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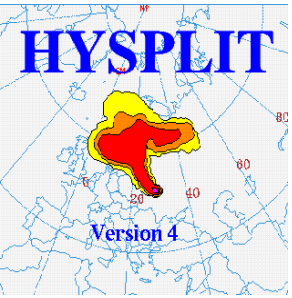

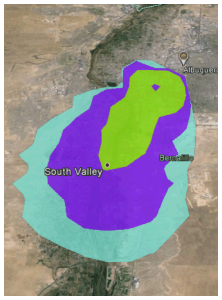

HYSPLIT Implementation and Verification for HazDAC and SUMMIT

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Mentors: Dr. Meghan Peterson

Dr. Nerayo Teclemariam

Sandia National Laboratories

Exceptional service in the national interest

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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Overview

Sandia National Laboratories

- Current rising junior at Princeton University
  - Majoring in Chemical Engineering
  - Minors in computer science and materials science
- Working on incorporating models into toolkits
  - HazDAC
  - SUMMIT
- Verifying that the models work correctly and are consistent
  - HYSPLIT
  - HPAC

Bioterrorism Preparation

Sandia National Laboratories

- Need to be prepared for possible agent release
  - Where to place sensors to best detect a release?
  - How should emergency response teams prepare?
- Two Options:
  - Tracer experiments
    - Expensive and time intensive
    - Only accounts for one place/time
    - But is real
  - Simulations
    - Can account for any place/time
    - Cheap and not time intensive
    - But only as good as algorithm and input data

Modeling as a Preparation Tool

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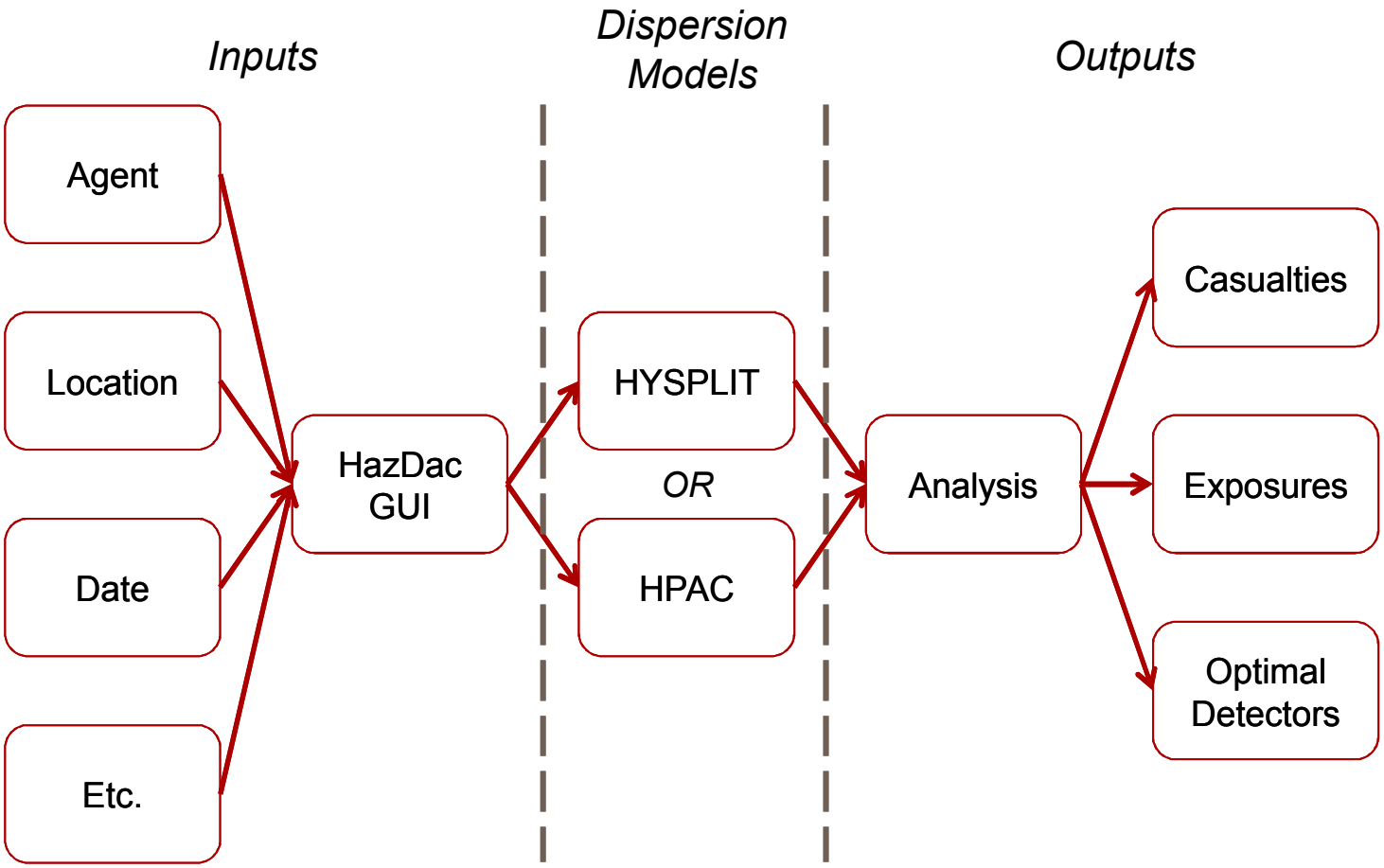
- Many models simulate the release of an agent
- HPAC – various agent release simulations
  - DTRA created
  - Standard for threat modelling
  - But a pain to install, only works on 32-bit windows
- HYSPLIT – atmospheric dispersion simulations
  - NOAA created
  - Platform independent and very lightweight

HazDAC Overview

- Integrated toolset for simulating chem and bio incidents and responses



Verification of HYSPLIT Necessary

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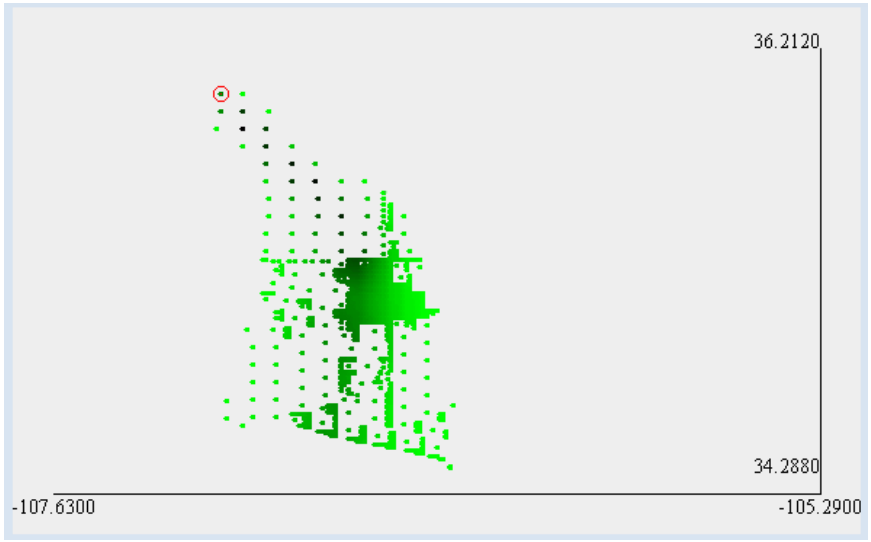
- HPAC
  - HazDAC default model
  - Assume accurate
- *NEW* HYSPLIT
  - Much easier to install for clients
- Can we trust HYSPLIT?
  - Need to affirm that HYSPLIT is “equivalent” to HPAC for HazDAC’s needs

Visualization of HPAC and HYSPLIT

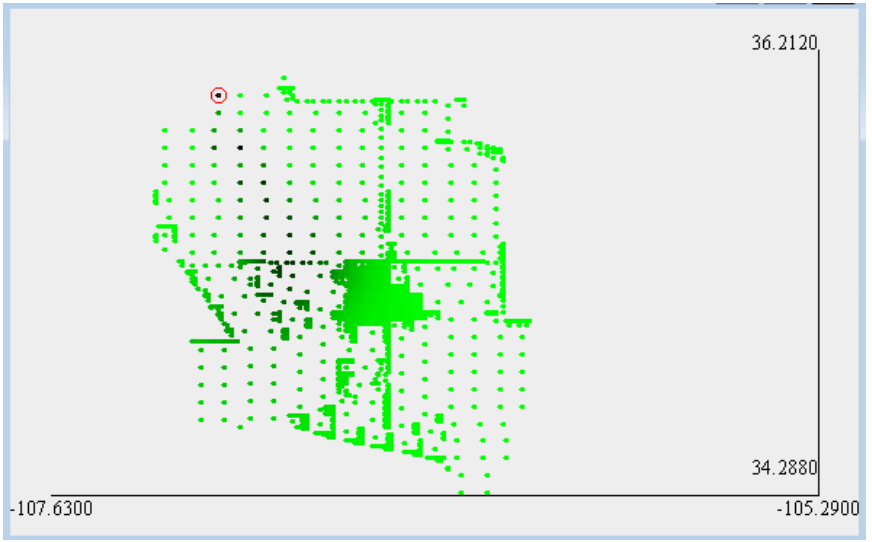
Location: Albuquerque (ABQ)
Duration: 12.0 hrs
Agent: Anthrax
Start date: 01/01/08 03:00:00

Concentration normalized to a scale of 0 – 1 then translated to colored pixel.

HYSPLIT:
(normalized to 4.9E-7, MAX = 4.9E-7, MIN = 3.23E-13)



HPAC:
(normalized to 8.9E-7, MAX = 8.9E-6, MIN = 1.0E-13)



** Four points excluded from normalization in HPAC run*

Quantifying Comparisons

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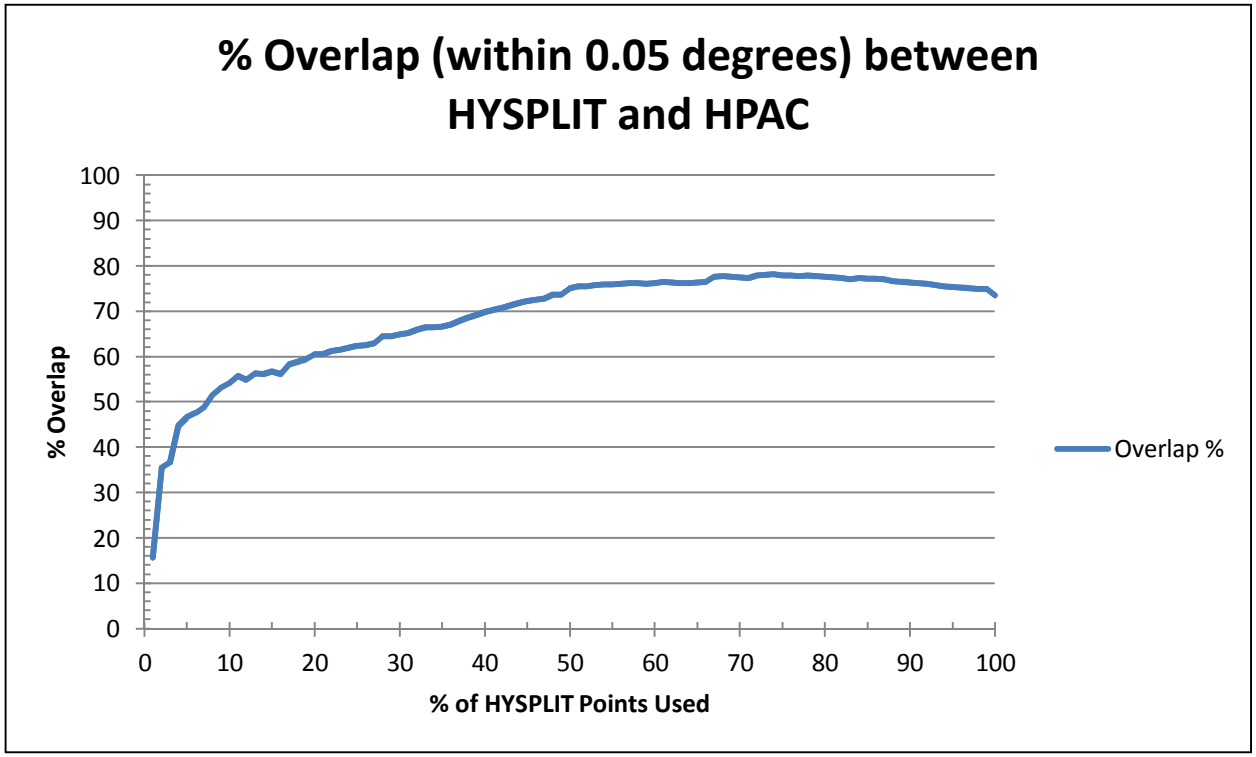
- Concentration overlap
  - How much of the top x% points are the same in HYSPLIT and HPAC?
- Concentration profile
  - How do the absolute concentration numbers compare?
- Exposures and casualties
  - How do they compare?
- Detection optimization
  - How does the percent detected compare?
  - How do the optimal detection locations compare?

- Remember: HPAC and HYSPLIT will **never** be exactly the same

Similar Concentration Overlap

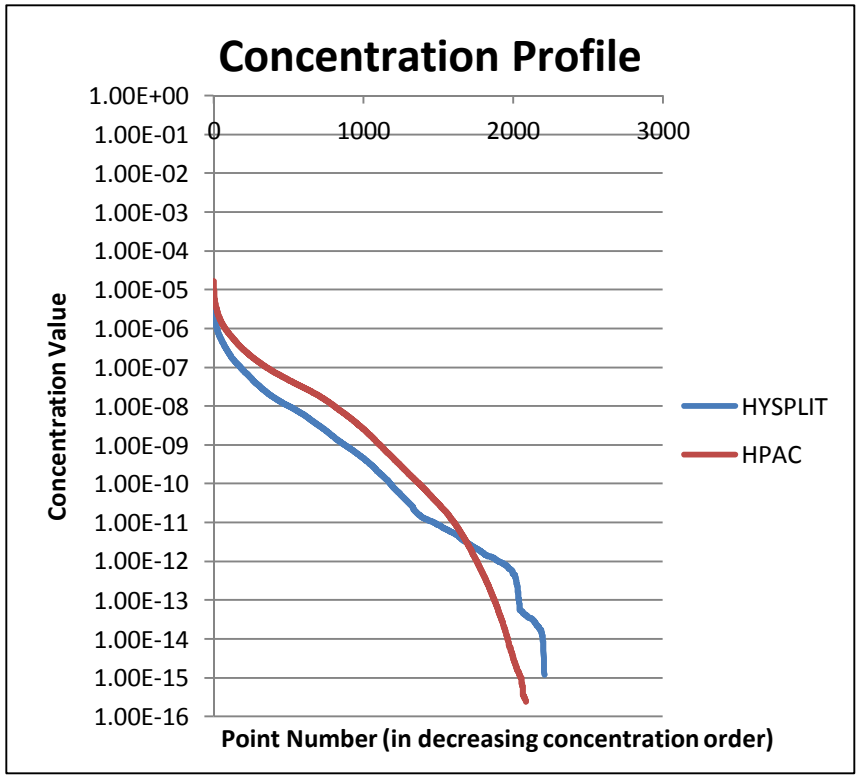
- Significant overlap in the regions covered by both models

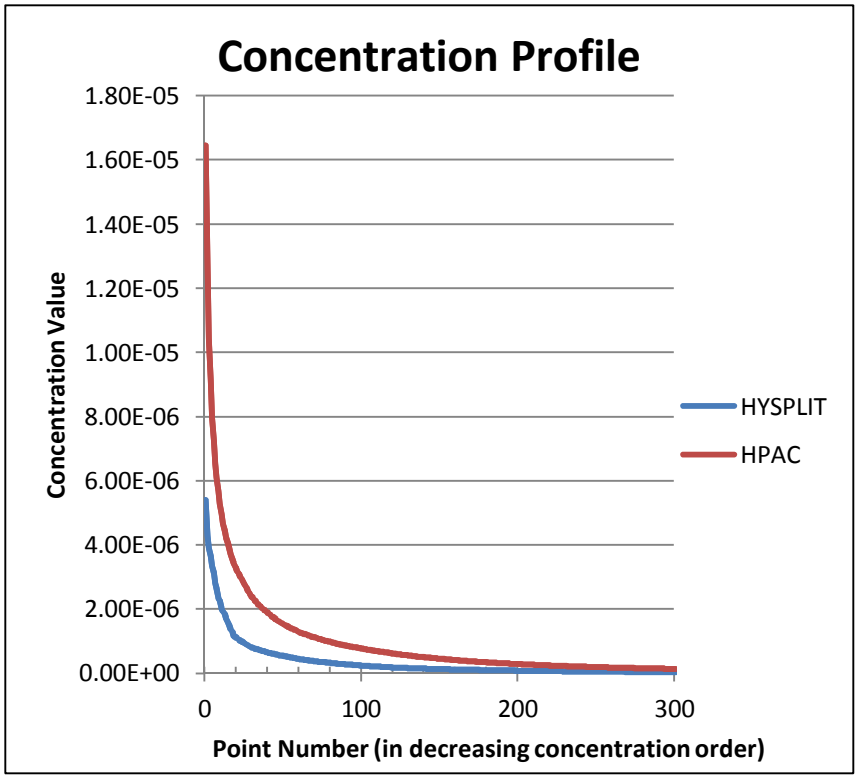


** 57 random locations*

Larger HPAC Concentration Profile

- HPAC appears to have more “concentration” than HYSPLIT

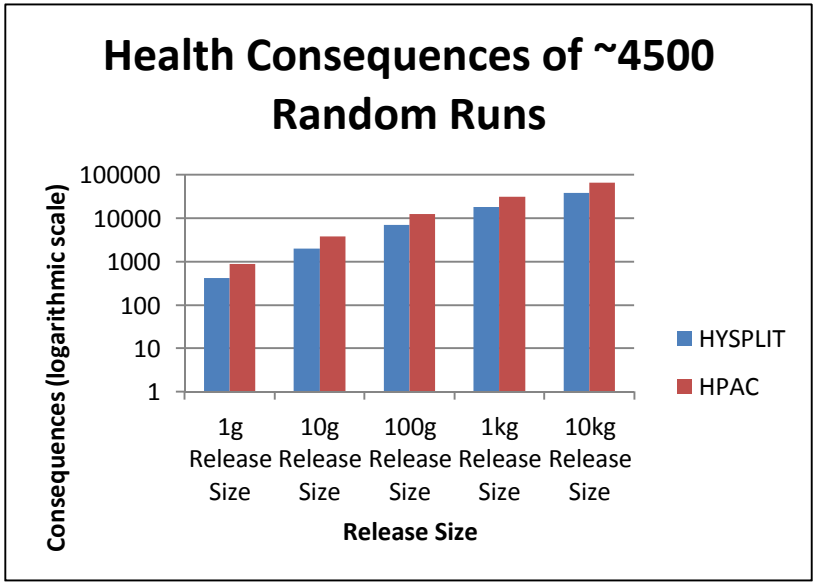


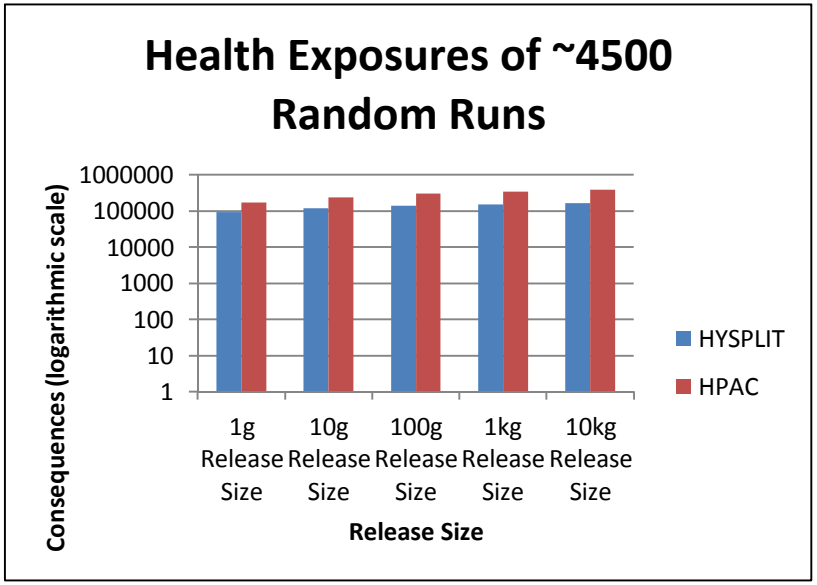


** 450 random locations in ABQ*

Larger HPAC Health Effects

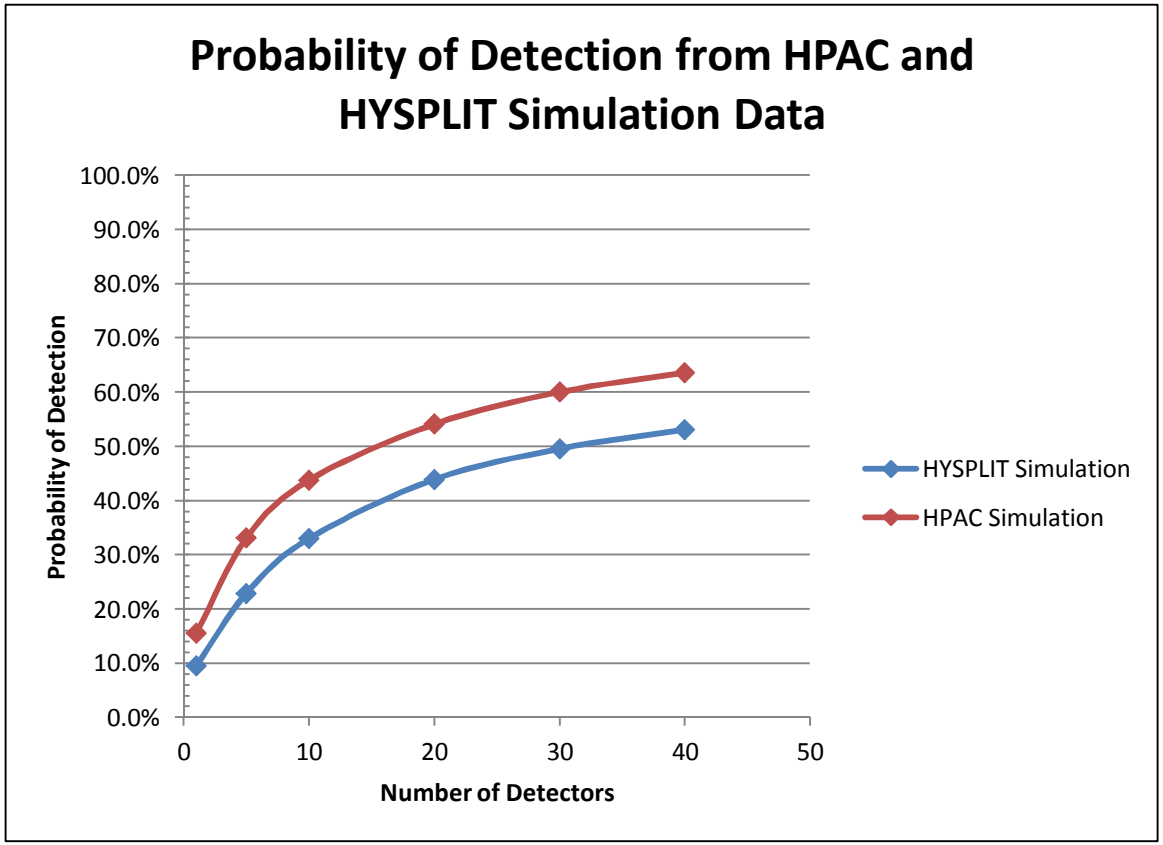
- HYSPLIT and HPAC are same order of magnitude
- But HPAC consistently ~2 times more than HYSPLIT





Higher HPAC Detector Optimization

- A *very* good metric of comparison
- ~4500 random runs in ABQ



Model Differences: Consistent?

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- HYSPLIT and HPAC have a reasonable overlap
- The exposure and consequence numbers are comparable

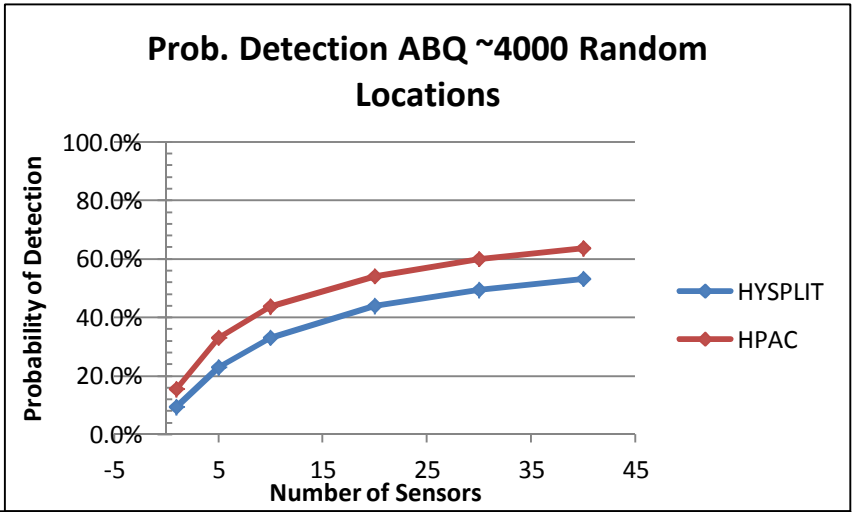
- Yet HPAC leads to higher probabilities of detection
  - Also has consistently higher exposure and consequence numbers
  - Could be caused by larger concentration values

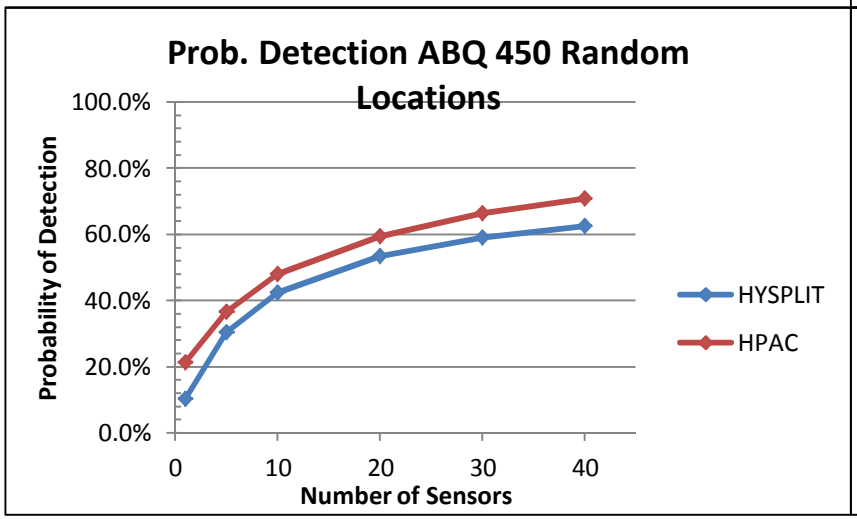
- Next Steps:
  - Find reasonable run size
  - Check consistency of results

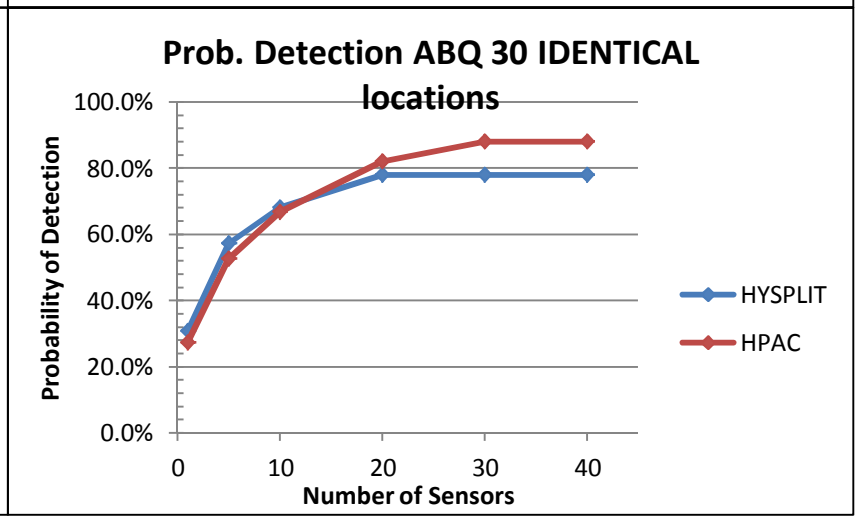
Reasonable Run Sample - 450

- Memory
- Time

- 450 is a reasonable run size

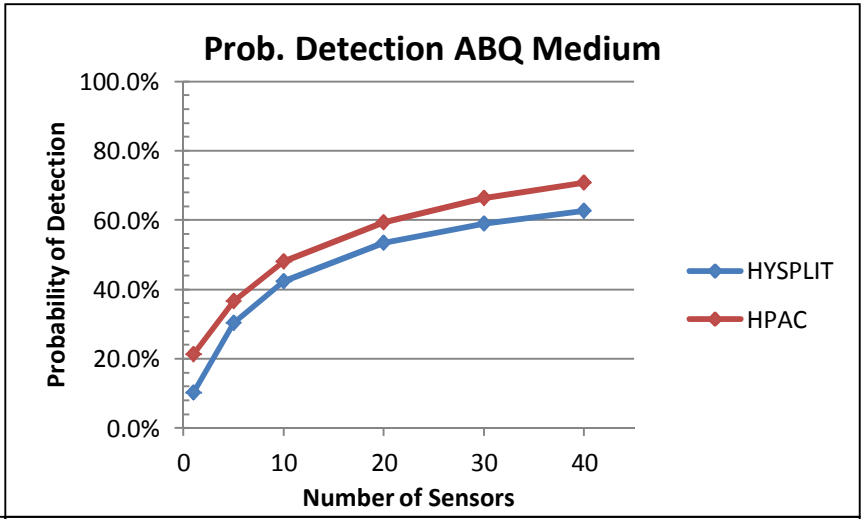


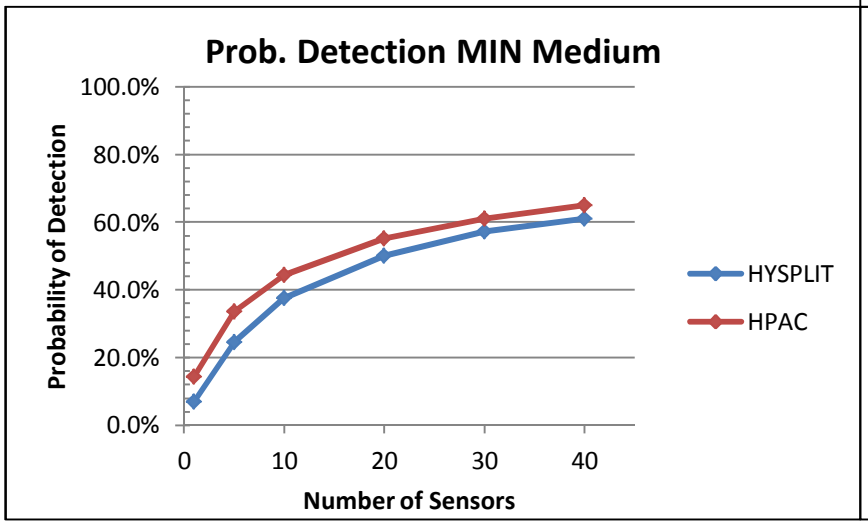


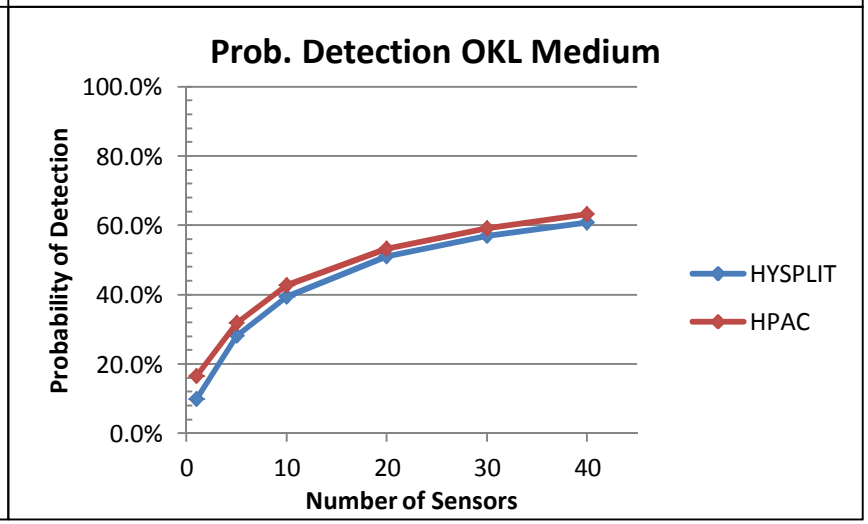


Model Differences Consistent

- HPAC consistently results in higher probabilities of detection

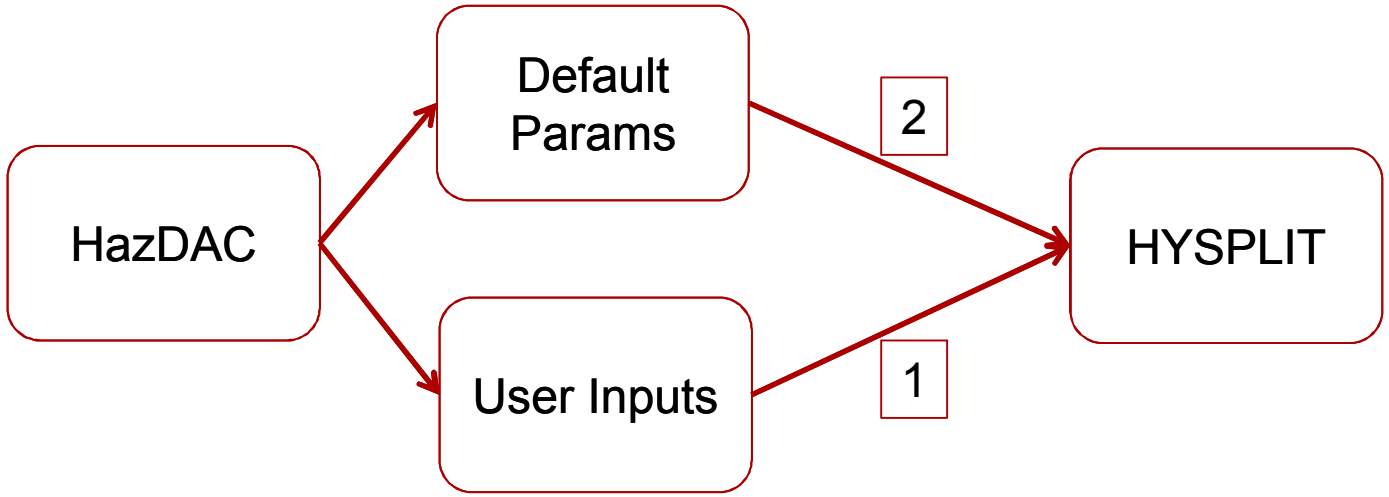






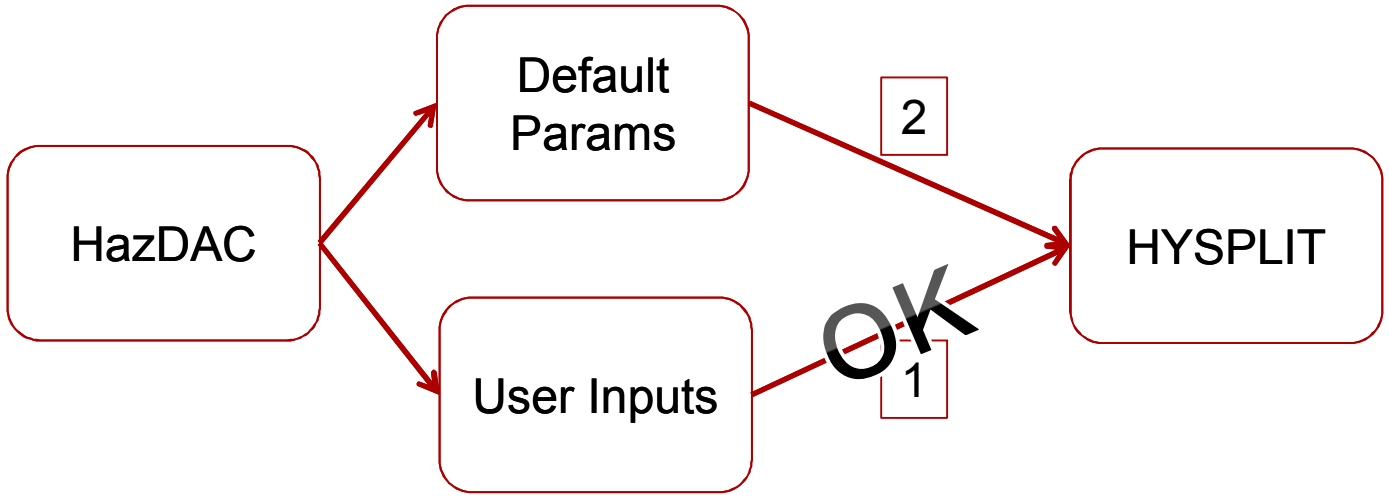
Three Possible Explanations

1) HazDAC is not translating user inputs to HYSPLIT correctly
   - Can be easily fixed
2) Default parameters in HYSPLIT are different than HPAC
   - Can probably be identified and fixed
3) HPAC and HYSPLIT are fundamentally different
   - Experimental validation required



1) Translating User Inputs: OKAY

- Inputs such as mass released, release location, etc.
- Conclusion: User inputs correctly given to HYSPLIT



2) HYSPLIT Default Parameters

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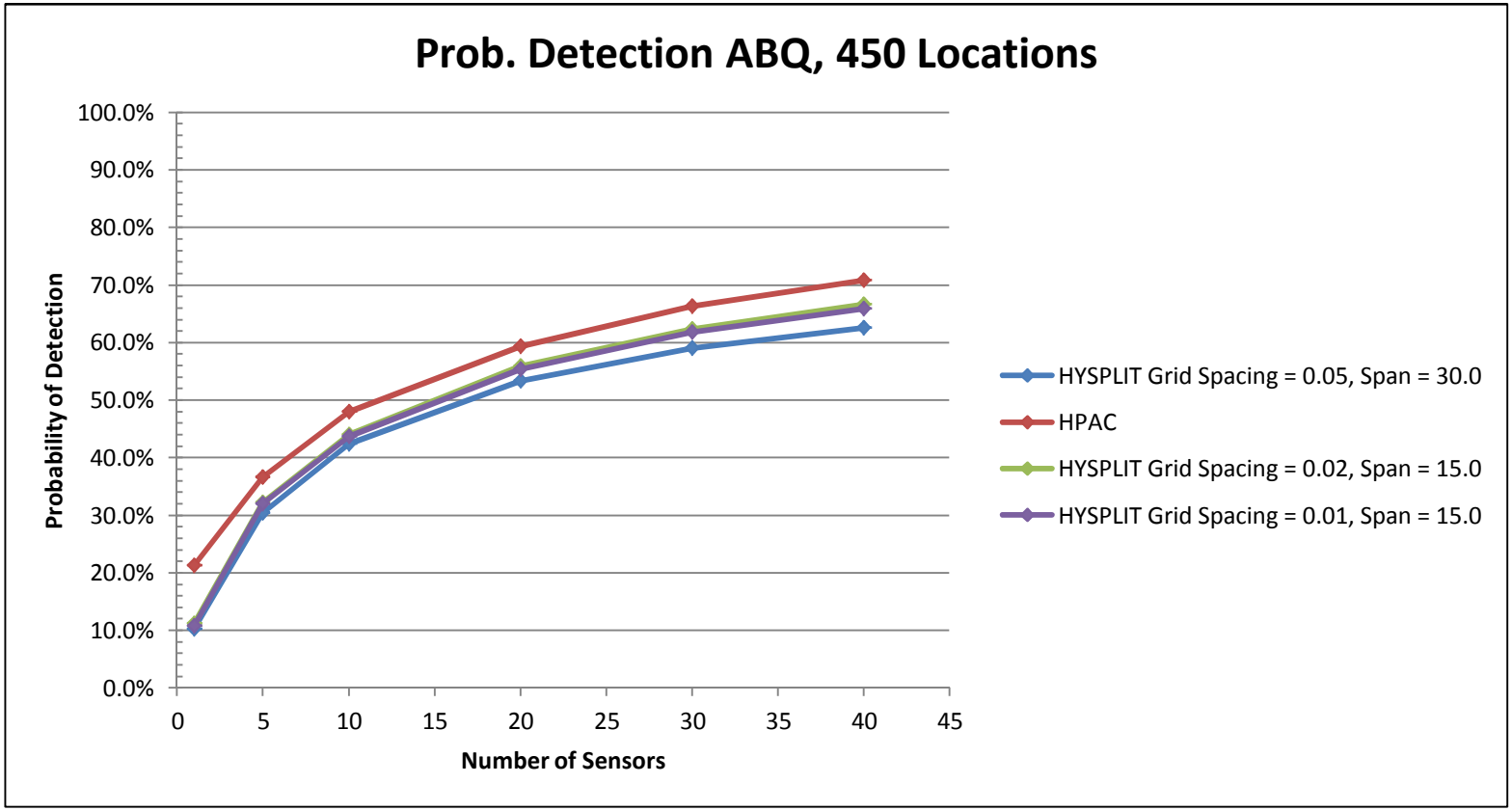
- Parameters that can be easily changed:
  - Grid Spacing
  - Time step
  - Release particle number
  - Gaussian distribution

- Other advanced parameters:
  - Deposition constants
  - Split-merge constants
  - Turbulence methods

Smaller Grid Reduces Differences

- Decreasing grid size brings HYSPLIT curve close to HPAC

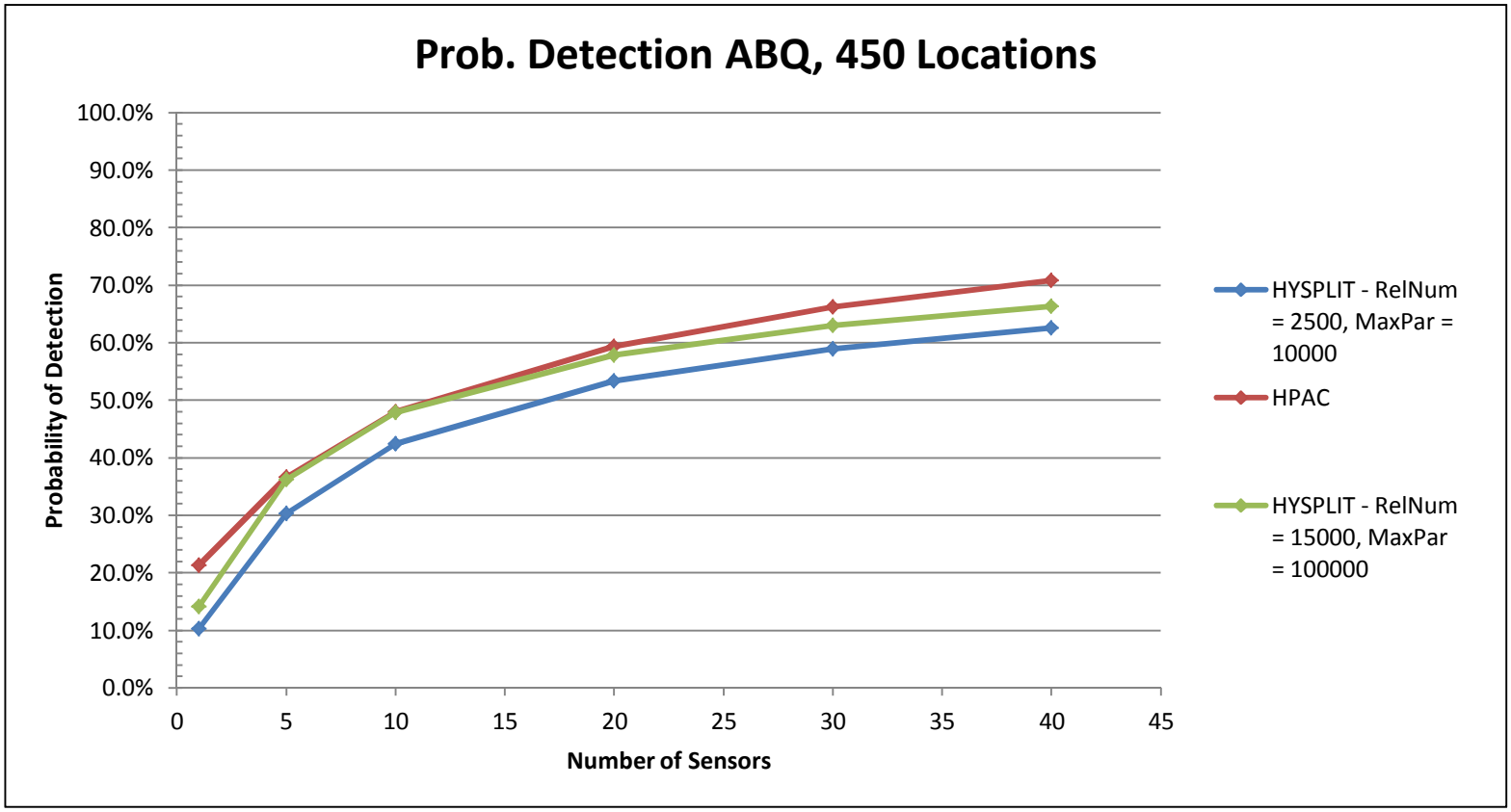


Smaller Δt Reduces Differences

- Decreasing time step brings HYSPLIT curve closer to HPAC

Larger Releases Reduce Differences

- Increasing the number of initial particles released brings curves closer



Time/Memory vs. Accuracy

Sandia National Laboratories

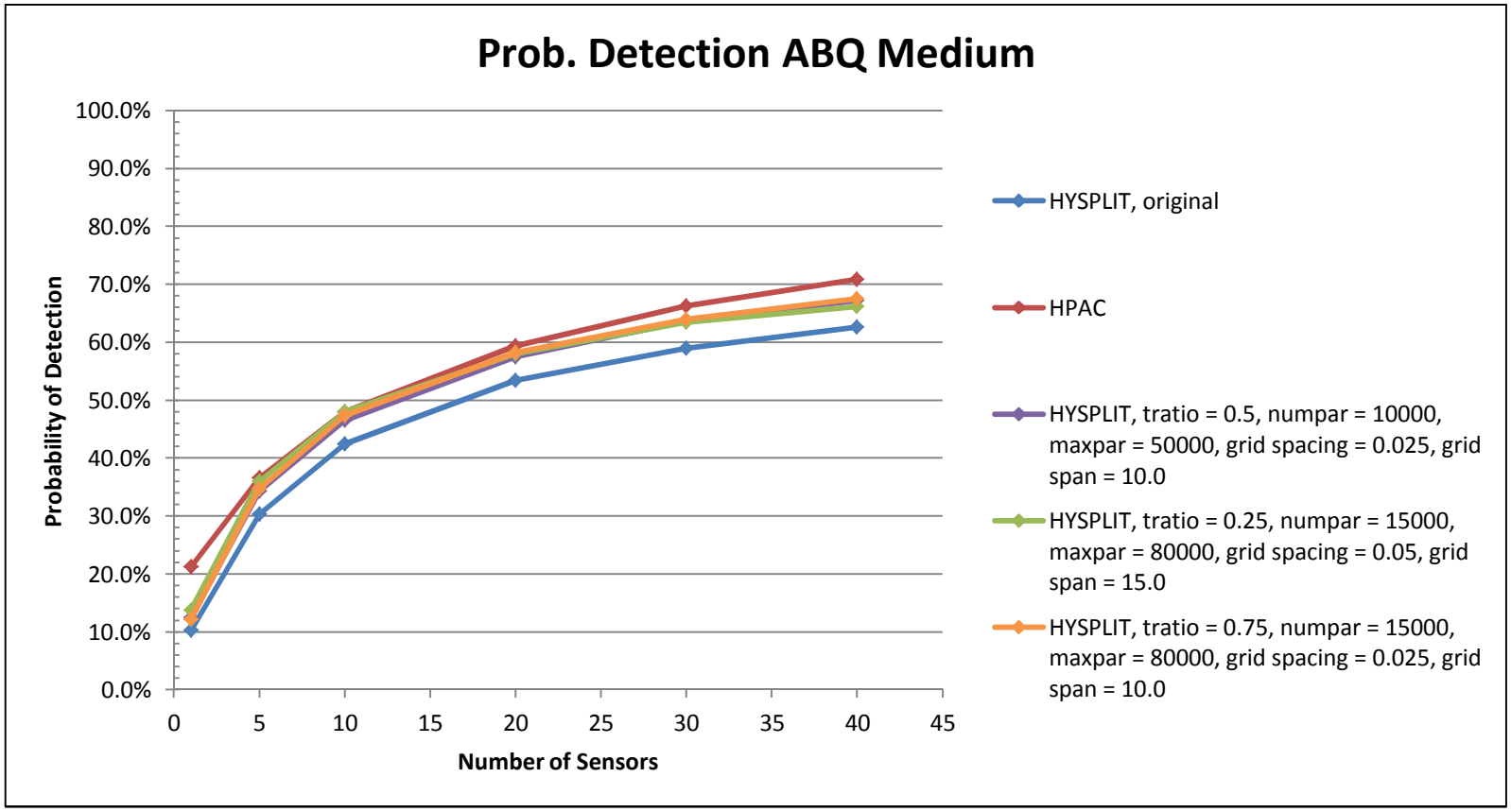
- Important parameters that affect accuracy
  - Grid spacing, time step, and release numbers

- Smaller time step = more accurate, but also longer
- Same with grid size and release numbers

- Where is the happy median?
  - HPAC's exact parameters are unknown

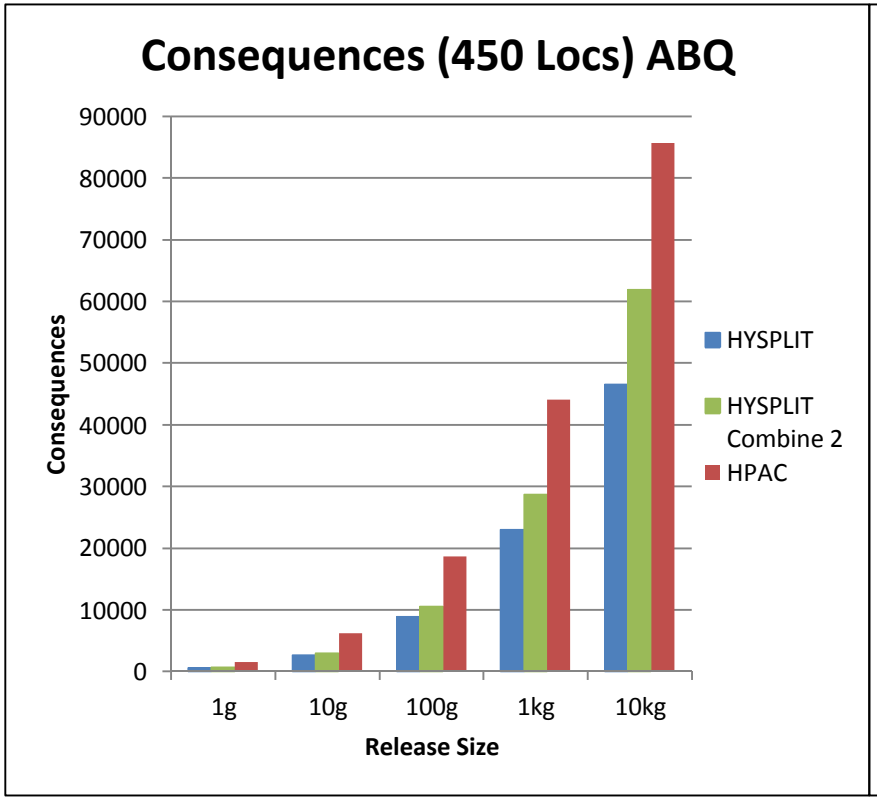
Happy Median: Δt and Release Size

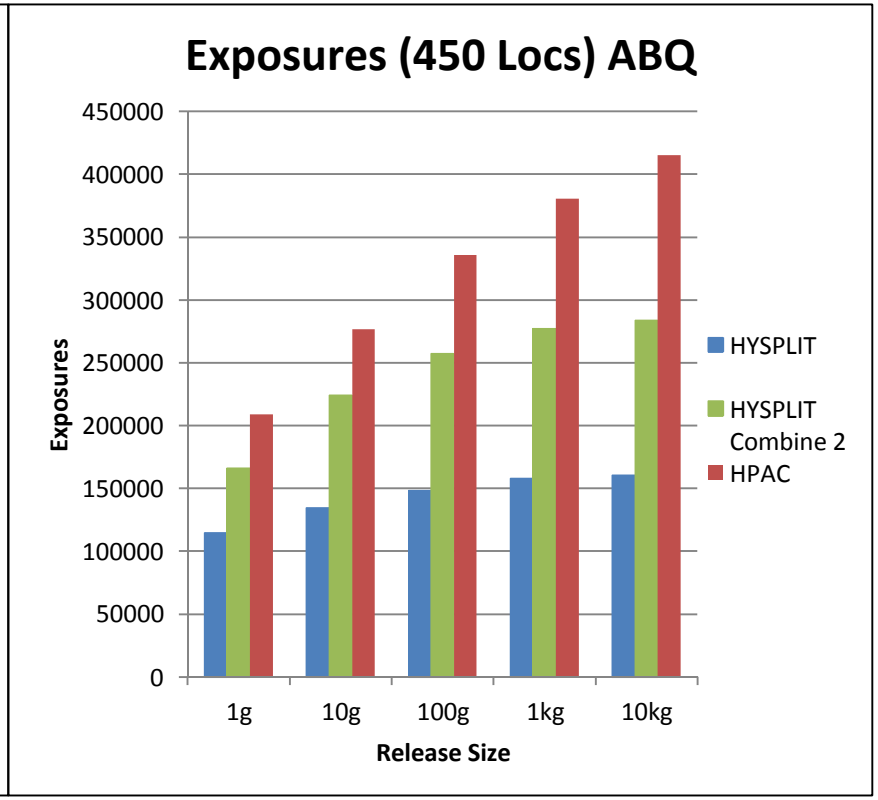
- Minimal compounded effect
  - Release number has greatest impact



Health Predictions Comparable

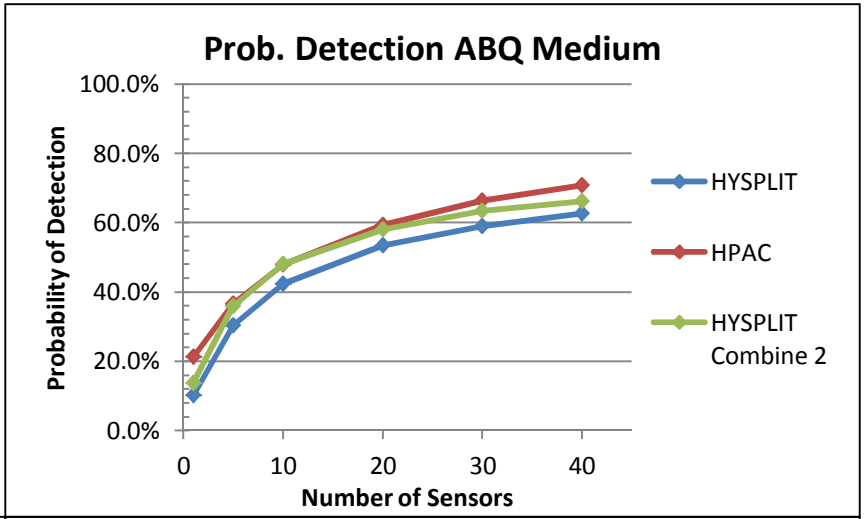
- HYSPLIT numbers much closer to HPAC numbers
- HPAC still consistently results in larger numbers

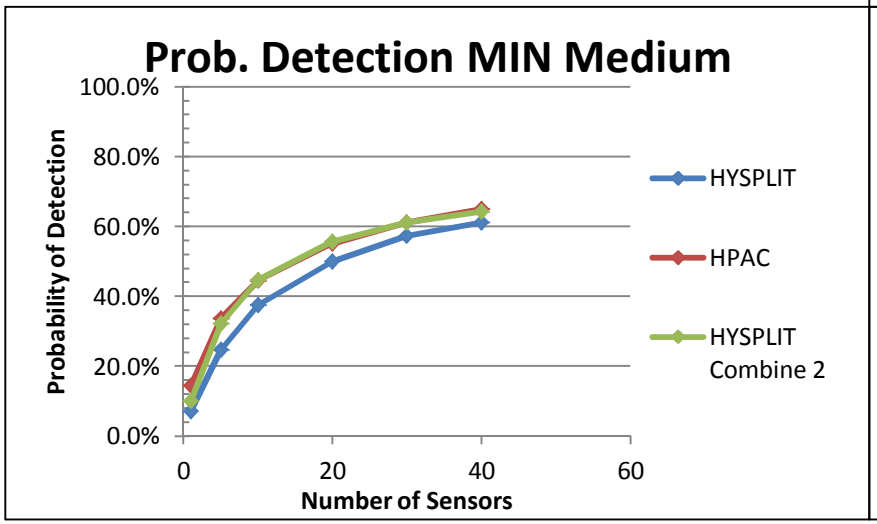


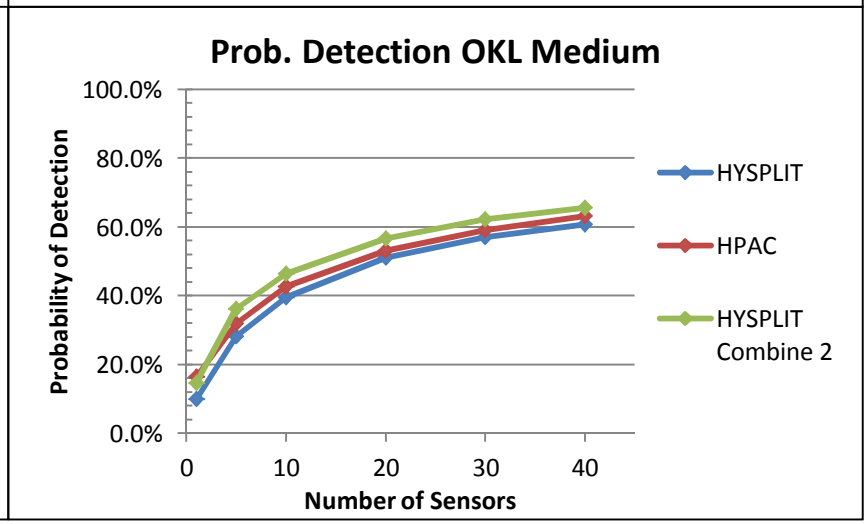


Similar Results in Other Cities

- HYSPLIT curves match HPAC ones very well!
- Successful adjustments







HazDAC Summary

- In general, HYSPLIT gives lower predictions
- Three possible parameters to bring numbers closer
  - Implementation of HYSPLIT in code - OKAY
  - Default parameters for HYSPLIT – Some Problems
  - Fundamentally different models – Still a possibility
- Release numbers are most important factor

- But, HPAC still has generally higher numbers than HYSPLIT
- Likely, the models are fundamentally different and will never yield exactly the same numbers

Future HazDAC Work

Sandia National Laboratories

- Find absolute best happy median
  - Requires more runs with variations in parameters
- Contact expert in HPAC (and maybe HYSPLIT)
  - Figure out *exactly* what the differences are
- Run more tests with different agents, cities, etc.
- Validate against real life tracer experiments
  - This could demonstrate whether HPAC or HYSPLIT is “better”

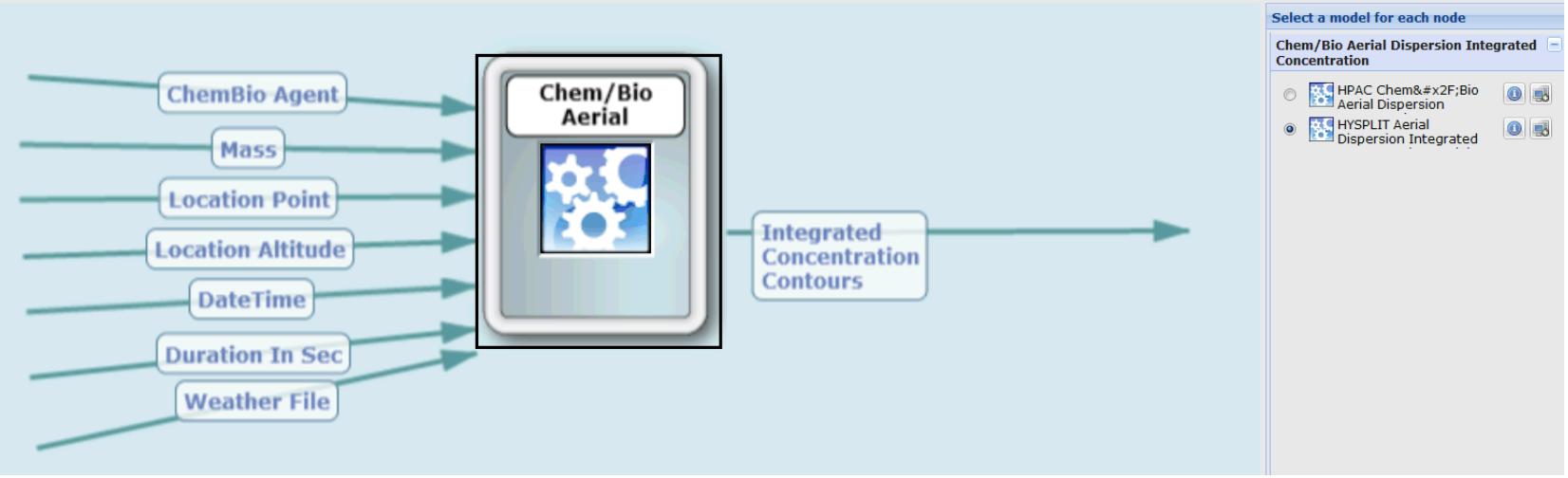
SUMMIT: Background

Sandia National Laboratories

- SUMMIT links different models together
  - Has models for many purposes
- Goal:
    - To give users the most options
    - To pull together similar software in one place
- SUMMIT will model aerosol dispersion for chem/bio agents
  - Needs to incorporate HYSPLIT

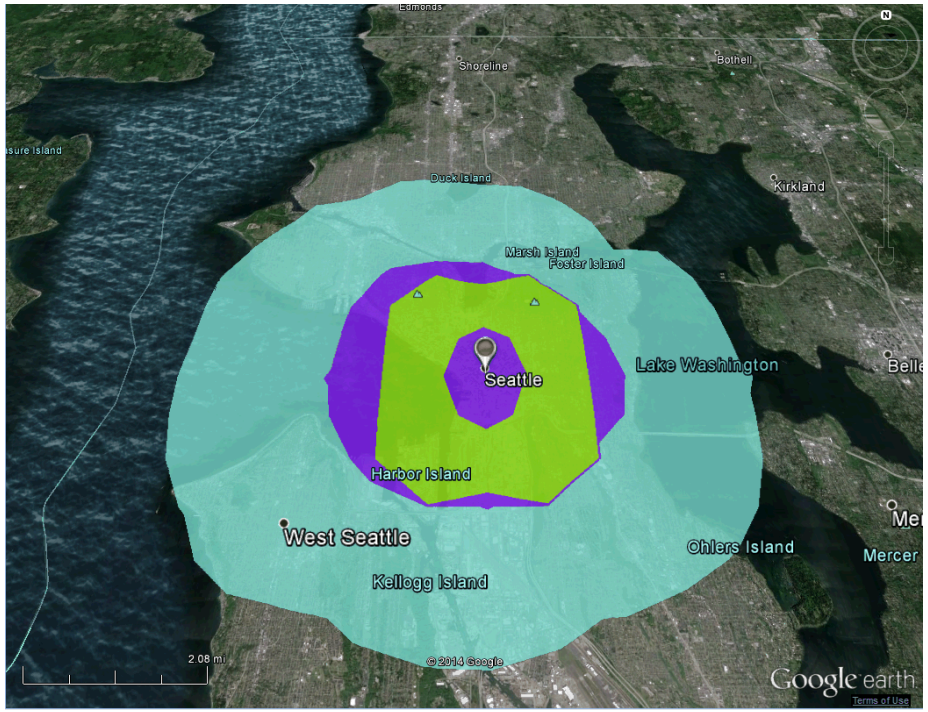
HYSPLIT in SUMMIT

- Want HYSPLIT to be correctly implemented
- Want inputs to be the same as for similar models (i.e. HPAC)
- Want outputs to be displayed in user-friendly format



Success!

- Used knowledge from HazDAC discussed above
- Implemented of HYSPLIT for releases
- Wrote implementation code



Future SUMMIT Work

Sandia National Laboratories

- Document thoroughly for future coders
- Run more verification tests
  - SUMMIT is different use case than HazDAC
- Implement a time-lapse output to see plume moving
- Add other more specific inputs for more advanced users

Conclusions

- Bioterrorism is bad.

Conclusions

- Bioterrorism is bad.
- But Sandia (and California) is fun!

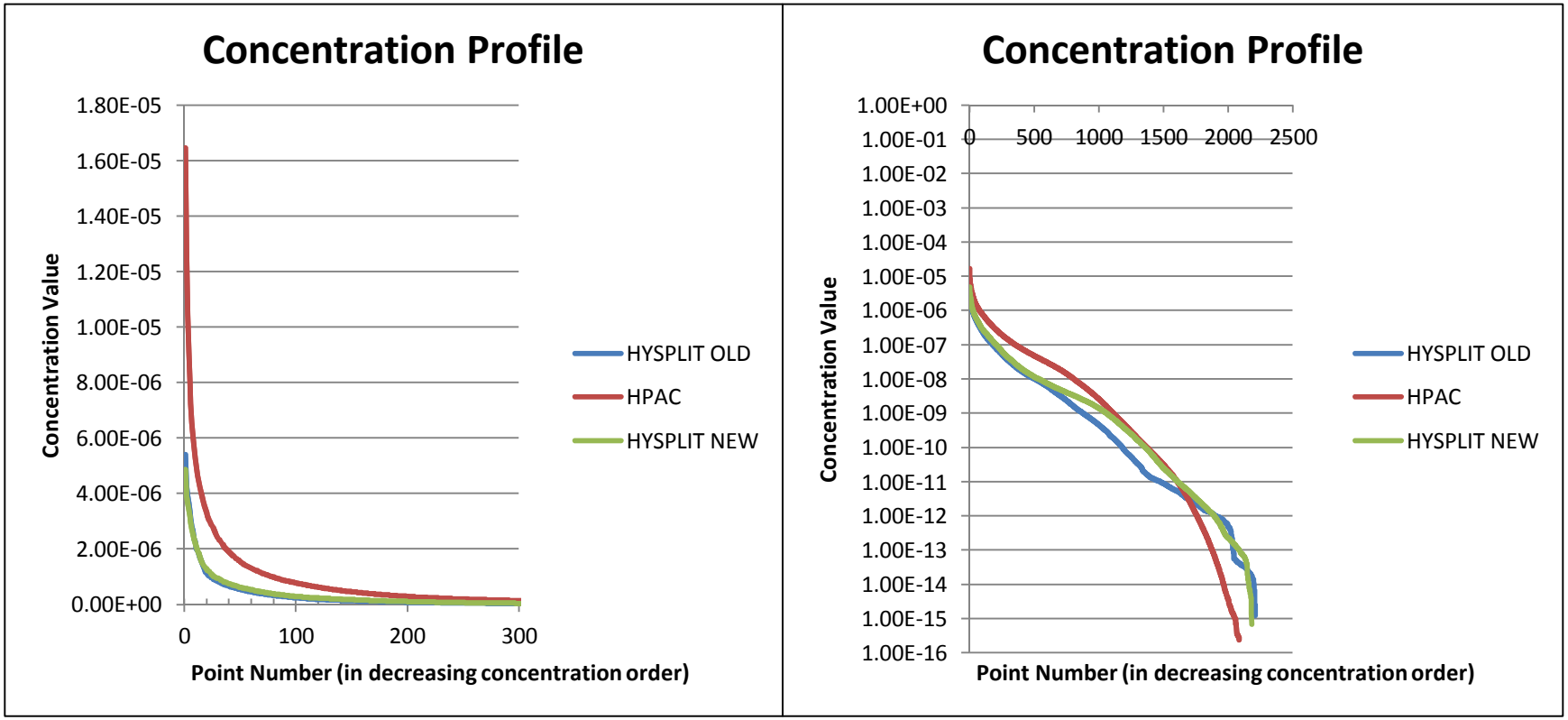
PICTURE OF INTERNS HAVING FUN HERE

Thanks!

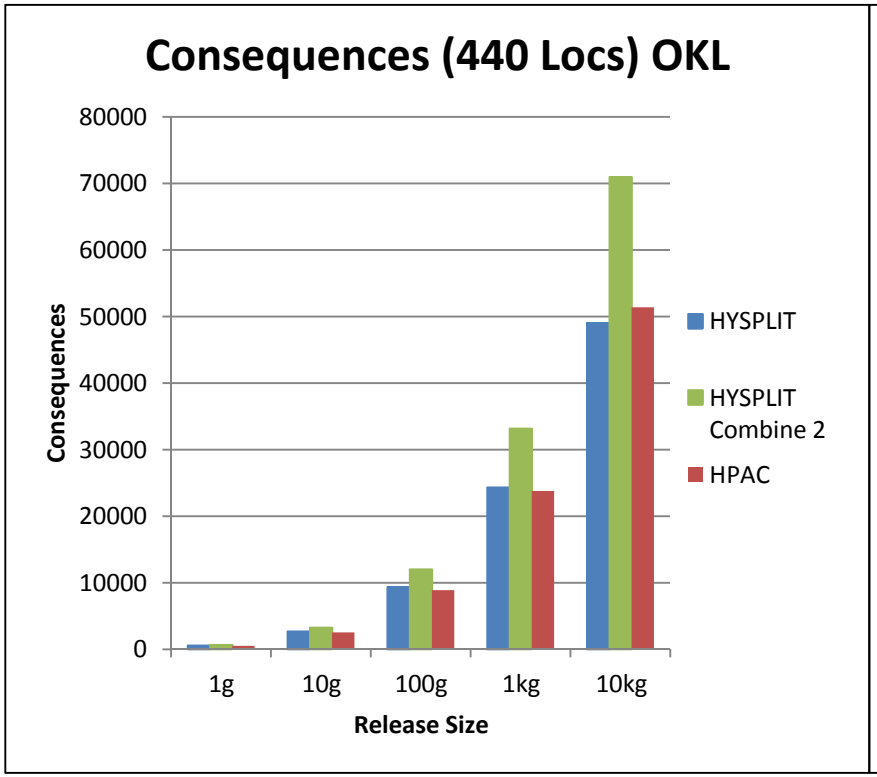
- Thanks to my mentors Dr. Peterson and Dr. Teclemariam
- Thanks to all the other mentor-like people
- Thanks to the interns for being generally awesome
- Thanks to Sandia for giving me this opportunity

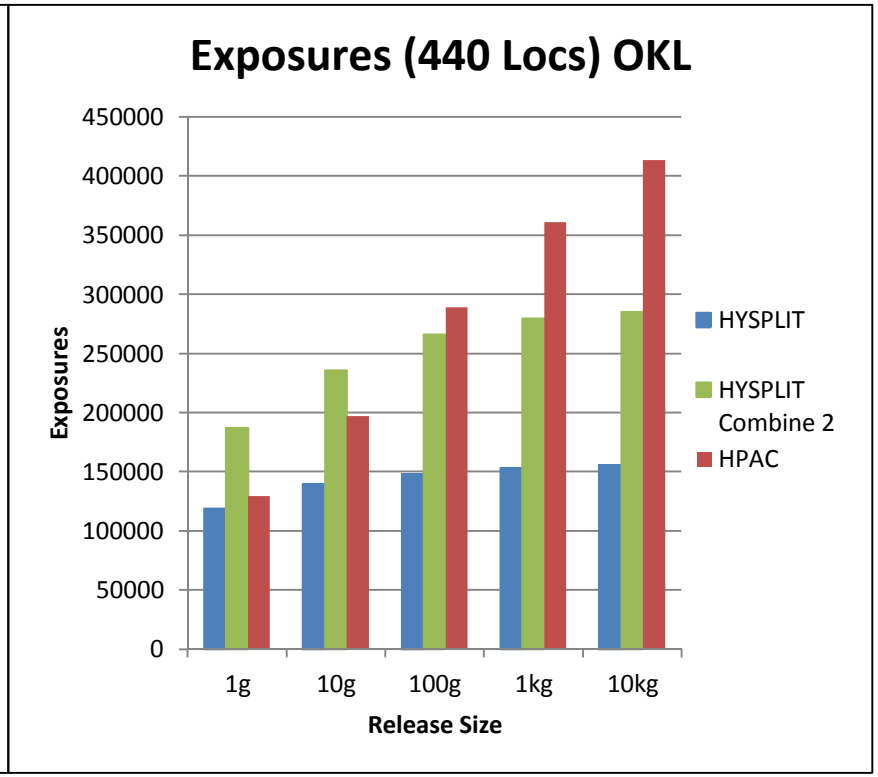
Improved Concentration Profiles

- No obvious improvement…
- But could be grid spacing? Or just ABQ?



Health Effects: OKL





Health Effects: MIN