

A path to dynamic subglacial water systems and why they matter

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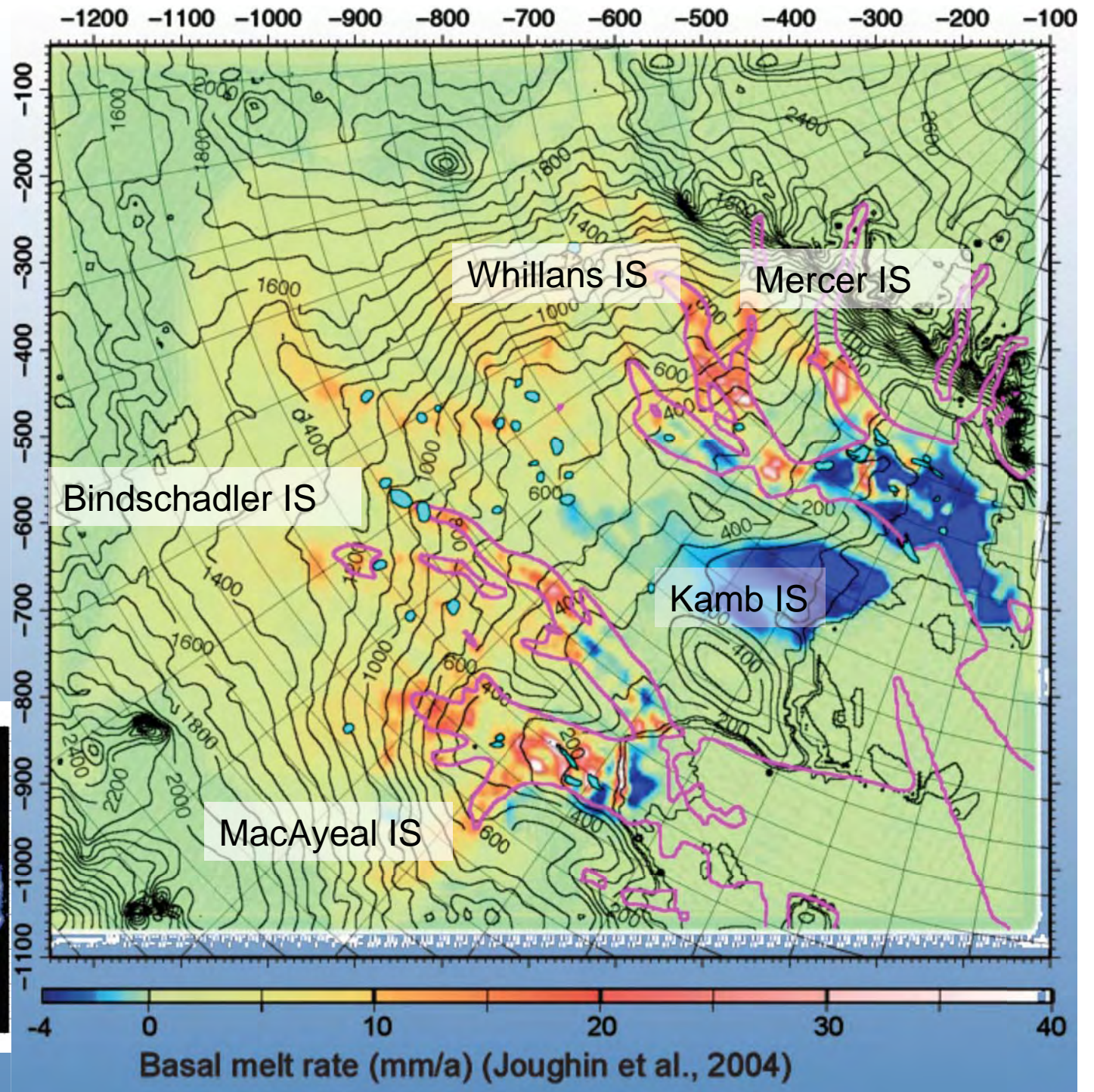
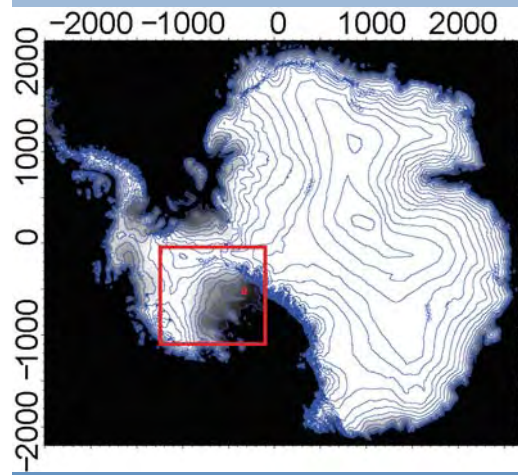


U.S. DEPARTMENT OF
ENERGY



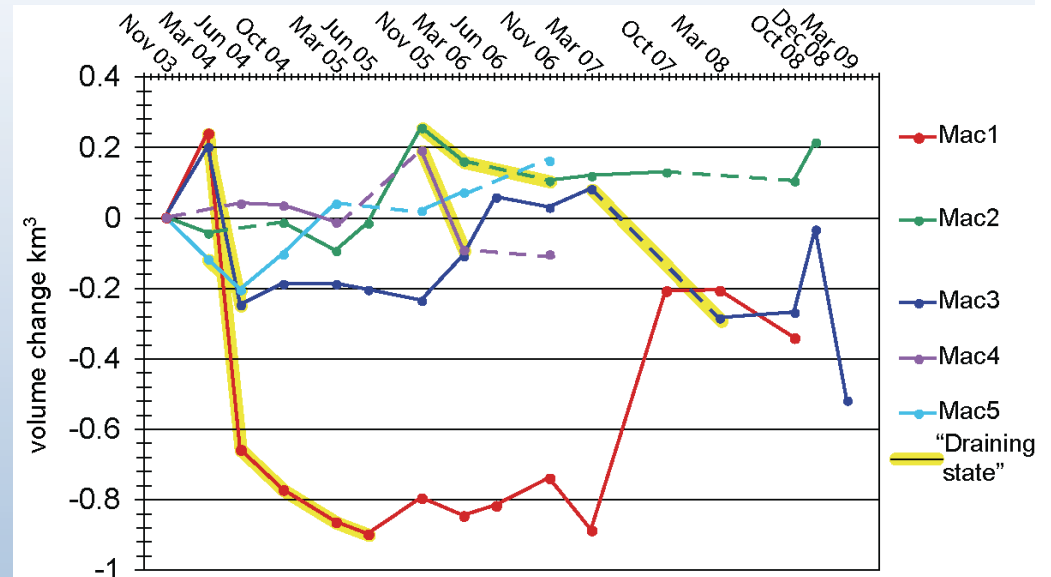
Subglacial Water Introduction

- Water is important for basal lubrication
- Water source is basal melt
- Transported down hydraulic potential

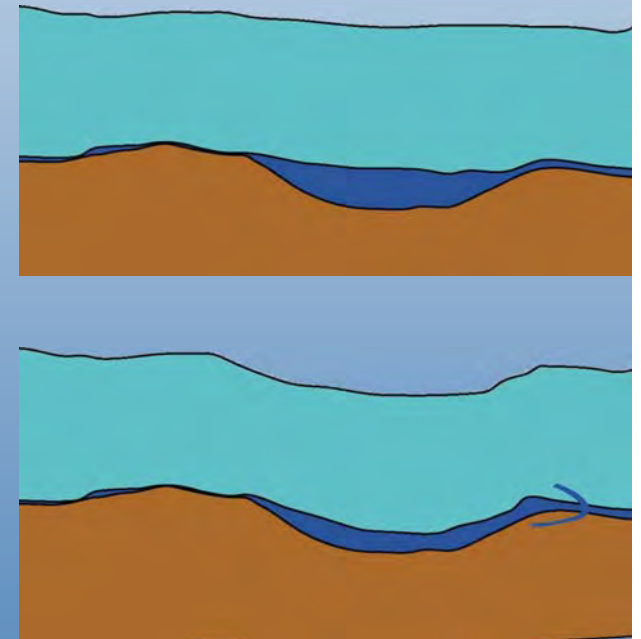
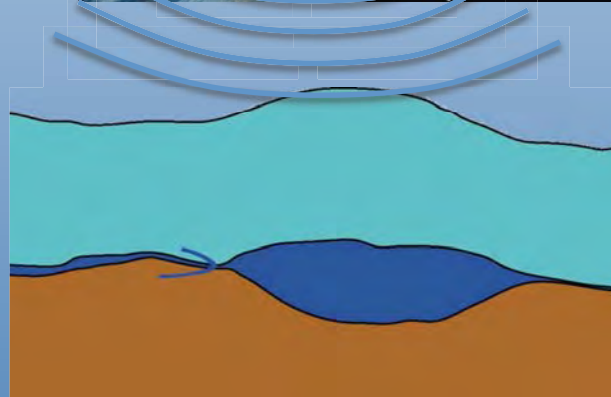
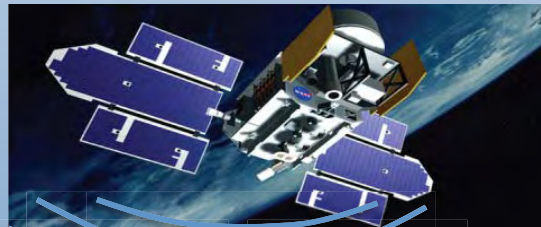


Subglacial lakes

- Fill and drain on time frames of months to decades
- To incorporate into model:
 - Filling lake = sink
 - Draining lake = source
 - For now we use lake distribution and volume time series from (Fricker et al., 2009; 2010 and Smith et al., 2009)
- Goal: to identify a simple rule to parameterize lakes in absence of such data

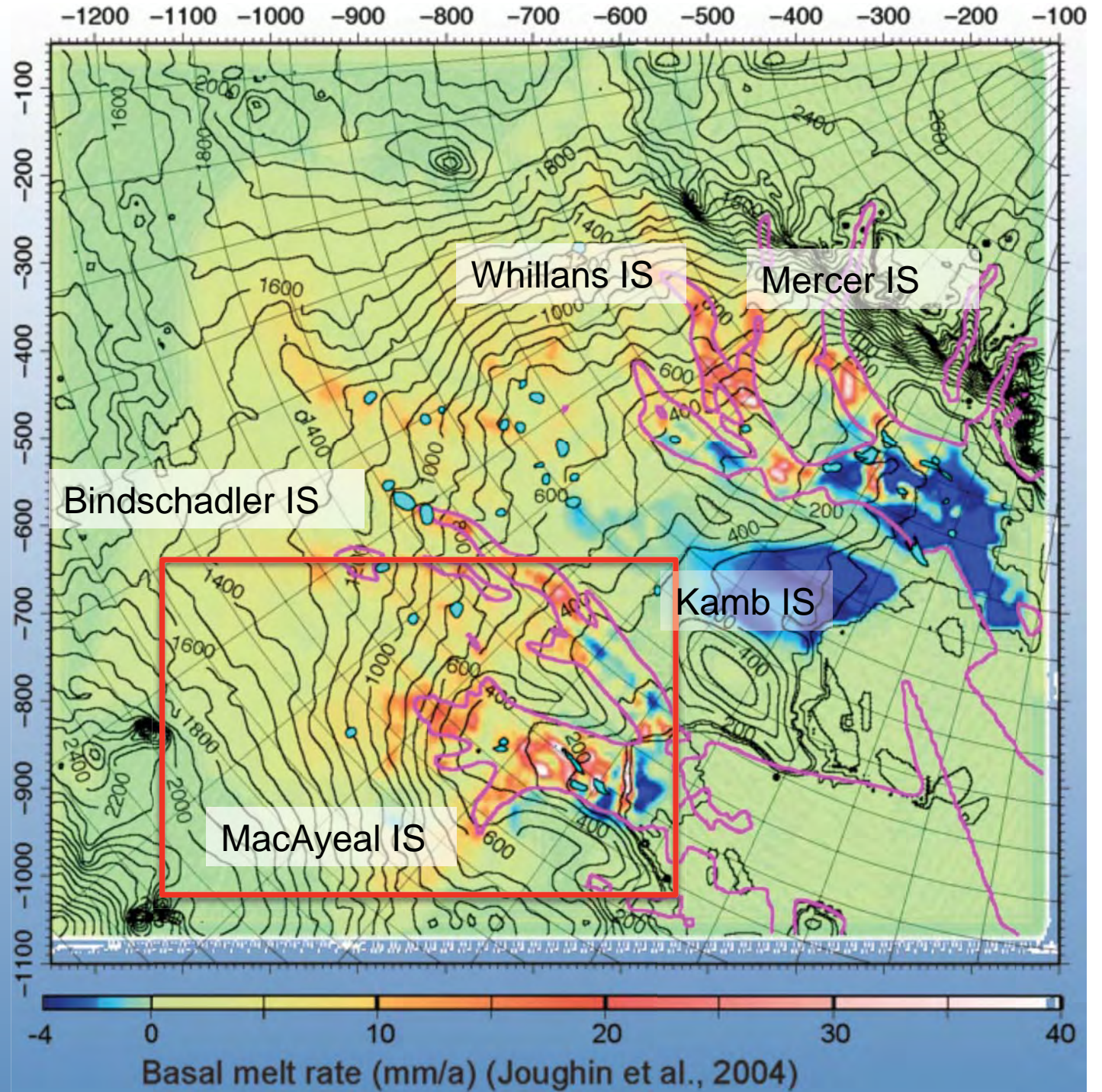


(Carter et al., in review)

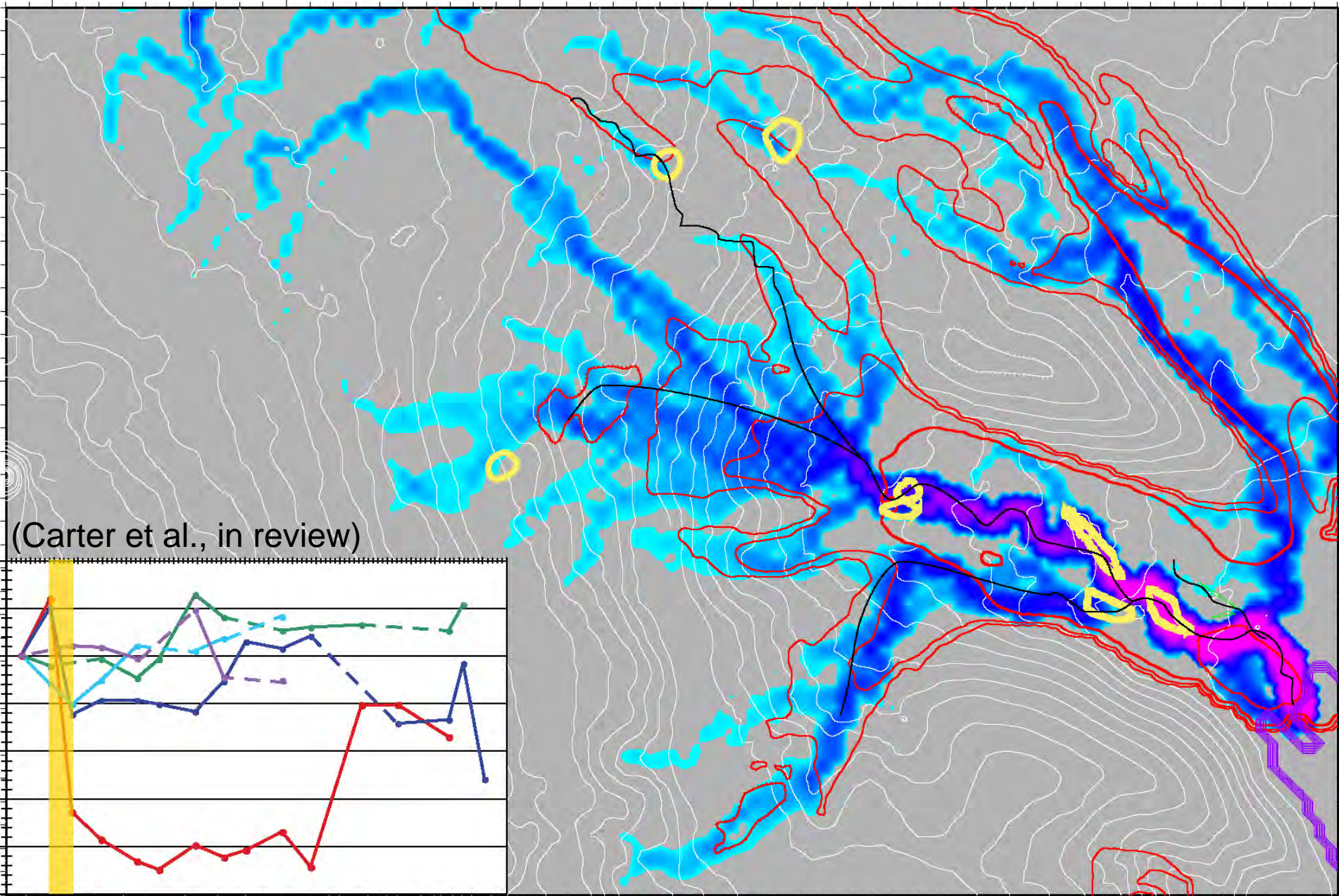


MacAyeal Ice Stream

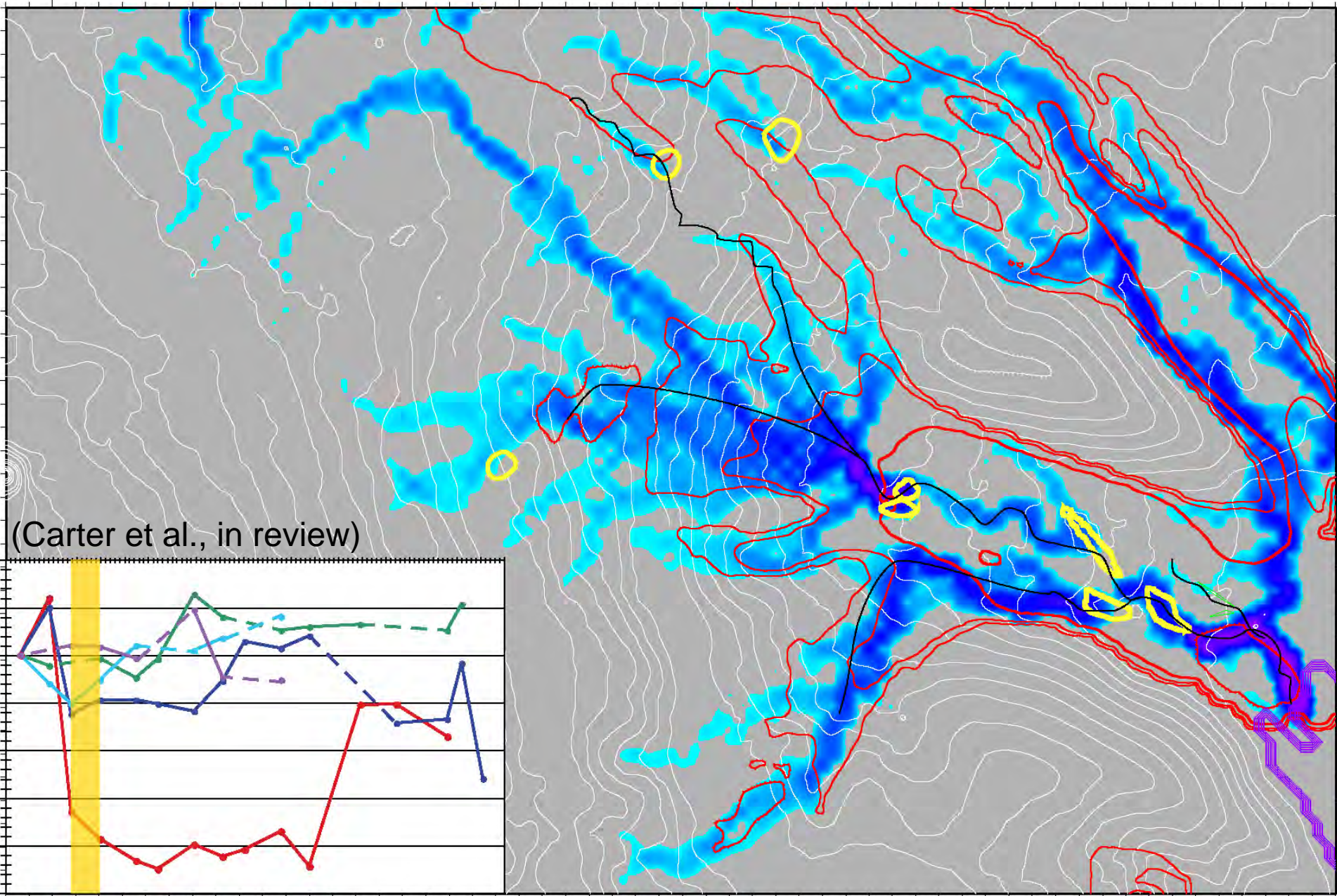
Time series from Fricker et al., 2010.



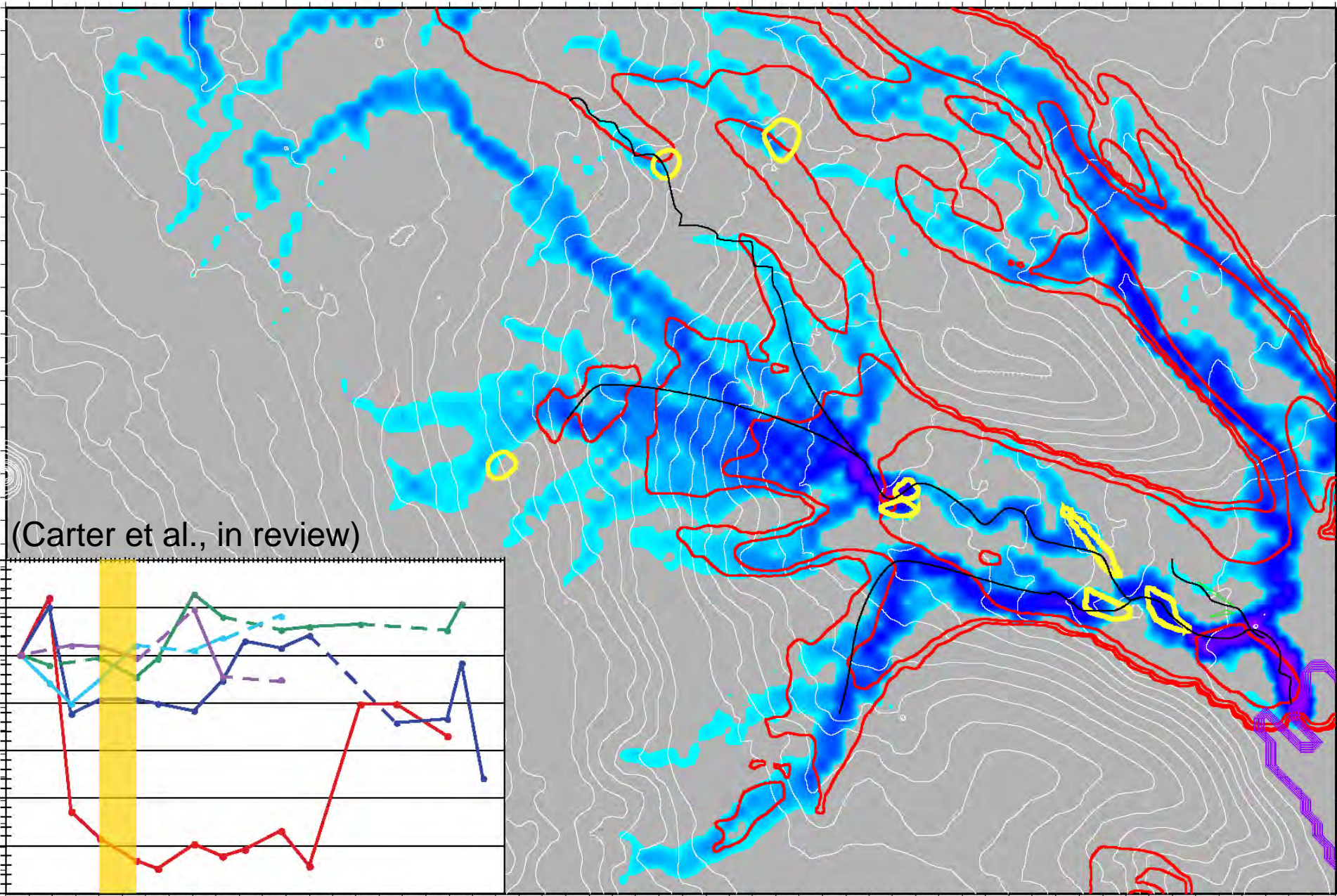
Discharge with time



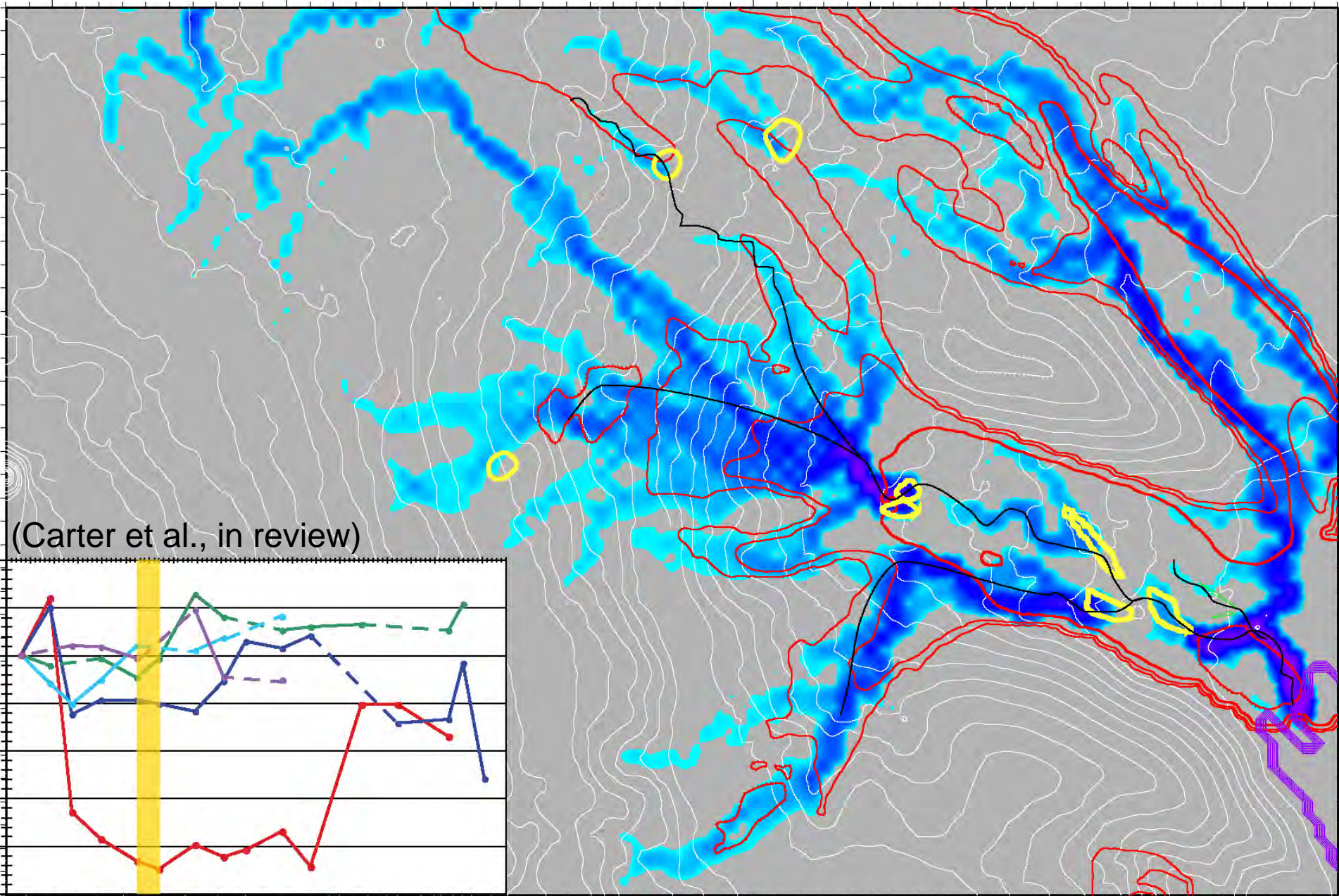
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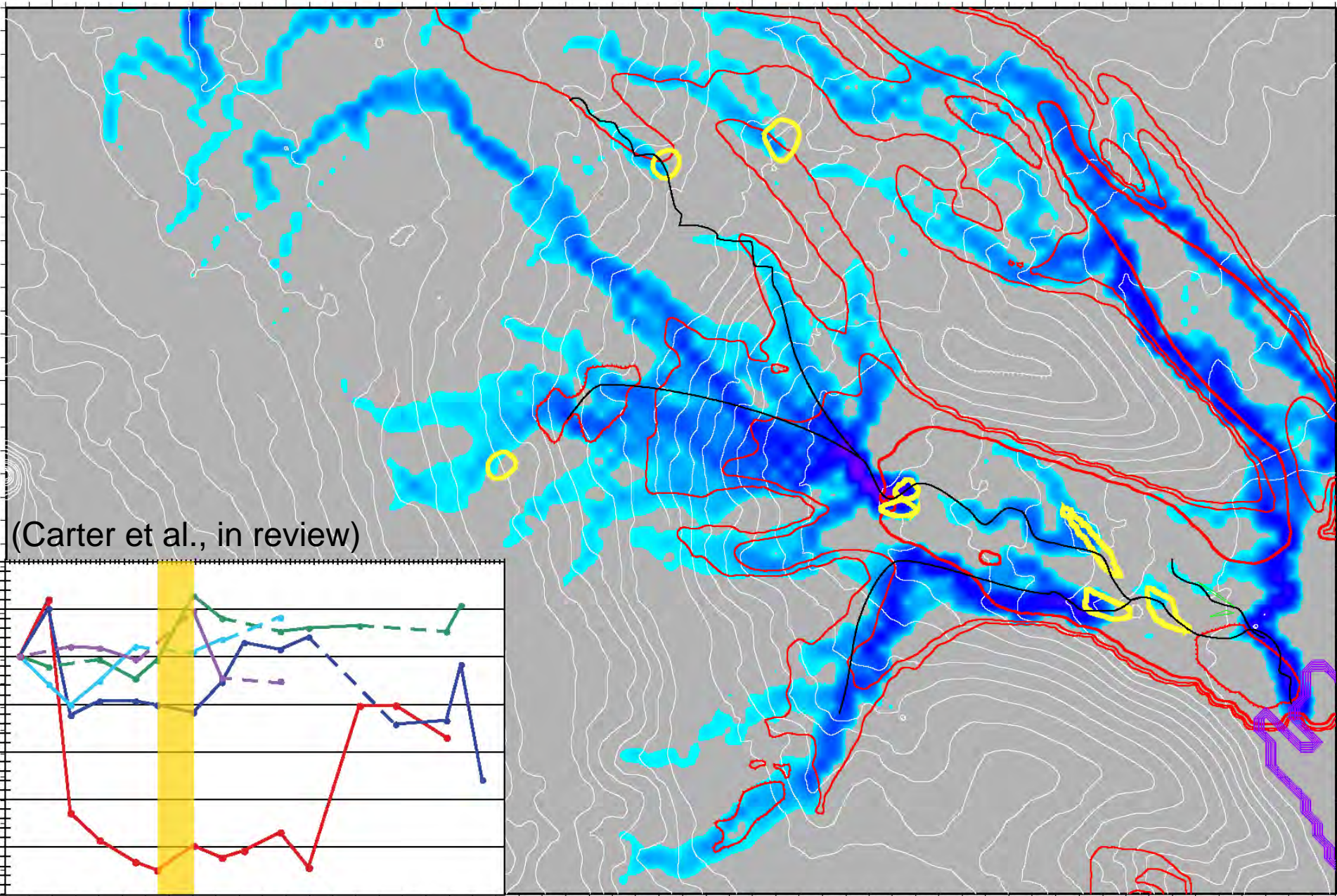
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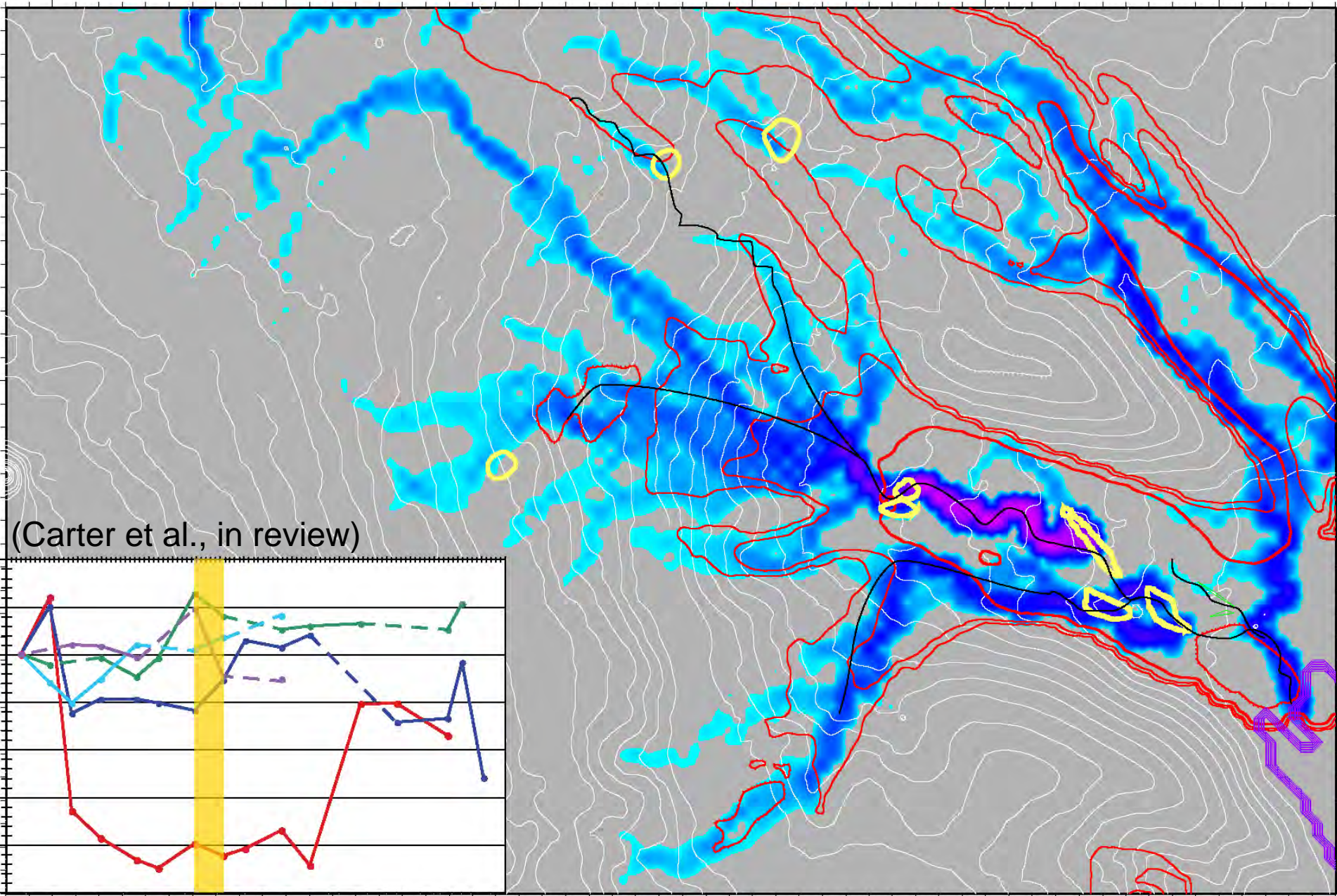
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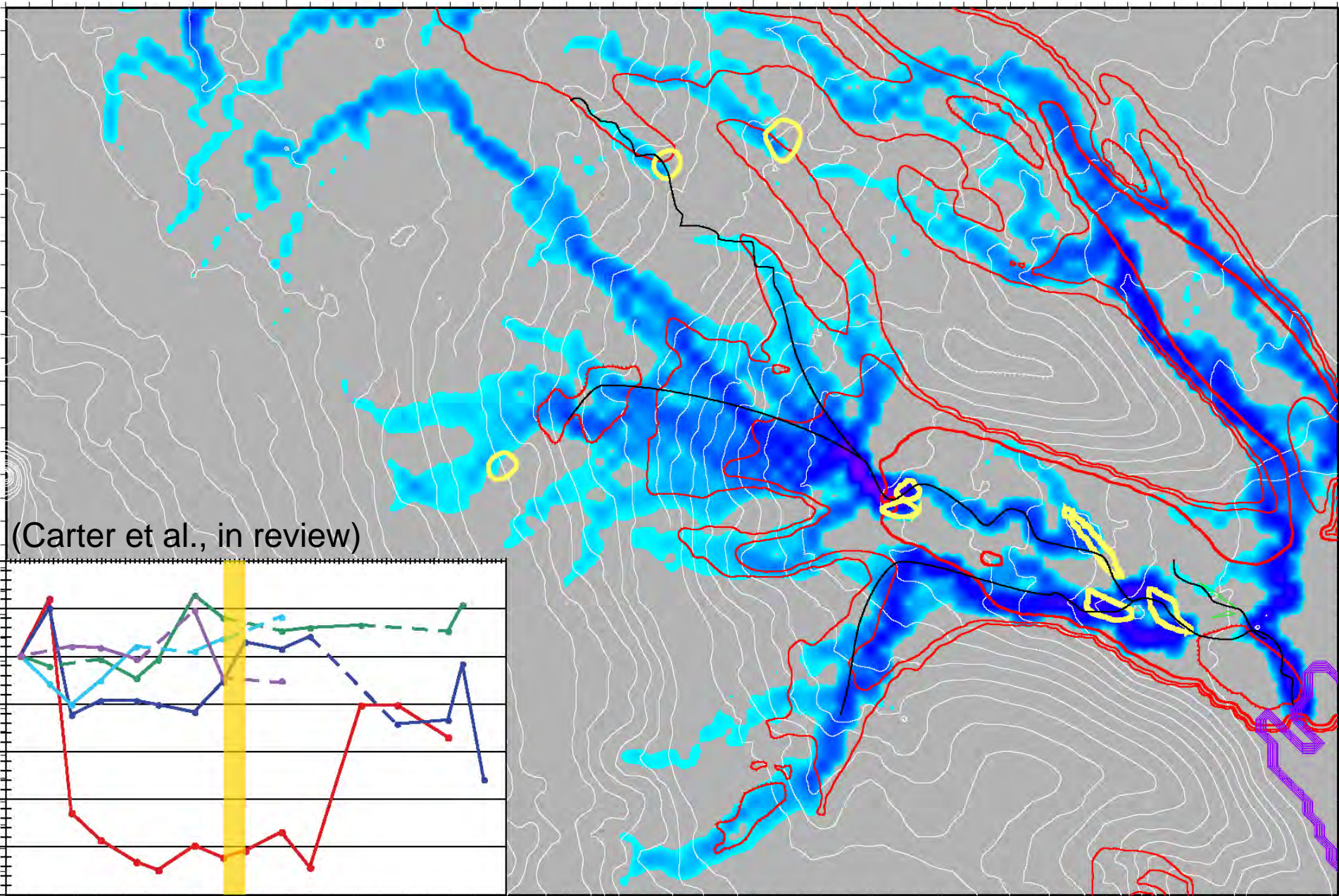
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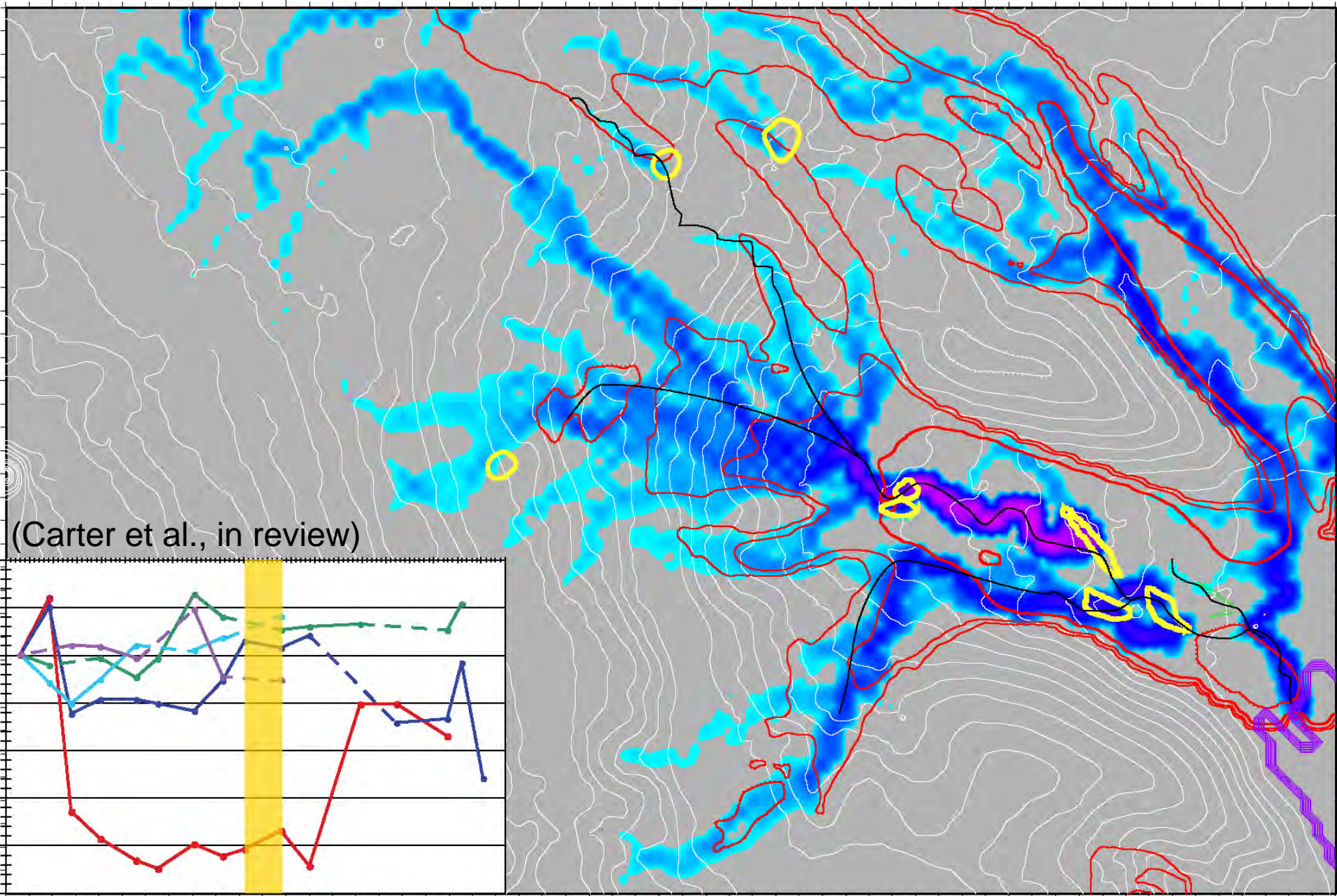
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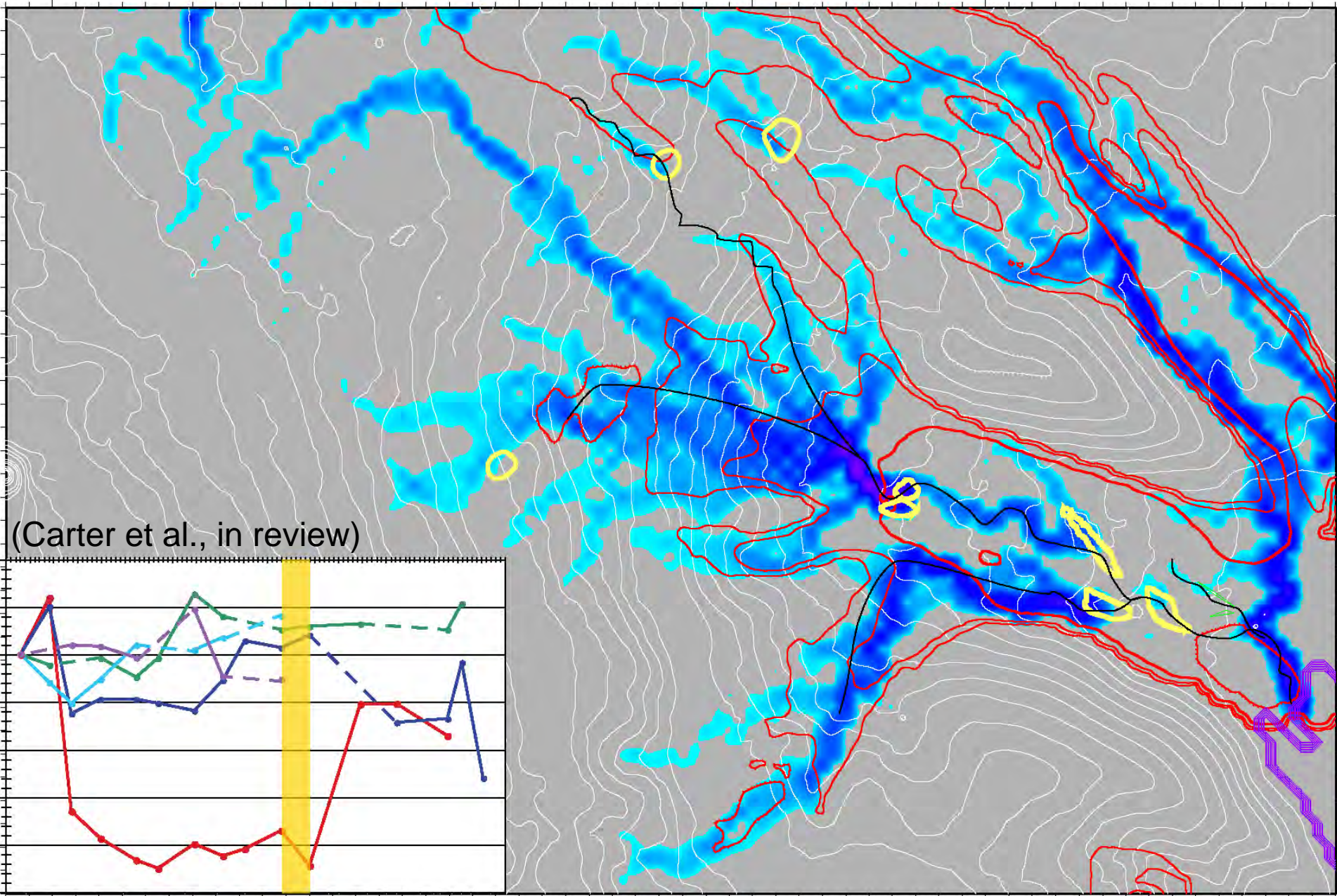
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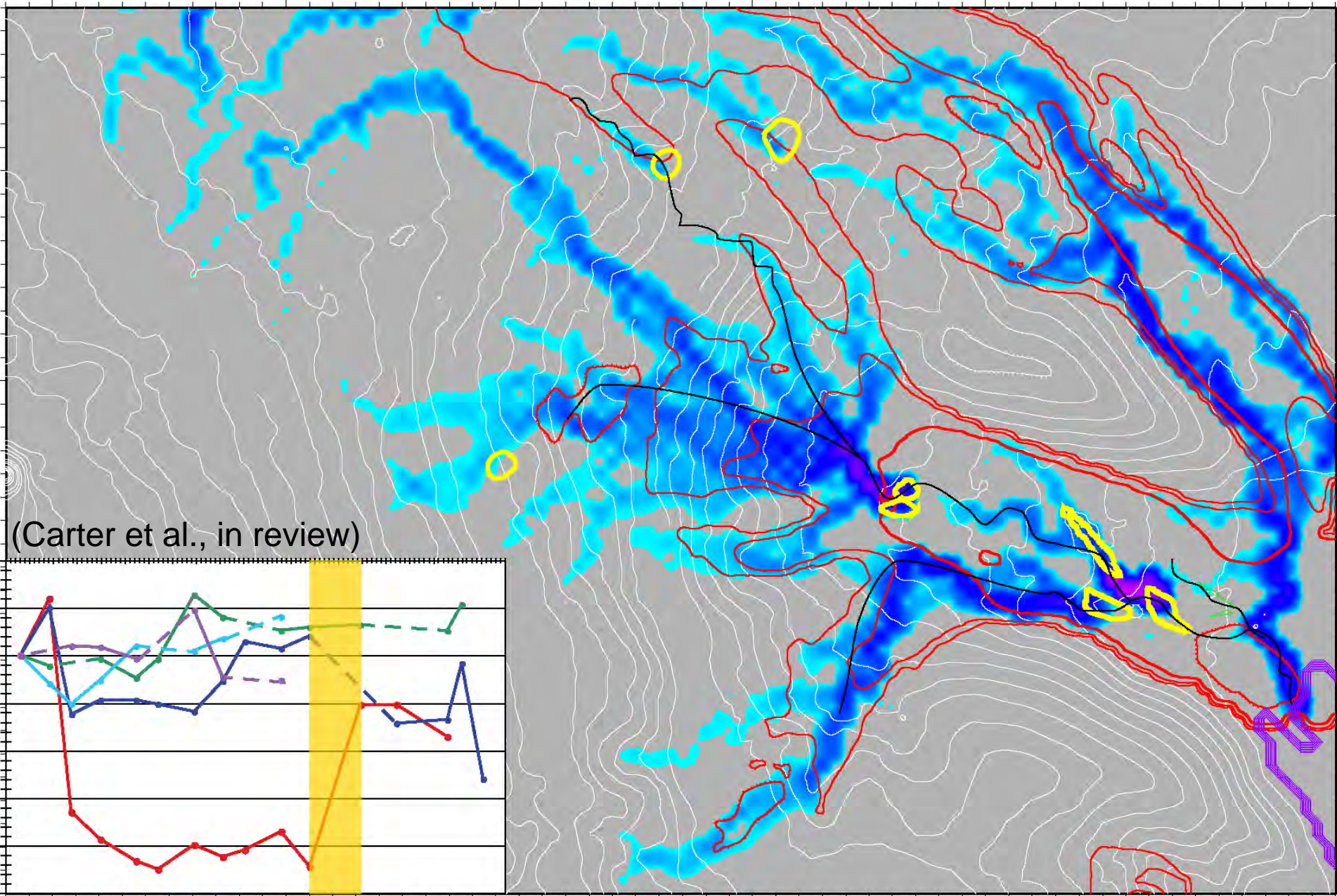
Discharge with time



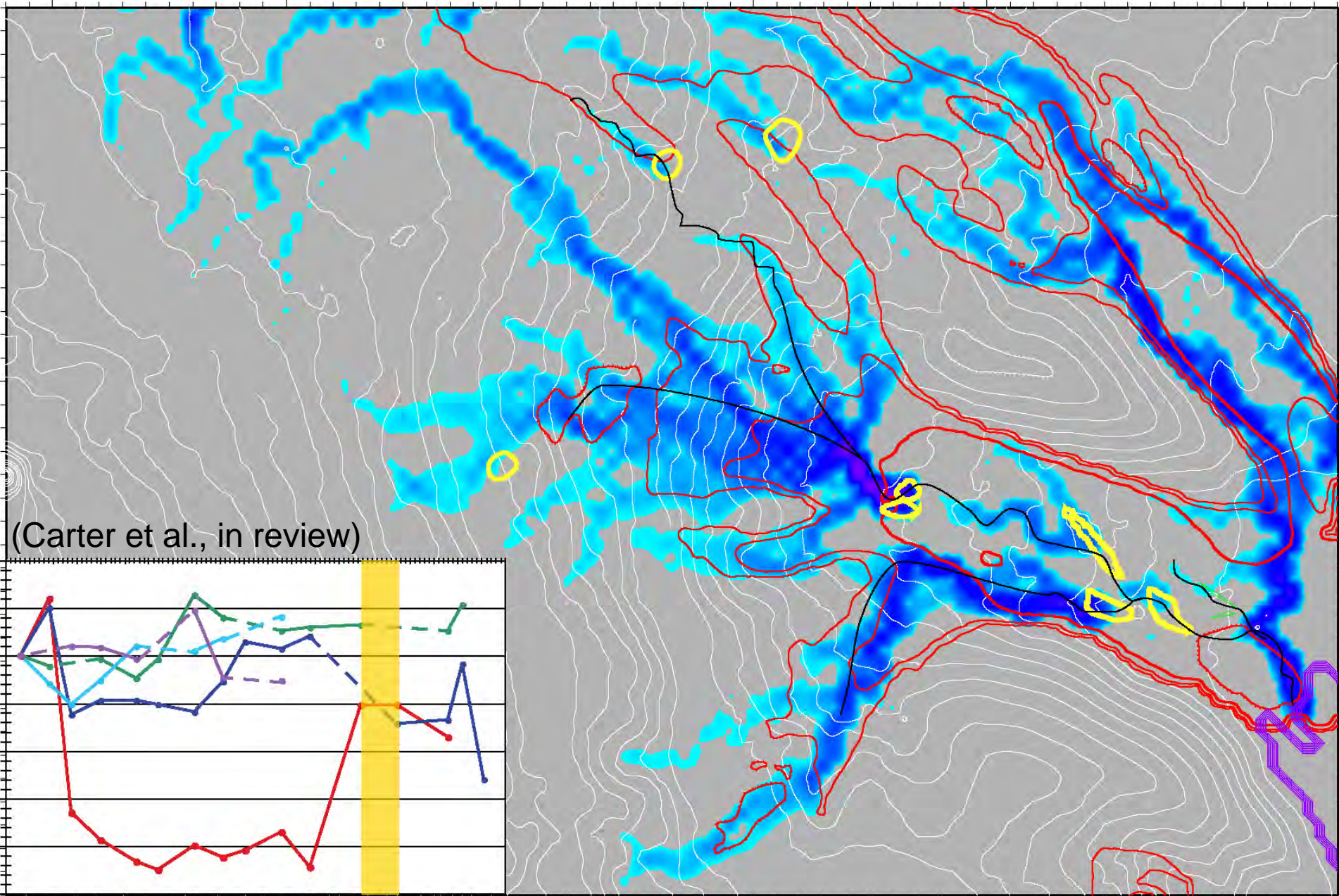
Discharge with time



Discharge with time

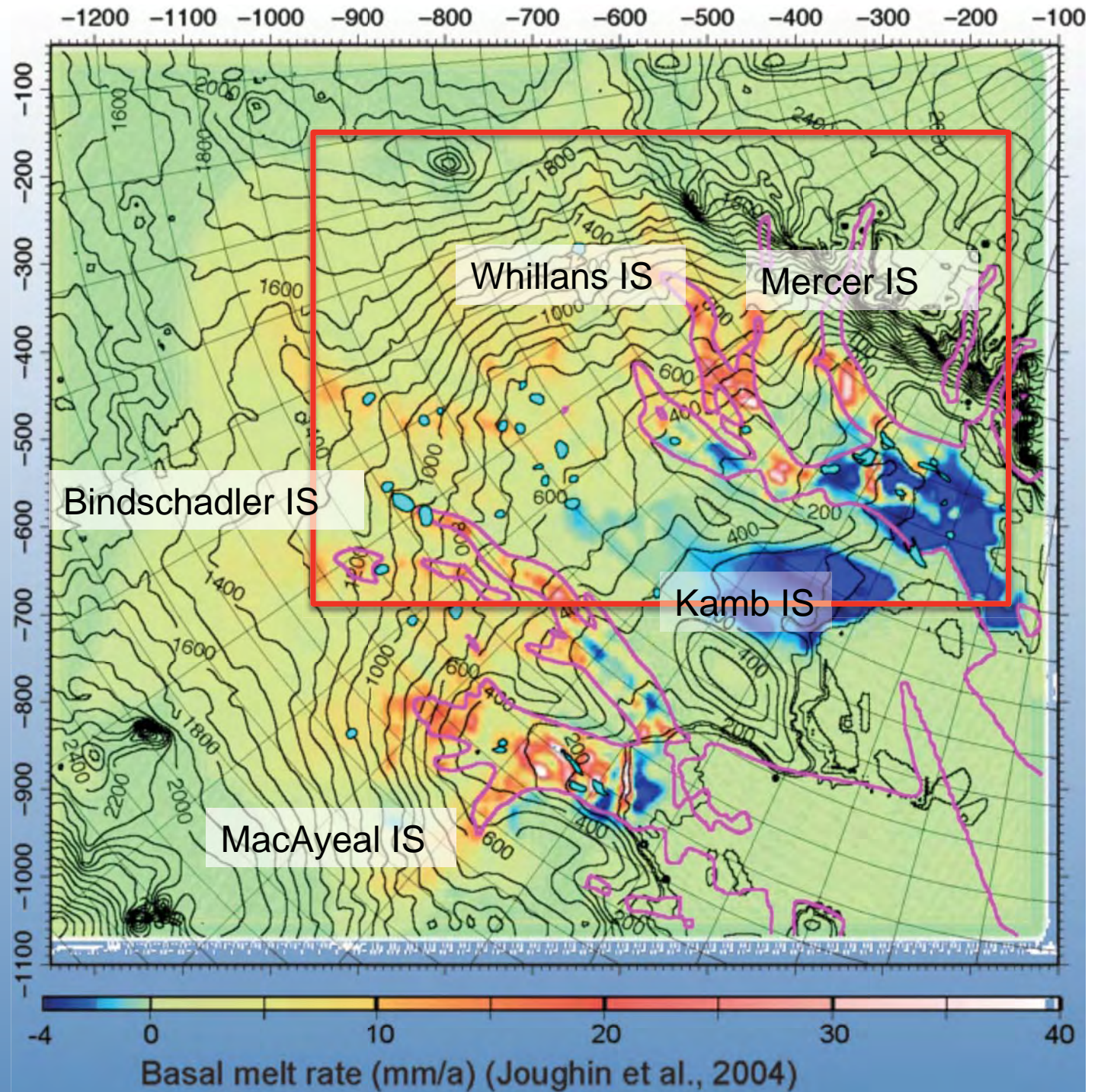


Discharge with time

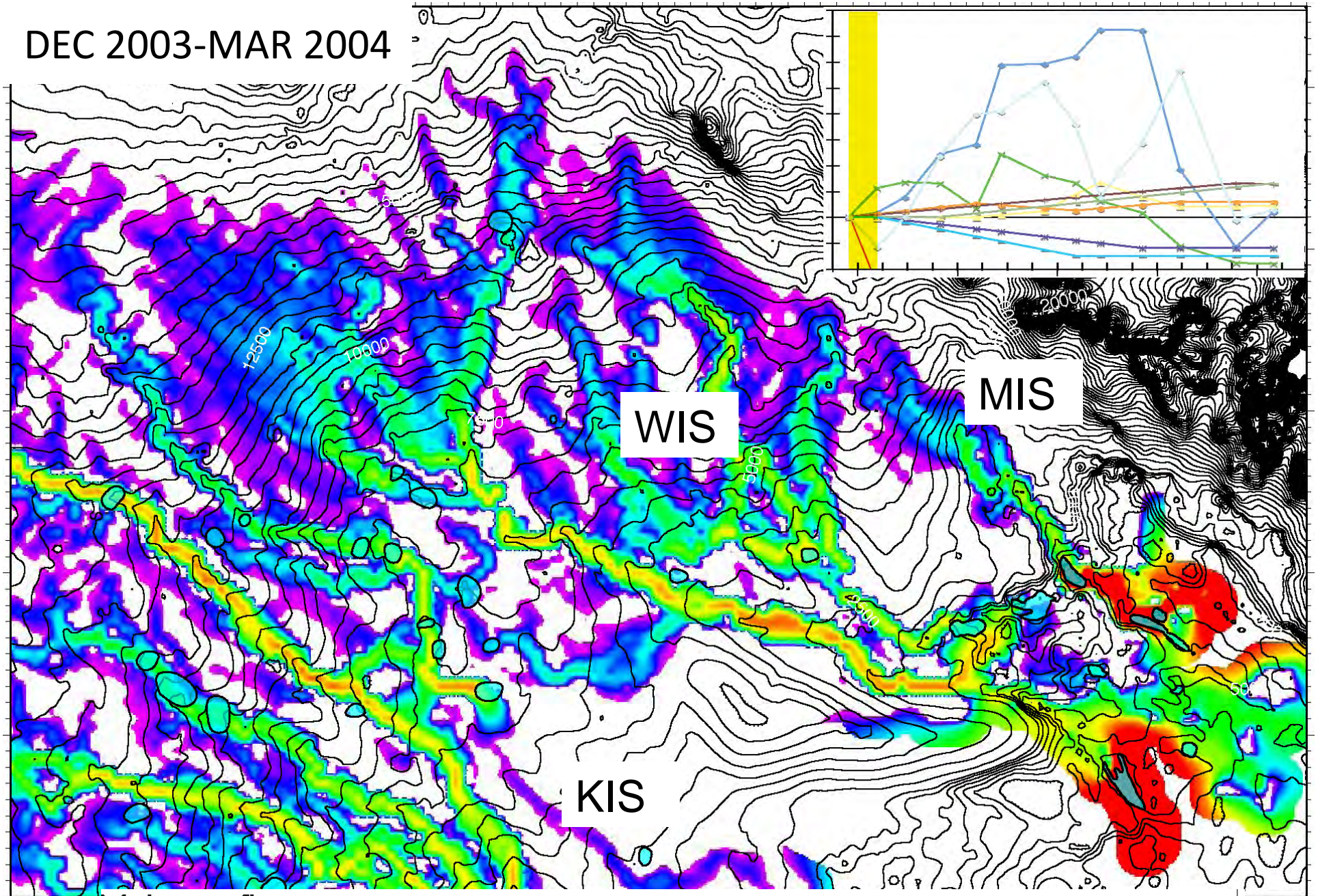


Kamb and Whillans ice streams

Time series from Smith et al (2009) and Fricker and Scambos (2009).



DEC 2003-MAR 2004

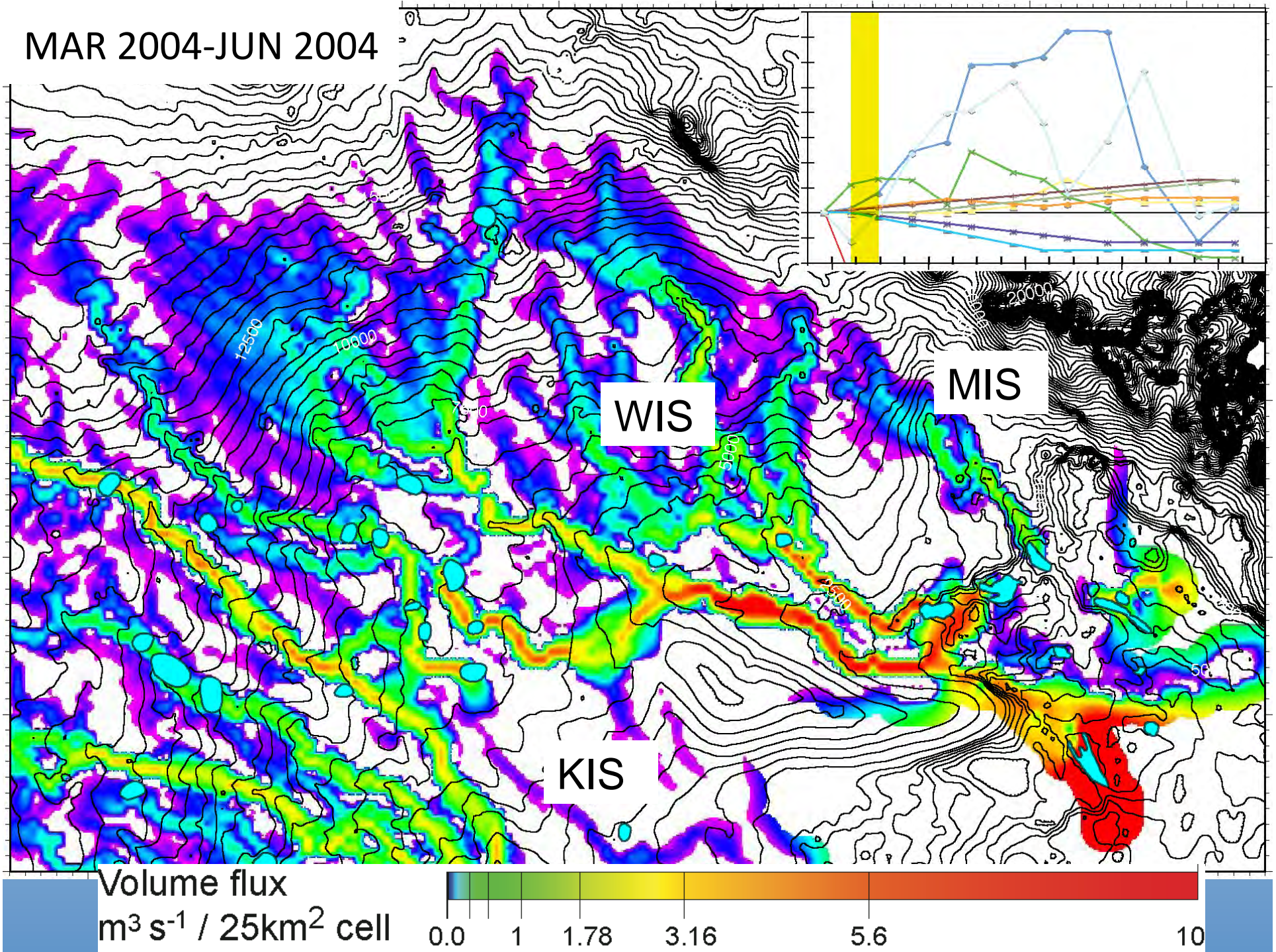


Volume flux

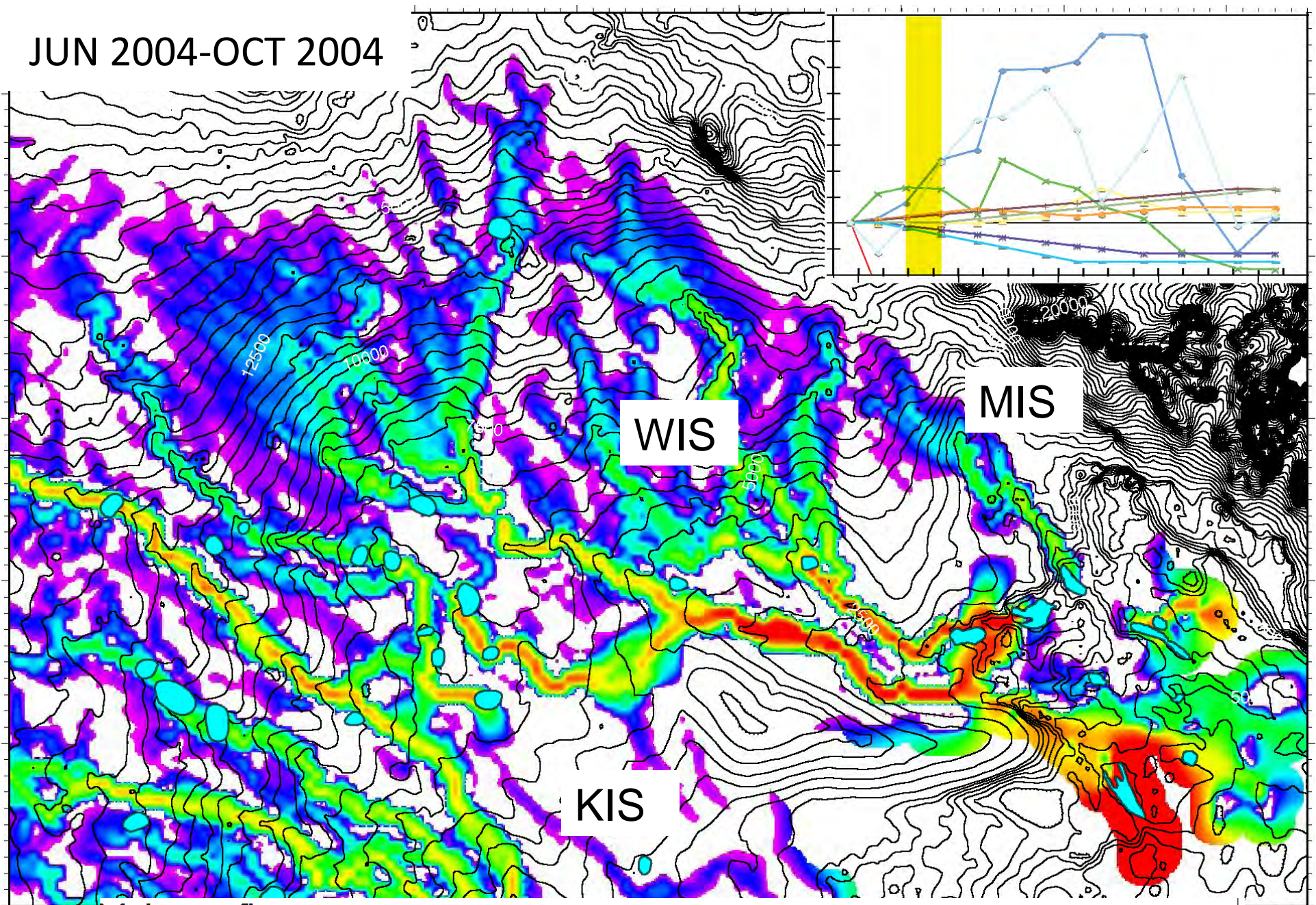
$\text{m}^3 \text{s}^{-1} / 25\text{km}^2 \text{ cell}$



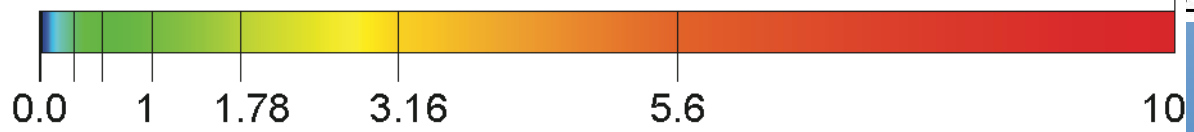
MAR 2004-JUN 2004



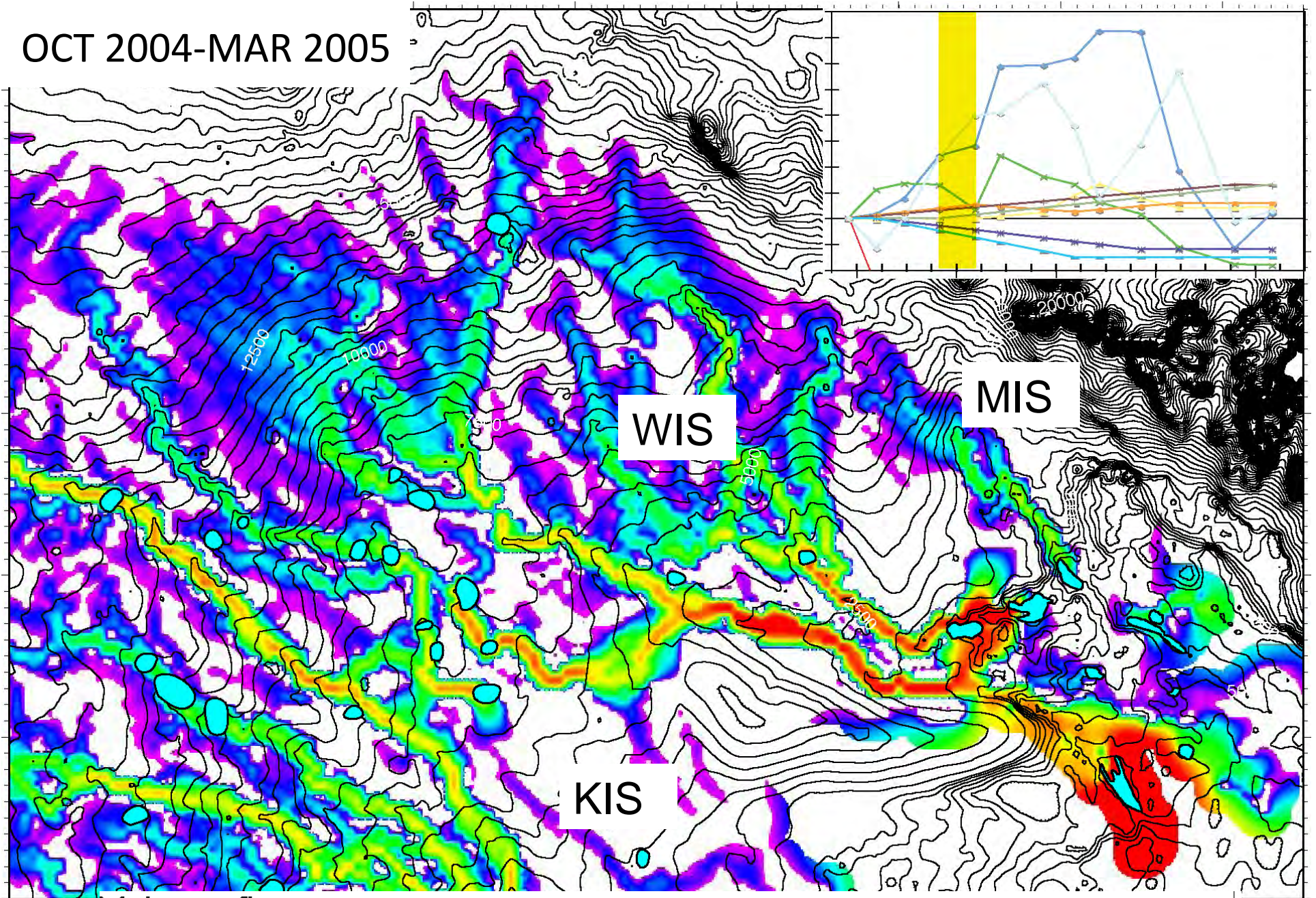
JUN 2004-OCT 2004



Volume flux
 $\text{m}^3 \text{s}^{-1} / 25\text{km}^2 \text{ cell}$



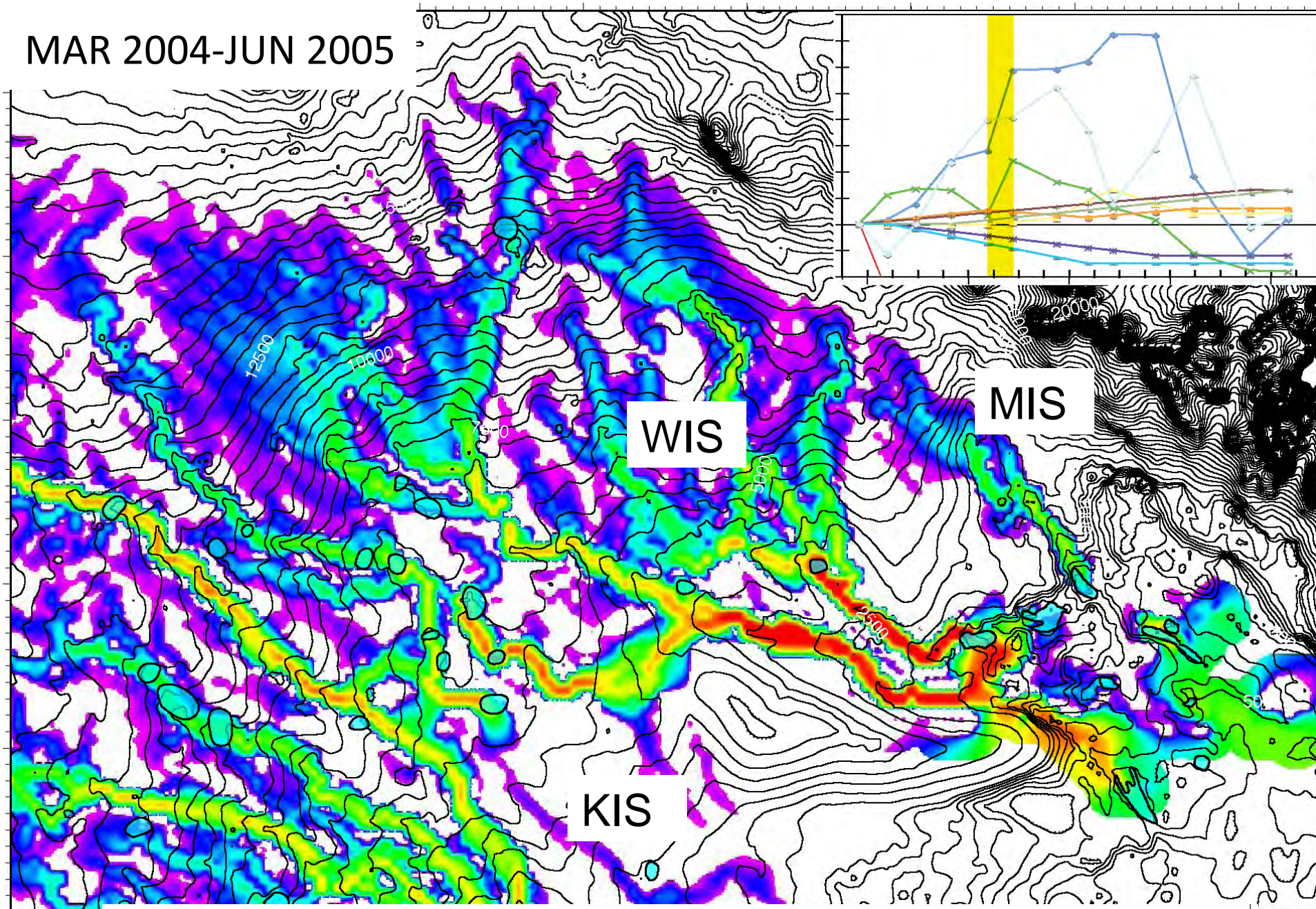
OCT 2004-MAR 2005



Volume flux
 $\text{m}^3 \text{s}^{-1} / 25\text{km}^2 \text{ cell}$



MAR 2004-JUN 2005



Volume flux

$\text{m}^3 \text{s}^{-1} / 25\text{km}^2 \text{ cell}$

0.0

1

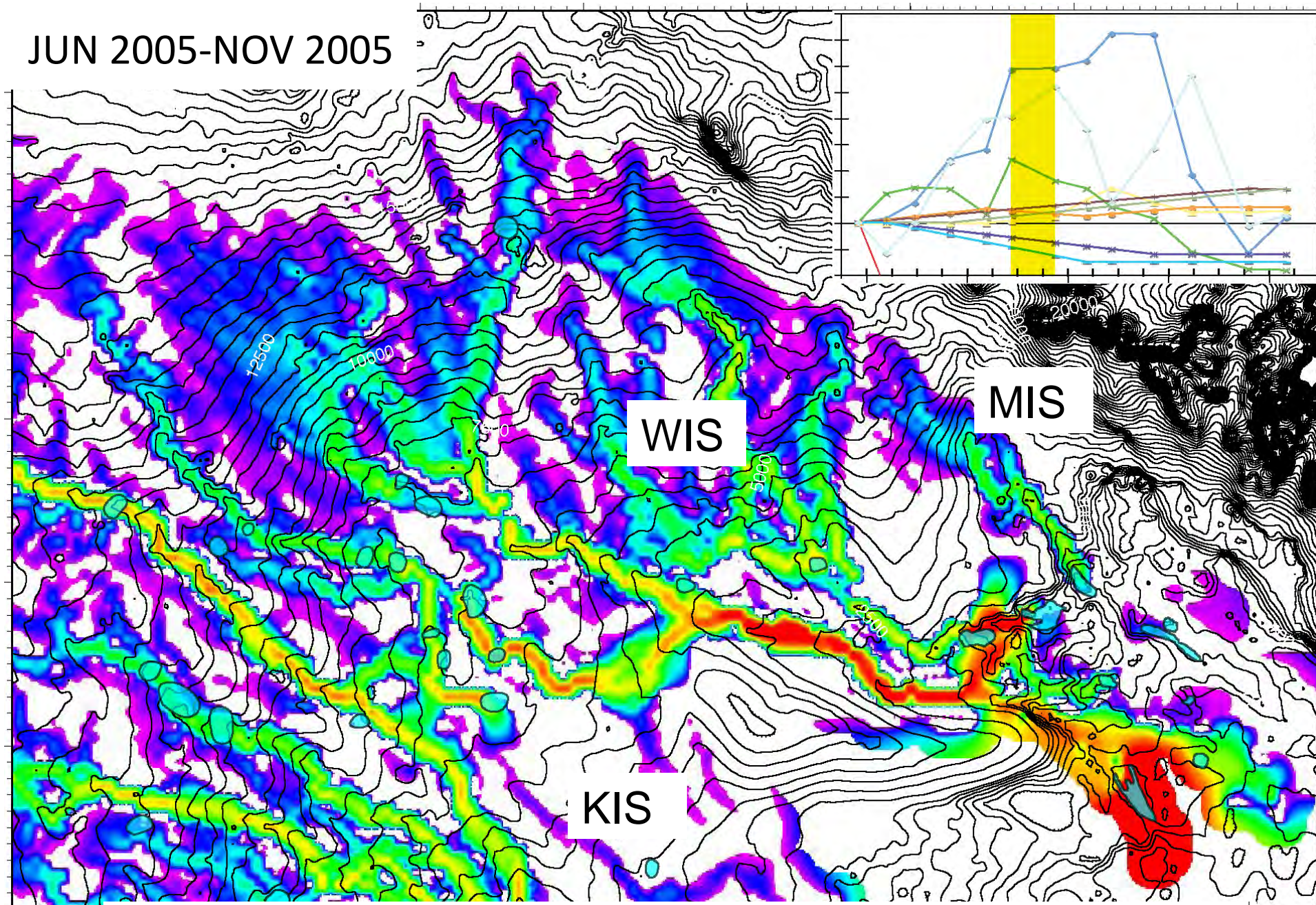
1.78

3.16

5.6

10

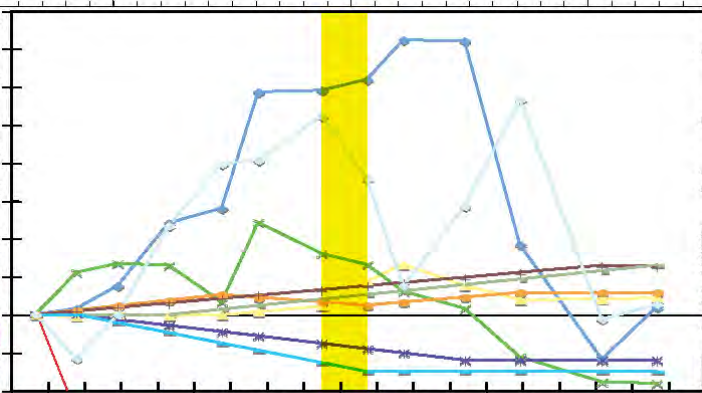
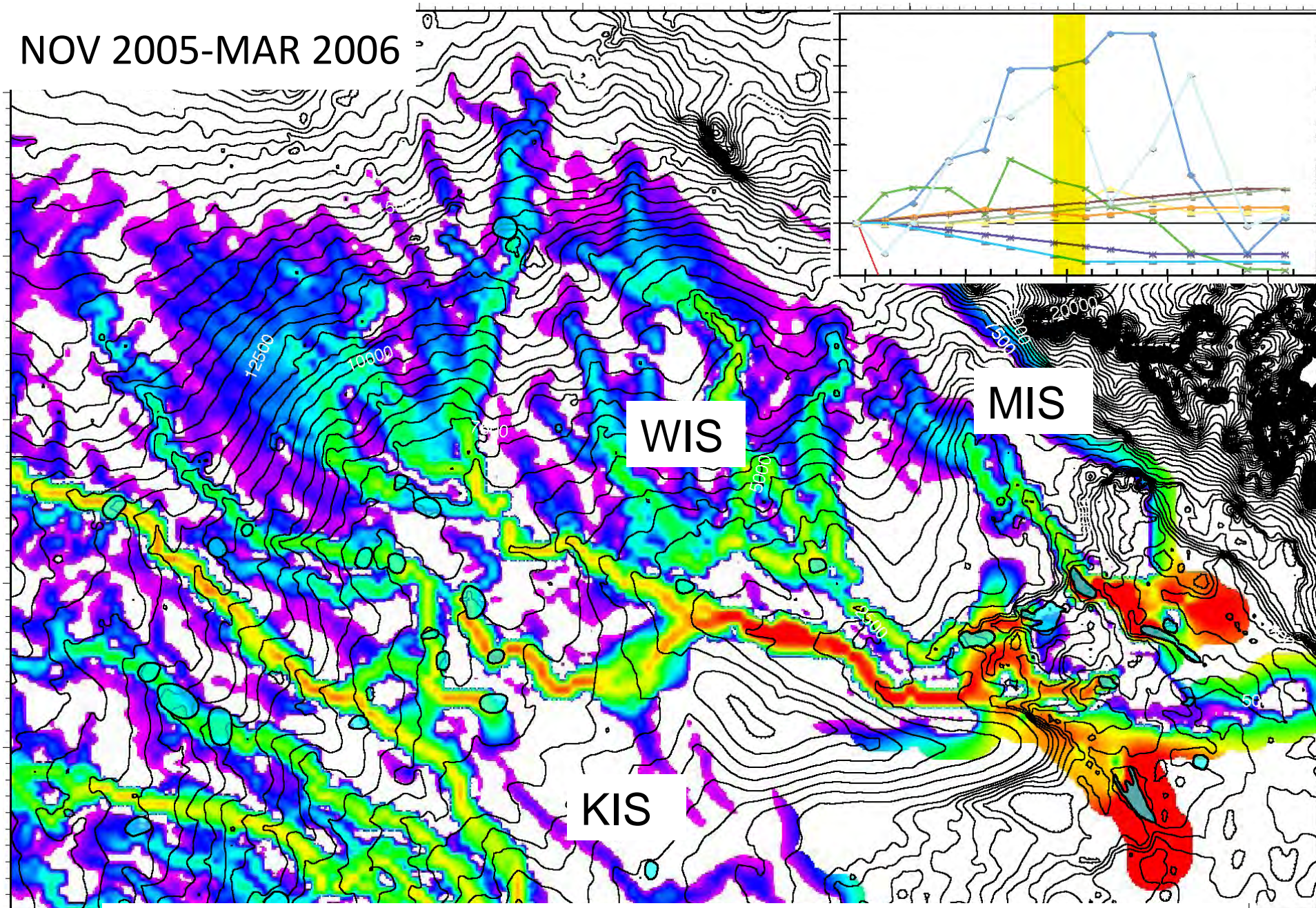
JUN 2005-NOV 2005



Volume flux
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NOV 2005-MAR 2006



Volume flux

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0.0

1

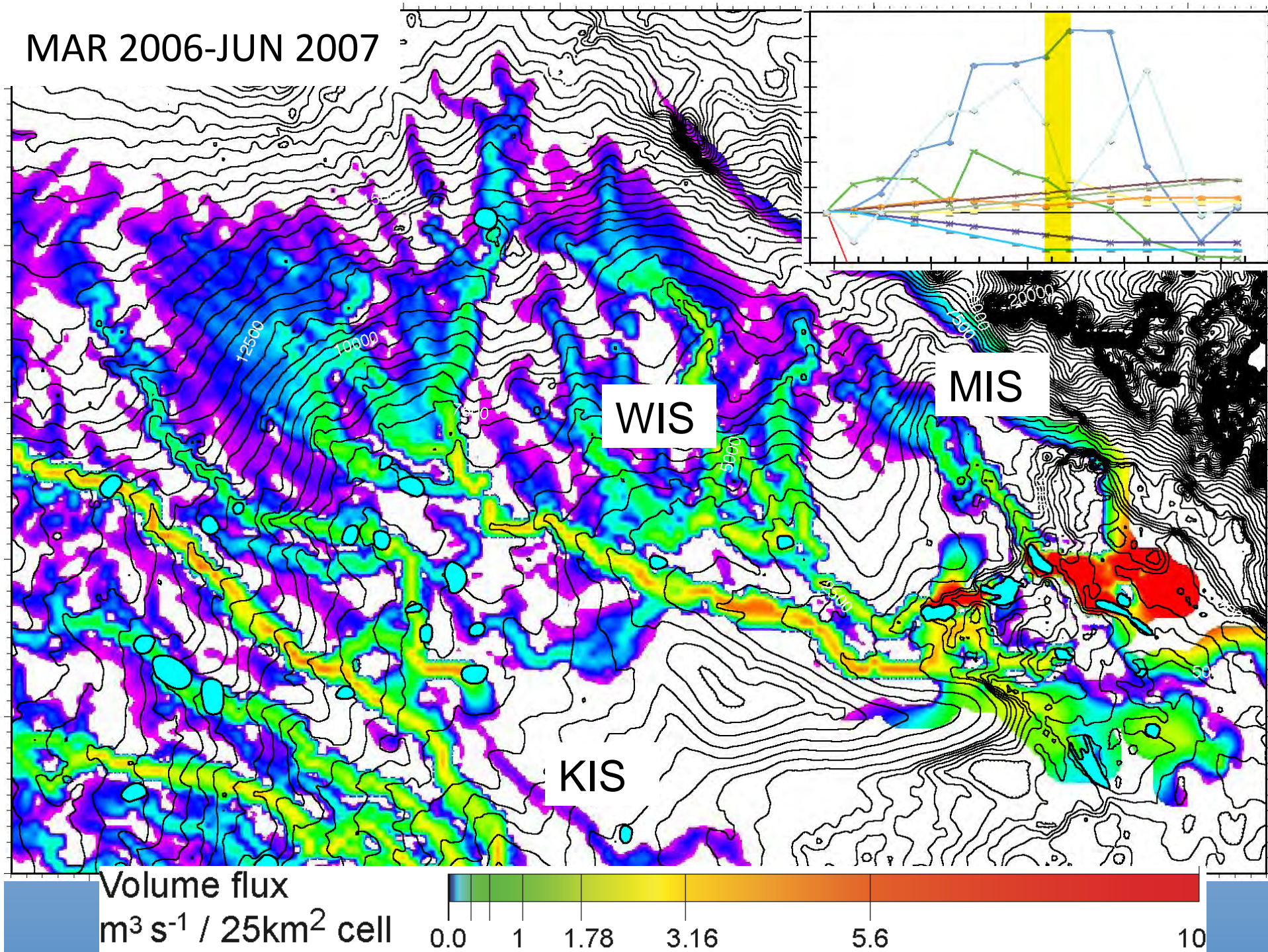
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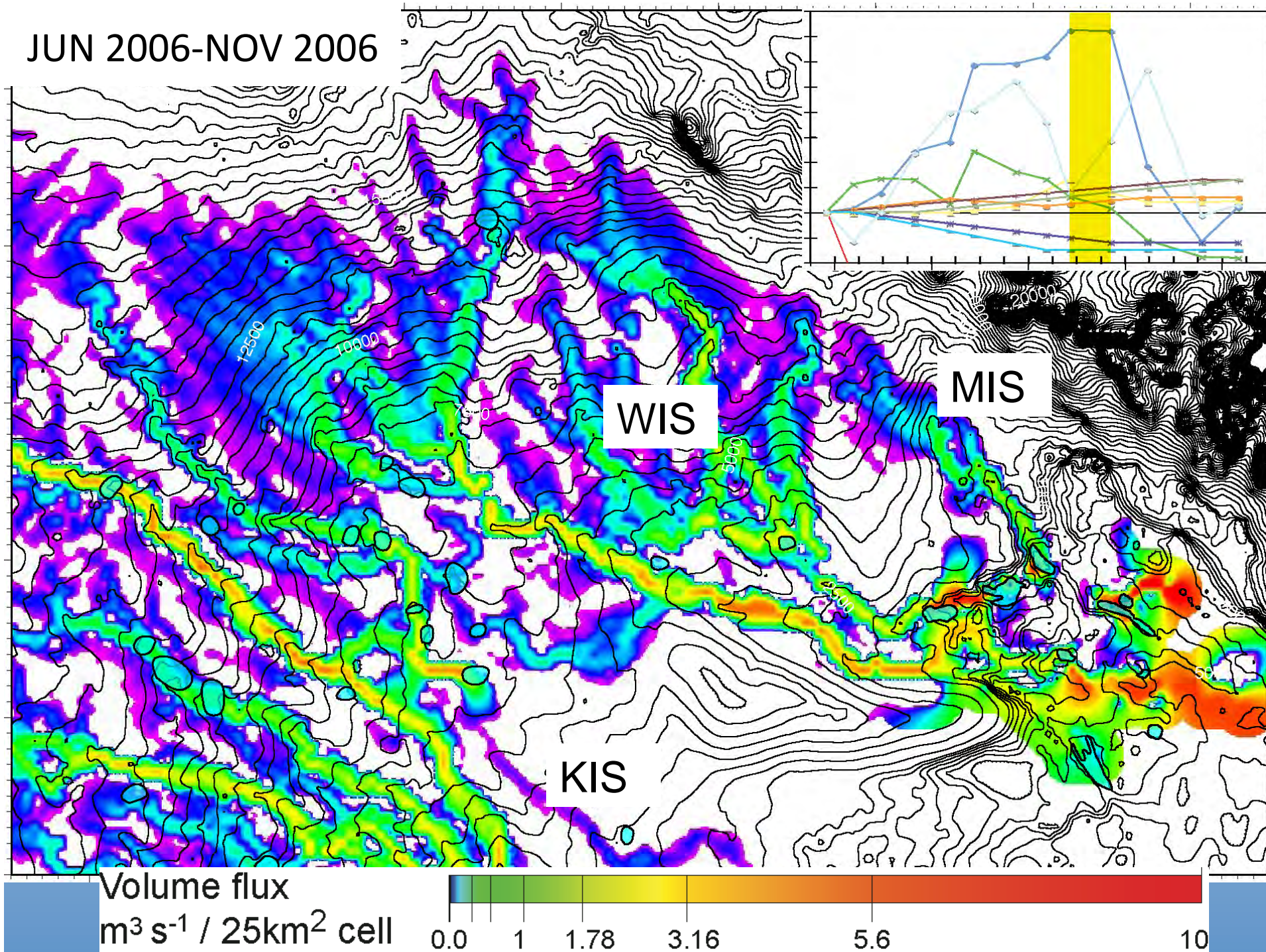
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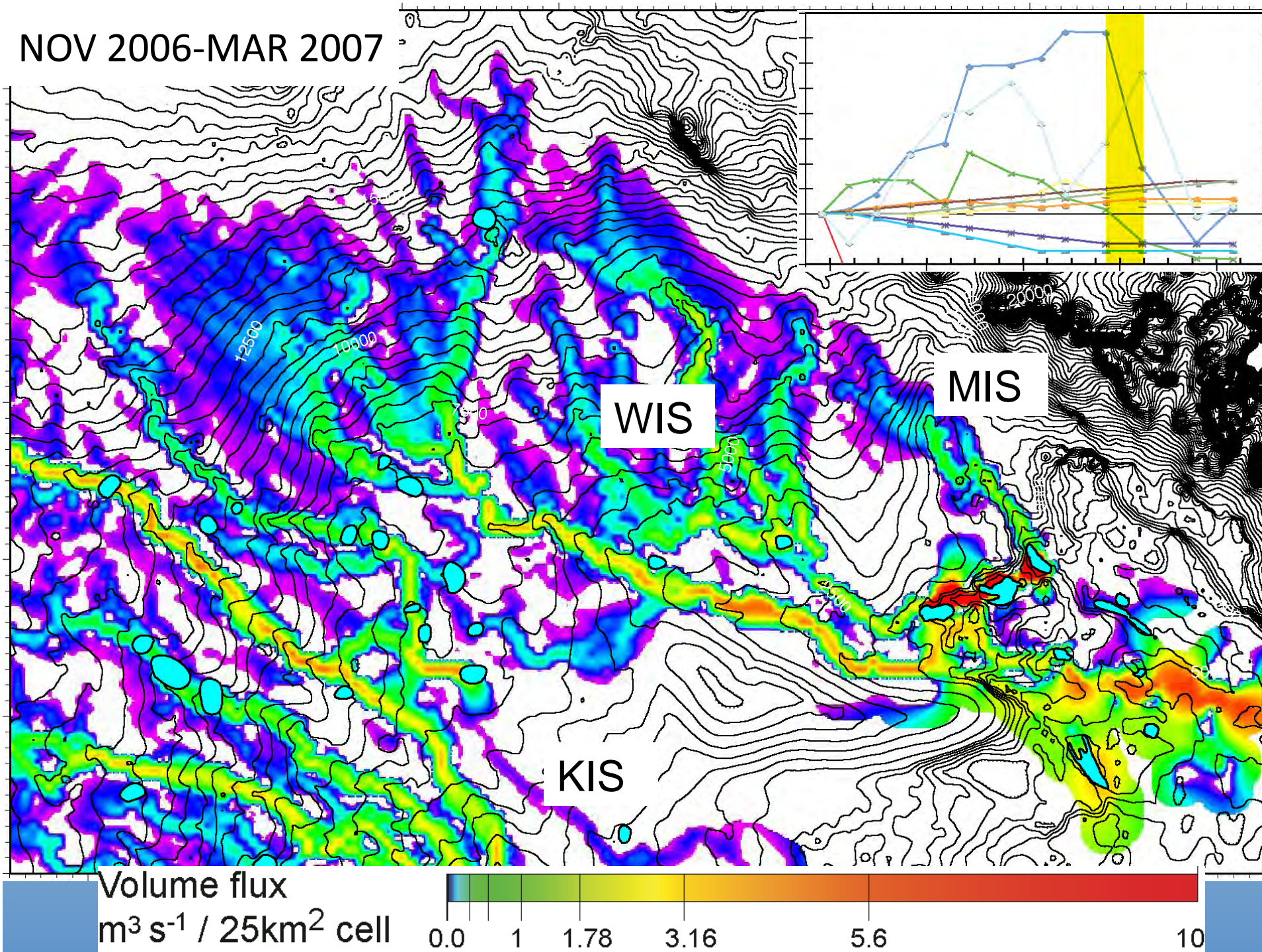
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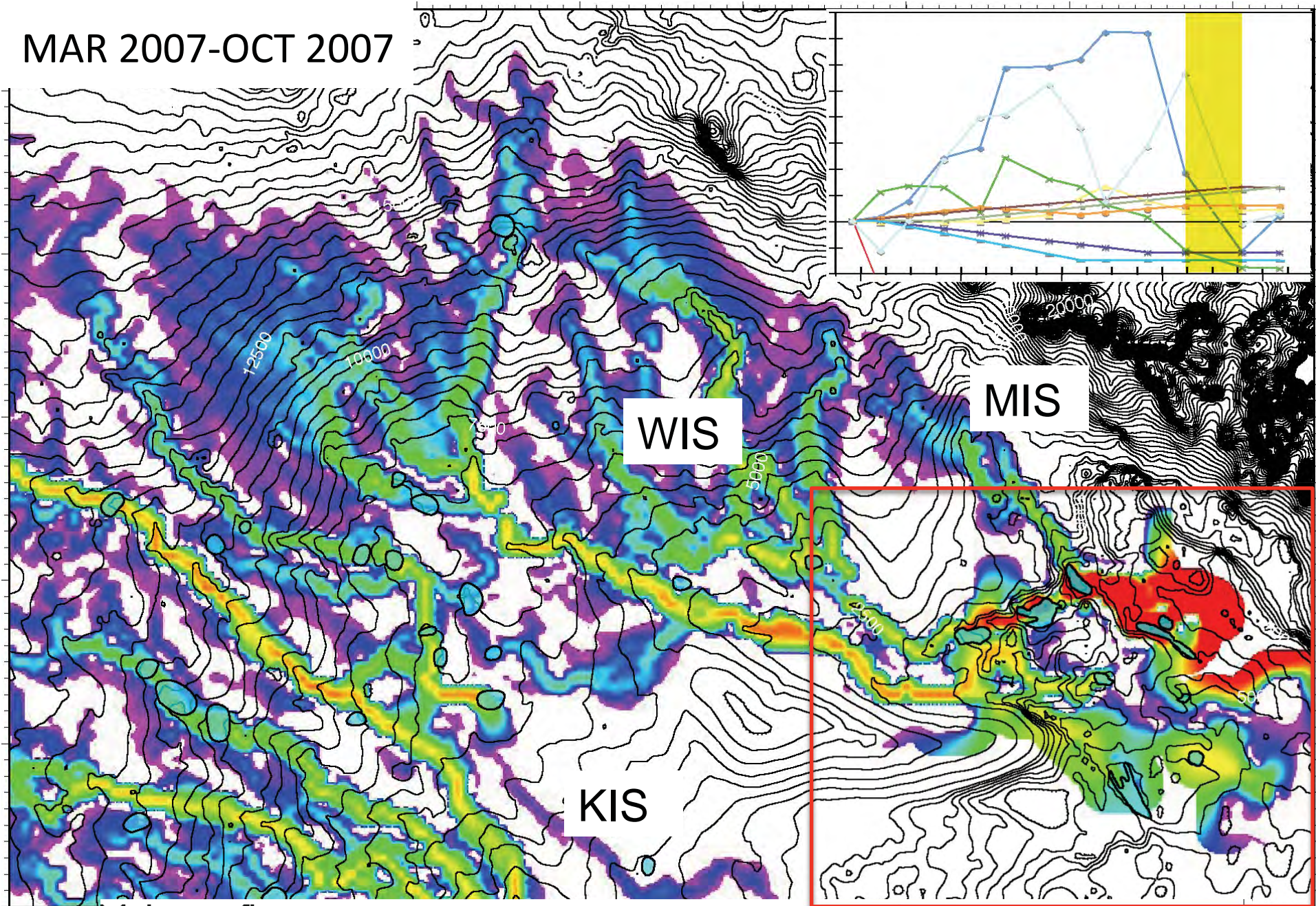
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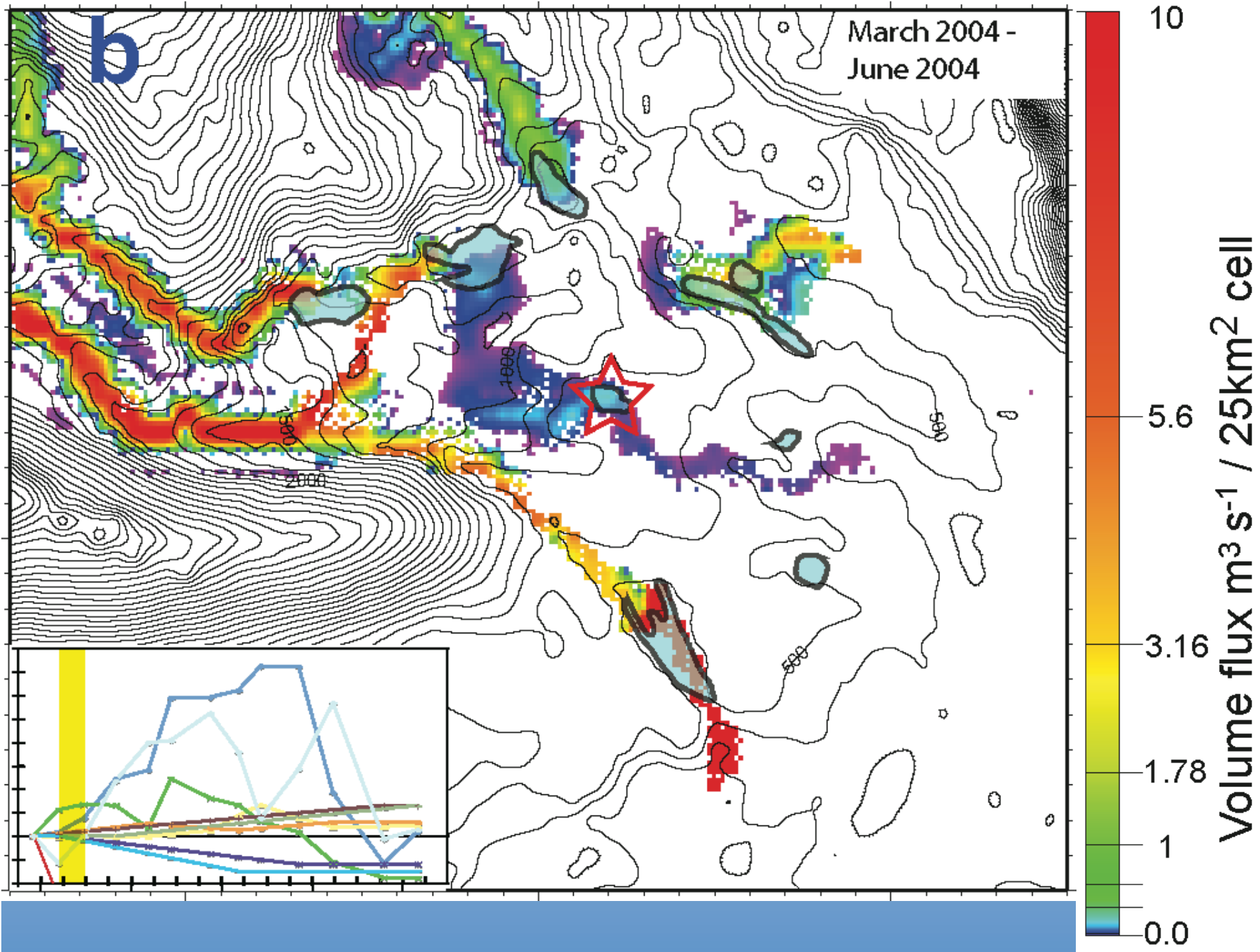


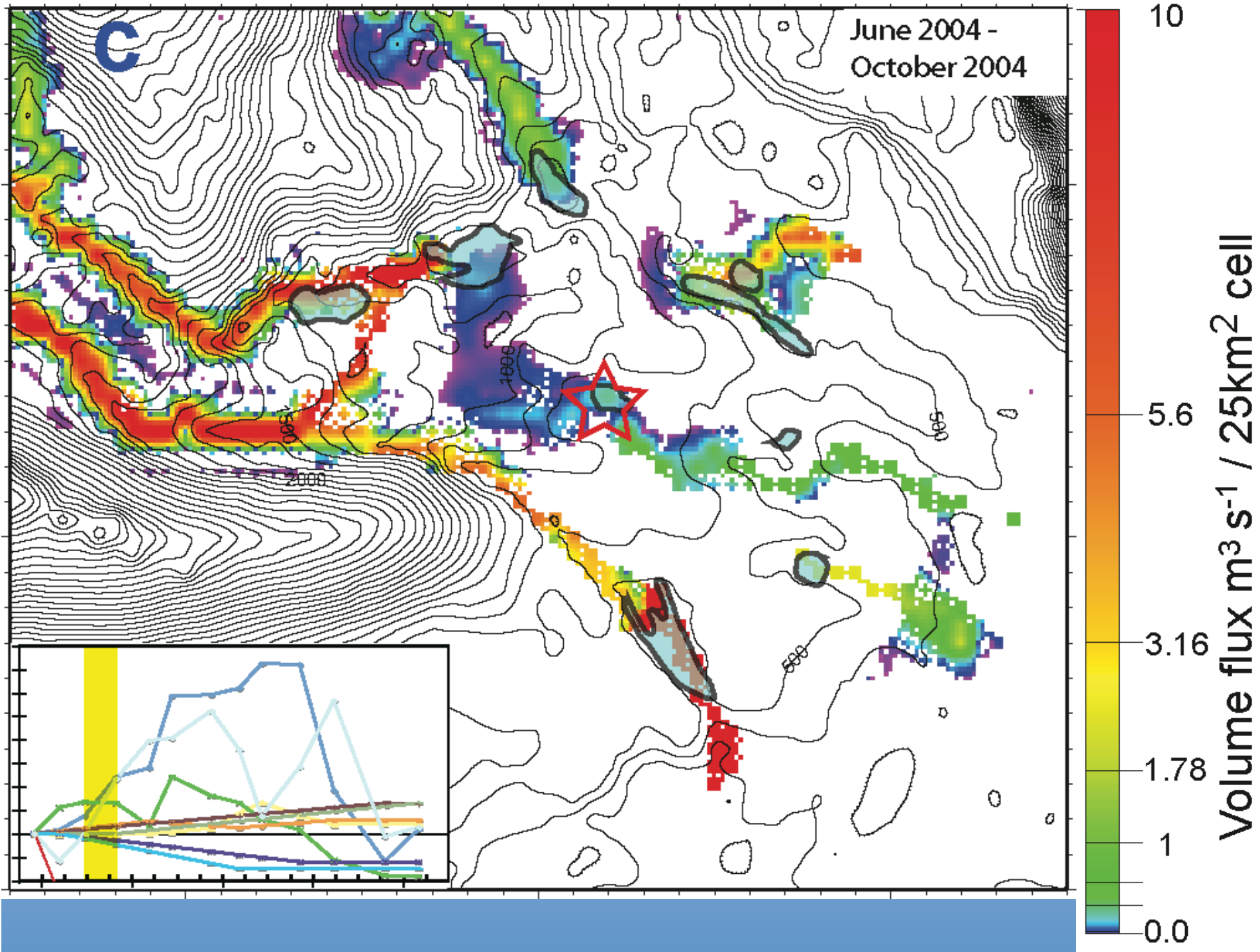
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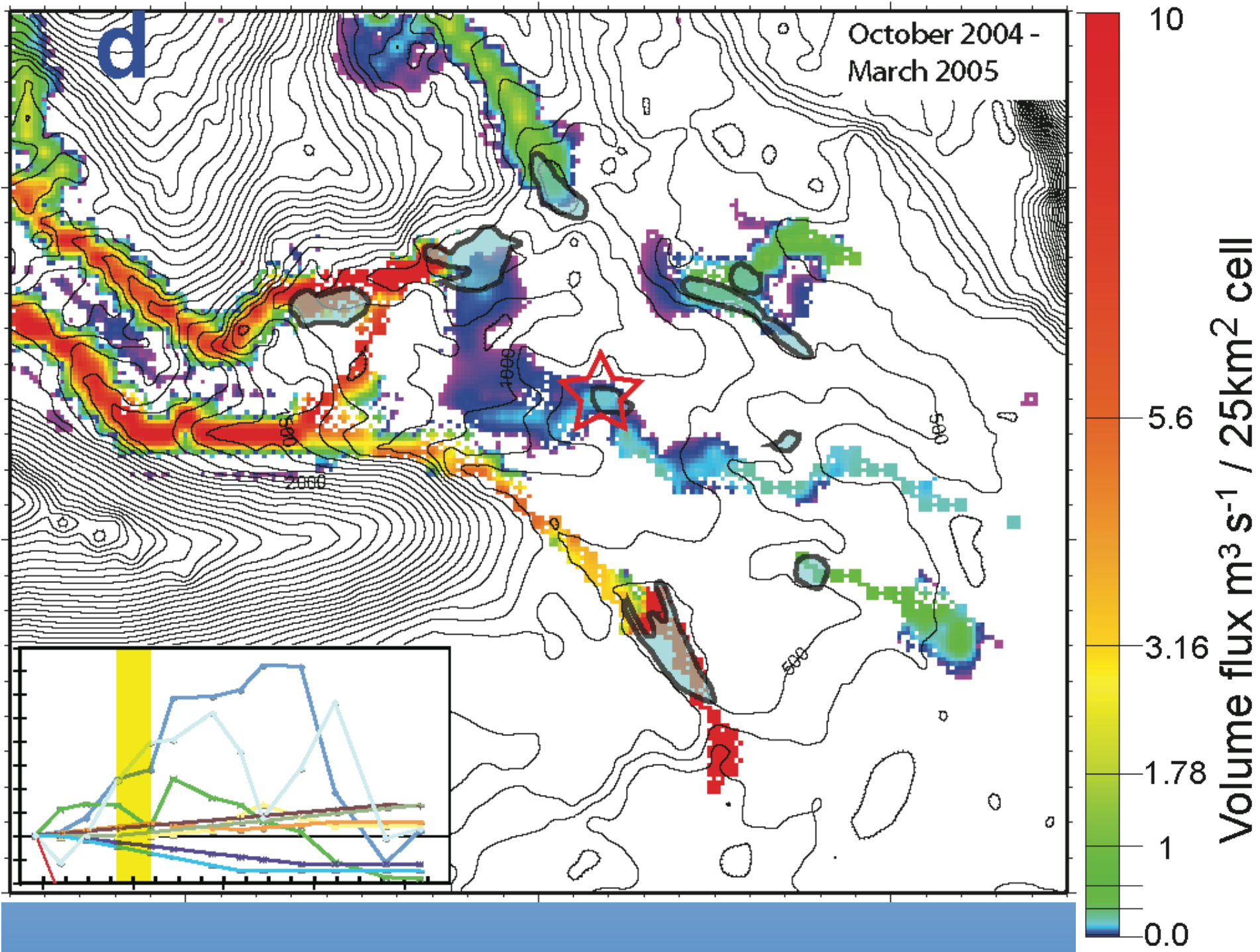


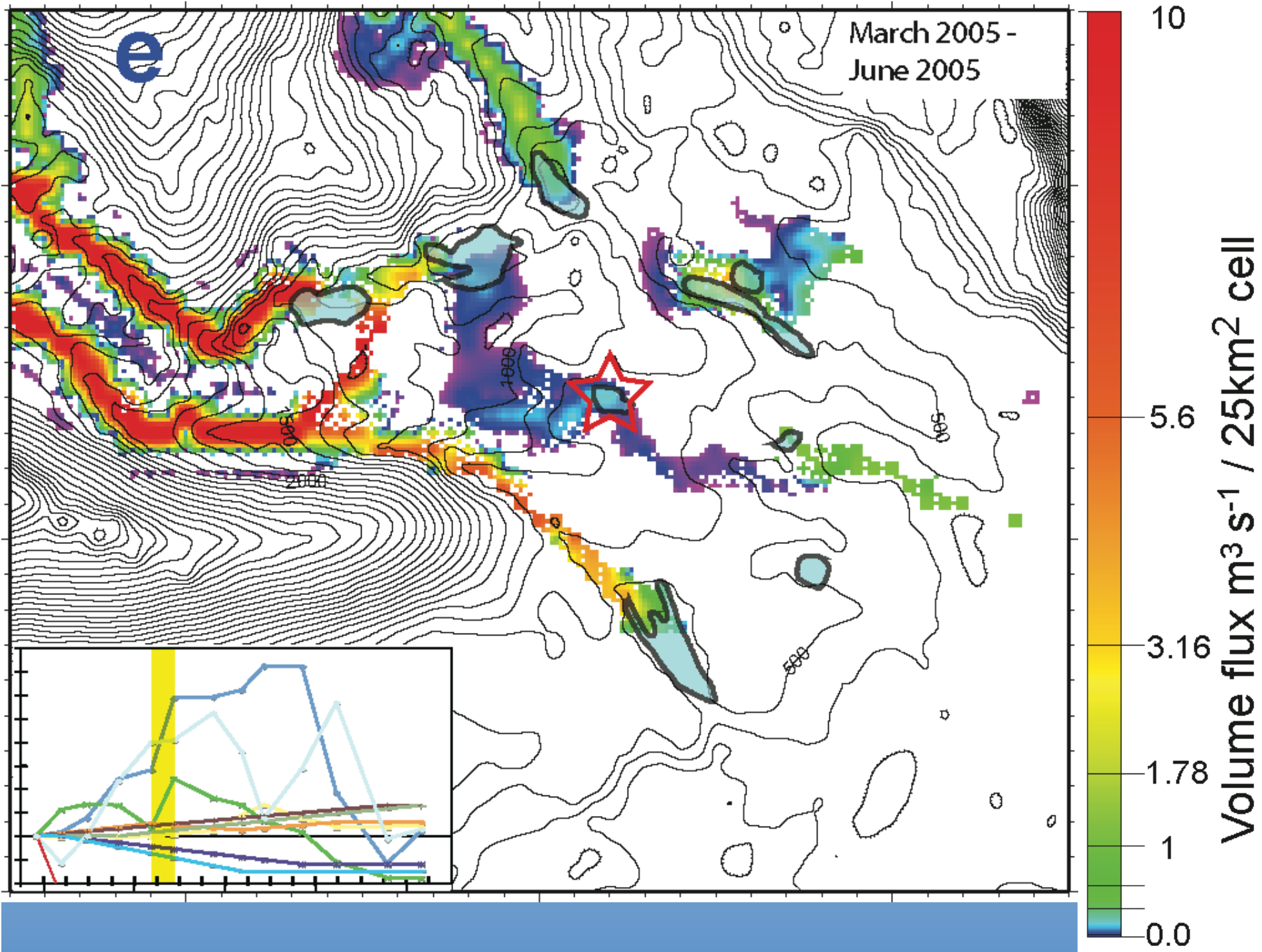
Volume flux
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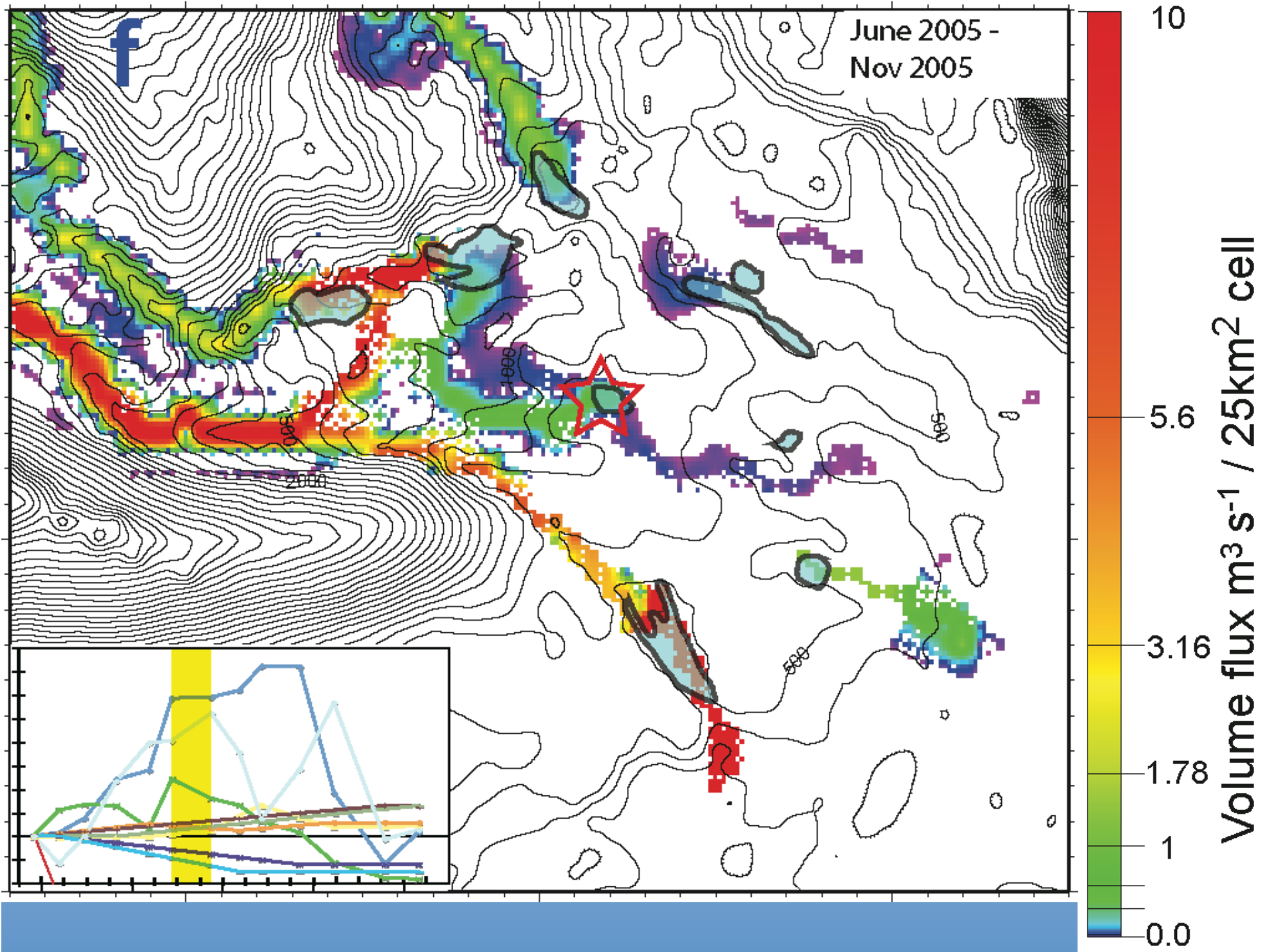


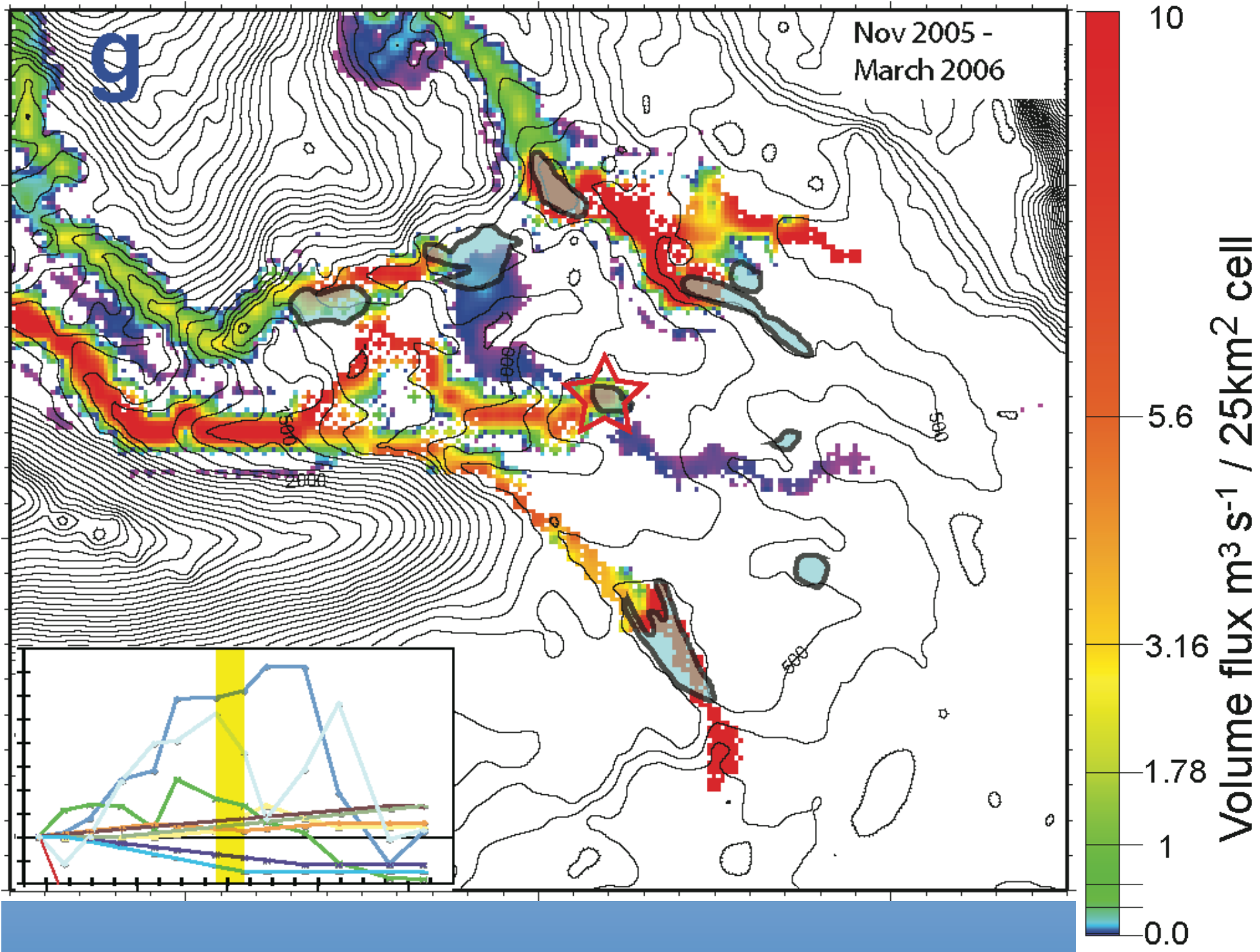


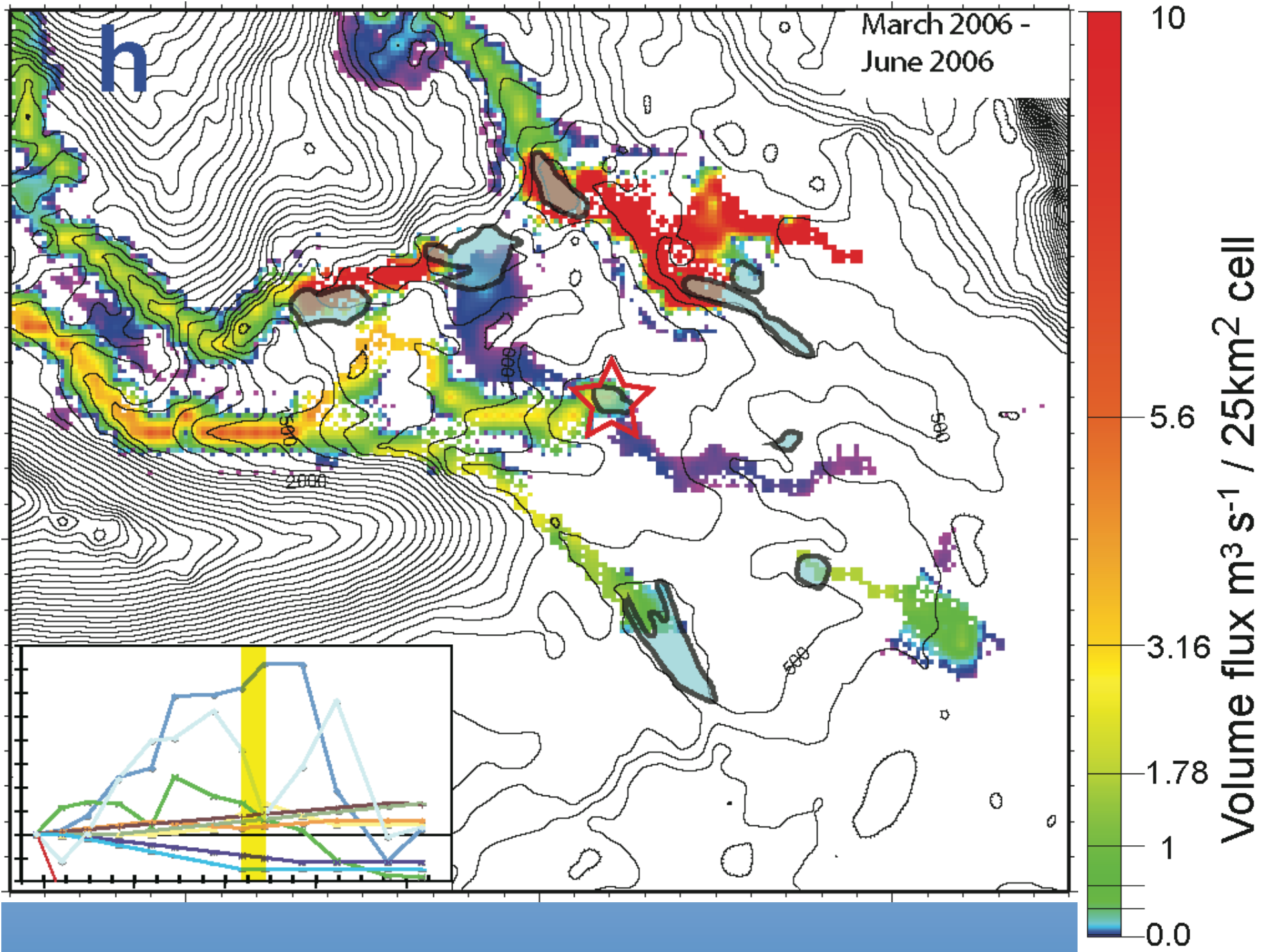


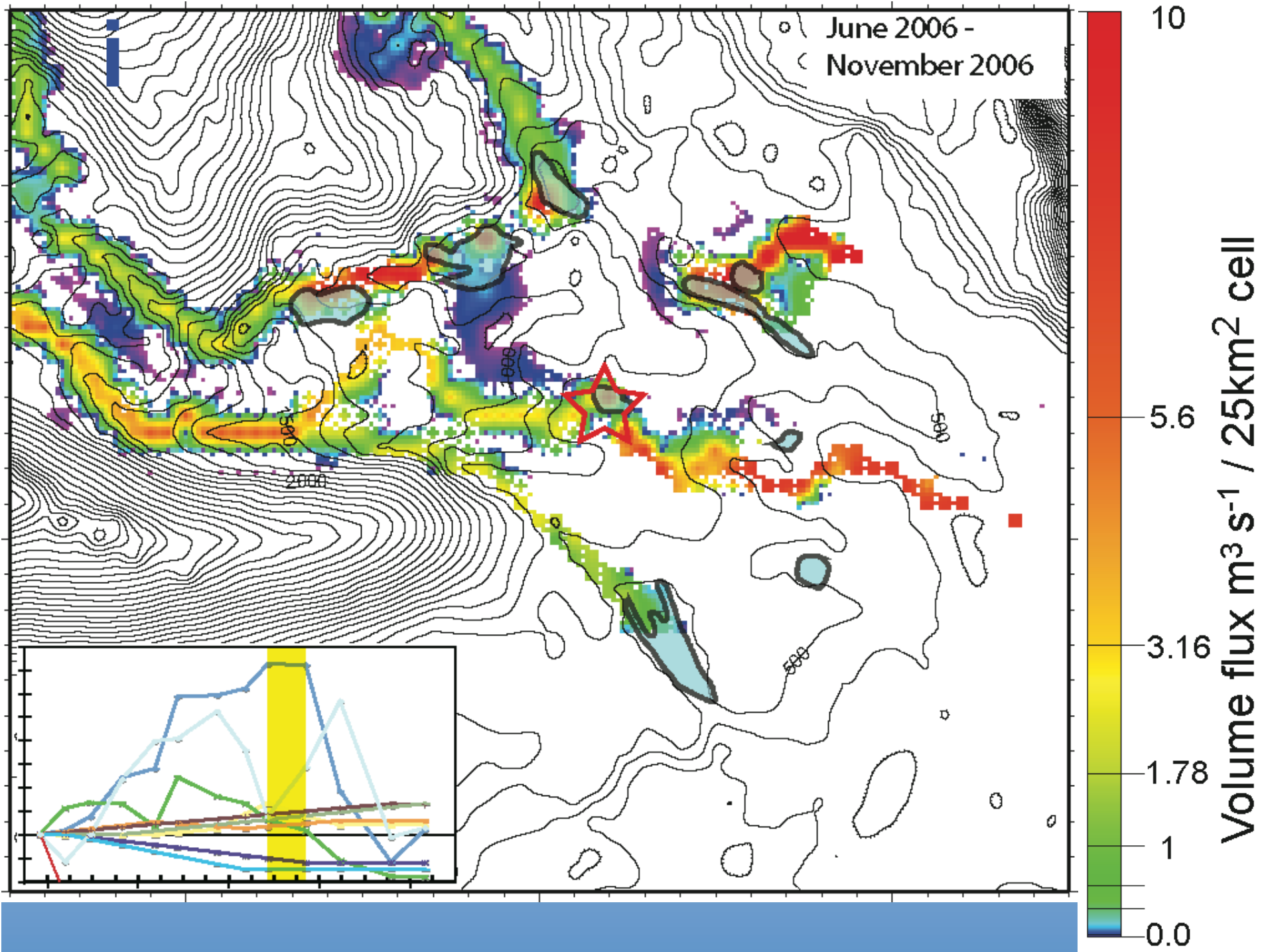


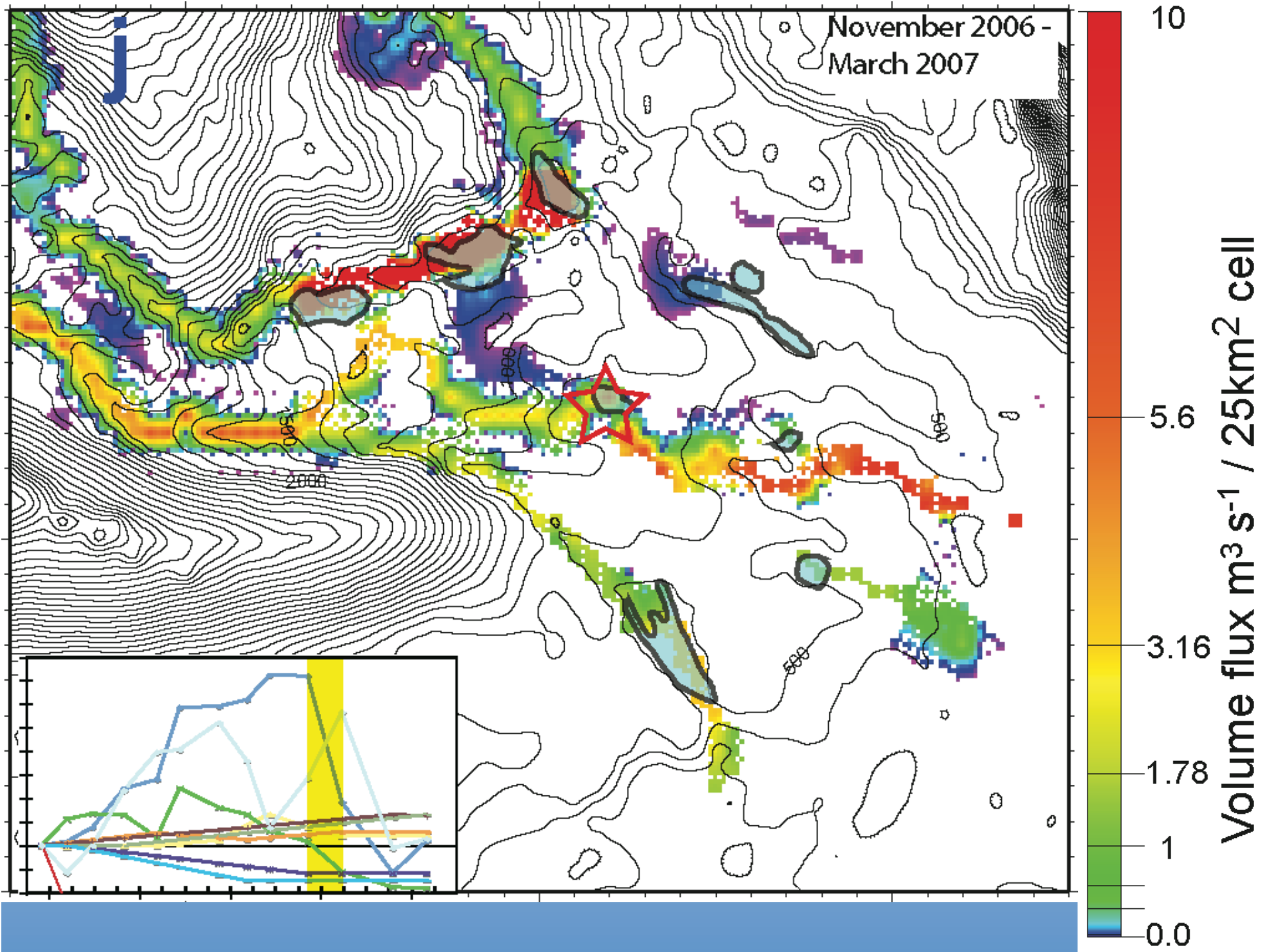


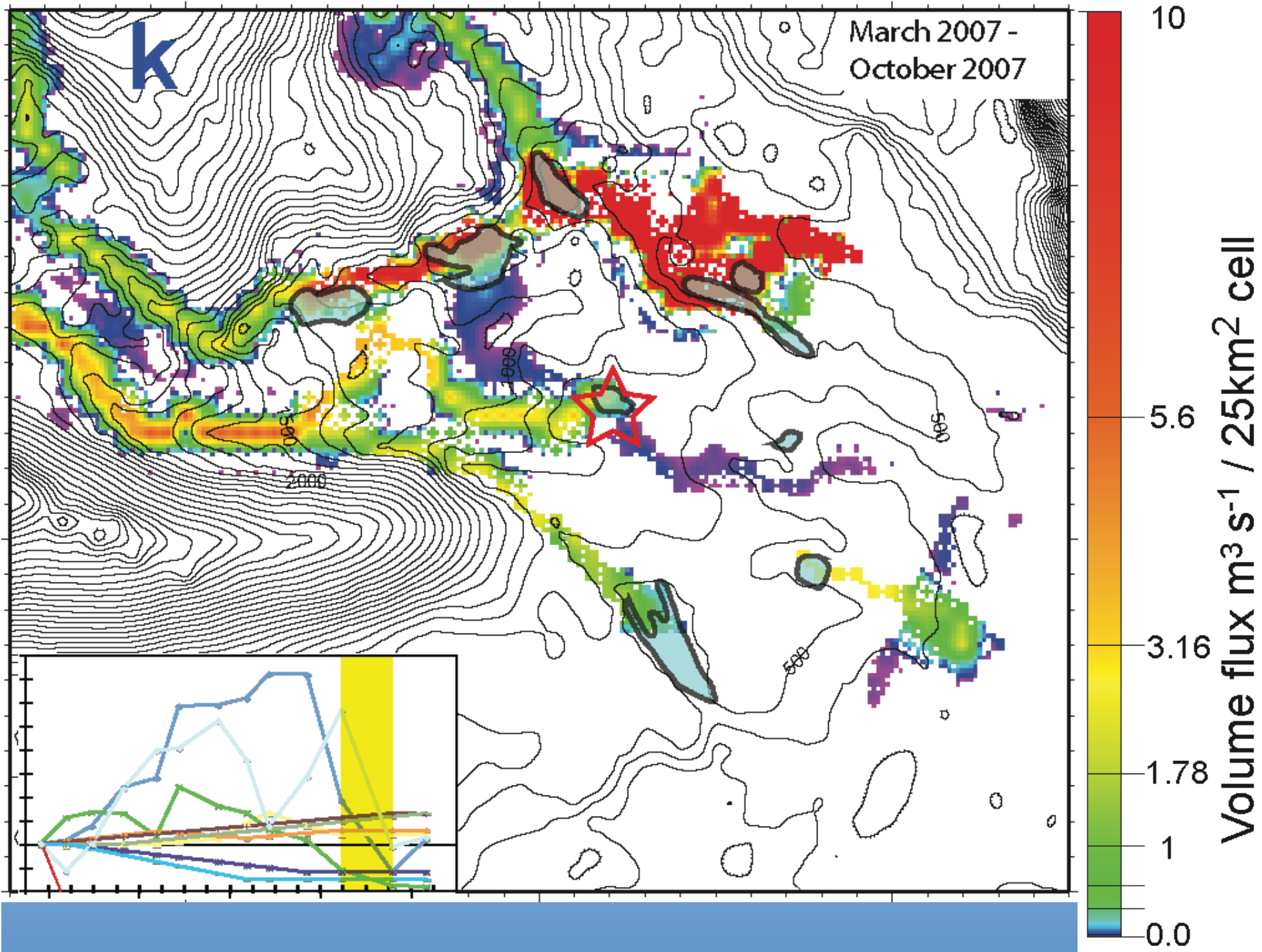






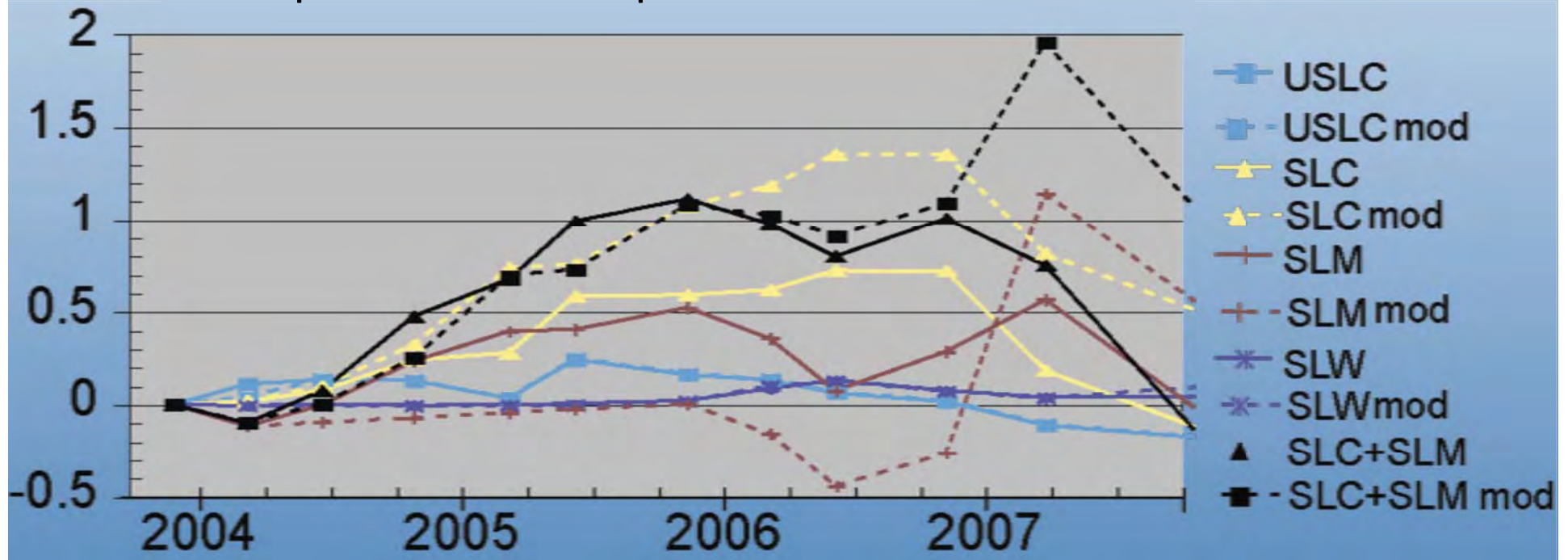




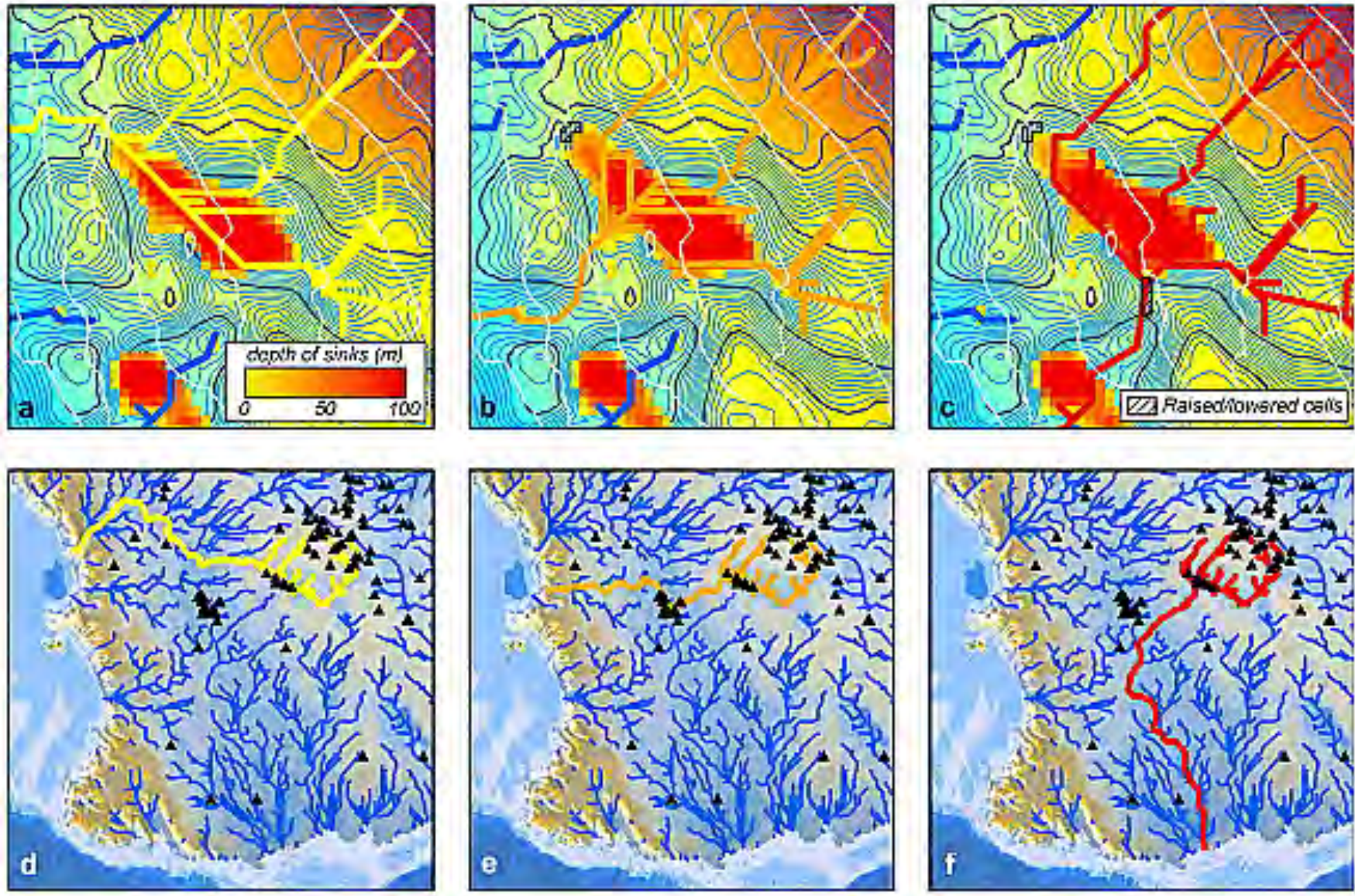


Water Budget Balances But . . .

- Only as good as your melt rates
- Needs really precise Surface bed topography
- Precise lake geometry
- ICESat I time series (2003-2009)
- Works great for well surveyed Siple Coast
- Other places and time periods lack sufficient data

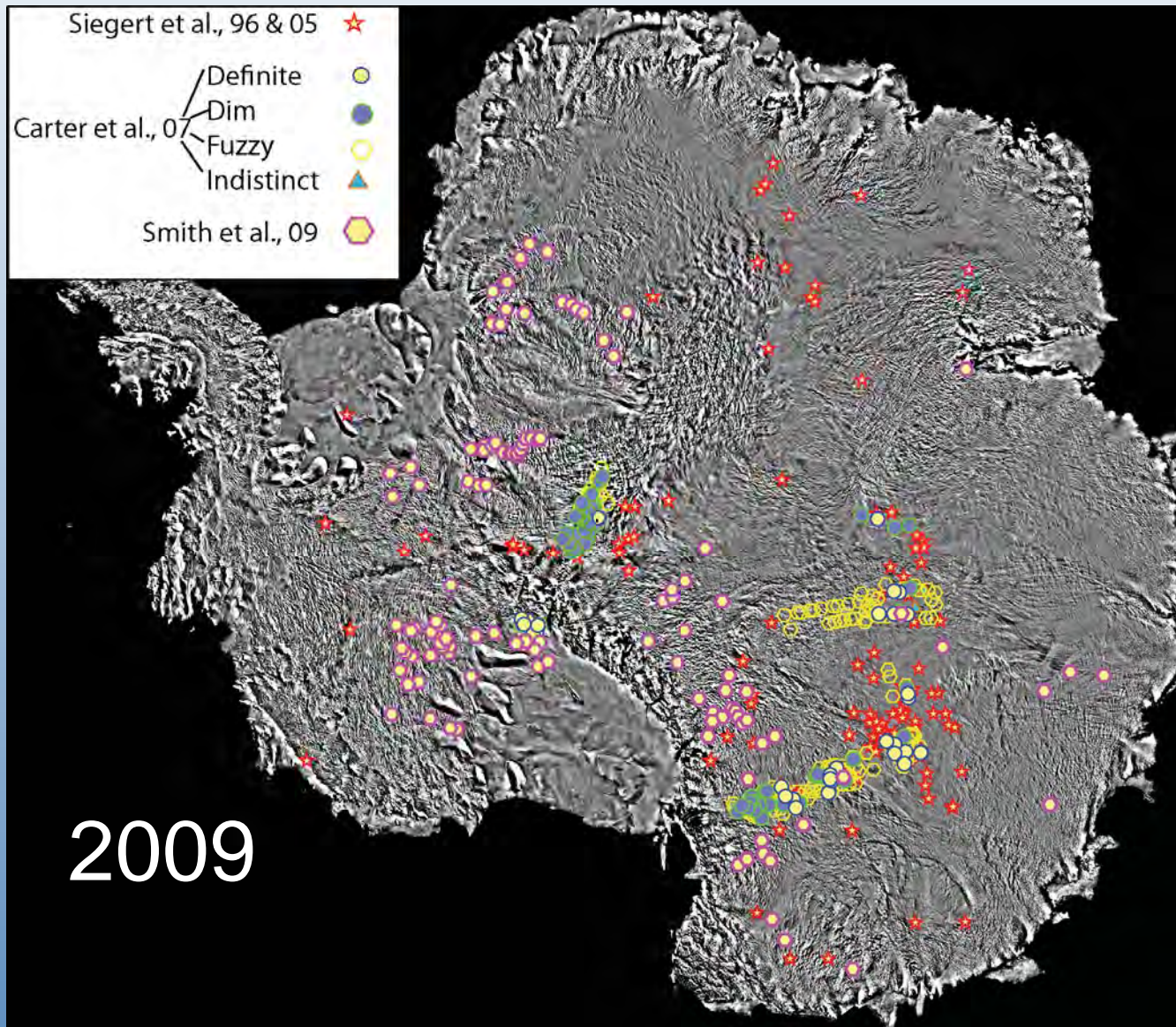


Small changes in surface elevation redistribute water substantially



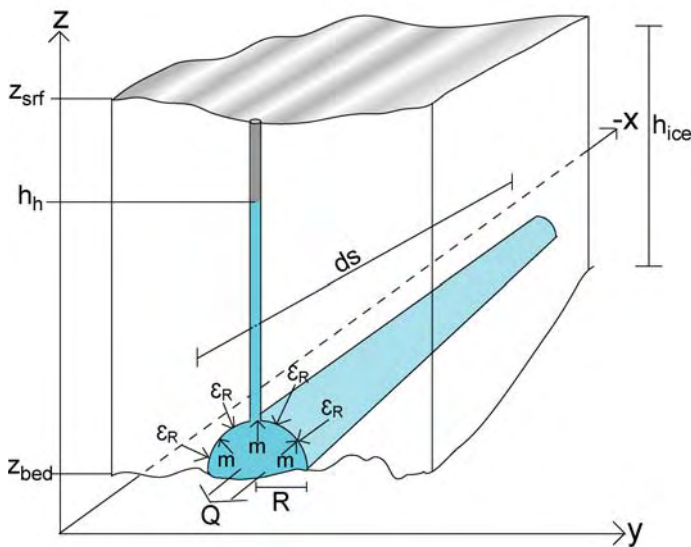
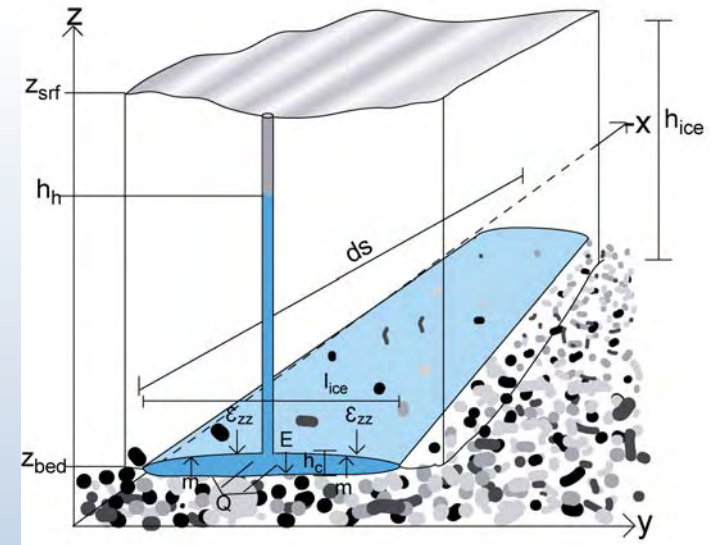
Wright, A. P., M. J. Siegert, A. M. Le Brocq, and D. B. Gore (2008), High sensitivity of subglacial hydrological pathways in Antarctica to small ice-sheet changes, *Geophys. Res. Lett.*, 35, L17504, doi:10.1029/2008GL034937.

- Lakes are prevalent in most fast flowing regions of Antarctica
- Where they are present water distribution varies considerably over the ICESat Observation cycle

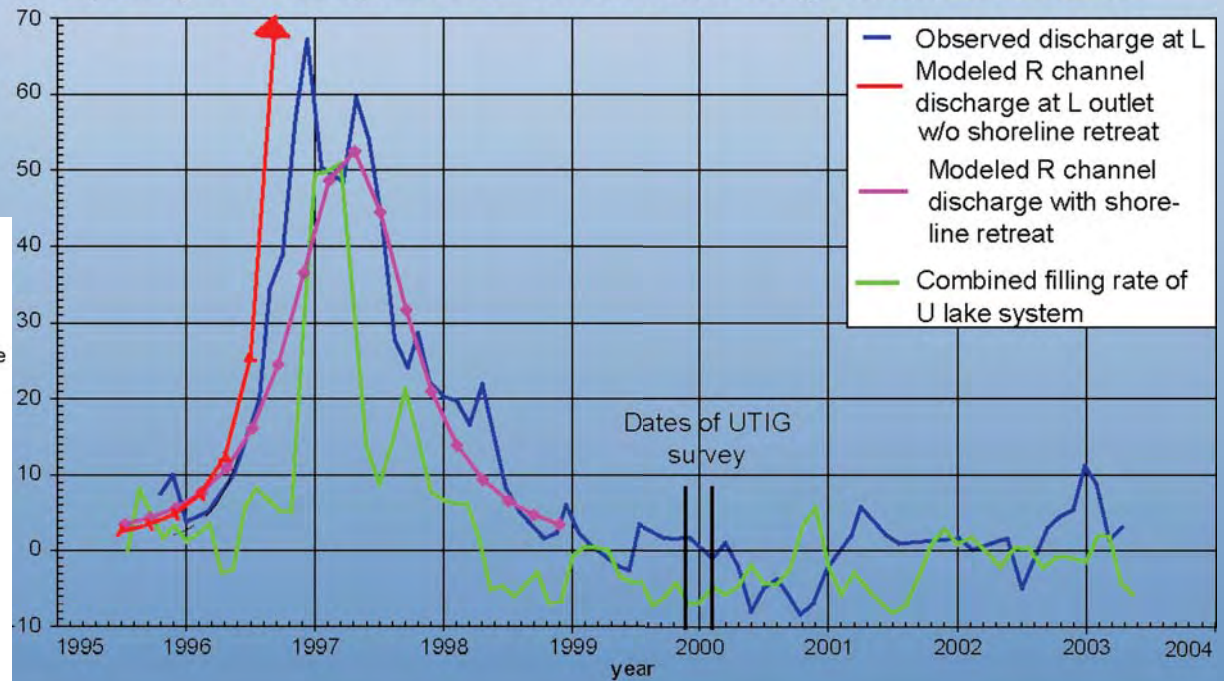


Ongoing work

- Flood evolution
 - Channelization
 - Triggering
 - Effective pressure / sliding
- Lake / ice velocity / basal traction feedback
- Surging Ice sheets?



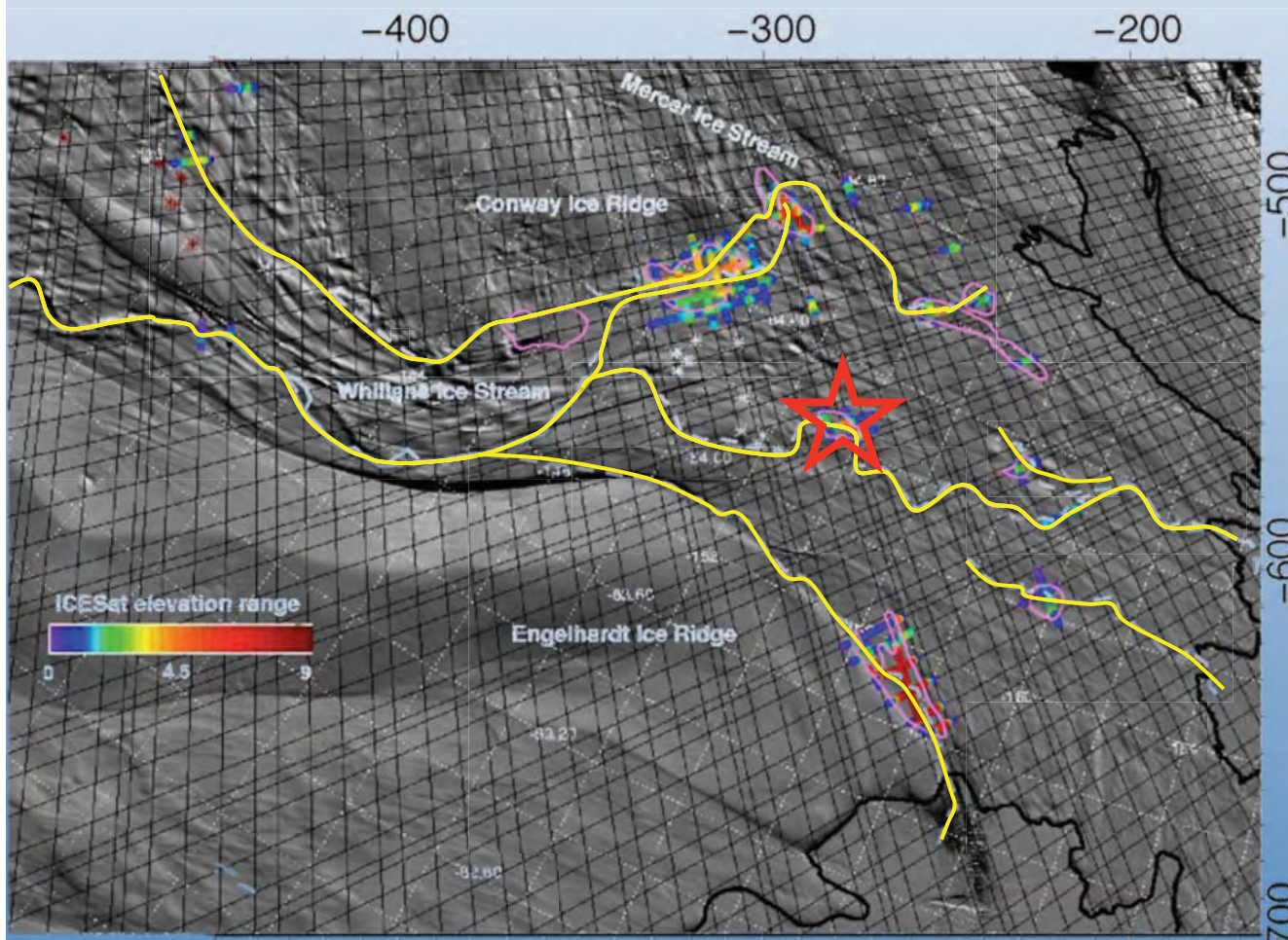
A) Filling and draining rates of Adventure Trench Subglacial Lakes 1995-2003



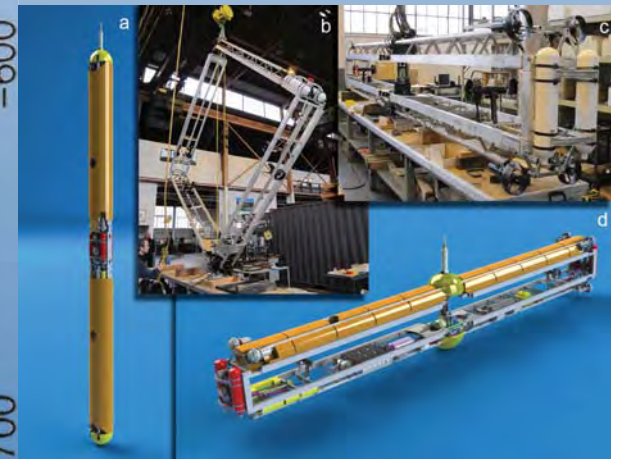
(Carter et al., 2009)

Hope and approximations

- Floods primarily affect flow paths (we can do 1-D water flood models)
- Lakes seem to be very close to floatation when they flood
- Flood duration and magnitude relates to surface slope



More data
arriving all the
time



Conclusions

- Lakes greatly influence water distribution over time
- Outbursts could either deliver more water to areas which would otherwise not receive it or channelize water and limit its ability to lubricate
- Subglacial water systems in fast flowing regions highly sensitive to small changes in surface elevation

Special thanks to:

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