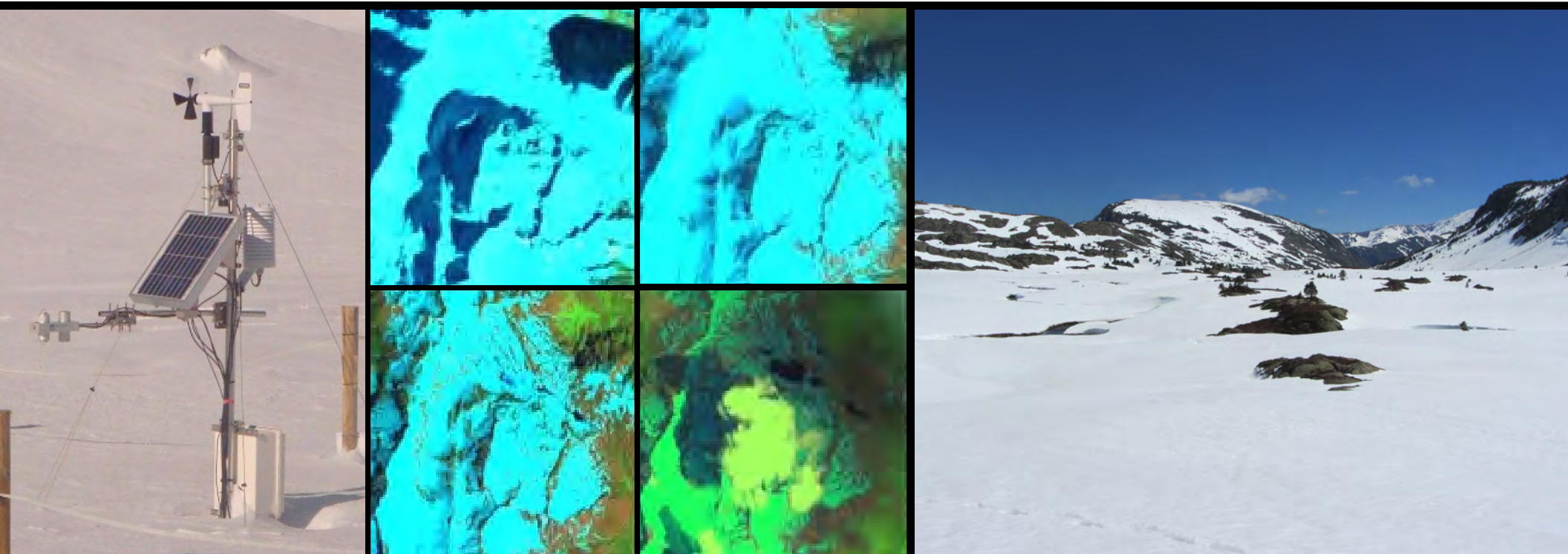




Application of remote sensing to snow modelling in the Pyrenees



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Centre d'Etudes Spatiales de la Biosphère (CESBIO) - Toulouse, France

General context of the study

Big impact of climate change in mountainous areas of the southern part of Europe (Intergovernmental Panel on Climate Change, IPCC)

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Fast changes of the land-use (reforestation processes)

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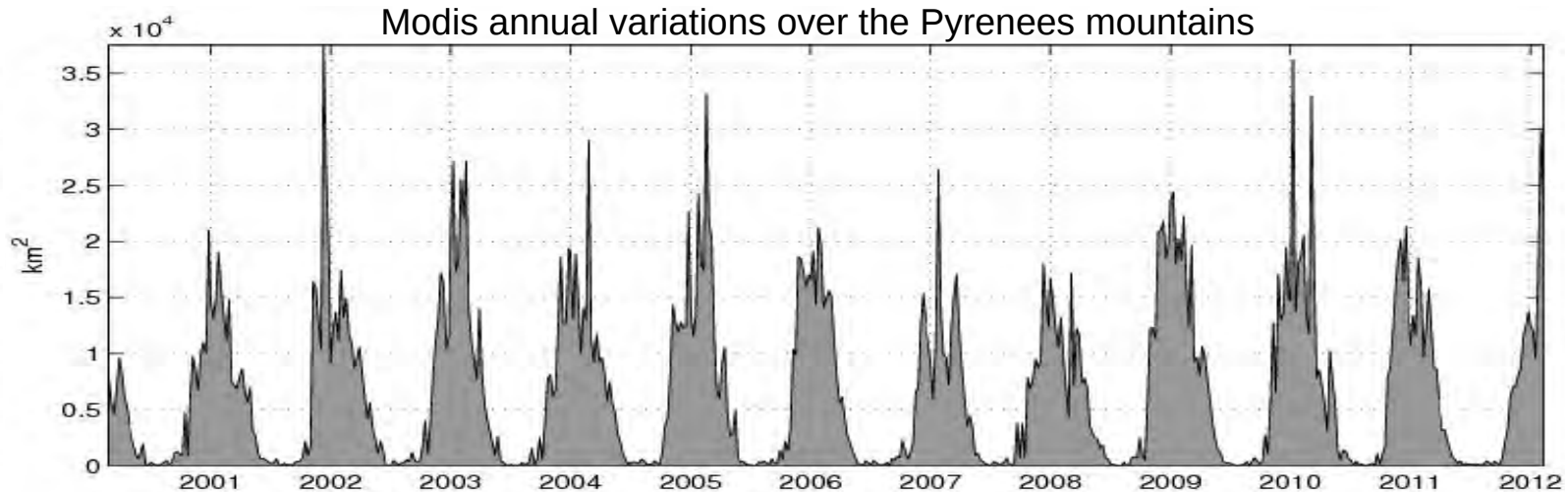
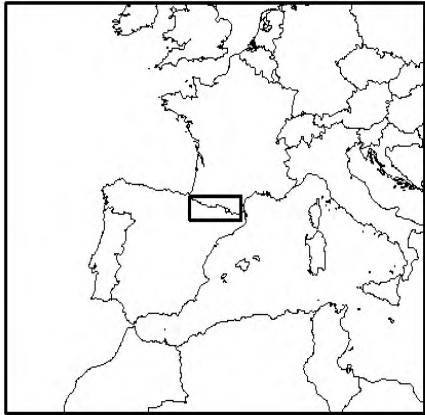
→ **Impact on the pyrenean snow cover**

Validation of other satellite product at the whole Pyrenees mountain scale

Validation of model simulations at the catchment basin scale



At the scale of the whole mountain range...

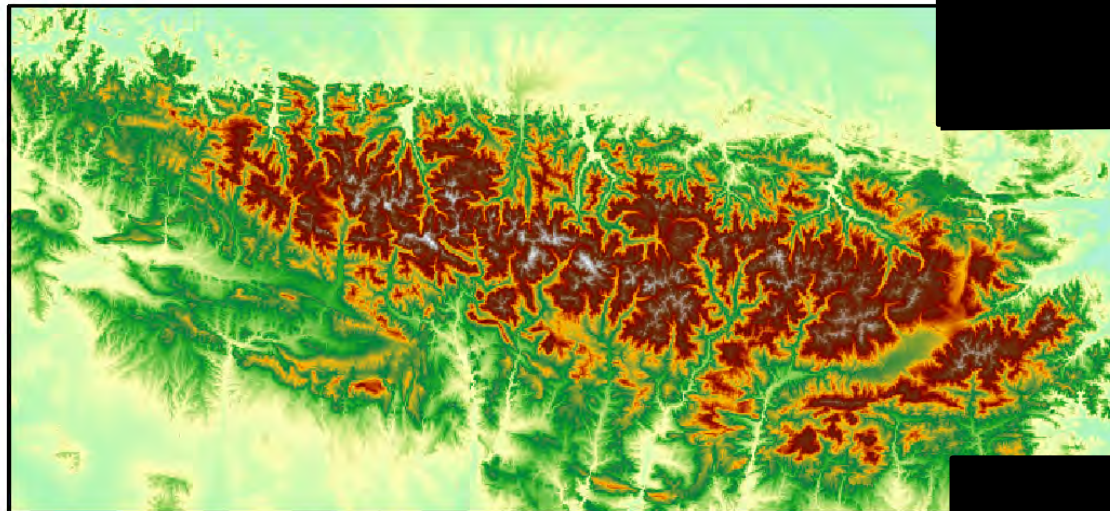
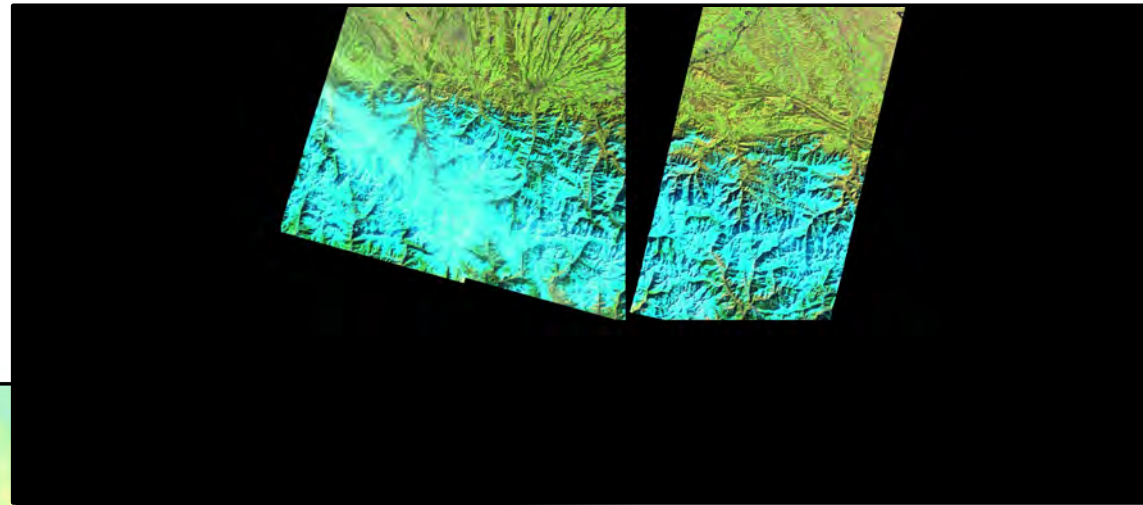


- Monitoring of the evolution of the snow cover area during a winter season.
- Comparison of the mean annual snow cover area, from one year to another over the Pyrenees mountain range.
- MODIS satellite product permits to monitor these evolution at a 500 m resolution at a daily time step over 2000-2013.
- High-resolution data (as Landsat, **SPOT4 Take5**) are useful to assess low-resolution MODIS data.



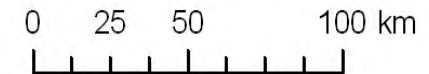
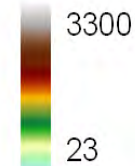
At the scale of the whole mountain range...

SPOT4 Take5 image :
17.02.2013

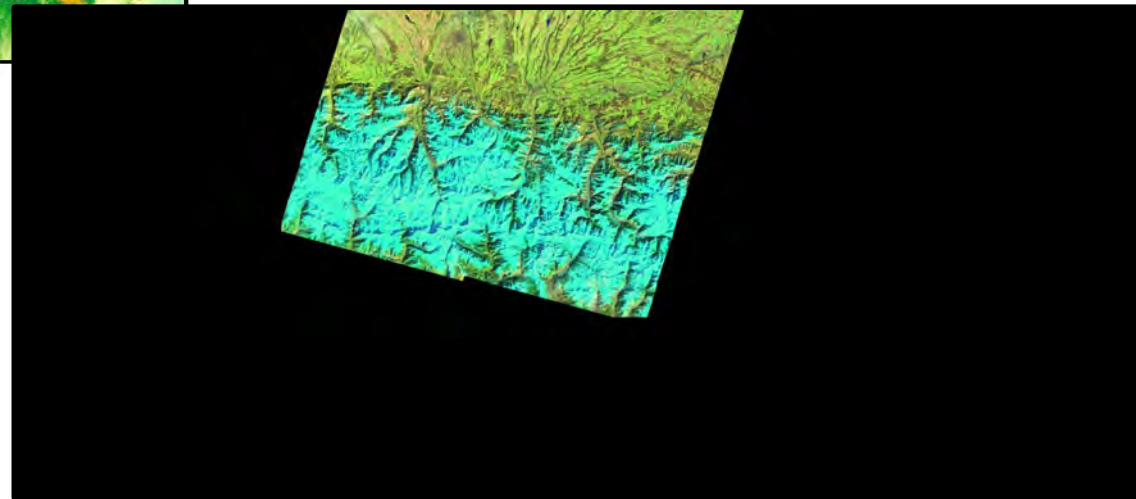


ASTER DEM 500-m

Elevation (m)



SPOT4 Take5 image :
03.03.2013





Objectives of the study

Study the impact of future environmental conditions (climate, vegetation) on the snow cover



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- *In situ observation (1-D validation)*

- *SPOT4 high-resolution multispectral images – 20m resolution*



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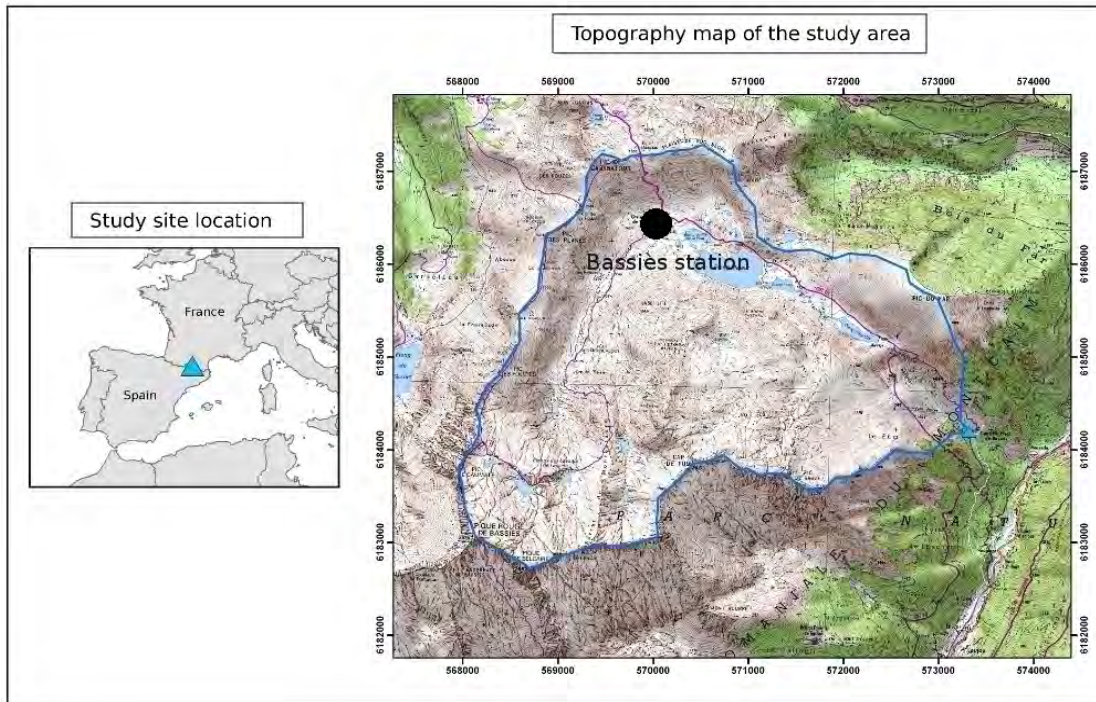
- SPOT4 high-resolution multispectral images – 20m resolution

3. Impact study of the temperature, precipitation and land-use on the snow depth annual evolution

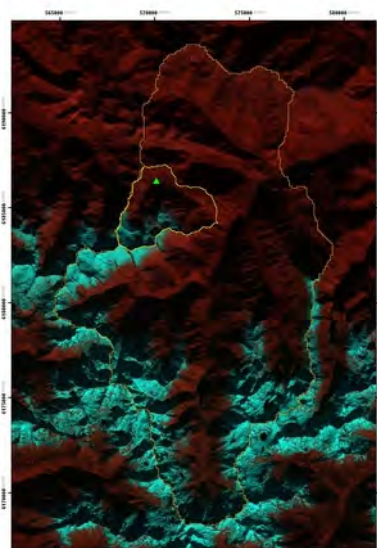
- Meteo-France SCAMPEI scenarios + new vegetation maps



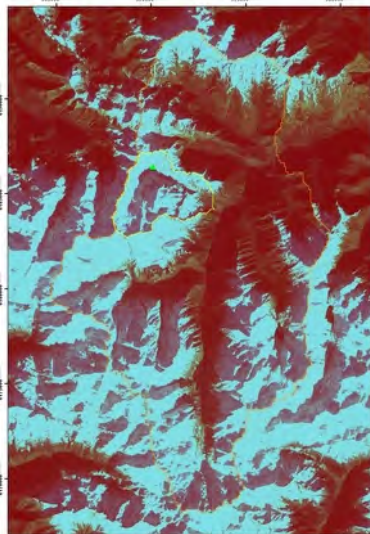
At the scale of the Bassies catchment...



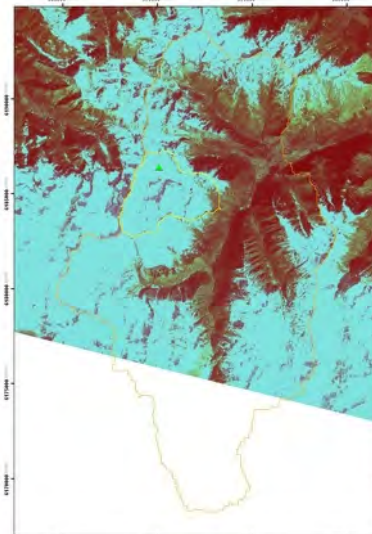
- Bassies catchment area, Ariège
- 5 SPOT4-5 images from november 2011 to march 2012.
- Normalized Difference Snow Index (NDSI). $NDSI > 0.4 \rightarrow$ snow (Dozier, 1989)



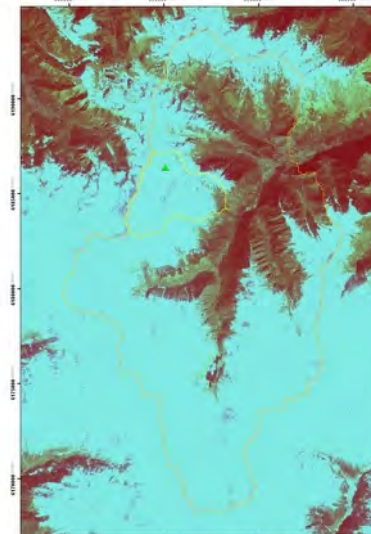
Vicdessos-20111130-S5



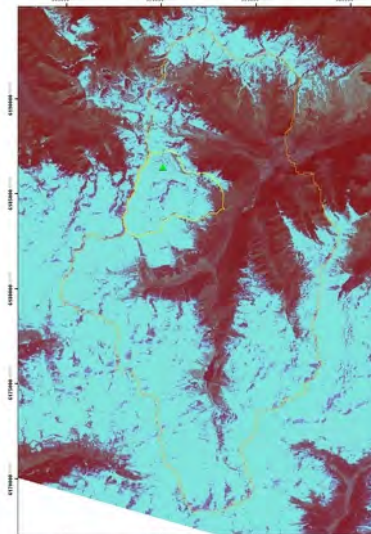
Vicdessos-20120114-S4



Vicdessos-20120316-S4

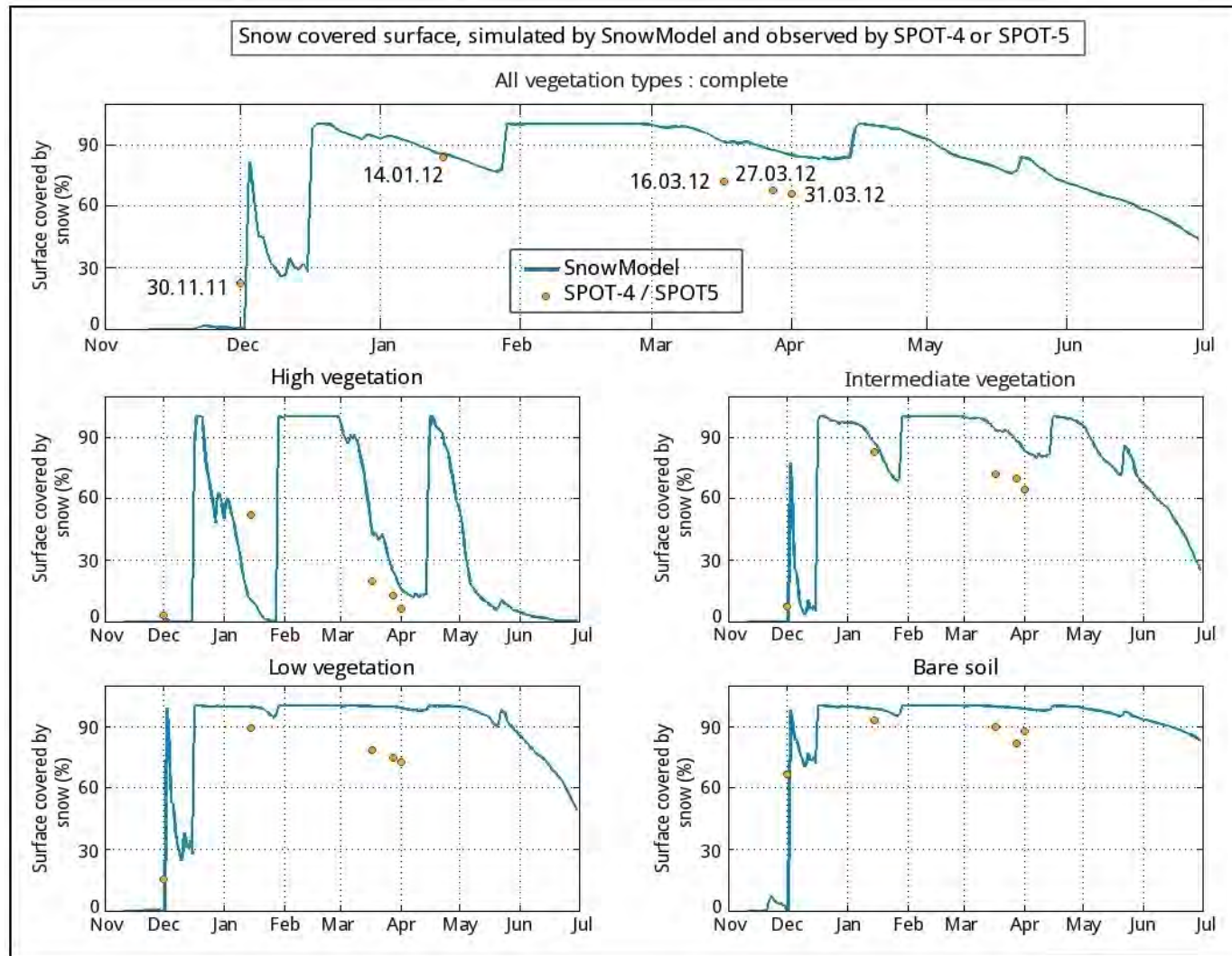


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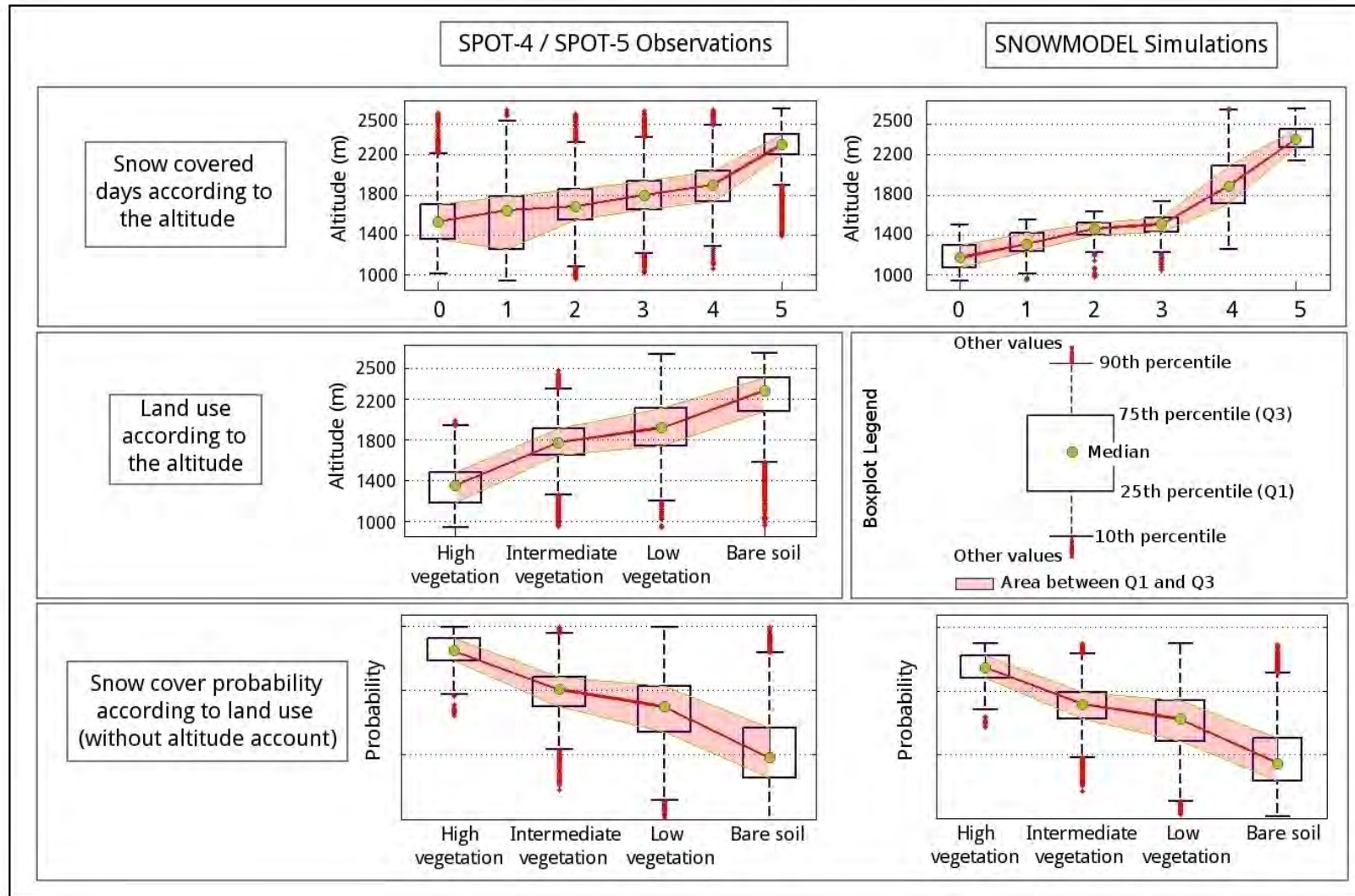
Vicdessos-20120331-S4

At the scale of the Bassies catchment...



Snow cover fraction (%), simulated by SnowModel and remotely sensed by SPOT-4 and SPOT-5. This result is given (top) for the whole watershed and (bottom) for 4 limited areas depending on vegetation type.

At the scale of the Bassies catchment...



Boxplots presenting links between (1) altitude of a grid point and the number of days when the considered grid point is snow-covered, (2) altitude and vegetation type and (3) snow-cover probability according to land use and without altitude account. Results obtained with SPOT4 and Snowmodel.



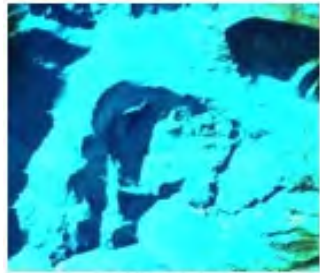
SPOT4 – Take5 – The year 2013 - Bassies



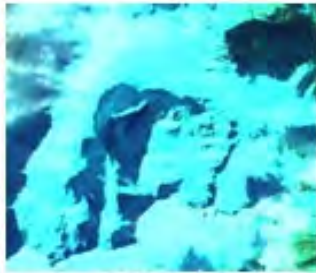
- Exceptional year in terms of snowfall (approx. 4m in Bassies).
- The Bassies station was buried in snow from January to June – no in situ meteorological and snow depth observations during this period.
- A mini station was installed to record air temperature and humidity. Possibility to use **SPOT4 Take5** data with a more simple modelling approach.
- A lot of cloudy days, as well.
- Clouds on **SPOT4 Take5** multispectral images – some of them are unworkable.
- But the snowmelt is visible at the end of the season.



SPOT4 – Take5 – The year 2013 - Bassies



20130217



20130222



20130227



20130304



20130309



20130314



20130319



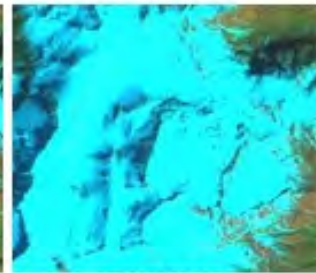
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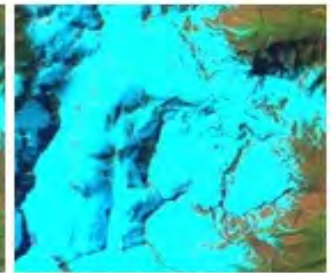
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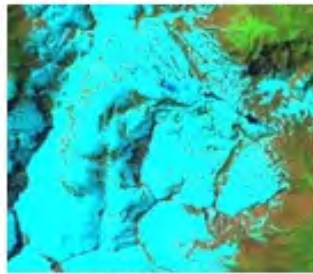
20130423



20130428



20130503



20130513



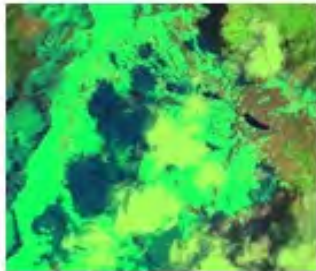
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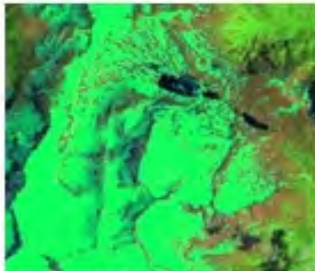
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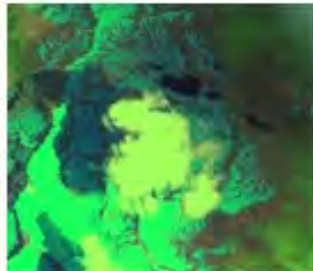
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20130607



20130612



20130617



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SPOT4 vs. Time-lapse cameras

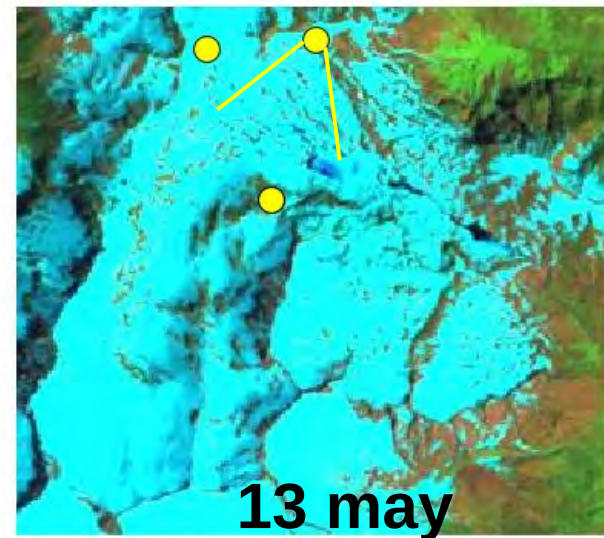
The SPOT4 images could be investigated differently :

- Comparison between the **SPOT4 Take5** high resolution images and photographs.
- Ph.D of Renaud Marti, CESBIO/GEODE laboratories. Study performed over the Bassies catchment basin.
- Analyse and validation of **SPOT4 Take5** images with the time-lapse cameras.



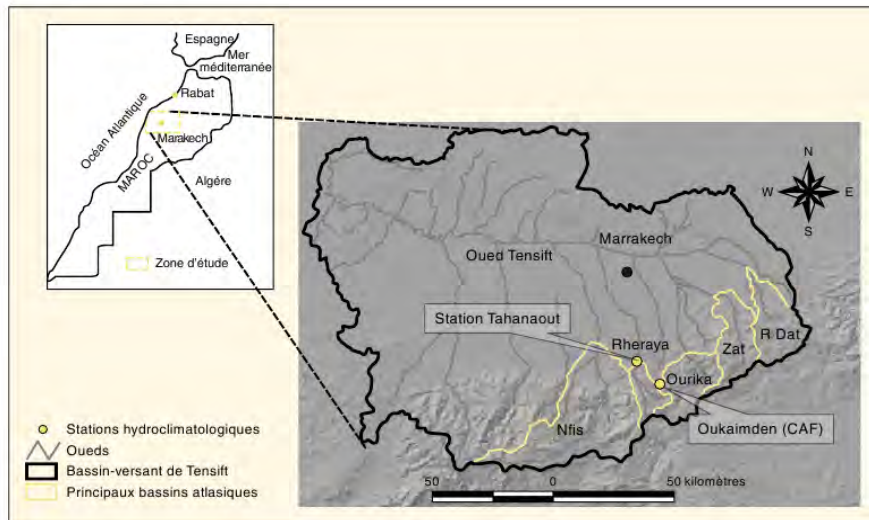


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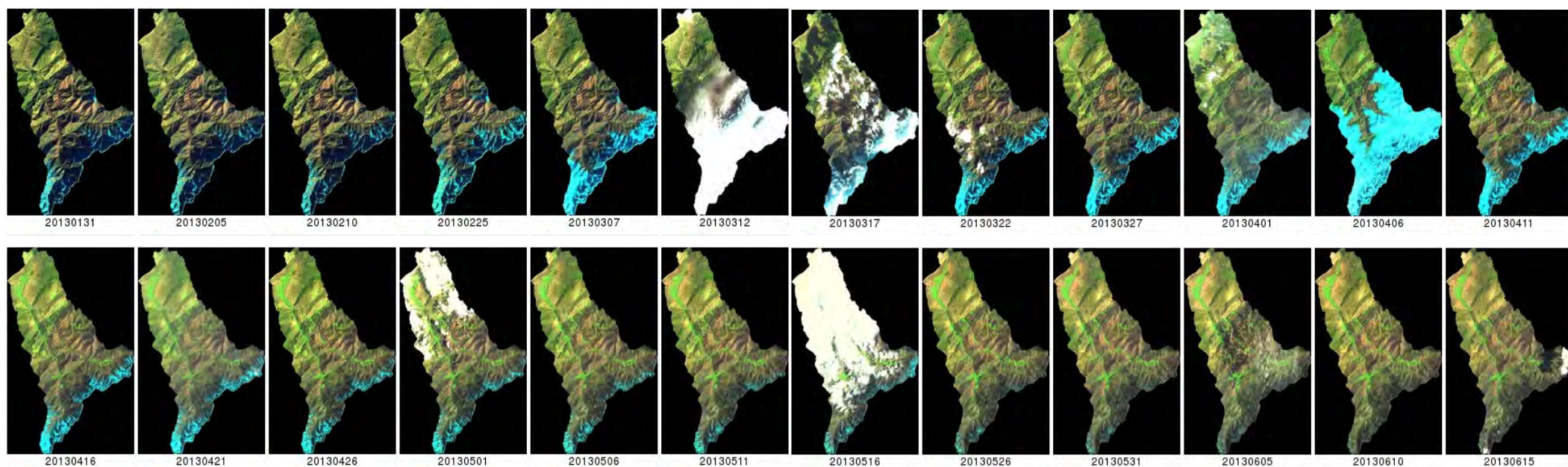


SPOT4 – Morocco - Rheraya



(Boudhar et al., 2009)

- Similar modelling studies can be extended to other areas.
- Clear images → good monitoring of snow accumulation and ablation.
- 06.04.2013 : snowfall



SPOT4 high resolution multispectral images



Conclusion

1. Assessment of the studies performed with data similar to the **SPOT4 Take5** data:

- 2011-2012 SPOT series to validate snow cover area model simulations.
- High resolution Landsat images to validate the low resolution MODIS product

2. The 2013 **SPOT4 Take 5** images will be used in similar studies:

- Limits: meteorological data in Bassies – more simple approach
- Time-laps cameras comparison

3. ANR Amethyst: Hydrological modelling of the Tensift area and validation of the simulated snow with the **Take5** data.



THANK YOU FOR YOUR ATTENTION !



OBSERVATOIRE PYRÉNÉEN
DU CHANGEMENT CLIMATIQUE

