Barcelona, 15 November 2016

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Predictability of water resources at seasonal time-scales: the Boadella reservoir case (North-Eastern Spain)

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Marcos, R. et al., 2016. Seasonal predictability of water resources in a Mediterranean freshwater reservoir and assessment of its utility for end-users. Science of The Total Environment.

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GAMA Meteorological Hazards Analysis

observatori de l'Ebre

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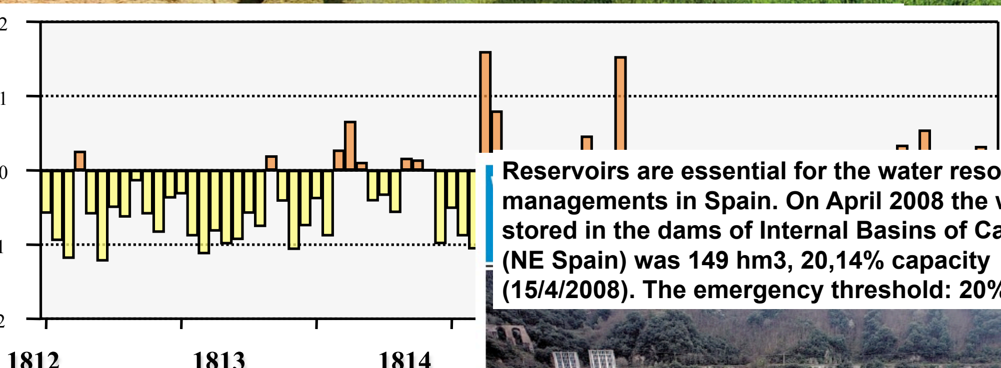
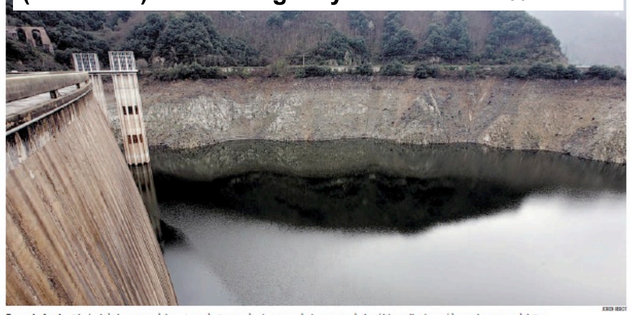
- Water scarcity is a recurrent problem in the Mediterranean

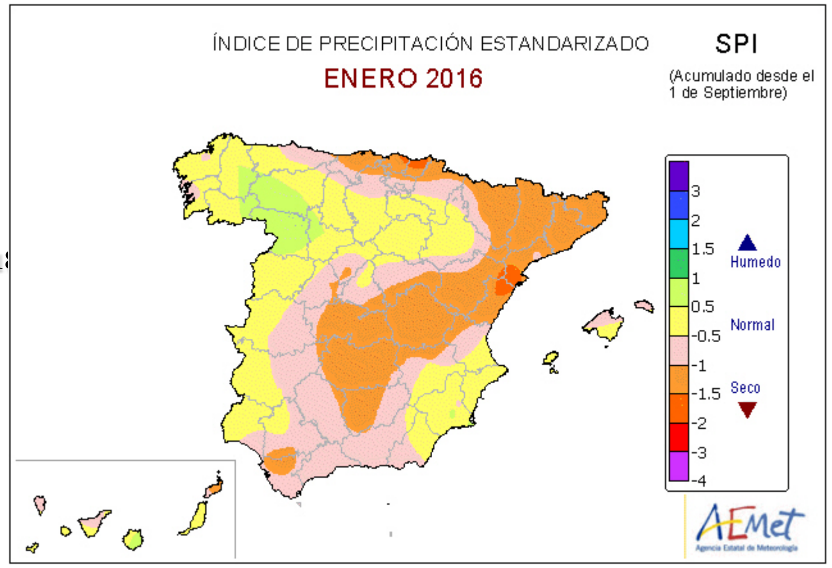


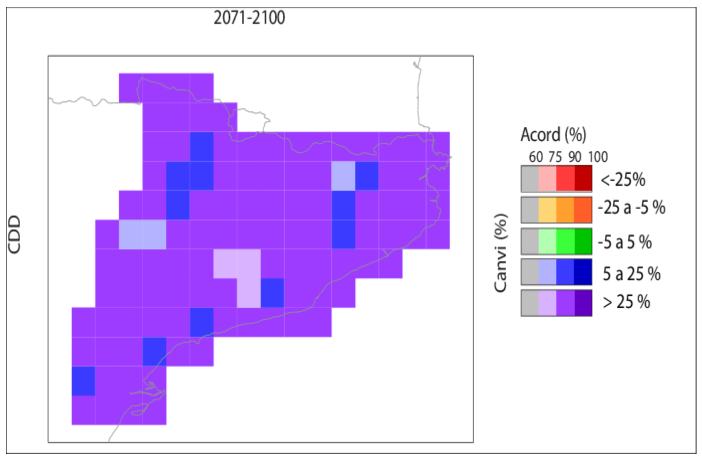
Reservoirs are essential for the water resources managements in Spain. On April 2008 the water stored in the dams of Internal Basins of Catalonia (NE Spain) was 149 hm3, 20,14% capacity (15/4/2008). The emergency threshold: 20%



Emergencia nacional

El Govern califica en términos dramáticos la sequía y trata de buscar un pacto con CiU que ahuyente la guerra del agua





Mediterranean water scarcity

- Water scarcity is a recurrent problem in the Mediterranean

- Linked to the relationship among:

Water supplies ↔ Droughts ↔ Water demands

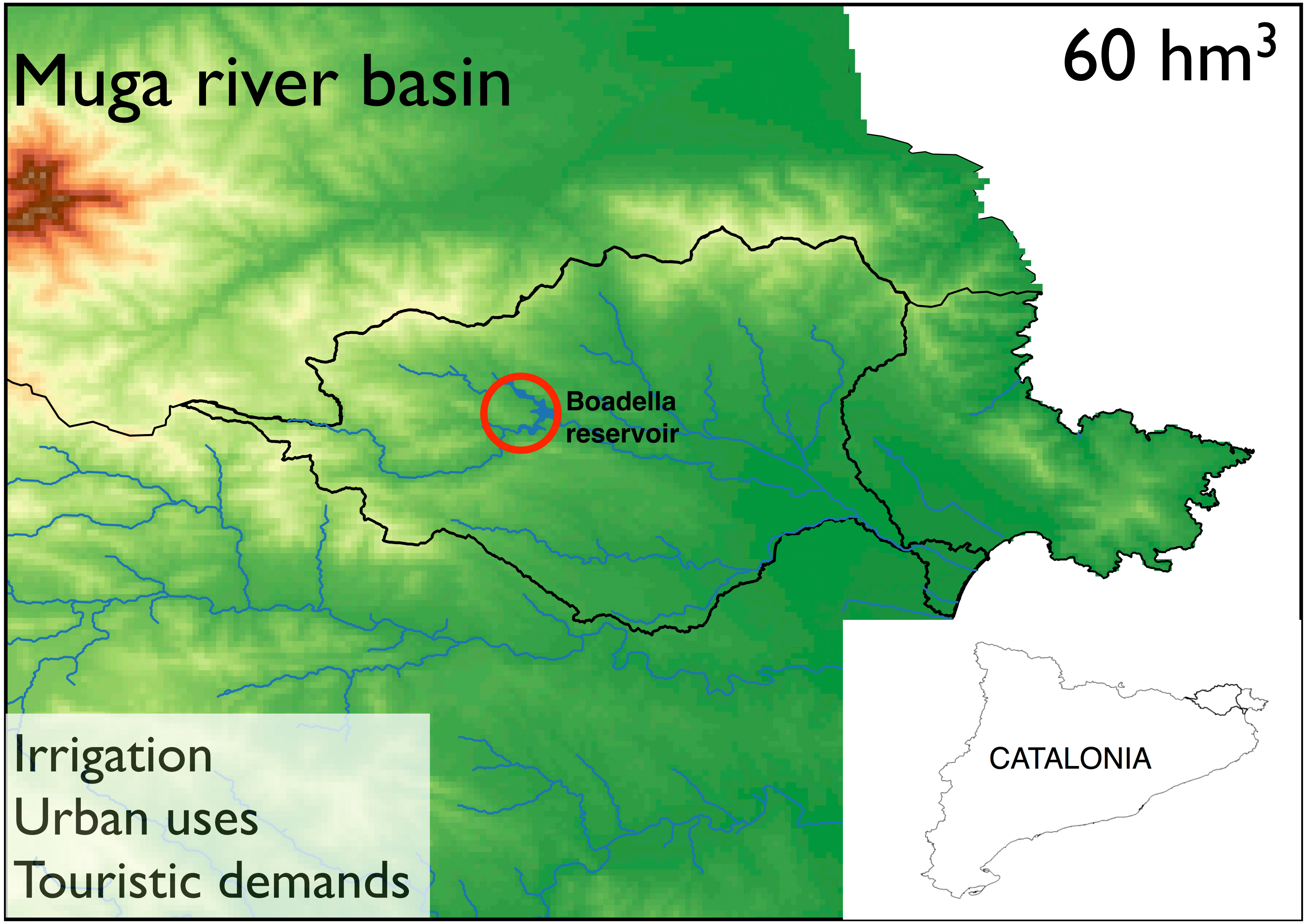
- Water scarcity is a recurrent problem in the Mediterranean

In this context foretelling the behaviour of dam **supplies** with months **in advance** can be used to optimize water management

- Linked to the relationship betv

Water supplies

Boadella reservoir



Case study description

MLR construction

Predictability

ECMWF System 4 data

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- Monthly **ECMWF System-4** precipitation and temperature **15-**member ensemble re-forecasts (0.75° x 0.75°) for the period **1981-2010**. Each initialization starts in the 1st day of each month encompassing a **7-month** time integration

Interpretation example

April S4 Forecasts

Issued 1st **Apr.**
Lead **1** (m-0)

Issued 1st **Mar.**
Lead **2** (m-1)

Issued 1st **Feb.**
Lead **3** (m-2)

Issued 1st **Jan.**
Lead **4** (m-3)

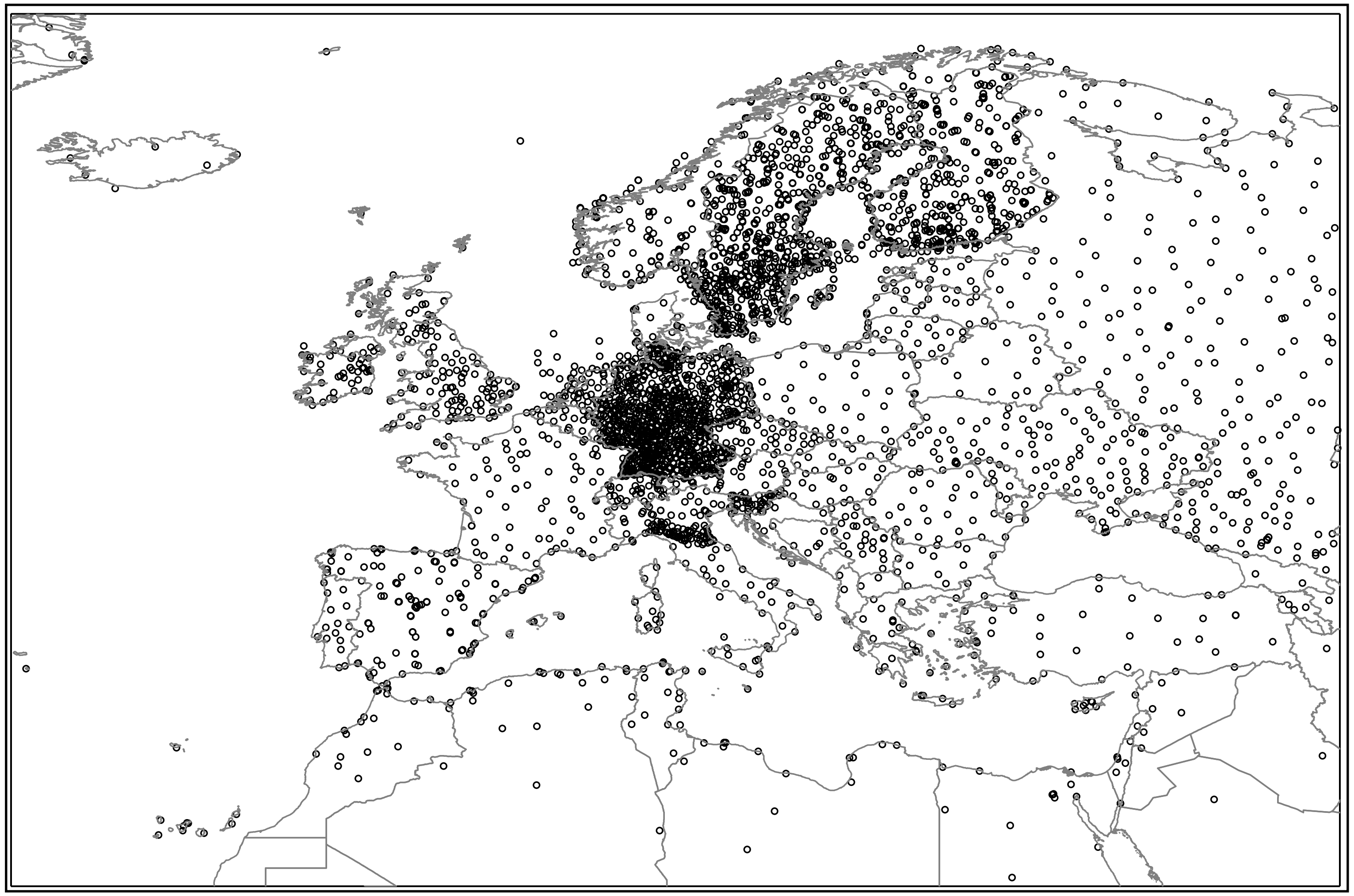
Issued 1st **Dec.**
Lead 5 (m-4)

Issued 1st **Nov.**
Lead **6** (m-5)

Issued 1st **Oct.**
Lead **7** (m-6)

E-OBS data

- **E-OBS** daily **precipitation** and **temperature** high-resolution (0.25° x 0.25°) gridded dataset over the period **1981-2010**



E-OBS v8.0 temperature station cover map for Europe.

Case study description | MLR construction | Predictability

Boadella data

- Monthly in-flow, out-flow and volume data **observed** at the **Boadella** reservoir for the period **1981-2010**

Boadella reservoir.

Multiple Linear Regression strategy

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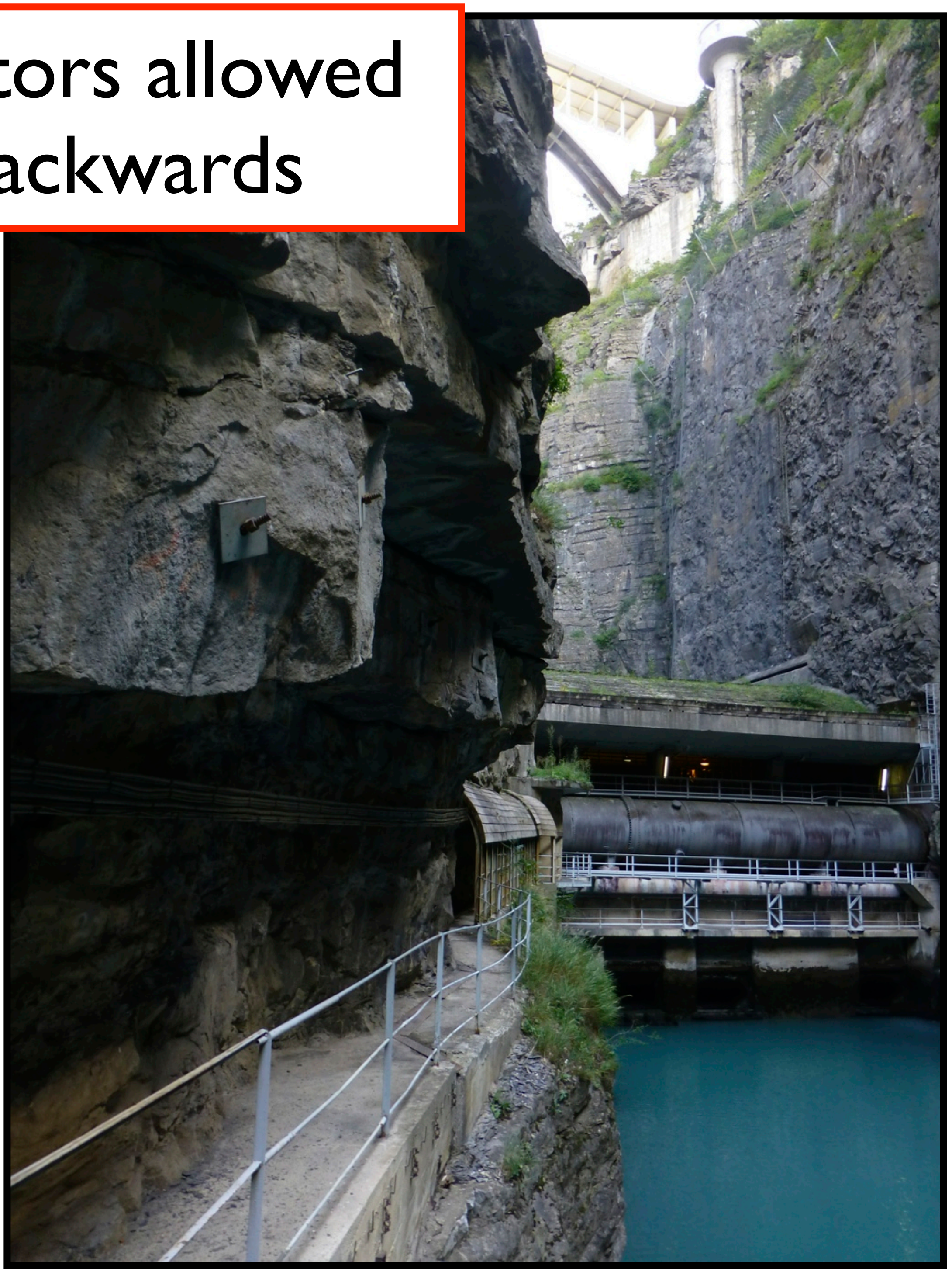
Predictors

Antecedent predictors allowed up-to **1 year** backwards

- **In-flow**
  - Precip - Tmax - Tmin
- **Volume**
  - In-flow - Tmax - Tmin
- **Out-flow**
  - Vol - Tmax - Tmin



Case study description | MLR construction | Predictability

MLR perfect prognosis

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In-flow

	Best Predictor Combination	R^2
Jan	$\{rr_{(12-12)}, rr_{(1-1)}, Tx_{(1-1)}, Tn_{(10-1)}\}$	0.81
Feb	$\{rr_{(12-12)}, rr_{(1-2)}, Tx_{(6-9)}, Tn_{(11-1)}\}$	0.77
Mar	$\{rr_{(5-8)}, rr_{(1-2)}, Tx_{(7-7)}\}$	0.41
Apr	$\{rr_{(4-4)}, rr_{(12-3)}, Tx_{(6-6)}, Tn_{(5-7)}, Tn_{(8-10)}\}$	0.66
May	$\{rr_{(4-5)}, rr_{(7-7)}, rr_{(10-10)}\}$	0.73
Jun	$\{rr_{(6-6)}, Tn_{(9-9)}, Tn_{(11-11)}\}$	0.63
Jul	$\{rr_{(6-7)}, Tx_{(10-1)}, Tn_{(11-12)}\}$	0.79
Aug	$\{rr_{(7-8)}, Tx_{(1-7)}, Tn_{(10-1)}\}$	0.51
Sep	$\{rr_{(6-9)}, Tx_{(3-3)}, Tn_{(8-8)}\}$	0.31
Oct	$\{rr_{(9-10)}, Tx_{(11-3)}, Tn_{(1-2)}\}$	0.76
Nov	$\{rr_{(11-11)}, rr_{(7-7)}, Tn_{(4-5)}\}$	0.57
Dec	$\{rr_{(10-12)}, Tn_{(5-7)}, Tn_{(8-9)}\}$	0.55

Case study description

MLR construction

Predictability

MLR perfect prognosis

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Volume

	Best Predictor Combination	R^2
Jan	$\{flwin_{(5-1)}, Tx_{(9-9)}, Tn_{(11-11)}, Tn_{(2-4)}\}$	0.76
Feb	$\{flwin_{(5-2)}, Tx_{(10-10)}, Tn_{(10-11)}\}$	0.69
Mar	$\{flwin_{(5-12)}, flwin_{(2-3)}, Tn_{(9-9)}, Tx_{(6-7)}\}$	0.68
Apr	$\{flwin_{(2-4)}, flwin_{(5-12)}, Tx_{(1-1)}, Tx_{(6-9)}, Tn_{(8-9)}\}$	0.66
May	$\{flwin_{(3-4)}, flwin_{(6-12)}, Tn_{(8-9)}, Tx_{(1-1)}\}$	0.60
Jun	$\{flwin_{(3-4)}, flwin_{(11-12)}, Tn_{(9-9)}, Tx_{(12-1)}, Tx_{(9-9)}\}$	0.66
Jul	$\{flwin_{(3-6)}, flwin_{(7-7)}, Tn_{(6-7)}, Tn_{(9-9)}, Tx_{(9-9)}, Tx_{(7-7)}\}$	0.67
Aug	$\{flwin_{(3-5)}, flwin_{(6-8)}, Tn_{(6-7)}, Tx_{(1-1)}, Tx_{(9-9)}\}$	0.79
Sep	$\{flwin_{(3-6)}, flwin_{(7-8)}, Tn_{(6-7)}, Tx_{(7-8)}, Tx_{(9-9)}\}$	0.76
Oct	$\{flwin_{(3-4)}, flwin_{(6-10)}, Tx_{(1-1)}, Tx_{(10-10)}, Tx_{(9-9)}\}$	0.82
Nov	$\{flwin_{(4-4)}, flwin_{(7-10)}, Tn_{(12-4)}, Tx_{(2-2)}\}$	0.84
Dec	$\{flwin_{(5-12)}, Tn_{(6-7)}, Tx_{(2-2)}, Tx_{(9-9)}\}$	0.83

Case study description | **MLR construction** | Predictability

MLR perfect prognosis

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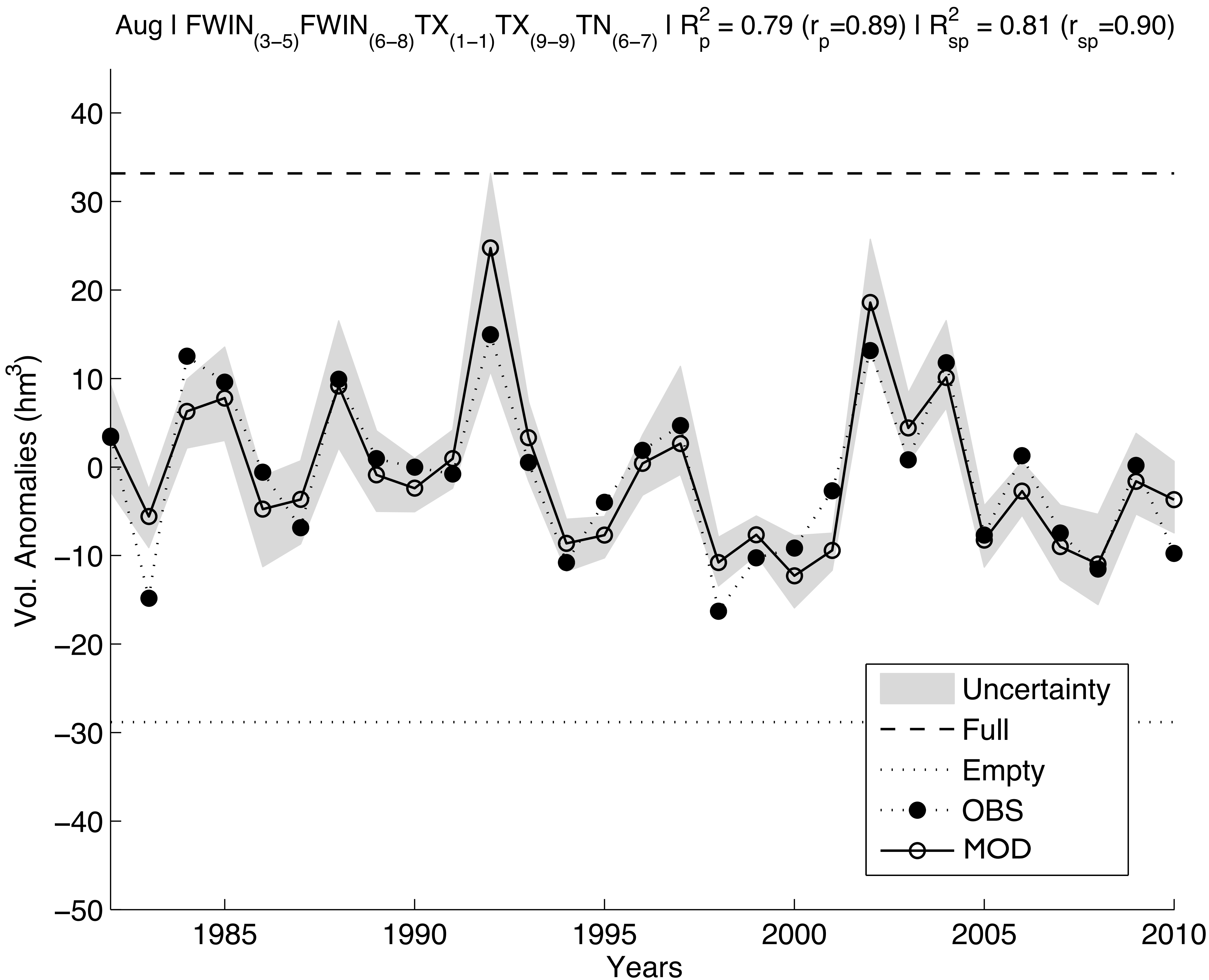
Out-flow

	Best Predictor Combination	R^2
Jan	$\{rr_{(10-1)}, Tx_{(11-1)}\}$	0.60
Feb	$\{rr_{(1-2)}, Tx_{(7-9)}, Tn_{(1-1)}\}$	0.86
Mar	$\{rr_{(7-8)}, vl_{(12-2)}\}$	0.42
Apr	$\{rr_{(10-2)}\}$	0.32
May	$\{rr_{(4-5)}, vl_{(10-4)}\}$	0.55
Jun	$\{vl_{(3-4)}\}$	0.33
Jul	$\{Tx_{(4-4)}, Tn_{(10-11)}, vl_{(3-5)}\}$	0.75
Aug	$\{vl_{(3-5)}, vl_{(6-6)}, vl_{(7-7)}\}$	0.90
Sep	$\{Tx_{(5-6)}, vl_{(7-7)}, vl_{(8-8)}\}$	0.85
Oct	$\{rr_{(1-4)}, rr_{(6-6)}, Tn_{(7-7)}\}$	0.51
Nov	$\{rr_{(1-6)}, Tn_{(4-5)}\}$	0.18
Dec	$\{rr_{(10-12)}, Tx_{(9-11)}, Tn_{(10-12)}\}$	0.18

Case study description | MLR construction | Predictability

MLR perfect prognosis



Forecasting strategies

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- Climatology → Current **operational** approach
- Persistence
- Antecedent + Climatology (MLR)
- Antecedent + BC S4 (MLR)
- Antecedent + MOS-analog S4 (MLR)
- Antecedent + LR S4 (MLR)

Case study description | MLR construction | Predictability

Economic Value

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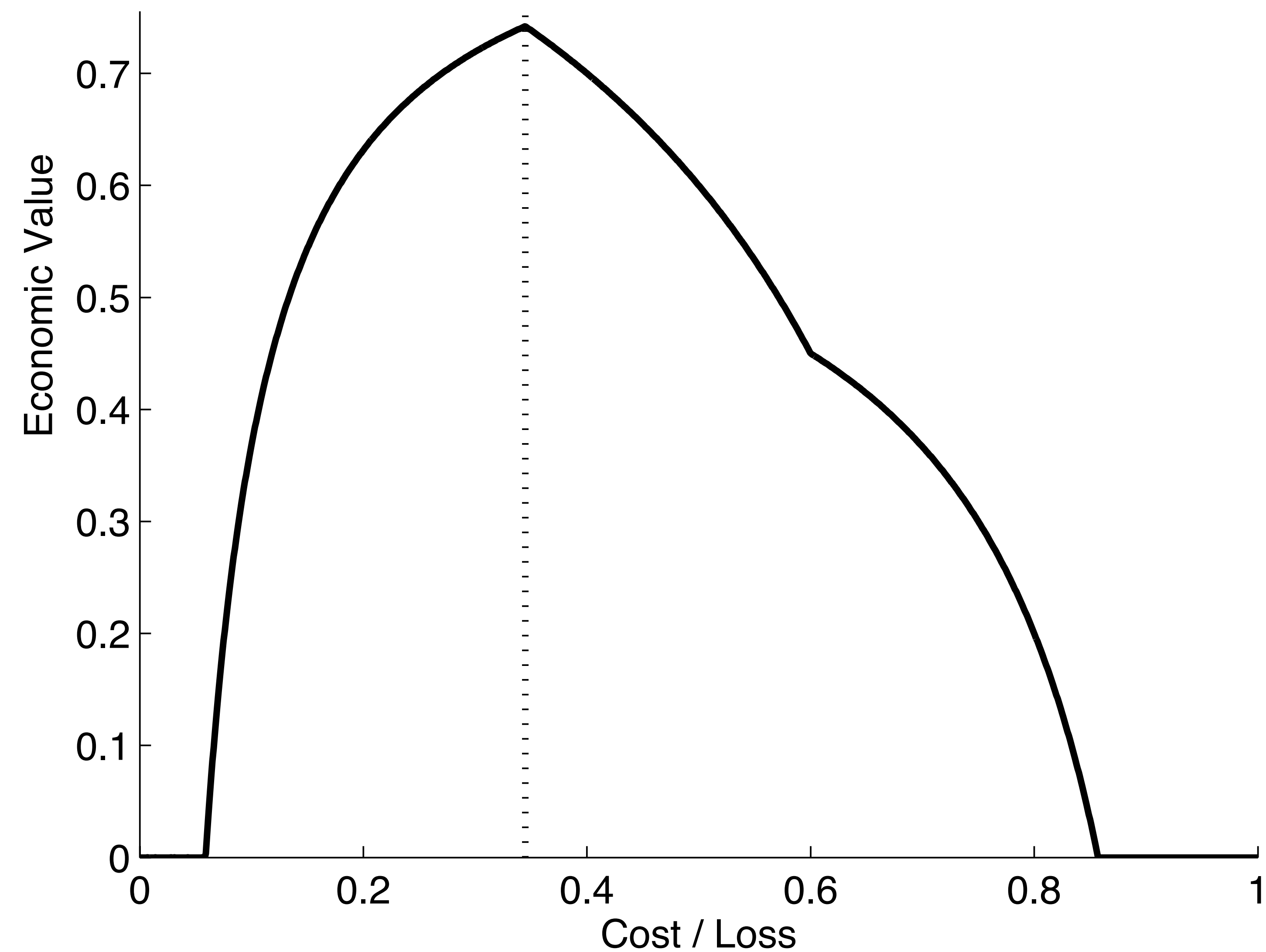
Preventive Action	Ocurrence: Yes	Ocurrence: No
Yes	αC	βC
No	γL	0

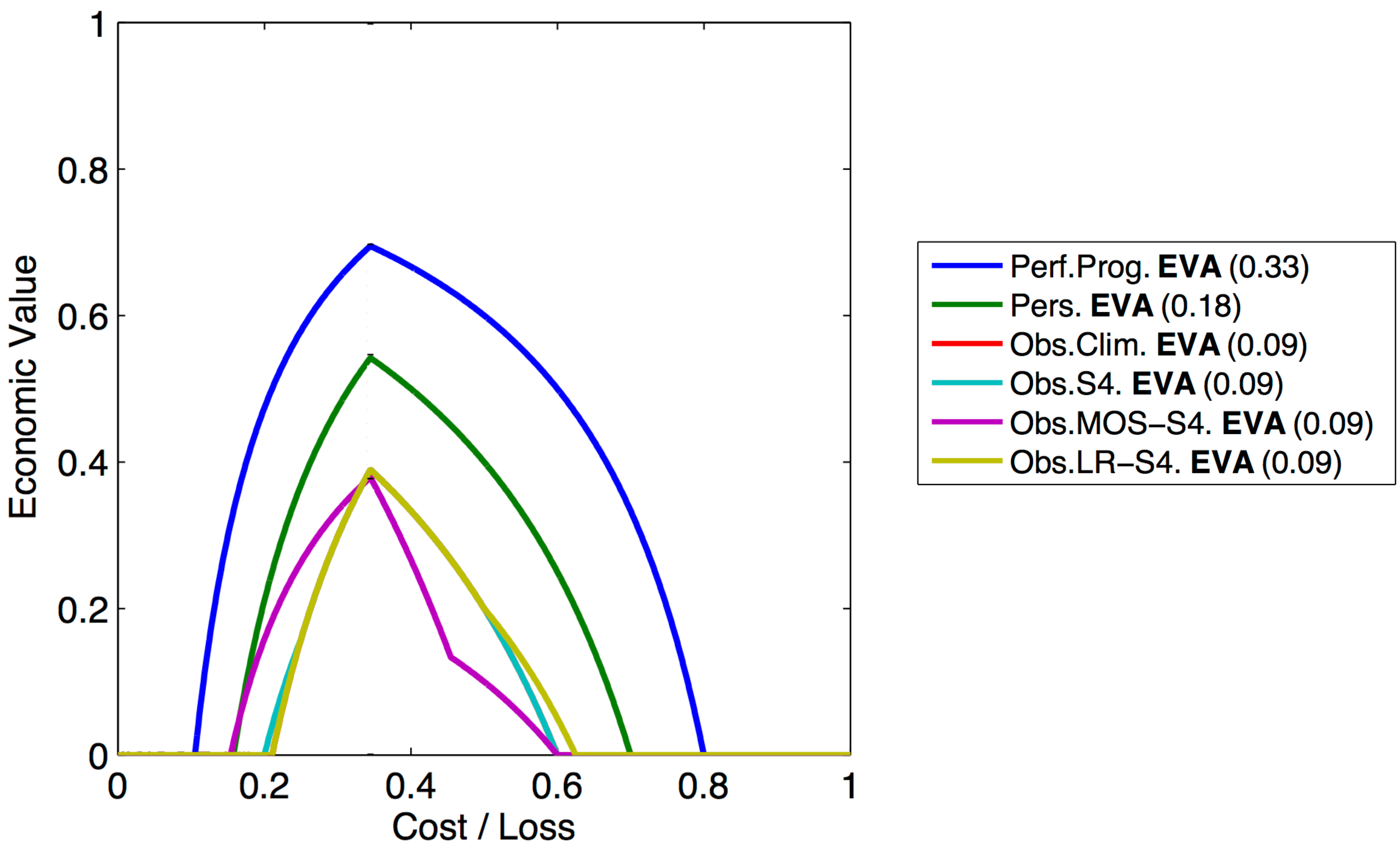
$$EV = \frac{TE - TE_{\text{clim}}}{TE_{perf} - TE_{\text{clim}}}$$

$$R = C/L$$

$$EV = \frac{H\ p_c\ R + F\,(1 - p_c)\,R + (1 - H)p_c - \min\{R, p_c\}}{p_c R - \min\{R, p_c\}}$$

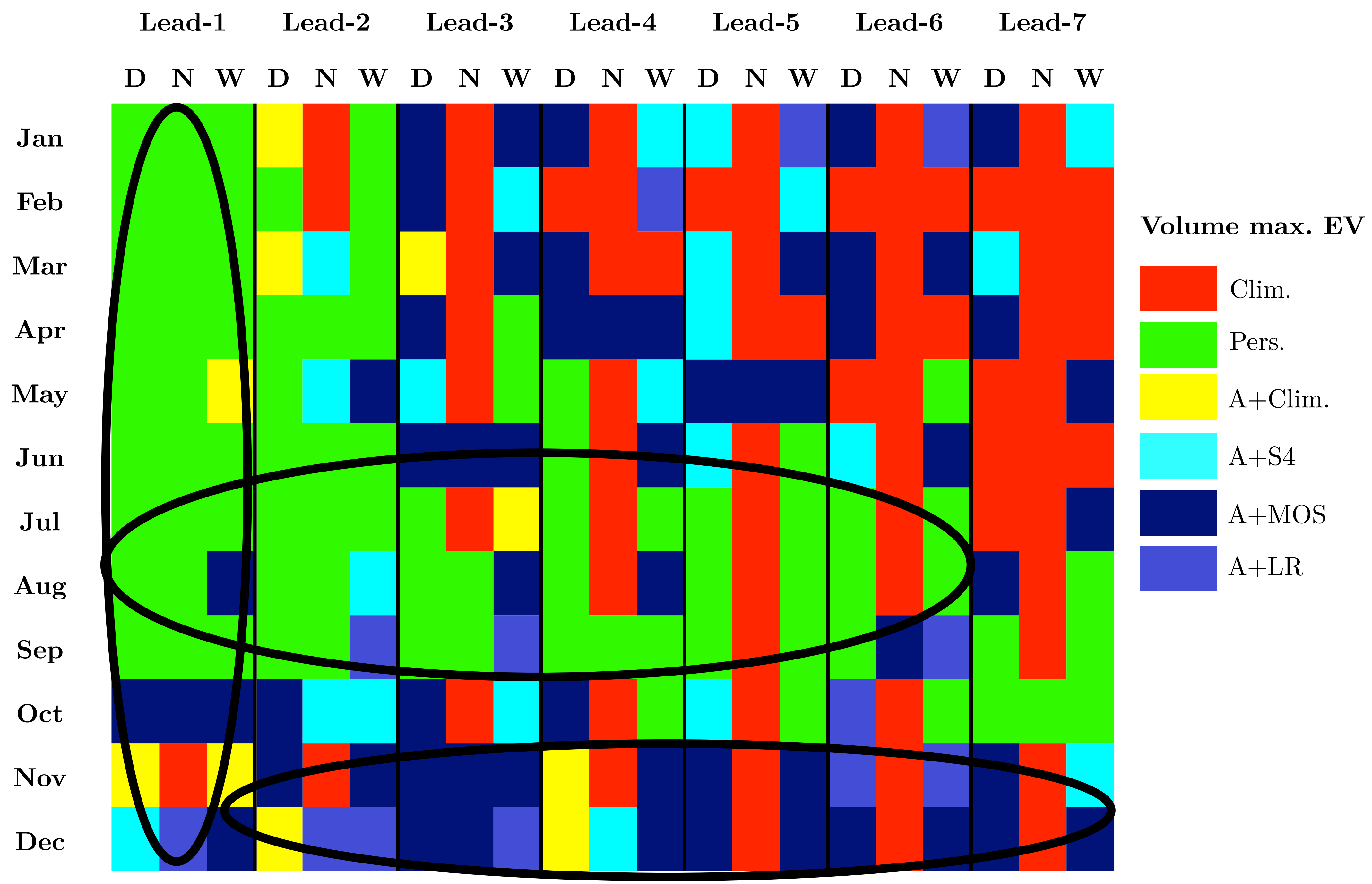


Economic Value (July - Lead 5 - Humid conditions)



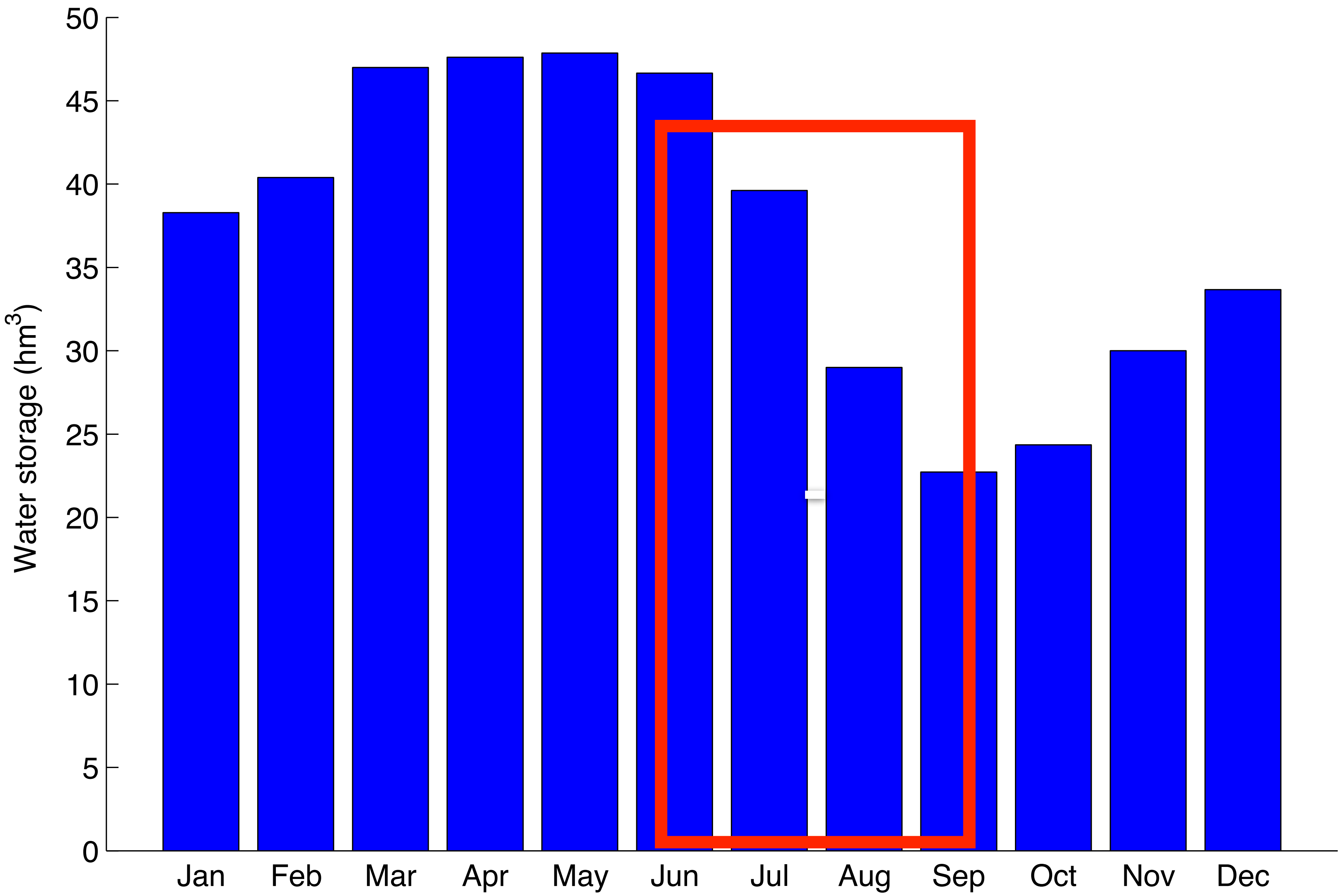
Case study description | MLR construction | **Predictability**

EV - 12 month - 7 lead



Case study description | MLR construction | Predictability

Climatology: volume + demands



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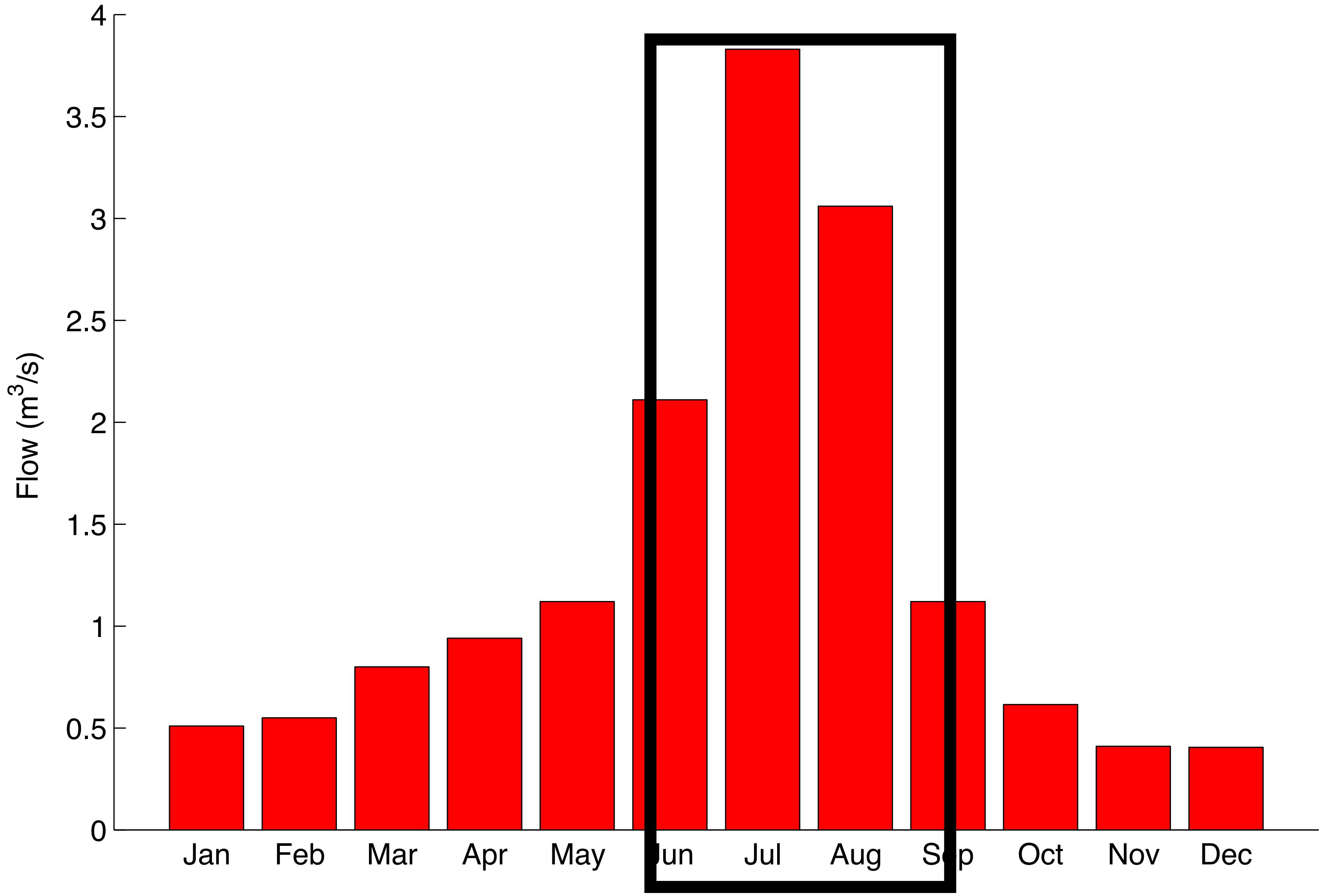
Climatology: volume + demands



Case study description | MLR construction | Predictability

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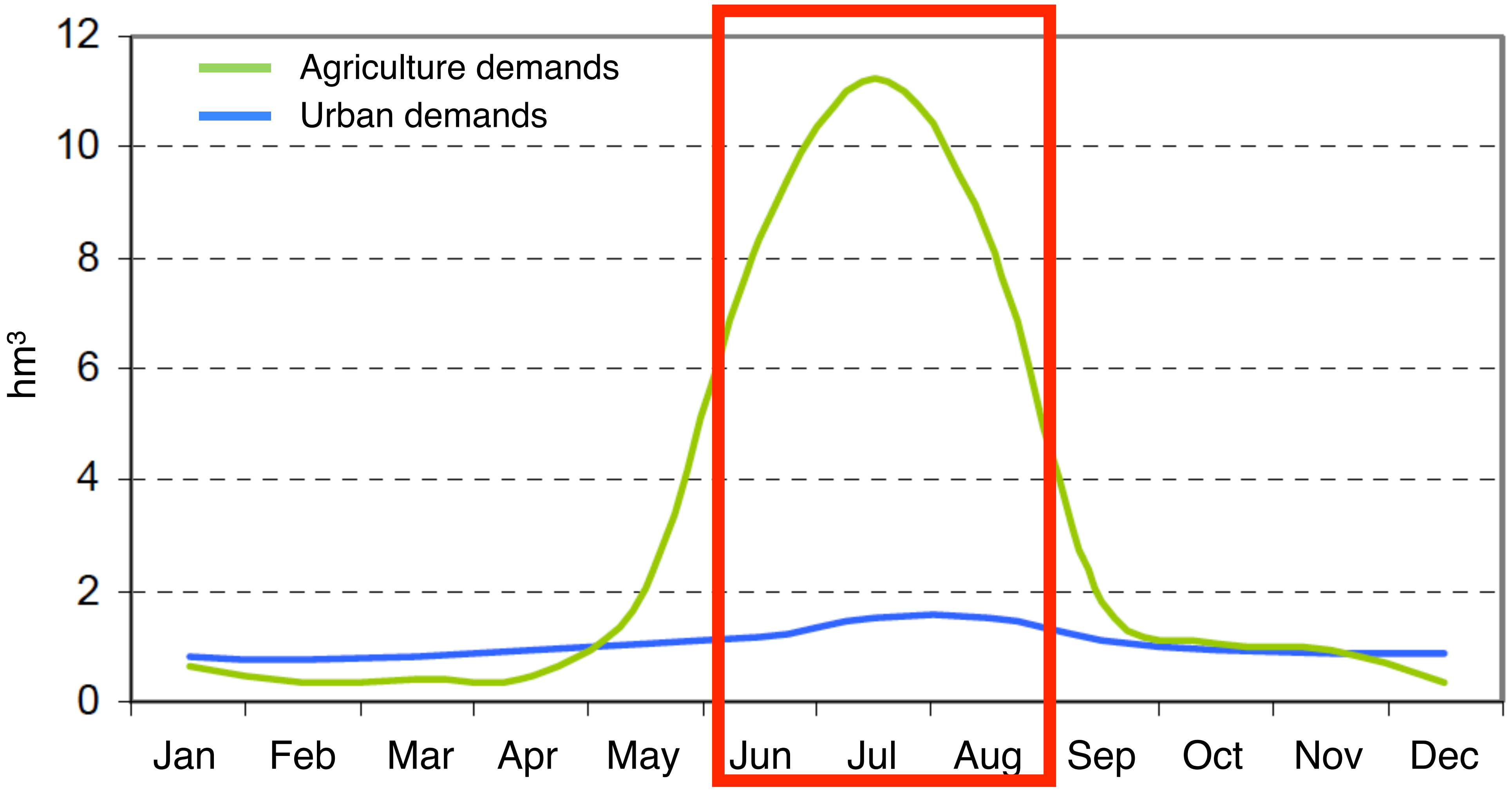
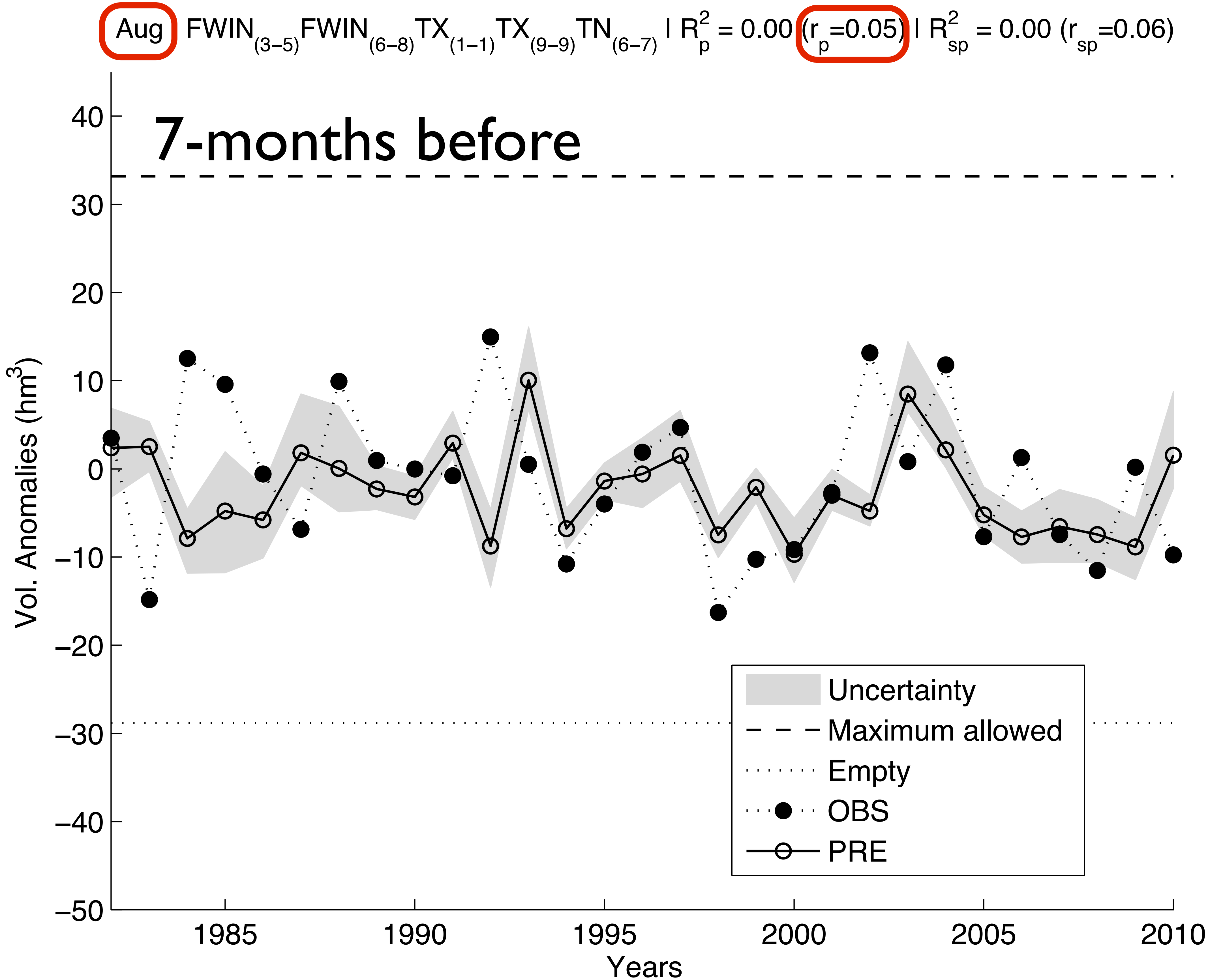
Climatology: volume + demands

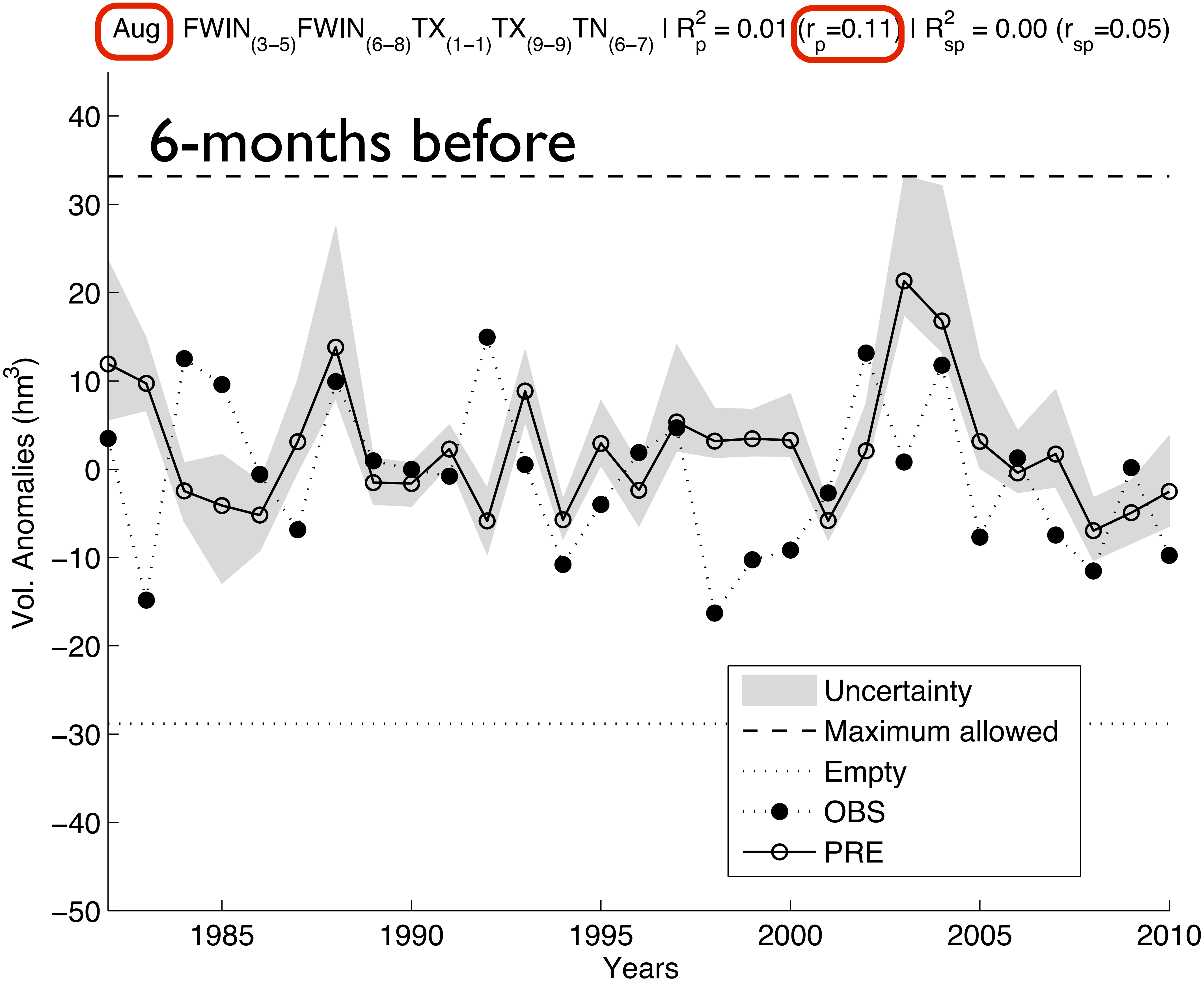


Case study description | MLR construction | Predictability

Seasonal forecast (volume)



Seasonal forecast (volume)



Seasonal forecast (volume)

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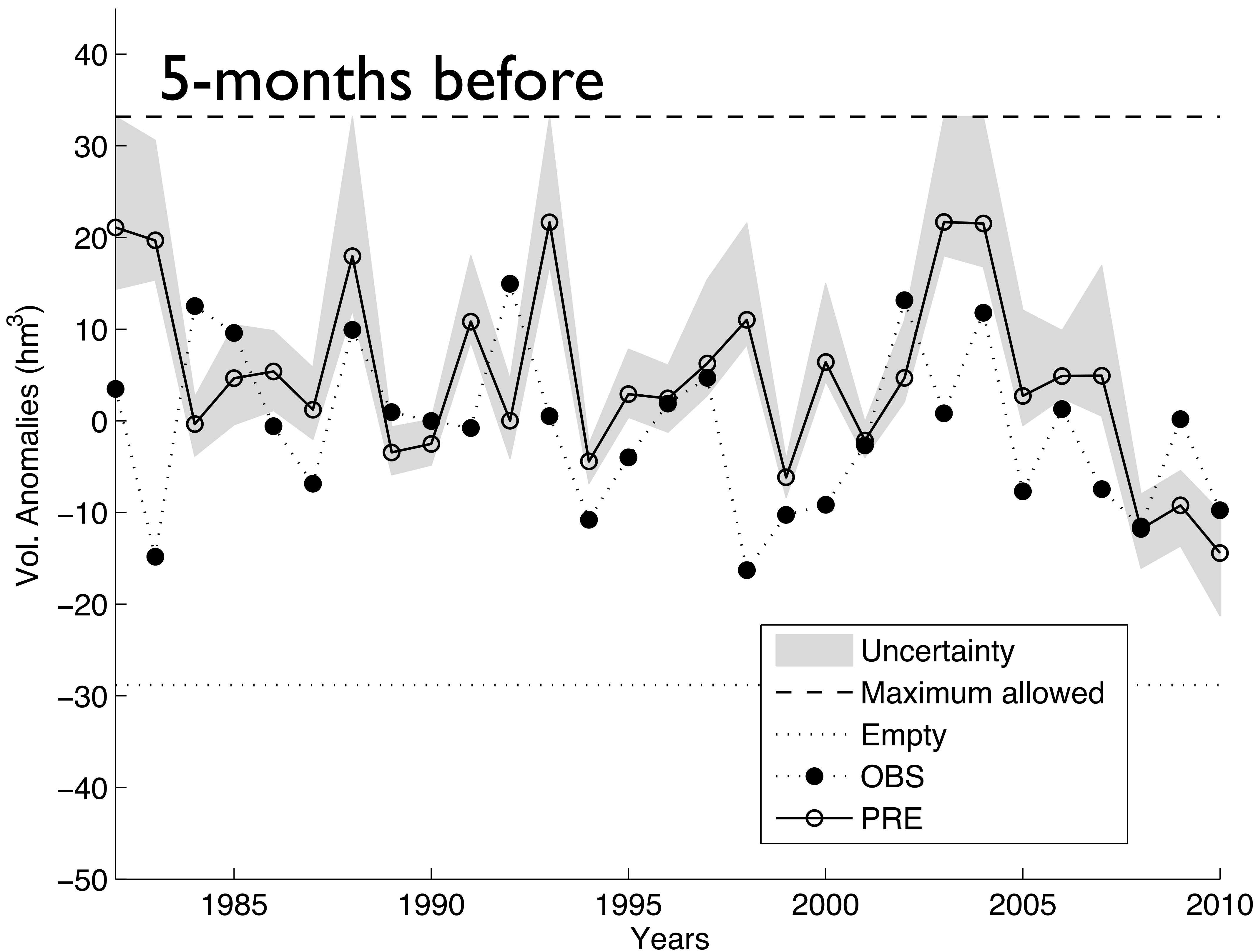
Aug FWIN$_{(3-5)}$FWIN$_{(6-8)}$TX$_{(1-1)}$TX$_{(9-9)}$TN$_{(6-7)}$ I R_p^2 = 0.05 (r_p=0.23) I R_{sp}^2 = 0.05 (r_{sp}=0.23)



Seasonal forecast (volume)

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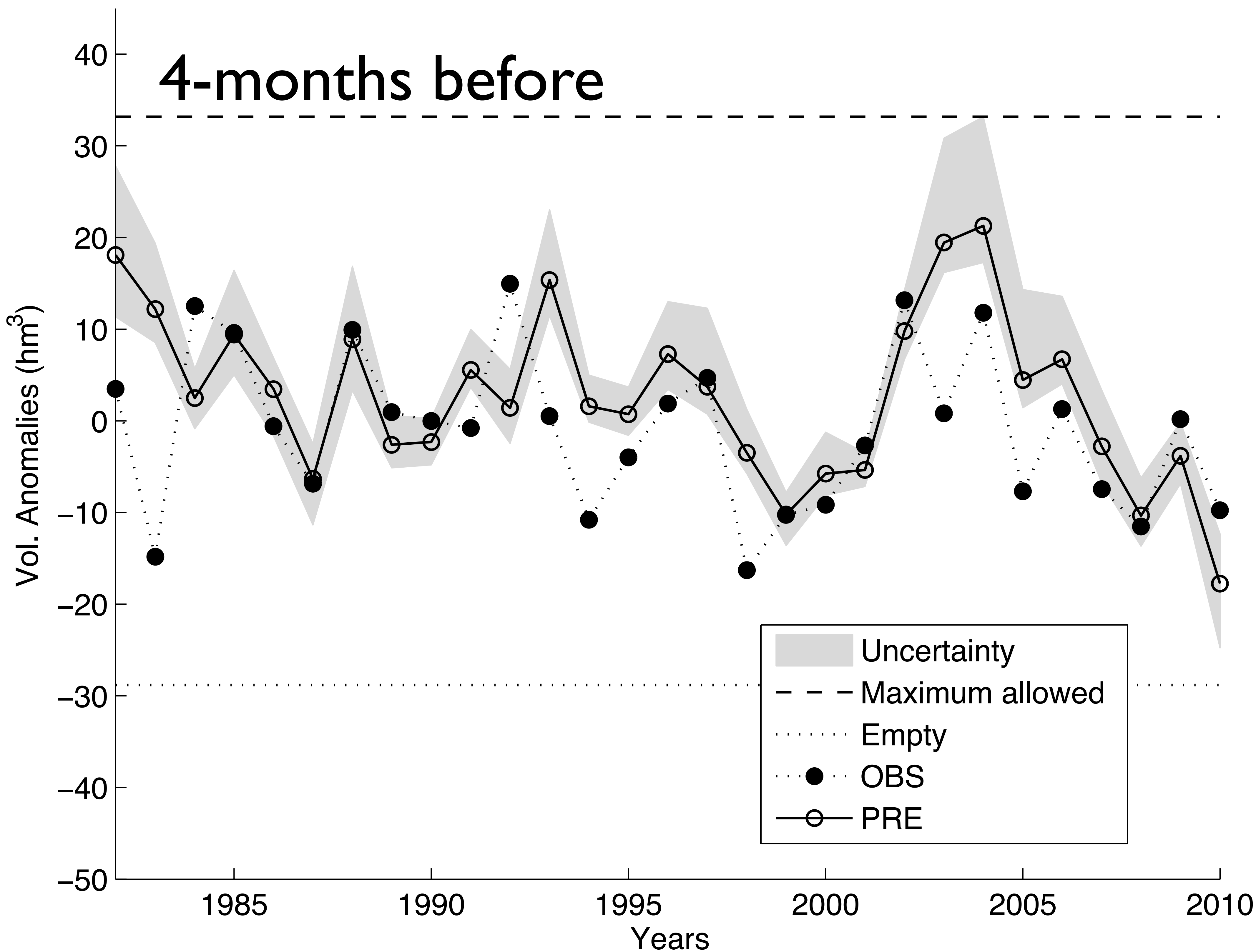
Aug $FWIN_{(3-5)} FWIN_{(6-8)} TX_{(1-1)} TX_{(9-9)} TN_{(6-7)}$ | $R^2_p = 0.26$ (r_p =0.51) | $R^2_{sp} = 0.32$ (r_{sp} =0.56)



Seasonal forecast (volume)

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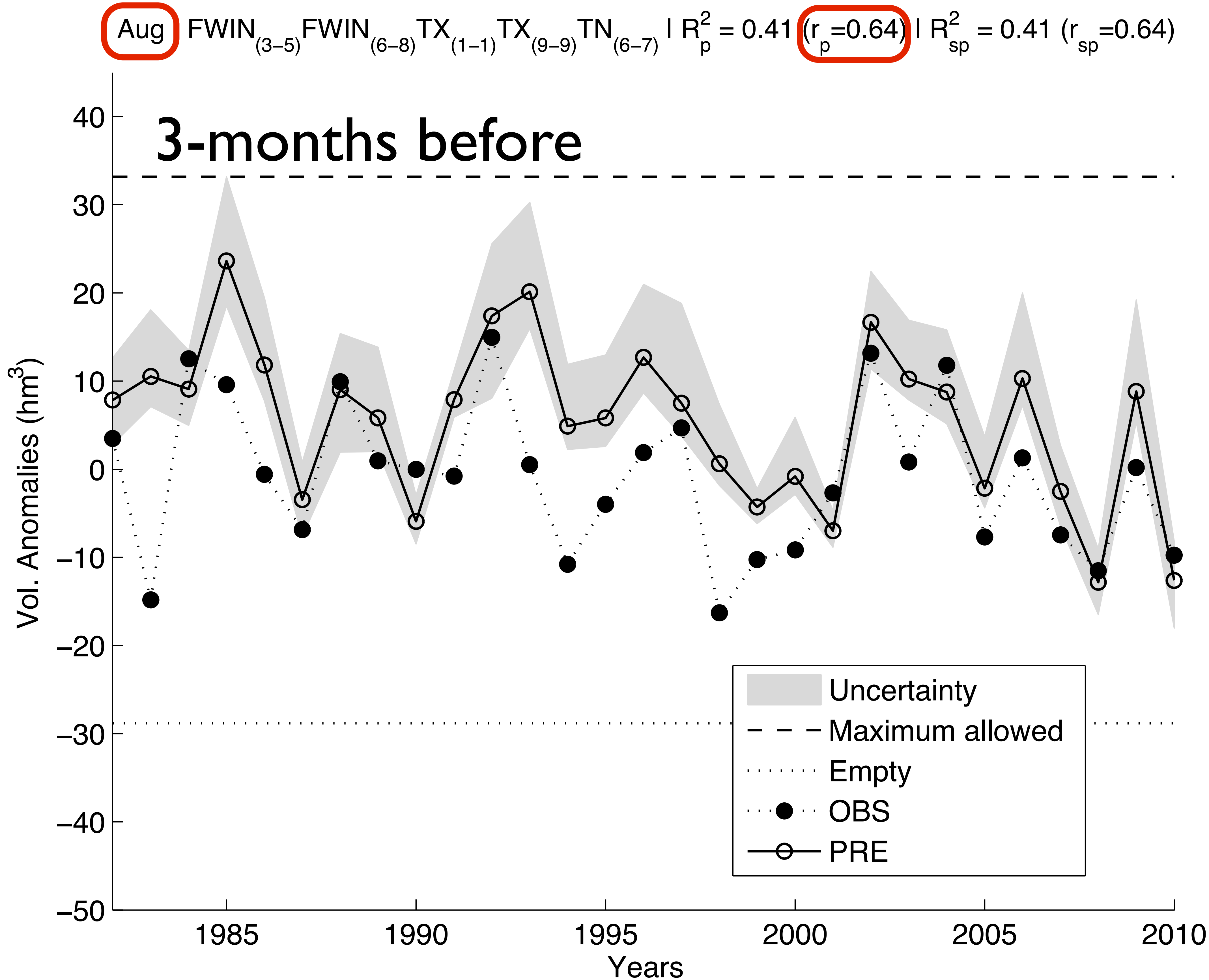
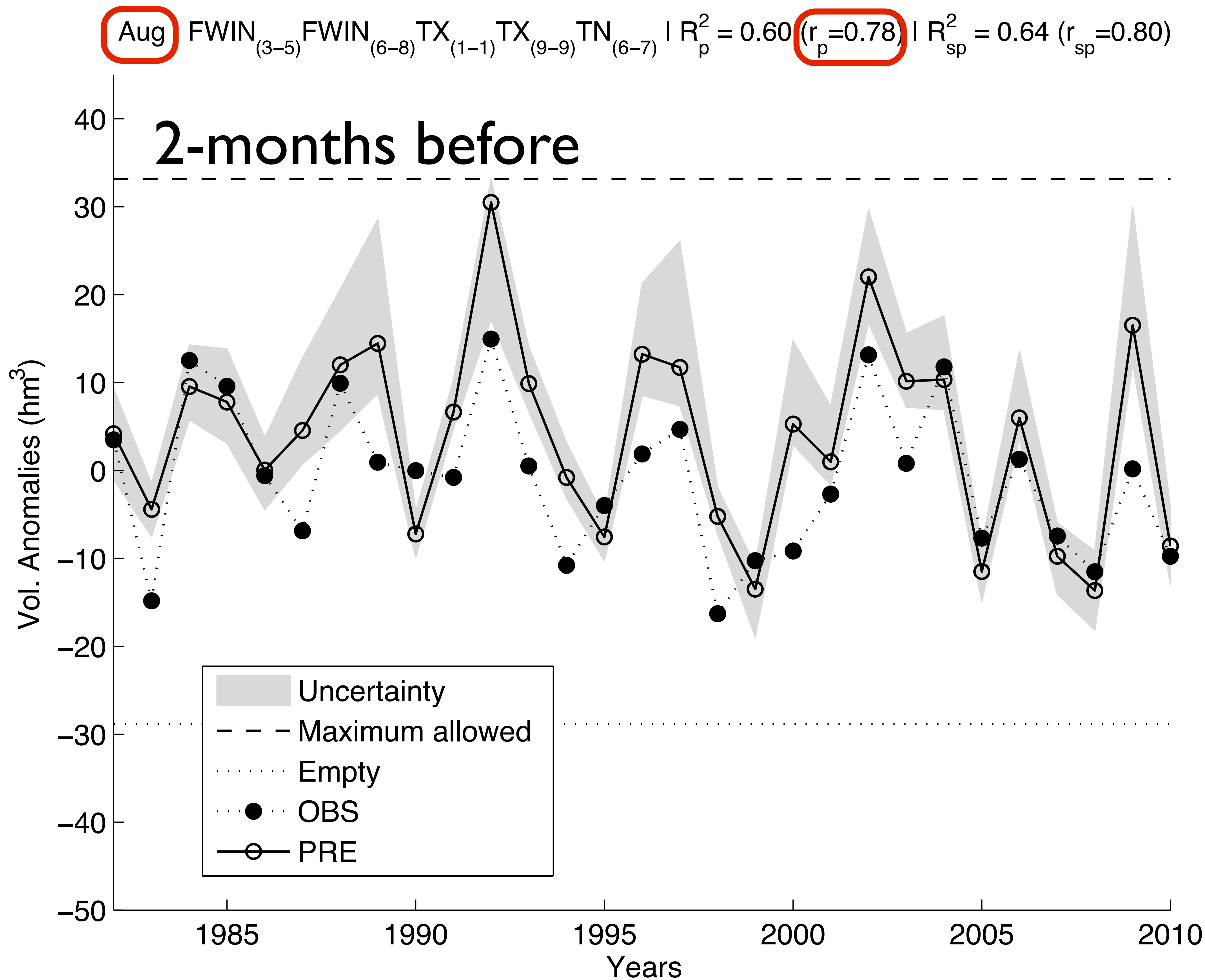


Seasonal forecast (volume)



Seasonal forecast (volume)

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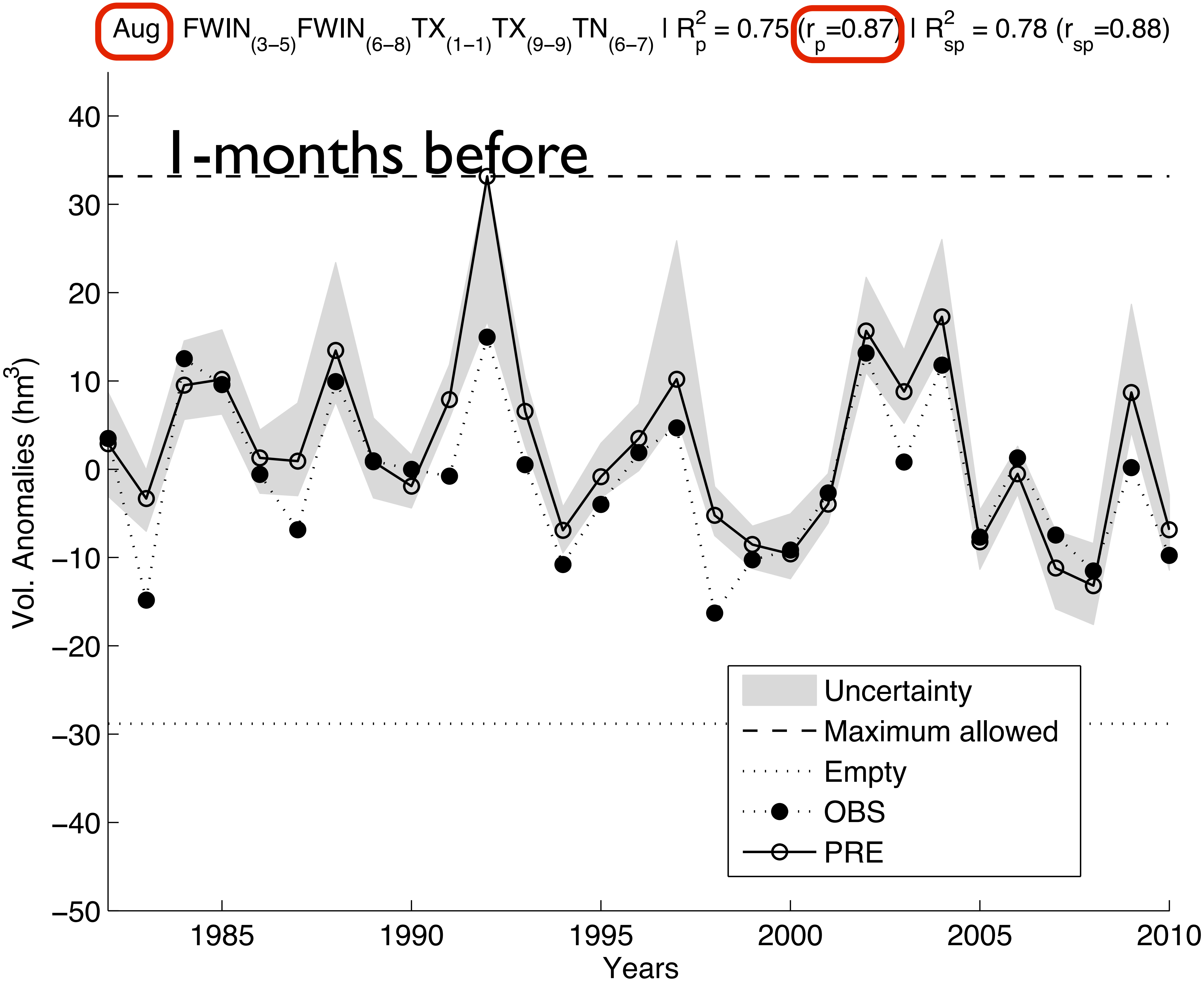

Synthesis

✦ In-flow

- Predictability beyond climatology generally restricted to **lead one**

✦ Volume

- Predictability beyond climatology up to **lead four** in all months but February
- Positive Economic Value up to **lead seven** from August to January

✦ Out-flow

- Predictability beyond climatology at **lead one** for almost all months
- From August to October enhanced predictabilities up to **lead seven**

Take home messages

a) Generally, all the three variables can be **successfully** modelled with **MLR** in perfect prognosis conditions. **Volume** is the best modelled variable, followed by **in-flow** and **out-flow.**

b) **Summer** seasonal forecasts with skill beyond climatology can be issued from a minimum of **four months** in advance for volume and out-flow variables.

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Thank you for your attention!

For further information please contact
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