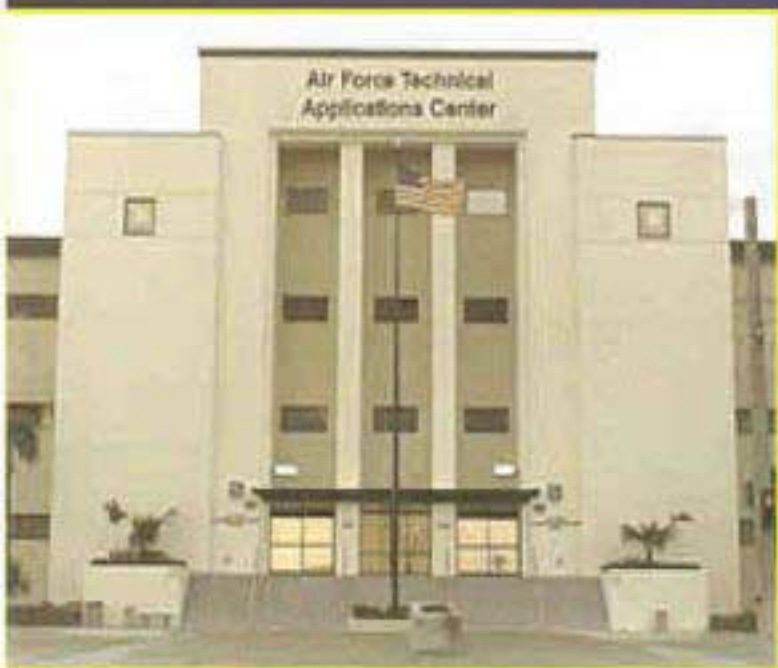




CTBT Meteorology at the U.S. NDC

Craig Sloan

The views in this presentation are not necessarily the views of
the United States government

Introduction

- **Meteorology infrastructure**
 - **Models**
 - **Data**
- **CTBT applications**

Nuclear Detections



Russia

France

China

India

PNET

Pakistan

1960

1970

1980

1990

1950

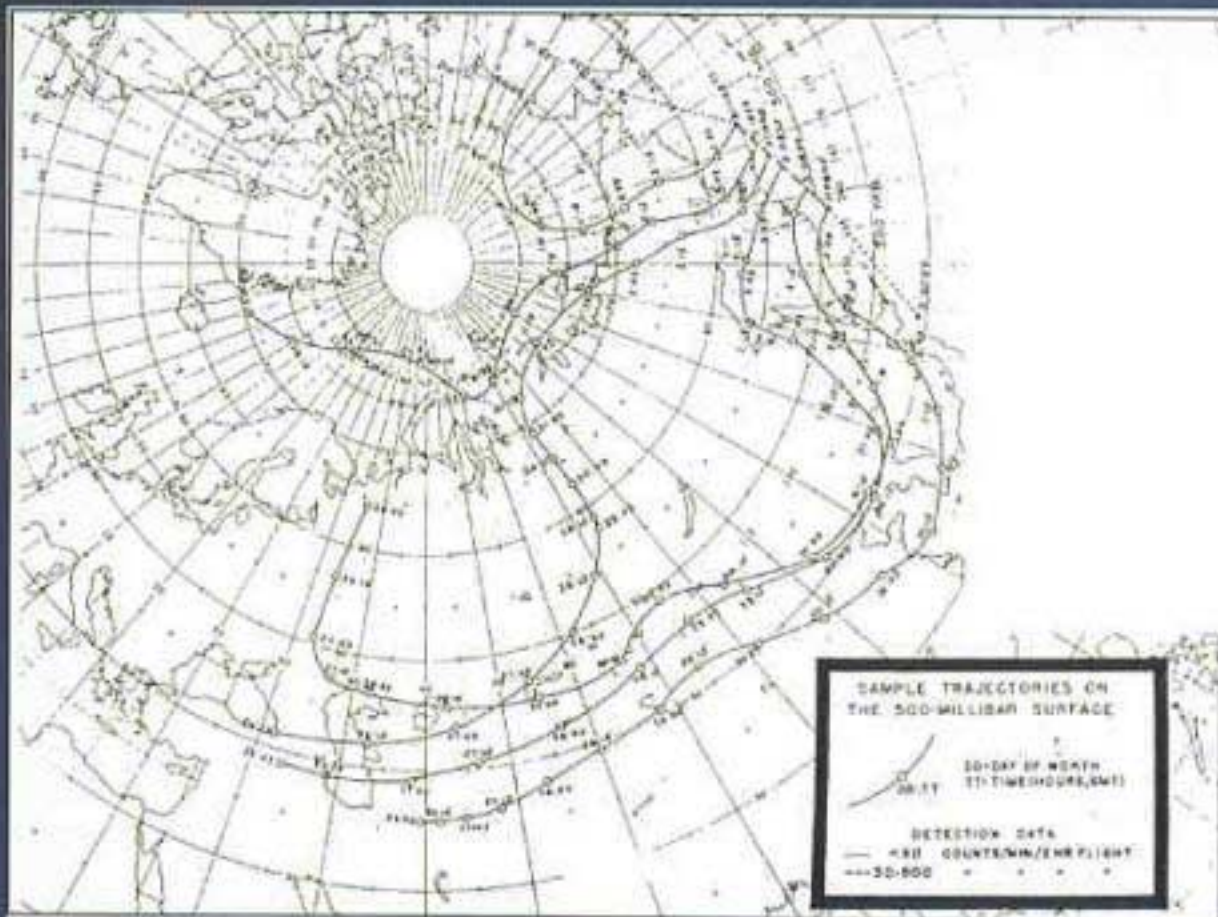
LTBT

TTBT

INF

CTBT

First Soviet Test



Basics--Data

- **Event data**
 - Time/location
- **Meteorological Data**
 - Current regional observations
 - Naval Operational Gridded Atmospheric Prediction System (NOGAPS) data
 - Aviation (AVN) data from NOAA

Basics--Models

- **Suite of Transport and Dispersion Models**
 - **Developed both in-house and COTS/GOTS**
 - **Using multiple models provides greater confidence**
 - **Not all models perform well in all scenarios**
 - **Some models provide ability to give quick, first-look answer**

Basics--Models and Uses

- **SLAM (ENSCO)--Short-range (up to few days transport)**
- **GAMUT (ENSCO)--Long-range**
- **HYSPLIT (NOAA)--Short or long-range**
- **MATHEW/ADPIC (LLNL)--complex terrain, data rich area**
- **ADAPT/LODI (LLNL)--complex terrain**
- **SCIPUFF (DTRA)--short or long-range**
- **RAMS (CSU) and COAMPS (NRL/FNMOC)--mesoscale models used in above transport and dispersion models**
- **HOTMAC/RAPTAD (LANL/YSA)--extremely short-range problems with weak large-scale forcing**

Basics--Hardware

- **Model Server: 3 SGI 2000s**
 - 48 processors
(R10K chips - 195-250 MHz)
 - 10 gigabyte RAM
 - Terabyte disk space
- **Cross-platform evaluator systems**
 - SUN, SGI, PC
- **Database**
 - Surface, upper-air, and gridded data
 - Enterprise 6000
 - Access 30 years of met data

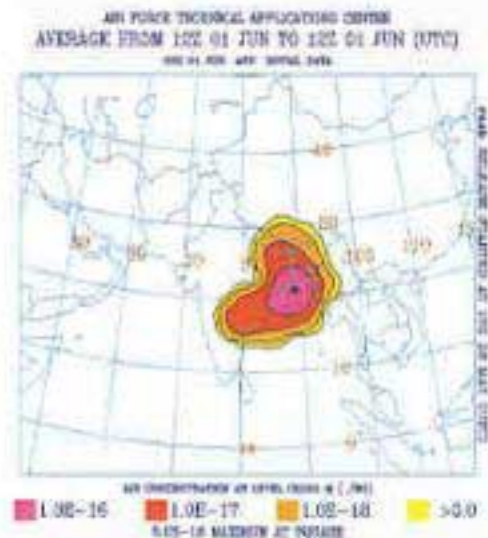
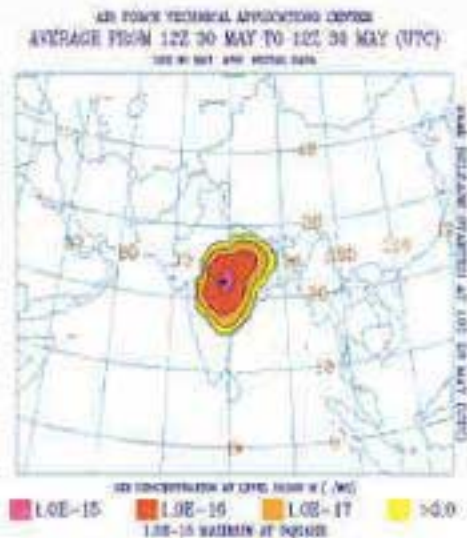
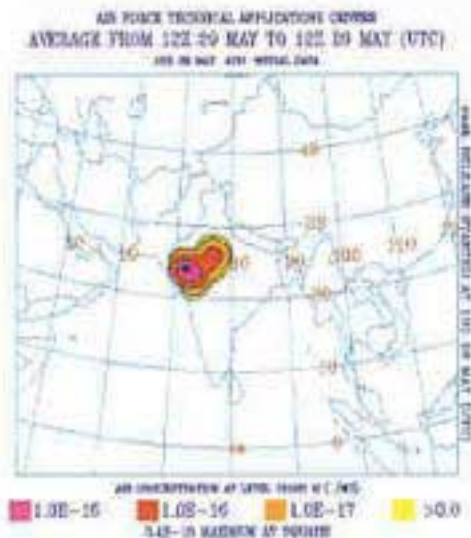
Models

HYSPLIT

- **HYbrid Single-Particle Lagrangian Integrated Trajectory**
- **Lagrangian formulation**
 - Dispersion computed following particle/puff
- **Simple PBL height (Z_i) formulation**
 - Height where θ first exceeds value at ground by 2 K
- **Uses AVN data at $\sim 1.5^\circ$ resolution**
- **Can also use RAMS and COAMPS fields**
- **Parameterizations for wet/dry deposition and radioactive decay**

Models--HYSPLIT

HYbrid Single-Particle Lagrangian Integrated Trajectory



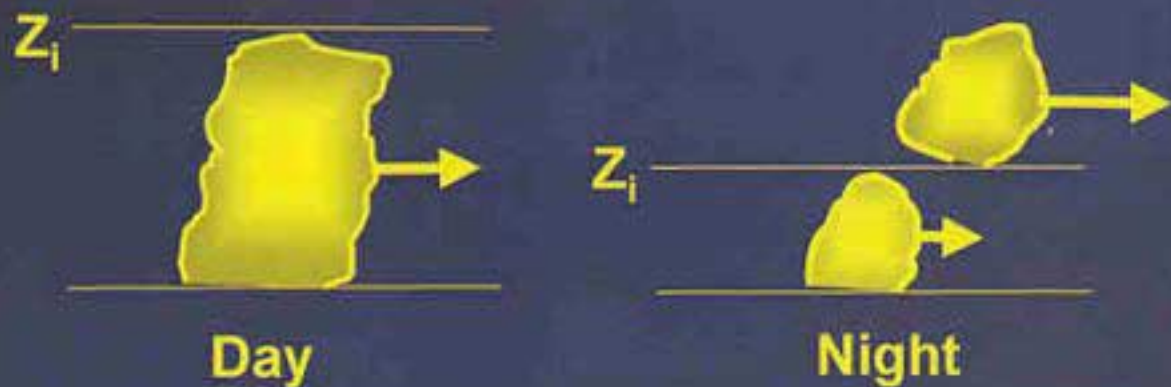
Models

SLAM

- **Short-range Layered Atmospheric Model**
- **Two layers--splits occur at diurnal interfaces**
- **Z_i calculated using one of three methods**
 - **POTEMP** $\frac{\partial \theta}{\partial z}$ exceeds a set of thresholds
 - **Richardson** $Ri = \frac{g}{\theta} \left[\frac{\partial \theta}{\partial z} / \left(\frac{\partial}{\partial z} |\vec{v}| \right)^2 \right]$
 - **PIMIX**--determine level where lapse rate is significantly less than moist adiabatic

SLAM Techniques

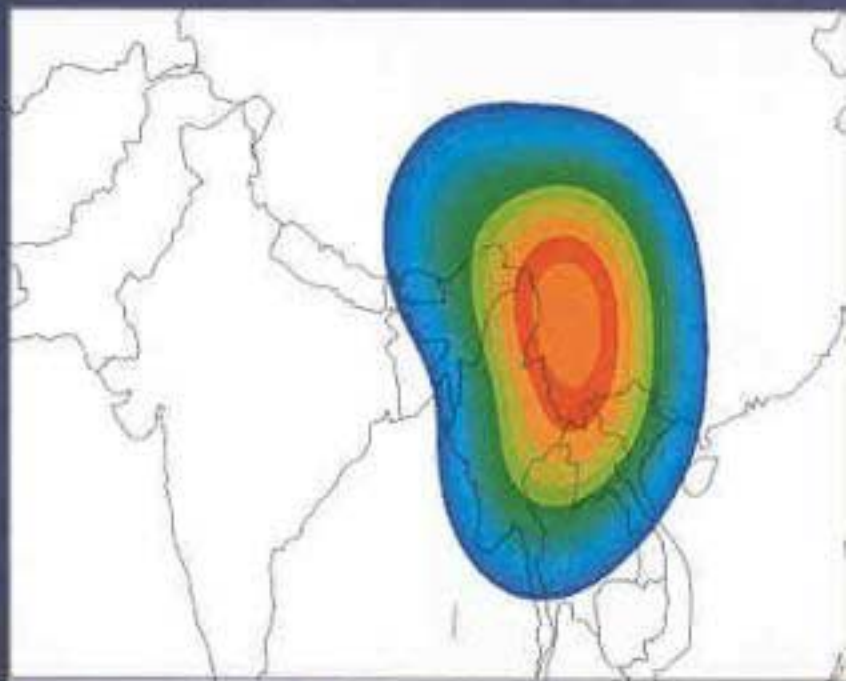
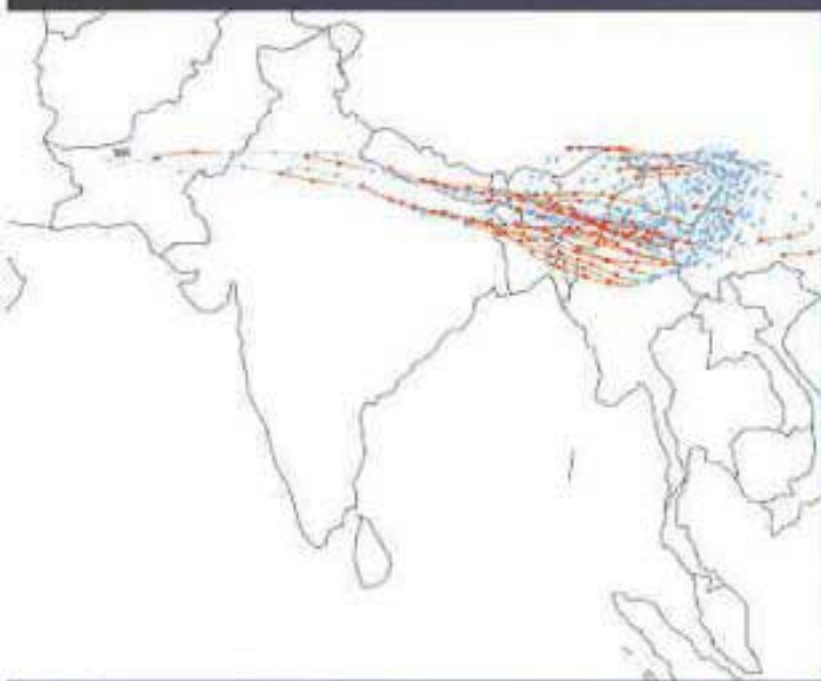
Splitting



Gaussian diffusion

SLAM

Short-range Layered Atmospheric Model



GAMUT

Techniques

- Global Atmospheric Multi-layer Transport model
- Nine vertical layers up to 12,000 m
- Preprocessed grid using U/A and NOGAPS data
- Vertical motion based on static energy changes

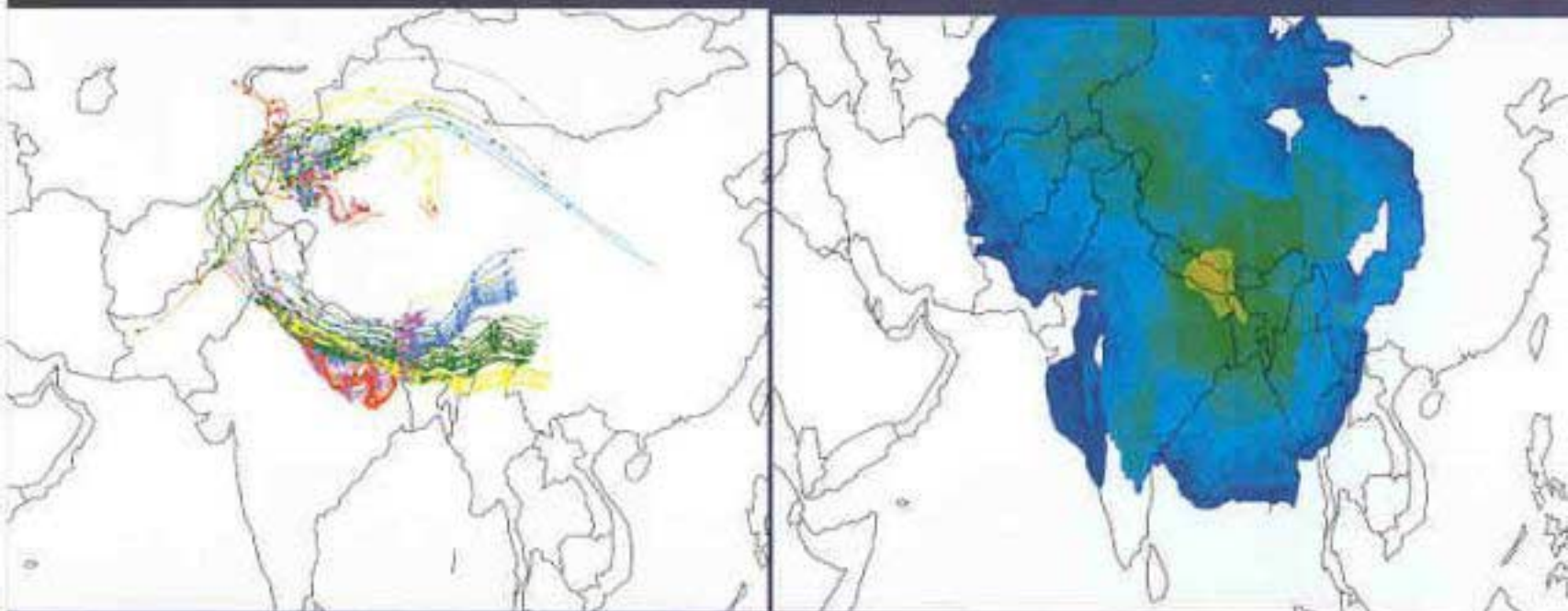
$$s_e = C_p T + gz + L_v q$$



– New version gets w from NOGAPS

GAMUT

Global Atmospheric Multi-layer Transport model



Models

MATHEW/ADPIC

- **Mass-Adjusted THrEe-dimensional Wind model**
 - produces mass-consistent windfield using obs, gridded or model winds
 - user inputs z_i --different parameterizations $z > z_i$
 - requires decent quantity/quality data
- **Atmospheric Diffusion Particle-In-Cell model**
 - 3-d Lagrangian particle diffusion code w/Monte Carlo
 - wet/dry deposition, radioactive decay

ADPIC

Techniques

- Lagrangian formulation of advection-diffusion equation

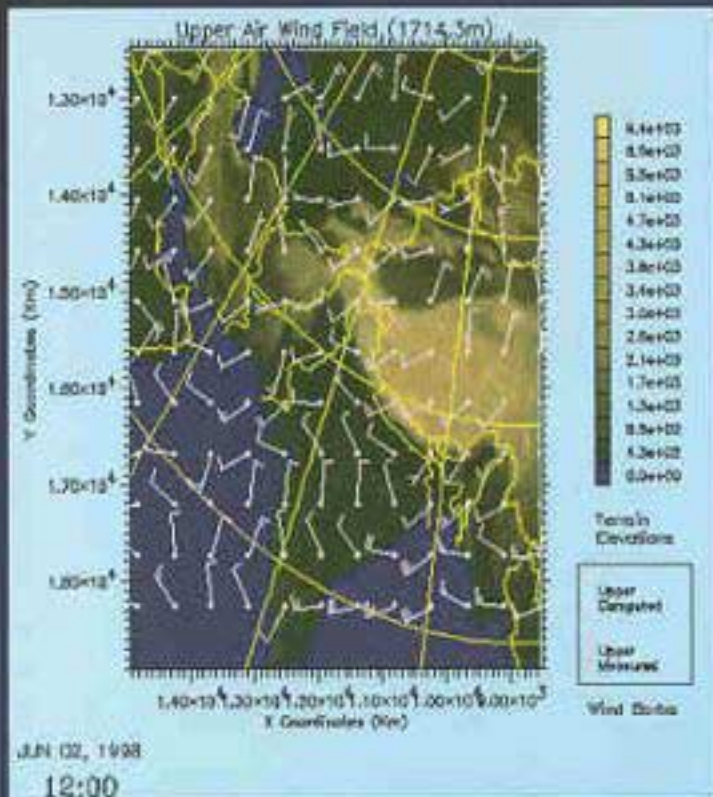
$$dx = \bar{u}dt + (2K_x)^{1/2} dW_x$$

$$dy = \bar{v}dt + (2K_y)^{1/2} dW_y$$

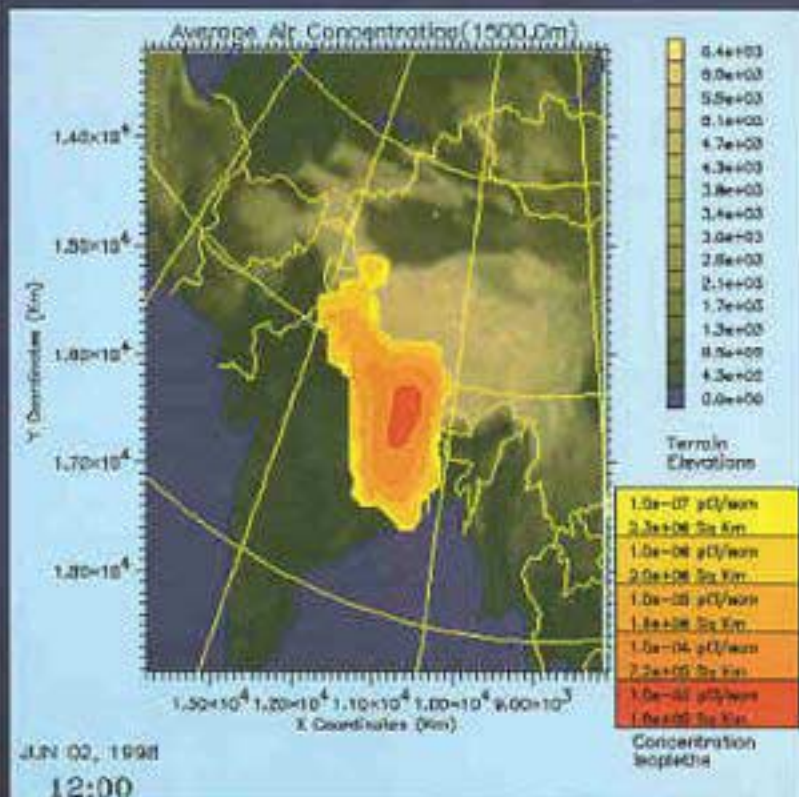
$$dz = \bar{w}dt + \frac{\partial K_z}{\partial z} dt + (2K_z)^{1/2} dW_z$$

MATHEW/ADPIC

Mass-Adjusted Three-dimensional Wind model



Atmospheric Diffusion Particle-In-Cell model



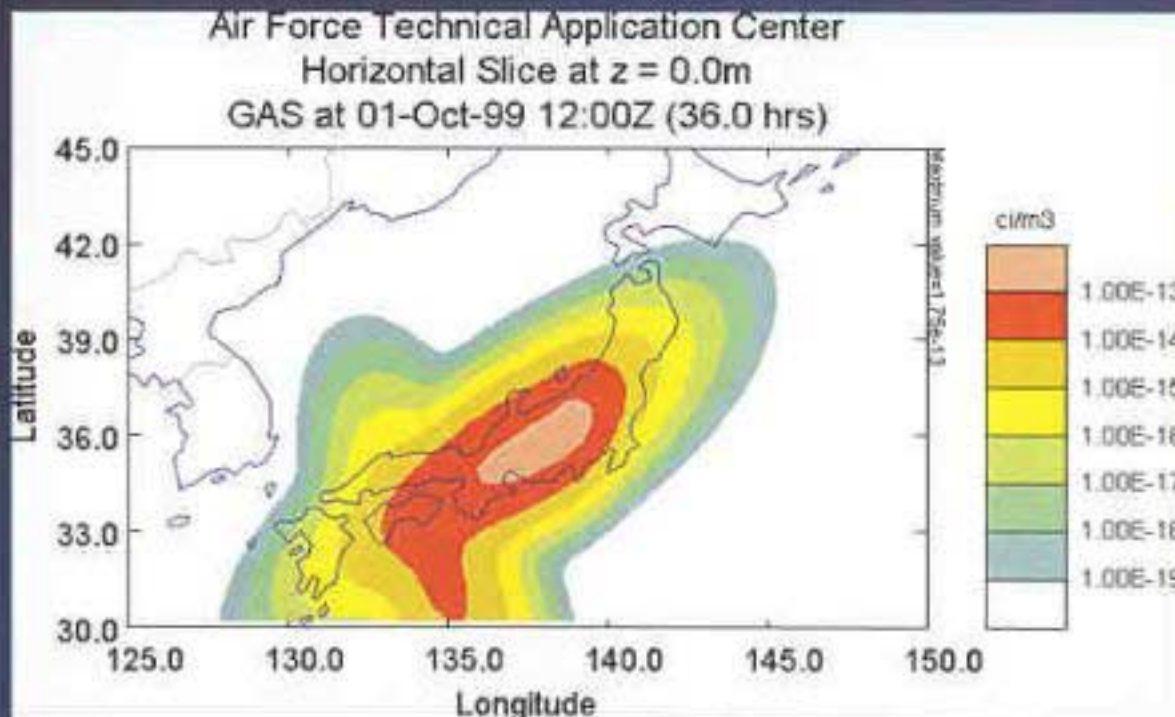
Models

SCIPUFF

- **Second-order Closure Integrated PUFF**
 - uses Gaussian puffs to solve Lagrangian dispersion model equations
 - represents concentration fields as 3-d puffs
 - puffs can split and recombine
- **Linked to various NBC facility models**
- **Combined package is Hazard Prediction and Assessment Capability (HPAC)**

SCIPUFF

Second-order Closure Integrated PUFF

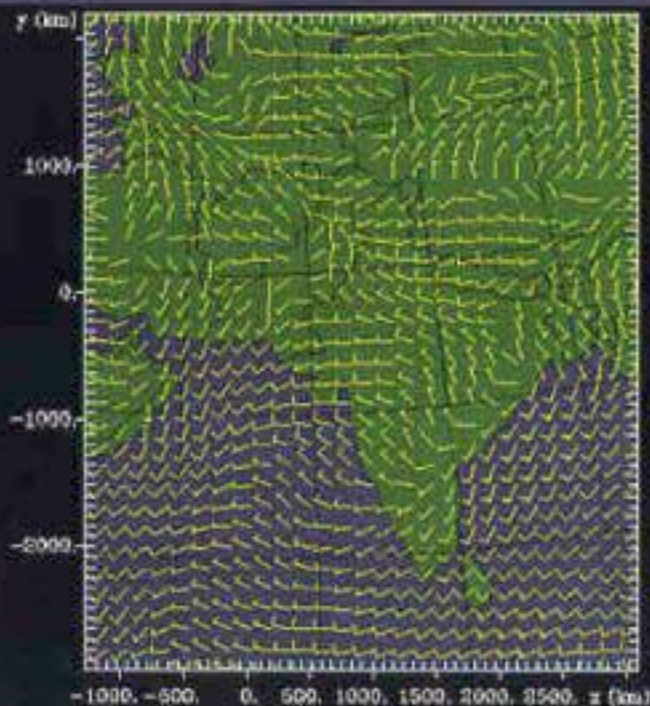


Mesoscale Models

RAMS/COAMPS

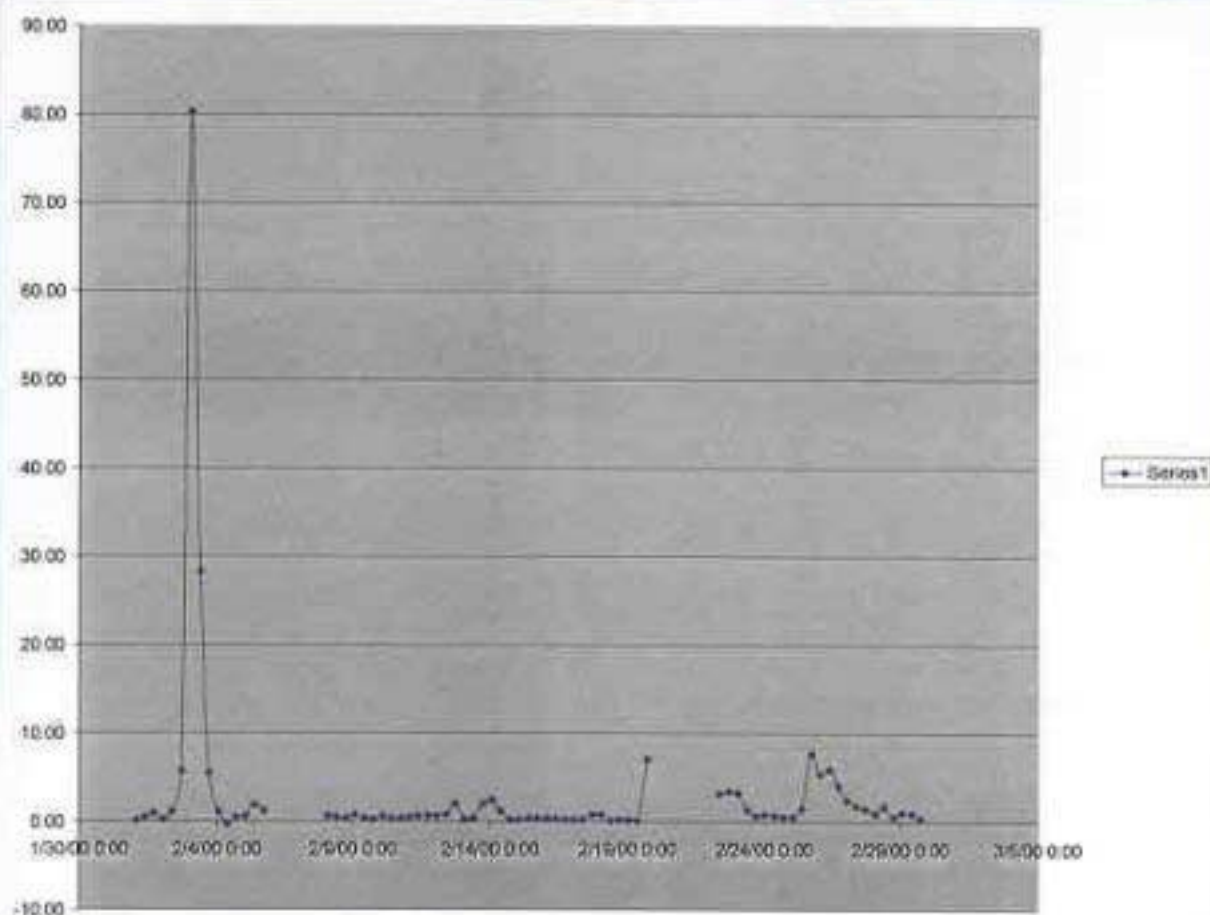
- **Regional Atmospheric Modeling System**
- **Coupled Ocean Atmosphere Mesoscale Prediction System**
- **Predict state of the atmosphere at range of scales**
- **Parameterizations for many phenomena**
 - cumulus convection, surface fluxes, subgrid-scale mixing, moist physics, radiation
- **Nested grid structure**
 - Initialize outer grid with NOGAPS
 - allow 2-way interaction between nests

RAMS

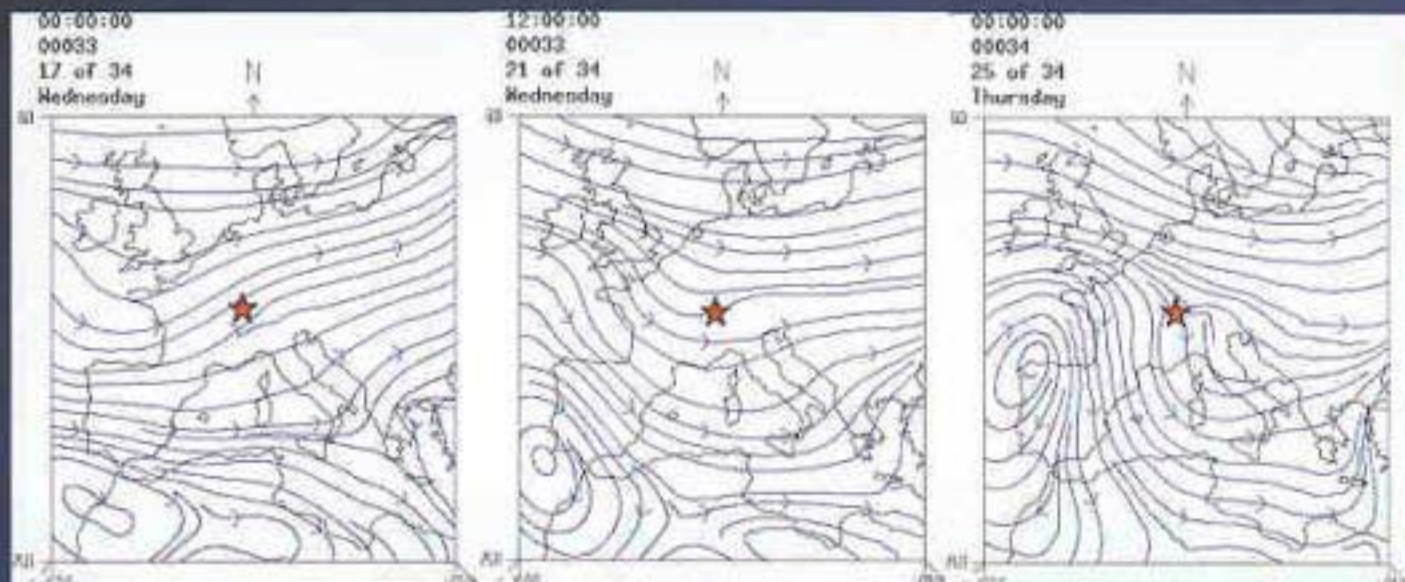


Test		Grid 1			
$z = -130.7$ m	1000-2000-3000-4000-5000-6000-7000-8000-9000-10000-11000-12000-13000-14000-15000-16000-17000-18000-19000-20000-21000-22000-23000-24000-25000-26000-27000-28000-29000-30000-31000-32000-33000-34000-35000-36000-37000-38000-39000-40000-41000-42000-43000-44000-45000-46000-47000-48000-49000-50000-51000-52000-53000-54000-55000-56000-57000-58000-59000-60000-61000-62000-63000-64000-65000-66000-67000-68000-69000-70000-71000-72000-73000-74000-75000-76000-77000-78000-79000-80000-81000-82000-83000-84000-85000-86000-87000-88000-89000-90000-91000-92000-93000-94000-95000-96000-97000-98000-99000-100000-101000-102000-103000-104000-105000-106000-107000-108000-109000-110000-111000-112000-113000-114000-115000-116000-117000-118000-119000-120000-121000-122000-123000-124000-125000-126000-127000-128000-129000-130000-131000-132000-133000-134000-135000-136000-137000-138000-139000-140000-141000-142000-143000-144000-145000-146000-147000-148000-149000-150000-151000-152000-153000-154000-155000-156000-157000-158000-159000-160000-161000-162000-163000-164000-165000-166000-167000-168000-169000-170000-171000-172000-173000-174000-175000-176000-177000-178000-179000-180000-181000-182000-183000-184000-185000-186000-187000-188000-189000-190000-191000-192000-193000-194000-195000-196000-197000-198000-199000-200000-201000-202000-203000-204000-205000-206000-207000-208000-209000-210000-211000-212000-213000-214000-215000-216000-217000-218000-219000-220000-221000-222000-223000-224000-225000-226000-227000-228000-229000-230000-231000-232000-233000-234000-235000-236000-237000-238000-239000-240000-241000-242000-243000-244000-245000-246000-247000-248000-249000-250000-251000-252000-253000-254000-255000-256000-257000-258000-259000-260000-261000-262000-263000-264000-265000-266000-267000-268000-269000-270000-271000-272000-273000-274000-275000-276000-277000-278000-279000-280000-281000-282000-283000-284000-285000-286000-287000-288000-289000-290000-291000-292000-293000-294000-295000-296000-297000-298000-299000-300000-301000-302000-303000-304000-305000-306000-307000-308000-309000-310000-311000-312000-313000-314000-315000-316000-317000-318000-319000-320000-321000-322000-323000-324000-325000-326000-327000-328000-329000-330000-331000-332000-333000-334000-335000-336000-337000-338000-339000-340000-341000-342000-343000-344000-345000-346000-347000-348000-349000-350000-351000-352000-353000-354000-355000-356000-357000-358000-359000-360000-361000-362000-363000-364000-365000-366000-367000-368000-369000-370000-371000-372000-373000-374000-375000-376000-377000-378000-379000-380000-381000-382000-383000-384000-385000-386000-387000-388000-389000-390000-391000-392000-393000-394000-395000-396000-397000-398000-399000-400000-401000-402000-403000-404000-405000-406000-407000-408000-409000-410000-411000-412000-413000-414000-415000-416000-417000-418000-419000-420000-421000-422000-423000-424000-425000-426000-427000-428000-429000-430000-431000-432000-433000-434000-435000-436000-437000-438000-439000-440000-441000-442000-443000-444000-445000-446000-447000-448000-449000-450000-451000-452000-453000-454000-455000-456000-457000-458000-459000-460000-461000-462000-463000-464000-465000-466000-467000-468000-469000-470000-471000-472000-473000-474000-475000-476000-477000-478000-479000-480000-481000-482000-483000-484000-485000-486000-487000-488000-489000-490000-491000-492000-493000-494000-495000-496000-497000-498000-499000-500000-501000-502000-503000-504000-505000-506000-507000-508000-509000-510000-511000-512000-513000-514000-515000-516000-517000-518000-519000-520000-521000-522000-523000-524000-525000-526000-527000-528000-529000-530000-531000-532000-533000-534000-535000-536000-537000-538000-539000-540000-541000-542000-543000-544000-545000-546000-547000-548000-549000-550000-551000-552000-553000-554000-555000-556000-557000-558000-559000-560000-561000-562000-563000-564000-565000-566000-567000-568000-569000-570000-571000-572000-573000-574000-575000-576000-577000-578000-579000-580000-581000-582000-583000-584000-585000-586000-587000-588000-589000-590000-591000-592000-593000-594000-595000-596000-597000-598000-599000-600000-601000-602000-603000-604000-605000-606000-607000-608000-609000-610000-611000-612000-613000-614000-615000-616000-617000-618000-619000-620000-621000-622000-623000-624000-625000-626000-627000-628000-629000-630000-631000-632000-633000-634000-635000-636000-637000-638000-639000-640000-641000-642000-643000-644000-645000-646000-647000-648000-649000-650000-651000-652000-653000-654000-655000-656000-657000-658000-659000-660000-661000-662000-663000-664000-665000-666000-667000-668000-669000-670000-671000-672000-673000-674000-675000-676000-677000-678000-679000-680000-681000-682000-683000-684000-685000-686000-687000-688000-689000-690000-691000-692000-693000-694000-695000-696000-697000-698000-699000-700000-701000-702000-703000-704000-705000-706000-707000-708000-709000-710000-711000-712000-713000-714000-715000-716000-717000-718000-719000-720000-721000-722000-723000-724000-725000-726000-727000-728000-729000-730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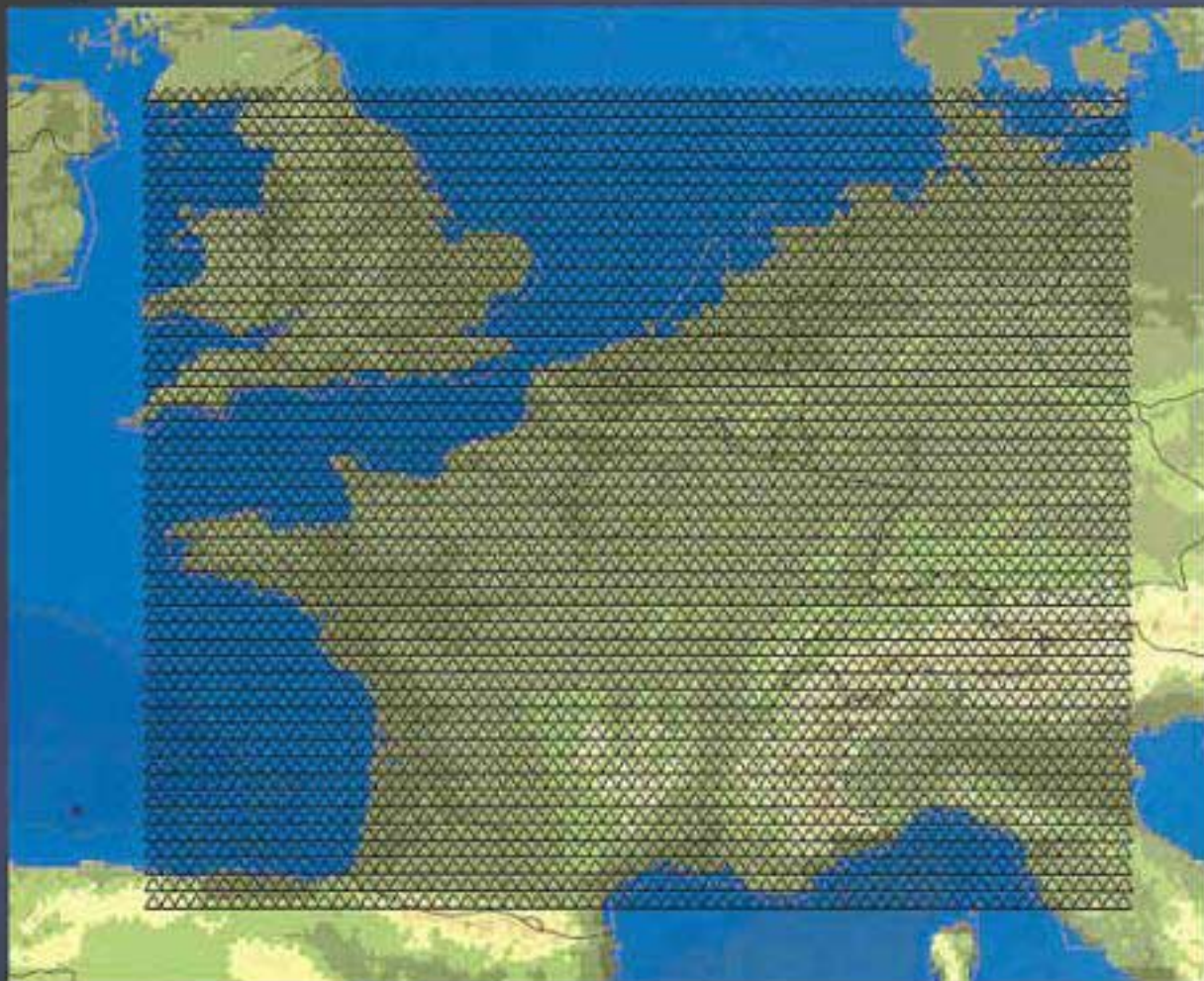
CTBT Evaluation



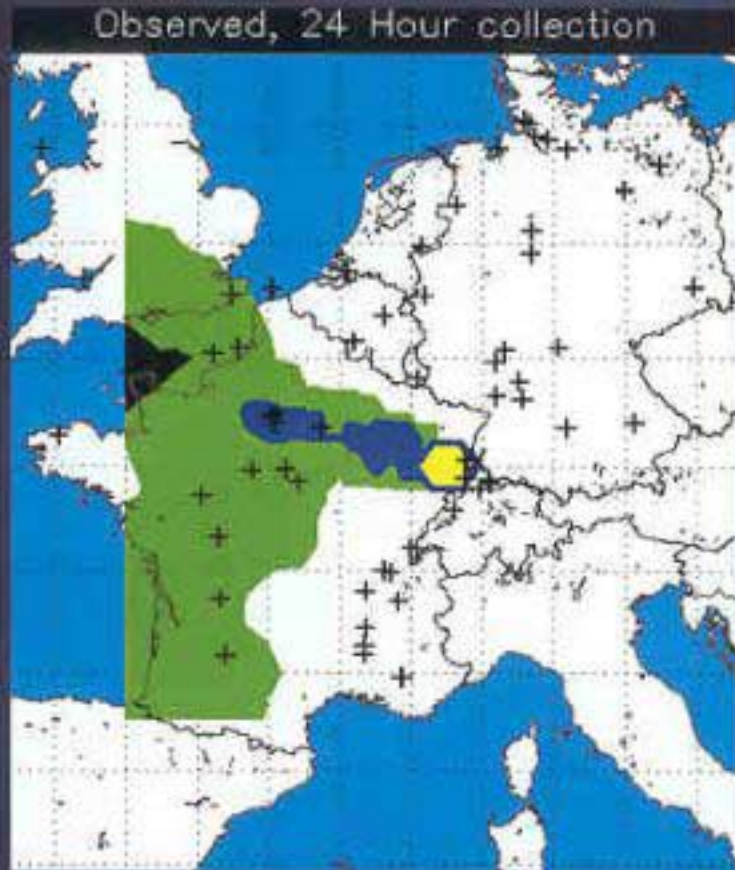
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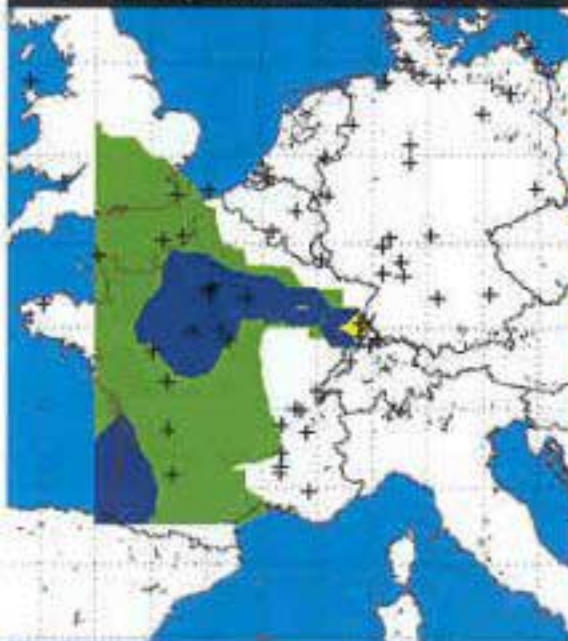


CTBT Evaluation--Obs



CTBT Evaluation--Obs

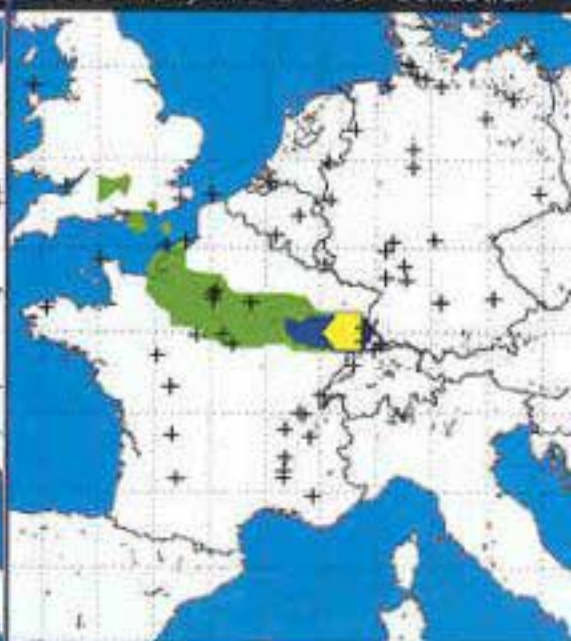
Observed, 1st 8 Hour collection



Observed, 2nd 8 Hour collection



Observed, 3rd 8 Hour collection



CTBT Evaluation--RAMS



CTBT Evaluation--RAMS

RAMS, 1st 8 Hour collection



RAMS, 2nd 8 Hour collection



RAMS, 3rd 8 Hour collection



CTBT Evaluation--AVN



CTBT Evaluation--AVN

AVN, 1st 8 Hour Collection



AVN, 2nd 8 Hour Collection



AVN, 3rd 8 Hour Collection



Topography



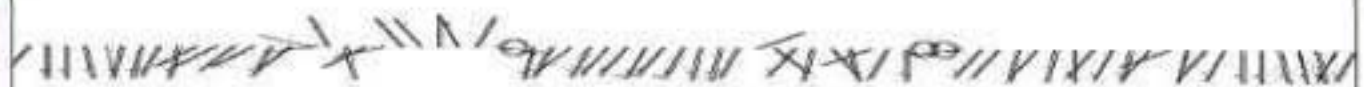
Time Series



47.6, 7.52



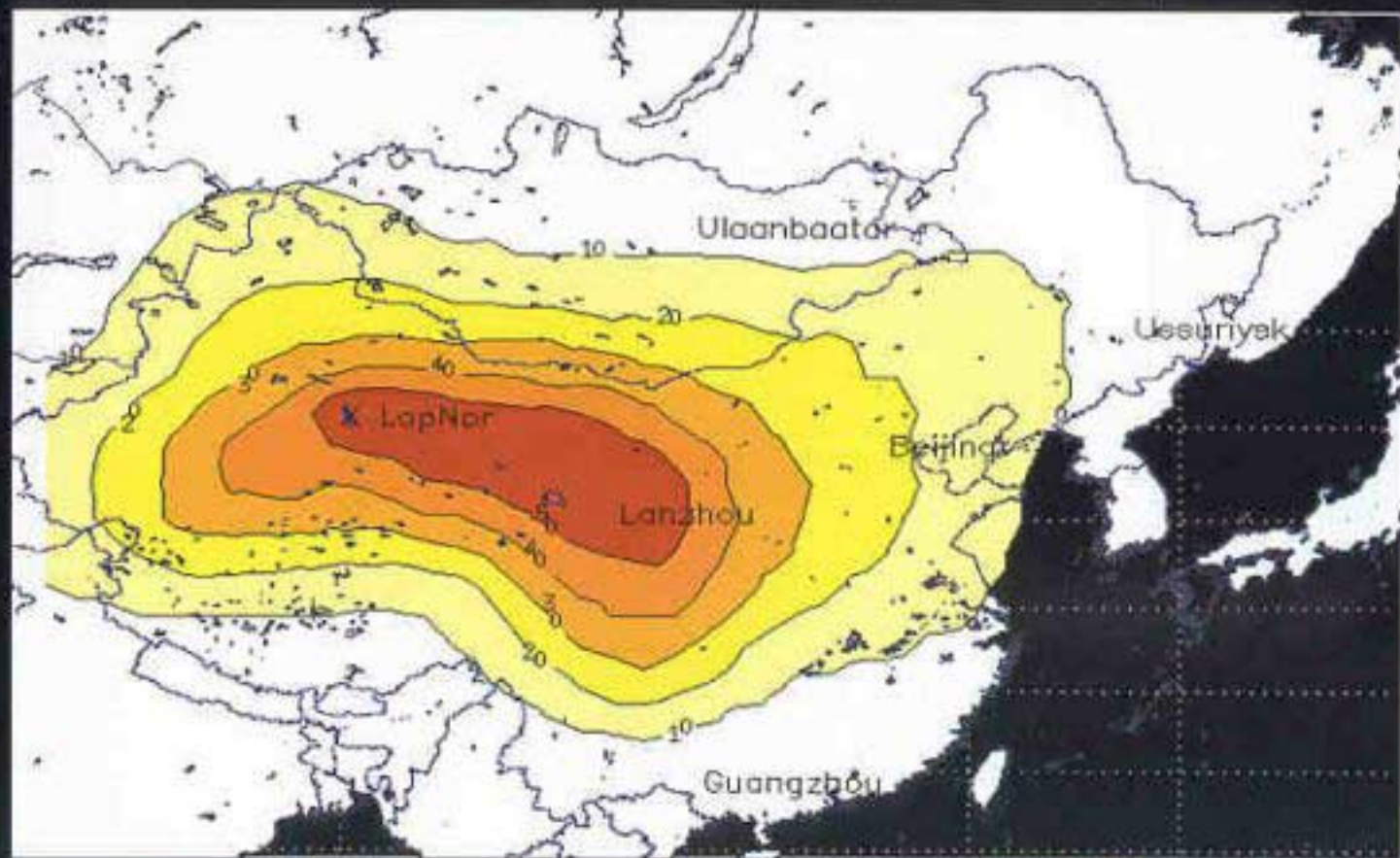
47.92, 7.4



48.37, 7.83

CTBT Climatologies

Lop Nur 1 Kt Annual Detection Probability Climo



Conclusion

- **U.S. NDC has outstanding meteorological capability**
 - 10 year on-line weather database
 - Suite of models provides greater confidence in results
 - Over 50 years organizational experience