

Subsidence associated with oil extraction, measured from time-series analysis of Sentinel-1 data

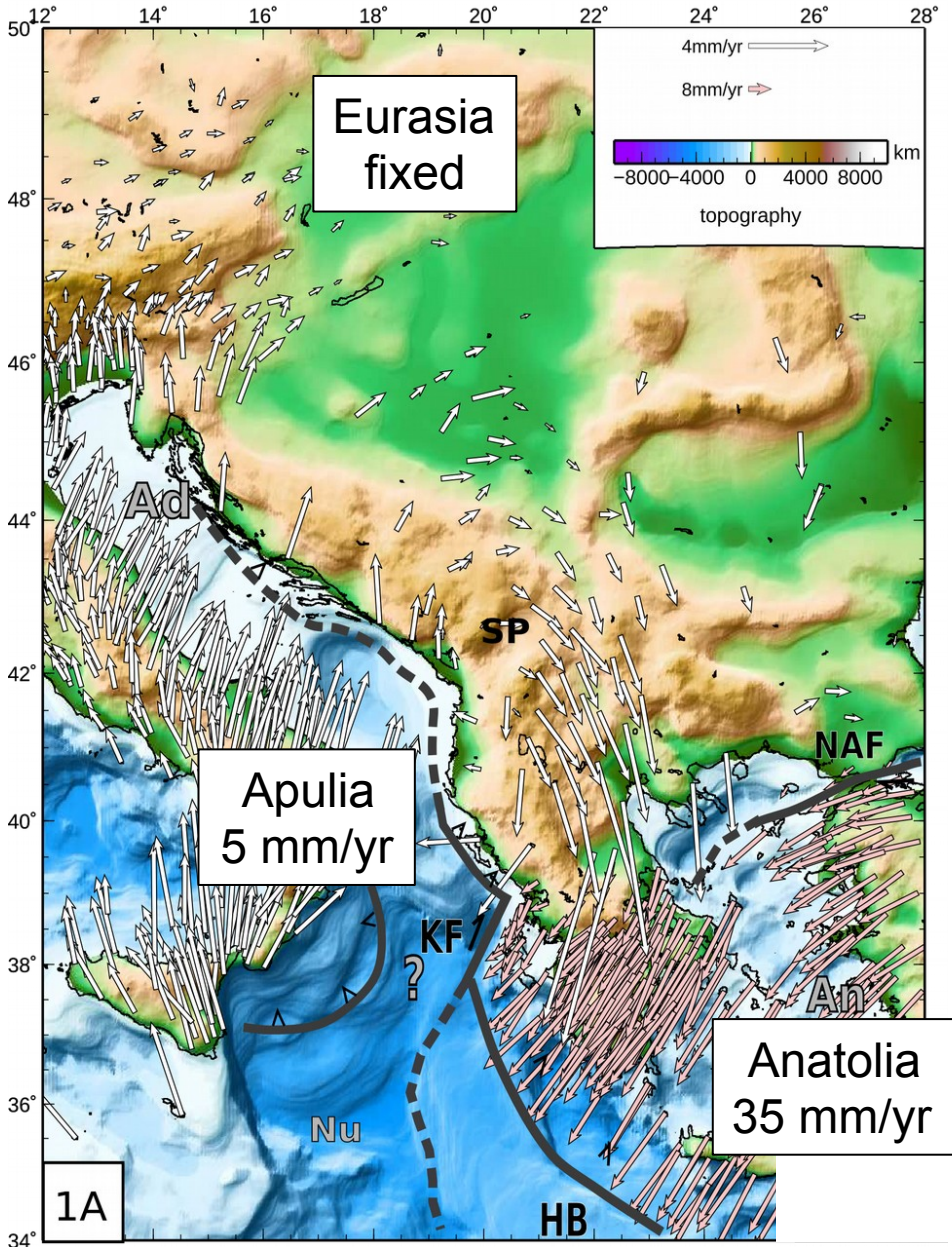
Case study of the Patos-Marinza oil field, Albania

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MDIS, Strasbourg, 2019

Albania : Seismotectonic context

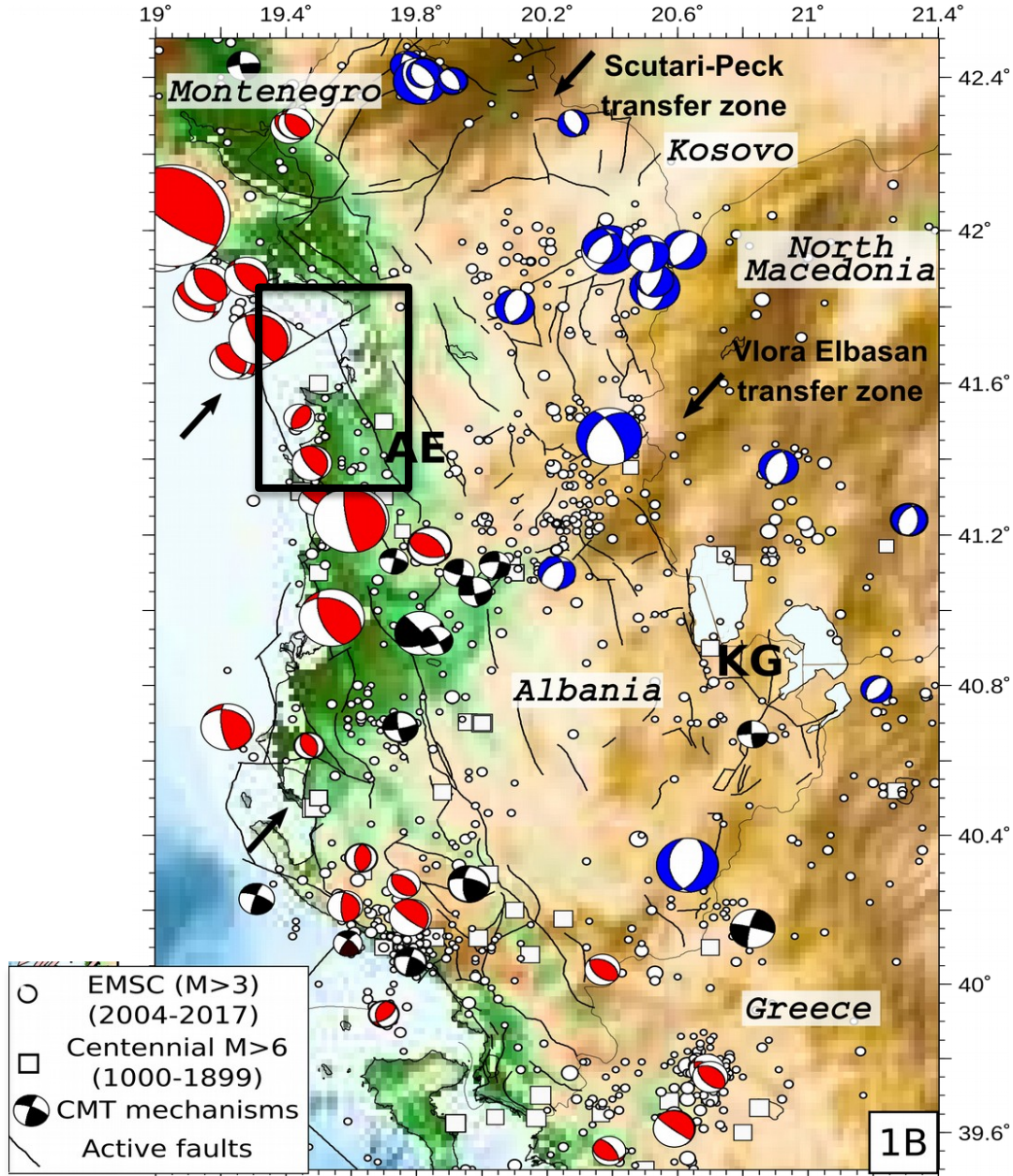
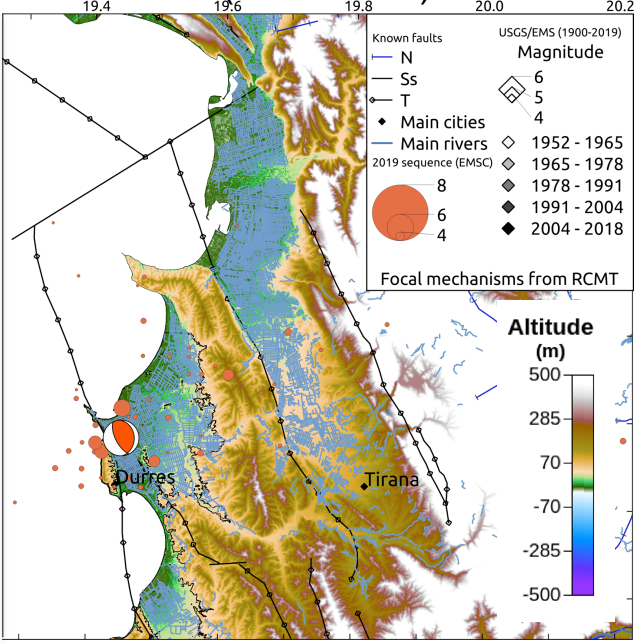


- At the heart of the interaction zone between Eurasia, Adria-Apulia and Anatolia plates
- Transition zone between the Hellenic subduction zone and the Dinarides collision front

Albania : Seismotectonic context

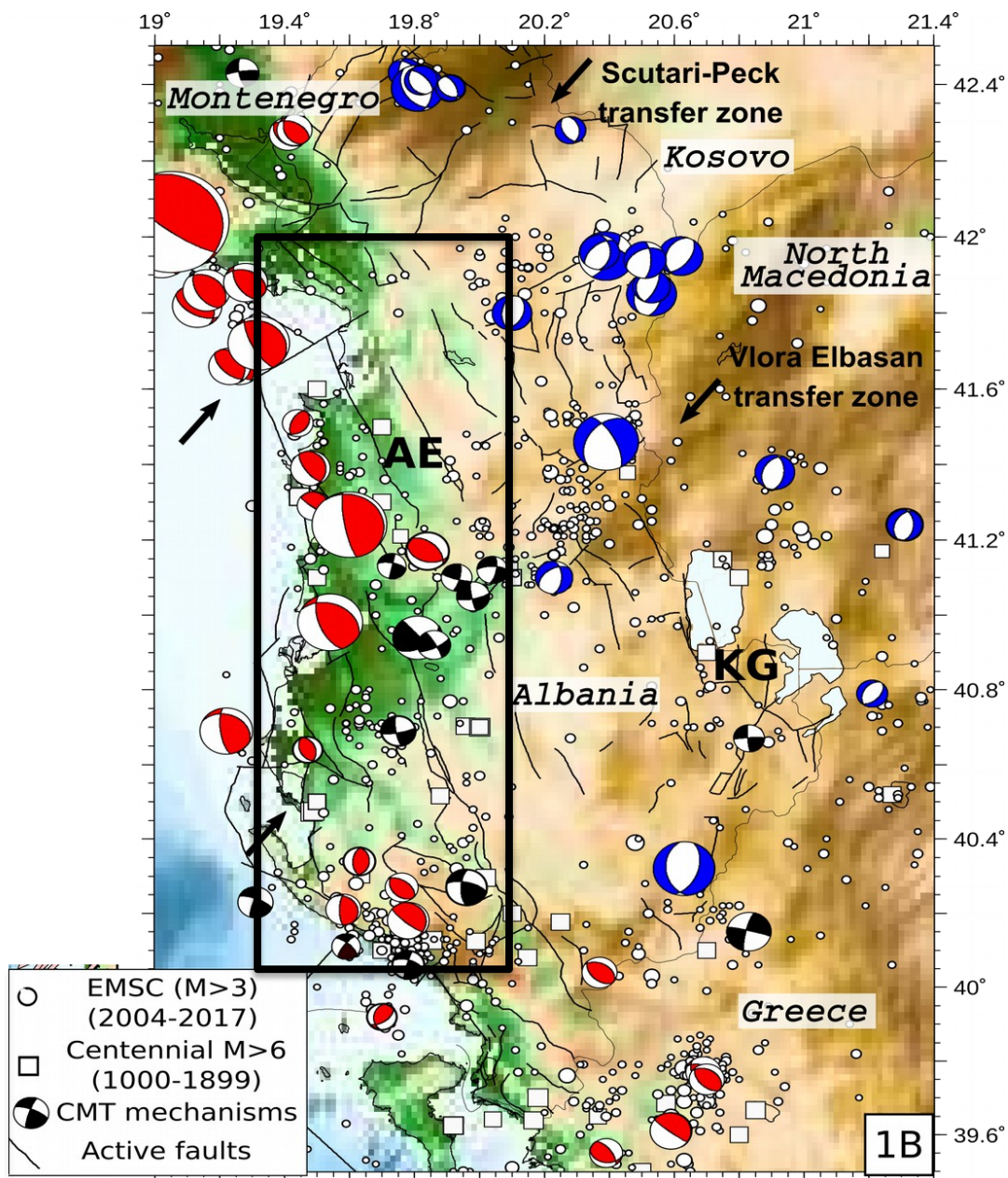
- Intense seismic activity with distinct tectonics styles between inner and outer Albanides

Sept. 2019 Durrës EQ sequence (Mw 5.1-5.6)



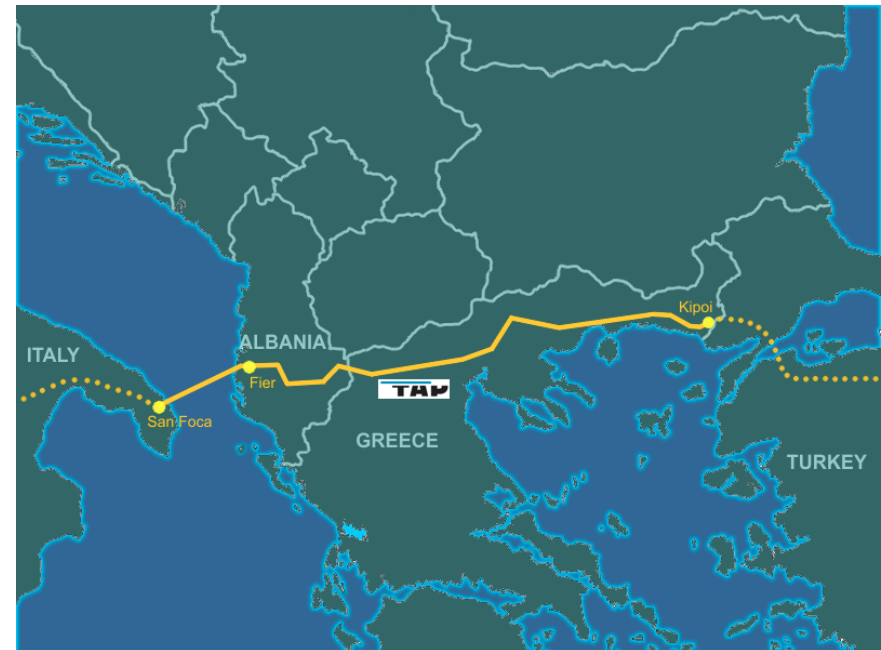
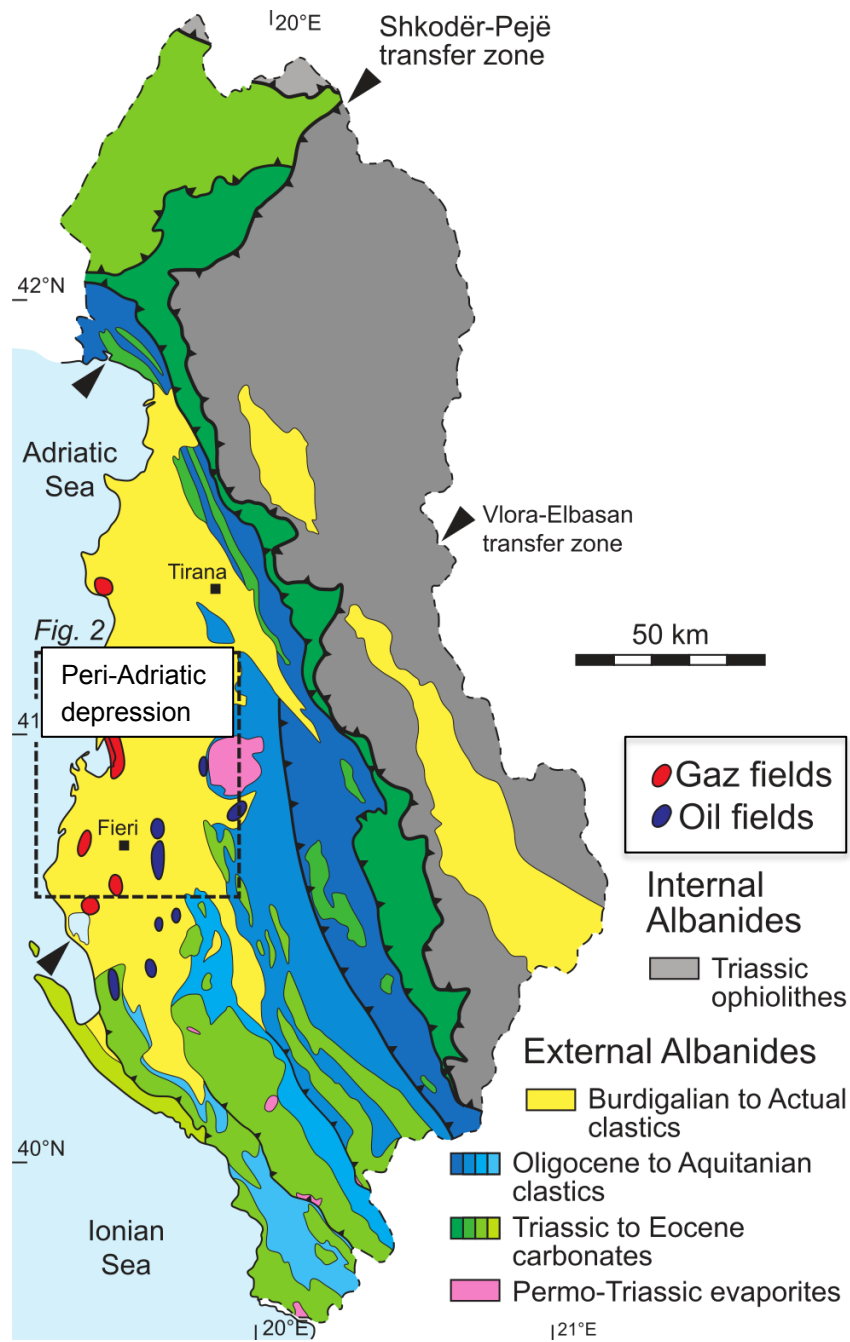
Albania : Seismotectonic context

- Intense seismic activity with distinct tectonics styles between inner and outer Albanides



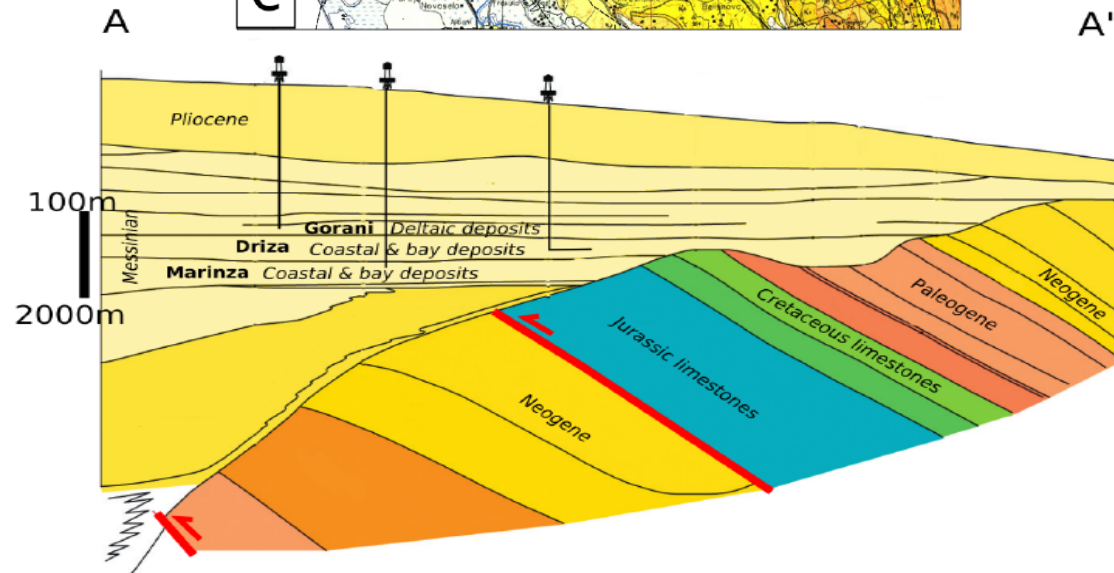
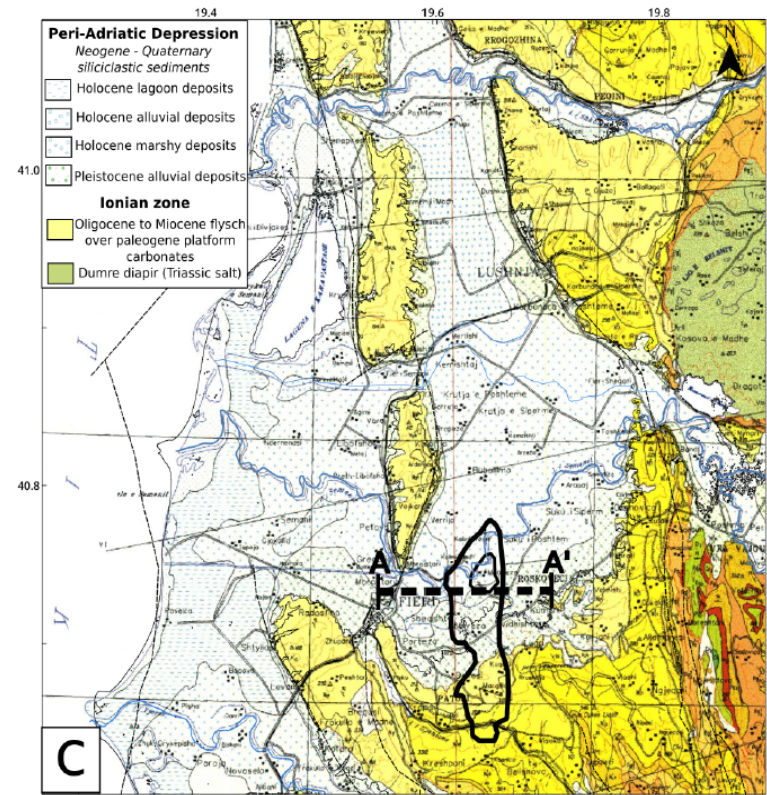
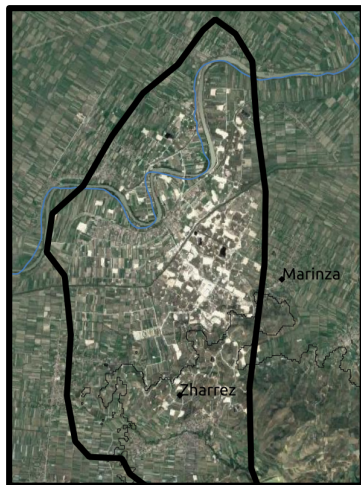
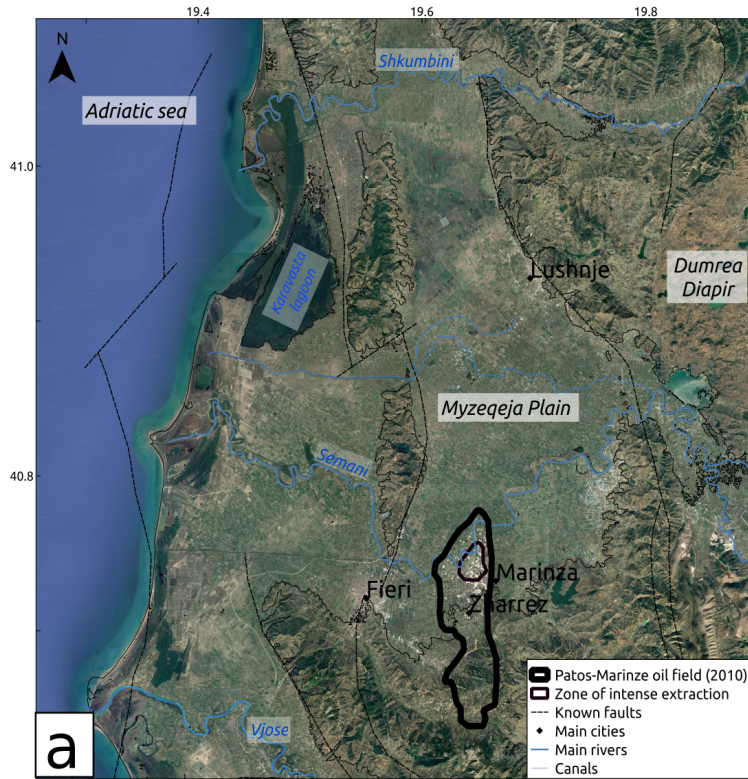
Geology and Oil and gas fields in external Albanides

- Onshore oil and gas fields operated since Roman time in the external Albanides
- Peri-Adriatic Depression : thrust and folded Ionian carbonates (source) overlaid by discordant siliclastic deposits (reservoirs)
- Hub for gas/oil transport from middle East to Europe

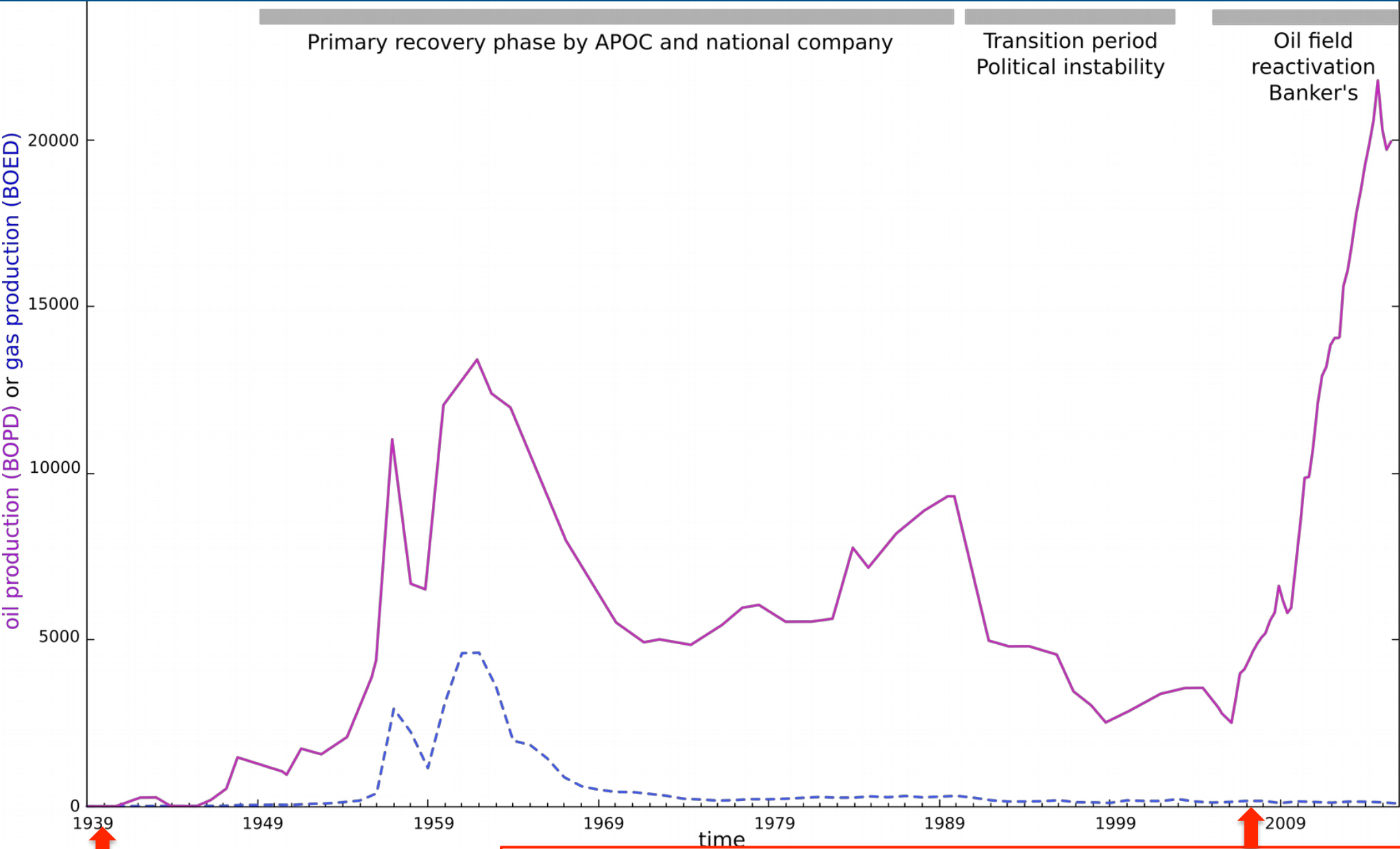


The Patos-Marinza oil field

- One of the most important onshore field in Europe



History of the Patos-Marinza oil field



Primary recovery phase by APOC and national company

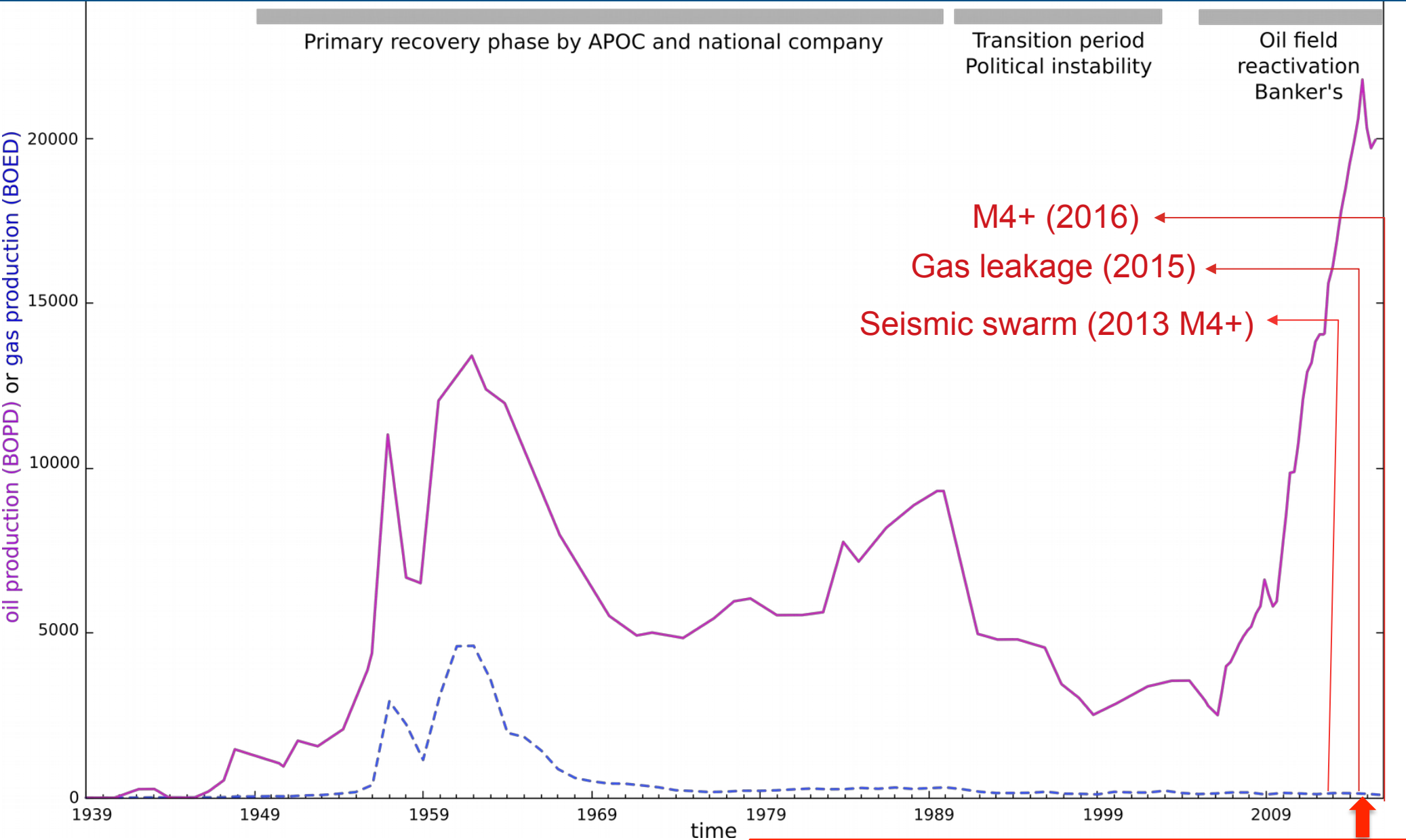
Transition period
Political instability

Oil field reactivation
Banker's

Operated since 1939

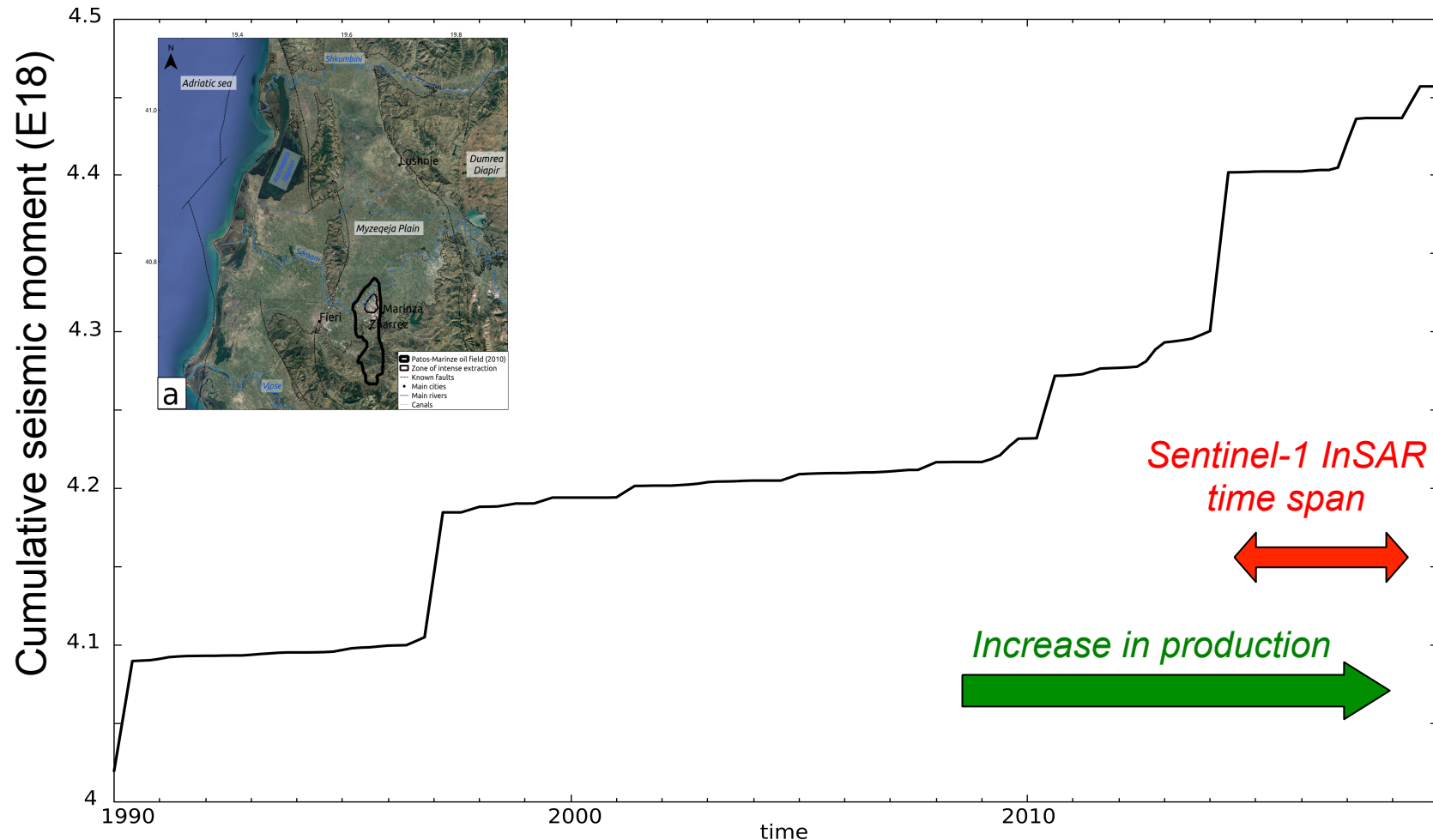
Reactivation by Banker's & production increase with wild use of Enhanced Oil Recovery techniques (waterflood / thermal / infill)

History of the Patos-Marinza oil field



Increasing concern from the inhabitants

Patos-Marinza oil field exploitation and regional seismicity

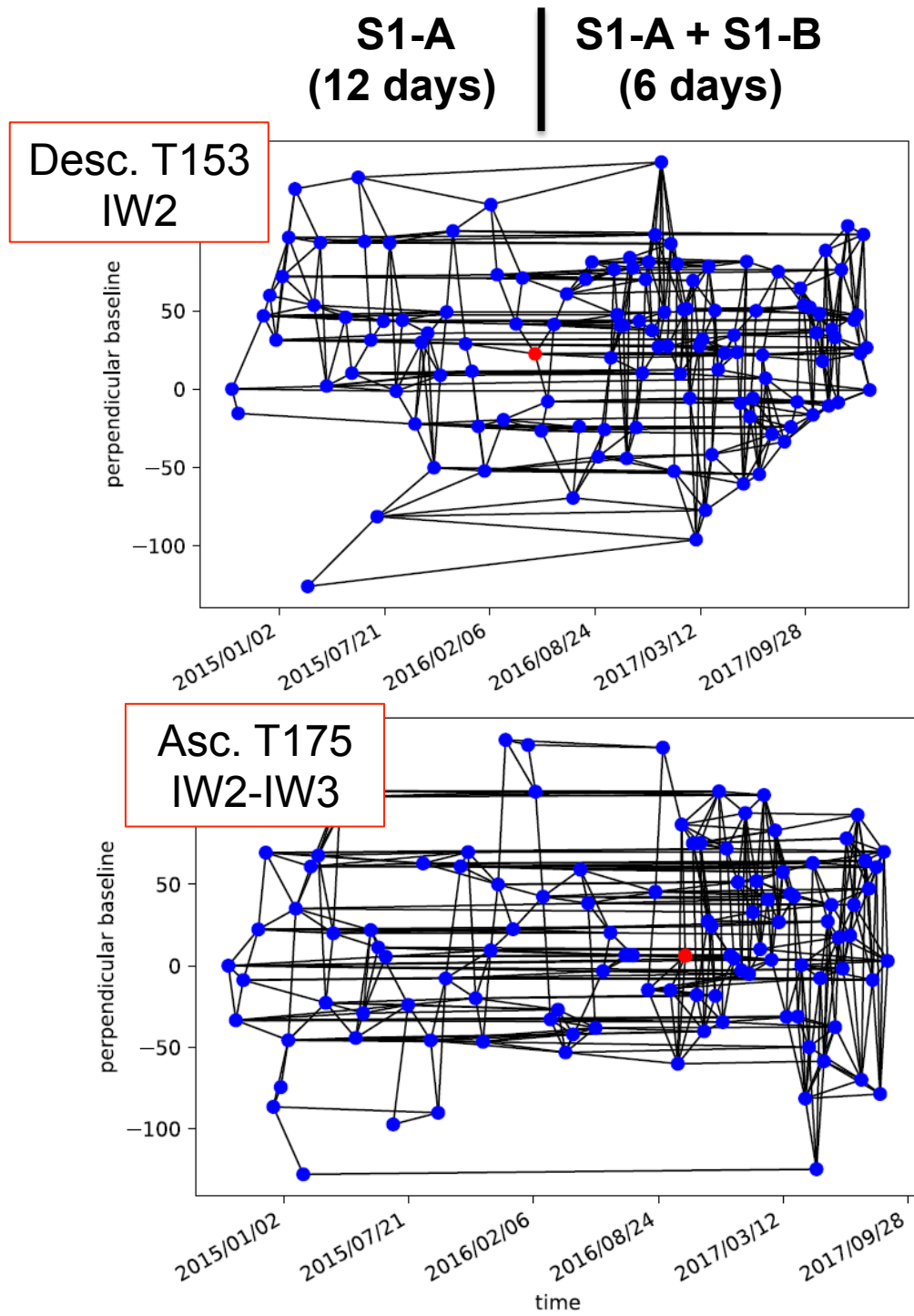


- Increased seismicity induced by oil exploitation ?
 - Local seismic network too sparse and recent to conclude
 - The whole region is tectonically active (historical EQ that have destroyed Fieri, recent Durres sequence...)
- Any deformation associated with the oil field ?
 - **Monitoring from InSAR**

InSAR data set (Sentinel-1)

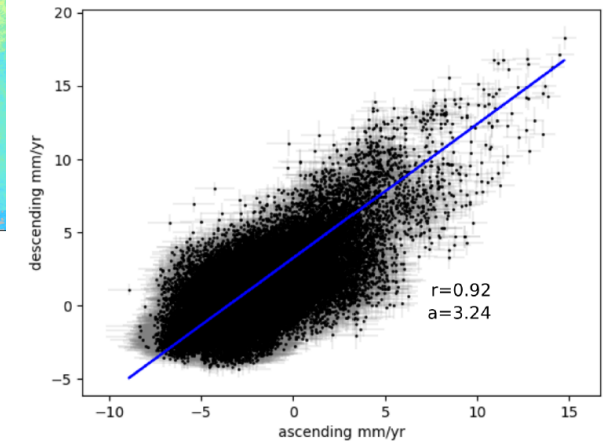
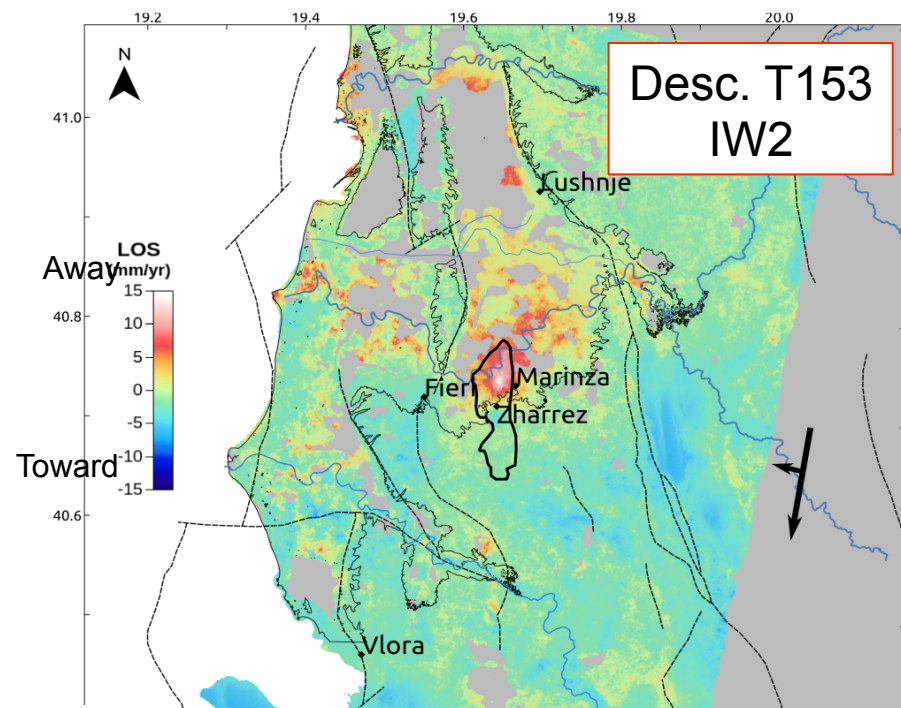
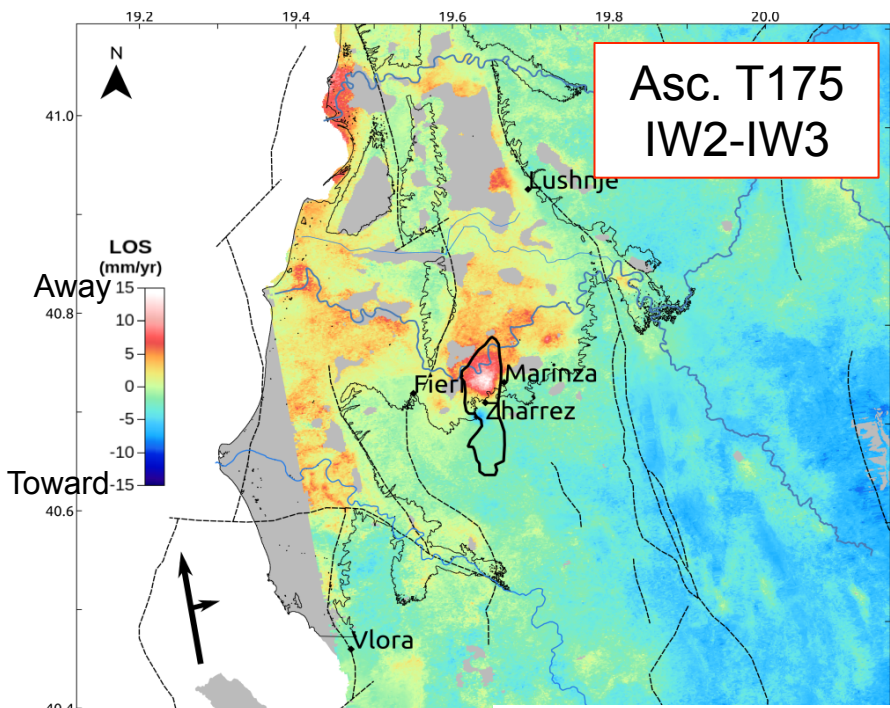


- 2014-2018 time span
- NSBAS processing (Doin et al., 2011, Grandin, 2015) including spectral diversity and atmospheric corrections



Large scale average velocity maps

- Mostly vertical motion

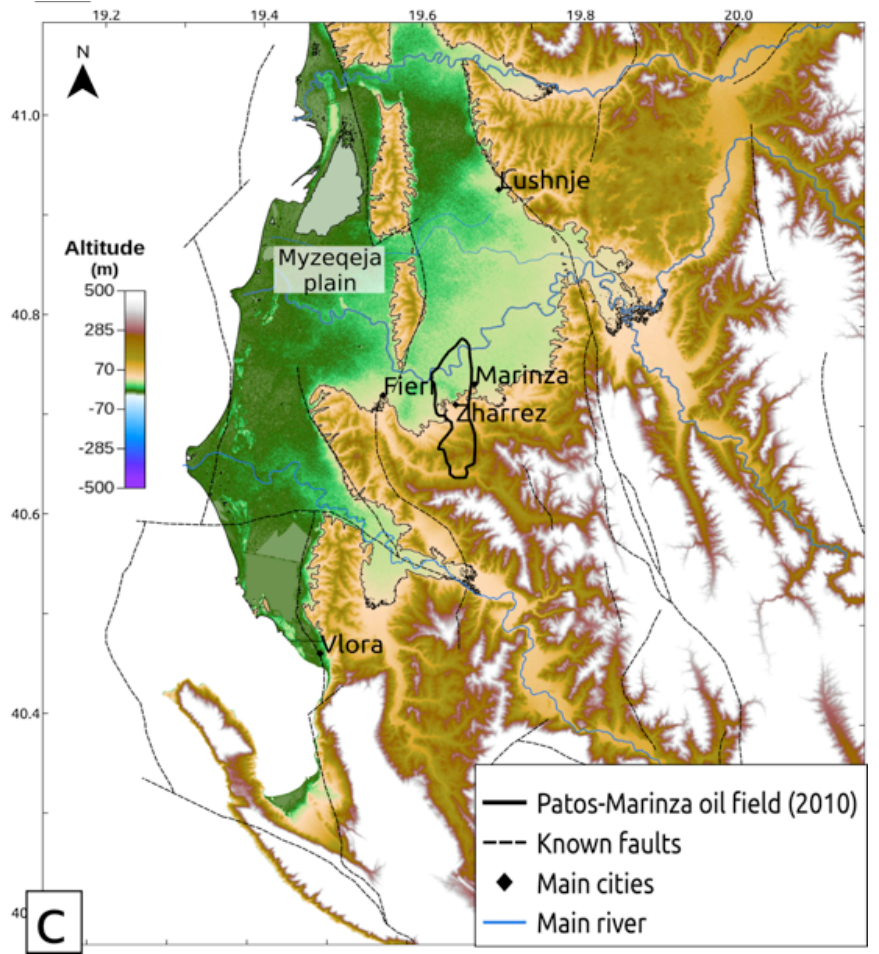
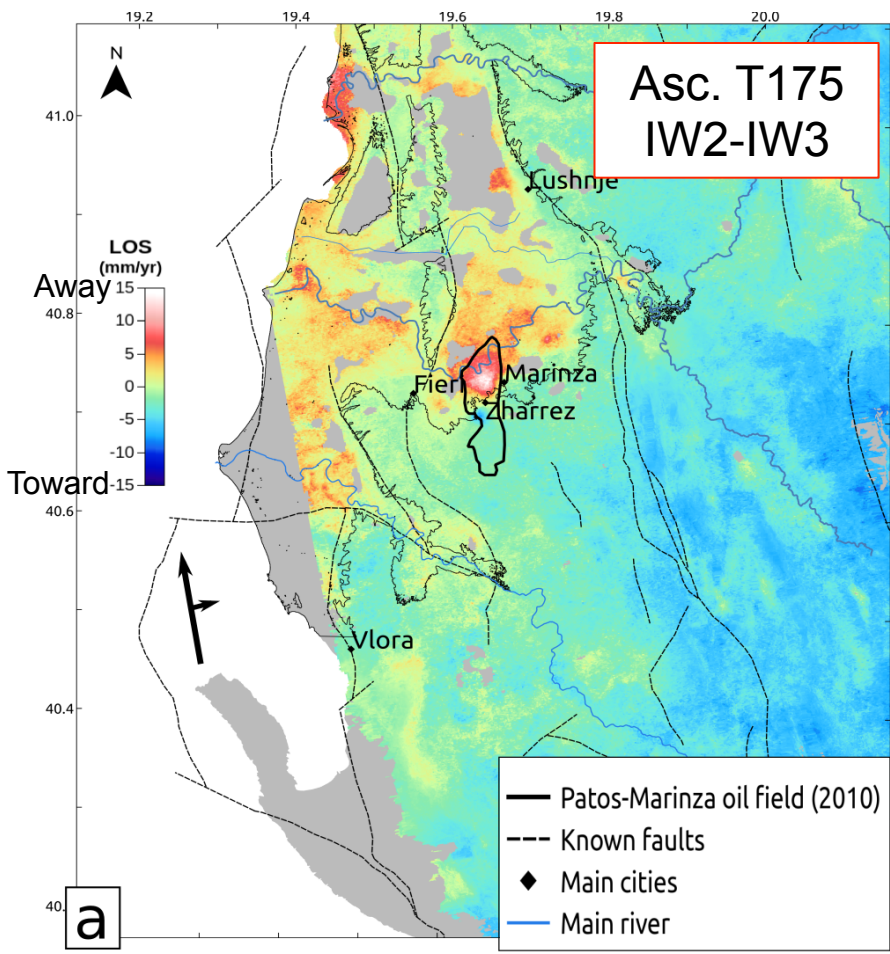


- Patos-Marinza oil field (2010)
- - - Known faults
- ◆ Main cities
- Main river

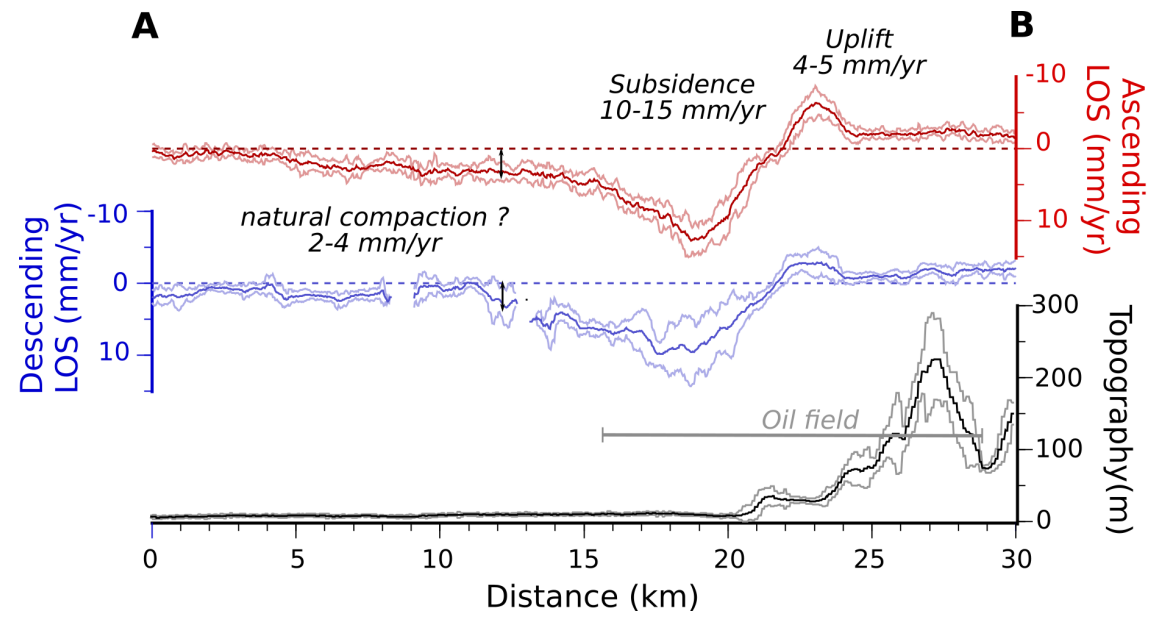
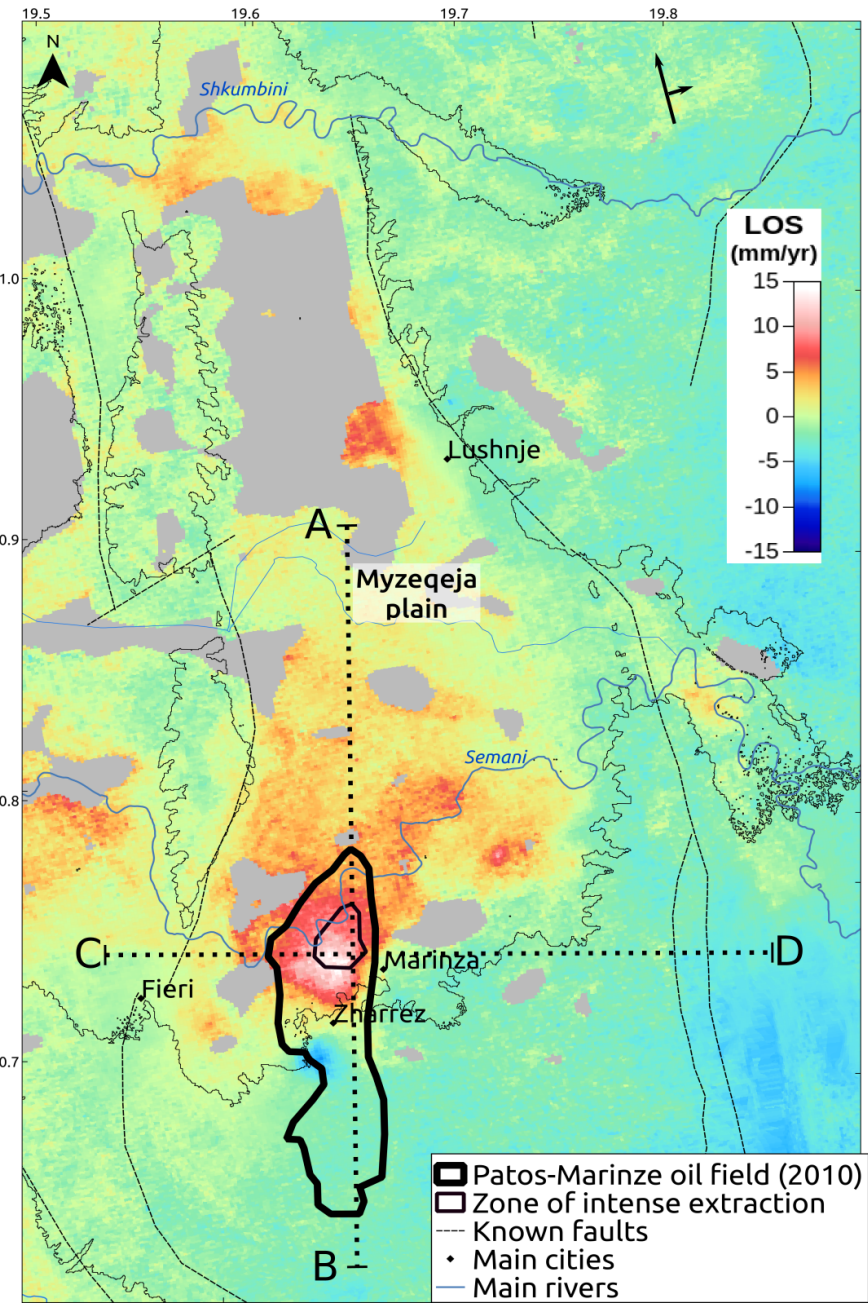
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Large scale average velocity maps

- Mostly vertical motion
- Overall subsidence of the Neogene/Quaternary sedimentary basins (mm/yr to cm/yr) : natural + anthropogenic compaction (pumping, reclamation work over marshy areas...)

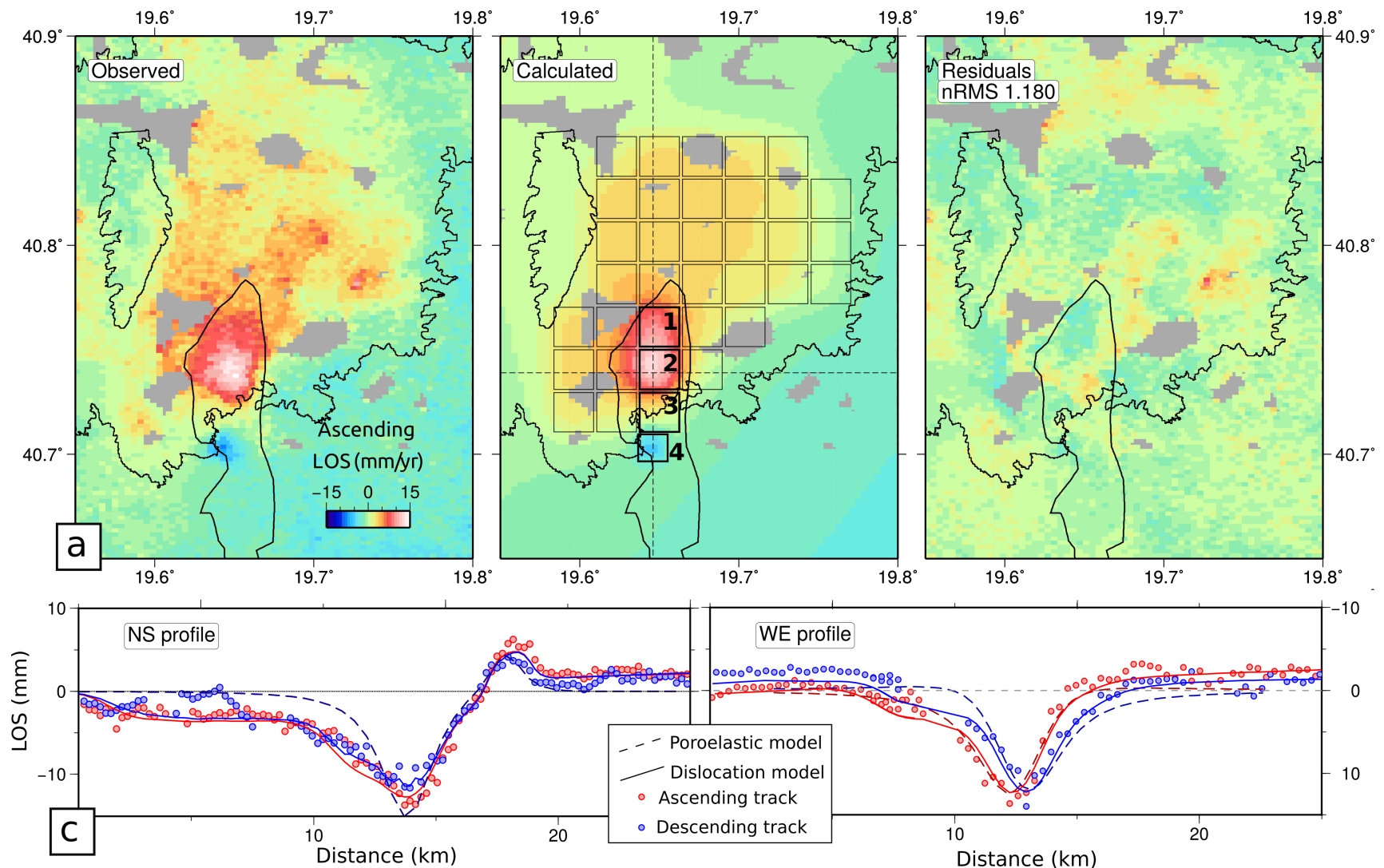


Ground deformation in the Patos-Marinza oil field



- Overall subsidence of the plain (2-4 mm/yr)
- **Highest subsidence (~1.5 cm/yr) in northern part of the oil field**, where well density is the highest and EOR techniques are massively used : **induced compaction**
- Local area of uplift (~4 mm/yr) immediately south of it : leakage of injection well ? wastewater injection ?

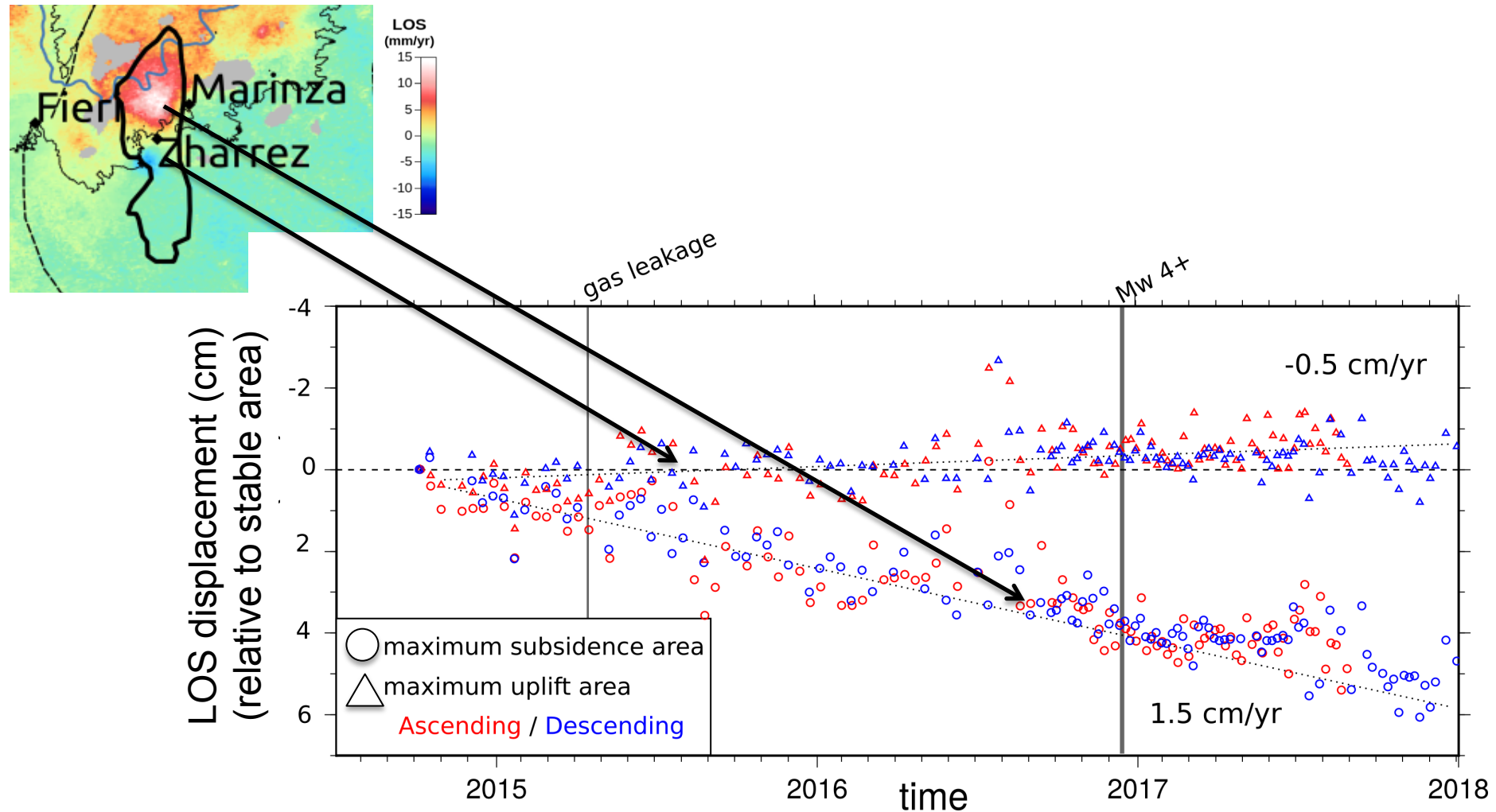
First-order modeling of the compaction



First order 1D poroelastic modeling of LOS profiles and 2D elastic dislocation model of LOS velocity maps well reproduce InSAR observations

Relatively low pressure changes ($\Leftrightarrow 0.2 \text{ Mm}^3/\text{yr}$) in a 1.6km depth reservoir

Any temporal evolution ?



- Rather stable subsidence/uplift rates during the Sentinel-1 observation period : when did these deformation patterns started to develop ?
- No obvious changes during gas leakage or largest local seismic events

Conclusion and perspectives

- **Sentinel-1 InSAR time series analysis** allows to quantify for the first time subsidence of the Quaternary/Neogene sediments in western Albania
- This **subsidence (at mm/yr to cm/yr rates)** is likely **due to natural compaction** of alluvial and deltaic sediments but also to **human activities**
- The **strongest subsidence** is observed **in the northern part of the Patos-Marinza oil field**; we interpret it as related to **compaction due to intensive oil extraction**. When did it start ?
- The analysis of stress changes due to oil extraction and of their potential relationship with local seismicity will require a densification of the local seismic network and an improved knowledge on the reservoir characteristics (pressure evolution, geometry...)
- **Longer InSAR time series** (backward with ERS-Envisat-ALOS data and forward with future Sentinel-1 acquisitions) will **provide independant monitoring of strain evolution** in the oil field area

Thank you for your attention

Reference :

Métois, M., Benjelloun, M., Lasserre, C., Grandin, R., Barrier, L., Dushi, E., and Koçi, R. Subsidence associated with oil extraction, measured from time-series analysis of Sentinel-1 data: case study of the Patos-Marinza oil field, Albania, *Solid Earth Discuss.*, <https://doi.org/10.5194/se-2019-121>, in review, 2019