"Capacity Building and Strengthening Institutional Arrangement"

Analysis and sampling of water and water pollution

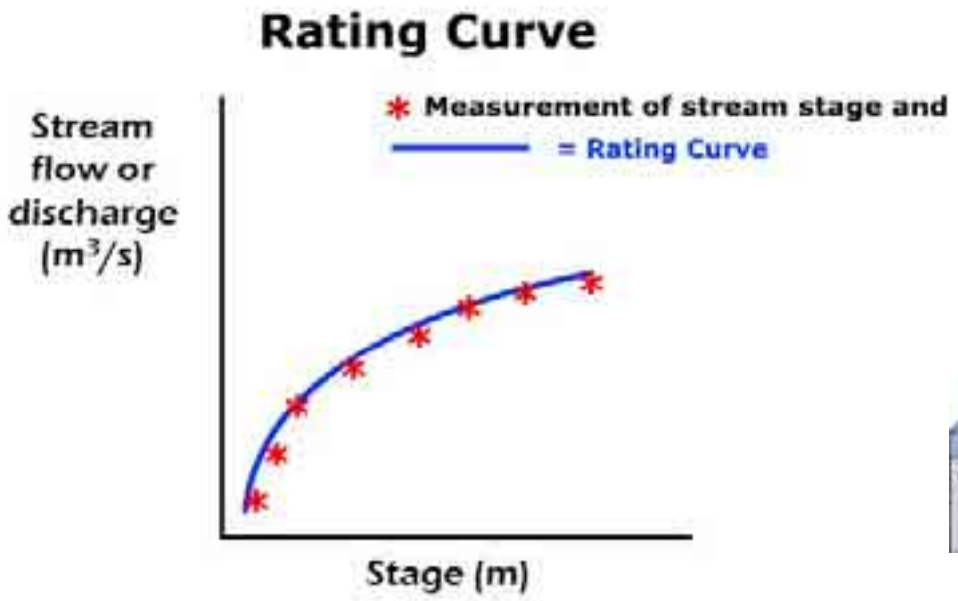
WATER DISCHARGES TO THE SEA

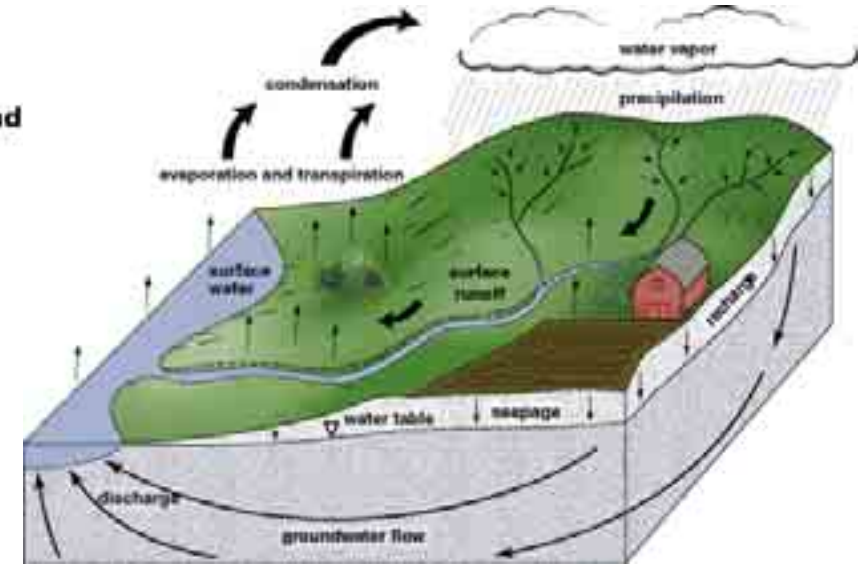
Mr. Stefano Corsini
APAT
Agency for Environmental Protection and Technical Services

Exchange and update of stage-discharge relationships & knowledge on runoff processes for basins

Hydrological models can use the stage-discharge relationship as:

- input data;
- boundary condition at the downstream outflow;
- data for calibration and validation;



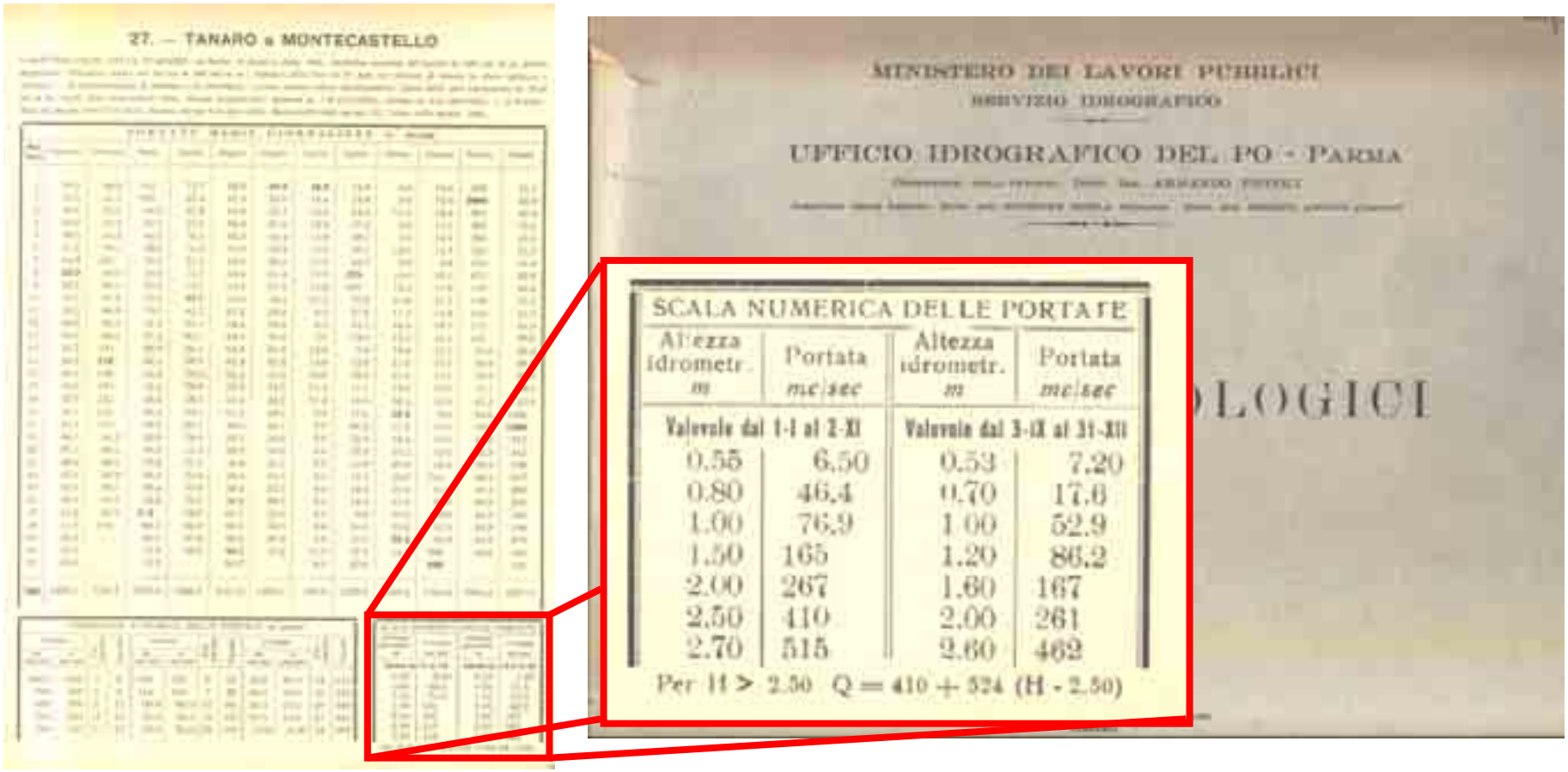


Exchange and update of stage-discharge relationships & knowledge on runoff processes for basins

Stage-Discharge relationship:
several methods are used to determine this relationship; traditionally it is obtained from direct discharge measurements for a set of water surface levels [scatter plot of discharge (Q) vs. stage (h)].
Thus, the stage-discharge function is developed as the best fit curve through the observed stage-discharge measurements.
Factors affecting the stage-discharge relationship include:

- bed forms
- water temperature
- debris or other obstructions,
- unsteady flow effects (leading to a non-unique Q-h correspondence)
- variation in hydraulic roughness with season, sediment transport, channel scour or deposition
- changes in channel shape during or as a result of flood events

Exchange and update of stage-discharge relationships & knowledge on runoff processes for basins



27. — TANARO a MONTECASTELLO

MINISTERO DEI LAVORI PUBBLICI
SERVIZIO IDROGRAFICO

UFFICIO IDROGRAFICO DEL PO - PARMA

SCALA NUMERICA DELLE PORTATE

Altezza idrometr. m	Portata mc/sec	Altezza idrometr. m	Portata mc/sec
Valevole dal 1-I al 2-XI		Valevole dal 3-IX al 31-XII	
0.55	6.50	0.53	7.20
0.80	46.4	0.70	17.6
1.00	76.9	1.00	52.9
1.50	165	1.20	86.2
2.00	267	1.60	167
2.50	410	2.00	261
2.70	515	2.60	462

Per H > 2.50 Q = 410 + 524 (H - 2.50)

Exchange and update of stage-discharge relationships & knowledge on runoff processes for basins

In the past, the former *Italian National Hydrographic and Maregraphic Service* published each year the **"Annali Idrologici"** which contain for each hydrometric station a stage-discharge relationship in a numerical form.

For values greater than the maximum discharge measure, it was also included an analytical expression. Moreover for the highest discharge measures, the rating curve was extrapolated using an expression as follows:

SCALA NUMERICA DELLE PORTATE

Altezza idrometr. m	Portata mc/sec	Altezza idrometr. m	Portata mc/sec
Valevole dal 1-I al 2-II		Valevole dal 3-II al 31-XII	
0.55	6.50	0.53	7.20
0.80	46.4	0.70	17.6
1.00	76.9	1.00	52.9
1.50	165	1.20	86.2
2.00	267	1.60	167
2.50	410	2.00	261
2.70	515	2.60	462

Per H > 2.50 Q = 410 + 524 (H - 2.50)

$$Q = c \cdot h^{3/2} - d$$

Q = discharge
h = stage
c,d = coeff. to estimate

At the moment, in the framework of the **ANNALI Project**, the *APAT Hydrologic and Inland Waters Service* is performing the digitalization of all data and info contained in these publications.

Exchange and update of stage-discharge relationships & knowledge on runoff processes for basins

The relevance of the discharge measures

The discharge measures are important features for the quantitative monitoring and forecasting of extreme events, such as floods and droughts.
Furthermore, it is relevant in the framework of the quali-quantitative integrated protection of water resource.
Thus, it is necessary to provide to the measurement and the dissemination of these data following some common standards.

For example, as indicated by the WMO “Guide to Hydrological Pratices”:,
<<Factors to be considered in scheduling the number and the distribution of discharge measurements within the year include:

(a) Stability of stage-discharge relationships;
(b) Seasonal discharge characteristics and variability;
(c) Accessibility of the gauge in various seasons.

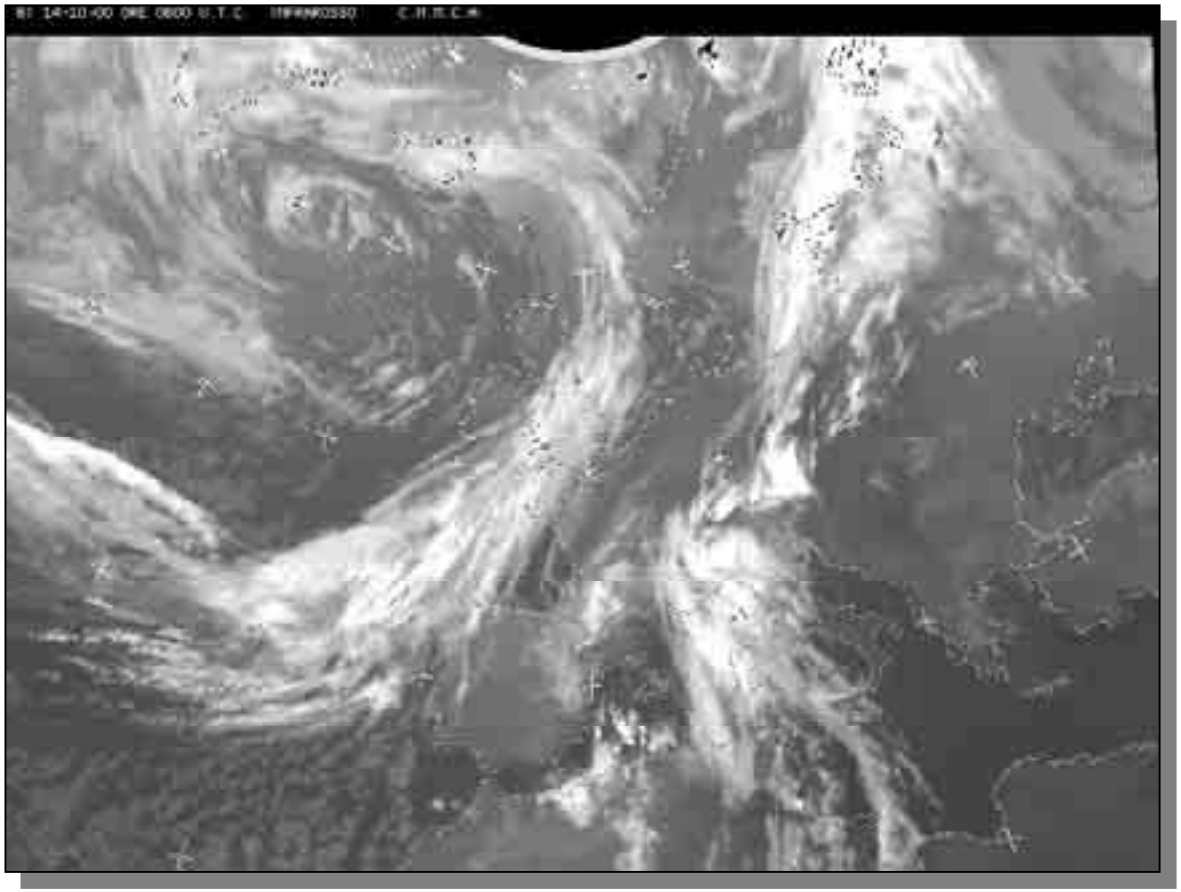
[…] a minimum of ten discharge measurements per year is recommended.>>

FLOOD - Autumn 2000

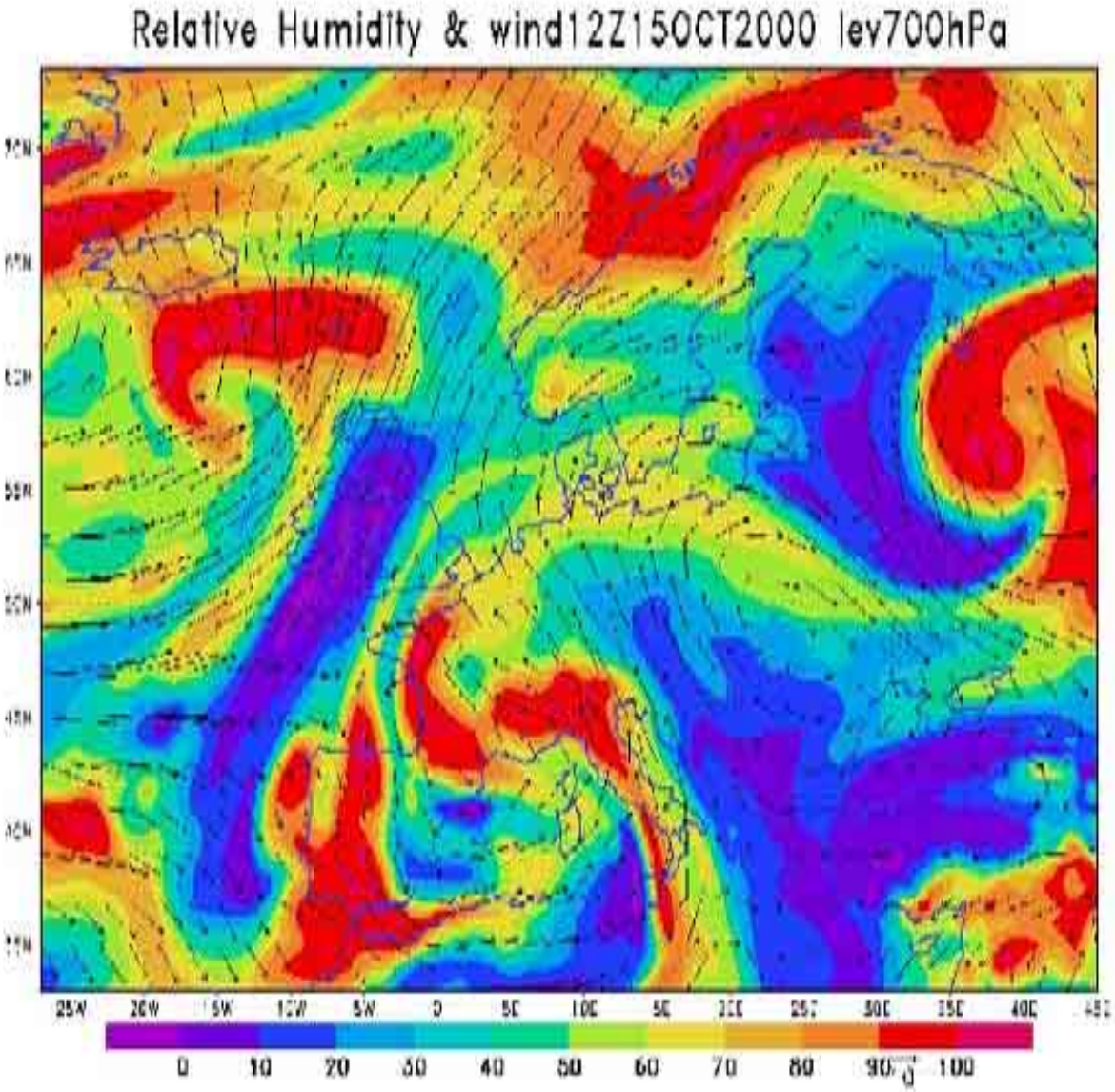
WEATHER CONDITIONS




IR Meteosat image 14 october 2000 06 am



The clouds system, on northern Italy is limited by the warm front of the african air, pushed to central and eastern Europe by the cyclon flux due to the weather formation centered near Corsica island



15 october

(ECMWF) Medium range forecast
15 October – 12 pm

Red areas show 100% Relative Humidity

FLOOD - Autumn 2000

RAINFALL REAL TIME MEASUREMENTS

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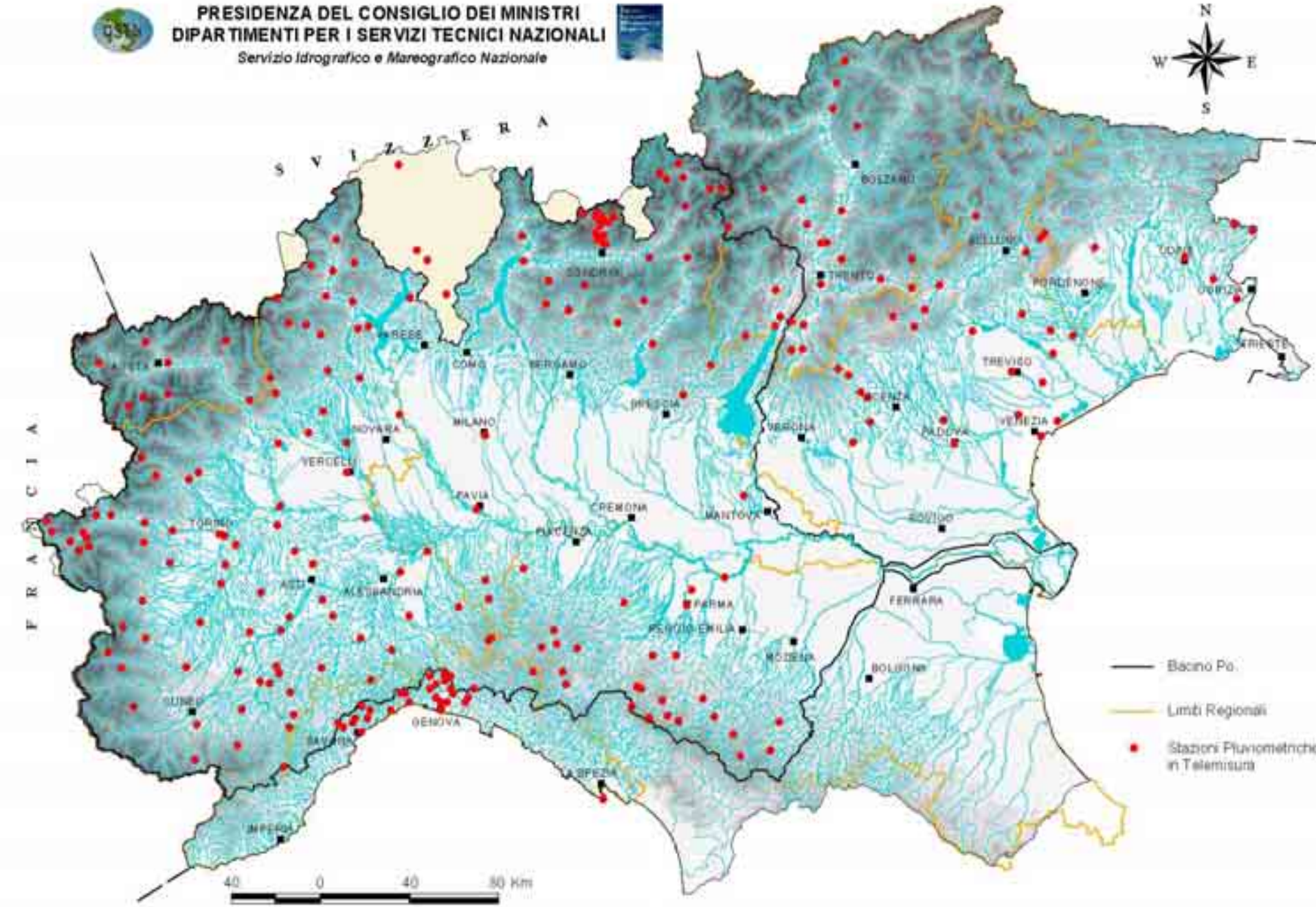
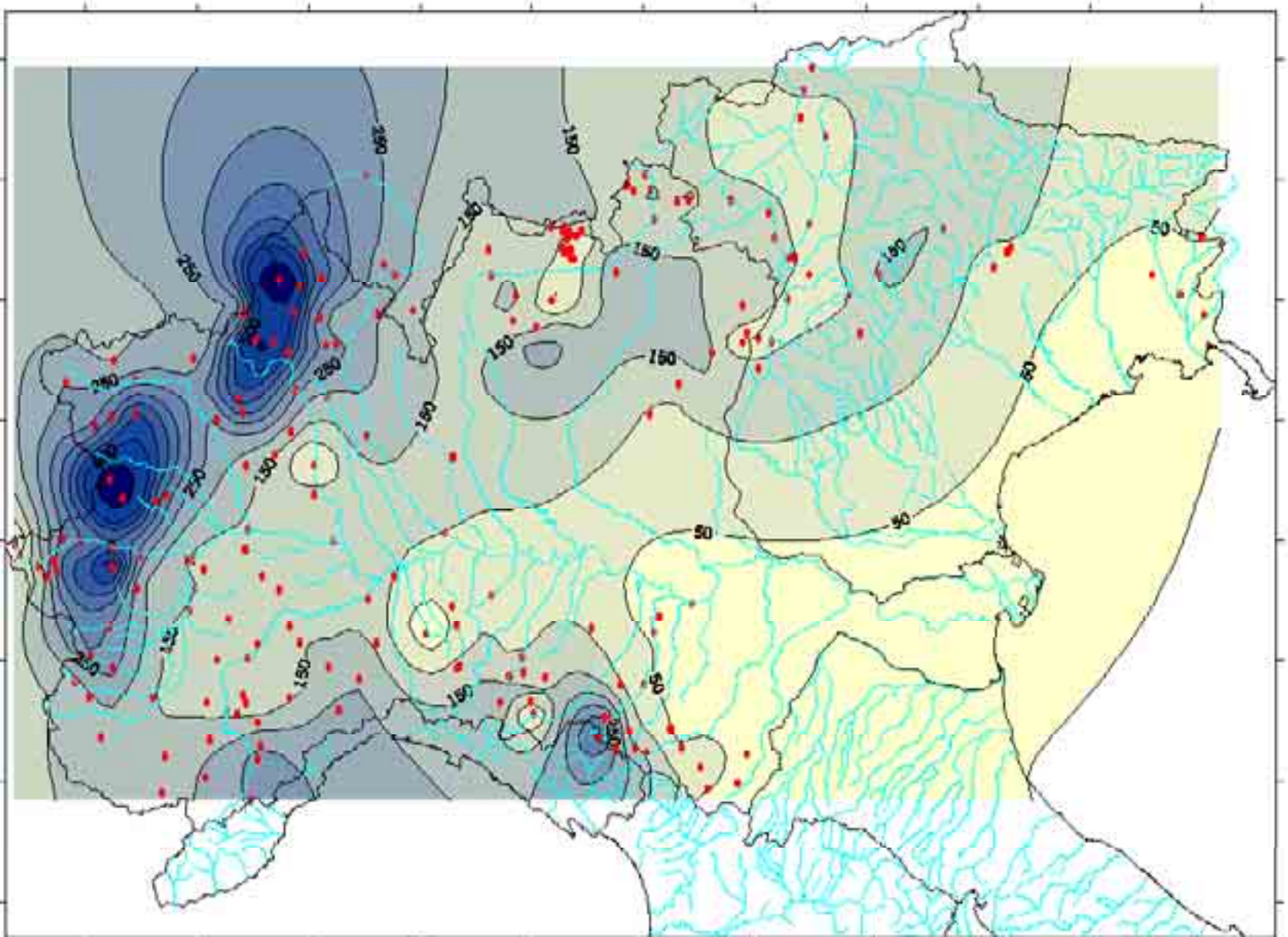
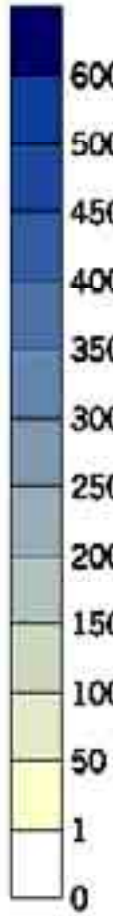
Servizio Idrografico e Mareografico Nazionale



Sensori	*11 ott*	*12 ott*	*13 ott*	*14 ott*	*15 ott*	*16 ott*	*17 ott*	*Cumulate*
	[mm]							
ACQUI	32,8	20,6	15,8	33,2	56	27,8	2,2	188,4
ALA DI STURA	9,8	7,4	192	252	227,8	45,2	0,2	734,4
ALESSANDRIA	15,6	23,4	20,6	15	38,8	32	2,4	147,8
BELVEDERE LANGHE	2	8,2	10,6	37,6	72,6	17	1,8	149,8
BOGNANCO	40	36,6	334,6	219,8	150	46,4	-	827,4
BORGOSESIA	18,4	21,4	32,4	50	130,6	70,8	1,8	325,4
BOVES	14,4	2,8	4,8	76,2	63,8	23	0,4	185,4
BRA	0,2	1,8	5,2	34,2	63,6	16,6	0,8	122,4
COAZZE	5,2	2,2	88,2	183	259,8	68,2	0,6	607,2
CORIO	4,6	4	33,4	86,6	161,6	50	2,8	343,0
CRISSOLO	13,4	5,2	17,2	100	166,8	21,2	0,4	324,2
CUMIANA	1,2	0,2	19,2	61,4	102,6	35,6	3	223,2
DOMODOSSOLA	28,6	17,2	137,6	71,6	160,8	49,4	7,6	472,8
FARIGLIANO	1,6	3,8	7,4	40,8	62	17,2	0,8	133,6
FOBELLO	25	30,8	224,8	116	175,2	64	2,6	638,4
FORNO ALPI GRAIE	10,2	10,8	239,4	164,8	251,8	34,2	0	711,2
FOSSANO	1,6	2,4	5,2	50	65,4	13	1,4	139,0
GARESSIO	65,2	34	15,6	42,6	118,2	46	0,2	321,8
LANZO FUA	5	6,2	50,4	128,2	163	57,2	1,4	411,4
LIMONE PIEMONTE	22	30,2	6,2	45,2	63,8	21,6	0,2	189,2
MONCALIERI	0,2	0,8	7	30,2	108,2	13,2	3,2	162,8
PONTECHIANALE	20,2	5,6	24,6	51,2	73,2	11,8	0,2	186,8
PONZONE	46,4	22,8	42	20,2	89,2	40,4	1,4	262,4
PRAGELATO	14,8	0,6	53,2	91,2	224,4	4,2	0	388,4
SABBIA	30,8	34	90,6	82,8	189,2	82,8	4,4	514,6
TORINO (ITALGAS)	0	1,2	12,8	30,8	87,8	15,2	2	149,8
VARZO	29,8	23	263,4	169	125,4	40,6	-	651,2

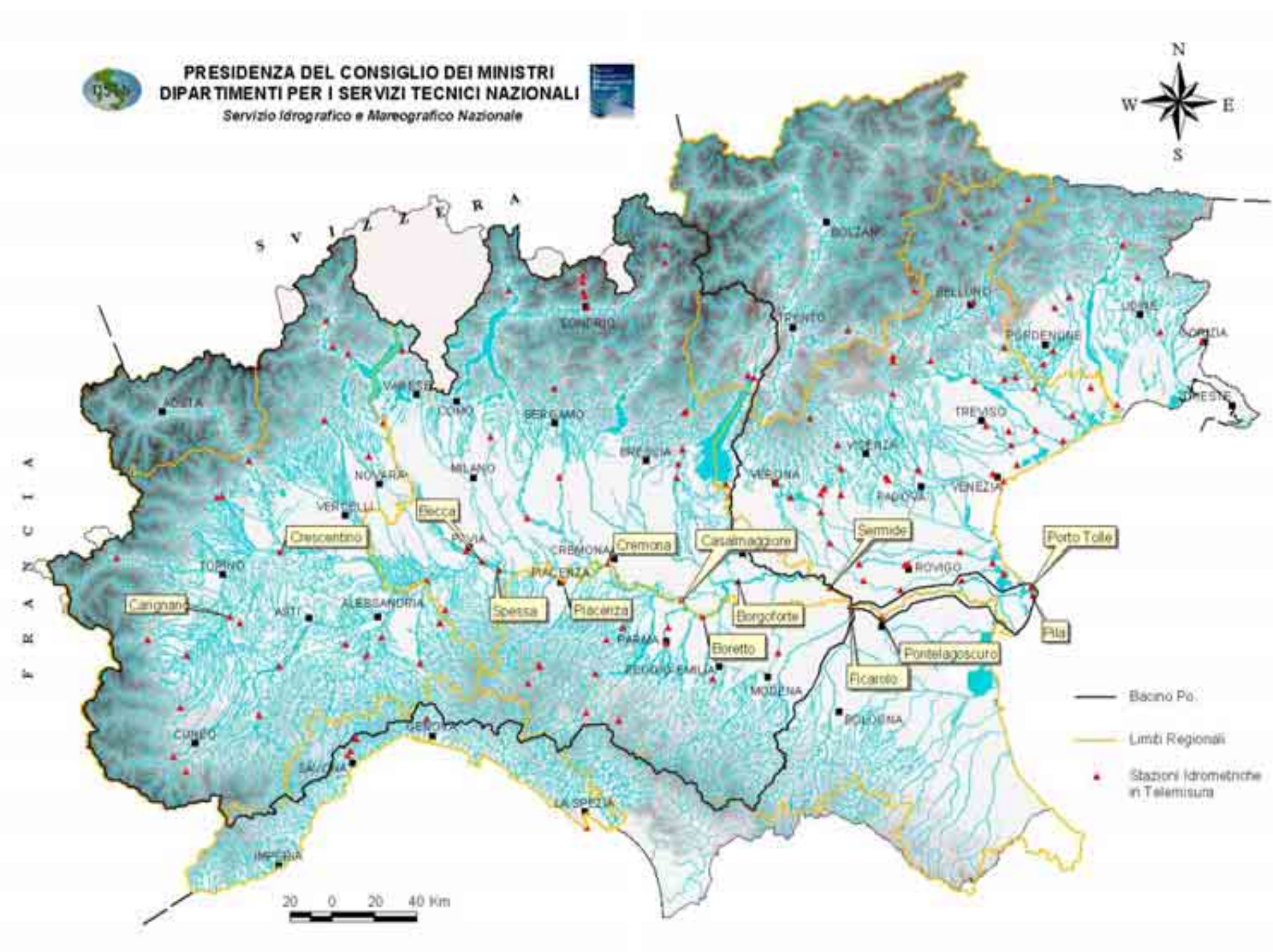
Cumulative rainfall 12, 13, 14, 15 e 16 ottobre 2000





FLOOD - Autumn 2000

WATER LEVEL REAL TIME MEASUREMENTS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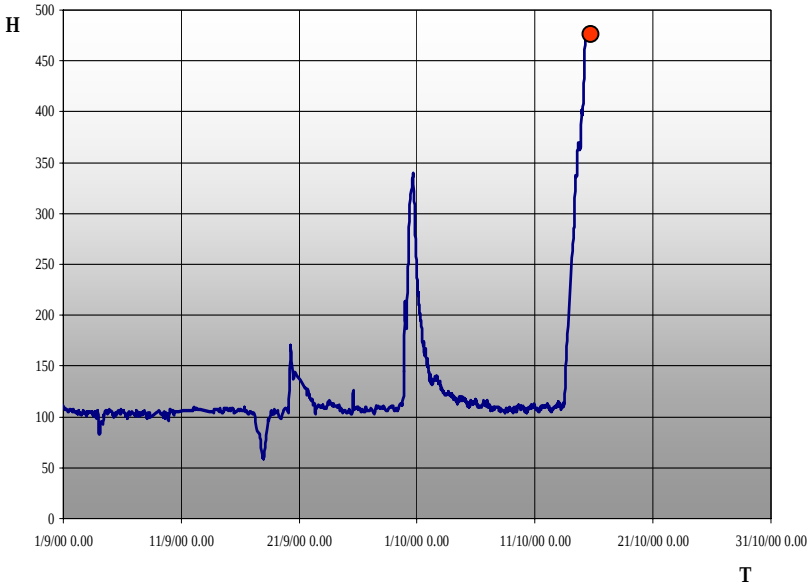
BERGAMO
BRESCIA
TRENTO
TREVISO
VICENZA
VERONA
PADOVA
VENEZIA
NOVARA
MILANO
VERCELLI
Becca
Crescentino
PAVIA
CREMONA
Cremona
Casalmaggiore
Sermide
Porto Tolle
TORINO
PIACENZA
ROVIGO
Carignano
ASTI
ALESSANDRIA
Spessa
Piacenza
Borgoforte
PARMA
Boretto
Pontelagoscuro
REGGIO EMILIA
Ficarolo
MODENA
BOLOGNA
CUNEO
SAVONA
GENOVA
LA SPEZIA
IMPERIA
20 0 20 40 Km
Bacino Po
Limiti Regionali
Stazioni Idrometriche in Telemisura

	Evento del 2000			Evento del 1994		Evento del 1951	
SEZIONE	ora di passaggio colmo	Altezza Idrometrica al colmo (m)	Portata al colmo stimata (m^3/s)	Altezza Idrometrica al colmo (m)	Portata al colmo stimata (m^3/s)	Altezza Idrometrica al colmo (m)	Portata al colmo stimata (m^3/s)
Becca	Ore 10.00 del giorno 17 ott	7,75	11.600	7,60	11.500	7,80	11.250
Ponte Spessa	Ore 12.00 del giorno 17 ott.	8,93	11.200	_	_	_	_
Piacenza	Ore 20.00 del giorno 17 ott.	10,58	_	9,88	_	10,25	12.800
Cremona	Ore 4.00 del giorno 18 ott.	6,26	12.100	5,94	11.300	5,94	_
Casalmaggiore	Ore 2.00 del giorno 19 ott.	8,00	_	_	_	_	12.100
Boretto *	Ore 8.00 del giorno 19 ott.	9,06	11.800	8,42	10.300	8,50	12.800
Borgoforte	Ore 21.00 del giorno 19 ott.	9,92	11.900	9,35	10.800	9,96	11.800
Pontelagoscuro	Ore 8.00 del giorno 20 ott.	3,55	9.600	3,04	8.700	4,28	10.300**

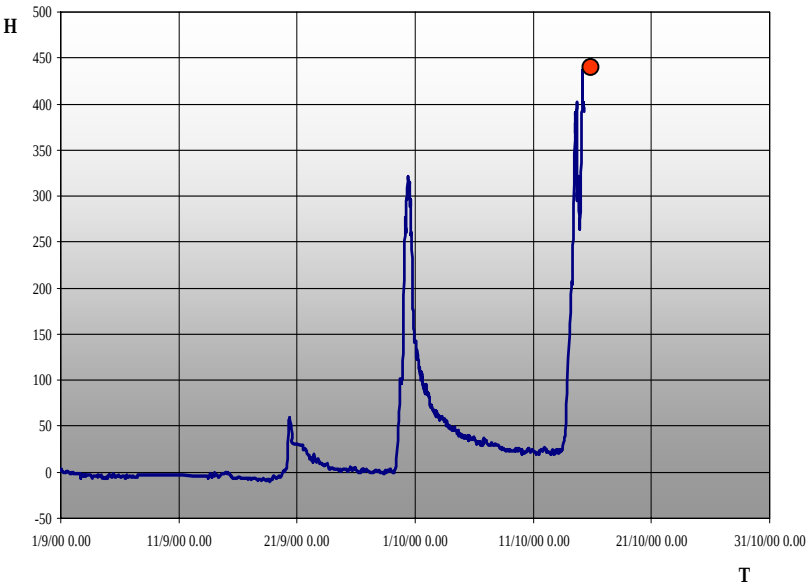
*) Scala di deflusso modificata rispetto al 1951

**) Valore della portata al colmo ricostruita, stimata senza rotta, circa 12.000 m^3/s

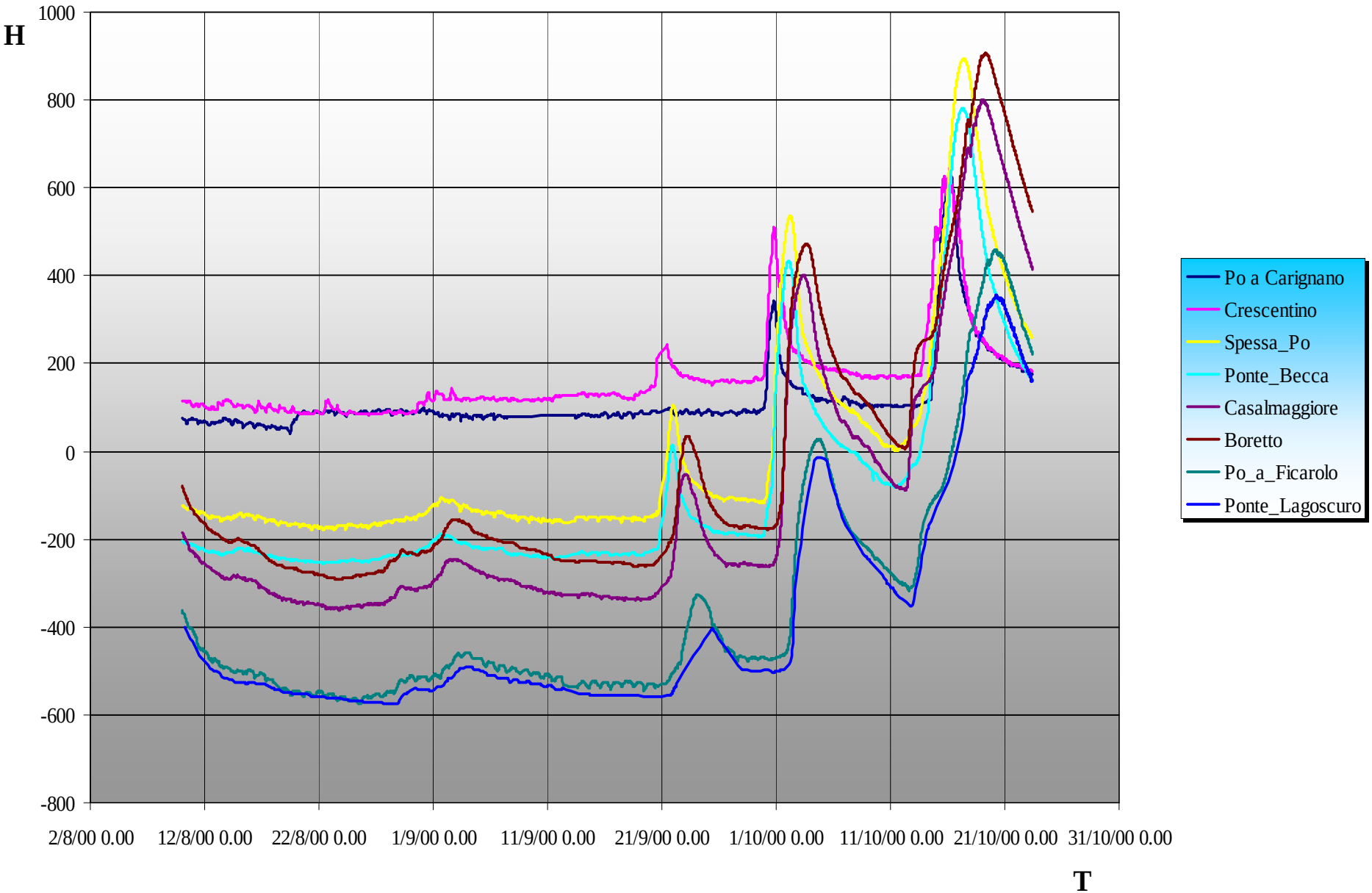
Dora Baltea a Tavagnasco



Stura di Lanzo a Lanzo

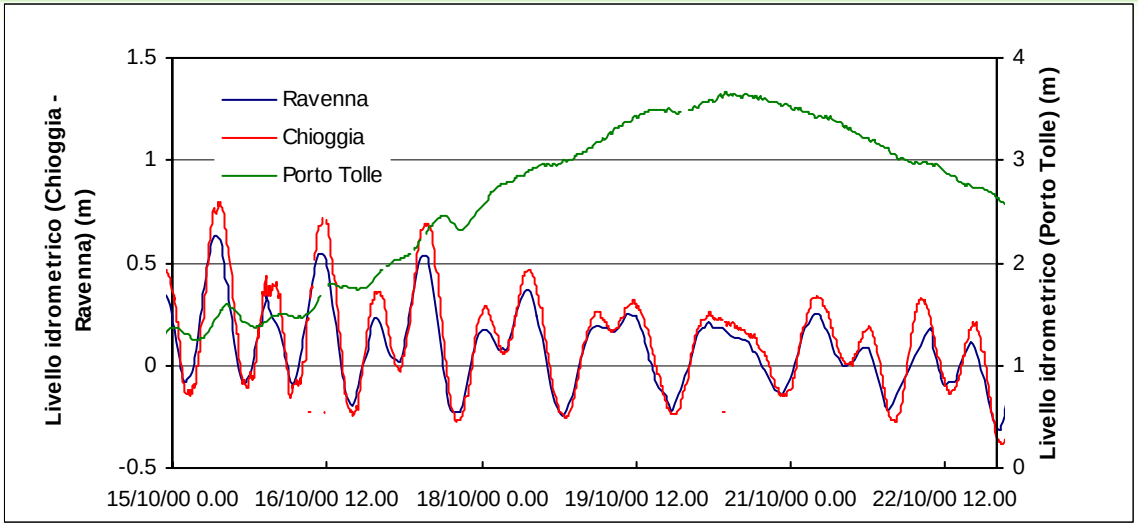


Livelli idrometrici lungo l'asta del Po

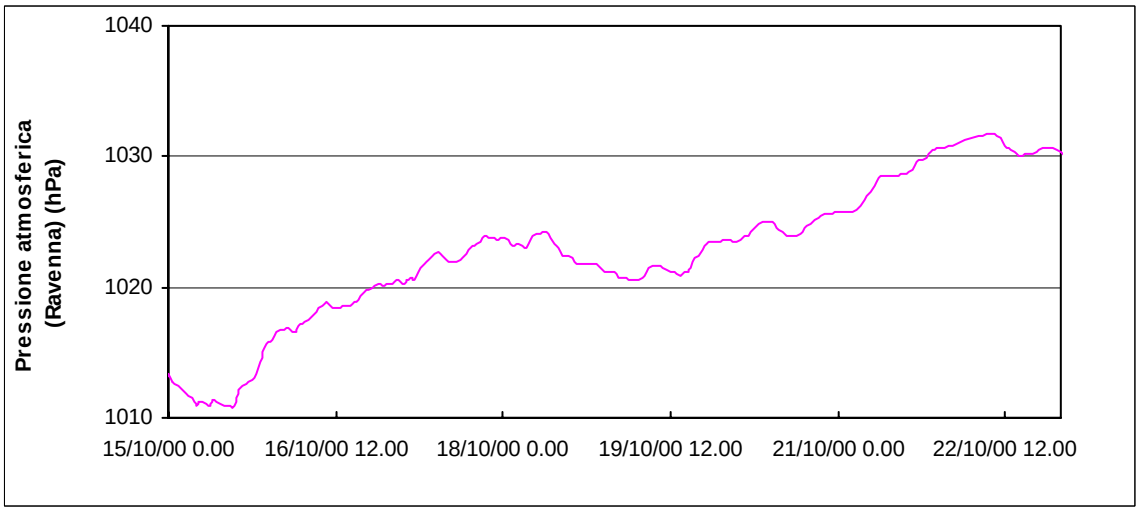


FLOOD - Autumn 2000

MARINE CONDITIONS

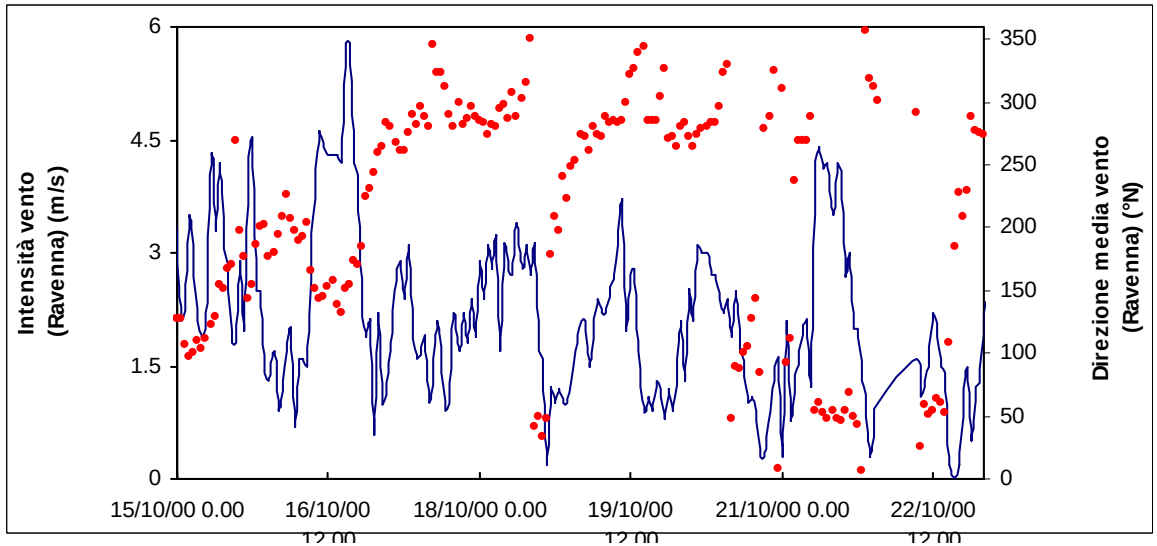


Water levels at the river mouth, Porto Tolle, and sea levels observed at Chioggia and Ravenna tidal stations



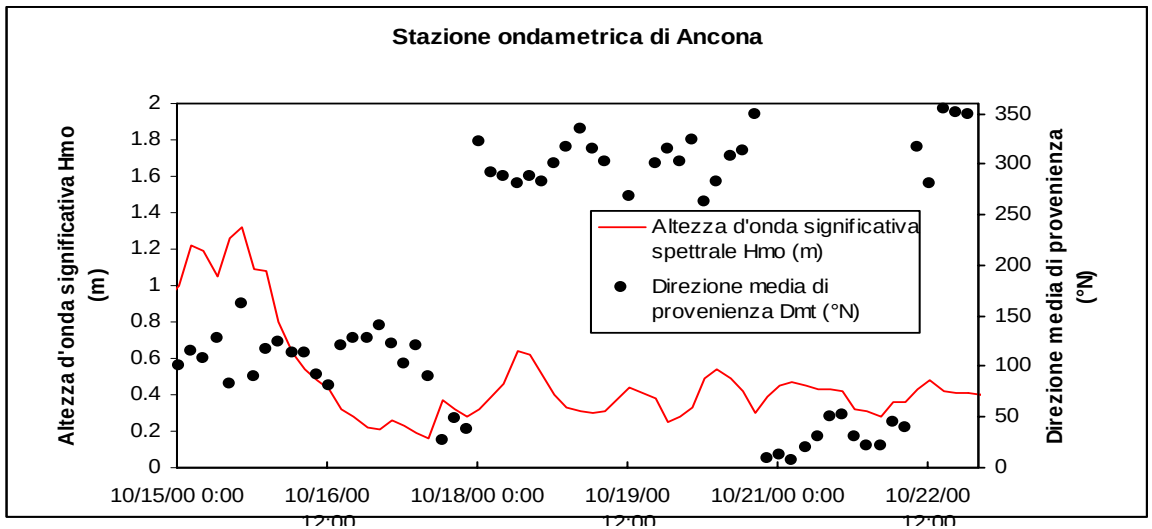
The sea level in the area shows a decreasing behaviour in time while air pressure is increasing

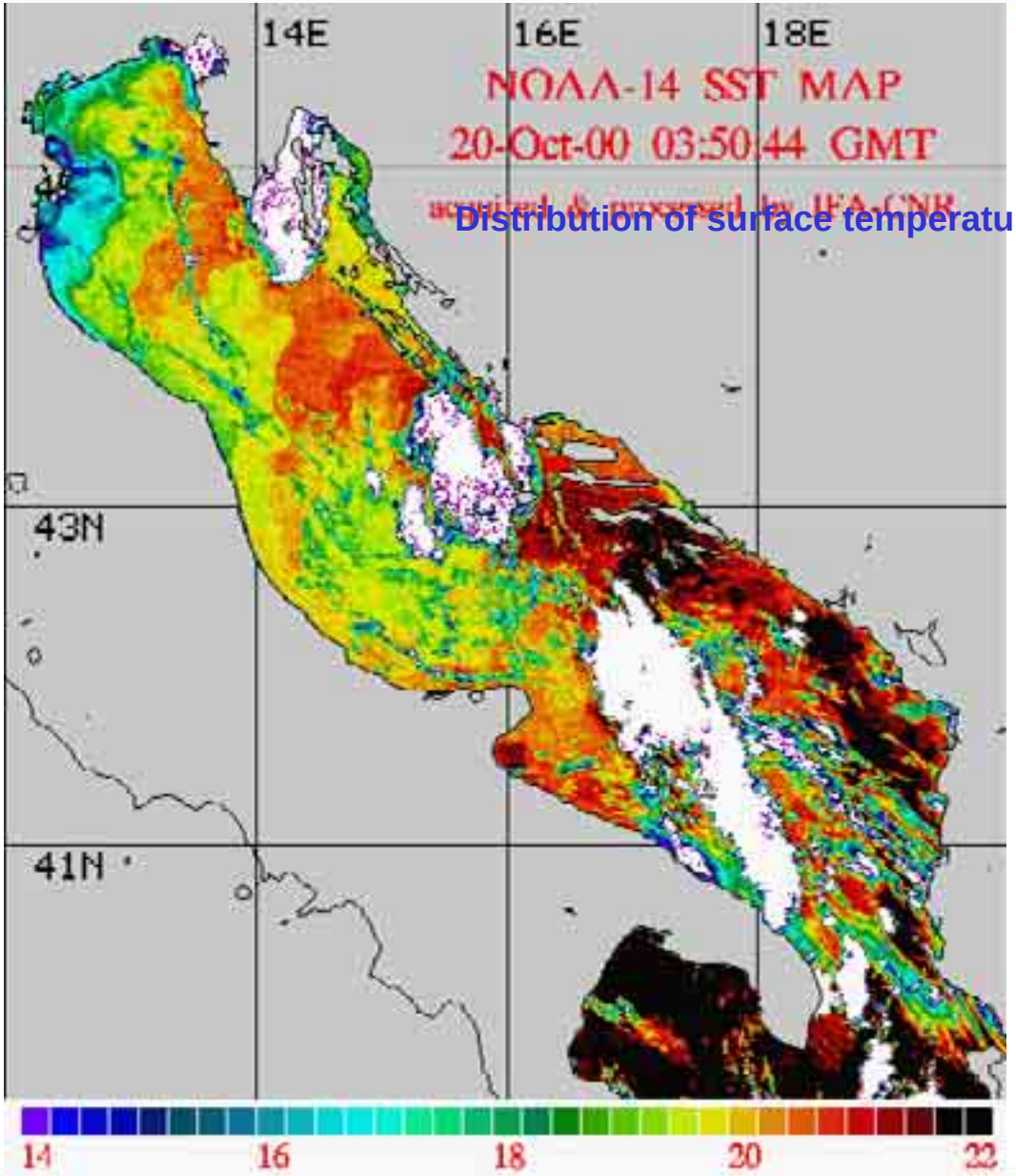
The main incoming direction of wind rotates towards north, with consequent further reduction of wind set up



Time series of waves measured at Ancona buoy of National Wave Measuring Network

The storm waves, coming from south-east until midnigth 17/10, stops completely rotating towards north-west





Distribution of surface temperature

The blue zone, at lower temperature, is affected by the flooding flux, propagating mainly towards south pushed by wind action and following the general circulation of Adriatic

FLOOD - Autumn 2000

THE AFFECTED MUNICIPALITIES

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