Radiation Measurements of the Fukushima Accident

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Background and Motivation

- March 11, 2011 - Earthquake and Tsunami damage the nuclear reactor containments at the Fukushima Daiichi power plants
- Reactor core meltdown and spent fuel storage containment damage resulted in release of radioactive particles (^{137}Cs and ^{131}I)
- Dose to humans measured in Sieverts (Sv)
    - Annual background dose: 1 - 10 mSv/yr (0.114 - 1.141 µSv/hr)
    - Lowest observed increase in probability of cancer in lifetime: 100 mSv/yr (11.41 µSv/hr)
    - 5% increase in probability of cancer in lifetime 1000 mSv/yr (114.1 µSv/hr)
- Allegations that official Japanese government sources downplayed risk from radiation release
- **Research Question: Do the Japanese government dose rate measurements differ from independent dose rate measurements?**

Data Sources

MEXT MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

Official Japanese government measurements

- 330,000 measurements from March 14, 2011 to January 1, 2012
- Fixed point measurements: 47 different (latitude, longitude) locations
- Readings reported in μSv/hr

SAFECAST

“Pro-data” non-profit that aggregates independent measurements

- 32.1 million measurements from April 23, 2011 to October 5, 2015
- Vehicle-side measurements. Nearly all at different (latitude,longitude) locations
- Readings reported in counts/second

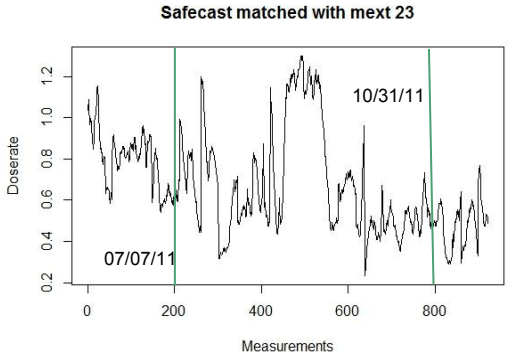
Data Manipulation

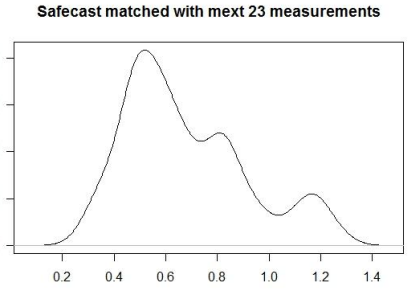
- Need to compare measurements that are similar in space and time
- Converted Safecast readings from counts/second to µSv/hr based on ‘Device ID’ field
- Safecast measurements within time period of MEXT measurements: 2.1 million
- Created pairs of MEXT and Safecast Measurements within **500m and 1 hour**
    - Of the 47 MEXT locations, only 7 had associated Safecast measurements
    - Two locations, 23 and 25, had >500 associated Safecast measurements

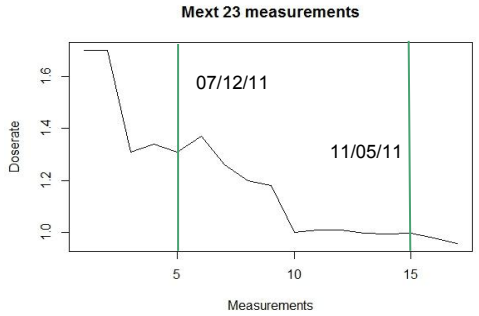
	lat	long	datetime	doserate	mlat	mlong	mloc_id	mtime	mdr	distance	timediff	drdiff
0	37.748375	140.473912	2011-05-07 19:37:22	1.037143	37.750361	140.469389	23	2011-05-07 20:00:00	1.7	0.48055	1358	0.66286
1	37.748352	140.473557	2011-05-07 19:37:27	1.088571	37.750361	140.469389	23	2011-05-07 20:00:00	1.7	0.45342	1353	0.61143

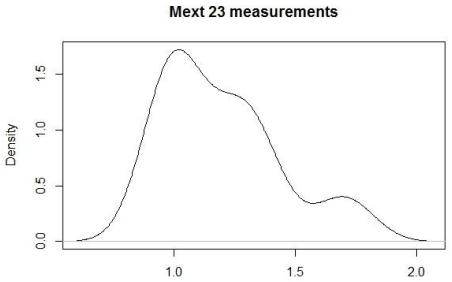
Time Series Analysis: MEXT Location 23 (Fukushima)

Safecast	**MEXT**
Mean: 0.62	Mean: 1.2
Min: 0.23	Min: 0.96
Max: 1.3	Max: 1.7
Positive Skew	Positive Skew
Downward Trend	Downward Trend
Spikes revert to mean over time	Mean is not stationary



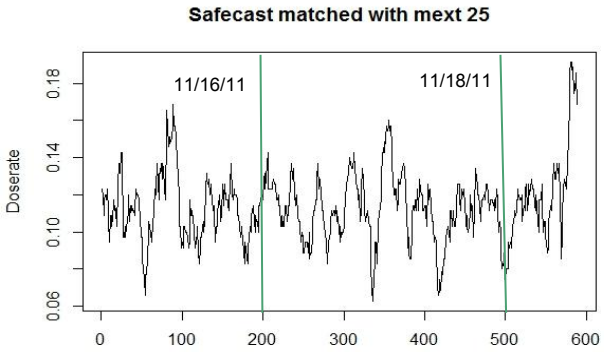


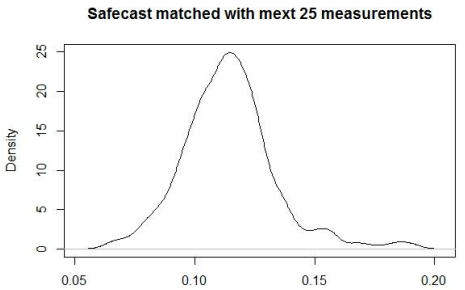


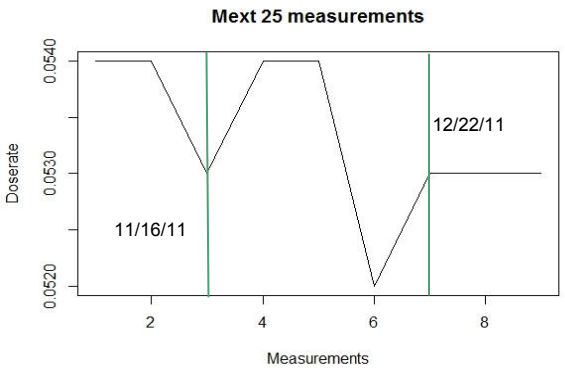


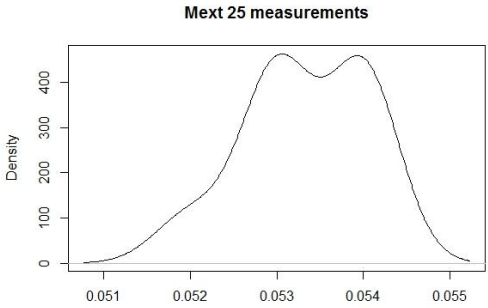
Time Series Analysis: MEXT Location 25 (Tokyo)

Safecast	**MEXT**
Mean: 0.11	Mean: 0.53
Min: 0.06	Min: 0.52
Max: 0.19	Max: 0.54
Slight Positive Skew	Negative Skew
Mostly Random Process	Downward Trend
Stationary Mean	







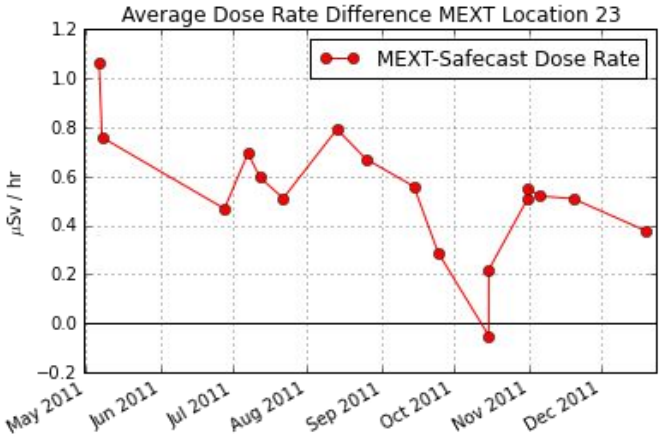


Dose Rate Differences

Averaged Safecast measurements associated with each MEXT (location, time) in order to examine any potential differences in dose rates

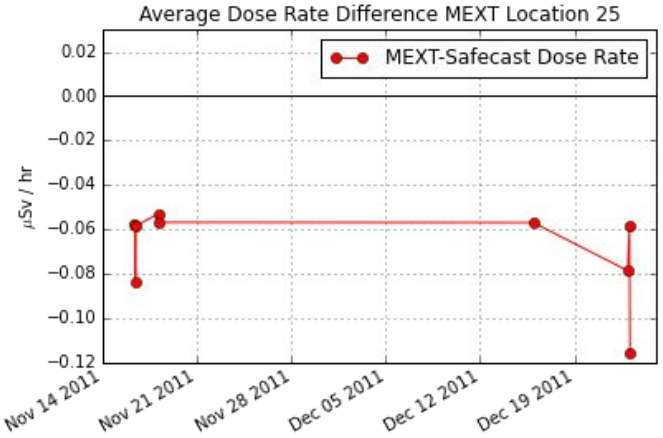
MEXT Location 23 (Fukushima)

- MEXT almost always higher
- Differences less than 1.1 µSv/hr



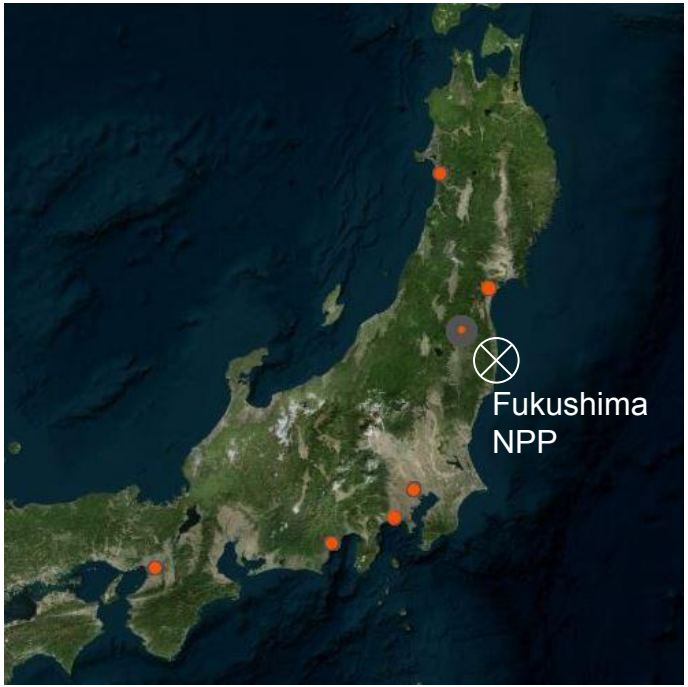
MEXT Location 25 (Tokyo)

- Safecast almost always higher
- Differences less than 0.12 µSv/hr



Visualizing All Associated Data Points

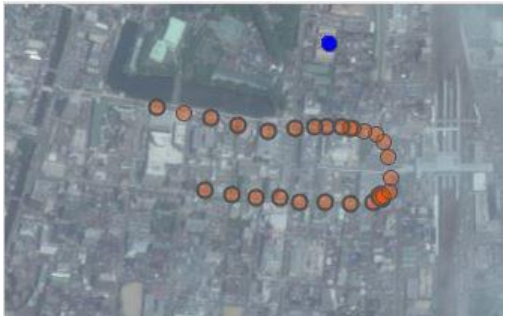
Safecast



MEXT

mloc_ID = 9

mloc_ ID = 11



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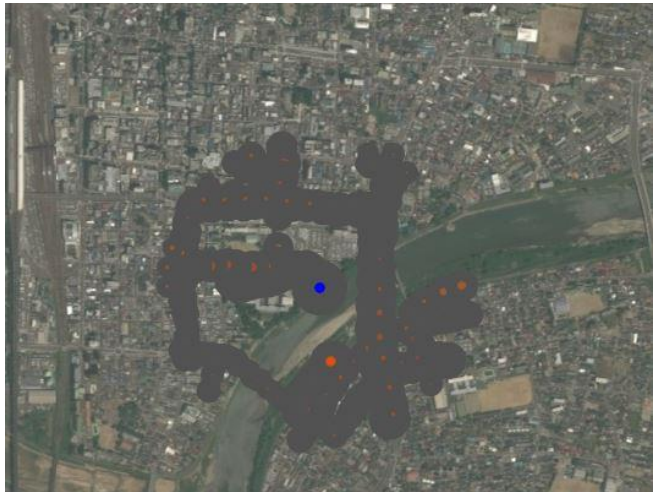
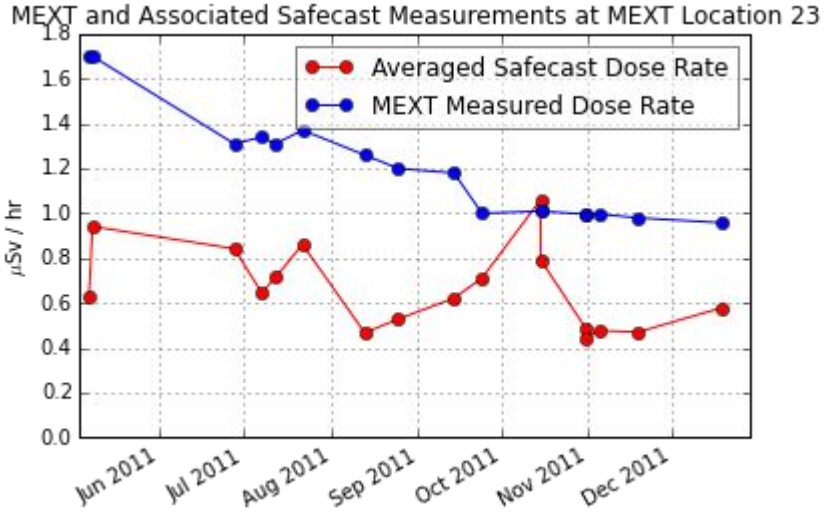
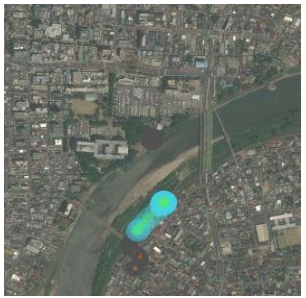


mloc_ID = 23

mloc_ID = 25

MEXT Location 23 (Fukushima) by Time





10/15
7 am

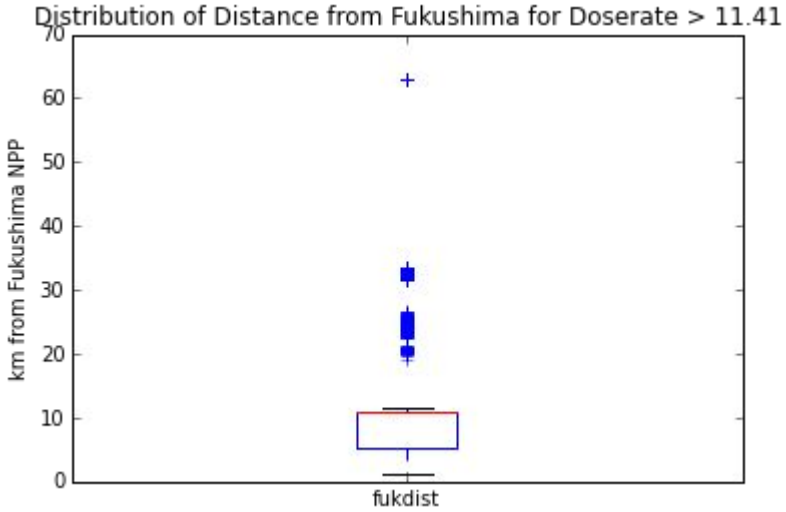
10/15
8 am

Cancer Risk Assessment

11.41 µSv/hr: Minimum dose rate where increased cancer risk has been observed

Most of these “elevated measurements within 10 km of Fukushima plant

Exclusion Zone: 20km from plant



Conclusions

- Lack of comparable data in space and time required association and averaging
- No large practical differences observed between Safecast and MEXT measurements
- Radiation threat is largely overstated
- Independent measurements assist government agencies in data collection while also validating their measurements