ISOCAM Long Term Transient
Description and Correction

Application to Galactic cirrus

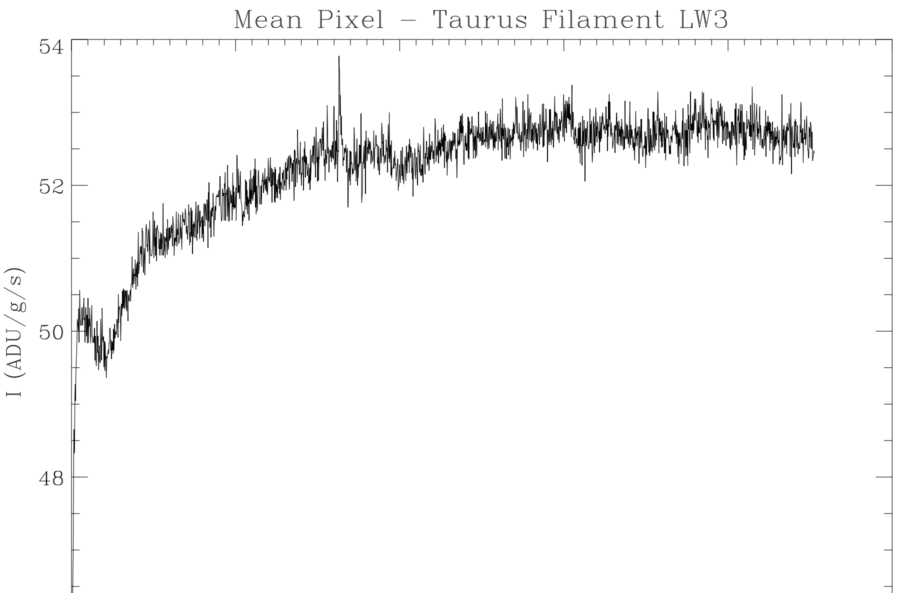
Marc-Antoine Miville-Deschênes
Institut d'Astrophysique Spatiale

Long Term Transient (LTT) - Description

- Very slow flux stabilization (few % per hour).
- Not taken into account in the usual transient correction.
- Could completely dominate large scale emission.
- The LTT seems to be smaller for small flux steps.
  - **No LTT observed on dark observations.**
- The LTT not always present $\rightarrow$ **not reproducible.**
- The LTT is globally rising (oscillations observed).

In Short:

- We don't know where it comes from.
- We can't predict it.
- We can't correct it.


Mean Pixel – Taurus Filament LW3
I (ADU/g/s)
t (sec)
46
48
50
52
54
0
1000
2000
3000
4000
5000

Determination of the LTT using the spatial redundancy of raster observations

- The LTT is difficult the characterize:
  - Small amplitude effect - difficult to extract from the data
  - Not reproducible...
  - No model available to deconvolved the flux.

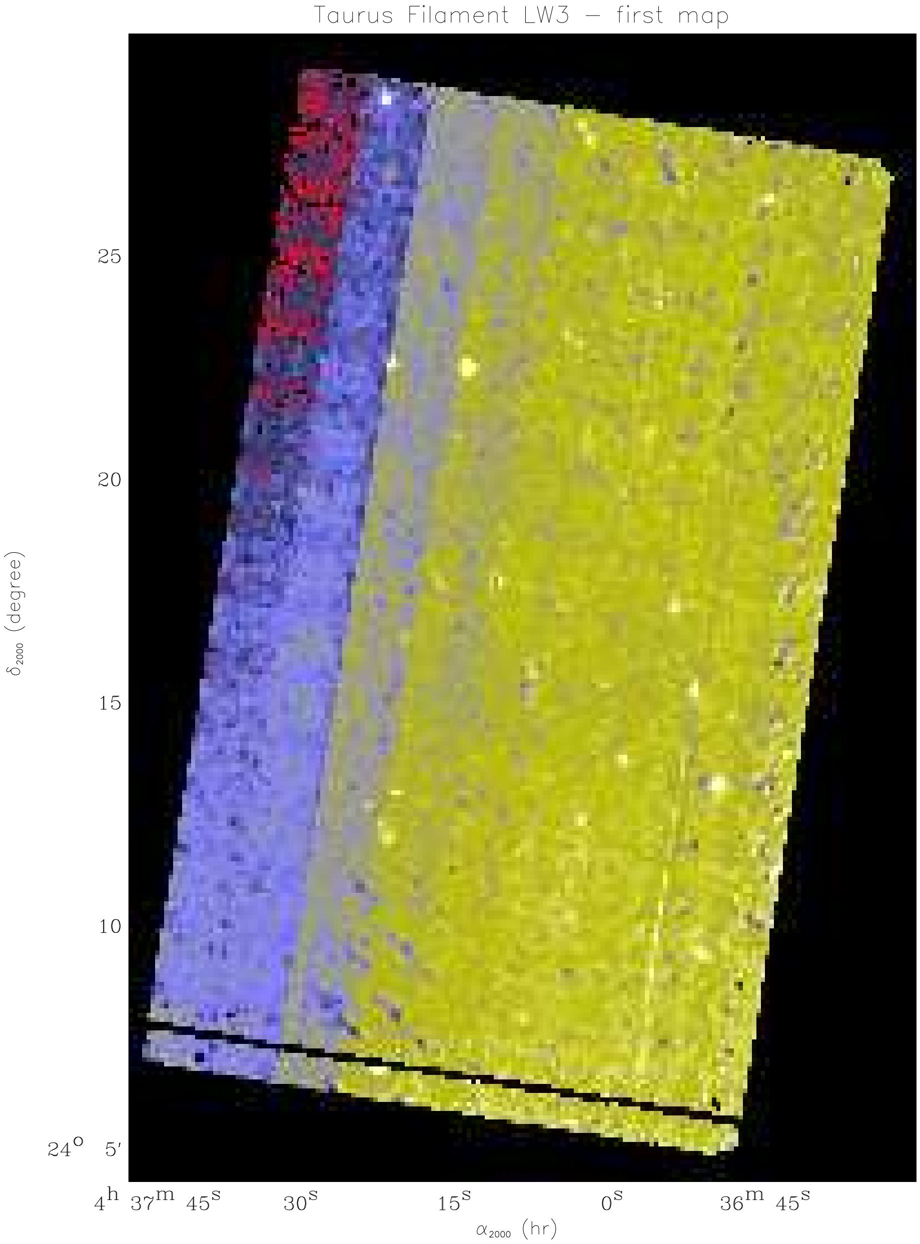
- Alternative: **extract the LTT from the data**.
  - We supposed that

    $$I_{obs}(x,y,t) = F(x,y,t)\, I_{inc}(x,y,t) + \Delta(t,I)$$

    where
    $I_{obs}(x,y,t)$: Observed flux at time t on pixel (x,y).
    $I_{inc}(x,y,t)$: Incident flux at time t on pixel (x,y).
    $F(x,y,t)$: Time-dependent flat field.
    $\Delta(t,I)$: Long term transient.

  - Find $\Delta(t,I)$ by a minimisation.

We look for the $\Delta(t)$ that minimises the differences between pixels that have seen the same sky.



Taurus Filament LW3 – first map
25
20
15
10
24° 5′
δ_{2000} (degree)
4h 37m 45s
30s
15s
0s
36m 45s
α_{2000} (hr)

HOW TO PROCEED ?

- By comparing pixels that have seen the same position on the sky:

$$I_{obs}(x,y,t) = F(x,y,t)\, I_{inc}(x,y,t) + \Delta(t,I)$$

must put all readouts in same reference frame

$$(x,y) \rightarrow (\alpha,\delta)$$

$$I_{obs}(\alpha,\delta,t) = F(\alpha,\delta,t)\, I_{inc}(\alpha,\delta,t) + \Delta(t,I)$$

- I_{inc} disappears by comparing flat corrected intensities $S(\alpha,\delta,t)$:

$$S(\alpha,\delta,t) = I_{inc}(\alpha,\delta,t) + \frac{\Delta(t,I)}{F(\alpha,\delta,t)}$$

$$S(\alpha,\delta,t_1) - S(\alpha,\delta,t_2) = \frac{\Delta(t_1)}{F(\alpha,\delta,t_1)} - \frac{\Delta(t_2)}{F(\alpha,\delta,t_2)}.$$

- **Minimisation Criterion:**
  minimise differences between pixels that have seen the same sky.

$$\chi^2 = \sum_{\alpha,\delta,t_i,t_j} \left[S(\alpha,\delta,t_i) - S(\alpha,\delta,t_j) - \frac{\Delta(t_i)}{F(\alpha,\delta,t_i)} + \frac{\Delta(t_j)}{F(\alpha,\delta,t_j)} \right]^2$$

Sum on all pixel pairs that have seen the same (α,δ) *at different time* t.

- Minimisation process:

$$\frac{d\chi^2}{d\Delta(t_i)} = 0$$

$$\sum_{\alpha,\delta,t_{j\cap i}} \left[S(\alpha,\delta,t_i) - S(\alpha,\delta,t_j) - \frac{\Delta(t_i)}{F(\alpha,\delta,t_i)} + \frac{\Delta(t_j)}{F(\alpha,\delta,t_j)} \right] = 0.$$

This is a set of linear equations !!

- Solve the following system for $A\,\Delta(t) = B$
  - A diagonal terms

$$A(i,i) = \sum_{\alpha_j,\delta_j,t_{j\cap i}} \frac{1}{F(\alpha_j,\delta_j,t_i)}$$

  - A non-diagonal terms

$$A(i,j) = \sum_{\alpha_i,\delta_i} \frac{1}{F(\alpha_i,\delta_i,t_j)}$$

  - B terms

$$B(i) = \sum_{\alpha_i,\delta_i,t_{j\cap i}} \left[S(\alpha_i,\delta_i,t_i) - S(\alpha_i,\delta_i,t_j) \right]$$

- Simulations of raster observation affected by a LTT.
  - Extract perfectly $\Delta(t)$ on noise free data.
  - Does-it erase real sky structures ? $\Rightarrow$ NO
  - How does-it behave with noise ?
    $\Rightarrow$ Well when LTT $\geq$ noise/2.

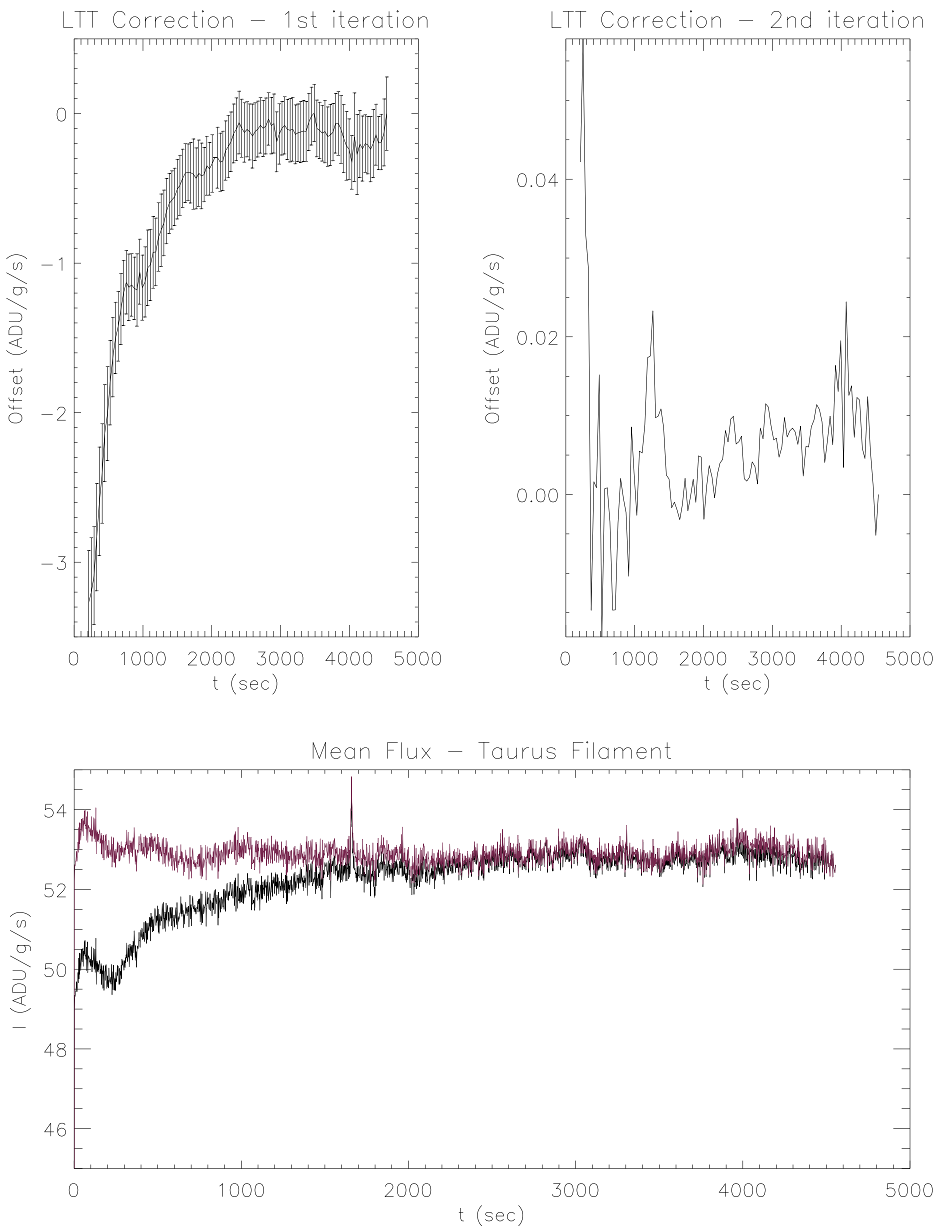
- Statistical error on the LTT correction found:

$$\sigma(t_i) = \sqrt{\frac{1}{n-1} \sum_{\alpha,\delta,t_{j\cap i}} (\Delta(t_i) - A(\alpha,\delta,t_i,t_j))^2}$$

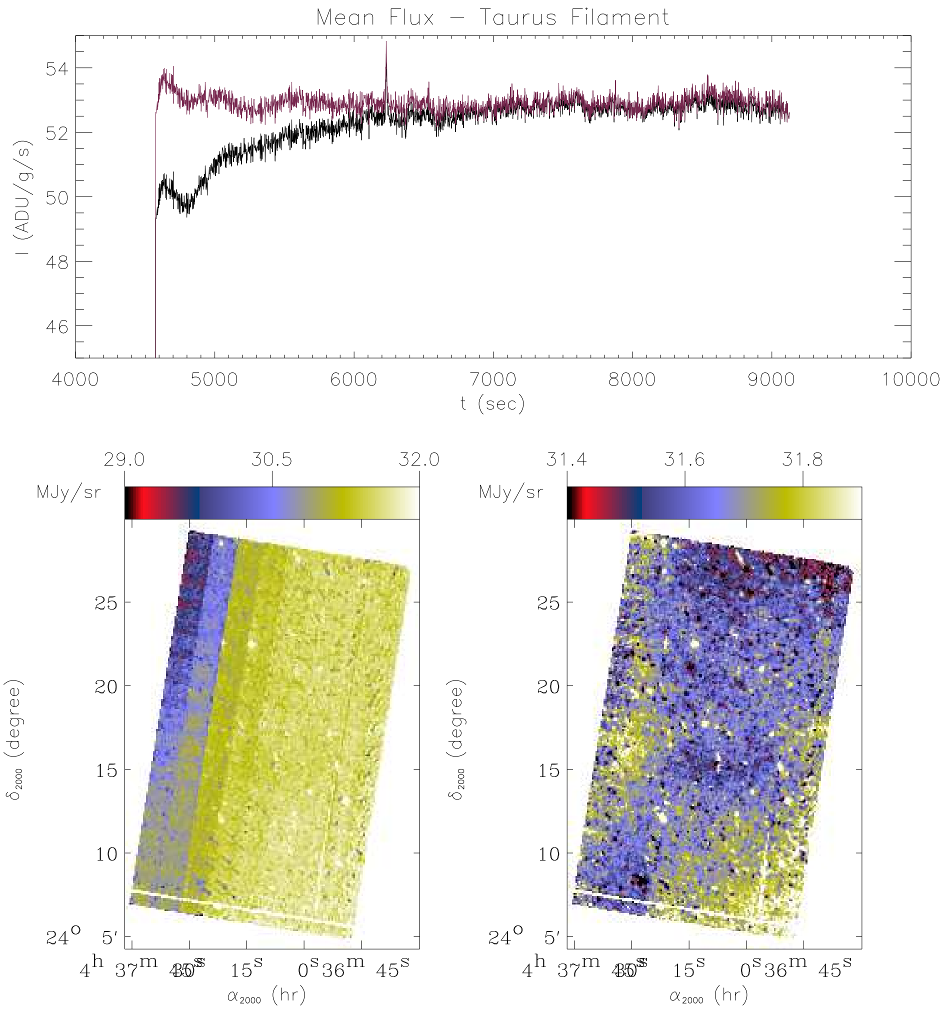
where

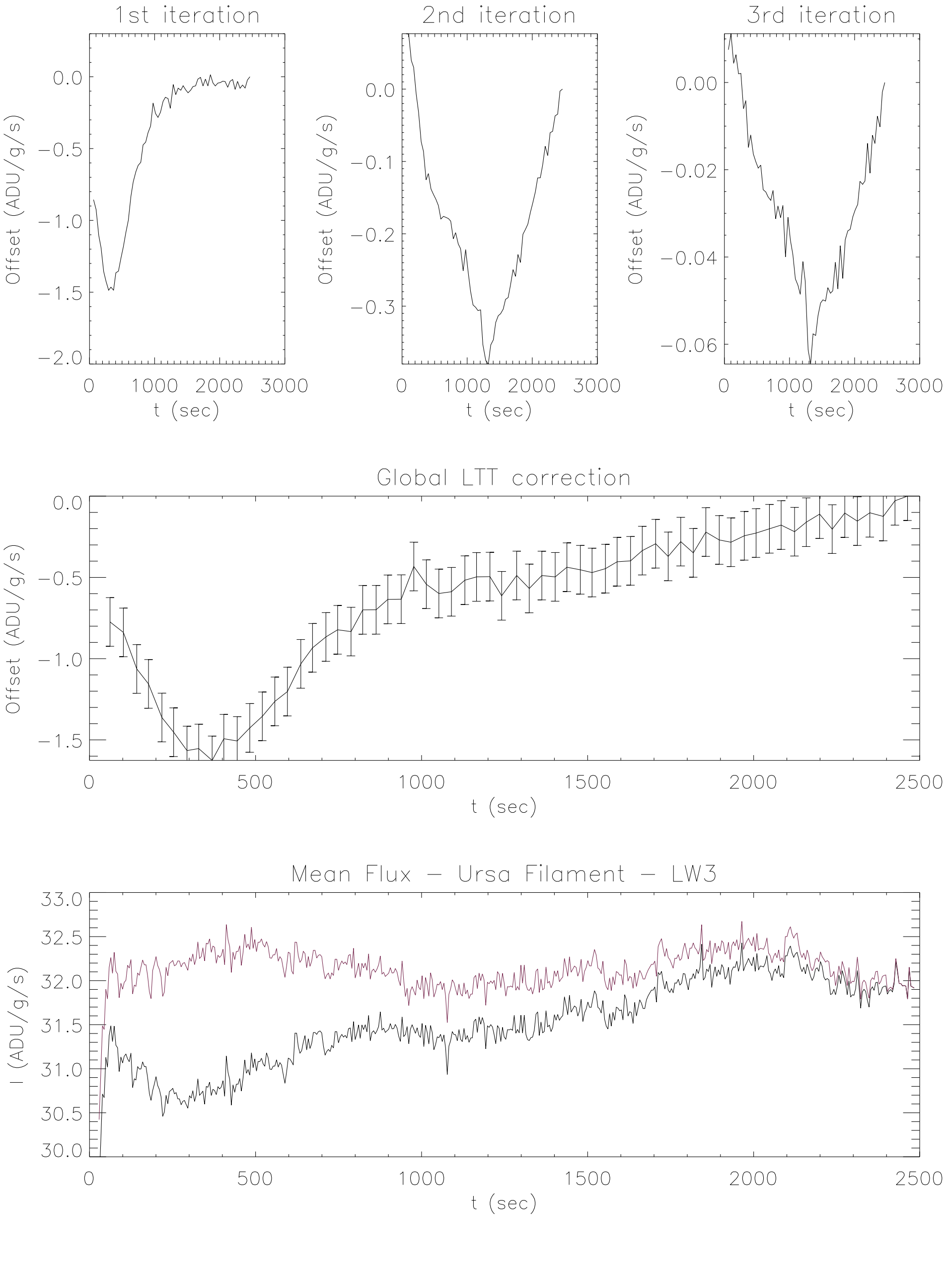
$$\begin{aligned} A(\alpha,\delta,t_i,t_j) &= F(\alpha,\delta,t_i) \times \\ &\left[S(\alpha,\delta,t_i) - S(\alpha,\delta,t_j) + \frac{\Delta(t_j)}{F(\alpha,\delta,t_j)} \right]. \end{aligned}$$

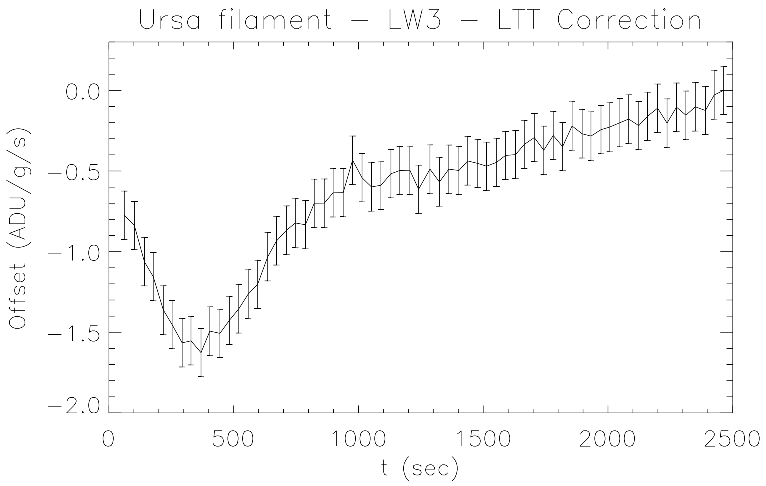
  - This error determination is very conservative (based on the simulations).
  - The main uncertainty comes from the variable flat determination.



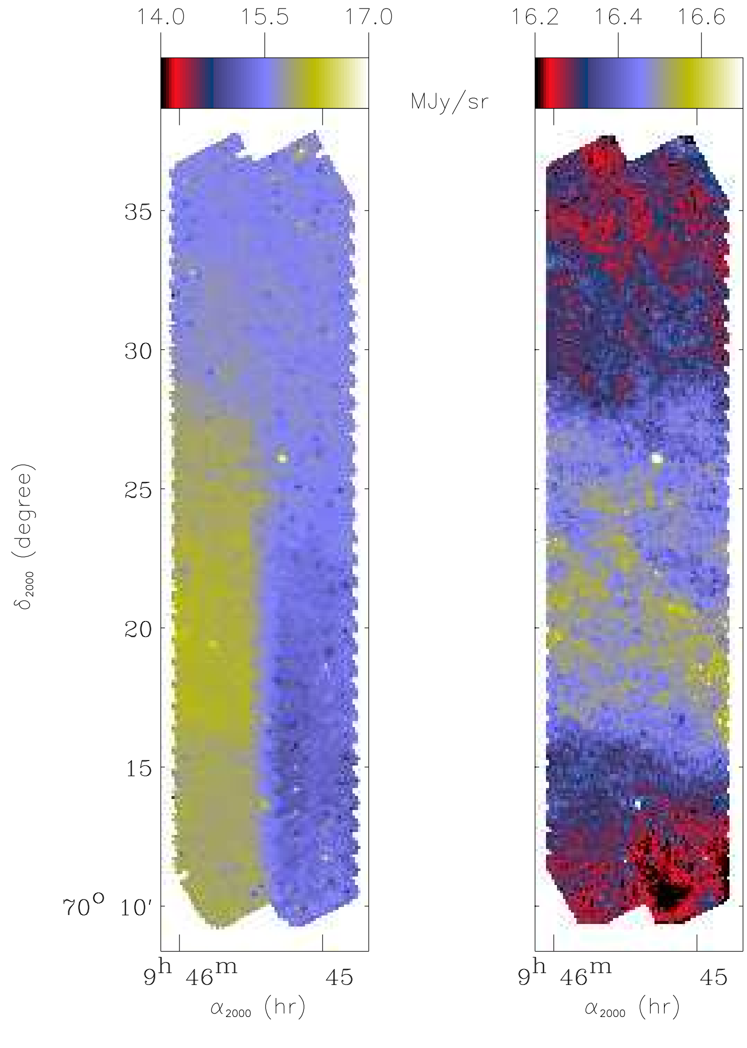
LTT Correction – 1st iteration
Offset (ADU/g/s)
t (sec)
LTT Correction – 2nd iteration
Offset (ADU/g/s)
t (sec)
Mean Flux – Taurus Filament
I (ADU/g/s)
t (sec)


Mean Flux – Taurus Filament
I (ADU/g/s)
t (sec)
4000
5000
6000
7000
8000
9000
10000
46
48
50
52
54
MJy/sr
29.0
30.5
32.0
MJy/sr
31.4
31.6
31.8
δ2000 (degree)
α2000 (hr)
24°
5′
10
15
20
25
4h 37m 30s 15s 0s 36m 45s

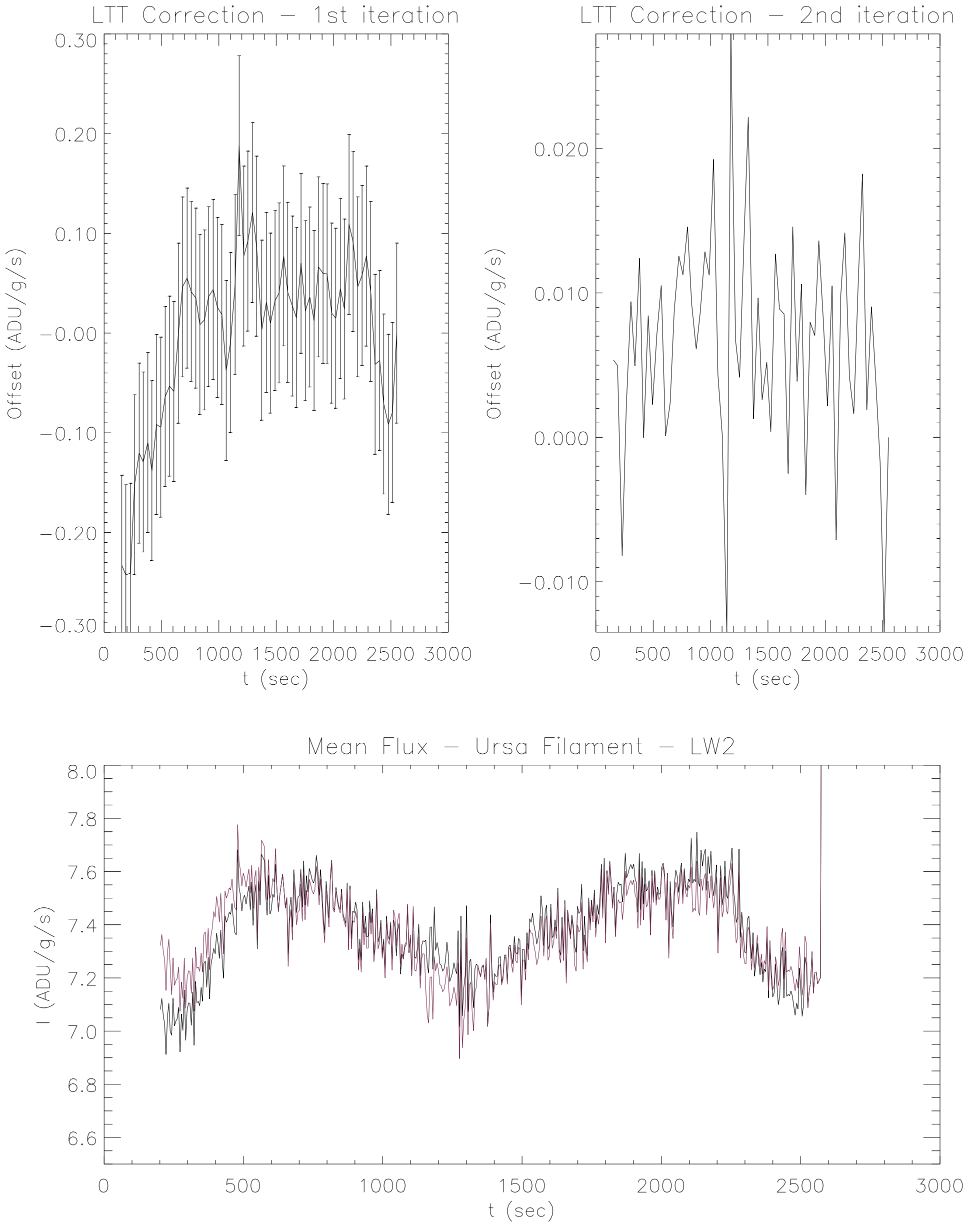

1st iteration
2nd iteration
3rd iteration
Offset (ADU/g/s)
t (sec)
Global LTT correction
Offset (ADU/g/s)
t (sec)
Mean Flux – Ursa Filament – LW3
I (ADU/g/s)
t (sec)

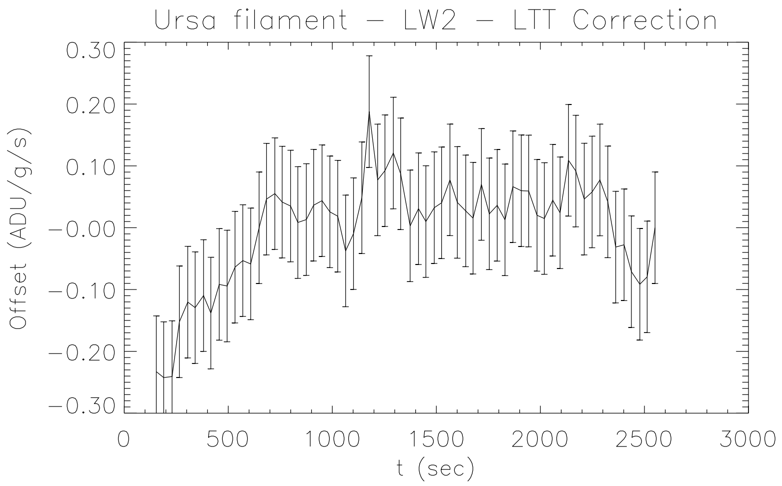


Ursa filament – LW3 – LTT Correction
0.0
−0.5
−1.0
−1.5
−2.0
Offset (ADU/g/s)
0
500
1000
1500
2000
2500
t (sec)

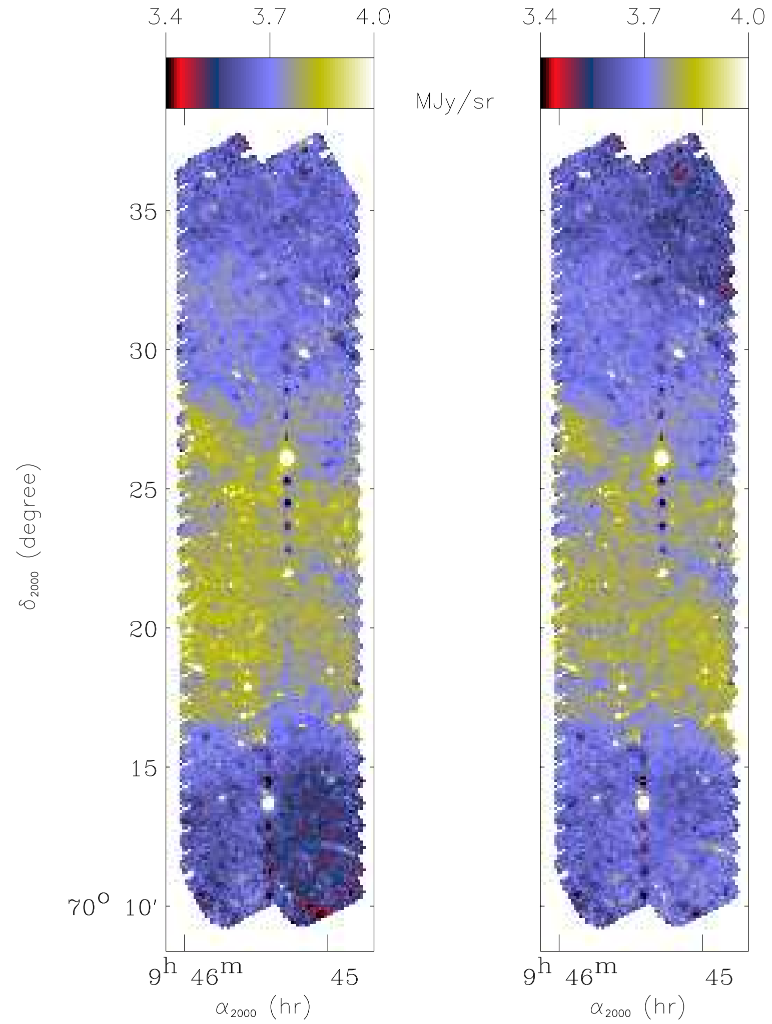


14.0
15.5
17.0
16.2
16.4
16.6
MJy/sr
35
30
25
20
15
70° 10′
δ_{2000} (degree)
9^h 46^m
45
α_{2000} (hr)
9^h 46^m
45
α_{2000} (hr)

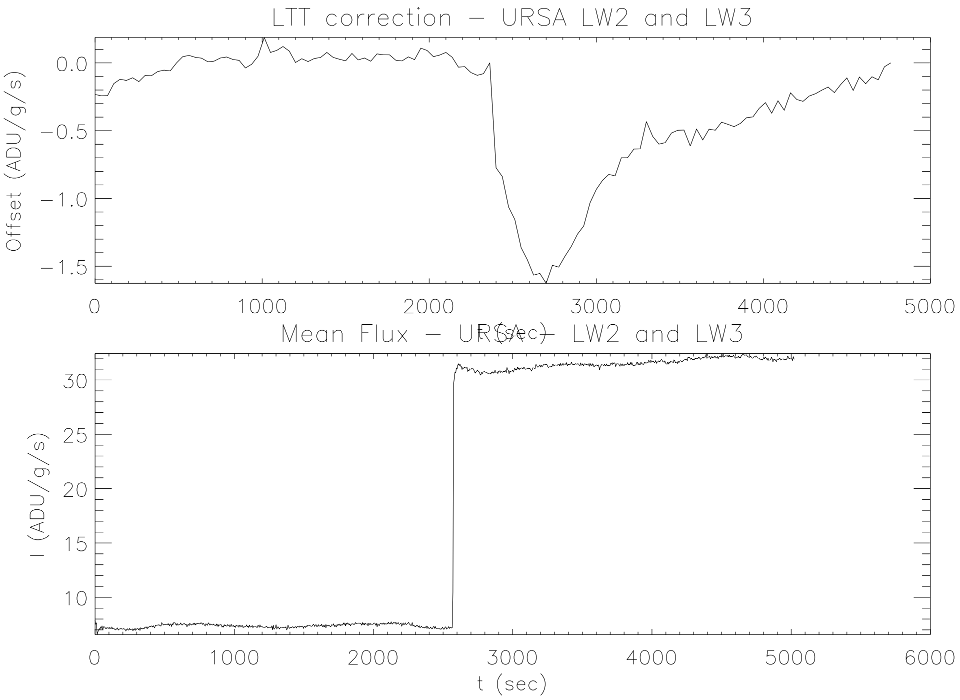

LTT Correction – 1st iteration
Offset (ADU/g/s)
t (sec)
LTT Correction – 2nd iteration
Offset (ADU/g/s)
t (sec)
Mean Flux – Ursa Filament – LW2
I (ADU/g/s)
t (sec)



Ursa filament – LW2 – LTT Correction
Offset (ADU/g/s)
0.30
0.20
0.10
–0.00
–0.10
–0.20
–0.30
0
500
1000
1500
2000
2500
3000
t (sec)

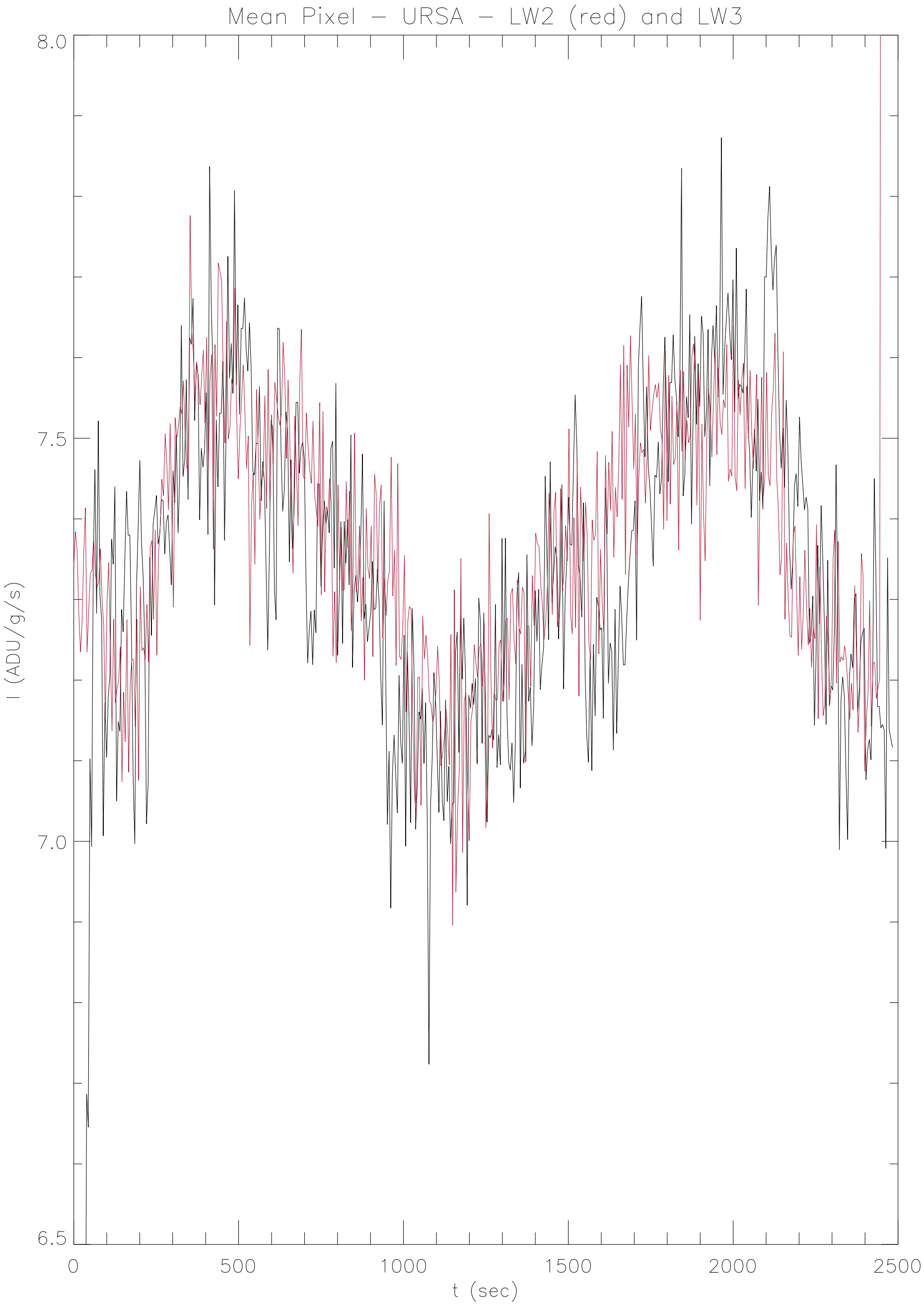


3.4
3.7
4.0
MJy/sr
δ_{2000} (degree)
35
30
25
20
15
70° 10′
9h 46m
45
α_{2000} (hr)



Correlation avec la température ?

- **Observations**:
  Transitoire long toujours montant
  Température toujours décroissante (en mode filtre)
  - Chauffage par le moteur de la roue à filtre.
  - Refroidissement graduel pendant l'observation.
- Relation linéaire avec T ?
- Contre-exemple dans Ursa Major
  même marche de flux et même dérive en température mais transitoire long différent...


Mean Pixel – URSA – LW2 (red) and LW3
8.0
7.5
7.0
6.5
I (ADU/g/s)
0
500
1000
1500
2000
2500
t (sec)

Conclusion

What have we learned on the Long Term Transient ?

- It seems to be always rising (oscillations ?).
- Impossible to predict (not a classical transient).
- Stronger on strong flux steps.
- Sometimes totally absent.
- Not a temperature effect.

Temporary solution

- Use the redundancy of raster observations to extract the LTT from the data.
- *Very satisfactory results on diffuse emission !!!*
- Should be tested on more contrasted observations.

Where do we go from here ?

- Extract LTT systematically.
- Study of whole ISO orbit.