Innovative Methods for Improving the Prediction of the Weather Conditions along Mountain Roads

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3. Forecast Verification
4. Areas of Application
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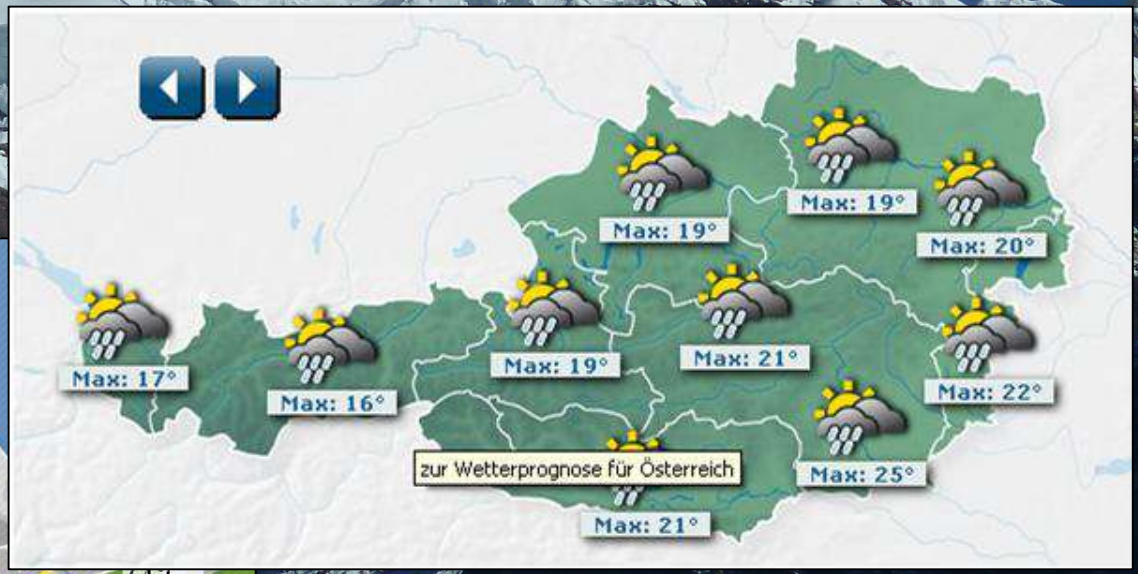
Conventional Weather Forecasts:

Problem: Lack of accuracy over mountains



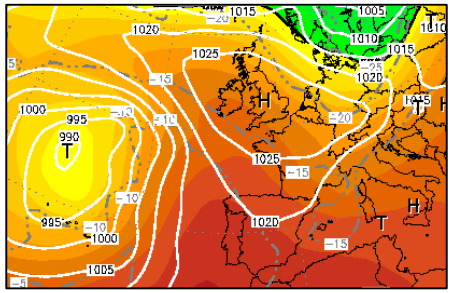
Improved forecasts important for:

- Decrease of risk of accidents
- Planning of resources
- Cost reduction for traffic operation centers and other weather-dependent institutions

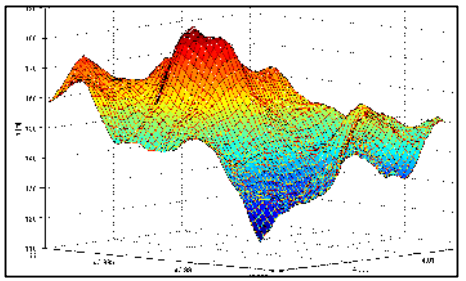
Approach: MetGIS

Weather observations

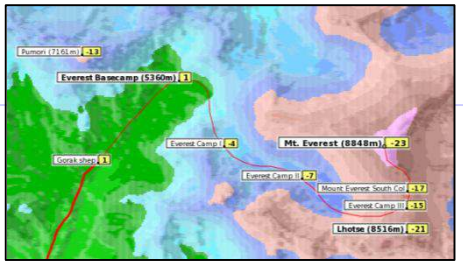
Meteorological forecast models (**Met.**-data)



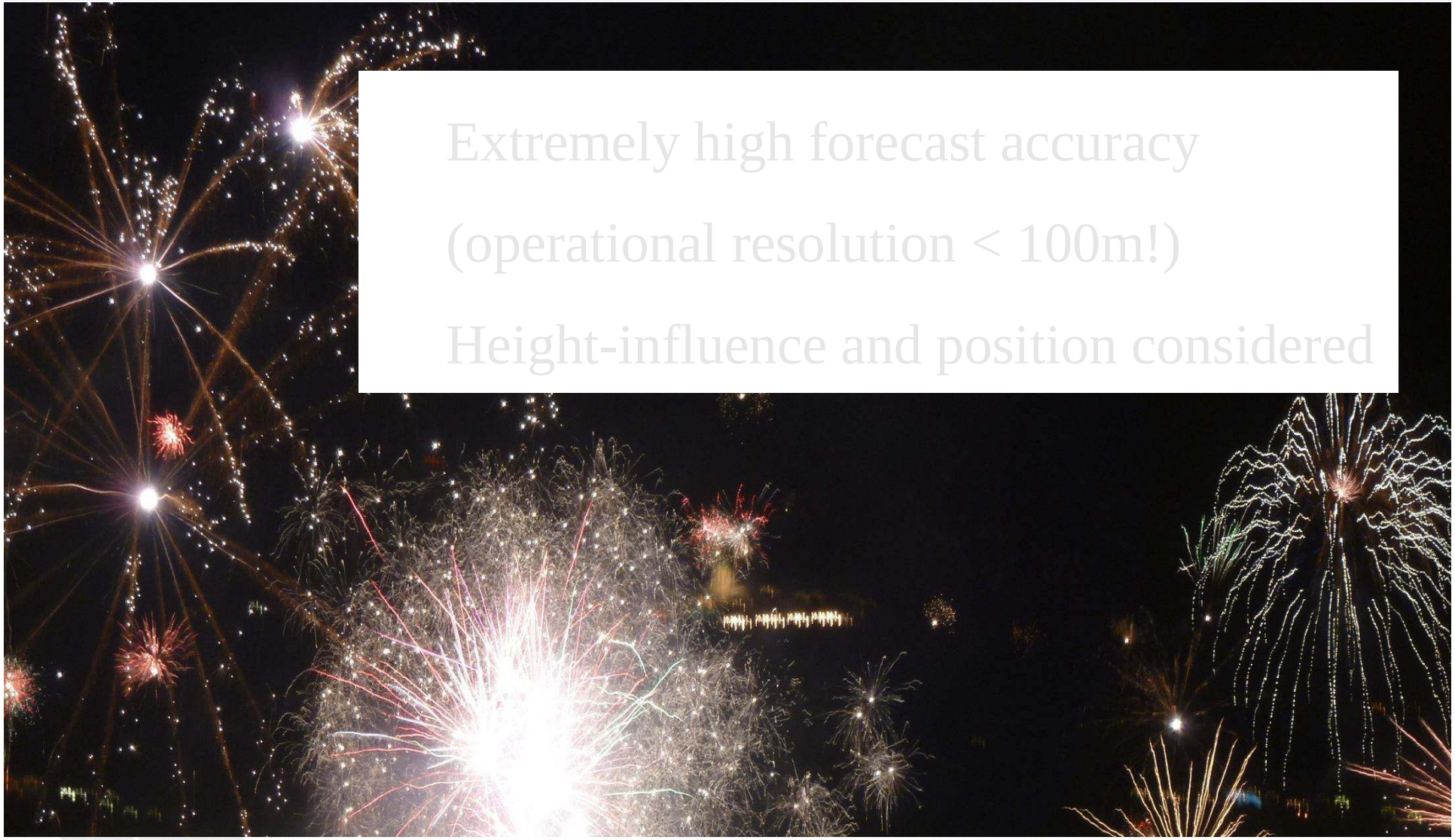
High-resolution terrain databases (**GIS**-data)



MetGIS forecasts



Advantages of Approach

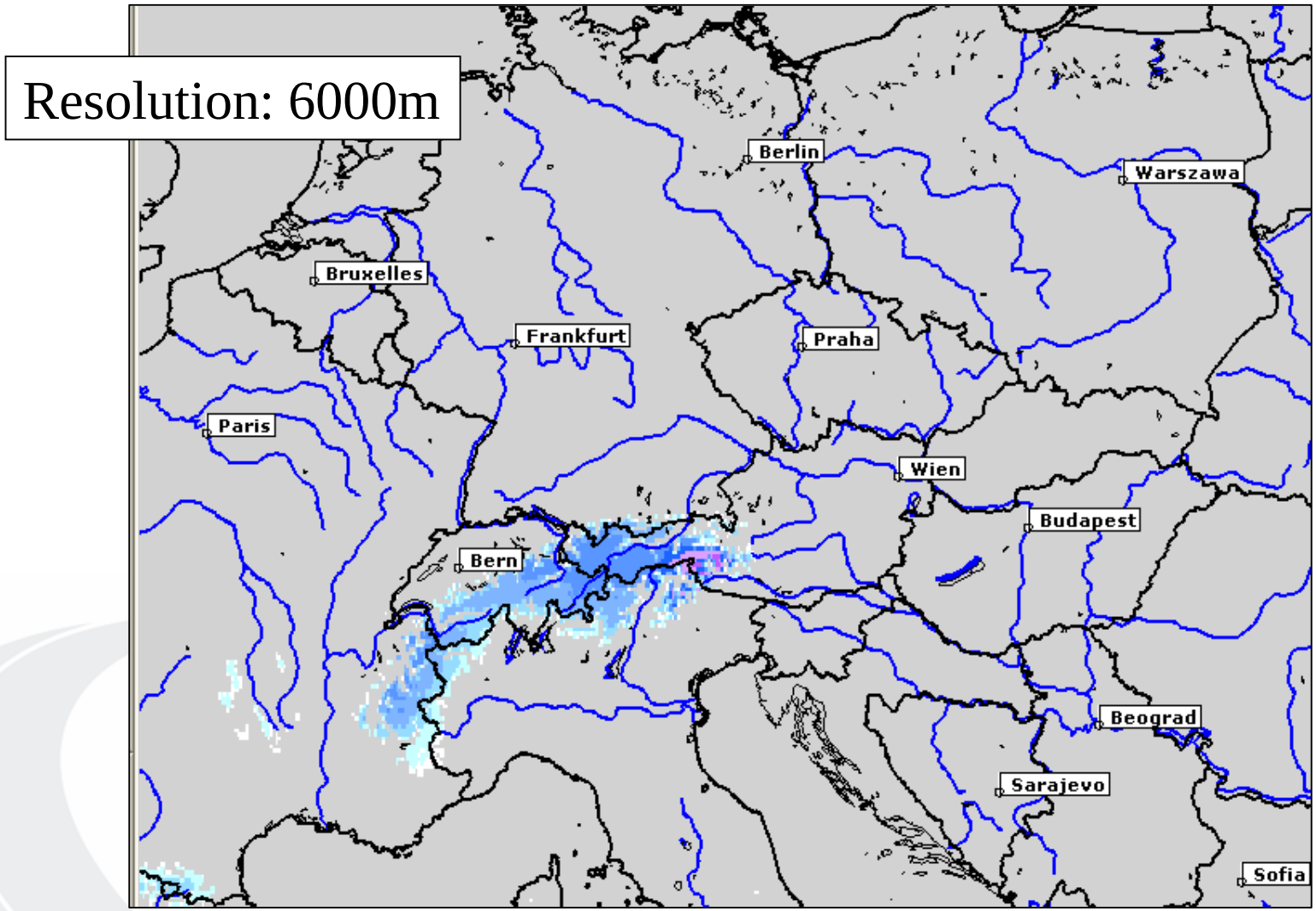


Extremely high forecast accuracy

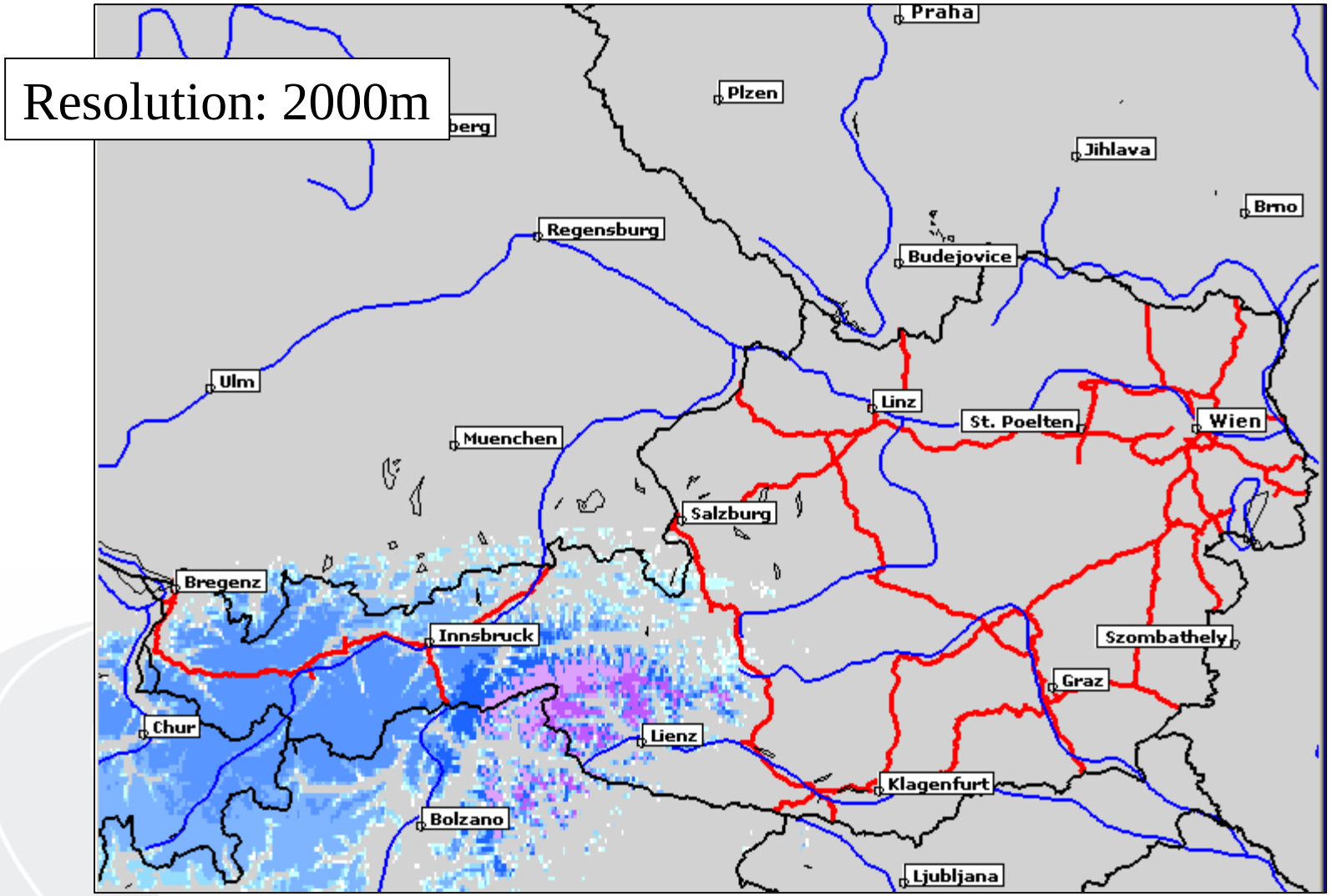
(operational resolution < 100m!)

Height-influence and position considered

Example: Detail of Fresh Snow Forecast



Example: Detail of Fresh Snow Forecast



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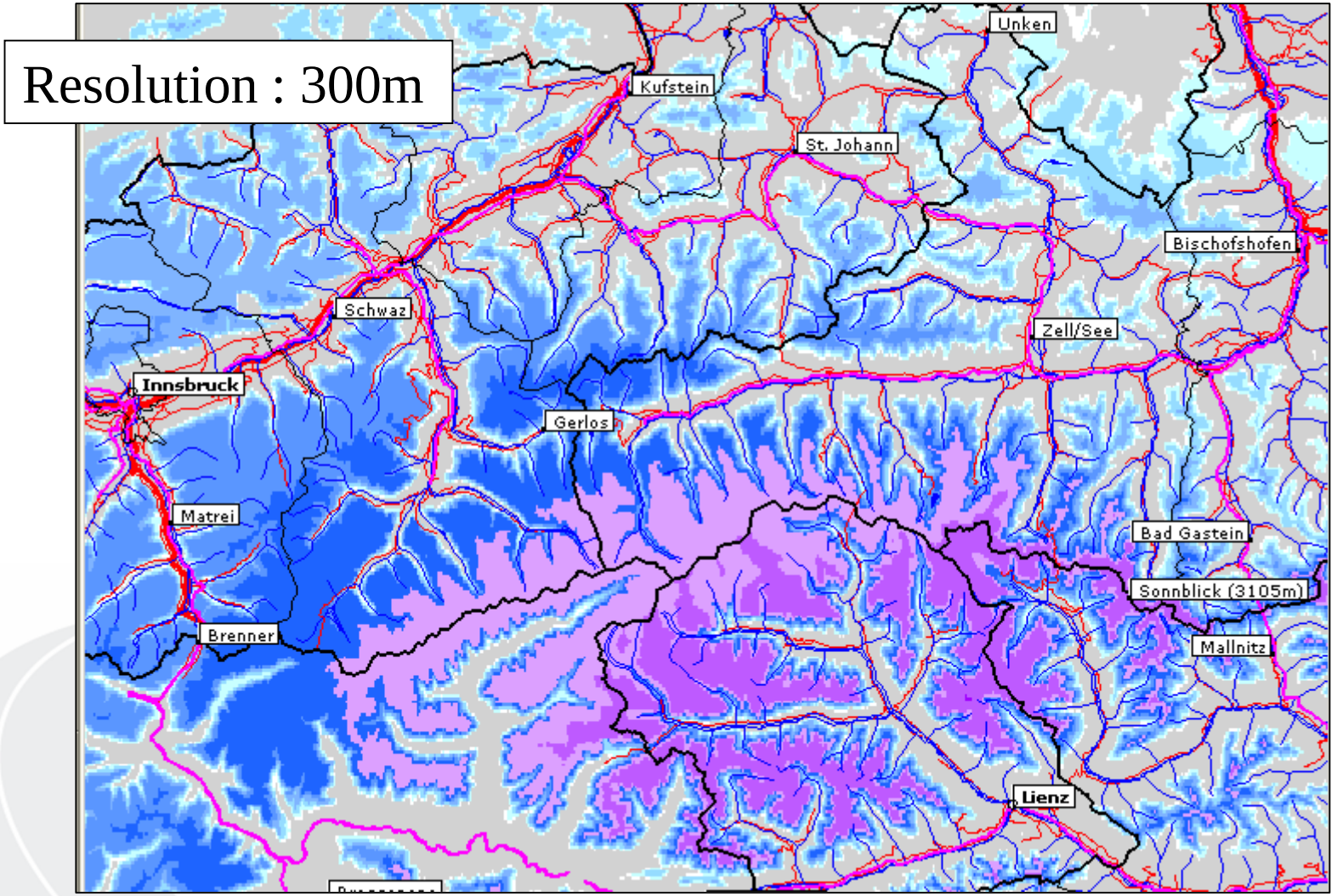

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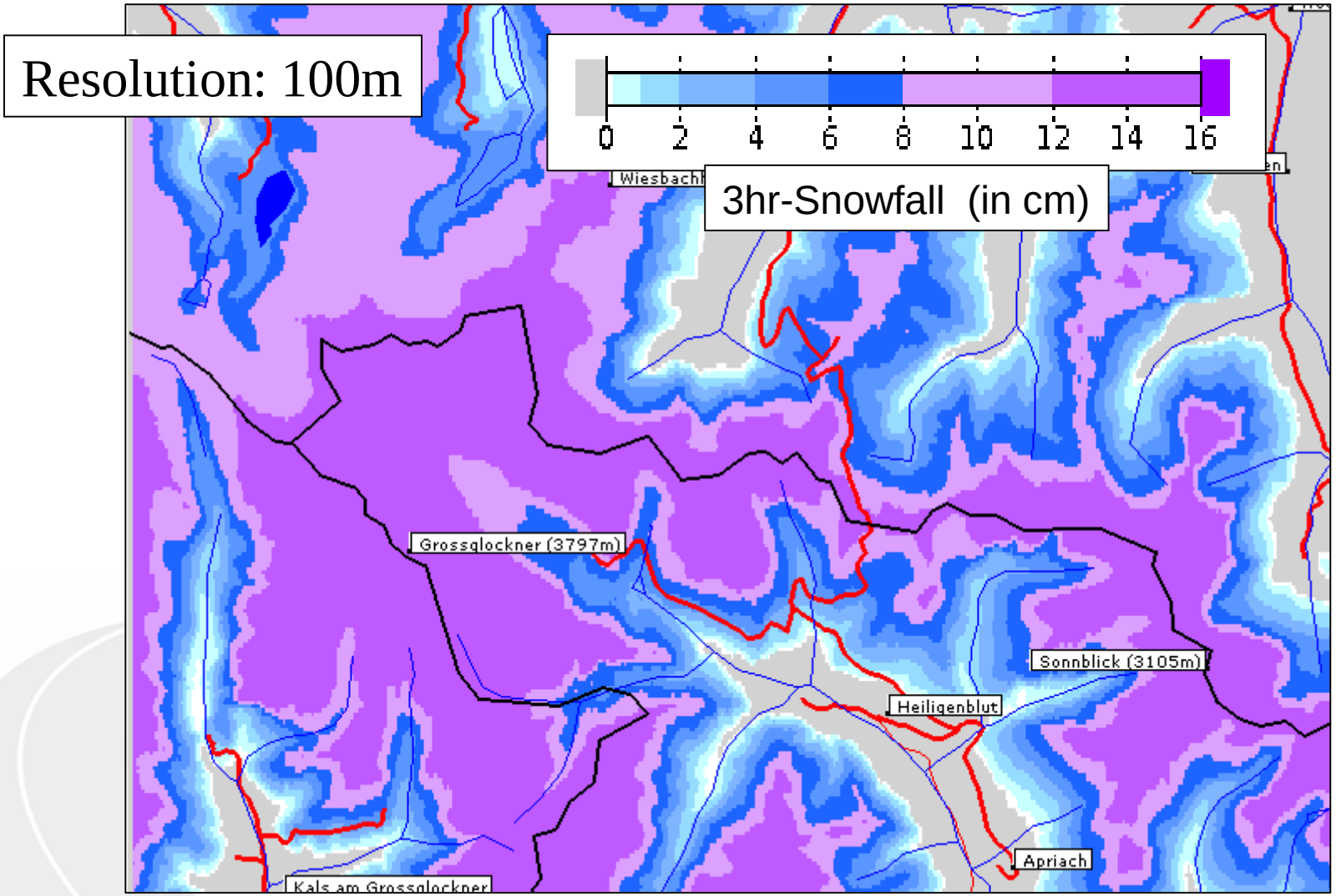

Base of MetGIS

- More then 10 years of international development
- Combines expertise in meteorology, snow science, GIS

Contributions for Development of MetGIS

Country/City	Research Institution	Contribution/Achievement
USA (Boulder, CO)	**WELS** Research Corporation/ Alden Electronics	Basics about combination betw. GIS and meteo forecast
Switzerland (Davos)	**SLF** (Swiss Federal Institute for Snow and Avalanche Research)	Java technology for GUIs, SNOWPACK visualization
Peru (Lima)	**SENAMHI** (Servicio Nacional de Meteorología e Hidrología)	Start programming Java-based GIS
Japan (Nagaoka)	**NIED/NISIS** (National Research Institute for Earth Science and Disaster Prevention)	Continue GIS, Start programming interface for meteorological forecast models
Argentina (Mendoza)	**IANIGLA** (Instituto Argentino de Nivelogía y Glaciología)	Integration of SRTM terrain data
Chile (Santiago)	**DGF** (Departamento de Geofísica, Universidad de Chile)	Foreign forecast model integration
Austria (Vienna)	**IMG** (Institute of Meteorology and Geophysics, University of Vienna)	Coordination of MetGIS development work 2005-2012

Research and Operational Application

Projects of basic and applied science:

•Cordination by **University of Vienna**

•Basic research projects, financed by Austrian Science Funds

•Applied research projects, co-financed by Austrian government and national highway agency ASFINAG

Operational application of MetGIS:

•Cordinated by **MetGIS GmbH**

•Since 2007, currently users in 10 countries

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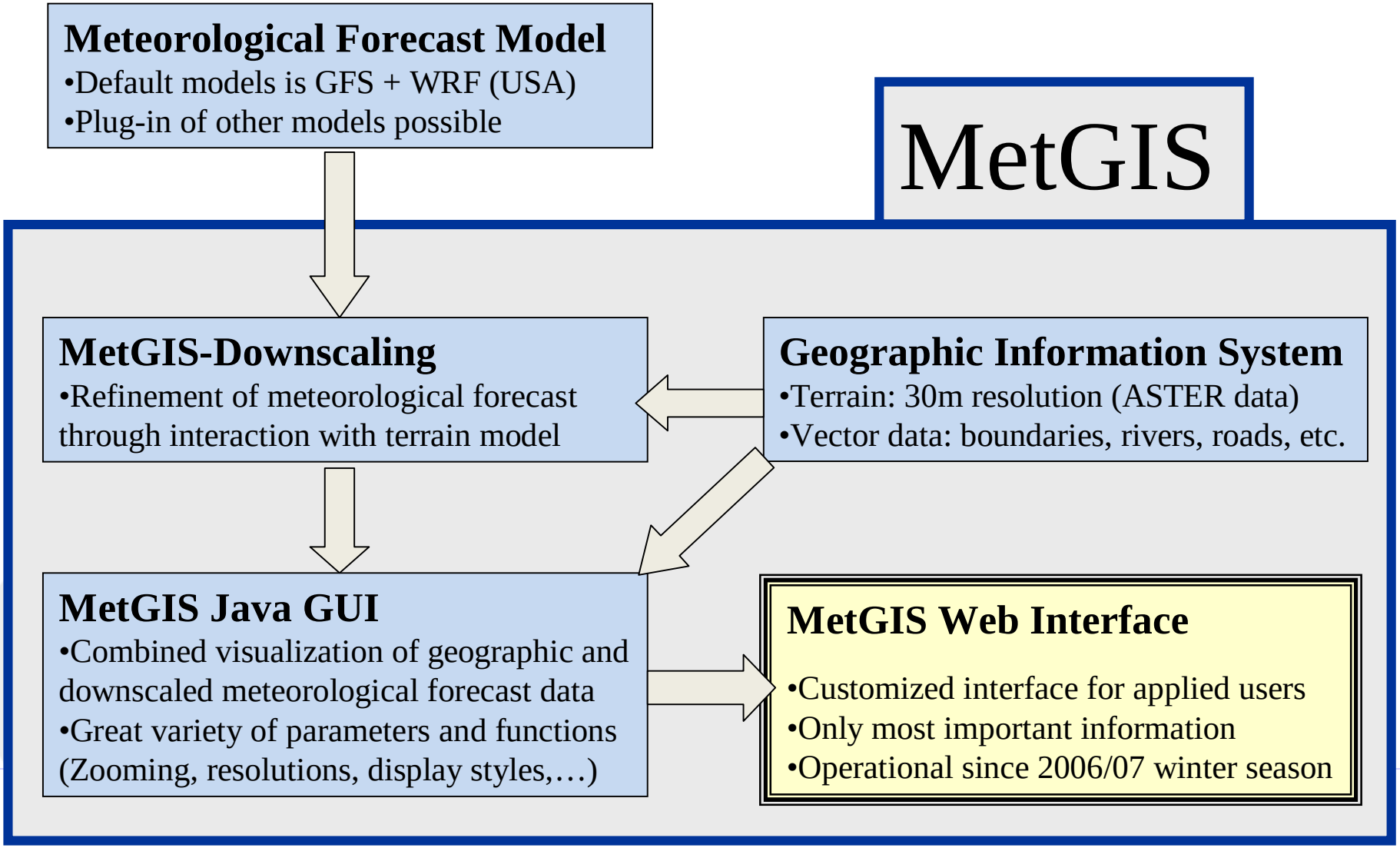
MetGIS Components



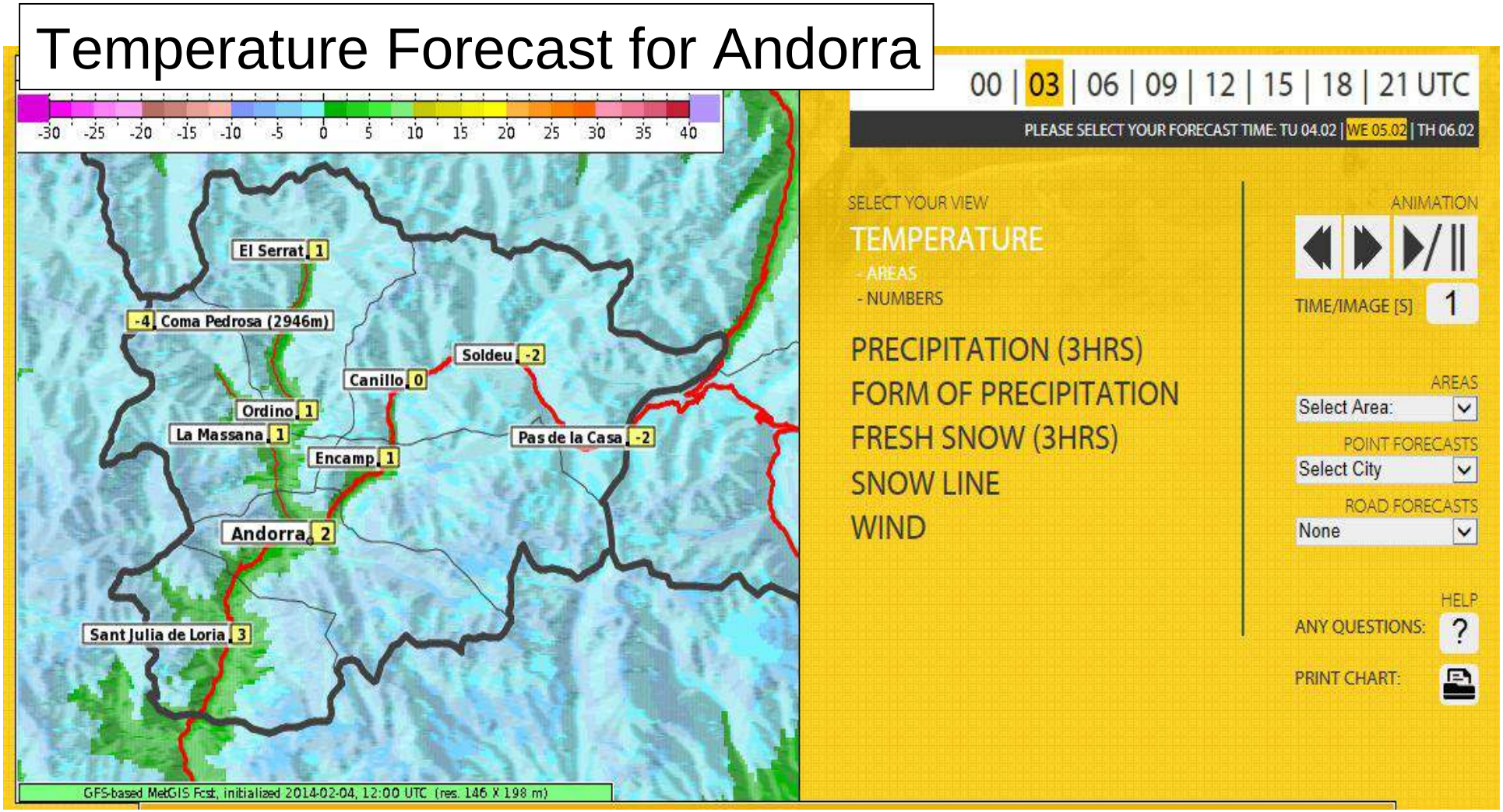
MetGIS Web Interface

www.metgis.com

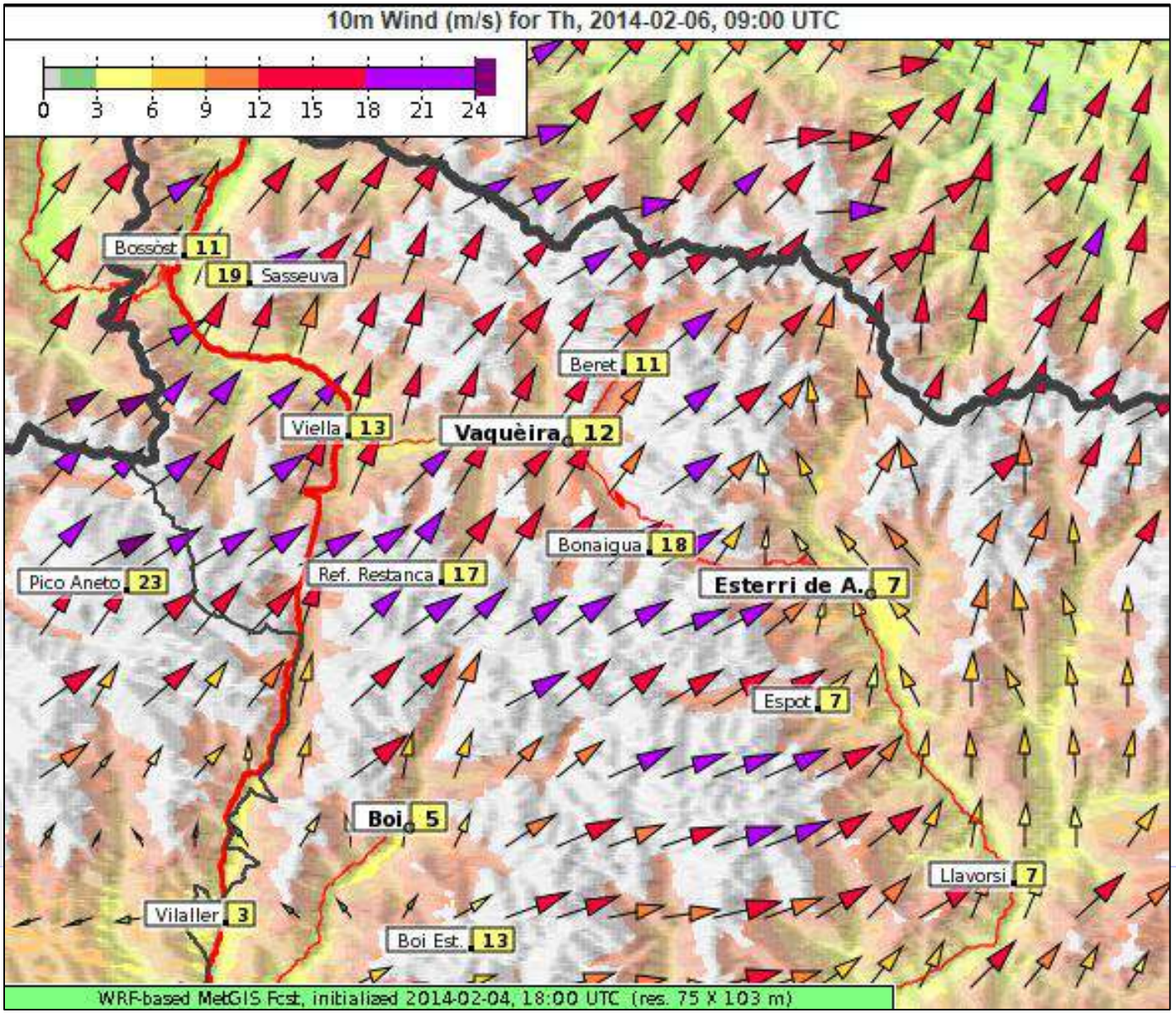
Access to MetGIS forecasts for users
(e.g. traffic operation centers)

MetGIS Web Interface: www.metgis.com

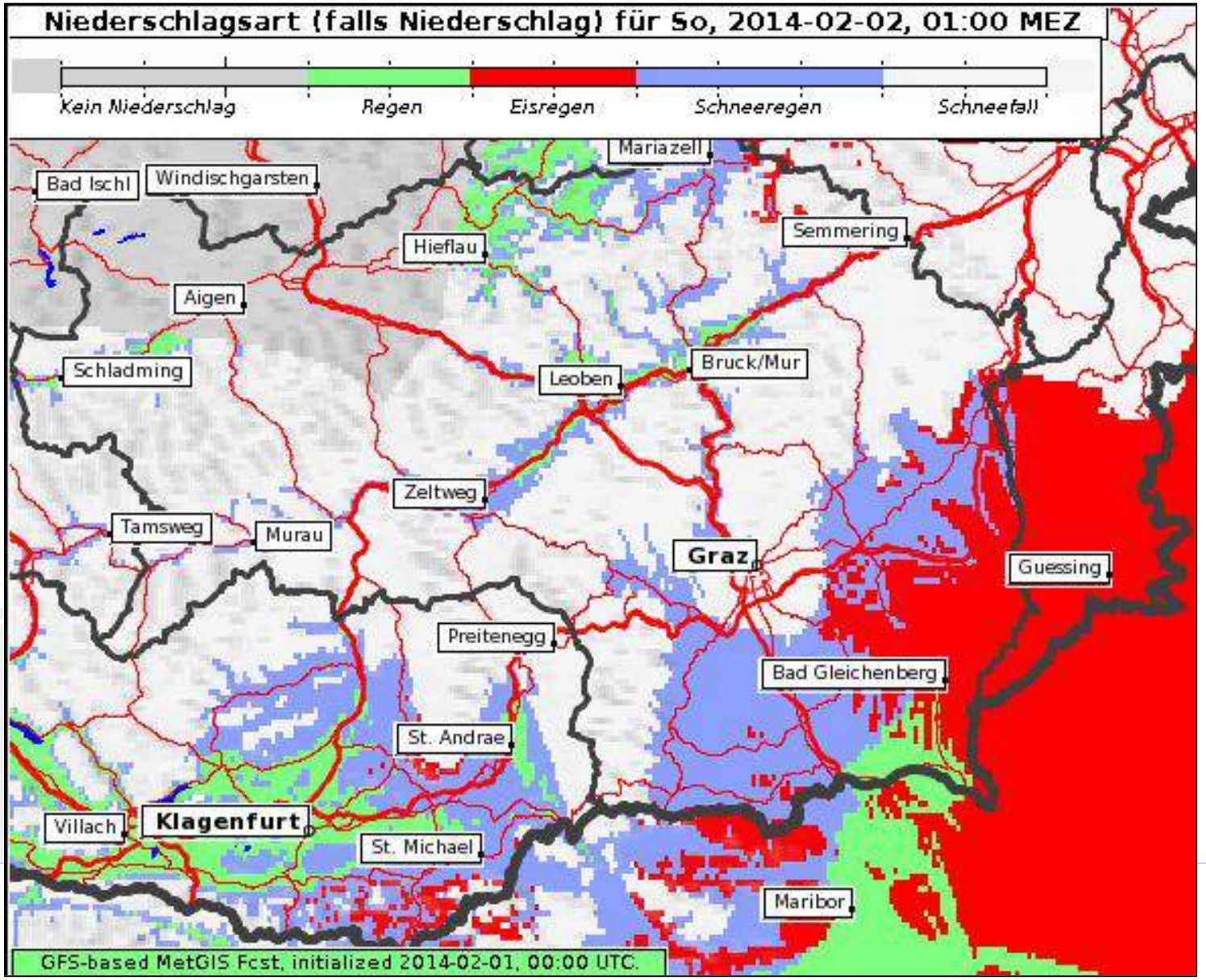
Four times a day: updated high resolution MetGIS forecasts



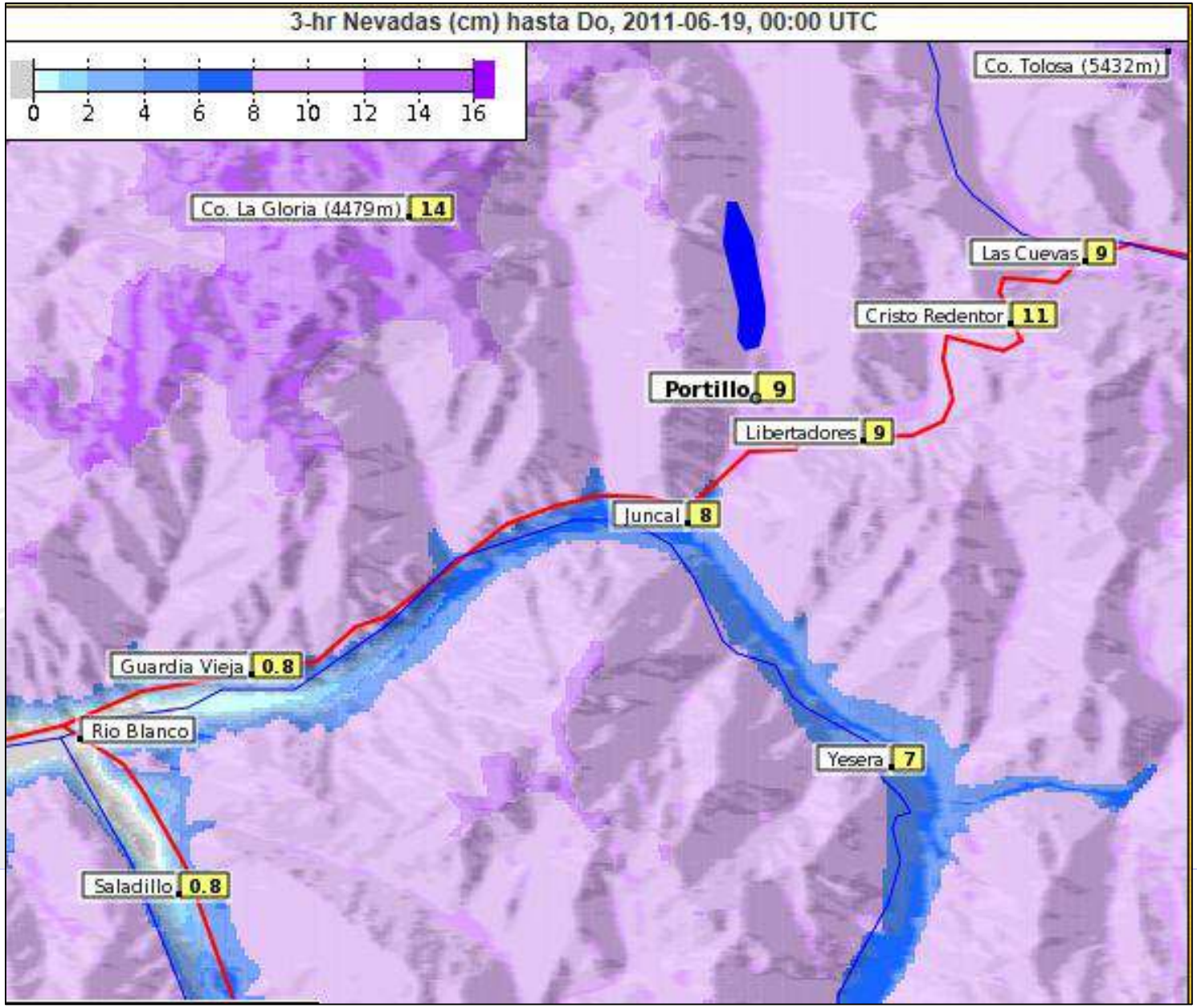
Wind Forecast: Val d‘Aran (Spain)



Form of Precipitation Forecast: SE-Austria

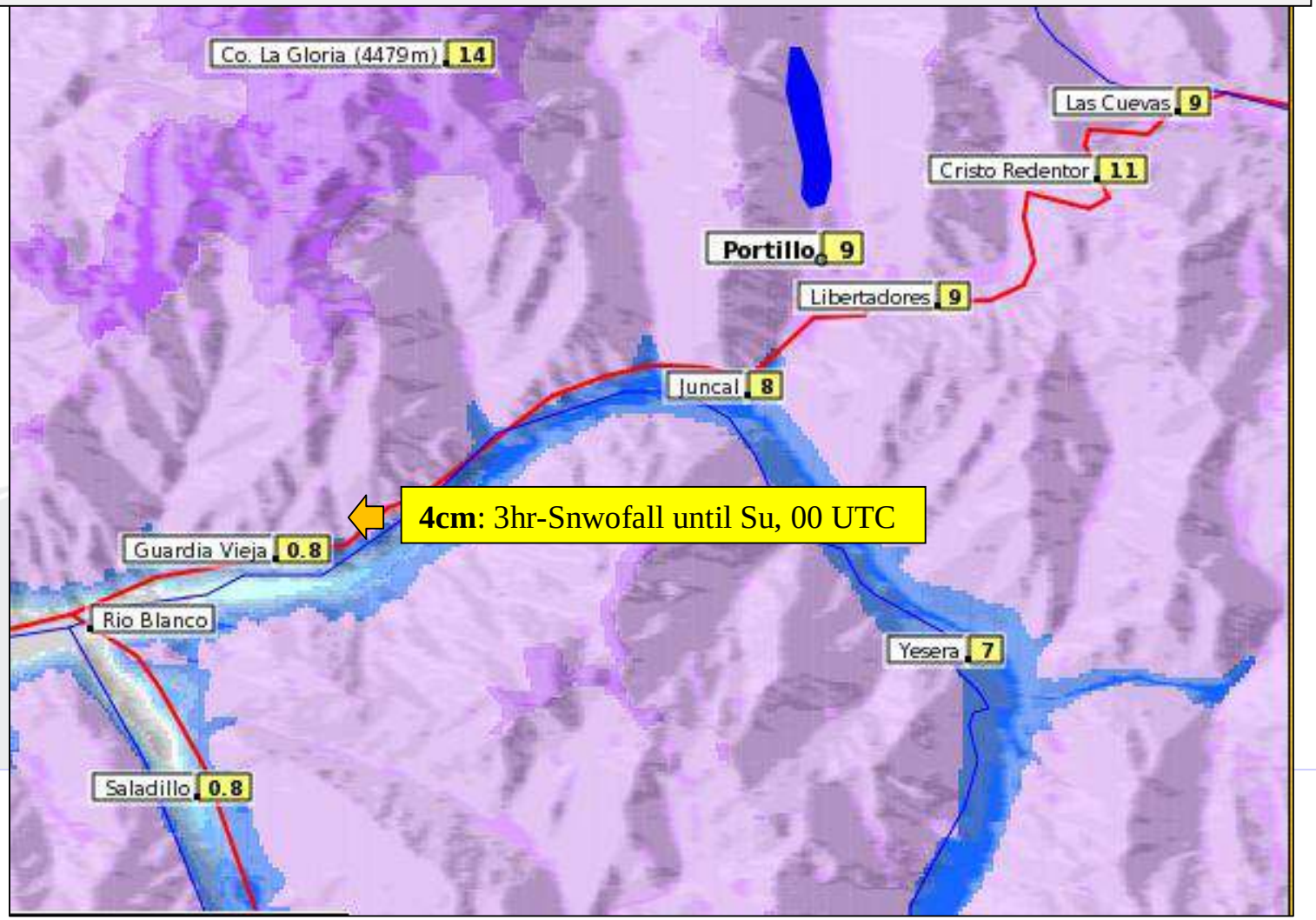


Fresh Snow Forecast: Portillo (Chile)



Fresh Snow Forecast: Portillo (Chile)

Numerical Values are always visible beside mouse cursor!



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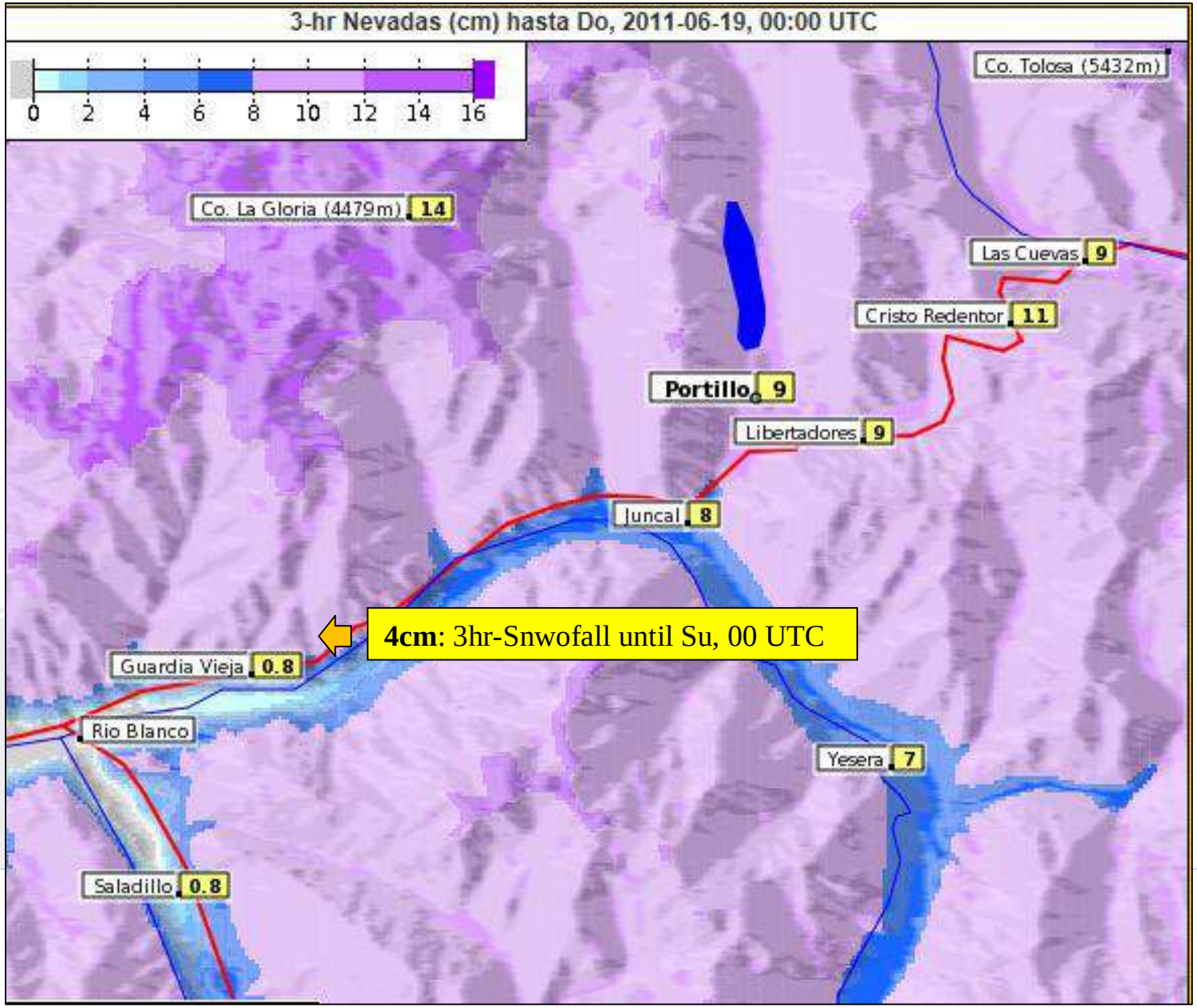

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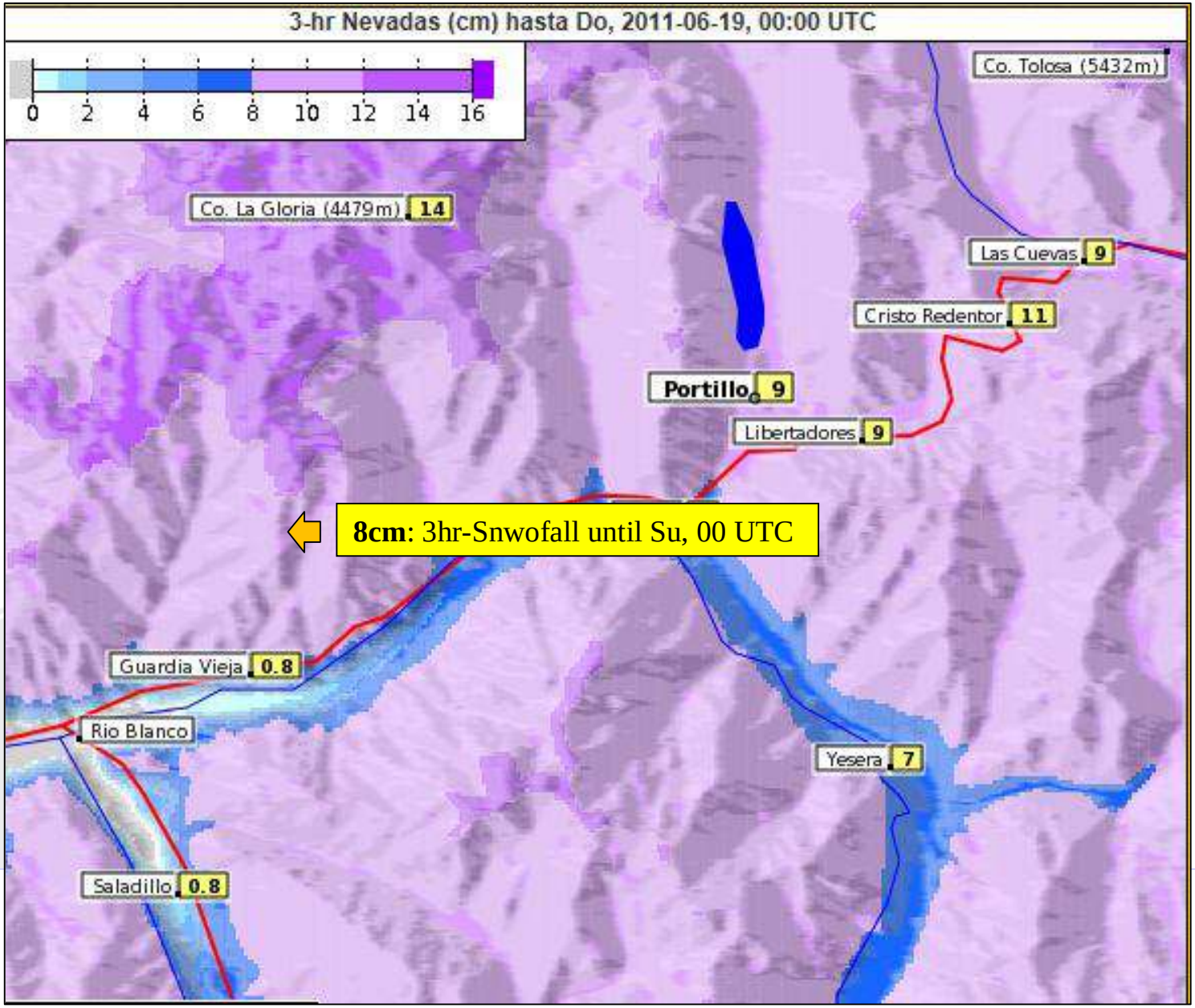

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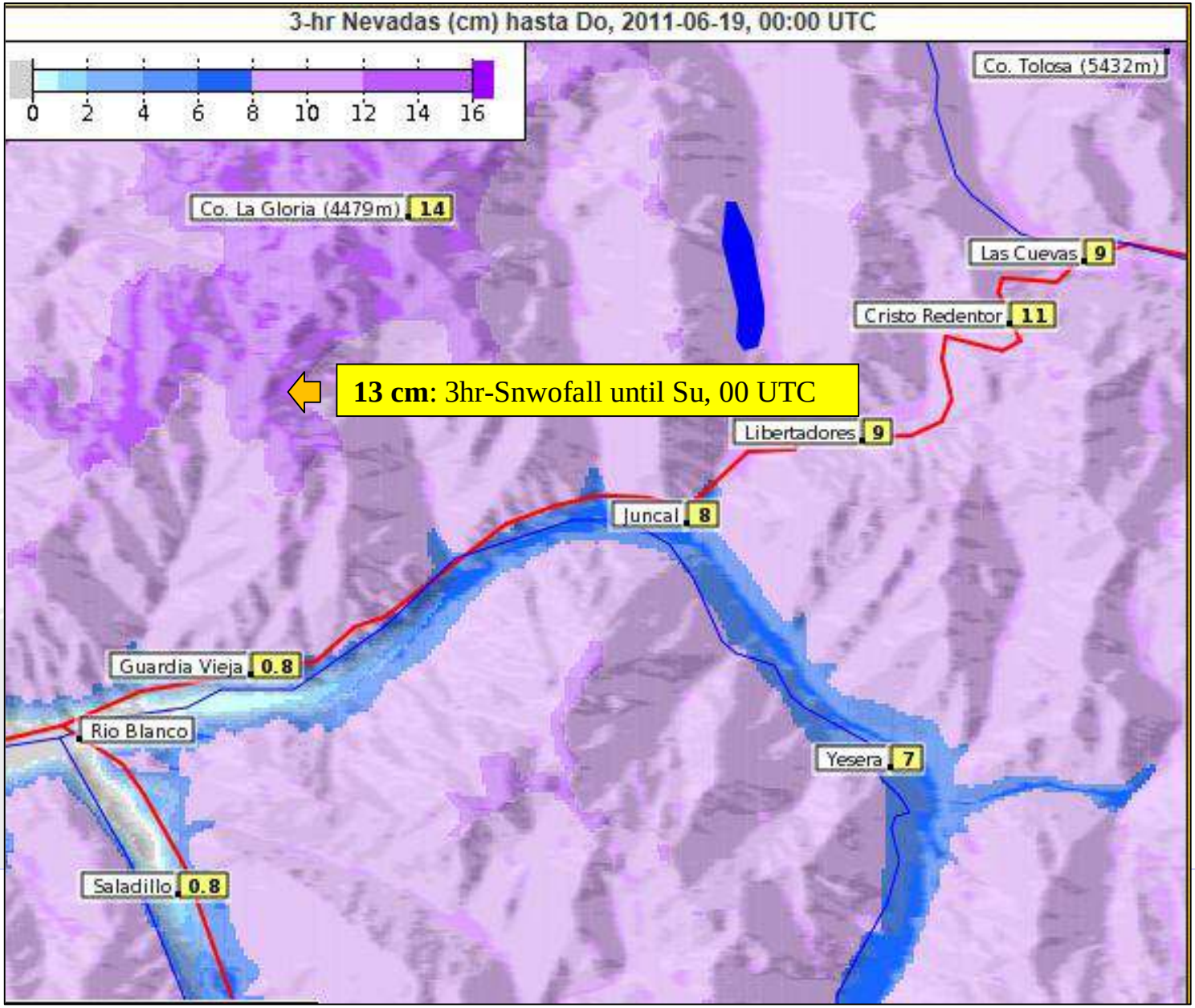
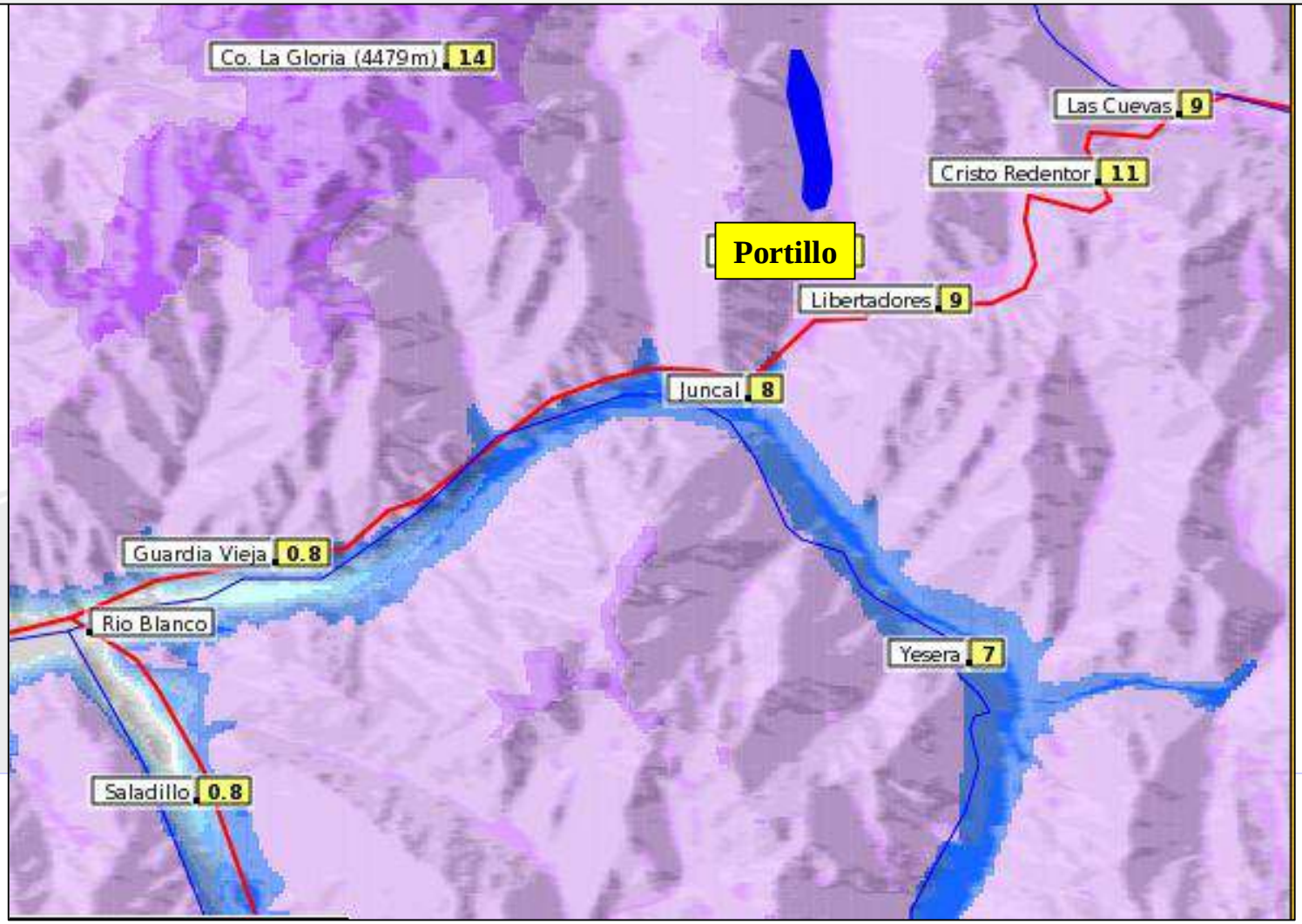


Point Forecasts

7-day point forecasts always pop up when clicking the mouse over specific points



Point Forecast

Example of a 7-day point forecast for Portillo

Pronóstico MetGIS/GFS para Portillo (2850 m) - Windows Internet Explorer

http://www.metgis.com/casestudies/GFS-PORT_2011061800/PTFCST/GFS-FCST7_Portillo_es_mg2.htm

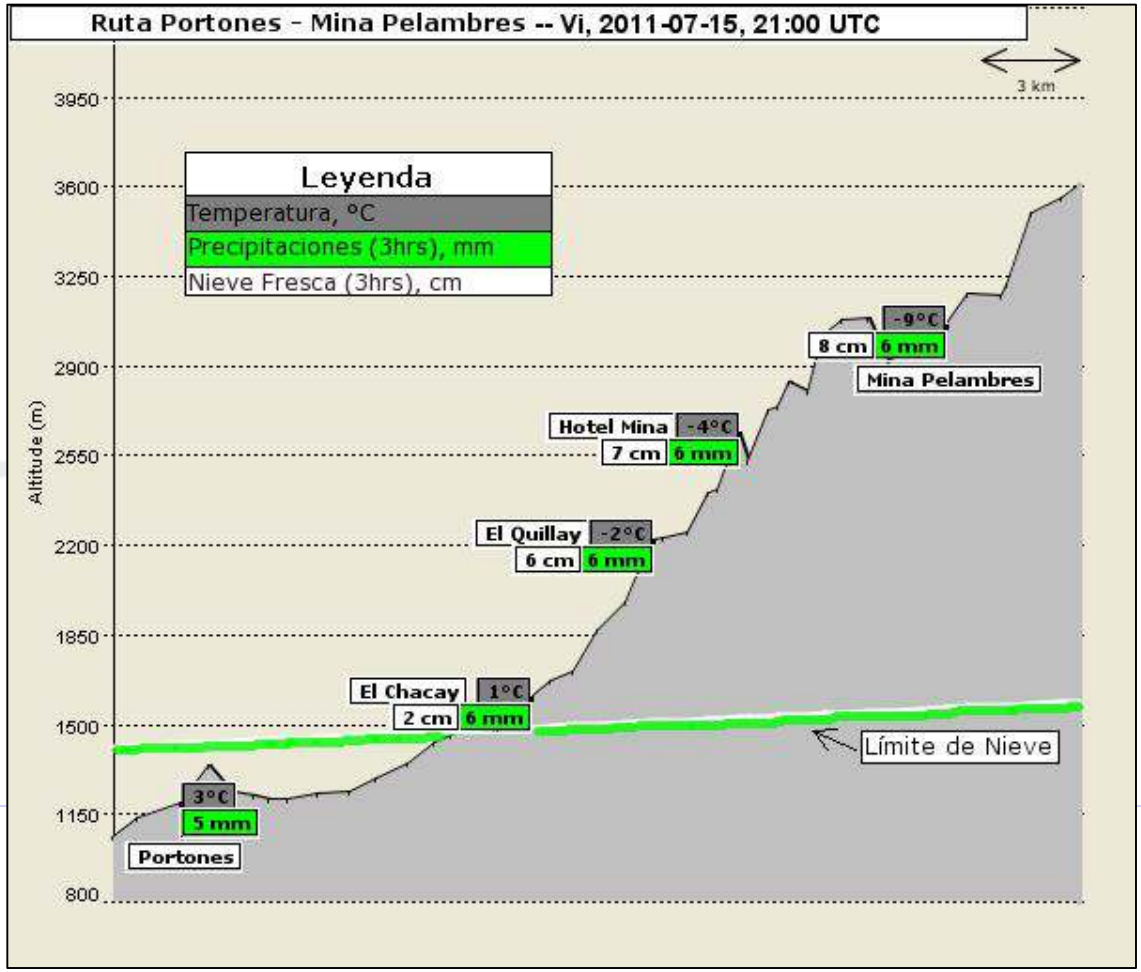
Pronóstico MetGIS/GFS para Portillo (2850 m)
Salida del pronóstico: Sa, 2011-06-18, 00:00 UTC

	Sa								Do								Sum	
Pronóstico valido para (hora):	00	03	06	09	12	15	18	21	00	03	06	09	12	15	18	21	Sa-Do	Lu-Vi
Temperatura [°C]	-2	-2	-3	-4	-4	-4	-5	-5	-6	-7	-7	-8	-8	-7	-6	-5	-	-
Precipitaciones (3hrs) [mm]	-	<1	<1	<1	<1	<1	4	8	7	4	2	2	1	1	2	2	36	14
Nieve Fresca (3hrs) [cm]	-	<1	<1	<1	<1	1	5	10	9	5	3	2	2	2	3	3	46	18
Límite de Nieve [m]	2300	2200	2100	2000	2000	2000	1900	1800	1700	1600	1500	1500	1500	1700	1800	1900	-	-
Viento [m/s]	NO 4	N 5	NO 5	NO 5	N 6	NO 6	NO 8	O 8	O 6	NO 6	NO 6	NO 6	NO 6	NO 6	NO 6	NO 6	-	-

	Lu				Ma				Mi				Ju				Vi			
Pronóstico valido para (hora):	00	06	12	18	00	06	12	18	00	06	12	18	00	06	12	18	00	06	12	18
Temperatura [°C]	-5	-6	-7	-5	-6	-7	-6	-4	-5	-7	-6	-2	-4	-4	-4	0	-1	-1	-2	2
Precipitaciones (3hrs) [mm]	3	1	3	3	2	1	2	1	1	0	0	<1	<1	0	0	0	0	0	0	0
Nieve Fresca (3hrs) [cm]	4	2	4	3	3	2	2	1	1	0	0	<1	<1	0	0	0	0	0	0	0
Límite de Nieve [m]	1800	1600	1600	1900	1600	1600	1600	2100	1900	1600	1700	2300	2000	2000	2000	2700	2500	2500	2300	2900
Viento [m/s]	NO 5	N 4	NE 4	N 3	E 3	NE 2	NE 1	S 1	E 4	E 4	E 3	O 3	O 2	O 3	O 2	O 4	O 2	O 3	O 3	O 5

Route Forecasts

Example of a forecast for the access route to the Pelambres Mine (Chile).



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MetGIS Forecast Quality Monitoring

Motivation: Try to detect weaknesses of model, so that the quality of future forecasts can be further improved

Parameters studied: temperature, precipitation, fresh snow

Verification studies processed:

- Alps (Austria): several studies since winter 2007/08
- Pyrenees (Spain): several studies since winter 2008/09
- Southern Andes (Chile): winter 2009, 2010, 2011
- Himalaya (Bhutan): study with data from 2010/2011
- Caucasus (Russia): 2009

Involved stations:

- regular SYNOP stations, stations from avalanche warning services and mining companies
- locations: valley, lowland, high elevation, mountain tops

Temperature Forecast Verification

Station: Schmittenhöhe (1953m), Austria
Period: winter 2011/2012

Forecast Range (Days)	1	2	3	4	5
% of forecasts with errors < 1 deg	60,9	56,1	43,2	36,7	28,6
% of forecasts with errors < 2 deg	86,2	82,4	75,9	60,1	53,5
% of forecasts with errors < 3 deg	95,8	95,8	91,2	79,9	72,3
Mean absolute error (deg)	1,03	1,15	1,36	1,82	2,32
Correlation coefficient	0,98	0,98	0,97	0,95	0,90

Fresh Snow Forecast Verification

Difficuties:

- Representativity of observation stations, used for comparison
- Measurement errors
- Observation times and periods for fresh snow partly not standardized
- Between 2 observation times snowpack may form and melt away
- Wind influence on fallen snow
- Settling of the snow pack

Fresh Snow Forecast Verification

Most important snowstorms hitting the station
Los Pelambres (Chile) during a winter season.

Snowfall observed at Los Pelambres		**Depth of observed fresh snow [cm]**	**Depth of fresh snow forecast by MetGIS [cm]**
From (start time)	Until (end time)		
2009-05-29 09:00	2009-05-30 00:00	**9**	**6**
2009-06-28 04:30	2009-06-30 03:00	**103**	**87**
2009-07-14 11:00	2009-07-15 07:00	**12**	**21**
2009-07-21 07:00	2009-07-22 13:00	**55**	**53**
2009-07-31 23:00	2009-08-01 04:00	**4**	**1**
2009-08-15 03:00	2009-08-16 04:00	**51**	**89**
2009-08-17 19:00	2009-08-19 11:00	**44**	**92**
2009-09-06 10:00	2009-09-06 23:30	**4**	**3**
2009-09-07 03:30	2009-09-07 12:00	**6**	**5**

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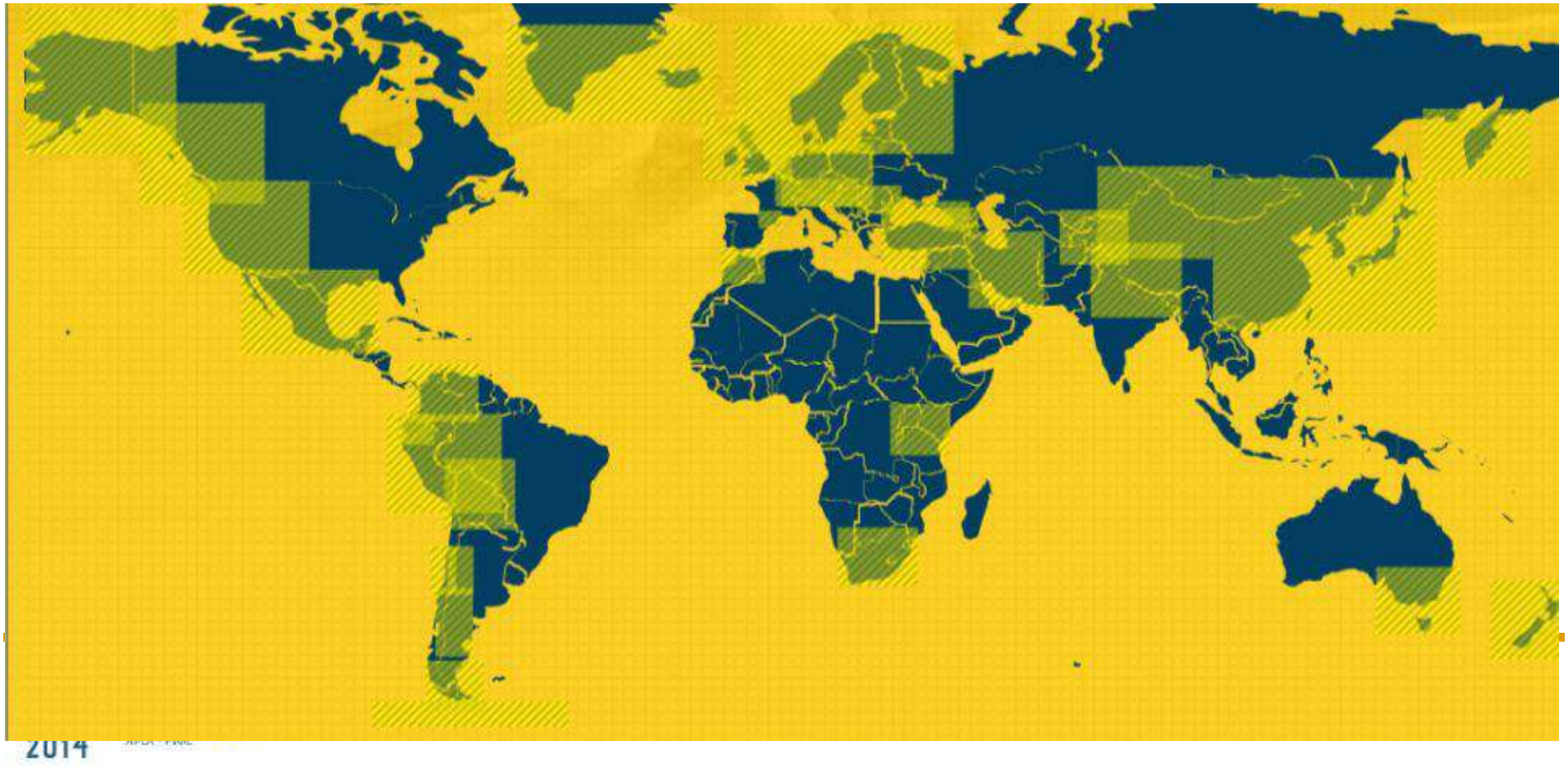
Typical Users of MetGIS Forcasts

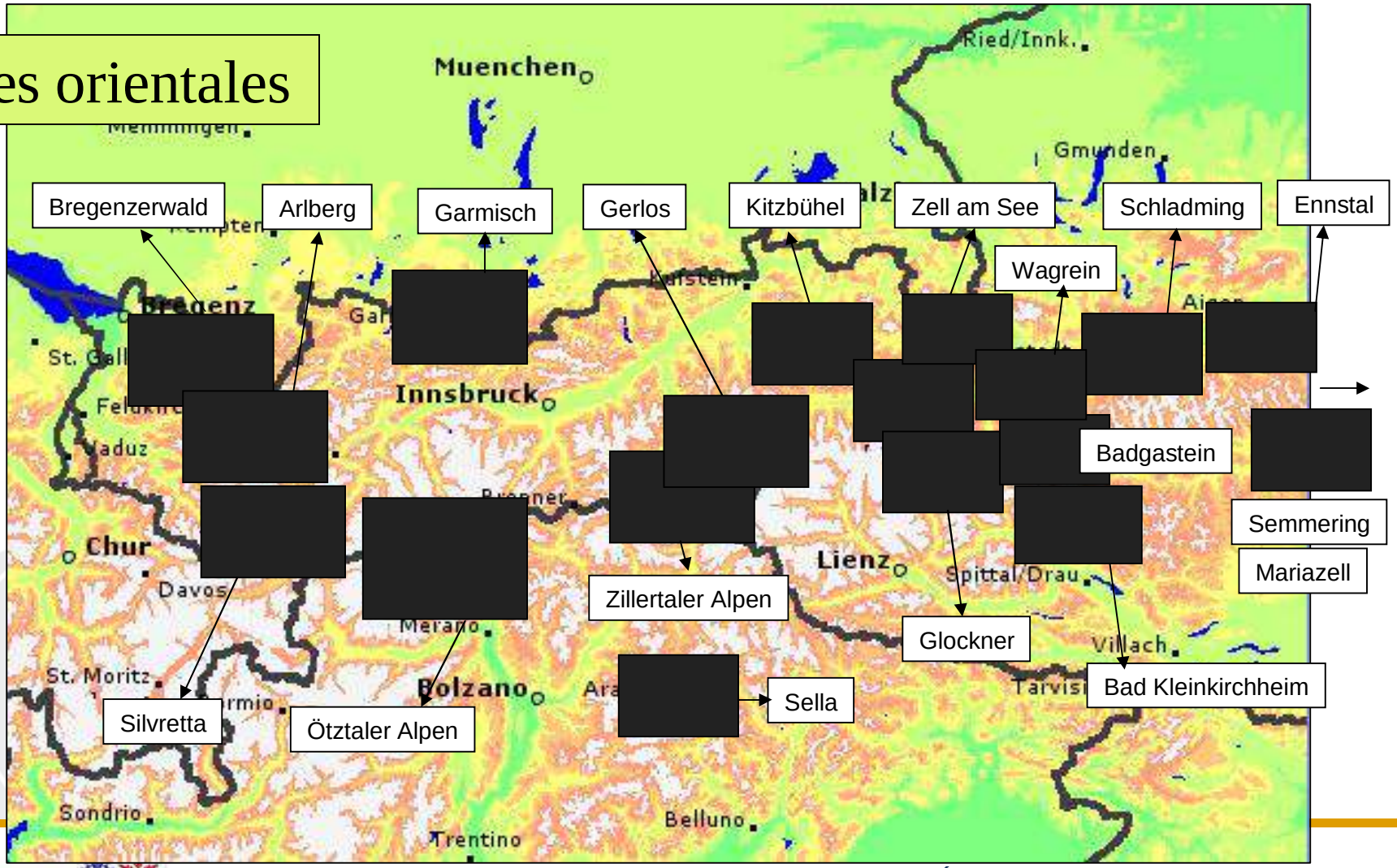
- Traffic operation centers
- Open-pit mining industry
- Ski centers
- Avalanche control centers
- State meteorological services

Forecast Coverage

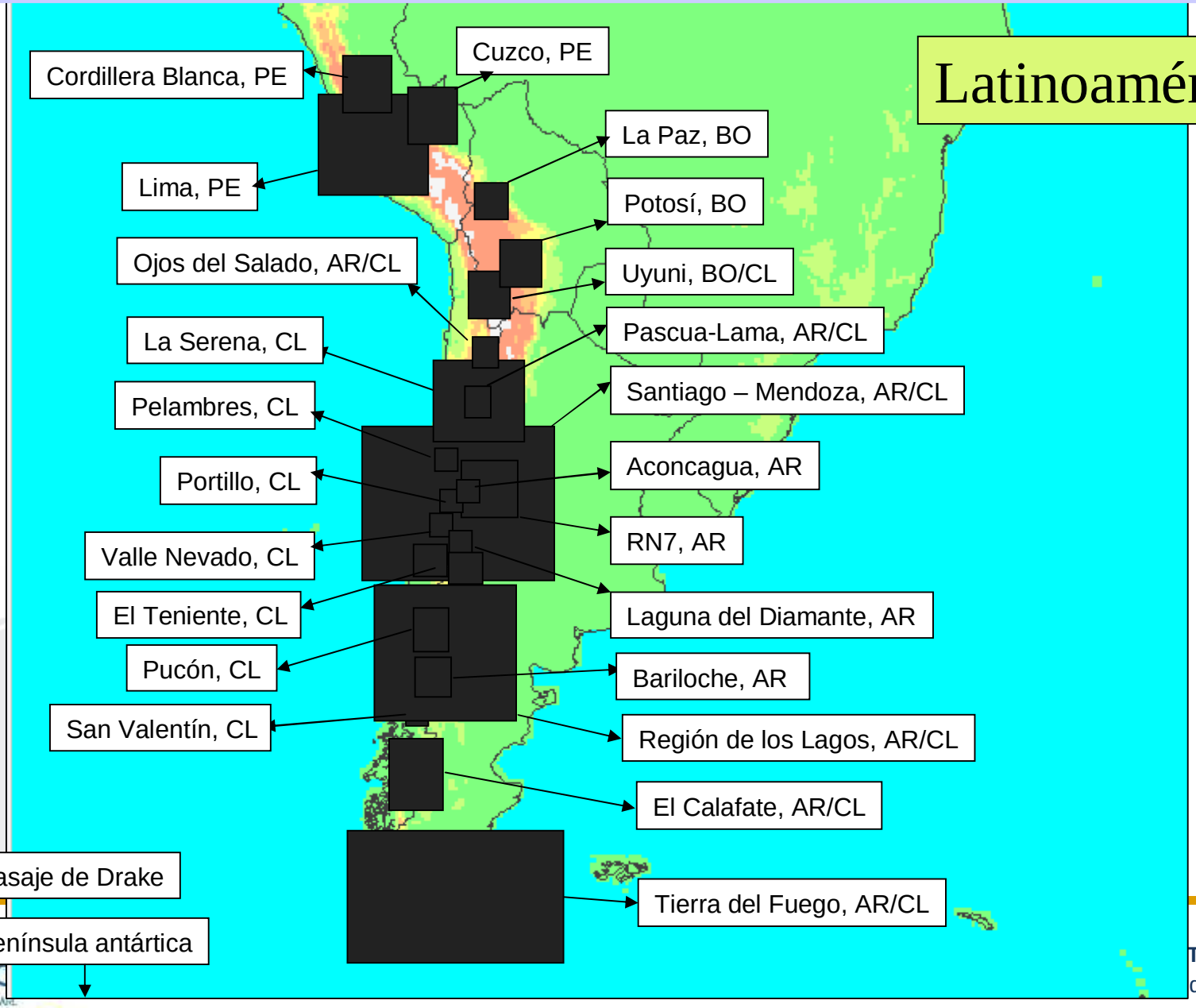
- Real-time forecasts for 2oo regions world-wide
- 8 languages (English, French, Spanish, Italian, German, Slowenian, Russian, Japanese)



Forecast Coverage (Eastern Alps)



Forecast Coverage Chile, Argentina, Peru



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Summary and Outlook

The innovative combination of meteorological prediction models with high resolution terrain data may **significantly increase the quality of weather forecasts**, especially over the mountains.

Improved weather forecasts in combination with an easy-to-manage user interface may help traffic operation centers to **use their resources in a more efficient way** and thus save money.

The constantly **ongoing developments** in the MetGIS software (algorithms, physics, graphics) will further increase the competitive capacities of the forcast system.


Thank you for your attention!
More information:
www.metgis.com