Validation of the ECMWF Reanalyses in a mountain area

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Introduction

- Participation in ERA-15 and ERA-40 to validate ERA against observed and analysed data in the French Alps.
  - Temperature
  - Precipitation
  - Snow water equivalent
- The validation of reanalyses in mountain areas is a challenge
  - Differences in elevation with validation data
  - Valley cold temperature in winter
  - Precipitation enhanced by orography
- Use of procedures to extrapolate ERA data or compare ERA with another analysis (SAFRAN/CROCUS)

Interest and difficulties of this validation

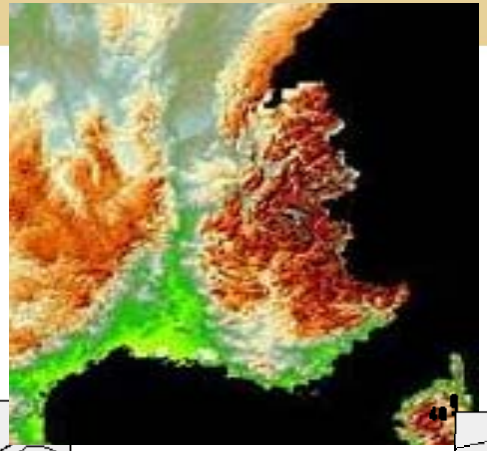
- Most data are independant
- Verify approximations used in another context (meteorological analysis system SAFRAN)
- Address the resolution issue of ERA in mountain

But :

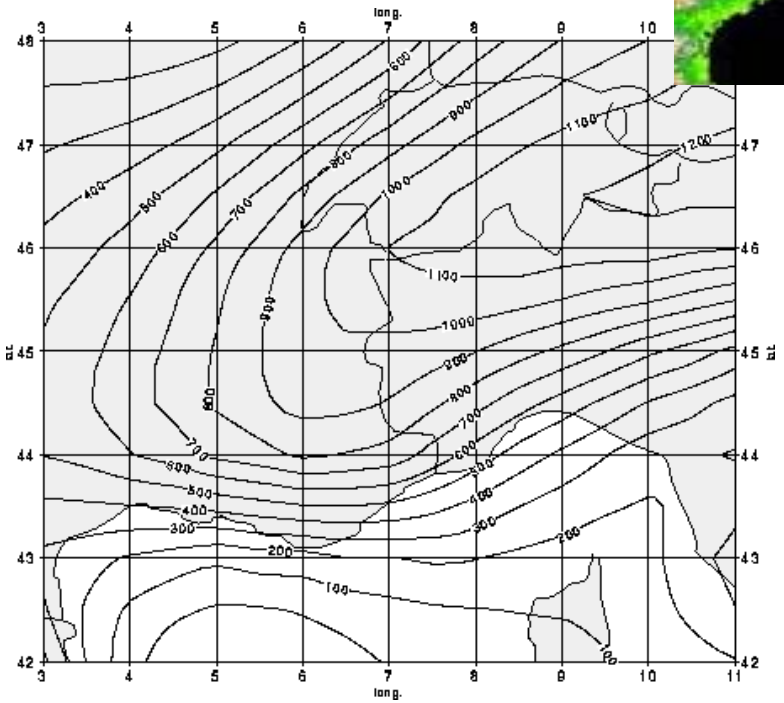
- Observed phenomena beyond the ERA resolution

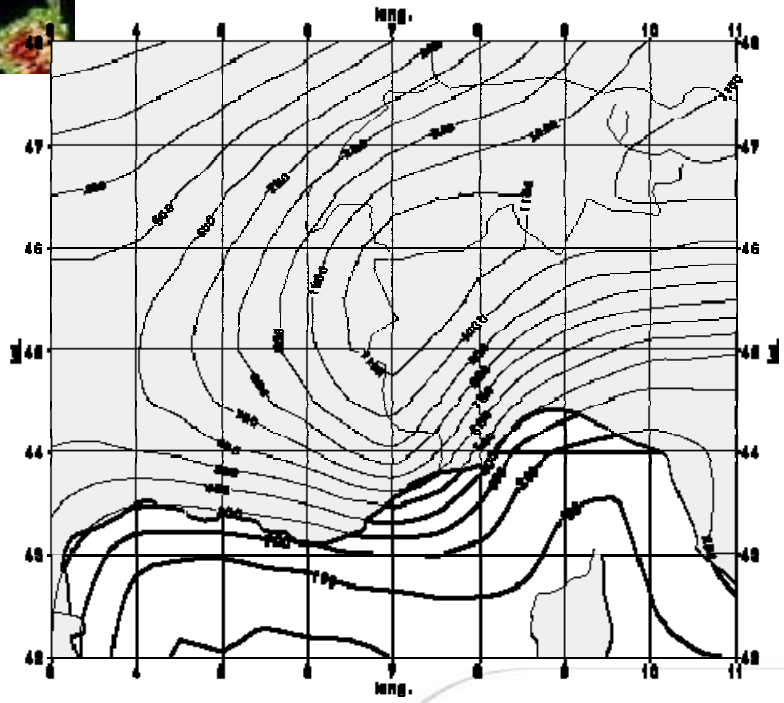
Model Orography

ERA-15



ERA-40





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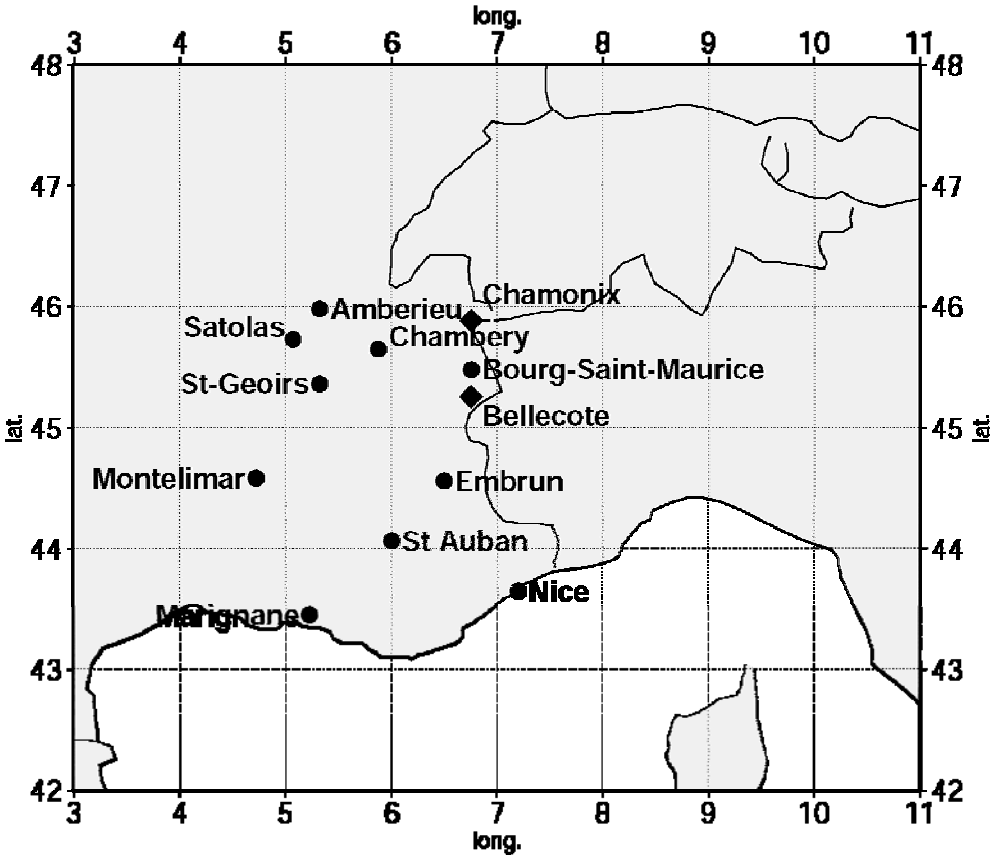
DATA (observation /Safran Crocus)



- Synoptic stations
- High elevation station (3000m)

Analysed data :

- Safran/Crocus data for
  - Meteorological analysis
  - Snow cover model

Various elevations

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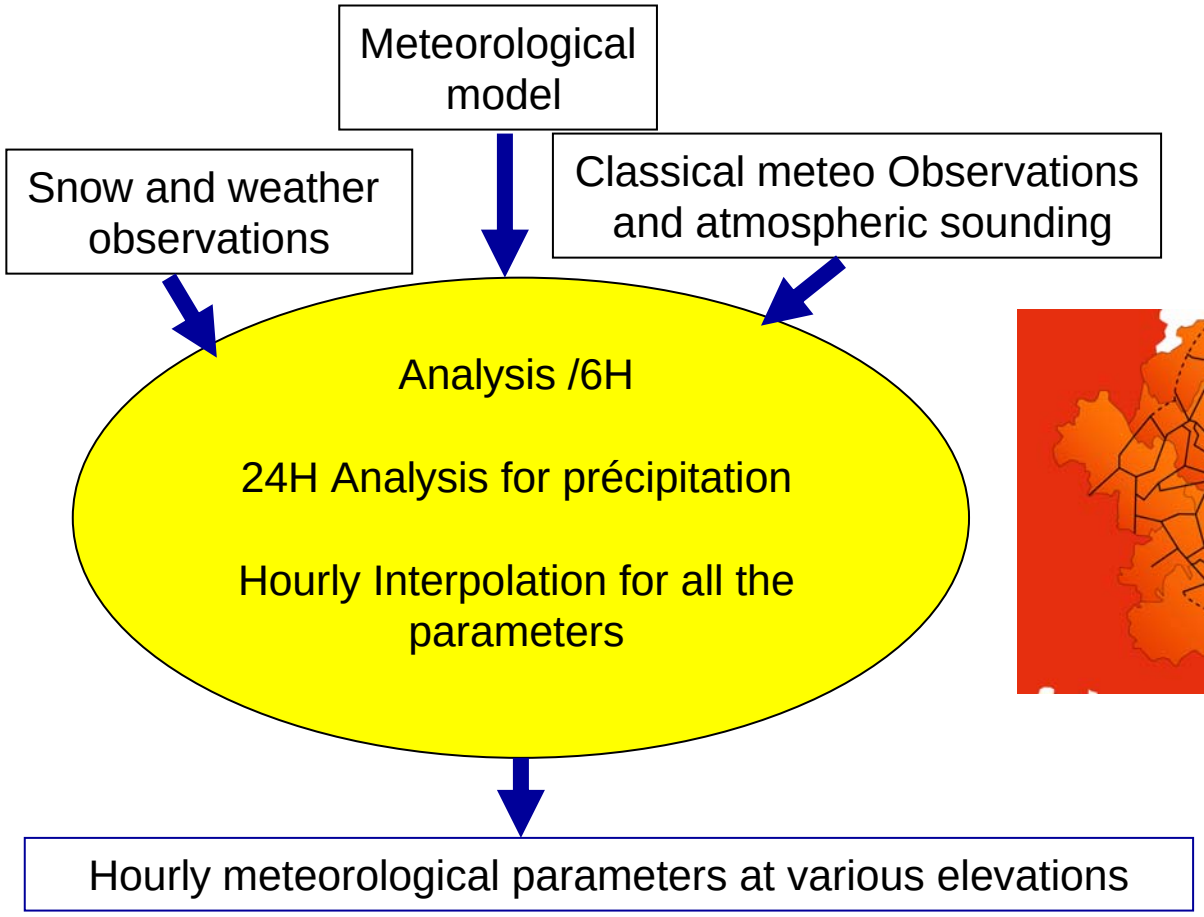
SAFRAN



- Meteorological analysis for mountain regions
- Take into account sharp horizontal gradients (analysis by zones)
- Mix altitude and surface data

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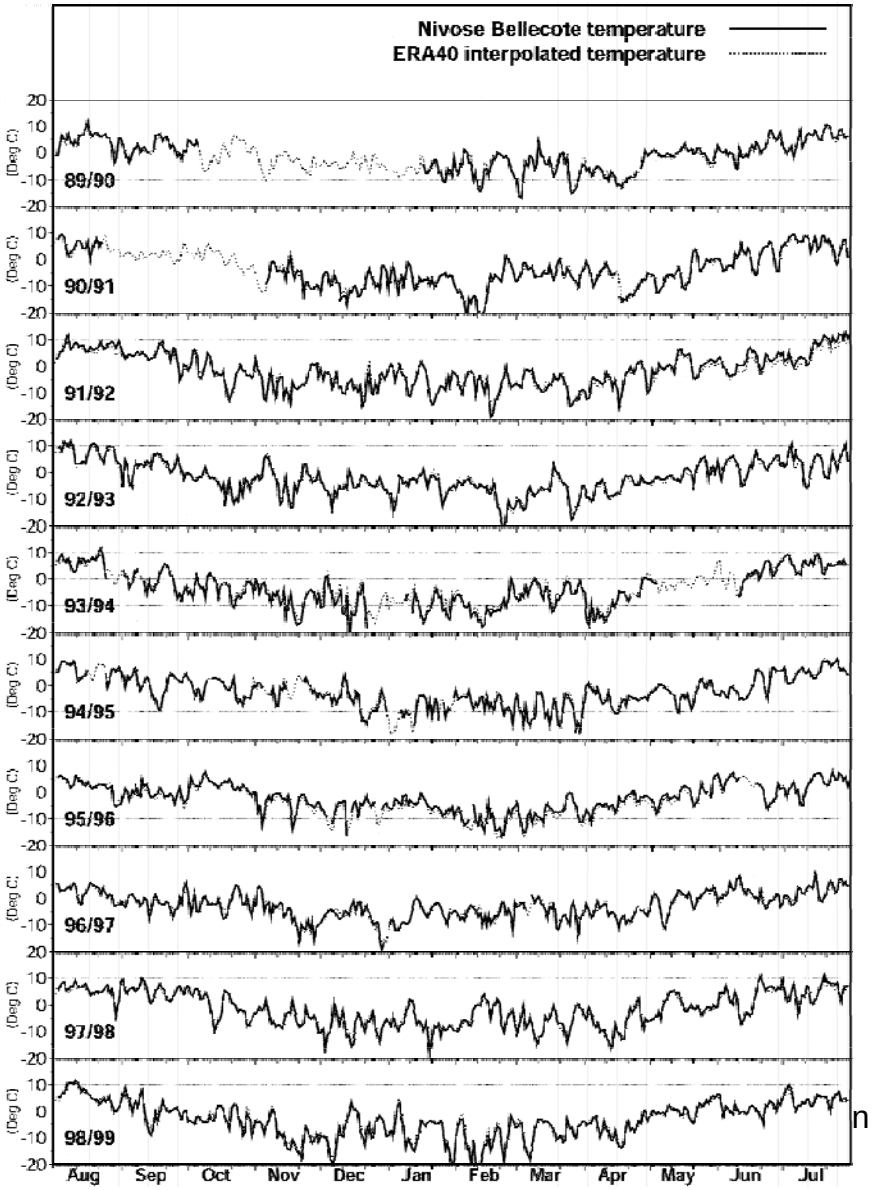
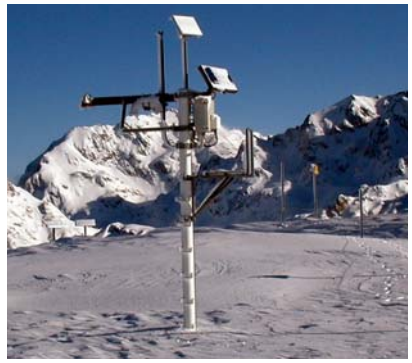
Temperature (Nivose Bellecote 3000 m) DJF





Average on 10 winter :

- In mountain formed by isolated peaks (e.g. the Alps), the 2m temperature is very close to the free air temperature

DJF (81/82 – 98/99)

- Op ana – Obs : -0.16 K
- ERA40 – Obs : 0.38 K

- **Comparison with ERA15 (period 81/91) :**
- ERA40-ERA15 : 0.02°C
- **ERA 40** is slightly warmer than Operational analysis and Observation

n atmospheric reanalysis

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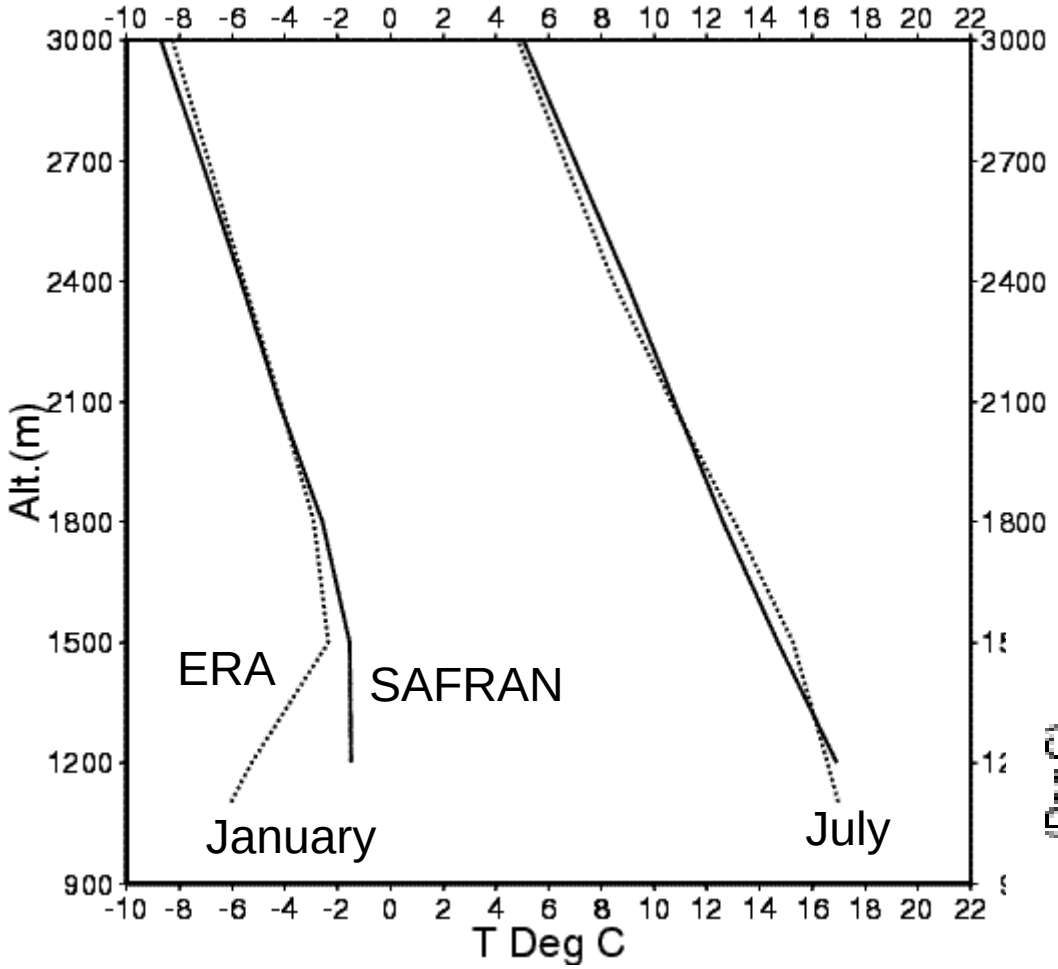
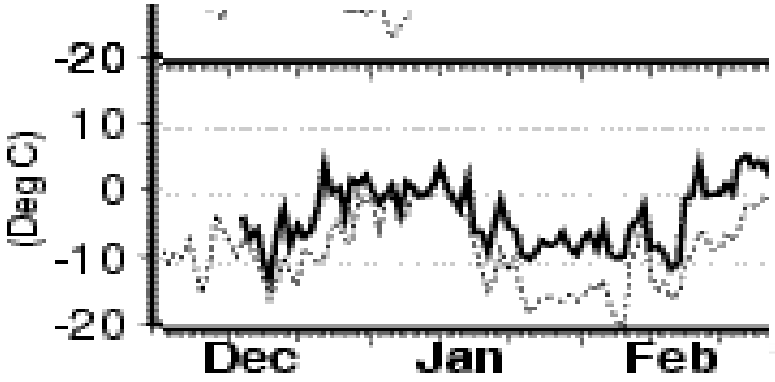
Temperature profile : boundary layer



- SAFRAN anlaysis (Mont-Blanc region) vs **ERA-15**.
- Model surface temperature to cold in winter
- Chamonix



ERA15
less pronounced in ERA40

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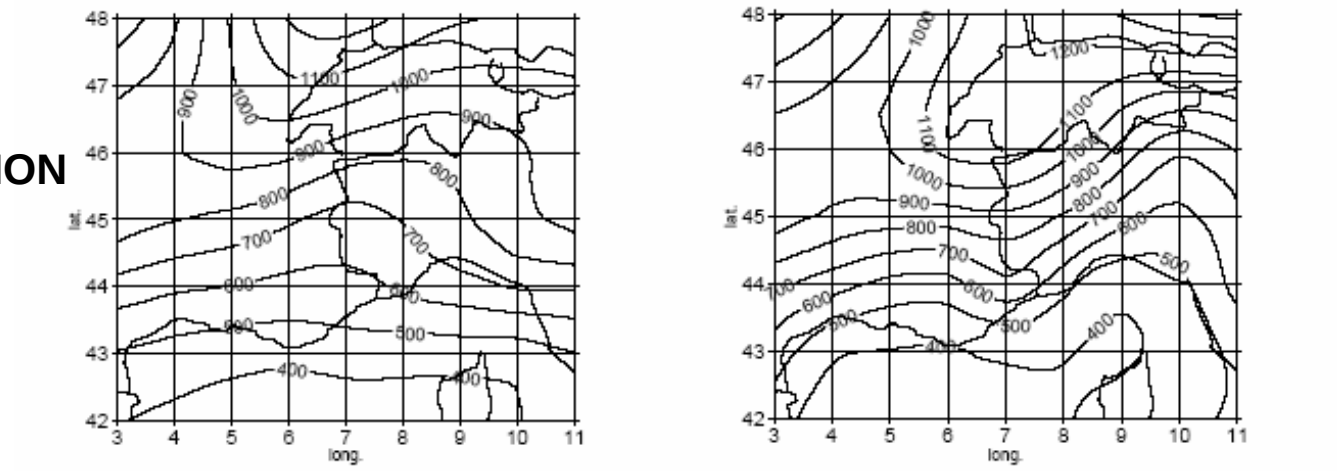
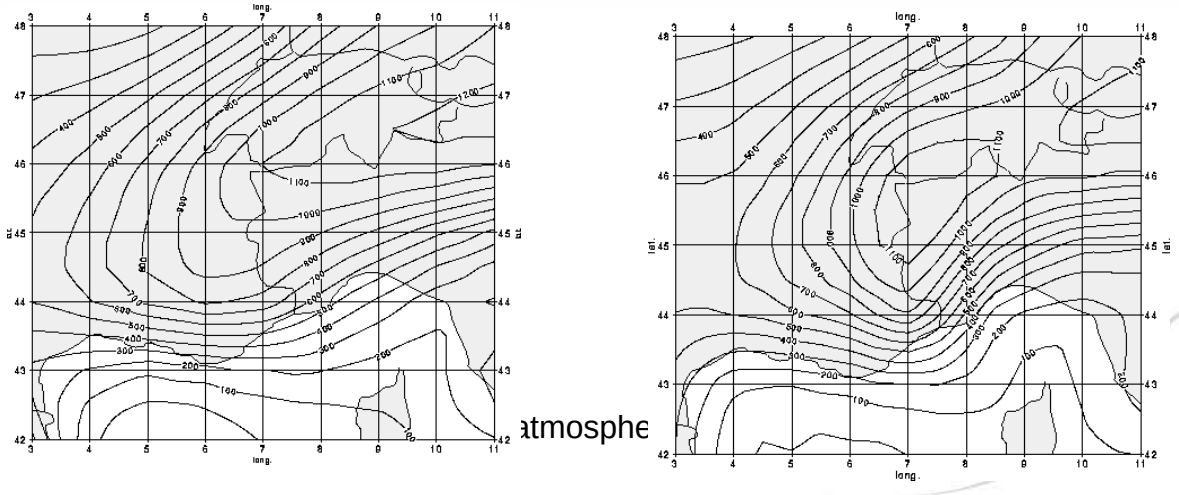
Precipitation fields and Orography

ERA-15 ERA40

PRECIPITATION



OROGRAPHY



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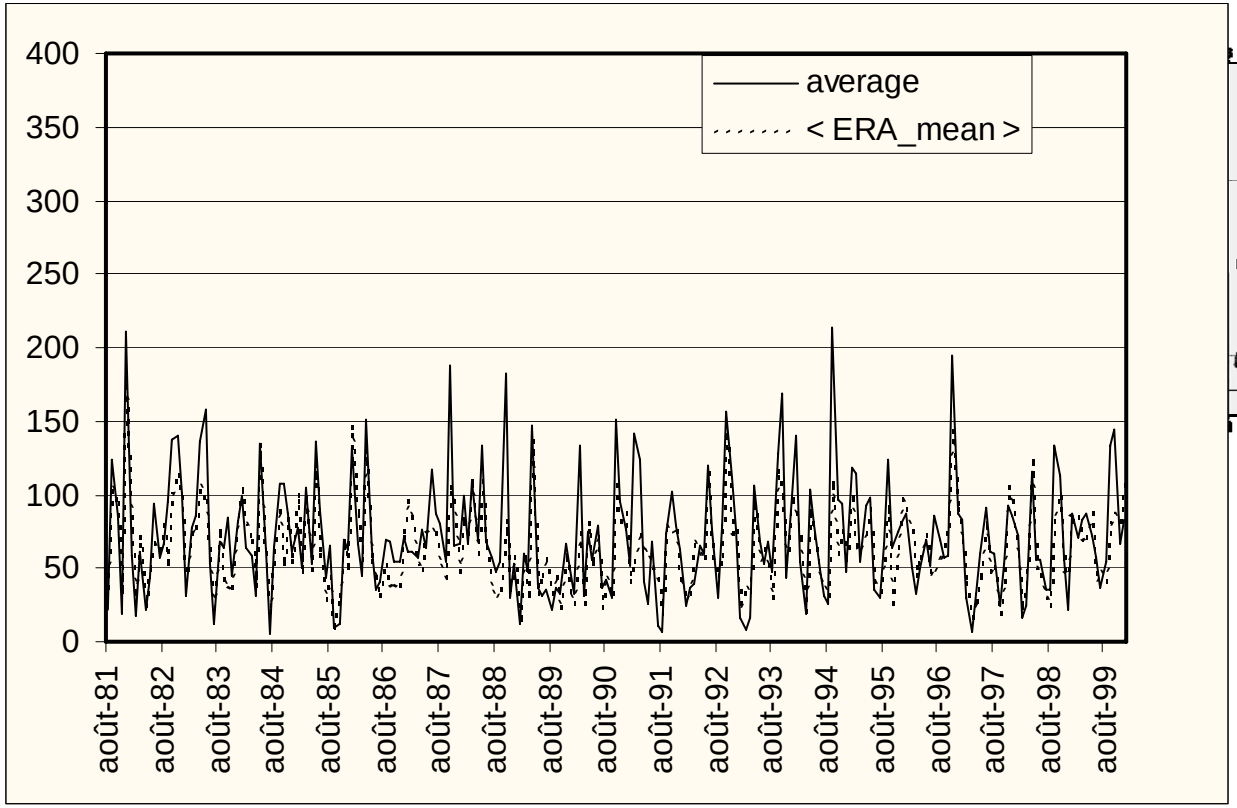
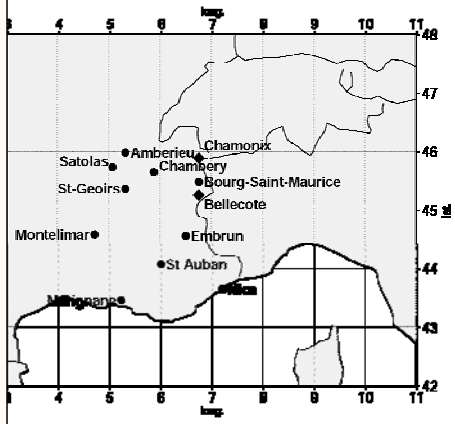
Precipitation (ERA-40)
Monthly average





- Good correlation between mean monthly precipitation at the 10 stations and ERA
- Underestimation of the wettest months

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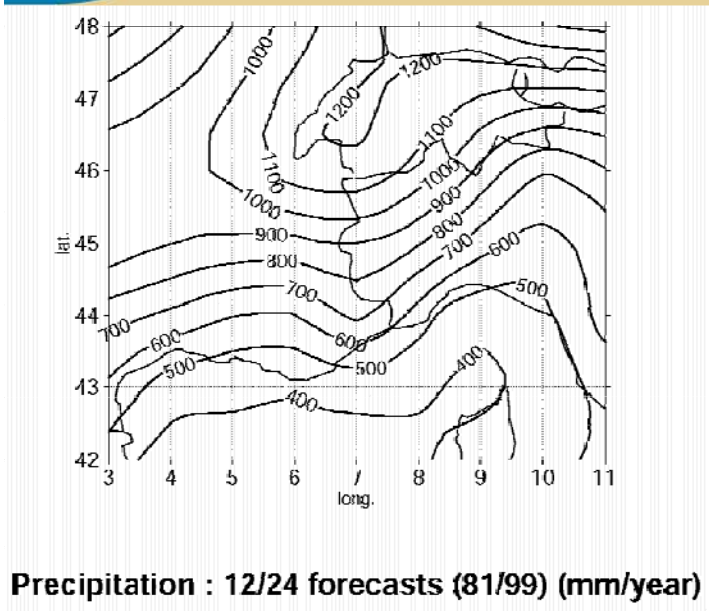
Precipitation



Precipitation : 12/24 forecasts (81/99) (mm/year)

	OBS	ERA40 00-12H forecast	ERA40 12-24 forecast
Period 81-99 (mm y^{-1})	**836**	**690**	**829**

- **Comparison : 10 stations vs nearest ERA grid point**
- The spin up is enhanced (absolute values and percentages) at the mountain top
- ERA40 precipitation are better than ERA15 (ERA15 underestimate precipitation because of orography shape ?)

	OBS	ERA15 12-24H forecast	ERA40 12-24 forecast
Period 81-91 (mm y^{-1})	**858**	**723**	**850**

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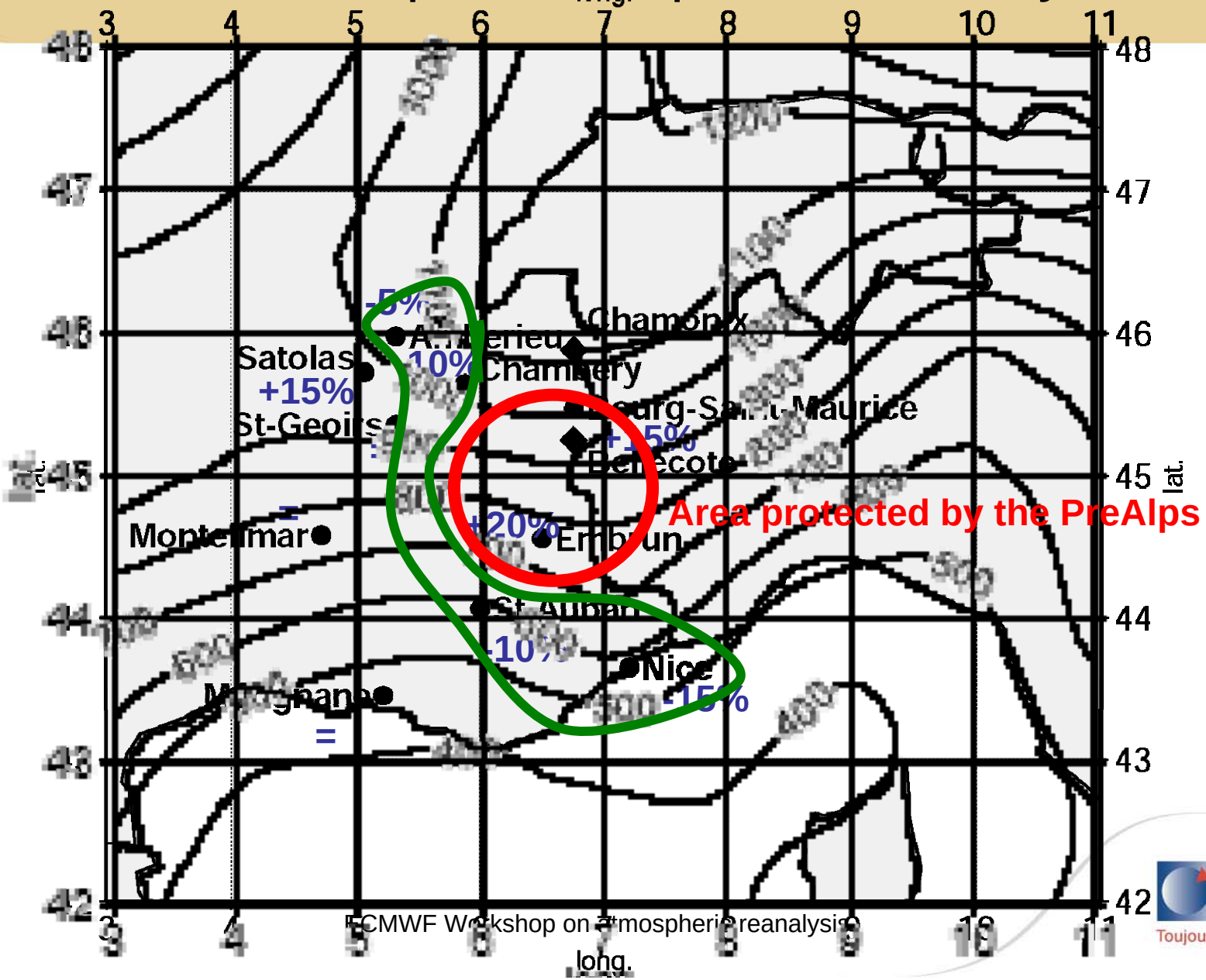
Precipitation : spatial variability



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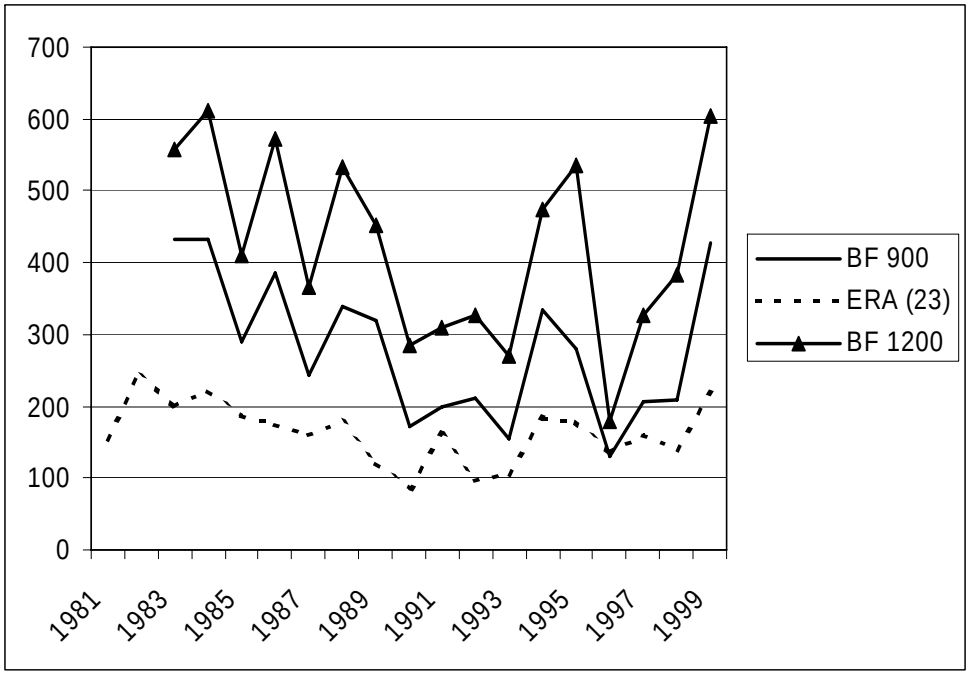
Annual snowfall : point 46N, 7E (1100m) vs Safran analysis, massif Beaufortain 900 and 1200 m

ERA40 : 1100 m
SAFRAN/CROCUS : 900 and 1200 m.



- Underestimation of snowfall :
- ERA40 underestimates snowfall when compared to Safran analysis
- 1990= winter 1989/90

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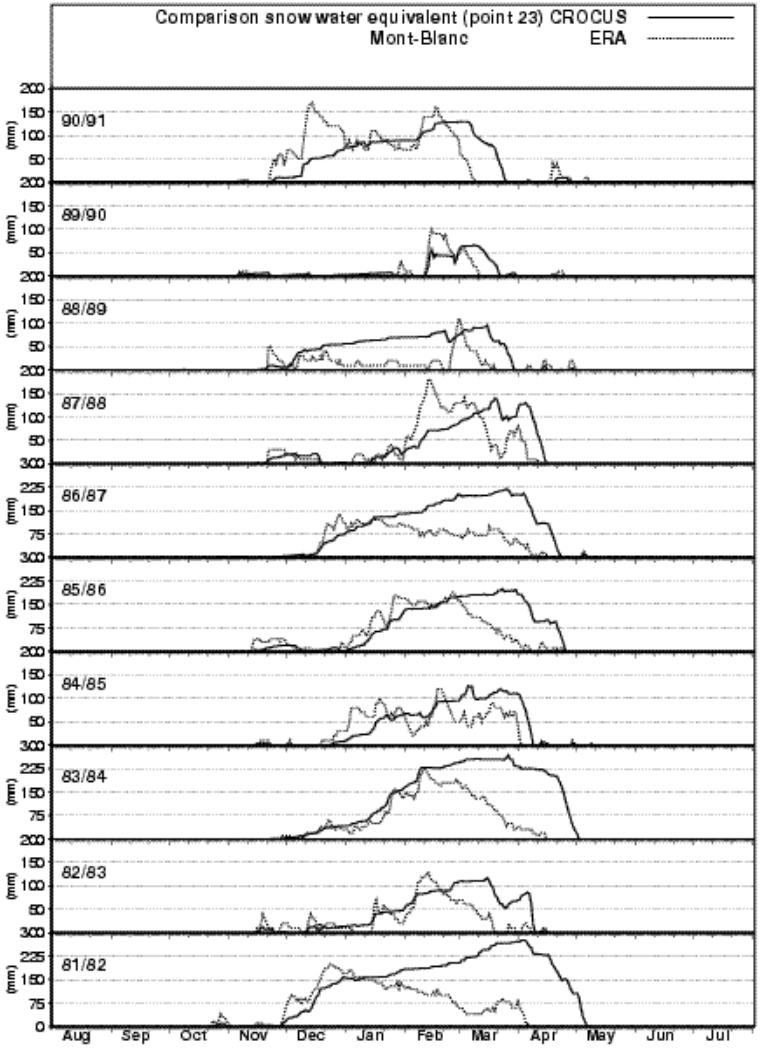
Snow cover

- Two strategies :
  - Compare ERA snow cover with analysed SAFRAN/CROCUS snow cover at the same elevation
  - Use SAFRAN algorithms to extrapolate data at higher elevation (demonstration)

ERA-15 snow water equivalent compared to Safran/Crocus simulation



- Unrealistic snow cover evolution
- ERA-15 snow cover mainly based on analysis,
- snow density assumed to be 250 kg/m^3
- >>> Snow cheme changed between ERA15 an ERA40

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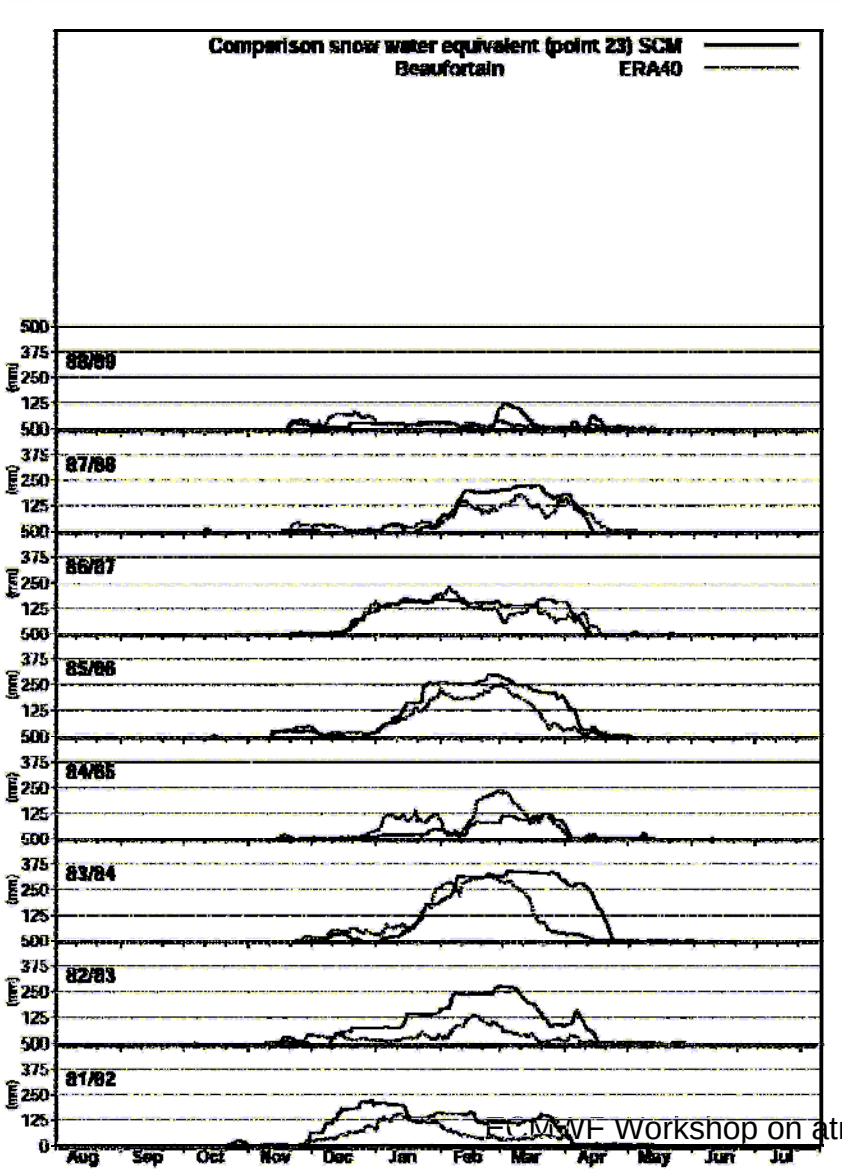
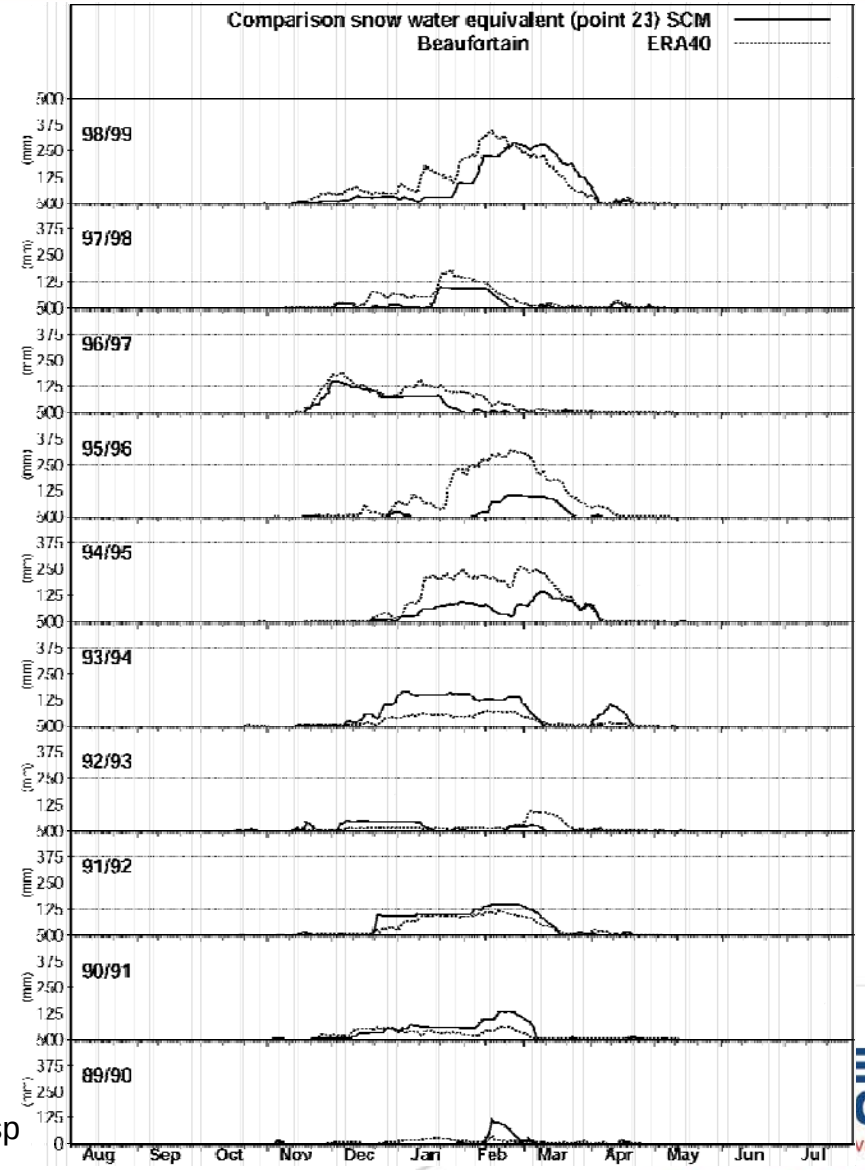
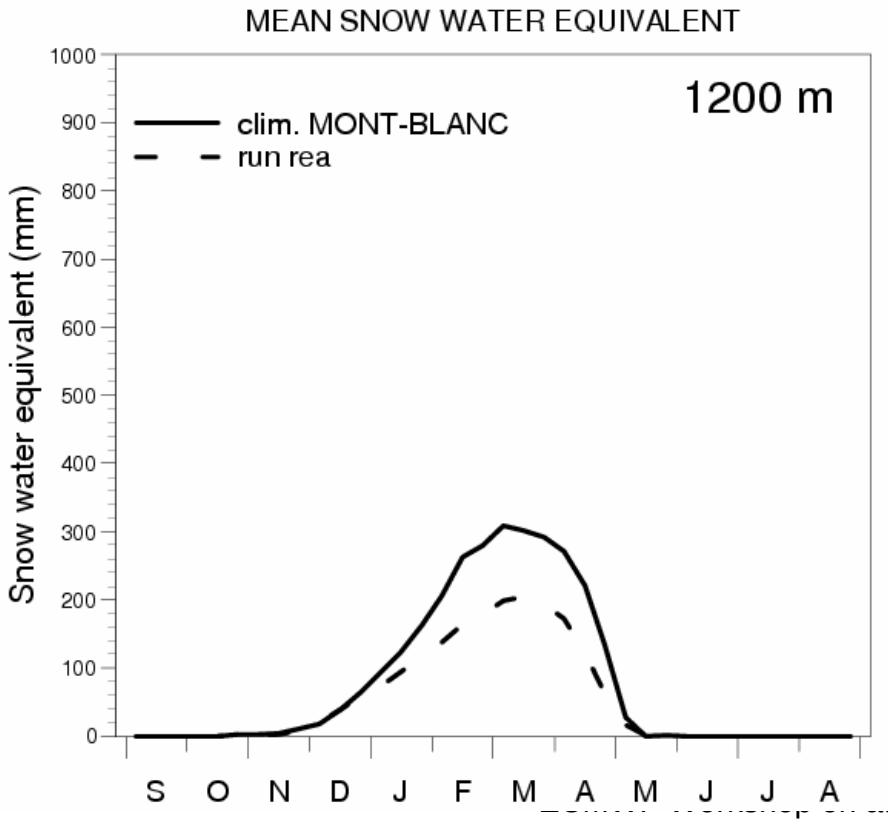
ERA-40 snow water equivalent compared to Safran/Crocus simulation

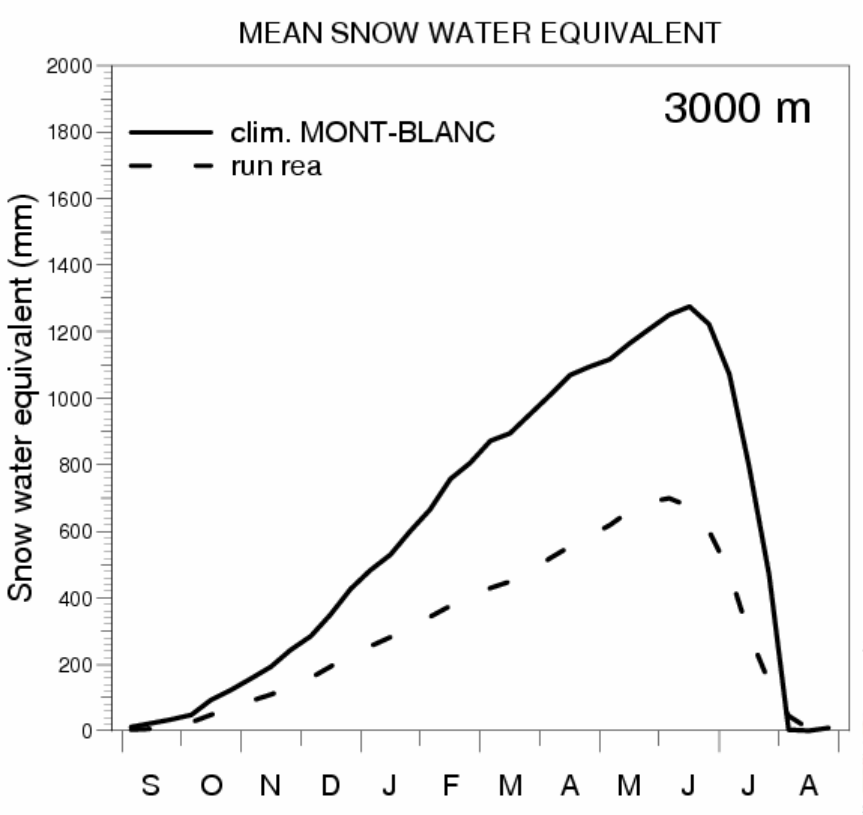




Extrapolation of ERA data at various elevation

- Usual snowfall gradient applied
- Underestimation of precipitation
- Good results on snow cover duration





Conclusion

Temperature :

- Enough quality for free air temperature
- Lower quality for valley bottom

Precipitation

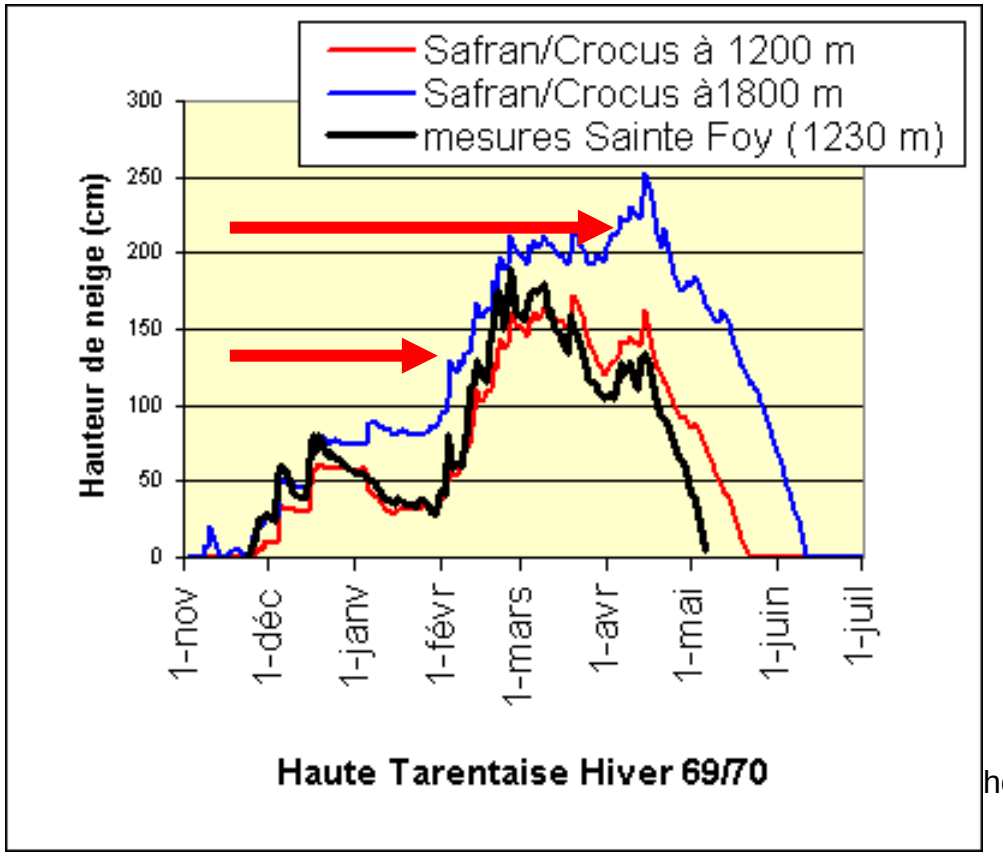
- Good overall shape on average, good montly variability
- Spatial variability linked to the model orography
- Snowfall underestimated
- Spin up affecting less snowfall than total precipitation (10% vs 30 %)

Snow cover

- Difficult to validate :
  - Model snow cover : low elevations
  - Extrapolation of ERA surface fluxes to compare to a climatology
    It is more a demonstration than a validation. Pratical interest for GCM derived equilibrium lines of glaciers.

Snow climatology derived from ERA40

- Snow trends
- Document past avalachance periods
  Major avalnches of the 1970 winter
  (Val d'Isère : 39 people killed)
- Help for avalanche forecasting



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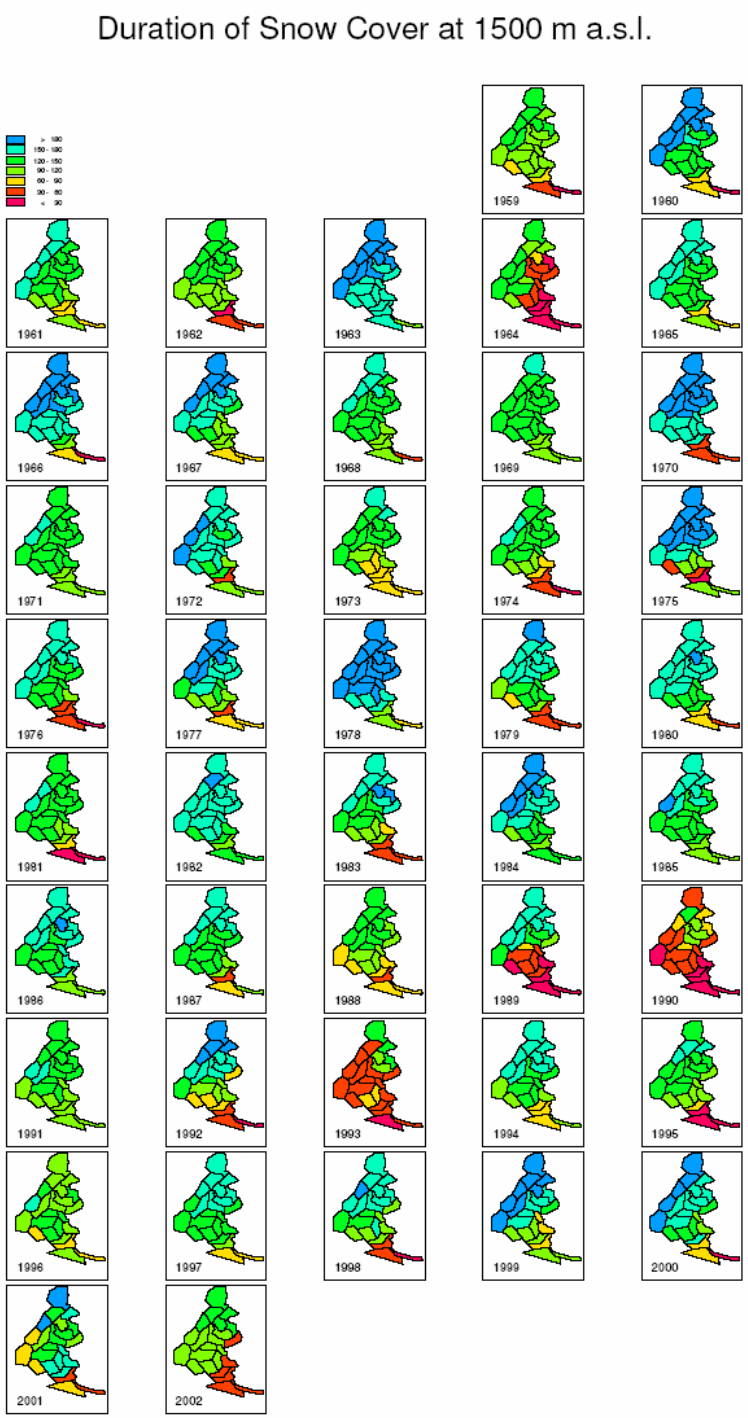

And for the next steps ?

Temperature :

- How to handle the stable surface boundary layer in winter ?
  - ERA40 better than ERA15
  - The issue of cold temperature in valleys, importance for the atmosphere ?

Precipitation

- Sharp horizontal gradients are observed between mountain ranges, can we refine ERA only by diminushing the grid ?
  - Small grids mean higher orography, less easy to compare with observation in valleys

Snow cover

- A snow cover …
  - To be compared with measurements ? (differences in elevation)
  - For hydrological applications ? (compare with areal estimations)
  - To simulate realistic surface fluxes for atmosphere ? (compare with … ?)

- We need to define objectives for the treatment of land-surface in moutain regions (some are contradictory)
- How far can we go in ERA-interim ? And in EURRA ?