Thermal radiation effects in the atmosphere initiated by pre-earthquake processes

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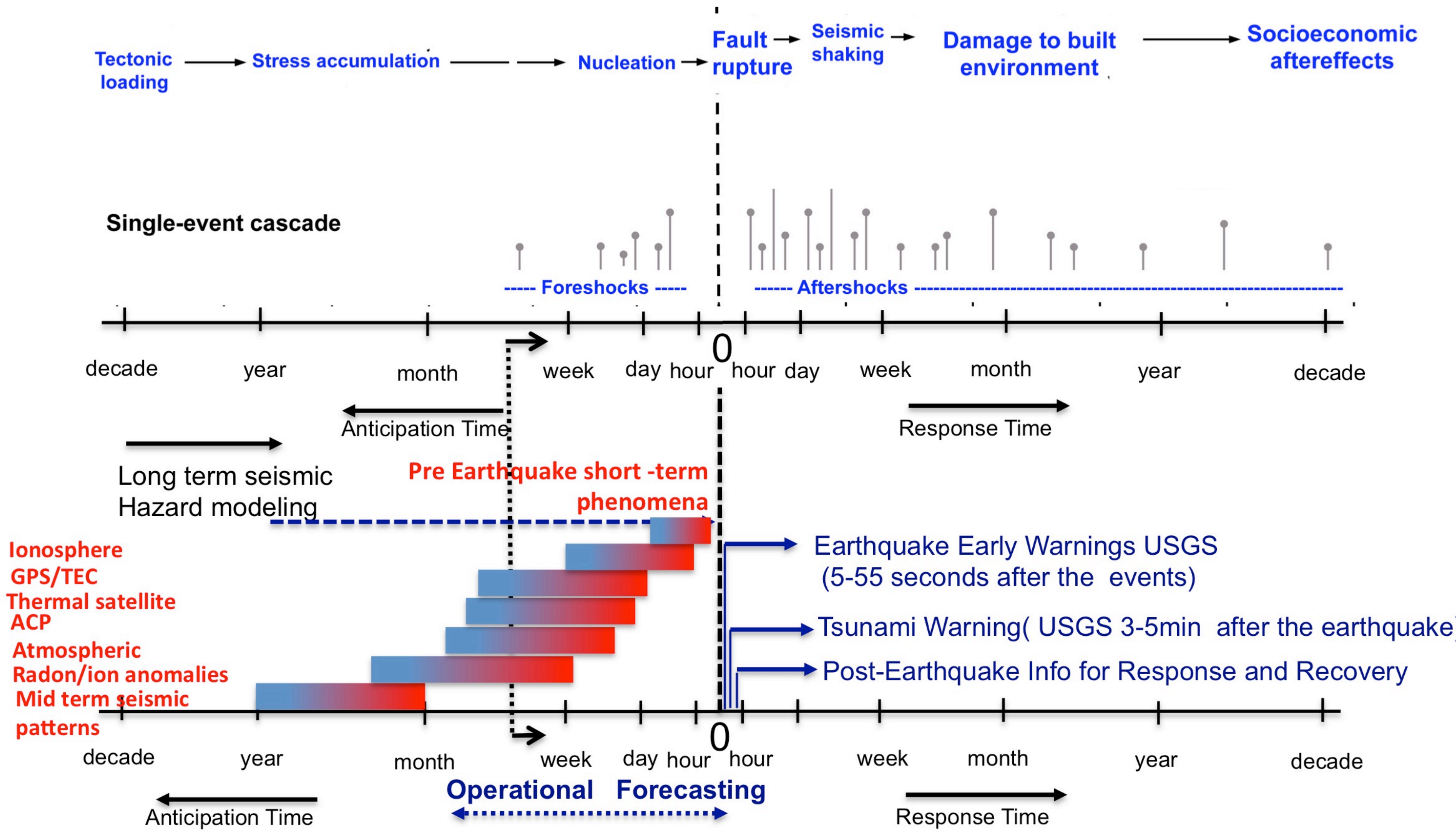
Introduction

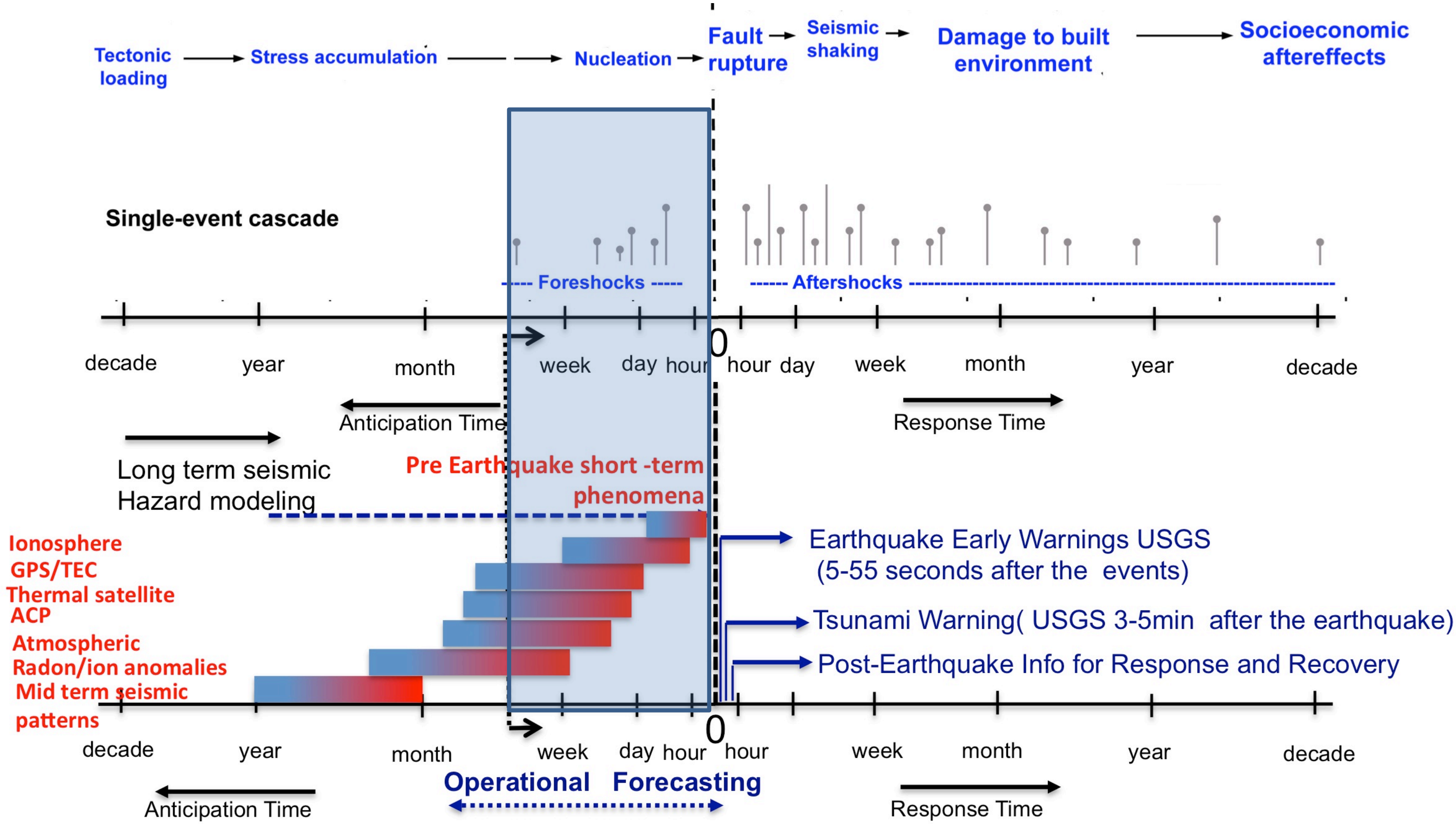
- Pre-earthquake phenomena
- Thermal radiation anomalies and earthquakes processes
- Napa M6 earthquake of Aug 24 2014 in California
- Nepal M7.8 of Apr 25, 2015 and M7.3 of May 12, 2015
- Takeaway

Earthquakes progress as chain reactions



After Tom Jordan (SCEC, Monterey CA,2011)

Earthquakes progress as chain reactions

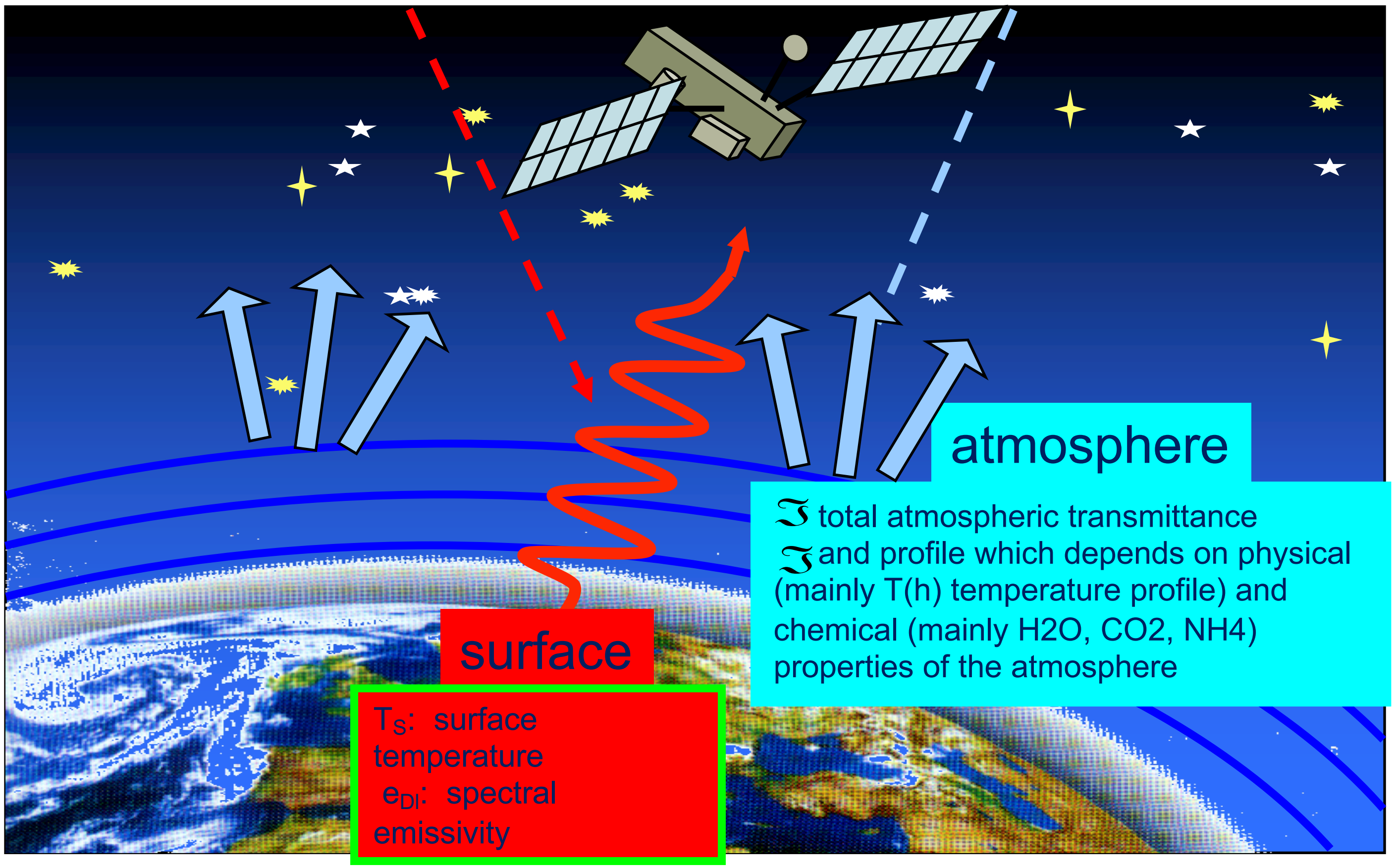


After Tom Jordan (SCEC, Monterey CA,2011)

Thermally emitted Earth's radiation

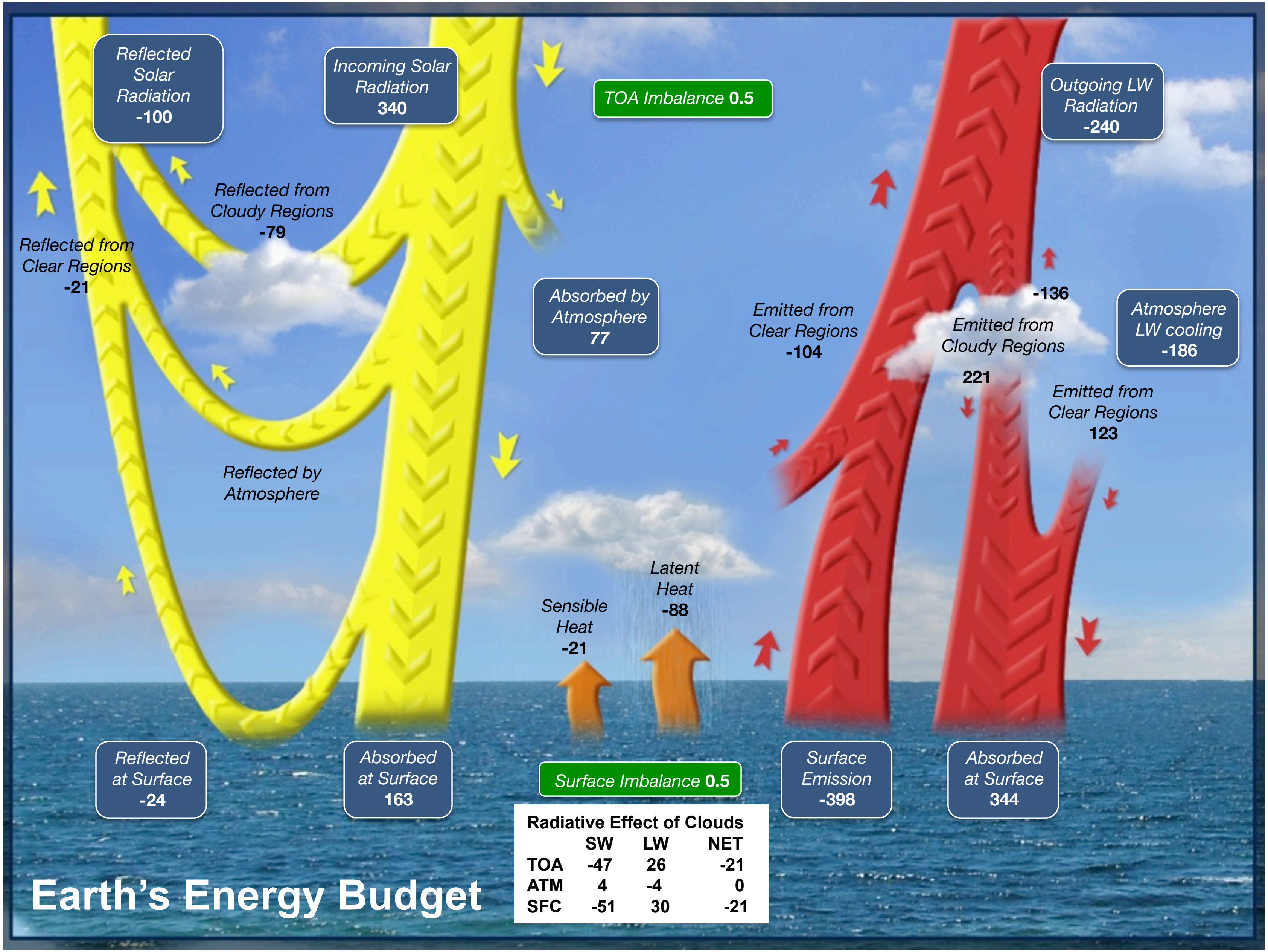
$$R_{\Delta\lambda} = \varepsilon_{\Delta\lambda} B_{\Delta\lambda}(T_s)\Im_{\Delta\lambda} + \int_0^{h_{sat}} B_{\Delta\lambda}[T(h)] \frac{\partial \Im_{\Delta\lambda}(h)}{\partial h} dh + ..$$

Tramutoli et al, 2007



1. Since '80s a candidate parameter suggesed by several physycal models

2. Global satellite coverage to measure it with high space-time continuity since more than 30 years (continuation planned for decades)



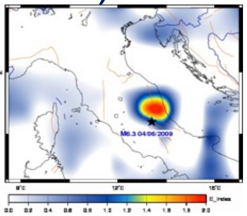
Radiative Effect of Clouds

	SW	LW	NET
TOA	-47	26	-21
ATM	4	-4	0
SFC	-51	30	-21

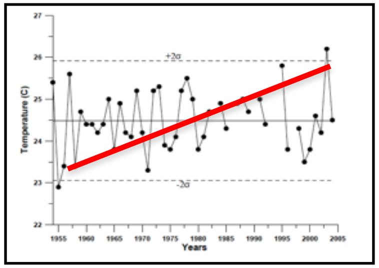
NASA, 2012

Lithosphere Atmosphere Ionosphere Coupling (LAIC)
Thermal Interface

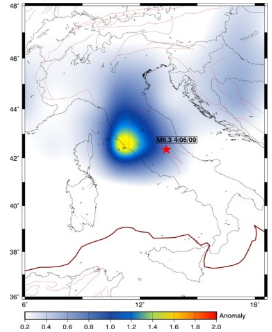
OLR anomalies



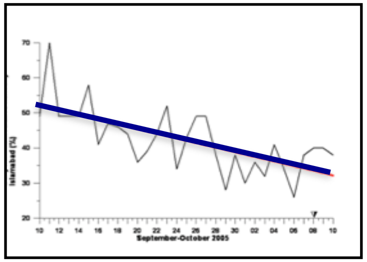
Air temperature growth



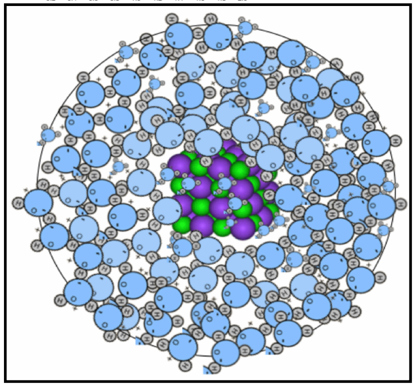
Latent heat release



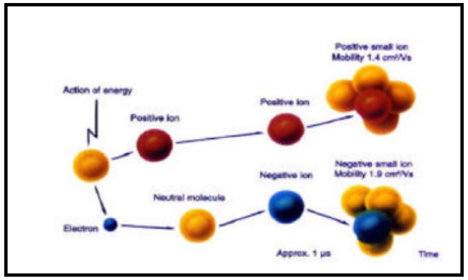
Humidity drop



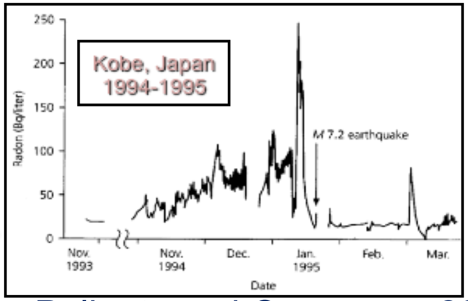
Ions hydration– formation of aerosol size particles



Air ionization by α-particles – product of radon decay

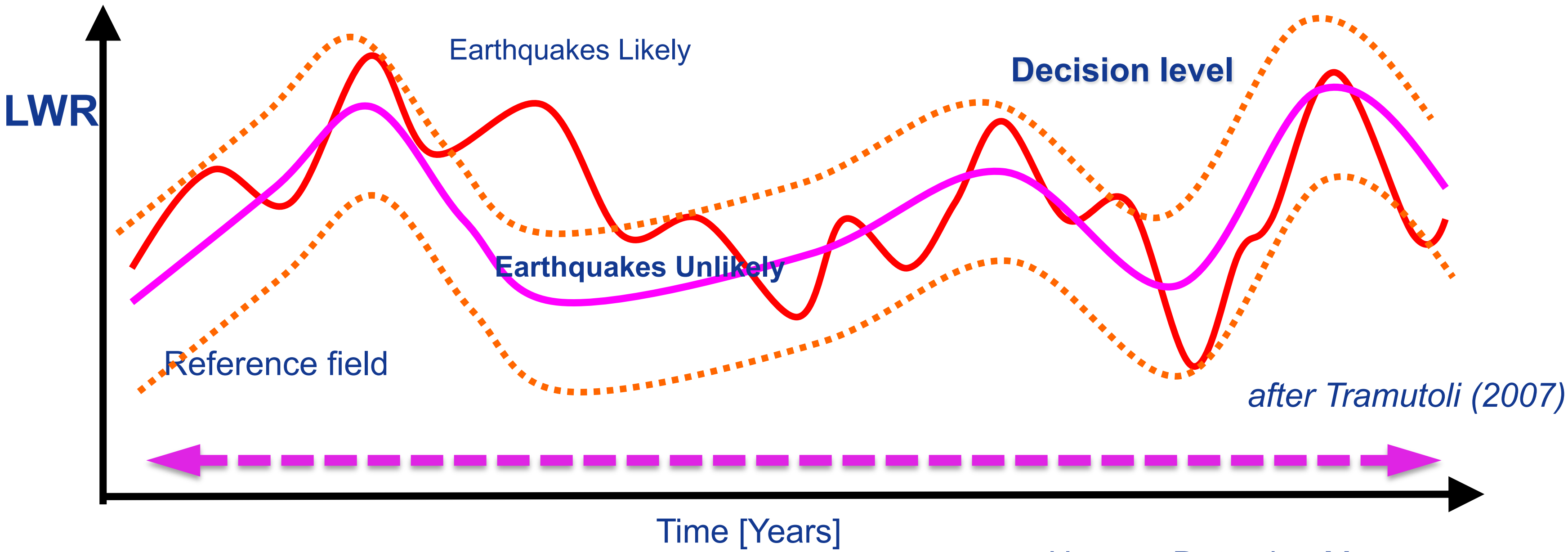


Faults activation – permeability changes
Gas discharges including radon emanation

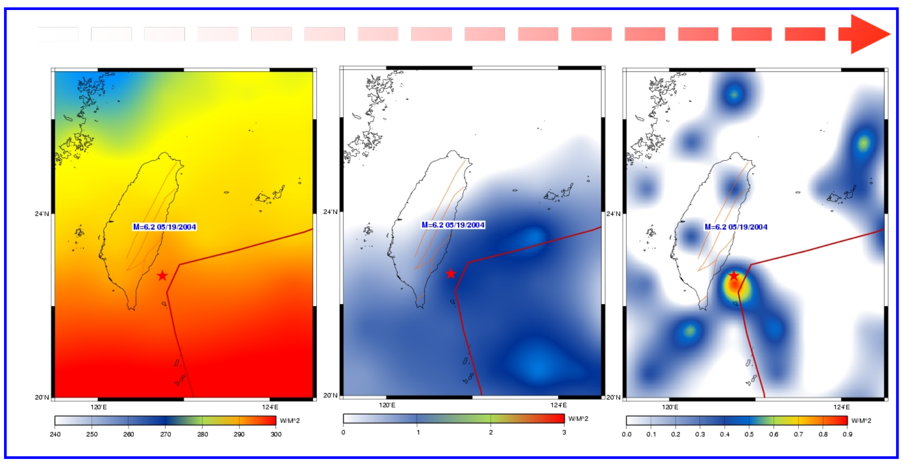


Pulinets and Ouzounov, 2011

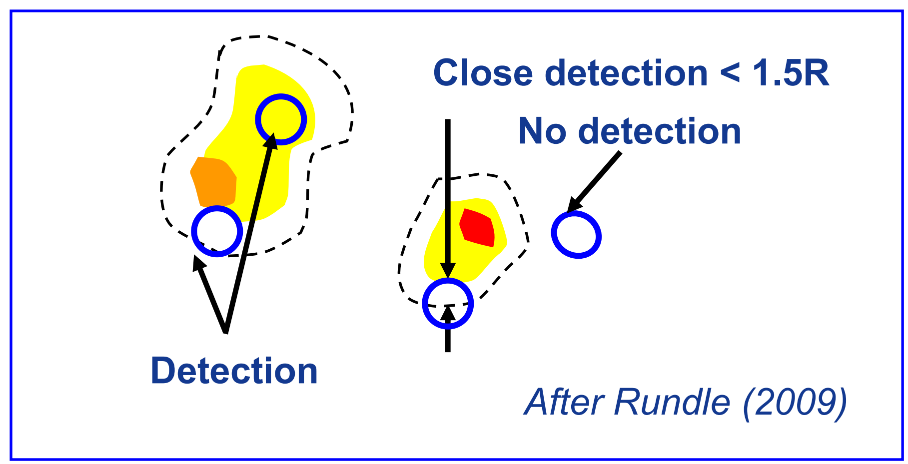
The principles of OLR atmospheric anomaly definition



Anomalous index based on Signal/noise detection ratio (Shannon)



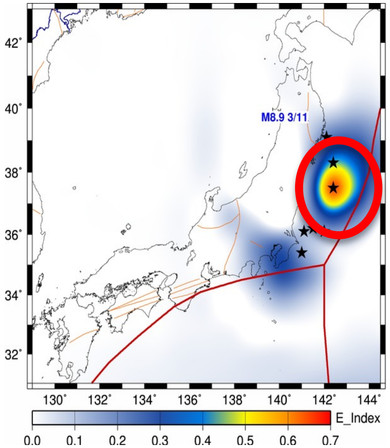
Hotspot Detection Map



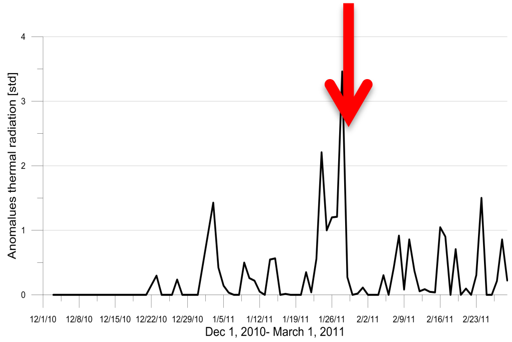
Areas of application for OLR thermal anomalies

1. Pre- earthquake detection
2. Alerting for volcanoes eruption
3. Man-made environmental hazards
4. Detection of natural radioactivity source

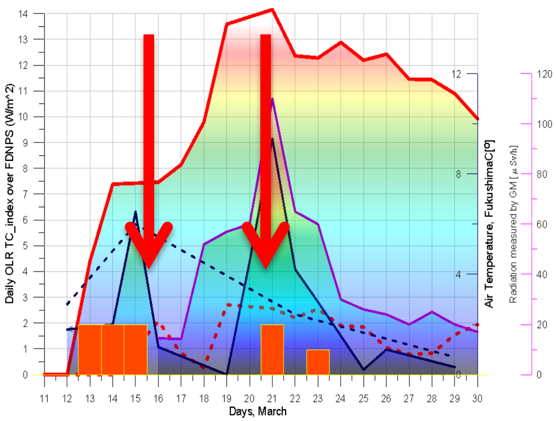
(1) Sendai, Japan March 2011



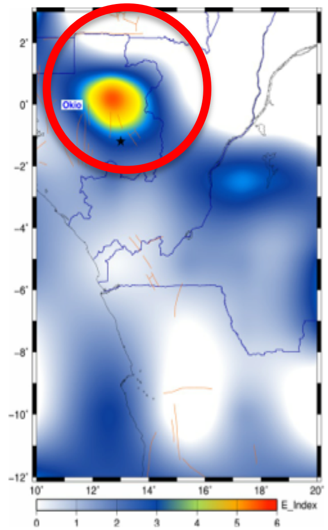
(2) Shinmoedake volcano, January, Japan 2011



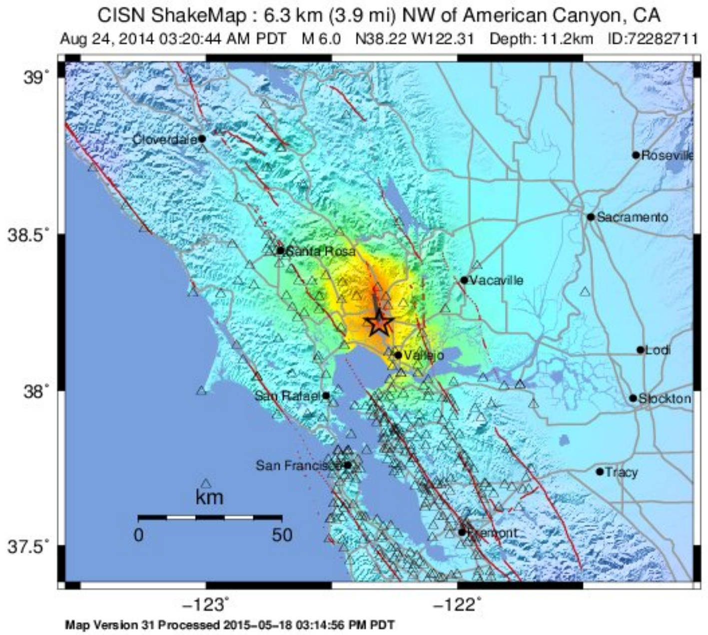
(3) Fukushima, Japan March, 2011



(4) Gabon, Africa

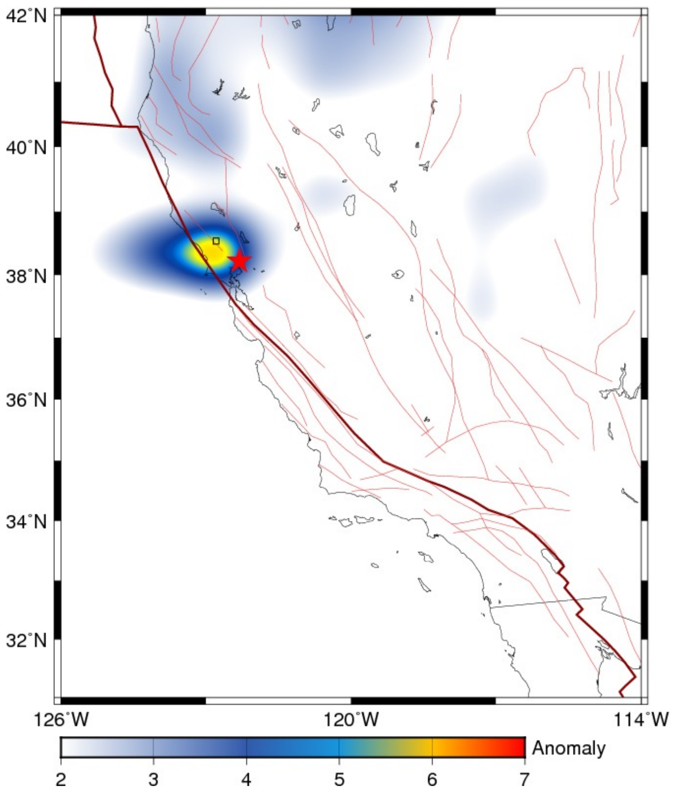


M6.0 Aug 24, 2014 Napa Valley, California



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.1	0.5	2.4	6.7	13	24	44	83	>156
PEAK VEL.(cm/s)	<0.07	0.4	1.9	5.8	11	22	43	83	>160
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Wald, et al.; 1999



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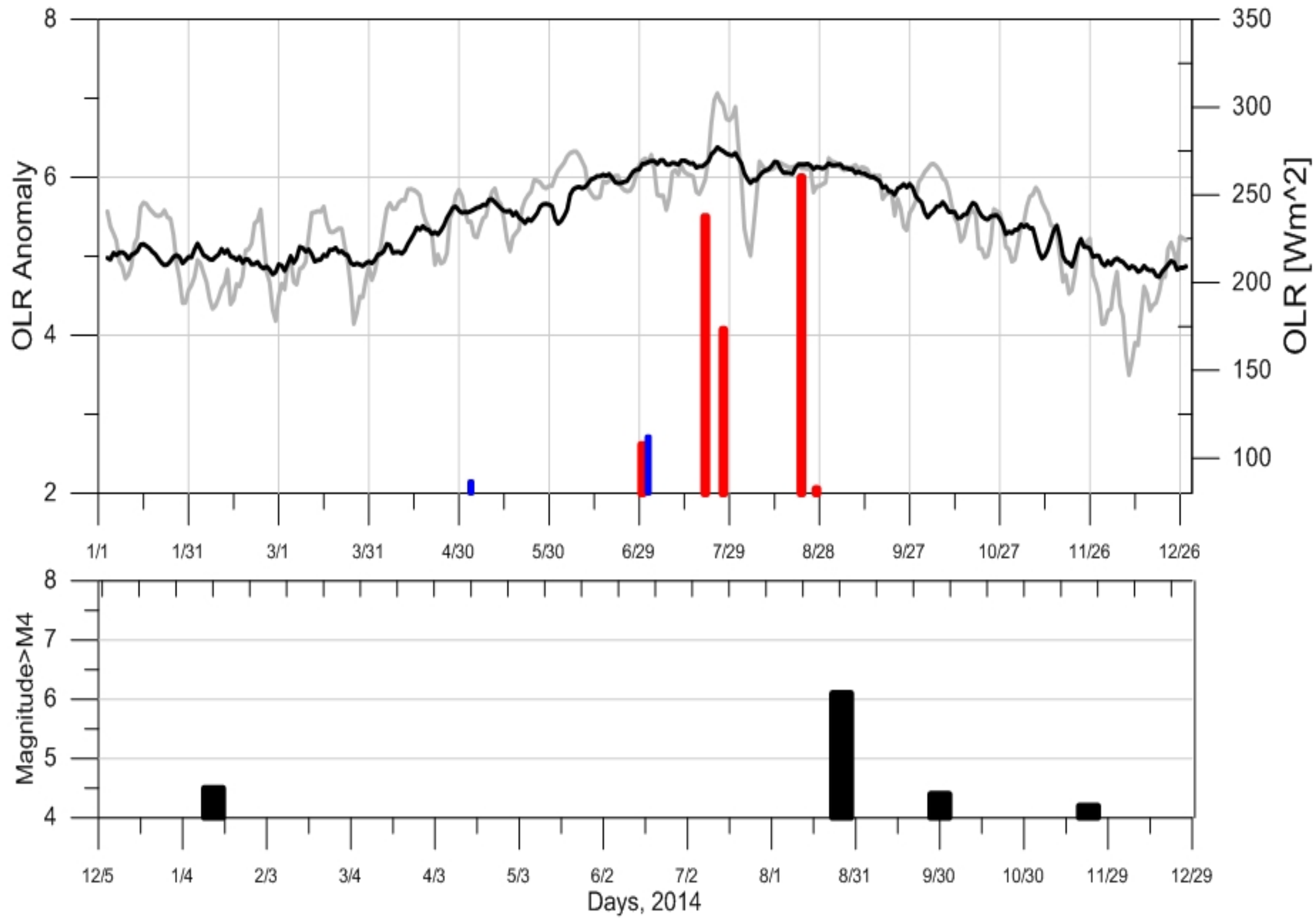
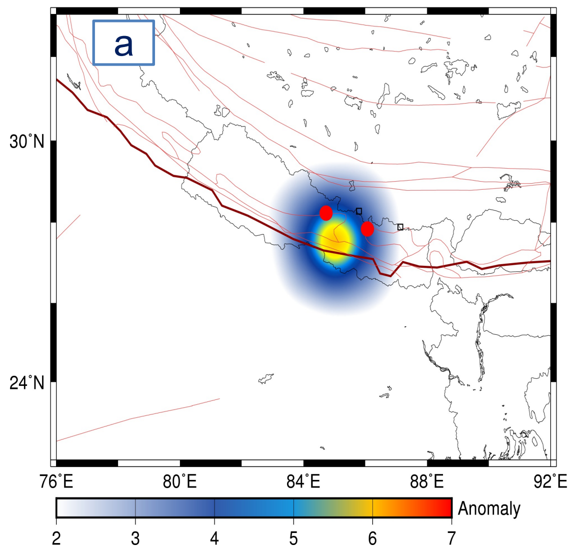
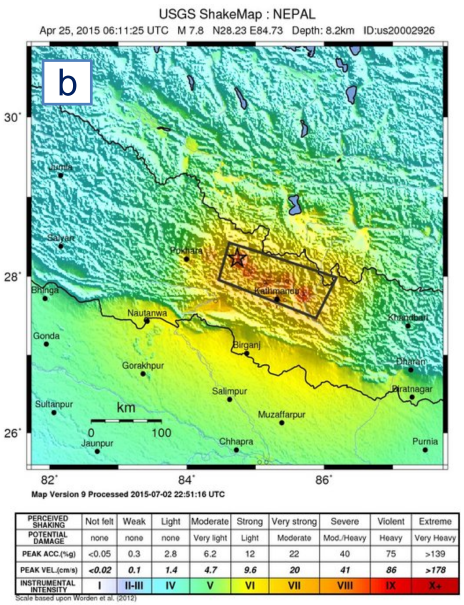


Nepal M7.8 of Apr 25, 2015 and M7.3 of May 12, 2015

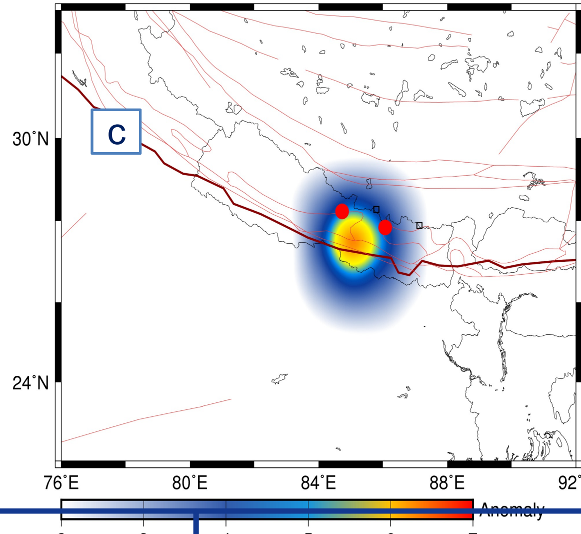
Thermal anomaly 04.23.2015



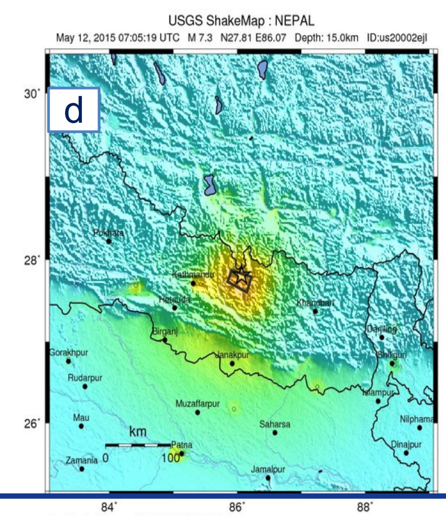
Nepal M7.8 of Apr 25, 2015



Thermal anomaly 05.02.2015



Nepal M7.3 of May 12, 2015



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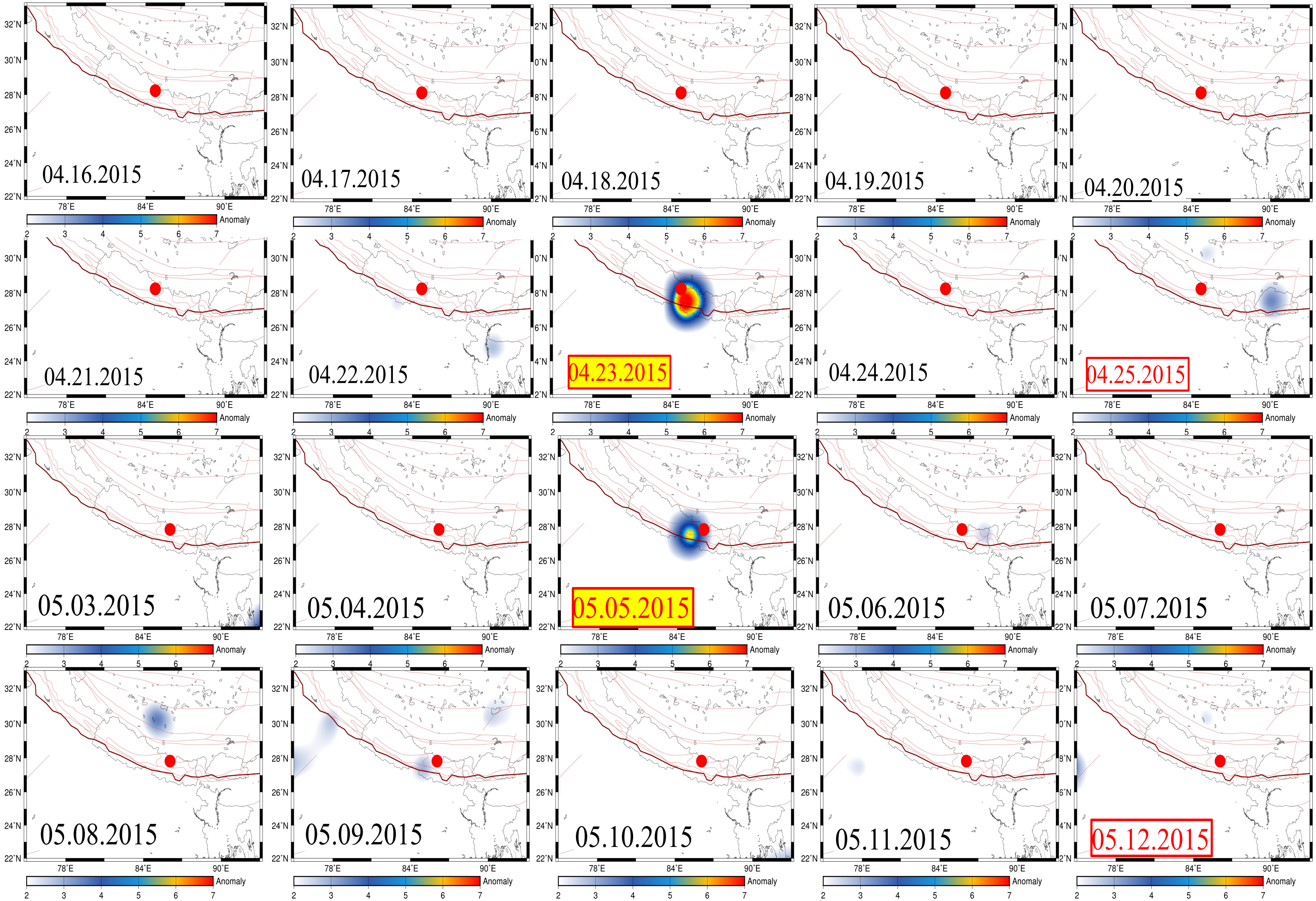

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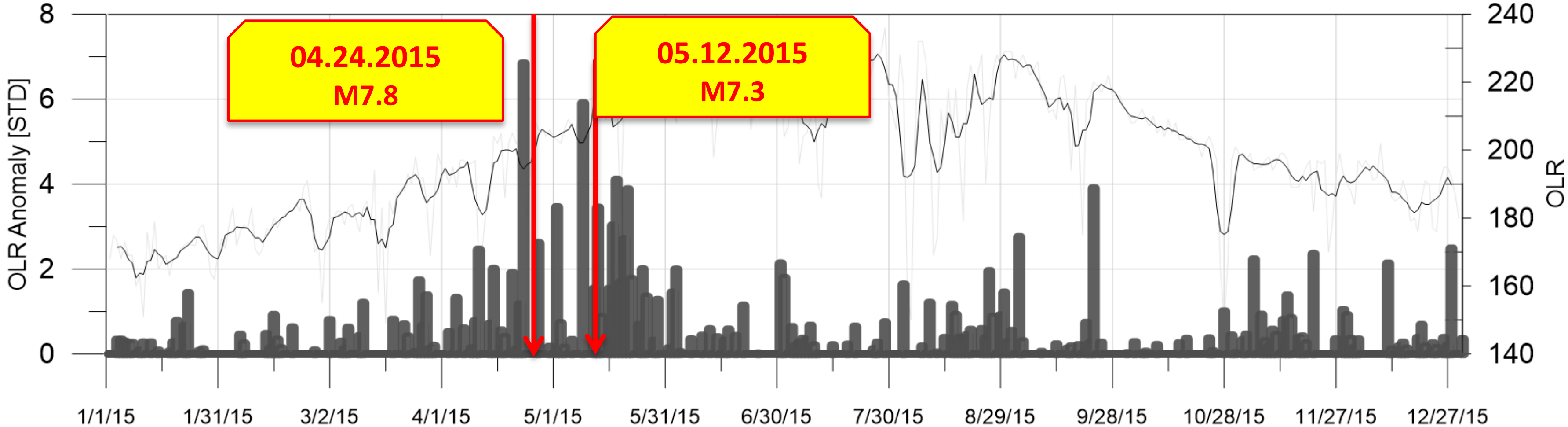
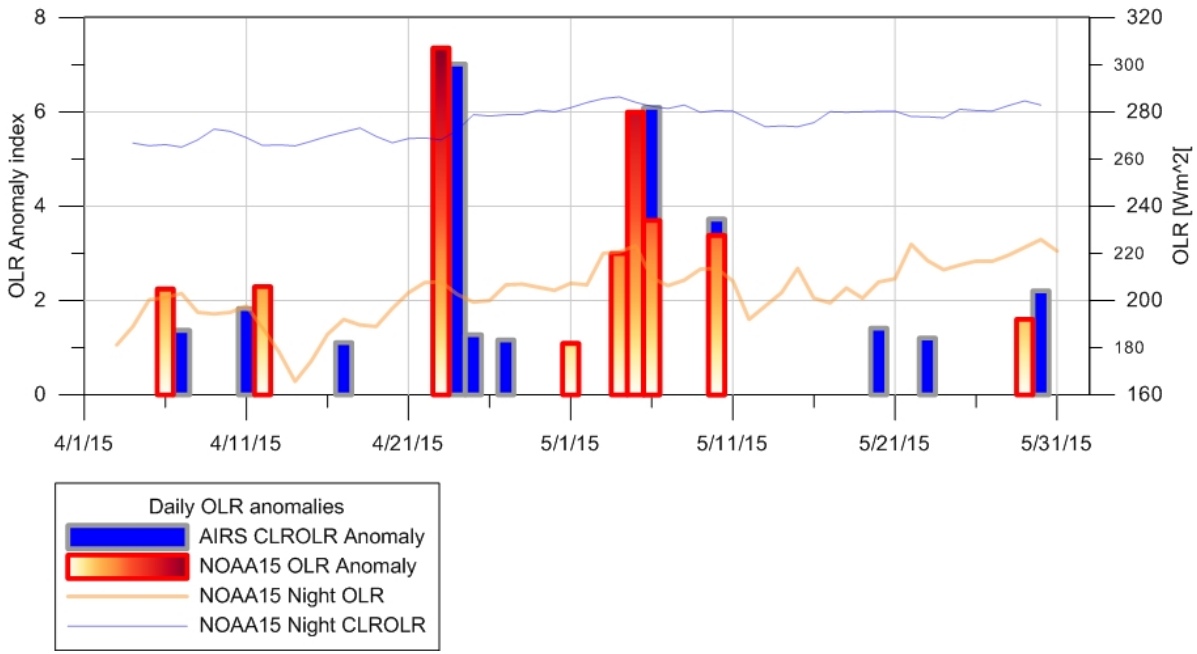




Points to take home

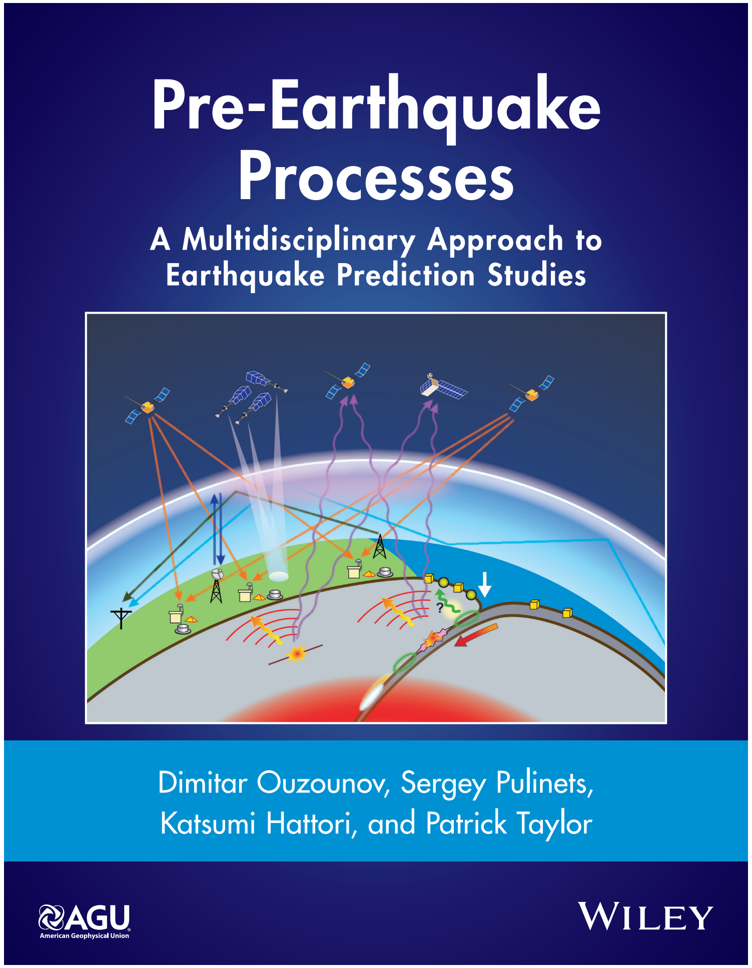
What we know so far?

- We have illustrated the possible link of transient thermal fields on the ground with pre-earthquake processes by using retrospectively/prospectively the transient variations of the OLR parameter in the atmosphere during the time of the 2014 M6 earthquake in California and 2015 M7.8 and M7.3 events in Nepal.
- From space-born observations of the atmospheric conditions, we have shown that there is a consistent occurrence of radiative emission (OLR) anomalies at the TOA, over the region of maximum stress associated with, and preceding, large earthquakes. Because of their relatively long duration, these anomalies do not appear to be of meteorological origins.
- Our analysis of atmospheric parameters for recent major earthquakes has demonstrated the presence of correlated variations of transient OLR anomalies in the atmosphere, implying their connection with pre-earthquake processes.
- Our results suggest the existence of a thermal radiation response in atmosphere triggered by the coupling processes between the lithosphere and atmosphere.

Questions about the Pre- Earthquake processes?

Check this out.

AGU Geophysical Monograph Series (2018)



IOP Expanding Physics(2018)