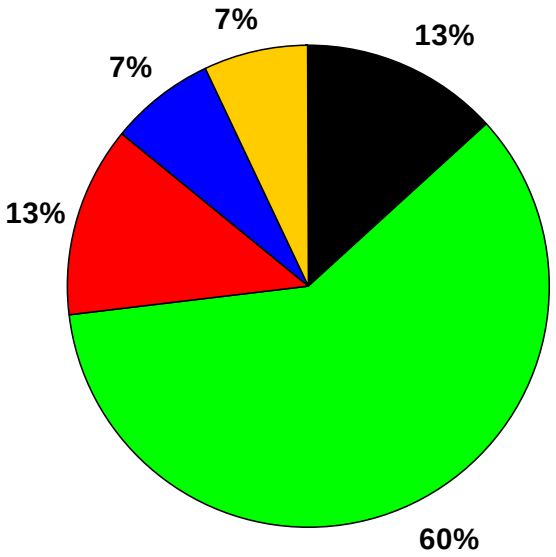


Main components: sulfate and organic aerosols

Summer vs. Winter

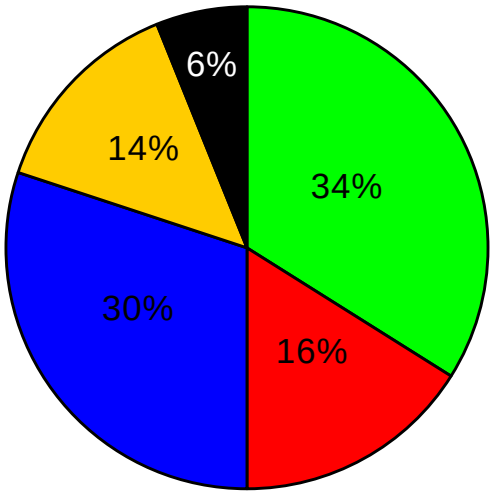
Organic Aerosols (OA) vs. Inorganic Aerosols (IA)

Average aerosol composition (measured)



June 2006

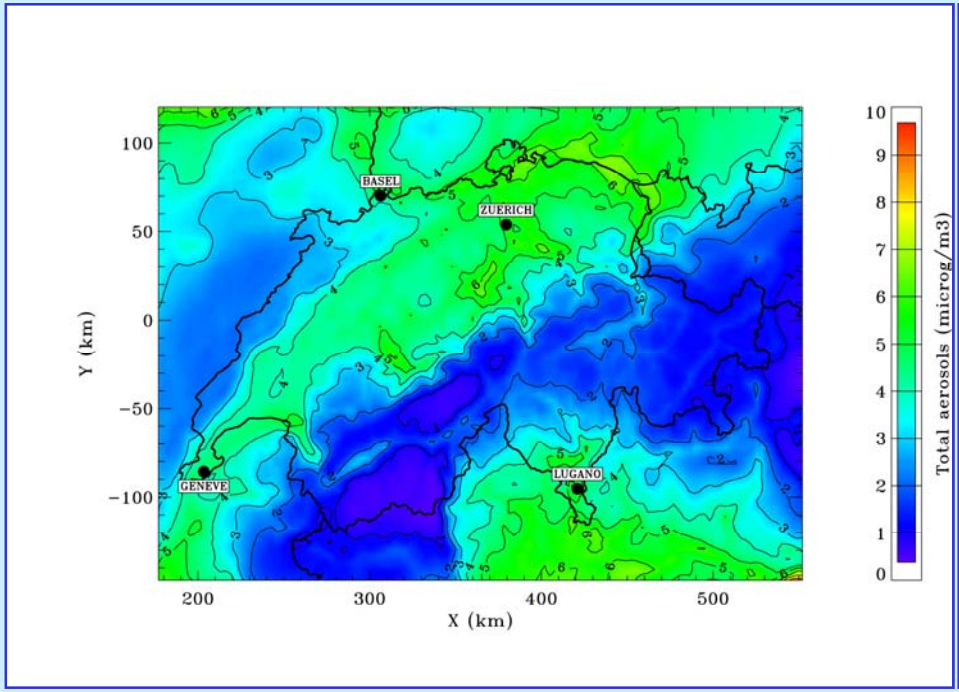
Black Carbon
Organic mass
Nitrate
Sulfate
Ammonium



January 2006

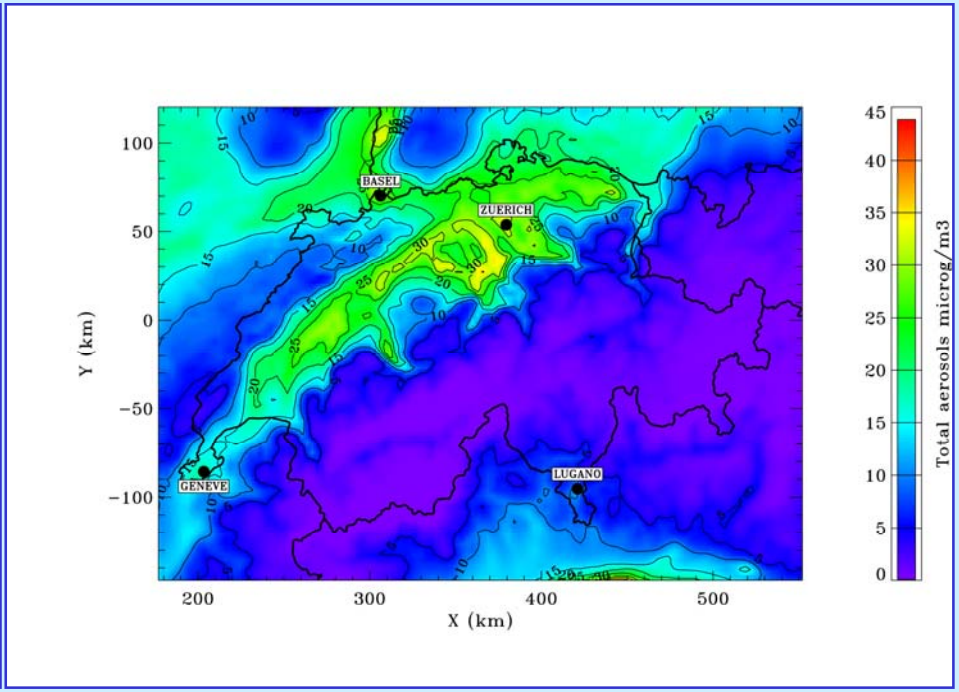
Total aerosol mass concentrations (daily average)

summer



15.6.2006

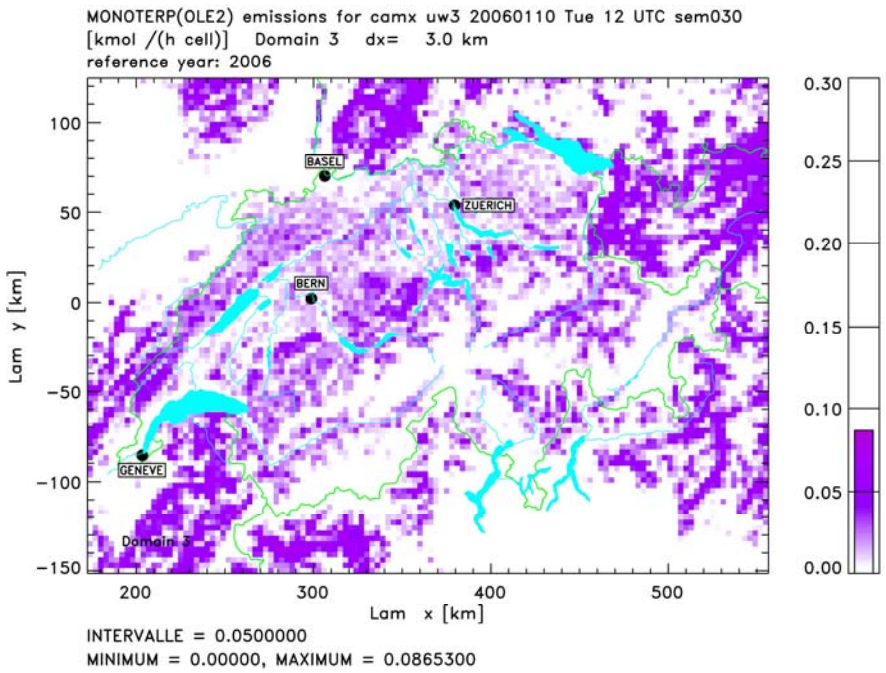
winter



19.01.2006

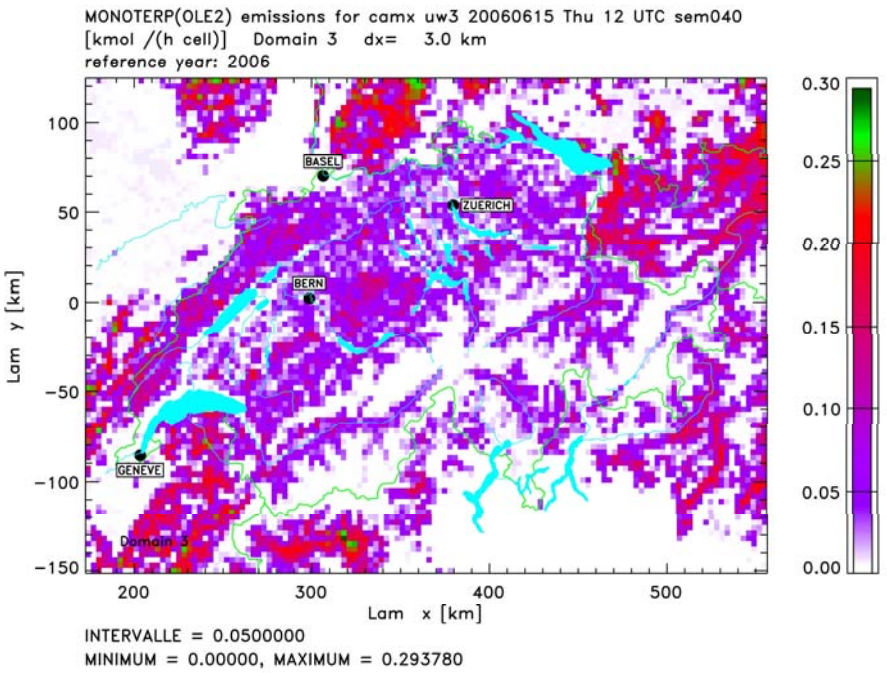
Monoterpene emissions in Switzerland (kmol h^{-1} $cell^{-1}$)

winter



10 January 2006, 12 UTC

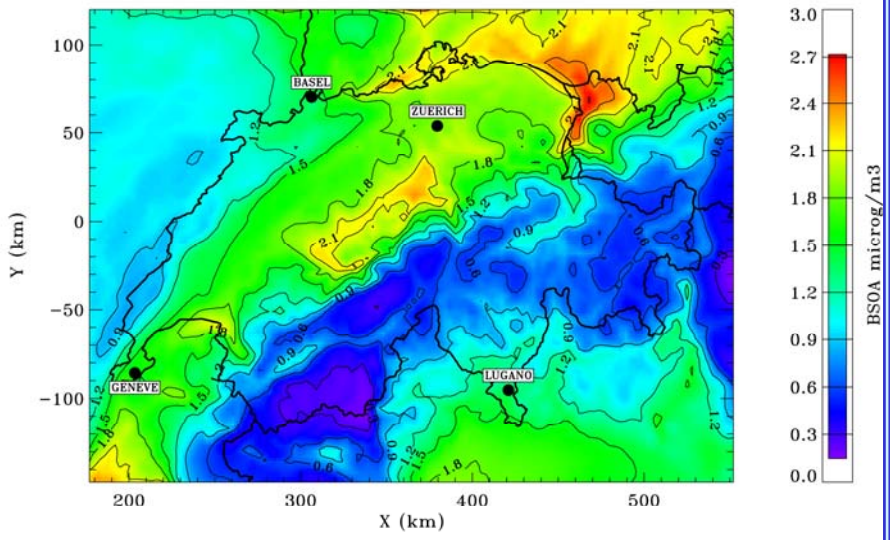
summer



15 June 2006, 12 UTC

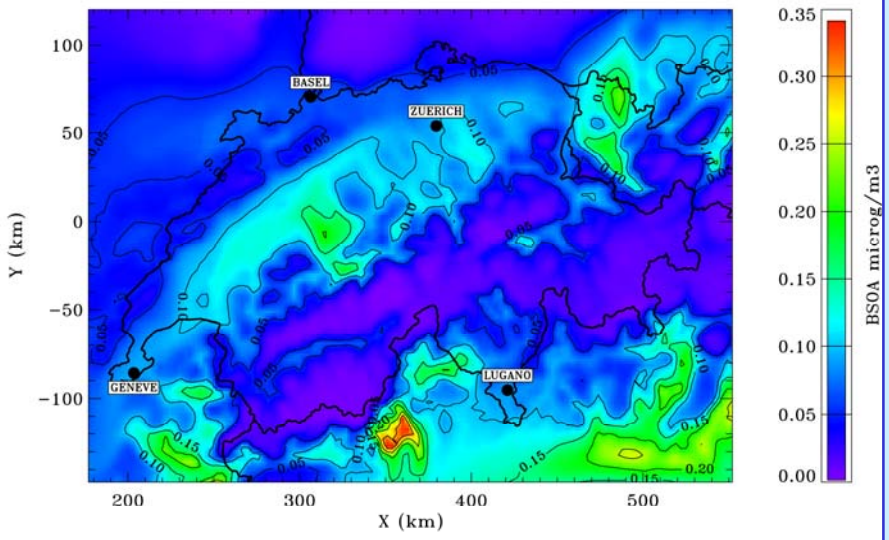
Biogenic SOA in Summer and Winter

summer



15.06.2006

winter



19.01.2006

Biogenic vers. Anthropogenic SOA

Average percentage contribution of biogenic emissions to OC in Zurich

(Szidat et al., JGR, 2006)

summer	winter
60 %	27 %

Conclusions

- ✓ Low wind patterns are insufficiently reproduced by MM5 in winter and in summer
- ✓ Fog is hardly captured by MM5
- ✓ According to both measurements and CAMx in the north of the Swiss Alps the main components are
  - ✓organic aerosols and nitrate in winter,
  - ✓organic aerosols and sulfate in summer.
- ✓ SOA dominate the organic aerosol composition in summer and winter.

Conclusions (cont'd)

- ✓ Measurements suggest that the contribution of biogenic emissions to OC is about 60 % in summer, 27% in winter.
- ✓ Relative contributions of inorganic aerosols to aerosol composition could be well predicted (60%) while organic aerosols are underestimated.
- ✓ Both measurements and model calculations suggest that the biogenic precursors contribute more to SOA than anthropogenic ones in the north. Non fossil SOA sources in winter are not yet clear.
- ✓ Wood burning is a very important source in Switzerland in winter. Emissions have to be implemented.

Outlook

- ✓ Improvement of meteorological parameterization in MM5
- ✓ Implementation of wood burning emissions in the emission inventory
- ✓ SOA formation from isoprene, sesquiterpenes

Acknowledgements

- BAFU/NABEL/EMPA
- S. Szidat, V. Lanz
- MeteoSwiss
- INFRAS, FUB, UBA, TNO, METEOTEST
- INTROP (ESF)
- M. Schultz
- M. Tinguely
- ACCENT

Thank you for your attention !

Selected MM5 3.7.2 Input Parameters for Winter Periods in Switzerland

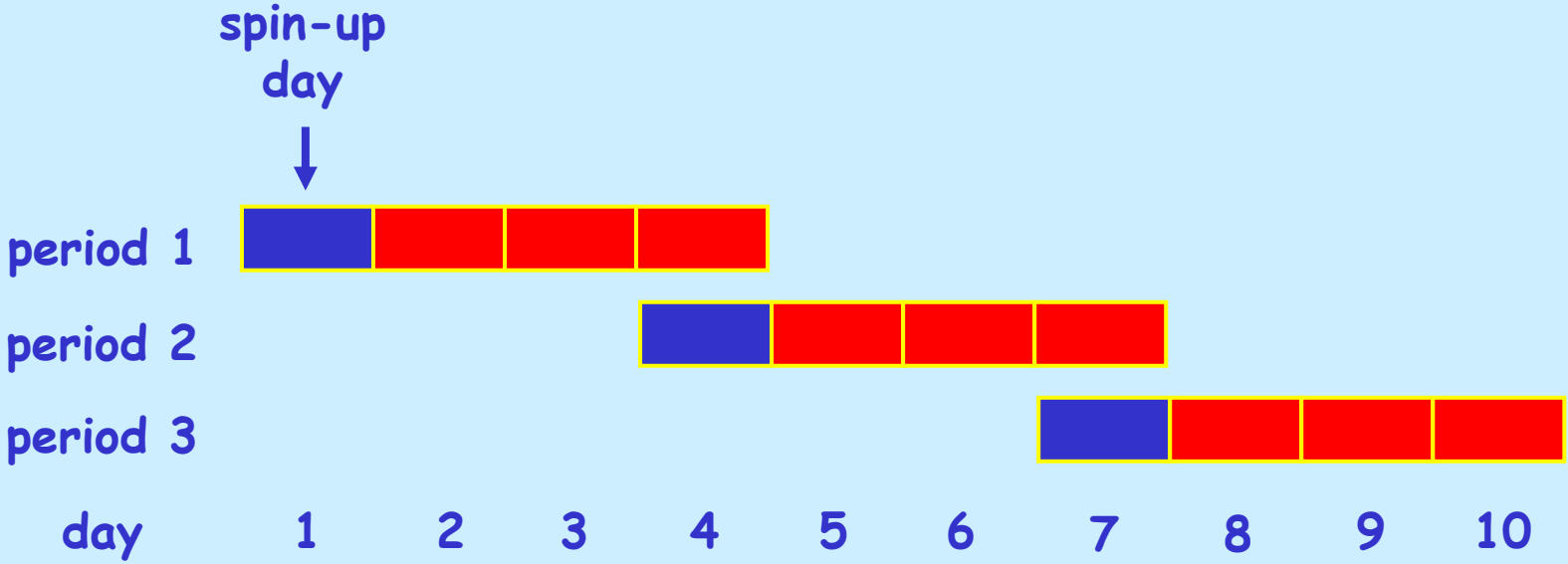
- One way nesting (with NESTDOWN)
- FDDA with assimilated aLMo grids for domains 1 and 2 (I4D=1), no FDDA for domain 3 (I4D=0)

- Grell cumulus parameterization (ICUPA=3)
- Eta PBL scheme (IBLTYP=4)
- Goddard microphysics moisture scheme (IMPHYS=6)
- Cloud radiation scheme (IFRAD=2)
- Noah Land-Surface Model (LSM) (ISOIL=2)

- Horizontal diffusion (ITPDIF=2)
- Orographic shadowing for domain 3 (OROSHAW=1)

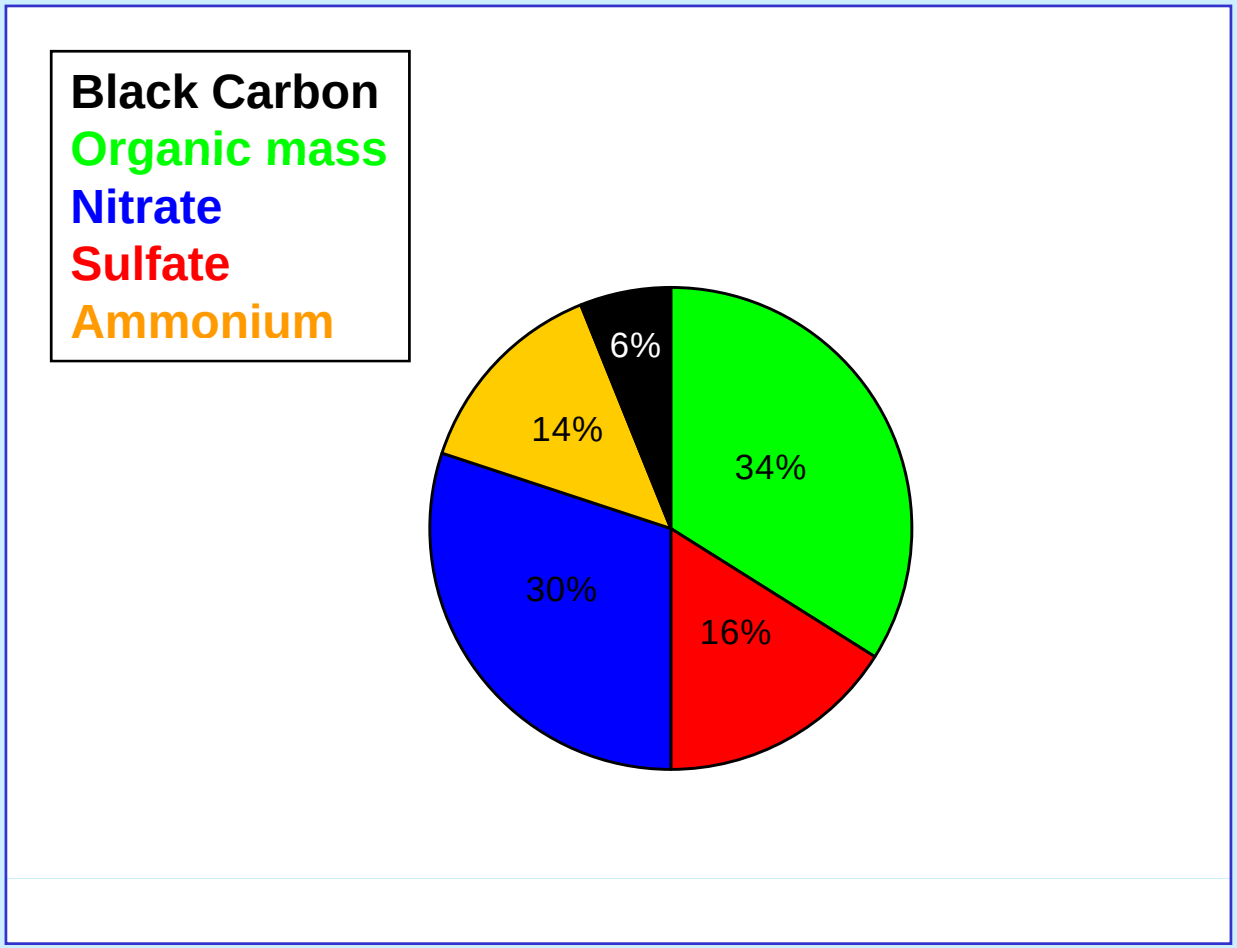
FDDA: 4-dimensional data assimilation

Staggering of the Simulation Periods for Jan 1-10, 2006 (Example)



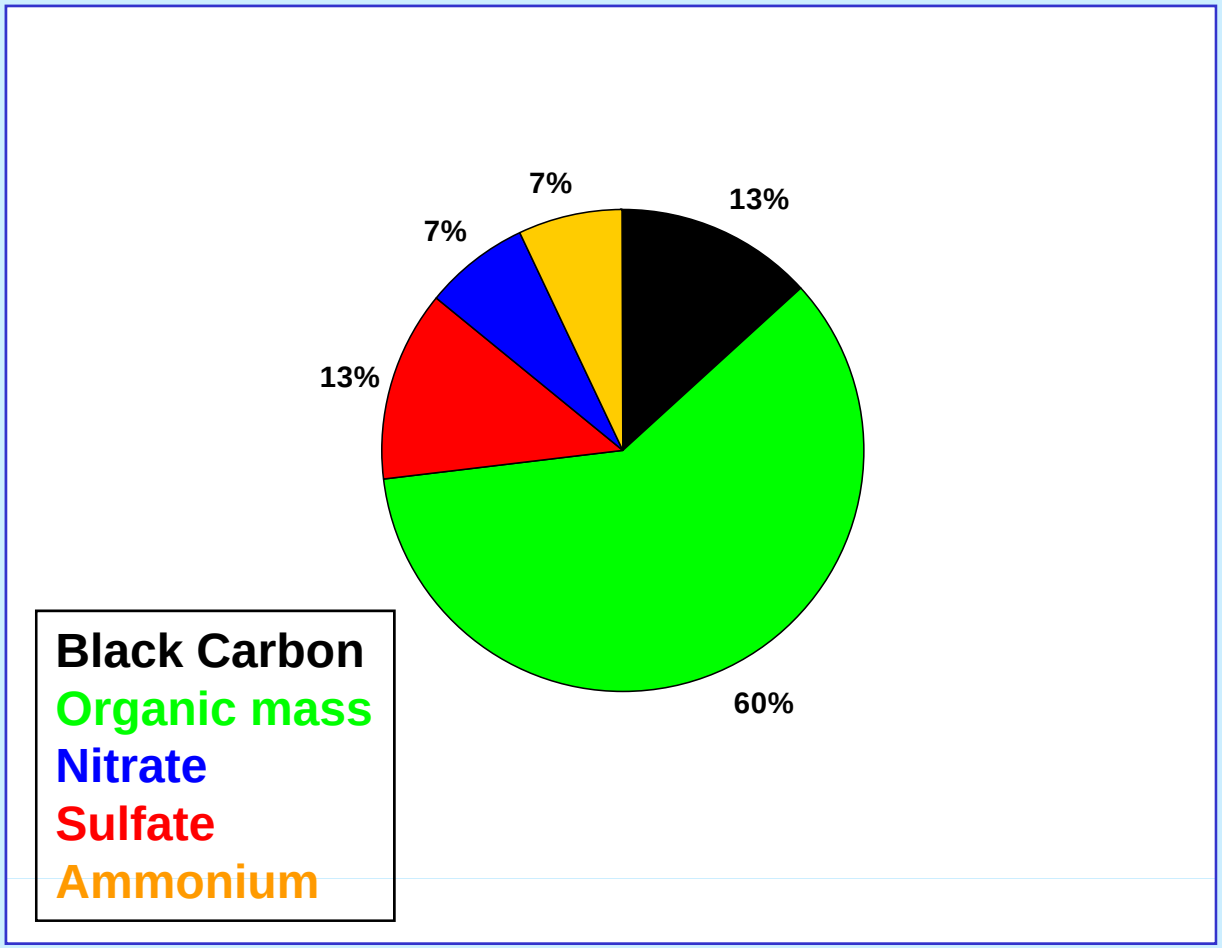
Organic Aerosols (OA) vs Inorganic Aerosols (IA)

Average Aerosol Composition in Zurich, January 2006

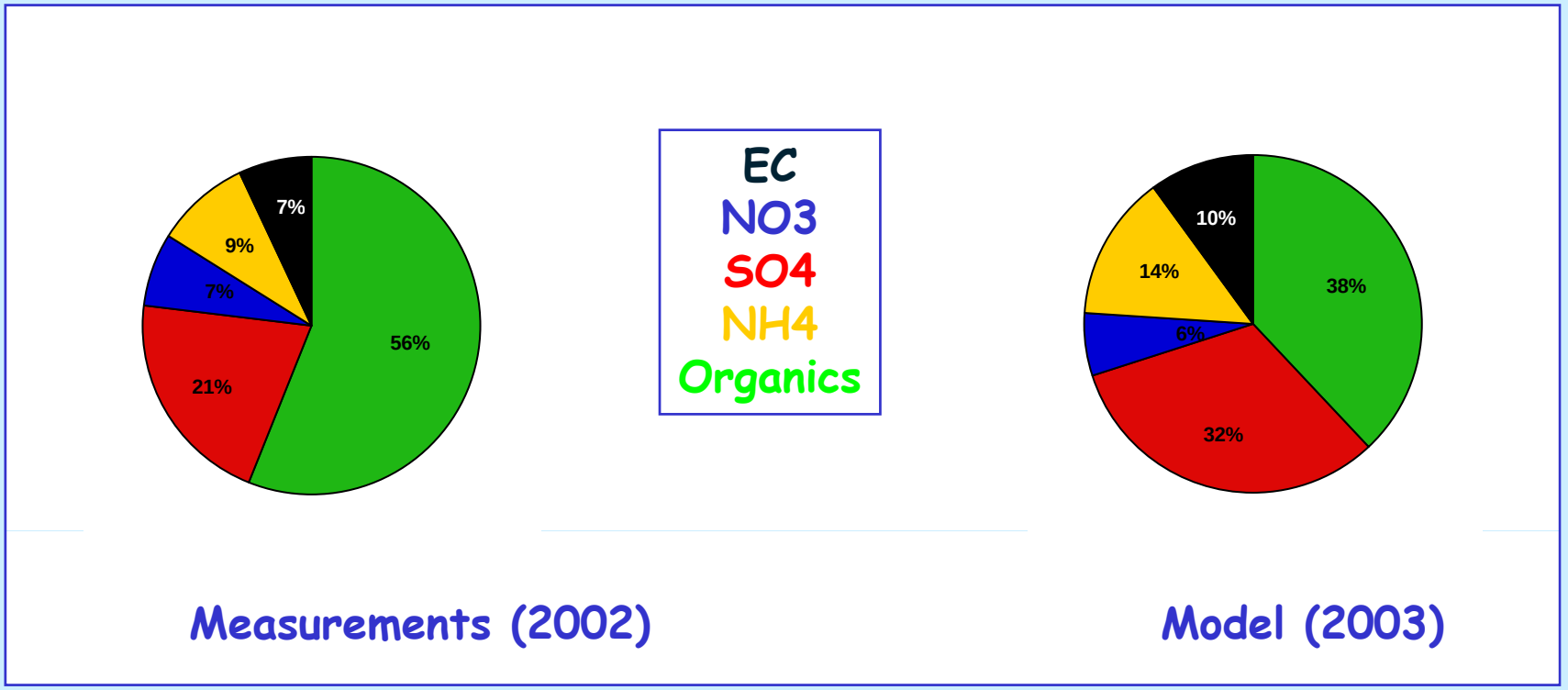


Organic Aerosols (OA) vs Inorganic Aerosols (IA)

Average Aerosol Composition in Zurich, June 2006



Comparison of model results with measurements
(Zurich, summer 2002, 2003)

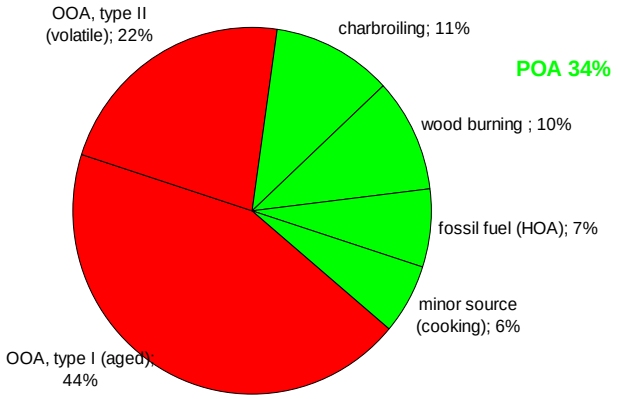


Main components are organic aerosols and sulfate in summer

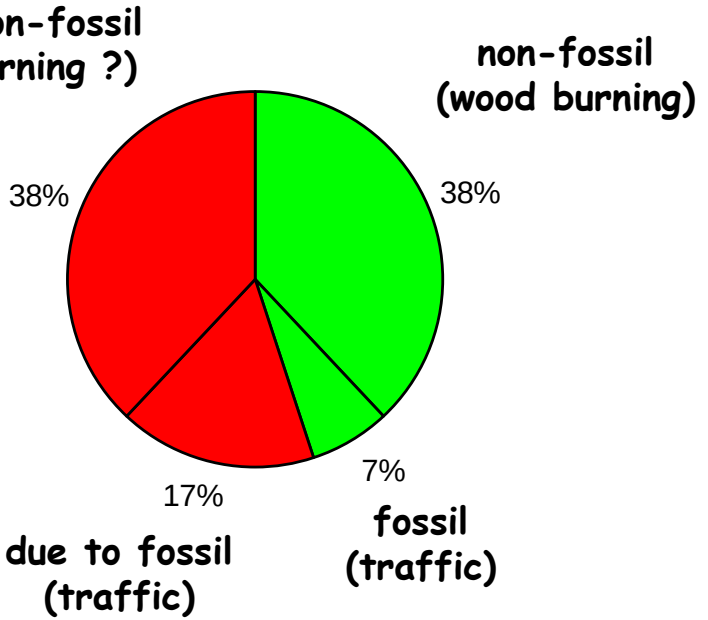
SOA vs. POA

Organic aerosol composition in Zurich

OOA (66%)



SOA POA



summer
(Lanz et al., ACP, 2007)

winter
(Lanz et al., submitted to ES&T)

Importance of biogenic emissions for SOA formation

biogenic species		*potential for SOA formation*
isoprene	(C_5H_8)	?
monoterpenes	($C_{10}H_{16}$)	high
sesquiterpenes	($C_{15}H_{24}$)	very high (but emission rates are not well known)