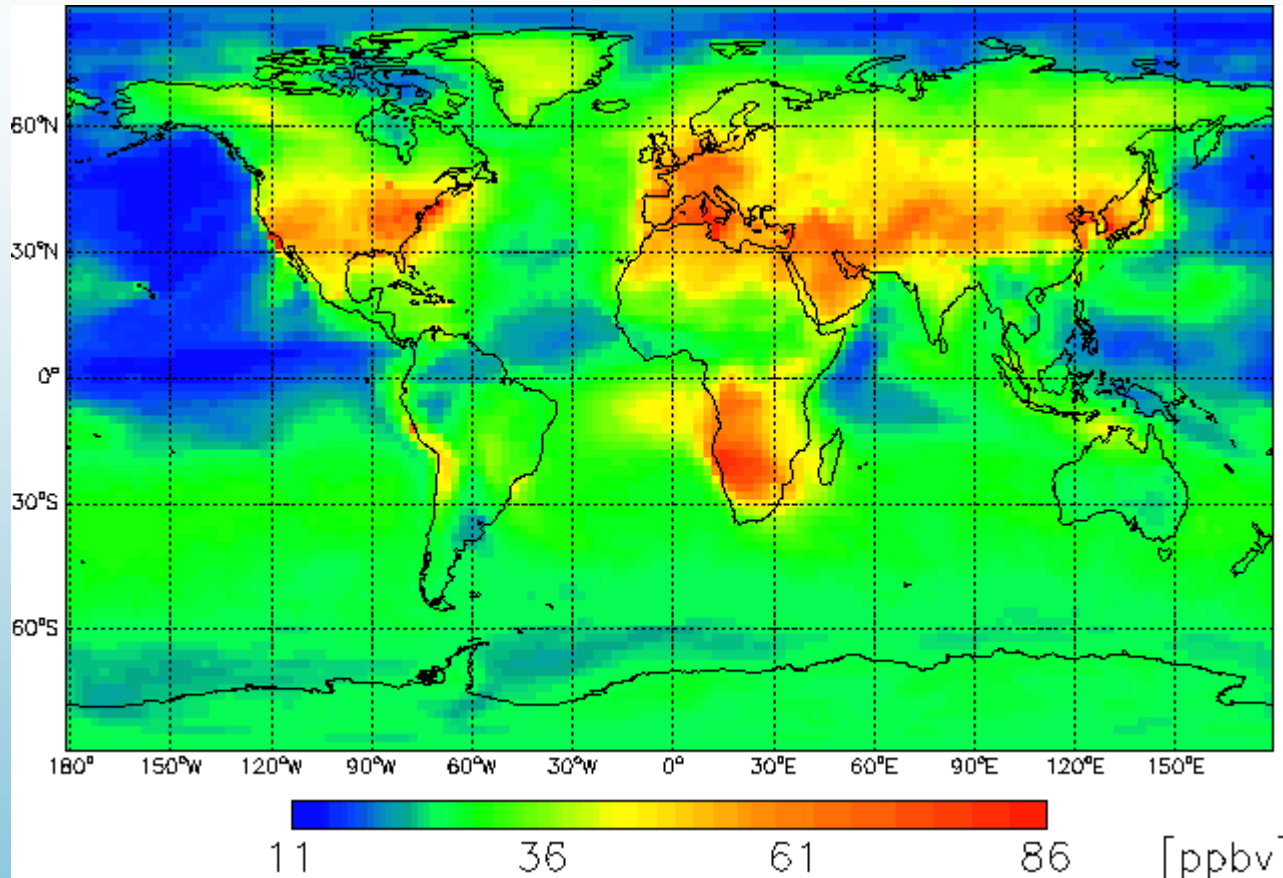


Coastal Ozone in Sea Breeze Circulation: Episode Analysis by mean of Aircraft Measurements and Mesoscale Modelling in Naples

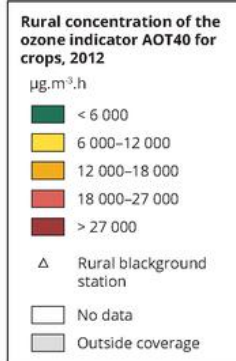
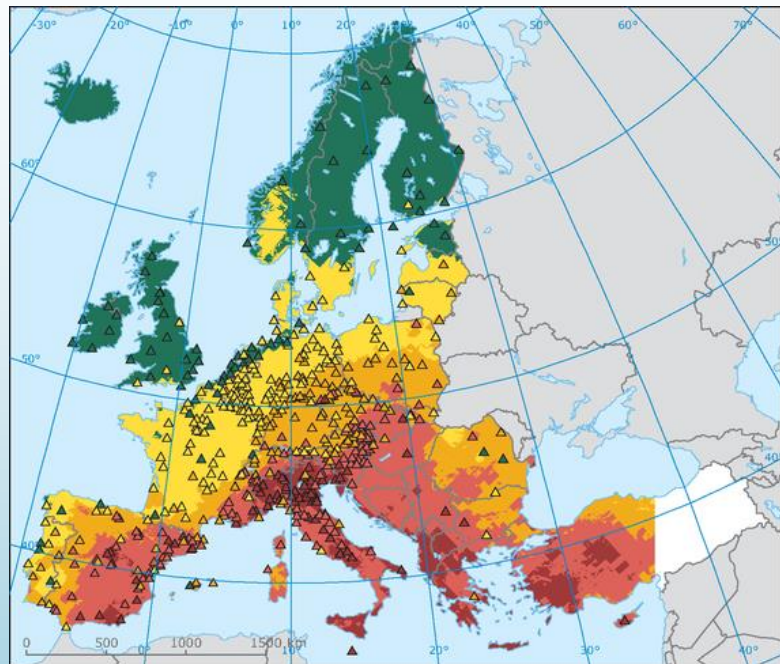
Sandro Finardi, Daniele Gasbarra, Giuseppe Calori, Alessio D'Allura, Beniamino Gioli, Giuseppe Agrillo, Pantaleone Carlucci, Luca Shindler, Vincenzo Magliulo, Giuseppe Brusasca, Rita Baraldi, Paolo Ciccioli



Monthly mean afternoon (1 to 4 PM) surface ozone concentrations calculated for July 2011 using Harvard GEOS-CHEM model.

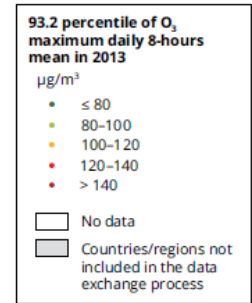
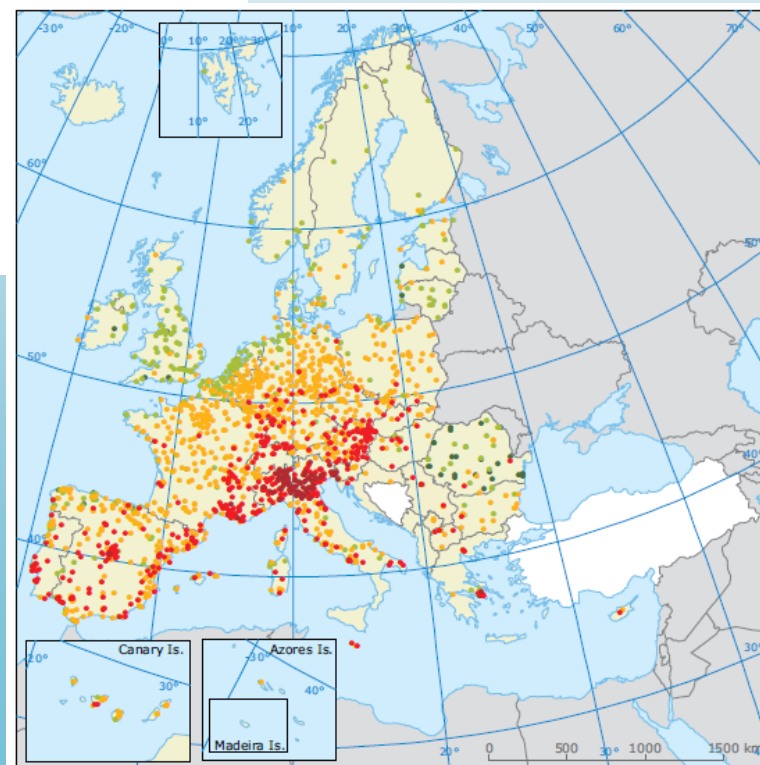
Mediterranean area vulnerability

EEA ozone indicators



AOT40 - 2012

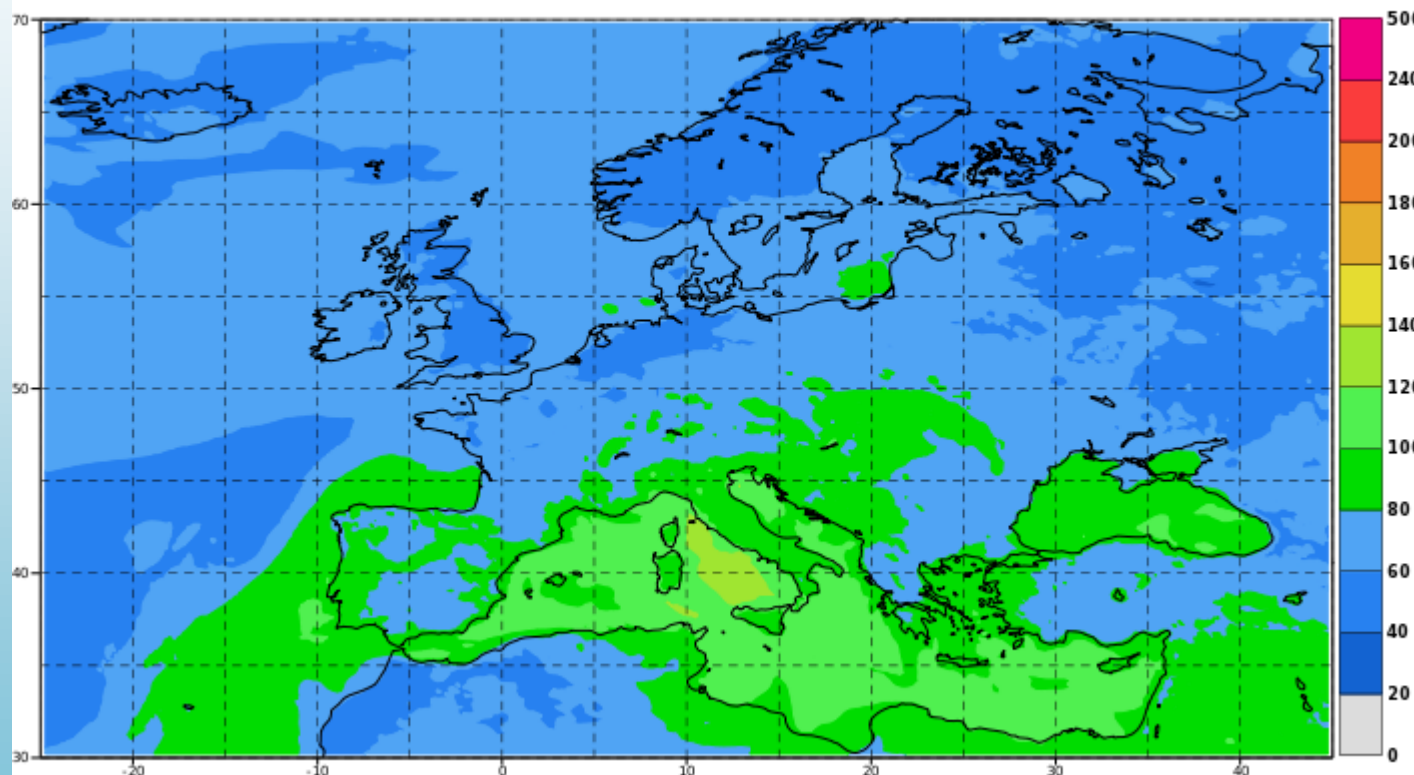
93.2 percentile of O₃ maximum daily 8-hours mean 2013



Ozone accumulation over the Mediterranean sea

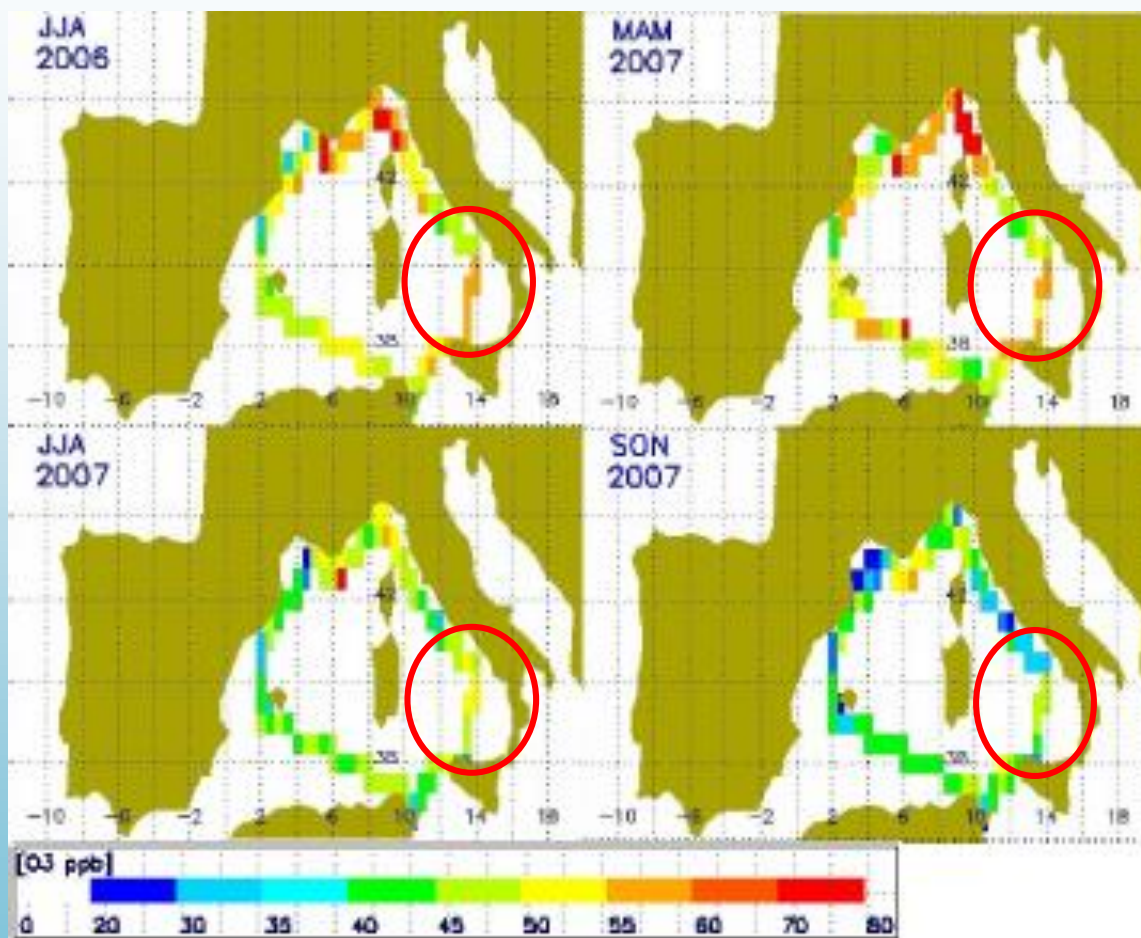
Model simulations

Saturday 03 September 2016 00UTC MACC-RAQ Forecast D+0 VT: Saturday 03 September 2016
 Model: ENSEMBLE Median (N=7) Height level: Surface Parameter: Ozone Daily Mean [$\mu\text{g}/\text{m}^3$]



Ozone accumulation over the Mediterranean sea

Shipborne observations



Velchev et al., 2011: Ozone over the Western Mediterranean Sea – results from two years of shipborne measurements, Atmos. Chem. Phys.



Naples (> 3 millions inhabitants):

- one of the largest conurbation on the EU shores of the Med. sea.
- highest population density in Italy (exceeding 10000 inh/km² in some municipalities).



Project *AriaSaNa* (www.ariasana.org)

Surface and airborne measurements

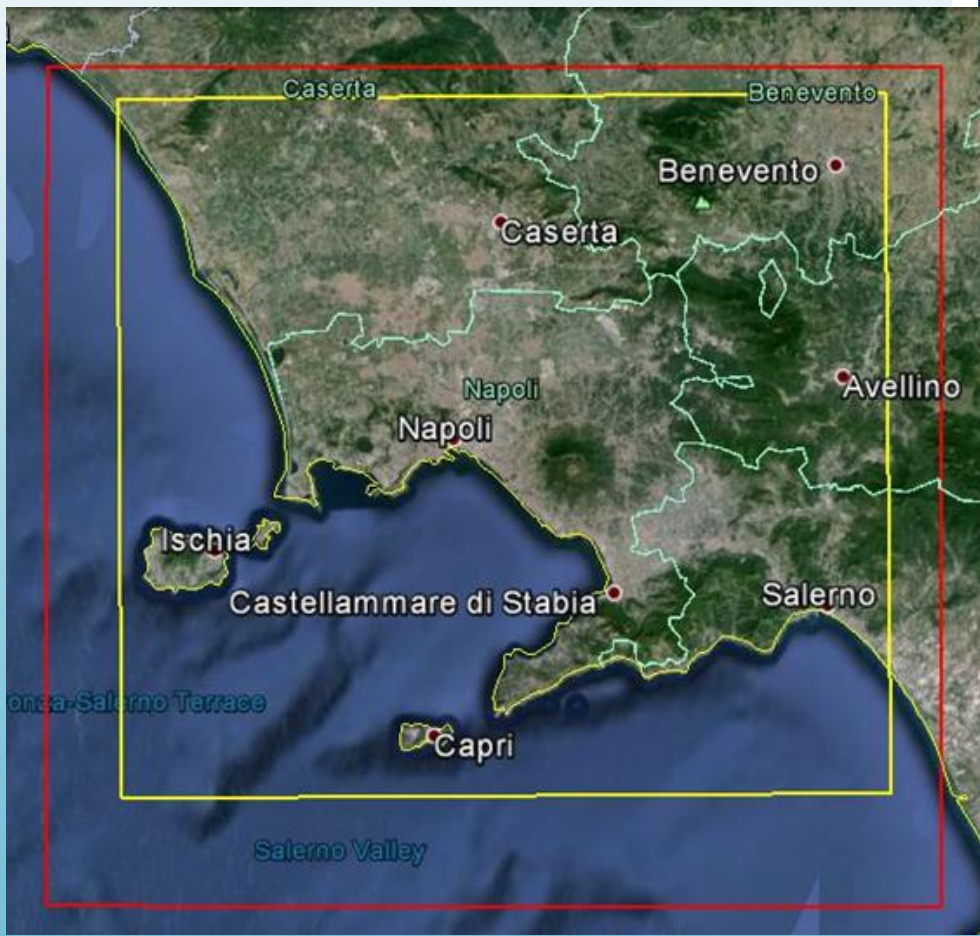
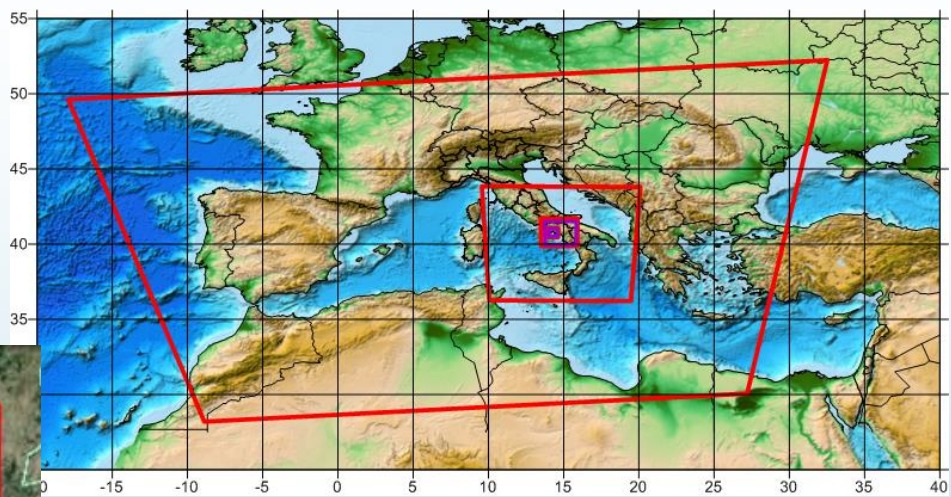
Local scale meteorological and air quality modelling



cruise flight speed: 45 m s⁻¹
(160 km/h)

- measuring:**
- 3D-wind; T_{air}; CO₂, H₂O (50 Hz);
 - CH₄ (10 Hz);
 - O₃ (2 sec);
 - PM (8 classes) (6 sec);
 - NO, NO₂ (20 sec);

WRF V3.5.1
Grid spacing: 45, 9, 3, 1 km
Vertical grid: 41 levs (up to 50 hPa)
BCs: GFS
Land Cover: CORINE 2006



FARM
Grid spacing: 4, 1 km
Vertical grid: 16 levs (up to 10 km)
Emission inventory: ISPRA2010
 downscaled at municipal level for
 Campania Region
BCs: air quality forecast from QualeAria

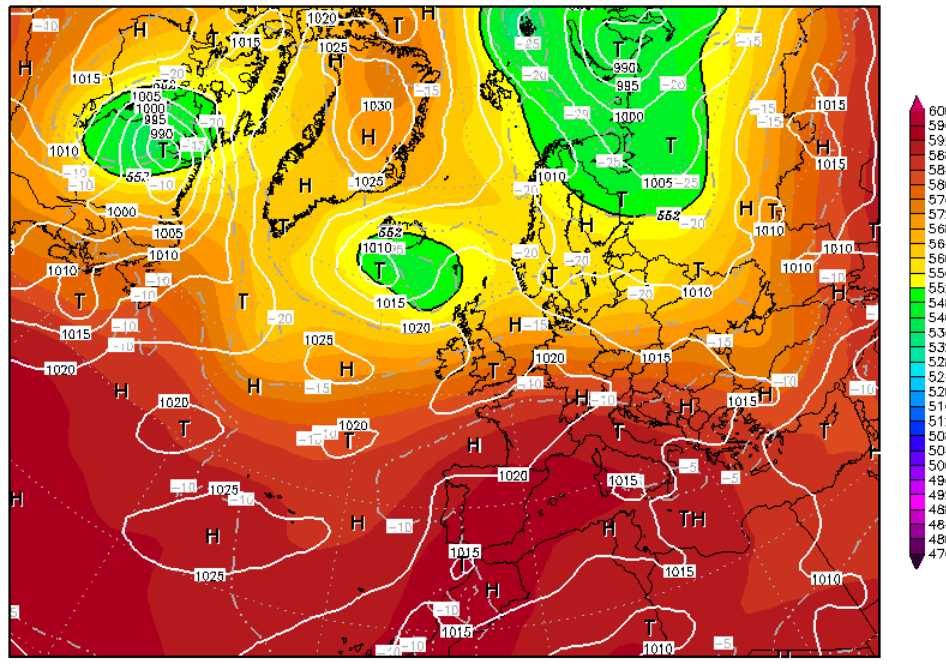
- SAPRC99** gas phase chemical mechanism implemented using KPP
- aero3** (CMAQ) aerosol module

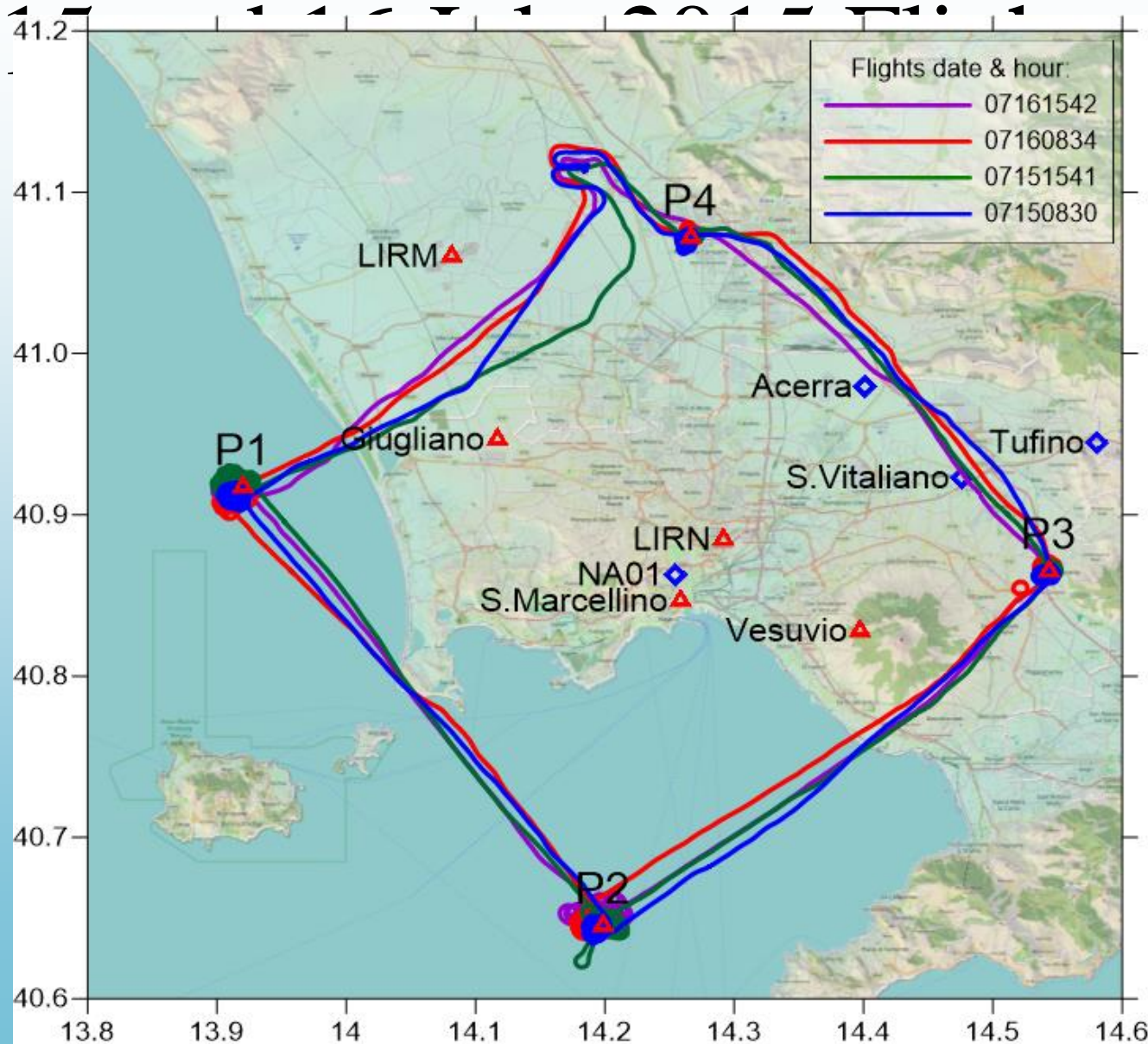
Summer 2015 ozone episode

Persisting high pressure

15/07/2015 00:00 UTC

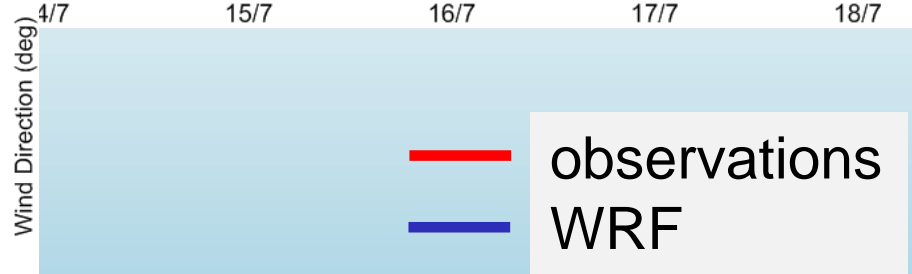
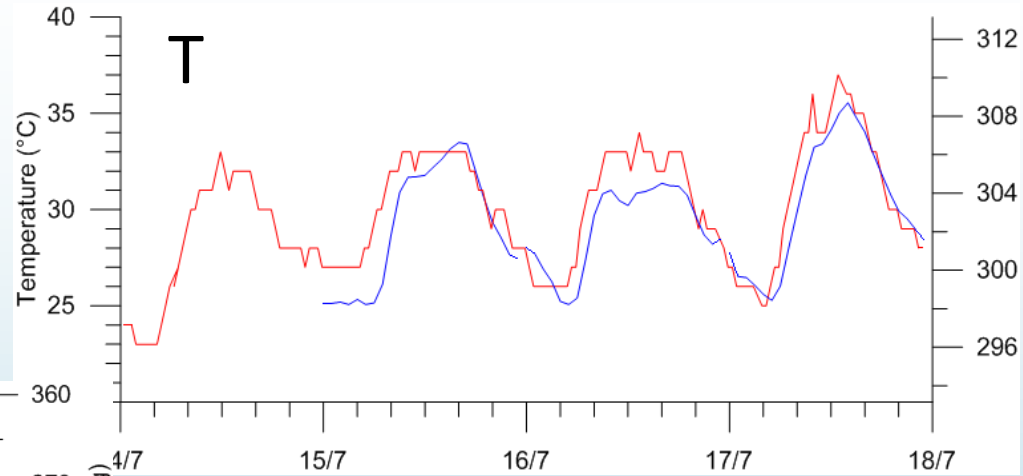
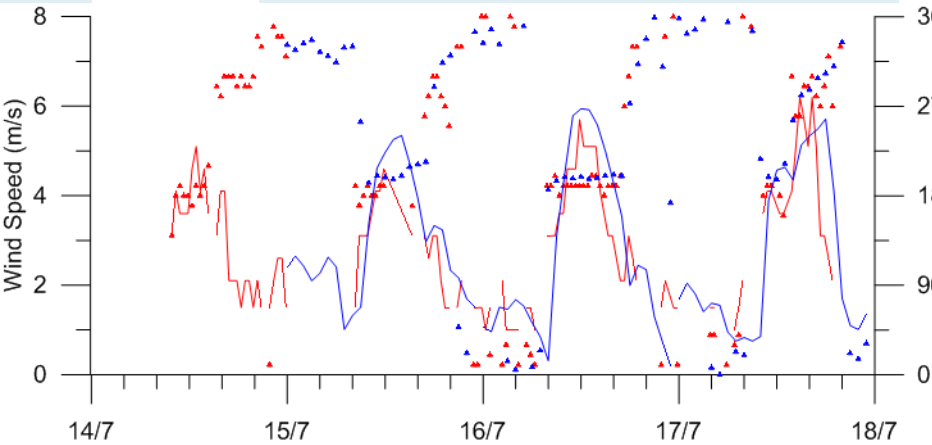
Init : Wed,15JUL2015 00Z Valid: Wed,15JUL2015 00Z
 500 hPa Geopot.(gpm), T (C) und Bodendr. (hPa)





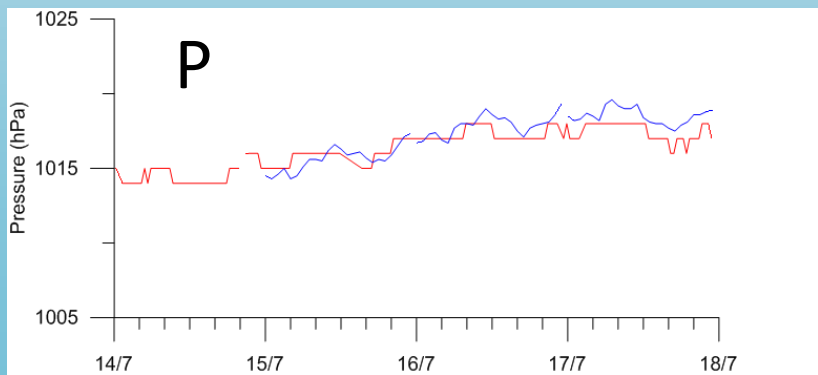
Napoli Capodichino

Wind

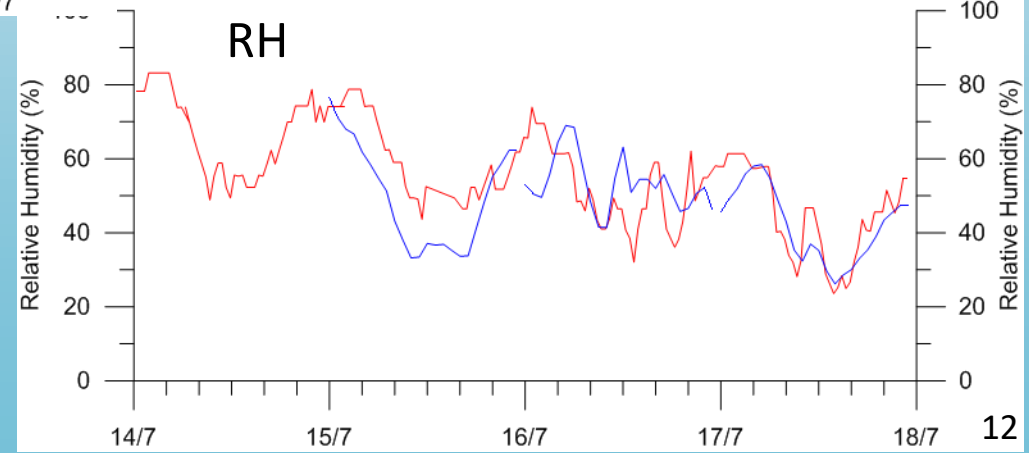


— observations
— WRF

P



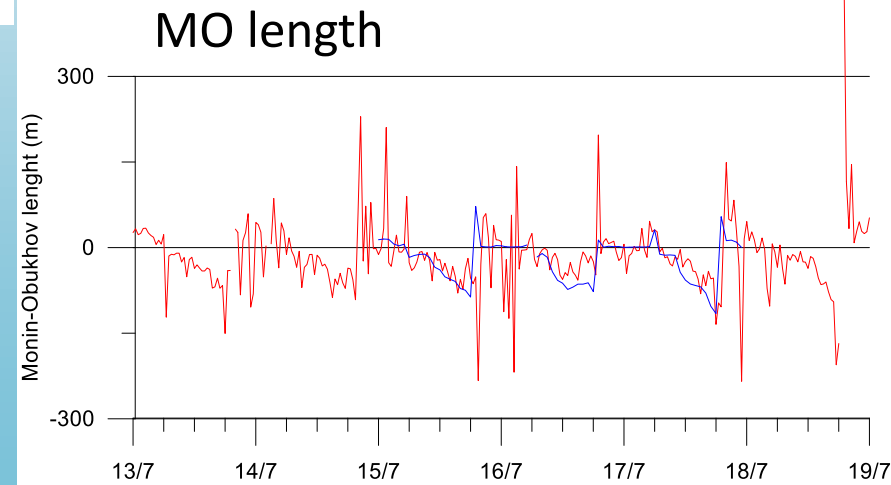
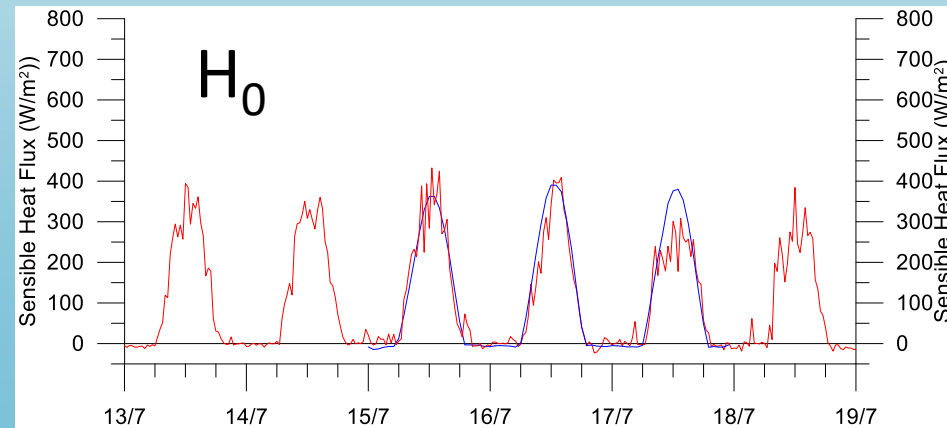
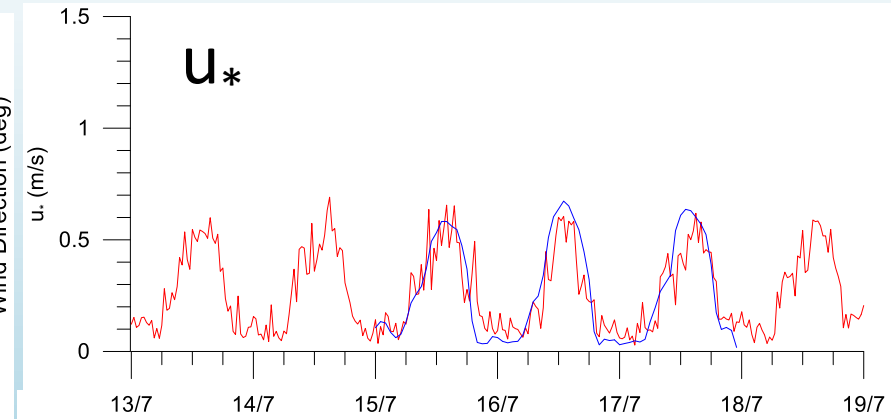
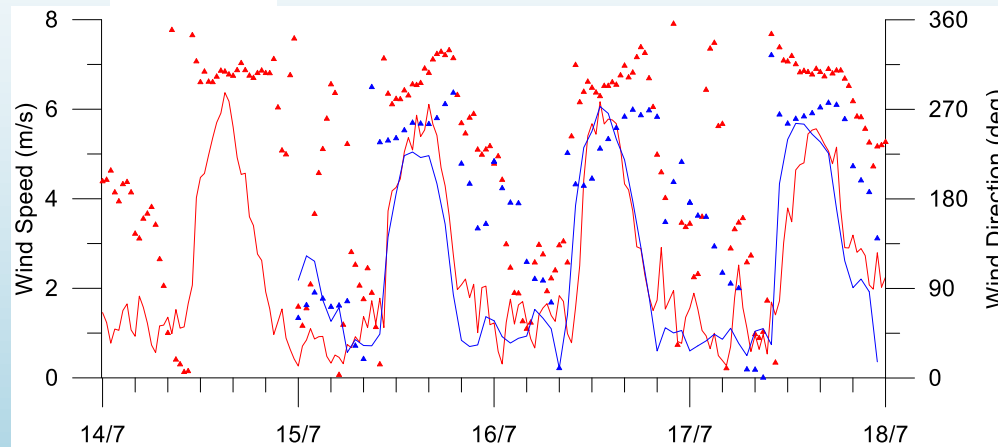
RH



Giugliano (rural)

— Observations
— WRF

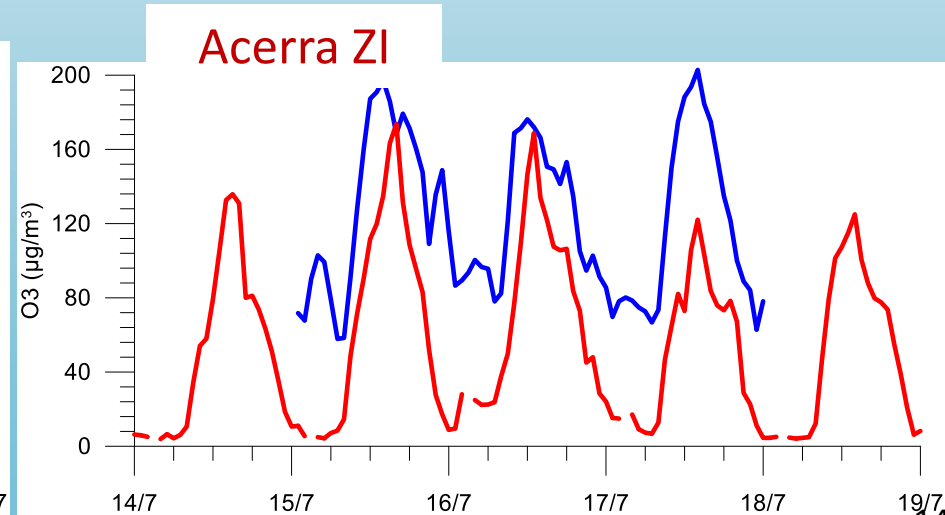
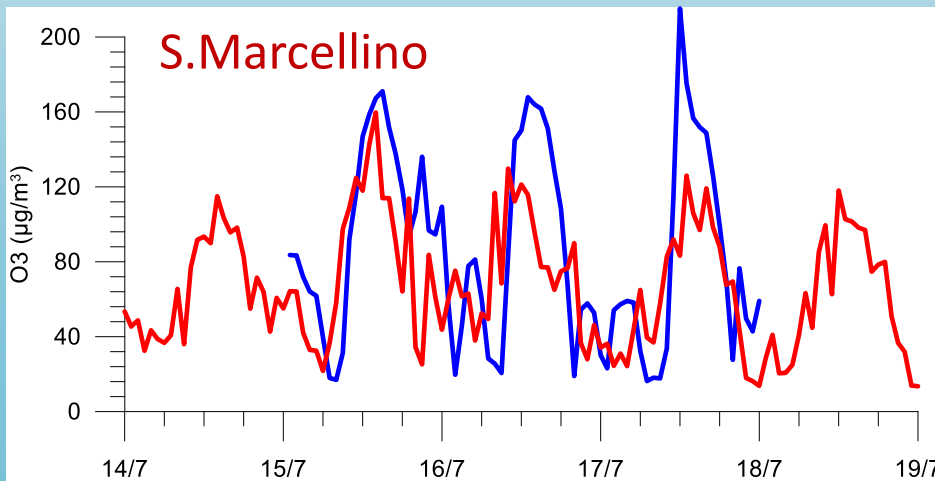
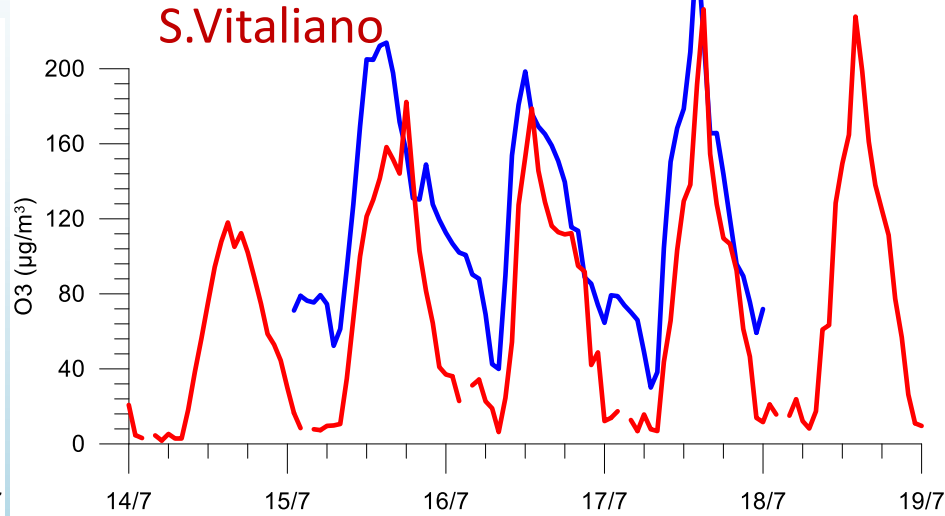
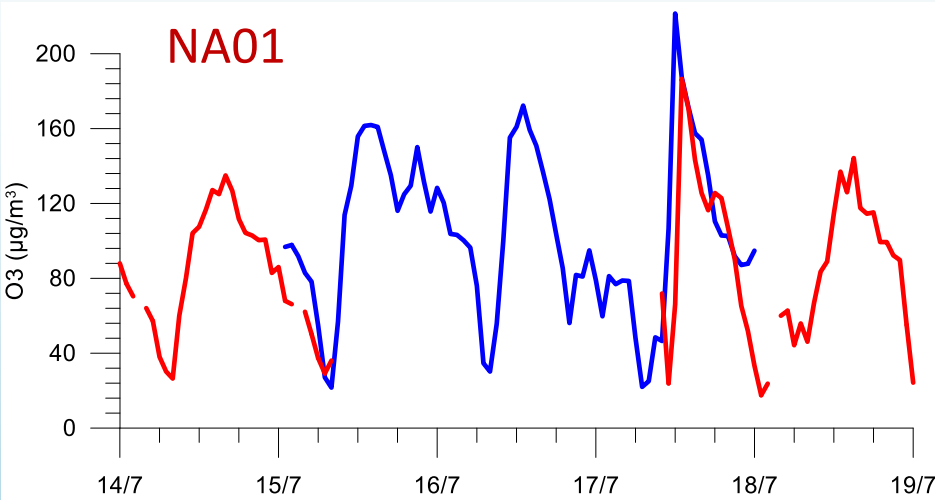
Wind



— observations
— FARM

Napoli city

Inland area

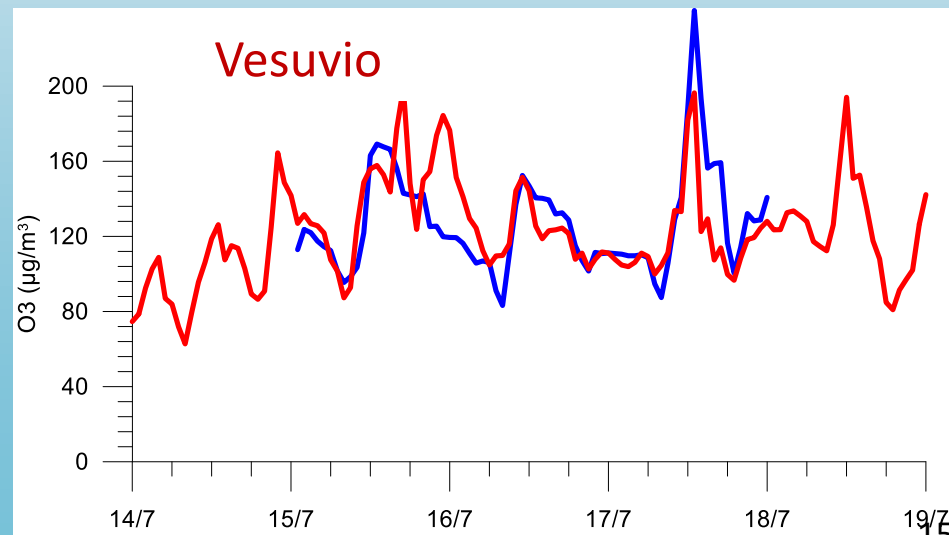
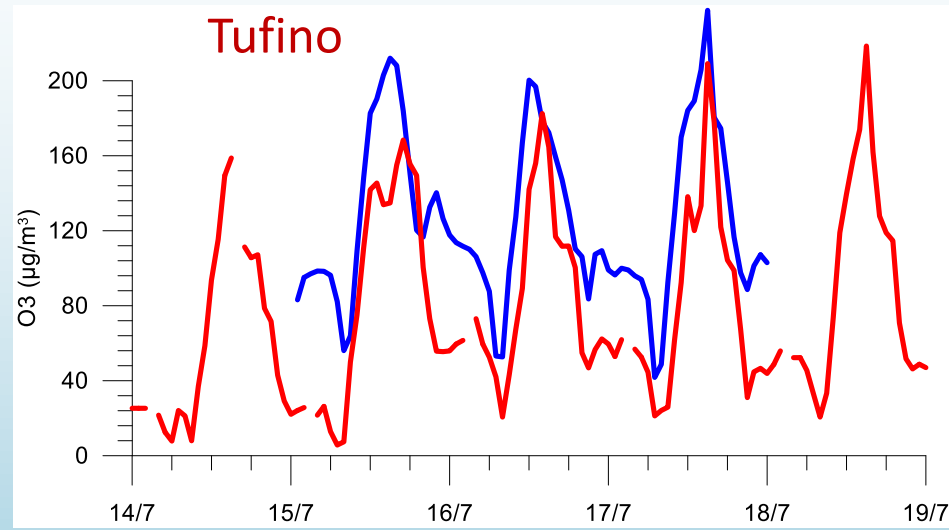


O3 concentration



— observations
— FARM

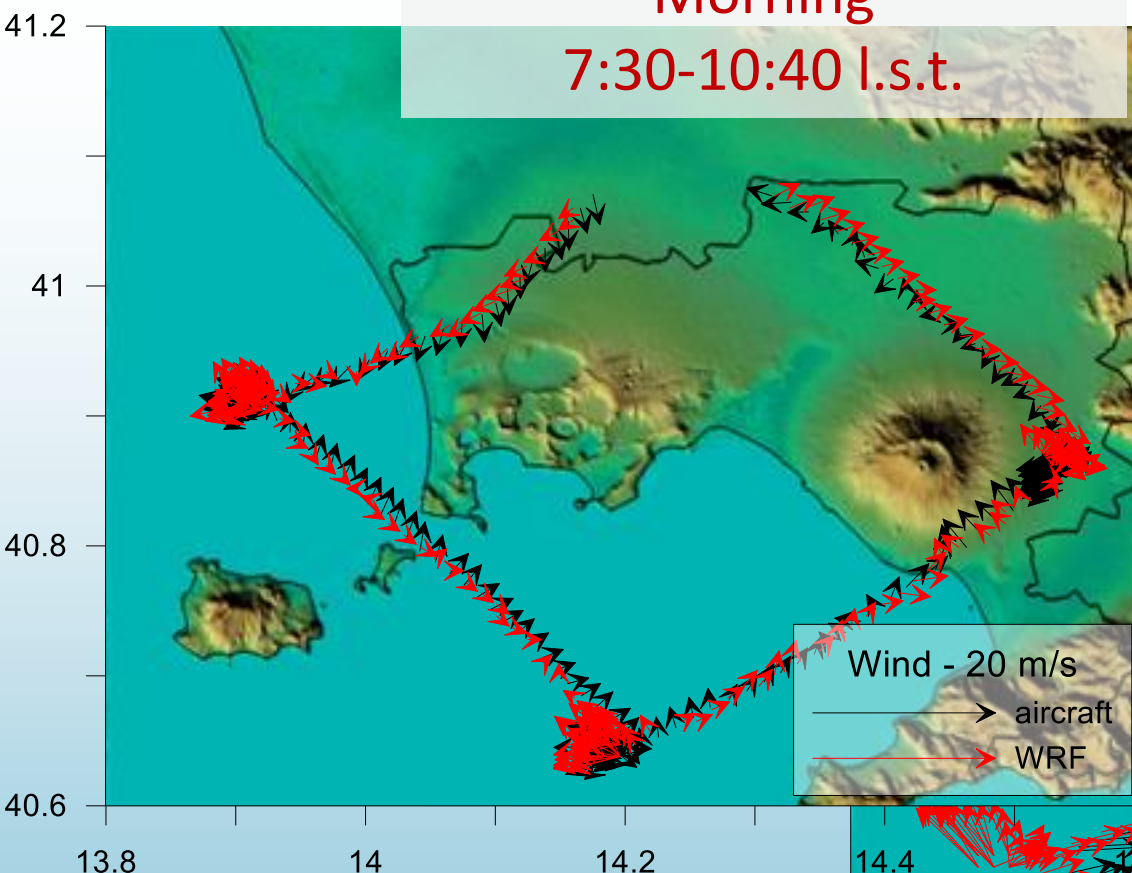
Inland area



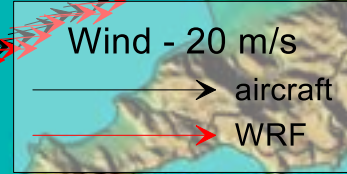
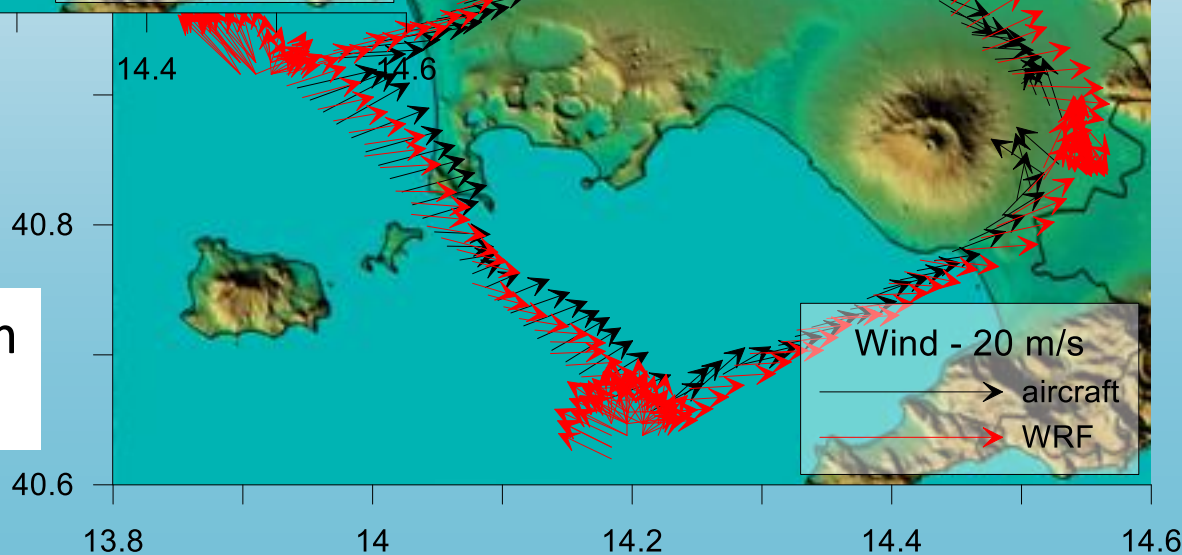
Morning
7:30-10:40 l.s.t.

15/07/2015

Afternoon
14:43-17:39 l.s.t.



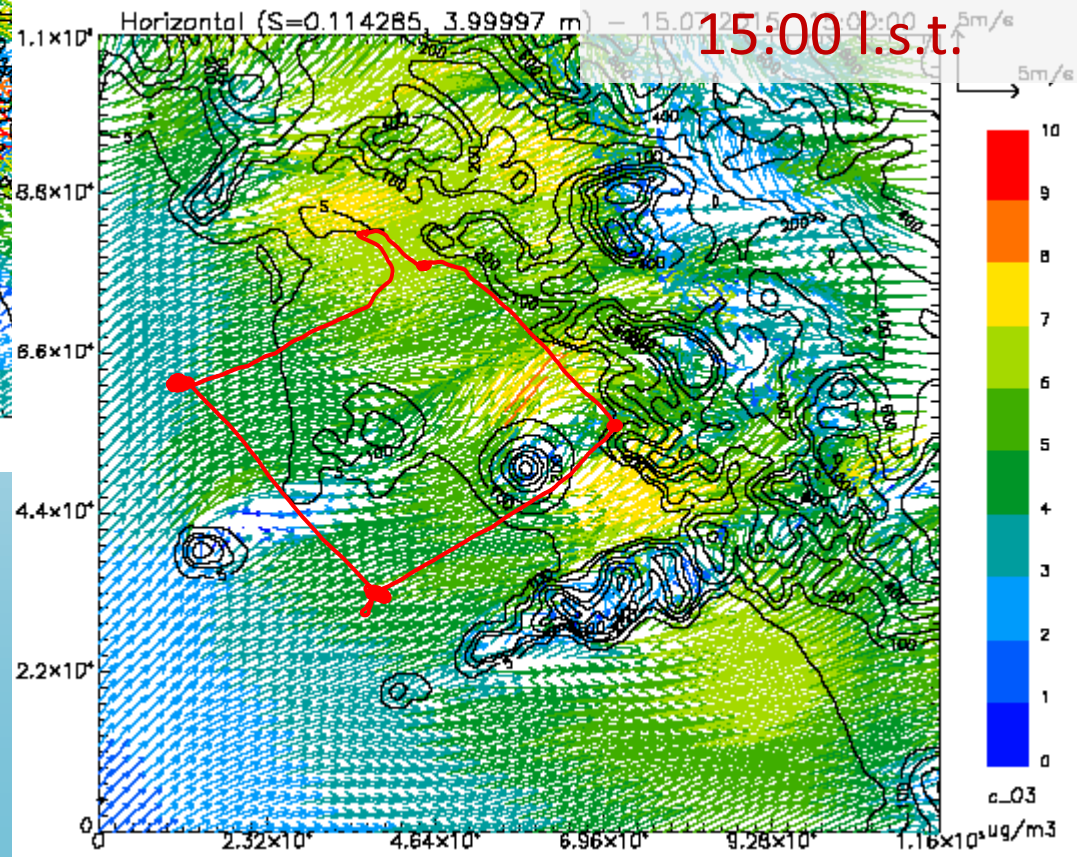
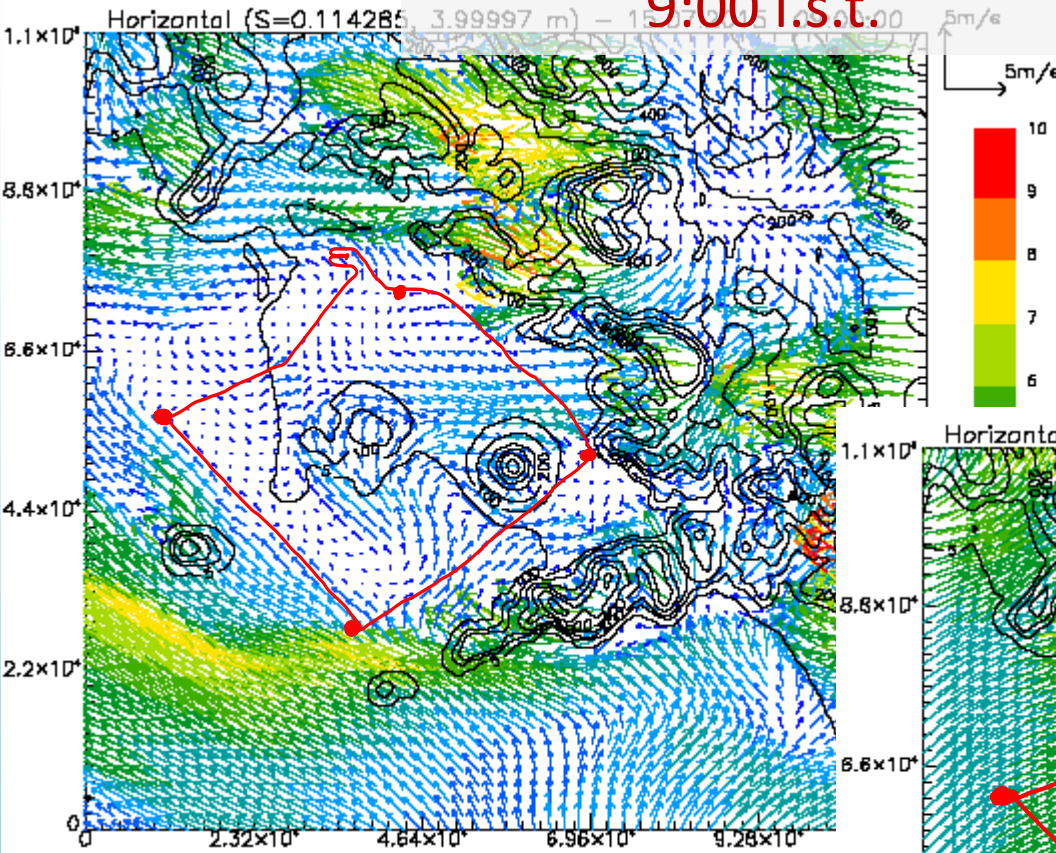
horizontal legs length ~ 30 km
average height ~ 150 m a.g.l.



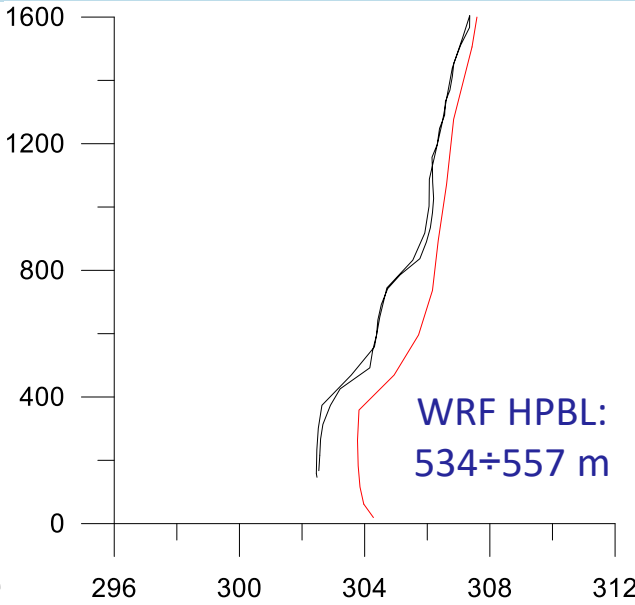
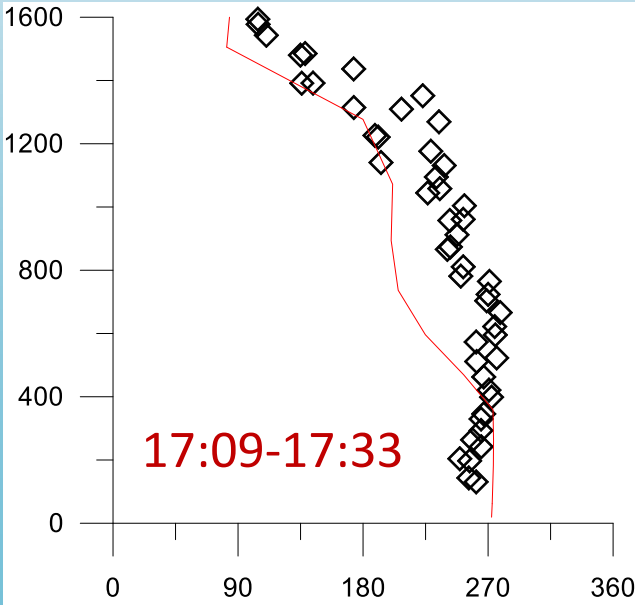
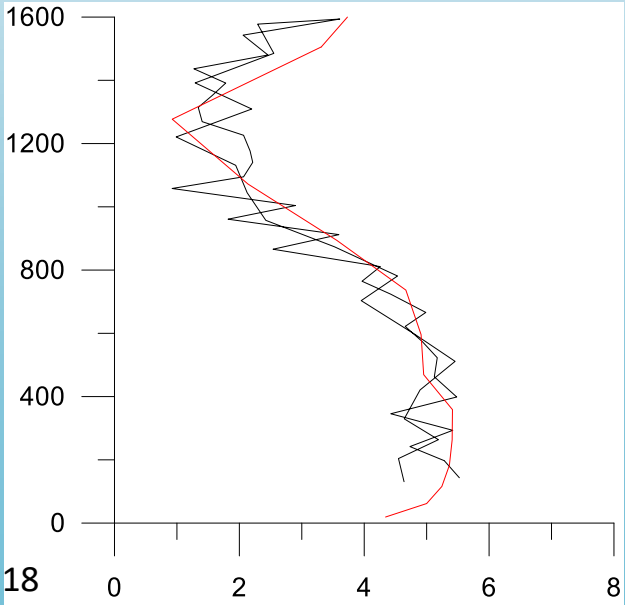
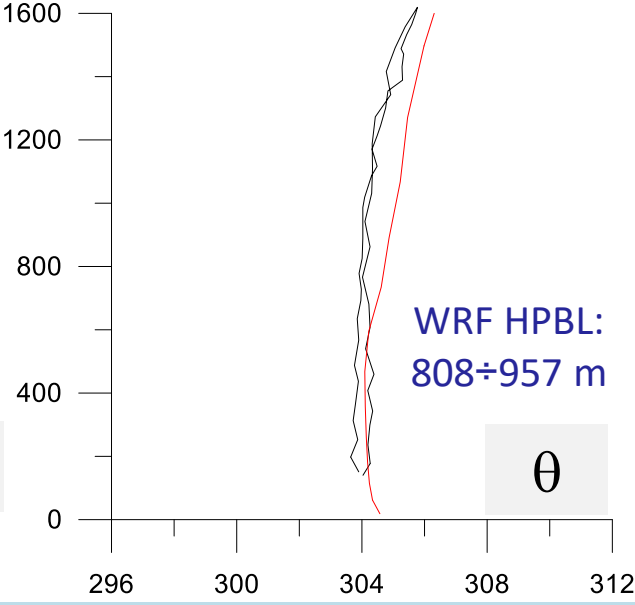
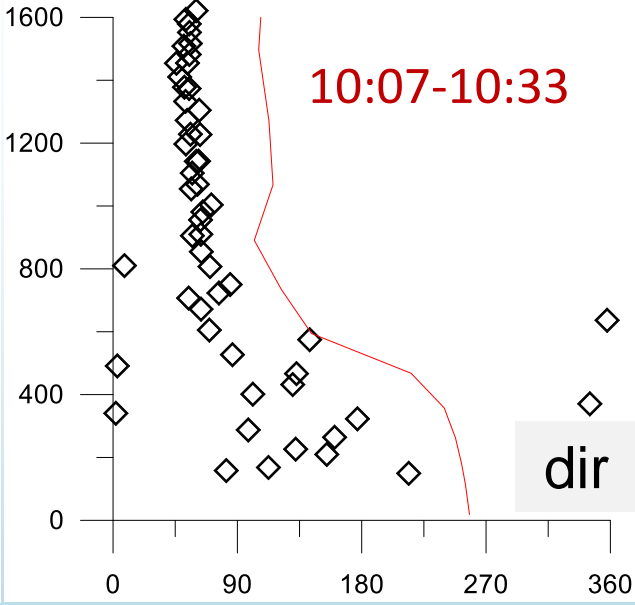
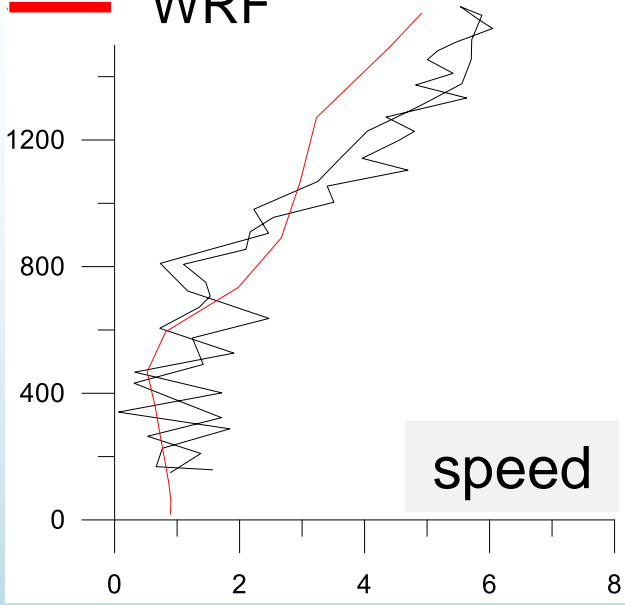
Morning
9:00 l.s.t.

15/07/2015

Afternoon
15:00 l.s.t.



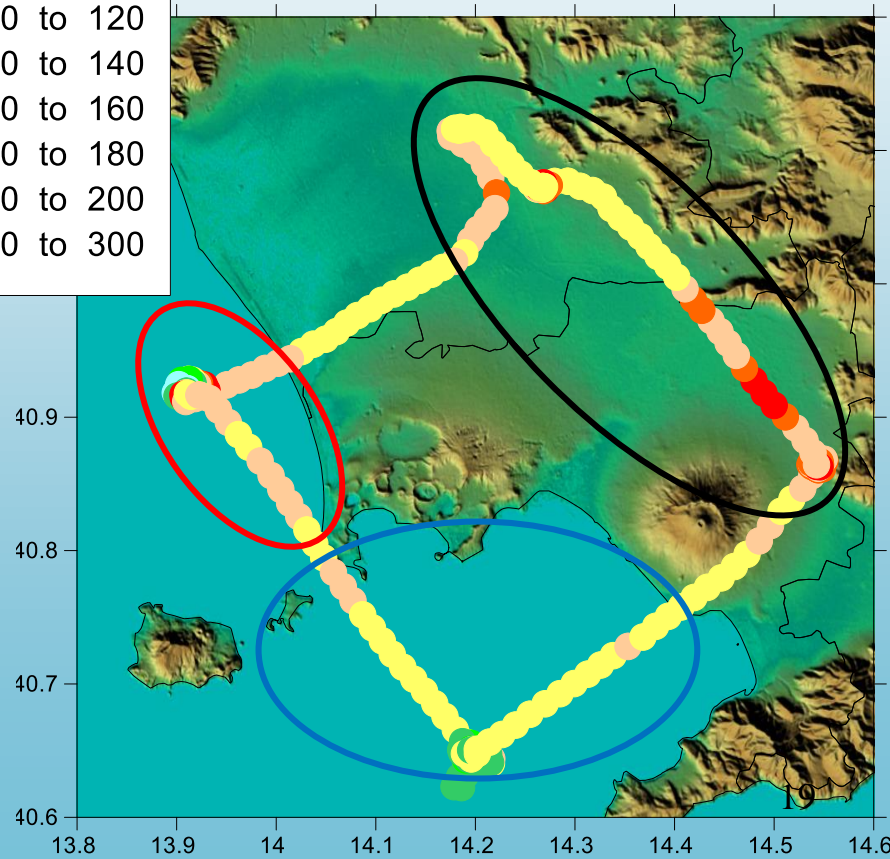
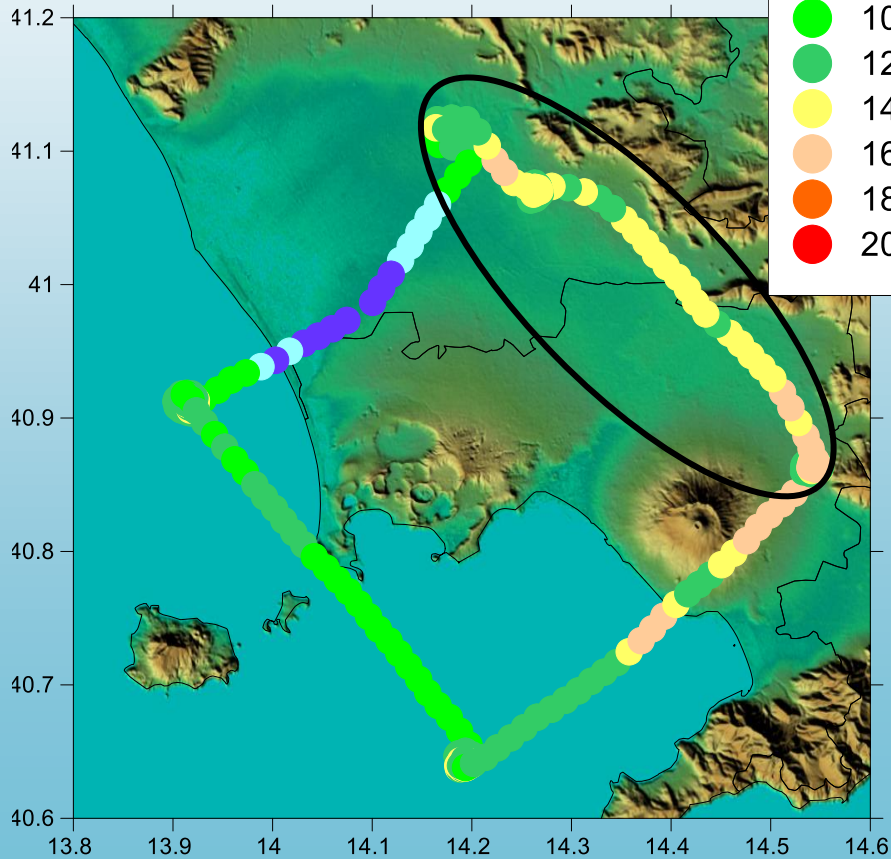
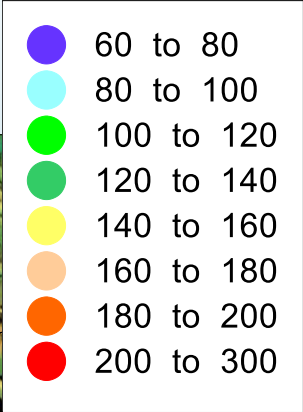
— Aircraft
 — WRF



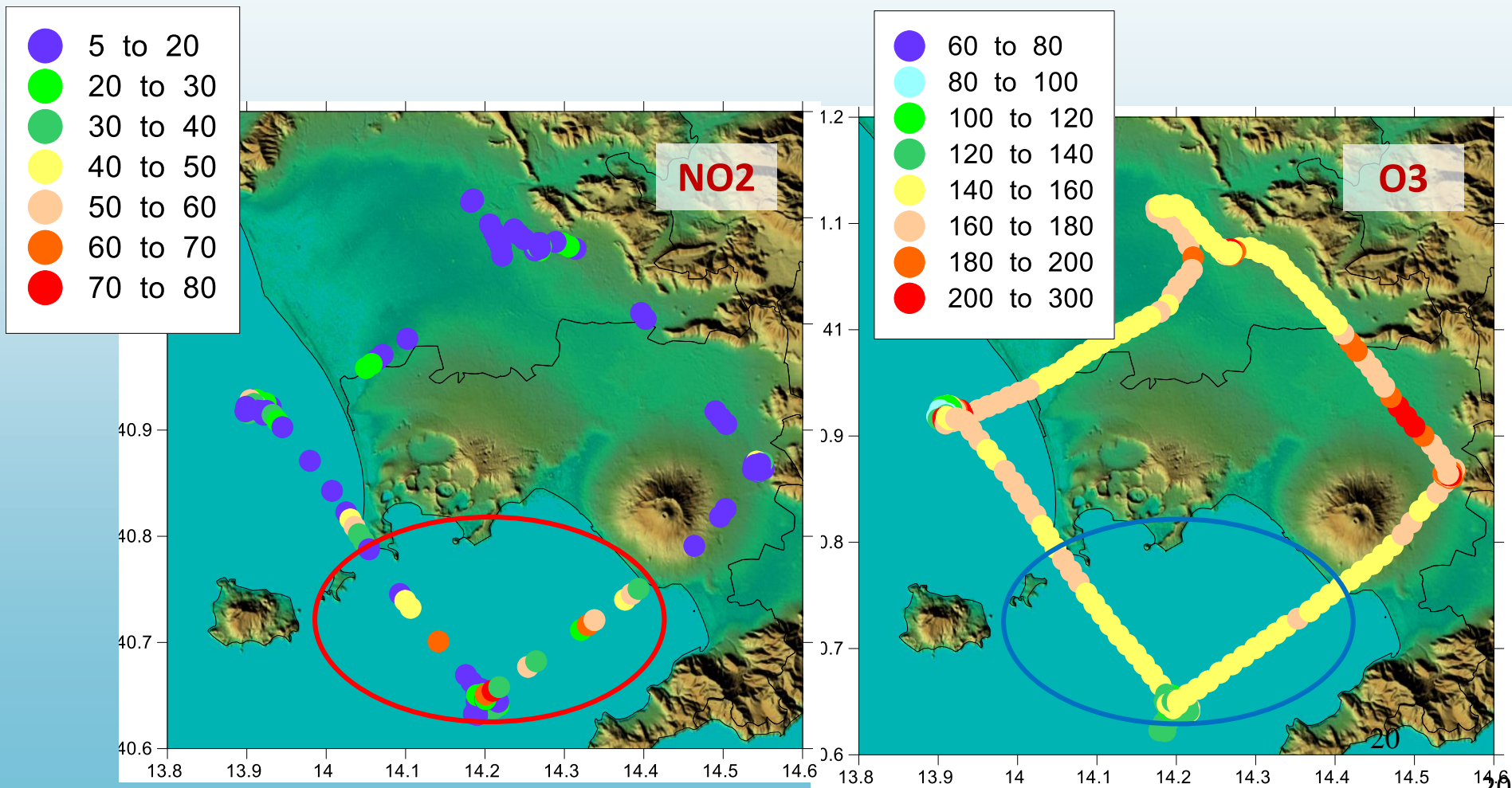
15/07/2015 - O3 concentrations

morning

afternoon



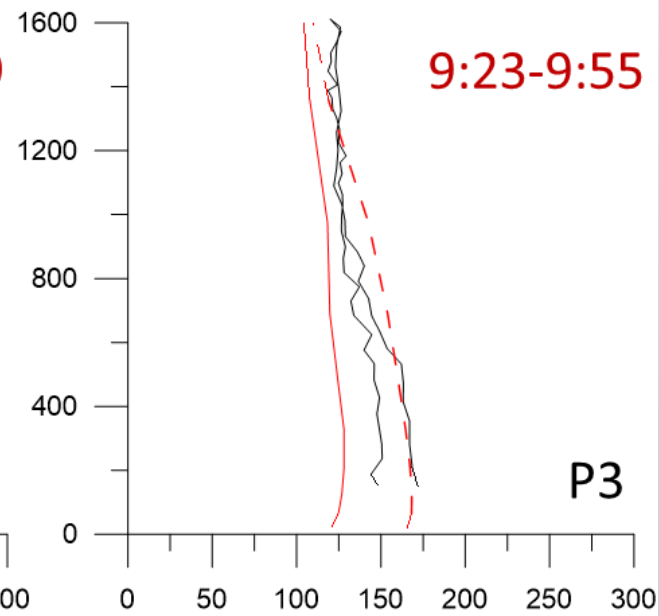
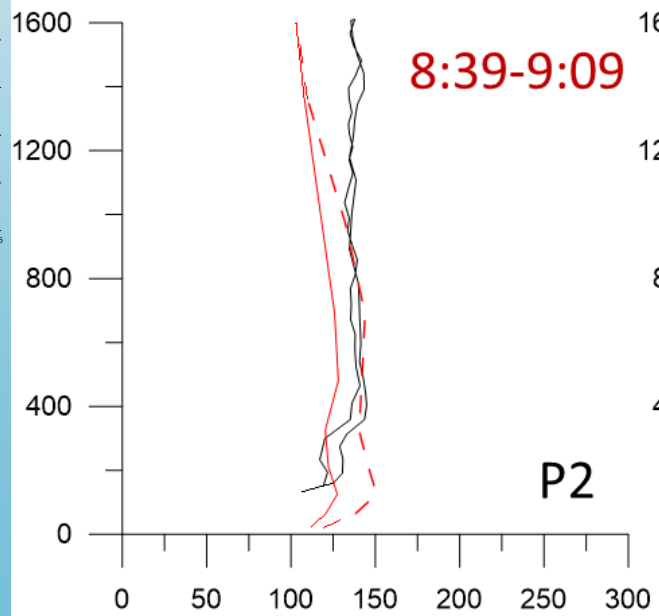
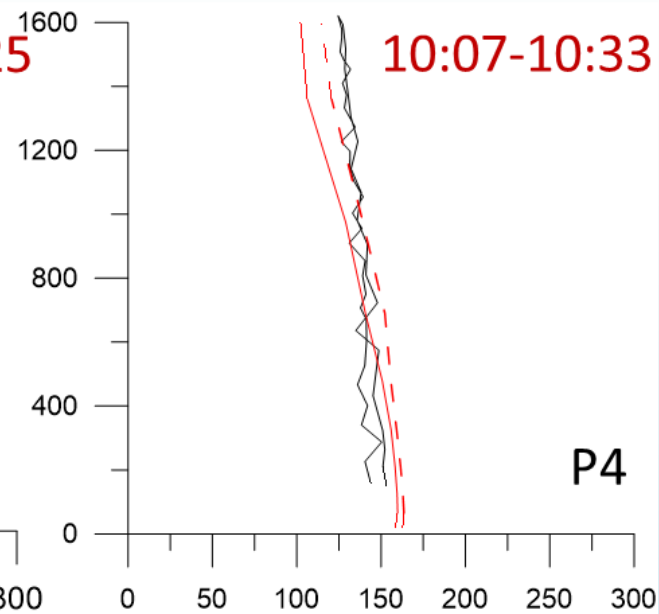
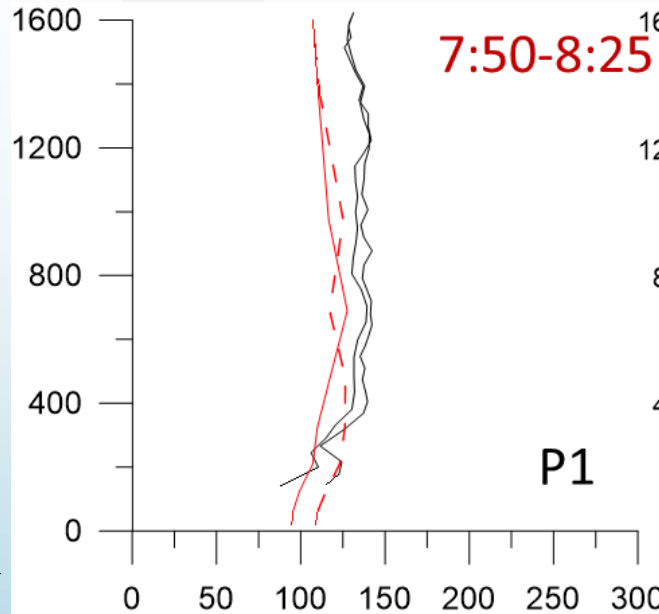
15/07/2015 afternoon O3 concentrations



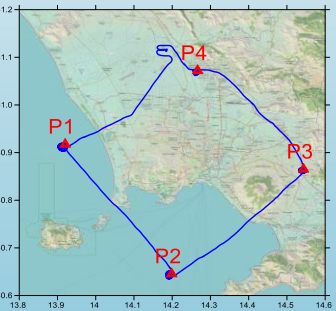
O3

sea

land

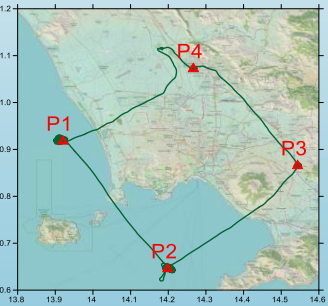


15/07/2015



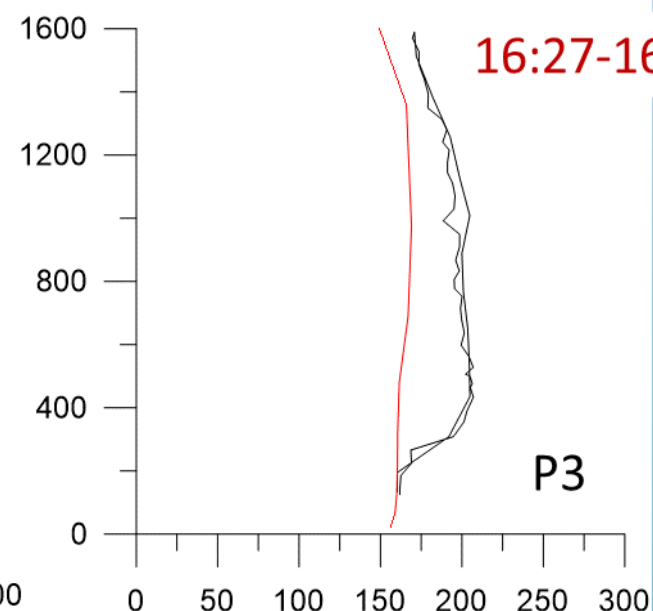
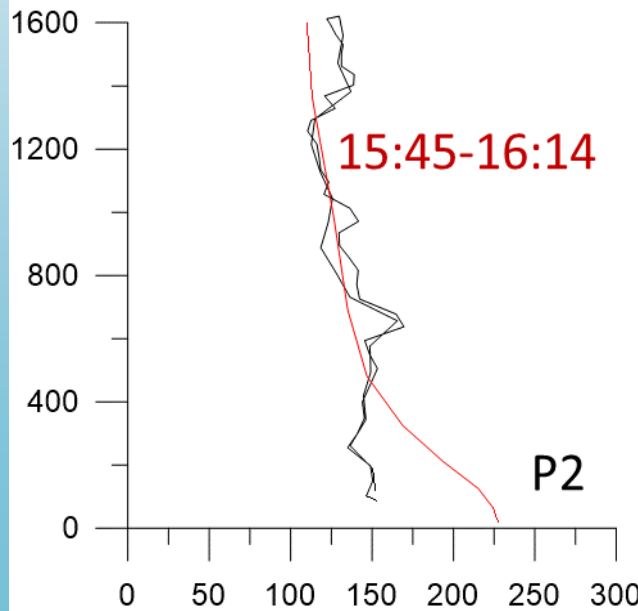
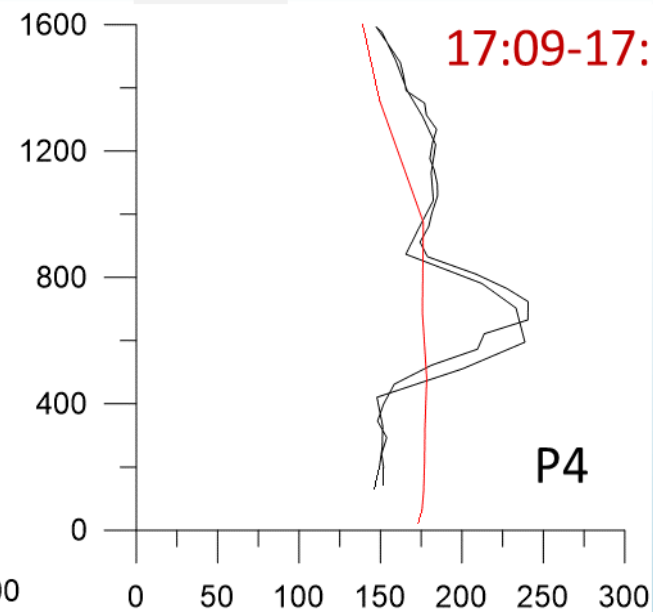
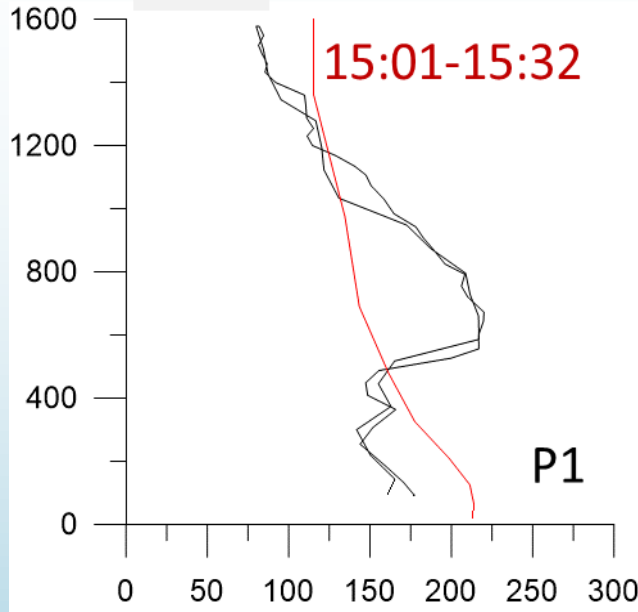
03

15/07/2015



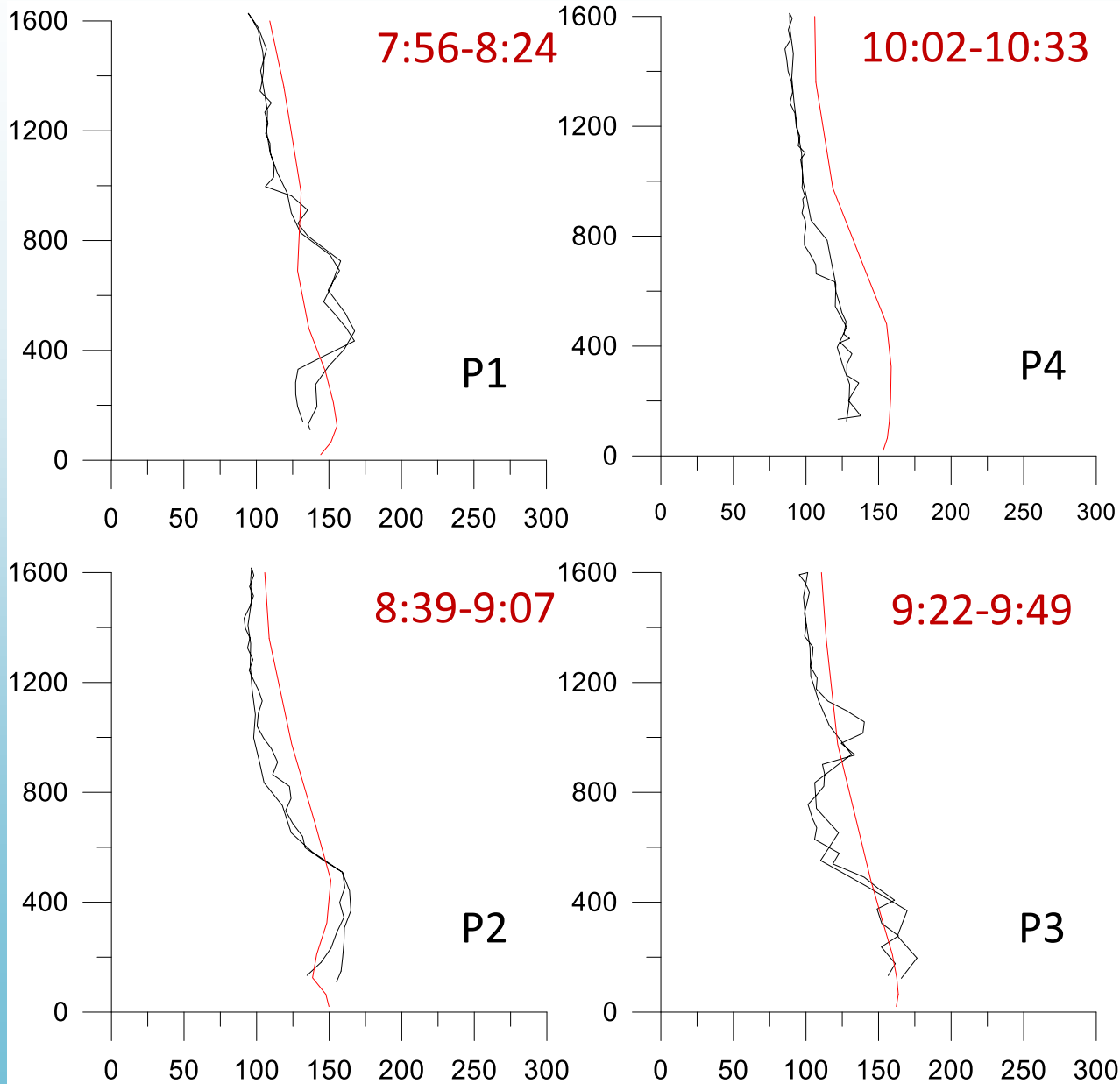
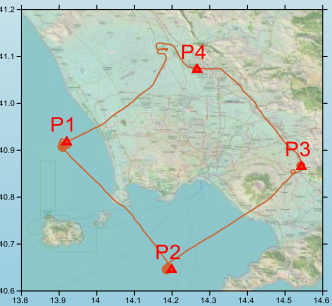
sea

land



03

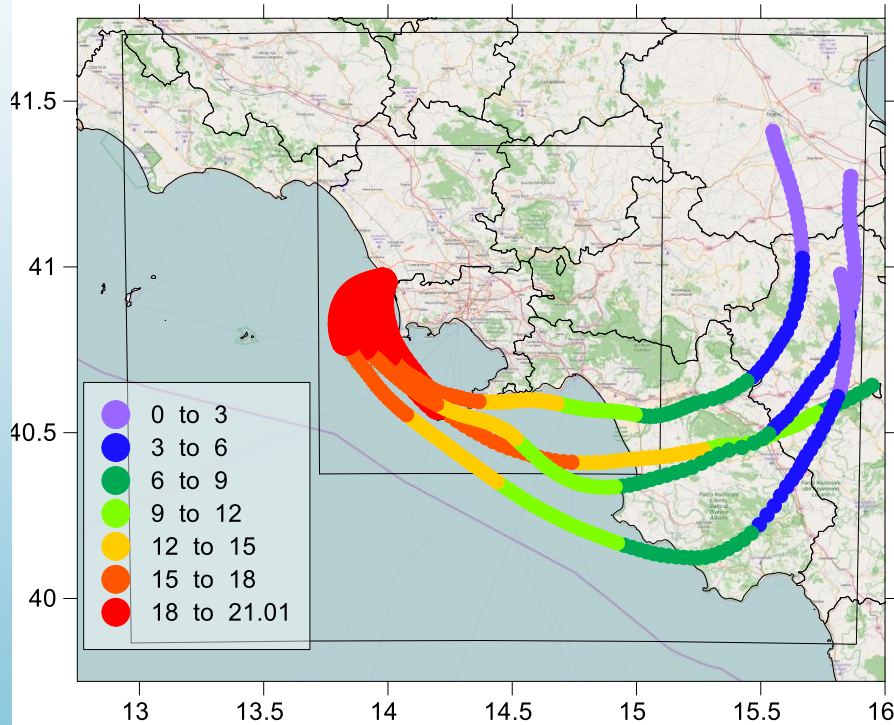
16/07/2015



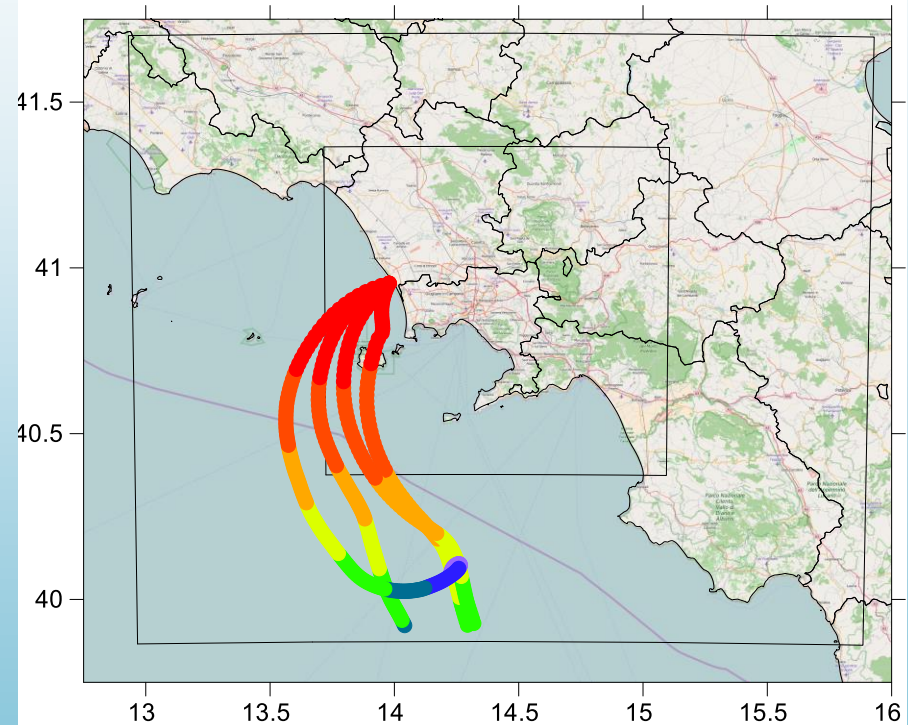
WRF back-trajectories

arriving at P1 location from 350 to 735 m a.s.l.

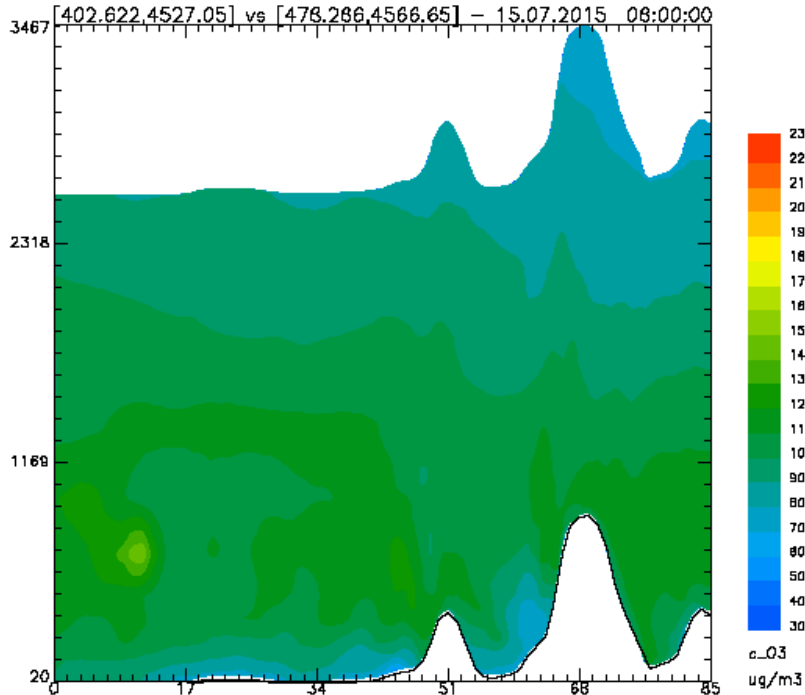
Backtrajectories 15/07/2015 15:00



Backtrajectories 16/07/2015 15:00

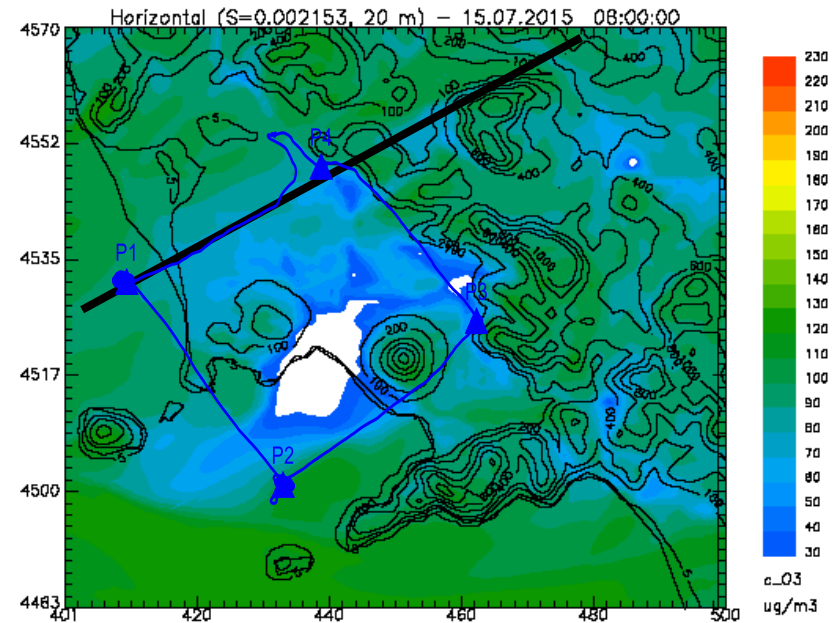


AMSU 1.10.0 15/December/2015 15:34
 File: C:\Users\fnard\andrea\AriaSaNa\Vol...aere\quasar\simulazioni\hires\conc.g4.20150715.nc
 Model FARM Simulation time: 15.07.2015 08:00:00 Variable: c_03
 Area range [0,20] [85.4005,3466,88] Top of domain 0
 Global data range: [7.56398,161.127] Actual: [51.7281,148.528]

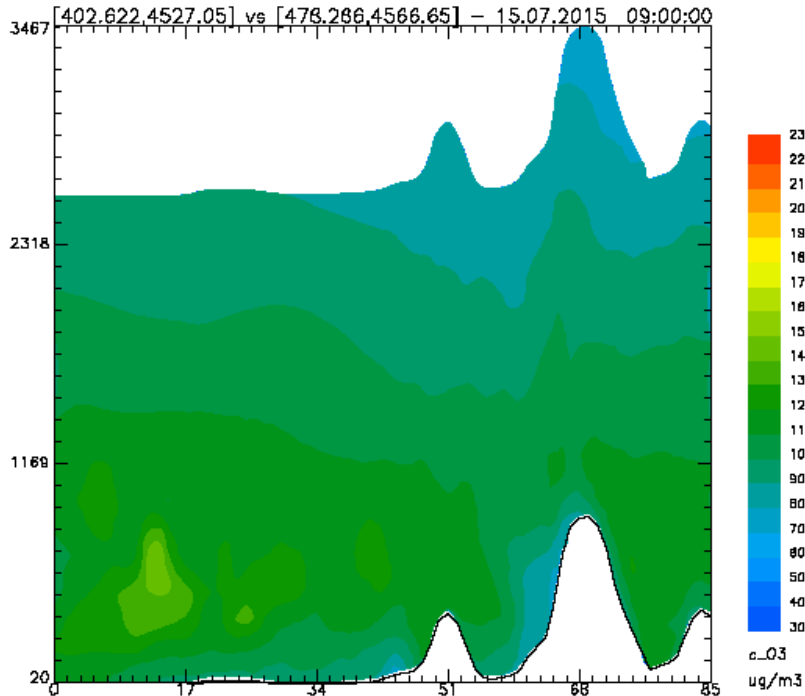


15/07/2015 08:00

AMSU 1.10.0 15/December/2015 15:30
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 Model FARM Simulation time: 15.07.2015 08:00:00 Variable: c_03
 Area range [400.5,4482.5] [499.5,4569.5] Top of domain 0
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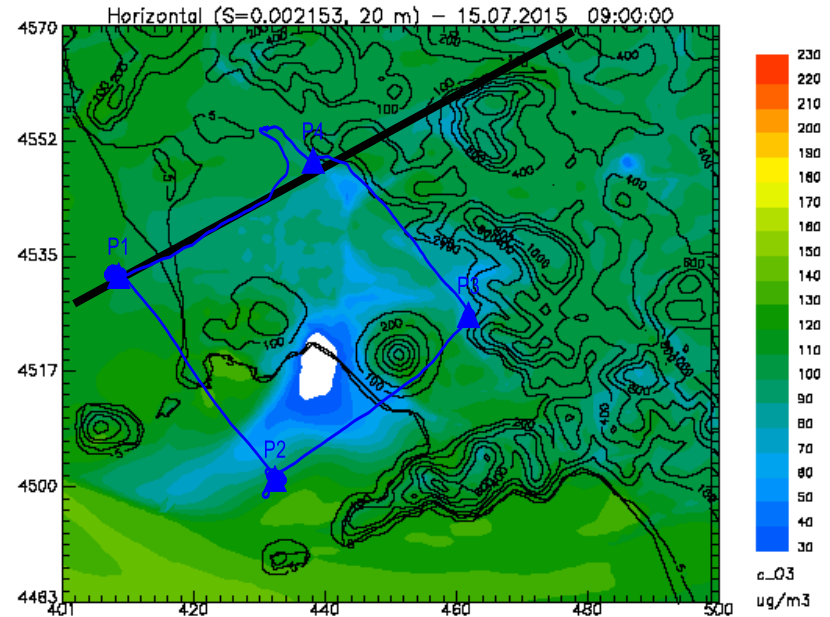


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 Model FARM Simulation time: 15.07.2015 09:00:00 Variable: c_03
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 Global data range: [10.2578,170.02] Actual: [70.3904,150.16]

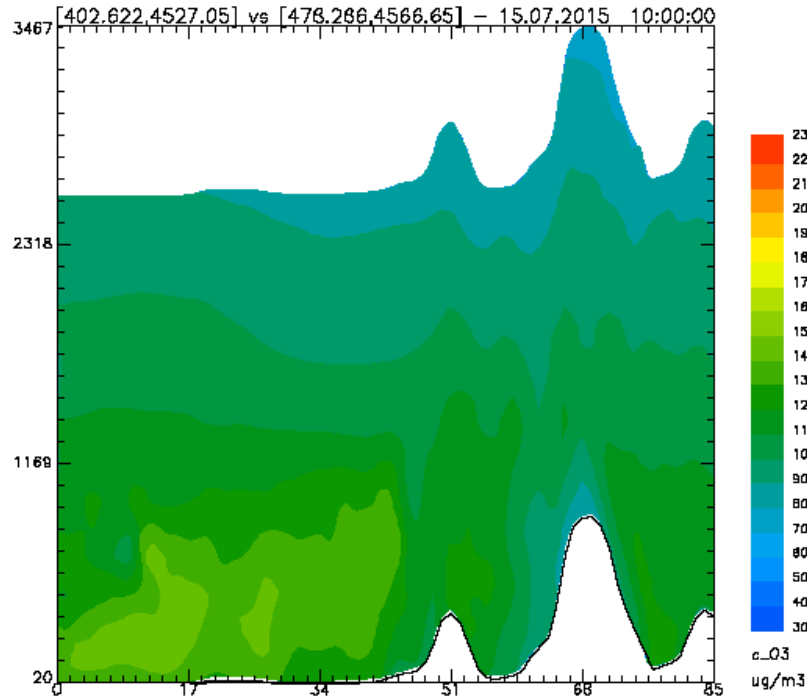


15/07/2015 09:00

AMSU 1.10.0 15/December/2015 15:30
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 Model FARM Simulation time: 15.07.2015 09:00:00 Variable: c_03
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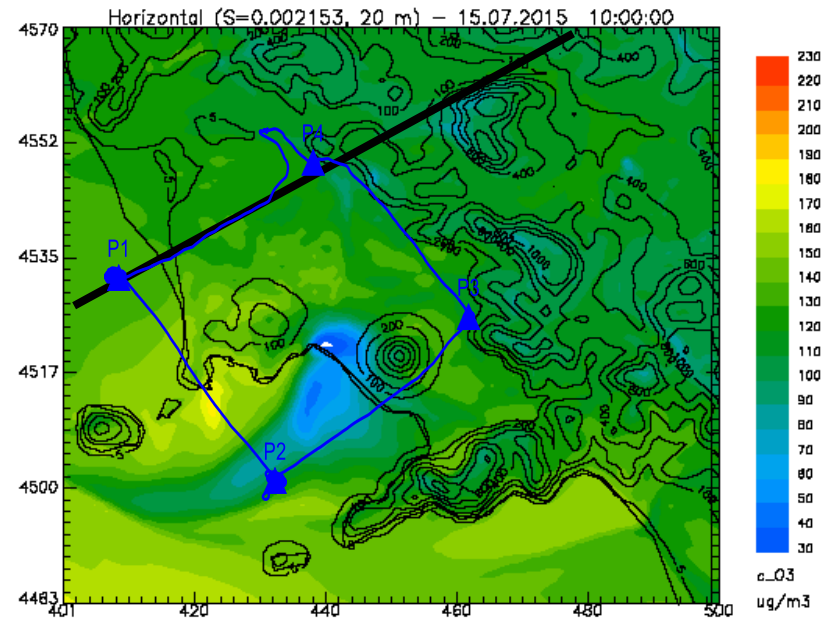


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 Model FARM Simulation time: 15.07.2015 10:00:00 Variable: c_03
 Area range [0,20] [85.4005,3466.88] Top of domain 0
 Global data range: [27.8201,182.826] Actual: [75.6305,150.131]



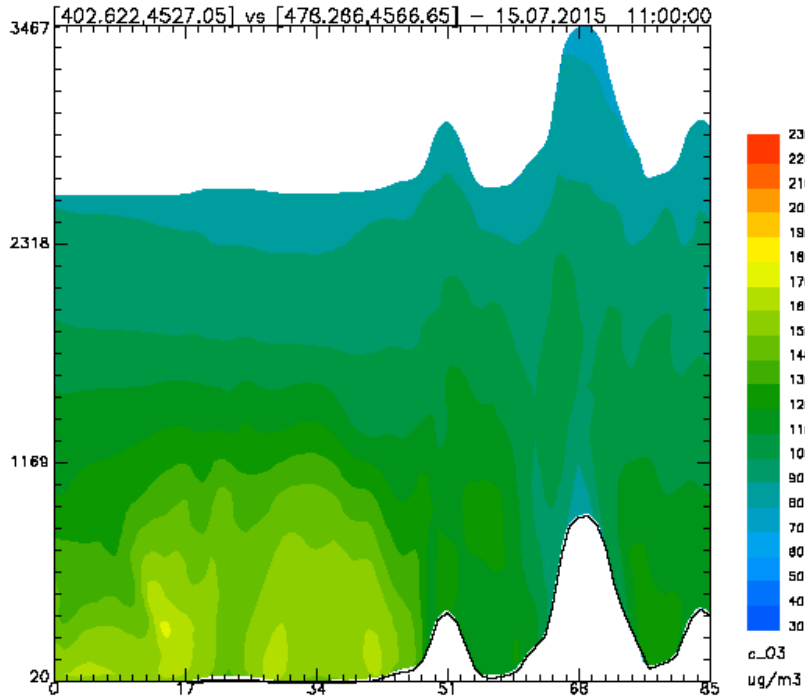
15/07/2015 10:00

AMSU 1.10.0 15/December/2015 15:30
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 Model FARM Simulation time: 15.07.2015 10:00:00 Variable: c_03
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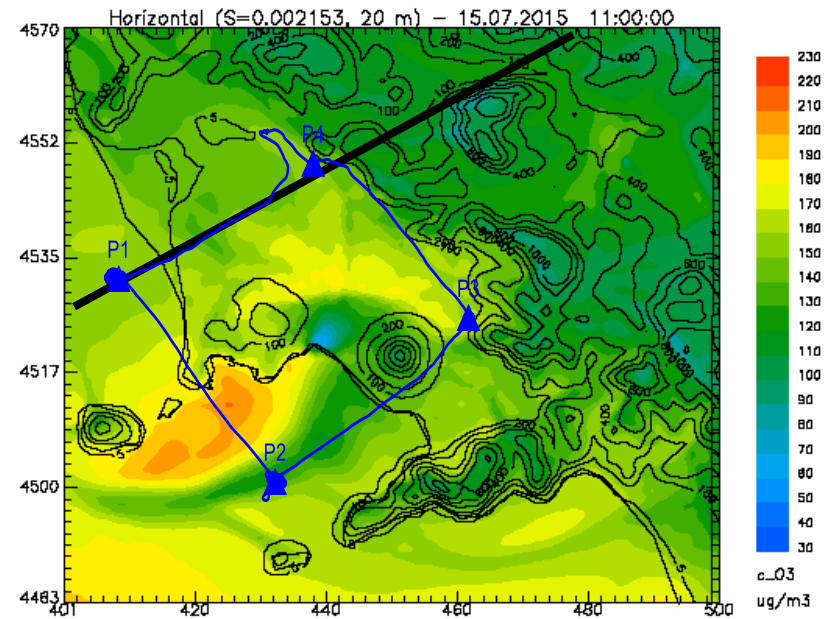


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 Model FARM Simulation time: 15.07.2015 11:00:00 Variable: c_03
 Area range [0,20] [85.4005,3466.88] Top of domain 0
 Global data range: [52.7403,210.889] Actual: [76.1267,171.659]

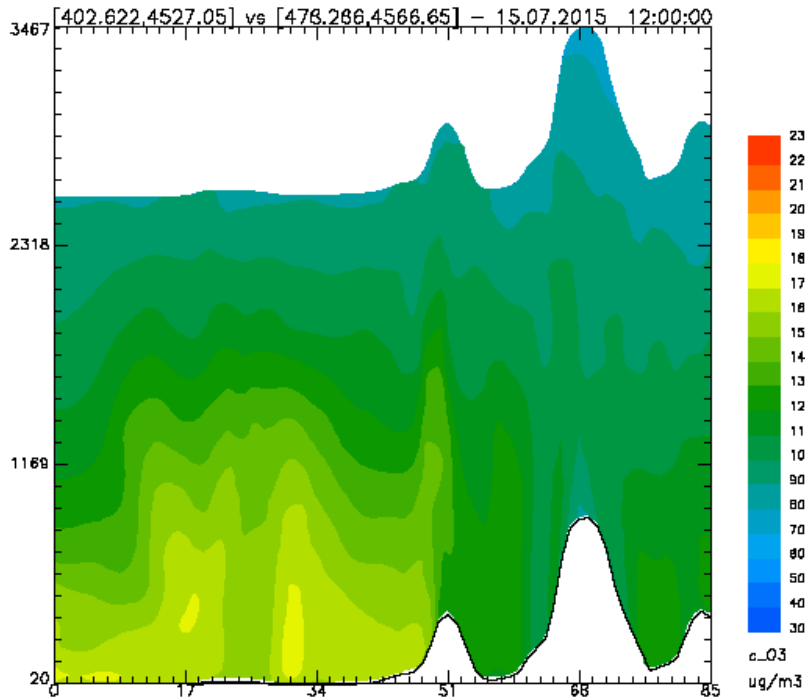
15/07/2015 11:00



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 Model FARM Simulation time: 15.07.2015 11:00:00 Variable: c_03
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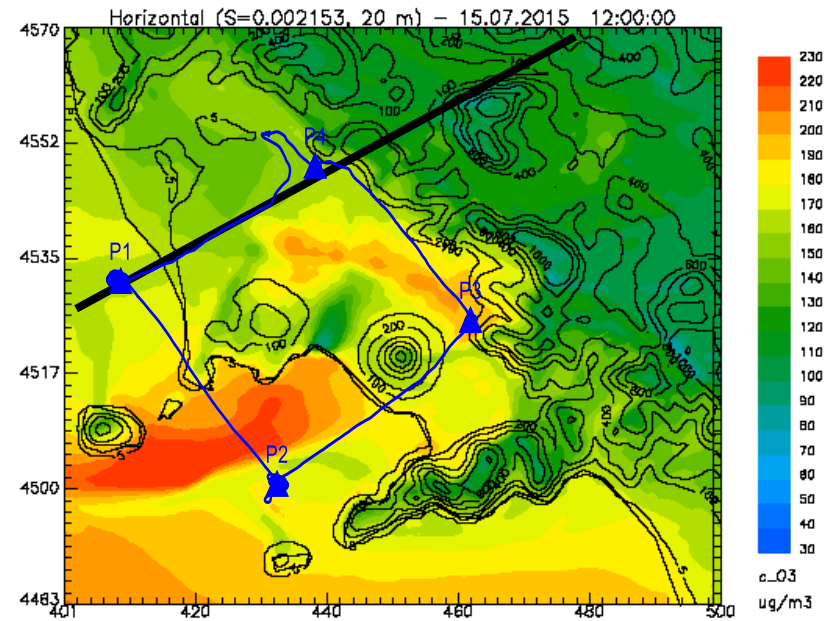


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 Model FARM Simulation time: 15.07.2015 12:00:00 Variable: c_03
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 Global data range: [53.0637,241.05] Actual: [76.1586,173.98]

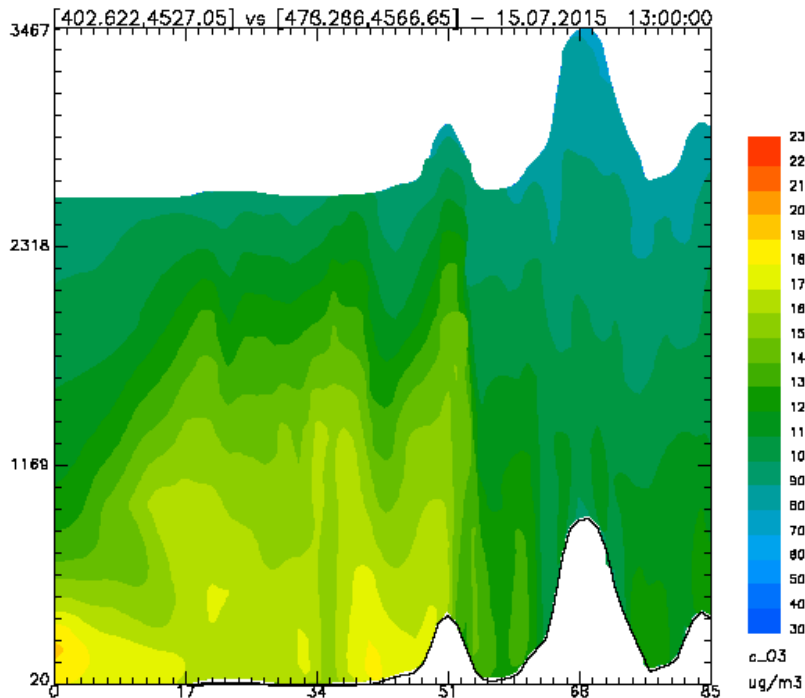


15/07/2015 12:00

AMSU 1.10.0 15/December/2015 15:30
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 Model FARM Simulation time: 15.07.2015 12:00:00 Variable: c_03
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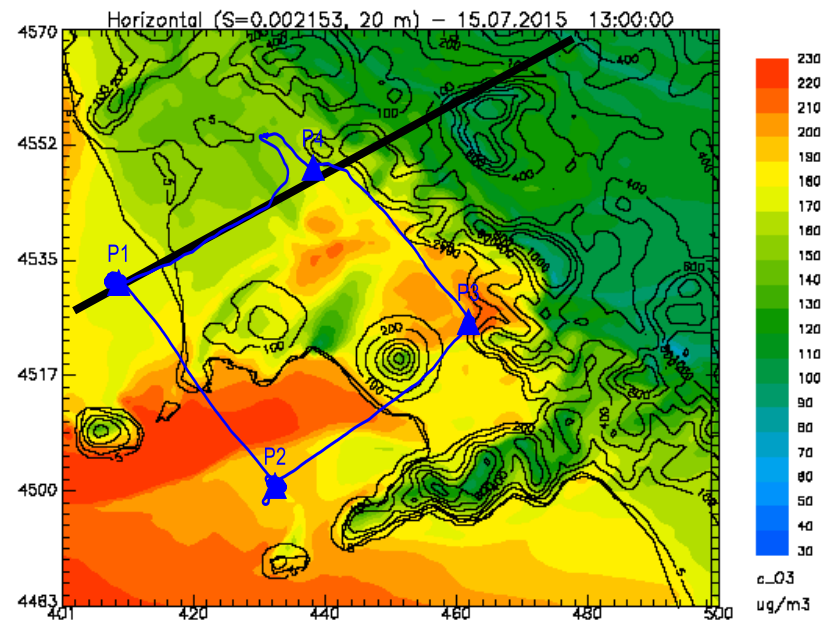


AVSU 1.10.0
 File: C:\Users\fnard\andro\AriaSaNa\Volli_aere\quasar\simulazioni\hires\conc.g4.20150715.nc
 Model FARM Simulation time: 15.07.2015 13:00:00 Variable: c_03
 Area range [0,20] [85.4005,3466.88] Top of domain 0
 Global data range: [52.6176,262.854] Actual: [77.628,193.128]

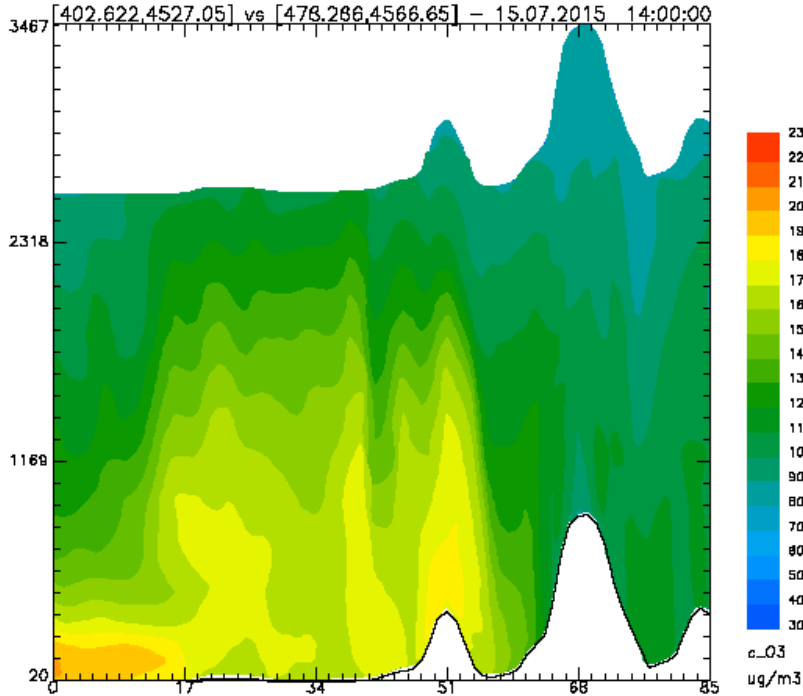


15/07/2015 13:00

AVSU 1.10.0
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 Area range [400.5,4482.5] [499.5,4569.5] Top of domain 0
 Global data range: [52.6176,262.854] Actual: [78.0635,262.854]

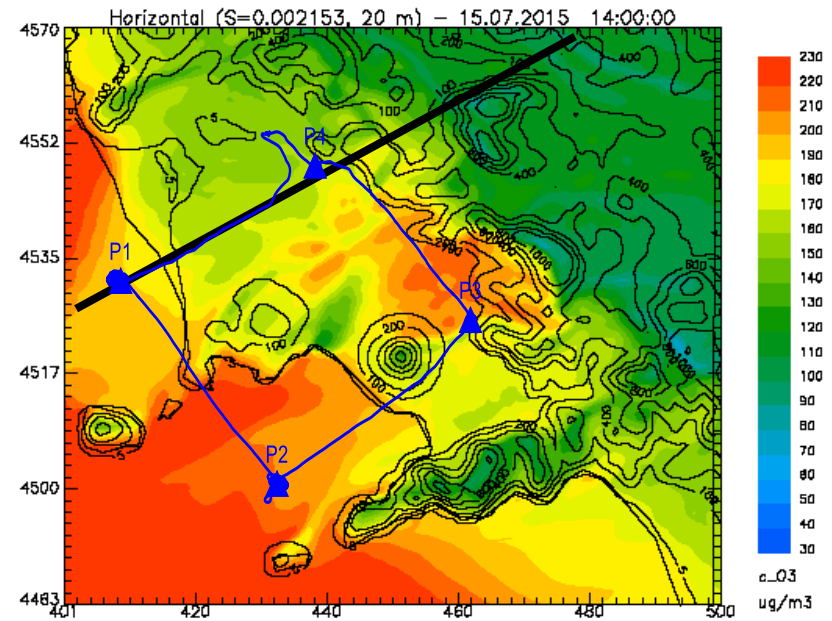


AMSU 1.10.0 15/December/2015 15:35
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 Model FARM Simulation time: 15.07.2015 14:00:00 Variable: c_03
 Area range [0,20] [85.4005,3466.88] Top of domain 0
 Global data range: [52.5374,249.659] Actual: [81.4956,202.279]

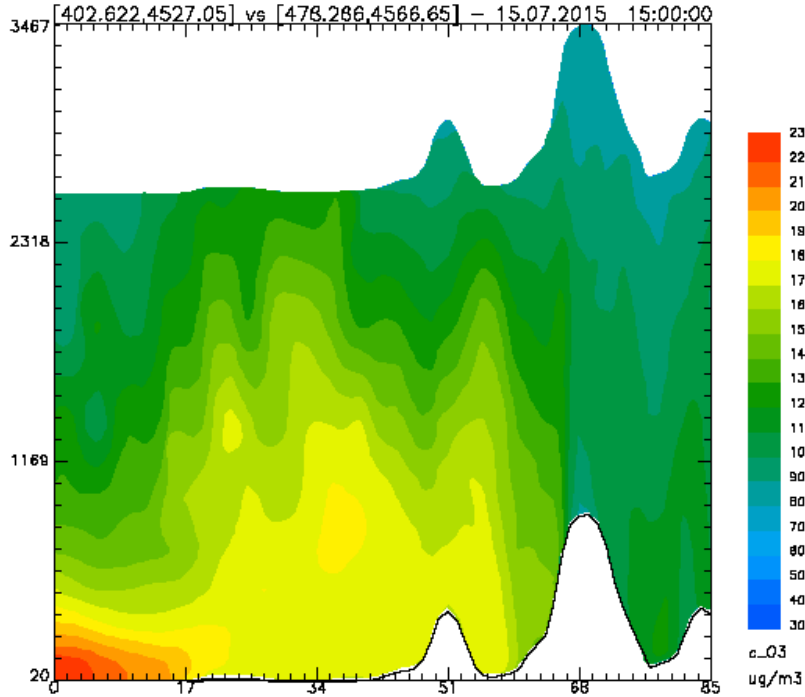


15/07/2015 14:00

AMSU 1.10.0 15/December/2015 15:30
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 Model FARM Simulation time: 15.07.2015 14:00:00 Variable: c_03
 Area range [400.5,4482.5] [499.5,4569.5] Top of domain 0
 Global data range: [52.5374,249.659] Actual: [74.2151,249.659]

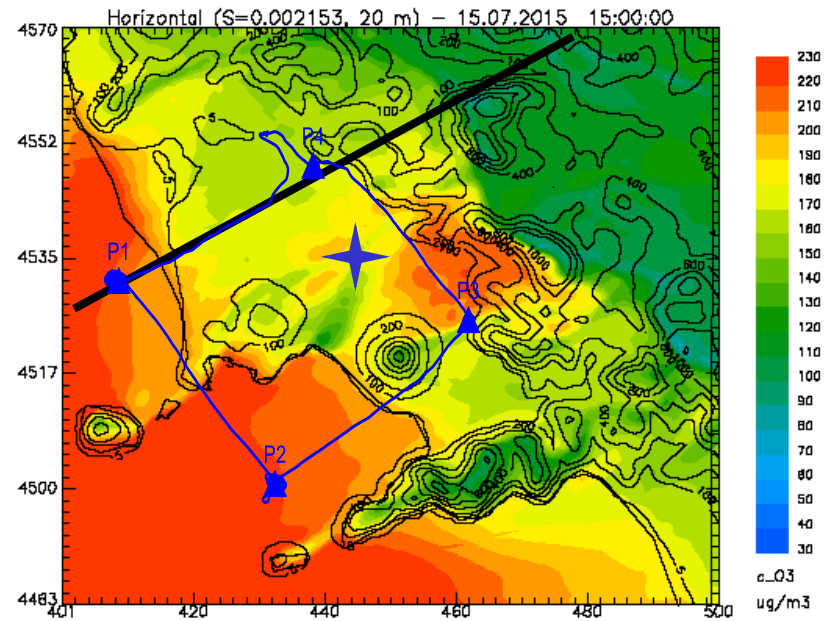


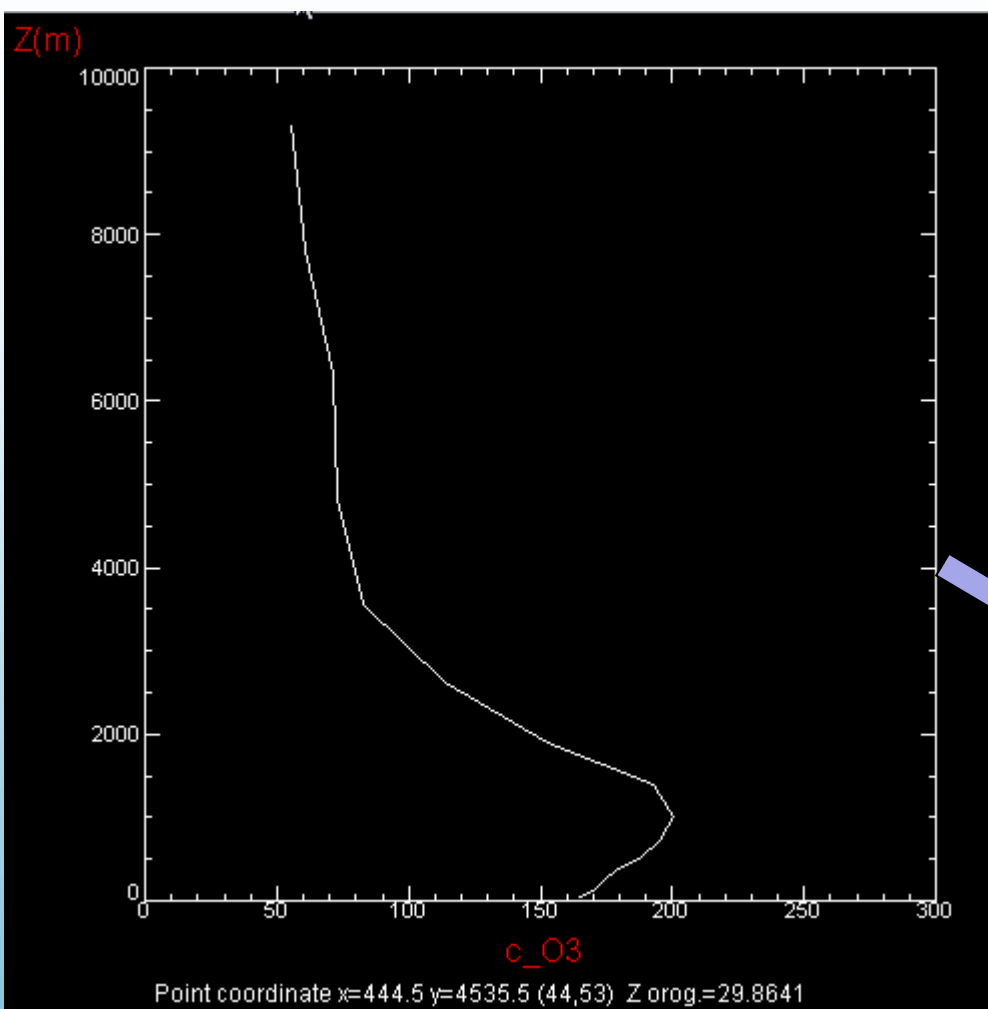
AVSU 1.10.0
 File: C:\Users\fnard\andrea\AriaSaNa\Volli_aere\quasar\simulazioni\hires\conc.g4.20150715.nc
 Model FARM Simulation time: 15.07.2015 15:00:00 Variable: c_03
 Area range [0,20] [85.4005,3466.68] Top of domain 0
 Global data range: [51.4621,260.719] Actual: [83.4513,232.364]



15/07/2015 15:00

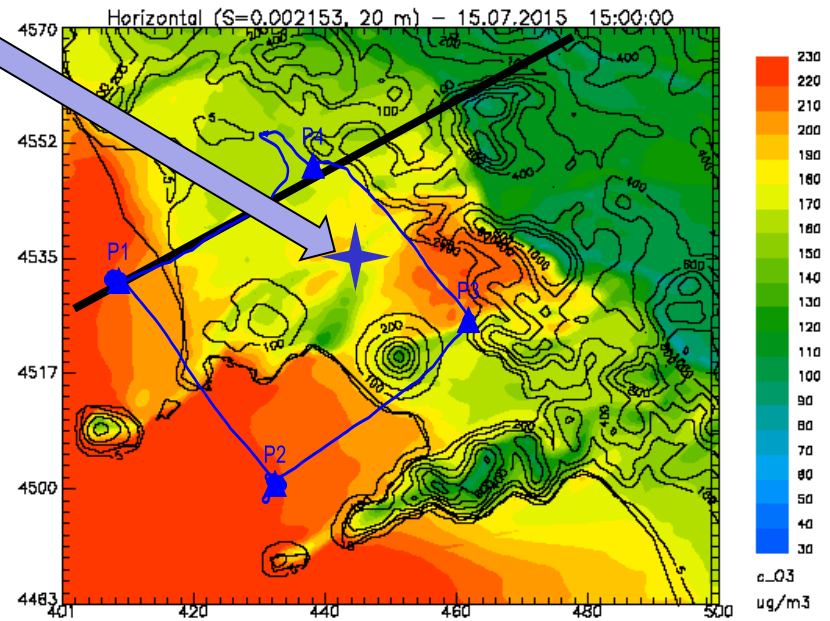
AVSU 1.10.0
 File: C:\Users\fnard\andrea\AriaSaNa\Volli_aere\quasar\simulazioni\hires\conc.g4.20150715.nc
 Model FARM Simulation time: 15.07.2015 15:00:00 Variable: c_03
 Area range [400.5,4482.5] [499.5,4569.5] Top of domain 0
 Global data range: [51.4621,260.719] Actual: [75.6873,260.719]



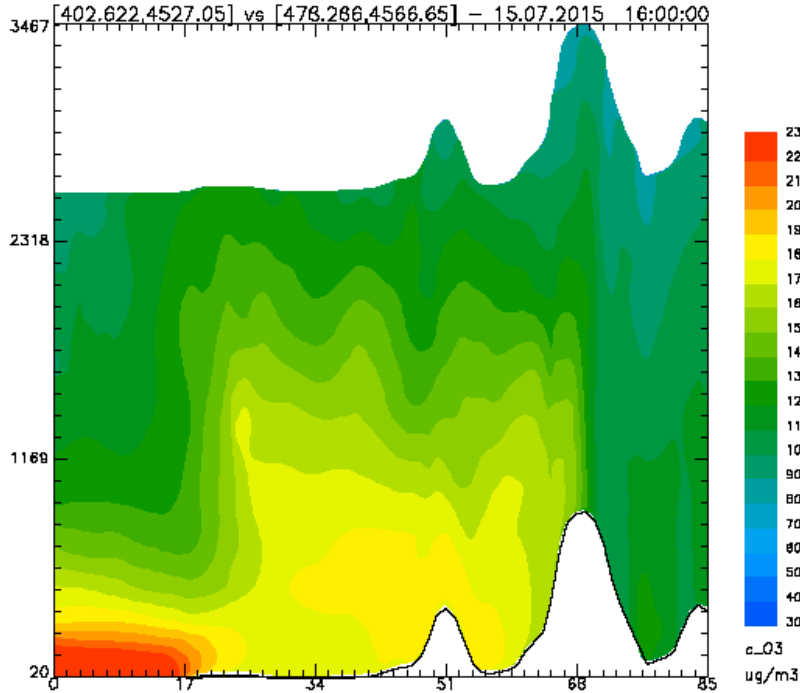


15/07/2015 15:00

AVISU 1.10.0 15/December/2015 15:30
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 Model FARM Simulation time: 15.07.2015 15:00:00 Variable: c_O3
 Area range [400.5,4482.5] [499.5,4569.5] Top of domain 0
 Global data range: [51.4621,260.719] Actual: [75.6873,260.719]

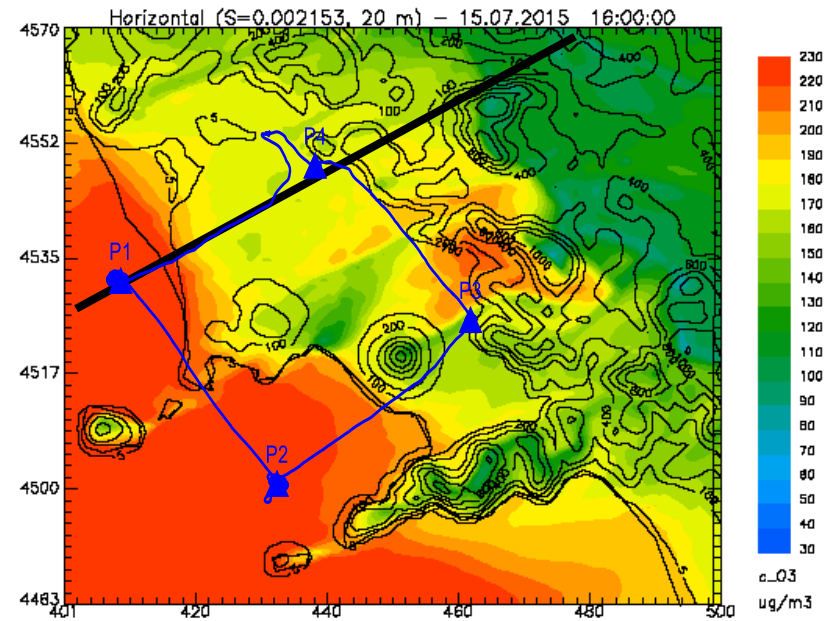


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 Model FARM Simulation time: 15.07.2015 16:00:00 Variable: c_03
 Area range [0,0] [85.4005,3466.68] Top of domain 0
 Global data range: [51.1352,261.917] Actual: [83.4378,249.147]

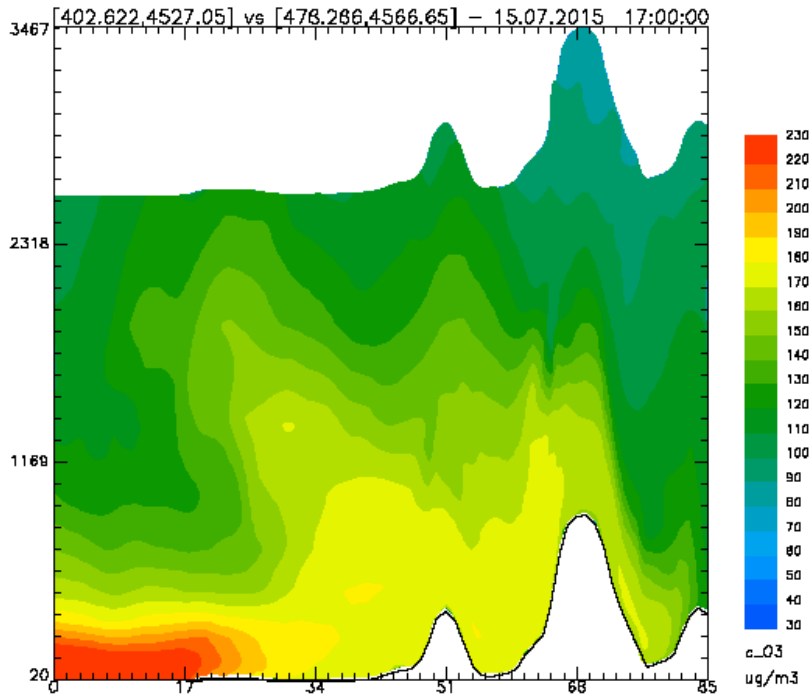


15/07/2015 16:00

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 Model FARM Simulation time: 15.07.2015 16:00:00 Variable: c_03
 Area range [400.5,4482.5] [499.5,4569.5] Top of domain 0
 Global data range: [51.1352,261.917] Actual: [76.3473,261.917]

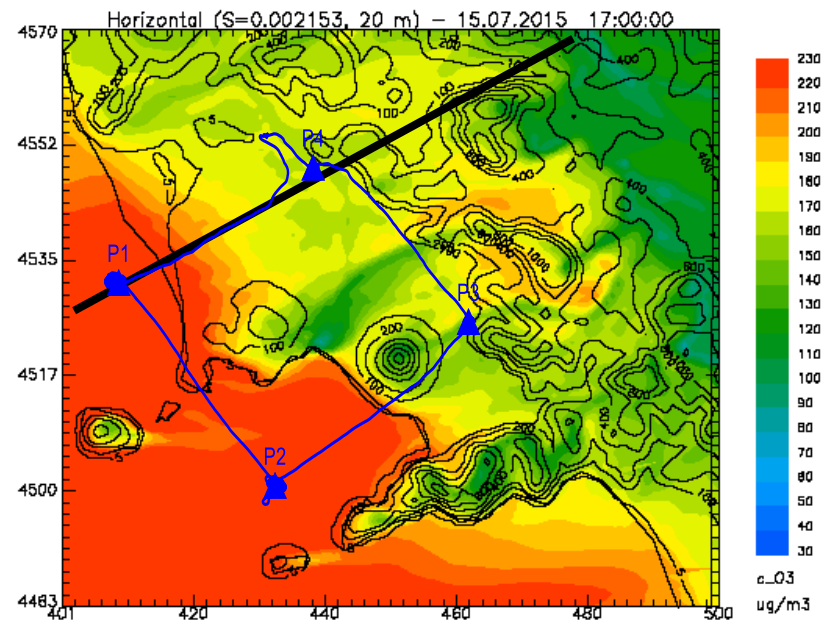


AVISU 1.10.0
 File: C:\Users\finard\andrea\AriaSaNa\Volli_aere\quasar\simulazioni\hires\conc.g4.20150715.nc
 Model FARM Simulation time: 15.07.2015 17:00:00 Variable: c_03
 Area range [0,0] [85.4005,3466.68] Top of domain 0
 Global data range: [52.0494,261.697] Actual: [80.5122,247.303]

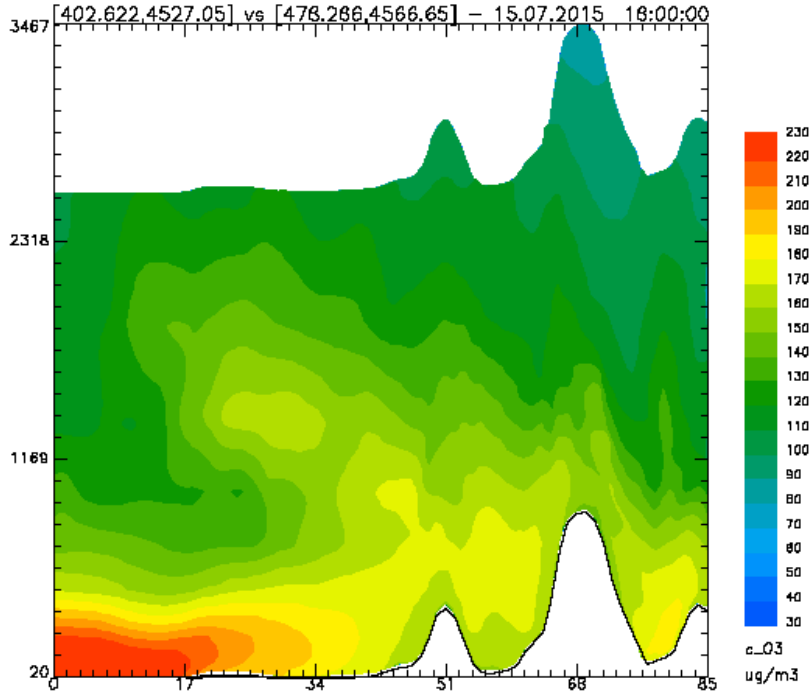


15/07/2015 17:00

AVISU 1.10.0
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 Model FARM Simulation time: 15.07.2015 17:00:00 Variable: c_03
 Area range [400.5,4482.5] [499.5,4569.5] Top of domain 0
 Global data range: [52.0494,261.697] Actual: [84.2691,261.697]

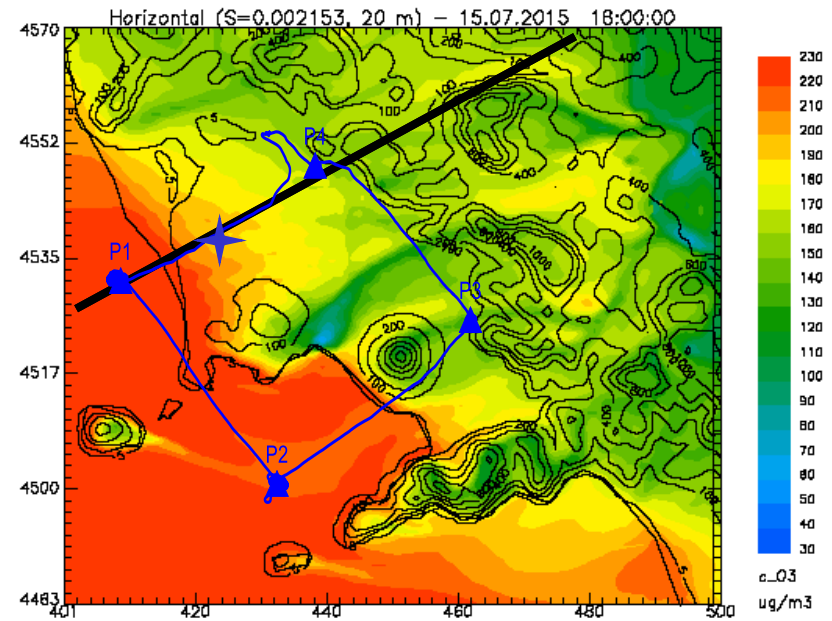


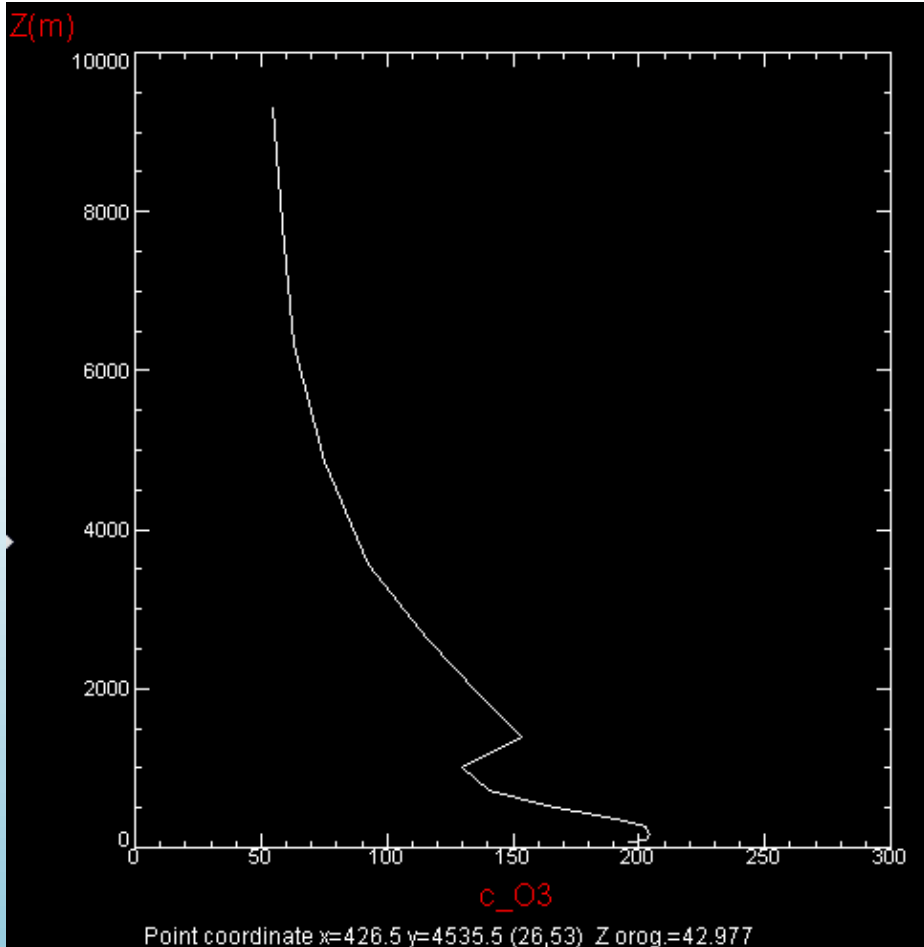
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 File: C:\Users\fnard\andrea\AriaSaNa\Volli_aere\quasar\simulazioni\hires\conc.g4.20150715.nc
 Model FARM Simulation time: 15.07.2015 18:00:00 Variable: c_O3
 Area range [0,0] [85.4005,3466.68] Top of domain 0
 Global data range: [51.897,252.89] Actual: [64.6701,243.308]



15/07/2015 18:00

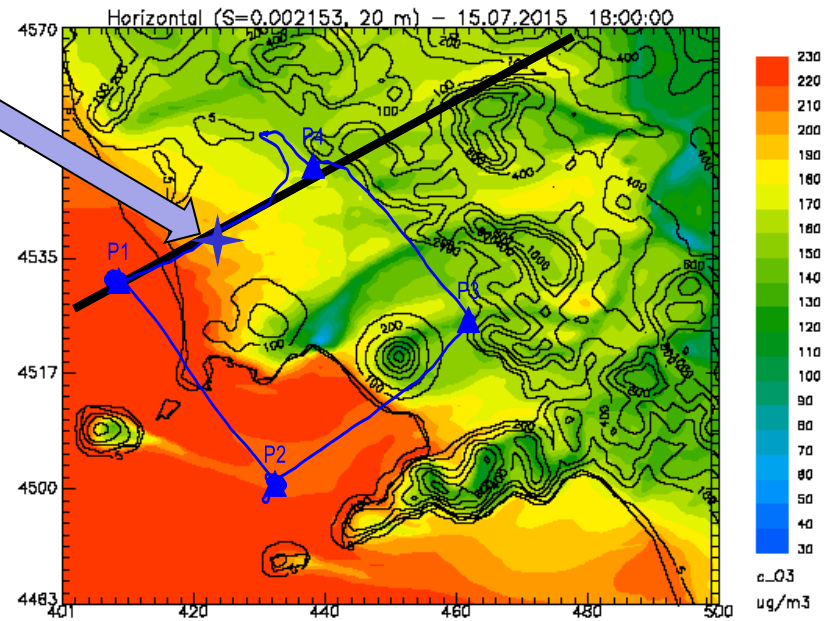
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 Model FARM Simulation time: 15.07.2015 18:00:00 Variable: c_O3
 Area range [400.5,4482.5] [499.5,4569.5] Top of domain 0
 Global data range: [51.897,252.89] Actual: [55.6105,252.89]



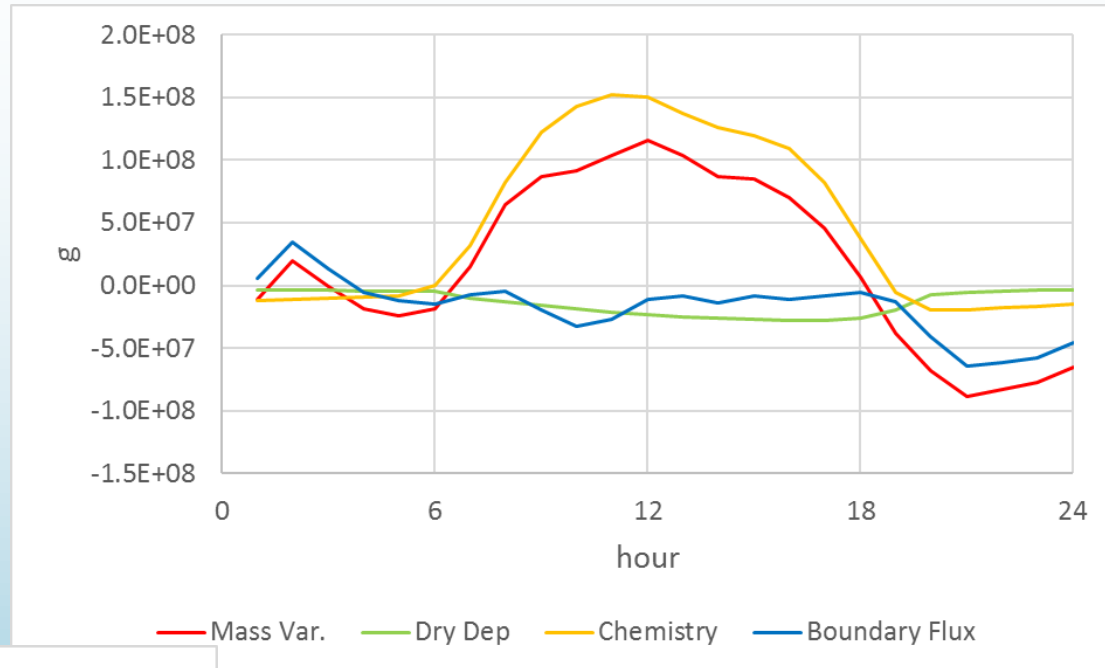
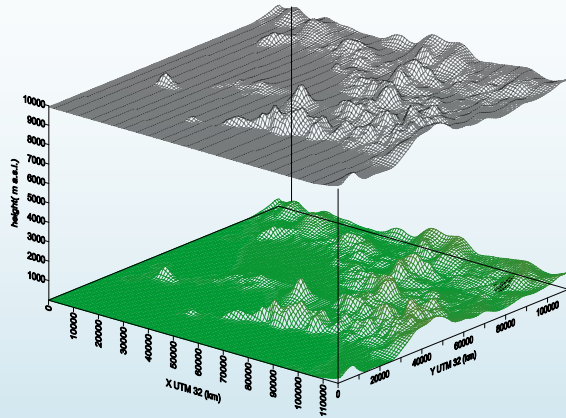


15/07/2015 18:00

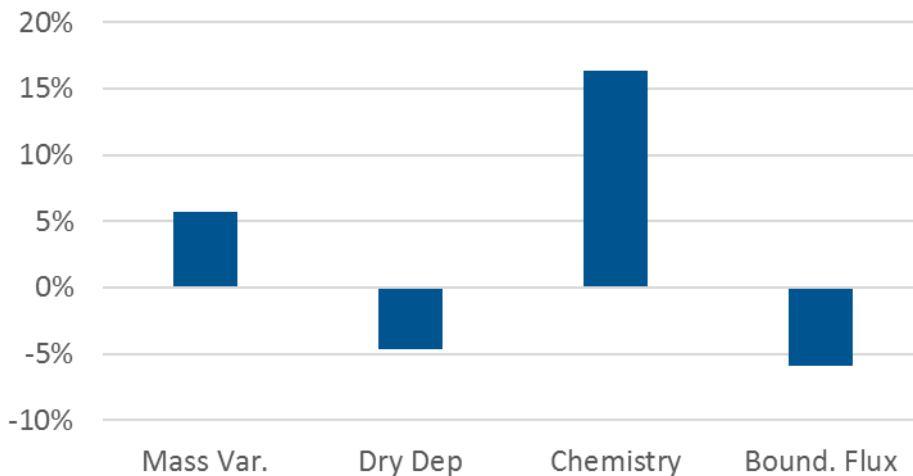
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 Model FARM Simulation time: 15.07.2015 18:00:00 Variable: c_03
 Area range [400.5,4482.5] [499.5,4569.5] Top of domain 0
 Global data range: [51.897,252.89] Actual: [55.6105,252.89]



Ozone mass balance



15/07/2015 Ozone daily mass balance



Integrated values over FARM computational domain

Conclusions

- ✓ Measurements and model results confirm that elevated ozone concentrations affect Naples inland flat region, where photochemical production takes place.
- ✓ Low ozone values over Napoli gulf could be explained by titration effect of marine traffic emissions possibly underestimated by model simulation.
- ✓ The elevated ozone rich layer (500-1000m) detected by airborne measurements can be caused by a combination vertical dispersion, surface titration and recirculation in the afternoon residual layer.
- ✓ Model results show seaward ozone transport in return current over 1200m.
- ✓ Naples conurbation role of O₃ source is confirmed.

Thank you



AriaSaNa project has been funded by Regione Campania and coordinated by the Institute for Mediterranean Agriculture and Forest Systems (ISAFOM) of the National Research Council.

S.No.	Name of Instrument	Parameters measured	Accuracy
1.	LICOR-7500	CO2 and H2O densities of air	Within 1 % of reading for CO2 and within 2% of reading for H2O
2.	Best Aircraft Turbulence (BAT) probe	3D wind speed with respect to aircraft	
3.	Riegl Laser Altimeter LD90-3	Aircraft flying height from the ground	Typically 0.5 m at highest range and 10 cm at minimum range
4.	C-MIGITS (Accelerometer)	Position, velocity, and attitude information	Position (SEP): 3.9 m, Velocity (1 sigma, horiz/vert): 0.1/0.1 m/s, Pitch and Roll (1 sigma): 1.0 mrad, Timemark Output 1 pps: 1 microsecond, Heading (1 sigma, in motion): 1.5 mrad
5.	GRIMM 1.109 Optical Particulate Counter	Fine dust analyses within the size range 0.25 - 32 μm in 31 size channels and also determine the dust mass from that	$\pm 3\%$ in max. range
6.	2B Technologies Model 202 Ozone Monitor™	Ozone ranging from low ppb up to 100,000 ppb (0-100 ppm)	~ 1 ppb
7.	2B Technologies 405 nm NO2/NO/NOx Monitor	Atmospheric NO2, NO and Nox (= NO + NO2)	0-10 ppm in the concentration range 0-10,000 ppb for NO2 and 0-2 ppm in the range of 0-2,000 ppb for NO and NOx
8.	LI-190SA Photosynthetically Active Radiation (PAR)-Radiometer	Photosynthetic Photon Flux Density (PPFD)	Sensitivity: Typically 5 μA to 10 μA per 1,000 $\mu\text{mol s}^{-1} \text{m}^{-2}$ Linearity: Maximum deviation of 1% up to 10,000 $\mu\text{mol s}^{-1} \text{m}^{-2}$
9.	Everest IRT (Infrared Temperature)	Infrared temperature of the soil	
10.	Micro LiDAR	Vertical profiler of the atmosphere based on laser technology for optical remote sensing.	
11.	ARK 3360	Industrial PC ark 3360 for the acquisition of data with Ubuntu OS	-

WRF AWR V3.5.1 Configuration



WRF scheme	physics	Input option	namelist	description
Microphysics		mp_physics=6		Single-Moment 6-class scheme (ice, snow and graupel processes)
Longwave Radiation		ra_lw_physics=1		RRTM (Rapid Radiative Transfer Model), accurate scheme using look-up tables
Shortwave Radiation		ra_sw_physics=2		Goddard shortwave (two-stream multi-band scheme with ozone climatology and cloud effects)
Cumulus Parameterization		cu_physics=1		Kain-Fritsch scheme (deep and shallow convection)
Land Surface		sf_surface_physics=2		Noah Land Surface Model
Surface Layer		sf_sfclay_physics=2		Eta similarity (based on Monin-Obukhov theory).
Planetary Boundary layer		bl_pbl_physics=2		Mellor-Yamada-Janjic operational scheme