Relationship between radar-estimated precipitation and synoptic weather patterns in the European Alps

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MOTIVATION

Why precipitation?

Insufficient information on effect of climate change where topography generates fine spatial scales (IPCC, 2008)

Further development is needed of catchment-scale climate models relevant to water management (IPCC, 2008)

Why radar?

Radar provides unmatched spatial and temporal resolution *(as compared to rain gauges)*

Why mountains?

Mountainous regions play an important role in the water cycle: storage, runoff, flash flooding

Why the Alps?

MeteoSwiss operational radar network provides multi-year high-quality data with excellent coverage over complex terrain

Why a climatology approach?

Several case studies in literature, fewer long-term analysis

Go beyond individual case -studies

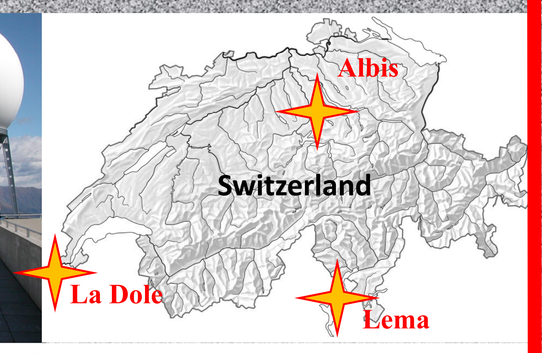
OBJECTIVES

1.a. Utilize operational-radar data to analyze decade-length precipitation distribution over complex terrain.

1.b. Relate precipitation distribution to synoptic weather patterns.

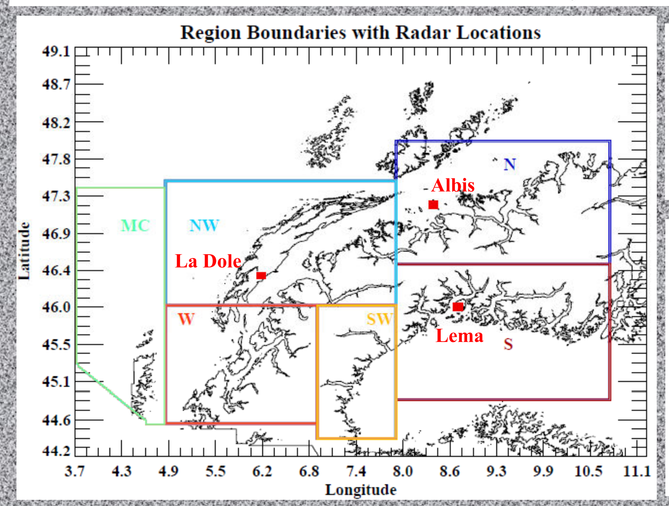
2. Apply relationship between precipitation and synoptic patterns to downscale precipitation from global climate model.

BASIS



MeteoSwiss Radar

- **3 locations: Lema (Lugano), Albis (Zurich), La Dole (Geneva)**
- **C-band Doppler weather radar**
- **Scans 20 elevations every 5 minutes**



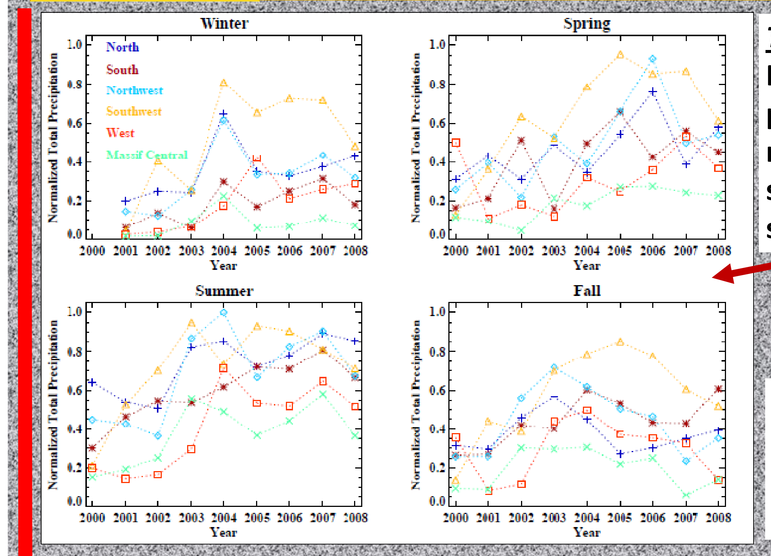
Define Regions

- **Within 200km range of radars**
- **Aligned with topographic aspect**

Use *RAIN product*

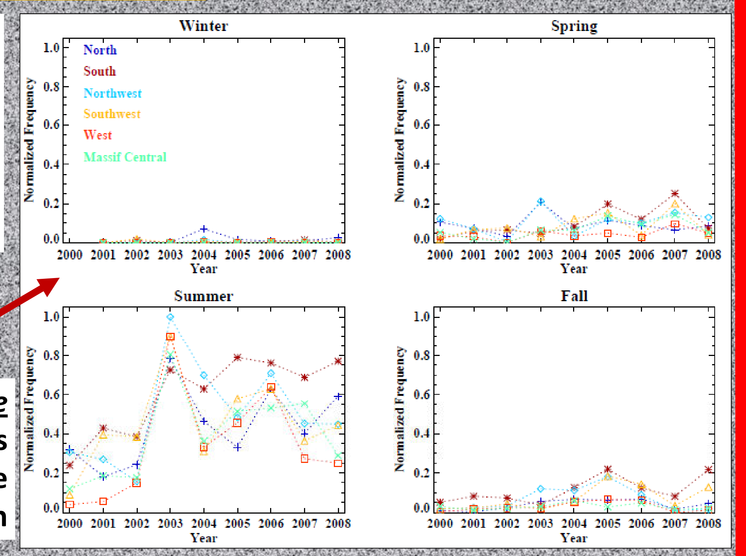
- **Ground-level precipitation rate**
- **30 minute running average**
- **Updated every 5 minutes**
- **2 x 2 km² resolution**

OBJECTIVE 1.a. Radar –based precipitation distribution : 2000-2008



Total Precip.
Radar estimated precip. from 30 minute intervals summed over season

High Precip. Rate
Count of pixels with rain rate > 20 mm/h



Total Precip

- **Summer is wettest season in all regions, except SW**
- **All regions show increase in summer precipitation**
- **No evidence for seasonal negative trend in any region**
- **Similar annual pattern in all regions**

Objective 1.a. Conclusions

High Precip Rate

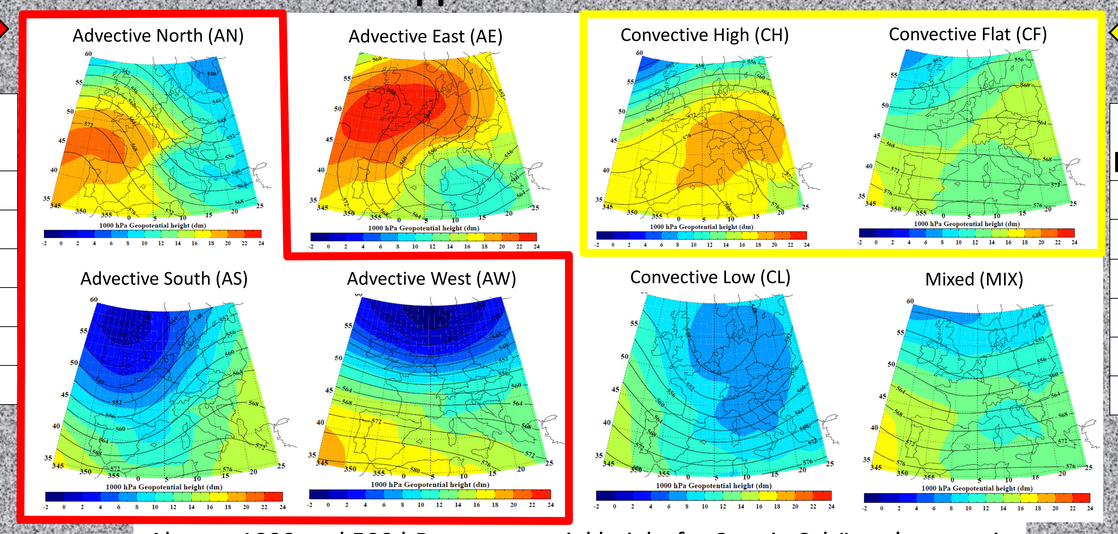
- **Most frequent in summer for all regions**
- **S and NW have highest summer frequency**
- **Summer frequency appears to increase in 2003-2008 relative to 2000-2002**

OBJECTIVE 1.b. Relation to synoptic weather patterns

Schüepp's weather classifications

Total Precipitation

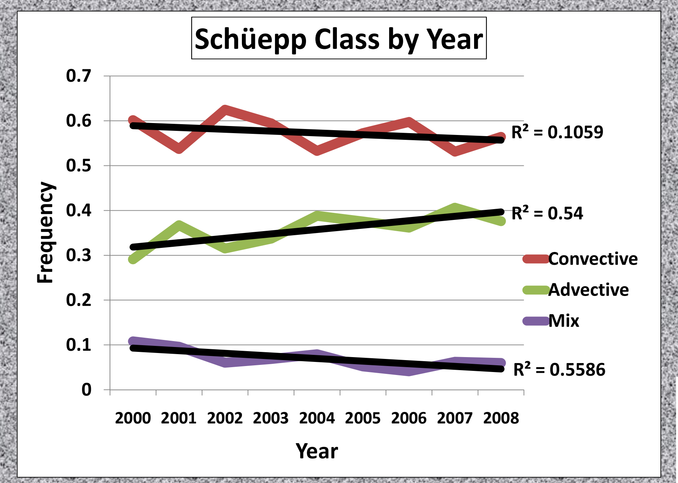
Region	Max Median	Max 90%
N	AN	AW
S	AS	AS
NW	AS	AS
SW	AS	AS
W	AS	AS
MC	AS	AS



High Precip. Rate

Region	Max Median	Max 90%
N	CF,CH	CH
S	CF	MIX
NW	CH	CH
SW	CH	CH
W	CH	CH
MC	CH	CH

Above: 1000 and 500 hPa geopotential height for 8 main Schüepp's synoptic weather classifications from ERA-Interim reanalysis for 2000-2008. (color contours: Z1000; linear contours: Z500)



Objective 1.b Conclusions: Relation to synoptic patterns

advective pattern → precipitation quantity

- Increase in advective pattern frequency may explain increases in daily precip

convective pattern → high precipitation rate

- Decrease in convective pattern frequency, but increase in high precip rate

References

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Acknowledgements

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OBJECTIVE 2 Apply relationship between precipitation and synoptic patterns to downscale precipitation from global climate model.

Historical (2000-2008) ***Future (2010-2099)***

ECMWF ERA Interim Z1000, Z500 daily 1.5°x1.5°

MeteoSwiss Schüepp's daily synoptic weather class

NCAR CCSM3 PSL, Z500 daily ~1.4°x1.4°

CCSM3: Community Climate System Model Version3

Associate daily ERA data to synoptic pattern

Match patterns in model data to "observed" patterns

Learning Vector Quantization (LVQ)

Determine frequency, trends of each pattern in model

MeteoSwiss Radar

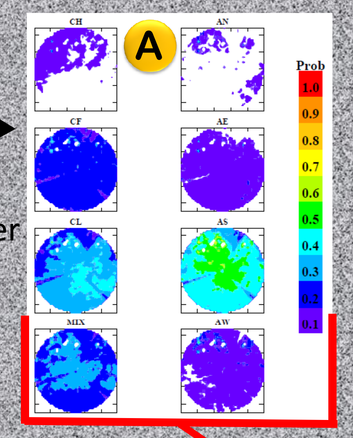
A P(rain)

B median rainfall

C Calculate expected precipitation (for each 2 x 2 km²)

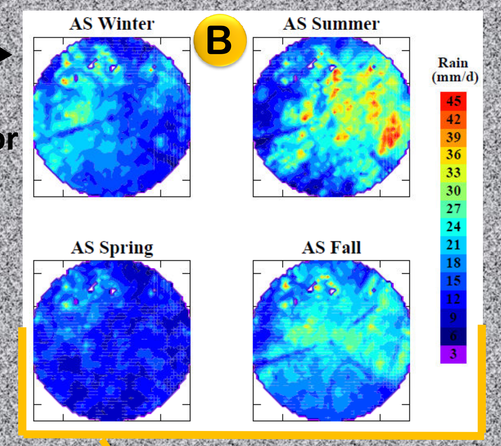
Probability of precip. for each synoptic classification

- > 0.5 mm/h over 1 hour
- 50 km radius around Lema location



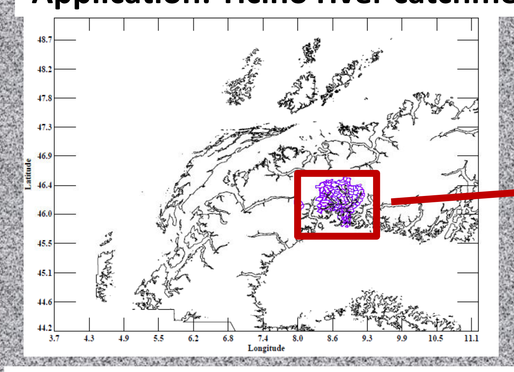
Seasonal median 24 h precip total for synoptic classification

- Advective South (AS) shown as example



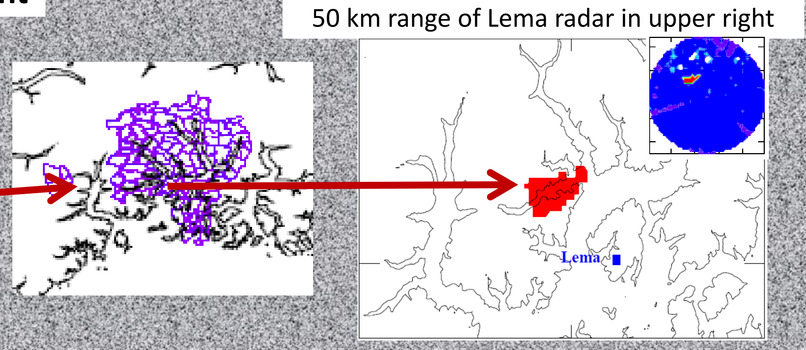
C $\overline{Rainfall} = \sum_{k}^{k} \{P(Rain|Class_k) \times P(Class_k) \times Median\ R_{Class_k}\}$

Application: Ticino river catchment

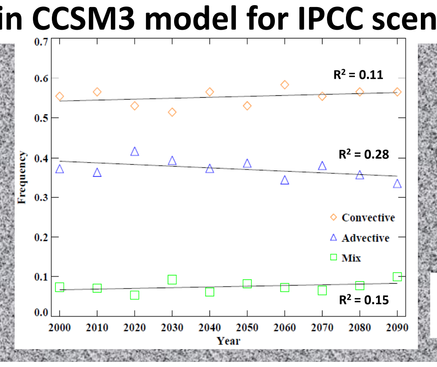


Sub-catchment 60174 (~80 km²)

50 km range of Lema radar in upper right



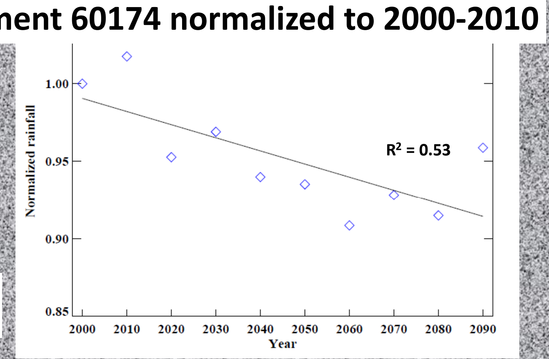
Frequency of synoptic classes identified in CCSM3 model for IPCC scenario A1B



Freq.	class	normalized rainfall
↓	AE	1.00
	AS	0.61
	MIX	0.58
	CF	0.43
↓	CL	0.39
	AN	0.39
↑	CH	0.22
	AW	0.20

Reduced frequency of patterns that generate more precip.

Total decadal precipitation for sub-catchment 60174 normalized to 2000-2010



(Preliminary) Objective 2 Conclusions

- Dynamic changes in frequency of synoptic weather patterns result in decreased precipitation for Ticino river sub-catchment

Future Work (Downscaling)

- Seasonal analysis
- Expand geographic scope
- Additional IPCC climate scenarios
- Replicate runs of GCM