Tributary volumetric flux estimates II: Incorporation of seasonality

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These slides were presented at the Wood River Valley Modeling Technical Advisory Committee meeting Thursday, 05Jan2014, 10am-3pm at the Community Campus, Rm 200, in Hailey. Taken outside the context of the original presentation, these slides may not provide a complete or accurate representation of the speaker's intent.

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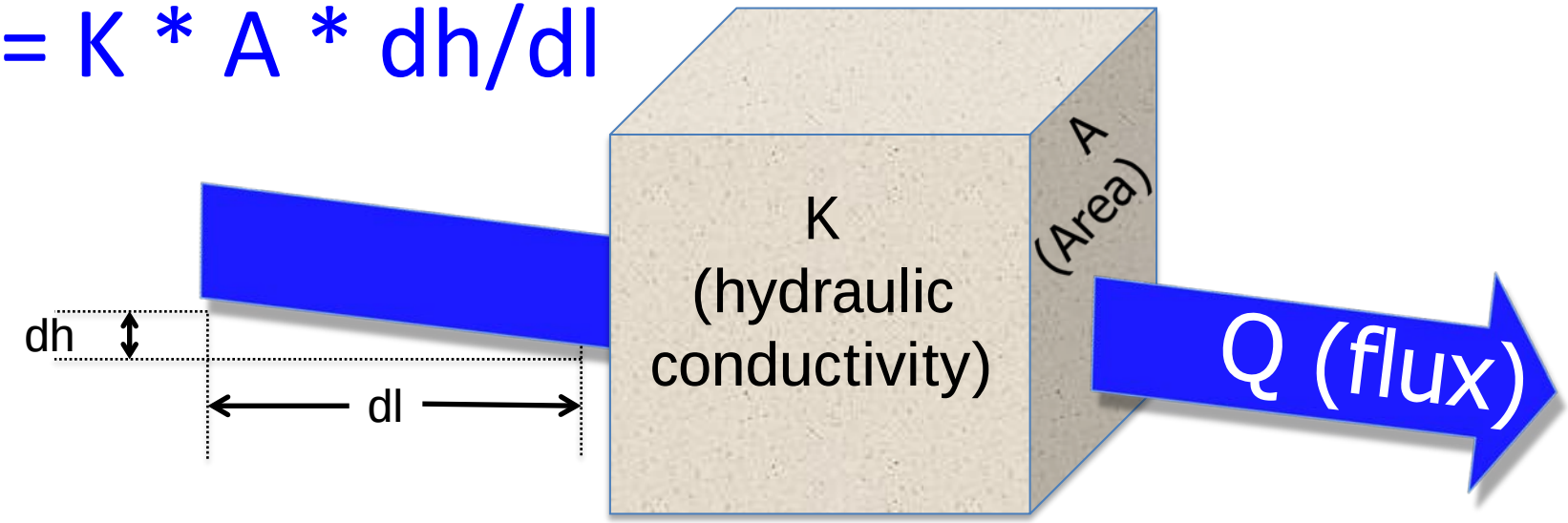
Problem: Representation of subsurface tributary inflow

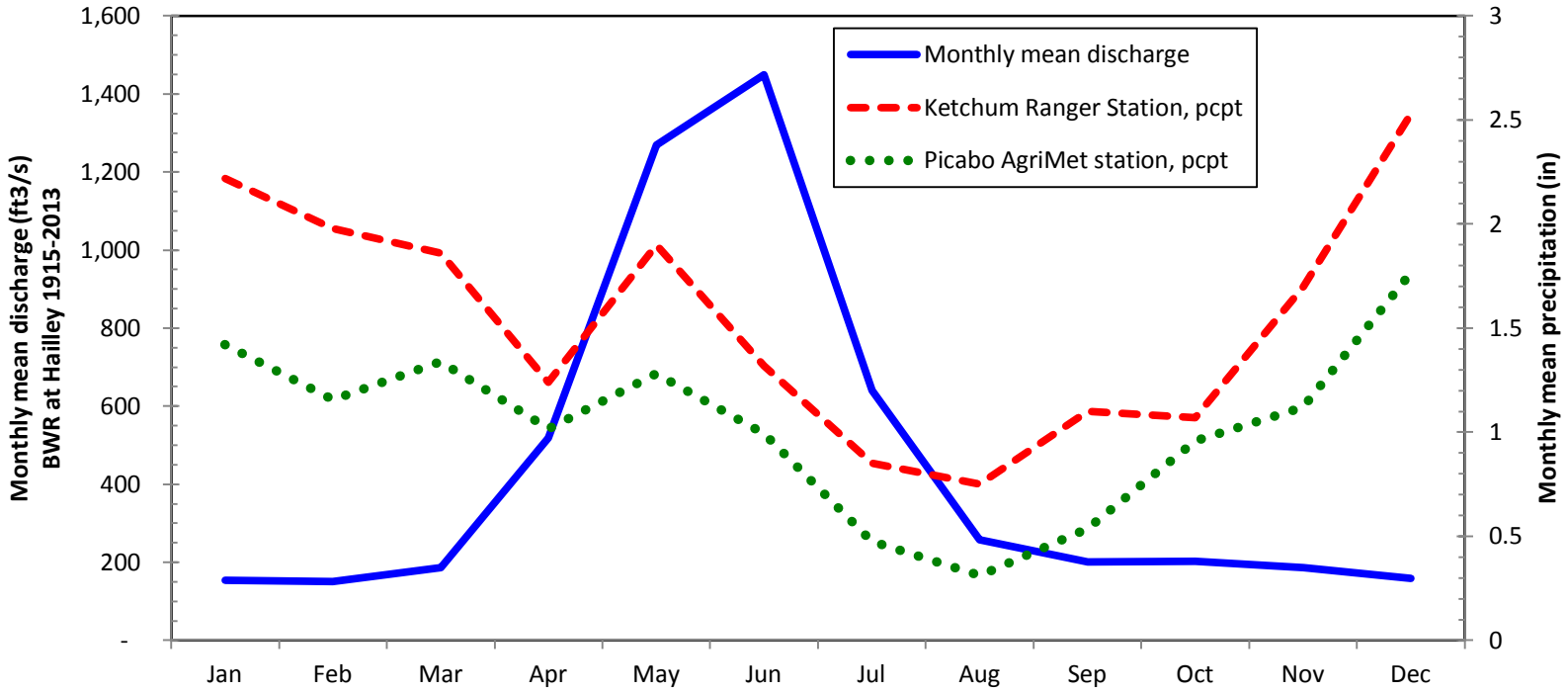
$$Q = K * A * dh/dl$$



- Subsurface flow from tributary canyons into the aquifer system is difficult to quantify with any certainty
- Decided to use Darcian flux approach—presented at Dec 2013 MTAC meeting
- Yielded a "mean" flux rate

Seasonality of tributary underflow

- Tributary underflow, especially in the smaller canyons, is not a constant flux—some temporal variation is needed.
- What is the best way to shape the flux?
  - Precipitation doesn't capture snowmelt
  - Discharge aggregates precipitation and snowmelt



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Quarterly multiplier for seasonality

- Mean monthly discharge (MMD) for Hailey streamgage, 1995-2010

Month	MMD
Jan1995	105
Feb1995	129
Mar1995	277
Apr1995	627
May1995	1,598
Jun1995	2,928
Jul1995	2,196
Aug1995	622
Sep1995	309
Oct1995	266
Nov1995	244
Dec1995	204
…	…

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Quarterly multiplier for seasonality

- Mean monthly discharge (MMD) for Hailey streamgage, 1995-2010
- Quarterly mean discharge (QMD) = 3-month $\overline{\text{MMD}}$

Quarter	QMD
Jan1995	170
Apr1995	1718
Jul1995	1042
Oct1995	238
…	…
Jan2010	154
Apr2010	859
Jul2010	363
Oct2010	176
Mean:	463

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Quarterly multiplier for seasonality

- Mean monthly discharge (MMD) for Hailey streamgage, 1995-2010
- Quarterly mean discharge (QMD) = 3-month $\overline{MMD}$
- Quarterly multiplier (QM) = QMD ÷ $\overline{QMD}$
- QM ranged from 0.25-4.78

Quarter	QMD	QM
Jan1995	170	0.37
Apr1995	1718	3.71
Jul1995	1042	2.25
Oct1995	238	0.51
…	…	…
Jan2010	154	0.33
Apr2010	859	1.85
Jul2010	363	0.78
Oct2010	176	0.38
Mean:	**463**	…

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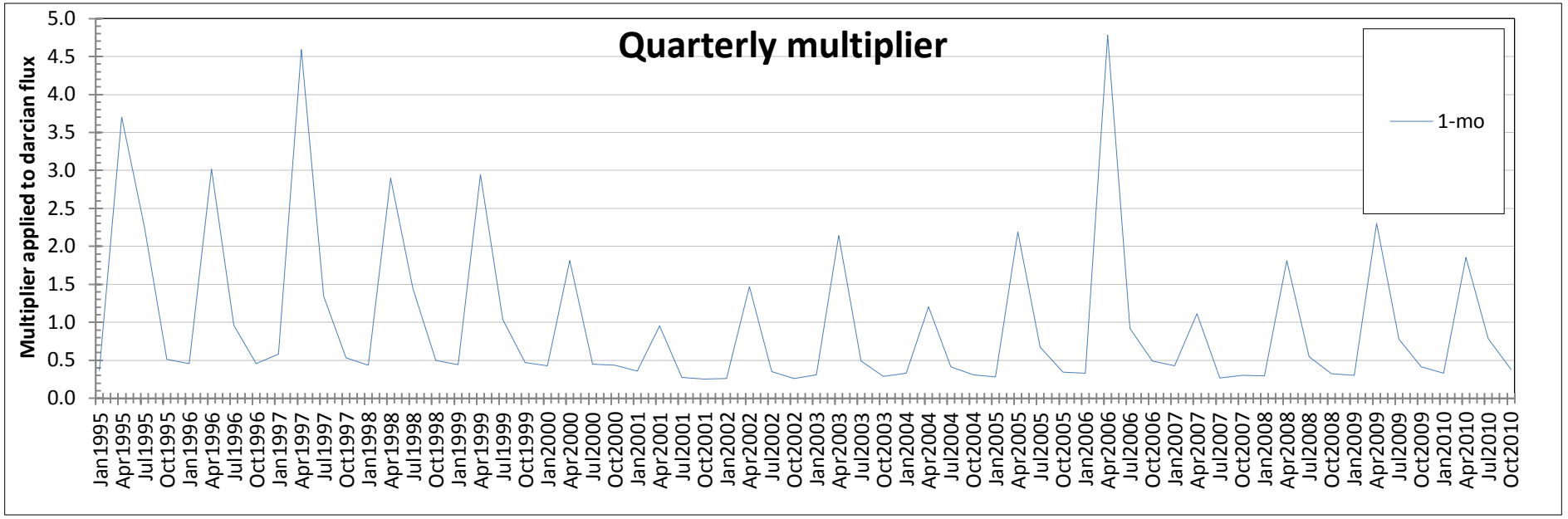
Smoothing



- Applied a moving average to monthly mean discharge
  - Smoothed the months prior to and including the month
- Tried 1, 3, 4, 6, 9, and 12 month averages
- Quarterly multipliers then recalculated

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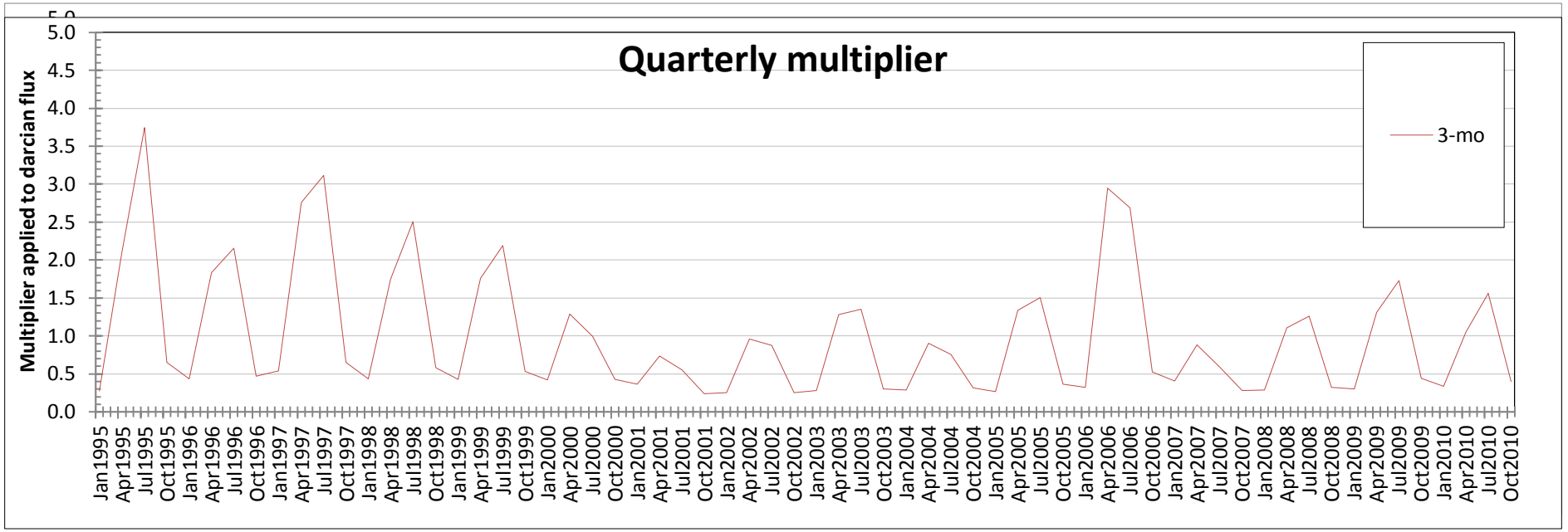
Smoothing



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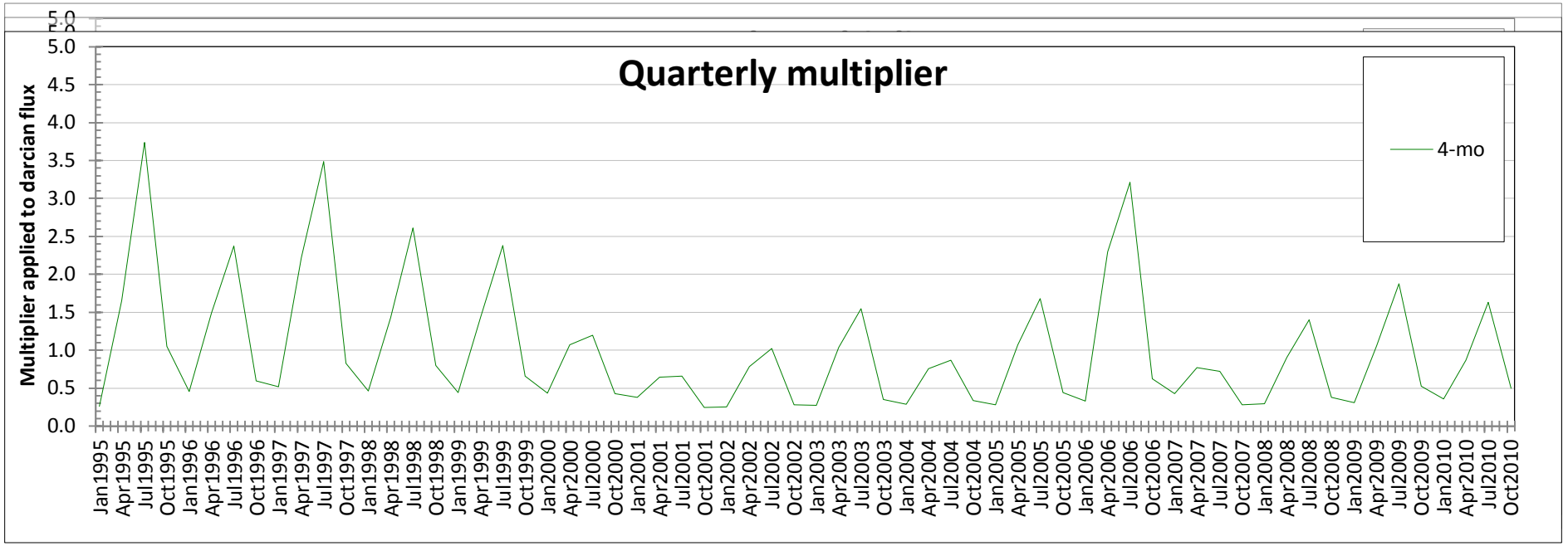

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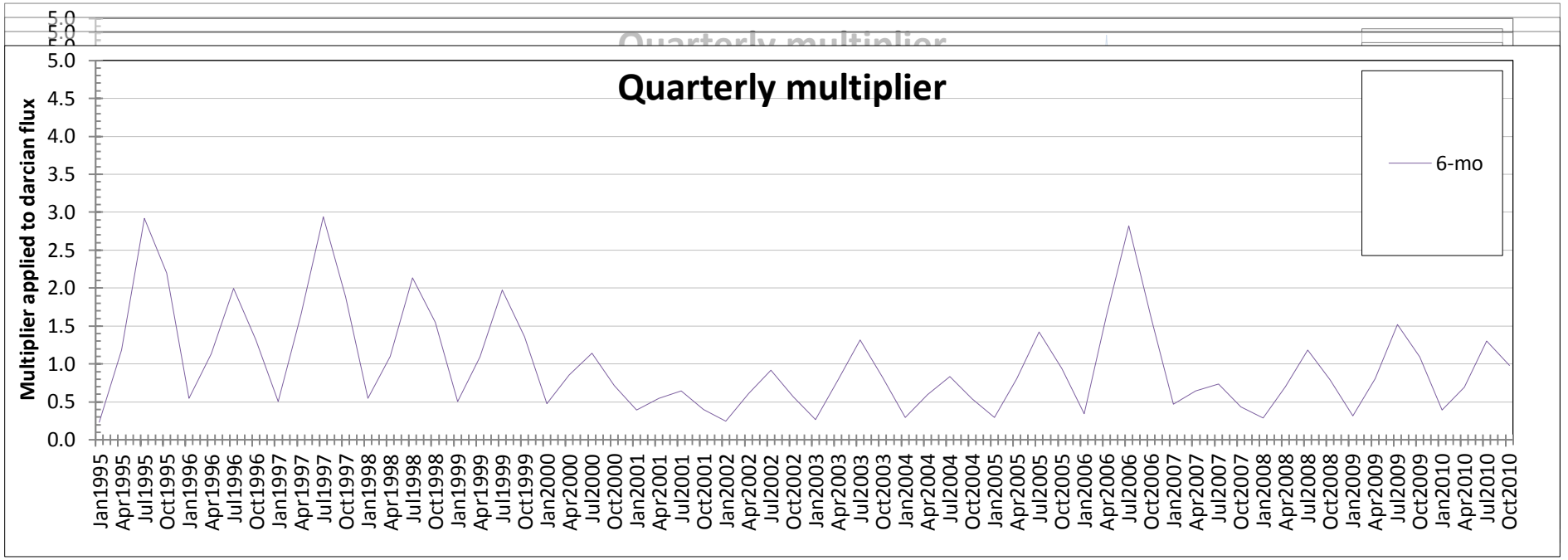

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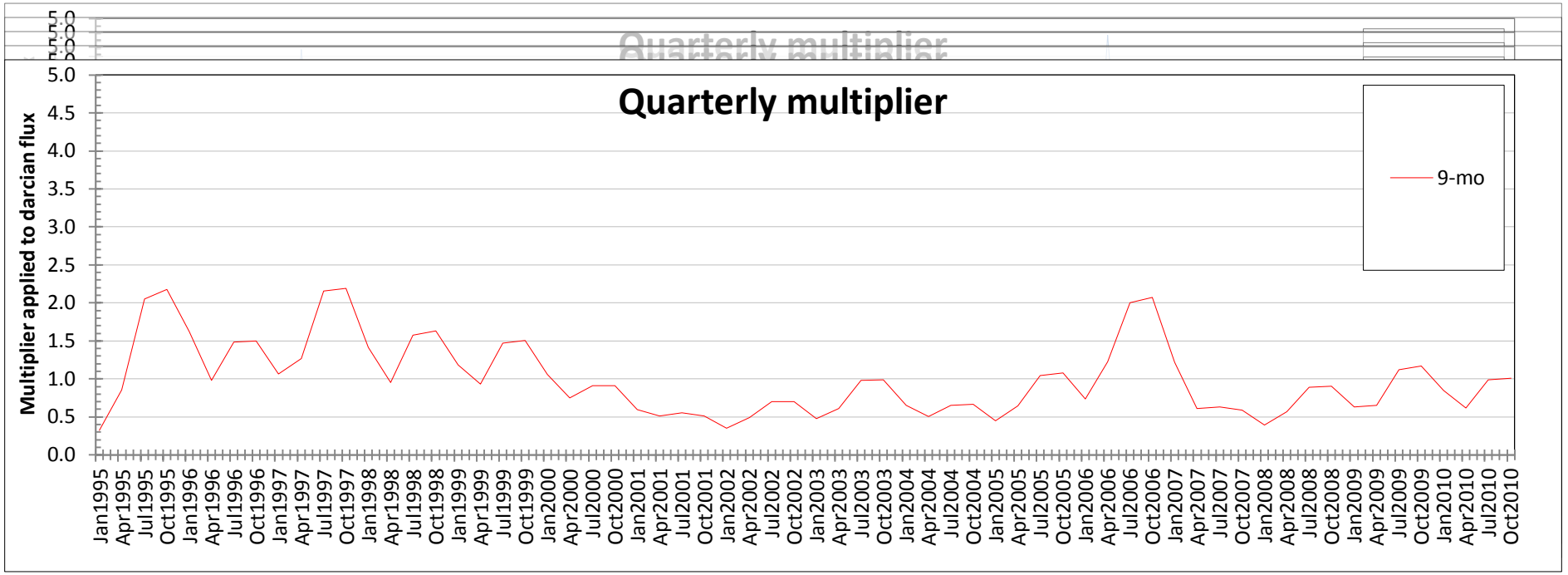

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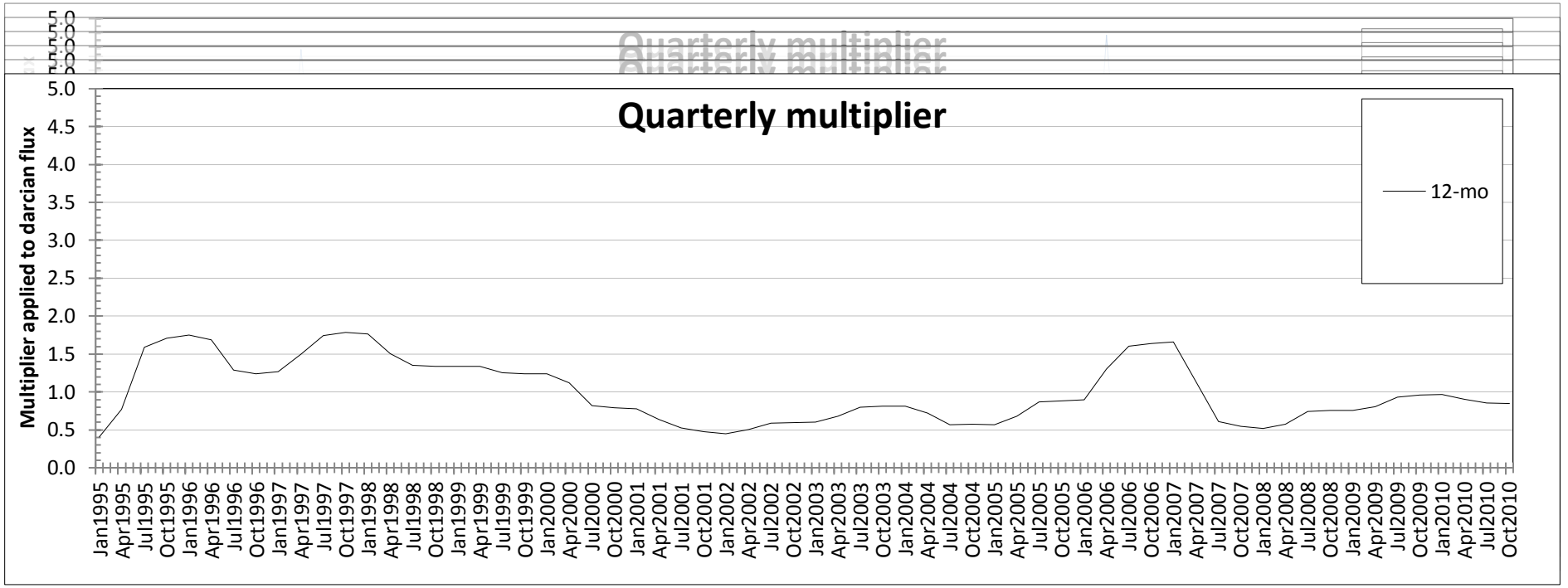

- Applied a moving average to monthly mean discharge
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- Tried 1, 3, 4, 6, 9, and 12 month averages
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- 9-month average was chosen as best compromise between smoothing and signal

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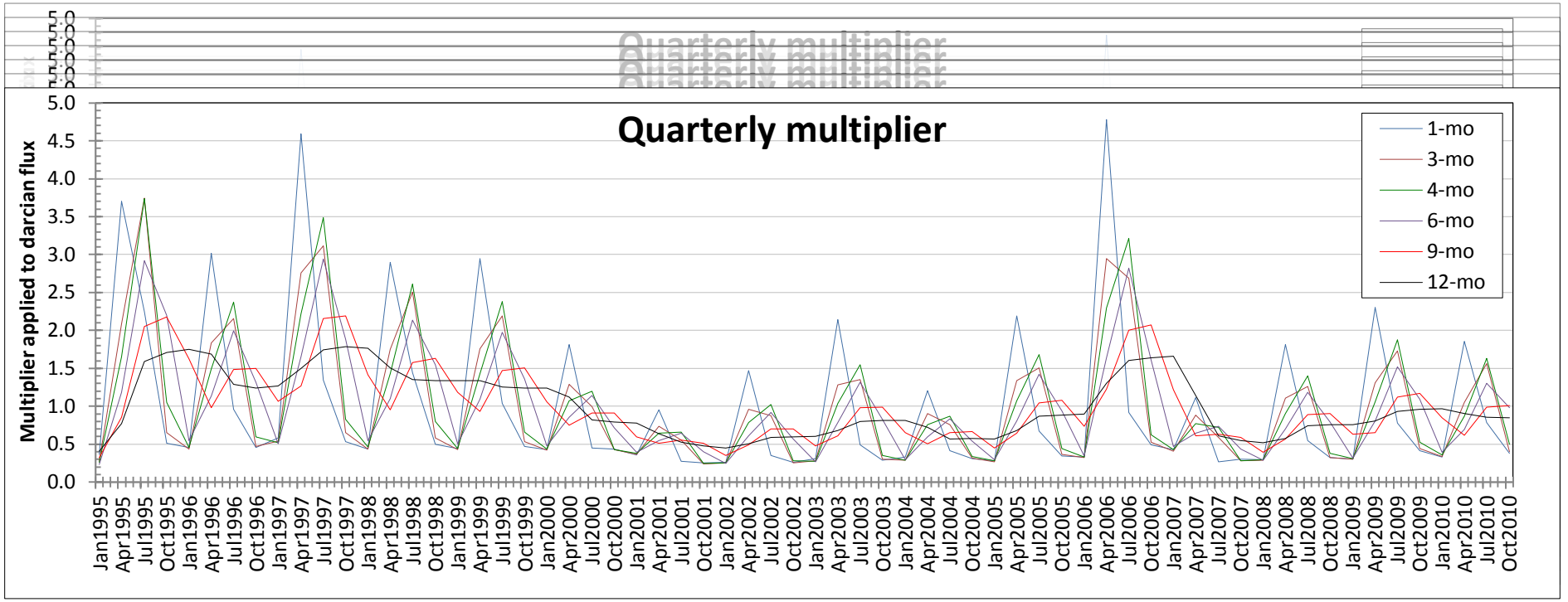
Smoothing



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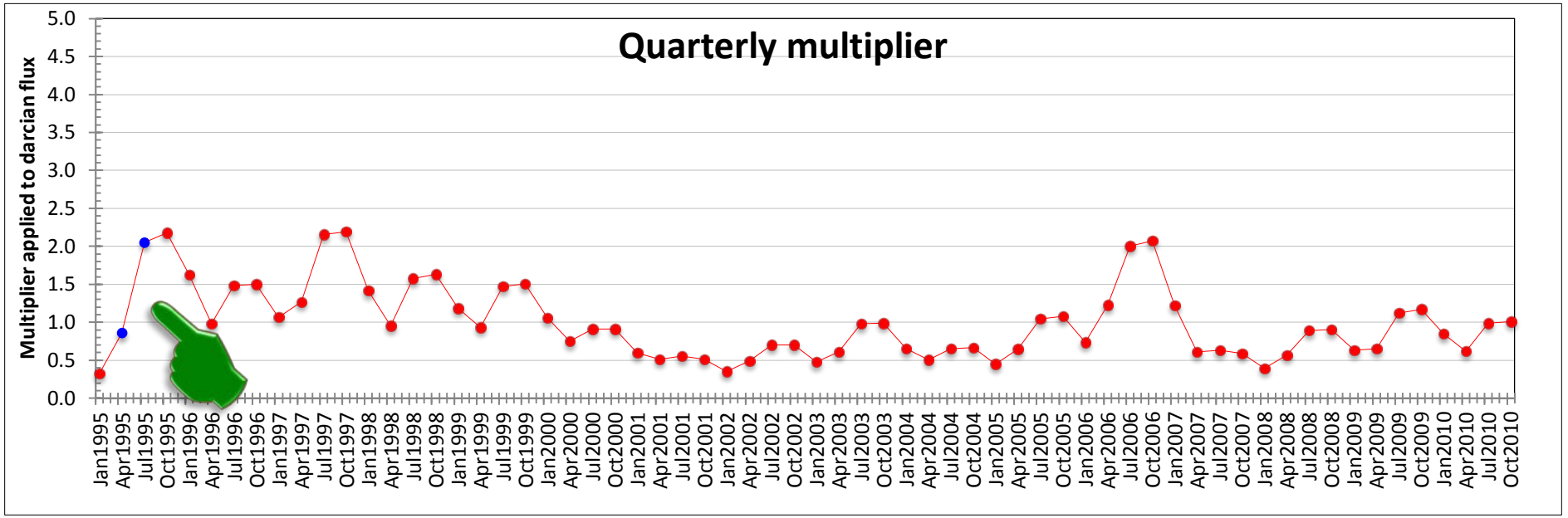
Smoothed multiplier for seasonality



- Large variation remains in the QM: 0.32-2.19
- 119 % max change
- Additional process needed for this variation

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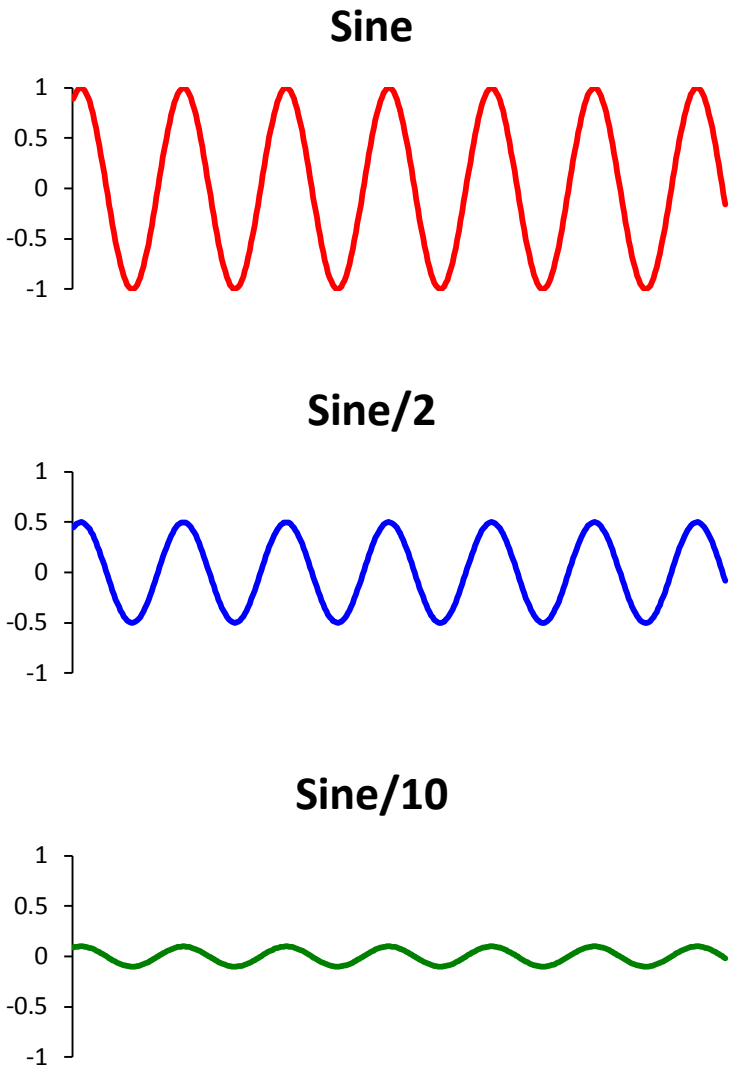
Damping

- **Damping** is an influence within or upon an oscillatory system that has the effect of reducing, restricting or preventing its oscillations. --Wikipedia
- The proposed technique reduces the magnitude of a signal: the mean remains the same but the total range is reduced.



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Damping process

- Choose a *reasonable* Reduction Factor (RF) ≥ 1

Quarter	QMD	SQD (9-mo)
Jan1995	170	147
Apr1995	1,718	394
Jul1995	1,042	942
Oct1995	238	1,000
…	…	…
Jan2010	154	388
Apr2010	859	283
Jul2010	363	455
Oct2010	176	465
Mean:	463	460

Damping process

- Choose a *reasonable* Reduction Factor (RF) ≥ 1
- Temporary Signal (TS) = smoothed quarterly discharge (SQD) ÷ RF

RF = 2

Quarter	SQD (9-mo)	TS
Jan1995	147	74
Apr1995	394	197
Jul1995	942	471
Oct1995	1,000	500
…	…	…
Jan2010	388	194
Apr2010	283	141
Jul2010	455	227
Oct2010	465	232
Mean:	460	230

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Damping process

- Choose a *reasonable* Reduction Factor (RF) ≥ 1
- Temporary Signal (TS) = smoothed quarterly discharge (SQD) ÷ RF
- Single Amplitude Reduction (SAR) = $(\overline{SQD} - \overline{TS}) + TS$

RF = 2

Quarter	SQD (9-mo)	TS	SAR
Jan1995	147	74	303
Apr1995	394	197	427
Jul1995	942	471	701
Oct1995	1,000	500	730
…	…	…	…
Jan2010	388	194	424
Apr2010	283	141	371
Jul2010	455	227	457
Oct2010	465	232	462
Mean:	**460**	**230**	460

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Damping process

- Choose a *reasonable* Reduction Factor (RF) ≥ 1
- Temporary Signal (TS) = smoothed quarterly discharge (SQD) ÷ RF
- Single Amplitude Reduction (SAR) = ($\overline{SQD}$ – $\overline{TS}$) + TS
- Damped Quarterly Multiplier (DQM) = $\overline{SAR}$ ÷ SAR

RF = 2

Quarter	SAR	DQM
Jan1995	303	0.66
Apr1995	427	0.93
Jul1995	701	1.52
Oct1995	730	1.59
…	…	…
Jan2010	424	0.92
Apr2010	371	0.81
Jul2010	457	0.99
Oct2010	462	1.01
Mean:	**460**	…

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Damping process

- Choose a *reasonable* Reduction Factor (RF) ≥ 1
- Temporary Signal (TS) = smoothed quarterly discharge (SQD) ÷ RF
- Single Amplitude Reduction (SAR) = ($\overline{SQD}$ – $\overline{TS}$) + TS
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RF = 2

Quarter	DQM	QM
Jan1995	0.66	0.37
Apr1995	0.93	3.71
Jul1995	1.52	2.25
Oct1995	1.59	0.51
…	…	…
Jan2010	0.92	0.33
Apr2010	0.81	1.85
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Mean:	…	…

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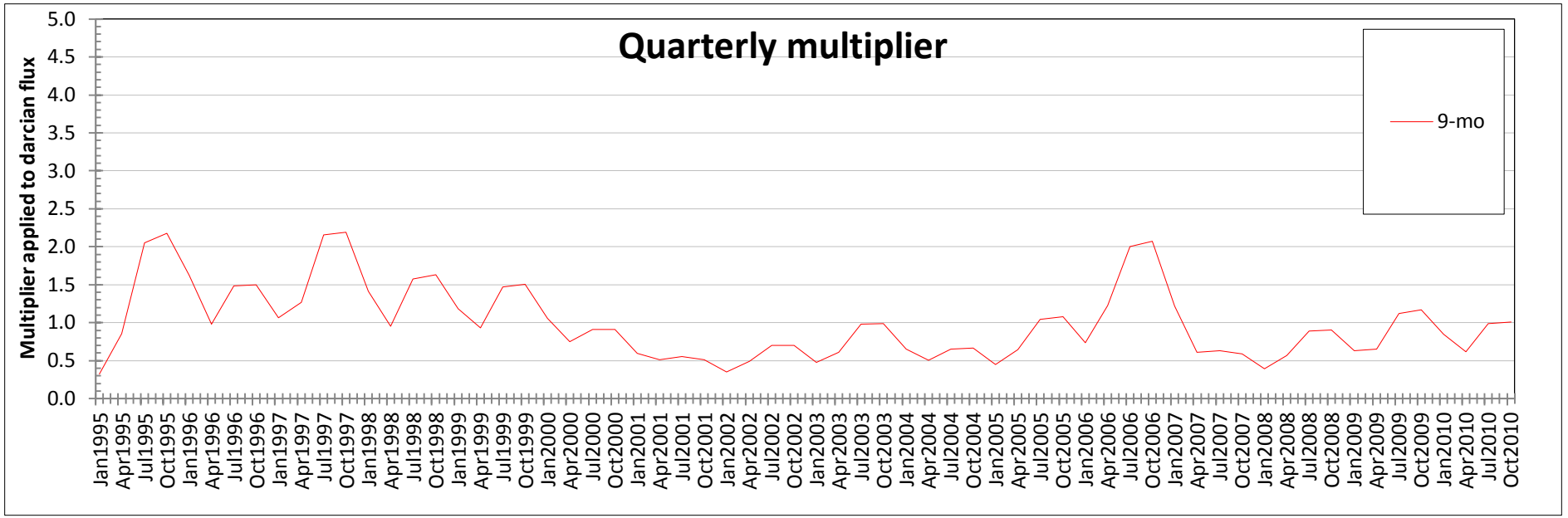
Seasonality



- How does the Reduction Factor (RF) affect the Damped quarterly multiplier (DQM)?

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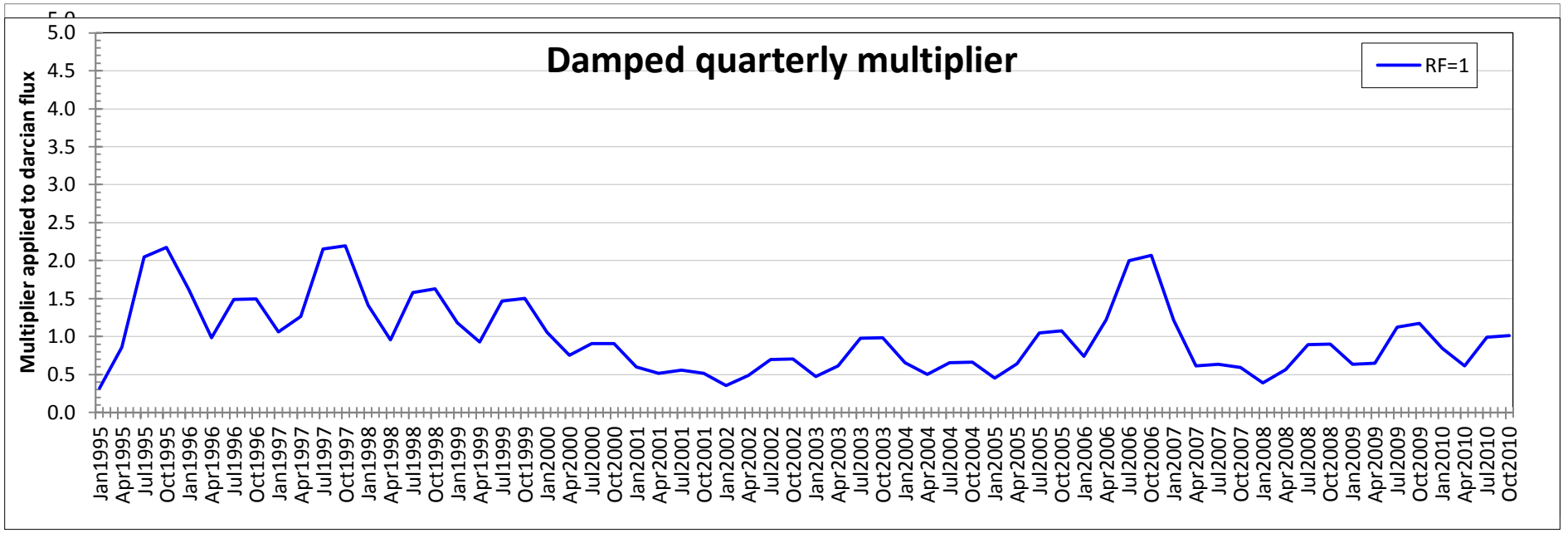
Seasonality



- How does the Reduction Factor (RF) affect the Damped quarterly multiplier (DQM)?

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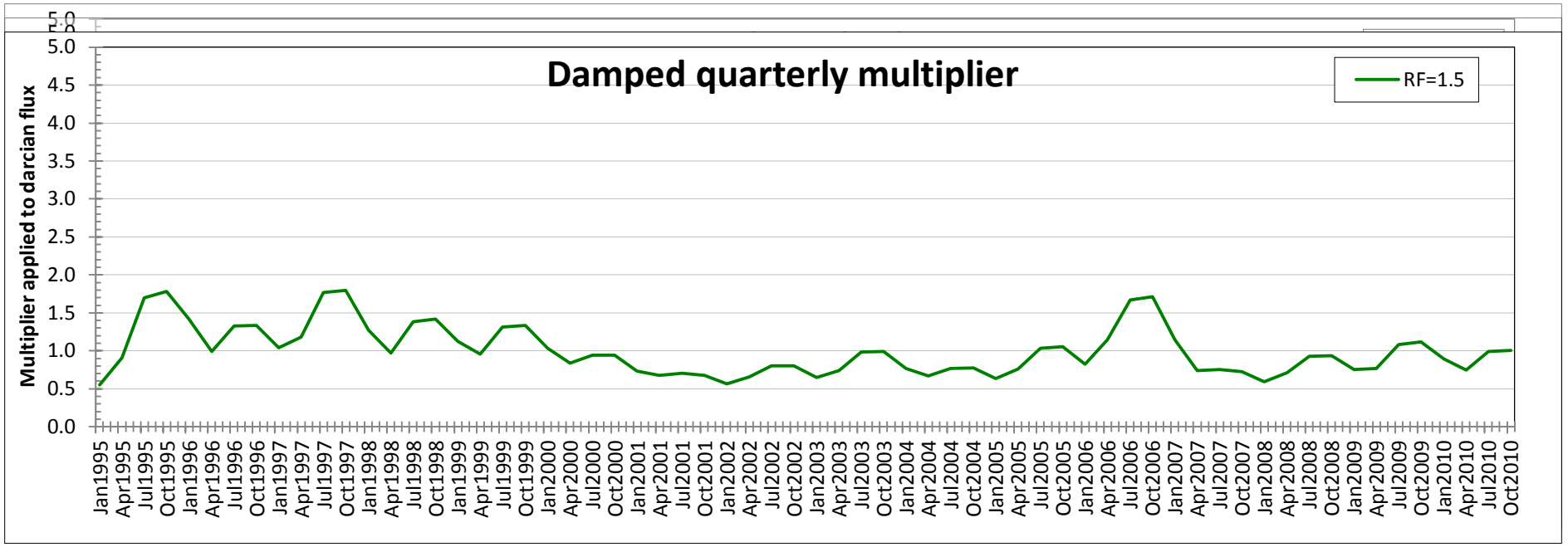
Seasonality



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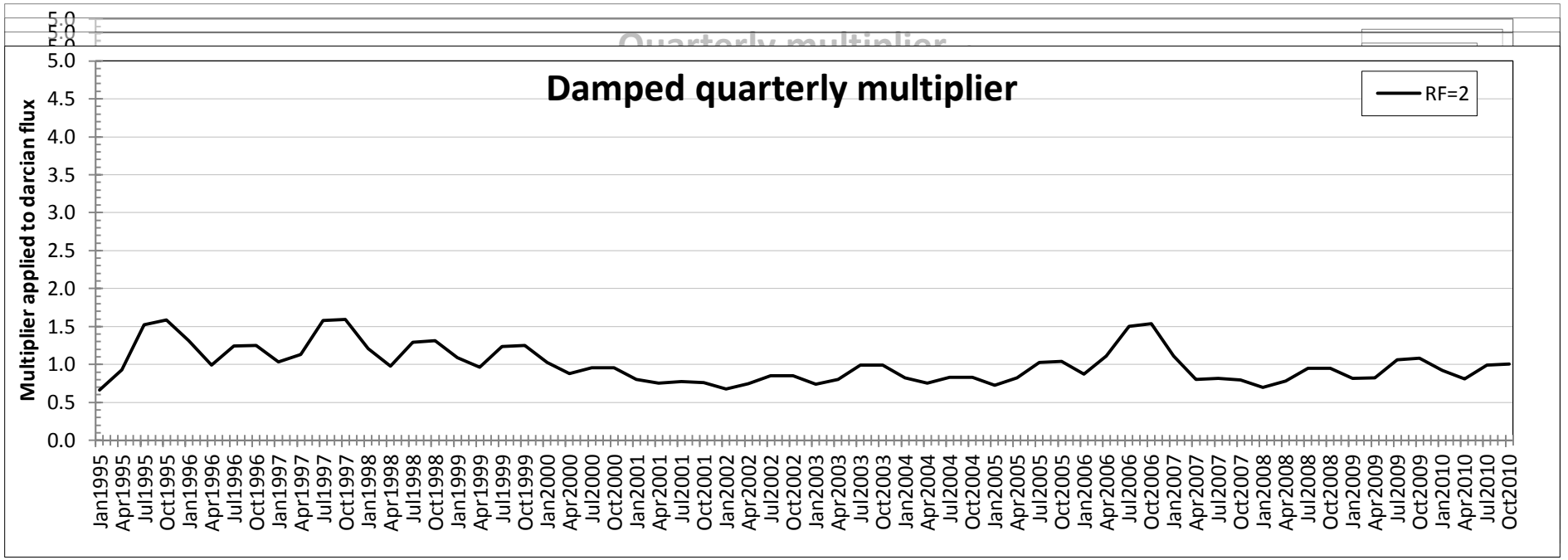

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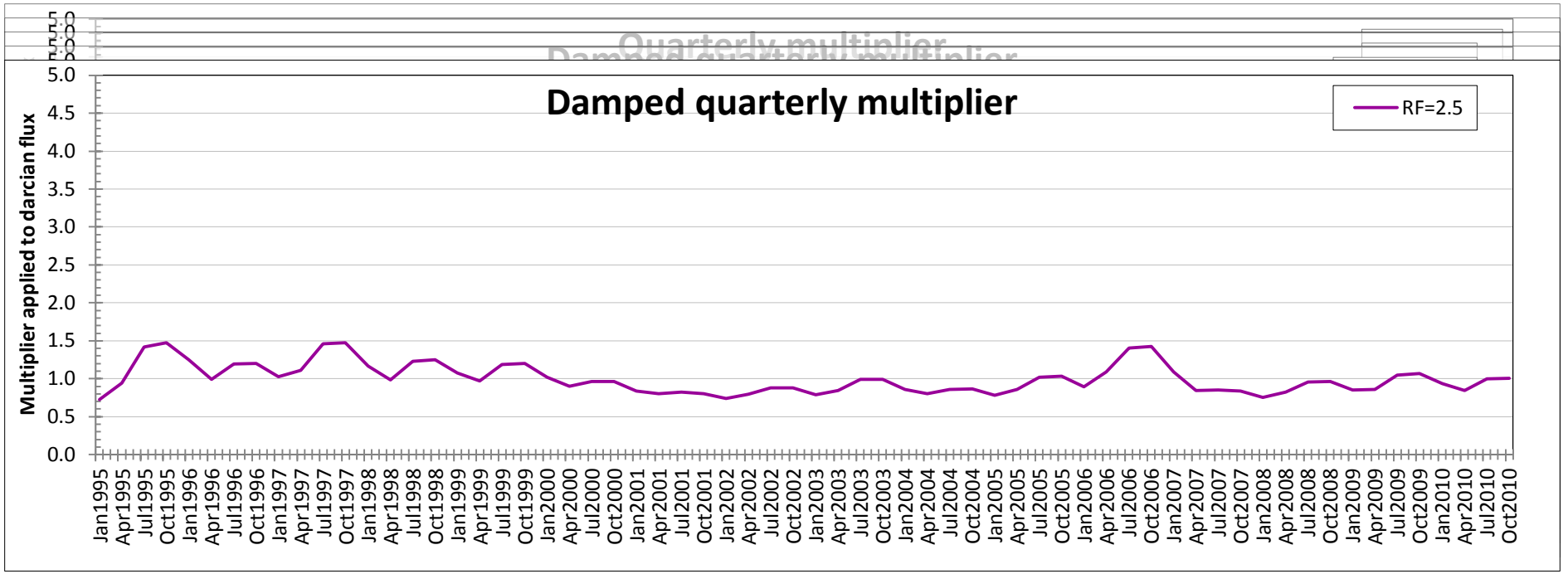
Seasonality



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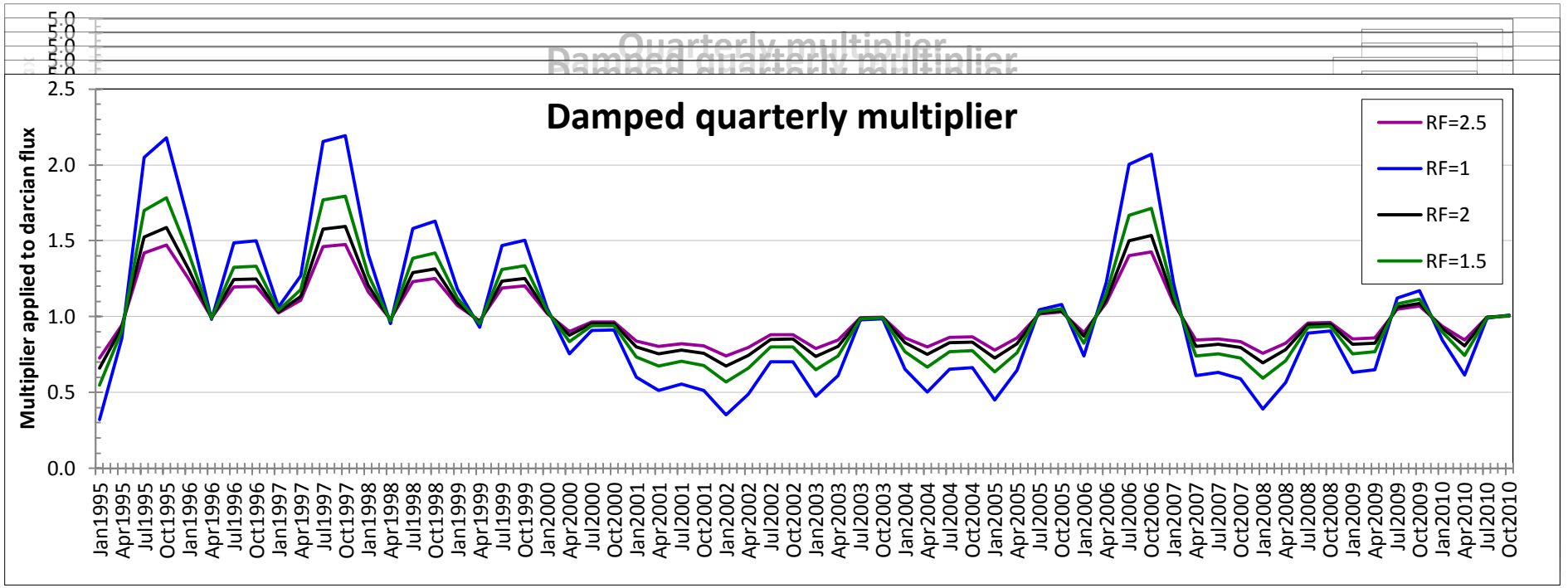
Seasonality



- How does the Reduction Factor (RF) affect the Damped quarterly multiplier (DQM)?
- Starting value for RF = 2
- PEST will be allowed to vary RF during calibration

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Implementation

Estimated tributary underflow by season (ft^3/s): RF=2

		Adm	ChG	Clr	…	Twn	Trl	WmS
Seas	DQM	1.18	0.072	0.190	…	0.080	4.00	0.673
Jan1995	0.660	0.776	0.047	0.125	…	0.053	2.64	0.444
Apr1995	0.928	1.09	0.066	0.176	…	0.074	3.72	0.624
Jul1995	1.52	1.79	0.109	0.289	…	0.121	6.10	1.03
Oct1995	1.59	1.87	0.114	0.301	…	0.126	6.36	1.07
…	…	…	…	…	…	…	…	…
Jan2010	0.922	1.08	0.066	0.175	…	0.073	3.69	0.620
Apr2010	0.808	0.949	0.058	0.153	…	0.064	3.23	0.543
Jul2010	0.995	1.17	0.071	0.189	…	0.079	3.98	0.669
Oct2010	1.01	1.18	0.072	0.191	…	0.080	4.03	0.677

- Questions or thoughts?

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