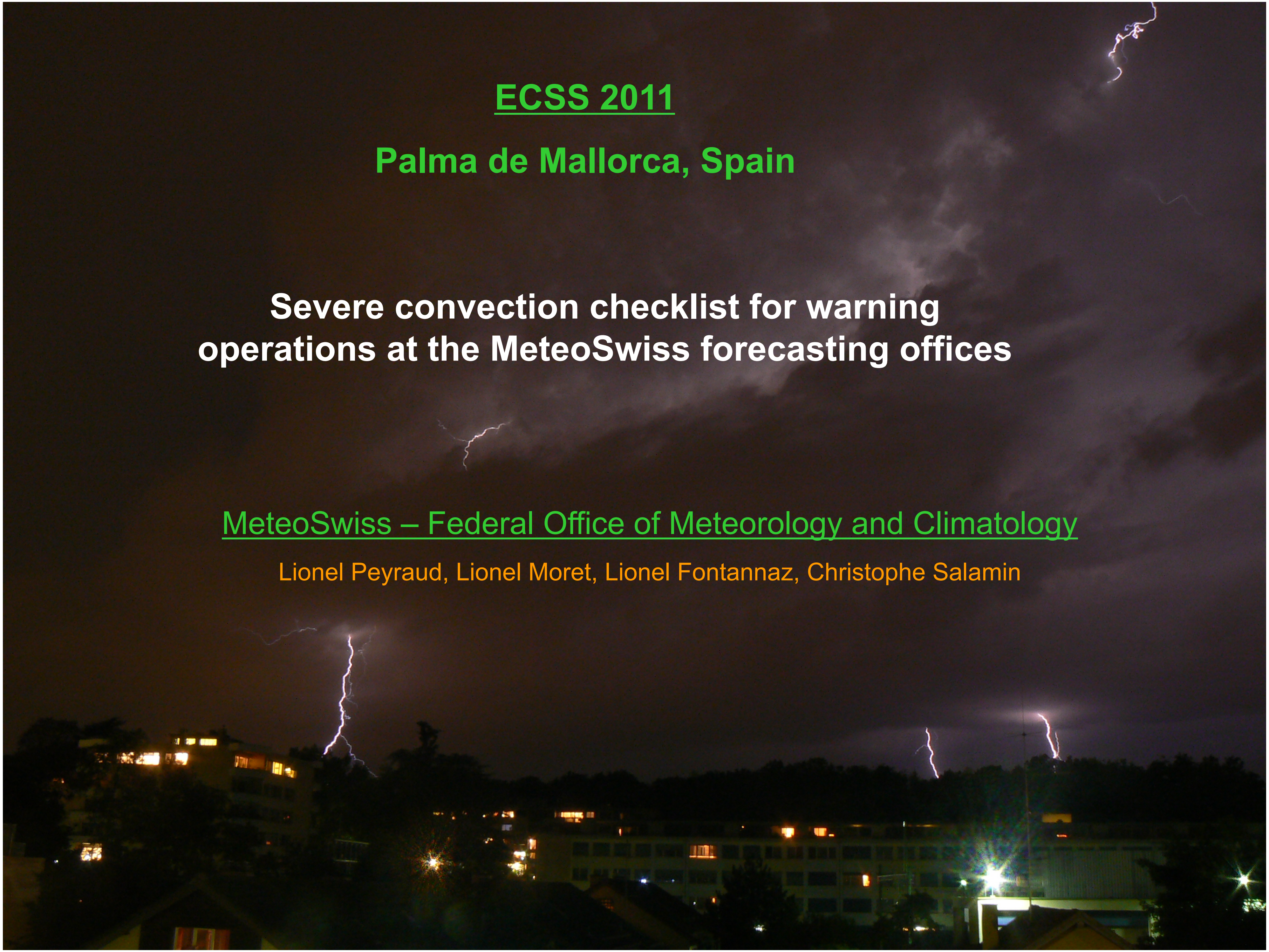


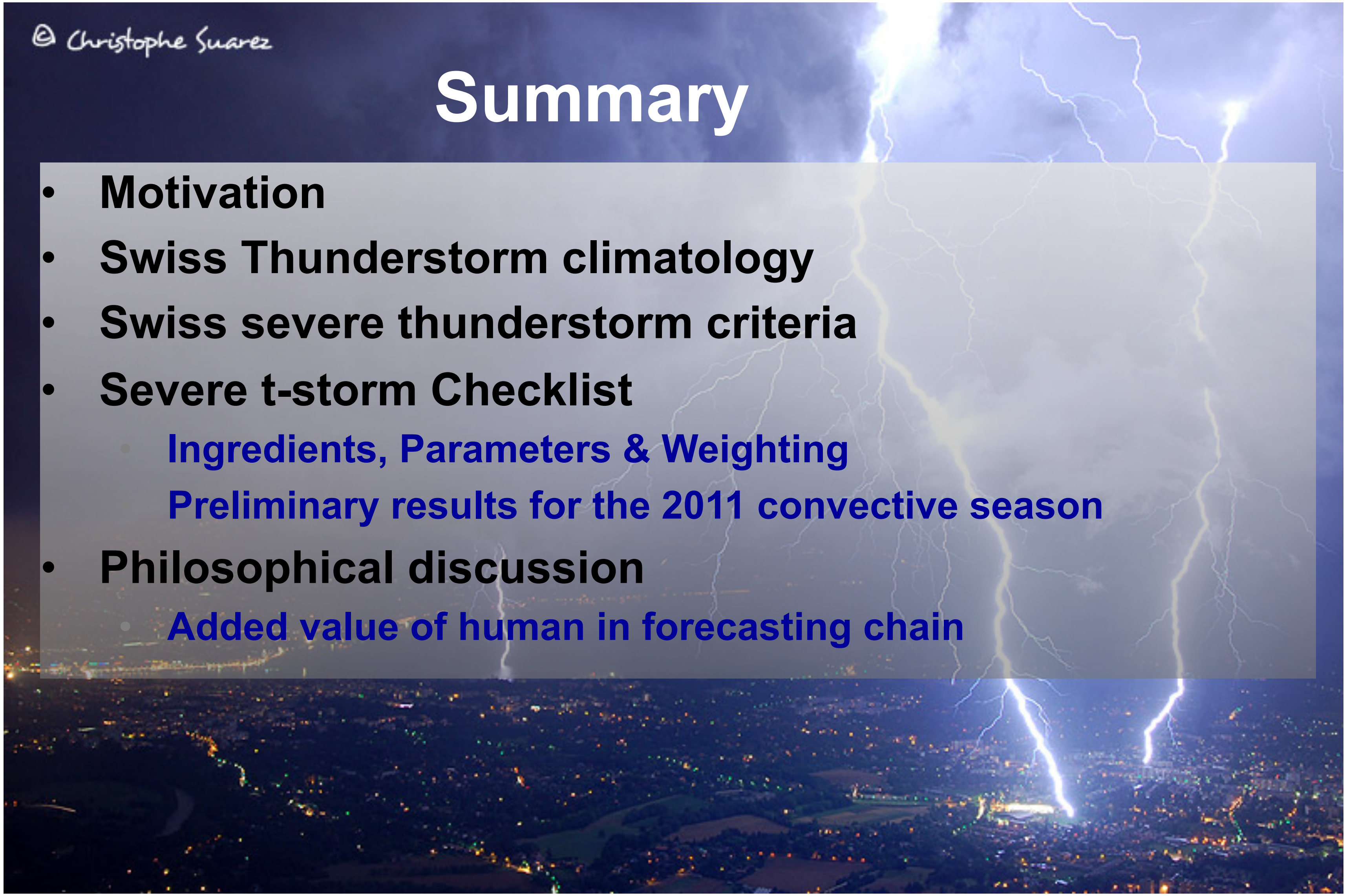
ECSS 2011

Palma de Mallorca, Spain

Severe convection checklist for warning operations at the MeteoSwiss forecasting offices

MeteoSwiss – Federal Office of Meteorology and Climatology

Lionel Peyraud, Lionel Moret, Lionel Fontannaz, Christophe Salamin



Summary

- **Motivation**
- **Swiss Thunderstorm climatology**
- **Swiss severe thunderstorm criteria**
- **Severe t-storm Checklist**
  - **Ingredients, Parameters & Weighting**
  - **Preliminary results for the 2011 convective season**
- **Philosophical discussion**
  - **Added value of human in forecasting chain**

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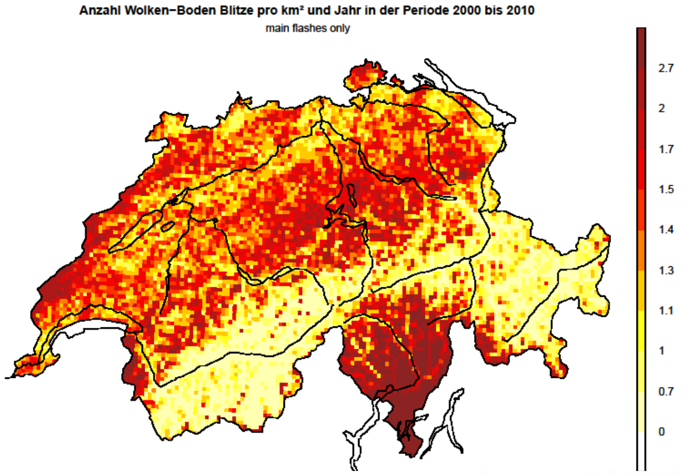
Motivation / Goals

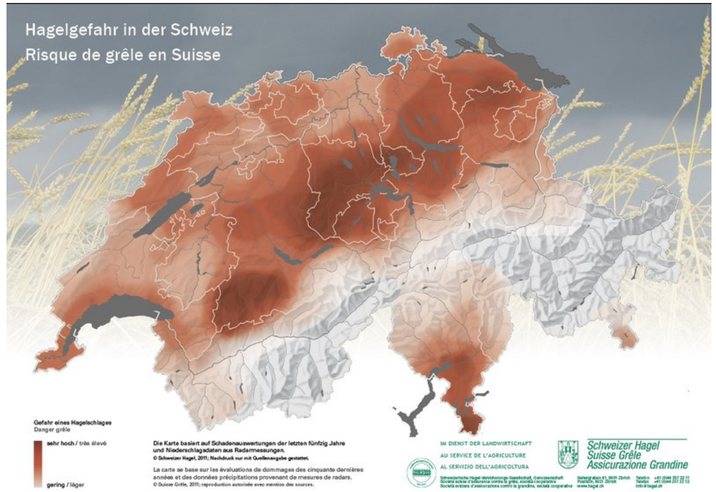
- **MeteoSwiss forecasting branch has a warning (watch) system composed of various intensity levels for hazardous weather phenomena.**
- **Regarding severe thunderstorms, the forecasting centers wanted to be able to better distinguish environments favoring low-end intensity storms and high-end intensity storms.**
- **Introduction in Spring 2011 of an ingredient-based checklist with specific thresholds aiming to better differentiate between these two types of environments.**
- **Another goal was to introduce a more objective method in the severe t-storm watch/warning decision making process.**

Swiss thunderstorm climatology

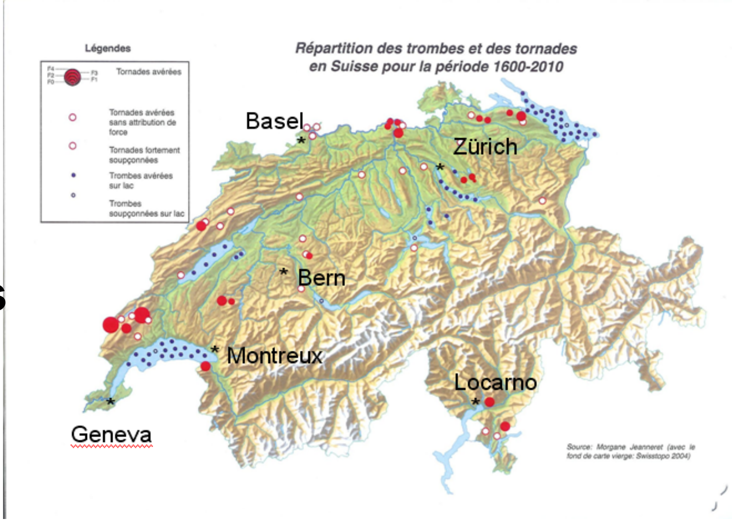
Lightning (CG)



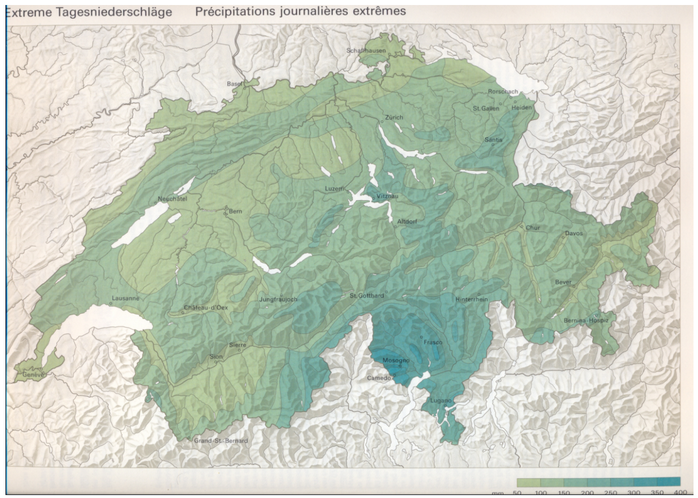
Hail



Tornadoes

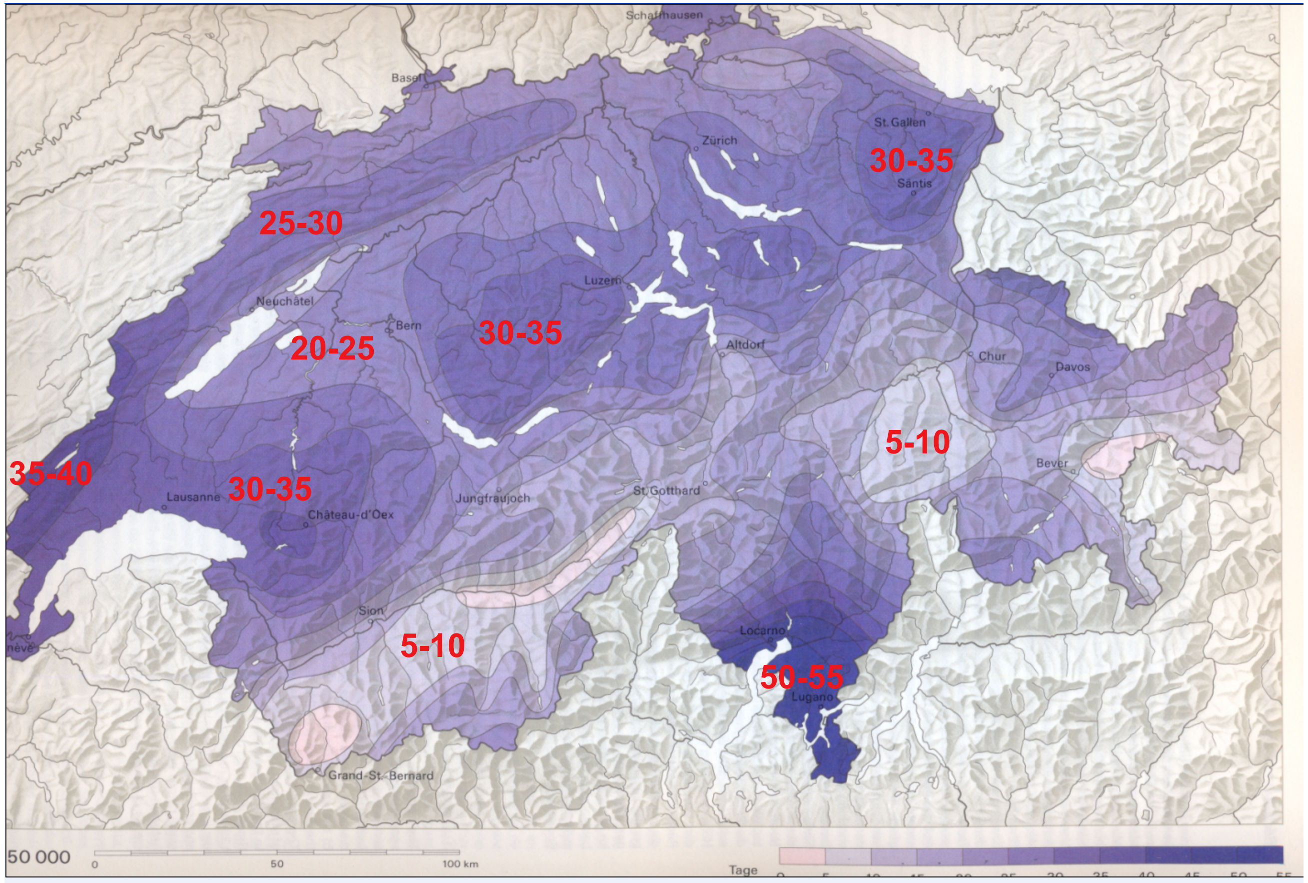


Extreme rainfall



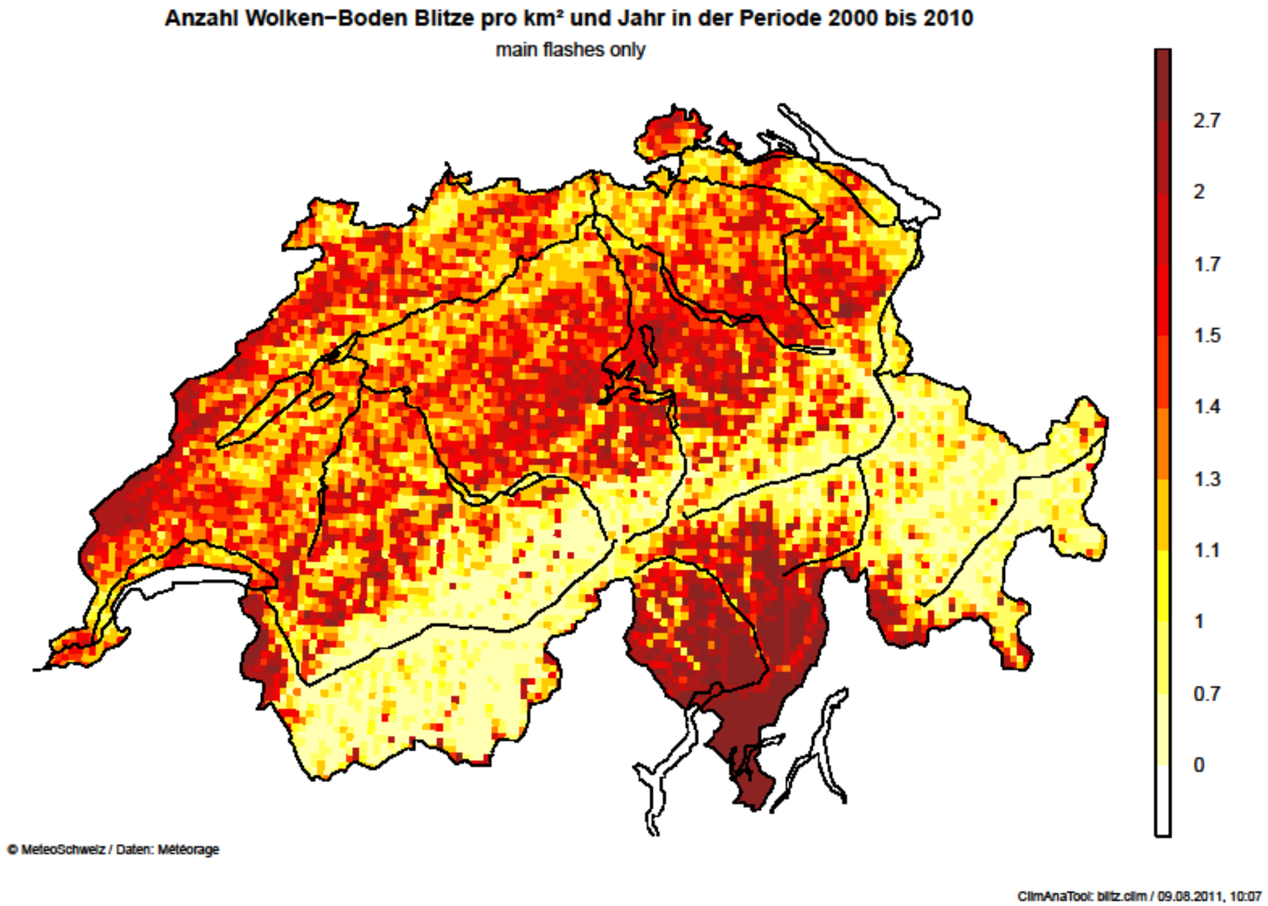
Swiss thunderstorm climatology

Thunder days between 1971-1980



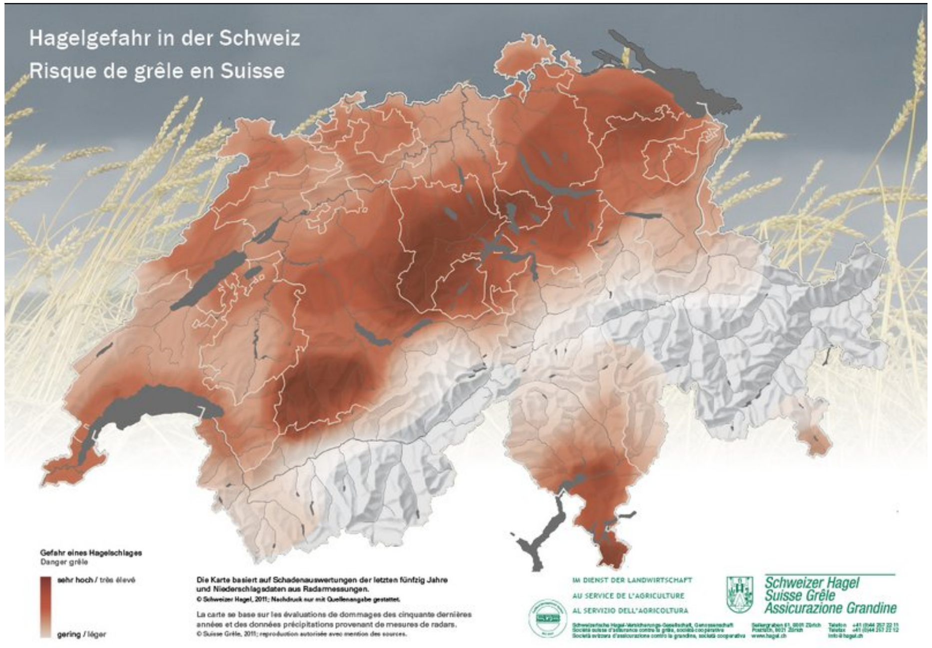
Swiss thunderstorm climatology

C-G lightning frequency based on Météorage triangulation system



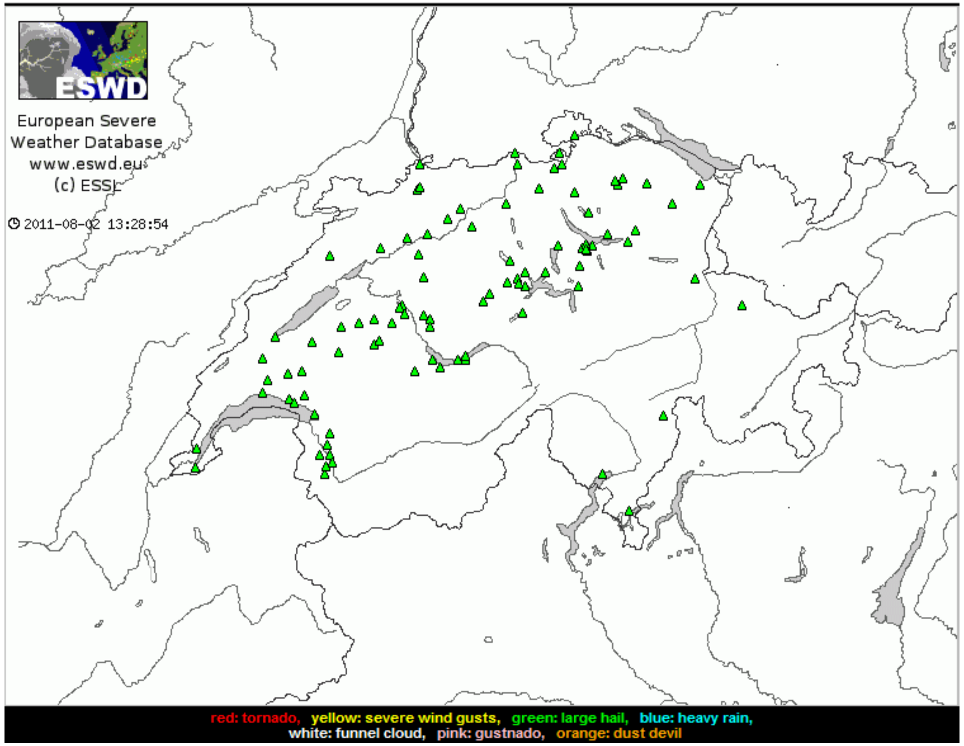
Swiss severe thunderstorm climatology

Hail



1960 – 2010 (based on insurance claims)

Large hail > 2 cm



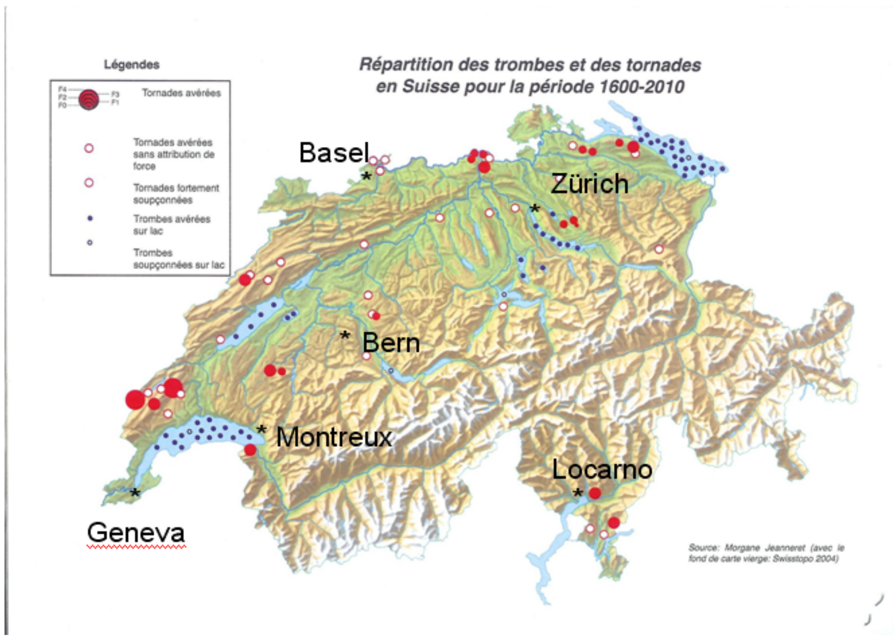
1800 – July 2011 (99)

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Département fédéral de l'intérieur DFI
Office fédéral de météorologie et de climatologie MétéoSuisse

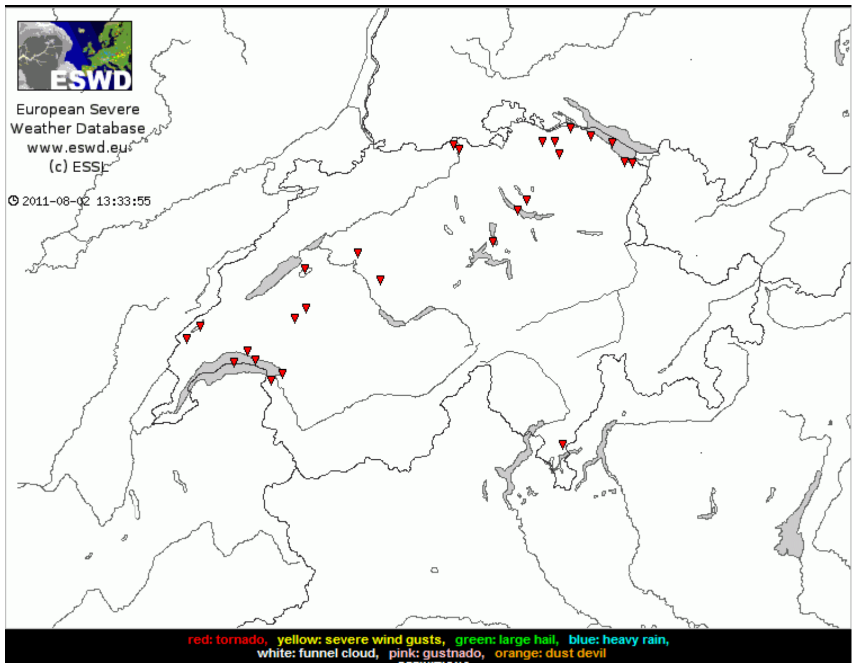
Swiss severe thunderstorm climatology

Tornadoes + waterspouts



1600 – July 2010 (?)

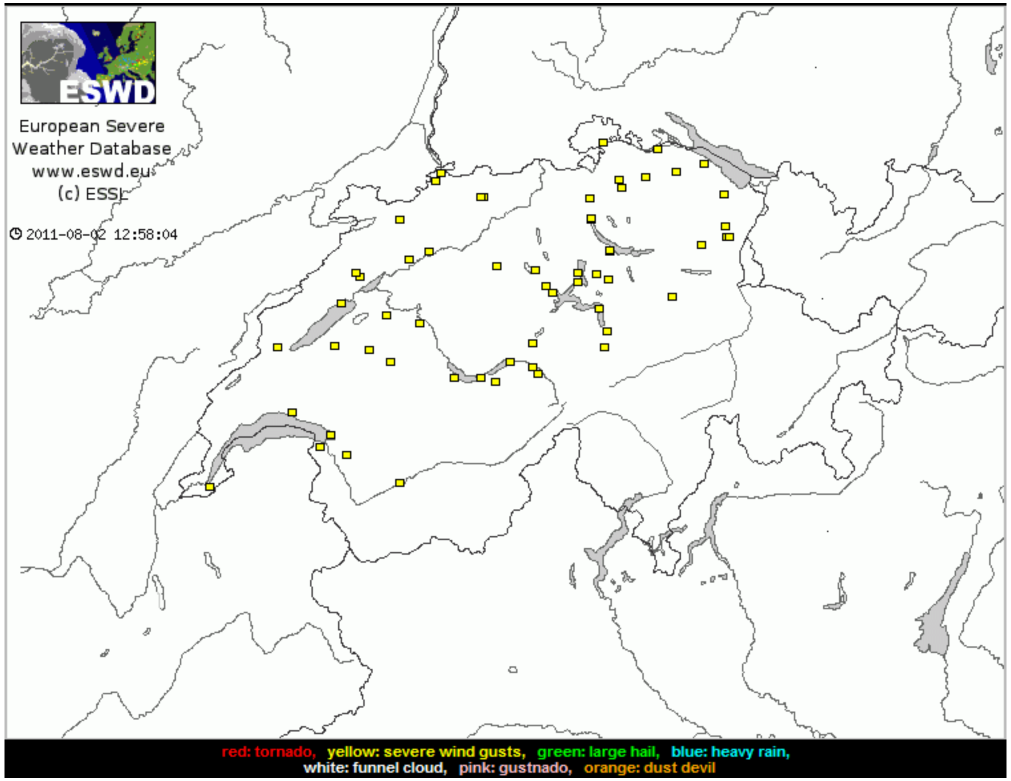
Tornadoes + waterspouts



1600 – July 2011 (27)

Swiss severe thunderstorm climatology

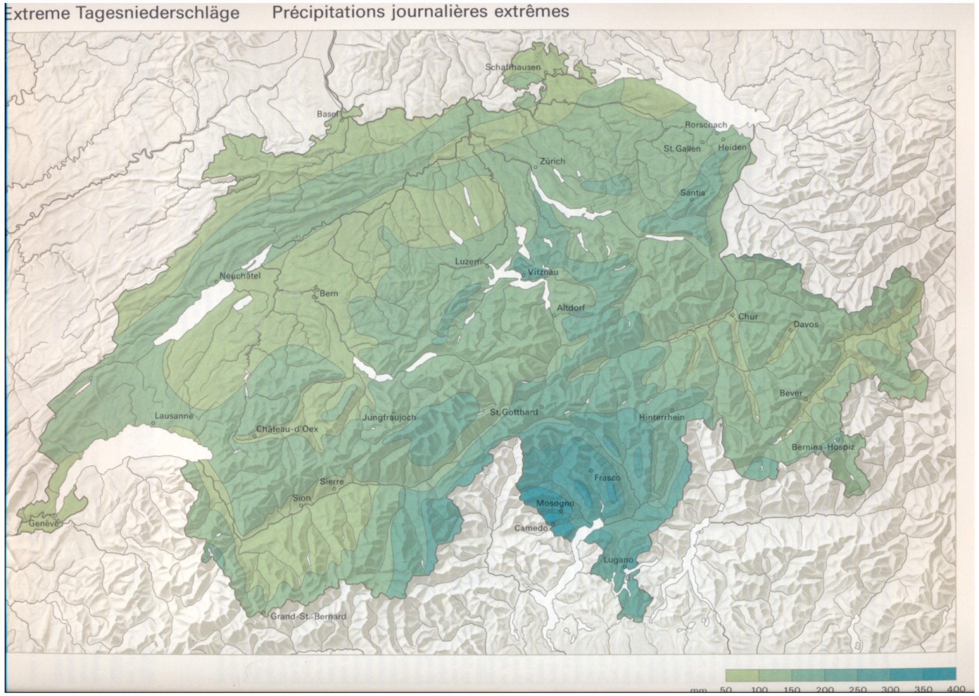
Severe straight-line wind gusts (> 25 m/s)



1800 - July 2011 (73)

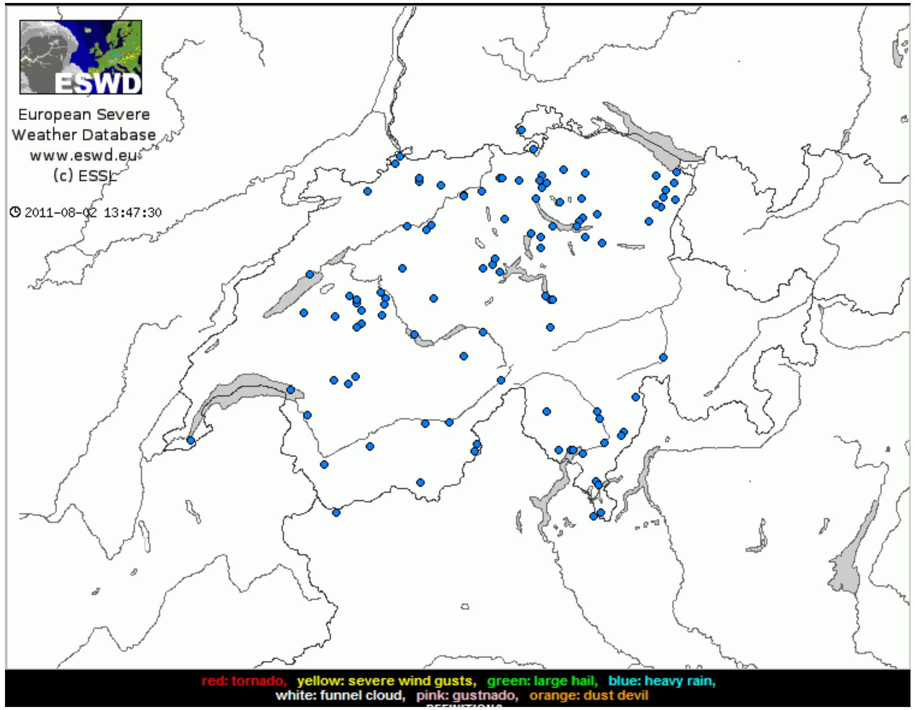
Swiss severe thunderstorm climatology

Extreme 24hr rainfall



1901 - 1980

Heavy rain events



1800 - July 2011 (125)

Swiss severe t-storm watch criteria

- MeteoSwiss presently tries to anticipate severe thunderstorm environments by issuing severe thunderstorm watches/outlooks of 2 different intensity levels :

Watch criteria (and/or)	Degree 3 (orange)	Degree 4 (red)
Wind gusts	75 km/h (42 kts; 20 m/s)	110 km/h (61 kts; 30 m/s)
Hail diameter	2 cm	4 cm
Rainfall rate	25 mm / hr	50 mm / hr

- Lead time : 6 – 36 hrs
- Degree 4 watches are SOV watches

Swiss severe t-storm warning definitions

- MeteoSwiss presently warns severe thunderstorms based on different radar criteria calculated via the Thunderstorm Radar Tracking (TRT) algorithm which calculates 4 storm intensities :

RANK = Round((2.0*(cell_max_VIL/75.0)*4.0 + 2.0*R_ET45mean + 1.0*R_dBZmax + 2.0*R_area57dBZ)/7.0)

TRT ranking thresholds	Very Weak	Weak	Moderate	Severe
Category	1	2	3	4
VIL [kg/m^2]	0-15	15-35	35-55	55-75
Mean Echo Top 45 dBZ [km]	< 4	4-6	6-8	> 8
Max dBZ [dBZ]	> 48	> 51	> 54	> 57
Area [km^2]	> 48	> 48	---	---

MESHS (cm)	---	---	2	4
1hr acc. Radar QPE (mm/h)	---	---	25 mm/h	50 mm/h

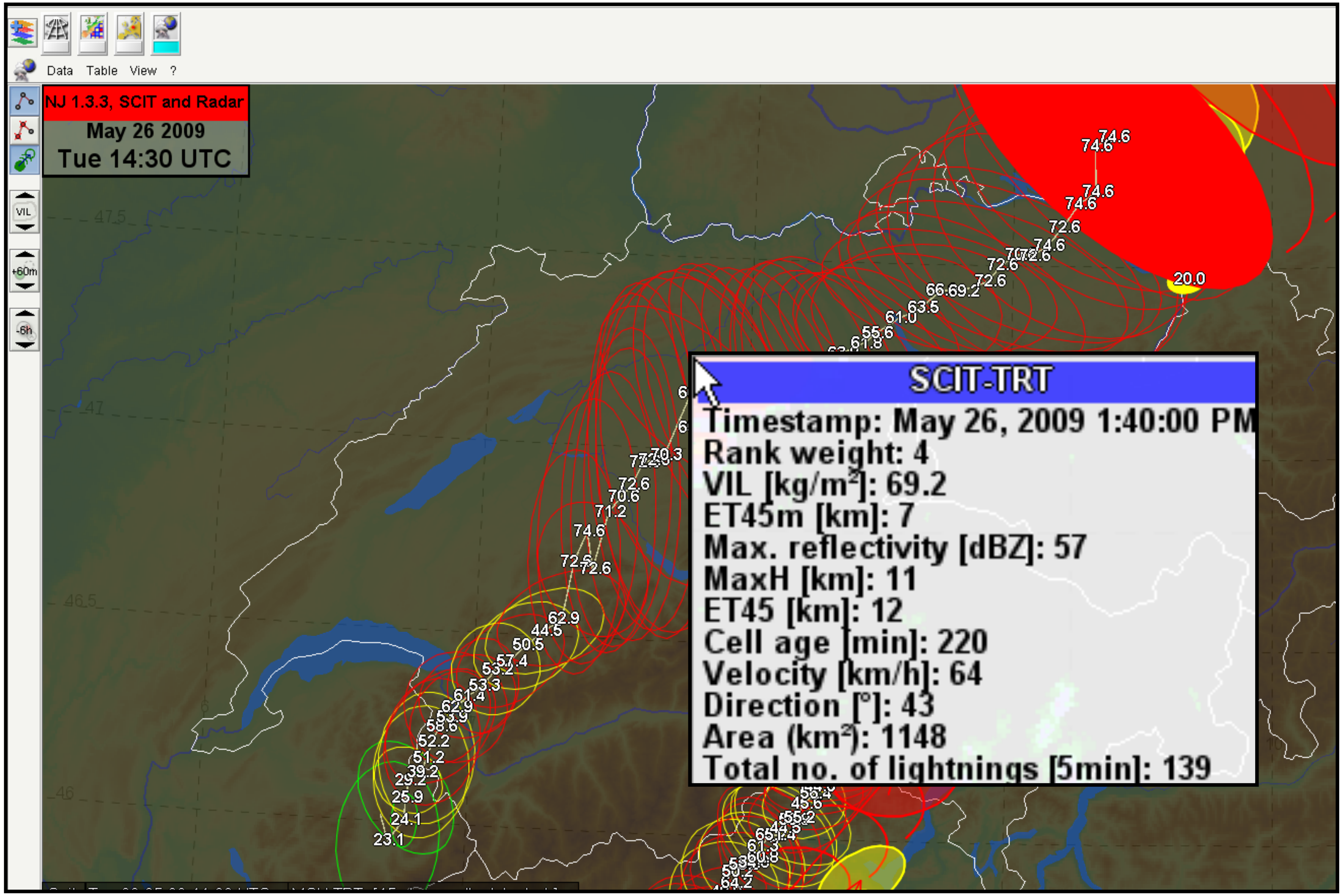
- Lead time : 0 – 1 hr ; currently no mesocyclone detection algorithm

Swiss severe t-storm warning definitions

- The TRT ranking algorithm calculates 4 t-storm intensities based on the following formula :
  - **RANK = Round((2.0*(cell_max_VIL/75.0)*4.0 + 2.0*R_ET45mean + 1.0*R_dBZmax + 2.0*R_area57dBZ)/7.0)**
- ff

Thresholds	Category	VIL $[kg/m^2]$	Mean EchoTop 45 dBZ [km]	Max dBZ [dBZ]	Area $[km^2]$
VERY WEAK	1	0-15	<4	>48	>48
WEAK	2	15-35	4-6	>51	>48
MODERATE	3	35-55	6-8	>54	-
SEVERE	4	55-75	>8	>57	-

Example : TRT algorithm and SCIT table



Severe thunderstorm checklist

- Pre-requesites for severe t-storm checklist acceptance within forecasting operations :
  - Criteria based on available model fields
  - Straightforward and easy to apply
  - Must not take more than 15 minutes to fill out
- Goal of the checklist
  - Best differentiate between low-end and high-end severe thunderstorm environments based on an ingredient-based approach
  - To apply different weights to the different parameters representing each ingredient depending on its importance on t-storm development
  - To propose the most relevant available parameters and propose realistic thresholds
  - To propose a final checklist value to the forecaster to aid in his/her decision making process (maximum value normalized to 100)

Severe thunderstorm checklist

- **4 checklist ingredients :**
  - **Synoptic configuration (Lift)**
    - Flow curvature, jet streaks, thermal gradients
  - **Instability**
    - CAPE, mid-level lapse rates, Lifted Index
  - **Vertical wind shear**
    - Bulk shear : Deep-layer (0-6km), Low-level (0-3km)
  - **Humidity**
    - Sfc dewpoint, Theta-E 850hPa, precipitable water
- Parameters chosen on availibility, relevance and limited complexity
- Swiss topography also a factor (i.e. we do not forecast tornadoes)
- CIN not included in checklist but taken into account to access risk.

Nom : mor

Date : 07.06.2011 09:41

Date échéance : 07.06.2011

CHECK-LISTE ORAGES VIOLENTS POSSIBLES				Résultats
	Situation synoptique			
Synoptique	Marais 0	Préfrontal peu dynamique 1	Préfrontal dynamique 0	21
Flux 500 / 300	Anticyclonique ou col 0	Cyclonique ou rectiligne SW 1	Onde courte dans flux de SW (faible OK pour stationnaire) 0	
Jet 300 hPa	Zone de NVA ou ras 0	PVA (sortie froide OU entrée chaude de jet) 1	PVA (sortie froide ET entrée chaude de jet) 0	
Isotherme 850 hPa	Axé W - E 0	Axé N - S 1	Axé N - S très serré 0	
	Instabilité			
Cape	Cape < 500 j/kg 0	500 j/kg <= Cape < 1500 j/kg 1	Cape >= 1500 j/kg 0	9
T°850 - T°500 hPa	Delta T < 25° 0	25° <= Delta T < 30° 1	Delta T >= 30° 0	
Lifted Index	LI > -2° 0	-2° >= LI > -7° 1	LI <= -7° 0	
	Cisaillement			
Cis. sol - 6 km	Cis. < 25 kt 1	25 kt <= Cis. < 40 kt 0	Cis. >= 40 kt 0	2
Cis. sol - 3 km	Cis. < 15 kt 1	15 kt <= Cis. < 30 kt 0	Cis. >= 30 kt 0	
	Humidité			
T°point de rosée	T'd < 13° 0	13° <= T'd < 18° 1	T'd >= 18° 0	12
Theta-E 850 hPa	Te < 40° 0	40° < Te < 55° 1	Te > 55° 0	
Eau précipitable	PWAT < 20 mm 0	20 mm <= PWAT < 35 mm 1	PWAT >= 35 mm 0	

Evaluation Avis	56	R < 60 : pas d'avis 60 <= R <= 80 : orages violents dynamiques possibles : DD3 R > 80 : orages violents dynamiques possibles : DD4

orage sationnaire

orage dynamique

rchive de la feuille

Archive

Vos remarques :

Remarques sur l'interprétation :

Les seuils ne sont pas des frontières rigides mais des indications à interpréter prudamment, compte tenu de la grande variabilité des facteurs composant l'indice (en particulier les paramètres dépendant des basses couches de l'atmosphère).

Severe thunderstorm checklist

- **Weighting of values :**
- For organized convection, weights maximized for :
  - Strong synoptic forcing
  - High instability
  - Strong shear
  - High humidity
  - => favors organized severe MCSs (strong squall lines, bow echoes, supercells)

- For airmass convection, weights maximized for :
  - Strong curvature (small short waves) with weak flow
  - High instability
  - Weak shear
  - High humidity
  - => favors pulse-like severe t-storms with stationary character

- Checklist then tested vs. past real cases to fine-tune parameter threshold ranges to local climatology

- In the future, MeteoSwiss may implement « flash-flood » watches, which could perhaps lead us to drop the heavy-rain rate criteria in the severe t-storm watches..? (not in the cards right now)

Severe thunderstorm checklist

- **Weighting and normalization of values :**

Orage stationnaire

Coefficient	(vert)	(orange)	(rouge)
Synoptique	3	5	1
Flux 500 / 300	1	2	9
Jet 300 hPa	2	1	1
Delta T° 850 hPa	1	3	5
Cape	1	3	8
T° 850 - T° 500 hPa	1	3	8
Lifted Index	1	5	8
Cisaillement 0-3 km	6	3	1
Cisaillement 0-6 km	6	3	1
T° point de rosée	1	3	9
Theta-E 850 hPa	1	3	9
PWAT	1	3	9

R < 60 : orages violents peu probable
60 <= R <= 80 : orages violents **stationnaires** possibles : DD3
R > 80 : orages violents stationnaires possibles : DD4

Orage dynamique

Coefficient	(vert)	(orange)	(rouge)
Synoptique	1	5	7
Flux 500 / 300	1	5	7
Jet 300 hPa	1	6	9
Delta T° 850 hPa	1	5	7
Cape	1	3	7
T° 850 - T° 500 hPa	1	3	4
Lifted Index	1	3	5
Cisaillement 0-3 km	1	5	7
Cisaillement 0-6 km	1	5	7
T° point de rosée	1	4	8
Theta-E 850 hPa	1	4	5
PWAT	1	4	5

R < 60 : orages violents peu probables
60 <= R <= 80 : orages violents **dynamiques** possibles : DD3
R > 80 : orages violents dynamiques possibles : DD4

- Weights in each column normalized (max value possible of 100)

$$N = \frac{\text{Max column}}{\text{Max score}} * 100$$

- In future, will attempt to normalize ingredient rows to ensure min value (kill factor) and max values (to increase independence of parameters within each ingredient class)

Severe t-storm checklist : 2011 results

All t-storms	#	H	FA	M	POD	FAR	CSI
Checklist < Threshold 1	29	27	2	5	84%	7%	79%
Checklist > Threshold 1	14	9	5	2	82%	36%	56%
Checklist > Threshold 2	1	0	1	0	0%	100%	0%
Organized t-storms							
Checklist < Threshold 1	11	11	0	4	73%	0%	73%
Checklist > Threshold 1	12	8	4	0	100%	33%	67%
Checklist > Threshold 2	1	0	1	0	0%	100%	0%
Airmass t-storms							
Checklist < Threshold 1	18	16	2	1	94%	11%	84%
Checklist > Threshold 1	2	1	1	2	33%	50%	25%
Checklist > Threshold 2	0	0	0	0	---	---	---

Forecasting complications in our region of responsibility (in proximity to Alps)

- Cold and drier air filtering at surface ahead of strongest upper-level forcing

  => tends to limit thunderstorm severity
- Distinguishing whether convection will concern orography only or both orography and plain regions

  => a function of wind shear and whether CAPE is both elevated and ground-based or not
- Large uncertainties in low-level moisture values in heterogeneous terrain as calculated by NWP

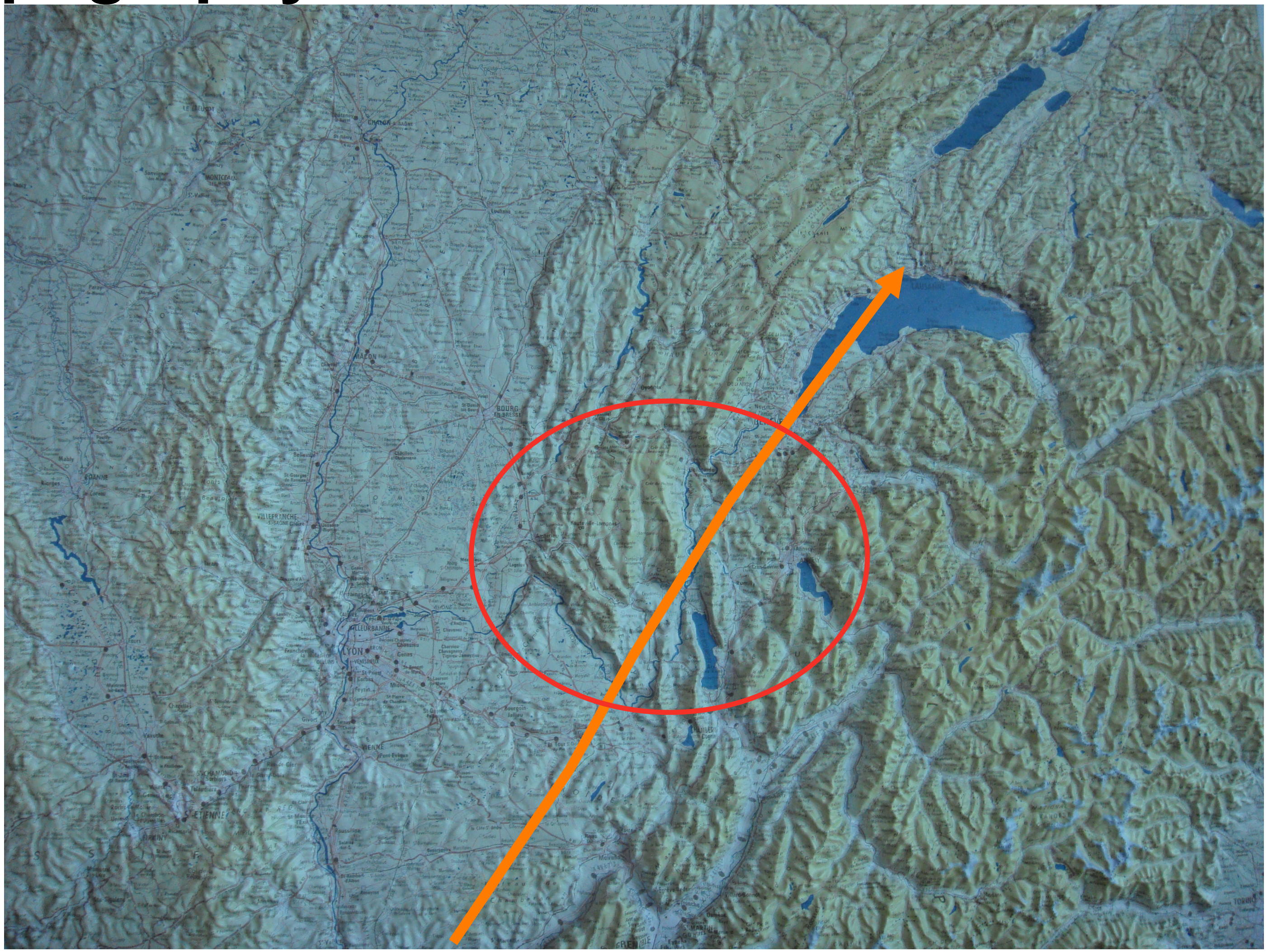
  =>large impact on forecasted 2m Td, 850 hPa Theta-E and CAPE values (difficult to have a large homogeneous CAPE field)

Forecasting complications in our region of responsibility (in proximity to Alps)

- In topographical terrain, much more difficult to get all favorable convective parameters « in phase »…
- Limited utility of certain conceptual models in topographical terrain vs. flat terrain

  ⇒ it's not a level playing field because the field is not level

Topography around Western Switzerland



Example of forecasting complexity

26 August 2011: severe t-storm checklist

Nom : Didier **Date :** 24.08.2011 10:05

Date échéance : 26.08.2011

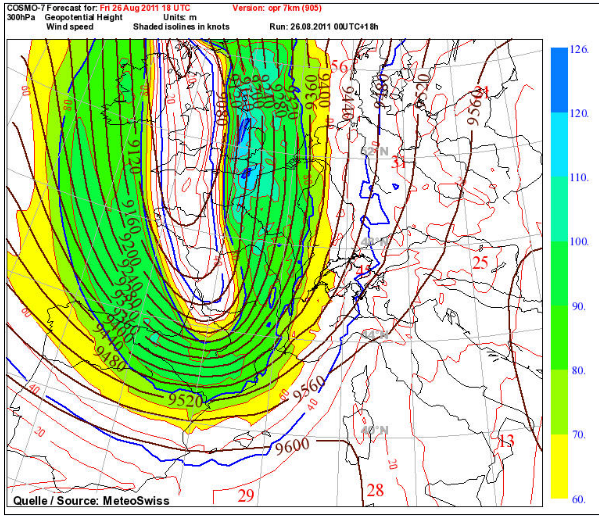
CHECK-LISTE ORAGES VIOLENTS POSSIBLES			
	Situation synoptique		
Synoptique	Marais 0	Préfrontal peu dynamique 0	Préfrontal dynamique 1
Flux 500 / 300	Anticyclonique ou col 0	Cyclonique ou rectiligne SW 0	Onde courte dans flux de SW (faible OK pour stationnaire) 1
Jet 300 hPa	Zone de NVA ou ras 0	PVA (sortie froide OU entrée chaude de jet) 1	PVA (sortie froide ET entrée chaude de jet) 0
Isotherme 850 hPa	Axé W - E 0	Axé N - S 0	Axé N - S très serré 1
	Instabilité		
Cape	Cape < 700 j/kg 0	700 j/kg <= Cape < 1500 j/kg 1	Cape >= 1500 j/kg 0
T°850 - T°500 hPa	Delta T < 27° 0	27° <= Delta T < 30° 1	Delta T >= 30° 0
Lifted Index	LI > -4° 0	-4° >= LI > -7° 1	LI <= -7° 0
	Cisaillement		
Cis. sol - 6 km	Cis. < 25 kt 0	25 kt <= Cis. < 40 kt 0	Cis. >= 40 kt 1
Cis. sol - 3 km	Cis. < 15 kt 0	15 kt <= Cis. < 30 kt 0	Cis. >= 30 kt 1
	Humidité		
T°point de rosée	Td < 15° 0	15° <= Td < 18° 1	Td >= 18° 0
Theta-E 850 hPa	Te < 40° 0	40° < Te < 55° 0	Te > 55° 1
Eau précipitable	PWAT < 25 mm 0	25 mm <= PWAT < 35 mm 1	PWAT >= 35 mm 0

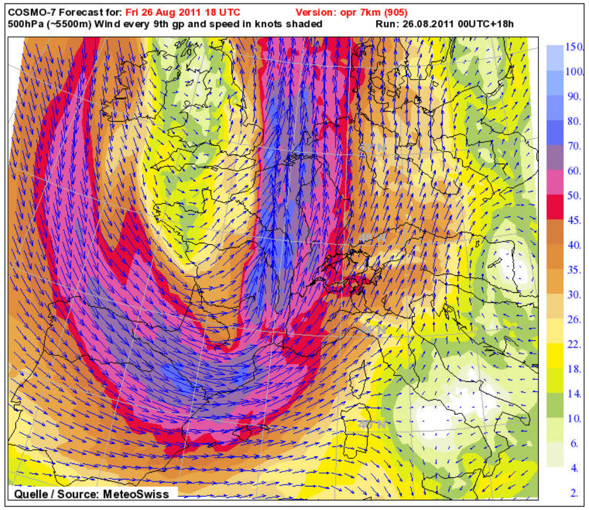
Evaluation Avis	**81**	R < 60 : orages violents peu probables 60 <= R <= 80 : orages violents dynamiques possibles : DD3 **R > 80 : orages violents dynamiques possibles : DD4**

August 26th 2011: COSMO fields

COSMO 7
300 hPa
Winds

18 UTC



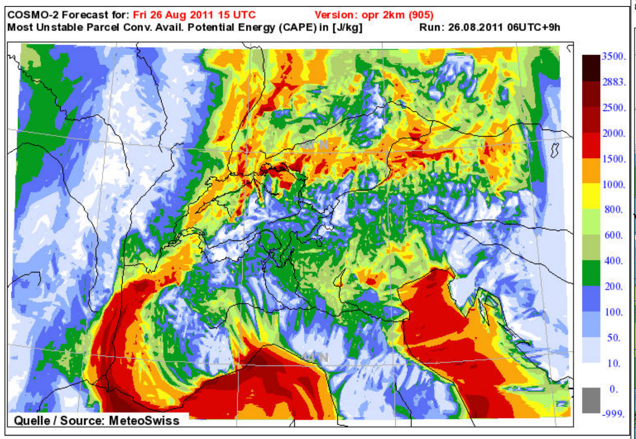


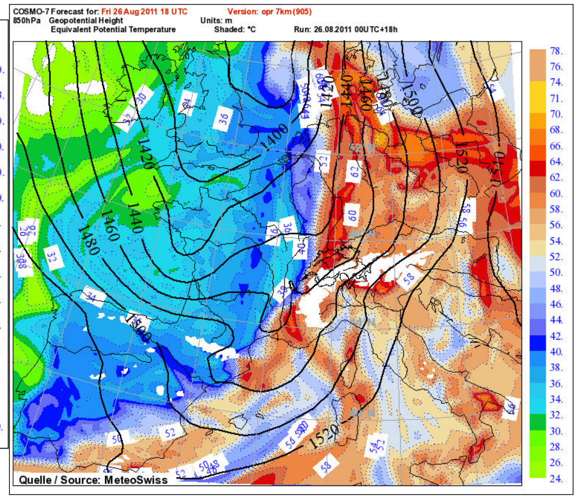
COSMO 7
500 hPa
Winds

18 UTC

COSMO 2
MUCAPE

15 UTC





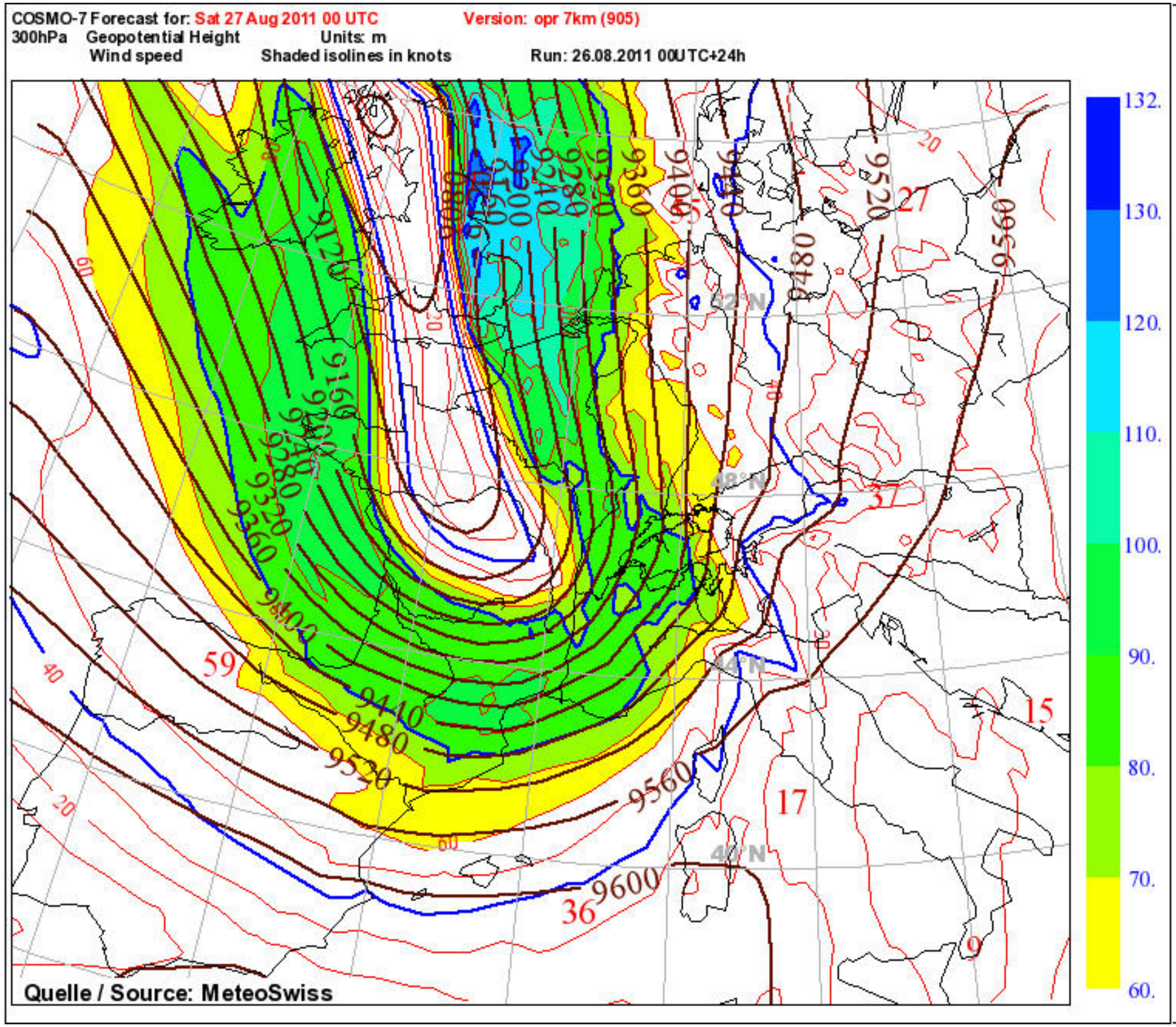
COSMO 7
850 hPa
Theta-e

18 UTC

August 26th 2011

DD4 case

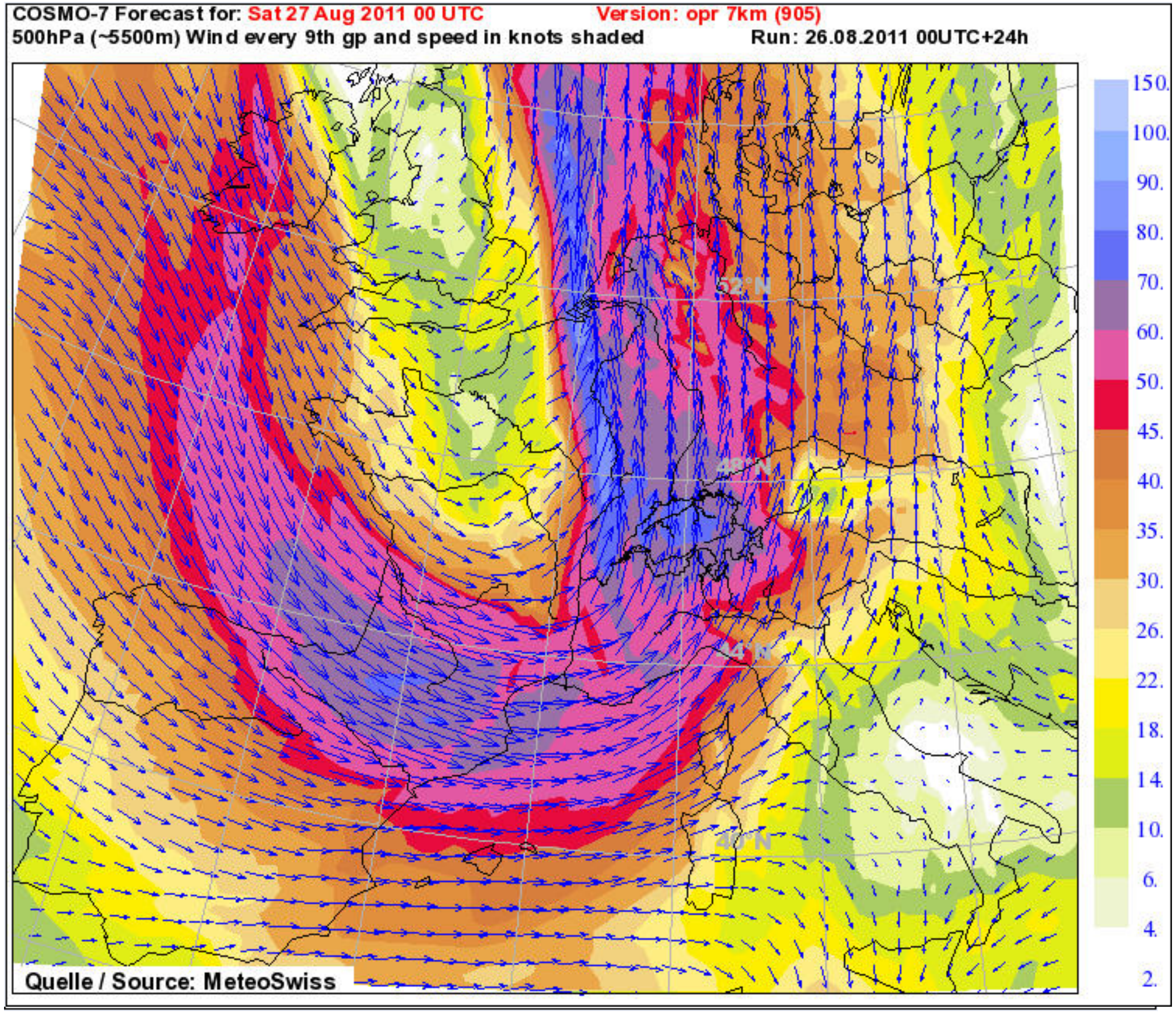
300 hPa Jet



August 26th 2011

DD4 case

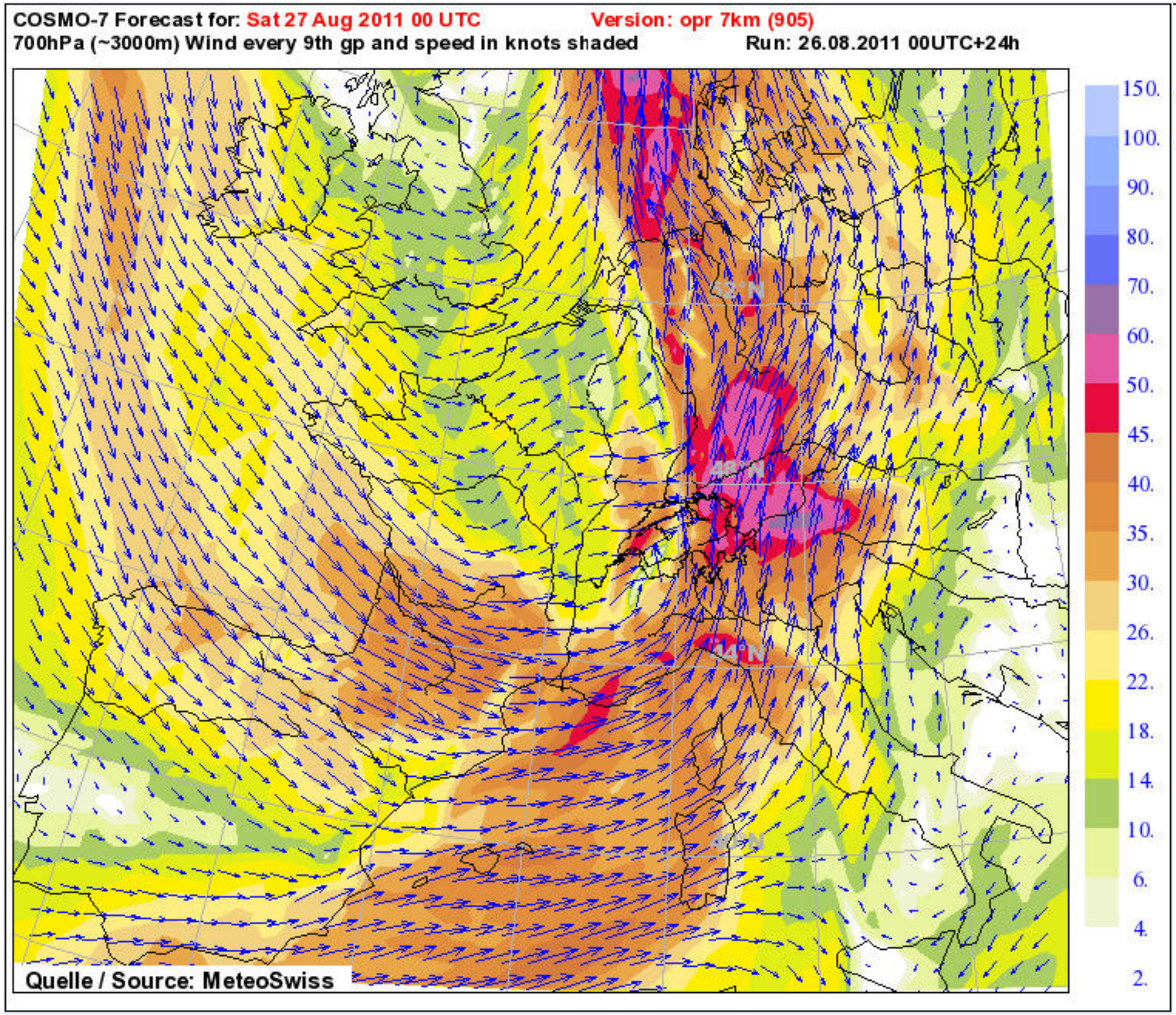
500 hPa Jet



August 26th 2011

DD4 case

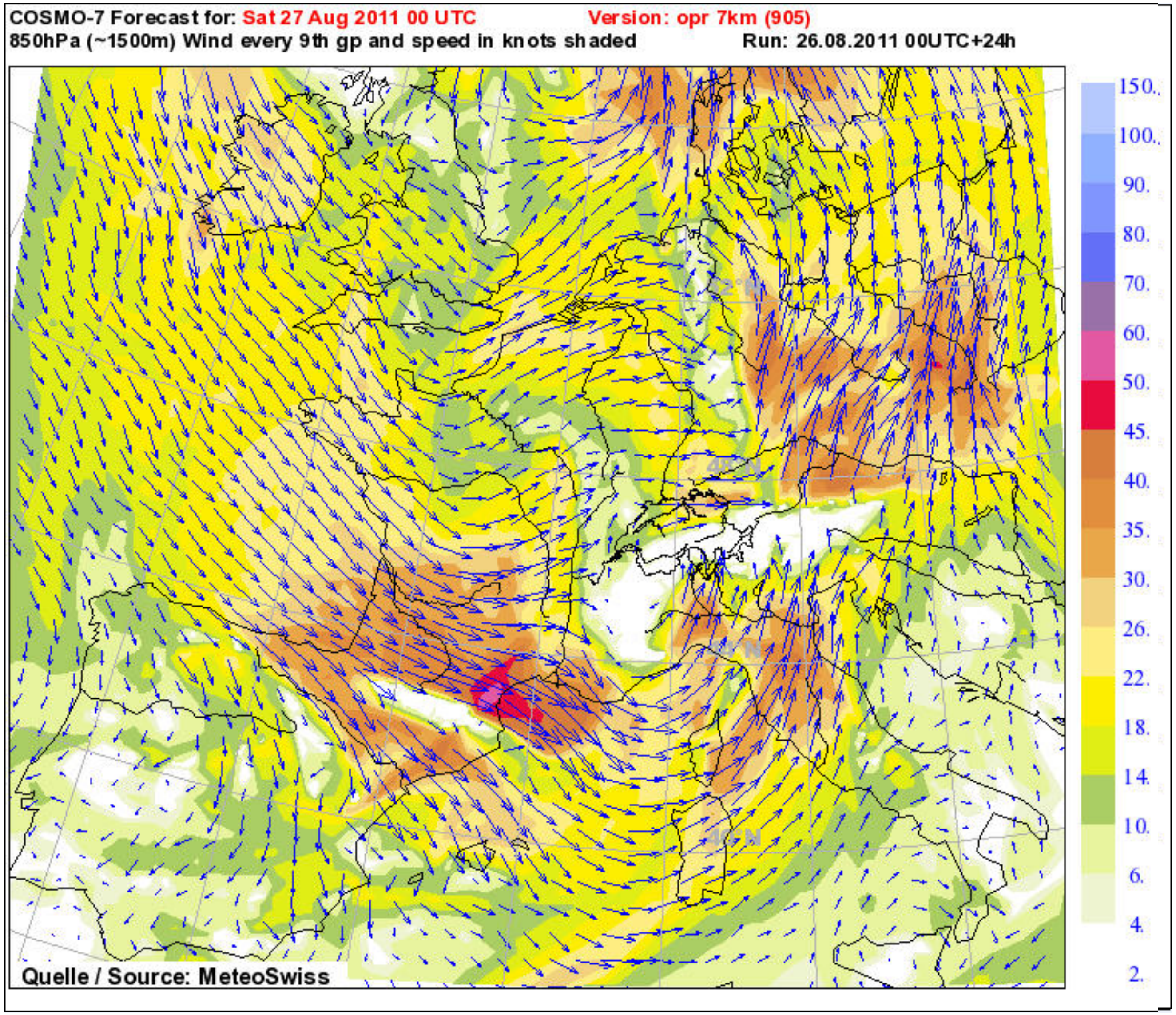
700 hPa Jet



August 26th 2011

DD4 case

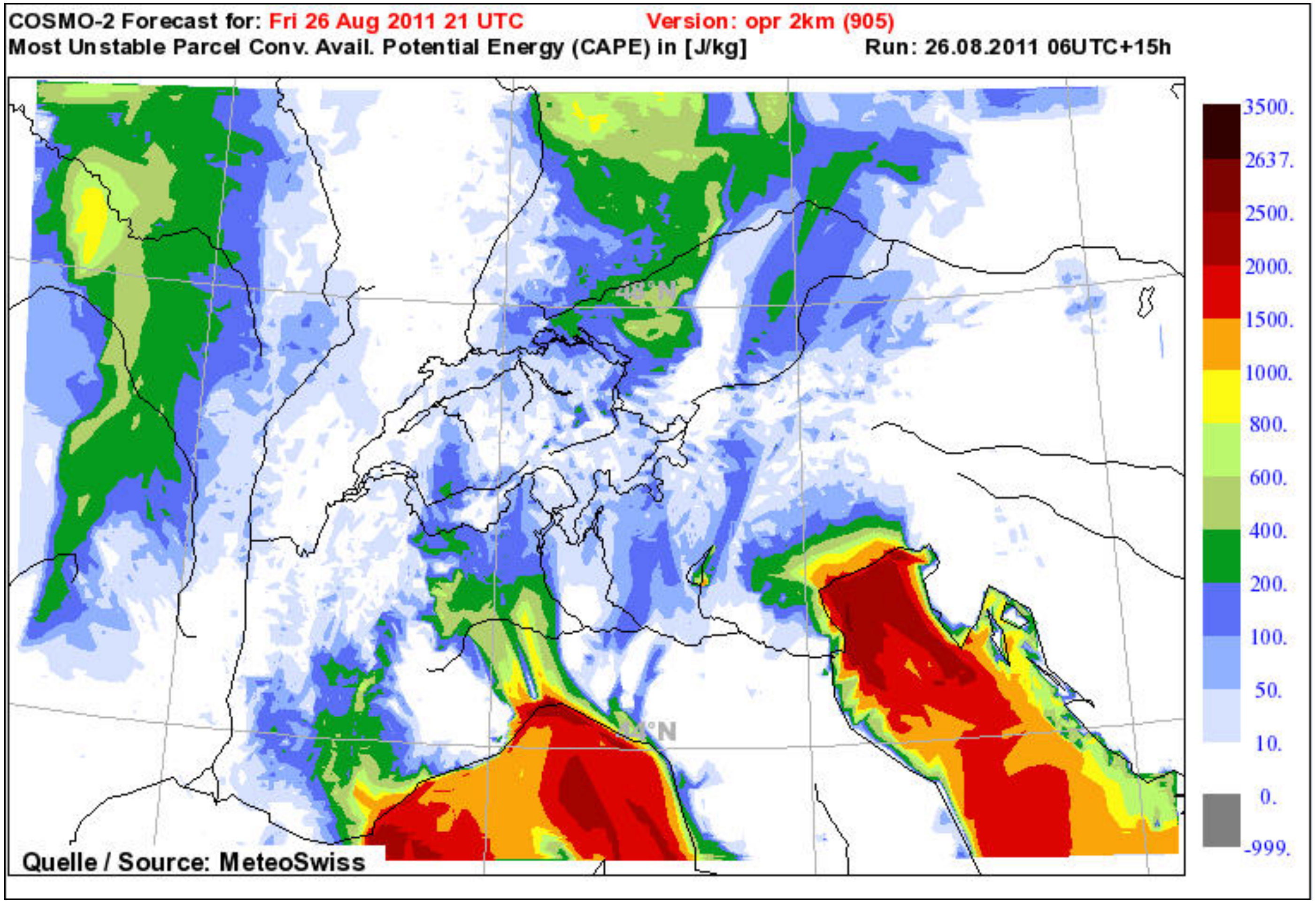
850 hPa Jet



August 26th 2011

DD4 case

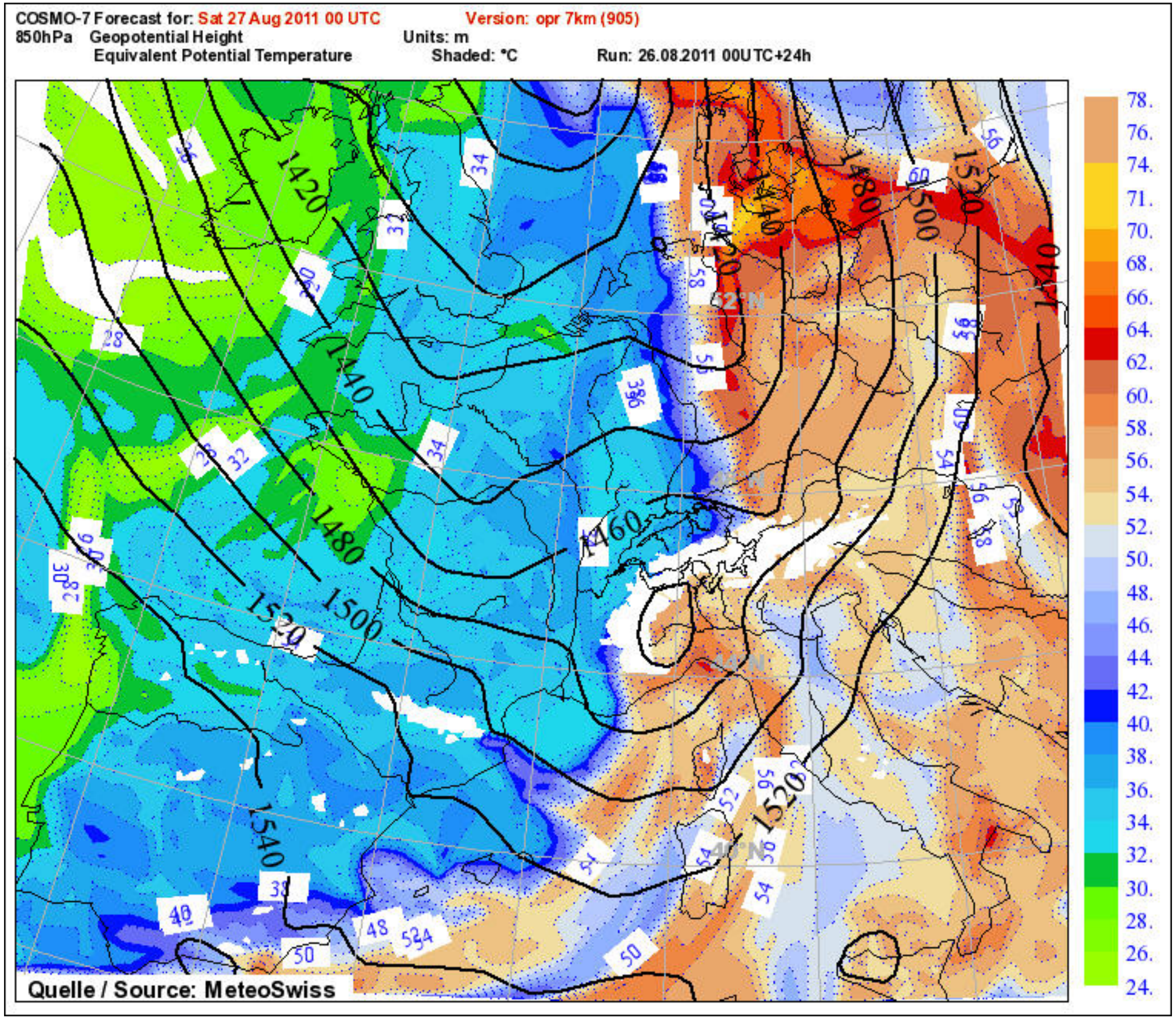
MUCAPE



August 26th 2011

DD4 case

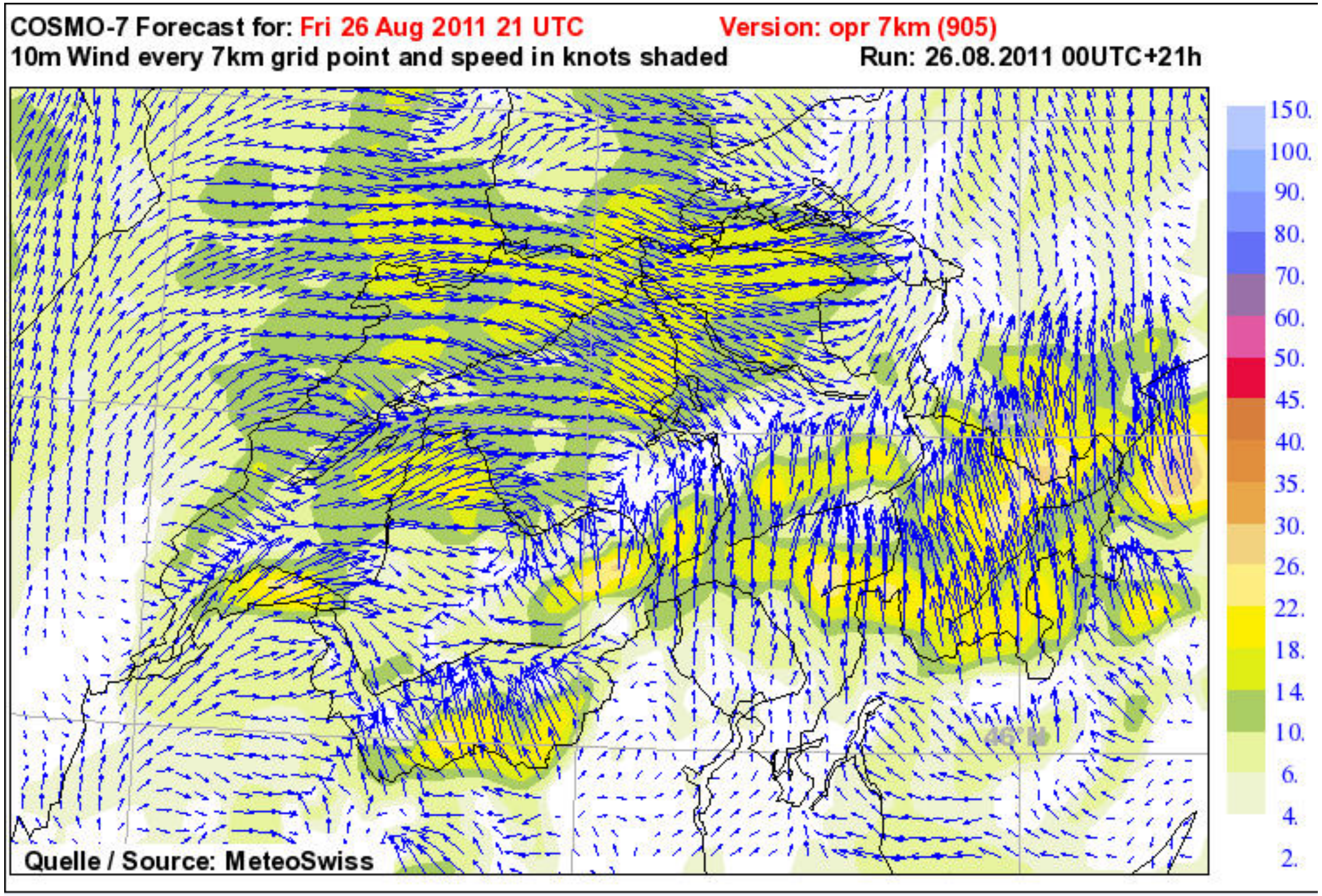
Theta-e 850 hPa



August 26th 2011

DD4 case

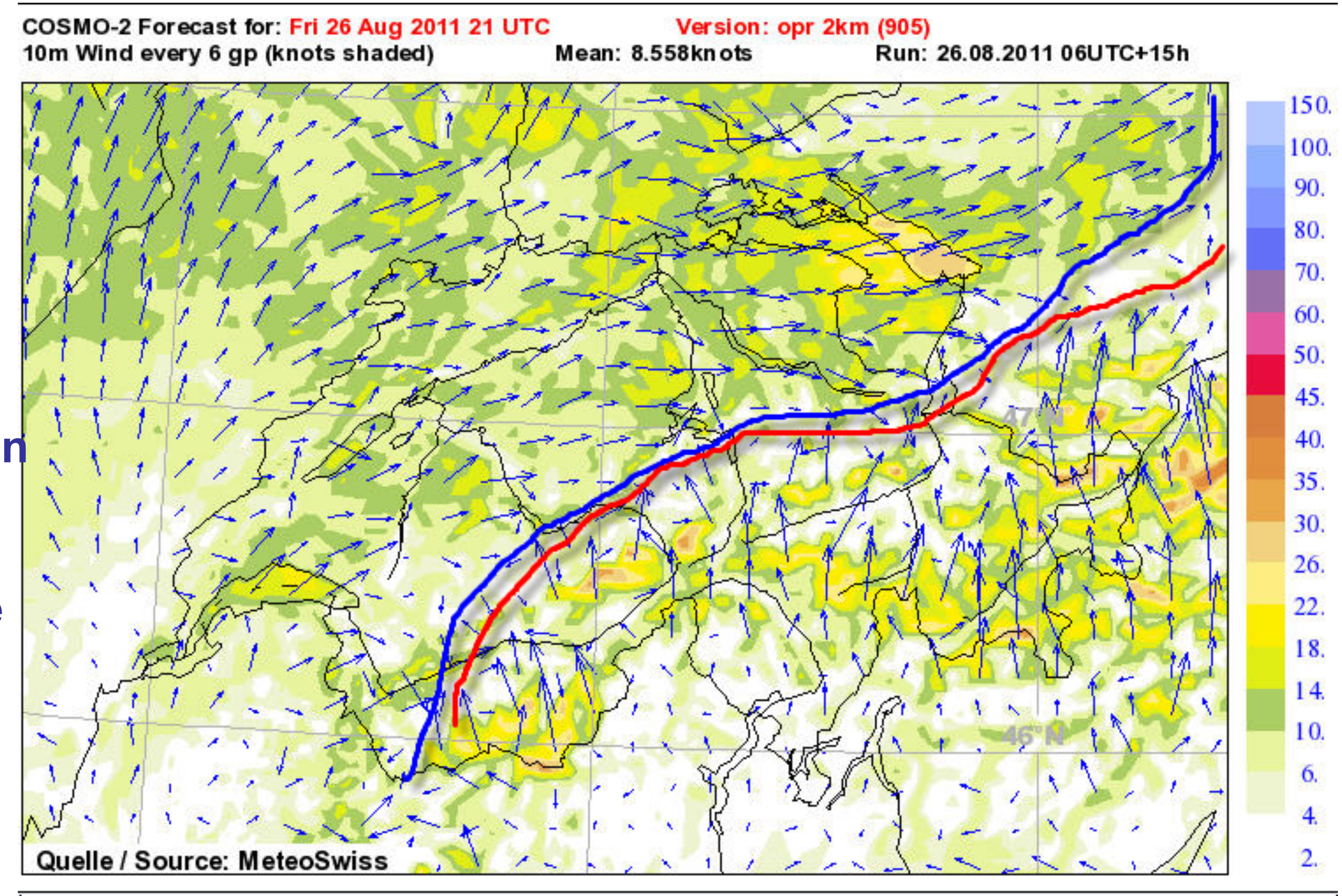
10 m wind



August 26th 2011: COSMO 2 (10 m wind field)

Dephasing of favorable ingredients for widespread severe t-storm development

- Sfc dryline and cold front interaction (surging)
-foehn affects aloft retarded convective initiation
- upper-level large scale lift (PVA) arrived too late



August 26th 2011

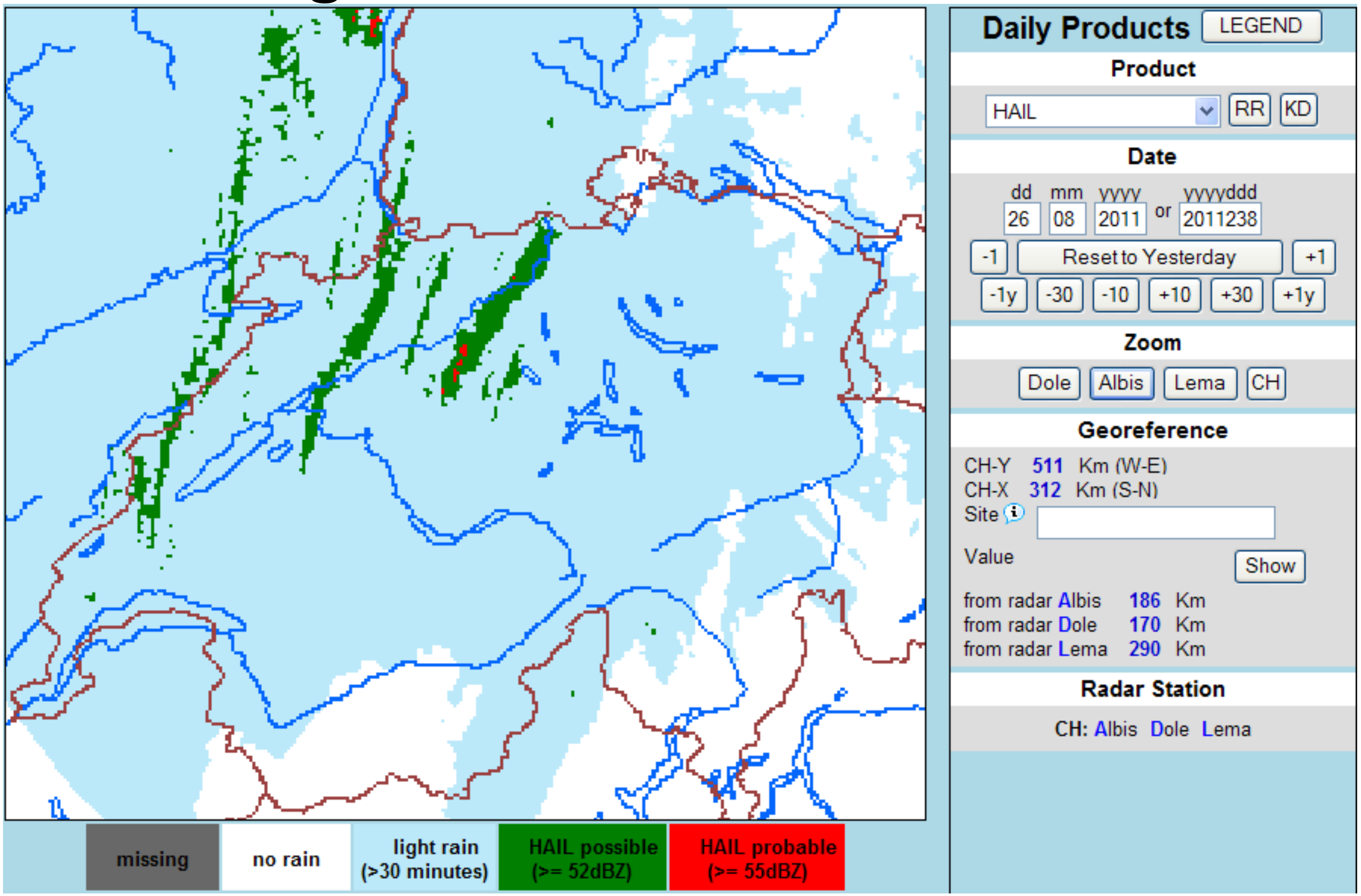
DD4 case

-OBS 12 UTC
- time series of Td and wind dd ff

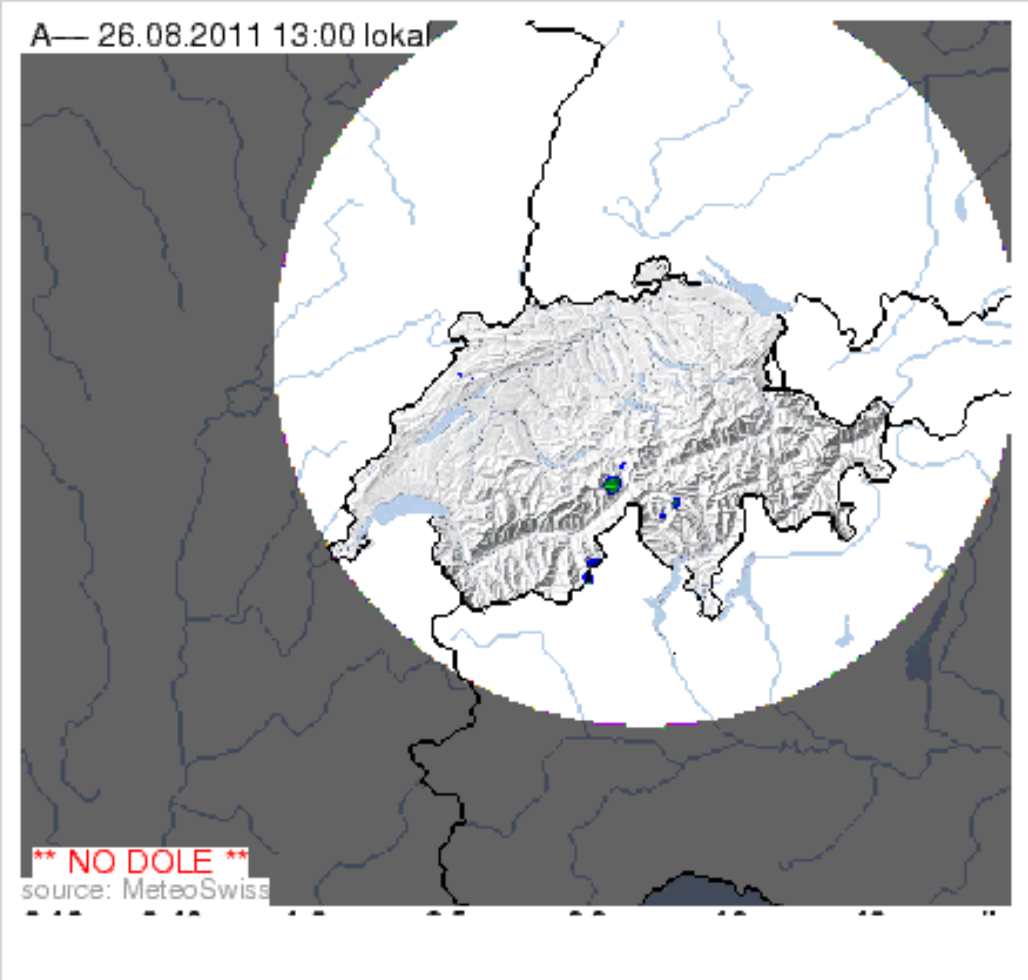
Taupunkt 2 m über Boden; Momentanwert [°C]
26.08.2011 12:00 UTC

26.08.2011 18:20	10.4	278	31.0	67.0
26.08.2011 18:10	10.9	281	23.4	47.2
26.08.2011 18:00	11.9	279	32.0	64.1
26.08.2011 17:50	13.3	273	29.5	58.0
26.08.2011 17:40	14.3	283	31.0	57.6
26.08.2011 17:30	14.7	293	26.6	51.5
26.08.2011 17:20	15.9	292	30.2	59.8
26.08.2011 17:10	16.2	290	28.1	55.8
26.08.2011 17:00	17.0	280	19.8	42.1
26.08.2011 16:50	17.0	285	19.4	42.1
26.08.2011 16:40	17.7	285	17.6	34.9
26.08.2011 16:30	17.6	287	19.1	36.4
26.08.2011 16:20	17.8	289	16.2	32.4
26.08.2011 16:10	17.5	280	17.3	32.4
26.08.2011 16:00	17.6	275	20.5	40.0
26.08.2011 15:50	17.2	272	24.1	40.7
26.08.2011 15:40	17.5	284	23.4	41.8
26.08.2011 15:30	16.8	259	14.4	39.2
26.08.2011 15:20	9.6	168	22.7	42.8
26.08.2011 15:10	10.4	154	24.1	37.8
26.08.2011 15:00	10.7	158	23.0	36.7
26.08.2011 14:50	10.6	164	16.6	28.1

August 26th 2011: DD4 case



26 August 2011 : Radar animation



Philosophical discussion on operational forecasting

- **Synergy between NWP community and forecasters**
  - Close mutual exchanges between the 2 are paramount

    => Does NWP understand forecaster needs and vice versa?
  - Convincing NWP community that forecasters are also users (clients) of the models

    =>need different model output fields than the general public
  - State run programs tend to be heavier and slower to react to client (external/internal) needs in general

    => our NWP group concentrates more time and effort on model development than on specific user needs
  - Synergies with private entities whether profit or non-profit can be beneficial in accelerating transition R&D=>Ops

Philosophical discussion on operational forecasting

- **Role of humans in forecast chain**
  - Convincing hierachy of importance of humans in the forecast process is becoming increasingly difficult

    ⇒ political/economic aspects of forecasting automation

    ⇒ belief that models and matrices can replace humans with no loss in product value
  - Convincing hierachy that continual on-job training of forecasters is as important as product development

    ⇒ Forecaster training is crucial (COMET, EUMETRAIN, etc…)

    ⇒ If NWP models improve faster than the continuing education of forecasters, forecasters become increasingly dependent on model output… without adequate continuing forecaster training imposed, its becoming harder to convince certain decision makers in NWSFO's that humans in the forecast chain make a difference (vicious circle)

Philosophical discussion on operational forecasting

- **Role of humans in forecast chain**
  - What is undesirable : forecasters becoming too passive and depending too heavily on model output for their primary forecasting decisions…

    ⇒ Analogy with Air France Rio-Paris disaster in 2009

    ⇒ freezing of wind speed sensors

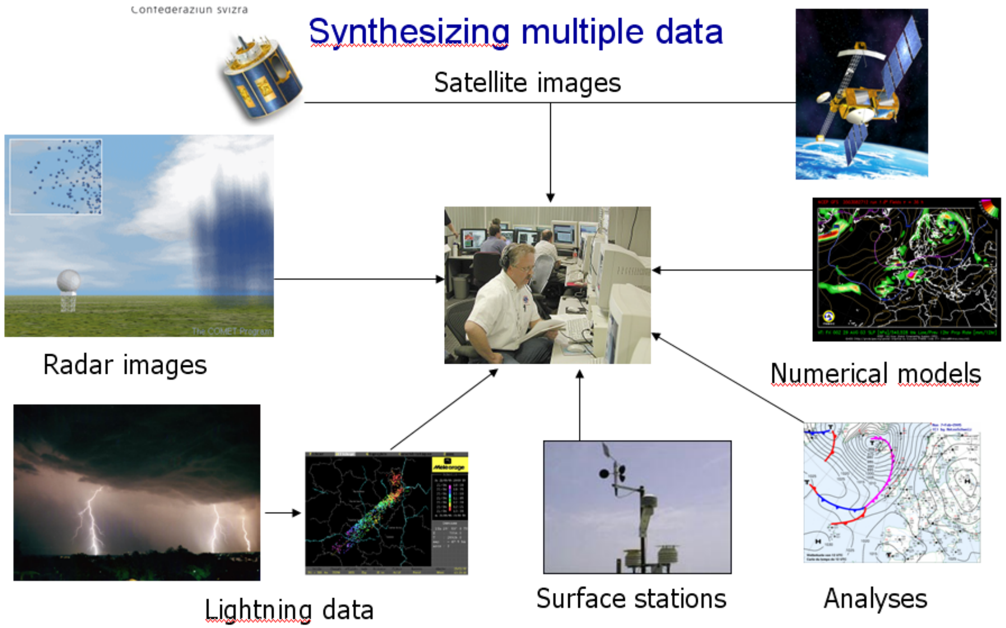
    ⇒ autopilot disengages

    ⇒ copilots don't apply procedures for loss of speed, don't recognize the signs of stalling with chaotic alarms going off

    ⇒ insufficient pilot training partly blamed for inappropriate human response in high altitude manual piloting, training which the copilots did not have…

Philosophical discussion on operational forecasting

- **Role of humans in forecast chain**
  - Role humans play in convective forecasting a great example
  - Importance of conceptual models, field observation, complex thermodynamic and dynamic interactions, etc…)



Philosophical discussion on operational forecasting

- **Role of humans in forecast chain**
  - To pretend that forecasters are useless is a fallacy that needs to be more vigourously defended worldwide!
    - Proof : with all numerical automated products available today (smartphones, applications), people still call us at the weather office to know what the weather will be since the forecast apps contradict each other on a regular basis…

Concluding remarks

- **MeteoSwiss has implemented an ingredient-based severe convection checklist in forecast operations in an attempt to better discriminate between environments more conducive to the development of low-end or high-end severe thunderstorms and to introduce a more objective method for forecasters.**
- **The checklist can be easily and rapidly applied and is based on available model fields of specific weather parameters deemed most relevant for the development of severe convection within the complex Swiss alpine environment**
- **The weather parameter thresholds were determined based on local climatology and different weights were attributed to each threshold class for both low-shear and high-shear environments**
- **Preliminary results for the 2011 convective season are somewhat encouraging despite a tendency of the forecasters to overwarn the convective events within the highly heterogeneous terrain**
- **A more robust statistical procedure is planned in the future in order to more accurately determine both appropriate parameter thresholds and the weights within each threshold class**


Thank you!