



4° Congresso Nazionale AISAM – Università di Milano 15-18 Febbraio 2022

Combinazione numerico-logica di campi lagrangiani *backward* per individuare una sorgente di odori molesti a partire da segnalazioni dei cittadini nel sistema NOSE

Francesco Uboldi¹, Silvia Trini Castelli², Gianni Tinarelli¹, Paolo Bonasoni³



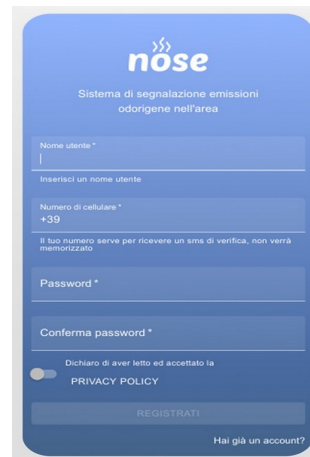
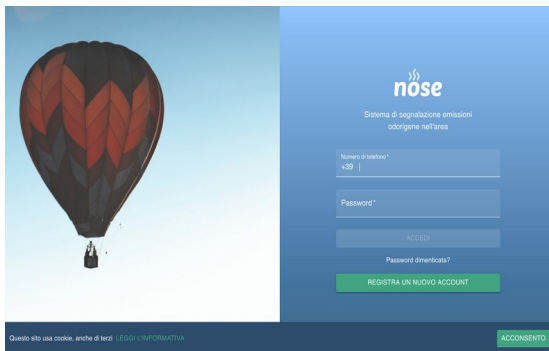
1 ARIANET, Milano; 2 CNR-ISAC, Torino; 3 CNR-ISAC, Bologna





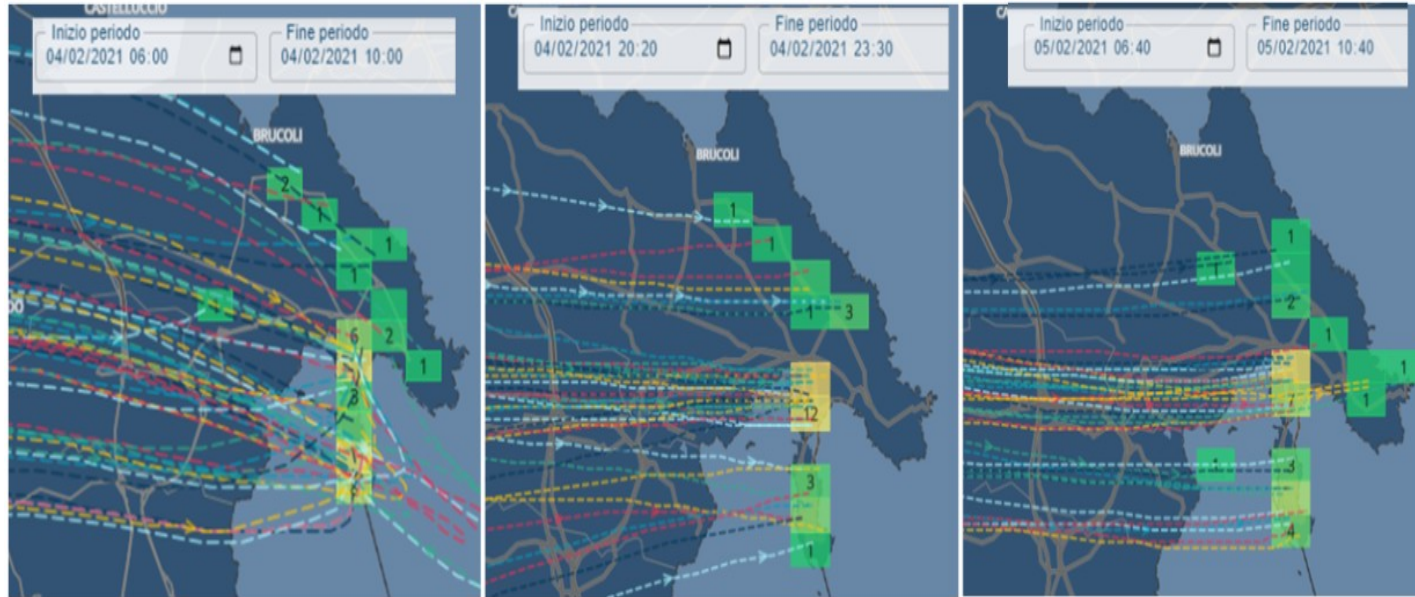
Un progetto di ricerca con finalità operative a supporto delle attività di controllo del territorio eseguite da ARPA Sicilia.

- Un sistema modulare per un controllo in *near-real-time* delle molestie olfattivi grazie alle segnalazioni dei cittadini.
- Una **WebApp** gratuita (smartphone, PC, tablet) scaricabile dal sito: nose-cnr.arpa.sicilia.it che permette di raccogliere in tempo reale e in forma anonima le segnalazioni geo-referenziate delle molestie olfattive percepite dai cittadini.



Individuare la sorgente delle emissioni odorigene. Approccio modellistico

Attualmente in NOSE è possibile calcolare retro-traiettorie deterministiche a partire da tempi e posizioni delle segnalazioni dei cittadini, utilizzando i campi di vento a 10 m e a 100 m dal suolo previsti operativamente dal modello meteorologico ad alta risoluzione **MOLOCH** (Malguzzi *et al.*, 2006) di CNR-ISAC, al fine di individuare il percorso delle sostanze odorigene.



MOLOCH:

Malguzzi P., Grossi, G., Buzzi, A., Ranzi, R., and Buizza, R., 2006. The 1966 'century' flood in Italy: A meteorological and hydrological revisitation. *J. Geophys. Res*, **111**, D24106

Individuare la sorgente delle emissioni odorigene

Il lavoro attuale riguarda l'implementazione di un metodo STE – *Source Term Reconstruction* basato sull'utilizzo del modello di dispersione lagrangiano a particelle **SPRAY** e, in particolare, la sua versione *backward in time*, **RetroSPRAY** (Armand *et al.*, 2013; Tinarelli *et al.*, 2018).

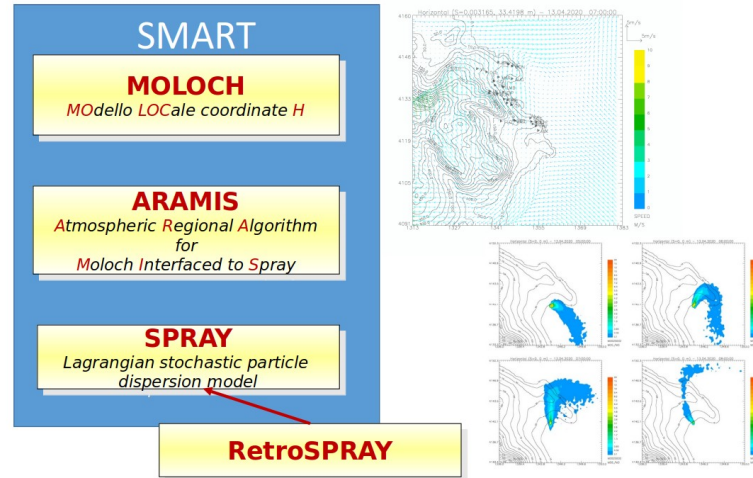
RetroSPRAY:

- Armand P., Olry C., Albergel A., Duchenne C. and Moussafir J., 2013. Development and application of Retro-Spray, a backward atmospheric transport and dispersion model at the regional and urban scale. *Proceedings of the 15th Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes* – 6-9 May 2013, Madrid, Spain, pp. 789-893.
- Tinarelli, G., Ubaldi F., Carlino G., 2018. Source term estimation using an adjoint model: a comparison of two different algorithms. *Int. J. Environment and Pollution*, **64**, Nos. 1/3.

Individuare la sorgente delle emissioni odorigene

Si usano i campi meteorologici previsti da MOLOCH. **SPRAY** può già essere usato con **MOLOCH** i due modelli sono stati integrati nella *suite* modellistica meteo-dispersiva **SMART** (*SPRAY-MOLOCH Atmospheric Regional Tool*, Bisignano *et al.*, 2020; Trini Castelli *et al.*, 2020). Lo stesso vale per RetroSPRAY.

The NOSE Web-App and the modelling system



SMART:

- Bisignano A., Trini Castelli S., and Malguzzi P., 2020. Development and verification of a new meteo-dispersive modelling system for accidental releases in the Italian territory: SMART. *Air Pollution Modeling and its Application XXVI*, C. Mensink, W. Gong and A. Hakami (eds.) Springer Proceedings in Complexity, Springer International Publishing Switzerland, 77-81.
- Trini Castelli S., Bisignano A., Donato A., Landi T.C., Martano P., Malguzzi P., 2020. Evaluation of the turbulence parameterisation in the MOLOCH meteorological model. *Quart J Roy Meteorol Soc*, **146**, 124-140

Individuare la sorgente delle emissioni odorigene

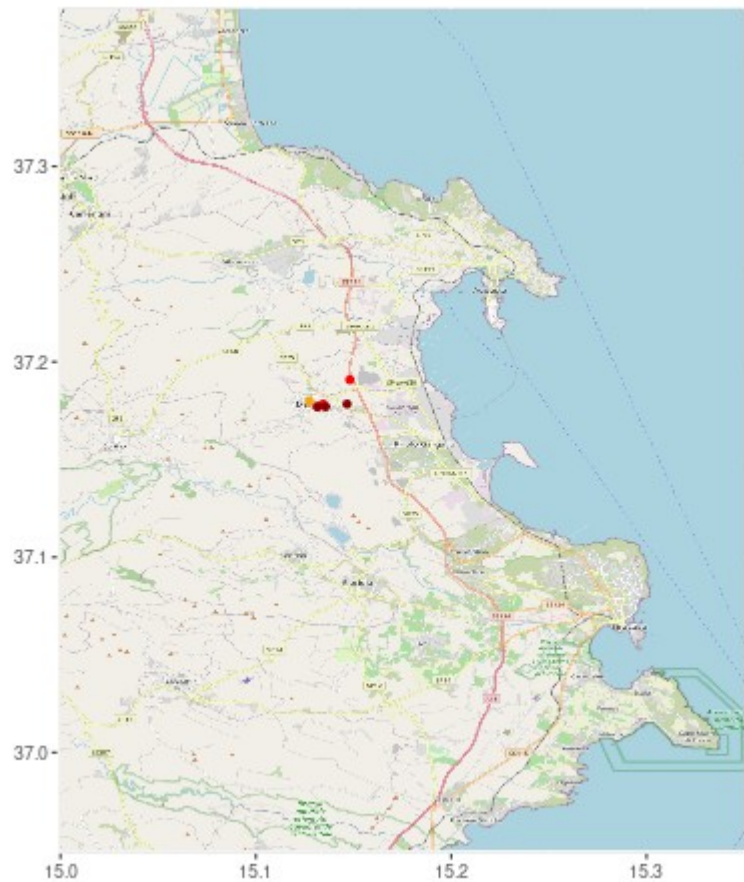
I campi di retro-concentrazione prodotti da RetroSPRAY sono poi combinati ed elaborati per arrivare a stimare la posizione della sorgente. Le tecniche STE basate su RetroSPRAY sono state sviluppate e sono usate per stimare non solo la **posizione**, ma anche le **masse emesse** e i **tempi di emissione** da parte di sorgenti ignote **a partire da misure quantitative** di concentrazione di inquinanti.

Individuare la sorgente delle emissioni odorigene

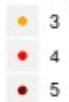
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Le segnalazioni di molestia olfattiva da parte dei cittadini in NOSE **non costituiscono misure quantitative**. Si tratta comunque di informazioni su un fenomeno reale, e si vuole trovare il modo di utilizzarle, almeno per **delimitare un'area di possibili posizioni** della sorgente delle emissioni odorigene.

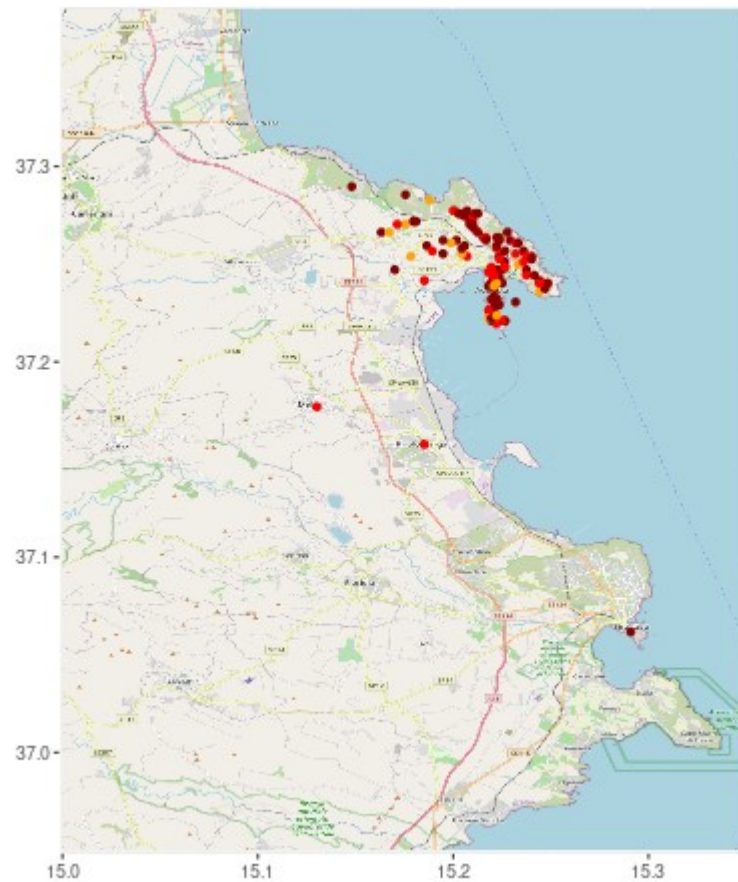
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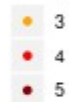
intensity



2020-04-13 10:30



intensity



Aggregazione di segnalazioni in pseudo-osservazioni

Le segnalazioni hanno anche una “intensità” indicata soggettivamente dai cittadini con un valore da 1 a 5. Si sceglie di prendere in considerazione solo segnalazioni con “intensità” almeno 3. Si trascurano quindi segnalazioni con intensità pari a 1 o 2.

Scelta di aggregazione temporale: intervalli di 30 minuti

Aggregazione spaziale 1: conteggio delle segnalazioni in celle 500m x 500m di un grigliato regolare.

Aggregazione spaziale 2: applicazione elementare di ***cluster analysis***

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Si costruiscono quindi delle **pseudo-osservazioni**, caratterizzate da:

1) Posizione: il centro della cella o del *cluster*

2) Tempo: l'intervallo da 30 minuti in cui si sono verificate

3) “valore”: il numero di segnalazioni in quella cella o *cluster*, in quell'intervallo di tempo

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usati da RetroSPRAY

3) **“valore”**: il numero di segnalazioni in quella cella o *cluster*, in quell'intervallo di tempo

possibile uso in post-elaborazione

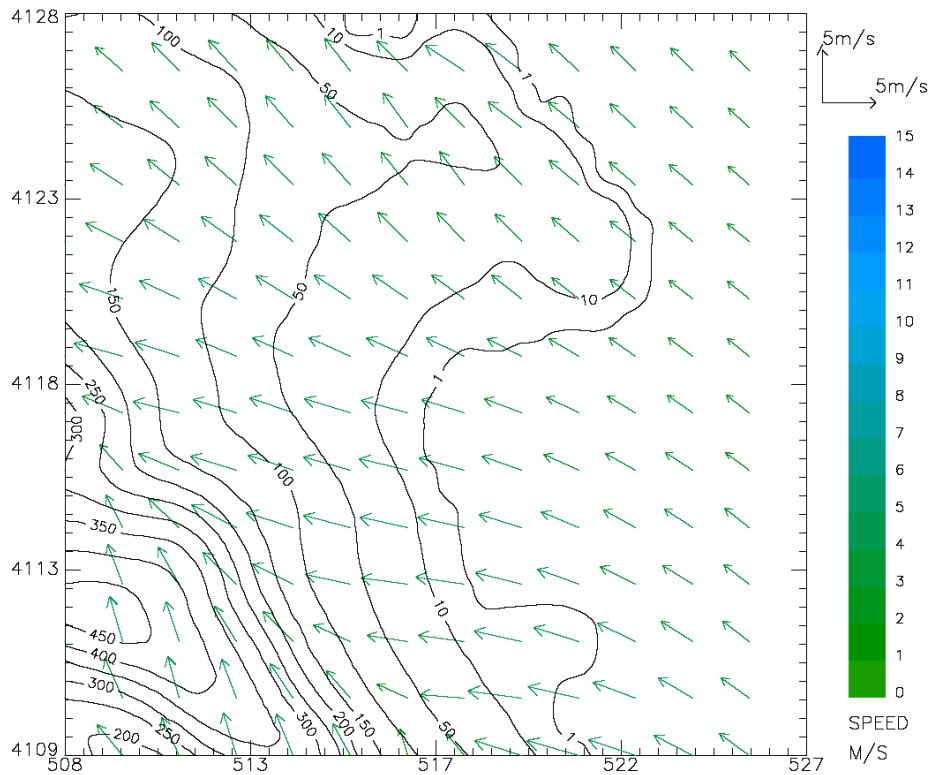
RetroSPRAY

RetroSPRAY è un modello di dispersione stocastico Lagrangiano a particelle, come SPRAY, ma procede all'indietro nel tempo (*backward in time*).

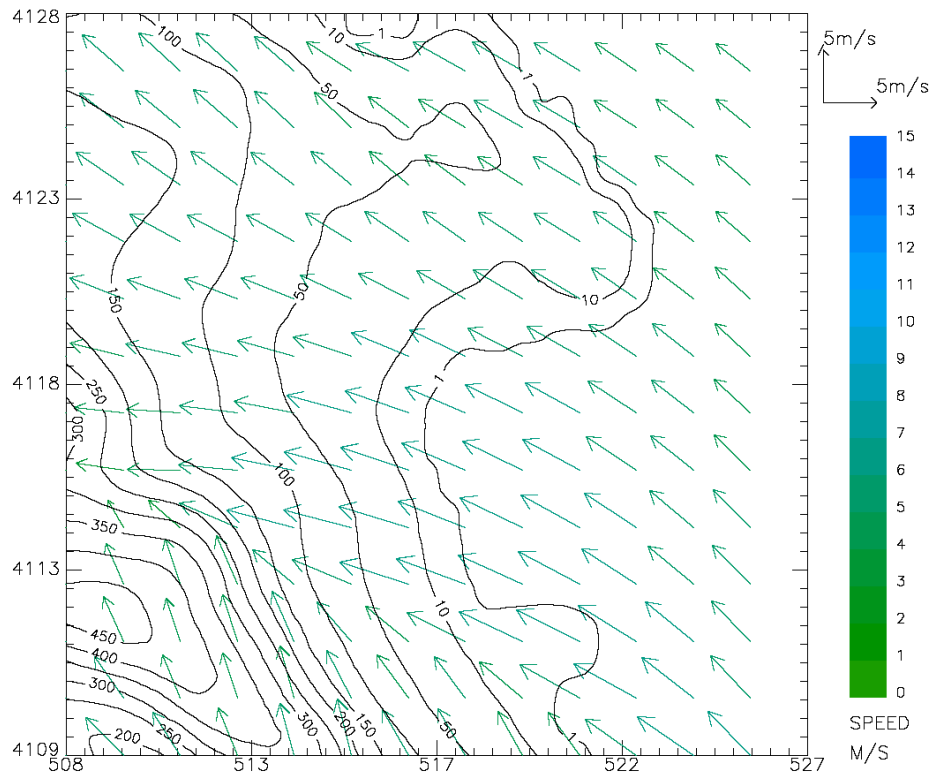
In corrispondenza di tempo e posizione delle pseudo-osservazioni si definiscono retro-emissioni. Da ogni pseudo-osservazione viene emesso un ***retro-puff*** costituito da particelle di cui viene simulata la traiettoria stocastica contro-vento: retro-avvezione e dispersione. Vengono costruiti dei campi di (*retro-*)concentrazione mediando nello spazio e nel tempo il transito delle particelle, come per una integrazione in avanti (*forward*) di SPRAY.

Il *retro-puff* generato da una (pseudo-)osservazione indica le posizioni possibili di una sorgente che in un'integrazione in avanti di SPRAY potrebbe dare luogo a quella osservazione.

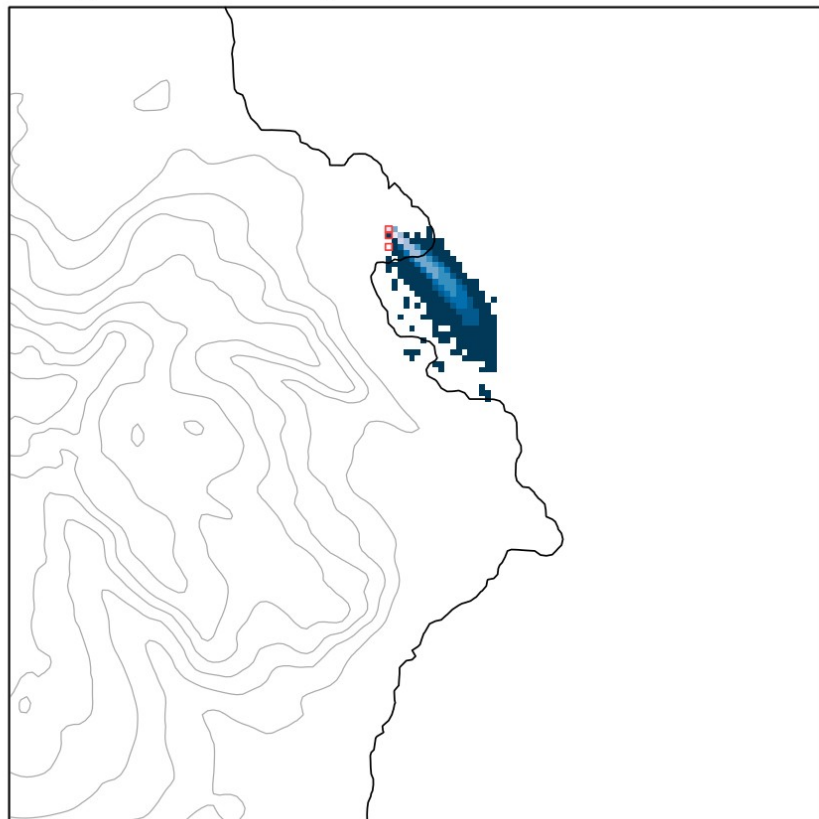
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Model ARAMIS21 Simulation time: 13.04.2020 09:00:00 Wind colored by: SPEED
Area range [507.712,4108.57] [527.212,4128.07] Top of domain 10515.4
Global data range: [0,17.2393] Actual: [2.18176,5.66454]



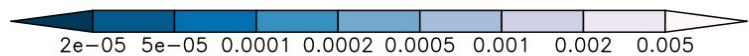
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Global data range: [0,18.4536] Actual: [2.60076,6.99312]



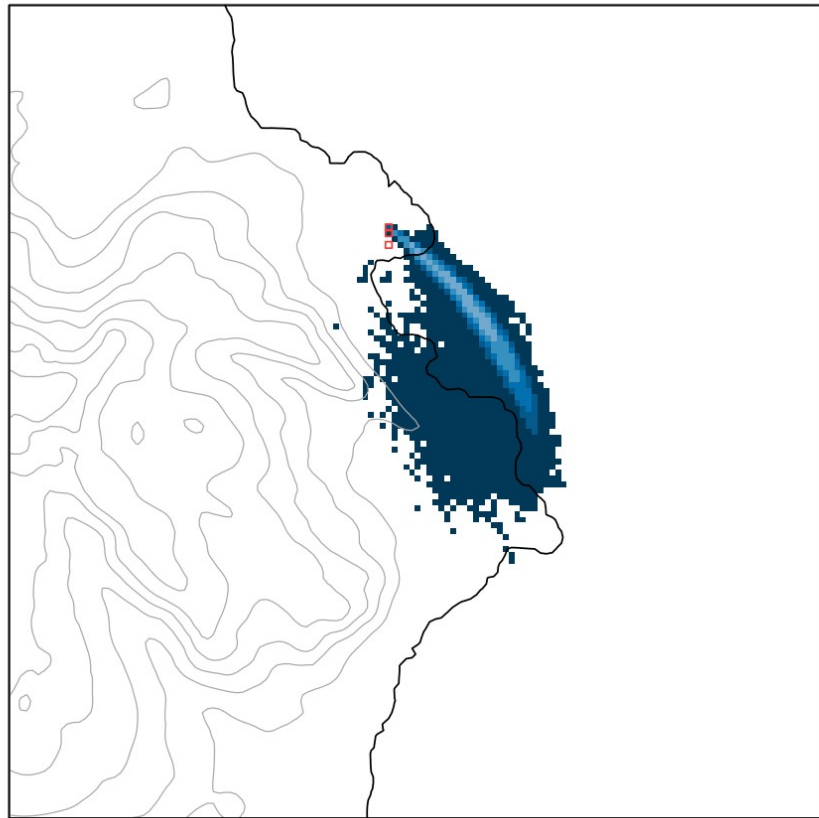
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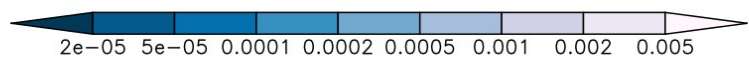
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11:00 – 11:30



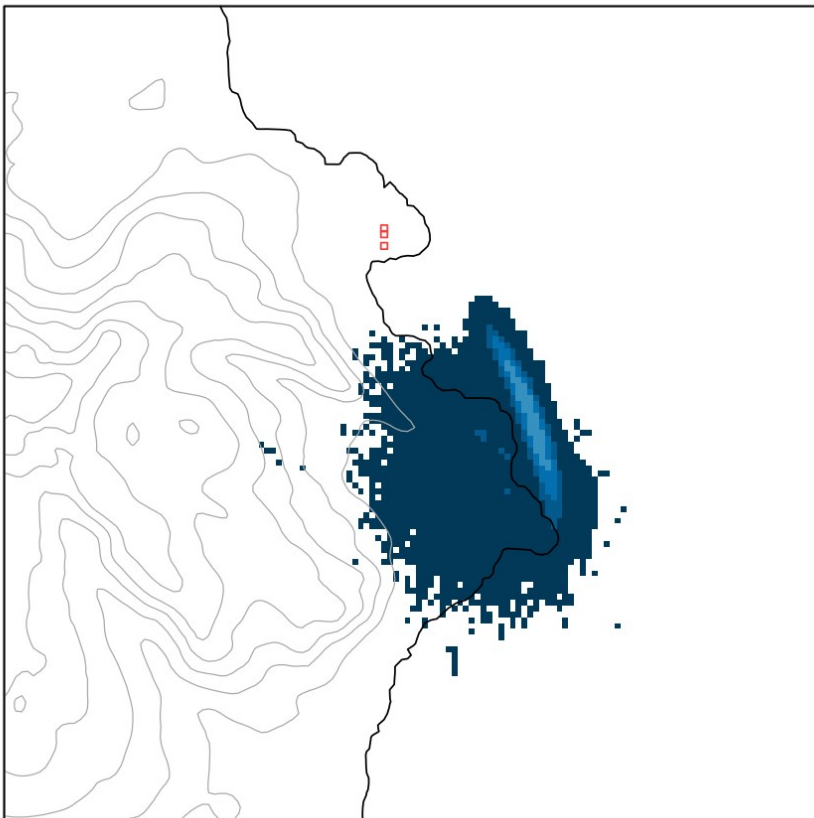
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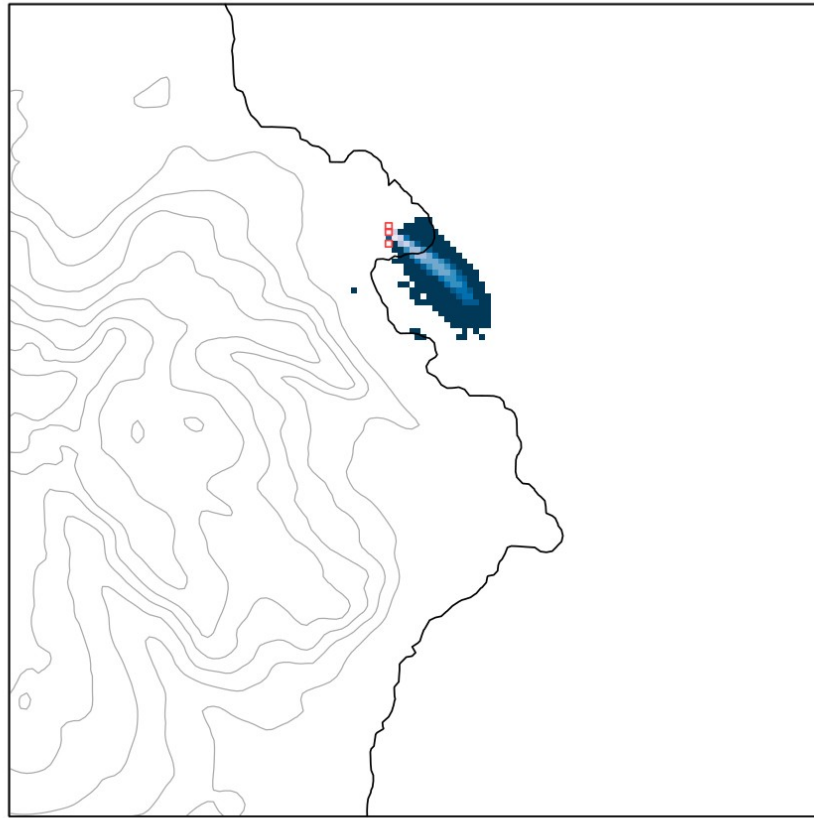
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10:30 – 11:00



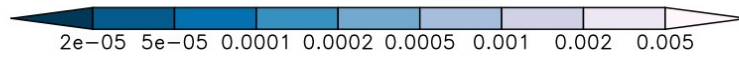
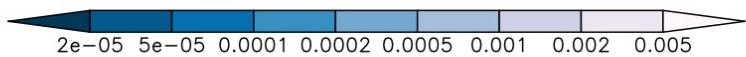
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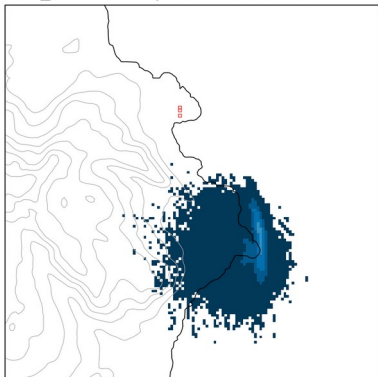
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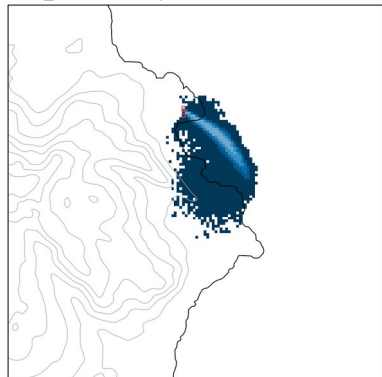
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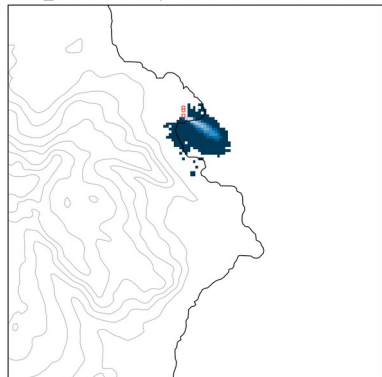
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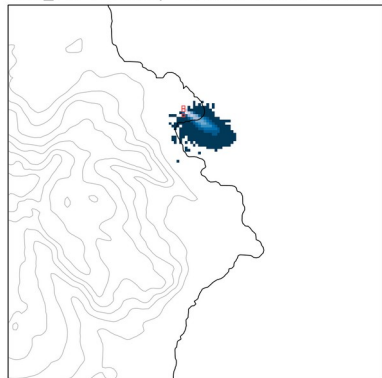
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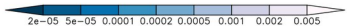
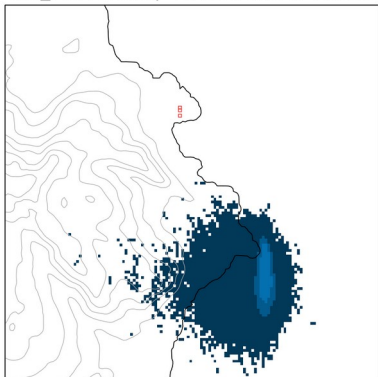


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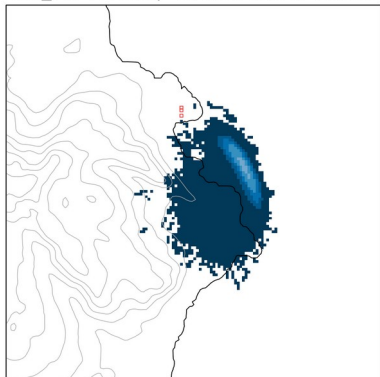


Forward time $n=8$
09:30 – 10:00

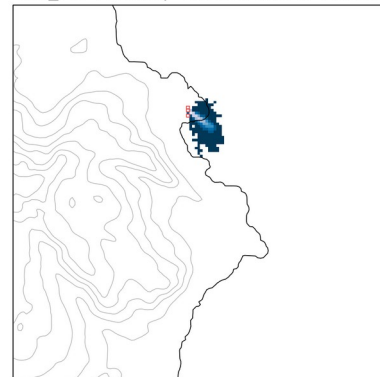
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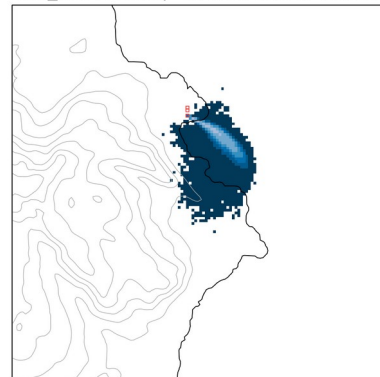
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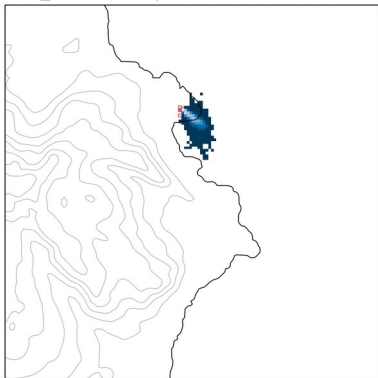
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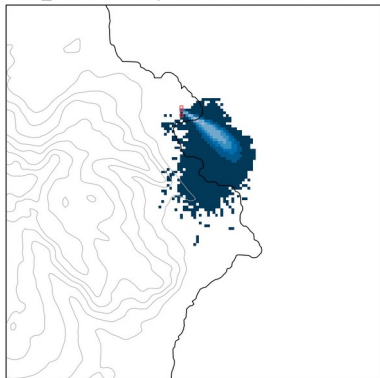
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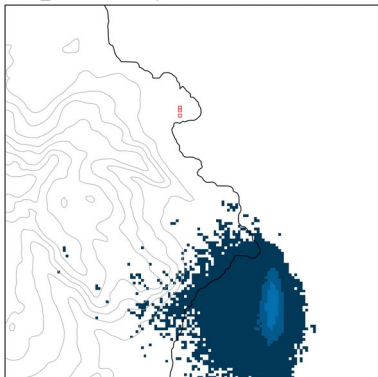


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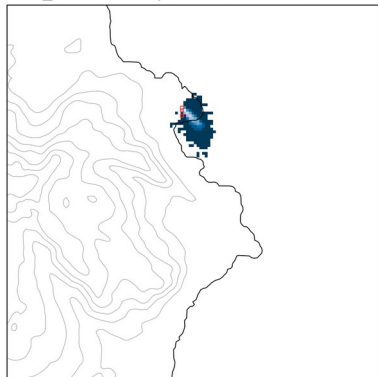


Forward time $n=7$
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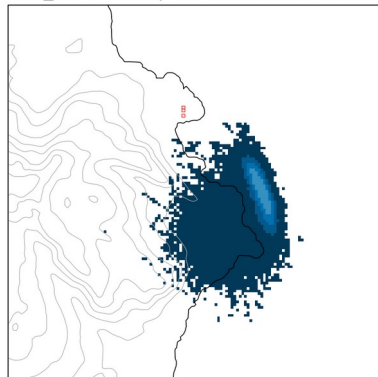
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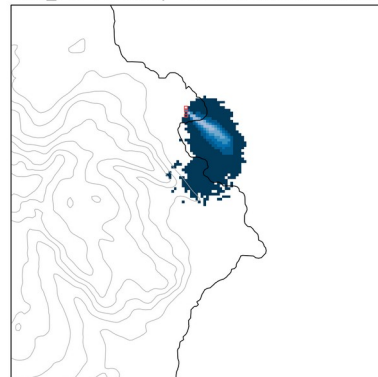
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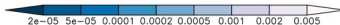
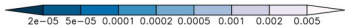
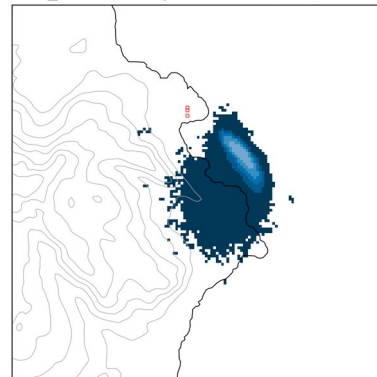
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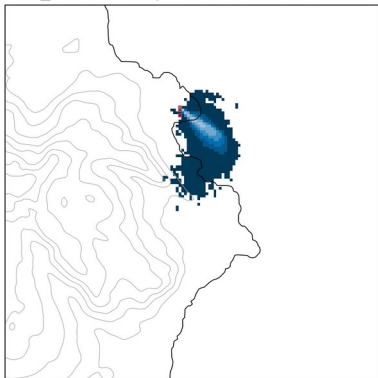
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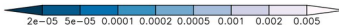
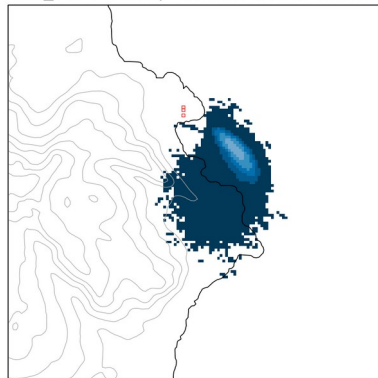
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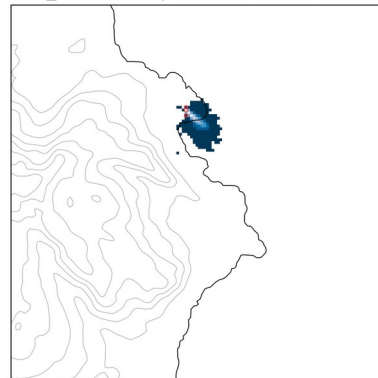
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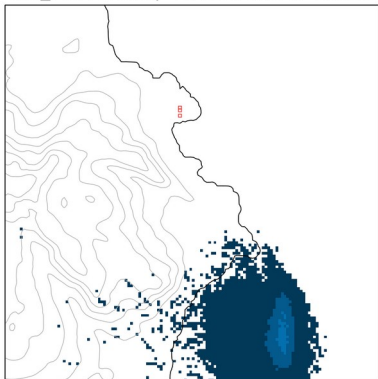


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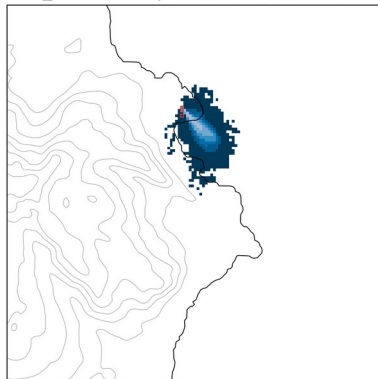


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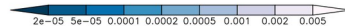
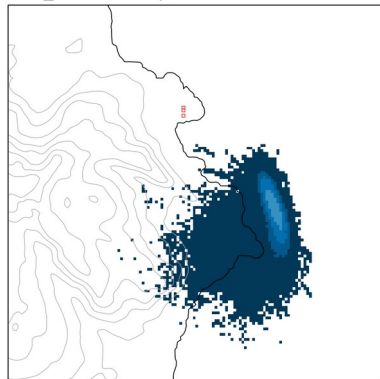
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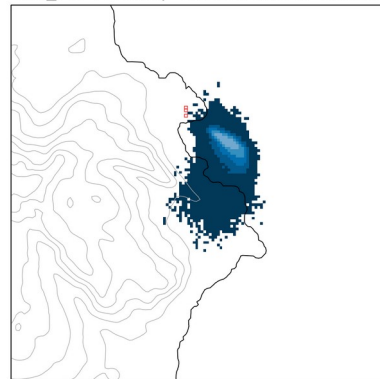
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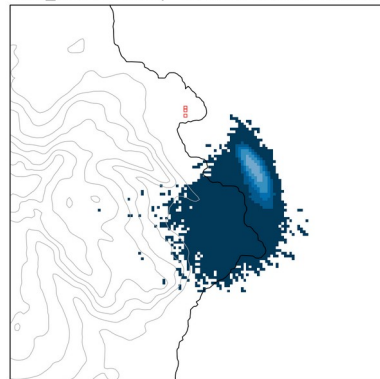
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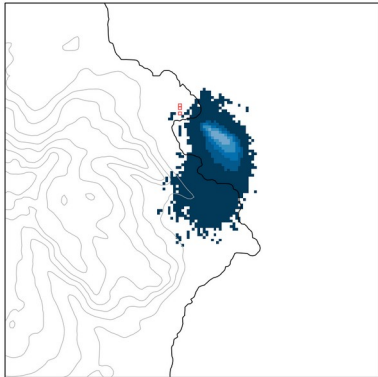
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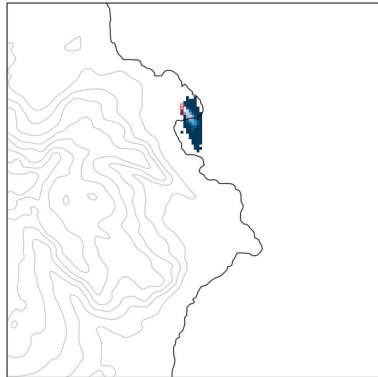
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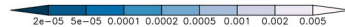
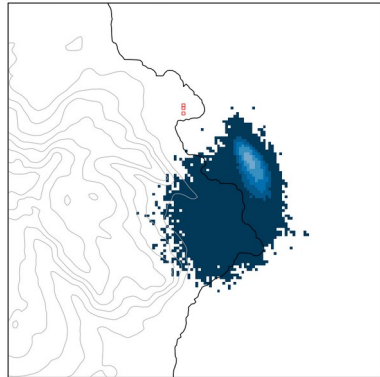
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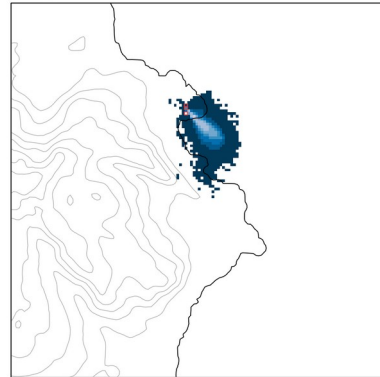
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066_101 retroem:j=4,10:00; time n=5,08:30

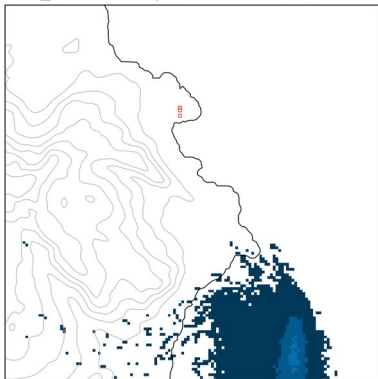


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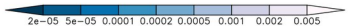
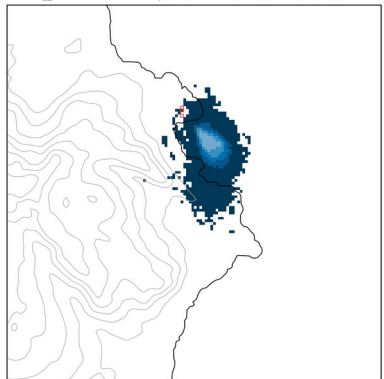


Forward time $n=5$
08:00 – 08:30

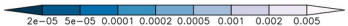
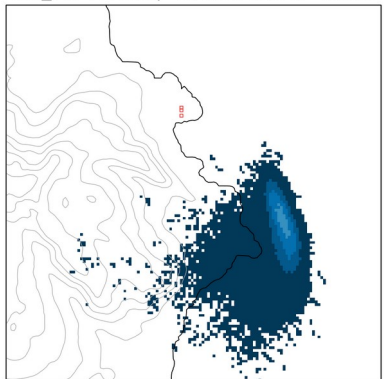
066_102 retroem:j=7,11:30; time n=4,08:00



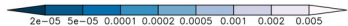
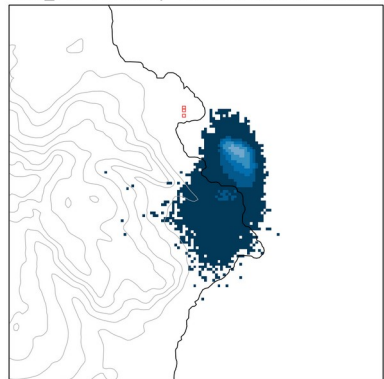
066_102 retroem:j=2,09:00; time n=4,08:00



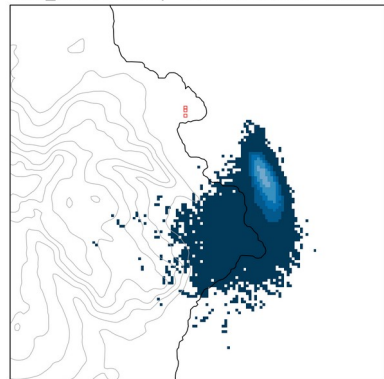
066_101 retroem:j=5,10:30; time n=4,08:00



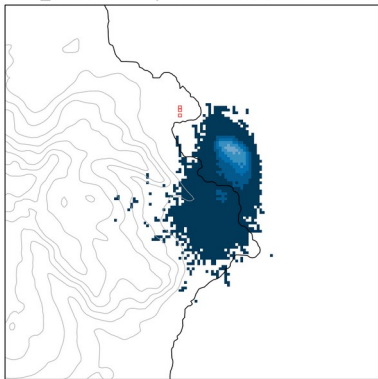
066_101 retroem:j=3,09:30; time n=4,08:00



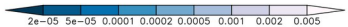
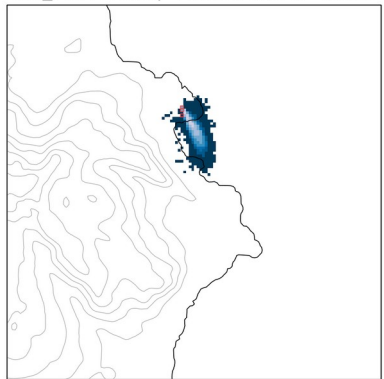
066_099 retroem:j=4,10:00; time n=4,08:00



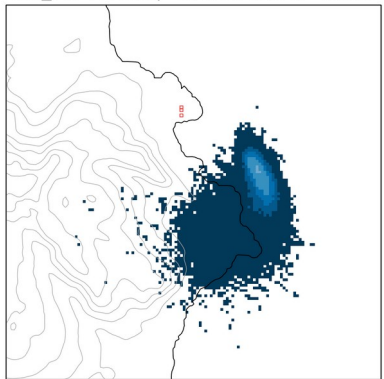
066_102 retroem:j=3,09:30; time n=4,08:00



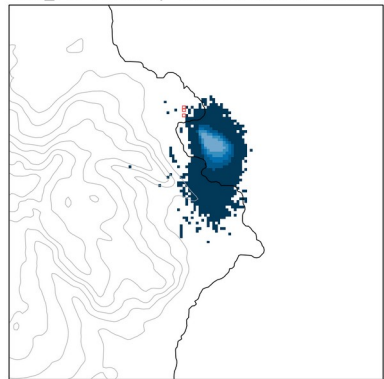
066_102 retroem:j=1,08:30; time n=4,08:00



066_101 retroem:j=4,10:00; time n=4,08:00

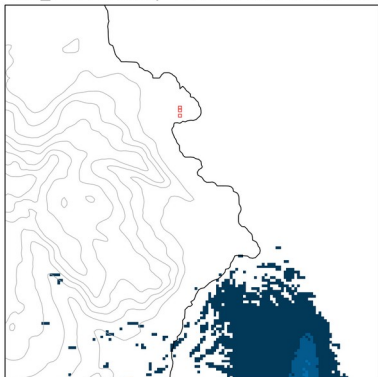


066_101 retroem:j=2,09:00; time n=4,08:00

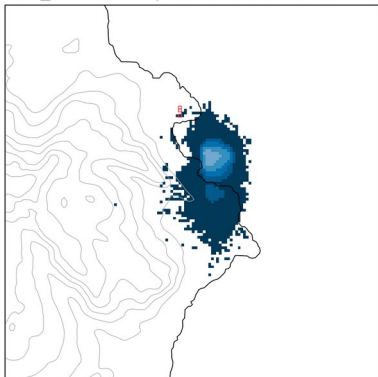


Forward time $n=4$
07:30 – 08:00

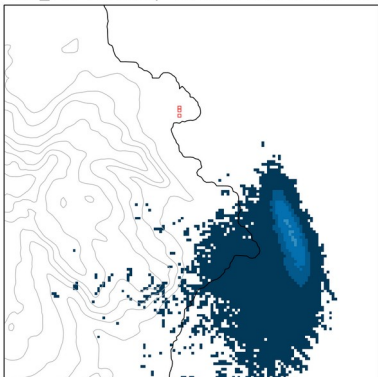
066_102 retroem:j=7,11:30; time n=3,07:30



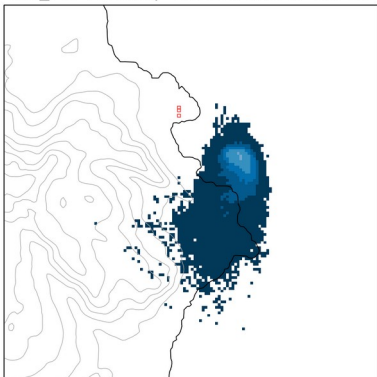
066_102 retroem:j=2,09:00; time n=3,07:30



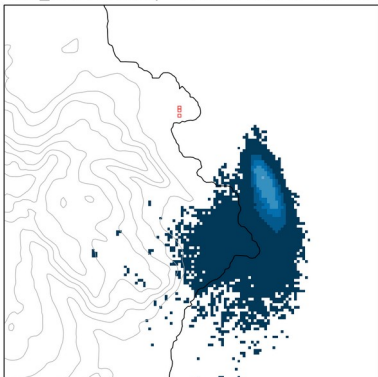
066_101 retroem:j=5,10:30; time n=3,07:30



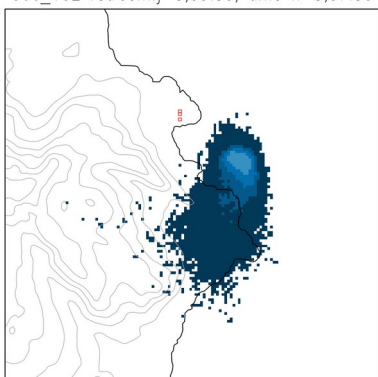
066_101 retroem:j=3,09:30; time n=3,07:30



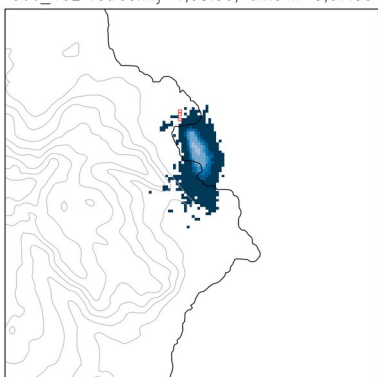
066_099 retroem:j=4,10:00; time n=3,07:30



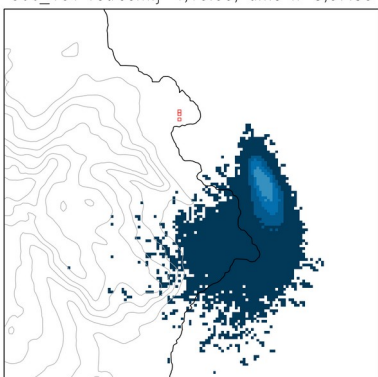
066_102 retroem:j=3,09:30; time n=3,07:30



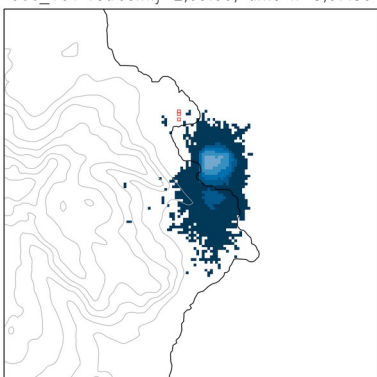
066_102 retroem:j=1,08:30; time n=3,07:30



066_101 retroem:j=4,10:00; time n=3,07:30

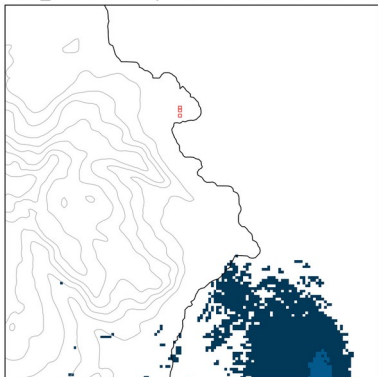


066_101 retroem:j=2,09:00; time n=3,07:30

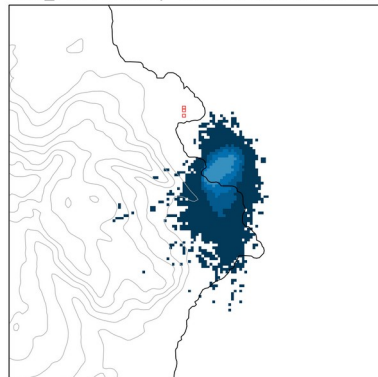


Forward time $n=3$
07:00 – 07:30

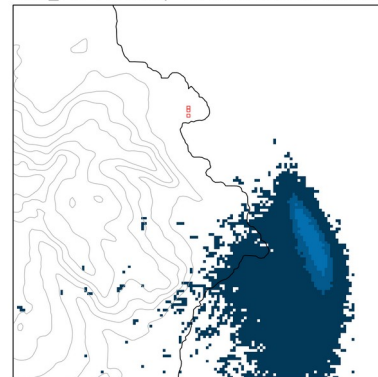
066_102 retroem:j=7,11:30; time n=2,07:00



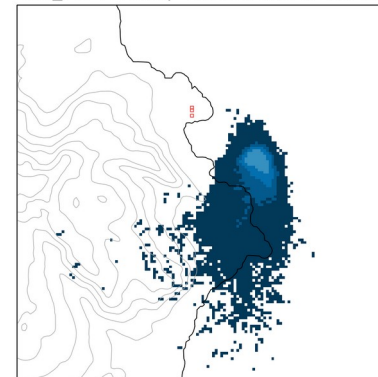
066_102 retroem:j=2,09:00; time n=2,07:00



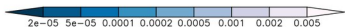
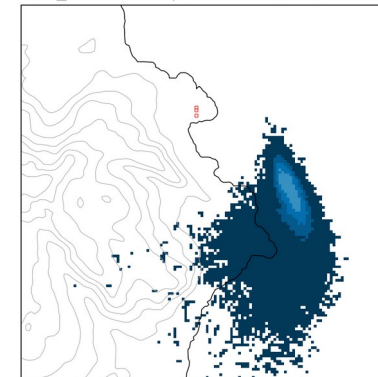
066_101 retroem:j=5,10:30; time n=2,07:00



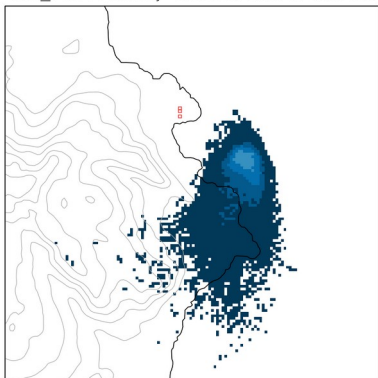
066_101 retroem:j=3,09:30; time n=2,07:00



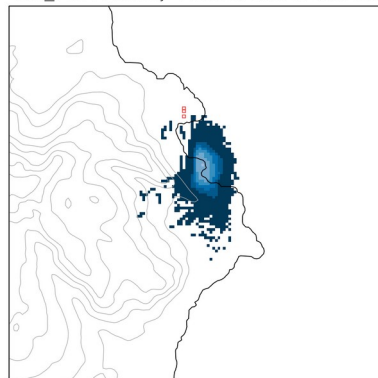
066_099 retroem:j=4,10:00; time n=2,07:00



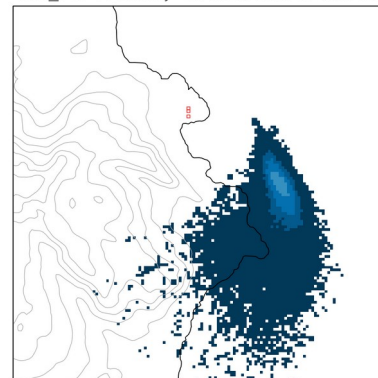
066_102 retroem:j=3,09:30; time n=2,07:00



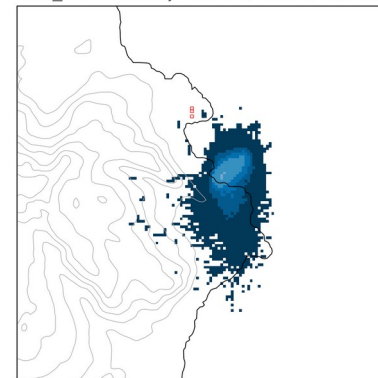
066_102 retroem:j=1,08:30; time n=2,07:00



066_101 retroem:j=4,10:00; time n=2,07:00

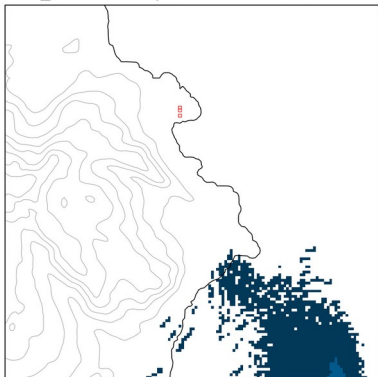


066_101 retroem:j=2,09:00; time n=2,07:00

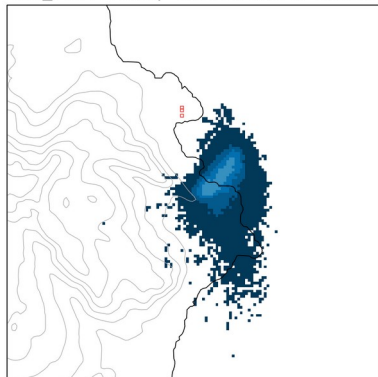


Forward time $n=2$
06:30 – 07:00

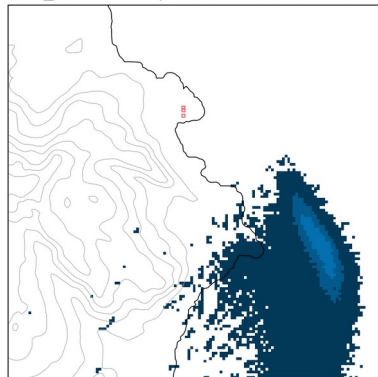
066_102 retroem:j=7,11:30; time n=1,06:30



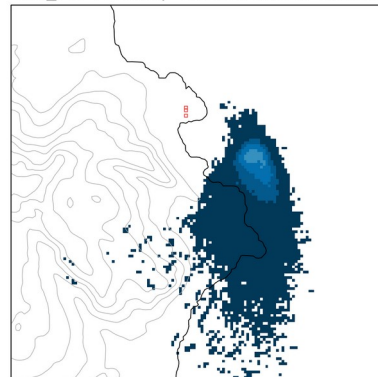
066_102 retroem:j=2,09:00; time n=1,06:30



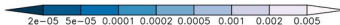
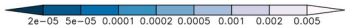
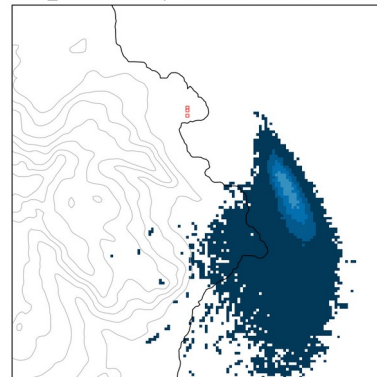
066_101 retroem:j=5,10:30; time n=1,06:30



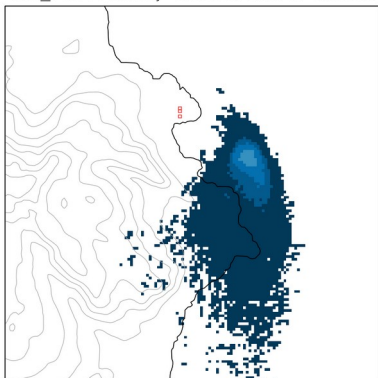
066_101 retroem:j=3,09:30; time n=1,06:30



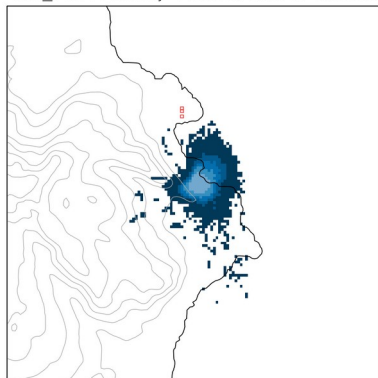
066_099 retroem:j=4,10:00; time n=1,06:30



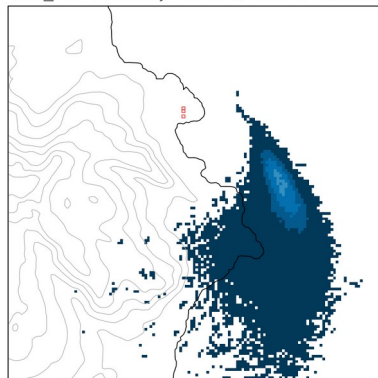
066_102 retroem:j=3,09:30; time n=1,06:30



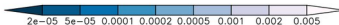
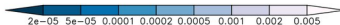
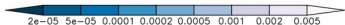
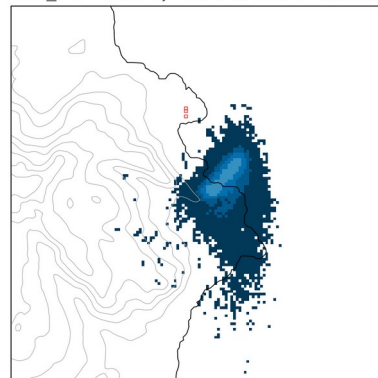
066_102 retroem:j=1,08:30; time n=1,06:30



066_101 retroem:j=4,10:00; time n=1,06:30



066_101 retroem:j=2,09:00; time n=1,06:30



Forward time $n=1$
06:00 – 06:30

Combinazione di *retro-puff*

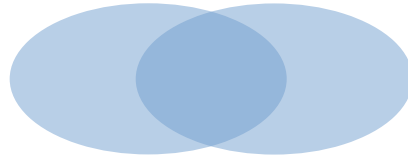
Si cerca una sola sorgente, una posizione spaziale, che con emissioni in uno o più intervalli di tempo possa aver dato origine alle (pseudo-)osservazioni, ovvero alla molestia olfattiva che è stata segnalata.

➔ La sorgente deve dare origine a **tutte** le pseudo-osservazioni: **AND**

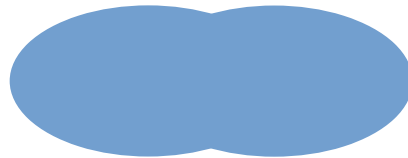
➔ Le pseudo-osservazioni possono essere originate da un tempo di emissione **O** da un altro: **OR**

Combinazione di *retro-puff*

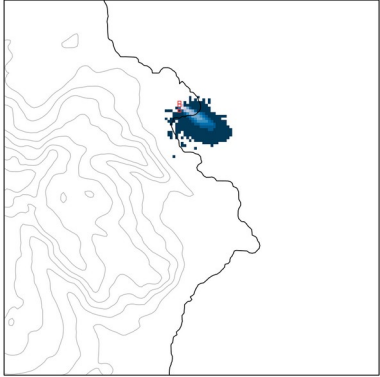
Il prodotto (punto a punto) di due campi è grande dove sono grandi entrambi, ed è piccolo dove è piccolo anche solo uno dei due. La **media geometrica** di N campi rappresenta un **AND** logico (intersezione).



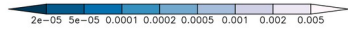
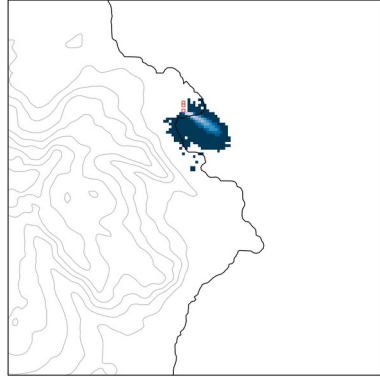
La somma (punto a punto) di due campi è grande dove è grande anche solo uno dei due, ed è piccola solo dove sono piccoli entrambi. La **media aritmetica** di N campi rappresenta un **OR** logico (unione).



066_101 retroem:j=4,10:00; time n=8,10:00



066_099 retroem:j=4,10:00; time n=8,10:00

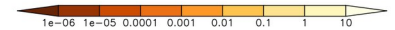
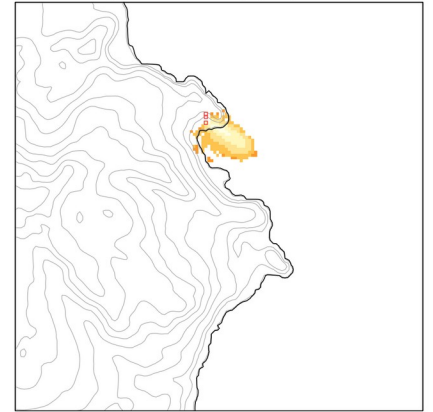


AND:

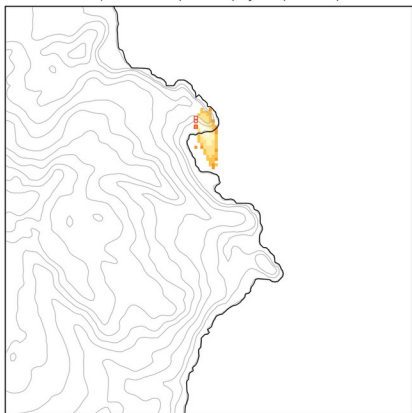
Media geometrica



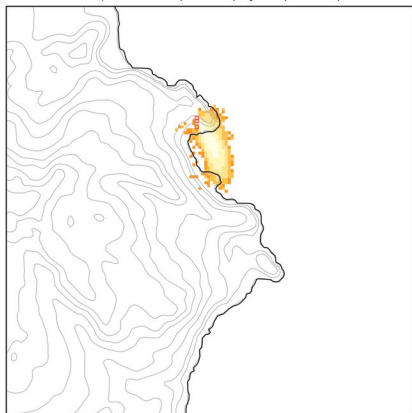
chipos n=8(10:00) j=4(10:00)



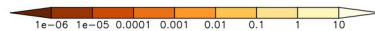
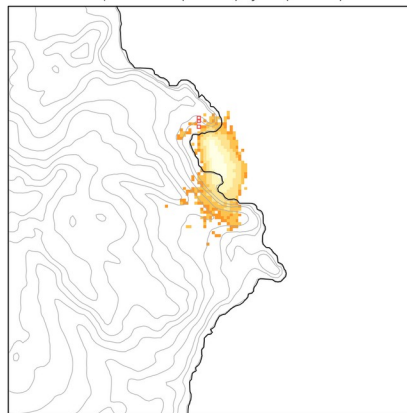
chupos n=5(08:30) j=1(08:30)



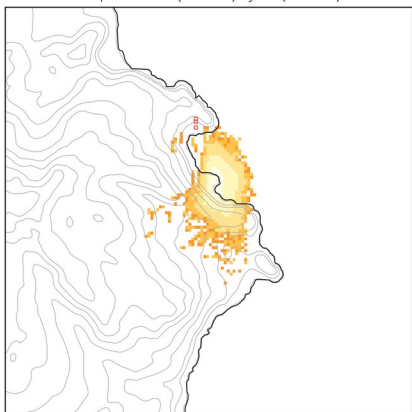
chupos n=4(08:00) j=1(08:30)



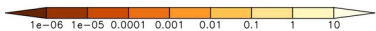
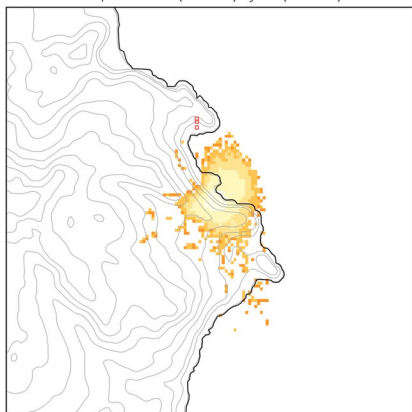
chupos n=3(07:30) j=1(08:30)



chupos n=2(07:00) j=1(08:30)



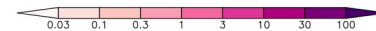
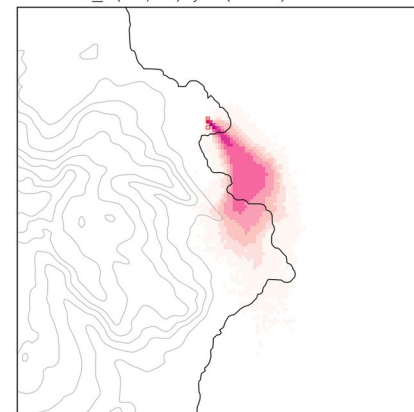
chupos n=1(06:30) j=1(08:30)

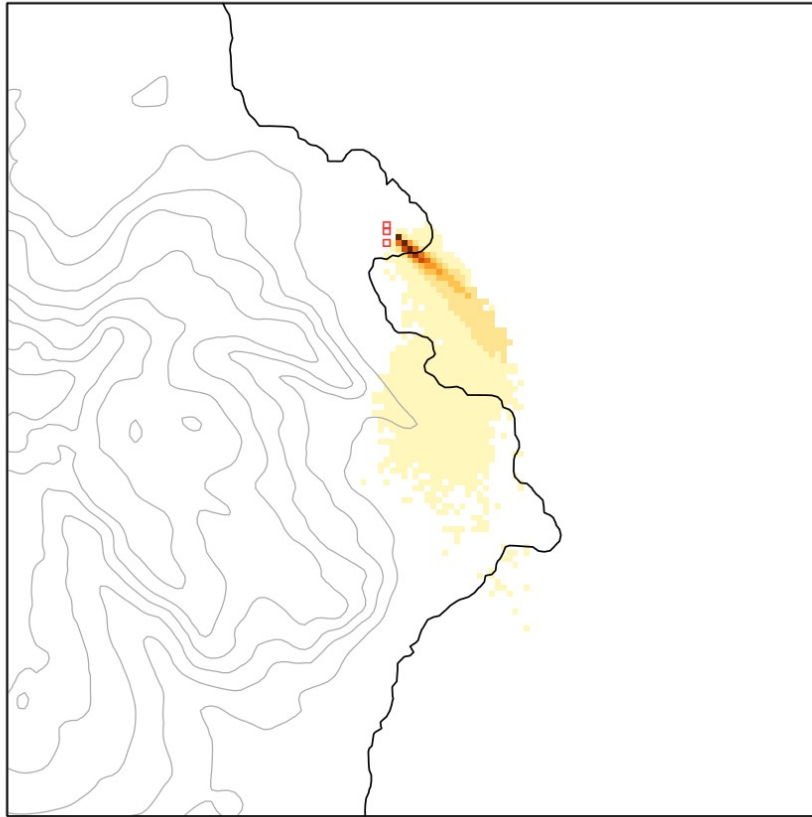


OR:
Media aritmetica



SUM_n(chupos) j=2(09:00) NO zmask



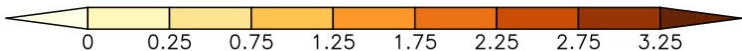


Caso del 13 Aprile 2020

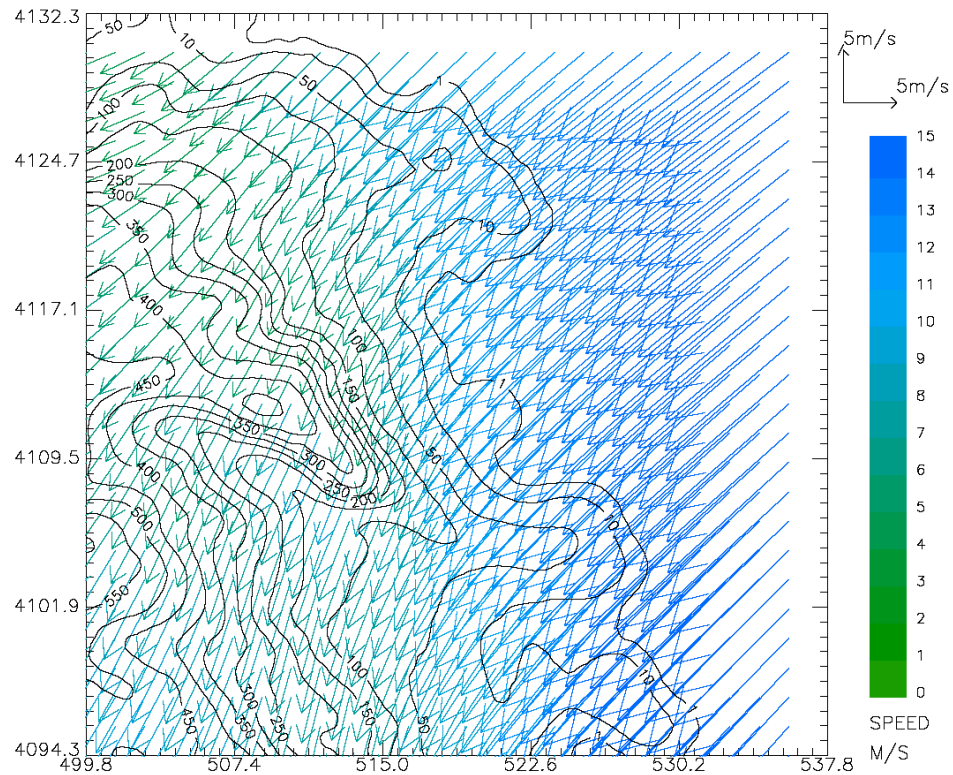
Mappa delle possibili posizioni della sorgente

In un'integrazione di SPRAY in avanti:

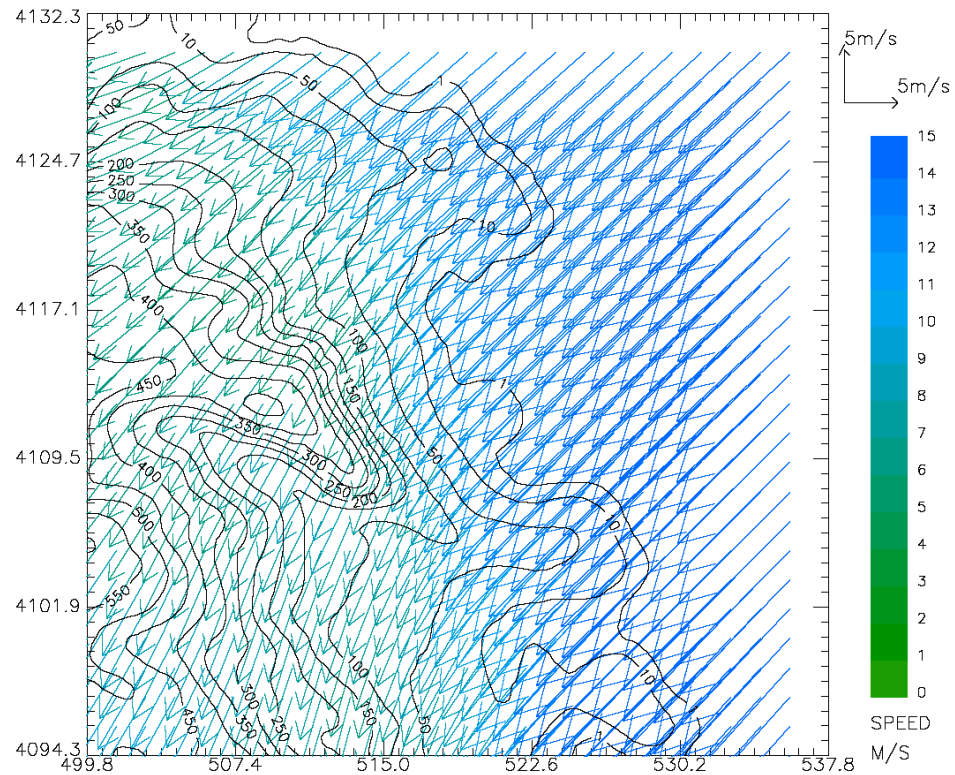
- Una sorgente collocata nelle aree più scure può dare origine alle pseudo-osservazioni (segnalazioni aggregate) con minori quantità emesse, il pennacchio investe le zone di segnalazione in modo diretto.
- Una sorgente collocata nelle aree più chiare per dare origine alle pseudo-osservazioni deve emettere molto di più, il pennacchio investe le zone di segnalazione in modo marginale.



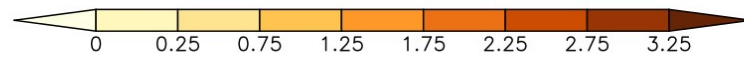
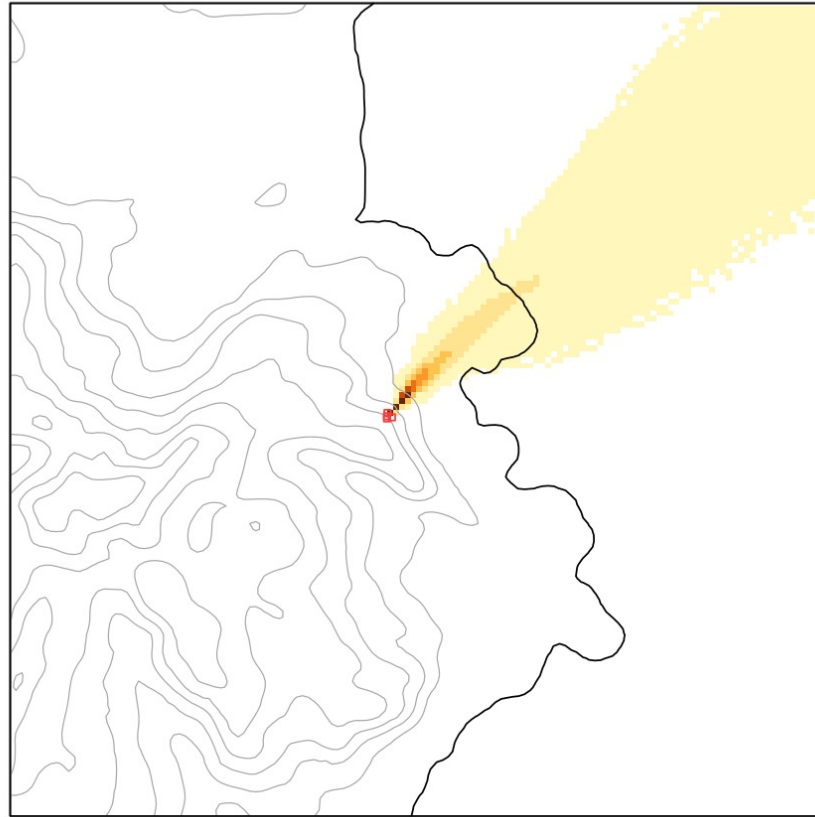
AVISU 1.13.0 14/February/2022 17:17
File: C:\Users\User\Documents\progett\NOSE\retrospray\meteo\aramis_cest_030420.bin
Model ARAMIS Simulation time: 03.04.2020 20:00:00 Wind colored by: SPEED
Area range [499.834,4094.27] [537.834,4132.27] Top of domain 10557.6
Global data range: [0,29.7898] Actual: [4.2965,15.6253]



AVISU 1.13.0 14/February/2022 17:17
File: C:\Users\User\Documents\progett\NOSE\retrospray\meteo\aramis_cest_030420.bin
Model ARAMIS Simulation time: 03.04.2020 21:00:00 Wind colored by: SPEED
Area range [499.834,4094.27] [537.834,4132.27] Top of domain 10557.6
Global data range: [0,28.8132] Actual: [5.15167,15.2731]



chicomb POS - N0 zmask



Conclusioni

È possibile utilizzare **informazioni** con forti componenti **qualitative e soggettive**, quali le segnalazioni dei cittadini tramite Web-App su un evento di molestia olfattiva, per arrivare a delimitare con **tecniche numeriche** l'area di possibile posizione della sorgente delle sostanze odorigene.

La **combinazione di retro-puff** basata su **AND** e **OR numerici** è efficace nel sintetizzare le informazioni prodotte da RetroSPRAY.

La *suite* modellistica **SMART** assicura una riproduzione accurata della circolazione e della dispersione atmosferica, in quanto composta da modelli numerici avanzati rappresentativi dello stato dell'arte, **MOLOCH** e **SPRAY/RetroSPRAY**.

È prevista l'**implementazione operativa** nell'ambito del progetto NOSE. Tempi di calcolo brevi: è possibile eseguire l'analisi a ridosso dell'evento.

Ringraziamenti: I campi di MOLOCH ad alta risoluzione, 500m, sono stati forniti da **Piero Malguzzi** e **Oxana Drofa** di CNR-ISAC, Bologna.

Trini Castelli S., Tinarelli G., Uboldi F., Malguzzi P., Bonasoni P., 2022. Developments of SPRAY Lagrangian particle dispersion model for tracing the origin of odour nuisance. In: Air Pollution Modeling and its Application XXVIII, Mensink C. and Jorba Casellas O. Eds, Springer Proceedings in Complexity, Springer Publisher, in press.