5TH BRAZILIAN SOIL PHYSICS MEETING - 2019

PEDOTRANSFER FUNCTIONS OF HYDRAULIC PROPERTIES FOR BRAZILIAN SOILS: A REVIEW

-PRELIMINARY RESULTS-

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2019

INTRODUCTION

Soil water is the basis of life in the continents and of food production. Its amount and regime depend strongly on climate (rain/evapotranspiration) conditions and on soil hydraulic properties.

Fresh surface water (rivers and reservoirs) and groundwater also depend on soil hydraulic properties, because of the strong influence of these properties on rainfall infiltration and runoff generation, as well as on groundwater recharge.

Brazil is a rich country in water and soil resources, with an international leadership in food production. Besides, food sale is the main income source of the country in its international trade balance.

Therefore, to invest in the hydraulic knowledge of soils is to invest in conservation and sustainability of life and also in wealth generation in the country.

The measurement of the hydraulic properties is cumbersome and time consuming.

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PTF DEVELOPMENT

OBJECTIVE

TO PROVIDE AN UP-TO-DATE REPOSITY OF PAST AND RECENT PUBLICATIONS DEALING WITH THE DEVELOPMENT OF HYDRAULIC PTFs FOR BRAZILIAN SOILS

METHODOLOGY

- ✓ GOOGLE ACADEMIC– USING THE TERM PEDOTRANSFER FUNCTIONS
- ✓ BARROS & DE JONG VAN LIER (2014): PEDOTRANSFER FUNCTIONS FOR BRAZILIAN SOILS
- ✓ BOTULA ET AL. (2014): PEDOTRANSFER FUNCTIONS TO PREDICT WATER RETENTION FOR SOILS OF THE HUMID TROPICS: A REVIEW
- ✓ DA SILVA AND ARMINDO (2018). IMPORTÂNCIA DAS FUNÇÕES DE PEDOTRANSFERÊNCIA NO ESTUDO DAS PROPRIEDADES E FUNÇÕES HIDRÁULICAS DOS SOLOS DO BRASIL

CATEGORIZATION OF PTFs

<table>
<tr><td colspan="5">57 PTFs</td></tr>
<tr><td colspan="5">57 CONTINUOUS</td></tr>
<tr><td colspan="3">38 All DATABASE</td><td colspan="2">19 GROUPS
(soil Depths, Brazilian States, Soil Pedological Classes, Textural Classes, etc)</td></tr>
<tr><td colspan="3">43 POINT</td><td>12 PARAMETRIC</td><td>2 NI</td></tr>
<tr><td>3 SEMI-PHYSICAL</td><td colspan="4">54 EMPIRICAL</td></tr>
<tr><td></td><td>47 MLR</td><td>1 RT</td><td>4 ANN</td><td>2 NI</td></tr>
</table>

NI – Not informed; MLR – Multilinear Regression; RT – Regression Tree; ANN – Artificial Neural Network

PTFs SELECTED FROM LITERATURE – PART 1/7

References	Year	Predicted variable	Geographic Domain	Number of Samples	Sample Type
Almeida et al. (2010)	2010	Ug33kPa Ug1500kPa	Pernambuco	x	disturbed
Alvarenga et al. (2010)	2010	W6kPa W1500kPa	Minas Gerais	325	undisturbed/disturbe d
Andrade and Stone	2011	FC empirical	various	472-2242	x
Andrade et al. (2008)	2008	Available Water Content	Paraíba	36	disturbed
Arruda et al. (1987)	1987	Ug33kPa Ug1500kPa	São Paulo	218	disturbed
Assad et al. (2001)	2001	W10kPa W150kPa W10kPa-W1500kPa	São Paulo, Espírito Santo, São Paulo, Minas Gerais, Bahia	228 calibration 135 test	undisturbed
Balbino et al. (2002)	2002	Ug10kPa	Cerrado	40, 43, 57	x
Barros et al. (2013)	2013	VG parameters	Northeastern Brazil	673 calibration 113 validation	disturbed, undisturbed
Bernades (2010)	2010	W33kPa W1500kPa W33kPa-W1500kPa	Rio de Janeiro	28	undisturbed
Bortoline and Aluquerque (2018)	2018	W10kPa W150kPa W10kPa-W1500kPa	Santa Catarina	515 calibration 1425 validation	undisturbed
Coelho et al. (1997)	1997	Ug33kPa Ug1500kPa	Minas Gerais Piauí	90	undisturbed
Costa (2012)	2012	W10kPa W33kPa W1500kPa AWC VG parameters	Santa Catarina	151 calibration 49 validation	undisturbed

PTFs SELECTED FROM LITERATURE – PART 2/7

References	Year	Predicted variable	Geographic Domain	Number of Samples	Sample Type
da Silva (2014)	2014	Ug33kPa Ug1500kPa	Brazilian Coastal Plains region	280	disturbed
da Silveira et al. (2018)	2018	water retention curve	Bahia	x	undisturbed
Dalbianco (2009)	2009	Ks	Rio Grande do Sul	414	undisturbed/disturbe
de Mello et al. (2002)	2002	Drenable proposity: TP-FC AWC	Minas Gerais	36	undisturbed
de Mello et al. (2005)	2005	VG parameters	Minas Gerais	36	undisturbed/disturbe
de Souza et al. (2014)	2014	W0kPa W6kPa W10kPa W33kPa W100kPa W500kPa W1500kPa	Espírito Santo	36 calibration 36 validation	undisturbed
dos Santos et al. (2013)	2013	Ks Ug33kPa Ug1500kPa	Rio Grande do Sul	988 calibration 398 validation	disturbed
Fernandes et al. (2008)	2008	Ug10kPa Ug-500kPa	Minas Gerais, bahia, Espírito Santo	559	disturbed
Ferreira and Crestana (2014)	2014	W1kPa W33kPa W100kPa W300kPa W1500kPa	São Paulo	275	undisturbed
Fidalski e Tormena (2007)	2007	VG parameters	Paraná	216	undisturbed
Gaiser et al. (2000)	2000	W33kPa W1500kPa	tropical regions	433 calibration 194 - validation	disturbed

PTFs SELECTED FROM LITERATURE – PART 3/7

References	Year	Predicted variable	Geographic Domain	Number of Samples	Sample Type
Giarola et al. (2002)	2002	W10kPa W1500kPa W10kPa-W1500kPa	Santa Catarina e Rio Grande do Sul	35	undisturbed/disturbed
Junior et al. (2014)	2014	W10kPa W33kPa W1500kPa Rijtema (1969) parameters VG parameters	Mato Grosso	80 calibration 25 validation	undisturbed (?)
Klein et al. (2010)	2010	Ug1500kPa	Rio Grande do Sul e Santa	100	disturbed (psicrômetro)
Klein et al. (2015)	2015	Ks	Rio Grande do Sul	64 (?)	undisturbed, permeâmetro de carga
Marcolin (2009)	2009	W8kPa; W1500kPa Aeration porosity: TP-0.1; Total Porosity	Rio Grande do Sul	60	undisturbed/disturbed
Masutti (1997)	1997	W33kPa W1500kPA W33kPA-W1500kPa	Pernambuco	62-validation; 44-validation	disturbed (CC, PMP, Ksat)
Medeiros et al. (2012)	2012	VG parameters	Pará	36 samples	undisturbed
Medrado e Lima (2014)	2014	VG parameters	Amazônia, Distrito Federal, Goiás, Maranhão, Minas Gerais, Mato Grosso, Pará, Tocantins	1092 - calibração; 309 - vallidação	undisturbed

PTFs SELECTED FROM LITERATURE – PART 4/7

References	Year	Predicted variable	Geographic Domain	Number of Samples	Sample Type
Menegaz et al. (2015)	2015	W0kPa W1kPa W33kPa W100kPa W500kPa W1500kPa	Rio Grande do Sul, Bahia, Minas Gerais, Goiás e Mato Grosso	4626	undisturbed/disturbed
Michelon et al. (2010)	2010	W0kPa W1kPa W33kPa W100kPa W500kPa W1500kPa	Rio Grande do Sul	1200	undisturbed/disturbed
Nascimento et al. (2010)	2010	Ug33kPa Ug1500kPa Ug33kPa-Ug1500kPa	Alagoas, Amazonia, Bahia, Pernambuco, Rio de Janeiro, Sergipe	682	x
Netto (2007)	2007	water retention curve	São Paulo	275	undisturbed
Nunes (2016)	2016	W1kPa W6kPa W33kPa W100kPa	Rio Grande do Sul	1973 calibration 1315 validation	undisturbed/disturbed
Oliveira et al. (2002)	2002	Ug33kPa Ug1500kPa Ug33kPa-Ug1500kPa	Pernambuco	467 calibration 92 validation	undisturbed
Ottoni Filho et al. (2016)	2016	in sity FC	Rio de Janeiro	207	$1m^2$ flooded area/undisturbed

PTFs SELECTED FROM LITERATURE – PART 5/7

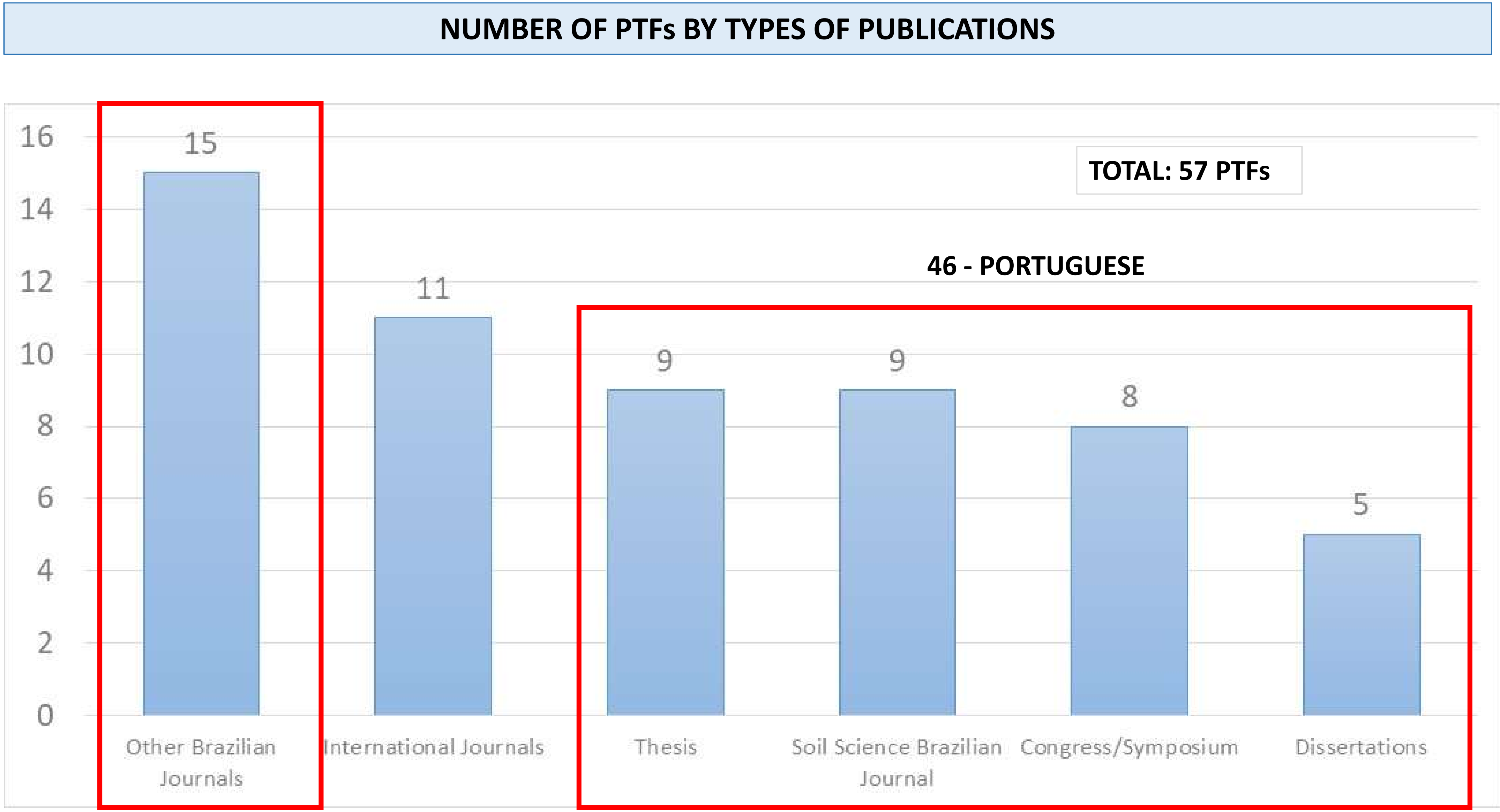
References	Year	Predicted variable	Geographic Domain	Number of Samples	Sample Type
Pequeno (2016)	2016	W6kPa W10kPa W33kPa W100kPa W300kPa W500kPa W1000kPa W1500kPa	Paraíba	126 calibration 54 validation	undisturbed
Ramos (2017)	2017	W6kPa W1500kPa W6kPa-W1500kPa	Piauí	100 calibration 26 validation	undisturbed (?)
Reichert et al. (2009)	2009	Ug6kPa Ug10kPa Ug33kPa Ug100kPa Ug500kPa Ug1500kPa	Rio Grande do Sul	249-685 calibration 239 validation	x
Rodrigues e Maia (2011)	2011	W1500kPa Wsaturation Ks	Distrito Federal	828	undisturbed
Rodrigues et al. (2011)	2011	W6kPa W33kPa	Distrito Federal	99	undisturbed
Silva et al. (2008)	2008	Hutson & Cass (1987)	São Paulo	180	undisturbed
Silveira et al. (2004)	2004	W6kPa W33kPa W100kPa W500kPa W1500kPa	Bahia, Goiás, Minas Gerais e Rio Grande do Sul	572	undisturbed/disturbed

PTFs SELECTED FROM LITERATURE – PART 6/7

References	Year	Predicted variable	Geographic Domain	Number of Samples	Sample Type
Soares (2013)	2013	W0kPa W6kPa W10kPa W33kPa W100kPa W500kPa W1500kPa	Rio Grande do Sul	1091 calibration 731 validation	x
Soares et al. (2014)	2014	W0kPa W6kPa W10kPa W33kPa W100kPa W500kPa W1500kPa	Rio Grande do Sul	1279 calibration 548 validation	x
Tomasella e Hodnett (1997)	1997	Ks BC Kunsat	São Paulo, Paraná, Ceará, Amazonas, Minas Gerais	124 calibration Ks 2740 data pairs	x
Tomasella e Hodnett (1998)	1998	W0kPa W1kPa W3kPa W6kPa W10kPa W33kPa W100kPa W1500kPa BC parameters	Amazonic Basin	196 a 416 (calibracao dos pontos da curva de retencao); 559 validation (brook Corey)	x

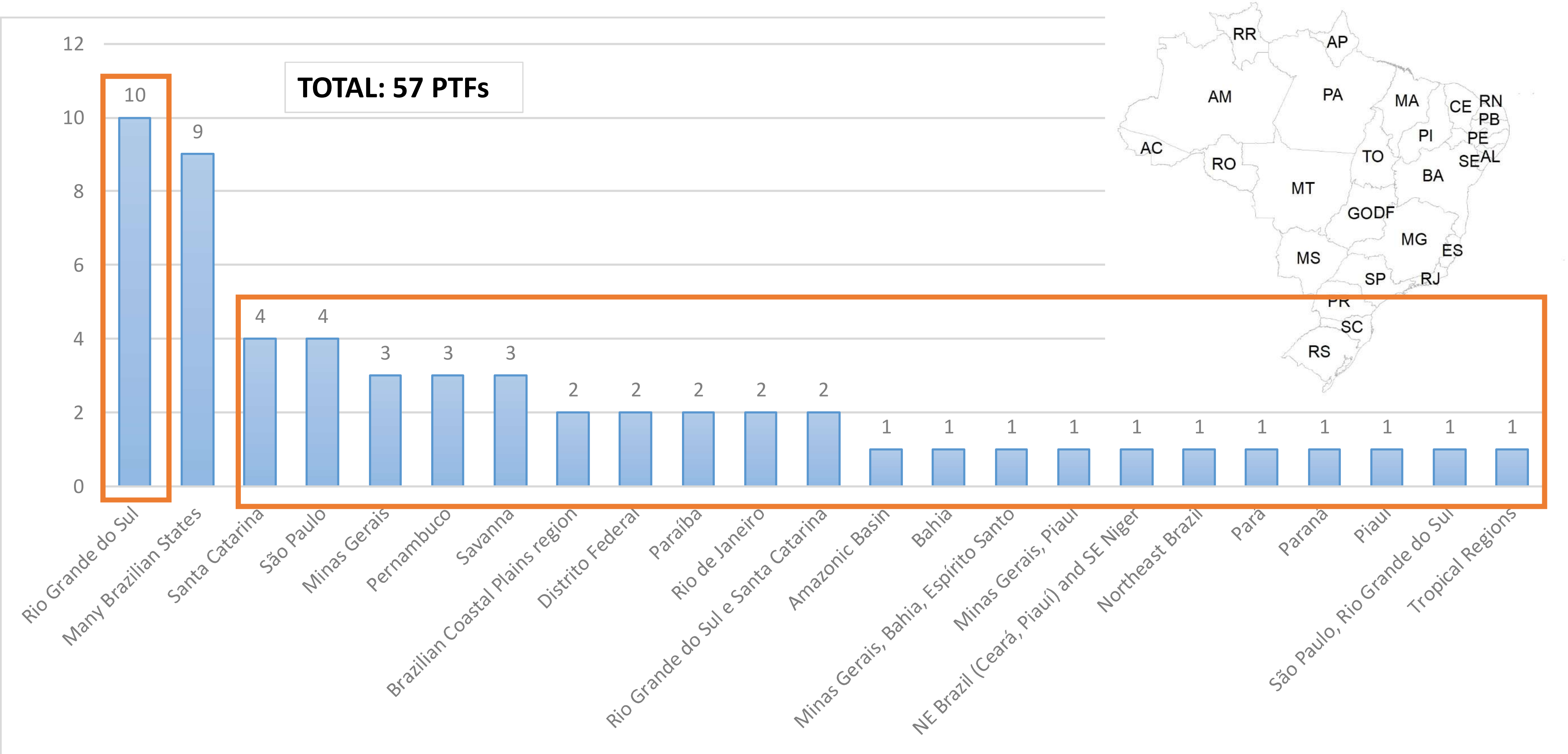
PTFs SELECTED FROM LITERATURE – PART 7/7

References	Year	Predicted variable	Geographic Domain	Number of Samples	Sample Type
Tomasella et al. (2000)	2000	VG parameters	Paraná, Amazonas, Bahia, Rio Grande do Norte, Minas Gerais, Pará, São Paulo, rio de Janeiro, Distrito Federal	517 calibration 113 validation	undisturbed/disturbed
Tomasella et al. (2003)	2003	W0kPa W6kPa W10kPa W33kPa W100kPa W1500kPa	Brazil	629 calibration 209 validation	undisturbed/disturbed
Urach (2007)	2007	VG parameters W1kPa W6kPa W10kPa W33kPa W100kPa W500kPa W1500kPa	Rio Grande do Sul	963	undisturbed/disturbed
van den Berg et al. (1997)	1997	W10kPa W1500kPa W33kPa-W1500kPA VG parameters	Brazil, China, Equador, Colombia, Indonesia, Ivory Coast, Kenya, Malasia, Zambia e Mocambique	91 calibration 35 validation	undisturbed/disturbed
Vaz et al. (2005)	2005	water retention curve	São Paulo, Rio Grande do Sul	104	undisturbed



NUMBER OF PTFs BY TYPES OF PUBLICATIONS
TOTAL: 57 PTFs
46 - PORTUGUESE
16
14
12
10
8
6
4
2
0
15
11
9
9
8
5
Other Brazilian Journals
International Journals
Thesis
Soil Science Brazilian Journal
Congress/Symposium
Dissertations

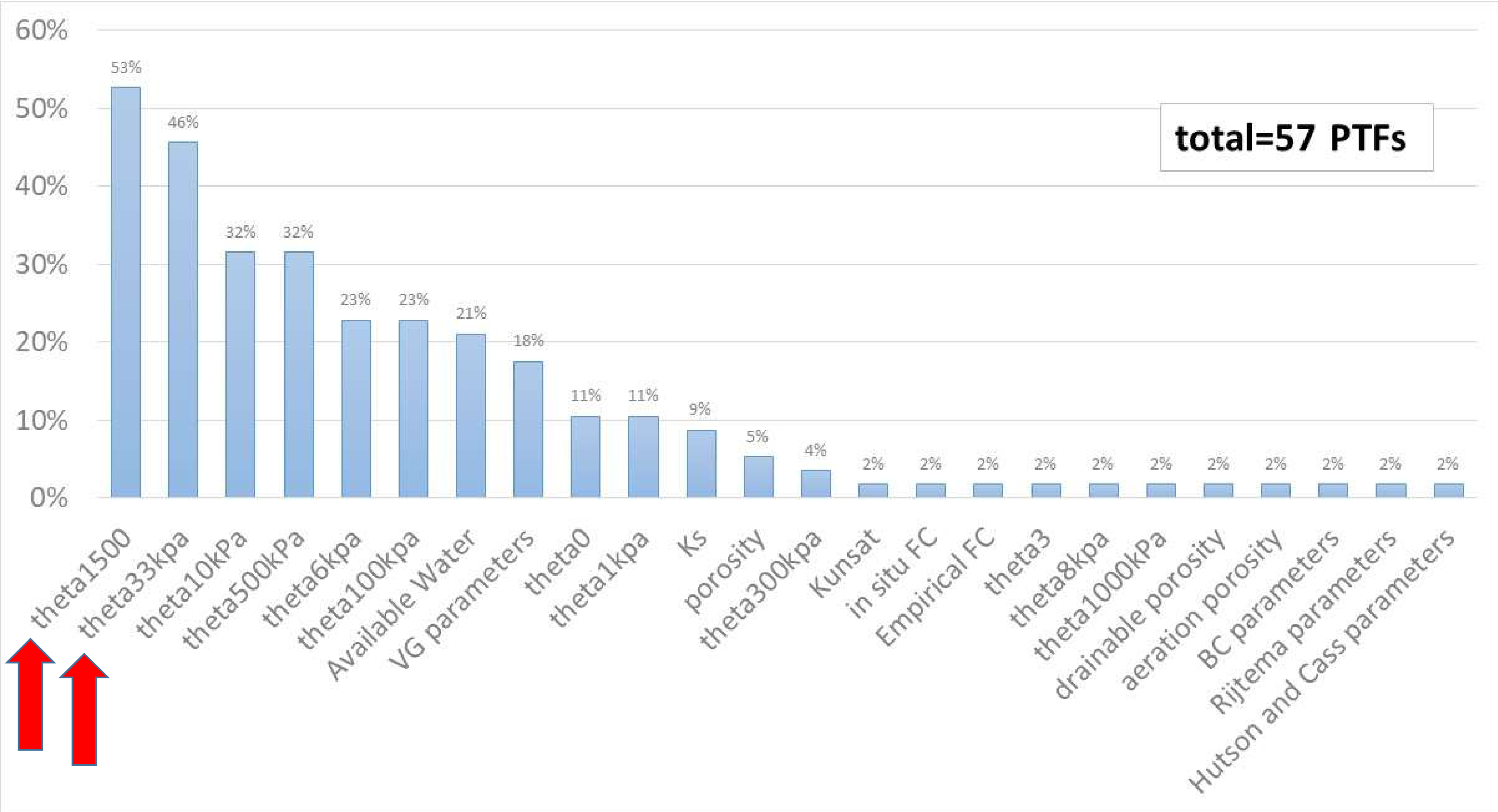
NUMBER OF PTFs BY BRAZILIAN STATES



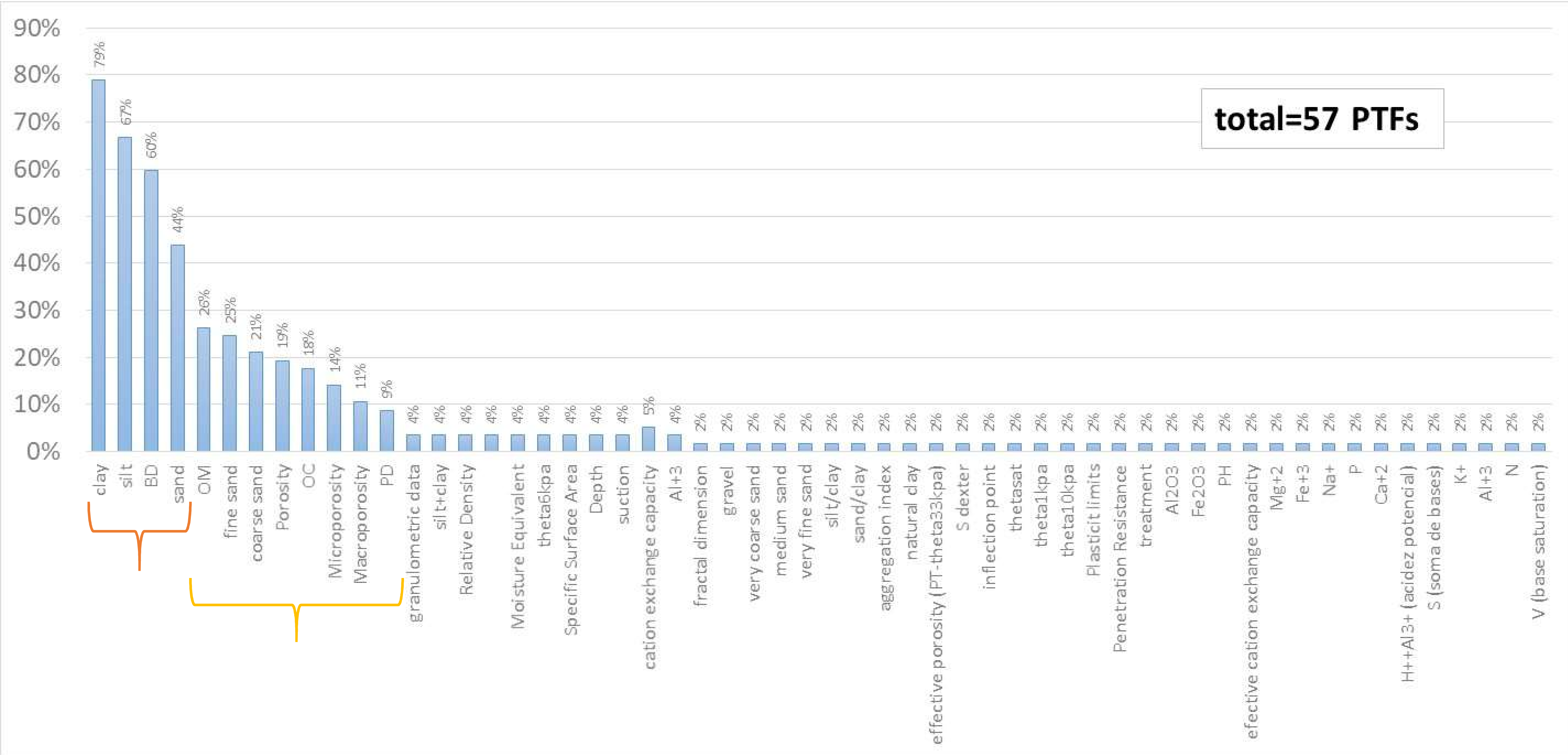
PTFs – Brazil scale

References	Year	Predicted variable	Geographic Domain	Number of Samples	Sample Type
Barros et al. (2013)	2013	VG parameters	Northeastern Brazil	673 calibration 113 validation	disturbed, undisturbed
Medrado e Lima (2014)	2014	VG parameters	Amazônia, Distrito Federal, Goiás, Maranhão, Minas Gerais, Mato Grosso, Pará, Tocantins	1092 - calibração; 309 - vallidação	undisturbed
Nascimento et al. (2010)	2010	Ug33kPa Ug1500kPa Ug33kPa-Ug1500kPa	Alagoas, Amazonia, Bahia, Pernambuco, Rio de Janeiro, Sergipe	682	x
Tomasella et al. (2000)	2000	VG parameters	Paraná, Amazonas, Bahia, Rio Grande do Norte, Minas Gerais, Pará, São Paulo, rio de Janeiro, Distrito Federal	517 calibration 113 validation	undisturbed/disturbed
Tomasella et al. (2003)	2003	W0kPa W6kPa W10kPa W33kPa W100kPa W1500kPa VG parameters	Brazil	629 calibration 209 validation	undisturbed/disturbed

PERCENTAGE OF THE USE OF PREDICTED PROPERTIES IN PTF DEVELOPMENT

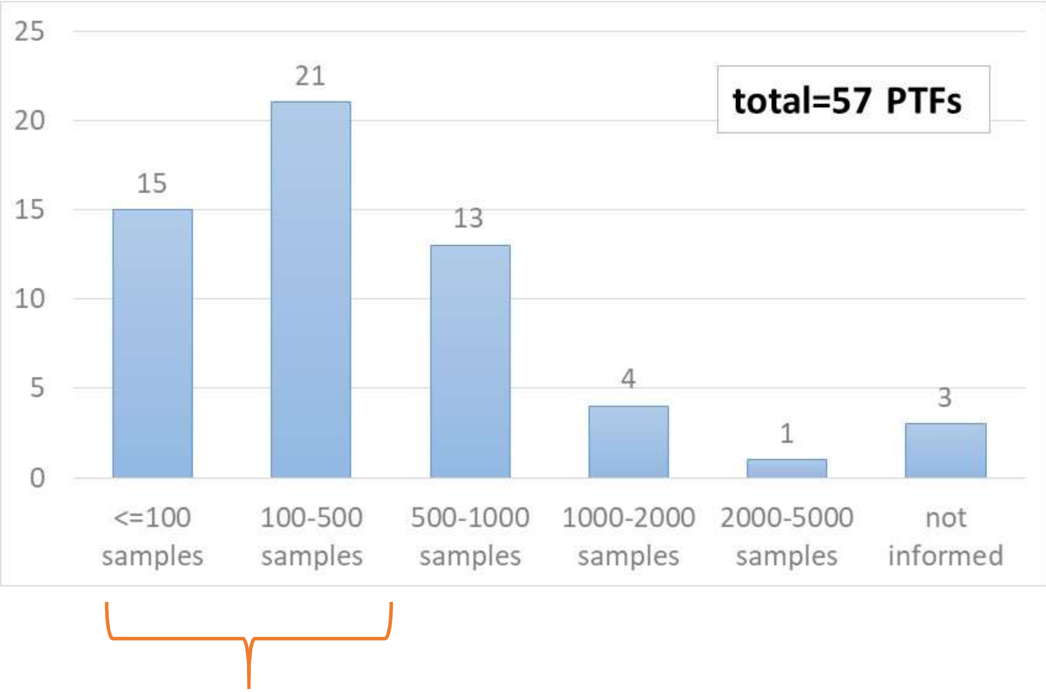


PERCENTAGE OF THE USE OF PREDICTORS IN PTF DEVELOPMENT

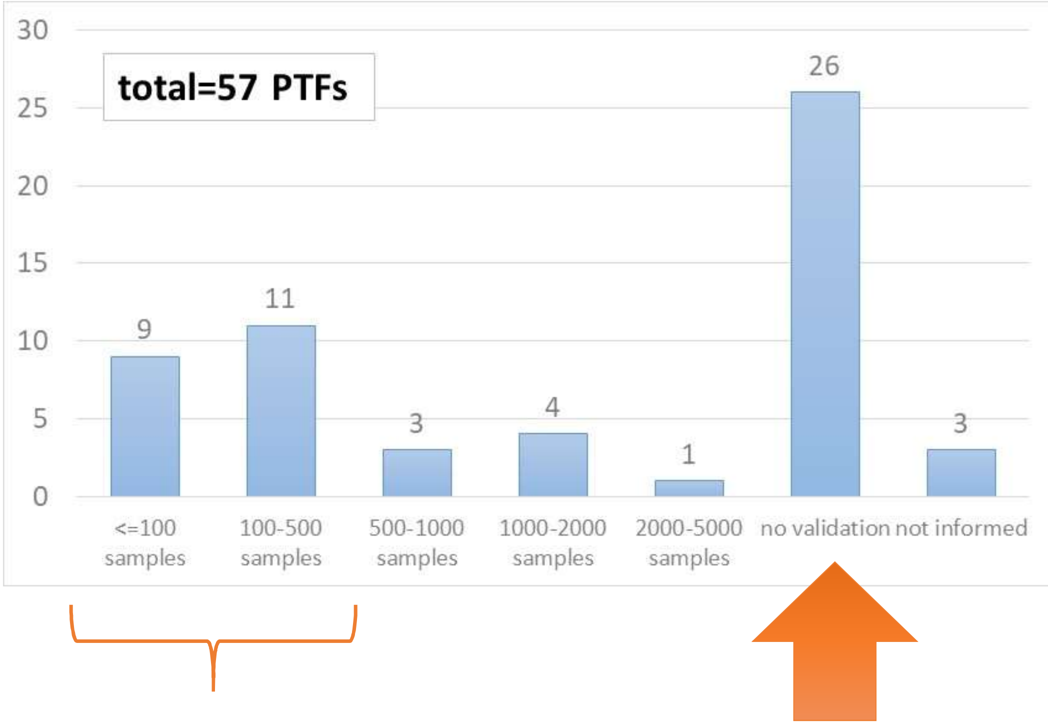


NUMBER OF PTFs BY DATABASE SIZE

CALIBRATION DATABASE

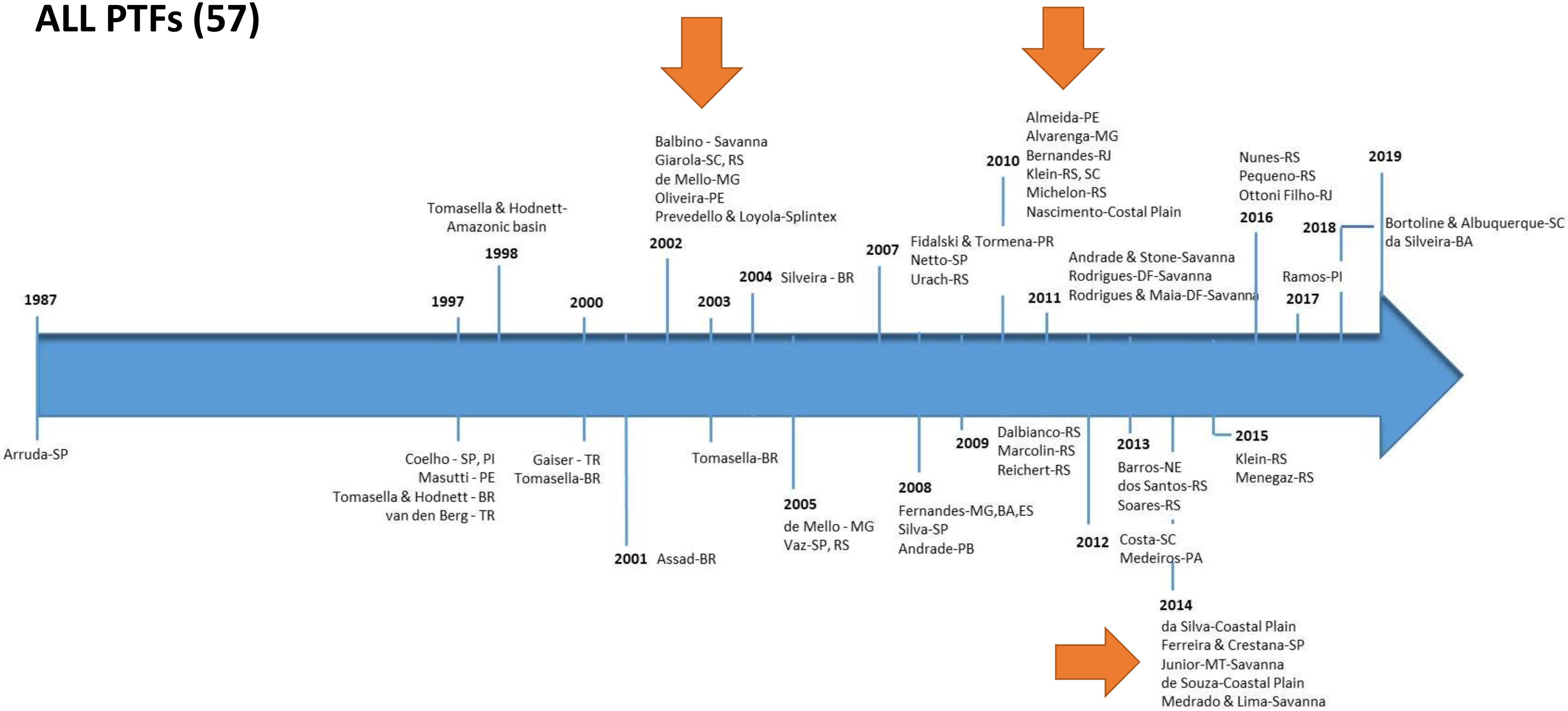


VALIDATION DATABASE



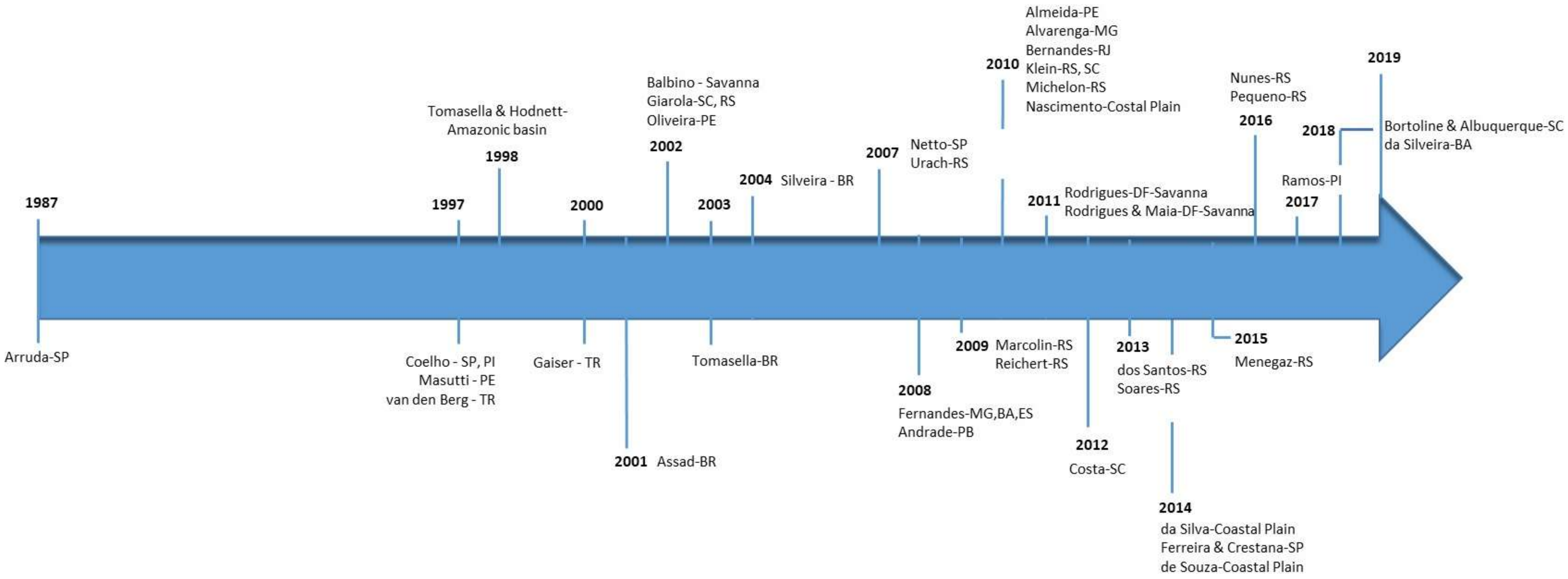
PTF DEVELOPMENT IN TIME SCALE

ALL PTFs (57)



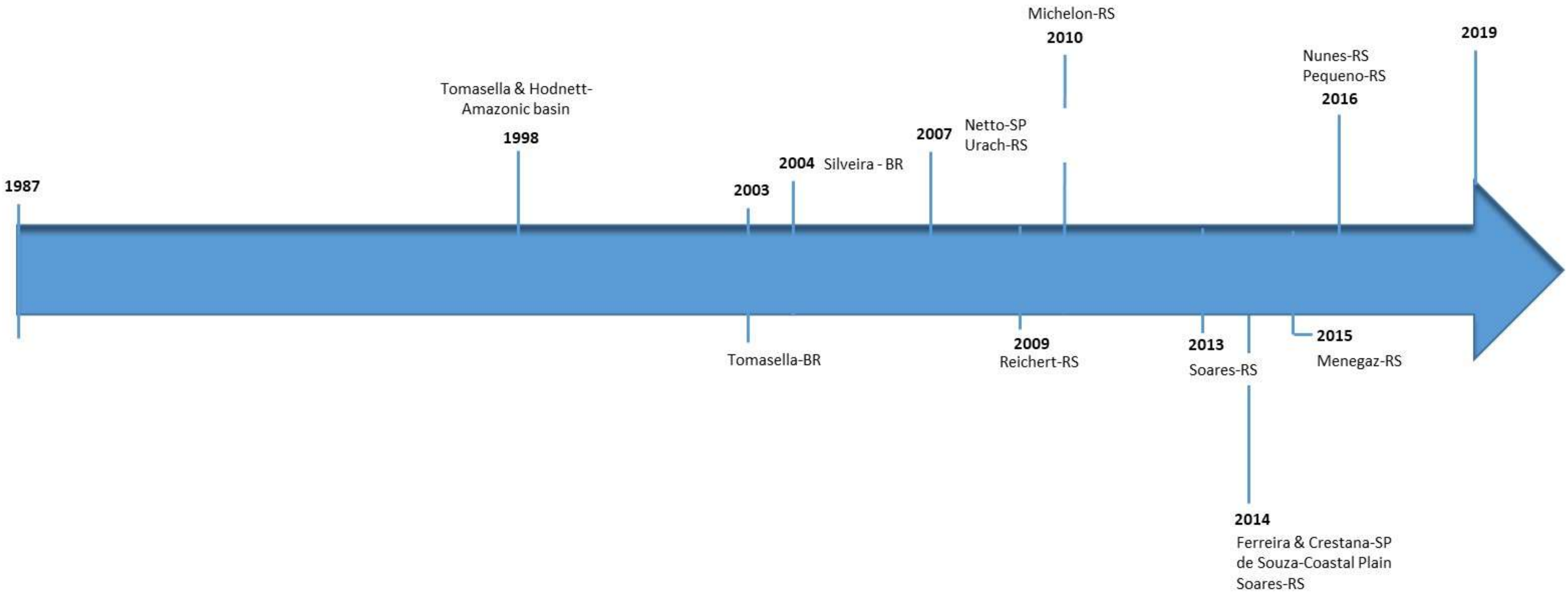
PTF DEVELOPMENT IN TIME SCALE

FIELD CAPACITY, WILTING POINT, AVAILABLE WATER



PTF DEVELOPMENT IN TIME SCALE

MANY WATER RETENTION POINTS



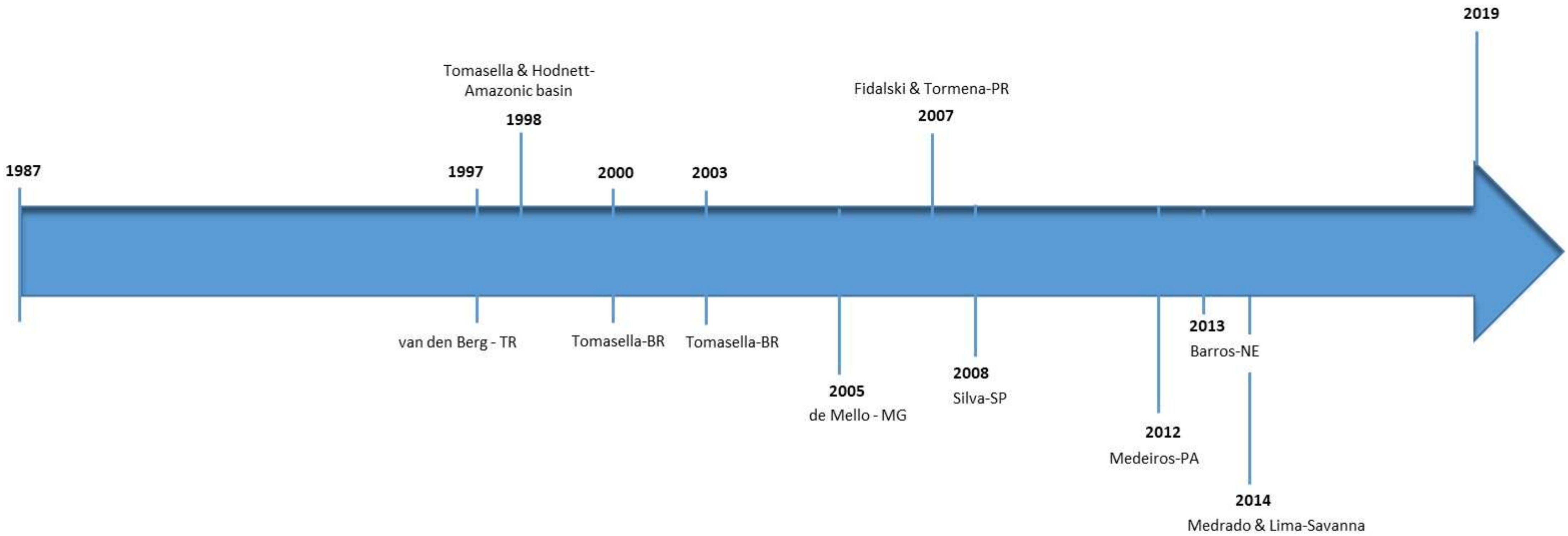
PTF DEVELOPMENT IN TIME SCALE

KSAT

Ottoni et al. (2019)-
Ks=f(effective porosity)-
international soil database

PTF DEVELOPMENT IN TIME SCALE

PARAMETRIC PTFs – Water Retention



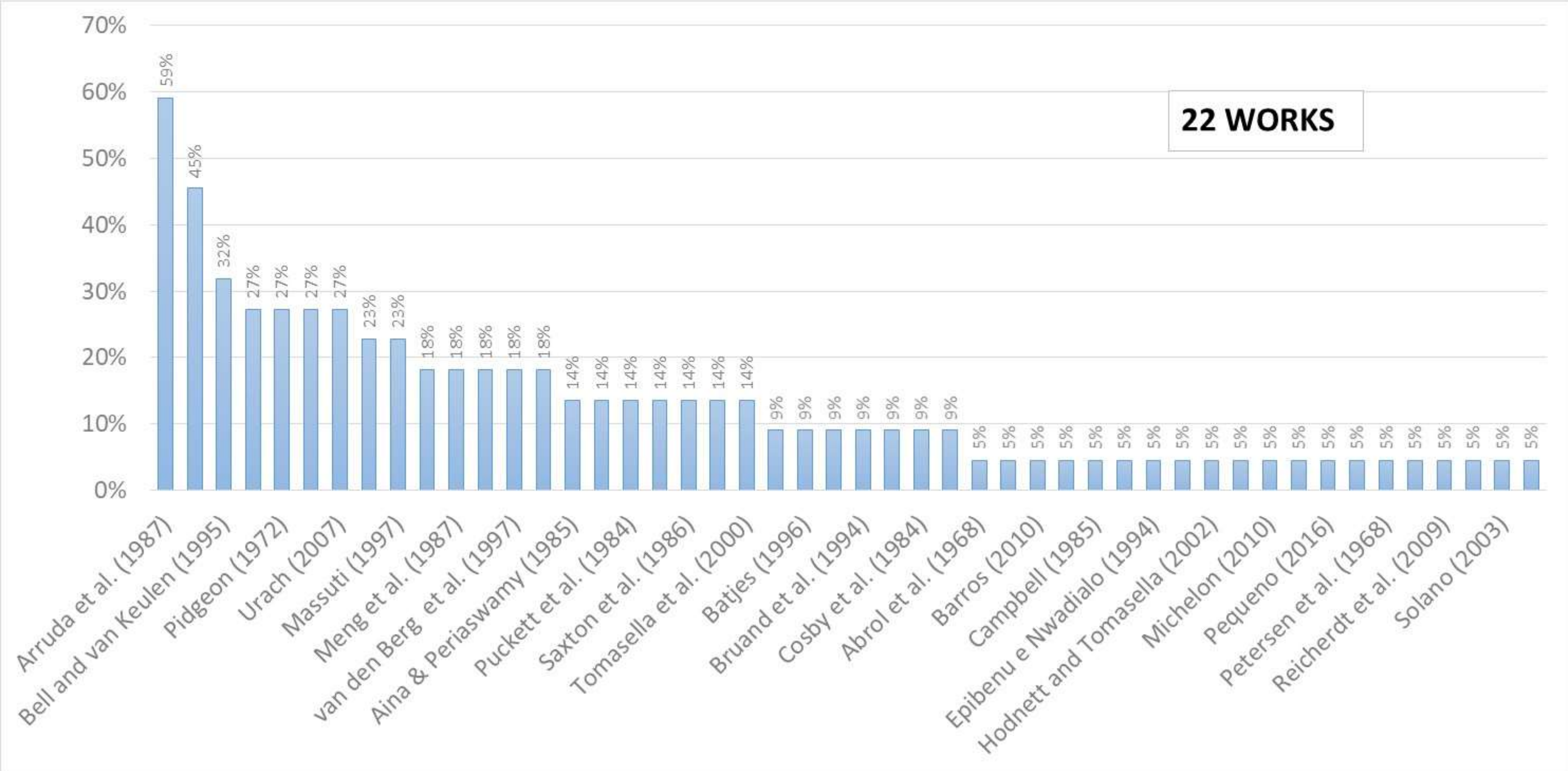
PTF DEVELOPMENT IN TIME SCALE

PARAMETRIC PTFs - Kunsat

PTF DEVELOPMENT IN TIME SCALE

IN SITU FIELD CAPACITY

PTFs VALIDATION



BRAZILIAN SOIL DATABASE

HYBRAS

Hydrophysical Database for Brazilian Soils

1075 samples with retention data (at least 5 points) x basic soil atributes

412 samples with Ks data x basic soil attributes

<u>INCLUDING MORE INFORMATION (FC, PMP):</u>

- ✓ 415 samples: AL, RR, PA, PI, RJ, PB, SC, RS, SP, PA
- ✓ 1411 samples from LEONOR-ASSAD: MG, SC, CE, GO, PR, RJ, RN, SP

NEW BRAZILIAN PTFs (UNDER DEVELOPMENT)

Table 3: RMSE para diferentes modelos de PTF em diferentes tensões

modelo	parametros	obs	TH0.01Mpa	TH0.033Mpa	TH1.5Mpa
RF1	sand silt clay	886	0.060	0.058	0.050
RF2	sand silt clay org_carb	598	0.045	0.045	0.042
RF3	sand silt clay bulk_den	886	0.053	0.051	0.047
RF4	sand silt clay bulk_den org_carb	598	0.040	0.040	0.039
RF5	f_sand c_sand silt clay org_carb	276	0.042	0.041	0.036
RF6	f_sand c_sand silt clay org_carb bulk_den	276	0.037	0.037	0.033
Tomasella, nivel 3	f_sand, c_sand, silt, clay, org_carb, bulk_dens	276	0.073	0.073	0.070
Tomasella, nivel 4	f_sand, c_sand, silt, clay, org_carb	276	0.062	0.059	0.055

DISCUSSION AND CONCLUSIONS

- THERE **MANY PTFs OF HYDRAULIC PROPERTIES FOR BRAZILIAN SOILS**, BUT MOST OF THEM ARE PUBLISHED IN **PORTUGUESE**;

- MOST OF THE BRAZILIAN PTFs WERE DEVELOPED FOR **FC** AND **PWP**, BUT ONLY 1 FOR THE **IN SITU FIELD CAPACITY**;

- THERE ARE **FEW PTFS FOR KS,** ONLY **1 FOR KUNSAT** (FEW AVALIABLE KS AND KUNSAT DATA IN BRAZIL), AND **NONE** FOR **INFILTRATION CAPACICITY**;

- **NO CLASS PTFs WERE FOUND** IN THE LITERATURE. DO WE NEED PTFs FOR TEXTURAL CLASSES AND FOR SOIL TYPE (FERRALSOL, ACRISOL, REGOSOLS...)???

- **MLR IS THE MOST USED STATISTICAL METHOD**→OTHER METHODS SHOULD BE TESTED.

- MOST OF THE **PTFs WERE CALIBRATED FOR REGIONAL AREAS** AND WITH **SMALL DATABASES**. APPLICATION OF SUCH PTFs FOR SIMULATING LARGER SCALE PROCESSES MUST BE EVALUATED (and vice-versa: LARGE SCALE PTFs TO SIMULATE LOCAL SCALE PROCESSES);

DISCUSSION AND CONCLUSIONS

- THE **UNCERTAINTIES** OF THE PTFs ARE NOT PROVIDED!
- THE PTFs ARE APPLIED WITHOUT CONSIDERING THEIR APPLICABILITY TO THE EVALUATED SOIL DATABASE;
- **PTFS FOR REGOSOLS, FLUVISOLS, LEPTSOLS, ARENOSOLS** (3RD MOST COMMON SOIL IN BRASIL). NEED TO CHECK.
- NEED TO EVALUATE THE **ERRORS VALUES RANGE** CONSIDERING THE PTFs DATABASE OF THIS STUDY;
- **TOMASELLA'S PTFs ARE THE ONLY MODELS APPLIED FOR THE COUNTRY SCALE.** DO WE NEED TO UPDATE THESE PTFs WITH MORE REPRESENTATIVE SAMPLES??
- THERE ARE **FEW** STUDIES **VALIDATING PTFs** THAT WERE CALIBRATED, AND ALMOST **NONE PTF FUNCTIONAL VALIDATION**;

DISCUSSION AND CONCLUSIONS

- USE OF **DISTURBED SAMPLES** TO ESTIMATE HYDRAULIC PROPERTIES. HOW LARGE ARE THE ERRORS?? DO THESE ERRORS IMPACT SIMULATION OF HYDROLOGICAL PROCESSES??

- THERE IS VERY LITTLE INFORMATION **(INCLUDING MANAGEMENTS ATTRIBUTES, FIELD AND LABORATORY METHODOLOGY)** AND **METADATA** ABOUT THE CALIBRATION AND VALIDATION DATASETS

- THE **KS** RMSE IS CALCULATED CONSIDERING THE **OWN VALUE** OF KS!!! WE ARE NOT USING THE TRANSFORMED VALUE (LN OR LOG)

- THE MOST COMMON STATISTIC TO EVALUATE PTFs IS R2;

- **STRUCTURAL VARIABLES** ARE NOT BEING LARGELY USED TO GENERATE BRAZILIAN PTFS. THE USE OF **$\theta 6$** (MICROPOROSITY) CAN IMPROVE THE ESTIMATES;

DISCUSSION AND CONCLUSIONS

- THE USE OF **GEOENVIRONMENTAL VARIABLE** (REMOTE SENSING, TOPOGRAPHICAL, AND GEOGRAPHICAL INFORMATION, ETC) MIGHT BE USED FOR PTF DEVELOPMENT IN ORDER TO PREDICT THE SPATIAL VARIABILITY OF SOIL PROPERTIES;

- THE BRAZILIAN PTFs ARE BEING **USED**? IN WHICH CASES??

- DO WE NEED PTFs WHICH TAKE INTO ACCOUNT TIME INFLUENCE? THESE MODELS COULD BE USEFUL FOR **EARTH SYSTEM MODELING**.

- STABLISHMENT OF **WATER AND SOIL MONITORING NETWORK**. DO WE NEED IT?

- WE NEED TO MEASURE **MORE RETENTION DATA,** SPECIALLY IN THE **VERY WET** AND **DRY SUCTION RANGES** .

- HOW DO WE GET **MORE DATA** OF HYDRAULIC PROPERTIES FROM THE LITERATURE IF OUR CULTURE IS TO KEEP THEM IN OUR COMPUTERS??

DISCUSSION AND CONCLUSIONS

- **FINALLY, WE HAVE MANY PTFs in BRAZIL!! HOW TO USE THEM MORE EFFICENTLY??**

THANK YOU VERY MUCH!!!

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