FLASH FLOODS AND PLUVIAL FLOODING

ISPRA

REGIONE AUTONOMA DELLA SARDEGNA

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

Working Group F Thematic Workshop

DETERMINING FLOOD HAZARD PATTERNS THROUGH A COMBINED STOCHASTIC-DETERMINISTIC APPROACH

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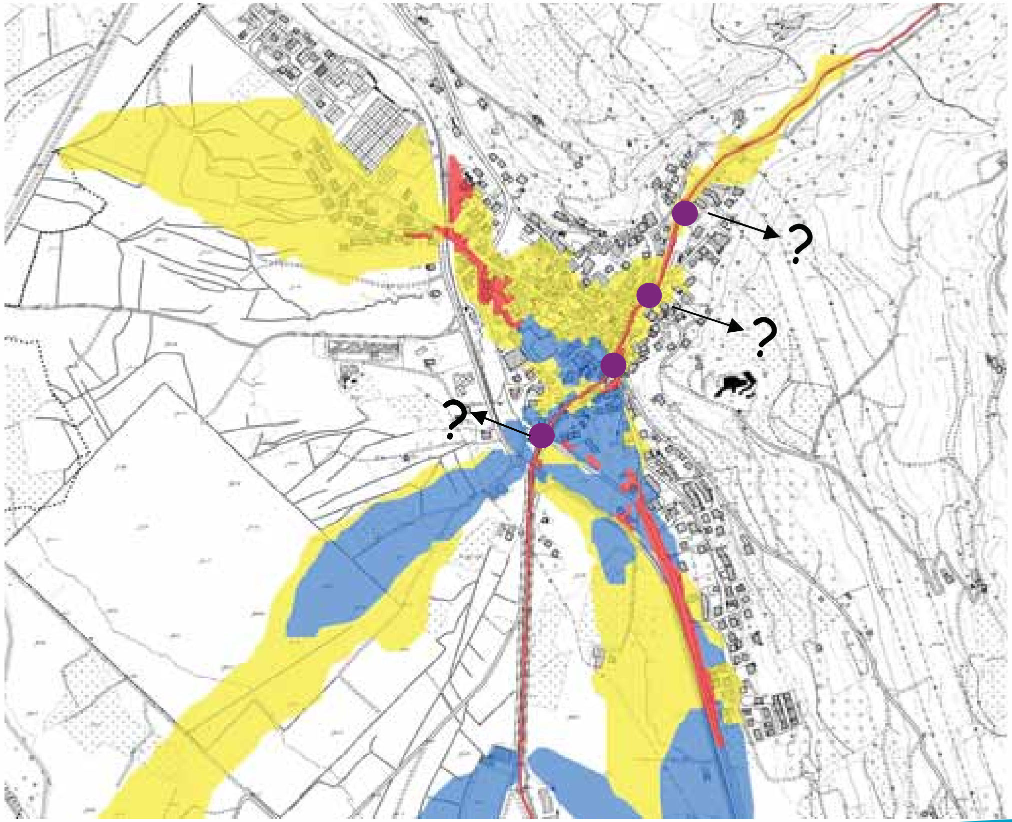
AdaptAlp – Adaptation to Climate Change in the Alpine Space

26th-28th May 2010, Cagliari, Italy

HOW RELIABLE ARE HAZARD MAPS ?



Example:
Schluderns (Prov. BZ, Italy)

FLOOD HAZARD IS USUALLY ASSIGNED BASED ON WATER DEPTH AND VELOCITY (PROCESS INTENSITY) FOR GIVEN RECURRENCE INTERVALS

↓

DEPTH AND VELOCITY ARE USUALLY ESTIMATED RUNNING DETERMINISTIC HYDRODYNAMIC MODELS ON A DTM (usually fixed, no morphodynamic changes)

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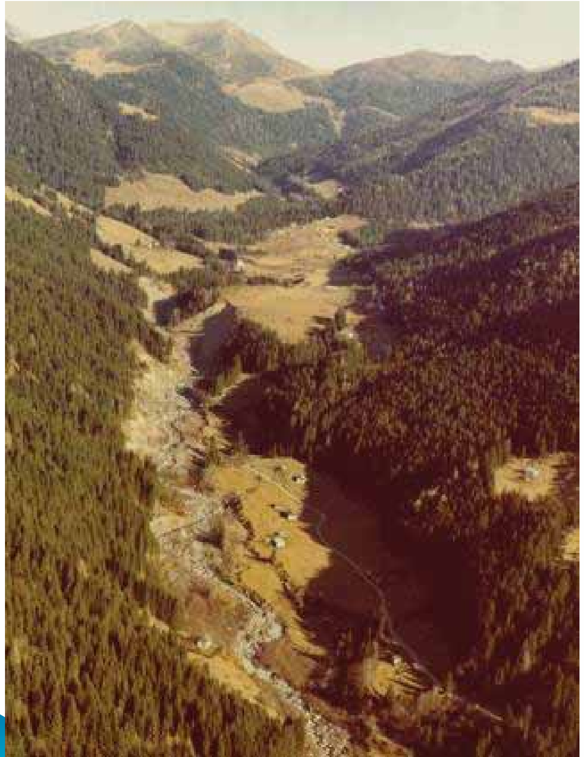
BUT DO FLOOD EVENTS EXHIBIT A DETERMINISTIC BEHAVIOUR ?

MORPHODYNAMIC PROCESSES OCCURING DURING FLOODS



Aggradation

Incision

Vertical changes up to 10 m in mountain streams !

MORPHODYNAMIC PROCESSES OCCURING DURING FLOODS

Avulsion

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STOCHASTIC PROCESSES OCCURING DURING FLOODS

Levee failure

Bridge obstruction

MORPHODYNAMIC AND STOCHASTIC PROCESSES MAY RENDER DETERMINISTIC HAZARS MAPS WRONG !

• Directing flood flows to routes not predicted by numerical models (not including the stochastic description of levee failure, bridge obstruction, morphodynamic changes)

• Changing flow depth / velocity on areas where flooding was predicted by numerical models

→ Magnitude-frequency relationships of inundation altered !

HOW TO COPE WITH SUCH PROCESSES ?

- Potentially, channel changes during flood events could be accounted for by using morphodynamic models (but with large uncertainties, especially in mountain rivers)

- But how could we include stochastic process stemming from wood transport and/or geotechnical issues in the hazard mapping ?

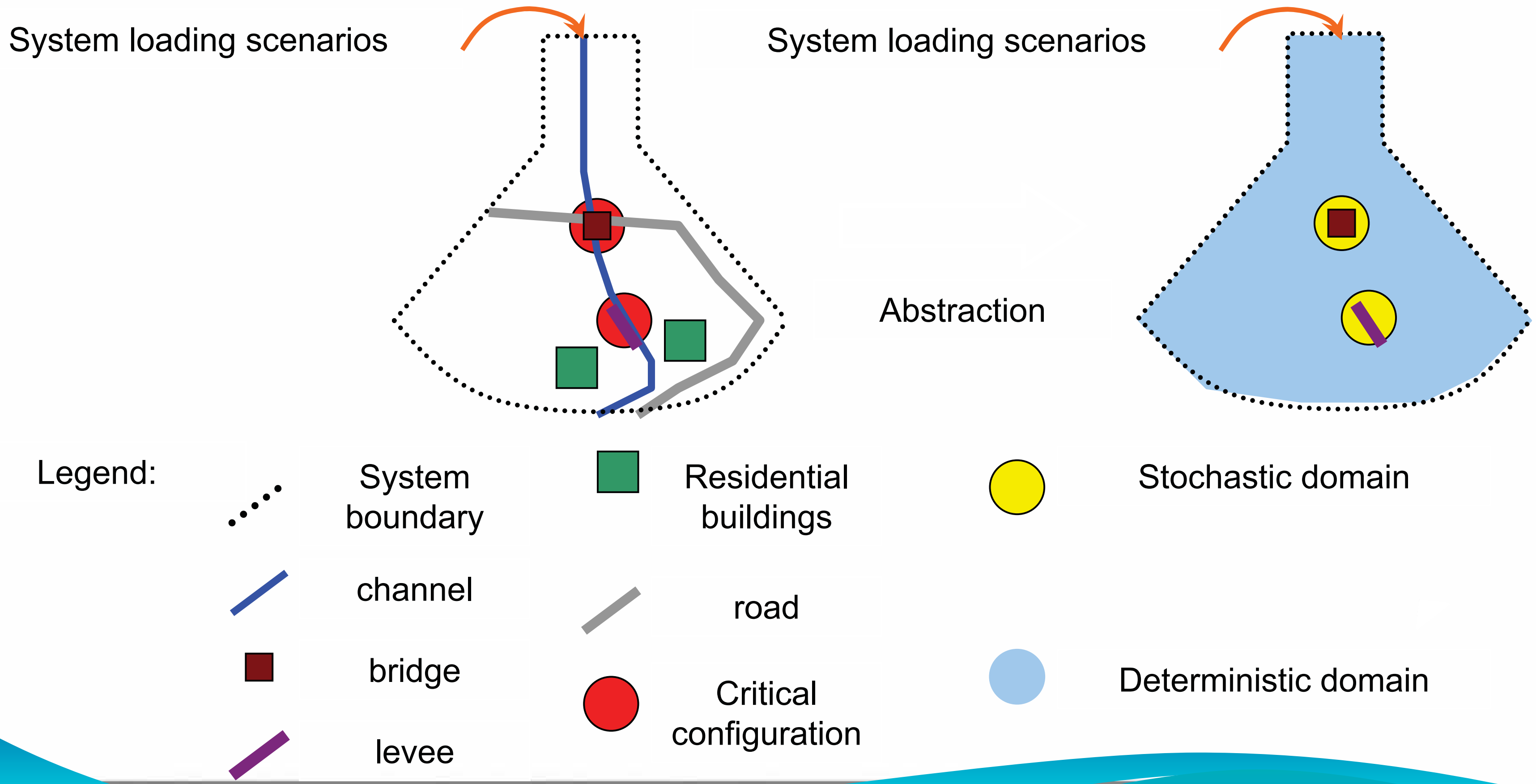
PROPOSAL OF A NEW APPROACH

• Within a "response system" (e.g. alluvial fan, floodplain):

→ Deterministic domains (channel and flooded area) ⇒ *hydrodynamic laws apply*

→ Stochastic domains (critical bridges, culverts, levees) ⇒ *probability laws apply*

Response System ***Abstracted Response System***



- Each stochastic node, depending on the intensity of the hazard process, can feature only a finite (and small) set of possible states

- A node undergoes a variation of its state through transitions, whose number is also finite

- A matrix describing the possible transitions among states for different process intensity can be written for each node

➡ The probability for each transition must be provided by experts

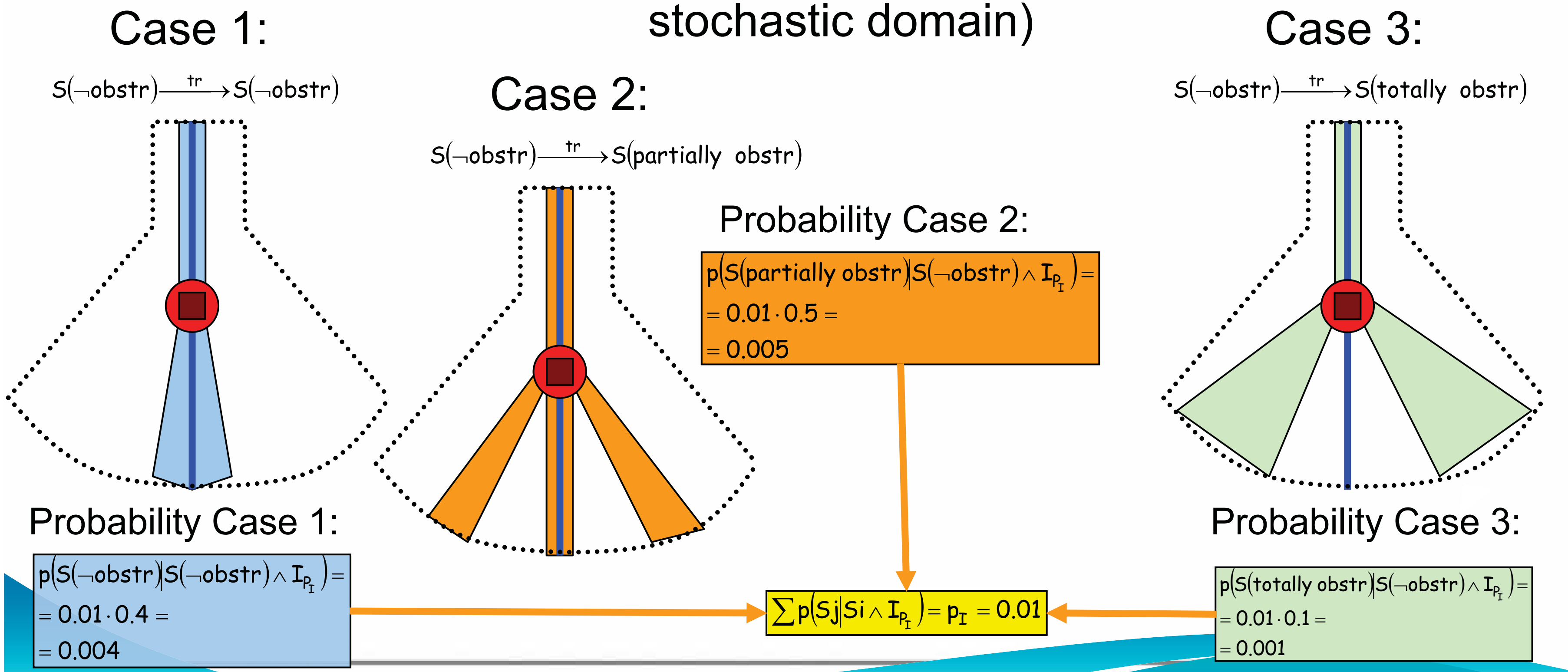
⬇

Based either on empirical relationships and/or on subjective probability theory

An introductory example:

A response system with only one stochastic domain:

alluvial fan (one single paved channel and one bridge cross section as a stochastic domain)



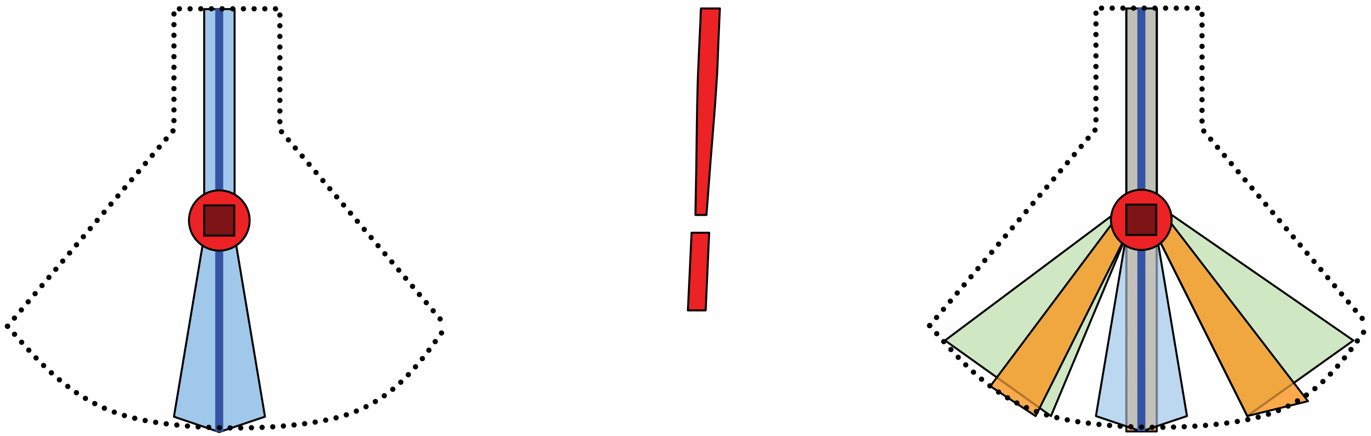
An introductory example:

A response system with only one stochastic domain:

→ alluvial fan (one single channel and one bridge)

Single Scenario normally considered in hazard mapping

Overlapping Scenarios that should be considered in hazard mapping



The general case:

- A response system with n stochastic domains
- n matrices describing the possible transitions among domain states for different process intensities are needed

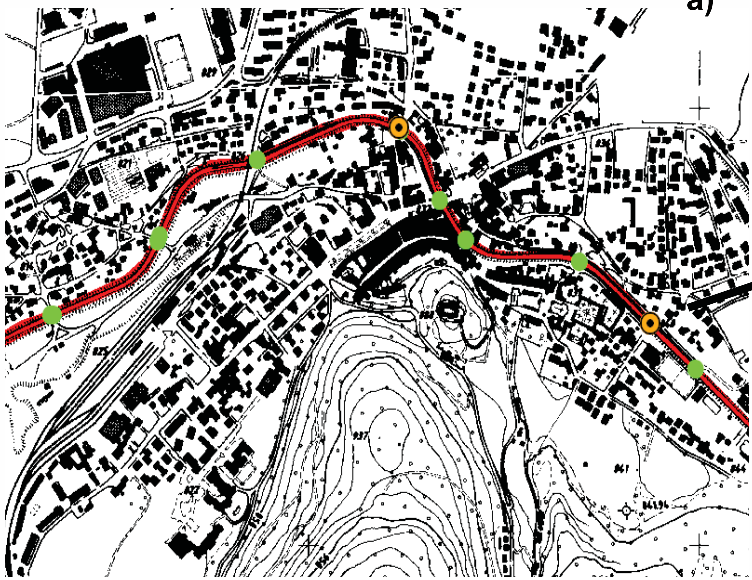
	$\left(S_1 \xrightarrow{tr} S_1\right)$	:	$\left(S_i \xrightarrow{tr} S_j\right)$	:	$\left(S_n \xrightarrow{tr} S_n\right)$
I_1	$p(S_1 \| (S_1 \wedge I_1))$	:	$p(S_j \| (S_i \wedge I_1))$	:	$p(S_n \| (S_n \wedge I_1))$
		:		:	
:	:	:	:	:	:
I_N	$p(S_1 \| (S_1 \wedge I_N))$	:	$p(S_j \| (S_i \wedge I_N))$	:	$p(S_n \| (S_n \wedge I_N))$

$\forall$ STOCASTIC DOMAIN

- Depending on the local process intensities and the “response behaviour”, the probabilistic state transition for each stochastic domain is selected

Test case: The Rienz River in Brunico

a)



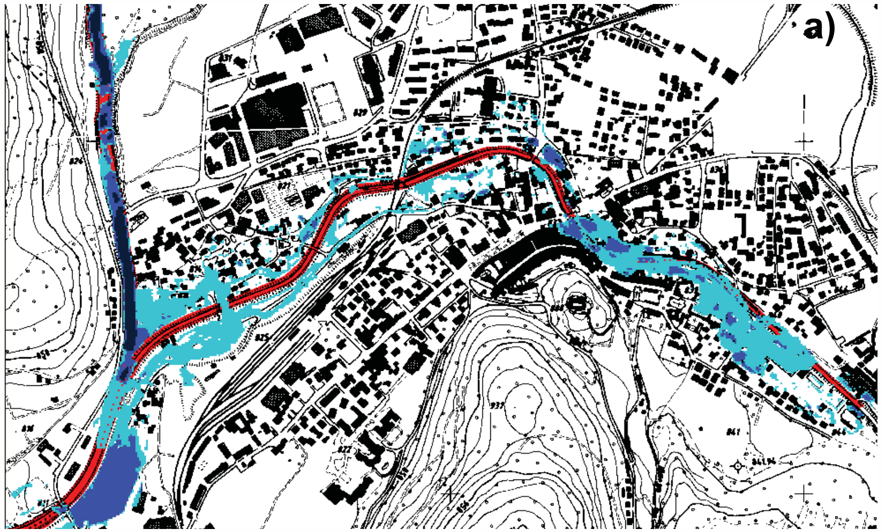
High wood load expected

for RI > 30 - 50 yr

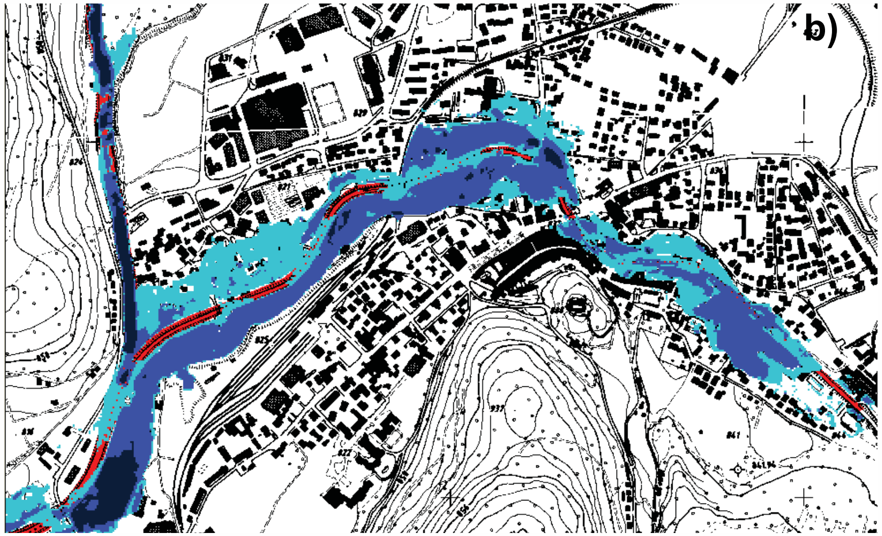
Test case (in progress): the Rienz River in Brunico

- Inundation maps at the flood peak (inflow hydrograph R.I. 100 yr) for a subset of the possible propagation scenarios for the Rienz in Bruneck

bridges not clogged



both critical bridges clogged



CONCLUSIONS

- Flood hazard mapping procedures carried out without taking into account different scenarios can result in highly erroneous evaluations.
- A nested approach entailing deterministic simulations as well as stochastic evaluation is thus advocated for in order to achieve a more reliable determination of flood risks.
- The necessary system representation step "forces" the analyst to consider a broad set of possible system behaviors.
- Knowledge resulting from past event documentation should be appropriately integrated into hazard assessment.
- Benefits for the whole risk governance cycle (risk assessment, insurance policy, intervention planning).


THANK YOU !