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Entering Prediction Research: Learning by Doing

V. Keilis-Borok, A. Soloviev,

UCLA & MITPAN, Moscow
MITPAN, Moscow & ICTP, Trieste

Strada Costiera 11, 34014 Trieste, Italy - Tel. +39 040 2240 111; Fax +39 040 224 163 - sci_info@ictp.it, www.ictp.it

ENTERING PREDICTION RESEARCH: LEARNING BY DOING

V. Keilis-Borok, and A. Soloviev

vkb@ess.ucla.edu soloviev@mitp.ru

SMALL PROJECT: HOW TO START?

Pour commencer il faut commencer ("to start one should start", French proverb)

Problem

Extreme events that you want to predict ____________________________

Qualitatively (e.g. strong earthquakes) ________________________________

Quantitatively (e.g. magnitude, territory, lead time) ______________________

Available time series possibly containing precursors (one at a time)

____

Possible precursors (one at a time)

____

A possibility: Analyze a time series generated by the model

The data

A list of extreme events – the targets of your prediction

Time series hypothetically containing precursors to these events.

Prediction targets might be given;
otherwise you have to identify them by data analysis

NOTATIONS

T_e – times of extreme events, e = 1, 2, ...

$S(t)$ – observable function hypothetically containing precursor. It is often given as a time series.

$(t_i, m_i, h_i), i = 1, 2, \ldots$

t is the time of the event, $t_i, \le t_{i+1}$; m is its size (often given in logarithmic scale), h stands for additional parameters that might be indicated (e.g. coordinates of earthquake's hypocenter)

c_f – an adjustable numerical parameter, $f = 1, 2, \ldots$

WHAT NEXT?

Good news: e*arthquakes are predictable*.
Existing algorithms based on earthquakes sequences do provide rather useful predictions. That is not trivial for extreme events ("low probability, large consequences")

But *: accuracy of existing predictions is limited*.
They allow preventing a considerable part of damage. (Non-trivial prediction is useful if its accuracy is *known*, but not necessarily *high*; such is the case with many disasters, war included).
But remaining damage sill might be unacceptable, to put it gently.

We have a ***"paradox of want amidst plenty"*** (contemporaries' view of the Great Depression): *there is plenty of yet untapped data, models, and theories.*

What next: *launch predicting-in-advance; develop better algorithms*

YET UNTAPPED DATA

Seismology itself - source mechanisms, slow earthquakes, wave spectra, slow deformations, etc.

Geology Geomorphology Geochemistry

Fluid regime All geophysical fields

They are connected by the common origin – lithosphere dynamics

FOUR PARADIGMS IN EARTHQUAKE PREDICTION:

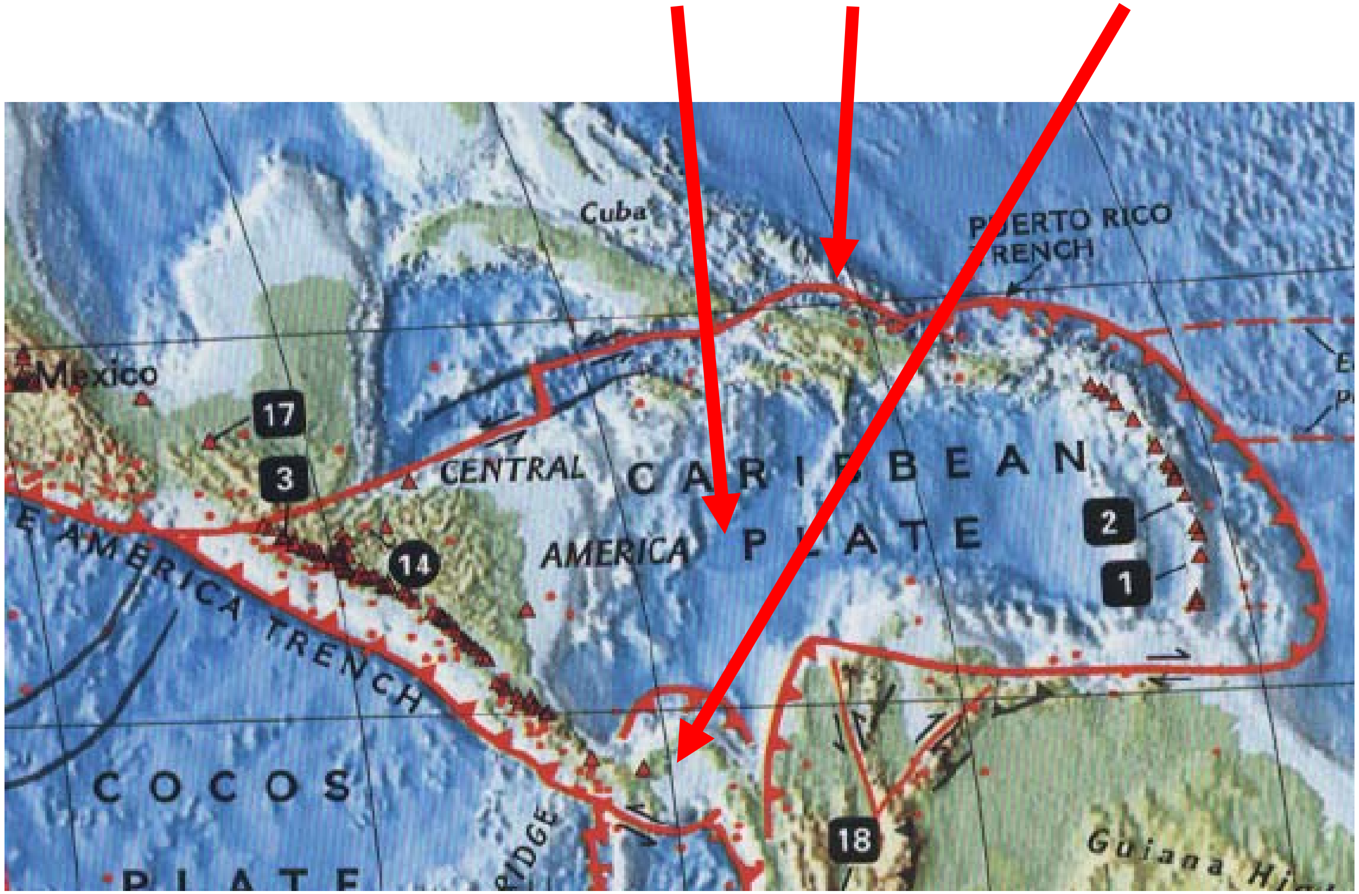
Types of precursors Similarity

Long-range correlations Dual nature

This suggests *how to use these data at least for a start.*

MORE UNTAPPED POSSIBILITIES:
INTEGRATING FAULT NETWORK INTO PREDICTION - 1

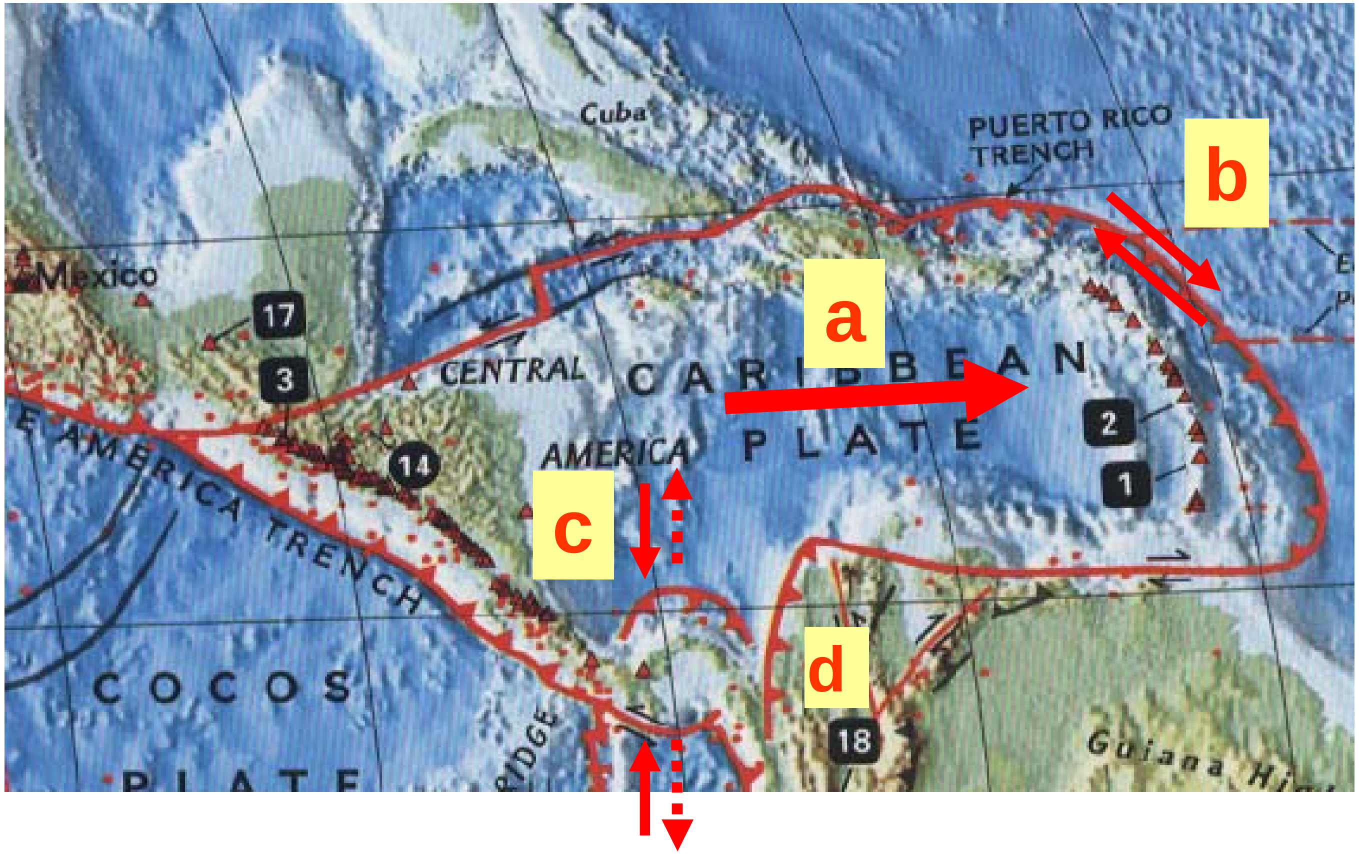
Different precursors in blocks, faults, and nodes.



INTEGRATING FAULT NETWORK INTO PREDICTION - 2

Using satellite data

a) absolute displacement averaged over blocks;
b) relative displacement on the faults
c) Compression vs. tension in the nodes.
d) Heat flow at the faults and nodes.



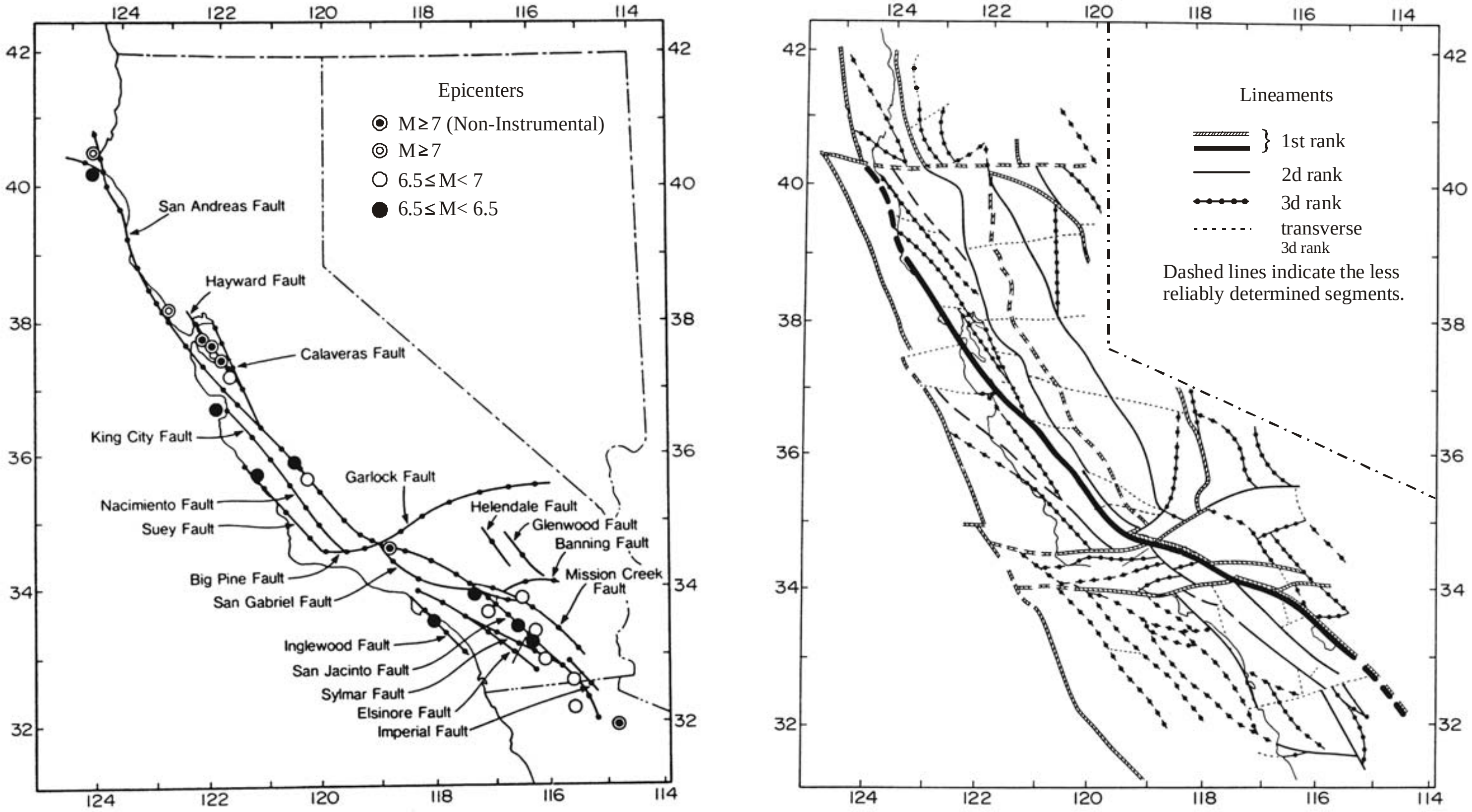
INTEGRATING FAULT NETWORK INTO PREDICTION - 3

Awareness gap: Many significant faults/boundary layers remain unrecognized in seismotectonics, although they would be routinely mapped in structural geology and mineral prospecting. After the earthquake they are called “blind faults”.

More faults-more intersections-more nodes-more instability-more precursors.

Ditto – platforms

Example:



Gelfand, I.M., Guberman, Sh.A., Keilis-Borok, V.I., Knopoff, L., Press, F., Ranzman, E.Ya., Rotwain, I.M., Sadovsky, A.M., 1976. Phys. Earth Planet. Inter. 11:227–83

FINALLY

There is a good chance for:

-- About five fold increase of prediction accuracy
-- Prediction months-, weeks-, and may be days in advance
-- Integration with preparedness

In the general scheme of things our problem is important for:

Development of the newly integrated dynamics of solid Earth
extending to
-- a fundamental concept, succeeding the plate tectonics,
-- interaction with other geospheres, and
-- prediction and control of geological disasters.

Predictive understanding of extreme events in nature and society
also known as bifurcations, singularities, phase transitions etc.
In applications they called natural and human-made disasters,
catastrophes and crises.

HOW TO PUT OUR ACT TOGETHER?

There is no complete pure theory governing lithosphere dynamics

Holistic approach per se is insufficient to overcome complexity of lithosphere and chronic imperfection of data.

At the same time we have seen a wealth of yet untapped possibilities.

The focus on the prediction goal is no less important.

Classical example follows

Romeo and Juliet

Shakespeare

ROMEO

It is the east, and Juliet is the sun.
Arise, fair sun, and kill the envious moon,
Who is already sick and pale with grief,
That thou her maid art far more fair than she:
Be not her maid, since she is envious;
Her vestal livery is but sick and green
…..
Two of the fairest stars in all the heaven,
Having some business, do entreat her eyes
To twinkle in their spheres till they return.
What if her eyes were there, they in her head?
The brightness of her cheek would shame those stars,
As daylight doth a lamp; her eyes in heaven

JULIET

If that thy bent of love be honourable,
Thy purpose marriage, send me word to-morrow,
By one that I'll procure to come to thee,
Where and what time thou wilt perform the rite…